DL126
REV 3

Small-Signal

Transistors, FETs and Diodes Device Data

MOTOROLA

MOTOROLA SMALL-SIGNAL TRANSISTORS, FETs AND DIODES

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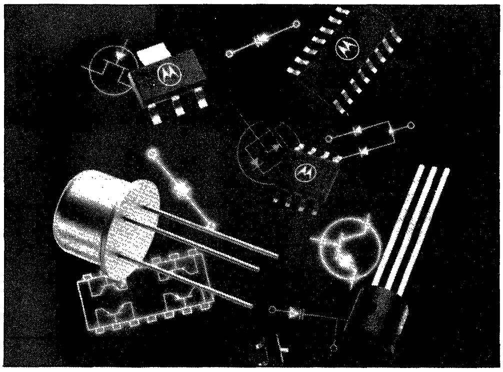

MOTOROLA

SMALL-SIGNAL TRANSISTORS, FETs AND DIODES

This publication presents technical information for the several product families that comprise the Motorola small-signal semiconductor line. The families include bipolar, field-effect transistors, and diodes. These are available in a variety of packages; metal can, plastic, and surface mount. Complete device specifications and typical performance curves are given on individual data sheets, which are grouped by the various families.

A quick comparison of performance characteristics is presented in the easy-to-use selector guide in the first section. The tables will assist in the selection of the proper device for a specific application.

Separate sections are included to describe package outline drawings and footprints and product reliability and quality considerations.

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WHAT'S NEW

In keeping with Motorola's objective of providing information to our customers that is both current and easy to use, a few changes have been made to this revision of the *Small-Signal Transistors, FETs and Diodes* data book. A review of the following items will help you better understand the format of the data and provide you with some useful information to access it more easily.

The bulleted items below give you a brief overview of "What's New" in the data book. Following that is a more detailed explanation of what has been added or changed in this edition of the data book.

- Device Status defined as Preferred, Current or Not Recommended for New Design
- Replacement Devices Index for Devices that have been Removed from the Data Book
- Explanation of SOT-23 and SC-59 Device and Date Code Markings
- New Products: SMALLBLOCK Product Line, SC-59 Package Devices, Bias Resistor Transistors (BRT's) and SOT-223 Package Devices
- SOT-23 Device titles now include T1; for example, MMBTXXXXLT1 replaced MMBTXXXXL
- Mail-in Cards for your critique and comment on the *Small-Signal Transistors, FETs and Diodes* data book. Two cards are available at the front of the book and a third card is available at the back of the book.

1. Motorola Device Classifications

In an effort to provide current information to the customer regarding the status of any given device, Motorola has classified all devices into three categories: Preferred devices, Current product and Not Recommended for New Design products.

A Preferred device is a device which is recommended as a first choice for future use. These devices are "preferred" by virtue of their performance, price functionality, or combination of attributes which offer the overall "best" value to the customer. This category contains both advanced and mature devices which will remain available for the foreseeable future (generally 3 to 5 years).

> All Small-Signal transistors, FETs, SMALLBLOCKS or Diodes that are classified as a "preferred device" have a star symbol (★) at the end of the device title on the individual data sheets.

Device types identified as "current" are not a first choice product for **new** designs, but will continue to be available because of the popularity and/or standardization or volume usage in current production designs. These products can be acceptable for new designs but the preferred types are considered better alternatives for long term usage.

> Any device that has not been identified as a "preferred device" is a "current" device.

Products designated as "Not Recommended for New Design" may become obsolete as dictated by poor market acceptance, or a technology or package that is reaching the end of its life cycle. Devices in this category have an uncertain future and do not represent a good selection for new device designs or long term usage.

> All "Not Recommended for New Design" devices have been removed from the data book. In the event the device you need is no longer found within an appropriate section of the data book, refer to the Replacement Devices index at the back of the book to see if there is a Replacement Part for the device in question.

2. Replacement Devices Index for Devices That Have Been Removed From The Data Book

An index to devices that have been removed from the data book is provided in Section 10. A direct or similar replacement part is listed for those devices which have replacement parts. Additionally, a code is listed next to the device which indicates the reason why the device is no longer supported by a data sheet.

3. New Products

SMALLBLOCK Product Line

This new series of MOSFET turn-off devices offers an economical way to reduce the turn-off time of power MOSFETs. Refer to Section 6 for information on this family of devices.

SC-59 Package

The SC-59 package is a Surface Mount package that is used extensively in Japan. It is very similar to the SOT-23 but is slightly larger. Devices offered in the SC-59 package are standard transistors (see pages 2-386 through 2-395), bias resistor transistors (see pages 2-396 through 2-400) and switching diodes (see pages 5-16 through 5-19).

Bias Resistor Transistors (BRT's) SC-59

This new series of digital transistors is designed to replace a single device and its external resistor bias network. The BRT contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space and reduce insertions and product inventory. Bias resistor transistors can be found on pages 2-396 through 2-400.

SOT-223 Package

The SOT-223 package is a Surface Mount package that offers higher power capabilities for Small-Signal Surface Mount products. Devices offered in this package are bipolar transistors (see pages 2-142, 2-143, 2-148 and 2-417 through 2-425), FET's (see pages 4-66 through 4-70) and a tuning diode (see page 5-68).

4. Tape and Reel/Device Markings

In addition to Section 7, which contains information on Tape and Reel Specifications, some additional information has been added to the second page of each of the device sections as follows:

Ordering information for device packages that are available only in Tape and Reel or Ammo Pack has been presented so that the customer can quickly and easily get the information necessary to complete an order.

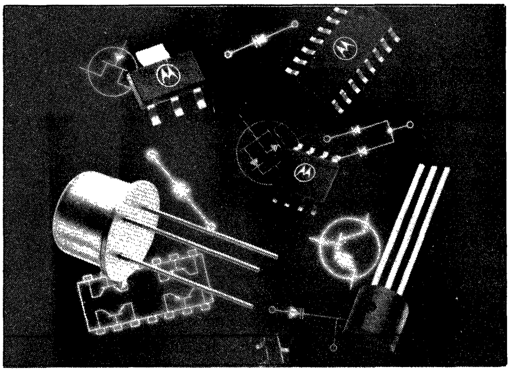
Information concerning device markings for the SOT-23 and SC-59 packages has been provided. Since some customers have been confused by the date code marking on these device packages we have provided a visual and written explanation of the date code marking found on the SOT-23 and SC-59 packages.

ALPHANUMERIC INDEX

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

Selector Guide



This selector guide highlights semiconductors that are the most popular and have a history of high usage for the most applications.

It covers a wide range of Small-Signal plastic and metal-can semiconductors.

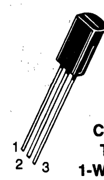
A large selection of encapsulated plastic transistors, FETs and diodes are available for surface mount and insertion assembly technology. Plastic packages include TO-92 (TO-226AA), 1 Watt TO-92 (TO-226AE), SOT-23, SC-59, and SOT-223. Plastic multiples are available in 14-pin and 16-pin dual-in-line packages for insertion applications: SO-14 and SO-16 for surface mount applications.

Metal-can packages are available for applications requiring higher power dissipation or having hermetic requirements in TO-18 (TO-206AA) and TO-39 (TO-205AD).

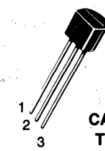
Table of Contents

Plastic-Encapsulated Transistors

Motorola's small-signal TO-226 plastic transistors encompass hundreds of devices with a wide variety of characteristics for general-purpose, amplifier and switching applications. The popular high-volume package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems. All devices are laser marked for ease of identification and shipped in antistatic containers, as part of Motorola's ongoing practice of maintaining the highest standards of quality and reliability.



CASE 29-03
TO-226AE
1-WATT (TO-92)



CASE 29-04
TO-226AA
(TO-92)

Table 1. Plastic-Encapsulated General-Purpose Transistors

These general-purpose transistors are designed for small-signal amplification from dc to low radio frequencies. They are also useful as oscillators and general-purpose switches. Complementary devices shown where available (Tables 1–4).

NPN	PNP	Pin Out	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	mA	I_C mA Max	h_{FE} @ I_C Min	Max	mA	NF dB Max
Case 29-04 — TO-226AA (TO-92)										
MPS8099	MPS8599	EBC	80	150	10	200	100	300	1.0	—
MPSA06	MPSA56	EBC	80	100	10	500	100	—	100	—
2N4410	—	EBC	80	60	10	250	60	400	10	—
BC546	BC556	CBE	65	150	10	100	120	450	2.0	10
BC546A	BC556A	CBE	65	150	10	100	120	220	2.0	10
BC546B	BC556B	CBE	65	150	10	100	180	450	2.0	10
MPSA05	MPSA55	EBC	60	100	10	500	50	—	100	—
	MPS2907A	EBC	60	200	50	600	100	300	150	—
BC182	BC212	ECB	50	200	10	100	120	460	2.0	10
BC237B	BC307B	CBE	45	150	10	100	200	460	2.0	10
BC337	BC327	CBE	45	210*	10	800	100	600	100	—
BC547	BC557	CBE	45	150	10	100	120	450	2.0	10
BC547A	BC557A	CBE	45	150	10	100	120	220	2.0	10
BC547B	BC557B	CBE	45	150	10	100	180	450	2.0	10
BC547C	BC557C	CBE	45	150	10	100	380	800	2.0	10
MPSA20	MPSA70	EBC	40	125	5.0	100	40	400	5.0	—
MPS2222A		EBC	40	300	20	600	100	300	150	—
2N4401	2N4403	EBC	40	200	20	600	100	300	150	—
2N4400	2N4402	EBC	40	150	20	600	50	150	150	—
MPS6602	MPS6652	EBC	40	100	50	1000	50	—	500	—
2N3903	2N3905	EBC	40	200	10	200	50	150	10	6
2N3904	2N3906	EBC	40	250	10	200	100	300	10	5
BC548		CBE	30	300*	10	100	120	300	2.0	10
BC548A		CBE	30	300*	10	100	120	220	2.0	10
BC548B	BC558B	CBE	30	300*	10	100	180	450	2.0	10
BC548C		CBE	30	300	10	100	380	800	2.0	10
2N4123	2N4125	EBC	30	200	10	200	50	150	2.0	6
2N4124	2N4126	EBC	25	250	10	200	120	360	2.0	5
BC338	BC328	CBE	25	210*	10	800	100	600	100	—

*Typical

Table 1. Plastic-Encapsulated General-Purpose Transistors (continued)

Case 29-03 — TO-226AE (1-WATT TO-92)

NPN	PNP	Pin Out	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	mA	I_C A Max	h_{FE} @ I_C Min	Max	mA	$V_{CE(sat)}$ @ I_C @ I_B Volts Max	mA	mA
BDB01D	BDB02D	EBC	100	50	200	0.5	40	400	100	0.7	1000	100
BDC01D	BDC02D	ECB	100	50	200	0.5	40	400	100	0.7	1000	100
BDB01C	BDB02C	EBC	80	50	200	0.5	40	400	100	0.7	1000	100
BDC01C	BDC02C	ECB	80	50	200	0.5	40	400	100	0.7	1000	100
MPS6717		EBC	80	50	200	0.5	80	—	50	0.5	250	10
MPSW06	MPSW56	EBC	80	50	200	0.5	80	—	50	0.4	250	10

Table 2. Plastic-Encapsulated Low-Noise and Good h_{FE} Linearity

These devices are designed to use on applications where good h_{FE} linearity and low-noise characteristics are required: Instrumentation, hi-fi preamplifier.

NPN	PNP	Pin Out	$V_{(BR)CEO}$ Volts	h_{FE} @ I_C Min	Max	mA	V_T[1] mV Typ	NF[2] dB Max	f_T MHz Typ
Case 29-04 — TO-226AA (TO-92)									
—	MPS4249	EBC	60	100	300	0.1	—	3.0	100
—	2N5087	EBC	50	250	800	0.1	—	2.0	40
—	2N5086	EBC	50	150	500	0.1	—	3.0	40
MM6428	—	EBC	50	250	650	0.1	7.0**	3.5***	100†
BC239	BC309	CBE	45	120	800	2.0	9.5	2.0	240
BC550B	BC560B	CBE	45	180	460	2.0	8.0	2.5	250
BC550C	BC560C	CBE	45	380	800	2.0	8.0	2.5	250
MPSA18	—	EBC	45	500	—	2.0	7.0	—	160
MPS3904	MPS3906	EBC	40	100	300	10	—	5.0	200
—	MPS4250	EBC	40	250	—	10	—	2.0	250
BC549B	BC559B	CBE	30	180	800	2.0	8.0	2.5	250
BC549C	BC559C	CBE	30	380	800	2.0	8.0	2.5	250
2N5088	—	EBC	30	350	—	2.0	—	3.0	150
2N5089*	—	EBC	25	450	—	2.0	—	2.0	150
MPS6521	MPS6523	EBC	25	300	—	2.0	—	3.0	340*

[1] V_T: Total Input Noise Voltage (see BC413/BC414 and BC415/BC416 Data Sheets) at R_S = 2.0 kΩ, I_C = 200 μA, V_{CE} = 5.0 Volts.
[2] N_F: Noise Figure at R_S = 2.0 k, I_C = 200 μA, V_{CE} = 5.0 Volts. f = 30 Hz to 15 kHz.
* "S" version.
** R_S = 10 kΩ, BW = 1.0 Hz, f = 100 MHz
*** R_S = 500 Ω, BW = 1.0 Hz, f = 10 MHz
† Min

SMALL-SIGNAL BIPOLAR TRANSISTORS — PLASTIC-ENCAPSULATED TRANSISTORS (continued)

Table 3. Plastic-Encapsulated Darlington Transistors

Darlington amplifiers are cascade transistors used in applications requiring very high-gain and input impedance. These devices have monolithic construction.

NPN	PNP	Pin Out	$V_{(BR)CEO}$ Volts	I_C Max	h_{FE} @ I_C Min	Max	mA	Volts Max	I_C mA	$V_{CE(sat)}$ I_B mA	f_T Min	I_C
Case 29-03 — TO-226AE (1-WATT TO-92)												
MPSW45A	—	EBC	50	1000	25K	—	200	1.5	1000	2.0	100	200
—	MPSW64	EBC	30	1000	20K	—	100	1.5	100	0.1	125	10
Case 29-04 — TO-226AA (TO-92)												
MPSA29	—	EBC	100	500	10K	—	100	1.4	100	0.1	125	10
BC373	—	EBC	80	1000	25K	160K	100	1.0	250	0.25	100	100
MPSA27	MPSA77	EBC	60	500	10K	—	100	1.5	100	0.1	125	10
BC618	—	CBE	55	1000	10K	50K	200	1.1	200	0.2	150	500
	MPSA75	EBC	40	500	10K	—	100	1.5	100	0.1	125	10
2N6427	—	EBC	40	500	20K	200K	100	1.5	500	0.5	125	10
2N6426	—	EBC	40	500	30K	300K	100	1.5	500	0.5	125	10
MPSA14	MPSA64	EBC	30	500	20K	—	100	1.5	100	0.1	125	10
MPSA13	MPSA63	EBC	30	500	10K	—	100	1.5	100	0.1	125	10
BC517	—	CBE	30	400	30K	—	20	1.0	100	0.1	125	10

Table 4. Plastic-Encapsulated High-Current Transistors

The following table is a listing of devices that are capable of handling a higher current range for small-signal transistors.

Case 29-03 — TO-226AE (1-WATT TO-92)

NPN	PNP	Pin Out	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	mA	I_C mA Max	h_{FE} @ I_C Min	Max	mA	$V_{CE(sat)}$ @ I_C @ I_B Volts Max	mA	mA
MPS6715	MPS6727	EBC	40	50	50	1000	50	—	1000	0.5	1000	100
MPSW01A	MPSW51A	EBC	40	50	50	1000	50	—	1000	0.5	1000	100

Case 29-04 — TO-226AA (TO-92)

NPN	PNP	Pin Out	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	mA	I_C mA Max	h_{FE} @ I_C Min	Max	mA	$V_{CE(sat)}$ @ I_C @ I_B Volts Max	mA	mA
BC489	BC490	CBE	80	200/150*	50	1000	60	400	100	0.3/0.5	1000	100
BC639	BC640	ECB	80	60	10	1000	40	160	150	0.5	500	50
MPS651	MPS751	EBC	60	75	50	2000	75	—	1000	0.5	2000	200
MPS650	MPS750	EBC	40	70	50	2000	75	—	1000	0.5	2000	200
BC368	BC369	EBC	20	60	10	1000	60	—	1000	0.5	1000	100

*Typical

Table 5. Plastic-Encapsulated High-Voltage Amplifier Transistors

These high-voltage transistors are designed for driving neon bulbs and indicator tubes, for direct line operation, and for other applications requiring high-voltage capability at relatively low collector current. These devices are listed in order of decreasing breakdown voltage ($V_{(BR)CEO}$).

Device Type	Pin Out	$V_{(BR)CEO}$ Volts Min	I_C Amp Max	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA
Case 29-03 — TO-226AE (1-WATT TO-92) — NPN										
BDC05	ECB	300	0.5	40	25	2.0	20	2.0	60	10
MPSW42	EBC	300	0.3	40	30	0.5	20	2.0	50	10
Case 29-03 — TO-226AE (1-WATT TO-92) — PNP										
BDC06	ECB	300	0.5	40	25	2.0	20	2.0	60	10
MPSW92	EBC	300	0.3	25	30	0.5	20	2.0	50	10
Case 29-04 — TO-226AA (TO-92) — NPN										
BF844	EBC	400	0.5	40	30	0.5	10	1.0	50	10
MPSA44	EBC	400	0.3	40	100	0.75	50	5.0	20	10
2N6517	EBC	350	0.5	30	30	0.3	10	1.0	40	10
BF393	EBC	300	0.5	40	10	0.2	20	2.0	50	10
MPSA42	EBC	300	0.5	40	10	0.5	20	2.0	50	10
2N5551	EBC	160	0.6	80	10	0.15	10	1.0	100	10
Case 29-04 — TO-226AA (TO-92) — PNP										
BF493S	EBC	350	0.5	40	10	20	20	2.0	50	10
2N6520	EBC	350	0.5	30	30	0.3	10	1.0	40	10
MPSA92	EBC	300	0.5	40	10	0.5	20	2.0	50	10
2N6519	EBC	300	0.5	45	30	0.3	10	1.0	40	10
2N5401	EBC	150	0.6	60	10	0.2	10	1.0	100	10

Case 29-04 — TO-226AA (TO-92)

NPN	PNP	Pin Out	$V_{(BR)CEO}$ Volts Min	I_C Amp Cont	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C @ I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA
BF420	BF421	ECB	300	0.1	40	25	2.0	20	2.0	60	10
BF422	BF423	ECB	250	0.1	50	25	2.0	20	2.0	60	10

1

Table 6. Plastic-Encapsulated RF Transistors

The RF transistors are designed for small-signal amplification from RF to VHF/UHF frequencies. They are also used as mixers and oscillators in the same frequency ranges.

Device Type	Pin Out	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} @ I_C Min	mA	V_{CE} V	f_T MHz Typ	CRE/CRB pF Max	NF dB Typ	f MHz
Case 29-04 — TO-226AA (TO-92) — NPN										
BF224	CEB	30	50	30	7.0	10	600	0.28	2.5	100
MPSH24	BEC	30	100	30	8.0	10	400*	0.36	—	—
MPSH20	BEC	30	100	25	4.0	10	400*	0.65	—	—
MPSH07A	EBC	30	25	20	3.0	10	400*	0.3	3.2(1)	100
MPS3866	EBC	30	400	10	50	5.0	500*	—	—	—
MPSH11	BEC	25	25	60	4.0	10	660*	—	—	—
MPSH10	BEC	25	100	60	4.0	10	1500	0.7	—	—
BF199	CEB	25	100	40	7.0	10	750	0.35	2.5	35
BF959	CEB	20	100	40	20	10	800	0.65	3.0	200
MPS6568A	BEC	20	50	20	4	5	375*	0.65	3.3(1)	200
MPSH17	BEC	15	100	25	5.0	10	1600	0.9	6.0(1)	200
MPS918	EBC	15	50	20	8.0	10	800	1.7	6.0(1)	60
MPS5179	EBC	12	50	25	3.0	1.0	2000	—	4.5(1)	200
MPS3563	EBC	12	50	20	8.0	10	800	1.7	6.0(1)	60
MPS6595	EBC	12	50	25	10	5	1200*	1.3	—	—
Case 29-04 — TO-226AA (TO-92) — PNP										
MPSH81	BEC	20	50	60	5.0	10	700	0.85	—	—
MPSH69	EBC	15	50	30	10		2000	0.3	—	—

*Min
(1)Max
(2)AGC Capable

Table 7. Plastic-Encapsulated High-Speed Saturated Switching Transistors

The transistors listed in this table are specially optimized for high-speed saturated switches. They are heavily gold doped and processed to provide very short switching times and low output capacitance (below 6.0 pF). The transistors are listed in order of decreasing turn-on time (t_{on}).

Device Type	t_{on} ns Max	t_{off} ns Max	@ I_C mA	$V_{(BR)CEO}$ Volts Min	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	& I_B mA	f_T MHz Min	@ I_C mA
Case 29-04 — TO-226AA (TO-92) — NPN											
2N4264	25	35	10	15	40	10	0.22	10	1.0	300	10
2N4265	25	35	10	12	100	10	0.22	10	1.0	300	10
MPS3646	18	28	300	15	30	30	0.2	30	3.0	350	30
MPS2369A	12	18	10	15	40	10	0.2	10	1.0	500	10
Case 29-04 — TO-226AA (TO-92) — PNP											
MPS3640	25	35	50	12	30	10	0.2	10	1.0	500	10
MPS4258	15	20	10	12	30	50	0.15	10	1.0	700	10
MPS5771	15	20	10	15	35	10	0.18	10	1.0	850	10

Table 8. Plastic-Encapsulated Choppers

Devices are listed in decreasing $V_{(BR)EBO}$.

Device Type	Pin Out	$V_{(BR)EBO}$ Volts Min	I_C Amp* Max	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA
Case 29-04 — TO-226AA (TO-92) — NPN										
MPSA17	EBC	15	100	200	5.0	0.25	10	1.0	100	5.0
MPSA16	EBC	12	100	200	5.0	0.25	10	1.0	80	5.0
Case 29-04 — TO-226AA (TO-92) — PNP										
MPS404A	EBC	−25	−150	30	−12	−0.2	−24	1.0	—	—

*Typ

Table 9. Plastic-Encapsulated Telecom Transistors

These devices are special product ranges intended for use in telecom applications.

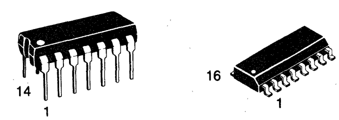
Device Type	Pin Out	$V_{(BR)CEO}$ Volts	P_D mW 25°C Amb	I_C mA Cont	h_{FE} @ I_C @ V_{CE} Min	Max	mA	Volts	f_T MHz Min
Case 29-04 — TO-226AA (TO-92) — NPN									
P2N2222A	CBE	40	625	600	75	—	10	10	300
PBF259,S*	EBC	300	625	500	25	—	1.0	10	40
Case 29-04 — TO-226AA (TO-92) — PNP									
P2N2907A	CBE	60	625	600	100	—	10	10	200
PBF493,S**	EBC	300	625	500	40	—	1.0	10	40

*"S" version, h_{FE} Min 60 @ I_C = 20 mA, V_{CE} = 10 V.
**"S" version, h_{FE} Min 40 @ I_C = 0.1 mA, V_{CE} = 1.0 V.

Plastic-Encapsulated Multiple Transistors

The manufacturing trend has been toward printed circuit board design with requirements for smaller packages with more functions. In the case of discrete components the use of the multiple device package helps to reduce board space requirements and assembly costs.

Many of the most popular devices are offered in the standard plastic DIP and surface mount IC packages. This includes small-signal NPN and PNP bipolar transistors, N-channel and P-channel FETs, as well as diode arrays.



CASE 646-06 (TO-116) | CASE 751B-03 SO-16

Specification Tables

The following short form specifications include Quad and Dual bipolar transistors listed in alphanumeric order. Some columns denote two different types of data indicated by either **bold** or *italic* typeface. See key and headings for proper identification. This applies to Table 1 and 2 of this section only.

KEY

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE} Volts	Subscript	I_C Amp Max	h_{FE} @ I_C Min	Unit	f_T MHz Min	C_{ob} pF Max	h_{FE1}/h_{FE2} / *t_{on} ns Max*	ΔV_{BE} mV Max / *t_{off} ns Max*	G_p dB Min / *$V_{CE(sat)}$ Volts Max*	NF dB Max / *@ I_C/I_B*	@ f / *& I_C*	Unit

Alphanumeric listing type numbers

Identification Code
1st Letter: Polarity
C — both types in multiple device
N — NPN
P — PNP
2nd Letter; Use
A — General Purpose Amplifier
E — Low Noise Audio Amplifier
F — Low Noise RF Amplifier
G — General Purpose Amplifier and Switch
H — Tuned RF/IF Amplifier
M — Differential Amplifier
S — High Speed Switch
D — Darlington

Power Dissipation specified at 25°C. Single die rating.
Ref. Point: A — Ambient temperature
C — Case temperature

Rated Minimum Collector-Emitter Voltage
Subscript letter identifies base termination listed below in order of preference.
SUBSCRIPT:
0 — V_{CEO}, open

Continuous (DC) Collector Current

Common-emitter DC Current Gain.
Units for test current:
A — ampere
m — mA
u — μA

Current-Gain-Bandwidth Product.

Output Capacitance, common-base. Shown without distinction:
C_{cb} — Collector-Base Capacitance
C_{re} — Common-Emitter Reverse Transfer Capacitance

h_{FE1}/h_{FE2} — Current Gain Ratio
V_{BE} — Differential Base Voltage $|V_{BE1} - V_{BE2}|$. Differential Amplifiers
t_{on} — turn-on time
t_{off} — turn-off time

G_p — Power Gain
NF — Noise Figure
f — Test Frequency
AUD — 10–15 kHz
Frequency Units:
H — Hertz M — MHz
K — kHz G — GHz
$V_{CE(sat)}$ — Collector-Emitter Saturation Voltage
I_C — Test Current
Current Units: u — μA
m — mA
A — Amp

Table 1. Plastic-Encapsulated Multiple Transistors — Quad

The following table is a listing of the most popular multiple devices available in the plastic DIP package. These devices are available in NPN, PNP, and NPN/PNP configurations. (See note.)

Type No.	I_D	P_D Watts One Die Only	V_{CE}- Volts		I_C Amp Max	h_{FE} @ Min	I_C	f_T MHz Min	C_{ob} pF Max	h_{FE1}/h_{FE2} / t_{on} ns Max	ΔV_{BE} mV Max / t_{off} ns Max	G_p dB Min / $V_{CE(sat)}$ @ Volts Max	NF dB Max Typ* @ / I_C/I_B	f / I_C
Case 646-06 — TO-116														
MPQ2222A	NA	0.65 A	40	O	0.5	100	150 m	200	8.0	35*	285*	0.3	10	150 m
MPQ2369	NS	0.5 A	15	O	0.5	40	10 m	450	4.0	9.0*	15*	0.25	10	10 m
MPQ2483	NA	0.625 A	40	O	0.05	150	1.0 m	50					3.0*	AUD
MPQ2484	NA	0.625 A	40	O	0.05	300	1.0 m	50					2.0*	AUD
MPQ2907A	PA	0.65 A	60	O	0.6	100	150 m	200	8.0	45*	180*	0.4	10	150 m
MPQ3467	PS	0.75 A	40	O	1.0	20	500 m	125	25	40	90	0.5	10	500 m
MPQ3725	NS	1.0 A	40	O	1.0	25	500 m	250	10	35	60	0.45	10	500 m
MPQ3762	PS	0.75 A	40	O	1.5	35	150 m	150	15	50	120	0.55	10	500 m
MPQ3798	PA	0.625 A	40	O	0.05	150	0.1 m	60	4.0				3.0*	AUD
MPQ3799	PA	0.625 A	60	O	0.05	300	0.1 m	60	4.0				2.0*	AUD
MPQ3904	NG	0.5 A	40	O	0.2	75	10 m	250	4.0	37*	136*	0.2	10	10 m
MPQ3906	PG	0.5 A	40	O	0.2	75	10 m	200	4.5	43*	155*	0.25	10	10 m
MPQ6001	CG	0.65 A	30	O	0.5	40	150 m	200	8.0	30*	225*	0.4	10	150 m
MPQ6002	CG	0.65 A	30	O	0.5	100	150 m	200	8.0	30*	225*	0.4	10	150 m
MPQ6100A	CA	0.5 A	45	O	0.05	150	1.0 m	50	4.0				4.0*	AUD
MPQ6426	ND	0.5 A	30	O	0.5	10K	100 m	125	8.0	—	—	1.5	10	100 m
MPQ6501	CG	0.65 A	30	O	0.5	40	150 m	200	8.0	30*	225*	0.4	10	150 m
MPQ6502	CG	0.65 A	30	O	0.5	100	150 m	200	8.0	30*	225*	0.4	10	150 m
MPQ6600A1	CA	0.5 A	45	O	0.05	150	1.0 m	50	4.0	0.8	20	0.25	10	1.0 m
MPQ6700	CA	0.5 A	40	O	0.2	70	10 m	200	4.5			0.25	10	1.0 m
MPQ6842	CA	0.75 A	40	O	0.5	70	10 m	300	4.5	45	150	0.15	10	0.5 m
MPQ7043	NA	0.75 A	250	O	0.5	25	1.0 m	50	5.0			0.5	10	20 m
MPQ7042	NA	0.75 A	200	O	0.5	25	1.0 m	50	5.0			0.5	10	20 m
MPQ7051	CG	0.75 A	150	O	0.5	25	1.0 m	50	6.0			0.7	10	20 m
MPQ7093	PA	0.75 A	250	O	0.5	25	1.0 m	50	5.0			0.5	10	20 m

*Typ

NOTE: Some columns show 2 different types of data indicated by either **bold** or *italic* typefaces. See key and headings.

Table 2. Plastic-Encapsulated Multiple Transistors — Quad Surface Mount

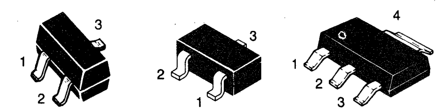
The following table is a listing of the most popular multiple devices available in the plastic SOIC surface mount package. These devices are available in NPN, PNP, and NPN/PNP configurations.

Device	$V_{(BR)CEO}$	$V_{(BR)CBO}$	h_{FE} @ I_C Min	mA	f_T @ I_C MHz Min	mA
Case 751B-03 — SO-16						
MMPQ2222A	40	75	40	500	350*	20
MMPQ2369	15	40	20	100	450	10
MMPQ2907A	50	60	50	500	350*	50
MMPQ3467	40	40	20	500	125	50
MMPQ3725	40	60	25	500	250	50
MMPQ3799	60	60	300	0.5	60	1
MMPQ3904	40	60	75	10	250	10
MMPQ3906	40	40	75	10	200	10
MMPQ6700**	40	40	70	10	200	10

**NPN/PNP

Plastic-Encapsulated Surface Mount Transistors

This section of the selector guide lists the small-signal plastic devices that are available for surface mount applications. These devices are encapsulated with the latest state-of-the-art mold compounds that enhance reliability and exhibit excellent performance in high temperature and high humidity environments. This package offers higher power dissipation capability for small-signal applications.



CASE 318-07 TO-236AB SOT-23	CASE 318D-03 SC-59	CASE 318E-04 SOT-223

Table 1. Plastic-Encapsulated Surface Mount General-Purpose Transistors

The following tables are a listing of small-signal general-purpose transistors in the SOT-23 and SC-59 surface mount packages. These devices are intended for small-signal amplification for DC, audio, and lower RF frequencies. They also have applications as oscillators and general-purpose, low voltage switches.

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN						
BC846ALT1	1A	65	110	220	2	100
BC846BLT1	1B	65	200	450	2	100
BC817-16LT1	6A	45	100	250	100	200
BC817-25LT1	6B	45	160	400	100	200
BC817-40LT1	6C	45	250	600	100	200
BC847ALT1	1E	45	110	220	2	100
BC847BLT1	1F	45	200	450	2	100
BC847CLT1	1G	45	420	800	2	100
MMBT2222ALT1	1P	40	100	300	150	200
MMBT3904LT1	1AM	40	100	300	10	200
BC848ALT1	1J	30	110	220	2	100
BC848BLT1	1K	30	200	450	2	100
BC848CLT1	1L	30	420	800	2	100
MMBT4401LT1	2X	40	100	300	150	250
MMBT8099LT1	KB	80	100	300	1	150
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBT8599LT1	2W	80	75	—	100	150
BC856ALT1	3A	65	125	250	2	100
BC856BLT1	3B	65	220	475	2	100
MMBT2907ALT1	2F	60	50	—	500	200
BC807-16LT1	5A	45	100	250	100	200
BC807-25LT1	5B	45	160	400	100	200
BC807-40LT1	5C	45	250	600	100	200
BC857ALT1	3E	45	125	250	2	100
BC857BLT1	3F	45	220	475	2	100
MMBT3906LT1	2A	40	100	300	10	250
MMBT4403LT1	2T	40	100	300	150	200
BC858ALT1	3J	30	125	250	2	100
BC858BLT1	3K	30	220	475	2	100
BC858CLT1	3L	30	420	800	2	100

Table 1. Plastic-Encapsulated Surface Mount General-Purpose Transistors (continued)

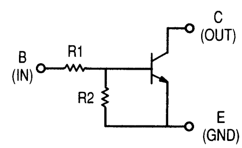
Pinout: 1-Emitter, 2-Base, 3-Collector

Devices are listed in order of descending breakdown voltage.

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318D-03 — SC-59 — NPN						
MSD601-RT1	YR	25	210	340	2	150*
MSD601-ST1	YS	25	290	460	2	150*
MSD602-RT1	WR	25	120	240	150	200*
MSD1328-RT1	1DR	20	200	350	500	200*
Case 318D-03 — SC-59 — PNP						
MSB709-RT1	AR	25	210	340	2	100*
MSB709-ST1	AS	25	290	460	2	100*
MSB710-QT1	CQ	25	85	170	150	200*
MSB710-RT1	CR	25	120	240	150	200*

*Typical

Table 2. Plastic-Encapsulated Surface Mount Bias Resistor Transistors for General Purpose Applications



These devices include bias resistors on the semiconductor chip with the transistor.
See the BRT diagram for orientation of resistors.

Device NPN	Device PNP	Marking NPN	Marking PNP	$V_{(BR)CEO}$ Volts (Min)	h_{FE} @ I_C Min	mA	I_C mA Max	R_1 Ohm	R_2 Ohm
Case 318D-03 — SC-59									
MUN2211T1	MUN2111T1	8A	6A	50	35	5.0	100	10K	10K
MUN2212T1	MUN2112T1	8B	6B	50	60	5.0	100	22K	22K
MUN2213T1	MUN2113T1	8C	6C	50	80	5.0	100	47K	47K

Table 3. Plastic-Encapsulated Surface Mount Switching Transistors

The following tables are a listing of devices intended for high-speed, low saturation voltage, switching applications. These devices have very fast switching times and low output capacitance for optimized switching performance.

Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	Switching Time (ns) t_{on}	t_{off}	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN								
MMBT2369LT1	M1J	12	18	15	20	—	100	—
BSV52LT1	B2	12	18	12	40	120	10	400
Case 318-07 — TO-236AB (SOT-23) — PNP								
MMBT3640LT1	2J	25	35	12	20	—	50	500
Pinout: 1-Emitter, 2-Base, 3-Collector								
Case 318D-03 — SC-59 — NPN								
MSC1621T1	RB	20	40	20	40	180	1	200

Table 4. Plastic-Encapsulated Surface Mount VHF/UHF Amplifiers, Mixers, Oscillators

The following table is a listing of devices intended for small-signal RF amplifier applications to VHF/UHF frequencies. These devices may also be used as VHF/UHF oscillators and mixers.

Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	$V_{(BR)CEO}$	C_{cb}* pF Max	f_T @ I_C GHz Min	mA
Case 318-07 — TO-236AB (SOT-23) — NPN					
MMBTH10LT1	3E	25	0.7	0.65	4
MMBT918LT1	3B	15	1.7**	0.6	4
MMBTH24LT1	3A	30	0.45	0.4	8
Case 318-07 — TO-236AB (SOT-23) — PNP					
MMBTH81LT1	3D	20	0.85	0.6	5
MMBTH69LT1	3J	15	0.35*	2.0	10
Pinout: 1-Emitter, 2-Base, 3-Collector					
Case 318D-03 — SC-59 — NPN					
MSC2295-BT1	VB	20	1.5*	0.15	1
MSC2295-CT1	VC	20	1.5*	0.15	1
MSC2404-CT1	UC	20	1*	0.45	1
MSC3130T1	1S	10	—	1.4	5
Case 318D-03 — SC-59 — PNP					
MSA1022-BT1	EB	20	2*	0.15	1
MSA1022-CT1	EC	20	2*	0.15	1

*C_{re}
**C_{ob}

Table 5. Plastic-Encapsulated Surface Mount Choppers

The following table is a listing of small-signal devices intended for chopper applications where a higher than normal $V_{(BR)CEO}$ is required in the circuit application.

Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	$V_{(BR)EBO}$	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBT404ALT1	2N	25	35	100	400	12

Table 6. Plastic-Encapsulated Surface Mount Darlingtons

The following table is a listing of small-signal devices that have very high h_{FE} and input impedance characteristics. These devices utilize monolithic, cascade transistor construction.

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending h_{FE}.

Device	Marking	$V_{(BR)CEO}$	$V_{CE(sat)}$ Volts Max	h_{FE} @ I_C Min	Max	mA
Case 318-07 — TO-236AB (SOT-23) — NPN						
MMBTA14LT1	1N	40	1.5	20K	—	100
MMBTA13LT1	1M	30	1.5	10K	—	100
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBTA64LT1	2V	30	1.5	20K	—	100

Table 7. Plastic-Encapsulated Surface Mount Low-Noise Transistors

The following table is a listing of small-signal devices intended for low noise applications in the audio range. These devices exhibit good linearity and are candidates for hi-fi and instrumentation equipment.

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of ascending NF.

Device	Marking	NF dB Typ	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN							
MMBT5089LT1	1R	1	30	400	—	10	50
MMBT2484LT1	1U	3	60	—	800	10	50
MMBT6428LT1	1K	3	50	250	—	10	100
MMBT6429LT1	1L	3	45	500	—	10	100
Case 318-07 — TO-236AB (SOT-23) — PNP							
MMBT5087LT1	2Q	1	50	250	—	10	40

*Max

Table 8. Plastic-Encapsulated Surface Mount High-Voltage Transistors

The following table is a listing of small-signal high-voltage devices designed for direct line operation requiring high voltage breakdown and relatively low current capability.

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN						
MMBT6517LT1	1Z	350	15	—	100	40
MMBTA42LT1	1D	300	40	—	30	50
MMBT5551LT1	G1	160	30	—	50	100
Case 318-07 — TO-236AB (SOT-23) — PNP						
MMBT6520LT1	2Z	350	15	—	100	40
MMBTA92LT1	2D	300	25	—	30	50
MMBT5401LT1	2L	150	50	—	50	100

SMALL-SIGNAL BIPOLAR TRANSISTORS — PLASTIC-ENCAPSULATED SURFACE MOUNT TRANSISTORS (continued)

Table 9. Plastic-Encapsulated Surface Mount Drivers

The following is a listing of small-signal devices intended for medium voltage driver applications at fairly high current levels.

Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	$V_{(BR)CEO}$	h_{FE} @ I_C Min	Max	mA	f_T MHz Min
Case 318-07 — TO-236AB (SOT-23) — NPN						
MMBTA06LT1	1G	80	50	—	100	100
BSS64LT1	AM	80	20	80	4	50
Case 318-07 — TO-236AB (SOT-23) — PNP						
BSS63LT1	BM	100	30	—	25	50
MMBTA56LT1	2G	80	50	—	100	50

Table 10. Plastic-Encapsulated Surface Mount RF Transistors

The following table is a listing of small-signal RF transistors intended for low-noise, high-power gain, Class A, AB or C amplifiers. These devices are used as pre-drivers in power amplifier applications.

Pinout: 1-Base, 2-Emitter, 3-Collector

		f_T @ I_C @ V_{CE}			NF @ I_C @ V_{CE}			MAG @ I_C @ V_{CE} @ f			
Device	Marking	GHz Typ	mA	V	dB Typ	mA	V	dB Typ	mA	V	MHz
Case 318-07 — TO-236AB (SOT-23) — NPN											
MMBR571LT1	7X	8	50	5	2	10	6	16.5	5	6	500
MMBR941LT1	7Y	8	15	6	2.1	5	6	8.5	5	6	2000
MMBR951LT1	7Z	8	30	8	2.1	5	6	7.5	5	6	2000
MMBR911LT1	7P	6	30	10	2	10	10	17	10	10	500
MMBR930LT1	7C	5.5	30	5	1.9	2	5	11	30	5	500
MMBR920LT1	7B	4.5	14	10	2.4	2	10	15	2	10	500
MMBR901LT1	7A	4	15	10	1.9	5	6	12	5	6	1000
BFR92LT1	P1	3.4	14	10	3	3	1.5	—	—	—	500
BFR93LT1	R1	3.4	30	5	2.5	2	5	—	—	—	30
MMBR931LT1	7D	3	1	1	4.3	0.25	1	10	0.25	1	1000
MMBR5179LT1	7H	1.4	5	6	4.5	1.5	6	15	5	6	200
MMBR2060LT1	7E	1	20	1	3.5	1.5	10	13	1.5	10	450
MMBR5031LT1	7G	1	5	6	2.5	1	6	17	1	6	450
MMBR2857LT1	7K	1	4	10	4.5	1.5	6	12.5	1.5	6	450
BFS17LT1	E1	1	2	5	5	2	5	—	—	—	30
Case 318-07 — TO-236AB (SOT-23) — PNP											
MMBR536LT1	7R	5.5	20	5	4.5	10	5	14	10	5	500
MMBR4957LT1	7F	1.2	2	10	3	2	10	17	2	10	450

Table 11. Plastic-Encapsulated Surface Mount Switching Transistors

Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

Device	Marking	t_{on}	t_{off}	$V_{(BR)CEO}$	h_{FE} Min	Max	f_T @ I_C (mA)	Min (MHz)
Case 318E-04 — SOT-223 — NPN								
PZT2222AT1	2222A	35	285	40	100	300	20	300
Case 318E-04 — SOT-223 — PNP								
PZT2907AT1	2907A	45	100	60	100	300	50	200

Table 12. Plastic-Encapsulated Surface Mount Darlingtons

Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

Device	Marking	$V_{(BR)CEO}$	$V_{CE(sat)}$ Max (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)
Case 318E-04 — SOT-223 — PNP						
PZTA64T1	ZTA64	30	1.5	20k	—	100

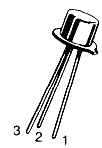
Table 13. Plastic-Encapsulated Surface Mount High-Voltage Transistors

Pinout: 1-Base, 2-Collector, 3-Emitter, 4-Collector

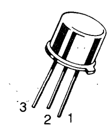
Device	Marking	$V_{(BR)CEO}$	h_{FE} Min	h_{FE} Max	f_T @ I_C (mA)	f_T Min (MHz)
Case 318E-04 — SOT-223 — NPN						
PZTA42T1	TZA42	300	40	—	10	50
BF720T1	BF720	250	50	—	10	60
Case 318E-04 — SOT-223 — PNP						
PZTA92T1	TZA92	300	40	—	10	50
BF721T1	BF721	250	50	—	10	60
PZTA96T1	ZTA96	450	50	150	10	50
BSP16T1	BSP16	300	30	150	10	15

Metal-Can Transistors

Metal-can packages are intended for use in industrial applications where harsh environmental conditions are encountered. These packages enhance reliability of the end products due to their resistance to varying humidity and extreme temperature ranges.



CASE 22-03
TO-206AA
(TO-18)



CASE 79-04
TO-205AD
(TO-39)

Table 1. Metal-Can General-Purpose Transistors

These transistors are designed for DC to VHF amplifier applications, general-purpose switching applications, and complementary circuitry. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package group.

Device Type	$V_{(BR)CEO}$ Volts Min	f_T @ I_C MHz Min	mA	I_C mA Max	h_{FE} @ I_C Min	Max	mA
Case 22-03 — TO-206AA (TO-18) — NPN							
2N720A	80	50	50	150	40	120	150
2N3700	80	80	1.0	1000	50	—	500
BC107	45	150	10	200	110	450	2.0
BC107A	45	150	10	200	110	220	2.0
BC107B	45	150	10	200	200	450	2.0
BCY59-IX	45	125	10	200	250	460	2.0
BCY59-VIII	45	125	10	200	180	310	2.0
2N2222A	40	300	20	800	100	300	150
2N3947	40	300	10	300	100	300	10
BCY58-VIII	32	125	10	200	180	310	2.0
BC109C	25	150	10	100	420	800	2.0
Case 22-03 — TO-206AA (TO-18) — PNP							
2N2906A	60	200	50	600	40	120	150
2N2907A	60	200	50	600	100	300	150
2N3251A	60	300	10	200	100	300	10
BC177B	45	200	10	200	180	460	2.0
BCY79-IX	45	180	10	200	250	460	2.0
BCY79-VIII	45	180	10	200	180	310	2.0
Case 79-04 — TO-205AD (TO-39) — NPN							
2N3019	80	100	50	1000	100	300	150
2N3020	80	80	50	1000	40	120	150
2N1893	80	50	50	500	40	120	150
2N2219A	40	300	20	800	100	300	150
2N2218A	40	250	20	800	40	120	150
Case 79-04 — TO-205AD (TO-39) — PNP							
MM5007	100	30	50	2000	50	250	250
2N4033	80	150	50	1000	25	—	100
2N4036	65	60	50	1000	40	140	150
2N2904A	60	200	50	600	40	120	150
2N2905A	60	200	50	600	100	300	150
2N4030	60	100	50	1000	15	—	100
2N4032	60	150	50	1000	40	—	100
BSV16-10	60	50	50	1000	63	160	100

Table 4. Metal-Can Switching Transistors

The following devices are intended for use in general-purpose switching and amplifier applications. Within each package group shown, the devices are listed in order of decreasing turn-on time (t_{on}).

Device Type	t_{on} & t_{off} @ I_C ns Max	ns Max	mA	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C @ I_B Volts Max	mA	mA	f_T MHz Min	I_C mA
Case 22-03 — TO-206AA (TO-18) — NPN												
2N4014	35	60	500	50	1000	35	500	0.52	500	50	300	50
2N2369A	12	18	10	15	200	40	10	0.2	10	1.0	500	10
BSX20	7.0	18	100	15	500	20	10	0.25	10	1.0	400	10
Case 22-03 — TO-206AA (TO-18) — PNP												
2N2894	60	90	30	12	200	40	30	0.2	30	3.0	400	30
2N869A	50	80	30	18	200	40	30	0.2	30	3.0	400	10
2N3546	40	30	50	12	—	25	50	0.25	50	5.0	700	10
MM4209	15	20	10	15	200	35	10	0.6	50	5.0	850	10
Case 79-04 — TO-205AD (TO-39) — NPN												
MM3725	35	60	500	40	2000	35	500	0.52	500	50	300	50
Case 79-04 — TO-205AD (TO-39) — PNP												
2N3467	40	90	500	40	100	40	500	0.5	500	50	175	50
2N3468	40	90	500	50	1000	25	500	0.6	500	50	150	50
2N3762	11.5	65	100	40	1500	30	1000	0.9	1000	100	180	50

Table 2. Metal-Can High-Gain/Low-Noise Transistors

These transistors are characterized for high-gain and low-noise applications. Devices are listed in decreasing order of NF.

Device Type	NF Wideband dB Typ* Max	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} @ I_C Min	Max	μA mA*	f_T @ I_C MHz Min	mA
Case 22-03 — TO-206AA (TO-18) — NPN								
2N2484	8.0*	60	50	100	500	10	15	0.05
2N930A	3.0	45	30	100	300	10	45	0.5
2N930	3.0	45	30	100	300	10	30	0.5
Case 22-03 — TO-206AA (TO-18) — PNP								
2N3963	10	80	200	100	450	1.0*	40	0.5
2N3964	4.0	45	200	250	600	1.0*	50	0.5
2N3799	2.5	60	50	300	900	500	30	0.5

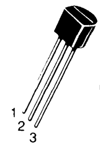
Table 3. Metal-Can High-Voltage/High-Current Transistors

The following table lists Motorola standard devices that have high collector-emitter breakdown voltage. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package type.

Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} @ I_C Min	mA	$V_{CE(sat)}$ @ I_C & I_B Volts Max	mA	mA	f_T @ I_C MHz Min	mA
Case 22-03 — TO-206AA (TO-18) — NPN									
2N6431	300	50	50	30	0.5	20	2.0	50	10
BSS73	300	500	40	30	0.5	50	5.0	100	20
Case 22-03 — TO-206AA (TO-18) — PNP									
2N6433	300	500	30	30	0.5	20	20	50	10
BSS76	300	500	35	30	0.5	50	5.0	100	20
2N3497	120	100	40	10	0.35	10	1.0	150	20
Case 79-04 — TO-205AD (TO-39) — NPN									
2N5058	300	150	35	30	1.0	30	3.0	30	10
BF259	300	100	25	30	1.0	30	6.0	110	30
2N4927	250	50	20	30	2.0	30	3.0	30	10
BF258	250	100	25	30	1.0	30	6.0	110	30
2N3500	150	300	40	150	0.4	150	15	150	20
2N3501	150	300	100	150	0.4	150	15	150	20
2N3499	100	500	100	150	0.6	300	30	150	20
MM3007	100	2500	50	250	0.35	150	15	50	50
Case 79-04 — TO-205AD (TO-39) — PNP									
2N4931	250	500	20	20	5.0	10	1.0	20	20
2N3636	175	1000	50	50	0.5	50	5.0	150	30
2N3637	175	1000	100	50	0.5	50	5.0	200	30
MM5007	100	2000	50	250	0.5	150	15	30	50

JFETs

JFETs operate in the depletion mode. They are available in both P- and N-channel and are offered in both Thruhole and Surface Mount packages. Applications include general-purpose amplifiers, switches and choppers, and RF amplifiers and mixers. These devices are economical and very rugged. The drain and source are interchangeable on many typical FETs.



CASE 29-04
TO-226AA
(TO-92)

Table 1. JFET Low-Frequency/Low-Noise

The following table is a listing of small-signal JFETs intended for low-noise applications in the audio range. These devices exhibit good linearity and are candidates for hi-fi and instrumentation equipment.

	$R_e \|Y_{fs}\|$ @ f		$R_e \|Y_{os}\|$ @ f		C_{iss}	C_{rss}	$V_{(BR)GSS}$ $V_{(BR)GDO}$ V	$V_{GS(off)}$ V		I_{DSS} mA	
Device	mmho Min	MHz	µmho Max	MHz	pF Max	pF Max	Min	Min	Max	Min	Max
Case 29-04 — TO-226AA (TO-92) — N-Channel											
J202	1.0	20	3.5*	20	5.0*	2.0*	40	0.8	4.0	0.9	4.5
2N5458	1.5	15	50	15	7.0	3.0	25	1.0	7.0	2.0	9.0
J203	1.5	20	10*	20	5.0*	2.0*	40	2.0	10	4.0	20
MPF3821	1.5	15	10	15	6.0	3.0	50	—	4.0	0.5	2.5
2N5457	2.0	15	50	15	7.0	3.0	25	0.5	6.0	1.0	5.0
2N5459	2.0	15	50	15	7.0	3.0	25	2.0	8.0	4.0	16
MPF3822	2.0	15	20	15	6.0	3.0	50	—	6.0	2.0	10
Case 29-04 — TO-226AA (TO-92) — P-Channel											
2N5460	1.0	0.001	50	0.001	7.0	2.0	40	0.75	6.0	1.0	5.0
2N5461	1.5	0.001	50	0.001	7.0	2.0	40	1.0	7.5	2.0	9.0
2N5462	2.0	0.001	50	0.001	7.0	2.0	40	1.8	9.0	4.0	16

*Typical

Table 2. JFET High-Frequency Amplifiers

The following is a listing of small-signal JFETs that are intended for hi-frequency applications. These are candidates for VHF/UHF oscillators, mixers and front-end amplifiers.

	$R_e \|Y_{fs}\|$ @ f		$R_e \|Y_{os}\|$ @ f		C_{iss}	C_{rss}	NF @ R_G = 1K		$V_{(BR)GSS}$ $V_{(BR)GDO}$ V	$V_{GS(off)}$ V		I_{DSS} mA	
Device	mmho Min	MHz	µmho Max	MHz	pF Max	pF Max	dB Max	f MHz	Min	Min	Max	Min	Max
Case 29-04 — TO-226AA (TO-92) — N-Channel													
2N5669	1.6	100	100	100	7.0	3.0	2.5	100	25	1.0	6.0	4.0	10
MPF102	1.6	100	200	100	7.0	3.0	—	—	25	—	8.0	2.0	20
2N5668	1.0	100	50	100	7.0	3.0	2.5	100	25	0.2	4.0	1.0	5.0
2N5484	2.5	100	75	100	5.0	1.0	3.0	100	25	0.3	3.0	1.0	5.0
2N5670	2.5	100	150	100	7.0	3.0	2.5	100	25	2.0	8.0	8.0	20
2N5485	3.0	400	100	400	5.0	1.0	4.0	400	25	1.0	4.0	4.0	10
J305	3.0*	400	80*	100	3.0*	0.8*	4.0*	400	30	0.5	3.0	1.0	8.0
2N5486	3.5	400	100	400	5.0	1.0	4.0	400	25	2.0	6.0	8.0	20
J300	4.5	0.001	200	0.001	5.5	1.1	—	—	25	—	1.0**	6.0	30
J304	4.2	400	80*	100	3.0*	0.8*	4.0*	400	30	2.0	6.0	5.0	15
J308	12*	100	250*	100	7.5	2.5	1.5*	100	25	1.0	6.5	12	60
J309	12*	100	250*	100	7.5	2.5	1.5*	100	25	1.0	4.0	12	30
J310	12*	100	250*	100	7.5	2.5	1.5*	100	25	2.0	6.5	24	60

*Typical

Table 3. JFET Switches and Choppers

The following is a listing of JFETs intended for switching and chopper applications.

Device	$r_{ds(on)}$ @ I_D Ω Max	µA	$V_{GS(off)}$ V Min	Max	I_{DSS} mA Min	Max	$V_{(BR)GSS}$ $V_{(BR)GDO}$ V Min	C_{iss} pF Max	C_{rss} pF Max	t_{on} ns Max	t_{off} ns Max
Case 29-04 — TO-226AA (TO-92) — N-Channel											
MPF4856	25	—	4.0	10	50	—	40	10	8.0	9.0	25
MPF4859	25	—	4.0	10	50	—	30	18	8.0	9.0	25
2N5638	30	1.0	—	(12)	50	—	30	10	4.0	9.0	15
J111	30	1.0	3.0	10	20	—	35	10*	5.0*	13	35
MPF4857	40	—	2.0	6.0	20	100	40	18	8.0	10	50
MPF4860	40	—	2.0	6.0	20	100	30	18	8.0	10	50
J112	50	1.0	1.0	5.0	5.0	—	35	10*	5.0*	13*	35*
MPF4392	60	1.0	2.0	5.0	25	75	20	10	3.5	15	35
2N5639	60	1.0	—	(8.0)*	25	—	30	10	4.0	14	30
MPF4858	60	—	0.8	4.0	8.0	80	40	18	8.0	20	100
MPF4861	60	—	0.8	4.0	8.0	80	30	18	8.0	20	100
MPF4393	100	1.0	0.5	3.0	5.0	30	20	10	3.5	15	55
2N5640	100	1.0	—	(6.0)	5.0	—	30	10	4.0	18	45
J113	100	1.0	0.5	3.0	2.0	—	35	10*	5.0*	13*	35*
2N5555	150	—	—	1.0**	15	—	25	5.0	1.2	10	25
BF246	—	—	0.5	14	10	300	25	—	—	—	—
BF246A	35*	1.0	1.5	4.0	30	80	25	—	—	—	—
BF246B	50*	1.0	3.0	7.0	60	140	25	—	—	—	—
BF246C	65*	1.0	5.5	12	110	250	25	—	—	—	—
J109	12	—	2.0	6.0	40	—	25	—	—	—	—
J110	18	—	0.5	4.0	10	—	25	—	—	—	—
Case 29-04 — TO-226AA (TO-92) — P-Channel											
MPF970	100	1.0	5.0	12	15	100	30	12	5.0	8.0	25
MPF971	250	1.0	1.0	7.0	2.0	80	30	12	5.0	10	120
J174	85	—	5.0	10	2.0	100	30	—	—	—	—
J175	125	—	3.0	6.0	7.0	60	30	—	—	—	—
J176	250	—	1.0	4.0	2.0	25	30	—	—	—	—
J177	300	—	0.8	2.5	1.5	20	30	—	—	—	—

*Typical
**$V_{GS(f)}$

MOSFETs

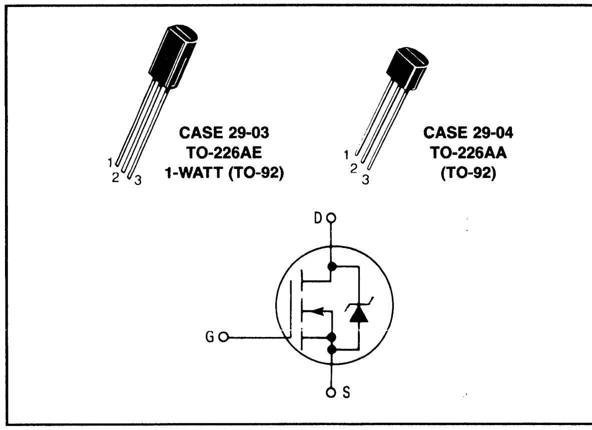


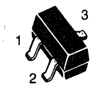
Table 1. TMOS Switches and Choppers

The following is a listing of small-signal TMOS devices that are intended for switching and chopper applications. These devices offer low $r_{DS(on)}$ characteristics.

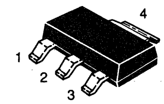
Device	$r_{DS(on)}$ @ I_D Ω Max	A	$V_{GS(th)}$ V Min	Max	$V_{(BR)DSS}$ V Min	C_{iss} pF Max	C_{rss} pF Max	t_{on} ns Max	t_{off} ns Max
Case 29-03 — TO-226AE (1-WATT TO-92) — N-Channel									
MPF930	1.4	1.0	1.0	3.5	35	70	18	15	15
MPF960	1.7	1.0	1.0	3.5	60	70	18	15	15
MPF6659	1.8	1.0	0.8	2.0	35	50	10	5.0	5.0
MPF990	2.0	1.0	1.0	3.5	90	70	18	15	15
MPF6660	3.0	1.0	0.8	2.0	60	50	10	5.0	5.0
MPF6661	4.0	1.0	0.8	2.0	90	50	10	5.0	5.0
MPF910	5.0	0.5	0.8	2.5	60	50	10	10	10
VN10LM	5.0	0.5	0.8	2.5	60	60	5	10	10
MPF89	6.4	0.25	1.0	2.7	200	90	3.5	15	15
Case 29-04 — TO-226AA (TO-92) — N-Channel									
VN0300L	1.2	1.0	0.8	2.5	30	100	25	30	30
2N7000	5.0	0.5	0.8	3.0	60	60	6.0	10	10
BS170	5.0	0.2	0.8	3.0	60	25 Typ	3.0 Typ	10	10
VN0610LL	5.0	0.5	0.8	2.5	60	60	5.0	10	10
VN1706L	6	0.5	0.8	2.0	170	120	20	8.0	18
VN2406L	6.0	0.5	0.8	2.0	240	125	20	8	23
BSS89	6.4	0.25	1.0	2.7	200	90	3.5	15	15
BS107A	6.4	0.25	1.0	3.0	200	70 Typ	6.0 Typ	15	15
VN2222LL	7.5	0.5	0.6	2.5	60	60	5.0	10	10
VN2410L	10	0.5	0.8	2.0	240	125	20	8.0	23
BS107	14	0.2	1.0	3.0	200	70 Typ	6.0 Typ	15	15

Surface Mount FETs

This section contains the FET plastic packages available for surface mount applications. Most of these devices are the most popular metal-can and insertion type parts carried over to the new surface mount packages.



CASE 318-07
TO-236AB
SOT-23



CASE 318E-04
SOT-223

Table 1. JFET Surface Mount RF

The following is a list of surface mount FETs which are intended for UHF/VHF RF amplifier applications.

Pinout: 1-Drain, 2-Source, 3-Gate

		NF		Y_{fs} @ V_{DS}			
Device	**Marking**	**dB Typ**	**f MHz**	**mmhos Min**	**mmhos Max**	**V**	$V_{(BR)GSS}$
Case 318-07 — TO-236AB (SOT-23) — N-Channel							
MMBFJ309LT1	6U	1.5	450	10	20	10	25
MMBFJ310LT1	6T	1.5	450	8	18	10	25
MMBFU310LT1	M6C	1.5	450	10	18	10	25
MMBF4416LT1	M6A	2**	100	4.5	7.5	15	30
MMBF5484LT1	M6B	2	100	3	6	15	25
MMBF5486LT1	6H	2	100	4	8	15	25

**Max

Table 2. JFET Surface Mount General-Purpose

The following table is a listing of surface mount small-signal general purpose FETs. These devices are intended for small-signal amplification for DC, audio, and lower RF frequencies. They also have applications as oscillators and general-purpose, low-voltage switches.

Pinout: 1-Drain, 2-Source, 3-Gate

			Y_{fs} @ V_{DS}			I_{DSS}	
Device	**Marking**	$V_{(BR)GSS}$	**mmhos Min**	**mmhos Max**	**V**	**mA Min**	**mA Max**
Case 318-07 — TO-236AB (SOT-23) — N-Channel							
MMBF5457LT1	6D	25	1	5	15	1	5
MMBF5459LT1	6L	25	2	6	15	4	16
Case 318-07 — TO-236AB (SOT-23) — P-Channel							
MMBF5460LT1	M6E	40	1	4	15	1	5

1

Table 3. JFET Surface Mount Choppers/Switches

The following is a listing of small-signal surface mount JFET devices intended for switching and chopper applications.

Pinout: 1-Drain, 2-Source, 3-Gate

Device	Marking	$r_{DS(on)}$ Ohms Max	t_{off} ns Max	$V_{(BR)GSS}$	$V_{GS(off)}$ V Min	$V_{GS(off)}$ V Max	I_{DSS} mA Min	I_{DSS} mA Max
Case 318-07 — TO-236AB (SOT-23) — N-Channel								
MMBF4856LT1	AAA	25	25	40	−4	−10	50	—
MMBF4391LT1	6J	30	20	30	−4	−10	50	150
MMBF4860LT1	6F	40	50	30	−2	−6	20	100
MMBF4392LT1	6K	60	35	30	−2	−5	25	75
MMBF4393LT1	6G	100	50	30	−0.5	−3	5	30
Case 318-07 — TO-236AB (SOT-23) — P-Channel								
MMBFJ175LT1	6W	125	30(t)	−30	3	6	−7	−60
MMBFJ177LT1	6Y	300	45(t)	−30	0.8	2.5	−1.5	−20

Table 4. TMOS FET Surface Mount

The following is a listing of small-signal surface mount TMOS FETs which exhibit low $r_{DS(on)}$ characteristics.

Case 318-07 — TO-236AB (SOT-23) — N-Channel
Pinout: 1-Gate, 2-Source, 3-Drain

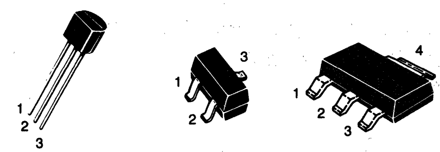
Device	Marking	$r_{DS(on)}$ @ I_D Ohm	$r_{DS(on)}$ @ I_D mA	V_{DSS}	$V_{GS(th)}$ V Min	$V_{GS(th)}$ V Max	Switching Time t_{on} ns	Switching Time t_{off} ns
MMBF170LT1	6Z	5	200	60	0.8	3	10	10
BSS123LT1	SA	6	100	100	0.8	2.8	20	40
2N7002LT1	702	7.5	500	60	1	2.5	20	20

Case 318E-04 — SOT-223 — N-Channel
Pinout: 1-Gate, 2-Drain, 3-Source, 4-Drain

Device	Marking	$r_{DS(on)}$ Ohm	$r_{DS(on)}$ mA	V_{DSS}	$V_{GS(th)}$ Min (V)	$V_{GS(th)}$ Max (V)	Switching Time (ns) t_{on}	Switching Time (ns) t_{off}
MMFT107T1	FT107	14	200	200	1	3	15	15
MMFT960T1	FT960	1.7	1000	60	1	3.5	15	15
MMFT6661T1	T6661	4	1000	90	0.8	2	5	5

Small-Signal SMALLBLOCK Products

SMALLBLOCK Products are a unique family of application specific "minigrated" circuits. These circuits will incorporate various transistor, resistor and diode configurations for use in certain applications. Since these SMALLBLOCK circuits are monolithic chips, they will reduce both component count and the required space on circuit boards, simplify circuitry and improve reliability.



CASE 29-04 (TO-226AA) TO-92 STYLE 33	CASE 318-07 (TO-236AB) SOT-23 STYLE 22	CASE 318E-04 (TO-261AA) SOT-223 STYLE 6

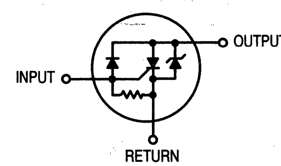


Table 1. MOSFET Turn-Off Devices

The first series in the SMALLBLOCK Product family is a series of MOSFET turn-off devices which offers an economical way to reduce the turn-off time of power MOSFETs. Additionally, they clamp the MOSFET gate voltage to a safe level. The use of a MOSFET turn-off device lowers component count, reduces system cost and board space, and optimizes the switching performance of the MOSFET. Applications for these devices include PWM circuits in switchmode power supplies, DC-OC converters and motor controls for brush and brushless motors.

The following table is a listing of MOSFET turn-off devices used for reduced turn-off of power MOSFETs.

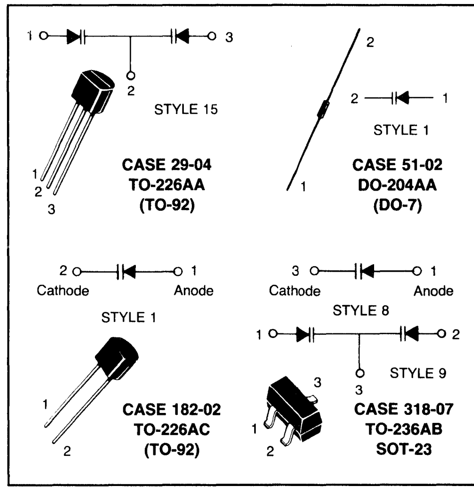
		V_{in} @ 2mA		V_{out} @ 2mA		t_{off} (1000 pF, from 9V to 1V)
Device	**Marking**	**Min**	**Max**	**Min**	**Max**	**Typ**
Case 29-04 — TO-226AA (TO-92) Pinout: 1. Return, 2. Input, 3. Output						
MDC1000A	MDC1000	9.5	12	9	12	15 ns
MDC1005A	MDC1005	5	—	5	—	22 ns
Case 318-07 — TO-236AB (SOT-23) Pinout: 1. Return, 2. Output, 3. Input						
MDC1000BLT1	C10	9.5	12	9	12	15 ns
MDC1005BLT1	C05	5	—	5	—	22 ns
Case 318E-04 — TO-261AA (SOT-223) Pinout: 1. Return, 2. Input, 3. Output, 4. Input						
MDC1000CT1	C1000	9.5	12	9	12	15 ns

Tuning Diodes — Abrupt Junction

Motorola supplies voltage-variable capacitance diodes serving the entire range of frequencies from HF through UHF. Used in RF receivers and transmitters, they have a variety of applications, including:

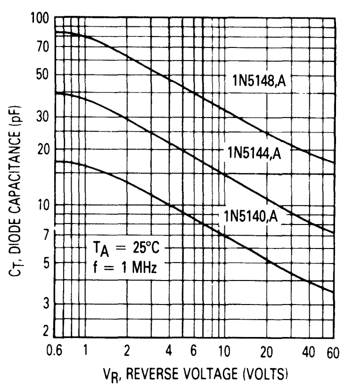
- Phase-locked loop tuning systems
- Local oscillator tuning
- Tuned RF preselectors
- RF filters
- RF phase shifters
- RF amplifiers
- Automatic frequency control
- Video filters and delay lines
- Harmonic generators
- FM modulators

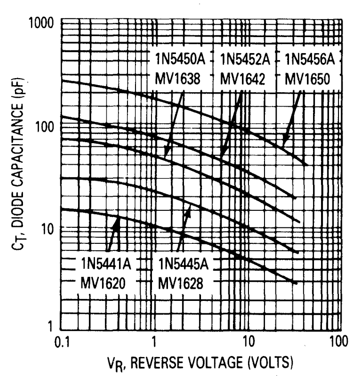
Two families of devices are available: Abrupt Junction and Hyper Abrupt Junction. The Abrupt Junction family includes devices suitable for virtually all tuned-circuit and narrow-range tuning applications throughout the spectrum.



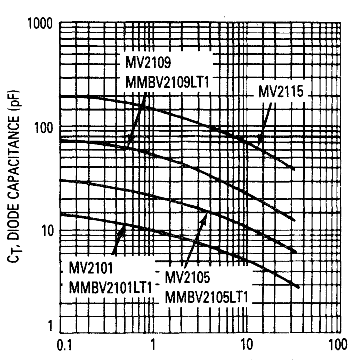
Typical Characteristics

Diode Capacitance versus Reverse Voltage

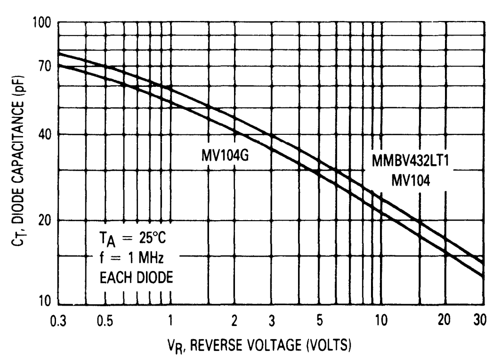




(See Tables 1 Thru 3)



(See Tables 4 And 5)



(See Table 6)

Table 1. General-Purpose Glass Abrupt Tuning Diodes

High Q Capacitance Ratio @ 4.0 Volts/60 Volts

The following is a listing of axial leaded, general-purpose, abrupt tuning diodes. These devices exhibit high Q characteristics.

Device*	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{(BR)R}$ Volts	Cap Ratio C4/C60 Min	Q 4.0 V, 60 MHz Min
Case 51-02 — DO-204AA (DO-7)						
1N5139	6.1	6.8	7.5	60	2.7	350
1N5140	9.0	10	11	60	2.8	300
1N5141	10.8	12	13.2	60	2.8	300
1N5142	13.5	15	16.5	60	2.8	250
1N5143	16.2	18	19.8	60	2.8	250
1N5144	19.8	22	24.2	60	3.2	200
1N5145	24.3	27	29.7	60	3.2	200
1N5146	29.7	33	36.3	60	3.2	200
1N5147	35.1	39	42.9	60	3.2	200
1N5148	42.3	47	51.7	60	3.2	200

*Suffix A = 5.0%

Table 2. General-Purpose Glass Abrupt Tuning Diodes

High Q Capacitance Ratio @ 2.0 Volts/30 Volts

The following is a listing of axial leaded, general-purpose, abrupt tuning diodes. These devices exhibit very high Q characteristics.

Device*	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{R(BR)R}$ Volts	Cap Ratio C2/C30 Min	Q 4.0 V, 50 MHz Min
Case 51-02 — DO-204AA (DO-7)						
1N5441A	6.1	6.8	7.5	30	2.5	450
1N5443A	9.0	10	11	30	2.6	400
1N5444A	10.8	12	13.2	30	2.6	400
1N5445A	13.5	15	16.5	30	2.6	400
1N5446A	16.2	18	19.8	30	2.6	350
1N5448A	19.8	22	24.2	30	2.6	350
1N5449A	24.3	27	29.7	30	2.6	350
1N5450A	29.7	33	36.3	30	2.6	350
1N5451A	35.1	39	42.9	30	2.6	300
1N5452A	42.3	47	51.7	30	2.6	250
1N5453A	50.4	56	61.6	30	2.6	200
1N5455A	73.8	82	90.2	30	2.7	175
1N5456A	90	100	110	30	2.7	175

*Suffix B = 5.0%

Table 3. General-Purpose Glass Abrupt Tuning Diodes

Capacitance Ratio @ 2.0 Volts/20 Volts

The following is a listing of axial leaded, general-purpose, abrupt tuning diodes. These devices exhibit high Q characteristics.

	C_T @ V_R = 4.0 V, 1.0 MHz				Cap Ratio	Q
Device	pF Min	pF Nominal	pF Max	$V_{R(BR)R}$ Volts	C2/C20 Min	4.0 V, 50 MHz Typ
Case 51-02 — DO-204AA (DO-7)						
MV1620	6.1	6.8	7.5	20	2.0	300
MV1624	9.0	10	11	20	2.0	300
MV1626	10.8	12	13.2	20	2.0	300
MV1628	13.5	15	16.5	20	2.0	250
MV1630	16.2	18	19.8	20	2.0	250
MV1634	19.8	22	24.2	20	2.0	250
MV1636	24.3	27	29.7	20	2.0	200
MV1638	29.7	33	36.3	20	2.0	200
MV1640	35.1	39	42.9	20	2.0	200
MV1642	42.3	47	51.7	20	2.0	200
MV1644	50.4	56	61.6	20	2.0	150
MV1648	73.8	82	90.2	20	2.0	150
MV1650	90	100	110	20	2.0	150

Table 4. General-Purpose Plastic Abrupt Tuning Diodes

Capacitance Ratio @ 2.0 Volts/30 Volts

The following is a listing of plastic package, general-purpose, abrupt tuning diodes. These devices exhibit high Q characteristics.

	C_T @ V_R = 4.0 V, 1.0 MHz				Cap Ratio	Q
Device	pF Min	pF Nominal	pF Max	$V_{R(BR)R}$ Volts	C4/C30 Min	4.0 V, 50 MHz Typ
Case 182-02 — TO-226AC (TO-92) — 2-Lead						
MV2101	6.1	6.8	7.5	30	2.5	450
MV2103	9.0	10	11	30	2.5	400
MV2104	10.8	12	13.2	30	2.5	400
MV2105	13.5	15	16.5	30	2.5	400
MV2107	19.8	22	24.2	30	2.5	350
MV2108	24.3	27	29.7	30	2.5	300
MV2109	29.7	33	36.3	30	2.5	200
MV2111	42.3	47	51.7	30	2.5	150
MV2113	61.2	68	74.8	30	2.5	150
MV2114	73.8	82	90.2	30	2.5	100
MV2115	90	100	110	30	2.6	100

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Table 5. Surface Mount Abrupt Tuning Diodes

Capacitance Ratio 2.0 Volts/30 Volts

The following is a listing of surface mount abrupt junction tuning diodes intended for general-purpose variable capacitance circuit applications.

Device	C_T @ V_R = 4.0 V, 1.0 MHz pF Min	pF Nominal	pF Max	$V_{R(BR)R}$ Volts	Cap Ratio C2/C30 Min	Q 4.0 V, 50 MHz Typ
Case 318-07 — TO-236AB (SOT-23)						
MMBV2101LT1	6.1	6.8	7.5	30	2.5	400
MMBV2103LT1	9.0	10	11	30	2.5	350
MMBV2104LT1	10.8	12	13.2	30	2.5	350
MMBV2105LT1	13.5	15	16.5	30	2.5	350
MMBV2107LT1	19.8	22	24.2	30	2.5	300
MMBV2108LT1	24.3	27	29.7	30	2.5	250
MMBV2109LT1	29.7	33	36.3	30	2.5	200

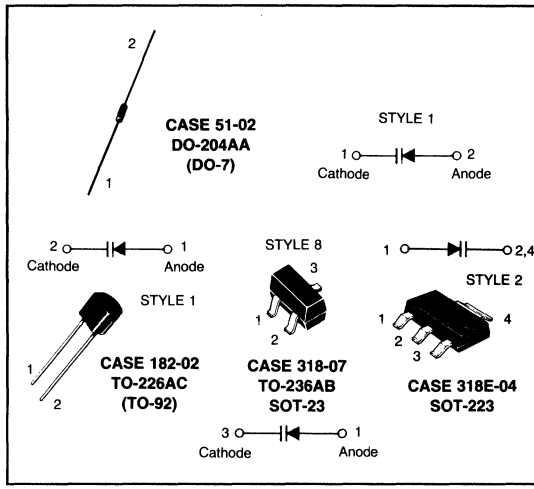
Table 6. Abrupt Tuning Diodes — Dual

The following is a listing of abrupt tuning diodes that are available as dual units in a single package.

Device	C_T @ V_R** pF Min	pF Max	Volts	Cap Ratio C3/C30 Min	Q 3.0 V, 50 MHz Min	$V_{(BR)R}$ Volts	Device Marking	Style
Case 29-04 — TO-226AA (TO-92)								
MV104	37	42	3.0	2.5	100	32	—	15
Case 318-07 — TO-236AB (SOT-23)								
MMBV432LT1	43	48.1	2.0	1.5*	100	14	M4B	9

*C2/C8
**Each Diode

Tuning Diodes — Hyper-Abrupt Junction



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The Hyper Abrupt family exhibits higher capacitance, and a much larger capacitance ratio. It is particularly well suited for wider-range applications such as AM/FM radio and TV tuning.

Typical Characteristics

Diode Capacitance versus Reverse Voltage

Figure 1. Diode Capacitance

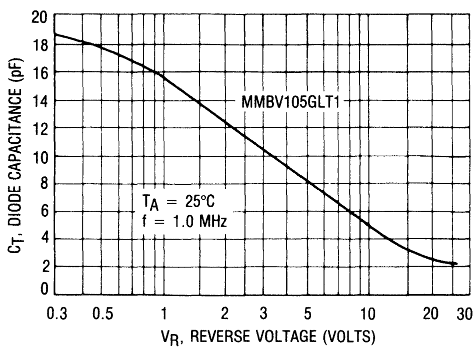


Figure 2. Diode Capacitance

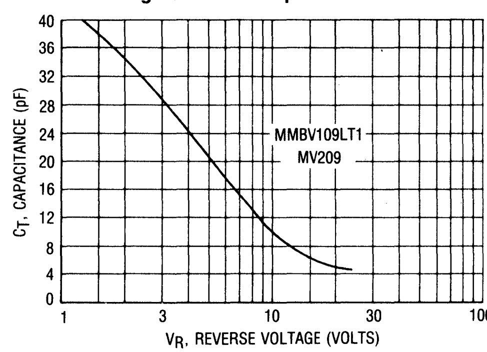


Figure 3. Diode Capacitance

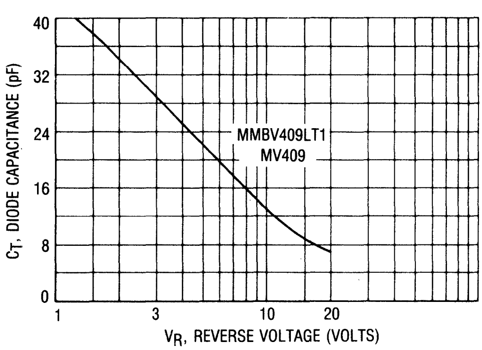
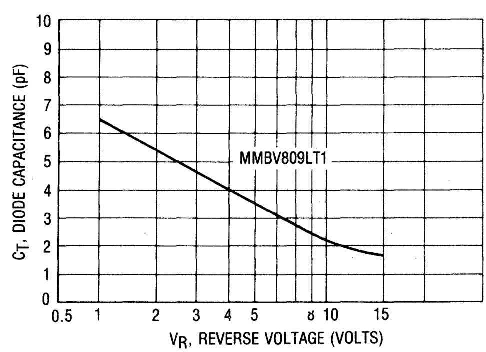


Figure 4. Diode Capacitance



SMALL-SIGNAL TUNING AND SWITCHING DIODES — TUNING DIODES/ HYPER-ABRUPT JUNCTION (continued)

Figure 5. Diode Capacitance

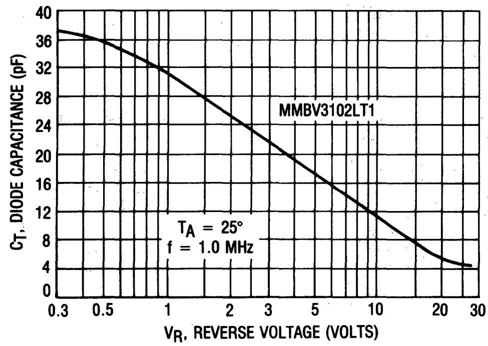
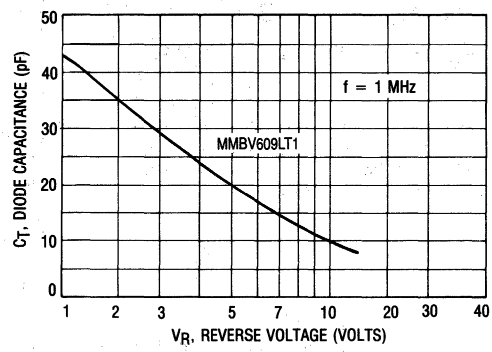
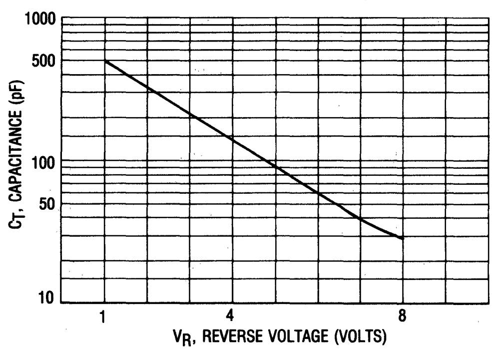


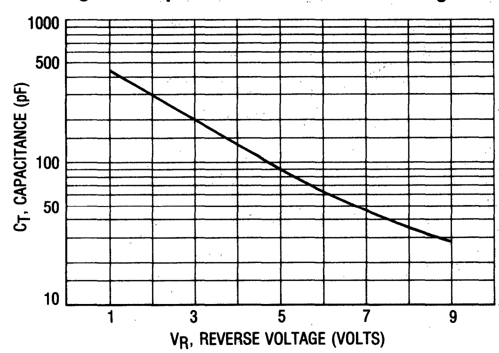
Figure 6. Diode Capacitance
Each Die



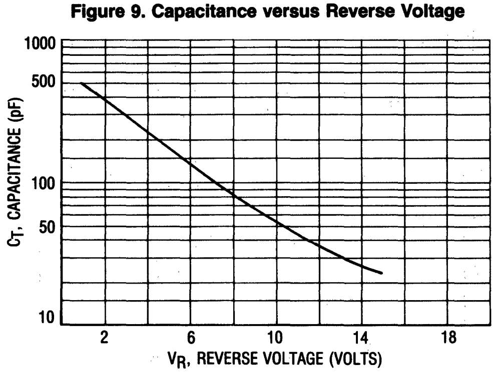
MVAM108
Figure 7. Capacitance versus Reverse Voltage



MVAM109/MV7005T1
Figure 8. Capacitance versus Reverse Voltage



MVAM115
Figure 9. Capacitance versus Reverse Voltage



MVAM125
Figure 10. Capacitance versus Reverse Voltage

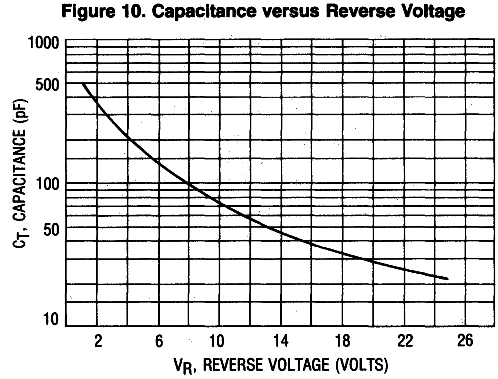


Figure 11. Diode Capacitance versus Reverse Voltage

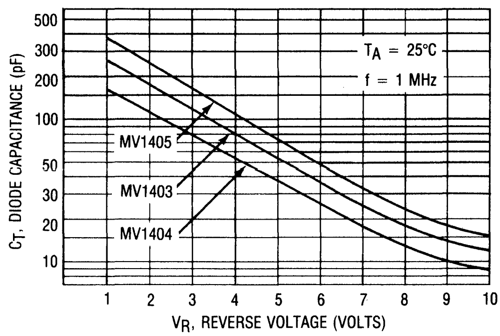


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Table 1. Hyper-Abrupt Tuning Diodes for FM Radio and TV — Single

The following is a listing of hyper-abrupt tuning diodes intended for high frequency, FM radio, and TV tuner applications.

Device	C_T @ V_R (f = 1.0 MHz) pF Min	pF Max	Volts	Cap Ratio @ V_R Min	Max	Volts	Q 3V Min	50 MHz Max	$V_{(BR)R}$ Volts	Device Marking	Case Style	CV Curve Fig
Case 182-02 — TO-226AC (TO-92)												
MV209	26	32	3.0	5.0	6.5	3/25	200	—	30	—	1	2
MV409	26	32	3.0	1.5	2.0	3/8	200	—	20	—	1	3
Case 318-07 — TO-236AB (SOT-23)												
MMBV105GLT1	1.8	2.8	25	4.0	6.0	3/25	200	—	30	M4E	8	1
MMBV109LT1	26	32	3.0	5.0	6.5	3/25	200	—	30	M4A	8	2
MMBV409LT1	26	32	3.0	1.5	2.0	3/8	200	—	20	X5	8	3
MMBV809LT1	4.5	6.1	2.0	1.8	2.6	2/8	300	—	20	5K	8	4
MMBV3102LT1	20	25	3.0	4.5	—	3/25	200	—	30	M4C	8	5

Table 2. Hyper-Abrupt Tuning Diodes for FM Radio and TV — Dual

Device	C_T @ V_R (f = 1.0 MHz) pF Min	pF Max	Volts	Cap Ratio @ V_R Min	Max	Volts	Q 3V Min	50 MHz Max	$V_{(BR)R}$ Volts	Device Marking	Case Style	CV Curve Fig
Case 318-07 — TO-236AB (SOT-23)												
MMBV609LT1	26	32	3	1.8	2.4	3/8	250	—	20	5L	9	6

1

Table 3. Hyper-Abrupt Tuning Diodes for AM Radio — Single

The following is a listing of AM, hyper-abrupt tuning diodes that have a large capacity range and are designed for low frequency circuit applications.

Device	C_T @ 1.0 MHz pF Min	pF Max	Volts	Cap Ratio @ V_R Min	Volts	$V_{(BR)R}$ Volts	Style	CV Curve Figure
Case 182-02 — TO-226AC (TO-92)								
MVAM108	440	560	1.0	15	1.0/8.0	12	1	7
MVAM109	400	520	1.0	12	1.0/9.0	15	1	8
MVAM115	440	560	1.0	15	1.0/15	18	1	9
MVAM125	440	560	1.0	15	1.0/25	28	1	10

Table 4. Hyper-Abrupt High Capacitance Voltage Variable Diode — Surface Mount

The following is a high capacitance voltage variable diode intended for AM radio applications and circuits requiring large tuning capacitance.

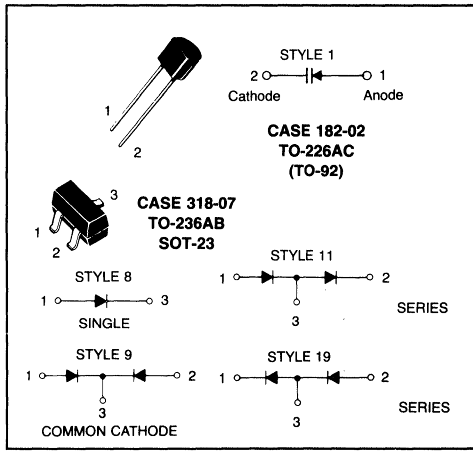
Device	$V_{(BR)R}$ Volts	I_R nA	C_T Diode Capacitance Min pF	Max pF	Cap Ratio Min	Q Min	Style	CV Curve Figure
Case 318E-04 — SOT-223 Pinout: 1-Anode, 2, 4-Cathode, 3-NC								
MV7005T1	15	100	400	520	12	150	2	8

Table 5. Hyper-Abrupt High Capacitance Tuning Diodes

Device	C_T @ V_R pF Min	pF Max	Volts	Cap Ratio C2/C10 Min	Q 2.0 V, 1.0 MHz Min	$V_{(BR)R}$ Volts	Style	CV Curve Figure
Case 51-02 — DO-204AA (DO-7)								
MV1404	96	144	2.0	10	200	12	1	11
MV1403	140	210	2.0	10	200	12	1	11
MV1405	200	300	2.0	10	200	12	1	11

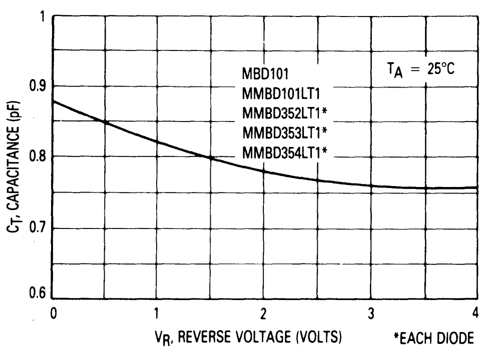
Hot-Carrier (Schottky) Diodes

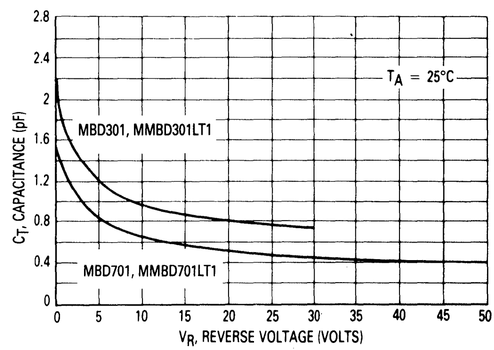
Hot-Carrier diodes are ideal for VHF and UHF mixer and detector applications as well as many higher frequency applications. They provide stable electrical characteristics by eliminating the point-contact diode presently used in many applications.



Typical Characteristics

Capacitance versus Reverse Voltage





(See Table 1)

Table 1. Hot-Carrier (Schottky) Diodes

The following is a listing of hot carrier (Schottky) diodes that exhibit low forward voltage drop for improved circuit efficiency.

Device	$V_{(BR)R}$ Volts	C_T @ V_R pF Max	V_F @ 10 mA Volts Max	I_R @ V_R nA Max	Minority Lifetime pS	Device Marking	Style
Case 182-02 — TO-226AC (TO-92)							
MBD701	70	1.0 @ 20 V	1.2	200 @ 35 V	15	—	1
MBD301	30	1.5 @ 15 V	0.6	200 @ 25 V	15	—	1
MBD101	4.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	—	1
Case 318-07 — TO-236AB (SOT-23)							
MMBD701LT1	70	1.0 @ 20 V	1.2	200 @ 35 V	15	5H	8
MMBD301LT1	30	1.5 @ 15 V	0.6	200 @ 25 V	15	4T	8
MMBD101LT1	4.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	4M	8
MMBD352LT1*	4.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	M5G	11
MMBD353LT1*	4.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	M4F	19
MMBD354LT1*	4.0	1.0 @ 0 V	0.6	250 @ 3.0 V	—	M6H	9

*Dual Diodes

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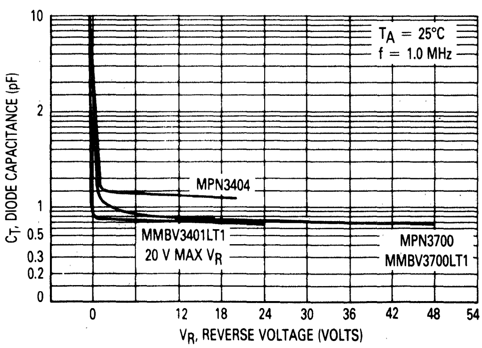
Switching Diodes

Small-signal switching diodes are intended for low current switching and steering applications. Hot-Carrier, PIN and general-purpose diodes allow a wide selection for specific application requirements.

Typical Characteristics
Capacitance versus Reverse Voltage



(See Table 1)

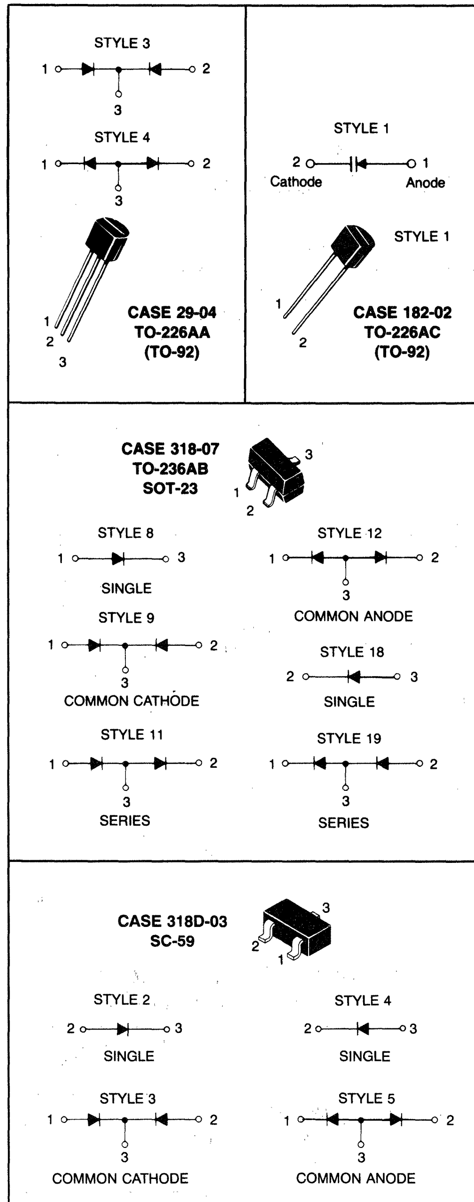


Table 1. PIN Switching Diodes

The following PIN diodes are designed for VHF band switching and general-purpose low current switching applications.

Device	$V_{(BR)R}$ Volts Min	C_T @ V_R @ 1.0 MHz pF Max	Volts	I_R @ V_R nA Max	Series Resistance Ohm Max	Device Marking	Style
Case 182-02 – TO-226AC (TO-92)							
MPN3700	200	1.0	20	0.1 @ 150	1.0 @ 10 mA	–	1
MPN3404	20	2.0	15	0.1 @ 25 V	0.85 @ 10 mA	–	1
Case 318-07 — TO-236AB (SOT-23)							
MMBV3700LT1	200	1.0	20	0.1 @ 150	1.0 @ 10 mA	4R	8
MMBV3401LT1	35	1.0	20	0.1 @ 25 V	0.7 @ 10 mA	4D	8

Table 2. General-Purpose Signal and Switching Diodes — Single

The following is a listing of small-signal switching diodes in surface mount packages. These diodes are intended for low current switching and signal steering applications.

		$V_{(BR)R}$		I_R		V_F			C_T	t_{rr}	Pin Out
Device	**Marking**	**Min (V)**	**@ I_{BR} (μA)**	**Max (μA)**	**@ V_R (V)**	**Min (V)**	**Max (V)**	**@ I_F (mA)**	**Max (pF)**	**Max (ns)**	**Case Style**
Case 318-07 — TO-236AB (SOT-23)											
BAS21LT1	A82	250	100	0.1	200		1	100	5	50	8
MMBD914LT1	5D	100	100	5	75		1	10	4	4	8
BAS16LT1	A6	75	100	1	75		1	50	2	6	8
MMBD6050LT1	5A	70	100	0.1	50	0.85	1.1	100	2.5	4	8
BAL99LT1	JF	70	100	2.5	70		1	50	1.5	6	18

		$V_{(BR)R}$		I_R		V_F					
Device	**Marking**	**Min (V)**	**@ I_{BR} (μA)**	**Max (μA)**	**@ V_R (V)**	**Min (V)**	**Max (V)**	**@ I_R (mA)**	**C_J Max (pF)**	**t_{rr} Max (μs)**	**Case Style**
Case 318D-03 — SC-59											
M1MA151AT1	MA	40	100	0.1	35	—	1.2	100	2	3	4
M1MA151KT1	MH	40	100	0.1	35	—	1.2	100	2	3	2

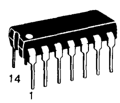
Table 3. General-Purpose Signal and Switching Diodes — Dual

The following is a listing of small-signal switching diodes in surface mount packages. These diodes are intended for low current switching and signal steering applications.

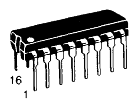
		$V_{(BR)R}$		I_R		V_F			C_T	t_{rr}	Pin Out
Device	**Marking**	**Min (V)**	**@ I_{BR} (μA)**	**Max (μA)**	**@ V_R (V)**	**Min (V)**	**Max (V)**	**@ I_F (mA)**	**Max (pF)**	**Max (ns)**	**Case Style**
Case 318-07 — TO-236AB (SOT-23)											
MMBD7000LT1	M5C	100	100	0.3	50	0.75	1.1	100	1.5	4	11
MMBD2836LT1	A2	75	100	0.1	50		1	10	4	4	12
MMBD2838LT1	A6	75	100	0.1	50		1	10	4	4	9
BAV70LT1	A4	70	100	5	70		1	50	1.5	6	9
BAV99LT1	A7	70	100	2.5	70		1	50	1.5	4	11
BAW56LT1	A1	70	100	2.5	70		1	50	2	6	12
MMBD6100LT1	5BM	70	100	0.1	50	0.85	1.1	100	2.5	4	9
BAV74LT1	JA	50	5	0.1	50		1	100	2	4	9
MMBD2835LT1	A3	35	100	0.1	30		1	10	4	4	12
MMBD2837LT1	A5	35	100	0.1	30		1	10	4	4	9
Case 318D-03 — SC-59											
M1MA151WAT1	MN	40	100	0.1	35	—	1.2	100	15	10	5
M1MA151WKT1	MT	40	100	0.1	35	—	1.2	100	2	3	3

Multiple Switching Diodes

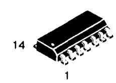
Multiple diode configurations utilize monolithic structures fabricated by the planar process. They are designed to satisfy fast switching requirements as in core driver and encoding/decoding applications where their monolithic configurations offer lower cost, higher reliability and space savings.



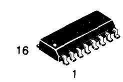
CASE 646-06
PIN DIP
PLASTIC



CASE 648-08
PIN DIP
PLASTIC



CASE 751A-02
SO-14
PLASTIC



CASE 751B-03
SO-16
PLASTIC

Diode Array Diagrams

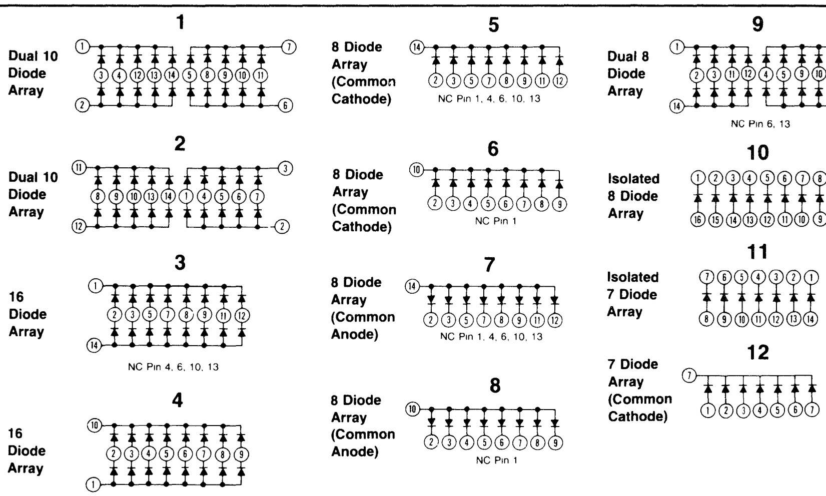
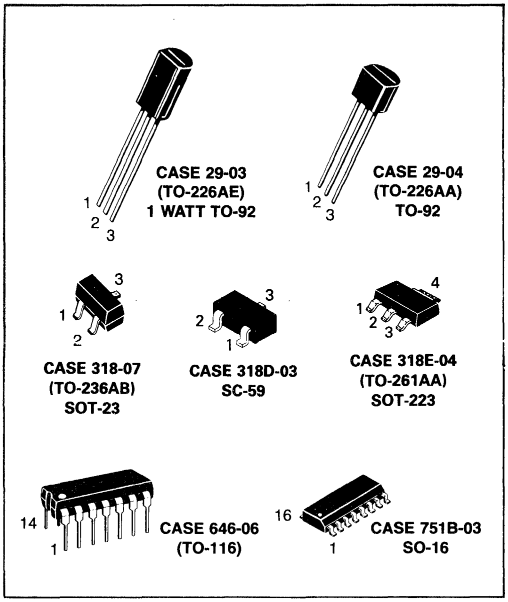


Table 1. Diode Arrays

Case 646-06 — TO-116

Device	Function	Pin Connections Diagram No.
MAD130P	Dual 10 Diode Array	1
MAD1103P	16 Diode Array	3
MAD1105P	8 Diode Common Cathode Array	5
MAD1107P	Dual 8 Diode Array	9
MAD1109P	7 Isolated Diode Array	11
Case 648-08		
MAD1108P	8 Isolated Diode Array	10
Case 751A-02 — SO-14		
MMAD130	Dual 10 Diode Array	2
MMAD1103	16 Diode Array	3
MMAD1105	8 Diode Common Cathode Array	5
MMAD1106	8 Diode Common Anode Array	7
MMAD1107	Dual 8 Diode Array	9
MMAD1109	7 Isolated Diode Array	11
Case 751B-03 — SO-16		
MMAD1108	8 Isolated Diode Array	10



Plastic-Encapsulated Transistors

2

Motorola's plastic transistors and diodes encompass hundreds of devices spanning the gamut from general-purpose amplifiers and switches with a wide variety of characteristics to dedicated special-purpose devices for the most demanding applications. The popular TO-92, 1-Watt TO-92 and TO-116 combine proven reliability performance and economy for through-the-hole manufacturing, while the SOT-23, SC-59, SOT-223, and SO-16 offer the same solutions for surface mount manufacturing.

As an additional service to our customers Motorola will, upon request, supply many of these devices in tape and reel for automatic insertion.

Contact your Motorola representative for ordering information.

This section contains both single and multiple plastic-encapsulated transistors.

NOTE: All SOT-23 package devices have had a "T1" suffix added to the device title.

EMBOSSED TAPE AND REEL

SOT-23, SC-59, SOT-223 and SO-16 packages are available only in Tape and Reel. Use the appropriate suffix indicated below to order any of the SOT-23, SC-59, SOT-223 and SO-16 packages. (See Section 7 on Packaging for additional information).

SOT-23: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SC-59: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SOT-223: available in 12 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/1000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/4000 unit reel.

SO-16: available in 16 mm Tape and Reel
Add an "R1" suffix to the device title to order the 7 inch/500 unit reel.
Add an "R2" suffix to the device title to order the 13 inch/2500 unit reel.

RADIAL TAPE REEL AND AMMO PACK

TO-92 packages are available in both bulk shipments and in Radial Tape Reel and Ammo Packs. Radial Tape Reel and Ammo Pack are the best methods for capturing devices for automatic insertion in printed circuit boards.

TO-92: available in 365 mm Radial Tape Reel
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Radial Tape Reel.

available in Ammo Pack (Fan Fold Box)
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Ammo Pack box.

*Refer to Section 7 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

SOT-23 and SC-59 packages have a device marking and a date code etched on the device. The generic example below depicts both the device marking and a representation of the date code that appears on the SC-59 and SOT-23 packages.

ABCD

The "D" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

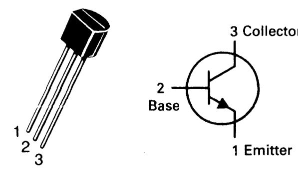
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

*Indicates Data in addition to JEDEC Requirements.

2N3903
2N3904★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)		I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		20 40	— —	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		35 70	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		30 60	— —	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		15 30	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3903 2N3904	f_T	250 300	— —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{ie}	1.0 1.0	8.0 10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{re}	0.1 0.5	5.0 8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)	2N3903 2N3904	NF	— —	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N3903 2N3904	t_s	— —	175 200	ns
Fall Time			t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

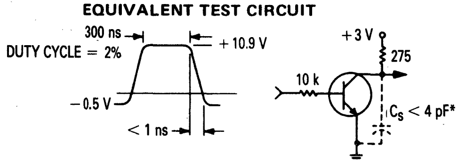
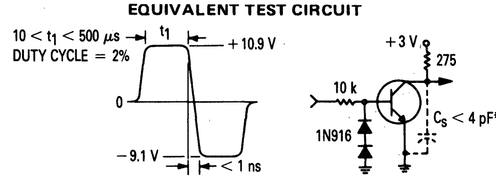


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

— T_J = 25°C - - - T_J = 125°C

FIGURE 3 — CAPACITANCE

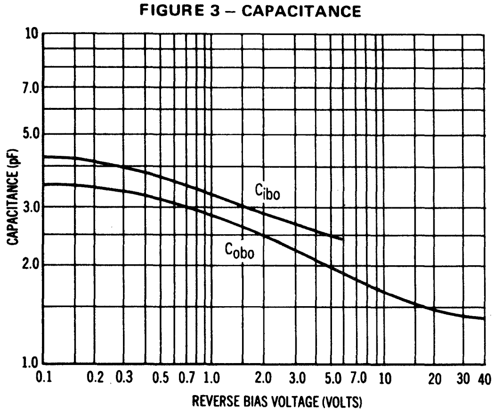


FIGURE 4 — CHARGE DATA

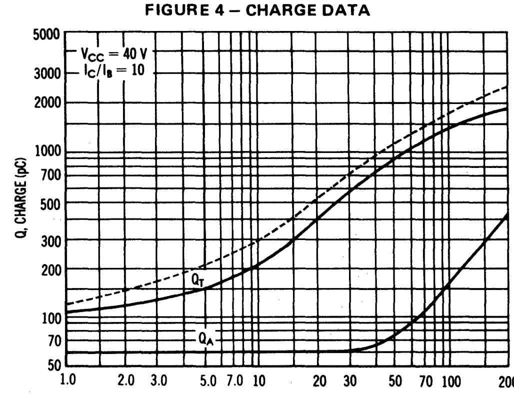


FIGURE 5 — TURN-ON TIME

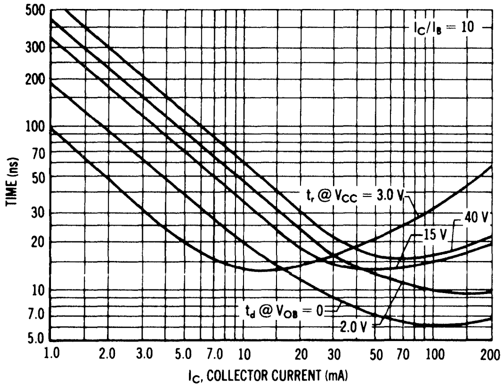


FIGURE 6 — RISE TIME

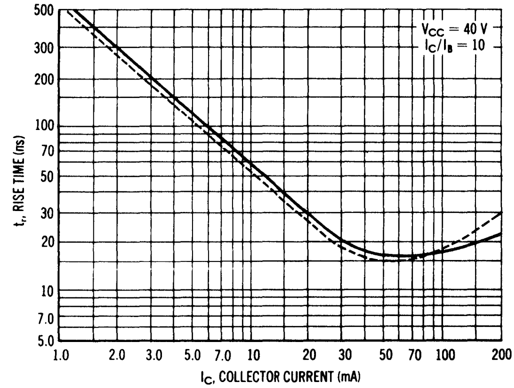


FIGURE 7 — STORAGE TIME

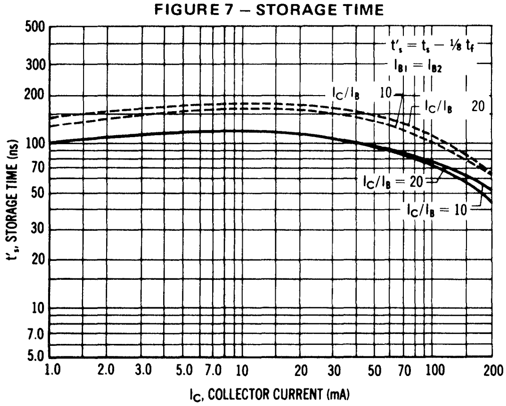
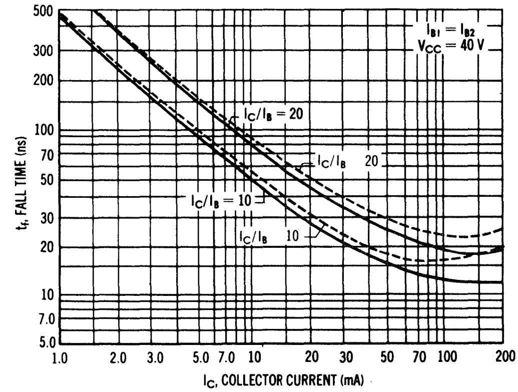


FIGURE 8 — FALL TIME



TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 9

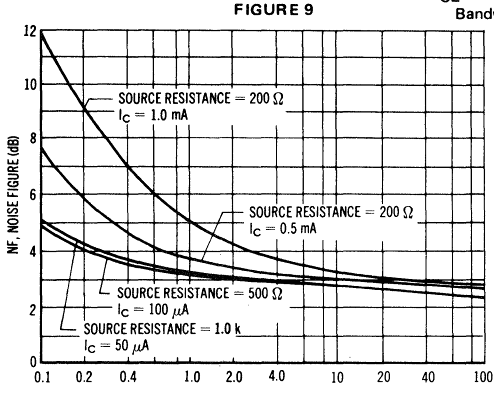
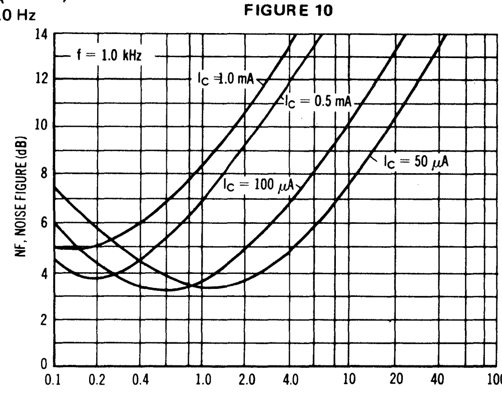


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 — CURRENT GAIN

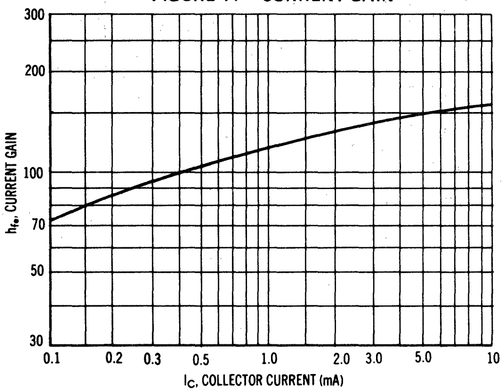


FIGURE 12 — OUTPUT ADMITTANCE

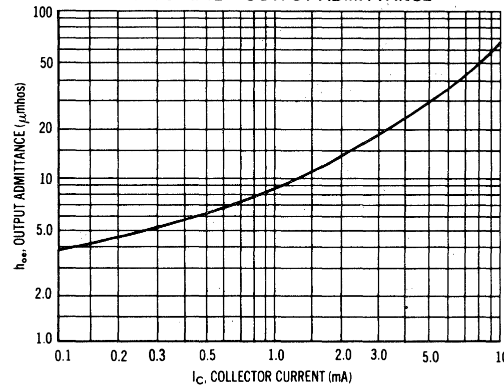


FIGURE 13 — INPUT IMPEDANCE

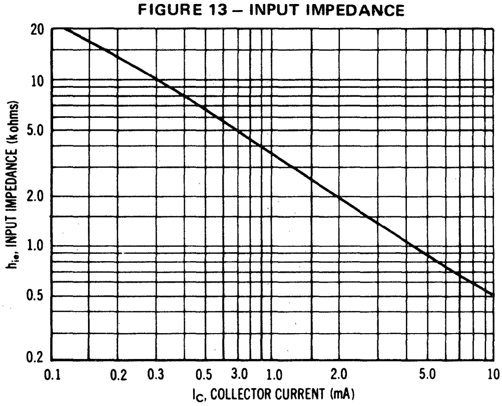
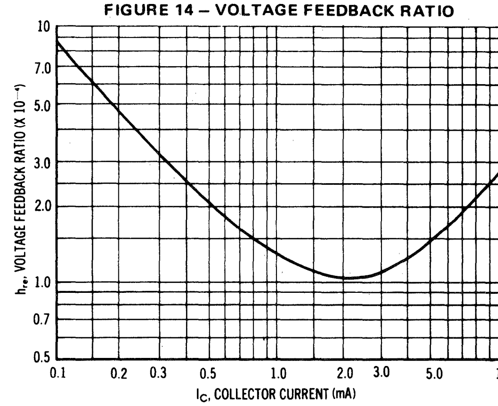


FIGURE 14 — VOLTAGE FEEDBACK RATIO



TYPICAL STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

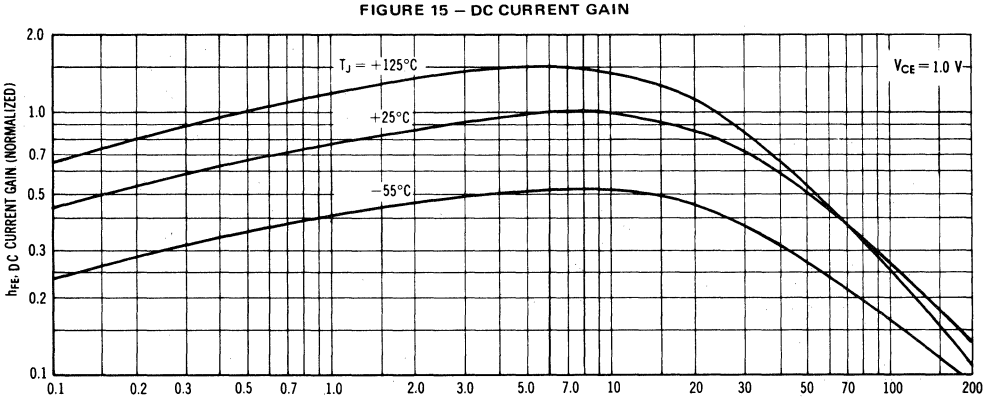


FIGURE 16 – COLLECTOR SATURATION REGION

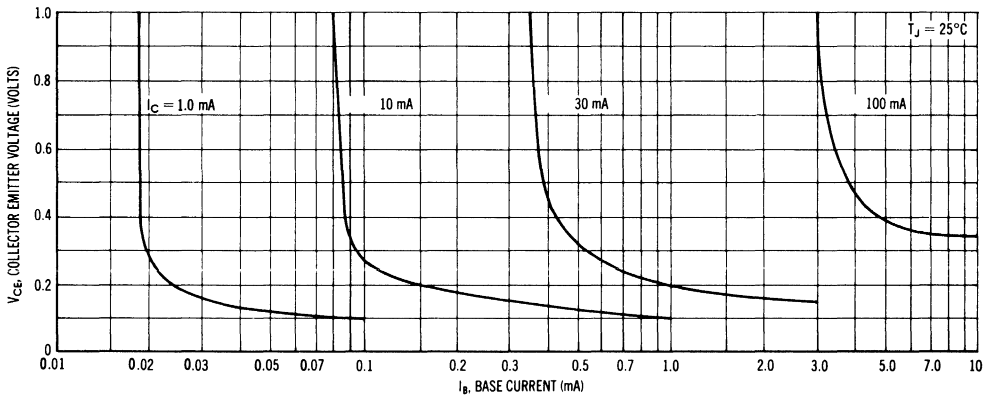


FIGURE 17 – "ON" VOLTAGES

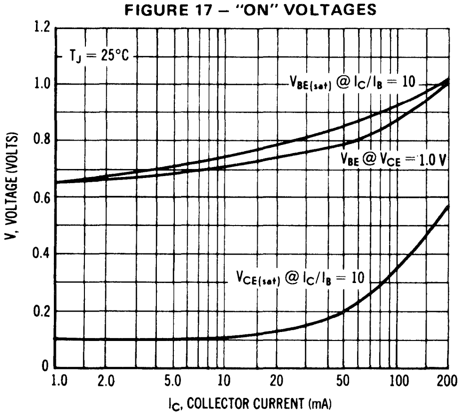
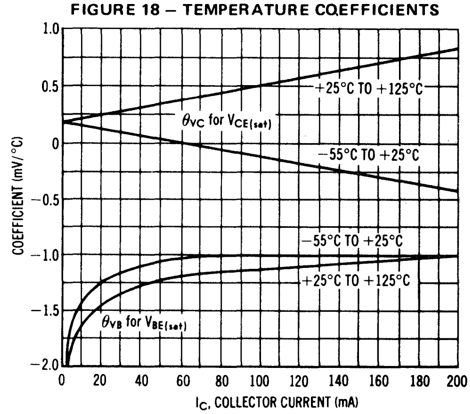


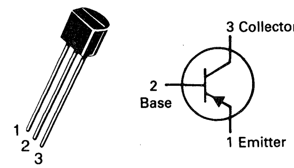
FIGURE 18 – TEMPERATURE COEFFICIENTS



2

2N3905
2N3906★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_A = 60°C	P_D	250	mW
Total Divice Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Base Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)		I_{BL}	—	−50	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)		I_{CEX}	—	−50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc)	2N3905 2N3906		30 60	— —	
(I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc)	2N3905 2N3906		40 80	— —	
(I_C = −10 mAdc, V_{CE} = −1.0 Vdc)	2N3905 2N3906		50 100	150 300	
(I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	2N3905 2N3506		30 60	— —	
(I_C = −100 mAdc, V_{CE} = −1.0 Vdc)	2N3905 2N3906		15 30	— —	
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{CE(sat)}$	 — —	 −0.25 −0.4	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	 −0.65 —	 −0.85 −0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	 2N3905 2N3906	f_T	 200 250	 — —	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz		C_{obo}	—	4.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10.0	pF
Input Impedance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz	2N3905 2N3906	h_{re}	0.1 0.1	5.0 10	X 10^{-4}
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{fe}	50 100	200 400	—
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	2N3905 2N3906	NF	— —	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = −3.0 Vdc, V_{BE} = −0.5 Vdc I_C = −10 mAdc, I_{B1} = −1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = −3.0 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	2N3905 2N3906	t_s	— —	200 225	ns
Fall Time		2N3905 2N3906	t_f	— —	60 75	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

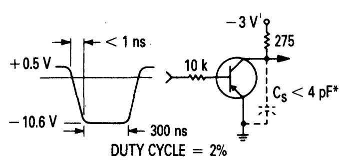
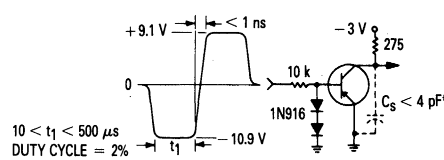


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

—— T_J = 25°C - - - T_J = 125°C

FIGURE 3 – CAPACITANCE

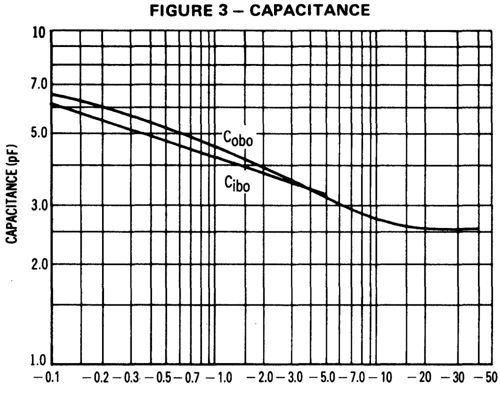


FIGURE 4 – CHARGE DATA

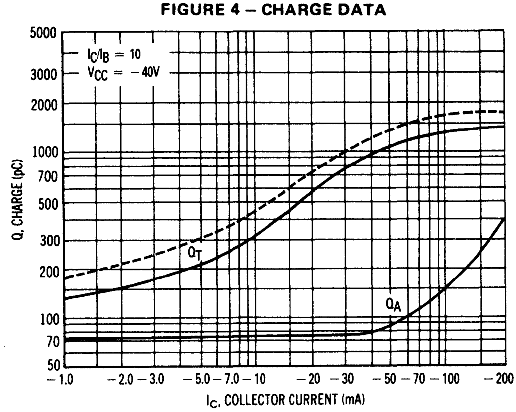


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FIGURE 5 — TURN-ON TIME

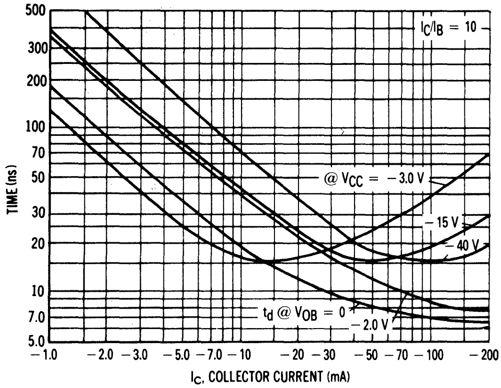
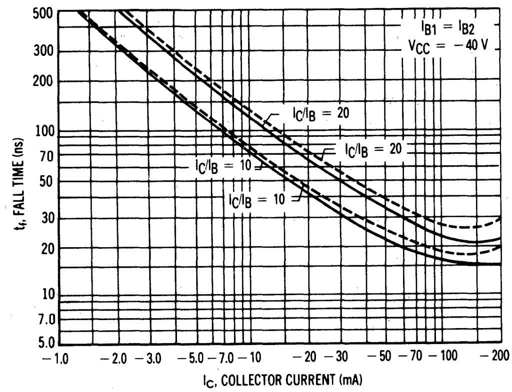


FIGURE 6 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = −5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 7 —

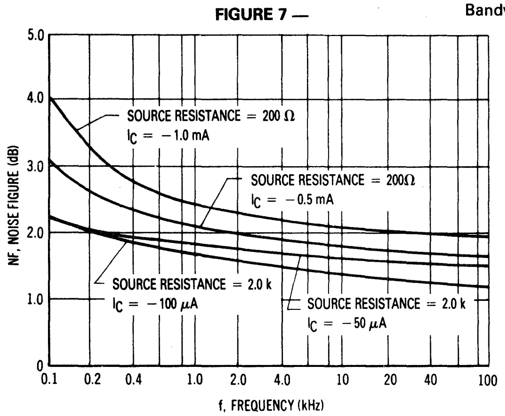
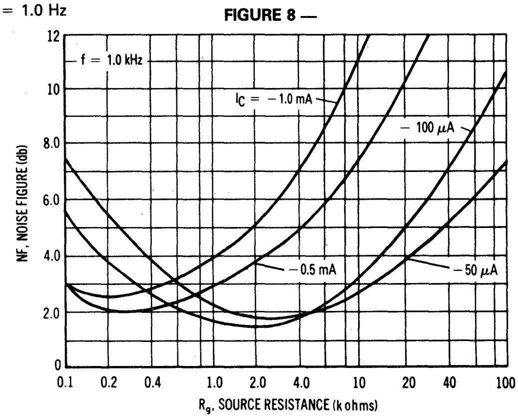


FIGURE 8 —



h PARAMETERS

(V_{CE} = −10 Vdc, f = 1.0 kHz, T_A = 25 °C)

FIGURE 9 — CURRENT GAIN

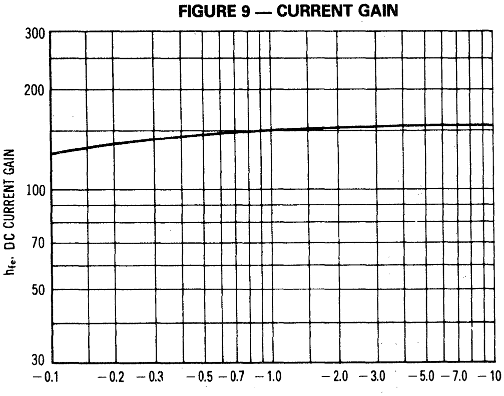


FIGURE 10 — OUTPUT ADMITTANCE

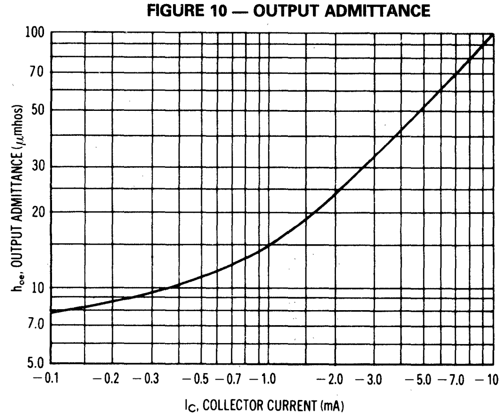


FIGURE 11 — INPUT IMPEDANCE

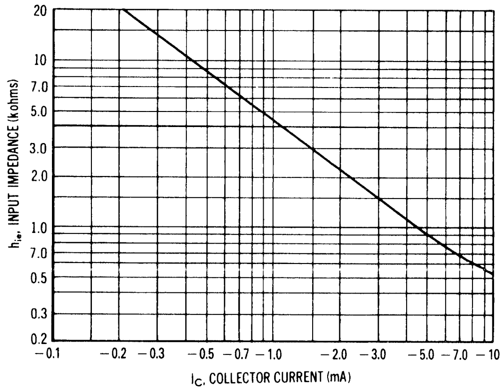
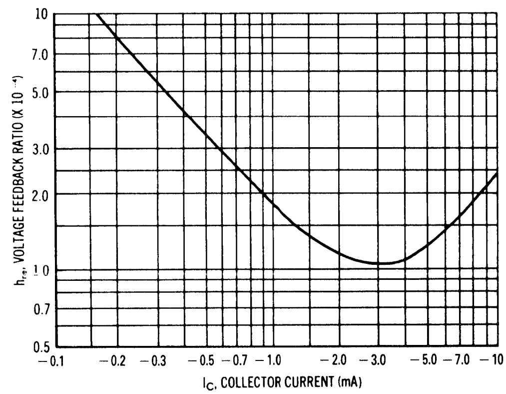


FIGURE 12 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 13 — DC CURRENT GAIN

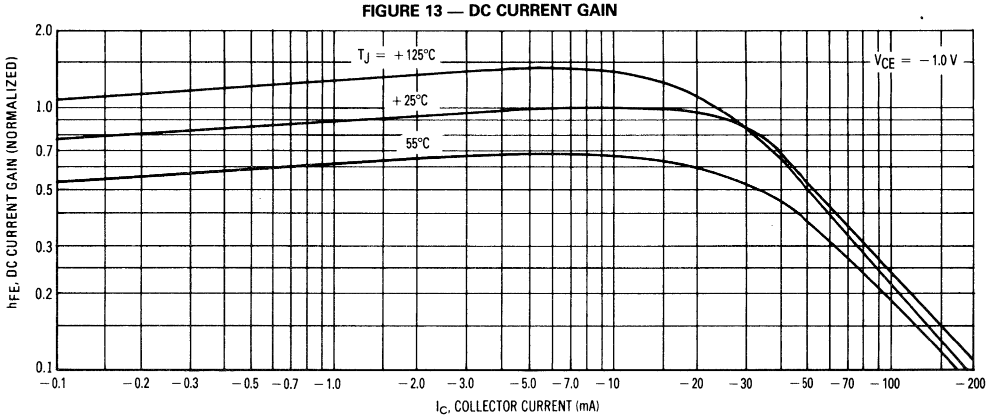
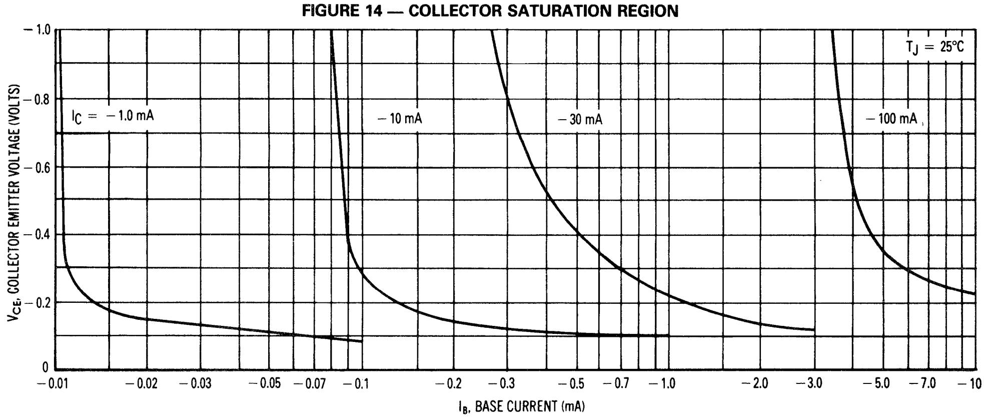


FIGURE 14 — COLLECTOR SATURATION REGION



2

FIGURE 15 — "ON" VOLTAGES

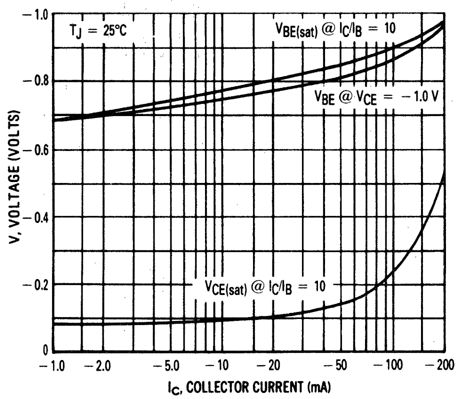
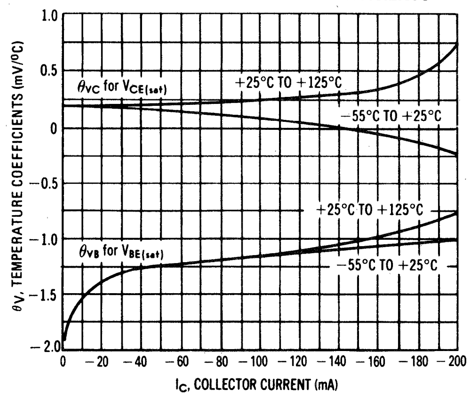
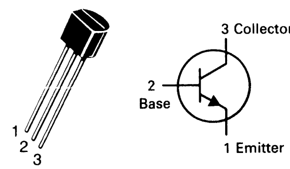


FIGURE 16 — TEMPERATURE COEFFICIENTS



2N4123
2N4124

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_E = 0)	2N4123 2N4124	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4123 2N4124	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc)	2N4123 2N4124	h_{FE}	50 120	150 360	—
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N4123 2N4124		25 60	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123 2N4124	f_T	250 300	— —	MHz
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Collector-Base Capacitance (I_E = 0, V_{CB} = 5.0 V, f = 1.0 MHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 10 k ohm, f = 1.0 kHz)	2N4123 2N4124	h_{fe}	50 120	200 480	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Current Gain — High Frequency		$\|h_{fe}\|$			—
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123		2.5	—	
	2N4124		3.0	—	
(I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	2N4123		50	200	
(I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	2N4124		120	480	
Noise Figure		NF			dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm,	2N4123		—	6.0	
f = 1.0 kHz)	2N4124		—	5.0	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2

FIGURE 1 — CAPACITANCE

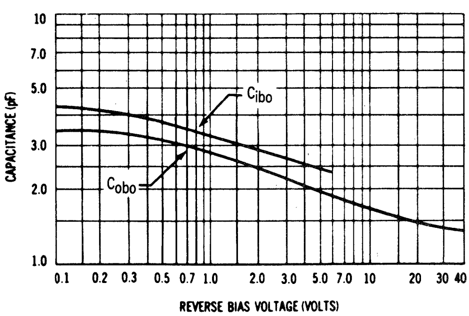
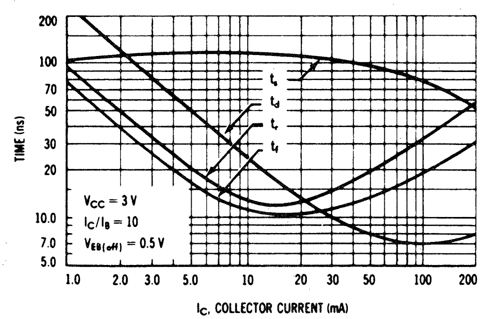


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

(V_{CE} = 5 Vdc, T_A = 25°C)
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

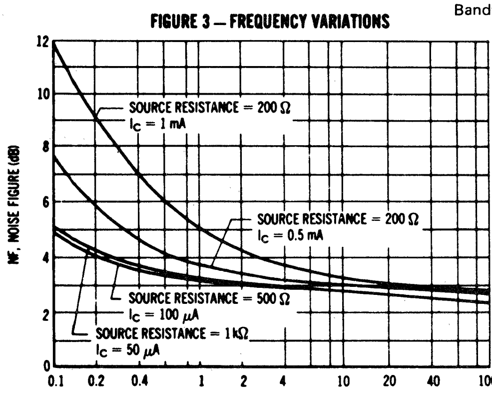
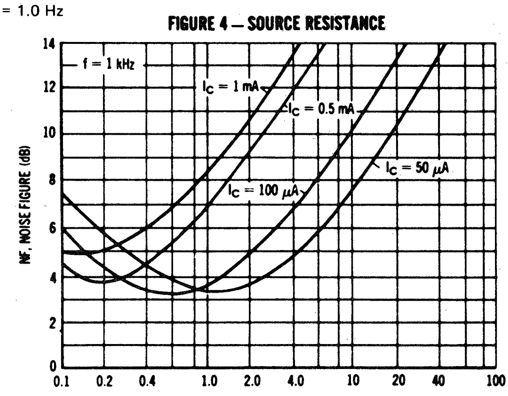


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

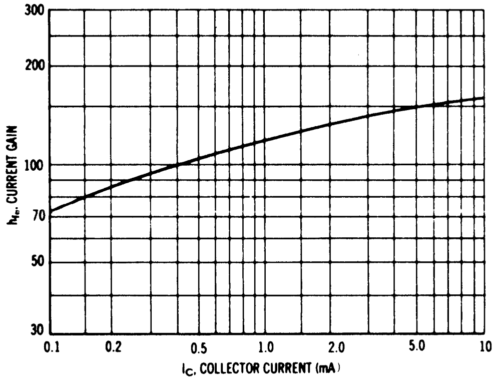


FIGURE 6 — OUTPUT ADMITTANCE

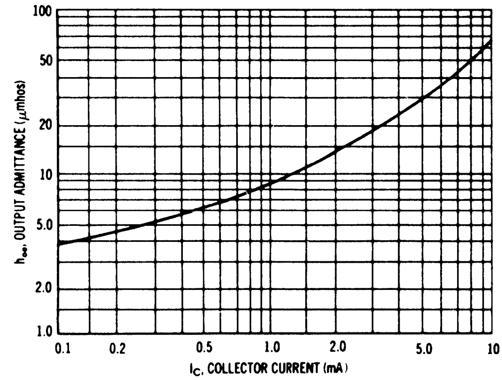


FIGURE 7 — INPUT IMPEDANCE

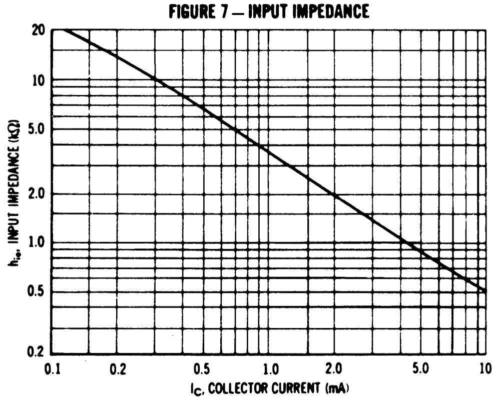
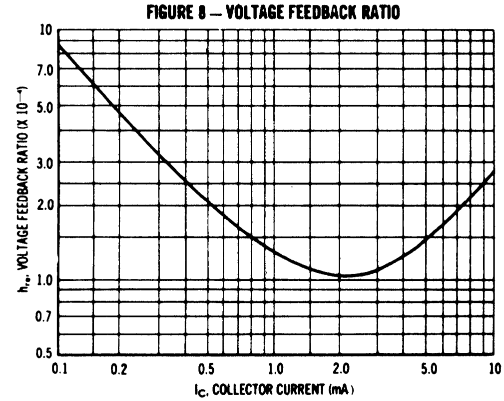


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 – DC CURRENT GAIN

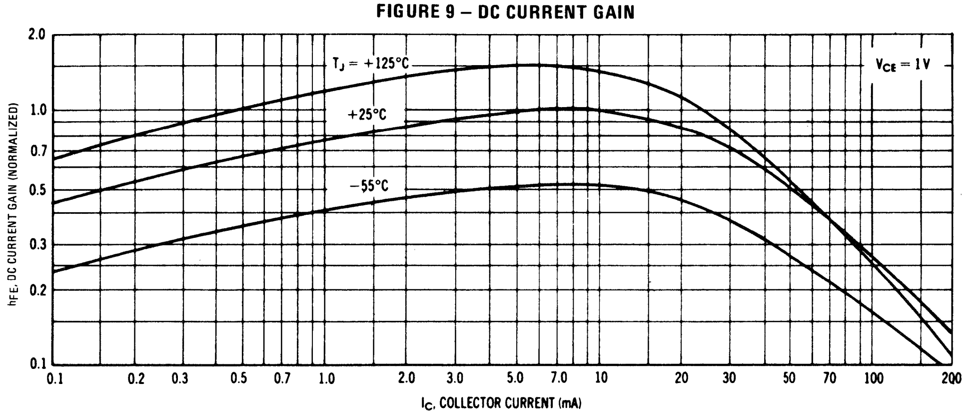


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FIGURE 10 — COLLECTOR SATURATION REGION

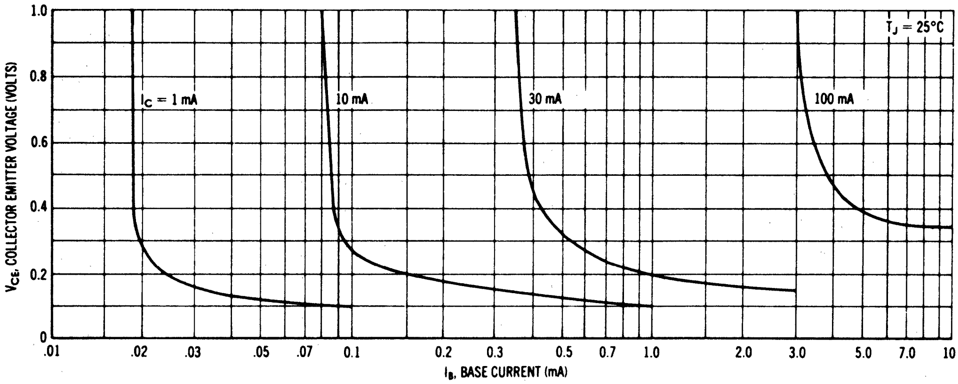


FIGURE 11 — "ON" VOLTAGES

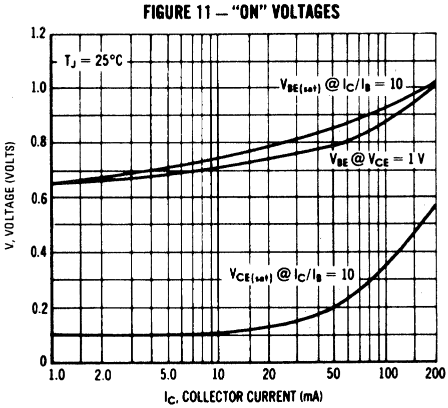
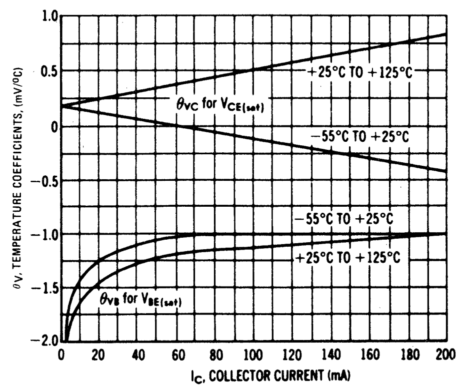
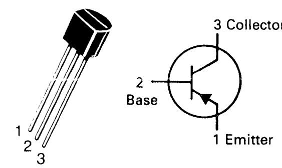


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4125
2N4126

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	−30	−25	Vdc
Collector-Base Voltage	V_{CBO}	−30	−25	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0		Vdc
Collector Current — Continuous	I_C	−200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_E = 0)	2N4125 2N4126	$V_{(BR)CEO}$	−30 −25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	2N4125 2N4126	$V_{(BR)CBO}$	−30 −25	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −20 Vdc, I_E = 0)		I_{CBO}	—	−50	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = −2.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	 2N4125 2N4126 2N4125 2N4126	h_{FE}	 50 120 25 60	 150 360 — —	—
Collector-Emitter Saturation Voltage (1) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{CE(sat)}$	—	−0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	—	−0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	 2N4125 2N4126	f_T	 200 250	 — —	MHz
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	pF
Collector-Base Capacitance (V_{CB} = −5.0 V_{dc}, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.5	pF
Small-Signal Current Gain (I_C = −2.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	 2N4125 2N4126	h_{fe}	 50 120	 200 480	—
Current Gain — High Frequency (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	 2N4125 2N4126	$\|h_{fe}\|$	 2.0 2.5	 — —	—
Noise Figure (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 KHz	 2N4125 2N4126	NF	 — —	 5.0 4.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle = 2.0%.

FIGURE 1 — CAPACITANCE

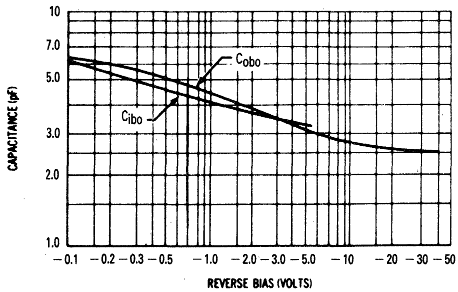
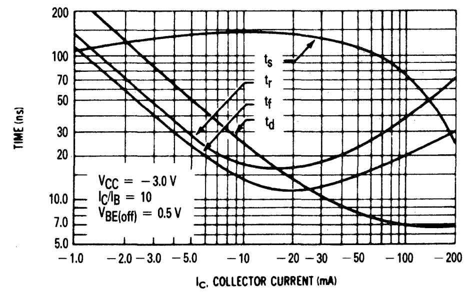


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = -5.0$ Vdc, $T_A = 25°C$,
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

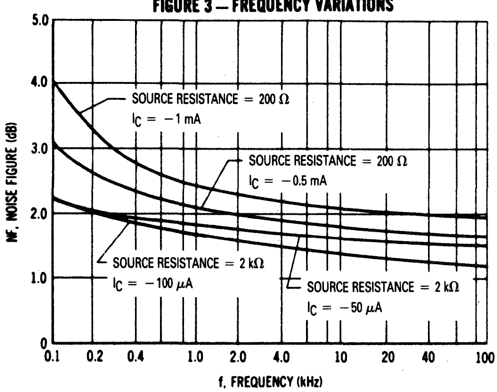
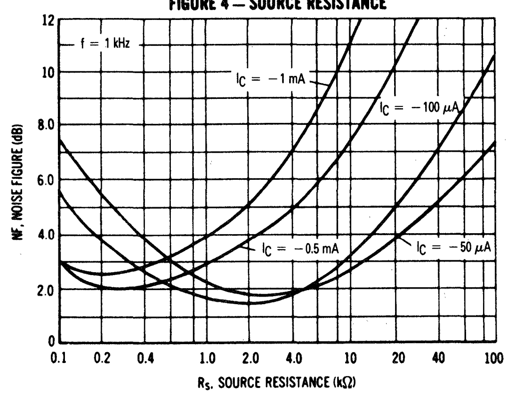


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

$V_{CE} = -10$ V, f = 1 kHz, $T_A = 25°C$

FIGURE 5 — CURRENT GAIN

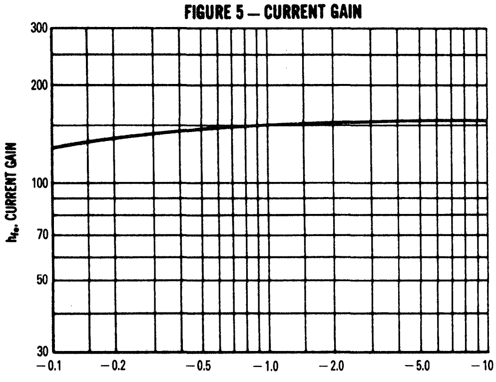


FIGURE 6 — OUTPUT ADMITTANCE

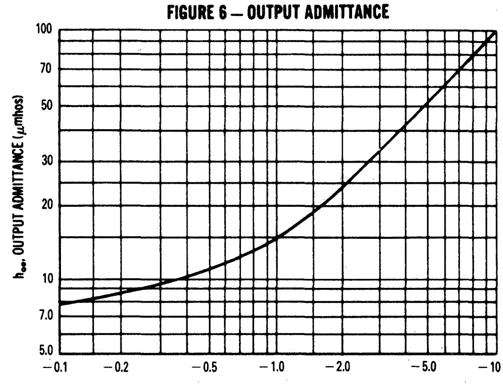


FIGURE 7 — INPUT IMPEDANCE

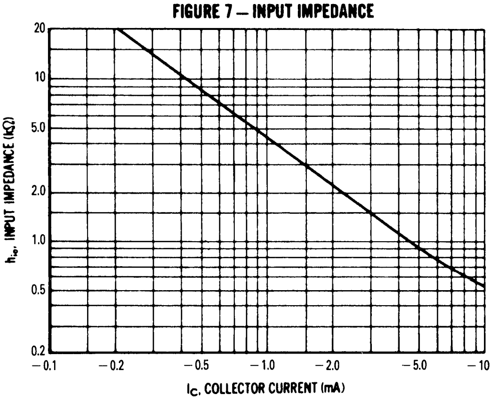
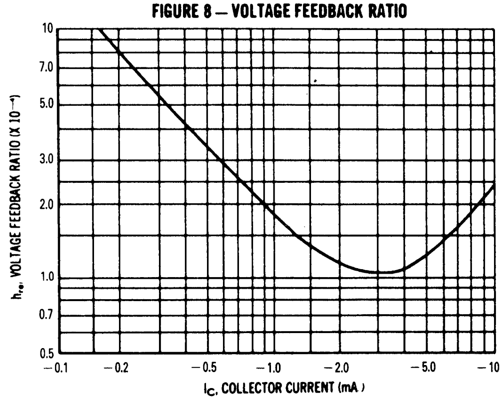


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

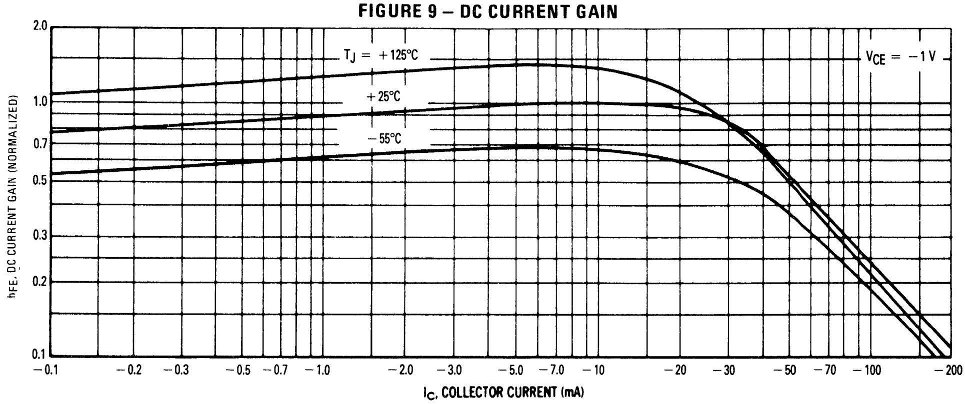


FIGURE 10 — COLLECTOR SATURATION REGION

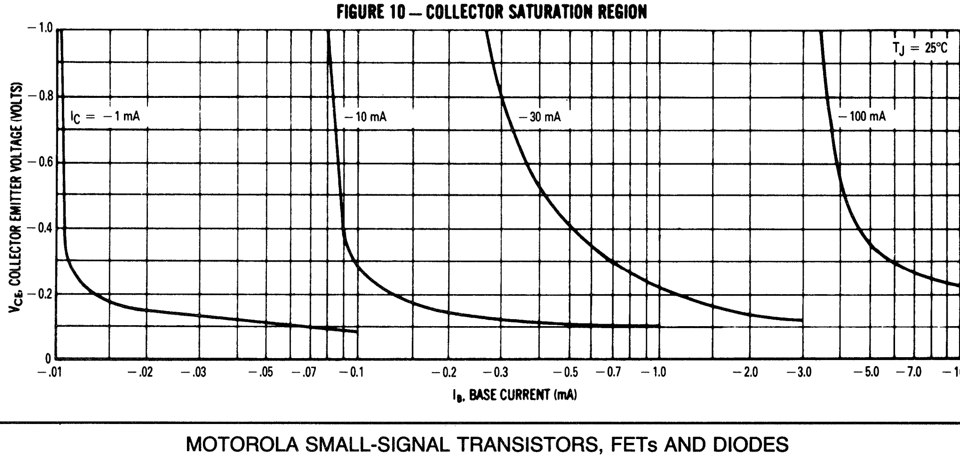


FIGURE 11 — "ON" VOLTAGES

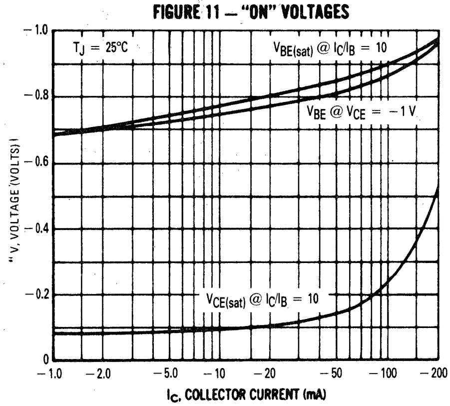
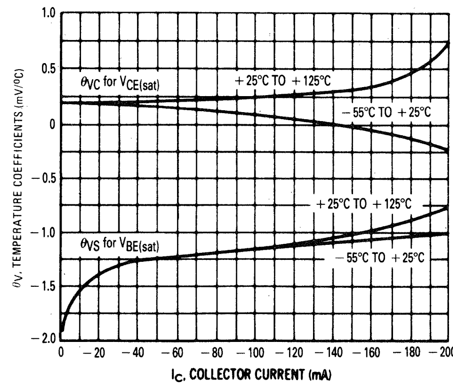


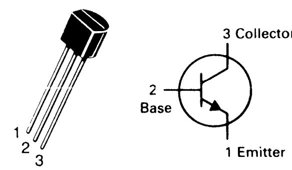
FIGURE 12 — TEMPERATURE COEFFICIENTS



2

2N4264
2N4265

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Characteristic	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	 2N4264 2N4265	$V_{(BR)CEO}$	 15 12	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_C = 0)		$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc) (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 100°C)		I_{BEV}	 — —	 0.1 10	μAdc
Collector Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc)		I_{CEX}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	 2N4264 2N4265	h_{FE}	 25 50	 — —	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4264 2N4265		40 100	160 400	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	2N4264 2N4265		20 45	— —	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)	2N4264 2N4265		40 90	— —	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(1)	2N4264 2N4265		30 55	— —	
(I_C = 200 mAdc, V_{CE} = 1.0 Vdc)(1)	2N4264 2N4265		20 55	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)(1)		$V_{CE(sat)}$	 — —	 0.22 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)(1)		$V_{BE(sat)}$	 0.65 0.75	 0.8 0.95	Vdc

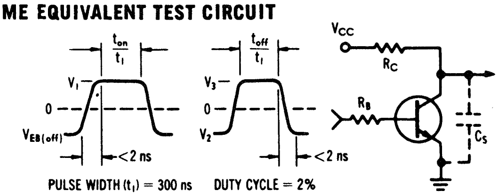
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	—	MHz
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz, I_E = 0)		C_{obo}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 10 Vdc, $V_{EB(off)}$ = 2.0 Vdc, I_C = 100 mAdc, I_{B1} = 10 mAdc) (Fig. 1, Test Condition C)	t_d	—	8.0	ns
Rise Time		t_r	—	15	ns
Storage Time	V_{CC} = 10 Vdc, (I_C = 10 mAdc, for t_s) (I_C = 100 mA for t_f) (I_{B1} = −10 mA) (I_{B2} = 10 mA) (Fig. 1, Test Condition C)	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time	(V_{CC} = 3.0 Vdc, $V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Fig. 1, Test Condition A)	t_{on}	—	25	ns
Turn-Off Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Fig. 1, Test Condition A)	t_{off}	—	35	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 10 mA, I_{B1} = I_{B2} = 10 mAdc) (Fig. 1, Test Condition B)	t_s	—	20	ns
Total Control Charge	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_B = mAdc) (Fig. 3, Test Condition A)	Q_T	—	80	pC

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I_C	V_{CC}	R_S	R_C	$C_{S(max)}$	$V_{BE(off)}$	V_1	V_2	V_3
	mA	V	Ω	Ω	pF	V	V	V	V
A	10	3	3300	270	4	−1.5	10.55	−4.15	10.70
B	10	10	560	960	4	—	—	−4.65	6.55
C	100	10	560	96	12	−2.0	6.35	−4.65	6.55



CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN

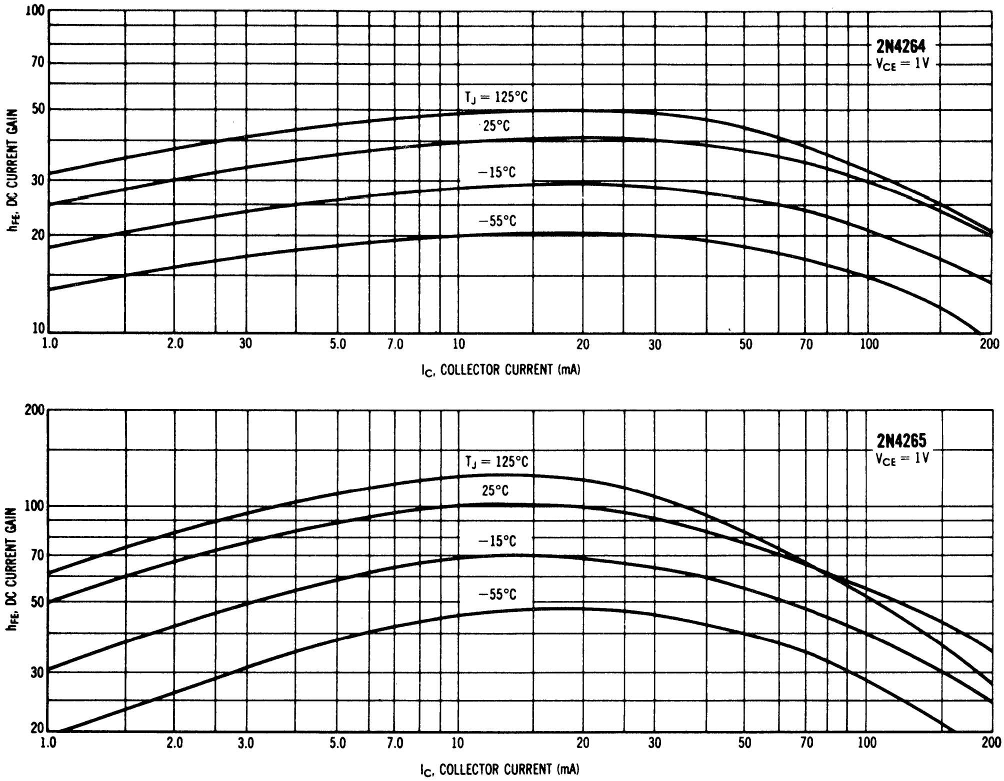


FIGURE 3 — Q_T TEST CIRCUIT

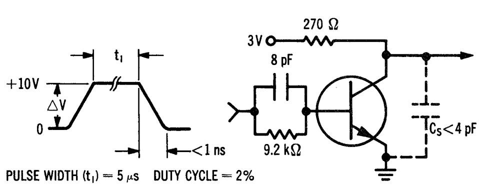
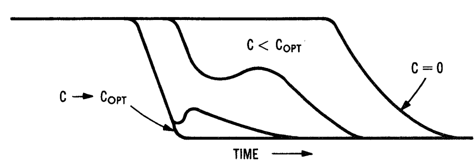


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_B, a charge, Q_S, is developed or "stored" in the transistor. Q_S may be written: $Q_S = Q_I + Q_V + Q_X$.

Q_I is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_V is the charge required to charge the collector-base feedback capacity. Q_X is excess charge resulting from overdrive, i.e., operation in saturation.

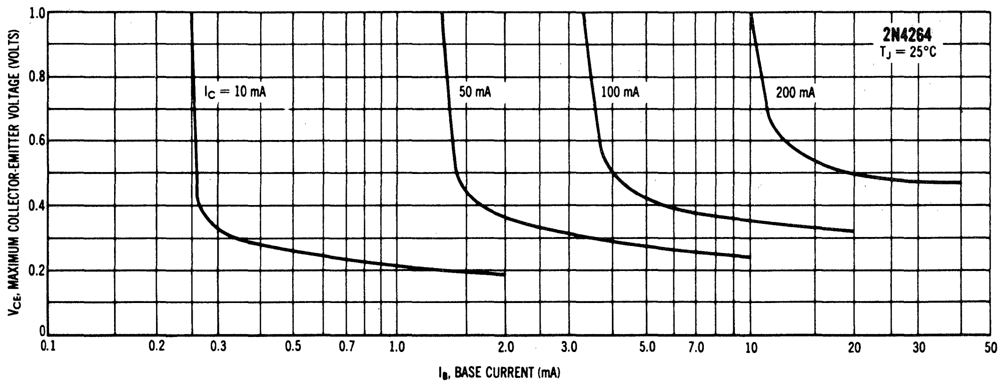
The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_I and Q_V which is defined as the active region charge, Q_A. $Q_A = I_{B1}t_r$ when the transistor is driven by a constant current step (I_{B1}) and $I_{B1} << \frac{I_C}{h_{FE}}$.

If I_B were suddenly removed, the transistor would continue to conduct until Q_S is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_T, of opposite polarity, equal in magnitude, can be stored on an external capacitor, C, to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_T from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_T/\triangle V$, where $\triangle V$ is defined in Figure 3.

2

"ON" CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION



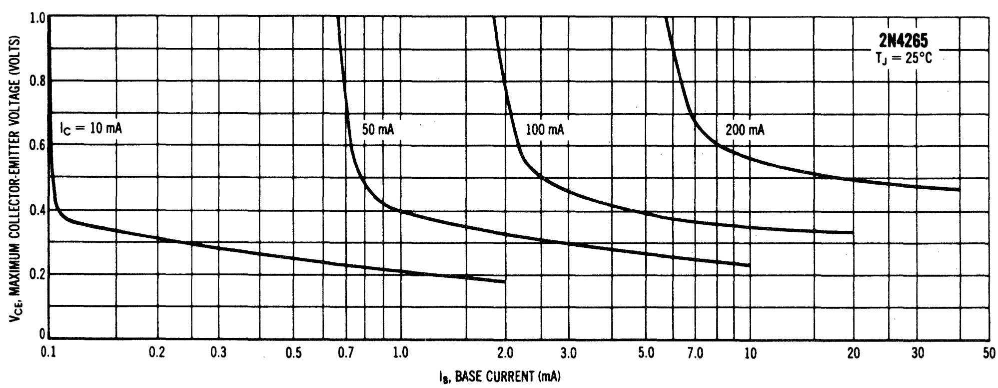


FIGURE 6 — SATURATION VOLTAGE LIMITS

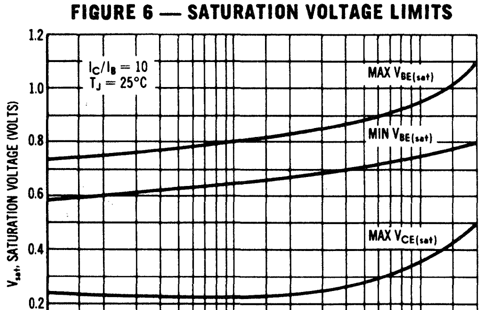
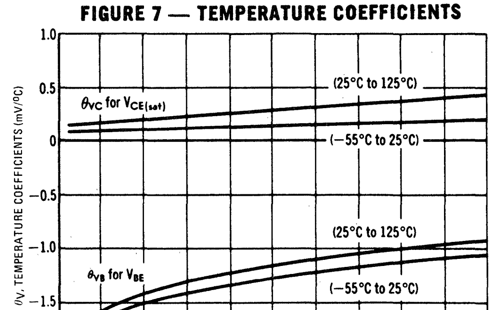


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

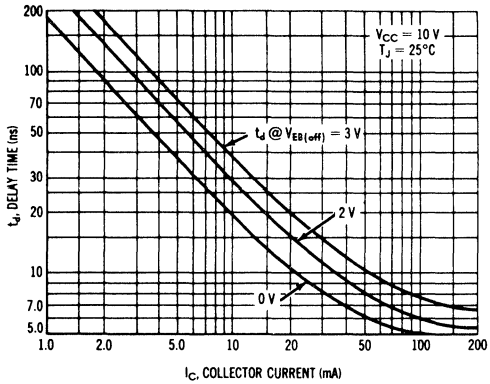


FIGURE 9 — RISE TIME

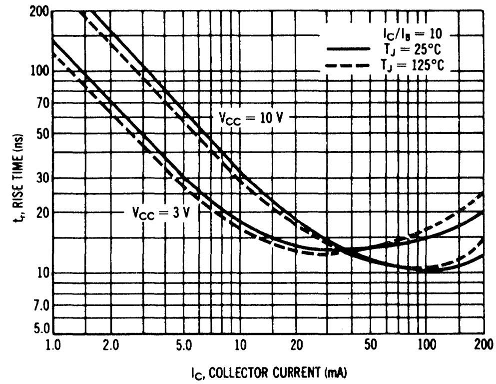


FIGURE 10 — STORAGE TIME

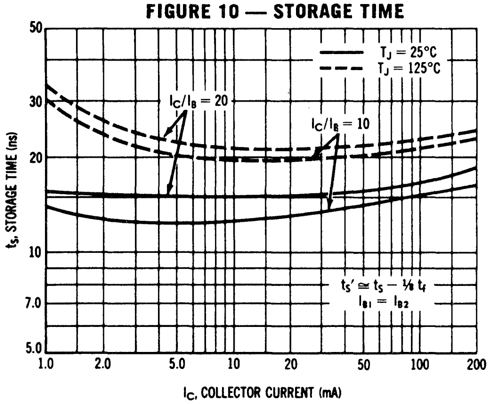


FIGURE 11 — FALL TIME

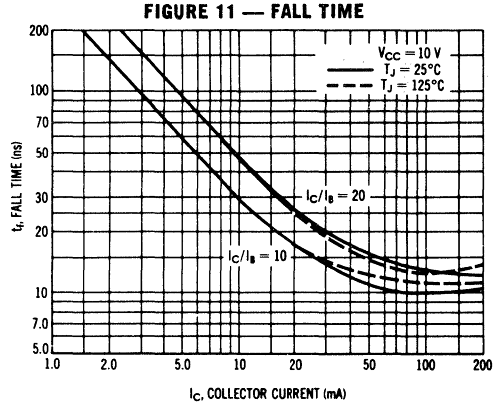


FIGURE 12 — JUNCTION CAPACITANCE

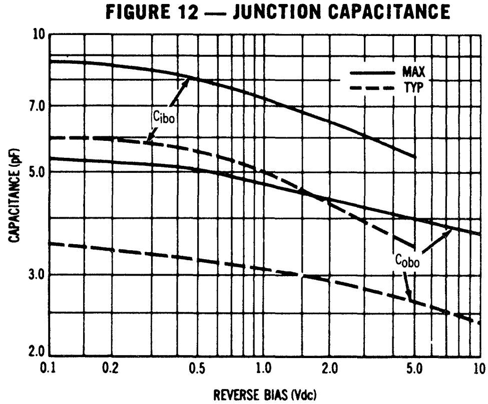
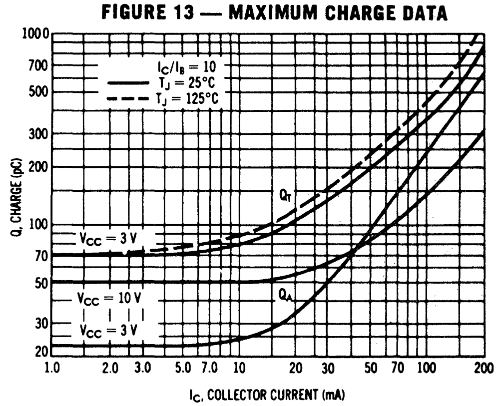
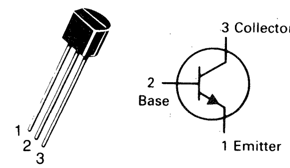


FIGURE 13 — MAXIMUM CHARGE DATA



2N4400
2N4401★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)		I_{BEV}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)		I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N4401		20	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		20 40	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		40 80	— —	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		50 100	150 300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N4400 2N4401		20 40	— —	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 — —	 0.4 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	 0.75 —	 0.95 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 2N4400 2N4401	f_T	 200 250	 — —	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	6.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400 2N4401	h_{ie}	0.5 1.0	7.5 15	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400 2N4401	h_{fe}	20 40	250 500	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

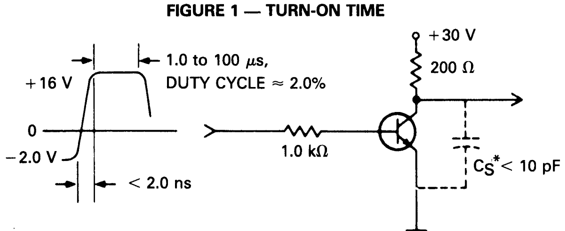
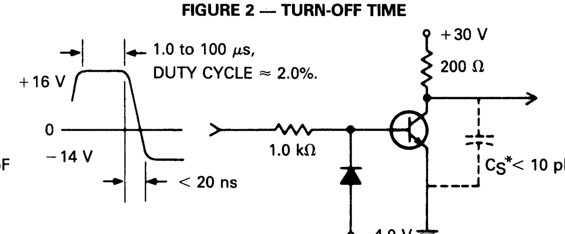


FIGURE 2 — TURN-OFF TIME



Scope rise time < 4.0 ns
*Total shunt capacitance of test jig connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

—— 25°C ― ― ― 100°C

FIGURE 3 — CAPACITANCES

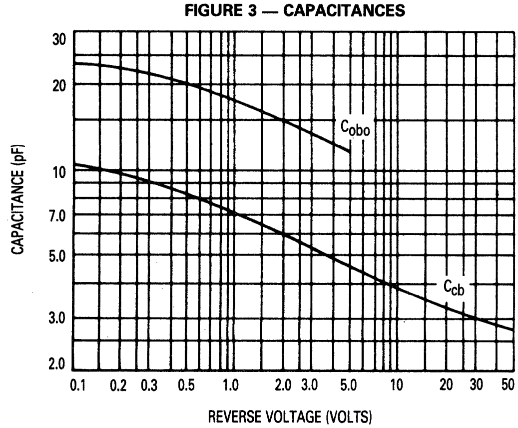
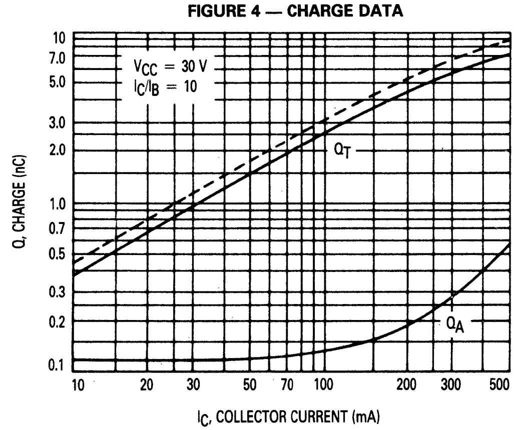


FIGURE 4 — CHARGE DATA



2

FIGURE 5 — TURN-ON TIME

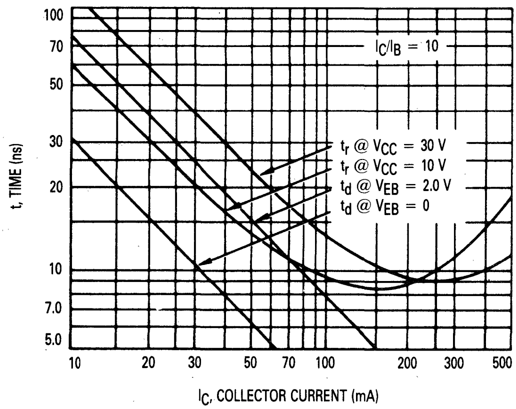


FIGURE 6 — RISE AND FALL TIMES

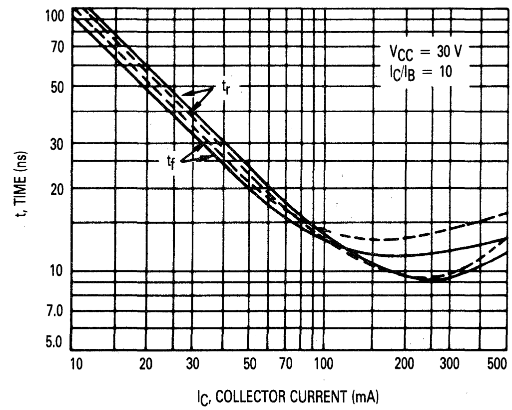


FIGURE 7 — STORAGE TIME

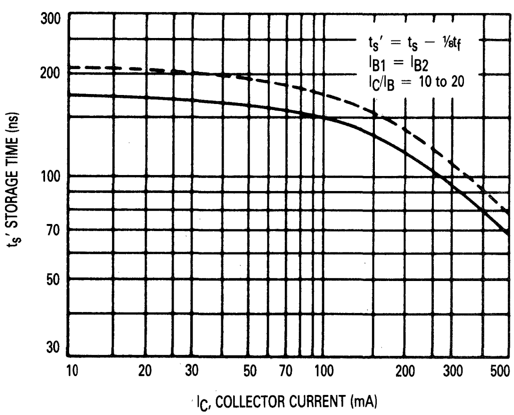
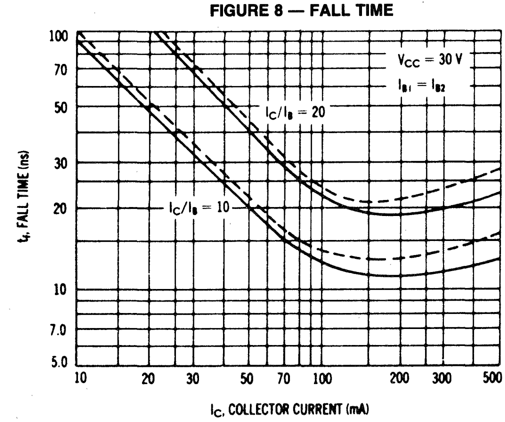


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

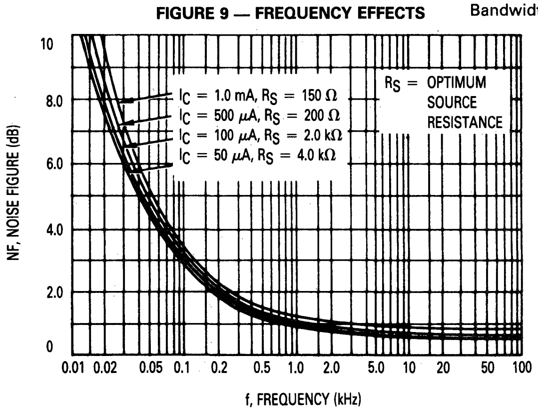
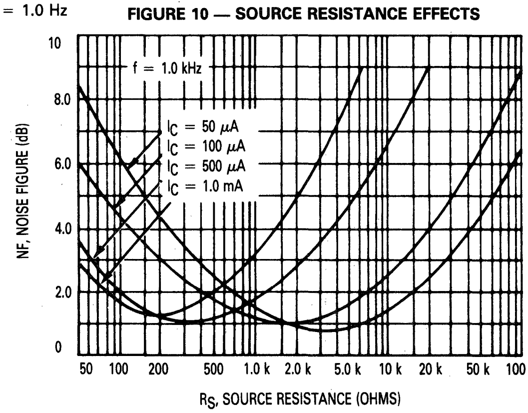


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

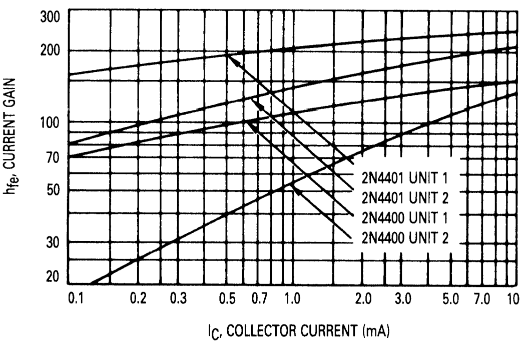


FIGURE 12 — INPUT IMPEDANCE

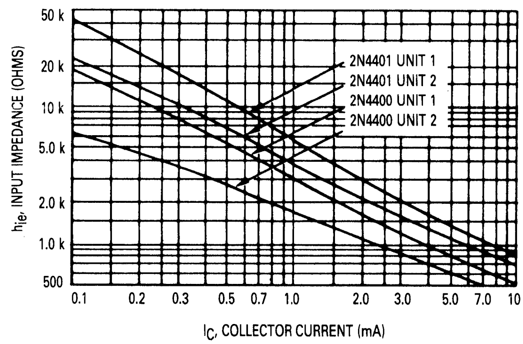


FIGURE 13 — VOLTAGE FEEDBACK RATIO

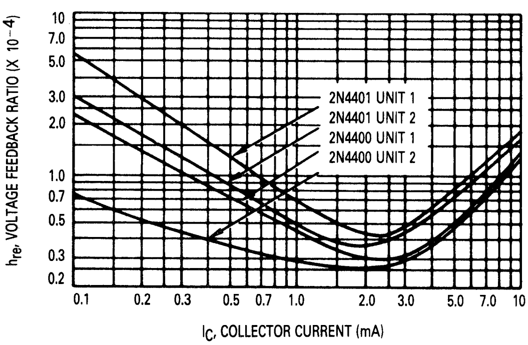
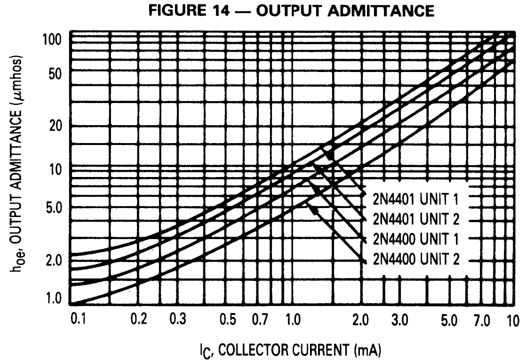


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

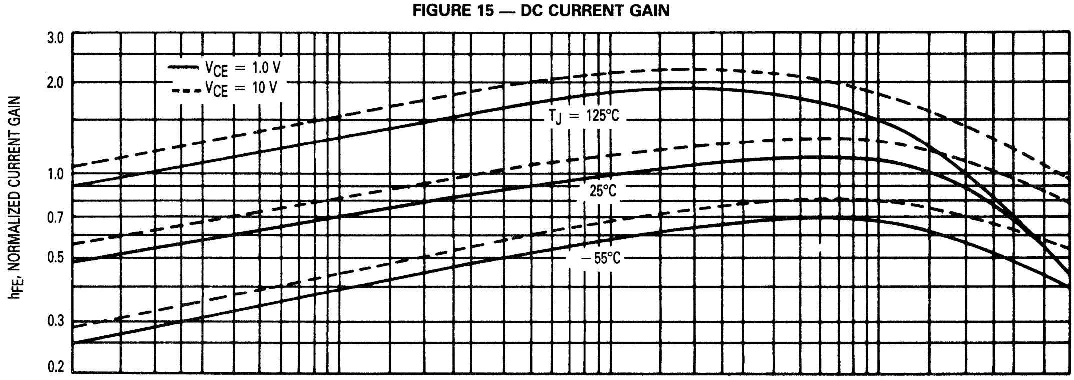


FIGURE 16 — COLLECTOR SATURATION REGION

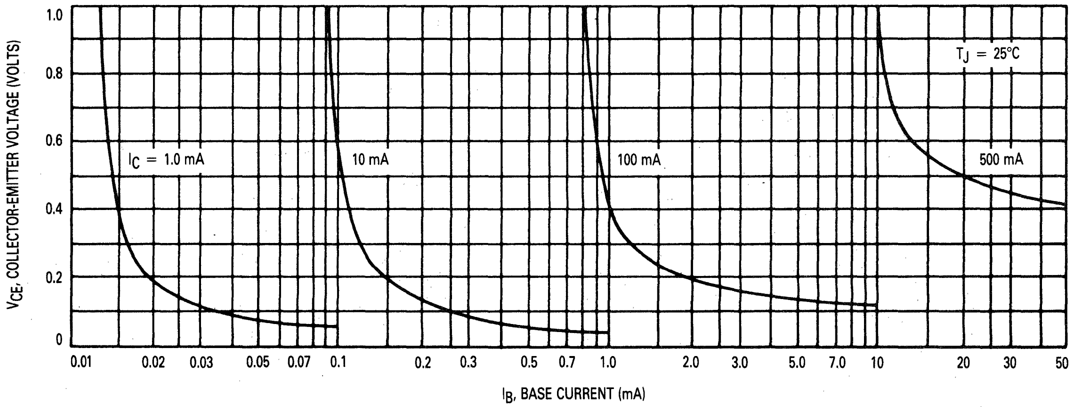


FIGURE 17 — "ON" VOLTAGES

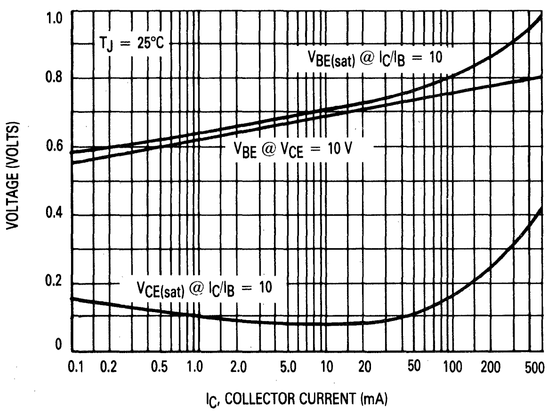
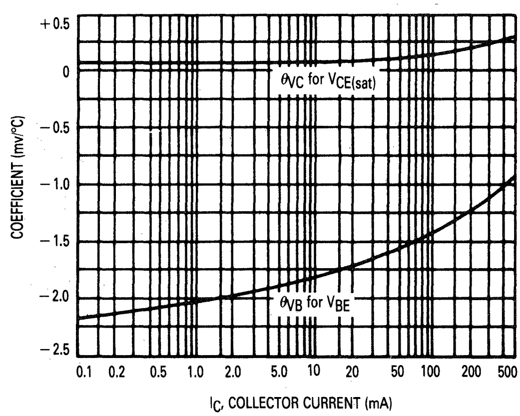
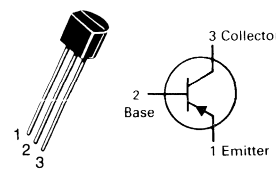


FIGURE 18 — TEMPERATURE COEFFICIENTS



2N4402
2N4403★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Base Cutoff Current (V_{CE} = −35 Vdc, V_{EB} = −0.4 Vdc)		I_{BEV}	—	−0.1	μAdc
Collector Cutoff Current (V_{CE} = −35 Vdc, V_{EB} = −0.4 Vdc)		I_{CEX}	—	−0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc)	2N4403		30	—	
(I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc)	2N4402 2N4403		30 60	— —	
(I_C = −10 mAdc, V_{CE} = −1.0 Vdc)	2N4402 2N4403		50 100	— —	
(I_C = −150 mAdc, V_{CE} = −2.0 Vdc)(1)	2N4402 2N4403		50 100	150 300	
(I_C = −500 mAdc, V_{CE} = −2.0 Vdc)(1)	Both		20	—	
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)		$V_{CE(sat)}$	 — —	 −0.4 −0.75	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)		$V_{BE(sat)}$	 0.75 —	 −0.95 −1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −20 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	 2N4402 2N4403	f_T	 150 200	 — —	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	30	pF
Input Impedance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	 2N4402 2N4403	h_{ie}	 750 1.5k	 7.5k 15k	ohms

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Voltage Feedback Ratio (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N4402 2N4403	h_{fe}	30 60	250 500	—
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	100	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 Vdc, V_{BE} = +2.0 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mA, I_{B2} = 15 mA)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — TURN-ON TIME

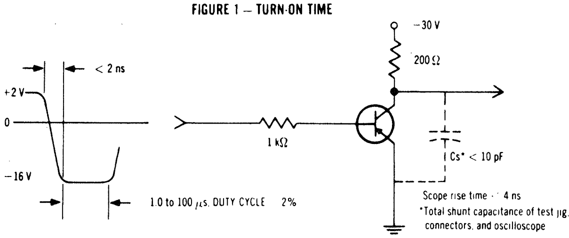
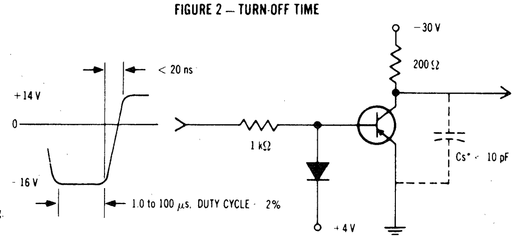


FIGURE 2 — TURN-OFF TIME



TRANSIENT CHARACTERISTICS

—— 25°C – – – 100°C

FIGURE 3 — CAPACITANCES

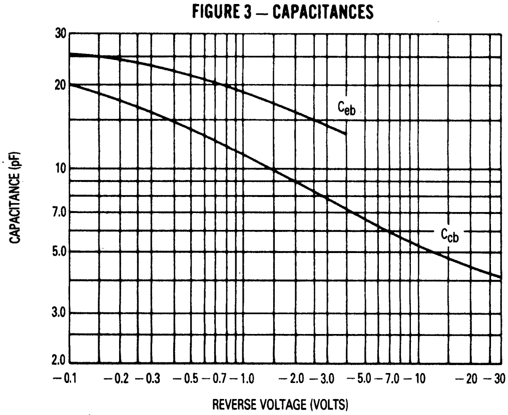


FIGURE 4 — CHARGE DATA

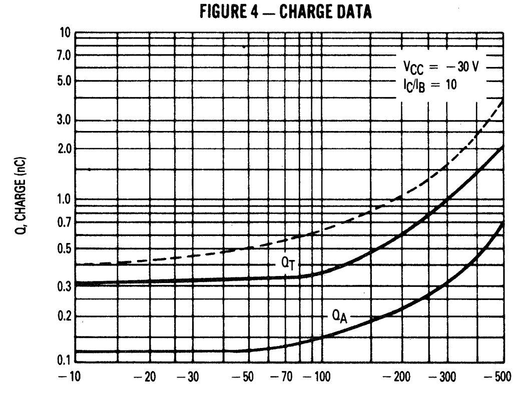


FIGURE 5 — TURN-ON TIME

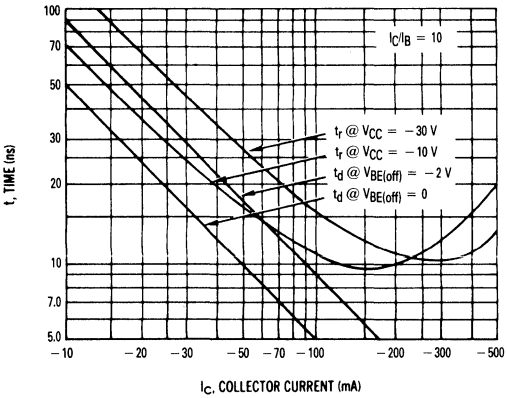


FIGURE 6 — RISE TIME

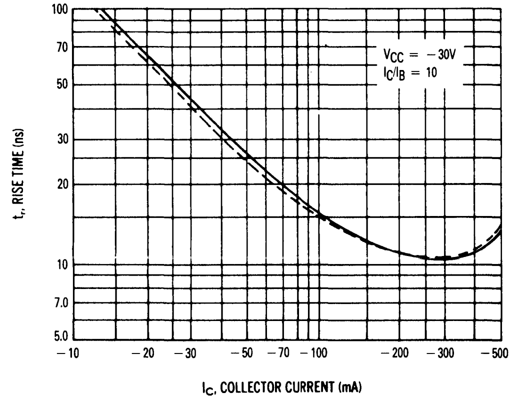
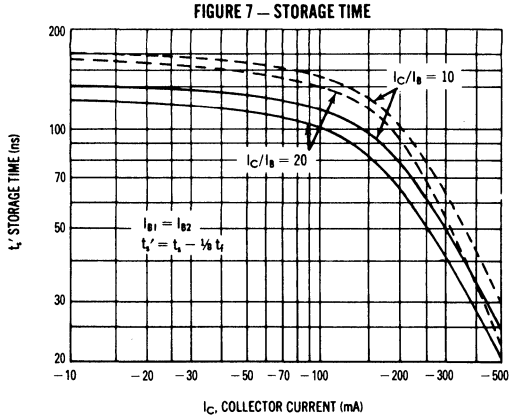


FIGURE 7 — STORAGE TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = -10$ Vdc, $T_A = 25°C$

Bandwidth = 1.0 Hz

FIGURE 8 — FREQUENCY EFFECTS

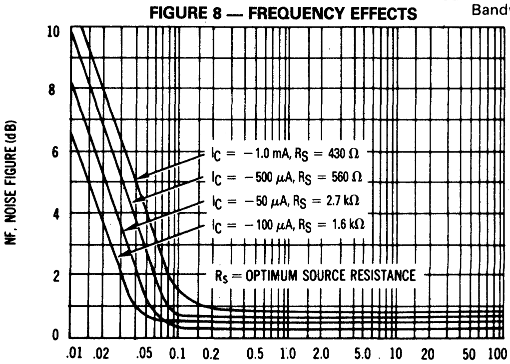
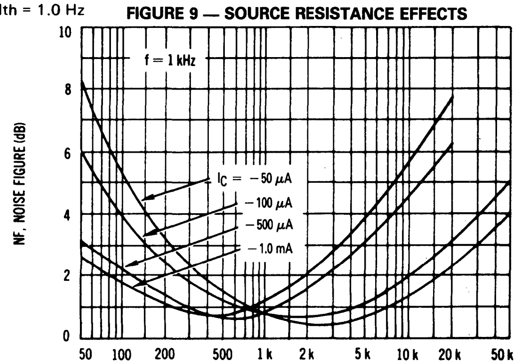


FIGURE 9 — SOURCE RESISTANCE EFFECTS



2

h PARAMETERS

V_{CE} = −10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4402 and 2N4403 lines, and the same units were used to develop the correspondingly-numbered curves on each graph.

FIGURE 10 — CURRENT GAIN

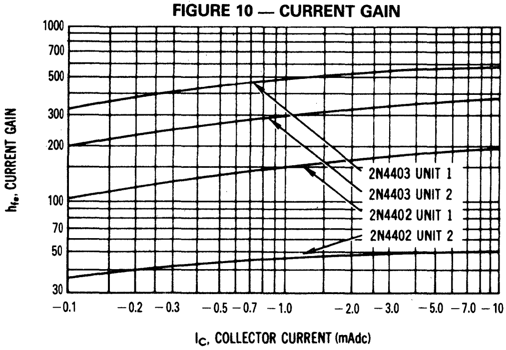


FIGURE 11 — INPUT IMPEDANCE

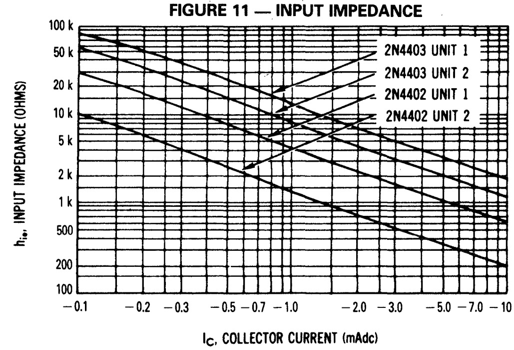


FIGURE 12 — VOLTAGE FEEDBACK RATIO

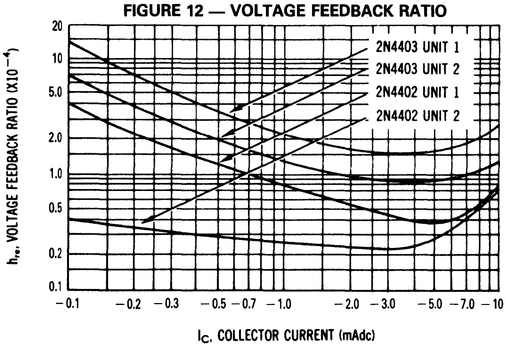
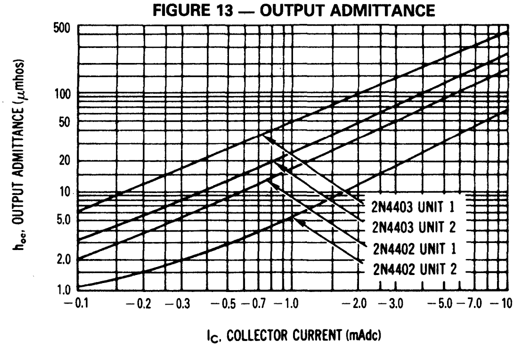


FIGURE 13 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 14 — DC CURRENT GAIN

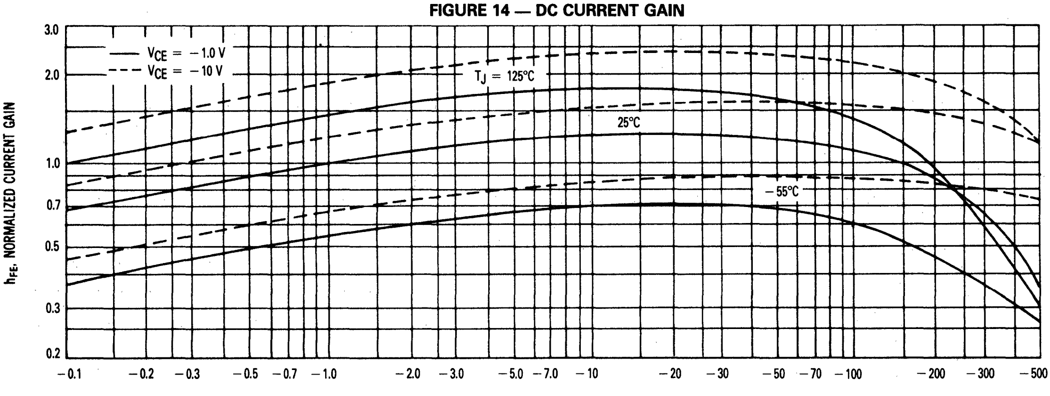


FIGURE 15 — COLLECTOR SATURATION REGION

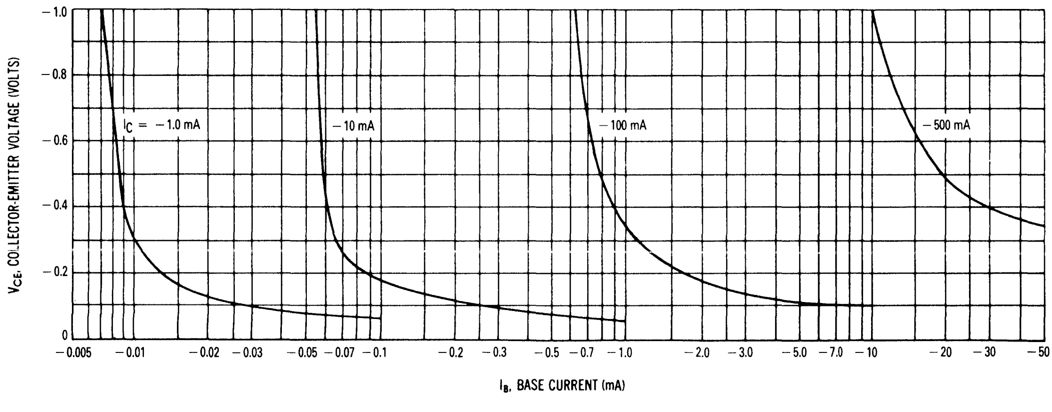


FIGURE 16 — "ON" VOLTAGES

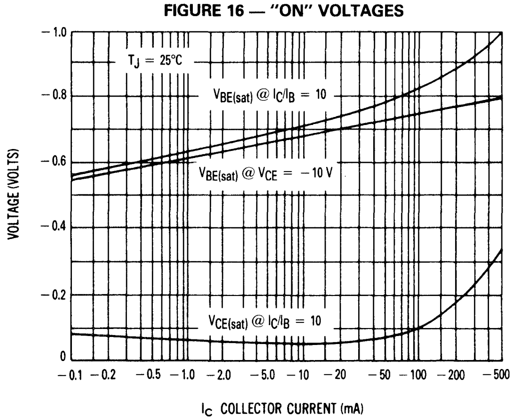
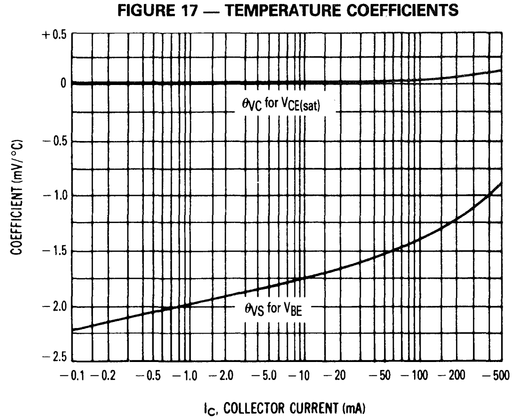


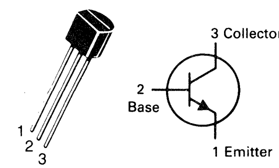
FIGURE 17 — TEMPERATURE COEFFICIENTS



2

2N4410

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	250	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

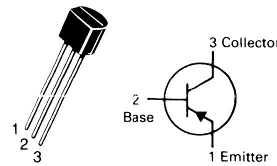
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, V_{BE} = 5.0 Vdc, R_{BE} = 8.2 k ohms)	$V_{(BR)CEX}$	120	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 0.01 1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	60 60	— 400	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$	—	0.8	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	300	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	C_{cb}	—	12	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz, collector guarded)	C_{eb}	—	50	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2N5086
2N5087★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON
★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−50	Vdc
Collector-Base Voltage	V_{CBO}	−50	Vdc
Emitter-Base Voltage	V_{EBO}	−3.0	Vdc
Collector Current — Continuous	I_C	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−50	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)		$V_{(BR)CBO}$	−50	—	Vdc
Collector Cutoff Current (V_{CB} = −35 Vdc, I_E = 0)		I_{CBO}	—	−50	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = −100 μAdc, V_{CE} = −5.0 Vdc)	2N5086 2N5087		150 250	500 800	
(I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc)	2N5086 2N5087		150 250	— —	
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)(2)	2N5086 2N5087		150 250	— —	
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)		$V_{CE(sat)}$	—	−0.3	Vdc
Base-Emitter On Voltage (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	—	−0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product (I_C = −500 μAdc, V_{CE} = −5.0 Vdc, f = 20 MHz)		f_T	40	—	MHz
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	2N5086 2N5087	h_{fe}	150 250	600 900	—
Noise Figure (I_C = −20 μAdc, V_{CE} = −5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	2N5086 2N5087	NF	— —	3.0 2.0	dB
(I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	2N5086 2N5087		— —	3.0 2.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL NOISE CHARACTERISTICS
(V_{CE} = −5.0 Vdc, T_A = 25°C)

FIGURE 1 — NOISE VOLTAGE

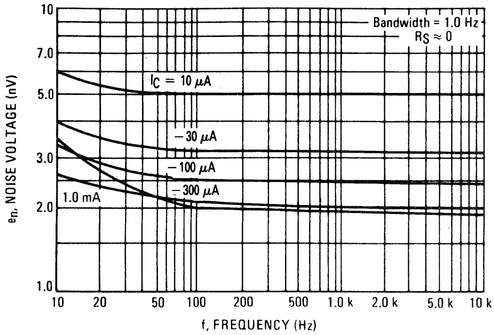
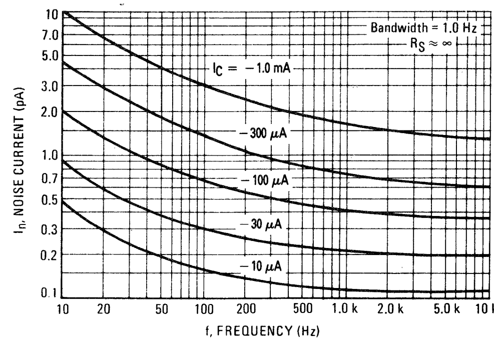


FIGURE 2 — NOISE CURRENT



NOISE FIGURE CONTOURS
(V_{CE} = −5.0 Vdc, T_A = 25°C)

FIGURE 3 — NARROW BAND, 100 Hz

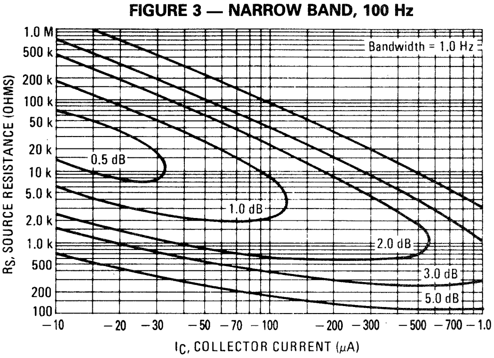


FIGURE 4 — NARROW BAND, 1.0 KHz

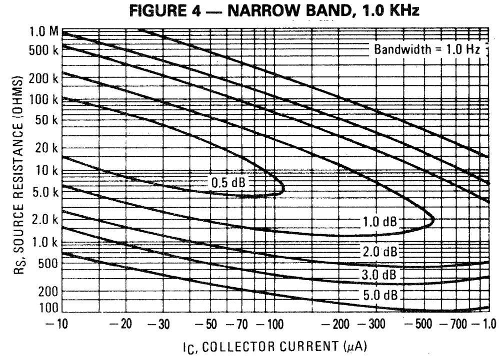
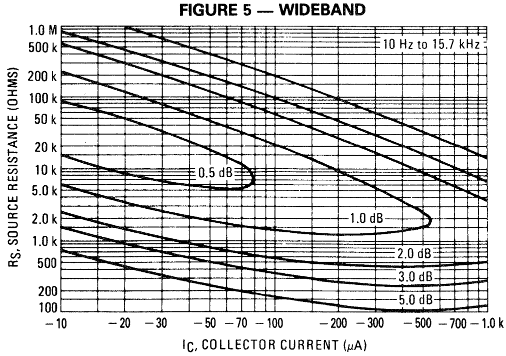


FIGURE 5 — WIDEBAND



Noise Figure is Defined as:

$$NF = 20 \log_{10} \left[\frac{e_n{}^2 + 4KTR_S + I_n{}^2 R_S{}^2}{4KTR_S} \right]^{1/2}$$

e_n = Noise Voltage of the Transistor referred to the input. (Figure 3)
I_n = Noise Current of the transistor referred to the input (Figure 4)
K = Boltzman's Constant (1.38 x 10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

FIGURE 6 — DC CURRENT GAIN

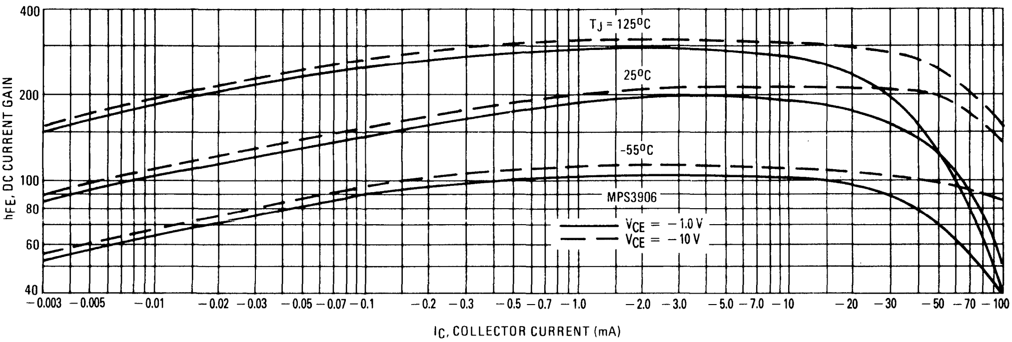


FIGURE 7 — COLLECTOR SATURATION REGION

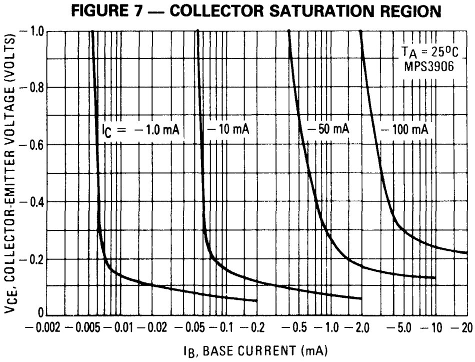


FIGURE 8 — COLLECTOR CHARACTERISTICS

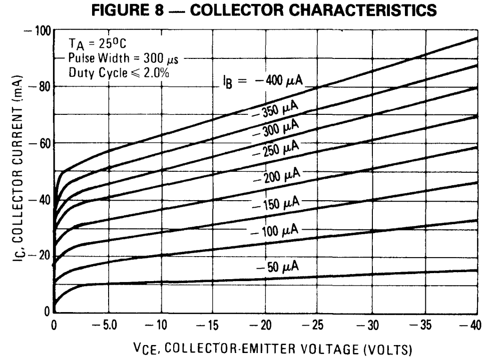


FIGURE 9 — "ON" VOLTAGES

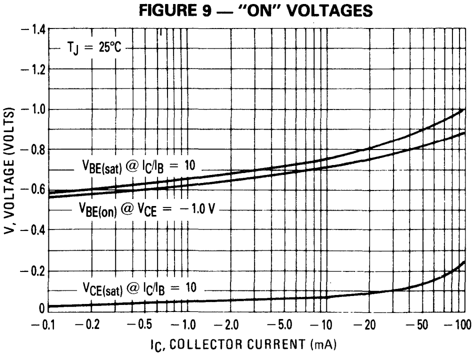
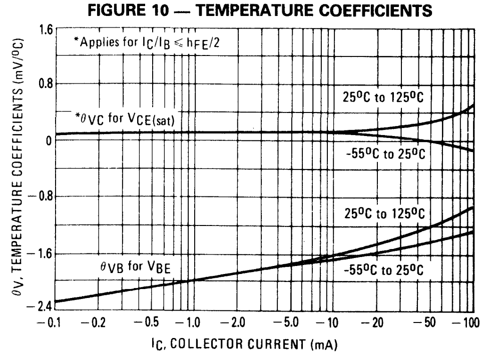


FIGURE 10 — TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

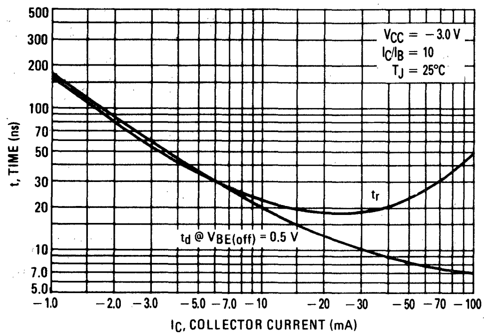


FIGURE 12 — TURN-OFF TIME

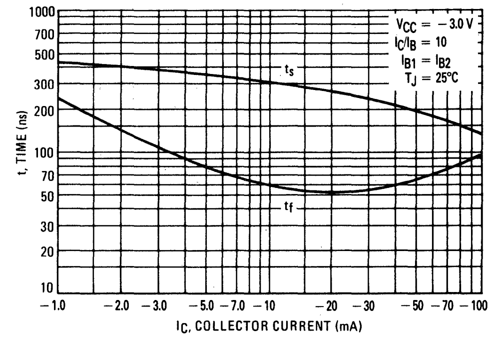


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FIGURE 13 — CURRENT-GAIN — BANDWIDTH PRODUCT

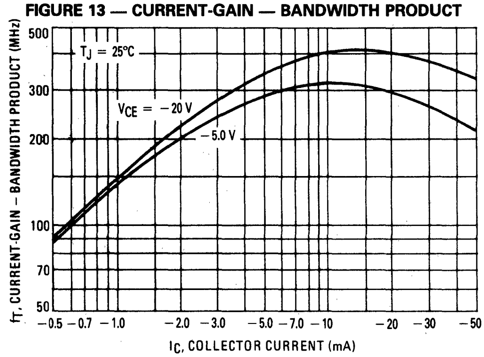


FIGURE 14 — CAPACITANCE

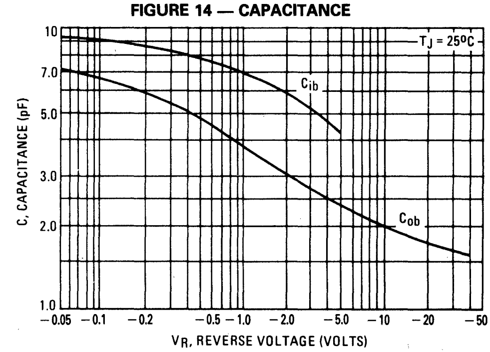


FIGURE 15 — INPUT IMPEDANCE

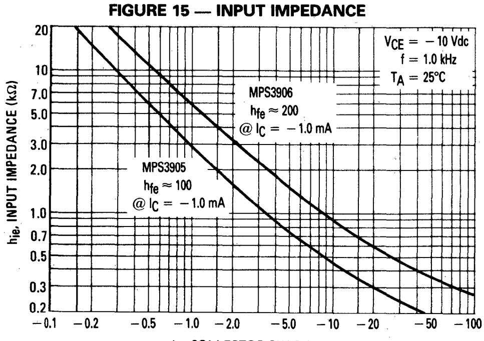


FIGURE 16 — OUTPUT ADMITTANCE

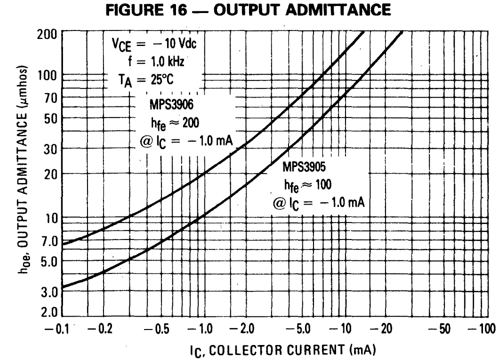


FIGURE 17 — THERMAL RESPONSE

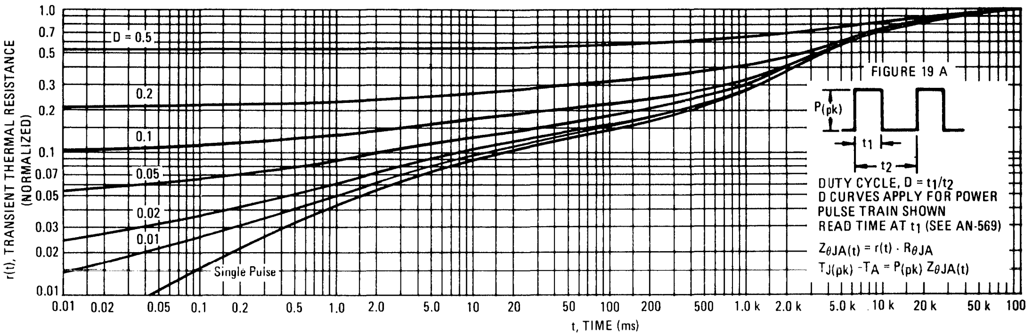
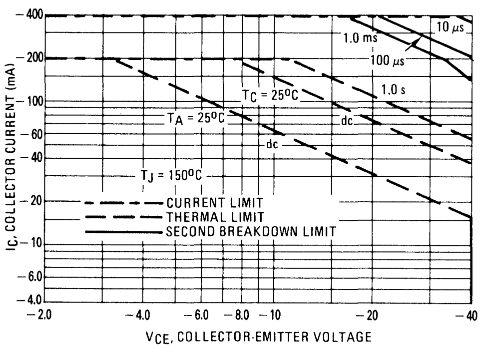


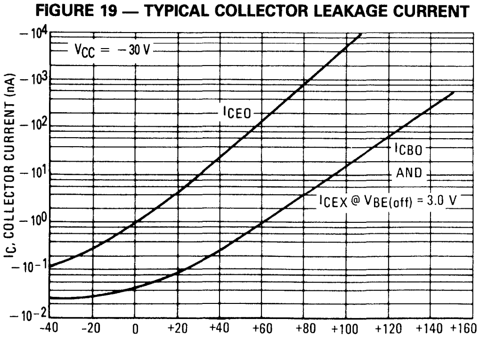
FIGURE 18 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 20 is based upon $T_{J(pk)} = 150°C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 19 — TYPICAL COLLECTOR LEAKAGE CURRENT



DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 19 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 19 by the steady state value $R_{\theta JA}$.

Example:

The MPS3905 is dissipating 2.0 watts peak under the following conditions:

$t1 = 1.0$ ms, $t2 = 5.0$ ms $(D = 0.2)$

Using Figure 19 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

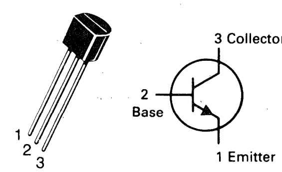
The peak rise in junction temperature is therefore

$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C$.

For more information, see AN-569.

2N5088
2N5089

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N5088	2N5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

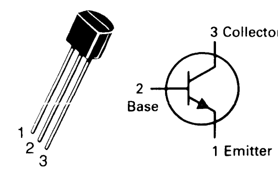
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	2N5088 2N5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N5088 2N5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0)	2N5088 2N5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0) ($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)		I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5088 2N5089		300 400	900 1200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5088 2N5089		350 450	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)	2N5088 2N5089		300 400	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)		$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	10	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5088 2N5089	h_{fe}	350 450	1400 1800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	2N5088 2N5089	NF	— —	3.0 2.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N5209
2N5210

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPSA18 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

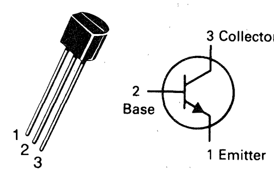
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5209 2N5210	h_{FE}	100 200	300 600	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5209 2N5210		150 250	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(1)	2N5209 2N5210		150 250	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	30	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5209 2N5210	h_{fe}	150 250	600 900	—
Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 22 k ohms, f = 1.0 kHz)	2N5209 2N5210	NF	— —	3.0 2.0	dB
(I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	2N5209 2N5210		— —	4.0 3.0	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2N5223

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3903 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

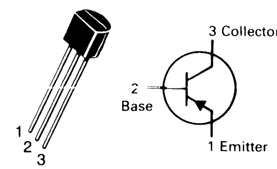
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	200	800	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	1600	—

2N5400
2N5401★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	2N5400	2N5401	Unit
Collector-Emitter Voltage	V_{CEO}	−120	−150	Vdc
Collector-Base Voltage	V_{CBO}	−130	−160	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	 2N5400 2N5401	$V_{(BR)CEO}$	 −120 −150	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 2N5400 2N5401	$V_{(BR)CBO}$	 −130 −160	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −100 Vdc, I_E = 0) (V_{CB} = −120 Vdc, I_E = 0) (V_{CB} = −100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = −120 Vdc, I_E = 0, T_A = 100°C)	 2N5400 2N5401 2N5400 2N5401	I_{CBO}	 — — — —	 −100 −50 −100 −50	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) (I_C = −50 mAdc, V_{CE} = −5.0 Vdc)	 2N5400 2N5401 2N5400 2N5401 2N5400 2N5401	h_{FE}	 30 50 40 60 40 50	 — — 180 240 — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{CE(sat)}$	 — —	 −0.20 −0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	 — —	 −1.0 −1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	 2N5400 2N5401	f_T	 100 100	 400 300	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	 2N5400 2N5401	h_{fe}	 30 40	 200 200	—
Noise Figure (I_C = −250 μAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)		NF	—	8.0	dB

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — DC CURRENT GAIN

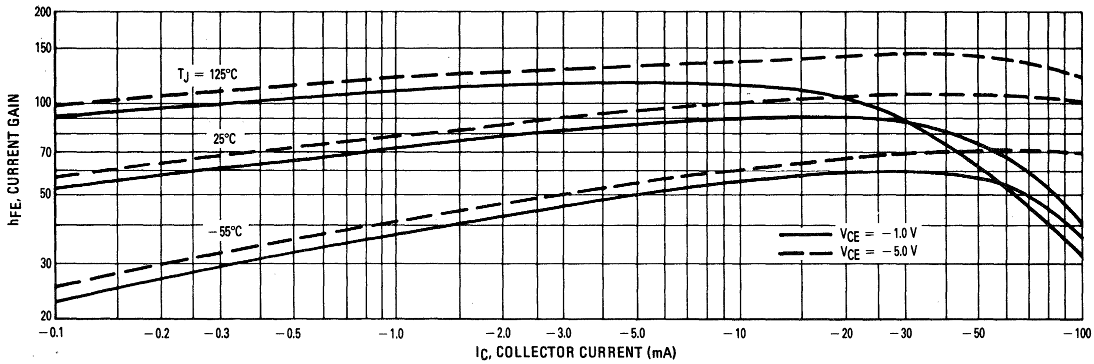


FIGURE 2 — COLLECTOR SATURATION REGION

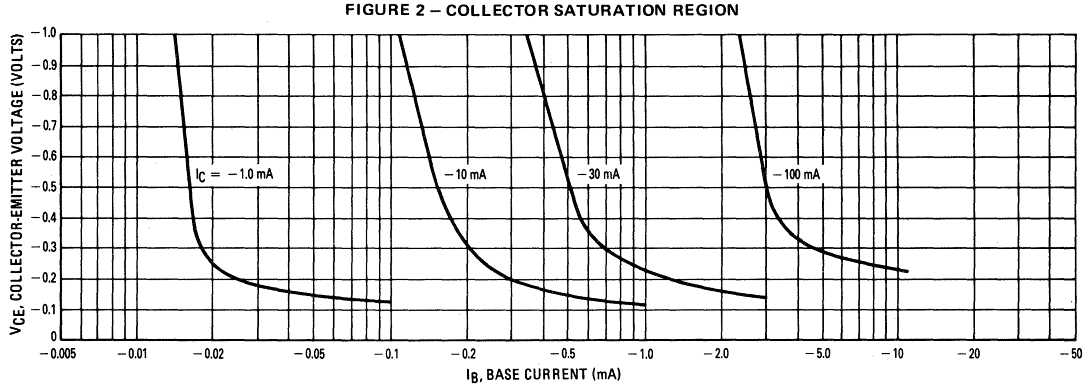


FIGURE 3 — COLLECTOR CUT-OFF REGION

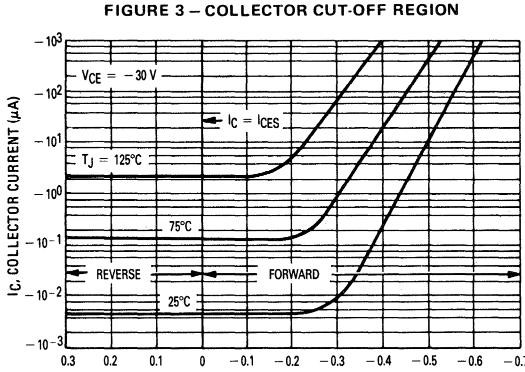


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FIGURE 4 — "ON" VOLTAGES

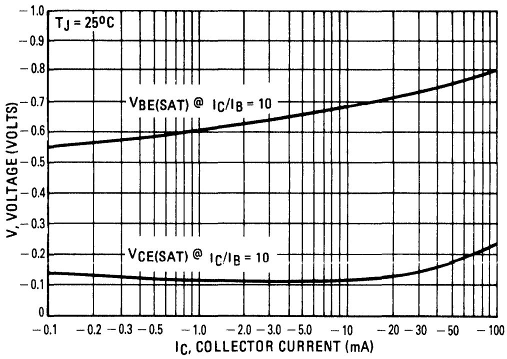


FIGURE 5 — TEMPERATURE COEFFICIENTS

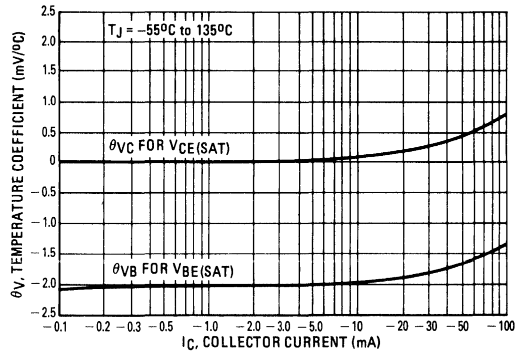


FIGURE 6 — SWITCHING TIME TEST CIRCUIT

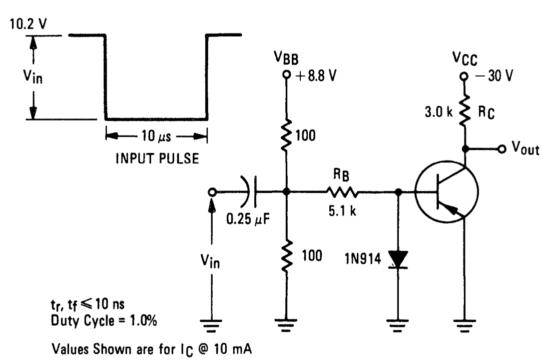


FIGURE 7 — CAPACITANCES

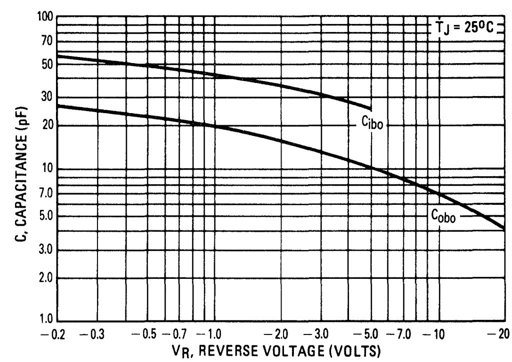


FIGURE 8 — TURN-ON TIME

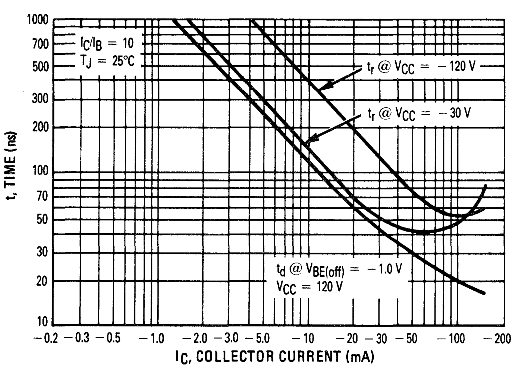
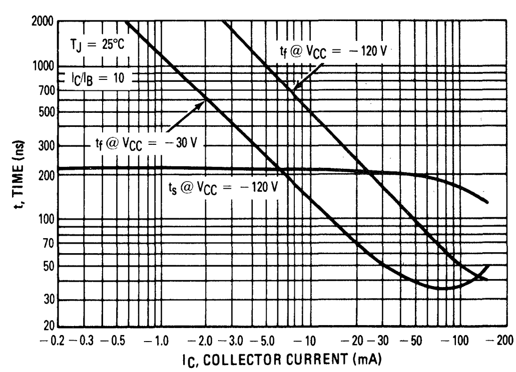
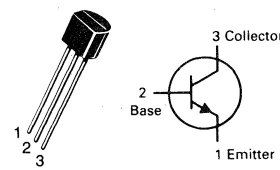


FIGURE 9 — TURN-OFF TIME



2N5550
2N5551★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	2N5550	2N5551	Unit
Collector-Emitter Voltage	V_{CEO}	140	160	Vdc
Collector-Base Voltage	V_{CBO}	160	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 2N5550 2N5551	$V_{(BR)CEO}$	 140 160	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N5550 2N5551	$V_{(BR)CBO}$	 160 180	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	 2N5550 2N5551 2N5550 2N5551	I_{CBO}	 — — — —	 100 50 100 50	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 2N5550 2N5551 2N5550 2N5551 2N5550 2N5551	h_{FE}	 60 80 60 80 20 30	 — — 250 250 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types 2N5550 2N5551	$V_{CE(sat)}$	 — — —	 0.15 0.25 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types 2N5550 2N5551	$V_{BE(sat)}$	 — — —	 1.0 1.2 1.0	Vdc

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N5550	C_{ibo}	—	30	pF
	2N5551		—	20	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	2N5550	NF	—	10	dB
	2N5551		—	8.0	

2

FIGURE 1 — DC CURRENT GAIN

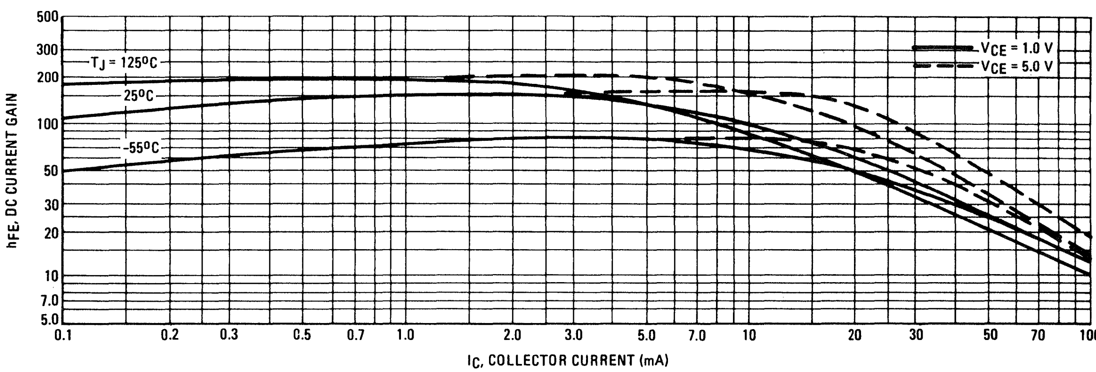


FIGURE 2 — COLLECTOR SATURATION REGION

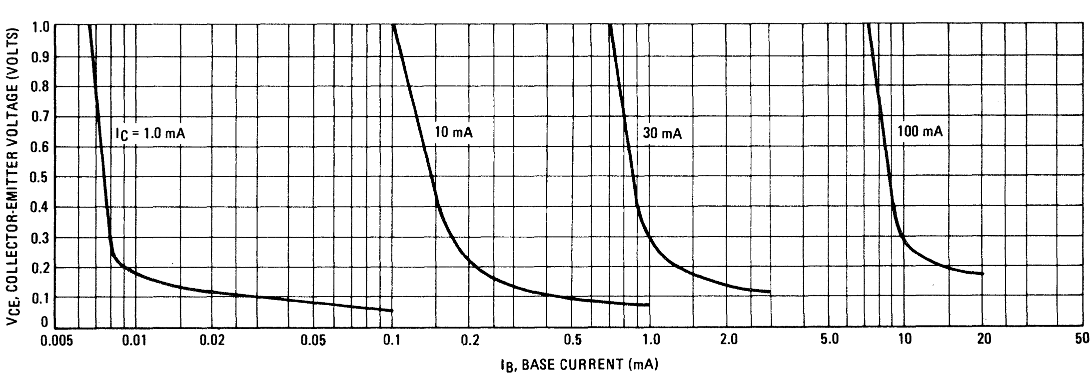


FIGURE 3 – COLLECTOR CUT-OFF REGION

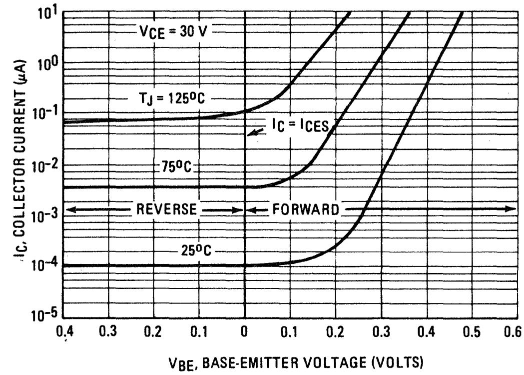


FIGURE 4 – "ON" VOLTAGES

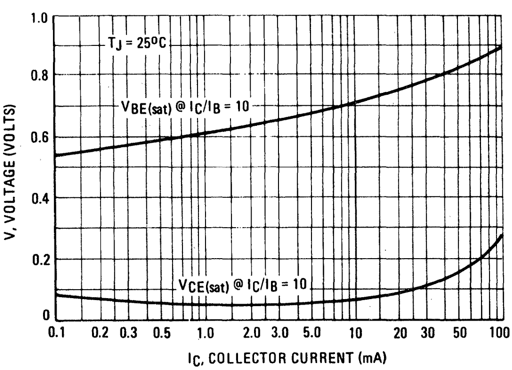


FIGURE 5 – TEMPERATURE COEFFICIENTS

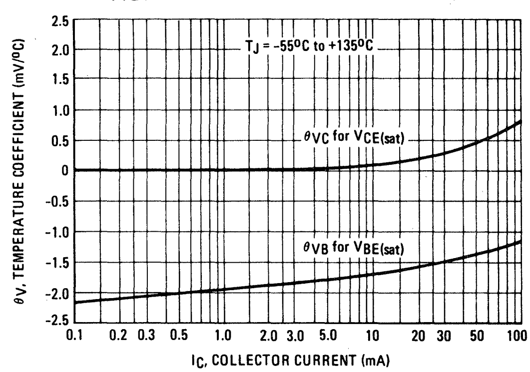


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

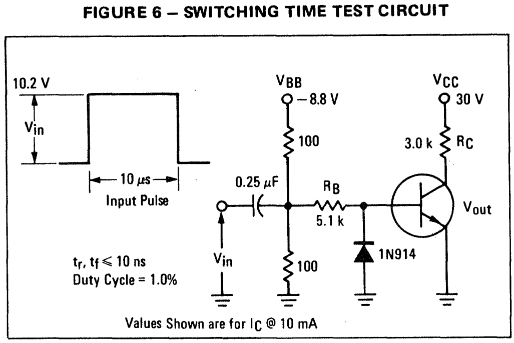


FIGURE 7 – CAPACITANCES

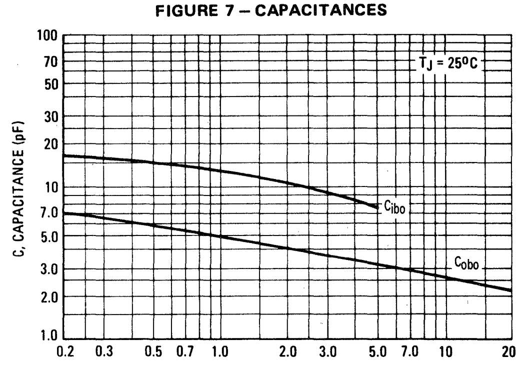


FIGURE 8 – TURN-ON TIME

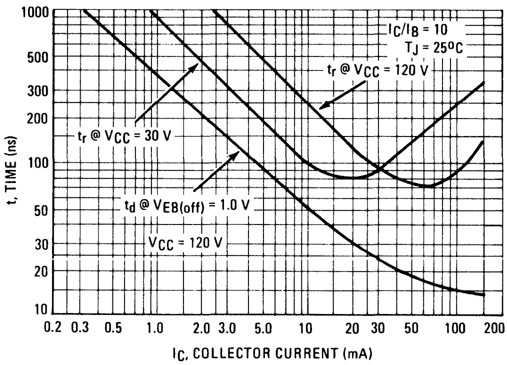
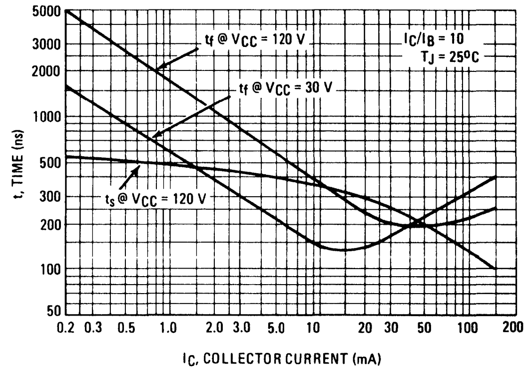


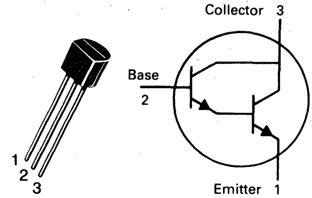
FIGURE 9 – TURN-OFF TIME



2

2N6426★
2N6427

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $V_{BE} = 0$)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $I_B = 0$)		I_{CEO}	—	—	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (1) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	 2N6426 2N6427	h_{FE}	 20,000 10,000	 — —	 200,000 100,000	—
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	2N6426 2N6427		30,000 20,000	— —	300,000 200,000	
($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	2N6426 2N6427		20,000 14,000	— —	200,000 140,000	
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 500$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	 — —	 0.71 0.9	 1.2 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 0.5$ mAdc)		$V_{BE(sat)}$	—	1.52	2.0	Vdc
Base-Emitter On Voltage ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	1.24	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	5.4	7.0	pF
Input Capacitance ($V_{EB} = 1.0$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	10	15	pF

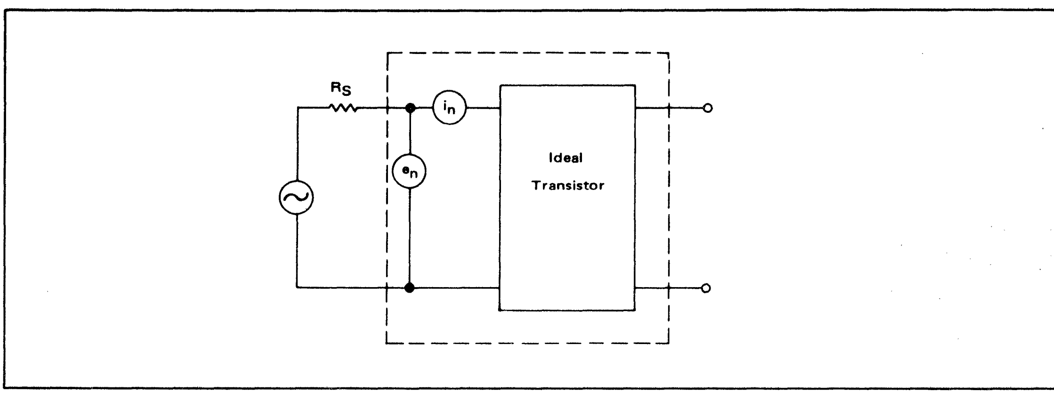
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Impedance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426	h_{ie}	100	—	2000	k Ω
	2N6427		50	—	1000	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426	h_{fe}	20,000	—	—	—
	2N6427		10,000	—	—	
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	2N6426	$\|h_{fe}\|$	1.5	2.4	—	—
	2N6427		1.3	2.4	—	
Output Admittance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{oe}	—	—	1000	μmhos
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 kΩ, f = 1.0 kHz)		NF	—	3.0	10	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 2 – NOISE VOLTAGE

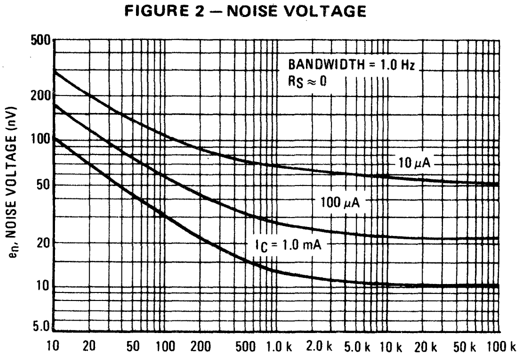


FIGURE 3 – NOISE CURRENT

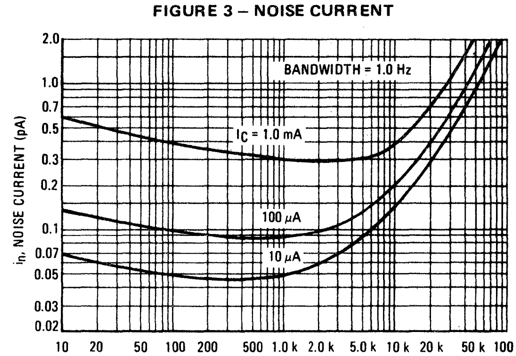


FIGURE 4 — TOTAL WIDEBAND NOISE VOLTAGE

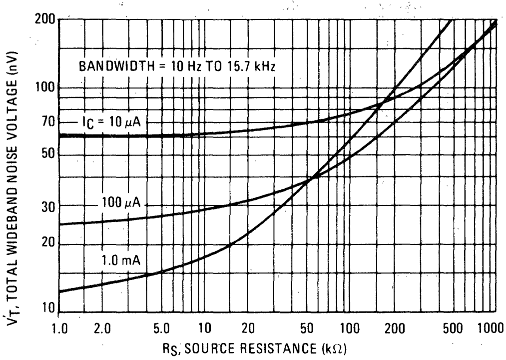
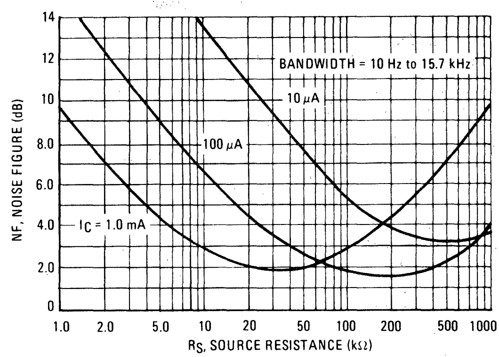


FIGURE 5 — WIDEBAND NOISE FIGURE



SMALL-SIGNAL CHARACTERISTICS

FIGURE 6 — CAPACITANCE

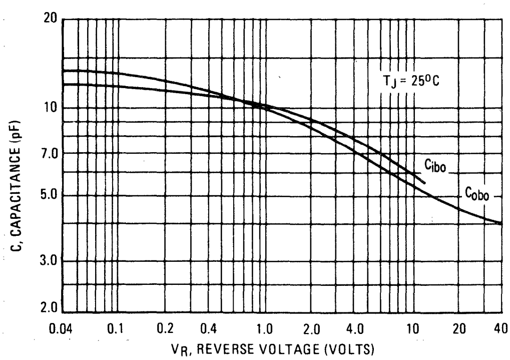


FIGURE 7 — HIGH FREQUENCY CURRENT GAIN

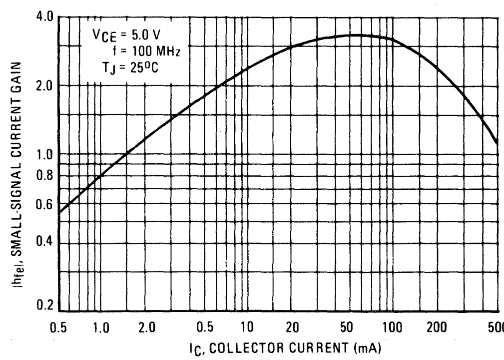


FIGURE 8 — DC CURRENT GAIN

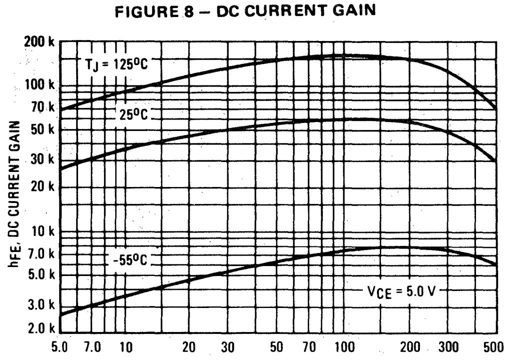


FIGURE 9 — COLLECTOR SATURATION REGION

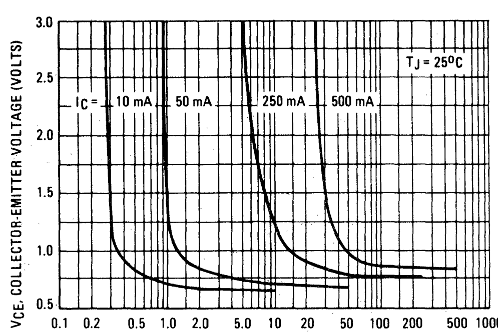


FIGURE 10 – "ON" VOLTAGES

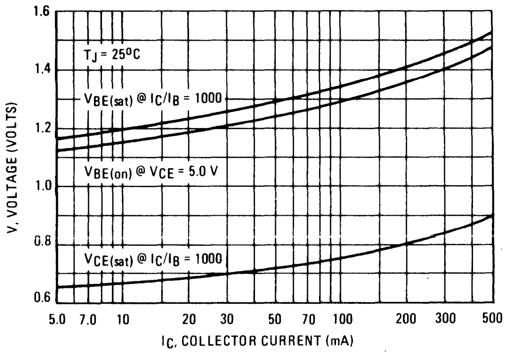


FIGURE 11 – TEMPERATURE COEFFICIENTS

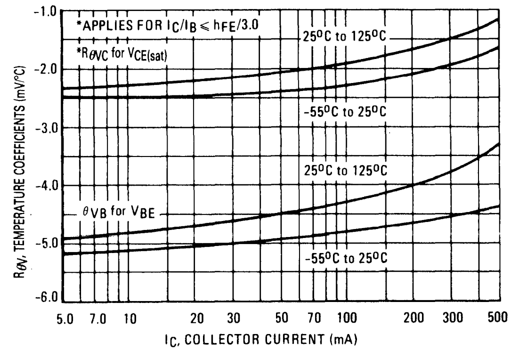


FIGURE 12 – THERMAL RESPONSE

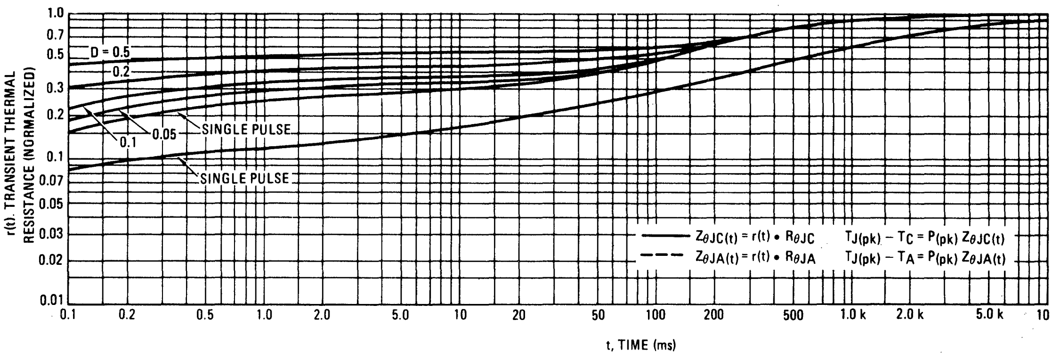
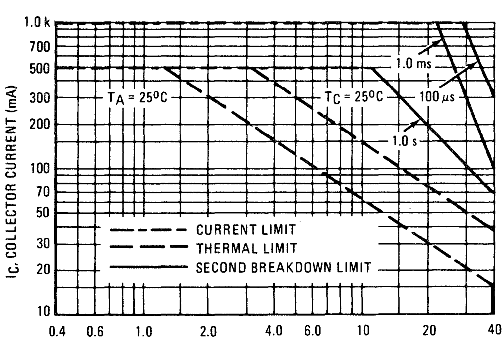
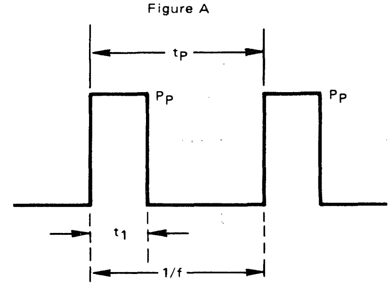


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A



Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

MAXIMUM RATINGS

Rating	Symbol	2N6515	2N6516 2N6519	2N6517 2N6520	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector-Base Voltage	C_{CBO}	250	300	350	Vdc
Emitter-Base Voltage 2N6515, 2N6516, 2N6517 2N6519, 2N6520	V_{EBO}	 6.0 5.0			Vdc
Base Current	I_B	250			mAdc
Collector Current — Continuous	I_C	500			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	1.5 12			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

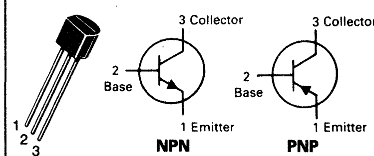
NPN

2N6515 thru 2N6517★

PNP

2N6519(2) 2N6520★(2)

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

★This is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	$V_{(BR)CEO}$	 250 300 350	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	$V_{(BR)CBO}$	 250 300 350	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 2N6515, 2N6516, 2N6517 2N6519, 2N6520	$V_{(BR)EBO}$	 6.0 5.0	 — —	Vdc
Collector Cutoff Current (V_{CB} = 150 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 250 Vdc, I_E = 0)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	I_{CBO}	 — — —	 50 50 50	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 2N6515, 2N6516, 2N6517 2N6519, 2N6520	I_{EBO}	 — —	 50 50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	 2N6515 2N6516, 2N6519 2N6517, 2N6520	h_{FE}	 35 30 20	 — — —	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		50 45 30	— — —	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		50 45 30	300 270 200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		45 40 20	220 200 200	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N6515 2N6516, 2N6519 2N6517, 2N6520		25 20 15	— — —	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.30	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.35	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.50	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.75	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.85	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.90	
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance	C_{eb}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) 2N6515 thru 2N6517		—	80	
2N6519, 2N6520		—	100	
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 10 mAdc)	t_{on}	—	200	µs
Turn-Off Time (V_{CC} = 100 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_{off}	—	3.5	µs

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(2) Voltage and current are negative for PNP transistors.

NPN | PNP

FIGURE 1 — DC CURRENT GAIN

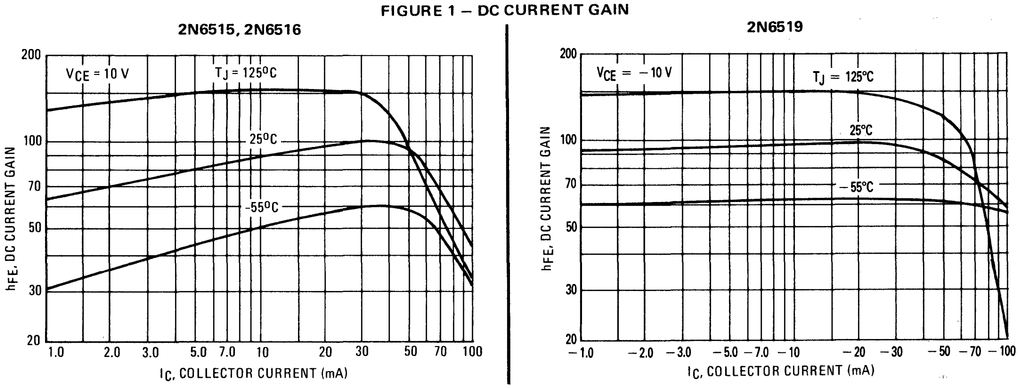


FIGURE 2 — DC CURRENT GAIN

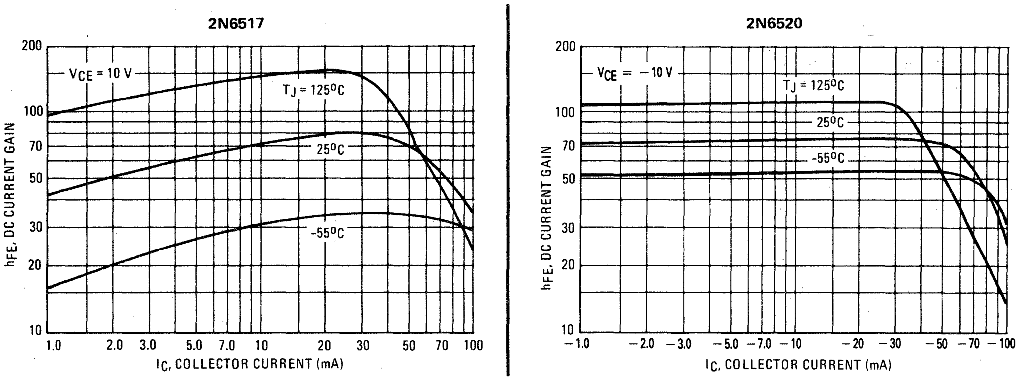


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT

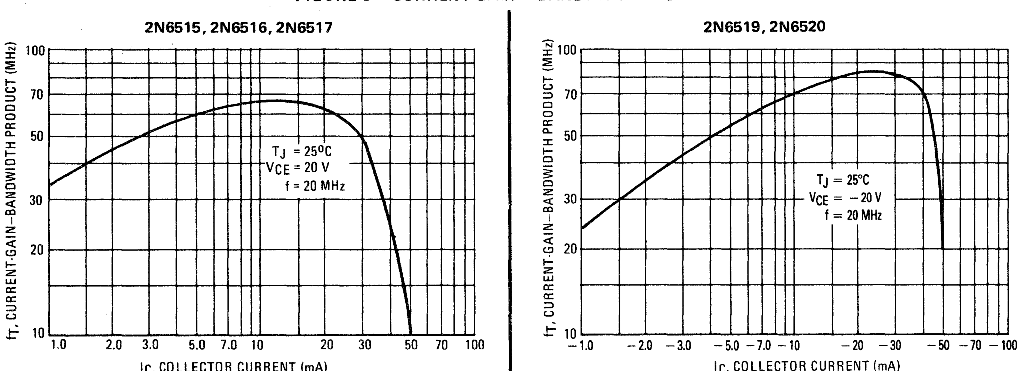


FIGURE 4 — "ON" VOLTAGES

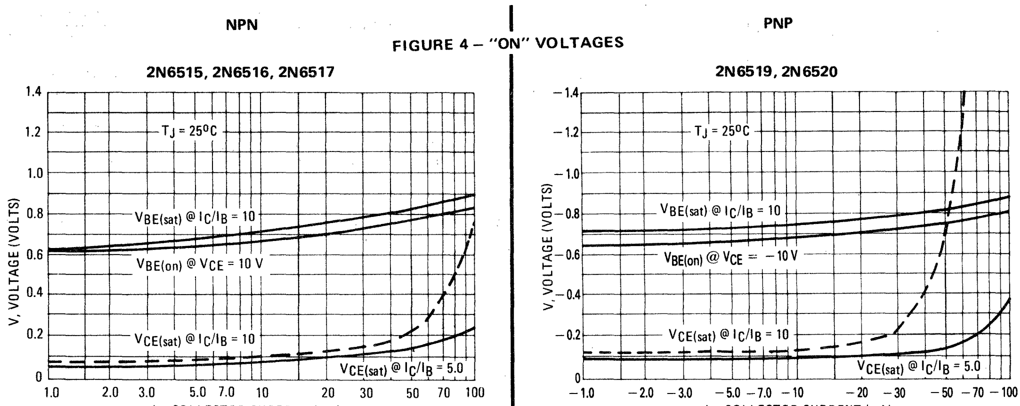
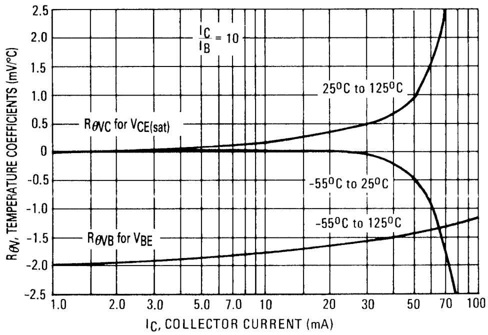


FIGURE 5 – TEMPERATURE COEFFICIENTS

2N6515, 2N6516, 2N6517



2N6519, 2N6520

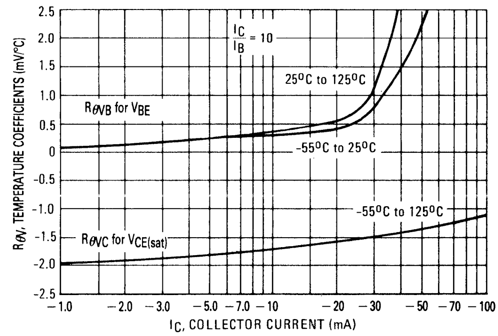
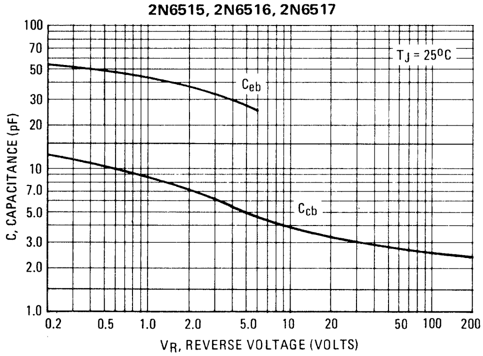


FIGURE 6 – CAPACITANCE

2N6515, 2N6516, 2N6517



2N6519, 2N6520

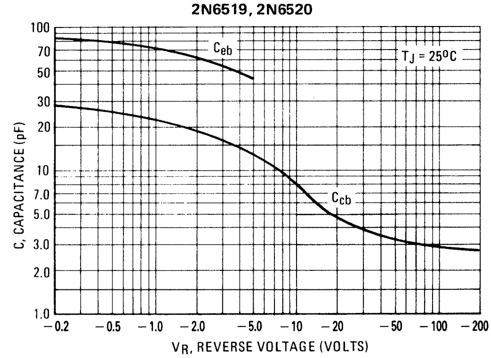
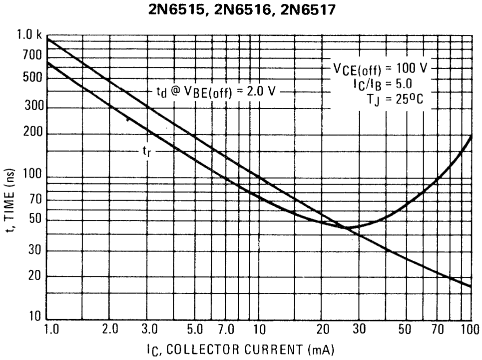


FIGURE 7 – TURN-ON TIME

NPN

2N6515, 2N6516, 2N6517



PNP

2N6519, 2N6520

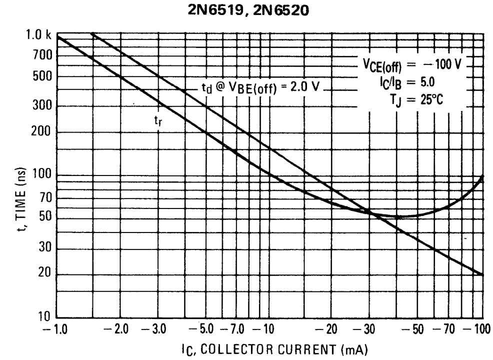


FIGURE 8 — TURN-OFF TIME

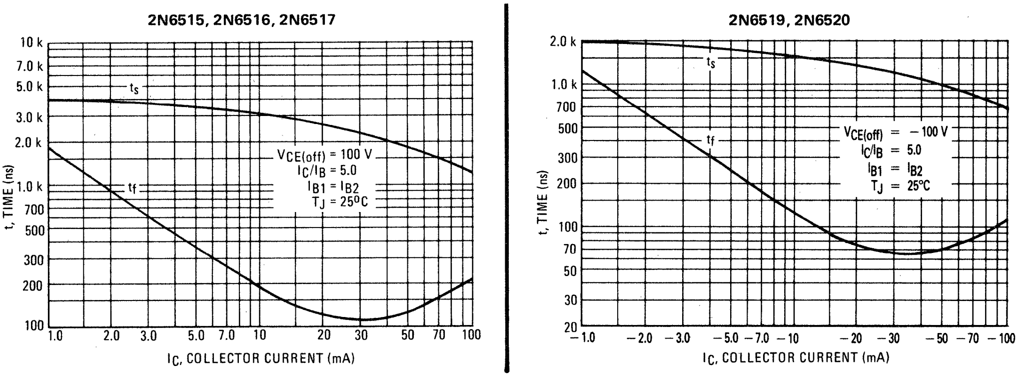


FIGURE 9 — SWITCHING TIME TEST CIRCUIT

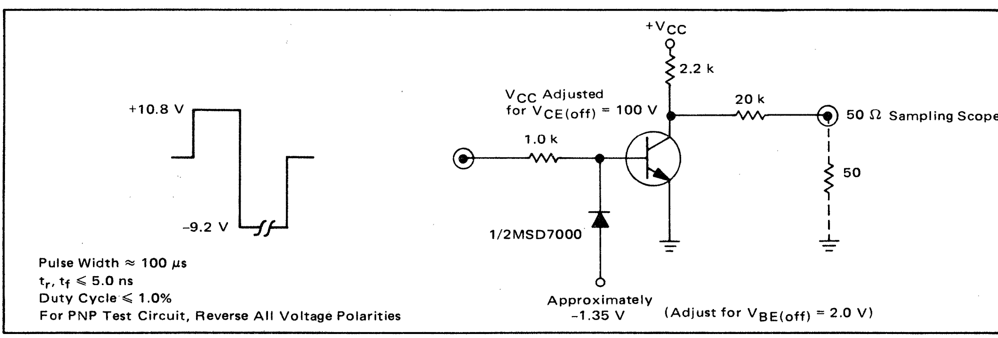


FIGURE 10 — THERMAL RESPONSE

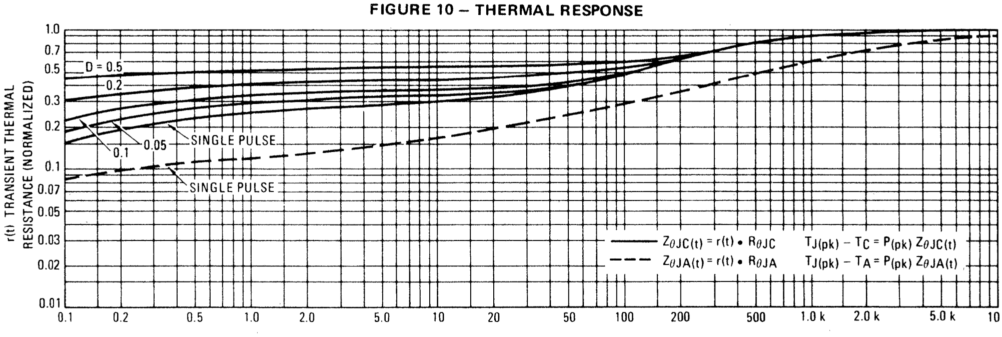
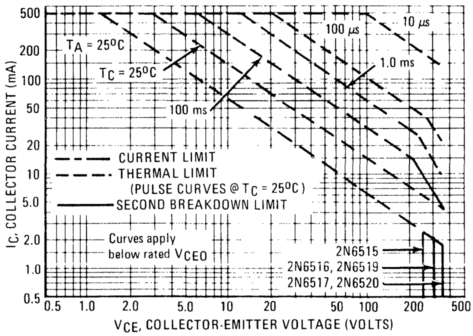
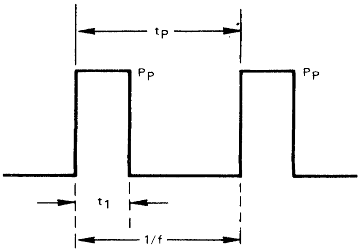


FIGURE 11 — ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A



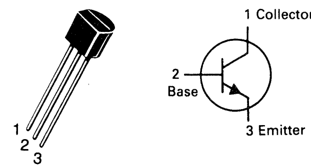
Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

2

BC182,A,B
BC183
BC184

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to BC237 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 182	BC 183	BC 184	Unit
Collector-Emitter Voltage	V_{CEO}	50	30	30	Vdc
Collector-Base Voltage	V_{CBO}	60	45	45	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current − Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mA, I_B = 0)	BC182	$V_{(BR)CEO}$	50	—	—	V
	BC183		30	—	—	
	BC184		30	—	—	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	BC182	$V_{(BR)CBO}$	60	—	—	V
	BC183		45	—	—	
	BC184		45	—	—	
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	V
Collector Cutoff Current (V_{CB} = 50 V, V_{BE} = 0)	BC182	I_{CBO}	—	0.2	15	nA
(V_{CB} = 30 V, V_{BE} = 0)	BC183		—	0.2	15	
	BC184		—	0.2	15	
Emitter-Base Leakage Current (V_{EB} = 4.0 V, I_C = 0)		I_{EBO}	—	—	15	nA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5.0 V)	BC182	h_{FE}	40	—	—	
	BC183		40	—	—	
	BC184		100	—	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC182		120	—	500	
	BC183		120	—	800	
	BC184		250	—	800	
(I_C = 100 mA, V_{CE} = 5.0 V)	BC182		80	—	—	
	BC183		80	—	—	
	BC184		130	—	—	
Collector-Emitter On Voltage	(I_C = 10 mA, I_B = 0.5 mA)	$V_{CE(sat)}$	—	0.07	0.25	V
	(I_C = 100 mA, I_B = 5.0 mA)*		—	0.2	0.6	
Base-Emitter Saturation Voltage	(I_C = 100 mA, I_B = 5.0 mA)*	$V_{BE(sat)}$	—	—	1.2	V
Base-Emitter On Voltage	(I_C = 100 μA, V_{CE} = 5.0 V)	$V_{BE(on)}$	—	0.5	—	V
	(I_C = 2.0 mA, V_{CE} = 5.0 V)		0.55	0.62	0.7	
	(I_C = 100 mA, V_{CE} = 5.0 V)*		—	0.83	—	

*Pulse Test: Tp 300 s, Duty Cycle 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

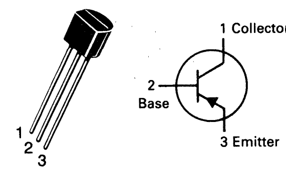
Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = 0.5 mA, V_{CE} = 3.0 V, f = 100 MHz)	BC182		—	100	—	
	BC183		—	120	—	
	BC184		—	140	—	
(I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	BC182		150	200	—	
	BC183		150	240	—	
	BC184		150	280	—	
Common Base Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1.0 MHz)		C_{ob}	—	—	5.0	pF
Common Base Input Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz)		C_{ib}	—	8.0	—	pF
Small-Signal Current Gain		h_{fe}				
(I_C = 2.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	BC182		125	—	500	
	BC183		125	—	900	
	BC184		240	—	900	
	BC182A		125	—	260	
	BC182B		240	—	500	
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 k ohms, f = 1.0 kHz)	BC184		—	2.0	4.0	
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 k ohms, f = 1.0 kHz, f = 200 Hz)	BC182		—	2.0	10	
	BC183		—	2.0	10	
	BC184		—	2.0	4.0	

2

2

BC212,B
BC213
BC214

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

Refer to BC307 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 212	BC 213	BC 214	Unit
Collector-Emitter Voltage	V_{CEO}	−50	−30	−30	Vdc
Collector-Base Voltage	V_{CBO}	−60	−45	−45	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0			Vdc
Collector Current — Continuous	I_C	−100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted).

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_B = 0)	BC212 BC213 BC214	$V_{(BR)CEO}$	−50 −30 −30	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μA, I_E = 0)	BC212 BC213 BC214	$V_{(BR)CBO}$	−60 −45 −45	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	BC212 BC213 BC214	$V_{(BR)EBO}$	−5 −5 −5	— — —	— — —	Vdc
Collector-Emitter Leakage Current (V_{CB} = −30 V)	BC212 BC213 BC214	I_{CBO}	— — —	— — —	−15 −15 −15	nAdc
Emitter-Base Leakage Current (V_{EB} = −4.0 V, I_C = 0)	BC212 BC213 BC214	I_{EBO}	— — —	— — —	−15 −15 −15	nAdc

ON CHARACTERISTICS

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	BC212 BC213 BC214	h_{FE}	40 40 100	— — —	— — —	
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	BC212 BC213 BC214		60 80 140	— — —	— — 600	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)*	BC212, BC214 BC213		— —	120 140	— —	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted).

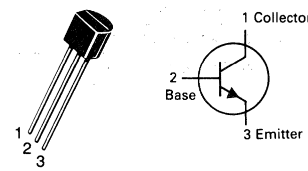
Characteristic	Type	Symbol	Min	Typ.	Max	Unit
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc) (I_C = −100 mAdc, I_B = −5.0 mAdc)*		$V_{CE(sat)}$	 — —	 −0.10 −0.25	 — −0.6	Vdc
Base-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	—	−1.0	−1.4	Vdc
Base-Emitter On Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	−0.6	−0.62	−0.72	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	 BC212 BC214 BC213	f_T	 — — —	 280 320 360	 — — —	MHz
Common-Base Output Capacitance (V_{CB} = −10 Vdc, I_C = 0, f = 1.0 MHz)		C_{ob}	—	—	6.0	pF
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1.0 kHz) (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1.0 kHz, f = 200 Hz)	 BC214 BC213 BC212	NF	 — — —	 — — —	 2 10 10	dB
Small Signal Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	 BC212 BC213 BC214 BC212B	h_{fe}	 60 80 140 200	 — — — —	 — — — 400	

* Pulst-test: Tp 300 s, Duty-cycle 2%.

2

BC237,A,B,C
BC238,B,C
BC239,C

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 237	BC 238	BC 239	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	25	Vdc
Collector-Emitter Voltage	V_{CES}	50	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	5.0	5.0	Vdc
Collector Current − Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mA, I_B = 0)	BC237 BC238 BC239	$V_{(BR)CEO}$	45 25 25			V
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	BC237 BC238 BC239	$V_{(BR)EBO}$	6 5 5			V
Collector Cutoff Current (V_{CE} = 30 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0)	BC238 BC239 BC237	I_{CES}		0.20 0.20 0.20	15 15 15	nA
(V_{CE} = 30 V, V_{BE} = 0) T_A = 125°C (V_{CE} = 50 V, V_{BE} = 0) T_A = 125°C	BC238 BC239 BC237			0.20 0.20 0.20	4 4 4	μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5 V)	BC237A BC237B/238B BC237C/238C/239C	h_{FE}		90 150 270		
(I_C = 2 mA, V_{CE} = 5 V)	BC237 BC238 BC239 BC237A BC237B/238B BC237C/238C/239C		120 120 120 120 200 380	 170 290 500	800 800 800 220 460 800	
(I_C = 100 mA, V_{CE} = 5 V)	BC237A BC237B/238B BC237C/238C/239C			120 180 300		
Collector-Emitter On Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA)	BC237/BC238/BC239 BC237/BC239 BC238	$V_{CE(sat)}$		0.07 0.20	0.20 0.60 0.8	V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA)		$V_{BE(sat)}$		0.60	0.83 1.05	V
Base-Emitter On Voltage (I_C = 100 μA, V_{CE} = 5 V) (I_C = 2 mA, V_{CE} = 5 V) (I_C = 100 mA, V_{CE} = 5 V)		$V_{BE(on)}$	 0.55	0.50 0.62 0.83	 0.70	V

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 0.5 mA, V_{CE} = 3.0 V, f = 100 MHz)	BC237		—	100	—	
	BC238		—	120	—	
	BC239		—	140	—	
(I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHZ)	BC237		150	200	—	
	BC238		150	240	—	
	BC239		150	280	—	
Collector-Base Capacitance (V_{CB} = 10 V, I_C = 0, f = 1.0 MHz)		C_{obo}	—	—	4.50	pF
Emitter-Base Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	—	pF
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 K ohms, f = 1.0 kHz)	BC239		—	2.0	4.0	
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2.0 K ohms f = 1.0 kHz, Δf = 200 Hz)	BC237		—	2.0	10	
	BC238		—	2.0	10	
	BC239		—	2.0	4.0	

FIGURE 1 – NORMALIZED DC CURRENT GAIN

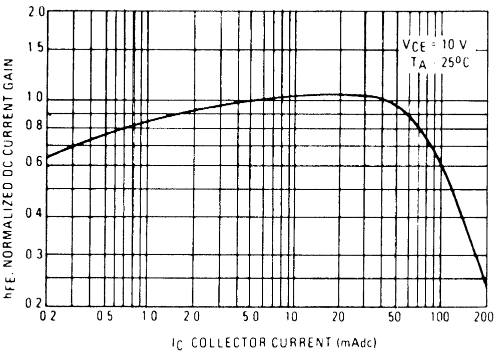


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

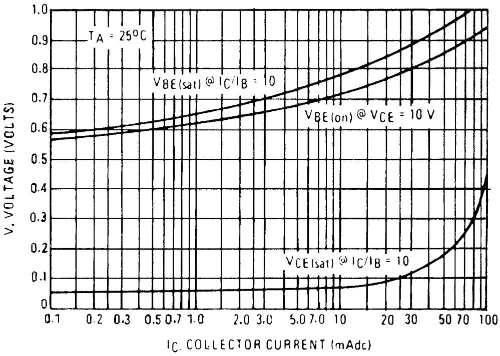


FIGURE 3 – CURRENT-GAIN-BANDWIDTH PRODUCT

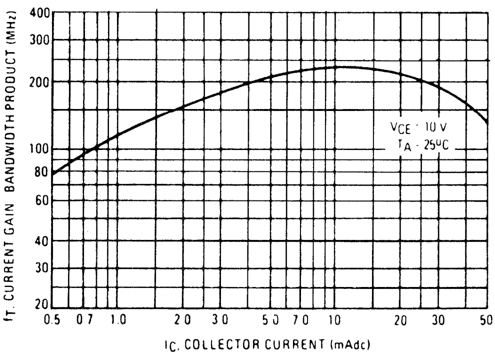


FIGURE 4 – CAPACITANCES

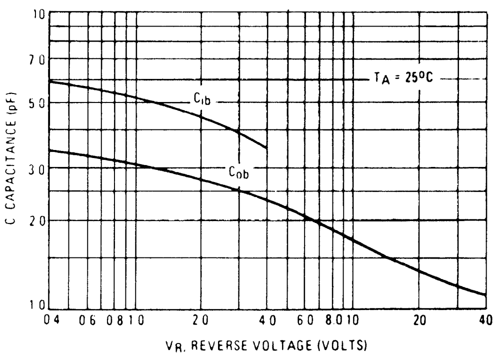
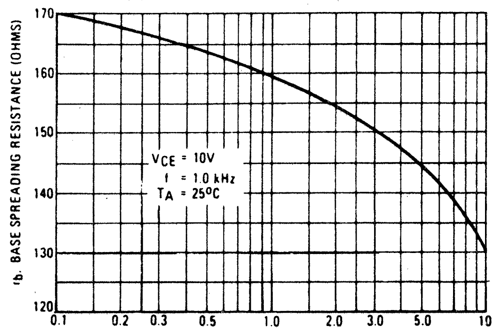
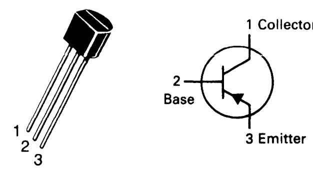


FIGURE 5 – BASE SPREADING RESISTANCE



BC307,B,C
BC308C
BC309,B

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC307	BC308C	BC309	Unit
Collector-Emitter Voltage	V_{CEO}	−45	−25	−25	Vdc
Collector-Base Voltage	V_{CBO}	−50	−30	−30	Vdc
Emitter-Base Voltage	V_{EBO}		−5.0		Vdc
Collector Current — Continuous	I_C		−100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage	BC307	$V_{(BR)CEO}$	−45	—	—	Vdc
(I_C = −2.0 mAdc, I_B = 0)	BC308C		−25	—	—	
	BC309		−25	—	—	
Emitter-Base Breakdown Voltage	BC307	$V_{(BR)EBO}$	−5	—	—	Vdc
(I_E = −100 μAdc, I_C = 0)	BC308C		−5	—	—	Vdc
	BC309		−5	—	—	
Collector-Emitter Leakage Current		I_{CES}				nAdc
(V_{CES} = −50 V, V_{BE} = 0)	BC307			−0.2	−15	
(V_{CES} = −30 V, V_{BE} = 0)	BC308C			−0.2	−15	
	BC309			−0.2	−15	
(V_{CES} = −50 V, V_{BE} = 0) T_A = 125°C	BC307			−0.2	−4.0	μA
(V_{CES} = −30 V, V_{BE} = 0) T_A = 125°C	BC308C			−0.2	−4.0	
	BC309			−0.2	−4.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	BC307B/309B		—	150	—	
	BC307C/308C		—	270	—	
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)						
	BC307		120	—	800	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	BC308C		120	—	800	
	BC309		120	—	800	
	BC307B/309B		200	290	460	
	BC307C/308C		420	500	800	
	BC307B/309B		—	180	—	
	BC307C/308C		—	300	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = −10 mAdc, I_B = −0.5 mAdc)			—	−0.10	−0.30	
(I_C = −10 mAdc, I_B = see Note 1)			—	−0.30	−0.60	
(I_C = −100 mAdc, I_B = −5.0 mAdc)			—	−0.25	—	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = −10 mAdc, I_B = −0.5 mAdc)			—	−0.70	—	
(I_C = −100 mAdc, I_B = −5.0 mAdc)			—	−1.00	—	
Base-Emitter On Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	−0.55	−0.62	−0.70	Vdc

Note 1: I_C = −10 mAdc on the constant base current characteristic, which yields the point I_C = −11 mAdc, V_{CE} = −1.0 V

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	BC307 BC308C BC309	f_T	— — —	280 320 360	— — —	MHz
Common-Base Capacitance (V_{CB} = −10 Vdc, I_C = 0, f = 1.0 MHz)		C_{cbo}	—	—	6.0	pF
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1.0 kHz) (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 k ohms, f = 1 kHz, f = 200 Hz)	BC309 BC307 BC308C BC309	NF	— — — —	2 2 2 2	4 10 10 4	dB

FIGURE 1 – NORMALIZED DC CURRENT GAIN

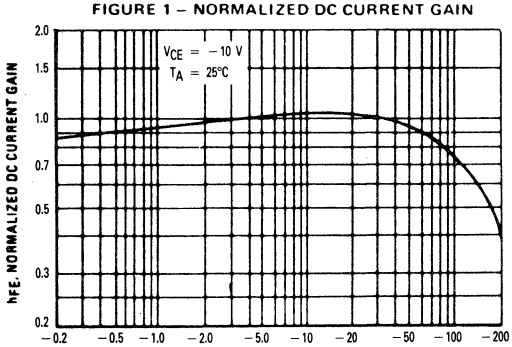


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

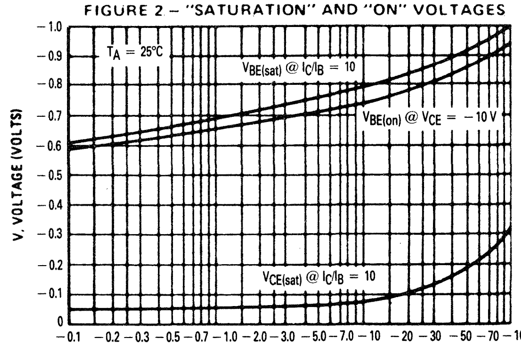


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

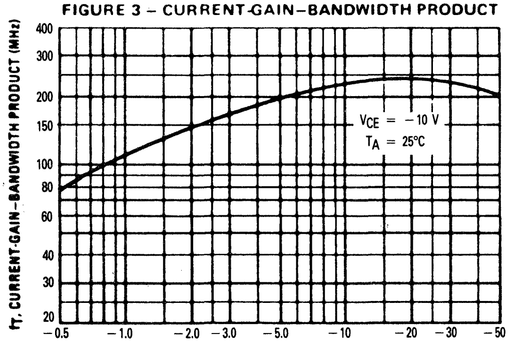


FIGURE 4 – CAPACITANCES

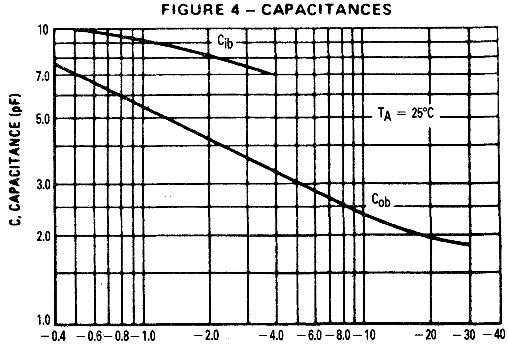


FIGURE 5 – OUTPUT ADMITTANCE

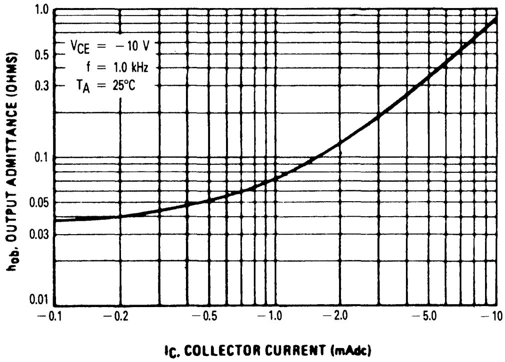
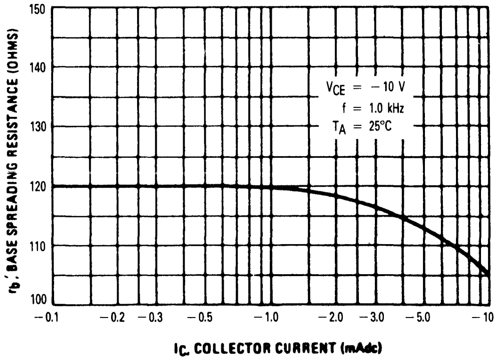


FIGURE 6 – BASE SPREADING RESISTANCE



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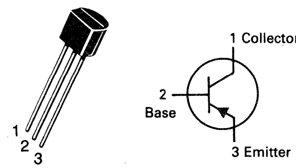
BC327,-16,-25
BC328,-16,-25

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC327	BC328	Unit
Collector-Emitter Voltage	V_{CEO}	−45	−25	Vdc
Collector-Base Voltage	V_{CBO}	−50	−30	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−800		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = -10$ mA, $I_B = 0$)	BC327 BC328	$V_{(BR)CEO}$	−45 −25	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = -100$ μA, $I_E = 0$)	BC327 BC328	$V_{(BR)CES}$	−50 −30	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = -10$ μA, $I_C = 0$)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = -30$ V, $I_E = 0$) ($V_{CB} = -20$ V, $I_E = 0$)	BC327 BC328	I_{CBO}	— —	— —	−100 −100	nAdc
Collector Cutoff Current ($V_{CE} = -45$ V, $V_{BE} = 0$) ($V_{CE} = -25$ V, $V_{BE} = 0$)	BC327 BC328	I_{CES}	— —	— —	−100 −100	nAdc
Emitter Cutoff Current ($V_{EB} = -4.0$ V, $I_C = 0$)		I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = -100$ mA, $V_{CE} = -1.0$ V)	BC327/BC328 BC327-16/BC328-16 BC327-25/BC328-25	h_{FE}	100 100 160	— — —	630 250 400	—
($I_C = -300$ mA, $V_{CE} = -1.0$ V)			40	—	—	
Base-Emitter On Voltage ($I_C = -300$ mA, $V_{CE} = -1.0$ V)		$V_{BE(on)}$	—	—	−1.2	Vdc
Collector-Emitter Saturation Voltage ($I_C = -500$ mA, $I_B = -50$ mA)		$V_{CE(sat)}$	—	—	−0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance ($V_{CB} = -10$ V, $I_E = 0$, f = 1.0 MHz)		C_{ob}	—	11	—	pF
Current-Gain — Bandwidth Product ($I_C = -10$ mA, $V_{CE} = -5.0$ V, f = 100 MHz		f_T	—	260	—	MHz

FIGURE 1 — THERMAL RESPONSE

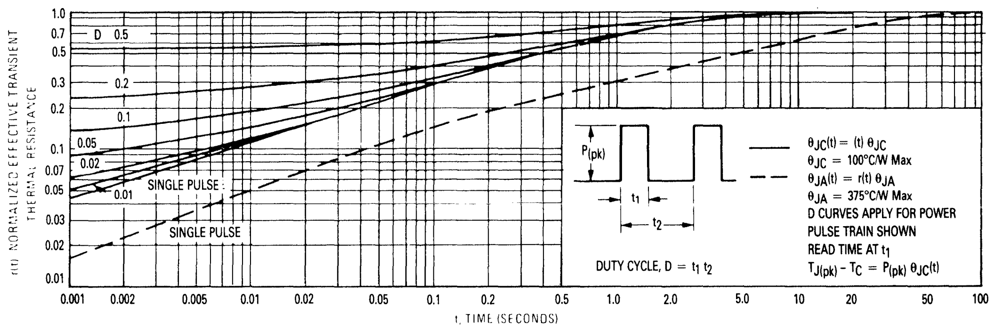


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREA

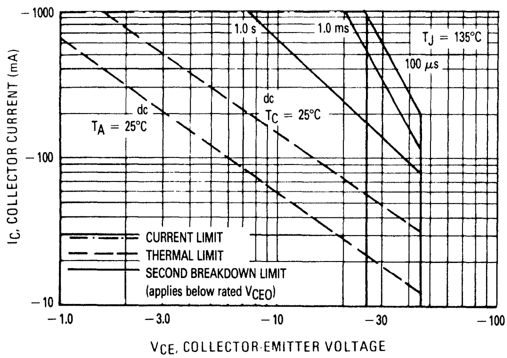


FIGURE 3 — DC CURRENT GAIN

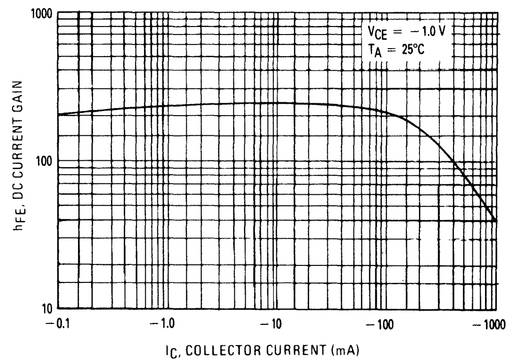


FIGURE 4 — SATURATION REGION

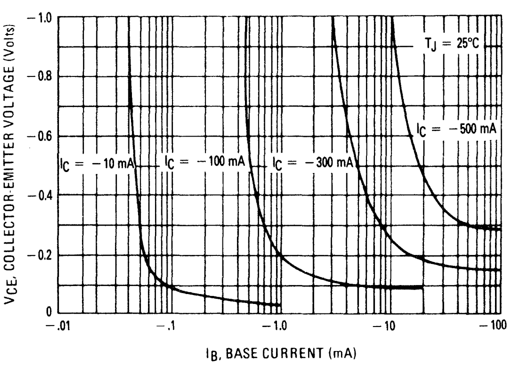


FIGURE 5 — "ON" VOLTAGES

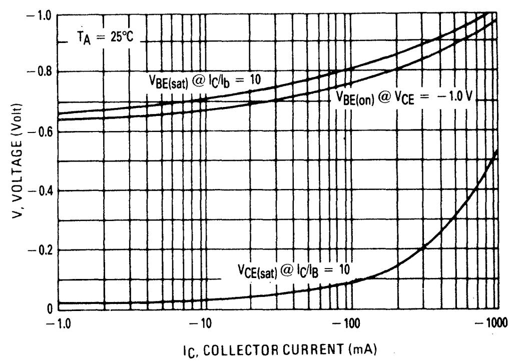


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FIGURE 6 — TEMPERATURE COEFFICIENTS

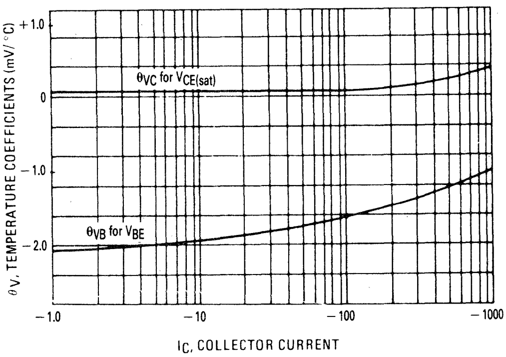
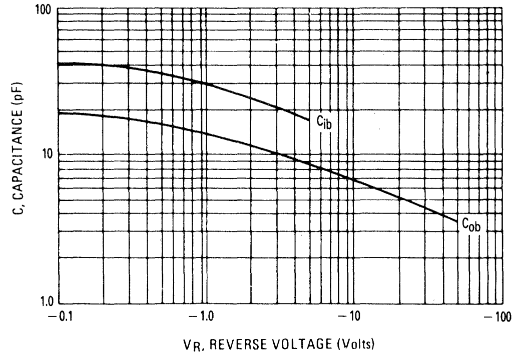
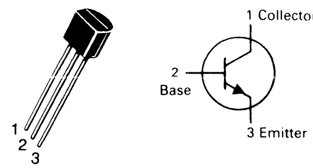


FIGURE 7 — CAPACITANCES



BC337, -16, -25, -40
BC338, -16, -25, -40

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC337	BC338	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	800		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	BC337 BC338	$V_{(BR)CEO}$	45 25	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μA, I_E = 0)	BC337 BC338	$V_{(BR)CES}$	50 30	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 V, I_E = 0) (V_{CB} = 20 V, I_E = 0)	BC337 BC338	I_{CBO}	— —	— —	100 100	nAdc
Collector Cutoff Current (V_{CE} = 45 V, V_{BE} = 0) (V_{CE} = 25 V, V_{BE} = 0)	BC337 BC338	I_{CES}	— —	— —	100 100	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 V, I_C = 0)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 mA, V_{CE} = 1.0 V)	BC337/BC338 BC337-16/BC338-16 BC337-25/BC338-25 BC337-40/BC338-40	h_{FE}	100 100 160 250	— — — —	630 250 400 630	—
(I_C = 300 mA, V_{CE} = 1.0 V)			60	—	—	
Base-Emitter On Voltage (I_C = 300 mA, V_{CE} = 1.0 V)		$V_{BE(on)}$	—	—	1.2	Vdc
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)		$V_{CE(sat)}$	—	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz)		C_{ob}	—	15	—	pF
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)		f_T	—	210	—	MHz

2

FIGURE 1 — THERMAL RESPONSE

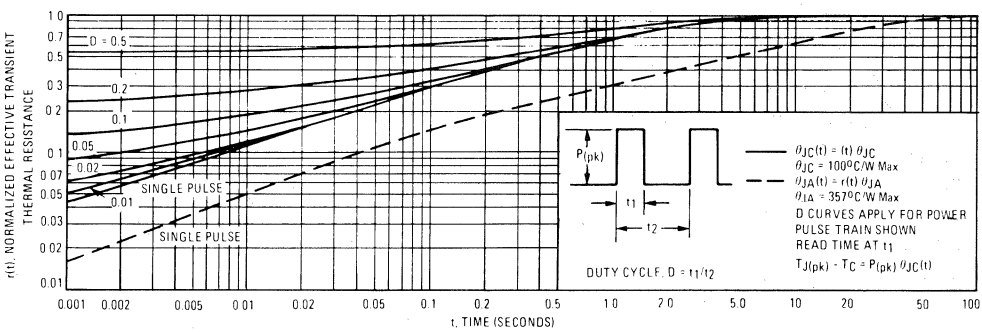


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREA

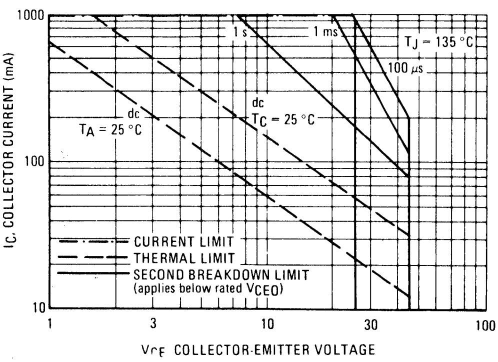


FIGURE 3 — DC CURRENT GAIN

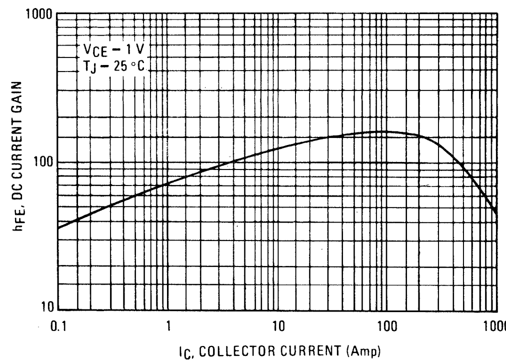


FIGURE 4 — SATURATION REGION

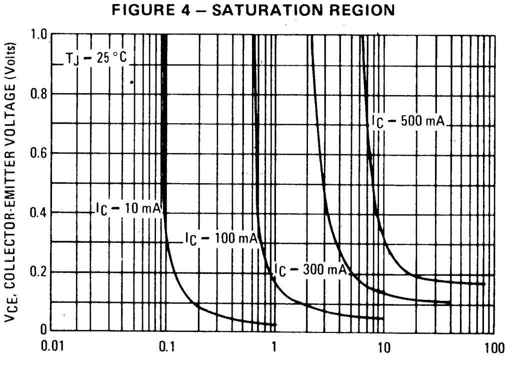


FIGURE 5 — "ON" VOLTAGES

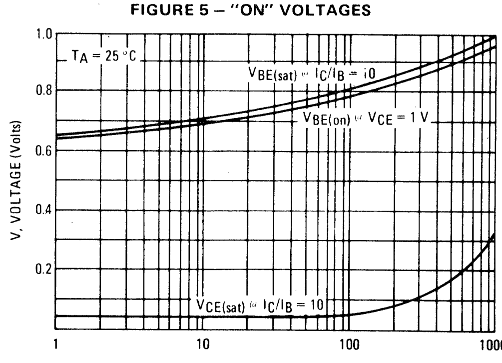


FIGURE 6 – TEMPERATURE COEFFICIENTS

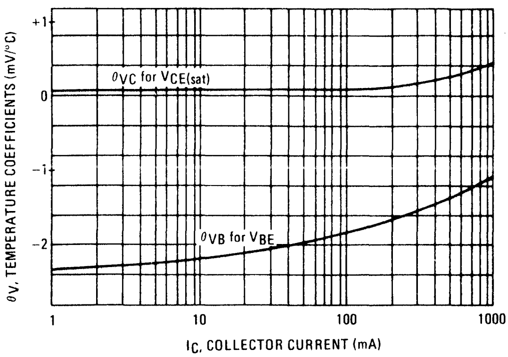
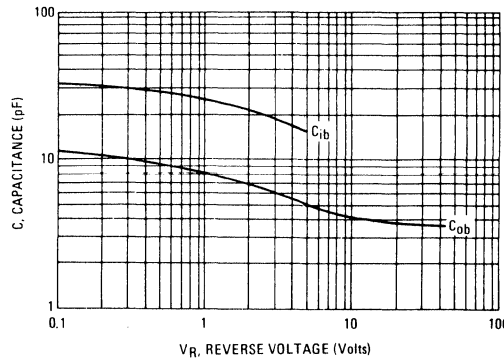


FIGURE 7 – CAPACITANCES



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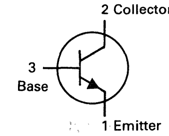
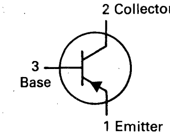
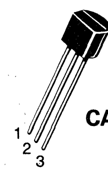
NPN
BC368



PNP
BC369(1)





CASE 29-04, STYLE 14
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 V, I_E = 0) (V_{CB} = 25 V, I_E = 0, T_J = 150°C)	I_{CBO}	 — —	 — —	 10 1.0	 μAdc mAdc
Emitter Cutoff Current (V_{EB} = 5.0 V, I_C = 0)	I_{EBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA) (V_{CE} = 1.0 V, I_C = 0.5 A) (V_{CE} = 1.0 V, I_C = 1.0 A)	h_{FE}	 50 85 60	 — — —	 — 375 —	—
Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 V, f = 20 MHz)	f_T	65	—	—	MHz
Collector-Emitter Saturation Voltage (I_C = 1.0 A, I_B = 100 mA)	$V_{CE(sat)}$	—	—	0.5	V
Base-Emitter On Voltage (I_C = 1.0 A, V_{CE} = 1.0 V)	$V_{BE(on)}$	—	—	1.0	V

(1) Voltage and current are negative for PNP Transistors.

2

FIGURE 1 — DC CURRENT GAIN

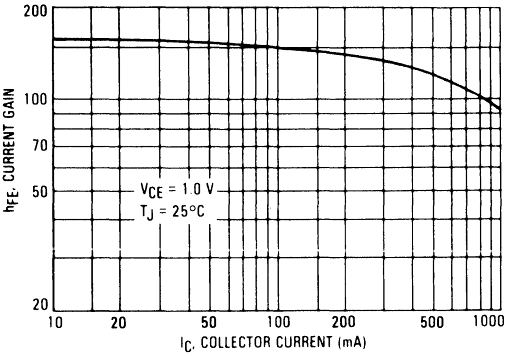


FIGURE 2 — COLLECTOR SATURATION REGION

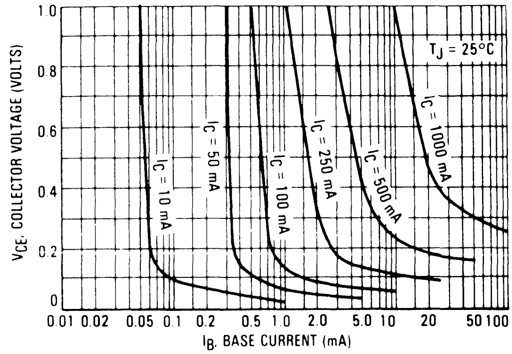


FIGURE 3 — ON VOLTAGES

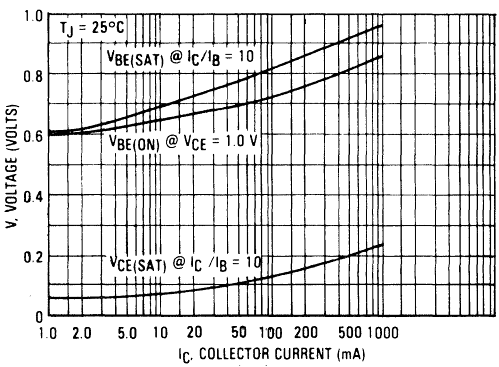


FIGURE 4 — TEMPERATURE COEFFICIENT

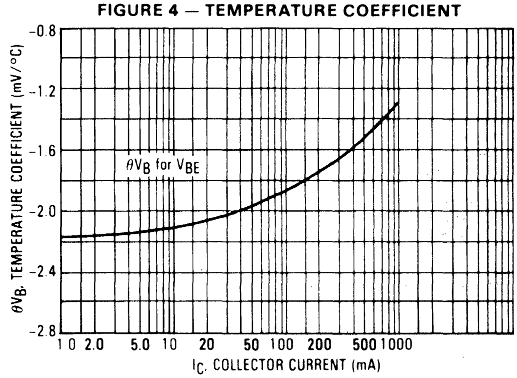


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

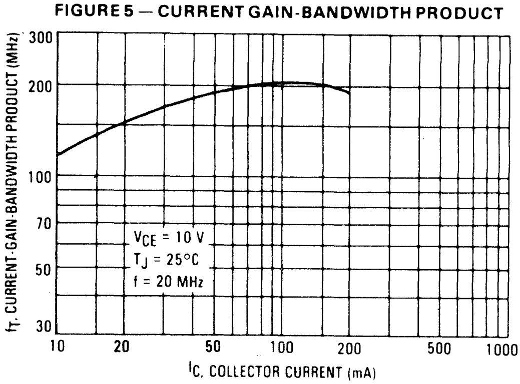
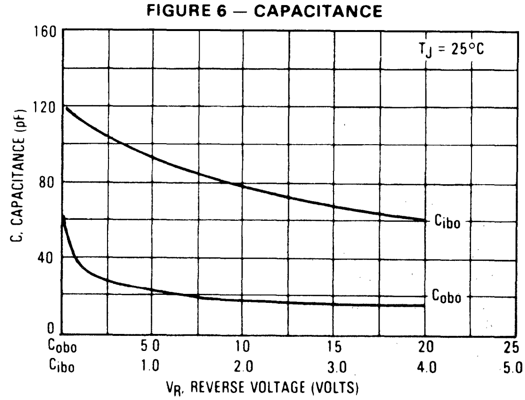
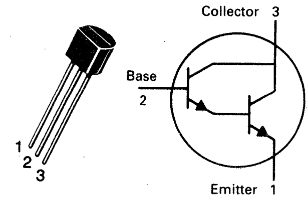


FIGURE 6 — CAPACITANCE



BC372
BC373

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE DARLINGTON TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC372	BC373	Unit
Collector-Emitter Voltage	V_{CES}	100	80	Vdc
Collector-Base Voltage	V_{CBO}	100	80	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 100 μAdc, I_B = 0)	 BC372 BC373	$V_{(BR)CES}$	 100 80	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 BC372 BC373	$V_{(BR)CBO}$	 100 80	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 BC372 BC373	I_{CBO}	 — —	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 10 V, I_C = 0)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS*						
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	 8.0 10	 — —	 — 160	K
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	—	1.0	1.1	Vdc
Base-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	—	1.4	2.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	—	10	25	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_g = 100 k ohm, f = 1.0 kHz)		NF	—	2.0	—	dB

*Pulse Test: Pulse Width = 300 μs, Duty Cycle 2.0%.

FIGURE 1 — DC CURRENT GAIN

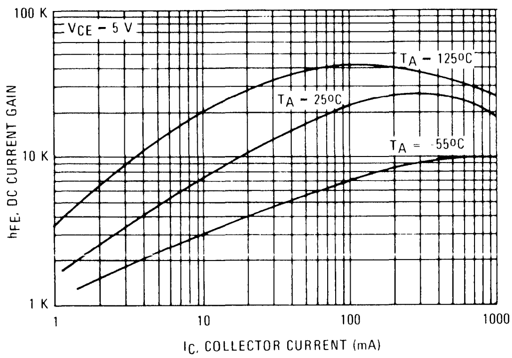


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

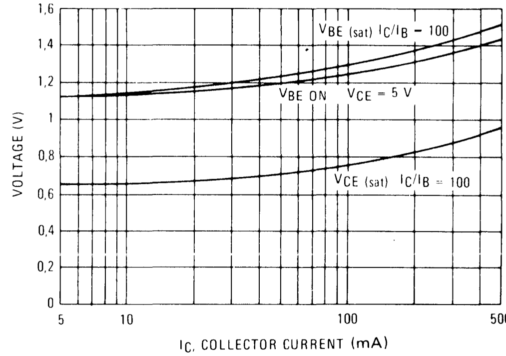


FIGURE 3 — CURRENT GAIN BANDWIDTH PRODUCT

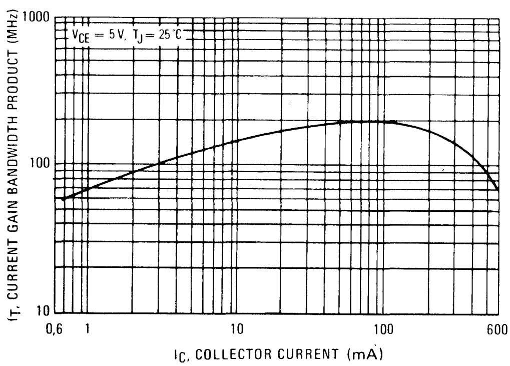
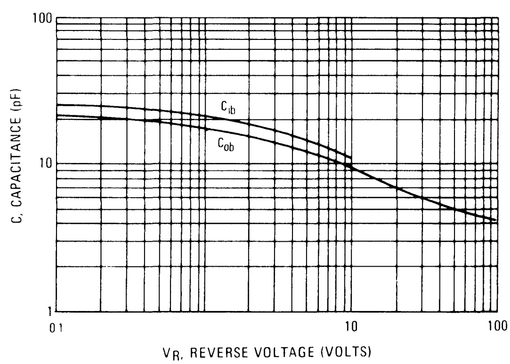


FIGURE 4 — CAPACITANCES



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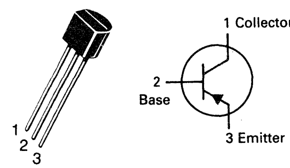
BC450,A

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPS8598 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−100	Vdc
Collector-Base Voltage	V_{CBO}	−100	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

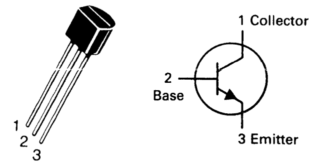
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = −1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−100	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA, I_E = 0)		$V_{(BR)CBO}$	−100	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −80 Vdc, I_E = 0)		I_{CBO}	—	—	−100	nAdc
ON CHARACTERISTICS*						
DC Current Gain		h_{FE}				
(I_C = −2.0 mA, V_{CE} = −5.0 V)	BC450		50	—	460	
	BC450A		120	—	220	
(I_C = −10 mA, V_{CE} = −5.0 V)	BC450		50	—	—	
	BC450A		100	—	—	
(I_C = −100 mA, V_{CE} = −5.0 V)	BC450		50	—	—	
	BC450A		60	—	—	
Collector-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −10 mAdc)		$V_{CE(sat)}$	—	−0.125	−0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −10 mAdc)		$V_{BE(sat)}$	—	−0.85	—	Vdc
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = −2.0 mA, V_{CE} = −5.0 V)			−0.55	—	−0.7	
(I_C = −100 mA, V_{CE} = −5.0 V)*			—	−0.76	−1.2	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	100	200	—	MHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

BC489,A,B

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH CURRENT TRANSISTORS

NPN SILICON

Refer to MPSA05 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$, Vdc — $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS*					
DC Current Gain ($I_C = 10$ mAdc — $V_{CE} = 2.0$ Vdc) ($I_C = 100$ mAdc — $V_{CE} = 2.0$ Vdc) BC489 BC489A BC489B ($I_C = 1.0$ Adc — $V_{CE} = 5.0$ Vdc)*	h_{FE}	40 60 100 160 15	— — 160 260 —	— 400 250 400 —	— — — — —
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc — $I_B = 50$ mAdc) ($I_C = 1.0$ Adc — $I_B = 100$ mAdc)	$V_{CE(sat)}$	 — —	 0.2 0.3	 0.50 —	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc — $I_B = 100$ mAdc)*	$V_{BE(sat)}$	 — —	 0.85 0.90	 1.20 —	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 2.0$ Vdc, f = 100 MHz)	f_T	—	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	7	—	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ib}	—	50	—	pF

*Pulse Test — Pulse Width = 300 μs — Duty Cycle 2%.

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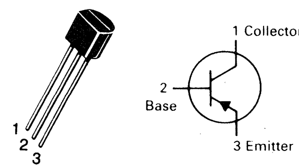
BC490,A,B

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH CURRENT TRANSISTORS

PNP SILICON

Refer to MPSA55 for graphs in MPSA05 data sheet.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−80	Vdc
Collector-Base Voltage	V_{CBO}	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

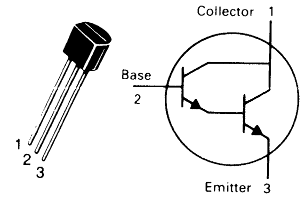
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = −10 mAdc, I_B = 0)		$V_{(BR)CEO}$	−80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)		$V_{(BR)CBO}$	−80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −60 Vdc — I_E = 0)		I_{CBO}	—	—	−100	nAdc
ON CHARACTERISTICS*						
DC Current Gain		h_{FE}				—
(I_C = −10 mAdc — V_{CE} = −2.0 Vdc)			40	—	—	
(I_C = −100 mAdc — V_{CE} = −2.0 Vdc)	BC490		60	—	400	
	BC490A		100	140	250	
	BC490B		160	260	400	
(I_C = −1.0 Adc — V_{CE} = −5.0 Vdc)			15	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = −500 mAdc, I_B = −50 mAdc)			—	−0.25	−0.50	
(I_C = −1.0 Adc, I_B = −100 mAdc)			—	−0.50	—	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = −500 mAdc, I_B = −50 mAdc)			—	−0.90	−1.20	
(I_C = −1.0 Adc, I_B = −100 mAdc)			—	−1.00	—	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −2.0 Vdc, f = 100 MHz)		f_T	—	150	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	—	9	—	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	—	110	—	pF

*Pulse Test — Pulse Width = 300 μs — Duty Cycle 2%.

BC517

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Power Dissipation $T_A = 25°C$ Derate above 25°C	P_D	625 12	mW mW/°C
Total Power Dissipation $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

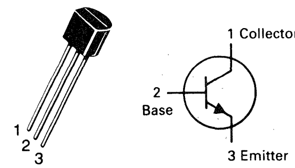
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 nAdc, I_C = 0)	$V_{(BR)EBO}$	10	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 V)	I_{CES}	—	—	500	nA
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 20 mAdc, V_{CE} = 2.0 V)	h_{FE}	30,000	—	—	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	—	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	—	200	—	MHz

(1) Pulse Test Pulse Width ≤ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$

BC546, A, B
BC547, A, B, C
BC548, A, B, C

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 546	BC 547	BC 548	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector-Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current − Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)	BC546 BC547 BC548	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector-Base Breakdown Voltage (I_C = 100 μAdc)	BC546 BC547 BC548	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BC546 BC547 BC548	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	— — —	V
Collector Cutoff Current		I_{CES}				
(V_{CE} = 70 V, V_{BE} = 0)	BC546		—	0.2	15	nA
(V_{CE} = 50 V, V_{BE} = 0)	BC547		—	0.2	15	
(V_{CE} = 35 V, V_{BE} = 0)	BC548		—	0.2	15	
(V_{CE} = 30 V, T_A = 125°C)	BC546/547/548		—	—	4.0	μA
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 10 μA, V_{CE} = 5.0 V)	BC546A/547A/548A		—	90	—	
	BC546B/547B/548B		—	150	—	
	BC548C		—	270	—	
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC546		110	—	450	
	BC547		110	—	800	
	BC548		110	—	800	
	BC546A/547A/548A		110	180	220	
	BC546B/547B/548B		200	290	450	
	BC547C/BC548C		420	520	800	
(I_C = 100 mA, V_{CE} = 5.0 V)	BC546A/547A/548A		—	120	—	
	BC546B/547B/548B		—	180	—	
	BC548C		—	300	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				V
(I_C = 10 mA, I_B = 0.5 mA)			—	0.09	0.25	
(I_C = 100 mA, I_B = 5.0 mA)			—	0.2	0.6	
(I_C = 10 mA, I_B = See Note 1)			—	0.3	0.6	
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA)		$V_{BE(sat)}$	—	0.7	—	V
Base-Emitter On Voltage		$V_{BE(on)}$				V
(I_C = 2.0 mA, V_{CE} = 5.0 V)			0.55	—	0.7	
(I_C = 10 mA, V_{CE} = 5.0 V)			—	—	0.77	

NOTE 1: I_B is value for which I_C = 11 mA at V_{CE} = 1.0 V.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	BC546		150	300	—	
	BC547		150	300	—	
	BC548		150	300	—	
Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1.0 MHz)		C_{obo}	—	1.7	4.5	pF
Input Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	—	pF
Small-Signal Current Gain		h_{fe}				—
(I_C = 2.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	BC546		125	—	500	
	BC547/548		125	—	900	
	BC546A/547A/548A		125	220	260	
	BC546B/547B/548B		240	330	500	
	BC547C/548C		450	600	900	
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5.0 V, R_S = 2 kohms,	BC546		—	2.0	10	
f = 1.0 kHz, Δf = 200 Hz)	BC547		—	2.0	10	
	BC548		—	2.0	10	

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FIGURE 1 — NORMALIZED DC CURRENT GAIN

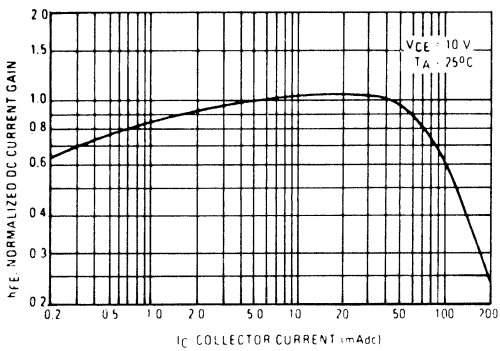


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

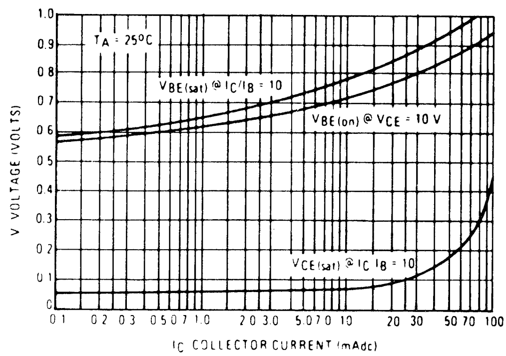


FIGURE 3 — COLLECTOR SATURATION REGION

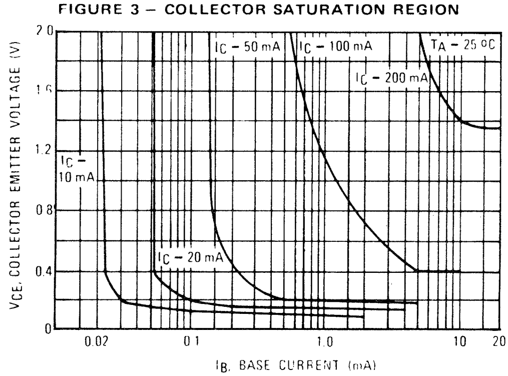
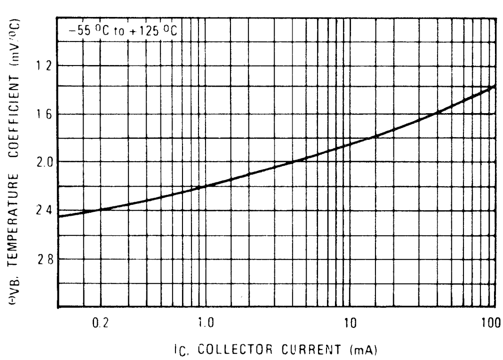


FIGURE 4 — BASE EMITTER TEMPERATURE COEFFICIENT



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BC547/BC548

FIGURE 5 — CAPACITANCES

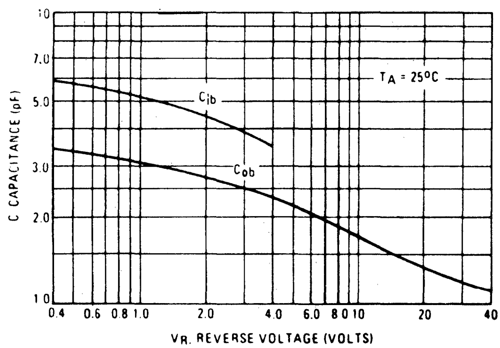


FIGURE 6 — CURRENT GAIN—BANDWIDTH PRODUCT

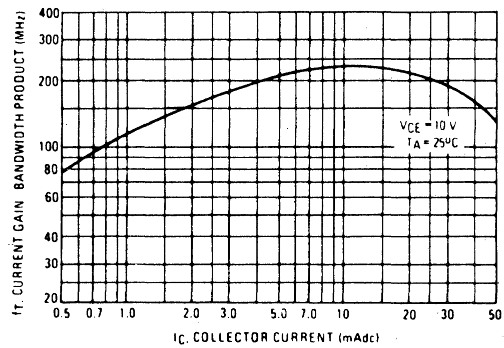


FIGURE 7 — DC CURRENT GAIN

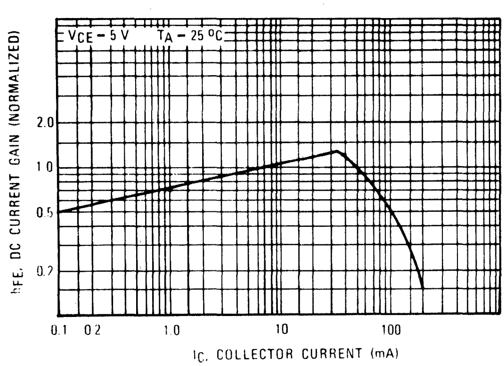


FIGURE 8 — "ON" VOLTAGE

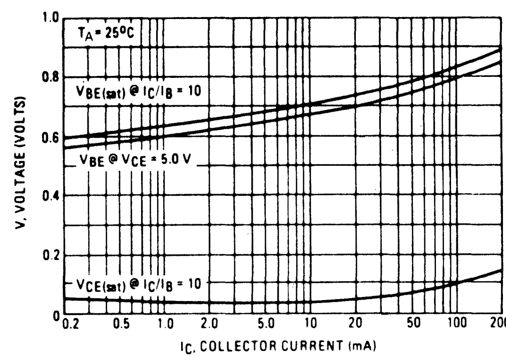


FIGURE 9 — COLLECTOR SATURATION REGION

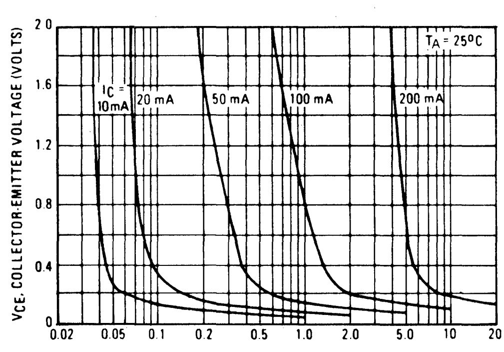
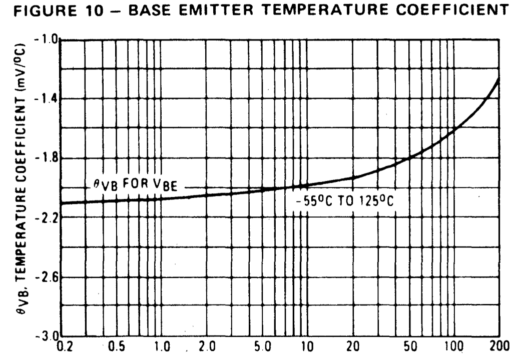


FIGURE 10 — BASE EMITTER TEMPERATURE COEFFICIENT



BC546

FIGURE 11 – CAPACITANCE

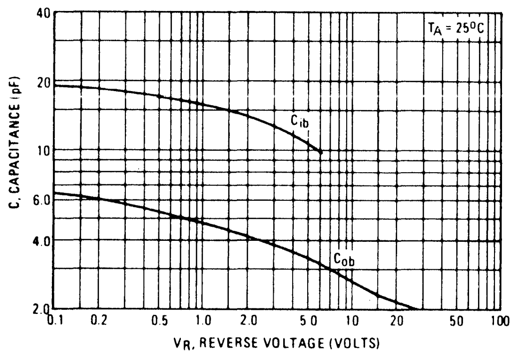
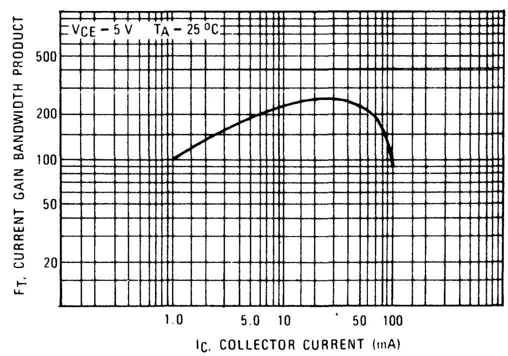
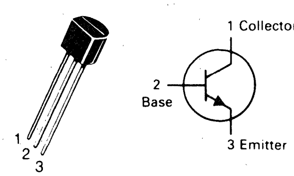


FIGURE 12 – CURRENT GAIN–BANDWIDTH PRODUCT



BC549B,C
BC550B,C

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



LOW NOISE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 549	BC 550	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	Vdc
Collector-Base Voltage	V_{CBO}	30	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage **(I_C = 10 mAdc, I_B = 0) BC549B,C** **BC550B,C**	$V_{(BR)CEO}$	 30 45			Vdc
Collector-Base Breakdown Voltage **(I_C = 10 µAdc, I_E = 0) BC549B,C** **BC550B,C**	$V_{(BR)CBO}$	 30 50			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = +125°C)	I_{CBO}			 15 5	 nAdc µAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}			 15	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 µAdc, V_{CE} = 5 Vdc) **BC549B/550B** **BC549C/550C** (I_C = 2 mAdc, V_{CE} = 5 Vdc) **BC549B/550B** **BC549C/550C**	h_{FE}	 100 100 200 420	 150 270 290 500	 450 800	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = see note 1) (I_C = 100 mAdc, I_B = 5 mAdc, see note 2)	$V_{CE(sat)}$		 0.075 0.3 0.25	 0.25 0.6 0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$		 1.1		Vdc
Base-Emitter On Voltage (I_C = 10 µAdc, V_{CE} = 5 Vdc) (I_C = 100 µAdc, V_{CE} = 5 Vdc) (I_C = 2 mAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	 0.55	 0.52 0.55 0.62	 **0.7**	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T		250		MHz
Collector-Base Capacitance **(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)**	C_{cbo}		2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

Note 2: Pulse test = 300 µs − Duty cycle = 2%

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 V, f = 1.0 kHz) BC549B/BC550B BC549C/BC550C	h_{fe}	 240 450	 330 600	 500 900	—
Noise Figure (I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz) (I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 100 kΩ, f = 1.0 kHz)	 NF_1 NF_2	 — —	 0.6 —	 2.5 10	dB

FIGURE 1 – TRANSISTOR NOISE MODEL

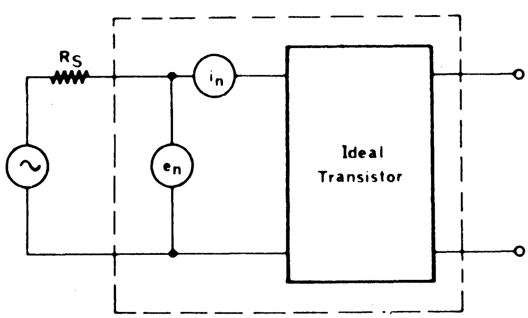


FIGURE 2 — NORMALIZED DC CURRENT GAIN

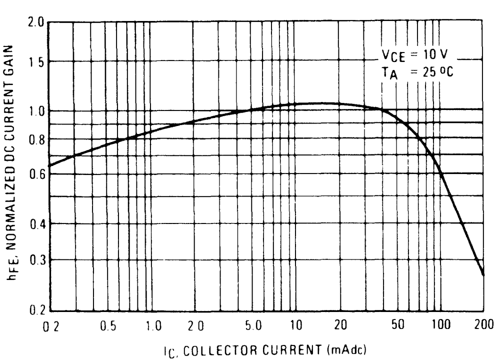
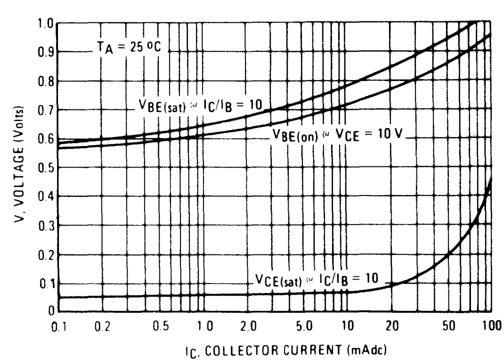


FIGURE 3 — "SATURATION" AND "ON" VOLTAGES



2

FIGURE 4 — CURRENT-GAIN BANDWIDTH PRODUCT

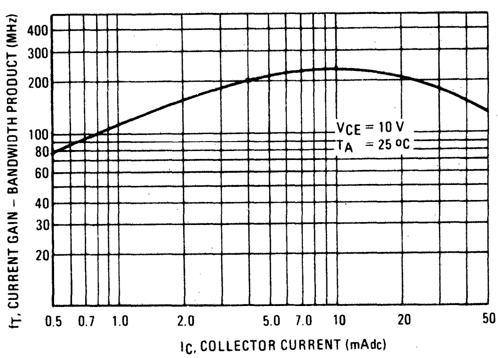


FIGURE 5 — CAPACITANCE

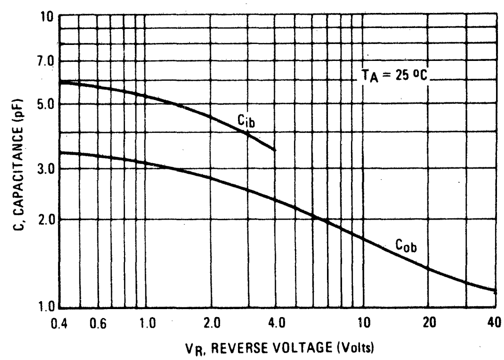
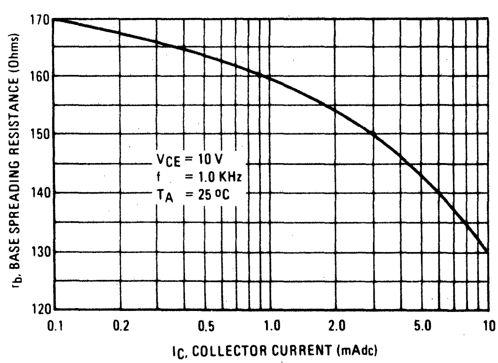
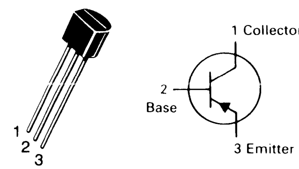


FIGURE 6 — BASE SPREADING RESISTANCE



BC556,A,B
BC557,A,B,C
BC558B

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC556	BC557	BC558	Unit
Collector-Emitter Voltage	V_{CEO}	−65	−45	−30	Vdc
Collector-Base Voltage	V_{CBO}	−80	−50	−30	Vdc
Emitter-Base Voltage	V_{EBO}		−5.0		Vdc
Collector Current — Continuous	I_C		−100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_B = 0)	BC556	$V_{(BR)CEO}$	−65	—	—	V
	BC557		−45	—	—	
	BC558		−30	—	—	
Collector-Base Breakdown Voltage (I_C = −100 μAdc)	BC556	$V_{(BR)CBO}$	−80	—	—	V
	BC557		−50	—	—	
	BC558		−30	—	—	
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	BC556	$V_{(BR)EBO}$	−5.0	—	—	V
	BC557		−5.0	—	—	
	BC558		−5.0	—	—	
Collector-Emitter Leakage Current (V_{CES} = −40 V)	BC556	I_{CES}	—	−2.0	−100	nA
(V_{CES} = −20 V)	BC557		—	−2.0	−100	
	BC558		—	−2.0	−100	
(V_{CES} = −20 V, T_A = 125°C)	BC556		—	—	−4.0	
	BC557		—	—	−4.0	μA
	BC558		—	—	−4.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 V)	BC556A/557A	h_{FE}	—	90	—	—
	BC556B/557B/558B		—	150	—	
	BC557C		—	270	—	
(I_C = −2.0 mAdc, V_{CE} = −5.0 V)	BC556		120	—	500	
	BC557		120	—	800	
	BC558		120	—	800	
	BC556A/557A		120	170	220	
	BC556B/557B/558B		180	290	460	
	BC557C		420	500	800	
(I_C = −100 mAdc, V_{CE} = −5.0 V)	BC556A/557A		—	120	—	
	BC556B/557B/558B		—	180	—	
	BC557C		—	300	—	
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc)		$V_{CE(sat)}$	—	−0.075	−0.3	V
(I_C = −10 mAdc, I_B = see Note 1)			—	−0.3	−0.6	
(I_C = −100 mAdc, I_B = −5.0 mAdc)			—	−0.25	−0.65	

NOTE 1: I_C = −10 mAdc on the constant base current characteristics, which yields the point I_C = −11 mAdc, V_{CE} = −1.0 V.

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (continued)						
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				V
(I_C = −10 mAdc, I_B = −0.5 mAdc)			—	−0.7	—	
(I_C = −100 mAdc, I_B = −5.0 mAdc)			—	−1.0	—	
Base-Emitter On Voltage		$V_{BE(on)}$				V
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)			−0.55	−0.62	−0.7	
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)			—	−0.7	−0.82	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = −10 mA, V_{CE} = −5.0 V, f = 100 MHz)	BC556		—	280	—	
	BC557		—	320	—	
	BC558		—	360	—	
Output Capacitance (V_{CB} = −10 V, I_C = 0, f = 1.0 MHz)		C_{ob}	—	3.0	6.0	pF
Noise Figure		NF				dB
(I_C = −0.2 mAdc, V_{CE} = −5.0 V,	BC556		—	2.0	10	
R_S = 2 k ohms, f = 1.0 kHz, Δf = 200 Hz)	BC557		—	2.0	10	
	BC558		—	2.0	10	
Small-Signal Current Gain		h_{fe}				—
(I_C = −2.0 mAdc, V_{CE} = −5.0 V, f = 1.0 kHz)	BC556		125	—	500	
	BC557/558		125	—	900	
	BC556A/557A		125	220	260	
	BC556B/557B/558B		240	330	500	
	BC557C		450	600	900	

BC557/BC558

FIGURE 1 — NORMALIZED DC CURRENT GAIN

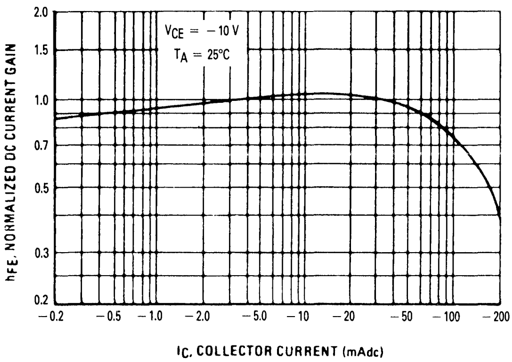


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

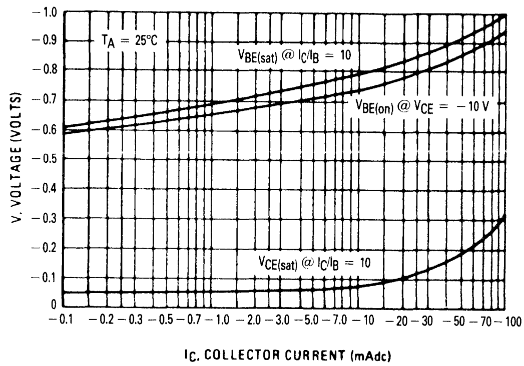


FIGURE 3 — COLLECTOR SATURATION REGION

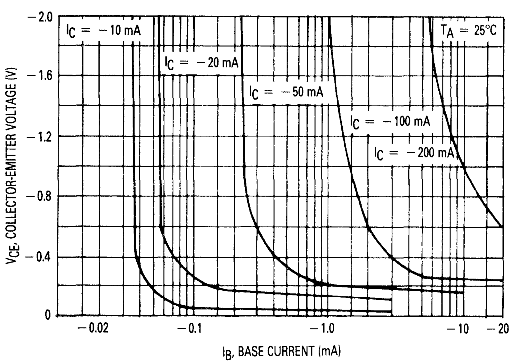


FIGURE 4 — BASE EMITTER TEMPERATURE COEFFICIENT

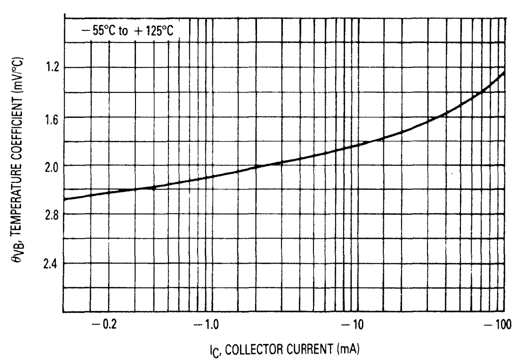


FIGURE 5 — CAPACITANCES

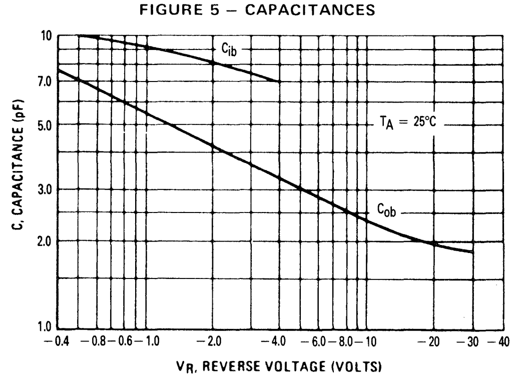
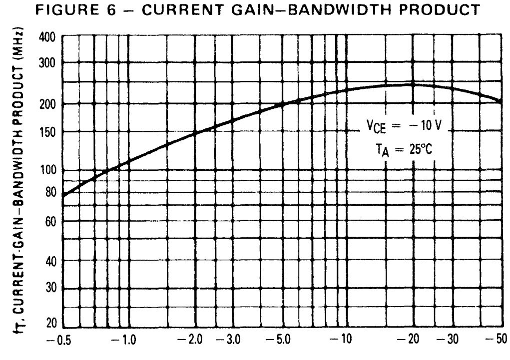


FIGURE 6 — CURRENT GAIN—BANDWIDTH PRODUCT



BC556

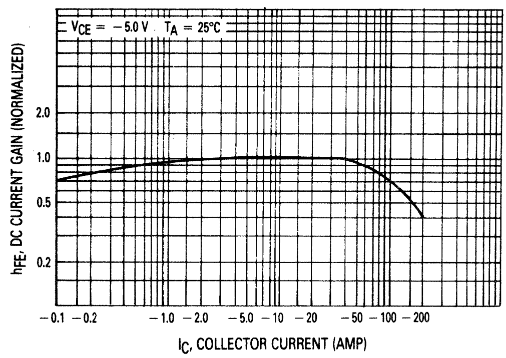


FIGURE 7 — DC CURRENT GAIN

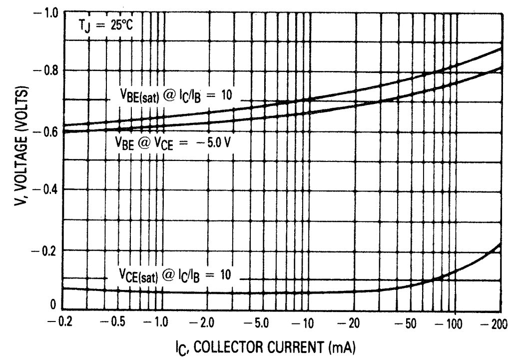


FIGURE 8 — "ON" VOLTAGE

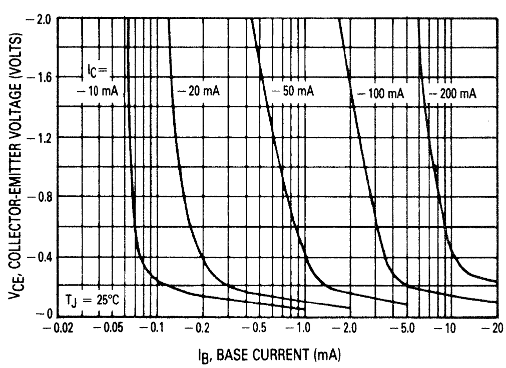


FIGURE 9 — COLLECTOR SATURATION REGION

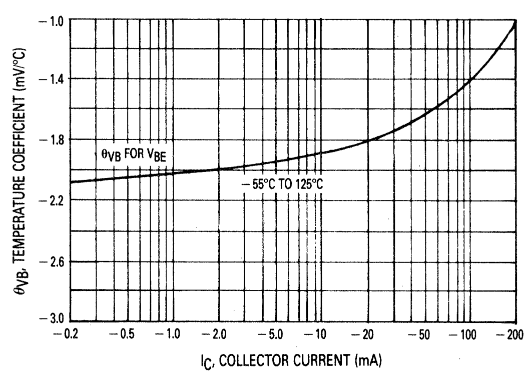


FIGURE 10 — BASE EMITTER TEMPERATURE COEFFICIENT

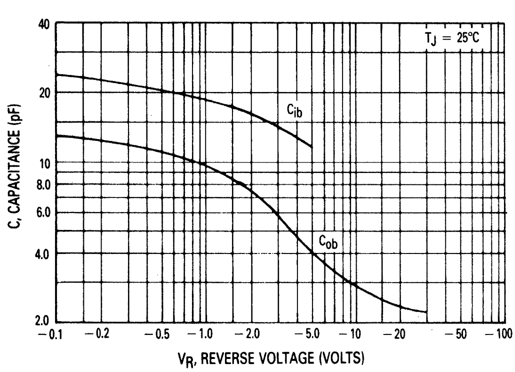


FIGURE 11 — CAPACITANCE

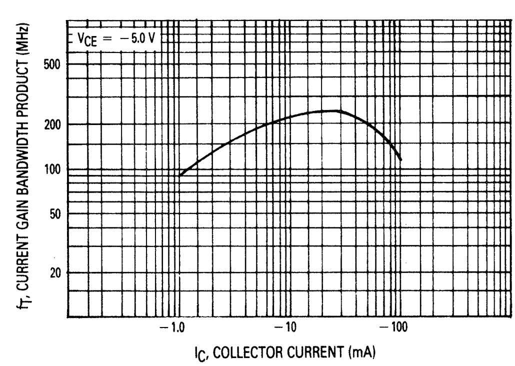


FIGURE 12 — CURRENT GAIN—BANDWIDTH PRODUCT

FIGURE 13 — THERMAL RESPONSE

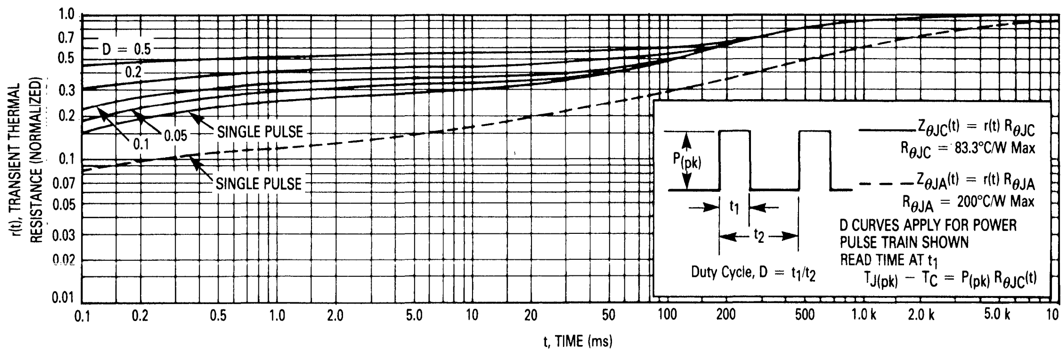
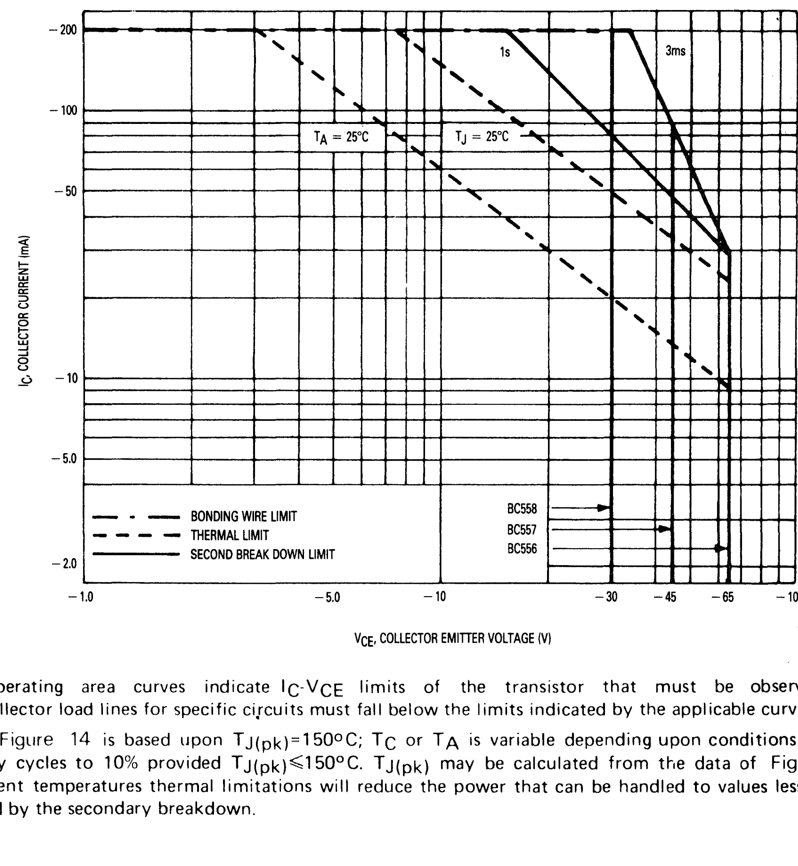


FIGURE 14 — ACTIVE REGION SAFE OPERATING AREA

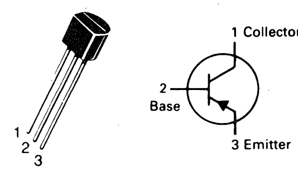


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 14 is based upon $T_{J(pk)}$=150°C; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150$°C. $T_{J(pk)}$ may be calculated from the data of Figure 13. At high case or ambient temperatures thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown.

BC559, B, C
BC560, B, C

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



LOW NOISE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC559	BC560	Unit
Collector-Emitter Voltage	V_{CEO}	−30	−45	Vdc
Collector-Base Voltage	V_{CBO}	−30	−50	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc, I_B = 0)	BC559 BC560	$V_{(BR)CEO}$	−30 −45	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	BC559 BC560	$V_{(BR)CBO}$	−30 −50	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5	—	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0) (V_{CB} = −30 Vdc, I_E = 0, T_A = +125°C)		I_{CBO}	— —	— —	−15 −5	nAdc μAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)		I_{EBO}	—	—	−15	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 Vdc) (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	 BC559B/560B BC559C/560C BC559B/560B BC559C/560C BC559/560	h_{FE}	 100 100 180 380 120	 150 270 290 500 —	 — — 460 800 800	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc) (I_C = −10 mAdc, I_B = see note 1) (I_C = −100 mAdc, I_B = −5.0 mAdc, see note 2)		$V_{CE(sat)}$	 — — —	 −0.075 −0.3 −0.25	 −0.25 −0.6 —	Vdc
Base-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	—	−1.1	—	Vdc
Base-Emitter On Voltage (I_C = −10 μAdc, V_{CE} = −5.0 Vdc) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc) (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	 — — −0.55	 −0.52 −0.55 −0.62	 — — −0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	—	250	—	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cbo}	—	2.5	—	pF
Small-Signal Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 V, f = 1.0 kHz)	BC559B/BC560B BC559C/BC560C	h_{fe}	240 450	330 600	500 900	—
Noise Figure (I_C = −200 μAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz) (I_C = −200 μA, V_{CE} = −5.0 V, R_S = 100 kΩ, f = 1.0 kHz, Δf = 200 Hz)		 NF_1 NF_2	 — —	 0.5 —	 2.0 10	dB

Note 1: I_B is value for which I_C = −11 mA at V_{CE} = −1.0 V

Note 2: Pulse test = 300 μs — Duty cycle = 2%.

FIGURE 1 — NORMALIZED DC CURRENT GAIN

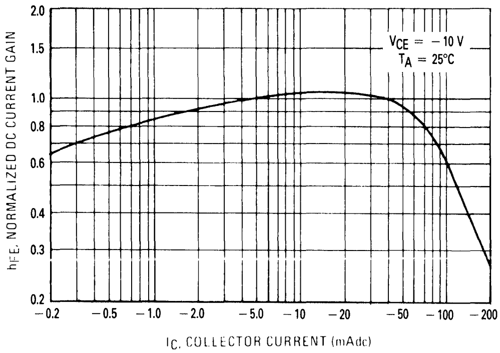


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

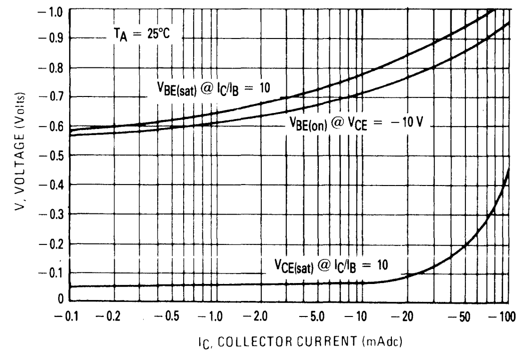


FIGURE 3 — CURRENT-GAIN BANDWIDTH PRODUCT

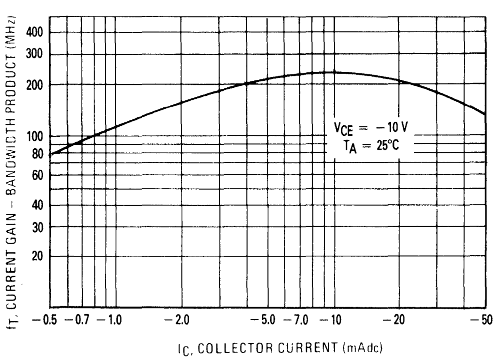


FIGURE 4 — CAPACITANCE

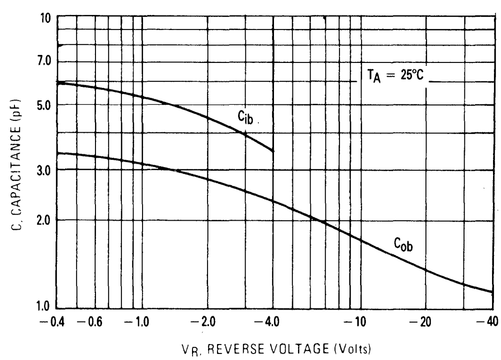
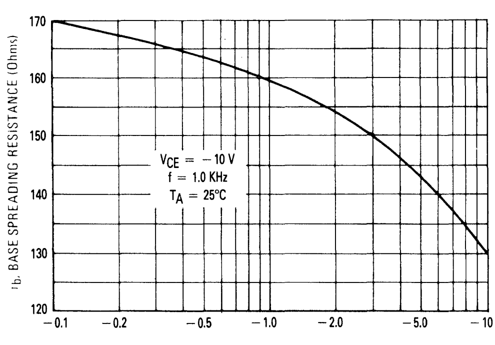


FIGURE 5 — BASE SPREADING RESISTANCE



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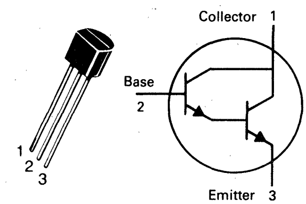
BC618

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	55	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

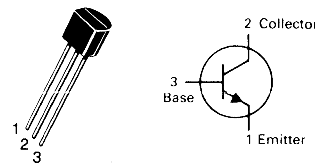
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	$V_{(BR)CEO}$	55	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	— —	— —	 50	nAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 200 mA, I_B = 0.2 mA)	$V_{CE(sat)}$	—	—	1.1	Vdc
Base-Emitter Saturation Voltage (I_C = 200 mA, I_B = 0.2 mA)	$V_{BE(sat)}$	—	—	1.6	Vdc
Current Gain (I_C = 100μA, V_{CE} = 5.0 V) (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 200 mA, V_{CE} = 5.0 V) (I_C = 1.0 A, V_{CE} = 5.0 V)	h_{FE}	 2000 4000 10000 4000	 — — — —	 — — 50000 —	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 mA, V_{CE} = 5.0 V, P = 100 MHz)	f_T	150	—	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	4.5	7.0	pF
Input Capacitance (V_{EB} = 5.0 V, I_E = 0, f = 1.0 MHz)	C_{ib}	—	5.0	9.0	pF

BC635
BC637
BC639

CASE 29-04, STYLE 14
TO-92 (TO-226AA)



HIGH CURRENT TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 635	BC 637	BC 639	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	0.5			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* ($I_C = 10$ mAdc, $I_B = 0$)	BC635 BC637 BC639	$V_{(BR)CEO}$	45 60 80	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BC635 BC637 BC639	$V_{(BR)CBO}$	45 60 80	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$, ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 125°C$)		I_{CBO}	— —	— —	100 10	nAdc μAdc
ON CHARACTERISTICS*						
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 500$ mA, $V_{CE} = 2.0$ V)	 BC635 BC637 BC639	h_{FE}	25 40 40 40 25	— — — — —	— 250 160 160 —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)		$V_{BE(on)}$	—	—	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 2.0$ Vdc, f = 100 MHz)		f_T	—	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{ob}	—	7.0	—	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ib}	—	50	—	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

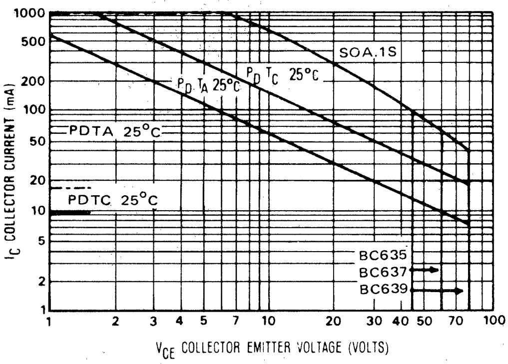


FIG. 2 — DC CURRENT GAIN

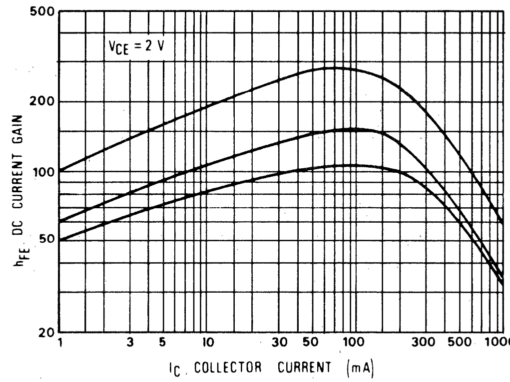


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

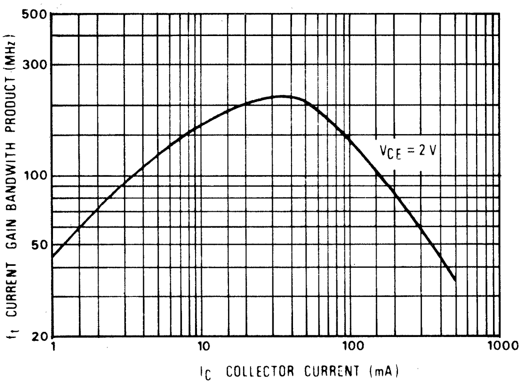


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

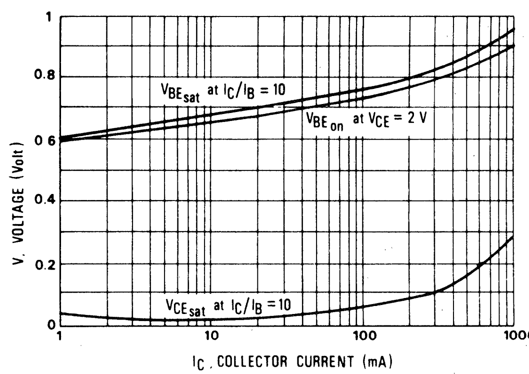
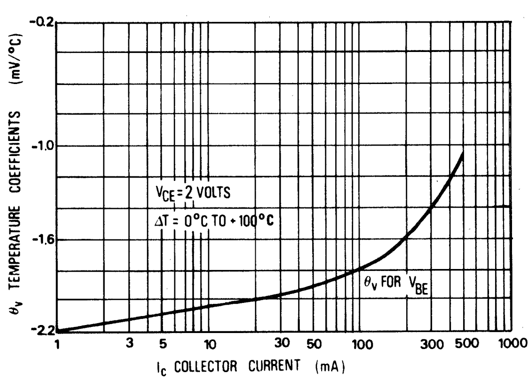
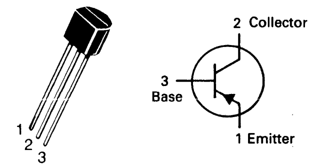


FIG. 5 — TEMPERATURE COEFFICIENTS



BC636
BC638
BC640

CASE 29-04, STYLE 14
TO-92 (TO-226AA)



HIGH CURRENT TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC636	BC638	BC640	Unit
Collector-Emitter Voltage	V_{CEO}	−45	−60	−80	Vdc
Collector-Base Voltage	V_{CBO}	−45	−60	−80	Vdc
Emitter-Base Voltage	V_{EBO}		−5.0		Vdc
Collector Current — Continuous	I_C		−0.5		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D		1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = -10$ mAdc, $I_B = 0$) BC636	$V_{(BR)CEO}$	−45	—	—	Vdc
BC638		−60	—	—	
BC640		−80	—	—	
Collector-Base Breakdown Voltage ($I_C = -100$ μAdc, $I_E = 0$) BC636	$V_{(BR)CBO}$	−45	—	—	Vdc
BC638		−60	—	—	
BC640		−80	—	—	
Emitter-Base Breakdown Voltage ($I_E = -10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = -30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	−100	nAdc
($V_{CB} = -30$ Vdc, $I_E = 0$, $T_A = 125°C$)		—	—	−10	μAdc
ON CHARACTERISTICS*					
DC Current Gain ($I_C = -5.0$ mAdc, $V_{CE} = -2.0$ Vdc)	h_{FE}	25	—	—	—
($I_C = -150$ mAdc, $V_{CE} = -2.0$ Vdc) BC636		40	—	250	
BC638		40	—	160	
BC640		40	—	160	
($I_C = -500$ mA, $V_{CE} = -2.0$ V)		25	—	—	
Collector-Emitter Saturation Voltage ($I_C = -500$ mAdc, $I_B = -50$ mAdc)	$V_{CE(sat)}$	— —	−0.25 −0.5	−0.5 —	Vdc
Base-Emitter On Voltage ($I_C = -500$ mAdc, $V_{CE} = -2.0$ Vdc)	$V_{BE(on)}$	—	—	−1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = -50$ mAdc, $V_{CE} = -2.0$ Vdc, f = 100 MHz)	f_T	—	150	—	MHz
Output Capacitance ($V_{CB} = -10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	9.0	—	pF
Input Capacitance ($V_{EB} = -0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ib}	—	110	—	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

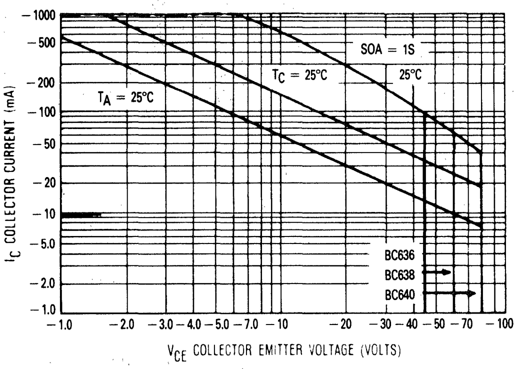


FIG. 2 — DC CURRENT GAIN

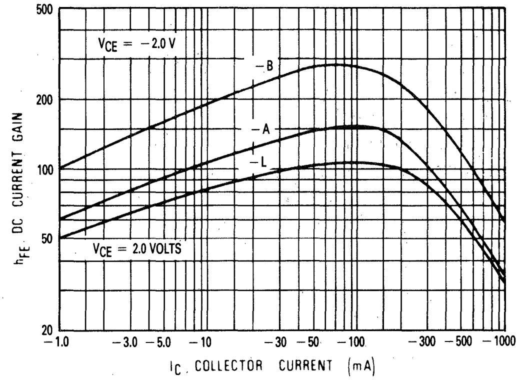


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

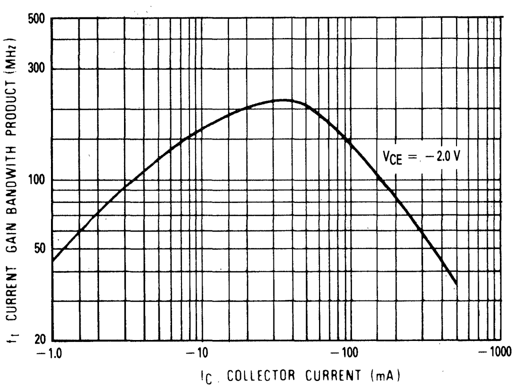


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

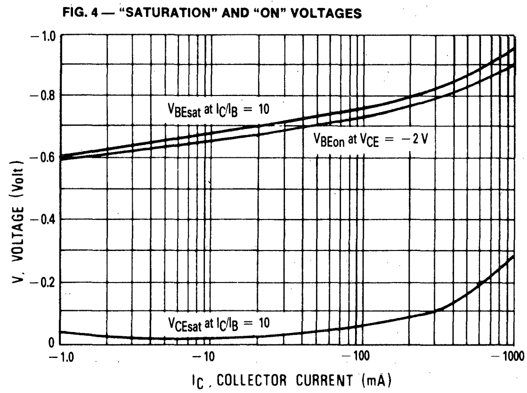
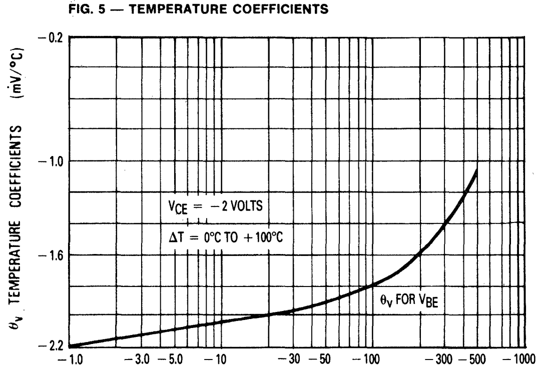


FIG. 5 — TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−45	V
Collector-Base Voltage	V_{CBO}	−50	V
Emitter-Base Voltage	V_{EBO}	−5.0	V
Collector Current — Continuous	I_C	−500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

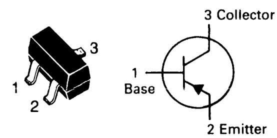
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BC807-16LT1 = 5A; BC807-25LT1 = 5B; BC807-40LT1 = 5C

BC807-16LT1
BC807-25LT1
BC807-40LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

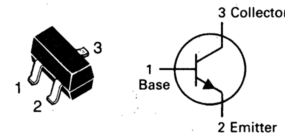
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = −10 mA)		$V_{(BR)CEO}$	−45	—	—	V
Collector-Emitter Breakdown Voltage (V_{EB} = 0, I_C = −10 μA)		$V_{(BR)CES}$	−50	—	—	V
Emitter-Base Breakdown Voltage (I_E = −1.0 μA)		$V_{(BR)EBO}$	−5.0	—	—	V
Collector Cutoff Current		I_{CBO}				
(V_{CB} = −20 V)			—	—	−100	nA
(V_{CB} = −20 V, T_J = 150°C)			—	—	−5.0	μA
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = −100 mA, V_{CE} = −1.0 V)	BC807-16		100	—	250	
	BC807-25		160	—	400	
	BC807-40		250	—	600	
(I_C = −500 mA, V_{CE} = −1.0 V)			40	—	—	
Collector-Emitter Saturation Voltage (I_C = −500 mA, I_B = −50 mA)		$V_{CE(sat)}$	—	—	−0.7	V
Base-Emitter On Voltage (I_C = −500 mA, I_B = −1.0 V)		$V_{BE(on)}$	—	—	−1.2	V
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −10 mA, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	200	—	—	MHz
Output Capacitance (V_{CB} = −10 V, f = 1.0 MHz)		C_{obo}	—	10	—	pF

Note: "LT1" must be used when ordering SOT-23 devices.

BC817-16LT1
BC817-25LT1
BC817-40LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	V
Collector-Base Voltage	V_{CBO}	50	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BC817-16LT1 = 6A; BC817-25LT1 = 6B; BC817-40LT1 = 6C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mA)	$V_{(BR)CEO}$	45	—	—	V
Collector-Emitter Breakdown Voltage (V_{EB} = 0, I_C = −10 μA)	$V_{(BR)CES}$	50	—	—	V
Emitter-Base Breakdown Voltage (I_E = −1.0 μA)	$V_{(BR)EBO}$	5.0	—	—	V
Collector Cutoff Current (V_{CB} = 20 V) (V_{CB} = 20 V, T_A = 150°C)	I_{CBO}	 — —	 — —	 100 5.0	 nA μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 1.0 V) BC817-16 BC817-25 BC817-40 (I_C = 500 mA, V_{CE} = 1.0 V)	h_{FE}	 100 160 250 40	 — — — —	 250 400 600 —	
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)	$V_{CE(sat)}$	—	—	0.7	V
Base-Emitter On Voltage (I_C = 500 mA, V_{CE} = 1.0 V)	$V_{BE(on)}$	—	—	1.2	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	200	—	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{obo}	—	10	—	pF

Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	BC846	BC847	BC848	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	30	V
Collector-Base Voltage	V_{CBO}	80	50	30	V
Emitter-Base Voltage	V_{EBO}	6.0	6.0	5.0	V
Collector Current — Continuous	I_C	100	100	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

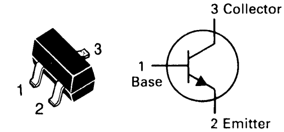
*FR-5 = 1.0 x 0.75 x 0.062 in. **Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BC846ALT1 = 1A; BC846BLT1 = 1B; BC847ALT1 = 1E; BC847BLT1 = 1F;
BC847CLT1 = 1G; BC848ALT1 = 1J; BC848BLT1 = 1K; BC848CLT1 = 1L

BC846ALT1★, BLT1★
BC847ALT1★, BLT1★, CLT1★
BC848ALT1★, BLT1★, CLT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★These are Motorola designated preferred devices.

Refer to BC546 for graphs.

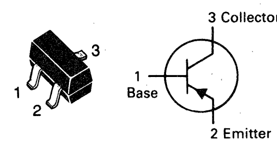
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	BC846A,B BC847A,B,C BC848A,B,C	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector-Emitter Breakdown Voltage (I_C = 10 μA, V_{EB} = 0)	BC846A,B BC847A,B,C BC848A,B,C	$V_{(BR)CES}$	80 50 30	— — —	— — —	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	BC846A,B BC847A,B,C BC848A,B,C	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter-Base Breakdown Voltage (I_E = 1.0 μA)	BC846A,B BC847A,B,C BC848A,B,C	$V_{(BR)EBO}$	6.0 6.0 5.0	— — —	— — —	V
Collector Cutoff Current (V_{CB} = 30 V) (V_{CB} = 30 V, T_A = 150°C)		I_{CBO}	— —	— —	15 5.0	nA μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5.0 V)	BC846A, BC847A, BC848A BC846B, BC847B, BC848B BC847C, BC848C	h_{FE}	— — —	90 150 270	— — —	—
(I_C = 2.0 mA, V_{CE} = 5.0 V)	BC846A, BC847A, BC848A BC846B, BC847B, BC848B BC847C, BC848C		110 200 420	180 290 520	220 450 800	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5.0 mA)		$V_{CE(sat)}$	— —	— —	0.25 0.6	V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5.0 mA)		$V_{BE(sat)}$	— —	0.7 0.9	— —	V
Base-Emitter Voltage (I_C = 2.0 mA, V_{CE} = 5.0 V) (I_C = 10 mA, V_{CE} = 5.0 V)		$V_{BE(on)}$	580 —	660 —	700 770	mV
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	—	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)		C_{obo}	—	—	4.5	pF
Noise Figure (I_C = 0.2 mA, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		N_F	—	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

BC856ALT1★, BLT1★
BC857ALT1★, BLT1★, CLT1★
BC858ALT1★, BLT1★, CLT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★These are Motorola designated preferred devices.

Refer to BC556 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC856	BC857	BC858	Unit
Collector-Emitter Voltage	V_{CEO}	−65	−45	−30	V
Collector-Base Voltage	V_{CBO}	−80	−50	−30	V
Emitter-Base Voltage	V_{EBO}	−5.0	−5.0	−5.0	V
Collector Current — Continuous	I_C	−100	−100	−100	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in. **Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BC856ALT1 = 3A; BC856BLT1 = 3B; BC857ALT1 = 3E; BC857BLT1 = 3F;
BC857CLT1 = 3G; BC858ALT1 = 3J; BC858BLT1 = 3K; BC858CLT1 = 3L

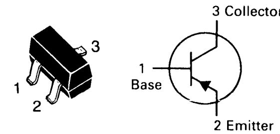
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = −10 mA)	BC856 Series BC857 Series BC858 Series	$V_{(BR)CEO}$	−65 −45 −30	— — —	— — —	V
Collector-Emitter Breakdown Voltage (I_C = −10 μA, V_{EB} = 0)	BC856 Series BC857 Series BC858 Series	$V_{(BR)CES}$	−10 −50 −30	— — —	— — —	V
Collector-Base Breakdown Voltage (I_C = −10 μA)	BC856 Series BC857 Series BC858 Series	$V_{(BR)CBO}$	−80 −50 −30	— — —	— — —	V
Emitter-Base Breakdown Voltage (I_E = −1.0 μA)	BC856 Series BC857 Series BC858 Series	$V_{(BR)EBO}$	−5.0 −5.0 −5.0	— — —	— — —	V
Collector Cutoff Current (V_{CB} = −30 V) (V_{CB} = −30 V, T_A = 150°C)		I_{CBO}	— —	— —	−15 −4.0	nA μA
ON CHARACTERISTICS						
DC Current Gain (I_C = −10 μA, V_{CE} = −5.0 V)	BC856A, BC857A, BC585A BC856A, BC857A, BC858A BC857C, BC858C	h_{FE}	— — —	90 150 270	— — —	—
(I_C = −2.0 mA, V_{CE} = −5.0 V)	BC856A, BC857A, BC858A BC856B, BC857B, BC858B BC857C, BC858C		125 220 420	180 290 520	250 475 800	
Collector-Emitter Saturation Voltage (I_C = −10 mA, I_B = −0.5 mA) ($_C$ = −100 mA, I_B = −5.0 mA)		$V_{CE(sat)}$	— —	— —	−0.3 −0.65	V
Base-Emitter Saturation Voltage (I_C = −10 mA, I_B = −0.5 mA) (I_C = −100 mA, I_B = −5.0 mA)		$V_{BE(sat)}$	— —	−0.7 −0.9	— —	V
Base-Emitter On Voltage (I_C = −2.0 mA, V_{CE} = −5.0 V) (I_C = −10 mA, V_{cE} = −5.0 V)		$V_{BE(on)}$	−0.6 —	— —	−0.75 −0.82	V
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = −10 mA, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	100	—	—	MHz
Output Capacitance (V_{CB} = −10 V, f = 1.0 MHz)		C_{ob}	—	—	4.5	pF
Noise Figure (I_C = −0.2 mA, V_{CE} = −5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

BCW29LT1
BCW30LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−32	Vdc
Collector-Base Voltage	V_{CBO}	−32	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW29LT1 = C1; BCW30LT1 = C2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	−32	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{EB} = 0)		$V_{(BR)CES}$	−32	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_C = 0)		$V_{(BR)CBO}$	−32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −32 Vdc, I_E = 0) (V_{CB} = −32 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	 — —	 −100 −10	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	 BCW29 BCW30	h_{FE}	 120 215	 260 500	 — —
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc)		$V_{CE(sat)}$	—	−0.3	Vdc
Base-Emitter On Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	−0.6	−0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (I_E = 0, V_{CB} = −10 Vdc, f = 1.0 MHz)		C_{obo}	—	7.0	pF
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

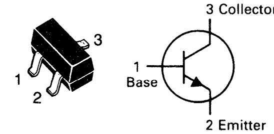
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW31LT1 = D1; BCW33LT1 = D3

BCW31LT1
BCW33LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to MPS3904 for graphs.

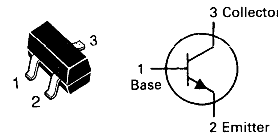
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW31 BCW33	h_{FE}	110 420	220 800	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.70	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

BCW60ALT1
BCW60BLT1
BCW60CLT1
BCW60DLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS
NPN SILICON

Refer to MPS3904 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	V
Collector-Base Voltage	V_{CBO}	32	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW60ALT1 = AA; BCW60BLT1 = AB; BCW60CLT1 = AC; BCW60DLT1 = AD

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current		I_{CES}			
(V_{CE} = 32 Vdc)			—	20	nAdc
(V_{CE} = 32 Vdc, T_A = 150°C)			—	20	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	BCW60A		20	—	
	BCW60B		30	—	
	BCW60C		40	—	
	BCW60D		100	—	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW60A		120	220	
	BCW60B		175	310	
	BCW60C		250	460	
	BCW60D		380	630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCW60A		60	—	
	BCW60B		70	—	
	BCW60C		90	—	
	BCW60D		100	—	
AC Current Gain		h_{fe}			—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCW60A		125	250	
	BCW60B		175	350	
	BCW60C		250	500	
	BCW60D		350	700	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			—	0.55	
(I_C = 10 mAdc, I_B = 0.25 mAdc)			—	0.35	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			0.7	1.05	
(I_C = 50 mAdc, I_B = 0.25 mAdc)			0.6	0.85	
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc

Note: "LT1" must be used when ordering SOT-23 devices.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	4.5	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−32	V
Collector-Base Voltage	V_{CBO}	−32	V
Emitter-Base Voltage	V_{EBO}	−5.0	V
Collector Current — Continuous	I_C	−100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

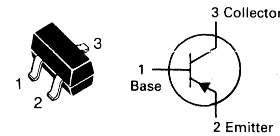
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW61ALT1 = BA; BCW61BLT1 = BB; BCW61CLT1 = BC; BCW61DLT1 = BD

BCW61ALT1
BCW61BLT1
BCW61CLT1
BCW61DLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

Refer to 2N5086 for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −32 Vdc)		I_{CES}	—	−20	nAdc
(V_{CE} = −32 Vdc, T_A = 150°C)			—	−20	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	BCW61A	h_{FE}	20	—	—
	BCW61B		30	—	
	BCW61C		40	—	
	BCW61D		100	—	
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	BCW61A		120	220	
	BCW61B		140	310	
	BCW61C		250	460	
	BCW61D		380	630	
(I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	BCW61A		60	—	
	BCW61B		80	—	
	BCW61C		100	—	
	BCW61D		100	—	
AC Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	BCW61A	h_{fe}	125	250	—
	BCW61B		175	350	
	BCW61C		250	500	
	BCW61D		350	700	
Collector-Emitter Saturation Voltage (I_C = −50 mAdc, I_B = −1.25 mAdc)		$V_{CE(sat)}$	—	−0.55	Vdc
(I_C = −10 mAdc, I_B = −0.25 mAdc)			—	−0.25	
Base-Emitter Saturation Voltage (I_C = −50 mAdc, I_B = −1.25 mAdc)		$V_{BE(sat)}$	−0.68	−1.05	Vdc
(I_C = −10 mAdc, I_B = −0.25 mAdc)			−0.6	−0.85	
Base-Emitter On Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	−0.6	−0.75	Vdc

Note: "LT1" must be used when ordering SOT-23 devices.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CE} = −10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = −1.0 mAdc, V_{BB} = −3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

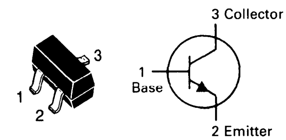
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW65ALT1 = EA

BCW65ALT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	32	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc, I_E = 0) (V_{CE} = 32 Vdc, I_E = 0, T_A = 150°C)	I_{CES}	 — —	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 75 100 35	 — — — —	 — 220 250 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — —	 0.7 0.3	 — —	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	80	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (I_{B1} = I_{B2} = 15 mAdc)	t_{on}	—	—	100	ns
Turn-Off Time (I_C = 150 mAdc, R_L = 150 Ω)	t_{off}	—	—	400	ns

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−45	Vdc
Collector-Base Voltage	V_{CBO}	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−800	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

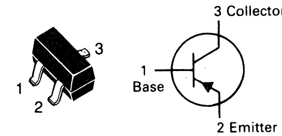
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW68GLT1 = DH

BCW68GLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

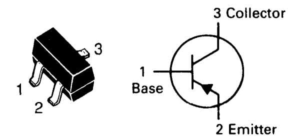
PNP SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−45	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −10 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = −45 Vdc, I_E = 0) (V_{CE} = −45 Vdc, I_B = 0, T_A = 150°C)	I_{CES}	 — —	 — —	 −20 −10	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	—	−20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc) (I_C = −300 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 120 160 60	 — — —	 400 — —	—
Collector-Emitter Saturation Voltage (I_C = −300 mAdc, I_B = −30 mAdc)	$V_{CE(sat)}$	—	—	−1.5	Vdc
Base-Emitter Saturation Voltage (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{BE(sat)}$	—	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −20 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	100	—	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	18	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	105	pF
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	N_F	—	—	10	dB

BCW69LT1
BCW70LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−45	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−100	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW69LT1 = H1; BCW70LT1 = H2

Refer to 2N5086 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−45	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	−50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −20 Vdc, I_E = 0) (V_{CB} = −20 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	— —	−100 −10	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc) BCW69 BCW70	h_{FE}	120 215	260 500	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc)	$V_{CE(sat)}$	—	−0.3	Vdc
Base-Emitter On Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	$V_{BE(on)}$	−0.6	−0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (I_E = 0, V_{CB} = −10 Vdc, f = 1.0 MHz)	C_{obo}	—	7.0	pF
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	N_F	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

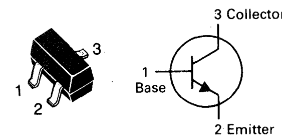
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCW71LT1 = K1; BCW72LT1 = K2

BCW71LT1
BCW72LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to MPS3904 for graphs.

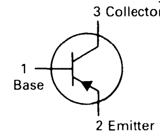
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

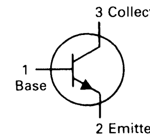
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, V_{EB} = 0)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, V_{EB} = 0)	$V_{(BR)CES}$	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 — —	 100 10	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc) BCW71 BCW72	h_{FE}	 110 200	 — —	 220 450	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	 — —	 — 0.21	 0.25 —	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	—	0.85	—	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.6	—	0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	—	300	—	MHz
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ibo}	—	9.0	—	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB

Note: "LT1" must be used when ordering SOT-23 devices.

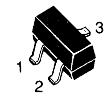
PNP **NPN**

BCX17LT1 [1] BCX19LT1
BCX18LT1 [1] BCX20LT1





CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

2

MAXIMUM RATINGS

Rating	Symbol	Value BCX17LT1 BCX19LT1	Value BCX18LT1 BCX20LT1	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCX17LT1 = T1; BCX18LT1 = T2; BCX19LT1 = U1; BCX20LT1 = U2

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	BCX17, 19	$V_{(BR)CEO}$	45	—	—	Vdc
	BCX18, 20		25	—	—	
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $I_C = 0$)	BCX17, 19	$V_{(BR)CES}$	50	—	—	Vdc
	BCX18, 20		30	—	—	
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	—	—	100	nAdc
($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150°C$)			—	—	5.0	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	10	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	100	—	600	—
($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc)			70	—	—	
($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)			40	—	—	
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	—	—	0.62	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	—	1.2	Vdc

(1) Voltage and current are negative for PNP transistors.
Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

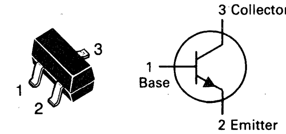
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BCX70GLT1 = AG; BCX70JLT1 = AJ; BCX70KLT1 = AK

BCX70GLT1
BCX70JLT1
BCX70KLT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to MPS3904 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current		I_{CES}			
(V_{CE} = 32 Vdc)			—	20	nAdc
(V_{CE} = 32 Vdc, T_A = 150°C)			—	20	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	BCX70G		—	—	
	BCX70J		40	—	
	BCX70K		100	—	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCX70G		120	220	
	BCX70J		250	460	
	BCX70K		380	630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCX70G		60	—	
	BCX70J		90	—	
	BCX70K		100	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			—	0.55	
(I_C = 10 mAdc, I_B = 0.25 mAdc)			—	0.35	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)			0.7	1.05	
(I_C = 50 mAdc, I_B = 0.25 mAdc)			0.6	0.85	
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.75	Vdc

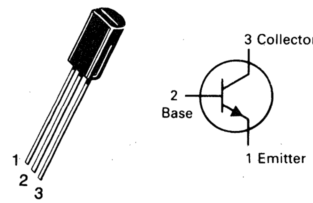
Note: "LT1" must be used when ordering SOT-23 devices.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}			—
	BCX70G		125	250	
	BCX70J		250	500	
	BCX70K		350	700	
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz		NF	—	6.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R1 = R2 = 5.0 kΩ, R_L = 990 Ω)		t_{off}	—	800	ns

BDB01C,D

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT
AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BDB01C	BDB01D	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CES}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	0.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°c/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage (I_C = 10 mA, I_B = 0)	BDB01C BDB01D	$V_{(BR)CEO}$	80 100	— —	Vdc
Collector Cutoff Current (V_{CB} = 80 V, I_E = 0) (V_{CB} = 100 V, I_E = 0)	BDB01C BDB01D	I_{CBO}	— —	.01 .01	μAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = 5.0 V)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 1.0 V) (I_C = 500 mA, V_{CE} = 2.0 V)		h_{FE}	40 25	400 —	—
Collector-Emitter Saturation Voltage* (I_C = 1000 mA, I_B = 100 mA)		$V_{CE(sat)}$	—	0.7	Vdc
Collector-Emitter On Voltage* (I_C = 1000 mA, V_{CE} = 1.0 V)		$V_{BE(on)}$	—	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 200 mA, V_{CE} = 5.0 V, f = 20 MHz		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz		C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

FIGURE 1 – D.C. CURRENT GAIN

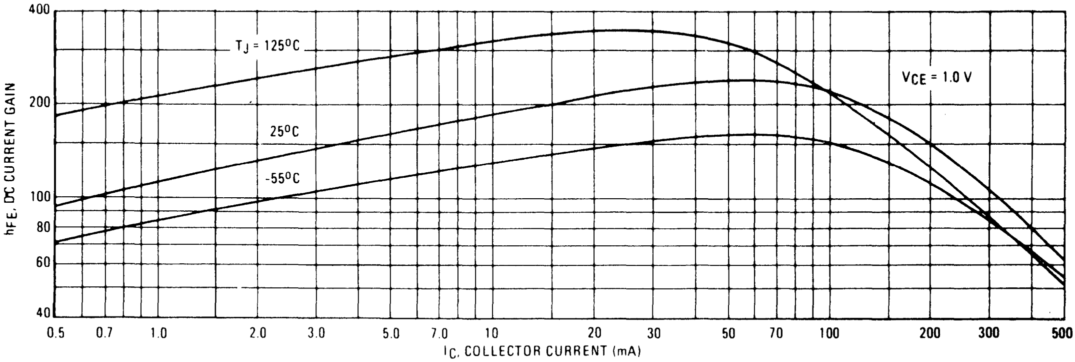


FIGURE 2 – COLLECTOR SATURATION REGION

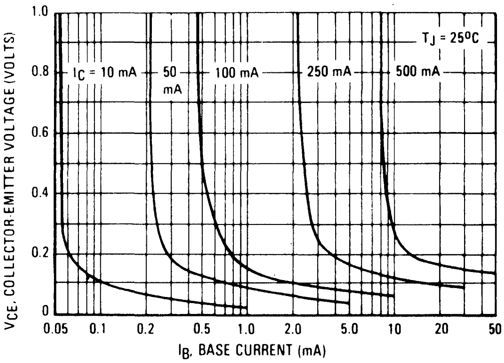


FIGURE 3 – ON VOLTAGES

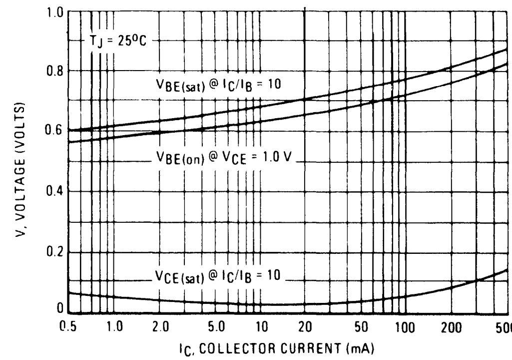


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

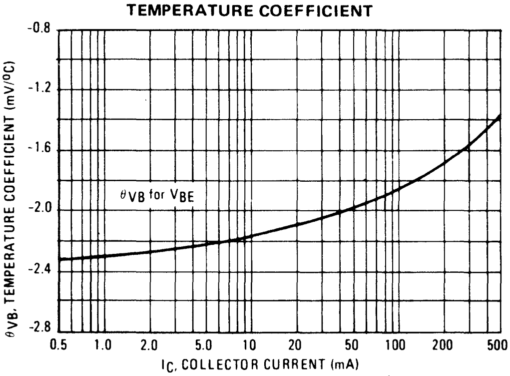


FIGURE 5 – CAPACITANCE

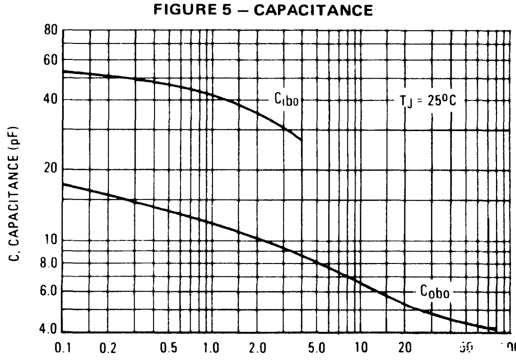


FIGURE 6 – CURRENT GAIN-BANDWIDTH PRODUCT

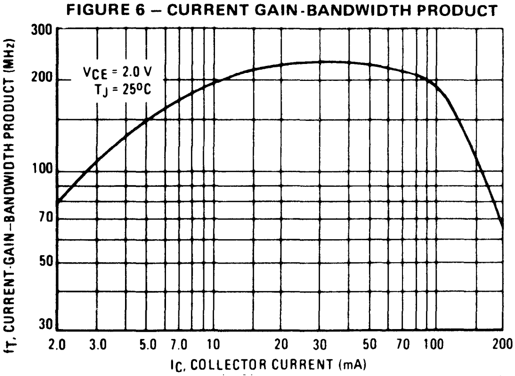
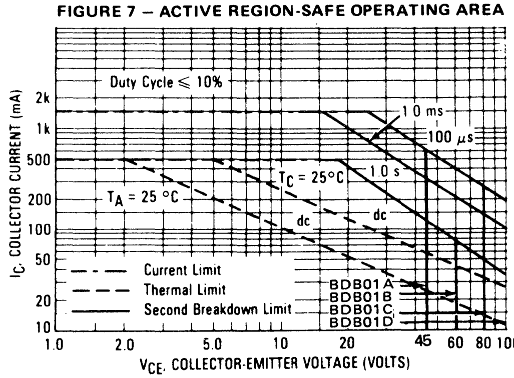
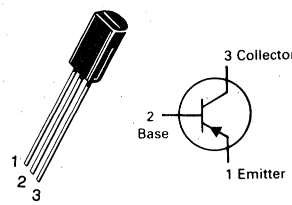


FIGURE 7 – ACTIVE REGION-SAFE OPERATING AREA



BDB02C,D

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BDB02C	BDB02D	Unit
Collector-Emitter Voltage	V_{CEO}	−80	−100	Vdc
Collector-Base Voltage	V_{CES}	−80	−100	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−0.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°c/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage (I_C = −10 mA, I_B = 0)	BDB02C BDB02D	$V_{(BR)CEO}$	−80 −100	— —	Vdc
Collector Cutoff Current (V_{CB} = −80 V, I_E = 0) (V_{CB} = −100 V, I_E = 0)	BDB02C BDB02D	I_{CBO}	— —	−0.1 −0.1	μAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = −5.0 V)		I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −100 mA, V_{CE} = −1.0 V) (I_C = −500 mA, V_{CE} = −2.0 V)		h_{FE}	40 25	400 —	—
Collector-Emitter Saturation Voltage* (I_C = −1000 mA, I_B = −100 mA)		$V_{CE(sat)}$	—	−0.7	Vdc
Collector-Emitter On Voltage* (I_C = −1000 mA, V_{CE} = −1.0 V)		$V_{BE(on)}$	—	−1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = −200 mA, V_{CE} = −5.0 V, f = 20 MHz		f_T	50	—	MHz
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz		C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

FIGURE 1 — D.C. CURRENT GAIN

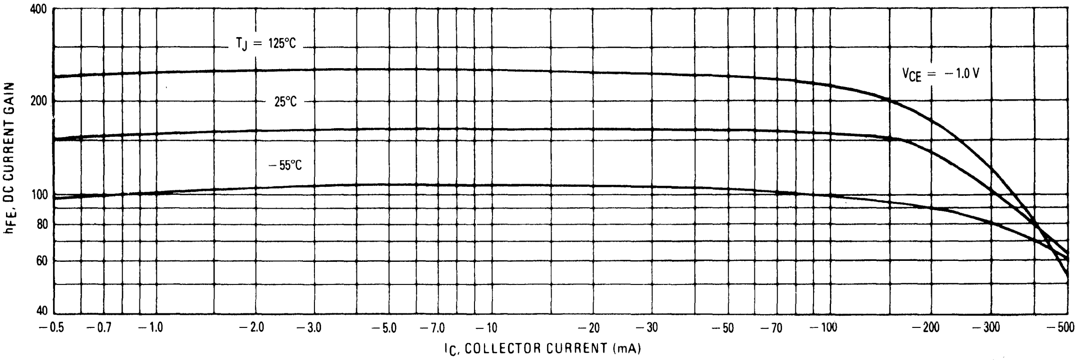


FIGURE 2 — COLLECTOR SATURATION REGION

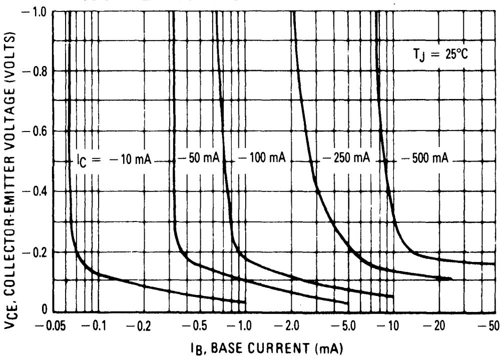


FIGURE 3 — ON VOLTAGES

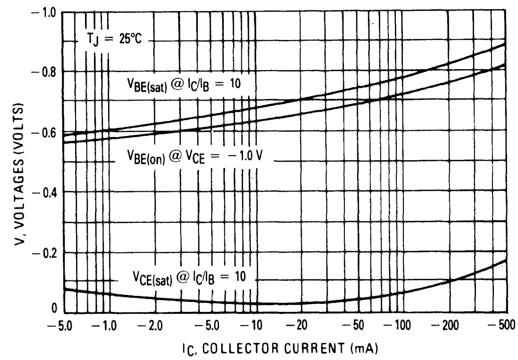


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

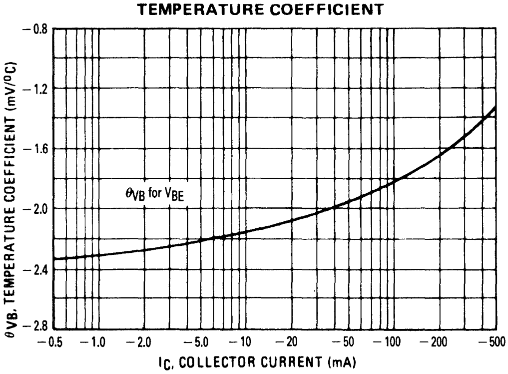


FIGURE 5 — CAPACITANCE

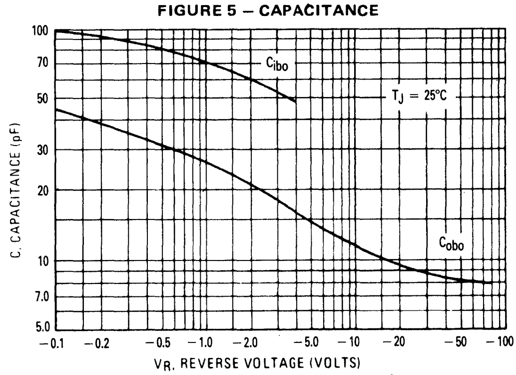


FIGURE 6 — CURRENT GAIN-BANDWIDTH PRODUCT

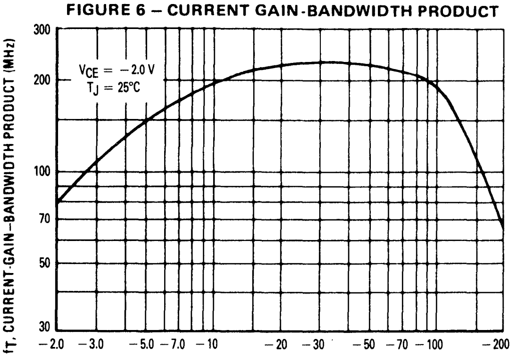
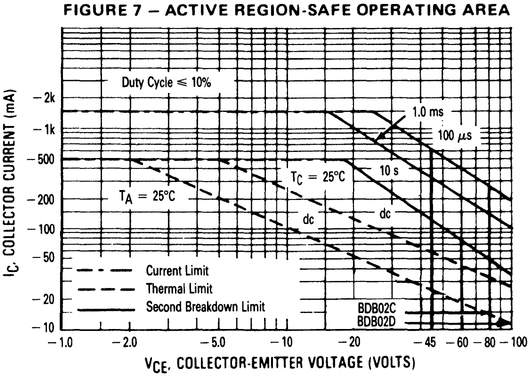


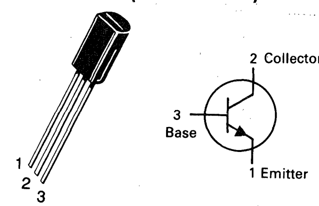
FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



2

BDC01D

CASE 29-03, STYLE 14
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSW05 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BDC01D	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

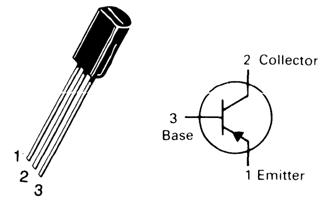
ELECTRICAL CHARACTERISTICS (T_A = 25°c unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	100	—	Vdc
Collector Cutoff Current (V_{CB} = 100 V, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = 5.0 V)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mA, V_{CE} = 1.0 V) (I_C = 500 mA, V_{CE} = 2.0 V)	h_{FE}	 40 25	 400 —	—
Collector-Emitter Saturation Voltage* (I_C = 1000 mA, I_B = 100 mA)	$V_{CE(sat)}$	—	0.7	Vdc
Collector-Emitter On Voltage* (I_C = 1000 mA, V_{CE} = 1.0 V)	$V_{BE(on)}$	—	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 200 mA, V_{CE} = 5.0 V, f = 20 MHz	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

BDC02D

CASE 29-03, STYLE 14
TO-92 (TO-226AE)



ONE WATT
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPSW55 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	BDC02D	Unit
Collector-Emitter Voltage	V_{CEO}	−100	Vdc
Collector-Base Voltage	V_{CBO}	−100	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

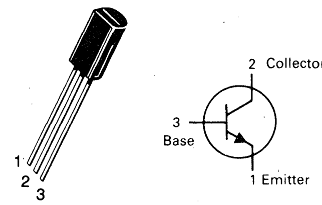
ELECTRICAL CHARACTERISTICS (T_A = 25°c unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage (I_C = −10 mA, I_B = 0)	$V_{(BR)CEO}$	−100	—	Vdc
Collector Cutoff Current (V_{CB} = −100 V, I_E = 0)	I_{CBO}	—	−0.1	μAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = −5.0 V)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −100 mA, V_{CE} = −1.0 V) (I_C = −500 mA, V_{CE} = −2.0 V)	h_{FE}	 40 25	 400 —	—
Collector-Emitter Saturation Voltage* (I_C = −1000 mA, I_B = −100 mA)	$V_{CE(sat)}$	—	−0.7	Vdc
Collector-Emitter On Voltage* (I_C = −1000 mA, V_{CE} = −1.0 V)	$V_{BE(on)}$	—	−1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = −200 mA, V_{CE} = −5.0 V, f = 20 MHz	f_T	50	—	MHz
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	30	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

BDC05

CASE 29-03, STYLE 14
TO-92 (TO-226AE)



ONE WATT
HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSW42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 50	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

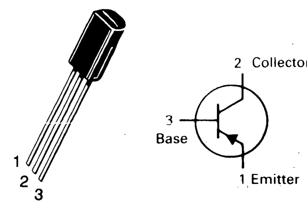
ELECTRICAL CHARACTERISTICS (T_A = 25°c unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 25 mAdc, V_{CE} = 20 Vdc)	h_{FE}	40	—	—
Collector-Emitter Saturation Voltage* (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	2	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)	$V_{BE(sat)}$	—	2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}	—	2.8	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

BDC06

CASE 29-03, STYLE 14
TO-92 (TO-226AE)



ONE WATT
HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to MPSW92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−300	Vdc
Collector-Base Voltage	V_{CBO}	−300	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°c unless otherwise noted)

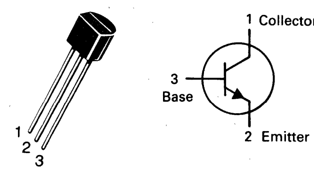
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−300	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)CEO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0)	I_{CBO}	—	−0.01	μAdc
Emitter Cutoff Current (V_{EB} = −5.0 Vdc, I_C = 0)	I_{EBO}	—	−10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −25 mA, V_{CE} = −20 Vdc)	h_{FE}	40	—	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	$V_{CE(sat)}$	—	−2.0	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mA, I_B = −2.0 mA)	$V_{BE(sat)}$	—	−2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = −30 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}	—	2.8	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.

2

BF199

CASE 29-04, STYLE 21
TO-92 (TO-226AA)



RF TRANSISTOR

NPN SILICON

Refer to BF240 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current − Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

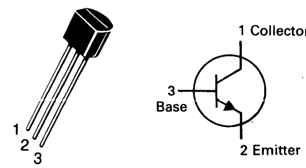
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	$V_{(BR)CEO}$	25			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4			Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	85		
Base-Emitter On Voltage (I_C = 7 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$		770	900	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain−Bandwidth Product (2) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	750		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}		0.25	0.35	pF
Noise Figure (I_C = 4 mA, V_{CE} = 10 V, R_S = 50 Ω, f = 35 MHz)	N_f		2.5		dB

BF224

CASE 29-04, STYLE 21
TO-92 (TO-226AA)



RF TRANSISTOR

NPN SILICON

Refer to BF240 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current − Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

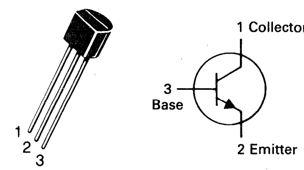
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	$V_{(BR)CEO}$	30			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	45			Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4			Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) T_A = 25°C	I_{CBO}			100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30			
Base-Emitter On Voltage (I_C = 7 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$		0.77	0.9	mVdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$			0.15	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain−Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 7 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	600 850		MHz
Common Emitter Feedback Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{re}		0.28		pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 100 MHz) f = 200 MHz	N_f		2.5 3.5		dB

BF240

CASE 29-04, STYLE 21
TO-92 (TO-226AA)



AM/FM TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current − Continuous	I_C	25	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	$V_{(BR)CEO}$	40			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4			Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 mAdc, V_{CE} = 10 Vdc)	h_{FE}	65		220	—
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	0.65	0.70	0.74	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain−Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T		600		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}		0.28	0.34	pF

(1) Pulse test: Pulse Width ≦ 300 μs. Duty cycle ≦ 2.0%.

FIGURE 1 — CURRENT GAIN-BANDWIDTH PRODUCT

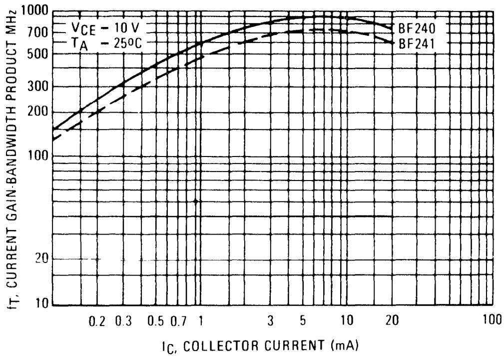


FIGURE 2 — CAPACITANCES

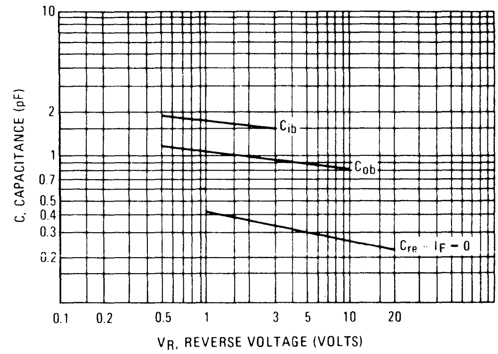


FIGURE 3 — DC CURRENT GAIN

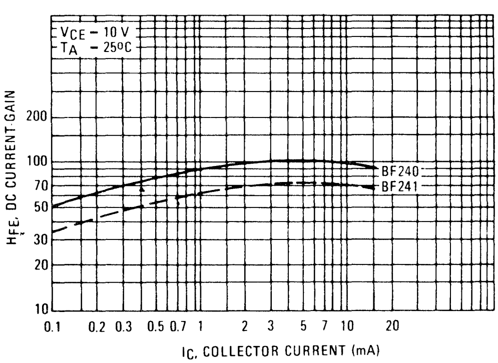


FIGURE 4 — b11e

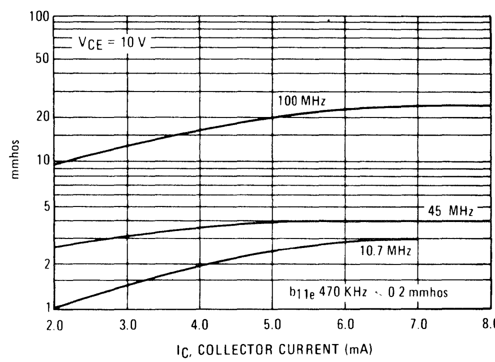


FIGURE 5 — b21e

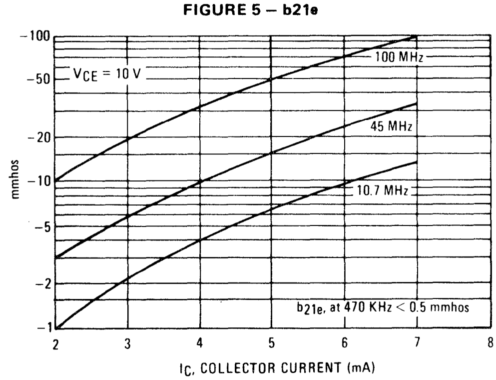


FIGURE 6 — b22e (boe)

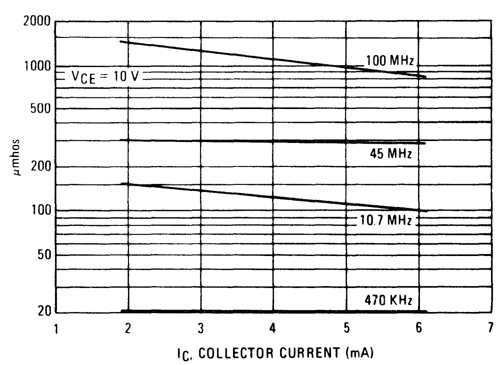


FIGURE 7 — g11e (gie)

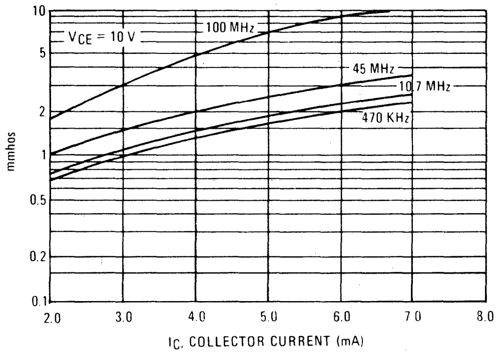


FIGURE 8 — g21e (Yfe)

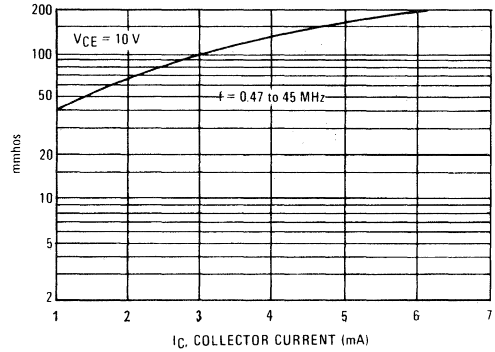
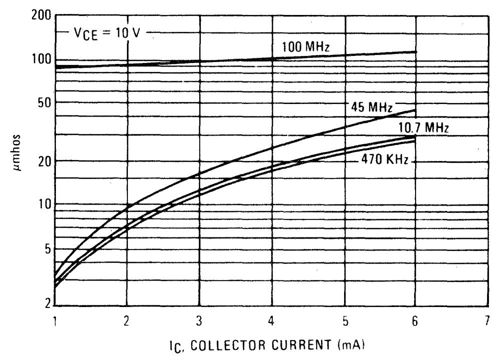
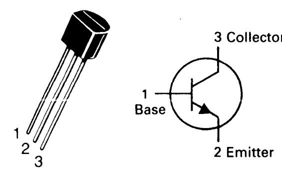


FIGURE 9 — g22e (goe)



BF374

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

Refer to MPSH10 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0			Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}			100	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	70		250	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$		 50 70		 mVdc mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$		830		mVdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc	$V_{BE(on)}$		 700 770		 mVdc mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	800		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}		0.55	0.6	pF
Collector-Base Time Constant (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz)	r_bC_c		6		ps
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz, R_s = 50 ohms)	N_f		4		dB
Common-Emitter Amplifier Power Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	G_{pe}		20		dB

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, frequency as stated)

Symbol	f = 10.7 MHz	f = 30 MHz	f = 100 MHz	Unit
G_{11e}	0.28	0.4	1.4	mmho
B_{11e}	0.6	1.6	5.0	mmho
G_{22e}	6.5	7	20	μmho
B_{22e}	0.1	0.3	1.0	mmho
G_{21e}	36	34	30	mmho
B_{21e}	− 0.8	− 2.5	− 9	mmho
B_{12e}	− 52	− 150	− 500	μmho

FIGURE 1 — INPUT ADMITTANCE
(Output short circuit)

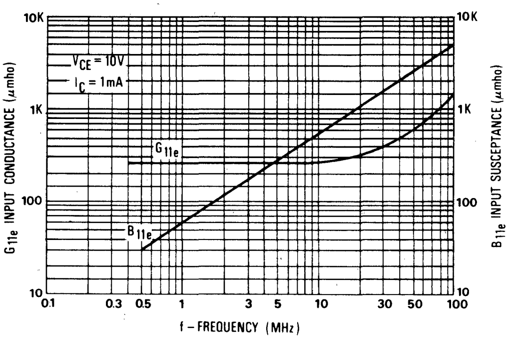


FIGURE 2 — OUTPUT ADMITTANCE
(Input short circuit)

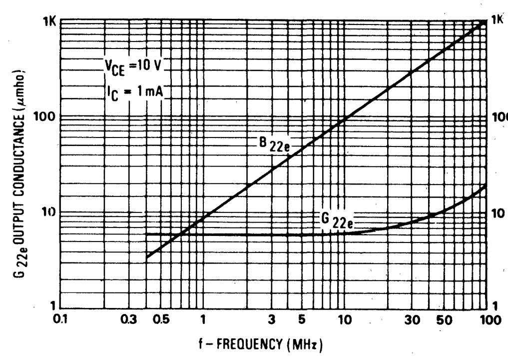


FIGURE 3 — FORWARD TRANSFER ADMITTANCE
(Output short circuit)

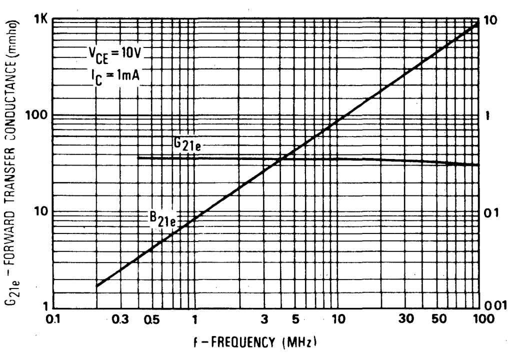
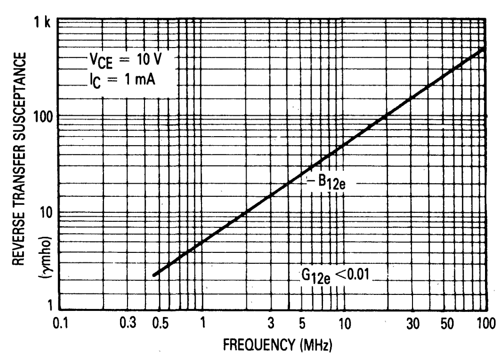
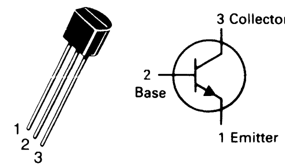


FIGURE 4 — REVERSE TRANSFER ADMITTANCE
(Input short circuit)



BF391 thru BF393

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 391	BF 392	BF 393	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	300	Vdc
Collector-Base Voltage	V_{CBO}	200	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current – Continuous	I_C	500			mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

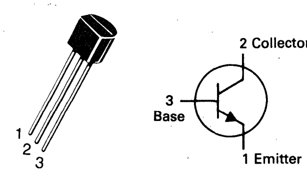
Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BF391 BF392 BF393	$V_{(BR)CEO}$	200 250 300	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BF391 BF392 BF393	$V_{(BR)CBO}$	200 250 300	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BF391 BF392 BF393	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	Vdc
Collector Cutoff Current (V_{CB} = 160 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0)	BF391 BF392 BF393	I_{CBO}	— — —	0.1 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0) (V_{EB} = 6.0 Vdc, I_C = 0) (V_{EB} = 6.0 Vdc, I_C = 0)	BF391 BF392 BF393	I_{EBO}	— — —	0.1 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types All Types	h_{FE}	25 40	— —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$		2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = 60 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		2.0	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2

BF420
BF422

CASE 29-04, STYLE 14
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 420	BF 422	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	Vdc
Collector-Base Voltage	V_{CBO}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

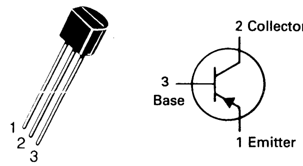
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	BF420 BF422	$V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BF420 BF422	$V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BF420 BF422	$V_{(BR)EBO}$	5.0 5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	BF420 BF422	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	BF420 BF422	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 25 mAdc, V_{CE} = 20 Vdc)	BF420 BF422	h_{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$		0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		1.6	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

BF421
BF423

CASE 29-04, STYLE 14
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 421	BF 423	Unit
Collector-Emitter Voltage	V_{CEO}	−300	−250	Vdc
Collector-Base Voltage	V_{CBO}	−300	−250	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_B = 0)	BF421 BF423	$V_{(BR)CEO}$	−300 −250	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	BF421 BF423	$V_{(BR)CBO}$	−300 −250	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	BF421 BF423	$V_{(BR)EBO}$	−5.0 −5.0	— —	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0)	BF421 BF423	I_{CBO}	— —	−0.01 —	μAdc
Emitter Cutoff Current (V_{EB} = −5.0 Vdc, I_C = 0)	BF421 BF423	I_{EBO}	— —	−100 —	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −25 mA, V_{CE} = −20 Vdc)	BF421 BF423	h_{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mA, I_B = −2.0 mA)		$V_{BE(sat)}$	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 20 MHz		f_T)	60	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = −30 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}	—	2.8	pF

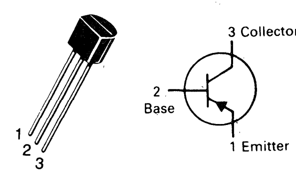
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

2

2

BF491 thru BF493

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF491	BF492	BF493	Unit
Collector-Emitter Voltage	V_{CEO}	−200	−250	−300	Vdc
Collector-Base Voltage	V_{CBO}	−200	−250	−300	Vdc
Emitter-Base Voltage	V_{EBO}		−6.0		Vdc
Collector Current — Continuous	I_C		−500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

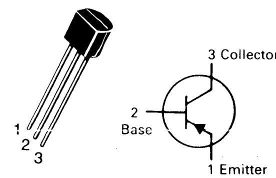
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_B = 0)	BF491 BF492 BF493	$V_{(BR)CEO}$	−200 −250 −300	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	BF491 BF492 BF493	$V_{(BR)CBO}$	−200 −250 −300	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	BF491 BF492 BF493	$V_{(BR)EBO}$	−6.0 −6.0 −6.0	— — —	Vdc
Collector Cutoff Current (V_{CB} = −160 Vdc, I_E = 0) (V_{CB} = −200 Vdc, I_E = 0) (V_{CB} = −200 Vdc, I_E = 0)	BF491 BF492 BF493	I_{CBO}	— — —	−0.1 −0.1 −0.1	μAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0) (V_{EB} = −6.0 Vdc, I_C = 0) (V_{EB} = −6.0 Vdc, I_C = 0)	BF491 BF492 BF493	I_{EBO}	— — —	−0.1 −0.1 −0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = 10 Vdc)	All Types All Types	h_{FE}	25 40	— —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{CE(sat)}$	—	−2.0	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mA, I_B = −2.0 mA)		$V_{BE(sat)}$	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = −100 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}	—	1.6	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

BF493S

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to MPSA93 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−350	Vdc
Collector-Base Voltage	V_{CBO}	−350	Vdc
Emitter-Base Voltage	V_{EBO}	−6.0	Vdc
Collector Current — Continuous	I_C	−500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−350	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−6.0	—	Vdc
Collector Cutoff Current (V_{CE} = −250 Vdc)	I_{CES}	—	−10	nAdc
Emitter Cutoff Current (V_{EB} = −6.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = −250 Vdc, I_E = 0, T_A = 25°C) (V_{CB} = −250 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 −0.005 −1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc)	h_{FE}	 25 40	 — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	$V_{CE(sat)}$	—	−2.0	Vdc
Base-Emitter On Voltage (I_C = −20 mA, I_B = −2.0 mA)	$V_{BE(sat)}$	—	−2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 20 MHz)	F_T	50	—	MHz
Common-Emitter Feedback Capacitance (V_{CB} = −100 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}	—	1.6	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Collector-Emitter Voltage	V_{CER}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation up to $T_A = 25°C$	P_D	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

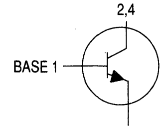
DC

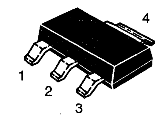
THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

BF720T1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
NPN SILICON
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

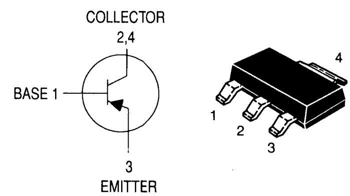
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $R_{BE} = 2.7$ kΩ)	$V_{(BR)CER}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector-Base Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)	I_{CBO}	—	10	nAdc
Collector-Emitter Cutoff Current ($V_{CE} = 250$ Vdc, $R_{BE} = 2.7$ kΩ) ($V_{CE} = 200$ Vdc, $R_{BE} = 2.7$ kΩ, $T_J = 150°C$)	I_{CER}	— —	50 10	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 25$ mAdc, $V_{CE} = 20$ Vdc)	h_{FE}	50	—	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 35 MHz)	f_T	60	—	MHz
Feedback Capacitance ($V_{CE} = 30$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{re}	—	1.6	pF

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

BF721T1★

CASE 318E-04, STYLE 1 (TO-261AA)



SOT-223 PACKAGE PNP SILICON TRANSISTOR SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 300	Vdc
Collector-Base Voltage	V_{CBO}	– 300	Vdc
Collector-Emitter Voltage	V_{CER}	– 300	Vdc
Emitter-Base Voltage	V_{EBO}	– 5.0	Vdc
Collector Current	I_C	– 100	mAdc
Total Power Dissipation up to T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

DF

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

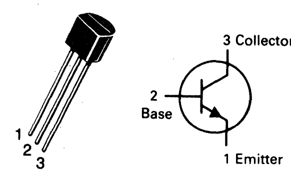
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = – 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	– 300	—	Vdc
Collector-Base Breakdown Voltage (I_C = – 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	– 300	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = – 100 μAdc, R_{BE} = 2.7 kΩ)	$V_{(BR)CER}$	– 300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = – 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	– 5.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = – 200 Vdc, I_E = 0)	I_{CBO}	—	– 10	nAdc
Collector-Emitter Cutoff Current (V_{CE} = – 250 Vdc, R_{BE} = 2.7 kΩ) (V_{CE} = – 200 Vdc, R_{BE} = 2.7 kΩ, T_J = 150°C)	I_{CER}	— —	– 50 – 10	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = – 25 mAdc, V_{CE} = – 20 Vdc)	h_{FE}	50	—	—
Collector-Emitter Saturation Voltage (I_C = – 30 mAdc, I_B = – 5.0 mAdc)	$V_{CE(sat)}$	—	– 0.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = – 10 Vdc, I_C = – 10 mAdc, f = 35 MHz)	f_T	60	—	MHz
Feedback Capacitance (V_{CE} = – 30 Vdc, I_C = 0, f = 1.0 MHz)	C_{re}	—	1.6	pF

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

2

BF844

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSA44 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	Vdc
Collector-Base Voltage	V_{CBO}	450	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	400	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	450	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	450	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 400 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 400 Vdc, V_{BE} = 0)	I_{CES}	—	500	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 40 50 45 20	 — 200 — —	—
Collector-Emitter Saturation Voltage (1) (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — — —	 0.4 0.5 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.75	Vdc

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS				
High Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	$\|h_{fe}\|$	1.0	—	
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	110	pF
Turn-On Time (V_{CC} = 150 Vdc, $V_{BE(off)}$ = 4.0 V, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	0.6	μs
Turn-Off Time (V_{CC} = 150 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 3.0 mAdc)	t_{off}	—	10	μs

FIGURE 1 — DC CURRENT GAIN

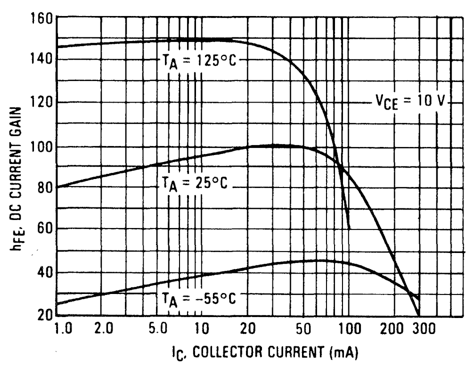
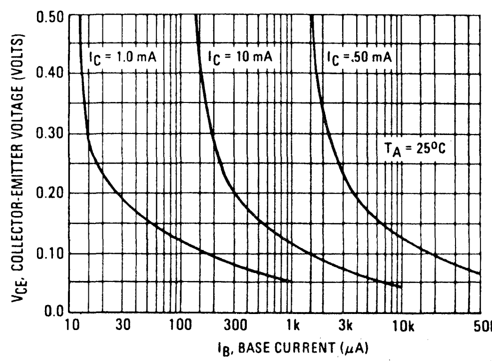


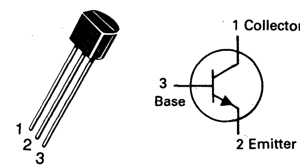
FIGURE 2 — COLLECTOR SATURATION REGION



2

BF959

CASE 29-04, STYLE 21
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5 mAdc, V_{CE} = 10 Vdc) (I_C = 20 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 35 40	 — —	 — —	
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	—	—	1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_t	 700 600	 — —	 — —	MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, P_f = 0, f = 10 MHz)	C_{re}	—	0.65'	—	pF
Noise Figure (I_C = 4 mA, V_{CE} = 10 V, R_S = 50 Ω, f = 200 MHz)	N_f	—	3	—	dB

FIGURE 1 – Hfe AT 10 V

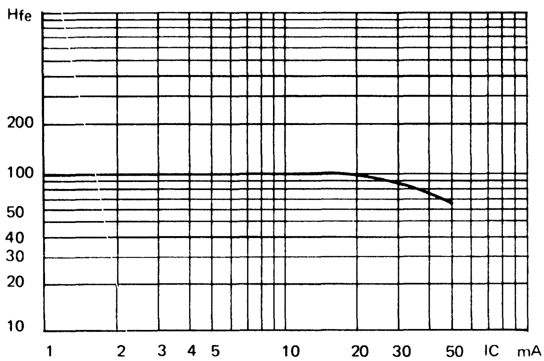


FIGURE 2 – VCE Sat AT IC/IB = 10

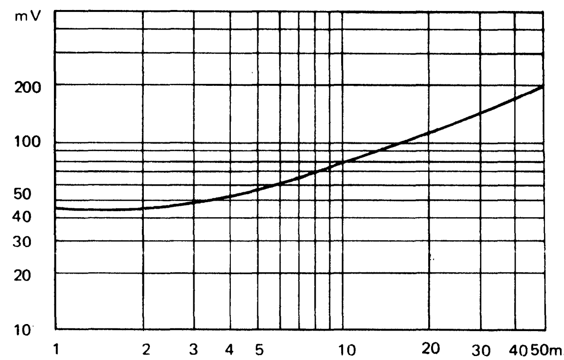


FIGURE 3 – CURRENT-GAIN – BANDWIDTH-PRODUCT

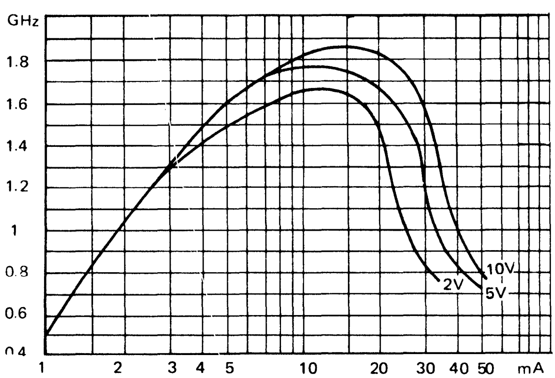


FIGURE 4 – CAPACITANCES

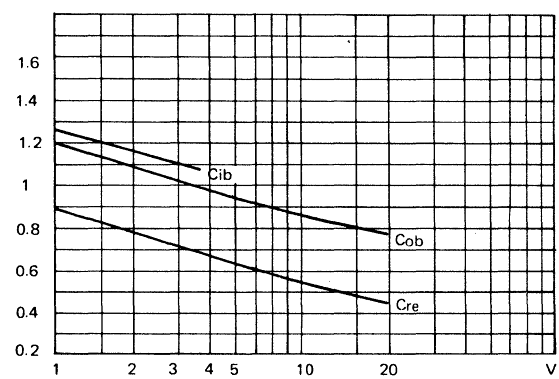


FIGURE 5 – INPUT IMPEDANCE AT 30 MHz

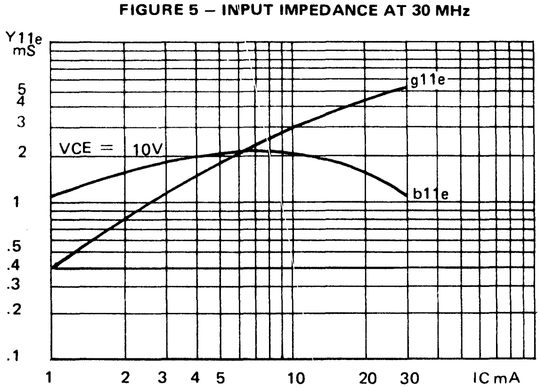
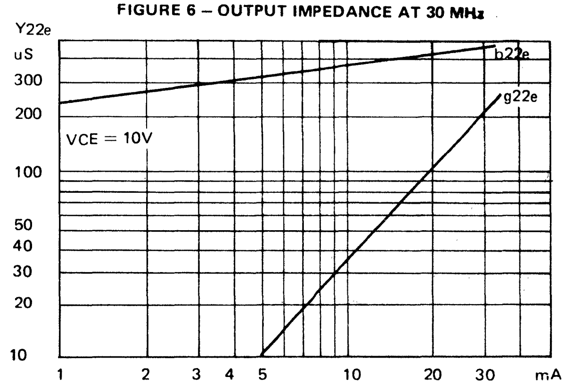
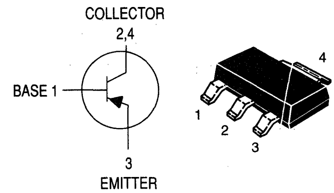


FIGURE 6 – OUTPUT IMPEDANCE AT 30 MHz



BSP16T1★

CASE 318E-04, STYLE 1
(TO-261AA)



SOT-223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 300	Vdc
Collector-Base Voltage	V_{CBO}	– 350	Vdc
Emitter-Base Voltage	V_{EBO}	– 6.0	Vdc
Collector Current	I_C	– 1000	mAdc
Base Current	I_B	– 500	mAdc
Total Power Dissipation, T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

BT2

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = – 50 mAdc, I_B = 0, L = 25 mH)	$V_{(BR)CEO}$	– 300	—	Vdc
Collector-Base Breakdown Voltage (I_C = – 100 µAdc, I_E = 0)	$V_{(BR)CBO}$	– 300	—	Vdc
Collector-Emitter Cutoff Current (V_{CE} = – 250 Vdc, I_B = 0)	I_{CEO}	—	– 50	µAdc
Collector-Base Cutoff Current (V_{CB} = – 280 Vdc, I_E = 0)	I_{CBO}	—	– 1.0	µAdc
Emitter-Base Cutoff Current (V_{EB} = – 6.0 Vdc, I_C = 0)	I_{EBO}	—	– 20	µAdc
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = – 10 Vdc, I_C = – 50 mAdc)	h_{FE}	30	120	—
Collector-Emitter Saturation Voltage (I_C = – 50 mAdc, I_B = – 5.0 mAdc)	$V_{CE(sat)}$	—	– 2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = – 10 Vdc, I_C = – 10 mAdc, f = 30 MHz)	f_T	15	—	MHz
Collector-Base Capacitance (V_{CB} = – 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−100	Vdc
Collector-Emitter Voltage R_{BE} = 10 kΩ	V_{CER}	−110	Vdc
Collector Current — Continuous	I_C	−100	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

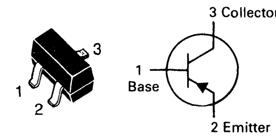
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BSS63LT1 = T1

BSS63LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

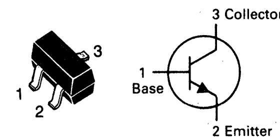
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc)	$V_{(BR)CEO}$	−100	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −10 μAdc, I_E = 0, R_{BE} = 10 kΩ)	$V_{(BR)CER}$	−110	—	—	Vdc
Collector-Base Breakdown Voltage (I_E = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−110	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc)	$V_{(BR)EBO}$	−6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −90 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
Collector Cutoff Current (V_{CE} = −110 Vdc, R_{BE} = 10 kΩ)	I_{CER}	—	—	−10	μAdc
Emitter Cutoff Current (V_{EB} = −6.0 Vdc, I_C = 0)	I_{EBO}	—	—	−200	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −25 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 30 30	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = −25 mAdc, I_B = −2.5 mAdc)	$V_{CE(sat)}$	—	—	−250	mVdc
Base-Emitter Saturation Voltage (I_C = −25 mAdc, I_B = −2.5 mAdc)	$V_{BE(sat)}$	—	—	−900	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I_C = −25 mAdc, V_{CE} = −5.0 Vdc, f = 20 MHz)	f_T	50	95	—	MHz
Case Capacitance (I_E = I_C = 0, V_{CB} = −10 Vdc, f = 1.0 MHz)	C_C	—	—	5.0	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mA

BSS64LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DRIVER TRANSISTOR

NPN SILICON

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

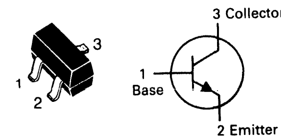
BSS64LT1 = AM

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 4.0 mA)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 90 V) (T_A = 150°C)	I_{CBO}	 — —	 0.1 500	μA
Emitter Cutoff Current (V_{EB} = 4.0V)	I_{EBO}	—	200	nA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 1.0 V, I_C = 10 mA)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 4.0 mA, I_B = 400 μA) (I_C = 50 mA, I_B = 15 mA)	$V_{CE(sat)}$	 — —	 0.15 0.2	Vdc
Forward Base-Emitter Voltage	$V_{BE(sat)}$	—	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mA, V_{CE} = 10 V, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{ob}	—	5.0	pF

BSV52LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

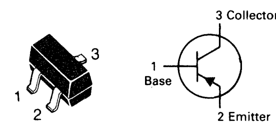
BSV52LT1 = B2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc)	$V_{(BR)CEO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
(V_{CB} = 10 Vdc, I_E = 0, T_A = 125°C)		—	5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	—	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		25	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 300 μAdc)	$V_{CE(sat)}$	—	300	mVdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	250	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	400	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	700	850	mVdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	1200	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.5	pF
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	—	13	ns
Turn-On Time (V_{BE} = 1.5 Vdc, I_C = 10 mAdc, I_B = 3.0 mAdc)	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mAdc, I_B = 3.0 mAdc)	t_{off}	—	18	ns

MMBT404ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



CHOPPER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−35	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−25	Vdc
Collector Current — Continuous	I_C	−150	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

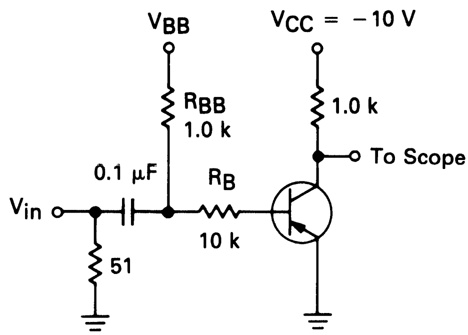
MMBT404ALT1 = 2N

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−35	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−25	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −10 Vdc, I_C = 0)	I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −12 mAdc, V_{CE} = −0.15 Vdc)	h_{FE}	100	—	400	—
Collector-Emitter Saturation Voltage (I_C = −12 mAdc, I_B = −0.4 mAdc) (I_C = −24 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	 — —	 — —	 −0.15 −0.20	Vdc
Base-Emitter Saturation Voltage (I_C = −12 mAdc, I_B = −0.4 mAdc) (I_C = −24 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$	 — —	 — —	 −0.85 −1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = −6.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	20	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = −10 Vdc, I_C = −10 mAdc) (Figure 1)	t_d	—	43	—	ns
Rise Time (I_{B1} = −1.0 mAdc, $V_{BE(off)}$ = −14 Vdc)	t_r	—	180	—	ns
Storage Time (V_{CC} = −10 Vdc, I_C = −10 mAdc)	t_s	—	675	—	ns
Fall Time (I_{B1} = I_{B2} = −1.0 mAdc) (Figure 1)	t_f	—	160	—	ns

2

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d, t_r	− 12	+1.4
t_{off}, t_s and t_f	+20.6	−11.6

Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and I_{B1} = I_{B2}

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

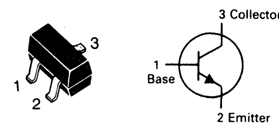
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT918LT1 = M3B

MMBT918LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



VHF/UHF TRANSISTOR

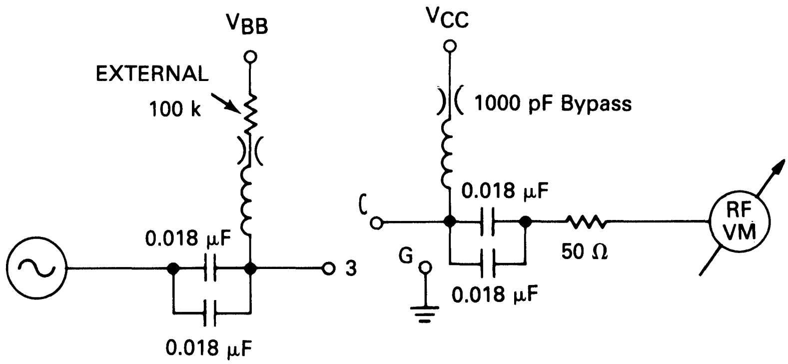
NPN SILICON

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance (V_{CB} = 0 Vdc, I_E = 0, f = 1.0 MHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	 — —	 3.0 1.7	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 Ω, f = 60 MHz) (Figure 1)	NF	—	6.0	dB
Power Output (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz)	P_{out}	30	—	mW
Common-Emitter Amplifier Power Gain (I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz)	G_{pe}	11	—	dB

FIGURE 1 — NF, Gpe MEASUREMENT CIRCUIT 20-200

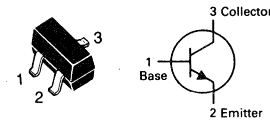


NF Test Conditions
I_C = 1.0 mA
V_{CE} = 6.0 Volts
R_S = 50 Ω
f = 60 MHz

G_{pe} Test Conditions
I_C = 6.0 mA
V_{CE} = 12 Volts
f = 200 MHz

MMBT2222LT1
MMBT2222ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPS2222 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBT2222	MMBT2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2222LT1 = M1B; MMBT2222ALT1 = 1P

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			Vdc
(I_C = 10 mAdc, I_B = 0)	MMBT2222		30	—	
	MMBT2222A		40	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 10 μAdc, I_E = 0)	MMBT2222		60	—	
	MMBT2222A		75	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MMBT2222		5.0	—	
	MMBT2222A		6.0	—	
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MMBT2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	MMBT2222		—	0.01	
(V_{CB} = 60 Vdc, I_E = 0)	MMBT2222A		—	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	MMBT2222		—	10	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	MMBT2222A		—	10	
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	MMBT2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MMBT2222A	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)			35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	MMBT2222A only		35	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)			100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)			50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	MMBT2222		30	—	
	MMBT2222A		40	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMBT2222		—	0.4	
	MMBT2222A		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMBTS2222		—	1.6	
	MMBT2222A		—	1.0	

Note: "LT1" must be used when ordering SOT-23 devices.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

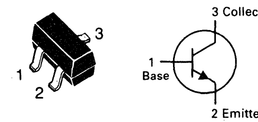
Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMBT2222		—	1.3	
	MMBT2222A		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMBT2222		—	2.6	
	MMBT2222A		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMBT2222		250	—	
	MMBT2222A		300	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MMBT2222		—	30	
	MMBT2222A		—	25	
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MMBT2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MMBT2222A	NF	—	4.0	dB
SWITCHING CHARACTERISTICS MMBT2222A only					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2

MMBT2369LT1
MMBT2369ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N2369 in Section 3 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2369LT1 = M1J   MMBT2369ALT1 = 1JA

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

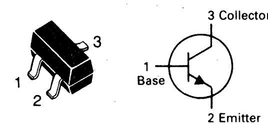
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)		$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 — —	 — —	 0.4 30	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	MMBT2369A	I_{CES}	—	—	0.4	μAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = −55°C) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	 MMBT2369 MMBT2369A MMBT2369A MMBT2369A MMBT2369A MMBT2369 MMBT2369A	h_{FE}	 40 — 40 20 30 20 20	 — — — — — — —	 120 120 — — — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	 MMBT2369 MMBT2369A MMBT2369A MMBT2369A MMBT2369A	$V_{CE(sat)}$	 — — — — —	 — — — — —	 0.25 0.20 0.30 0.25 0.50	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = −55°C) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	 MMBT2369,A MMBT2369A MMBT2369A MMBT2369A	$V_{BE(sat)}$	 0.7 — — —	 — — — —	 0.85 1.02 1.15 1.60	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS					
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc)	t_s	—	5.0	13	ns
Turn-On Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	8.0	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	—	10	18	ns

MMBT2484LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



LOW NOISE TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2484LT1 = 1U

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0, T_A 150°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 250 —	 — 800	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	3.0	dB

MAXIMUM RATINGS

Rating	Symbol	MMBT2907	MMBT2907A	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

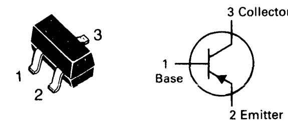
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT2907LT1 = M2B MMBT2907ALT1 = 2F

MMBT2907LT1
MMBT2907ALT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPS2907 for graphs.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	 MMBT2907 MMBT2907A	$V_{(BR)CEO}$	 −40 −60	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc)		I_{CEX}	—	−50	nAdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0, T_A = 125°C)	 MMBT2907 MMBT2907A MMBT2907 MMBT2907A	I_{CBO}	 — — — —	 −0.020 −0.010 −20 −10	μAdc
Base Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc		I_B	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 Vdc (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −150 mAdc, V_{CE} = −10 Vdc)(1) (I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	 MMBT2907 MMBT2907A MMBT2907 MMBT2907A MMBT2907 MMBT2907A MMBT2907 MMBT2907A MMBT2907 MMBT2907A	h_{FE}	 35 75 50 100 75 100 100 30 50	 — — — — — — 300 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)		$V_{CE(sat)}$	 — —	 −0.4 −1.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)		$V_{BE(sat)}$	 — —	 −1.3 −2.6	Vdc

Note: "LT1" must be used when ordering SOT-23 devices.

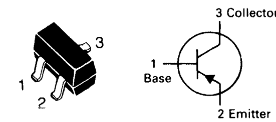
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1),(2) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-On Time	(V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 mAdc)	t_{off}	—	100	ns
Delay Time		t_s	—	80	ns
Rise Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MMBT3640LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−12	Vdc
Collector-Base Voltage	V_{CBO}	−12	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−80	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT3640LT1 = 2J

Refer to MPS3640 for graphs.

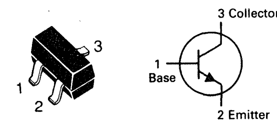
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	— —	−0.01 −1.0	μAdc
Base Current (V_{CE} = −6.0 Vdc, V_{EB} = 0)	I_B	—	−10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −10 mAdc, V_{CE} = −0.3 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	— — —	−0.2 −0.6 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	−0.75 −0.8 —	−0.95 −1.0 −1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time — (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{EB(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc)	t_d	—	10	ns
Rise Time — (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{EB(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc)	t_r	—	30	ns
Storage Time — (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_s	—	20	ns
Fall Time — (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_f	—	12	ns
Turn-On Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{EB(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = −0.5 mAdc)	t_{on}	 — —	 25 60	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{EB(off)}$ = −1.9 V, I_{B1} = I_{B2} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −0.5 mAdc)	t_{off}	 —	 35 75	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT3904LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N3903 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT3904LT1 = 1AM

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CEO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain(1)	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		40	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		70	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		60	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		30	—	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.3	
Base-Emitter Saturation Voltage(1)	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	0.95	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.5	8.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°c unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)		NF	—	5.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = −0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	200	ns
Fall Time		t_f	—	50	

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

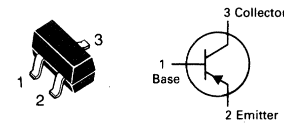
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT3906LT1 = 2.0 A

MMBT3906LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3905 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Base Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)	I_{BL}	—	−50	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc	I_{CEX}	—	−50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 60 80 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	 — —	 −0.25 −0.4	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	 −0.65 —	 −0.85 −0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	10.0	pF
Input Impedance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{ie}	2.0	12	k ohms
Voltage Feedback Ratio (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{re}	0.1	10	X 10^{-4}
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

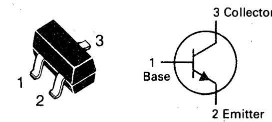
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted).

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = −3.0 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	75	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT4401LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N4401 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT4401LT1 = 2X

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)	(I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage	(I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage	(I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current	(V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current	(V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)	I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain	(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	20 40 80 100 40	— — — 300 —	—
Collector-Emitter Saturation Voltage	(I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage	(I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.75 —	0.95 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product	(I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance	(V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	6.5	pF
Emitter-Base Capacitance	(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	30	pF
Input Impedance	(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	15	k ohms
Voltage Feedback Ratio	(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.1	8.0	$X\ 10^{-4}$
Small-Signal Current Gain	(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	40	500	—
Output Admittance	(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	30	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, V_{EB} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−600	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

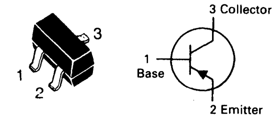
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT4403LT1 = 2T

MMBT4403LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



SWITCHING TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N4402 for graphs.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

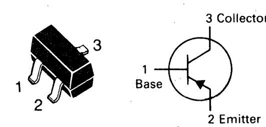
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)	(I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage	(I_C = −0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage	(I_E = −0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Base Cutoff Current	(V_{CE} = −35 Vdc, V_{EB} = −0.4 Vdc)	I_{BEV}	—	−0.1	μAdc
Collector Cutoff Current	(V_{CE} = −35 Vdc, V_{EB} = −0.4 Vdc)	I_{CEX}	—	−0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain	(I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −150 mAdc, V_{CE} = −2.0 Vdc)(1) (I_C = −500 mAdc, V_{CE} = −2.0 Vdc)(1)	h_{FE}	30 60 100 100 20	— — — 300 —	—
Collector-Emitter Saturation Voltage(1)	(I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{CE(sat)}$	— —	−0.4 −0.75	Vdc
Base-Emitter Saturation Voltage(1)	(I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{BE(sat)}$	−0.75 —	−0.95 −1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product	(I_C = −20 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Collector-Base Capacitance	(V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	8.5	pF
Emitter-Base Capacitance	(V_{BE} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	30	pF
Input Impedance	(I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{ie}	1.5k	15k	ohms
Voltage Feedback Ratio	(I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{re}	0.1	8.0	$X 10^{-4}$
Small-Signal Current Gain	(I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	60	500	—
Output Admittance	(I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	100	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 Vdc, V_{EB} = −2.0 Vdc,	t_d	—	15	ns
Rise Time	I_C = −150 mAdc, I_{B1} = −15 mAdc)	t_r	—	20	ns
Storage Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc,	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = −15 mAdc)	t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MMBT5087LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



LOW NOISE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−50	Vdc
Collector-Base Voltage	V_{CBO}	−50	Vdc
Emitter-Base Voltage	V_{EBO}	−3.0	Vdc
Collector Current — Continuous	I_C	−50	mAdc

THERMAL CHARACTERISITCS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5087LT1 = 2Q

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−50	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−50	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0) (V_{CB} = −35 Vdc, I_E = 0)	I_{CBO}	 — —	 −10 −50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −100 μAdc, V_{CE} = −5.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	h_{FE}	 250 250 250	 800 — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.3	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$	—	−0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −500 μAdc, V_{CE} = −5.0 Vdc, f = 20 MHz)	f_T	40	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	h_{fe}	250	900	—
Noise Figure (I_C = −20 mAdc, V_{CE} = −5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 3.0 kΩ, f = 1.0 kHz)	NF	 — —	 2.0 2.0	dB

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MMBT5088	MMBT5089	
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

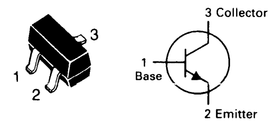
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5088LT1 = 1Q; MMBT5089LT1 = 1R

MMBT5088LT1
MMBT5089LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



LOW NOISE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPSA18 for graphs.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MMBT5088 MMBT5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBT5088 MMBT5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0)	MMBT5088 MMBT5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0) ($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)	MMBT5088 MMBT5089	I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089	h_{FE}	300 400	900 1200	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		350 450	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		300 400	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.8	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz emitter guarded)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz collector guarded)		C_{eb}	—	10	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	MMBT5088 MMBT5089	h_{fe}	350 450	1400 1800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz)	MMBT5088 MMBT5089	NF	— —	3.0 2.0	dB

Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−150	Vdc
Collector-Base Voltage	V_{CBO}	−160	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

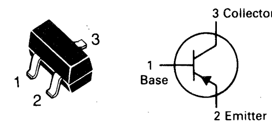
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5401LT1 = 2L

MMBT5401LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N5401 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−150	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−160	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −120 Vdc, I_E = 0) (V_{CB} = −120 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 −50 −50	 nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) (I_C = −50 mAdc, V_{CE} = −5.0 Vdc)	h_{FE}	 50 60 50	 — 240 —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	 — —	 −0.20 −0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	 — —	 −1.0 −1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	100	300	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Small Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	40	200	—
Noise Figure (I_C = −200 μAdc, V_{CE} = −5.0 Vdc, R_S = 10 ohms, f = 1.0 kHz)	NF	—	8.0	dB

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	140	Vdc
Collector-Base Voltage	V_{CBO}	160	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

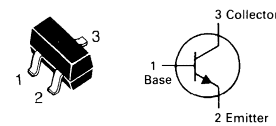
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT5550LT1 = M1F; MMBT5551LT1 = G1

MMBT5550LT1
MMBT5551LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N5550 for graphs.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	MMBT5550 MMBT5551	$V_{(BR)CEO}$	140 160	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBT5550 MMBT5551	$V_{(BR)CBO}$	160 180	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	 MMBT5550 MMBT5551 MMBT5550 MMBT5551	I_{CBO}	 — — — —	 100 50 100 50	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 MMBT5550 MMBT5551 MMBT5550 MMBT5551 MMBT5550 MMBT5551	h_{FE}	 60 80 60 80 20 30	 — — 250 250 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types MMBT5550 MMBT5551	$V_{CE(sat)}$	 — — —	 0.15 0.25 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types MMBT5550 MMBT5551	$V_{BE(sat)}$	 — — —	 1.0 1.2 1.0	Vdc

(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

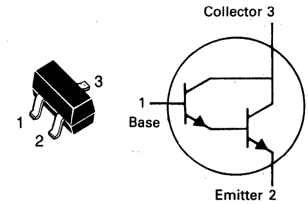
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT6427LT1 = 1V

MMBT6427LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DARLINGTON TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CEO}	—	1.0	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 10,000 20,000 14,000	 100,000 200,000 140,000	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 0.5 mAdc) (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$*	 — —	 1.2 1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	7.0	pF
Input Capacitance (V_{EB} = 0.5, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	15	pF
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	$\|h_{fe}\|$	1.3	—	Vdc
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 kΩ, f = 1.0 kHz)	NF	—	10	dB

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MMBT6428	MMBT6429	
Collector-Emitter Voltage	V_{CEO}	50	45	Vdc
Collector-Base Voltage	V_{CBO}	60	55	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

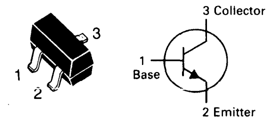
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT6428LT1 = 1KM; MMBT6429LT1 = 1L

MMBT6428LT1
MMBT6429LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPSA18 for graphs.

2

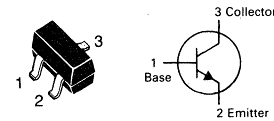
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			Vdc
(I_C = 1.0 mAdc, I_B = 0)	MMBT6428		50	—	
(I_C = 1.0 mAdc, I_B = 0)	MMBT6429		45	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 0.1 mAdc, I_E = 0)	MMBT6428		60	—	
(I_C = 0.1 mAdc, I_E = 0)	MMBT6429		55	—	
Collector Cutoff Current (V_{CE} = 30 Vdc)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	650	
	MMBT6429		500	1250	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)			—	0.2	
(I_C = 100 mAdc, I_B = 5.0 mAdc)			—	0.6	
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.56	0.66	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	700	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF

Note: "LT1" must be used when ordering SOT-23 devices.

MMBT6517LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6517 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	250	mA
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT6517LT1 = 1Z

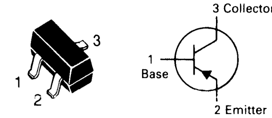
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 V)	I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 5.0 V)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 30 mA, V_{CE} = 10 V) (I_C = 50 mA, V_{CE} = 10 V) (I_C = 100 mA, V_{CE} = 10 V)	h_{FE}	 20 30 30 20 15	 — — 200 200 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{CE(sat)}$*	 — — — —	 0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA)	$V_{BE(sat)}$	 — — —	 0.75 0.85 0.90	Vdc
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 10 V)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	80	pF

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MMBT6520LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N6520 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−350	Vdc
Collector-Base Voltage	V_{CBO}	−350	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Base Current	I_B	−250	mA
Collector Current — Continuous	I_C	−500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBT6520LT1 = 2Z

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mA)	$V_{(BR)CEO}$	−350	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA)	$V_{(BR)CBO}$	−350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −250 V)	I_{CBO}	—	−50	nA
Emitter Cutoff Current (V_{EB} = −4.0 V)	I_{EBO}	—	−50	nA
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = −1.0 mA, V_{CE} = −10 V)		20	—	
(I_C = −10 mA, V_{CE} = −10 V)		30	—	
(I_C = −30 mA, V_{CE} = −10 V)		30	200	
(I_C = −50 mA, V_{CE} = −10 V)		20	200	
(I_C = −100 mA, V_{CE} = −10 V)		15	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = −10 mA, I_B = −1.0 mA)		—	−0.30	
(I_C = −20 mA, I_B = −2.0 mA)		—	−0.35	
(I_C = −30 mA, I_B = −3.0 mA)		—	−0.50	
(I_C = −50 mA, I_B = −5.0 mA)		—	−1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = −10 mA, I_B = −1.0 mA)		—	−0.75	
(I_C = −20 mA, I_B = −2.0 mA)		—	−0.85	
(I_C = −30 mA, I_B = −3.0 mA)		—	−0.90	
Base-Emitter On Voltage (I_C = −100 mA, V_{CE} = −10 V)	$V_{BE(on)}$	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mA, V_{CE} = −20 V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = −20 V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)	C_{eb}	—	100	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−80	V
Collector-Base Voltage	V_{CBO}	−80	V
Emitter-Base Voltage	V_{EBO}	−5.0	V
Collector Current — Continuous	I_C	−500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

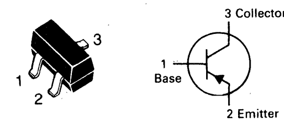
DEVICE MARKING

MMBT8599LT1 = 2W

2

MMBT8599LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N4125 for graphs.

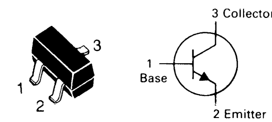
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_E = 0)	$V_{(BR)CEO}$	−80	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −80 Vdc, I_E = 0)	I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) (I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	h_{FE}	 100 100 75	 300 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −100 mAdc, I_B = −10 mAdc) (I_C = −100 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	 — —	 −0.3 −0.4	Vdc
Base-Emitter On Voltage(1) (I_C = −10 mAdc, I_B = −5.0 mAdc)	$V_{BE(on)}$	 −0.6	 −0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	150	—	MHz
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	4.5	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MMBTA05LT1
MMBTA06LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DRIVER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	MMBTA05	MMBTA06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA05LT1 = 1H; MMBTA06LT1 = 1GM

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MMBTA05 MMBTA06	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MMBTA05 MMBTA06	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 100 100	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mA, V_{CE} = 2.0 V, f = 100 MHz)		f_T	100	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	300	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

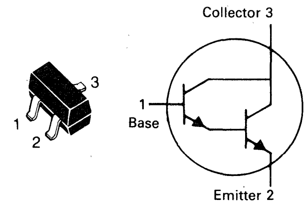
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA13LT1 = 1M; MMBTA14LT1 = 1N

MMBTA13LT1
MMBTA14LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DARLINGTON AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6426 for graphs.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBTA13 MMBTA14	h_{FE}	5000 10,000	— —	—
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MMBTA13 MMBTA14		10,000 20,000	— —	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		V_{BE}	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.
Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

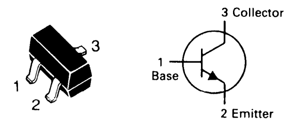
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA20LT1 = 1C

MMBTA20LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



GENERAL PURPOSE AMPLIFIER

NPN SILICON

Refer to MPS3904 for graphs.

2

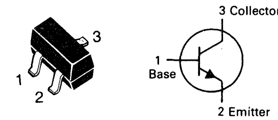
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF

2

MMBTA42LT1★
MMBTA43LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBTA42	MMBTA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA42LT1 = 1D; MMBTA43LT1 = M1E

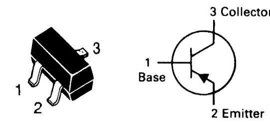
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MMBTA42 MMBTA43	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBTA42 MMBTA43	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	MMBTA42 MMBTA43	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	MMBTA42 MMBTA43	I_{EBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	Both Types Both Types MMBTA42 MMBTA43	h_{FE}	25 40 40 40	— — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MMBTA42 MMBTA43	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MMBTA42 MMBTA43	C_{cb}	— —	3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

MMBTA55LT1
MMBTA56LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DRIVER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MMBTA55	MMBTA56	Unit
Collector-Emitter Voltage	V_{CEO}	−60	−80	Vdc
Collector-Base Voltage	V_{CBO}	−60	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0		Vdc
Collector Current — Continuous	I_C	−500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA55LT1 = 2H; MMBTA56LT1 = 2GM

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	 MMBTA55 MMBTA56	$V_{(BR)CEO}$	 −60 −80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CE} = −60 Vdc, I_B = 0)		I_{CEO}	—	−0.1	μAdc
Collector Cutoff Current (V_{CB} = −60 Vdc, I_E = 0) (V_{CB} = −80 Vdc, I_E = 0)	 MMBTA55 MMBTA56	I_{CBO}	 — —	 −0.1 −0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc)		h_{FE}	 100 100	 — —	—
Collector-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −10 mAdc)		$V_{CE(sat)}$	—	−0.25	Vdc
Base-Emitter On Voltage (I_C = −100 mAdc, V_{CE} = −1.0 Vdc)		$V_{BE(on)}$	—	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc, f = 100 MHz)		f_T	50	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
Note: "LT1" must be used when ordering SOT-23 devices.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	−30	Vdc
Collector-Base Voltage	V_{CBO}	−30	Vdc
Emitter-Base Voltage	V_{EBO}	−10	Vdc
Collector Current — Continuous	I_C	−500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$ Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

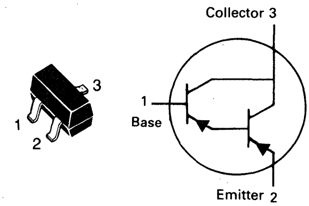
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA63LT1 = 2U; MMBTA64LT1 = 2V

MMBTA63LT1
MMBTA64LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



DARLINGTON TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPSA75 for graphs.

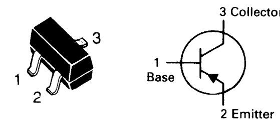
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = -100\ \mu Adc$)		$V_{(BR)CES}$	−30	—	Vdc
Collector Cutoff Current ($V_{CB} = -30$ Vdc)		I_{CBO}	—	−100	nAdc
Emitter Cutoff Current ($V_{EB} = -10$ Vdc)		I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			—
($I_C = -10$ mAdc, $V_{CE} = -5.0$ Vdc)	MMBTA63		5,000	—	
($I_C = -10$ mAdc, $V_{CE} = -5.0$ Vdc)	MMBTA64		10,000	—	
($I_C = -100$ mAdc, $V_{CE} = -5.0$ Vdc)	MMBTA63		10,000	—	
($I_C = -100$ mAdc, $V_{CE} = -5.0$ Vdc)	MMBTA64		20,000	—	
Collector-Emitter Saturation Voltage ($I_C = -100$ mAdc, $I_B = -0.1$ mAdc)		$V_{CE(sat)}$	—	−1.5	Vdc
Base-Emitter On Voltage ($I_C = -100$ mAdc, $V_{CE} = -5.0$ Vdc)		$V_{BE(on)}$	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = -10$ mAdc, $V_{CE} = -5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

MMBTA70LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AA)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA70LT1 = M2C

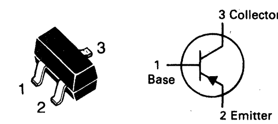
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −5.0 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF

2

MMBTA92LT1★
MMBTA93LT1

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBTA92	MMBTA93	Unit
Collector-Emitter Voltage	V_{CEO}	−300	−200	Vdc
Collector-Base Voltage	V_{CBO}	−300	−200	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	−5.0	Vdc
Collector Current — Continuous	I_C	−500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTA92LT1 = 2D; MMBTA93LT1 = 2E

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	MMBTA92 MMBTA93	$V_{(BR)CEO}$	−300 −200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	MMBTA92 MMBTA93	$V_{(BR)CBO}$	−300 −200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0) (V_{CB} = −160 Vdc, I_E = 0)	MMBTA92 MMBTA93	I_{CBO}	— —	−0.25 −0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = − 1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −30 mAdc, V_{CE} = −10 Vdc)	Both Types Both Types MMBTA92 MMBTA93	h_{FE}	25 40 25 25	— — — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	MMBTA92 MMBTA93	$V_{CE(sat)}$	— —	−0.5 −0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	MMBTA92 MMBTA93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
Note: "LT1" must be used when ordering SOT-23 devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

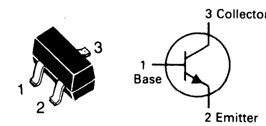
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH10LT1 = 3EM

MMBTH10LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



VHF/UHF TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPSH10 for graphs.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	—	—
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	V_{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.7	pF
Common-Base Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	—	0.65	pF
Collector Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	9.0	ps

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

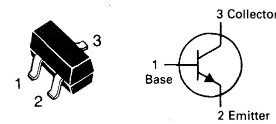
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH24LT1 = M3A

MMBTH24LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



VHF MIXER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

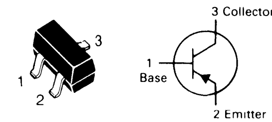
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.25	0.45	pF
Conversion Gain	—				dB
(213 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)	C_G	19	24	—	
(60 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)		24	29	—	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

- Designed for UHF/VHF Amplifier Applications
- High Current Gain Bandwidth Product
  f_T = 2000 MHz Min @ 10 mA

MMBTH69LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



UHF/VHF TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−15	Vdc
Collector-Base Voltage	V_{CBO}	−15	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH69LT1 = M3J

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc)	h_{FE}	30	—	300	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	2000	—	—	MHz
Collector-Base Capacitance (V_{CE} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	—	—	0.35	pF

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−20	Vdc
Collector-Base Voltage	V_{CBO}	−20	Vdc
Emitter-Base Voltage	V_{EBO}	−3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

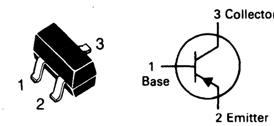
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBTH81LT1 = 3D

MMBTH81LT1★

CASE 318-07, STYLE 6
SOT-23 (TO-236AB)



UHF/VHF TRANSISTOR

PNP SILICON

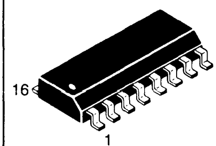
★This is a Motorola designated preferred device.

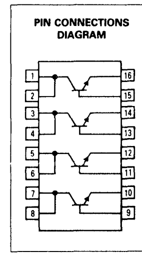
ELECTRICAL CHARACTERISTICS (T_A = 25°c unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −2.0 Vdc, I_C = 0)	I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage (I_C = −5.0 mAdc, I_B = −0.5 mAdc)	$V_{CE(sat)}$	—	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	$V_{BE(on)}$	—	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −5.0 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = −10 Vdc, f = 1.0 MHz)	C_{ce}	—	—	0.65	pF

MMPQ2222,A★

CASE 751B-03, STYLE 1
SO-16





QUAD GENERAL-PURPOSE TRANSISTORS

NPN SILICON

★MMPQ2222A is a Motorola designated preferred device.

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MAXIMUM RATINGS

Rating	Symbol	MMPQ2222	MMPQ2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.52 4.2	1.0 8.0	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.8 6.4	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MMPQ2222 MMPQ2222A	$V_{(BR)CEO}$	30 40	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MMPQ2222 MMPQ2222A	$V_{(BR)CBO}$	60 75	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0 —	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 MMPQ2222 MMPQ2222A	I_{CBO}	 — —	 — —	 50 10	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	MMPQ2222 MMPQ2222A	I_{EBO}	— —	— —	50 10	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 100 μA, V_{CE} = 10 V) (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 150 mA, V_{CE} = 10 V) (I_C = 300 mA, V_{CE} = 10 V) (I_C = 500 mA, V_{CE} = 10 V) (I_C = 150 mA, V_{CE} = 1.0 V)	 MMPQ2222A MMPQ2222A MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A MMPQ2222A	h_{FE}	 35 50 75 75 100 100 30 40 50	 — — — — — — — — —	 — — — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A	$V_{CE(sat)}$	 — — — —	 — — — —	 0.4 0.3 1.6 1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MMPQ2222 MMPQ2222A MMPQ2222 MMPQ2222A	$V_{BE(sat)}$	 — — — —	 — — — —	 1.3 1.2 2.6 2.0	Vdc

ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	—	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	4.5	—	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	17	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	25	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	250	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

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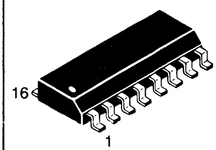
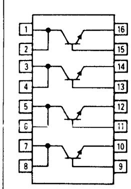
MMPQ2369★

CASE 751B-03, STYLE 1
SO-16



PIN CONNECTIONS DIAGRAM



QUAD SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	500	mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5 —	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.4	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	450	550	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	2.5	4.0	pF
Input Capacitance V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, ($V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	9.0	—	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	—	15	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

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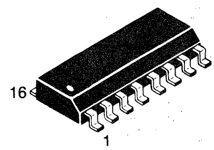
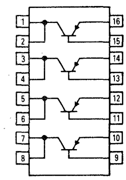
MMPQ2907,A★

CASE 751B-03, STYLE 1
SO-16



PIN CONNECTIONS DIAGRAM



QUAD GENERAL PURPOSE TRANSISTORS

PNP SILICON

★MMPQ2907A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MMPQ2907	MMPQ2907A	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CB}	−60		Vdc
Emitter-Base Voltage	V_{EB}	−5.0		Vdc
Collector Current — Continuous	I_C	−600		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.52 4.2	1.0 8.0	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.8 6.4	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	MMPQ2907 MMPQ2907A	$V_{(BR)CEO}$	−40 −60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0 —	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0)	 MMPQ2907 MMPQ2907A	I_{CBO}	 — —	 — —	 −50 −10	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	—	−50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = −100 μAdc, V_{CE} = −10 V) (I_C = −1.0 mAdc, V_{CE} = −10 V) (I_C = −10 mAdc, V_{CE} = −10 V) (I_C = −150 mAdc, V_{CE} = −10 V) (I_C = −300 mAdc, V_{CE} = −10 V) (I_C = −500 mAdc, V_{CE} = −10 V)	 MMPQ2907A MMPQ2907A MMPQ2907/2907A MMPQ2907/2907A MMPQ2907/2907A MMPQ2907/2907A	h_{FE}	 75 100 75/100 100 30/50 50	 — — — — — —	 — — — 300 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −300 mAdc, I_B = −30 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)	 MMPQ2907 MMPQ2907 MMPQ2907	$V_{CE(sat)}$	 — — —	 — — —	 −0.4 −1.6 −1.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −300 mAdc, I_B = −30 mAdc) (I_C = −500 mAdc, I_B = −15 mAdc)	 MMPQ2907 MMPQ2907 MMPQ2907A	$V_{BE(sat)}$	 — — —	 — — —	 −1.3 −2.6 −2.6	Vdc

ELECTRICAL CHARACTERISTICS (Continued)

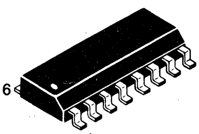
Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	—	350	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	6.0	—	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	20	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc)	t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 mAdc)	t_{off}	—	100	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

2

MMPQ3467★

CASE 751B-03, STYLE 1
SO-16

16

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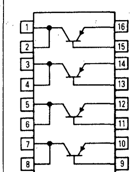
PIN CONNECTIONS DIAGRAM



QUAD MEMORY DRIVER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

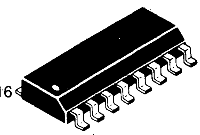
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	−40		Vdc
Collector-Base Voltage	V_{CB}	−40		Vdc
Emitter-Base Voltage	V_{EB}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.52 4.2	1.2 9.6	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

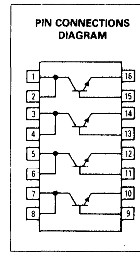
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0 —	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	—	−200	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	—	−200	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(1) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{CE(sat)}$	—	−0.23	−0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{BE(sat)}$	—	−0.9	−1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	—	190	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	10	—	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	55	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = −500 mAdc, I_{B1} = −50 mAdc)	t_{on}	—	20	—	ns
Turn-Off Time (I_C = −500 mAdc, I_{B1} = I_{B2} = −50 mAdc)	t_{off}	—	60	—	ns

MMPQ3725★

CASE 751B-03, STYLE 1
SO-16





QUAD CORE DRIVER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C
		Each Transistor	**Four Transistors Equal Power**	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.8	1.4 11.2	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 2.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

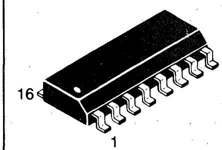
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0 —	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 25	 75 45	 200 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.32	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	0.9	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	—	275	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	5.1	—	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	62	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = −3.8 Vdc)	t_{on}	—	20	—	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	—	ns

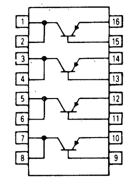
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMPQ3799★

CASE 751B-03, STYLE 1
SO-16



PIN CONNECTIONS DIAGRAM



QUAD AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−60	Vdc
Collector-Base Voltage	V_{CB}	−60	Vdc
Emitter-Base Voltage	V_{EB}	−5.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc

		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

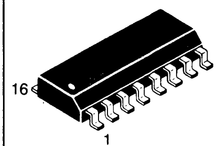
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)	I_{CBO}	—	—	−10	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	—	−20	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 Vdc) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc) (I_C = −500 μAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	h_{FE}	 225 300 300 250	 — — — —	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = −100 μAdc, I_B = −10 μAdc) (I_C = −1.0 mAdc, I_B = −100 μAdc)	$V_{CE(sat)}$	 — —	 −0.12 −0.07	 −0.2 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −100 μAdc, I_B = −10 μAdc) (I_C = −1.0 mAdc, I_B = −100 μAdc)	$V_{BE(sat)}$	 — —	 −0.62 −0.68	 −0.7 −0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	60	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	2.1	4.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	5.5	8.0	pF
Noise Figure (I_C = −100 μAdc, V_{CE} = −10 Vdc, R_S = 3.0 kohms, f = 1.0 kHz)	NF	—	1.5	—	dB

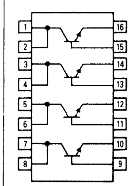
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMPQ3904★

CASE 751B-03, STYLE 1
SO-16



PIN CONNECTIONS DIAGRAM



QUAD AMPLIFIER/SWITCH TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

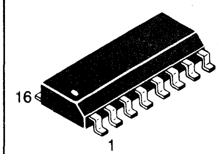
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0 —	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 30 50 75	 90 160 200	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.1	0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.65	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	250	300	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	2.0	4.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ib}	—	4.0	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = 10$ Vdc, $V_{BE(off)} = -0.5$ Vdc, $I_{B1} = 1.0$ mAdc)	t_{on}	—	37	—	ns
Turn-Off Time ($I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc)	t_{off}	—	136	—	ns

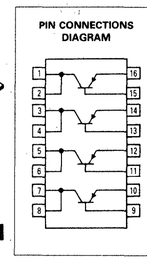
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MMPQ3906★

CASE 751B-03, STYLE 1
SO-16





QUAD AMPLIFIER/SWITCH TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	−40		Vdc
Collector-Base Voltage	V_{CB}	−40		Vdc
Emitter-Base Voltage	V_{EB}	−5.0		Vdc
Collector Current — Continuous	I_C	−200		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

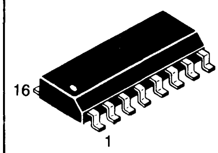
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	—	−50	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	—	−50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 40 60 75	 160 180 200	 — — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.1	−0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$	—	−0.65	−0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	3.3	4.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	4.8	10	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = −10 mAdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = −1.0 mAdc)	t_{on}	—	43	—	ns
Turn-Off Time (I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	155	—	ns

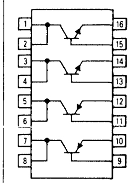
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMPQ6700★

CASE 751B-03, STYLE 1
SO-16



PIN CONNECTIONS DIAGRAM



QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP(2)/NPN SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

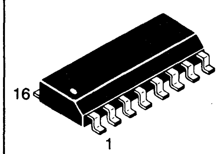
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

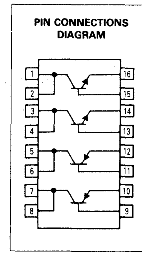
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 70	 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) PNP NPN	C_{ib}	 — —	 10 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

MMPQ6842

CASE 751B-03, STYLE 1
SO-16





QUAD MPU CLOCK BUFFER TRANSISTOR

PNP(2)/NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

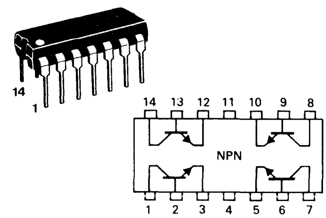
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 3.2	0.72 6.4	Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.66 5.3	1.92 15.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				—
(I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)		30			
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		50	—	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		70	—	—	
Collector-Emitter Saturation Voltage (I_C = 0.5 mAdc, I_B = 0.05 mAdc, 0°C ≤ T ≤ 70°C)	$V_{CE(sat)}$	—	0.05	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 0.5 mAdc, I_B = 0.05 mAdc)	$V_{BE(sat)}$	—	0.65	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	3.0	4.5	pF
Input Capacitance	C_{ib}				pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) PNP		—	5.0	10	
NPN		—	4.0	8.0	
SWITCHING CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 Vdc)					
Propagation Delay Time					ns
(50% Points TP1 to TP3)	t_{PLH}	—	15	25	
(50% Points TP2 to TP4)	t_{PHL}	—	6.0	15	
Rise Time (0.3 V to 4.7 V, TP3 or TP4)	t_r	5.0	25	35	ns
Fall Time (4.7 V to 0.3 V, TP3 or TP4)	t_f	5.0	10	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

MPQ2222,A★



CASE 646-06, STYLE 1
TO-116

QUAD GENERAL PURPOSE TRANSISTORS
NPN SILICON

★MPQ2222A is a Motorola designated preferred device.

Refer to MD2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ2222	MPQ2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.65 5.2	1.9 15.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	66	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$			Vdc
(I_C = 10 mAdc, I_B = 0)	MPQ2222		40	—	
	MPQ2222A		40	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 10 μAdc, I_E = 0)	MPQ2222		60	—	
	MPQ2222A		75	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MPQ2222		5.0	—	
	MPQ2222A		6.0	—	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 50 Vdc, I_E = 0)	MPQ2222		—	50	
(V_{CB} = 60 Vdc, I_E = 0)	MPQ2222A		—	10	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 3.0 Vdc, I_C = 0)	MPQ2222		—	50	
	MPQ2222A		—	10	
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPQ2222A		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPQ2222A		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ2222,A		75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ2222,A		100	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ2222		30	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPQ2222A		40	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPQ2222		—	0.4	
	MPQ2222A		—	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MPQ2222		—	1.6	
(I_C = 500 mA, I_B = 50 mA)	MPQ2222A		—	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPQ2222		—	1.3	
	MPQ2222A		0.6	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	MPQ2222		—	2.6	
(I_C = 500 mA, I_B = 50 mA)	MPQ2222A		—	2.0	

2

ELECTRICAL CHARACTERISTICS — Continued (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) MPQ2222A	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) MPQ2222A	t_{off}	—	285	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

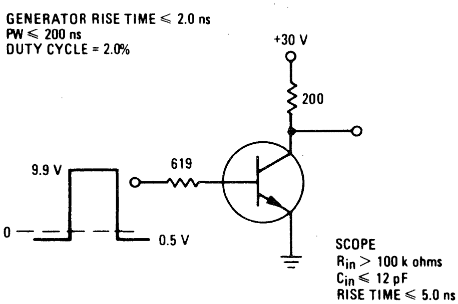
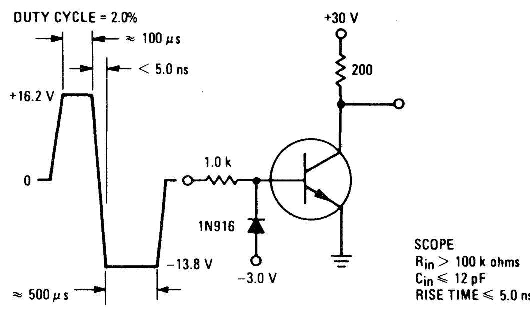
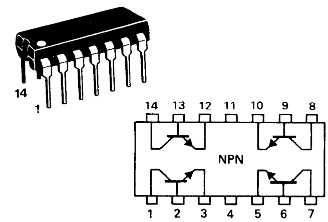


FIGURE 2 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



MPQ2369★

CASE 646-06, STYLE 1
TO-116



QUAD
SWITCHING TRANSISTOR
NPN SILICON

★This is a Motorola designated preferred device.

Refer to MD2369 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 5.0	1.5 15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	83	°C/W

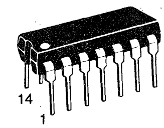
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

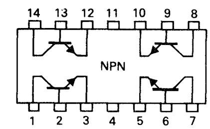
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.4	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	40 20	— —	— —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	450	550	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.5	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, V_{BE} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	9.0	—	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	—	15	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

MPQ2483
MPQ2484★

CASE 646-06, STYLE 1
TO-116





QUAD AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	134	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		100	—	—	
	MPQ2484		200	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			—	0.13	0.35	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.15	0.5	
Base-Emitter Saturation Voltage(2)		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	0.58	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			—	0.70	0.8	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

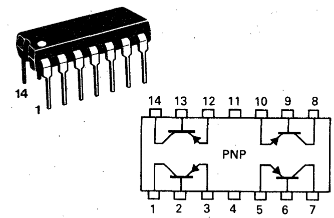
Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	100	—	MHz
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	4.0	8.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	1.8	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, BW = 10 kHz)	MPQ2483	NF	—	3.0	—	dB
	MPQ2484		—	2.0	—	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPQ2906
MPQ2907,A★

CASE 646-06, STYLE 1
TO-116



QUAD
GENERAL PURPOSE
TRANSISTORS
PNP SILICON

★MPQ2907A is a Motorola designated preferred device.

Refer to MD2905 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	MPQ2906 MPQ2907	MPQ2907A	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−600		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.65 6.5	1.9 19	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	66	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	 MPQ2906, MPQ2907 MPQ2907A	$V_{(BR)CEO}$	 −40 −60	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0)	 MPQ2906, MPQ2907 MPQ2907A	I_{CBO}	—	−50	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_E = 0)	MPQ2906,7 Only	I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = −100 μAdc, V_{CE} = −10 Vdc) (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −150 mAdc, V_{CE} = −10 Vdc) (I_C = −150 mAdc, V_{CE} = −10 Vdc) (I_C = −300 mAdc, V_{CE} = −10 Vdc) (I_C = −500 mAdc, V_{CE} = −10 Vdc)	 MPQ2907A MPQ2907A MPQ2906 MPQ2907 MPQ2907A MPQ2907A MPQ2906 MPQ2907 MPQ2906 MPQ2907 MPQ2907A	h_{FE}	 75 100 35 75 100 100 40 100 20 30 50	 — — — — — 300 — — — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −300 mAdc, I_B = −30 mAdc) (I_C = −500 mA, I_B = −500 mA)	 MPQ2906, MPQ2907 MPQ2907A	$V_{CE(sat)}$	 — — —	 −0.4 −1.6 −1.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −300 mAdc, I_B = −30 mAdc) (I_C = −500 mA, I_B = −50 mA)	 MPQ2906, MPQ2907 MPQ2906, MPQ2907 MPQ2907A	$V_{BE(sat)}$	 — — —	 −1.3 −2.6 −2.6	Vdc

ELECTRICAL CHARACTERISTICS — Continued (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance, (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance, (V_{EB} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = 15 mAdc) MPQ2907A Only	t_{on}	—	45	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = 15 mAdc) MPQ2907A Only	t_{off}	—	180	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

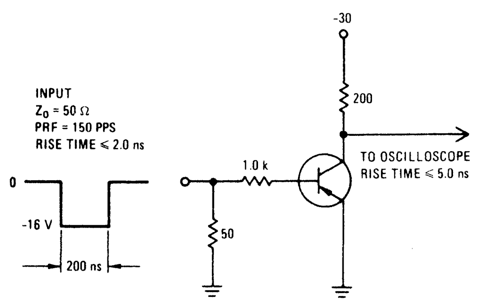
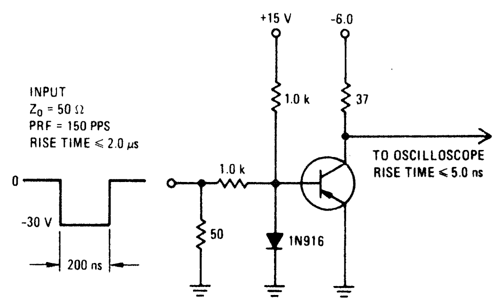
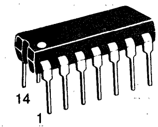


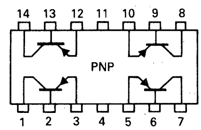
FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



MPQ3467★

CASE 646-06, STYLE 1
TO-116





QUAD MEMORY DRIVER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3467 in Section 3 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	−40		Vdc
Collector-Base Voltage	V_{CBO}	−40		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	 650 5.2	 1500 12	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 1.25 10	 3.2 25.6	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 2 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die	100	193	°C/W
	Effective, 4 Die	39	83.2	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	45	55	%
	Q1-Q2 or Q3-Q4	5.0	10	%

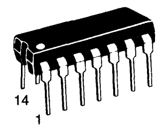
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

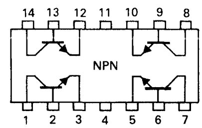
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	—	−200	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	—	−200	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	−20	—	—	—
Collector-Emitter Saturation Voltage(2) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{CE(sat)}$	—	−0.23	−0.5	Vdc
Base-Emitter Saturation Voltage(2) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{BE(sat)}$	—	−0.90	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	125	190	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	10	25	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = −500 mAdc, I_{B1} = −50 mAdc)	t_{on}	—	—	40	ns
Turn-Off Time (I_C = −500 mAdc, I_{B1} = I_{B2} = −50 mAdc)	t_{off}	—	—	90	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ3725★

CASE 646-06, STYLE 1
TO-116





QUAD
CORE DRIVER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MM3725 in Section 3 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max		Unit
		One Transistor	Effective For Four Transistors	
Thermal Resistance, Junction to Ambient(1)	$R_{\theta JA}$	125	50	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	μAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 25	 75 45	 200 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.32	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	0.9	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	275	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	5.1	10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	62	80	pF

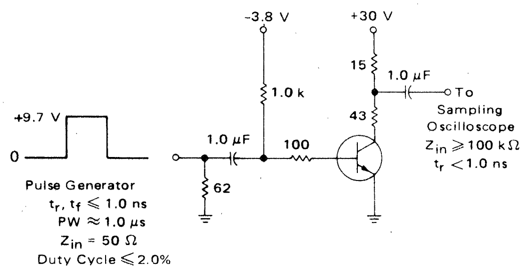
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = −3.8 Vdc)	t_{on}	—	20	35	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	60	ns

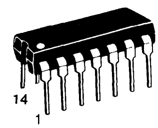
2

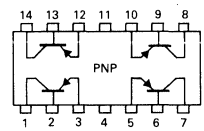
FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



MPQ3762

CASE 646-06, STYLE 1
TO-116





QUAD MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to 2N3467 in Section 3 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	−40		Vdc
Collector-Base Voltage	V_{CBO}	−40		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 5.98	1700 13.6	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = −150 mAdc, V_{CE} = −1.0 Vdc) (I_C = −500 mAdc, V_{CE} = −2.0 Vdc) (I_C = −1.0 Adc, V_{CE} = −2.0 Vdc)	h_{FE}	 35 30 20	 70 65 35	 — — —	—
Collector-Emitter Saturation Voltage (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{CE(sat)}$	 — —	 −0.3 −0.6	 −0.55 −0.9	Vdc
Base-Emitter Saturation Voltage (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{BE(sat)}$	 — —	 −0.9 −1.0	 −1.25 −1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	150	275	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	9.0	15	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = −30 Vdc, I_C = −1.0 Adc, I_{B1} = −100 mAdc, $V_{BE(off)}$ = 2.0 Vdc)	t_{on}	—	—	50	ns
Turn-Off Time (V_{CC} = −30 Vdc, I_C = −1.0 Adc, I_{B1} = I_{B2} = −100 mAdc)	t_{off}	—	—	120	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON

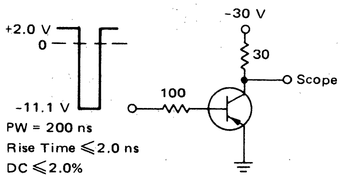
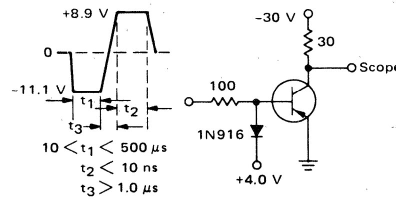
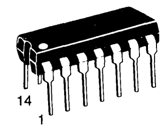


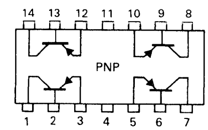
FIGURE 2 — TURN-OFF



MPQ3798
MPQ3799★

CASE 646-06, STYLE 1
TO-116





QUAD AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3810 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ3798	MPQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−50		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	 0.5 4.0	 0.9 7.2	 Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 0.825 6.7	 2.4 19.2	 Watts m/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	 MPQ3798 MPQ3799	$V_{(BR)CEO}$	 −40 −60	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)		I_{CBO}	—	—	−10	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	—	−20	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	 MPQ3798 MPQ3799	h_{FE}	 100 225	 — —	 — —	—
(I_C = −100 μAdc, V_{CE} = −5.0 Vdc)	MPQ3798 MPQ3799		150 300	— —	— —	
(I_C = −500 μAdc, V_{CE} = −5.0 Vdc)	MPQ3798 MPQ3799		150 300	— —	— —	
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	MPQ3798 MPQ3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage (I_C = −100 μAdc, I_B = −10 μAdc) (I_C = −1.0 mAdc, I_B = −100 μAdc)		$V_{CE(sat)}$	 — —	 −0.12 −0.07	 −0.2 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −100 μAdc, I_B = −10 μAdc) (I_C = −1.0 mAdc, I_B = −100 μAdc)		$V_{BE(sat)}$	 — —	 −0.62 −0.68	 −0.7 −0.8	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	60	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	2.1	4.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	5.5	8.0	pF
Noise Figure (I_C = −100 μAdc, V_{CE} = −10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	MPQ3798	NF	—	2.5	—	dB
	MPQ3799		—	1.5	—	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MAXIMUM RATINGS

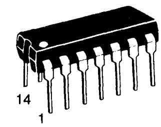
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

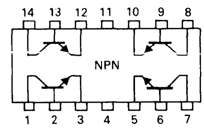
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

MPQ3904★

CASE 646-06, STYLE 1
TO-116





QUAD
AMPLIFIER SWITCHING
TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N3904 for graphs.

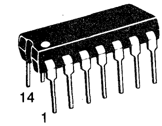
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

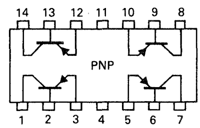
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 40 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 75	 90 160 200	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.1	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.0	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.0	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, $V_{BE(off)}$ = −0.5 Vdc, I_{B1} = 1.0 mAdc)	t_{on}	—	37	—	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	—	136	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ3906★

CASE 646-06, STYLE 1
TO-116





QUAD AMPLIFIER SWITCHING TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3906 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	−40		Vdc
Collector-Base Voltage	V_{CBO}	−40		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−200		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 825 6.7	 2.4 19.2	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	—	−50	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	—	−50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 40 60 75	 160 180 200	 — — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.1	−0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$	—	−0.65	−0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.3	4.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.8	10	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = −10 mAdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = −1.0 mAdc)	t_{on}	—	43	—	ns
Turn-Off Time (I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	155	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

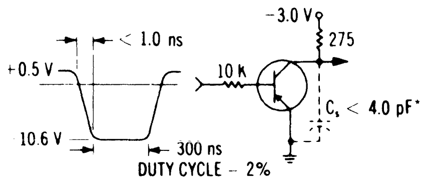
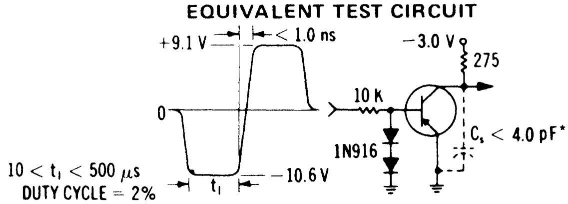


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

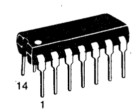
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	0.65	1.25	Watts
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		5.18	10	mW/°C
Total Device Dissipation @ T_C = 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	1.0	3.0	Watts
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		8.0	24	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

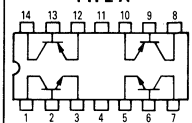
MPQ6001 MPQ6501
MPQ6002★ MPQ6502★

STYLE 1 TYPE A **STYLE 1 TYPE B**

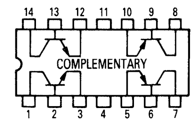
CASE 646-06 TO-116



TYPE A



TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTORS

NPN/PNP(1) SILICON

★These are Motorola designated preferred devices.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance				°C/W
Each Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502	125	193	
Effective, 4 Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502	41.6	100	
Coupling Factors				%
Q1–Q4 or Q2–Q3	MPQ6001, MPQ6002, MPQ6501, MPQ6502	30	60	
Q1–Q2 or Q3–Q4	MPQ6001, MPQ6002, MPQ6501, MPQ6502	20	24	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	30	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		25	—	—	
	MPQ6002, MPQ6502		50	—	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		35	—	—	
	MPQ6002, MPQ6502		75	—	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		40	—	—	
	MPQ6002, MPQ6502		100	—	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		20	—	—	
	MPQ6002, MPQ6502		30	—	—	

(1) Voltage and Current are negative for PNP Transistors.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage(2) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{CE(sat)}$	 — —	 — —	 0.4 1.4	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{BE(sat)}$	 — —	 — —	 1.3 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) PNP NPN	C_{obo}	 — —	 6.0 4.5	 8.0 8.0	pF
Input Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 1.0 MHz) PNP NPN	C_{ibo}	 — —	 20 17	 30 30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, V_{EB} = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1)	t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	225	—	ns

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

NPN DATA

FIGURE 1 — NORMALIZED DC CURRENT GAIN

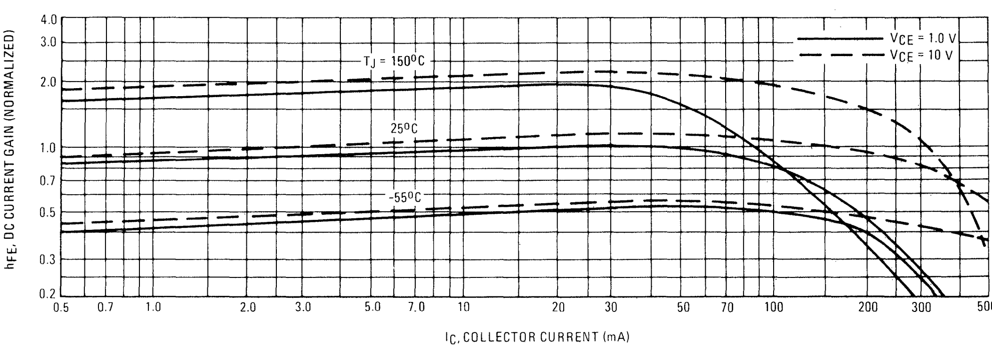


FIGURE 2 — "ON" VOLTAGES

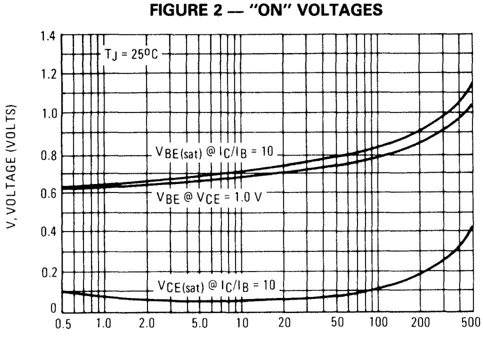
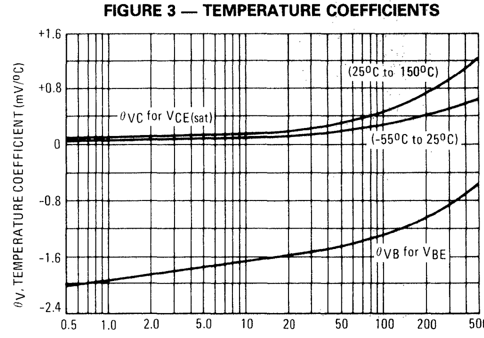


FIGURE 3 — TEMPERATURE COEFFICIENTS



NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 4 — FREQUENCY EFFECTS

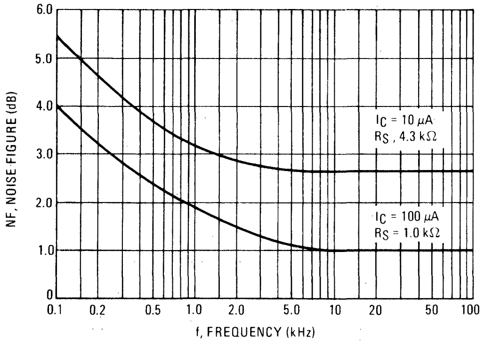
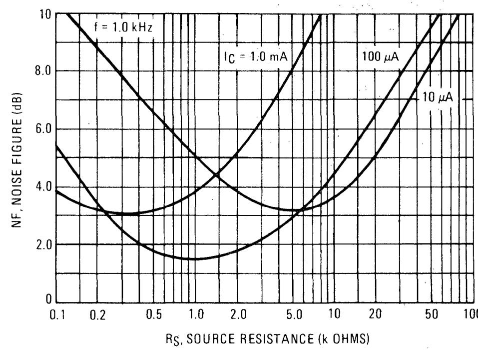


FIGURE 5 — SOURCE RESISTANCE EFFECTS



2

MAXIMUM RATINGS

Rating	Symbol	MPQ6100A MPQ6600A1		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	 0.825 6.7	 2.4 19.2	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

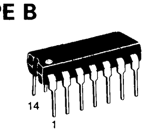
MPQ6100A

STYLE 1
TYPE A

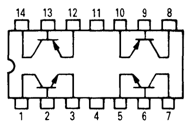
MPQ6600A1★

STYLE 1
TYPE B

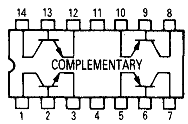
CASE 646-06
TO-116



TYPE A



TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTORS

NPN/PNP(1) SILICON

★This is a Motorola designated preferred device.

Refer to 2N3799 in Section 3 for PNP Curves.

2

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	 MPQ6100A,6600A1	$V_{(BR)CEO}$	 45	 —	 —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	 60	 —	 —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	 5.0	 —	 —	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	 —	 —	 10	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 500 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	 MPQ6100A,6600A1 MPQ6100A,6600A1 MPQ6100A,6600A1 MPQ6100A,6600A1	h_{FE}	 100 150 150 125	 — — — —	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	 PNP NPN	C_{obo}	 — —	 1.2 1.8	 4.0 4.0	pF

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	PNP	C_{ibo}	—	—	8.0	pF
	NPN		—	—	8.0	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, BW = 10 kHz)		NF	—	4.0	—	dB
MATCHING CHARACTERISTICS (MPQ6600A1 ONLY)						
DC Current Gain Ratio (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		h_{FE1}/h_{FE2}	0.8	—	1.0	—
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$\|V_{BE1}-V_{BE2}\|$	—	—	20	mVdc

(1) Voltage and Current are negative for PNP Transistors.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Die	Four Die Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

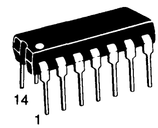
(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

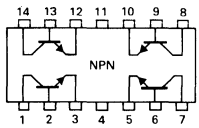
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

MPQ6426

CASE 646-06, STYLE 1
TO-116





QUAD
DARLINGTON TRANSISTOR

NPN SILICON

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain	h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		5000	—	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		10,000	—	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	15	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

NOISE CHARACTERISTICS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 1 — NOISE VOLTAGE

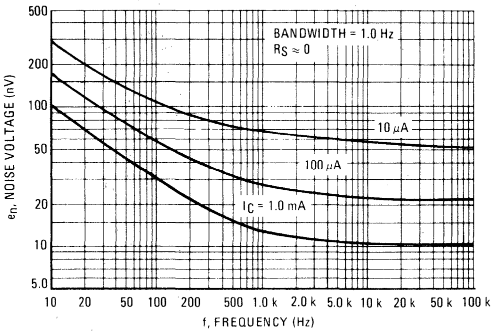


FIGURE 2 — NOISE CURRENT

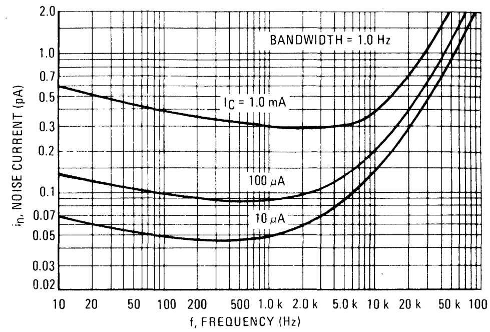


FIGURE 3 — TOTAL WIDEBAND NOISE VOLTAGE

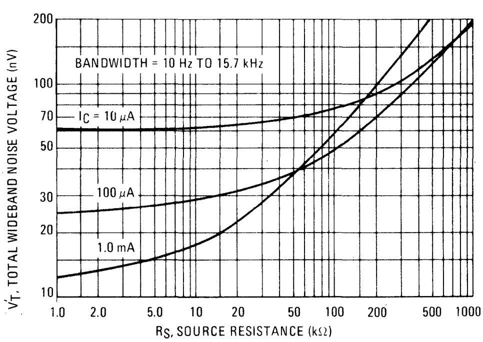
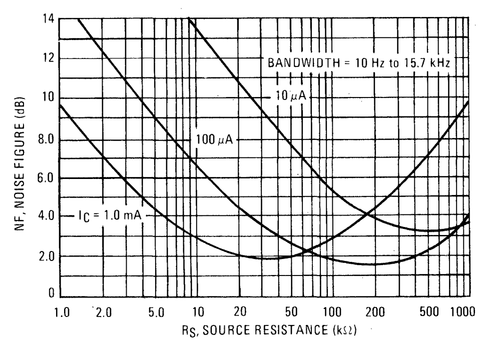


FIGURE 4 — WIDEBAND NOISE FIGURE



DYNAMIC CHARACTERISTICS

FIGURE 5 — CAPACITANCE

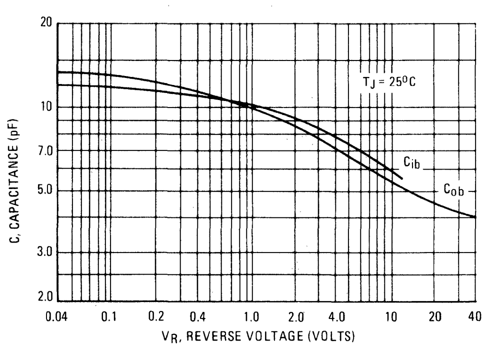
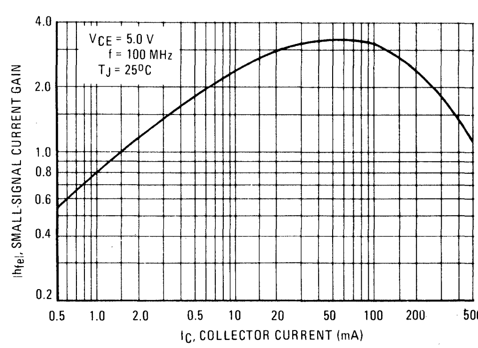


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



MPQ6501, MPQ6502 For Specifications, See MPQ6001 Data
MPQ6600A1 For Specifications, See MPQ6100A Data

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

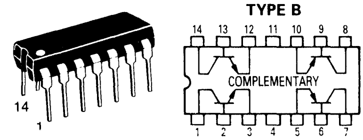
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

MPQ6700★

CASE 646-06, STYLE 1
TO-116
TYPE B

TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP(2) SILICON

★This is a Motorola designated preferred device.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

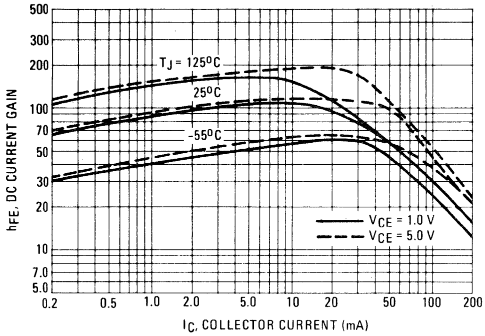
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 70	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) PNP NPN	C_{ibo}	 — —	 10 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

2

NPN | PNP

FIGURE 1 – DC CURRENT GAIN



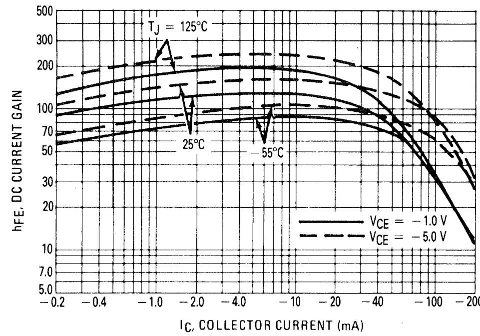
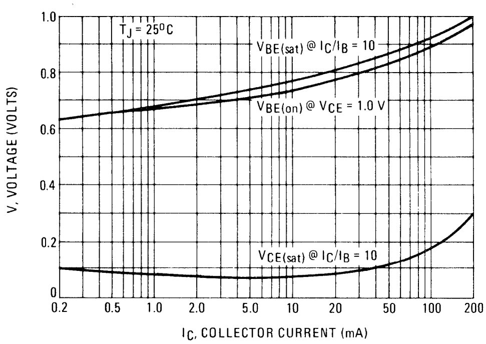


FIGURE 2 – "ON" VOLTAGE



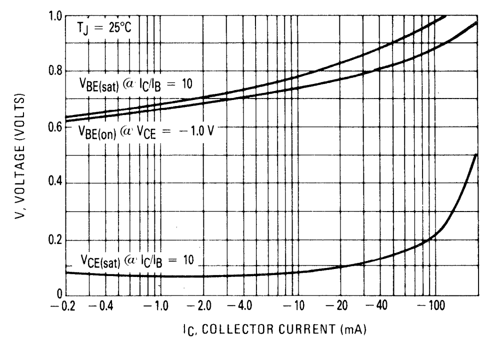
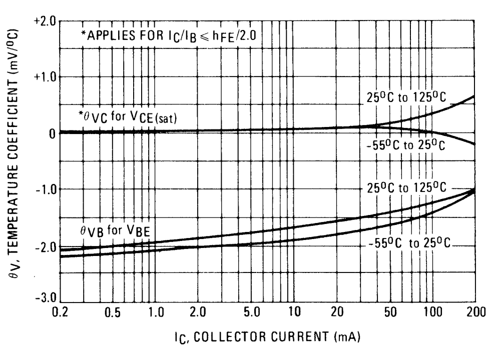
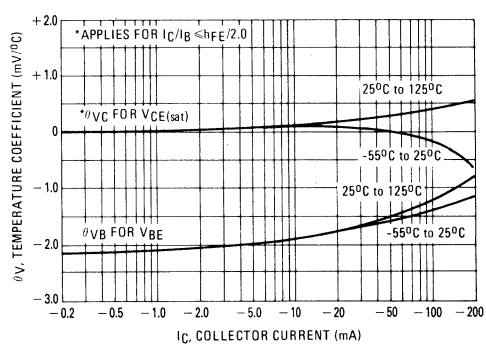


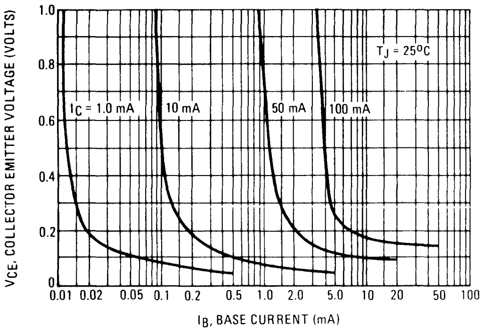
FIGURE 3 – TEMPERATURE COEFFICIENTS





NPN | PNP

FIGURE 4 – COLLECTOR SATURATION REGION



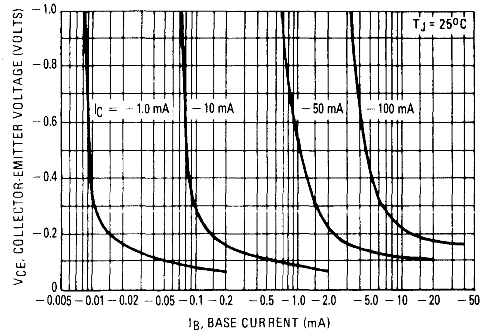
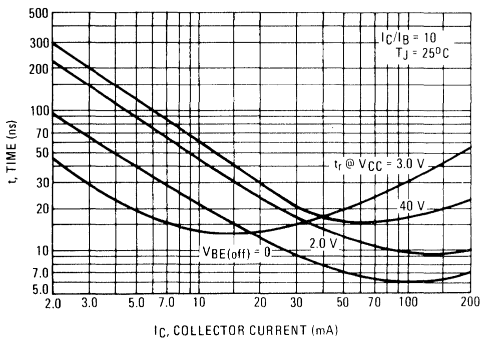


FIGURE 5 – TURN-ON TIME



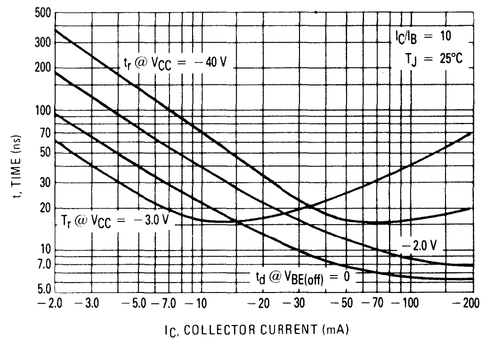
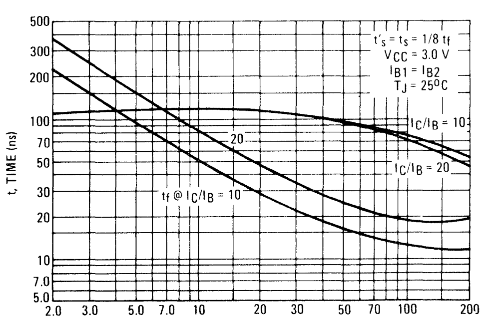
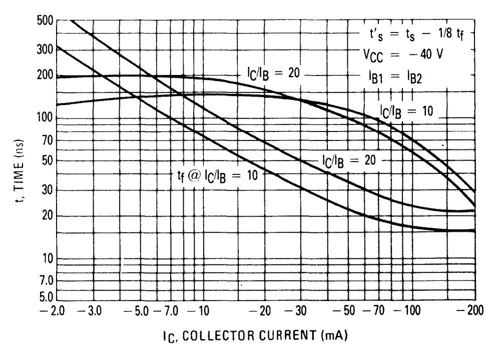


FIGURE 6 – TURN-OFF TIME





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NPN PNP

FIGURE 7 — CURRENT-GAIN — BANDWIDTH PRODUCT

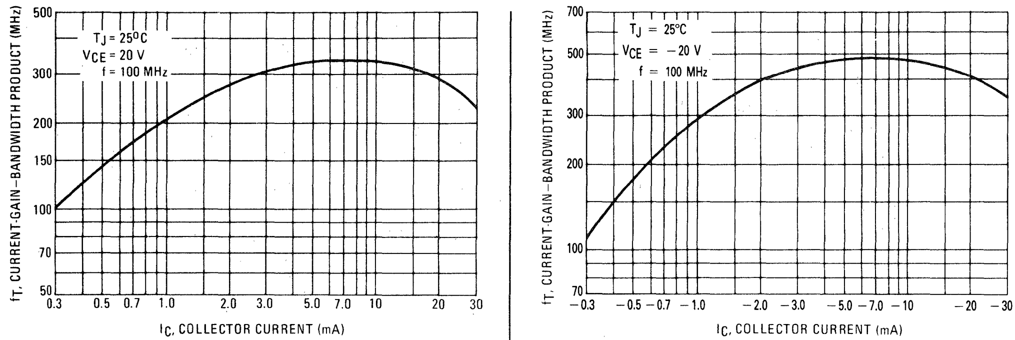
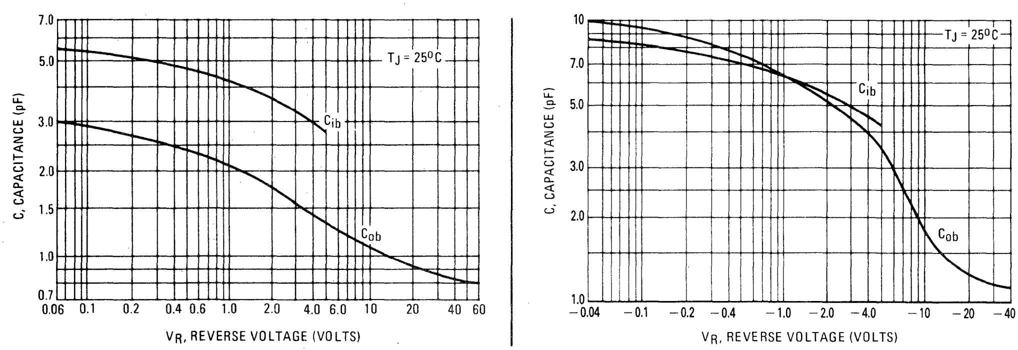


FIGURE 8 — CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 825 6.7	 2400 19.2	 mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

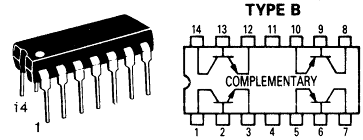
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

MPQ6842

CASE 646-06, STYLE 1
TO-116
TYPE B

TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP(2) SILICON

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 50 70	— — —	— — —	—
Collector-Emitter Saturation Voltage (I_C = 0.5 mAdc, I_B = 0.05 mAdc, 0°C ≤ T ≤ 70°C)	$V_{CE(sat)}$	—	0.05	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 0.5 mAdc, I_B = 0.05 mAdc)	$V_{BE(sat)}$	—	0.65	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz	C_{obo}	—	3.0	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz PNP NPN	C_{ibo}	 — —	 5.0 4.0	 10 8.0	pF
SWITCHING CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 Vdc)					
Propagation Delay Time (50% Points TP1 to TP3) (50% Points TP2 to TP4)	 t_{PLH} t_{PHL}	 — —	 15 6.0	 25 15	ns
Rise Time (0.3 V to 4.7 V, TP3 or TP4)	t_r	5.0	25	35	ns
Fall Time (4.7 V to 0.3 V, TP3 or TP4)	t_f	5.0	10	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

2

NPN | **PNP**

FIGURE 1 — DC CURRENT GAIN

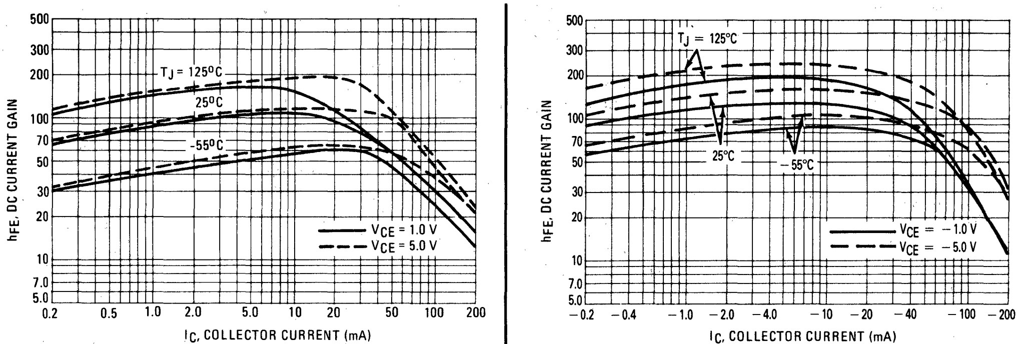


FIGURE 2 — "ON" VOLTAGE

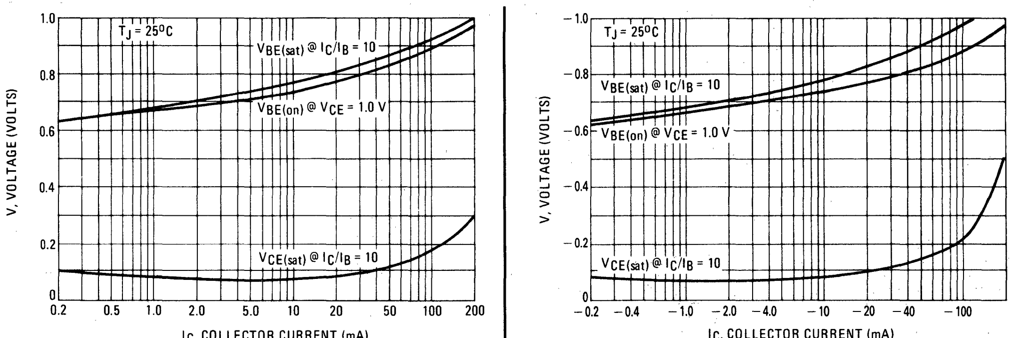


FIGURE 3 — TEMPERATURE COEFFICIENTS

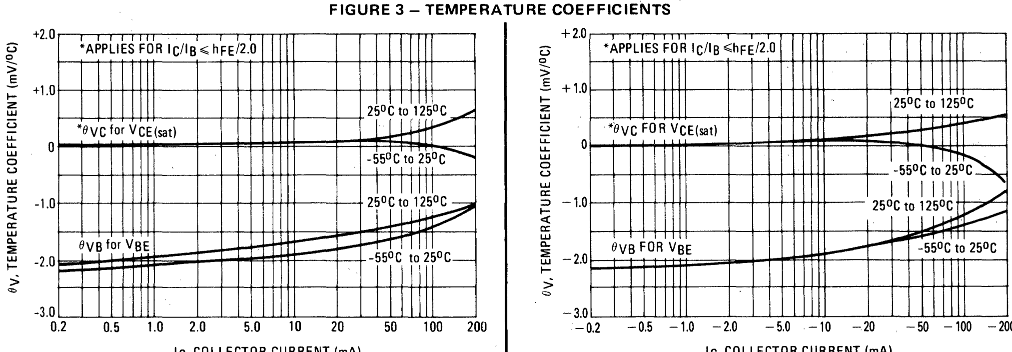


FIGURE 4 – COLLECTOR SATURATION REGION

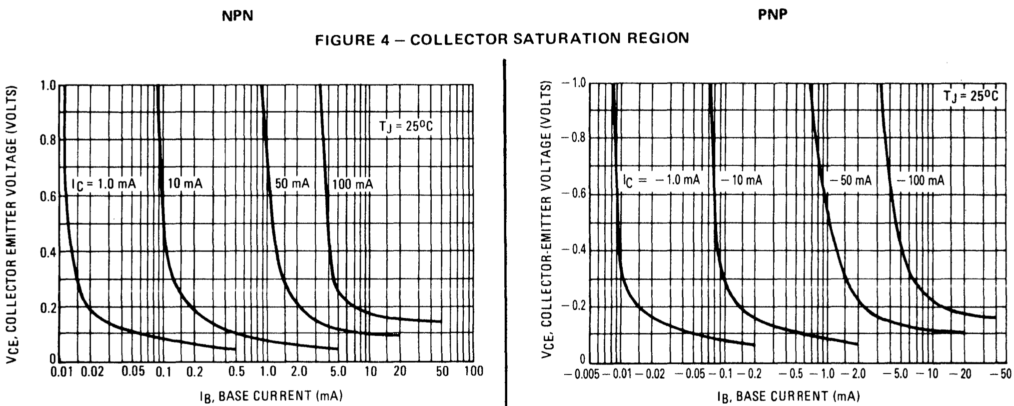
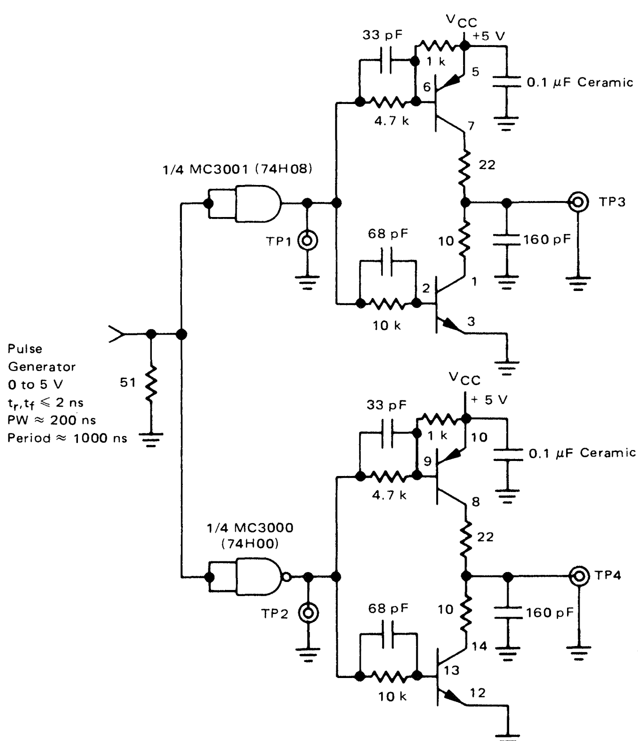
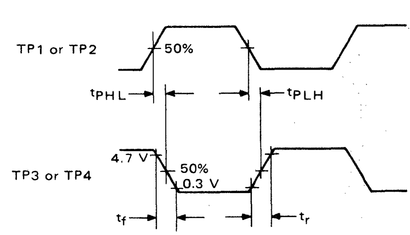


FIGURE 5 – SWITCHING TIMES TEST CIRCUIT AND WAVEFORMS



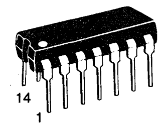
NOTES:

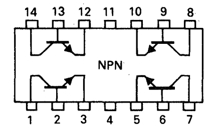
1. Unless otherwise noted, all resistors carbon composition ¼ W ±5%, all capacitors dipped mica ±2%.
2. Use short interconnect wiring with good power and ground busses.
3. TP1 thru TP4 are coaxial connectors to accept scope probe tip and provide a good ground.
4. Device under test is MPQ6842.
5. 160 pF load does not include stray or scope probe capacitance.
6. Scope probe resistance > 5 kΩ. Scope probe capacitance < 10 pF.



MPQ7041
MPQ7042
MPQ7043★

CASE 646-06, STYLE 1
TO-116





QUAD AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to MPQ7051 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ7041	MPQ7042	MPQ7043	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	**Four Die Equal Power**		
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CEO}$	150 200 250	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CBO}$	150 200 250	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0) (V_{CB} = 180 Vdc, I_E = 0)	MPQ7041 MPQ7042 MPQ7043	I_{CBO}	— — —	— — —	100 100 100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)		h_{FE}	25 40 40	45 60 80	— — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	0.3	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	80	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	2.5	5.0	pF
Input Capacitance (V_{EB} = 3.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	40	50	pF

MAXIMUM RATINGS

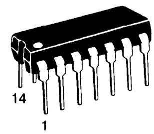
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	150		Vdc
Collector-Base Voltage	V_{CBO}	150		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Die	Four Die Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 750 5.98	 1700 13.6	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 1.25 10	 3.2 25.6	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

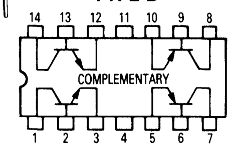
Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	46 5.0	56 10	% %

MPQ7051★

CASE 646-06, TYPE B
TO-116



TYPE B



QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP(1) SILICON

★This is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0)	I_{CBO}	—	250	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25 35 25	— — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 3.0 Vdc, I_C = 0, f = 1.0 MHz) NPN PNP	C_{ibo}	 — —	 50 75	pF

(1) Voltage and current are negative for PNP transistors.

DC CHARACTERISTICS

NPN | **PNP**

FIGURE 1 — DC CURRENT GAIN

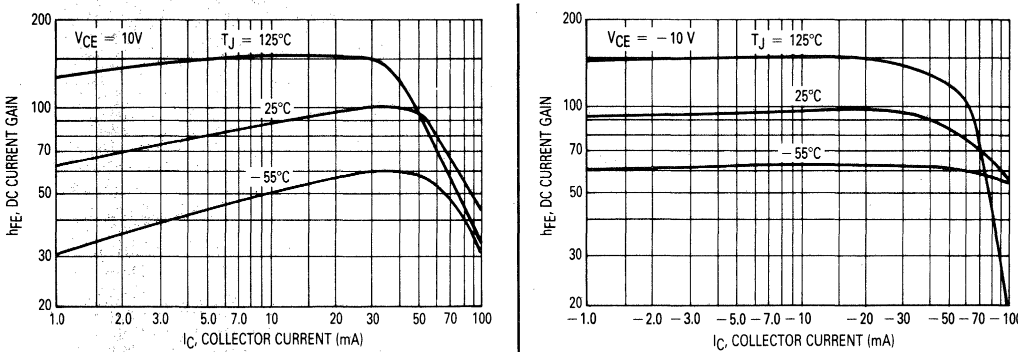


FIGURE 2 — "ON" VOLTAGES

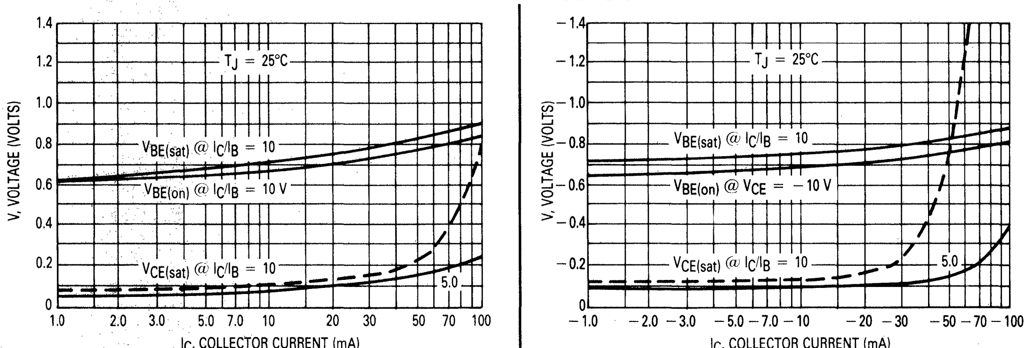
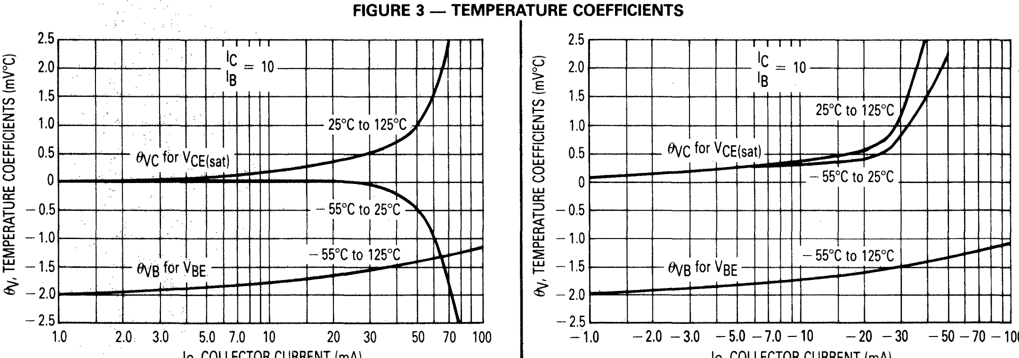
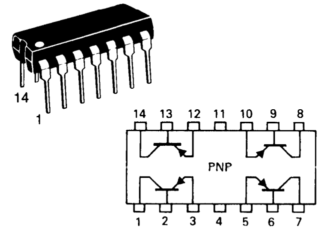


FIGURE 3 — TEMPERATURE COEFFICIENTS



MPQ7091
MPQ7093★

CASE 646-06, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to MPQ7051 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	MPQ7091	MPQ7093	Unit
Collector-Emitter Voltage	V_{CEO}	−150	−250	Vdc
Collector-Base Voltage	V_{CBO}	−150	−250	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−500		mAdc
		Each Die	**Four Die Equal Power**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 750 5.98	 1700 13.6	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 1.25 10	 3.2 25.6	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

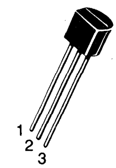
Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	MPQ7091	$V_{(BR)CEO}$	−150	—	—	Vdc
	MPQ7093		−250	—	—	
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	MPQ7091	$V_{(BR)CBO}$	−150	—	—	Vdc
	MPQ7093		−250	—	—	
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −120 Vdc, I_E = 0)	MPQ7091	I_{CBO}	—	—	−250	nAdc
	MPQ7093		—	—	−250	
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = −1.0 mAdc, V_{CE} = −10 Vdc)			25	40	—	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)			35	55	—	
(I_C = −30 mAdc, V_{CE} = −10 Vdc)			25	50	—	
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{CE(sat)}$	—	−0.3	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{BE(sat)}$	—	−0.7	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	50	70	—	MHz
Output Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	5.0	pF
Input Capacitance (V_{EB} = −3.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	60	75	pF

MPS404A★

CASE 29-02, STYLE 1
TO-92 (TO-226AA)



CHOPPER TRANSISTOR
PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−35	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−25	Vdc
Collector Current — Continuous	I_C	−150	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−35	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−25	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{BE} = −10 Vdc, I_C = 0)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −12 mAdc, V_{CE} = −0.15 Vdc)	h_{FE}	30	400	—
Collector-Emitter Saturation Voltage (I_C = −12 mAdc, I_B = −0.4 mAdc) (I_C = −24 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	 — —	 −0.15 −0.20	Vdc
Base-Emitter Saturation Voltage (I_C = −12 mAdc, I_B = −0.4 mAdc) (I_C = −24 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$	 — —	 −0.85 −1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Common-Base Cutoff Frequency (I_C = −1.0 mAdc, V_{CB} = 6.0 Vdc)	f_{ob}	4.0	—	MHz
Output Capacitance (V_{CB} = −6.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	20	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — COLLECTOR-EMITTER VOLTAGE

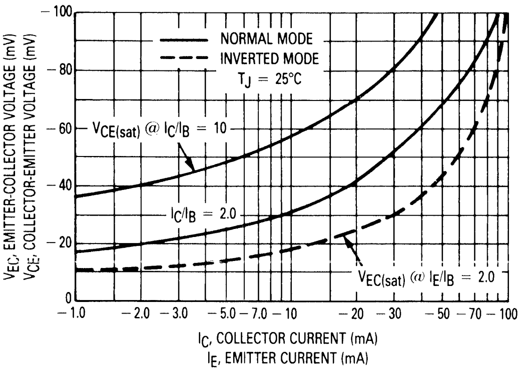
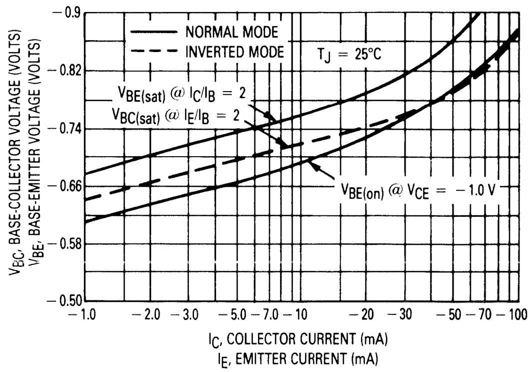


FIGURE 2 — BASE "ON" VOLTAGE



NORMAL MODE

FIGURE 3 — DC CURRENT GAIN @ V_{CE} = −0.15 Vdc

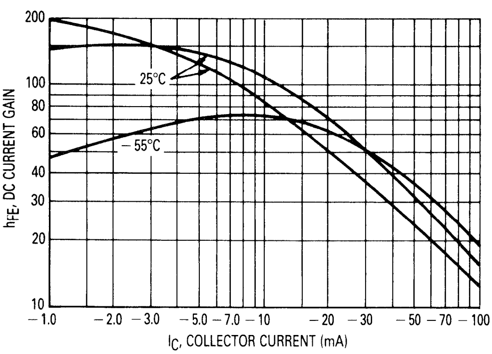
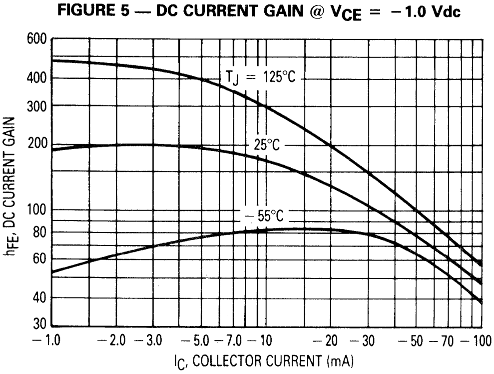


FIGURE 5 — DC CURRENT GAIN @ V_{CE} = −1.0 Vdc



INVERTED MODE

FIGURE 4 — DC CURRENT GAIN @ V_{EC} = −0.15 Vdc

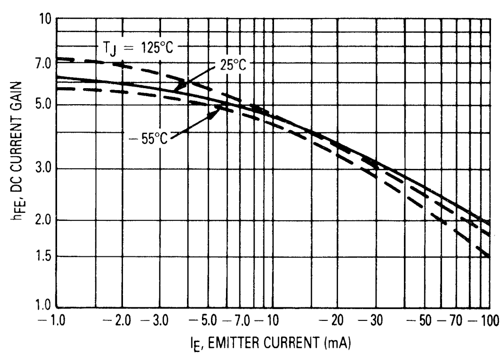


FIGURE 6 — DC CURRENT GAIN @ V_{EC} = −1.0 Vdc

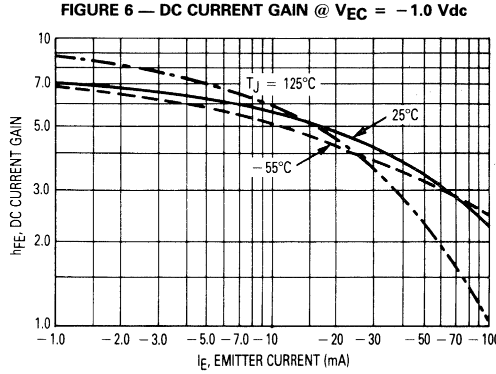


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FIGURE 7 — COLLECTOR SATURATION REGION

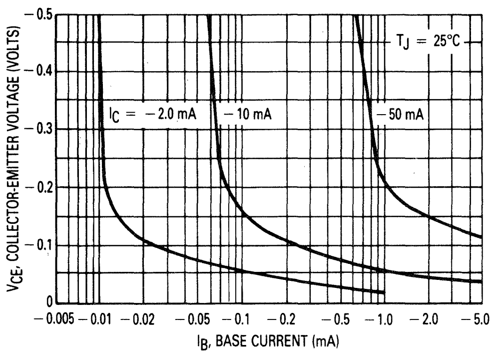


FIGURE 8 — EMITTER SATURATION REGION

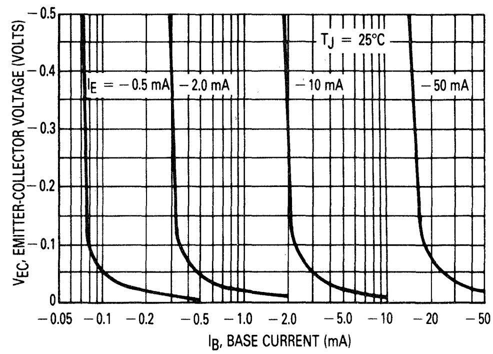


FIGURE 9 — EMITTER-COLLECTOR "ON" RESISTANCE

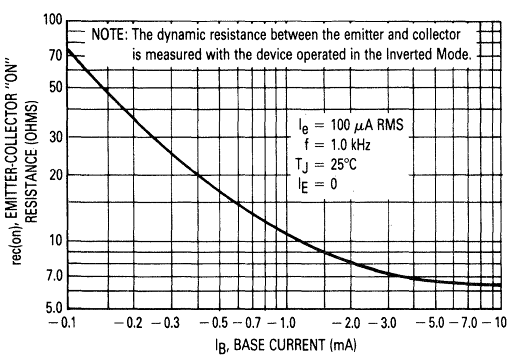


FIGURE 10 — CAPACITANCE

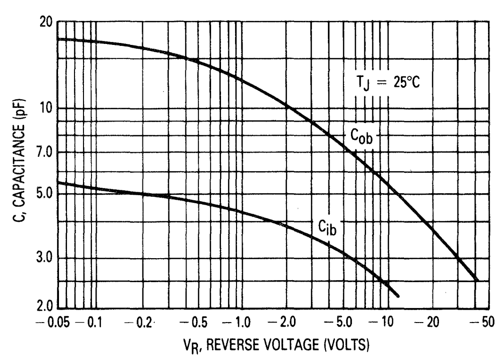


FIGURE 11 — TURN-ON TIME

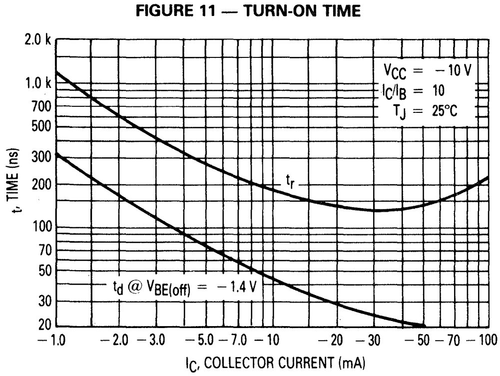


FIGURE 12 — TURN-OFF TIME

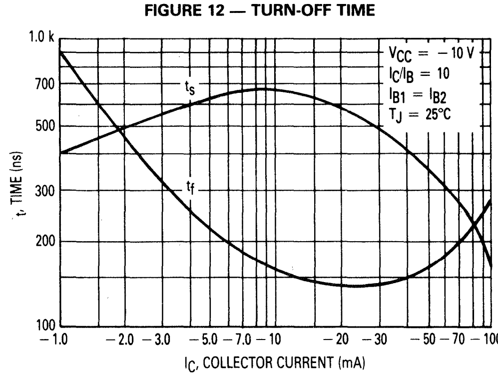
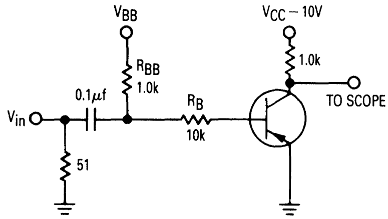


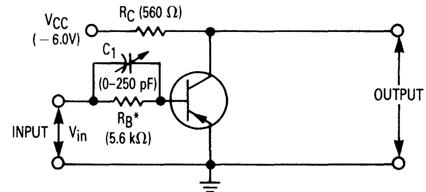
FIGURE 13 — SWITCHING TIME TEST CIRCUIT



	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d and t_r	−12	+1.4
t_{off}, t_s and t_f	+20.6	−11.6

Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and I_{B1} = I_{B2}. Resistor values changed to obtain curves in Figures 11 and 12.

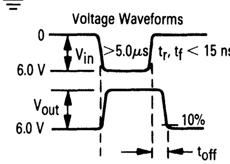
FIGURE 14 — STORED BASE CHARGE TEST CIRCUIT



MEASUREMENT PROCEDURE

C_1 is increased until the t_{off} time of the output waveform is decreased to 0.2 μs, Q_S is then calculated by $Q_S = C_1 V_{in}$.

Q_{S3} or Q_{S7} by B-Line Electronics or equivalent may also be used.

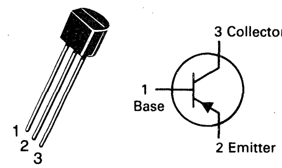


2

2

MPS536

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS536	Unit
Collector-Emitter Voltage	V_{CEO}	−10	Vdc
Collector-Base Voltage	V_{CBO}	−15	Vdc
Emitter-Base Voltage	V_{EBO}	−4.5	Vdc
Collector Current — Continuous	I_C	−30	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

*Free air

ELECTRICAL CHARACTERISTICS (T_C = 25°C *For both package types unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −2.0 mA, I_B = 0)	$V_{(BR)CEO}$	−10	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA, I_E = 0)	$V_{(BR)CBO}$	−15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −20 mA, V_{CE} = −5.0 V)	h_{FE}	20	—	200	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −20 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, I_F = 0, f = 1.0 MHz)	C_{cb}	—	0.8	1.2	pF
FUNCTIONAL TESTS					
Gain @ Noise Figure (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) f = 500 MHz f = 1.0 GHz	G_{NF}	 — —	 14 8.0	 — —	dB
Noise Figure (I_C = −10 mAdc, V_{CE} = −5.0 Vdc f = 500 MHz f = 1.0 GHz	NF	 — —	 4.5 6.0	 — —	dB

2

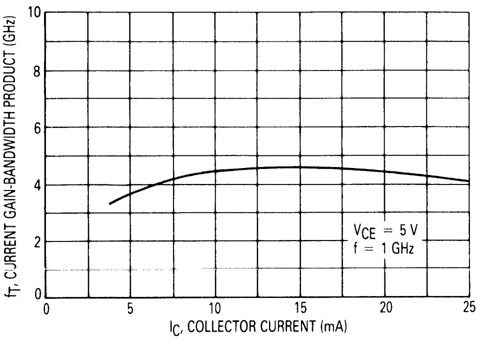


Figure 1. Current Gain-Bandwidth Product versus Collector Current

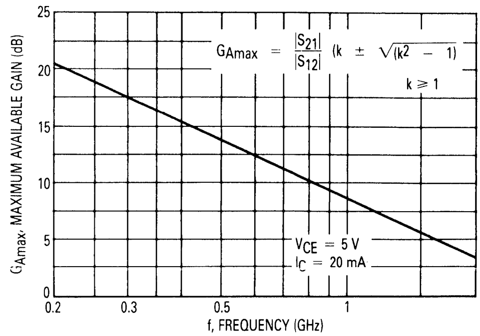


Figure 2. Maximum Available Gain (G_{Amax}) versus Frequency

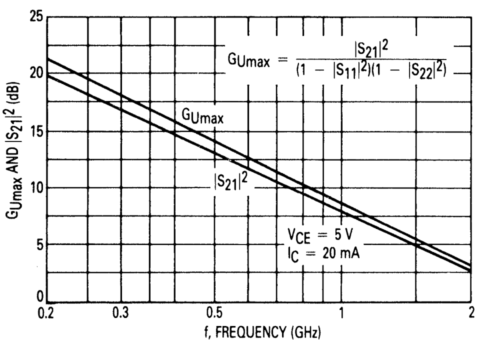


Figure 3. Maximum Unilateral Gain (G_{Umax}) and Insertion Gain ($|S_{21}|^2$) versus Frequency

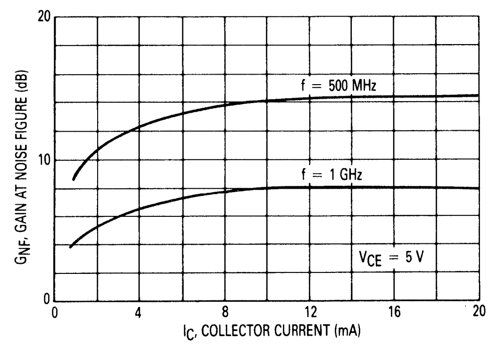


Figure 4. Gain at Noise Figure versus Collector Current

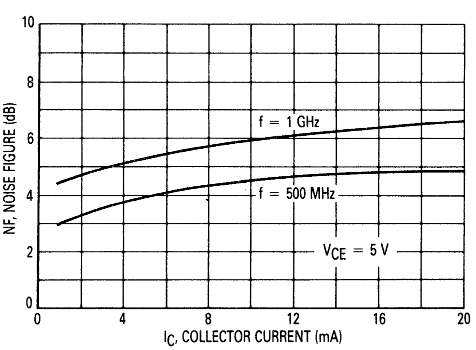


Figure 5. Noise Figure versus Collector Current

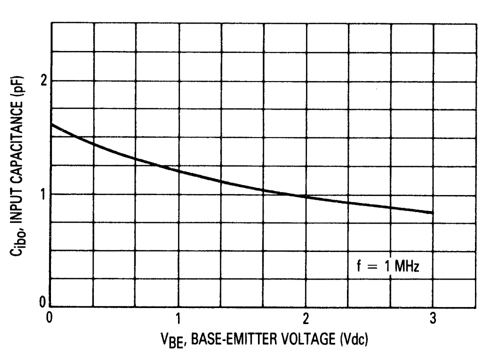


Figure 6. Input Capacitance versus Emitter-Base Voltage

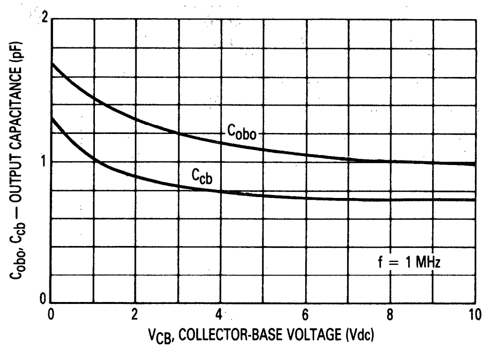
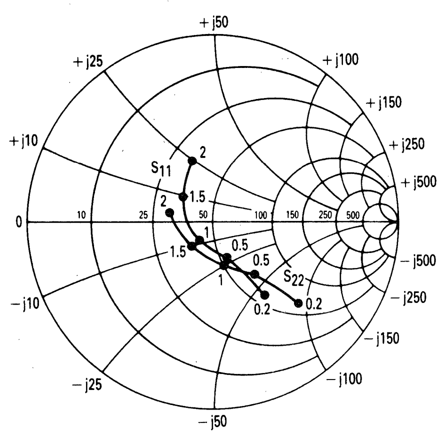
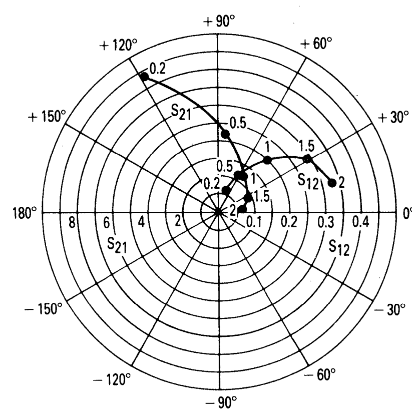


Figure 7. Output Capacitance versus Collector-Base Voltage

INPUT/OUTPUT REFLECTION COEFFICIENT versus FREQUENCY V_{CE} = 10 V, I_C = 10 mA



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY V_{CE} = 10 V, I_C = 10 mA



COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠φ	$\|S_{21}\|$	∠φ	$\|S_{12}\|$	∠φ	$\|S_{22}\|$	∠φ
10	5	200	0.60	−43	6.60	125	0.07	68	0.71	−35
		500	0.30	−60	3.64	87	0.14	57	0.47	−43
		1000	0.17	−103	2.11	56	0.22	43	0.32	−69
		1500	0.15	156	1.70	28	0.30	28	0.22	−112
		2000	0.28	110	1.29	2	0.33	13	0.25	−174
	10	200	0.48	−52	8.78	118	0.06	69	0.62	−42
		500	0.21	−66	4.31	84	0.12	60	0.37	−46
		1000	0.12	−122	2.40	54	0.20	47	0.24	−73
		1500	0.18	138	1.90	29	0.29	31	0.16	−126
		2000	0.32	104	1.41	4	0.33	16	0.23	170
	20	200	0.38	−59	10.21	112	0.06	70	0.54	−46
		500	0.14	−76	4.72	81	0.12	63	0.30	−47
		1000	0.11	−144	2.58	53	0.20	49	0.19	−74
		1500	0.22	132	1.99	28	0.29	34	0.12	−139
		2000	0.35	103	1.46	4	0.33	19	0.22	161

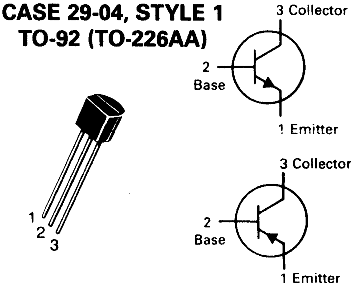
NPN

MPS650, MPS651★

PNP(3)

MPS750, MPS751★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★**These are Motorola designated preferred devices.**

MAXIMUM RATINGS

Rating	Symbol	MPS650 MPS750	MPS651 MPS751	Unit
Collector-Emitter Voltage	V_{CE}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MPS650, MPS750 MPS651, MPS751	$V_{(BR)CEO}$	40 60	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPS650, MPS750 MPS651, MPS751	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage ($I_C = 0$, $I_E = 10$ μAdc)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	MPS650, MPS750 MPS651, MPS751	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ V, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 50$ mA, $V_{CE} = 2.0$ V) ($I_C = 500$ mA, $V_{CE} = 2.0$ V) ($I_C = 1.0$ A, $V_{CE} = 2.0$ V) ($I_C = 2.0$ A, $V_{CE} = 2.0$ V)		h_{FE}	75 75 75 40	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 2.0$ A, $I_B = 200$ mA) ($I_C = 1.0$ A, $I_B = 100$ mA)		$V_{CE(sat)}$	— —	0.5 0.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ A, $V_{CE} = 2.0$ V)		$V_{BE(on)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ A, $I_B = 100$ mA)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	75	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) Voltage and current are negative for PNP transistors.

FIGURE 1 — MPS650, MPS651
TYPICAL DC CURRENT GAIN
NPN

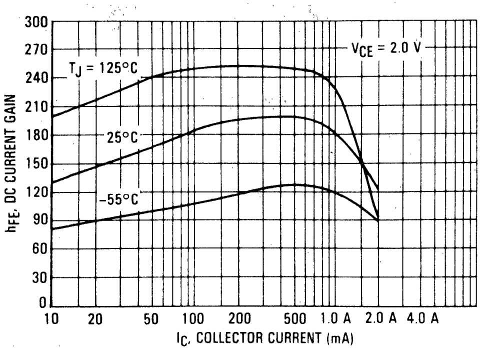


FIGURE 2 — MPS750, MPS751
TYPICAL DC CURRENT GAIN
PNP

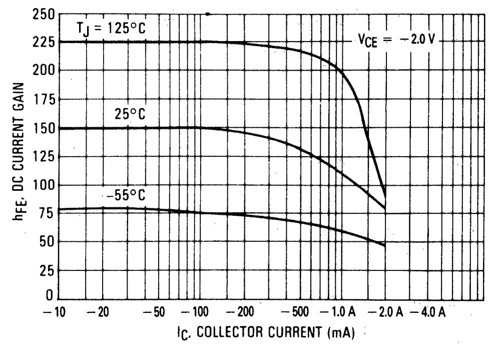


FIGURE 3 — MPS650, MPS651
ON VOLTAGES
NPN

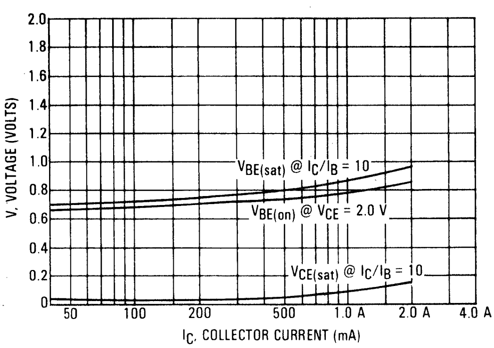


FIGURE 4 — MPS750, MPS751
ON VOLTAGES
PNP

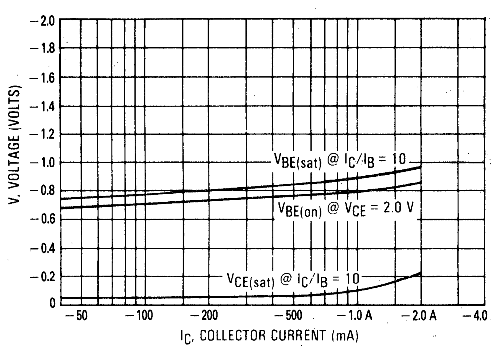


FIGURE 5 — MPS650, MPS651
COLLECTOR SATURATION REGION
NPN

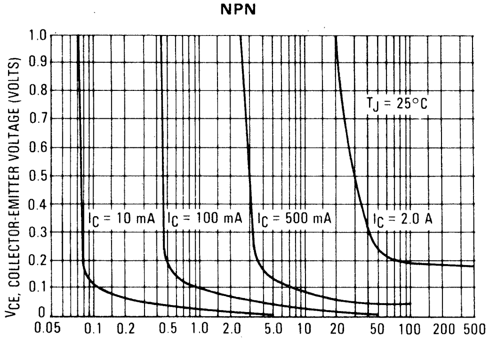


FIGURE 6 — MPS750, MPS751
COLLECTOR SATURATION REGION
PNP

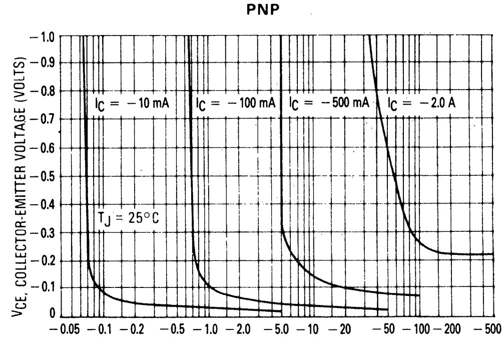


FIGURE 7 — MPS650, MPS651 SOA, SAFE OPERATING AREA

NPN

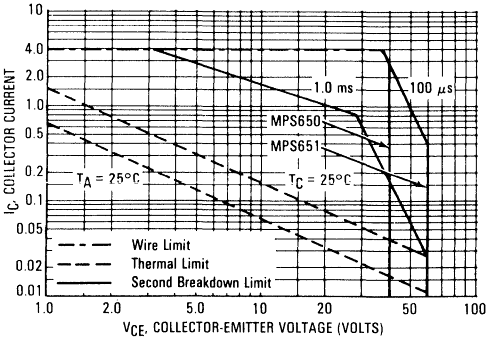
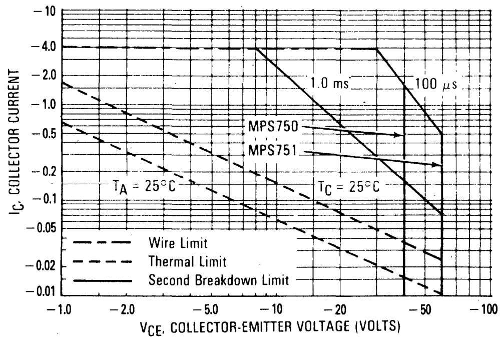


FIGURE 8 — MPS750, MPS751 SOA, SAFE OPERATING AREA

PNP



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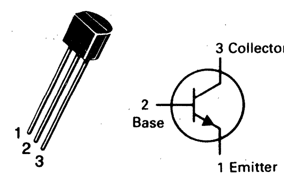
MPS918★
MPS3563

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPS918	MPS3563	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	2.0	Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.85 6.8		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	147	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2)		$V_{(BR)CEO}$			Vdc
(I_C = 3.0 mAdc, I_B = 0)	MPS918		15	—	
	MPS3563		12	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 1.0 μAdc, I_E = 0)	MPS918		30	—	
(I_C = 100 μAdc, I_E = 0)	MPS3563		30	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MPS918		3.0	—	
	MPS3563		2.0	—	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 15 Vdc, I_E = 0)	MPS918		—	10	
	MPS3563		—	50	
ON CHARACTERISTICS					
DC Current Gain(2)		h_{FE}			—
(I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	MPS918		20	—	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	MPS3563		20	200	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS918		600	—	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS3563		600	1500	
Output Capacitance		C_{obo}			pF
(V_{CB} = 0 Vdc, I_E = 0, f = 1.0 MHz)	MPS918		—	3.0	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS918		—	1.7	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS3563		—	1.7	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS918	C_{ibo}	—	2.0	pF
Small-Signal Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3563	h_{fe}	20	250	—
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	MPS918	NF	—	6.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

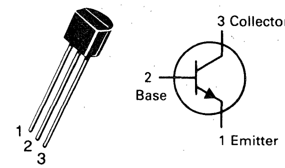
Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain		G_{pe}			dB
(I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz)	MPS918		15	—	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz) ($G_{fd} + G_{re} < -20$ dB)	MPS3563		14	—	
Power Output (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz)	MPS918	P_{out}	30	—	mW
Oscillator Collector Efficiency (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, P_{out} = 30 mW, f = 500 MHz)	MPS918	η	25	—	%

2

2

MPS2222,A★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★MPS2222A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPS2222	MPS2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			Vdc
(I_C = 10 mAdc, I_B = 0)	MPS2222		30	—	
	MPS2222A		40	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 10 μAdc, I_E = 0)	MPS2222		60	—	
	MPS2222A		75	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	MPS2222		5.0	—	
	MPS2222A		6.0	—	
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MPS2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	MPS2222		—	0.01	
(V_{CB} = 60 Vdc, I_E = 0)	MPS2222A		—	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	MPS2222		—	10	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	MPS2222A		—	10	
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	MPS2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MPS2222A	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)			35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	MPS2222A only		35	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)			100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)			50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	MPS2222		30	—	
	MPS2222A		40	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPS2222		—	0.4	
	MPS2222A		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	MPS2222		—	1.6	
	MPS2222A		—	1.0	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPS2222		—	1.3	
	MPS2222A		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	MPS2222		—	2.6	
	MPS2222A		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MPS2222		250	—	
	MPS2222A		300	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS2222		—	30	
	MPS2222A		—	25	
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MPS2222A	$r_b'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MPS2222A	NF	—	4.0	dB

SWITCHING CHARACTERISTICS MPS2222A only

Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

FIGURE 2 — TURN-OFF TIME

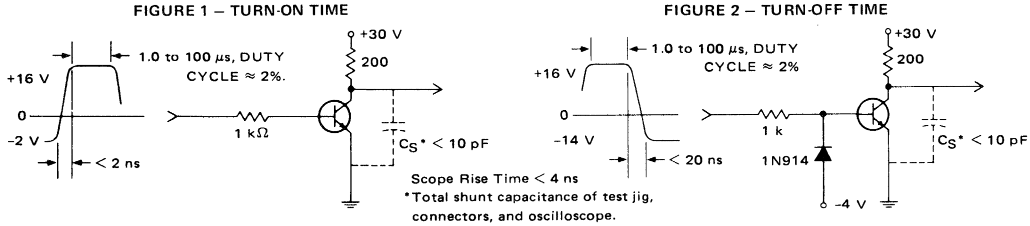


FIGURE 3 – DC CURRENT GAIN

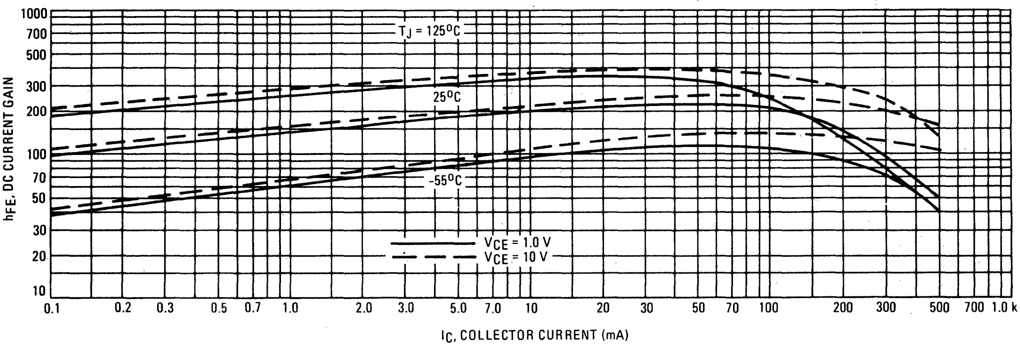


FIGURE 4 – COLLECTOR SATURATION REGION

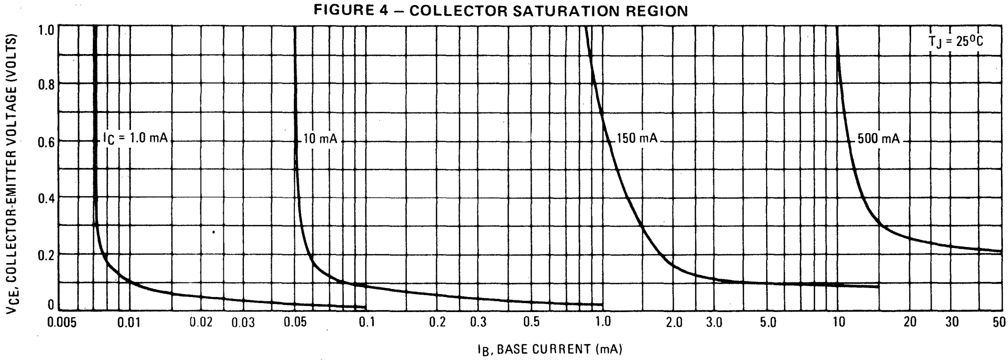


FIGURE 5 – TURN-ON TIME

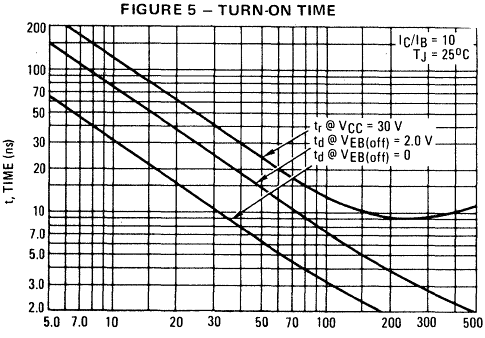


FIGURE 6 – TURN-OFF TIME

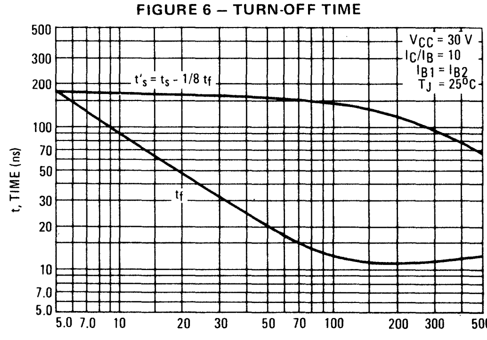


FIGURE 7 – FREQUENCY EFFECTS

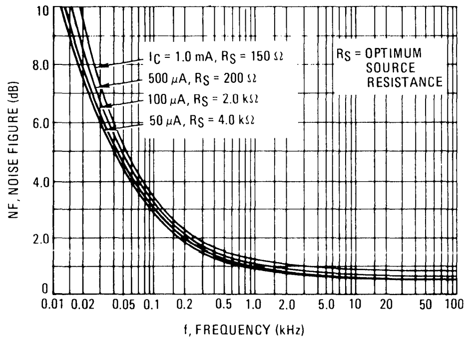


FIGURE 8 – SOURCE RESISTANCE EFFECTS

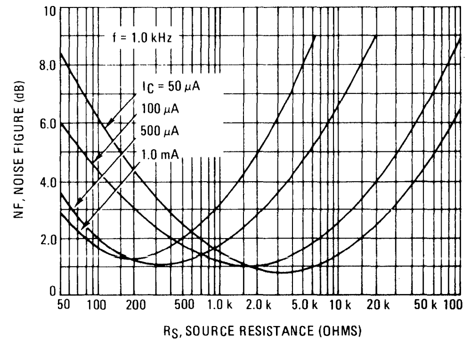


FIGURE 9 – CAPACITANCES

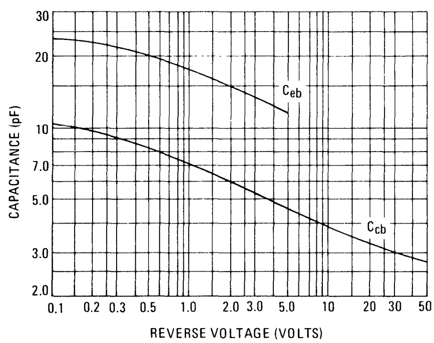


FIGURE 10 – CURRENT-GAIN BANDWIDTH PRODUCT

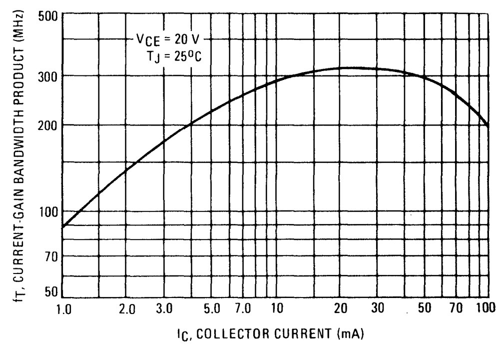


FIGURE 11 – "ON" VOLTAGES

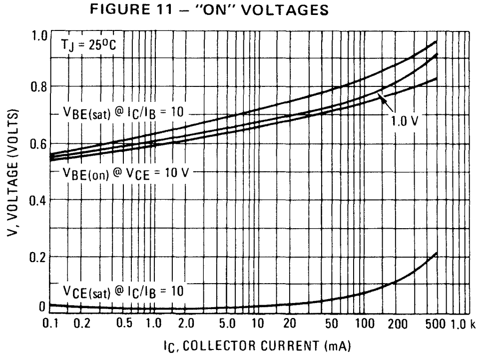
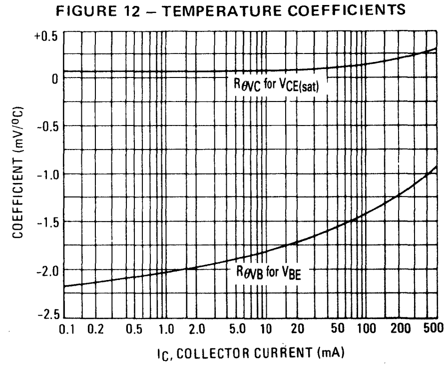


FIGURE 12 – TEMPERATURE COEFFICIENTS



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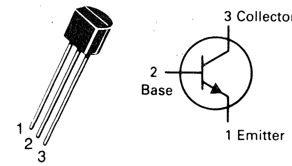
MPS2369,A★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTORS

NPN SILICON

★MPS2369A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPS2369A	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	MPS2369,A	$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS2369,A	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS2369,A	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 125°C)	 MPS2369,A	I_{CBO}	 — —	 — —	 0.4 30	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	MPS2369,A	I_{CES}	—	—	0.4	μAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 V)	MPS2369A		—	—	120	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	MPS2369		20	—	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MPS2369		40	—	120	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc)	MPS2369A		40	—	—	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = −55°C)	MPS2369A		20	—	—	
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	MPS2369A		30	—	—	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	MPS2369		20	—	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MPS2369A		20	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS2369		—	—	0.25	
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS2369A		—	—	0.20	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)	MPS2369A		—	—	0.30	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	MPS2369A		—	—	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	MPS2369A		—	—	0.50	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS2369		0.7	—	0.85	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)	MPS2369A		0.5	—	—	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = −55°C)	MPS2369A		—	—	1.02	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	MPS2369A		—	—	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)	MPS2369A		—	—	1.60	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (Continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MPS2369,A	C_{obo}	—	—	4.0	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS2369,A	h_{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS						
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc) (Figure 3)	MPS2369,A	t_s	—	5.0	13	ns
Turn-On Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Figure 1)	MPS2369,A	t_{on}	—	8.0	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Figure 2)	MPS2369,A	t_{off}	—	10	18	ns

FIGURE 1 — t_{on} CIRCUIT

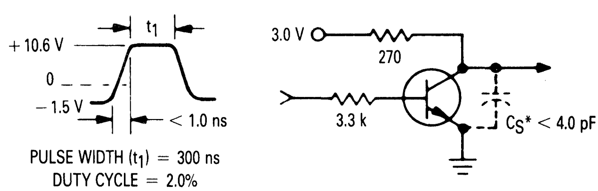


FIGURE 2 — t_{off} CIRCUIT

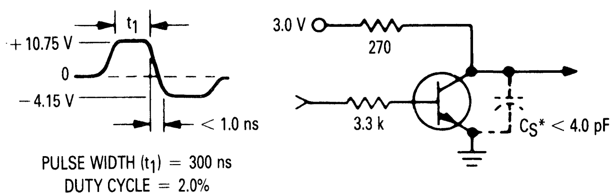
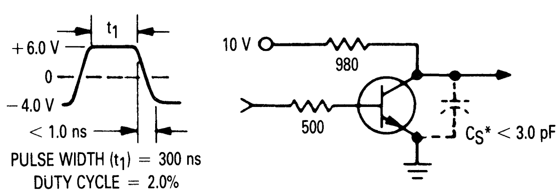


FIGURE 3 — STORAGE TEST CIRCUIT



*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS.

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MAXIMUM RATINGS

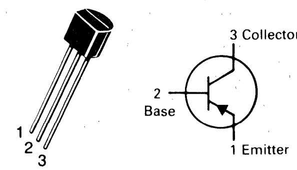
Rating	Symbol	MPS2907	MPS2907A	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−500 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

MPS2907,A★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★MPS2907A is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	MPS2907 MPS2907A	$V_{(BR)CEO}$	−40 −60	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc)		I_{CEX}	—	−50	nAdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)	MPS2907 MPS2907A	I_{CBO}	— —	−0.020 −0.010	μAdc
(V_{CB} = −50 Vdc, I_E = 0, T_A = 150°C)	MPS2907 MPS2907A		— —	−20 −10	
Base Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc)		I_B	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 Vdc)	MPS2907 MPS2907A	h_{FE}	35 75	— —	—
(I_C = −1.0 mAdc, V_{CE} = −10 Vdc)	MPS2907 MPS2907A		50 100	— —	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)	MPS2907 MPS2907A		75 100	— —	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)(1)	MPS2907, MPS2907A		100	300	
(I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	MPS2907 MPS2907A		30 50	— —	
Collector-Emitter Saturation Voltage (1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)		$V_{CE(sat)}$	— —	−0.4 −1.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)		$V_{BE(sat}$	— —	−1.3 −2.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1),(2) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc) (Figures 1 and 5)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	(V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_{off}	—	100	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

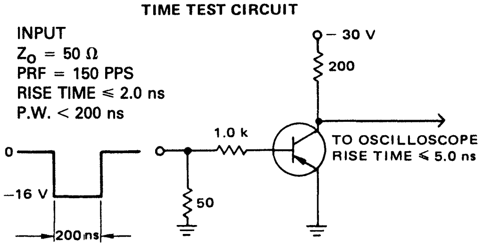
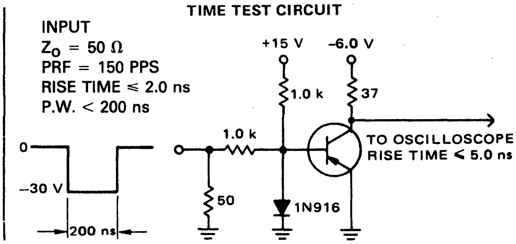


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 3 – DC CURRENT GAIN

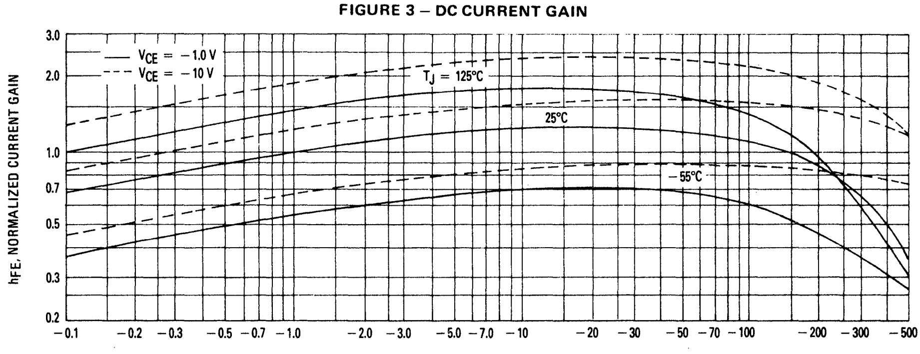


FIGURE 4 — COLLECTOR SATURATION REGION

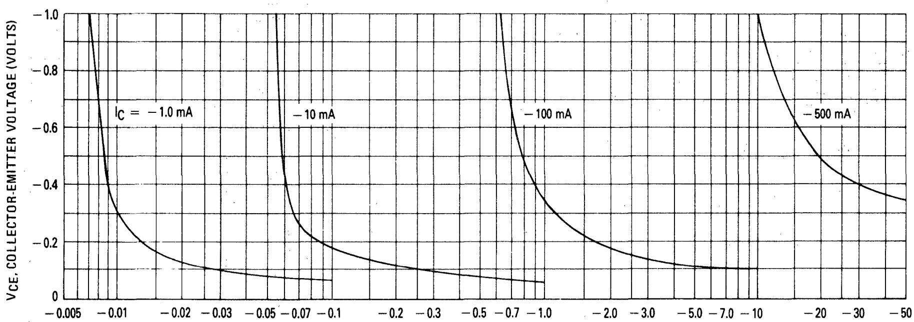


FIGURE 5 — TURN-ON TIME

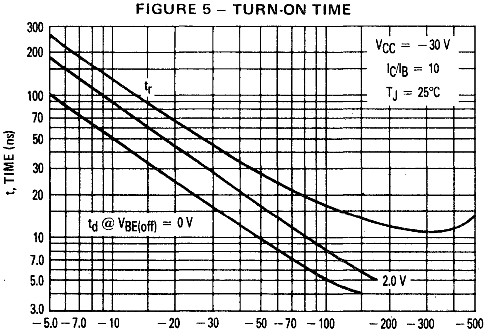
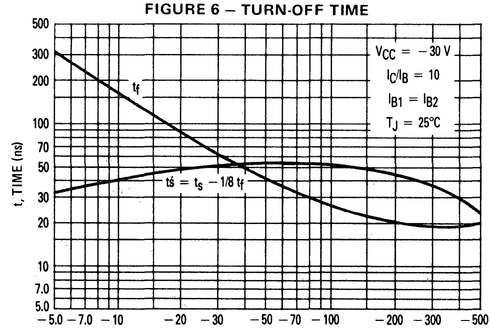


FIGURE 6 — TURN-OFF TIME



TYPICAL SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE
V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 7 — FREQUENCY EFFECTS

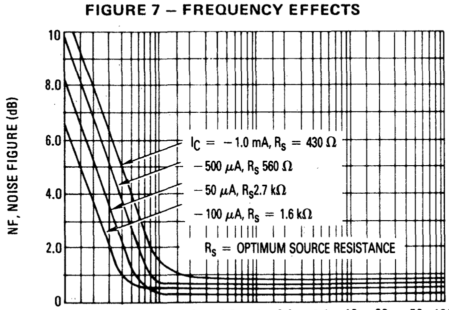


FIGURE 8 — SOURCE RESISTANCE EFFECTS

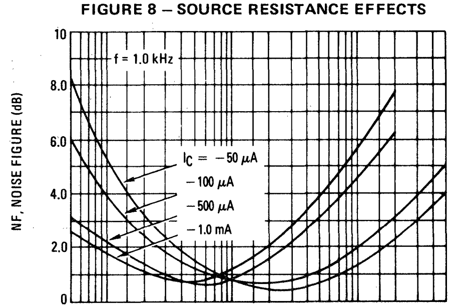


FIGURE 9 — CAPACITANCES

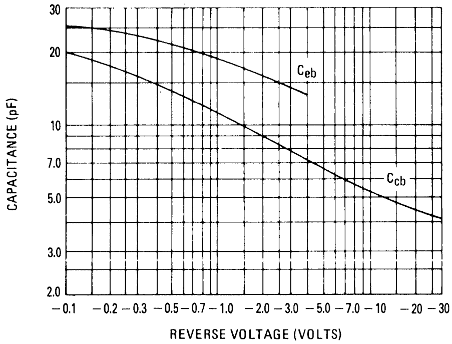


FIGURE 10 — CURRENT-GAIN — BANDWIDTH PRODUCT

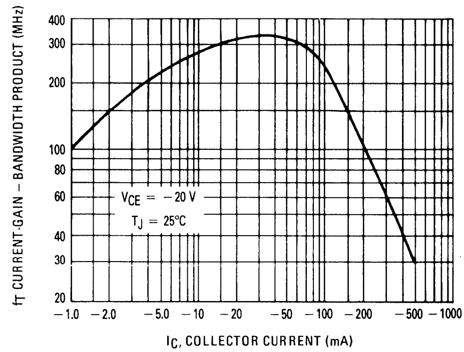


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FIGURE 11 — "ON" VOLTAGE

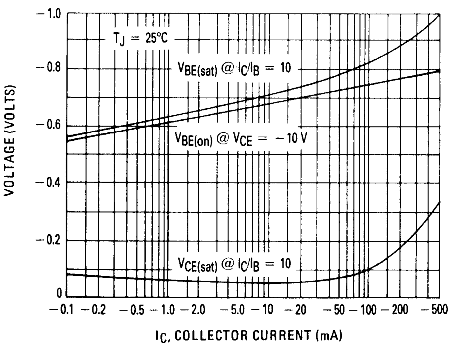
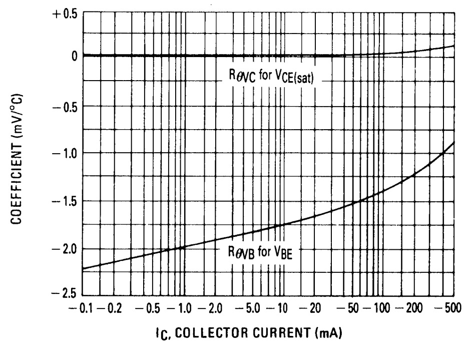


FIGURE 12 — TEMPERATURE COEFFICIENTS



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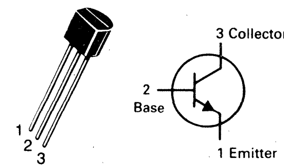
MPS3568

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS8098 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

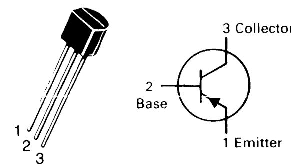
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 75°C)	I_{CBO}	 — —	 50 5.0	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	25	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 30 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 100 100	 — 300	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{obo}	—	20	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	80	pF

(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MPS3638, A

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTORS

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−25	Vdc
Collector-Emitter Voltage	V_{CES}	−25	Vdc
Collector-Base Voltage	V_{CBO}	−25	Vdc
Emitter-Base Voltage	V_{EBO}	−40	Vdc
Collector Current — Continuous	I_C	−500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1)$R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = -100\ \mu Adc, V_{BE} = 0$)		$V_{(BR)CES}$	−25	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = -10$ mAdc, $I_B = 0$)		$V_{CEO(sus)}$	−25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = -100\ \mu Adc, I_E = 0$)		$V_{(BR)CBO}$	−25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = -100\ \mu Adc, I_C = 0$)		$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = -15$ Vdc, $V_{BE} = 0$) ($V_{CE} = -15$ Vdc, $V_{BE} = 0$, $T_A = -65°C$)		I_{CES}	 — —	 −0.035 −2.0	μAdc
Emitter Cutoff Current ($V_{EB} = -3.0$ V, $I_C = 0$)		I_{EBO}	—	−35	nA
Base Current ($V_{CE} = -15$ Vdc, $V_{BE} = 0$)		I_B	—	−0.035	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = -1.0$ mAdc, $V_{CE} = -10$ Vdc)	 MPS3638A	h_{FE}	 80	 —	—
($I_C = -10$ mAdc, $V_{CE} = -10$ Vdc)	MPS3638 MPS3638A		20 100	— —	
($I_C = -50$ mAdc, $V_{CE} = -1.0$ Vdc)	MPS3638 MPS3638A		30 100	— —	
($I_C = -300$ mAdc, $V_{CE} = -2.0$ Vdc)	MPS3638 MPS3638A		20 20	— —	
Collector-Emitter Saturation Voltage ($I_C = -50$ mAdc, $I_B = -2.5$ mAdc) ($I_C = -300$ mAdc, $I_B = -30$ mAdc)		$V_{CE(sat)}$	 — —	 −0.25 −1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = -50$ mAdc, $I_B = -2.5$ mAdc) ($I_C = -300$ mAdc, $I_B = -30$ mAdc)		$V_{BE(sat)}$	 — −0.80	 −1.1 −2.0	Vdc

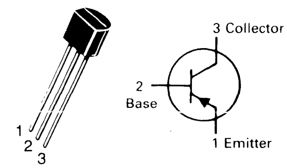
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = −3.0 Vdc, I_C = −50 mAdc, f = 100 MHz)	MPS3638	f_T	100	—	MHz
	MPS3638A		150	—	
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	MPS3638	C_{obo}	—	20	pF
	MPS3638A		—	10	
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS3638	C_{ibo}	—	65	pF
	MPS3638A		—	25	
Input Impedance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{ie}	—	2000	Ohms
Voltage Feedback Ratio (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	MPS3638	h_{re}	—	26	X 10^{-4}
	MPS3638A		—	15	
Small-Signal Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	MPS3638	h_{fe}	25	—	—
	MPS3638A		100	—	
Output Admittance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	—	1.2	mmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −10 Vdc, I_C = −300 mAdc, I_{B1} = −30 mAdc)	t_d	—	20	ns
Rise Time		t_r	—	70	ns
Storage Time	(V_{CC} = −10 Vdc, I_C = −300 mAdc, I_{B1} = −30 mAdc, I_{B2} = −30 mAdc)	t_s	—	140	ns
Fall Time		t_f	—	70	ns
Turn-On Time	(I_C = −300 mAdc, I_{B1} = −30 mAdc)	t_{on}	—	75	ns
Turn-Off Time	(I_C = −300 mAdc, I_{B1} = −30 mAdc, I_{B2} = 30 mAdc)	t_{off}	—	170	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MPS3640

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−12	Vdc
Collector-Base Voltage	V_{CBO}	−12	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−80	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derante above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

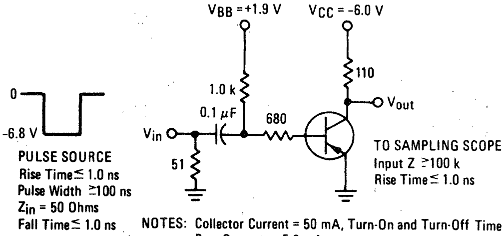
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	— —	−0.01 −1.0	μAdc
Base Current — (V_{CE} = −6.0 Vdc, V_{EB} = 0)	I_B	—	−10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −10 mAdc, V_{CE} = −0.3 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	 — — —	 −0.2 −0.6 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −0.5 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	−0.75 −0.75 —	−0.95 −1.0 −1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{BE(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc)	t_d	—	10	ns
Rise Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, $V_{BE(off)}$ = −1.9 Vdc, I_{B1} = −5.0 mAdc)	t_r	—	30	ns
Storage Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_s	—	20	ns
Fall Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_f	—	12	ns
Turn-On Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = −0.5 mAdc)	t_{on}	 — —	 25 60	ns
Turn-Off Time (V_{CC} = −6.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc) (V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −0.5 mAdc)	t_{off}	— —	 35 75	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

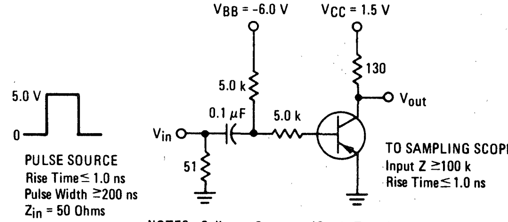
2

FIGURE 1



NOTES: Collector Current = 50 mA, Turn-On and Turn-Off Time Base Currents = 5.0 mA.

FIGURE 2



NOTES: Collector Current = 10 mA, Turn-On and Turn-Off Time Base Currents = 0.5 mA.

FIGURE 3 — DC CURRENT GAIN

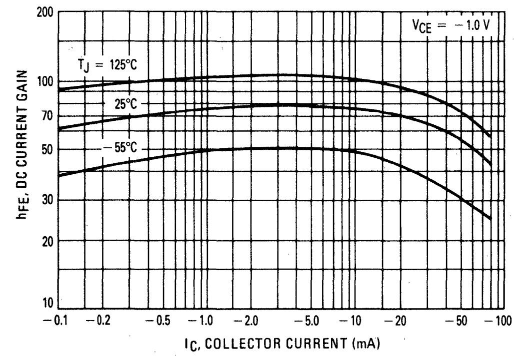


FIGURE 4 — "ON" VOLTAGES

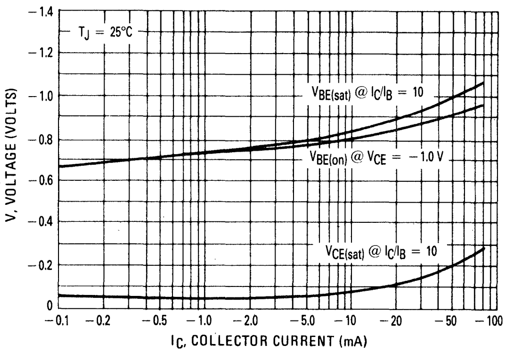


FIGURE 5 — COLLECTOR SATURATION REGION

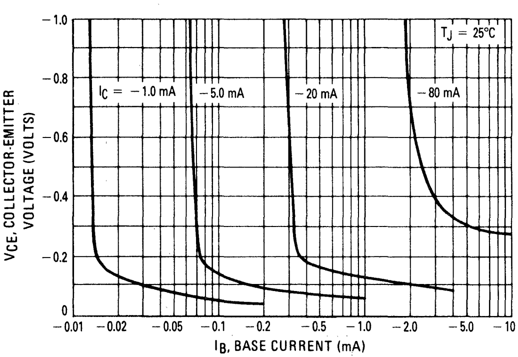


FIGURE 6 — TEMPERATURE COEFFICIENTS

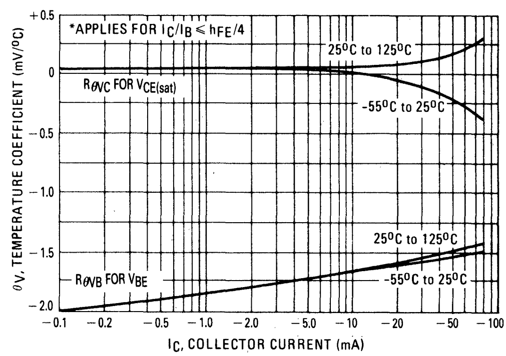


FIGURE 7 — CURRENT-GAIN—BANDWIDTH PRODUCT

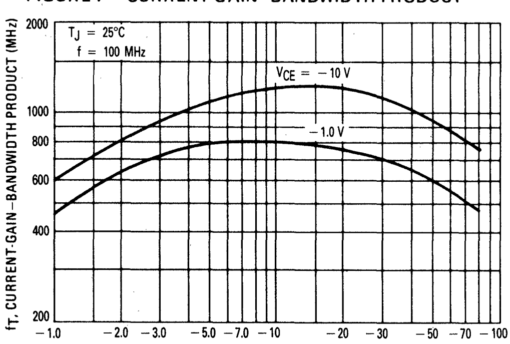
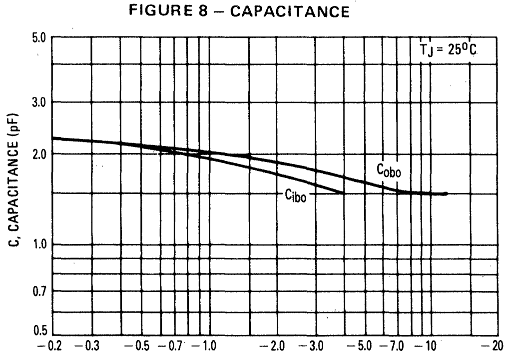


FIGURE 8 — CAPACITANCE



MAXIMUM RATINGS

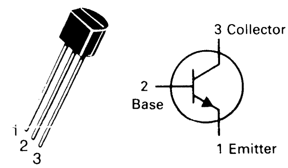
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous — 10 μs Pulse	I_C	300 500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

MPS3646★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N4264 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$) ($V_{CE} = 20$ Vdc, $V_{BE} = 0$, $T_A = 65°C$)	I_{CES}	— —	0.5 3.0	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 0.5$ Vdc) ($I_C = 300$ mA, $V_{CE} = 1.0$ Vdc)	h_{FE}	30 25 15	120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc) ($I_C = 30$ mA, $I_B = 3.0$ mA, $T_A = 65°C$)	$V_{CE(sat)}$	— — — —	0.2 0.28 0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mA)	$V_{BE(sat)}$	0.73 — —	0.95 1.2 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	5.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	9.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = 30$ mAdc) (Figure 1)	t_{on}	—	18	ns
Delay Time ($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = 30$ mAdc) (Figure 1)	t_d	—	10	ns
Rise Time ($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = 30$ mAdc) (Figure 1)	t_r	—	15	ns
Turn-Off Time ($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = I_{B2} = 30$ mAdc) (Figure 1)	t_{off}	—	28	ns
Fall Time ($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = I_{B2} = 30$ mAdc) (Figure 1)	t_f	—	15	ns
Storage Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 10$ mAdc) (Figure 2)	t_s	—	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

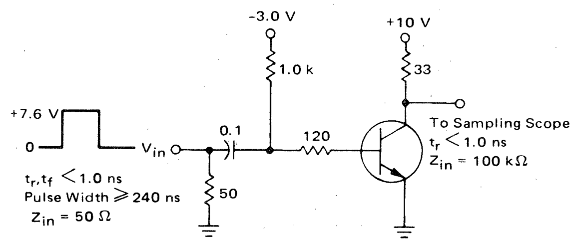
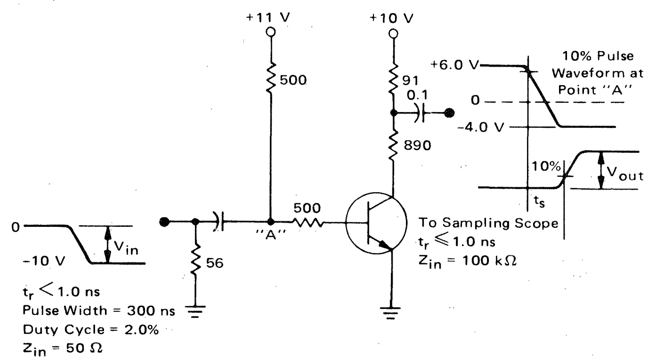
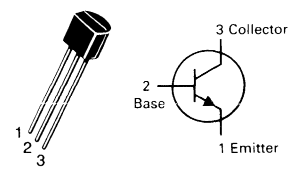


FIGURE 2 — CHARGE STORAGE TIME TEST CIRCUIT



MPS3866

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

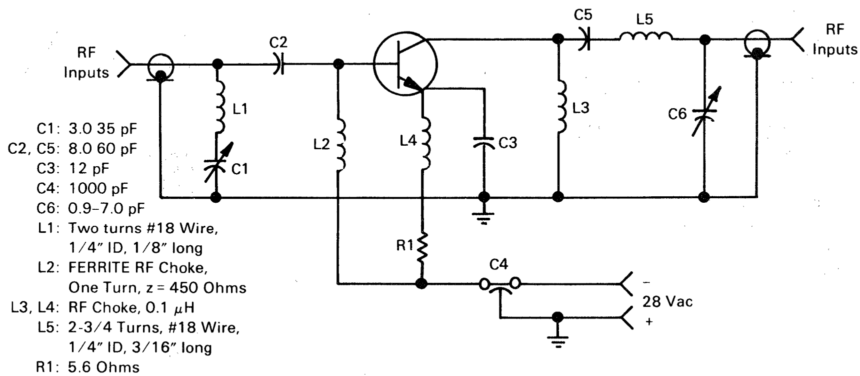
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ω)	$V_{CER(sus)}$	55	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	—	0.02	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = −1.5 Vdc (Rev.), T_C = 150°C) (V_{CE} = 55 Vdc, V_{EB} = −1.5 Vdc (Rev.)	I_{CEX}	 — —	 5.0 0.1	mAdc
Emitter Cutoff Current (V_{EB} = 3.5 Vdc, I_C = 0)	I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 5.0 10	 — 200	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	pF
FUNCTIONAL TEST				
Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	G_{pe}	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	η	45	—	%

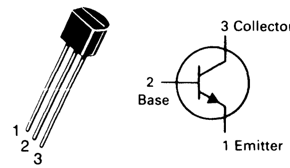
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — 400 MHz TEST CIRCUIT SCHEMATIC



MPS3904

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ $T_A = 60°C$	P_D	450	mW
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	I_{CEX}	—	50	nAdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	I_{BL}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 40 70 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	 0.65 —	 0.85 1.1	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	10	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.5	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	NF	—	5.0	dB
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_r	—	50	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	900	ns
Fall Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_f	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

EQUIVALENT SWITCHING TIME TEST CIRCUITS

FIGURE 1 – TURN-ON TIME

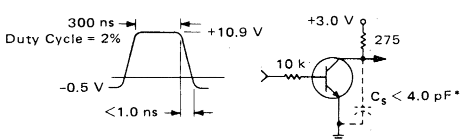
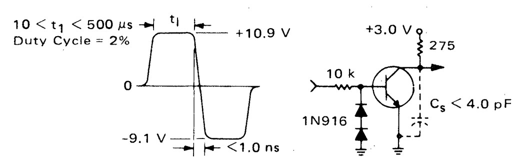


FIGURE 2 – TURN-OFF TIME



*Total shunt capacitance of test jig and connectors

TYPICAL NOISE CHARACTERISTICS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 3 — NOISE VOLTAGE

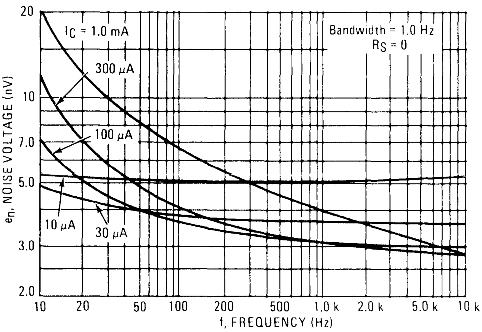
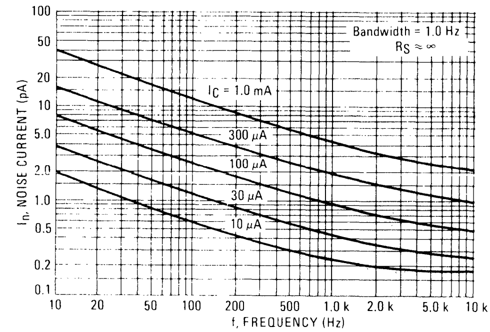


FIGURE 4 — NOISE CURRENT



NOISE FIGURE CONTOURS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 5 — NARROW BAND, 100 Hz

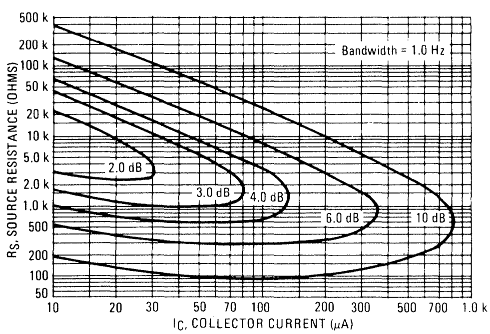


FIGURE 6 — NARROW BAND, 1.0 kHz

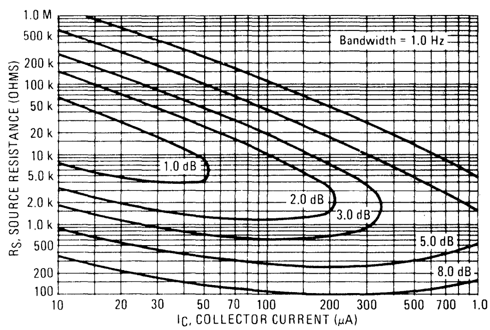
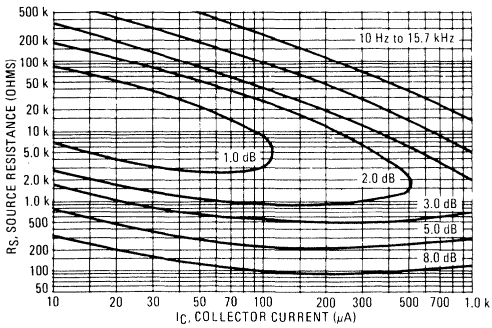


FIGURE 7 — WIDEBAND



Noise Figure is Defined as:

$$NF = 20 \log_{10}\left(\frac{e_n^2 + 4KTR_S + I_n^2 R_S^2}{4KTR_S}\right)^{1/2}$$

e_n = Noise Voltage of the Transistor referred to the input. (Figure 3)
I_n = Noise Current of the transistor referred to the input (Figure 4)
K = Boltzman's Constant (1.38×10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

FIGURE 8 — DC CURRENT GAIN

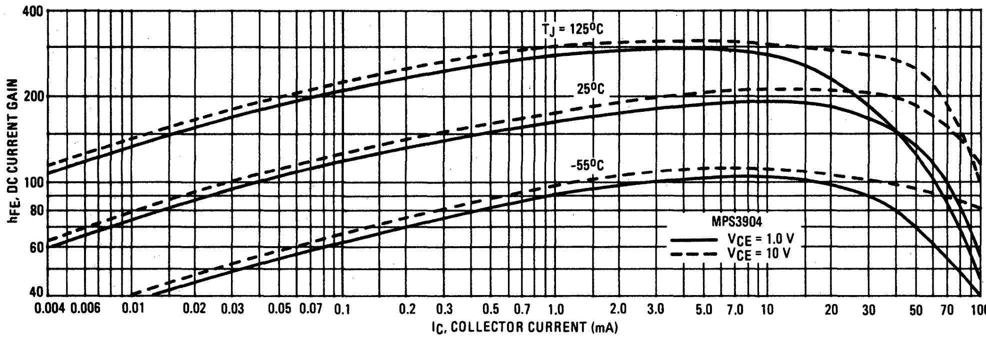


FIGURE 9 — COLLECTOR SATURATION REGION

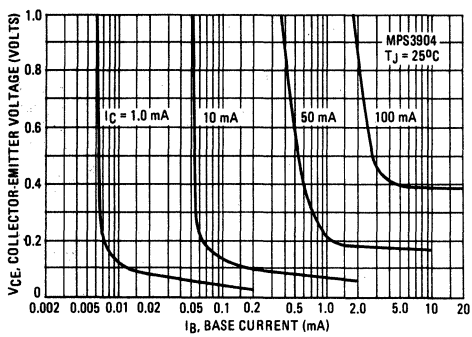


FIGURE 10 — COLLECTOR CHARACTERISTICS

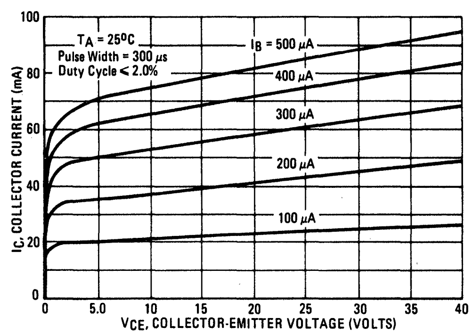


FIGURE 11 — "ON" VOLTAGES

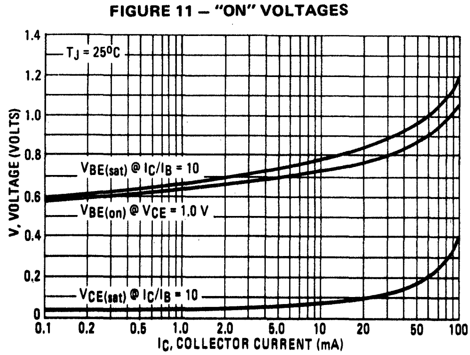
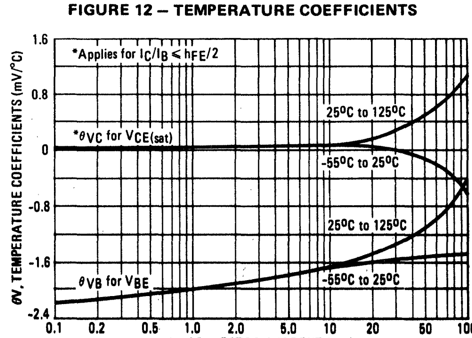


FIGURE 12 — TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 13 — TURN-ON TIME

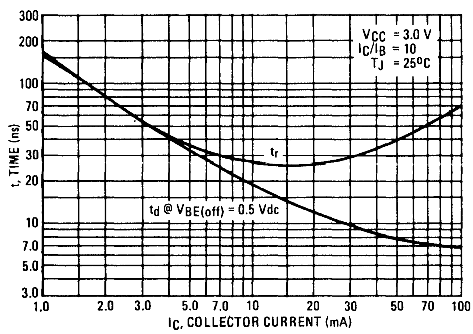


FIGURE 14 — TURN-OFF TIME

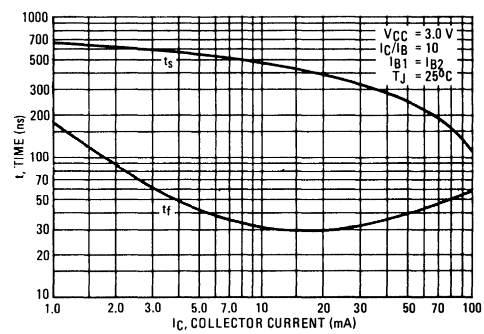


FIGURE 15 — CURRENT-GAIN — BANDWIDTH PRODUCT

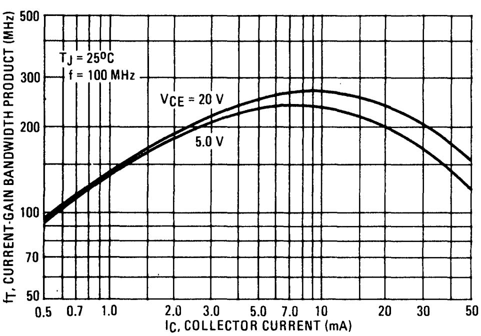


FIGURE 16 — CAPACITANCE

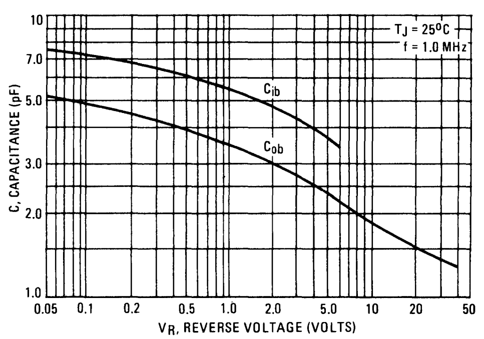


FIGURE 17 — INPUT IMPEDANCE

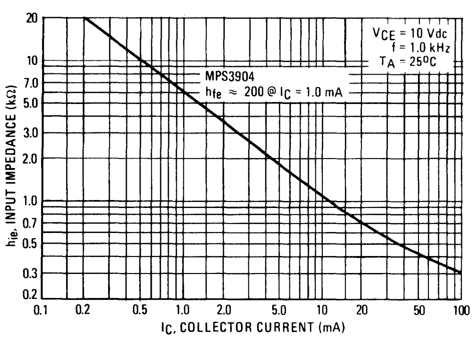


FIGURE 18 — OUTPUT ADMITTANCE

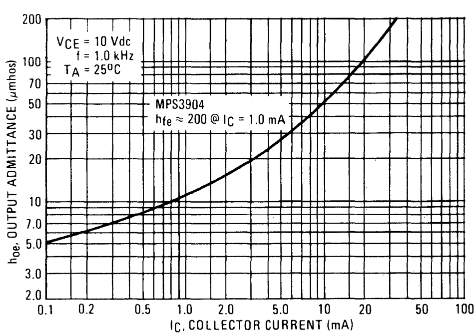


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FIGURE 19 – THERMAL RESPONSE

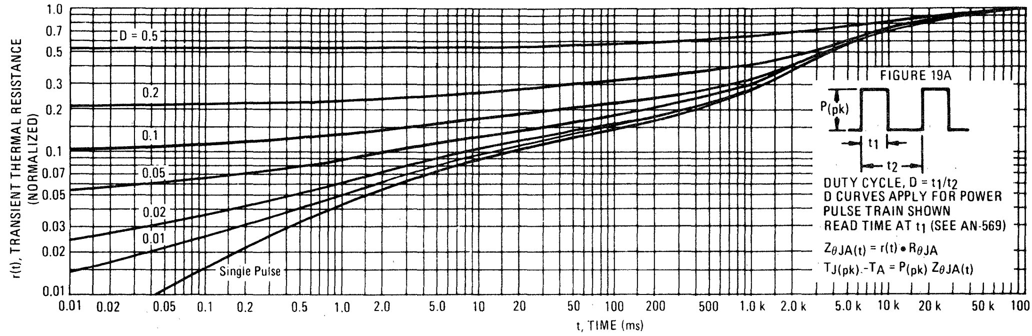
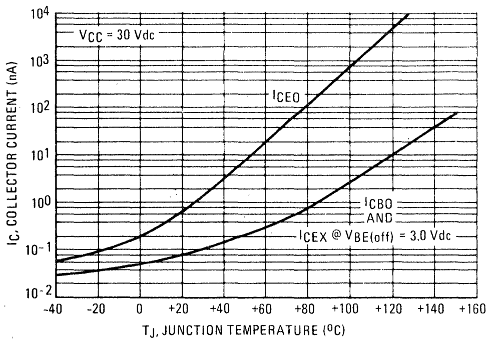


FIGURE 19A



DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 19 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 19 by the steady state value $R_{\theta JA}$.

Example:

The MPS3904 is dissipating 2.0 watts peak under the following conditions:

$t_1 = 1.0$ ms, $t_2 = 5.0$ ms. ($D = 0.2$)

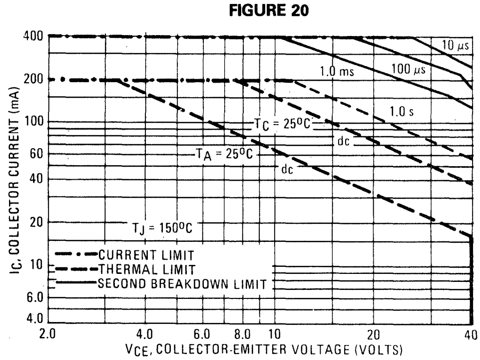
Using Figure 19 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88°C.$$

For more information, see AN-569.

FIGURE 20

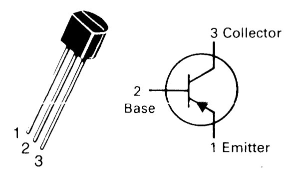


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 20 is based upon $T_{J(pk)} = 150°C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown.

MPS3906

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−200	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −3.0 Vdc)	I_{CEX}	—	−50	nAdc
Base Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −3.0 Vdc)	I_{BL}	—	−50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 60 80 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	 — —	 −0.25 −0.4	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	 −0.65 —	 −0.85 −0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 V, f = 100 MHz)	f_T	250	—	MHz

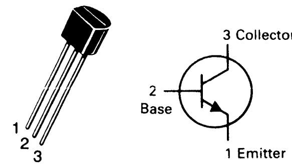
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	pF
Input Impedance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{ie}	2.0	12	k ohms
Voltage Feedback Ratio (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{re}	1.0	10	X 10^{-4}
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{fe}	100	400	—
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −3.0 Vdc, $V_{BE(off)}$ = +0.5 Vdc, I_C = −10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	50	ns
Storage Time	(V_{CC} = −3.0 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_s	—	600	ns
Fall Time		t_f	—	90	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPS4123
MPS4124

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS4123	MPS4124	Unit
Collector-Emitter Voltage	V_{CE}	30	25	Vdc
Collector-Base Voltage	V_{CB}	40	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

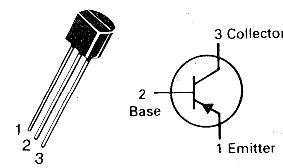
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mA, $I_B = 0$)	MPS4123 MPS4124	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$, $I_E = 0$)	MPS4123 MPS4124	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_C = 0$, $I_E = 10\ \mu A$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ V, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ V, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mA, $V_{CE} = 1.0$ V) ($I_C = 50$ mA, $V_{CE} = 1.0$ V)	 MPS4123 MPS4124 MPS4123 MPS4124	h_{FE}	 50 120 25 60	 150 360 — —	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mA, $I_B = 5.0$ mA)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mA, $I_B = 5.0$ mA)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mA, $V_{CE} = 20$ V, f = 100 MHz)	MPS4123 MPS4124	f_T	100 170	— —	MHz
Output Capacitance ($V_{CB} = 5.0$ V, $I_E = 0$, f = 1.0 MHz)		C_{ob}	—	4.0	pF
Input Capacitance ($V_{EB} = 0.5$ V, $I_C = 0$, f = 1.0 MHz)	MPS4123 MPS4124	C_{ib}	— —	14 13.5	pF
Small-Signal Current Gain ($I_C = 2.0$ mA, $V_{CE} = 1.0$ V, f = 1.0 kHz)	MPS4123 MPS4124	h_{fe}	50 120	200 480	—
Noise Figure ($I_C = 100\ \mu A$, $V_{CE} = 5.0$ V, $R_S = 1.0$ kΩ, f = 1.0 kHz)	 MPS4123 MPS4124	NF	 — —	 6.0 5.0	dB

MPS4125
MPS4126

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS4125	MPS4126	Unit
Collector-Emitter Voltage	V_{CE}	−30	−25	Vdc
Collector-Base Voltage	V_{CB}	−10	−25	Vdc
Emitter-Base Voltage	V_{EB}	−4.0		Vdc
Collector Current — Continuous	I_C	−200		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

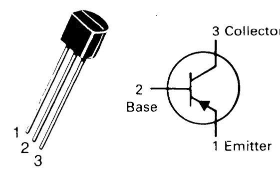
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mA, I_B = 0)	MPS4125 MPS4126	$V_{(BR)CEO}$	−30 −25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μA, I_E = 0)	MPS4125 MPS4126	$V_{(BR)CBO}$	−30 −25	— —	Vdc
Emitter-Base Breakdown Voltage (I_C = 0, I_E = −10 μA)		$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −20 V, I_E = 0)		I_{CBO}	—	−50	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 V, I_C = 0)		I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −2.0 mA, V_{CE} = −1.0 V) (I_C = −50 mA, V_{CE} = −1.0 V)	 MPS4125 MPS4126 MPS4125 MPS4126	h_{FE}	 50 120 25 60	 150 360 — —	—
Collector-Emitter Saturation Voltage (I_C = −50 mA, I_B = −5.0 mA)		$V_{CE(sat)}$	—	−0.4	Vdc
Base-Emitter Saturation Voltage (I_C = −50 mA, I_B = −5.0 mA)		$V_{BE(sat)}$	—	−0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product (I_C = −10 mA, V_{CE} = −20 V, f = 100 MHz)	MPS4125 MPS4126	f_T	150 170	— —	MHz
Output Capacitance (V_{CB} = −5.0 V, I_E = 0, f = 1.0 MHz)		C_{ob}	—	4.5	pF
Input Capacitance (V_{EB} = −0.5 V, I_C = 0, f = 1.0 MHz)	MPS4125 MPS4126	C_{ib}	— —	12 11.5	pF
Small-Signal Current Gain (I_C = −2.0 mA, V_{CE} = −1.0 V, f = 1.0 kHz)	MPS4125 MPS4126	h_{fe}	50 120	200 480	—
Noise Figure (I_C = −100 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz)	 MPS4125 MPS4126	NF	 — —	 5.0 4.0	dB

MPS4249
MPS4250

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS4250	MPS4249	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Emitter Voltage	V_{CES}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−40	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	−5.0	Vdc
Collector Current — Continuous	I_C	—	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	1.5 12	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 μA) (I_C = −5.0 mA)	 MPS4249 MPS4250	$V_{(BR)CES}$	 −60 −40	 — —	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −5.0) (I_C = −5.0)	 MPS4250 MPS4249	$V_{(BR)CEO(sus)}$	 −40 −60	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μA) (I_C = −10 μA)	 MPS4250 MPS4249	$V_{(BR)CBO}$	 −40 −60	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μA)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −40 V) (V_{CB} = −50 V) (V_{CB} = −40 V, T_A = 65°C)	 MPS4249 MPS4250 MPS4249, MPS4250	I_{CBO}	 — — —	 −10 −10 −3.0	nA
Emitter Cutoff Current (V_{EB} = −3.0 V)		I_{EBO}	—	−20	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = −100 μA, V_{CE} = −5.0 V) (I_C = −1.0 mA, V_{CE} = −5.0 V) (I_C = −1.0 mA, V_{CE} = −5.0 V) (I_C = −10 mA, V_{CE} = −5.0 V) (I_C = −10 mA, V_{CE} = −5.0 V)	 MPS4249 MPS4249 MPS4250 MPS4249 MPS4250	h_{FE}	 100 100 250 100 250	 300 — — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA)		$V_{CE(sat)}$	—	−0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA)		$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = −5.0 V, f = 1.0 MHz)		C_{obo}	—	6.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

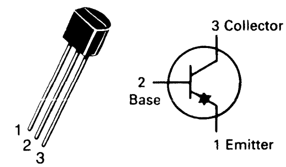
Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)		C_{ibo}	—	16	pF
Small-Signal Current Gain		h_{fe}			—
(I_C = −1.0 mA, V_{CE} = −5.0 V, f = 1.0 kHz)	MPS4249		100	500	
(I_C = −1.0 mA, V_{CE} = −5.0 V, f = 1.0 kHz)	MPS4250,A		250	800	
(I_C = −0.5 mA, V_{CE} = −5.0 V, f = 20 MHz)	MPS4249,50		2.0	—	
Noise Figure		NF			dB
(I_C = −20 μA, V_{CE} = −5.0 V, R_S = 10 kΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4250,A		—	2.0	
(I_C = −20 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4249		—	3.0	
(I_C = −250 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4250,A		—	2.0	
(I_C = −250 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4249		—	3.0	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2

MPS4258

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

PNP SILICON

Refer to MPS3640 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−12	Vdc
Collector-Base Voltage	V_{CBO}	−12	Vdc
Emitter-Base Voltage	V_{EBO}	−4.5	Vdc
Collector Current — Continuous	I_C	−80	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = +65°C)	I_{CES}	 — —	 −0.01 −5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −0.5 Vdc) (I_C = −10 mAdc, V_{CE} = −3.0 Vdc) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 15 30 30	 — 120 —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	 — —	 −0.15 −0.5	Vdc
Base-Emitter On Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	 −0.75 —	 −0.95 −1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product(2) (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	700	—	MHz
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

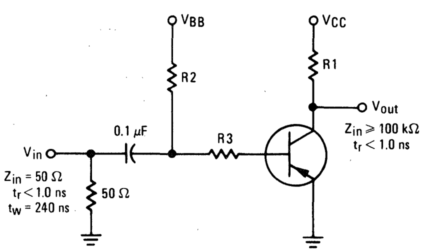
2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −1.5 Vdc, $V_{EB(off)}$ = 0, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	20	ns
Storage Time		t_s	—	10	ns
Fall Time		t_f	—	20	ns
Storage Time ($I_C \approx -10$ mAdc, $I_{B1} \approx -10$ mAdc, $I_{B2} \approx 10$ mAdc)		t_s	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

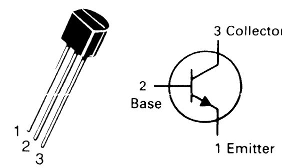
FIGURE 1 — SWITCHING TIME TEST CIRCUIT



	V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R1 Ohms	R2 Ohms	R3 Ohms	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	GND	-1.5	130	2.2 k	5 k	10	1.0	–
t_{off}	+9.8	-8.0	-1.5	130	2.2 k	5 k	10	1.0	1.0
t_s	+9.0	-10	-3.0	270	510	390	10	10	10

MPS5179★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

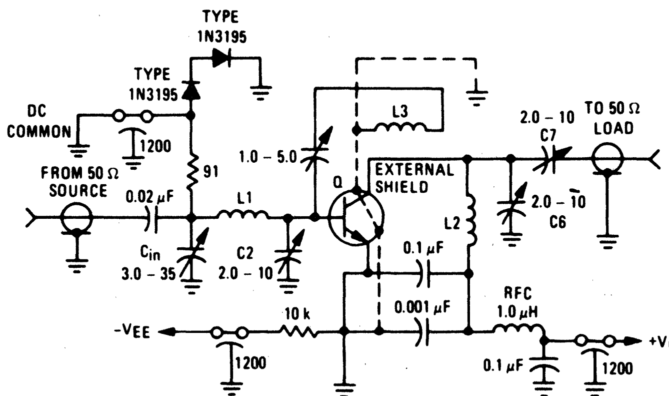
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.001 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.02 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	250	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	900	2000	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	—	1.0	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	25	300	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b'C_c$	3.0	14	ps
Noise Figure (See Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	5.0	dB
Common-Emitter Amplifier Power Gain (See Figure 1) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	15	—	dB

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

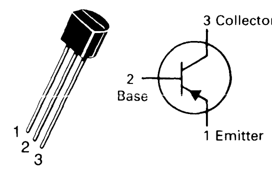
FIGURE 1 — 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT



L1 1-3/4 Turns, #18 AWG, 0.5" L, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" L, 0.5" Diameter
L3 2 Turns, #13 AWG, 0.25" L, 0.5" Diameter (Position 1/4" from L2)

MPS5771

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−15	Vdc
Collector-Base Voltage	V_{CBO}	−15	Vdc
Emitter-Base Voltage	V_{EBO}	−4.5	Vdc
Collector Current — Continuous	I_C	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −3.0 mA)(1)	$V_{(BR)CEO}$	−15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μA)	$V_{(BR)CES}$	−15	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μA)	$V_{(BR)CBO}$	−15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μA)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CB} = −8.0 Vdc)	I_{CBO}	—	−10	nA
Collector Cutoff Current (V_{CE} = −8.0 Vdc) (V_{CE} = −8.0 Vdc, T_A = 125°C)	I_{CES}	— —	−10 −5.0	nA μA
Emitter Cutoff Current (V_{EB} = −4.5 Vdc)	I_{EBO}	—	−1.0	μA
ON CHARACTERISTICS				
DC Current (I_C = −1.0 mA, V_{CE} = −0.5 Vdc)(1) (I_C = −10 mA, V_{CE} = −1.0 Vdc)(1) (I_C = −50 mA, V_{CE} = −1.0 Vdc)(1) (I_C = −10 mA, V_{CE} = −1.0 Vdc, T_A = −55°C)	h_{FE}	30 35 25 15	— 120 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −1.0 mA, I_B = −0.1 mA) (I_C = −10 mA, I_B = −1.0 mA) (I_C = −50 mA, I_B = −5.0 mA)	$V_{CE(sat)}$	 — — —	 −0.15 −0.18 −0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −1.0 mA, I_B = −0.1 mA) (I_C = −10 mA, I_B = −1.0 mA) (I_C = −50 mA, I_B = −5.0 mA)	$V_{BE(sat)}$	— −0.75 —	−0.8 −0.95 −1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = −5.0 Vdc, f = 140 kHz, f = 1.0 MHz)	C_{cb}	—	3.0	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, f = 140 kHz, f = 1.0 MHz)	C_{eb}	—	3.5	pF
Small-Signal Current Gain (I_C = −10 mA, V_{CE} = −10 Vdc, f = 100 MHz)	h_{fe}	8.5	—	—

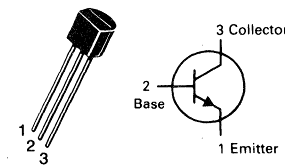
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	(V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_B = −1.0 mA)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 V, I_C = −10 mA, I_{B1} = I_{B2} = −1.0 mA)	t_{off}	—	20	ns
Fall Time		t_f	—	10	ns
Storage Time	(V_{CC} = −1.5 V, I_C = −10 mA, I_{B1} ≈ I_{B2} ≈ −10 mA)	t_s	—	20	ns

(1) Pulse Conditions: Pulse Length = 300 μs, Duty Cycle = 1.0%.

MPS6428

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc)	I_{CEO}	—	0.025	μA
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	0.01	μA
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.01	μA
ON CHARACTERISTICS				
DC Current Gain ($V_{CE} = 5.0$ Vdc, $I_C = 0.01$ mAdc) ($V_{CE} = 5.0$ Vdc, $I_C = 0.1$ mAdc) ($V_{CE} = 5.0$ Vdc, $I_C = 1.0$ mAdc) ($V_{CE} = 5.0$ Vdc, $I_C = 10$ mAdc)	h_{FE}	 250 250 250 250	 — 650 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 100$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.2 0.6	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	0.56	0.66	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ V, f = 100 MHz)	f_T	100	700	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	3.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	3.0	30	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	2.0	20	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	200	800	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos

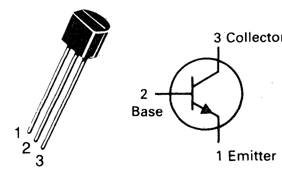
NOISE FIGURE/TOTAL NOISE VOLTAGE CHARACTERISTICS

	NF Max (1)	V_T Max (1)	NF Max (2)	V_T Max (2)	NF Max (3)	V_T Max (3)	Unit	
Noise Figure/Voltage (V_{CE} = 5.0 V, I_C = 0.1 mA, T_A = 25°C)	7.0	18.1	6.0	5700	3.5	4.3	dB	nV

(1) R_S = 10 kΩ, BW = 1.0 Hz, f = 100 Hz
(2) R_S = 50 kΩ, BW = 15.7 kHz, f = 10 Hz–10 kHz
(3) R_S = 500 Ω, BW = 1.0 Hz, f = 10 Hz

MPS6507

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 60°C)	I_{CBO}	 — —	 — —	 50 1.0	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	75	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	800	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	1.25	2.5	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	20	—	—	—

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

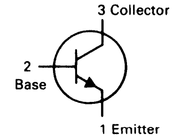
MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6520, MPS6521 MPS6523	V_{CEO}	 25 —	 — 25	Vdc
Collector-Base Voltage MPS6520, MPS6521 MPS6523	V_{CBO}	 40 —	 — 25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

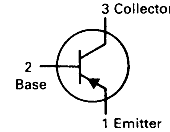
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

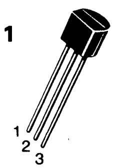
NPN MPS6520 MPS6521★



PNP(1) MPS6523



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★This is a Motorola designated preferred device.

Refer to MPS3904 for NPN graphs.
Refer to 2N5086 for PNP graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		$V_{(BR)CEO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0)	 MPS6520,MPS6521 MPS67523	I_{CBO}	 — —	 0.05 0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc)	 MPS6520 MPS6521	h_{FE}	 100 150	 — —	—
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6520 MPS6521		200 300	400 600	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6523		150	—	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6523		300	600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	—	3.0	dB

*Refer to 2N5086 for PNP graphs.
(1) Voltage and Current are negative for PNP Transistors.

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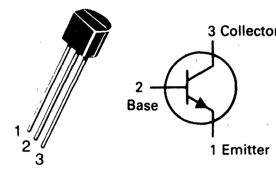
MPS6530
MPS6531

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to 2N4400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	°C

THERMAL CHARACTERISTICS

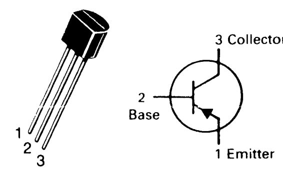
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 60°C)		I_{CBO}	 — —	 0.05 2.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	 MPS6530 MPS6531	h_{FE}	 30 60	 — —	—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MPS6530 MPS6531		40 90	120 270	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPS6530 MPS6531		25 50	— —	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	 MPS6530 MPS6531	$V_{CE(sat)}$	 — —	 0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	5.0	pF

MPS6534

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	°C

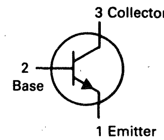
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/mW

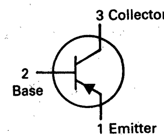
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0) (I_B = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	 −5.0 4.0	 — —	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	I_{CBO}	 — —	 0.05 2.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc) (I_C = −500 mAdc, V_{CE} = −10 Vdc)	h_{FE}	 60 90 50	 — 270 —	—
Collector-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{CE(sat)}$	—	−0.3	Vdc
Base-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{BE(sat)}$	—	−1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	7.0	pF

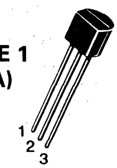
NPN MPS6560



PNP[2] MPS6562



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AUDIO TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/mW

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CEO}	—	100	nAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 35 50 50	 — — 200	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

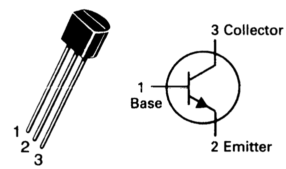
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case(1)	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MPS6568A

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_C = 0)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	375	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	C_{cb}	—	0.65	pF
Noise Figure (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	3.3	dB
FUNCTIONAL TEST				
Amplifier Power Gain (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz)	G_{pe}	20	27	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 200 MHz)	V_{AGC}	4.0	5.0	Vdc

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AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 OHMS, SEE FIGURES 9 AND 10

FIGURE 1 — POWER GAIN

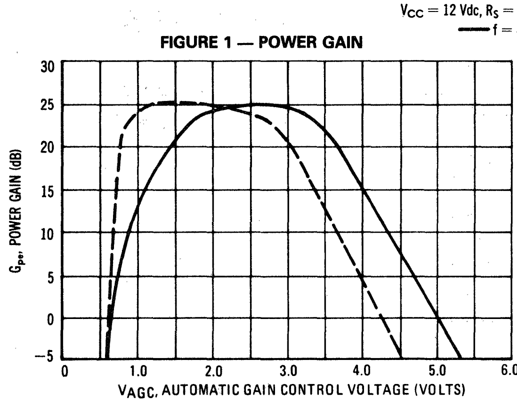


FIGURE 2 — NOISE FIGURE

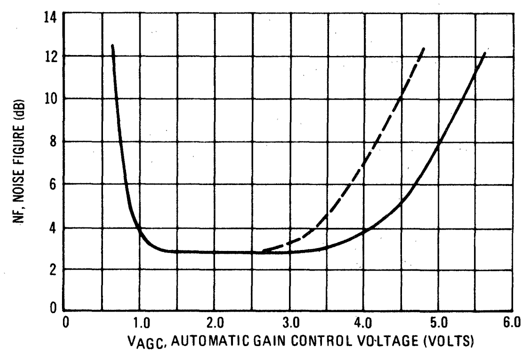
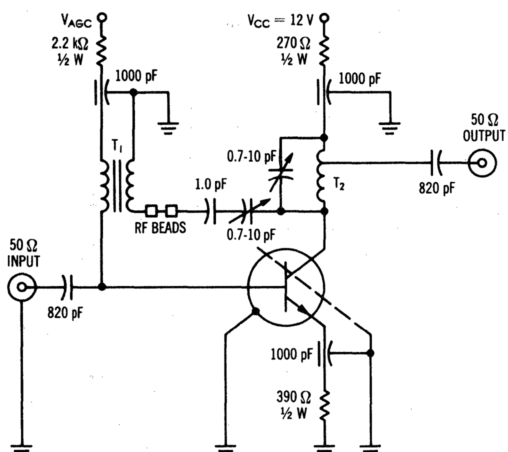
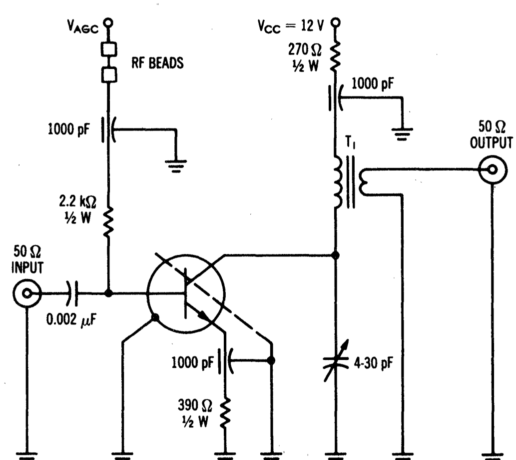


FIGURE 3 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼″, L = ¾″.

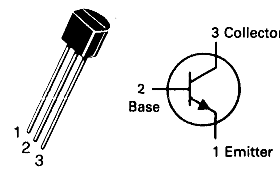
FIGURE 4 — 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



T_1 = TOROID 4:1 RATIO 8T-PRI 2T-SEC } #22 WIRE

MPS6571

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

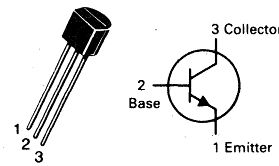
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB(off)} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	250	—	1000	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	f_T	50	175	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	—	4.5	pF
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms, f = 100 Hz)	NF	—	1.2	—	dB

2

MPS6595★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

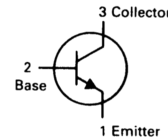
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

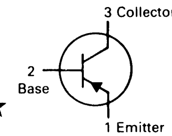
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 25 20	 — —	 250 230	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	1200	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	—	—	1.3	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

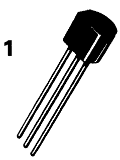
NPN
MPS6601
MPS6602★



PNP(1)
MPS6651
MPS6652★



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6601/6651 MPS6602/6652	V_{CEO}	 25 40	Vdc
Collector-Base Voltage MPS6601/6651 MPS6602/6652	V_{CBO}	 25 30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

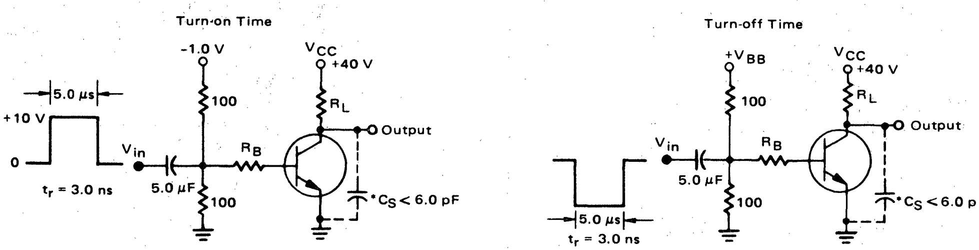
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CEO}$	 25 40	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CBO}$	 25 40	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $I_B = 0$) ($V_{CE} = 30$ Vdc, $I_B = 0$)	 MPS6601/6651 MPS6602/6652	I_{CEO}	 — —	 0.1 0.1	μAdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$)	 MPS6601/6651 MPS6602/6652	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 50 50 30	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	100	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	30	pF
SWITCHING CHARACTERISTICS					
Delay Time	($V_{CC} = 40$ Vdc, $I_C = 500$ mAdc, $I_{B1} = 50$ mAdc, $t_p \geq 300$ ns Duty Cycle)	t_d	—	25	ns
Rise Time		t_r	—	30	ns
Storage Time		t_s	—	250	ns
Fall Time		t_f	—	50	ns

(1) Voltage and Current are negative for PNP Transistors.

2

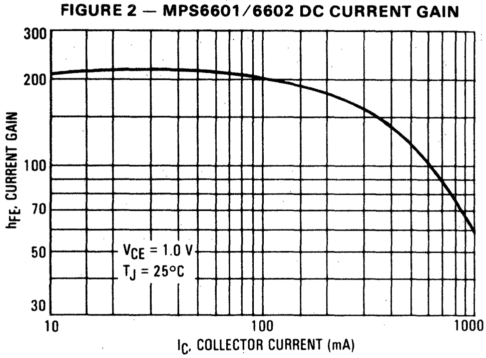
FIGURE 1 — SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

NPN

FIGURE 2 — MPS6601/6602 DC CURRENT GAIN



PNP

FIGURE 3 — MPS6651/6652 DC CURRENT GAIN

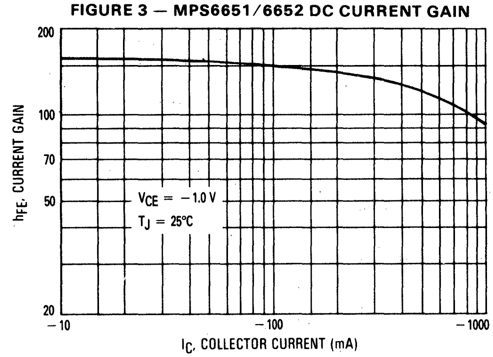


FIGURE 4 — CURRENT GAIN BANDWIDTH PRODUCT

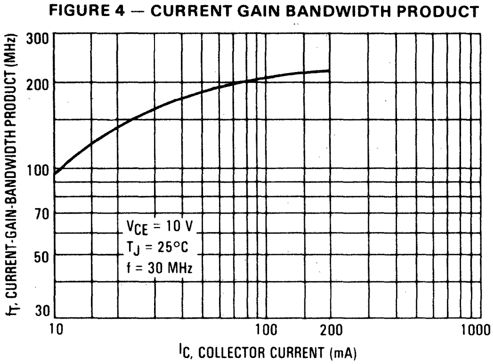


FIGURE 5 — CURRENT GAIN BANDWIDTH PRODUCT

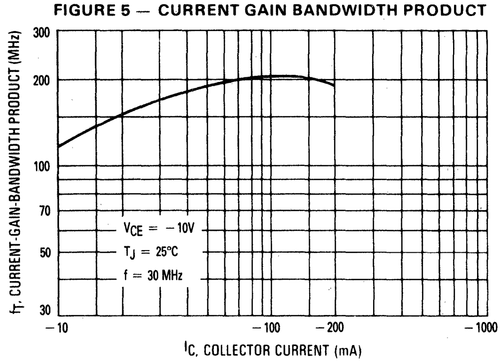


FIGURE 6 — ON VOLTAGES

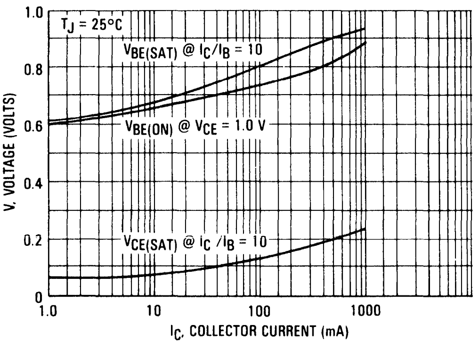
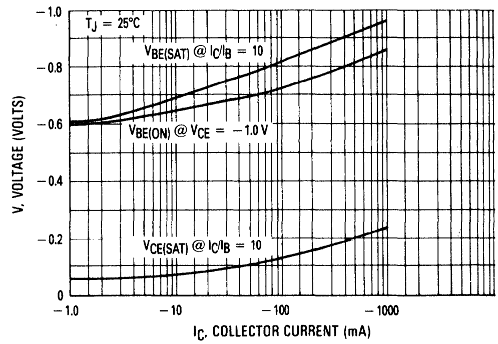


FIGURE 7 — ON VOLTAGES



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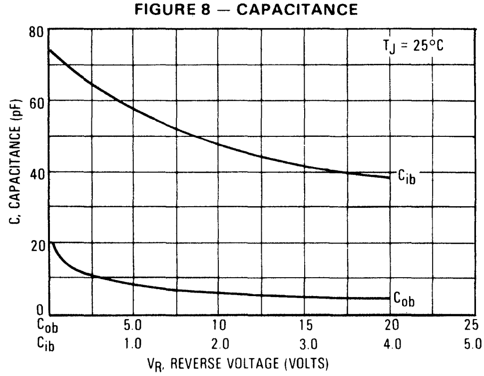
NPN

FIGURE 8 — CAPACITANCE



PNP

FIGURE 9 — CAPACITANCE

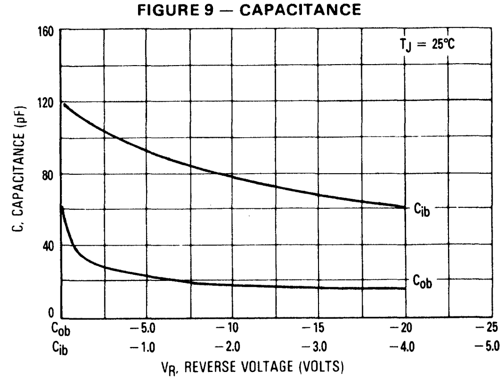


FIGURE 10 — MPS6601/6602 NOISE FIGURE

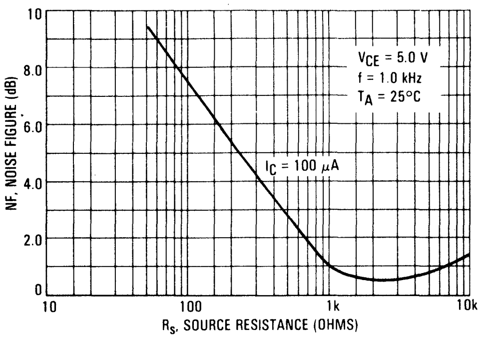


FIGURE 11 — MPS6651/6652 NOISE FIGURE

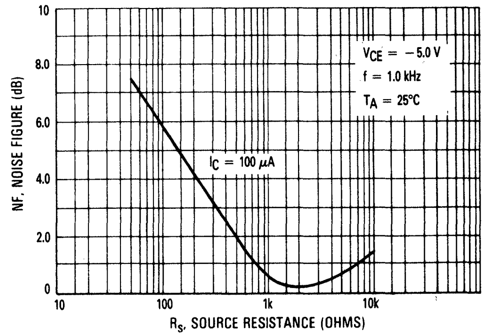


FIGURE 12 — MPS6601/6602 SWITCHING TIMES

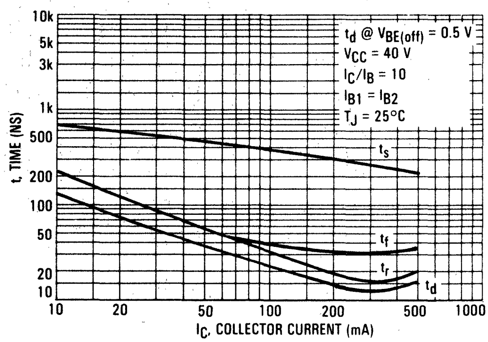
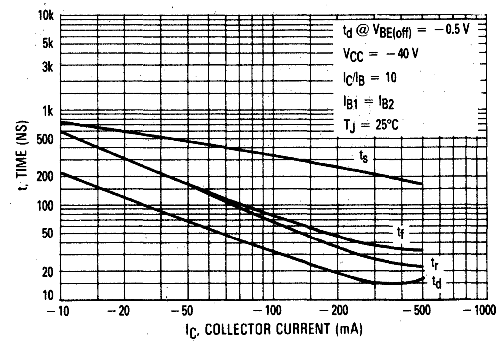
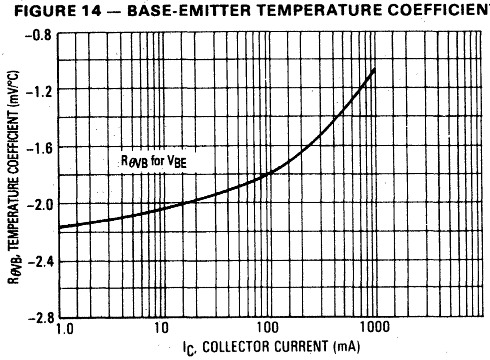


FIGURE 13 — MPS6651/6652 SWITCHING TIMES



NPN

FIGURE 14 — BASE-EMITTER TEMPERATURE COEFFICIENT



PNP

FIGURE 15 — BASE-EMITTER TEMPERATURE COEFFICIENT

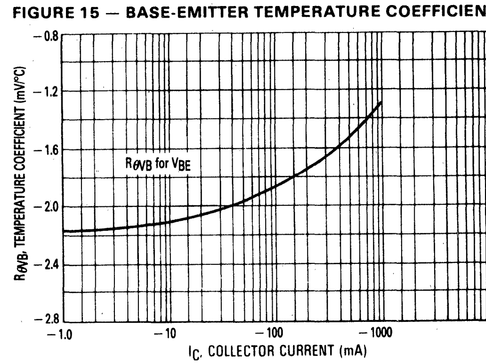


FIGURE 16 — SAFE OPERATING AREA

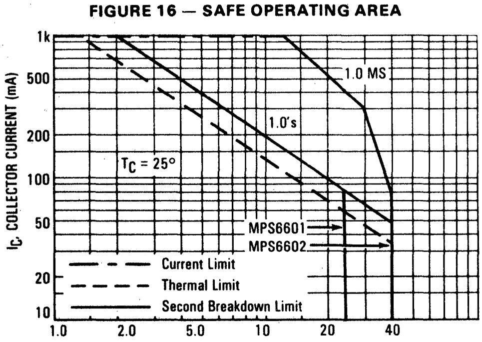


FIGURE 17 — SAFE OPERATING AREA

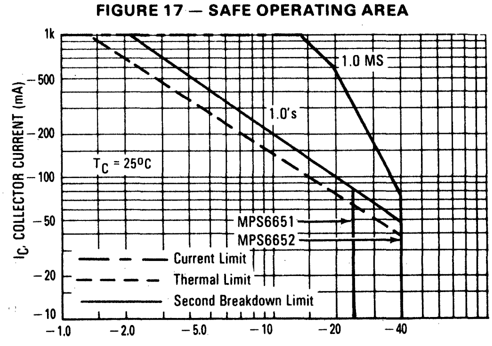


FIGURE 18 — MPS6601/6602 SATURATION REGION

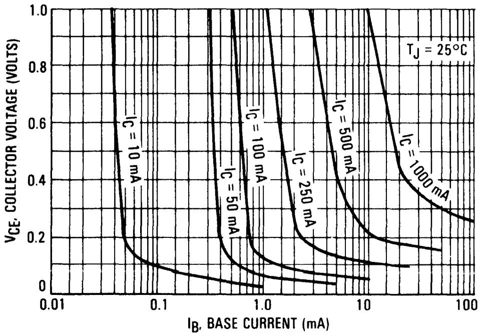


FIGURE 19 — MPS6651/6652 SATURATION REGION

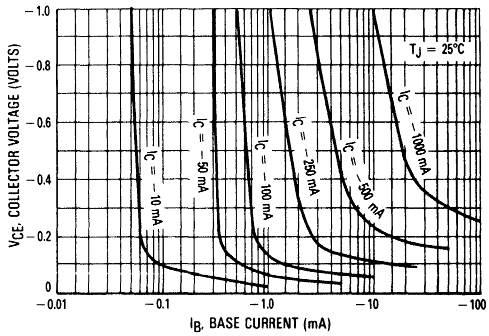
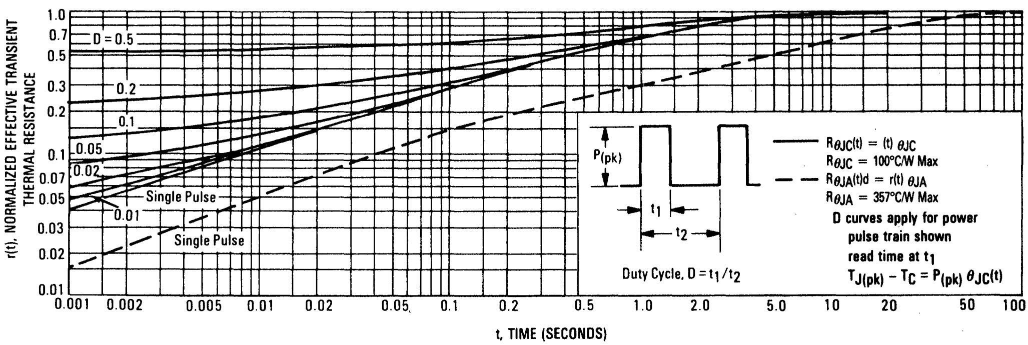


FIGURE 20 — THERMAL RESPONSE



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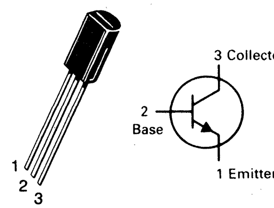
MPS6714
MPS6715

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPSW01 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6714 MPS6715	V_{CEO}	 30 40	Vdc
Collector-Base Voltage MPS6714 MPS6715	V_{CBO}	 40 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

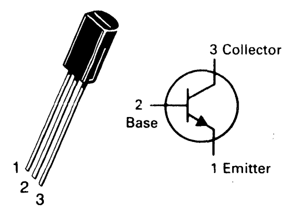
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MPS6714 MPS6715	$V_{(BR)CEO}$	 30 40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS6714 MPS6715	$V_{(BR)CBO}$	 40 50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0)	 MPS6714 MPS6715	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 60 50	 — 250	—
Collector-Emitter Saturation Voltage (I_C = 1000 mAdc, I_B = 100 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 30 μs, Duty Cycle ≤ 2.0%.

MPS6717

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSW05 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 80 50	 — 250	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	30	pF
Small-Signal Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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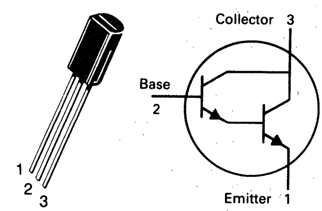
MPS6724
MPS6725

CASE 29-03, STYLE 1
(TO-226AE)



ONE WATT DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS6724	MPS6725	Unit
Collector-Emitter Voltage	V_{CES}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	1000		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

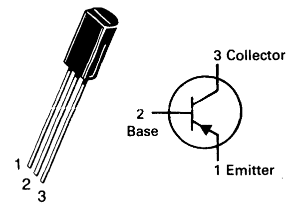
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPS6724 MPS6725	$V_{(BR)CES}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0\ \mu$Adc, $I_E = 0$)	 MPS6724 MPS6725	$V_{(BR)CBO}$	 50 60	 — —	 Vdc Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$)	 MPS6724 MPS6725	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)		h_{FE}	 25,000 4,000	 — 40,000	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	100	1000	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	10	pF

MPS6726
MPS6727

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

Refer to MPSW51 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6726 MPS6727	V_{CEO}	 −30 −40	Vdc
Collector-Base Voltage MPS6726 MPS6727	V_{CBO}	 −40 −50	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc, I_B = 0)	 MPS6726 MPS6727	$V_{(BR)CEO}$	 −30 −40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 MPS6726 MPS6727	$V_{(BR)CBO}$	 −40 −50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −40 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0)	 MPS6726 MPS6727	I_{CBO}	—	 −0.1 −0.1	μAdc
Emitter Cutoff Current (V_{EB} = −5.0 Vdc, I_C = 0)		I_{EBO}	—	−0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −100 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1000 mAdc, V_{CE} = −1.0 Vdc)		h_{FE}	 60 50	 — 250	—
Collector-Emitter Saturation Voltage (I_C = −1000 mAdc, I_B = −100 mAdc)		$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −1000 mAdc, V_{CE} = −1.0 Vdc)		$V_{BE(on)}$	—	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

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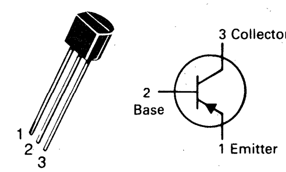
MPS8093

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 60°C	P_D	450	mW
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −20 V)	I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 V)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −50 mAdc, V_{CE} = −2.0 Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	—	−0.25	Vdc
Base-Emitter On Voltage (I_C = −50 mAdc, V_{CE} = −2.0 V)	$V_{BE(on)}$	−0.6	−1.0	Vdc

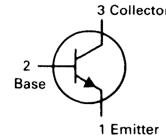
MAXIMUM RATINGS

Rating	Symbol	MPS8098 MPS8598	MPS8099 MPS8599	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
		MPS8099	MPS8598 MPS8599	
Emitter-Base Voltage	V_{EBO}	6.0	5.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

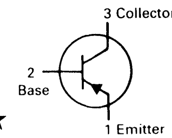
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

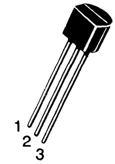
NPN
MPS8098
MPS8099★



PNP(2)
MPS8598
MPS8599★



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

★These are Motorola designated preferred devices.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

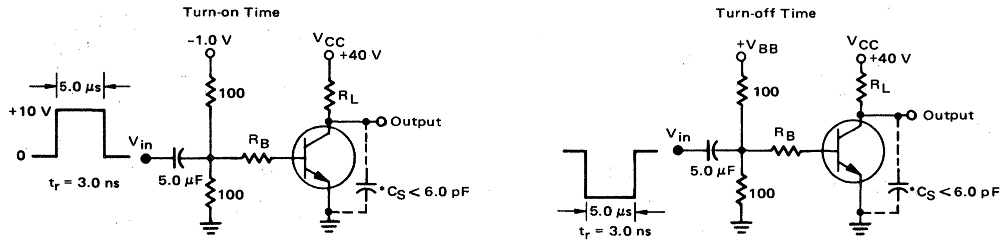
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	 MPS8098, MPS8099 MPS8598, MPS8599	$V_{(BR)EBO}$	 6.0 5.0	 — —	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $I_B = 0$)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPS8098, MPS8598 MPS8099, MPS8599	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$) ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	 MPS8098, MPS8099 MPS8598, MPS8599	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		h_{FE}	100 100 75	300 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	— —	0.4 0.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPS8098, MPS8098 MPS8099, MPS8599	$V_{BE(on)}$	 0.5 0.6	 0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{obo}	 — —	 6.0 8.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{ibo}	 — —	 25 30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
(2) Voltage and Current are negative for PNP Transistors.

2

NPN MPS8098, MPS8099, PNP MPS8598, MPS8599

FIGURE 1 — SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 — CURRENT-GAIN — BANDWIDTH PRODUCT

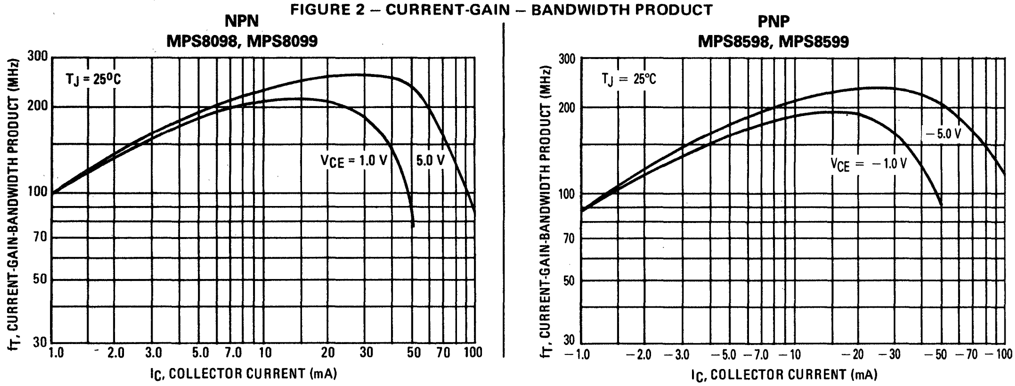


FIGURE 3 — CAPACITANCE

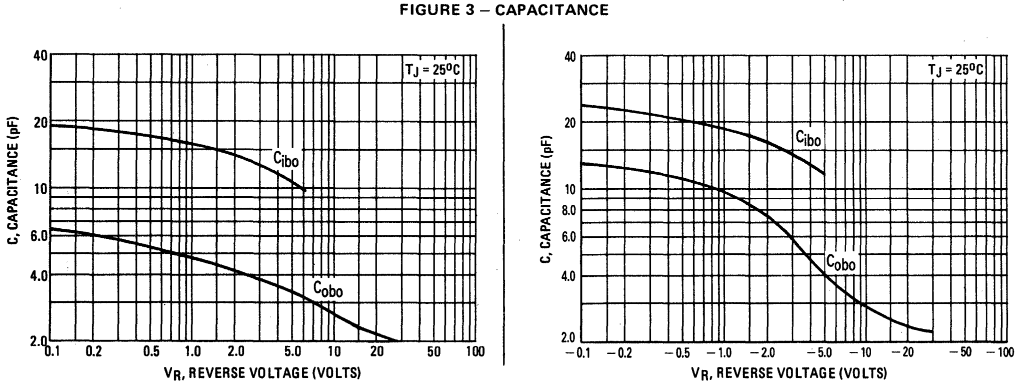


FIGURE 4 — SWITCHING TIMES

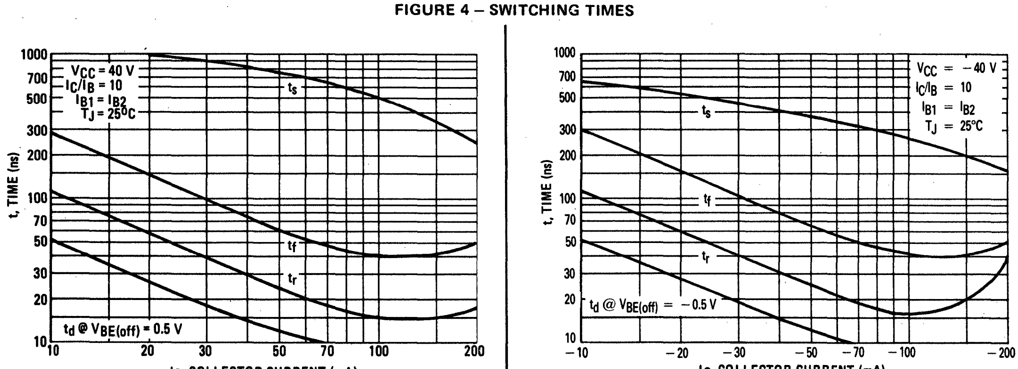


FIGURE 5 – THERMAL RESPONSE

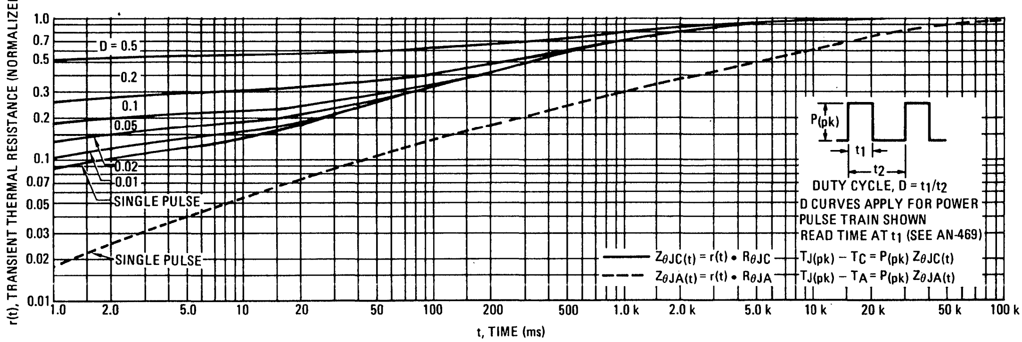


FIGURE 6 — ACTIVE REGION, SAFE OPERATING AREA MPS8098, MPS8099

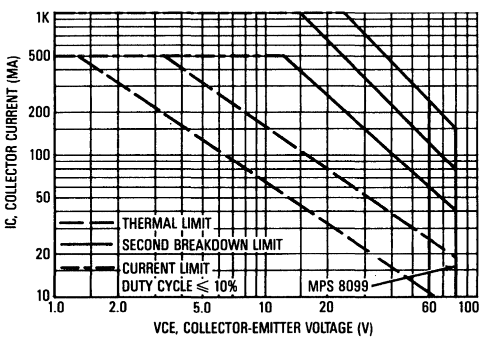
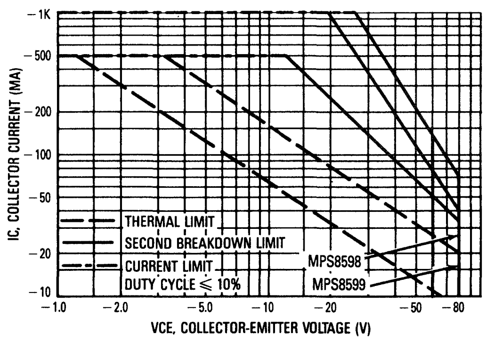


FIGURE 6 — ACTIVE REGION, SAFE OPERATING AREA MPS8598, MPS8599



MPS8098, MPS8099

FIGURE 7 – DC CURRENT GAIN

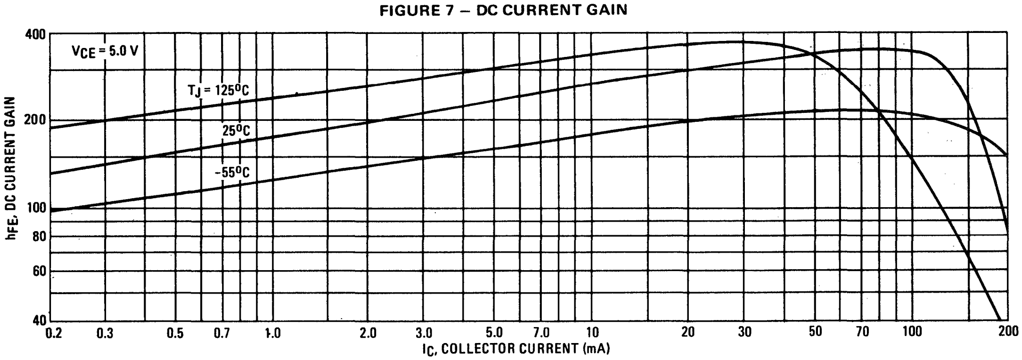


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FIGURE 8 — "ON" VOLTAGES

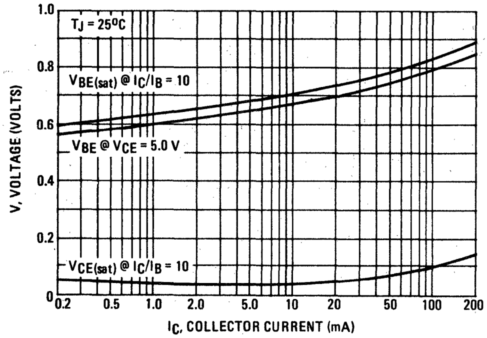


FIGURE 9 — COLLECTOR SATURATION REGION

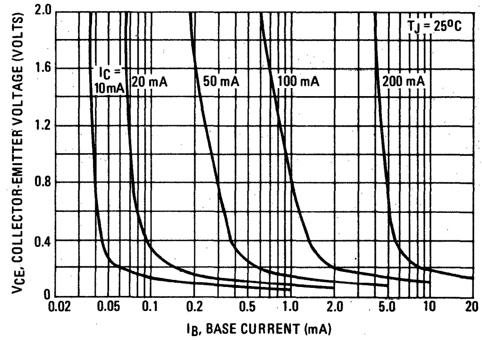
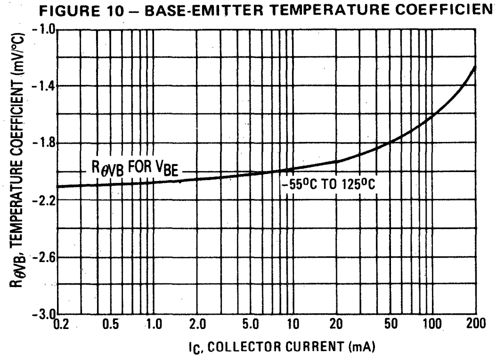


FIGURE 10 — BASE-EMITTER TEMPERATURE COEFFICIENT



MPS8598, MPS8599

FIGURE 11 — DC CURRENT GAIN

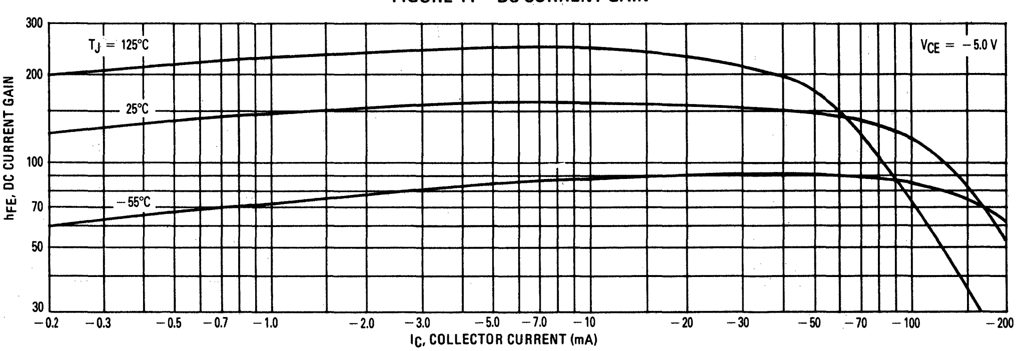


FIGURE 12 – "ON" VOLTAGES

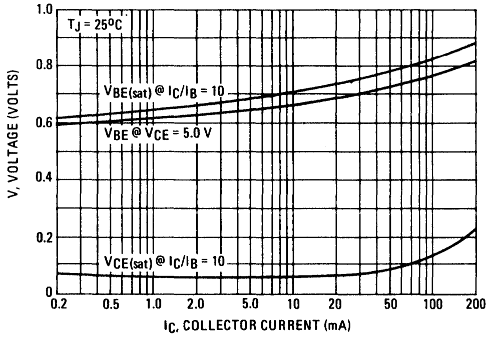


FIGURE 13 – COLLECTOR SATURATION REGION

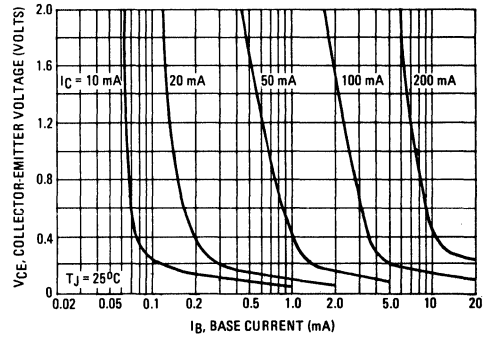
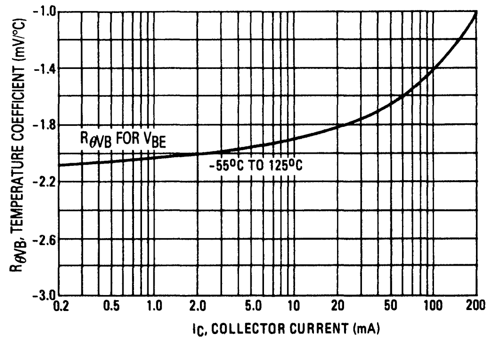


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



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MAXIMUM RATINGS

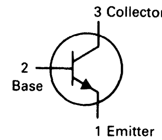
Rating	Symbol	MPSA05 MPSA55	MPSA06 MPSA56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

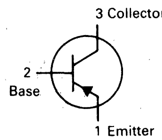
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

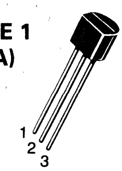
NPN
MPSA05
MPSA06★



PNP(3)
MPSA55
MPSA56★



CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

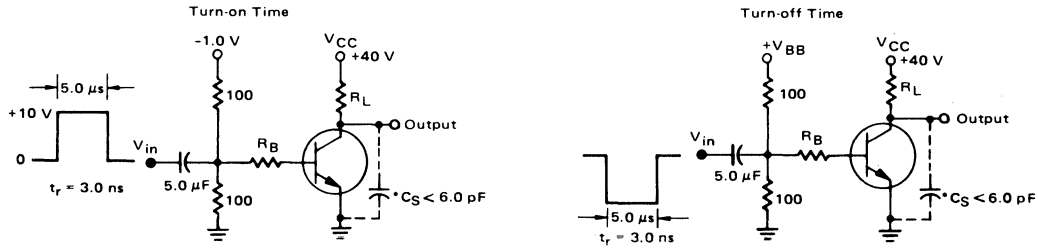
★These are Motorola designated preferred devices.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSA05, MPSA55 MPSA06, MPSA56	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $I_B = 0$)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPSA05, MPSA55 MPSA06, MPSA56	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 100 100	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mA, $V_{CE} = 2.0$ V, f = 100 MHz) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc, f = 100 MHz)	 MPSA05 MPSA06 MPSA55 MPSA56	f_T	 100 50	 — —	MHz

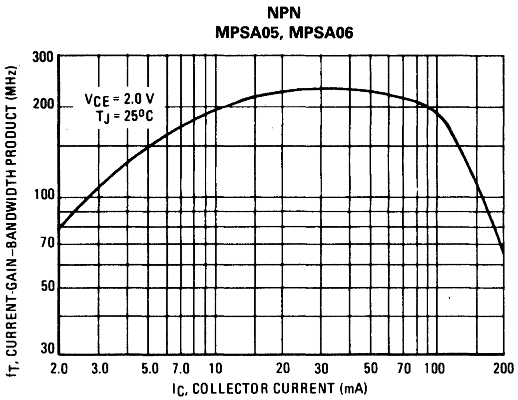
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) Voltage and Current are negative for PNP Transistors.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 — CURRENT-GAIN — BANDWIDTH PRODUCT



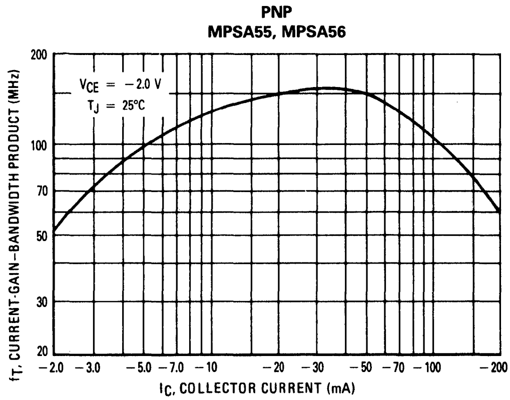
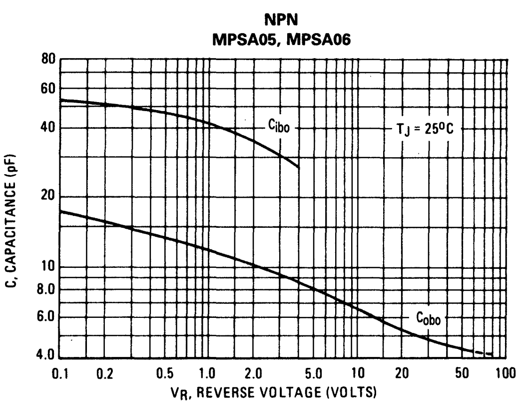


FIGURE 3 — CAPACITANCE



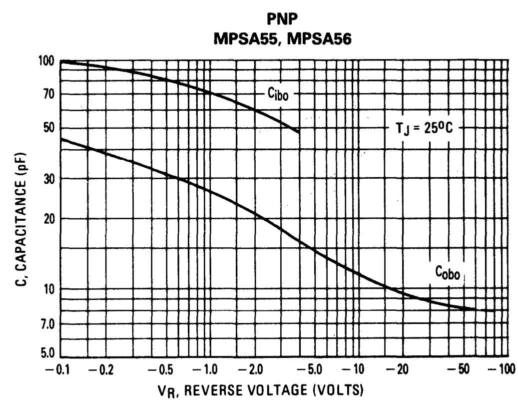


FIGURE 4 — SWITCHING TIME

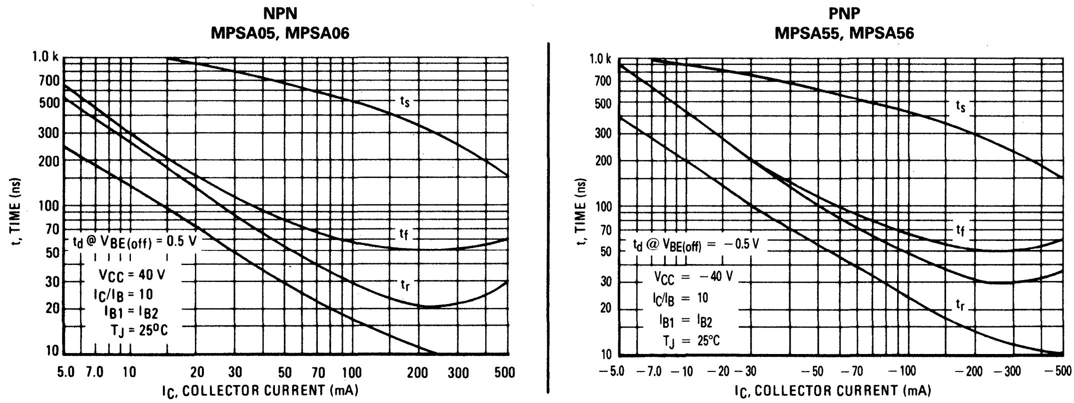


FIGURE 5 — THERMAL RESPONSE
MPSA05, MPSA06, MPSA55, MPSA56

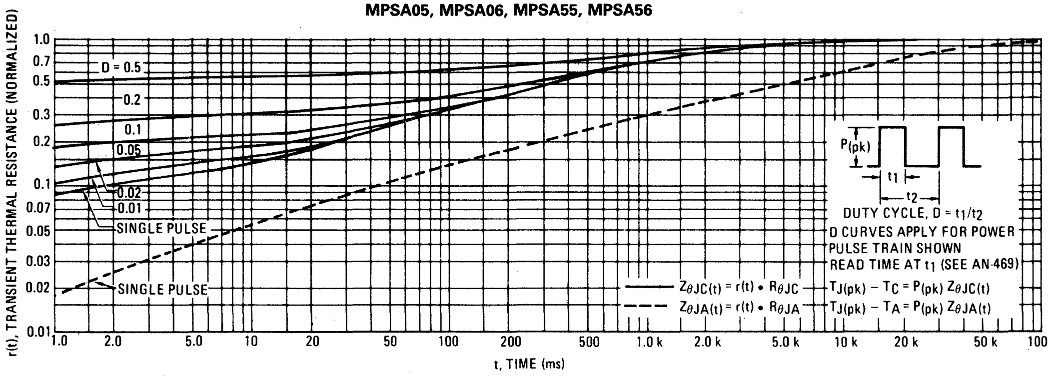
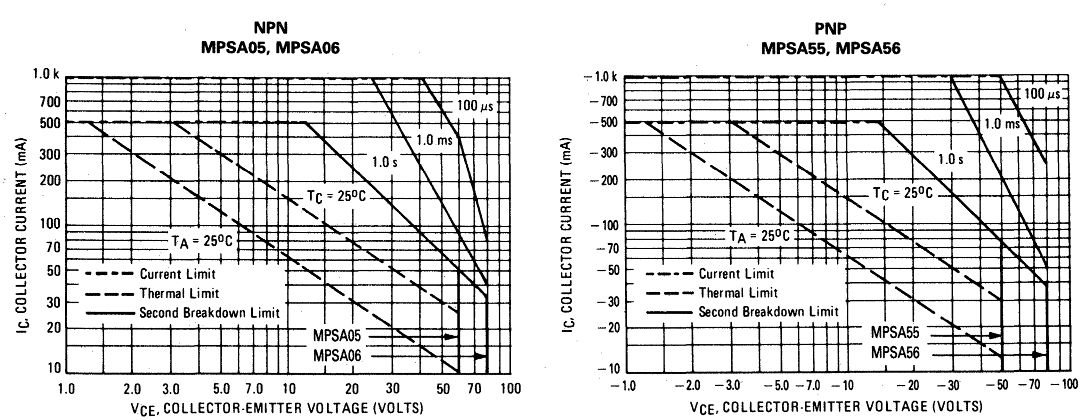


FIGURE 6 — ACTIVE — REGION SAFE OPERATING AREA



NPN
MPSA05, MPSA06

FIGURE 7 — DC CURRENT GAIN

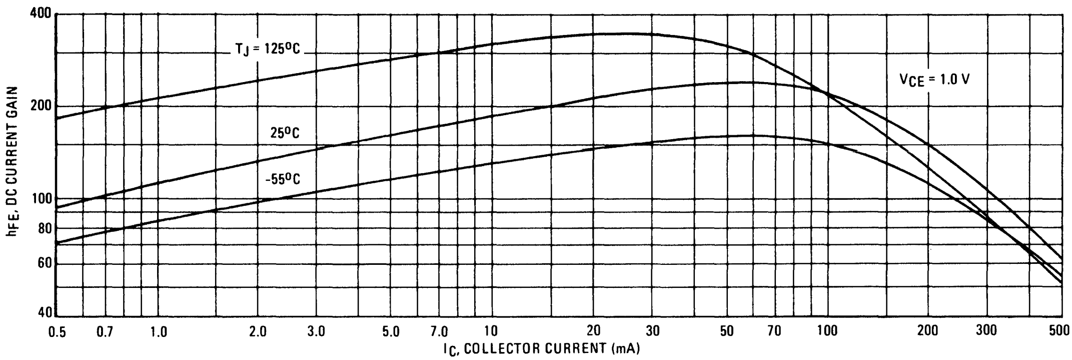


FIGURE 8 — "ON" VOLTAGES

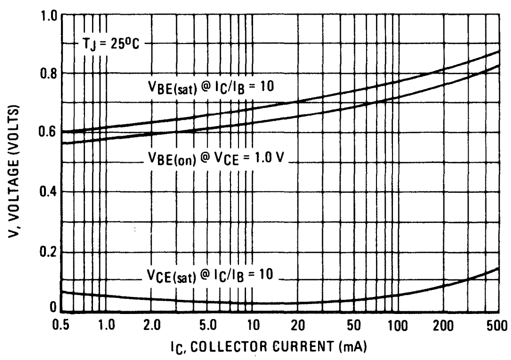


FIGURE 9 — COLLECTOR SATURATION REGION

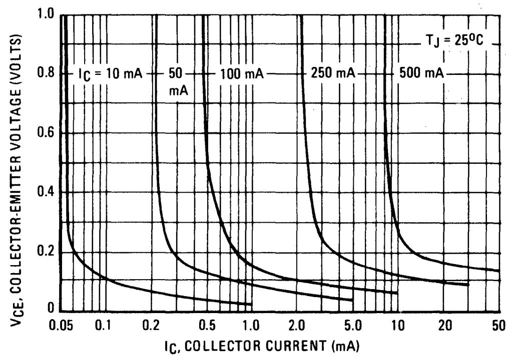
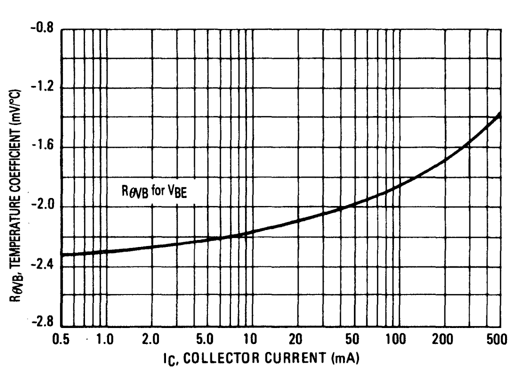


FIGURE 10 — BASE-EMITTER TEMPERATURE COEFFICIENT



PNP
MPSA55, MPSA56

FIGURE 11 — DC CURRENT GAIN

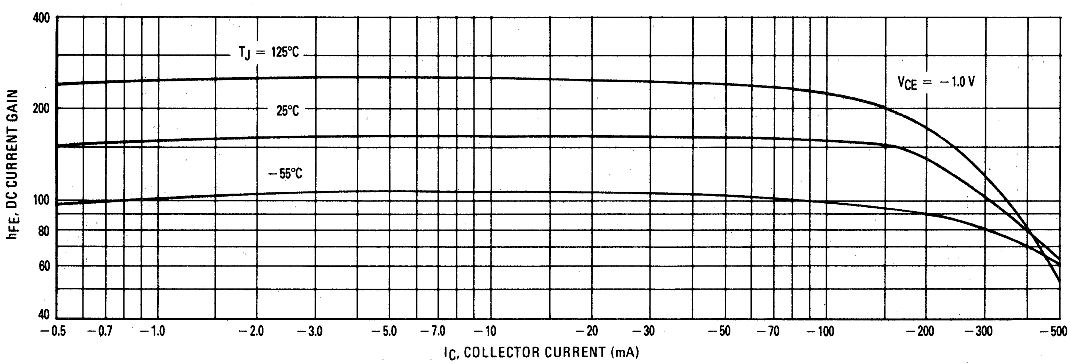


FIGURE 12 — "ON" VOLTAGES

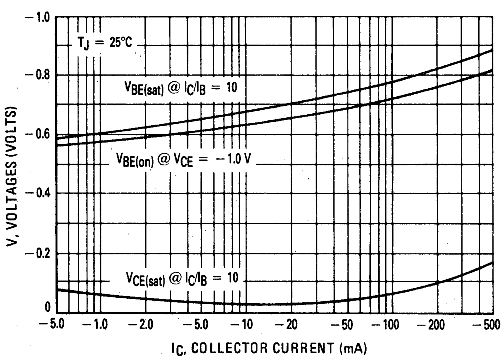


FIGURE 13 — COLLECTOR SATURATION REGION

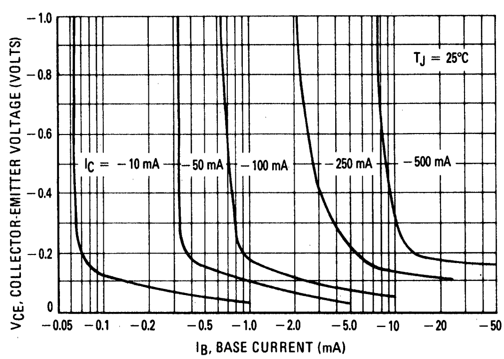
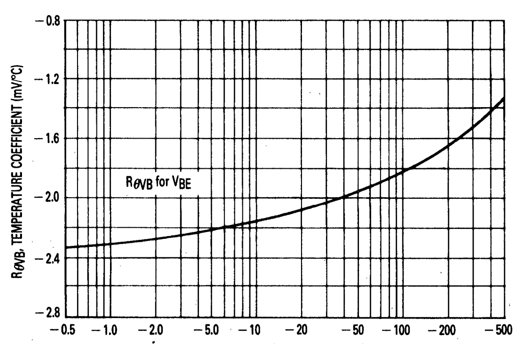
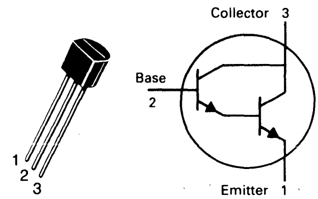


FIGURE 14 — BASE-EMITTER TEMPERATURE COEFFICIENT



MPSA13
MPSA14★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	– 55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

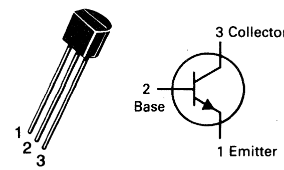
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPSA13 MPSA14	h_{FE}	 5000 10,000	 — —	—
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MPSA13 MPSA14		10,000 20,000	— —	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		V_{BE}	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

MPSA16
MPSA17★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



CHOPPER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPS-A16	MPS-A17	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	12	15	Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	MPS-A16 MPS-A17	$V_{(BR)EBO}$	12 15	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	200	600	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	MPS-A16 MPS-A17	f_T	100 80	— —	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	4.0	pF

FIGURE 1 – DC CURRENT GAIN

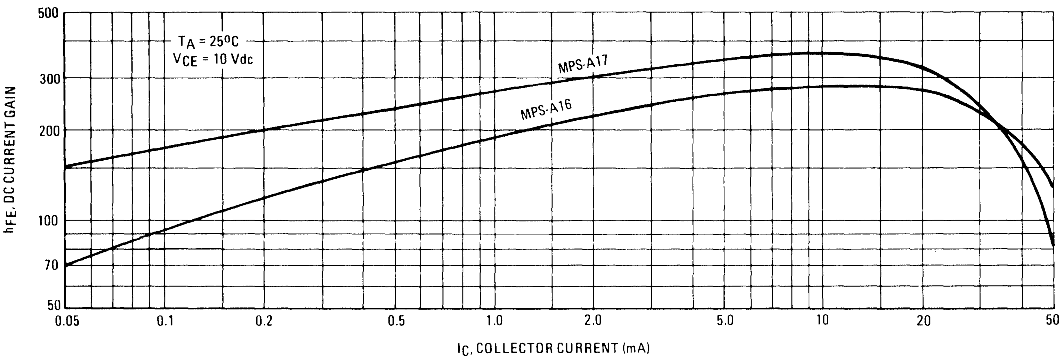


FIGURE 2 – SMALL SIGNAL CURRENT GAIN

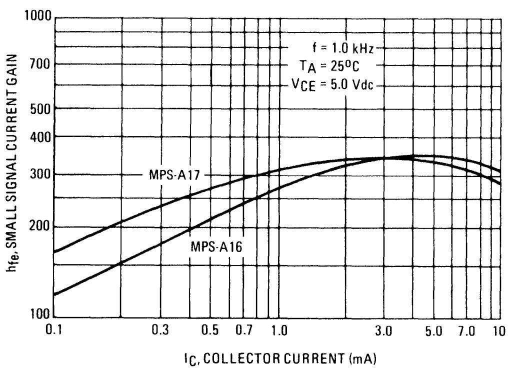


FIGURE 3 – SATURATION AND ON VOLTAGES

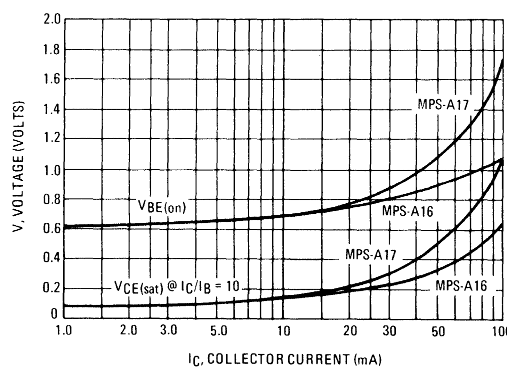


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

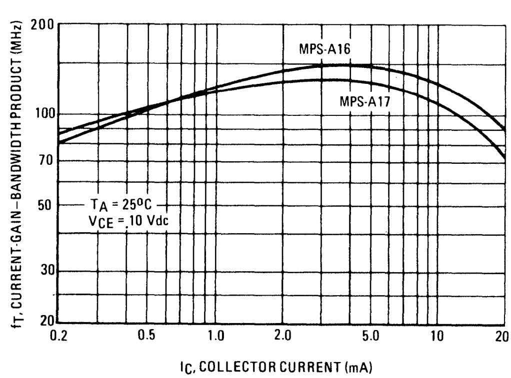
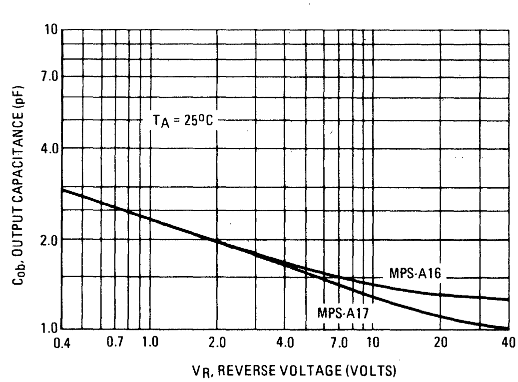
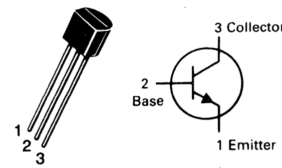


FIGURE 5 – OUTPUT CAPACITANCE



MPSA18★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



LOW NOISE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	6.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

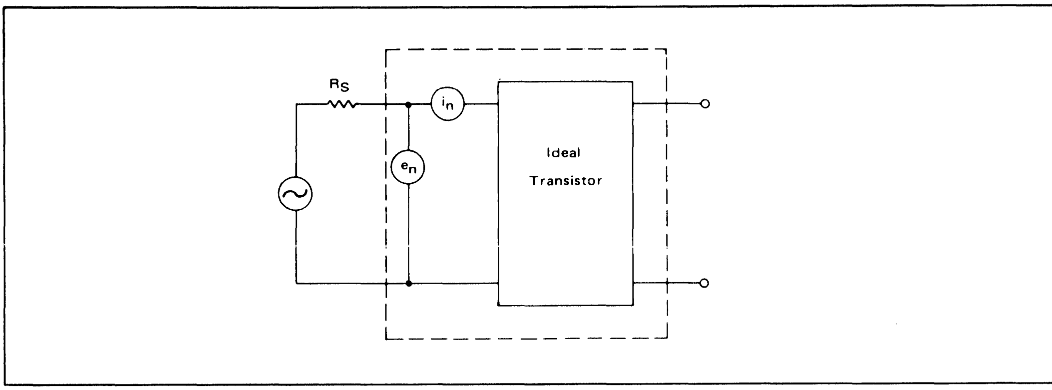
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	1.0	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 400 500 500 500	 580 850 1100 1150	 — — — 1500	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 — 0.08	 0.2 0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	0.6	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	160	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.7	3.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	5.6	6.5	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 100 Hz)	NF	 — —	 0.5 4.0	 1.5 —	dB
Equivalent Short Circuit Noise Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 100 Hz)	V_T	—	6.5	—	nV/√Hz

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

FIGURE 2 – EFFECTS OF FREQUENCY

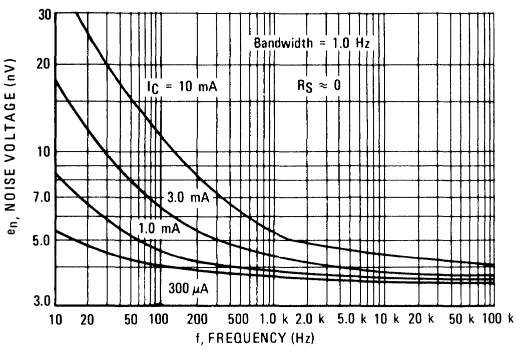


FIGURE 3 – EFFECTS OF COLLECTOR CURRENT

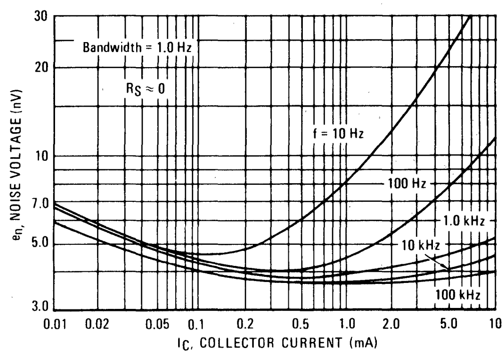


FIGURE 4 – NOISE CURRENT

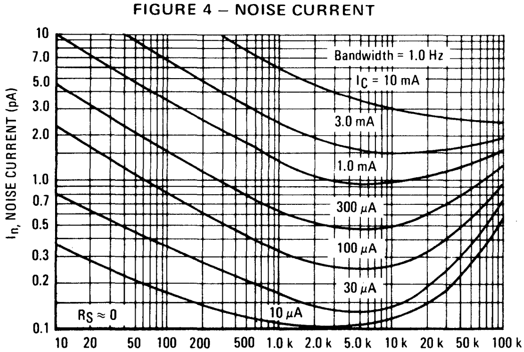
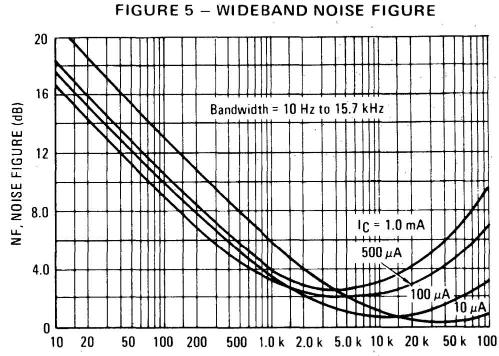


FIGURE 5 – WIDEBAND NOISE FIGURE



2

100 Hz NOISE DATA

FIGURE 6 – TOTAL NOISE VOLTAGE

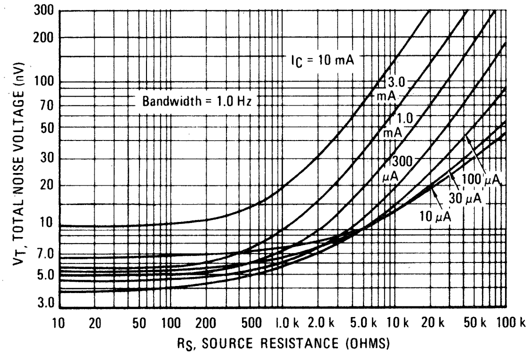


FIGURE 7 – NOISE FIGURE

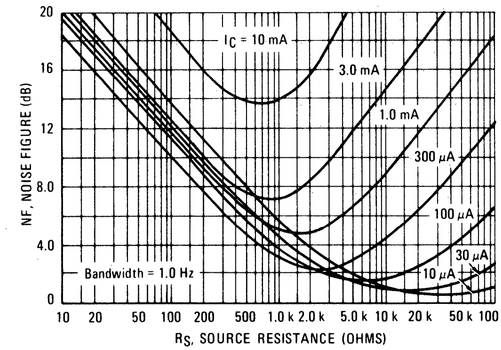


FIGURE 8 — DC CURRENT GAIN

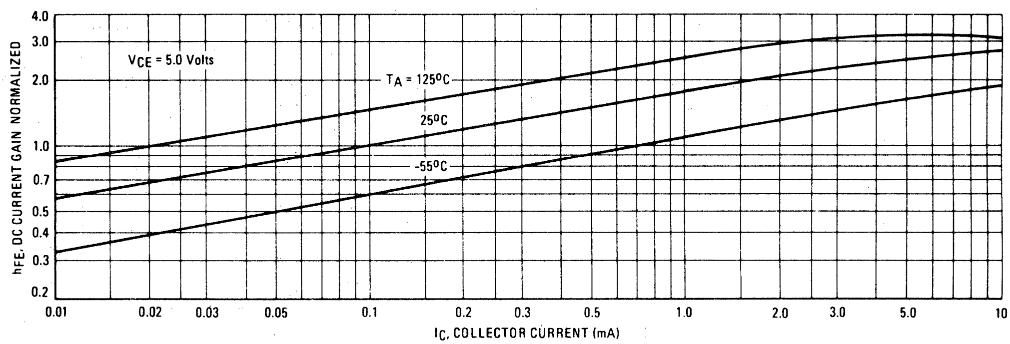


FIGURE 9 – "ON" VOLTAGES

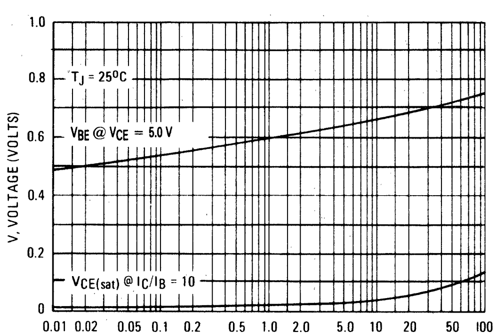


FIGURE 10 – TEMPERATURE COEFFICIENTS

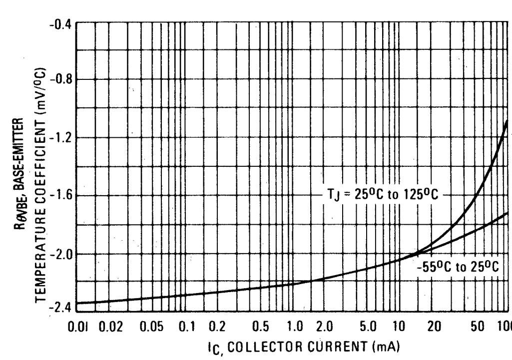


FIGURE 11 – CAPACITANCE

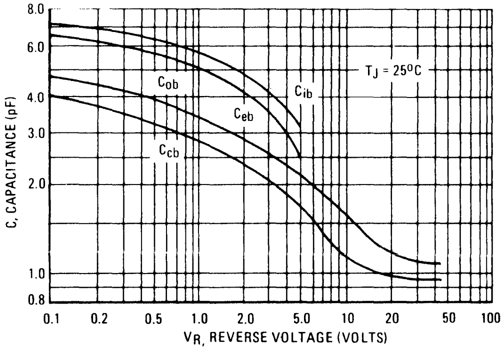
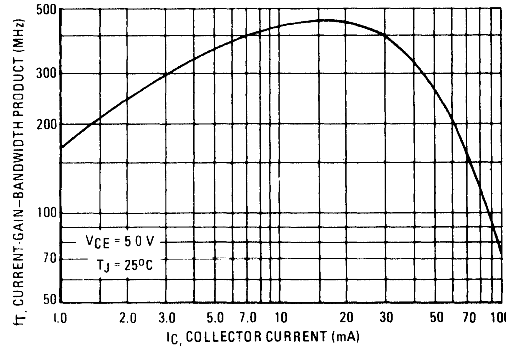


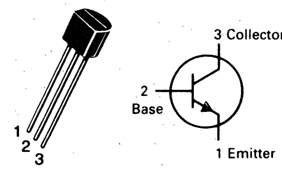
FIGURE 12 – CURRENT-GAIN–BANDWIDTH PRODUCT



2

MPSA20

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

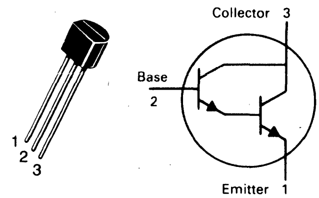
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz	f_T	125	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	4.0	pF

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSA27

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A25	MPS-A26	MPS-A27	Unit
Collector-Emitter Voltage	V_{CES}	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}		10		Vdc
Collector Current — Continuous	I_C		500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 V, I_E = 0) (V_{CB} = 40 V, I_E = 0) (V_{CB} = 50 V, I_E = 0)	I_{CBO}	—	—	100	nAdc
Collector Cutoff Current (V_{CE} = 30 V, V_{BE} = 0) (V_{CE} = 40 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0)	I_{CES}	—	—	500	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	 10,000 10,000	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small Signal Current Gain (I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	h_{fe}	1.25	2.4	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — DC CURRENT GAIN

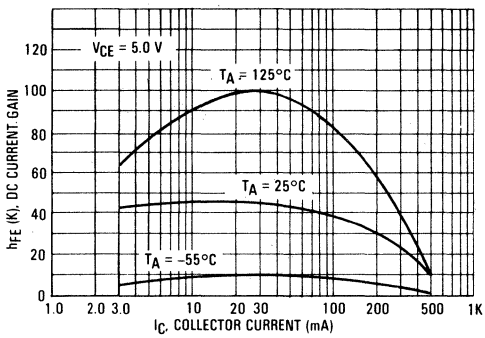


FIGURE 2 — "ON" VOLTAGES

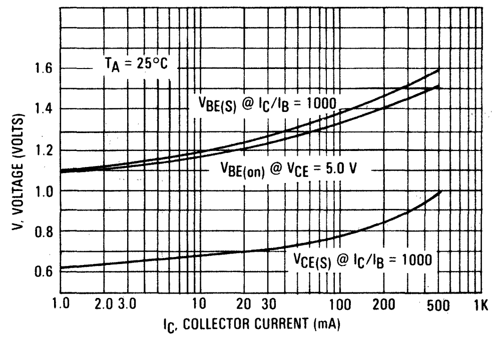


FIGURE 3 — COLLECTOR SATURATION REGION

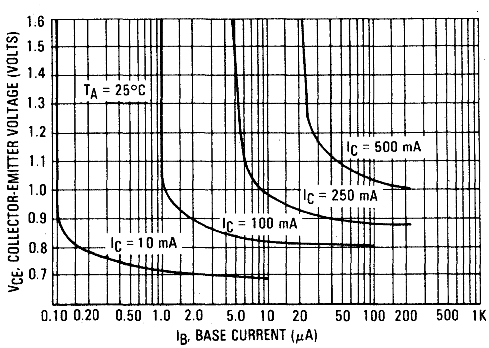


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

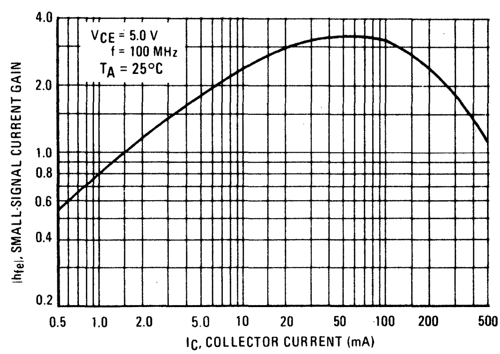
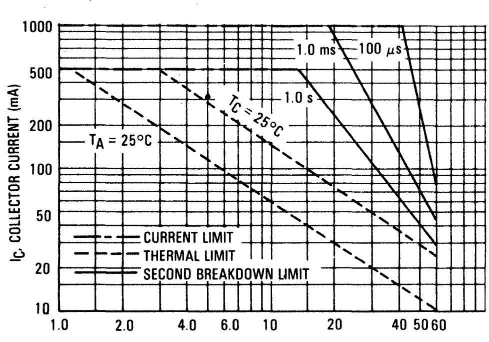
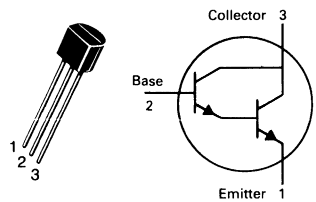


FIGURE 5 — ACTIVE REGION SAFE OPERATING AREA



MPSA28
MPSA29★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPSA28	MPSA29	Unit
Collector-Emitter Voltage	V_{CES}	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc, V_{BE} = 0$)	 MPSA28 MPSA29	$V_{(BR)CES}$	 80 100	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc, I_E = 0$)	 MPSA28 MPSA29	$V_{(BR)CBO}$	 80 100	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc, I_C = 0$)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPSA28 MPSA29	I_{CBO}	 — —	 — —	 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE} = 0$) ($V_{CE} = 80$ Vdc, $V_{BE} = 0$)	 MPSA28 MPSA29	I_{CES}	 — —	 — —	 500 500	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		h_{FE}	 10,000 10,000	 — —	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.01$ mAdc) ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	 — —	 0.7 0.8	 1.2 1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	1.4	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	5.0	8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = h_{fe} \cdot f_{test}$.

2

FIGURE 1 — DC CURRENT GAIN

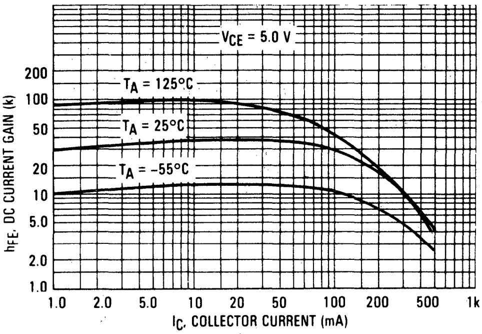


FIGURE 2 — ON VOLTAGES

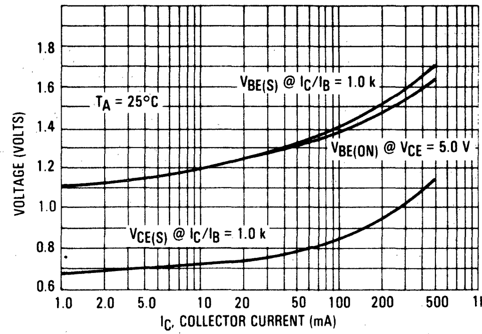


FIGURE 3 — TEMPERATURE COEFFICIENTS

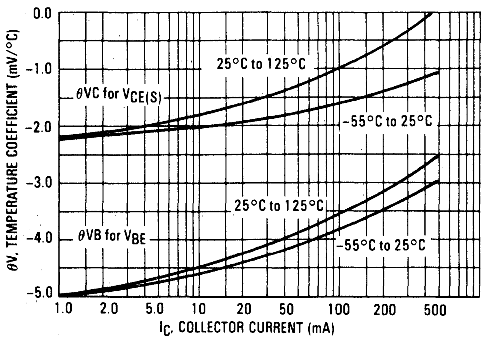


FIGURE 4 — COLLECTOR SATURATION REGION

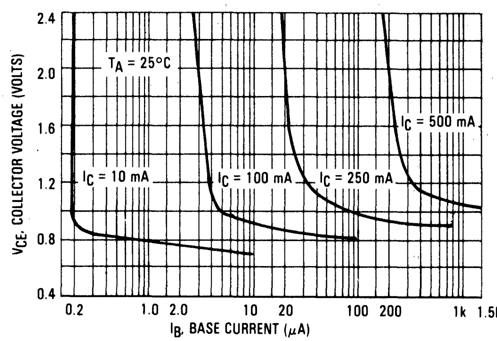


FIGURE 5 — ACTIVE REGION — SAFE OPERATING AREA

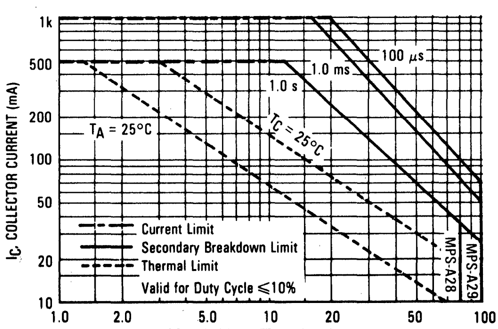
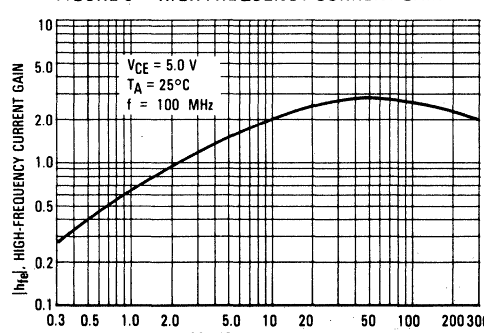
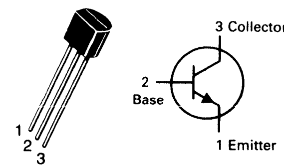


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



MPSA42★
MPSA43

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPSA42	MPSA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MPSA42 MPSA43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPSA42 MPSA43	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	 MPSA42 MPSA43	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 MPSA42 MPSA43	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)		h_{FE}	 25 40 40	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	 MPSA42 MPSA43	$V_{CE(sat)}$	 — —	 0.5 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	 MPSA42 MPSA43	C_{cb}	 — —	 3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

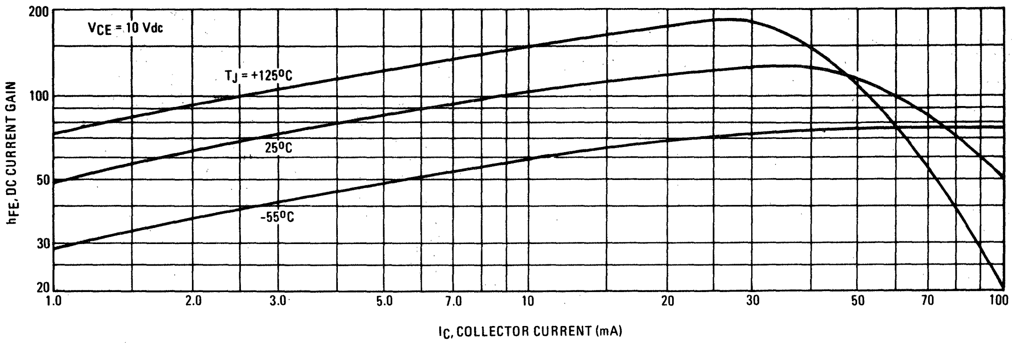


FIGURE 2 — CAPACITANCES

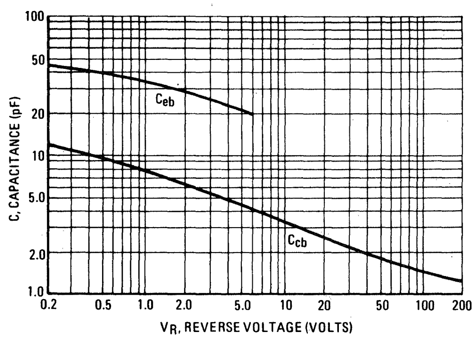


FIGURE 3 — CURRENT-GAIN—BANDWIDTH PRODUCT

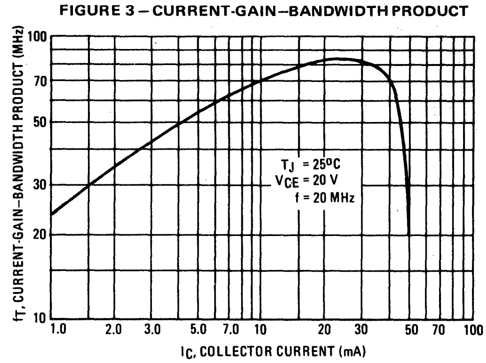


FIGURE 4 — "ON" VOLTAGES

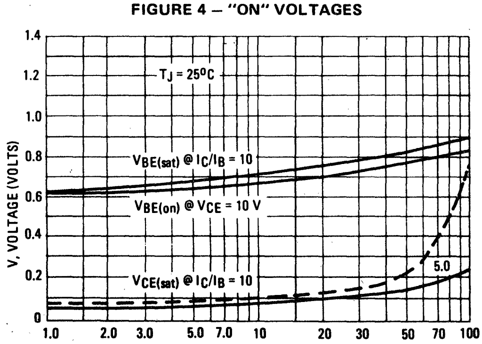
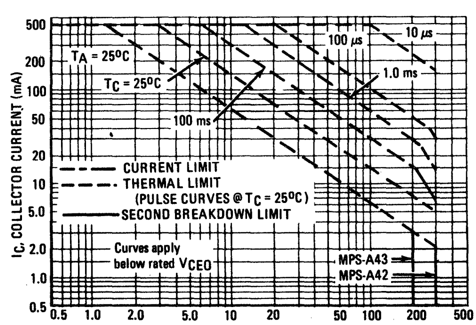
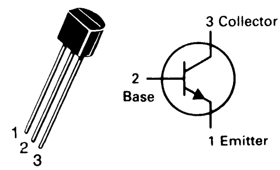


FIGURE 5 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA



MPSA44★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	Vdc
Collector-Base Voltage	V_{CBO}	500	Vdc
Emitter-Base Voltage	V_{CBO}	6.0	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	400	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	500	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100, μAdc, I_E = 0)	$V_{(BR)CBO}$	500	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 400 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 400 Vdc, V_{BE} = 0)	I_{CES}	—	500	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain(1) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40 50 45 40	— 200 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	— — —	0.4 0.5 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	7.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	130	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	1.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — DC CURRENT GAIN

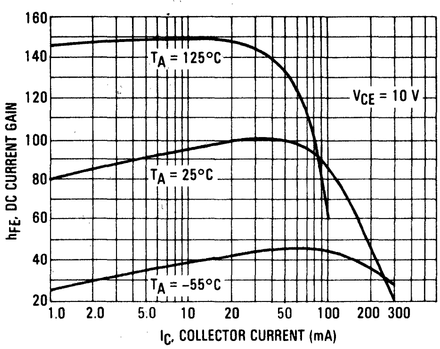


FIGURE 2 — COLLECTOR SATURATION REGION

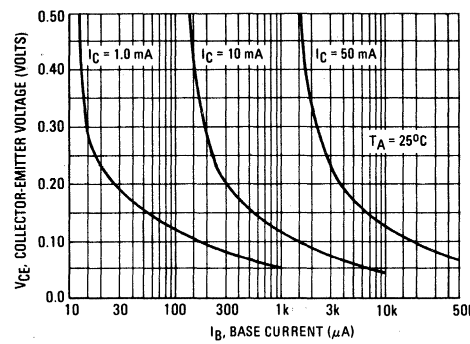


FIGURE 3 — ON VOLTAGES

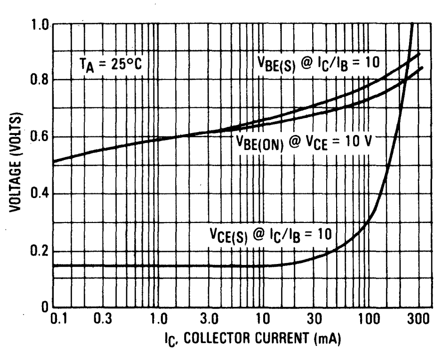


FIGURE 4 — ACTIVE REGION — SAFE OPERATING AREA

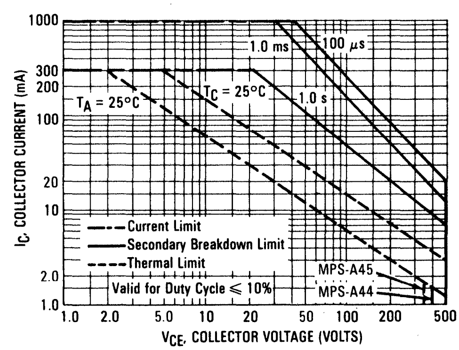


FIGURE 5 — CAPACITANCE

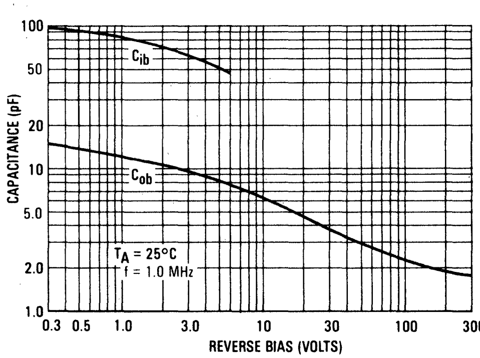


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

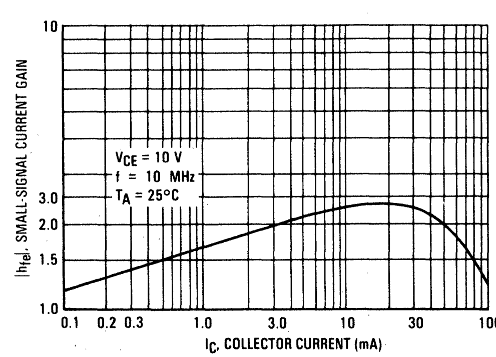


FIGURE 7 — TURN-ON SWITCHING TIMES AND TEST CIRCUIT

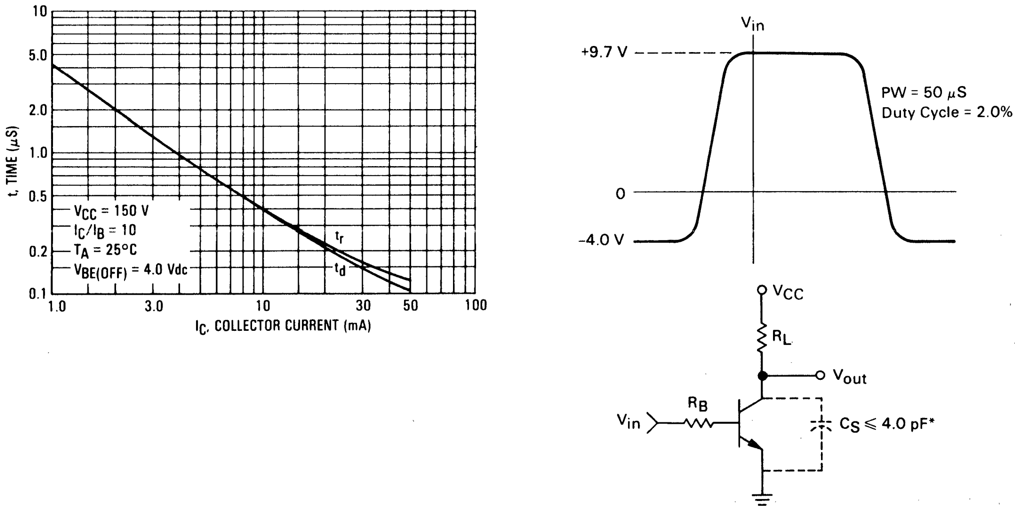
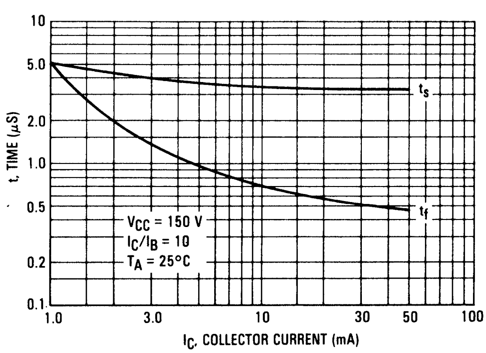
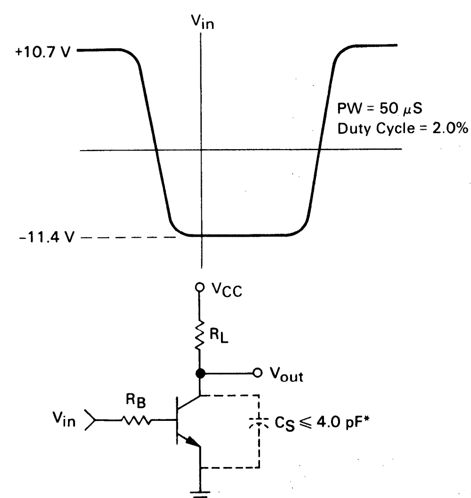


FIGURE 8 — TURN-OFF SWITCHING TIMES AND TEST CIRCUIT





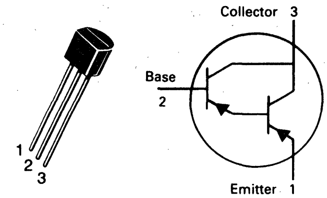
*Total Shunt Capacitance or Test Jig and Connectors.

MPSA55, MPSA56

For Specifications, See MPSA05, MPSA06 Data

MPSA62 thru MPSA64★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

PNP SILICON
★MPSA64 is a Motorola designated preferred device.

Refer to MPSA75 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPSA62	MPSA63 MPSA64	Unit
Collector-Emitter Voltage	V_{CES}	−20	−30	Vdc
Collector-Base Voltage	V_{CBO}	−20	−30	Vdc
Emitter-Base Voltage	V_{EBO}	−10		Vdc
Collector Current — Continuous	I_C	−500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

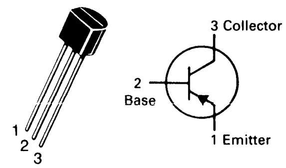
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CES}$			Vdc
(I_C = −100 μAdc, V_{BE} = 0)	MPSA62		−20	—	
	MPSA63, MPSA64		−30	—	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = −15 Vdc, I_E = 0)	MPSA62		—	−100	
(V_{CB} = −30 Vdc, I_E = 0)	MPSA63, MPSA64		—	−100	
Emitter Cutoff Current (V_{EB} = −10 Vdc, I_C = 0)		I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	MPSA63		5000	—	
	MPSA64		10,000	—	
	MPSA62		20,000	—	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	MPSA63		10,000	—	
	MPSA64		20,000	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = −10 mAdc, I_B = −0.01 mAdc)	MPSA62		—	−1.0	
(I_C = −100 mAdc, I_B = −0.1 mAdc)	MPSA63, MPSA64		—	−1.5	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	MPSA62		—	−1.4	
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	MPSA63, MPSA64		—	−2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = −100 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)	MPSA63, MPSA64	f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

MPSA70

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

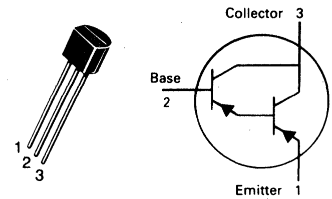
ELECTRICAL CHARACTERISTICS T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)	I_{CBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −5.0 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pf

2

MPSA75
MPSA77

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



DARLINGTON TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA75	MPSA77	Unit
Collector-Emitter Voltage	V_{CES}	−40	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−10		Vdc
Collector Current — Continuous	I_C	−500		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	 MPSA75 MPSA77	$V_{(BR)CES}$	 −40 −60	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPSA75 MPSA77	$V_{(BR)CBO}$	 −40 −60	 — —	 — —	Vdc
Collector Cutoff Current (V_{CB} = −30 V, I_E = 0) (V_{CB} = −50 V, I_E = 0)	 MPSA75 MPSA77	I_{CBO}	 — —	 — —	 −100 −100	nAdc
Collector Cutoff Current (V_{CE} = −30 V, V_{BE} = 0) (V_{CE} = −50 V, V_{BE} = 0)	 MPSA75 MPSA77	I_{CES}	 — —	 — —	 −500 −500	nAdc
Emitter Cutoff Current (V_{EB} = −10 Vdc)		I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = −10 mA, V_{CE} = −5.0 V) (I_C = −100 mA, V_{CE} = −5.0 V)		h_{FE}	 10,000 10,000	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = −100 mA, I_B = −0.1 mAdc)		$V_{CE(sat)}$	—	—	−1.5	Vdc
Base-Emitter On Voltage (I_C = −100 mA, V_{CE} = −5.0 Vdc)		V_{BE}	—	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — High Frequency (I_C = −10 mA, V_{CE} = −5.0 V, f = 100 MHz)		$\|h_{fe}\|$	1.25	2.4	—	—

FIGURE 1 — DC CURRENT GAIN

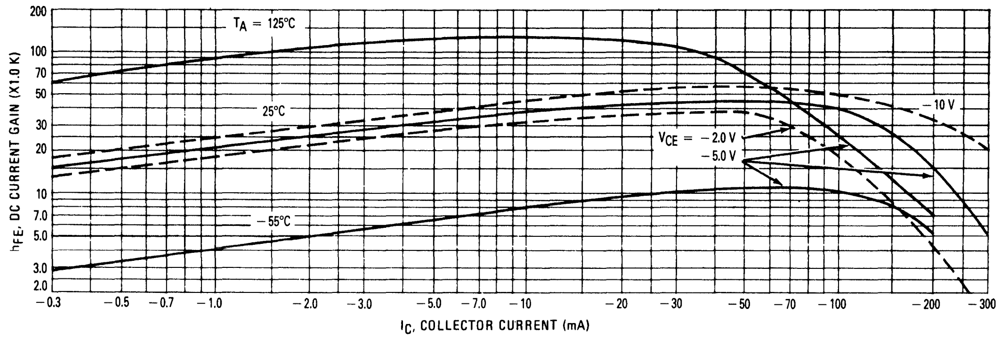


FIGURE 2 — "ON" VOLTAGE

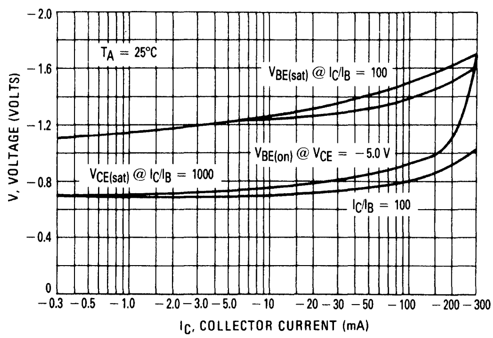


FIGURE 3 — COLLECTOR SATURATION REGION

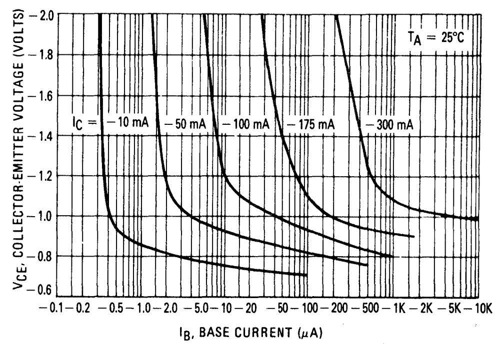


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

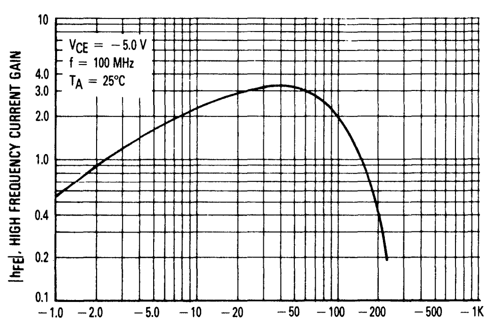
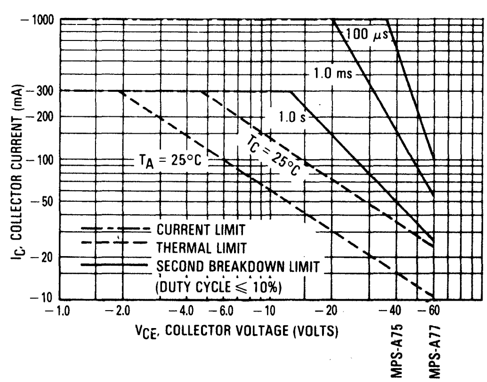
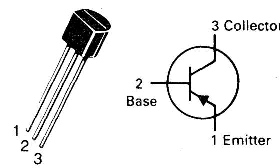


FIGURE 5 — ACTIVE REGION, SAFE OPERATING AREA



MPSA92★
MPSA93

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPSA92	MPSA93	Unit
Collector-Emitter Voltage	V_{CEO}	−300	−200	Vdc
Collector-Base Voltage	V_{CBO}	−300	−200	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−500		mAdc
Total Device Dissipation @ T_A = 25°c Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	 MPSA92 MPSA93	$V_{(BR)CEO}$	 −300 −200	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 MPSA92 MPSA93	$V_{(BR)CBO}$	 −300 −200	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0) (V_{CB} = −160 Vdc, I_E = 0)	 MPSA92 MPSA93	I_{CBO}	 — —	 −0.25 −0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −30 mAdc, V_{CE} = −10 Vdc)	 Both Types Both Types MPSA92 MPSA93	h_{FE}	 25 40 25 25	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	 MPSA92 MPSA93	$V_{CE(sat)}$	 — —	 −0.5 −0.4	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	 MPSA92 MPSA93	C_{cb}	 — —	 6.0 8.0	pF

FIGURE 1 — DC CURRENT GAIN

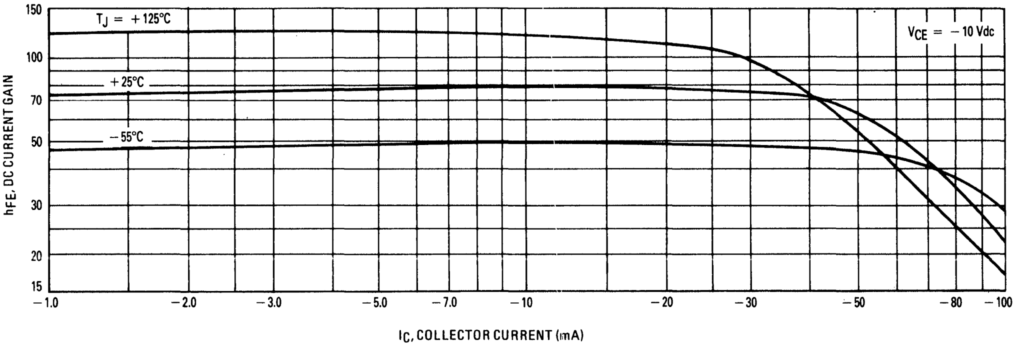


FIGURE 2 — CAPACITANCES

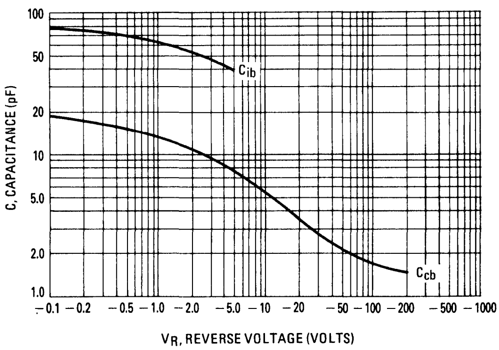


FIGURE 3 — CURRENT-GAIN—BANDWIDTH PRODUCT

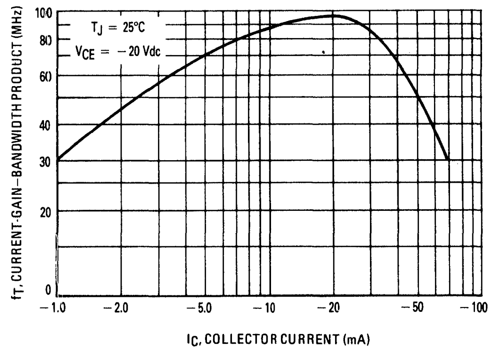


FIGURE 4 — "ON" VOLTAGES

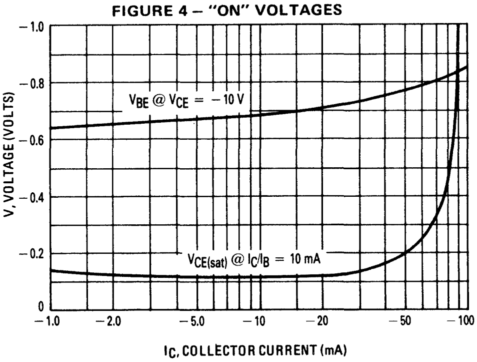
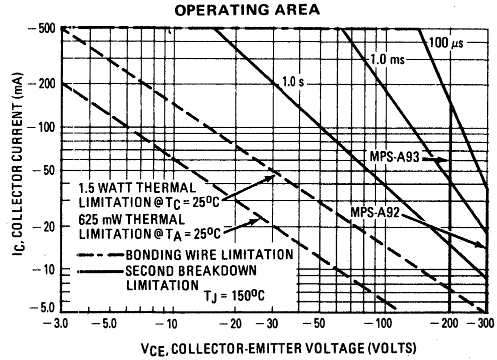


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



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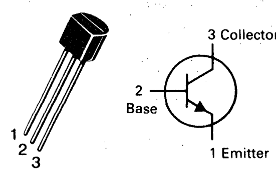
MPSH04

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

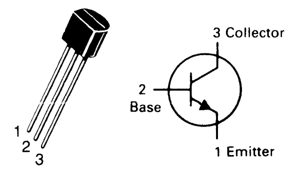
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	— —	120	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Crrent-Gain — Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	80	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	—	—	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	—	5.0	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz) MPSH04	NF	—	—	2.0	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSH07A

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



FM/VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—
Base-Emitter On Voltage (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)	C_{ce} (C_{rb})	—	0.3	pF
Noise Figure (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 100 MHz)	NF	—	3.2	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 100 MHz) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	G_{pb}	 18 14	 — —	dB
Forward AGC Current (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 100 MHz)	I_{AGC}	5.0	8.0	mAdc

AGC CHARACTERISTICS

V_{CC} = 10 Vdc, R_S = 50 Ohms, See Figure 9

—— f = 100 MHz – – – f = 200 MHz

FIGURE 1 – POWER GAIN

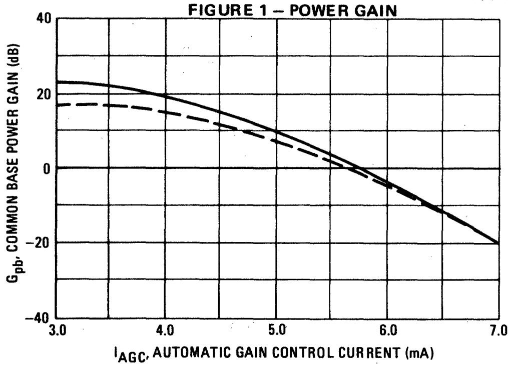
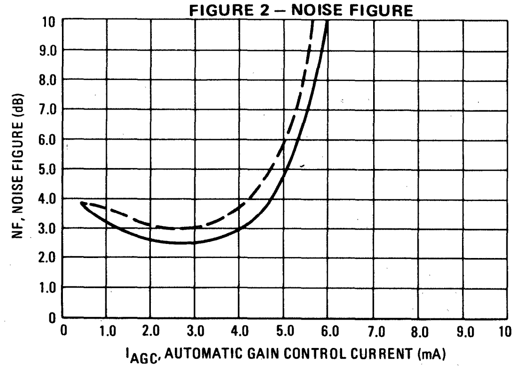


FIGURE 2 – NOISE FIGURE



COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, T_A = 25°C

—— f = 100 MHz – – – f = 200 MHz

FIGURE 3 – INPUT ADMITTANCE

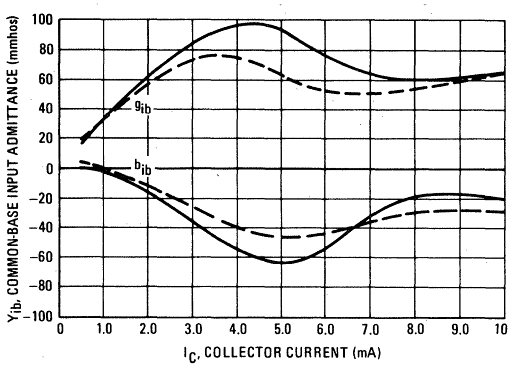


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

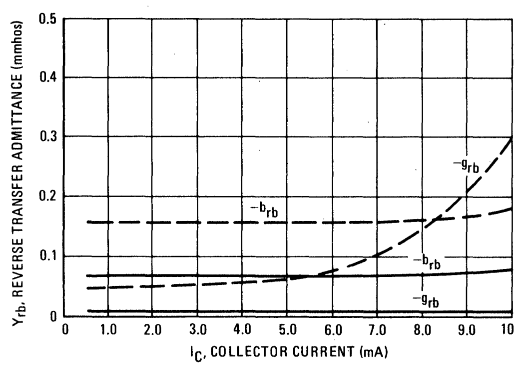


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

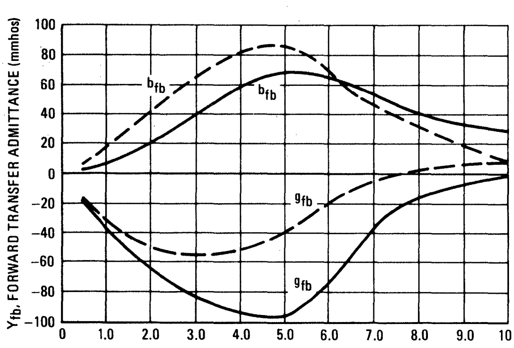


FIGURE 6 – OUTPUT ADMITTANCE

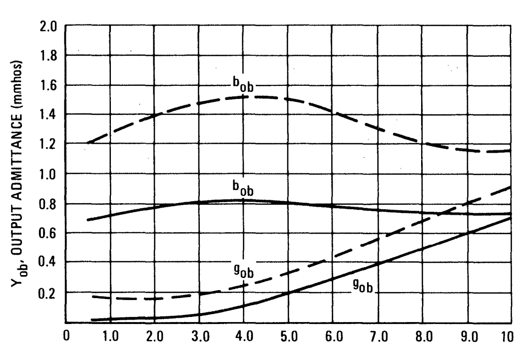


FIGURE 7 — COLLECTOR-BASE TIME CONSTANT

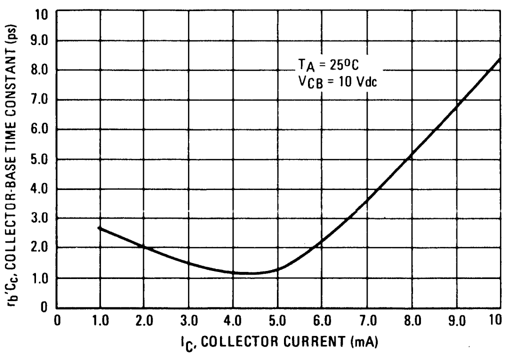


FIGURE 8 — CURRENT-GAIN BANDWIDTH PRODUCT

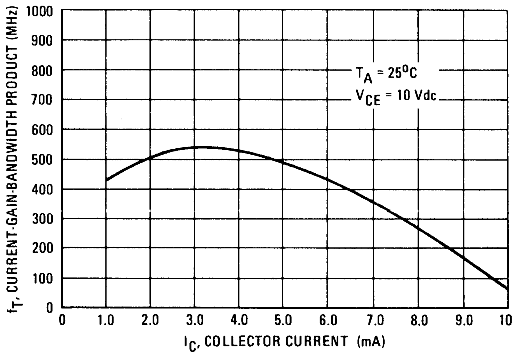
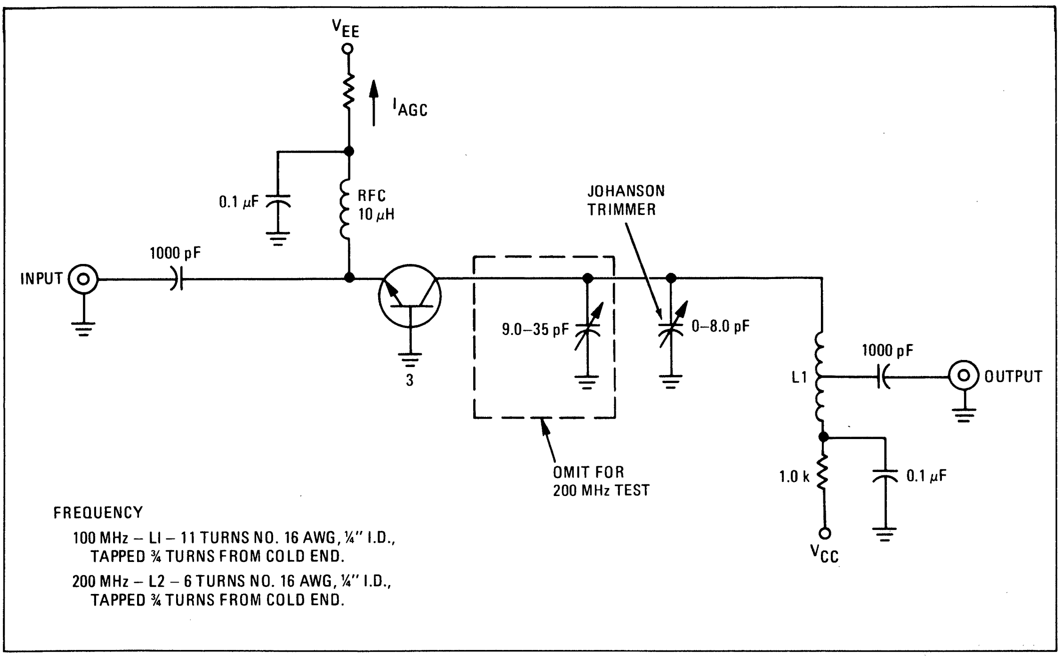


FIGURE 9 — 100-MHz AND 200-MHz COMMON-BASE AMPLIFIER



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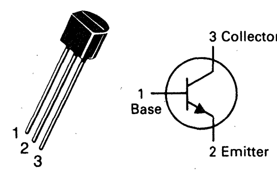
MPSH10★
MPSH11★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF/UHF TRANSISTORS

NPN SILICON

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	—	—
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	V_{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.7	pF
Common-Base Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) MPS-H10 MPS-H11	C_{rb}	 0.35 0.6	 0.65 0.9	pF
Collector Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$rb'C_c$	—	9.0	ps

COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

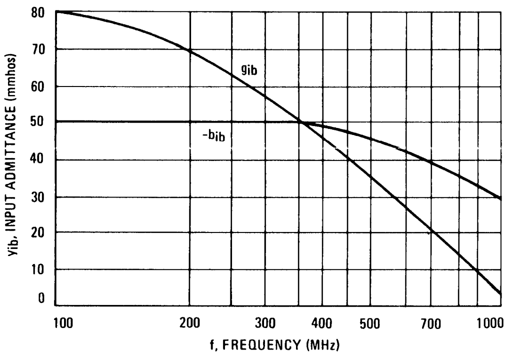
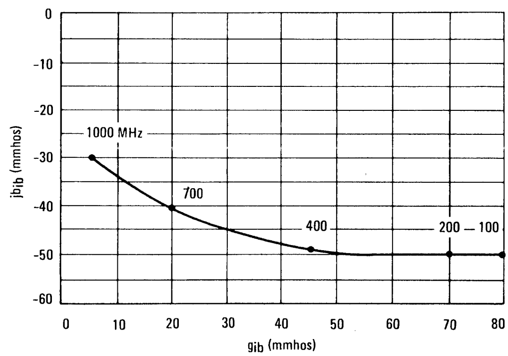


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

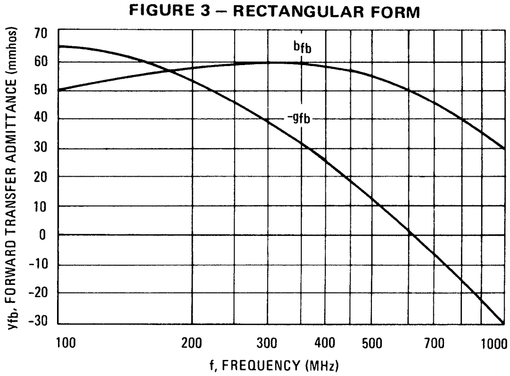
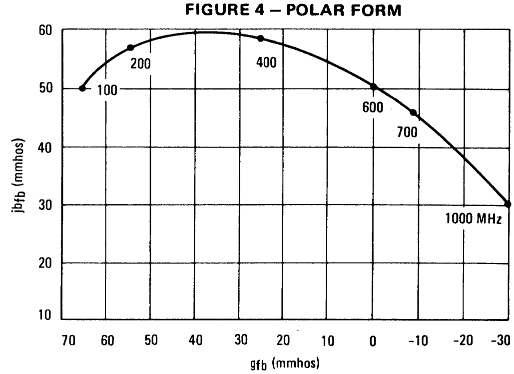


FIGURE 4 – POLAR FORM



y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

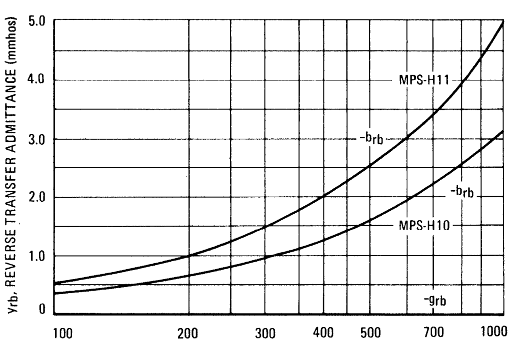
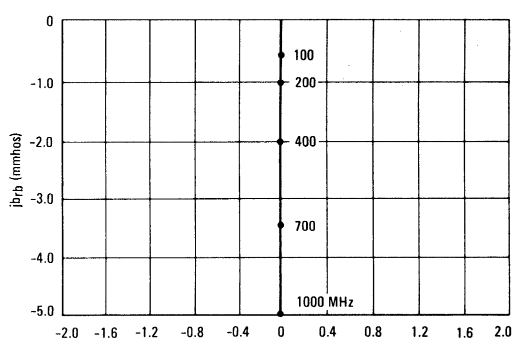


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

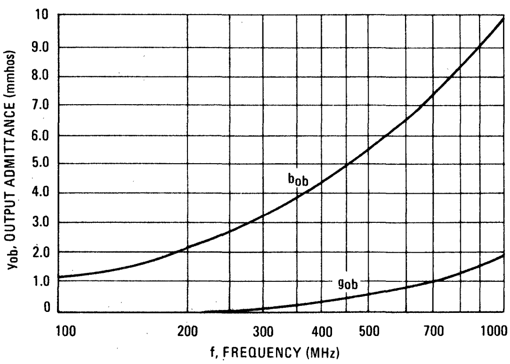
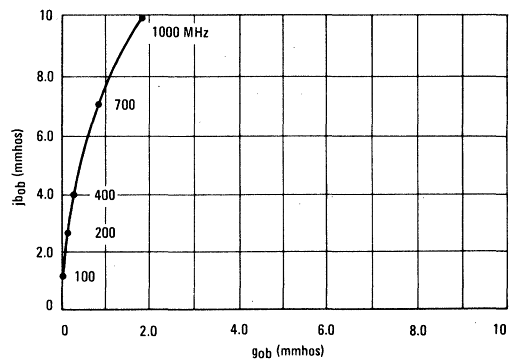
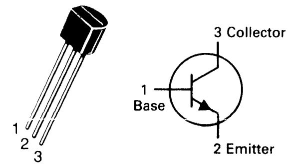


FIGURE 8 – POLAR FORM



MPSH17★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



CATV TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	357	°C/W

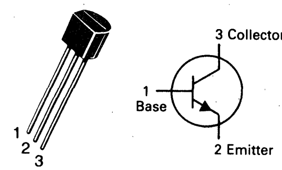
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	800	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	0.3	—	0.9	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	—	—	—
Noise Figure (I_C = 5.0 mAdc, V_{CC} = 12 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	—	6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain (I_C = 5.0 mAdc, V_{CC} = 12 Vdc, R_S = 50 ohms, f = 200 MHz)	G_{pe}	—	24	—	dB

2

MPSH20★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.5	0.65	pF
Collector Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$rb'C_c$	—	10	—	ps
Conversion Gain (213 to 45 MHz) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, Oscillator Injection = 200 mVdc)	G_C	18	23	—	dB

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 – VARIATION WITH COLLECTOR CURRENT

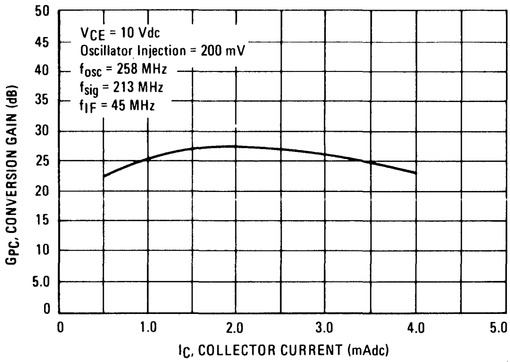
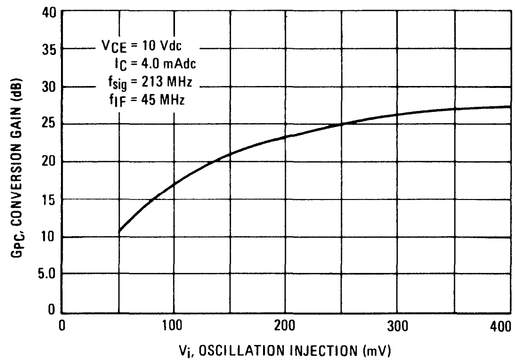


FIGURE 2 – VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

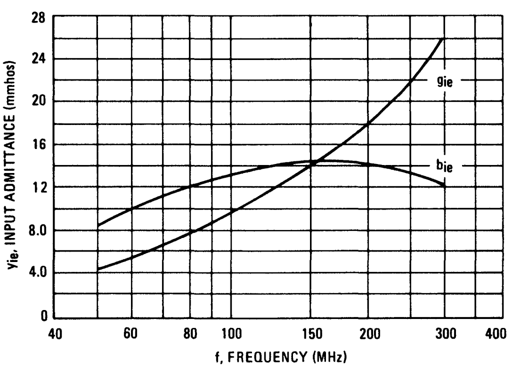
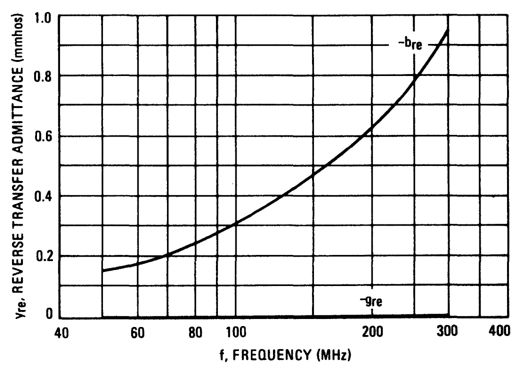


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

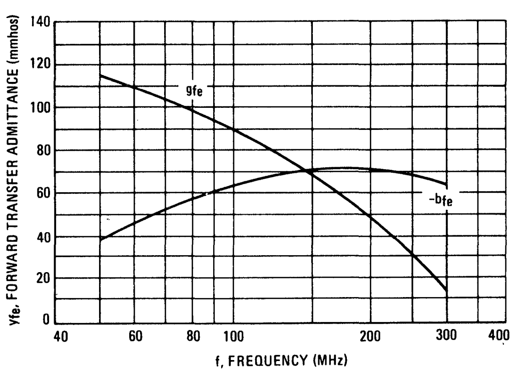


FIGURE 6 – OUTPUT ADMITTANCE

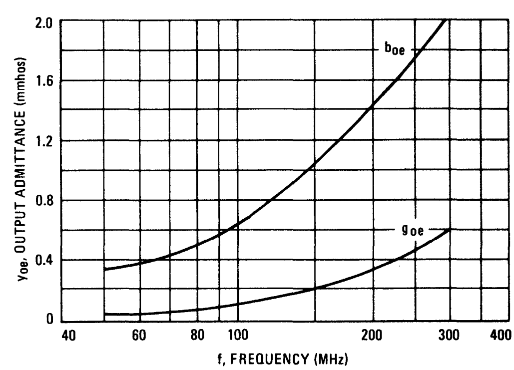


FIGURE 7 — CURRENT-GAIN—BANDWIDTH PRODUCT

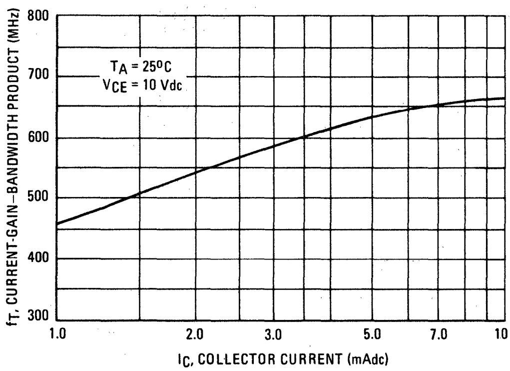


FIGURE 8 — CAPACITANCES

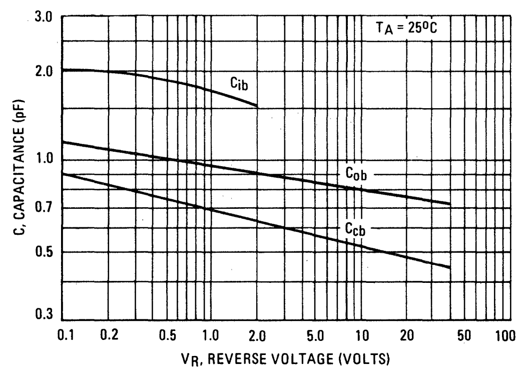
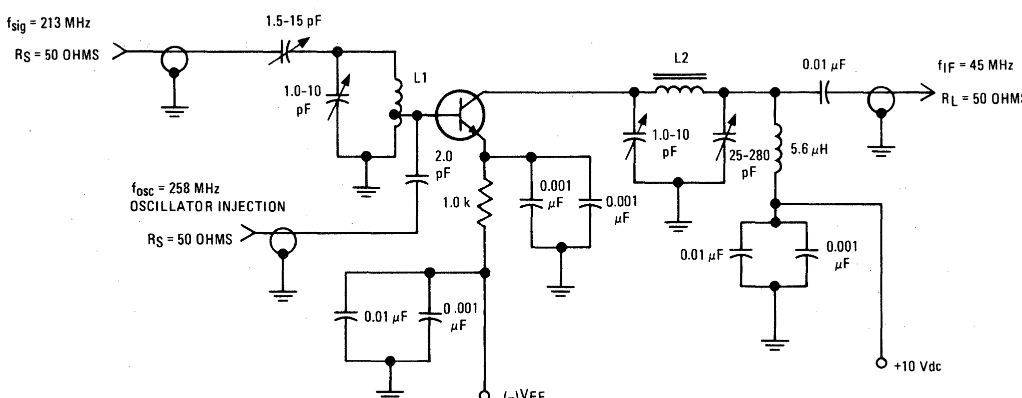


FIGURE 9 — MIXER TEST CIRCUIT

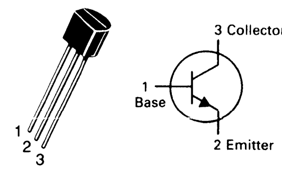


L1 = 3 TURNS #18 ENAMELED WIRE,
1/4" I.D., AIR WOUND, WINDING LENGTH 1/2";
BASE TAPPED 1 TURN FROM GROUND.

L2 = 10 TURNS #26 INSULATED WIRE, WOUND
ON 1/4" I.D. COIL FORM, ARNOLD PART
NO. A1-10 IRON POWDER CORE.

MPSH24

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.25	0.36	pF
Conversion Gain (213 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms) (60 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)	G_C	 19 24	 24 29	 — —	dB

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

(V_{CC} = 20 Vdc, $R_S = R_L$ = 50 Ohms, f_{if} = 44 MHz, B.W. = 6.0 MHz)

FIGURE 1 — CONVERSION GAIN versus COLLECTOR CURRENT

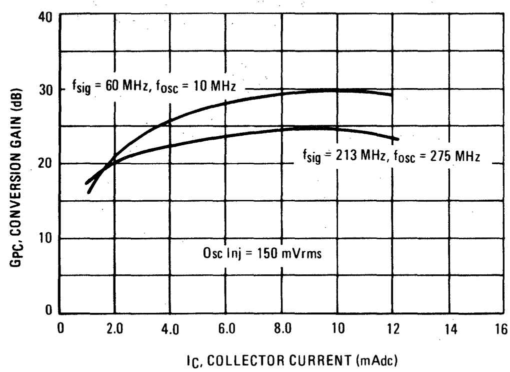
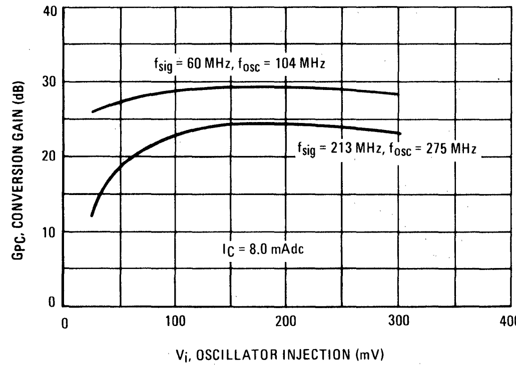


FIGURE 2 — CONVERSION GAIN versus INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

(V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 — INPUT ADMITTANCE

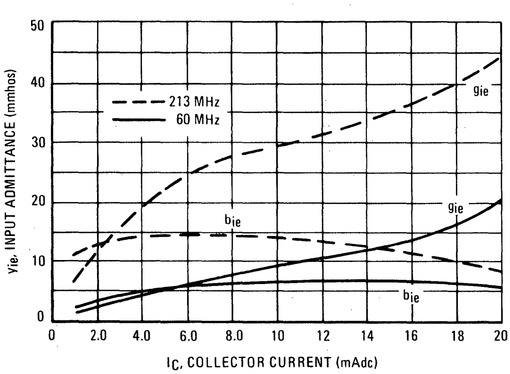


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

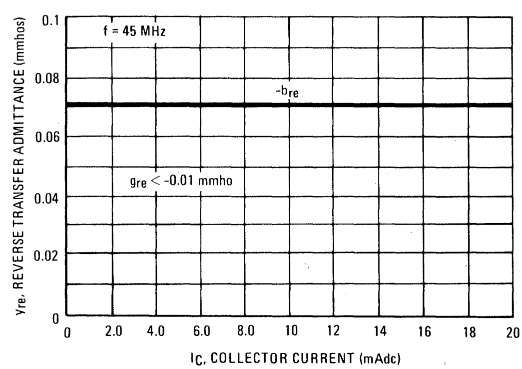


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

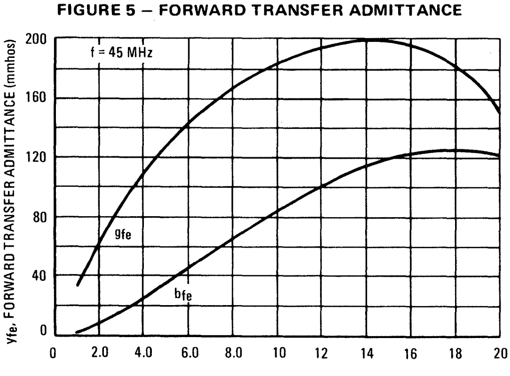


FIGURE 6 — OUTPUT ADMITTANCE

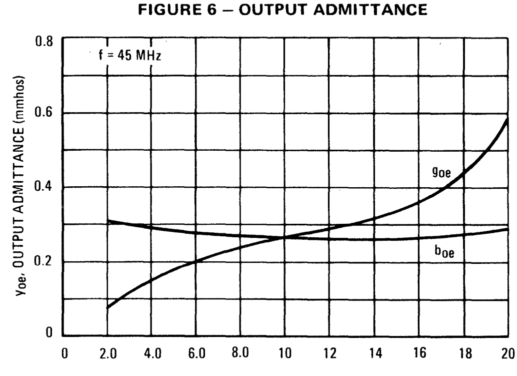
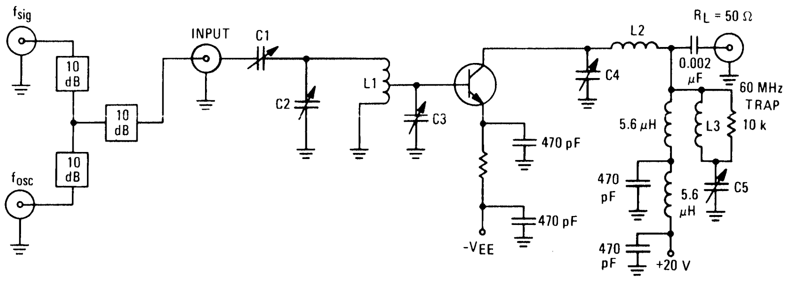


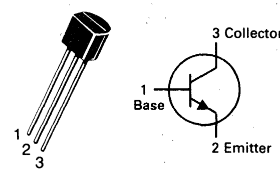
FIGURE 7 – VHF MIXER TEST CIRCUIT
(f_{if} = 44 MHz, B.W. = 6.0 MHz)

f_{sig}	60 MHz	213 MHz
f_{osc}	105 MHz	258 MHz
C1	1.5-20 pF	1.5-20 pF
C2	8.0-60 pF	6.0-12 pF
C3	8.0-60 pF	1.5-20 pF
C4	3.0-35 pF	–
C5	1.5-20 pF	–
L1	5 Turns #26 Air, Tap 1 Turn	3 Turns #16 Air, Tap ½ Turn
L2	10 Turns #26 Air	10 Turns #26 Arnold A1-10 Core
L3	Ohmite Z235	–



MPSH34

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



IF TRANSISTOR

NPN SILICON

Refer to MPSH24 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

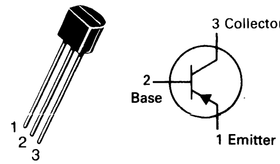
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7.0 mAdc, V_{CE} = 15 Vdc) (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 15	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 7.0 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 7.0 mAdc, V_{CE} = 15 Vdc)	$V_{BE(on)}$	—	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 15 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	500	720	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.25	0.32	pF

- Designed for UHF/VHF Amplifier Applications
- High Current Bandwidth Product
  f_T = 2000 MHz @ 10 mAdc

MPSH69★

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



RF AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−15	Vdc
Collector-Base Voltage	V_{CBO}	−15	Vdc
Emitter-Base Voltage	V_{EBO}	−4	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

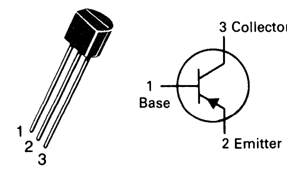
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc)	h_{FE}	30	—	300	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	2000	—	—	MHz
Collector-Base Capacitance (V_{CE} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	—	—	0.3	pF

MPSH81★

CASE 29-04, STYLE 2
TO-92 (TO-226AA)



RF AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−20	Vdc
Collector-Base Voltage	V_{CBO}	−20	Vdc
Emitter-Base Voltage	V_{EBO}	−3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −10 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −2.0 Vdc, I_C = 0)	I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage (I_C = −5.0 mAdc, I_B = −0.5 mAdc)	$V_{CE(sat)}$	—	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −5.0 mAdc, V_{CE} = −10 Vdc)	$V_{BE(on)}$	—	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −5.0 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = −10 Vdc, f = 1.0 MHz	C_{ce}	—	—	0.65	pF

TYPICAL COMMON-BASE y-PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 1 – INPUT ADMITTANCE

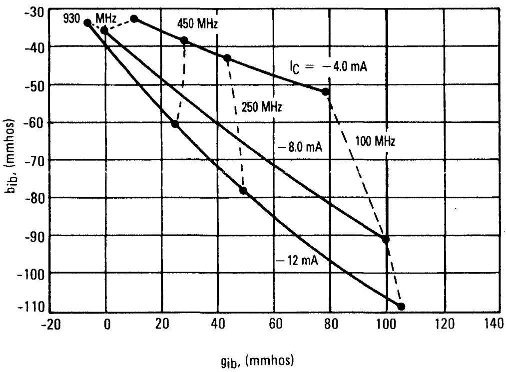


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

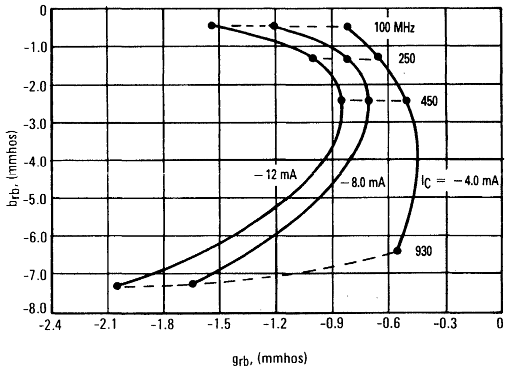


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

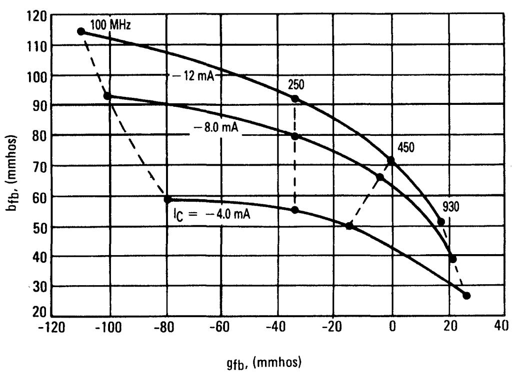


FIGURE 4 – OUTPUT ADMITTANCE

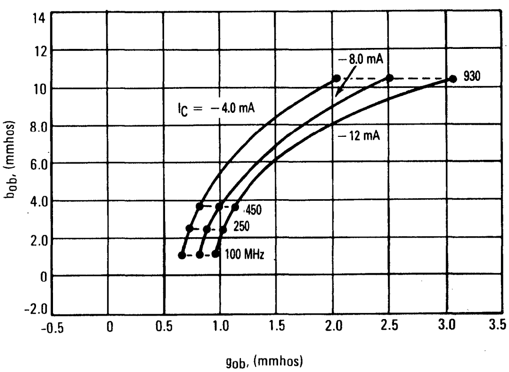
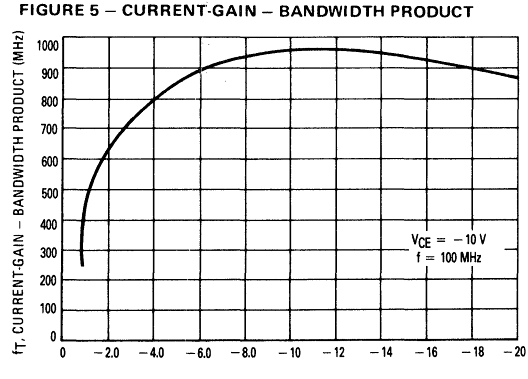


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT



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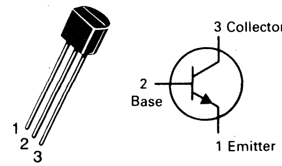
MPSL01

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CBO}	140	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

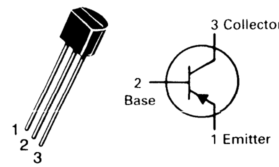
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	120	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	300	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.20 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)(1)	$V_{BE(sat)}$	 — —	 1.2 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	—	—

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPSL51

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5400 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−100	Vdc
Collector-Base Voltage	V_{CBO}	−100	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Ctoninuous	I_C	−600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

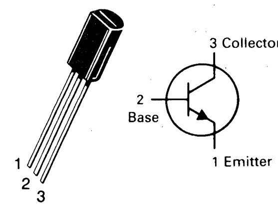
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, 1_B = 0)	$V_{(BR)CEO}$	−100	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−100	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)	I_{CBO}	—	−1.0	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain(1) (I_C = −50 mAdc, V_{CE} = −5.0 Vdc)	h_{FE}	40	250	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{CE(sat)}$	 — —	 -0.25 -0.30	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)	$V_{BE(sat)}$	 — —	 −1.2 −1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	20	—	—

(1) Pulse Test: Pulse Test = 300 μs, Duty Cycle = 2.0%.

MPSW01, A★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT
HIGH CURRENT TRANSISTORS

NPN SILICON

★MPSW01A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW01 MPSW01A	V_{CEO}	30 40	Vdc
Collector-Base Voltage MPSW01 MPSW01A	V_{CBO}	40 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPSW01 MPSW01A	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSW01 MPSW01A	$V_{(BR)CBO}$	40 50	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0)	MPSW01 MPSW01A	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	55 60 50	— — —	—
Collector-Emitter Saturation Voltage (I_C = 1000 mAdc, I_B = 100 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

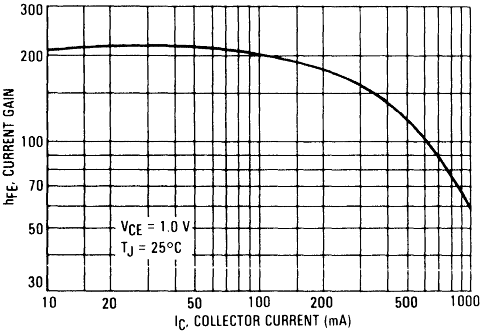


FIGURE 2 — COLLECTOR SATURATION REGION

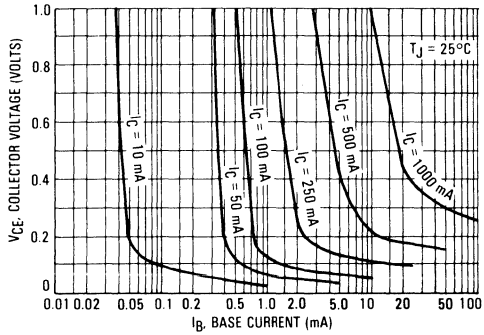


FIGURE 3 — ON VOLTAGES

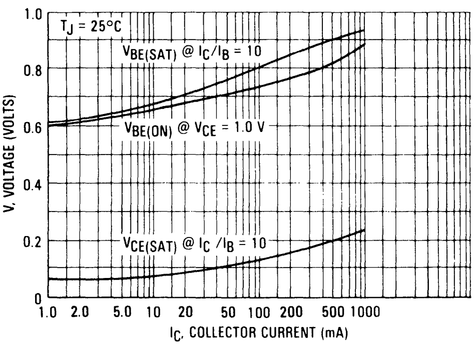


FIGURE 4 — TEMPERATURE COEFFICIENT

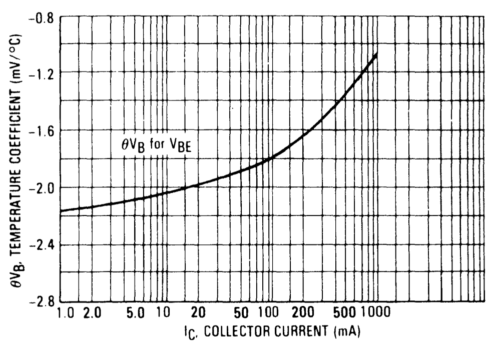


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

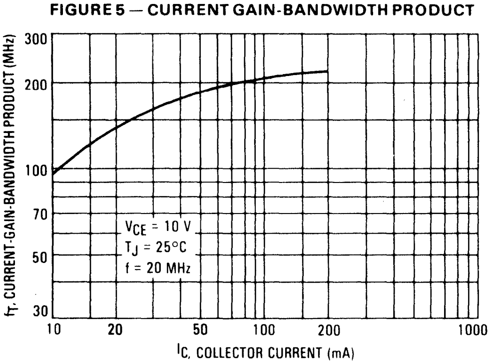


FIGURE 6 — CAPACITANCE

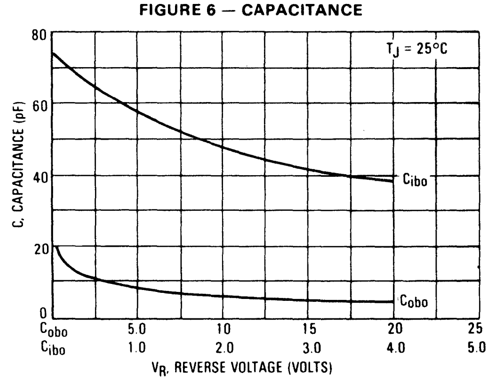


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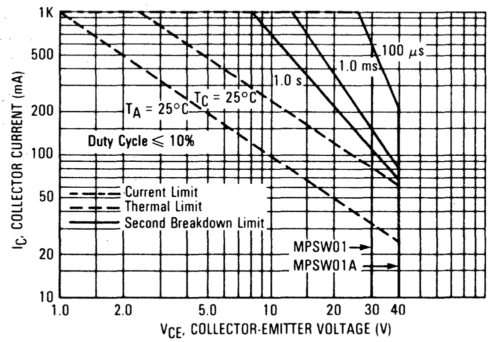
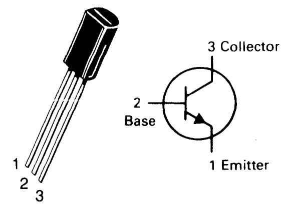
FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



MPSW05
MPSW06★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

NPN SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	MPSW05	MPSW06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MPSW05 MPSW06	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, I_B = 0) (V_{CE} = 60 Vdc, I_B = 0)	 MPSW05 MPSW06	I_{CEO}	 — —	 0.5 0.5	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 MPSW05 MPSW06	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 80 60	 — —	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.40	Vdc
Base-Emitter Saturation Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — D.C. CURRENT GAIN

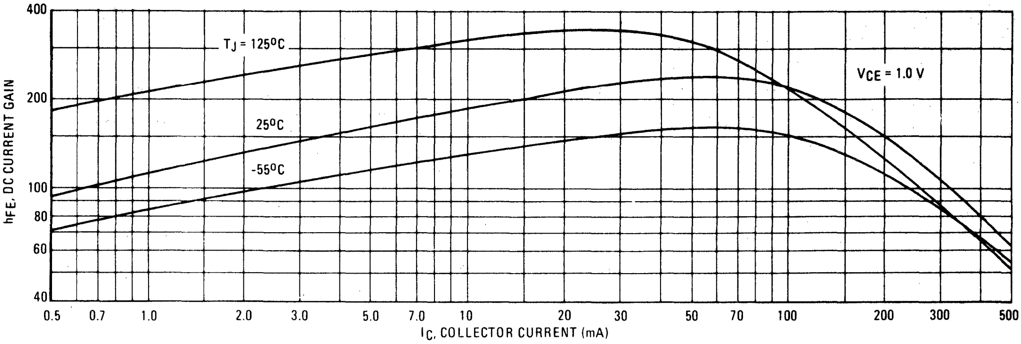


FIGURE 2 — COLLECTOR SATURATION REGION

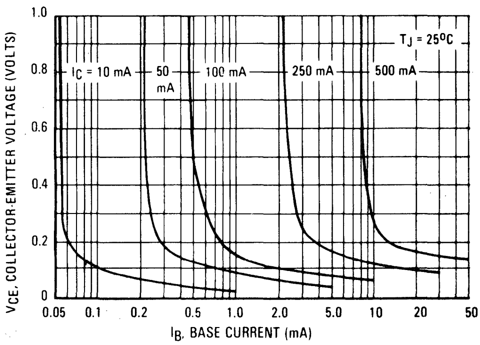


FIGURE 3 — ON VOLTAGES

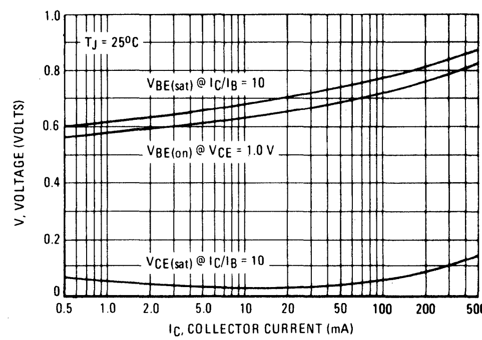


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

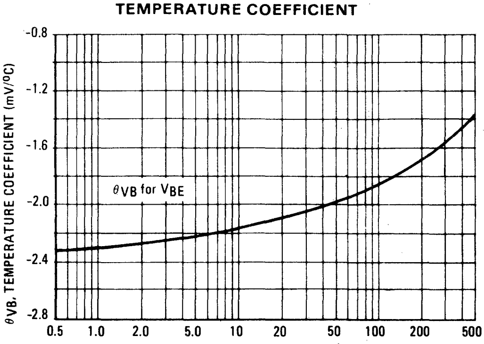


FIGURE 5 — CAPACITANCE

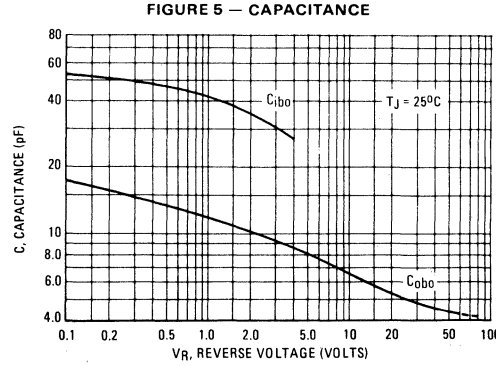


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

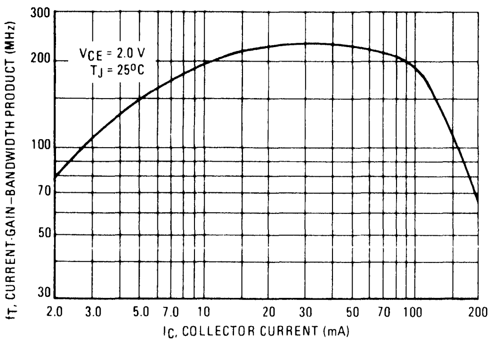
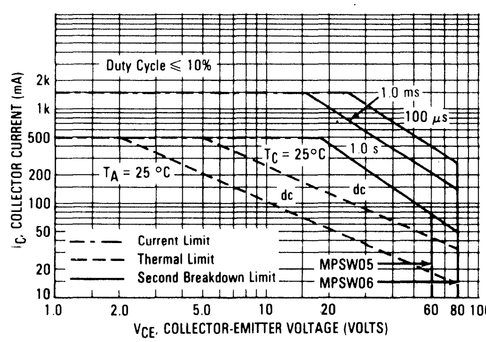


FIGURE 7 — ACTIVE REGION - SAFE OPERATING AREA



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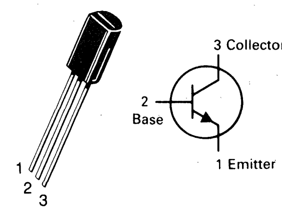
MPSW10

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT
HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSW42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

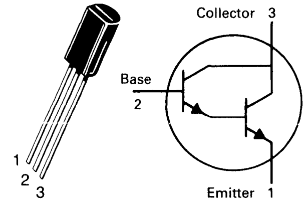
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.2	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 40 40	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	—	0.75	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	45	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW13
MPSW14

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT
DARLINGTON TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPSW13 MPSW14	h_{FE}	 5000 10,000	 — —	—
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MPSW13 MPSW14		10,000 20,000	— —	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

FIGURE 1 — ACTIVE REGION SAFE OPERATING AREA

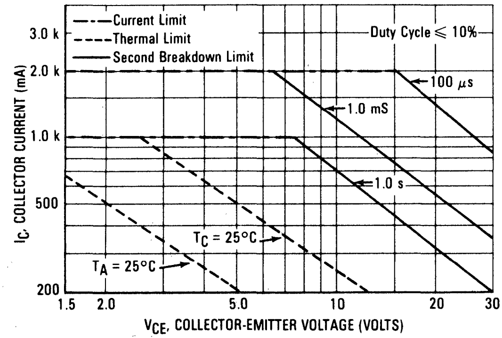


FIGURE 2 — DC CURRENT GAIN

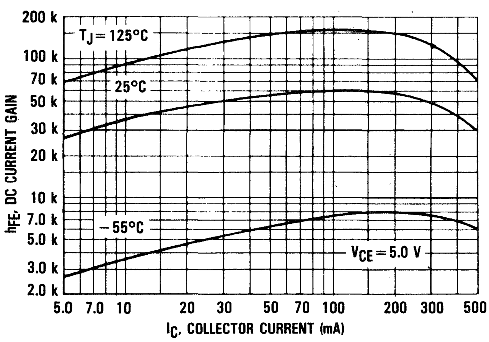


FIGURE 3 — COLLECTOR-SATURATION REGION

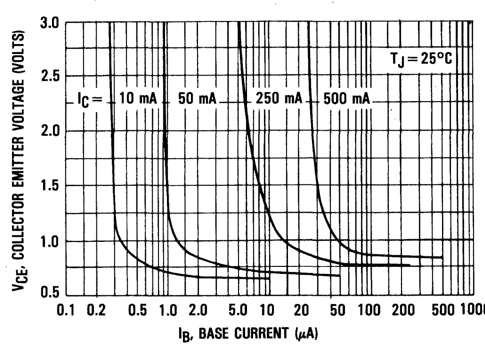


FIGURE 4 — ON VOLTAGES

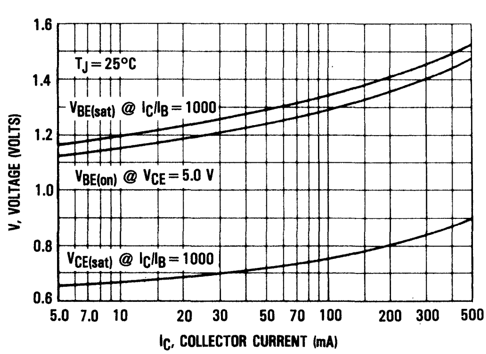


FIGURE 5 — TEMPERATURE COEFFICIENTS

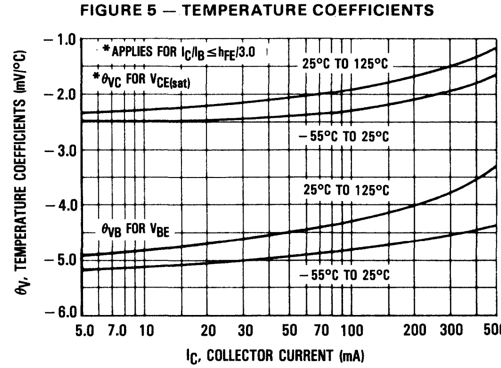


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

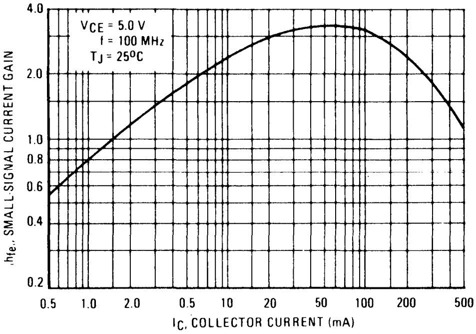
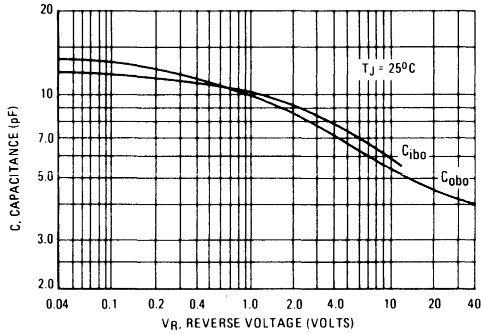


FIGURE 7 — CAPACITANCE



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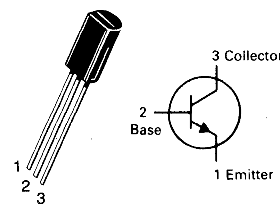
MPSW42★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT HIGH VOLTAGE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 40 40	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — D.C. CURRENT GAIN

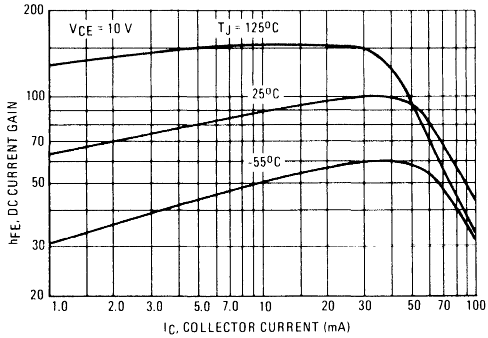


FIGURE 2 — COLLECTOR SATURATION REGION

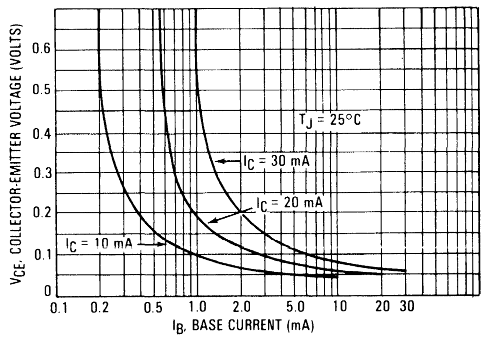


FIGURE 3 — ON VOLTAGES

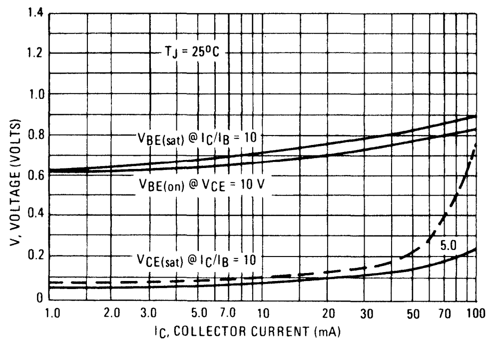


FIGURE 4 — TEMPERATURE COEFFICIENTS

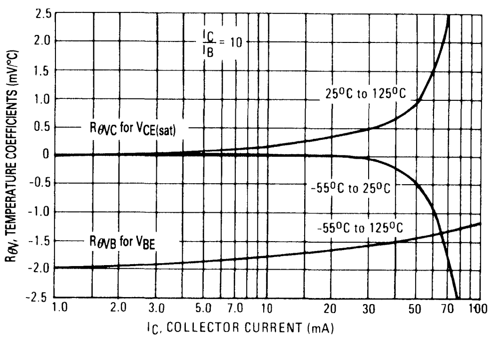


FIGURE 5 — CAPACITANCE

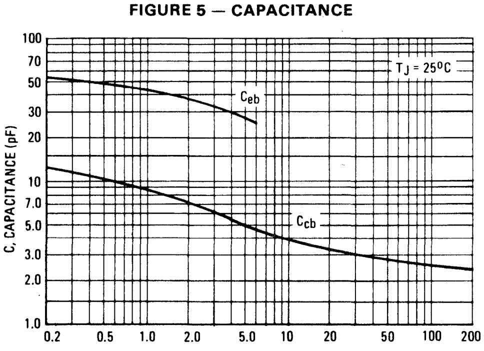
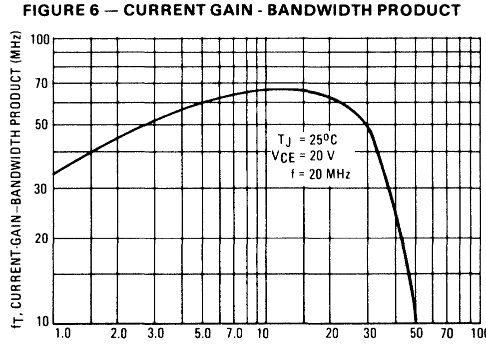
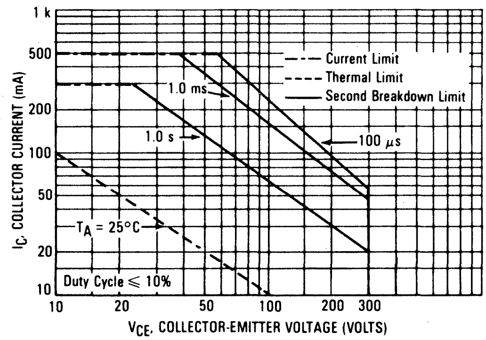


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT



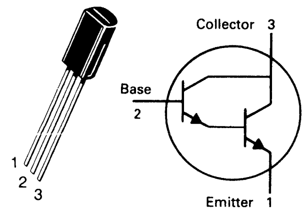
2

FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



MPSW45,A★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT DARLINGTON TRANSISTORS

NPN SILICON

★**MPSW45A is a Motorola designated preferred device.**

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPSW45	MPSW45A	Unit
Collector-Emitter Voltage	V_{CES}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	12	12	Vdc
Collector Current — Continuous	I_C	1.0	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

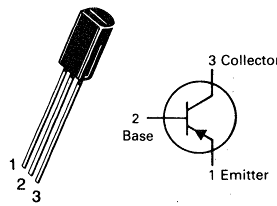
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	MPSW45 MPSW45A	$V_{(BR)CES}$	40 50	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSW45 MPSW45A	$V_{(BR)CBO}$	50 60	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0)	MPSW45 MPSW45A	I_{CBO}	— —	100 100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	25,000 15,000 4,000	150,000 — —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW51,A★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT HIGH CURRENT TRANSISTORS

PNP SILICON

★MPSW51A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector-Emitter Voltage	MPSW51 MPSW51A	V_{CEO}	−30 −40	Vdc
Collector-Base Voltage	MPSW51 MPSW51A	V_{CBO}	−40 −50	Vdc
Emitter-Base Voltage		V_{EBO}	−5.0	Vdc
Collector Current — Continuous		I_C	−1000	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C		P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C		P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = -1.0$ mAdc, $I_B = 0$)	MPSW51 MPSW51A	$V_{(BR)CEO}$	−30 −40	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = -100\ \mu$Adc, $I_E = 0$)	MPSW51 MPSW51A	$V_{(BR)CBO}$	−40 −50	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = -100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = -30$ Vdc, $I_E = 0$) ($V_{CB} = -40$ Vdc, $I_E = 0$)	MPSW51 MPSW51A	I_{CBO}	— —	−0.1 −0.1	μAdc
Emitter Cuttoff Current ($V_{EB} = -3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	−0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = -10$ mAdc, $V_{CE} = -1.0$ Vdc) ($I_C = -100$ mAdc, $V_{CE} = -1.0$ Vdc) ($I_C = -1000$ mAdc, $V_{CE} = -1.0$ Vdc)		h_{FE}	55 60 50	— — —	—
Collector-Emitter Saturation Voltage ($I_C = -1000$ mAdc, $I_B = -100$ mAdc)		$V_{CE(sat)}$	—	−0.7	Vdc
Base-Emitter On Voltage ($I_C = -1000$ mAdc, $V_{CE} = -1.0$ Vdc)		$V_{BE(on)}$	—	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = -50$ mAdc, $V_{CE} = -10$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = -10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — DC CURRENT GAIN

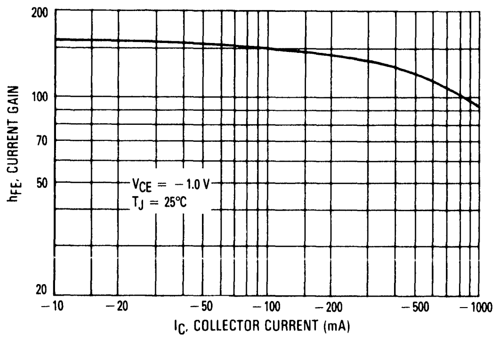


FIGURE 2 — COLLECTOR SATURATION REGION

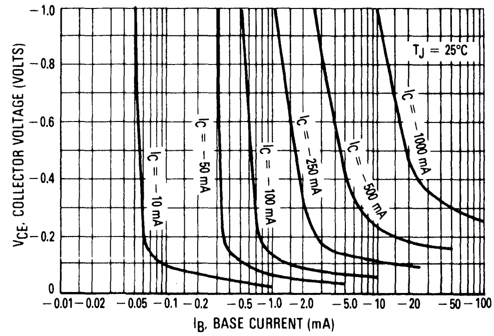


FIGURE 3 — ON VOLTAGES

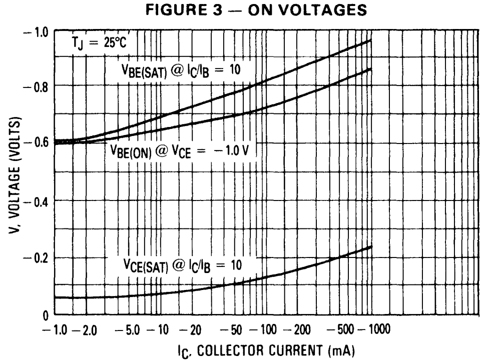


FIGURE 4 — TEMPERATURE COEFFICIENT

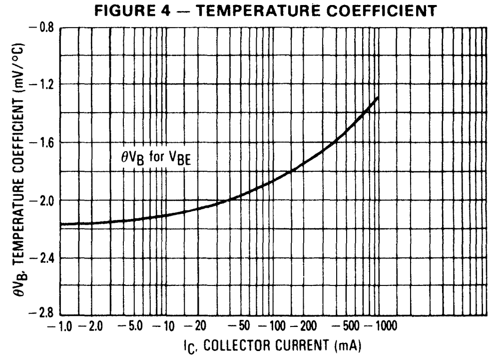


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

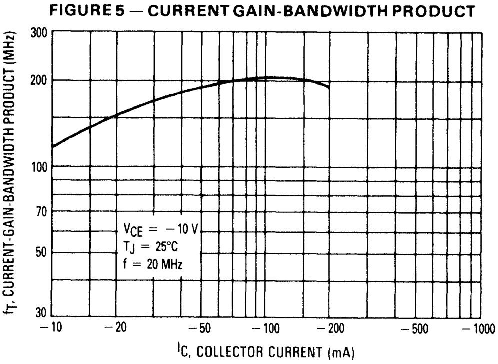


FIGURE 6 — CAPACITANCE

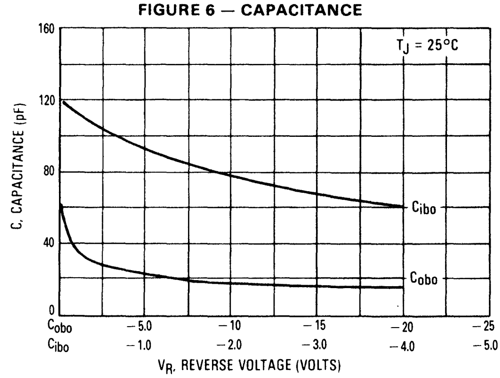
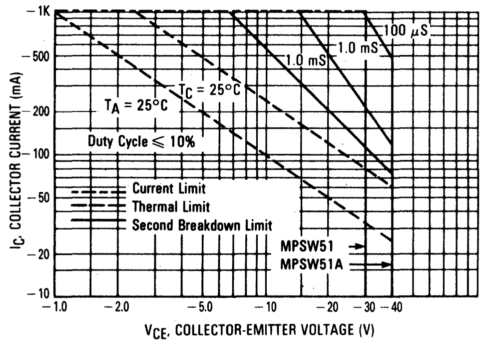
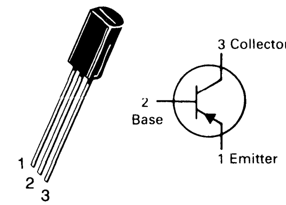


FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



MPSW55
MPSW56★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	MPSW55	MPSW56	Unit
Collector-Emitter Voltage	V_{CEO}	−60	−80	Vdc
Collector-Base Voltage	V_{CBO}	−60	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0		Vdc
Collector Current — Continuous	I_C	−500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	 MPSW55 MPSW56	$V_{(BR)CEO}$	 −60 −80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CE} = −40 Vdc, I_B = 0) (V_{CE} = −60 Vdc, I_B = 0)	 MPSW55 MPSW56	I_{CEO}	 — —	 −0.5 −0.5	μAdc
Collector Cutoff Current (V_{CB} = −40 Vdc, I_E = 0) (V_{CB} = −60 Vdc, I_E = 0)	 MPSW55 MPSW56	I_{CBO}	 — —	 −0.1 −0.1	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −50 mAdc, V_{CE} = −1.0 Vdc) (I_C = −250 mAdc, V_{CE} = −1.0 Vdc)		h_{FE}	 100 50	 — —	—
Collector-Emitter Saturation Voltage (I_C = −250 mAdc, I_B = −10 mAdc)		$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter On Voltage (I_C = −250 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	—	−1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −250 mAdc, V_{CE} = −5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, f = 1.0 MHz)		C_{obo}	—	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW55, MPSW56

FIGURE 1 — D.C. CURRENT GAIN

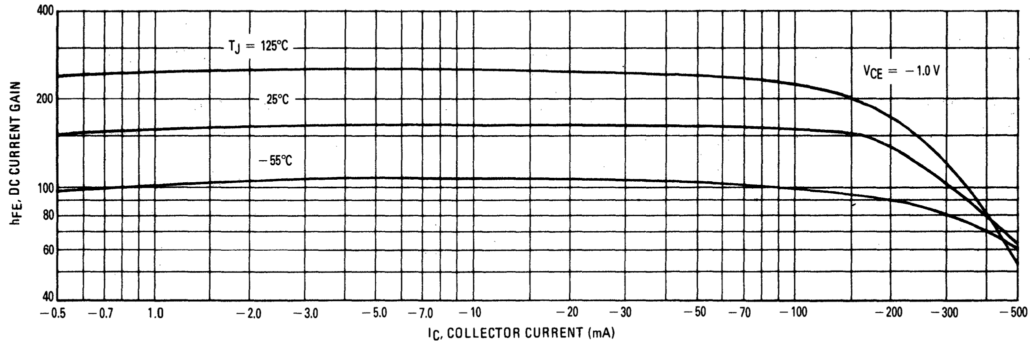


FIGURE 2 — COLLECTOR SATURATION REGION

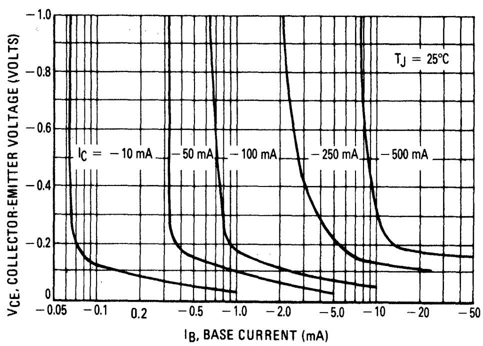


FIGURE 3 — ON VOLTAGES

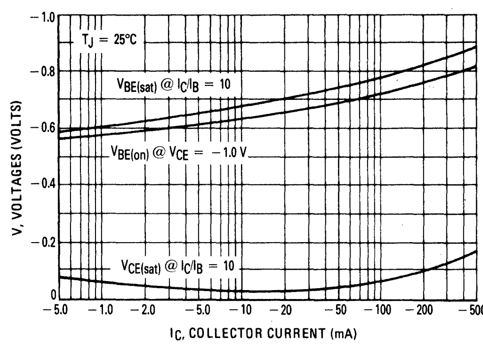


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

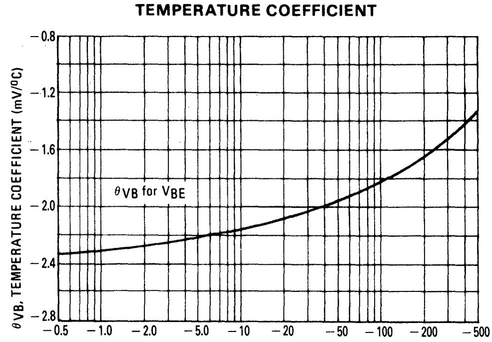


FIGURE 5 — CAPACITANCE

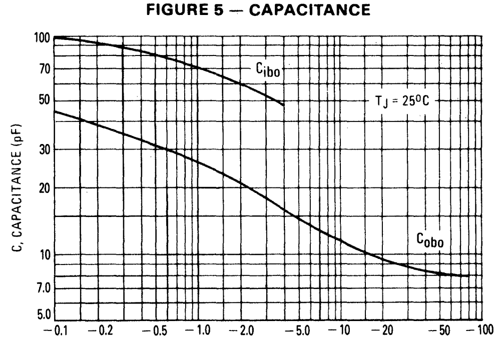


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

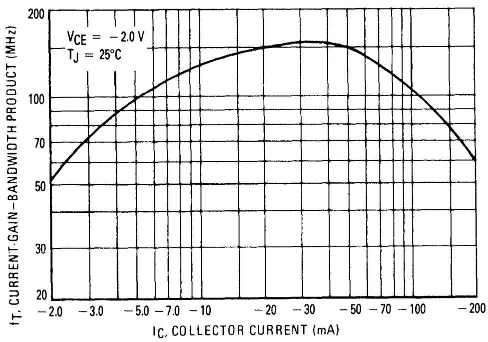
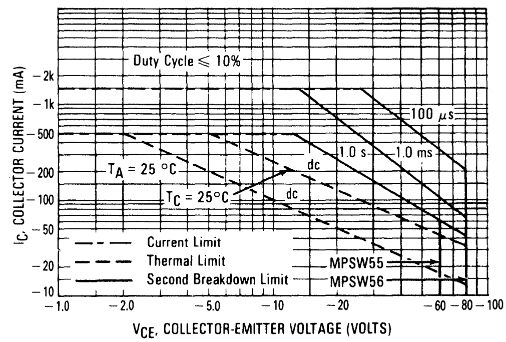


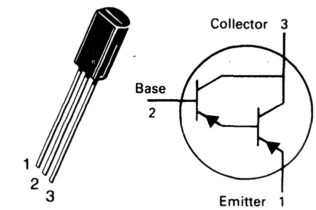
FIGURE 7 — ACTIVE REGION - SAFE OPERATING AREA



2

MPSW63
MPSW64★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT
DARLINGTON TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MPSW63 MPSW64	Unit
Collector-Emitter Voltage	V_{CES}	−30	Vdc
Collector-Base Voltage	V_{CBO}	−30	Vdc
Emitter-Base Voltage	V_{EBO}	−10	Vdc
Collector Current — Continuous	I_C	−500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)		$V_{(BR)CES}$	−30	—	Vdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0)		I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −10 Vdc, I_C = 0)		I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −10 mAdc, V_{CE} = −5.0 Vdc)	MPSW63 MPSW64	h_{FE}	5,000 10,000	— —	—
(I_C = −100 mAdc, V_{CE} = −5.0 Vdc)	MPSW63 MPSW64		10,000 20,000	— —	
Collector-Emitter Saturation Voltage (I_C = −100 mAdc, I_B = −0.1 mAdc)		$V_{CE(sat)}$	—	−1.5	Vdc
Base-Emitter On Voltage (I_C = −100 mAdc, V_{CE} = −5.0 Vdc)		$V_{BE(on)}$	—	−2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

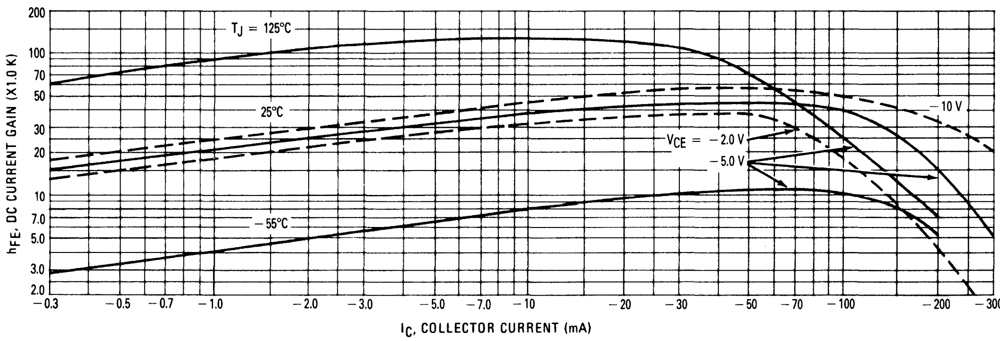


FIGURE 2 — "ON" VOLTAGE

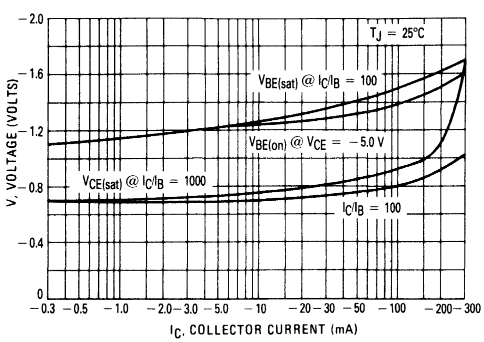


FIGURE 3 — COLLECTOR SATURATION REGION

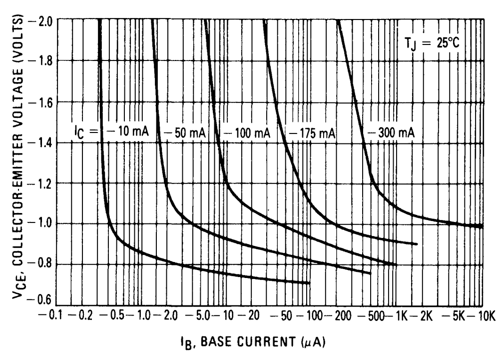


FIGURE 4 — TEMPERATURE COEFFICIENTS

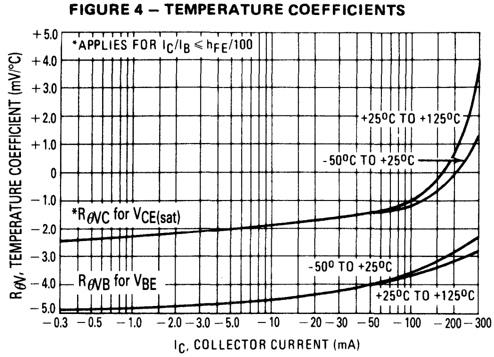


FIGURE 5 — CURRENT-GAIN—BANDWIDTH PRODUCT

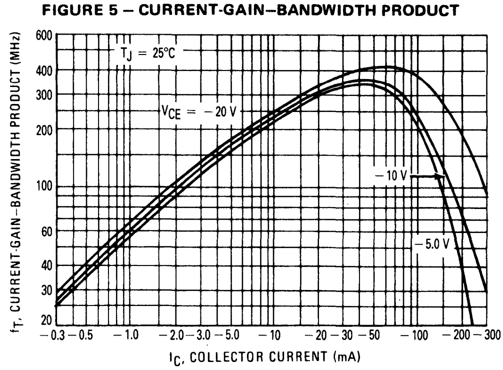


FIGURE 6 — CAPACITANCE

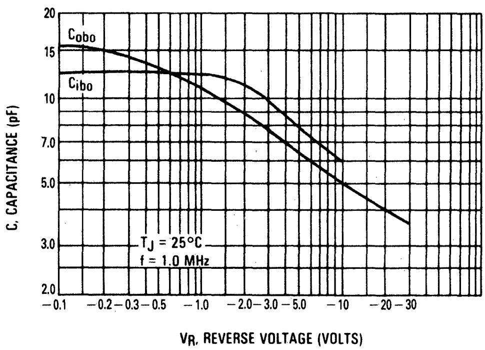
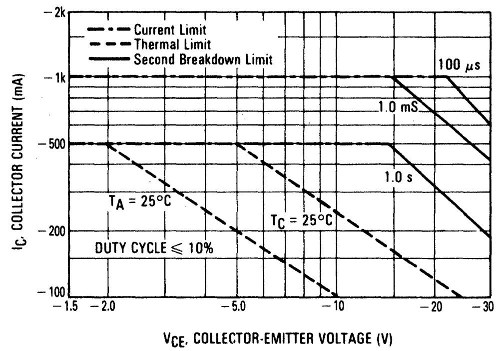
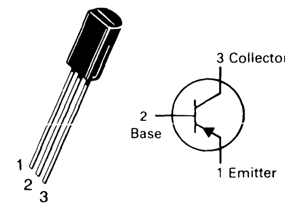


FIGURE 7 — ACTIVE REGION, SAFE OPERATING AREA



MPSW92★

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT
HIGH VOLTAGE
TRANSISTOR

PNP SILICON

★**This is a Motorola designated preferred device.**

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−300	Vdc
Collector-Base Voltage	V_{CBO}	−300	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−300	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0)	I_{CBO}	—	−0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −30 mAdc, V_{CE} = −10 Vdc)	h_{FE}	 25 40 25	 — — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)	$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 20 MHz)	f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — D.C. CURRENT GAIN

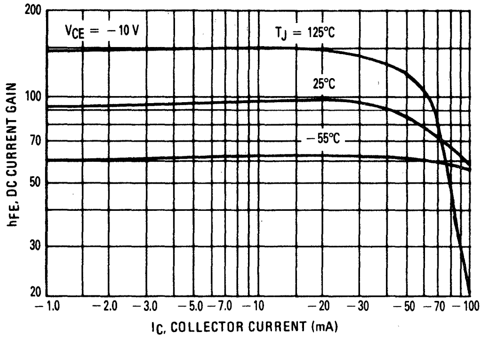


FIGURE 2 — COLLECTOR SATURATION REGION

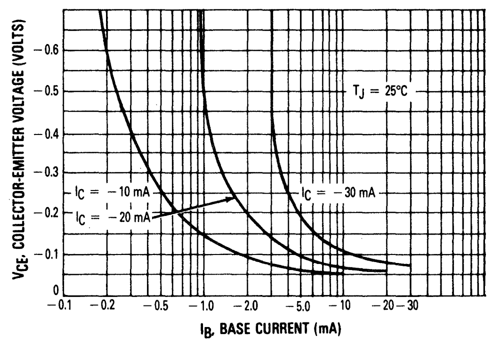


FIGURE 3 — ON VOLTAGES

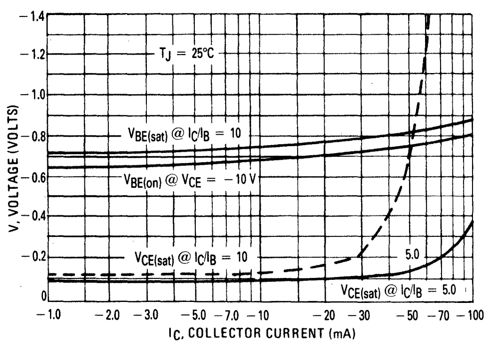


FIGURE 4 — TEMPERATURE COEFFICIENTS

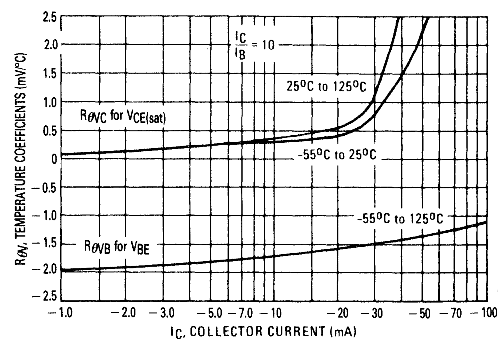


FIGURE 5 — CAPACITANCE

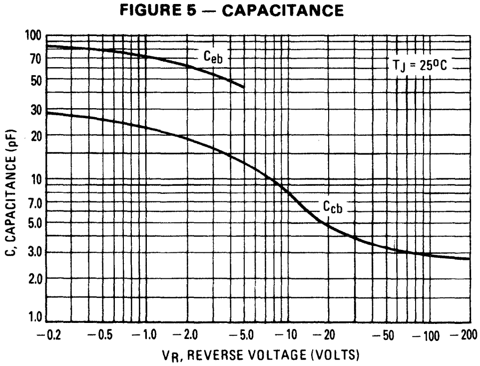


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

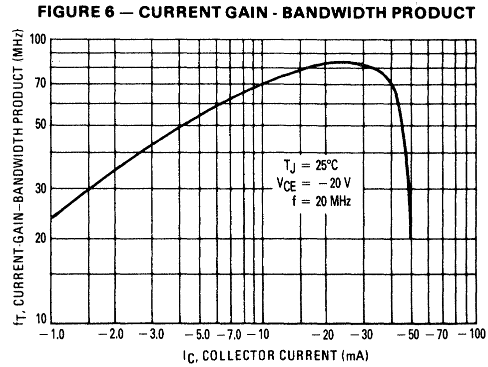
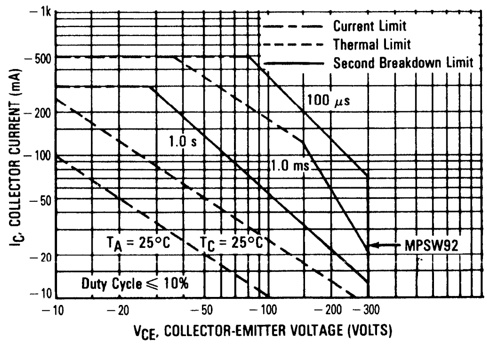


FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA

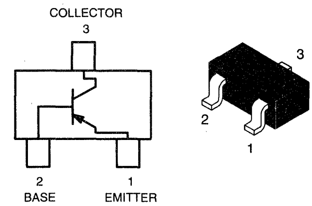


2

2

MSA1022-BT1★
MSA1022-CT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
PNP RF AMPLIFIER
TRANSISTORS
SURFACE MOUNT

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	–30	V
Collector-Emitter Voltage	V_{CEO}	–20	V
Emitter-Base Voltage	V_{EBO}	–5	V
Collector Current-Continuous	I_C	–30	mA

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

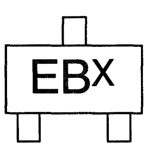
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector Cutoff Current	I_{CBO}	V_{CB} = –10 V, I_E = 0	—	– 0.1	μA
Collector-Emitter Breakdown Voltage	I_{CEO}	V_{CE} = –20 V, I_B = 0	—	–100	μA
Emitter-Base Breakdown Voltage	I_{EBO}	V_{EB} = –5 V, I_C = 0	—	–10	μA
DC Current Gain	h_{FE}*	V_{CE} = –10 V, I_C = –1 mA			
		MSA1022-BT1	70	140	—
		MSA1022-CT1	110	220	—
Current-Gain — Bandwidth Product	f_T	V_{CB} = –10 V, I_E = 1 mA	150	—	MHz

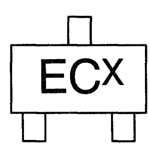
*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSA1022-BT1

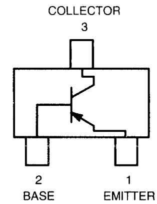


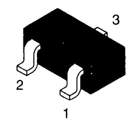
MSA1022-CT1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSB709-RT1★
MSB709-ST1

CASE 318D-03, STYLE 1





SC-59 PACKAGE
PNP GENERAL PURPOSE
AMPLIFIER TRANSISTORS
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	–25	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	–25	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	–7	Vdc
Collector Current-Continuous	I_C	–100	mAdc
Collector Current-Peak	$I_{C(P)}$	–200	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

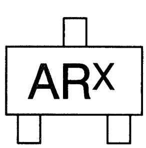
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = –2.0 mA, I_B = 0	–25	–	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = –10 μA, I_E = 0	–25	–	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = –10 μA, I_E = 0	–7	–	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = –20 V, I_E = 0	–	–0.1	μA
Collector-Emitter Cutoff Current	I_{CEO}	V_{CE} = –10 V, I_B = 0	–	–100	μA
DC Current Gain	h_{FE1}*	V_{CE} = –10 V, I_C = –2.0 mA MSB709-RT1 MSB709-ST1	 210 290	 340 460	 – –
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = –100 mA, I_B = –10 mA	–	–0.5	Vdc

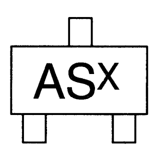
*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSB709-RT1

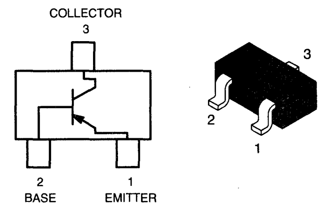


MSB709-ST1

The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSB710-QT1
MSB710-RT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
PNP GENERAL PURPOSE
AMPLIFIER TRANSISTORS
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	–30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	–25	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	–7	Vdc
Collector Current-Continuous	I_C	–500	mAdc
Collector Current-Peak	$I_{C(P)}$	–1	Adc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

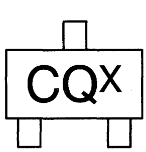
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = –10 mA, I_B = 0	–25	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = –10 μA, I_E = 0	–30	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = –10 μA, I_C = 0	–7	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = –20 V, I_E = 0	—	–0.1	μA
DC Current Gain	h_{FE1}*	V_{CE} = –10 V, I_C = –150 mA			
		MSB710-QT1	85	170	—
		MSB710-RT1	120	240	—
	h_{FE2}*	V_{CE} = –10 V, I_C = 500 mA	40	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = –300 mA, I_B = –30 mA	—	–0.6	Vdc
Collector-Base Saturation Voltage	$V_{BE(sat)}$	I_C = –300 mA, I_B = –30 mA	—	–1.5	Vdc
Output Capacitance	C_{ob}	V_{CB} = –10 V, I_E = 0, f = 1.0 MHz	—	15	pF

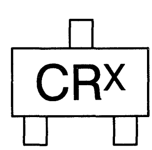
*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSB710-QT1

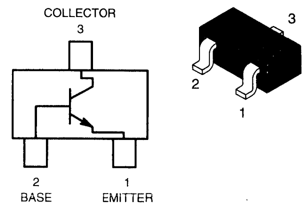


MSB710-RT1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSC1621T1★

CASE 318D-03, STYLE 1



2

SC-59 PACKAGE
NPN SWITCHING
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current-Continuous	I_C	200	mA

THERMAL CHARACTERISTICS

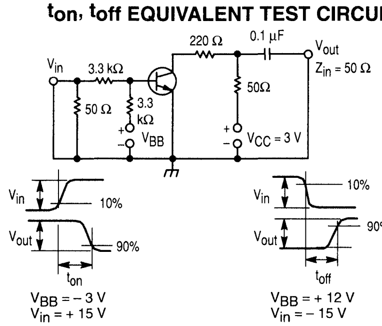
Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

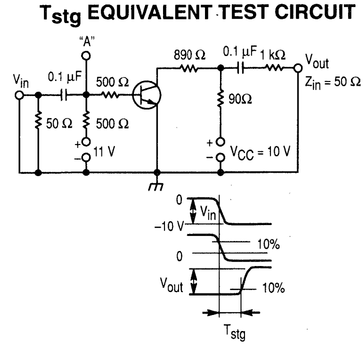
Characteristic	Symbol	Condition	Min	Max	Unit
Collector Cutoff Current	I_{CBO}	V_{CB} = 30 V, I_E = 0	—	0.1	μA
Emitter Base Cutoff Current	I_{EBO}	V_{EB} = 4.0 V, I_C = 0	—	0.1	μA
DC Current Gain	h_{FE}*	V_{CE} = 0.5 V, I_C = 1 mA	40	180	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 10 mA, I_B = 1.0 mA	—	0.25	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 10 mA, I_B = 1.0 mA	—	0.85	V
Current-Gain — Bandwidth Product	f_T	V_{CE} = 10 V, I_E = –10 mA	200	—	MHz
Output Capacitance	C_{ob}	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz	—	6.0	pF
Turn On Time	t_{on}	I_C = 10 mA in Equivalent Test Circuit	—	20	ns
Storage Temperature Range	T_{stg}		—	20	ns
Turn Off Time	t_{off}		—	40	ns

*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

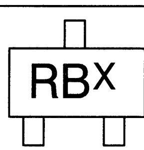
t_{on}, t_{off} EQUIVALENT TEST CIRCUIT



T_{stg} EQUIVALENT TEST CIRCUIT



Marking Symbol

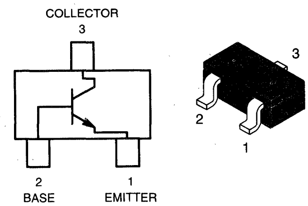


DEVICE MARKING

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSC2295-BT1★
MSC2295-CT1★

CASE 318D-03, STYLE 1



**SC-59 PACKAGE
NPN RF AMPLIFIER
TRANSISTORS
SURFACE MOUNT**

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	20	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	5	Vdc
Collector Current-Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

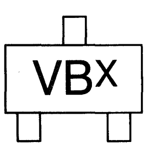
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 10 V, I_E = 0	—	0.1	μA
DC Current Gain	h_{FE}*	V_{CB} = 10 V, I_E = –1 mA MSC2295-BT1 MSC2295-CT1	 70 110	 140 220	 — —
Collector-Gain — Bandwidth Product	f_T	V_{CB} = 10 V, I_E = –1 mA	150	—	MHz
Reverse Transistor Capacitance	C_{re}	V_{CE} = 10 V, I_C = 1 mA, f = 10.7 MHz	—	1.5	pF

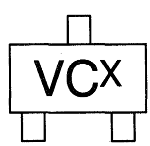
*Pulse Test: Pulse Width ≤ 300 μs, D.C. < 2%.

DEVICE MARKING

Marking Symbol



MSC2295-BT1

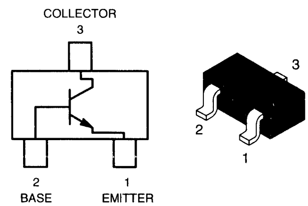


MSC2295-CT1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSC2404-CT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN RF AMPLIFIER
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	20	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	3	Vdc
Collector Current-Continuous	I_C	15	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	150	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

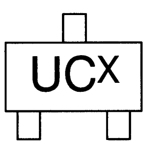
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 µA, I_E = 0	30	—	Vdc
Collector Emitter Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 µA, I_C = 0	3	—	Vdc
DC Current Gain	h_{FE}*	V_{CB} = 6 V, I_E = –1 mA	65	160	—
Current-Gain — Bandwidth Product	f_T	V_{CB} = 6 V, I_E = –1 mA	450	—	MHz
Reverse Transfer Capacitance	C_{re}	V_{CE} = 6 V, I_C = 1 mA, f = 10.7 MHz	—	1	pF

*Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

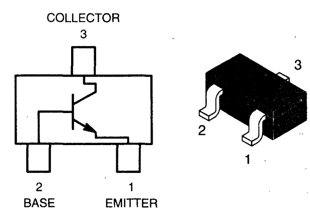
Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSC3130T1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN RF AMPLIFIER
TRANSISTOR
SURFACE MOUNT

★**This is a Motorola designated preferred device.**

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	15	V
Collector-Emitter Voltage	V_{CEO}	10	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current-Continuous	I_C	50	mA

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

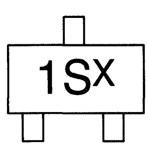
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 V, I_E = 0	—	1	μA
Collector-Emitter Breakdown Voltage	V_{CEO}	I_C = 2 mA, I_B = 0	10	—	V
Emitter-Base Breakdown Voltage	V_{EBO}	I_E = 10 μA, I_C = 0	3	–	V
DC Current Gain	h_{FE}*	V_{CE} = 4 V, I_C = 5 mA	75	400	–
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 20 mA, I_B = 4 mA	–	0.5	V
Current-Gain — Bandwidth Product	f_T	V_{CB} = 4 V, I_E = –5 mA	1.4	2.5	GHz

*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

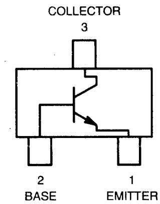
Marking Symbol

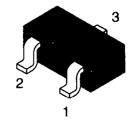


The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSD601-RT1★
MSD601-ST1

CASE 318D-03, STYLE 1





SC-59 PACKAGE
NPN GENERAL PURPOSE
AMPLIFIER TRANSISTORS
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	25	Vdc
Emitter-Base Voltage	$V_{(BR)EBO}$	7	Vdc
Collector Current-Continuous	I_C	100	mAdc
Collector Current-Peak	$I_{C(P)}$	200	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

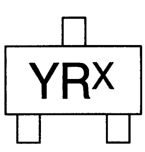
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 2.0 mA, I_B = 0	25	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 μA, I_E = 0	30	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 μA, I_C = 0	7	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 20 V, I_E = 0	—	0.1	μA
Collector-Emitter Cutoff Current	I_{CEO}	V_{CE} = 10 V, I_B = 0	—	100	μA
DC Current Gain	h_{FE1}*	V_{CE} = 10 V, I_C = 2.0 mA MSD601-RT1 MSD601-ST1	 210 290	 340 460	 — —
	h_{FE2}*	V_{CE} = 2.0 V, I_C = 100 mA	90	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 100 mA, I_B = 10 mA	—	0.5	Vdc

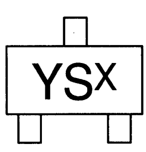
*Pulse Test: Pulse Width ≤ 300 μs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



MSD601-RT1

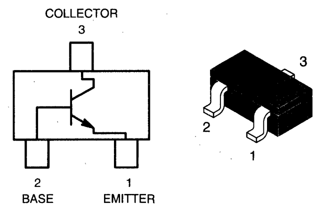


MSD601-ST1

The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

MSD602-RT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN GENERAL PURPOSE
AMPLIFIER TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	30	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	25	Vdc
Emitter-Base Voltage	$V_{E(BR)BO}$	7	Vdc
Collector Current-Continuous	I_C	500	mAdc
Collector Current-Peak	$I_{C(P)}$	1	Adc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	–55 ~ + 150	°C

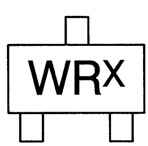
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 10 mA, I_B = 0	25	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 µA, I_E = 0	30	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 µA, I_C = 0	7	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 20 V, I_E = 0	—	0.1	µA
DC Current Gain	h_{FE1}*	V_{CE} = 10 V, I_C = 150 mA	120	240	—
	h_{FE2}*	V_{CE} = 10 V, I_C = 500 mA	40	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 300 mA, I_B = 30 mA	—	0.6	Vdc
Output Capacitance	C_{ob}	V_{CB} = 10 V, I_E = 0, f = 1 MHz	—	15	pF

*Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

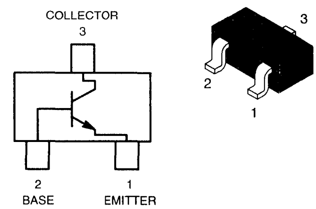
Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicate the actual month in which the part was manufactured.

MSD1328-RT1★

CASE 318D-03, STYLE 1



SC-59 PACKAGE
NPN LOW VOLTAGE
OUTPUT AMPLIFIER
SURFACE MOUNT

★**This is a Motorola designated preferred device.**

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Collector-Base Voltage	$V_{(BR)CBO}$	25	Vdc
Collector-Emitter Voltage	$V_{(BR)CEO}$	20	Vdc
Emitter-Base Voltage	$V_{E(BR)BO}$	12	Vdc
Collector Current-Continuous	I_C	500	mAdc
Collector Current-Peak	$I_{C(P)}$	1000	mAdc

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	−55 ~ + 150	°C

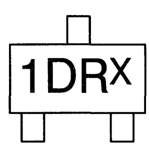
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 1.0 mA, I_B = 0	20	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 10 µA, I_E = 0	25	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 10 µA, I_E = 0	12	—	Vdc
Collector-Base Cutoff Current	I_{CBO}	V_{CB} = 25 V, I_E = 0	—	0.1	µA
DC Current Gain	h_{FE}*	V_{CE} = 2 V, I_C = 500 mA	200	350	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 500 mA, I_B = 20 mA	—	0.4	Vdc
Base–Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 500 mA, I_B = 50 mA	—	1.2	Vdc

*Pulse Test: Pulse Width ≤ 300 µs, D.C. ≤ 2%.

DEVICE MARKING

Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

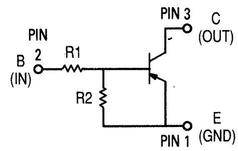
2

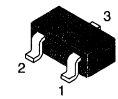
This new series of digital transistors is designed to replace a single device and its external resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SC-59 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Power dissipation of 200 milliwatts on standard FR5/G10 glass epoxy printed circuit board and up to 400 milliwatts on ceramic or Thermal Clad substrates using recommended footprint
- The SC-59 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.

MUN2111T1★
MUN2112T1★
MUN2113T1★

CASE 318D-03, STYLE 1
(SC-59)





BIAS RESISTOR TRANSISTORS

PNP SILICON

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200* 1.6	mW mW/°C
Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	625	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to +150	°C

DEVICE MARKING

MUN2111T1 = 6A; MUN2112T1 = 6B; MUN2113T1 = 63

* Device mounted on a glass epoxy printed circuit board using the minimum recommended footprint as shown in Section 8.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Voltage (V_{CE} = 50 V, I_B = 0)		I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MUN2111 MUN2112 MUN2113	I_{EBO}	— — —	— — —	0.5 0.2 0.1	mAdc
Collector-Base Breakdown Voltage (I_C = 10 µA, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	—	—	Vdc
ON CHARACTERISTICS*						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MUN2111 MUN2112 MUN2113	h_{FE}	35 60 80	60 100 140	— — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_E = 3.0 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
Input Voltage (on) (V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ) (V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	 MUN2111 MUN2112 MUN2113	V_{OL}	 — — —	 — — —	 0.2 0.2 0.2	Vdc
Input Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
Input Resistor	MUN2111 MUN2112 MUN2113	R1	7.0 15.4 32.9	10 22 47	13 28.6 61.1	k ohms
Resistor Ratio		R_1/R_2	0.9	1.0	1.1	—

* Pulse Test: Pulse Width < 300 µs. Duty Cycle < 2.0%.
Note: "T1" must be used when ordering SC-59 devices.

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2111T1

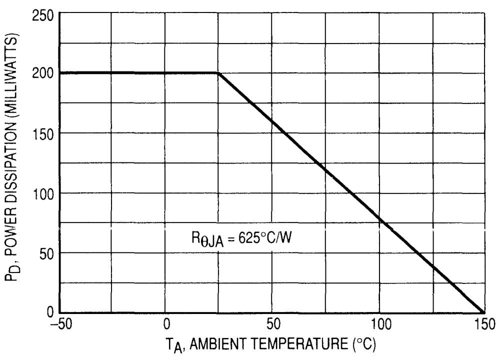


Figure 1. Derating Curve

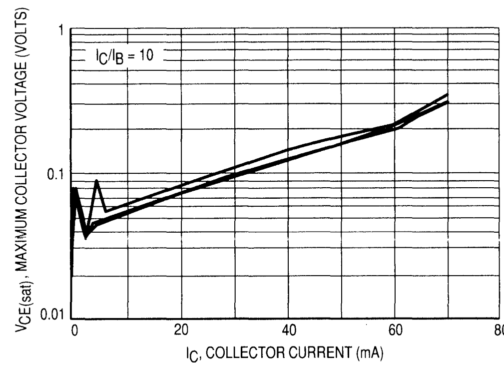


Figure 2. $V_{CE(sat)}$ versus I_C

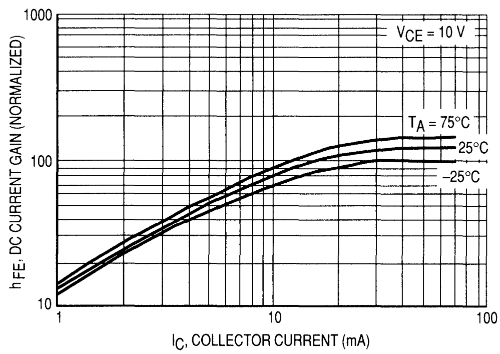


Figure 3. DC Current Gain

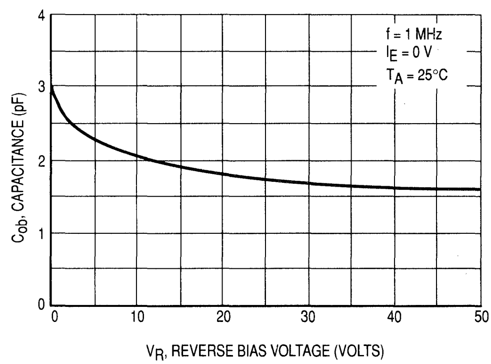


Figure 4. Output Capacitance

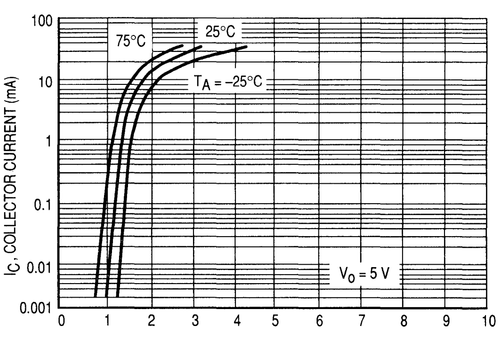


Figure 5. Output Current versus Input Voltage

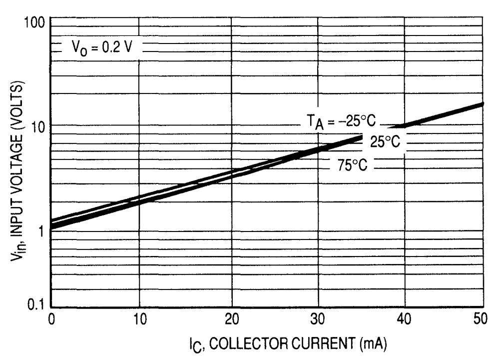


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2112T1

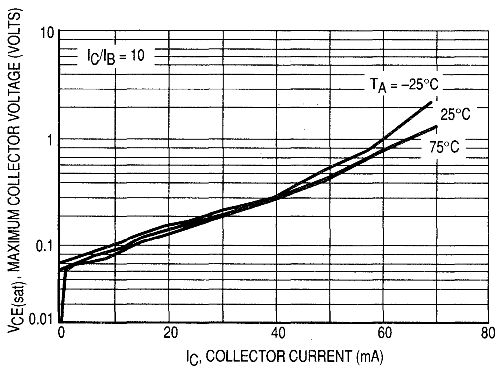


Figure 7. $V_{CE(sat)}$ versus I_C

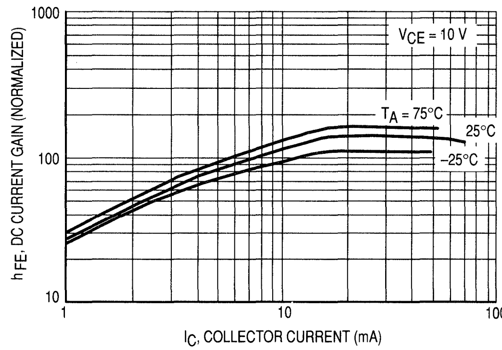


Figure 8. DC Current Gain

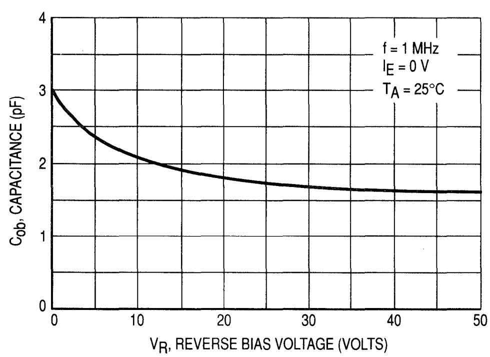


Figure 9. Output Capacitance

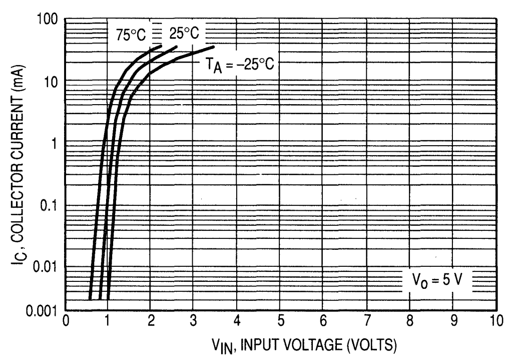


Figure 10. Output Current versus Input Voltage

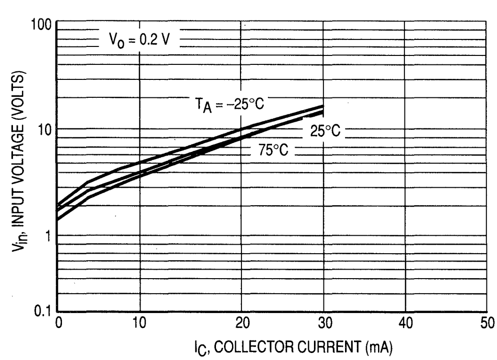


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2113T1

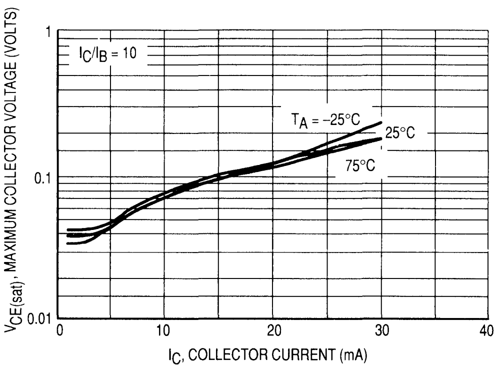


Figure 12. $V_{CE(sat)}$ versus I_C

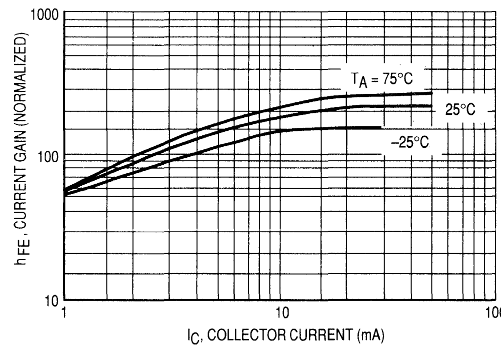


Figure 13. DC Current Gain

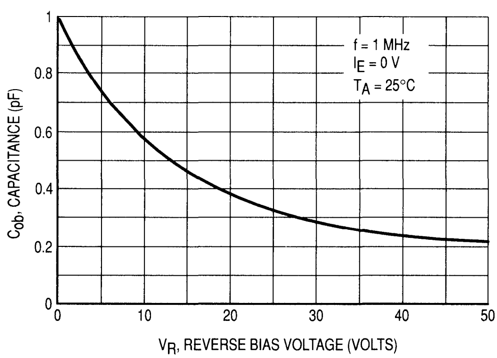


Figure 14. Output Capacitance

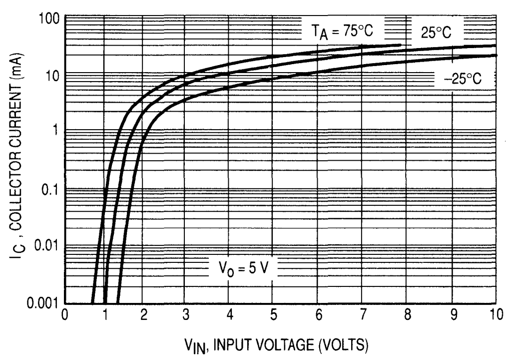


Figure 15. Output Current versus Input Voltage

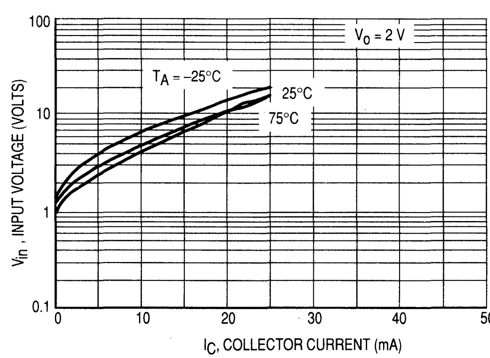
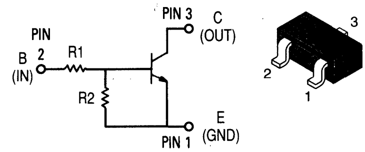


Figure 16. Input Voltage versus Output Current

2

MUN2211T1★
MUN2212T1★
MUN2213T1★

CASE 318D-03, STYLE 1
(SC-59)



BIAS RESISTOR TRANSISTORS

NPN SILICON

★These are Motorola designated preferred devices.

This new series of digital transistors is designed to replace a single device and its internal resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SC-59 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space
- Reduces Component Count
- Power dissipation of 200 milliwatts on standard FR5/G10 glass epoxy printed circuit board and up to 400 milliwatts on ceramic or Thermal Clad substrates using recommended footprint
- The SC-59 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200* 1.6	mW mW/°C
Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	625	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to +150	°C

DEVICE MARKING

MUN2211T1 = 8A; MUN2212T1 = 8B; MUN2213T1 = 8C

*** Device mounted on a glass epoxy printed circuit board using the minimum recommended footprint as shown in Section 8.**

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	—	—	100	nAdc
Collector-Emitter Cutoff Voltage (V_{CE} = 50 V, I_B = 0)		I_{CEO}	—	—	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MUN2211 MUN2212 MUN2213	I_{EBO}	— — —	— — —	0.5 0.2 0.1	mAdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		BV_{CBO}	50	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mA, I_B = 0)		BV_{CEO}	50	—	—	Vdc
ON CHARACTERISTICS*						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MUN2211 MUN2212 MUN2213	h_{FE}	35 60 80	60 100 140	— — —	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA)		$V_{CE(sat)}$	—	—	0.25	Vdc
Input Voltage (ON) (V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 kΩ) (V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 kΩ)	 MUN2211 MUN2212 MUN2213	V_{OL} V_{OL}	 — — —	 — — —	 0.2 0.2 0.2	Vdc
Input Voltage (OFF) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 kΩ)		V_{OH}	4.9	—	—	Vdc
Input Resistor	MUN2211 MUN2212 MUN2213	R1	7.0 15.4 32.9	10 22 47	13 28.6 61.1	k ohms
Resistor Ratio		R1/R2	0.9	1.0	1.1	

*** Pulse Test: Pulse Width < 300 μs. Duty Cycle < 2.0%.**
Note: "T1" must be used when ordering SC-59 devices.

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2211T1

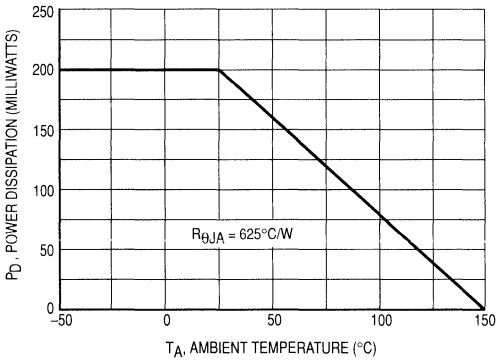


Figure 1. Derating Curve

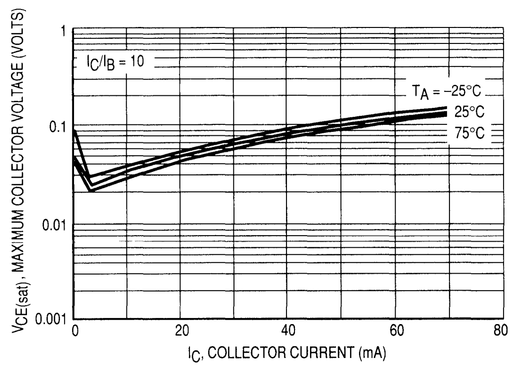


Figure 2. $V_{CE(sat)}$ versus I_C

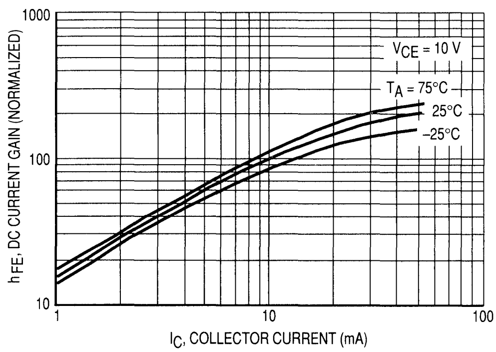


Figure 3. DC Current Gain

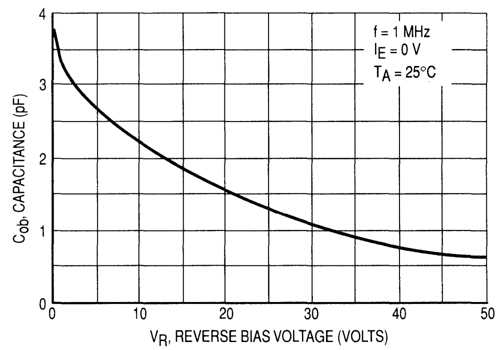


Figure 4. Output Capacitance

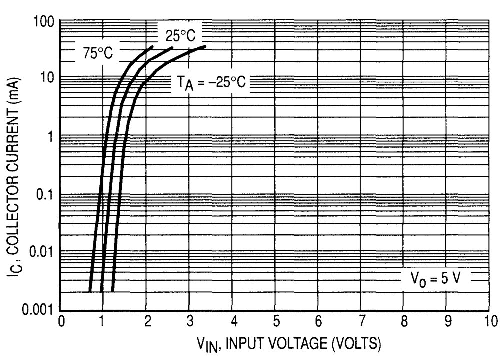


Figure 5. Output Current versus Input Voltage

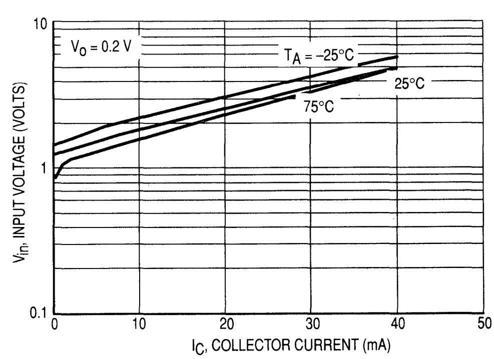


Figure 6. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2212T1

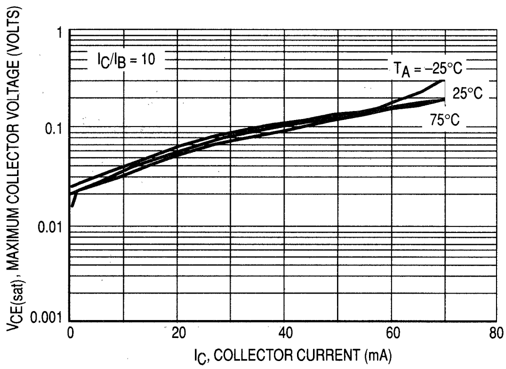


Figure 7. $V_{CE(sat)}$ versus I_C

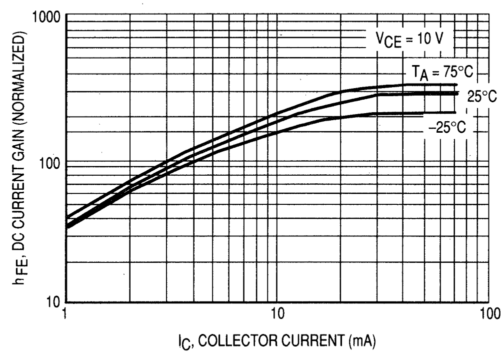


Figure 8. DC Current Gain

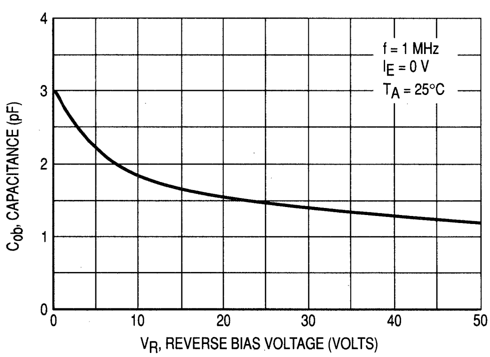


Figure 9. Output Capacitance

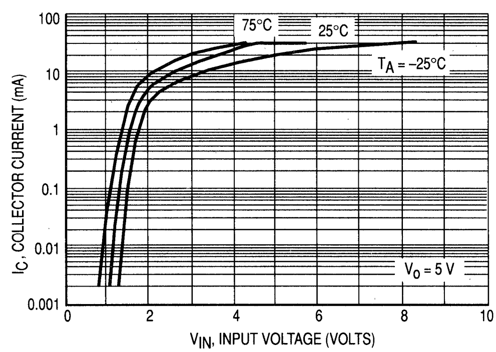


Figure 10. Output Current versus Input Voltage

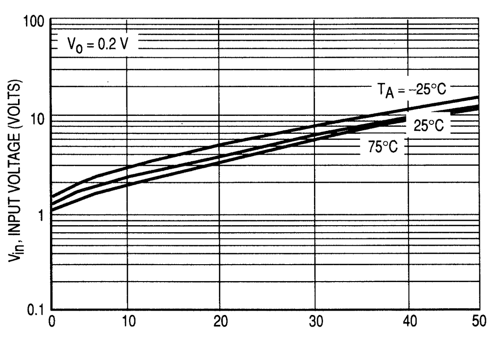


Figure 11. Input Voltage versus Output Current

TYPICAL ELECTRICAL CHARACTERISTICS — MUN2213T1

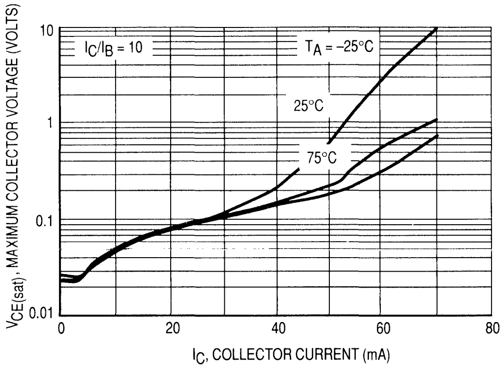


Figure 12. $V_{CE(sat)}$ versus I_C

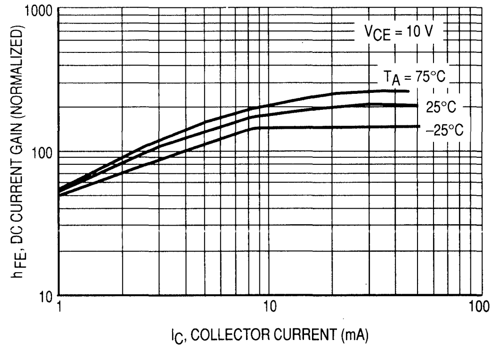


Figure 13. DC Current Gain

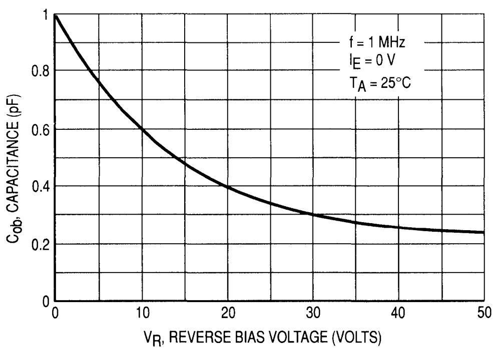


Figure 14. Output Capacitance

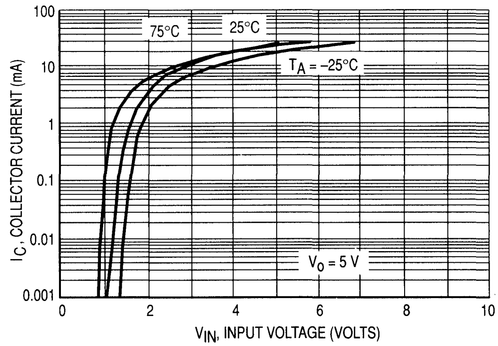


Figure 15. Output Current versus Input Voltage

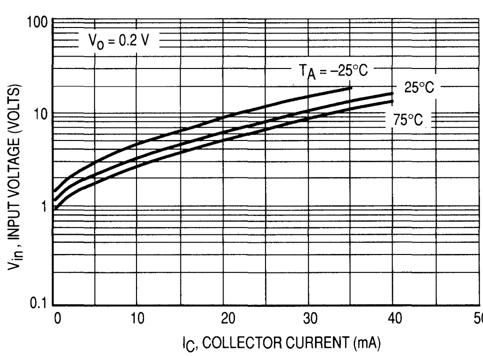
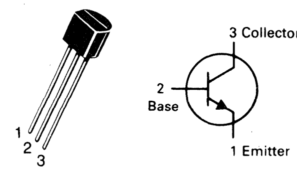


Figure 16. Input Voltage versus Output Current

2

PBF259, S

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	PBF259, S	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

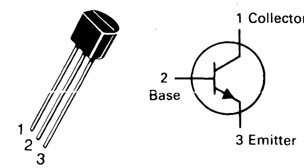
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 V)	I_{EBO}	—	20	nAdc
Collector Cutoff Current (V_{CE} = 10 V)	I_{CEO}	—	50	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 20 mAdc, V_{CE} = 10 Vdc) PBF259S (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) All Types (I_C = 30 mAdc, V_{CE} = 10 Vdc) All Types	h_{FE}	 60 25 25	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 1.5 mAdc) (I_C = 30 mAdc, I_B = 60 mAdc)	$V_{CE(sat)}$	 — —	 0.5 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	40	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	pF

PBF259RS

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	PBF493RS	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

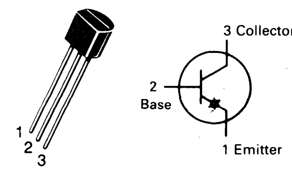
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 250$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ V)	I_{EBO}	—	20	nAdc
Collector Cutoff Current ($V_{CE} = 10$ V)	I_{CEO}	—	50	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 60 25 25	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 1.5$ mAdc) ($I_C = 30$ mAdc, $I_B = 60$ mAdc)	$V_{CE(sat)}$	 — —	 0.5 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mA, $I_B = 2.0$ mA)	$V_{BE(sat)}$	—	0.9	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	40	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	3.0	pF

2

PBF493, S

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−300	Vdc
Collector-Base Voltage	V_{CBO}	−300	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

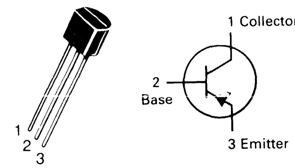
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−300	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0)		I_{CBO}	—	−0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 V)		I_{EBO}	—	−20	nAdc
Collector Cutoff Current (V_{CE} = −10 V)		I_{CEO}	—	−250	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −30 mAdc, V_{CE} = −10 Vdc)	 PBF493S All Types All Types	h_{FE}	 40 40 25	 — — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF

PBF493R, RS

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−300	Vdc
Collector-Base Voltage	V_{CBO}	−300	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

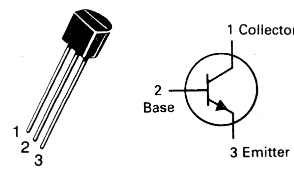
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	−300	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc, I_E = 0)		I_{CBO}	—	−0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 V)		I_{EBO}	—	−20	nAdc
Collector Cutoff Current (V_{CE} = −10 Vdc)		I_{CEO}	—	−250	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −30 mAdc, V_{CE} = −10 Vdc)	 PBF493RS All Types All Types	h_{FE}	 40 40 25	 — — —	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)		$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF

P2N2222A

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MPS2222 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	I_{CEX}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 0.01 10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	10	nAdc
Collector Cutoff Current ($V_{CE} = 10$ V)	I_{CEO}	—	10	nAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	I_{BEX}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	h_{FE}	 35 50 75 35 100 50 40	 — — — — 300 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	 — —	 0.3 1.0	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	 0.6 —	 1.2 2.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	 2.0 0.25	 8.0 1.25	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	 — —	 8.0 4.0	$X10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	 50 75	 300 375	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	 5.0 25	 35 200	μmhos
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)		$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)		N_F	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −2.0 V, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%. (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

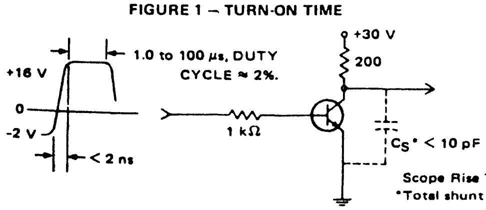
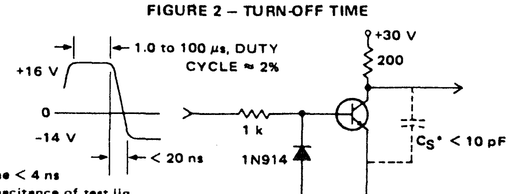


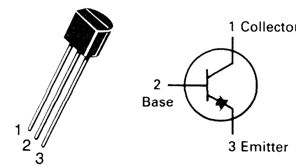
FIGURE 2 — TURN-OFF TIME



Scope Rise Time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

P2N2907A

CASE 29-04, STYLE 17
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPS2907 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−60	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc)	I_{CEX}	—	−50	nAdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 −0.01 −10	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc)	I_{EBO}	—	−10	nAdc
Collector Cutoff Current (V_{CE} = −10 V)	I_{CEO}	—	−10	nAdc
Base Cutoff Current (V_{CE} = −30 Vdc, $V_{EB(off)}$ = −0.5 Vdc)	I_{BEX}	—	−50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 Vdc) (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −150 mAdc, V_{CE} = −10 Vdc)(1) (I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	h_{FE}	 75 100 100 100 50	 — — — 300 —	—
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{CE(sat)}$	 — —	 −0.4 −1.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc)	$V_{BE(sat)}$	 — —	 −1.3 −2.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (1), (2) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc) (Figures 1 and 5)	t_{on}	—	50	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	(V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 mAdc (Figure 2)	t_{off}	—	110	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

2

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

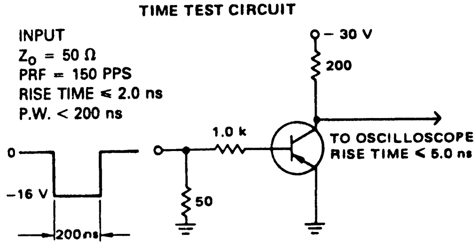
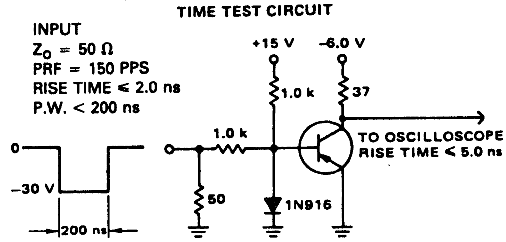
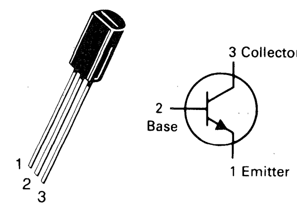


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



P2N3019

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current − Continuous	I_C	1.0	Adc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

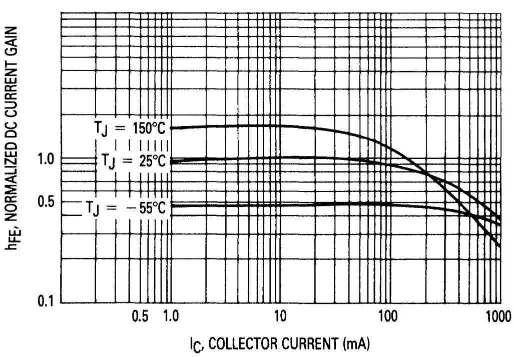
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 30$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 90$ Vdc, $I_E = 0$) ($V_{CB} = 90$ Vdc, $I_E = 0$, $T_A = +150°C$)		I_{CBO}	 — —	 0.01 10	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc, $T_C = -55°C$) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc)	 P2N3019 P2N3019 P2N3019 P2N3019 P2N3019 	h_{FE}	 50 90 100 40 50 15	 — — 300 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	P2N3019	f_T	80	—	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

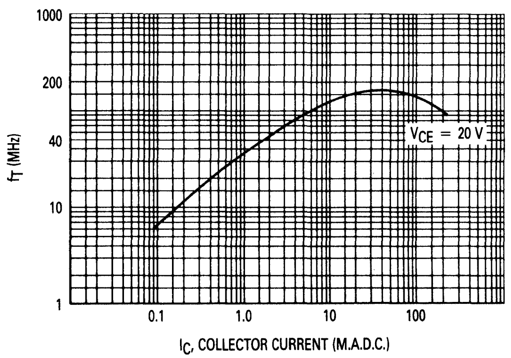
Characteristic	Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	60	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) P2N3019	h_{fe}	80	400	—
Collector Base Time Constant (I_E = 10 mAdc, V_{CB} = 10 Vdc, f = 4.0 MHz) P2N3019	$rb'C_C$	—	400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} – 10 Vdc, R_S = 1.0 kohms, f = 1.0 kHz)	N_F	—	4.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

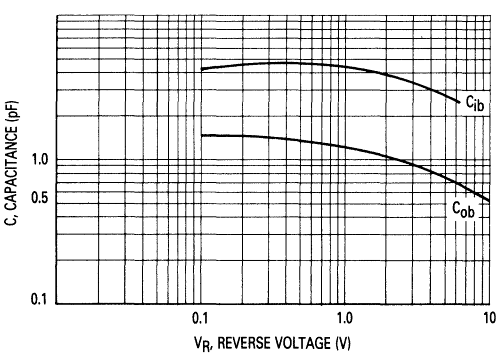
DC CURRENT GAIN
P2N3019



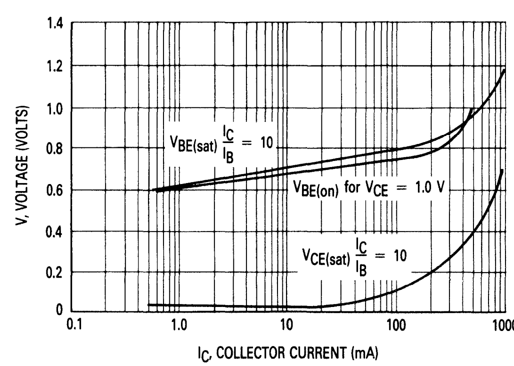
CURRENT GAIN — BANDWIDTH PRODUCT



CAPACITANCE

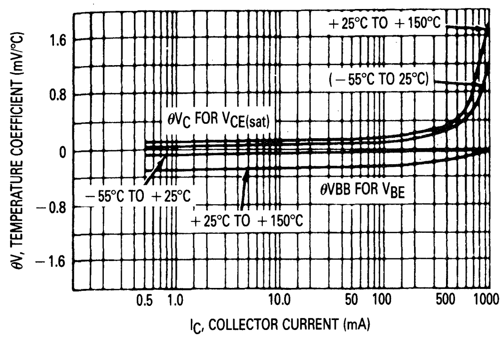


"ON" VOLTAGES

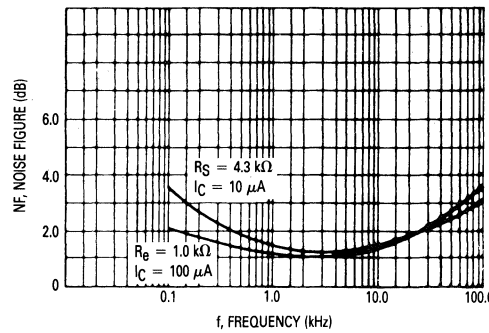


2

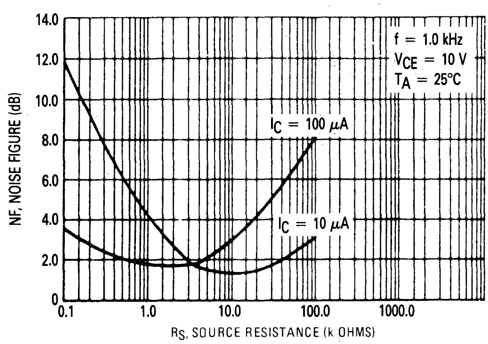
TEMPERATURE COEFFICIENTS



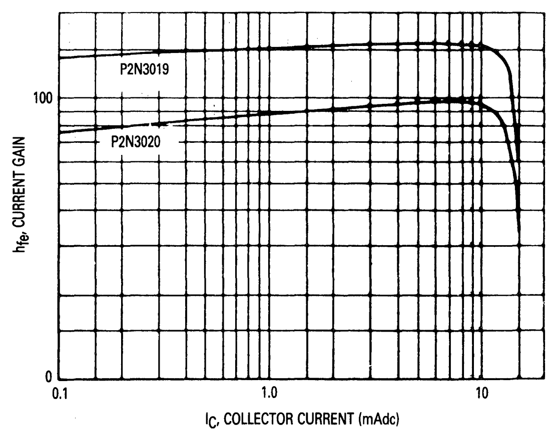
FREQUENCY EFFECTS



SOURCE RESISTANCE EFFECTS

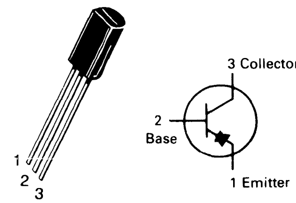


CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT — 1 kHz h_{fe}



P2N4033

CASE 29-03, STYLE 1
TO-92 (TO-226AE)



ONE WATT AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−80	Vdc
Collector-Base Voltage	V_{CBO}	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −10 mA)	$V_{(BR)CEO}$	−80	—	V
Collector-Base Breakdown Voltage (I_C = −10 μA)	$V_{(BR)CBO}$	−80	—	V
Emitter-Base Breakdown Voltage (I_E = −10 μA)	$V_{(BR)EBO}$	−5.0	—	V
Collector Cutoff Current (V_{CB} = −60 V) (V_{CB} = −60 V, T_A = 150°C)	I_{CBO}	 — —	 −5.0 −50	 nA μA
Emitter Cutoff Current (V_{EB} = −5.0 V)	I_{EBO}	—	−10	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = −100 mA, V_{CE} = −5.0 V, −55°C) (I_C = −100 μA, V_{CE} = −5.0 V) (I_C = −100 mA, V_{CE} = −5.0 V) (I_C = −500 mA, V_{CE} = −5.0 V) (I_C = −1.0 A, V_{CE} = −5.0 V)	h_{FE}	 40 75 100 70 25	 — — 300 — —	—
Collector-Emitter Saturation Voltage (I_C = −150 mA, I_B = −15 mA) (I_C = −500 mA, I_B = −50 mA)	$V_{CE(sat)}$	 — —	 −0.15 −0.5	V
Base-Emitter Saturation Voltage (I_C = −150 mA, I_B = −15 mA) (I_C = −500 mA, I_B = −50 mA)	$V_{BE(sat)}$	 — —	 −0.9 −1.1	V

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CE} = −10, f = 1.0 MHz)	C_{obo}	—	25	pF
Input Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)	C_{ibo}	—	150	pF
Current Gain — Bandwidth Product (I_C = −50 mA, V_{CC} = −10 V, f = 100 MHz)	f_T	150	—	MHz
SWITCHING CHARACTERISTICS				
Turn-On Time (see Figure 1) (I_C = −500 mA, I_{B1} = −50 mA)	t_{on}	—	100	ns
Turn-Off Time (see Figure 1) (I_C = −500 mA, I_{B1} = I_{B2} = −50 mA)	t_{off}	—	400	ns

(1) Pulse Width = 300 µs, Duty Cycle 1.0%.

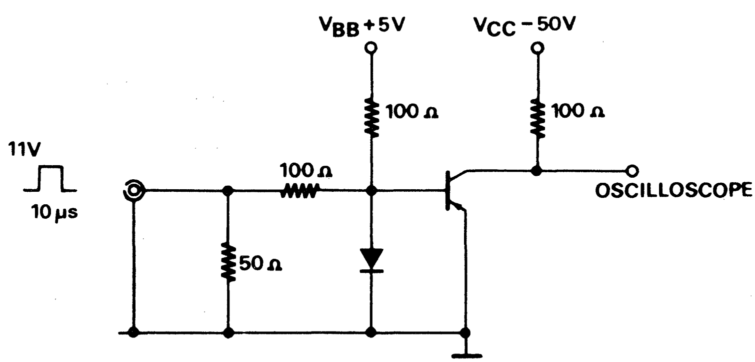
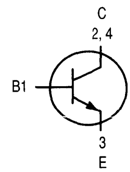
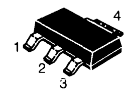


FIGURE 1: SWITCHING TIMES TEST CIRCUIT

PZT2222AT1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
NPN SILICON
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage (Open Collector)	V_{EBO}	6.0	Vdc
Collector Current	I_C	600	mAdc
Total Power Dissipation up to T_A = 25°C*	P_D	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

DEVICE MARKING

P1F

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Base-Emitter Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = – 3.0 Vdc)	I_{BEX}	—	20	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = – 3.0 Vdc)	I_{CEX}	—	10	nAdc
Emitter-Base Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc

*Device mounted on an epoxy printed circuit board 1.575 inches x 1.575 inches x 0.059 inches; mounting pad for the collector lead min. 0.93 inches^2.

ELECTRICAL CHARACTERISTICS — continued (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS (continued)				
Collector-Base Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = – 55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 35 50 70 35 100 50 40	 — — — — 300 — —	—
Collector-Emitter Saturation Voltages (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	 — —	 0.3 1.0	Vdc
Base-Emitter Saturation Voltages (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	 0.6 —	 1.2 2.0	Vdc
Input Impedance (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz) (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)	h_{ie}	 2.0 0.25	 8.0 1.25	kΩ
Voltage Feedback Ratio (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz) (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)	h_{re}	 — —	 8.0×10^{-4} 4.0×10^{-4}	—
Small-Signal Current Gain (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz) (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)	$\|h_{fe}\|$	 50 75	 300 375	—
Output Admittance (V_{CE} = 10 Vdc, I_C = 1.0 mAdc, f = 1.0 kHz) (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 1.0 kHz)	h_{oe}	 5.0 25	 25 200	μmhos
Noise Figure (V_{CE} = 10 Vdc, I_C = 100 μAdc, f = 1.0 kHz)	F	—	4.0	dB
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_c	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_e	—	25	pF

SWITCHING TIMES (T_A = 25°C)

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	**(V_{CC} = 30 Vdc, I_C = 150 mAdc, $I_{B(on)}$ = 15 mAdc, $V_{BE(off)}$ = –0.5 Vdc) Figure 1**	t_d	—	10	ns
Rise Time		t_r	—	25	
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, $I_{B(on)}$ = $I_{B(off)}$ = 15 mAdc) Figure 2	t_s	—	225	ns
Fall Time		t_f	—	60	

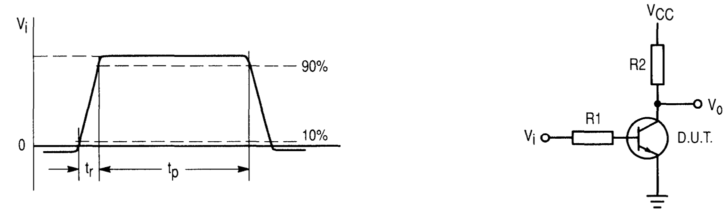


Figure 1. Input Waveform and Test Circuit for Determining Delay Time and Rise Time

V_i = – 0.5 V to +9.9 V, V_{CC} = +30 V, R1 = 619 Ω, R2 = 200 Ω.

PULSE GENERATOR:		OSCILLOSCOPE:	
PULSE DURATION	$t_p \le$ 200 ns	INPUT IMPEDANCE	Z_i > 100 kΩ
RISE TIME	$t_r \le$ 2 ns	INPUT CAPACITANCE	C_i < 12 pF
DUTY FACTOR	δ = 0.02	RISE TIME	t_r < 5 ns

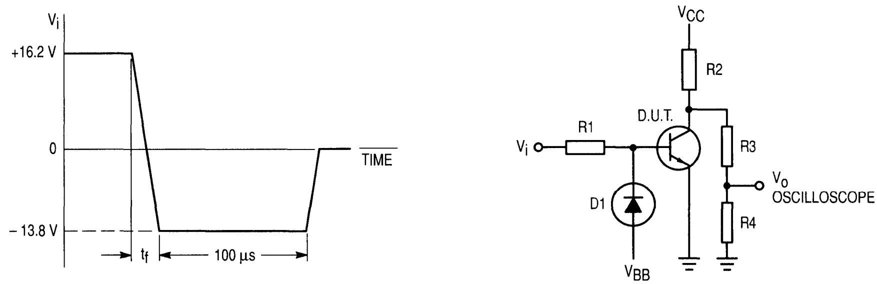
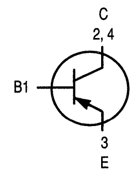
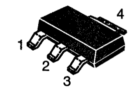


Figure 2. Input Waveform and Test Circuit for Determining Storage Time and Fall Time

PZT2907AT1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
PNP SILICON
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 60	Vdc
Collector-Base Voltage	V_{CBO}	– 60	Vdc
Emitter-Base Voltage	V_{EBO}	– 5.0	Vdc
Collector Current	I_C	– 600	mAdc
Total Power Dissipation, T_A = 25°C*	P_D	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient in Free Air*	$R_{\theta JA}$	83.3	°C/W

DEVICE MARKING

P2F

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	– 60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	– 60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	– 5.0	—	Vdc
Base-Emitter Cutoff Current (V_{BE} = – 30 Vdc, V_{EB} = – 0.5 Vdc)	I_{BEX}	—	– 50	nAdc
Collector-Emitter Cutoff Current (V_{CE} = – 30 Vdc, V_{EB} = – 0.5 Vdc)	I_{CEX}	—	– 50	nAdc
Collector-Base Cutoff Current (V_{CB} = – 50 Vdc, I_E = 0)	I_{CBO}	—	– 10	nAdc

*Device mounted on an epoxy printed circuit board 1.575 inches x 1.575 inches x 0.059 inches; mounting pad for the collector lead min. 0.93 $inches^2$.

ELECTRICAL CHARACTERISTICS — continued (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = – 0.1 mAdc, V_{CE} = – 10 Vdc)		75	—	
(I_C = – 1.0 mAdc, V_{CE} = – 10 Vdc)		100	—	
(I_C = – 10 mAdc, V_{CE} = – 10 Vdc)		100	—	
(I_C = – 150 mAdc, V_{CE} = – 10 Vdc)*		100	300	
(I_C = – 500 mAdc, V_{CE} = – 10 Vdc)*		50	—	
Collector-Emitter Saturation Voltages	$V_{CE(sat)}$			Vdc
(I_C = – 150 mAdc, I_B = – 15 mAdc)		—	– 0.4	
(I_C = – 500 mAdc, I_B = – 50 mAdc)		—	– 1.6	
Base-Emitter Saturation Voltages	$V_{BE(sat)}$			Vdc
(I_C = – 150 mAdc, I_B = – 15 mAdc)		—	– 1.3	
(I_C = – 500 mAdc, I_B = – 50 mAdc)		—	– 2.6	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = – 50 mAdc, V_{CE} = – 20 Vdc, T_A = 25°C, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance @ f = 1.0 MHz (V_{CB} = – 10 Vdc, I_E = 0)	C_c	—	8.0	pF
Input Capacitance @ f = 1.0 MHz (V_{EB} = – 2.0 Vdc, I_C = 0)	C_e	—	30	pF

SWITCHING TIMES (T_A = 25°C)

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	(V_{CC} = – 30 Vdc, I_C = – 150 mAdc, I_{B1} = – 15 mAdc) Figure 1	t_{on}	—	45	ns
Delay Time		t_d	—	10	
Rise Time		t_r	—	40	
Turn-Off Time	(V_{CC} = – 6.0 Vdc, I_C = – 150 mAdc, I_{B1} = I_{B2} = – 15 mAdc) Figure 2	t_{off}	—	100	ns
Storage Time		t_s	—	80	
Fall Time		t_f	—	30	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

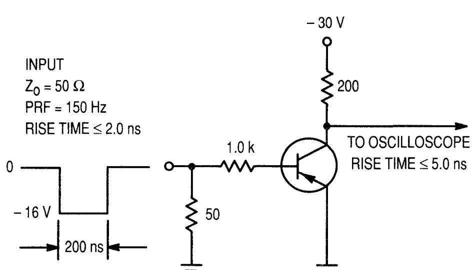


Figure 1. Delay and Rise Time Test Circuit

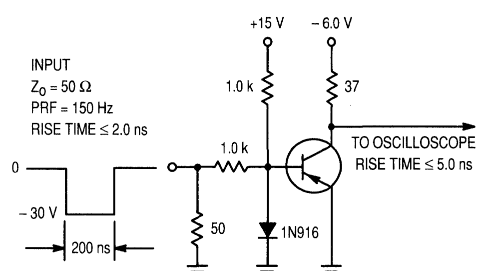
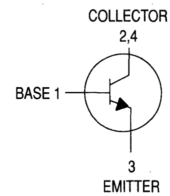
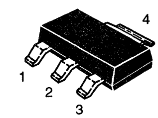


Figure 2. Storage and Fall Time Test Circuit

PZTA42T1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
NPN SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Open Base)	V_{CEO}	300	Vdc
Collector-Base Voltage (Open Emitter)	V_{CBO}	300	Vdc
Emitter-Base Voltage (Open Collector)	V_{EBO}	6.0	Vdc
Collector Current (DC)	I_C	500	mAdc
Total Power Dissipation up to $T_A = 25°C$*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

P1D

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

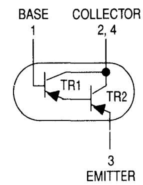
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector-Base Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)	I_{CBO}	—	0.1	μAdc
Emitter-Base Cutoff Current ($V_{BE} = 6.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)		25	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		40	—	
($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		40	—	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	50	—	MHz
Feedback Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{re}	—	3.0	pF
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc

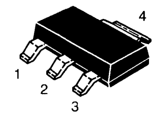
* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2

(1) Pulse Test Conditions, $t_p = 300$ μs, $\delta = 0.02$.

PZTA64T1★

CASE 318E-04, STYLE 1
(TO-261AA)





SOT-223 PACKAGE
PNP SILICON
TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	– 30	Vdc
Collector-Base Voltage	V_{CBO}	– 30	Vdc
Emitter-Base Voltage	V_{EBO}	– 10	Vdc
Total Power Dissipation up to T_A = 25°C*	P_D*	1.5	Watts
Collector Current	I_C	– 500	mAdc
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

P2V

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C/W

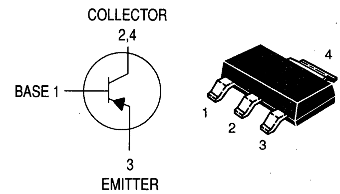
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = – 100 µAdc, V_{BE} = 0)	$V_{(BR)CES}$	– 30	—	Vdc
Collector-Base Breakdown Voltage (I_C = – 100 µA, I_E = 0)	$V_{(BR)CBO}$	– 30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = – 100 µA, I_C = 0)	$V_{(BR)EBO}$	– 10	—	Vdc
Emitter-Base Cutoff Current (V_{BE} = – 10 Vdc, I_C = 0)	I_{EBO}	—	– 0.1	µAdc
Collector-Base Cutoff Current (V_{CB} = – 30 Vdc, I_E = 0)	I_{CBO}	—	– 0.1	µAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = – 10 mAdc, V_{CE} = – 5.0 Vdc) (I_C = – 100 mAdc, V_{CE} = – 5.0 Vdc)	h_{FE}	 10,000 20,000	 — —	—
Collector-Emitter Saturation Voltage (I_C = – 100 mAdc, I_B = – 0.1 mAdc)	$V_{CE(sat)}$	—	– 1.5	Vdc
Base-Emitter On-Voltage (V_{CE} = – 5.0 Vdc, I_C = – 100 mAdc)	$V_{BE(on)}$	—	– 2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = – 10 mAdc, V_{CE} = – 5.0 Vdc, f = 100 MHz)	f_T	125	—	MHz

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

PZTA92T1★

CASE 318E-04, STYLE 1
(TO-261AA)



SOT-223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★**This is a Motorola designated preferred device.**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 300	Vdc
Collector-Base Voltage	V_{CBO}	– 300	Vdc
Emitter-Base Voltage	V_{EBO}	– 5.0	Vdc
Collector Current	I_C	– 500	mAdc
Total Power Dissipation up to T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

P2D

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{θJA}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

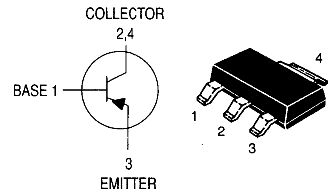
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = – 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	– 300	—	Vdc
Collector-Base Breakdown Voltage (I_C = – 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	– 300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = – 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	– 5.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = – 200 Vdc, I_E = 0)	I_{CBO}	—	– 0.25	μAdc
Emitter-Base Cutoff Current (V_{BE} = – 3.0 Vdc, I_C = 0)	I_{EBO}	—	– 0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (1)	h_{FE}			—
(I_C = – 1.0 mAdc, V_{CE} = – 10 Vdc)		25	—	
(I_C = – 10 mAdc, V_{CE} = – 10 Vdc)		40	—	
(I_C = – 30 mAdc, V_{CE} = – 10 Vdc)		25	—	
Saturation Voltages				Vdc
(I_C = – 20 mAdc, I_B = – 2.0 mAdc)	$V_{CE(sat)}$	—	– 0.5	
(I_C = – 20 mAdc, I_B = – 2.0 mAdc)	$V_{BE(sat)}$	—	– 0.9	
DYNAMIC CHARACTERISTICS				
Collector-Base Capacitance @ f = 1.0 MHz (V_{CB} = – 20 Vdc, I_E = 0)	C_{cb}	—	6.0	pF
Current-Gain — Bandwidth Product (I_C = – 10 mAdc, V_{CE} = – 20 Vdc, f = 100 MHz)	f_T	50	—	MHz

* Device mounted on a glass epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

(1) Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle = 2.0%.

PZTA96T1★

CASE 318E-04, STYLE 1
(TO-261AA)



SOT-223 PACKAGE
PNP SILICON
HIGH VOLTAGE TRANSISTOR
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	– 450	Vdc
Collector-Base Voltage	V_{CBO}	– 450	Vdc
Emitter-Base Voltage	V_{EBO}	– 5.0	Vdc
Collector Current	I_C	– 500	mAdc
Total Power Dissipation up to T_A = 25°C*	P_D*	1.5	Watts
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	150	°C

DEVICE MARKING

ZTA96

THERMAL CHARACTERISTICS

Thermal Resistance from Junction to Ambient*	$R_{\theta JA}$	83.3	°C

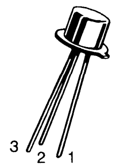
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	– 450	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = –100 µAdc, I_E = 0)	$V_{(BR)CBO}$	– 450	—	Vdc
Emitter-Base Breakdown Voltage (I_E = –10 µAdc, I_C = 0)	$V_{(BR)EBO}$	– 5.0	—	Vdc
Collector-Base Cutoff Current (V_{CB} = –400 Vdc, I_E = 0)	I_{CBO}	—	– 0.1	µAdc
Emitter-Base Cutoff Current (V_{BE} = –4.0 Vdc, I_C = 0)	I_{EBO}	—	– 0.1	µAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = –10 mAdc, V_{CE} = –10 Vdc)	h_{FE}	50	150	—
Saturation Voltages (I_C = –20 mAdc, I_B = –2.0 mAdc) (I_C = –20 mAdc, I_B = –2.0 mAdc)	 $V_{CE(sat)}$ $V_{BE(sat)}$	 — —	 – 0.6 – 1.0	Vdc

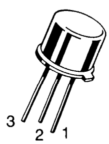
* Device mounted on an epoxy printed circuit board 1.575 in. x 1.575 in. x 0.059 in.; mounting pad for the collector lead min. 0.93 in^2.

(1) Pulse Test: Pulse Width ≤ 300 µs; Duty Cycle = 2.0%.

2



CASE 22-03
(TO-206AA)
TO-18



CASE 79-04
(TO-205AD)
TO-39

Motorola's metal-can transistor product offering includes: general purpose, switching, high voltage, choppers, Darlingtons, and low noise amplifiers.

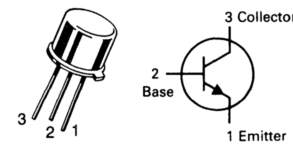
Metal-Can Transistors

3

3

2N697

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N2218A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	290	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	88	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} = 10 ohms)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 1.0 100	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{obo}	—	35	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	2.5	—	MHz

(1) Pulse Test: Pulse Length ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

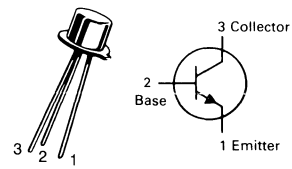
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage(1)	V_{CER}	20	Volts
Collector-Base Voltage	V_{CBO}	25	Volts
Emitter-Base Voltage	V_{EBO}	5.0	Volts
Collector Current	I_C	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.7	Watts mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	0.5	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

2N706A

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2369 for graphs.

3

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage(2) (R = 10 ohms, I_C = 10 mAdc)	$V_{(BR)CER}$	20	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	 — — —	 0.5 30 10	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, R_{BE} = 100k)	I_{CER}	—	10	μAdc
Emitter Cuttoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (2) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	60	—
Collector-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1 MHz)	C_{obo}	—	5.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter (V_{CE} = 10 Vdc, I_E = 10 mAdc, f = 100 MHz)	$\|h_{fe}\|$	2.0	—	—

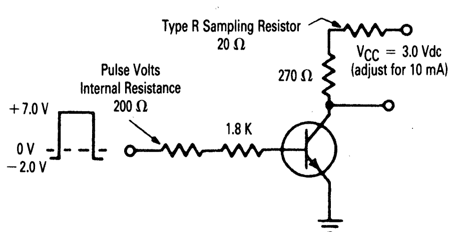
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector Base Time Constant (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 300 MHz)	r_b	—	50	ohms
Turn-On Time (I_{B1} = 3.0 mA, I_{B2} = 1.0 mA)	t_{on}	—	40	ns
Turn-Off Time (I_{B1} = 3.0 mA, I_{B2} = 1.0 mA)	t_{off}	—	75	ns
Charge Storage Time Constant(2)	τ_s	—	25	ns

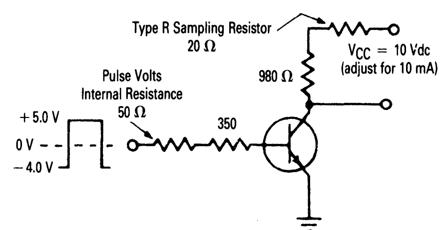
(1) Refers to collector breakdown voltage in the high current region when R_{be} = 10 Ω.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) Switching Times Measured with Tektronix Type R Plug-In (50 Ω Internal Impedance).

3

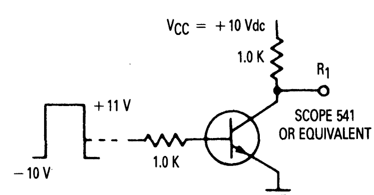
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT

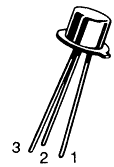


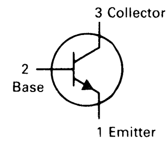
MEASUREMENT CIRCUIT



2N718A
2N956

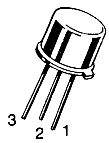
CASE 22-03, STYLE 1
TO-18 (TO-206AA)





2N1711

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1711	Unit
Collector-Emitter Voltage	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CBO}	75		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	800 4.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N718A 2N956	2N1711	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	58	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	219	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_{BE} \leq$ 10 ohms)(1)		$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 — —	 0.001 —	 0.01 10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	 2N718A, 2N956, 2N1711	I_{EBO}	 — —	 — —	 0.010 0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 10 Vdc)	 2N956, 2N1711	h_{FE}	 20	 —	 —	—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		20 35	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		35 75	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N718A, 2N956, 2N1711		20 35	— —	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N718A, 2N956, 2N1711		40 100	— —	120 300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N718A, 2N956, 2N1711		20 40	— —	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.24	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.0	1.3	Vdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

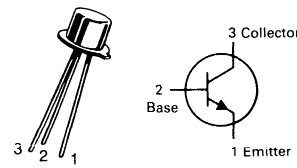
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N718A,		60	300	—	
	2N956, 2N1711		70	300		
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{obo}	—	4.0	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ibo}	—	20	80	pF
Input Impedance		h_{ib}				ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)			24	—	34	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			4.0	—	8.0	
Voltage Feedback Ratio		h_{rb}				$X10^{-4}$
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N718A,		—	—	3.0	
	2N956, 2N1711		—	—	5.0	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N718A,		—	—	3.0	
	2N956, 2N1711		—	—	5.0	
Small-Signal Current Gain		h_{fe}				—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N718A,		30	—	100	
	2N956, 2N1711		50	—	200	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A,		35	—	150	
	2N956, 2N1711		70	—	300	
Output Admittance		h_{ob}				μmhos
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)			0.05	—	0.5	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			0.05	—	0.5	
Noise Figure		NF				dB
(I_C = 300 μAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A,		—	—	12	
	2N956, 2N1711		—	—	8.0	

3

2N720A★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

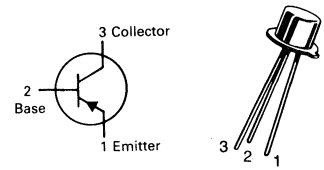
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} ≤ 10 ohms)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	.010 15	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	.010	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1 MHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.50	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30 45	100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

2N869A

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−18	Vdc
Collector-Emitter Voltage	V_{CES}	−25	Vdc
Collector-Base Voltage	V_{CBO}	−25	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.2 0.686 6.86	Watts Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −10μAdc,V_{BE} = 0)	$V_{(BR)CES}$	−25	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{CEO(sus)}$	−18	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	—	−25	μAdc
Collector Cutoff Current (V_{CE} = −15 Vdc, V_{BE} = 0)	I_{CES}	—	−10	nAdc
Base Current (V_{CE} = −15 Vdc, V_{BE} = 0)	I_B	—	−10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = −10 mAdc, V_{CE} = −0.3 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc) (I_C = −30 mAdc, V_{CE} = −0.5 Vdc) (I_C = −30 mAdc, V_{CE} = −0.5 Vdc, T_A = −55°C) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc)	h_{FE}	 30 40 40 17 25	 — 120 120 — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −30 mAdc, I_B = −3.0 mAdc) (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{CE(sat)}$	 — — —	 −0.15 −0.2 −0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −30 mAdc, I_B = −3.0 mAdc) (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{BE(sat)}$	 −0.78 −0.85 —	 −0.98 −1.2 −1.7	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = −10 mAdc, V_{CE} = −15 Vdc, f = 100 MHz)		f_T	400	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ibo}	—	6.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	I_C = −30 mAdc, V_{CC} = −2.0 Vdc, I_{B1} = −1.5 mAdc	t_{on}	—	50	ns
Delay Time		t_d	—	35	ns
Rise Time		t_r	—	20	ns
Turn-Off Time	I_C = −30 mAdc, V_{CC} = −20 Vdc, I_{B1} = I_{B2} = −1.5 mAdc	t_{off}	—	80	ns
Storage Time		t_s	—	65	ns
Fall Time		t_f	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%
(2) f_T is defined as the frequency at which $|h_{FE}|$ extrapolates unity.

3

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 — CAPACITANCE

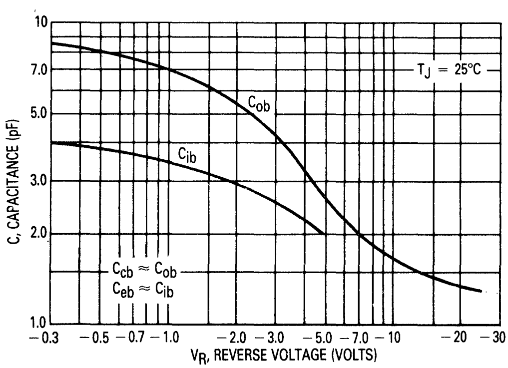


FIGURE 2 — DC CURRENT GAIN

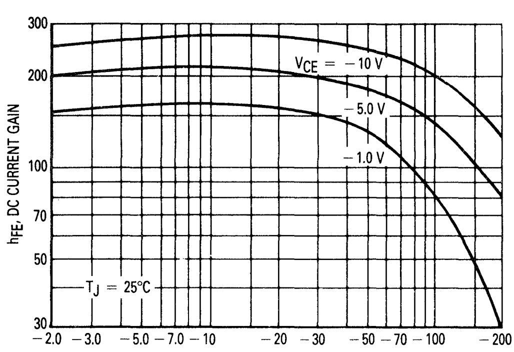


FIGURE 3 — "ON" VOLTAGES

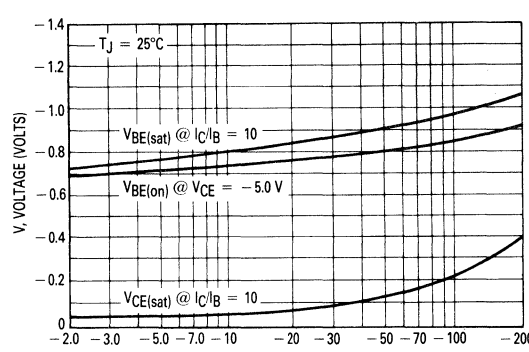


FIGURE 4 — CURRENT-GAIN — BANDWIDTH PRODUCT

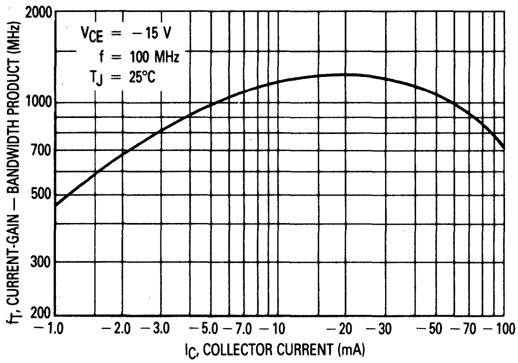


FIGURE 5 — TURN-ON TIME

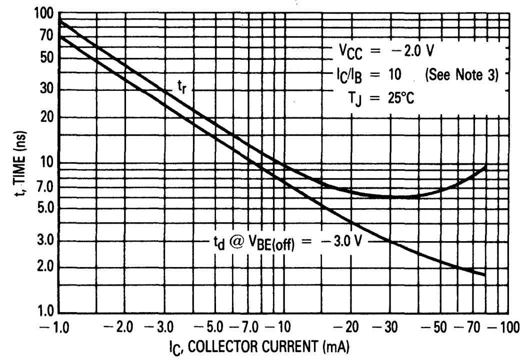


FIGURE 6 — TURN-OFF TIME

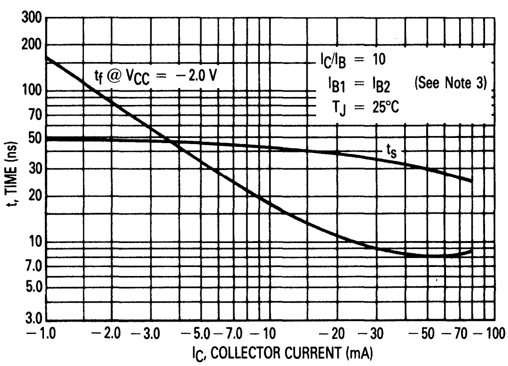


FIGURE 7 — SWITCHING TIME TEST CIRCUIT

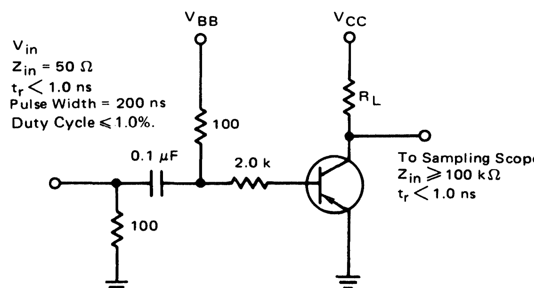


FIGURE 8 — SWITCHING TEST CIRCUIT VALUES

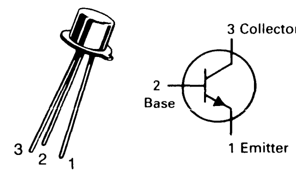
		V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R_L Ohms	I_C mA	I_{B1}(4) mA	I_{B2}(4) mA
t_{on}, t_r, t_d	2N869A	−7.0	−3.0	−2.0	62	−30	−1.5	—
t_{off}, t_s, t_f	2N869A	+6.0	−4.0	−2.0	62	−30	−1.5	−1.5

(3) I_C/I_B = 10. Switching is shown to reflect current industry practices. Compare the values shown in Figures 1 and 2 @ I_C = −30 mA to the typical values in the Electrical Characteristics table @ I_C/I_B = 20.

(4) I_{B1} = I_{B2} = − 3.0 mA @ I_C/I_B = 10

2N930, A

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTORS

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	2N930	2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	45	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current	I_C	30		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.33		W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9		Watt mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +175		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N930 2N930A	$V_{(BR)CBO}$	45 60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 2N930 2N930A	$V_{(BR)EBO}$	 5.0 6.0	— —	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	—	2.0	nAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	 2N930 2N930A	I_{CBO}	 — —	 10 2.0	nAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, V_{BE} = 0) (V_{CE} = 45 Vdc, V_{BE} = 0, T_A = 170°C)	 2N930 2N930A 2N930 2N930A	I_{CES}	 — — — —	 10 2.0 10 2.0	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	 2N930 2N930A	I_{EBO}	 — —	 10 2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	 2N930A	h_{FE}	60	—	—
(I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)			100	300	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	2N930 2N930A		20 30	— —	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N930 2N930A		150 —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(1)	2N930 2N930A		— —	600 600	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N930 2N930A	$V_{CE(sat)}$	— —	1.0 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N930 2N930A	$V_{BE(sat)}$	0.6 0.7	1.0 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	2N930 2N930A	f_T	30 45	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N930 2N930A	C_{obo}	— —	8.0 6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	—	600	X 10^{-6}
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	150	600	—
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)		NF	—	3.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

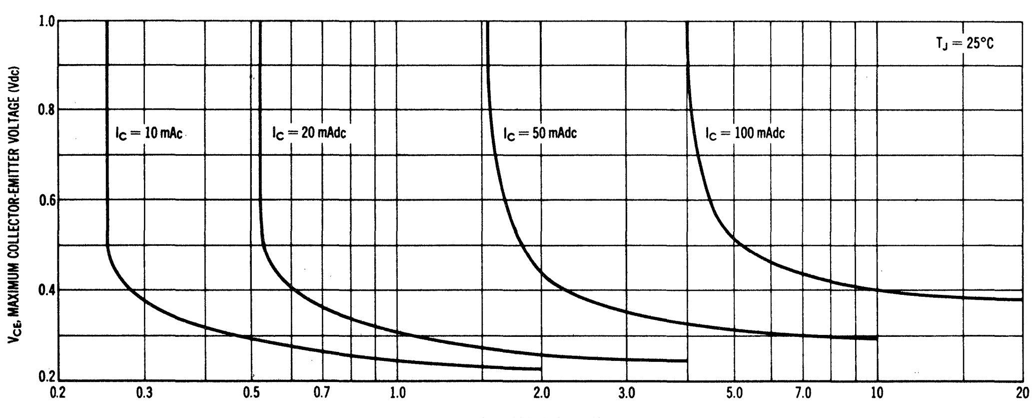


FIGURE 2 — MINIMUM CURRENT GAIN CHARACTERISTICS

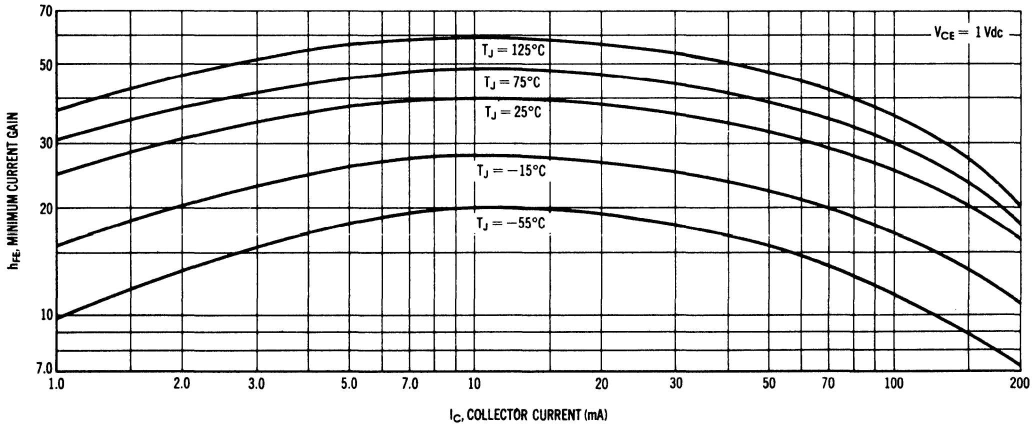


FIGURE 3 — LIMITS OF SATURATION VOLTAGES

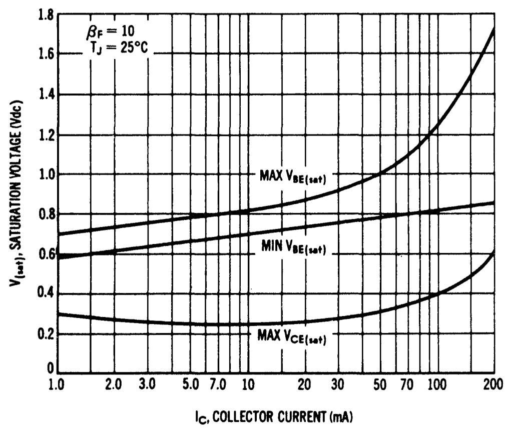
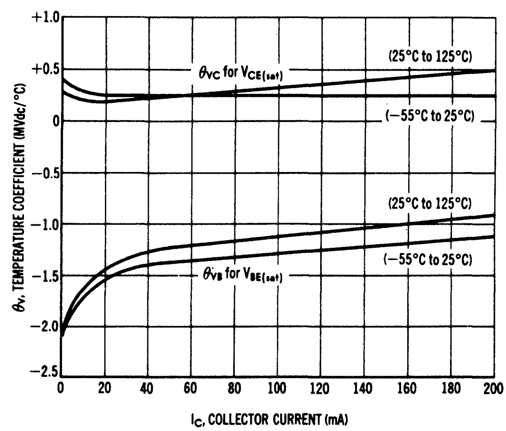


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS



TYPICAL SWITCHING CHARACTERISTICS

FIGURE 5 — TURN-ON TIME VARIATIONS WITH VOLTAGE

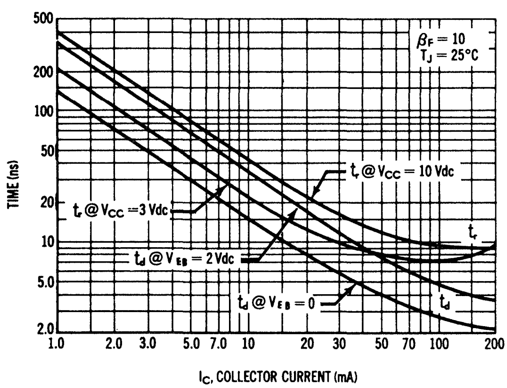


FIGURE 6 — RISE TIME BEHAVIOR

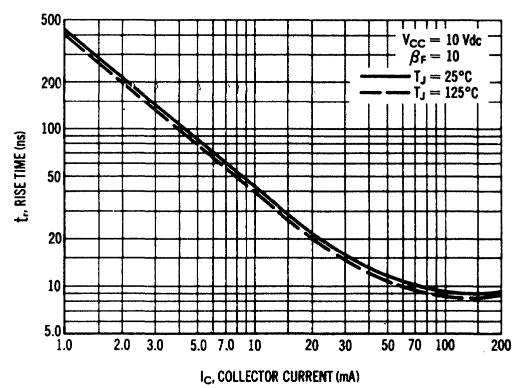


FIGURE 7 — STORAGE TIME BEHAVIOR

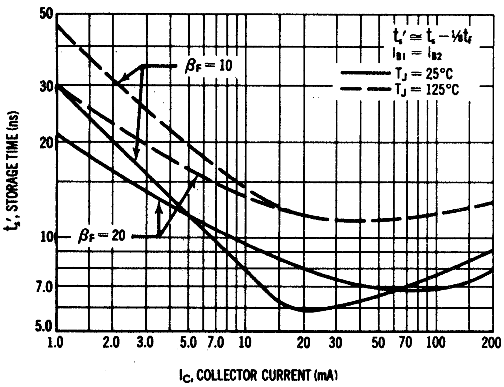


FIGURE 8 — FALL TIME BEHAVIOR

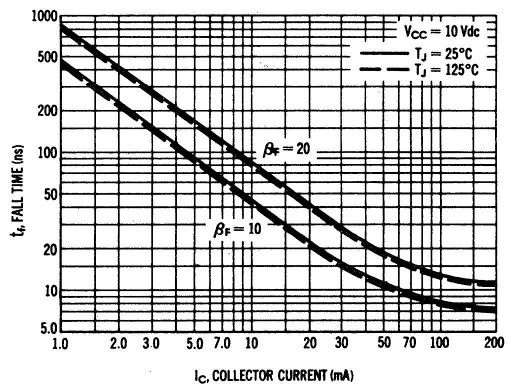


FIGURE 9 — JUNCTION CAPACITANCE VARIATIONS

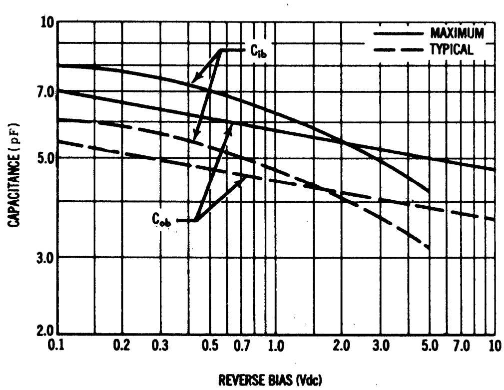
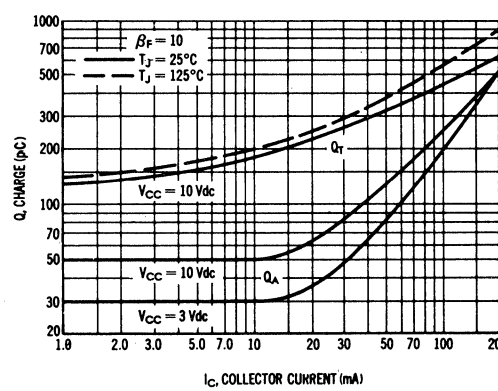
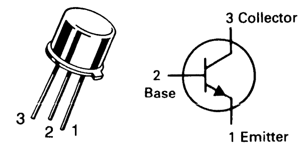


FIGURE 10 — MAXIMUM CHARGE DATA



2N1613

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} \leq 10$ Ohms)	V_{CER}	50	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, $R_{BE} \leq 10$ Ohms)	$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	20 35 20 40 20	35 50 — 80 30	— — — 120 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(1)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(1)	$V_{BE(sat)}$	—	0.78	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	10	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	50	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	— —	3.0 3.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30 35	— —	100 150	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 Ohms, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	—	—	12	dB
SWITCHING CHARACTERISTICS					
Switching Time	$t_d+t_r+t_f$	—	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N1711 For Specifications, See 2N718A Data.

MAXIMUM RATINGS

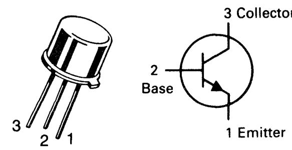
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	°C/W

2N1893

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR
NPN SILICON

Refer to 2N3019 for graphs.

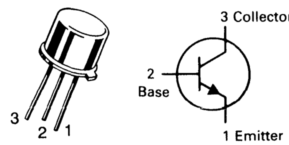
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, R_{BE} = 10 ohms)(1)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)(1)	$V_{CEO(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.01 15	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.5	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30 45	100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmho

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2102

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10$ Ohms	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

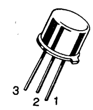
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

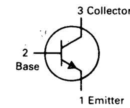
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $R_{BE} \leq 10$ ohms)(2)	$V_{CER(sus)}$	80	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 100$ mAdc, $I_B = 0$)(2)	$V_{CEO(sus)}$	65	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{EB} = 1.5$ Vdc)	$V_{(BR)CEX}$	120	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	120	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	2.0 2.0	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)(2) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$)(2) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(2) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(2) ($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc)(2)	h_{FE}	20 35 20 40 25 10	— — — — — —	— — — 120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)(2)	$V_{CE(sat)}$	—	0.15	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)(2)	$V_{BE(sat)}$	—	0.88	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	15	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	50	80	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{rb}	— —	— —	3.0 3.0	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30 35	— —	100 150	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ob}	0.01 0.01	— —	0.5 1.0	μmho
Noise Figure ($I_C = 300$ μAdc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ k Ohm, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	—	4.0	6.0	dB
SWITCHING CHARACTERISTICS					
Switching Time	$t_d + t_r + t_f$	—	—	30	ns

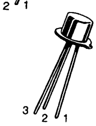
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board. (2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2218A,2N2219,A★ 2N2222,A★

2N2218, A/2N2219,A
CASE 79-04
TO-39 (TO-205AD)
STYLE 1







A/2N2222,A
CASE 22-03
TO-18 (TO-206AA)
STYLE 1

GENERAL PURPOSE TRANSISTORS

NPN SILICON

★2N2219A and 2N2222A are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	2N2219 2N2222	2N2218A 2N2219A 2N2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	mAdc
		2N2218A 2N2219,A	2N2222,A	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	0.4 2.28	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.1	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N2218A 2N2219,A	2N2222,A	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	145.8	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	437.5	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	 Non-A Suffix A-Suffix	$V_{(BR)CEO}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 Non-A Suffix A-Suffix	$V_{(BR)CBO}$	 60 75	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 Non-A Suffix A-Suffix	$V_{(BR)EBO}$	 5.0 6.0	 — —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	 A-Suffix	I_{CEX}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	 Non-A Suffix A-Suffix Non-A Suffix A-Suffix	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	 A-Suffix	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	 A-Suffix	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	 2N2218A 2N2219,A, 2N2222,A	h_{FE}	 20 35	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218A 2N2219,A, 2N2222,A		25 50	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N2218A 2N2219,A, 2N2222,A		35 75	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)(1)	2N2218A 2N2219,A, 2N2222,A		15 35	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2218A 2N2219,A, 2N2222,A		40 100	120 300	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218A		20	—	
	2N2219,A, 2N2222,A		50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2219, 2N2222		30	—	
	2N2218A		25	—	
	2N2219A, 2N2222A		40	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		—	0.4	
	A-Suffix		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		—	1.6	
	A-Suffix		—	1.0	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		0.6	1.3	
	A-Suffix		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		—	2.6	
	A-Suffix		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except		250	—	
	2N2219A, 2N2222A		300	—	
Output Capacitance(3) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance(3)		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	Non-A Suffix		—	30	
	A-Suffix		—	25	
Input Impedance		h_{ie}			kohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		1.0	3.5	
	2N2219A, 2N2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		0.2	1.0	
	2N2219A, 2N2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			$X\ 10^{-4}$
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		—	5.0	
	2N2219A, 2N2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		—	2.5	
	2N2219A, 2N2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		30	150	
	2N2219A, 2N2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		50	300	
	2N2219A, 2N2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		3.0	15	
	2N2219A, 2N2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		10	100	
	2N2219A, 2N2222A		15	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20Vdc, f = 31.8 MHz)	A-Suffix	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)	2N2222A	NF	—	4.0	dB
Real Part of Common-Emitter High Frequency Input Impedance (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 300 MHz)	2N2218A, 2N2219A 2N2222A	$Re(h_{ie})$	—	60	Ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) 2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

3

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 12)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 13)	t_s	—	225	ns
Fall Time		t_f	—	60	ns
Active Region Time Constant (I_C = 150 mAdc, V_{CE} = 30 Vdc) (See Figure 11 for 2N2218A, 2N2219A, 2N2221A, 2N2222A)		T_A	—	2.5	ns

3

FIGURE 1 — NORMALIZED DC CURRENT GAIN

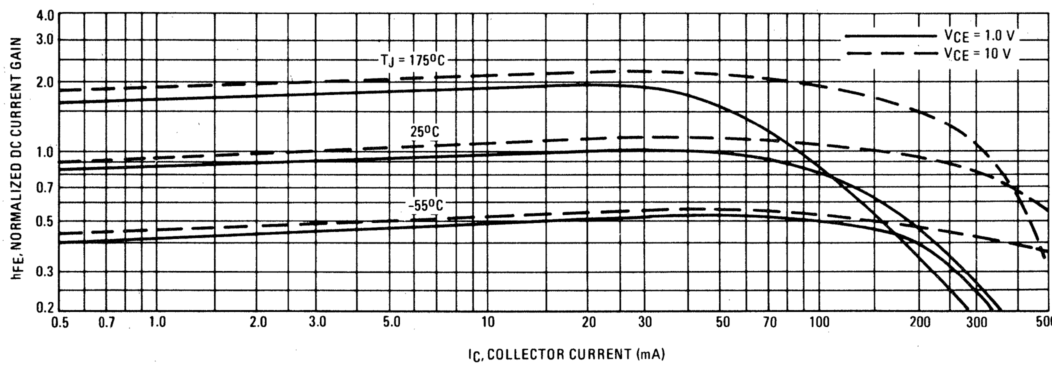
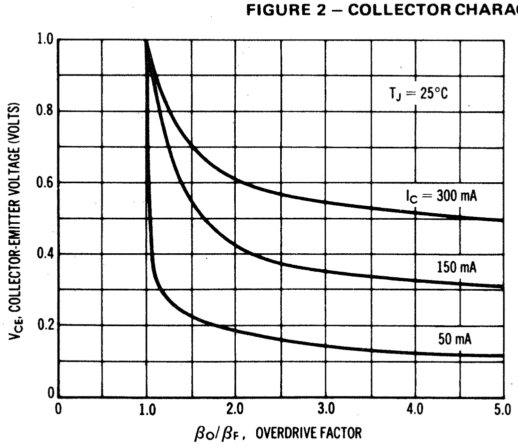


FIGURE 2 — COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, β_o = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_F} = \frac{h_{FE} @ 1.0\,V}{I_C/I_{BF}} \qquad 2.5 = \frac{62}{150/I_{BF}} \qquad I_{BF} \approx 6.0 \text{ mA}$$

FIGURE 3 — "ON" VOLTAGES

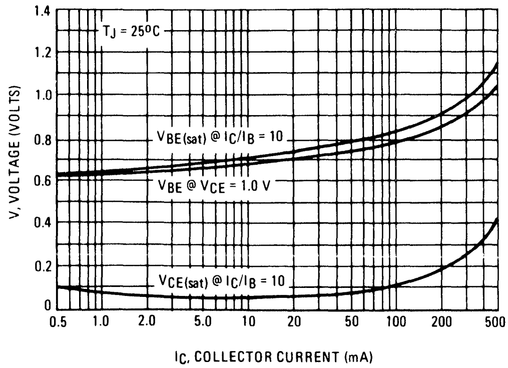
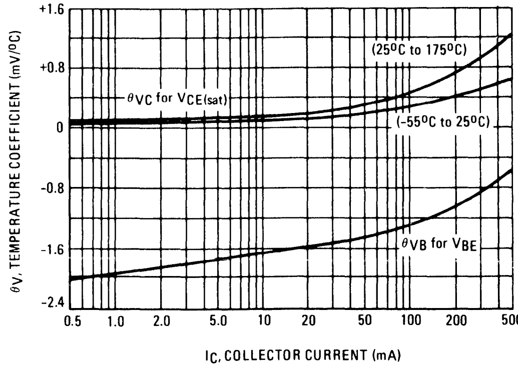


FIGURE 4 — TEMPERATURE COEFFICIENTS



h PARAMETERS

$V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25^oC$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 5 — INPUT IMPEDANCE

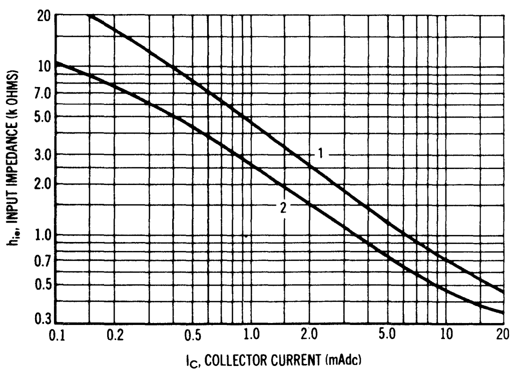


FIGURE 6 — VOLTAGE FEEDBACK RATIO

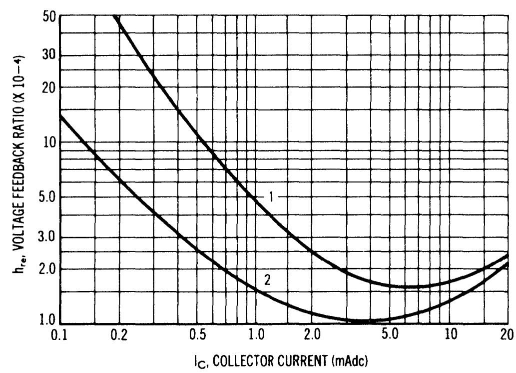


FIGURE 7 — CURRENT GAIN

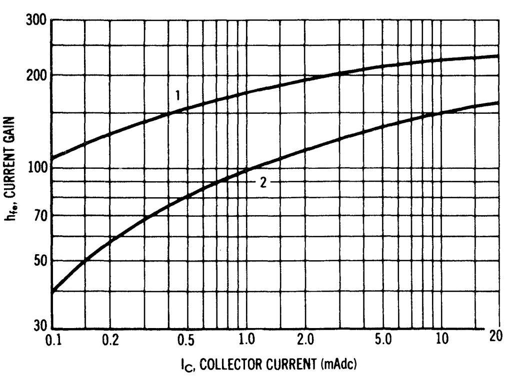
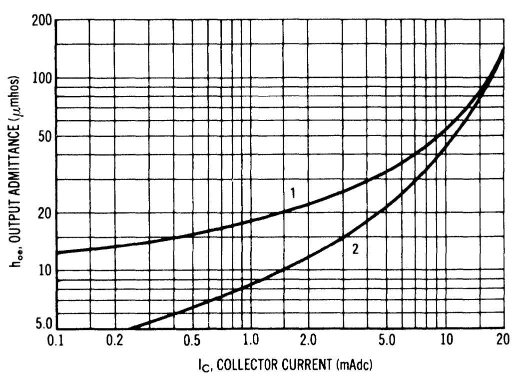


FIGURE 8 — OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 9 — TURN-ON TIME

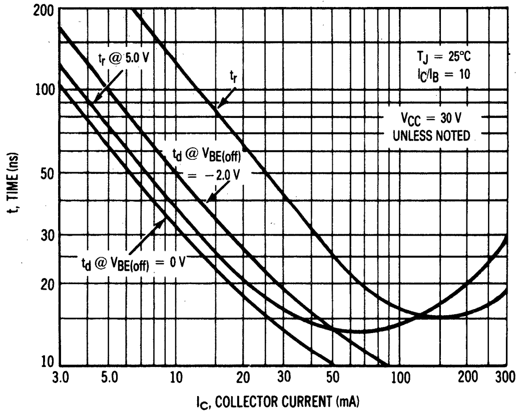


FIGURE 10 — CHARGE DATA

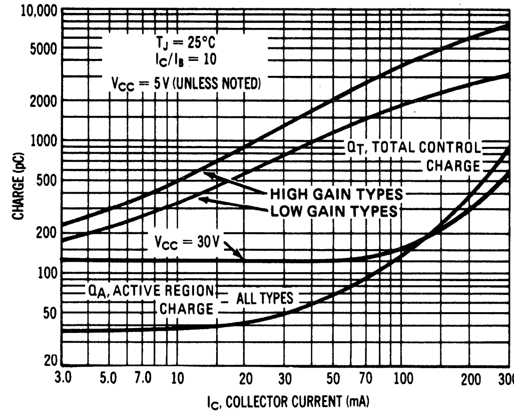


FIGURE 11 — TURN-OFF BEHAVIOR

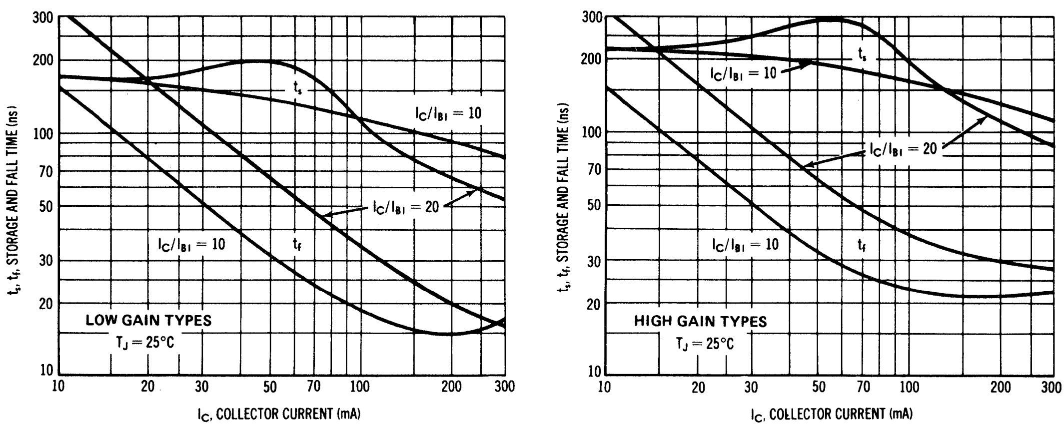


FIGURE 12 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

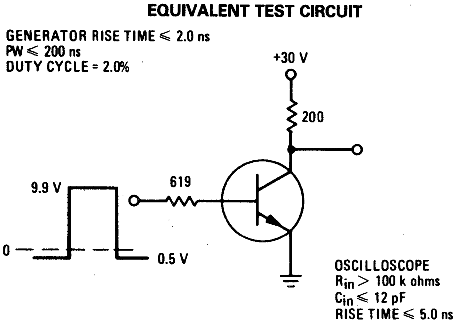
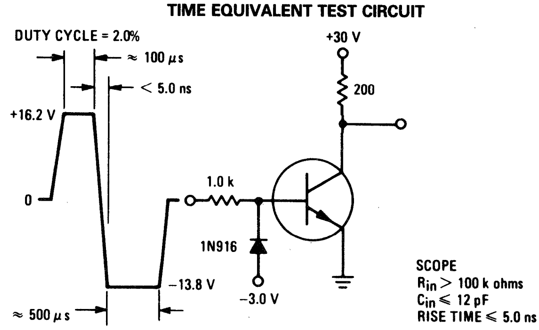
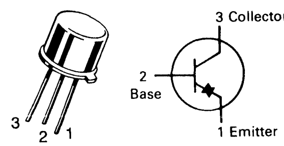


FIGURE 13 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



2N2270

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10$ Ohms	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

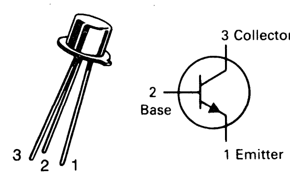
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 100$ mAdc, $R_{BE} \leq 10$ Ohms)	$V_{(BR)CER}$	60	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 100$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.05$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_C = 25°C$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_C = 150°C$)	I_{CBO}	— —	— —	0.05 100	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(2)	h_{FE}	 30 50	 90 135	 — 200	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)(2)	$V_{CE(sat)}$	—	0.15	0.9	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)(2)	$V_{BE(sat)}$	—	0.88	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	100	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	10	15	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	60	80	pF
Small-Signal Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	50	—	275	—
Noise Figure ($I_C = 0.3$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ k Ohm, f = 1.0 kHz, B.W. = 1.0 Hz)	NF	—	7.0	10	dB
SWITCHING CHARACTERISTICS					
Total Switching Time	$t_{on} + t_{off}$	—	—	30	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

2N2369,A★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTORS

NPN SILICON

★2N2369A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current (10 μs pulse)	$I_{C(Peak)}$	500	mA
Collector Current — Continuous	I_C	200	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	.68 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	147	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 μA, V_{BE} = 0)		$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_B = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	 2N2369 2N2369A	I_{CBO}	 — —	 0.4 30	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_{CES}	—	0.4	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_B	—	0.4	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = −55°C) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	 2N2369 2N2369A 2N2369 2N2369A 2N2369A	h_{FE}	 40 — 20 20 30	 120 120 — — —	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N2369A		20	—	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	2N2369		20	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N2369		—	0.25	
	2N2369A		—	0.20	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)	2N2369A		—	0.30	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N2369A		—	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A		—	0.50	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		0.70	0.85	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)	2N2369A		0.59	—	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = −55°C)	2N2369A		—	1.02	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N2369A		—	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A		—	1.60	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	500	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Storage Time (I_C = I_{B1} = 10 mAdc, I_{B2} = −10 mAdc)		t_s	—	13	ns
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)		t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)		t_{off}	—	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS FOR 2N2369, 2N3227

FIGURE 1 — t_{on} CIRCUIT — 10 mA

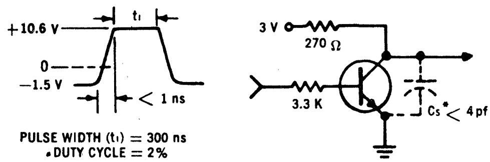


FIGURE 3 — t_{off} CIRCUIT — 10 mA

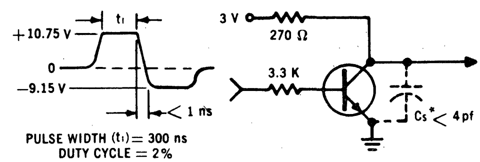


FIGURE 2 — t_{on} CIRCUIT — 100 mA

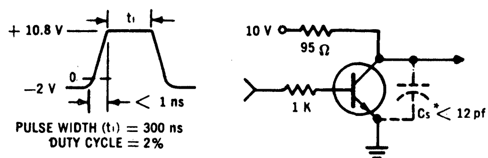
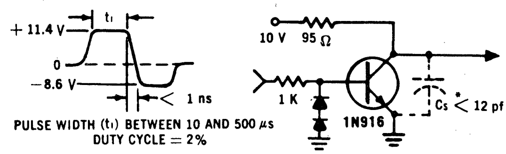


FIGURE 4 — t_{off} CIRCUIT — 100 mA



* Total shunt capacitance of test jig and connectors.

FIGURE 5 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

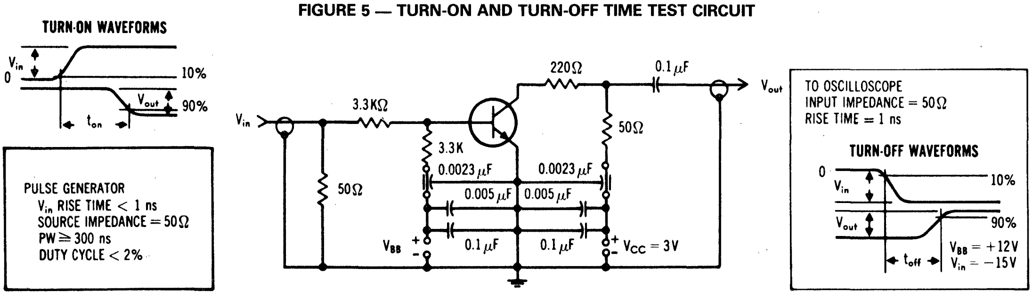


FIGURE 6 — JUNCTION CAPACITANCE VARIATIONS

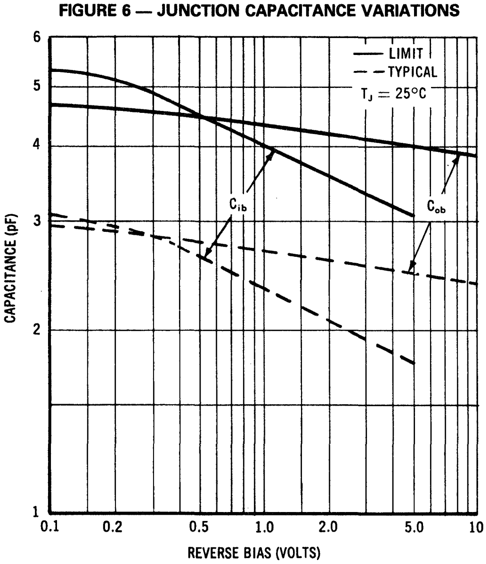


FIGURE 7 — TYPICAL SWITCHING TIMES

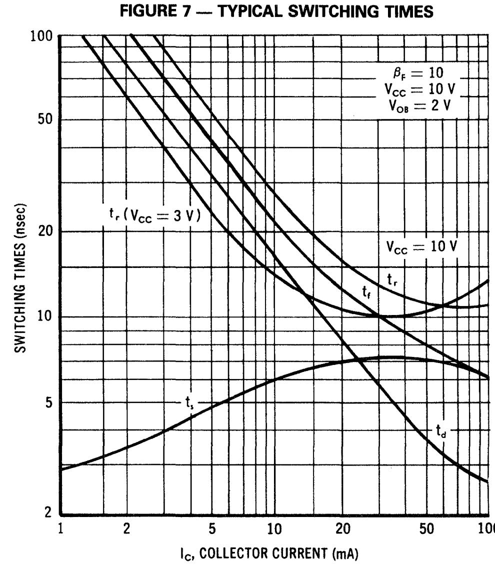


FIGURE 8 — MAXIMUM CHARGE DATA

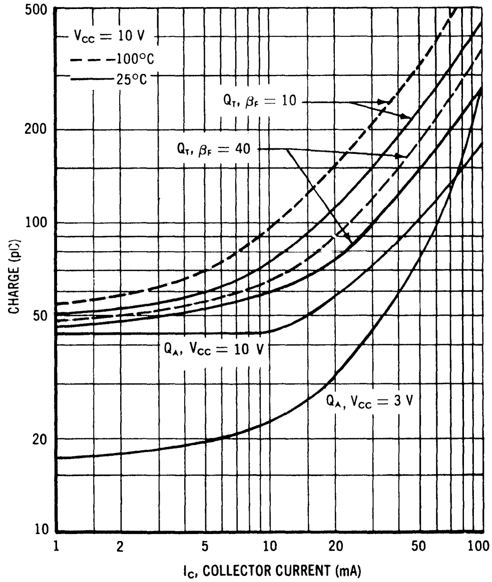


FIGURE 9 — Q_T TEST CIRCUIT

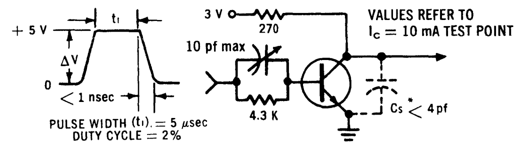


FIGURE 10 — TURN-OFF WAVE FORM

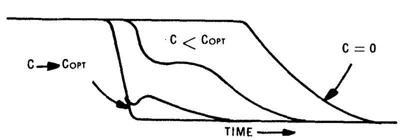


FIGURE 11 — STORAGE TIME EQUIVALENT TEST CIRCUIT

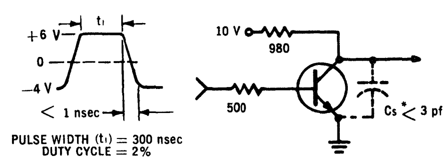


FIGURE 12 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

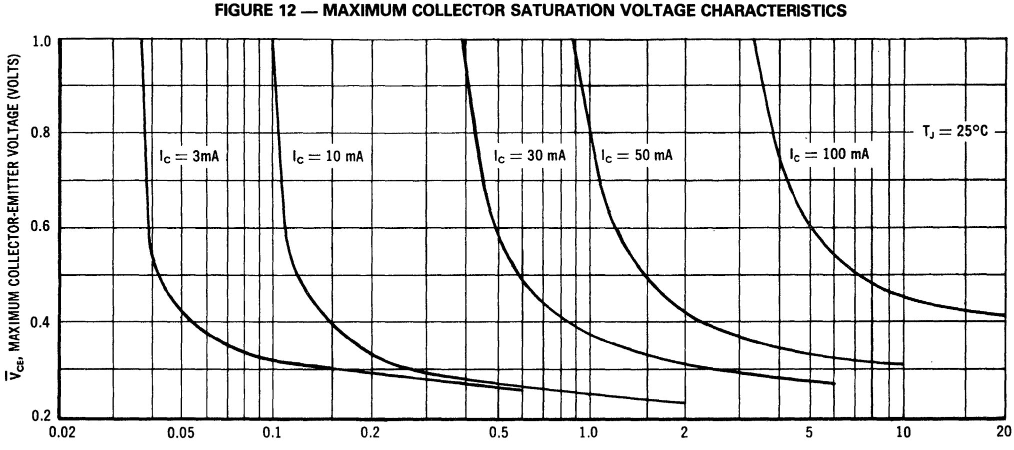


FIGURE 13 — MINIMUM CURRENT GAIN CHARACTERISTICS

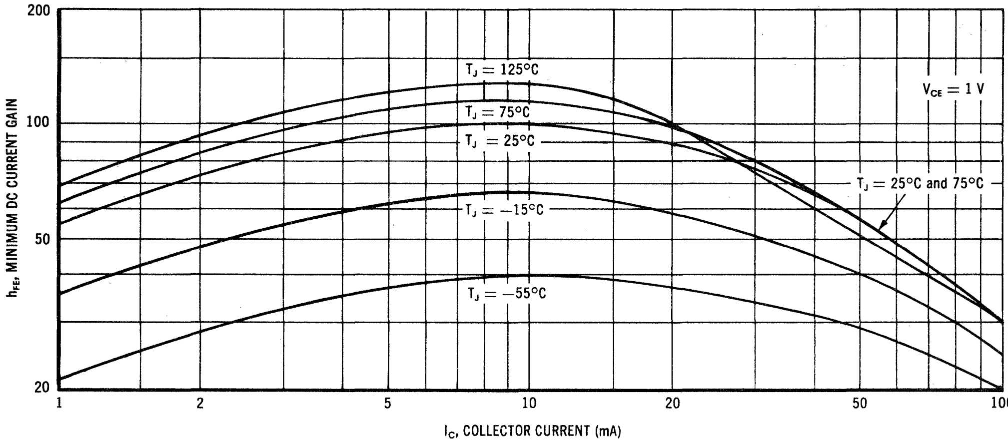


FIGURE 14 — SATURATION VOLTAGE LIMITS

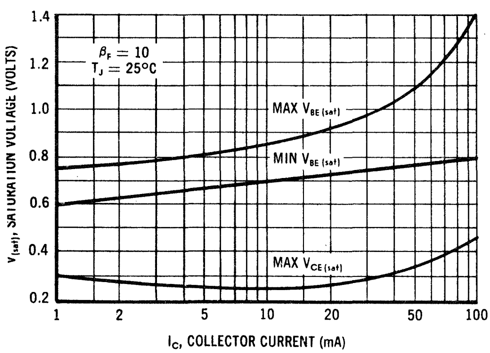
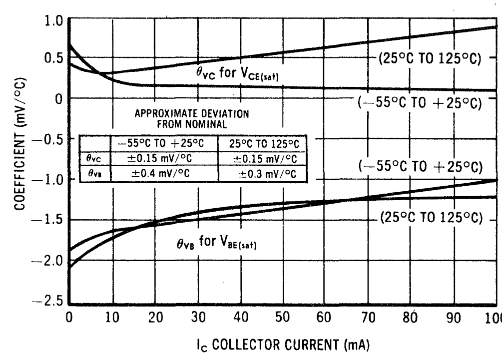
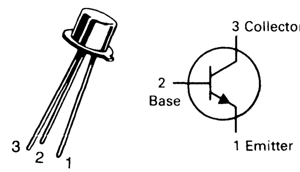


FIGURE 15 — TYPICAL TEMPERATURE COEFFICIENTS



2N2484★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	485	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

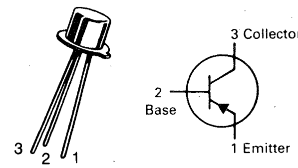
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 500 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)	h_{FE}	30 100 20 175 200 250 —	190 250 40 275 300 350 400	— 500 — — — — 800	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter On Voltage (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.5	0.65	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 0.05 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz) (I_C = 0.5 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	15 60	50 100	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.0	6.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	3.5	—	24	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	—	—	800	x 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = kHz)	h_{fe}	150	—	900	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	—	—	40	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ f = 100 Hz, BW = 20 Hz) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ f = 1.0 kHz, BW = 200 Hz) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ f = 10 kHz, BW = 2.0 kHz) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ f = 1.0 kHz)	NF	— — — —	8.0 — — —	10 3.0 2.0 3.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2894

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N869A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	−12	Vdc
Collector-Base Voltage	V_{CEO}	−12	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1200 6.85	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Emitter Sustaining Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{CEO(sus)}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_B = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −6.0 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	—	−10	μAdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0)	I_{CES}	—	−80	nAdc
Base Current (V_{CE} = −6.0 Vdc, V_{BE} = 0)	I_B	—	−80	nAdc
ON CHARACTERISTICS				
DC Current Gain(2) (I_C = −10 mAdc, V_{CE} = −0.3 Vdc) (I_C = −30 mAdc, V_{CE} = −0.5 Vdc) (I_C = −30 mAdc, V_{CE} = −0.5 Vdc, T_A = −55°C) (I_C = −100 mAdc, V_{CE} = −1.0 Vdc)(2)	h_{FE}	 30 40 17 25	 — 150 — —	—
Collector-Emitter Saturation Voltage(2) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −30 mAdc, I_B = −3.0 mAdc) (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{CE(sat)}$	 — — —	 −0.15 −0.2 −0.5	Vdc
Base-Emitter Saturation Voltage(2) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −30 mAdc, I_B = −3.0 mAdc (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{BE(sat)}$	 −0.78 −0.85 —	 −0.98 −1.2 −1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −30 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = −2.0 Vdc, V_{EB} = −3.0 Vdc, I_{B1} = −1.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time (V_{CC} = −2.0 Vdc, I_C = −30 mAdc, I_{B1} = I_{B2} = −1.5 mAdc)	t_{off}	—	90	ns

(1) Applicable from 0.01 to 10 mAdc.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2.0%.

MAXIMUM RATINGS

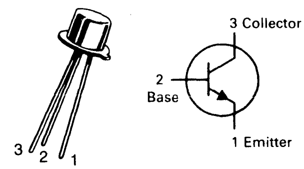
Rating	Symbol	2N2895	2N2896	Unit
Collector-Emitter Voltage	V_{CEO}	65	90	Vdc
Collector-Emitter Voltage	V_{CER}	80	140	Vdc
Collector-Base Voltage	V_{CBO}	120	140	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 0.5 2.86		 Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 1.8 10.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

2N2895, 2N2896

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

3

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CER}$			Vdc
(I_C = 100 mAdc, R_{BE} = 10 ohms)	2N2895		80	—	
	2N2896		140	—	
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N2895		65	—	
	2N2896		90	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	120	—	Vdc
(I_C = 0.1 mAdc, I_E = 0)	2N2895		140	—	
	2N2896				
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	7.0	—	Vdc
(I_E = 0.1 mAdc, I_C = 0)					
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 60 Vdc, I_C = 0)	2N2895		—	0.002	
	2N2896		—	0.01	
(V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	2N2895		—	2.0	
(V_{CB} = 90 Vdc, I_E = 0)	2N2896		—	0.01	
(V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)	2N2896		—	10	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 5.0 Vdc, I_C = 0)	2N2895		—	0.005	
	2N2896		—	0.01	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 10 Vdc)	2N2895		10	—	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N2895		20	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2896		35	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2895		35	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N2895,2N2896		20	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2895		40	120	
	2N2896		60	200	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2895		25	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 Adc)	$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	120	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) 2N2895	h_{fe}	50	200	—
2N2896		50	275	
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 500 Ohms, SN2895 f = 1.0 kHz)	NF	—	8.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.8%.

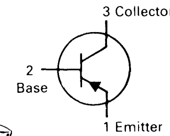
PNP SILICON ANNULAR HERMETIC TRANSISTORS

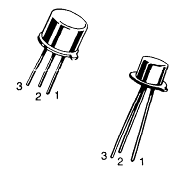
. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- High DC Current Gain Specified — 0.1 to 500 mAdc
- High Current-Gain — Bandwidth Product — f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- 2N2904, A thru 2N2907, A Complement to NPN 2N2218, A, 2N2219, A, 2N2221, A, 2N2222, A

2N2904,A★ thru 2N2907,A★

2N2904,A/2N2905,A
CASE 79-04, STYLE 1
TO-39 (TO-205AD)





2N2906,A/2N2907,A
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTORS
PNP SILICON

★2N2905A and 2N2907A are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Non-A Suffix	A-Suffix	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60		Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−600		mAdc
		2N2904,A 2N2905,A	**2N2906,A 2N2907,A**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 600 3.43	 400 2.28	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 3.0 17.2	 1.2 6.85	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
		2N2904,A; 2N2905,A	**2N2906,A 2N2907,A**	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	292	438	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	 Non-A Suffix A-Suffix	$V_{(BR)CEO}$	 −40 −60	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −0.5 Vdc)		I_{CEX}	—	—	−50	nAdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0, T_A = 150°C)	 Non-A Suffix A-Suffix Non-A Suffix A-Suffix	I_{CBO}	 — — — —	 — — — —	 −0.02 −0.01 −20 −10	μAdc
Base Current (V_{CE} = −30 Vdc, V_{EB} = −0.5 Vdc)		I_B	—	—	−50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 Vdc)	 2N2904, 2N2906 2N2905, 2N2907 2N2904A, 2N2906A 2N2905A, 2N2907A	h_{FE}	 20 35 40 75	 — — — —	 — — — —	—

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

(continued)

3

3

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (continued)						
DC Current Gain			25	—	—	
(I_C = −1.0 mAdc, V_{CE} = −10 Vdc)	2N2904, 2N2906		50	—	—	
	2N2905, 2N2907		40	—	—	
	2N2904A, 2N2906A		100	—	—	
	2N2905A, 2N2907A					
(I_C = −10 mAdc, V_{CE} = −10 Vdc)	2N2904, 2N2906		35	—	—	
	2N2905, 2N2907		75	—	—	
	2N2904A, 2N2906A		40	—	—	
	2N2905A, 2N2907A		100	—	—	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)(1)	2N2904,A, 2N2906,A	h_{FE}	40	—	120	
	2N2905,A, 2N2907,A		100	—	300	
(I_C = −500 mAdc, V_{CE} = −10 Vdc)(1)	2N2904, 2N2906		20	—	—	
	2N2905, 2N2907		30	—	—	
	2N2904A, 2N2906A		40	—	—	
	2N2905A, 2N2907A		50	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)			—	—	−0.4	
(I_C = −500 mAdc, I_B = −50 mAdc)			—	—	−1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)(1)			—	—	−1.3	
(I_C = −500 mAdc, I_B = −50 mAdc)(1)			—	—	−2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	—	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	—	—	8.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	—	—	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = −30 Vdc, I_C = −150 mAdc, I_{B1} = −15 mAdc) (Figure 15a)	t_{on}	—	26	45	ns
Delay Time		t_d	—	6.0	10	
Rise Time		t_r	—	20	40	
Turn-Off Time	(V_{CC} = −6.0 Vdc, I_C = −150 mAdc, I_{B1} = I_{B2} = −15 mAdc) (Figure 15b)	t_{off}	—	70	100	ns
Storage Time		t_s	—	50	80	
Fall Time		t_f	—	20	30	

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — NORMALIZED DC CURRENT GAIN

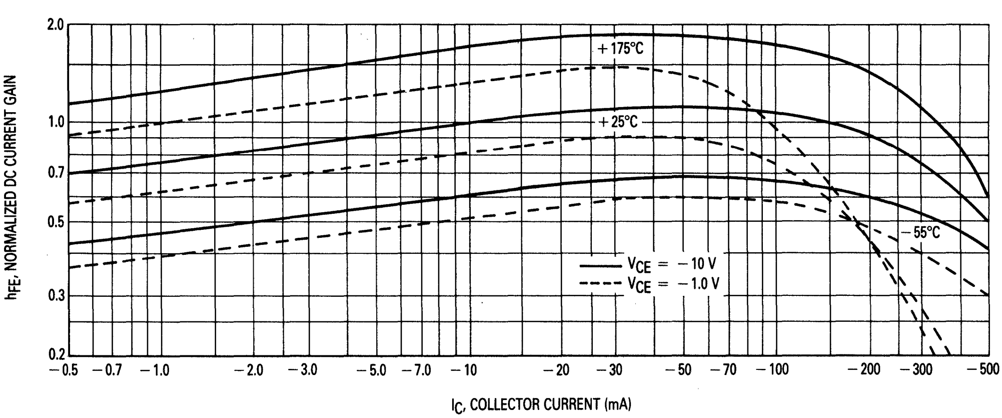
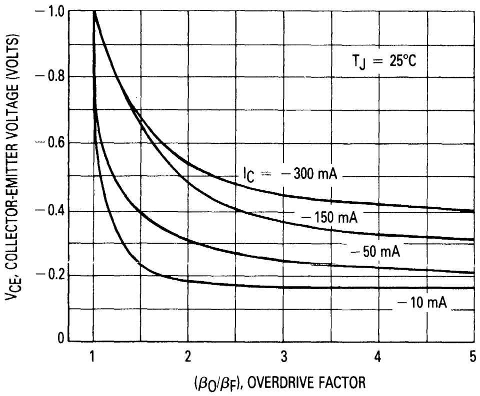


FIGURE 2 — NORMALIZED COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O (current gain at edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2905, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 mA an overdrive factor of at least 3 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.60 of h_{FE} @ 10 volts. Using the guaranteed minimum of 100 @ 150 mA and 10 V, β_O = 60 and substituting values in the overdrive equation, we find:

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\text{ V}}{I_C/I_{BF}} \qquad 3 = \frac{60}{150/I_{BF}} \qquad I_{BF} \approx 7.5\text{ mA}$$

3

FIGURE 3 — "ON" VOLTAGES

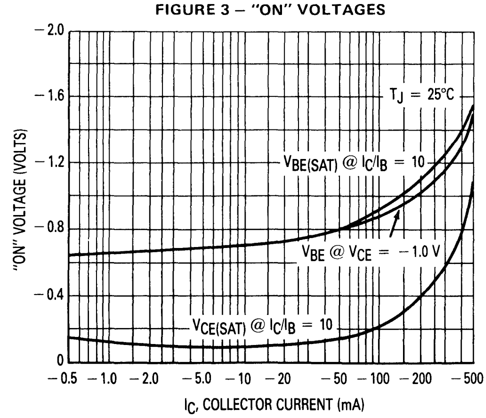
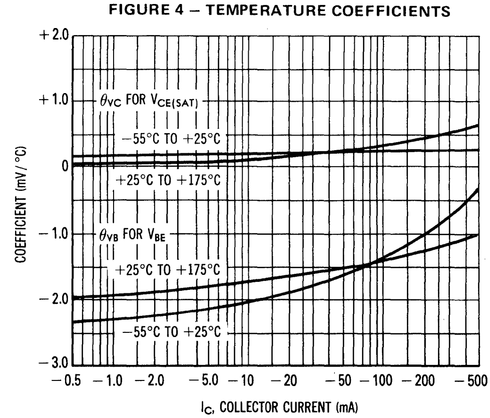


FIGURE 4 — TEMPERATURE COEFFICIENTS



SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE
V_{CE} = 10 V, T_A = 25°C

FIGURE 5 — FREQUENCY EFFECTS

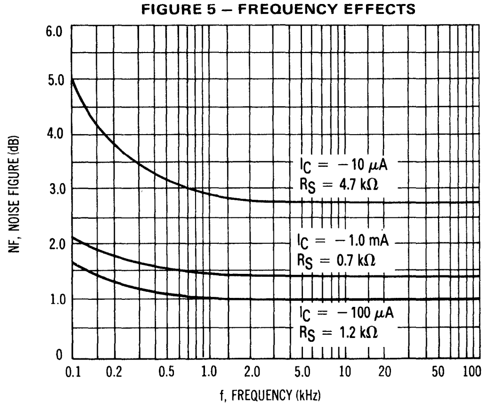
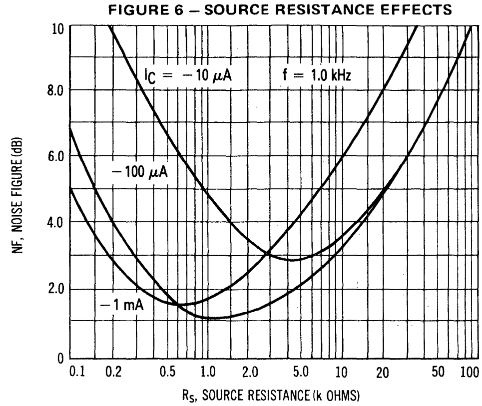


FIGURE 6 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 7 — INPUT IMPEDANCE

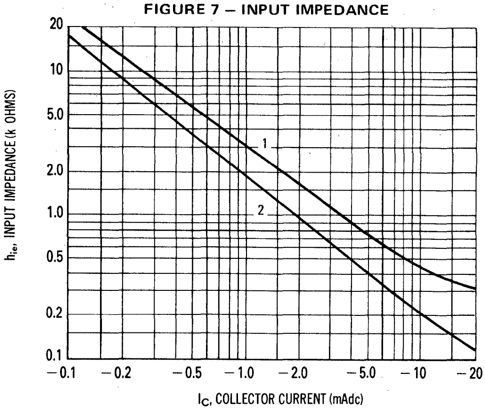


FIGURE 8 — VOLTAGE FEEDBACK RATIO

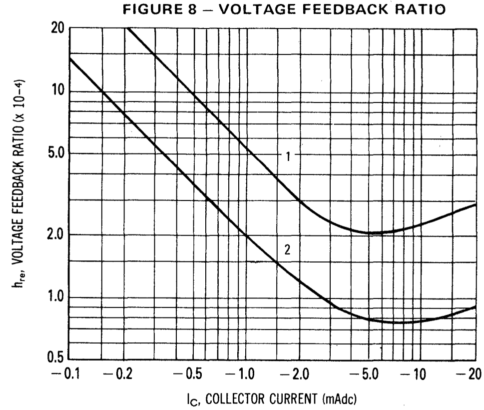


FIGURE 9 — CURRENT GAIN

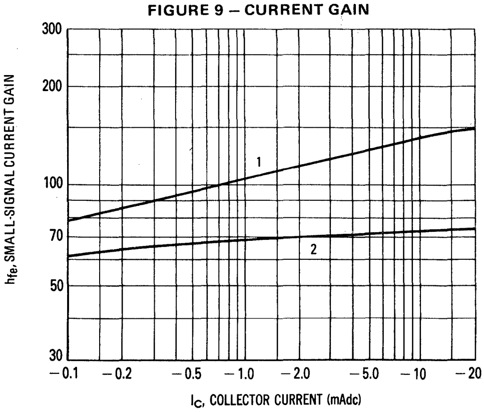


FIGURE 10 — OUTPUT ADMITTANCE

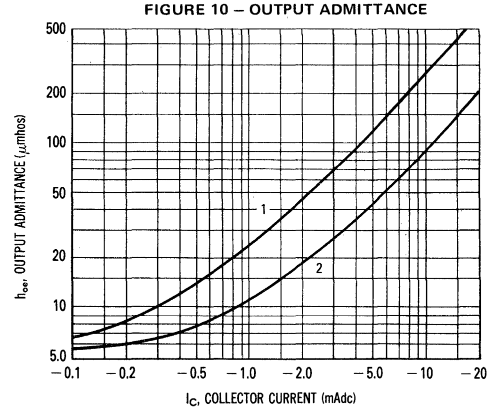


FIGURE 11 — TURN ON TIME

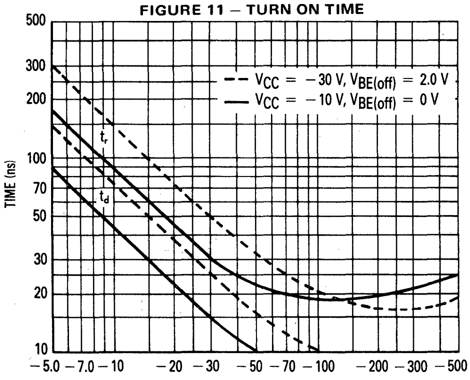


FIGURE 12 — CHARGE DATA

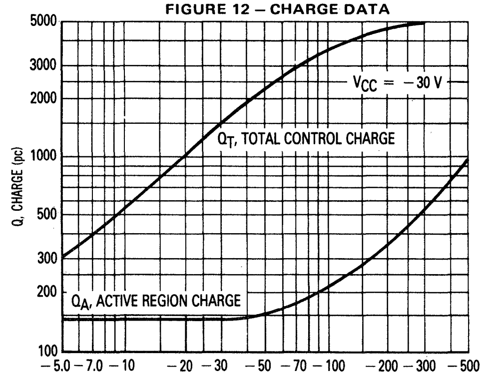


FIGURE 13 — STORAGE TIME

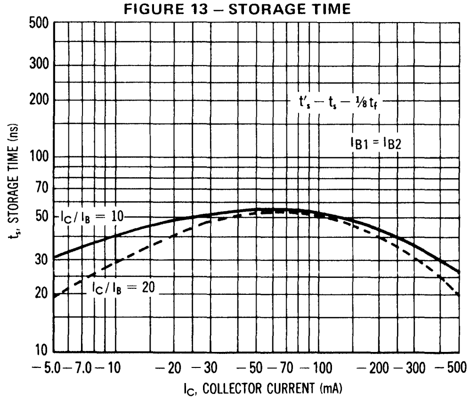


FIGURE 14 — FALL TIME

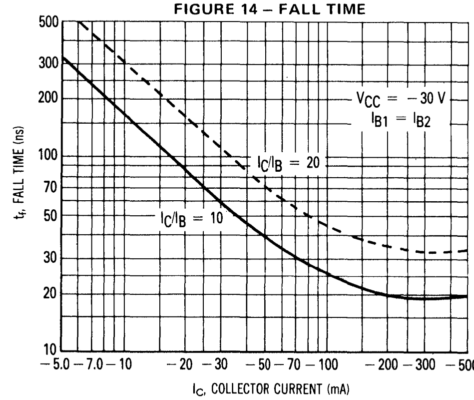


FIGURE 15a — DELAY AND RISE TIME TEST CIRCUIT

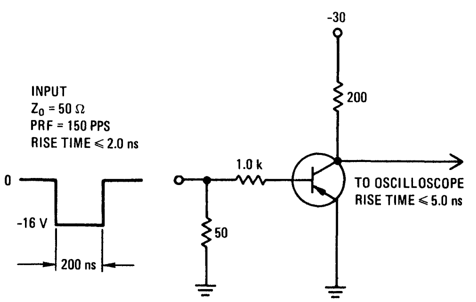


FIGURE 15b — STORAGE AND FALL TIME TEST CIRCUIT

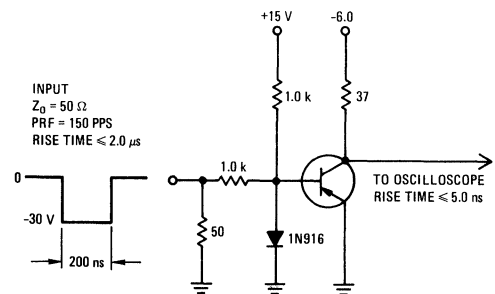


FIGURE 16 — CURRENT-GAIN—BANDWIDTH PRODUCT

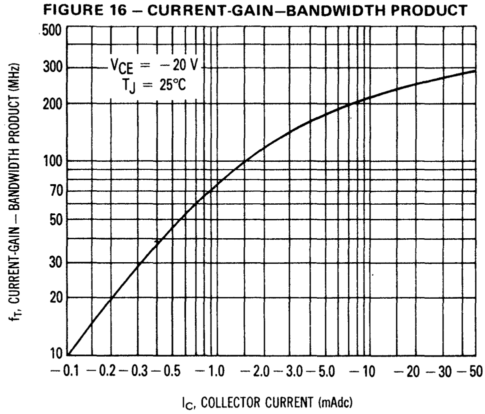


FIGURE 17 — CAPACITANCES

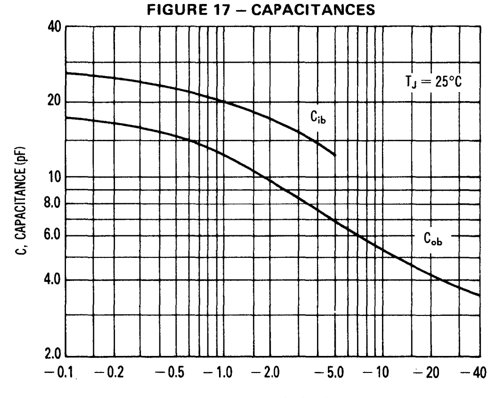
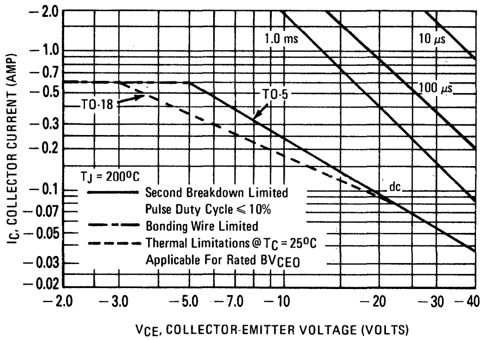


FIGURE 18 – ACTIVE REGION SAFE OPERATING AREAS

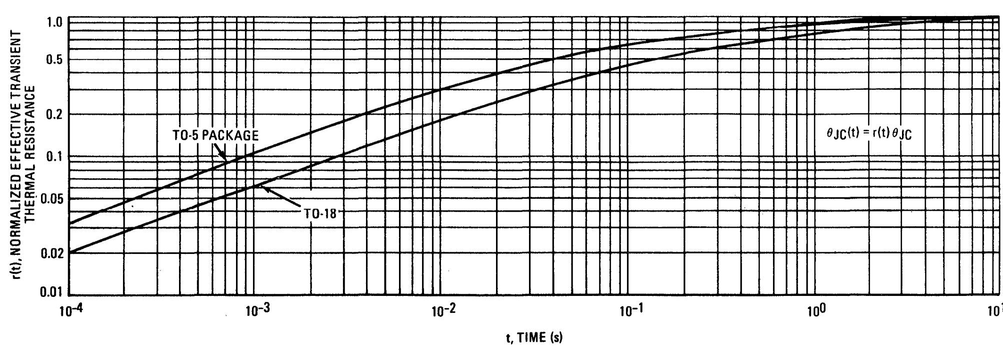


This graph shows the maximum I_C-V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown. For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table.

To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve. Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown.

For pulse applications, the maximum I_C-V_{CE} product indicated by the dc thermal limits can be exceeded. Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

FIGURE 19 – THERMAL RESISTANCE



MAXIMUM RATINGS

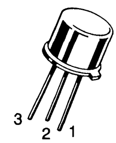
Rating	Symbol	2N3019 2N3020	2N3700	Unit
Collector-Emitter Voltage	V_{CEO}	80	80	Vdc
Collector-Base Voltage	V_{CBO}	140	140	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	7.0	Vdc
Collector Current — Continuous	I_C	1.0	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6	0.5 2.85	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	1.8 10.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

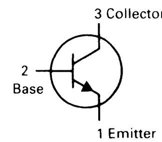
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3019 2N3020	2N3700	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	217	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	97	°C/W

2N3019★
2N3020

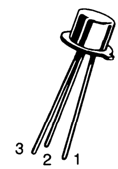
CASE 79-04, STYLE 1
TO-39 (TO-205AD)





2N3700★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL TRANSISTORS

NPN SILICON

★2N3019 and 2N3700 are Motorola designated preferred devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)		I_{CBO}	 — —	 0.01 10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3700, 2N3019 2N3020		50 30	— 100	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N3700, 2N3019 2N3020		90 40	— 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N3700, 2N3019 2N3020		100 40	300 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = −55°C)(1)	2N3700, 2N3019		40	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N3700, 2N3019 2N3020		50 30	— 100	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)(1)	All Types		15	—	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	 2N3020 2N3019, 2N3700	f_T	 80 100	 — 400	MHz

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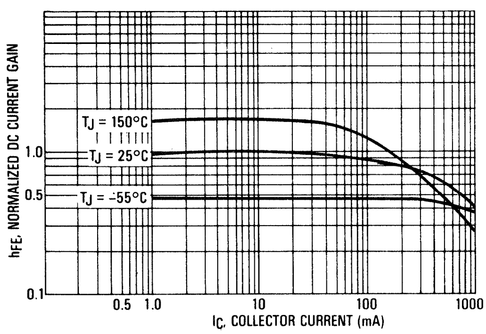
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

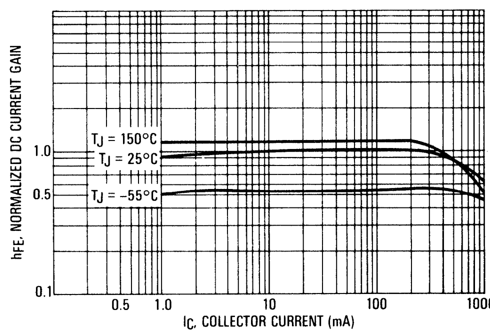
Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz		C_{ibo}	—	60	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N3700, 2N3019 2N3020	h_{fe}	80 30	400 200	—
Collector Base Time Constant (I_E = 10 mAdc, V_{CB} = 10 Vdc, f = 79.8 MHz)	2N3019, 2N3020 2N3700	$rb'C_c$	— 15	400 400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)	2N3019, 2N3700	NF	—	4	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

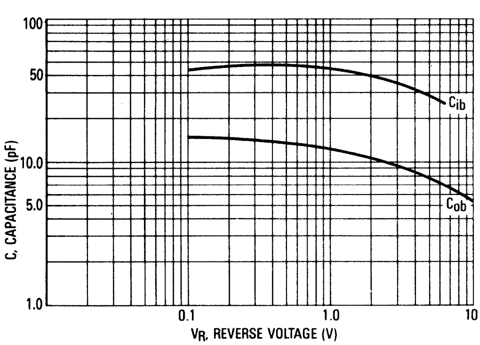
DC CURRENT GAIN
2N3019, 2N3700



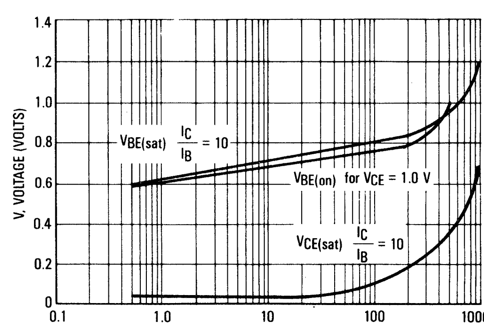
DC CURRENT GAIN
2N3020



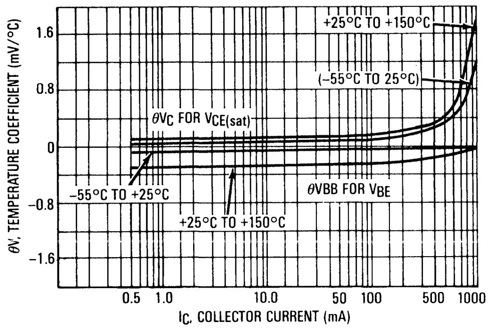
CAPACITANCE



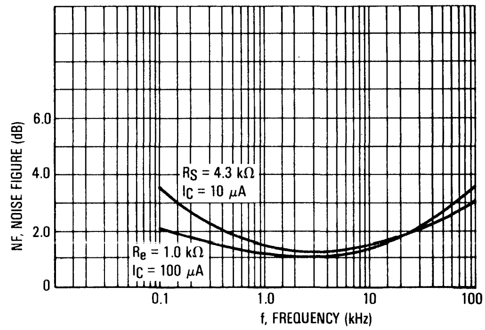
"ON" VOLTAGES



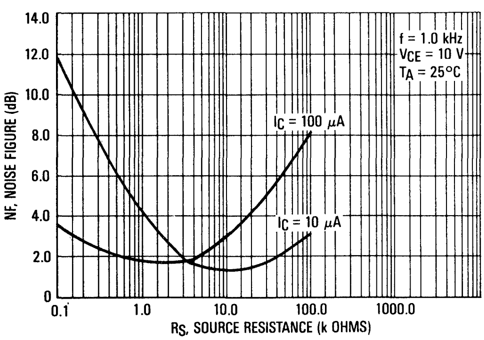
TEMPERATURE COEFFICIENTS



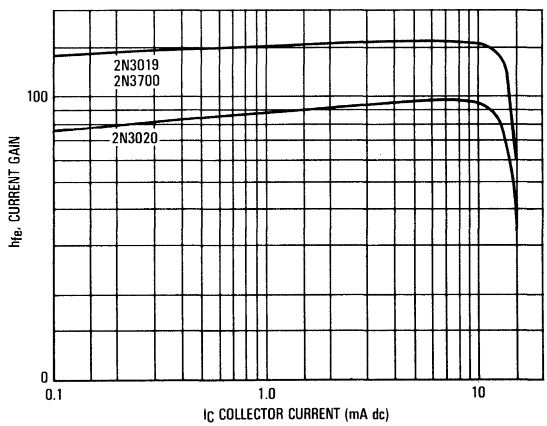
FREQUENCY EFFECTS



SOURCE RESISTANCE EFFECTS



CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT — 1 kHz h_{fe}



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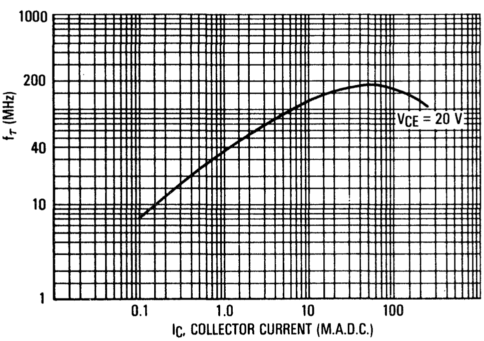
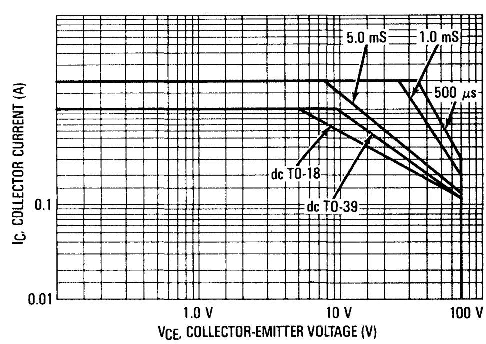
CURRENT GAIN — BANDWIDTH PRODUCT

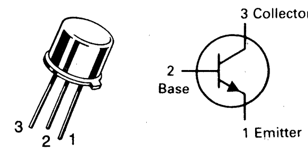


ACTIVE REGION SAFE OPERATING AREA



2N3053, A

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3053	2N3053A	Unit
Collector-Emitter Voltage(1)	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	700		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

(1) Applicable 0 to 100 mA (Pulsed):
Pulse Width ≤ 300 μsec., Duty Cycle ≤ 2.0%.
0 to 700 mA; Pulse Width ≤ 10 μsec., Duty Cycle ≤ 2.0%.

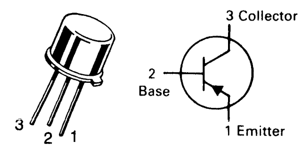
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	2N3053 2N3053A	$V_{(BR)CEO}$	40 60	— —	Vdc
Collector-Emitter Breakdown Voltage(2) (I_C = 100 mAdc, R_{BE} = 10 ohms)	2N3053 2N3053A	$V_{(BR)CER}$	50 70	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N3053 2N3053A	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 60 Vdc, $V_{EB(OFF)}$ = 1.5 Vdc)	2N3053 2N3053A	I_{CEX}	—	0.25	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	2N3053	I_{EBO}	—	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N3053 2N3053A	I_{BL}	—	0.25	μAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 2.5 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)		h_{FE}	25 50	— 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	2N3053 2N3053A	$V_{CE(sat)}$	— —	1.4 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	2N3053 2N3053A	$V_{BE(sat)}$	— 0.6	1.7 1.0	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	2N3053 2N3053A	$V_{BE(on)}$	— —	1.7 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	80	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3244

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Base Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)	I_{BEV}	—	−80	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)	I_{CEX}	—	−50	nAdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0) (V_{CB} = −30 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 −0.050 −10	μAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	−30	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −150 mAdc, V_{CE} = −1.0 Vdc) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 Adc, V_{CE} = −5.0 Vdc)	h_{FE}	 60 50 25	 — 150 —	—
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{CE(sat)}$	 — — —	 −0.3 −0.5 −1.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc) (I_C = −750 mA, I_B = −75 mA)		$V_{BE(sat)}$	 — −0.75 — —	 −1.1 −1.5 −2.0 −2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		f_T	175	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	25	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = −500 mA, I_{B1} = −50 mA V_{BE} = +2.0 V, V_{CC} = −30 V)	t_d	—	15	ns
Rise Time		t_r	—	35	ns
Storage Time	(I_C = −500 mA, V_{CC} = −30 V I_{B1} = I_{B2} = −50 mA)	t_s	—	140	ns
Fall Time		t_f	—	45	ns
Total Control Charge (I_C = −500 mA, I_B = −50 mA, V_{CC} = −30 V)		Q_T	—	14	nC

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

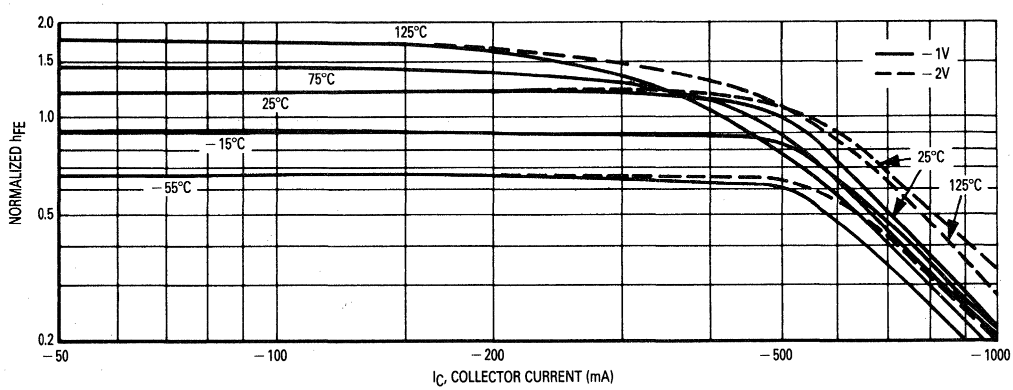


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS

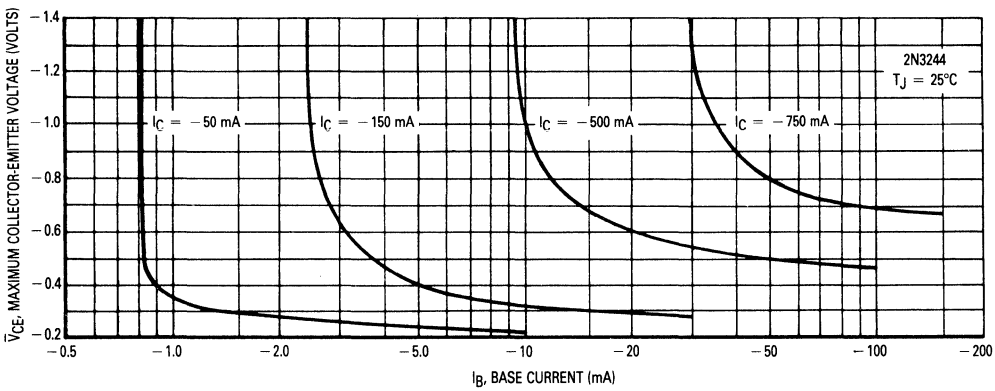


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

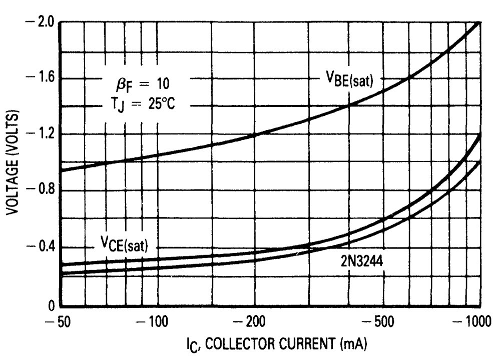


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

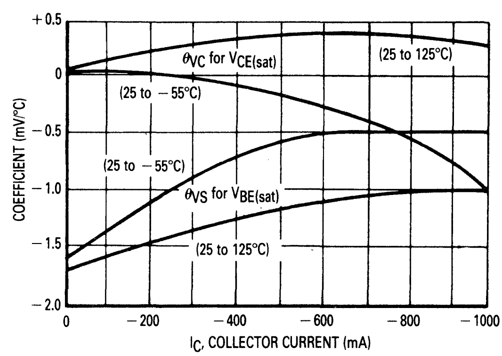


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FIGURE 5 — JUNCTION CAPACITANCE

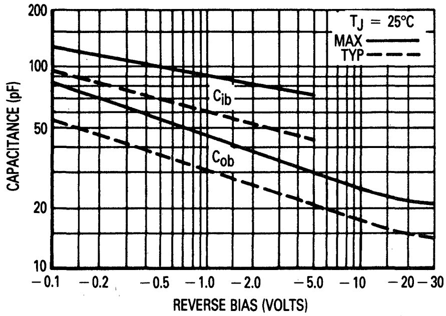


FIGURE 6 — TYPICAL SWITCHING TIMES

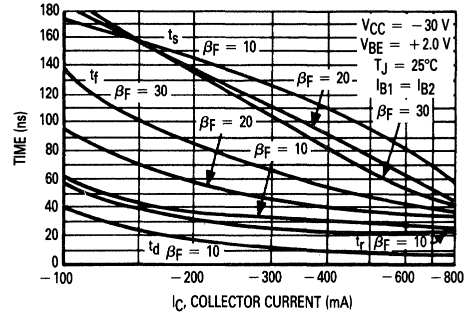


FIGURE 7 — CHARGE DATA

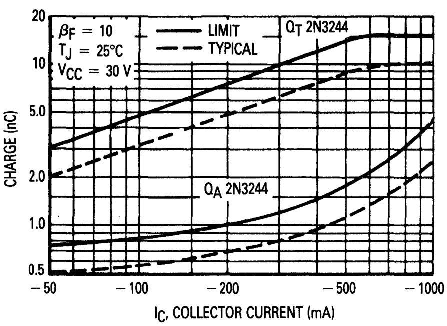


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

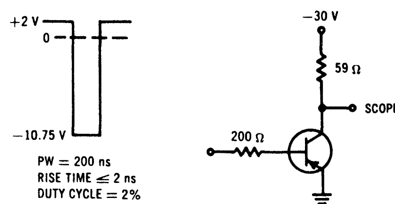


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

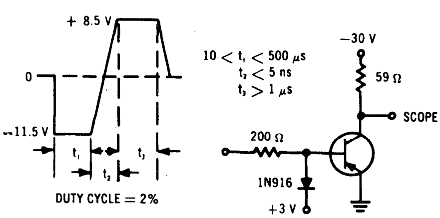


FIGURE 10 — Q_T TEST CIRCUIT

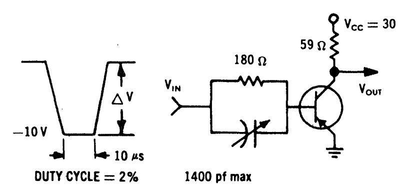
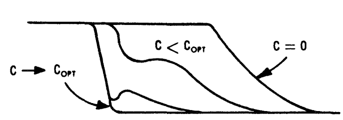
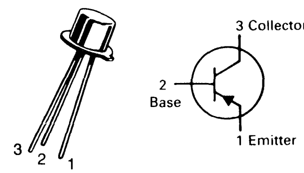


FIGURE 11 — TURN-OFF WAVEFORM



2N3250
2N3251,A★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

★2N3251A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	2N3250 2N3251	2N3251A	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−50	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current	I_C	−200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9		Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc)	2N3250, 2N3251 2N3251A	$V_{(BR)CEO}$	−40 −60	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc)	2N3250, 2N3251 2N3251A	$V_{(BR)CBO}$	−50 −60	—	Vdc
Emitter-Base Breakdown Voltage I_E = −10 μAdc)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −40 Vdc, V_{EB} = −3.0 Vdc)		I_{CEX}	—	−20	nA
Base Cutoff Current (V_{CE} = −40 Vdc, V_{EB} = −3.0 Vdc)		I_{BL}	—	−50	nAdc
ON CHARACTERISTICS					
DC Forward Current Transfer Ratio (I_C = −0.1 mAdc, V_{CE} = −10 Vdc)	 2N3250 2N3251, 2N3251A	h_{FE}	 40 80	 — —	—
(I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc)	2N3250 2N3251, 2N3251A		45 90	— —	
(I_C = −10 mAdc, V_{CE} = −1.0 Vdc)(1)	2N3250 2N3251, 2N3251A		50 100	150 300	
(I_C = −50 mAdc, V_{CE} = −1.0 Vdc)(1)	2N3250 2N3251, 2N3251A		15 30	— —	
Collector-Emitter Saturation Voltage (1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc		$V_{CE(sat)}$	 — —	 −0.25 −0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	 −0.6 —	 −0.9 −1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	2N3250 2N3251, 2N3251A	f_T	250 300	— —	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capaciatance (V_{EB} = −1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Impedance (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{ie}	1.0 2.0	6.0 12	kohms
Voltage Feedback Ratio (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{re}	— —	10 20	X 10^{-4}
Small-Signal Current Gain (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{fe}	50 100	200 400	—
Output Admittance (I_C = −1.0 mA, V_{CE} = −10 V, f = 1.0 kHz)	2N3250 2N3251, 2N3251A	h_{oe}	4.0 10	40 60	μmhos
Collector Base Time Constant (I_C = −10 mA, V_{CE} = −20 V, f = 31.8 MHz)		$r_{b'}C_C$	—	250	ps
Noise Figure (I_C = −100 μA, V_{CE} = −5.0 V, R_S = 1.0 kΩ, f = 100 Hz)		NF	—	6.0	dB

SWITCHING CHARACTERISTICS

Characteristic			Symbol	Max	Unit
Delay Time	(V_{CC} = −3.0 Vdc, V_{BE} = +0.5 Vdc I_C = −10 mAdc, I_{B1} = −1.0 mA)		t_d	35	ns
Rise Time			t_r	35	ns
Storage Time	I_C = −10 mAdc, I_{B1} = I_{B1} = −1.0 mAdc) (V_{CC} = −3.0 V)	2N3250 2N3251, 2N3251A	t_s	175 200	ns
Fall Time			t_f	50	ns

(1) Pulse Test: PW = 300 μs, Duty Cycle = 2.0%.

3

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

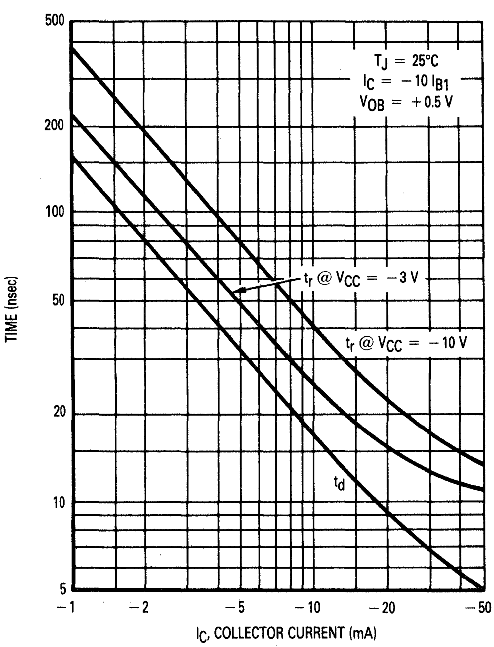
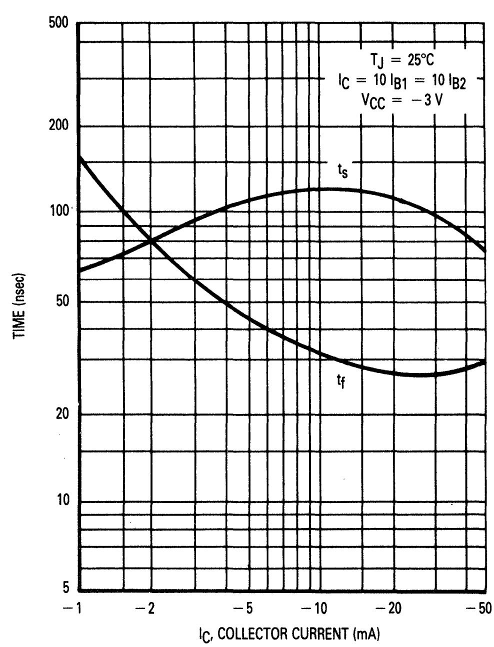


FIGURE 2 — STORAGE AND FALL TIME



AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
(V_{CE} = 6.0 V, T_A = 25°C)

FIGURE 3 — FREQUENCY

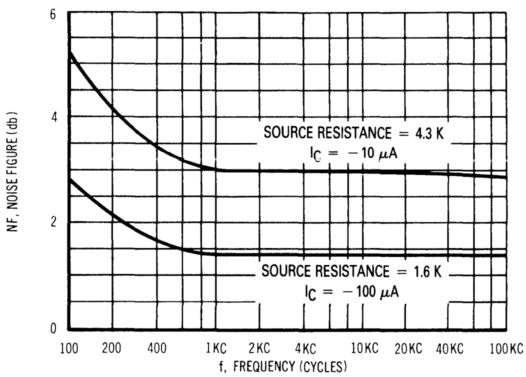
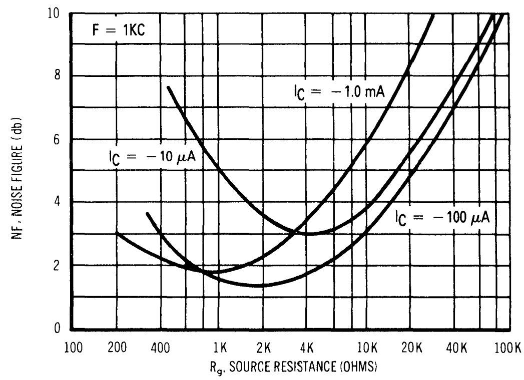


FIGURE 4 — SOURCE RESISTANCE



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h PARAMETERS
V_{CE} = 10 V, f = 1.0 kc, T_A = 25°C

FIGURE 5 — CURRENT GAIN

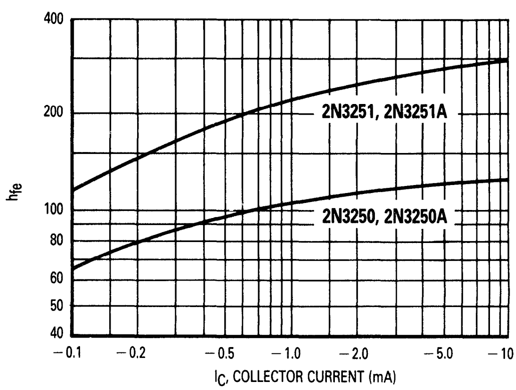

FIGURE 6 — OUTPUT ADMITTANCE

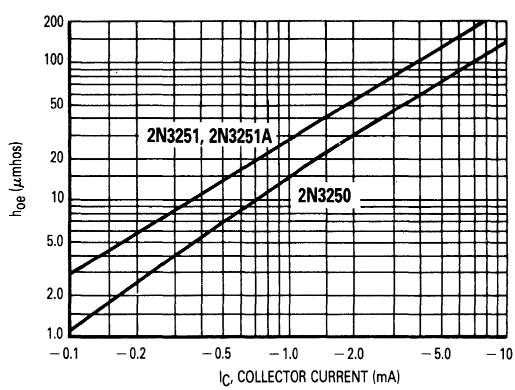

FIGURE 7 — VOLTAGE FEEDBACK RATIO

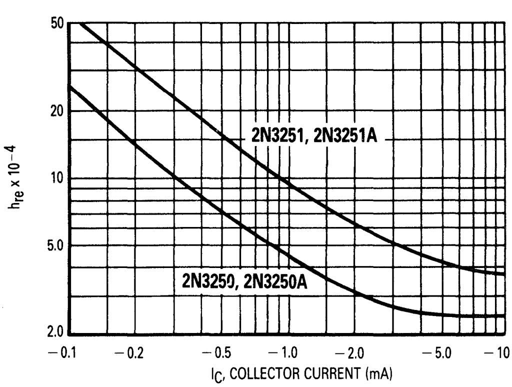

FIGURE 8 — INPUT IMPEDANCE

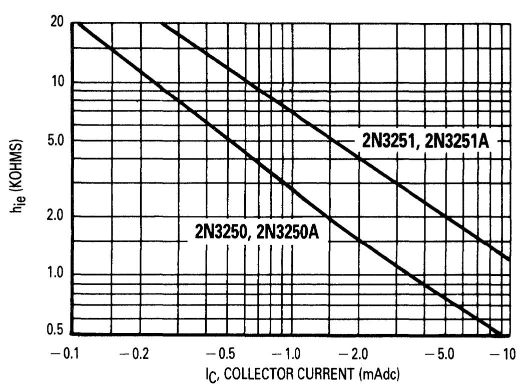

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FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

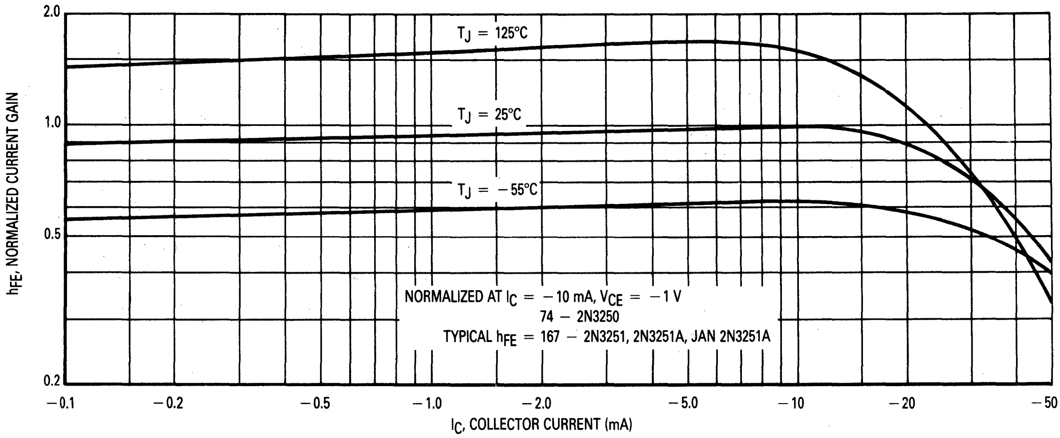
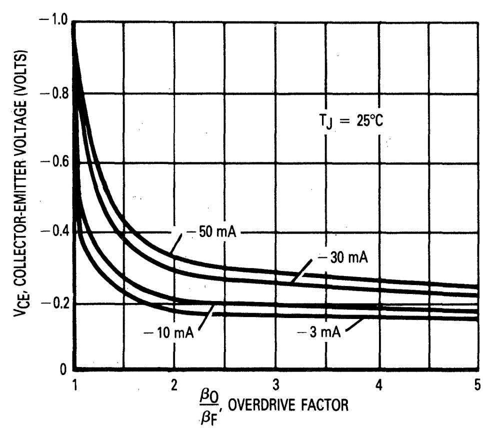


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at $I_C = 10$ mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design)...

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} \text{ @ 1 Volt}}{I_C/I_{BF}} \qquad 2.5 = \frac{167}{10\,\text{mA}/I_{BF}} \qquad I_{BF} \approx -6.68\ \text{mA}$$

FIGURE 11 — SATURATION VOLTAGES

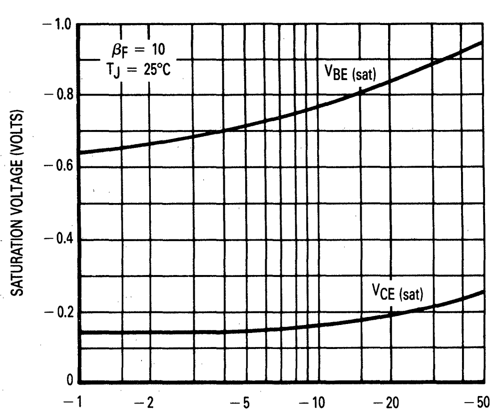


FIGURE 12 — TEMPERATURE COEFFICIENTS

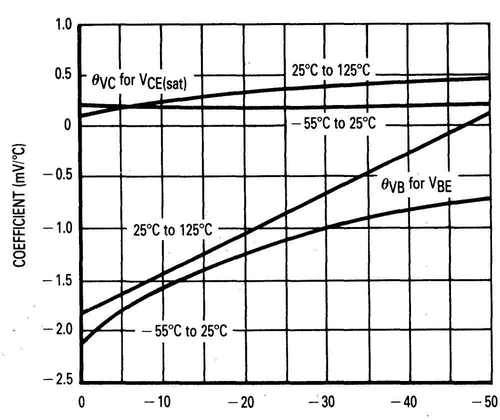


FIGURE 13 — f_T AND $r_b'C_c$ versus I_C

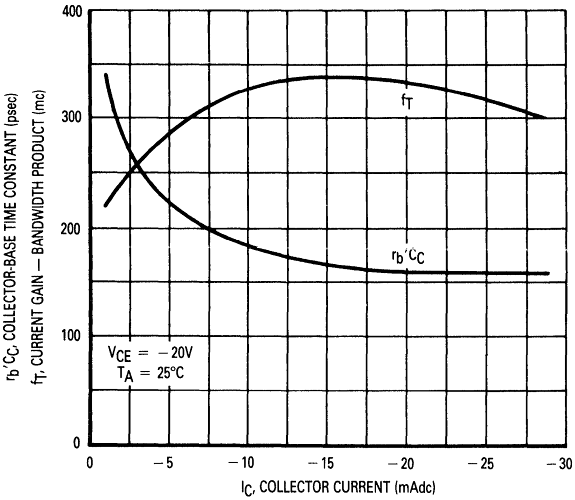


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

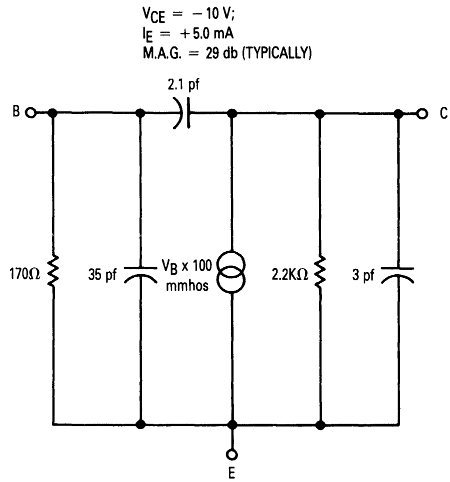


FIGURE 15 — JUNCTION CAPACITANCE

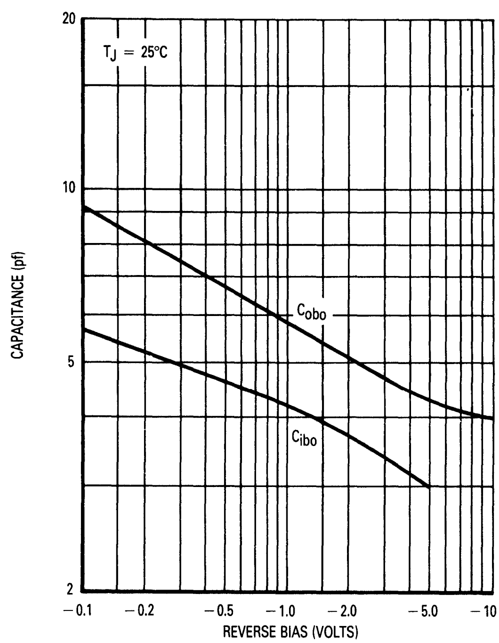
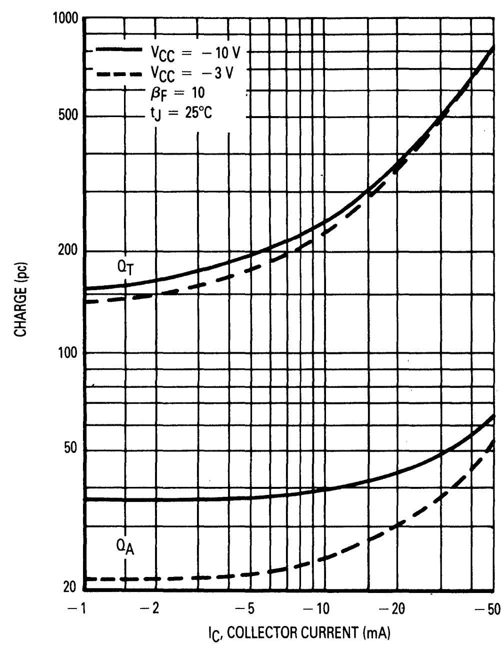
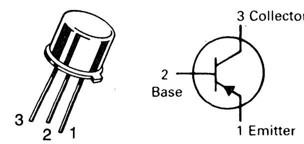


FIGURE 16 — CHARGE DATA



2N3467★
2N3468★

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTORS

PNP SILICON

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	2N3467	2N3468	Unit
Emitter-Collector Voltage	V_{CEO}	−40	−50	Vdc
Collector-Base Voltage	V_{CBO}	−40	−50	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	2N3467 2N3468	$V_{(BR)CEO}$	−40 −50	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	2N3467 2N3468	$V_{(BR)CBO}$	−40 −50	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Base Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)		I_{BEV}	—	−120	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{EB} = −3.0 Vdc)		I_{CEX}	—	−100	nAdc
Collector Cutoff Current (V_{CB} = −30 Vdc, I_E = 0) (V_{CB} = −30 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	— —	−0.10 −15	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = −150 mAdc, V_{CE} = −1.0 Vdc)	2N3467 2N3468	h_{FE}	40 25	— —	—
(I_C = −500 mAdc, V_{CE} = −1.0 Vdc)	2N3467 2N3468		40 25	120 75	
(I_C = −1.0 Adc, V_{CE} = −5.0 Vdc)	2N3467 2N3468		40 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc)	2N3467 2N3468	$V_{CE(sat)}$	— —	−3.0 −0.36	Vdc
(I_C = −500 mAdc, I_B = −50 mAdc)	2N3467 2N3468		— —	−0.5 −0.6	
(I_C = −1.0 Adc, I_B = −100 mAdc)	2N3467 2N3468		— —	−1.0 −1.2	
Base-Emitter Saturation Voltage(1) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)		$V_{BE(sat)}$	— −0.8 —	−1.0 −1.2 −1.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	2N3467	f_T	175	—	MHz
	2N3468		150	—	
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	25	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = −500 mA, I_{B1} = −50 mA, V_{BE} = 2.0 V, V_{CC} = 30 V)	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	(I_C = −500 mA, I_{B1} = I_{B2} = −50 mA, V_{CC} = −30 V)	t_s	—	60	ns
Fall Time		t_f	—	30	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		Q_T	—	6.0	nC

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

FIGURE 1 — STORAGE TIME VARIATION WITH TEMPERATURE

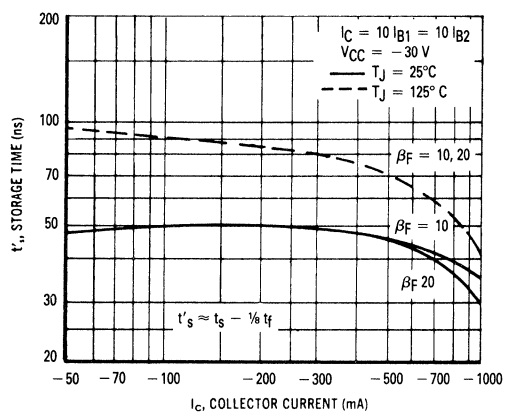


FIGURE 2 — LIMITS OF SATURATION VOLTAGE

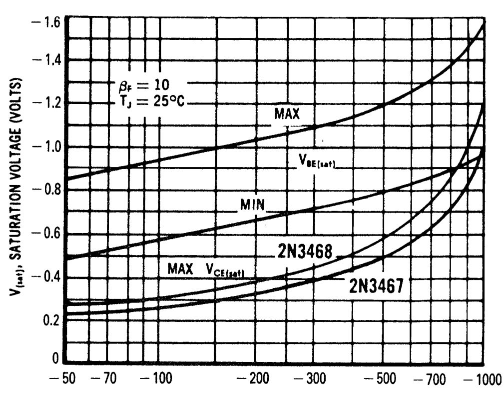
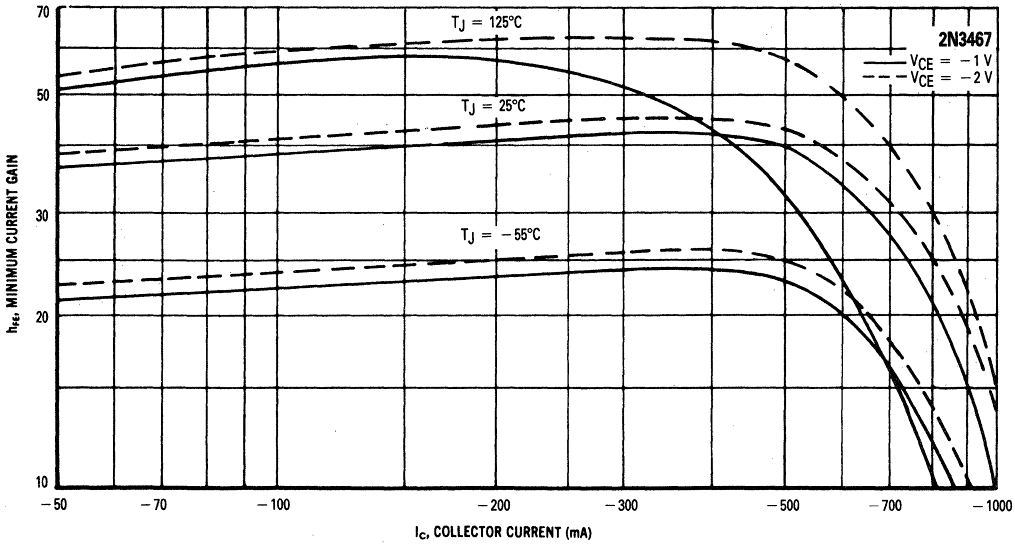
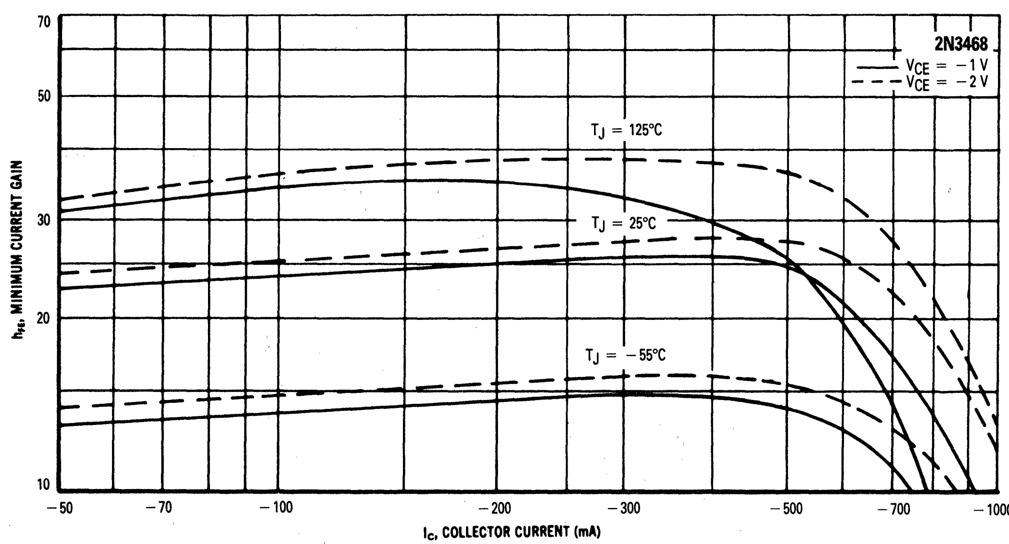


FIGURE 3 — MINIMUM CURRENT GAIN CHARACTERISTICS
2N3467



2N3468



3

MAXIMUM RATINGS

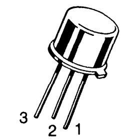
Rating	Symbol	Value		Unit
Emitter-Collector Voltage	V_{CEO}	−120		Vdc
Collector-Base Voltage	V_{CBO}	−120		Vdc
Emitter-Base Voltage	V_{EBO}	−4.5		Vdc
Collector Current — Continuous	I_C	−100		mAdc
		2N3495	2N3497	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 3.43	400 2.28	mW mW/°C
Total Device Dissipation @ T_C = 25°C* Derate above 25°C	P_D	3.0 17.2	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

*Indicates Data in addition to JEDEC Requirements.

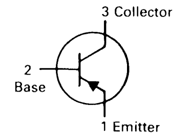
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

2N3495

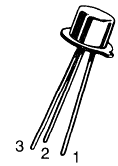


CASE 79-04, STYLE 1
TO-39 (TO-205AD)



2N3497

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−120	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CB} = −90 Vdc, I_E = 0)	I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−25	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −100 μAdc, V_{CE} = −10 Vdc) (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc) (I_C = −50 mAdc, V_{CE} = −10 Vdc)	h_{FE}	 35 40 40 40	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−0.35	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$	−0.6	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I_C = −20 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	150	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
Input Impedance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	H_{ie}	0.1	1.2	k ohms
Voltage Feedback Ratio (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{re}	—	2.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	40	300	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{oe}	—	300	μmhos
Real Part of Input Impedance (I_C = −20 mAdc, V_{CE} = −10 Vdc, f = 300 MHz)	$Re(h_{ie})$	—	30	Ohms

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Turn-On Time (V_{CC} = −30 Vdc, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	300	ns
Turn-Off Time (V_{CC} = −30 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	1000	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle = 2.0%.
(2) f_T is defined as the frequency at which h_{fe} extrapolates to unity.

3

FIGURE 1 – TURN-ON TIME TEST CIRCUIT

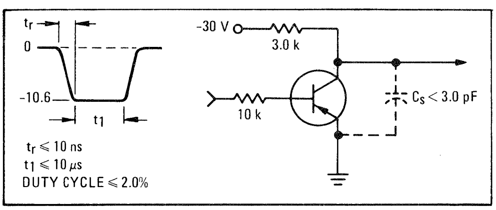


FIGURE 2 – TURN-OFF TIME TEST CIRCUIT

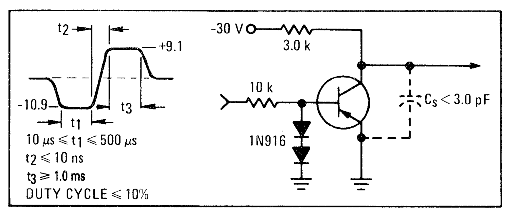


FIGURE 3 — V_{CE} (sat) versus I_C

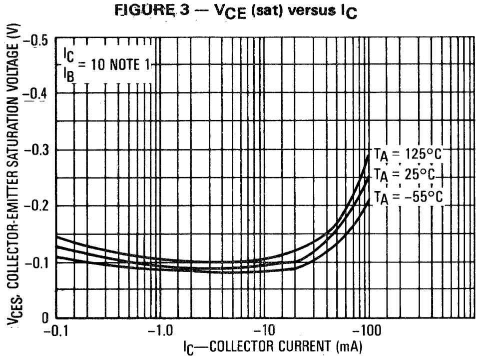


FIGURE 4 — I_{CBO} versus T_A

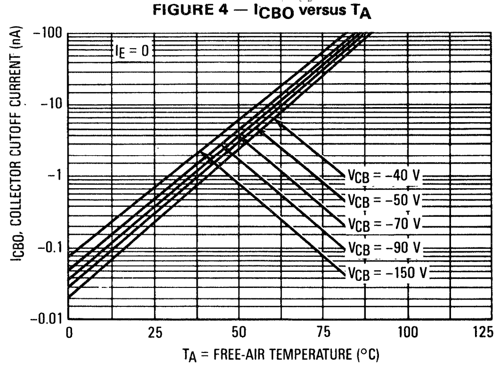


FIGURE 5 — h_{FE} versus I_C

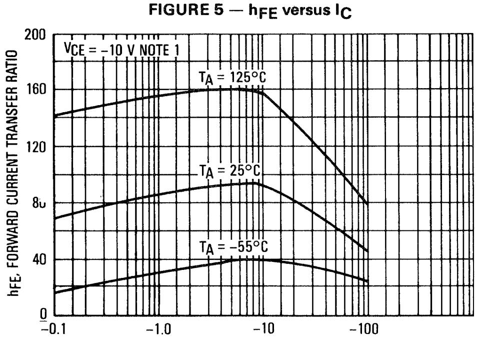


FIGURE 6 — V_{BE} versus I_C

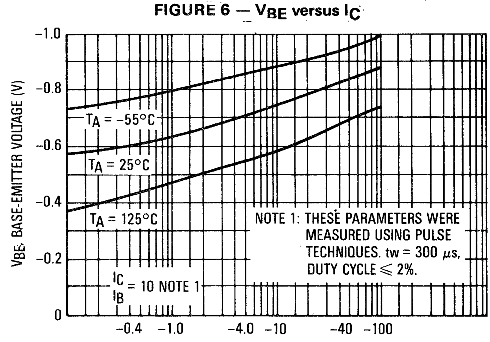


FIGURE 7 — f_T versus I_C

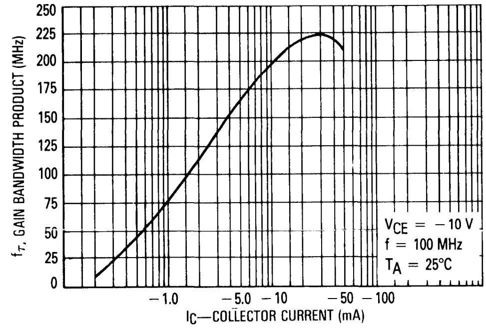


FIGURE 8 — C_{OBO} versus V_{CB}

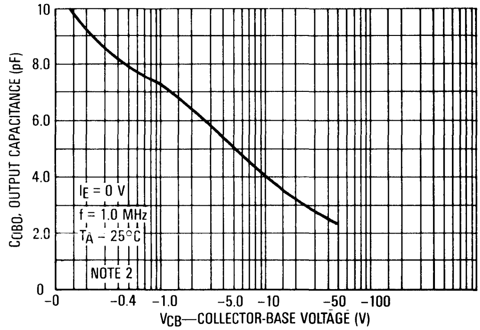
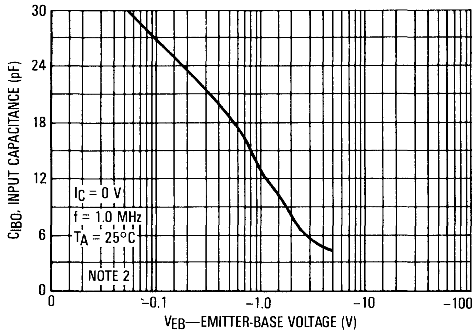


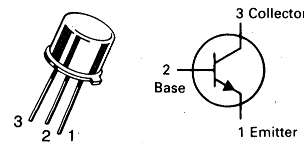
FIGURE 9 — C_{IBO} versus V_{EB}



NOTE 2: CAPACITANCE MEASURE MADE WITH TO-18 PACKAGE.

2N3499 thru 2N3501★

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

NPN SILICON

★2N3501 is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	2N3499	2N3500 2N3501	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N3499 2N3500, 2N3501	$V_{(BR)CEO}$	100 150	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3499 2N3500, 2N3501	$V_{(BR)CBO}$	100 150	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)	 2N3499 2N3500, 2N3501 	I_{CBO}	 — — — —	 — — — —	 –0.050 50 0.050 50	μAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	25	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	 2N3500 2N3499, 2N3501	h_{FE}	 20 35	 — —	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3500 2N3499, 2N3501		25 50	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N3500 2N3499, 2N3501		35 75	— —	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N3500 2N3499, 2N3501		40 100	— —	120 300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)	2N3500 2N3501		15 20	— —	— —	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N3499		20	—	—	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	 All Types All Types 2N3500, 2N3501 2N3499	$V_{CE(sat)}$	 — — — —	 — — — —	 0.2 0.25 0.4 0.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		—	—	0.8	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		—	—	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		—	—	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3499		—	—	1.4	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)		f_T	150	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N3499	C_{obo}	—	—	10	pF
	2N3500, 2N3501		—	—	8.0	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	80	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{ie}	0.2	—	1.0	k ohms
	2N3499, 2N3501		0.25	—	1.25	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{re}	—	—	2.5	$X\ 10^{-4}$
	2N3499, 2N3501		—	—	4.0	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{fe}	50	—	300	—
	2N3499, 2N3501		75	—	375	
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3500	h_{oe}	—	—	100	μmhos
	2N3499, 2N3501		—	—	200	
SWITCHING CHARACTERISTICS						
Delay Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = −2.0 Vdc)		t_d	—	20	—	ns
Rise Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = −2.0 Vdc)		t_r	—	35	—	ns
Storage Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_s	—	800	—	ns
Fall Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_f	—	80	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

3

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FIGURE 1 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3499

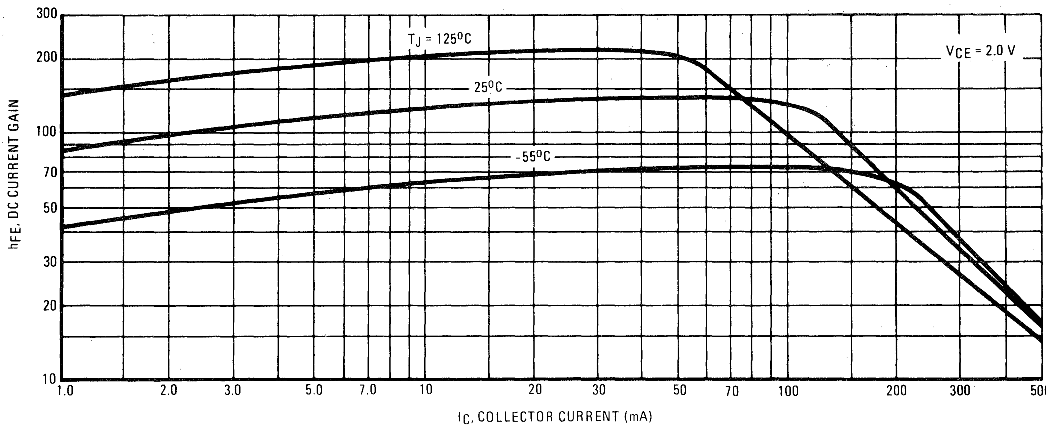


FIGURE 2 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

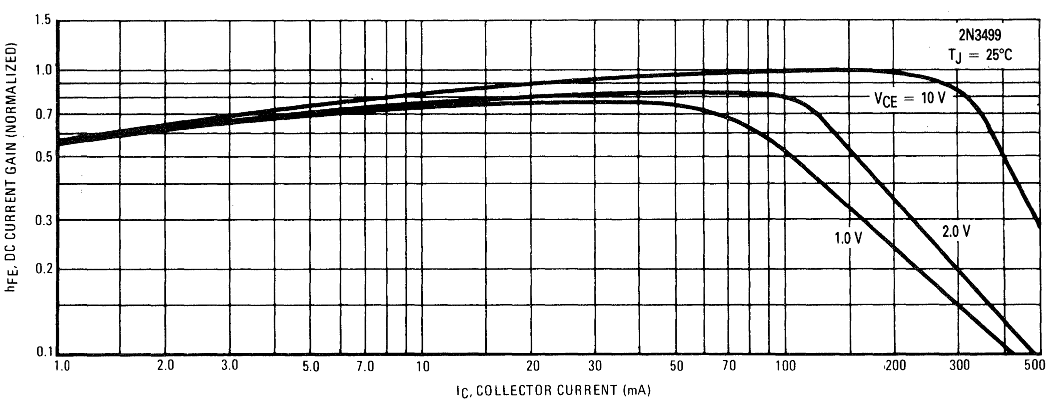
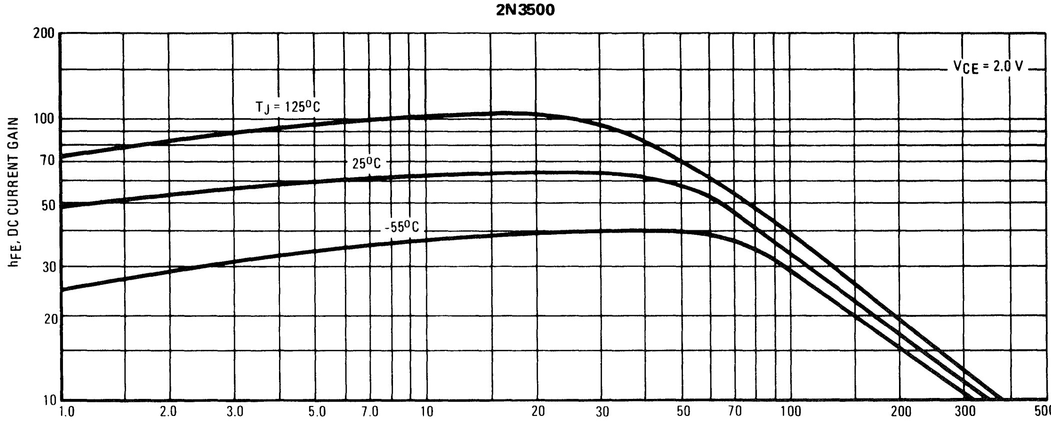


FIGURE 3 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3500



2N3501

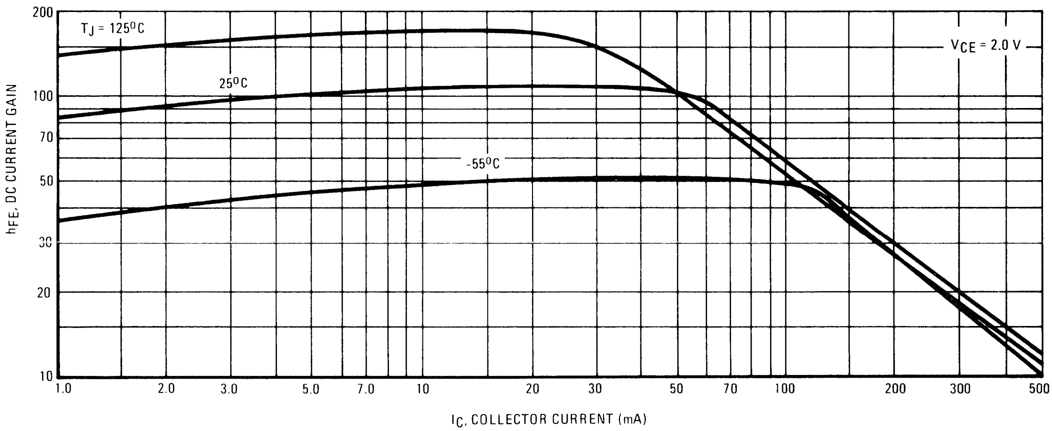


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

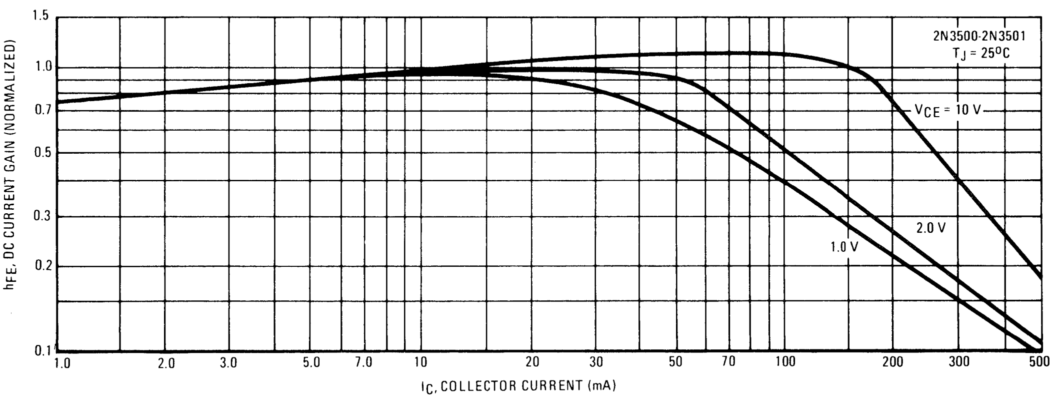


FIGURE 5 — "ON" VOLTAGES

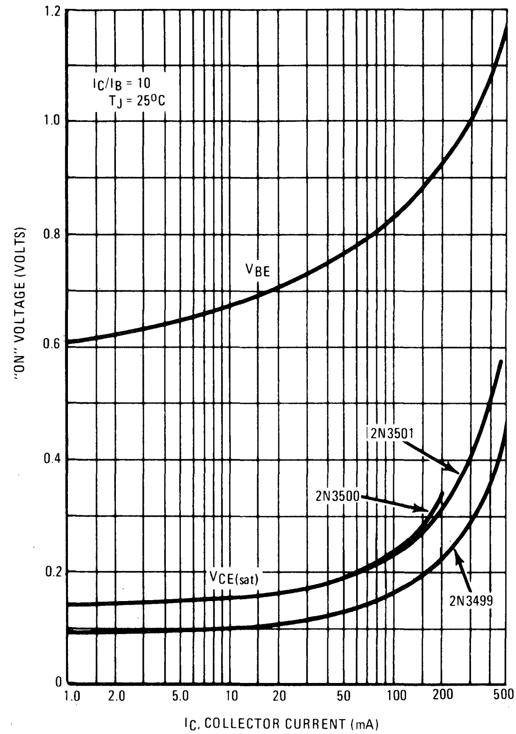


FIGURE 6 — TEMPERATURE COEFFICIENTS

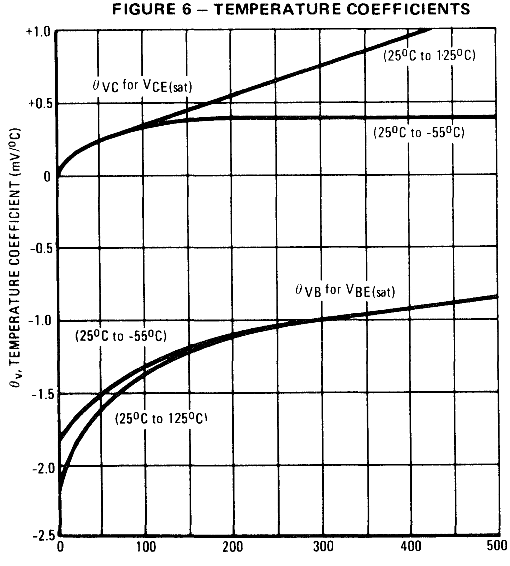
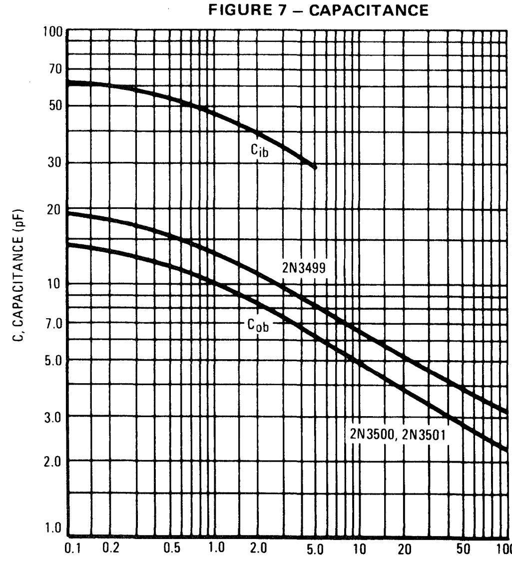


FIGURE 7 — CAPACITANCE



AUDIO SMALL-SIGNAL h PARAMETER CHARACTERISTICS

(V_{CE} = 10 Vdc, T_A = 25°C, f = 1.0 kHz)

FIGURE 8 – CURRENT GAIN

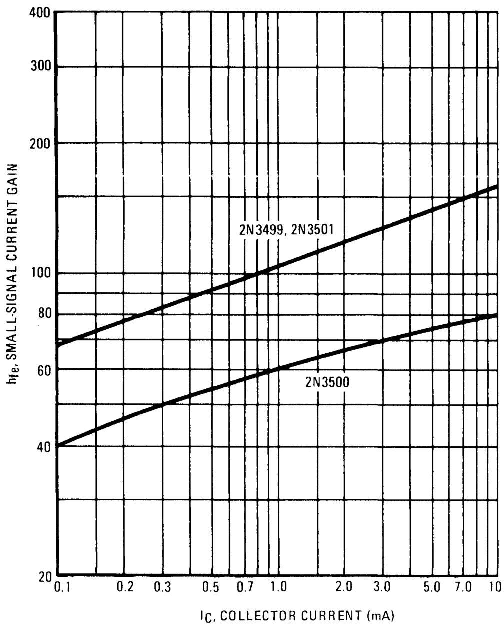


FIGURE 9 – OUTPUT IMPEDANCE

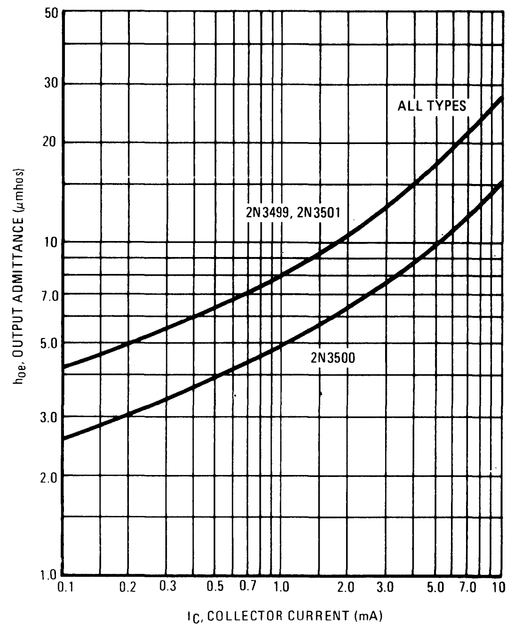


FIGURE 10 – INPUT IMPEDANCE

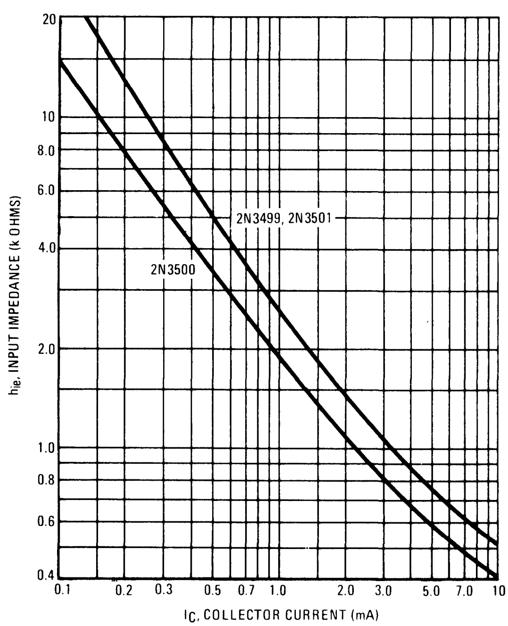
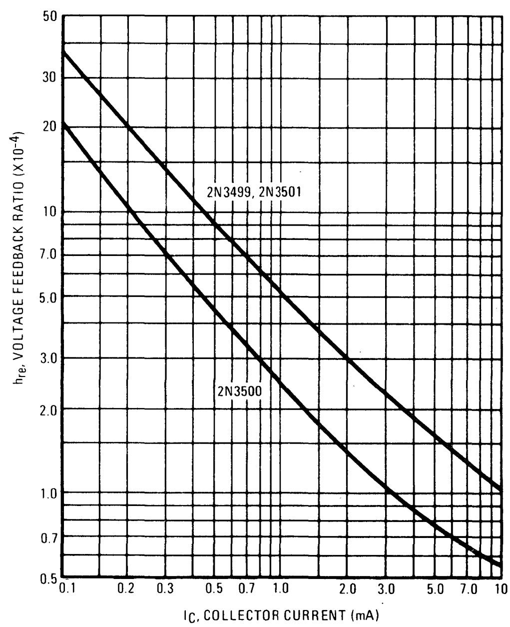
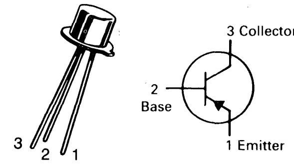


FIGURE 11 – VOLTAGE FEEDBACK RATIO



2N3546

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−12	Vdc
Collector-Base Voltage	V_{CBO}	−15	Vdc
Emitter-Base Voltage	V_{EBO}	−4.5	Vdc
DC Collector Current	I_C	−200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Base Cutoff Current (V_{CE} = −10 Vdc, V_{EB} = −3.0 Vdc)	I_{BEV}	—	−0.10	μAdc
Collector Cutoff Current (V_{CE} = −10 Vdc, V_{EB} = −3.0 Vdc)	I_{CEX}	—	−0.010	μAdc
Collector Cutoff Current (V_{CB} = −10 Vdc) (V_{CB} = −10 Vdc, T_A = 150°C)	I_{CBO}	— —	−0.010 −10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = 10 mAdc, V_{CE} = −1.0 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)(1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(1)	h_{FE}	 20 30 15 25 15	 — 120 — — —	—
Collector-Emitter Saturation Voltage (1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{CE(sat)}$	 — — —	 −0.15 −0.25 −0.50	Vdc
Base-Emitter Saturation Voltage (1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −100 mAdc, I_B = −10 mAdc)	$V_{BE(sat)}$	 −0.7 −0.8 —	 −0.9 −1.3 −1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)	f_T	700	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	5.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	I_C = −50 mA, I_{B1} = −5.0 mA V_{BE} = 2.0 V, V_{CC} = −3.0 V	t_d	—	10	ns
Rise Time		t_r	—	15	ns
Storage Time	I_C = −50 mA, I_{B1} = I_{B2} = −5.0 mA V_{CC} = −3.0 V	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time		t_{on}	—	40	ns
Turn-Off Time		t_{off}	—	30	ns
Total Control Charge (I_C = 50 mA, I_B = 5.0 mA, V_{CC} = 3.0 V)		Q_T	—	400	pC

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2.0%.

3

FIGURE 1 — LIMITS OF SATURATION VOLTAGES

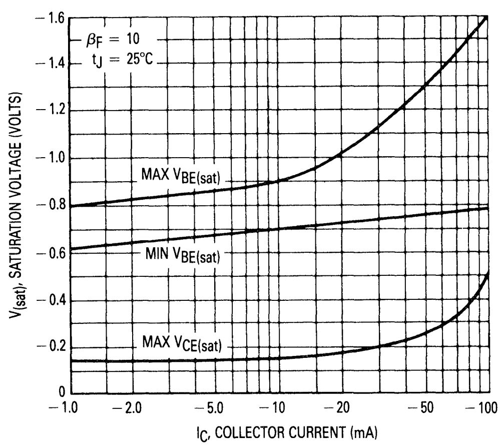


FIGURE 2 — STORAGE TIME BEHAVIOR

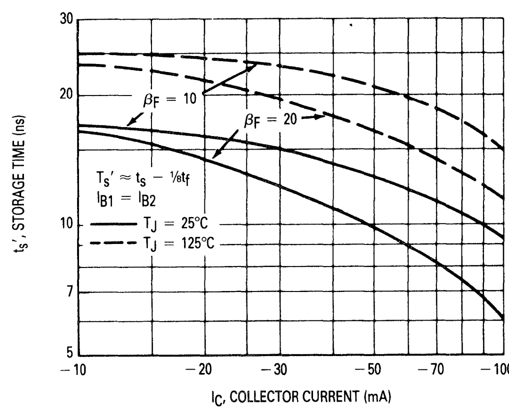
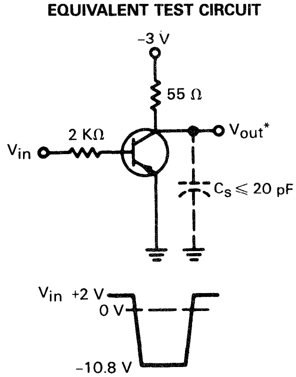
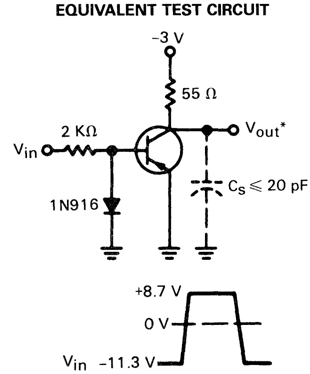


FIGURE 3 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



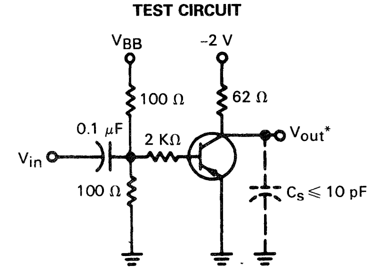
PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

FIGURE 4 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

FIGURE 5 — SWITCHING TIME TEST CIRCUIT

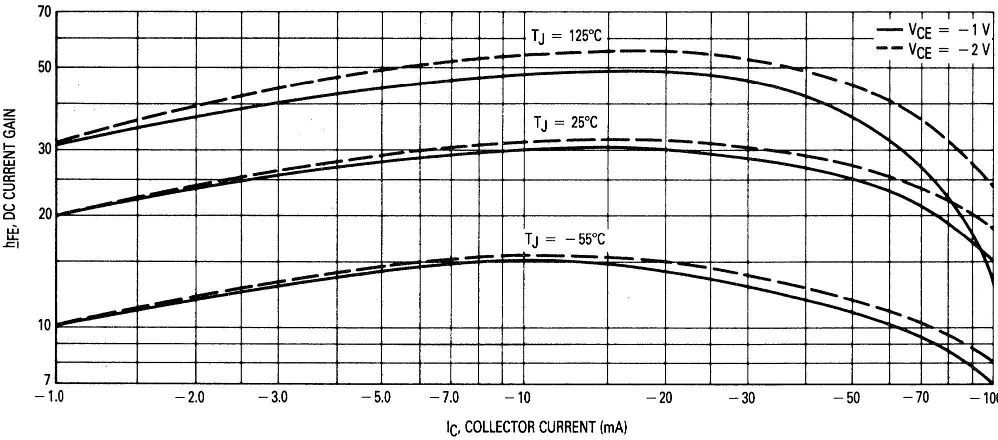


PULSE WIDTH > 200 ns
RISE TIME < 2 ns
Z_{in} = 50 Ω

t_{on}: V_{BB} = +3 V, V_{in} = −7 V
t_{off}: V_{BB} = −4 V, V_{in} = +6 V

*OSCILLOSCOPE RISE TIME ≤ 1 ns

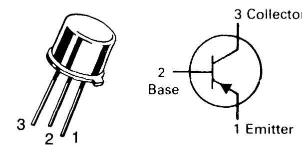
FIGURE 6 — MINIMUM CURRENT GAIN CHARACTERISTICS



3

2N3634 thru 2N3637

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	2N3634 2N3635	2N3636 2N3637	Unit
Collector-Emitter Voltage	V_{CEO}	−140	−175	Vdc
Collector-Base Voltage	V_{CBO}	−140	−175	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	 2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CEO}$	 −140 −175	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	 2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CBO}$	 −140 −175	 — —	Vdc
Emitter-Base Breakdown Voltage I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −100 Vdc, I_E = 0)		I_{CBO}	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 Vdc)	 2N3634, 2N3636 2N3635, 2N3637	h_{FE}	 40 80	 — —	—
(I_C = −1.0 mAdc, V_{CE} = −10 Vdc)	2N3634, 2N3636 2N3635, 2N3637		45 90	— —	
(I_C = −10 mAdc, V_{CE} = −10 Vdc)(1)	2N3634, 2N3636 2N3635, 2N3637		50 100	— —	
(I_C = −50 mAdc, V_{CE} = −10 Vdc)(1)	2N3634, 2N3636 2N3635, 2N3637		50 100	150 300	
(I_C = −150 mAdc, V_{CE} = −10 Vdc)(1)	2N3634, 2N3636 2N3635, 2N3637		25 50	— —	
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{CE(sat)}$	 — —	 −0.3 −0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc)		$V_{BE(sat)}$	 — −0.65	 −0.8 −0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = −30 Vdc, I_C = −30 mAdc, f = 100 MHz)	 2N3634, 2N3636 2N3635, 2N3637	f_T	 150 200	 — —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	10	pF
Input Capacitance (V_{EB} = −1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	75	pF
Input Impedance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{ie}	100 200	600 1200	ohms
Voltage Feedback Ratio (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{re}	—	3.0	$X 10^{-4}$
Small-Signal Current Gain (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{fe}	40 80	160 320	—
Output Admittance (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)		h_{oe}	—	200	μmhos
Noise Figure (I_C = −0.5 mAdc, V_{CE} = −10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)		NF	—	3.0	dB

SWITCHING CHARACTERISTICS

		Symbol	Min	Max	Unit
Turn-On Time	(V_{CC} = −100 Vdc, V_{BE} = 4.0 Vdc, I_C = −50 mAdc, I_{B1} = I_{B2} = −5.0 mAdc)	t_{on}	—	400	ns
Turn-Off Time		t_{off}	—	600	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

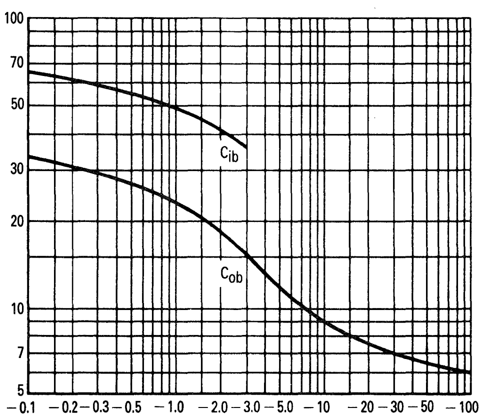


FIGURE 2 — GAIN-BANDWIDTH PRODUCT

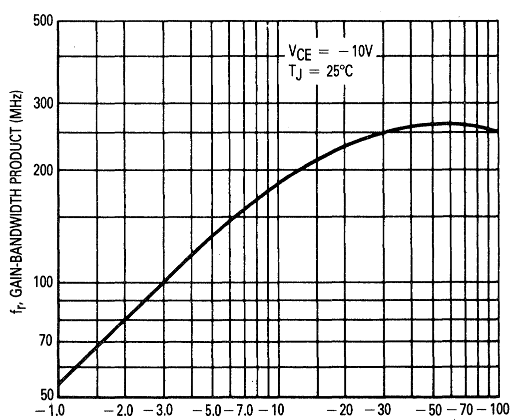
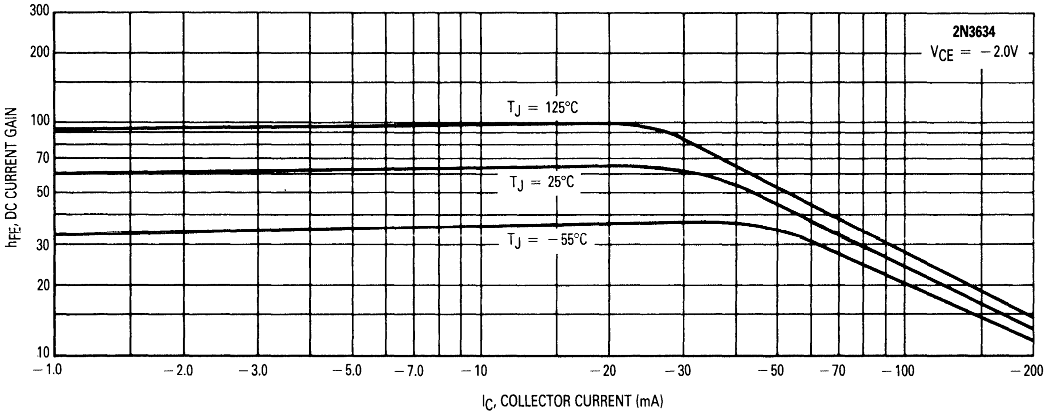


FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

2N3634



2N3637

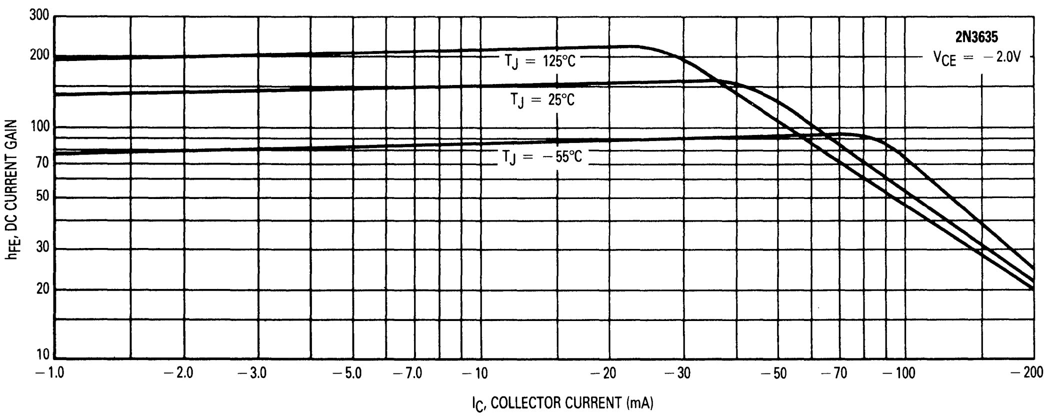


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FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

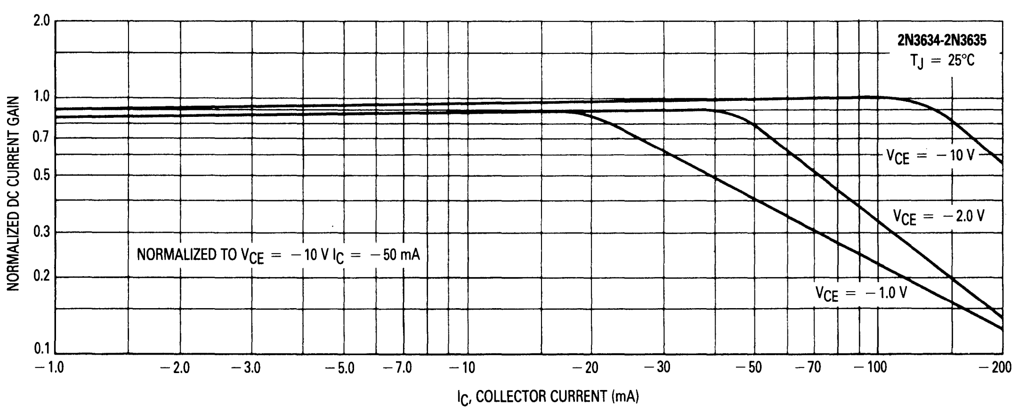
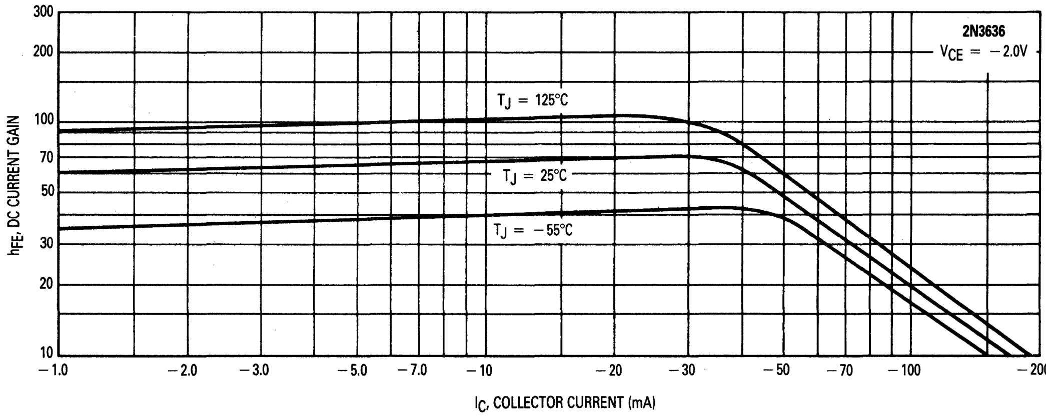


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

2N3636



2N3637

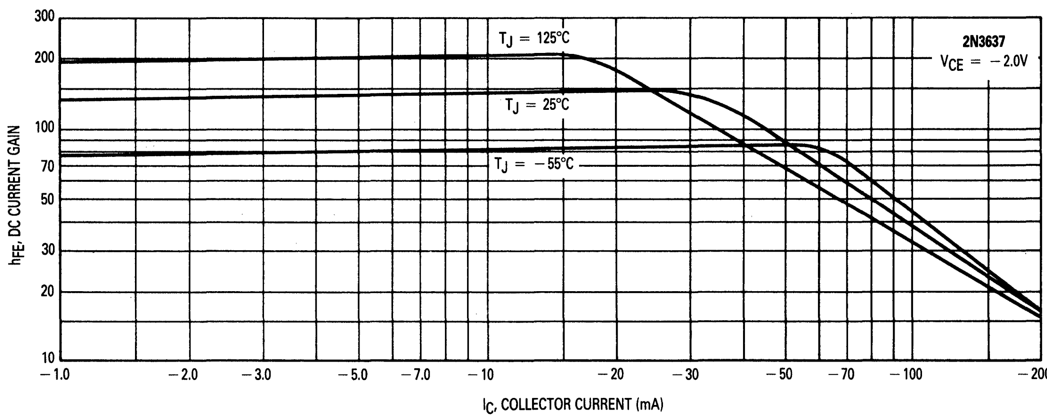


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

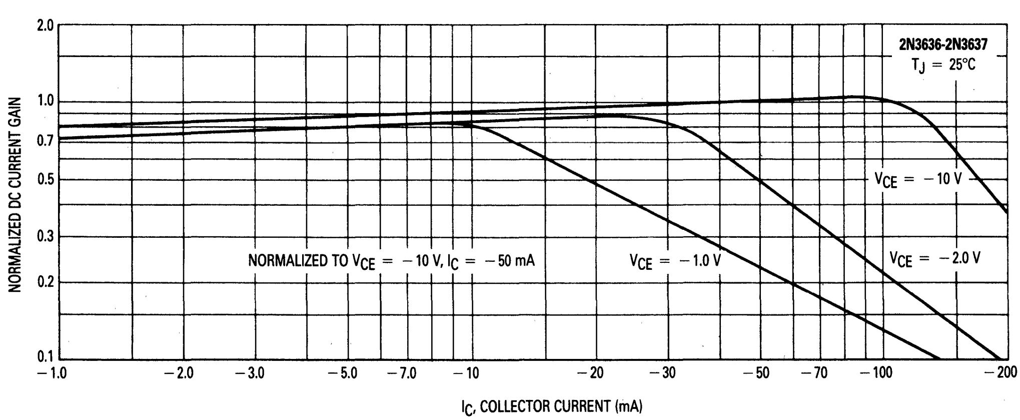


FIGURE 7 — INPUT IMPEDANCE

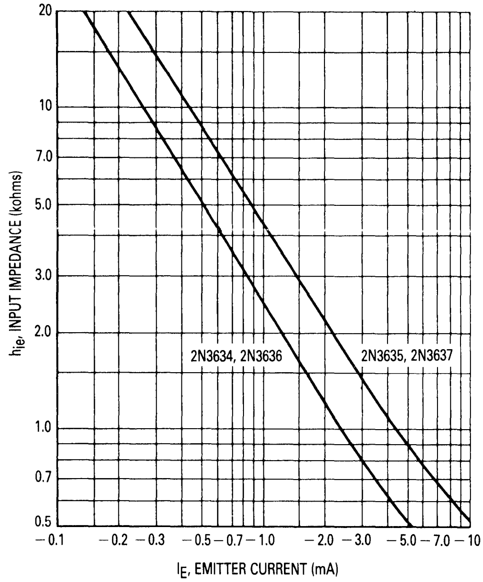


FIGURE 8 — OUTPUT IMPEDANCE

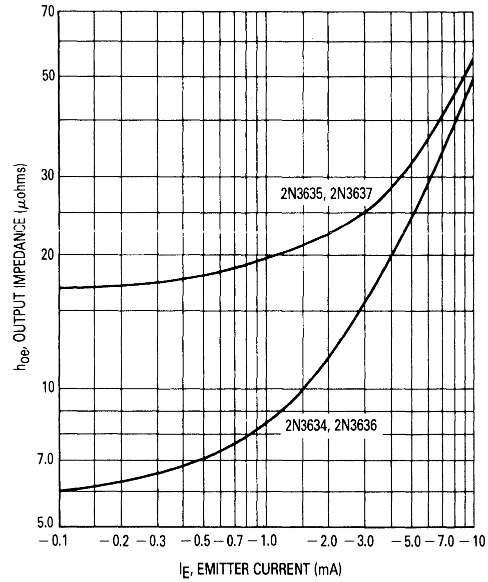


FIGURE 9 — CURRENT GAIN

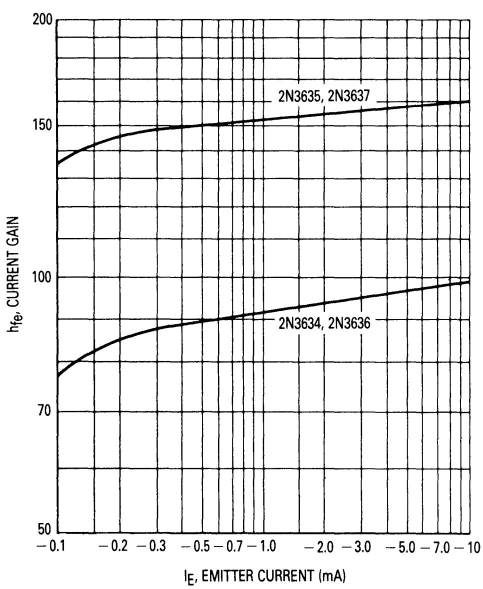


FIGURE 10 — VOLTAGE FEEDBACK RATIO

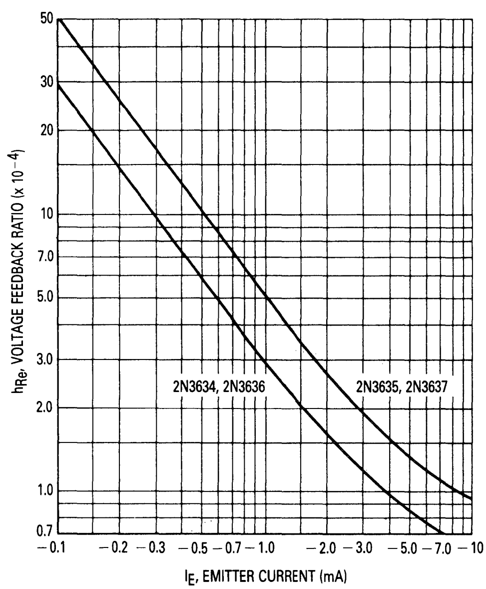


FIGURE 11 — SATURATION VOLTAGES

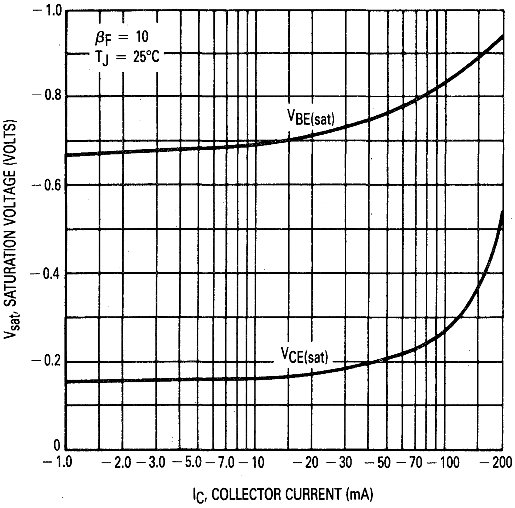


FIGURE 12 — TEMPERATURE COEFFICIENTS

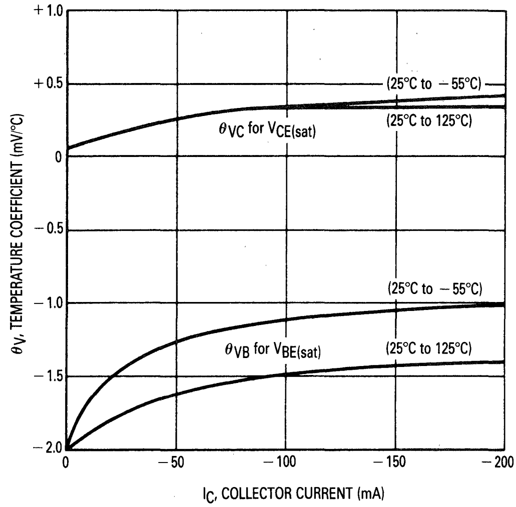
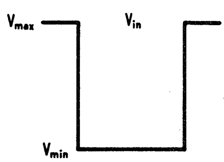


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. ≅ 20 μs
DUTY CYCLE ≤ 2%
RISE TIME ≤ 20 ns

	V_{max}	V_{min}
TURN-ON	+4.0 V	−5.65 V
TURN-OFF	+4.1 V	−5.9 V

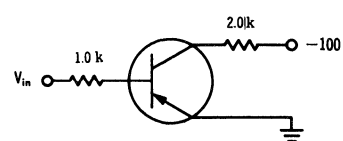


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

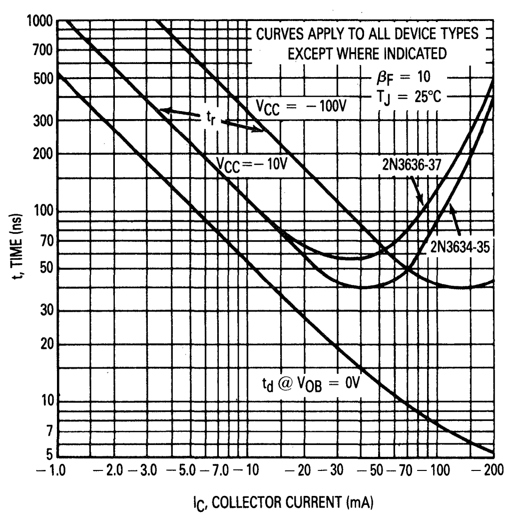
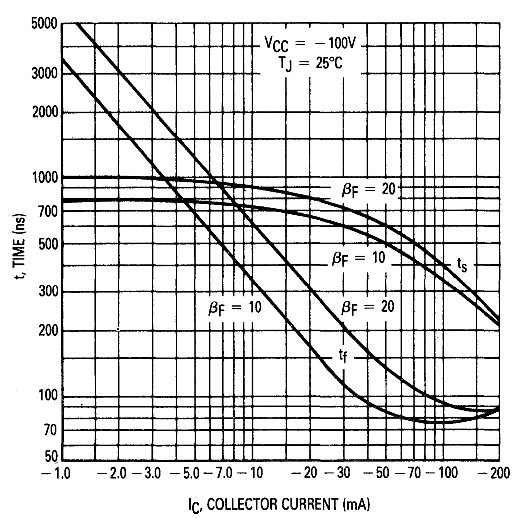


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN



MAXIMUM RATINGS

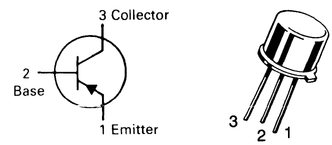
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−40	Vdc
Collector-Base Voltage	V_{CBO}	−40	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.5	Adc
		TO-39 2N3762	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	+235	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	°C/W

2N3762

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

PNP SILICON

3

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−40	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CE} = −20 Vdc, V_{EB} = −2.0 Vdc) (V_{CE} = −20 Vdc, V_{EB} = −2.0 Vdc, T_A = 100°C)	I_{CEX}	 — —	 −0.10 −10	μAdc
Base Cutoff Current (V_{CE} = −20 Vdc, V_{EB} = −2.0 Vdc)	I_{BL}	—	−0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc) (I_C = −150 mAdc, V_{CE} = −1.0 Vdc) (I_C = −500 mAdc, V_{CE} = −1.0 Vdc) (I_C = −1.0 Adc, V_{CE} = −1.5 Vdc) (I_C = −1.5 Adc, V_{CE} = −5.0 Vdc)	h_{FE}	 35 40 35 30 30	 — — — 120 —	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{CE(sat)}$	 — — — —	 −0.1 −0.22 −0.5 −0.9	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −150 mAdc, I_B = −15 mAdc) (I_C = −500 mAdc, I_B = −50 mAdc) (I_C = −1.0 Adc, I_B = −100 mAdc)	$V_{BE(sat)}$	 — — — −0.9	 −0.8 −1.0 −1.2 −1.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	15	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	80	pF
Current Gain — High Frequency (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		$\|h_{fe}\|$	1.8	—	—
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 V, V_{BE} = 2.0 V, I_C = −1.0 Amp, I_{B1} = −100 mA)	t_d	—	8.0	ns
Rise Time		t_r	—	3.5	ns
Storage Time	V_{CC} = −30 V, I_C = −1.0 Amp, I_{B1} = I_{B2} = −100 mA)	t_s	—	80	ns
Fall Time		t_f	—	35	ns
Total Control Charge (I_C = −1.0 Amp, I_B = −100 mA, V_{CC} = −30 V)		Q_T	—	30	pC

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

"ON" CONDITION CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

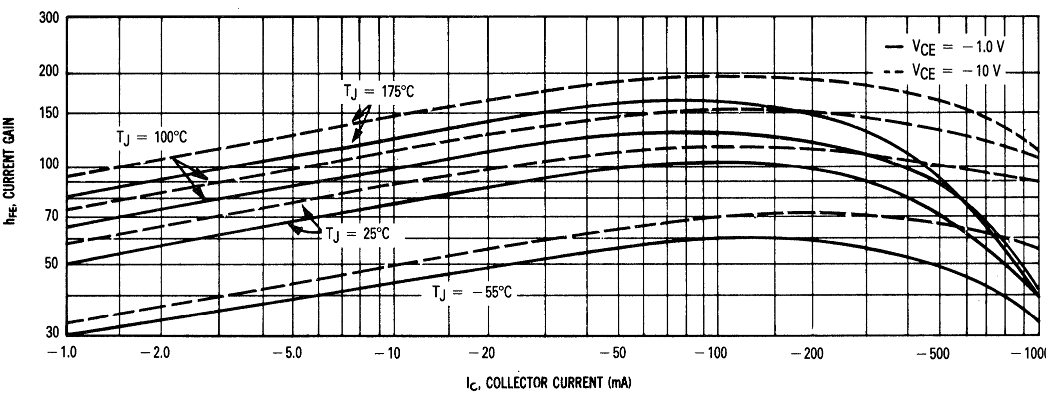
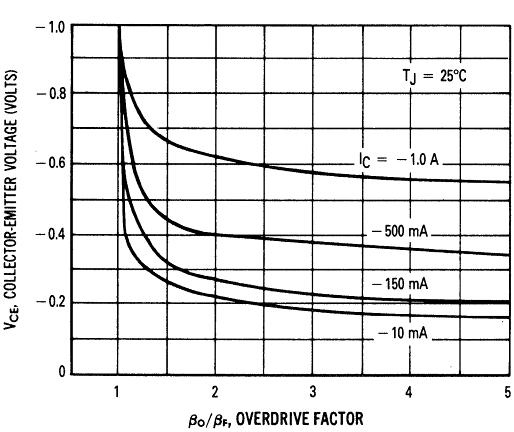


FIGURE 2 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector of 500 mA.

Observe that at I_C = 500 mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ \text{Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\ \text{mA}/I_{BF}} \qquad I_{BF} \approx 18.5\ \text{mA typ}$$

FIGURE 3 — "ON" VOLTAGES

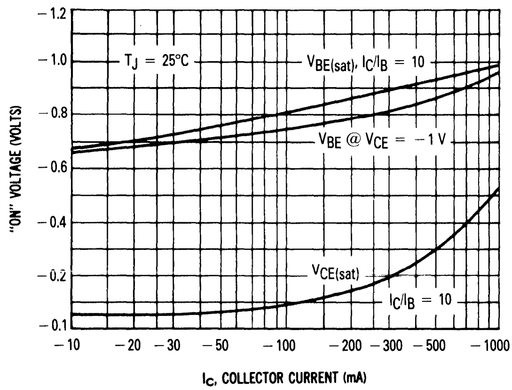


FIGURE 4 — TEMPERATURE COEFFICIENTS

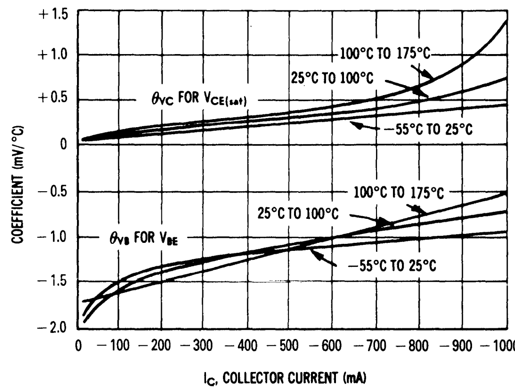


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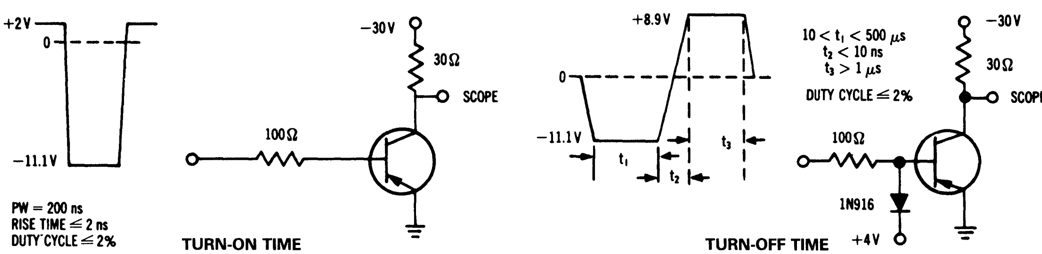
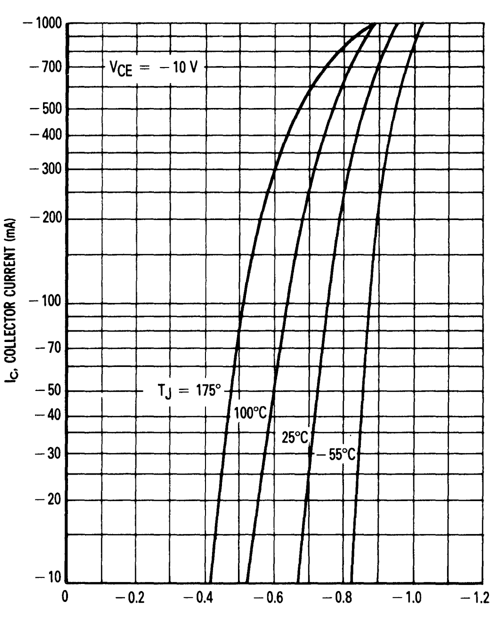
FIGURE 5 — SWITCHING TIME EQUIVALENT TEST CIRCUITS



LARGE SIGNAL CHARACTERISTICS

FIGURE 6 — TRANSCONDUCTANCE



"OFF" CONDITION CHARACTERISTICS

FIGURE 7 — TRANSCONDUCTANCE

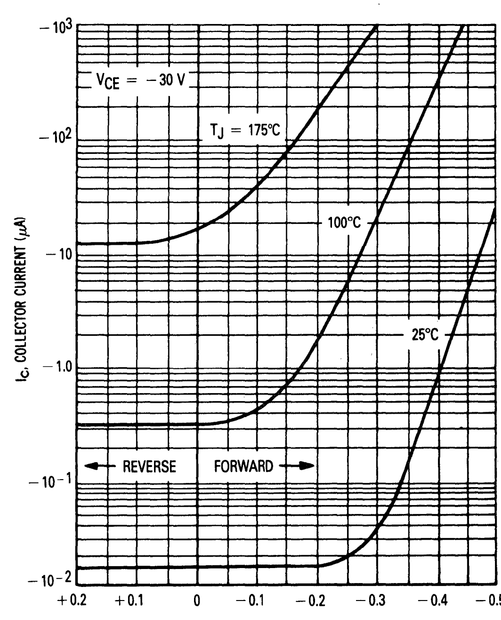


FIGURE 8 — INPUT ADMITTANCE

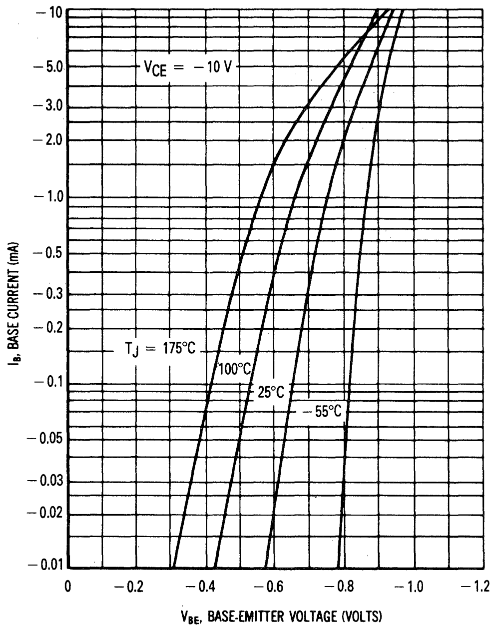
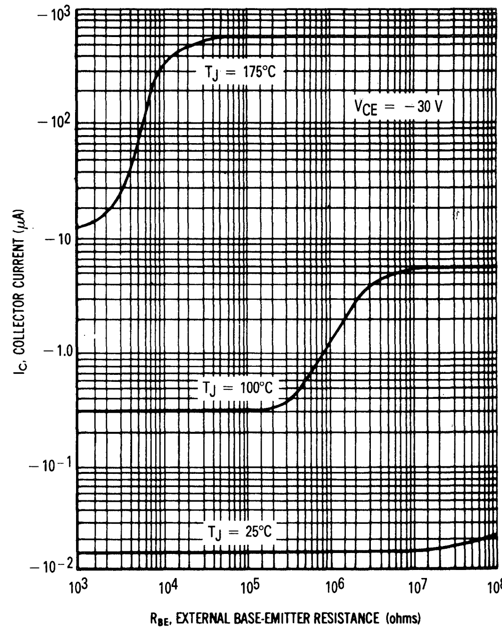


FIGURE 9 — EFFECT OF BASE-EMITTER RESISTANCE



SWITCHING CHARACTERISTICS

— T_J = 25°C
- - T_J = 150°C

FIGURE 10 — TURN-ON TIME

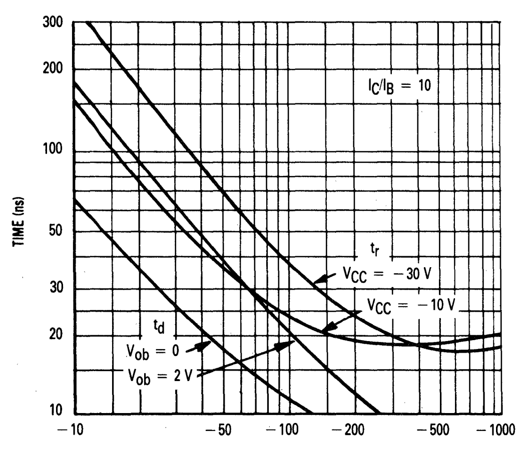


FIGURE 11 — RISE AND FALL TIME

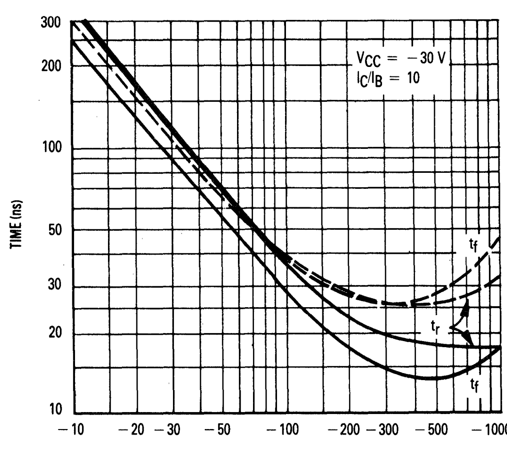


FIGURE 12 — STORAGE TIME

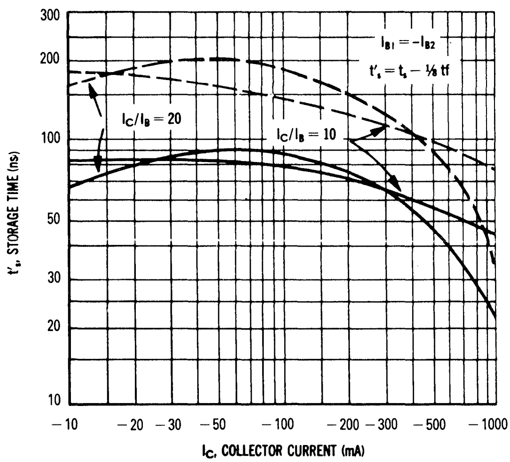


FIGURE 13 — FALL TIME

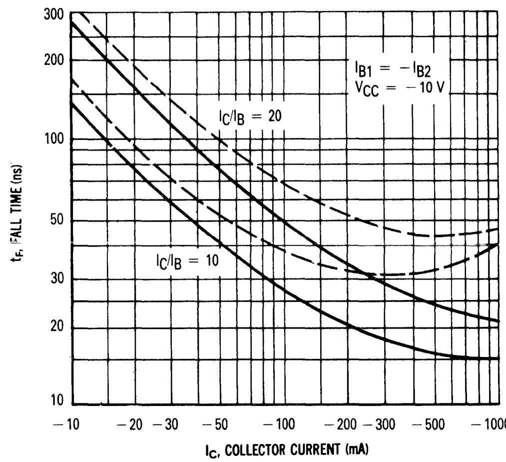


FIGURE 14 — CHARGE DATA

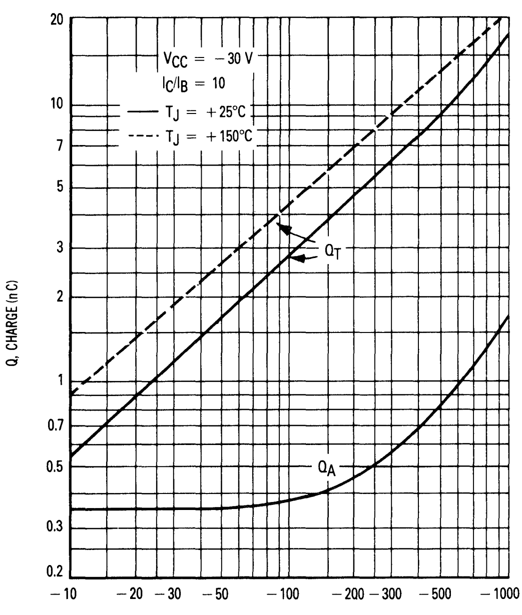


FIGURE 15 — CAPACITANCE

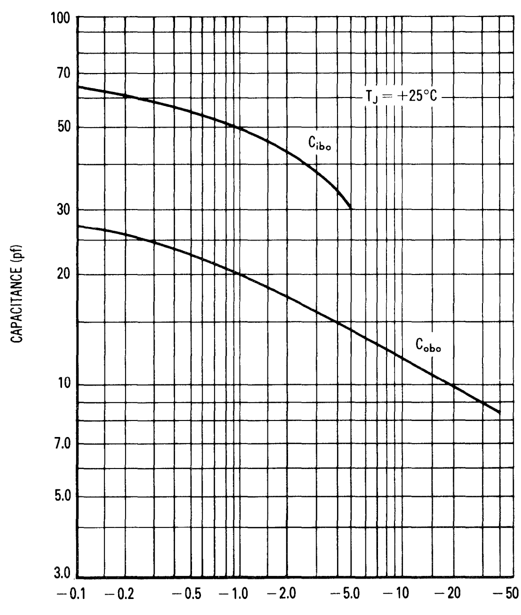
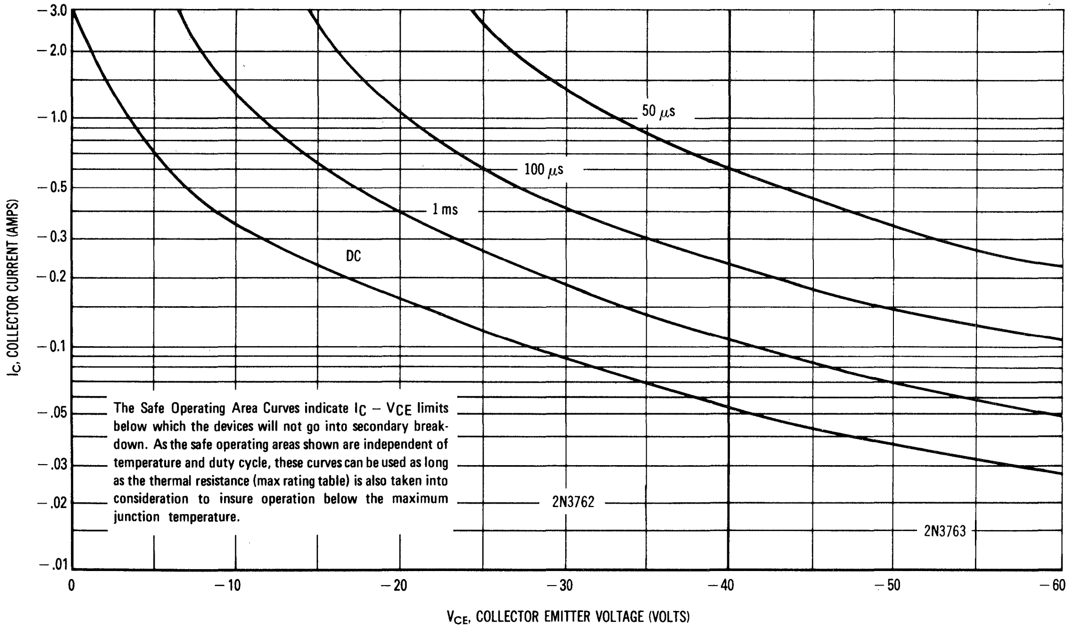
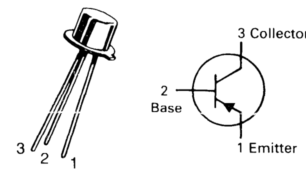


FIGURE 16 — ACTIVE REGION SAFE OPERATING AREAS



2N3799★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Emitter Voltage	V_{CEO}	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0) (V_{CB} = −50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 — —	 −0.01 −10	μAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	—	−20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −1.0 μAdc, V_{CE} = −5.0 Vdc) (I_C = −10 μAdc, V_{CE} = −5.0 Vdc) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc) (I_C = −100 μAdc, V_{CE} = −5.0 Vdc, T_A = −55°C) (I_C = −500 μAdc, V_{CE} = −5.0 Vdc) (I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc) (I_C = −10 mAdc, V_{CE} = −5.0 Vdc)(1)	h_{FE}	 75 225 300 150 300 300 250	 — — — — — — —	 — — — — 900 — —	—
Collector-Emitter Saturation Voltage (I_C = −100 μAdc, I_B = −10 μAdc) (I_C = −1.0 mAdc, I_B = −100 μAdc)	$V_{CE(sat)}$	 — —	 — —	 −0.2 −0.25	Vdc
Base-Emitter Saturation Voltage (I_C = −100 μAdc, I_B = −10 μAdc) (I_C = −1.0 mAdc, I_B = −100 μAdc)	$V_{BE(sat)}$	 — —	 — —	 −0.7 −0.8	Vdc
Base-Emitter On Voltage (I_C = −100 μAdc, V_{CE} = −5.0 Vdc)	$V_{BE(on)}$	—	—	−0.7	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)	f_T				MHz
(I_C = −500 μAdc, V_{CE} = −5.0 Vdc, f = 20 MHz)		30	—	—	
(I_C = −1.0 mAdc, V_{CE} = −5.0 Vdc, f = 100 MHz)		100	—	500	
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	8.0	pF
Input Impedance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{ie}	10	—	40	k ohms
Voltage Feedback Ratio (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{re}	—	—	25	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{fe}	300	—	900	—
Output Admittance (I_C = −1.0 mAdc, V_{CE} = −10 Vdc, f = 1.0 kHz)	h_{oe}	5.0	—	60	μmhos
Noise Figure (I_C = −100 μAdc, V_{CE} = −10 Vdc, R_G = 3.0 k ohms),	NF				dB
f = 100 Hz, B.W. = 20 Hz		—	2.5	4.0	
Spot f = 1.0 kHz, B.W. = 200 Hz		—	0.8	1.5	
Noise f = 10 kHz, B.W. = 2.0 kHz		—	0.8	1.5	
f = 1.0 kHz		—	1.5	2.5	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

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SPOT NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 1 — SOURCE RESISTANCE EFFECTS, f = 1.0 kHz

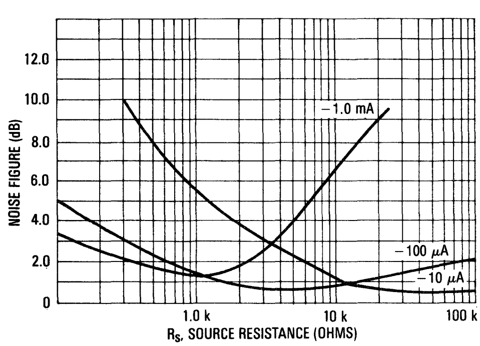


FIGURE 2 — SOURCE RESISTANCE EFFECTS, f = 10 Hz

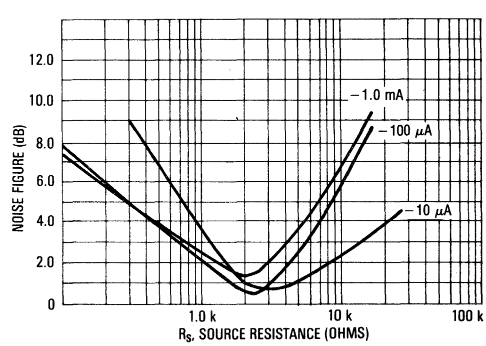


FIGURE 3 — FREQUENCY EFFECTS

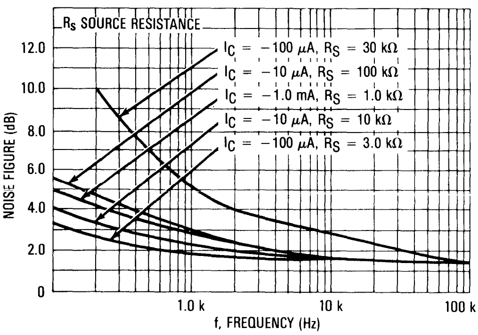
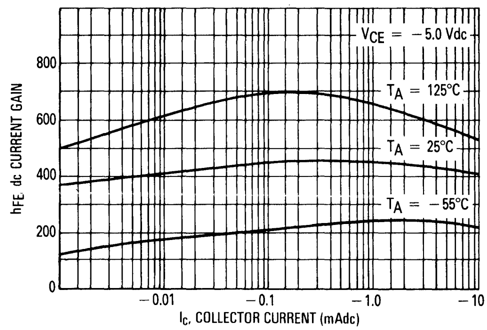


FIGURE 4 — TYPICAL CURRENT GAIN CHARACTERISTICS — 2N3799



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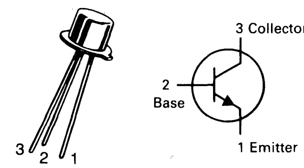
2N3947★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{EB} = 3.0 Vdc) (V_{CE} = 40 Vdc, V_{EB} = 3.0 Vdc, T_A = 150°C)	I_{CEX}	 — —	 0.010 15	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{EB} = 3.0 Vdc)	I_{BL}	—	.025	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)(1)	h_{FE}	 60 90 100 40	 — — 300 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 0.6 —	 0.9 1.0	—
SMALL-SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance (V_{EB} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{ie}	2.0	12	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{re}	—	20	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{fe}	100	700	—
Output Admittance (I_C = 10 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos
Collector Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 31.8 MHz)	$r_b'C_c$	—	200	ps
Noise Figure (I_C = 100 μA, V_{CE} = 5.0 V, R_g = 1.0 kΩ, f = 1.0 kHz)	NF	—	5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	V_{CC} = 3.0 Vdc, V_{BE} = −0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mA	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	V_{CC} = 3.0 V, I_C = 10 mA, I_{B1} = I_{B2} = 1.0 mAdc	t_s	—	375	ns
Fall Time		t_f	—	75	ns

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

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TYPICAL SWITCHING CHARACTERISTICS
(T_A = 25°C unless otherwise noted)

FIGURE 1 — DELAY AND RISE TIME

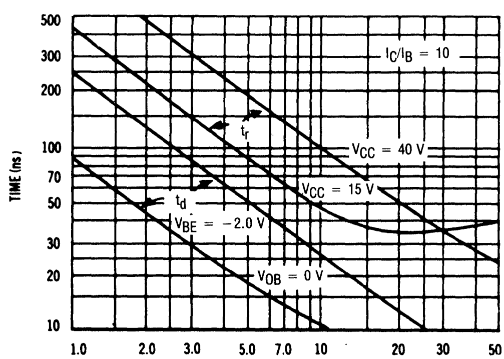


FIGURE 2 — RISE TIME

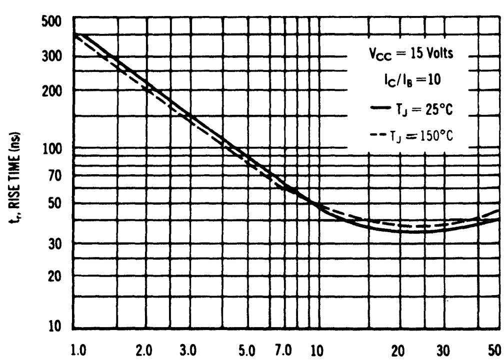


FIGURE 3 — STORAGE AND FALL TIMES

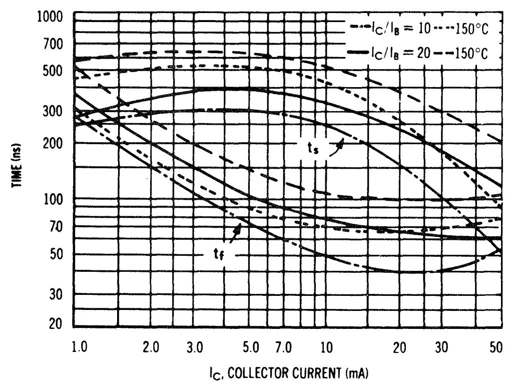


FIGURE 4 — TURN-ON TIME EQUIVALENT TEST CIRCUIT

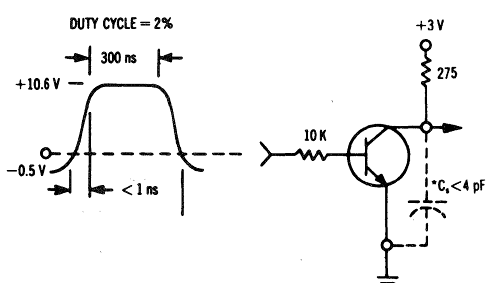
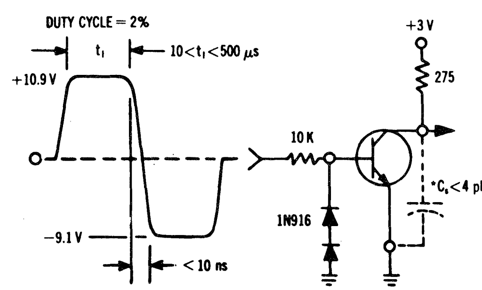


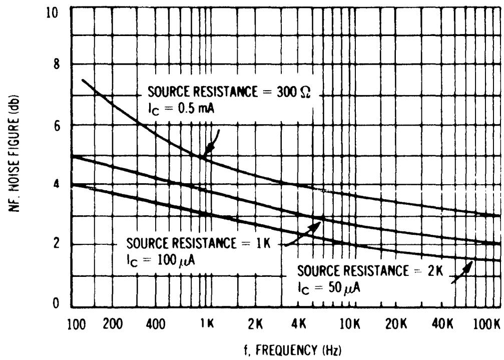
FIGURE 5 — TURN-OFF TIME EQUIVALENT TEST CIRCUIT

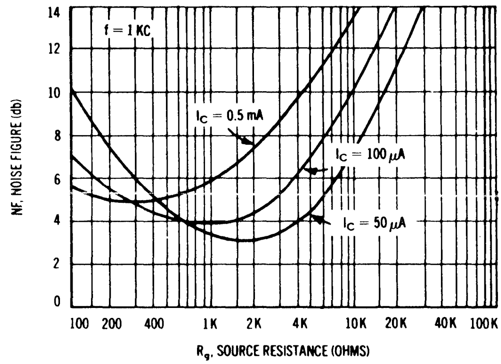


*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

AUDIO SMALL-SIGNAL CHARACTERISTICS

FIGURE 6 — NOISE FIGURE VARIATIONS
V_{CE} = 5.0 V, T_A = 25°C





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h PARAMETERS
V_{CE} = 10 V, T_A = 25°C, f = 1.0 kc

FIGURE 7 — CURRENT GAIN

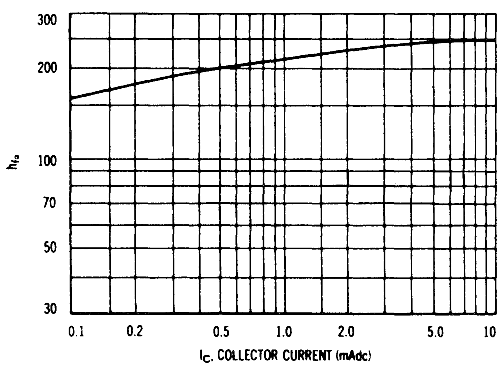


FIGURE 8 — OUTPUT CAPACITANCE

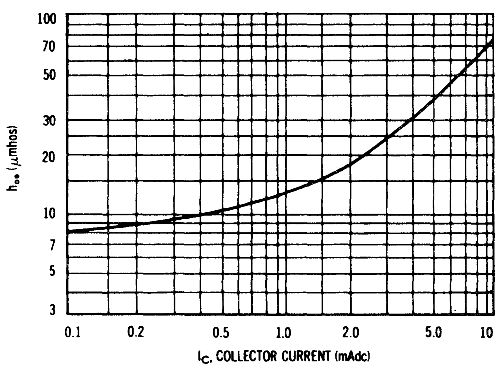


FIGURE 9 — INPUT IMPEDANCE

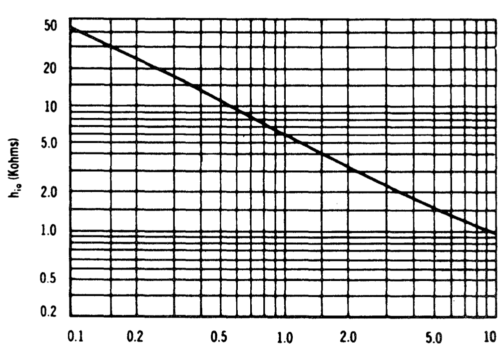


FIGURE 10 — VOLTAGE FEEDBACK RATIO

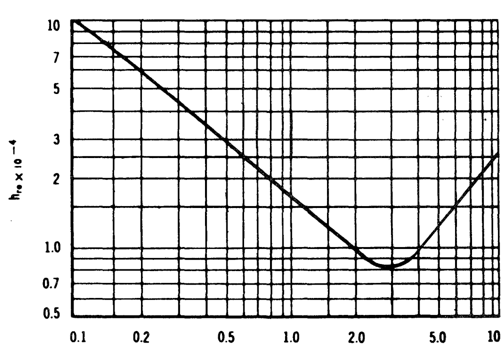


FIGURE 11 — CURRENT GAIN CHARACTERISTICS

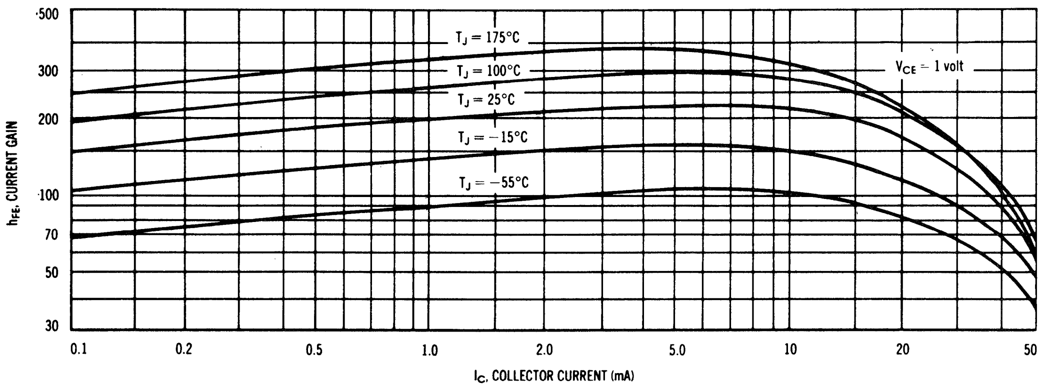


FIGURE 12 — CAPACITANCE

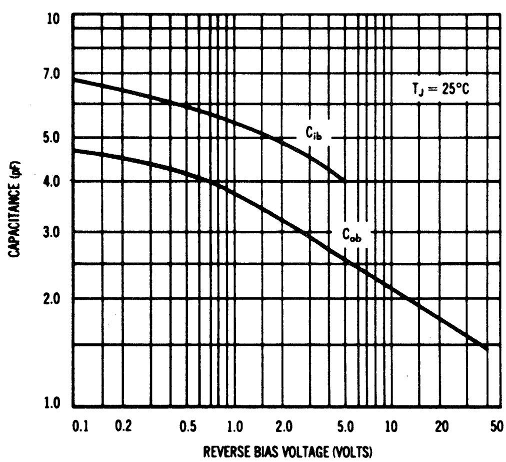


FIGURE 13 — CHARGE DATA

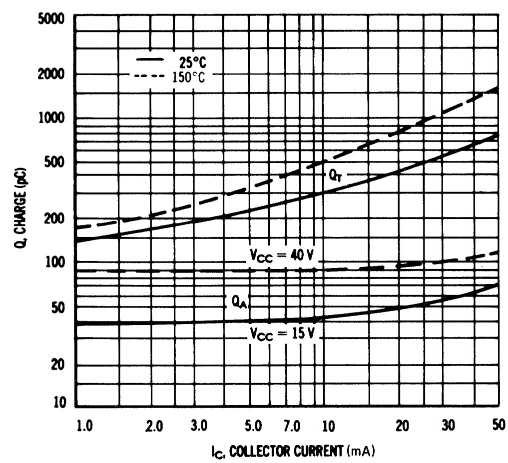


FIGURE 14 — COLLECTOR SATURATION REGION

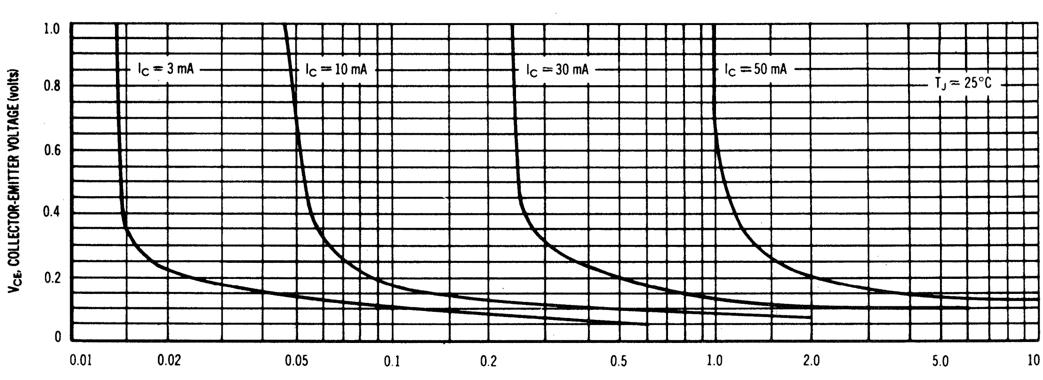


FIGURE 15 — "ON" VOLTAGES

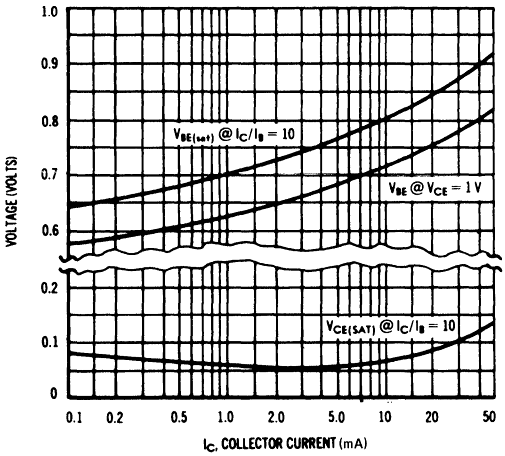
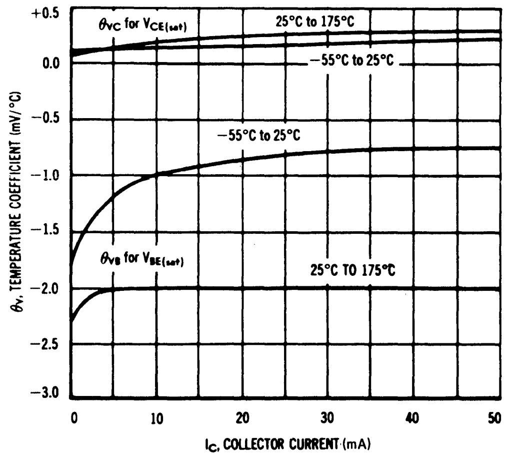


FIGURE 16 — TEMPERATURE COEFFICIENTS



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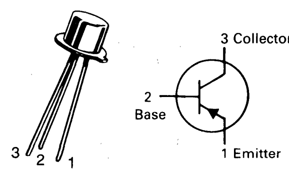
2N3963, 2N3964★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTORS

PNP SILICON

★This is a Motorola designated preferred device.

Refer to 2N3799 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3964	2N3963	Unit
Collector-Emitter Voltage	V_{CEO}	−45	−80	V
Collector-Base Voltage	V_{CBO}	−45	−80	V
Emitter-Base Voltage	V_{EBO}	−6.0		V
Collector Current — Continuous	I_C	−200		mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −5.0 mA)	2N3963 2N3964	$V_{(BR)CEO}$	−80 −45	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = −10 µA)	2N3963 2N3964	$V_{(BR)CES}$	−80 −45	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −10 µA)	2N3963 2N3964	$V_{(BR)CBO}$	−80 −45	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 µA		$V_{(BR)EBO}$	−6.0	—	Vdc
Collector Cutoff Current (V_{CE} = −40 V) (V_{CE} = −70 V)	2N3964 2N3963	I_{CBO}	— —	−10 −10	nAdc
Collector Cutoff Current (V_{CE} = −70 V) (V_{CE} = −40 V)	2N3963 2N3964	I_{CES}	— —	−10 −10	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 V)		I_{EBO}	—	−10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −10 µA, V_{CE} = −5.0 V)	2N3963 2N3964	h_{FE}	100 250	300 500	—
(I_C = −100 µA, V_{CE} = −5.0 V)	2N3963 2N3964		100 250	— —	
(I_C = −1.0 mA, V_{CE} = −5.0)	2N3963 2N3964		100 250	450 600	
(I_C = −10 µA, V_{CE} = −5.0, T_A = −55°C)	2N3963 2N3964		40 100	— —	

(continued)

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

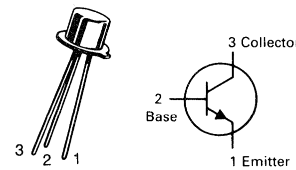
Characteristic		Symbol	Min	Max	Unit
DC Current Gain continued					
(I_C = −1.0 mA, V_{CE} = −5.0 V, T_A = 100°C))	2N3963		—	600	
	2N3964		—	800	
(I_C = −1.0 μA, V_{CE} = −5.0 V)	2N3963		60	—	
	2N3964		180	—	
(I_C = −10 μA, V_{CE} = −5.0 V)	2N3963		100	—	
	2N3964		200	—	
(I_C = −50 mA, V_{CE} = −5.0)(1)	2N3963		90	—	
	2N3964		180	—	
(I_C = −50 mA, V_{CE} = −5.0, T_A = −55°C)(1)	2N3963		45	—	
	2N3964		90	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			
(I_C = −10 mA, I_B = −0.5 mA)(1)			—	−0.25	V
(I_C = −50 mA, I_B = −5.0 mA)(1)			—	−0.4	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			
(I_C = −10 mA, I_B = −0.5 mA)(1)			—	0.9	V
(I_C = −50 mA, I_B = −5.0 mA)(1)			—	0.95	V
SMALL-SIGNAL CHARACTERISTICS					
Ouput Capacitance (V_{CB} = −5.0 V, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)		C_{ibo}	—	15	pF
Input Impedance		h_{ie}			kΩ
(I_C = −1.0 mA, V_{CE} = −5.0 V, f = 1.0 kHz)	2N3963		2.5	17	
	2N3964		6.0	20	
Voltage Feedback Ratio (I_C = −1.0 mA, V_{CE} = −5.0, f = 1.0 kHz)		h_{re}	—	10	10^{-4}
Small Signal Current Gain		h_{fe}			
(I_C = −1.0 mA, V_{CE} = −5.0 V, f = 1.0 kHz)	2N3963		100	550	—
	2N3964		250	700	—
Magnitude of Forward Current Transfer Ratio, Common-Emitter		$\|h_{fe}\|$			
(I_C = −0.5 mA, V_{CE} = −5.0 V, f = 20 MHz)	2N3963		2.0	8.0	—
	2N3964		2.5	8.0	—
Output Admittance		h_{oe}			μmhos
(I_C = −1.0 mA, V_{CE} = −5.0, f = 1.0 kHz)	2N3963		5.0	40	
	2N3964		5.0	50	
Noise Figure		NF			dB
(I_C = −20 mA, V_{CE} = −5.0 V, BW = 15.7 kHz)	2N3963		—	3	
	2N3964		—	2	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 1.5 kHz, f = 10 kHz, R_S = 10 kΩ)	2N3963		—	3	
	2N3964		—	2	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 150 Hz, f = 1.0 kHz, R_S = 10 kΩ)	2N3963		—	3	
	2N3964		—	2	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 15 Hz, f = 100 Hz, R_S = 10 hΩ)	2N3963		—	10	
	2N3964		—	4	
(I_C = −20 μA, V_{CE} = −5.0 V, BW = 2.0 Hz, f = 10 Hz, R_S = 10 kΩ)	2N3964		—	8	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

2N4014

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	2N4014	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous — Peak	I_C	1.0 2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.4 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 0.12 —	 1.7 120	μAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{EB} = 0)	I_{CES}	—	0.15	10	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 800 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	 30 60 30 40 35 20 20 25	 — — — — — — — —	 — 150 — — — — — —	—

(continued)

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.17	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.19	0.26	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	0.25	0.40	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.30	0.52	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	0.43	0.80	
(I_C = 1.0 mAdc, I_B = 100 mAdc)		—	0.55	0.95	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	—	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	—	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)		0.8	—	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	—	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	—	1.7	

SMALL-SIGNAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	55	pF

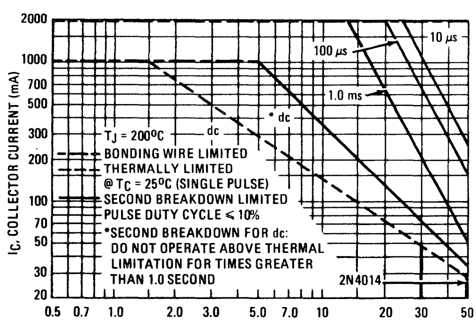
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8,10)	t_d	—	5.0	10	ns
Rise Time		t_r	—	15	30	
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9,10)	t_s	—	30	50	ns
Fall Time		t_f	—	20	25	ns
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_{on}	—	20	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

3

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



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TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

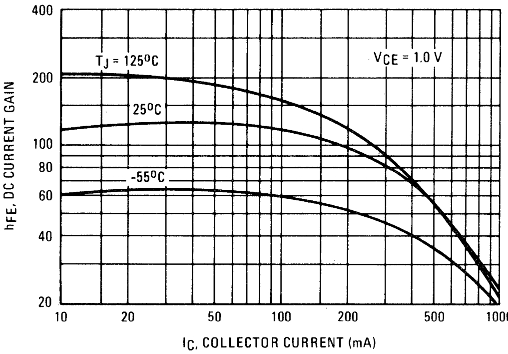


FIGURE 3 – "ON" VOLTAGES

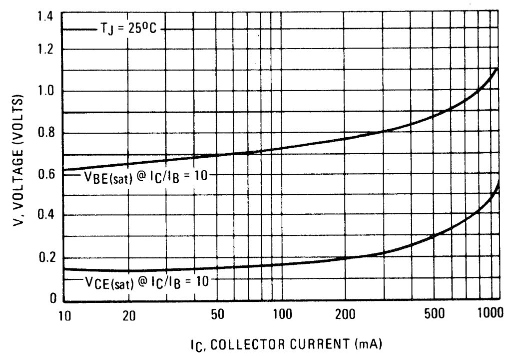


FIGURE 4 – COLLECTOR SATURATION REGION

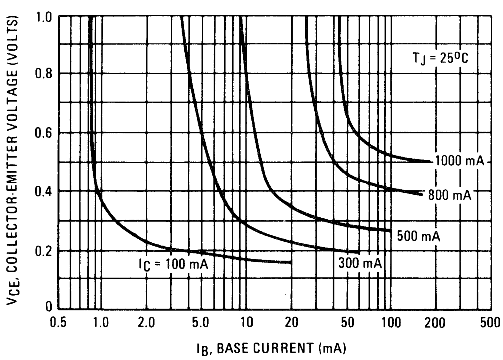
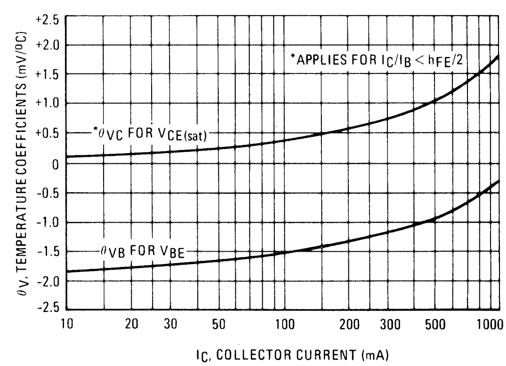


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

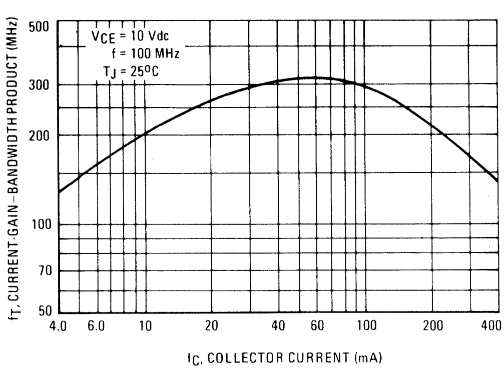


FIGURE 7 – CAPACITANCE

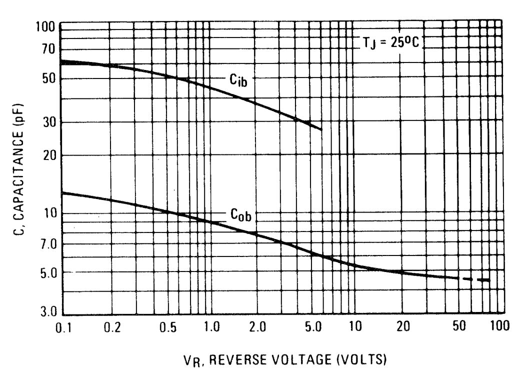


FIGURE 8 – TURN-ON TIME

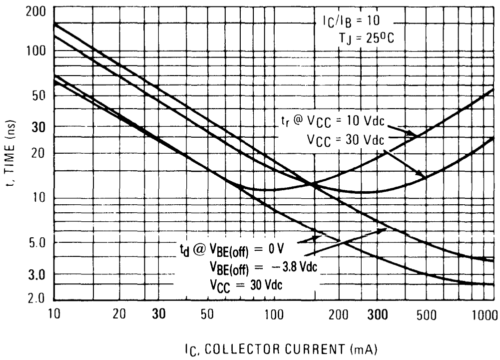


FIGURE 9 – TURN-OFF TIME

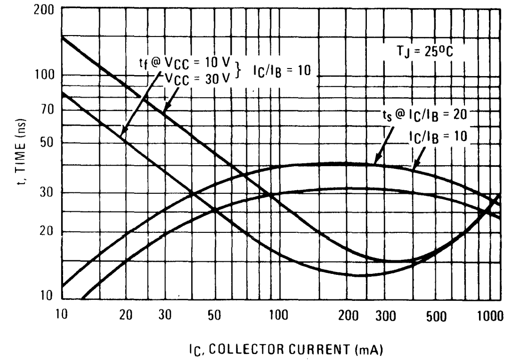
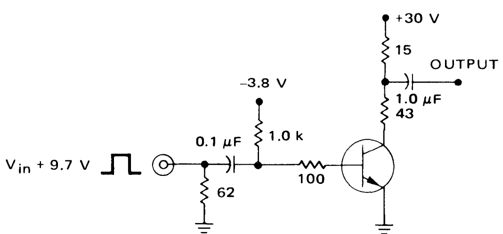
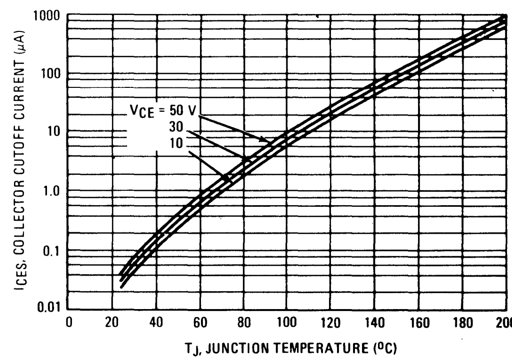


FIGURE 10 – SWITCHING TIME TEST CIRCUIT



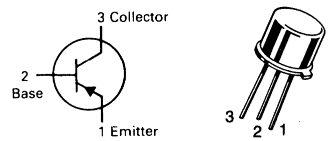
$t_r \leq 1.0$ ns
P.W. ≥ 200 ns
Duty Cycle ≤ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

FIGURE 11 – COLLECTOR CUTOFF CURRENT



2N4032
2N4033

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

Refer to 2N4404 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4032	2N4033	Unit
Collector-Emitter Voltage	V_{CEO}	−60	−80	Vdc
Collector-Base Voltage	V_{CBO}	−60	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	−5.0	Vdc
		2N4032	2N4033	
Collector Current — Continuous	I_C	−1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.56		W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mA)	 2N4032 2N4033	$V_{(BR)CEO}$	 −60 −80	 — —	V
Collector-Base Breakdown Voltage (I_C = −10 μA)	 2N4032 2N4033	$V_{(BR)CBO}$	 −60 −80	 — —	V
Emitter-Base Breakdown Voltage (I_E = −10 μA)		$V_{(BR)EBO}$	−5.0	—	V
Collector Cutoff Current (V_{CB} = −50 V) (V_{CB} = −60 V) (V_{CB} = −50 V, T_A = 150°C) (V_{CB} = −60 V, T_A = 150°C)	 2N4032 2N4033 2N4032 2N4033	I_{CBO}	 — — — —	 −50 −50 −50 −50	nA μA
Emitter Cutoff Current (V_{EB} = −5.0 V)		I_{EBO}	—	−10	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = −100 mA, V_{CE} = −5.0 V, @ −55°C)(1)	 2N4032,33	h_{FE}	 40	 —	—
(I_C = −100 μA, V_{CE} = −5.0 V)	2N4032,33		75	—	
(I_C = −100 mA, V_{CE} = −5.0 V)(1)	2N4032,33		100	300	
(I_C = −500 mA, V_{CE} = −5.0 V)(1)	2N4032,33		70	—	
(I_C = −1.0 A, V_{CE} = −5.0 V)F(1)	2N4032 2N4033		40 25	— —	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$			V
(I_C = −150 mA, I_B = −15 mA)		—	−0.15	
(I_C = −500 mA, I_B = −50 mA)		—	−0.50	
(I_C = −1.0 A, I_B = −100 mA) 2N4032		—	−1.0	
Base-Emitter Saturation Voltage(1) (I_C = −150 mA, I_B = −15 mA)	$V_{BE(sat)}$	—	−0.9	V
Base-Emitter On Voltage	$V_{BE(on)}$			V
(I_C = −1.0 A, V_{CE} = −1.0 V) 2N4032		—	−1.2	
(I_C = −500 mA, V_{CE} = −0.5 V)(1)		—	−1.1	
SMALL-SIGNAL CHARACTERISTICS				
Ouput Capacitance (V_{CE} = −10 V, f = 1.0 MHz)	C_{obo}	—	20	pF
Input Capacitance (V_{EB} = −0.5 V, f = 1.0 MHz)	C_{ibo}	—	110	pF
Small Signal Current Gain (I_C = −50 mA, V_{CE} = −10 V, f = 100 MHz)	h_{fe}	1.5	5.0	—
SWITCHING CHARACTERISTICS				
Storage Time (I_C = −500 mA, I_{B1} = I_{B2} = −50 mA)	t_s	—	350	ns
Turn-On Time (I_C = −500 mA, I_{B1} = −50 mA)	t_{on}	—	100	ns
Fall Time (I_C = −500 mA, I_{B1} = I_{B2} = −50 mA)	t_f	—	50	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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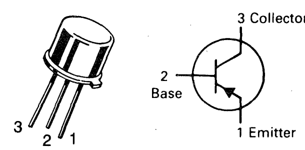
2N4036
2N4037

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	2N4036	2N4037	Unit
Collector-Emitter Voltage	V_{CEO}	−65	−40	Vdc
Collector-Base Voltage	V_{CBO}	−90	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−7.0	−7.0	Vdc
Base Current	I_B	−0.5		Adc
Collector Current — Continuous	I_C	−1.0		Adc
Continuous Power Dissipation at or Below T_C = 25°C Linear Derating Factor	P_D	5.0 28.6	5.0 28.6	Watts mW/°C
Continuous Power Dissipation at or Below T_A = 25°C Linear Derating Factor	P_D	1.0 5.72	1.0 5.72	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	230		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4036	2N4037	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = −100 mAdc, I_B = 0)(1)	2N4036 2N4037	$V_{CEO(sus)}$	−65 −40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = −0.1 mAdc)	2N4037	$V_{(BR)CBO}$	−60	—	Vdc
Collector Cutoff Current (V_{CE} = −85 V, V_{EB} = −1.5 V) (V_{CE} = −30 V, V_{EB} = −1.5 V, T_C = 150°C)	2N4036 2N4037	I_{CEX}	— —	−0.1 −100	mAdc
Collector Cutoff Current (V_{CB} = −90 V, I_E = 0) (V_{CB} = −60 V, I_E = 0)	2N4036 2N4037	I_{CBO}	— —	−1.0 −0.25	μAdc
Emitter Cutoff Current (V_{EB} = −7.0 Vdc, I_C = 0) (V_{EB} = −5.0 Vdc, I_C = 0)	2N4036 2N4037	I_{EBO}	— —	−10 −1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −0.1 mAdc, V_{CE} = −10 V) (I_C = −1.0 mAdc, V_{CE} = −10 V)	2N4036 2N4037	h_{FE}	20 15	— —	—
(I_C = −150 mAdc, V_{CE} = −10 V)(1)	2N4036 2N4037		40 50	140 250	
(I_C = −150 mAdc, V_{CE} = −2.0 V)(1)	2N4036		20	200	
(I_C = −500 mAdc, V_{CE} = −10 V)(1)	2N4036		20	—	
Collector-Emitter Saturation Voltage (I_C = −150 mA, I_B = −15 mA)(1)	2N4036 2N4037	$V_{CE(sat)}$	— —	−0.65 −1.4	V
Base-Emitter Saturation Voltage (I_C = −150 mA, I_B = −15 mA)(1)	2N4036	$V_{BE(sat)}$	—	−1.4	V
Base-Emitter On Voltage (I_C = −150 mA, V_{CE} = −10 V)(1)	2N4037	$V_{BE(on)}$	—	−1.5	V
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = −10 V, f = 1.0 MHz)	2N4037	C_{cb}	—	30	pF
Current Gain — High Frequency (I_C = −50 mA, V_{CE} = −10 V, f = 20 MHz)	2N4036 2N4037	$\|h_{fe}\|$	3.0 3.0	— 10	—
SWITCHING CHARACTERISTICS					
Rise Time (I_{B1} = −15 mA)	2N4036	t_r	—	70	ns
Storage Time (I_{B2} = −15 mA)	2N4036	t_s	—	600	ns
Fall Time (I_{B2} = −15 mA)	2N4036	t_f	—	100	ns
Turn-On Time (I_{B1} = I_{B2})	2N4036	t_{on}	—	110	ns
Turn-Off Time (I_{B1} = I_{B2})	2N4036	t_{off}	—	700	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

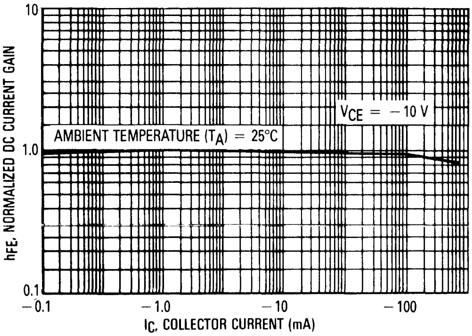


FIGURE 2 — DISSIPATION DERATING CURVE

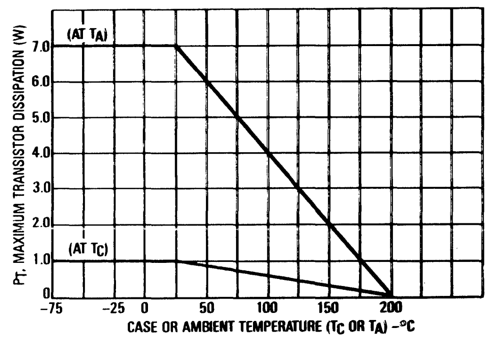


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FIGURE 3 — TYPICAL COLLECTOR-CUTOFF CURRENT versus JUNCTION TEMPERATURE

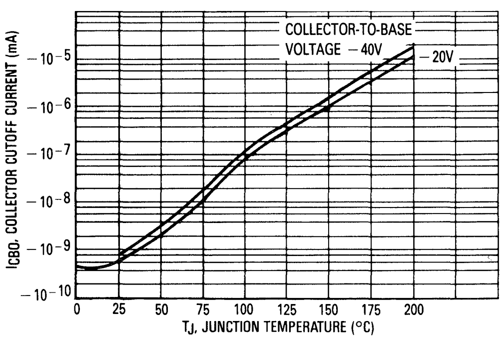


FIGURE 4 — TYPICAL SATURATION-VOLTAGE CHARACTERISTICS

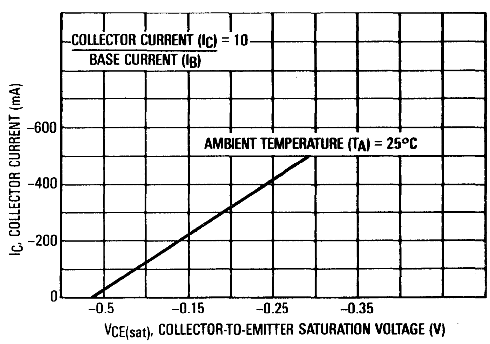


FIGURE 5 — TYPICAL SMALL-SIGNAL BETA CHARACTERISTICS

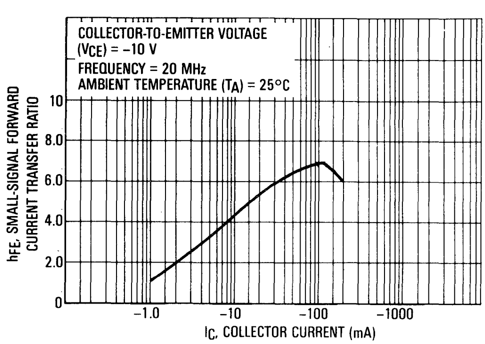
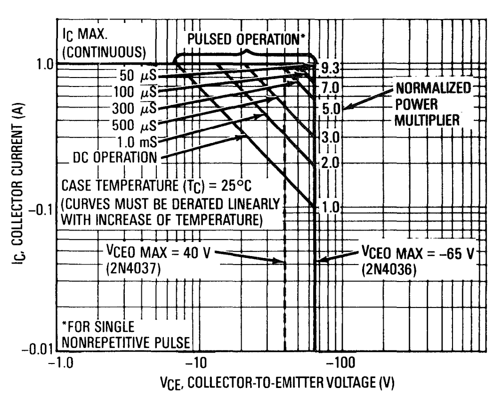
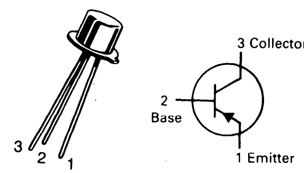


FIGURE 6 — MAXIMUM SAFE OPERATING AREAS (SOA)



2N4208

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−12	Vdc
Collector-Base Voltage	V_{CBO}	−12	Vdc
Emitter-Base Voltage	V_{EBO}	−4.5	Vdc
Collector Current — Continuous	I_C	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.0	Watts mW/°C
Operating and Storage Jucntion Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage(1) (I_C = −3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−12	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−12	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CE} = −6.0 Vdc, V_{BE} = 0) (V_{CE} = −6.0 Vdc, V_{BE} = 0, T_A = 125°C)	I_{CES}	— —	−10 −5.0	nAdc μAdc
Base Current (V_{CE} = −6.0 Vdc, V_{BE} = 0)	I_B	—	−1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −0.5 Vdc) (I_C = −10 mAdc, V_{CE} = −0.3 Vdc)(1) (I_C = −10 mAdc, V_{CE} = −0.3 Vdc, T_A = −55°C)(1) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)(1)	h_{FE}	 15 30 12 30	 — 120 — —	—
Collector-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = −0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{CE(sat)}$	 — — —	 −0.13 −0.15 −0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = − 0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{BE(sat)}$	 — −0.75 —	 −0.8 −0.95 −1.5	Vdc

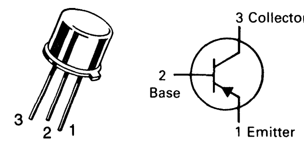
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		f_T	700	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −1.5 Vdc, V_{BE} = 0, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 Vdc, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	20	ns
Storage Time		t_s	—	20	ns
Fall Time		t_f	—	10	ns
Storage Time (I_C ≈ −10 mAdc, I_{B1} ≈ −10 mAdc, I_{B2} ≈ −10 mAdc)		t_s	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
(2) f_T is defined as the freqency at which $|h_{fe}|$ extrapolates to unity.

2N4404
2N4405

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−80	Vdc
Collector-Base Voltage	V_{CBO}	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)		$V_{(BR)CEO}$	−80	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)		$V_{(BR)CBO}$	−80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)		$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −60 Vdc, I_E = 0)		I_{CBO}	—	−25	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)		I_{EBO}	—	−25	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = −0.1 mAdc, V_{CE} = −5.0 Vdc)	2N4404		30	—	
	2N4405		75	—	
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)(1)	2N4404		40	—	
	2N4405		100	—	
(I_C = −150 mAdc, V_{CE} = −5.0 Vdc)(1)	2N4404		40	120	
	2N4405		100	300	
(I_C = −500 mAdc, V_{CE} = −5.0 Vdc)(1)	2N4404		30	—	
	2N4405		50	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = −10 mAdc, I_B = −1.0 mAdc)(1)			—	−0.15	
(I_C = −150 mAdc, I_B = −15 mAdc)(1)			—	−0.2	
(I_C = −500 mAdc, I_B = −50 mAdc)(1)			—	−0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = −10 mAdc, I_B = −1.0 mAdc)(1)			—	−0.8	
(I_C = −500 mAdc, I_B = −50 mAdc)(1)			−0.85	−1.2	
Base-Emitter On Voltage (I_C = −150 mAdc, V_{CE} = −1.0 Vdc)(1)		$V_{BE(on)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)		f_T	200	600	MHz
Collector-Base Capacitance (I_C = −10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	75	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 Vdc, $V_{BE(off)}$ = +2.0 Vdc, I_C = −500 mAdc, I_{B1} = −50 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = −30 Vdc, I_C = −500 mAdc, I_{B1} = I_{B2} = −50 mAdc)	t_s	—	175	ns
Fall Time		t_f	—	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON

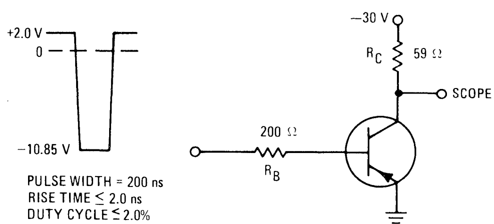
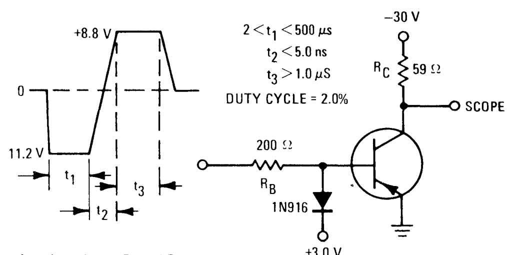


FIGURE 2 — TURN-OFF



To obtain data for curves, voltage levels are approximately as shown, R_B and R_C are varied.

TRANSIENT CHARACTERISTICS

25°C 100°C

FIGURE 3 — CAPACITANCES

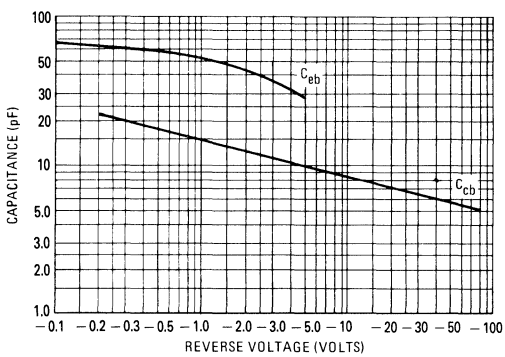


FIGURE 4 — CHARGE DATA

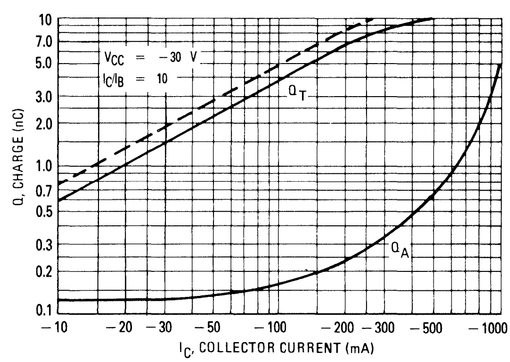


FIGURE 5 — DELAY TIME

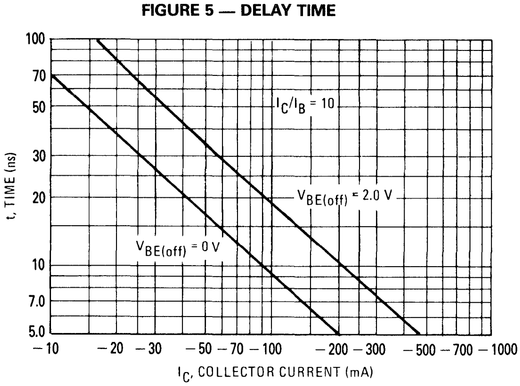


FIGURE 6 — RISE TIME

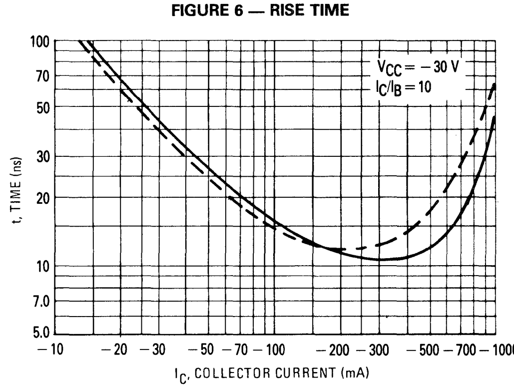


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FIGURE 7 — STORAGE TIME

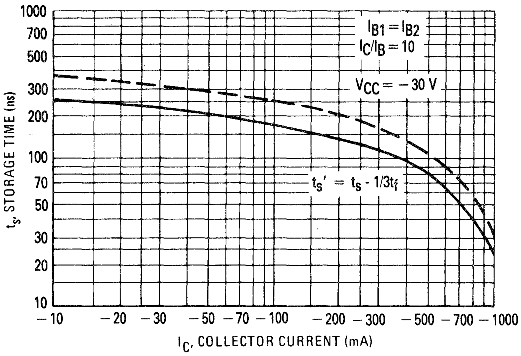
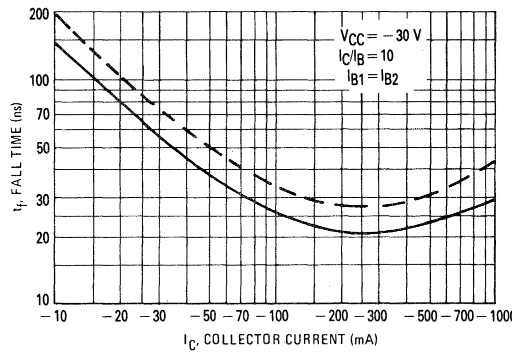


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE
$V_{CE} = 10$ Vdc, $T_A = 25°C$

FIGURE 9 — FREQUENCY EFFECTS

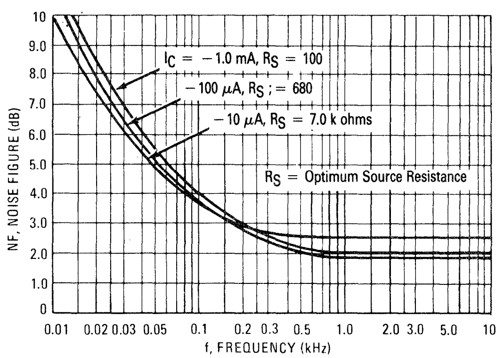
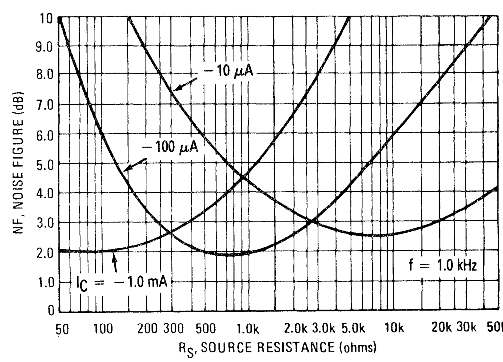


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS
$V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25°C$

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 11 — CURRENT GAIN

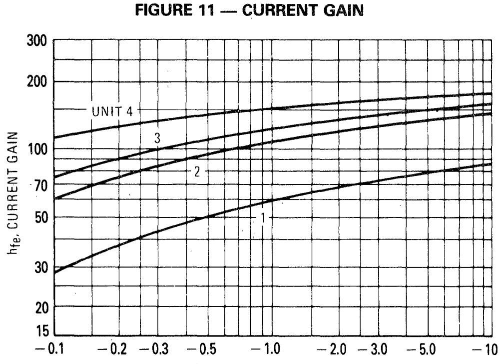


FIGURE 12 — INPUT IMPEDANCE

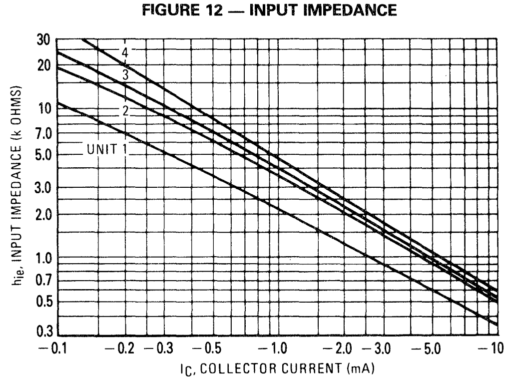


FIGURE 13 — VOLTAGE FEEDBACK RATIO

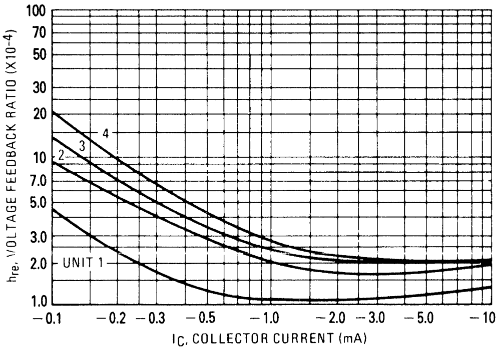
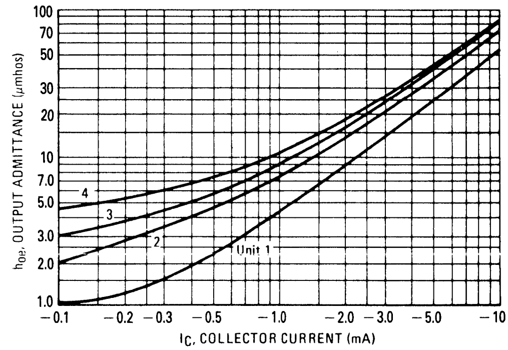


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

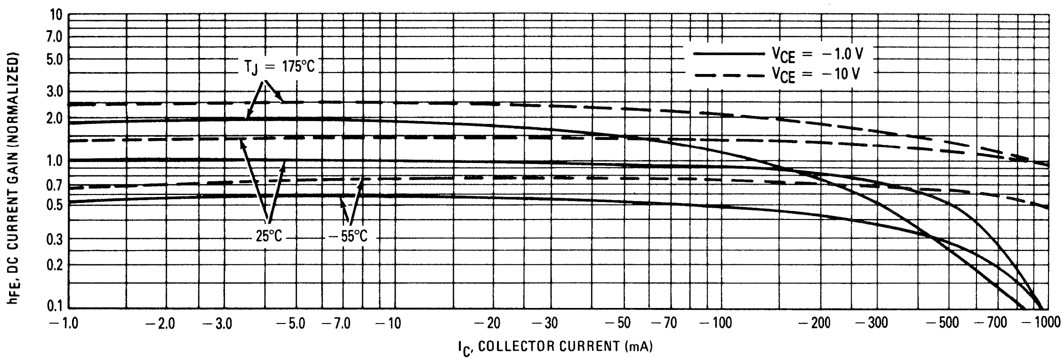


FIGURE 16 — COLLECTOR SATURATION REGION

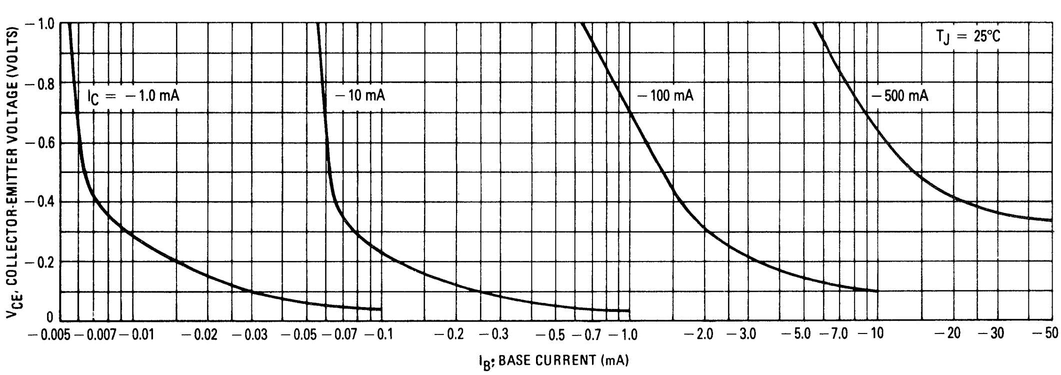


FIGURE 17 — "ON" VOLTAGES

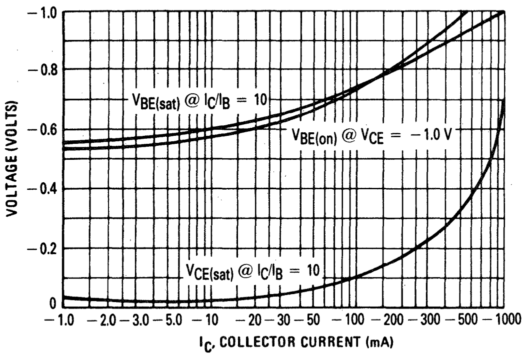
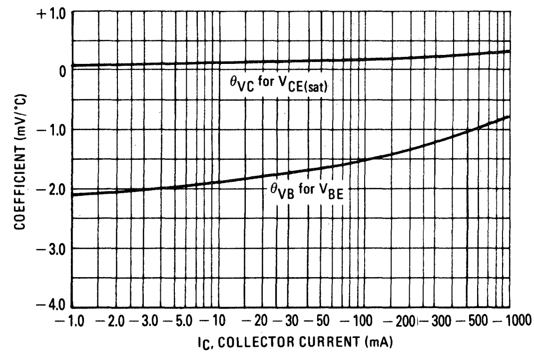


FIGURE 18 — TEMPERATURE COEFFICIENTS



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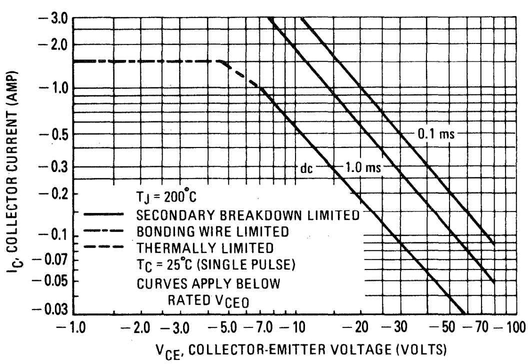
RATINGS AND THERMAL DATA

FIGURE 19 — SAFE OPERATING AREA

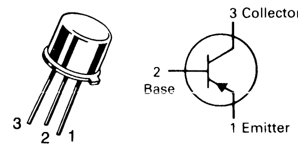


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 19 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqq 200$°C. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

2N4407

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CBO}	−80	Vdc
Collector-Base Voltage	V_{CEO}	−80	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−2.0	Amps
Total Device Dissipation @ T_A = 25°C* Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C* Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance to Case	$R_{\theta JC}$	20	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Uni
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−80	—	Vdc
Collector-Base Breakdown Voltage (I_C = −10 μAdc, I_E = 0)	$V_{(BR)CBO}$	−80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −10 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −60 Vdc, I_E = 0)	I_{CBO}	—	−25	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−25	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain	h_{FE}			—
(I_C = −10 mAdc, V_{CE} = −5.0 Vdc)		80	—	
(I_C = −150 mAdc, V_{CE} = −5.0 Vdc)		80	—	
(I_C = −500 mAdc, V_{CE} = −5.0 Vdc)		80	240	
(I_C = −1.0 Adc, V_{CE} = −5.0 Vdc)		30	—	
(I_C = −1.5 Adc, V_{CE} = −5.0 Vdc)		10	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)		—	−0.2	
(I_C = −500 mAdc, I_B = −50 mAdc)		—	−0.4	
(I_C = −1.0 Adc, I_B = −100 mAdc)		—	−0.7	
(I_C = −1.5 Adc, I_B = −150 mAdc)		—	−1.5	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = −150 mAdc, I_B = −15 mAdc)		—	−0.9	
(I_C = −1.0 Adc, I_B = −100 mAdc)		−0.9	−1.3	
(I_C = −1.5 Adc, I_B = −150 mAdc)		—	−1.5	
Base-Emitter On Voltage (I_C = −500 mAdc, V_{CE} = −1.0 Vdc)	$V_{BE(on)}$	—	−1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −50 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	150	750	MHz
Collector-Base Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	15	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	160	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristics		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = −30 Vdc, $V_{BE(off)}$ = +2.0 Vdc, I_C = −1.0 Adc, I_{B1} = −100 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	60	ns
Storage Time	(V_{CC} = −30 Vdc, I_C = −1.0 Adc, I_{B1} = I_{B2} = −100 mAdc)	t_s	—	175	ns
Fall Time		t_f	—	50	ns

STATIC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

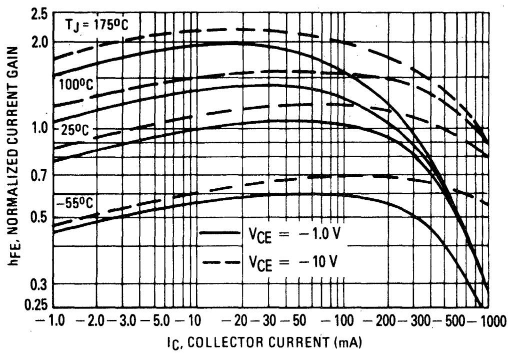


FIGURE 2 — COLLECTOR SATURATION REGION

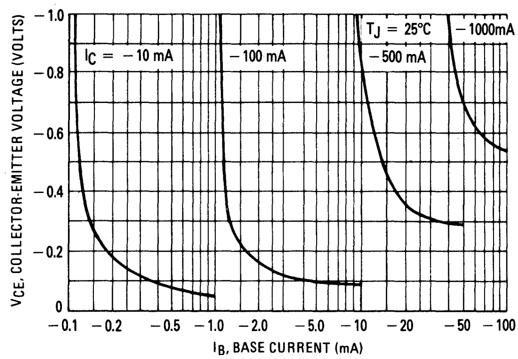


FIGURE 3 — "ON" VOLTAGES

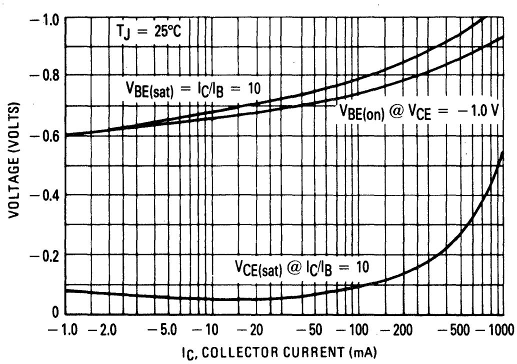


FIGURE 4 — TEMPERATURE COEFFICIENTS

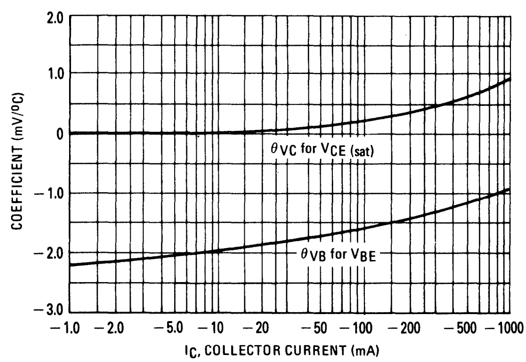
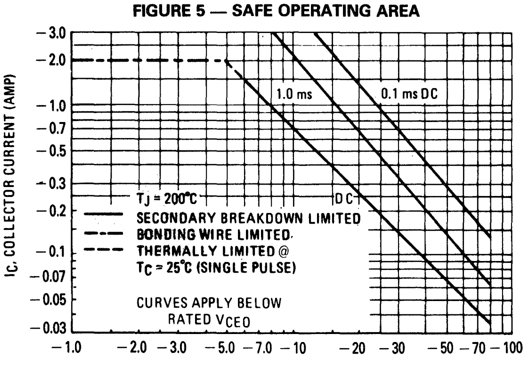


FIGURE 5 — SAFE OPERATING AREA



The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 200°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TRANSIENT CHARACTERISTICS

25°C 100°C

FIGURE 6 — CAPACITANCES

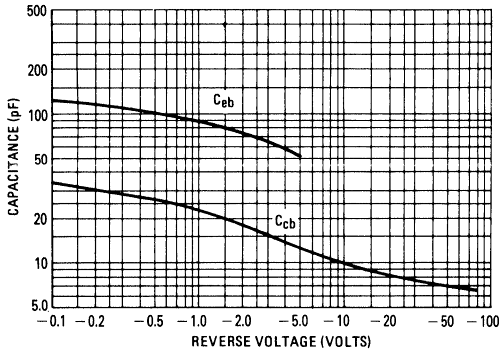


FIGURE 7 — CHARGE DATA

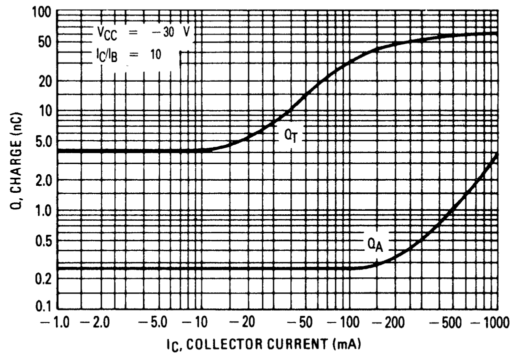


FIGURE 8 — TURN-ON TIME

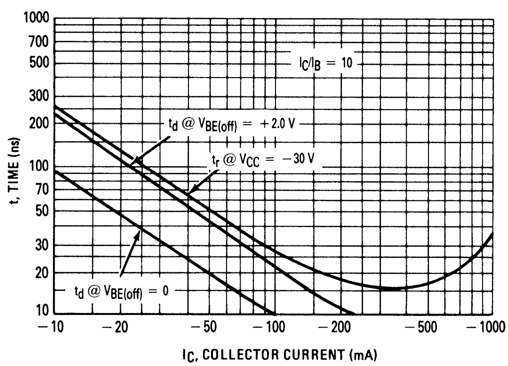
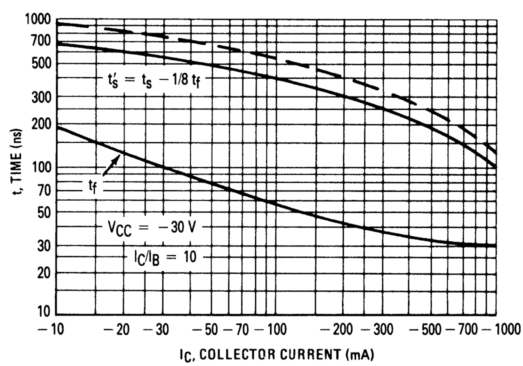


FIGURE 9 — TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 10 — TURN-ON TIME

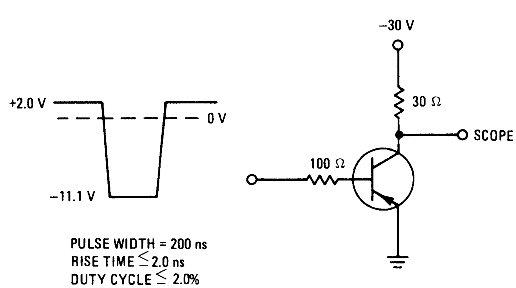
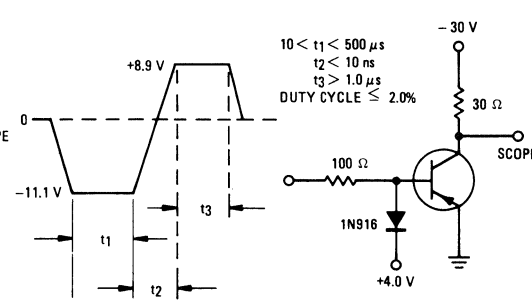
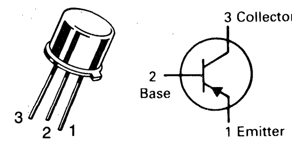


FIGURE 11 — TURN-OFF TIME



2N4931

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4931	Unit
Collector-Emitter Voltage	V_{CEO}	−250	Vdc
Collector-Base Voltage	V_{CBO}	−250	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0	Vdc
Collector Current — Continuous	I_C	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−250	—	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = −100 μAdc)	$V_{(BR)CBO}$	−250	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −150 Vdc, I_E = 0)	I_{CBO}	—	−1.0	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc)(1) (I_C = −30 mAdc, V_{CE} = −10 Vdc)(1)	h_{FE}	 20 20 20	 200 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$	—	−5.0	Vdc
Base-Emitter On Voltage (I_C = −10 mAdc, V_{CE} = −10 Vdc)	$V_{BE(on)}$	—	−1.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −20 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	20	200	MHz
Collector-Base Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	20	pF
Emitter-Base Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	400	pF

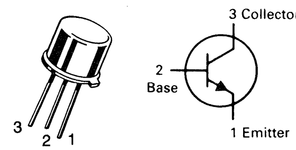
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

3

2N5058

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3724 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

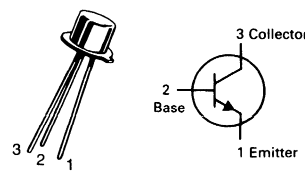
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 30 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = +125°C)	I_{CBO}	— —	0.05 20	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS (2)				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 25 Vdc) (I_C = 30 mAdc, V_{CE} = 25 Vdc) (I_C = 30 mAdc, V_{CE} = 25 Vdc, T_A = −55°C) (I_C = 100 mAdc, V_{CE} = 25 Vdc)	h_{FE}	 10 35 10 35	 — 150 — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	—	0.85	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 25 Vdc)	$V_{BE(on)}$	—	0.82	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (3) (I_C = 10 mAdc, V_{CE} = 25 Vdc, f = 20 MHz)	f_T	30	160	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	75	pF

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) f_T is defined as the frequency at which the $|h_{fe}|$ extrapolates to unity.

2N6431★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 30 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	 25 40 50	 — — 200	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)(1)	$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)(1)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	50	500	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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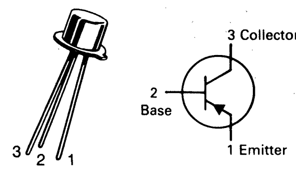
2N6433★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	2N6433	Unit
Collector-Emitter Voltage	V_{CEO}	−300	Vdc
Collector-Base Voltage	V_{CBO}	−300	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

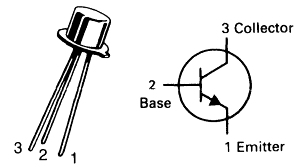
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = −1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−300	—	Vdc
Collector-Base Breakdown Voltage (I_C = −0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	−300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	-5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −200 Vdc)	I_{CBO}	—	−0.25	μAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_C = 0)	I_{EBO}	—	−0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −10 Vdc) (I_C = −10 mAdc, V_{CE} = −10 Vdc)(1) (I_C = −30 mAdc, V_{CE} = −10 Vdc)(1)	h_{FE}	 25 40 30	 — — 150	—
Collector-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)(1)	$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter Saturation Voltage (I_C = −20 mAdc, I_B = −2.0 mAdc)(1)	$V_{BE(sat)}$	—	−0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −20 Vdc, f = 100 MHz)	f_T	50	500	MHz
Collector-Base Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BC107, A, B, C thru BC109, A, B, C

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	BC 107	BC 108	BC 109	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	6	5	5	Vdc
Collector Current − Continuous	I_C	0.2			Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.43			Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1 5.7			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Base Leakage Current		I_{CBO}				
(I_E = 0, V_{CB} = 45 V)	BC107				15	nA
(I_E = 0, V_{CB} = 45 V, T_{Amb} = 125°C)	BC107				4	μA
(I_E = 0, V_{CB} = 25 V)	BC108/109				15	nA
(I_E = 0, V_{CB} = 25 V, T_{Amb} = 125°C)	BC108/109				4	μA
Emitter Base Breakdown Voltage		$V_{(BR)EBO}$				V
(I_E = 10 μA, I_C = 0)	BC107		6			
	BC108/109		5			
Collector Emitter Breakdown Voltage		$V_{(BR)CEO}$				V
(I_C = 2 mA, I_E = 0)	BC107		45			
	BC108/109		25			
ON CHARACTERISTICS						
DC Current gain		h_{FE}				
(V_{CE} = 5 V, I_C = 2 mA)	BC107		110		450	
	BC108		110		800	
	BC109		200		800	
	A group		110		220	
	B group		200		450	
	C group		420		800	
(V_{CE} = 5 V, I_C = 10 μA)	B group		40			
	C group		100			
Base Emitter Saturation Voltage(1)		$V_{BE(sat)}$				V
(I_C = 10 mA, I_B = 0.5 mA)				0.7	0.83	
(I_C = 100 mA, I_B = 5 mA)				1.0	1.05	
Collector Emitter Saturation Voltage(1)		$V_{CE(sat)}$				V
(I_C = 10 mA, I_B = 0.5 mA)					0.25	
(I_C = 100 mA, I_B = 5 mA)					0.60	
Base Emitter on Voltage		$V_{BE(on)}$				V
(I_C = 2 mA, V_{CE} = 5 V)			0.55		0.70	
(I_C = 10 mA, V_{CE} = 5 V)(1)					0.77	
Collector Knee Voltage		$V_{CE(K)}$				V
(I_C = 10 mA, I_B = the value for which I_C = 11 mA at V_{CE} = 1 V)				0.4	0.6	
DYNAMIC CHARACTERISTICS						
Transition Frequency		f_T				MHz
(I_C = 10 mA, f = 100 MHz, V_{CE} = 5 V)			150	300		
Noise Figure		NF				dB
(V_{CE} = 5 V, I_C = 0.2 mA, R_g = 2 KΩ)						
F = 1.0 KHz	BC109				4	
F = 1 kHz, ΔF = 200 Hz	BC109				4	
	BC107/108				10	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)		C_{obo}			4.5	pF
h_{21e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	BC107/108	h_{21e}	125		500	
	BC109		240		900	
	A group		125		260	
	B group		240		500	
	C group		450		900	
h_{11e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	A group	h_{11e}	1.6		4.5	KΩ
	B group		3.2		8.5	
	C group		6.0		15	
h_{22e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	A group	h_{22e}			30	μhos
	B group				60	
	C group				110	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — EMITTER-BASE CAPACITANCE COLLECTOR-BASE CAPACITANCE

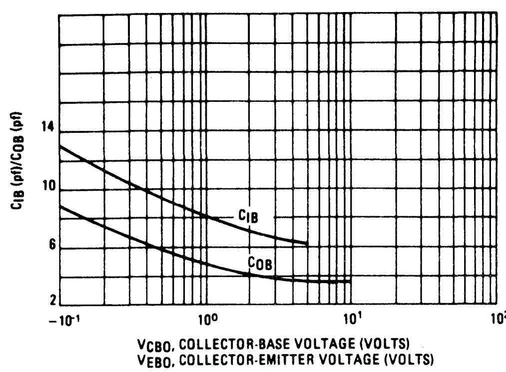


FIGURE 2 — CURRENT GAIN — BANDWIDTH PRODUCT

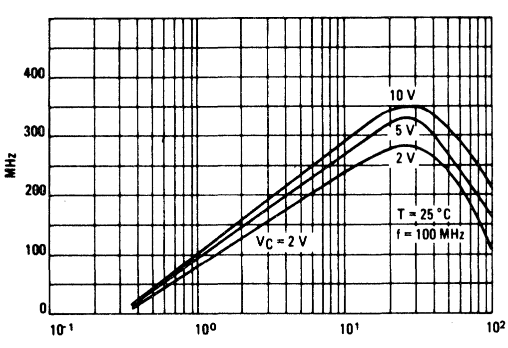
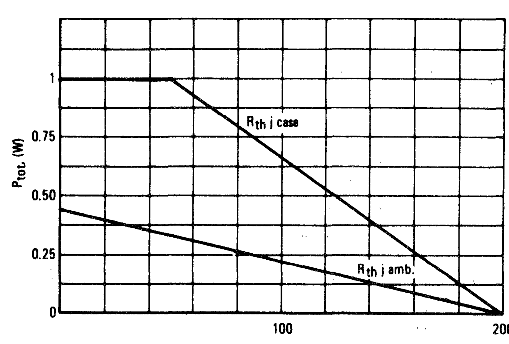
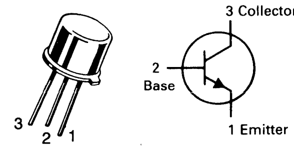


FIGURE 3 — TOTAL PERMISSIBLE POWER DISSIPATION



BC140-10, -16
BC141-10, -16

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTORS

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 140	BC 141	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	7		Vdc
Collector Current — Continuous	I_C	1		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.7 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

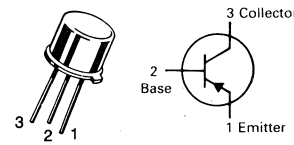
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (I_E = 0, V_{CE} = 60 V)	 T_A = 150°C	I_{CES}		100 100	nA μA
Collector-Emitter Breakdown Voltage (I_{CES} = 100 μA, I_E = 0)	BC140 Series BC141 Series	$V_{(BR)CES}$	80 100		V
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mA, I_B = 0)	BC140 Series BC141 Series	$V_{(BR)CEO}$	40 60		V
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)		$V_{(BR)EBO}$	7		V
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 mA, V_{CE} = 1 V)	for BC140, 141, -10 for BC140, 141, -16	h_{FE}	63 100	160 250	
Collector-Emitter Saturation Voltage(1) (I_C = 1 A, I_B = 0.1 A)		$V_{CE(sat)}$		1	V
Base-Emitter Voltage(1) (I_C = 1 A, V_{CE} = 1 V)		$V_{BE(on)}$		2	V
SMALL SIGNAL CHARACTERISTICS					
Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)		f_T	50		MHz
Input Capacitance (V_{EB} = 0,5 V, I_C = 0, f = 1 MHz		C_{ib}		80	pF
Capacitance (I_E = 0, V_{CB} = 10 V, f = 1 MHz)		C_{ob}		25	pF
Turn On Time (I_C = 150 mA, I_{B1} = 7.5 mA)		t_{on}		250	ns
Turn Off Tlme (I_C = 150 mA, I_{B1} = I_{B2} = 7.5 mA)		t_{off}		850	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 2.0%.

BC160-16
BC161-16

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTORS

PNP SILICON

Refer to 2N4404 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 160–16	BC 161–16	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−60	Vdc
Collector-Base Voltage	V_{CBO}	−40	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.7 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

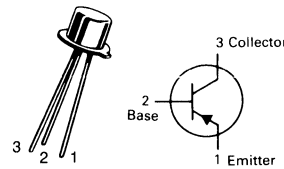
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current I_E = 0, V_{CES} = −40 V for BC160–16 V_{CES} = −60 V for BC161–16 V_{CES} = −40 V for BC160–16 T_{Amb} = 150°C V_{CES} = −60 V for BC161–16 T_{Amb} = 150°C	I_{CES}		 −100 −100 −100 −100	 nA μA
Collector-Emitter Breakdown Voltage I_C = −100 μA, I_E = 0 for BC160–16 for BC161–16	$V_{(BR)CES}$	 −40 −60		V
Collector-Emitter Breakdown Voltage(1) I_C = −10 mA, I_B = 0 for BC160–16 for BC161–16	$V_{(BR)CEO}$	 −40 −60		V
Emitter-Base Breakdown Voltage I_E = −100 μA, I_C = 0	$V_{(BR)EBO}$	−5.0		V
ON CHARACTERISTICS				
DC Current Gain(1) I_C = −100 mA, V_{CE} = −1.0 V for BC160, BC161, -16	h_{FE}	100	250	
Collector-Emitter Saturation Voltage(1) (I_C = −1.0 A, I_B = −0.1 A)	$V_{CE(sat)}$		−1.0	V
Base-Emitter Saturation Voltage(1) (I_C = −1.0 A, V_{CE} = −1.0 V)	$V_{BE(on)}$		−1.7	V
SMALL-SIGNAL CHARACTERISTICS				
Gain Bandwidth Product (I_C = −50 mA, V_{CE} = −10 V, f = 20 MHz)	f_T	50		MHz
Input Capacitance (V_{EB} = −10 V, f = 1.0 MHz)	C_{ib}		180	pF
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)	C_{obo}		30	pF
Turn On Time (I_C = −100 mA, I_{B1} = −5.0 μA)	T_{on}		500	ns
Turn Off Time (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 μA)	T_{off}		650	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 2.0%.

BC177,A,B

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−45	Vdc
Collector-Emitter Voltage	V_{CES}	−50	Vdc
Collector-Base Voltage	V_{CBO}	−50	Vdc
Emitter-Base Voltage	V_{EBO}	−5	Vdc
Collector Current — Continuous	I_C	−0.2	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.43	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Leakage Current (V_{CE} = −20 V, I_E = 0) (V_{CE} = −20 V, I_E = 0, T_{Amb} = 125°C)		I_{CES}			 −100 −4	 nA μA
Collector Base Breakdown Voltage (I_C = −10 μA)		$V_{(BR)CBO}$	−50			V
Collector Emitter Breakdown Voltage (I_C = −2.0 mA, I_E = 0)		$V_{(BR)CEO}$	−45			V
Emitter Base Breakdown Voltage (I_E = −10 μA, I_C = 0)		$V_{(BR)EBO}$	−5.0			V
ON CHARACTERISTICS						
DC Current Gain (I_C = −2.0 mA, V_{CE} = −5.0 V)	BC177 A Group B Group	h_{FE}	120 120 180		460 220 460	
Collector Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA) (I_C = −100 mA, I_B = −5.0 mA)		$V_{CE(sat)}$			 −0.2 −0.6	V
Base Emitter Saturation Voltage(1) (I_C = −10 mA, I_B = −0.5 mA) (I_C = −100 mA, I_B = −5.0 mA)		$V_{BE(sat)}$		 −0.7 −0.9	 −0.8	V
Base Emitter on Voltage (I_C = −2.0 mA, V_{CE} = −5.0 V)		$V_{BE(on)}$	 −0.6		 −0.75	V
Collector Knee Voltage (I_C = −10 mA, I_B = the value for which I_C = −11 mA, at V_{CE} = −1.0 V)		$V_{CE(K)}$		 −0.4	 −0.6	V
DYNAMIC CHARACTERISTICS						
Transition Frequency (V_{CE} = −5.0 V, I_C = −10 mA, f = 100 MHz)		f_T	200	300		MHz
Noise Figure (V_{CE} = −5.0 V, I_C = −0.2 mA, R_g = 2 KΩ) F = 1.0 kHz F = 1.0 kHz, F = 200 Hz		NF			 4.0 4.0 10	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

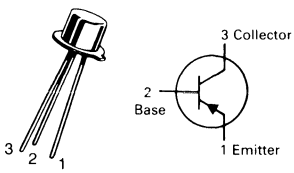
Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = −10 V, f = 1.0 MHz)		C_{obo}		3.5	4.0	pF
h_{21e} Parameters (V_{CE} = −5.0 V, I_C = −2.0 mA, f = 1.0 kHz)	BC177	h_{21e}	125		500	
	A Group		125		260	
	B Group		240		500	
h_{11e} Parameters (V_{CE} = −5.0 V, I_C = −2.0 mA, f = 1.0 kHz)		h_{11e}				KΩ
	A Group		1.6		4.5	
	B Group		3.2		8.5	
h_{22e} Parameters (V_{GE} = −5.0 V, I_C = −2.0 mA, f = 1.0 kHz)		h_{22e}				μmhos
	A Group				30	
	B Group				60	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

BC393

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTOR

PNP

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−180	Vdc
Collector-Base Voltage	V_{CBO}	−180	Vdc
Emitter-Base Voltage	V_{EBO}	−6	Vdc
Collector Current — Continuous	I_C	−0.5	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 2.66	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.5 10.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

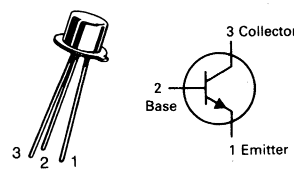
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mA, I_B = 0)	$V_{(BR)CEO}$	−180			Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−180			Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−6			Vdc
Collector Cutoff Current (V_{CB} = −100 V, I_E = 0)	I_{CBO}			−50	nA
Collector-Emitter Cutoff (V_{CE} = −100 V, I_B = 0) (T_{Amb} = 150°C)	I_{CEO}			−50	μA
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = −10 mA, V_{CE} = −10 V)	h_{FE}	50	100		
Collector-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{CE(sat)}$		−0.15	−0.3	Vdc
Base-Emitter Saturation Voltage (I_C = −10 mAdc, I_B = −1.0 mAdc)	$V_{BE(sat)}$		−0.7	−0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −20 mAdc, V_{CE} = −20 Vdc, f = 20 MHz)	f_T	50	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = −20 Vdc, f = 1.0 MHz)	C_{obo}	—	3.5	7	pF
Input Capacitance (I_C = 0, V_{EB} = −0.5 Vdc, f = 1.0 MHz)	C_{ib}	—	75	—	pF
Turn-On Time (I_{B1} = −10 mA, I_C = −50 mAdc, V_{CC} = −100 Vdc)	t_{on}	—	100	—	ns
Turn-Off Time (I_{B2} = −10 mAdc, I_C = −50 mAdc, V_{CC} = −100 Vdc)	t_{off}	—	400	—	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

BC394

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTOR

NPN

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	180	Vdc
Collector-Base Voltage	V_{CBO}	180	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
Collector Current — Continuous	I_C	0.5	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 2.66	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.5 10.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

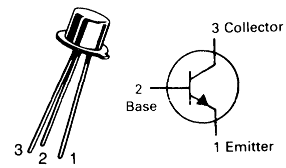
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	180			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	180			Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6			Vdc
Collector Cutoff Current (V_{CB} = 100 V, I_E = 0)	I_{CBO}			50	nA
Collector-Emitter Cutoff (V_{CE} = 100 V, I_B = 0) (T_{Amb} = 150°C)	I_{CEO}			50	μA
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mA, V_{CE} = 10 V)	h_{FE}	50	100		
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$		0.15	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$		0.7	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1.0 MHz)	C_{obo}	—	3.5	7	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1.0 MHz)	C_{ib}	—	75	—	pF
Turn-On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{on}	—	100	—	ns
Turn-Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{off}	—	400	—	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

BCY58-VIII,-IX,-X
BCY59-VII,-VIII,-IX,-X

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BCY 58	BCY 59	Unit
Collector-Emitter Voltage	V_{CEO}	32	45	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CES}	32	45	Vdc
Emitter-Base Voltage	V_{EBO}	7		Vdc
Collector Current − Continuous	I_C	0.2		Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.43		Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1 5.7		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	291	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_C = 0)	BCY58 BCY59	$V_{(BR)CEO}$	32 45			Vdc
Emitter-Base Breakdown Voltage (I_E = 1μAdc, I_C = 0)	all	$V_{(BR)EBO}$	 7			Vdc
Collector Cutoff Current						nAdc
(V_{CE} = 32 V)	BCY58	I_{CES}		0.2	10	
(V_{CE} = 45 V)	BCY59			0.2	10	
(V_{CE} = 32 V, T_A = 100°C, V_{BE} = 0.2 V)	BCY58	I_{CEX}			20	μAdc
(V_{CE} = 45 V, T_A = 100°C, V_{BE} = 0.2 V)	BCY59				20	
(V_{CE} = 32 V, T_A = 150°)	BCY58	I_{CES}		0.2	10	μAdc
(V_{CE} = 45 V, T_A = 150°)	BCY59			0.5	10	
Emitter Base Cutoff Current (V_{EB} = 5 V)	all	I_{EBO}			 10	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	BCY59-VII,					
	BCY59-VIII, BCY58-VIII		20	145		
	BCY59-IX, BCY58-IX		40	220		
	BCY59-X, BCY58-X		100	300		
(I_C = 2 mAdc, V_{CE} = 5 Vdc)	BCY59-VII,		120	170	220	
	BCY59-VIII, BCY58-VIII		180	250	310	
	BCY59-IX, BCY58-IX		250	350	460	
	BCY59-X, BCY58-X		380	500	630	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)(1)	BCY59-VII,		80	190		
	BCY59-VIII, BCY58-VIII		120	260	400	
	BCY59-IX, BCY58-IX		160	380	630	
	BCY59-X, BCY58-X		240	550	1000	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)(1)	BCY59-VII,		40			
	BCY59-VIII, BCY58-VIII		45			
	BCY59-IX, BCY58-IX		60			
	BCY59-X, BCY58-X		60			
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 2.5 mAdc)	all		0.15	0.30	0.70	
(I_C = 10 mAdc, I_B = 0.25 mA)			0.05	0.12	0.35	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mA, I_B = 0.25 mA)	all		0.6	0.70	0.85	
(I_C = 100 mA, I_B = 2.5 mA)			0.75	0.90	1.2	
Base-Emitter on Voltage (I_C = 2 mAdc, V_{CE} = 5 Vdc)	 all	$V_{BE(on)}$	 0.55	 0.62	 0.70	Vdc

3

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 V, f = 100 MHz)	all	f_T	125	200		MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1 MHz)	all	C_{ob}		3.5	6	pF
Input Capacitance (V_{EB} = 0.5 V, I_C = 0, f = 1 MHz)	all	C_{ib}		8	15	pF
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{fe} (h_{21e})	125 175 250 350	200 260 330 520	250 350 500 700	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{oe} (h_{22e})			30 50 60 100	μmhos
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{ie} (h_{11e})	1.6 2.5 3.2 4.5		4.5 6 8.5 12	Kohms
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = kHz)	BCY59-VII BCY58-VIII, BCY59-VIII BCY58-IX, BCY59-IX BCY58-X, BCY59-X	h_{re} (h_{12e})		1.5 2 2 3		$\times 10^{-4}$
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 Kohms, f = 1 kHz)	all	N_F		2	6	dB
SWITCHING CHARACTERISTICS						
I_C = 10 mA, I_{B1} = 1 mA, I_{B2} = 1 mA V_{BB} = −3.6 V, R_1 = R_2 = 5 KΩ R_L = 990 ohms * See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		35 50 85 400 80 480	 150 800	nS
I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 10 mA V_{BB} = 5 V, R_1 = 500 Ω, R_2 = 700 Ω R_L = 98 ohms * See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		5 50 55 250 200 450	 150 800	nS

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TEST CIRCUIT

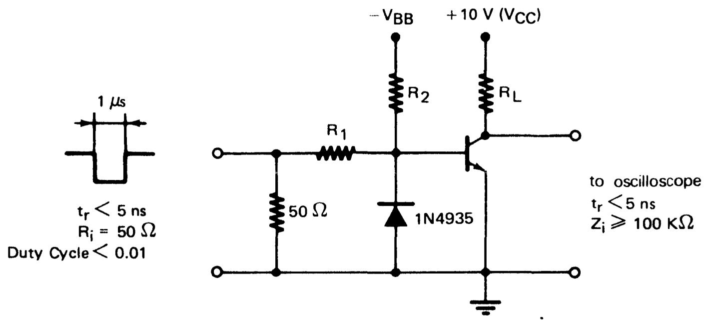


FIGURE 1 — CURRENT GAIN (BCY59-VII)

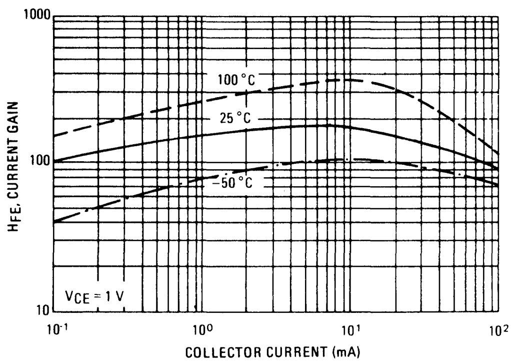


FIGURE 2 — CURRENT GAIN (BCY58-VIII/BCY59-VIII)

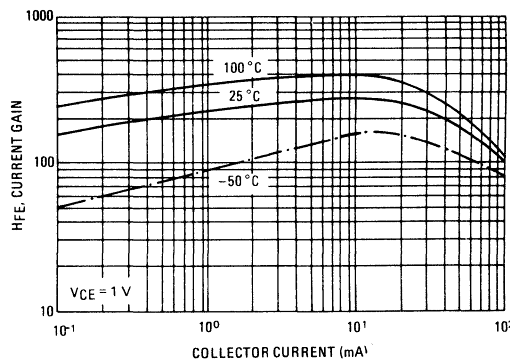


FIGURE 3 — CURRENT GAIN (BCY58-IX/BCY59-IX)

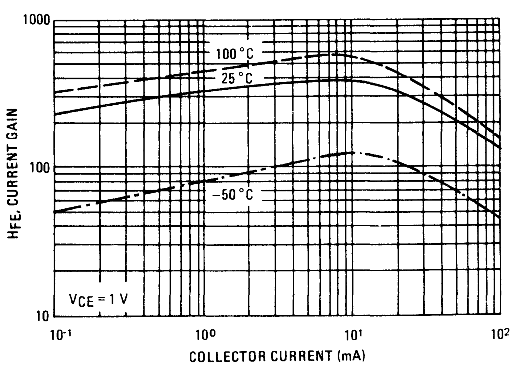


FIGURE 4 — CURRENT GAIN (BCY58-X/BCY59-X)

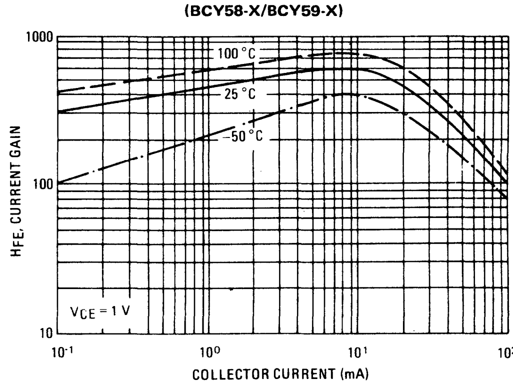


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FIGURE 5 — SATURATION VOLTAGE

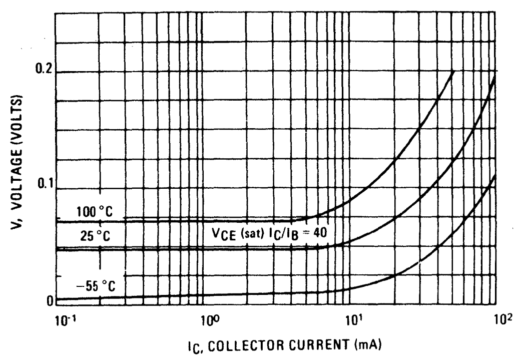

FIGURE 6 — SATURATION VOLTAGE

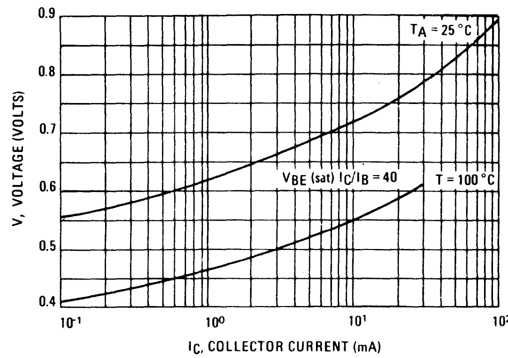

FIGURE 7 — INPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

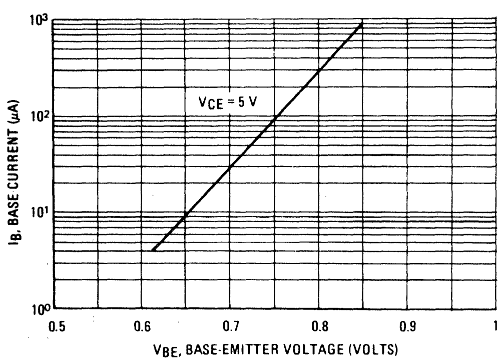

FIGURE 8 — OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

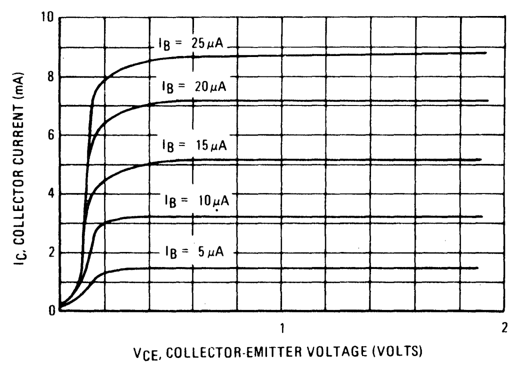

FIGURE 9 — OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

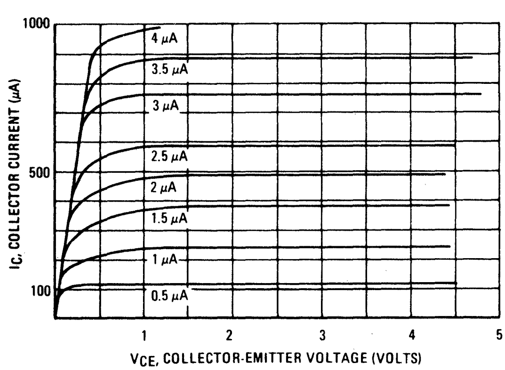

FIGURE 10 — OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

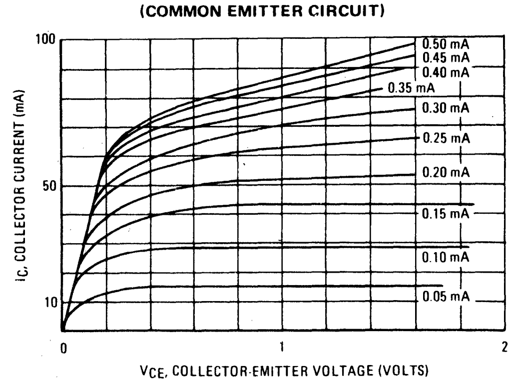

FIGURE 11 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

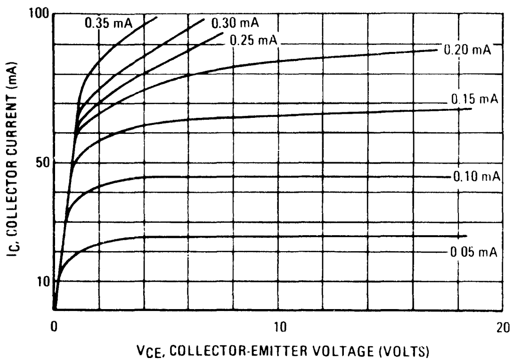

FIGURE 12 – EMITTER-BASE CAPACITANCE COLLECTOR-BASE CAPACITANCE

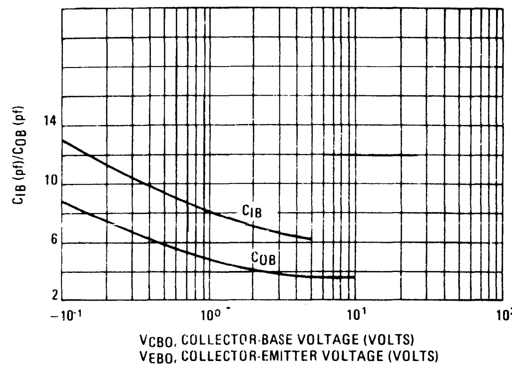

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FIGURE 13 – CURRENT GAIN – BANDWIDTH PRODUCT

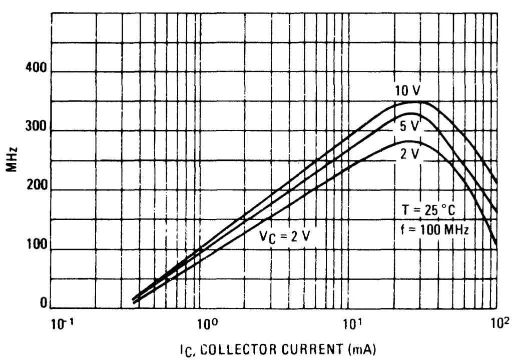
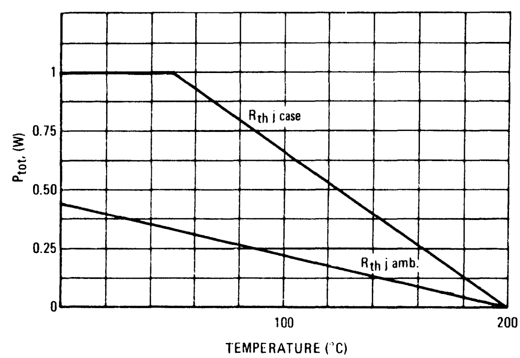


FIGURE 14 – TOTAL PERMISSIBLE POWER DISSIPATION (BCY58/BCY59)



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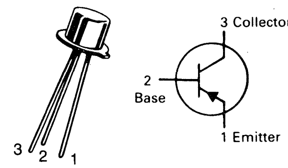
BCY70 thru BCY72

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS

PNP SILICON

Refer to 2N3799 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BCY 70	BCY 71	BCY 72	Unit
Collector-Emitter Voltage	V_{CEO}	−40	−45	−25	Vdc
Collector-Base Voltage	V_{CBO}	−50	−45	−25	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0			Vdc
Collector Current — Continuous	I_C	−0.2			Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06			mWatt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	0.6 3.43			mWatt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	292	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$				Vdc
(I_C = −2.0 mA, I_B = 0)	BCY70		−40			
	BCY71		−45			
	BCY72		−25			
Collector-Base Leakage Current		I_{CBO}				
(I_E = 0, V_{CB} = −50V)	BCY70				−0.5	μA
(I_E = 0, V_{CB} = −45V)	BCY71				−0.5	
(I_E = 0, V_{CB} = −25V)	BCY72				−0.5	
(I_E = 0, V_{CB} = −40V, T_{Amb} = 100°C)	BCY70				−2.0	
(I_E = 0, V_{CB} = −40V, T_{Amb} = 100°C)	BCY71				−2.0	
(I_E = 0, V_{CB} = −20V, T_{Amb} = 100°C)	BCY72				−2.0	
(I_E = 0, V_{CB} = −40V)	BCY70				−10	nA
(I_E = 0, V_{CB} = −40V)	BCY71				−50	
(I_E = 0, V_{CB} = −20V)	BCY72				−50	
Emitter-Base Leakage Current		I_{EBO}				
(V_{EB} = −5.0 V, I_C = 0)					−0.5	μA
(V_{EB} = −4.0 V, I_C = 0)					−10	nA
(V_{EB} = −4.0 V, I_C = 0, T_{Amb} = 100°C)					−2.0	μA
Collector-Emitter Leakage Current		I_{CEX}				nA
(V_{CE} = −50 V, V_{EB} = −3.0 V)	BCY70				−20	

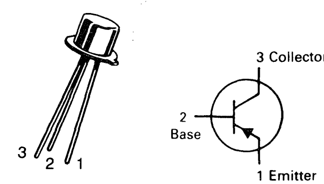
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(V_{CE} = −1.0 V, I_C = −10 μA)	BCY71		40			
(V_{CE} = −1.0 V, I_C = −100 μA)	BCY70		40			
	BCY71		80			
(V_{CE} = −1.0 V, I_C = −1.0 mA)	BCY70		45			
	BCY71		90			
	BCY72		40			
(V_{CE} = −1.0 V, I_C = −10 mA)(1)	BCY70		50			
	BCY71		100		600	
	BCY72		50			
(V_{CE} = −1.0 V, I_C = −50 mA)(1)	BCY70		15			
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				V
(I_C = −50 mA, I_B = −5.0 mA)	BCY70/71				−1.2	
(I_C = −10 mA, I_B = −1.0 mA)	BCY70/71		−0.6		−0.9	
Collector-Emitter, Saturation Voltage(1)		$V_{CE(sat)}$				V
(I_C = −50 mA, I_B = −5.0 mA)					−0.50	
(I_C = −10 mA, I_B = −1.0 mA)					−0.25	
DYNAMIC CHARACTERISTICS						
Transition Frequency		f_T				MHz
(I_C = −10 mA, f = 100 MHz, V_{CE} = −20 V)	All types		250			
(I_C = −100 μA, f = 20 MHz, V_{CE} = −20 V)	BCY71 only		15			
Noise Figure		NF				dB
(V_{CE} = −5.0 V, I_C = −100 μA, Rg = 2.0 KΩ, f = 1.0 kHz						
	BCY70/72				6.0	
	BCY71				2.0	
Switching Times						ns
(I_C = −10 mA, I_{B1} = I_{B2} = −1.0 mA)	BCY70/72	t_{on}			65	
	BCY70/72	t_{off}			420	
	BCY70/72	t_d			35	
	BCY70/72	t_r			35	
	BCY70/72	t_s			350	
	BCY70/72	t_f			80	
h parameters		h_{12e}	—		20×10^{-4}	—
(V_{CE} = −10 V, I_C = −1.0 mA, f = 1.0 kHz)	BCY71	h_{21e}	100		400	—
		h_{22e}	10		60	μs
		h_{11e}	2.0		12	KΩ
Common Base Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)		C_{ob}			6.0	pF
Input Capacitance (V_{EB} = −1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}			8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BCY78-VIII,-IX
BCY79-VII,-VIII,-IX

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCY 78	BCY 79	Unit
Collector-Emitter Voltage	V_{CEO}	−32	−45	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CES}	−32	−45	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0		Vdc
Collector Current — Continuous	I_C	−0.2		Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.43		Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	291	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = − 10 mAdc, I_C = 0)	BCY78 Series BCY79 Series	$V_{(BR)CEO}$	−32 −45			Vdc
Emitter-Base Breakdown Voltage I_E = −2.0 μAdc, I_C = 0)	all	$V_{(BR)EBO}$	−5.0			Vdc
Collector Cutoff Current						
(V_{CE} = −32 V)	BCY78 Series	I_{CES}		−0.2	−100	nA
(V_{CE} = −45 V)	BCY79 Series			−0.2	−100	
(V_{CE} = −32 V, T_A = 100°C, V_{BE} = −0.2 V)	BCY78 Series	I_{CEX}			−20	μAdc
(V_{CE} = −45 V, T_A = 100°C, V_{BE} = −0.2 V)	BCY79 Series				−20	
(V_{CE} = −25 V, T_A = 150°)	BCY78 Series	I_{CES}		−0.2	−10	μAdc
(V_{CE} = −35 V, T_A = 150°)	BCY79 Series			−0.5	−10	
Emitter-Base Cutoff Current (V_{EB} = −4.0 V)	all	I_{EBO}			20	nA
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = −10 μAdc, V_{CE} = −5.0 Vdc)	BCY79-VII					
	BCY79-VIII, BCY78-VIII		30	145		
	BCY79-IX, BCY78-IX		40	220		
(I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	BCY79-VII		120	170	220	
	BCY79-VIII, BCY78-VIII		180	250	310	
	BCY79-IX, BCY78-IX		250	350	460	
(I_C = −10 mAdc, V_{CE} = −1.0 Vdc)(1)	BCY79-VII		80	190		
	BCY79-VIII, BCY78-VIII		120	260	400	
	BCY79-IX, BCY78-IX		160	380	630	
(I_C = −100 mAdc, V_{CE} = −1.0 Vdc)(1)	BCY79-VII		40			
	BCY79-VIII, BCY78-VIII		45			
	BCY79-IX, BCY78-IX		60			
Collector-Emitter Saturation Voltage(1)	all	$V_{CE(sat)}$				Vdc
(I_C = −100 mAdc, I_B = −2.5 mAdc)			−0.15	−0.30	−0.80	
(I_C = −10 mAdc, I_B = −0.25 mA)			−0.05	−0.12	−0.25	
Base-Emitter Saturation Voltage(1)	all	$V_{BE(sat)}$				Vdc
(I_C = −10 mA, I_B = −0.25 mA)			−0.60	−0.70	−0.85	
(I_C = −100 mA, I_B = −2.5 mA)			−0.75	−0.90	−1.20	
Base-Emitter on Voltage (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc)	all	$V_{BE(on)}$	−0.60	−0.62	−0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product (I_C = −10 mAdc, V_{CE} = −5.0 V, f = 100 MHz)	all	f_T	180	300		MHz
Output Capacitance (V_{CE} = −10 Vdc, I_C = 0, f = 1.0 MHz)	all	C_{ob}		3.5	7.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	all	C_{ib}		8.0	15	pF
Small Signal Current Gain (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX	h_{fe} (h_{21e})		200 260 330		
Input Impedance (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX	h_{ie} (h_{11e})	1.6 2.5 3.2		4.5 6.0 8.5	Kohms
Voltage Feedback Ratio (I_C = −2.0 mAdc, V_{CE} = −5.0 Vdc, f = 1.0 kHz)	BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX	h_{re} (h_{12e})		1.5 2.0 2.0		X 10^{-4}
Noise Figure (I_C = −0.2 mAdc, V_{CE} = −5.0 Vdc, R_S = 2.0 Kohms, f = 1.0 kHz)	all	N_F		2.0	6.0	dB
SWITCHING CHARACTERISTICS						
I_C = −10 mA, I_{B1} = −1.0 mA, I_{B2} = −1.0 mA V_{BB} = +3.6 V, R_1 = R_2 = 5.0 KΩ R_L = 990 ohms *See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		35 50 85 400 80 480	 150 800	nS
I_C = −100 mA, I_{B1} = −10 mA, I_{B2} = −10 mA V_{BB} = +5.0 V, R_1 = 500 Ω, R_2 = 700 Ω R_L = 98 ohms *See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		5.0 50 55 250 200 450	 150 800	nS

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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TEST CIRCUIT

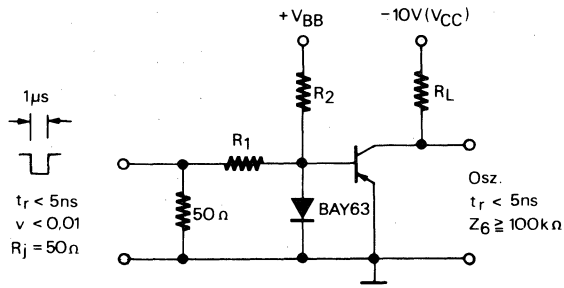

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FIGURE 1 – CURRENT GAIN (BCY79-VII)

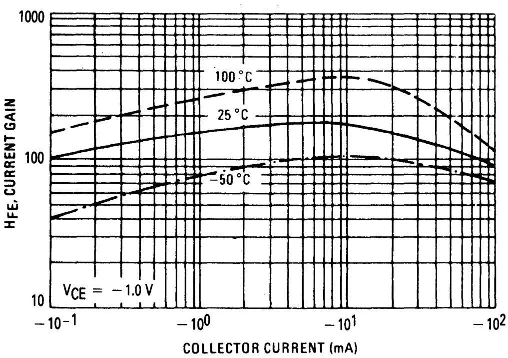


FIGURE 2 – CURRENT GAIN (BCY78-VIII/BCY79-VIII)

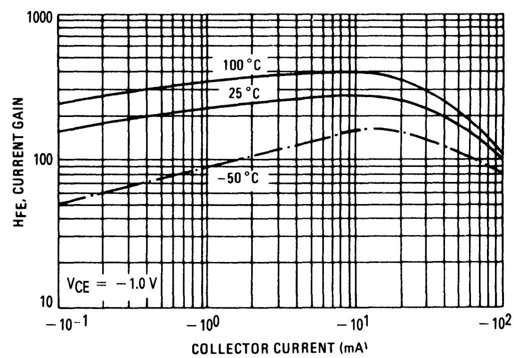


FIGURE 3 – CURRENT GAIN (BCY78-IX/BCY79-IX)

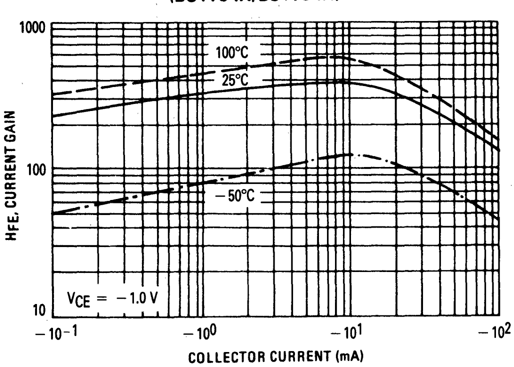


FIGURE 4 – CURRENT GAIN (BCY78-X)

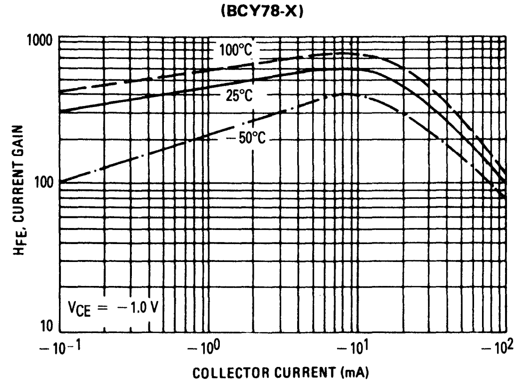


FIGURE 5 – SATURATION VOLTAGE

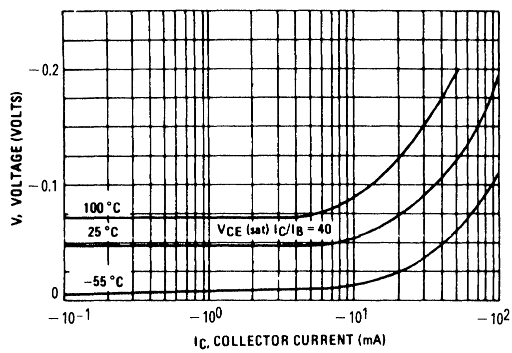


FIGURE 6 – SATURATION VOLTAGE

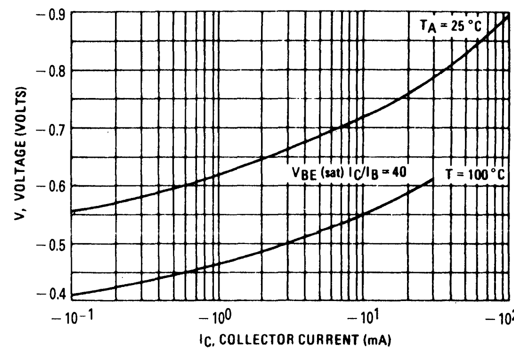


FIGURE 7 – INPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

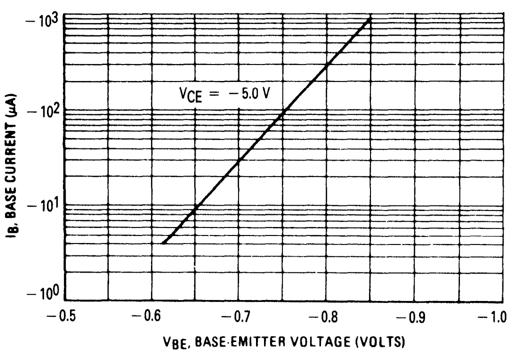


FIGURE 8 – TOTAL PERMISSIBLE POWER DISSIPATION (BCY78/BCY79)

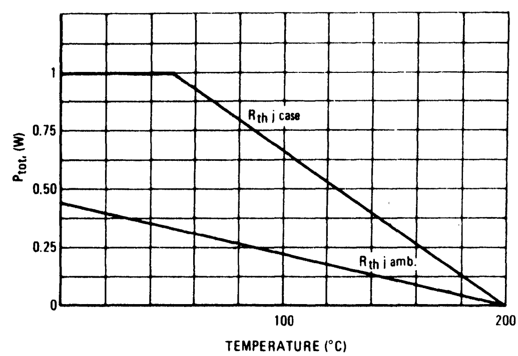


FIGURE 9 – CURRENT GAIN BANDWIDTH PRODUCT

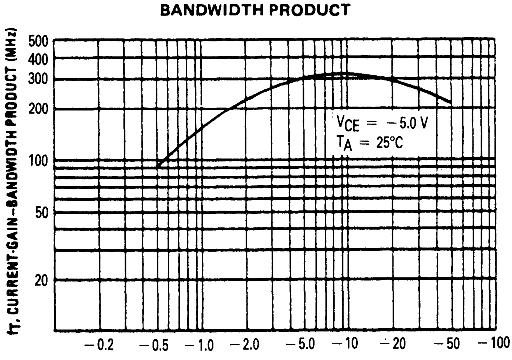
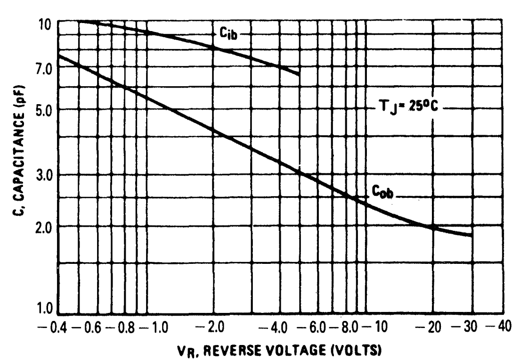


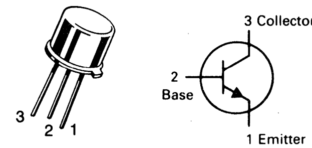
FIGURE 10 – CAPACITANCES



3

BF258
BF259

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



HIGH VOLTAGE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BF258	BF259	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	Vdc
Collector-Emitter Voltage	V_{CER}	250	300	Vdc
Collector-Base Voltage	V_{CBO}	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	0.1		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

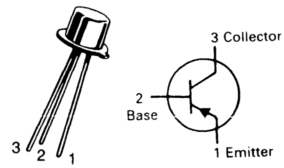
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 30$ mAdc, $I_B = 0$)	BF258 BF259	$V_{(BR)CEO}$	250 300	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	BF258 BF259	$V_{(BR)CBO}$	250 300	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 250$ Vdc, $I_E = 0$)	 BF258 BF259	I_{CBO}	 — —	 1.0 1.0	 50 50	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25	80	—	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 6.0$ mAdc)		$V_{CE(sat)}$	—	0.1	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current Gain-Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	—	110	—	MHz
Reverse Transfer Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{re}	—	3.5	—	pF
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	5.5	—	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BFW43

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−150	Vdc
Collector-Base Voltage	V_{CBO}	−150	Vdc
Emitter-Base Voltage	V_{EBO}	−6.0	Vdc
Collector Current — Continuous	I_C	−0.1	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 2.28	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.4 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	438	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = −2.0 mA, I_B = 0)	$V_{(BR)CEO}$	−150			Vdc
Collector Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−150			Vdc
Emitter Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−6.0			Vdc
Collector Cutoff Current (V_{CB} = −100 V, I_E = 0)	I_{CBO}			−10	nA
Collector Emitter Cutoff Current (V_{CB} = −100 V, I_B = 0) T_A = 125°C	I_{CEO}			−10	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = −1.0 mA, V_{CE} = −10 V) (I_C = −10 mA, V_{CE} = −10 V)(1) (I_C = −10 μA, V_{CE} = −10 V, T_A = −55°C)	h_{FE}	 40 40	 30		
Collector Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1 mAdc)	$V_{CE(sat)}$		−0.15	−0.5	Vdc
Base Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1 mAdc)	$V_{BE(sat)}$		−0.7	−0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)	f_T	60	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = −20 Vdc, f = 1.0 MHz)	C_{obo}	—	3.5	7.0	pF
Turn On Time (I_{B1} = −10 mA, I_C = −50 mAdc, V_{CC} = −100 Vdc)	t_{on}	—	100	—	ns
Turn Off Time (I_{B2} = −10 mAdc, I_C = −50 mAdc, V_{CC} = −100 Vdc)	t_{off}	—	400	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 1 – CURRENT-GAIN–BANDWIDTH PRODUCT

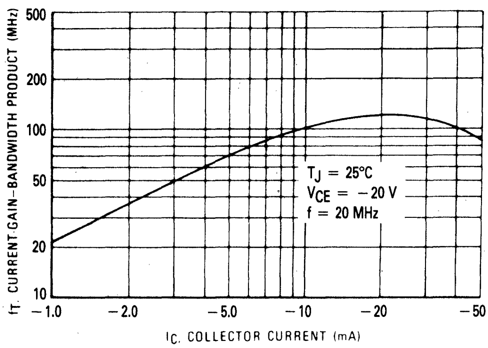


FIGURE 2 – TURN-ON TIME

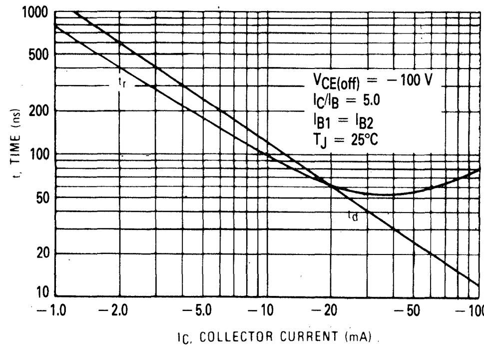


FIGURE 3 – TURN-OFF TIME

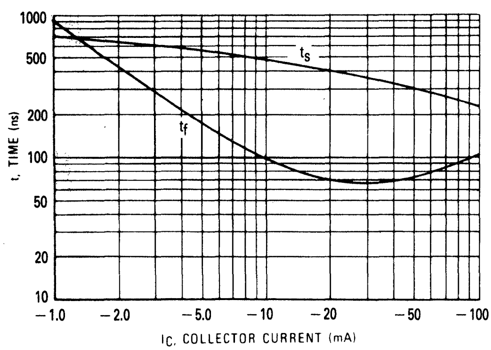
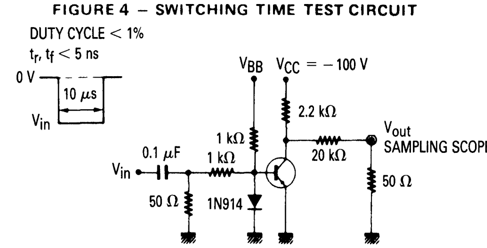


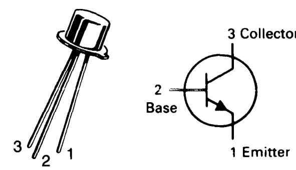
FIGURE 4 – SWITCHING TIME TEST CIRCUIT



	V_{in}	V_{BB}
t_{on}	−10.6 V	
t_{off}	−20 V	+9.2 V

BSS71
thru
BSS73

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTORS
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BSS 71	BSS 72	BSS 73	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	300	Vdc
Collector-Base Voltage	V_{CBO}	200	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current − Continuous	I_C	0.5			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 14.3			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$				Vdc
(I_C = 10 mA, I_B = 0)	BSS71		200	—	—	
	BSS72		250	—	—	
	BSS73		300	—	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
(I_C = 100 μAdc, I_E = 0)	BSS71		200	—	—	
	BSS72		250	—	—	
	BSS73		300	—	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$				Vdc
(I_E = 100 μAdc, I_C = 0)	BSS71		6	—	—	
	BSS72		6	—	—	
	BSS73		6	—	—	
Collector Cutoff Current		I_{CBO}				nA
(V_{CB} = 150 V, I_E = 0)	BSS71		—	—	50	
(V_{CB} = 200 V, I_E = 0)	BSS72		—	—	50	
(V_{CB} = 250 V, I_E = 0)	BSS73		—	—	50	
Collector-Emitter Cutoff Current		I_{CEO}				nA
(V_{CE} = 150 V, I_B = 0)	BSS71		—	—	500	
(V_{CE} = 200 V, I_B = 0)	BSS72		—	—	500	
(V_{CE} = 300 V, I_B = 0)	BSS73		—	—	500	
Emitter-Cutoff Current		I_{EBO}				nA
(V_{EB} = 5.0 Vdc, I_C = 0)	ALL		—	—	50	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = 0.1 mA, V_{CE} = 1 V)	BSS71		20	40	—	—
(I_C = 1 mA, V_{CE} = 10 V)	ALL		30	45	—	
(I_C = 10 mA, V_{CE} = 10 V)(1)	ALL		50	120	—	
(I_C = 30 mA, V_{CE} = 10 V)(1)	ALL		40	140	250	
(I_C = 100 mA, V_{CE} = 10 V)(1)	BSS73		—	35	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	ALL		—	0.15	0.3	
(I_C = 30 mAdc, I_B = 3 mAdc)	ALL		—	0.25	0.4	
(I_C = 50 mAdc, I_B = 5 mAdc)	ALL		—	0.35	0.5	
(I_C = 100 mAdc, I_B = 20 mAdc)	BSS73		—	0.25	—	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	ALL		—	0.7	0.8	
(I_C = 30 mAdc, I_B = 3 mAdc)	ALL		—	0.8	0.9	
(I_C = 50 mAdc, I_B = 5 mAdc)	ALL		—	0.85	1.0	
(I_C = 100 mAdc, I_B = 10 mAdc)	BSS73		—	0.9	—	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_t	50	70	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	45	—	pF
Turn On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{on}	—	100	—	ns
Turn Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{off}	—	400	—	ns

FIGURE 1 — DC CURRENT GAIN

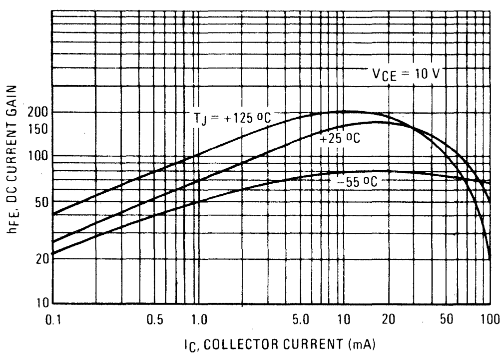


FIGURE 2 — CAPACITANCES

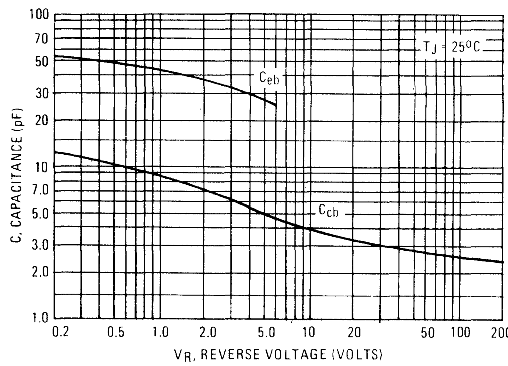


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT

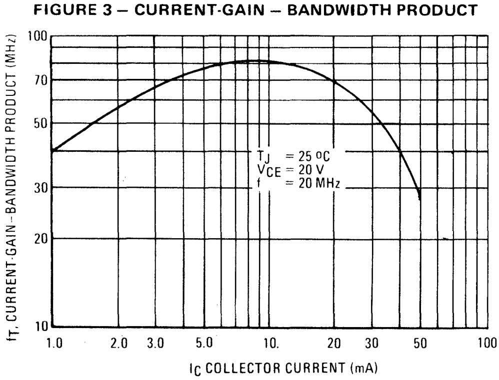


FIGURE 4 — ACTIVE-REGION SAFE OPERATING AREA

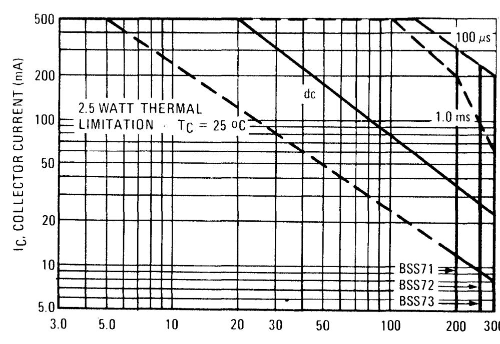


FIGURE 5 — "ON" VOLTAGES

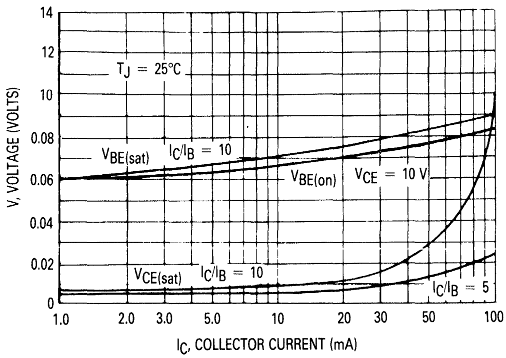


FIGURE 6 — TEMPERATURE COEFFICIENTS

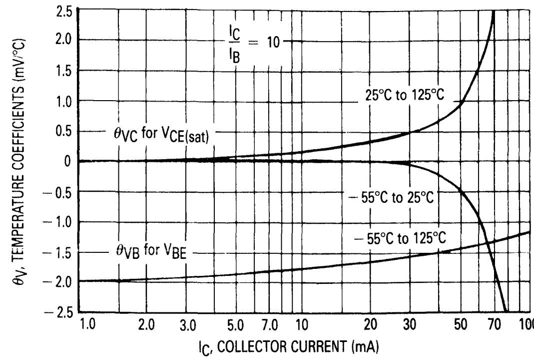


FIGURE 7 — TURN-ON TIME

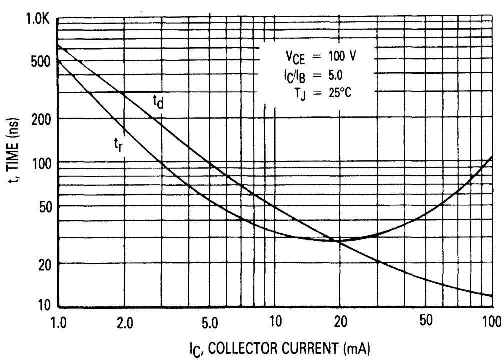


FIGURE 8 — TURN-OFF TIME

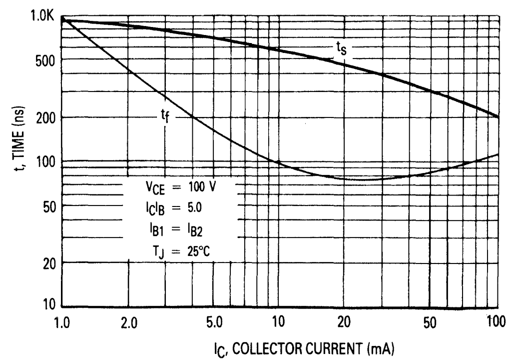
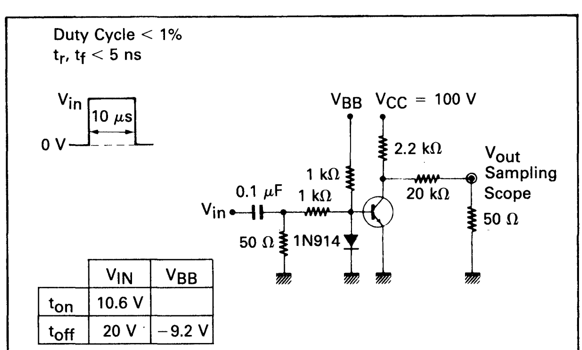


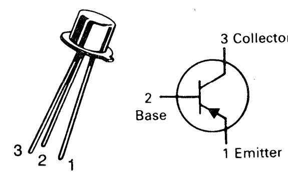
FIGURE 9 — SWITCHING TIME TEST CIRCUIT



	V_{IN}	V_{BB}
t_{on}	10.6 V	
t_{off}	20 V	−9.2 V

BSS74 thru BSS76

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



HIGH VOLTAGE TRANSISTORS

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	BSS 74	BSS 75	BSS 76	Unit
Collector-Emitter Voltage	V_{CEO}	−200	−250	−300	Vdc
Collector-Base Voltage	V_{CBO}	−200	−250	−300	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0			Vdc
Collector Current — Continuous	I_C	−0.5			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mA, I_B = 0)	BSS74 BSS75 BSS76	$V_{(BR)CEO}$	−200 −250 −300	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	BSS74 BSS75 BSS76	$V_{(BR)CBO}$	−200 −250 −300	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	BSS74 BSS75 BSS76	$V_{(BR)EBO}$	−6 −6 −6	— — —	— — —	Vdc
Collector Cutoff Current (V_{CB} = −150 V, I_E = 0) (V_{CB} = −200 V, I_E = 0) (V_{CB} = −250 V, I_E = 0)	BSS74 BSS75 BSS76	I_{CBO}	— — —	— — —	−50 −50 −50	nA
Collector-Emitter Cutoff Current (V_{CE} = −150 V, I_B = 0) (V_{CE} = −200 V, I_B = 0) (V_{CE} = −300 V, I_B = 0)	BSS74 BSS75 BSS76	I_{CEO}	— — —	— — —	−500 −500 −500	nA
Emitter-Cutoff Current (V_{EB} = −5.0 Vdc, I_C = 0)	ALL	I_{EBO}	—	—	−50	nA
ON CHARACTERISTICS						
DC Current Gain (I_C = −0.1 mA, V_{CE} = −1.0 V) (I_C = −1.0 mA, V_{CE} = −10 V) (I_C = −10 mA, V_{CE} = −10 V)(1) (I_C = −30 mA, V_{CE} = −10 V)(1) (I_C = −100 mA, V_{CE} = −10 V)(1)	BSS74 ALL ALL ALL BSS76	h_{FE}	20 30 35 35 —	40 45 50 55 40	— — — 150 —	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −30 mAdc, I_B = −3.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −100 mAdc, I_B = −20 mAdc)	ALL ALL ALL BSS76	$V_{CE(sat)}$	— — — —	−0.15 −0.25 −0.35 −0.40	−0.3 −0.4 −0.5 —	Vdc
Base-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc) (I_C = −30 mAdc, I_B = −3.0 mAdc) (I_C = −50 mAdc, I_B = −5.0 mAdc) (I_C = −100 mAdc, I_B = −10 mAdc)	ALL ALL ALL BSS76	$V_{BE(sat)}$	— — — —	−0.7 −0.8 −0.85 −0.9	−0.8 −0.9 −1.0 —	Vdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth product (I_C = −20 mAdc, V_{CE} = −20 Vdc, f = 20 MHz)	f_T	50	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = −20 Vdc, f = 1.0 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = −0.5 Vdc, f = 1.0 MHz)	C_{ib}	—	45	—	pF
Turn-On Time (I_{B1} = −10 mA, I_C = −50 mAdc, V_{CC} = −100 Vdc)	t_{on}	—	100	—	ns
Turn-Off Time (I_{B2} = −10 mAdc, I_C = −50 mAdc, V_{CC} = −100 Vdc)	t_{off}	—	400	—	ns

FIGURE 1 — DC CURRENT GAIN

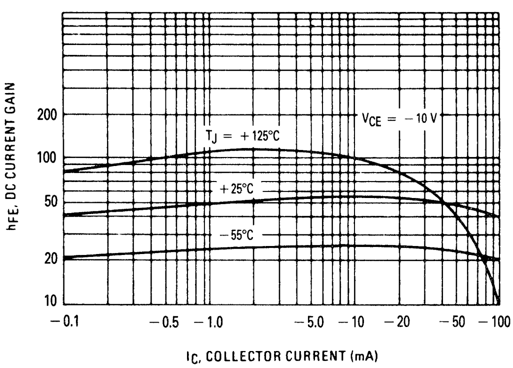


FIGURE 2 — CAPACITANCES

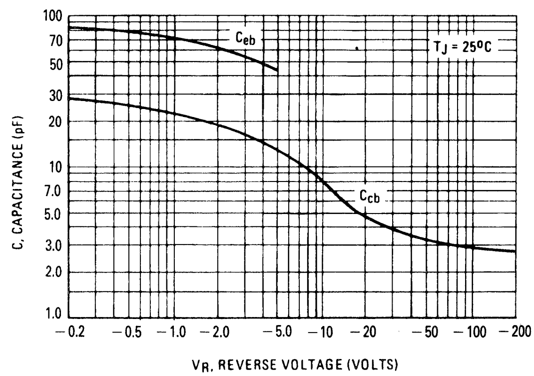


FIGURE 3 — "ON" VOLTAGES

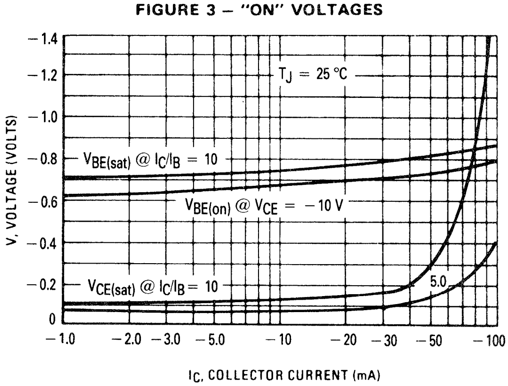


FIGURE 4 — TEMPERATURE COEFFICIENTS

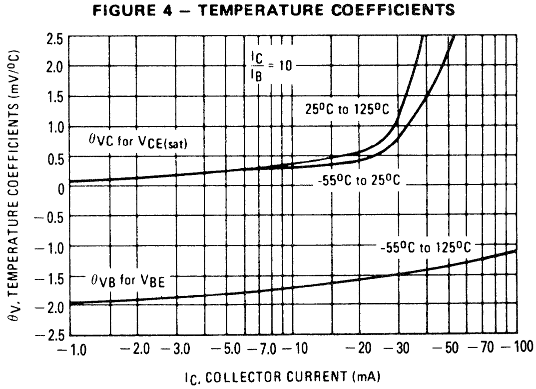


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FIGURE 5 — CURRENT-GAIN—BANDWIDTH PRODUCT

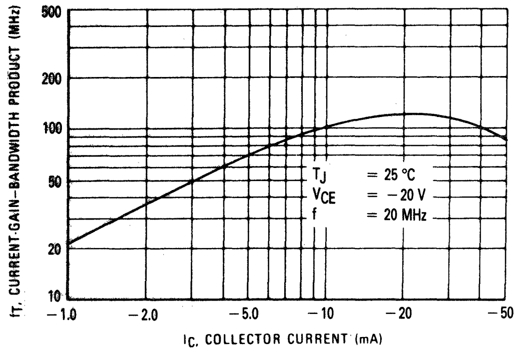


FIGURE 6 — TURN-ON TIME

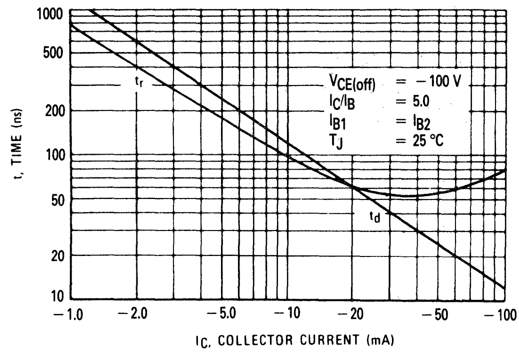


FIGURE 7 — TURN-OFF TIME

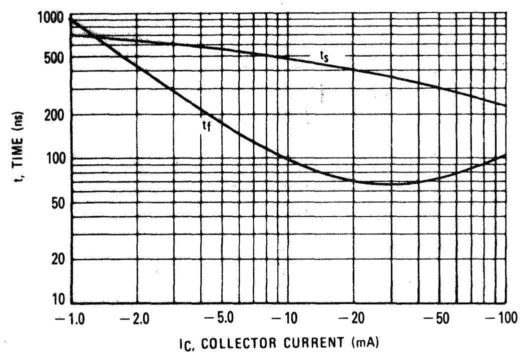


FIGURE 8 — SWITCHING TIME TEST CIRCUIT

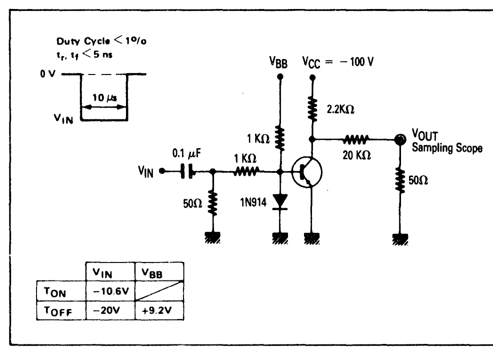
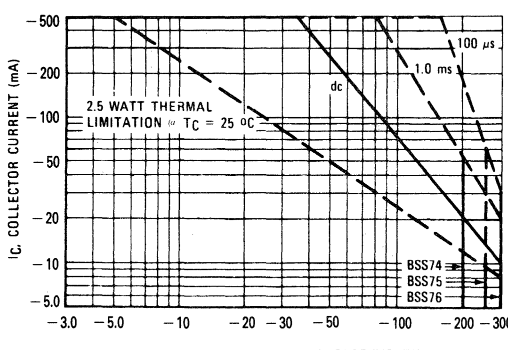
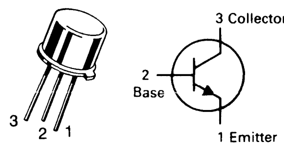


FIGURE 9 — ACTIVE-REGION SAFE OPERATING AREA



BSS78

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Base Voltage	V_{CBO}	250	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	250	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	250	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 200 V, I_E = 0)	I_{CBO}	—	—	50	nA
Collector-Emitter Cutoff Current (V_{CE} = 200 V, I_B = 0)	I_{CEO}	—	—	500	nA
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mA, V_{CE} = 1.0 V) (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V)(1) (I_C = 30 mA, V_{CE} = 10 V)(1) (I_C = 100 mA, V_{CE} = 10 V)(1)	h_{FE}	 20 30 50 40 —	 40 45 120 140 35	 — — — 250 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	 — — — —	 0.15 0.25 0.35 0.25	 0.3 0.4 0.5 —	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 — — — —	 0.7 0.8 0.85 0.9	 0.8 0.9 1.0 —	Vdc

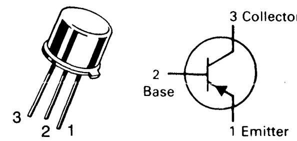
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	70	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	45	—	pF
Turn On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{on}	—	100	—	ns
Turn Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{off}	—	400	—	ns

BSV16-10

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

PNP SILICON

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Refer to 2N4405 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−60	Vdc
Collector-Emitter Voltage	V_{CES}	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

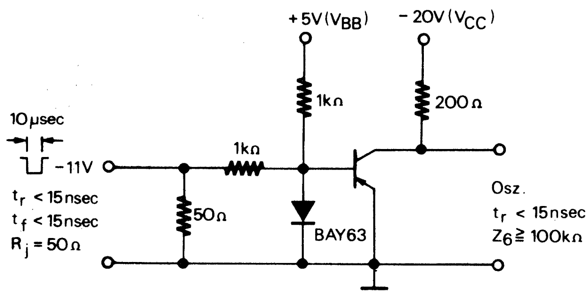
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current (V_{CE} = −60 V) (V_{CE} = −60 V, T_A = 150°C) (V_{CE} = −60 V, V_{BE} = −0.2 V, T_A = 100°C)	I_{CES}	 — — —	 −50 −50 −50	 nA μA
Emitter Cutoff Current (V_{EB} = −4.0 V)	I_{EBO}	—	−50	nA
Collector-Emitter Breakdown Voltage (I_C = −50 mA)(1)	$V_{(BR)CEO}$	−60	—	V
Collector-Emitter Breakdown Voltage (I_C = −10 μA)	$V_{(BR)CES}$	−60	—	V
Emitter-Base Breakdown Voltage (I_E = −10 μA)	$V_{(BR)EBO}$	−5.0	—	V
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = −1.0 V, I_C = −0.1 mA) (V_{CE} = −1.0 V, I_C = −100 mA)(1) (V_{CE} = −1.0 V, I_C = −500 mA)(1)	h_{FE}	 20 63 25	 — 160 —	—
Base-Emitter Voltage (V_{CE} = −1.0 V, I_C = −100 mA)(1) (V_{CE} = −1.0 V, I_C = −500 mA)(1)	$V_{BE(on)}$	 — −0.7	 −1.0 −1.4	V
SMALL-SIGNAL CHARACTERISTICS				
Current Gain-Bandwidth Product (I_C = −50 mA, V_{CE} = −10 V, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	25	pF
Small-Signal Current Gain (I_C = −1.0 mA, V_{CE} = −5.0V, f = 1.0 MHz)	h_{fe}	20	—	—
Turn On Time (Fig. 1) (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 mA) Storage Time (Fig. 1) (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 mA)	t_{on} t_s	— —	500 500	ns
Fall Time (Fig. 1) (I_C = −100 mA, I_{B1} = I_{B2} = −5.0 mA)	t_f	—	150	ns

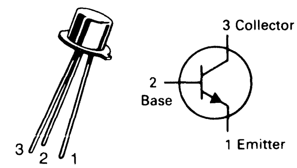
(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 2%.

FIGURE 1 — SWITCHING TIME CIRCUIT



BSX20

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current − Continuous	I_C	500	mAmp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mWatt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.2 6.85	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0) (I_C = 10 mAdc, R_{BE} = 10 Ω)	 $V_{(BR)CEO}$ $V_{(BR)CER}$	 15 20		Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5		Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_j = 150°C)	I_{CBO}		 400 30	 nAdc μAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_j = 55°C) (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}		 0.4 1.0	μAdc
Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 3.0 V, T_j = 55°C)	I_{CEX} I_{BEX}		0.6 0.6	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_j = −55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20 10	 120	
Base-Emitter On Voltage (I_C = 30 μAdc, V_{CE} = 20 Vdc, T_j = 100°C)	$V_{BE(on)}$		0.35	Vdc
Emitter-Collector Saturation Voltage(1) (I_C = 10 mAdc, I_B = 0.3 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$		 0.30 0.25 0.60	Vdc
Emitter-Base Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 0.70	 0.85 1.50	Vdc

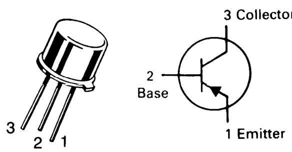
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current Gain-Bandwidth Product (I_C = 10 mA, V_{CE} = 10 V, f = 100 MHz)	f_T	500		MHz
Output Capacitance (V_{CB} = 5.0 V, I_E = 0, f = 1.0 MHz)	C_{obo}		4.0	pF
Input Capacitance (V_{EB} = 1.0 V, I_C = 0, f = 1.0 MHz)	C_{ibo}		4.5	pF
Time (I_C = 10 mA, I_{B1} = I_{B2} = 10 mA)	t_s		1.3	ns
Turn-On Time	t_{on}			ns
(I_C = 10 mA, I_{B1} = 3.0 mA)			12	
(I_C = 100 mA, I_{B1} = 40 mA)			7.0	
Turn-Off Time	t_{off}			ns
(I_C = 10 mA, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA)			18	
(I_C = 100 mA, I_{B1} = 40 mA, I_{B2} = −20 mA)			21	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

CV9507

(CECC 50004-050)
CASE 79-04, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N2904 for graphs.

3

MAXIMUM RATINGS

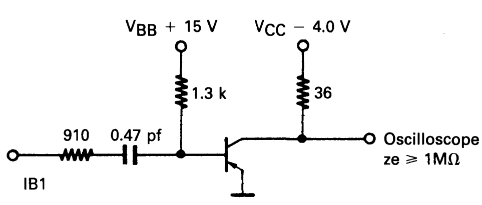
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−65	Vdc
Collector-Base Voltage	V_{CBO}	−65	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−0.6	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 3.33	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = -10$ mA, $I_B = 0$)	$V_{CEO(sus)}$	−65		Vdc
Collector Cutoff Current ($V_{CB} = -50$ V, $I_E = 0$) ($V_{CB} = -50$ V, $I_E = 0$, $T_A = 100°C$)	I_{CBO}		 −75 −1.0	 nA µA
Emitter Cutoff Current ($V_{EB} = -3.0$ V, $I_C = 0$) ($V_{EB} = -5.0$ V, $I_C = 0$)	I_{EBO}		 −100 −10	 nA µA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage(1) ($I_C = -150$ mA, $I_B = -15$ mA)	$V_{CE(sat)}$		−0.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = -150$ mA, $I_B = -15$ mA) ($I_C = -30$ mA, $I_B = -1.0$ mA)	$V_{BE(sat)}$		 −1.3 −0.9	Vdc
DC Current Gain ($I_C = -1.0$ mA, $V_{CE} = -0.4$ V) ($I_C = -10$ mA, $V_{CE} = -0.4$ V)(1) ($I_C = -50$ mA, $V_{CE} = -0.4$ V)(1) ($I_C = -150$ mA, $V_{CE} = -0.4$ V)(1)	h_{FE}	 40 50 20 10	 200 	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = -50$ mA, $V_{CE} = -10$ V, f = 20 MHz)	f_T	50		MHz
Output Capacitance ($V_{CB} = -10$ V, f = 1.0 MHz)	C_{obo}		12	pF
SWITCHING CHARACTERISTICS				
Storage Time (See Figure 1) ($V_{CC} = -4.0$ V, $I_C = -100$ mA) ($I_{B1} = I_{B2} = 10$ mA)	t_s		250	ns

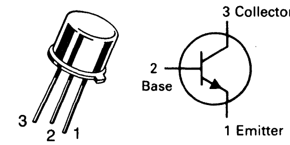
(1) Pulsed: Pulse Duration = 300 µs, Duty Cycle = 2%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



CV12253

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current – Continuous	I_C	0.6	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.43	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	292	°C/W

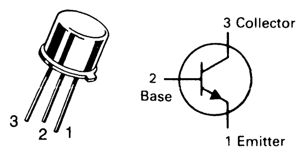
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$	65		V
Collector Cutoff Current (V_{CB} = 50 V, I_E = 0)	I_{CBO}		20	nA
Emitter Cutoff Current (I_{EBO}(1) V_{EB} = 3 V, I_C = 0) (I_{EBO}(2) V_{EB} = 5 V, I_C = 0)	I_{EBO}		20 2	nA μA
Collector Cutoff Current (V_{CE} = 50 V, T_A = 100°C)	I_{CEO}		80	μA
ON CHARACTERISTICS				
DC Current Gain (h_{21e}(1) I_C = 1.0 mA, V_{CE} = 0.4 V) (h_{21e}(2) I_C = 10 mA, V_{CE} = 0.4 V)(1) (h_{21e}(3) I_C = 150 mA, V_{CE} = 0.75 V)(1) (h_{21e}(4) I_C = 50 mA, V_{CE} = 0.4 V)(1)	h_{FE}	40 50 25 35	— 200 — —	
Base-Emitter Saturation Voltage(1) (I_C = 30 mA, I_B = 1 mA) (I_C = 150 mA, I_B = 15 mA)	$V_{BE(sat)}$		0.9 1.3	V
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)	f_T	60		MHz
Storage Time (V_{CC} = 45 V, I_C = 100 mA, I_{B1} = I_{B2} = 10 mA)	t_s	172	550	ns
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)	C_{ob}		20	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 2%.

MM3001
MM3002

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MM3001	MM3002	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MM3001 MM3002	$V_{(BR)CEO}$	150 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0)	MM3001 MM3002	I_{CBO}	— —	1.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MM3001 MM3002	C_{obo}	— —	7.0 1.5	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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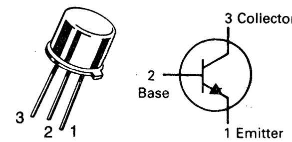
MM3005
MM3007

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AUDIO TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MM3005	MM3007	Unit
Collector-Emitter Voltage	V_{CEO}	60	100	Vdc
Collector-Base Voltage	V_{CBO}	80	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	2.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.0 45.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	22	°C/W

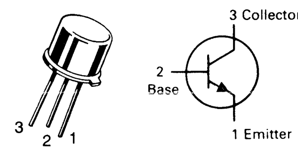
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MM3005 MM3007	$V_{(BR)CEO}$	 60 100	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MM3005 MM3007	$V_{(BR)CBO}$	 80 120	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0)	 MM3005 MM3007	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)(1)	 All Types MM3005 MM3007	h_{FE}	 40 50 50	 — 250 250	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter On Voltage(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	0.60	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3725★

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

NPN SILICON

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	MM3725	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0 T_A = 100°C) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — — — —	 0.12 — — —	 1.7 — 120 —	μAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{EB} = 0) (V_{CE} = 50 Vdc, V_{EB} = 0)	I_{CES}	 — —	 0.15 —	 10 —	μAdc
Base Current (V_{CE} = 50 V, V_{EB} = 0) (V_{CE} = 80 V, V_{EB} = 0)	I_B	—	—	10	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 800 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 800 mA, V_{CE} = 2.0 V) (I_C = 1.0 Adc, V_{CE} = 5.0 V)	h_{FE}	 30 60 30 40 35 20 25 30 20 25	 — — — — — — — — — —	— 150 — — — — — — — —	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.17	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.19	0.26	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	0.25	0.40	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.30	0.52	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	0.43	0.80	
(I_C = 1.0 mAdc, I_B = 100 mAdc)		—	0.55	0.95	
Base-Emitter Saturation Voltage(1)	$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	—	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	—	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)		—	—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)		0.8	—	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)		—	—	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	—	1.7	

SMALL-SIGNAL CHARACTERISTICS

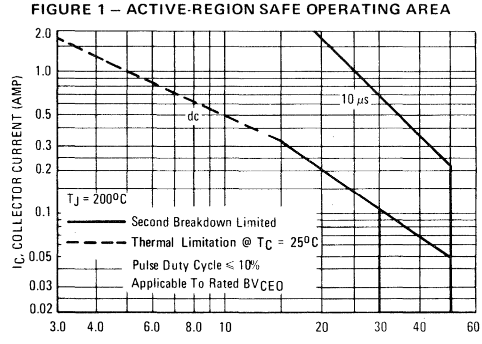
Characteristic	Symbol	Min	Typ	Max	Unit
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	55	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_d	—	5.0	10	ns
Rise Time		t_r	—	15	30	ns
Turn-On Time		t_{on}	—	20	35	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	t_s	—	35	50	ns
Fall Time		t_f	—	20	25	ns
Turn-Off Time		t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%
(2) f_T = $|h_{fe}| \cdot f_{test}$

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

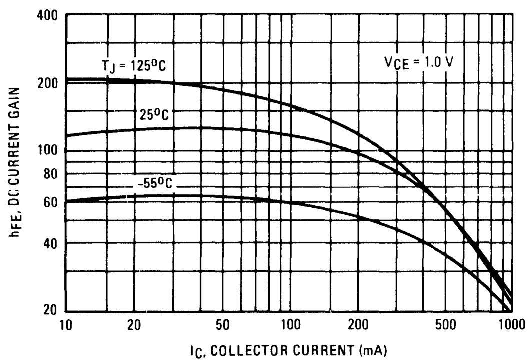


FIGURE 3 – "ON" VOLTAGES

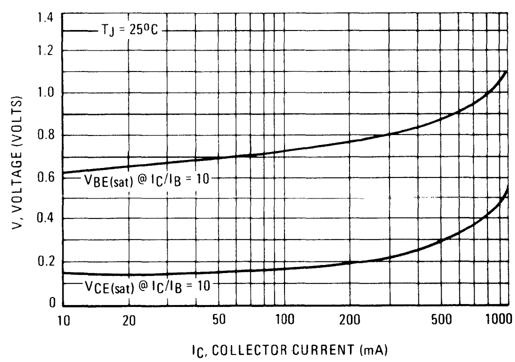


FIGURE 4 – COLLECTOR SATURATION REGION

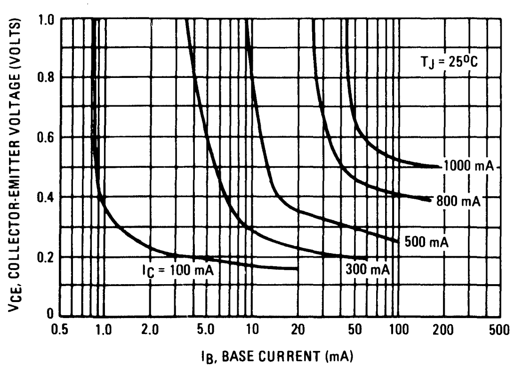
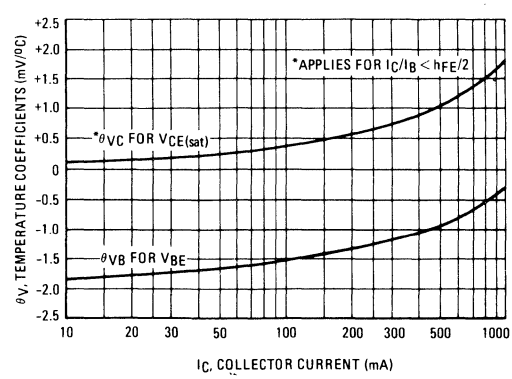


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

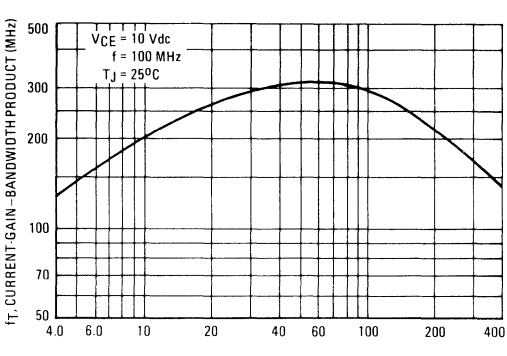


FIGURE 7 – CAPACITANCE

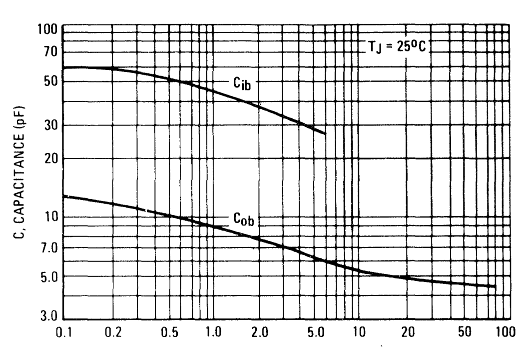


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FIGURE 8 – TURN-ON TIME

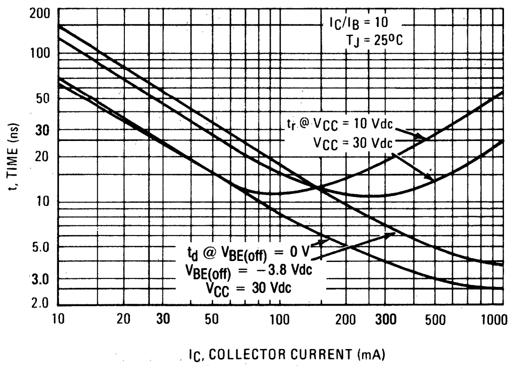


FIGURE 9 – TURN-OFF TIME

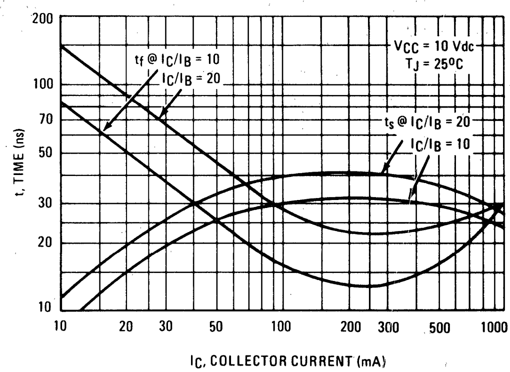


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

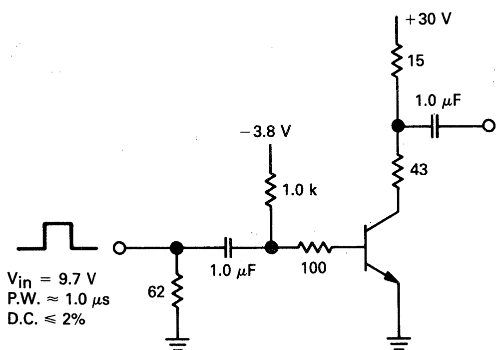
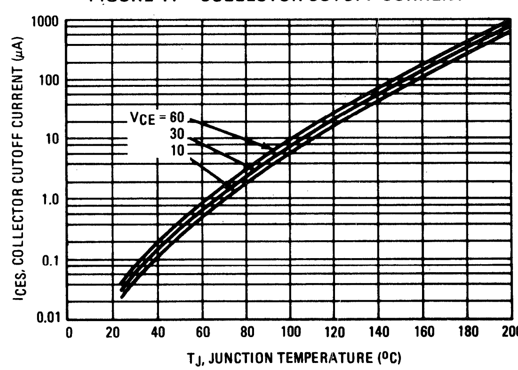
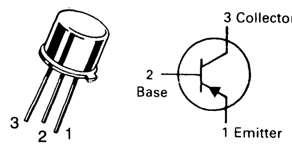


FIGURE 11 – COLLECTOR CUTOFF CURRENT



MM4001
MM4003

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MM4001	MM4003	Unit
Collector-Emitter Voltage	V_{CEO}	−150	−250	Vdc
Collector-Base Voltage	V_{CBO}	−150	−250	Vdc
Emitter-Base Voltage	V_{EBO}	−4.0		Vdc
Collector Current — Continuous	I_C	−500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	292	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	°C/W

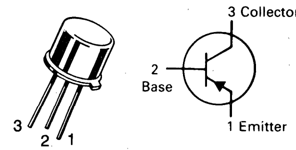
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	 MM4001 MM4003	$V_{(BR)CEO}$	 −150 −250	 — —	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = −100 μAdc)	 MM4001 MM4003	$V_{(BR)CBO}$	 −150 −250	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)		$V_{(BR)EBO}$	−4.0	—	Vdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0) (V_{CB} = −75 Vdc, I_E = 0) (V_{CB} = −150 Vdc, I_E = 0)	 MM4001 MM4003	I_{CBO}	 — — —	 −1.0 −5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = −10 mAdc, V_{CE} = −10 Vdc)		h_{FE}	20	—	—
Collector-Emitter Saturation Voltage(1) (I_C = −10 mAdc, I_B = −1.0 mAdc)	 MM4001 MM4003	$V_{CE(sat)}$	 — —	 −0.6 −5.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = −20 Vdc, I_E = 0, f = 1.0 MHz)	 MM4001 MM4003	C_{obo}	 — —	 10 20	pF

(1) Pluse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM4005

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−60	Vdc
Collector-Base Voltage	V_{CBO}	−60	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

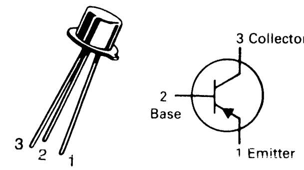
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = −50 Vdc, I_E = 0)	I_{CBO}	—	—	−100	nAdc
Emitter Cutoff Current (V_{EB} = −3.0 Vdc, I_E = 0)	I_{EBO}	—	—	−100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −150 mAdc, V_{CE} = −1.0 Vdc)(2)	h_{FE}	 40 50	 90 150	 — —	—
Collector-Emitter Saturation Voltage (I_C = −150 mAdc, I_B = −15 mAdc)	$V_{CE(sat)}$	—	−0.1	—	Vdc
Base-Emitter Saturation Voltage (I_C = −150 mAdc, I_B = −15 mAdc)	$V_{BE(sat)}$	—	−0.7	—	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)	f_T	50	250	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	10	—	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	100	—	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM4209★

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

PNP SILICON

★This is a Motorola designated preferred device.

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	−15	Vdc
Collector-Base Voltage	V_{CBO}	−15	Vdc
Emitter-Base Voltage	V_{EBO}	−4.5	Vdc
Collector Current — Continuous	I_C	−50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.0	Watts mW/°C
Operating and Storage Jucntion Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage(1) (I_C = −3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	−15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = −100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	−15	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−4.5	—	Vdc
Collector Cutoff Current (V_{CE} = −8.0 Vdc, V_{BE} = 0) (V_{CE} = −8.0 Vdc, V_{BE} = 0, T_A = 125°C)	I_{CES}	— —	−10 −5.0	nAdc μAdc
Base Current (V_{CE} = −8.0 Vdc, V_{BE} = 0)	I_B	—	−1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −0.5 Vdc) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc)(1) (I_C = −10 mAdc, V_{CE} = −1.0 Vdc, T_A = −55°C)(1) (I_C = −50 mAdc, V_{CE} = −1.0 Vdc)(1)	h_{FE}	 30 35 15 25	 — 120 — —	—
Collector-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = −0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{CE(sat)}$	 — — —	 −0.15 −0.18 −0.6	Vdc
Base-Emitter Saturation Voltage (I_C = −1.0 mAdc, I_B = − 0.1 mAdc) (I_C = −10 mAdc, I_B = −1.0 mAdc)(1) (I_C = −50 mAdc, I_B = −5.0 mAdc)(1)	$V_{BE(sat)}$	 — −0.75 —	 −0.8 −0.95 −1.5	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = −10 mAdc, V_{CE} = −10 Vdc, f = 100 MHz)		f_T	850	—	MHz
Output Capacitance (V_{CB} = −5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	pF
Input Capacitance (V_{EB} = −0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = −1.5 Vdc, V_{BE} = 0, I_C = −10 mAdc, I_{B1} = −1.0 mAdc)	t_{on}	—	15	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	(V_{CC} = −1.5 Vdc, V_{BE} = 0, I_C = −10 mAdc, I_{B1} = I_{B2} = −1.0 mAdc)	t_{off}	—	20	ns
Storage Time		t_s	—	20	ns
Fall Time		t_f	—	10	ns
Storage Time (I_C ≈ −10 mAdc, I_{B1} ≈ −10 mAdc, I_{B2} ≈ −10 mAdc)		t_s	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
(2) f_T is defined as the freqency at which $|h_{fe}|$ extrapolates to unity.

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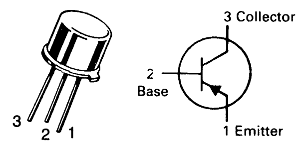
MM5007

CASE 79-04, STYLE 1
TO-39 (TO-205AD)



AUDIO TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Emitter Voltage	V_{CEO}	−100	Vdc
Collector-Base Voltage	V_{CBO}	−120	Vdc
Emitter-Base Voltage	V_{EBO}	−5.0	Vdc
Collector Current — Continuous	I_C	−2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 1.5 8.57	 Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 8.0 45.7	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	117	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	22	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

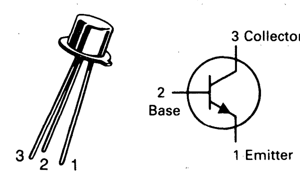
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = −10 mAdc, I_B = 0)	$V_{(BR)CEO}$	−100	—	Vdc
Collector-Base Breakdown Voltage (I_C = −100 μAdc, I_E = 0)	$V_{(BR)CBO}$	−120	—	Vdc
Emitter-Base Breakdown Voltage I_E = −100 μAdc, I_C = 0)	$V_{(BR)EBO}$	−5.0	—	Vdc
Collector Cutoff Current (V_{CB} = −100 Vdc, I_E = 0)	I_{CBO}	—	−200	nAdc
Emitter Cutoff Current (V_{EB} = −4.0 Vdc, I_C = 0)	I_{EBO}	—	−100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = −1.0 mAdc, V_{CE} = −1.0 Vdc) (I_C = −250 mAdc, V_{CE} = −2.5 Vdc)(1)	h_{FE}	 40 50	 — 250	—
Collector-Emitter Saturation Voltage (I_C = −150 mAdc, I_B = −15 mAdc)(1)	$V_{CE(sat)}$	—	−0.5	Vdc
Base-Emitter On Voltage(1) (I_C = −150 mAdc, V_{CE} = −2.5 Vdc)	$V_{BE(on)}$	−0.65	−0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = −50 mAdc, V_{CE} = −10 Vdc, f = 20 MHz)	f_T	30	—	MHz
Output Capacitance (V_{CB} = −10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MM6427

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	375 2.14	mW W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 7.15	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

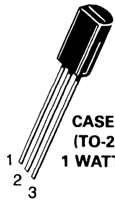
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	467	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	140	°C/W

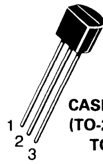
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 5000 10,000	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	15	pF
Small-Signal Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	h_{fe}	1.25	—	—

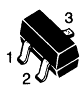
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



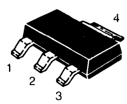
CASE 29-03
(TO-226AE)
1 WATT TO-92



CASE 29-04
(TO-226AA)
TO-92



CASE 318-07
(TO-236AB)
SOT-23



CASE 318E-04
(TO-261AA)
SOT-223

Field-Effect Transistors

4

The data sheets on the following pages are designed to emphasize those FETs that by virtue of widespread industry use, ease of manufacture, and low relative cost, merit first consideration for new equipment design.

CAUTION:

Static electricity is a surface phenomenon which most commonly occurs when two dissimilar materials come into contact and then separate. Electro Static Discharge (ESD) damage of semiconductor components by operating personnel is quickly becoming a very prominent and significant problem. From simple bipolar designs to sensitive MOSFET structures, ESD has its unforgiving effect of degradation or destruction.

Motorola believes it is important to extend any emphasizing note of cautiousness when handling and testing *ANY* FET product. Precautions include, but are not limited to, the implementation of static safe workstations and proper handling techniques. Additionally, it is very important to keep FET devices in their antistatic shipping containers and away from static-generating materials.

The MDC1000 and MDC1005 series provides rapid turn-off of MOSFETs with a single driving device versus using a four device circuit (see SMALLBLOCK Products, Section 6).

NOTE: All SOT-23 package devices have had a "T1" suffix added to the device title.

EMBOSSED TAPE AND REEL

SOT-23 and SOT-223 packages are available only in Tape and Reel. Use the appropriate suffix indicated below to order any of the SOT-23 and SOT-223 packages. (See Section 7 on Packaging for additional information).

SOT-23: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SOT-223: available in 12 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/1000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/4000 unit reel.

RADIAL TAPE REEL AND AMMO PACK

TO-92 packages are available in both bulk shipments and in Radial Tape Reel and Ammo Packs. Radial Tape Reel and Ammo Pack are the best methods for capturing devices for automatic insertion in printed circuit boards.

TO-92: available in 365 mm Radial Tape Reel
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Radial Tape Reel.

available in Ammo Pack (Fan Fold Box)
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Ammo Pack box.

*Refer to Section 7 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

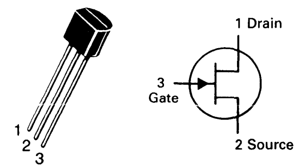
The SOT-23 package has a device marking and a date code etched on the device. The generic example below depicts both the device marking and a representation of the date code that appears on the SOT-23 package.

ABCD

The "D" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

2N5457 thru 2N5459★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs
GENERAL PURPOSE

N-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 −1.0 −200	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5457 2N5458 2N5459	$V_{GS(off)}$	 −0.5 −1.0 −2.0	 — — —	 −6.0 −7.0 −8.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 100 μAdc) (V_{DS} = 15 Vdc, I_D = 200 μAdc) (V_{DS} = 15 Vdc, I_D = 400 μAdc)	 2N5457 2N5458 2N5459	V_{GS}	 — — —	 −2.5 −3.5 −4.5	 — — —	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5457 2N5458 2N5459	I_{DSS}	 1.0 2.0 4.0	 3.0 6.0 9.0	 5.0 9.0 16	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5457 2N5458 2N5459	$\|y_{fs}\|$	 1000 1500 2000	 — — —	 5000 5500 6000	μmhos
Output Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.5	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

FIGURE 1 — NOISE FIGURE versus FREQUENCY

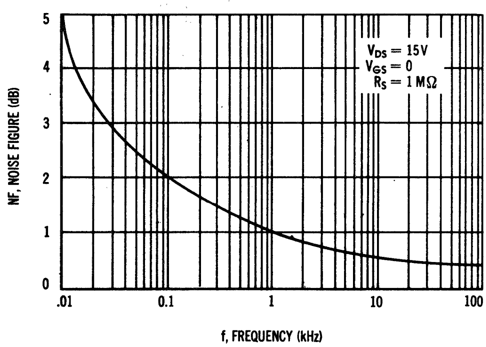


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE

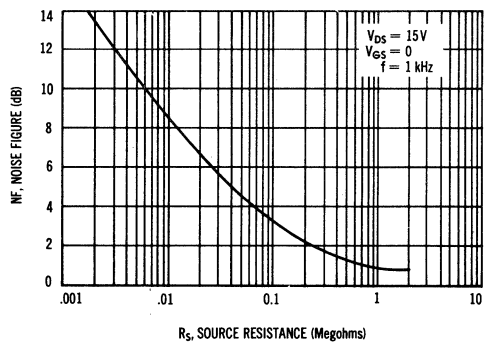


FIGURE 3 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -1.2$ VOLTS

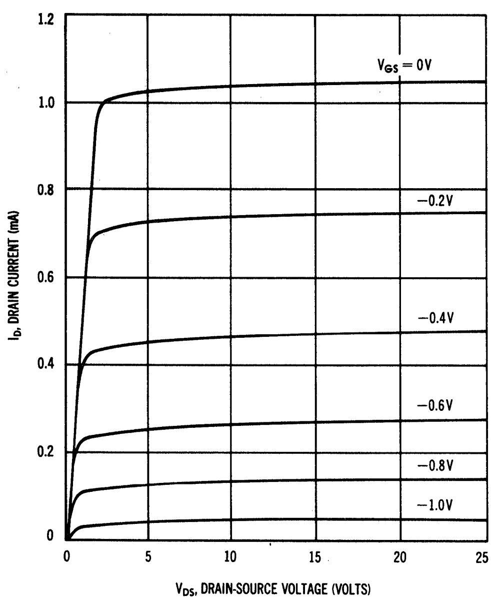


FIGURE 4 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -1.2$ VOLTS

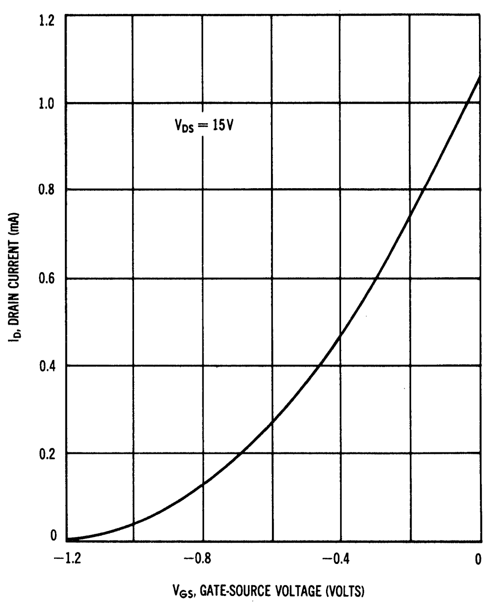


FIGURE 5 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -3.5$ VOLTS

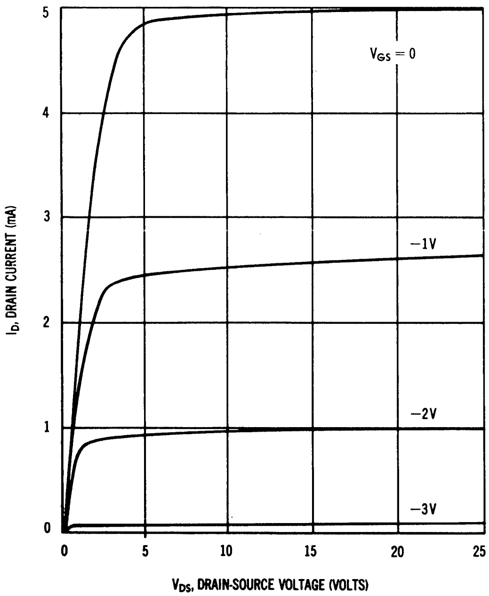


FIGURE 6 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -3.5$ VOLTS

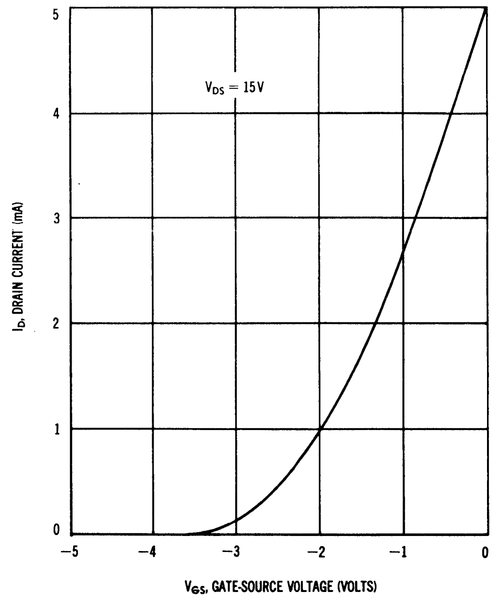


FIGURE 7 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -5.8$ VOLTS

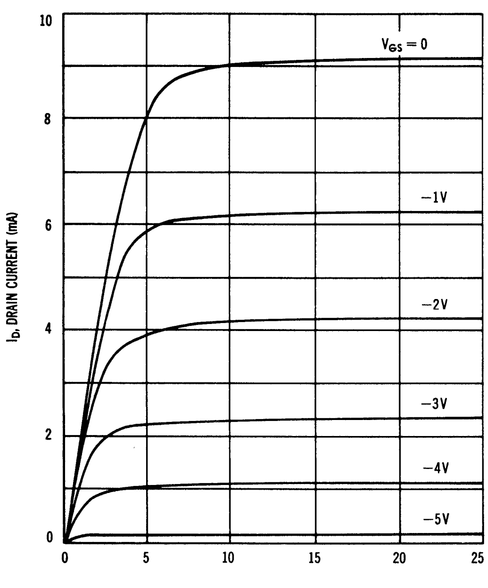
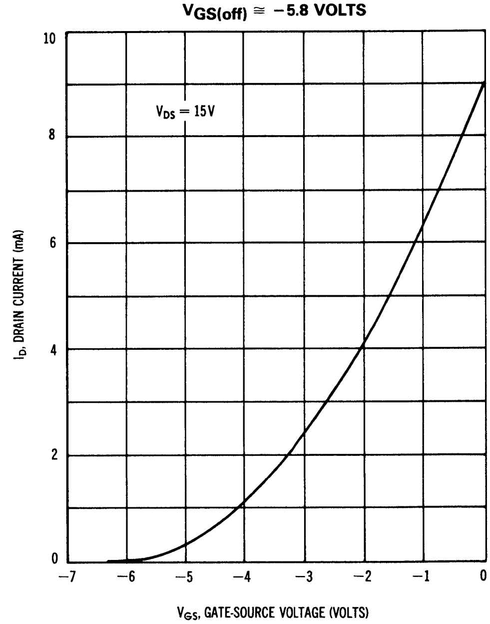


FIGURE 8 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -5.8$ VOLTS

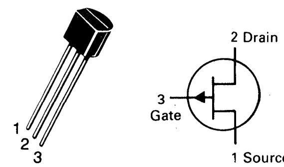


NOTES:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS} (See Figure 10).
2. Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

2N5460 thru 2N5462★

CASE 29-04, STYLE 7
TO-92 (TO-226AA)



JFET AMPLIFIERS

P-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	−65 to +135	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	2N5460, 2N5461, 2N5462	$V_{(BR)GSS}$	40	—	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 30 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C) (V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 100°C)	2N5460, 2N5461, 2N5462 2N5460, 2N5461, 2N5462	I_{GSS}	— —	— —	5.0 1.0	nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	2N5460 2N5461 2N5462	$V_{GS(off)}$	0.75 1.0 1.8	— — —	6.0 7.5 9.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.1 mAdc) (V_{DS} = 15 Vdc, I_D = 0.2 mAdc) (V_{DS} = 15 Vdc, I_D = 0.4 mAdc)	2N5460 2N5461 2N5462	V_{GS}	0.5 0.8 1.5	— — —	4.0 4.5 6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5460 2N5461 2N5462	I_{DSS}	−1.0 −2.0 −4.0	— — —	−5.0 −9.0 −16	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5460 2N5461 2N5462	$\|y_{fs}\|$	1000 1500 2000	— — —	4000 5000 6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	—	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	—	1.0	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	—	60	115	nV/√Hz

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 — $V_{GS(off)}$ = 2.0 VOLTS

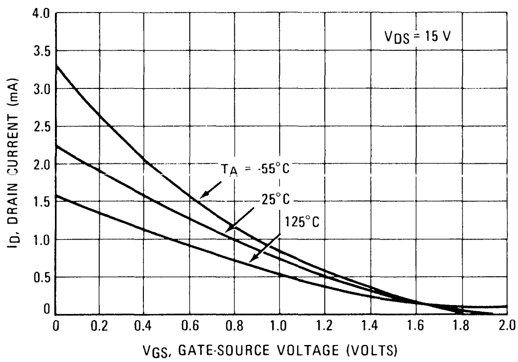


FIGURE 2 — $V_{GS(off)}$ = 4.0 VOLTS

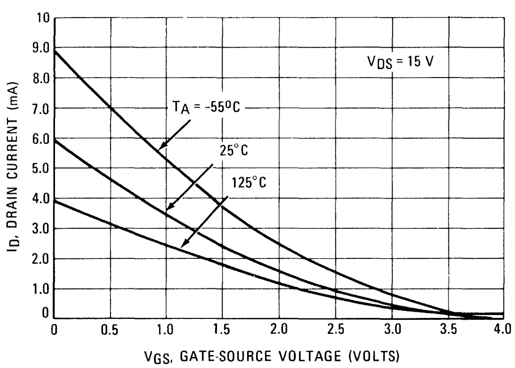
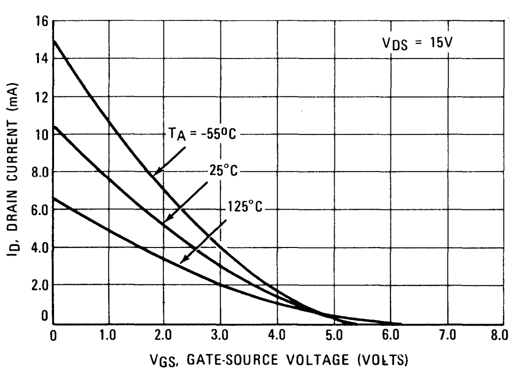


FIGURE 3 — $V_{GS(off)}$ = 5.0 VOLTS



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 4 — $V_{GS(off)}$ = 2.0 VOLTS

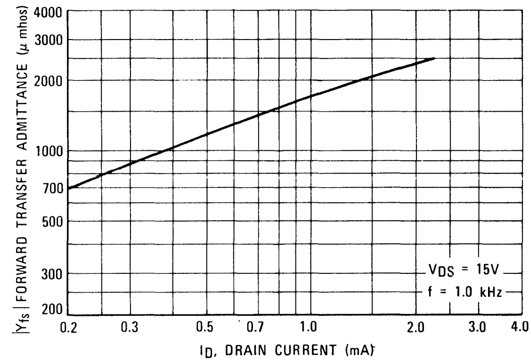


FIGURE 5 — $V_{GS(off)}$ = 4.0 VOLTS

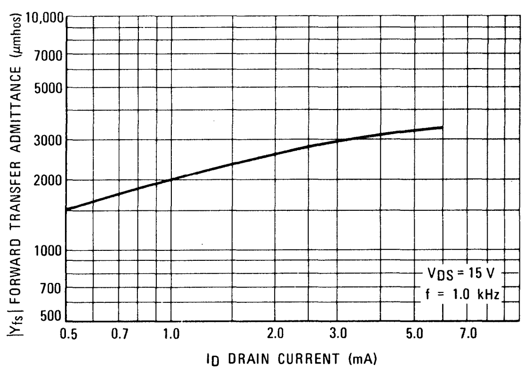


FIGURE 6 — $V_{GS(off)}$ = 5.0 VOLTS

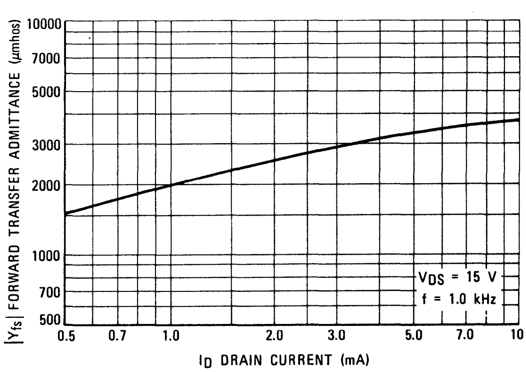


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FIGURE 7 – OUTPUT RESISTANCE VERSUS DRAIN CURRENT

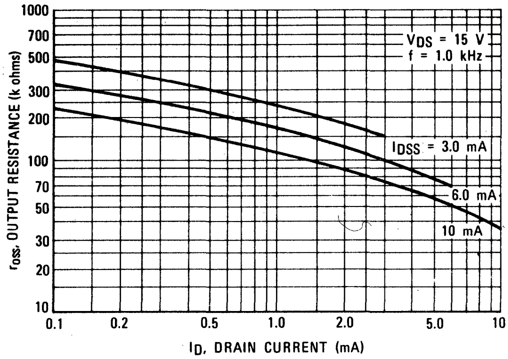


FIGURE 8 – CAPACITANCE VERSUS DRAIN-SOURCE VOLTAGE

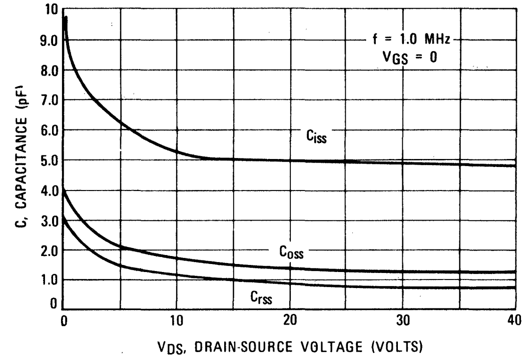


FIGURE 9 – NOISE FIGURE VERSUS FREQUENCY

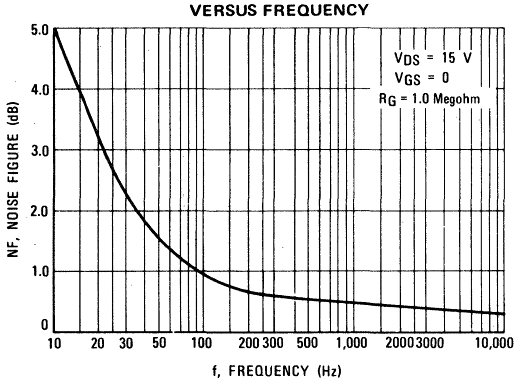


FIGURE 10 – NOISE FIGURE VERSUS SOURCE RESISTANCE

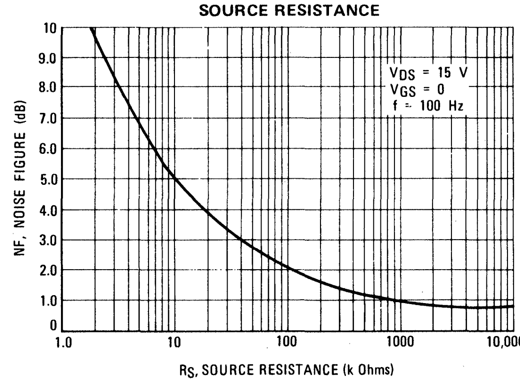
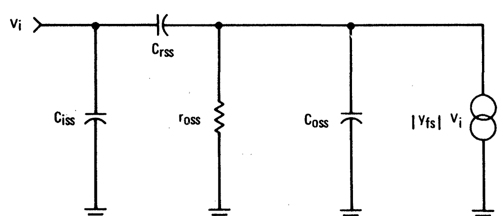


FIGURE 11 – EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}{}^* + 1/r_{oss}$

$y_{fs} = |y_{fs}|$

$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

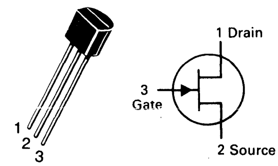
NOTE:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

4

2N5484 thru 2N5486★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET VHF/UHF AMPLIFIERS

N-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Drain Current	I_D	30	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	— —	— —	−1.0 −0.2	nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5484 2N5485 2N5486	$V_{GS(off)}$	−0.3 −0.5 −2.0	— — —	−3.0 −4.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5484 2N5485 2N5486	I_{DSS}	1.0 4.0 8.0	— — —	5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484 2N5485 2N5486	$\|y_{fs}\|$	3000 3500 4000	— — —	6000 7000 8000	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5484 2N5485, 2N5486	$Re(y_{is})$	— —	— —	100 1000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484 2N5485 2N5486	$\|y_{os}\|$	— — —	— — —	50 60 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5484 2N5485, 2N5486	$Re(y_{os})$	— —	— —	75 100	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5484 2N5485 2N5486	$Re(y_{fs})$	2500 3000 3500	— — —	— — —	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	—	1.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	—	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)			—	—	2.5	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, R_G ≈ 1.0 k ohm, f = 100 MHz)	2N5484		—	—	3.0	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, R_G ≈ 1.0 k ohm, f = 200 MHz)	2N5484		—	4.0	—	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, R_G ≈ 1.0 k ohm, f = 100 MHz)	2N5485, 2N5486		—	—	2.0	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, R_G ≈ 1.0 k ohm, f = 400 MHz)	2N5485, 2N5486		—	—	4.0	
Common Source Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	2N5484		16	—	25	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 200 MHz)	2N5484		—	14	—	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)	2N5485, 2N5486		18	—	30	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)	2N5485, 2N5486		10	—	20	

4

POWER GAIN

FIGURE 1 – EFFECTS OF DRAIN CURRENT

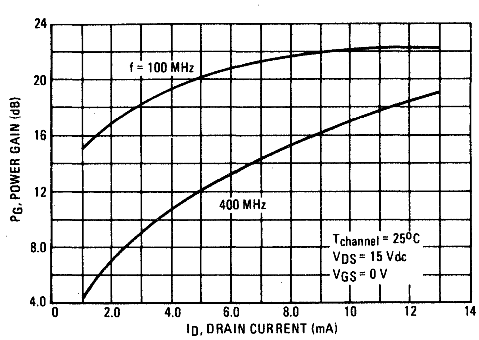
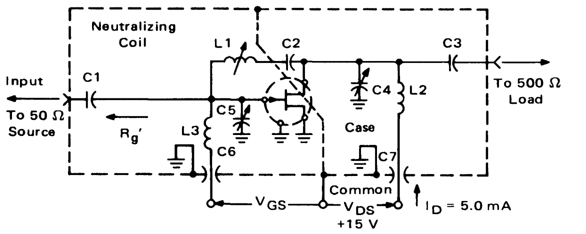


FIGURE 2 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for
I_D = 50 mA
V_{GS}< 0 Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.
L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).
L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.
L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).
L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

4

NOISE FIGURE

($T_{channel}$ = 25°C)

FIGURE 3 — EFFECTS OF DRAIN-SOURCE VOLTAGE

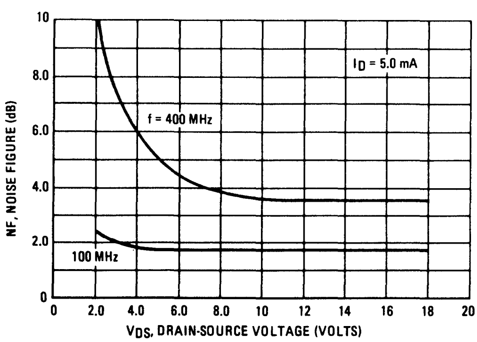
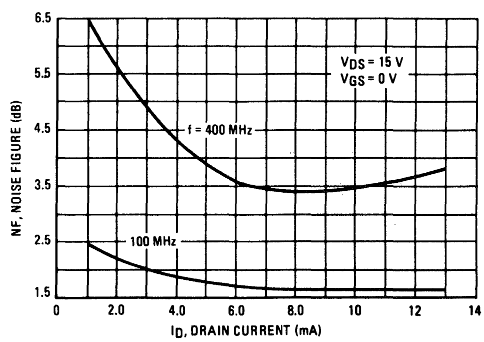
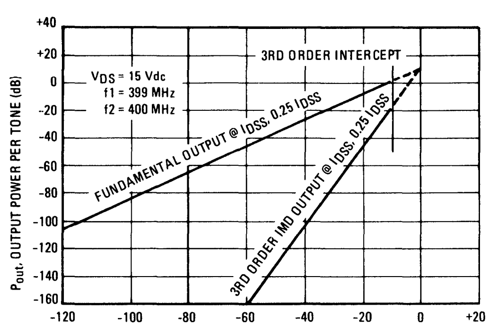


FIGURE 4 — EFFECTS OF DRAIN CURRENT



INTERMODULATION CHARACTERISTICS

FIGURE 5 — THIRD ORDER INTERMODULATION DISTORTION



COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 6 – INPUT ADMITTANCE (y_{is})

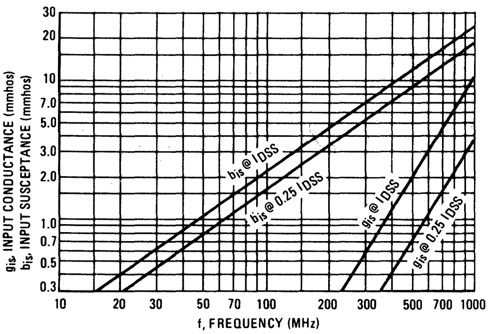


FIGURE 7 – REVERSE TRANSFER ADMITTANCE (y_{rs})

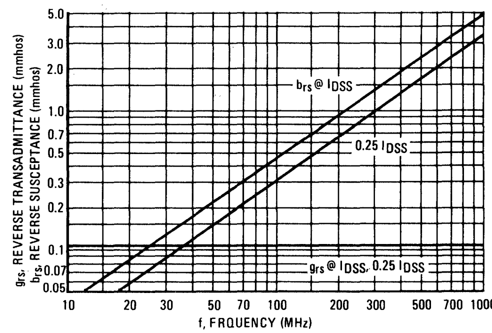


FIGURE 8 – FORWARD TRANSADMITTANCE (y_{fs})

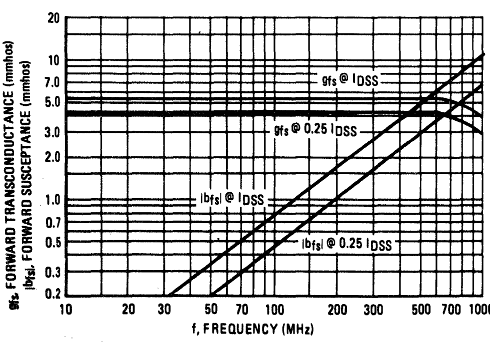
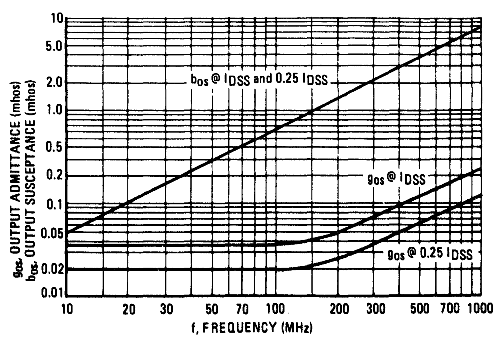


FIGURE 9 – OUTPUT ADMITTANCE (y_{os})



COMMON SOURCE CHARACTERISTICS

S-PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 10 – S_{11s}

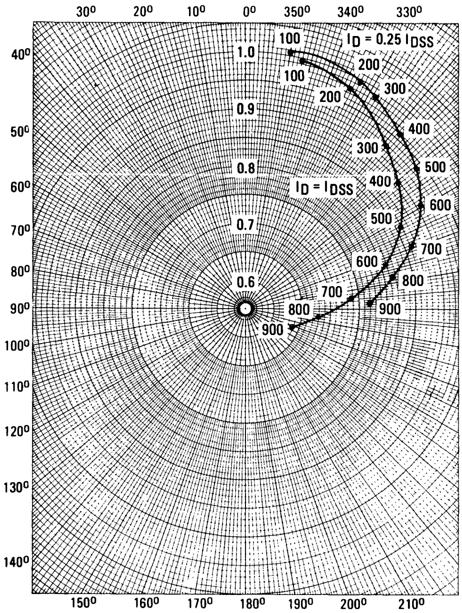


FIGURE 11 – S_{12s}

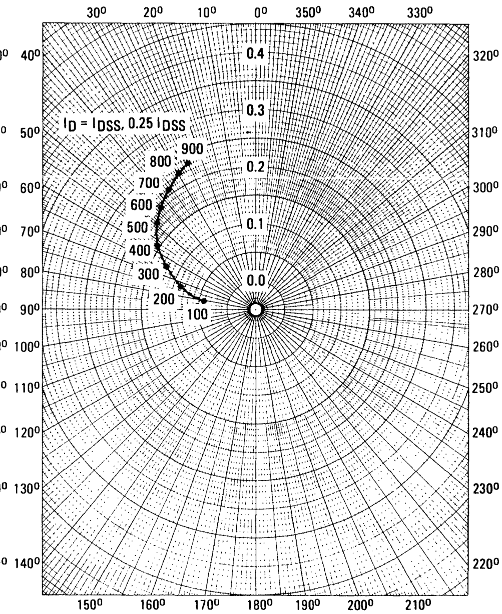


FIGURE 12 – S_{21s}

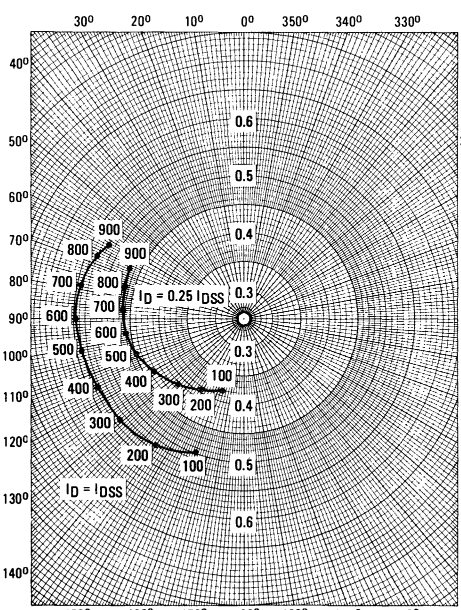
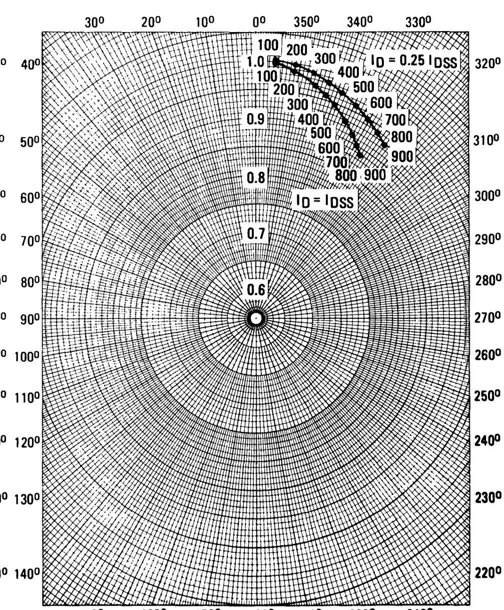


FIGURE 13 – S_{22s}



4

COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 14 – INPUT ADMITTANCE (y_{ig})

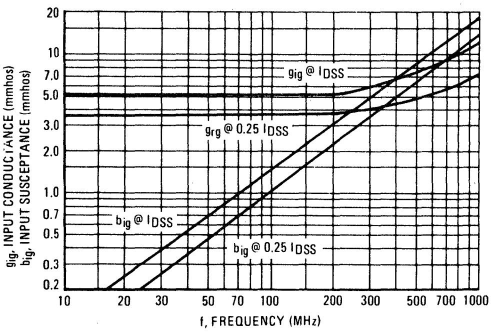


FIGURE 15 – REVERSE TRANSFER ADMITTANCE (y_{rg})

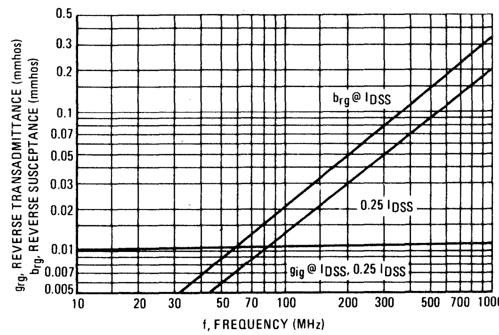


FIGURE 16 – FORWARD TRANSFER ADMITTANCE (y_{fg})

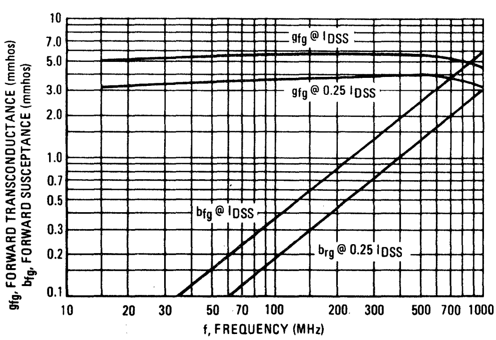
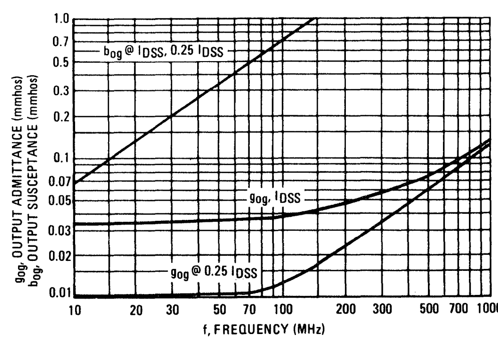


FIGURE 17 – OUTPUT ADMITTANCE (y_{og})



4

COMMON GATE CHARACTERISTICS

S-PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 18 — S_{11g}

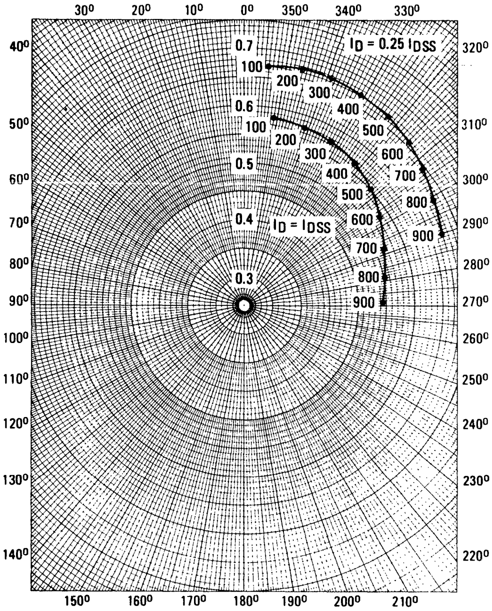


FIGURE 19 — S_{12g}

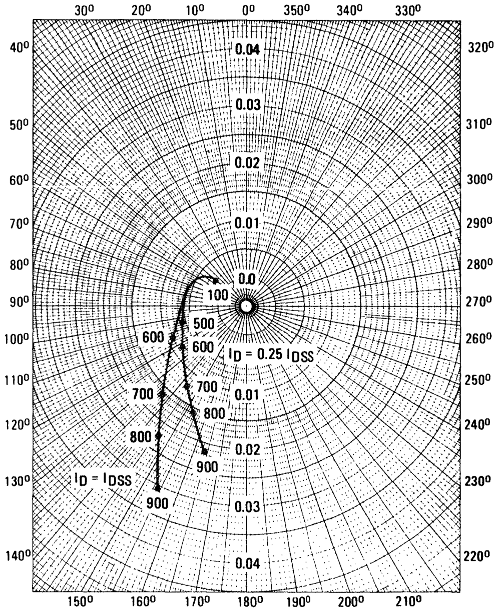


FIGURE 20 — S_{21g}

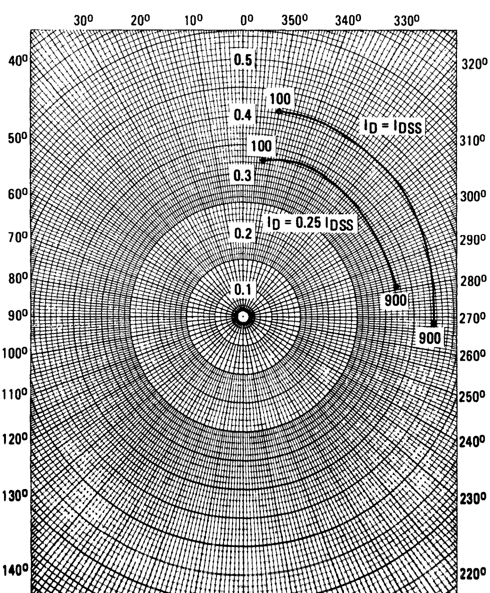
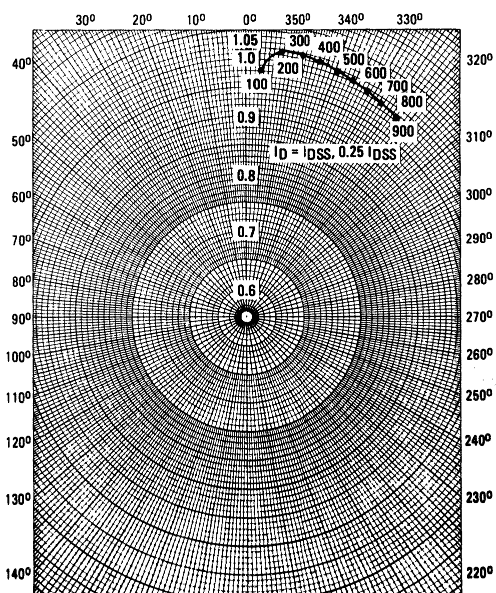


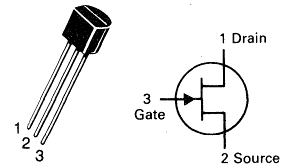
FIGURE 21 — S_{22g}



4

2N5555

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET SWITCHING

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

4

MAXIMUM RATINGS

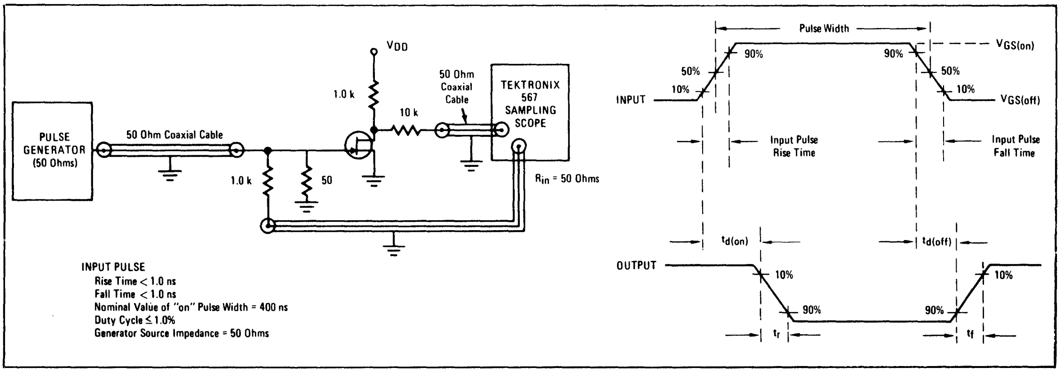
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	1.0	nAdc
Drain Cutoff Current (V_{DS} = 12 Vdc, V_{GS} = −10 V) (V_{DS} = 12 Vdc, V_{GS} = −10 V, T_A = 100°C)	$I_{D(off)}$	 — —	 10 2.0	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	15	—	mAdc
Gate-Source Forward Voltage ($I_{G(f)}$ = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage (I_D = 7.0 mAdc, V_{GS} = 0)	$V_{DS(on)}$	—	1.5	Vdc
Static Drain-Source On Resistance (I_D = 0.1 mAdc, V_{GS} = 0)	$r_{DS(on)}$	—	150	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Small-Signal Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	150	Ohms
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{rss}	—	1.2	pF
SWITCHING CHARACTERISTICS				
Turn-On Delay Time — (V_{DD} = 10 Vdc, $I_{D(on)}$ = 7.0 mAdc,	$t_{d(on)}$	—	5.0	ns
Rise Time — $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc) (See Figure 1)	t_r	—	5.0	ns
Turn-Off Delay Time — (V_{DD} = 10 Vdc, $I_{D(on)}$ = 7.0 mAdc,	$t_{d(off)}$	—	15	ns
Fall Time — $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc) (See Figure 1)	t_f	—	10	ns

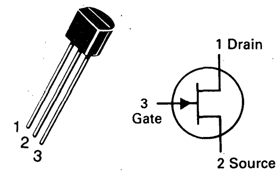
*Pulse Test: Pulse Width < 300 μs, Duty Cycle < 3.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N5638 thru 2N5640

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs SWITCHING

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 1.0 1.0	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −6.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −6.0 Vdc, T_A = 100°C)	 2N5638 2N5639 2N5640 2N5638 2N5639 2N5640	$I_{D(off)}$	 — — — — — —	 1.0 1.0 1.0 1.0 1.0 1.0	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	I_{DSS}	 50 25 5.0	 — — —	mAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	$V_{DS(on)}$	 — — —	 0.5 0.5 0.5	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	$r_{DS(on)}$	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N5638 2N5639 2N5640	$r_{ds(on)}$	 — — —	 30 60 100	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{iss}	—	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{rss}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

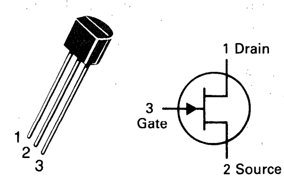
Characteristic				Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS							
Turn-On Delay Time		$I_{D(on)}$ = 12 mAdc	2N5638	$t_{d(on)}$	—	4.0	ns
		6.0 mAdc	2N5639		—	6.0	
		3.0 mAdc	2N5640		—	8.0	
Rise Time	V_{DD} = 10 Vdc,	$I_{D(on)}$ = 12 mAdc	2N5638	t_r	—	5.0	ns
		6.0 mAdc	2N5639		—	8.0	
	$V_{GS(on)}$ = 0,	3.0 mAdc	2N5640		—	10	
Turn-Off Delay Time	$V_{GS(off)}$ = −10 Vdc,	$I_{D(on)}$ = 12 mAdc	2N5638	$t_{d(off)}$	—	5.0	ns
		6.0 mAdc	2N5639		—	10	
	R_G' = 50 ohms	3.0 mAdc	2N5640		—	15	
Fall Time		$I_{D(on)}$ = 12 mAdc	2N5638	t_f	—	10	ns
		6.0 mAdc	2N5639		—	20	
		3.0 mAdc	2N5640		—	30	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

4

2N5668 thru 2N5670

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
VHF AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

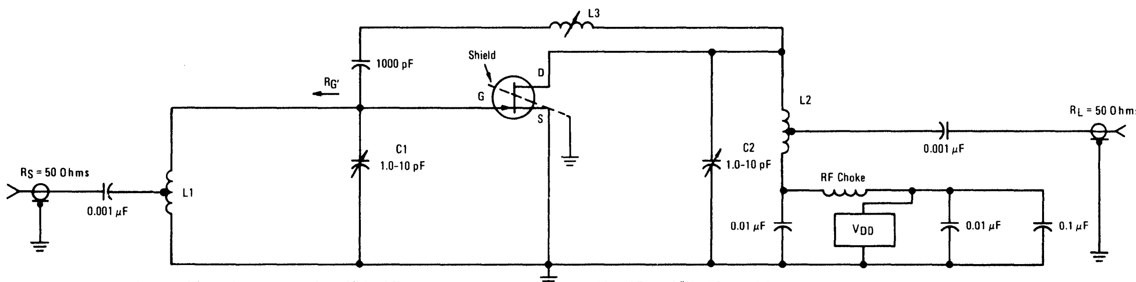
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 2.0 2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5668 2N5669 2N5670	$V_{GS(off)}$	 −0.2 −1.0 −2.0	 — — —	 −4.0 −6.0 −8.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5668 2N5669 2N5670	I_{DSS}	 1.0 4.0 8.0	 — — —	 5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{fs}\|$	 1500 2000 3000	 — — —	 6500 6500 7500	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		$Re(y_{is})$	—	125	800	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{os}\|$	 — — —	 — — —	 20 50 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{os})$	 — — —	 10 25 35	 50 100 150	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{fs})$	 1000 1600 2500	 — — —	 — — —	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.7	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	3.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	1.4	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz at R_G' = 1.0 k ohm)	NF	—	—	2.5	dB
Common Source Power Gain (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	G_{ps}	16	—	—	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

100 MHz, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



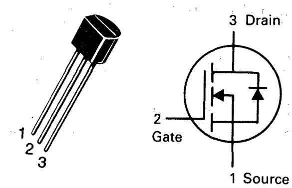
L1 ≈ 8.5 Turns of #14 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 0.9" Long. Tapped at ≈ 2-1/2 Turns (adjust to give R_G' = 1.0 k ohm); Parallel Resistance = 40 k ohms; tunes at ≈ 8.0 pF.

L2 ≈ 13.5 Turns #16 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 1.2" Long. Tapped at ≈ 5 Turns; Parallel Resistance = 40 k ohms; tunes at ≈ 4.0 pF.

L3 ≈ 17 Turns of #28 AWG Enameled Copper Wire, Close Wound on 9/32" Ceramic Form, Tuning Provided by a Powdered Iron Slug.

2N7000★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Gate-Source Voltage	V_{GS}	±40	Vdc
Drain Current Continuous Pulsed	 I_D I_{DM}	 200 500	mAdc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 V, V_{GS} = 0) (V_{DS} = 48 V, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 1.0 1.0	 μAdc mA
Gate-Body Leakage Current, Forward (V_{GSF} = 15 Vdc, V_{DS} = 0)	I_{GSSF}	—	−10	nAdc
ON CHARACTERISTICS*				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	3.0	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 0.5 Adc) (V_{GS} = 4.5 V, I_D = 75 mA)	$r_{DS(on)}$	 — —	 5.0 6.0	Ohm
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 0.5 Adc) (V_{GS} = 4.5 V, I_D = 75 mA)	$V_{DS(on)}$	 — —	 2.5 0.45	Vdc
On-State Drain Current (V_{GS} = 4.5 V, V_{DS} = 10 V)	$I_{d(on)}$	75	—	mA
Forward Transconductance (V_{DS} = 10 V, I_D = 200 mA)	g_{fs}	100	—	μmhos

DYNAMIC CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	pF
Output Capacitance		C_{oss}	—	25	
Reverse Transfer Capacitance		C_{rss}	—	5.0	

SWITCHING CHARACTERISTICS*

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Delay Time	(V_{DD} = 15 V, I_D = 500 mA, R_{gen} = 25 ohms, R_L = 25 ohms)	t_{on}	—	10	ns
Turn-Off Delay Time		t_{off}	—	10	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

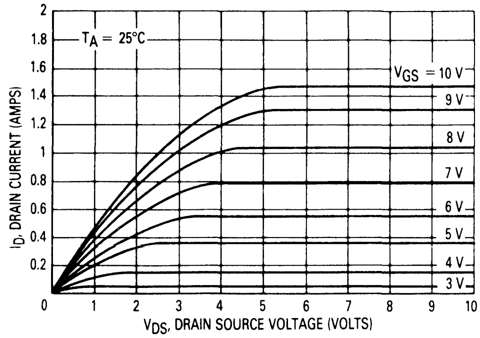


Figure 1. Ohmic Region

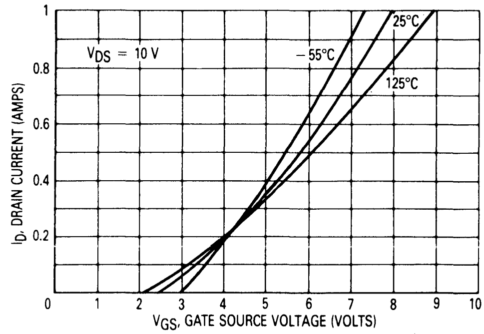


Figure 2. Transfer Characteristics

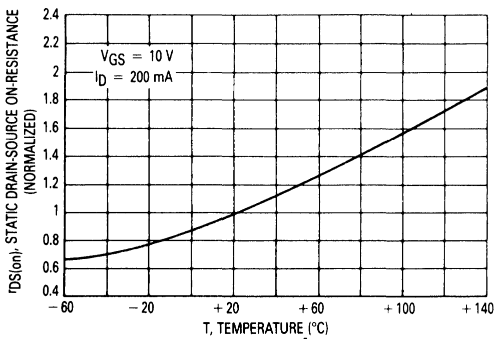


Figure 3. Temperature versus Static Drain-Source On-Resistance

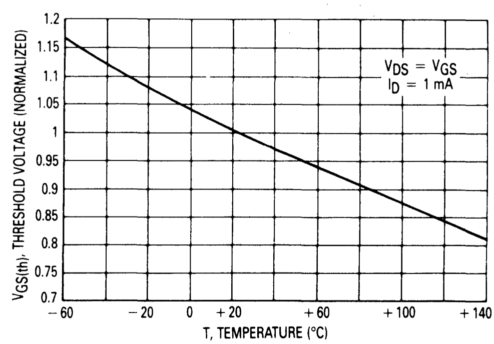


Figure 4. Temperature versus Gate Threshold Voltage

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Drain Current — Continuous T_C = 25°C(1) T_C = 100°C(1) — Pulsed(2)	I_D I_D I_{DM}	±115 ±75 ±800	mA
Gate-Source Voltage	V_{GS}	±40	Vdc
Total Power Dissipation T_C = 25°C T_C = 100°C Derate above 25°C ambient	P_D	200 80 0.16	mW mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

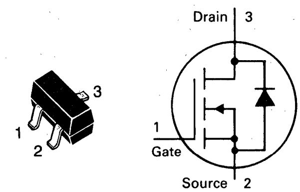
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

2N7002LT1 = 702

2N7002LT1★

CASE 318-07 STYLE 21
SOT-23 (TO-236AB)



TMOS FET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N7000 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current (V_{GS} = 0, V_{DS} = 60 V) T_J = 25°C T_J = 125°C	I_{DSS}	 — —	 — —	 1.0 500	μAdc
Gate-Body Leakage Current Forward (V_{GS} = 20 Vdc)	I_{GSSF}	—	—	100	nAdc
Gate-Body Leakage Current Reverse (V_{GS} = −20 Vdc)	I_{GSSR}	—	—	−100	nAdc

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μA)	$V_{GS(th)}$	1.0	—	2.5	Vdc
On-State Drain Current (V_{DS} ≥ 2.0 $V_{DS(on)}$, V_{GS} = 10 V)	$I_{D(on)}$	500	—	—	mA
Static Drain-Source On-State Voltage (V_{GS} = 10 V, I_D = 500 mA) (V_{GS} = 5.0 V, I_D = 50 mA)	$V_{DS(on)}$	 — —	 — —	 3.75 1.5	Vdc
Static Drain-Source On-State Resistance (V_{GS} = 10 V, I_D = 500 mA) T_C = 25°C T_C = 100°C (V_{GS} = 5.0 V, I_D = 50 mA) T_C = 25°C T_C = 100°C	$r_{DS(on)}$	 — — — —	 — — — —	 7.5 13.5 7.5 13.5	Ohms
Forward Transconductance (V_{DS} ≥ 2.0 $V_{DS(on)}$, I_D = 200 mA)	g_{FS}	80	—	—	mmhos

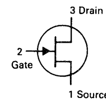
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	—	50	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	—	5.0	pF
SWITCHING CHARACTERISTICS*						
Turn-On Delay Time	(V_{DD} = 30 V, $I_D \cong$ 200 mA, R_G = 25 Ω, R_L = 150 Ω)	$t_{d(on)}$	—	—	20	ns
Turn-Off Delay Time		$t_{d(off)}$	—	—	20	ns
BODY-DRAIN DIODE RATINGS						
Diode Forward On-Voltage (I_S = 11.5 mA, V_{GS} = 0 V)		V_{SD}	—	—	−1.5	V
Source Current Continuous (Body Diode)		I_S	—	—	−115	mA
Source Current Pulsed		I_{SM}	—	—	−800	mA

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

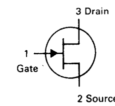
BF244,A,B,C

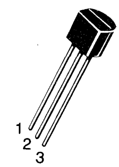
CASE 29-04, STYLE 22
TO-92 (TO-226AA)



BF245,A,B,C

CASE 29-04, STYLE 23
TO-92 (TO-226AA)





JFET
VHF/UHF AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

4

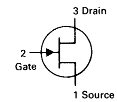
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	V
Gate-Source (V_{DS} = 15 Vdc, I_D = 200 μA)	BF245(1), BF244(2) BF245A, BF244A BF245B, BF244B BF245C, BF244C	V_{GS}	0.4 0.4 1.6 3.2	— — — —	7.5 2.2 3.8 7.5	V
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nA)		$V_{GS(off)}$	−0.5	—	−8	V
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	5	nA
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	BF245(1), BF244(2) BF245A, BF244A BF245B, BF244B BF245C, BF244C	I_{DSS}	2 2 6 12		25 6.5 15 25	mA
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 KHz)		$\lvert Y_{fs} \rvert$	3.0		6.5	mmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 KHz)		$\lvert Y_{os} \rvert$		40		μmhos
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$\lvert Y_{fs} \rvert$		5.6		mmhos
Reverse Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$\lvert Y_{rs} \rvert$		1.0		mmhos
Input Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc)		C_{iss}		3		pF
Reverse Transfer Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc, f = 1 MHz)		C_{rss}		0.7		pF
Output Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc, f = 1 MHz)		C_{oss}		0.9		pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1 KΩ, f = 100 MHz)		N_F		1.5		db
Cut-off Frequency(3) (V_{DS} = 15 Vdc, V_{GS} = 0)		$F_{(Yfs)}$		700		MHz

(1) On orders against the BF245, any or all subgroups might be shipped.
(2) On orders against the BF244, any or all subgroups might be shipped.
(3) The frequency at which gfs is 0.7 of its value at 1 KHz.

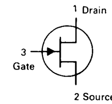
BF246,A,B,C

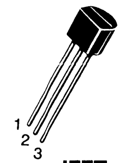
CASE 29-04, STYLE 22
TO-92 (TO-226AA)



BF247,A,B,C

CASE 29-04, STYLE 5
TO-92 (TO-226AA)





JFETs
SWITCHING

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

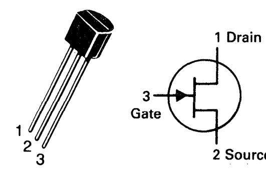
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS							
Gate-Source Breakdown Voltage (I_G = 1 μA, V_{DS} = 0)			$V_{(BR)GSS}$	25	—	—	V
Gate-Source (V_{DS} = 15 V, I_D = 200 μA)	BF246, BF246A, BF246B, BF246C,	BF247 BF247A BF247B BF247C	V_{GS}	−0.5 −1.5 −3 −5.5	— — — —	−14 −4 −7 −12	V
Gate-Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)			$V_{GS(off)}$	0.6	—	14.5	V
Gate Cutoff Current (V_{GS} = 15 V, V_{DS} = 0)			I_{GSS}	—	—	5	nA
ON CHARACTERISTICS							
Zero-Gate Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	BF246, BF246A, BF246B, BF246C,	BF247 BF247A BF247B BF247C	I_{DSS}	30 30 60 110		250 80 140 250	mA
SMALL-SIGNAL CHARACTERISTICS							
Forward Transfer Admittance (V_{DS} = 15 V, I_D = 10 mA, f = 1 kHz)			$\|Y_{fs}\|$	8	23		mmhos
Reverse Transfer Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 kHz)			C_{rss}		3.3		pF
Input Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 MHz)			C_{in}		6		pF
Output Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 MHz)			C_{out}		5		pF
Cutoff Frequency (V_{DS} = 15 V, V_{GS} = 0)			$F_{(Yfs)}$		450		MHz

4

BF256,B,C

CASE 29-04, STYLE 23
TO-92 (TO-226AA)



JFET
VHF/UHF AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

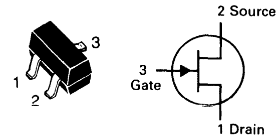
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 200 μA)	$V_{GS(off)}$	−0.5	—	−7.5	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	5	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current) (V_{DS} = 15 Vdc, V_{GS} = 0) BF256(1) BF256B BF256C	I_{DSS}	 3 6 11	 — — —	 18 13 18	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	$\|Y_{fs}\|$	4.5	5	—	mmhos
Reverse Transfer Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1Vdc, f = 1 MHz)	C_{rss}	—	0.7	—	pF
Output Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1 MHz)	C_{oss}	—	1.0	—	pF
Noise Figure (V_{DS} = 10 Vdc, R_s = 47Ω, f = 800 MHz)	N_F	—	7.5	—	db
Cut-off Frequency(2) (V_{DS} = 15 Vdc, V_{GS} = 0)	f_{gfs}	—	1000	—	MHz
Power Gain (V_{DS} = 15 Vdc, R_s = 47 Ω, f = 800 MHz)	G_p	—	11	—	dB

(1) On orders against the BF256, any or all subgroups might be shipped.
(2) The frequency at which gfs is 0.7 of its value at 1 kHz.

BFR30LT1
BFR31LT1

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET AMPLIFIERS

N-CHANNEL

Refer to 2N5457 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BFR30LT1 = M1; BFR31LT1 = M2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

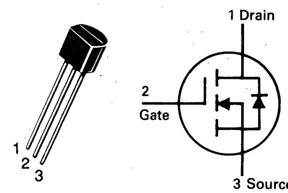
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0)		I_{GSS}	—	0.2	nAdc
Gate Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 10 Vdc)	BFR30 BFR31	$V_{GS(off)}$	— —	5.0 2.5	Vdc
Gate Source Voltage (I_D = 1.0 mAdc, V_{DS} = 10 Vdc)	BFR30 BFR31	V_{GS}	−0.7 —	−3.0 −1.3	Vdc
(I_D = 50 μAdc, V_{DS} = 10 Vdc)	BFR30 BFR31		— —	−4.0 −2.0	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0)	BFR30 BFR31	I_{DSS}	4.0 1.0	10 5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transconductance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)	BFR30 BFR31	$\|Y_{fs}\|$	1.0 1.5	4.0 4.5	mAdc
(I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)	BFR30 BFR31		0.5 0.75	— —	
Output Admittance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 kHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc)	BFR31 BFR31	$\|Y_{os}\|$	40 20	25 15	μAdc
Input Capacitance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	— —	5.0 4.0	pF
Reverse Transfer Capacitance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{rss}	— —	1.5 1.5	pF

Note: "LT1" must be used when ordering SOT-23 devices.

4

BS107,A★

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

★BS107A is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}	 250 500	 mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to 150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 130 V, V_{GS} = 0)	I_{DSS}	—	—	30	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})	$V_{GS(Th)}$	1.0	—	3.0	Vdc
Static Drain-Source On Resistance BS107 (V_{GS} = 2.6 V, I_D = 20 mA) (V_{GS} = 10 V, I_D = 200 mA) BS107A (V_{GS} = 10 Vdc) (I_D = 100 mA) (I_D = 250 mA)	$r_{DS(on)}$	 — — — —	 — — 4.5 4.8	 28 14 6.0 6.4	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	6.0	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	30	—	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 250 mA)	g_{fs}	200	400	—	mmhos
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	—	6.0	15	ns
Turn-Off Time	t_{off}	—	12	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

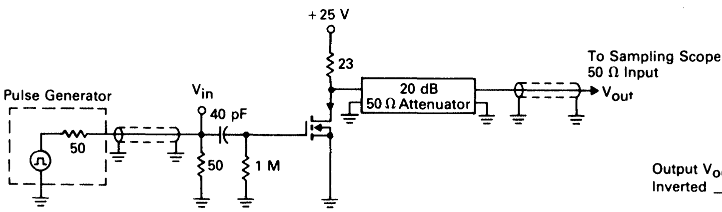


FIGURE 2 — SWITCHING WAVEFORMS

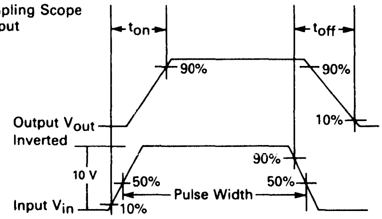


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FIGURE 3 — ON VOLTAGE versus TEMPERATURE

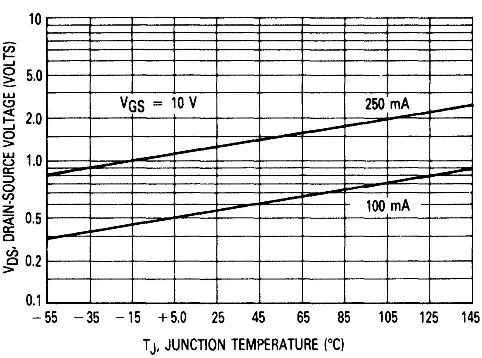


FIGURE 4 — CAPACITANCE VARIATION

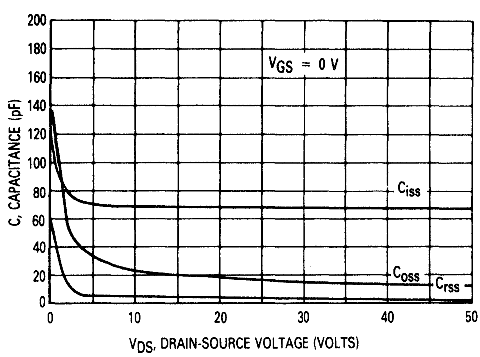


FIGURE 5 — TRANSFER CHARACTERISTIC

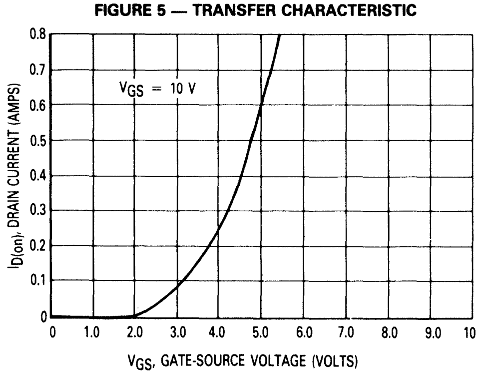


FIGURE 6 — OUTPUT CHARACTERISTIC

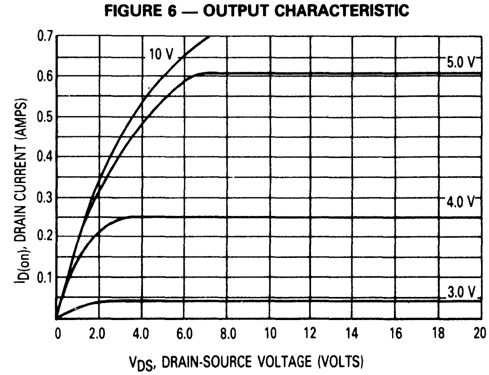
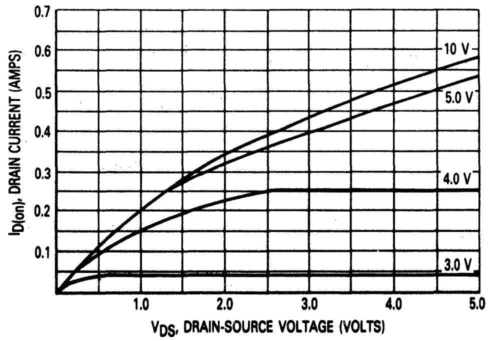


FIGURE 7 — SATURATION CHARACTERISTIC



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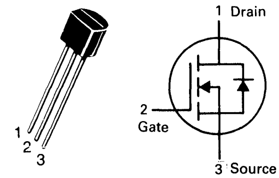
BS170★

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



TMOS FET
SWITCHING

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current(1)	I_D	0.5	Adc
Total Device Dissipation @ T_A = 25°C	P_D	350	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current (V_{GS} = 15 V, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS(2)					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(Th)}$	0.8	2.0	3.0	Vdc
Static Drain-Source On Resistance (V_{GS} = 10 V, I_D = 200 mA)	$r_{DS(on)}$	—	1.8	5.0	Ohms
Drain Cutoff Current (V_{DS} = 25 V, V_{GS} = 0 V)	$I_{D(off)}$	—	—	0.5	μA
Forward Transconductance (V_{DS} = 10 V, I_D = 250 mA)	g_{fs}	—	200	—	mmhos
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	—	60	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_D = 0.2 A) See Figure 1	t_{on}	—	4.0	10	ns
Turn-Off Time (I_D = 0.2 A) See Figure 1	t_{off}	—	4.0	10	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

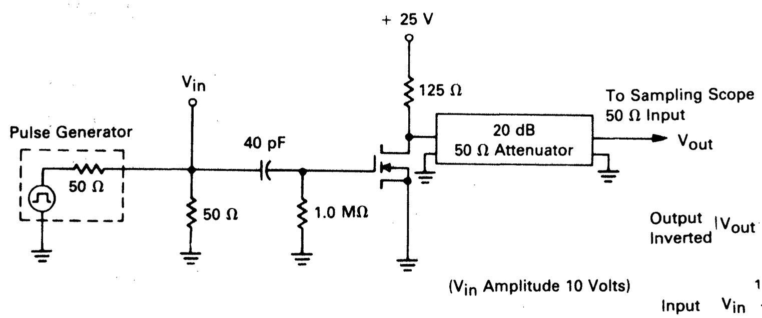


FIGURE 2 — SWITCHING WAVEFORMS

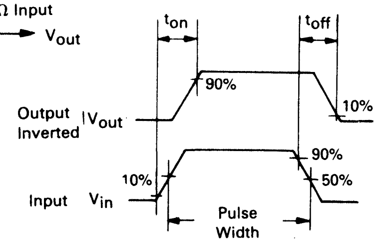


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

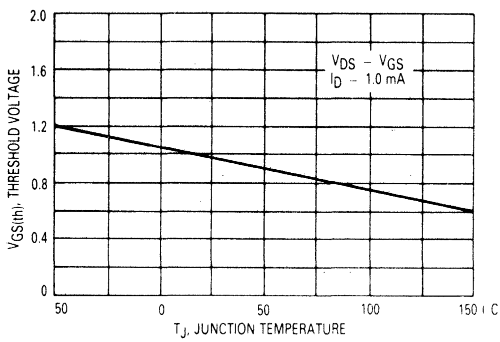


FIGURE 4 — ON-REGION CHARACTERISTICS

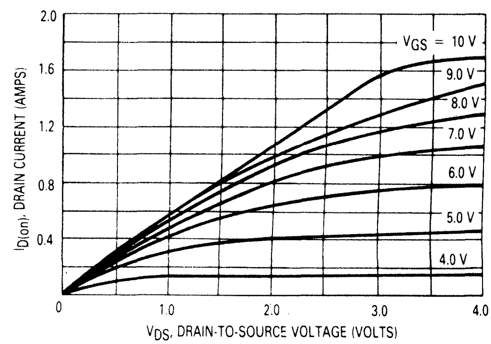


FIGURE 5 — OUTPUT CHARACTERISTICS

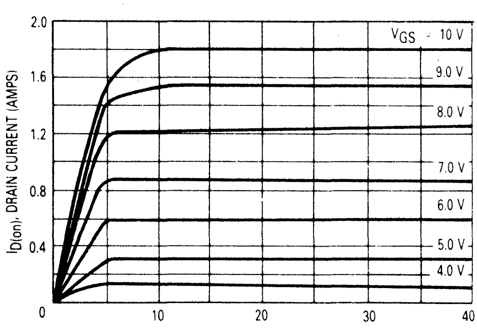
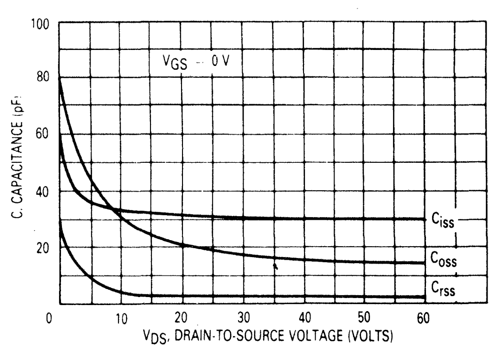
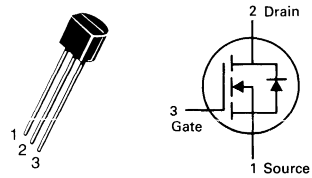


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



BSS89

CASE 29-04, STYLE 7
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

Refer to BS107 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous (1) — Pulsed (2)	I_D I_{DM}	400 800	mAdc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to 150	°C
Thermal Resistance Junction to Ambient	θ_{JA}	208	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

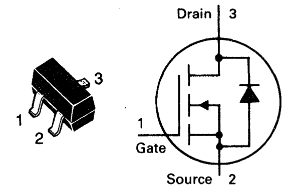
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 0.5$ mA)	$V_{(BR)DSS}$	200	—	—	Vdc
Zero Gate Voltage Drain Current ($V_{DS} = 200$ V, $V_{GS} = 0$)	I_{DSS}	—	0.1	60	μAdc
Gate-Body Leakage Current ($V_{GS} = 20$ V, $V_{DS} = 0$)	I_{GSS}	—	0.01	100	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage ($I_D = 1.0$ mA, $V_{DS} = V_{GS}$)	$V_{GS(th)}$	1.0	—	2.7	Vdc
Drain-Source On-Voltage ($V_{GS} = 10$ V) ($I_D = 100$ mA) ($I_D = 300$ mA) ($I_D = 500$ mA)	$V_{DS(on)}$	 — — —	 0.45 1.2 3.0	 0.6 1.8 —	Vdc
On-State Drain Current ($V_{DS} = 25$ V, $V_{GS} = 10$ V)	$I_{D(on)}$	500	700	—	mA
Static Drain-Source On-Resistance ($V_{GS} = 10$ Vdc) ($I_D = 150$ mA) ($I_D = 300$ mA) ($I_D = 500$ mA)	$r_{DS(on)}$	 — — —	 4.5 — 6.0	 6.0 6.0 —	Ohms
Forward Transconductance ($V_{DS} = 25$ V, $I_D = 300$ mA)	g_{fs}	140	400	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	72	—	pF
Output Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{oss}	—	15	—	pF
Reverse Transfer Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	2.8	—	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time (See Figure 1)	t_{on}	—	6.0	—	ns
Turn-Off Time (See Figure 1)	t_{off}	—	12	—	ns

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

BSS123LT1★

CASE 318-07, STYLE 21
SOT-23 (TO-236AB)



TMOS FET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N7000 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	100	Vdc
Gate-Source Voltage	V_{GS}	±35	Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}	 0.17 0.68	Adc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

BSS123LT1 = 5A

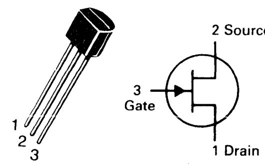
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 250 μA)	$V_{(BR)DSS}$	100	—	—	Vdc
Zero Gate Voltage Drain Current (V_{GS} = 0, V_{DS} = 100 V) T_J = 25°C T_J = 125°C	I_{DSS}	 — —	 — —	 15 60	μAdc
Gate-Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	—	2.8	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 100 mA)	$r_{DS(on)}$	—	5.0	6.0	Ohms
Forward Transconductance (V_{DS} = 25 V, I_D = 100 mA)	g_{fs}	80	—	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	20	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	9.0	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	4.0	—	pF
SWITCHING CHARACTERISTICS*					
Turn-On Delay Time (V_{CC} = 30 V, I_C = 0.28 A,	$t_{d(on)}$	—	20	—	ns
Turn-Off Delay Time V_{GS} = 10 V, R_{GS} = 50 Ω)	$t_{d(off)}$	—	40	—	ns
REVERSE DIODE					
Diode Forward On-Voltage (I_D = 0.34 A, V_{GS} = 0 V)	V_{SD}	—	—	1.3	V

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

J109
J110

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
GENERAL-PURPOSE
TRANSISTORS

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	135	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −10 μAdc)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 −3.0 −200	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	J109 J110	$V_{GS(off)}$	−2.0 −0.5	— —	−6.0 −4.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15, V_{GS} = 0)	J109 J110	I_{DSS}	40 10	— —	— —	mAdc
Drain-Source On-Resistance (V_{DS} < 0.1 V, V_{GS} = 0 V)	J109 J110	$r_{DS(on)}$	— —	— —	12 18	ohms
SMALL-SIGNAL CHARACTERISTICS						
Drain Gate + Source Gate On-Capacitance (V_{DS} = 0 Vdc, V_{GS} = 0, f = 1.0 MHz)		$C_{dg(on)}$ + $C_{sg(on)}$	—	—	85	pF
Drain Gate Off-Capacitance (V_{DS} = 0 Vdc, V_{GS} = −10 V, f = 1.0 MHz)		$C_{dg(off)}$	—	—	15	pF
Source Gate Off-Capacitance (V_{DS} = 0 Vdc, V_{GS} = −10 V, f = 1.0 MHz)		$C_{sg(off)}$	—	—	15	pF

(1) Pulse Duration 300 μs, Duty Cycle ≤ 2.0%.

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FIGURE 1 — COMMON SOURCE INPUT CAPACITANCE versus GATE-SOURCE VOLTAGE

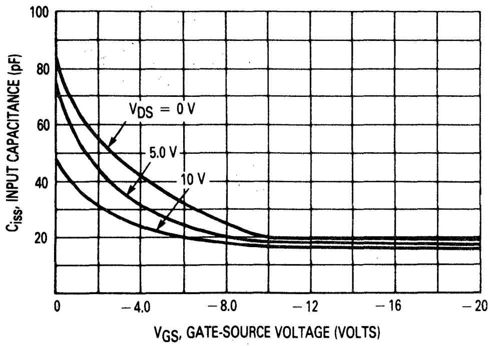

FIGURE 2 — COMMON SOURCE REVERSE FEEDBACK CAPACITANCE versus GATE-SOURCE VOLTAGE

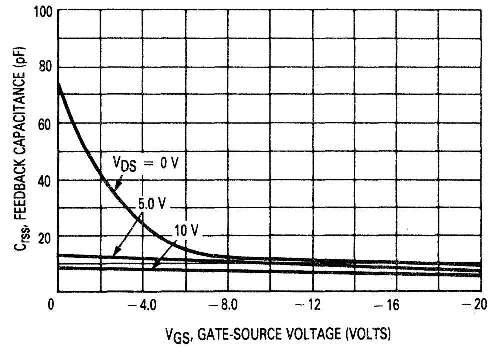

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FIGURE 3 — ON-RESISTANCE versus GATE-SOURCE CUTOFF VOLTAGE

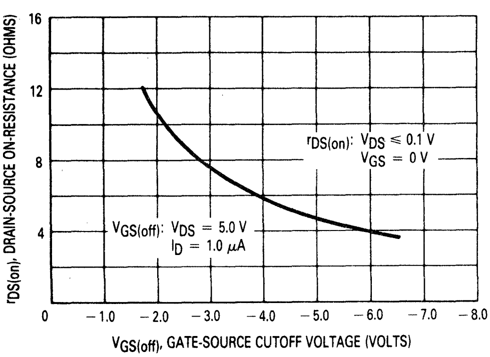


FIGURE 4 — OUTPUT CHARACTERISTIC

$V_{GS(off)}$ = −2.0 V

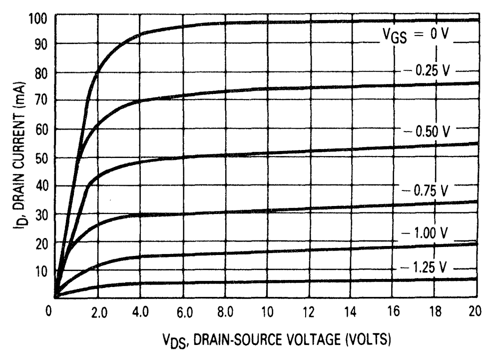


FIGURE 5 — OUTPUT CHARACTERISTIC

$V_{GS(off)}$ = −3.0 V

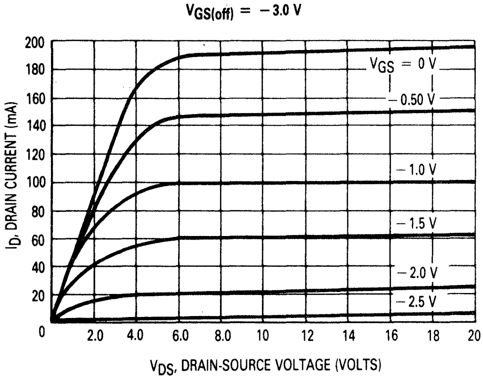


FIGURE 6 — OUTPUT CHARACTERISTIC

$V_{GS(off)}$ = −4.0 V

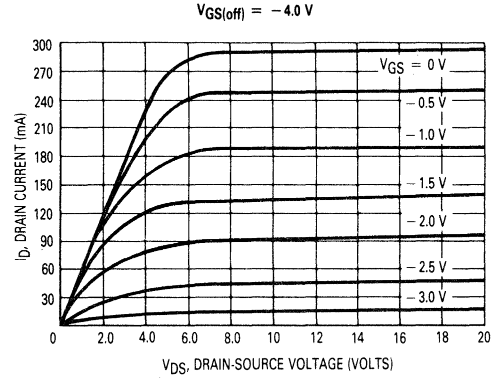
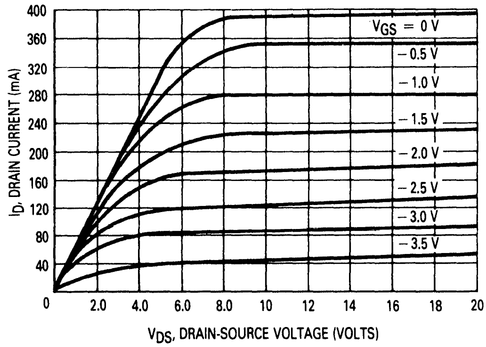


FIGURE 7 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -5.0$ V



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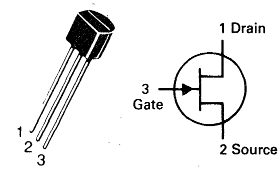
J111 thru J113

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
CHOPPER TRANSISTORS

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−35	Vdc
Gate-Source Voltage	V_{GS}	−35	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

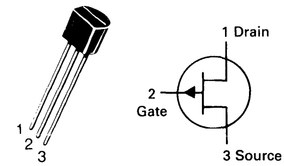
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA)		$V_{(BR)GSS}$	35	—	Vdc
Gate Reverse Current (V_{GS} = −15 V)		I_{GSS}	—	−1.0	nA
Gate Source Cutoff Voltage (V_{DS} = 5.0 V, I_D = 1.0 μA)	J111 J112 J113	$V_{GS(off)}$	−3.0 −1.0 −0.5	−10 −5.0 −3.0	V
Drain-Cutoff Current (V_{DS} = 5.0 V, V_{GS} = −10 V)		$I_{D(off)}$	—	1.0	nA
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 V)	J111 J112 J113	I_{DSS}	20 5.0 2.0	— — —	mA
Static Drain-Source On Resistance (V_{DS} = 0.1 V)	J111 J112 J113	$r_{DS(on)}$	— — —	30 50 100	Ohms
Drain Gate and Source Gate On-Capacitance (V_{DS} = V_{GS} = 0, f = 1.0 MHz)		$C_{dg(on)}$ + $C_{sg(on)}$	—	28	pF
Drain Gate Off-Capacitance (V_{GS} = −10 V, f = 1.0 MHz)		$C_{dg(off)}$	—	5.0	pF
Source Gate Off-Capacitance (V_{GS} = −10 V, f = 1.0 MHz)		$C_{sg(off)}$	—	5.0	pF

*Pulse Width = 300 μs, Duty Cycle = 3.0%.

4

J174 thru J177★

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



JFET
CHOPPER TRANSISTORS

P-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

Refer to MPF970 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

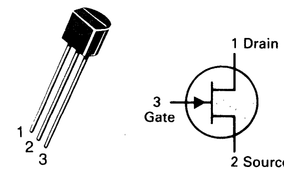
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Volts)		I_{GSS}	—	1.0	nA
Gate Source Cutoff Voltage (V_{DS} = −15 V, I_D = −10 nA)	J174 J175 J176 J177	$V_{GS(off)}$	5.0 3.0 1.0 0.8	10 6.0 4.0 2.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = −15 V)	J174 J175 J176 J177	I_{DSS}*	−2.0 −7.0 −2.0 −1.5	−100 −60 −25 −20	mA
Static Drain-Source On Resistance (V_{DS} ≤ −0.1 Volt)	J174 J175 J176 J177	$r_{DS(on)}$	— — — —	85 125 250 300	Ω

*Pulse Width = 300 μs, Duty Cycle ≤ 3.0%.

4

J202
J203

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs
LOW FREQUENCY/LOW NOISE

N-CHANNEL — DEPLETION

Refer to 2N5457 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

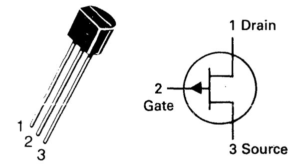
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{GS} = −20 V)		I_{GSS}	—	−100	pA
Gate Source Cutoff Voltage (V_{DS} = 20 V, I_D = 10 nA)	J202 J203	$V_{GS(off)}$	−0.8 −2.0	−4.0 −10.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 20 V)	J202 J203	I_{DSS}*	0.9 4.0	4.5 20.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 20 V, f = 1.0 kHz)	J202 J203	$\|y_{fs}\|$*	1000 1500	— —	μmhos

*Pulse Width ≤ 2.0 ms.

J270

CASE 29-04, STYLE 30
TO-92 (TO-226AA)



JFET CHOPPER TRANSISTOR

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

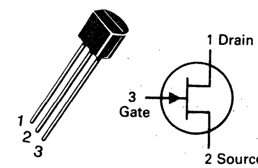
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μA)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Volts)	I_{GSS}	—	200	pA
Gate Source Cutoff Voltage (V_{DS} = −15 V, I_D = −1.0 nA)	$V_{GS(off)}$	0.5	2.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = −15 V)	I_{DSS}*	−2.0	−15	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = −15 V, f = 1.0 kHz)	$\|y_{fs}\|$	6000	15000	μmhos
Output Admittance (V_{DS} = −15 V, f = 1.0 kHz)	$\|y_{os}\|$	—	200	μmhos
Input Capacitance (V_{DS} = −15 V, f = 1.0 MHz)	C_{iss}	—	32	pF
Reverse Transfer Capacitance (V_{DS} = −15 V, f = 1.0 MHz)	C_{rss}	—	8.0	pF

*Pulse Width ≤ 2.0 ms.

J300

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
HIGH FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

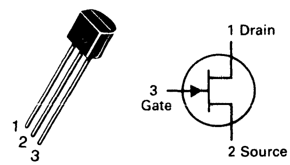
Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−25	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 V, V_{DS} = 0)	I_{GSS}	—	500	pA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 mA)	$V_{GS(off)}$	−1.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	I_{DSS}	6.0	30	mA
Gate-Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mA)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{fs}\|$	4500	9000	μmhos
Output Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{os}\|$	—	200	μmhos
Input Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{iss}	—	5.5	pF
Reverse Transfer Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{rss}	—	1.7	pF

J304
J305

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
HIGH FREQUENCY
AMPLIFIERS

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

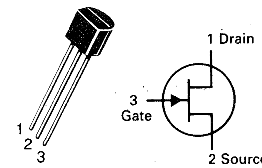
Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −20 V, V_{DS} = 0)		I_{GSS}	—	100	pA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 1.0 nA)	J304 J305	$V_{GS(off)}$	−2.0 −0.5	−6.0 −3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	J304 J305	I_{DSS}	5.0 1.0	15 8.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	50	μmhos
Forward Transconductance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	J304 J305	$Re(y_{fs})$	4500 3000	7500 —	μmhos

J308 thru J310★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
VHF/UHF AMPLIFIERS

N-CHANNEL — DEPLETION

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	−65 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 25°C) (V_{GS} = −15 V, V_{DS} = 0, T_A = +125°C)		I_{GSS}	 — —	 — —	 −1.0 −1.0	 nA μA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 nA)	 J308 J309 J310	$V_{GS(off)}$	 −1.0 −1.0 −2.0	 — — —	 −6.5 −4.0 −6.5	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 V, V_{GS} = 0)	 J308 J309 J310	I_{DSS}	 12 12 24	 — — —	 60 30 60	mA
Gate-Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mA)		$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Source Input Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)	 J308 J309 J310	$Re(y_{is})$	 — — —	 0.7 0.7 0.5	 — — —	mmhos
Common-Source Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{os})$	—	0.25	—	mmhos
Common-Gate Power Gain (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		G_{pg}	—	16	—	dB
Common-Source Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{fs})$	—	12	—	mmhos
Common-Gate Input Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{ig})$	—	12	—	mmhos
Common-Source Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	 J308 J309 J310	g_{fs}	 8000 10000 8000	 — — —	 20000 20000 18000	μmhos
Common-Source Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)		g_{os}	—	—	250	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common-Gate Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308 J309 J310	g_{fg}	— — —	13000 13000 12000	— — —	μmhos
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308 J309 J310	g_{og}	— — —	150 100 150	— — —	μmhos
Gate-Drain Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gd}	—	1.8	2.5	pF
Gate-Source Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gs}	—	4.3	5.0	pF

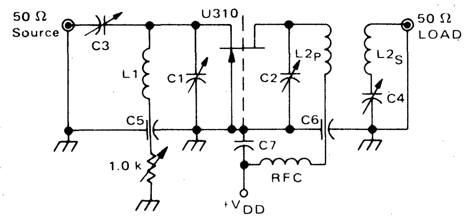
FUNCTIONAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Noise Figure (V_{DS} = 10 V, I_D = 10 mA, f = 450 MHz)	NF	—	1.5	—	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 V, I_D = 10 mA, f = 100 Hz)	$\bar{e}_n$	—	10	—	$nV/\sqrt{Hz}$

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

4

FIGURE 1 – 450 MHz COMMON-GATE AMPLIFIER TEST CIRCUIT



C1 = C2 = 0.8 10 pF. JFD #MVM010W.
C3 = C4 = 8 35 pF Erie #539-002D.
C5 = C6 = 5000 pF Erie (2443-000).
C7 = 1000 pF. Allen Bradley #FA5C.
RFC = 0.33 μH Miller #9230-30.
L1 = One Turn #16 Cu, 1/4" I.D. (Air Core).
L2P = One Turn #16 Cu, 1/4" I.D. (Air Core).
L2S = One Turn #16 Cu, 1/4" I.D. (Air Core).

4

FIGURE 2 – DRAIN CURRENT and TRANSFER CHARACTERISTICS versus GATE-SOURCE VOLTAGE

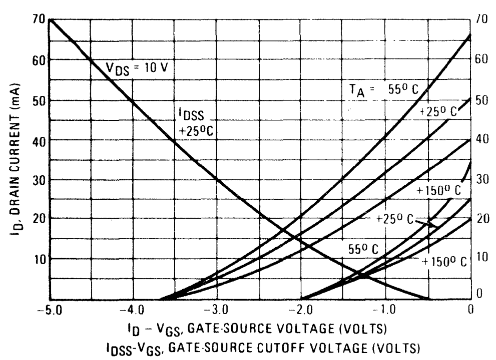


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus GATE-SOURCE VOLTAGE

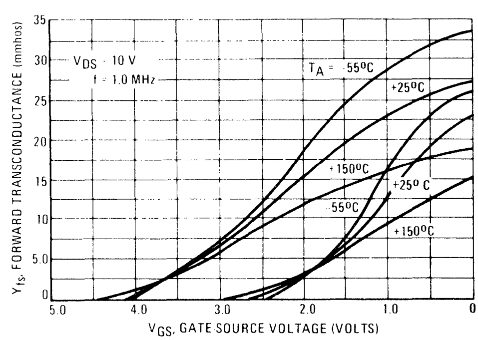


FIGURE 4 – COMMON-SOURCE OUTPUT ADMITTANCE and FORWARD TRANSCONDUCTANCE versus DRAIN CURRENT

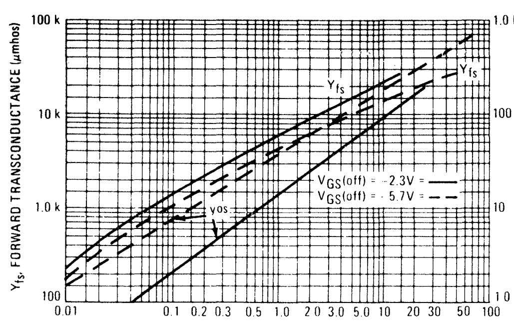


FIGURE 5 – ON RESISTANCE and JUNCTION CAPACITANCE versus GATE-SOURCE VOLTAGE

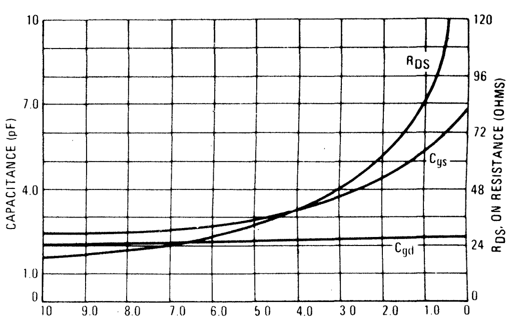


FIGURE 6 – COMMON-GATE Y PARAMETER MAGNITUDE versus FREQUENCY

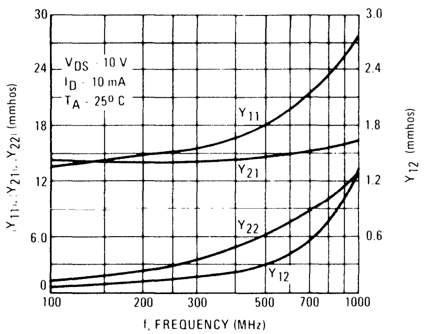


FIGURE 7 – COMMON-GATE S PARAMETER MAGNITUDE versus FREQUENCY

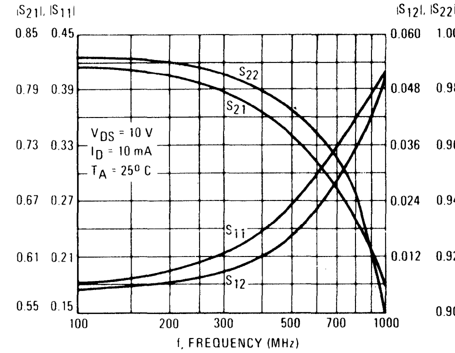


FIGURE 8 – COMMON-GATE Y PARAMETER PHASE-ANGLE versus FREQUENCY

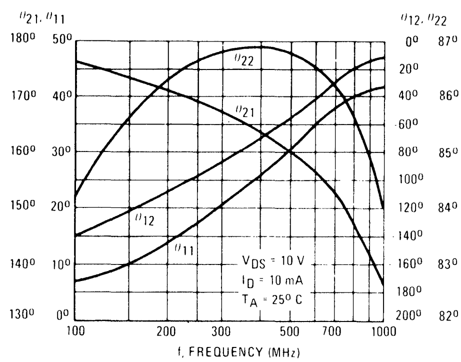


FIGURE 9 – S PARAMETER PHASE-ANGLE versus FREQUENCY

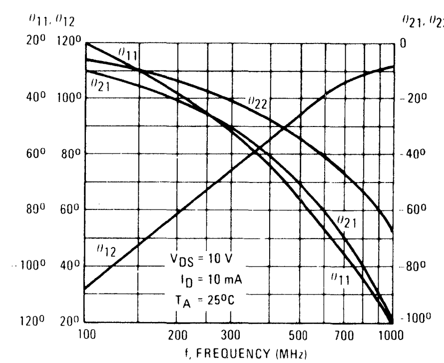


FIGURE 10 – NOISE FIGURE and POWER GAIN versus DRAIN CURRENT

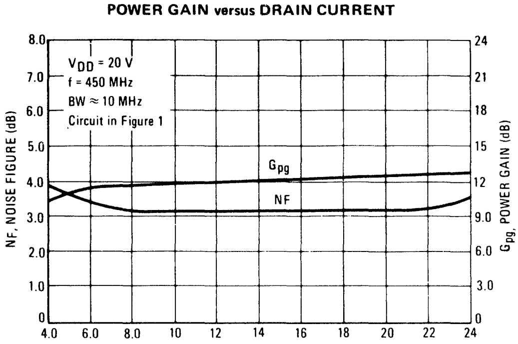


FIGURE 11 – NOISE FIGURE and POWER GAIN versus FREQUENCY

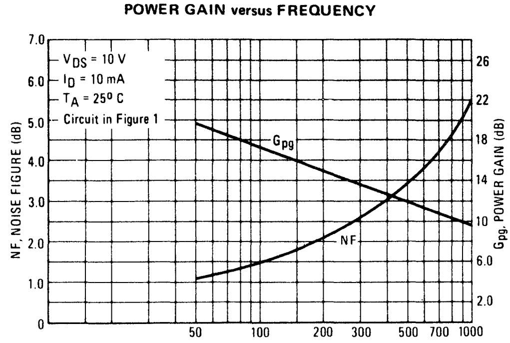


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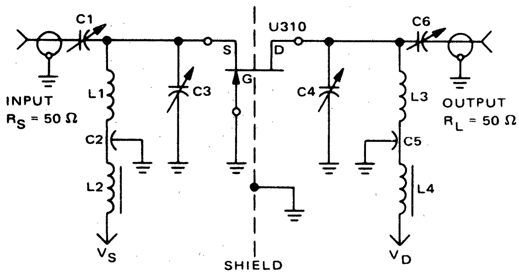
FIGURE 12 — 450 MHz IMD EVALUATION AMPLIFIER



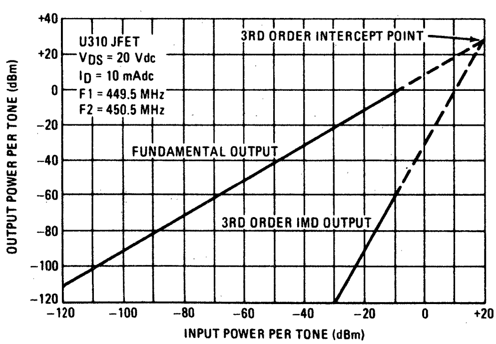
B_W (3dB) — 36.5 MHz
I_D — 10 mAdc
V_{DS} — 20 Vdc
Device case grounded
IM test tones — f1 = 449.5 MHz, f2 = 450.5 MHz

C1 = 1-10 pf Johanson Air variable trimmer.
C2, C5 = 100 pf feed thru button capacitor.
C3, C4, C6 = 0.5-6 pf Johanson Air variable trimmer.
L1 = 1/8" x 1/32" x 1-5/8" copper bar
L2, L4 = Ferroxcube Vk200 choke.
L3 = 1/8" x 1/32" x 1-7/8" copper bar.

Amplifier power gain and IMD products are a function of the load impedance. For the amplifier design shown above with C4 and C6 adjusted to reflect a load to the drain resulting in a nominal power gain of 9 dB, the 3rd order intercept point (IP) value is 29 dBm. Adjusting C4, C6 to provide larger load values will result in higher gain, smaller bandwidth and lower IP values. For example, a nominal gain of 13 dB can be achieved with an intercept point of 19 dBm.

4

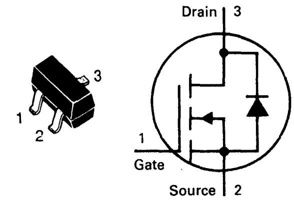
FIGURE 13 — TWO TONE 3RD ORDER INTERCEPT POINT



Example of intercept point plot use:
Assume two in-band signals of −20 dBm at the amplifier input. They will result in a 3rd order IMD signal at the output of −90 dBm. Also, each signal level at the output will be −11 dBm, showing an amplifier gain of 9.0 dB and an intermodulation ratio (IMR) capability of 79 dB. The gain and IMR values apply only for signal levels below compression.

MMBF170LT1

CASE 318-07, STYLE 21
SOT-23 (TO-236AB)



TMOS FET TRANSISTOR

N-CHANNEL

Refer to 2N7000 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage	V_{DGS}	60	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous Pulsed	I_D I_{DM}	0.5 0.8	Adc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF170LT1 = 6Z

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)		$V_{(BR)DSS}$	60	—	Vdc
Gate-Body Leakage Current, Forward (V_{GSF} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(th)}$	0.8	3.0	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 200 mA)		$r_{DS(on)}$	—	5.0	Ohm
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 0)		$I_{D(off)}$	—	0.5	μA
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0 V, f = 1.0 MHz)		C_{iss}	—	60	pF
SWITCHING CHARACTERISTICS*					
Turn-On Delay Time	(V_{DD} = 25 V, I_D = 500 mA, R_{gen} = 50 Ohms) Figure 1	$t_{d(on)}$	—	10	ns
Turn-Off Delay Time		$t_{d(off)}$	—	10	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

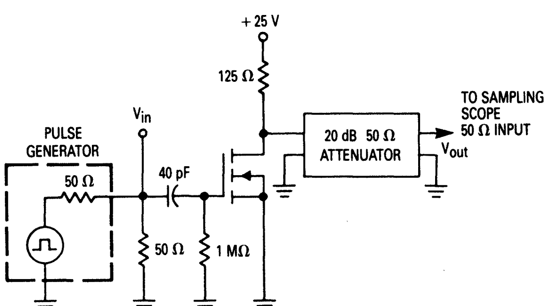
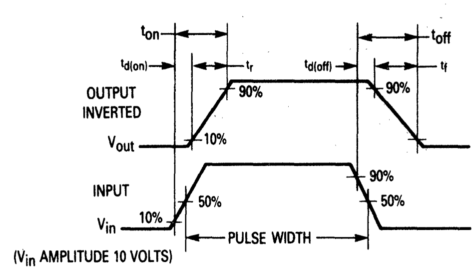


Figure 1. Switching Test Circuit

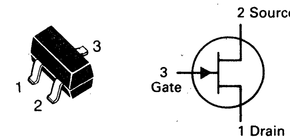
SWITCHING WAVEFORM



4

MMBF4391LT1 thru MMBF4393LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET SWITCHING TRANSISTORS

N-CHANNEL

★These are Motorola designated preferred devices.

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF4391LT1 = 6J; MMBF4392LT1 = 6K; MMBF4393LT1 = 6G

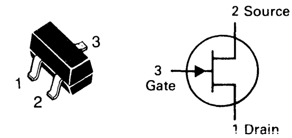
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 25°C) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 1.0 0.20	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 MMBF4391 MMBF4392 MMBF4393	$V_{GS(off)}$	 −4.0 −2.0 −0.5	 −10 −5.0 −3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	 MMBF4391 MMBF4392 MMBF4393	I_{DSS}	 50 25 5.0	 150 75 30	mAdc
Drain Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 15, V_{GS} = 12 Vdc, T_A = 100°C)		I_D	 — —	 1.0 1.0	 nAdc μAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	 MMBF4391 MMBF4392 MMBF4393	$V_{DS(on)}$	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MMBF4391 MMBF4392 MMBF4393	$r_{DS(on)}$	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	14	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)		C_{rss}	—	3.5	pF

Note: "LT1" must be used when ordering SOT-23 devices.

MMBF4416LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
VHF/UHF AMPLIFIER TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF4416LT1 = 6A

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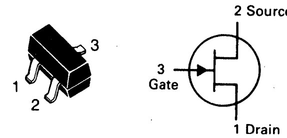
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	 — —	 1.0 200	 nAdc nAdc
Gate Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	—	−6.0	Vdc
Gate Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	−1.0	−5.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{GS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	15	μAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	4500	7500	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{os}\|$	—	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ω, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ω, f = 400 MHz)	NF	 — —	 2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)	G_{ps}	 18 10	 — —	dB

MMBF4856LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
SWITCHING

N-CHANNEL — DEPLETION

★This is a Motorola designated preferred device.

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	V
Reverse Gate-Source Voltage	$V_{GS(R)}$	−25	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF4856LT1 = AAA

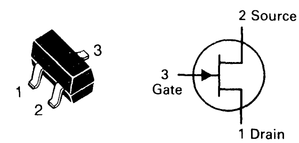
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($V_{DS} = 0$, $I_D = 1.0\ \mu A$)		$V_{(BR)GSS}$	−40	—	V
Gate Reverse Current ($V_{DS} = 0$ V, $V_{GS} = 20$ V)		I_{GSS}	—	0.5	nA
Gate Source Cutoff Voltage ($V_{DS} = 15$, $I_D = 0.5$ nA)		$V_{GS(OFF)}$	−4.0	−10	V
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{GS} = 0$, $V_{DS} = 15$ V)		I_{DSS}	50	—	mA
Drain Cutoff Current ($V_{DS} = 15$ V, $V_{GS} = 10$ V)		$I_{D(off)}$	—	0.25	nA
Drain Source On Voltage ($V_{GS} = 0$, $I_D = 20$ mA)		$V_{DS(on)}$	—	0.75	V
Drain Source On Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)		$r_{DS(on)}$	—	25	Ω
Input Capacitance	$V_{DS} = 0$, $V_{GS} = -10$ V f = 1.0 MHz	C_{iss}	—	18	pF
Reverse Transfer Capacitance		C_{rss}	—	8	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	$V_{DD} = 10$ V, $I_{D(on)} = 20$ mA $V_{GS(on)} = 0$, $V_{GS(off)} = -10$ V	t_d	—	6	nS
Rise Time		t_r	—	3	
Turn-Off Time		t_{off}	—	25	

(1) Pulse Test; Pulse Width < 300 μs, Duty Cycle ≤ 2%.

MMBF4860LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
SWITCHING TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

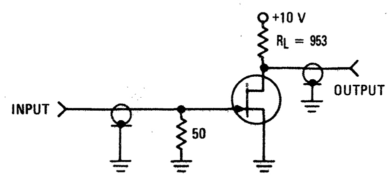
MMBF4860LT1 = 6F

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

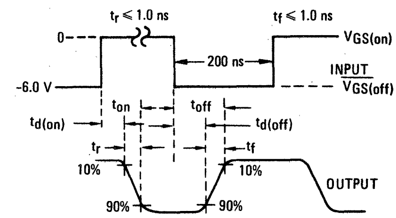
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	— —	0.5 2.0	nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	$V_{GS(off)}$	−2.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	20	100	mAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 10 Vdc, T_A = 150°C)	$I_{D(off)}$	— —	0.25 0.5	nAdc μAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0)	$V_{DS(on)}$	—	0.5	Vdc
Static Drain-Source On Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{DS(on)}$	—	40	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{iss}	—	18	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{rss}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc) ($V_{G(on)}$ = 0, $V_{GS(off)}$ = 10 Vdc)	t_d	—	6.0	ns
Rise Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc) ($V_{GS(on)}$ = 0, $V_{GS(off)}$ = 6.0 Vdc) (Figure 1)	t_r	—	4.0	ns
Turn-Off Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc) ($V_{GS(on)}$ = 0, $V_{GS(off)}$ = 4.0 Vdc) (Figure 1)	t_{off}	—	50	ns

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: 1. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%

2. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.75$ ns, $R_{in} \geq 1.0$ megohm, $C_{in} \leq 2.5$ pF.

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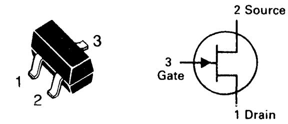
MMBF5457LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
GENERAL PURPOSE TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5457 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF5457LT1 = 6D

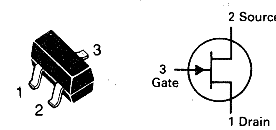
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	—	1.0	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)		—	—	200	
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	$V_{GS(off)}$	0.5	—	−6.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 100 μAdc)	V_{GS}	—	−2.5	—	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	1.0	—	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	1000	—	5000	μmhos
Reverse Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{rs}\|$	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.5	3.0	pF

(1) Pulse test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

MMBF5459LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5457 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	−25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

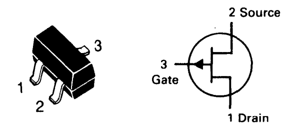
MMBF5459LT1 = 6L

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −10 μA, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −15 V, V_{DS} = 0)	I_{G1SS}	—	1.0	nA
Gate 2 Leakage Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 100°C)	I_{G2SS}	—	200	nA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−2.0	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	I_{DSS}	4.0	16	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	2000	6000	μmhos
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Input Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.0	pF

MMBF5460LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
GENERAL PURPOSE
TRANSISTOR

P-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF5460LT1 = 6E

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	40	—	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	5.0	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)		—	—	1.0	μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	0.75	—	6.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.1 mAdc)	V_{GS}	0.5	—	4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	−1.0	—	−5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	1000	—	4000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	—	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	2.0	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 MΩ, f = 100 Hz, BW = 1.0 Hz)	$\bar{e}_n$	—	20	—	nV/√Hz

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Continuous Device Dissipation at or Below T_C = 25°C Linear Derating Factor	P_D	200 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

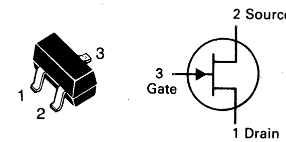
*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBF5484LT1 = 6B

MMBF5484LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

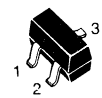
Refer to 2N5484 for graphs.

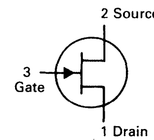
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −20 V, V_{DS} = 0) (V_{GS} = −20 V, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 −1.0 −0.2	 nA μA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−0.3	−3.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	I_{DSS}	1.0	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	3000	6000	μmhos
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Input Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Output Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 V, I_D = 1.0 mA, YG′ = 1.0 mmhos) (R_G = 1.0 kΩ, f = 100 MHz) (V_{DS} = 15 V, V_{GS} = 0, YG′ = 1.0 μmho) (R_G = 1.0 MΩ, f = 1.0 kHz)	NF	 — —	 3.0 2.5	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	G_{ps}	16	25	dB

MMBF5486LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)





JFET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to 2N5484 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

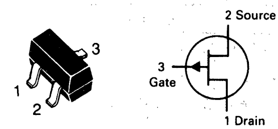
MMBF5486LT1 = 6H

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −1.0 μA)	$V_{(BR)GSS}$	−25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −20 V, V_{DS} = 0)	I_{G1SS}	—	−1.0	nA
Gate 2 Leakage Current (V_{GS} = −20 V, V_{DS} = 0, T_A = 100°C)	I_{G2SS}	—	−0.2	μA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−2.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{GS} = 0, V_{DS} = 15 V)	I_{DSS}	8.0	20	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	4000	8000	μmhos
Input Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{is})$	—	1000	μmhos
Output Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\lvert y_{os} \rvert$	—	75	μmhos
Output Conductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{os})$	—	100	μmhos
Forward Transconductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{fs})$	3500	—	μmhos
Input Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Output Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz, Y_G = 1.0 μmhos) (V_{DS} = 15 V, I_D = 4.0 mA, R_G = 1.0 kΩ, f = 400 MHz, Y_G = 1.0 μmhos) (V_{GS} = 0, V_{DS} = 15 V, R_G = 1.0 mΩ, f = 1.0 kHz, Y_G = 1.0 μmhos)	NF	 — — —	 2.0 4.0 2.5	dB
Common Source Power Gain (V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz) (V_{DS} = 15 V, I_D = 4.0 mA, f = 400 MHz)	G_{ps}	 18 10	 30 20	dB

MMBFJ175LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
CHOPPER

P-CHANNEL — DEPLETION

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	V
Reverse Gate-Source Voltage	$V_{GS(r)}$	−25	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBFJ175LT1 = 6W

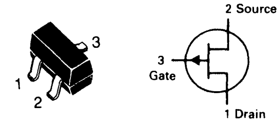
ELECTRICAL CHARACTERISTICS (T_A = 25°C, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (V_{DS} = 0, I_D = 1.0 μA)		$V_{(BR)GSS}$	30	—	V
Gate Reverse Current (V_{DS} = 0 V, V_{GS} = 20 V)		I_{GSS}	—	1.0	nA
Gate Source Cutoff Voltage (V_{DS} = 15, I_D = 10 nA)		$V_{GS(OFF)}$	3.0	6.0	V
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{GS} = 0, V_{DS} = 15 V)		I_{DSS}	7.0	60	mA
Drain Cutoff Current (V_{DS} = 15 V, V_{GS} = 10 V)		$I_{D(off)}$	—	1.0	nA
Drain Source On Resistance (I_D = 500 nA)		$r_{DS(on)}$	—	125	Ω
Input Capacitance	V_{DS} = 0, V_{GS} = 10 V f = 1.0 MHz	C_{iss}	—	11	pF
Reverse Transfer Capacitance		C_{rss}	—	5.5	

(1) Pulse Test; Pulse Width < 300 μs, Duty Cycle ≤ 2%.

MMBFJ177LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
CHOPPER

P-CHANNEL — DEPLETION

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	V
Reverse Gate-Source Voltage	$V_{GS(r)}$	−25	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBFJ175LT1 = 6W

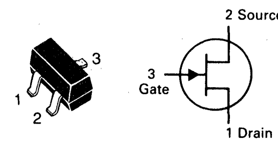
ELECTRICAL CHARACTERISTICS (T_A = 25°C, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (V_{DS} = 0, I_D = 1.0 μA)		$V_{(BR)GSS}$	30	—	V
Gate Reverse Current (V_{DS} = 0 V, V_{GS} = 20 V)		I_{GSS}	—	1.0	nA
Gate Source Cutoff Voltage (V_{DS} = 15, I_D = 10 nA)		$V_{GS(OFF)}$	0.8	2.5	V
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{GS} = 0, V_{DS} = 15 V)		I_{DSS}	1.5	20	mA
Drain Cutoff Current (V_{DS} = 15 V, V_{GS} = 10 V)		$I_{D(off)}$	—	1.0	nA
Drain Source On Resistance (I_D = 500 nA)		$r_{DS(on)}$	—	300	Ω
Input Capacitance	V_{DS} = 0, V_{GS} = 10 V f = 1.0 MHz	C_{iss}	—	11	pF
Reverse Transfer Capacitance		C_{rss}	—	5.5	

(1) Pulse Test; Pulse Width < 300 μs, Duty Cycle ≤ 2%.

MMBFJ309LT1★
MMBFJ310LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET
VHF/UHF AMPLIFIER
TRANSISTOR

N-CHANNEL

★These are Motorola designated preferred devices.

Refer to J309 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

MMBFJ309LT1 = 6U; MMBFJ310LT1 = 6T

4

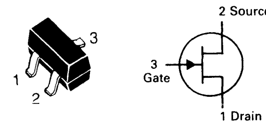
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current		I_{GSS}				
(V_{GS} = −15 V)			—	—	−1.0	nAdc
(V_{GS} = −15 V, T_A = 125°C)			—	—	−1.0	μAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	MMBFJ309	$V_{GS(off)}$	−1.0	—	−4.0	Vdc
	MMBFJ310		−2.0		−6.5	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0)	MMBFJ309	I_{DSS}	12	—	30	mAdc
	MMBFJ310		24		60	
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)		$\|Y_{fs}\|$	8.0	—	18	mmhos
Output Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)		$\|Y_{os}\|$	—	—	250	μmhos
Input Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)		C_{rss}	—	—	2.5	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 Hz)		$\bar{e}_n$	—	10	—	$nV/\sqrt{Hz}$

Note: "LT1" must be used when ordering SOT-23 devices.

MMBFU310LT1★

CASE 318-07, STYLE 10
SOT-23 (TO-236AB)



JFET TRANSISTOR

N-CHANNEL

★This is a Motorola designated preferred device.

Refer to J310 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.

DEVICE MARKING

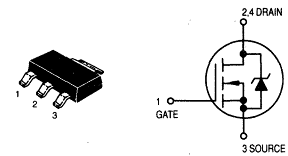
MMBFU310LT1 = 6C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −15 V, V_{DS} = 0)	I_{G1SS}	–	−150	pA
Gate 2 Leakage Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 125°C)	I_{G2SS}	—	−150	nA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 nA)	$V_{GS(off)}$	−2.5	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	I_{DSS}	24	60	mA
Gate-Source Forward Voltage (I_G = 10 mA, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	$\|Y_{fs}\|$	10	18	mmhos
Output Admittance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	$\|y_{os}\|$	—	250	μmhos
Input Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)	C_{rss}	—	2.5	pF

MMFT107T1★

CASE 318E-04, STYLE 3
SOT-223 (TO-261AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_C = 25°C Unless Otherwise Noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DSS}	200	Volts
Drain-to-Gate Voltage	V_{DG}	200	Volts
Gate-to-Source Voltage — Continuous	V_{GS}	±20	Volts
Drain Current — Continuous — Pulsed	I_D I_{DM}	250 500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

FT107

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Maximum Time in Solder Bath	T_L	260 10	°C Sec

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C Unless Otherwise Noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 µA)		$V_{(BR)DSS}$	200	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 130 V, V_{GS} = 0)		I_{DSS}	—	—	30	nAdc
Gate-Body Leakage Current — Reverse (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	1.0	—	3.0	Vdc
Static Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 200 mA)		$r_{DS(on)}$	—	—	14	Ohms
Drain-to-Source On-Voltage (V_{GS} = 10 V, I_D = 200 mA)		$V_{DS(on)}$	—	—	2.8	Vdc
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	—	pF
Output Capacitance		C_{oss}	—	30	—	
Transfer Capacitance		C_{rss}	—	6.0	—	
SWITCHING CHARACTERISTICS						
Turn-On Time (See Figure 1)		t_{on}	—	6.0	15	ns
Turn-Off Time (See Figure 1)		t_{off}	—	12	15	

Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

Figure 1. Switching Test Circuit

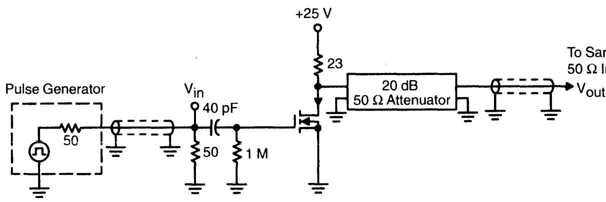
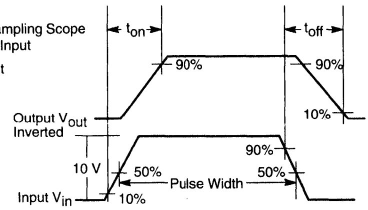


Figure 2. Switching Waveforms



MAXIMUM RATINGS (T_C = 25°C Unless Otherwise Noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DSS}	90	Volts
Drain-to-Gate Voltage	V_{DG}	90	Volts
Gate-to-Source Voltage — Continuous	V_{GS}	±30	Volts
Drain Current — Continuous — Pulsed	I_D I_{DM}	1.0 2.0	Amps
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

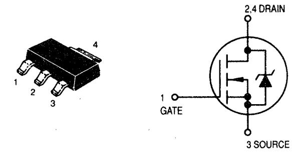
T6661

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Maximum Time in Solder Bath	T_L	260 10	°C Sec

MMFT6661T1★

CASE 318E-04, STYLE 3
SOT-223 (TO-261AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C Unless Otherwise Noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)		$V_{(BR)DSS}$	90	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 90 V, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS*						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)		$V_{GS(th)}$	0.8	1.4	2.0	Vdc
Static Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)		$r_{DS(on)}$	—	1.2	4.0	Ohms
Drain-to-Source On-Voltage (V_{GS} = 10 V, I_D = 1.0 A) (V_{GS} = 5.0 V, I_D = 0.3 A)		$V_{DS(on)}$	 — —	 — —	 4.0 1.6	Vdc
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 Vdc)		$I_{D(on)}$	1.0	2.0	—	Amps
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{FS}	170	—	—	mmhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	30	—	pF
Output Capacitance		C_{oss}	—	20	—	
Transfer Capacitance		C_{rss}	—	3.6	—	
SWITCHING CHARACTERISTICS (See Figure 1)						
Rise Time	(V_{DD} = 25 V, I_D = 0.5 Rated I_D, R_{gen} = 50 Ohms) See Figures 1 and 2	t_r	—	—	5.0	ns
Fall Time		t_f	—	—	5.0	
Turn-On Time		t_{on}	—	—	5.0	
Turn-Off Time		t_{off}	—	—	5.0	

Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

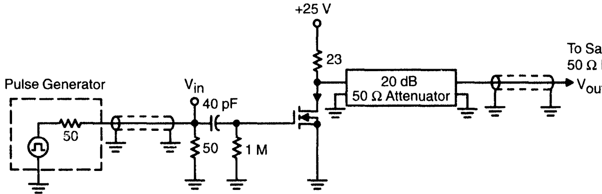


Figure 1. Switching Test Circuit

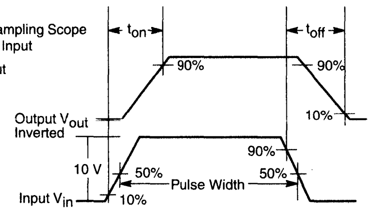
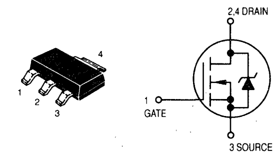


Figure 2. Switching Waveforms

MMFT960T1★

CASE 318E-04, STYLE 3
SOT-223 (TO-261AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

4

MAXIMUM RATINGS (T_C = 25°C Unless Otherwise Noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DSS}	60	Volts
Drain-to-Gate Voltage	V_{DG}	60	Volts
Gate-to-Source Voltage — Continuous	V_{GS}	±30	Volts
Drain Current — Continuous — Pulsed	I_D I_{DM}	1.0 2.0	Amps
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 6.4	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

DEVICE MARKING

FT960

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Ambient	$R_{\theta JA}$	156	°C/W
Maximum Temperature for Soldering Purposes Maximum Time in Solder Bath	T_L	260 10	°C Sec

ELECTRICAL CHARACTERISTICS (T_A = 25°C Unless Otherwise Noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-to-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 60 V, V_{GS} = 0)	I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current — Reverse (V_{GSR} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mAdc)	$V_{GS(th)}$	1.0	—	3.5	Vdc
Static Drain-to-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	$r_{DS(on)}$	—	1.2	1.7	Ohms
Drain-to-Source On-Voltage (V_{GS} = 10 Vdc) (I_D = 0.5 A) (I_D = 1.0 A)	$V_{DS(on)}$	 — —	 — —	 0.8 1.7	Vdc
On-State Drain Current (V_{GS} = 10 Vdc, I_D = 1.0 Amp)	$I_{D(on)}$	1.0	2.0	—	Amps
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	49	—	pF
Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	13	—	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time (See Figure 1)	t_{on}	—	7.0	15	ns
Turn-Off Time (See Figure 1)	t_{off}	—	7.0	15	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

Figure 1. Switching Test Circuit

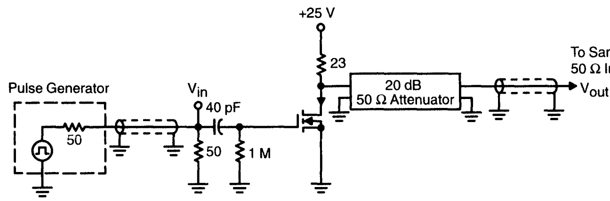
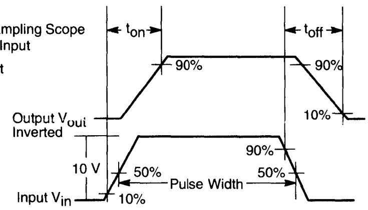


Figure 2. Switching Waveforms



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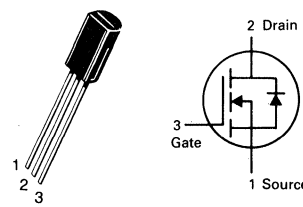
MPF89

CASE 29-03, STYLE 7
TO-92 (TO-226AE)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous (1) — Pulsed (2)	I_D I_{DM}	400 800	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to 150	°C
Thermal Resistance Junction to Ambient	θ_{JA}	208	°C/W

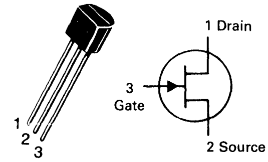
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 0.5 mA)	$V_{(BR)DSS}$	200	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 200 V, V_{GS} = 0)	I_{DSS}	—	0.1	60	μAdc
Gate-Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	0.01	100	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})	$V_{GS(th)}$	1.0	—	2.7	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 100 mA) (I_D = 300 mA) (I_D = 500 mA)	$V_{DS(on)}$	 — — —	 0.45 1.2 3.0	 0.6 1.8 —	Vdc
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	500	700	—	mA
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc) (I_D = 150 mA) (I_D = 300 mA) (I_D = 500 mA)	$r_{DS(on)}$	 — — —	 4.5 — 6.0	 6.0 6.0 —	Ohms
Forward Transconductance (V_{DS} = 25 V, I_D = 300 mA)	g_{fs}	140	400	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	72	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	15	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.8	—	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time (See Figure 1)	t_{on}	—	6.0	—	ns
Turn-Off Time (See Figure 1)	t_{off}	—	12	—	ns

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPF102

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N5484 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

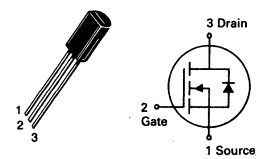
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 −2.0 −2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 2.0 nAdc)	$V_{GS(off)}$	—	−8.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.2 mAdc)	V_{GS}	−0.5	−7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	2.0	20	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	 2000 1600	 7500 —	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

MPF910

MPF910
CASE 29-03, STYLE 22
TO-92 (TO-226AE)



TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to MPF6659 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	±15	Vdc
Drain Current — Continuous(1) Pulsed(2)	I_D I_{DM}	0.5 1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C MPF910	P_D	1.0 8.0	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C MFE910	P_D	6.25 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

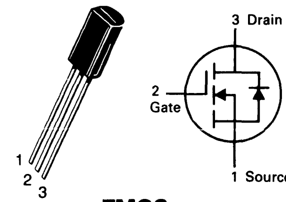
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 40 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate Reverse Current (V_{GS} = 10 V, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.3	1.5	2.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}$	—	—	2.5	Vdc
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	500	—	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 500 mA)	g_{fs}	100	—	—	mmhos

4

MPF930★
MPF960★
MPF990★

CASE 29-03, STYLE 22
TO-92 (TO-226AE)



TMOS SWITCHING

N-CHANNEL — ENHANCEMENT

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MPF930	MPF960	MPF990	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}	±30			Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}	 2.0 3.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 1.0 8.0			 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to 150			°C
Thermal Resistance	θ_{JA}	125			°C/W

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	MPF930 MPF960 MPF990	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 0.5 A)	MPF930 MPF960 MPF990	$V_{DS(on)}$	— — —	0.4 0.6 0.6	0.7 0.8 1.2	Vdc
(I_D = 1.0 A)	MPF930 MPF960 MPF990		— — —	0.9 1.2 1.2	1.4 1.7 2.4	
(I_D = 2.0 A)	MPF930 MPF960 MPF990		— — —	2.2 2.8 2.8	3.0 3.5 4.8	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MPF930 MPF960 MPF990	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	70	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	20	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	—	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS						
Turn-On Time		t_{on}	—	7.0	15	ns
Turn-Off Time		t_{off}	—	7.0	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

4

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

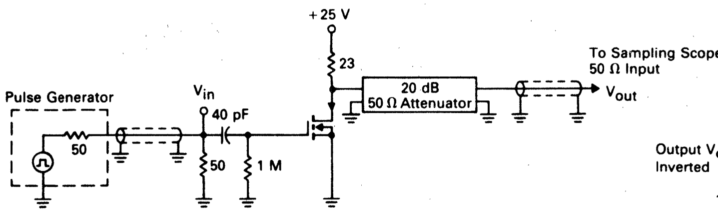


FIGURE 2 — SWITCHING WAVEFORMS

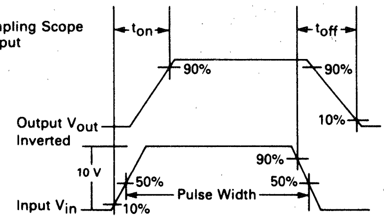


FIGURE 3 — ON VOLTAGE versus TEMPERATURE,

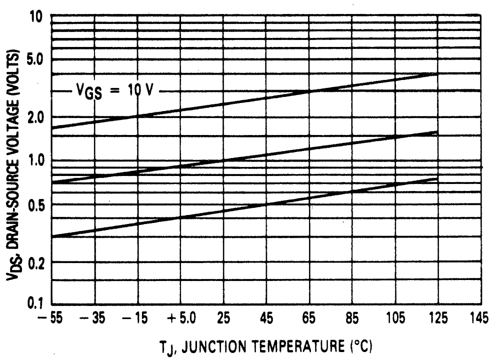


FIGURE 4 — CAPACITANCE VARIATION

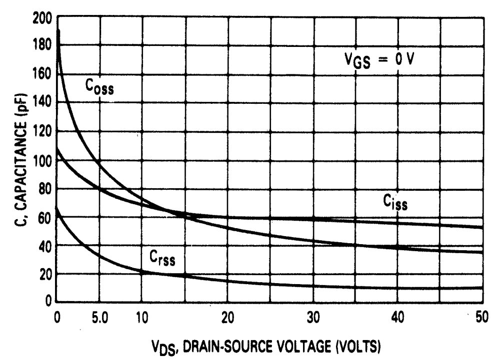


FIGURE 5 — TRANSFER CHARACTERISTIC

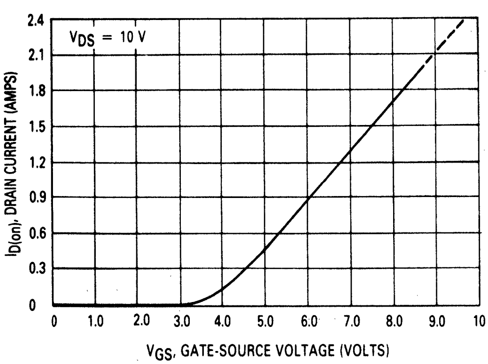


FIGURE 6 — OUTPUT CHARACTERISTIC

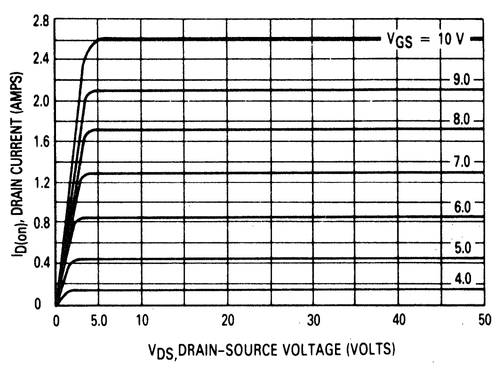
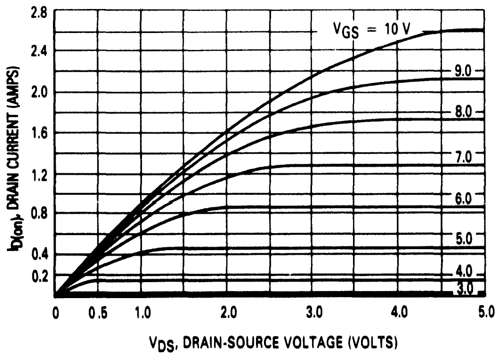


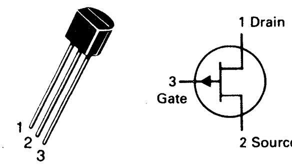
FIGURE 7 — SATURATION CHARACTERISTIC



4

MPF970
MPF971

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET SWITCHING

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C
Operating Temperature Range	$T_{channel}$	−65 to +150	°C

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 — —	 1.0 1.0	 nAdc μAdc
Drain-Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C) (V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc, T_A = 150°C)	 MPF970 MPF970 MPF971 MPF971	$I_{D(off)}$	 — — — —	 — — — —	 10 10 10 10	 nAdc μAdc nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 MPF970 MPF971	$V_{GS(off)}$	 5.0 1.0	 — —	 12 7.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 MPF970 MPF971	I_{DSS}	 −15 −2.0	 — —	 −100 −50	mAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0) (I_D = 1.5 mAdc, V_{GS} = 0)		$V_{DS(on)}$	 — —	 — —	 1.5 1.5	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MPF970 MPF971	$r_{DS(on)}$	 — —	 — —	 100 250	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MPF970 MPF971	$r_{ds(on)}$	 — —	 — —	 100 250	Ohms
Input Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz) (V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 MPF970 MPF971	C_{iss}	 — —	 — —	 12 12	pF
Reverse Transfer Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz) (V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 MPF970 MPF971	C_{rss}	 — —	 — —	 5.0 5.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS (See Figure 6, R_K = 0) (1)						
Rise Time		t_r				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	2.0	5.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	3.0	5.0	
Fall Time		t_f				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	9.0	15	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	68	80	
Turn-On Time		t_{on}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	3.5	8.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	5.0	10	
Turn-Off Time		t_{off}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	13	25	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	88	120	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

4

FIGURE 1 — EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE

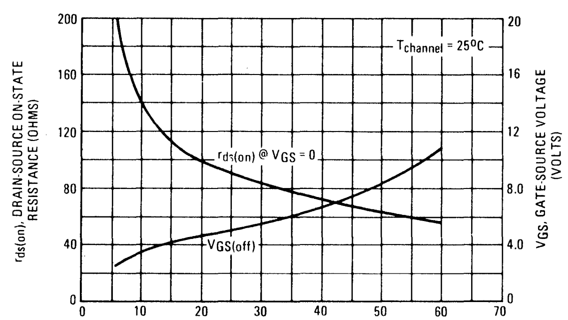


FIGURE 2 — TURN-ON DELAY TIME

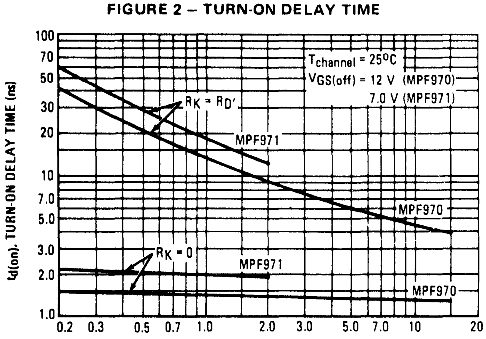


FIGURE 3 — RISE TIME

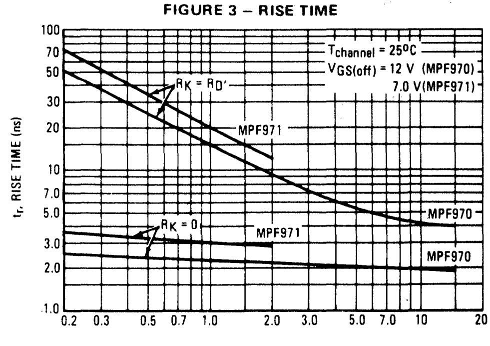


FIGURE 4 — TURN-OFF DELAY TIME

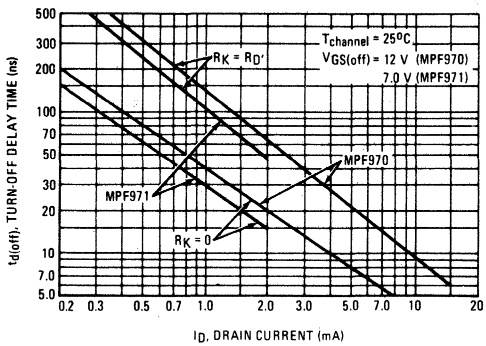


FIGURE 5 — FALL TIME

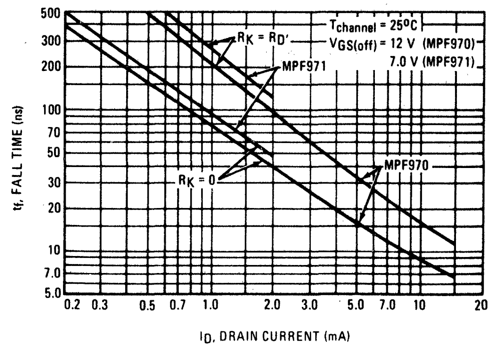
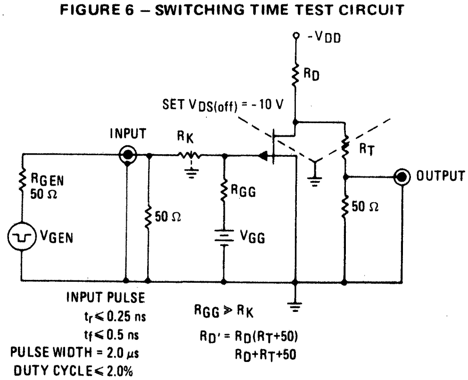


FIGURE 6 — SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 6. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($+V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D, which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

FIGURE 7 — TYPICAL FORWARD TRANSFER ADMITTANCE

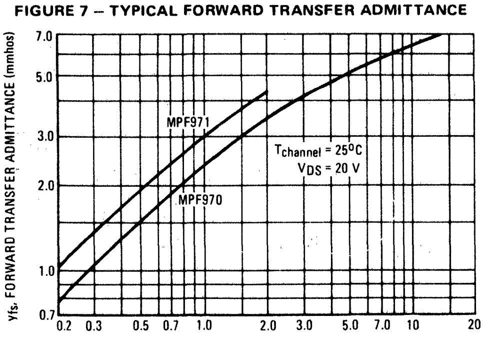


FIGURE 8 — TYPICAL CAPACITANCE

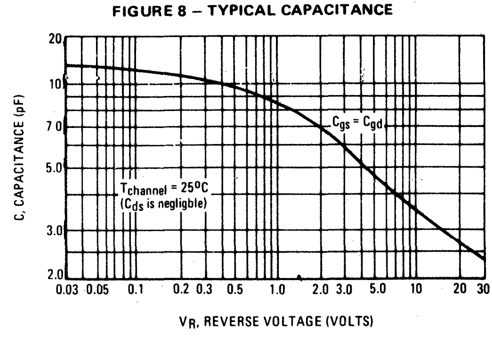


FIGURE 9 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

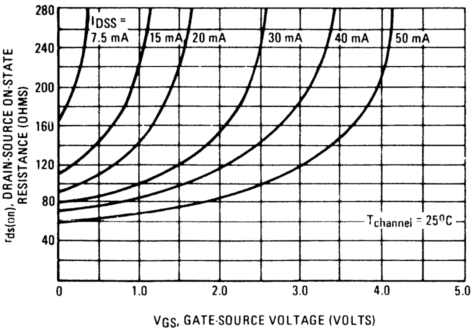


FIGURE 10 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE

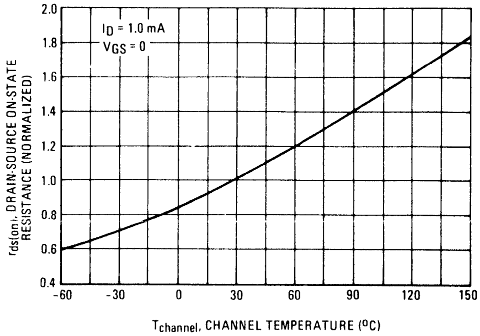
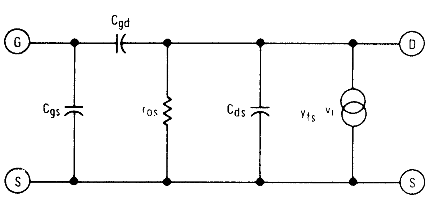


FIGURE 11 – LOW FREQUENCY CIRCUIT MODEL

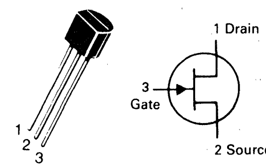


$y_{is} = j\omega C_{iss}$
$y_{os} = 1/r_{oss} + j\omega C_{oss}$
$y_{fs} = y_{fs}$
$y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds}, C_{ds} \approx 0$

MPF3821
MPF3822

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET
GENERAL PURPOSE

N-CHANNEL — DEPLETION

Refer to 2N5457 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	−50	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	−65 to 150	°C

4

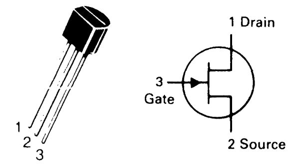
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current ($V_{GS} = -30$ Vdc, $V_{DS} = 0$) ($V_{GS} = -30$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		I_{GSS}	 — —	 −0.1 −100	nAdc
Gate Source Cutoff Voltage ($I_D = 0.5$ nAdc, $V_{DS} = 15$ Vdc)	 MPF3821 MPF3822	$V_{GS(off)}$	 — —	 −4.0 −6.0	Vdc
Gate Source Voltage ($I_D = 50\ \mu Adc$, $V_{DS} = 15$ Vdc) ($I_D = 200\ \mu Adc$, $V_{DS} = 15$ Vdc)	 MPF3821 MPF3822	V_{GS}	 −0.5 −1.0	 −2.0 −4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	 MPF3821 MPF3822	I_{DSS}	 0.5 2.0	 2.5 10	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz)	 MPF3821 MPF3822 MPF3821 MPF3822	$\|y_{fs}\|$	 1500 3000 1500 3000	 4500 6500 — —	μmhos
Output Admittance(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	 MPF3821 MPF3822	$\|y_{os}\|$	 — —	 10 20	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{rss}	—	3.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $R_S = 1.0$ megohm, f = 10 Hz, Noise Bandwidth = 5.0 Hz)		NF	—	5.0	dB
Equivalent Input Noise Voltage ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 10 Hz, Noise Bandwidth = 5.0 Hz)		e_n	—	200	$nv/Hz^{1/2}$

(1) Pulse Test: Pulse Width ≤ 100 ms, Duty Cycle ≤ 10%.

MPF4391 thru MPF4393★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFETs SWITCHING

N-CHANNEL — DEPLETION

★MPF4392 and MPF4393 are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current		I_{GSS}				
(V_{GS} = 15 Vdc, V_{DS} = 0)			—	—	1.0	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)			—	—	0.2	μAdc
Drain-Cutoff Current		$I_{D(off)}$				
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)			—	—	1.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 100°C)			—	—	0.1	μAdc
Gate Source Voltage		V_{GS}				Vdc
(V_{DS} = 15 Vdc, I_D = 10 nAdc)	MPF4391		50	—	150	
	MPF4392		25	—	75	
	MPF4393		5.0	—	30	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1)		I_{DSS}				mAdc
(V_{DS} = 15 Vdc, V_{GS} = 0)	MPF4391		60	—	130	
	MPF4392		25	—	75	
	MPF4393		5.0	—	30	
Drain-Source On-Voltage		$V_{DS(on)}$				Vdc
(I_D = 12 mAdc, V_{GS} = 0)	MPF4391		—	—	0.4	
(I_D = 6.0 mAdc, V_{GS} = 0)	MPF4392		—	—	0.4	
(I_D = 3.0 mAdc, V_{GS} = 0)	MPF4393		—	—	0.4	
Static Drain-Source On Resistance		$r_{DS(on)}$				Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	MPF4391		—	—	30	
	MPF4392		—	—	60	
	MPF4393		—	—	100	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance		$\|y_{fs}\|$				mmhos
(V_{DS} = 15 Vdc, I_D = 60 mAdc, f = 1.0 kHz)	MPF4391		—	20	—	
(V_{DS} = 15 Vdc, I_D = 25 mAdc, f = 1.0 kHz)	MPF4392		—	17	—	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	MPF4393		—	12	—	
Drain-Source "ON" Resistance		$r_{ds(on)}$				Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MPF4391		—	—	30	
	MPF4392		—	—	60	
	MPF4393		—	—	100	
Input Capacitance (V_{GS} = 15 Vdc, V_{DS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	10	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Transfer Capacitance		C_{rss}				pF
(V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)			—	2.5	3.5	
(V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)			—	3.2	—	
SWITCHING CHARACTERISTICS						
Rise Time (See Figure 2)		t_r				ns
($I_{D(on)}$ = 12 mAdc)	MPF4391		—	1.2	5.0	
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		—	2.0	5.0	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		—	2.5	5.0	
Fall Time (See Figure 4)		t_f				ns
($V_{GS(off)}$ = 12 Vdc)	MPF4391		—	7.0	15	
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		—	15	20	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		—	29	35	
Turn-On Time (See Figures 1 and 2)		t_{on}				ns
($I_{D(on)}$ = 12 mAdc)	MPF4391		—	3.0	15	
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		—	4.0	15	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		—	6.5	15	
Turn-Off Time (See Figures 3 and 4)		t_{off}				ns
($V_{GS(off)}$ = 12 Vdc)	MPF4391		—	10	20	
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		—	20	35	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		—	37	55	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

4

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON DELAY TIME

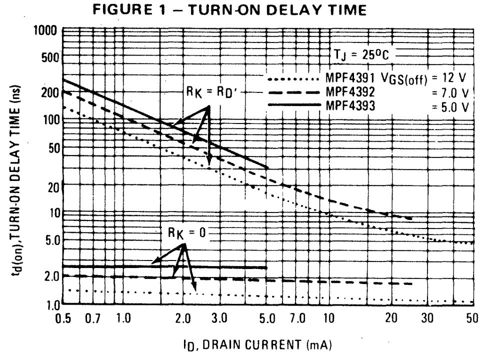


FIGURE 2 – RISE TIME

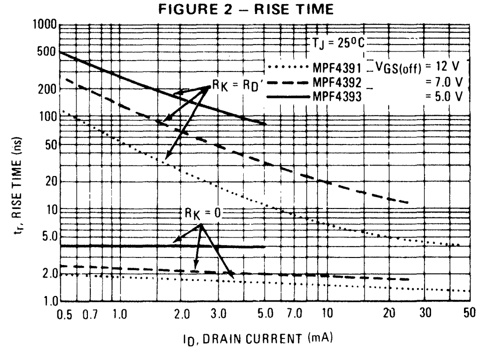


FIGURE 3 – TURN-OFF DELAY TIME

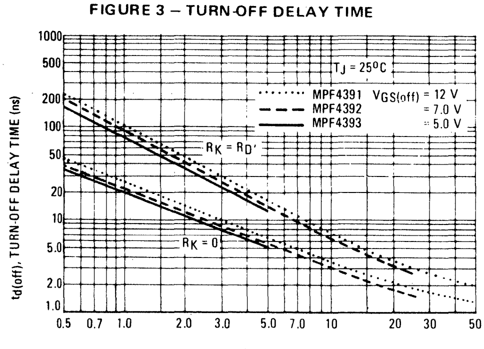


FIGURE 4 – FALL TIME

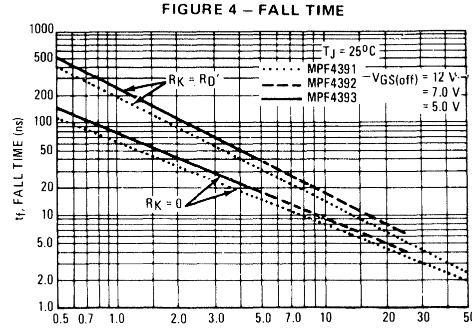
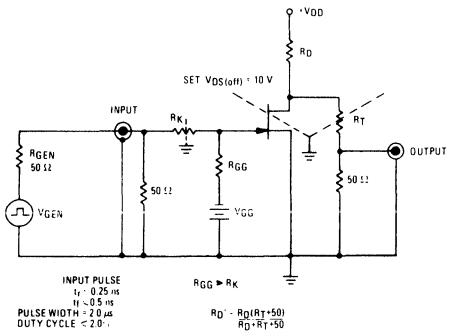


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 5. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($-V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply, Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D, which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

4

FIGURE 6 – TYPICAL FORWARD TRANSFER ADMITTANCE

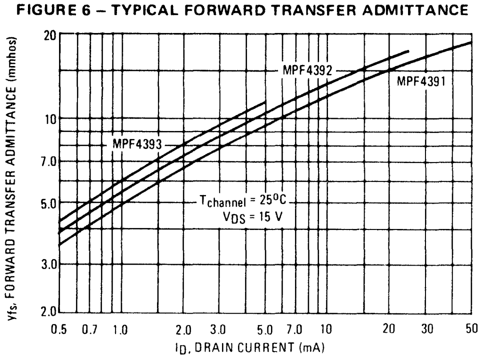


FIGURE 7 – TYPICAL CAPACITANCE

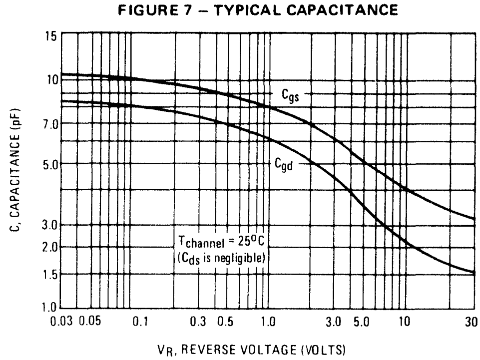


FIGURE 8 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

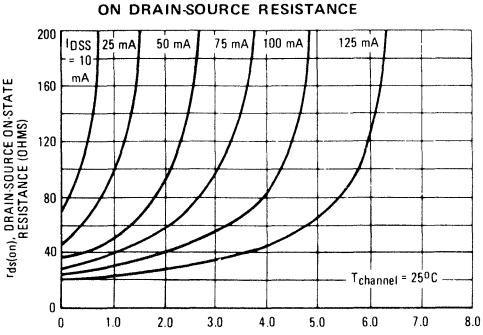


FIGURE 9 – EFFECT OF TEMPERATURE ON DRAIN–SOURCE ON-STATE RESISTANCE

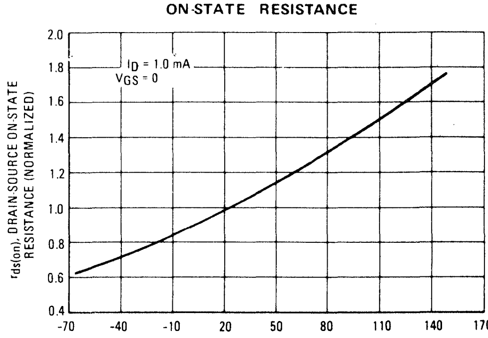
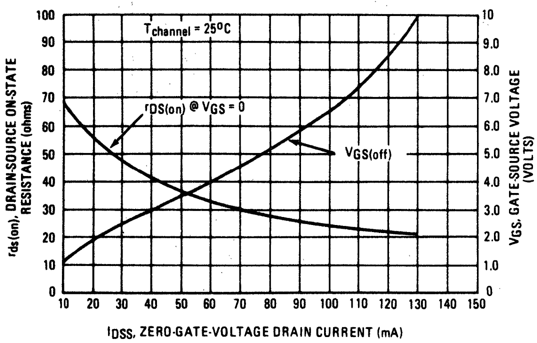


FIGURE 10 – EFFECT OF IDSS ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



NOTE 2

The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 10. This data will be useful in predicting the characteristic variations for a given part number.

For example:

Unknown

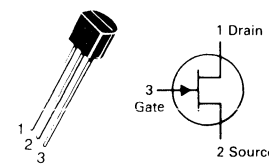
$r_{ds(on)}$ and V_{GS} range for an MPF4392

The electrical characteristics table indicates that an MPF4392 has an I_{DSS} range of 25 to 75 mA. Figure 10, shows $r_{ds(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

4

MPF4856 thru MPF4861★

CASE 29-04, STYLE 5
TO-92 (TO-226AA)



JFET SWITCHING

N-CHANNEL — DEPLETION

★These are Motorola preferred devices.

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPF4856 MPF4857 MPF4858	MPF4859 MPF4860 MPF4861	Unit
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−40	−30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

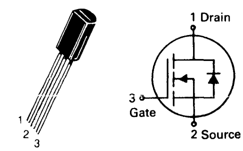
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	MPF4856, MPF4857, MPF4858 MPF4859, MPF4860, MPF4861	$V_{(BR)GSS}$	−40 −30	— —	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 150°C) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C)	 MPF4856, MPF4857, MPF4858 MPF4859, MPF4860, MPF4861 MPF4856, MPF4857, MPF4858 MPF4859, MPF4860, MPF4861	I_{GSS}	 — — — —	 0.25 0.25 0.5 0.5	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	MPF4856, MPF4859 MPF4857, MPF4860 MPF4858, MPF4861	$V_{GS(off)}$	−4.0 −2.0 −0.8	−10 −6.0 −4.0	Vdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc, T_A = 150°C)		$I_{D(off)}$	 — —	 0.25 0.5	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	MPF4856, MPF4859 MPF4857, MPF4860 MPF4858, MPF4861	I_{DSS}	50 20 8.0	— 100 80	mAdc
Drain-Source On-Voltage (I_D = 20 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0) (I_D = 5.0 mAdc, V_{GS} = 0)	 MPF4856, MPF4859 MPF4857, MPF4860 MPF4858, MPF4861	$V_{DS(on)}$	 — — —	 0.75 0.5 0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MPF4856, MPF4859 MPF4857, MPF4860 MPF4858, MPF4861	$r_{ds(on)}$	— — —	25 40 60	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	MPF4856 thru MPF4861	C_{iss}	—	18	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	MPF4856 thru MPF4861	C_{rss}	—	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	Conditions for MPF4856, MPF4859: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc)	MPF4856, MPF4859	$t_{d(on)}$	—	6.0	ns
		MPF4857, MPF4860		—	6.0	
		MPF4858, MPF4861		—	10	
Rise Time	Conditions for MPF4857, MPF4860: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −6.0 Vdc)	MPF4856, MPF4859	t_r	—	3.0	ns
		MPF4857, MPF4860		—	4.0	
		MPF4858, MPF4861		—	10	
Turn-Off Time	Conditions for MPF4858, MPF4861: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −4.0 Vdc)	MPF4856, MPF4859	t_{off}	—	25	ns
		MPF4857, MPF4860		—	50	
		MPF4858, MPF4861		—	100	

MPF6659 thru MPF6661★

CASE 29-03, STYLE 22
TO-92 (TO-226AE)



TMOS FET TRANSISTORS

N-CHANNEL — ENHANCEMENT

★MPF6660 and MPF6661 are Motorola designated preferred devices.

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MAXIMUM RATINGS

Rating	Symbol	MPF6659	MPF6660	MPF6661	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}	±30			Vdc
Drain Current —					Adc
Continuous (1)	I_D	2.0			
Pulsed (2)	I_{DM}	3.0			
Total Device Dissipation	P_D				
@ T_C = 25°C		2.5			Watts
Derate above 25°C		20			mW/°C
Total Device Dissipation	P_D				
@ T_A = 25°C		1.0			Watts
Derate above 25°C		8.0			mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
Drain-Source Breakdown Voltage		$V_{(BR)DSX}$				Vdc
(V_{GS} = 0, I_D = 10 μA)	MPF6659		35	—	—	
	MPF6660		60	—	—	
	MPF6661		90	—	—	
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(Th)}$	0.8	1.4	2.0	Vdc
Drain-Source On-Voltage		$V_{DS(on)}$				Vdc
(V_{GS} = 10 V, I_D = 1.0 A)	MPF6659		—	—	1.8	
	MPF6660		—	—	3.0	
	MPF6661		—	—	4.0	
(V_{GS} = 5.0 V, I_D = 0.3 A)	MPF6659		—	0.8	1.5	
	MPF6660		—	0.9	1.5	
	MPF6661		—	0.9	1.6	
Static Drain-Source On Resistance		$r_{DS(on)}$				Ohms
(V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MPF6659		—	—	1.8	
	MPF6660		—	—	3.0	
	MPF6661		—	—	4.0	
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	30	—	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	3.6	—	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	20	—	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	170	—	—	mmhos

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS(1)					
Rise Time	t_r	—	—	5.0	ns
Fall Time	t_f	—	—	5.0	ns
Turn-On Time	t_{on}	—	—	5.0	ns
Turn-Off Time	t_{off}	—	—	5.0	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

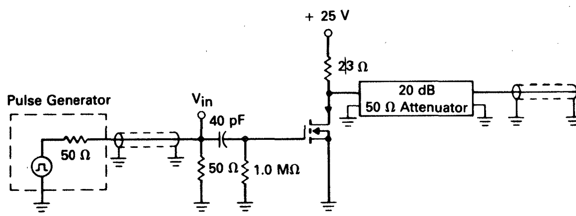


FIGURE 2 — SWITCHING WAVEFORMS

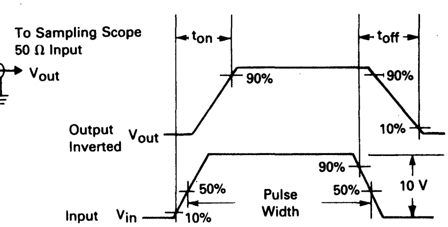


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

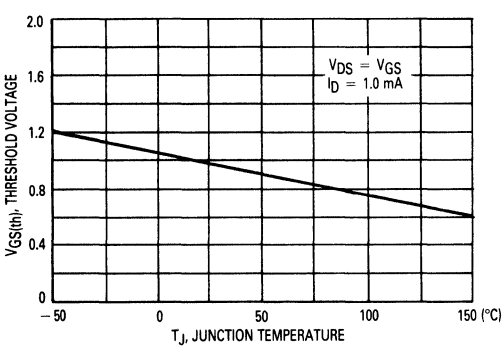


FIGURE 4 — ON-REGION CHARACTERISTICS

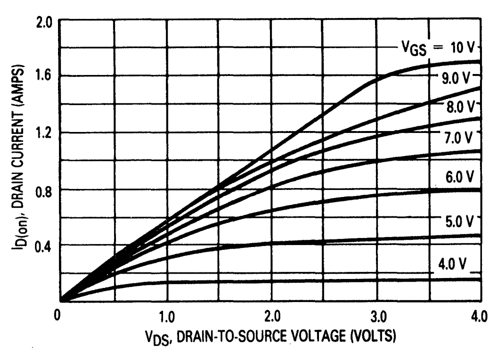


FIGURE 5 — OUTPUT CHARACTERISTICS

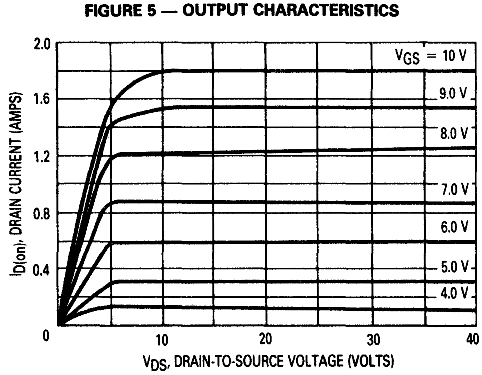


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE

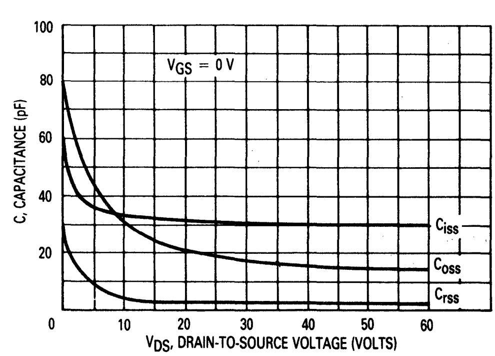
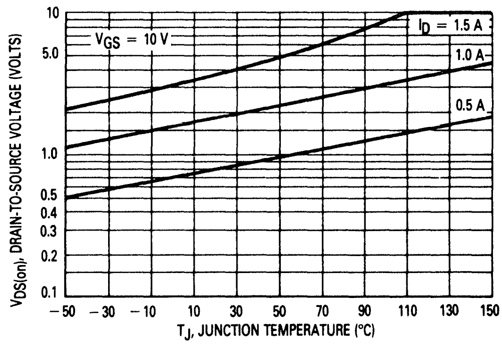


FIGURE 7 — ON-VOLTAGE versus TEMPERATURE



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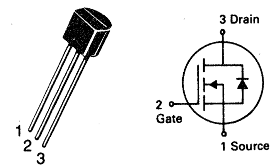
CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
STATIC CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)		$V_{(BR)DSS}$	30	—	V
Zero Gate Voltage Drain Current		I_{DSS}			μA
(V_{DS} = 48 V, V_{GS} = 0)			—	10	
(V_{DS} = 48 V, V_{GS} = 0, T_A = 125 °C)			—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±30 V)		I_{GSS}		±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(th)}$	0.8	2.5	V
On-State Drain Current* (V_{DS} = V_{GS}, I_D = 1.0 mA)		$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*		$r_{DS(on)}$			
(V_{GS} = 5.0 V, I_D = 0.3 A)			—	3.3	Ω
(V_{GS} = 10 V, I_D = 1.0 A)			—	1.2	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)		g_{fs}	200	—	mS
DYNAMIC CHARACTERISTICS					
Input Capacitance	V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz	C_{iss}	—	100	pF
Output Capacitance		C_{oss}	—	95	
Reverse Transfer Capacitance		C_{rss}	—	25	
SWITCHING CHARACTERISTICS					
Turn-On Time	V_{DD} = 25 V, I_D = 1.0 A, R_L = 24 Ω, RG = 25 Ω	t_{on}	—	30	ns
Turn-Off Time		t_{off}	—	30	

* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%

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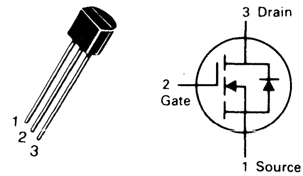
CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

Refer to BS170 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Gate-Source Voltage	V_{GS}	±40	Vdc
Drain Current Continuous Pulsed	 I_D I_{DM}	 190 1000	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 3.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 V, V_{GS} = 0) (V_{DS} = 48 V, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 10 500	μAdc
Gate-Body Leakage Current, Forward (V_{GSF} = 30 Vdc, V_{DS} = 0)	I_{GSSF}	—	−100	nAdc
ON CHARACTERISTICS*				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.5	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 500 mA) (V_{GS} = 10 Vdc, I_D = 500 mA, T_C = 125°C)	$r_{DS(on)}$	 — —	 5.0 9.0	Ohm
Drain-Source On-Voltage (V_{GS} = 5.0 V, I_D = 200 mA) (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}$	 — —	 1.5 2.5	Vdc
On-State Drain Current (V_{GS} = 10 V, $V_{DS} \geq 2.0\ V_{DS(on)}$)	$I_{D(on)}$	750	—	mA
Forward Transconductance ($V_{DS} \geq 2.0\ V_{DS(on)}$, I_D = 500 mA)	g_{fs}	100	—	μmhos
DYNAMIC CHARACTERISTICS				
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS*				
Turn-On Delay Time (V_{DD} = 15 V, I_D = 600 mA, R_{gen} = 25 ohms, R_L = 23 ohms)	t_{on}	—	10	ns
Turn-Off Delay Time (V_{DD} = 15 V, I_D = 600 mA, R_{gen} = 25 ohms, R_L = 23 ohms)	t_{off}	—	10	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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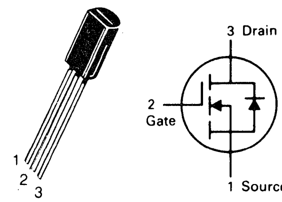
CASE 29-03, STYLE 22
TO-92 (TO-226AE)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current — Continuous(1) Pulsed(2)	I_D I_{DM}	0.3 1.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−40 to +150	°C

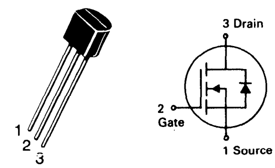
(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 45 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate-Body Leakage Current (V_{GS} = −15 V, V_{DS} = 0)	$I_{GSS}1$	—	—	100	nAdc
Gate-Body Leakage Current (V_{GS} = 15 V, V_{DS} = 0)	$I_{GSS}2$	—	—	−100	nAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	—	2.5	Vdc
On-State Drain Current (V_{DS} = 15 V, V_{GS} = 10 V)	$I_{D(on)}$	750	—	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 500 mA)	g_{fs}	200	—	—	mmhos
Drain-Source On-Voltage (V_{GS} = 5.0 V, I_D = 200 mA)	$V_{DS(on)}1$	—	—	1.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}2$	—	—	2.5	Vdc
Drain-Source On-Resistance (V_{GS} = 5.0 V, I_D = 200 mA)	$r_{DS(on)}1$	—	—	7.5	Ω
Drain-Source On-Resistance (V_{GS} = 10 V, I_D = 500 mA)	$r_{DS(on)}2$	—	—	5.0	Ω
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	—	60	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{rss}	—	—	5.0	pF
Turn-On Time (V_{DS} = 15 V, R_L = 23 Ω, R_G = 50 Ω, V_{in} = 20 V)	t_{on}	—	—	10	ns
Turn-Off Time (V_{DS} = 15 V, R_L = 23 Ω, R_G = 50 Ω, V_{in} = 20 V)	t_{off}	—	—	10	ns

VN1706L★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}	—	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

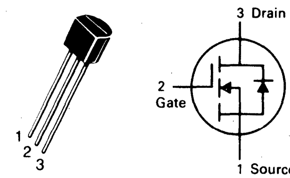
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
STATIC CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)		$V_{(BR)DSS}$	170	—	V
Zero Gate Voltage Drain Current		I_{DSS}			μA
(V_{DS} = 120 V, V_{GS} = 0)			—	10	
(V_{DS} = 120 V, V_{GS} = 0, T_A = 125 °C)			—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)		I_{GSS}	—	±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(th)}$	0.8	2.0	V
On-State Drain Current* (V_{GS} = 10 V, V_{DS} ≥ 2.0 $V_{DS(on)}$)		$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*		$r_{DS(on)}$			Ω
(V_{GS} = 2.5 V, I_D = 0.1 A)			—	10	
(V_{GS} = 10 V, I_D = 0.5 A)			—	6.0	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)		g_{fs}	300	—	mS
DYNAMIC CHARACTERISTICS					
Input Capacitance	V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz	C_{iss}	—	125	pF
Output Capacitance		C_{oss}	—	50	
Reverse Transfer Capacitance		C_{rss}	—	20	
SWITCHING CHARACTERISTICS					
Turn-On Time	V_{DD} = 60 V, I_D = 0.1 A, R_L = 150 Ω, R_G = 25 Ω	$t_{(on)}$	—	8.0	ns
		t_r	—	8.0	
Turn-Off Time		$t_{(off)}$	—	18	
		$t_{(f)}$	—	12	

* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%

VN2222LL★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Gate-Source Voltage	V_{GS}	±40	Vdc
Drain Current Continuous Pulsed	 I_D I_{DM}	 150 1000	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 3.2	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 V, V_{GS} = 0) (V_{DS} = 48 V, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 10 500	μAdc
Gate-Body Leakage Current, Forward (V_{GSF} = 30 Vdc, V_{DS} = 0)	I_{GSSF}	—	−100	nAdc
ON CHARACTERISTICS*				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.6	2.5	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 0.5 Adc) (V_{GS} = 10 Vdc, I_D = 0.5 V, T_C = 125°C)	$r_{DS(on)}$	 — —	 7.5 13.5	Ohm
Drain-Source On-Voltage (V_{GS} = 5.0 V, I_D = 200 mA) (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}$	 — —	 1.5 3.75	Vdc
On-State Drain Current (V_{GS} = 10 Vdc, V_{DS} ≥ 2.0 $V_{DS(on)}$)	$I_{D(on)}$	750	—	mA
Forward Transconductance (V_{DS} = 10 V, I_D = 500 mA)	g_{fs}	100	—	μmhos

DYNAMIC CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0 f = 1.0 MHz)	C_{iss}	—	60	pF
Output Capacitance		C_{oss}	—	25	
Reverse Transfer Capacitance		C_{rss}	—	5.0	

SWITCHING CHARACTERISTICS*

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Delay Time	(V_{DD} = 15 V, I_D = 600 mA R_{gen} = 25 ohms, R_L = 23 ohms)	t_{on}	—	10	ns
Turn-Off Delay Time		t_{off}	—	10	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

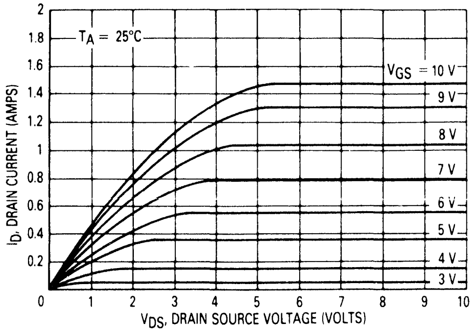


Figure 1. Ohmic Region

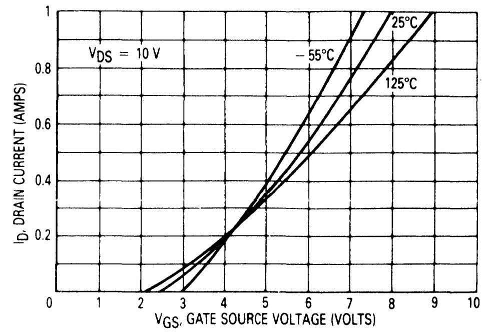


Figure 2. Transfer Characteristics

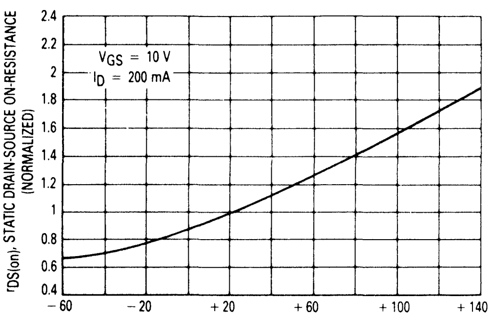


Figure 3. Temperature versus Static Drain-Source On-Resistance

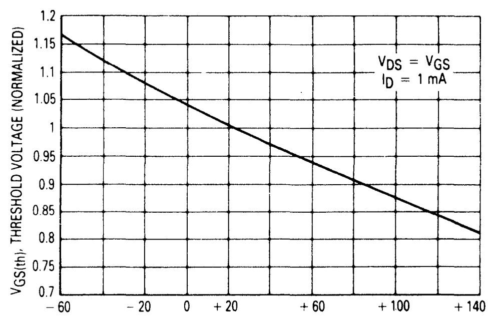
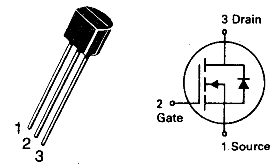


Figure 4. Temperature versus Gate Threshold Voltage

4

VN2406L★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

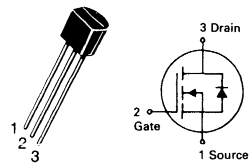
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
STATIC CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	240	—	V
Zero Gate Voltage Drain Current	I_{DSS}			μA
(V_{DS} = 120 V, V_{GS} = 0)		—	10	
(V_{DS} = 120 V, V_{GS} = 0, T_A = 125 °C)		—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)	I_{GSS}	—	±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.0	V
On-State Drain Current* (V_{GS} = 10 V, V_{DS} ≥ 2.0 $V_{DS(on)}$)	$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*	$r_{DS(on)}$			Ω
(V_{GS} = 2.5 V, I_D = 0.1 A)		—	10	
(V_{GS} = 10 V, I_D = 0.5 A)		—	6.0	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)	g_{fs}	300	—	mS
DYNAMIC CHARACTERISTICS				
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	125	pF
Output Capacitance	C_{oss}	—	50	pF
Reverse Transfer Capacitance	C_{rss}	—	20	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{DD} = 60 V, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω)	$t_{(on)}$	—	8.0	ns
	t_r	—	8.0	ns
Turn-Off Time	$t_{(off)}$	—	23	ns
	$t_{(f)}$	—	34	ns

* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%

VN2410L★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	V
Drain-Gate Voltage	V_{DGR}	60	V
Gate-Source Voltage	V_{GS}	−40	V
Continuous Drain Current	I_D	200	mA
Pulsed Drain Current	I_{DM}	500	mA
Power Dissipation @ T_C = 25°C	P_D	350	mW
Derate above 25°C		2.8	mW/°C
Operating and Storage Temperature	T_J, T_{stg}		°C

THERMAL CHARACTERISTICS

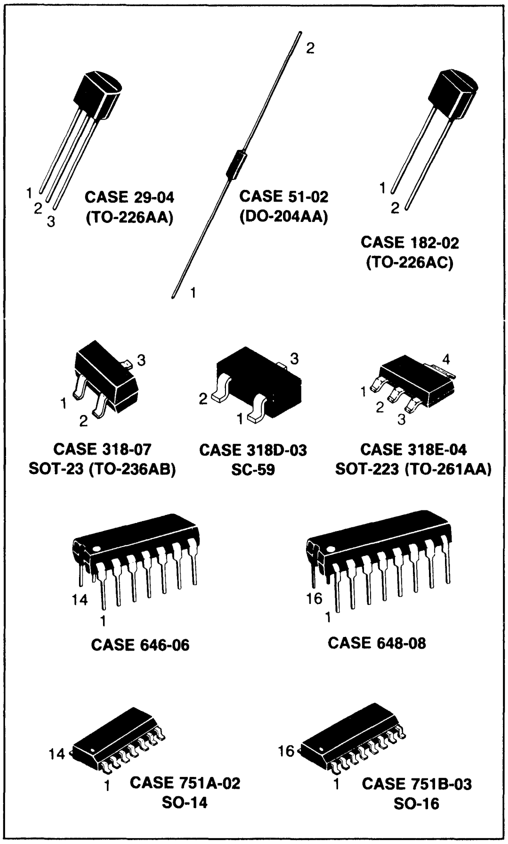
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16″ from case for 10 seconds	T_L	300	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
STATIC CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	240	—	V
Zero Gate Voltage Drain Current	I_{DSS}			μA
(V_{DS} = 120 V, V_{GS} = 0)		—	10	
(V_{DS} = 120 V, V_{GS} = 0, T_A = 125 °C)		—	500	
Gate-Body Leakage (V_{DS} = 0, V_{GS} = ±15 V)	I_{GSS}	—	±100	nA
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.8	2.0	V
On-State Drain Current* (V_{GS} = 10 V, V_{DS} ≥ 2.0 $V_{DS(on)}$)	$I_{D(on)}$	1.0	—	A
Drain-Source On Resistance*	$r_{DS(on)}$			
(V_{GS} = 2.5 V, I_D = 0.1 A)		—	10	Ω
(V_{GS} = 10 V, I_D = 0.5 A)			10	
Forward Transconductance* (V_{DS} = 10 V, I_D = 0.5 A)	g_{fs}	300	—	mS
DYNAMIC CHARACTERISTICS				
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	125	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	50	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	20	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{DD} = 60 V, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω)	$t_{(on)}$	—	8.0	ns
	t_r	—	8.0	ns
Turn-Off Time (V_{DD} = 60 V, I_D = 0.4 A, R_L = 150 Ω, R_G = 25 Ω)	$t_{(off)}$	—	23	ns
	$t_{(f)}$	—	34	ns

* Pulse Test; Pulse width < 300 μs, Duty Cycle ≤ 2%

4



Packaging options include plastic DIPs and surface mount packages. Most SOT-23, SC-59 and SOT-223 package devices are only available in Tape and Reel.

NOTE: All SOT-23 package devices have had a "T1" suffix added to the device title.

Small-Signal Tuning and Switching Diodes

5

EMBOSSED TAPE AND REEL

SOT-23, SC-59, SOT-223, SO-14 and SO-16 packages are available in Tape and Reel. Use the appropriate suffix indicated below to order any of the SOT-23, SC-59, SOT-223, SO-14 and SO-16 packages. (See Section 7 on Packaging for additional information).

SOT-23: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SC-59: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SOT-223: available in 12 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/1000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/4000 unit reel.

SO-14: available in 16 mm Tape and Reel
Add an "R1" suffix to the device title to order the 7 inch/500 unit reel.
Add an "R2" suffix to the device title to order the 13 inch/2500 unit reel.

SO-16: available in 16 mm Tape and Reel
Add an "R1" suffix to the device title to order the 7 inch/500 unit reel.
Add an "R2" suffix to the device title to order the 13 inch/2500 unit reel.

RADIAL TAPE REEL AND AMMO PACK

TO-92 packages are available in both bulk shipments and in Radial Tape Reel and Ammo Packs. Radial Tape Reel and Ammo Pack are the best methods for capturing devices for automatic insertion in printed circuit boards.

TO-92: available in 365 mm Radial Tape Reel
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Radial Tape Reel.

available in Ammo Pack (Fan Fold Box)
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Ammo Pack box.

*Refer to Section 7 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

SOT-23 and SC-59 packages have a device marking and a date code etched on the device. The generic example below depicts both the device marking and a representation of the date code that appears on the SC-59 and SOT-23 packages.

ABCD

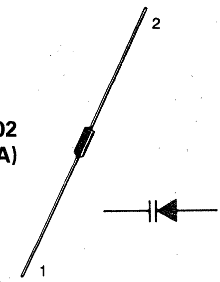
The "D" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

1N5139,A thru 1N5148,A

SILICON EPICAP DIODES

. . . are designed for electronic tuning and harmonic-generation applications, and provide solid-state reliability to replace mechanical tuning methods.

- Guaranteed High-Frequency Q
- Guaranteed Wide Tuning Range
- Guaranteed Temperature Coefficient
- Standard 10% Capacitance Tolerance
- Complete Typical Design Curves



CASE 51-02 (DO-204AA)

6.8–47 pF EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODES

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Volts
Forward Current	I_F	250	mA
RF Power Input*	P_{in}	5.0	Watts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_C	2.0 13.3	Watts mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

*The RF power input rating assumes that an adequate heatsink is provided.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	60	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 55 Vdc, T_A = 25°C) (V_R = 55 Vdc, T_A = 150°C)	I_R	— —	— —	0.02 20	μAdc
Series Inductance (f = 250 MHz, L ≈ 1/16″)	L_S	—	4.0	—	nH
Case Capacitance (f = 1.0 MHz, L ≈ 1/16″)	C_C	—	0.17	—	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	200	—	ppm/°C

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	α V_R = 4.0 Vdc, f = 1.0 MHz		TR, Tuning Ratio C_4/C_{60} f = 1.0 MHz	
Device	**Min**	**Typ**	**Max**	**Min**	**Min**	**Typ**	**Min**	**Typ**
1N5139	6.1	6.8	7.5	350	0.37	0.4	2.7	2.9
1N5139A	6.5	6.8	7.1	350	0.37	0.4	2.7	2.9
1N5140	9.0	10	11	300	0.38	0.41	2.8	3.0
1N5140A	9.5	10	10.5	300	0.38	0.41	2.8	3.0
1N5141	10.8	12	13.2	300	0.38	0.41	2.8	3.0
1N5141A	11.4	12	12.6	300	0.38	0.41	2.8	3.0
1N5142	13.5	15	16.5	250	0.38	0.41	2.8	3.0
1N5142A	14.3	15	15.7	250	0.38	0.41	2.8	3.0
1N5143	16.2	18	19.8	250	0.38	0.41	2.8	3.0
1N5143A	17.1	18	18.9	250	0.38	0.41	2.8	3.0
1N5144	19.8	22	24.2	200	0.43	0.45	3.2	3.4
1N5144A	20.9	22	23.1	200	0.43	0.45	3.2	3.4
1N5145	24.3	27	29.7	200	0.43	0.45	3.2	3.4
1N5145A	25.7	27	28.3	200	0.43	0.45	3.2	3.4
1N5146	29.7	33	36.3	200	0.43	0.45	3.2	3.4
1N5146A	31.4	33	34.6	200	0.43	0.45	3.2	3.4
1N5147	36.1	39	42.9	200	0.43	0.45	3.2	3.4
1N5147A	37.1	39	40.9	200	0.43	0.45	3.2	3.4
1N5148	42.3	47	51.7	200	0.43	0.45	3.2	3.4
1N5148A	44.7	47	49.3	200	0.43	0.45	3.2	3.4

5

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter). L = lead length.

2. C_C, CASE CAPACITANCE
C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO
TR is the ratio of C_T measured at 4.0 Vdc divided by C_T measured at 60 Vdc.

5. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8).

6. α, DIODE CAPACITANCE REVERSE VOLTAGE SLOPE
The diode capacitance, C_T (as measured at V_R = 4.0 Vdc, f = 1.0 MHz) is compared to C_T (as measured at V_R = 60 Vdc, f = 1.0 MHz) by the following equation which defines α.

$$\alpha = \frac{\log C_T(4) - \log C_T(60)}{\log 60 - \log 4}$$

Note that a C_T versus V_R law is assumed as shown in the following equation where C_C is included.

$$C_T = \frac{K}{V\alpha}$$

7. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = −65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \left| \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \right| \cdot \frac{10^6}{C_T(25°C)}$$

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

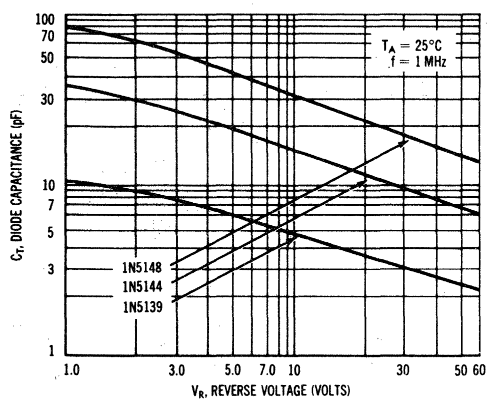


FIGURE 2 — FIGURE OF MERIT versus REVERSE VOLTAGE

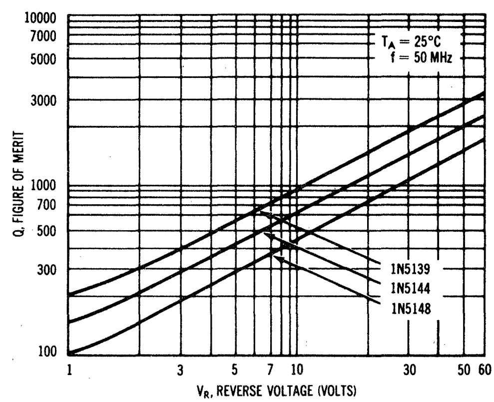


FIGURE 3 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

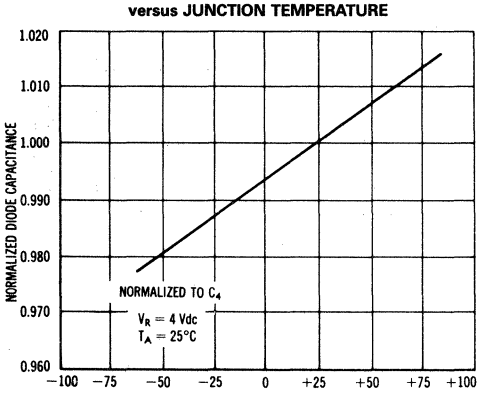


FIGURE 4 — NORMALIZED FIGURE OF MERIT versus JUNCTION TEMPERATURE

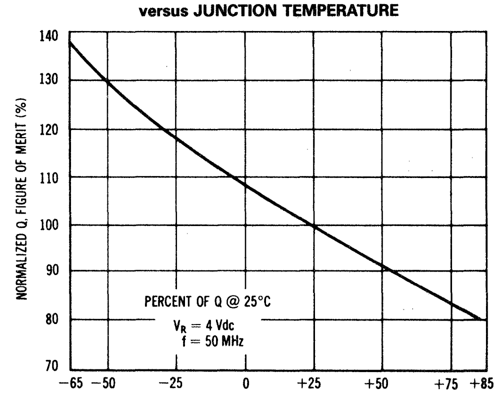


FIGURE 5 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

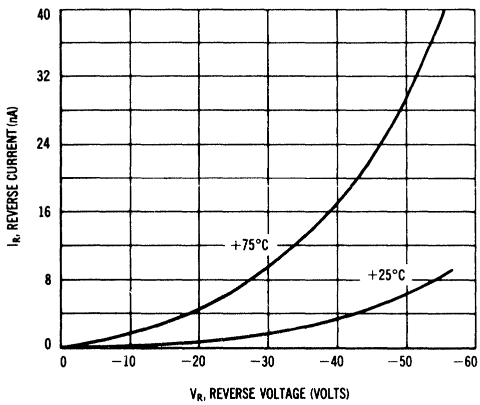
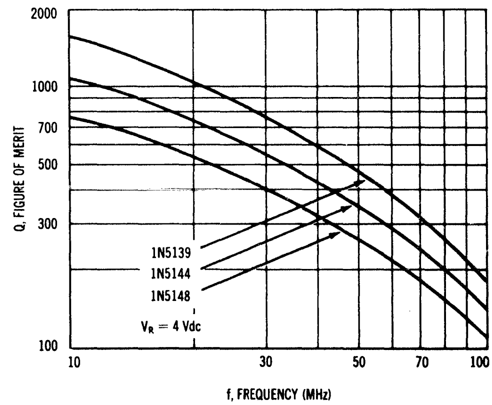


FIGURE 6 — FIGURE OF MERIT versus FREQUENCY



5

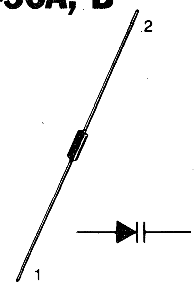
SILICON EPICAP DIODES

. . . epitaxial passivated abrupt junction tuning diodes designed for electronic tuning, FM, AFC and harmonic-generation applications in AM through UHF ranges, providing solid-state reliability to replace mechanical tuning methods.

- Excellent Q Factor at High Frequencies
- Guaranteed Capacitance Change — 2.0 to 30 V
- Guaranteed Temperature Coefficient
- Capacitance Tolerance — 10% and 5.0%
- Complete Typical Design Curves

1N5441A, B thru 1N5456A, B

CASE 51-02 (DO-204AA)



6.8–100 pF
30 VOLTS
VOLTAGE-VARIABLE CAPACITANCE DIODES

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Operating Junction Temperature Range	T_J	+175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C) (V_R = 25 Vdc, T_A = 150°C)	I_R	— —	— —	0.02 20	μAdc
Series Inductance (f = 250 MHz, lead length ≈ 1/16″)	L_S	—	4.0	—	nH
Case Capacitance (f = 1.0 MHz, lead length ≈ 1/16″)	C_C	—	0.17	—	pF
Diode Capacitance Temperature Coefficient (Note 6) (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	300	—	ppm/°C

Device	C_T, Diode Capacitance (1) V_R = 4.0 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz
	Min (Nom −10%)	Nom	Max (Nom +10%)	Min	Max	Min
1N5441A	6.1	6.8	7.5	2.5	3.1	450
1N5443A	9.0	10	11	2.6	3.1	400
1N5444A	10.8	12	13.2	2.6	3.1	400
1N5445A	13.5	15	16.5	2.6	3.1	400
1N5446A	16.2	18	19.8	2.6	3.1	350
1N5448A	19.8	22	24.2	2.6	3.2	350
1N5449A	24.3	27	29.7	2.6	3.2	350
1N5450A	29.7	33	36.3	2.6	3.2	350
1N5451A	35.1	39	42.9	2.6	3.2	300
1N5452A	42.3	47	51.7	2.6	3.2	250
1N5453A	50.4	56	61.6	2.6	3.3	200
1N5455A	73.8	82	90.2	2.7	3.3	175
1N5456A	90	100	110	2.7	3.3	175

(1) To order devices with C_T Nom ±5.0% add Suffix B.
*Indicates JEDEC Registered Data.

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).

2. C_C, CASE CAPACITANCE
C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO
TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

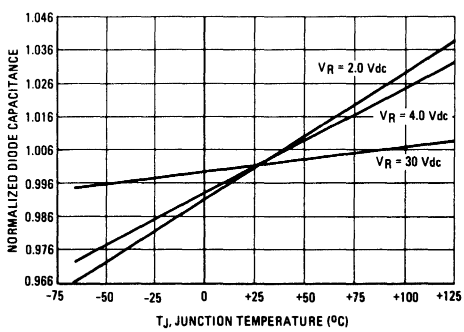
(Boonton Electronics Model 33AS8 or equivalent).

6. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT
TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = −65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation, which defines TC_C:

$$TC_C = \left| \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \right| \cdot \frac{10^6}{C_T(25°C)}$$

Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



TYPICAL DEVICE PERFORMANCE

FIGURE 2 — DIODE CAPACITANCE versus REVERSE VOLTAGE

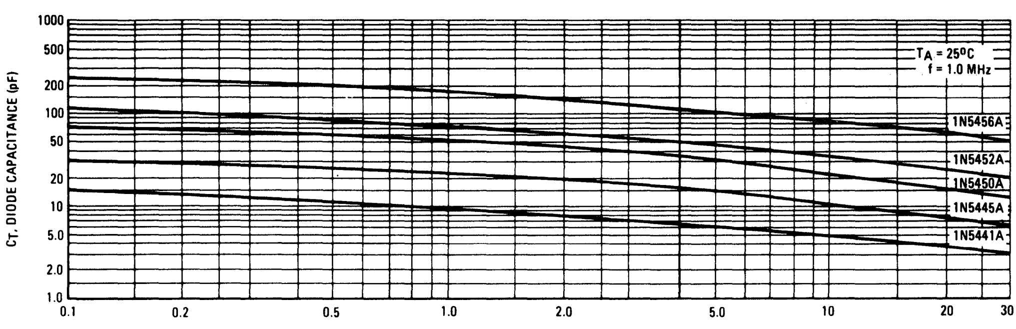


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FIGURE 3 — FIGURE OF MERIT versus REVERSE VOLTAGE

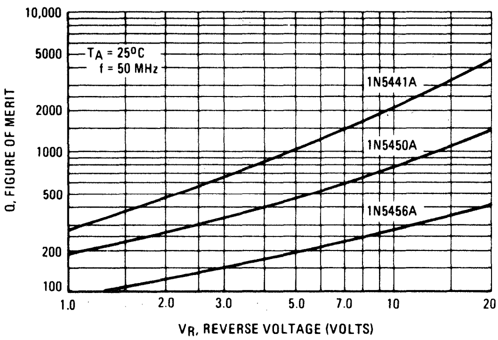


FIGURE 4 — FIGURE OF MERIT versus FREQUENCY

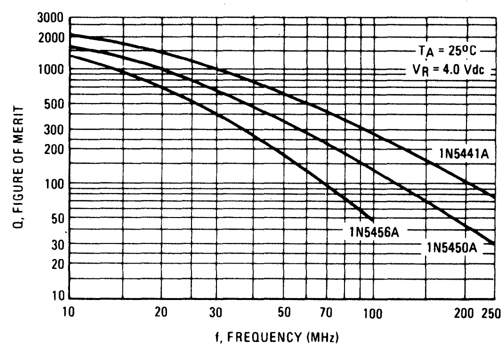


FIGURE 5 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

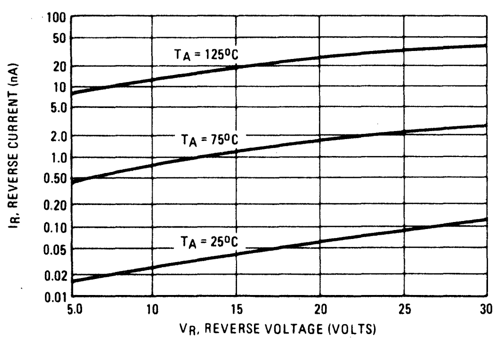
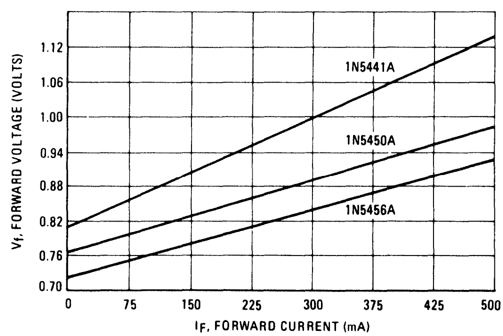


FIGURE 6 — FORWARD VOLTAGE versus FORWARD CURRENT



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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	70	Vdc
Peak Forward Current	I_F	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

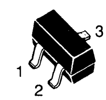
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BAL99LT1 = JF

BAL99LT1★

CASE 318-07, STYLE 18
SOT-23 (TO-236AB)



SWITCHING DIODE

★This is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 70 V) (V_R = 25 V, T_J = 150°C) (V_R = 70 V, T_J = 150°C)	I_R	 — — —	 2.5 30 50	μA
Reverse Breakdown Voltage (I_R = 100 μA)	$V_{(BR)}$	70	—	V
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA) (I_F = 50 mA) (I_F = 150 mA)	V_F	 — — — —	 715 855 1000 1250	mV
Recovery Current (I_F = 10 mA, V_R = 5.0 V, R_L = 500 Ω)	Q_S	—	45	pC
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mA, R_L = 100 Ω, measured at I_R = 1.0 mA)	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V

5

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	75	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

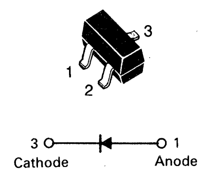
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

BAS16LT1 = A6

BAS16LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



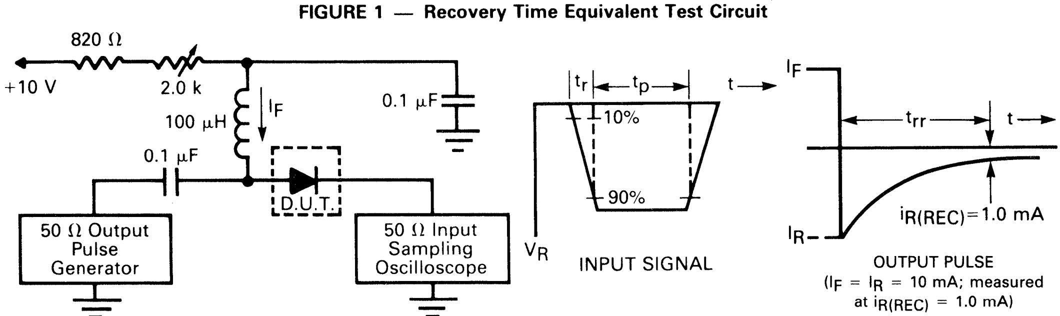
SWITCHING DIODE

★This is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 75 V) (V_R = 75 V, T_J = 150°C) (V_R = 25 V, T_J = 150°C)	I_R	 — — —	 1.0 50 30	μA
Reverse Breakdown Voltage (I_{BR} = 100 μA)	$V_{(BR)}$	75	—	V
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA) (I_F = 50 mA) (I_F = 100 mA)	V_F	 — — — —	 715 855 1000 1250	mV
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V
Reverse Recovery Time (I_F = I_R = 10 mA, R_L = 50 Ω)	t_{rr}	—	6.0	ns
Stored Charge (I_F = 10 mA to V_R = 5.0 V, R_L = 500 Ω)	Q_S	—	45	pC

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	250	Vdc
Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	625	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

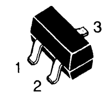
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

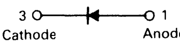
DEVICE MARKING

BAS21LT1 = JS

BAS21LT1★

CASE 318-07, STYLE 8
SOT-23 (TO)-236AB)





SWITCHING DIODE

★This is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 200 V) (V_R = 200 V, T_J = 150°C)	I_R	 — —	 0.1 100	μA
Reverse Breakdown Voltage (I_{BR} = 100 μA)	$V_{(BR)}$	250	—	V
Forward Voltage (I_F = 100 mA) (I_F = 200 mA)	V_F	 — —	 1000 1250	mV
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	5.0	pF
Reverse Recovery Time (I_F = I_R = 30 mA, R_L = 100 Ω)	t_{rr}	—	50	ns

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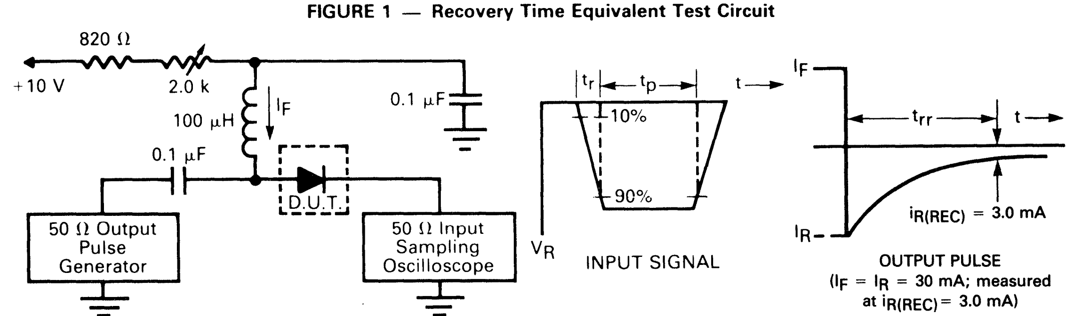
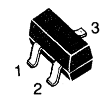
FIGURE 1 — Recovery Time Equivalent Test Circuit

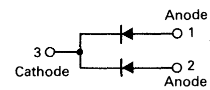


Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 30 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 30 mA.
3. $t_p \gg t_{rr}$

BAV70LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)





SWITCHING DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

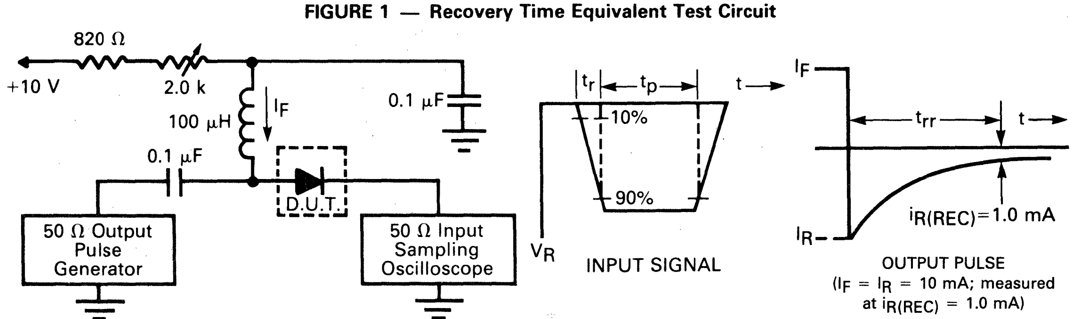
DEVICE MARKING

BAV70LT1 = A4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	>70	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 60 5.0 100	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mA)	V_F	 — — — —	 715 855 1000 1250	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns

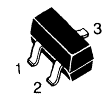
FIGURE 1 — Recovery Time Equivalent Test Circuit

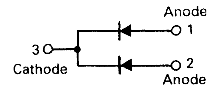


Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. t_p » t_{rr}

BAV74LT1

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)





SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

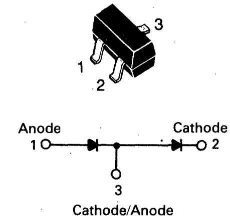
BAV74LT1 = JA

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 5.0 μAdc)	$V_{(BR)}$	50	—	Vdc
Reverse Voltage Leakage Current	I_R			μAdc
(V_R = 50 Vdc, T_J = 125°C)		—	100	
(V_R = 50 Vdc)		—	0.1	
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Voltage (I_F = 100 mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc, measured at I_R = 1.0 mA, R_L = 100 Ω)	t_{rr}	—	4.0	ns

BAV99LT1★

CASE 318-07, STYLE 11
SOT-23 (TO-236AB)



DUAL SERIES SWITCHING DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	150	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

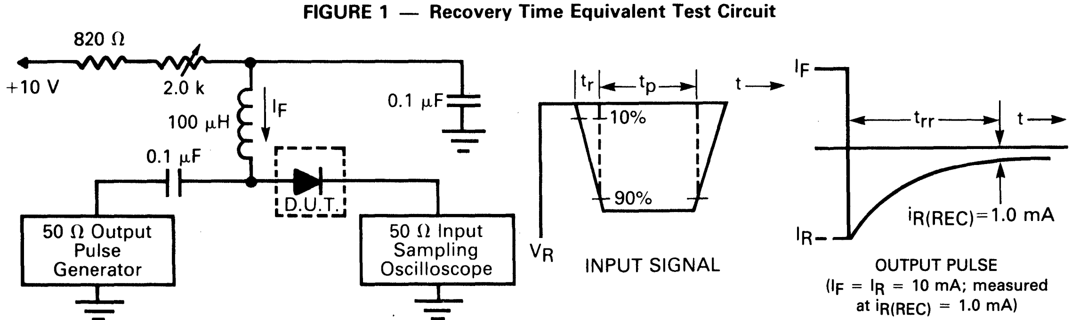
DEVICE MARKING

BAV99LT1 = A7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μA)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 70 Vdc) (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc, T_J = 150°C)	I_R	— — —	2.5 30 50	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 150 mAdc)	V_F	— — — —	715 855 1000 1250	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* $T_A = 25°C$	P_D	225	mW
Derate above 25°C		1.8	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.4	mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

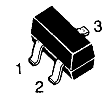
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

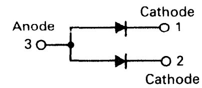
DEVICE MARKING

BAW56LT1 = A1

BAW56LT1★

CASE 318-07, STYLE 12
SOT-23 (TO-236AB)





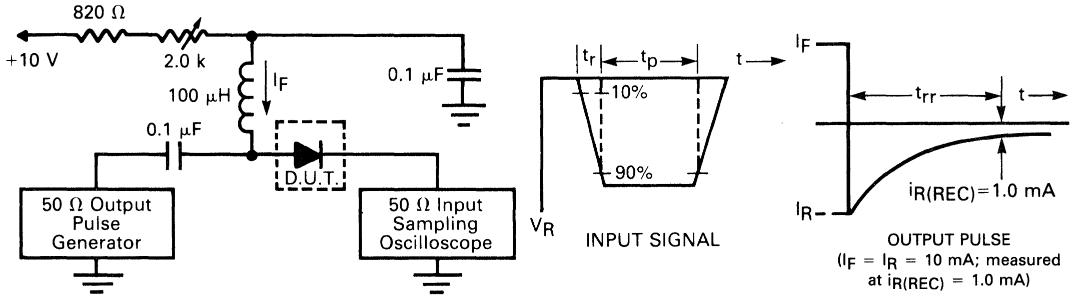
DUAL SWITCHING DIODE

★This is a Motorola designated preferred device.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)} = 100\ \mu Adc$)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current	I_R			μAdc
($V_R = 25$ Vdc, $T_J = 150°C$)		—	30	
($V_R = 70$ Vdc)		—	2.5	
($V_R = 70$ Vdc, $T_J = 150°C$)		—	50	
Diode Capacitance ($V_R = 0$, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Voltage	V_F			mVdc
($I_F = 1.0$ mAdc)		—	715	
($I_F = 10$ mAdc)		—	855	
($I_F = 50$ mAdc)		—	1000	
($I_F = 150$ mA)		—	1250	
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $I_{R(REC)} = 1.0$ mAdc) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p » t_{rr}$

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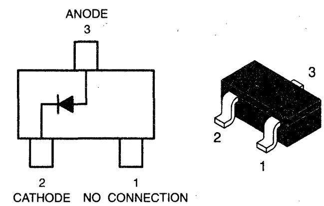
M1MA151AT1★

CASE 318D-03, STYLE 4



SC-59 PACKAGE SINGLE SILICON SWITCHING DIODE SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	40	Vdc
Peak Reverse Voltage	V_{RM}	40	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Current	I_{FM}	225	mAdc
Peak Forward Surge Current	I_{FSM}*	500	mAdc

*t = 1 SEC

THERMAL CHARACTERISTICS

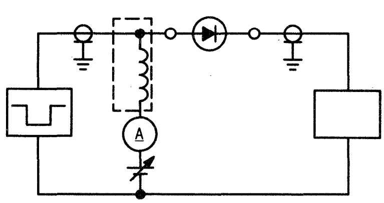
Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

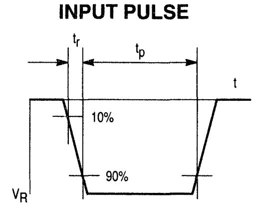
Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	µA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	2	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3	ns

*t_{rr} Test Circuit

RECOVERY TIME EQUIVALENT TEST CIRCUIT

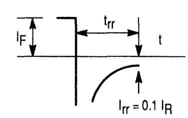


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

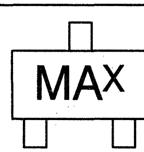
OUTPUT PULSE



I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

Marking Symbol

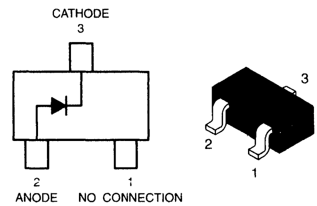


The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

5

M1MA151KT1★

CASE 318D-03, STYLE 2



SC-59 PACKAGE
SINGLE SILICON
SWITCHING DIODE
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	40	Vdc
Peak Reverse Voltage	V_{RM}	40	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Current	I_{FM}	225	mAdc
Peak Forward Surge Current	I_{FSM}*	500	mAdc

*t = 1 SEC

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

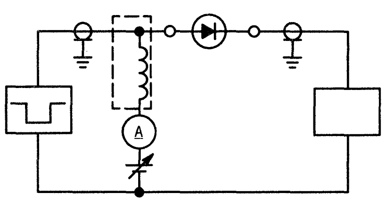
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	µA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	2	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3	ns

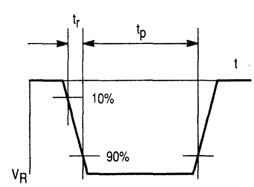
*t_{rr} Test Circuit

5

RECOVERY TIME EQUIVALENT TEST CIRCUIT

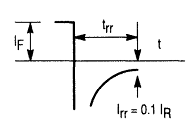


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

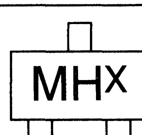
OUTPUT PULSE



I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

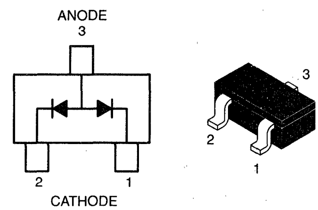
Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

M1MA151WAT1★

CASE 318D-03, STYLE 5



**SC-59 PACKAGE
COMMON ANODE
DUAL SWITCHING DIODE
SURFACE MOUNT**

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	40	Vdc
Peak Reverse Voltage		V_{RM}	40	Vdc
Forward Current	Single	I_F	100	mAdc
	Dual		150	
Peak Forward Current	Single	I_{FM}	225	mAdc
	Dual		340	
Peak Forward Surge Current	Single	I_{FSM}*	500	mAdc
	Dual		750	

*t = 1 SEC

THERMAL CHARACTERISTICS

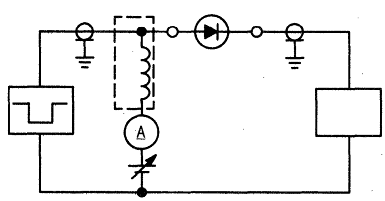
Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

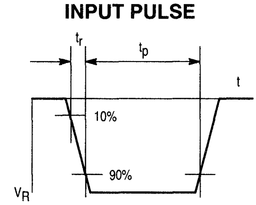
Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	µA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 µA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	15	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	10	ns

*t_{rr} Test Circuit

RECOVERY TIME EQUIVALENT TEST CIRCUIT

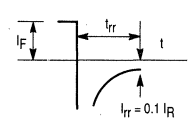


INPUT PULSE



t_p = 2 µs
t_r = 0.35 ns

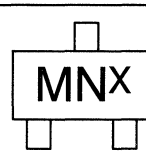
OUTPUT PULSE



I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

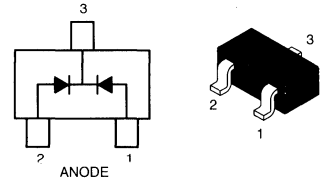
Marking Symbol



The "X" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

M1MA151WKT1★

CASE 318D-03, STYLE 3



**SC-59 PACKAGE
COMMON CATHODE
DUAL SWITCHING DIODE
SURFACE MOUNT**

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (T_A = 25°C)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	40	Vdc
Peak Reverse Voltage		V_{RM}	40	Vdc
Forward Current	Single	I_F	100	mAdc
	Dual		150	
Peak Forward Current	Single	I_{FM}	225	mAdc
	Dual		340	
Peak Forward Surge Current	Single	I_{FSM}*	500	mAdc
	Dual		750	

*t = 1 SEC

THERMAL CHARACTERISTICS

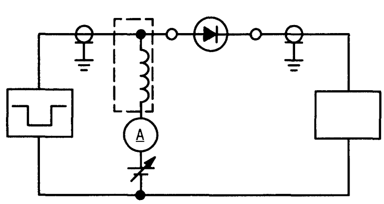
Rating	Symbol	Max	Unit
Power Dissipation	P_D	200	mW
Junction Temperature	T_J	150	°C
Storage Temperature	T_{stg}	–55 ~ + 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

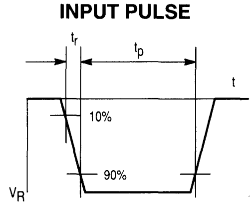
Characteristic	Symbol	Condition	Min	Max	Unit
Reverse Voltage Leakage Current	I_R	V_R = 35 V	—	0.1	μA
Forward Voltage	V_F	I_F = 100 mA	—	1.2	Vdc
Reverse Breakdown Voltage	V_R	I_R = 100 μA	40	—	Vdc
Diode Capacitance	C_D	V_R = 0, f = 1 MHz	—	2	pF
Reverse Recovery Time	t_{rr}*	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, I_{rr} = 0.1 I_R	—	3	ns

*t_{rr} Test Circuit

RECOVERY TIME EQUIVALENT TEST CIRCUIT

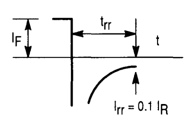


INPUT PULSE



t_p = 2 μs
t_r = 0.35 ns

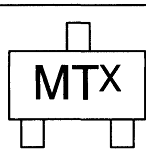
OUTPUT PULSE



I_F = 10 mA
V_R = 6 V
R_L = 100 Ω

DEVICE MARKING

Marking Symbol



The “X” represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

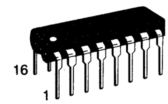
5

MAXIMUM RATINGS (@ 25°C Free-Air Temperature unless otherwise noted.)

Rating	Symbol	MAD130P	MAD1103P	MAD1107P MAD1108P	Unit
Peak Reverse Voltage(1)	V_{RM}	50	50	50	Vdc
Steady-State Reverse Voltage	V_R	25	25	40	Vdc
Peak Forward Current at (or below) 25°C Free-Air Temperature(1)	I_{FM}		500		mA
Continuous Forward Current at (or below) 25°C Free-Air Temperature(2)	I_F		400		mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature(3)	P_D		600		mW
Operating Free-Air Temperature Range	T_A		−65 to +125		°C
Storage Temperature Range	T_{stg}		−65 to +150		°C
Lead Temperature 1/16″ from Case for 10 Seconds			260		°C

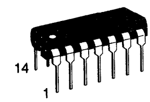
NOTES:
1. These values apply for PW ≤ 100 μs, duty cycle ≤ 20%.
2. Derate linearity to +125°C temperature at rate of 3.2 mA/°C.
3. Derate linearity to +125°C temperature at rate of 6.0 mW/°C.

MAD130P★
MAD1103P★
MAD1107P★
MAD1108P★



MAD1108P
CASE 648-08

MAD130P
MAD1103P, MAD1107P
CASE 646-06



MONOLITHIC DIODE ARRAYS

★These are Motorola designated preferred devices.

5

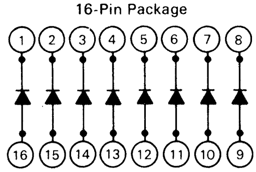
PACKAGE OPTIONS

Device	PLASTIC P Suffix Pin Connection Ref. No.	PLASTIC P Suffix Case	Device	PLASTIC P Suffix Pin Connection Ref. No.	PLASTIC P Suffix Case
MAD130P Dual 10-Diode Array	3	646-06	MAD1107P Dual 8-Diode Array	2	646-06
MAD1103P Dual 8-Diode Array	4	646-06	MAD1108P 8-Diode Array	1	648-08

PIN CONNECTION DIAGRAMS

1

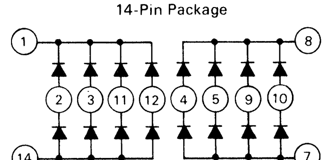
8-Diode Array
16-Pin Package



Case 648

2

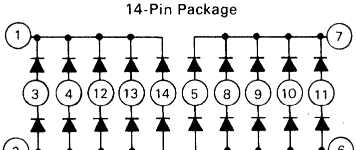
Dual 8-Diode Array
14-Pin Package



*Pins 6, 13 = NC
Case 646

3

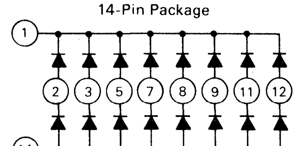
Dual 10-Diode Array
14-Pin Package



Case 646

4

Dual 8-Diode Array
14-Pin Package



*Pins 4, 6, 10, 13 = NC
Case 646

ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic		Symbol	Limit Min	Limit Max	Unit
Reverse Breakdown Voltage(1) (I_R = 10 μA)	MAD130	$V_{(BR)}$	40	—	Vdc
	MAD1103/1107/1108		50	—	
Static Reverse Current (V_R = 40 V)		I_R	—	0.1	μA
			—		
Static Forward Voltage (I_F = 100 mA)		V_F	—	1.1	Vdc
(I_F = 500 mA)(2)			—	1.5	
Peak Forward Voltage(3) (I_F = 500 mA)		V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value		Unit
Forward Recovery Time, Figure 3 (I_F = 500 mA)	t_{fr}	20		ns
Reverse Recovery Time, Figure 2 (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	MAD1108	8.0	ns
		Others	10.0	

NOTES:
1. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
2. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
3. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

5

FIGURE 1 — TYPICAL CHARACTERISTICS STATIC FORWARD VOLTAGE

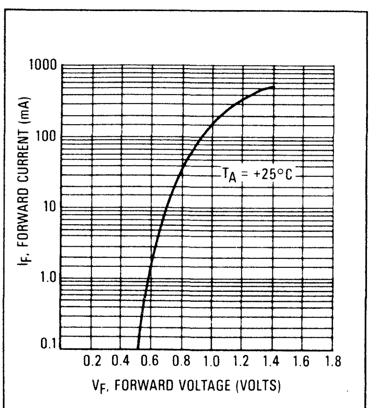


FIGURE 2 — FORWARD RECOVERY TIME AND PEAK FORWARD VOLTAGE TEST CIRCUIT AND WAVEFORMS

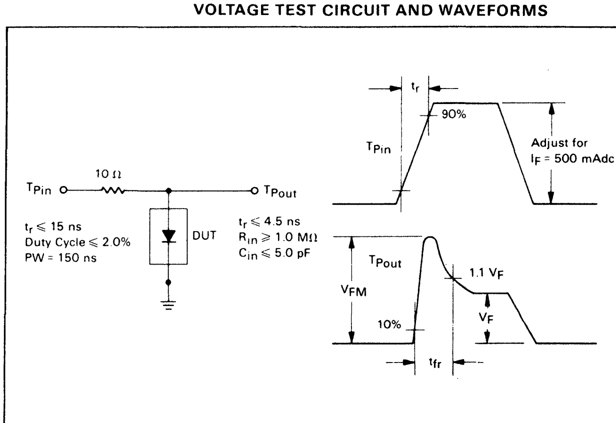
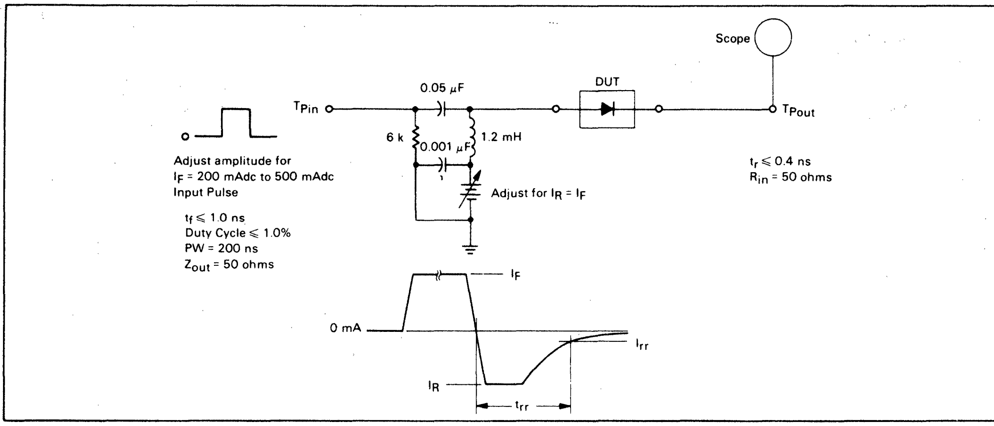


FIGURE 3 — REVERSE RECOVERY TIME TEST CIRCUIT AND WAVEFORMS



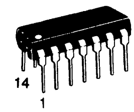
5

MAXIMUM RATINGS (@ 25°C Free-Air Temperature unless otherwise noted.)

Rating	Symbol	Value	Unit
Peak Reverse Voltage(1)	V_{RM}	50	Vdc
Steady-State Reverse Voltage	V_R	40	Vdc
Peak Forward Current at (or below) 25°C Free-Air Temperature(1)	I_{FM}	500	mA
Continuous Forward Current at (or below) 25°C Free-Air Temperature(2)	I_F	400	mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature(3)	P_D	600	mW
Operating Free-Air Temperature Range	T_A	−55 to +125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C
Lead Temperature 1/16″ from Case for 10 Seconds		260	°C

NOTES:
1. These values apply for PW ≤ 100 μs, duty cycle ≤ 20%.
2. Derate linearity to +125°C temperature at rate of 3.2 mA/°C.
3. Derate linearity to +125°C temperature at rate of 6.0 mW/°C.

MAD1109P★

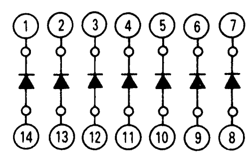


PLASTIC
CASE 646-06
TO-116

MONOLITHIC DIODE ARRAY

★This is a Motorola designated preferred device.

PIN CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Limit Min	Limit Max	Unit
Reverse Breakdown Voltage(4) (I_R = 10 μA)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 V)	I_R	—	0.1	μA
Static Forward Voltage (I_F = 100 mA) (I_F = 500 mA)(5)	V_F	— —	1.1 1.5	Vdc
Peak Forward Voltage(6) (I_F = 500 mA)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value	Unit
Forward Recovery Time, Figure 3 (I_F = 500 mA)	t_{fr}	20	ns
Reverse Recovery Time, Figure 2 (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	8.0	ns

NOTES:
4. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
5. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
6. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

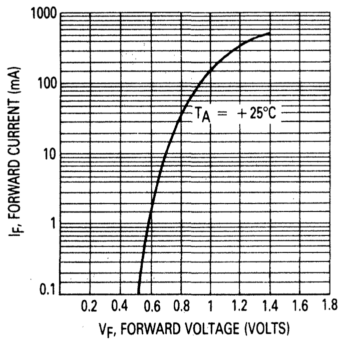


Figure 1. Typical Characteristics Static Forward Voltage

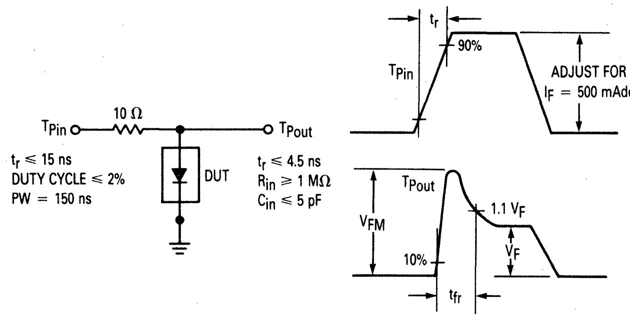


Figure 2. Forward Recovery Time and Peak Forward Voltage Test Circuit and Waveforms

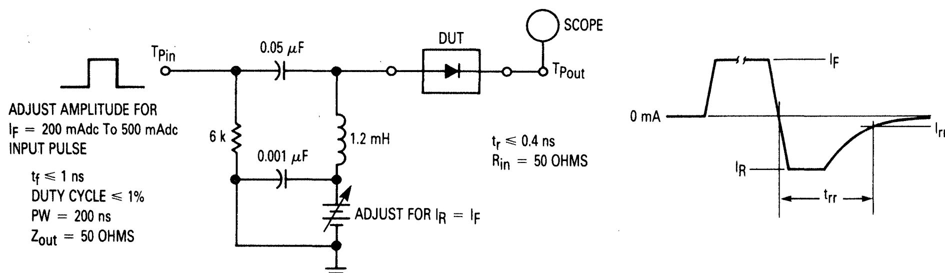


Figure 3. Reverse Recovery Time Test Circuit and Waveforms

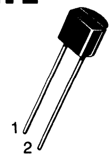
SILICON HOT-CARRIER DIODE
(SCHOTTKY BARRIER DIODE)

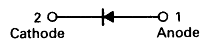
. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in an inexpensive plastic package for low-cost, high-volume consumer requirements. Also available in Surface Mount package.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure — 6.0 dB Typ @ 1.0 GHz
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- High Forward Conductance — 0.5 Volts (Typ) @ I_F = 10 mA

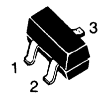
MBD101★
MMBD101LT1★

CASE 182-02, STYLE 1
(TO-226AC)





CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



SILICON HOT-CARRIER
UHF MIXER DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MBD101	MMBD101LT1	Unit
		Value		
Reverse Voltage	V_R	4.0		Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 280 2.8	 200 2.0	 mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBD101LT1 = 4M

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	—	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	—	0.88	1.0	pF
Forward Voltage (1) (I_F = 10 mA)	V_F	—	0.5	0.6	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	—	6.0	—	dB
Reverse Leakage (V_R = 3.0 V)	I_R	—	0.02	0.25	μA

MMBD101LT1 is also available in bulk packaging. Use MMBD101L as the device title to order this device in bulk.

5

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 — REVERSE LEAKAGE

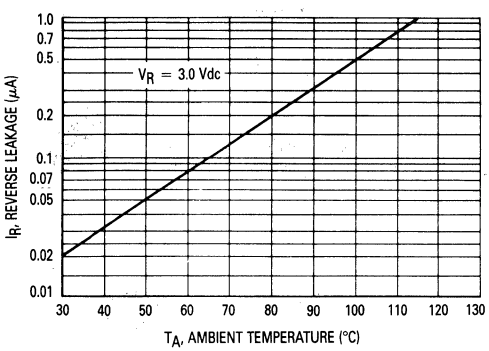


FIGURE 2 — FORWARD VOLTAGE

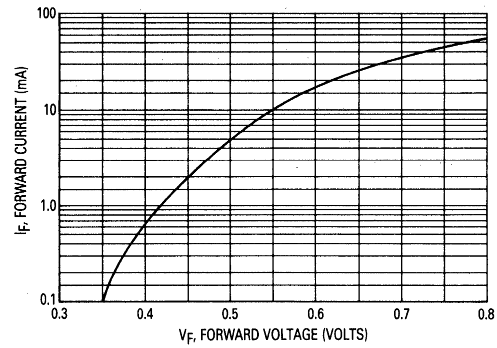


FIGURE 3 — CAPACITANCE

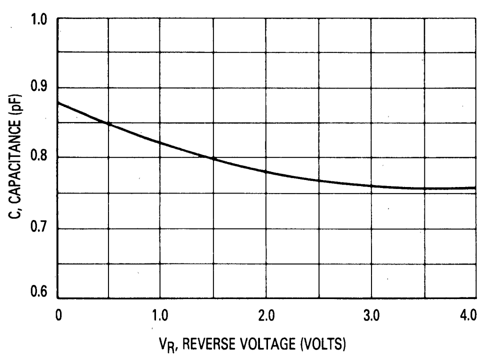


FIGURE 4 — NOISE FIGURE

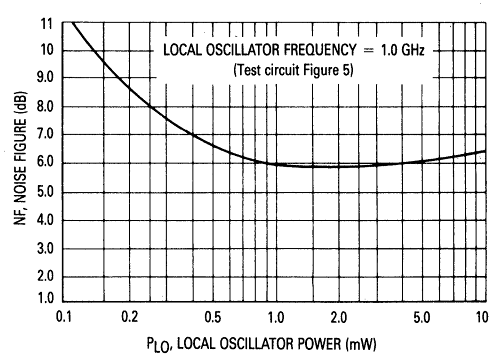
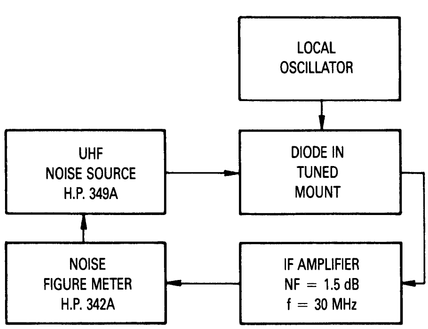


FIGURE 5 — NOISE FIGURE TEST CIRCUIT



NOTES ON TESTING AND SPECIFICATIONS

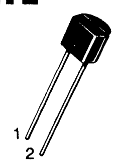
Note 1 — C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 — Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 — L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

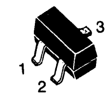
MBD301★
MMBD301LT1★

CASE 182-02, STYLE 1
(TO-226AC)



2 —◄— 1
Cathode Anode

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



3 —◄— 1
Cathode Anode

30 VOLTS
SILICON HOT-CARRIER
DETECTOR AND SWITCHING
DIODES

★These are Motorola designated preferred devices.

SILICON HOT-CARRIER DIODE
(SCHOTTKY BARRIER DIODE)

. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in an inexpensive plastic package for low-cost, high-volume consumer and industrial/commercial requirements. Also available in Surface Mount package.

- The Schottky Barrier Construction Provides Ultra-Stable Characteristics By Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime — 15 ps (Typ)
- Very Low Capacitance — 1.5 pF (Max) @ V_R = 15 V
- Low Reverse Leakage — I_R = 13 nAdc (Typ) MBD301, MMBD301

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value: MBD301	Value: MMBD301LT1	Unit
Reverse Voltage	V_R	30		Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	 280 2.8	 200 2.0	 mW mW/°C
Operating Junction Temperature Range	T_J	−55 to +125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBD301LT1 = 4T

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	30	—	—	Volts
Total Capacitance, Figure 1 (V_R = 15 Volts, f = 1.0 MHz)	C_T	—	0.9	1.5	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)	τ	—	15	—	ps
Reverse Leakage, Figure 3 (V_R = 25 V)	I_R	—	13	200	nAdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)	V_F	—	0.5	0.6	Vdc

MMBD301LT1 is also available in bulk packaging. Use MMBD301L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — TOTAL CAPACITANCE

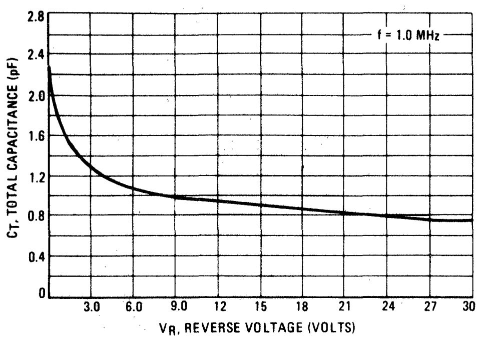


FIGURE 2 — MINORITY CARRIER LIFETIME

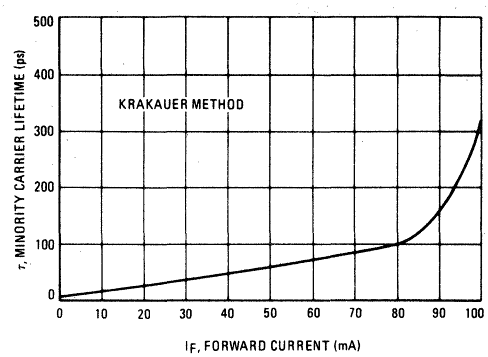


FIGURE 3 — REVERSE LEAKAGE

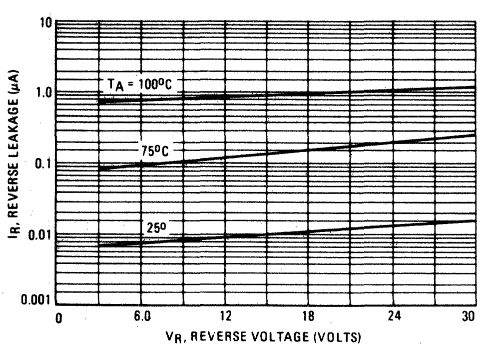
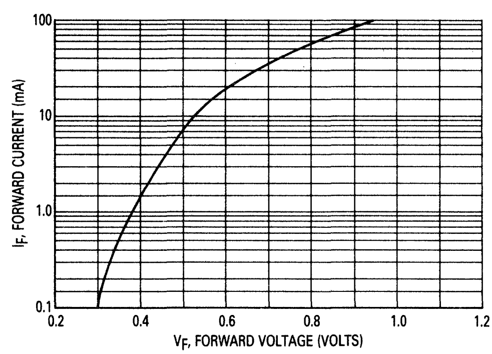
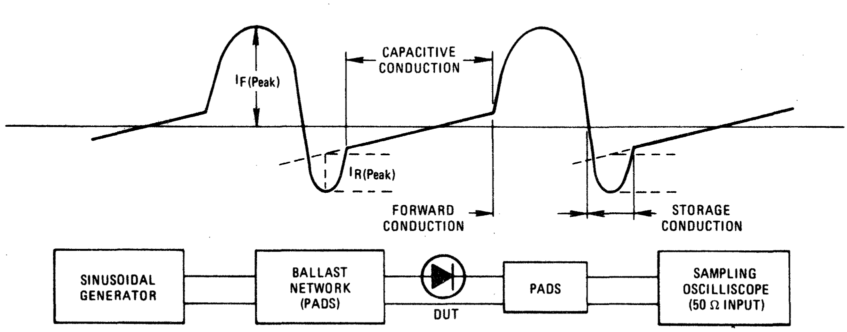


FIGURE 4 — FORWARD VOLTAGE



KRAKAUER METHOD OF MEASURING LIFETIME



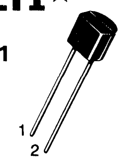
SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

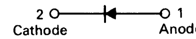
. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in an inexpensive plastic package for low-cost, high-volume consumer and industrial/commercial requirements. Also available in Surface Mount package.

- The Schottky Barrier Construction Provides Ultra-Stable Characteristics by Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime — 15 ps (Typ)
- Very Low Capacitance — 1.0 pF @ V_R = 20 V
- High Reverse Voltage — to 70 Volts
- Low Reverse Leakage — 200 nA (Max)

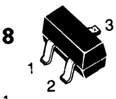
MBD701★
MMBD701LT1★

CASE 182-02, STYLE 1
(TO-226AC)





CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



70 VOLTS HIGH-VOLTAGE SILICON HOT-CARRIER DETECTOR AND SWITCHING DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

		MBD701	MMBD701LT1	
Rating	**Symbol**	**Value**		**Unit**
Reverse Voltage MBD701	V_R	70		Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	280 2.8	200 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	−55 to +125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBD701LT1 = 5H

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	70	—	—	Volts
Total Capacitance, Figure 1 (V_R = 20 Volts, f = 1.0 MHz)	C_T	—	0.5	1.0	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)	τ	—	15	—	ps
Reverse Leakage, Figure 3 (V_R = 35 V)	I_R	—	9.0	200	nAdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)	V_F	—	1.0	1.2	Vdc

MMBD701LT1 is also available in bulk packaging. Use MMBD701L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — TOTAL CAPACITANCE

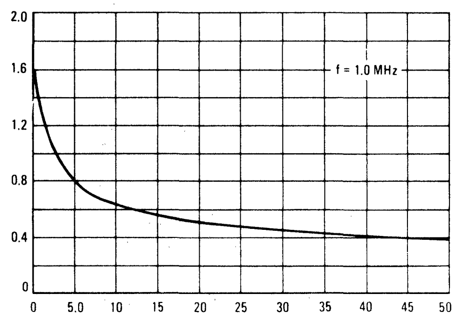


FIGURE 2 — MINORITY CARRIER LIFETIME

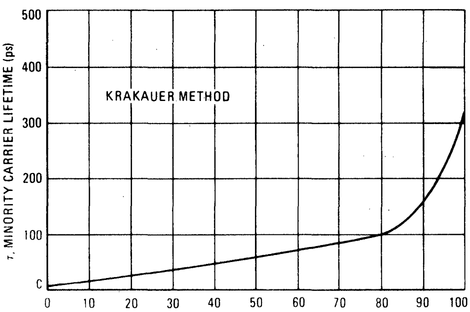


FIGURE 3 — REVERSE LEAKAGE

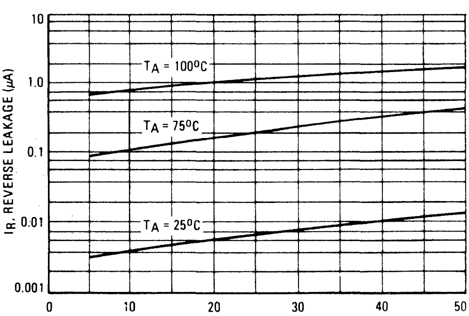
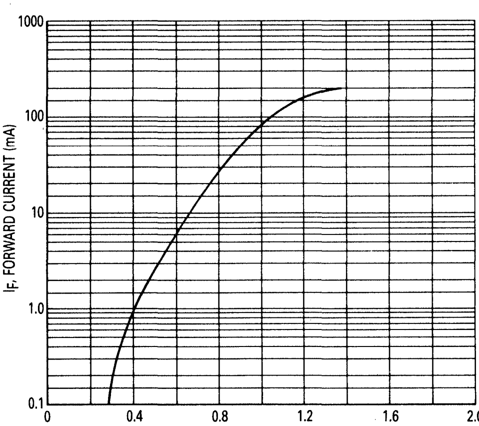
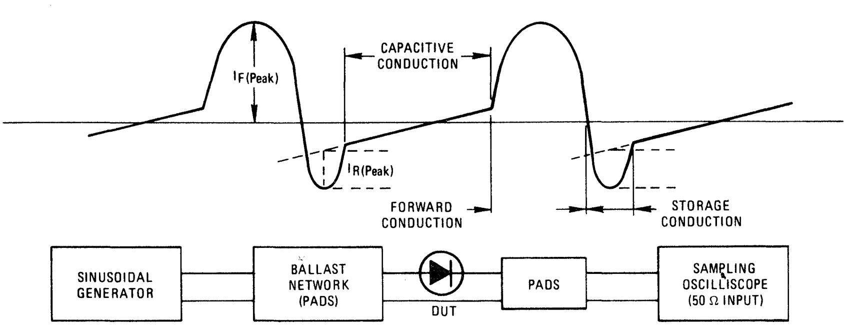


FIGURE 4 — FORWARD VOLTAGE



KRAKAUER METHOD OF MEASURING LIFETIME



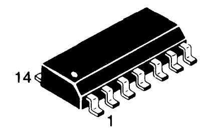
SURFACE MOUNT DIODE ARRAYS

These diode arrays are multiple diode junctions fabricated by a planar process and mounted in integrated circuit packages for use in high-current, fast-switching core-driver applications. These arrays offer many of the advantages of integrated circuits such as high-density packaging and improved reliability. These advantages result from such factors as fewer glass-to-metal seals.

- Designed for Use in Computers and Peripheral Equipment
- Applications Include:
  - Magnetic Cores
  - Thin-Film Memories
  - Plated-Wire Memories
  - Decoding or Encoding Applications

MMAD130
MMAD1103
thru
MMAD1107
MMAD1109★

CASE 751A-02
SO-14



MONOLITHIC DIODE ARRAYS

★**MMAD130, MMAD1103, MMAD1107 and MMAD1109 are Motorola designated preferred devices.**

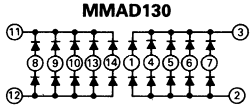
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Voltage	V_{RM}	50	Vdc
Steady-State Reverse Voltage	V_R	40	Vdc
Peak Forward Current 25°C	I_{FM}	500	mA
Continuous Forward Current	I_F	400	mA
Power Dissipation Derating Factor	P_D	500 4.0	mW mW/°C
Operating Temperature	T_A	−65 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

SO-14 Pin Diagram

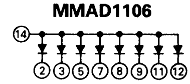
1. Dual 10 Diode Array

MMAD130



5. 8 Diode Array (Common Anode)

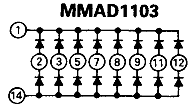
MMAD1106



NC Pin 1, 4, 6, 10, 13

2. 16 Diode Array

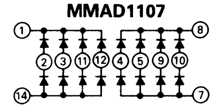
MMAD1103



NC Pin 4, 6, 10, 13

6. Dual 8 Diode Array

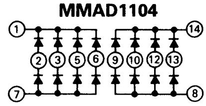
MMAD1107



NC Pin 6, 13

3. Dual 8 Diode Array

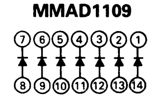
MMAD1104



NC Pin 4, 11

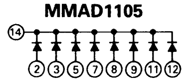
7. 7 Diode Array (Independant)

MMAD1109



4. 8 Diode Array (Common Cathode)

MMAD1105



NC Pin 1, 4, 6, 10, 13

Device	Description	Diagram
MMAD130	Dual 10 Diode Array	1
MMAD1103	16 Diode Array	2
MMAD1104	Dual 8 Diode Array	3
MMAD1105	8 Diode Array Common Cathode	4
MMAD1106	8 Diode Array Common Anode	5
MMAD1107	Dual 8 Diode Array	6
MMAD1109	7 Diode Array	7

5

ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Limit		Unit
		Min	Max	
Reverse Breakdown Voltage (1) (I_R = 10 μA)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 V)	I_R	—	0.1	μA
Static Forward Voltage (I_F = 100 mA) (I_F = 500 mA) (2)	V_F	— —	1.1 1.5	Vdc
Peak Forward Voltage (3) (I_F = 500 mA)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value	Unit
Forward Recovery Time (I_F = 500 mA)	t_{fr}	20	ns
Reverse Recovery Time (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	8.0	ns

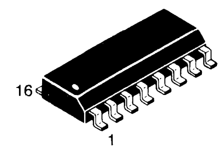
1. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
2. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
3. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

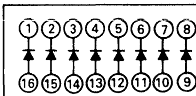
5

SURFACE MOUNT ISOLATED 8-DIODE ARRAY

MMAD1108★

CASE 751B-03
SO-16





Pin Connections Diagram

MONOLITHIC DIODE ARRAY

★This is a Motorola designated preferred device.

This diode array is a multiple diode junction fabricated by a planar process and mounted in integrated circuit packages for use in high-current, fast-switching core-driver applications. This array offers the advantages of an integrated circuit with high-density packaging and improved reliability. This advantage results from such factors as fewer connections, more uniform device parameters, smaller size, less weight and fewer glass-to-metal seals.

- Designed for use in Computers and Peripheral Equipment
- Applications Include:
  - Magnetic Cores
  - Thin-Film Memories
  - Plated-Wire Memories
  - Decoding or Encoding

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Voltage	V_{RM}	50	Vdc
Steady-State Reverse Voltage	V_R	40	Vdc
Peak Forward Current 25°C	I_{FM}	500	mA
Continuous Forward Current	I_F	400	mA
Power Dissipation Derating Factor	P_D	500 4.0	mW mW/°C
Operating Temperature	T_A	−65 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Limit		Unit
		Min	Max	
Reverse Breakdown Voltage (1) (I_R = 10 μA)	$V_{(BR)}$	50	—	Vdc
Static Reverse Current (V_R = 40 V)	I_R	—	0.1	μA
Static Forward Voltage (I_F = 100 mA) (I_F = 500 mA) (2)	V_F	 — —	 1.1 1.5	Vdc
Peak Forward Voltage (3) (I_F = 500 mA)	V_{FM}	—	5.0	Vdc

SWITCHING CHARACTERISTICS (@ 25°C Free-Air Temperature)

Characteristic	Symbol	Typical Value	Unit
Forward Recovery Time (I_F = 500 mA)	t_{fr}	20	ns
Reverse Recovery Time (I_F = 200 mA, I_{RM} = 200 mA, R_L = 100 Ω, i_{rr} = 20 mA)	t_{rr}	8.0	ns

1. This parameter must be measured using pulse techniques. PW = 100 μs, duty cycle ≤ 20%.
2. This parameter is measured using pulse techniques. PW = 300 μs, duty cycle ≤ 2.0%. Read time is 90 μs from the leading edge of the pulse.
3. The initial instantaneous value is measured using pulse techniques. PW = 150 ns, duty cycle ≤ 2.0%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

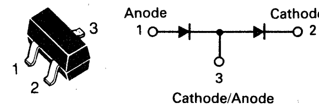
DUAL SILICON HOT-CARRIER DIODES (SCHOTTKY BARRIER DIODES)

. . . designed primarily for UHF mixer applications. but suitable also for use in detector and ultra-fast switching circuits.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- Low Forward Voltage — 0.5 Volts (Typ) @ I_F = 10 mA

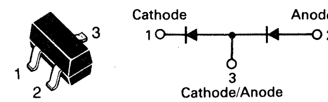
MMBD352LT1★

CASE 318-07, STYLE 11
SOT-23 (TO-236AB)



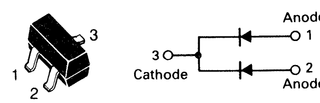
MMBD353LT1★

CASE 318-07, STYLE 19
SOT-23 (TO-236AB)



MMBD354LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)



DUAL HOT CARRIER MIXER DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	4.0	V_{CC}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +125	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBD352LT1 = M5G; MMBD353LT1 = M4F; MMBD354LT1 = M6H

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.) (EACH DIODE)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Forward Voltage (I_F = 10 mA)	V_F	—	0.60	V
Reverse Voltage Leakage Current (V_R = 3.0 V) (V_R = 4.0 V)	I_R	 — —	 0.25 10	μA
Capacitance (V_R = 0 V, f = 1.0 MHz)	C	—	1.0	pF

MMBD352LT1, MMBD353LT1 and MMBD354LT1 are also available in bulk packaging. Use MMBD352L, MMBD353L or MMBD354L as the device title when ordering these devices in bulk.

FIGURE 1 — FORWARD VOLTAGE

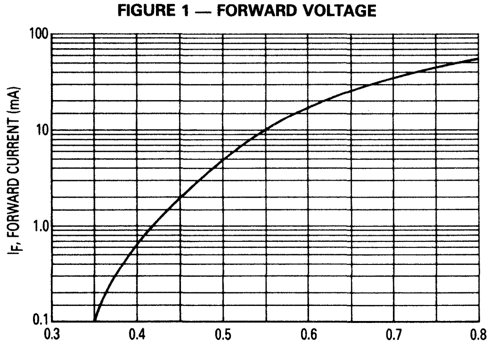
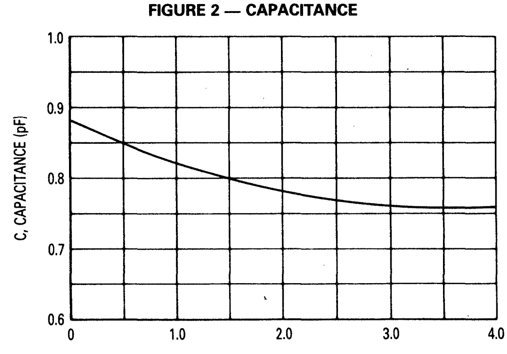
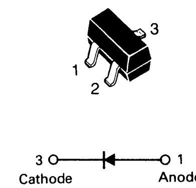


FIGURE 2 — CAPACITANCE



MMBD914LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



HIGH-SPEED SWITCHING DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBD914LT1 = 5D

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_R = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current (V_R = 20 Vdc) (V_R = 75 Vdc)	I_R	 — —	 25 5.0	 nAdc μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	4.0	pF
Forward Voltage (I_F = 10 mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	4.0	ns

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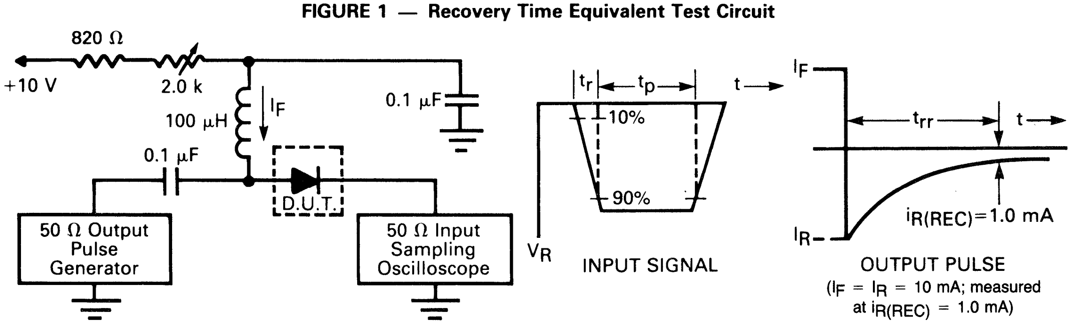
FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. t_p » t_{rr}

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Reverse Voltage	MMBD2836LT1 MMBD2835LT1	V_R	75 35	Vdc
Forward Current		I_F	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

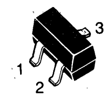
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

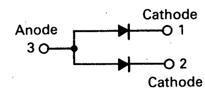
DEVICE MARKING

MMBD2835LT1 = A3; MMBD2836LT1 = A2

MMBD2835LT1
MMBD2836LT1

CASE 318-07, STYLE 12
SOT-23 (TO-236AB)



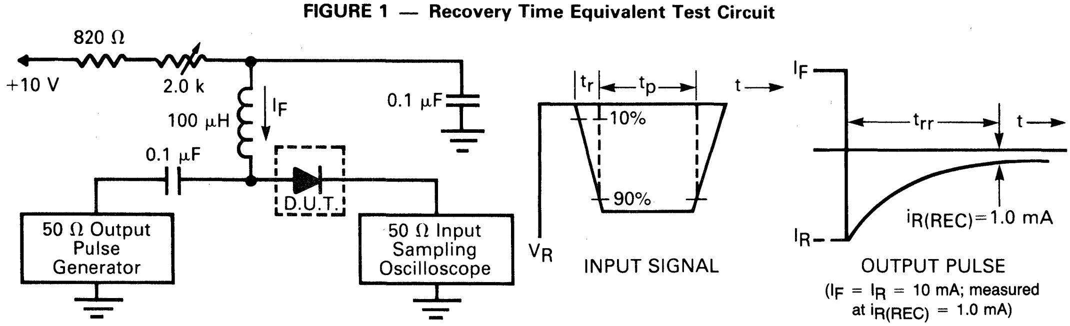


DUAL SWITCHING DIODES

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 100 μAdc)	MMBD2835LT1 MMBD2836LT1	$V_{(BR)}$	35 75	— —	Vdc
Reverse Voltage Leakage Current (V_R = 30 Vdc) (V_R = 50 Vdc)	MMBD2835LT1 MMBD2836LT1	I_R	— —	100 100	nAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)		C_T	—	4.0	pF
Forward Voltage (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)		V_F	— — —	1.0 1.0 1.2	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)		t_{rr}	—	4.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

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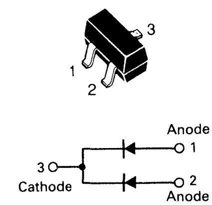
MMBD2837LT1
MMBD2838LT1

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)



DUAL SWITCHING DIODES

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Peak Reverse Voltage		V_{RM}	75	Vdc
D.C. Reverse Voltage	MMBD2837LT1 MMBD2838LT1	V_R	30 50	Vdc
Peak Forward Current		I_{FM}	450 300	mAdc
Average Rectified Current		I_O	150 100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

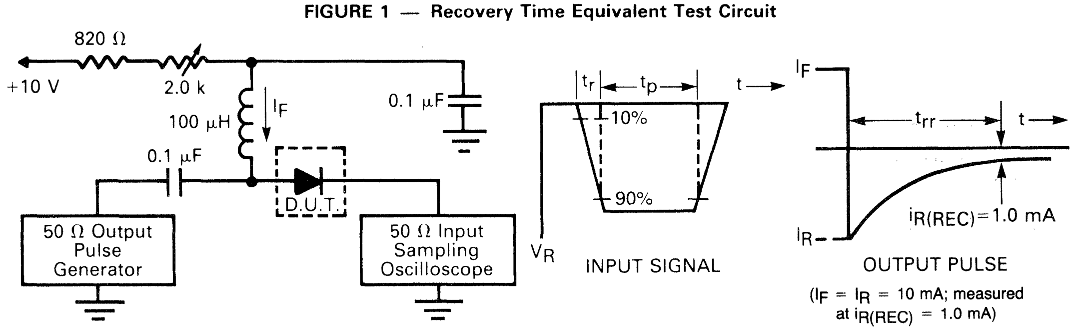
DEVICE MARKING

MMBD2837LT1 = A5; MMBD2838LT1 = A6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	 MMBD2837LT1 MMBD2838LT1	$V_{(BR)}$	 35 75	 — —	Vdc
Reverse Voltage Leakage Current (V_R = 30 Vdc) (V_R = 50 Vdc)	 MMBD2837LT1 MMBD2838LT1	I_R	 — —	 0.1 0.1	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)		C_T	—	4.0	pF
Forward Voltage (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)		V_F	 — — —	 1.0 1.0 1.2	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)		t_{rr}	—	4.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

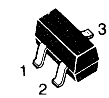
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBD6050LT1 = 5A

MMBD6050LT1

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



SWITCHING DIODE

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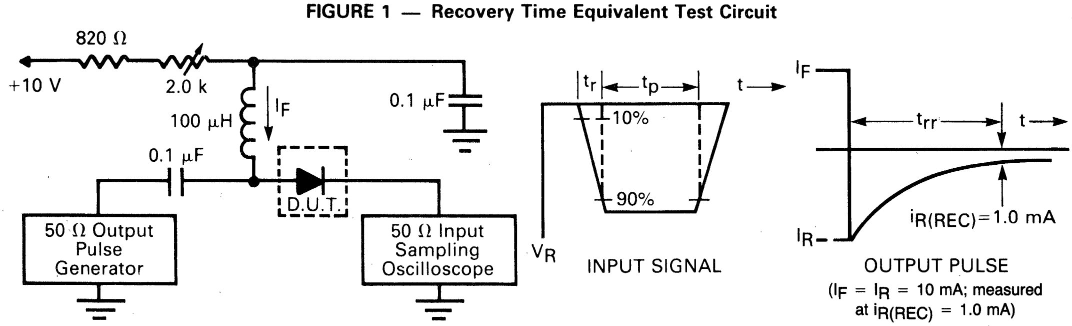
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.85	 0.7 1.1	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	4.0	ns
Capacitance (V_R = 0)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

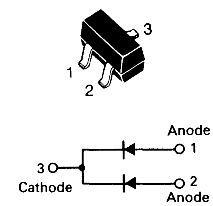
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBD6100LT1 = 5BM

MMBD6100LT1

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)

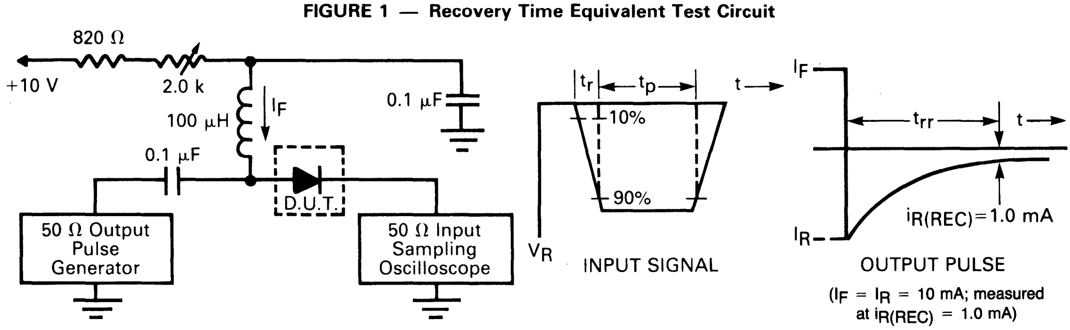


DUAL SWITCHING DIODE

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.85	 0.7 1.1	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	4.0	ns
Capacitance (V_R = 0)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. t_p » t_{rr}

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation FR-5 Board,* T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	556	°C/W
Total Device Dissipation Alumina Substrate,** T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	417	°C/W
Junction and Storage Temperature	T_J, T_{stg}	−55 to +150	°C

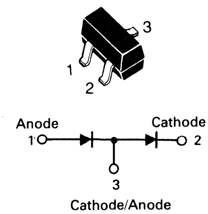
*FR-5 = 1.0 x 0.75 x 0.062 in.
**Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.

DEVICE MARKING

MMBD7000LT1 = M5C

MMBD7000LT1★

CASE 318-07, STYLE 11
SOT-23 (TO-236AB)



DUAL SWITCHING DIODE

★This is a Motorola designated preferred device.

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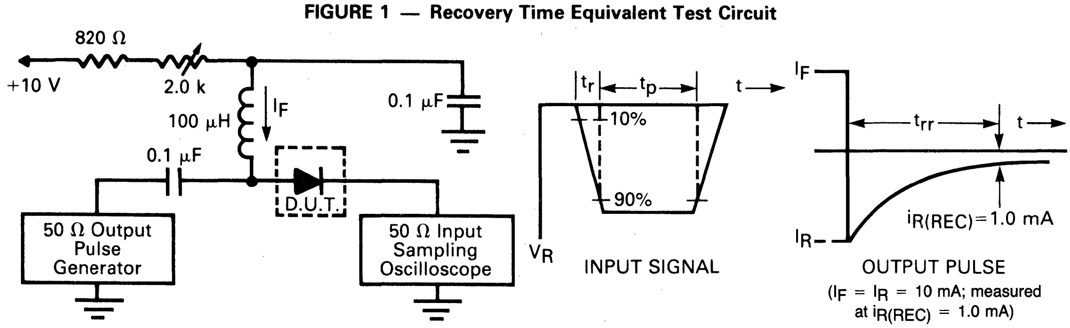
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current				μAdc
(V_R = 50 Vdc)	I_R	—	0.30	
(V_R = 100 Vdc)	I_{R2}	—	0.5	
(V_R = 50 Vdc, 125°C)	I_{R3}	—	100	
Forward Voltage	V_F			Vdc
(I_F = 1.0 mAdc)		0.55	0.7	
(I_F = 10 mAdc)		0.67	0.82	
(I_F = 100 mAdc)		0.75	1.1	
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	4.0	ns
Capacitance (V_R = 0)	C	—	1.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

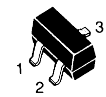
SILICON EPICAP DIODE

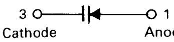
. . . designed in the Surface Mount package for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Controlled and Uniform Tuning Ratio

MMBV105GLT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





30 VOLT
VOLTAGE VARIABLE
CAPACITANCE DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

DEVICE MARKING

MMBV105GLT1 = M4E

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	Vdc
Reverse Voltage Leakage Current (VR = 28 V)	I_R	—	50	nAdc

Device Type	C_T V_R = 25 Vdc pF		Q f = 100 MHz V_R = 3.0 V	C_3/C_{25}	
	Min	Max	Typ	Min	Max
MMBV105GLT1	1.8	2.8	150	4.0	6.0

MMBV105GLT1 is also available in bulk packaging. Use MMBV105GL as the device title to order this device in bulk.

FIGURE 1 — DIODE CAPACITANCE

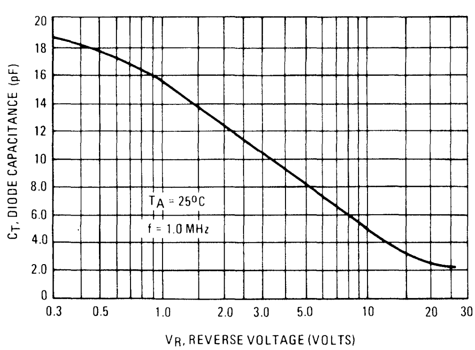


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FIGURE 2 — FIGURE OF MERIT

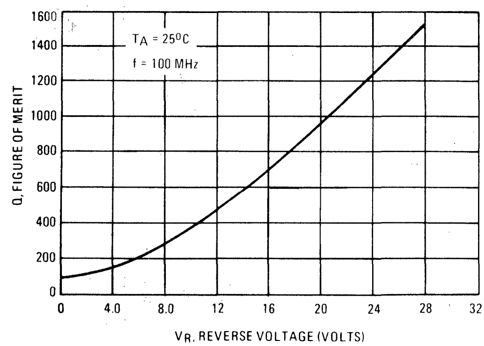
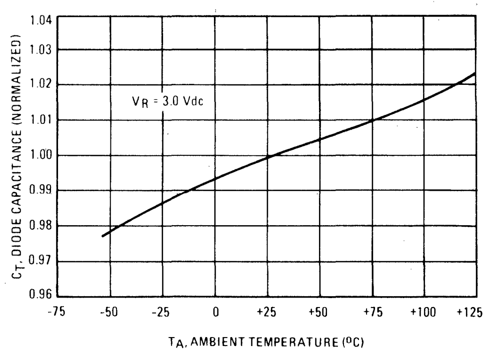


FIGURE 3 — DIODE CAPACITANCE



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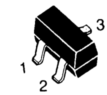
SILICON EPICAP DIODES

. . . designed for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

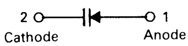
- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package

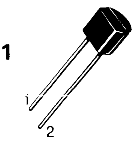
MMBV109LT1★
MV209★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



CASE 182-02, STYLE 1
(TO-226AC)





26–32 pF
VOLTAGE VARIABLE
CAPACITANCE DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	Value MV209	Value MMBV109LT1	Unit
Reverse Voltage	V_R	30		Volts
Forward Current	I_F	200		mA
Forward Power Dissipation @ T_A = 25°C	P_D	280	200	mW
Derate above 25°C		2.8	2.0	mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV109LT1 = M4A

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	—	300	—	ppm/°C

	C_t, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz (Note 1)	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz (Note 2)	
Device	Min	Nom	Max	Min	Min	Max
MMBV109LT1, MV209	26	29	32	200	5.0	6.5

MMBV109LT1 is also available in bulk packaging. Use MMBV109L as the device title to order this device in bulk.

FIGURE 1 — DIODE CAPACITANCE

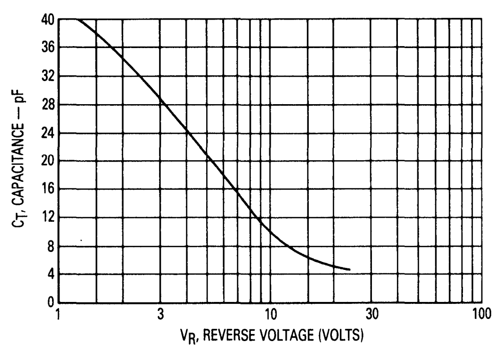


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FIGURE 2 — FIGURE OF MERIT

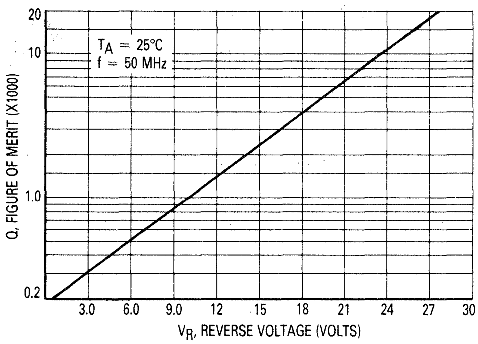


FIGURE 3 — LEAKAGE CURRENT

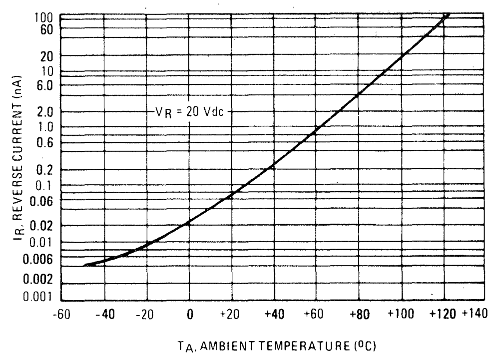
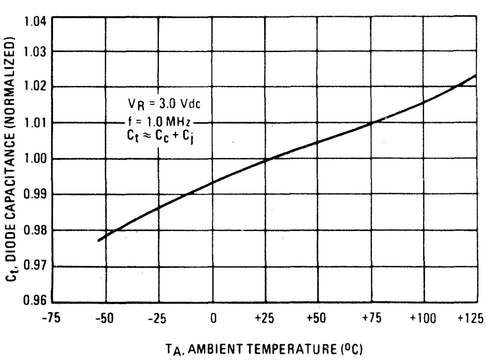


FIGURE 4 — DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

2. C_R is the ratio of C_t measured at 3.0 Vdc divided by C_t measured at 25 Vdc.

5

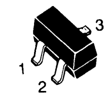
SILICON EPICAP DIODES

. . . designed for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package

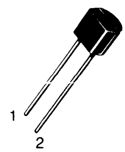
MMBV409LT1★
MV409★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)



3 —|◄— 1
Cathode Anode

CASE 182-02, STYLE 1
TO-92 (TO-226AC)



2 —|◄— 1
Cathode Anode

VOLTAGE VARIABLE CAPACITANCE DIODES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MV409	MMBV409LT1	Unit
		Value		
Reverse Voltage	V_R	20		Volts
Forward Current	I_F	200		mA
Forward Power Dissipation @ T_A = 25°C	P_D	280	200	mW
Derate above 25°C		2.8	2.0	mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV409LT1 = X5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic — All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 3 Vdc, f = 1 MHz)	TC_C	—	300	—	ppm/°C

Device	C_t, Diode Capacitance V_R = 3 Vdc, f = 1 MHz pF Min	Nom	Max	Q, Figure of Merit V_R = 3 Vdc f = 50 MHz (Note 1) Min	C_R, Capacitance Ratio C_3/C_8 f = 1 MHz (Note 2) Min	Max
MMBV409LT1, MV409	26	29	32	200	1.5	1.9

NOTES ON TESTING AND SPECIFICATIONS

(1) Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

(2) C_R is the ratio of C_t measured at 3 Vdc divided by C_t measured at 8 Vdc.

MMBV409LT1 is also available in bulk packaging. Use MMBV409LT1 as the device title to order this device in bulk.

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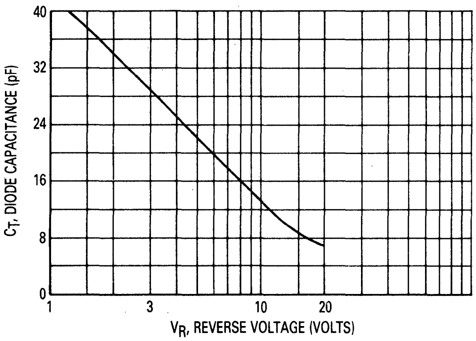


Figure 1. Diode Capacitance

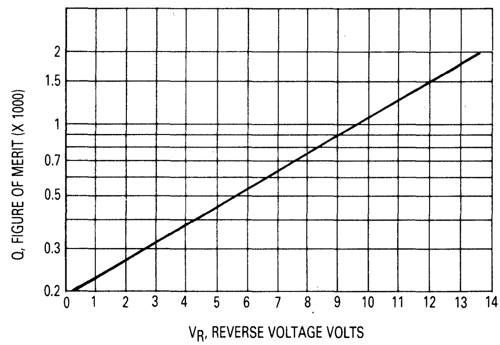


Figure 2. Figure of Merit

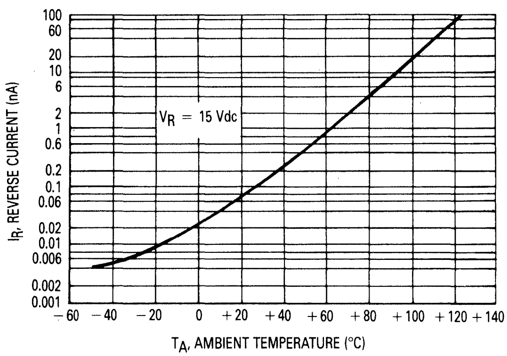


Figure 3. Leakage Current

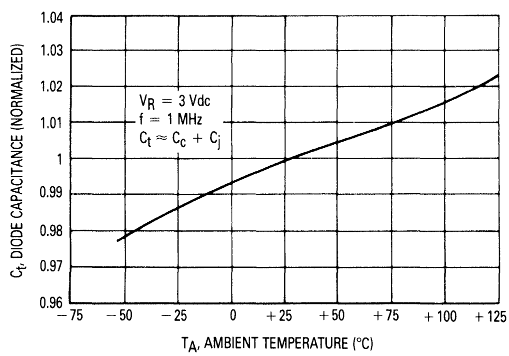


Figure 4. Diode Capacitance

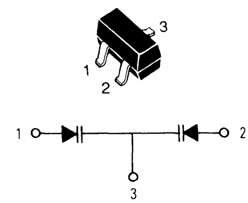
SILICON EPICAP DIODE

. . . designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configuration for minimum signal distortion and detuning. This device is supplied in the SOT-23 plastic package for high volume, pick and place assembly requirements.

- High Figure of Merit — Q = 150 (Typ) @ V_R = 2.0 Vdc, f = 50 MHz
- Guaranteed Capacitance Range
- Dual Diodes — Save Space and Reduce Cost
- Surface Mount Package
- Available in 8 mm Tape and Reel
- Monolithic Chip Provides Improved Matching — Guaranteed ±1.0% (Max) Over Specified Tuning Range

MMBV432LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)



DUAL VOLTAGE-VARIABLE CAPACITANCE DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (Each Diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	14	Volts
Forward Current	I_F	200	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

DEVICE MARKING

MMBV432LT1 = M4B

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	14	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 9.0 Vdc)	I_R	—	—	100	nAdc
Diode Capacitance (V_R = 2.0 Vdc, f = 1.0 MHz)	C_T	43	—	48.1	pF
Capacitance Ratio C2/C8 (f = 1.0 MHz)	C_R	1.5	—	2.0	—
Figure of Merit* (V_R = 2.0 Vdc, f = 50 MHz)	Q	100	150	—	—

$$*Q = \frac{2\pi fC}{G}$$

MMBV432LT1 is also available in bulk packaging. Use MMBV432L as the device title to order this device in bulk.

TYPICAL CHARACTERISTICS (Each Diode)

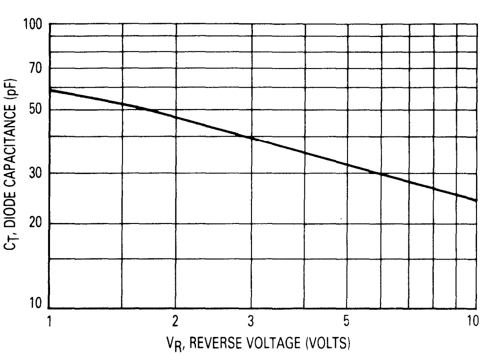


Figure 1. Diode Capacitance (Each Diode)

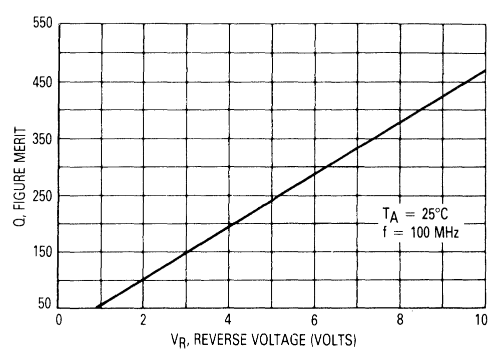


Figure 2. Figure of Merit versus Voltage

TYPICAL CHARACTERISTICS (Each Diode)

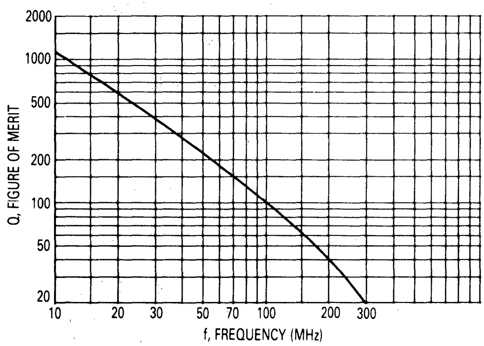


Figure 3. Figure of Merit versus Frequency

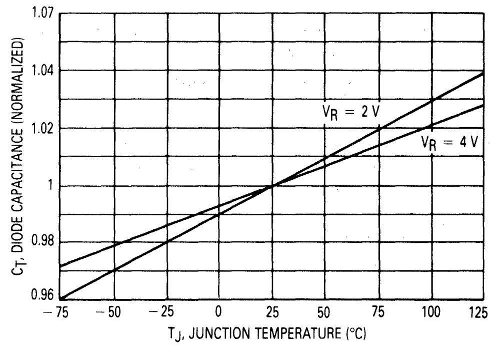


Figure 4. Diode Capacitance versus Temperature

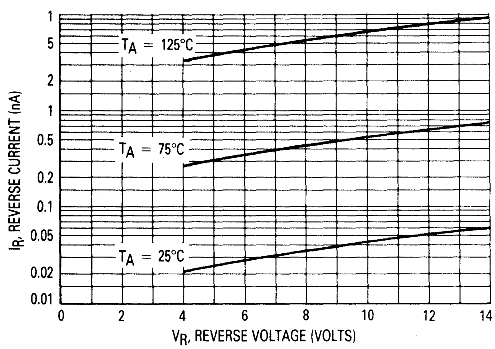


Figure 5. Reverse Current versus Reverse Voltage

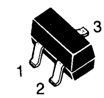
SILICON EPICAP DIODE

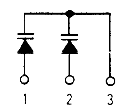
... designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configuration for minimum signal distortion and detuning. This device is supplied in the SOT-23 plastic package for high volume, pick and place assembly requirements.

- High Figure of Merit — Q = 350 (Typ) @ V_R = 3.0 Vdc, f = 50 MHz
- Guaranteed Capacitance Range
- Dual Diodes — Save Space and Reduce Cost
- Surface Mount Package
- Available in 8 mm Tape and Reel
- Monolithic Chip Provides Improved Matching
- Hyper Abrupt Junction Process Provides High Tuning Ratio

MMBV609LT1★

CASE 318-07, STYLE 9
SOT-23 (TO-236AB)





DUAL VOLTAGE-VARIABLE CAPACITANCE DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS (Each Diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	100	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

DEVICE MARKING

MMBV609LT1 = 5L

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc)	I_R	—	—	10	nAdc
Diode Capacitance (V_R = 3.0 Vdc, f = 1.0 MHz)	C_T	26	—	32	pF
Capacitance Ratio C3/C8 (f = 1.0 MHz)	C_R	1.8	—	2.4	—
Figure of Merit (V_R = 3.0 Vdc, f = 50 MHz)	Q	250	350	—	—

MMBV609LT1 is also available in bulk packaging. Use MMBV609L as the device title to order this device in bulk.

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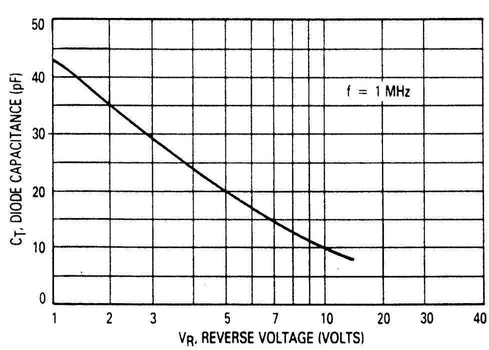


Figure 1. Diode Capacitance

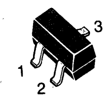
SILICON EPICAP DIODE

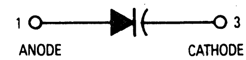
... designed for 900 MHz frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Controlled and Uniform Tuning Ratio
- Available in Surface Mount Package
- Available in 8 mm Tape and Reel

MMBV809LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





VOLTAGE VARIABLE CAPACITANCE DIODE
4.5–6.1 pF

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	20	mA
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225* 1.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

*FR5 Board 1.0 × 0.75 × 0.62 in.

DEVICE MARKING

MMBV809LT1 = 5K

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic — All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc)	I_R	—	—	50	nAdc

	C_t, Diode Capacitance V_R = 2.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz (Note 1)	C_R, Capacitance Ratio C_2/C_8 f = 1.0 MHz (Note 2)	
Device	**Min**	**Typ**	**Max**	**Min**	**Min**	**Max**
MMBV809LT1	4.5	5.3	6.1	300	1.8	2.6

NOTES ON TESTING AND SPECIFICATIONS

(1) Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

(2) C_R is the ratio of C_t measured at 2.0 Vdc divided by C_t measured at 8.0 Vdc.

MMBV809LT1 is also available in bulk packaging. Use MMBV809L as the device title to order this device in bulk.

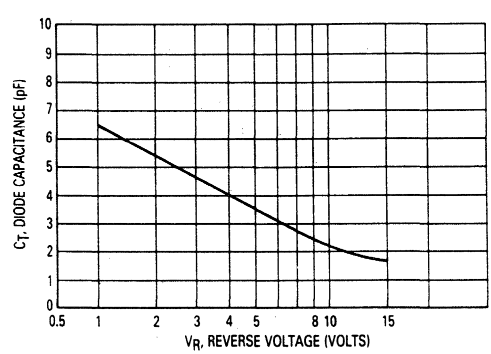


Figure 1. Diode Capacitance

SILICON EPICAP DIODES

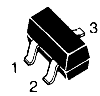
. . . designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

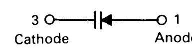
Also available in Surface Mount Package up to 33 pF.

- High Q with Guaranteed Minimum Values
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance — 10%
- Complete Typical Design Curves

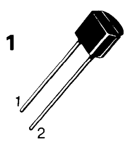
MMBV2101LT1
MMBV2103LT1 thru
MMBV2105LT1
MMBV2107LT1 thru
MMBV2109LT1★
MV2101
MV2103 thru MV2105
MV2107 thru MV2109
MV2111
MV2113 thru MV2115★

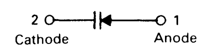
CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





CASE 182-02, STYLE 1
(TO-226AC)





6.8–100 pF
30 VOLTS
VOLTAGE-VARIABLE
CAPACITANCE DIODES

★MMBV2101LT1, MMBV2105LT1, MMBV2109LT1, MV2101, MV2104, MV2108, MV2109, MV2111, MV2113 and MV2115 are Motorola designated preferred devices.

MAXIMUM RATINGS

Rating	Symbol	MV21XX	MMBV21XXLT1	Unit
		Value		
Reverse Voltage	V_R	30		Volts
Forward Current	I_F	200		mA
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	 280 2.8	 200 2.0	 mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV2101LT1 = M4G	MMBV2105LT1 = 4U	MMBV2109LT1 = 4J
MMBV2103LT1 = 4H	MMBV2107LT1 = 4W	
MMBV2104LT1 = 4Z	MMBV2108LT1 = 4X	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	280	—	ppm/°C

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		
Device	Min	Nom	Max	Typ	Min	Typ	Max
MMBV2101LT1/MV2101	6.1	6.8	7.5	450	2.5	2.7	3.2
MMBV2103LT1/MV2103	9.0	10	11	400	2.5	2.9	3.2
MMBV2104LT1/MV2104	10.8	12	13.2	400	2.5	2.9	3.2
MMBV2105LT1/MV2105	13.5	15	16.5	400	2.5	2.9	3.2
MMBV2107LT1/MV2107	19.8	22	24.2	350	2.5	2.9	3.2
MMBV2108LT1/MV2108	24.3	27	29.7	300	2.5	3.0	3.2
MMBV2109LT1/MV2109	29.7	33	36.3	200	2.5	3.0	3.2
MV2111	42.3	47	51.7	150	2.5	3.0	3.2
MV2113	61.2	68	74.8	150	2.6	3.0	3.3
MV2114	73.8	82	90.2	100	2.6	3.0	3.3
MV2115	90	100	110	100	2.6	3.0	3.3

MMBV2101LT1, MMBV2103LT1 thru MMBV2105LT1 and MMBV2107LT1 thru MMBV2109LT1 are also available in bulk. Use the device title and drop the "T1" suffix when ordering any of these devices in bulk.

5

PARAMETER TEST METHODS

1. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$), C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

2. TR, TUNING RATIO
TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

3. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈ 1/16".

4. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT
TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = −65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \cdot \frac{10^6}{C_R(25°C)}$$

Accuracy limited by measurement of C_T to ± 0.1 pF.

TYPICAL DEVICE PERFORMANCE

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

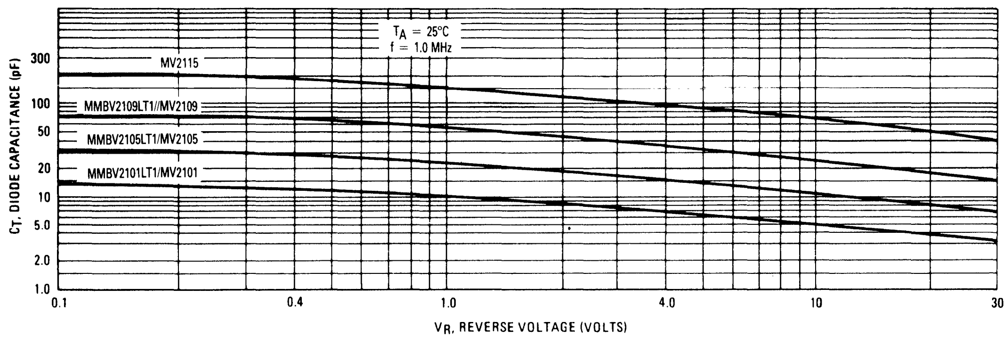


FIGURE 2 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

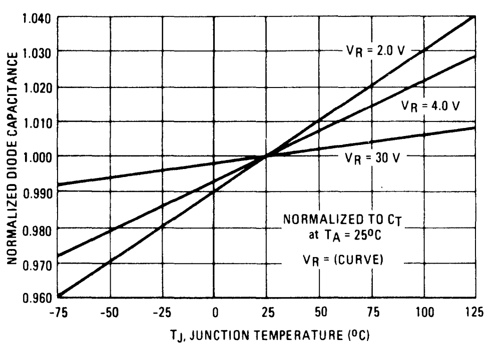


FIGURE 3 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

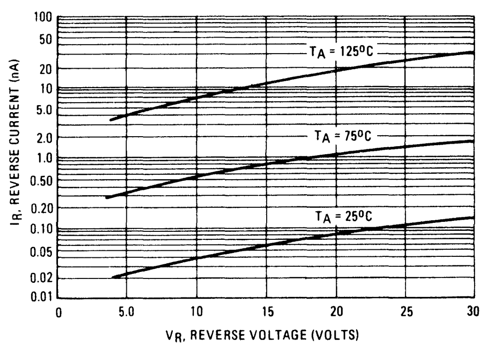


FIGURE 4 — FIGURE OF MERIT versus REVERSE VOLTAGE

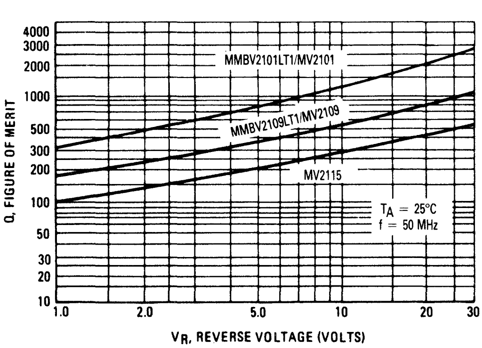
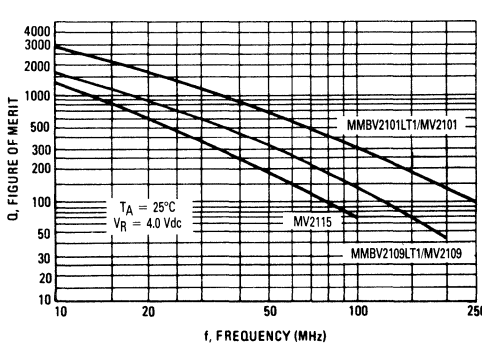


FIGURE 5 — FIGURE OF MERIT versus FREQUENCY



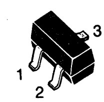
SILICON EPICAP DIODE

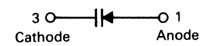
. . . designed in the Surface Mount package for general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio

MMBV3102LT1

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





22 pF (Nominal)
30 VOLTS
VOLTAGE VARIABLE
CAPACITANCE DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

DEVICE MARKING

MMBV3102LT1 = M4C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	—	—	0.1	μAdc
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	300	—	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc, f = 50 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz	
Device	**Min**	**Nom**	**Max**	**Min**	**Min**	**Typ**
MMBV3102LT1	20	22	25	200	4.5	4.8

MMBV3102LT1 is also available in bulk packaging. Use MMBV3102L as the device title to order this device in bulk.

FIGURE 1 — DIODE CAPACITANCE

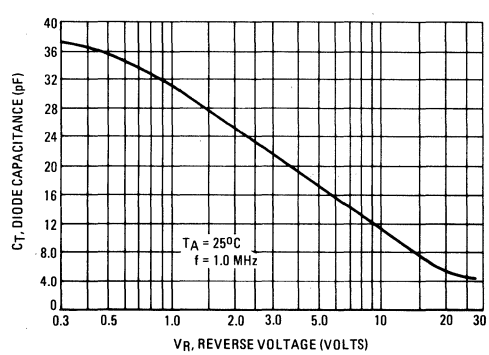


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FIGURE 2 — FIGURE OF MERIT

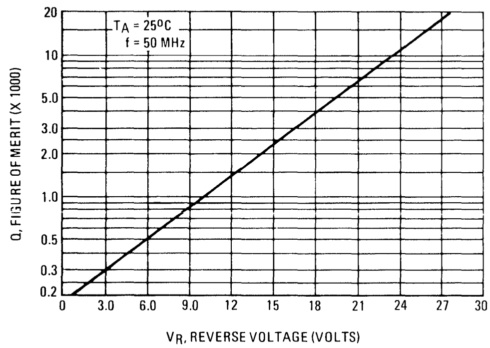


FIGURE 3 — LEAKAGE CURRENT

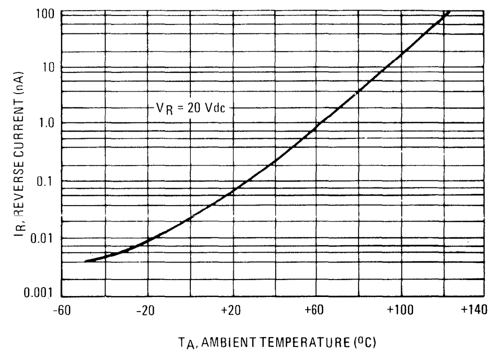
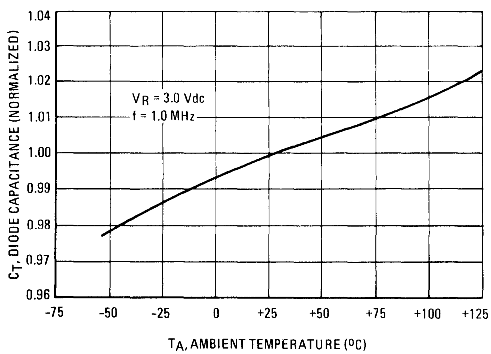


FIGURE 4 — DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

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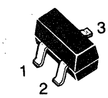
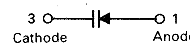
MMBV3401LT1★

CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





SILICON PIN SWITCHING DIODE

★This is a Motorola designated preferred device.

SILICON PIN DIODE

. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching circuits. Supplied in a Surface Mount package.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Low Capacitance — 0.7 pF Typ at V_R = 20 V
- Very Low Series Resistance at 100 MHz — 0.34 Ohms (Typ) @ I_F = 10 mAdc

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	200 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

DEVICE MARKING

MMBV3401LT1 = 4D

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	35	—	—	Volts
Diode Capacitance (V_R = 20 V)	C_T	—	—	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mA) f = 100 MHz	R_S	—	—	0.7	Ohms
Reverse Leakage Current (V_R = 25 V)	I_R	—	—	0.1	μA

MMBV3401LT1 is also available in bulk packaging. Use MMBV3401L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

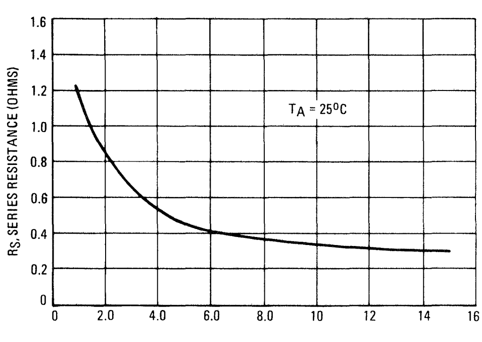


FIGURE 2 – FORWARD VOLTAGE

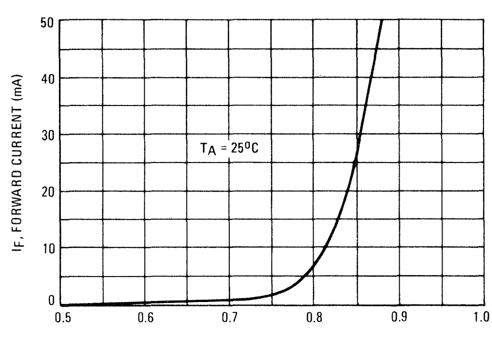


FIGURE 3 — DIODE CAPACITANCE

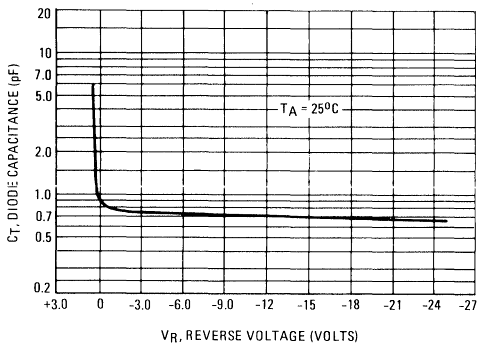


FIGURE 4 — LEAKAGE CURRENT

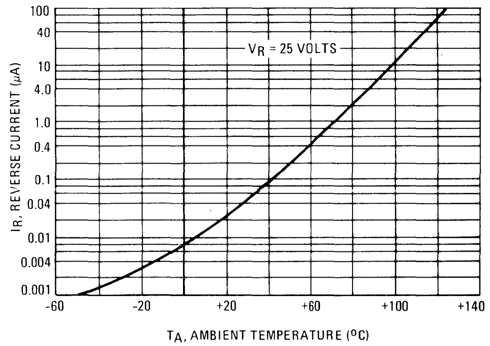
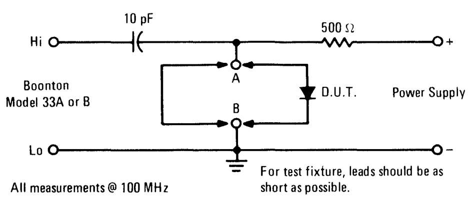


FIGURE 5 — FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G — in micromhos,
C — in pF,
R_S — in ohms

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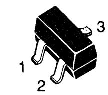
HIGH VOLTAGE SILICON PIN DIODES

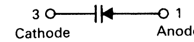
... designed primarily for VHF band switching applications but also suitable for use in general-purpose switching circuits. Supplied in a cost effective plastic package for economical, high-volume consumer and industrial requirements. Also available in surface mount.

- Long Reverse Recovery Time
  t_{rr} = 300 ns (Typ)
- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Low Series Resistance @ 100 MHz —
  R_S = 0.7 Ohms (Typ) @ I_F = 10 mAdc
- Reverse Breakdown Voltage = 200 V (Min)

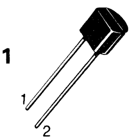
MMBV3700LT1
MPN3700

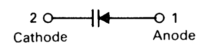
CASE 318-07, STYLE 8
SOT-23 (TO-236AB)





CASE 182-02, STYLE 1
(TO-226AC)





SILICON PIN SWITCHING DIODES

MAXIMUM RATINGS

Rating	Symbol	MPN3700 Value	MMBV3700LT1 Value	Unit
Reverse Voltage	V_R	200		Volts
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	200 2.0	mW mW/°C
Junction Temperature	T_J	+125		°C
Storage Temperature Range	T_{stg}	−55 to +150		°C

DEVICE MARKING

MMBV3700LT1 = 4R

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	200	—	—	Volts
Diode Capacitance (V_R = 20 Vdc, f = 1.0 MHz)	C_T	—	—	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mA)	R_S	—	0.7	1.0	Ohms
Reverse Leakage Current (V_R = 150 Vdc)	I_R	—	—	0.1	μA
Reverse Recovery Time (I_F = I_R = 10 mA)	t_{rr}	—	300	—	ns

MMBV3700LT1 is also available in bulk packaging. Use MMBV3700L as the device title to order this device in bulk.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — SERIES RESISTANCE

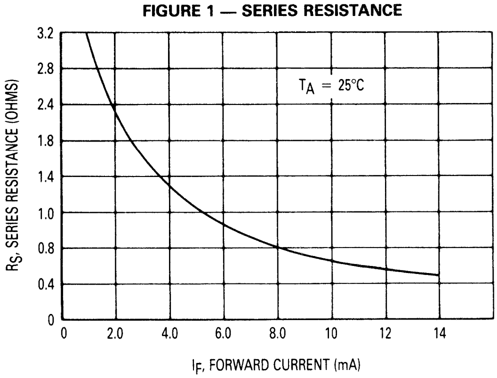


FIGURE 2 — FORWARD VOLTAGE

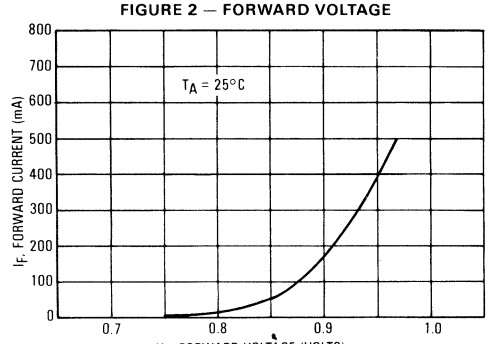


FIGURE 3 — DIODE CAPACITANCE

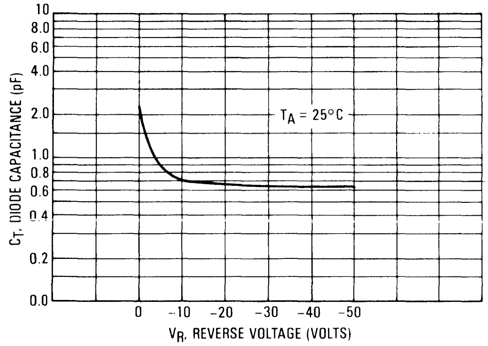


FIGURE 4 — LEAKAGE CURRENT

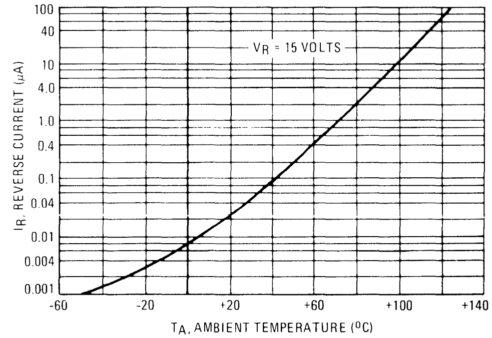
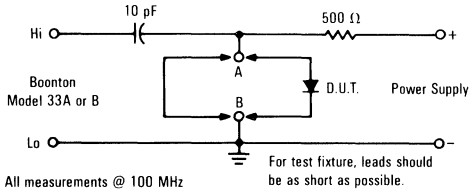


FIGURE 5 — FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\ G}{C^2}$$

Where:
G — in micromhos,
C — in pF,
R_S — in ohms

5

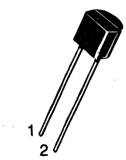
SILICON PIN DIODE

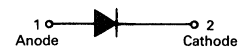
. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching circuits. Supplied in a cost effective TO-92 type plastic package for economical, high-volume consumer and industrial requirements.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Low Series Resistance @ 100 MHz — R_S = 0.7 Ohms (Typ) @ I_F = 10 mAdc
- Sturdy TO-92 Style Package for Handling Ease

MPN3404★

CASE 182-02, STYLE 1
(TO-226AC)





SILICON PIN
SWITCHING DIODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	20	—	—	Volts
Diode Capacitance (V_R = 15 Vdc, f = 1.0 MHz)	C_T	—	1.3	2.0	pF
Series Resistance (Figure 5) (I_F = 10 mA)	R_S	—	0.7	0.85	Ohms
Reverse Leakage Current (V_R = 15 Vdc)	I_R	—	—	0.1	μA

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TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

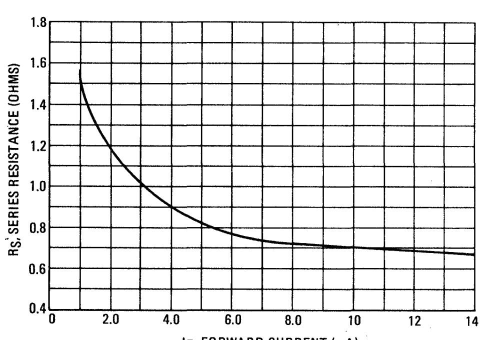


FIGURE 2 – FORWARD VOLTAGE

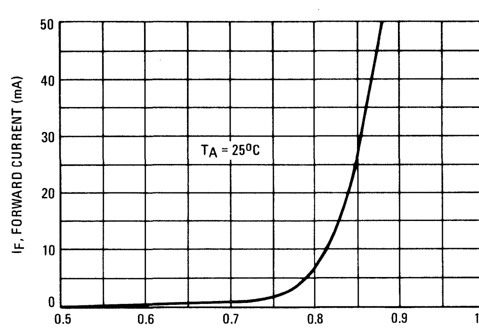


FIGURE 3 — DIODE CAPACITANCE

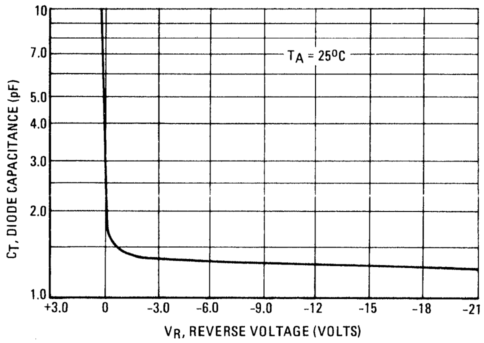


FIGURE 4 — LEAKAGE CURRENT

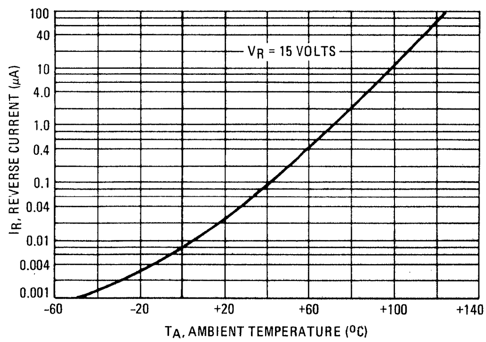
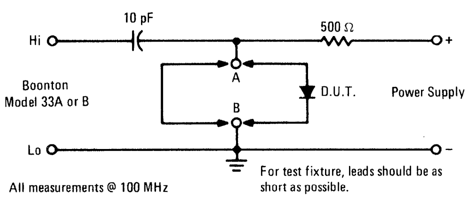


FIGURE 5 — FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G — in micromhos,
C — in pF,
R_S — in ohms

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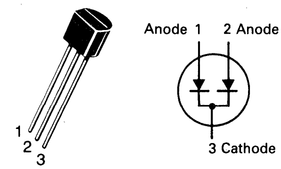
MSD6100★

CASE 29-04, STYLE 3
TO-92 (TO-226AA)



DUAL SWITCHING DIODE
COMMON CATHODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Poak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

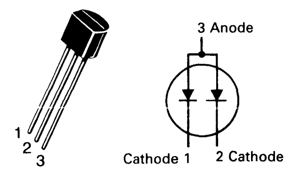
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Current (V_R = 100 Vdc) (V_R = 50 Vdc) (V_R = 50 Vdc, T_A = 125°C)	I_R	 — — —	 5.0 0.1 50	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.67 0.75	 0.7 0.82 1.1	Vdc
Capacitance (V_R = 0)	C	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	4.0	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = −65 to +150°C, θ_{JC} = 125°C/W.

MSD6150★

CASE 29-04, STYLE 4
TO-92 (TO-226AA)



DUAL DIODE COMMON ANODE

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.80	1.0	Vdc
Capacitance (V_R = 0)	C	—	5.0	8.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	—	100	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J, T_{stg} = −55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.

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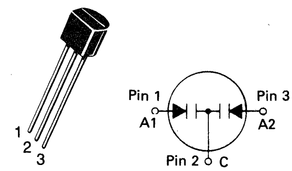
MV104★

CASE 29-04, STYLE 15
(TO-226AA)



DUAL VOLTAGE-VARIABLE CAPACITANCE DIODE

★This is a Motorola designated preferred device.

SILICON EPICAP DIODE

. . . designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configurations for minimum signal distortion and detuning. This device is supplied in the popular TO-92 plastic package for high volume, economical requirements of consumer and industrial applications.

- High Figure of Merit — $Q = 140$ (Typ) @ $V_R = 3.0$ Vdc, f = 100 MHz
- Guaranteed Capacitance Range 37–42 pF @ $V_R = 3.0$ Vdc (MV104)
- Dual Diodes — Save Space and Reduce Cost
- TO-92 Package for Easy Handling and Mounting
- Monolithic Chip Provides Near Perfect Matching — Guaranteed ±1% (Max) Over Specified Tuning Range

MAXIMUM RATINGS (Each Device)

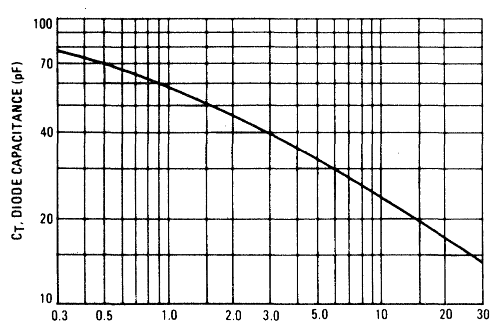
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	32	Volts
Forward Current	I_F	200	mA
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_F	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10$ μAdc)	$V_{(BR)R}$	32	—	—	Vdc
Reverse Voltage Leakage Current $T_A = 25°C$ ($V_R = 30$ Vdc) $T_A = 60°C$	I_R	— —	— —	50 500	nAdc
Diode Capacitance Temperature Coefficient ($V_R = 4.0$ Vdc, f = 1.0 MHz)	TC_C	—	280	—	ppm/°C

	C_T, Diode Capacitance $V_R = 3.0$ Vdc, f = 1.0 MHz pF		Q, Figure of Merit $V_R = 3.0$ Vdc f = 100 MHz		C_R, Capacitance Ratio C_3/C_{30} f = 1.0 MHz	
Device	**Min**	**Max**	**Min**	**Typ**	**Min**	**Max**
MV104	37	42	100	140	2.5	2.8

FIGURE 1 — DIODE CAPACITANCE (Each Diode)



TYPICAL CHARACTERISTICS (Each Device)

FIGURE 2 – FIGURE OF MERIT versus VOLTAGE

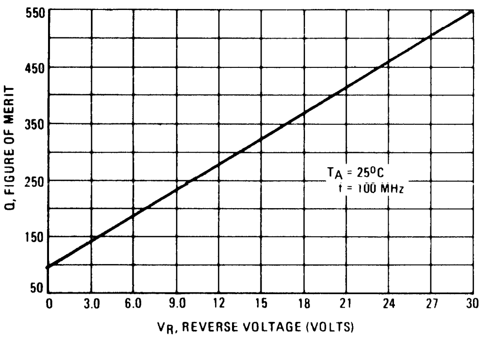


FIGURE 3 – FIGURE OF MERIT versus FREQUENCY

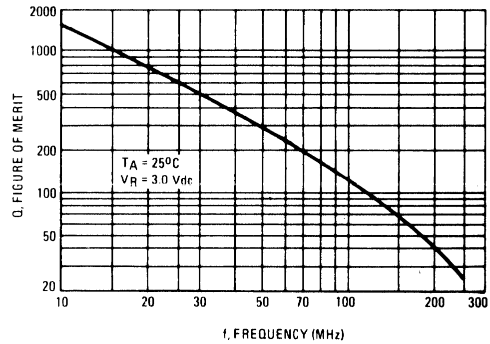


FIGURE 4 – DIODE CAPACITANCE versus TEMPERATURE

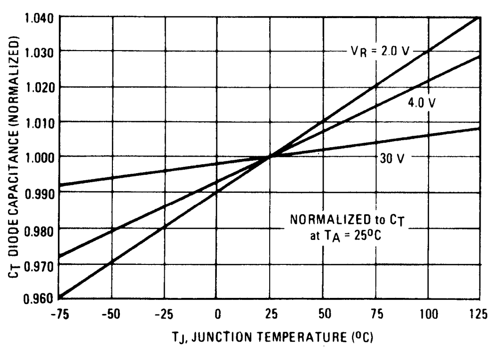
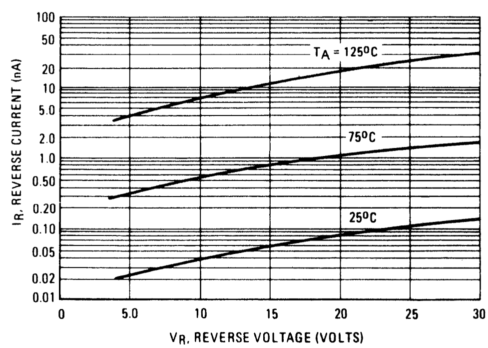


FIGURE 5 – REVERSE CURRENT versus REVERSE VOLTAGE



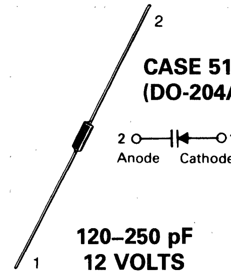
5

SILICON HYPER-ABRUPT TUNING DIODES

... designed with high capacitance and a capacitance change of greater than TEN TIMES for a bias change from 2.0 to 10 volts. Provides tuning over broad frequency ranges; tunes AM radio broadcast band, general AFC and tuning applications in lower RF frequencies.

- High Capacitance: 120–250 pF
- Large Capacitance Change with Small Bias Change
- Guaranteed High Q
- Available in Standard Axial Glass Packages
- H Suffix Devices with 100% Screening

MV1403
MV1404
MV1405



CASE 51-02 (DO-204AA)

120–250 pF
12 VOLTS

HIGH TUNING RATIO VOLTAGE-VARIABLE CAPACITANCE DIODES

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

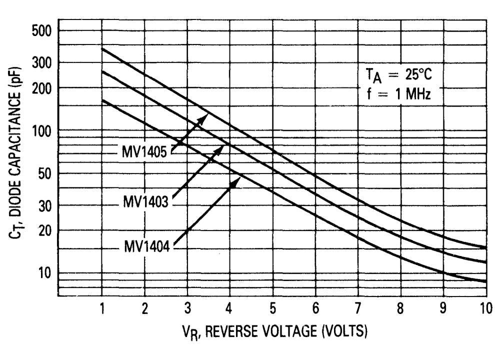
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	12	—	—	Vdc
Leakage Current at Reverse Voltage (V_R = 10 Vdc, T_A = 25°C)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16″)	L_S	—	5.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	—	0.25	—	pF

5

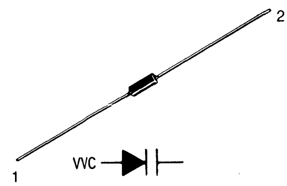
Device	C_T, Diode Capacitance V_R = 2.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 2.0 Vdc, f = 1.0 MHz	TR, Tuning Ratio C_1/C_{10} f = 1.0 MHz	TR, Tuning Ratio C_2/C_{10} f = 1.0 MHz
	Min	Nom	Max	Min	Min	Min
MV1403	140	175	210	200	—	10
MV1404	96	120	144	200	—	10
MV1405	200	250	300	200	—	10

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE



MV1620 thru MV1650

CASE 51-02
DO-204AA (DO-7)



VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8–100 pF
20 VOLTS

SILICON EPICAP DIODES

. . . epitaxial passivated tuning diodes designed for AFC applications in radio, TV, and general electronic-tuning.

- Maximum Working Voltage of 20 V
- Excellent Q Factor at High Frequencies
- Solid-State Reliability to Replace Mechanical Tuning Methods

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

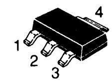
Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	20	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 15 Vdc, T_A = 25°C)	I_R	—	—	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16″)	L_S	—	4.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	—	0.17	—	pF

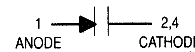
	C_t, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz	T_R, Tuning Ratio C_2/C_{20} f = 1.0 MHz	
Device	**Min**	**Nom**	**Max**	**Typ**	**Min**	**Max**
MV1620	6.1	6.8	7.5	300	2.0	3.2
MV1624	9.0	10.0	11.0	300	2.0	3.2
MV1626	10.8	12.0	13.2	300	2.0	3.2
MV1628	13.5	15.0	16.5	250	2.0	3.2
MV1630	16.2	18.0	19.8	250	2.0	3.2
MV1634	19.8	22.0	24.2	250	2.0	3.2
MV1636	24.3	27.0	29.7	200	2.0	3.2
MV1638	29.7	33.0	36.3	200	2.0	3.2
MV1640	35.1	39.0	42.9	200	2.0	3.2
MV1642	42.3	47.0	51.7	200	2.0	3.2
MV1644	50.4	56.0	61.6	150	2.0	3.2
MV1648	73.8	82.0	90.2	150	2.0	3.2
MV1650	90.0	100.0	110.0	150	2.0	3.2

TR, Tuning Ratio, is the ratio of C_T measured at 2 Vdc divided by C_T measured at 20 Vdc.

MV7005T1★

CASE 318E-04, STYLE 2
TO-261AA





SOT-223 PACKAGE
HIGH CAPACITANCE
VOLTAGE-VARIABLE DIODE
SURFACE MOUNT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	15	Volts
Forward Current	I_F	50	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	–55 to +125	°C

DEVICE MARKING

V7005

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	15	—	Vdc
Reverse Voltage Leakage Current (V_R = 9.0 Vdc)	I_R	—	100	nAdc
Diode Capacitance (V_R = 1.0 Vdc, f = 1.0 MHz)	C_T	400	520	pF
Capacitance Ratio C1/C9 (f = 1.0 MHz)	C_R	12	—	—
Figure of Merit (V_R = 1.0 Vdc, f = 1.0 MHz)	Q	150	—	—

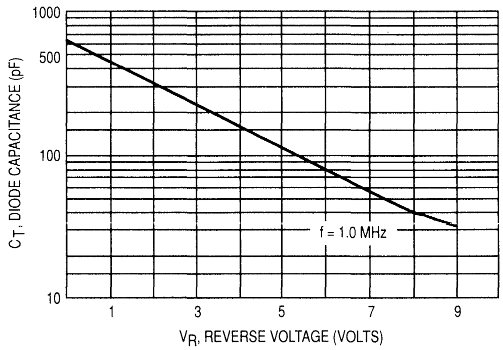


Figure 1. Diode Capacitance versus Reverse Voltage

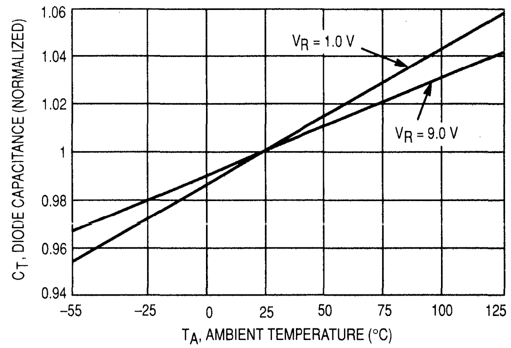


Figure 2. Diode Capacitance versus Ambient Temperature

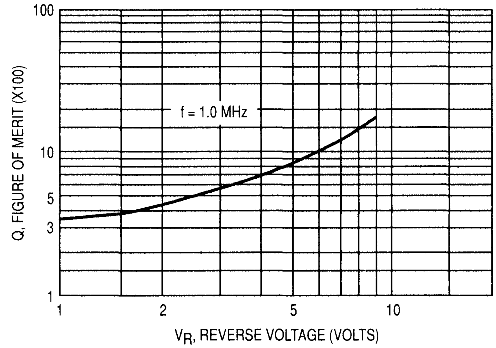
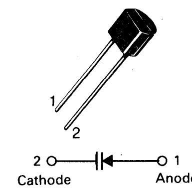


Figure 3. Figure of Merit

5

MVAM108★
MVAM109★
MVAM115★
MVAM125★

CASE 182-02, STYLE 1
(TO-226AC)



TUNING DIODES WITH VERY HIGH CAPACITANCE RATIO

★These are Motorola designated preferred devices.

SILICON TUNING DIODES

. . . designed for electronic tuning of AM receivers and high capacitance, high tuning ratio applications.

- High Capacitance Ratio — C_R = 15 (Min), MVAM108, 115, 125
- Guaranteed Diode Capacitance — C_t = 440 pF (Min) — 560 pF (Max) @ V_R = 1.0 VDc, f = 1.0 MHz, MVAM108, MVAM115, MVAM125
- Guaranteed Figure of Merit — Q = 150 (Min) @ V_R = 1.0 Vdc, f = 1.0 MHz

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Reverse Voltage	MVAM108	V_R	12	Volts
	MVAM109		15	
	MVAM115		18	
	MVAM125		28	
Forward Current		I_F	50	mA
Power Dissipation @ T_A = 25°C		P_D	280	mW
Derate above 25°C			2.8	mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−55 to +125	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, Each Device)

Characteristic		Symbol	Min	Typ	Max	Unit
Breakdown Voltage		$V_{(BR)R}$				Vdc
(I_R = 10 μAdc)	MVAM108		12	—	—	
	MVAM109		15	—	—	
	MVAM115		18	—	—	
	MVAM125		28	—	—	
Reverse Current		I_R				nAdc
(V_R = 8.0 V)	MVAM108		—	—	100	
(V_R = 9.0 V)	MVAM109		—	—	100	
(V_R = 15 V)	MVAM115		—	—	100	
(V_R = 25 V)	MVAM125		—	—	100	
Diode Capacitance Temperatujre Coefficient (1) (V_R = 1.0 Vdc, f = 1.0 MHz, T_A = −40°C to +85°C)		TC_C	—	435	—	ppm/°C
Case Capacitance (f = 1.0 MHz, Lead Length 1/16″)		C_C	—	0.18	—	pF
Diode Capacitance (2)		C_t				pF
(V_R = 1.0 Vdc, f = 1.0 MHz)	MVAM108, 115, 125		440	500	560	
	MVAM109		400	460	520	
Figure of Merit (f = 1.0 MHz, Lead Length 1/16″, V_R = 1.0 Vdc)		Q	150	—	—	—
Capacitance Ratio						—
(f = 1.0 MHz)	MVAM108	C1/C8	15	—	—	
	MVAM109	C1/C9	12	—	—	
	MVAM115	C1/C15	15	—	—	
	MVAM125	C1/C25	15	—	—	

NOTES:
1. The effect of increasing temperature 1.0°C, at any operating point, is equivalent to lowering the effective tuning voltage 1.25 mV. The percent change of capacitance per °C is nearly constant from −40°C to +100°C.
2. Upon request, diodes are available in matched sets. All diodes in a set can be matched for capacitance to 3% or 2.0 pF (whichever is greater) at all points along the specified tuning range.

FIGURE 1 — TYPICAL AM RADIO APPLICATION

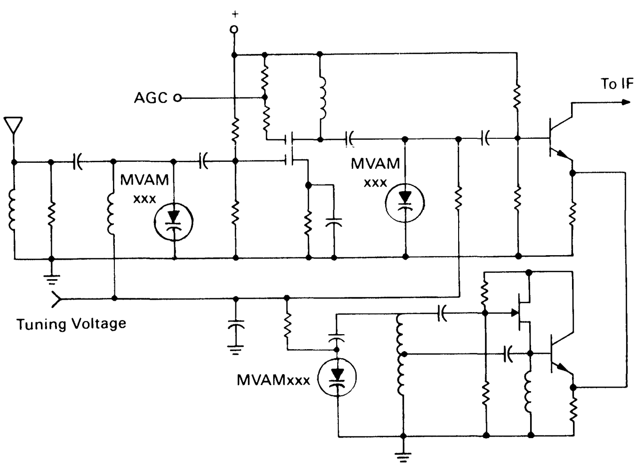


FIGURE 2 — CAPACITANCE versus REVERSE VOLTAGE

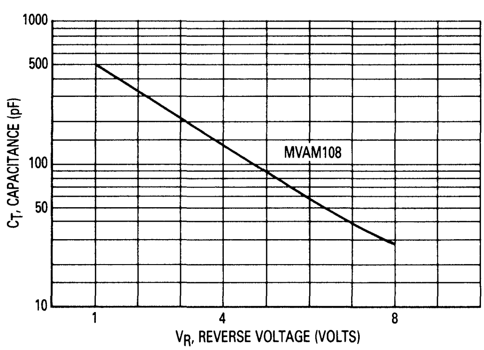


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE

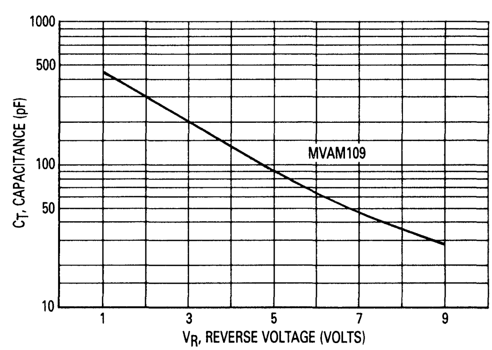


FIGURE 4 — CAPACITANCE versus REVERSE VOLTAGE

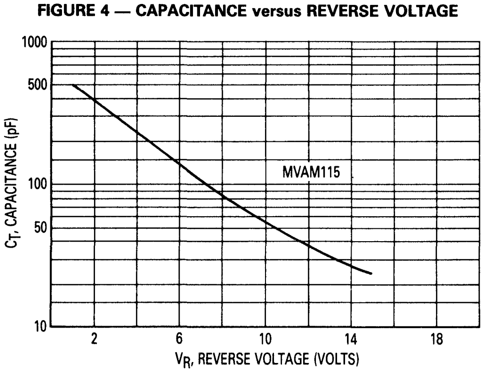
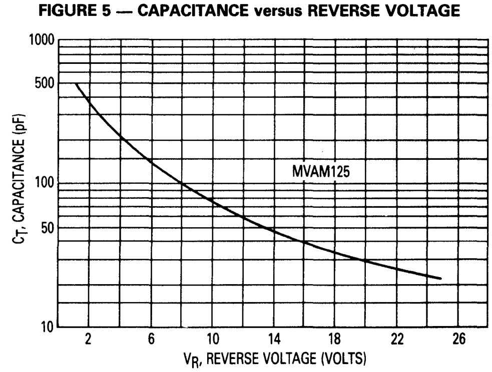
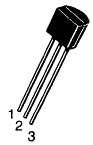
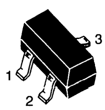


FIGURE 5 — CAPACITANCE versus REVERSE VOLTAGE

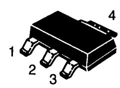




CASE 29-04
(TO-226AA)
TO-92
STYLE 33



CASE 318-07
(TO-236AB)
SOT-23
STYLE 22



CASE 318E-04
(TO-261AA)
SOT-223
STYLE 6

SMALLBLOCK Products are a unique family of application specific "minigrated" circuits. These circuits will incorporate various transistor, resistor and diode configurations for use in certain applications. Since these SMALLBLOCK circuits are monolithic chips, they will reduce both component count and the required space on circuit boards, simplify circuitry and improve reliability.

SMALLBLOCK Products

6

EMBOSSED TAPE AND REEL

SOT-23 and SOT-223 packages are available only in Tape and Reel. Use the appropriate suffix indicated below to order any of the SOT-23 and SOT-223 packages. (See Section 7 on Packaging for additional information).

SOT-23: available in 8 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/3000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/10,000 unit reel.

SOT-223: available in 12 mm Tape and Reel
Use the device title (which already includes the "T1" suffix) to order the 7 inch/1000 unit reel.
Replace the "T1" suffix in the device title with a "T3" suffix to order the 13 inch/4000 unit reel.

RADIAL TAPE REEL AND AMMO PACK

TO-92 packages are available in both bulk shipments and in Radial Tape Reel and Ammo Packs. Radial Tape Reel and Ammo Pack are the best methods for capturing devices for automatic insertion in printed circuit boards.

TO-92: available in 365 mm Radial Tape Reel
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Radial Tape Reel.

available in Ammo Pack (Fan Fold Box)
Add an "RLR" suffix and the appropriate Style code* to the device title to order the Ammo Pack box.

*Refer to Section 7 on Packaging for Style code characters and additional information on ordering requirements.

DEVICE MARKINGS/DATE CODE CHARACTERS

The SOT-23 package has a device marking and a date code etched on the device. The generic example below depicts both the device marking and a representation of the date code that appears on the SOT-23 package.

ABCD

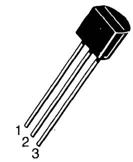
The "D" represents a smaller alpha digit Date Code. The Date Code indicates the actual month in which the part was manufactured.

The MDC1000 series is a silicon turn-off device designed to reduce the turn-off time of a MOSFET or an IGBT. It also clamps the MOSFET gate voltage to a safe level. This device eliminates the use of individual components by integrating them into a single device. The use of the MDC1000 series can reduce system cost and board space, while optimizing the switching performance of the MOSFET. The MOSFET Turn-Off Device is a member of the SMALLBLOCK family.

- Output Voltage Clamped to 12.5 Volts to Protect the MOSFET Gate
- Very Fast Turn-Off Time, 15 Nanoseconds Typical
- Simplifies Circuit Design
- Reduces Board Space
- Three Package Styles: TO-92 for Insertion, SOT-23 and SOT-223 for Surface Mount
- Applications Literature: EB-142; The MOSFET Turn-Off Device, A New Circuit Building Block; AN1078; New Components Simplify Brush DC Motor Drives; AN1087; Speeding up Horizontal Outputs; AN1101; One-Horsepower Off-Line Brushless Permanent Magnet Motor Drive

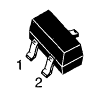
MDC1000A★

CASE 29-04
STYLE 33
TO-226AA (TO-92)



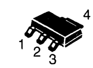
MDC1000BLT1★

CASE 318-07
STYLE 22
TO-236AB (SOT-23)



MDC1000CT1★

CASE 318E-04
STYLE 6
TO-261AA (SOT-223)



SMALLBLOCK
MOSFET TURN-OFF DEVICES

★These are Motorola designated preferred devices.

MAXIMUM RATINGS (T_A = 25°C unless otherwise specified)

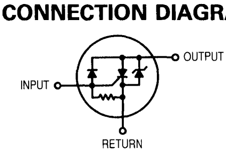
Rating	Symbol	Value	Unit
Input — Continuous	I_{IN}	50	mA
Input — Current Peak (Pulse Width = 20 µs, Duty Cycle ≤ 2%)	I_{INM}	500	mA
Thermal Resistance — Junction to Ambient	$R_{θJA}$		°C/mW
MDC1000A		0.227	
MDC1000BLT1		0.625	
MDC1000CT1		0.227	
Total Power Dissipation @ T_A = 25°C	P_D		mW
MDC1000A		550	
MDC1000BLT1*		200	
MDC1000CT1*		550	
Derate above 25°C			mW/°C
MDC1000A		1.82	
MDC1000BLT1*		5.7	
MDC1000CT1*		1.82	
Operating and Storage Temperature Range	T_J, T_{stg}	– 65 to +150	°C
Lead Soldering Temperature**	T_L	260	°C

*Device mounted on an FR-5 printed circuit board 1.0 x 0.75 x 0.062 inches using footprint shown in Section 8.
**Additional information on soldering of the MDC1000BLT1,CT1 surface mount packages is shown in Section 8.

DEVICE MARKING

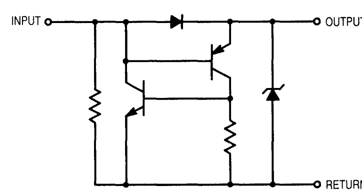
MDC1000A	MDC1000
MDC1000BLT1	C10
MDC1000CT1	C1000

PIN CONNECTION DIAGRAMS



MDC1000A	MDC1000BLT1	MDC1000CT1
1-Return	1-Return	1-Return
2-Input	2-Output	2-Input
3-Output	3-Input	3-Output
		4-Input

EQUIVALENT CIRCUIT



6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Clamp Voltage [Note 1]	(I_{IN} = 2.0 mA) (I_{IN} = 50 mA)	V_{in}	9.5 9.5	11 11.2	12 12.5	Vdc
Output Clamp Voltage [Note 2]	(I_{OUT} = 2.0 mA) (I_{OUT} = 50 mA)	V_{out}	9.0 9.0	10.4 10.8	11.5 12	Vdc
Turn-Off Time (1000 pF, from 9.0 V to 1.0 V) See Figures 1 and 2		t_{off}	—	15	—	ns
Storage Time		t_s	—	60	—	ns
Propagation Delay		t_{prop}	—	5.0	—	ns
Input Capacitance @ 10 Volts, f = 1.0 MHz		C_{in}	—	5.0	—	pF
Dropout Current [Note 4]		$I_{(sus)}$	50	110	—	µA

[1] Input pin (+) to return pin(–) with output pin open.
[2] Input and output pins common(+) to return pin(–).
[3] MDC1000s should be mounted as close as possible to the MOSFET being controlled to minimize noise difficulties. In particular, the return lead should have as short a run to the MOSFET source lead as possible. Also, Kelvin connections between the MDC1000 return lead and the MOSFET source lead will enhance noise immunity.
[4] Output Current level below which MTO must fall to insure driver MOSFET will turn back on.

SWITCHING

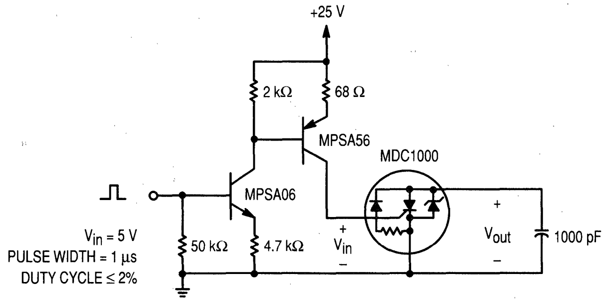


Figure 1. Turn-Off Time Test Circuit

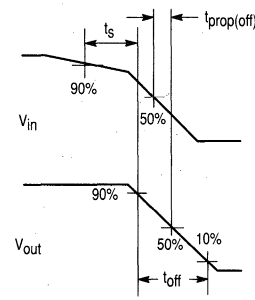


Figure 2. Turn-Off Waveforms

TYPICAL CHARACTERISTICS

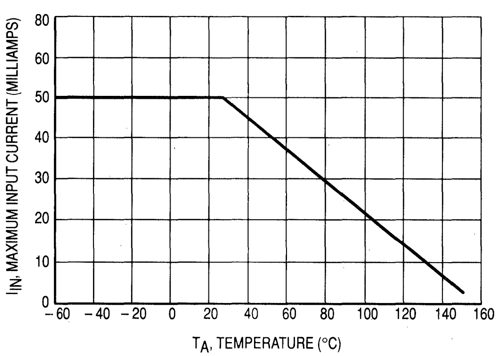


Figure 3. Allowable Input Current versus Ambient Temperature

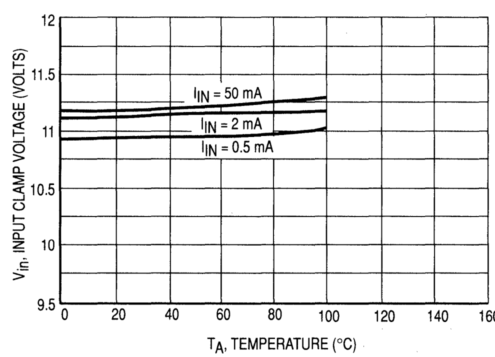


Figure 4. Input Clamp Voltage versus Ambient Temperature

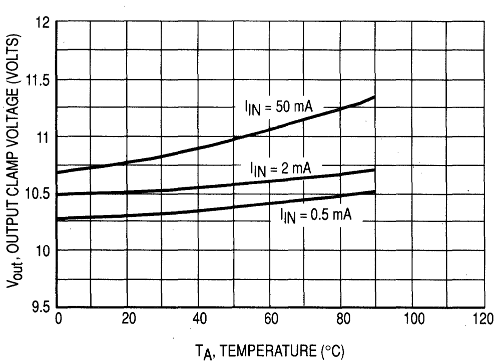


Figure 5. Output Clamp Voltage versus Ambient Temperature

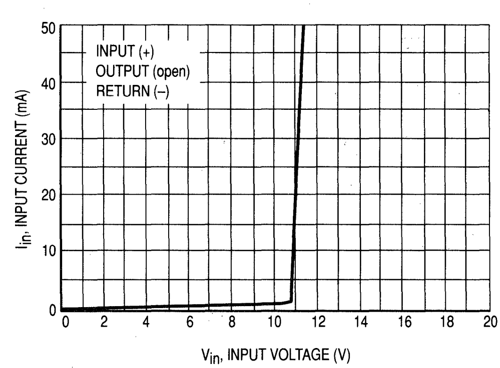


Figure 6. Input Characteristics

TYPICAL CHARACTERISTICS

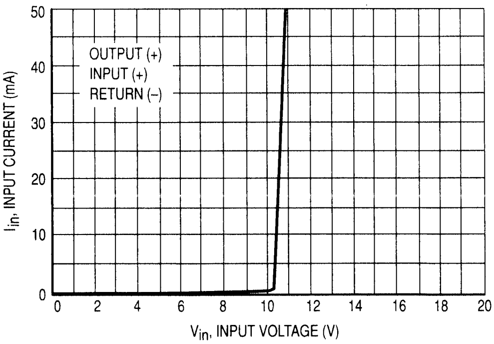


Figure 7. Output Characteristics

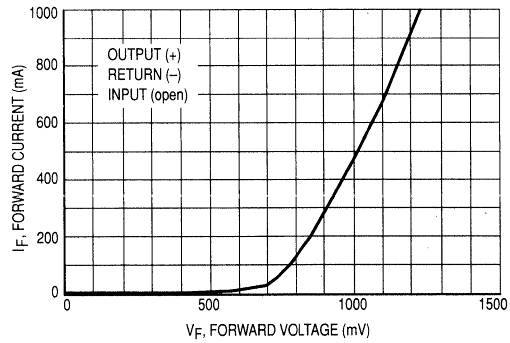


Figure 8. Forward Voltage Drop

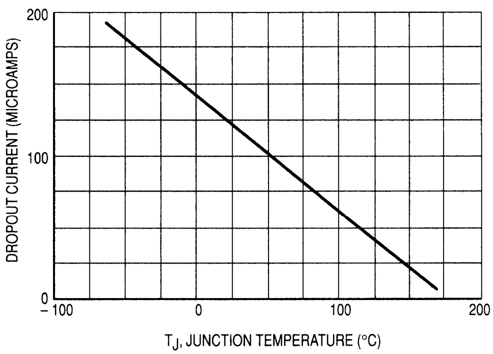


Figure 9. Dropout Current versus Temperature

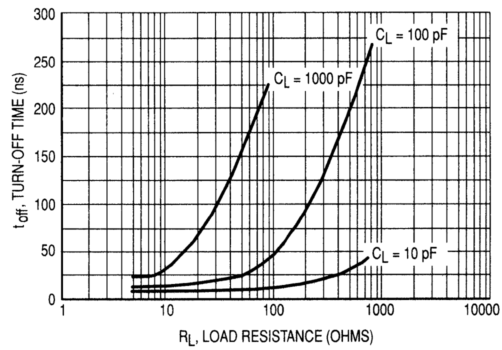


Figure 10. t_{off} versus Load Resistance/ Load Capacitance

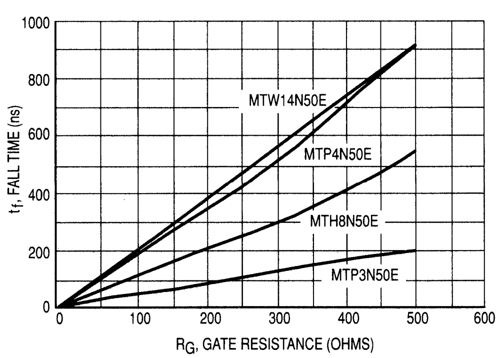


Figure 11. MOSFET Fall Time versus Gate Resistance

6

OPERATING DESCRIPTION

The MDC1000 series provides an economical and space saving method of turning off a power MOSFET while achieving a level of circuit improvement at the same time. It reduces the component count of an active gate turn-off network for MOSFETs. The device quickly discharges the gate-source and gate-drain capacitances when the input signal is removed and provides protection of the gate-source in the event of an overvoltage condition on the control line.

To turn a MOSFET off, it is necessary to discharge the input capacitance to drive the gate-source voltage to below $V_{GS(th)}$. Turning on a MOSFET is fairly straight-forward, but turning it off frequently calls for some form of active turn-off network to help speed up the turn-off process. Typically, this has been achieved with a network comprised of several active and passive components. The effect of the turn-off network is to provide a low impedance discharge path for the MOSFET input capacitance and therefore speed up its turn-off.

Instead of a single PNP transistor which is commonly used for the turn-off function, an NPN has been added and is connected to the PNP in the configuration of an SCR. This combination provides the regenerative turn-on action of an SCR, further speeding up the process of discharging the gate of the MOSFET. It also contains an integral 10.4 volt zener diode, providing the MOSFET gate with overvoltage protection. Using the MDC1000 series, a power MOSFET can typically be turned off in tens of nanoseconds.

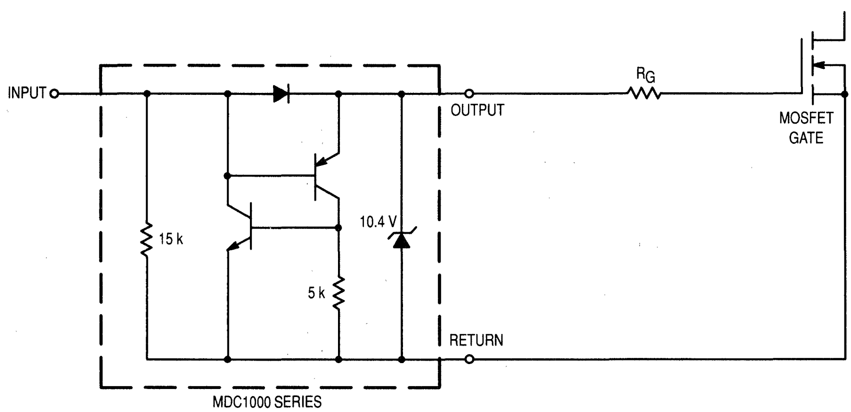


Figure 12. Recommended Gate Drive Circuit

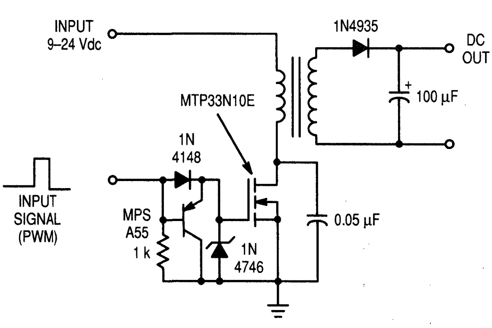


Figure 13a. Utilizing Discrete Components

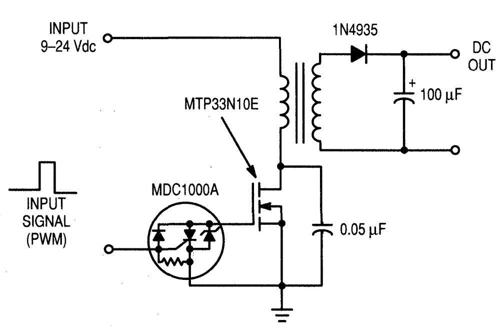


Figure 13b. Utilizing MDC1000A

Figure 13. Active MOSFET Gate Turn-Off Circuit

TYPICAL APPLICATIONS UTILIZING THE MDC1000A

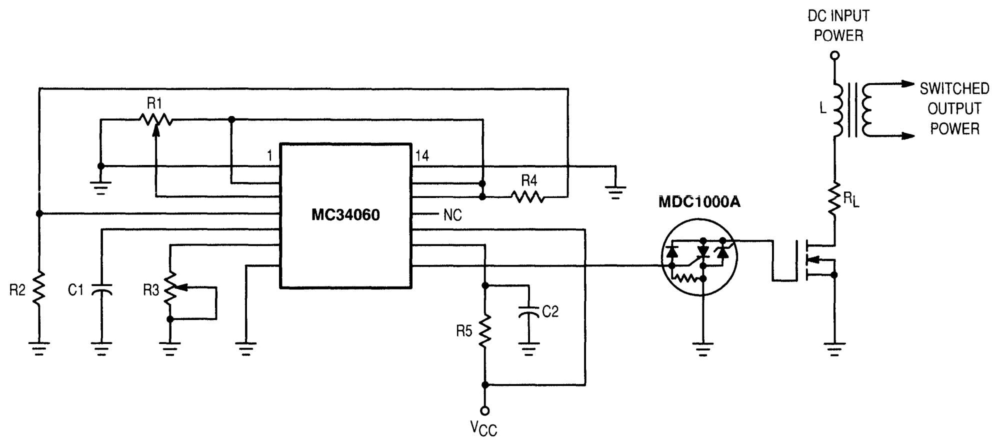


Figure 14. PWM Portion of Switchmode Power Supply for Power MOSFET Gate Control

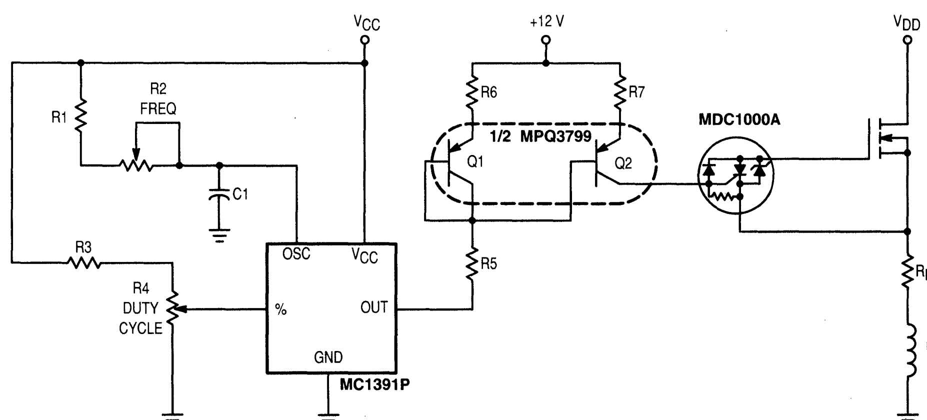


Figure 15. Horizontal Gain Circuit for Power MOSFET Gate Control and PNP Current Mirror for Gate Drive Circuit

6

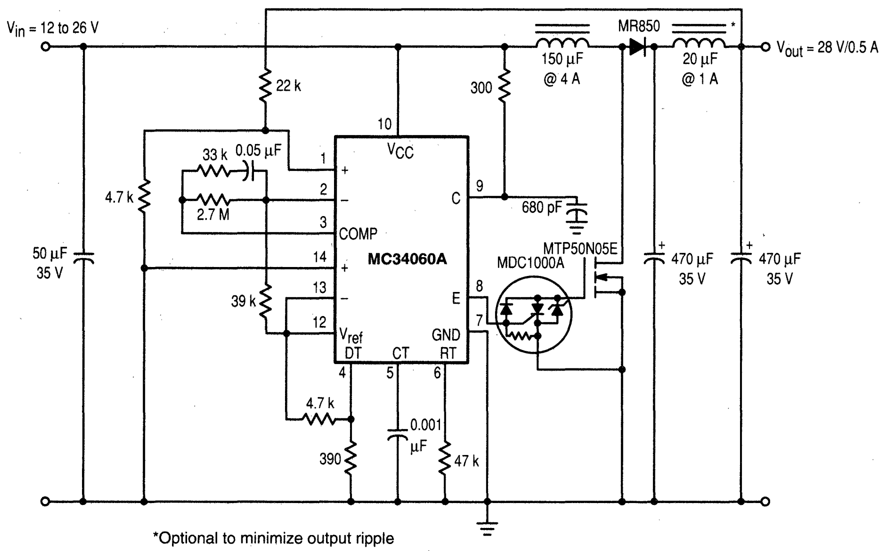


Figure 16. DC-DC Converter

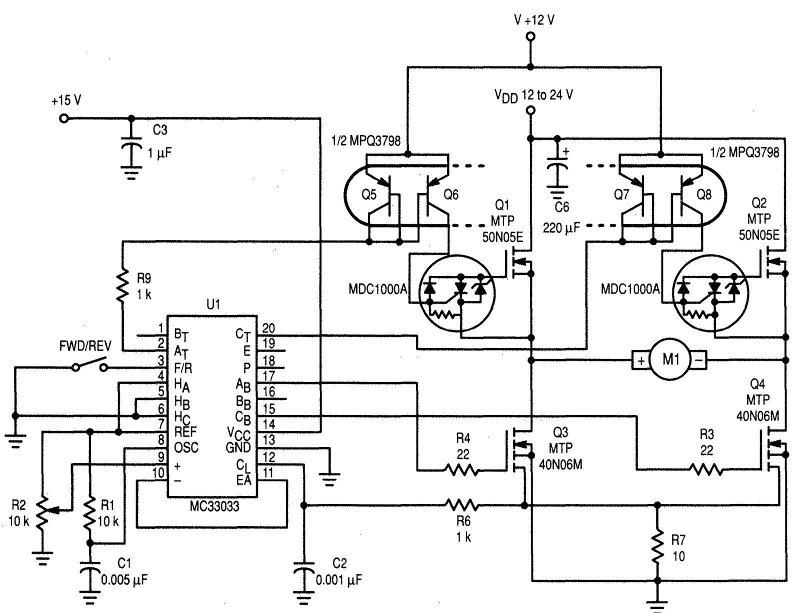


Figure 17. DC Motor Control Utilizing High Side MOSFET Switches

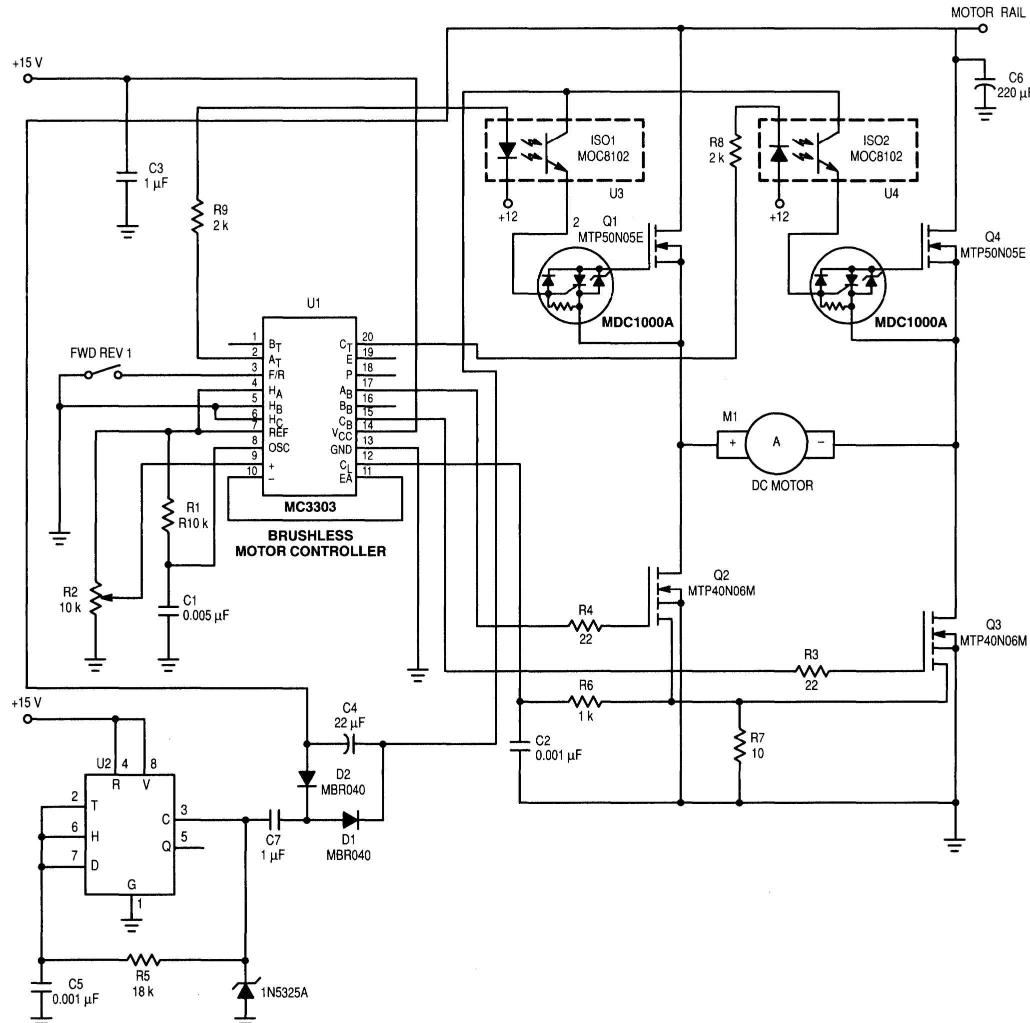


Figure 18. DC Motor Control With Optoisolated Level Shift

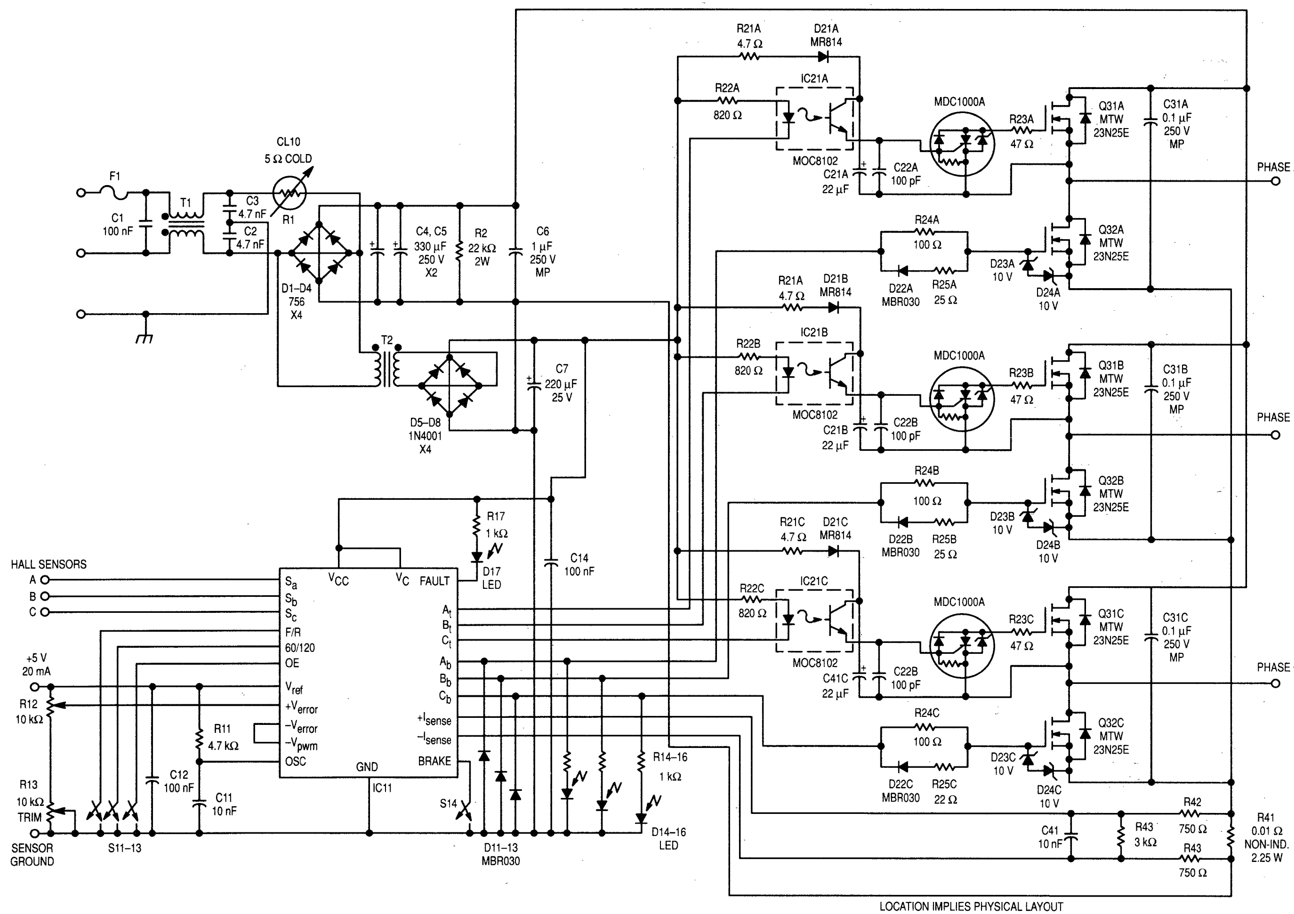
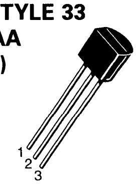


Figure 19. Optoisolated Brushless DC Motor Drive

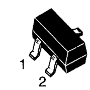
MDC1005A★

CASE 29-04, STYLE 33
TO-226AA
(TO-92)



MDC1005BLT1★

CASE 318-07, STYLE 22
TO-236AB
(SOT-23)



SMALLBLOCK
MOSFET TURN-OFF DEVICES

★These are Motorola designated preferred devices.

The MDC1005 series is a silicon turn-off device designed to reduce the turn-off time of a MOSFET. It also clamps the MOSFET gate voltage to a safe level. This device eliminates the use of individual components by integrating them into a single device. The use of the MDC1005 series can reduce system cost and board space, while optimizing the switching performance of the MOSFET. The MOSFET Turn-Off Device is a member of the SMALLBLOCK family.

- Output Voltage Clamped to 5.0 Volts to Protect the MOSFET Gate
- Very Fast Turn-Off Time, 22 Nanoseconds Typical
- Simplifies Circuit Design
- Reduces Board Space
- Two Package Styles: TO-92 for Insertion, SOT-23 for Surface Mount (SOT-23 available only in Tape and Reel)
- Applications Literature: EB-142; The MOSFET Turn-Off Device, A New Circuit Building Block

MAXIMUM RATINGS (T_A = 25°C unless otherwise specified)

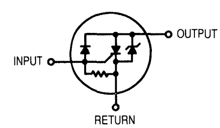
Rating	Symbol	Value	Unit
Input — Continuous	I_{IN}	50	mA
Input — Current Peak (Pulse Width = 20 μs, Duty Cycle ≤ 2%)	I_{INM}	500	mA
Thermal Resistance — Junction to Ambient	$R_{\theta JA}$		°C/mW
MDC1005A		0.227	
MDC1005BLT1		0.625	
Total Power Dissipation @ T_A = 25°C	P_D		mW
MDC1005A		550	
MDC1005BLT1*		200	
Derate above 25°C			mW/°C
MDC1005A		1.82	
MDC1005BLT1*		5.7	
Operating and Storage Temperature Range	T_J, T_{stg}	– 65 to +150	°C
Lead Soldering Temperature**	T_L	260	°C

*Device mounted on an FR-5 printed circuit board 1.0 x 0.75 x 0.062 inches using footprint shown in Section 8.
**Additional information on soldering of the MDC1005BLT1 surface mount package is shown in Section 8.

DEVICE MARKING

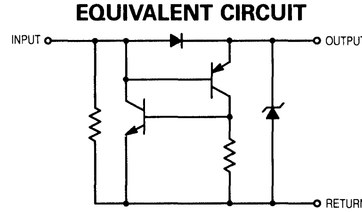
MDC1005A	MDC1005
MDC1005BLT1	C05

PIN CONNECTION DIAGRAMS



MDC1005A	MDC1005BLT1
1-Return	1-Return
2-Input	2-Output
3-Output	3-Input

EQUIVALENT CIRCUIT



6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Clamp Voltage [Note 1]	(I_{IN} = 2.0 mA) (I_{IN} = 50 mA)	V_{in}	5.5 5.5	5.8 6.0	6.5 6.8	V
Output Clamp Voltage [Note 2]	(I_{OUT} = 2.0 mA) (I_{OUT} = 50 mA)	V_{out}	5.0 5.0	5.2 5.5	6.0 6.3	V
Fall Time (1000 pF, from 5.0 V to 1.0 V) See Figures 1 and 2		t_f	—	22	—	ns
Propagation Delay (on)		$t_{prop(on)}$	—	6.0	—	ns
Propagation Delay (off)		$t_{prop(off)}$	—	22	—	ns
Input Capacitance @ 5.0 Volts, f = 1.0 MHz		C_{in}	—	7.0	—	pF
Dropout Current [Note 4]		$I_{(sus)}$	50	110	—	μA

[1] Input pin (+) to return pin(–) with output pin open.
[2] Input and output pins common(+) to return pin(–).
[3] MDC1005s should be mounted as close as possible to the MOSFET being controlled to minimize noise difficulties. In particular, the return lead should have as short a run to the MOSFET source lead as possible. Also, Kelvin connections between the MDC1005 return lead and the MOSFET source lead is recommended.
[4] Output Current level below which MTO must fall to insure driver MOSFET will turn back on.

SWITCHING

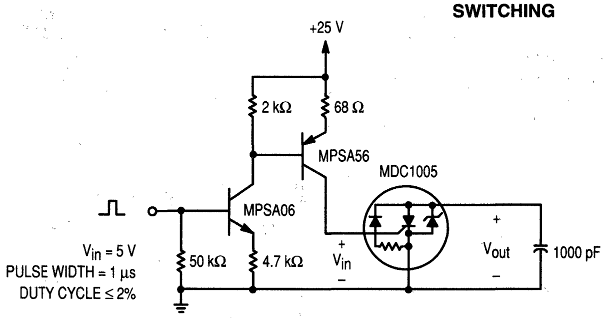


Figure 1. Turn-Off Time Test Circuit

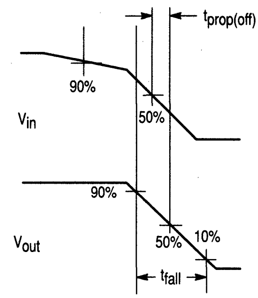


Figure 2. Turn-Off Waveforms

TYPICAL CHARACTERISTICS

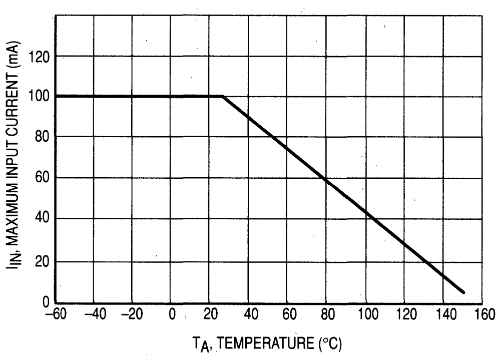


Figure 3. Allowable Input Current versus Ambient Temperature

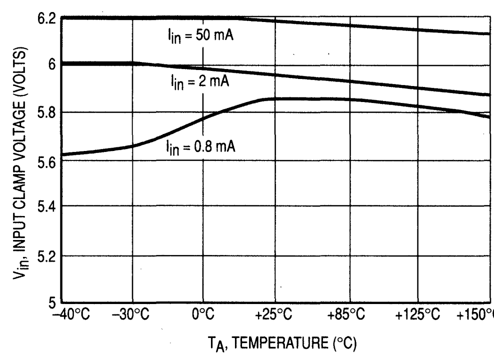


Figure 4. Input Clamp Voltage versus Ambient Temperature

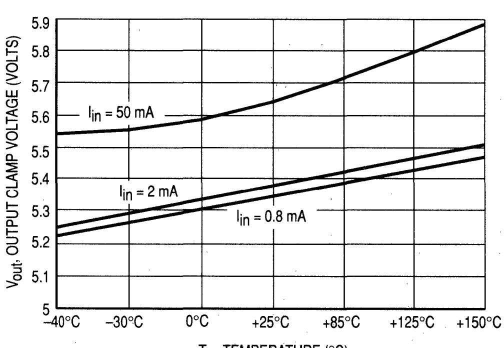


Figure 5. Output Clamp Voltage versus Ambient Temperature

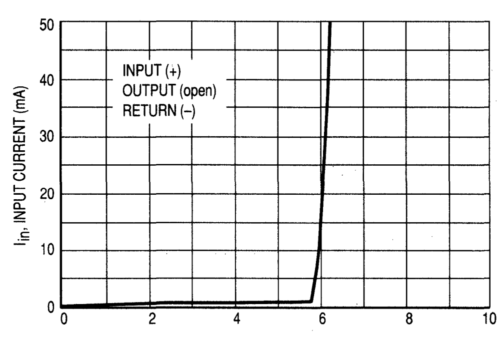


Figure 6. Input Characteristics

TYPICAL CHARACTERISTICS

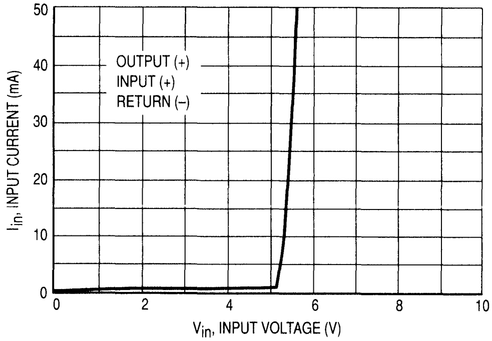


Figure 7. Output Characteristics

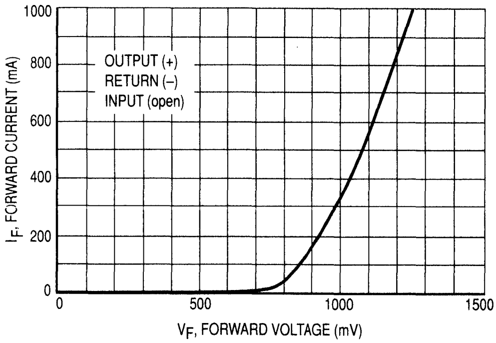


Figure 8. Forward Voltage Drop

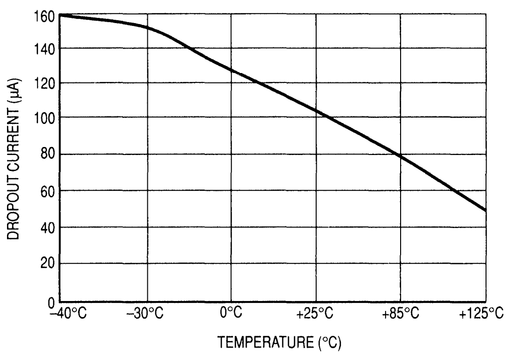


Figure 9. Dropout Current versus Temperature

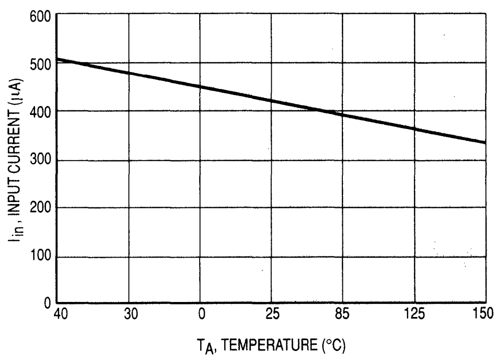


Figure 10. Input Current versus Temperature

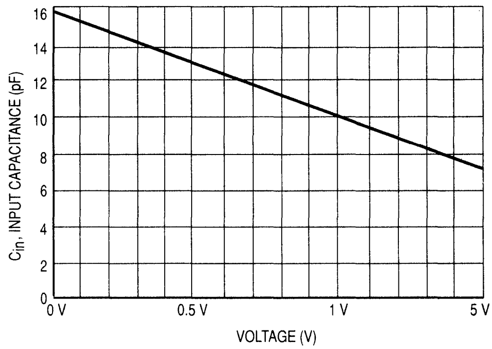


Figure 11. Input Capacitance versus Voltage

6

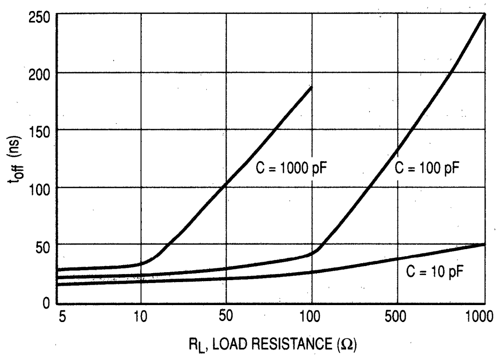


Figure 12. t_{off} versus Load Resistance

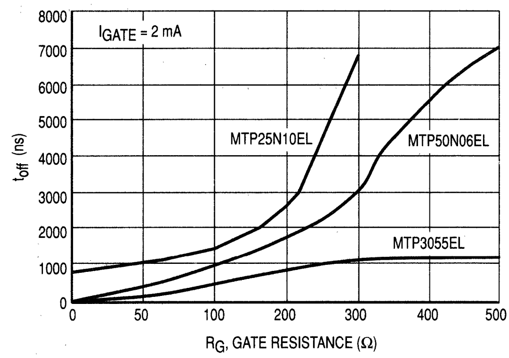


Figure 13. t_{off} versus Gate Resistance

OPERATING DESCRIPTION

The MDC1005 series provides an economical and space saving method of turning off a power MOSFET while achieving a level of circuit improvement at the same time. It reduces the component count of an active gate turn-off network for MOSFETs. The device quickly discharges the gate-source and gate-drain capacitances when the input signal is removed and provides protection of the gate-source in the event of an overvoltage condition on the control line.

To turn a MOSFET off, it is necessary to discharge the input capacitance to drive the gate-source voltage to below $V_{GS(th)}$. Turning on a MOSFET is fairly straight-forward, but turning it off frequently calls for some form of active turn-off network to help speed up the turn-off process. Typically, this has been achieved with a network comprised of several active and passive components. The effect of the turn-off network is to provide a low impedance discharge path for the MOSFET input capacitance and therefore speed up its turn-off.

Instead of a single PNP transistor which is commonly used for the turn-off function, an NPN has been added and is connected to the PNP in the configuration of an SCR. This combination provides the regenerative turn-on action of an SCR, further speeding up the process of discharging the gate of the MOSFET. It also contains an integral 5.2 volt zener diode, providing the MOSFET gate with overvoltage protection. Using the MDC1005 series, a power MOSFET can typically be turned off in tens of nanoseconds.

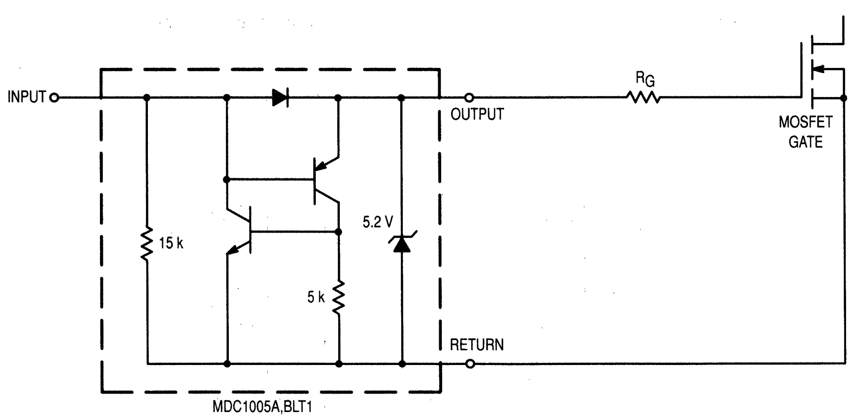


Figure 14. Recommended Gate Drive Circuit

TYPICAL APPLICATIONS UTILIZING THE MDC1005A

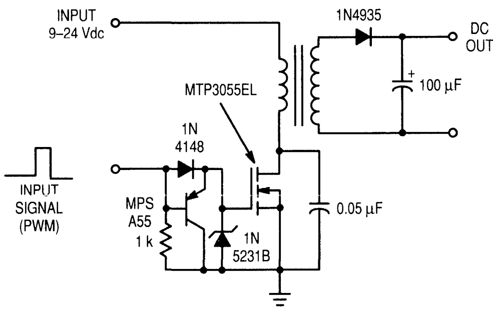


Figure 15a. Utilizing Discrete Components

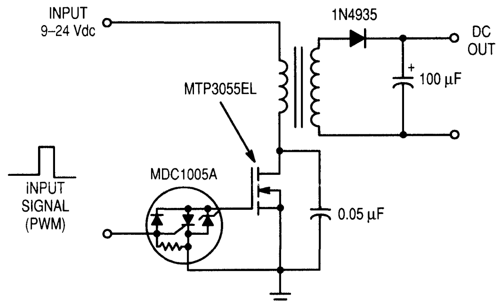


Figure 15b. Utilizing MDC1005A

Figure 15. Active MOSFET Gate Turn-Off Circuit

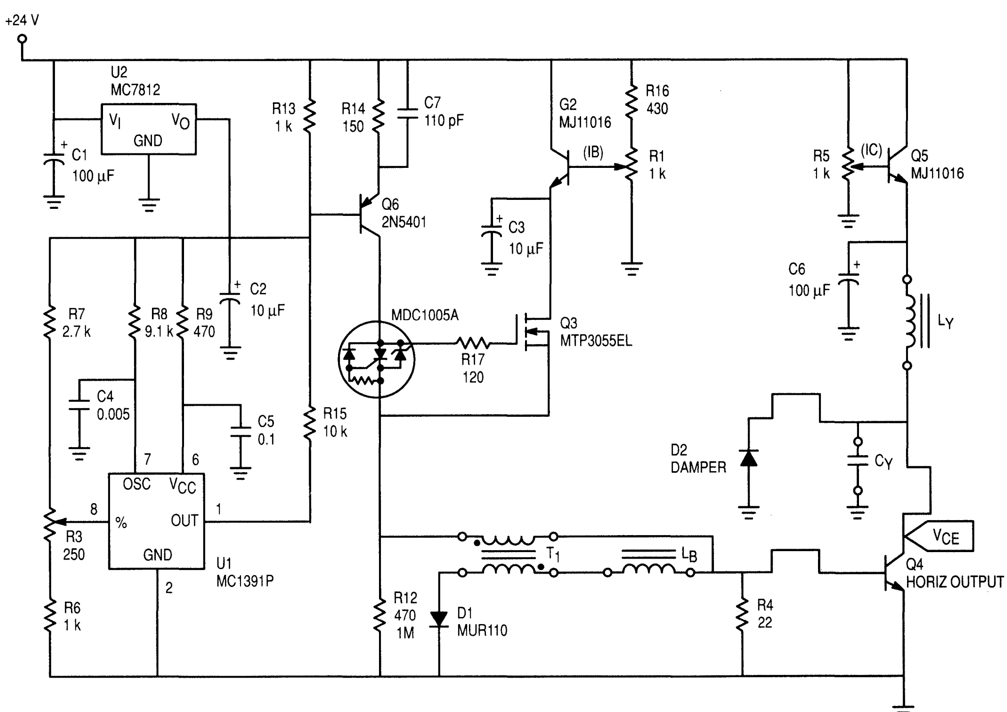
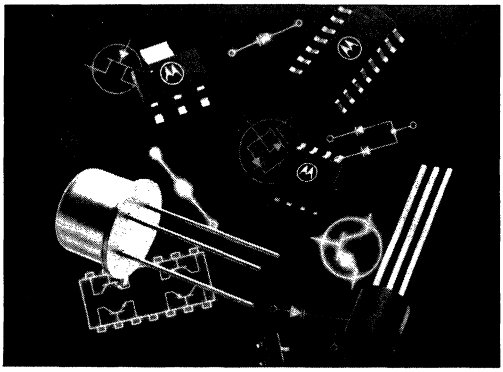


Figure 16. High Resolution Deflection Application Simulator



Tape and Reel Specifications and Packaging Specifications

7

Embossed Tape and Reel

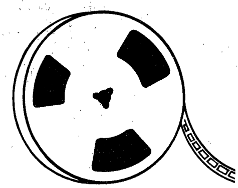
Embossed Tape and Reel is used to facilitate automatic pick and place equipment feed requirements. The tape is used as the shipping container for various products and requires a minimum of handling. The antistatic/conductive tape provides a secure cavity for the product when sealed with the "peel-back" cover tape.

- Two Reel Sizes Available (7" and 13")
- Used For Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, IEC 286-3, EIAJ RC-1009B
- SOT-23, SC-59 in 8 mm Tape
- SO-8, SOT-223 in 12 mm Tape
- SO-14, SO-16 in 16 mm Tape

Ordering Information

Use the standard device title and add the required suffix as listed in the option table below. Note that the individual reels have a finite number of devices depending on the type of product contained in the tape. Also note the minimum lot size is one full reel for each line item, and orders are required to be in increments of the single reel quantity. Minimum order $200.00/line-line.

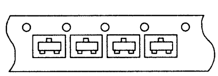
Tape and Reel Data for Discrete Surface Mount Devices



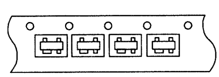
PACKAGES

SO-8 SOT-23
SO-14 SOT-143
SO-16 SOT-223
SC-59

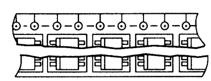
SC-59, SOT-23
8 mm



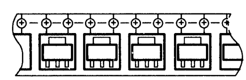
SOT-143
8 mm



SO-8, 14, 16
12, 16 mm



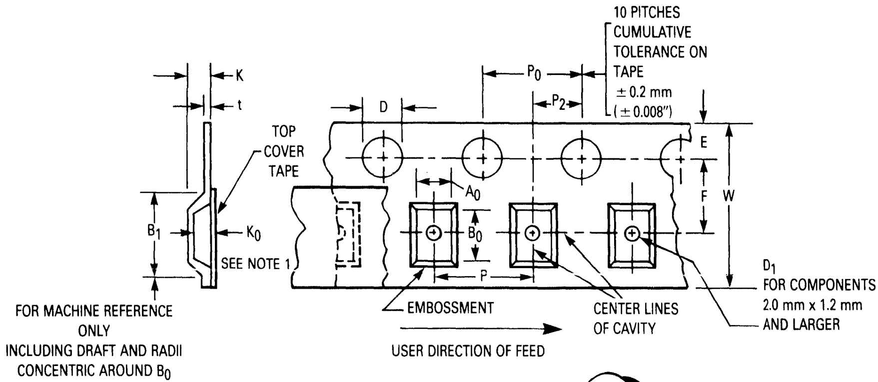
SOT-223
12 mm

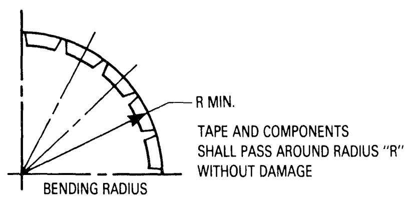


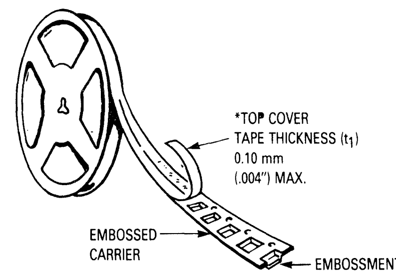
Package	Tape Width (mm)	Device per Reel	Reel Size (inch)	Tape & Reel Lot Size (Min)	Device Suffix
SOT-23 SC-59	8 8	3,000 10,000	7 13	3,000 10,000	T1 T3
SOT-143	8 8	3,000 10,000	7 13	3,000 10,000	T1 T3
SO-8	12 12	500 2,500	7 13	500 2,500	R1 R2
SOT-223	12	1,000 4,000	7 13	1,000 4,000	T1 T3
SO-14	16 16	500 2,500	7 13	500 2,500	R1 R2
SO-16	16 16	500 2,500	7 13	500 2,500	R1 R2

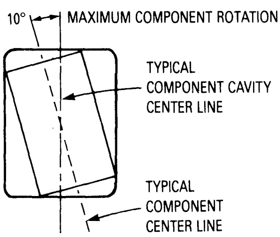
TAPE AND REEL DATA FOR DISCRETE SMD

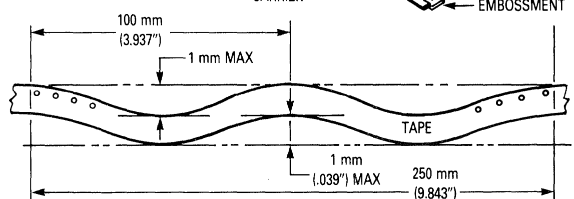
CARRIER TAPE SPECIFICATIONS











CAMBER (TOP VIEW)
ALLOWABLE CAMBER TO BE 1 mm/100 mm NONACCUMULATIVE OVER 250 mm

DIMENSIONS

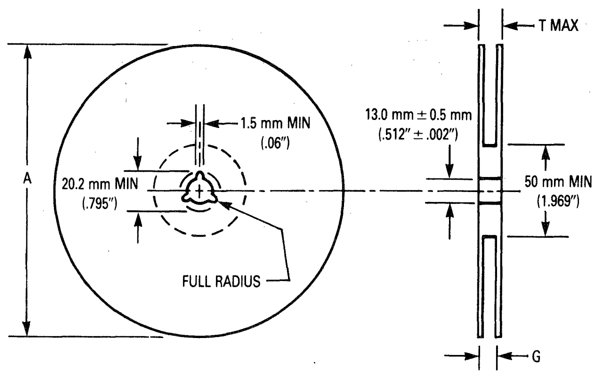
Tape Size	B_1 Max	D	D_1	E	F	K	P	P_0	P_2	R Min	T Max	W
8 mm	4.2 mm (.165")	1.5 + 0.1 mm − 0.0 (.059 + .004" − 0.0)	1.0 ± 0.1 mm Min (.039")	1.75 ± 0.1 mm (.069 ± .004")	3.5 ± 0.05 mm (.138 ± .002")	2.4 mm Max (.094")	4.0 ± 0.1 mm (.157 ± .004")	4.0 ± 0.1 mm (.157 ± .004")	2.0 ± 0.1 mm (.079 ± .002")	25 mm (.98")	0.400 mm (.016")	8.0 ± .30 mm (.315 ± .012")
12 mm	8.2 mm (.323")		1.5 mm Min (.060")		5.0 ± 0.05 mm (217 ± .002")	4.5 mm Max (.177")	4.0 ± 0.1 mm (.157 ± .004") 8.0 ± .01 mm (.315 ± .004")			25 mm (1.18")		12 ± .30 mm (.470 ± .012")
16 mm	12.1 mm (.476")				7.5 ± 0.10 mm (.295 ± .004")	6.5 mm (.256")	4.0 ± 0.1 mm (.157 ± .004") 8.0 ± .01 mm (.315 ± .004") 12.0 ± .004 mm (.472 ± .004")		2.0 ± .010 mm (.079 ± .004")	40 mm (1.575")		16 ± .30 mm (.630 ± .012")

Metric Dimensions Govern — English are in parentheses for reference only.

NOTE 1: A_0, B_0, and K_0 are determined by component size. The clearance between the components and the cavity must be within .05 min. to .50 max., the component cannot rotate more than 10° within the determined cavity.

REEL DIMENSIONS

Metric Dimensions Govern — English are in Parentheses for Reference only.



Size	A Max	G	T Max
8 mm	330 mm (12.992")	8.4 mm + 1.5 mm, − 0.0 (.33" + .059", − 0.00)	14.4 mm (.56")
12 mm	330 mm (12.992")	12.4 mm + 2.0 mm, − 0.0 (.49" + .079", − 0.00)	18.4 mm (.72")
16 mm	360 mm (14.173")	16.4 mm + 2.0 mm, − 0.00 (.646" + .078", − 0.00)	22.4 mm (.882")

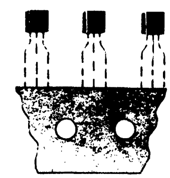
7

TO-92 EIA, IEC, EIAJ Radial Tape Reel or Ammo Pack

Radial tape reel and ammo pack of the reliable TO-92 package are the best methods of capturing devices for automatic insertion in printed circuit boards. These methods of taping are compatible with various equipment for active and passive component insertion.

- Available on 365 mm Reels
- Available in Ammo Pack (Fan Fold Box)
- Accommodates All Standard Inserters
- Allows Flexible Circuit Board Layout
- 2.5 mm Pin Spacing for Soldering
- EIA-468, IEC 286-2, EIAJ RC1008B

TO-92 RADIAL TAPE REEL OR AMMO PACK



Ordering Notes:

When ordering radial tape on reel or in ammo pack, specify the style per Figures 3 thru 8. Add the suffix "RLR" and "Style" to the device title, i.e. MPS3904RLRA. This will be a standard MPS3904 radial taped and supplied on a reel per Figure 3.

Reel Information — Minimum order quantity 1 Reel/$200LL.
Order in increments of 2000.

Ammo Pack Information — Minimum order quantity 1 Box/$200LL.
Order in increments of 2000.

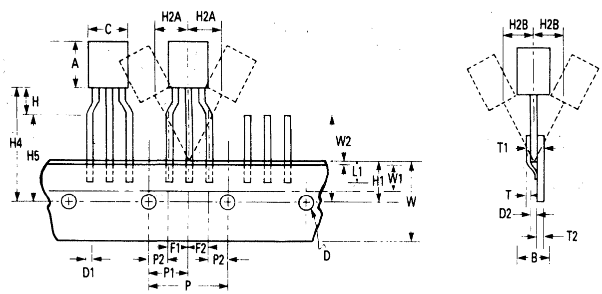
US/European Suffix Conversions

US	EUROPE
RLRA	RL
RLRE	RL1
RLRM	ZL1

7

TO-92 EIA RADIAL TAPE REEL OR AMMO PACK

Figure 1. Device Positioning on Tape



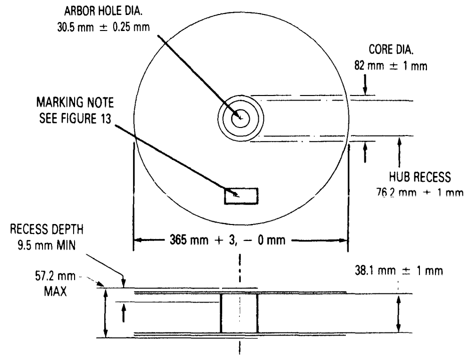
Symbol	Item	Specification			
		Inches		Millimeter	
		Min	Max	Min	Max
A	Component Body Height	0.170	0.210	4.32	5.33
B	Component Body Width	0.125	0.165	3.18	4.19
C	Component Body Length along Tape	0.1748	0.2052	4.44	5.21
D	Tape Feedhole Diameter	0.145	0.1693	3.7	4.3
D1	Component Lead Width Dimension	0.016	0.022	0.41	0.56
D2	Component Lead Thickness Dimension	0.015	0.020	0.38	0.51
F1, F2	Component Lead Pitch	0.0945	0.110	2.4	2.8
H	Bottom of Component to Seating Plane	.059	.156	1.5	4.0
H1	Feedhole Location	0.3346	0.3741	8.5	9.5
H2A	Deflection Left or Right	0	0.039	0	1
H2B	Deflection Front or Rear	0	0.051	0	1.3
H3	Feedhole to Overall Component Height	0	1.2600	0	32
H4	Feedhole to Bottom of Component	0.7086	0.768	18	19.5
H5	Feedhole to Seating Plane	0.610	0.649	15.5	16.5
L	Defective Unit Clipped Dimension	0.3346	0.433	8.5	11
L1	Lead Wire Enclosure	0.09842	—	2.5	—
P	Feedhole Pitch	0.4921	0.5079	12.5	12.9
P1	Feedhole Center to Center Lead	0.2342	0.2658	5.95	6.75
P2	First Lead Spacing Dimension	0.1397	0.1556	3.55	3.95
T	Adhesive Tape Thickness	0.06	0.08	0.15	0.20
T1	Overall Taped Package Thickness	—	0.0567	—	1.44
T2	Carrier Strip Thickness	0.014	0.027	0.35	0.65
W	Carrier Strip Width	0.6889	0.07481	17.5	19
W1	Adhesive Tape Width	0.2165	0.2841	5.5	6.3
W2	Adhesive Tape Position	—	0.01968	—	0.5

NOTES:
1. Maximum alignment deviation between leads not to be greater than 0.2 mm.
2. Defective components shall be clipped from the carrier tape such that the remaining protrusion (L) does not exceed a maximum of 11 mm.
3. Component lead to tape adhesion must meet the pull test requirements established in Figures 10, 11 and 12.
4. Maximum non-cumulative variation between tape feed holes shall not exceed 1 mm in 20 pitches.
5. Holddown tape not to extend beyond the edge(s) of carrier tape and there shall be no exposure of adhesive.
6. No more than 1 consecutive missing component is permitted.
7. A tape trailer and leader, having at least three feed holes is required before the first and after the last component.
8. Splices will not interfere with the sprocket feed holes.

TO-92 EIA RADIAL TAPE REEL OR AMMO PACK

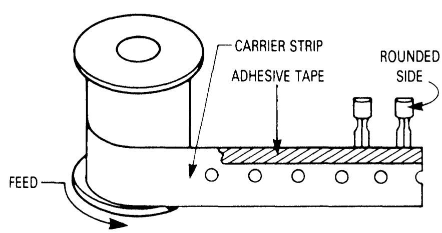
REEL STYLES

Figure 2. Reel Specifications



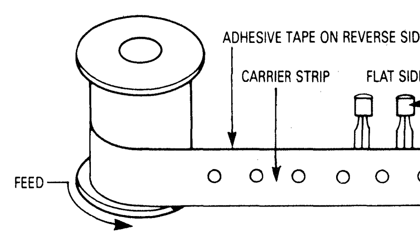
Material used must not cause deterioration of components or degrade lead solderability.

Figure 3. Style A



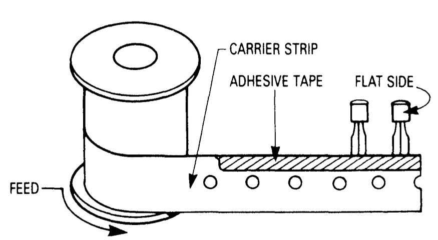
Rounded size of transistor and adhesive tape visible.

Figure 4. Style B



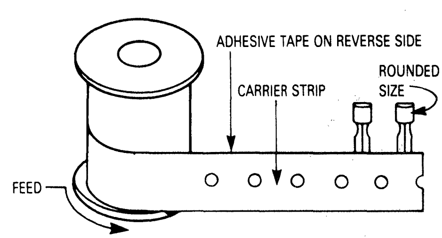
Flat side of transistor and carrier strip visible (adhesive tape on reverse side).

Figure 5. Style E



Flat side of transistor and adhesive tape visible.

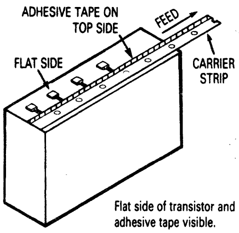
Figure 6. Style F



Rounded side of transistor and carrier strip visible (adhesive tape on reverse side).

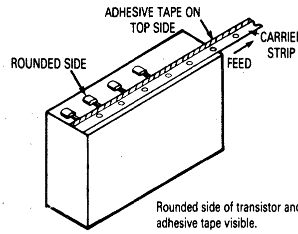
AMMO PACK STYLES

Figure 7. Style M



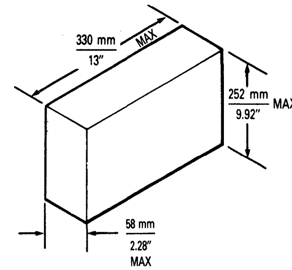
Style M ammo pack is equivalent to Styles E and F of reel pack dependent on feed orientation from box.

Figure 8. Style P



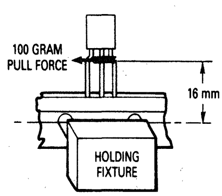
Style P ammo pack is equivalent to Styles A and B of reel pack dependent on feed orientation from box.

Figure 9. Ammo Pack Dimensions



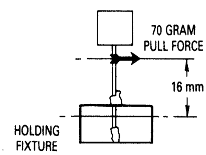
ADHESION PULL TESTS

Figure 10. Test #1



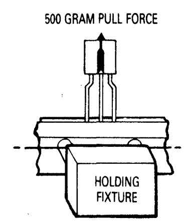
The component shall not pull free with a 300 gram load applied to the leads for 3 ± 1 second.

Figure 11. Test #2



The component shall not pull free with a 70 gram load applied to the leads for 3 ± 1 second.

Figure 12. Test #3



There shall be no deviation in the leads and no component leads shall be pulled free of the tape with a 500 gram load applied to the component body for 3 ± 1 second.

7

TO-92 Lead Forming

Figure 13. Ordering Notes

How to choose Lead Form option:

1. Determine option either TO-18 or TO-5, see Dimensional Drawings
   *Identify measurement between centres of the two outside leads:
   i.e. 2.5 mm for TO-18
   5.0 mm for TO-5
2. Determine the pinout of the device (Style Number — see Product Data Sheet)
3. Identify Drawing corresponding to Style Number (see Figures 8a and 8b).

Example:
BC237B configured TO-18. . . .
See Data Sheet for Style Number
Style 17 . . . Drawing indicates Dimensions, and that position of Centre Lead is towards the round side of the product (towards the back)
Order type: **BC237B18**

Other Examples:

P2N2222-18	P2N2222A18
2N5551-5	BC488A18
BC337-25-5	BC547C5

Note: For reverse configurations, please consult the factory.

Bar Code Labelling

The Intermediate Package Label shall contain, as a minimum, the Motorola part number, Motorola lot number, Motorola manufacturing date (date code), and quantity as shown in Exhibit 4a. Customer part number (CPN) label, Exhibit 4b, shall be added when CPN is available.

Data Identifier Codes

Data identifier codes shall be included on both the Intermediate Labels and the Shipping Labels. On these labels a data identifier code in the first position following the start code of the bar code symbol is used to identify the information to follow. This character is not to be included in the human readable line, but is shown in the human readable title for the appropriate data area. See Exhibits 2 and 3.

No additional bar code symbols will be placed on the Shipping Identification Label nor on the Intermediate Package Label unless it contains a data identifier to differentiate it from other bar code symbols.

Motorola had initially attempted to standardize on a set of data identifiers which it believed to be the preferred standard. However, with the establishment of the EIA STANDARD EIA-556A, Electronic Industries Association Shipping Container Bar Code Label Standard and their adoption of the "Standard of the Federation of Automated Coding Technologies" (FACT) identifiers, we have altered our standards to comply with this new Industry Standard. Therefore, the following identifiers will be used to identify data found on our labels:

P — Customer Product Identification — (Customer part number)
1P — Motorola Part Number
Q — Quantity
K — Transaction Number — (Customer P.O. No.)
3S — Package Identification assigned by Motorola to the lowest level of shipping package.* (This is the most common designator used by Motorola.)
4S — Package Identification assigned by Motorola to a master package containing the same items. (Single Product / Single Order)* Lower levels of packaging within this master package will contain separate packaging labels.
5S — Package Identification assigned by Motorola to a master package containing unlike items. (MIXED LOAD / Single Order)* Lower levels of packaging within this master package will contain separate packaging labels.
6S — Package Identification assigned by Motorola to a master package containing the same items over multiple customer orders. (Single Product / Multiple Customer Orders)* Lower levels of packaging within this master package will contain separate packaging labels.
7S — Package Identification assigned by Motorola to a master package containing unlike items over multiple customer orders. (MIXED LOAD / Multiple Customer Orders)* Lower levels of packaging within this master package will contain separate packaging labels.

*NOTE: Supplier Package ID is made up of Vendor ID (Motorola's EIA ID is 185) followed by a "plus" (+) and the ship date (YYWW) and the Packing List Number. This combination will provide a unique identification not repeated by Motorola.
(Example — 185 + 884510000A for Motorola shipment of 45th week 1988 with packing list number 10000A.)

*NOTE: Some identifier codes only apply to shipping labels and others only intermediate containers and vice versa.

9D — Manufacturing Date (Date Code — YYWW)
1T — Motorola Manufacturing Lot Number for traceability
V — Vendor Code assigned by Customer
6V — EIA Manufacturer's identification code for Motorola (185)

Example: Motorola part number in human readable form = MC146805E2CP
Bar code symbol for Motorola part number = 1PMC146805E2CP
Customer part number in human readable form = 1401-23456
Bar code symbol for Customer part number = P1401-23456

7

The human readable part number characters shall be bold and a minimum 0.125 inch (3 mm) high. The bar code symbol of the part number shall be directly below the human readable characters and shall be a minimum 0.250 inch (6.35 mm) high. Depending on the nominal dimension of the narrow bar code elements, part numbers of varying lengths can be printed on one line. The maximum length of any bar code symbol should not exceed 3.5 inches (89 mm). The part number shall be designated by Motorola for Standard Devices or by the customer for Special Devices. The maximum length anticipated for the part number is sixteen (16) characters plus the data identifier ("P" for Customer Part Number or "1P" for Motorola Part Number).

Bar Code Symbology

Bar Codes shall be of the 3-of-9 (Code 39) type and shall conform to the Bar Code Symbology Standard for 3-of-9 Bar Codes published by EIA-556A. In addition to this symbology specification, the following paragraphs cover specific requirements for the Motorola Intermediate and Shipping Labels.

Code Configuration

The Code 39 configuration is in accordance with (AIM) USS 39 Symbol specification.

Code Density and Dimensions

The bar heights shall be a minimum of 0.250 inch (6.35 mm). The width of the narrow elements ('X' dimension) shall be within the range of .007 to 0.16 inch. The ratio of the nominal width of the wide to narrow elements shall be 3:1, with an allowable range of 2.8:1 to 3.2:1.

Check Digits

Check digits shall not be used in the bar codes.

Reflectivity and Contrast

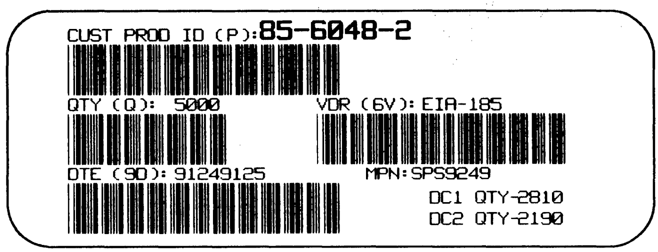
The printed bar code symbols shall meet the contrast and reflectivity requirements specified in EIA-556A, at all electromagnetic wave lengths from B633 to B900 nanometers.

Quiet Zone

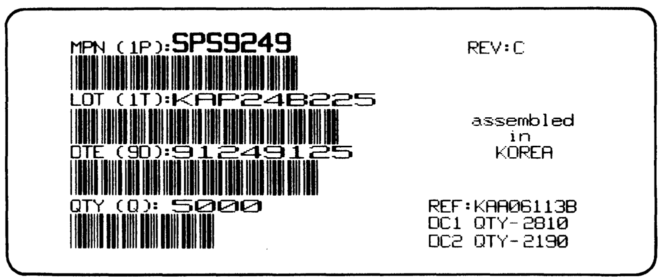
The minimum quiet zone for each bar coded data element shall be 0.25 inch.

Special Labels

While we hope that these specifications will cover most situations, there will be circumstances where requirements will dictate special arrangements between customers and Motorola. Every effort to minimize these situations should be a goal of all so that complexities and costs are not added.

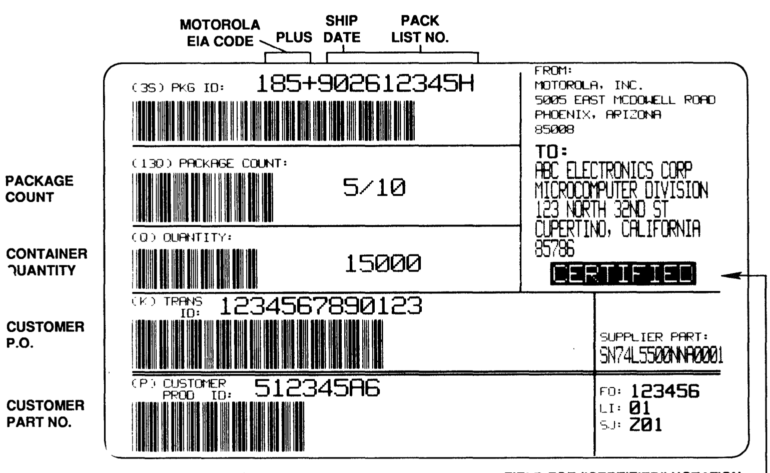


MOTOROLA "INTERNAL USE" INTERMEDIATE CONTAINER LABEL



CUSTOMER PART NUMBER INTERMEDIATE CONTAINER LABEL

(Added to container when customer part number is available)
Label size may be adjusted to fit intermediate packing, but it shall contain all Bar Code information shown above as a minimum.



MOTOROLA STANDARD DEVICE SHIPPING LABEL

7

TO-92 Lead Forming

Lead configurations conform to TO-18 or TO-5 pin circles.

Ordering Notes:
When ordering Lead Formed TO-92, verify the style per Figures 1a and 1b.

Figure 1a. TO-18 Styles and Dimensions

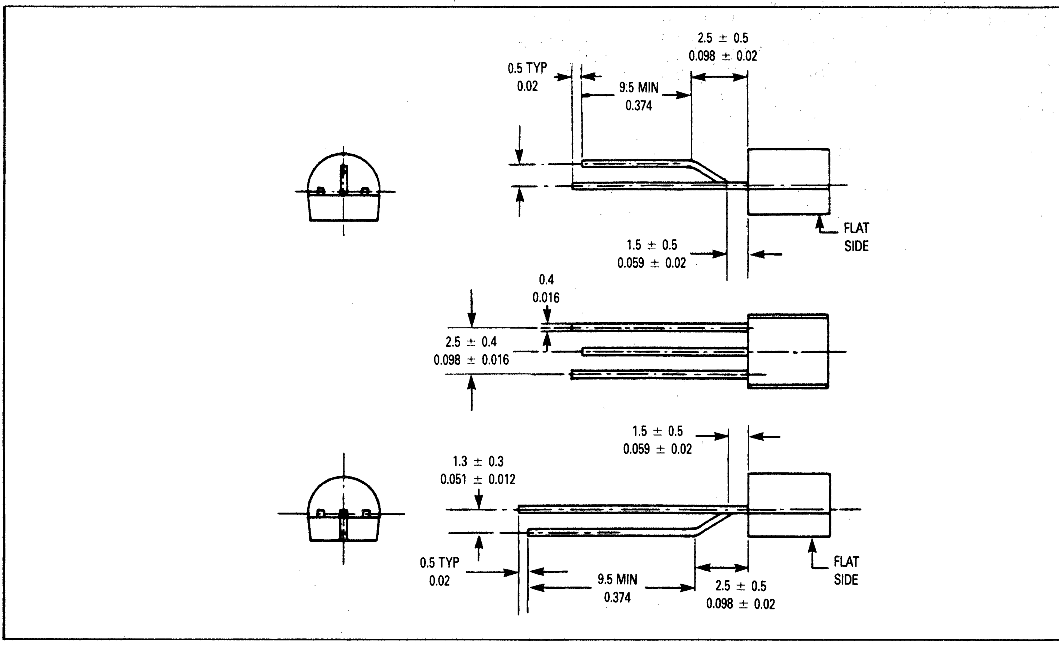
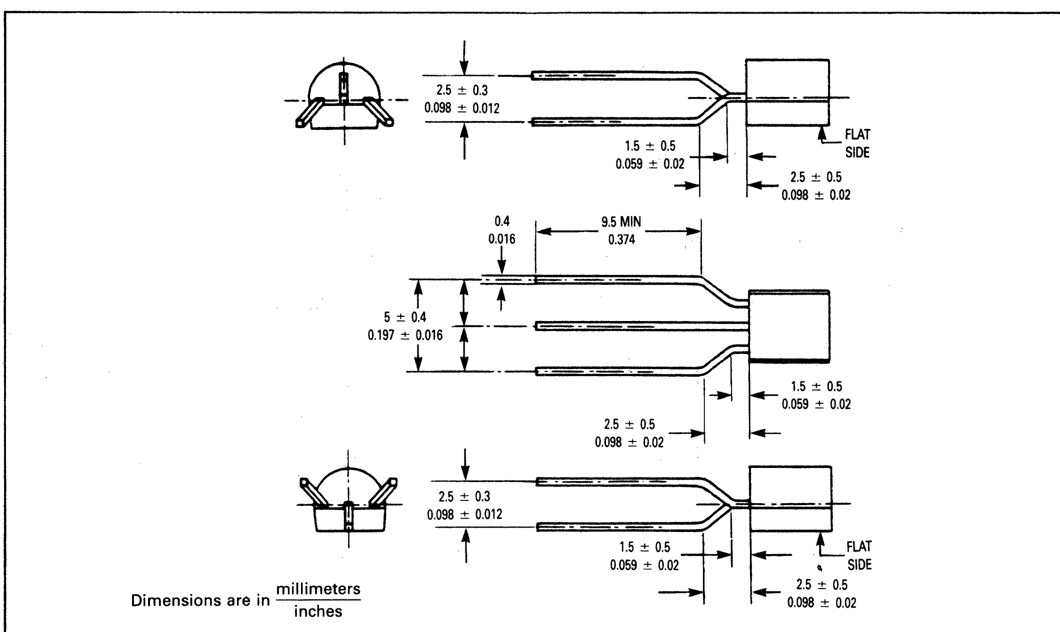
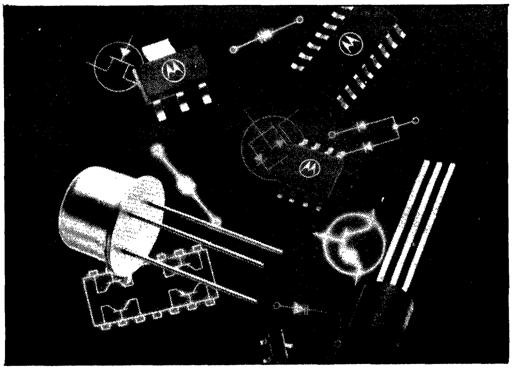


Figure 1b. TO-5 Styles and Dimensions





The following pages contain information on the various packages referenced on the individual data sheets. Information includes: a picture of the package, dimensions in both millimeters and inches, the various pinout configurations (styles), a cross reference for case numbers, old JEDEC "TO" numbers, the new JEDEC "TO" designation, and footprint dimensions for surface mount packages to assist in board layout.

Additionally, abstracts of available application notes are provided. Please contact your local sales representative for those desired.

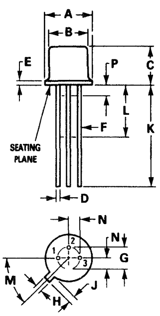
Package Outline Dimensions, Footprints, and Applications Literature

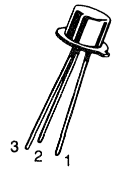
8

Package Outline Dimensions

Dimensions are in inches unless otherwise noted.

CASE 22-03 TO-18 (TO-206AA) METAL





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22 STYLES

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. SOURCE, SUBSTRATE AND CASE
2. GATE
3. DRAIN

STYLE 3:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

STYLE 5:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

STYLE 6:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 7:
PIN 1. ANODE
2. BASE
3. CATHODE

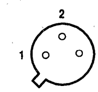
STYLE 8:
PIN 1. GATE
2. ANODE 1
3. ANODE 2

STYLE 9:
PIN 1. ANODE 2
2. ANODE 1
3. GATE (CONNECTED TO CASE)

STYLE 10:
PIN 1. BASE
2. EMITTER
3. BASE

STYLE 11:
PIN 1. DRAIN
2. GATE
3. SOURCE, SUBSTRATE

STYLE 12:
PIN 1. SOURCE
2. GATE
3. DRAIN (CASE)

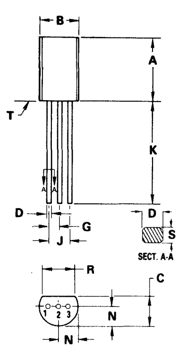


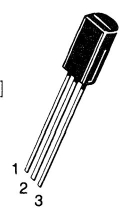
STYLE 13:
PIN 1. ANODE
2. GATE
3. CATHODE

STYLE 14:
PIN 1. ANODE
2. OPEN
3. CATHODE

CASE 29-03 (TO-226E) TO-92 1-WATT PLASTIC

NOTES:
1. DIMENSIONS -A- AND -B- ARE DATUMS.
2. -T- IS SEATING PLANE.
3. POSITIONAL TOLERANCE FOR LEADS:
⌖ | φ 0.10 (0.004) Ⓜ | T | A Ⓜ | B Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1982.
5. CONTROLLING DIM: INCH.

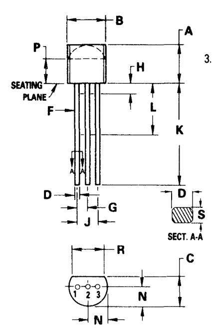


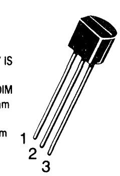


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.37	7.87	0.290	0.310
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.46	0.61	0.018	0.024
G	1.27 BSC		0.050 BSC	
J	2.54 BSC		0.100 BSC	
K	12.70	—	0.500	—
N	2.03	2.92	0.080	0.115
R	3.43	—	0.135	—
S	0.46	0.61	0.018	0.024

CASE 29-04 (TO-226AA) TO-92 PLASTIC

NOTES:
1. CONTOUR OF PACKAGE BEYOND ZONE "P" IS UNCONTROLLED.
2. DIM "F" APPLIES BETWEEN "H" AND "L". DIM "D" & "S" APPLIES BETWEEN "L" & 12.70mm (0.5") FROM SEATING PLANE. LEAD DIM IS UNCONTROLLED IN "H" & BEYOND 12.70mm (0.5") FROM SEATING PLANE.
3. CONTROLLING DIM: INCH.





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.20	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.55	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.15	1.39	0.045	0.055
H	—	2.54	—	0.100
J	2.42	2.66	0.095	0.105
K	12.70	—	0.500	—
L	6.35	—	0.250	—
N	2.04	2.66	0.080	0.105
P	2.93	—	0.115	—
R	3.43	—	0.135	—
S	0.39	0.50	0.015	0.020

CASE 29 STYLES

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 6:
PIN 1. GATE
2. SOURCE AND SUBSTRATE
3. DRAIN

STYLE 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 8:
PIN 1. DRAIN
2. GATE
3. SOURCE AND SUBSTRATE

STYLE 9:
PIN 1. BASE 1
2. EMITTER
3. BASE 2

STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 11:
PIN 1. ANODE
2. CATHODE AND ANODE
3. CATHODE

STYLE 12:
PIN 1. MAIN TERMINAL 1
2. GATE
3. MAIN TERMINAL 2

STYLE 13:
PIN 1. ANODE 1
2. GATE
3. CATHODE 2

STYLE 14:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 15:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2

STYLE 16:
PIN 1. ANODE
2. GATE
3. CATHODE

STYLE 17:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 18:
PIN 1. ANODE
2. CATHODE
3. NOT CONNECTED

STYLE 19:
PIN 1. GATE
2. ANODE
3. CATHODE

STYLE 20.
PIN 1. NOT CONNECTED
2. CATHODE
3. ANODE

STYLE 21:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

STYLE 22:
PIN 1. SOURCE
2. GATE
3. DRAIN

STYLE 23:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 24:
PIN 1. EMITTER
2. COLLECTOR/ANODE
3. CATHODE

STYLE 25:
PIN 1. MT 1
2. GATE
3. MT 2

STYLE 26:
PIN 1. V_{CC}
2. GROUND 2
3. OUTPUT

STYLE 27:
PIN 1. MT
2. SUBSTRATE
3. MT

STYLE 28:
PIN 1. CATHODE
2. ANODE
3. GATE

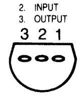
STYLE 29
PIN 1. NOT CONNECTED
2. ANODE
3. CATHODE

STYLE 30:
PIN 1. DRAIN
2. GATE
3. SOURCE

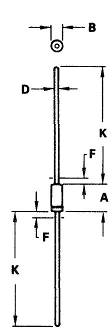
STYLE 31:
PIN 1. GATE
2. DRAIN
3. SOURCE

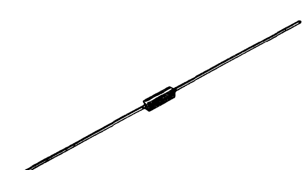
STYLE 32:
PIN 1. BASE
2. COLLECTOR
3 EMITTER

STYLE 33:
PIN 1. RETURN
2. INPUT
3. OUTPUT



CASE 51-02





NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

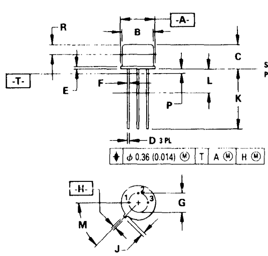
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	—	1.27	—	0.050
K	25.40	38.10	1.000	1.500

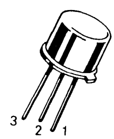
All JEDEC dimensions and notes apply

8

PACKAGE OUTLINE DIMENSIONS (continued)

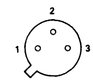
CASE 79-04 (TO-205AD) TO-39 METAL





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.39	0.335	0.370
B	7.75	8.50	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.41	0.53	0.016	0.021
E	0.23	1.04	0.009	0.041
F	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.72	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	19.05	0.500	0.750
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
P	—	1.27	—	0.050
R	2.54	—	0.100	—

CASE 79 STYLES



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION J MEASURED FROM DIMENSION A MAXIMUM.
4. DIMENSION B SHALL NOT VARY MORE THAN 0.25 (0.010) IN ZONE R. THIS ZONE CONTROLLED FOR AUTOMATIC HANDLING.
5. DIMENSION F APPLIES BETWEEN DIMENSION P AND L. DIMENSION D APPLIES BETWEEN DIMENSION L AND K MINIMUM. LEAD DIAMETER IS UNCONTROLLED IN DIMENSION P AND BEYOND DIMENSION K MINIMUM.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 3:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 4:
PIN 1. MAIN TERM. 1
2. GATE
3. MAIN TERM. 2

STYLE 5:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 6:
PIN 1. SOURCE
2. GATE
3. DRAIN (CASE)

STYLE 7:
PIN 1. DRAIN
2. GATE
3. SOURCE

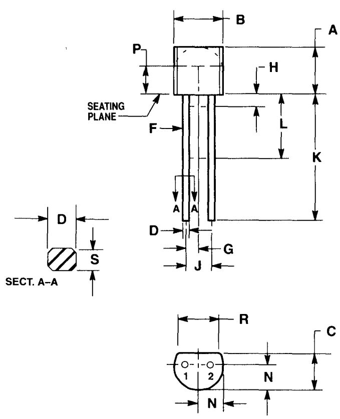
STYLE 8:
PIN 1. ANODE
2. ANODE
3. CATHODE

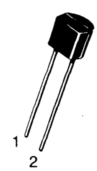
STYLE 9:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 10:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

STYLE 11:
PIN 1. ANODE
2. OPEN
3. CATHODE

CASE 182-02 (TO-226AC) TO-92 PLASTIC





STYLE 1:
PIN 1. ANODE
2. CATHODE

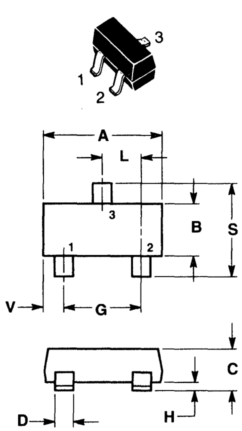
STYLE 2:
PIN 1. CATHODE
2. ANODE

STYLE 3:
PIN 1. MAIN TERMINAL 1
2. MAIN TERMINAL 2

NOTES:
1. CONTOUR OF PACKAGE BEYOND ZONE P IS CONTROLLED.
2. DIMENSION F APPLIES BETWEEN H AND L. DIMENSION D AND S APPLIES BETWEEN L AND 12.70mm (0.5") FROM SEATING PLANE. LEAD DIMENSION IS UNCONTROLLED IN H AND BEYOND 12.70mm (0.5") FROM SEATING PLANE.
3. 182-01 AND 182-03 OBSOLETE, NEW STANDARD 182-02.

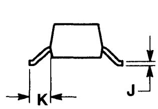
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–
S	0.36	0.41	0.014	0.016

CASE 318-07 TO-236AB (SOT-23) PLASTIC



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. 318-03 OBSOLETE, NEW STANDARD 318-07.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0.1102	0.1197
B	1.20	1.40	0.0472	0.0551
C	0.89	1.11	0.0350	0.0440
D	0.37	0.50	0.0150	0.0200
G	1.78	2.04	0.0701	0.0807
H	0.013	. 0.100	0.0005	0.0040
J	0,085	0.177	0.0034	0.0070
K	0.45	0.60	0.0180	0.0236
L	0.89	1.02	0.0350	0.0401
S	2.10	2.50	0.0830	0.0984
V	0.45	0.60	0.0177	0.0236



CASE 318 STYLES

STYLE 6:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 7:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 8:
PIN 1. ANODE
2. NO CONNECTION
3. CATHODE

STYLE 9:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 10:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 11:
PIN 1. ANODE
2. CATHODE
3. CATHODE-ANODE

STYLE 12:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 13:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 14:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 15:
PIN 1. GATE
2. CATHODE
3. ANODE

STYLE 16:
PIN 1. ANODE
2. CATHODE
3. CATHODE

STYLE 17:
PIN 1. NO CONNECTION
2. ANODE
3. CATHODE

STYLE 18:
PIN 1. NO CONNECTION
2. CATHODE
3. ANODE

STYLE 19:
PIN 1. CATHODE
2. ANODE
3. CATHODE-ANODE

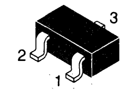
STYLE 20:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 21:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 22:
PIN 1. RETURN
2. OUTPUT
3. INPUT

STYLE 23:
PIN 1. ANODE
2. ANODE
3. CATHODE

CASE 318D-03 (SC-59)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. N.C.
2. ANODE
3. CATHODE

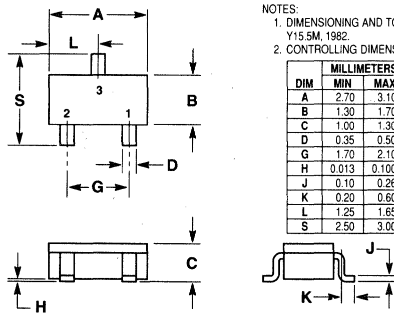
STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. N.C.
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. CATHODE
2. CATHODE
3. ANODE

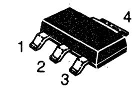
STYLE 6:
PIN 1. CATHODE
2. ANODE
3. ANODE/CATHODE

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y15.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETERS.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.70	3.10	0.1063	0.1220
B	1.30	1.70	0.0512	0.0669
C	1.00	1.30	0.0394	0.0511
D	0.35	0.50	0.0138	0.0196
G	1.70	2.10	0.0670	0.0826
H	0.013	0.100	0.0005	0.0040
J	0.10	0.26	0.0040	0.0102
K	0.20	0.60	0.0079	0.0236
L	1.25	1.65	0.0493	0.0649
S	2.50	3.00	0.0985	0.1181

CASE 318E-04 (SOT-223)



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. ANODE
2. CATHODE
3. NC
4. CATHODE

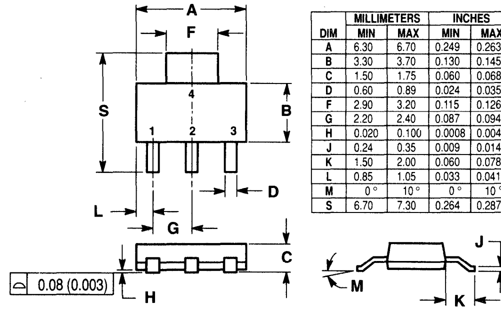
STYLE 3:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE
4. DRAIN

STYLE 5:
PIN 1. DRAIN
2. GATE
3. SOURCE
4. GATE

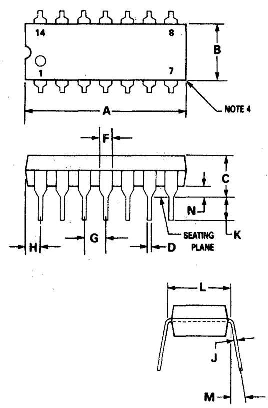
STYLE 6:
PIN 1. RETURN
2. INPUT
3. OUTPUT
4. INPUT

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETERS.



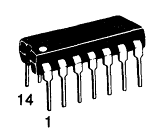
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.30	6.70	0.249	0.263
B	3.30	3.70	0.130	0.145
C	1.50	1.75	0.060	0.068
D	0.60	0.89	0.024	0.035
F	2.90	3.20	0.115	0.126
G	2.20	2.40	0.087	0.094
H	0.020	0.100	0.0008	0.0040
J	0.24	0.35	0.009	0.014
K	1.50	2.00	0.060	0.078
L	0.85	1.05	0.033	0.041
M	0°	10°	0°	10°
S	6.70	7.30	0.264	0.287

CASE 646-06 (14-PIN DIP) PLASTIC



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NO CONNECTION
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NO CONNECTION
12. EMITTER
13. BASE
14. COLLECTOR

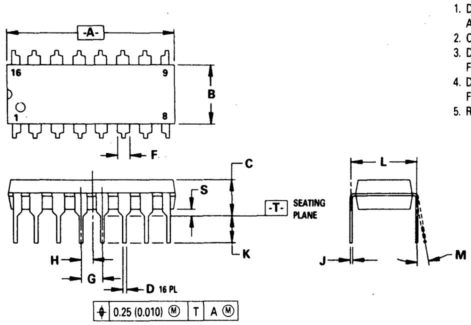
STYLE 5:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. NO CONNECTION
5. SOURCE
6. DRAIN
7. GATE
8. GATE
9. DRAIN
10. SOURCE
11. NO CONNECTION
12. SOURCE
13. DRAIN
14. GATE



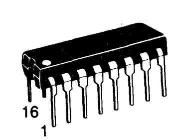
NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
4. ROUNDED CORNERS OPTIONAL.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	19.56	0.715	0.770
B	6.10	6.60	0.240	0.260
C	3.69	4.69	0.145	0.185
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	1.32	2.41	0.052	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0.39	1.01	0.015	0.039

CASE 648-08 (16-PIN DIP) PLASTIC



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

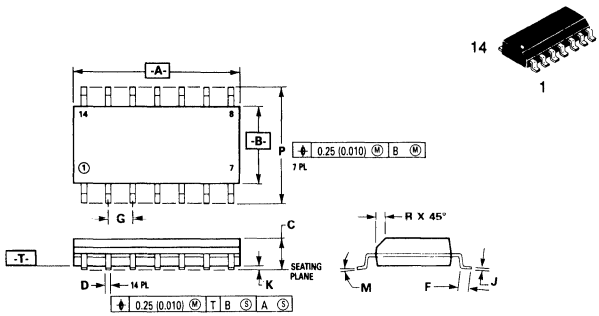


STYLE 1:
PIN 1. CATHODE
2. CATHODE
3. CATHODE
4. CATHODE
5. CATHODE
6. CATHODE
7. CATHODE
8. CATHODE
9. ANODE
10. ANODE
11. ANODE
12. ANODE
13. ANODE
14. ANODE
15. ANODE
16. ANODE

STYLE 2:
PIN 1. COMMON DRAIN
2. COMMON DRAIN
3. COMMON DRAIN
4. COMMON DRAIN
5. COMMON DRAIN
6. COMMON DRAIN
7. COMMON DRAIN
8. COMMON DRAIN
9. GATE
10. SOURCE
11. GATE
12. SOURCE
13. GATE
14. SOURCE
15. GATE
16. SOURCE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.80	19.55	0.740	0.770
B	6.35	6.85	0.250	0.270
C	3.69	4.44	0.145	0.175
D	0.39	0.53	0.015	0.021
F	1.02	1.77	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	1.27 BSC		0.050 BSC	
J	0.21	0.38	0.008	0.015
K	2.80	3.30	0.110	0.130
L	7.50	7.74	0.295	0.305
M	0°	10°	0°	10°
S	0.51	1.01	0.020	0.040

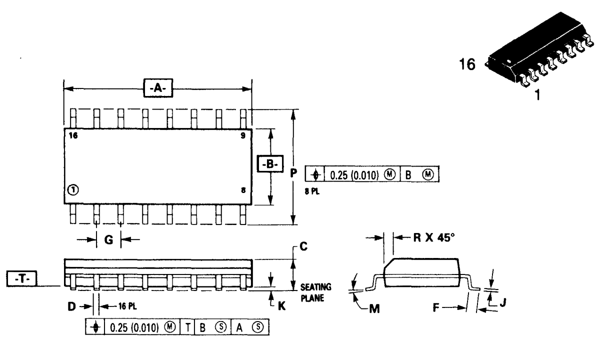
CASE 751A-02 (SO-14) PLASTIC



NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

CASE 751B-03 (SO-16) PLASTIC



NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

8

INFORMATION FOR USING SMALL SIGNAL SURFACE MOUNT PACKAGES

THERMAL INFORMATION

The power dissipation of small signal surface mount packages is generally a function of the collector/drain pad size. This can vary from the minimum pad size for soldering to a pad size given for maximum power dissipation. Power dissipation for a surface mount device is determined by $T_{J(max)}$, the maximum rated junction temperature of the die, $R_{ØJA}$, the thermal resistance from the device junction to ambient, and the operating temperature, T_A. Using the values provided on the data sheet for the SOT-23 package, P_D can be calculated as follows.

$$P_D = \frac{T_{J(max)} - T_A}{R_{ØJA}}$$

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature T_A of 25°C, one can calculate the power dissipation of the device which in this case is 225 milliwatts.

$$P_D = \frac{150°C - 25°C}{0.556° C/mW} = 225 \text{ milliwatts}$$

The 0.556 °C/mW for the SOT-23 package assumes the recommended collector/drain pad area of 37 mil^2 on FR-4 glass epoxy printed circuit board to achieve a power dissipation of 225 milliwatts using the footprint shown. Another alternative is to use a ceramic substrate or an aluminum core board such as Thermal Clad. By using an aluminum core board material such as Thermal Clad, the power dissipation can be doubled using the same footprint.

GENERAL SOLDERING PRECAUTIONS

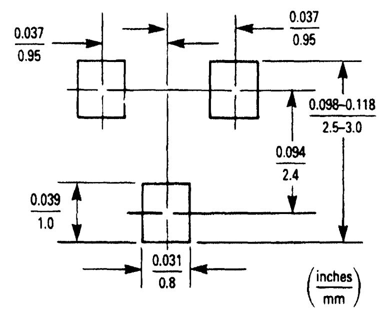
The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device
- The delta temperature between the preheat and soldering should be 100°C or less*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference in temperatures of the case and the leads shall be $^{\Delta}$10°C or less.
- The soldering temperature and time shall not exceed 260°C for more than 10 seconds
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less
- After soldering has been completed, the device should be allowed to cool naturally for three minutes or more. Gradual cooling should be used as forced cooling will increase the temperature gradient and result in latent mechanical stress
- One should not apply mechanical stress or shock during cooling

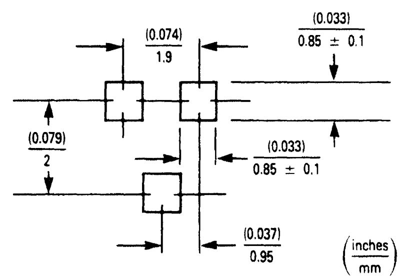
* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device

MINIMUM RECOMMENDED FOOTPRINTS FOR SURFACE MOUNTED APPLICATIONS

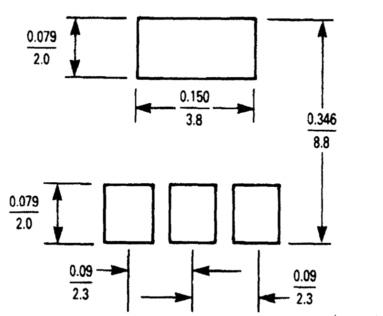
Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to insure proper solder connection interface between the board and the package. The footprint is also important with regard to the power dissipation. With the correct pad geometry, the packages will self align when subjected to a solder reflow process. The recommended footprints for the SC-59, SOT-223, SOT-23, SO-14 and SO-16 are shown below.



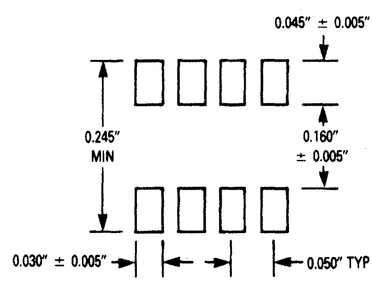
SC-59



SOT-23



SOT-223



SO-8, OPTO SO-8, SO-14, SO-16

8

Application Note Abstracts

(Application Notes are available upon request.)

AN-211A Field-Effect Transistors in Theory and Practice

The basic theory, construction, and application information for field-effect transistors (junction and MOS types) are given. Also included are some typical test circuits for checking FET parameters.

AN-220 FETs in Chopper and Analog Switching Circuits

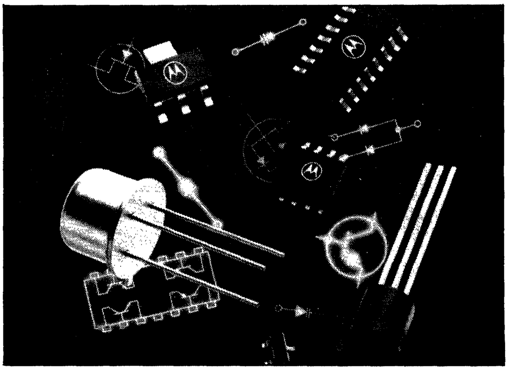
The author's discussion begins with elementary chopper and analog switch characteristics — explores fully the considerations required for conventional FET chopper and analog switch design — and finishes with specific FET circuit examples.

AN-847 Tuning Diode Design Techniques

Tuning diodes are voltage variable capacitors employing the junction capacitance of a reverse biased PN junction. This note presents a simplified theory of tuning diodes and discusses a number of considerations to be employed in designs using tuning diodes.

AR-300 The Hidden Dangers of Electrostatic Discharge — ESD

An in-depth discussion on damage from electrostatic discharge to electronic components. This article covers topics such as ESD Generation, electronic component susceptibility to ESD, typical electrostatic voltages, damage to specific families of electronic devices, static-sensitive components, static protection, combatting ESD and the importance of electronic component packaging.



This Reliability and Quality Assurance section contains information on the measurement of outgoing quality, reliability data analysis, reliability stress test descriptions with the applicable MIL-STD methods, statistical process control techniques, and quality assurance processing.

Reliability and Quality Assurance

9

OUTGOING QUALITY

The Average Outgoing Quality (AOQ) refers to the number of devices per million that are outside the specification limits at the time of shipment. Motorola has established Six Sigma goals to improve its outgoing quality and will continue its "error free performance" focus to achieve the goal of zero parts per million (PPM) outgoing quality. Motorola's present quality level has lead to vendor certification programs with many of its customers. These programs ensure a level of quality which allows the customer either to reduce or eliminate the need for incoming inspections.

AVERAGE OUTGOING QUALITY (AOQ) CALCULATION

AOQ = (Process Average) • (Probability of Acceptance) • (10^6) (PPM)

- Process Average = $\dfrac{\text{Total Projected Reject Devices}}{\text{Total Number of Devices}}$
- Projected Reject Devices = $\dfrac{\text{Defects in Sample}}{\text{Sample Size}}$ • Lot Size
- Total Number of Devices = Sum of units in each submitted lot
- Probability of Acceptance = $1 - \dfrac{\text{Number of Lots Rejected}}{\text{Number of Lots Tested}}$
- 10^6 = Conversion to parts per million (PPM)

RELIABILITY DATA ANALYSIS

Reliability is the probability that a semiconductor device will perform its specified function in a given environment for a specified period. In other words, reliability is quality over time and environmental conditions. The most frequently used reliability measure for semiconductor devices is the failure rate (λ). The failure rate is obtained by dividing the number of failures observed by the product of the number of devices on test and the interval in hours, usually expressed as percent per thousand hours or failures per billion device hours (FITS). This is called a point estimate because it is obtained from observations on a portion (sample) of the population of devices.

To project from the sample to the population in general, one must establish confidence intervals. The application of confidence intervals is a statement of how "confident" one is that the sample failure rate approximates that for the population. To obtain failure rates at different confidence levels, it is necessary to make use of specific probability distributions. The chi-square ($\chi 2$) distribution that relates observed and expected frequencies of an event is frequently used to establish confidence intervals. The relationship between failure rate and the chi-square distribution is as follows:

$$\lambda = \frac{\chi 2\ (\alpha,\ d.\ f.)}{2t}$$

where:

λ = failure rate
$\chi 2$ = chi-square function
α = (100 – confidence level) /100
d.f. = degrees of freedom = 2r + 2
r = number of failures
t = device hours

Chi-square values for 60% and 90% confidence intervals for up to 12 failures are shown below.

Chi-Square Table

Chi-Square Distribution Function			
60% Confidence Level		90% Confidence Level	
No. Fails	$\chi 2$ Quantity	No. Fails	$\chi 2$ Quantity
0	1.833	0	4.605
1	4.045	1	7.779
2	6.211	2	10.645
3	8.351	3	13.362
4	10.473	4	15.987
5	12.584	5	18.549
6	14.685	6	21.064
7	16.780	7	23.542
8	18.868	8	25.989
9	20.951	9	28.412
10	23.031	10	30.813
11	25.106	11	33.196
12	27.179	12	35.563

The failure rate of semiconductor devices is inherently low. As a result, the industry uses a technique called accelerated testing to assess the reliability of semiconductors. During accelerated tests, elevated stresses are used to produce, in a short period, the same failure mechanisms as would be observed under normal use conditions. The objective of this testing is to identify these failure mechanisms and eliminate them as a cause of failure during the useful life of the product.

Temperature, relative humidity, and voltage are the most frequently used stresses during accelerated testing. Their relationship to failure rates has been shown to follow an Eyring type of equation of the form:

$$\lambda = A\exp(\phi kT) \bullet \exp(B/RH) \bullet \exp(CE)$$

Where A, B, C, ϕ, and k are constants, more specifically B, C, and ϕ are numbers representing the apparent energy at which various failure mechanisms occur. These are called activation energies. "T" is the temperature, "RH" is the relative humidity, and "E" is the electric field. The most familiar form of this equation (shown on following page) deals with the first exponential term that shows an Arrhenius type relationship of the failure rate versus the junction temperature of semiconductors. The junction temperature is related to the ambient temperature through the thermal resistance and power dissipation. Thus, we can test devices near their maximum junction temperatures, analyze the failures to assure that they are the types that are accelerated by temperature and then by applying known acceleration factors, estimate the failure rates for lower junction temperatures.

The Table on the following page shows observed activation energies with references.

Table 1 – Time Dependent Failure Mechanisms in Semiconductor Devices (Applicable to Discrete and Integrated Circuits)

Device Association	Process	Relevant Factors	Accelerating Factors	Typical Activation Energy in eV	Model	Reference
Silicon Oxide Silicon-Silicon Oxide Interface	Surface Charges Inversion, Accumulation	Mobile Ions E/V, T	T, V	1.0	Fitch, et al. Peck	1A 2
	Oxide Pinholes	E/V, T	E, T	0.7 - 1.0 (Bipolar) 1.0 (Bipolar)	1984 WRS Hokari, et al.	18 5
	Dielectric Breakdown (TDDB)	E/V, T	E, T	0.3-0.4 (MOS) 0.3 (MOS)	Domangue, et al. Crook, D.L.	3 4
	Charge Loss	E, T	E, T	0.8 (MOS) EPROM	Gear, G.	11
Metallization	Electromigration	T, J	J, T	1.0 Large grain Al (glassivated)	Nanda, et al.	6
		Grain Size		0.5 Small grain Al	Black, J.R.	7
		Doping		0.7 Cu-Al/Cu-Si-Al (sputtered)	Black, J.R.	12
	Corrosion Chemical Galvanic Electrolytic	Contamination	H, E/V, T	0.6-0.7 (for electrolysis) E/V may have thresholds	Lycoudes, N.E.	8
Bond and Other Mechanical Interfaces	Intermetallic Growth	T, Impurities Bond Strength	T	1.0 (Au/Al)	Fitch, W.T.	9
Various Wafer Fab, Assembly, and Silicon Defects	Metal Scratches Mask Defects, etc. Silicon Defects	T, V	T, V	0.5-0.7 eV 0.5 eV	Howes, et al. MMPD	10 13

V = voltage; E = electric field; T = temperature; J = current density; H = humidity

NO. REFERENCE

1A 1.0 eV activation for leakage type failures.
Fitch, W.T.; Greer, P.; Lycoudes, N.; "Data to Support 0.001%/1000 Hours for Plastic I/C's." Case study on linear product shows 0.914 eV activation energy which is within experimental error of 0.9 To 1.3 eV activation energies for reversible leakage (inversion) failures reported in the literature.

1B 0.7 To 1.0 eV for oxide defect failures for bipolar structures. This is under investigation subsequent to information obtained from 1984 Wafer Reliability Symposium, especially for bipolar capacitors with silicon nitride as dielectric.

2 1.0 eV activation for leakage type failures.
Peck, D.S.; "New Concerns About Integrated Circuit Reliability" 1978 Reliability Physics Symposium.

3 0.36 eV for dielectric breakdown for MOS gate structures.
Domangue, E.; Rivera, R.; Shedard, C.; "Reliability Prediction Using Large MOS Capacitors", 1984 Reliability Physics Symposium.

4 0.3 eV for dielectric breakdown.
Crook, D.L.; "Method of Determining Reliability Screens for Time Dependent Dielectric Breakdown", 1979 Reliability Physics Symposium.

5 1.0 eV for dielectric breakdown.
Hokari, Y.; et al.; IEDM Technical Digest, 1982.

6 1.0 eV for large grain Al-Si (compared to line width).
Nanda, Vangard, Gj-P; Black, J.R.; "Electromigration of Al-Si Alloy Films", 1978 Reliability Physics Symposium.

7 0.5 eV Al, 0.7 eV Cu-Al small grain (compared to line width).
Black, J.R.; "Current Limitation of Thin Film Conductor" 1982 Reliability Physics Symposium.

8 0.65 eV for corrosion mechanism.
Lycoudes, N.E.; "The Reliability of Plastic Microcircuits in Moist Environments", 1978 Solid State Technology.

9 1.0 eV for open wires or high resistance bonds at the pad bond due to Au-Al intermetallics.
Fitch, W.T.; "Operating Life vs Junction Temperatures for Plastic Encapsulated I/C (1.5 mil Au wire)", unpublished report.

10 0.7 eV for assembly related defects.
Howes, M.G.; Morgan, D.V.; "Reliability and Degradation, Semiconductor Devices and Circuits" John Wiley and Sons, 1981.

11 Gear, G.; "FAMOUS PROM Reliability Studies", 1976 Reliability Physics Symposium

12 Black, J.R.: unpublished report.

13 Motorola Memory Products Division; unpublished report.

THERMAL RESISTANCE

Circuit performance and long-term circuit reliability are affected by die temperature. Normally, both are improved by keeping the junction temperatures low.

Electrical power dissipated in any semiconductor device is a source of heat. This heat source increases the temperature of the die about some reference point, normally the ambient temperature of 25° C in still air. The temperature increase, then, depends on the amount of power dissipated in the circuit and on the net thermal resistance between the heat source and the reference point.

The temperature at the junction depends on the packaging and mounting system's ability to remove heat generated in the circuit from the junction region to the ambient environment. The basic formula for converting power dissipation to estimated junction temperature is:

$$T_J = T_A + P_D (\overline{\theta}_{JC} + \overline{\theta}_{CA}) \quad (1)$$

or:

$$T_J = T_A + P_D (\overline{\theta}_{JA}) \quad (2)$$

where:

T_J = maximum junction temperature

T_A = maximum ambient temperature

P_D = calculated maximum power dissipation, including effects of external loads when applicable

$\overline{\theta}_{JC}$ = average thermal resistance, junction to case

$\overline{\theta}_{CA}$ = average thermal resistance, case to ambient

$\overline{\theta}_{JA}$ = average thermal resistance, junction to ambient

This Motorola recommended formula has been approved by RADC and DESC for calculating a "practical" maximum operating junction temperature for MIL-M-38510 devices.

Only two terms on the right side of equation (1) can be varied by the user, the ambient temperature and the device case-to-ambient thermal resistance, $\overline{\theta}_{CA}$. (To some extent the device power dissipation can also be controlled, but under recommended use the supply voltage and loading dictate a fixed power dissipation.) Both system air flow and the package mounting technique affect the $\overline{\theta}_{CA}$ thermal resistance term. $\overline{\theta}_{JC}$ is essentially independent of air flow and external mounting method, but is sensitive to package material, die bonding method, and die area.

For applications where the case is held at essentially a fixed temperature by mounting on a large or temperature controlled heat sink, the estimated junction temperature is calculated by:

$$T_J = T_C + P_D (\overline{\theta}_{JC}) \quad (3)$$

where T_C = maximum case temperature and the other parameters are as previously defined.

AIR FLOW

Air flow over the packages (due to a decrease in $\overline{\theta}_{CA}$) reduces the thermal resistance of the package, therefore permitting a corresponding increase in power dissipation without exceeding the maximum permissible operating junction temperature.

For thermal resistance values for specific packages, see the Motorola Data Book or Design Manual for the appropriate device family or contact your local Motorola sales office.

ACTIVATION ENERGY

Determination of activation energies is accomplished by testing randomly selected samples from the same population at various stress levels and comparing failure rates due to the same failure mechanism. The activation energy is represented by the slope of the curve relating to the natural logarithm of the failure rate to the various stress levels.

In calculating failure rates, the comprehensive method is to use the specific activation energy for each failure mechanism applicable to the technology and circuit under consideration. A common alternative method is to use a single activation energy value for the "expected" failure mechanism(s) with the lowest activation energy.

RELIABILITY STRESS TESTS

The following are brief descriptions of the reliability tests commonly used in the reliability monitoring program. Not all of the tests listed are performed by each product division. Other tests may be performed when appropriate.

AUTOCLAVE (aka, PRESSURE COOKER)

Autoclave is an environmental test which measures device resistance to moisture penetration and the resultant effects of galvanic corrosion. Autoclave is a highly accelerated and destructive test.

Typical Test Conditions: T_A = 121° C, rh = 100%, p = 1 atmosphere (15 psig), t = 24 to 96 hours
Common Failure Modes: Parametric shifts, high leakage and/or catastrophic
Common Failure Mechanisms: Die corrosion or contaminants such as foreign material on or within the package materials. Poor package sealing

HIGH HUMIDITY HIGH TEMPERATURE BIAS (H3TB, H3TRB, or THB)

This is an environmental test designed to measure the moisture resistance of plastic encapsulated devices. A bias is applied to create an electrolytic cell necessary to accelerate corrosion of the die metallization. With time, this is a catastrophically destructive test.

Typical Test Conditions: T_A = 85° C to 95° C, rh = 85% to 95%, Bias = 80% to 100% of Data Book max. rating, t = 96 to 1750 hours
Common Failure Modes: Parametric shifts, high leakage and/or catastrophic
Common Failure Mechanisms: Die corrosion or contaminants such as foreign material on or within the package materials. Poor package sealing

HIGH TEMPERATURE GATE BIAS (HTGB)

This test is designed to electrically stress the gate oxide under a bias condition at high temperature.

Typical Test Conditions: T_A = 150° C, Bias = 80% of Data Book max. rating, t = 120 to 1000 hours
Common Failure Modes: Parametric shifts in gate leakage and gate threshold voltage
Common Failure Mechanisms: Random oxide defects and ionic contamination
Military Reference: MIL-STD-750, Method 1042

HIGH TEMPERATURE REVERSE BIAS (HTRB)

The purpose of this test is to align mobile ions by means of temperature and voltage stress to form a high-current leakage path between two or more junctions.

Typical Test Conditions: T_A = 85° C to 150° C, Bias = 80% to 100% of Data Book max. rating, t = 120 to 1000 hours
Common Failure Modes: Parametric shifts in leakage and gain
Common Failure Mechanisms: Ionic contamination on the surface or under the metallization of the die
Military Reference: MIL-STD-750, Method 1039

HIGH TEMPERATURE STORAGE LIFE (HTSL)

High temperature storage life testing is performed to accelerate failure mechanisms which are thermally activated through the application of extreme temperatures.

Typical Test Conditions: T_A = 70° C to 200° C, no bias, t = 24 to 2500 hours
Common Failure Modes: Parametric shifts in leakage and gain
Common Failure Mechanisms: Bulk die and diffusion defects
Military Reference: MIL-STD-750, Method 1032

INTERMITTENT OPERATING LIFE (IOL)

The purpose of this test is the same as SSOL in addition to checking the integrity of both wire and die bonds by means of thermal stressing.

Typical Test Conditions: T_A = 25° C, Pd = Data Book maximum rating, $T_{on} = T_{off} = \Delta$ of 50° C to 100° C, t = 42 to 30000 cycles
Common Failure Modes: Parametric shifts and catastrophic
Common Failure Mechanisms: Foreign material, crack and bulk die defects, metallization, wire and die bond defects
Military Reference: MIL-STD-750, Method 1037

9

MECHANICAL SHOCK

This test is used to determine the ability of the device to withstand a sudden change in mechanical stress due to abrupt changes in motion as seen in handling, transportation, or actual use.

Typical Test Conditions: Acceleration = 1500 g's, Orientation = X_1, Y_1, Y_2 plane, t = 0.5 msec, Blows = 5

Common Failure Modes: Open, short, excessive leakage, mechanical failure

Common Failure Mechanisms: Die and wire bonds, cracked die, package defects

Military Reference: MIL-STD-750, Method 2015

MOISTURE RESISTANCE

The purpose of this test is to evaluate the moisture resistance of components under temperature/humidity conditions typical of tropical environments.

Typical Test Conditions: T_A = –10° C to 65° C, rh = 80% to 98%, t = 24 hours/cycle, cycle = 10

Common Failure Modes: Parametric shifts in leakage and mechanical failure

Common Failure Mechanisms: Corrosion or contaminants on or within the package materials. Poor package sealing

Military Reference: MIL-STD-750, Method 1021

SOLDERABILITY

The purpose of this test is to measure the ability of device leads/terminals to be soldered after an extended period of storage (shelf life).

Typical Test Conditions: Steam aging = 8 hours, Flux = R, Solder = Sn60, Sn63

Common Failure Modes: Pin holes, dewetting, non-wetting

Common Failure Mechanisms: Poor plating, contaminated leads

Military Reference: MIL-STD-750, Method 2026

SOLDER HEAT

This test is used to measure the ability of a device to withstand the temperatures as may be seen in wave soldering operations. Electrical testing is the endpoint criterion for this stress.

Typical Test Conditions: Solder Temperature = 260° C, t = 10 seconds

Common Failure Modes: Parameter shifts, mechanical failure

Common Failure Mechanisms: Poor package design

Military Reference: MIL-STD-750, Method 2031

STEADY STATE OPERATING LIFE (SSOL)

The purpose of this test is to evaluate the bulk stability of the die and to generate defects resulting from manufacturing aberrations that are manifested as time and stress-dependent failures.

Typical Test Conditions: T_A = 25° C, P_D = Data Book maximum rating, t = 16 to 1000 hours

Common Failure Modes: Parametric shifts and catastrophic

Common Failure Mechanisms: Foreign material, crack die, bulk die, metallization, wire and die bond defects

Military Reference: MIL-STD-750, Method 1026

TEMPERATURE CYCLING (AIR TO AIR)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and transitions between temperature extremes. This testing will also expose excessive thermal mismatch between materials.

Typical Test Conditions: T_A = –65° C to 200° C, cycle = 10 to 4000

Common Failure Modes: Parametric shifts and catastrophic

Common Failure Mechanisms: Wire bond, cracked or lifted die and package failure

Military Reference: MIL-STD-750, Method 1051

THERMAL SHOCK (LIQUID TO LIQUID)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and sudden transitions between temperature extremes. This testing will also expose excessive thermal mismatch between materials.

Typical Test Conditions: T_A = 0° C to 100° C, cycle = 20 to 300

Common Failure Modes: Parametric shifts and catastrophic

Common Failure Mechanisms: Wire bond, cracked or lifted die and package failure

Military Reference: MIL-STD-750, Method 1056

VARIABLE FREQUENCY VIBRATION

This test is used to examine the ability of the device to withstand deterioration due to mechanical resonance.

Typical Test Conditions: Peak acceleration = 20 g's, Frequency range = 20 Hz to 20 KHz, t = 48 minutes.

Common Failure Modes: Open, short, excessive leakage, mechanical failure

Common Failure Mechanisms: Die and wire bonds, cracked die, package defects

Military Reference: MIL-STD-750, Method 2056

STATISTICAL PROCESS CONTROL

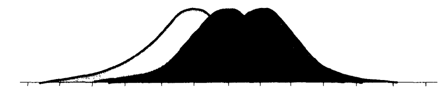
Motorola's Discrete and Materials Technologies Group (DMTG) is continually pursuing new ways to improve product quality. Initial design improvement is one method that can be used to produce a superior product. Equally important to outgoing product quality is the ability to produce product that consistently conforms to specification. Process variability is the basic enemy of semiconductor manufacturing since it leads to product variability. Used in all phases of Motorola's product manufacturing, STATISTICAL PROCESS CONTROL (SPC) replaces variability with predictability. The traditional philosophy in the semiconductor industry has been adherence to the data sheet specification. Using SPC methods assures the product will meet specific process requirements throughout the manufacturing cycle. The emphasis is on defect prevention, not detection. Predictability through SPC methods requires the manufacturing culture to focus on constant and permanent improvements. Usually these improvements cannot be bought with state-of-the-art equipment or automated factories. With quality in design, process and material selection, coupled with manufacturing predictability, Motorola can produce world class products.

The immediate effect of SPC manufacturing is predictability through process controls. Product centered and distributed well within the product specification benefits Motorola with fewer rejects, improved yields and lower cost. The direct benefit to Motorola's customers includes better incoming quality levels, less inspection time and ship-to-stock capability. Circuit performance is often dependent on the cumulative effect of component variability. Tightly controlled component distributions give the customer greater circuit predictability. Many customers are also converting to just-in-time (JIT) delivery programs. These programs require improvements in cycle time and yield predictability achievable only through SPC techniques. The benefit derived from SPC helps the manufacturer meet the customer's expectations of higher quality and lower cost product.

Ultimately, Motorola will have Six Sigma capability on all products. This means parametric distributions will be centered within the specification limits with a product distribution of plus or minus Six Sigma about mean. Six Sigma capability, shown graphically in Figure 1-1 , details the benefit in terms of yield and outgoing quality levels. This compares a centered distribution versus a 1.5 sigma worst case distribution shift.

New product development at Motorola requires more robust design features that make them less sensitive to minor variations in processing. These features make the implementation of SPC much easier.

A complete commitment to SPC is present throughout Motorola. All managers, engineers, production operators, supervisors and maintenance personnel have received multiple training courses on SPC techniques. Manufacturing has identified 22 wafer processing and 8 assembly steps considered critical to the processing of semiconductor products. Processes, controlled by SPC methods, that have shown significant improvement are in the diffusion, photolithography and metallization areas.



Distribution Centered	Distribution Shifted ± 1.5
At ± 3 σ 2700 ppm defective 99.73% yield	66810 ppm defective 93.32% yield
At ± 4 σ 63 ppm defective 99.9937% yield	6210 ppm defective 99.379% yield
At ± 5 σ 0.57 ppm defective 99.999943% yield	233 ppm defective 99.9767% yield
At ± 6 σ 0.002 ppm defective 99.9999998% yield	3.4 ppm defective 99.99966% yield

Figure 1-1 – AOQL and Yield from a Normal Distribution of Product With 6σ Capability

To better understand SPC principles, brief explanations have been provided. These cover process capability, implementation and use.

PROCESS CAPABILITY

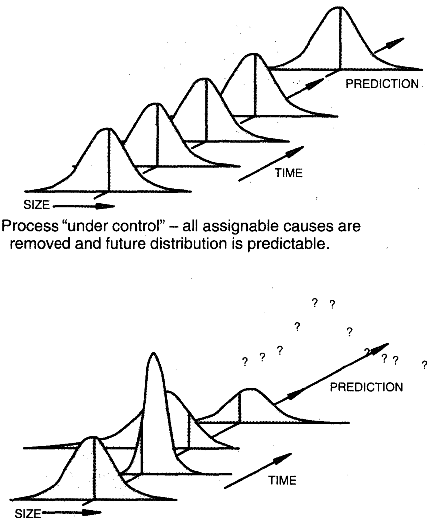
One goal of SPC is to ensure a process is **CAPABLE**. Process capability is the measurement of a process to produce products consistently to specification requirements. The purpose of a process capability study is to separate the inherent **RANDOM VARIABILITY** from **ASSIGNABLE CAUSES**. Once completed, steps are taken to identify and eliminate the most significant assignable causes. Random variability is generally present in the system and does not fluctuate. Sometimes, these are considered basic limitations associated with the machinery, materials, personnel skills or manufacturing methods. Assignable cause inconsistencies relate to time variations in yield, performance or reliability.

Traditionally, assignable causes appear to be random due to the lack of close examination or analysis. Figure 1-2 shows the impact on predictability that assignable cause can have. Figure 1-3 shows the difference between process control and process capability.

A process capability study involves taking periodic samples from the process under controlled conditions. The performance characteristics of these samples are charted against time. In time, assignable causes can be identified and engineered out. Careful documentation of the process is key to accurate diagnosis and successful removal of the assignable causes. Sometimes, the assignable causes will remain unclear requiring prolonged experimentation.

Elements which measure process variation control and capability are Cp and Cpk respectively. Cp is the specification width divided by the process width or Cp = (specification width) / 6σ. Cpk is the absolute value of the closest specification value to the mean, minus the mean, divided by half the process width or Cpk = I closest specification $-\overline{X}/3\sigma$.

9



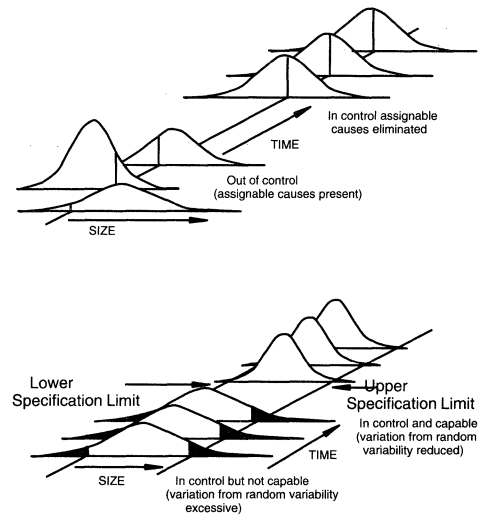


Figure 1-2 – Impact of Assignable Causes on Process Predictable

Figure 1-3 – Difference Between Process Control and Process Capability

At Motorola, for critical parameters, the process capability is acceptable with a Cpk = 1.33. The desired process capability is a Cpk = 2 and the ideal is a Cpk = 5. Cpk, by definition, shows where the current production process fits with relationship to the specification limits. Off center distributions or excessive process variability will result in less than optimum conditions

SPC IMPLEMENTATION AND USE

DMTG uses many parameters that show conformance to specification. Some parameters are sensitive to process variations while others remain constant for a given product line. Often, specific parameters are influenced when changes to other parameters occur. It is both impractical and unnecessary to monitor all parameters using SPC methods. Only critical parameters that are sensitive to process variability are chosen for SPC monitoring. The process steps affecting these critical parameters must be identified also. It is equally important to find a measurement in these process steps that correlates with product performance. This is called a critical process parameter.

Once the critical process parameters are selected, a sample plan must be determined. The samples used for measurement are organized into **RATIONAL SUBGROUPS** of approximately 2 to 5 pieces. The subgroup size should be such that variation among the samples within the subgroup remain small. All samples must come from the same source e.g., the same mold press operator, etc.. Subgroup data should be collected at appropriate time intervals to detect variations in the process. As the process begins to show improved stability, the interval may be increased. The data collected must be carefully documented and maintained for later correlation. Examples of common documentation entries would include operator, machine, time, settings, product type, etc.

Once the plan is established, data collection may begin. The data collected will generate $\overline{X}$ and R values that are plotted with respect to time. $\overline{X}$ refers to the mean of the values within a given subgroup, while R is the range or greatest value minus least value. When approximately 20 or more $\overline{X}$ and R values have been generated, the average of these values is computed as follows:

$$\overline{\overline{X}} = (\overline{X} + \overline{X}2 + \overline{X}3 + ...)/K$$
$$\overline{R} = (R1 + R2 + R3 + ...)/K$$

where K = the number of subgroups measured.

The values of $\overline{\overline{X}}$ and $\overline{R}$ are used to create the process control chart. Control charts are the primary SPC tool used to signal a problem. Shown in Figure 1-4, process control charts show $\overline{X}$ and R values with respect to time and concerning reference to upper and lower control limit values. Control limits are computed as follows:

R upper control limit = $UCL_R = D4\,\overline{R}$
R lower control limit = $LCL_R = D3\,\overline{R}$
$\overline{X}$ upper control limit = $UCL_{\overline{X}} = \overline{\overline{X}} + A2\,\overline{R}$
$\overline{X}$ lower control limit = $LCL\overline{X} = \overline{\overline{X}} - A2\,\overline{R}$

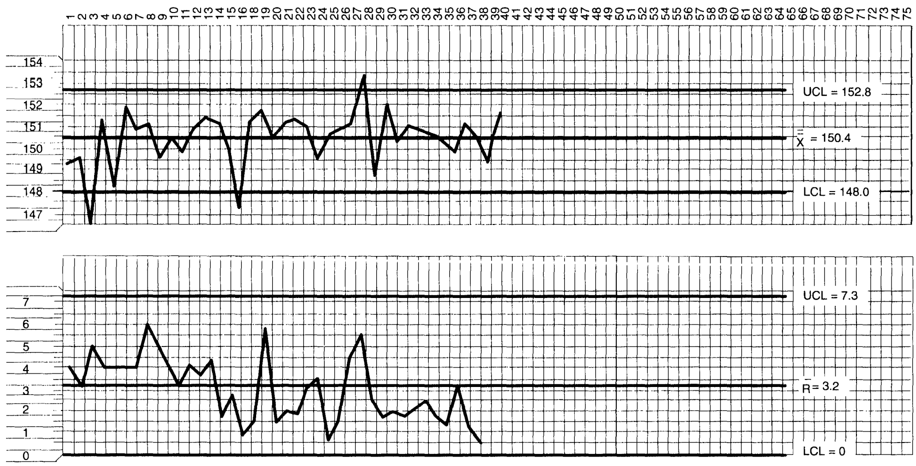


Figure 1-4 – Example of Process Control Chart Showing Oven Temperature Data

Where D4, D3 and A2 are constants varying by sample size, with values for sample sizes from 2 to 10 shown in the following partial table:

n	2	3	4	5	6	7	8	9	10
D_4	3.27	2.57	2.28	2.11	2.00	1.92	1.86	1.82	1.78
D_3	*	*	*	*	*	0.08	0.14	0.18	0.22
A_2	1.88	1.02	0.73	0.58	0.48	0.42	0.37	0.34	0.31

* For sample sizes below 7, the LCL_R would technically be a negative number; in those cases there is no lower control limit; this means that for a subgroup size 6, six "identical" measurements would not be unreasonable.

Control charts are used to monitor the variability of critical process parameters. The R chart shows basic problems with piece to piece variability related to the process. The X chart can often identify changes in people, machines, methods, etc. The source of the variability can be difficult to find and may require experimental design techniques to identify assignable causes.

Some general rules have been established to help determine when a process is **OUT-OF-CONTROL**. Figure 1-9 shows a control chart subdivided into zones A, B, and C corresponding to 3 sigma, 2 sigma, and 1 sigma limits respectively. In Figure 1-8 through Figure 1-6 four of the tests that can be used to identify excessive variability and the presence of assignable causes are shown. As familiarity with a given process increases, more subtle tests may be employed successfully.

Once the variability is identified, the cause of the variability must be determined. Normally, only a few factors have a significant impact on the total variability of the process. The importance of correctly identifying these factors is stressed in the following example. Suppose a process variability depends on the variance of five factors A, B, C, D and E. Each has a variance of 5, 3, 2, 1 and 0.4 respectively.

Since:

$$\sigma\,\text{tot} = \sqrt{\sigma A^2 + \sigma B^2 + \sigma C^2 + \sigma D^2 + \sigma E^2}$$

$$\sigma\,\text{tot} = \sqrt{5^2 + 3^2 + 2^2 + 1^2 + (0.4)^2} = 6.3$$

Now if only D is identified and eliminated then;

$$\sigma\,\text{tot} = \sqrt{5^2 + 3^2 + 2^2 + (0.4)^2} = 6.2$$

This results in less than 2% total variability improvement. If B, C and D were eliminated, then;

$$\sigma\,\text{tot} = \sqrt{5^2 + (0.4)^2} = 5.02$$

This gives a considerably better improvement of 23%. If only A is identified and reduced from 5 to 2, then;

$$\sigma\,\text{tot} = \sqrt{2^2 + 3^2 + 2^2 + 1^2 + (0.4)^2} = 4.3$$

Identifying and improving the variability from 5 to 2 gives us a total variability improvement of nearly 40%.

Most techniques may be employed to identify the primary assignable cause(s). Out-of-control conditions may be correlated to documented process changes. The product may be analyzed in detail using best versus worst part comparisons or Product Analysis Lab equipment. Multi-variance analysis can be used to determine the family of variation (positional, critical or temporal). Lastly, experiments may be run to test theoretical or factorial analysis. Whatever method is used, assignable causes must be identified and eliminated in the most expeditious manner possible.

After assignable causes have been eliminated, new control limits are calculated to provide a more challenging variability criteria for the process. As yields and variability improve, it may become more difficult to detect improvements because they become much smaller. When all assignable causes have been eliminated and the points remain within control limits for 25 groups, the process is said to be in a state of control.

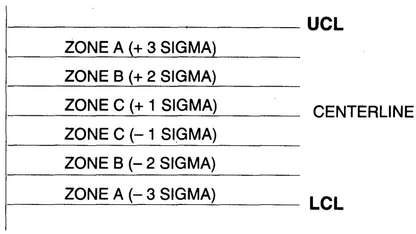


Figure 1-9 – Control Chart Zones

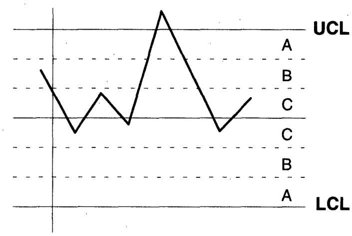


Figure 1-8 – One Point Outside Control Limit Indicating Excessive Variability

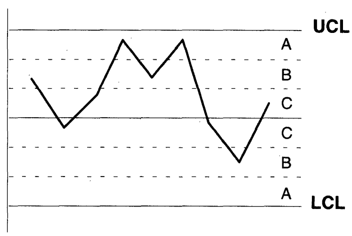


Figure 1-5 – Two Out of Three Points in Zone A or Beyond Indicating Excessive Variability

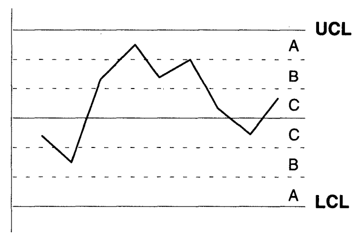


Figure 1-7 – Four Out of Five Points in Zone B or Beyond Indicating Excessive Variability

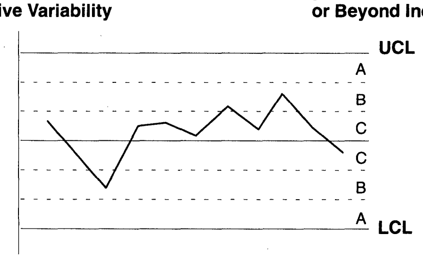
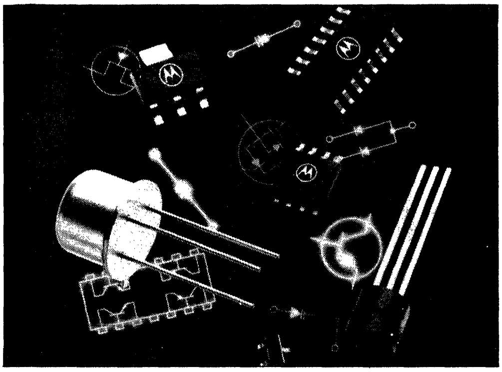


Figure 1-6 – Seven Out of Eight Points in Zone C or Beyond Indicating Excessive Variability

SUMMARY

Motorola is committed to the use of STATISTICAL PROCESS CONTROLS. These principles, used throughout manufacturing, have already resulted in many significant improvements to the processes. Continued dedication to the SPC culture will allow Motorola to reach the Six Sigma and zero defect capability goals. SPC will further enhance the commitment to **TOTAL CUSTOMER SATISFACTION**.



The Replacement Devices index provides you with a list of devices which had been supported with data sheets in the prior edition of the *Small-Signal Transistors, FETs and Diodes* data book (DL126 Rev 2) but are no longer supported in this new edition.

A direct or similar replacement part is listed for those devices which have replacement parts. Additionally, a code is provided for each device indicating why the device is no longer supported by a data sheet. Refer to the legend at the bottom of each page in the Replacement Devices index for an explanation of each code.

Motorola is continuing to supply many of these devices. However, all of these devices are not recommended for new design.

Replacement Devices

REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE
1N5442A	1N5441A/3A	1
1N5442B	1N5441B/3B	1
1N5447A	1N5446A/8A	1
1N5442A	1N5441A/3A	1
1N5442B	1N5441B/3B	1
1N5447A	1N5446A/8A	1
1N5447B	1N5446B/8B	1
1N5454A	1N5453A/5A	1
1N5454B	1N5453B/5B	1
1N5461A	1N5441A	1
1N5461B	1N5441B	1
1N5462A	1N5441A/3A	1
1N5462B	1N5441B/3B	1
1N5463A	1N5443A	1
1N5463B	1N5443B	1
1N5464A	1N5444A	1
1N5464B	1N5444B	1
1N5465A	1N5445A	1
1N5465B	1N5445B	1
1N5466A	1N5446A	1
1N5466B	1N5446B	1
1N5467A	1N5446A/8A	1
1N5467B	1N5446B/8B	1
1N5468A	1N5448A	1
1N5468B	1N5448B	1
1N5469A	1N5449A	1
1N5469B	1N5449B	1
1N5470A	1N5450A	1
1N5470B	1N5450B	1
1N5471A	1N5451A	1
1N5471B	1N5451B	1
1N5472A	1N5452A	1
1N5472B	1N5452B	1
1N5473A	1N5453A	1
1N5473B	1N5453B	1
1N5474A	1N5453A/5A	1
1N5474B	1N5453B/5B	1
1N5475A	1N5455A	1
1N5475B	1N5455B	1
1N5476A	1N5456A	1
1N5476B	1N5456B	1
2N1132	2N2904♦	1
2N1132A	2N2904♦	1
2N2060	None	2
2N2218	2N2218A♦	1
2N2221	2N2221A♦	1
2N2223	None	2
2N2223 A	None	2
2N2368	2N2369A♦	1
2N2453	None	2
2N2453A	None	2
2N2480A	None	2
2N2481	2N2369A♦	1
2N2501	2N2369A	1
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2N2639	None	2
2N2640	None	2
2N2641	None	2
2N2642	None	2
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2N2643	None	2
2N2644	None	2
2N2652	None	2
2N2652A	None	2
2N2721	None	2
2N2722	None	2
2N2723	MPSA13	1
2N2785	MPSA13	1
2N2800	2N2905A♦	1
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2N2844	None	1
2N2897	2N3700♦	1
2N2903	None	2
2N2913	None	2
2N2914	None	2
2N2915	None	2
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2N2945A	None	2
2N2946	None	2
2N2946A	None	2
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2N3013	2N2369A	1
2N3014	2N2369A	1
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2N3044	None	2
2N3045	None	2
2N3048	None	2
2N3073	2N2906A♦	1
2N3114	2N3500♦	1
2N3135	2N2906A♦	1
2N3227	2N2369A	1
2N3245	2N3468♦	1
2N3249	2N869A♦	1
2N3250A	2N3251A	1
2N3252	MM3725	1
2N3253	MM3725	1
2N3300	2N2219A♦	1
2N3302	2N2222A♦	1
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2N3308	2N4959	2, 5
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2N3438	None	1
2N3439	None	3
2N3440	None	3
2N3444	MM3725	2
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2N3460	None	1
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2N3485A	2N2906A	2
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2N3648	2N4014	2
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2N3725	MM3725	3
2N3726	None	2
2N3727	None	2
2N3734	MM3725	1
2N3735	MM3725	3
2N3737	MM3725	2
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2N3798	2N3799	1
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2N3807A	None	2
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2N3808A	None	2
2N3809	None	2
2N3809A	None	2
2N3810	None	2
2N3810A	None	2
2N3811	None	2
2N3811A	None	2
2N3821	MPF3821	2
2N3822	MPF3822	2
2N3823	None	2
2N3838	None	2
2N3909	None	2
2N3909A	None	2
2N3962	2N3799	1
2N3965	2N3799	1
2N3971	None	2
2N3972	None	2

♦ This a direct replacement part.

Note: All replacement parts are similar replacement parts unless otherwise indicated.

Codes:
1: Low Volume
2: Obsolete Technology
3: Unpredictable Process
4: See TVS/Zener Data Book for Device Information
5: See RF Device Data Book for Device Information

REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE
2N3993	None	2
2N3994	None	2
2N4013	2N4014	1
2N4015	None	2
2N4016	None	2
2N4026	2N4033	1
2N4027	2N4033	1
2N4028	2N4033	1
2N4029	2N4033	1
2N4030	2N4032	1
2N4031	2N4033	1
2N4091	MPF4091	2
2N4092	None	2
2N4093	None	2
2N4209	MM4209	3
2N4220	None	2
2N4220A	None	2
2N4221	None	2
2N4221A	None	2
2N4222	None	2
2N4222A	None	2
2N4234	None	3
2N4235	None	3
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2N4237	None	3
2N4238	None	3
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2N4260	None	3
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2N4340	None	3
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2N4352	None	2
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2N4393	MPF4393	2
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2N4409	2N4410	1
2N4416	None	2
2N4416A	None	2
2N4453	2N869A♦	1
2N4854	None	2
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2N4858	None	2
2N4858A	None	2
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2N4859A	MPF4859	2
2N4860	None	2
2N4860A	None	2

DEVICE	REPLACEMENT PART	CODE
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2N4939	None	2
2N4941	None	2
2N5022	2N3468	1
2N5023	2N3467	1
2N5059	2N5058	1
2N5208	MPSH81	1
2N5222	MPSH10♦	1
2N5226	2N4403♦	1
2N5227	2N3906♦	1
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2N6428A	MPS6428	3
2N6430	2N6431	1
2N657	2N3500	1
2N6782	None	1
2N6784	None	1
2N6788	None	1
2N6790	None	1
2N6796	None	1
2N6798	None	1
2N6800	None	1
2N6802	None	1

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2N6989	None	2
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2N706B	2N2369A	1
2N708	2N2369A	1
2N718	2N3700	1
2N835	2N2369A	1
2N910	2N3700	1
2N914	2N2369A	1
2N915	2N3947	1
2N916	2N3947	1
2N918	None	2
3N155	None	2
3N157	None	2
3N169	None	2
3N170	None	2
3N171	None	2
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BC161	2N4033	1
BC161–10	2N4033	1
BC161–6	2N4033	1
BC171A	BC182A	1
BC171B	BC182B	1
BC172A	BC182A	1
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BC172C	BC184C	1
BC174A	BC546A	1
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BC213B	BC213	1
BC213C	BC213	1
BC214B	BC214	1
BC214C	BC214	1
BC238A	BC237A	1
BC239B	BC237B	1

♦ This a direct replacement part.

Note: All replacement parts are similar replacement parts unless otherwise indicated.

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10

DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE
BC308	BC309	1	BC487B	BC489B	1	BCX71GL	BC857ALT1	1
BC308A	BC309	1	BC487L	BC489	1	BCX71KL	BC857BLT1	1
BC308B	BC309B	1	BC488	BC490	1	BCX78–10L	BC557C	1
BC309A	BC558A	1	BC488A	BC490A	1	BCX78–7L	BC557A	1
BC309C	BC558B	1	BC488B	BC490B	1	BCX78–8L	BC557B	1
BC317	MPS3904	1	BC488L	BC490	1	BCX78–9L	BC557C	1
BC317A	MPS3904	1	BC489L	BC489	1	BCX79–10L	BC557C	1
BC317B	MPS3904	1	BC490L	BC490	1	BCX79–7L	BC557A	1
BC320	2N5086	1	BC517S	BC517	1	BCX79–8L	BC557B	1
BC320A	2N5086	1	BC549	BC548	1	BCX79–9L	BC557C	1
BC320B	2N5087	1	BC549A	BC548A	1	BCY58–VII	2N2484	1
BC327–40	BC327–25	1	BC550	BC546	1	BCY78–VII	BCY78–VIII	1
BC328–40	BC328–25	1	BC550A	BC546A	1	BCY78–X	None	1
BC372–16	BC372	1	BC558	BC558B	1	BCY79–X	BCY79–IX	1
BC372–25	BC372	1	BC558A	BC558B	1	BDB01A	BDB01D	1
BC372–40	BC372	1	BC558C	BC558B	1	BDB01B	BDB01D	1
BC373–16	BC373	1	BC617	BC618	1	BDB02A	BDB02D	1
BC373–25	BC373	1	BC650	BC548C	1	BDB02B	BDB02D	1
BC375D	BF374	1	BC650C	BC548C	1	BDC01A	BDC01D	1
BC413	BC237B	1	BC650CS	BC548C	1	BDC01B	BDC01D	1
BC413B	BC237B	1	BC650S	BC548C	1	BDC01C	BDC01D	1
BC413C	BC237C	1	BC651	BC547C	1	BDC02A	BDC02D	1
BC414	BC237B	1	BC651C	BC547C	1	BDC02B	BDC02D	1
BC414B	BC237B	1	BC651CS	BC547C	1	BDC02C	BDC02D	1
BC414C	BC237C	1	BC651S	BC547C	1	BDC07	BDC05	1
BC415	BC307B.	1	BC808–16L	BC807–16LT1	1	BDC08	BDC06	1
BC415B	BC307B	1	BC808–25L	BC807–25LT1	1	BF241	BF240	1
BC415C	BC307C	1	BC808–40L	BC807–40LT1	1	BF254	BF240	1
BC416	BC307B	1	BC818–16L	BC817–16LT1	1	BF254–3	BF240	1
BC416B	BC307B	1	BC818–25L	BC817–25LT1	1	BF254–4	BF240	1
BC416C	BC307C	1	BC818–40L	BC817–40LT1	1	BF257	2N5058	1
BC445	BC489	1	BC849BL	BC848BLT1	1	BF366	MPS6568A	1
BC445A	BC489A	1	BC849CL	BC848CLT1	1	BF371	MPSH24	1
BC446	BC450	1	BC850BL	BC847BLT1	1	BF373	MPSH34	1
BC446A	BC450A	1	BC850CL	BC847CLT1	1	BF375	BF374	1
BC446B	BC450	1	BC859AL	BC858ALT1	1	BF375C	BF374	1
BC447	BC489	1	BC859BL	BC858BLT1	1	BF845	2N6517	1
BC447A	BC489A	1	BC859CL	BC858CLT1	1	BFR92L	RF Transistor	5
BC447B	BC489B	1	BC860AL	BC857ALT1	1	BFR93L	RF Transistor	5
BC448	BC450	1	BC860BL	BC857BLT1	1	BFS17	RF Transistor	5
BC448A	BC450A	1	BC860CL	BC858CLT1	1	BFX38	2N4033	1
BC448B	BC450	1	BCW66HL	MMBT2222ALT1	1	BFX40	2N4033	1
BC449	BC489	1	BCW67AL	BC807–16LT1	1	BFX48	2N869A	1
BC449A	BC489A	1	BCW67BL	BC807–25LT1	1	BFX85	2N3019	1
BC449B	BC489B	1	BCW67CL	BC807–40LT1	1	BFY50	2N3019	1
BC450B	BC450	1	BCW67L	BCX17LT1	1	BFY52	2N3019	1
BC485	BC489	1	BCW68FL	BC807–16LT1	1	BSR56L	MMBF4856LT1 ♦	1
BC485A	BC489A	1	BCW68L	BCX17LT1	1	BSR57L	None	1
BC485B	BC489B	1	BCX58–10	BC547C	1	BSR58L	None	1
BC485L	BC489	1	BCX58–7	BC547A	1	BSS50	None	3
BC486	BC490	1	BCX58–8	BC547B	1	BSS51	None	3
BC486A	BC490A	1	BCX58–9	BC547B	1	BSS52	None	3
BC486B	BC490B	1	BCX59–10	BC547C	1	BSS79BL	MMBT2222ALT1	1
BC486L	BC490	1	BCX59–7	BC547A	1	BSS79CL	MMBT2222ALT1	1
BC487	BC489	1	BCX59–8	BC547B	1	BSS80BL	MMBT2907ALT1	1
BC487A	BC489A	1	BCX59–9	BC547C	1			

♦ This a direct replacement part.

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REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE
BSS80CL	MMBT2907ALT1	1
BSS82BL	MMBT2907ALT1	1
BSS82CL	MMBT2907ALT1	1
BSV15–16	2N4033	1
BSV16–16	2N4033	1
BSV17–10	2N4033	1
BSV17–16	2N4033	1
BSW67A	MM3007	1
BSW68A	MM3007	1
BSX29	2N869A	1
BSX32	MM3725	1
BSX45–10	2N3019	1
BSX45–16	2N3019	1
BSX45–6	2N3019	1
BSX46–10	2N3019	1
BSX46–16	2N3019	1
BSX47–10	2N3019	1
BSX47–16	2N3019	1
BSX47–6	2N3019	1
BSX59	MM3725	1
BSX60	MM3725	1
BZX84C10L	Zener Diode	4
BZX84C11L	Zener Diode	4
BZX84C12L	Zener Diode	4
BZX84C13L	Zener Diode	4
BZX84C15L	Zener Diode	4
BZX84C16L	Zener Diode	4
BZX84C18L	Zener Diode	4
BZX84C20L	Zener Diode	4
BZX84C22L	Zener Diode	4
BZX84C24L	Zener Diode	4
BZX84C27L	Zener Diode	4
BZX84C30L	Zener Diode	4
BZX84C33L	Zener Diode	4
BZX84C4V7L	Zener Diode	4
BZX84C5V1L	Zener Diode	4
BZX84C5V6L	Zener Diode	4
BZX84C6V2L	Zener Diode	4
BZX84C6V8L	Zener Diode	4
BZX84C7V5L	Zener Diode	4
BZX84C8V2L	Zener Diode	4
BZX84C9V1L	Zener Diode	4
CV10253	2N3019	1
CV10440	2N2484	1
CV10814	2N2484	1
IRFD110	None	2
IRFD113	None	2
IRFD120	None	2
IRFD123	None	2
IRFD1Z0	None	2
IRFD1Z3	None	2
IRFD210	None	2
IRFD213	None	2
IRFD220	None	2
IRFD223	None	2
IRFD9110	None	2
IRFD9112	None	2

DEVICE	REPLACEMENT PART	CODE
IRFD9120	None	2
IRFD9123	None	2
IRFE110	None	2
IRFE113	None	2
IRFE9120	None	2
IRFE9123	None	2
IRFF110	None	2
IRFF113	None	2
IRFF120	None	2
IRFF123	None	2
IRFF210	None	2
IRFF213	None	2
IRFF220	None	2
IRFF223	None	2
IRFF230	None	2
IRFF233	None	2
IRFF330	None	2
IRFF333	None	2
IRFF430	None	2
IRFF433	None	2
JF1033B	2N5485♦	1
JF1033S	2N5486♦	1
JF1033Y	2N5484♦	1
MBAV70L	BAV70LT1♦	2
MBAV74L	BAV74LT1♦	2
MBAW56L	BAW56LT1♦	2
MBD201	MBD301	1
MBD501	MBD701	1
MD1121	None	2
MD1122	None	2
MD1132	None	2
MD2218	None	2
MD2218A	None	2
MD2218AF	None	2
MD2219A	None	2
MD2219AF	None	2
MD2369	None	2
MD2369A	None	2
MD2369AF	None	2
MD2369B	None	2
MD2369BF	None	2
MD2904	None	2
MD2904A	None	2
MD2904AF	None	2
MD2905	None	2
MD2905A	None	2
MD2905AF	None	2
MD3250	None	2
MD3250A	None	2
MD3250AF	None	2
MD3251	None	2
MD3251A	None	2
MD3251AF	None	2
MD3409	None	2
MD3410	None	2

DEVICE	REPLACEMENT PART	CODE
MD3467	None	2
MD3725	None	2
MD3762	None	2
MD3762F	None	2
MD4260	None	2
MD4261	None	2
MD5000	None	2
MD5000A	None	2
MD5000B	None	2
MD6001	None	2
MD6001F	None	2
MD6002	None	2
MD6002F	None	2
MD6003	None	2
MD7000	None	2
MD7001	None	2
MD7001F	None	2
MD7002	None	2
MD7002A	None	2
MD7002B	None	2
MD7003	None	2
MD7003A	None	2
MD7003B	None	2
MD7007	None	2
MD7007A	None	2
MD7007B	None	2
MD7007BF	None	2
MD7021	None	2
MD7021F	None	2
MD708	None	2
MD708A	None	2
MD708B	None	2
MD8001	None	2
MD8002	None	2
MD8003	None	2
MD918A	None	2
MD918AF	None	2
MD918B	None	2
MD982	None	2
MD982F	None	2
MD984	None	2
MD985	None	2
MFE120	None	2
MFE121	None	2
MFE122	None	2
MFE130	None	2
MFE131	None	2
MFE132	None	2
MFE2004	None	2
MFE2005	None	2
MFE2006	None	2
MFE201	None	2
MFE2010	None	2
MFE2011	None	2
MFE2012	None	2
MFE202	None	2

♦ This a direct replacement part.

Note: All replacement parts are similar replacement parts unless otherwise indicated.

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DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE
MFE203	None	2	MMBA811C5L	BC857ALT1	1	MMBZ5238BL	Zener Diode	4
MFE204	None	2	MMBA811C6L	BC857BLT1	1	MMBZ5239BL	Zener Diode	4
MFE209	None	2	MMBA811C7L	BC857BLT1	1	MMBZ5240BL	Zener Diode	4
MFE211	None	2	MMBA811C8L	BC857BLT1	1	MMBZ5241BL	Zener Diode	4
MFE212	None	2	MMBA812M5L	BC857ALT1	1	MMBZ5242BL	Zener Diode	4
MFE823	None	2	MMBA812M6L	BC857BLT1	1	MMBZ5243BL	Zener Diode	4
MFE825	None	2	MMBA812M7L	BC857BLT1	1	MMBZ5244BL	Zener Diode	4
MFE9200	None	2	MMBC1009F1L	BC848ALT1	1	MMBZ5245BL	Zener Diode	4
MFE930	None	2	MMBC1009F3L	BC848ALT1	1	MMBZ5246BL	Zener Diode	4
MFE960	None	2	MMBC1622D6L	BC847BLT1	1	MMBZ5247BL	Zener Diode	4
MFE990	None	2	MMBC1622D7L	BC847BLT1	1	MMBZ5248BL	Zener Diode	4
MFQ1000C	None	1	MMBC1623L5L	BC847ALT1	1	MMBZ5249BL	Zener Diode	4
MFQ1000C	None	1	MMBC1623L6L	BC847BLT1	1	MMBZ5250BL	Zener Diode	4
MFQ1000P	None	1	MMBC1623L7L	BC847CLT1	1	MMBZ5251BL	Zener Diode	4
MFQ1000P	None	1	MMBC1653N2L	MMBT5550LT1	1	MMBZ5252BL	Zener Diode	4
MFQ5460P	None	1	MMBC1653N3L	MMBT5551LT1	1	MMBZ5253BL	Zener Diode	4
MFQ6660C	None	1	MMBC1653N4L	MMBT5551LT1	1	MMBZ5254BL	Zener Diode	4
MFQ6660C	None	1	MMBC1654N5L	MMBT5551LT1	1	MMBZ5255BL	Zener Diode	4
MFQ6660P	None	1	MMBC1654N6L	MMBT5551LT1	1	MMBZ5256BL	Zener Diode	4
MFQ6660P	None	1	MMBC1654N7L	MMBT5551LT1	1	MMBZ5257BL	Zener Diode	4
MHQ2222	None	2	MMBD201L	MMBD301LT1	1	MMPQ3725A	MMPQ3725	3
MHQ2369	None	2	MMBD2835XL	BAW56LT1	2	MMPQ3762	MMPQ3467	1
MHQ2484	None	2	MMBD2836XL	BAW56LT1	2	MPF3330	2N5460♦	1
MHQ2484H	None	2	MMBD2837XL	BAV74LT1♦	2	MPF3970	MPF4391♦	1
MHQ2484HX	None	2	MMBD2838XL	BAV74LT1♦	2	MPF3972	MPF4393♦	1
MHQ2484HXV	None	2	MMBD501L	MMBD701LT1	1	MPF4221	2N5457♦	1
MHQ2906	None	2	MMBR2060L	RF Transistor	5	MPF4222A	2N5459♦	1
MHQ3467	None	2	MMBR2857L	RF Transistor	5	MPF4223	2N5459♦	1
MHQ3546	None	2	MMBR4957L	RF Transistor	5	MPF4856A	MPF4856♦	1
MHQ3724	None	2	MMBR5031L	RF Transistor	5	MPF4861A	MPF4858A♦	1
MHQ3724H	None	2	MMBR5179L	RF Transistor	5	MPF820	MPF4392♦	1
MHQ3724HX	None	2	MMBR536L	RF Transistor	5	MPQ2221	MPQ2222A	1
MHQ3724HXV	None	2	MMBR901L	RF Transistor	5	MPQ3546	None	1
MHQ3725	None	2	MMBR920L	RF Transistor	5	MPQ3725A	MPQ3725	3
MHQ3725H	None	2	MMBR930L	RF Transistor	5	MPQ6100	MPQ6100A	1
MHQ3725HX	None	2	MMBR931L	RF Transistor	5	MPQ6427	MPQ6426	1
MHQ3725HXV	None	2	MMBT3903L	MMBT3904LT1	1	MPQ6600	MPQ6600A1	1
MHQ6002	None	2	MMBT4123L	MMBT3904LT1	1	MPQ6600A	MPQ6600A1	1
MHQ918	None	2	MMBT4125L	MMBT3906LT1	1	MPQ7052	MPQ7051	1
MM1748A	2N2369A	1	MMBT5086L	MMBT5087LT1	1	MPQ7053	MPQ7051	1
MM2945A	None	2	MMBT8598L	MMBT8599LT1	1	MPQ7092	MPS7093	1
MM3006	MM3007	1	MMBT930L	BC847BLT1	1	MPS3403	MPS8099	1
MM3009	2N5058	1	MMBV2106L	MMBV2105LT1/7LT1	1	MPS3566	2N4401	1
MM3903	2N3947	2	MMBZ5226BL	Zener Diode	4	MPS3567	2N4400	1
MM3904	2N3947	2	MMBZ5227BL	Zener Diode	4	MPS3569	2N4400	1
MM3905	2N3251A	2	MMBZ5228BL	Zener Diode	4	MPS3702	2N4402	1
MM3906	2N3251A	2	MMBZ5229BL	Zener Diode	4	MPS3703	2N4402	1
MM4036	2N4033	1	MMBZ5230BL	Zener Diode	4	MPS3704	2N4401	1
MM4037	2N4033	1	MMBZ5231BL	Zener Diode	4	MPS3705	2N4400	1
MM4258	2N4208	1	MMBZ5232BL	Zener Diode	4	MPS3903	MPS3904	1
MM5005	MM5007♦	1	MMBZ5233BL	Zener Diode	4	MPS6569A	MPS6568A	1
MM5006	MM5007♦	1	MMBZ5234BL	Zener Diode	4	MPS6570A	MPS6568A	1
MM5262	MM3725	1	MMBZ5235BL	Zener Diode	4			
MM5415	None	3	MMBZ5236BL	Zener Diode	4			
MM5416	None	3	MMBZ5237BL	Zener Diode	4			

♦ This a direct replacement part.

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REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE
MPS6716	MPS6717♦	1
MPS6733	MPSW42♦	1
MPS6734	MPSW42♦	1
MPS6735	MPSW42♦	1
MPS8097	MPS6428	1
MPS930A	MPS3904	1
MPSA45	MPSA44♦	1
MPSD55	2N4403♦	1
MPSH07	MPSH07A♦	1
MPSH30	MPSH07A	1
MPSW43	MPSW42♦	1
MPSW93	MPSW92♦	1
MQ1120	None	2
MQ1120	None	2
MQ1129	None	2
MQ2218	None	2
MQ2218	None	2
MQ2218A	None	2
MQ2218A	None	2
MQ2219	None	2
MQ2219	None	2
MQ2219A	None	2
MQ2219A	None	2
MQ2369	None	2
MQ2904	None	2
MQ2904	None	2
MQ2905A	None	2
MQ2905A	None	2
MQ3251	None	2
MQ3251	None	2
MQ3467	None	2
MQ3467	None	2
MQ3725	None	2
MQ3725	None	2
MQ3762	None	2
MQ3762	None	2
MQ6001	None	2
MQ6001	None	2
MQ7001	None	2
MQ7001	None	2
MQ7003	None	2
MQ7003	None	2
MQ7007	None	2
MQ7007	None	2
MQ7021	None	2
MQ7021	None	2
MQ982	None	2
MQ982	None	2
MSD6100X	MSD6100♦	2
MSD6102	MSD6100	1
MV105G	MMBV105GLT1	1
MV2102	MV2101/3	1
MV2102L	MV2101L/3L	1
MV2106	MV2105/7	1
MV2110	MV2109/11	1
P2N2222	P2N2222A♦	1
P2N2907	P2N2907A♦	1
PBF259R	PBF259RS	1
U308	J308	2
U309	J309	2
U310	J310	2
1N5447B	1N5446B/8B	1
1N5454A	1N5453A/5A	1
1N5454B	1N5453B/5B	1
1N5461A	1N5441A	1
1N5461B	1N5441B	1
1N5462A	1N5441A/3A	1
1N5462B	1N5441B/3B	1
1N5463A	1N5443A	1
1N5463B	1N5443B	1
1N5464A	1N5444A	1
1N5464B	1N5444B	1
1N5465A	1N5445A	1
1N5465B	1N5445B	1
1N5466A	1N5446A	1
1N5466B	1N5446B	1
1N5467A	1N5446A/8A	1
1N5467B	1N5446B/8B	1
1N5468A	1N5448A	1
1N5468B	1N5448B	1
1N5469A	1N5449A	1
1N5469B	1N5449B	1
1N5470A	1N5450A	1
1N5470B	1N5450B	1
1N5471A	1N5451A	1
1N5471B	1N5451B	1
1N5472A	1N5452A	1
1N5472B	1N5452B	1
1N5473A	1N5453A	1
1N5473B	1N5453B	1
1N5474A	1N5453A/5A	1
1N5474B	1N5453B/5B	1
1N5475A	1N5455A	1
1N5475B	1N5455B	1
1N5476A	1N5456A	1
1N5476B	1N5456B	1
2N1132	2N2904♦	1
2N1132A	2N2904♦	1
2N2060	None	2
2N2218	2N2218A♦	1
2N2221	2N2221A♦	1
2N2223	None	2
2N2223 A	None	2
2N2368	2N2369A♦	1
2N2453	None	2
2N2453A	None	2
2N2480A	None	2
2N2481	2N2369A♦	1
2N2501	2N2369A	1
2N2605	2N3964	1
2N2639	None	2
2N2640	None	2
2N2641	None	2
2N2642	None	2
2N2642	None	2
2N2643	None	2
2N2644	None	2
2N2652	None	2
2N2652A	None	2
2N2721	None	2
2N2722	None	2
2N2723	MPSA13	1
2N2785	MPSA13	1
2N2800	2N2905A♦	1
2N2843	None	1
2N2844	None	1
2N2897	2N3700♦	1
2N2903	None	2
2N2913	None	2
2N2914	None	2
2N2915	None	2
2N2916	None	2
2N2918	None	2
2N2918	None	2
2N2917	None	2
2N2919	None	2
2N2920	None	2
2N2945	None	2
2N2945A	None	2
2N2946	None	2
2N2946A	None	2
2N3011	2N2369A♦	1
2N3012	2N869A	1
2N3013	2N2369A	1
2N3014	2N2369A	1
2N3043	None	2
2N3044	None	2
2N3045	None	2
2N3048	None	2
2N3073	2N2906A♦	1
2N3114	2N3500♦	1
2N3135	2N2906A♦	1
2N3227	2N2369A	1
2N3245	2N3468♦	1
2N3249	2N869A♦	1
2N3250A	2N3251A	1
2N3252	MM3725	1
2N3253	MM3725	1
2N3300	2N2219A♦	1
2N3302	2N2222A♦	1
2N3307	2N4959	2, 5

♦ This a direct replacement part.

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REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE
2N3308	2N4959	2, 5
2N3330	None	1
2N3331	None	1
2N3425	None	2
2N3437	None	1
2N3438	None	1
2N3439	None	3
2N3440	None	3
2N3444	MM3725	2
2N3459	None	1
2N3460	None	1
2N3485	2N2906A	2
2N3485A	2N2906A	2
2N3486	2N2907A	2
2N3486A	2N2907A	2
2N3494	2N3637♦	1
2N3495	2N3637♦	1
2N3496	2N3637	1
2N3498	2N3501	1
2N3506	None	1
2N3507	None	1
2N3648	2N4014	2
2N3724	MM3725	1
2N3725	MM3725	3
2N3726	None	2
2N3727	None	2
2N3734	MM3725	1
2N3735	MM3725	3
2N3737	MM3725	2
2N3743	2N4931	1
2N3764	2N3762	2
2N3765	2N3762	2
2N3796	None	1
2N3797	None	1
2N3798	2N3799	1
2N3806	None	2
2N3806A	None	2
2N3807	None	2
2N3807A	None	2
2N3808	None	2
2N3808	None	2
2N3808A	None	2
2N3809	None	2
2N3809A	None	2
2N3810	None	2
2N3810A	None	2
2N3811	None	2
2N3811A	None	2
2N3821	MPF3821	2
2N3822	MPF3822	2
2N3823	None	2
2N3838	None	2
2N3909	None	2
2N3909A	None	2
2N3962	2N3799	1

DEVICE	REPLACEMENT PART	CODE
2N3965	2N3799	1
2N3971	None	2
2N3972	None	2
2N3993	None	2
2N3994	None	2
2N4013	2N4014	1
2N4015	None	2
2N4016	None	2
2N4026	2N4033	1
2N4027	2N4033	1
2N4028	2N4033	1
2N4029	2N4033	1
2N4030	2N4032	1
2N4031	2N4033	1
2N4091	MPF4091	2
2N4092	None	2
2N4093	None	2
2N4209	MM4209	3
2N4220	None	2
2N4220A	None	2
2N4221	None	2
2N4221A	None	2
2N4222	None	2
2N4222A	None	2
2N4234	None	3
2N4235	None	3
2N4236	None	3
2N4237	None	3
2N4238	None	3
2N4239	None	3
2N4260	None	3
2N4261	None	3
2N4338	None	3
2N4339	None	3
2N4340	None	3
2N4341	None	3
2N4351	None	2
2N4352	None	2
2N4391	MPF4391	2
2N4392	MPF4392	2
2N4393	MPF4393	2
2N4406	2N4407	3
2N4409	2N4410	1
2N4416	None	2
2N4416A	None	2
2N4453	2N869A♦	1
2N4854	None	2
2N4855	None	2
2N4856	MPF4856	2
2N4856A	MPF4856	2
2N4857	None	2
2N4857A	None	2
2N4858	None	2
2N4858A	None	2
2N4859	MPF4859	2

DEVICE	REPLACEMENT PART	CODE
2N4859A	MPF4859	2
2N4860	None	2
2N4860A	None	2
2N4861	None	2
2N4861A	None	2
2N4890	2N4033	1
2N4926	MM3002	1
2N4927	MM3002	1
2N4928	2N3637	1
2N4929	2N3637	1
2N4930	2N4931	1
2N4937	None	2
2N4938	None	2
2N4939	None	2
2N4941	None	2
2N5022	2N3468	1
2N5023	2N3467	1
2N5059	2N5058	1
2N5208	MPSH81	1
2N5222	MPSH10♦	1
2N5226	2N4403♦	1
2N5227	2N3906♦	1
2N5230	None	2
2N5245	None	1
2N5246	None	1
2N5247	None	1
2N5320	None	3
2N5321	None	3
2N5322	None	3
2N5323	None	3
2N5415	None	3
2N5416	None	3
2N5581	2N2222A	2
2N5582	2N2222A	2
2N5679	None	3
2N5680	None	3
2N5681	None	3
2N5682	None	3
2N5771	MPS5771	3
2N5793	None	2
2N5794	None	2
2N5795	None	2
2N5796	None	2
2N5859	MM3725	1
2N5861	MM3725	1
2N6428	MPS6428	3
2N6428A	MPS6428	3
2N6430	2N6431	1
2N657	2N3500	1
2N6782	None	1
2N6784	None	1
2N6788	None	1
2N6790	None	1
2N6796	None	1

♦ This a direct replacement part.

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REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE
2N6798	None	1	BC238A	BC237A	1	BC486L	BC490	1
2N6800	None	1	BC239B	BC237B	1	BC487	BC489	1
2N6802	None	1	BC308	BC309	1	BC487A	BC489A	1
2N6987	None	2	BC308A	BC309	1	BC487B	BC489B	1
2N6988	None	2	BC308B	BC309B	1	BC487L	BC489	1
2N6989	None	2	BC309A	BC558A	1	BC488	BC490	1
2N699	2N3020	1	BC309C	BC558B	1	BC488A	BC490A	1
2N6990	None	2	BC317	MPS3904	1	BC488B	BC490B	1
2N7008	2N7000♦	3	BC317A	MPS3904	1	BC488L	BC490	1
2N706	2N2369A	1	BC317B	MPS3904	1	BC489L	BC489	1
2N706B	2N2369A	1	BC320	2N5086	1	BC490L	BC490	1
2N708	2N2369A	1	BC320A	2N5086	1	BC517S	BC517	1
2N718	2N3700	1	BC320B	2N5087	1	BC549	BC548	1
2N835	2N2369A	1	BC327–40	BC327–25	1	BC549A	BC548A	1
2N910	2N3700	1	BC328–40	BC328–25	1	BC550	BC546	1
2N914	2N2369A	1	BC372–16	BC372	1	BC550A	BC546A	1
2N915	2N3947	1	BC372–25	BC372	1	BC558	BC558B	1
2N916	2N3947	1	BC372–40	BC372	1	BC558A	BC558B	1
2N918	None	2	BC373–16	BC373	1	BC558C	BC558B	1
3N155	None	2	BC373–25	BC373	1	BC617	BC618	1
3N157	None	2	BC375D	BF374	1	BC650	BC548C	1
3N169	None	2	BC413	BC237B	1	BC650C	BC548C	1
3N170	None	2	BC413B	BC237B	1	BC650CS	BC548C	1
3N171	None	2	BC413C	BC237C	1	BC650S	BC548C	1
BC160	BC160–16	1	BC414	BC237B	1	BC651	BC547C	1
BC160–10	BC160–16	1	BC414B	BC237B	1	BC651C	BC547C	1
BC161	2N4033	1	BC414C	BC237C	1	BC651CS	BC547C	1
BC161–10	2N4033	1	BC415	BC307B.	1	BC651S	BC547C	1
BC161–6	2N4033	1	BC415B	BC307B	1	BC808–16L	BC807–16LT1	1
BC171A	BC182A	1	BC415C	BC307C	1	BC808–25L	BC807–25LT1	1
BC171B	BC182B	1	BC416	BC307B	1	BC808–40L	BC807–40LT1	1
BC172A	BC182A	1	BC416B	BC307B	1	BC818–16L	BC817–16LT1	1
BC172B	BC182B	1	BC416C	BC307C	1	BC818–25L	BC817–25LT1	1
BC172C	BC184C	1	BC445	BC489	1	BC818–40L	BC817–40LT1	1
BC174A	BC546A	1	BC445A	BC489A	1	BC849BL	BC848BLT1	1
BC174B	BC546B	1	BC446	BC450	1	BC849CL	BC848CLT1	1
BC177C	BC177B	1	BC446A	BC450A	1	BC850BL	BC847BLT1	1
BC178A	BC177B	1	BC446B	BC450	1	BC850CL	BC847CLT1	1
BC178B	BC177B	1	BC447	BC489	1	BC859AL	BC858ALT1	1
BC178C	BC177B	1	BC447A	BC489A	1	BC859BL	BC858BLT1	1
BC179	BC177	1	BC447B	BC489B	1	BC859CL	BC858CLT1	1
BC179A	BC177B	1	BC448	BC450	1	BC860AL	BC857ALT1	1
BC179B	BC177B	1	BC448A	BC450A	1	BC860BL	BC857BLT1	1
BC179C	BC177B	1	BC448B	BC450	1	BC860CL	BC858CLT1	1
BC183A	BC183	1	BC449	BC489	1	BCW66HL	MMBT2222ALT1	1
BC183B	BC183	1	BC449A	BC489A	1	BCW67AL	BC807–16LT1	1
BC183C	BC183	1	BC449B	BC489B	1	BCW67BL	BC807–25LT1	1
BC184B	BC184	1	BC450B	BC450	1	BCW67CL	BC807–40LT1	1
BC184C	BC184	1	BC485	BC489	1	BCW67L	BCX17LT1	1
BC212A	BC212	1	BC485A	BC489A	1	BCW68FL	BC807–16LT1	1
BC213A	BC213	1	BC485B	BC489B	1	BCW68L	BCX17LT1	1
BC213B	BC213	1	BC485L	BC489	1	BCX58–10	BC547C	1
BC213C	BC213	1	BC486	BC490	1	BCX58–7	BC547A	1
BC214B	BC214	1	BC486A	BC490A	1	BCX58–8	BC547B	1
BC214C	BC214	1	BC486B	BC490B	1	BCX58–9	BC547B	1

♦ This a direct replacement part.

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REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE	DEVICE	REPLACEMENT PART	CODE
BCX59–10	BC547C	1	BSS51	None	3	IRFD1Z3	None	2
BCX59–7	BC547A	1	BSS52	None	3	IRFD210	None	2
BCX59–8	BC547B	1	BSS79BL	MMBT2222ALT1	1	IRFD213	None	2
BCX59–9	BC547C	1	BSS79CL	MMBT2222ALT1	1	IRFD220	None	2
BCX71GL	BC857ALT1	1	BSS80BL	MMBT2907ALT1	1	IRFD223	None	2
BCX71JL	BC857BLT1	1	BSS80CL	MMBT2907ALT1	1	IRFD9110	None	2
BCX71KL	BC857BLT1	1	BSS82BL	MMBT2907ALT1	1	IRFD9112	None	2
BCX78–10L	BC557C	1	BSS82CL	MMBT2907ALT1	1	IRFD9120	None	2
BCX78–7L	BC557A	1	BSV15–16	2N4033	1	IRFD9123	None	2
BCX78–8L	BC557B	1	BSV16–16	2N4033	1	IRFE110	None	2
BCX78–9L	BC557C	1	BSV17–10	2N4033	1	IRFE113	None	2
BCX79–10L	BC557C	1	BSV17–16	2N4033	1	IRFE9120	None	2
BCX79–7L	BC557A	1	BSW67A	MM3007	1	IRFE9123	None	2
BCX79–8L	BC557B	1	BSW68A	MM3007	1	IRFF110	None	2
BCX79–9L	BC557C	1	BSX29	2N869A	1	IRFF113	None	2
BCY58–VII	2N2484	1	BSX32	MM3725	1	IRFF120	None	2
BCY78–VII	BCY78–VIII	1	BSX45–10	2N3019	1	IRFF123	None	2
BCY78–X	None	1	BSX45–16	2N3019	1	IRFF210	None	2
BCY79–X	BCY79–IX	1	BSX45–6	2N3019	1	IRFF213	None	2
BDB01A	BDB01D	1	BSX46–10	2N3019	1	IRFF220	None	2
BDB01B	BDB01D	1	BSX46–16	2N3019	1	IRFF223	None	2
BDB02A	BDB02D	1	BSX47–10	2N3019	1	IRFF230	None	2
BDB02B	BDB02D	1	BSX47–16	2N3019	1	IRFF233	None	2
BDC01A	BDC01D	1	BSX47–6	2N3019	1	IRFF330	None	2
BDC01B	BDC01D	1	BSX59	MM3725	1	IRFF333	None	2
BDC01C	BDC01D	1	BSX60	MM3725	1	IRFF430	None	2
BDC02A	BDC02D	1	BZX84C10L	Zener Diode	4	IRFF433	None	2
BDC02B	BDC02D	1	BZX84C11L	Zener Diode	4	JF1033B	2N5485♦	1
BDC02C	BDC02D	1	BZX84C12L	Zener Diode	4	JF1033S	2N5486♦	1
BDC07	BDC05	1	BZX84C13L	Zener Diode	4	JF1033Y	2N5484♦	1
BDC08	BDC06	1	BZX84C15L	Zener Diode	4			
BF241	BF240	1	BZX84C16L	Zener Diode	4	MBAV70L	BAV70LT1♦	2
BF254	BF240	1	BZX84C18L	Zener Diode	4	MBAV74L	BAV74LT1♦	2
BF254–3	BF240	1	BZX84C20L	Zener Diode	4	MBAW56L	BAW56LT1♦	2
BF254–4	BF240	1	BZX84C22L	Zener Diode	4	MBD201	MBD301	1
BF257	2N5058	1	BZX84C24L	Zener Diode	4	MBD501	MBD701	1
BF366	MPS6568A	1	BZX84C27L	Zener Diode	4	MD1121	None	2
BF371	MPSH24	1	BZX84C30L	Zener Diode	4	MD1122	None	2
BF373	MPSH34	1	BZX84C33L	Zener Diode	4	MD1132	None	2
BF375	BF374	1	BZX84C4V7L	Zener Diode	4	MD2218	None	2
BF375C	BF374	1	BZX84C5V1L	Zener Diode	4	MD2218A	None	2
BF845	2N6517	1	BZX84C5V6L	Zener Diode	4			
BFR92L	RF Transistor	5	BZX84C6V2L	Zener Diode	4	MD2218AF	None	2
BFR93L	RF Transistor	5	BZX84C6V8L	Zener Diode	4	MD2219A	None	2
BFS17	RF Transistor	5	BZX84C7V5L	Zener Diode	4	MD2219AF	None	2
BFX38	2N4033	1	BZX84C8V2L	Zener Diode	4	MD2369	None	2
BFX40	2N4033	1	BZX84C9V1L	Zener Diode	4	MD2369A	None	2
BFX48	2N869A	1	CV10253	2N3019	1	MD2369AF	None	2
BFX85	2N3019	1	CV10440	2N2484	1	MD2369B	None	2
BFY50	2N3019	1	CV10814	2N2484	1	MD2369BF	None	2
BFY52	2N3019	1	IRFD110	None	2	MD2904	None	2
BSR56L	MMBF4856LT1♦	1	IRFD113	None	2	MD2904A	None	2
BSR57L	None	1	IRFD120	None	2	MD2904AF	None	2
BSR58L	None	1	IRFD123	None	2	MD2905	None	2
BSS50	None	3	IRFD1Z0	None	2	MD2905A	None	2

♦ This a direct replacement part.

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REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE
MD2905AF	None	2
MD3250	None	2
MD3250A	None	2
MD3250AF	None	2
MD3251	None	2
MD3251A	None	2
MD3251AF	None	2
MD3409	None	2
MD3410	None	2
MD3467	None	2
MD3725	None	2
MD3762	None	2
MD3762F	None	2
MD4260	None	2
MD4261	None	2
MD5000	None	2
MD5000A	None	2
MD5000B	None	2
MD6001	None	2
MD6001F	None	2
MD6002	None	2
MD6002F	None	2
MD6003	None	2
MD7000	None	2
MD7001	None	2
MD7001F	None	2
MD7002	None	2
MD7002A	None	2
MD7002B	None	2
MD7003	None	2
MD7003A	None	2
MD7003B	None	2
MD7007	None	2
MD7007A	None	2
MD7007B	None	2
MD7007BF	None	2
MD7021	None	2
MD7021F	None	2
MD708	None	2
MD708A	None	2
MD708B	None	2
MD8001	None	2
MD8002	None	2
MD8003	None	2
MD918A	None	2
MD918AF	None	2
MD918B	None	2
MD982	None	2
MD982F	None	2
MD984	None	2
MD985	None	2
MFE120	None	2
MFE121	None	2
MFE122	None	2
MFE130	None	2
MFE131	None	2
MFE132	None	2
MFE2004	None	2
MFE2005	None	2
MFE2006	None	2
MFE201	None	2
MFE2010	None	2
MFE2011	None	2
MFE2012	None	2
MFE202	None	2
MFE203	None	2
MFE204	None	2
MFE209	None	2
MFE211	None	2
MFE212	None	2
MFE823	None	2
MFE825	None	2
MFE9200	None	2
MFE930	None	2
MFE960	None	2
MFE990	None	2
MFQ1000C	None	1
MFQ1000C	None	1
MFQ1000P	None	1
MFQ1000P	None	1
MFQ5460P	None	1
MFQ6660C	None	1
MFQ6660C	None	1
MFQ6660P	None	1
MFQ6660P	None	1
MHQ2222	None	2
MHQ2369	None	2
MHQ2484	None	2
MHQ2484H	None	2
MHQ2484HX	None	2
MHQ2484HXV	None	2
MHQ2906	None	2
MHQ3467	None	2
MHQ3546	None	2
MHQ3724	None	2
MHQ3724H	None	2
MHQ3724HX	None	2
MHQ3724HXV	None	2
MHQ3725	None	2
MHQ3725H	None	2
MHQ3725HX	None	2
MHQ3725HXV	None	2
MHQ6002	None	2
MHQ918	None	2
MM1748A	2N2369A	1
MM2945A	None	2
MM3006	MM3007	1
MM3009	2N5058	1
MM3903	2N3947	2
MM3904	2N3947	2
MM3905	2N3251A	2
MM3906	2N3251A	2
MM4036	2N4033	1
MM4037	2N4033	1
MM4258	2N4208	1
MM5005	MM5007♦	1
MM5006	MM5007♦	1
MM5262	MM3725	1
MM5415	None	3
MM5416	None	3
MMBA811C5L	BC857ALT1	1
MMBA811C6L	BC857BLT1	1
MMBA811C7L	BC857BLT1	1
MMBA811C8L	BC857BLT1	1
MMBA812M5L	BC857ALT1	1
MMBA812M6L	BC857BLT1	1
MMBA812M7L	BC857BLT1	1
MMBC1009F1L	BC848ALT1	1
MMBC1009F3L	BC848ALT1	1
MMBC1622D6L	BC847BLT1	1
MMBC1622D7L	BC847BLT1	1
MMBC1623L5L	BC847ALT1	1
MMBC1623L6L	BC847BLT1	1
MMBC1623L7L	BC847CLT1	1
MMBC1653N2L	MMBT5550LT1	1
MMBC1653N3L	MMBT5551LT1	1
MMBC1653N4L	MMBT5551LT1	1
MMBC1654N5L	MMBT5551LT1	1
MMBC1654N6L	MMBT5551LT1	1
MMBC1654N7L	MMBT5551LT1	1
MMBD201L	MMBD301LT1	1
MMBD2835XL	BAW56LT1	2
MMBD2836XL	BAW56LT1	2
MMBD2837XL	BAV74LT1♦	2
MMBD2838XL	BAV74LT1♦	2
MMBD501L	MMBD701LT1	1
MMBR2060L	RF Transistor	5
MMBR2857L	RF Transistor	5
MMBR4957L	RF Transistor	5
MMBR5031L	RF Transistor	5
MMBR5179L	RF Transistor	5
MMBR536L	RF Transistor	5
MMBR901L	RF Transistor	5
MMBR920L	RF Transistor	5
MMBR930L	RF Transistor	5
MMBR931L	RF Transistor	5
MMBT3903L	MMBT3904LT1	1
MMBT4123L	MMBT3904LT1	1
MMBT4125L	MMBT3906LT1	1
MMBT5086L	MMBT5087LT1	1
MMBT8598L	MMBT8599LT1	1
MMBT930L	BC847BLT1	1
MMBV2106L	MMBV2105LT1/7LT1	1
MMBZ5226BL	Zener Diode	4
MMBZ5227BL	Zener Diode	4
MMBZ5228BL	Zener Diode	4

♦ This a direct replacement part.

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REPLACEMENT DEVICES

DEVICE	REPLACEMENT PART	CODE
MMBZ5229BL	Zener Diode	4
MMBZ5230BL	Zener Diode	4
MMBZ5231BL	Zener Diode	4
MMBZ5232BL	Zener Diode	4
MMBZ5233BL	Zener Diode	4
MMBZ5234BL	Zener Diode	4
MMBZ5235BL	Zener Diode	4
MMBZ5236BL	Zener Diode	4
MMBZ5237BL	Zener Diode	4
MMBZ5238BL	Zener Diode	4
MMBZ5239BL	Zener Diode	4
MMBZ5240BL	Zener Diode	4
MMBZ5241BL	Zener Diode	4
MMBZ5242BL	Zener Diode	4
MMBZ5243BL	Zener Diode	4
MMBZ5244BL	Zener Diode	4
MMBZ5245BL	Zener Diode	4
MMBZ5246BL	Zener Diode	4
MMBZ5247BL	Zener Diode	4
MMBZ5248BL	Zener Diode	4
MMBZ5249BL	Zener Diode	4
MMBZ5250BL	Zener Diode	4
MMBZ5251BL	Zener Diode	4
MMBZ5252BL	Zener Diode	4
MMBZ5253BL	Zener Diode	4
MMBZ5254BL	Zener Diode	4
MMBZ5255BL	Zener Diode	4
MMBZ5256BL	Zener Diode	4
MMBZ5257BL	Zener Diode	4
MMPQ3725A	MMPQ3725	3
MMPQ3762	MMPQ3467	1
MPF3330	2N5460♦	1
MPF3970	MPF4391♦	1
MPF3972	MPF4393♦	1
MPF4221	2N5457♦	1
MPF4222A	2N5459♦	1
MPF4223	2N5459♦	1
MPF4856A	MPF4856♦	1
MPF4861A	MPF4858A♦	1
MPF820	MPF4392♦	1
MPQ2221	MPQ2222A	1

DEVICE	REPLACEMENT PART	CODE
MPQ3546	None	1
MPQ3725A	MPQ3725	3
MPQ6100	MPQ6100A	1
MPQ6427	MPQ6426	1
MPQ6600	MPQ6600A1	1
MPQ6600A	MPQ6600A1	1
MPQ7052	MPQ7051	1
MPQ7053	MPQ7051	1
MPQ7092	MPS7093	1
MPS3403	MPS8099	1
MPS3566	2N4401	1
MPS3567	2N4400	1
MPS3569	2N4400	1
MPS3702	2N4402	1
MPS3703	2N4402	1
MPS3704	2N4401	1
MPS3705	2N4400	1
MPS3903	MPS3904	1
MPS6569A	MPS6568A	1
MPS6570A	MPS6568A	1
MPS6716	MPS6717♦	1
MPS6733	MPSW42♦	1
MPS6734	MPSW42♦	1
MPS6735	MPSW42♦	1
MPS8097	MPS6428	1
MPS930A	MPS3904	1
MPSA45	MPSA44♦	1
MPSD55	2N4403♦	1
MPSH07	MPSH07A♦	1
MPSH30	MPSH07A	1
MPSW43	MPSW42♦	1
MPSW93	MPSW92♦	1
MQ1120	None	2
MQ1120	None	2
MQ1129	None	2
MQ2218	None	2
MQ2218	None	2
MQ2218A	None	2
MQ2218A	None	2
MQ2219	None	2

DEVICE	REPLACEMENT PART	CODE
MQ2219	None	2
MQ2219A	None	2
MQ2219A	None	2
MQ2369	None	2
MQ2904	None	2
MQ2904	None	2
MQ2905A	None	2
MQ2905A	None	2
MQ3251	None	2
MQ3251	None	2
MQ3467	None	2
MQ3467	None	2
MQ3725	None	2
MQ3725	None	2
MQ3762	None	2
MQ3762	None	2
MQ6001	None	2
MQ6001	None	2
MQ7001	None	2
MQ7001	None	2
MQ7003	None	2
MQ7003	None	2
MQ7007	None	2
MQ7007	None	2
MQ7021	None	2
MQ7021	None	2
MQ982	None	2
MQ982	None	2
MSD6100X	MSD6100♦	2
MSD6102	MSD6100	1
MV105G	MMBV105GLT1	1
MV2102	MV2101/3	1
MV2102L	MV2101L/3L	1
MV2106	MV2105/7	1
MV2110	MV2109/11	1
P2N2222	P2N2222A♦	1
P2N2907	P2N2907A♦	1
PBF259R	PBF259RS	1
U308	J308	2
U309	J309	2
U310	J310	2

♦ This a direct replacement part.

Note: All replacement parts are similar replacement parts unless otherwise indicated.

Codes:
1: Low Volume
2: Obsolete Technology
3: Unpredictable Process
4: See TVS/Zener Data Book for Device Information
5: See RF Device Data Book for Device Information

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