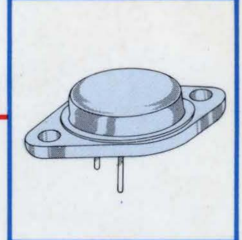
SAMSUNG

Data Book

SFET™

(Power MOSFET)

1990



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I. Semiconductor Product Guide

II. Transistor Data Book

- Vol. 1: Small Signal TR
- Vol. 2: Bipolar Power TR
- Vol. 3: TR Pellet

III. Linear IC Data Book

- Vol. 1: Audio/CDP/Toy
- Vol. 2: Video
- Vol. 3: Telecom
- Vol. 4: Industrial
- Vol. 5: Data Converter IC

IV. CMOS Consumer IC Data Book

V. High Speed CMOS Logic Data Book

VI. MOS Memory Data Book

VII. SFET Data Book

VIII. MPR Data Book

IX. CPL Data Book

X. Dot Matrix Data Book

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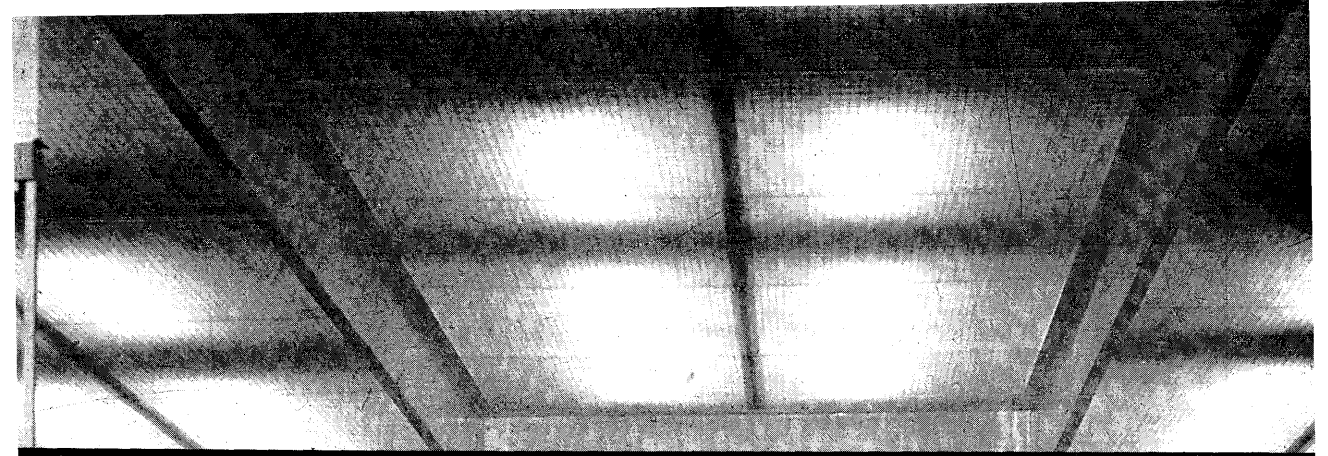

INTRODUCTION 1

INTRODUCTION TO SAMSUNG'S SFET™ FAMILY

Since the introduction of the first Power MOSFET products in the mid-70's, these devices have emerged as widely accepted components in medium-to-high frequency power control applications. Advances in Doubled Diffused MOS (DMOS) process and circuit design technology, as well as our understanding of how to use these devices in practical applications, have fueled the rapid growth of these products. As MOSFET applications have grown, economies of scale possible with high volume state-of-the-art manufacturing facilities such as Samsung's have reduced the price of these components to the point where many new applications are possible.

Samsung, with the proprietary HDMOS (TM) process technology, has advanced the basic DMOS technology to yet another level of performance, equivalent to the development of 1 Mb DRAM's in memory technology.

HDMOS™ (high-performance DMOS) is a combination of process innovation and design innovation capable of producing devices with very high breakdown voltages (in excess of 1000V), the lowest on-resistance per unit chip area, lowest capacitance, fastest switching time and highest energy absorption capability under unclamped inductive load switching.

This data book describes the complete family of Samsung power MOSFET products. The 328 parts in this family, in both N- and P- channel, have breakdown voltages ranging from 60V up to 700V, with currents as large as 40A. Samsung is continually expanding this family with additional products announced quarterly.

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FREEDOM FROM BIPOLAR LIMITATIONS

With this extensive family of power MOSFET products, designers of power conversion systems can finally dispense with traditional bipolar transistors and their associated constraints in terms of drive circuit complexity, reliability and switching speeds. Table 1 summarizes the advantages of MOSFET power transistors over older bipolar products.

Parameter	MOSFET	Bipolar
Input Impedence	High (>10^9 Ω)	Medium (−10KΩ)
Gain	High (>10^5)	Medium (10~100)
Switching Frequency	High (>100 kHz)	Low (<10 kHz)
On Resistance ($R_{DS(on)}$)	Low	Lower
Off Resistance	High	High
Voltage Capability	1000V and growing	1200V
Ruggedness	Excellent (2J)	Fair
Cost	Low	Low
Max Operating Temperature	200°C	150°C

Table 1. Bipolar vs. MOSFET Power Transistors

DRIVING THE SFET

Bipolar transistors are current controlled devices, and therefore require large base currents for operation. This large base current produces an even larger current flowing from collector to emitter. Power MOSFETs, on the other hand, are voltage controlled devices. A relatively small voltage applied between gate and source results in a large current flowing from drain to source. The gate oxide electrically isolates the gate, and results in extremely high input impedance and low gate input leakage currents.

The result of these fundamental differences in device operation is that MOSFETS utilize much simpler drive circuits, and hence lower system cost in many applications.

Power MOSFETs are majority carrier devices, and therefore do not suffer from minority carrier storage time limitations as do bipolar transistors. As a result, MOSFETs offer much better switching performance (up to 1 MHz and beyond) than do bipolar transistors (which are limited to 20 KHz and below).

INTRODUCTION TO SAMSUNG'S SFET™ FAMILY

Unlike bipolar transistors, Power MOSFETs do not suffer from secondary breakdown. This is frequently a major limitation in the power handling capability of bipolar power transistors. The insensitivity to second breakdown is due to the negative temperature coefficient for carrier mobility in power MOSFETs. As current increases, the device heats up. However, unlike bipolar transistors, carrier mobility decreases with increasing temperature, acting to reduce any further current increase. This self-limiting mechanism reduces the susceptibility of MOSFETs to localized heating that can lead to device destruction.

CMOS COMPATIBLE PROCESSING

Some key features of HDMOS technology includes the use of CMOS local oxidation techniques for definition of active area, exclusive use of ion implantation to introduce dopants, the use of multiple diffused guard rings and polysilicon plates for breakdown voltage enhancement and built-in redundancy, and a tight geometry octagonal cell design. Figure 1 compares conventional DMOS technology and HDMOS technology with local oxidation.

Conventional approaches for growing field oxide in power MOSFETs result in very thick initial oxide of one micron, causing problems in pattern definition and contact metalization. With HDMOS technology, an alternate approach is used for defining the field oxide that is compatible with high density VLSI CMOS processes. This alternate approach is local oxidation.

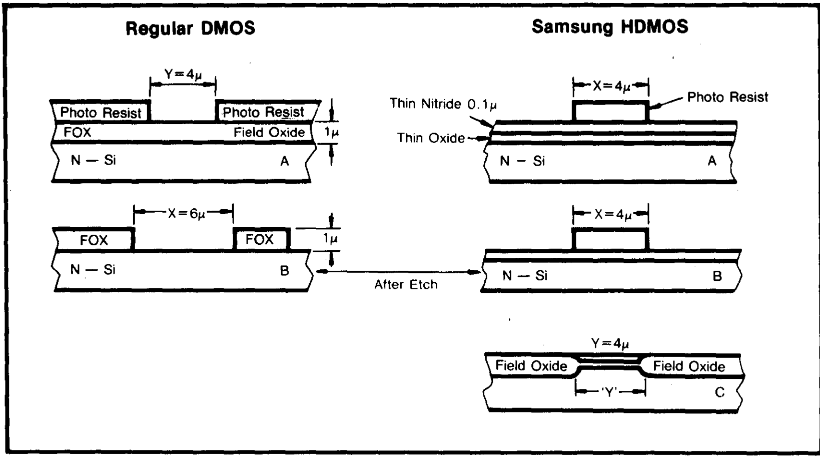

Figure 1: Conventional DMOS vs. HDMOS with Local Oxidation

By depositing and patterning a thin layer of silicon nitride, which selectively masks the silicon during oxide growth, the HDMOS features are more precisely defined. There is no undercutting of thick field oxide, and the resulting structure is more planar. This planar structure improves photolithographic resolution at other points in the process, and also reduces problems with metalization coverage. In addition, since one less etching sequence is required to pattern the thick field oxide, less chance exists of etch-induced pinholes in the field oxide. These pinholes reduce yields and device reliability.

In HDMOS, all impurities are introduced by ion implantation exclusively. This permits precise dopant control, eliminating variation in junction depths of both the main blocking junction and heavily doped source. Moreover, precise junction control allows the use of shallow junctions even in devices with blocking voltages well over 700V.

In N-channel devices, the main p-type junction well is defined by a unique double ion implant which significantly reduces parasitic bipolar transistor action. One implantation defines the p-well; the other is a heavier dose implant to create a central region of p+ in each cell. This reduces the sheet resistance of the well and prevents the parasitic NPN bipolar transistor from turning on.

This important advantage allows cell dimensions to be reduced to less than 12 microns, and cell densities to increase from 1 mllion to 2 million cells per square inch.

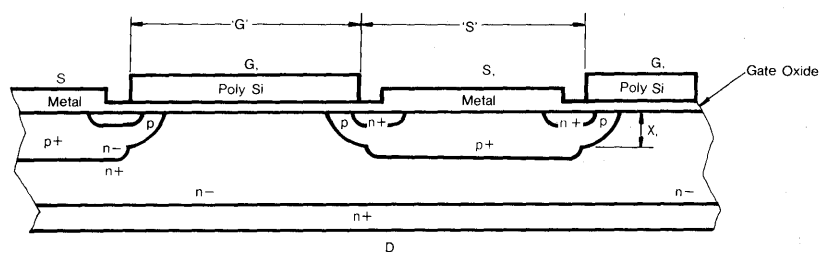

Figure 2: Extensive Use of Ion Implantation

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UNIQUE GUARD-RING DESIGN

HDMOS employs a unique guard ring design to achieve high blocking voltages with a planar structure without consuming large amounts of silicon area. A sequence of multiple self-aligned guard rings is used so that if a defect shorts out any pair of rings, the design has sufficient redundancy to ensure the rest of the rings will hold the necessary blocking voltage. Figure 3 shows a cross section of the HDMOS guard ring structure.

In addition, to improve surface stability of the field-oxide surfaces between the rings, a polysilicon layer is deposited at the gate of the HDMOS device. This poly layer is used as a field plate in reducing the electrical field at the edges of the die. A proprietary metal termination design is used to clamp the potential at the edge of the die. This is done so no depletion lines will reach the scribe area and create breakdown voltage variation due to surface effects in the scribe.

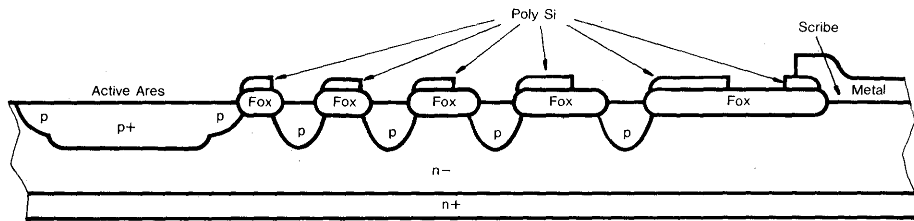


Figure 3: Multiple Self-aligned Guard Ring Structure

UNIQUE CELL DESIGN

Another key feature of HDMOS is an elongated octagonal cell design. This design minimizes parasitic NPN transistor base resistance, resulting in MOSFETs that are capable of withstanding high levels of inductive energy dissipation in inductive load switching without parasitic bipolar transistor turn-on.

HDMOS BENFEITS FOR DESIGNERS

For designers of power systems, HDMOS devices offer high performance under even exceptionally hostile circuit conditions. The exceptionally low input capacitance, as much as 35% lower than that of comparable devices, and low on-resistence are key to these performance advantages.

RUGGEDNESS

Unclamped inductive withstand energies of more than 2 J have been achieved for 700V (6A) devices, and 1.3 J for 500V devices (12A). Typical withstand energy levels for comparable devices is in the millijoule range. In practical terms, the strength of the Samsung devices allow a power control design engineer to be less concerned about stray inductance and voltage transients that can destroy conventional power MOSFETs, even in circuits which use voltage clamping techniques.

INTRODUCTION TO SAMSUNG'S SFET™ FAMILY

The ability of a power MOSFET to withstand high levels of inductive energy is not only a useful performance characteristic, but is also a measure of process quality. Poor process control leads to localized current crowding during inductive turn-off, which can lead to device failure during unclamped inductive load conditions.

Inductive load tests are used as a process control tool during final test. Samsung has found that test yields on conventional parameters such as breakdown voltage and leakage current were directly related to the results from inductive energy tests. Samsung tests 100% of its devices to a minimum inductive energy, and can select values that are specified by the customer.

An example is a two-phase step motor driven in the unipolar mode. The traditional solution is to clamp the peak V_{DS} that the power transistors see to below BV_{DSS} with an active or passive clamp circuit or snubber capable of dissipating 12.5W.

Even with the best motors, however, there is still some leakage reactance that is not coupled. When the transistor is turned off, the energy stored in the leakage inductance must be dissipated by the transistor, resulting in avalanche breakdown. For a typical motor, this leakage reactance might be 50μH, resulting in an inductive energy of 625μJ at 5A. Dissipation of the inductive energy in the MOSFET appears to be a very useful design approach. 625μJ is well below the HDMOS power device's unclamped energy-handling capability and 12.5W of additional dissipation can be handled with proper thermal design.

FASTER SWITCHING SPEED

Lower CISS (Gate Input Capacitance) and CRSS (Miller Effect Capacitance), coupled with improved gate bus layout features, results in a 2-1 decrease in switching time, turn-on and turn-off delay times, as well as current and voltage rise and fall times. This speed improvement means higher frequency and more efficient operation in switching mode. For the designer, it also means reduced gate drive dissipation and reduced drive circuit complexity. The Miller effect interaction CRSS drops by 30%-a major benefit for gate drive circuit designs.

HDMOS boosts dV/dt capability by providing a better base-emitter short and reduced Cjc on the parasitic bipolar transistor. As a result, the designer can actually take advantage of the higher speed switching without compromising device reliability due to parasitic dV/dt turn on.

APPLICATION AREAS

With the availability of rugged, reliable HDMOS power MOSFET designers have "bullet proof" solutions for even the most difficult power system applications, including flyback and forward converters, and power factor correction in switch-mode power supplies (SMPS).

HDMOS devices can reliably satisfy the requirements for flyback and one-transistor forward converters operating off 240 Vac lines, and can extend the power handling capability of these designs up to 1000W.

Designers using these devices have no need to resort to exotic schemes such as transformer designs with 2-1 clamp to primary turns ration (and a 340 percent maximum duty cycle) in order to overcome the limitations of lower voltage devices.

The two-transistor forward converter has become a very popular topology for 240 Vac operation, and 500V HDMOS devices provide a reliable solution. However, in most cases, in addition to paying for two devices instead of one, the real issue is driving the upper leg since the gate drive must be at a potential which is close to the high voltage source.

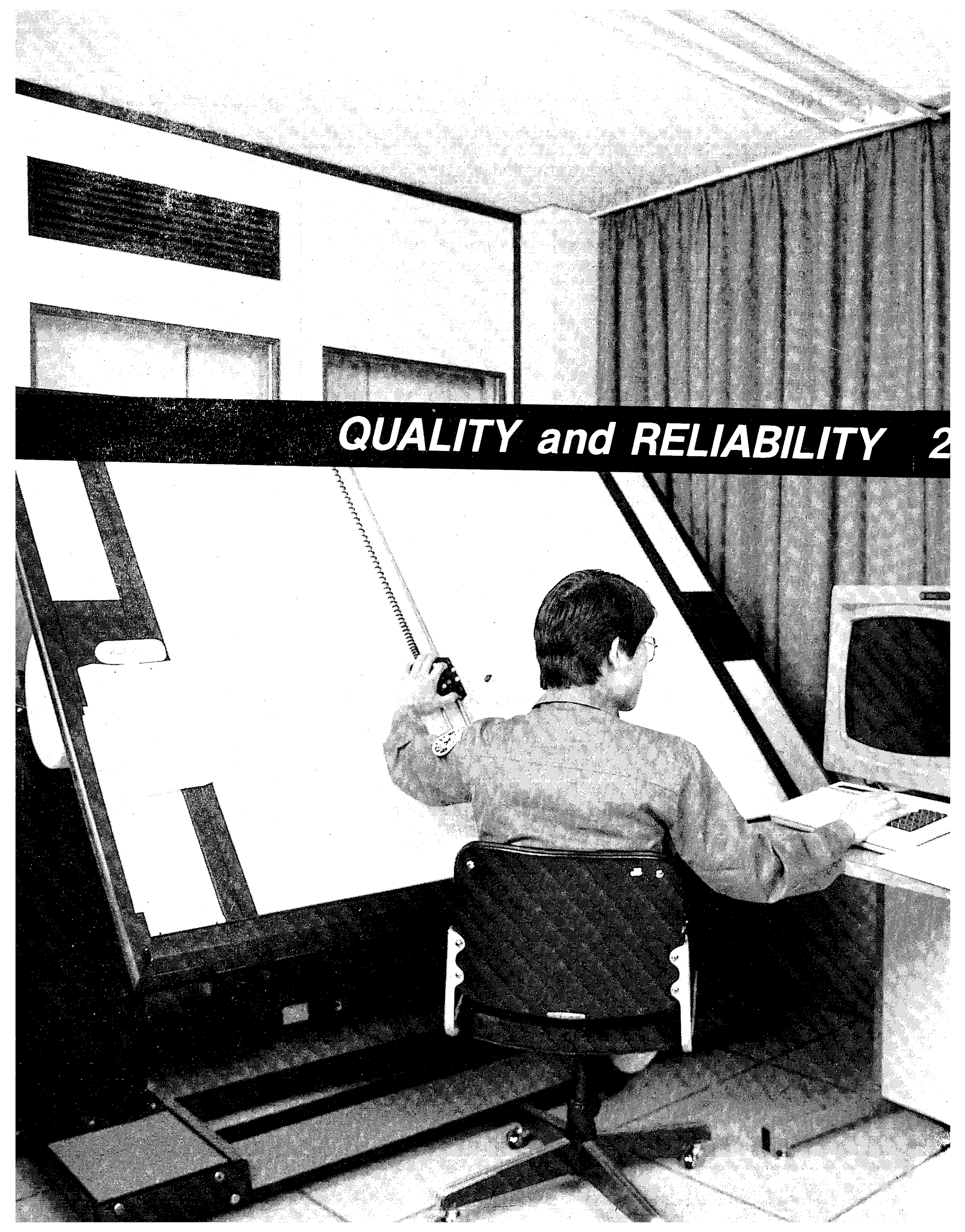
The requirement for this second gate drive operating at several hundred volts above ground potential greatly increases the cost and complexity of the two transistor circuit. The design time and cost of producing an equivalent supply would be considerably lower if it could be done reliably with a one transistor implementation. This is exactly what a HDMOS Power MOSFET provides.

Another area that lends itself well to HDMOS solutions in SMPS is power factor corrections. For some time, this has been an important issue in military applications, and power correction solutions are now trickling down into the commercial arena as systems become more sophisticated and system interaction and power distribution problems become more acute.

A typical architecture for such a system utilizes a boost-converter preprocessor followed by a conventional dc/dc converter. The rectified input voltage is used as a current reference signal to command sinusoidal line current from the preprocessor.

The input bridge rectifier "unfolds" the half-sine pulses to provide very clean (power factor greater than 0.9) sinusoidal input line current. The dc output voltage can simultaneously be regulated, simplifying the remainder of the power-supply design.

This application requires a 450-500 Vdc bus voltage and a 600-800V power MOSFET. Conducted line emissions standards will get only more stringent as time goes on. The higher voltage HDMOS devices will be needed for the new power supply and motor control circuit designs.



QUALITY and RELIABILITY 2

QUALITY and RELIABILITY

INTRODUCTION

Samsung's SFET Power MOSFET products are among the most reliable in the industry. Extensive qualification, monitor, and outgoing product programs are used to scrutinize all areas of product quality and reliability. Additionally, stringent controls and subsequent supporting documentation are applied to every wafer fabrication and assembly lot.

Actual and predicted data are presented, and show the devices as a whole to have an impressive FIT* rate of 2 for standard lifetest stress conditions.

RELIABILITY THEORY

This section is chiefy concerned with reliability. However, quality will be mentioned briefly, as reliability and quality are strongly interrelated.

The first concern of a customer is with the quality of incoming product. For this reason, Samsung utilizes tight outgoing quality procedures to assure all customers receive quality products. Details are outlined in another section. Additionally, lot-by-lot stressing, regular reliability monitors, exhaustive product qualification testing, and rigorous in-line process controls (details in another section) are all utilized to guarantee Samsung products are of the highest grade. Quality is Samsung's number one priority.

*NOTE: FIT=Failures In Test, or failures in one billion, or 10^9, device-hours.

QUALITY AND RELIABILITY PROGRAM

Three topics of prime concern regarding Samsung's quality programs are detailed below:

A. Qualification Program
B. Monitor Program
C. Outgoing Quality Program

QUALIFICATION PROGRAM

In order for the SFET family to be qualified for mass production purposes, extensive reliability information has been compiled. The purpose was to simulate all relevant user conditions, via accelerated and standard methods, prior to customer shipments. In this way, the processing and design of SFET devices are "wrung-out", and reliability strongly established, to ensure all product is of the highest quality.

The stresses used for qualification are detailed in another section (Reliability Test Results). Very stringent LTPD levels were applied to the various tests to guarantee a product quality level in the upper tier of the Power FET market.

MONITOR PROGRAM

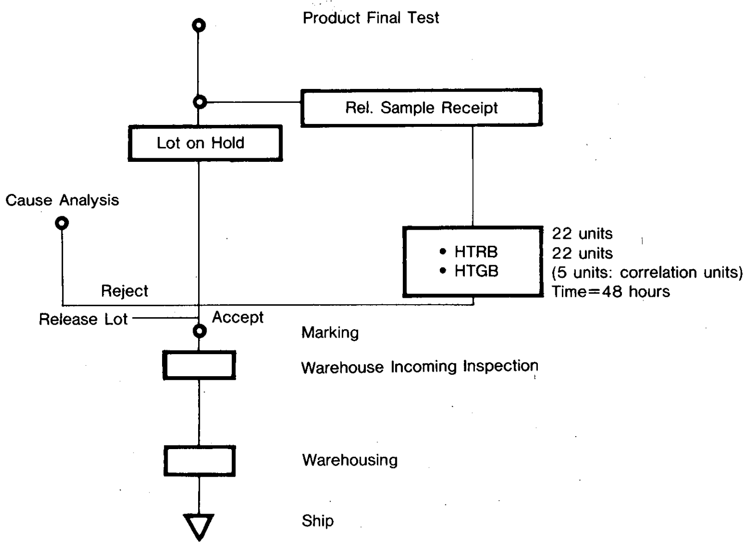
Twice per year devices duplicate their qualification tests to give long-term reliability data on SFET technology. In this way histrical data is collected and analyzed over all part types and thus assures the customer of ongoing device quality. Not only is the product therefore verified at its initial stages, but trends are noted to track continual process stability. These results are summarized in reliability reports issued periodically by Samsung Semiconductor.

OUTGOING QUALITY PROGRAM

All wafer lots are required to pass a "QC-Reliability-Gate" prior to product shipment. The purpose is to track "lot-by-lot" quality and reliability to catch any potential product anomaly at the factory site.

The customer can then expect only quality material to be delivered from Samsung. Any lot that fails the procedure listed below is scrutinized heavily, to make sure that corrective action takes place immediately.

By paying such close attention to every lot, product costs are kept at a minimum. Samsung's customer return rate is extremely low, which is where our tough outgoing policy is most powerful. Such a tight clamp to protect our customers is how we can assure that all Samsung's products are released with the highest confidence level possible



POWER FET OUTGOING FLOW

RELIABILITY AND PREDICTOR THEORY

RELIABILITY

Reliability can be loosely characterized as long-term product quality.

There are two types of reliability tests: those performed during design and development, and those carried out in production. The first type is usually performed on a small sample, but for long periods or under very accelerated conditions to investigate wearout failures and to determine tolerances and limits in the design process. The second type of tests is performed periodically during production to check, maintain, and improve the assured quality and reliability levels. All reliability tests performed by Samsung are under conditions more severe than those encountered in the field, and although accelerated, are chosen to simulate stresses that devices will be subjected to in actual operation. Care is taken to ensure that the failure modes and mechanisms are unchanged.

FUNDAMENTALS

A semiconductor device is very dependent on its conditions of use (*e.g.*, junction temperature, ambient temperature, voltage, current, *etc.*). Therefore, to predict failure rates, accelerated reliability testing is generally used. In accelerated testing, special stress conditions are considered as parametrically related to actual failure modes. Actual operating life time is predicted using this method. Through accelerated stresses, component failure rates are ascertained in terms of how many devices (in percent) are expected to fail for every 1000 hours of operation. A failure rate versus time of activity graph is shown below (the so-called "bath tub curve").

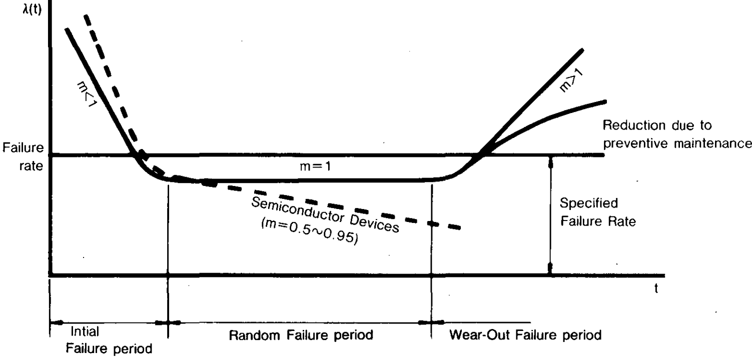


Figure 4: Failure Rate Curve ("Bath Tub Curve")

During the initial time period, products are affected by "infant mortailty", intrinsic to all semiconductor technologies. End users are very sensitive to this parameter, which causes early assembly/operation failures of their system. Periodically Samsung reviews and publishes life time results. The goal is a steady shift of the limits as shown below.

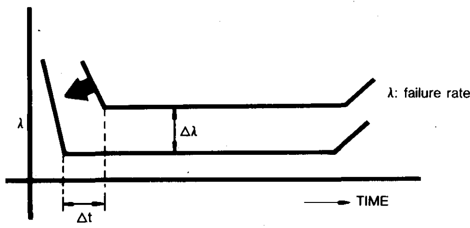


Figure 5: Failure Rate

ACCELERATED HUMIDITY TESTS

To evaluate the reliability of products assembled in plastic packages, Samsung performs accelerated humidity stressing, such as the Pressure Cooker Test (PCT) and Wet High Temperature Life Test (WHOPL).

Figure 6 shows some results obtained with these tests, which illustrate the improvements in recent years. These improvements result mainly from the introduction of purer molding resins, new process methods, and improved cleanliness

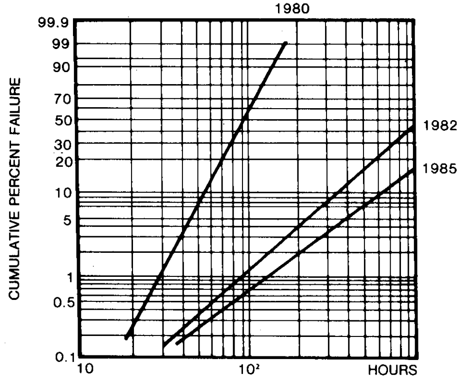


Figure 6: Improvement in Humidity Tests

ACCELERATED TEMPERATURE TESTS

Accelerated temperature tests are carried out at temperatures in a range from 75°C to 200°C for up to 1000 hours. These tests allow Samsung to evaluate reliability rapidly and economically, as failure rates are strongly dependent on temperature.

The validity of these tests is demonstrated by the good correlation between data collected in the field and laboratory results obtained using the Arrhenius model. Figure 7 shows the relationship between failure rates and temperatures obtained with this model.

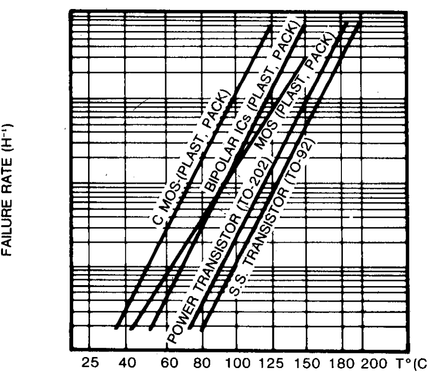


Figure 7: Failure Rate versus Temperature

FUNDAMENTAL THEORY FOR ACCELERATED TESTING

The accelerated life test is powerful because of its strong relation to failure physics. Arrhenius model, which is generally used, is explained below.

1. Arrhenius model

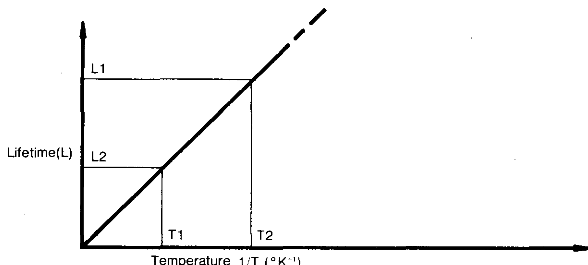
This model can be applied to accelerated Operating Life Tests and uses absolute (Kelvin) temperatures.

$L = A + Ea/K \cdot Tj$

L : Lifetime
A : Constant
Ea : Activation Energy
Tj : Absolute Junction temperature
K : Boltzman's constant

If life L1 and L2 correspond to T1, T2:

$$L1 = L2 \exp\left\{\frac{Ea}{K}\left(\frac{1}{T1} - \frac{1}{T2}\right)\right\}$$



The actual junction temperature should be used and can be computed using the following relationship:

$T_j = T_a + (P \times \theta ja)$

Where Tj=Junction Temperature
Ta=Ambient temperature
P=Actual power consumption
θja=Junction to Ambient thermal resistance (typically 100 degrees celsius/watt for a 16-Pin PDIP).

2. Activation Energy Estimate

Clearly the choice of an appropriate activation energy, Ea, is of paramount importance. The different mechanisms which could lead to circuit failure are characterized by specific activation energies whose values are published in the literature. The Arrhenius equation describes the rate of many processes responsible for the degradation and failure of electronic components. It follows that the transition of an item from an initially stable condition to a defined degraded state occurs by a thermally activated mechanism. The time for this transition is given by an equation of the form:

MTBF=B EXP (Ea/KT)
MTBF=Mean time between failures
B =Temperature-independent constant

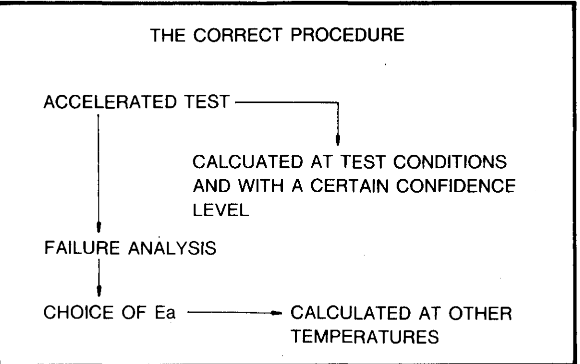
MTBF can be defined as the time to suffer a device degradation. The dramatic effect of the choice of the Ea value can be seen by plotting the MTBF equation. The acceleration effect for a 125°C device junction test with respect to 70°C actual device junction operation is equal to 1000 for Ea=1eV and 7 for Ea=0.3eV.

Some words of caution are needed about published values of Ea:

A. They are often related to high-temp tests where a single Ea (with high value) mechanism has become dominant.
B. They are specifically related to the devices produced by that supplier (and to its technology) for a given period of time.
C. They could be modified by the mutual action of other stresses (voltage, mechanical, *etc.*).
D. Field device-application conditions should be considered.

(Activation energy for each failure mode)

Failure Mechanism	Ea
Contamination	1~1.4 eV
Polarization	1 eV
Aluminum Migration	0.5~1 eV
Trapping	1 eV
Oxide Breakdown	0.3 eV
Silicon Defects	0.3~0.5 eV



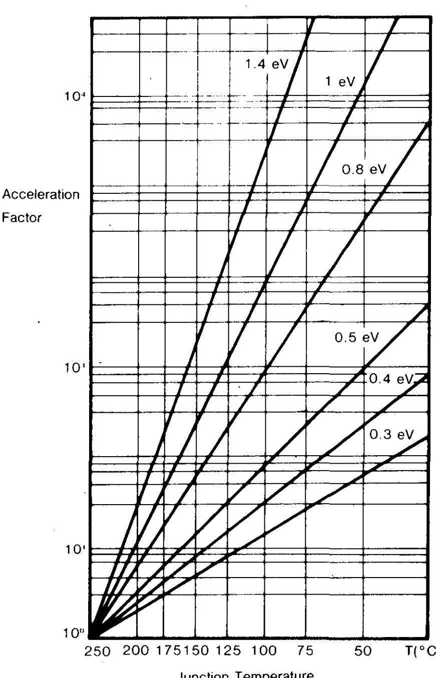


Figure 8: Life Hours

Failure Rate Predication

Accelerated testing defines the failure rate of products. By derating the data at different conditions, the life expectancy at actual operating conditions can be predicted. In its simplest form the failure rate (at a given temperature) is:

$$FR = \frac{N}{DH}$$

Where FR=Failure Rate
N =Number of failures
D =Number of components
H =Number of testing hours

If we intend to determine the FR at different temperatures, an acceleration factor must be considered. Some failure modes are accelerated via temperature stressing based upon the accelerations of the Arrhenius Law.

For two different temperatures:

$$F.R\ (T1) = FR\ (T2)\ \exp\left\{\frac{Ea}{K}\left(\frac{1}{T2} - \frac{1}{T1}\right)\right\}$$

FR (T1) is a point estimate, but to evaluate this data for an interval estimate, we generally use X^2 (chi square) distribution. An example follows:

Failure Rate Elaluation

Unit: %/1000HR

Dev. x Hours at 125°C	Fail	Failure Rate at 60% Confidence Level			
		Point Estimate	85°C	70°C	55°C
1.7×10^6	2	0.18	0.0068	0.0018	0.00036

The activation energy, from analysis, was chosen as 1.0 eV based upon test results. The failure rate at the lower operating temperature can be extrapolated by an Arrhenius plot.

RELIABILITY TESTS

Samsung has established a comprehensive reliability program to monitor and ensure the ongoing reliability of the SFET Power MOSFET family. This program involves not only reliability data collection and analysis on existing parts, but also rigorous in-line quality controls for all products.

Listed below are details of tests performed to ensure that manufactured product continues to meet Samsung's stringent quality standards. In-line quality controls are reviewed extensively in later sections.

The tests run by the Quality Department are accelerated tests, serving to model "real world" applications through boosted temperatures, voltages, and/or humidities. Accelerated conditions are used to derive device knowledge through means quicker than that of typical application situtations. These accelerated conditions are then used to assess differing failure rate mechanisms that correlate directly with ambient conditions.
Following are summaries of various stresses (and their conditions) run by Samsung on SFET devices.

High Temperature Reverse Bias (80% max V_{DS}, V_{GS}=0V, 150°C, static)

For this test, device integrity is checked through stressing of the main blocking junction at an elevated temperature and voltage. Overall product stability is investigated through leakage current monitoring; low leakage indicates good integrity.

High Temperature Gate Bias (V_{GS}=20V, V_{DS}=0V, 150°C, static)

HTGB is utilized to analyze gate oxide and junction stability over extended periods of accelerated temperatures and voltages. This is crucial as it is used to establish integrity at a point of high device stress.

Intermittent Operating Life (P_{MAX}, 25°C, 2 min on/2 min off)

This test is normally applied to scrutinize die bond thermal fatigue. A stressed device undergoes an "on" cycle, where there is thermal heating due to power dissipation, and an "off" cycle, where there is thermal cooling due to lack of inputted power. Die attach (between die and package) and bond attach (between wire and die) are the critical areas of concern.

Wet High Temperature Reverse Bias (80% max V_{DS}, V_{GS}=0V, 85°C, 85% R.H., static)

Wet high temperature reverse bias test is used to accelerate failure mechanisms by applying static bias on alternate pins at high temperature and humidity ambient (85°C/85% R.H.). This test checks for resistance to moisture penetration by using an electrolytic principle to accelerate corrosive mechanisms.

Pressure Cooker Test (Unbiased, 121°C, 15 PSIG, 100% R.H.)

The Pressure Cooker Test checks for resistance to moisture penetration. A highly pressurized vessel is used to force water (thereby promoting corrosion) into packaged devices located within the vessel.

High Temperature Storage (Unbiased, 150°C)

High Temperature Storage is utilized to test for both package and die weaknesses. For example, sensitivities to ionic contamination and bond integrity are closely scrutinized.

Temperature Cycling (Unbiased, −65°C to +150°C, air)

This stress uses a chamber with alternating temperatures of −65°C and +150°C (air ambient) to thermally cycle devices within it. No bias is applied. The cycling checks for mechanical integrity of the packaged device, in particular bond wires and die attach, along with metal/polysilcon microcracks.

Thermal Shock (Unbiased, −65°C to + 150°C, liquid)
This stress uses a chamber with alternating temperatures of −65°C to + 150°C (liquid ambient) to thermally cycle devices within it. No bias is applied. The cycling is very rapid, and primarily checks for die/package compatibility.

RELIABILITY TEST RESULTS

This section is divided into two parts-actual and predicted test results. Actual test results are those derived via accelerated stressing done by the QC Department. Predicated test results are calculated by taking actual test results and de-rating them using statistical and mathematical models to determine device performance in "real-time" user conditions.

ACTUAL TEST RESULTS

Stress	Conditions	Number of Devices	Number of Device Hours/Cycles	Number of Failures	Failure Rate (See Predicted Test Results)	MTBF*[years] (See Predicted Test Results)
HTRB	80% max. V_{DS}, V_{GS}=0V, 150°C Static	990	988,668	9	4 FIT	28,617
HTGB	V_{GS}=20V, V_{DS}=0V, 150°C Static	990	990,000	2	1 FIT	114,469
IOL	Pmax, 2min on/2 min off 25°C	342	342,000	2	0.91%/1k Hrs	12.6
WHTRB	80% max. V_{DS}, V_{GS}=85°C, 85% R.H., Static	342	341,000	2	43 FIT	2,662
PCT	121°C, 15 PSIG, 100% R.H.	240	23,040	0	3.99%/1k Hrs	2.9
HTS	150°C	684	684,000	1	1 FIT	114,469
Temperature Cycle	−65°C to 150°C, air-to-air	456	273,200	1	0.74%/1k Cyc	15.5
Thermal Shock	−65°C to 150°C liquid-to-liquid	228	136,800	0	0.672%/1kCyc	17.0

Note: MTBF is defined as "Mean Time Between Failures", and is the mathematical inverse of FIT.

Predicted Test Results

The Arrhenius Equation, which is reviewed in another section of this chapter, can be applied to derive typical "user-condition" device failure rates.

Stess: HTRB
988,668 device-hours at 150°C
9 failures
Average activation energy = 1.0 eV

De-rating to user-conditions yields:

55°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
2.79×10^9	0.0004	4	28,617

70°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
5.94×10^8	0.0017	17	6,733

90°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
9.19×10^7	0.0113	113	1,013

Stress: IOL
342,000 device-hours
2 failures

% Failures per per 1000 Hours (60% UCL)	FITs	MTBF (Years)
0.9064	9064	12.6

Stress: HTGB
990,000 device-hours at 150°C
2 failures
Average activation energy= 1.0 eV

De-rating to user-conditions yields:

55°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
2.80×10^9	0.0001	1	114,469

70°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
5.95×10^8	0.0005	5	22,894

90°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
9.21×10^7	0.0034	34	3,367

Stress: WHTRB*
341,000 device-hours
2 failures

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
7.20×10^7	0.0043	43	2,662

* Peck and Zierdt's Model is applied for failure rate prediction. Accelerated conditions are de-rated to 55°C and 50% R.H. conditions.

Stress: PCT
23,040 device-hours
0 failures

% Failures per per 1000 Cycles (60% UCL)	FITs	MTBF (Years)
3.9905	39,905	2.9

Stress: Temperature Cycle
273,200 device-cycles
1 failures

% Failures per per 1000 Cycles (60% UCL)	FITs	MTBF (Years)
0.7394	7,394	15.5

Stress: Thermal Shock
136,800 device-cycles
0 failures

% Failures per per 1000 Cycles (60% UCL)	FITs	MTBF (Years)
0.6720	6,720	17.0

Shress: HTS
684,000 device-hours at 150°C
1 failures
Activation energy= 1.0 eV

55°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
1.93×10^9	0.0001	1	114,469

70°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
4.11×10^8	0.0005	5	22,894

90°C Operation

Equivalent Device Hours	% Failures per 1000 Hours (60% UCL)	FITs	MTBF (Years)
6.36×10^7	0.0032	32	3,577

PROCESS CONTROL

GENERAL PROCESS CONTROL

The general process flow in Samsung is shown in Figure 9. This illustration contains the standard process flow from incoming parts and materials to customer shipment.

Process Step	Description
Parts and Materials	Acceptance inspection (according to acceptance inspection plan)
FAB	Process quality control • Check of each condition by process quality control procedures • Process inspection • Lot control • Equipment calibration and maintenance
EDS	100% Electrical Die Sorting
Assembly	Process Quality Control and screening of infant mortality defects • Thermal screen • Mechanical screen • Burn-in screen
Test	100% package sorting of electrical characteristics and marking
Process Rel. Testing	Reliability monitoring 1. PRT (Process Reliability Testing) 2. DRT (Device Reliability Testing) • High Temperature Reverse Bias • High Temperature Gate Bias • Environmental test • Life Test
Finished Goods Incoming Inspection	Sampling Inspection • Dimensions • Visual • Electrical characteristics • Periodic calibration of measuring equipment
Stock	Stock control • Age control
Finished Goods Outgoing Inspection	Sampling Inspection (when applicable)
Shipment	

Figure 9: General Process Flow Chart

WAFER FABRICATION

Process Controls

The Quality Control program utilizes the following methods of control to achieve its previously stated objectives: process audits, environmental monitors, process monitors, lot acceptance inspections, and process integrilty audits.

Definitions

The essential method of the Quality Control Program is defined as follows:

1. Process audit-Performed on all operations critical to product quality and reliability.
2. Environmental monitor-Monitors concerning the process environment; *i.e.*, water purity, temperature, humidity, particle counts.
3. Process monitor-Periodic inspection at designated process steps for verification of manufacturing inspection and maintenance of process average. These inspections provide both attribute and variable data.
4. Lot acceptance-Lot-by-lot sampling. This sampling method is reserved for those operations deemed as critical and require special attention.

Environmental Monitor

Process	Control Item	Spec. Limit	Insp. Frequency
Clean Room	• Temperature • Humidity • Particle • Air Velocity	• Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec.	24 Hrs. 24 Hrs. 24 Hrs. 24 Hrs.
D.I. Water	• Particle • Bacteria • Resistivity	• 5 ea/50ml (0.8μ) • 50 colonies/100ml (0.45μ) • Main (Line): More than 16 Mohm-cm • Using point: More than 14 Mohm-cm	24 Hrs. Weekly 24 Hrs. 24 Hrs.

*Instruments
- FMS (Facility Monitoring System) HIAC/ROYCO
- CPM (Central Particle Monitoring System-Dan Scientific)
- Liquid Dust Counter Etch Rate
- Filtration System for Bacterial check
- Air Particle counter
- Air Velocit[illegible]ter

Process Monitor

Process	Control Item	Spec. Limit	Insp. Frequency
Photo	• Aligner N_2 Flow Rate • Aligner Vacuum • Aligner Air • Aligner Pressure • Aligner Intensity • Coater Soft Bake Temperature Vacuum	• Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec.	Once/Shift Once/Shift Once/Shift Once/Shift Once/Shift Once/Shift Once/Shift Once/Shift
Etch	• Etchant Temp. • Etch Rate • Spin Dryer N_2 Flow RPM • Hard Bake Temp. N_2 Flow	• Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec.	Once/Shift Once/Shift Once/Shift Once/Shift Once/Shift Once/Shift

Process Monitor (Continued)

Process	Control Item	Spec. Limit	Insp. Frequency
Thin Film	• Cooling Water Temp. • Thickness	• 26±3°C • Individual Spec.	Once/Shift Once/Shift
CVD	• Pin Hole • Thickness	• Individual Spec. • Individual Spec.	Once/Shift Once/Shift
Diffusion	• Tube Temp. • C-V Plot Run Tube • Sheet Resistance • Thickness	• Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec. • Individual Spec.	Once/Shift Once/Shift Once/10days Once/Shift Once/Shift

Raw Material Incoming Inspection

1. Mask Inspection

Defect Detection	• Pinhole & Clear-extension • Opaque Projections & Spots • Scratch/Particle/Stain • Substrate Crack/Glass-chip • Others	All Masks	• Defect Size≤1.5μm • Defect Density ≤0.124EA/cm²
Registration	• Run-out (X-Y Coordinate) • Orthogonality • Drop-in Accuracy • Die Fit/Rotation	20% • All New Masks	±0.75μm ±0.75μm ±0.50μm ±0.50μm
Critical Dimension	• Critical Dimension	All Masks	Purchasing Spec.

* Instrument
- Auto mask inspection system for defect-detection (NJS 5MD-44)
- Comparator for registration (MVG 7X7)
- Automatic linewidth measuring system for CD (MPV-CD)

2. Wafer Inspection

Purpose	Insp. Items	Sample	Remarks
Structural	• Crystallographic Defect	All Lots	• Sirtl Etch
Electrical	• Resistivity • Conductivity	All Lots	• Monitor Water
Dimensional	• Thickness • Diameter • Orientation • Flatness	All Lots	TTV, NTV, Epi-thickness TIR (FPD) Local Slope
Visual	• Surface Quality • Cleanliness	All Lots	Purchasing Spec.

* Instrument
- 4 point probe for resistivity (Kokusai VR-40A, Tencor sonogage, ASM AFPP)
- Flatness measuring system (Siltec)
- Epi. layer thickness gauge (Digilab FTG-12, Qualimatic S-100)
- Automatic Surface Insp. System (Aeronca Wis-150)
- Non-contact thickness gauge (ADE6034)

In-Process Quality Inspection (FAB)

1. Manufacturing Section

Process Step	Process Control Insp.	Frequency
Oxidation	Oxide Thickness	All Lots
Diffusion	Oxide Thickness Sheet Resistance Visual	All Lots All Lots All Lots
Photo	Critical Dimension Visual Mask Clean Inspection	All Lots (MOS) All Lots All Masks with Spot Light (MOS) or Microscope (BIP)
Etch	Critical Dimension Visual	All Lots All Wafers
Thin Film	Metal Thickness Visual	All Lots All Lots
I_{on} Implant	Sheet Resistance	All Lots (Test Wafer)
Low Temp. Oxide	Thickness	All Lots
	Visual	All Lots
E-Test	Electrical Characteristics	All Lots
Fab. Out	Visual	All Wafers

2. FAB, QC Monitor/Gate

Process Step	FAB, QC Insp.	Frequency
Oxidation	Oxide Thickness C-V Test on Tubes Visual	Once/Shift Once/10 Days and After CLN. Once/Shift
Diffusion	Oxide Thickness C-V Test on Tubes Visual	Once/Shift Once/10 Days and After CLN. Once/Shift
Photo	Critical Dimension Visual Mask CLN Inspection	All Lots (MOS) Once/Shift All Masks After 10 Times Use
Etch	Critical Dimension Visual	All Lots (MOS) All Lots
Thin Film	C-V Test on Tubes on Lots Reflectivity	Once/10 Days and After CLN. Once/Shift Once/Shift
Low Temp. Oxide	Refractive Index, Wt% of Phosphorus Visual	1 Test Wafer/Lot 1 Test Wafer/Lot 1 Test Wafer/Lot
E-Test	Measuring Data	All Lots
Calibration	Instrument for Thickness and C.D Measuring	Once/week

3. Photo/Etch process quality control

Process Flow	Process Step	MFG. Control Item	QC Monitor/Gate
○	Prebake	Oven PM, Temperature Time	Oven-Particle Temp N_2 Flow Rate
○	Photo Resist (PR) —spin	Thickness Machine PM	
○	Soft Bake	Oven PM, Temperature Time	Temp. N_2 Flow Rate
○	Align/Expose	Light Uniformity Alignment, Focus Test Mask Clean Inspection Mask Clean Exposure Light Intensity	Light Intensity Mask Clean Insp.
○	Develop	Equipment PM Solution Control	Vacuum
□	Develop Check	PRC.D.'S Alignment Particles Mask and Resist Defects	
◇	QC Inspection		Critical Dimension
○	Hard Bake	Oven PM, Temperature Time	Temp. N_2 Flow Rate
○	Etch	Etch rate, Equipment PM & Settings, Etch Time to Clear	Etchant Temp. Etch Rate
□	Inspection	Over/Under	
○	PR Strip	Machine-PM	
□	Final Check	C.D.'S Over and under Etch, Particles, PR Residue, Defects, Scratches	
◇	QC Inspection		Same as Final Check, However, More Intense on limited Sample Basis. (AQL 6.5%)

4. Reliability-related Interlayer Dielectric, Metallization, and Passivation Process Quality Control Monitor

Item	Frequency
Wt% Phosphorus Content of the Dielectric Glass	1/Shift
Metallization Interconnect	1/Month
Al Step Coverage	1/Month
Metallization Reflectivity	1/Shift
Passivation Thickness and Composition	1/Shift
Thin Film Defect Density	1/Shift

Figure 10: General Wafer Fabrication Flow

Process Flow	Process Step	Major Control Item
	Wafer and Mask Input	
	Starting Material Incoming Inspection	Mask: (See mask Inspection) Wafer: (See wafer Inspection)
	Wafer Sorting and Labelling	Resistivity
	Initial Oxidation	Oxide Thickness
	Photo	• (See manufacturing section) • (See FAB, QC Monitor/gate)
	Inspection	• Critical Dimension • Visual/Mech — Major: AQL 1.0% — Minor: AQL 6.5%
Diff'n Metal	QC Gate	• Critical Dimension
	Etch	• (See manufacturing section) • (See FAB, QC Monitor/gate)
	Inspection	• Critical Dimension • Visual/Mech — Major: AQL 1.0% — Minor: AQL 6.5%
	QC Gate	• Critical Dimension • Visual/Mech
	Diffusion Metalization	• (See in-process Quality Inspection)
	E-test	• Electrical Characteristics

FIGURE 10. General Wafer Fabrication Flow (Continued)

Process Fow	Process Step	Major Control Item
◇	QC Gate	• Electrical Characterisitics
○	Back-Lap	• Thickness
○	Back Side Evaporation	• Thickness, Time Evaporation Rate
□	Final Inspection	• All Wafers Screened (Visual/Mech)
◇	QC Fab. Final Gate	• Visual/Mech. — Major: AQL 1.0% — Minor: AQL 6.5%
○	EDS (Electrical Die Sorting)	
◇	QC Gate	• Function Monitor
○	Sawing	
□	Inspection	• Chip Screen
◇ ↓ Die Attach	QC Final Inspection	• AQL 1.0% • Fab. Defect • Test Defect • Sawing Defect

ASSEMBLY

The process control and inspection points of the assembly operation are explained and listed below:

1. Die Inspection

   Following 100% inspection by manufacturing, in-process Quality Control samples each lot according to internal or customer specifications and standards.

2. Die Attach Inspection:

   Visual inspection of samples is done periodically on a machine/operator basis. Die Attach techniques are monitored and temperatures are verified.

3. Die Shear Strength:

   Following Die Attach, Die Shear Strength testing is performed periodically on a machine/operator basis. Either manual or automatic die attach is used.

4. Wire Bond Inspection:

   Visual inspection of samples is complemented by a wire pull test done periodically during each shift. These checks are also done on a machine/operator basis and $\bar{X}R$ data is maintained.

5. Pre-Seal/Pre-Encapsulation Inspection:

   Following 100% inspection of each lot, samples are taken on a lot acceptance basis and are inspected according to internal or customer criteria.

6. Seal Inspection:

   Periodic monitoring of the sealing operation checks the critical temperture profile of the sealing oven for both glass and metal seals.

7. Post-Seal Inspection:

   Subsequent to a 100% visual inspection, In-Process Quality Control samples each for conformance to visual criteria.

8. General Assembly Flow is shown in Figure 11.

Sampling Plans

1. Sampling plans are based on an AQL (Acceptable Quality Level) concept and are determined by internal or by customer specifications.

2. Raw Material Incoming Inspection.

2. Raw Material Incoming Inspection (confinued)

Meterial	Inspection Item	Acceptable Quality Level
Lead Frame	1) Visual Inspection 2) Dimension Inspection 3) Function Test 4) Work Test	LTPD 10%, C=2 LTPD 20%, C=0 LTPD 20%, C=0 LTPD 20%, C=0
Wafer	1) Visual Inspection	AQL 0.65%
Au/Al Wire	1) Visual Inspection 2) Bond Pull Strength Test 3) Bondability Test 4) Chemical Composition Analysis	n:5, C=0 n:13, C=0 Critical Defect: 0.65% Major Defect: 1.0% Minor Defect: 1.5% n:5, C=0
Molding Compound	1) Visual Inspection 2) Moldability Test 3) Chemical Composition Analysis	n:5, C=0 Critical Defect: 0.15% Major Defect: 1.0% Minor Defect: 1.5% n:5, C=0
Packing Tube & Pin	1) Visual Inspection 2) Dimension Inspection 3) Electro-Static Inspection 4) Hardness Test	LTPD 15%, C=2 LTPD 15% C=2 n:5, C=0 n:5, C=0
Solder	1) Visual Inspection 2) Weight Inspection 3) Chemical Composition Analysis	LTPD 20% C=0 LTPD 20% C=0 LTPD 20% C=0
Flux	1) Acidity Test 2) Specific Gravity Test 3) Chemical Composition Analysis	LTPD 20% C=0 LTPD 20% C=0 LTPD 20% C=0
Solder Preform	1) Visual Inspection 2) Work Test 3) Chemical Composition Analysis	AQL 1.0% AQL 1.0% AQL 1.0%
Coating Resin	1) Visual Inspection 2) Work Test 3) Chemical Composition Analysis	AQL 1.0% AQL 1.0% AQL 1.0%
Marking Ink	1) Work Test 2) Mark Permanency Test	Critical Defect: 0.15% Major Defect: 1.0% Minor Defect: 1.5% n:5, C=0
Chip Carrier	1) Visual Inspection 2) Dimension Inspection 3) Electro-Static Inspection 4) Hardness Test	LTPD 15% C=2 LTPD 15% C=0 n:5, C=0 n:5, C=0
Vinyl Pack	1) Visual Inspection 2) Work Test 3) Electro-Static Inspection	LTPD 20% C=0 LTPD 20% C=0 LTPD 15% C=0
Ag Epoxy	1) Work Test 2) Chemical Composition Analysis	n:8 C=0 n:8 C=0
Letter Marking	1) Visual Inspection 2) Work Test	
Spare Parts & Others	1) Dimension Inspection 2) Visual Inspection	n:5, C=0 n:5, C=0

3. In Process Quality Inspection

A. Assembly Lot Acceptance Inspection

(1) Acceptance quality level for wire bond gate inspection

Defect Class	Inspection Level	Type of Defect	
Critical Defect	AQL 0.65%	— Missing Metal — Chip Crack — No Probe — Epoxy on Die — Mixed Device — Wrong Bond — Missing Bond	— Diffusion Defect — Ink Die — Exposed Contact — Bond Short — Die Lift — Broken Wire
Major Defect	AQL 1.0%	— Metal Missing — Metal Adhesion — Pad Metal Discolored — Tilted Die — Die Orientation — Partial Bond	— Oxide Defect — Probe Damage — Metal Corrosion — Incomplete Wetting — Weakened Wire
Minor Defect	AQL 1.5%	— Adjacent Die — Passivation Glass — Die Attach Defect — Wire Loop Height — Extra Wire	— Contamination — Ball Size — Wire Clearance — Bond Deformation

(2) Acceptance quality level for Mold/Trim gate inspection

Defect Class	Inspection Level	Kind of Defect	
Critical Defect	AQL 0.15%	— Incomplete Mold — Void, Broken Package — Misalignment	— Deformation — No Plating — Broken Lead
Major Defect	AQL 0.4%	— Ejector Pin Defect — Package Burr — Flash on Lead	— Crack, Lead Burr — Rough Surface — Squashed Lead
Minor Defect	AQL 0.65%	— Lead Contamination — Poor Plating — Package Contamination	— Bent Lead

B. In-process monitor inspection

Inspection Item	Frequency	Reference
• Die Shear Test	Each Lot	MIL-STD-883C, 2019-2
• Bond Strength Test	Each Lot	MIL-STD-883C, 2011-4
• Solderability Test	Weekly	MIL-STD-883C, 2003-3
• Mark Permanency Test	Weekly	MIL-STD-883C, 2015-4
• Lead Integrity Test	Weekly	MIL-STD-883C, 2004-4
• In-Process Monitor Inspection for Product	4 Times/Shift/Each Process	Identify for Each Control Limit
• X-Ray Monitor Inspection for Molding	2 Times/Shift/Mold Press	Identify for Each Control Limit
• Monitor Inspection for Production Equipment	2 Times/Shift/Each Unit of Equipment	Identify for Each Control Limit

4. Outgoing quality inspection plan (LTPD)

Defect Class	Discrete	LSI	Kind of Defect
Critical Defect electrical visual	1%	2%	Open, short Wrong configuration, no marking
Major Defect electrical visual	1.5%	3%	Items which affect reliability most strongly
Minor Defect electrical visual	2%	5%	Items which minimally or do not affect reliability at all (cosmetic, appearance, etc.)

FIGURE 11. General Assembly Flow

Process Flow	Process Step	Major Control Item
	Wafer	
	Wafer Incoming Inspection	Q.C. Wafer Incoming Inspection AQL 4.0%
	Tape Mount	
	Sawing Q.C. Monitor	Q.C. Monitoring: — Chip-out — Scratch — Crack — Sawing Discoloration — Sawing-speed — Cut Count — D.I. Purity — CO_2 Bubble Purity
	Visual Inspection	100% Screen: — FAB Defect — EDS Test Defect — Sawing & Scratch Defect
	Q.C. Gate	1st AQL 1.0% Reinspection AQL: 0.65%
	Lead Frame (L/F)	
	Lead Frame Incoming	*Q.C.L/F Incoming Inspection 1. Acceptance Quality Level — Dimension: LTPD 20%, C=0 — Visual & Mechanical: LTPD 10%, C=2 — Functional Work Test: LTPD 10%, C=2
	Die Attach (D/A)	
	Q.C. Monitor	*Q.C.D/A Monitor Inspection 1. Bond force 2. Frequency: 4 Times/Station/Shift 3. Sample: 24 ea Time 4. Acceptance Criteria
	Cure	

Acceptance Criteria (Q.C. Monitor):

Defect	Acceptance	Reject
Critical	0	1
Major	1	2

FIGURE 11. General Assembly Flow (Continued)

Process Flow	Process Step	Major Control Item
	Q.C. Monitor	* Q.C. Cure Monitor Inspection 1. Control Item — Temperature — In/out Time 2. Frequency — 1 Time/Shift
	Au Wire	
	Bonding Wire Incoming Inspection	* Q.C. Au Wire Incoming Inspection 1. Visual Inspection: N=5, C=0 2. Bond Pull Test Strength Test: N=13, C=0 3. Bond Ability Test — Critical Defect: AQL 0.65% — Major Defect: AQL 1.0% — Minor Defect: AQL 1.5%
	Wire Bonding (W/B)	
	100% Visual Inspection	
	Q.C. Monitor	* Q.C. W/B Monitor Inspection 1. Frequency: 6 Times/Mach/Shift
	Q.C. Gate	1. Q.C. Acceptance Quality Level — Critical Defect: AQL 0.65% — Major Defect: AQL 1.0% — Minor Defect: AQL 1.5%
	Mold Compound	
	Incoming Inspection Mold	* Moldability Test — Critical Defect: AQL 0.15% — Major Defect: AQL 1.0% — Minor Defect: AQL 1.5%
	Mold	
	Q.C. Monitor	* Q.C. Mold Monitor Inspection 1. In-Process Monitor Inspection — Frequency: 4 Times/Station/Shift — Sample: 200 Units/Time 2. Acceptance Quality Level — Critical Defect: AQL 0.25% — Major Defect: AQL 0.4%

FIGURE 11. General Assembly Flow (Continued)

Process Flow	Process Step	Major Control Item
	Cure	
	Q.C. Monitor	* Q.C. Cure Monitor Inspection 1. Control Item — Temperature — In/out Time 2. Frequency — 1 Time/shift
	Deflash	
	Q.C. Monitor	* Q.C. Deflash Monitor Inspection 1. Control Item — Pressure — Belt Speed — Visual/Mechanical Inspection 2. Frequency: 4 Times/Mach/Shift 3. Identify each Defect Control Limit
	TRIM/BEND	
	Q.C. Monitor	* Q.C. Trim/Bend Monitor Inspection 1. Visual Inspection 2. Frequency: 4 times/Station/Shift
	Solder	100% Visual Inspection
	Q.C. Monitor	* Q.C. Solder Monitor Inspection 1. Frequency: 4 Times/Mach/Shift 2. Criteria — Critical Defect: AQL 0.65% — Major Defect: AQL 1.0%
	Q.C. Gate	* Q.C. Mold Gate — Acceptance Criteria Critical Defect: AQL 0.15% Major Defect: AQL 0.4% Minor Defect: AQL 0.65%
	Test	100% Electrical Test
	Q.C. Monitor	Correlation Sample Reading for Initial Device Test
	Mark	100% Visual Inspection

FIGURE 11. General Assembly Flow (Continued)

Process Flow	Process Step	Major Control Item
	PRT Monitoring (Process Reliability Testing)	1. PRT for SFET — HTRB (48 Hrs) HTGB (48 Hrs) — other (when applicable) 2. Acceptance Criteria: LTPD 10%
	Q.C. Monitor	* Q.C. Marking Monitor Inspection — Frequency: 4 Times/Station/Shift — Sample: 24 Units/Time — Identify for Each C.L. — Acceptance Criteria Defect / Acceptance / Reject Critical / 0 / 1 Major / 1 / 2
	Q.C. Gate	* Q.C. Final Acceptance Level — Critical Defect: AQL 0.15% — Major Defect: AQL 0.4% — Minor Defect: AQL 0.65%
	Q.A. Gate	* Q.A. Incoming inspection for SFET 1. Critical Defect: — Electrical Test: LTPD 2% (N=116, C=0) — Visual Test: LTPD 2% (N=116, C=0) 2. Major Defect: — Electrical Test: LTPD 3% (N=116, C=1) — Visual Test: LTPD 3% (N=116, C=1) 3. Minor Defect: —Electrical Test: LTPD 5% (N=116, C=2) — Visual Test: LTPD 5% (N=116, C=2)
	Stock	* Age Control
	Q.A. Gate	* Q.A. Outgoing Inspection 1. Quantity 2. Customer 3. Packing 4. Sampling Inspection (when applicable) — Sampling plan is same as incoming Inspection
	Shipment	

PRODUCT GUIDE 3

PRODUCT GUIDE

1. SELECTION GUIDE

TO-126

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
60.00	0.40	3.20	IRFA1Z3	71	
100.00	0.50	2.40	IRFA1Z0	71	

TO-220 N-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
50.00	10.00	0.28	SSP10N05	214	
	12.00	0.20	SSP12N05	220	
60.00	10.00	0.28	SSP10N06	214	
	12.00	0.20	SSP12N06	220	
80.00	4.90	0.74	IRF513	76	
	5.60	0.54	IRF511	76	
	8.00	0.36	IRF523	81	
	9.20	0.27	IRF521	81	
	10.00	0.33	SSP10N08	226	
	12.00	0.18	SSP12N08	232	
	12.00	0.23	IRF533	87	
	14.00	0.16	IRF531	87	
	25.00	0.10	IRF543	93	
	28.00	0.077	IRF541	93	
100.00	4.90	0.74	IRF512	76	
	5.60	0.54	IRF510	76	
	8.00	0.36	IRF522	81	
	9.20	0.27	IRF520	81	
	10.00	0.33	SSP10N10	226	
	12.00	0.18	SSP12N10	232	
	12.00	0.23	IRF532	87	
	14.00	0.16	IRF530	87	
	25.00	0.10	IRF542	93	
	28.00	0.077	IRF540	93	
120.00	7.00	0.70	SSP7N12	244	
	8.00	0.50	SSP8N12	250	
150.00	2.60	2.40	IRF613	105	
	3.30	1.50	IRF611	105	
	4.00	1.20	IRF623	110	
	5.00	0.80	IRF621	110	
	7.00	0.70	SSP7N15	244	
	8.00	0.60	IRF633	116	
	8.00	0.50	SSP8N15	250	
	9.00	0.40	IRF631	116	
	16.00	0.22	IRF643	122	
	18.00	0.18	IRF641	122	

TO-220 N-CHANNEL (continued)

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
180.00	7.00	0.70	SSP7N18	256	
	8.00	0.50	SSP8N18	262	
200.00	2.60	2.40	IRF612	105	
	3.30	1.50	IRF610	105	
	4.00	1.20	IRF622	110	
	5.00	0.80	IRF620	110	
	7.00	0.70	SSP7N20	256	
	8.00	0.60	IRF632	116	
	8.00	0.50	SSP8N20	262	
	9.00	0.40	IRF630	116	
	16.00	0.22	IRF642	122	
	18.00	0.18	IRF640	122	
250.00	1.60	3.00	IRF615	134	
	2.00	2.00	IRF614	134	
	3.30	1.50	IRF625	139	
	3.80	1.10	IRF624	139	
	6.50	0.68	IRF635	144	
	8.10	0.45	IRF634	144	
	13.00	0.34	IRF645	149	
	14.00	0.28	IRF644	149	
350.00	1.70	5.00	IRF713	161	
	2.00	3.60	IRF711	161	
	2.50	2.50	IRF723	166	
	3.00	1.80	IRF721	166	
	5.00	1.50	IRF733	172	
	5.00	1.00	SSP5N35	274	
	5.50	1.00	IRF731	172	
	8.00	0.80	IRF743	178	
	10.00	0.55	IRF741	178	
400.00	1.70	5.00	IRF712	161	
	2.00	3.60	IRF710	161	
	2.50	2.50	IRF722	166	
	3.00	1.80	IRF720	166	
	5.00	1.50	IRF732	172	
	5.00	1.00	SSP5N40	274	
	5.50	1.00	IRF730	172	
	8.00	0.80	IRF742	178	
	10.00	0.55	IRF740	178	
450.00	2.20	4.00	IRF823	190	
	2.50	3.00	IRF821	190	
	4.00	2.00	IRF833	196	
	4.00	1.50	SSP4N45	298	
	4.50	1.50	IRF831	196	
	7.00	1.10	IRF843	202	
	8.00	0.85	IRF841	202	
500.00	2.20	4.00	IRF822	190	
	2.50	3.00	IRF820	190	
	4.00	2.00	IRF832	196	
	4.00	1.50	SSP4N50	286	

TO-220 N-CHANNEL (continued)

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
500.00	4.50	1.50	IRF830	196	
	7.00	1.10	IRF842	202	
	8.00	0.85	IRF840	202	
550.00	4.00	3.00	SSP4N55	298	
	6.00	1.80	SSP6N55	304	
600.00	4.00	3.00	SSP4N60	298	
	6.00	1.80	SSP6N60	304	
700.00	3.00	6.00	SSP3N70	322	
	3.00	5.00	SSP3N70A	322	
	4.00	3.50	SSP4N70	328	
	4.00	2.50	SSP4N70A	328	

TO-220 P-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
−60.00	−2.50	1.60	IRF9513	346	
	−3.00	1.20	IRF9511	346	
	−5.00	0.80	IRF9523	351	
	−6.00	0.60	IRF9521	351	
	−10.00	0.40	IRF9533	357	
	−12.00	0.30	IRF9531	357	
	−15.00	0.30	IRF9543	363	
	−19.00	0.20	IRF9541	363	
−100.00	−2.50	1.60	IRF9512	346	
	−3.00	1.20	IRF9510	346	
	−5.00	0.80	IRF9522	351	
	−6.00	0.60	IRF9520	351	
	−10.00	0.40	IRF9532	357	
	−12.00	0.30	IRF9530	357	
	−15.00	0.30	IRF9542	363	
	−19.00	0.20	IRF9540	363	
−150.00	−1.50	4.50	IRF9613	369	
	−1.75	3.00	IRF9611	369	
	−3.00	2.40	IRF9623	374	
	−3.50	1.50	IRF9621	374	
	−5.50	1.20	IRF9633	380	
	−6.50	0.80	IRF9631	380	
	−9.00	0.70	IRF9643	386	
	−11.00	0.50	IRF9641	386	
−200.00	−1.50	4.50	IRF9612	369	
	−1.75	3.00	IRF9610	369	
	−3.00	2.40	IRF9622	374	
	−3.50	1.50	IRF9620	374	
	−5.50	1.20	IRF9632	380	
	−6.50	0.80	IRF9630	380	
	−9.00	0.70	IRF9642	386	
	−11.00	0.50	IRF9640	386	

PRODUCT GUIDE

TO-3P N-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
50.00	10.00	0.28	SSH10N05	214	
	12.00	0.20	SSH12N05	220	
60.00	10.00	0.28	SSH10N06	214	
	12.00	0.20	SSH12N06	220	
	60.00	0.03	SSH60N06	238	
	60.00	0.025	SSH60N06A	238	
80.00	8.00	0.36	IRFP123	81	
	9.20	0.27	IRFP121	81	
	10.00	0.33	SSH10N08	226	
	12.00	0.18	SSH12N08	232	
	12.00	0.23	IRFP133	87	
	14.00	0.16	IRFP131	87	
	25.00	0.10	IRFP143	93	
	28.00	0.077	IRFP141	93	
	34.00	0.080	IRFP153	99	
	40.00	0.055	IRFP151	99	
100.00	8.00	0.36	IRFP122	81	
	9.20	0.27	IRFP120	81	
	10.00	0.33	SSH10N10	226	
	12.00	0.18	SSH12N10	232	
	12.00	0.23	IRFP132	87	
	14.00	0.16	IRFP130	87	
	25.00	0.10	IRFP142	93	
	28.00	0.077	IRFP140	93	
	34.00	0.080	IRFP152	99	
	40.00	0.055	IRFP150	99	
	60.00	0.03	SSH60N10	238	
	60.00	0.025	SSH60N10A	238	
120.00	7.00	0.70	SSH7N12	244	
	8.00	0.50	SSH8N12	250	
150.00	4.00	1.20	IRFP233	110	
	5.00	1.80	IRFP221	110	
	7.00	0.70	SSH7N15	244	
	8.00	0.60	IRFP233	116	
	8.00	0.50	SSH8N15	250	
	9.00	0.40	IRFP231	116	
	16.00	0.22	IRFP243	122	
	18.00	0.18	IRFP241	122	
	25.00	0.12	IRFP253	128	
	30.00	0.085	IRFP251	128	
	40.00	0.065	SSH40N15A	268	
	40.00	0.080	SSH40N15	268	
180.00	7.00	0.70	SSH7N18	256	
	8.00	0.50	SSH8N18	262	
200.00	4.00	1.20	IRFP222	110	
	5.00	1.80	IRFP220	110	
	7.00	0.70	SSH7N20	256	
	8.00	0.60	IRFP232	116	
	8.00	0.50	SSH8N20	262	
	9.00	0.40	IRFP230	116	

TO-3P N-CHANNEL (continued)

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
200.00	16.00	0.22	IRFP242	122	
	18.00	0.18	IRFP240	122	
	25.00	0.12	IRFP252	128	
	30.00	0.085	IRFP250	128	
	40.00	0.065	SSH40N20A	268	
	40.00	0.080	SSM40N20	268	
250.00	13.00	0.34	IRFP245	149	
	14.00	0.28	IRFP244	149	
	21.00	0.17	IRFP255	155	
	23.00	0.14	IRFP254	155	
350.00	2.50	2.50	IRFP323	166	
	3.00	1.80	IRFP321	166	
350.00	5.00	1.50	IRFP333	172	
	5.00	1.00	SSH5N35	274	
	5.50	1.00	IRFP331	172	
	8.00	0.80	IRFP343	178	
	10.00	0.55	IRFP341	178	
	13.00	0.40	IRFP353	184	
	15.00	0.30	IRFP351	184	
	25.00	0.20	SSH25N35A	280	
	25.00	0.25	SSH25N35	280	
400.00	2.50	2.50	IRFP322	166	
	3.00	1.80	IRFP320	166	
	5.00	1.50	IRFP332	172	
	5.00	1.00	SSH5N40	274	
	5.50	1.00	IRFP330	172	
	8.00	0.80	IRFP342	178	
	10.00	0.55	IRFP340	178	
	13.00	0.40	IRFP352	184	
	15.00	0.30	IRFP350	184	
	25.00	0.20	SSM25N40A	280	
	25.00	0.25	SSM25N40	280	
450.00	2.20	4.00	IRFP423	190	
	2.50	3.00	IRFP421	190	
	4.00	2.00	IRFP433	196	
	4.00	1.50	SSH4N45	286	
	4.50	1.50	IRFP431	196	
	7.00	1.10	IRFP443	202	
	8.00	0.85	IRFP441	202	
	12.00	0.50	IRFP453	208	
	13.00	0.40	IRFP451	208	
	20.00	0.25	SSH20N45A	292	
	20.00	0.30	SSH20N45	292	
500.00	2.20	4.00	IRFP422	190	
	2.50	3.00	IRFP420	190	
	4.00	2.00	IRFP432	196	
	4.00	1.50	SSH4N50	286	
	4.50	1.50	IRFP430	196	
	7.00	1.10	IRFP442	202	
	8.00	0.85	IRFP440	202	
	12.00	0.50	IRFP452	208	

TO-3P N-CHANNEL (continued)

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
500.00	13.00	0.40	IRFP450	208	
	20.00	0.25	SSH20N50A	292	
	20.00	0.30	SSH20N50	292	
550.00	4.00	3.00	SSH4N55	298	
	6.00	1.80	SSH6N55	304	
	8.00	1.00	SSH8N55	310	
	15.00	0.45	SSH15N55A	316	
	15.00	0.50	SSH15N55	316	
600.00	6.00	1.80	SSH6N60	304	
	8.00	1.00	SSH8N60	310	
	15.00	0.45	SSH15N60A	316	
	15.00	0.50	SSH15N60	316	
700.00	3.00	6.00	SSH3N70	322	
	3.00	5.00	SSH3N70A	322	
	4.00	3.50	SSH4N70	328	
	4.00	2.50	SSH4N70A	328	
	6.00	1.90	SSH6N70	334	
	6.00	1.40	SSH6N70A	334	
	10.00	1.20	SSH10N70	340	
	10.00	0.90	SSH10N70A	340	

TO-3P P-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
−60.00	−5.00	0.80	IRFP9123	351	
	−6.00	0.60	IRFP9121	351	
	−10.00	0.40	IRFP9133	357	
	−12.00	0.30	IRFP9131	357	
	−15.00	0.30	IRFP9143	363	
	−19.00	0.20	IRFP9141	363	
−100.00	−5.00	0.80	IRFP9122	351	
	−6.00	0.60	IRFP9120	351	
	−10.00	0.40	IRFP9132	357	
	−12.00	0.30	IRFP9130	357	
	−15.00	0.30	IRFP9142	363	
	−19.00	0.20	IRFP9140	363	
−150.00	−3.00	2.40	IRFP9223	374	
	−3.50	1.50	IRFP9221	374	
	−5.50	1.20	IRFP9233	380	
	−6.50	0.80	IRFP9231	380	
	−9.00	0.70	IRFP9243	386	
	−11.00	0.50	IRFP9241	386	
−200.00	−3.00	2.40	IRFP9222	374	
	−3.50	1.50	IRFP9220	374	
	−5.50	1.20	IRFP9232	380	
	−6.50	0.80	IRFP9230	380	
	−9.00	0.70	IRFP9242	386	
	−11.00	0.50	IRFP9240	386	

PRODUCT GUIDE

TO-3 N-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
50.00	10.00	0.28	SSM10N05	214	
	12.00	0.20	SSM12N05	220	
60.00	10.00	0.28	SSM10N06	214	
	12.00	0.20	SSM12N06	220	
	60.00	0.03	SSM60N06	238	
	60.00	0.025	SSM60N06A	238	
80.00	8.00	0.36	IRF123	81	
	9.20	0.27	IRF121	81	
	10.00	0.33	SSM10N08	226	
	12.00	0.18	SSM12N08	232	
	12.00	0.23	IRF133	87	
	14.00	0.16	IRF131	87	
	25.00	0.10	IRF143	93	
	28.00	0.077	IRF141	93	
	34.00	0.080	IRF153	99	
	40.00	0.055	IRF151	99	
100.00	8.00	0.36	IRF122	81	
	9.20	0.27	IRF120	81	
	10.00	0.33	SSM10N10	226	
	12.00	0.18	SSM12N10	232	
	12.00	0.23	IRF132	87	
	14.00	0.16	IRF130	87	
	25.00	0.10	IRF142	93	
	28.00	0.077	IRF140	93	
	34.00	0.080	IRF152	99	
	40.00	0.055	IRF150	99	
	60.00	0.03	SSM60N10	238	
	60.00	0.025	SSM60N10A	238	
120.00	7.00	0.70	SSM7N12	244	
	8.00	0.50	SSM8N12	250	
150.00	4.00	1.20	IRF223	110	
	5.00	0.80	IRF221	110	
	7.00	0.70	SSM7N15	244	
	8.00	0.60	IRF233	116	
	8.00	0.50	SSM8N15	250	
	9.00	0.40	IRF231	116	
	16.00	0.22	IRF243	122	
	18.00	0.18	IRF241	122	
	25.00	0.12	IRF253	128	
	30.00	0.085	IRF251	128	
	40.00	0.065	SSM40N15A	268	
	40.00	0.080	SSM40N15	268	
180.00	7.00	0.70	SSM7N18	256	
	8.00	0.50	SSM8N18	262	
200.00	4.00	1.20	IRF222	110	
	5.00	0.80	IRF220	110	
	7.00	0.70	SSM7N20	256	
	8.00	0.60	IRF232	116	

TO-3 N-CHANNEL (continued)

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
200.00	8.00	0.50	SSM8N20	262	
	9.00	0.40	IRF230	116	
	16.00	0.22	IRF242	122	
	18.00	0.18	IRF240	122	
	25.00	0.12	IRF252	128	
	30.00	0.085	IRF250	128	
	40.00	0.065	SSM40N20A	268	
	40.00	0.080	SSM40N20	268	
250.00	21.00	0.17	IRF255	155	
	23.00	0.14	IRF254	155	
350.00	2.50	2.50	IRF323	166	
	3.00	1.80	IRF321	166	
	5.00	1.50	IRF333	172	
	5.00	1.00	SSM5N35	274	
	5.50	1.00	IRF331	172	
	8.00	0.80	IRF343	178	
	10.00	0.55	IRF341	178	
	13.00	0.40	IRF353	184	
	15.00	0.30	IRF351	184	
	25.00	0.20	SSM25N35A	280	
	25.00	0.25	SSM25N35	280	
400.00	2.50	2.50	IRF322	166	
	3.00	1.80	IRF320	166	
	5.00	1.50	IRF332	172	
	5.00	1.00	SSM5N40	274	
	5.50	1.00	IRF330	172	
	8.00	0.80	IRF342	178	
	10.00	0.55	IRF340	178	
	13.00	0.40	IRF352	184	
	15.00	0.30	IRF350	184	
	25.00	0.20	SSM25N40A	280	
	25.00	0.25	SSM25N40	280	
450.00	2.20	4.00	IRF423	190	
	2.50	3.00	IRF421	190	
	4.00	2.00	IRF433	196	
	4.00	1.50	SSM4N45	286	
	4.50	1.50	IRF431	196	
	7.00	1.10	IRF443	202	
	8.00	0.85	IRF441	202	
	12.00	0.50	IRF453	208	
	13.00	0.40	IRF451	208	
	20.00	0.25	SSM20N45A	292	
	20.00	0.30	SSM20N45	292	
500.00	2.20	4.00	IRF422	190	
	2.50	3.00	IRF420	190	
	4.00	2.00	IRF432	196	
	4.00	1.50	SSM4N50	286	
	4.50	1.50	IRF430	196	
	7.00	1.10	IRF442	202	
	8.00	0.85	IRF440	202	

TO-3 N-CHANNEL (continued)

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
500.00	12.00	0.50	IRF452	208	
	13.00	0.40	IRF450	208	
	20.00	0.25	SSM20N50A	292	
	20.00	0.30	SSM20N50	292	
550.00	4.00	3.00	SSM4N55	298	
	6.00	1.80	SSM6N55	304	
	8.00	1.00	SSM8N55	310	
	15.00	0.45	SSM15N55A	316	
	15.00	0.50	SSM15N55	316	
600.00	4.00	3.00	SSM4N60	298	
	6.00	1.80	SSM6N60	304	
	8.00	1.00	SSM8N60	310	
	15.00	0.45	SSM15N60A	316	
	15.00	0.50	SSM15N60	316	
700.00	3.00	6.00	SSM3N70	322	
	3.00	5.00	SSM3N70A	322	
	4.00	3.50	SSM4N70	328	
	4.00	2.50	SSM4N70A	328	
	6.00	1.90	SSM6N70	334	
	6.00	1.40	SSM6N70A	334	
	10.00	1.20	SSM10N70	226	
	10.00	0.90	SSM10N70A	226	

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TO-3 P-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
−60.00	−5.00	0.80	IRF9123	351	
	−6.00	0.60	IRF9121	351	
	−10.00	0.40	IRF9133	357	
	−12.00	0.30	IRF9131	357	
	−15.00	0.30	IRF9143	363	
	−19.00	0.20	IRF9141	363	
−100.00	−5.00	0.80	IRF9122	351	
	−6.00	0.60	IRF9120	351	
	−10.00	0.40	IRF9132	357	
	−12.00	0.30	IRF9130	357	
	−15.00	0.30	IRF9142	363	
	−19.00	0.20	IRF9140	363	
−150.00	−3.00	2.40	IRF9223	374	
	−3.50	1.50	IRF9221	374	
	−5.50	1.20	IRF9233	380	
	−6.50	0.80	IRF9231	380	
	−9.00	0.70	IRF9243	386	
	−11.00	0.50	IRF9241	386	
−200.00	−3.00	2.40	IRF9222	374	
	−3.50	1.50	IRF9220	374	
	−5.50	1.20	IRF9232	380	
	−6.50	0.80	IRF9230	380	
	−9.00	0.70	IRF9242	386	
	−11.00	0.50	IRF9240	386	

PRODUCT GUIDE

D-PAK N-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
50.00	6.70	0.300	†IRFR012	—	
	8.20	0.200	†IRFR010	—	
	14.00	0.120	†IRFR022	—	
	15.00	0.100	†IRFR020	—	
80.00	4.70	0.540	IRFR111	392	
	8.40	0.270	IRFR121	397	
100.00	4.70	0.540	IRFR110	392	
	8.40	0.270	IRFR120	397	
200.00	2.10	2.400	IRFR212	402	
	2.70	1.500	IRFR210	402	
	3.80	1.200	IRFR222	407	
	4.60	0.800	IRFR220	407	

D-PAK P-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
−50.00	−4.50	0.700	†IRFR9012	—	
	−5.30	0.500	†IRFR9010	—	
	−9.00	0.330	†IRFR9022	—	
	−9.90	0.280	†IRFR9020	—	
−80.00	−3.20	1.200	IRFR9111	412	
	−5.90	0.600	IRFR9121	417	
−100.00	−3.20	1.200	IRFR9110	412	
	−5.90	0.600	IRFR9120	417	
−200.00	−1.60	4.500	IRFR9212	422	
	−2.00	3.000	IRFR9210	422	
	−2.80	2.400	IRFR9222	427	
	−3.60	1.500	IRFR9220	427	

† Under Development

I-PAK N-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
50.00	6.70	0.300	†IRFU012	—	
	8.20	0.200	†IRFU010	—	
	14.00	0.120	†IRFU022	—	
	15.00	0.100	†IRFU020	—	
80.00	4.70	0.540	IRFU111	392	
	8.40	0.270	IRFU121	397	
100.00	4.70	0.540	IRFU110	392	
	8.40	0.270	IRFU120	397	
200.00	2.10	2.400	IRFU212	402	
	2.70	1.500	IRFU210	402	
	3.80	1.200	IRFU222	407	
	4.60	0.800	IRFU220	407	

I-PAK P-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
−50.00	−4.50	0.700	†IRFU9012	—	
	−5.30	0.500	†IRFU9010	—	
	−9.00	0.330	†IRFU9022	—	
	−9.90	0.280	†IRFU9020	—	
−80.00	−3.20	1.200	IRFU9111	412	
	−5.90	0.600	IRFU9121	417	
−100.00	−3.20	1.200	IRFU9110	412	
	−5.90	0.600	IRFU9120	417	
−200.00	−1.60	4.500	IRFU9212	422	
	−2.00	3.000	IRFU9210	422	
	−2.80	2.400	IRFU9222	427	
	−3.60	1.500	IRFU9220	427	

† Under Development

PRODUCT GUIDE

TO-247 FULL PACKAGE N-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
80.00	8.30	0.230	IRFS133	432	
	9.70	0.160	IRFS131	432	
	17.30	0.100	IRFS143	437	
	19.40	0.077	IRFS141	437	
	23.50	0.080	IRFS153	442	
	27.70	0.055	IRFS151	442	
100.00	8.30	0.230	IRFS132	432	
	9.70	0.160	IRFS130	432	
	17.30	0.100	IRFS142	437	
	19.40	0.077	IRFS140	437	
	23.50	0.080	IRFS152	442	
	27.70	0.055	IRFS150	442	
150.00	5.50	0.600	IRFS233	447	
	6.20	0.400	IRFS231	447	
	11.00	0.220	IRFS243	452	
	12.50	0.180	IRFS241	452	
	17.30	0.120	IRFS253	457	
	20.70	0.085	IRFS251	457	
200.00	5.50	0.600	IRFS232	447	
	6.20	0.400	IRFS230	447	
	11.00	0.220	IRFS242	452	
	12.50	0.180	IRFS240	452	
	17.30	0.120	IRFS252	457	
	20.70	0.085	IRFS250	457	
350.00	3.50	1.500	IRFS333	462	
	3.80	1.000	IRFS331	462	
	5.50	0.800	IRFS343	467	
	6.90	0.550	IRFS341	467	
	9.00	0.400	IRFS353	472	
	10.40	0.300	IRFS351	472	
400.00	3.50	1.500	IRFS332	462	
	3.80	1.000	IRFS330	462	
	5.50	0.800	IRFS342	467	
	6.90	0.550	IRFS340	467	
	9.00	0.400	IRFS352	472	
	10.40	0.300	IRFS350	472	
450.00	2.80	2.000	IRFS433	477	
	3.10	1.500	IRFS431	477	
	4.80	1.100	IRFS443	482	
	5.50	0.850	IRFS441	482	
	8.30	0.500	IRFS453	487	
	9.00	0.400	IRFS451	487	
500.00	2.80	2.000	IRFS432	477	
	3.10	1.500	IRFS430	477	
	4.80	1.100	IRFS442	482	
	5.50	0.850	IRFS440	482	
	8.30	0.500	IRFS452	487	
	9.00	0.400	IRFS450	487	

* Forming Acceptable

PRODUCT GUIDE

TO-247 FULL PACKAGE P-CHANNEL

BVdss(V)	ID(on)(A)	RDS(on)(Ω)	Part Number	Page	Package
−60.00	−6.90	0.40	IRFS9133	492	
	−8.30	0.30	IRFS9131	492	
	−10.40	0.30	IRFS9143	497	
	−13.20	0.20	IRFS9141	497	
−100.00	−6.90	0.40	IRFS9132	492	
	−8.30	0.30	IRFS9130	492	
	−10.40	0.30	IRFS9142	497	
	−13.20	0.20	IRFS9140	497	
−150.00	−3.80	1.20	IRFS9233	502	
	−4.50	0.80	IRFS9231	502	
	−6.20	0.70	IRFS9243	507	
	−7.60	0.50	IRFS9241	507	
−200.00	−3.80	1.20	IRFS9232	502	
	−4.50	0.80	IRFS9230	502	
	−6.20	0.70	IRFS9242	507	
	−7.60	0.50	IRFS9240	507	

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2. ALPHA NUMERIC INDEX

Part Number	Page Number	Part Number	Page Number	Part Number	Page Number
IRF120	81	IRF242	122	IRF422	190
IRF121	81	IRF243	122	IRF423	190
IRF122	81	IRF250	128	IRF430	196
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IRF130	87	IRF252	128	IRF432	196
IRF131	87	IRF253	128	IRF433	196
IRF132	87	IRF254	155	IRF440	202
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IRF150	99	IRF330	172	IRF452	208
IRF151	99	IRF331	172	IRF453	208
IRF152	99	IRF332	172	IRFA1Z0	71
IRF153	99	IRF333	172	IRFA1Z3	71
IRF220	110	IRF340	178	IRFP120	81
IRF221	110	IRF341	178	IRFP121	81
IRF222	110	IRF342	178	IRFP122	81
IRF223	110	IRF343	178	IRFP123	81
IRF230	116	IRF350	184	IRFP130	87
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IRF232	116	IRF352	184	IRFP132	87
IRF233	116	IRF353	184	IRFP133	87
IRF240	122	IRF420	190	IRFP140	93
IRF241	122	IRF421	190	IRFP141	93

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Part Number	Page Number	Part Number	Page Number	Part Number	Page Number
IRFP142	93	IRFP442	202	IRF722	166
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IRFP150	99	IRFP450	208	IRF730	172
IRFP151	99	IRFP451	208	IRF731	172
IRFP152	99	IRFP452	208	IRF732	172
IRFP153	99	IRFP453	208	IRF733	172
IRFP220	110	IRF510	76	IRF740	178
IRFP221	110	IRF511	76	IRF741	178
IRFP222	110	IRF512	76	IRF742	178
IRFP223	110	IRF513	76	IRF743	178
IRFP230	116	IRF520	81	IRF820	190
IRFP231	116	IRF521	81	IRF821	190
IRFP232	116	IRF522	81	IRF822	190
IRFP233	116	IRF523	81	IRF823	190
IRFP240	122	IRF530	87	IRF830	196
IRFP241	122	IRF531	87	IRF831	196
IRFP242	122	IRF532	87	IRF832	196
IRFP243	122	IRF533	87	IRF833	196
IRFP244	149	IRF540	93	IRF840	202
IRFP245	149	IRF541	93	IRF841	202
IRFP250	128	IRF542	93	IRF842	202
IRFP251	128	IRF543	93	IRF843	202
IRFP252	128	IRF610	105	SSH3N70	322
IRFP253	128	IRF611	105	SSH4N45	286
IRFP254	155	IRF612	105	SSH4N50	286
IRFP255	155	IRF613	105	SSH4N55	298
IRFP320	166	IRF614	134	SSH4N60	298
IRFP321	166	IRF615	134	SSH4N70	328
IRFP322	166	IRF620	110	SSH5N35	274
IRFP323	166	IRF621	110	SSH5N40	274
IRFP330	172	IRF622	110	SSH6N55	304
IRFP331	172	IRF623	110	SSH6N60	304
IRFP332	172	IRF624	139	SSH6N70	334
IRFP333	172	IRF625	139	SSH7N12	244
IRFP340	178	IRF630	116	SSH7N15	244
IRFP341	178	IRF631	116	SSH7N18	256
IRFP342	178	IRF632	116	SSH7N20	256
IRFP343	178	IRF633	116	SSH8N12	250
IRFP350	184	IRF634	144	SSH8N15	250
IRFP351	184	IRF635	144	SSH8N18	262
IRFP352	184	IRF640	122	SSH8N20	262
IRFP353	184	IRF641	122	SSH8N55	310
IRFP420	190	IRF642	122	SSH8N60	310
IRFP421	190	IRF643	122	SSH10N05	214
IRFP422	190	IRF644	149	SSH10N06	214
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IRFP430	196	IRF710	161	SSH10N10	226
IRFP431	196	IRF711	161	SSH10N70	340
IRFP432	196	IRF712	161	SSH12N05	220
IRFP433	196	IRF713	161	SSH12N06	220
IRFP440	202	IRF720	166	SSH12N08	232
IRFP441	202	IRF721	166	SSH12N10	232

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SSH15N60	316	SSP4N55	298	IRF9521	351
SSH20N45	292	SSP4N60	298	IRF9522	351
SSH20N50	292	SSP4N70	328	IRF9523	351
SSH25N35	280	SSP5N35	274	IRF9530	357
SSH25N40	280	SSP5N40	274	IRF9531	357
SSH40N15	268	SSP6N55	304	IRF9532	357
SSH40N20	268	SSP6N60	304	IRF9533	357
SSH60N06	238	SSP7N12	244	IRF9540	363
SSH60N10	238	SSP7N15	244	IRF9541	363
SSM3N70	322	SSP7N18	256	IRF9542	363
SSM4N45	286	SSP7N20	256	IRF9543	363
SSM4N50	286	SSP8N12	250	IRF9610	369
SSM4N55	298	SSP8N15	250	IRF9611	369
SSM4N60	298	SSP8N18	262	IRF9612	369
SSM4N70	328	SSP8N20	262	IRF9613	369
SSM5N35	274	SSP10N05	214	IRF9620	374
SSM5N40	274	SSP10N06	214	IRF9621	374
SSM6N55	304	SSP10N08	226	IRF9622	374
SSM6N60	304	SSP10N10	226	IRF9623	374
SSM6N70	334	SSP12N05	220	IRF9630	380
SSM7N12	244	SSP12N06	220	IRF9631	380
SSM7N15	244	SSP12N08	232	IRF9632	380
SSM7N18	256	SSP12N10	232	IRF9633	380
SSM7N20	256	IRF9120	351	IRF9640	386
SSM8N12	250	IRF9121	351	IRF9641	386
SSM8N15	250	IRF9122	351	IRF9642	386
SSM8N18	262	IRF9123	351	IRF9643	386
SSM8N20	262	IRF9130	357	IRFP9120	351
SSM8N55	310	IRF9131	357	IRFP9121	351
SSM8N60	310	IRF9132	357	IRFP9122	351
SSM10N05	214	IRF9133	357	IRFP9123	351
SSM10N06	214	IRF9140	363	IRFP9130	357
SSM10N08	226	IRF9141	363	IRFP9131	357
SSM10N10	226	IRF9142	363	IRFP9132	357
SSM10N70	340	IRF9143	363	IRFP9133	357
SSM12N05	220	IRF9220	374	IRFP9140	363
SSM12N06	220	IRF9221	374	IRFP9141	363
SSM12N08	232	IRF9222	374	IRFP9142	363
SSM12N10	232	IRF9223	374	IRFP9143	363
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SSM15N60	316	IRF9231	380	IRFP9221	374
SSM20N45	292	IRF9232	380	IRFP9222	374
SSM20N50	292	IRF9233	380	IRFP9223	374
SSM25N35	280	IRF9240	386	IRFP9230	380
SSM25N40	280	IRF9241	386	IRFP9231	380
SSM40N15	268	IRF9242	386	IRFP9232	380
SSM40N20	268	IRF9243	386	IRFP9233	380
SSM60N06	238	IRF9510	346	IRFP9240	386
SSM60N10	238	IRF9511	346	IRFP9241	386
SSP3N70	322	IRF9512	346	IRFP9242	386
SSP4N45	286	IRF9513	346	IRFP9243	386

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†IRFR011	—	IRFS133	432	IRFS441	482
†IRFR020	—	IRFS140	437	IRFS442	482
†IRFR021	—	IRFS141	437	IRFS443	482
IRFR110	392	IRFS142	437	IRFS450	487
IRFR111	392	IRFS143	437	IRFS451	487
IRFR120	397	IRFS150	442	IRFS452	487
IRFR121	397	IRFS151	442	IRFS453	487
IRFR210	402	IRFS152	442	IRFS9130	492
IRFR212	402	IRFS153	442	IRFS9131	492
IRFR220	407	IRFS230	447	IRFS9132	492
IRFR222	407	IRFS231	447	IRFS9133	492
†IRFU012	—	IRFS232	447	IRFS9140	497
†IRFU012	—	IRFS233	447	IRFS9141	497
†IRFU020	—	IRFS240	452	IRFS9142	497
†IRFU022	—	IRFS241	452	IRFS9143	497
IRFU110	392	IRFS242	452	IRFS9230	502
IRFU111	392	IRFS243	452	IRFS9231	502
IRFU120	397	IRFS250	457	IRFS9232	502
IRFU121	397	IRFS251	457	IRFS9233	502
IRFU210	402	IRFS252	457	IRFS9240	507
IRFU212	402	IRFS253	457	IRFS9241	507
IRFU220	407	IRFS330	462	IRFS9242	507
IRFU222	407	IRFS331	462	IRFS9243	507
†IRFR9010	—	IRFS332	462	†IRFU9010	—
†IRFR9012	—	IRFS333	462	†IRFU9012	—
†IRFR9020	—	IRFS340	467	†IRFU9020	—
†IRFR9022	—	IRFS341	467	†IRFU9022	—
IRFR9110	412	IRFS342	467	IRFU9110	412
IRFR9111	412	IRFS343	467	IRFU9111	412
IRFR9120	417	IRFS350	472	IRFU9120	417
IRFR9121	417	IRFS351	472	IRFU9121	417
IRFR9210	422	IRFS352	472	IRFU9210	422
IRFR9212	422	IRFS353	472	IRFU9212	422
IRFR9220	427	IRFS430	477	IRFU9220	427
IRFR9222	427	IRFS431	477	IRFU9222	427
IRFS130	432	IRFS432	477		
IRFS131	432	IRFS433	477		

3. CROSS REFERENCE GUIDE

The following table represents a cross reference for POWER MOSFETS.
The Samsung devices are a replacement for the Indicated Industry part numbers.

FAIRCHILD	SAMSUNG Direct Replacement	FAIRCHILD	SAMSUNG Direct Replacement	FAIRCHILD	SAMSUNG Direct Replacement	FAIRCHILD	SAMSUNG Direct Replacement
MTM15N35	IRF353	MTM4N50	SSM4N50	MTM8N35	IRF343	MTP5N40	SSP5N40
MTM15N40	IRF352	MTM5N35	SSM5N35	MTM8N40	IRF342		
MTM15N45	IRF453	MTM5N40	SSM5N40	MTP4N45	SSP4N45		
MTM15N50	IRF452	MTM7N45	IRF443	MTP4N50	SSP4N50		
MTM4N45	SSM4N45	MTM7N50	IRF442	MTP5N35	SSP5N35		

CROSS REFERENCE GUIDE (continued)

FAIRCHILD	SAMSUNG Direct Replacement	FAIRCHILD	SAMSUNG Direct Replacement	FAIRCHILD	SAMSUNG Direct Replacement	FAIRCHILD	SAMSUNG Direct Replacement
D84BK1	IRF523	D84DL2	IRF530	D84CL2	IRF120	D86EK4	IRF151
D84BK2	IRF523	D84DL3	IRF532	D85CL4	IRF122	D86EL4	IRF142
D84BK4	IRF511	D84DL4	IRF532	D85CM2	IRF221	D86EM1	IRF253
D84BL1	IRF510	D84DM1	IRF631	D86CM4	IRF221	D86EM2	IRF253
D84BL2	IRF510	D84DM2	IRF631	D86CN2	IRF220	D86EM4	IRF241
D84BL3	IRF512	D84DM4	IRF631	D86CN3	IRF222	D86EN2	IRF240
D84BL4	IRF512	D84DN1	IRF630	D86CN4	IRF222	D86EN3	IRF242
D84BM1	IRF611	D84DN2	IRF630	D86CQ1	IRF321	D86EN4	IRF242
D84BM2	IRF611	D84DN3	IRF632	D86CQ2	IRF320	D86EQ1	IRF341
D84BM3	IRF611	D84DN4	IRF632	D86CQ3	IRF323	D86EQ2	IRF340
D84BM4	IRF613	D84DQ1	IRF731	D86CQ4	IRF322	D86EQ3	IRF343
D84BN1	IRF610	D84DQ2	IRF730	D86CR1	IRF421	D86EQ4	IRF342
D84BN2	IRF610	D84DQ3	IRF733	D86CR2	IRF420	D86ER1	IRF441
D84BN3	IRF612	D84DQ4	IRF732	D86CR3	IRF423	D86ER2	IRF440
D84BN4	IRF612	D84DR1	IRF831	D86CR4	IRF422	D86ER3	IRF443
D84BQ1	IRF711	D84DR2	IRF830	86DK1	IRF131	D86ER4	IRF442
D84BQ2	IRF710	D84DR3	IRF833	D86DK2	IRF131	D86ES1	IRF430
D84BQ3	IRF713	D84DR4	IRF832	D86DK3	IRF133	D86ES2	IRF430
D84BQ4	IRF712	D84DS1	IRF832	D86DK4	IRF133	D86EU2	IRF420
D84CK3	IRF521	D84DS2	IRF832	D86DL1	IRF130	D86EV1	IRF422
D84CK4	IRF521	D84EL2	IRF540	D86DL2	IRF130	D86EV2	IRF422
D84CL2	IRF520	D84EL4	IRF542	D86DL3	IRF132	D86EW1	IRF422
D84CL4	IRF522	D84EM2	IRF641	D86DL4	IRF132	D86EW2	IRF422
D84CM2	IRF621	D84EM4	IRF643	D86DM1	IRF231	D86FL2	IRF150
D84CM4	IRF623	D84EN2	IRF640	D86DM2	IRF231	D86FL4	IRF152
D84CN1	IRF620	D84EN4	IRF642	D86DM3	IRF231	D86FM2	IRF251
D84CN2	IRF620	D84EQ1	IRF741	D86DM4	IRF231	D86FN2	IRF250
D84CN3	IRF622	D84EQ2	IRF740	D86DN1	IRF230	D86FN4	IRF252
D84CN4	IRF622	D84EQ3	IRF743	D86DN2	IRF230	D86FQ1	IRF351
D84CQ1	IRF721	D84DQ4	IRF742	D86DN3	IRF230	D86FQ2	IRF350
D84CQ2	IRF720	D84ER1	IRF841	D86DN4	IRF230	D86FQ3	IRF353
D84CQ3	IRF723	D84ER2	IRF840	D86DQ1	IRF331	D86FQ4	IRF352
D84CQ4	IRF722	D84ER3	IRF843	D86DQ2	IRF330	D86FR1	IRF451
D84CR1	IRF821	D84ER4	IRF842	D86DQ3	IRF333	D86FR2	IRF450
D84CR2	IRF820	D84EU2	IRF820	D86DQ4	IRF332	D86FR3	IRF453
D84CR3	IRF823	D84EV1	IRF822	D86DR1	IRF431	D86FR4	IRF452
D84CR4	IRF822	D84EV2	IRF822	D86DR2	IRF430	D86FU2	IRF432
D84DK1	IRF531	D84EW1	IRF822	D86DR3	IRF433		
D84DK2	IRF531	D84EW2	IRF822	D86DR4	IRF432		
D83DK3	IRF533	D86CK2	IRF131	D86DS1	IRF432		
D84DK4	IRF533	D86CK3	IRF121	D86DS2	IRF432		
D84DL1	IRF530	D84CK4	IRF121	D86EK3	IRF432		

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CROSS REFERENCE GUIDE (continued)

International Rectifier	SAMSUNG Direct Replacemont	International Rectifier	SAMSUNG Direct Replacement	International Rectifier	SAMSUNG Direct Replacement	International Rectifier	SAMSUNG Direct Replacement
IRF120	IRF120	IRF352	IRF352	IRF713	IRF713	IRF9620	IRF9620
IRF121	IRF121	IRF353	IRF353	IRF720	IRF720	IRF9621	IRF9621
IRF122	IRF122	IRF420	IRF420	IRF721	IRF721	IRF9622	IRF9622
IRF123	IRF123	IRF421	IRF421	IRF722	IRF722	IRF9623	IRF9623
IRF130	IRF130	IRF422	IRF422	IRF723	IRF723	IRF9630	IRF9630
IRF131	IRF131	IRF423	IRF423	IRF730	IRF730	IRF9631	IRF9631
IRF132	IRF132	IRF430	IRF430	IRF731	IRF731	IRF9632	IRF9632
IRF133	IRF133	IRF431	IRF431	IRF732	IRF732	IRF9633	IRF9633
IRF140	IRF140	IRF432	IRF432	IRF733	IRF733	IRF9640	IRF9640
IRF141	IRF141	IRF433	IRF433	IRF740	IRF740	IRF9641	IRF9641
IRF142	IRF142	IRF440	IRF440	IRF741	IRF741	IRF9642	IRF9642
IRF143	IRF143	IRF441	IRF441	IRF742	IRF742	IRF9643	IRF9643
IRF150	IRF150	IRF442	IRF442	IRF743	IRF743	IRFD1Z0	IRFA1Z0
IRF151	IRF151	IRF443	IRF443	IRF820	IRF820	IRFD1Z3	IRFA1Z3
IRF152	IRF152	IRF450	IRF450	IRF821	IRF821	IRFP131	IRFP131
IRF153	IRF153	IRF451	IRF451	IRF822	IRF822	IRFP132	IRFP132
IRF220	IRF220	IRF452	IRF452	IRF823	IRF823	IRFP133	IRFP133
IRF221	IRF221	IRF453	IRF453	IRF830	IRF830	IRFP140	IRFP140
IRF222	IRF222	IRF510	IRF510	IRF831	IRF831	IRFP141	IRFP141
IRF223	IRF223	IRF511	IRF511	IRF832	IRF832	IRFP142	IRFP142
IRF231	IRF231	IRF512	IRF512	IRF833	IRF833	IRFP143	IRFP143
IRF232	IRF232	IRF513	IRF513	IRF840	IRF840	IRFP150	IRFP150
IRF233	IRF233	IRF520	IRF520	IRF841	IRF841	IRFP151	IRFP151
IRF240	IRF240	IRF521	IRF521	IRF842	IRF842	IRFP152	IRFP152
IRF241	IRF241	IRF522	IRF522	IRF843	IRF843	IRFP153	IRFP153
IRF242	IRF242	IRF523	IRF523	IRF9510	IRF9510	IRFP230	IRFP230
IRF243	IRF243	IRF610	IRF610	IRF9511	IRF19511	IRFP231	IRFP231
IRF250	IRF250	IRF611	IRF611	IRF9512	IRF9512	IRFP232	IRFP232
IRF251	IRF251	IRF612	IRF612	IRF9513	IRF9513	IRFP233	IRFP233
IRF252	IRF252	IRF613	IRF613	IRF9520	IRF9520	IRFP240	IRFP240
IRF253	IRF253	IRF620	IRF620	IRF9521	IRF9521	IRFP241	IRFP241
IRF320	IRF320	IRF621	IRF621	IRF9522	IRF9522	IRFP242	IRFP242
IRF321	IRF321	IRF622	IRF622	IRF9523	IRF9523	IRFP243	IRFP243
IRF322	IRF322	IRF623	IRF623	IRF9530	IRF9530	IRFP250	IRFP250
IRF323	IRF323	IRF630	IRF630	IRF9531	IRF9531	IRFP251	IRFP251
IRF330	IRF330	IRF631	IRF631	IRF9532	IRF9532	IRFP252	IRFP252
IRF331	IRF331	IRF632	IRF632	IRF9533	IRF9533	IRFP253	IRFP253
IRF332	IRF332	IRF633	IRF633	IRF9540	IRF9540	IRFP330	IRFP330
IRF333	IRF333	IRF640	IRF640	IRF9541	IRF9541	IRFP331	IRFP331
IRF340	IRF340	IRF641	IRF641	IRF9542	IRF9542	IRFP332	IRFP332
IRF341	IRF341	IRF642	IRF642	IRF9543	IRF9543	IRFP333	IRFP333
IRF342	IRF342	IRF643	IRF643	IRF9610	IRF9610	IRFP340	IRFP340
IRF343	IRF343	IRF710	IRF710	IRF9611	IRF9611	IRFP341	IRFP341
IRF350	IRF350	IRF711	IRF711	IRF9612	IRF9612	IRFP342	IRFP342
IRF351	IRF351	IRF712	IRF712	IRF9613	IRF9613		

CROSS REFERENCES GUIDE (continued)

International Rectifier	SAMSUNG Direct Replacemont	International Rectifier	SAMSUNG Direct Replacement	International Rectifier	SAMSUNG Direct Replacement	International Rectifier	SAMSUNG Direct Replacement
IRFP343	IRFP343	IRFP9241	IRFP9241	IRFR121	IRFR121	IRFR9220	IRFR9220
IRFP350	IRFP350	IRFP9242	IRFP9242	IRFR110	IRFR110	IRFR9222	IRFR9222
IRFP351	IRFP351	IRFP9243	IRFP9243	IRFR111	IRFR111	IRFR9210	IRFR9210
IRFP352	IRFP352	IRFBC30	SSP4N60	IRFR020	†IRFR020	IRFR9212	IRFR9212
IRFP353	IRFP353	IRFBC40	SSP6N60	IRFU220	IRFU220	IRFR9120	IRFR9121
IRFP430	IRFP430	IRFP9133	IRFP9133	IRFU222	IRFU222	IRFR9110	IRFR9110
IRFP431	IRFP431	IRFP9140	IRFP9140	IRFU210	IRFU212	IRFR9111	IRFR9111
IRFP432	IRFP432	IRFP9141	IRFP9141	IRFU212	IRFU120	IRFR9020	†IRFR9020
IRFP433	IRFP433	IRFP9142	IRFP9142	IRFU120	IRFU210	IRFR9022	†IRFR9022
IRFP440	IRFP440	IRFP9143	IRFP9143	IRFU121	IRFU121	IRFR9010	†IRFR9010
IRFP441	IRFP441	IRFP9230	IRFP9230	IRFU110	IRFU110	IRFR9012	†IRFR9012
IRFP442	IRFP442	IRFP9231	IRFP9231	IRFU111	IRFU111	IRF614	IRF614
IRFP443	IRFP443	IRFP9232	IRFP9232	IRFU020	†IRFU020	IRF624	IRF624
IRFP450	IRFP450	IRFP9233	IRFP9233	IRFU022	†IRFU022	IRF634	IRF634
IRFP451	IRFP451	IRFP9240	IRFP9240	IRFR022	†IRFR022	IRF644	IRF644
IRFP452	IRFP452	IRFR220	IRFR220	IRFR010	†IRFR010	IRFP254	IRFP254
IRFP453	IRFP453	IRFR222	IRFR222	IRFR012	†IRFR012		
IRFP9130	IRFP9130	IRFR210	IRFR210				
IRFP9131	IRFP9131	IRFR212	IRFR212				
IRFP9132	IRFP9132	IRFR120	IRFR120				

HITACHI	SAMSUNG Direct Replacement	HITACHI	SAMSUNG Direct Replacement	HITACHI	SAMSUNG Direct Replacement	HITACHI	SAMSUNG Direct Replacement
2SK132	IRF122	2SK310	IRF710	2SK409	IRF612	2SJ112	IRF9142
2SK134(H)	IRF223	2SK311	IRF823	2SK411	IRF420	2SJ113	IRFP9142
2SK220	IRF222	2SK312	IRF342	2SK412	IRFP353	2SJ114	IRFP9242
2SK220(H)	IRF222	2SK313	IRF441	2SK413	IRFP243	2SJ117	IRF9612
2SK221(H)	IRF222	2SK319	IRF720	2SK414	IRFP242	2SJ118	IRFP9241
2SK258(H)	IRF331	2SK320	IRF833	2SK428	IRF543	2SJ119	IRFP9240
2SK259	IRF323	2SK345	IRF523	2SK440	IRF630	2SJ47	IRF9132
2SK260	IRF332	2SK346	IRF523	2SK556	IRFP453	2SJ49(H)	IRF9233
2SK261	IRF512	2SK349	IRFP342	2SK557	IRFP453	2SJ50(H)	IRF9232
2SK262	IRF613	2SK350	IRFP441	2SK559	IRFP451	2SJ55(H)	IRF9233
2SK263	IRF613	2SK382	IRF822	2SK560	IRFP450	2SJ56(H)	IRF9232
2SK289	IRF123	2SK383	IRF530	2SK622	IRFP251	2SJ85	IRF9512
2SK290	IRF122	2SK393	IRF132	2SK623	IRFP441	2SJ86	IRF9611
2SK294	IRF522	2SK399	IRFP142	2SK642	IRFP442	2SJ86	IRF9613
2SK295	IRF522	2SK400	IRFP242	2SK682	IRFP453	2SJ88	IRF9610
2SK296	IRF612	2SK401	IRF353	2SK683	IRFP452		
2SK298	IRF332	2SK402	IRFP342	2SJ101	IRF9533		
2SK299	IRF431	2SK403	IRFP443	2SJ102	IRF9533		
2SK308	IRF243	2SK408	IRF612				
2SK309	IRF722						

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MATSUSHITA	SAMSUNG Direct Replacement	MATSUSHITA	SAMSUNG Direct Replacement	MATSUSHITA	SAMSUNG Direct Replacement	MATSUSHITA	SAMSUNG Direct Replacement
2SK500	IRFP141	2SK627	IRFP151	2SK633A	IRFP252		
2SK501	IRFP342	2SK627A	IRFP151	2SK634	IRFP352		
2SK501A	IRFP441	2SK629	IRFP150	2SK634A	IRFP451		
2SK610	IRFP342	2SK629A	IRFP251	2Sk636	IRFP440		
2SK626	IRFP151	2SK633	IRFP252	2SK637	IRFP452		

MOTOROLA	SAMSUNG Direct Replacemont	MOTOROLA	SAMSUNG Direct Replacement	MOTOROLA	SAMSUNG Direct Replacement	MOTOROLA	SAMSUNG Direct Replacement
MTH6N55	SSH6N55	MTM7N12	IRF233	MTM12N20	IRF242	MTP2N35	IRF723
MTH6N60	SSH6N60	MTM7N15	IRF233	MTM15N05	IRF143	MTP2N40	IRF722
MTH8N55	SSH8N55	MTM1N18	IRF232	MTM15N06	IRF143	MTP2N45	IRF823
MTH8N60	SSH8N60	MTM7N20	IRF232	MTM15N12	IRF243	MTP2N50	IRF822
MTH7N35	IRFP343	MTM7N45	IRF441	MTM15N15	IRF243	MTP3N12	IRF623
MTH7N40	IRFP342	MTM7N50	IRF442	MTM15N18	IRF242	MTP3N15	IRF623
MTH8N35	IRFP343	MTM8N08	IRF120	MTM15N20	IRF242	MTP3N18	IRF622
MTH8N40	IRFP342	MTM8N10	IRF120	MTM15N35	IRF351	MTP3N20	IRF620
MTH15N18	IRFP242	MTM8N12	IRF233	MTM15N40	IRF350	MTP3N35	IRF721
MTH15N20	IRFP242	MTM8N15	IRF233	MTM15N45	SSM20N45	MTP3N40	IRF720
MTH20N12	IRFP253	MTM8N18	IRF232	MTM15N50	SSM20N50	MTP3N55	SSP4N55
MTH20N15	IRFP253	MTM8N20	IRF232	MTM20N08	IRF142	MTP3N60	SSP4N60
MTH25N08	IRFP140	MTM8N35	IRF343	MTM20N10	IRF142	MTP4N08	IRF510
MTH25N10	IRFP140	MTM8N40	IRF342	MTM20N12	IRF253	MTP4N10	IRF510
MTH35N05	IRFP151	MTM8P08	IRF9132	MTM20N15	IRF253	MTP4N12	IRF623
MTH35N06	IRFP151	MTM8P10	IRF9132	MTM25N05	IRF141	MTP4N15	IRF623
MTM2N45	IRF421	MTM10N05	IRF133	MTM25N06	IRF141	MTP4N45	IRF833
MTM2N50	IRF422	MTM10N06	IRF133	MTM25N08	IRF140	MTP4N50	IRF832
MTM3N35	IRF321	MTM10N08	IRF132	MTM25N10	IRF140	MTP5N05	IRF523
MTM3N40	IRF320	MTM10N10	IRF132	MTM35N05	IRF151	MTP5N06	IRF523
MTM3N55	SSM4N55	MTM10N12	IRF243	MTM35N06	IRF151	MTP5N18	IRF620
MTM3N60	SSM4N60	MTM10N15	IRF243	MTM40N18	SSM40N20	MTP5N20	IRF620
MTM4N45	IRF433	MTM10N25	IRF353	MTM40N20	SSM40N20	MTP5N35	IRF731
MTM4N50	IRF432	MTM12N05	IRF133	MTP1N45	IRF823	MTP5N40	IRF730
MTM5N18	IRF220	MTM12N06	IRF133	MTP1N50	IRF822	MTP7N12	IRF633
MTM5N20	IRF220	MTM12N08	IRF132	MTP2N18	IRF612	MTP7N15	IRF633
MTM5N35	IRF333	MTM12N10	IRF132	MTP2N20	IRF612	MTP7N18	IRF632
MTM5N40	IRF330	MTM12N12	IRF243	MTP2N25	IRF723	MTP7N20	IRF632
MTM6N55	SSM6N55	MTM12N15	IRF243	MTP12N06	IRF533	MTP15N15	IRF643
MTM6N60	SSM6N60	MTM12N18	IRF242	MTP12N08	IRF532	MTP20N08	IRF542
MTP8N08	IRF520	MTP10N05	IRF533	MTP12N10	IRF532	MTP20N20	IRF542
MTP8N10	IRF520	MTP10N06	IRF533	MTP12N18	IRF642	MTP20N05	IRF541
MTP8N12	IRF633	MTP10N08	IRF532	MTP12N20	IRF642	MTP25N06	IRF541
MTP8N15	IRF633	MTP10N10	IRF532	MTP15N05	IRF543		
MTP8N18	IRF632	MTP10N12	IRF643	MTP15N06	IRF543		
MTP8N20	IRF632	MTP10N15	IRF643	MTP15N12	IRF643		
MTP8P08	IRF9532	MTP10N25	IRF743				
MTP8P10	IRF9532	MTP12N05	IRF533				

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MOTOROLA	SAMSUNG Direct Replacement	MOTOROLA	SAMSUNG Direct Replacement
MTD10N05A	IRFR020	MTM3N60	SSM4N60
MTD4P05	IRFR9020	MTP10N05	†IRFZ10
MTD5N05A	†IRFR010	MTP16N05A	†IRFZ42
MTH6N60	SSH6N60	MTP6N60	SSP6N60
MTM6N60	SSM6N60	MTM6N60	SSM6N60

RCA	SAMSUNG Direct Replacemont	RCA	SAMSUNG Direct Replacement	RCA	SAMSUNG Direct Replacement	RCA	SAMSUNG Direct Replacement
RCA9192A	IRF120	RFM3N45	IRF421	RFM15N12	IRF253	RFP5P12	IRF9631
RCA9192B	IRF243	RFM3N50	IRF420	RFM15N15	IRF253	RFP5P15	IRF9631
RCA9195A	IRF142	RFM4N35	IRF321	RFM18N08	IRF142	RFP6P08	IRF9520
RCA9195B	IRF253	RFM4N40	IRF320	RFM18N10	IRF142	RFP6P10	IRF9520
RCA9212A	IRF520	RFM5P12	IRF9231	RFM25N05	IRF141	RFP7N45	IRF831
RCA9212B	IRF643	RFM5P15	IRF9231	RFM25N06	IRF141	RFP7N50	IRF830
RCA9213A	IRF512	RFM6P08	IRF9132	RFP1N35	IRF713	RFP8N18	IRF630
RCA9213B	IRF613	RFM6P10	IRF9232	RFP1N40	IRF712	RFP8N20	IRF630
RCA9230A	IRF542	RFM7N45	IRF431	RFP2N08	IRF512	RFP8N08	IRF9532
RFK15N35	IRF353	RFM7N50	IRF430	RFP2N10	IRF512	RFP8N10	IRF9532
RFK15N40	IRF352	RFM8N18	IRF230	RFP2N12	IRF611	RFP10N12	IRF643
RFK15N45	IRF441	RFM8N20	IRF230	RFP2N15	IRF611	RFP10N15	IRF643
RFK15N50	IRF440	RFM8P08	IRF9132	RFP2N18	IRF612	RFP10P12	IRF9532
RFK20P05	IRF9140	RFM8P10	IRF9132	RFP2N20	IRF612	RFP12N08	IRF530
RFK20P10	IRF9140	RFM10N12	IRF243	RFP2P08	IRF9512	RFP12N10	IRF530
RFK25N18	IRF252	RFM10N15	IRF243	RFP2P10	IRF9512	RFP12N20	IRF642
RFK25N20	IRF252	RFM10P12	IRF9241	RFP3N45	IRF821	RFP15N05	IRF543
RFK30N12	IRF251	RFM10P15	IRF9241	RFP3N50	IRF820	RFP15N06	IRF543
RFK30N15	IRF251	RFM12N18	IRF242	RFP4N05	IRF513	RFP15N12	IRF643
RFK35N08	IRF150	RFM12N20	IRF242	RFP4N06	IRF513	RFP18N10	IRF542
RFK35N10	IRF150	RFM15N05	IRF143	RFP4N35	IRF721	RFP25N05	IRF541
		RFM15N06	IRF143	RFP4N40	IRF720		

SGS	SAMSUNG Direct Replacement	SGS	SAMSUNG Direct Replacement	SGS	SAMSUNG Direct Replacement	SGS	SAMSUNG Direct Replacement
SEFH15N18	IRFP240	SEFH35N06	IRFP151	SGSP464	IRFP443	SGSP474	IRFP440
SEFH15N20	IRFP241	SEFH7N45	IRFP441	SGSP465	IRFP342	SGSP475	IRFP340
SEFH25N08	IRFP140	SEFH7N50	IRFP440	SGSP466	IRFP343	SGSP476	IRFP341
SEFH25N10	IRFP140	SGSP421	IRFP143	SGSP467	IRFP242	SGSP477	IRFP240
SEFH35N05	IRFP151	SGSP422	IRFP143	SGSP469	IRFP442	SGSP479	IRFP440
						SGSP481	IRFP151
SEFH35N06	IRFP151	SGSP461	IRFP142	SGSP471	IRFP140	SGSP482	IRFP151
SEFH7N45	IRFP441	SGSP462	IRFP142	SGSP472	IRFP150	SGSP491	IRFP151
SEFH7N50	IRFP440	SGSP463	IRFP342	SGSP473	IRFP351	SGSP492	IRFP151

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Siemens	SAMSUNG Direct Replace-mont	Simens	SAMSUNG Direct Replace-ment	Siemens	SAMSUNG Direct Replace-ment	Siemens	SAMSUNG Direct Replace-ment
BUZ10	IRF541	BUZ25	IRF140	BUZ41A	IRF830	BUZ60B	IRF732
BUZ10A	IRF543	BUZ27	IRFP140	BUZ41B	IRF831	BUZ60C	IRF733
BUZ10B	IRF533	BUZ28	IRFP141	BUZ42	IRF832	BUZ60D	IRF720
BUZ11A	IRF543	BUZ31	IRF640	BUZ42A	IRF833	BUZ63	IRF330
BUZ14A	IRF151	BUZ32	IRF630	BUZ42B	IRF820	BUZ63A	IRF331
BUZ14B	IRF153	BUZ32A	IRF631	BUZ42C	IRF821	BUZ63B	IRF332
BUZ17	IRF153	BUZ32B	IRF632	BUZ44	IRF422	BUZ63C	IRF333
BUZ18	IRF151	BUZ32C	IRF633	BUZ44A	IRF430	BUZ63D	IRF320
BUZ20	IRF530	BUZ34	IRF240	BUZ44B	IRF431	BUZ64	IRF352
BUZ20A	IRF532	BUZ35	IRF230	BUZ45	IRF452	BUZ64A	IRF353
BUZ20B	IRF520	BUZ35A	IRF231	BUZ45A	IRF452	BUZ67	IRFP340
BUZ201	IRF353	BUZ351	IRFP353	BUZ45B	IRF452	BUZ71	IRF541
BUZ21	IRF540	BUZ353	IRFP453	BUZ45C	IRF453	BUZ71A	IRF543
BUZ211	IRF452	BUZ354	IRFP453	BUZ46	IRF432	BUZ72A	IRF532
BUZ23	IRF130	BUZ36	IRF252	BUZ46A	IRF433	BUZ73A	IRF632
BUZ23A	IRF130	BUZ237	IRFP242	BUZ46B	IRF420	BUZ74	IRF820
BUZ23B	IRF120	BUZ38	IRFP240	BUZ48	IRFP450	BUZ74A	IRF822
BUZ24	IRF150	BUZ382	IRFP353	BUZ48A	IRFP452	BUZ76	IRF720
BUZ24A	IRF150	BUZ385	IRFP440	BUZ60	IRF730	BUZ76A	IRF722
BUZ24B	IRF152	BUZ41	IRF840	BUZ60A	IRF730		

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Siliconix	SAMSUNG Direct Replace-mont	Siliconix	SAMSUNG Direct Replace-ment	Siliconix	SAMSUNG Direct Replace-ment	Siliconix	SAMSUNG Direct Replace-ment
VN30AA	IRF123	VN0109N5	IRF512	VN0440N1	IRF340	VN1115N5	IRF611
VN33AJ	IRF123	VN0110N1	IRF122	VN0445N1	IRF453	VN1116N1	IRF222
VN35AA	IRF123	VN0110N5	IRF512	VN0450N1	IRF440	VN1116N5	IRF612
VN35AJ	IRF123	VN0114N1	IRF223	VN0600A	IRF143	VN1120N1	IRF222
VN40AD	IRF513	VN0114N5	IRF613	VN0600D	IRF543	VN1120N5	IRF612
VN46AD	IRF513	VN0116N1	IRF222	VN0601A	IRF143	VN1200A	IRF241
VN64AG	IRF123	VN0116N5	IRF612	VN0601D	IRF543	VN1200D	IRF641
VN66AD	IRF513	VN0120N1	IRF222	VN0800A	IRF130	VN1201A	IRF243
VN66AJ	IRF123	VN0120N5	IRF612	VN0800D	IRF530	VN1201D	IRF643
VN67AA	IRF123	VN0202N1	IRF123	VN0801A	IRF132	VN1202N1	IRF133
VN67AD	IRF513	VN0202N5	IRF513	VN1202N5	IRF533	VN2406D	IRF713
VN67AJ	IRF123	VN0203N1	IRF123	VN1203N1	IRF133	VN3500A	IRF331
VN88AD	IRF512	VN0203N5	IRF513	VN1203N5	IRF533	VN3500D	IRF731
VN89AA	IRF122	VN0204N1	IRF123	VN1204N1	IRF123	VN3501A	IRF333
VN89AD	IRF512	VN0204N5	IRF513	VN1204N5	IRF523	VN3501D	IRF733
VN90AA	IRF122	VN0206N1	IRF123	VN1206D	IRF613	VN3502A	IRF321
VN98AJ	IRF122	VN0206N5	IRF513	VN1206N1	IRF123	VN4000A	IRF330
VN99AA	IRF122	VN0208N1	IRF122	VN1206N5	IRF523	VN4000D	IRF730
VN99AJ	IRF122	VN0208N5	IRF512	VN1208N1	IRF122	VN4001A	IRF332
VN0102N1	IRF123	VN0209N1	IRF122	VN1208N5	IRF522	VN4001D	IRF732
VN0102N5	IRF513	VN0209N5	IRF512	VN1209N1	IRF122	VN4002A	IRF320
VN0103N1	IRF123	VN0201N1	IRF122	VN1209N5	IRF522	VN4501A	IRF431
VN0103N5	IRF513	VN0201N5	IRF512	VN1210N1	IRF122	VN4501D	IRF831
VN0104N1	IRF123	VN0214N1	IRF223	VN1210N5	IRF522	VN4502A	IRF433
VN0104N5	IRF513	VN0214N5	IRF613	VN1215N1	IRF233	VN4502D	IRF833
VN0106N1	IRF123	VN0215N5	IRF613	VN1215N5	IRF633	VN5001A	IRF430
VN0106N5	IRF513	VN0216N1	IRF222	VN1216N1	IRF222	VN5001D	IRF830
VN0108N1	IRF122	VN0216N5	IRF612	VN1216N5	IRF610	VN5002A	IRF432
VN0108N5	IRF512	VN0220N1	IRF222	VN1220N1	IRF222	VN5002D	IRF832
VN0109N1	IRF122	VN0220N5	IRF612	VN1220N5	IRF610	VNL001A	IRF331
VN0300D	IRF513	VN0801D	IRF532	VN1706D	IRF612	VNM001A	IRF330
VN0330N1	IRF323	VN1000A	IRF130	VN2306N1	IRF141	VNM002A	IRF431
VN0330N5	IRF723	VN1000D	IRF530	VN2306N5	IRF541	VNP002A	IRF430
VN0335N1	IRF323	VN1001A	IRF132	VN2310N1	IRF140	VNS008A	SSM6N60
VN0335N5	IRF723	VN1001D	IRF532	VN2310N5	IRF540	VNS008D	SSP6N60
VN0340N1	IRF322	VN1102N1	IRF123	VN2315N1	IRF241	VNS009A	SSM5N60
VN0340N5	IRF722	VN1102N5	IRF523	VN2315N5	IRF641	VNS009D	SSP5N60
VN0345A1	IRF441	VN1103N1	IRF123	VN2320N1	IRF242	VNT008A	SSM6N70
VN0345N1	IRF421	VN1103N5	IRF523	VN2320N5	IRF642	VNT008D	SSP6N70
VN0345N5	IRF821	VN1104N1	IRF123	VN2330N1	IRF341	VNT009A	SSM6N70
VN0350A1	IRF440	VN1104N5	IRF523	VN2330N5	IRF741	VNT009D	SSP6N70
VN0350N1	IRF422	VN1106N1	IRF123	VN2335N1	IRF341	VP0102N5	IRF9513
VN0355N1	SSM4N55	VN1106N5	IRF523	VN2335N5	IRF741	VP0103N5	IRF9513
VN0360N1	SSM4N60	VN1109N1	IRF122	VN2340N1	IRF340	VP0104N5	IRF9513
VN0400A	IRF143	VN1109N5	IRF522	VN2340N5	IRF740	VP0106N5	IRF9513
VN0400D	IRF543	VN1110N1	IRF122	VN2345N1	IRF453	VP0108N1	IRF9132
VN0401A	IRF143	VN1110N5	IRF522	VN2350N1	IRF442	VP0108N5	IRF9512
VN0401D	IRF543	VN1114N1	IRF223	VN2350N5	IRF842	VP0109N1	IRF9132
VN0430N1	IRF341	VN1114N5	IRF611				
VN0435N1	IRF341	VN1115N1	IRF223				

CROSS REFERENCE GUIDE (continued)

Siliconix	SAMSUNG Direct Replace-mont	Siliconix	SAMSUNG Direct Replace-ment	Siliconix	SAMSUNG Direct Replace-ment	Siliconix	SAMSUNG Direct Replace-ment
VP0109N5	IRF9512	VP1109N1	IRF9132	VP0216N1	IRF9232	VP1209N1	IRF9132
VP0110N5	IRF9512	VP1109N5	IRF9512	VP0216N5	IRF9612	VP1210N1	IRF9132
VP0114N5	IRF9613	VP1110N1	IRF9132	VP0220N1	IRF9232	VP1210N5	IRF9522
VP0202N1	IRF9133	VP1110N5	IRF9512	VP0220N5	IRF9612	VP1215N1	IRF9233
VP0202N5	IRF9513	VP1114N1	IRF9233	VP0335N1	IRF9232	VP1215N5	IRF9621
VP0203N1	IRF9133	VP1114N5	IRF9611	VP0335N5	IRF9612	VP1216N1	IRF9232
VP0203N5	IRF9513	VP1115N1	IRF9233	VP0340N1	IRF9232	VP1216N5	IRF9610
VP0204N1	IRF9133	VP1115N5	IRF9611	VP0340N5	IRF9612	VP1220N1	IRF9232
VP0204N5	IRF9513	VP1116N1	IRF9232	VP0345N1	IRF9232	VP1220N5	IRF9610
VP0206N1	IRF9133	VP1116N5	IRF9612	VP0345N5	IRF9612	ZVN0102L	IRF513
VP0206N5	IRF9513	VP1120N1	IRF9232	VP1102N1	IRF9133	ZNV0106L	IRF513
VP0208N1	IRF9132	VP1120N5	IRF9612	VP1102N5	IRF9523	ZNV0108L	IRF512
VP0208N5	IRF9512	VP1202N1	IRF9133	VP1103N1	IRF9133		
VP0209N1	IRF9132	VP1202N5	IRF9533	VP1103N5	IRF9523		
VP0209N5	IRF9512	VP1203N1	IRF9133	VP1104N1	IRF9133		
VP0210N1	IRF9132	VP1203N5	IRF9533	VP1104N5	IRF9513		
VP0210N5	IRF9512	VP1204N1	IRF9133	VP1106N1	IRF9133		
VP0214N1	IRF9233	VP1204N5	IRF9523	VP1106N5	IRF9513		
VP0214N5	IRF9613	VP1206N1	IRF9133	VP1208N1	IRF9132		
VP0215N5	IRF9613	VP1206N5	IRF9523	VP1208N5	IRF9522		

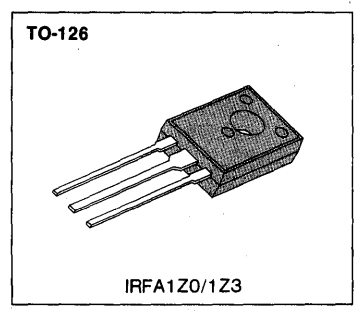
TOSHIBA	SAMSUNG Direct Re-placement	TOSHIBA	SAMSUNG Direct Re-placement	TOSHIBA	SAMSUNG Direct Re-placement	TOSHIBA	SAMSUNG Direct Re-placement
2SK385	IRFP340	2SK405	IRFP242	2SK643	IRFP441	2SK694	IRFP452
2SK386	IRFP453	2SK447	IRFP351	2SK675	IRFP151	2SJ115	IRFP9242
2SK387	IRFP241	2SK572	IRFP241	2SK678	IRFP450		
2SK388	IRFP351	2SK573	IRFP351	2SK693	IRFP451		

DATA SHEETS 4

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-126



IRFA1Z0/1Z3

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFA1Z0	100V	2.4Ω	0.5A
IRFA1Z3	60V	3.2Ω	0.4A

MAXIMUM RATINGS

Characteristic	Symbol	IRFA1Z0	IRFA1Z3	Unit
Drain-Source Voltage (1)	V_{DSS}	100	60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	60	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	0.5	0.4	Adc
Continuous Drain Current T_C=100°C	I_D	0.3	0.25	Adc
Drain Current—Pulsed (3)	I_{DM}	4.0	3.2	Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	1.0 0.008		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8" from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFA1Z0	100	—	—	V	V_{GS}=0V
	IRFA1Z3	60	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFA1Z0	0.5	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFA1Z3	0.4	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFA1Z0	—	1.5	2.4	Ω	V_{GS}=10V, I_D=0.25A
	IRFA1Z3	—	2	3.2	Ω	
g_{fs}	Forward Transconductance (2)	0.25	0.35	—	℧	V_{DS}>$I_{D(on)}$×$R_{DS(on)\ max}$ I_D=0.25A
C_{iss}	Input Capacitance	—	65	70	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	24	30	pF	
C_{rss}	Reverse Transfer Capacitance	—	9	100	pF	
$t_{d(on)}$	Turn-On Delay Time	—	10	20	ns	V_{DD}=0.5BV_{DSS}, I_D=0.25A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	15	25		ns	
$t_{d(off)}$	Turn-Off Delay Time	—	15	25	ns	
t_f	Fall Time	—	10	20	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	2.0	3.0	nC	V_{GS}=10V, I_D=1.2A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	0.6	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	1.4	—	nC	

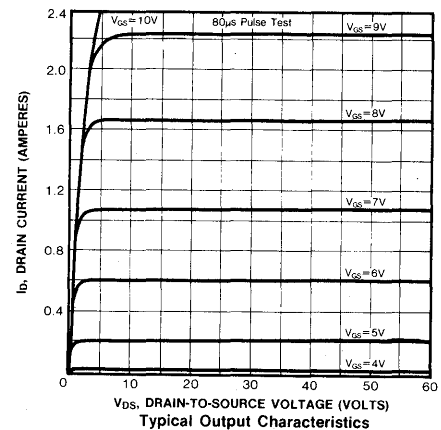
THERMAL RESISTANCE

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	120	KW	

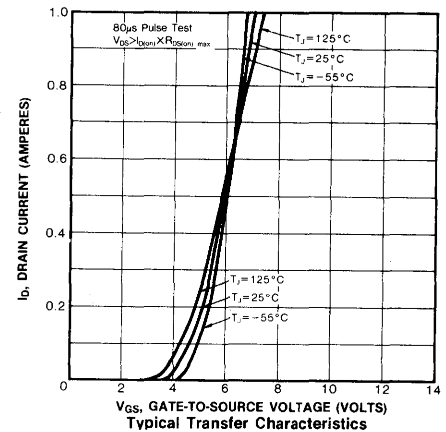
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRFA1Z0	—	—	0.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRFA1Z3	—	—	0.4	A	
I_{SM}	Pulse Source Current (Body Diode) (3)	IRFA1Z0	—	—	4.0	A	
		IRFA1Z3	—	—	3.2	A	
V_{SD}	Diode Forward Voltage (2)	IRFA1Z0	—	—	1.4	V	$T_C=25°C$, $I_S=0.5A$, $V_{GS}=0V$
		IRFA1Z3	—	—	2.5	V	$T_C=25°C$, $I_S=0.4A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time		—	100	—	ns	$T_J=25°C$, $I_F=0.5A$, $dI_F/dt=100A/\mu s$

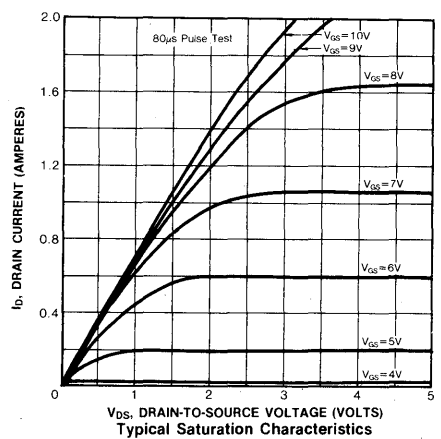
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



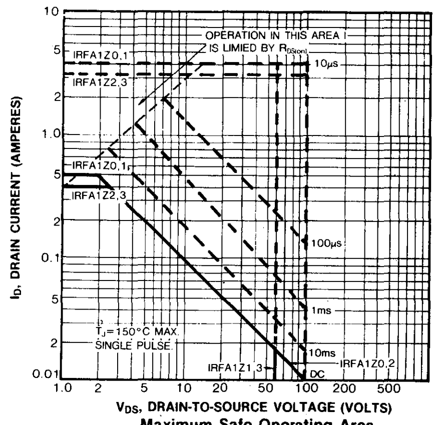
Typical Output Characteristics



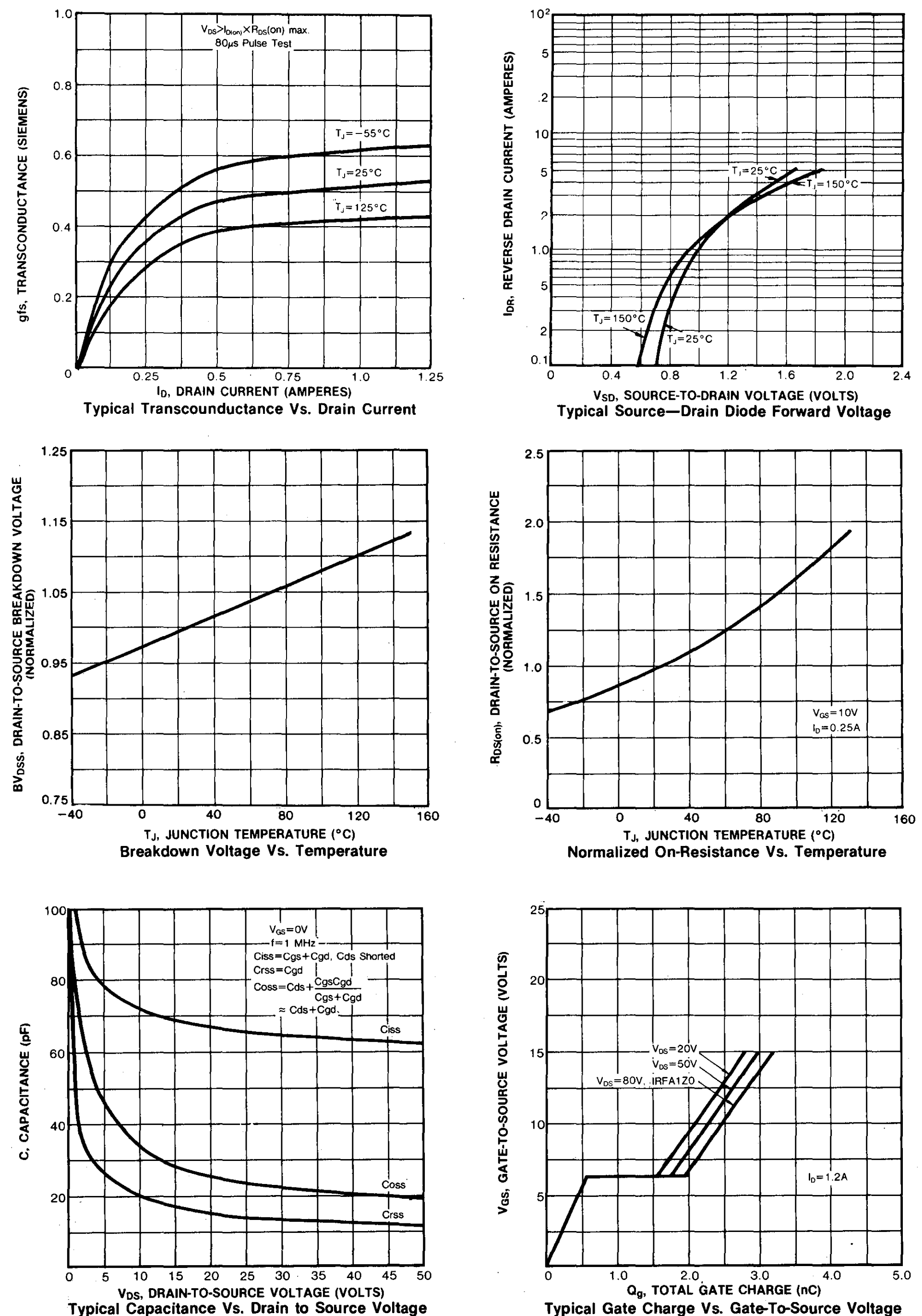
Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area



Typical Transcounductance Vs. Drain Current

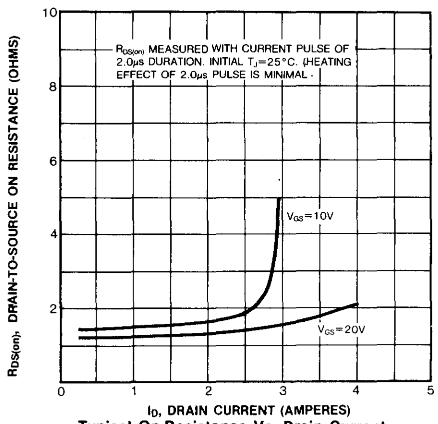
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

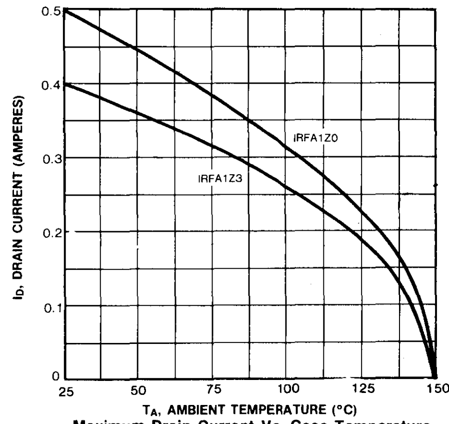
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

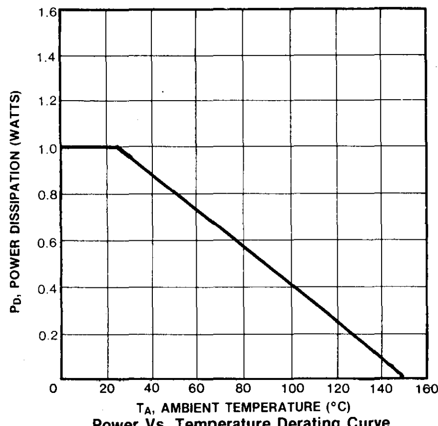
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

4

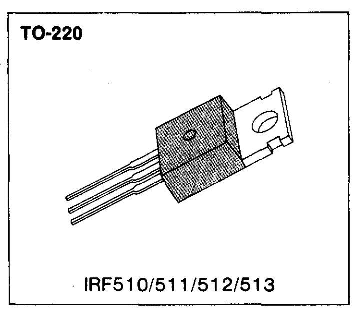
IRF510/511/512/513

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-220



IRF510/511/512/513

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF510	100V	0.54Ω	5.6A
IRF511	80V	0.54Ω	5.6A
IRF512	100V	0.74Ω	4.9A
IRF513	80V	0.74Ω	4.9A

MAXIMUM RATINGS

Characteristic	Symbol	IRF510	IRF511	IRF512	IRF513	Unit
Drain-Source Voltage (1)	V_{DSS}	100	80	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	5.6	5.6	4.9	4.9	Adc
Continuous Drain Current T_C=100°C	I_D	4.0	4.0	3.4	3.4	Adc
Drain Current—Pulsed (3)	I_{DM}	20	20	18	18	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	19				mJ
Avalanche Current	I_{AS}	5.6				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	43 0.24				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.19 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF510/512	100	—	—	V	V_{GS}=0V
	IRF511/513	80	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF510/511	5.6	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF512/513	—	0.54	0.74	Ω	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF510/511	—	0.41	0.54	Ω	V_{GS}=10V, I_D=3.4A
	IRF512/513	—	0.54	0.74	Ω	
g_{fs}	Forward Transconductance (2)	1.3	2.0	—	$\mho$	V_{DS}≥50V, I_D=3.4A
C_{iss}	Input Capacitance	—	180	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	82	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	20	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	7.6	11	ns	V_{DD}=0.5BV_{DSS}, I_D=3.4A. Z_O=24Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	24	36	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	14	21	ns	
t_f	Fall Time	—	14	21	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	5.2	7.7	nC	V_{GS}=10V, I_D=5.6A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	1.5	2.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	2.2	3.2	nC	

THERMAL RESISTANCE

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	2.9	KW	
R_{thCS}	Case-to-Sink	—	0.5	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

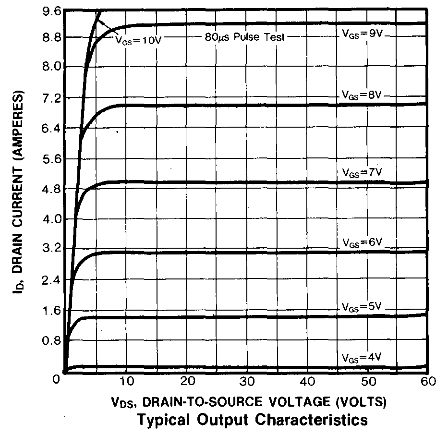
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

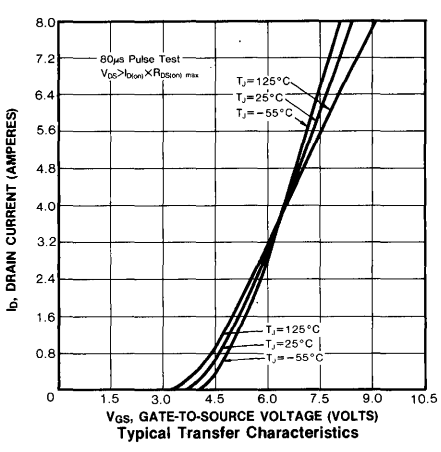
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRF510 IRF511	—	—	5.6	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRF512 IRF513	—	—	4.9	A	
I_{SM}	Pulse Source Current (Body Diode) 1	IRF510 IRF511	—	—	20	A	
		IRF512 IRF513	—	—	18	A	
V_{SD}	Diode Forward Voltage 2	IRF510 IRF511	—	—	2.5	V	T_C=25°C, I_S=5.6A, V_{GS}=0V
		IRF512 IRF513	—	—	2.0	V	T_C=25°C, I_S=4.9A, V_{GS}=0V
t_{rr}	Reverse Recovery Time		—	230	—	ns	T_J=25°C, I_F=5.6A, dI_F/dt=100A/μs

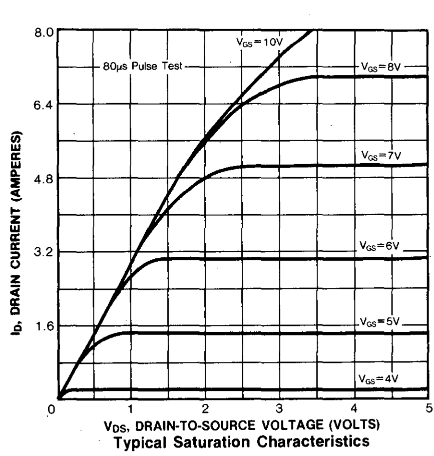
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



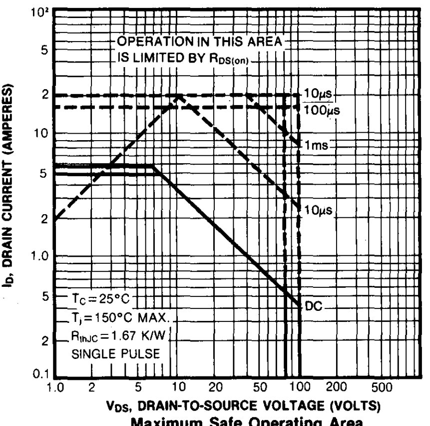
Typical Output Characteristics



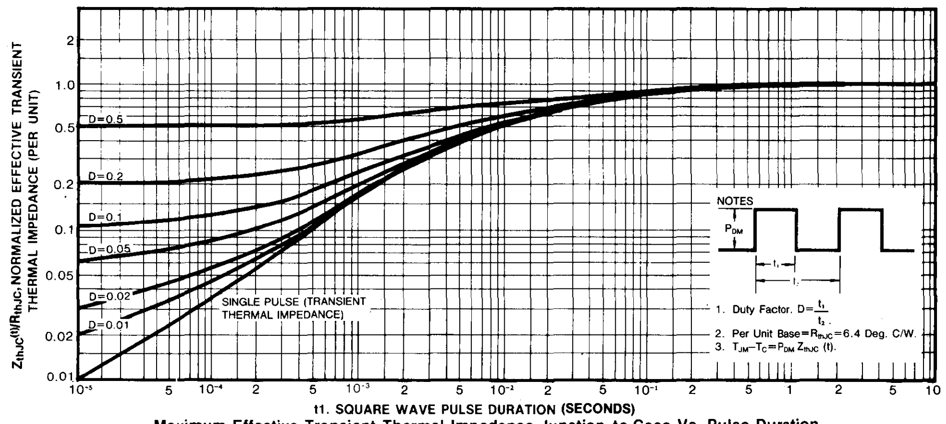
Typical Transfer Characteristics



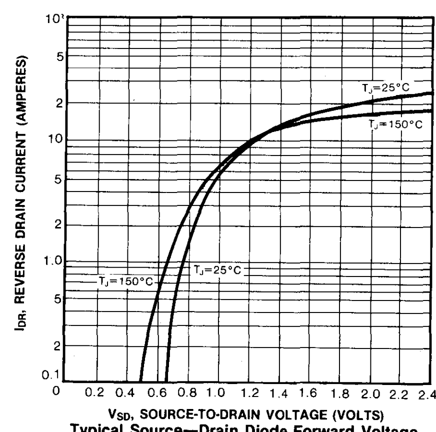
Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



gfs, TRANSCONDUCTACE (SIMENS)

80μs Pulse Test

$V_{DS} > I_{D(on)} \times R_{DS(on)\,max}$

T_J=−55°C

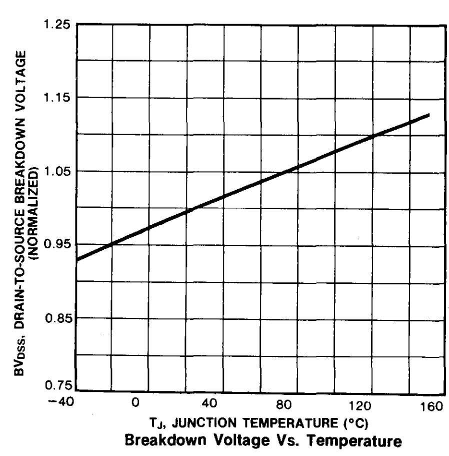
T_J=25°C

T_J=125°C

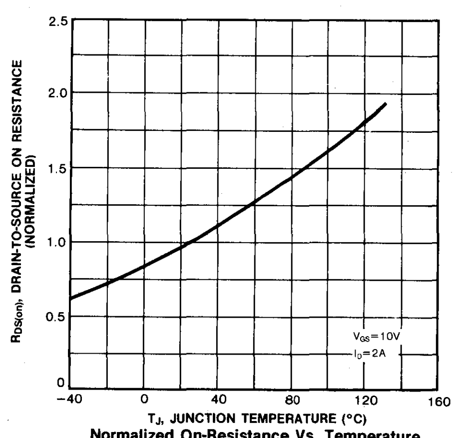
I_D, DRAIN CURRENT (AMPERES)

Typical Transcounductance Vs. Drain Current

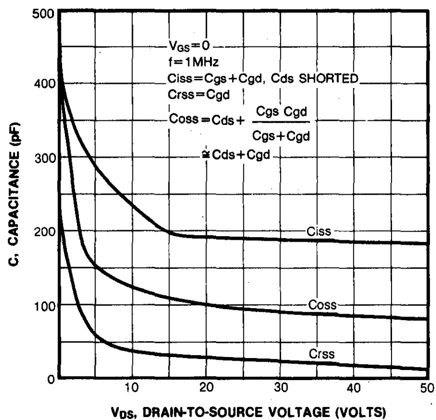
Typical Source—Drain Diode Forward Voltage



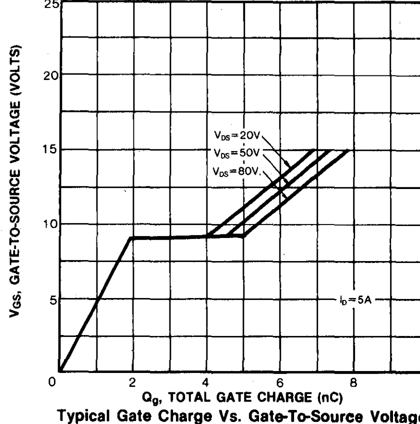
Breakdown Voltage Vs. Temperature



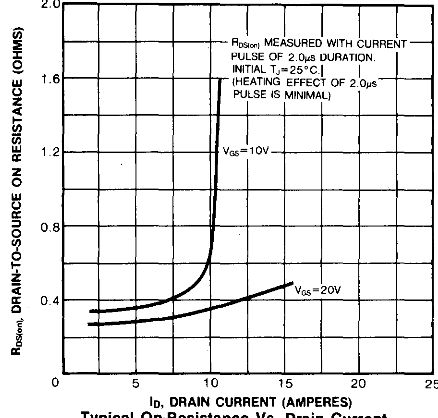
Normalized On-Resistance Vs. Temperature



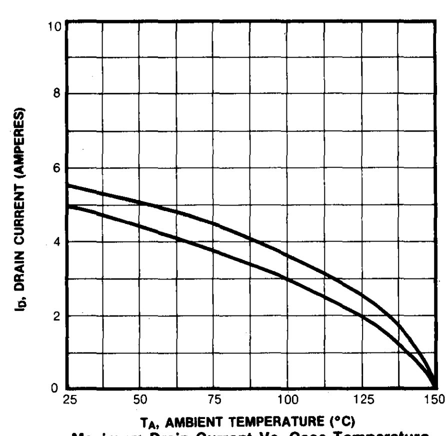
Typical Capacitance Vs. Drain to Source Voltage



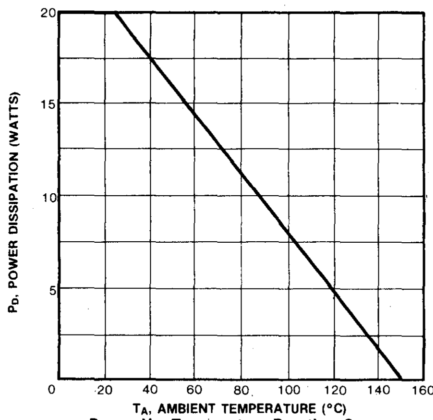
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



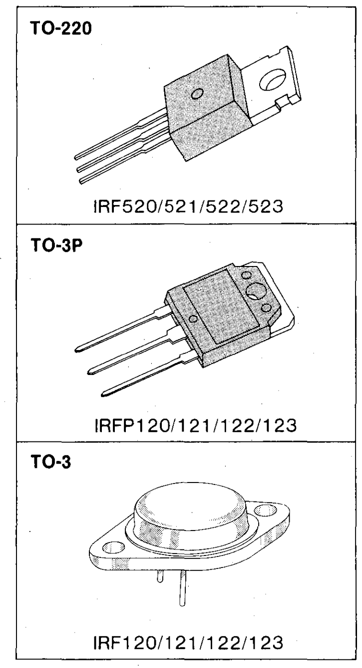
Power Vs. Temperature Derating Curve

IRF520/521/522/523
IRFP120/121/122/123
IRF120/121/122/123

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF520/IRFP120/IRF120	100V	0.27Ω	9.2A
IRF521/IRFP121/IRF121	80V	0.27Ω	9.2A
IRF522/IRFP122/IRF122	100V	0.36Ω	8.0A
IRF523/IRFP123/IRF123	80V	0.36Ω	8.0A

MAXIMUM RATINGS

Characteristics	Symbol	IRF520 IRFP120 IRF120	IRF521 IRFP121 IRF121	IRF522 IRFP122 IRF122	IRF523 IRFP123 IRF123	Unit
Drain-Source Voltage (1)	V_{DSS}	100	80	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	9.2	9.2	8.0	8.0	Adc
Continuous Drain Current T_C=100°C	I_D	6.5	6.5	5.6	5.6	Adc
Drain Current—Pulsed (3)	I_{DM}	37	37	37	37	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	36				mJ
Avalanche Current	I_{AS}	9.2				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	60 0.48				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.64 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF520/IRFP120/IRF120 IRF522/IRFP122/IRF122	100	—	—	V	V_{GS}=0V I_D=250μA
	IRF521/IRFP121/IRF121 IRF523/IRFP123/IRF123	80	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF520/IRFP120/IRF120 IRF521/IRFP121/IRF121	9.2	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max}$, V_{GS}=10V
	IRF522/IRFP122/IRF122 IRF523/IRFP123/IRF123	8.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF520/IRFP120/IRF120 IRF521/IRFP121/IRF121	—	0.25	0.27	Ω	V_{GS}=10V, I_D=5.6A
	IRF522/IRFP122/IRF122 IRF523/IRFP123/IRF123	—	0.27	0.36	Ω	
g_{fs}	Forward Transconductance (2)	2.7	4.1	—	℧	V_{DS}≥50V, I_D=5.6A
C_{iss}	Input Capacitance	—	400	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	130	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	40	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.8	13	ns	V_{DD}=0.5BV_{DSS}, I_D=5.6A, Z_O=18Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	30	45	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	19	27	ns	
t_f	Fall Time	—	20	30	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	9.8	15	nC	V_{GS}=10V, I_D=9.2A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.2	3.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	2.3	3.4	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRF520-3	IRFP120-3	IRF120-3	Unit	
R_{thJC}	Junction-to-Case	MAX	2.08	2.08	2.08	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF520/IRFP120/IRF120 IRF521/IRFP121/IRF121	—	—	9.2	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF522/IRFP122/IRF122 IRF523/IRFP123/IRF123	—	—	8.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF520/IRFP120/IRF120 IRF521/IRFP121/IRF121	—	—	37	A	
	IRF522/IRFP122/IRF122 IRF523/IRFP123/IRF123	—	—	32	A	
V_{SD}	Diode Forward Voltage (2) IRF520/IRFP120/IRF120 IRF521/IRFP121/IRF121	—	—	2.5	V	T_C=25°C, I_S=9.2A, V_{GS}=0V
	IRF522/IRFP122/IRF122 IRF523/IRFP123/IRF123	—	—	2.3	V	T_C=25°C, I_S=8.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	110	240	ns	T_j=25°C, I_F=9.2A, dI_F/dt=100A/μS

Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

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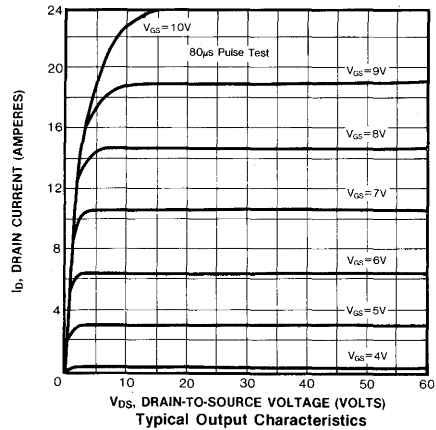
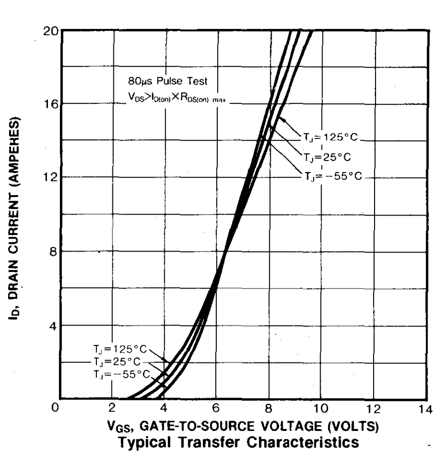


Typical Output Characteristics



Typical Transfer Characteristics

I_D, DRAIN CURRENT (AMPERES)

$V_{GS}=10V$
80μs Pulse Test
$V_{GS}=9V$
$V_{GS}=8V$
$V_{GS}=7V$
$V_{GS}=6V$
$V_{GS}=5V$
$V_{GS}=4V$

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Saturation Characteristics

I_D, DRAIN CURRENT (AMPERES)

OPERATION IN THIS AREA
IS LIMITED BY $R_{DS(on)}$
10μs
100μs
1ms
10ms
100ms
DC
$T_C=25°C$
$T_j=150°C$ MAX.
$R_{thJC}=1.67$ K/W
SINGLE PULSE

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Maximum Safe Operating Area

$Z_{thJC}(t)/R_{thJC}$, NORMALIZED EFFECTIVE TRANSIENT THERMAL IMPEDANCE (PER UNIT)

D=0.5
D=0.2
D=0.1
D=0.05
D=0.02
D=0.01
SINGLE PULSE (TRANSIENT THERMAL IMPEDANCE)

NOTES
P_{DM}
t_1
t_2
1. Duty Factor, $D=\frac{t_1}{t_2}$
2. Per Unit Base $=R_{thJC}=3.12$ Deg. C/W.
3. $T_{JM}-T_C=P_{DM}\,Z_{thJC}\,(t)$.

t1. SQUARE WAVE PULSE DURATION (SECONDS)

Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF520-3 And IRF120-3

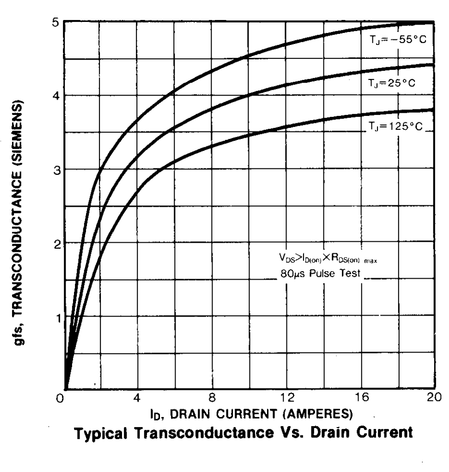
$Z_{thJC}(t)/R_{thJC}$, NORMALIZED EFFECTIVE TRANSIENT THERMAL IMPEDANCE (PER UNIT)

D=0.5
D=0.2
D=0.1
D=0.05
D=0.02
D=0.01
SINGLE PULSE (TRANSIENT THERMAL IMPEDANCE)

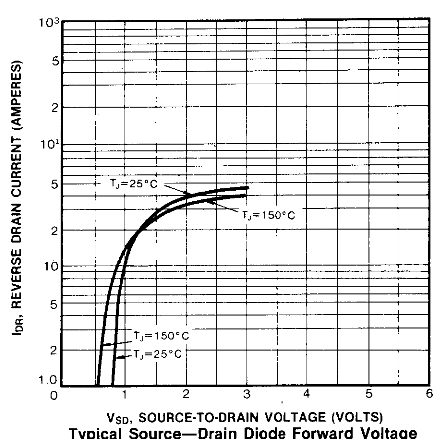
NOTES
P_{DM}
t_1
t_2
1. Duty Factor, $D=\frac{t_1}{t_2}$.
2. Per Unit Base $=R_{thJC}=3.12$ Deg. C/W.
3. $T_{JM}-T_C=P_{DM}\,Z_{thJC}\,(t)$.

t1. SQUARE WAVE PULSE DURATION (SECONDS)

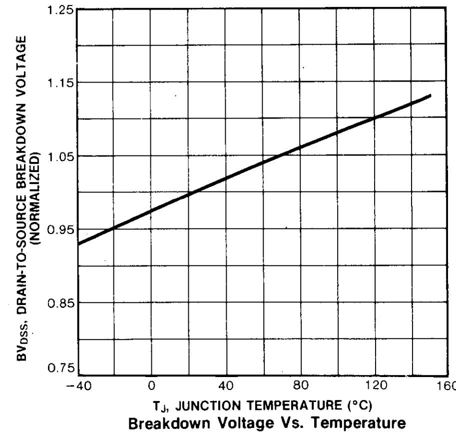
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP120-3



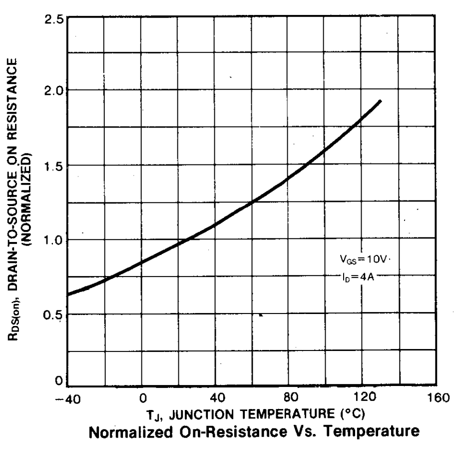
Typical Transconductance Vs. Drain Current



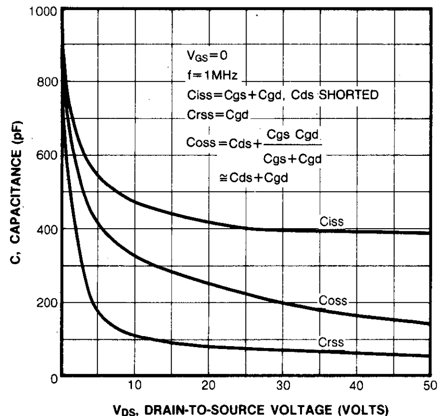
Typical Source—Drain Diode Forward Voltage



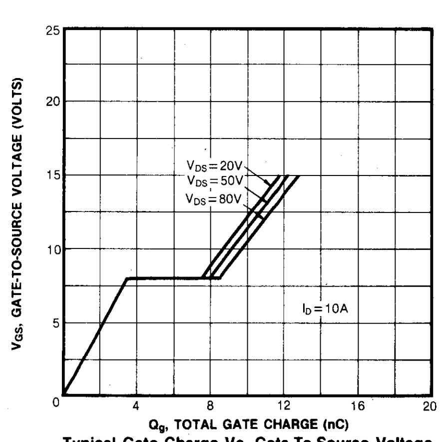
Breakdown Voltage Vs. Temperature



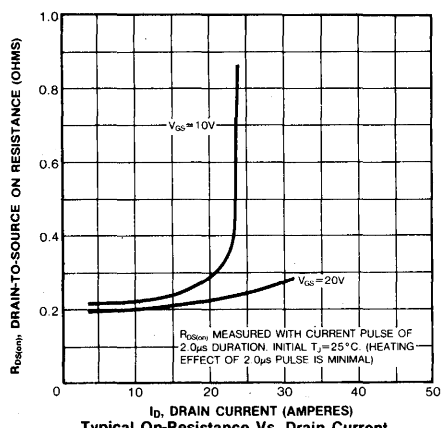
Normalized On-Resistance Vs. Temperature



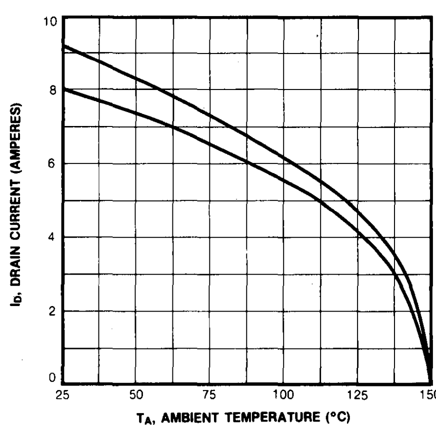
Typical Capacitance Vs. Drain to Source Voltage



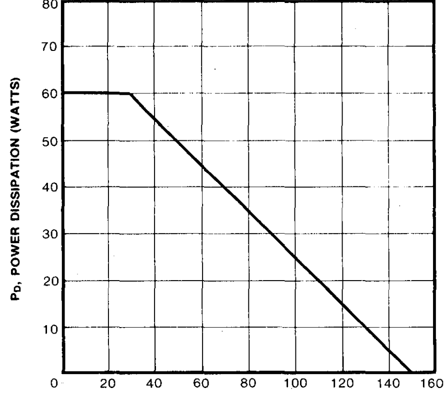
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



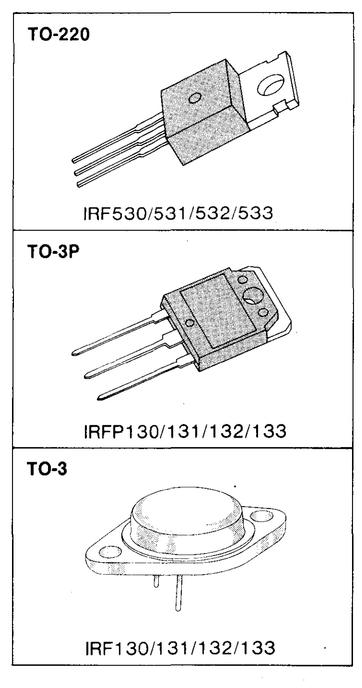
Power Vs. Temperature Derating Curve

IRF530/531/532/533
IRFP130/131/132/133
IRF130/131/132/133

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF530/IRFP130/IRF130	100V	0.16Ω	14A
IRF531/IRFP131/IRF131	80V	0.16Ω	14A
IRF532/IRFP132/IRF132	100V	0.23Ω	12A
IRF533/IRFP133/IRF133	80V	0.23Ω	12A

4

MAXIMUM RATINGS

Characteristics	Symbol	IRF530 IRFP130 IRF130	IRF531 IRFP131 IRF131	IRF532 IRFP132 IRF132	IRF533 IRFP133 IRF133	Unit
Drain-Source Voltage (1)	V_{DSS}	100	80	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	14	14	12	12	Adc
Continuous Drain Current T_C=100°C	I_D	10	10	8.3	8.3	Adc
Drain Current—Pulsed (3)	I_{DM}	56	56	48	48	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy(4)	E_{AS}	69				mJ
Avalanche Current	I_{AS}	14				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	77 0.62				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.53 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

IRF530/531/532/533
IRFP130/131/132/133
IRF130/131/132/133

N-CHANNEL POWER MOSFETS

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF530/IRFP130/IRF130 IRF532/IRFP132/IRF132	100	—	—	V	V_{GS}=0V I_D=250μA
	IRF531/IRFP131/IRF131 IRF533/IRFP133/IRF133	80	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF530/IRFP130/IRF130 IRF531/IRFP131/IRF131	14	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max}$, V_{GS}=10V
	IRF532/IRFP132/IRF132 IRF533/IRFP133/IRF133	12	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF530/IRFP130/IRF130 IRF531/IRFP131/IRF131	—	0.10	0.16	Ω	V_{GS}=10V, I_D=8.3A
	IRF532/IRFP132/IRF132 IRF533/IRFP133/IRF133	—	0.16	0.23	Ω	
g_{fs}	Forward Transconductance (2)	5.1	7.6	—	℧	V_{DS}≥50V, I_D=8.3A
C_{iss}	Input Capacitance	—	640	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	240	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	72	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	10	15	ns	V_{DD}=0.5BV_{DSS}, I_D=8.3A, Z_O=12Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	34	51	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	23	35	ns	
t_f	Fall Time	—	24	36	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	17	26	nC	V_{GS}=10V, I_D=14A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	3.7	5.5	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7	11	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRF530-3	IRFP130-3	IRF130-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.62	1.62	1.62	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF530/IRFP130/IRF130 IRF531/IRFP131/IRF131	—	—	14	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF532/IRFP132/IRF132 IRF533/IRFP133/IRF133	—	—	12	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF530/IRFP130/IRF130 IRF531/IRFP131/IRF131	—	—	56	A	
	IRF532/IRFP132/IRF132 IRF533/IRFP133/IRF133	—	—	48	A	
V_{SD}	Diode Forward Voltage (2) IRF530/IRFP130/IRF130 IRF531/IRFP131/IRF131	—	—	2.5	V	$T_C=25°C$, $I_S=14A$, $V_{GS}=0V$
	IRF532/IRFP132/IRF132 IRF533/IRFP133/IRF133	—	—	2.3	V	$T_C=25°C$, $I_S=12A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	120	250	ns	$T_j=25°C$, $I_F=14A$, $dI_F/dt=100A/\mu S$

Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leqslant300\mu s$, Duty Cycle$\leqslant2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature

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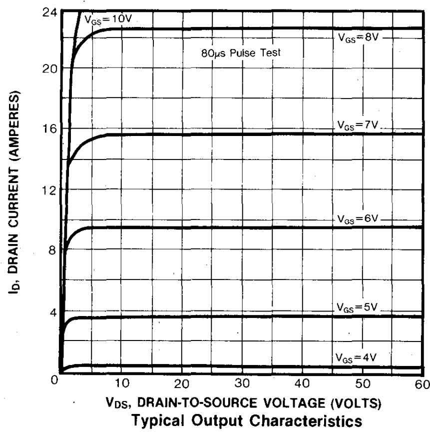
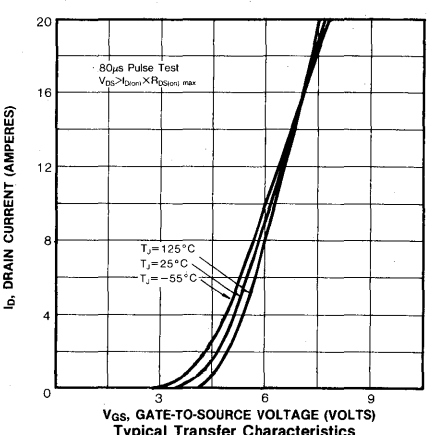
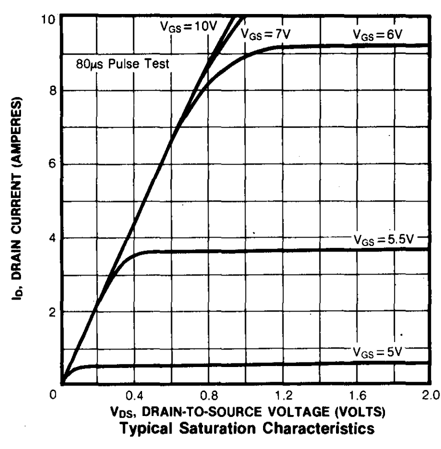


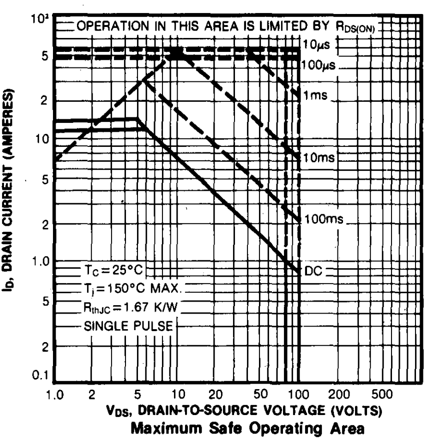
Typical Output Characteristics



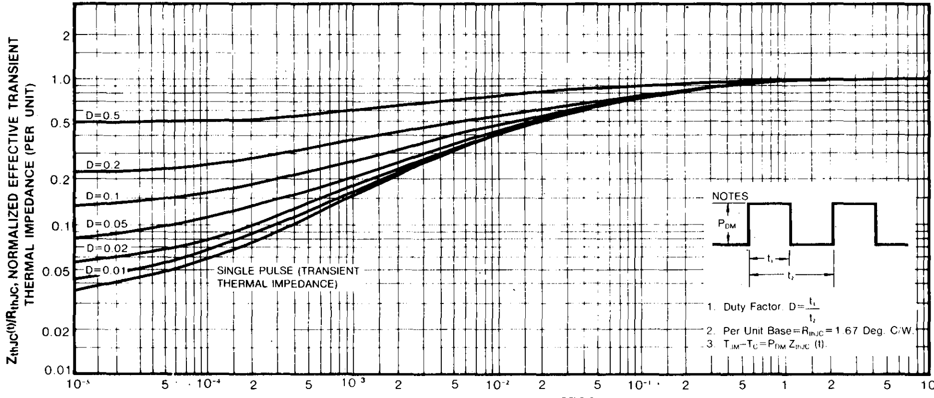
Typical Transfer Characteristics



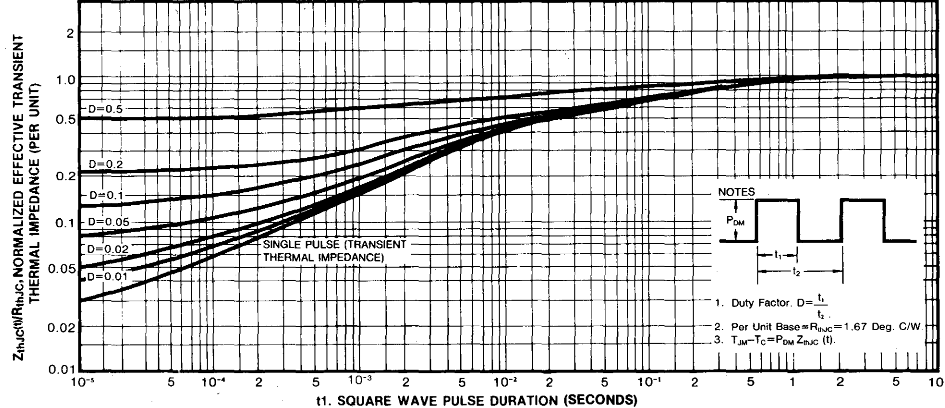
Typical Saturation Characteristics



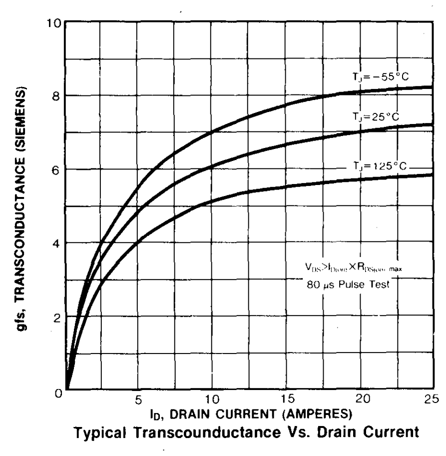
Maximum Safe Operating Area



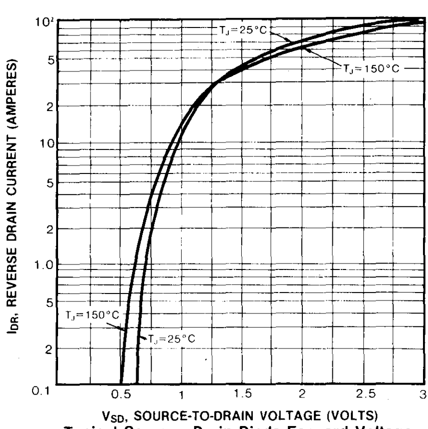
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF530-3 And IRF130-3



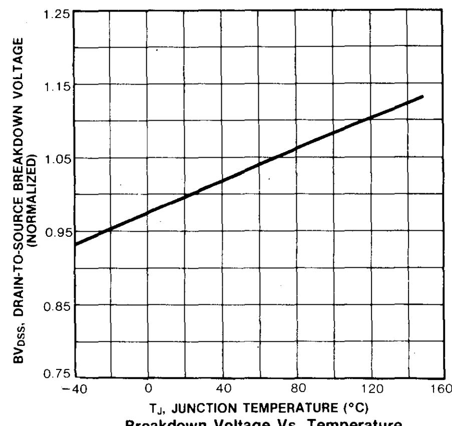
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP130-3



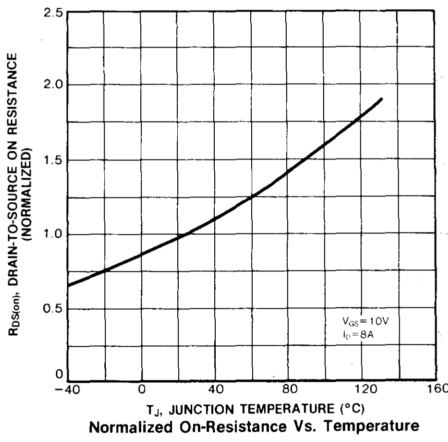
Typical Transcounductance Vs. Drain Current



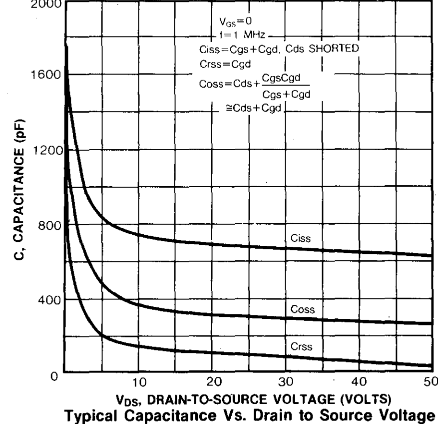
Typical Source—Drain Diode Forward Voltage



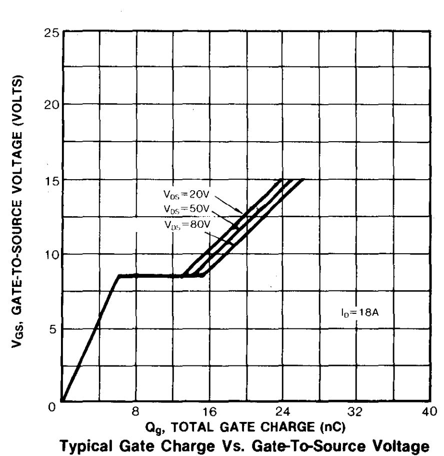
Breakdown Voltage Vs. Temperature



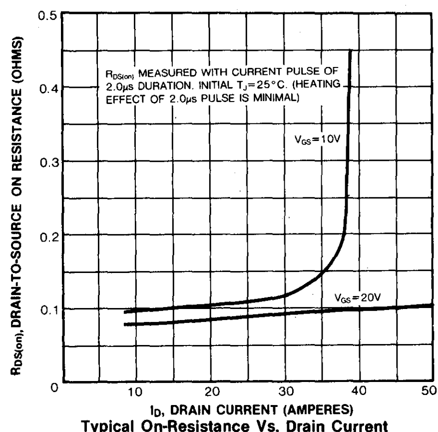
Normalized On-Resistance Vs. Temperature



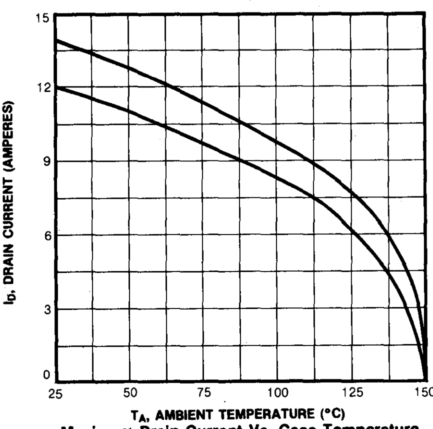
Typical Capacitance Vs. Drain to Source Voltage



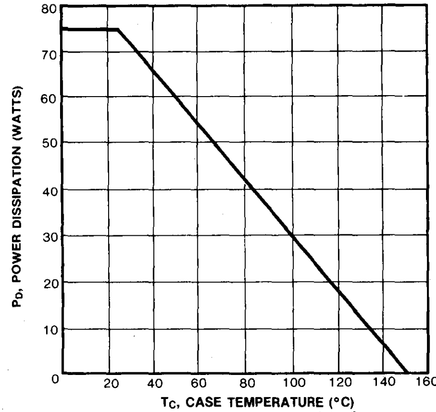
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



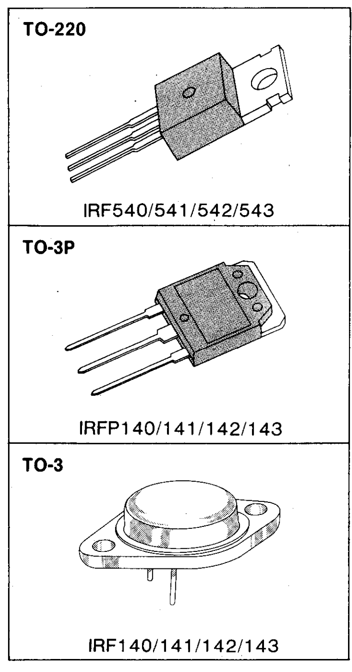
Power Vs. Temperature Derating Curve

IRF540/541/542/543
IRFP140/141/142/143
IRF140/141/142/143

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF540/IRFP140/IRF140	100V	0.077Ω	28A
IRF541/IRFP141/IRF141	80V	0.077Ω	28A
IRF542/IRFP142/IRF142	100V	0.10Ω	25A
IRF543/IRFP143/IRF143	80V	0.10Ω	25A

4

MAXIMUM RATINGS

Characteristics	Symbol	IRF540 IRFP140 IRF140	IRF541 IRFP141 IRF141	IRF542 IRFP142 IRF142	IRF543 IRFP143 IRF143	Unit
Drain-Source Voltage (1)	V_{DSS}	100	80	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	28	28	25	25	Adc
Continuous Drain Current T_C=100°C	I_D	20	20	17	17	Adc
Drain Current—Pulsed (3)	I_{DM}	110	110	100	100	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	230				mJ
Avalanche Current	I_{AS}	28				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.44 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF540/IRFP140/IRF140 IRF542/IRFP142/IRF142	100	—	—	V	V_{GS}=0V I_D=250μA
	IRF541/IRFP141/IRF141 IRF543/IRFP143/IRF143	80	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF540/IRFP140/IRF140 IRF541/IRFP141/IRF141	28	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max}$. V_{GS}=10V
	IRF542/IRFP142/IRF142 IRF543/IRFP143/IRF143	25	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF540/IRFP140/IRF140 IRF541/IRFP141/IRF141	—	0.06	0.077	Ω	V_{GS}=10V, I_D=17A
	IRF542/IRFP142/IRF142 IRF543/IRFP143/IRF143	—	0.08	0.10	Ω	
g_{fs}	Forward Transconductance (2)	8.7	13	—	℧	V_{DS}≥50V, I_D=17A
C_{iss}	Input Capacitance	—	1500	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	500	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	90	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	15	23	ns	V_{DD}=0.5BV_{DSS}, I_D=17A, Z_O=9.1Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	72	110	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	40	60	ns	
t_f	Fall Time	—	50	75	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	39	59	nC	V_{GS}=10V, I_D=28A,V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	7.8	12	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	19	38	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRF540-3	IRFP140-3	IRF140-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF540/IRFP140/IRF140 IRF541/IRFP141/IRF141	—	—	28	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF542/IRFP142/IRF142 IRF543/IRFP143/IRF143	—	—	25	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF540/IRFP140/IRF140 IRF541/IRFP141/IRF141	—	—	110	A	
	IRF542/IRFP142/IRF142 IRF543/IRFP143/IRF143	—	—	100	A	
V_{SD}	Diode Forward Voltage (2) IRF540/IRFP140/IRF140 IRF541/IRFP141/IRF141	—	—	2.5	V	T_C=25°C, I_S=28A, V_{GS}=0V
	IRF542/IRFP142/IRF142 IRF543/IRFP143/IRF143	—	—	2.3	V	T_C=25°C, I_S=25A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	150	300	ns	T_j=25°C, I_F=28A, dI_F/dt=100A/μS

Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

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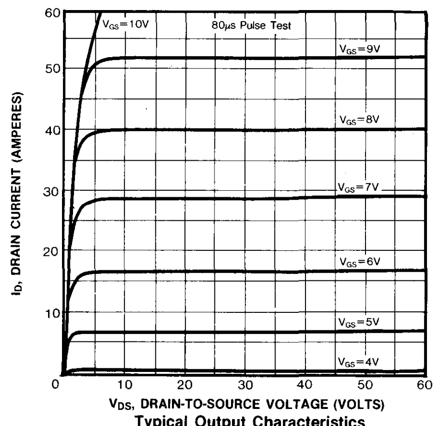
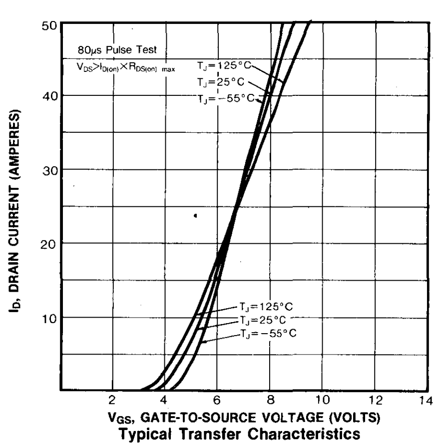
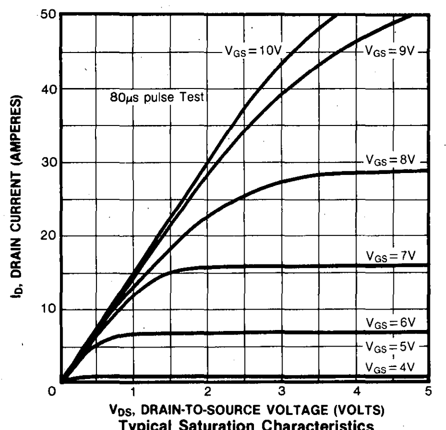


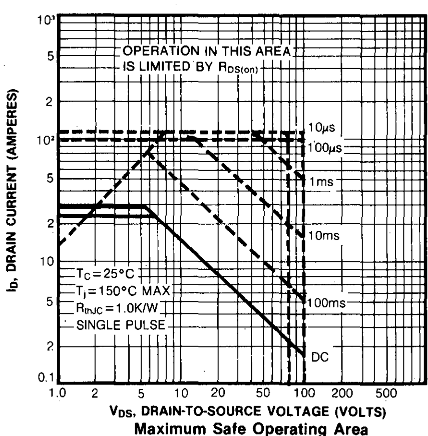
Typical Output Characteristics



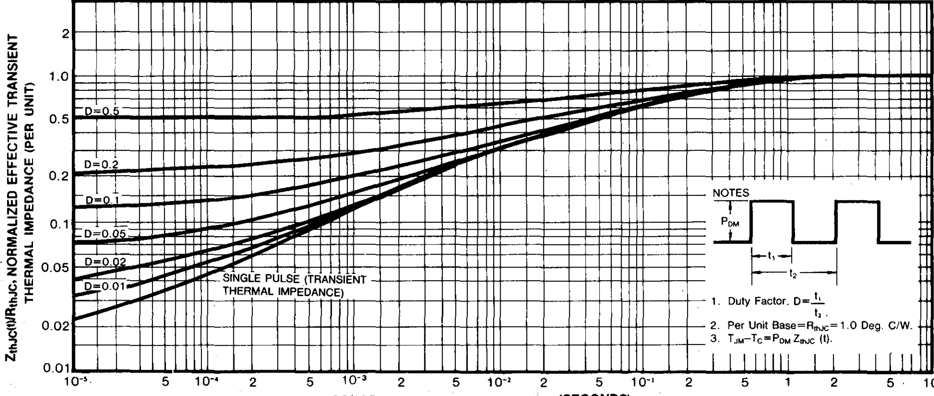
Typical Transfer Characteristics



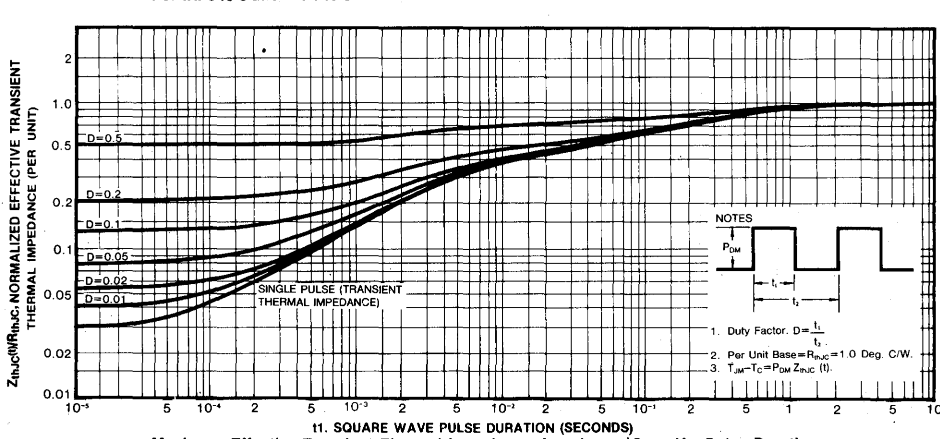
Typical Saturation Characteristics



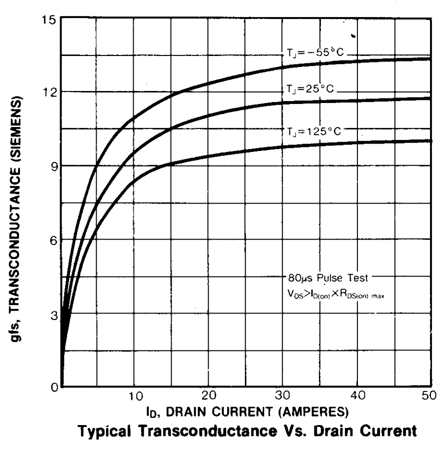
Maximum Safe Operating Area



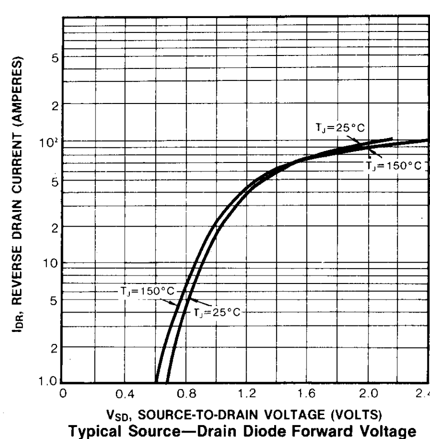
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF540-3 and IRF140-3



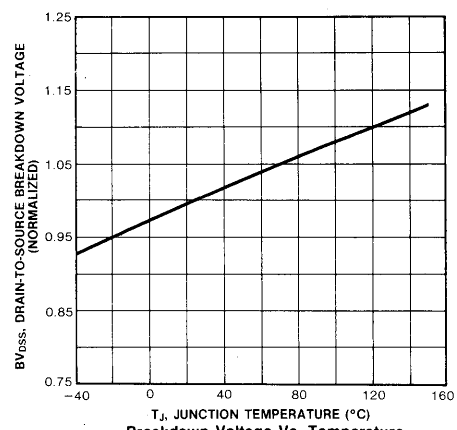
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP140-3



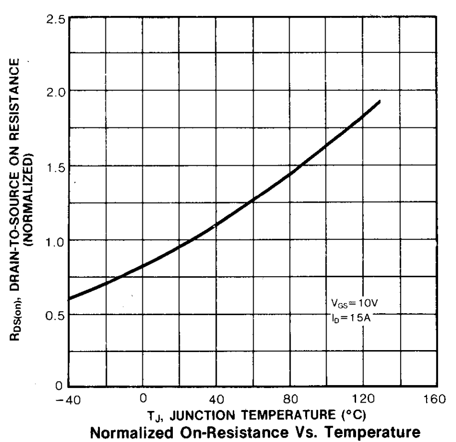
Typical Transconductance Vs. Drain Current



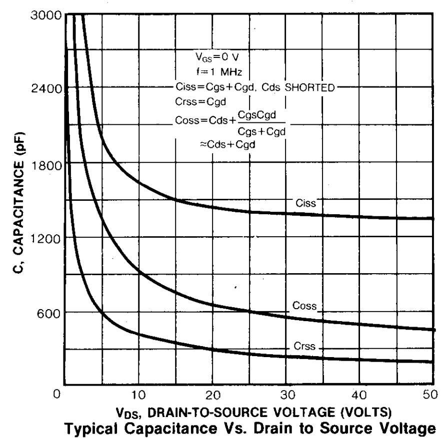
Typical Source—Drain Diode Forward Voltage



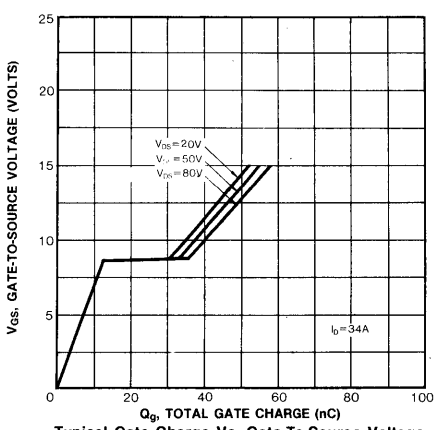
Breakdown Voltage Vs. Temperature



Normalized On-Resistance Vs. Temperature



Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage

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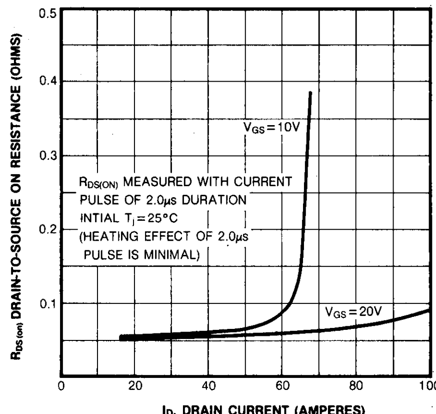
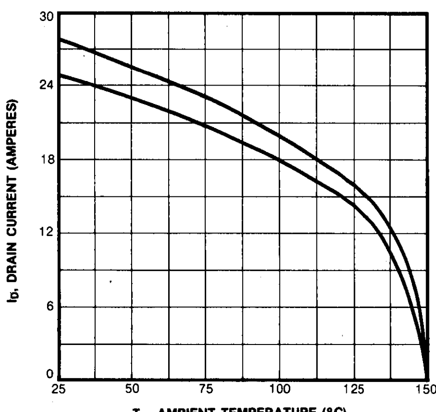
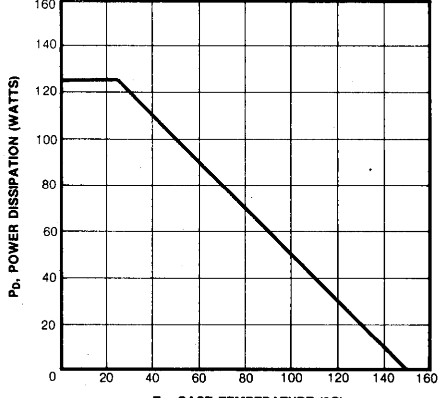


Typical On-Resistance Vs. Drain Current



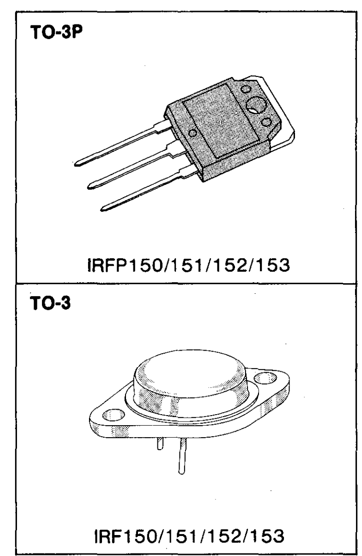
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

IRFP150/151/152/153
IRF150/151/152/153

N-CHANNEL POWER MOSFETS



FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFP150/IRF150	100V	0.055Ω	40A
IRFP150/IRF150	60V	0.055Ω	40A
IRFP150/IRF150	100V	0.08Ω	34A
IRFP150/IRF150	60V	0.08Ω	34A

MAXIMUM RATINGS

Characteristic	Symbol	IRFP150 IRF150	IRFP151 IRF151	IRFP152 IRF152	IRFP153 IRF153	Unit
Drain-Source Voltage (1)	V_{DSS}	100	60	100	60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	60	100	60	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	40	40	34	34	Adc
Continuous Drain Current T_C=100°C	I_D	26	26	22	22	Adc
Drain Current—Pulsed (3)	I_{DM}	100	100	140	140	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	374				mJ
Avalanche Current	I_{AS}	40				A
Total Power Dissipation @ T_C=25°C Derate above 25°C (4)	P_D	150 1.2				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.36 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF150/152/IRFP150/152	100	—	—	V	V_{GS}=0V
	IRF151/153/IRFP151/153	60	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF150/151/IRFP150/151	40	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF152/153/IRFP150/151	34	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF150/151/IRFP150/151	—	0.045	0.055	Ω	V_{GS}=10V, I_D=22A
	IRF152/153/IRFP152/153	—	0.06	0.08	Ω	
g_{fs}	Forward Transconductance (2)	13.0	20	—	℧	V_{DS}≥50V, I_D=20A
C_{iss}	Input Capacitance	—	2400	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	1000	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	200	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	24	ns	V_{DD}=0.5BV_{DSS}, I_D=20A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	210	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	84	ns	
t_f	Fall Time	—	—	140	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	72	110	nC	V_{GS}=10V, I_D=38A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	18	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	27	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRFP150-3	IRF150-3	Unit	
R_{thJC}	Junction-to-Case	MAX	0.7	0.83	K/W	
R_{thCS}	Case-to-Sink	TYP	0.1	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF150/151/IRFP150/151	—	—	40	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier (symbol terminals: D, G, S)
	IRF152/153/IRFP150/151	—	—	34	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF150/151/IRFP150/151	—	—	160	A	
	IRF152/153/IRFP152/153	—	—	132	A	
V_{SD}	Diode Forward Voltage (2) IRF150/151/IRFP150/151	—	—	2.5	V	T_C=25°C, I_S=40A, V_{GS}=0V
	IRF152/153/IRFP152/151	—	—	2.3	V	T_C=25°C, I_S=34A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	220	530	ns	T_j=25°C, I_F=40A, dI_F/dt=100A/μS

Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

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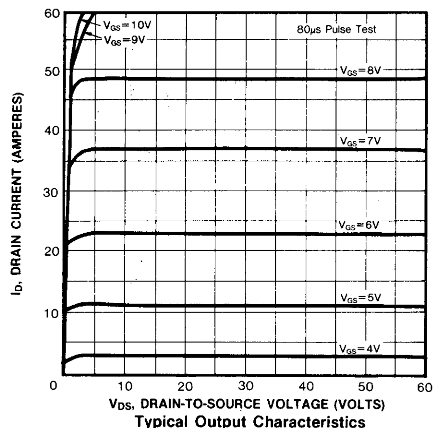
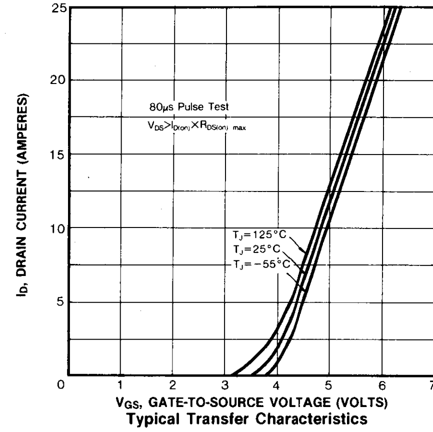
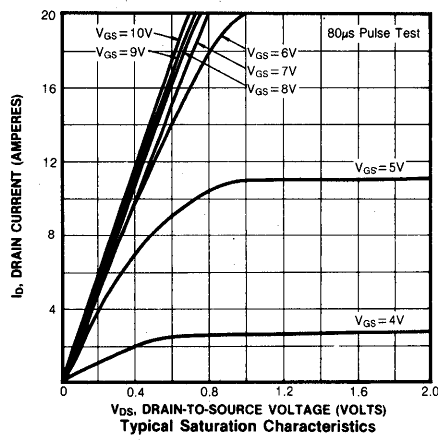


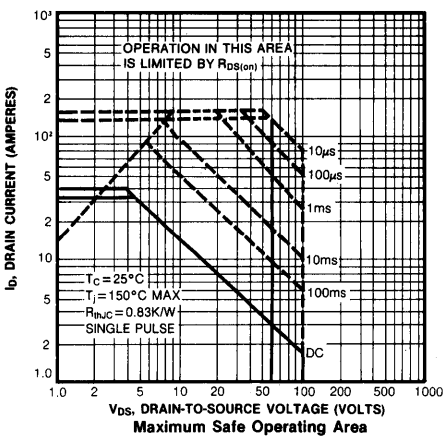
Typical Output Characteristics



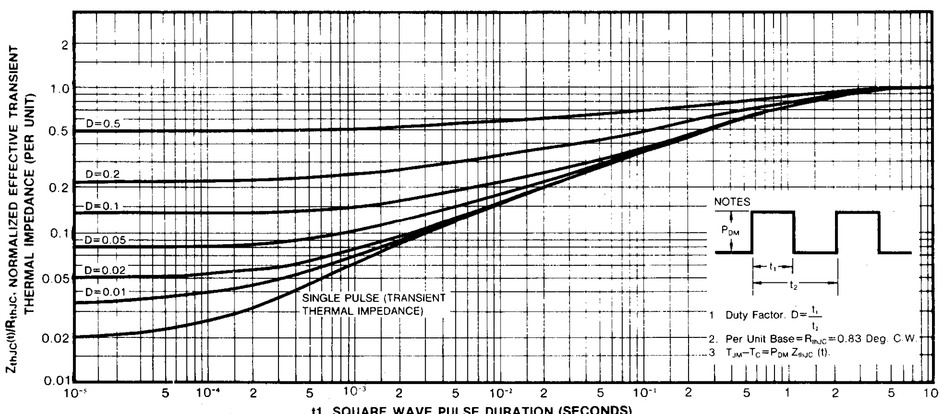
Typical Transfer Characteristics



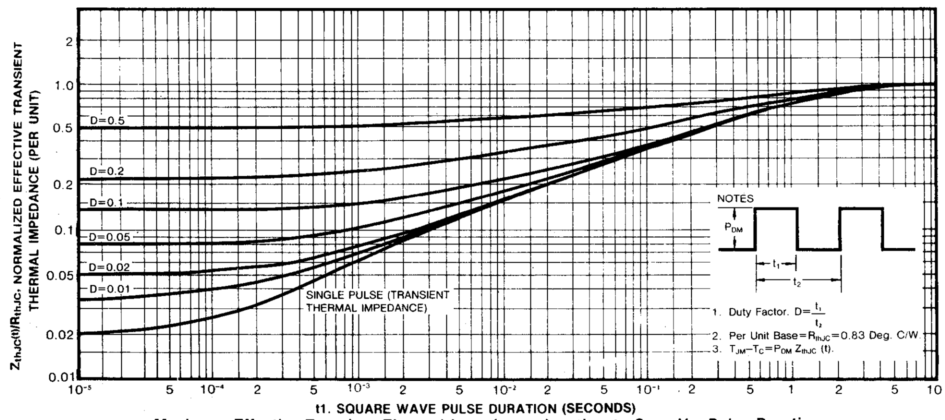
Typical Saturation Characteristics



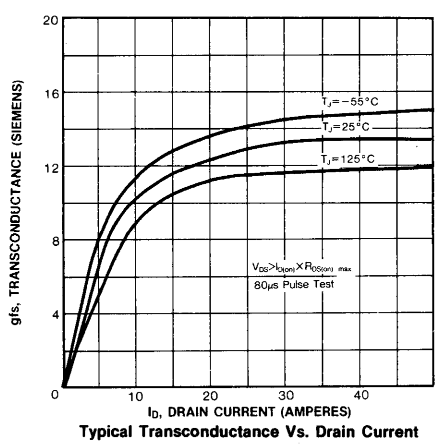
Maximum Safe Operating Area



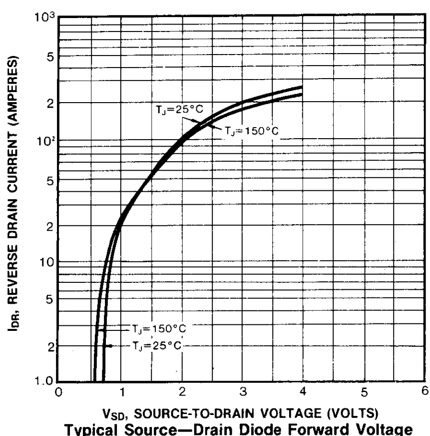
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP150-3



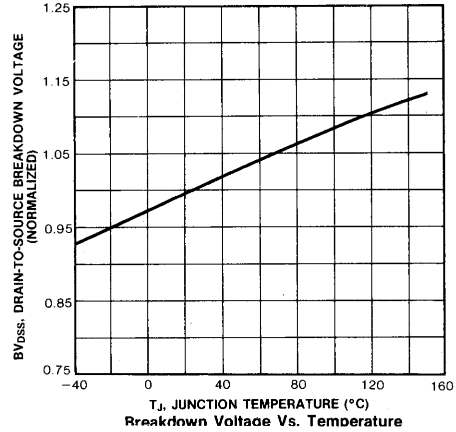
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF150-3



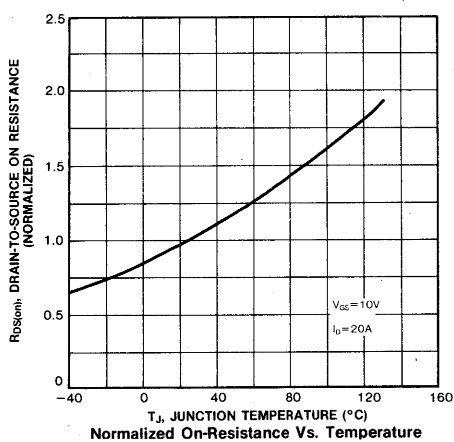
Typical Transconductance Vs. Drain Current



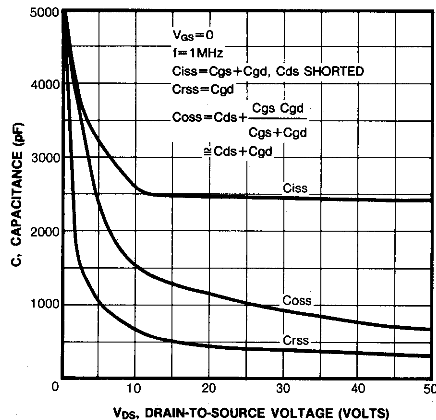
Typical Source—Drain Diode Forward Voltage



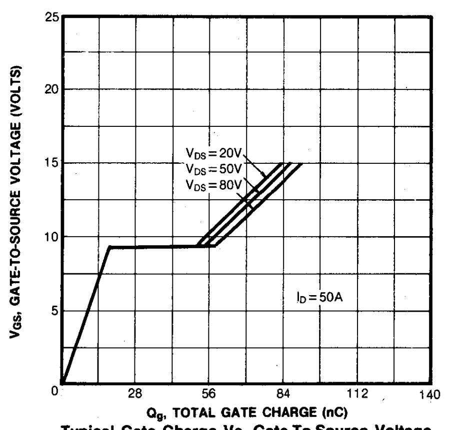
Breakdown Voltage Vs. Temperature



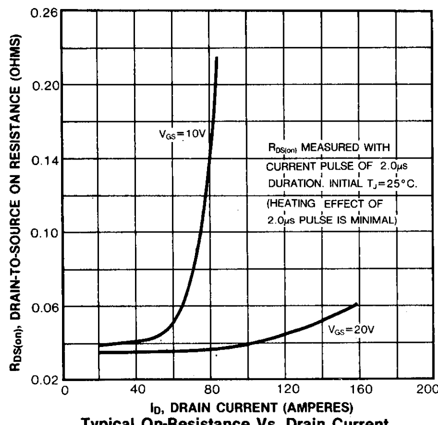
Normalized On-Resistance Vs. Temperature



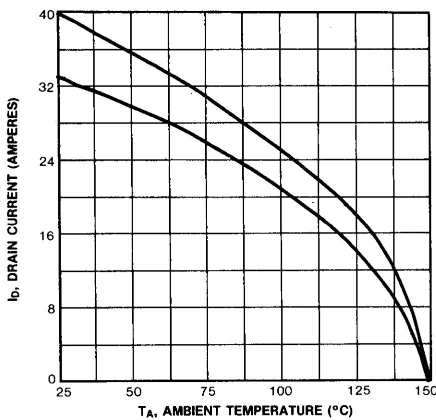
Typical Capacitance Vs. Drain to Source Voltage



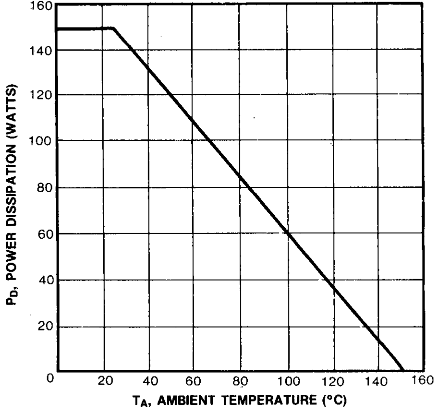
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

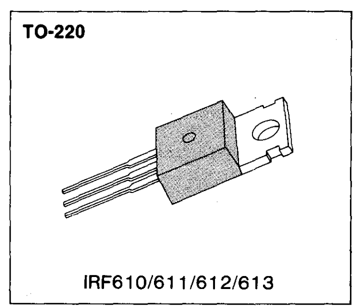


Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-220



IRF610/611/612/613

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF610	200V	1.5Ω	3.3A
IRF611	150V	1.5Ω	3.3A
IRF612	200V	2.4Ω	2.6A
IRF613	150V	2.4Ω	2.6A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRF610	IRF611	IRF612	IRF613	Unit
Drain-Source Voltage (1)	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	3.3	3.3	2.6	2.6	Adc
Continuous Drain Current T_C=100°C	I_D	2.1	2.1	1.6	1.6	Adc
Drain Current—Pulsed (3)	I_{DM}	8	8	6.5	6.5	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	46				mJ
Avalanche Current	I_{AS}	3.3				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	43 0.34				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=6.4 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF610/612	200	—	—	V	V_{GS}=0V
	IRF611/613	150	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF610/611	3.3	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max.}$ V_{GS}=10V
	IRF612/613	2.6	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF610/611	—	1.2	1.5	Ω	V_{GS}=10V, I_D=1.6A
	IRF612/613	—	1.5	2.4	Ω	
g_{fs}	Forward Transconductance (2)	0.8	1.4	—	℧	V_{DS}≥50V, I_D=1.6A
C_{iss}	Input Capacitance	—	180	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	56	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	22	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.2	12	ns	V_{DD}=0.5BV_{DSS}, I_D=3.3A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	17	26	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	14	21	ns	
t_f	Fall Time	—	8.9	13	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	5.5	8.2	nC	V_{GS}=10V, I_D=3.3A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	1.2	1.8	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	3.0	4.5	nC	

THERMAL RESISTANCE

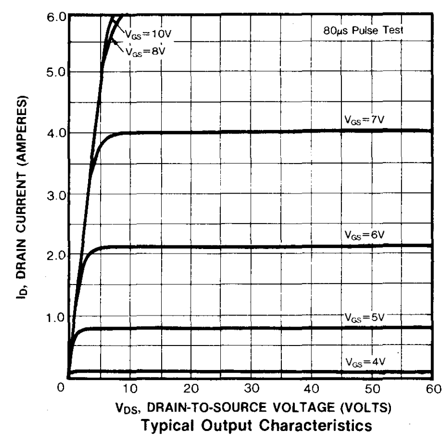
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	2.9	KW	
R_{thCS}	Case-to-Sink	—	0.5	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

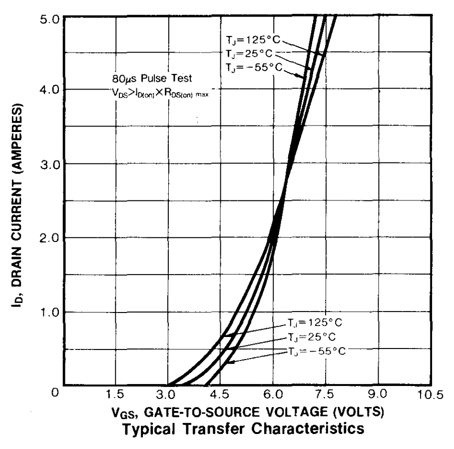
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRF610 IRF611	—	—	3.3	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRF612 IRF613	—	—	2.6	A	
I_{SM}	Pulse Source Current (Body Diode) (3)	IRF610 IRF611	—	—	8.0	A	
		IRF612 IRF613	—	—	6.5	A	
V_{SD}	Diode Forward Voltage (2)	IRF610 IRF611	—	—	2.5	V	T_C=25°C, I_S=3.3A, V_{GS}=0V
		IRF612 IRF613	—	—	2.0	V	T_C=25°C, I_S=2.6A, V_{GS}=0V
t_{rr}	Reverse Recovery Time		—	150	310	ns	T_J=25°C, I_F=3.3A, dI_F/dt=100A/μs

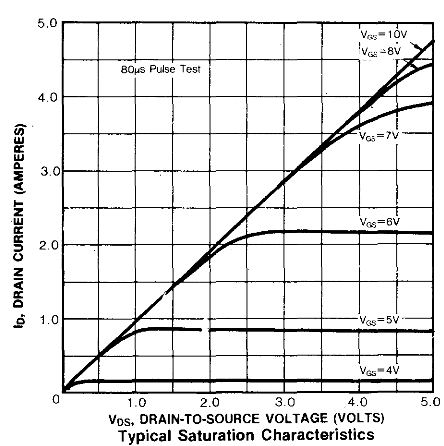
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



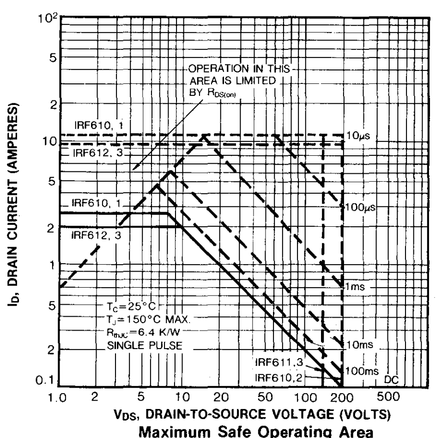
Typical Output Characteristics



Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area

$Z_{thJC}(t)/R_{thJC}$, NORMALIZED EFFECTIVE TRANSIENT THERMAL IMPEDANCE (PER UNIT)

D=0.5
D=0.2
D=0.1
D=0.05
D=0.02
D=0.01
SINGLE PULSE (TRANSIENT THERMAL IMPEDANCE)

NOTES
1. Duty Factor. $D=\frac{t_1}{t_2}$.
2. Per Unit Base=R_{thJC}=6.4 Deg. C/W.
3. $T_{JM}-T_C=P_{DM}Z_{thJC}(t)$.

t1. SQUARE WAVE PULSE DURATION (SECONDS)

Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

gfs, TRANSCONDUCTANCE (SIEMENS)

80μs Pulse Test
$V_{DS}>I_{D(on)}\times R_{DS(on)\ max}$
$T_J=-55°C$
$T_J=25°C$
$T_J=125°C$

I_D, DRAIN CURRENT (AMPERES)

Typical Transcounductance Vs. Drain Current

I_{DR}, REVERSE DRAIN CURRENT (AMPERES)

$T_J=150°C$
$T_J=25°C$

V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

T_J, JUNCTION TEMPERATURE (°C)

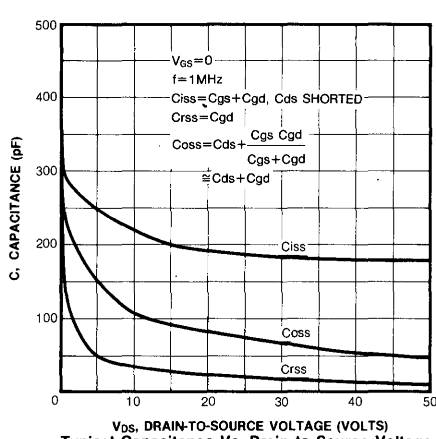
Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

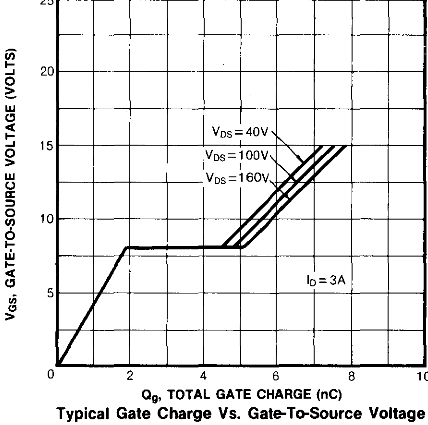
$V_{GS}=10V$
$I_D=1.25A$

T_J, JUNCTION TEMPERATURE (°C)

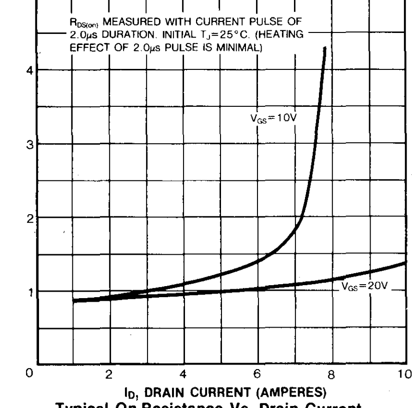
Normalized On-Resistance Vs. Temperature



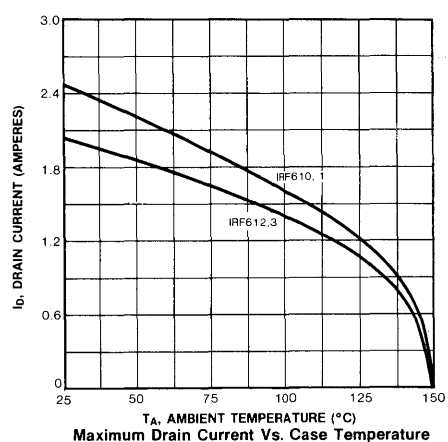
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

PD, POWER DISSIPATION (WATTS)

48
36
24
12
0
20 40 60 80 100 120 140 160

TC, CASE TEMPERATURE (°C)

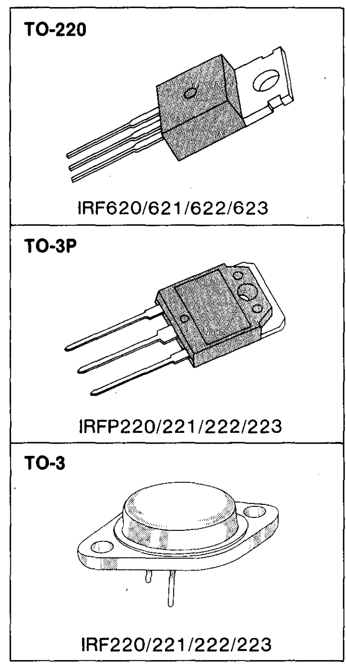
Power Vs. Temperature Derating Curve

IRF620/621/622/623
IRFP220/221/222/223
IRF220/221/222/223

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF620/IRFP220/IRF220	200V	0.80Ω	5.0A
IRF621/IRFP221/IRF221	150V	0.80Ω	5.0A
IRF622/IRFP222/IRF222	200V	1.2Ω	4.0A
IRF623/IRFP223/IRF223	150V	1.2Ω	4.0A

MAXIMUM RATINGS

Characteristics	Symbol	IRF620 IRFP220 IRF220	IRF621 IRFP221 IRF221	IRF622 IRFP222 IRF222	IRF623 IRFP223 IRF223	Unit
Drain-Source Voltage (1)	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	5.0	5.0	4.0	4.0	Adc
Continuous Drain Current T_C=100°C	I_D	3.0	3.0	16	16	Adc
Drain Current—Pulsed (3)	I_{DM}	20	20	16	16	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	85				mJ
Avalanche Current	I_{AS}	5.0				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	40 0.32				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=5 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF620/IRFP220/IRF220 IRF621/IRFP221/IRF221	200	—	—	V	V_{GS}=0V I_D=250μA
	IRF622/IRFP222/IRF222 IRF623/IRFP223/IRF223	150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF620/IRFP220/IRF220 IRF621/IRFP221/IRF221	5.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF622/IRFP222/IRF222 IRF623/IRFP223/IRF223	4.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF620/IRFP220/IRF220 IRF621/IRFP221/IRF221	—	0.4	0.8	Ω	V_{GS}=10V, I_D=2.5A
	IRF622/IRFP222/IRF222 IRF623/IRFP223/IRF223	—	0.8	1.2	Ω	
g_{fs}	Forward Transconductance (2)	1.3	2.8	—	℧	V_{DS}≥50V, I_D=2.5A
C_{iss}	Input Capacitance	—	450	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	150	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	50	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	20	40	ns	V_{DD}=0.5BV_{DSS}, I_D=2.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	30	60	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	50	100	ns	
t_f	Fall Time	—	30	60	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	12.5	15	nC	V_{GS}=10V, I_D=6.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	4.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	8.5	—	nC	

THERMAL RESISTANCE

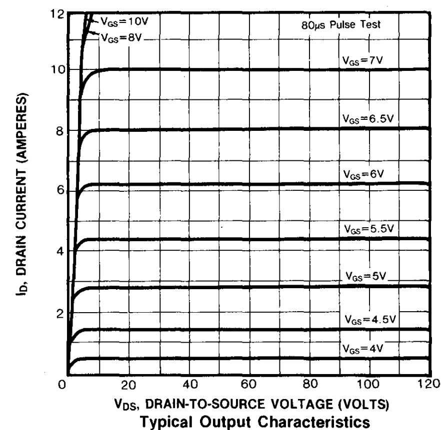
Symbol	Characteristic		IRF620-3	IRFP220-3	IRF220-3	Unit	
R_{thJC}	Junction-to-Case	MAX	3.12	3.12	3.12	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.2	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

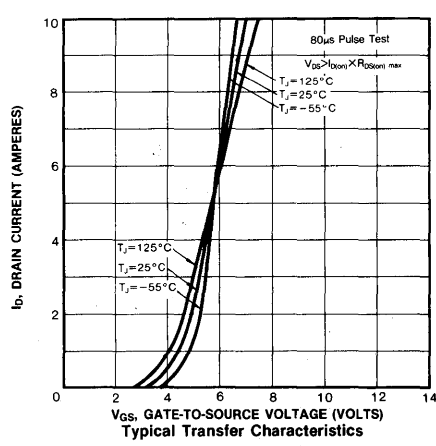
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF620/IRFP220/IRF220 IRF621/IRFP221/IRF221	—	—	5.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF622/IRFP222/IRF222 IRF623/IRFP223/IRF223	—	—	4.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF620/IRFP220/IRF220 IRF621/IRFP221/IRF221	—	—	20	A	
	IRF622/IRFP222/IRF222 IRF623/IRFP223/IRF223	—	—	16	A	
V_{SD}	Diode Forward Voltage (2) IRF620/IRFP220/IRF220 IRF621/IRFP221/IRF221	—	—	1.8	V	$T_C=25°C$, $I_S=5.0A$, $V_{GS}=0V$
	IRF622/IRFP222/IRF222 IRF623/IRFP223/IRF223	—	—	1.6	V	$T_C=25°C$, $I_S=4.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	350	—	ns	$T_j=150°C$, $I_F=5.0A$, $dI_F/dt=100A/\mu S$

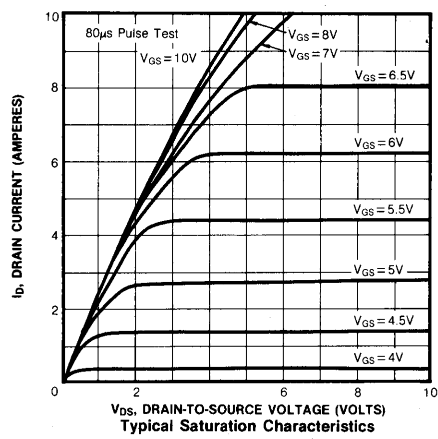
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



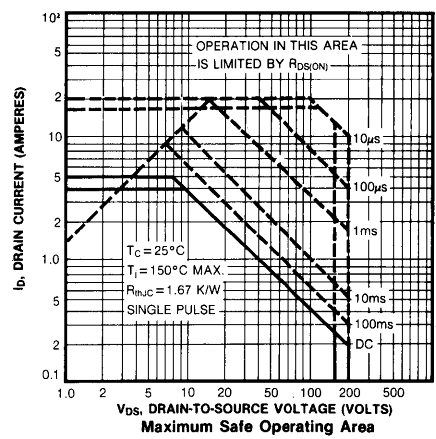
Typical Output Characteristics



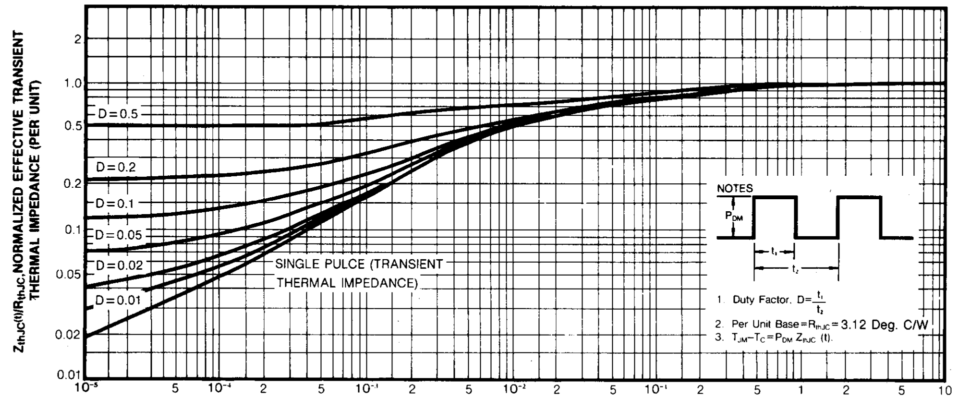
Typical Transfer Characteristics



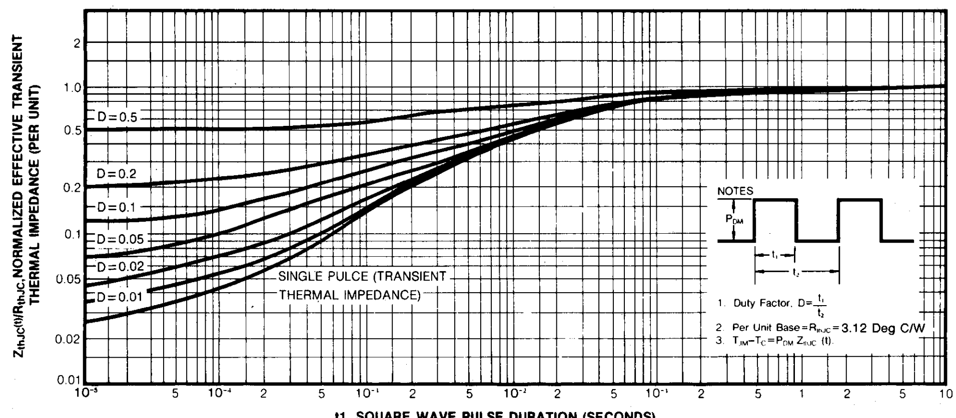
Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF620-3 And IRF220-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP220-3

gfs, TRANSCONDUCTANCE (SIEMENS)

$T_J = -55°C$
$T_J = 25°C$
$T_J = 125°C$

$V_{DS} > I_{D(on)} \times R_{DS(on)\ max}$
80μs Pulse Test

I_D, DRAIN CURRENT (AMPERES)

Typical Transconductance Vs. Drain Current

I_{DR}, REVERSE DRAIN CURRENT (AMPERES)

$T_J = 25°C$
$T_J = 150°C$

V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

$V_{GS} = 10V$
$I_D = 2.5A$

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

$V_{GS} = 0$
f = 1 MHz
Ciss = Cgs + Cgd, Cds SHORTED
Crss = Cgd
$Coss = Cds + \frac{CgsCgd}{Cgs + Cgd}$
$\cong Cds + Cgd$

Ciss
Coss
Crss

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

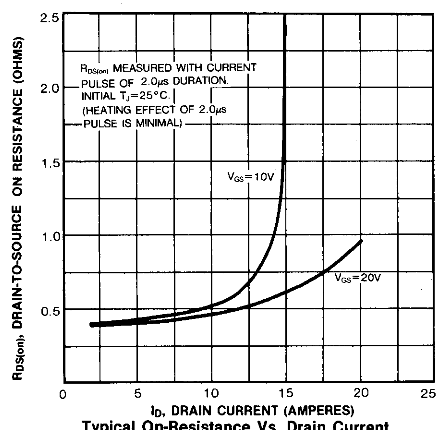
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

$V_{DS} = 40V$
$V_{DS} = 100V$
$V_{DS} = 160V$

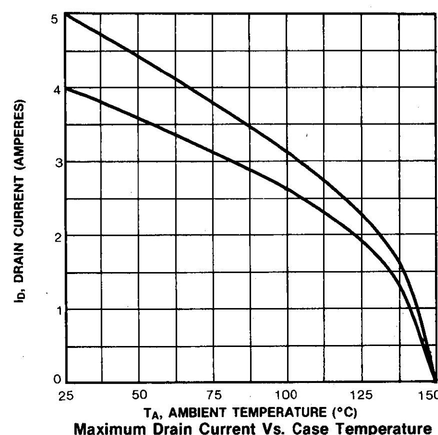
$I_D = 6A$

Q_g, TOTAL GATE CHARGE (nC)

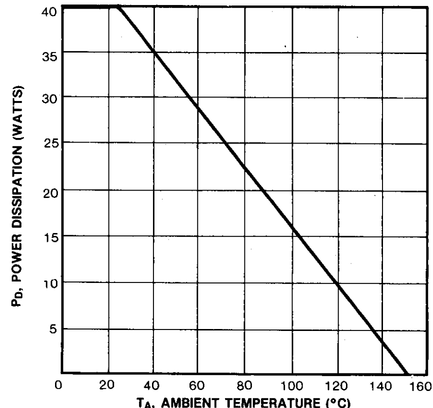
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

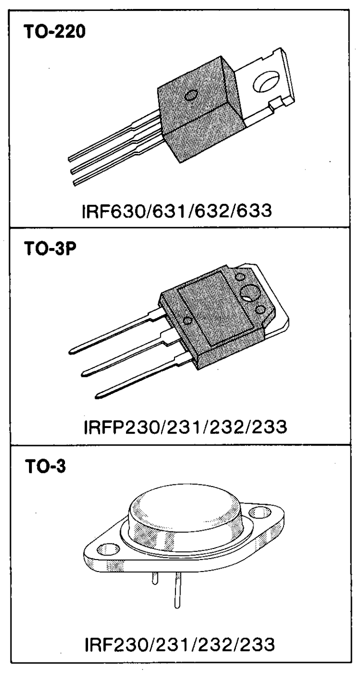
4

IRF630/631/632/633
IRFP230/231/232/233
IRF230/231/232/233

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF630/IRFP230/IRF230	200V	0.4Ω	9.0A
IRF631/IRFP231/IRF231	150V	0.4Ω	9.0A
IRF632/IRFP232/IRF232	200V	0.4Ω	8.0A
IRF633/IRFP233/IRF233	150V	0.6Ω	8.0A

MAXIMUM RATINGS

Characteristics	Symbol	IRF630 IRFP230 IRF230	IRF631 IRFP231 IRF231	IRF632 IRFP232 IRF232	IRF633 IRFP233 IRF233	Unit
Drain-Source Voltage (1)	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	9.0	9.0	8.0	8.0	Adc
Continuous Drain Current T_C=100°C	I_D	6.0	6.0	5.0	5.0	Adc
Drain Current—Pulsed (3)	I_{DM}	36	36	32	32	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	170				mJ
Avalanche Current	I_{AS}	9.0				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF630/IRFP230/IRF230 IRF632/IRFP232/IRF232	200	—	—	V	V_{GS}=0V I_D=250μA
	IRF631/IRFP231/IRF231 IRF633/IRFP233/IRF233	150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF630/IRFP230/IRF230 IRF631/IRFP231/IRF231	9.0	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max.}$ V_{GS}=10V
	IRF632/IRFP232/IRF232 IRF633/IRFP233/IRF233	8.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF630/IRFP230/IRF230 IRF631/IRFP231/IRF231	—	0.25	0.4	Ω	V_{GS}=10V, I_D=5.0A
	IRF632/IRFP232/IRF232 IRF633/IRFP233/IRF233	—	0.4	0.6	Ω	
g_{fs}	Forward Transconductance (2)	3.0	4.6	—	℧	V_{DS}≥50V, I_D=5.0A
C_{iss}	Input Capacitance	—	750	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	120	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	45	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD}=0.5BV_{DSS}, I_D=5.0A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	50	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	50	ns	
t_f	Fall Time	—	—	40	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	19	30	nC	V_{GS}=10V, I_D=12A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	50	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	14	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRF630-3	IRFP230-3	IRF230-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	1.0	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

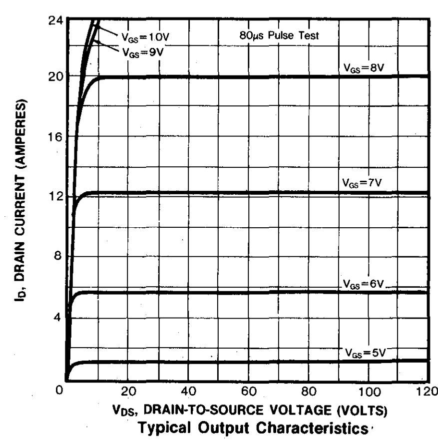
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

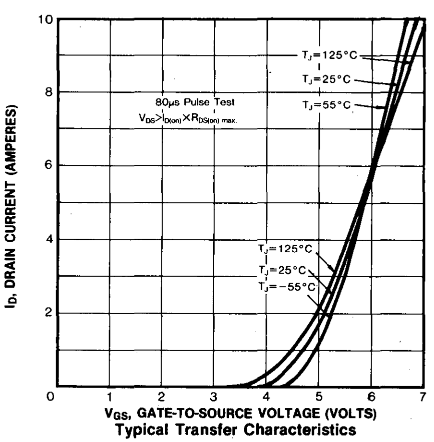
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF630/IRFP230/IRF230 IRF631/IRFP231/IRF231	—	—	9.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF632/IRFP232/IRF232 IRF633/IRFP233/IRF233	—	—	8.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF630/IRFP230/IRF230 IRF631/IRFP231/IRF231	—	—	36	A	
	IRF632/IRFP232/IRF232 IRF633/IRFP233/IRF233	—	—	32	A	
V_{SD}	Diode Forward Voltage (2) IRF630/IRFP230/IRF230 IRF631/IRFP231/IRF231	—	—	2.0	V	$T_C=25°C$, $I_S=9.0A$, $V_{GS}=0V$
	IRF632/IRFP232/IRF232 IRF633/IRFP233/IRF233	—	—	1.8	V	$T_C=25°C$, $I_S=8.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	450	—	ns	$T_j=150°C$, $I_F=9.0A$, $dI_F/dt=100A/\mu S$

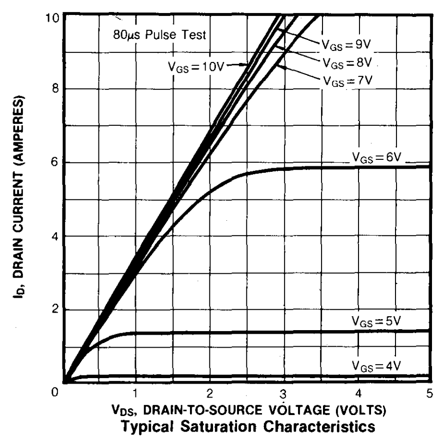
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



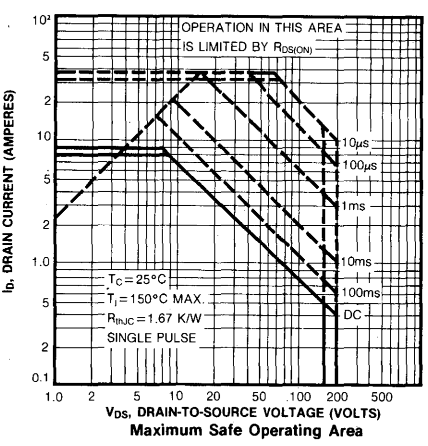
Typical Output Characteristics



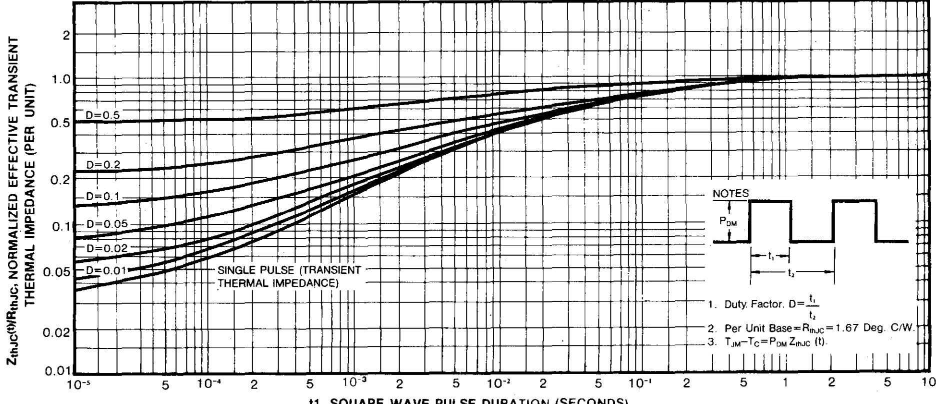
Typical Transfer Characteristics



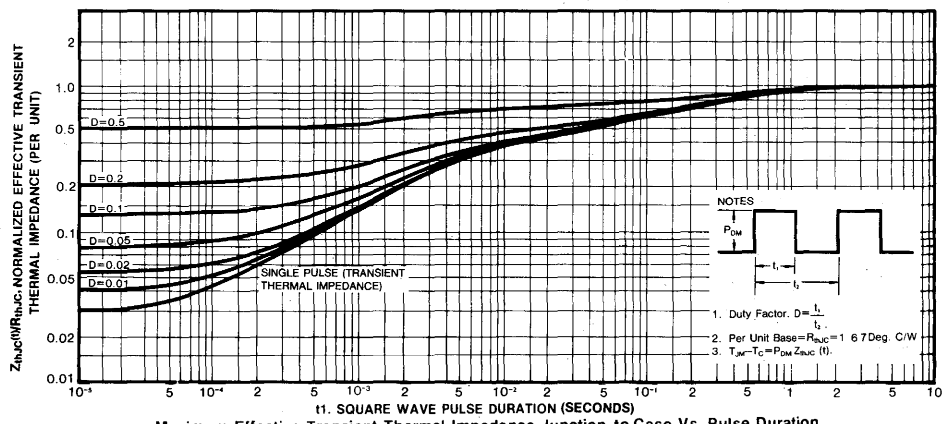
Typical Saturation Characteristics



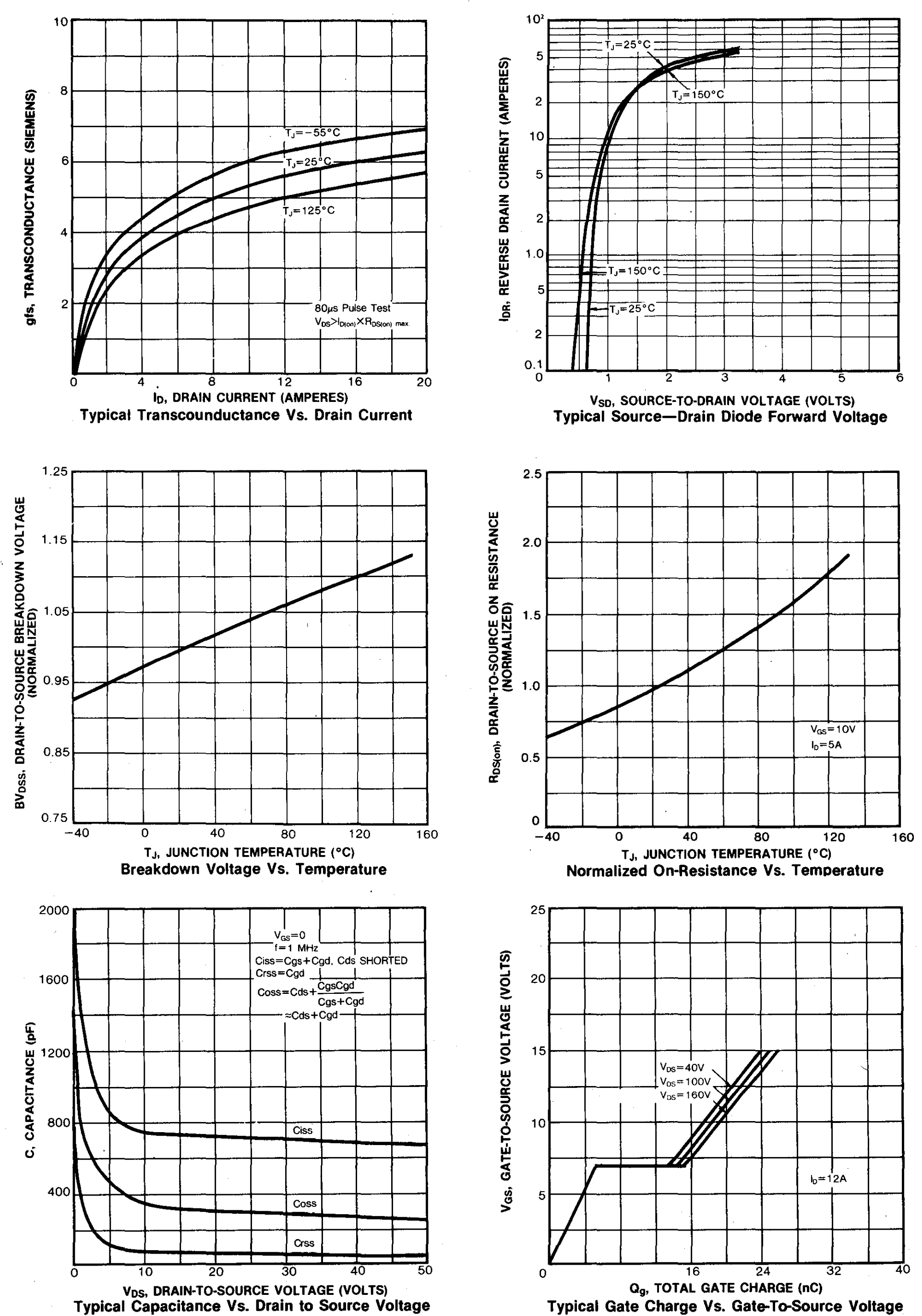
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF630-3 And IRF230-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP230-3



Typical Transcounductance Vs. Drain Current

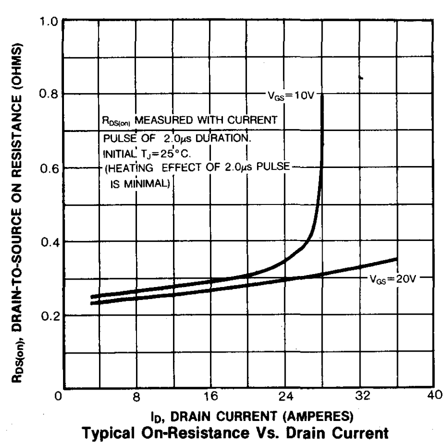
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

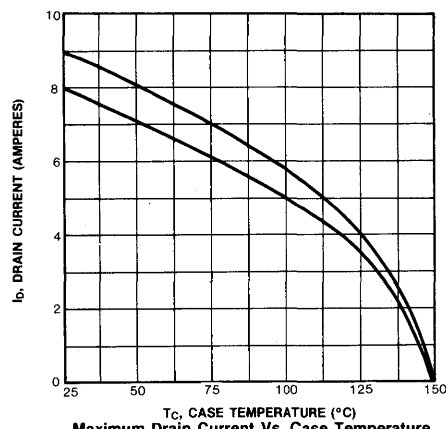
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

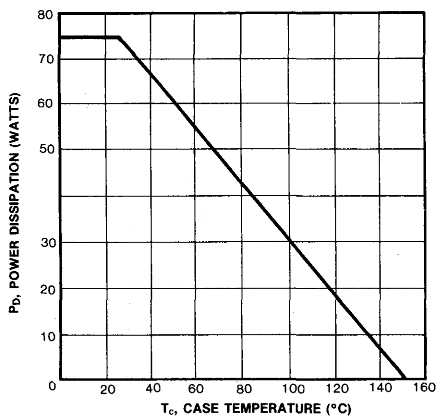
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

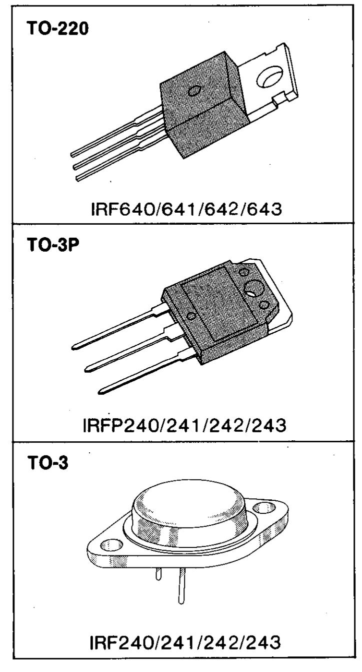
4

IRF640/641/642/643
IRFP240/241/242/243
IRF240/241/242/243

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF640/IRFP140/IRF140	200V	0.18Ω	18A
IRF641/IRFP241/IRF241	150V	0.18Ω	18A
IRF642/IRFP242/IRF242	200V	0.22Ω	16A
IRF643/IRFP243/IRF243	150V	0.22Ω	16A

MAXIMUM RATINGS

Characteristics	Symbol	IRF640 IRFP240 IRF240	IRF641 IRFP241 IRF241	IRF642 IRFP242 IRF242	IRF643 IRFP243 IRF243	Unit
Drain-Source Voltage (1)	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	18	18	16	16	Adc
Continuous Drain Current T_C=100°C	I_D	11	11	10	10	Adc
Drain Current—Pulsed (3)	I_{DM}	72	72	64	64	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	580				mJ
Avalanche Current	I_{AS}	18				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.44 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF640/IRFP240/IRF240 IRF642/IRFP242/IRF242	200	—	—	V	V_{GS}=0V I_D=250μA
	IRF641/IRFP241/IRF241 IRF643/IRFP243/IRF243	150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF540/IRFP240/IRF240 IRF541/IRFP241/IRF241	18	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF542/IRFP242/IRF242 IRF543/IRFP243/IRF243	16	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF640/IRFP240/IRF240 IRF641/IRFP241/IRF241	—	0.13	0.18	Ω	V_{GS}=10V, I_D=10A
	IRF642/IRFP242/IRF242 IRF643/IRFP243/IRF243	—	0.20	0.22	Ω	
g_{fs}	Forward Transconductance (2)	6.0	9.5	—	℧	V_{DS}≥50V, I_D=10A
C_{iss}	Input Capacitance	—	1400	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	240	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	95	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD}=0.5BV_{DSS}, I_D=10A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	60	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	80	ns	
t_f	Fall Time	—	—	60	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	44	60	nC	V_{GS}=10V, I_D=22A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	9	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	35	—	nC	

4

THERMAL RESISTANCE

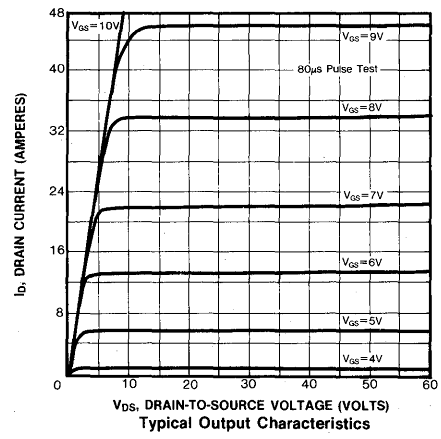
Symbol	Characteristic		IRF640-3	IRFP240-3	IRF240-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.0	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

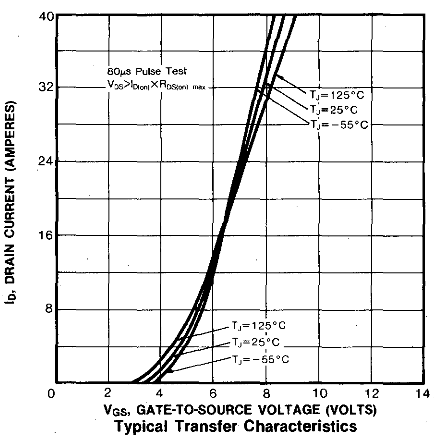
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF640/IRFP240/IRF240 IRF641/IRFP241/IRF241	—	—	18	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF642/IRFP242/IRF242 IRF643/IRFP243/IRF243	—	—	16	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF640/IRFP240/IRF240 IRF641/IRFP241/IRF241	—	—	72	A	
	IRF642/IRFP242/IRF242 IRF643/IRFP243/IRF243	—	—	64	A	
V_{SD}	Diode Forward Voltage (2) IRF640/IRFP240/IRF240 IRF641/IRFP241/IRF241	—	—	2.0	V	T_C=25°C, I_S=18A, V_{GS}=0V
	IRF642/IRFP242/IRF242 IRF643/IRFP243/IRF243	—	—	1.9	V	T_C=25°C, I_S=16A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	650	—	ns	T_j=25°C, I_F=18A, dI_F/dt=100A/μS

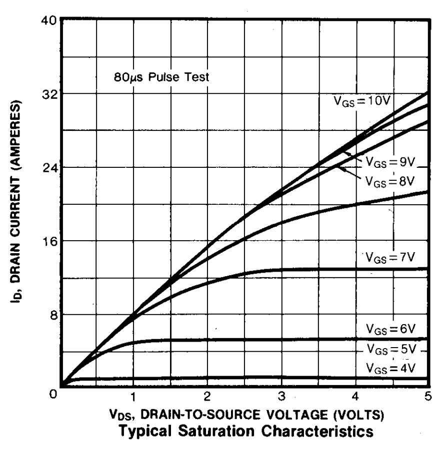
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



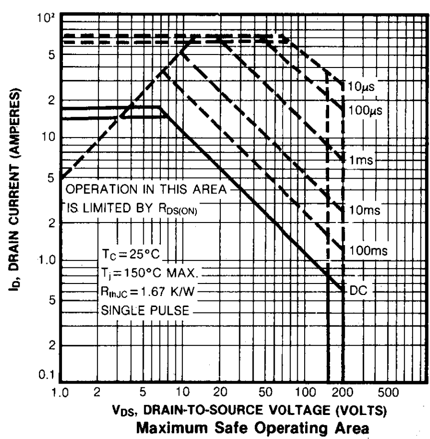
Typical Output Characteristics



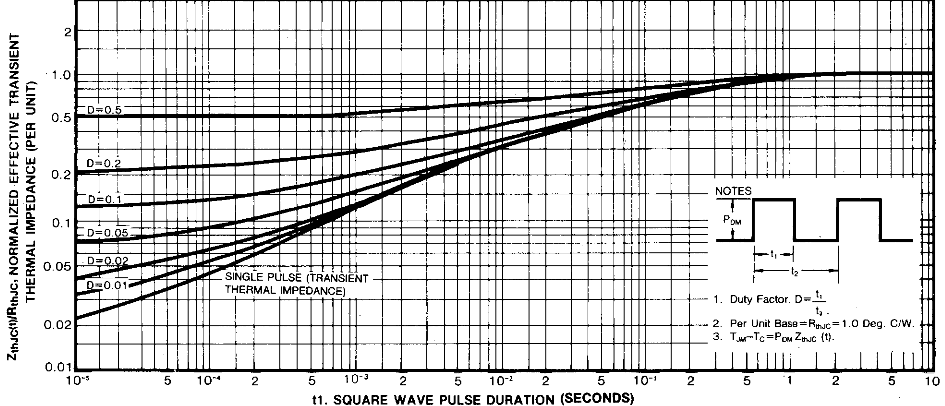
Typical Transfer Characteristics



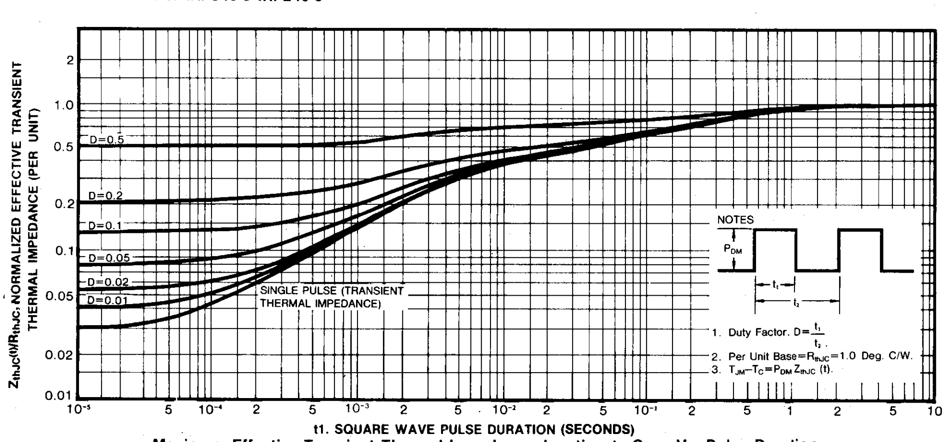
Typical Saturation Characteristics



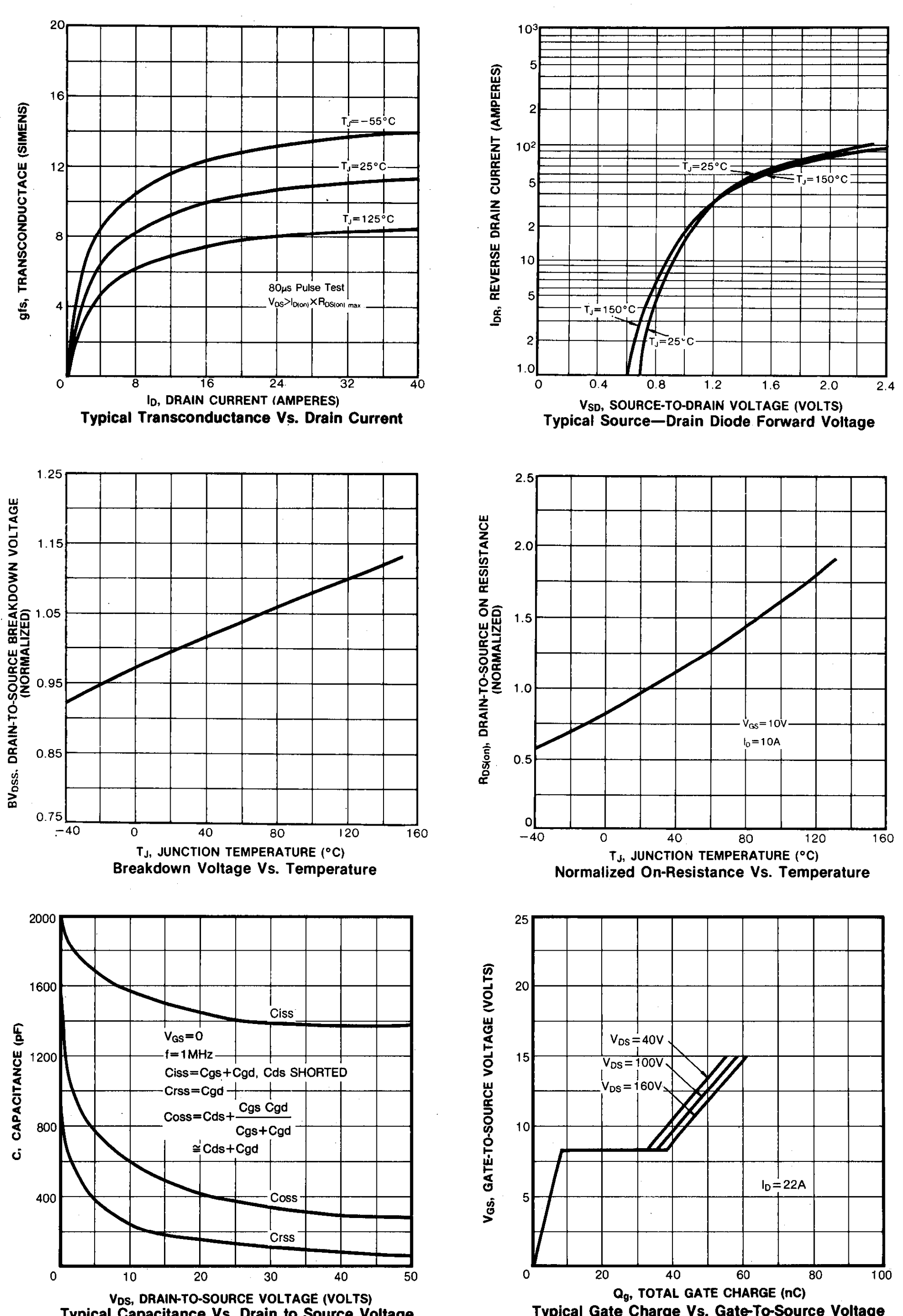
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF640-3 IRF240-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP240-3



Typical Transconductance Vs. Drain Current

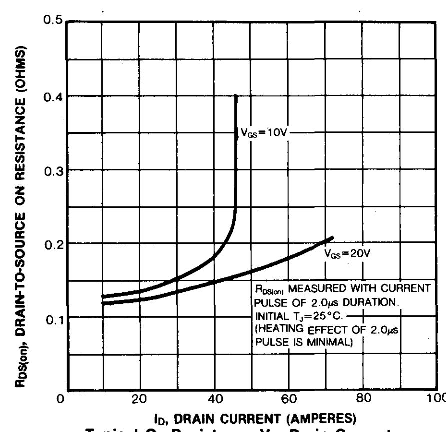
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

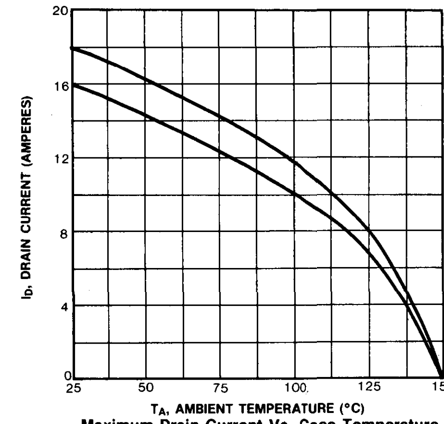
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

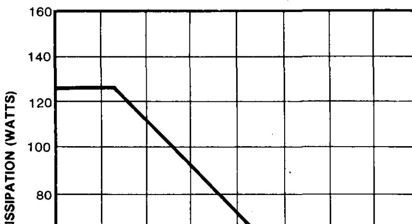
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



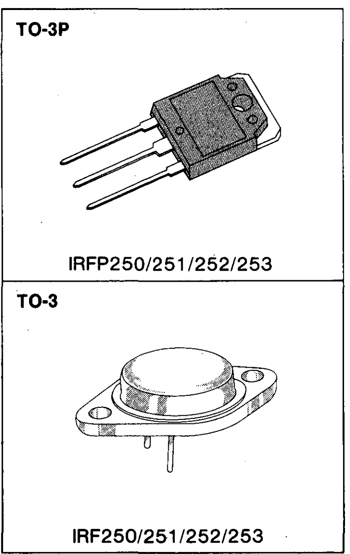
Power Vs. Temperature Derating Curve

IRFP250/251/252/253
IRF250/251/252/253

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFP250/IRF250	200V	0.085Ω	30A
IRFP251/IRF251	150V	0.085Ω	30A
IRFP252/IRF252	200V	0.120Ω	25A
IRFP253/IRF253	150V	0.120Ω	25A

MAXIMUM RATINGS

Characteristic	Symbol	IRFP250 IRF250	IRFP251 IRF251	IRFP252 IRF252	IRFP253 IRF253	Unit
Drain-Source Voltage (1)	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	30	30	25	25	Adc
Continuous Drain Current T_C=100°C	I_D	19	19	16	16	Adc
Drain Current—Pulsed (3)	I_{DM}	120	120	100	100	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	810				mJ
Avalanche Current	I_{AS}	33				A
Total Power Dissipation @ T_C=25°C Derate above 25°C (5)	P_D	150 1.2				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=1.1mH, V_{dd}=50V, R_G=250Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF250/252/IRFP250/252	200	—	—	V	V_{GS}=0V
	IRF251/253/IRFP251/253	150	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF250/251/IRFP250/251	33	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF252/253/IRFP252/253	27	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF250/251/IRFP250/251	—	0.07	0.085	Ω	V_{GS}=10V, I_D=16A
	IRF252/253/IRFP252/253	—	0.09	0.12	Ω	
g_{fs}	Forward Transconductance (2)	8.0		—	℧	V_{DS}≥50V, I_D=16A
C_{iss}	Input Capacitance	—	2498	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	533	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	228	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	V_{DD}=0.5BV_{DSS}, I_D=17A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	125	ns	
t_f	Fall Time	—	—	100	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	68	120	nC	V_{GS}=10V, I_D=38A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	18	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	50	—	nC	

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THERMAL RESISTANCE

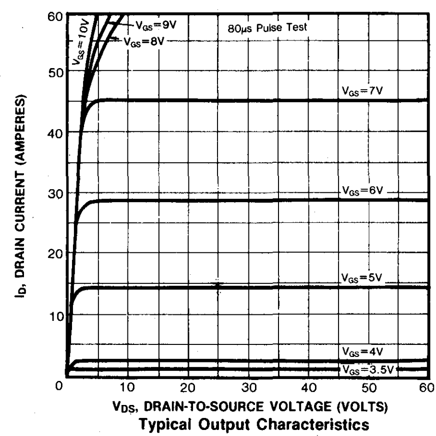
Symbol	Characteristic		IRFP250-3	IRF250-3	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.83	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

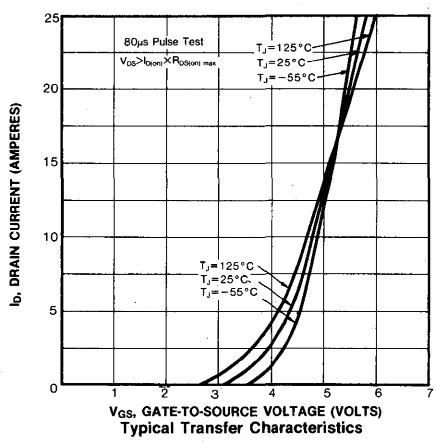
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF250/251/IRFP250/251	—	—	30	A	
	IRF252/253/IRFP250/251	—	—	25	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3) IRF250/251/IRFP250/251	—	—	120	A	
	IRF252/253/IRFP252/253	—	—	100	A	
V_{SD}	Diode Forward Voltage (2) IRF250/251/IRFP250/251	—	—	2.0	V	T_C=25°C, I_S=30A, V_{GS}=0V
	IRF252/253/IRFP252/251	—	—	1.8	V	T_C=25°C, I_S=25A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	630	ns	T_j=25°C, I_F=30A, dI_F/dt=100A/μS

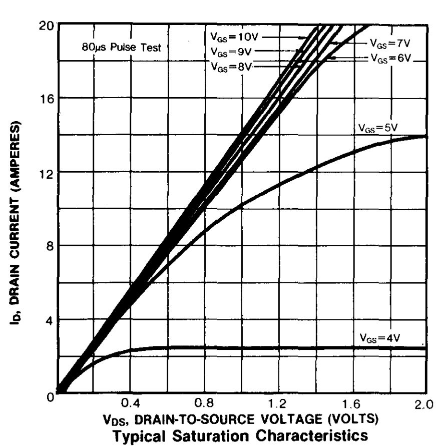
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



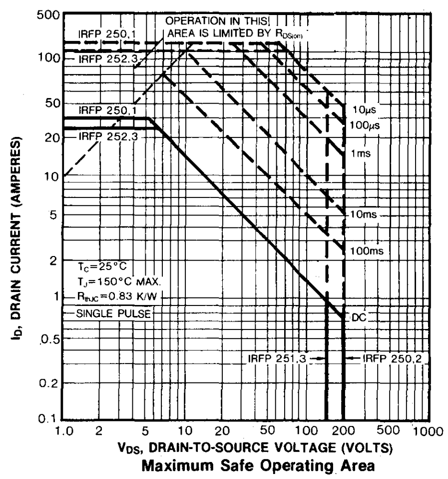
Typical Output Characteristics



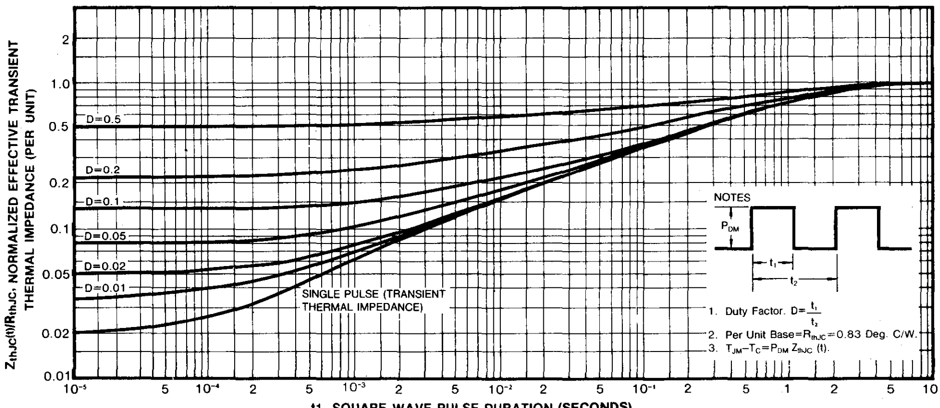
Typical Transfer Characteristics



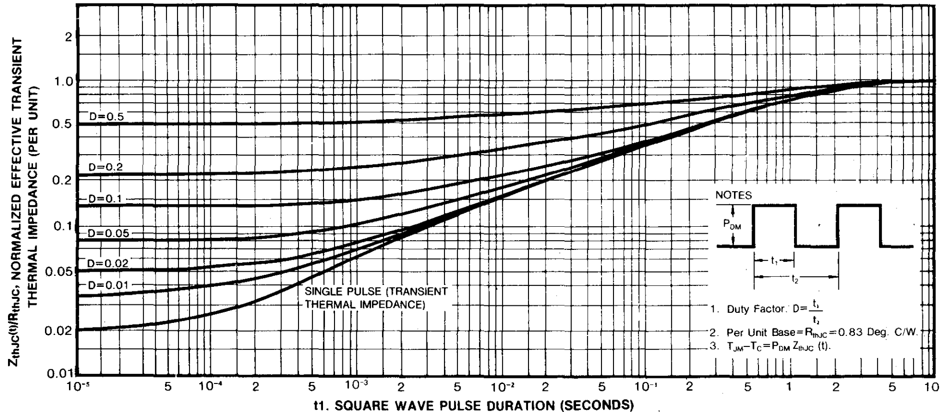
Typical Saturation Characteristics



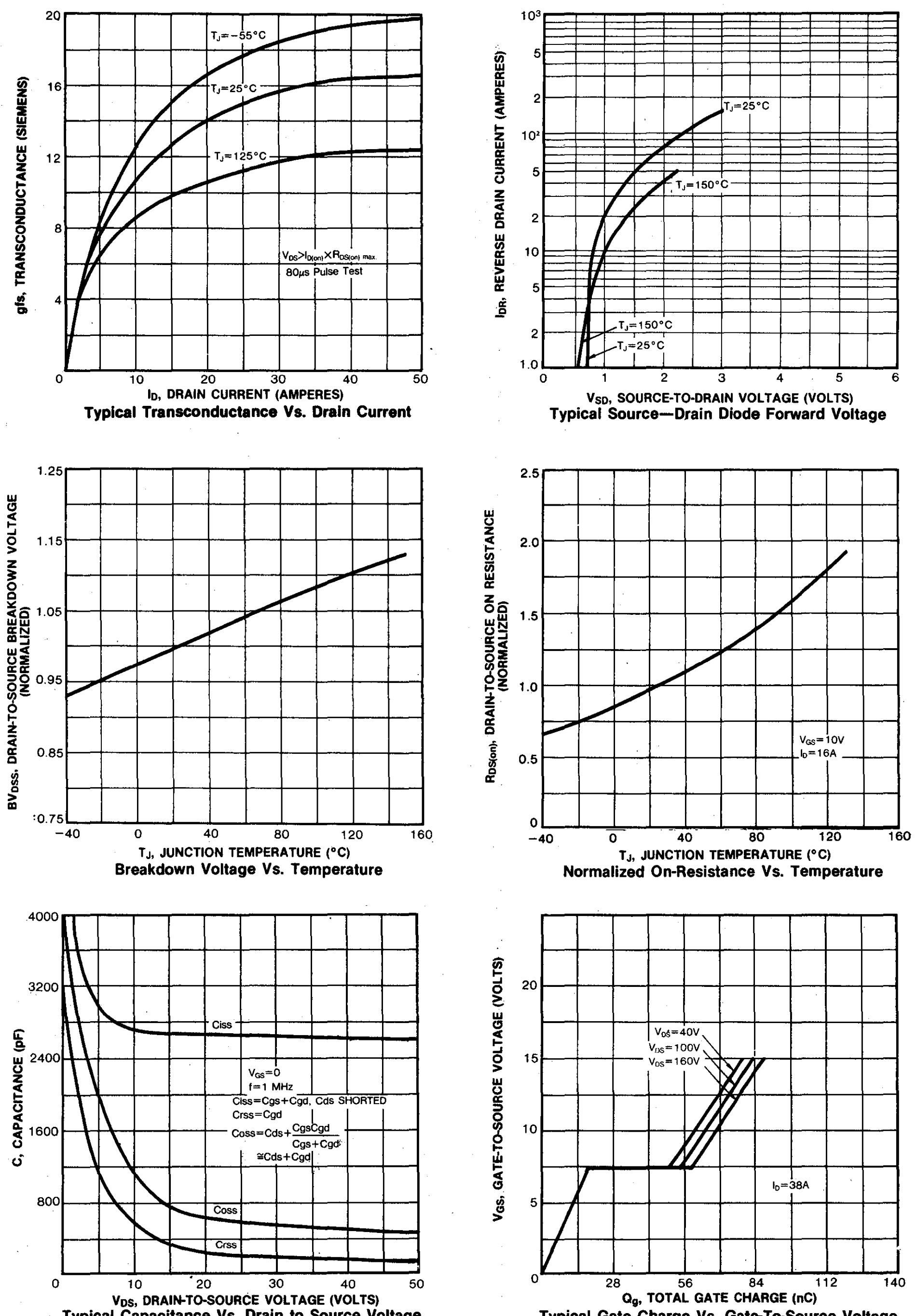
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP250-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF250-3



Typical Transconductance Vs. Drain Current

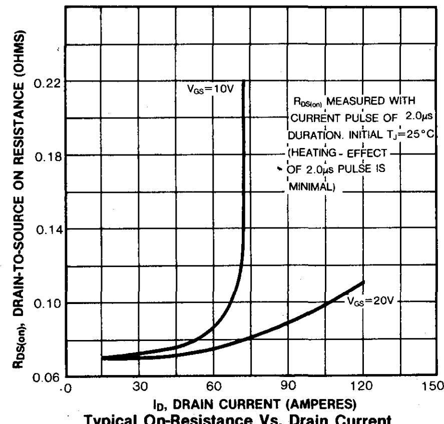
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

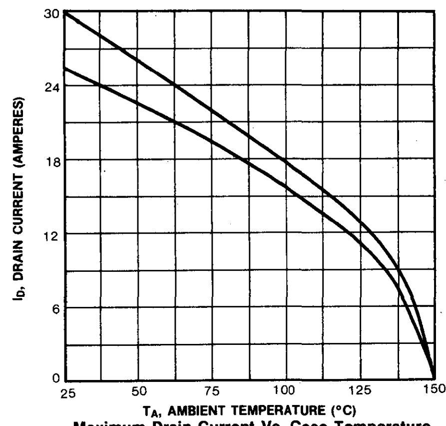
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

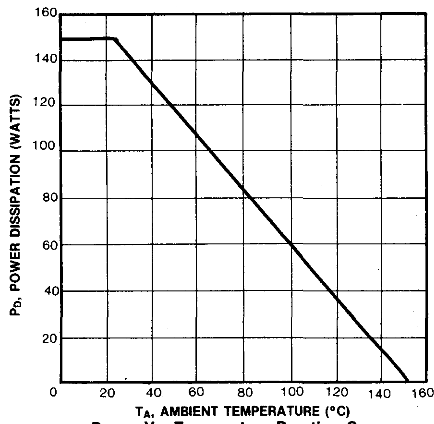
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



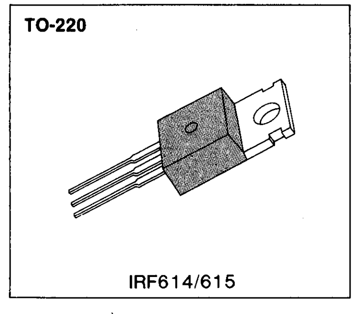
Power Vs. Temperature Derating Curve

4

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-220



IRF614/615

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF614	250V	2.0Ω	2.0A
IRF615	250V	3.0Ω	1.6A

MAXIMUM RATINGS

Characteristic	Symbol	IRF614	IRF615	Unit
Drain-Source Voltage (1)	V_{DSS}	250	250	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	250	250	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	2.0	1.6	Adc
Continuous Drain Current T_C=100°C	I_D	1.3	1.0	Adc
Drain Current—Pulsed (3)	I_{DM}	8.0	6.4	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	65		mJ
Avalanche Current	I_{AS}	2.0		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	20 0.16		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=25 mH, V_{dd}=50V, R_G=25Ω,Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	250	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF614	2.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF615	1.6	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF614	—	1.1	2.0	Ω	V_{GS}=10V, I_D=1.0A
	IRF615	—	2.0	3.0	Ω	
g_{fs}	Forward Transconductance (2)	0.80		—	℧	V_{DS}≥50V, I_D=1.0A
C_{iss}	Input Capacitance	—	180	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	37	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	15	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.9	13	ns	V_{DD}=0.5BV_{DSS}, I_D=1.0A, Z_O=24Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	12	18	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	18	27	ns	
t_f	Fall Time	—	8.9	13	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	9.6	14.4	nC	V_{GS}=10V, I_D=2.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.4	3.6	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	4.5	6.7	nC	

THERMAL RESISTANCE

R_{thJC}	Junction-to-Case	—	—	6.4	K/W	
R_{thCS}	Case-to-Sink	—	0.5	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

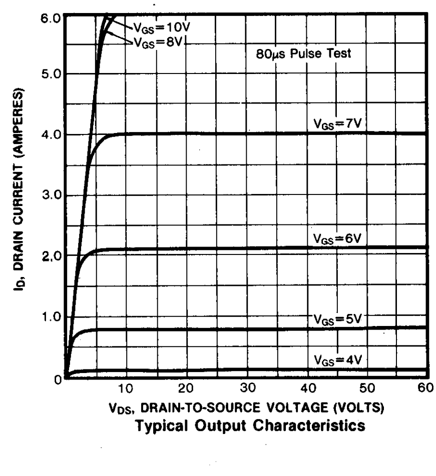
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

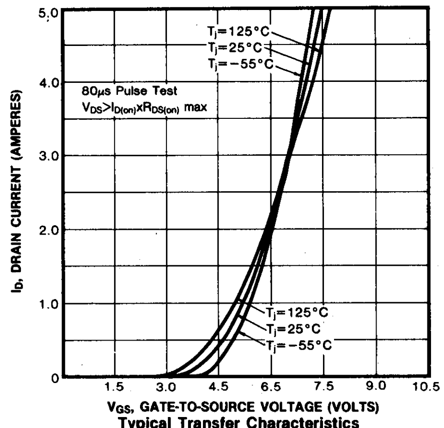
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRF614	—	—	2.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRF615	—	—	1.6	V	
I_{SM}	Pulse Source Current (Body Diode) (3)	IRF614	—	—	8.0	A	
		IRF615	—	—	6.4	V	
V_{SD}	Diode Forward Voltage (2)		—	—	2.0	V	$T_C=25°C$, $I_S=2.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time		—	150	340	ns	$T_J=25°C$, $I_F=2.0A$, $dI_F/dt=100A/\mu s$

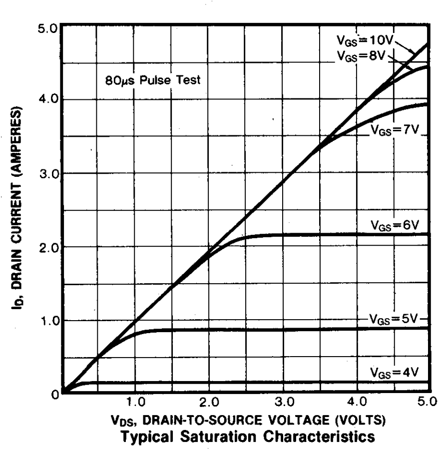
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



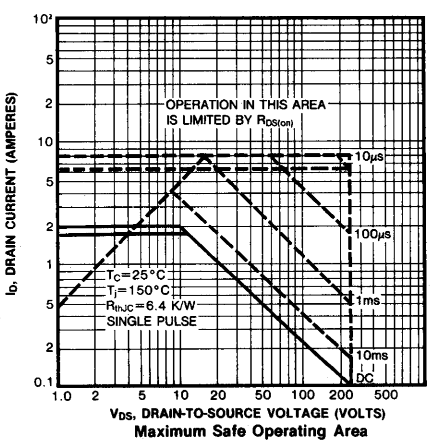
Typical Output Characteristics



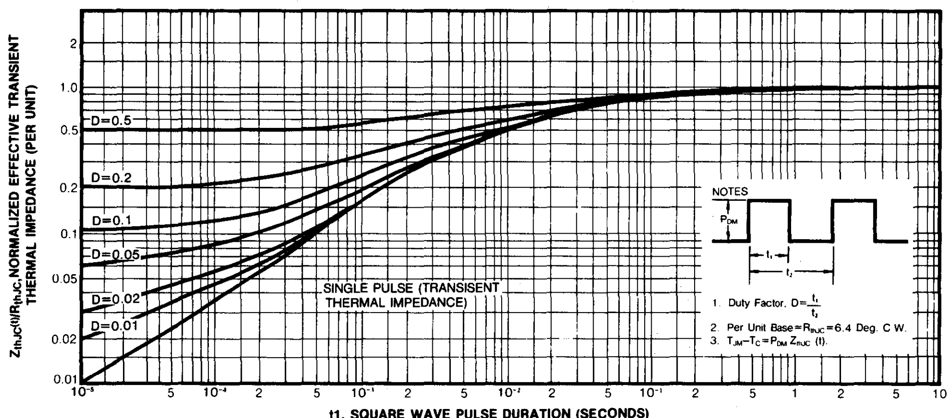
Typical Transfer Characteristics



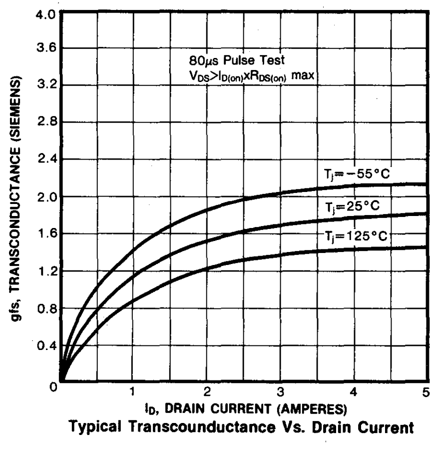
Typical Saturation Characteristics



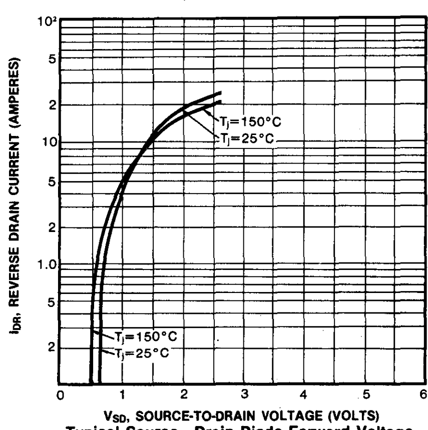
Maximum Safe Operating Area



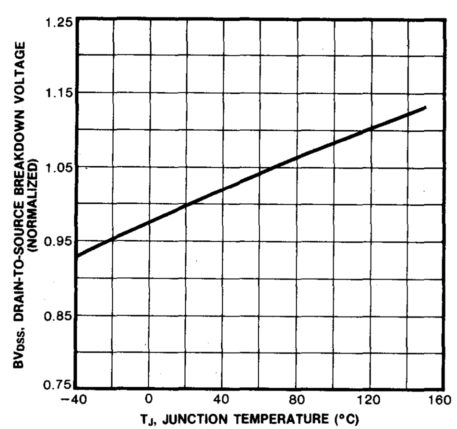
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



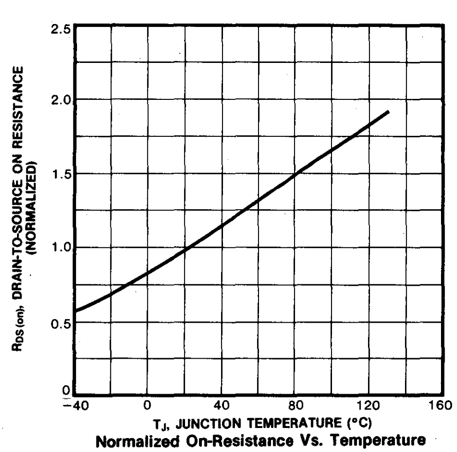
Typical Transcounductance Vs. Drain Current



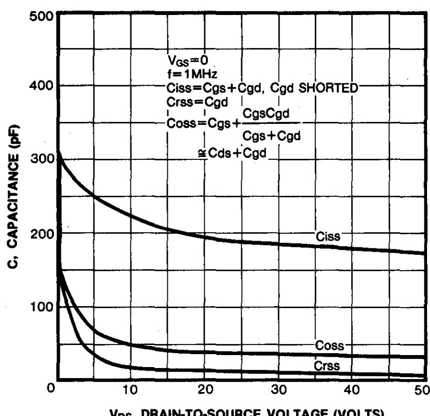
Typical Source—Drain Diode Forward Voltage



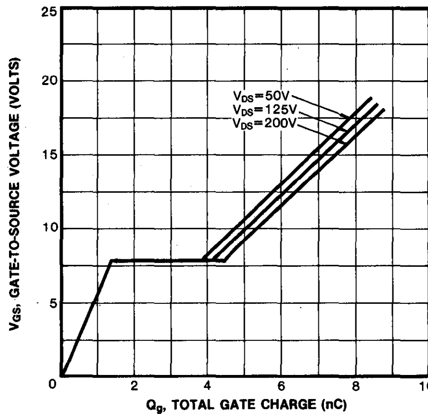
Breakdown Voltage Vs. Temperature



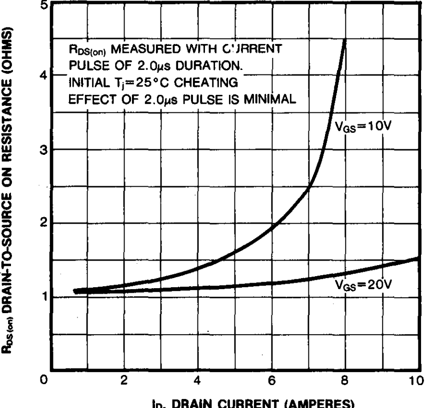
Normalized On-Resistance Vs. Temperature



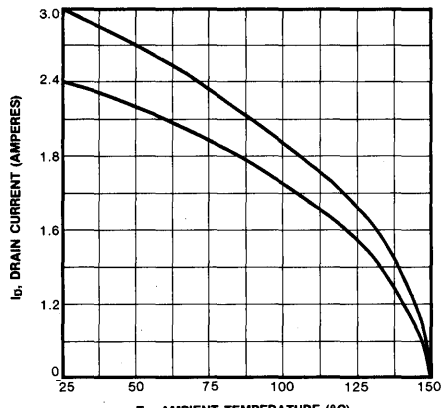
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

PD, POWER DISSIPATION (WATTS)

20
15
10
5
0

0 20 40 60 80 100 120 140

TC, CASE TEMPERATURE (°C)

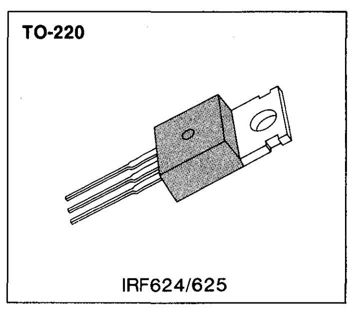
Power Vs. Temperature Derating Curve

IRF624/625

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF624	250V	1.1Ω	3.8A
IRF625	250V	1.5Ω	3.3A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRF624	IRF625	Unit
Drain-Source Voltage (1)	V_{DSS}	250	250	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	250	250	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	3.8	3.3	Adc
Continuous Drain Current T_C=100°C	I_D	2.4	2.1	Adc
Drain Current—Pulsed (3)	I_{DM}	15	13	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	110		mJ
Avalanche Current	I_{AS}	3.8		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	40 0.32		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=12 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	250	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF624	3.8	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max.}$ V_{GS}=10V
	IRF625	3.3	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF624	—	—	1.1	Ω	V_{GS}=10V, I_D=2.1A
	IRF625	—	—	1.5	Ω	
g_{fs}	Forward Transconductance (2)	1.4	2.1	—	℧	$V_{DS}\geq$50V, I_D=1.9A
C_{iss}	Input Capacitance	—	390	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	150	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	50	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	11	17	ns	V_{DD}=0.5BV_{DSS}, I_D=3.8A, Z_O=18Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	24	36	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	21	32	ns	
t_f	Fall Time	—	13	20	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	15	22	nC	V_{GS}=10V, I_D=3.8A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	4.0	6.0	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7.2	11	nC	

THERMAL RESISTANCE

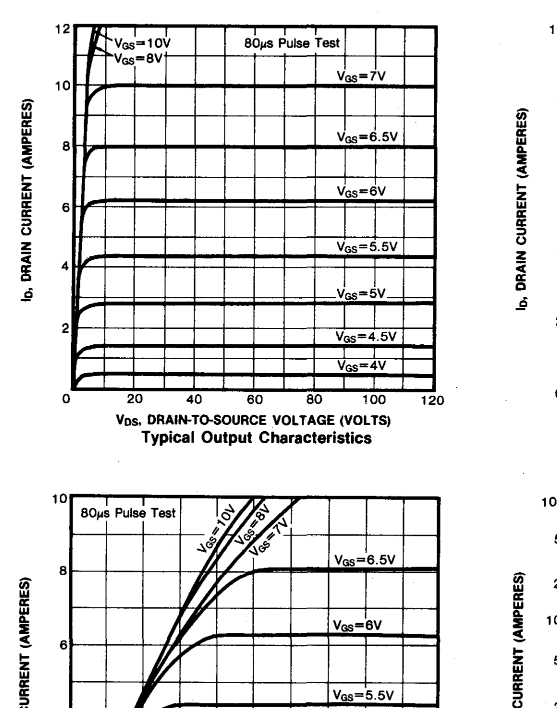
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	3.12	K/W	
R_{thCS}	Case-to-Sink	—	1.0	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

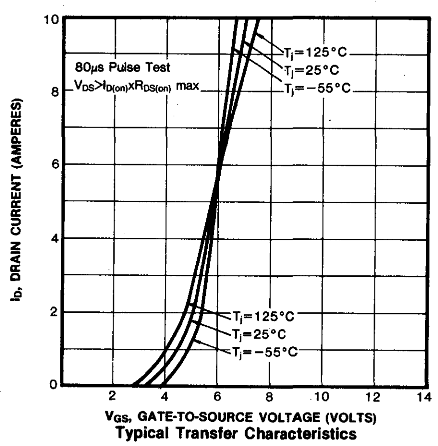
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRF624	—	—	3.8	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRF625	—	—	3.3	V	
I_{SM}	Pulse Source Current (Body Diode) (3)	IRF624	—	—	15	A	
		IRF625	—	—	13	V	
V_{SD}	Diode Forward Voltage (2)		—	—	1.8	V	$T_C=25°C$, $I_S=3.8A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time		—	180	—	ns	$T_J=25°C$, $I_F=3.8A$, $dI_F/dt=100A/\mu s$

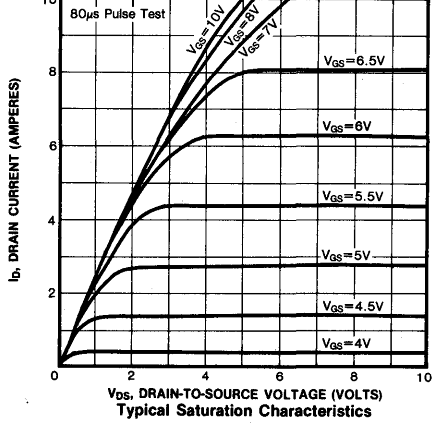
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq 300\mu s$, Duty Cycle$\leq 2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature



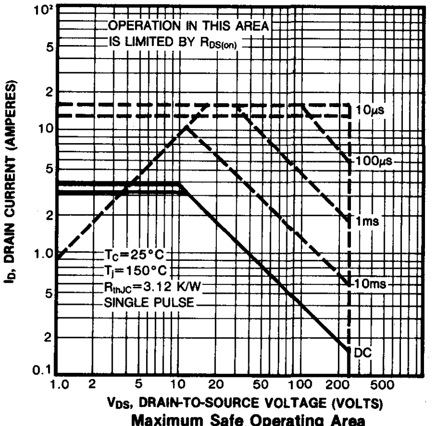
Typical Output Characteristics



Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area

$Z_{thJC}(t)/R_{thJC}$, NORMALIZED EFFECTIVE TRANSIENT THERMAL IMPEDANCE (PER UNIT)

t1. SQUARE WAVE PULSE DURATION (SECONDS)

D=0.5, D=0.2, D=0.1, D=0.05, D=0.02, D=0.01

SINGLE PULSE (TRANSISENT THERMAL IMPEDANCE)

NOTES

1. Duty Factor, $D=\frac{t_1}{t_2}$
2. Per Unit Base=R_{thJC}=6.4 Deg. C W.
3. $T_{JM}-T_C=P_{DM}\,Z_{thJC}\,(t)$.

Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

gfs, TRANSCONDUCTANCE (SIEMENS)

I_D, DRAIN CURRENT (AMPERES)

80μs Pulse Test
$V_{DS}>I_{D(on)}xR_{DS(on)}$ max

T_j=−55°C, T_j=25°C, T_j=125°C

Typical Transcounductance Vs. Drain Current

I_{DR}, REVERSE DRAIN CURRENT (AMPERES)

V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

T_j=25°C, T_j=150°C

Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

T_J, JUNCTION TEMPERATURE (°C)

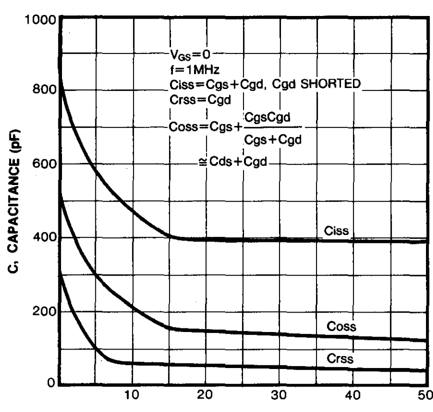
Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

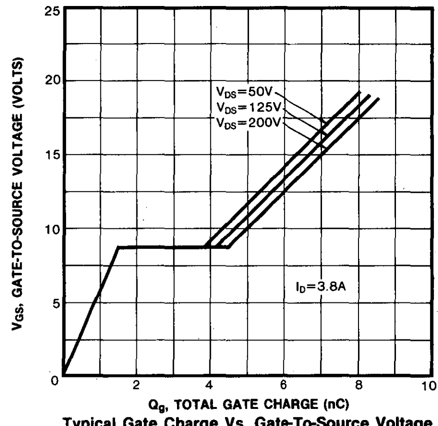
T_J, JUNCTION TEMPERATURE (°C)

V_{GS}=10V
I_D=2.5A

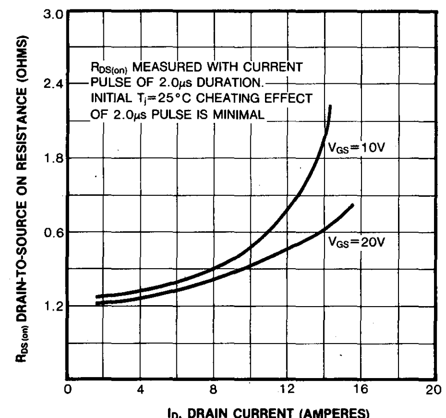
Normalized On-Resistance Vs. Temperature



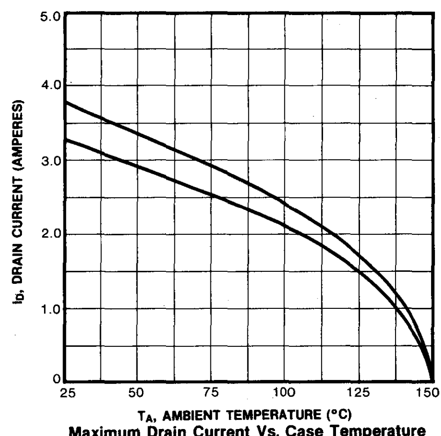
Typical Capacitance Vs. Drain to Source Voltage



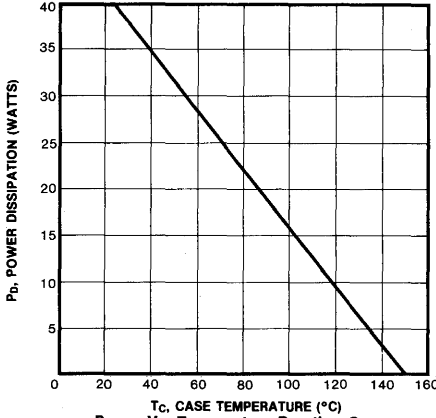
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



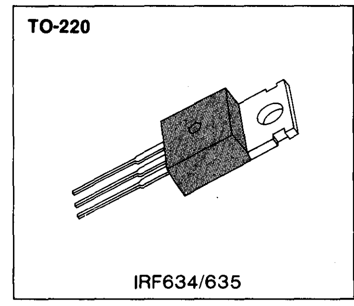
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF634	250V	0.45Ω	8.1A
IRF635	250V	0.68Ω	6.5A

MAXIMUM RATINGS

Characteristic	Symbol	IRF634	IRF635	Unit
Drain-Source Voltage (1)	V_{DSS}	250	250	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	250	250	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	8.1	6.5	Adc
Continuous Drain Current T_C=100°C	I_D	5.1	4.1	Adc
Drain Current—Pulsed (3)	I_{DM}	32	26	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	195		mJ
Avalanche Current	I_{AS}	8.1		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.60		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=5.5 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	250	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF634	8.1	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF635	6.5	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF634	—	0.40	0.45	Ω	V_{GS}=10V, I_D=4.1A
	IRF635	—	0.45	0.68	Ω	
g_{fs}	Forward Transconductance (2)	2.9		—	℧	V_{DS}≥50V, I_D=4.1A
C_{iss}	Input Capacitance	—	764	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	100	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	32	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	9.1	14	ns	V_{DD}=0.5BV_{DSS}, I_D=8.1A, Z_O=12Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—		35	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	31	47	ns	
t_f	Fall Time	—	19	29	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	24	35	nC	V_{GS}=10V, I_D=8.1A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	5.1	7.7	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	12	8.1	nC	

THERMAL RESISTANCE

R_{thJC}	Junction-to-Case	—	—	1.67	K/W	
R_{thCS}	Case-to-Sink	—	0.50	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C

(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%

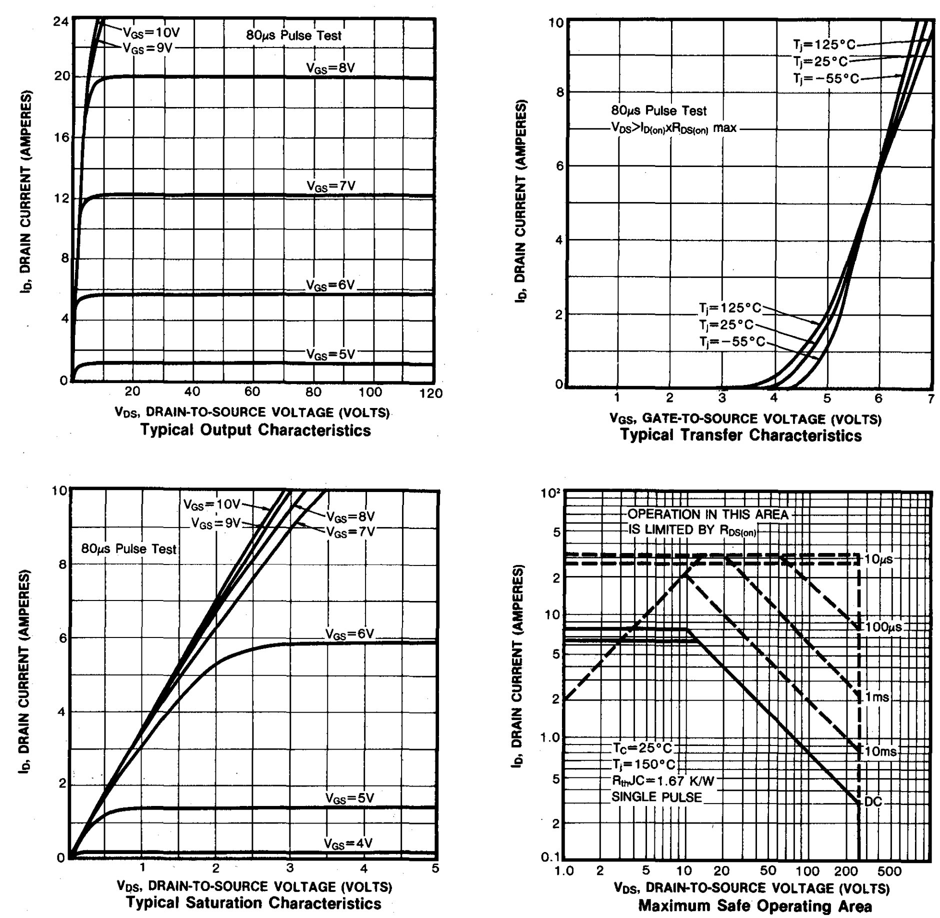
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRF634	—	—	8.1	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRF635	—	—	6.5	V	
I_{SM}	Pulse Source Current (Body Diode) (3)	IRF634	—	—	32	A	
		IRF635	—	—	26	V	
V_{SD}	Diode Forward Voltage (2)		—	—	2.0	V	$T_C=25°C$, $I_S=8.1A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time		—	190	390	ns	$T_J=25°C$, $I_F=8.1A$, $dI_F/dt=100A/\mu s$

Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

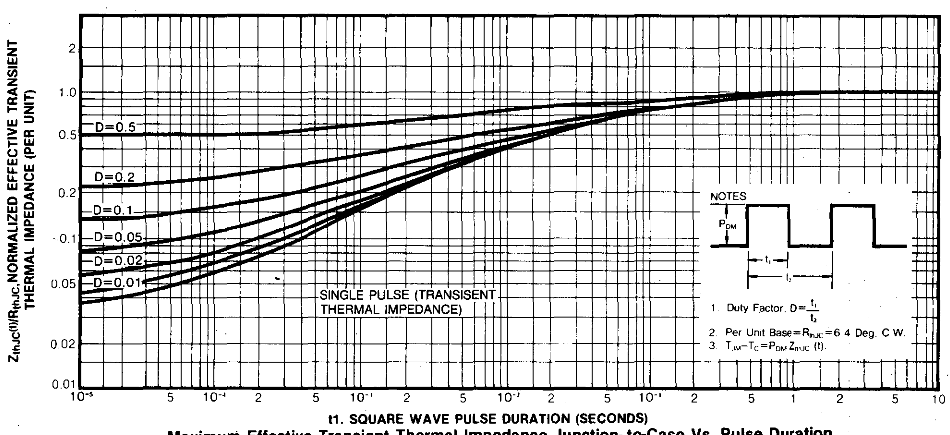


Typical Output Characteristics

Typical Transfer Characteristics

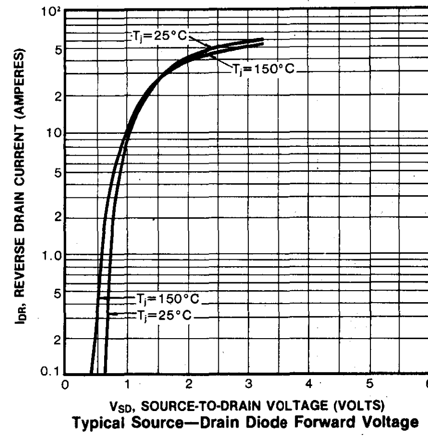
Typical Saturation Characteristics

Maximum Safe Operating Area

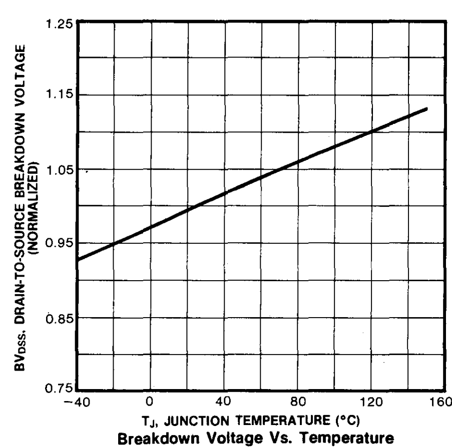


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

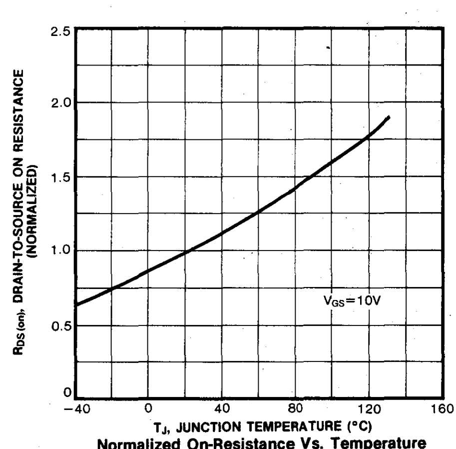
Typical Transcounductance Vs. Drain Current



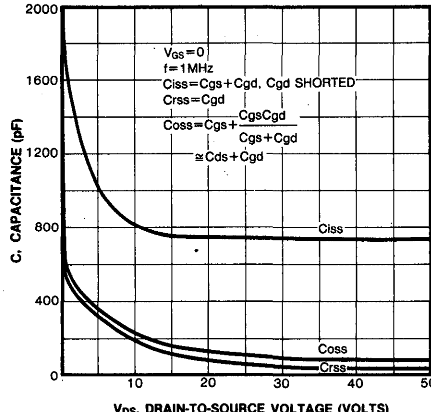
Typical Source—Drain Diode Forward Voltage



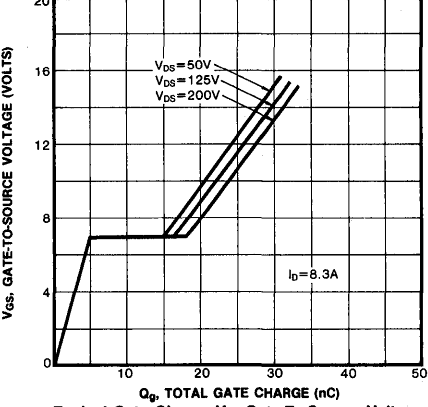
Breakdown Voltage Vs. Temperature



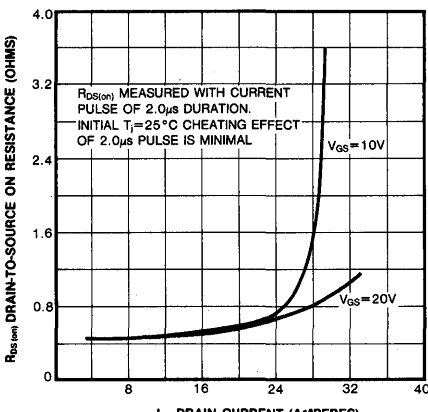
Normalized On-Resistance Vs. Temperature



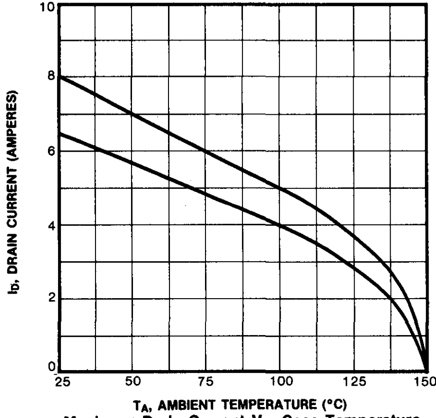
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

PD, POWER DISSIPATION (WATTS)

TC, CASE TEMPERATURE (°C)

Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-220

IRF644/645

TO-3P

IRFP244/245

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF644/IRFP244	250V	0.28Ω	14A
IRF645/IRFP245	250V	0.34Ω	13A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRF644 IRFP244	IRF645 IRFP245	Unit
Drain-Source Voltage (1)	V_{DSS}	250	250	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	250	250	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	14	13	Adc
Continuous Drain Current T_C=100°C	I_D	8.8	8.0	Adc
Drain Current—Pulsed (3)	I_{DM}	56	52	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	550		mJ
Avalanche Current	I_{AS}	15		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	250	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF644/IRFP244	14	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF645/IRFP245	13	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	0.23	0.28	Ω	V_{GS}=10V, I_D=8.0A
		—	0.28	0.34	Ω	
g_{fs}	Forward Transconductance (2)	6.7	10.2	—	℧	V_{DS}≥50V, I_D=8.0A
C_{iss}	Input Capacitance	—	1472	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	190	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	69	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	16	20	ns	V_{DD}=0.5BV_{DSS}, I_D=14A, Z_O=9.1Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	67	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	53	80	ns	
t_f	Fall Time	—	49	74	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	39	59	nC	V_{GS}=10V, I_D=14A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	6.6	9.9	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	20	30	nC	

THERMAL RESISTANCE

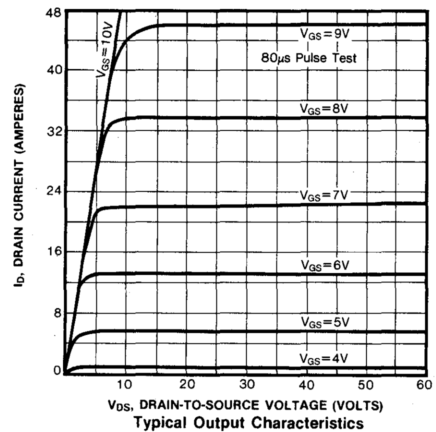
Symbol	Characteristic		IRF644-5	IRFP244-4	Unit	Test Conditions
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

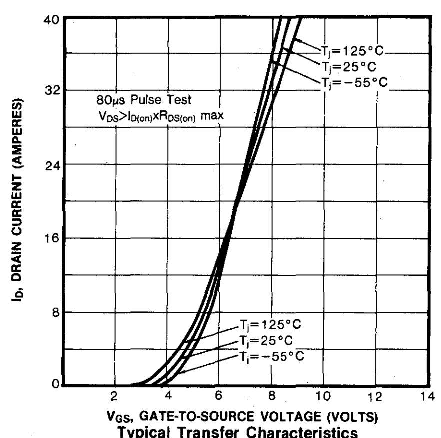
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRF644/ IRFP244	—	—	14	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRF645/ IRFP245	—	—	13	V	
I_{SM}	Pulse Source Current (Body Doide) (3)	IRF644/ IRFP244	—	—	56	A	
		IRF645/ IRFP245	—	—	52	V	
V_{SD}	Diode Forward Voltage (2)		—	—	1.8	V	$T_C=25°C$, $I_S=14A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time		—	300	—	ns	$T_J=25°C$, $I_F=14A$, $dI_F/dt=100A/\mu s$

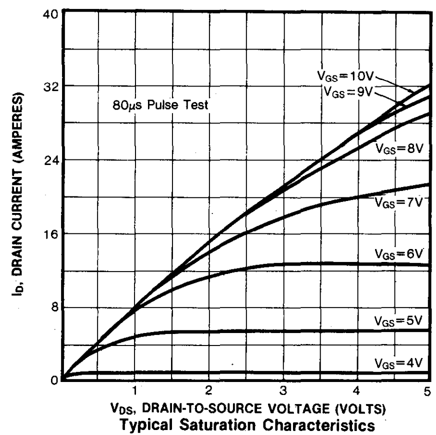
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



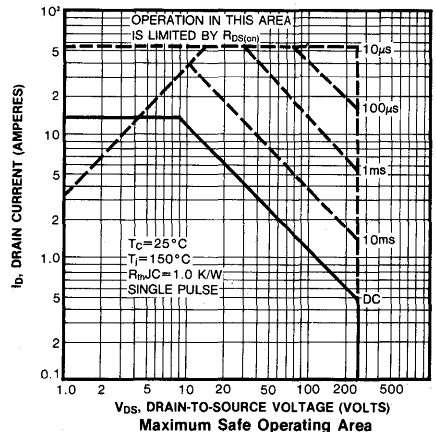
Typical Output Characteristics



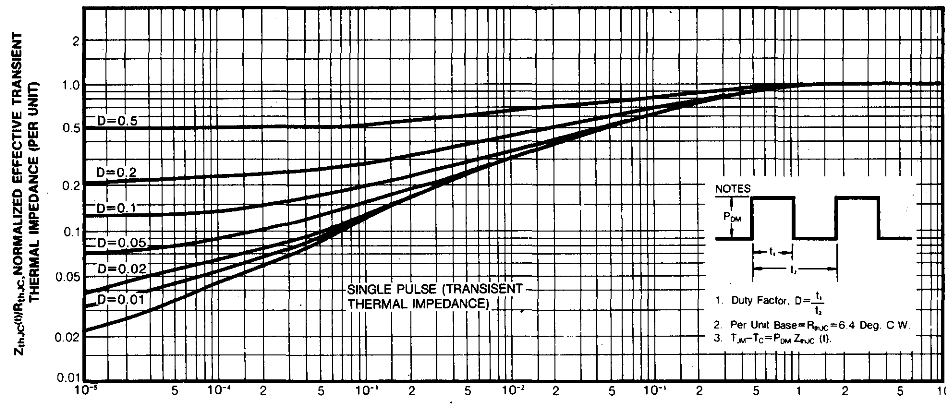
Typical Transfer Characteristics



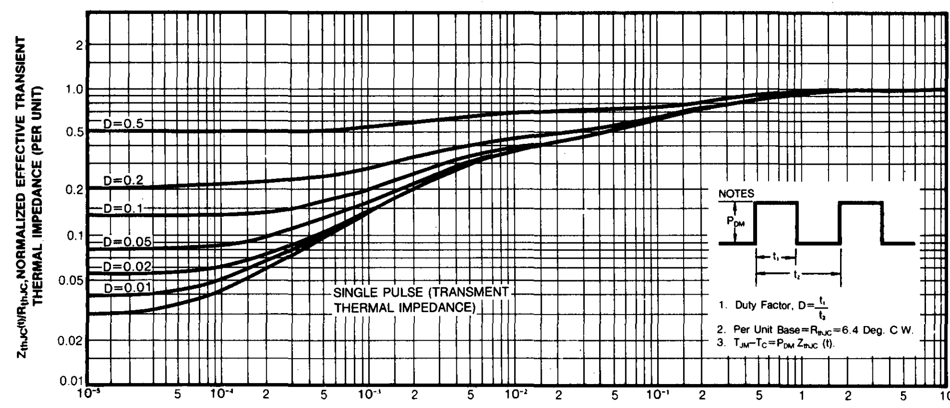
Typical Saturation Characteristics



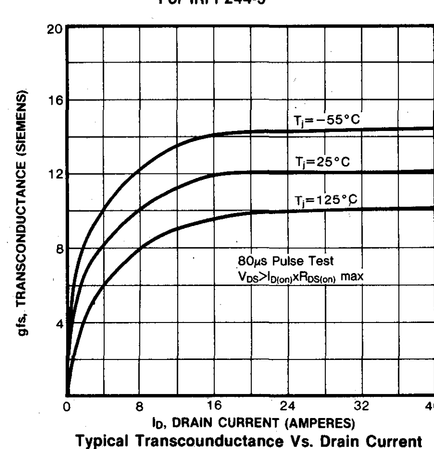
Maximum Safe Operating Area



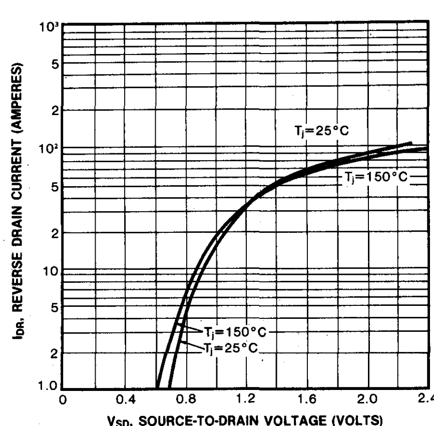
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF644-5



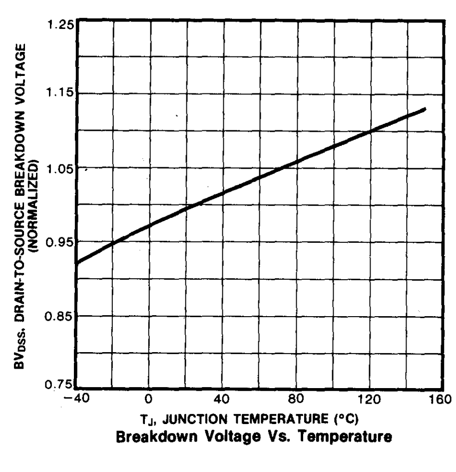
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP244-5



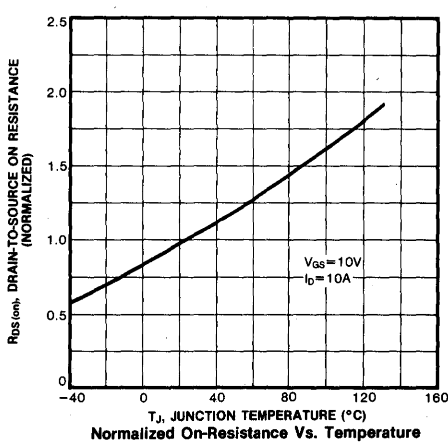
Typical Transcounductance Vs. Drain Current



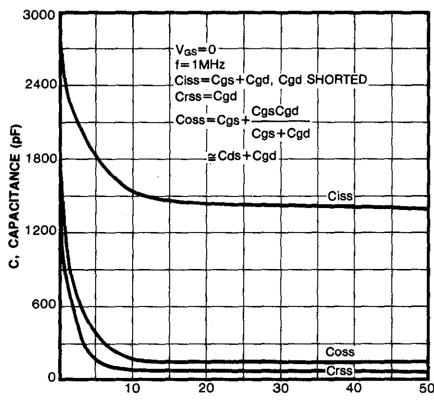
Typical Source—Drain Diode Forward Voltage



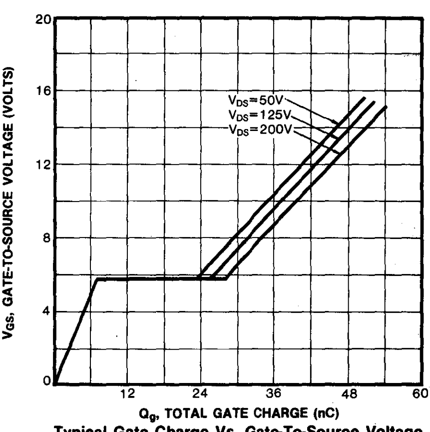
Breakdown Voltage Vs. Temperature



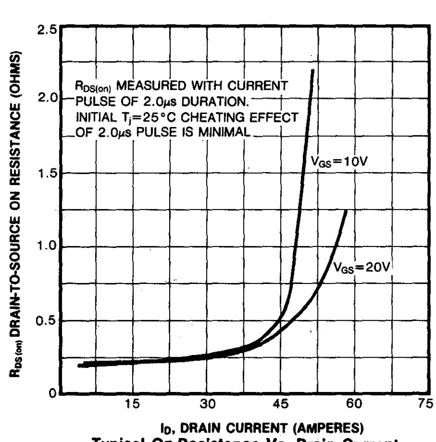
Normalized On-Resistance Vs. Temperature



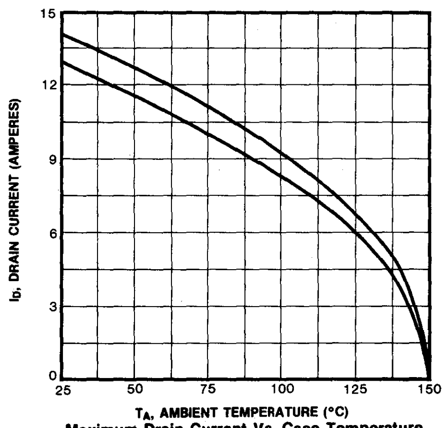
Typical Capacitance Vs. Drain to Source Voltage



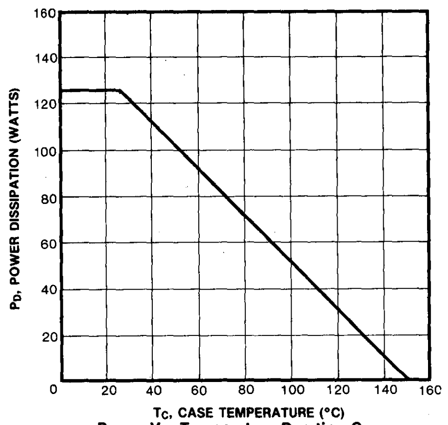
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



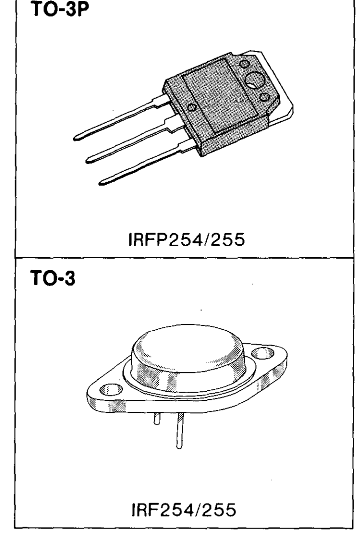
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFP254/IRF254	250V	0.14Ω	23A
IRFP255/IRF255	250V	0.17	21A

MAXIMUM RATINGS

Characteristic	Symbol	IRFP254 IRF254	IRFP255 IRF255	Unit
Drain-Source Voltage (1)	V_{DSS}	250	250	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	250	250	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	23	21	Adc
Continuous Drain Current T_C=100°C	I_D	15	13	Adc
Drain Current—Pulsed (3)	I_{DM}	92	84	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	800		mJ
Avalanche Current	I_{AS}	23		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150 1.2		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=3 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	250	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFP254/IRF254	23	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFP255/IRF255	21	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFP254/IRF254	—	0.098	0.14	Ω	V_{GS}=10V, I_D=13A
	IRFP255/IRF255	—	0.14	0.17	Ω	
g_{fs}	Forward Transconductance (2)	11	18.5	—	℧	V_{DS}≥50V, I_D=13A
C_{iss}	Input Capacitance	—	2890	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	376	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	140	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	19	29	ns	V_{DD}=0.5BV_{DSS}, I_D=22A, Z_O=6.2Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	84	130	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	75	110	ns	
t_f	Fall Time	—	65	98	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	87	130	nC	V_{GS}=10V, I_D=22A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	14	20	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	73	110	nC	

THERMAL RESISTANCE

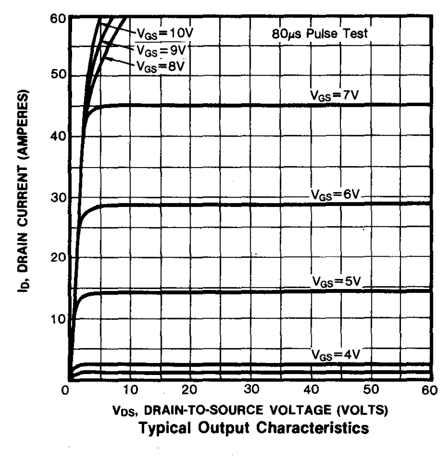
Symbol	Characteristic		IRFP254-5	IRF254-5	Unit	Test Conditions
R_{thJC}	Junction-to-Case	MAX	0.83	0.83	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

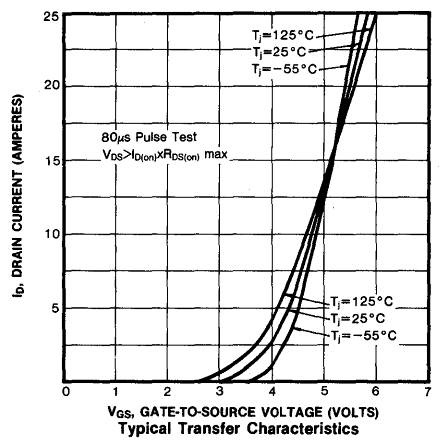
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFP254, IRF254	—	—	23	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFP255, IRF255	—	—	21	V	
I_{SM}	Pulse Source Current(Body Diode) (3) IRFP254, IRF254	—	—	92	A	
	IRFP255, IRF255	—	—	84	V	
V_{SD}	Diode Forward Voltage (2)	—	—	1.8	V	T_C=25°C, I_S=23A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	310	—	ns	T_J=25°C, I_F=22A, dI_F/dt=100A/μs

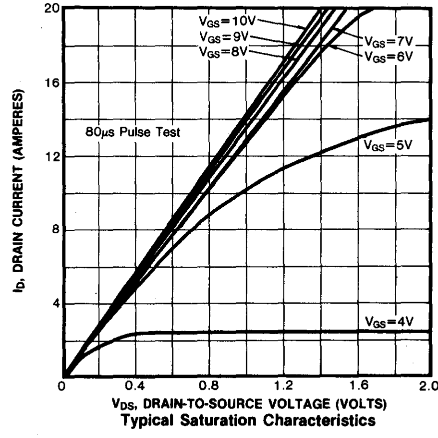
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



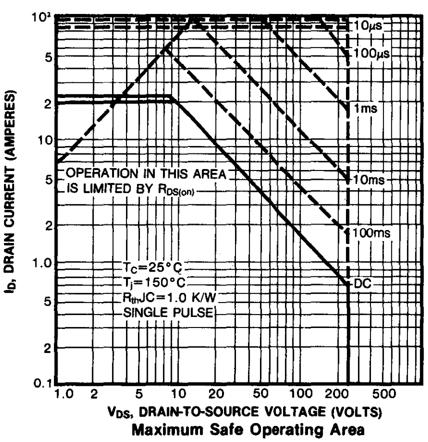
Typical Output Characteristics



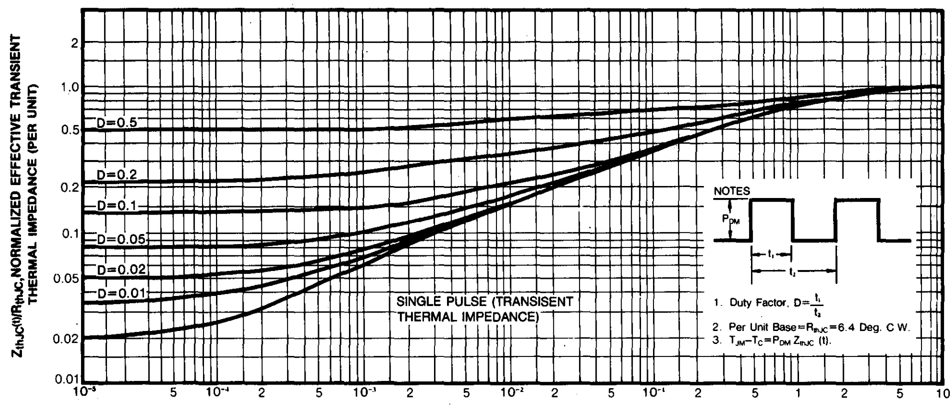
Typical Transfer Characteristics



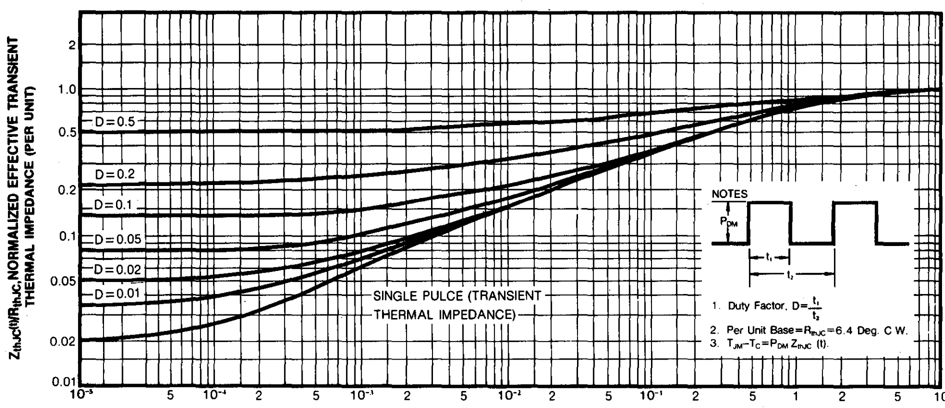
Typical Saturation Characteristics



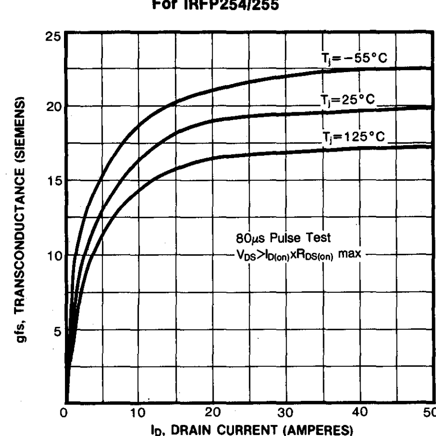
Maximum Safe Operating Area



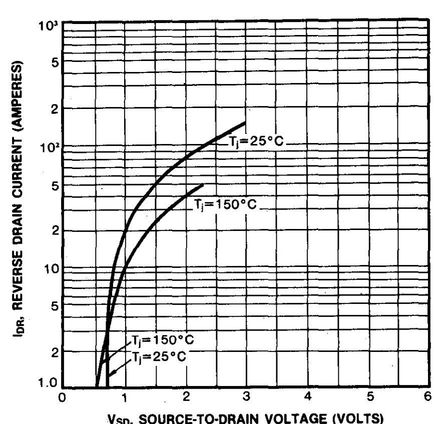
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF254/255



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP254/255



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
1.25, 1.15, 1.05, 0.95, 0.85, 0.75
−40, 0, 40, 80, 120, 160
T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
2.5, 2.0, 1.5, 1.0, 0.5, 0
V_{GS}=10V
I_D=16A
−40, 0, 40, 80, 120, 160
T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)
7500, 6000, 4500, 3000, 1500
V_{GS}=0
f=1MHz
Ciss=Cgs+Cgd, Cgd SHORTED
Crss=Cgd
$Coss=Cgs+\frac{CgsCgd}{Cgs+Cgd}$
≅Cds+Cgd
Ciss
Coss
Crss
0, 10, 20, 30, 40, 50
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
20, 16, 12, 8, 4
V_{DS}=50V
V_{DS}=125V
V_{DS}=200V
V_{GS}=10V
I_D=22A
0, 25, 50, 75, 100, 125
Q_g, TOTAL GATE CHARGE (nC)

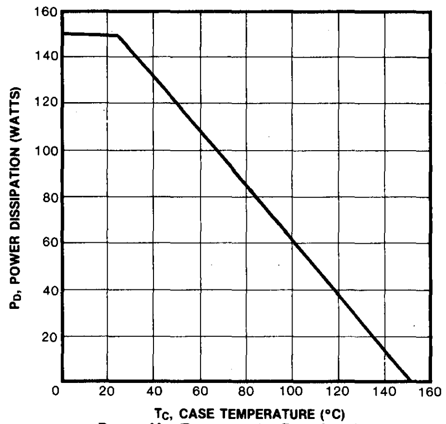
Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$ DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
0.25, 0.20, 0.15, 0.10, 0.05
$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL T_j=25°C CHEATING EFFECT OF 2.0μs PULSE IS MINIMAL
V_{GS}=10V
V_{GS}=20V
0, 20, 40, 60, 80, 100
I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

I_D, DRAIN CURRENT (AMPERES)
25, 20, 15, 10, 5, 0
25, 50, 75, 100, 125, 150
T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature

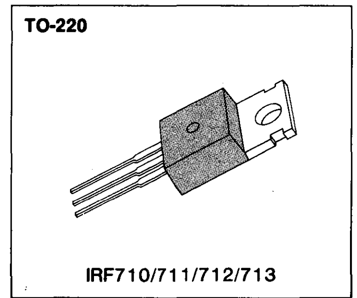


Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-220



IRF710/711/712/713

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF710	400V	3.6Ω	2.0A
IRF711	350V	3.6Ω	2.0A
IRF712	400V	5.0Ω	1.7A
IRF713	350V	5.0Ω	1.7A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRF710	IRF711	IRF712	IRF713	Unit
Drain-Source Voltage (1)	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	2.0	2.0	1.7	1.7	Adc
Continuous Drain Current T_C=100°C	I_D	1.2	1.2	1.1	1.1	Adc
Drain Current—Pulsed (3)	I_{DM}	5.0	5.0	4.3	4.3	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	120				mJ
Avalanche Current	I_{AS}	2.0				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	36 0.27				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=53 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF710/712	400	—	—	V	V_{GS}=0V
	IRF711/713	350	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF710/711	2.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF712/713	1.7	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF710/711	—	3.2	3.6	Ω	V_{GS}=10V, I_D=1.1A
	IRF712/713	—	3.5	5.0	Ω	
g_{fs}	Forward Transconductance (2)	0.5	1.0	—	℧	V_{DS}≥50V, I_D=1.1A
C_{iss}	Input Capacitance	—	180	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	40	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	14	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	7.9	12	ns	V_{DD}=0.5BV_{DSS}, I_D=2.0A, Z_O=24Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	9.9	15	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	21	32	ns	
t_f	Fall Time	—	11	17	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	7.7	12	nC	V_{GS}=10V, I_D=2.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	1.2	1.9	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	4.0	5.9	nC	

THERMAL RESISTANCE

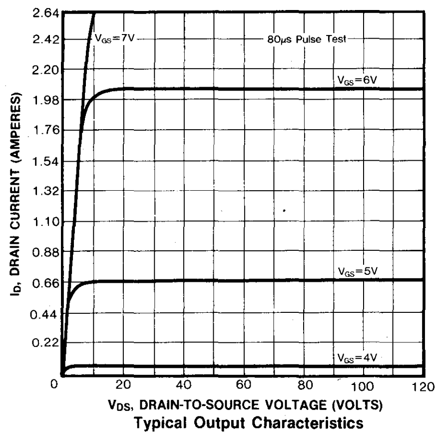
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	3.5	KW	
R_{thCS}	Case-to-Sink	—	0.5	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

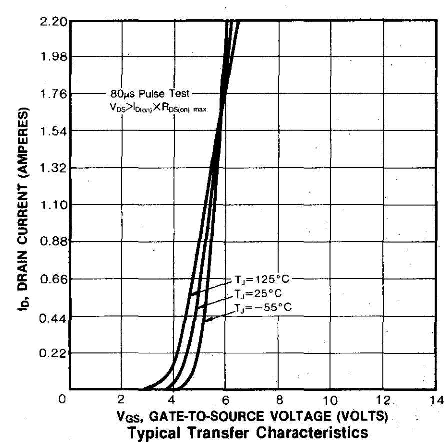
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Type	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	IRF710 IRF711	—	—	2.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
		IRF712 IRF713	—	—	1.7	A	
I_{SM}	Pulse Source Current (Body Diode) (3)	IRF710 IRF711	—	—	5.0	A	
		IRF712 IRF713	—	—	4.3	A	
V_{SD}	Diode Forward Voltage (2)	IRF710 IRF711	—	—	1.6	V	$T_C=25°C$, $I_S=2.0A$, $V_{GS}=0V$
		IRF712 IRF713	—	—	1.5	V	$T_C=25°C$, $I_S=1.7A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time		—	240	520	ns	$T_J=25°C$, $I_F=2.0A$, $dI_F/dt=100A/\mu s$

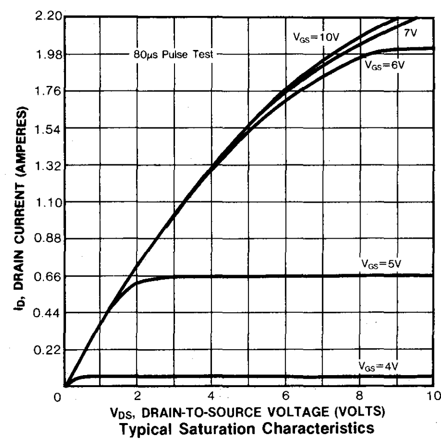
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



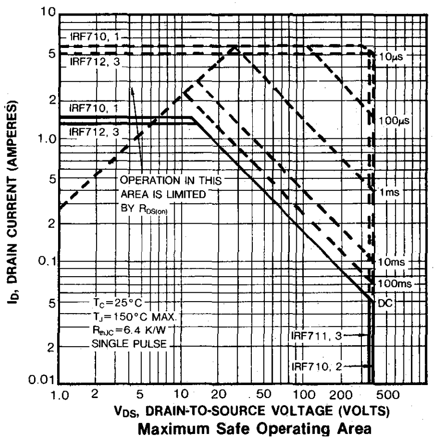
Typical Output Characteristics



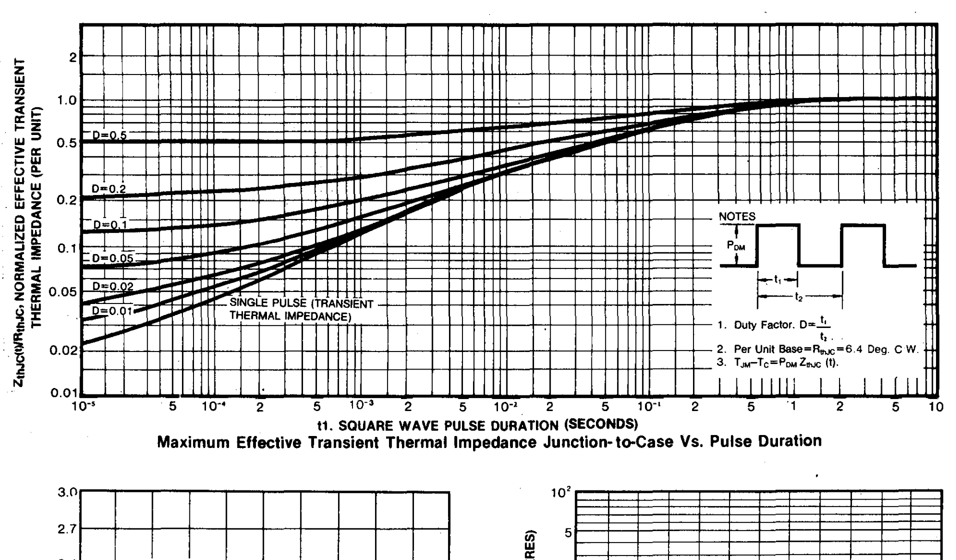
Typical Transfer Characteristics



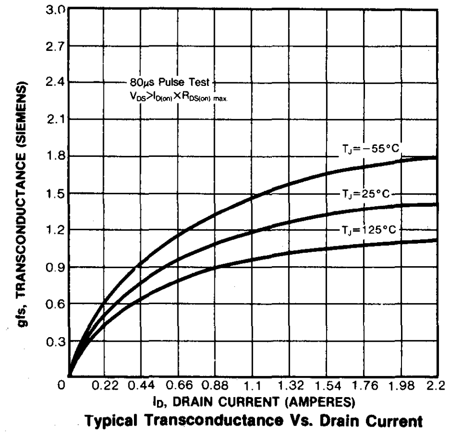
Typical Saturation Characteristics



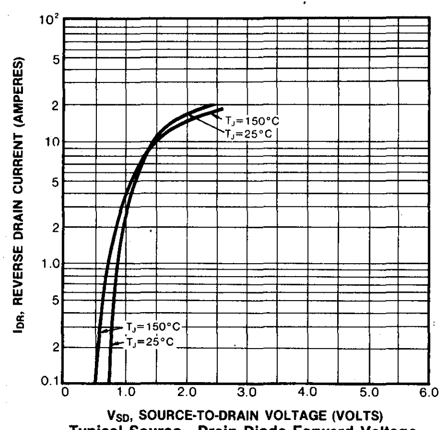
Maximum Safe Operating Area



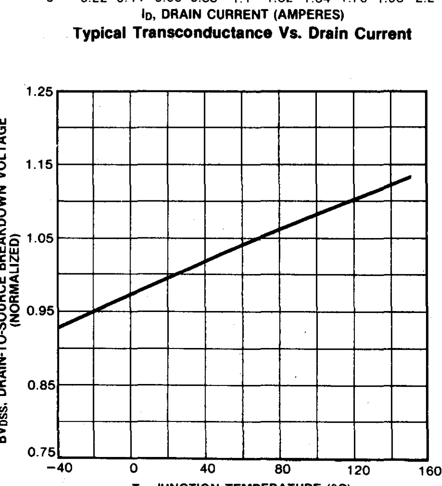
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



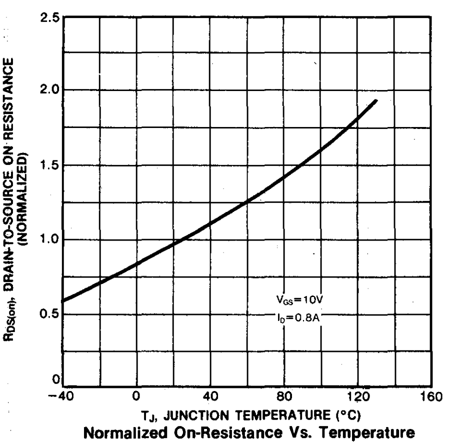
Typical Transconductance Vs. Drain Current



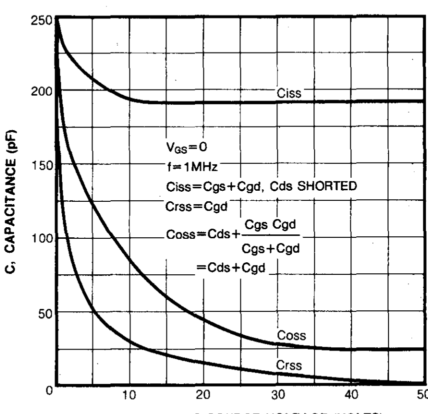
Typical Source—Drain Diode Forward Voltage



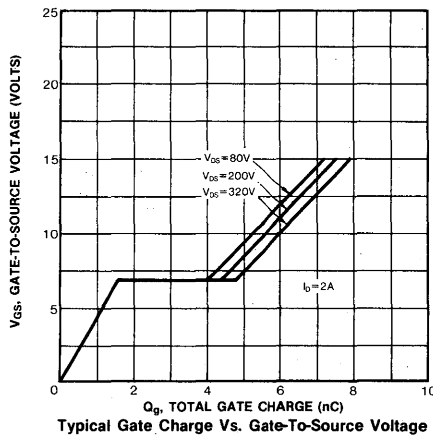
Breakdown Voltage Vs. Temperature



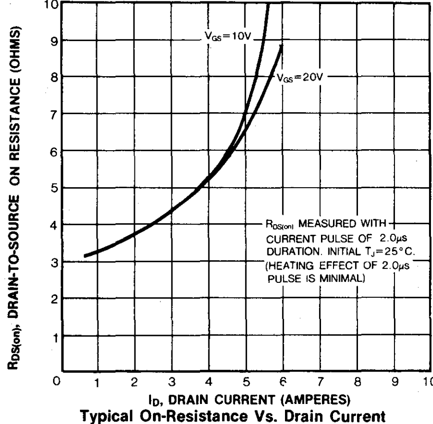
Normalized On-Resistance Vs. Temperature



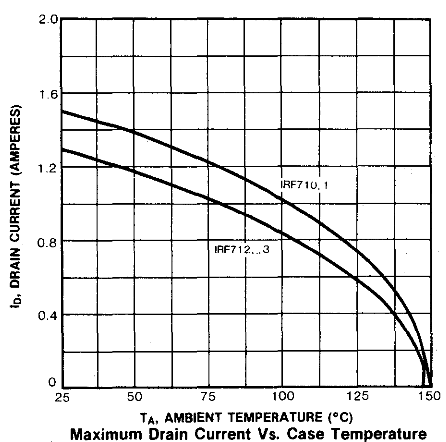
Typical Capacitance Vs. Drain to Source Voltage



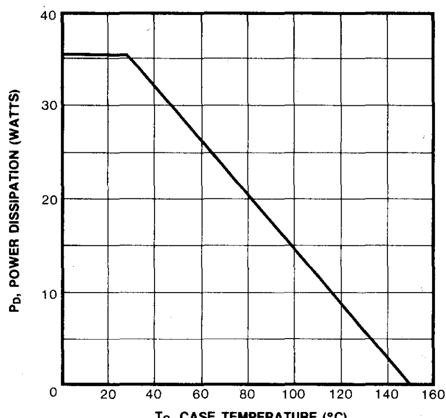
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



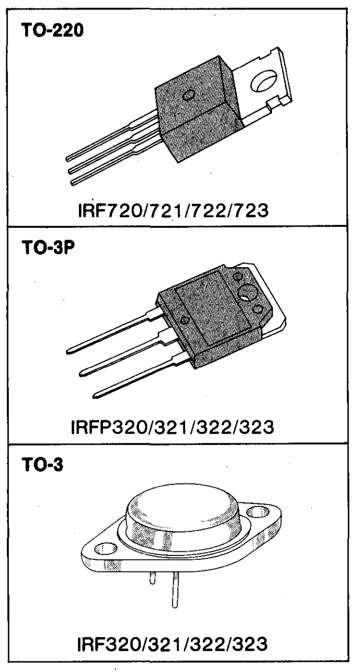
Power Vs. Temperature Derating Curve

IRF720/721/722/723
IRFP320/321/322/323
IRF320/321/322/323

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF720/IRFP320/IRF320	400V	1.8Ω	3.3A
IRF721/IRFP321/IRF321	350V	1.8Ω	3.3A
IRF722/IRFP322/IRF322	400V	2.5Ω	2.8A
IRF723/IRFP323/IRF323	350V	2.5Ω	2.8A

MAXIMUM RATINGS

Characteristics	Symbol	IRF720 IRFP320 IRF320	IRF721 IRFP321 IRF321	IRF722 IRFP322 IRF322	IRF723 IRFP323 IRF323	Unit
Drain-Source Voltage (1)	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	3.3	3.3	2.8	2.8	Adc
Continuous Drain Current T_C=100°C	I_D	2.1	2.1	1.8	1.8	Adc
Drain Current—Pulsed (3)	I_{DM}	13	13	11	11	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	190				mJ
Avalanche Current	I_{AS}	3.3				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	50 0.40				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=31 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF720/IRFP320/IRF320 IRF722/IRFP322/IRF322	400	—	—	V	V_{GS}=0V I_D=250μA
	IRF721/IRFP321/IRF321 IRF723/IRFP323/IRF323	350	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF720/IRFP320/IRF320 IRF721/IRFP321/IRF321	3.3	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF722/IRFP322/IRF322 IRF723/IRFP323/IRF323	2.8	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF720/IRFP320/IRF320 IRF721/IRFP321/IRF321	—	1.4	1.8	Ω	V_{GS}=10V, I_D=1.8A
	IRF722/IRFP322/IRF322 IRF723/IRFP323/IRF323	—	1.8	2.5	Ω	
g_{fs}	Forward Transconductance (2)	1.0	2.2	—	℧	V_{DS}≥50V, I_D=1.8A
C_{iss}	Input Capacitance	—	400	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	59.3	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	27	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	10	15	ns	V_{DD}=0.5BV_{DSS}, I_D=3.3A, Z_O=18Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	14	20	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	30	45	ns	
t_f	Fall Time	—	13	20	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	12.5	15	nC	V_{GS}=10V, I_D=9.2A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.8	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	9.7	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRF720-3	IRFP320-3	IRF320-3	Unit	
R_{thJC}	Junction-to-Case	MAX	2.5	2.5	2.5	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

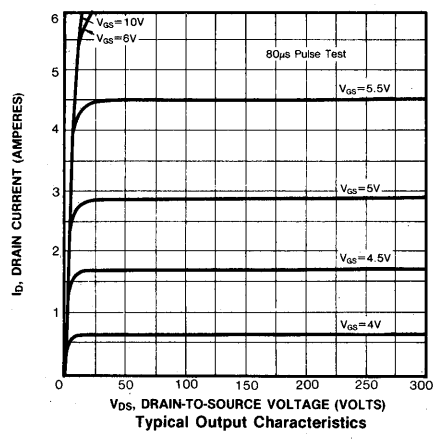
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

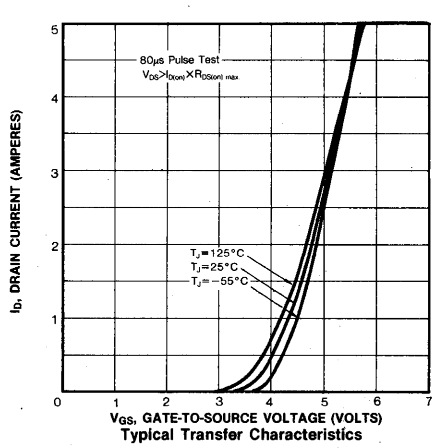
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF720/IRFP320/IRF320 IRF721/IRFP321/IRF321	—	—	3.3	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF722/IRFP322/IRF322 IRF723/IRFP323/IRF323	—	—	2.8	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF720/IRFP320/IRF320 IRF721/IRFP321/IRF321	—	—	13	A	
	IRF722/IRFP322/IRF322 IRF723/IRFP323/IRF323	—	—	11	A	
V_{SD}	Diode Forward Voltage (2) IRF720/IRFP320/IRF320 IRF721/IRFP321/IRF321	—	—	1.8	V	$T_C=25°C$, $I_S=3.3A$, $V_{GS}=0V$
	IRF722/IRFP322/IRF322 IRF723/IRFP323/IRF323	—	—	1.7	V	$T_C=25°C$, $I_S=2.8A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	270		ns	$T_j=25°C$, $I_F=3.3A$, $dI_F/dt=100A/\mu S$

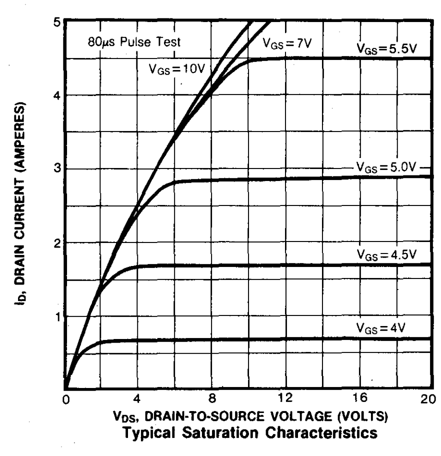
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



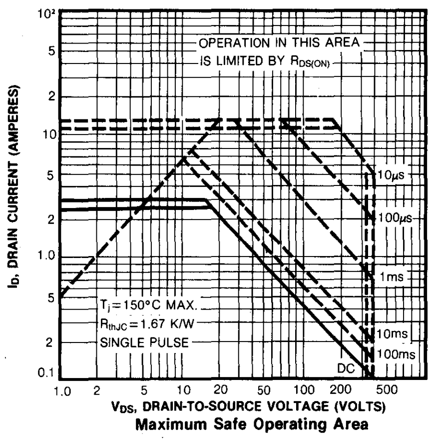
Typical Output Characteristics



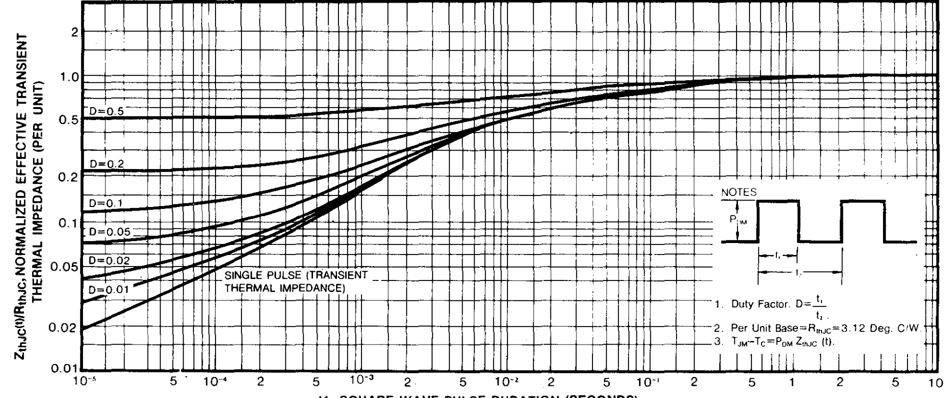
Typical Transfer Characteristics



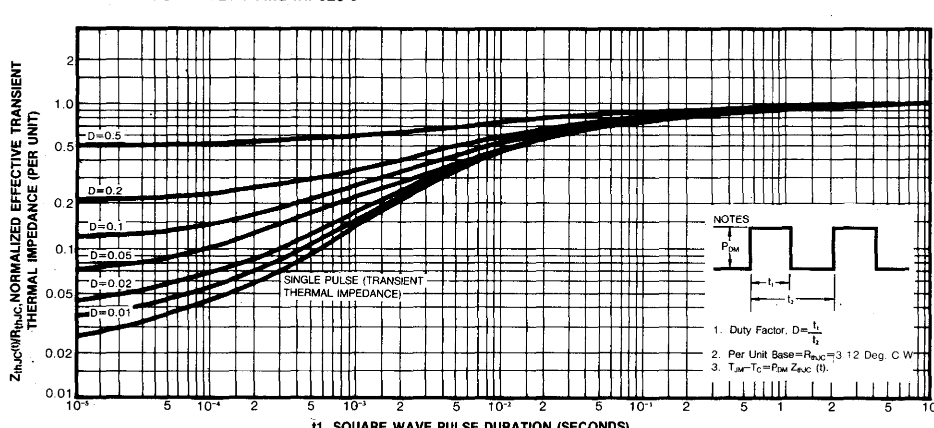
Typical Saturation Characteristics



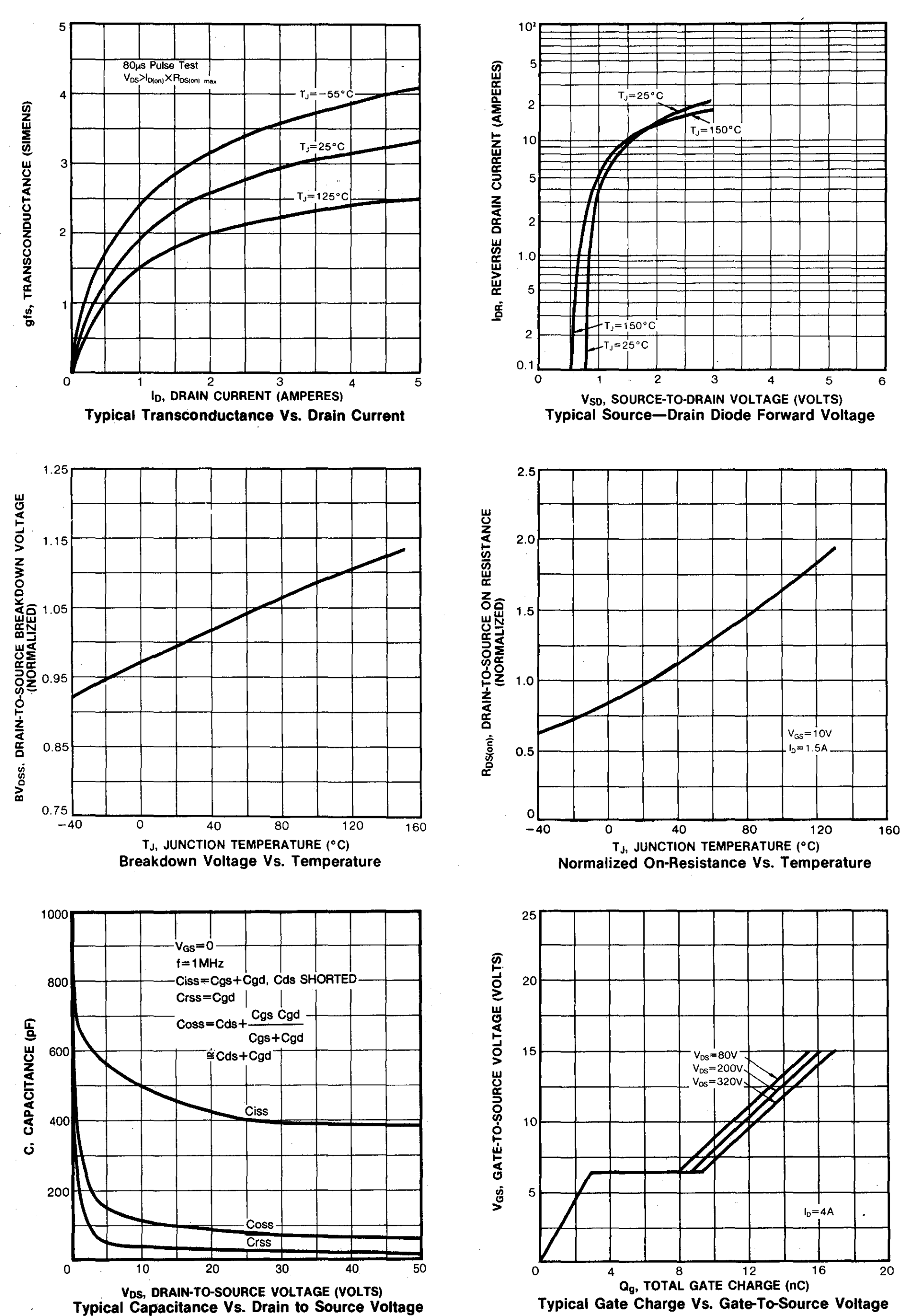
Maximum Safe Operating Area

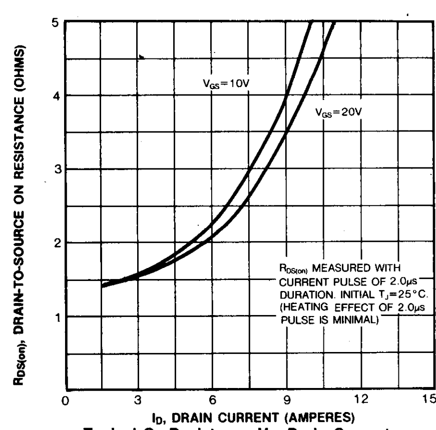


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF720-3 And IRF320-3

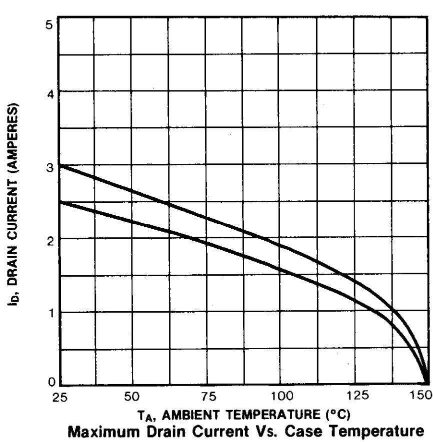


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP320-3

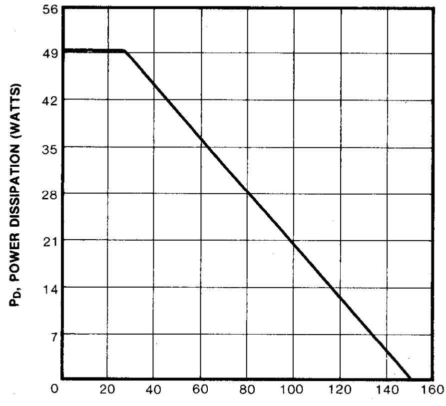

80μs Pulse Test
$V_{DS}>I_{D(on)} \times R_{DS(on)\ max}$
$T_J=-55°C$
$T_J=25°C$
$T_J=125°C$
gfs, TRANSCONDUCTANCE (SIEMENS)
I_D, DRAIN CURRENT (AMPERES)
Typical Transconductance Vs. Drain Current
$T_J=25°C$
$T_J=150°C$
I_{DR}, REVERSE DRAIN CURRENT (AMPERES)
V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)
Typical Source—Drain Diode Forward Voltage
BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
T_J, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
$V_{GS}=10V$
$I_D=1.5A$
T_J, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
$V_{GS}=0$
f=1MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss=Cds+$\frac{Cgs\ Cgd}{Cgs+Cgd}$
≅Cds+Cgd
Ciss
Coss
Crss
C, CAPACITANCE (pF)
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
$V_{DS}=80V$
$V_{DS}=200V$
$V_{DS}=320V$
$I_D=4A$
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
Q_g, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

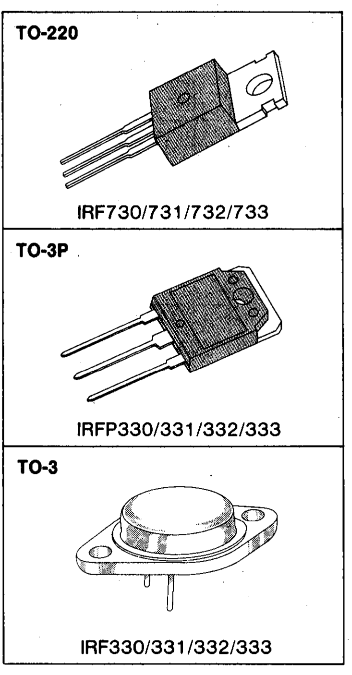
4

IRF730/731/732/733
IRFP330/331/332/333
IRF330/331/332/333

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF730/IRFP330/IRF330	400V	1.0Ω	5.5A
IRF731/IRFP331/IRF331	350V	1.0Ω	5.5A
IRF732/IRFP332/IRF332	400V	1.5Ω	4.5A
IRF733/IRFP333/IRF333	350V	1.5Ω	4.5A

MAXIMUM RATINGS

Characteristics	Symbol	IRF730 IRFP330 IRF330	IRF731 IRFP331 IRF331	IRF732 IRFP332 IRF332	IRF733 IRFP333 IRF333	Unit
Drain-Source Voltage (1)	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	5.5	5.5	4.5	4.5	Adc
Continuous Drain Current T_C=100°C	I_D	3.5	3.5	3.0	3.0	Adc
Drain Current—Pulsed (3)	I_{DM}	32	32	18	18	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	290				mJ
Avalanche Current	I_{AS}	5.5				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=17 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

IRF730/731/732/733
IRFP330/331/332/333
IRF330/331/332/333

N-CHANNEL POWER MOSFETS

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF730/IRFP330/IRF330 IRF732/IRFP332/IRF332	400	—	—	V	V_{GS}=0V I_D=250μA
	IRF731/IRFP331/IRF331 IRF733/IRFP333/IRF333	350	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF730/IRFP330/IRF330 IRF731/IRFP331/IRF331	5.5	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF732/IRFP332/IRF332 IRF733/IRFP333/IRF333	4.5	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF730/IRFP330/IRF330 IRF731/IRFP331/IRF331	—	0.8	1.0	Ω	V_{GS}=10V, I_D=3.0A
	IRF732/IRFP332/IRF332 IRF733/IRFP333/IRF333	—	1.0	1.5	Ω	
g_{fs}	Forward Transconductance (2)	2.9	4.4	—	℧	V_{DS}≥50V, I_D=3.0A
C_{iss}	Input Capacitance	—	780	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	99	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	43	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	11	17	ns	V_{DD}=0.5BV_{DSS}, I_D=5.5A, Z_O=12Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	19	29	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	37	56	ns	
t_f	Fall Time	—	16	24	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	18	30	nC	V_{GS}=10V, I_D=5.5A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	40	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	14	—	nC	

THERMAL RESISTANCE

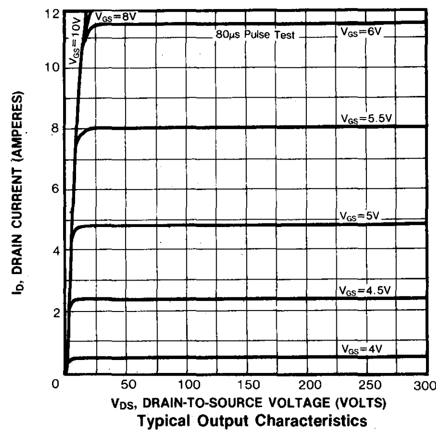
Symbol	Characteristic		IRF730-3	IRFP330-3	IRF330-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.50	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

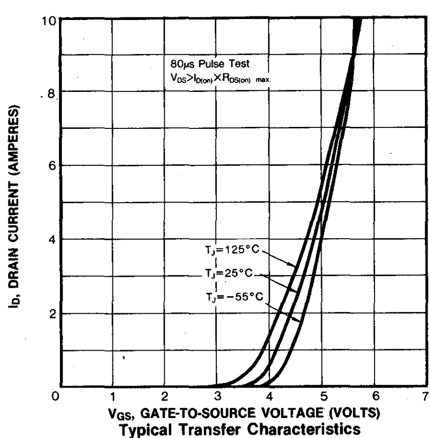
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF730/IRFP330/IRF330 IRF731/IRFP331/IRF331	—	—	5.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF732/IRFP332/IRF332 IRF733/IRFP333/IRF333	—	—	4.5	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF730/IRFP330/IRF330 IRF731/IRFP331/IRF331	—	—	22	A	
	IRF732/IRFP332/IRF332 IRF733/IRFP333/IRF333	—	—	18	A	
V_{SD}	Diode Forward Voltage (2) IRF730/IRFP330/IRF330 IRF731/IRFP331/IRF331	—	—	1.8	V	T_C=25°C, I_S=5.5A, V_{GS}=0V
	IRF732/IRFP332/IRF332 IRF733/IRFP333/IRF333	—	—	1.6	V	T_C=25°C, I_S=4.5A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	310	660	ns	T_j=25°C, I_F=5.5A, dI_F/dt=100A/μS

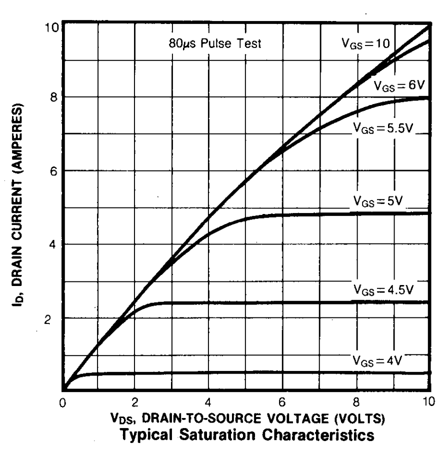
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



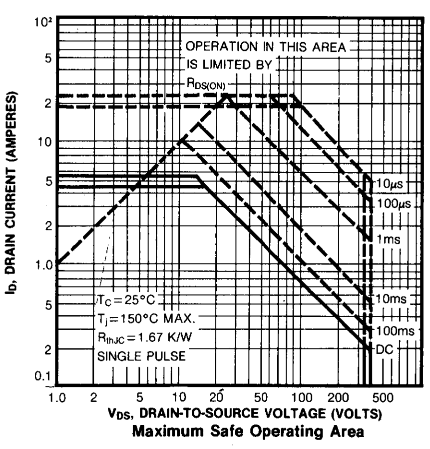
Typical Output Characteristics



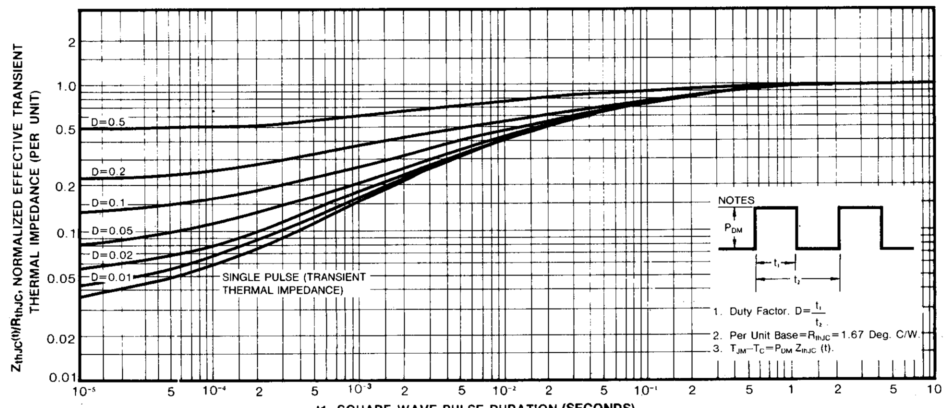
Typical Transfer Characteristics



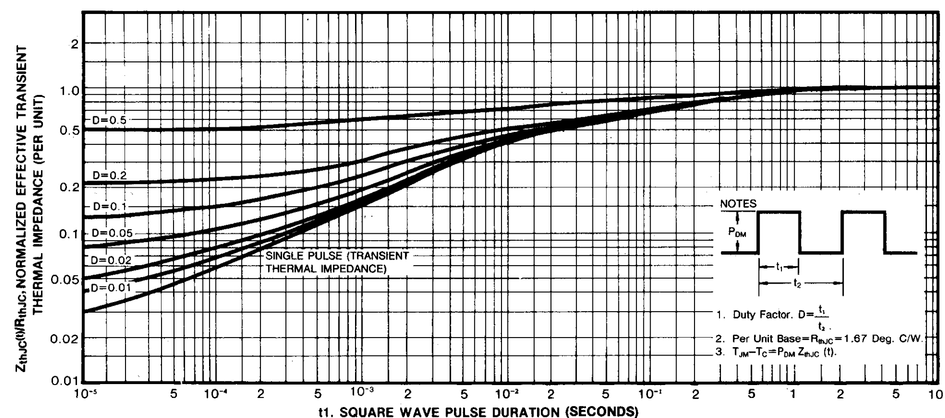
Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF730-3 And IRF330-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP330-3

80μs Pulse Test
$V_{DS} > I_{D(on)} \times R_{DS(on)}$ max.
$T_J = -55°C$
$T_J = 25°C$
$T_J = 125°C$
gfs, TRANSCONDUCTANCE (SIEMENS)
I_D, DRAIN CURRENT (AMPERES)

Typical Transcounductance Vs. Drain Current

$T_J = 25°C$
$T_J = 150°C$
I_{DR}, REVERSE DRAIN CURRENT (AMPERES)
V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$V_{GS} = 10V$
$I_D = 3A$
$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
T_J, JUNCTION TEMPERATURE (°C)

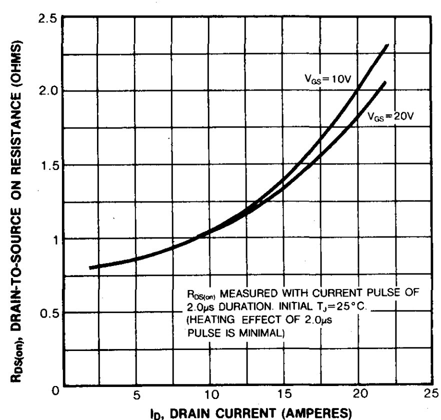
Normalized On-Resistance Vs. Temperature

$V_{GS} = 0$
f = 1 MHz
Ciss = Cgs + Cgd, Cds SHORTED
Crss = Cgd
$Coss = Cds + \frac{CgsCgd}{Cgs+Cgd} \approx Cds + Cgd$
Ciss
Coss
Crss
C, CAPACITANCE (pF)
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

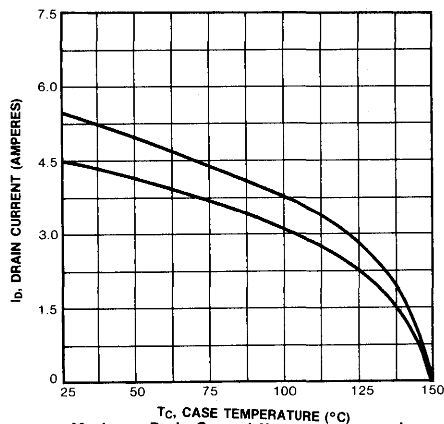
Typical Capacitance Vs. Drain to Source Voltage

$V_{DS} = 80V$
$V_{DS} = 200V$
$V_{DS} = 320V$
$I_D = 7A$
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
Q_g, TOTAL GATE CHARGE (nC)

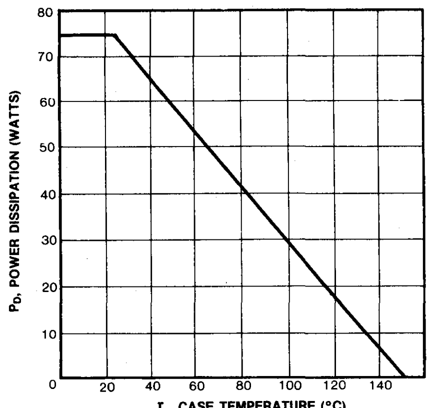
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



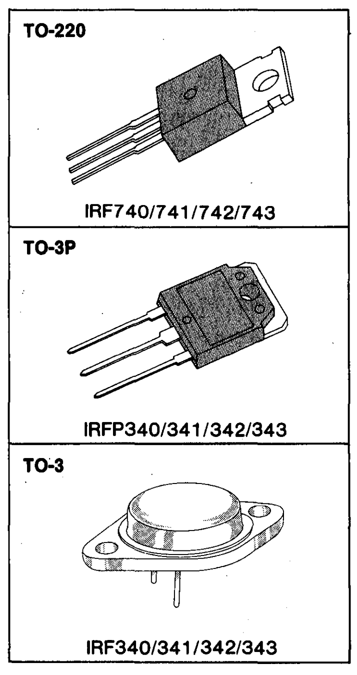
Power Vs. Temperature Derating Curve

IRF740/741/742/743
IRFP340/341/342/343
IRF340/341/342/343

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF740/IRFP340/IRF340	400V	0.55Ω	10A
IRF741/IRFP341/IRF341	350V	0.55Ω	10A
IRF742/IRFP342/IRF342	400V	0.80Ω	8.3A
IRF743/IRFP343/IRF343	350V	0.80Ω	8.3A

MAXIMUM RATINGS

Characteristics	Symbol	IRF740 IRFP340 IRF340	IRF741 IRFP341 IRF341	IRF742 IRFP342 IRF342	IRF743 IRFP343 IRF343	Unit
Drain-Source Voltage (1)	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	10	10	8.3	8.3	Adc
Continuous Drain Current T_C=100°C	I_D	6.3	6.3	5.2	5.2	Adc
Drain Current—Pulsed (3)	I_{DM}	40	40	33	33	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	520				mJ
Avalanche Current	I_{AS}	10				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.44 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF740/IRFP340/IRF340 IRF742/IRFP342/IRF342	400	—	—	V	V_{GS}=0V I_D=250μA
	IRF741/IRFP341/IRF341 IRF743/IRFP343/IRF343	350	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF740/IRFP340/IRF340 IRF741/IRFP341/IRF341	10	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF742/IRFP342/IRF342 IRF743/IRFP343/IRF343	8.3	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF740/IRFP340/IRF340 IRF741/IRFP341/IRF341	—	—	0.55	Ω	V_{GS}=10V, I_D=5.2A
	IRF742/IRFP342/IRF342 IRF743/IRFP343/IRF343	—	—	0.80	Ω	
g_{fs}	Forward Transconductance (2)	5.8	87	—	℧	V_{DS}≥50V, I_D=5.2A
C_{iss}	Input Capacitance	—	1500	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	178	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	75	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	14	21	ns	V_{DD}=0.5BV_{DSS}, I_D=10A, Z_O=9.1Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	27	41	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	50	75	ns	
t_f	Fall Time	—	24	36	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	42	63	nC	V_{GS}=10V, I_D=10A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	6.0	9.0	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	21	32	nC	

THERMAL RESISTANCE

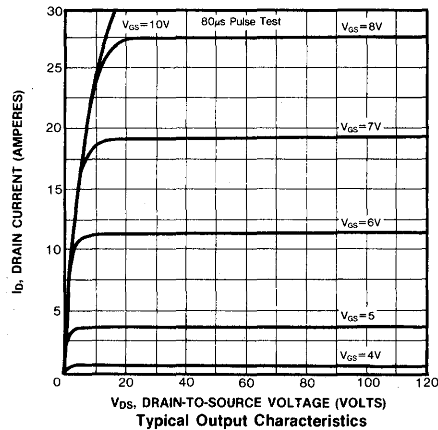
Symbol	Characteristic		IRF740-3	IRFP340-3	IRF340-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

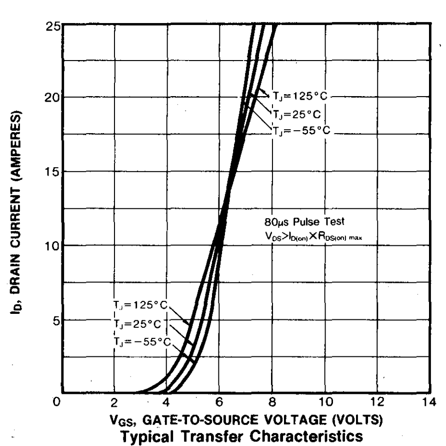
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF740/IRFP340/IRF340 IRF741/IRFP341/IRF341	—	—	10	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF742/IRFP342/IRF342 IRF743/IRFP343/IRF343	—	—	8.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF740/IRFP340/IRF340 IRF741/IRFP341/IRF341	—	—	40	A	
	IRF742/IRFP342/IRF342 IRF743/IRFP343/IRF343	—	—	32	A	
V_{SD}	Diode Forward Voltage (2) IRF740/IRFP340/IRF340 IRF741/IRFP341/IRF341	—	—	2.0	V	T_C=25°C, I_S=10A, V_{GS}=0V
	IRF742/IRFP342/IRF342 IRF743/IRFP343/IRF343	—	—	1.9	V	T_C=25°C, I_S=8.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	370		ns	T_j=25°C, I_F=10A, dI_F/dt=100A/μS

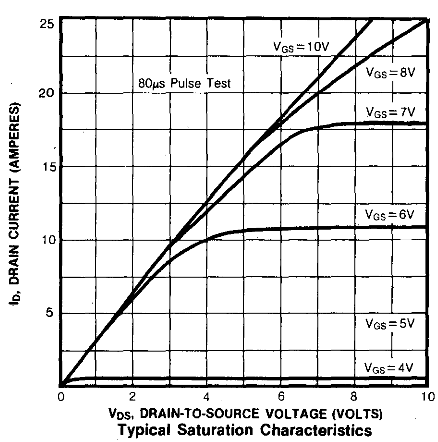
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



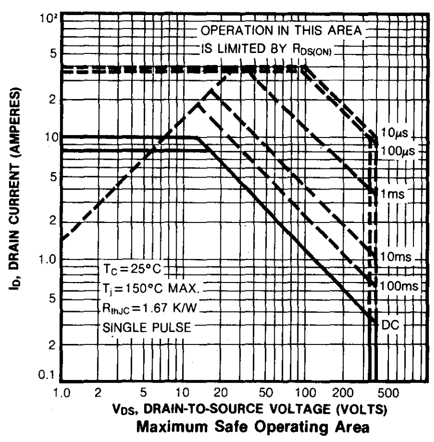
Typical Output Characteristics



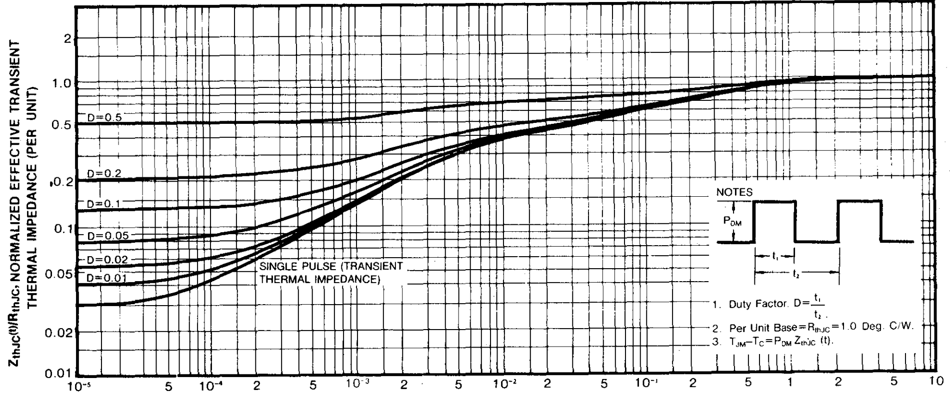
Typical Transfer Characteristics



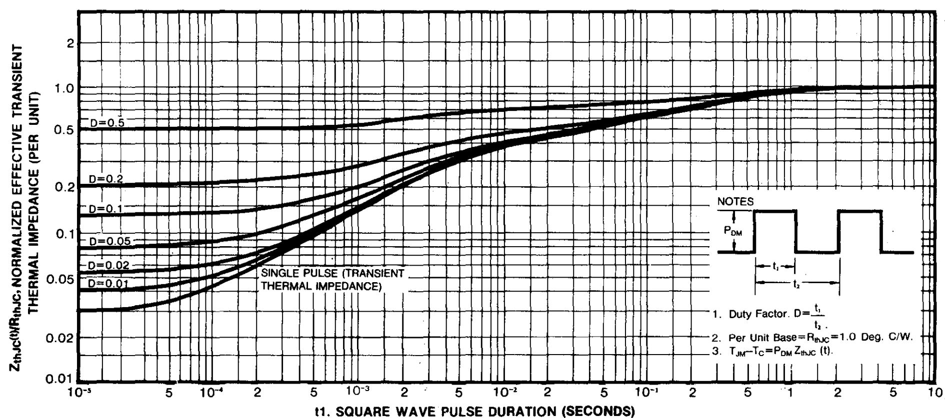
Typical Saturation Characteristics



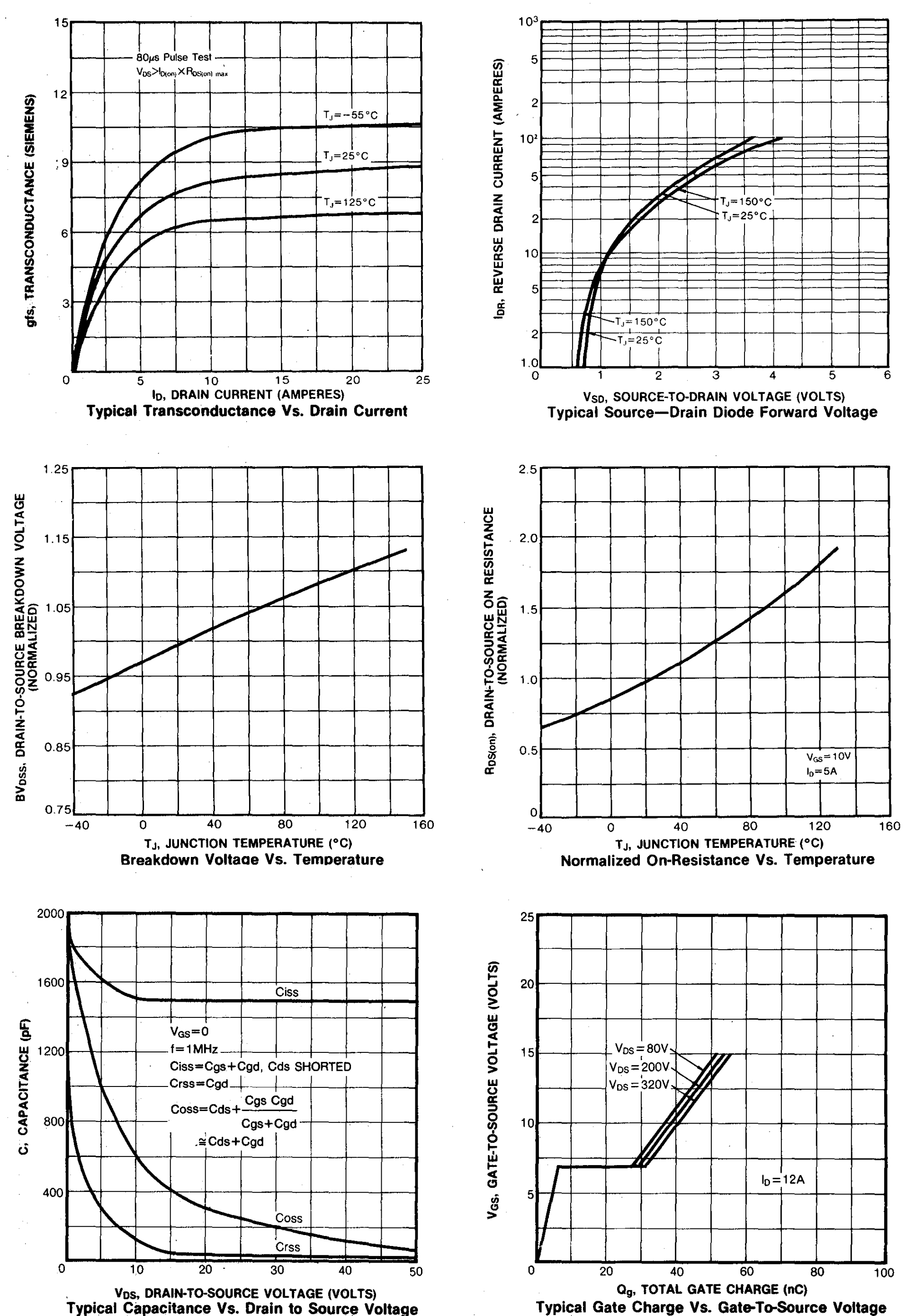
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF740-3 And IRF340-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP340-3



Typical Transconductance Vs. Drain Current

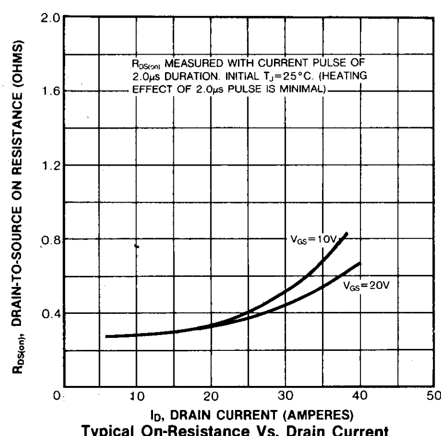
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

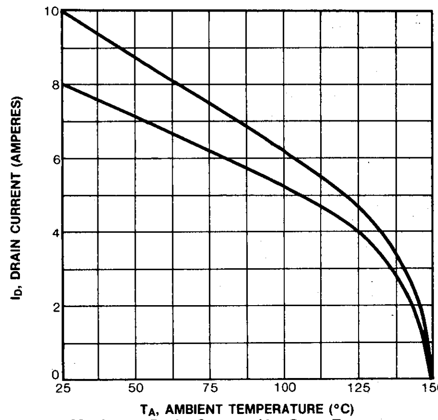
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

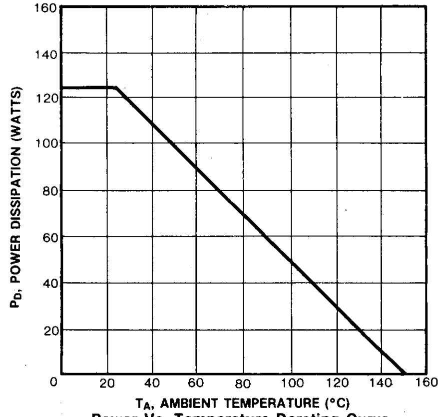
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



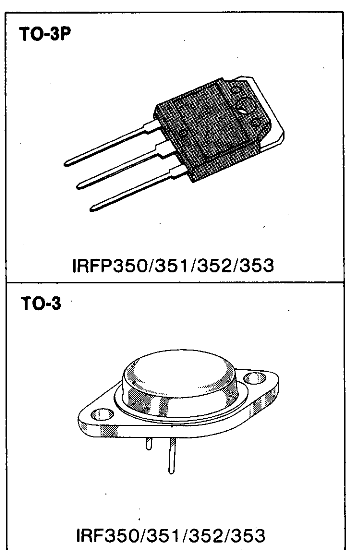
Power Vs. Temperature Derating Curve

IRFP350/351/352/353
IRF350/351/352/353

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFP350/IRF350	400V	0.3Ω	15A
IRFP351/IRF351	350V	0.3Ω	15A
IRFP352/IRF352	400V	0.4Ω	13A
IRFP353/IRF353	350V	0.4Ω	13A

MAXIMUM RATINGS

Characteristic	Symbol	IRFP350 IRF350	IRFP351 IRF351	IRFP352 IRF352	IRFP353 IRF353	Unit
Drain-Source Voltage (1)	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	15	15	13	13	Adc
Continuous Drain Current T_C=100°C	I_D	9.0	9.0	8.0	8.0	Adc
Drain Current—Pulsed (3)	I_{DM}	60	60	52	52	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	514				mJ
Avalanche Current	I_{AS}	15				A
Total Power Dissipation @ T_C=25°C Derate above 25°C (4)	P_D	150 1.4/1.2				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF350/352/IRFP350/352	400	—	—	V	V_{GS}=0V
	IRF351/353/IRFP351/353	300	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF350/351/IRFP350/351	15	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF352/353/IRFP352/353	13	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF350/351/IRFP350/351	—	0.25	0.3	Ω	V_{GS}=10V, I_D=8.0A
	IRF352/353/IRFP352/353	—	0.3	0.4	Ω	
g_{fs}	Forward Transconductance (2)	8.0	11	—	℧	V_{DS}≥50V, I_D=8.0A
C_{iss}	Input Capacitance	—	2980	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	338	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	150	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	V_{DD}=0.5BV_{DSS}, I_D=8.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	65	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	150	ns	
t_f	Fall Time	—	—	75	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	73	120	nC	V_{GS}=10V, I_D=18A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	14	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	59	—	nC	

4

THERMAL RESISTANCE

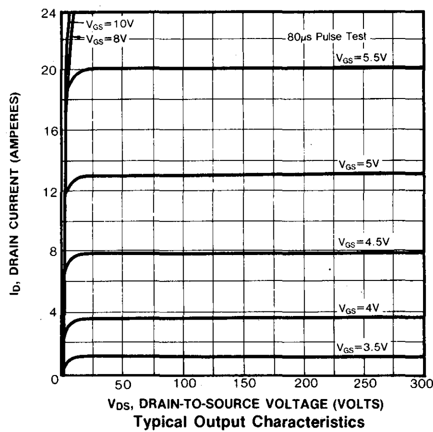
Symbol	Characteristic		IRFP350-3	IRF350-3	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.83	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

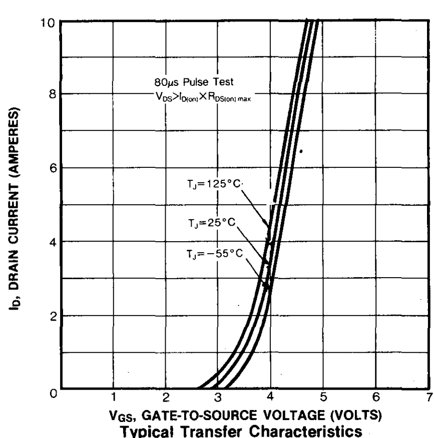
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF350/351/IRFP350/351	—	—	15	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF352/353/IRFP350/351	—	—	13	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF350/351/IRFP350/351	—	—	60	A	
	IRF352/353/IRFP352/353	—	—	52	A	
V_{SD}	Diode Forward Voltage (2) IRF350/351/IRFP350/351	—	—	1.6	V	$T_C=25°C$, $I_S=15A$, $V_{GS}=0V$
	IRF352/353/IRFP352/351	—	—	1.5	V	$T_C=25°C$, $I_S=13A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	600	1300	ns	$T_j=25°C$, $I_F=15A$, $dI_F/dt=100A/\mu S$

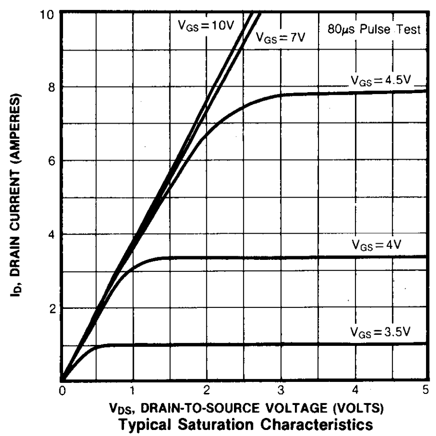
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300µs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



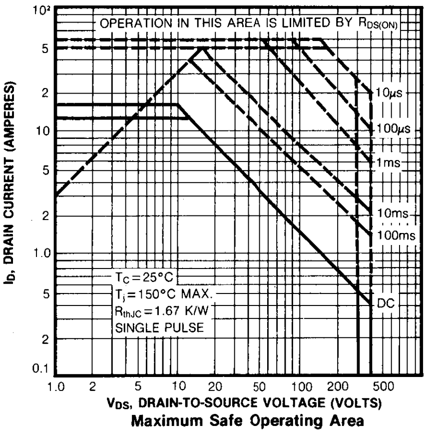
Typical Output Characteristics



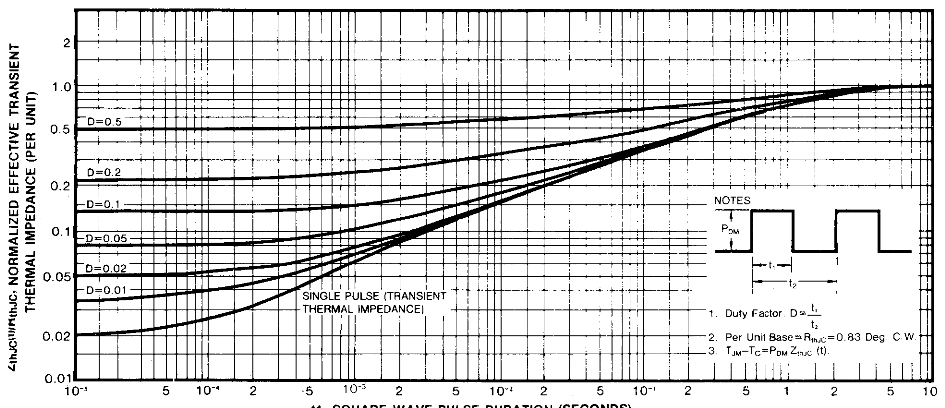
Typical Transfer Characteristics



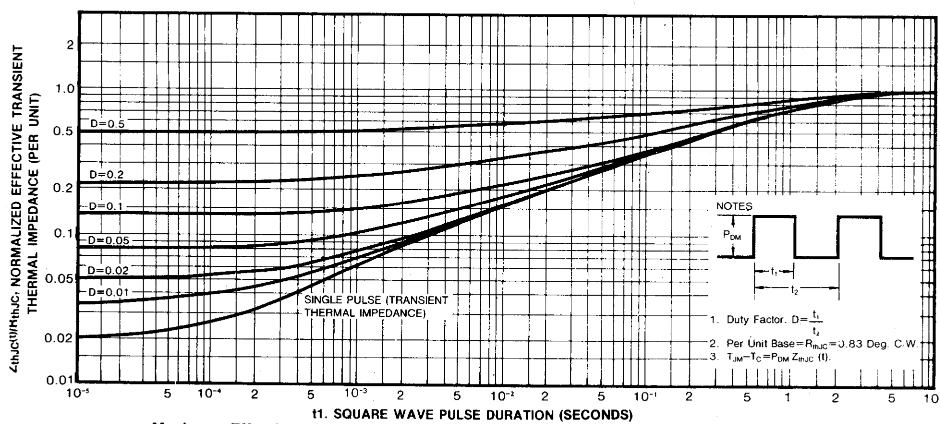
Typical Saturation Characteristics



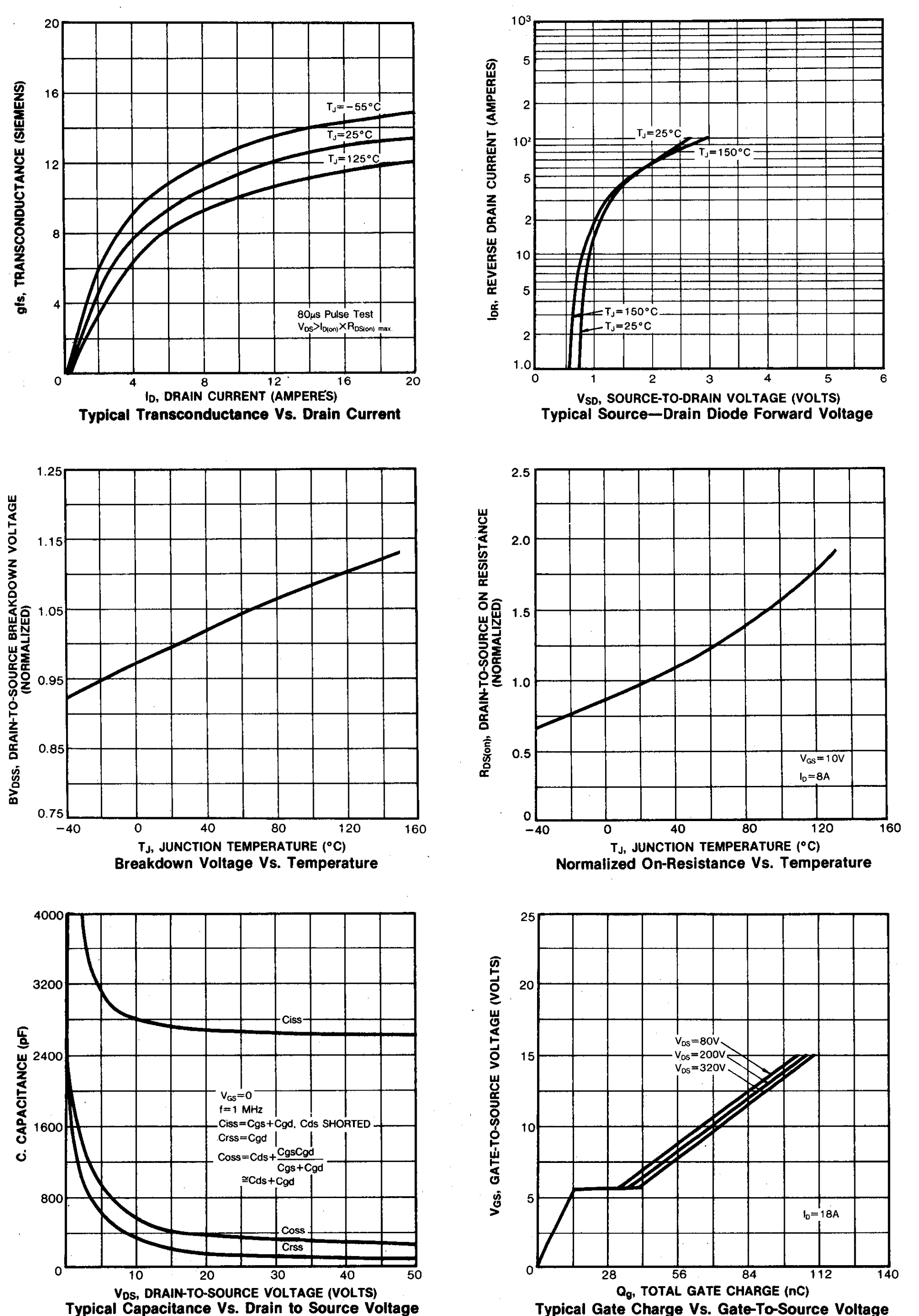
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP350-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF350-3



Typical Transconductance Vs. Drain Current

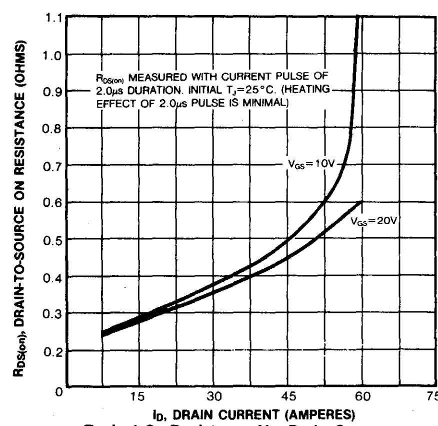
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

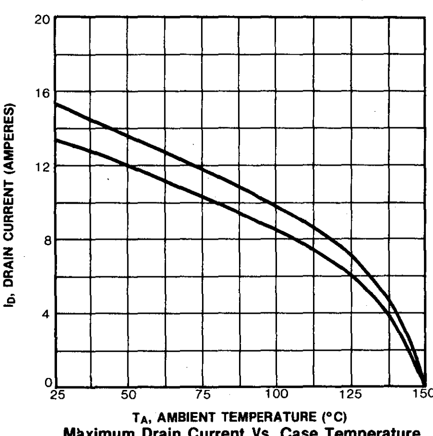
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

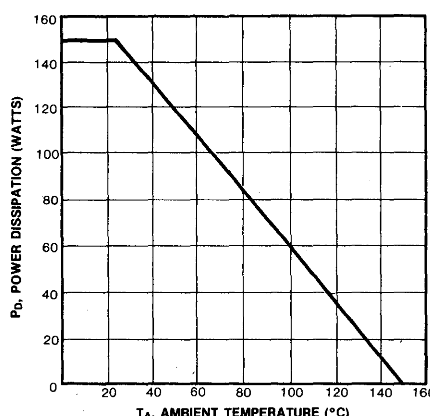
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



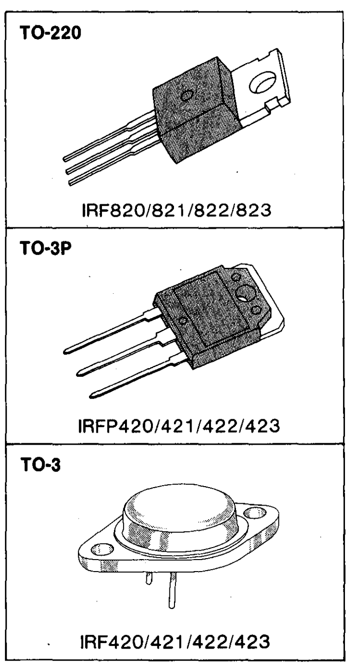
Power Vs. Temperature Derating Curve

IRF820/821/822/823
IRFP420/421/422/423
IRF420/421/422/423

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF820/IRFP420/IRF420	500V	3.0Ω	2.5A
IRF821/IRFP421/IRF421	450V	3.0Ω	2.5A
IRF822/IRFP422/IRF422	500V	4.0Ω	2.2A
IRF823/IRFP423/IRF423	450V	4.0Ω	2.2A

MAXIMUM RATINGS

Characteristics	Symbol	IRF820 IRFP420 IRF420	IRF821 IRFP421 IRF421	IRF822 IRFP422 IRF422	IRF823 IRFP423 IRF423	Unit
Drain-Source Voltage (1)	V_{DSS}	500	450	500	450	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	500	450	500	450	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	2.5	2.5	2.2	2.2	Adc
Continuous Drain Current T_C=100°C	I_D	1.6	1.6	1.4	1.4	Adc
Drain Current—Pulsed (3)	I_{DM}	8.0	8.0	7.0	7.0	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	210				mJ
Avalanche Current	I_{AS}	2.5				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	50 0.4				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=60 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS ($T_C=25°C$ unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF820/IRFP420/IRF420 IRF822/IRFP422/IRF422	500	—	—	V	$V_{GS}=0V$ $I_D=250\mu A$
	IRF821/IRFP421/IRF421 IRF823/IRFP423/IRF423	450	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, $I_D=250\mu A$
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	$V_{GS}=20V$
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	$V_{GS}=-20V$
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating $V_{GS}=0V$
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, $V_{GS}=0V$, $T_C=125°C$
$I_{D(on)}$	On-State Drain-Source Current (2) IRF820/IRFP420/IRF420 IRF821/IRFP421/IRF421	2.5	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max.}$ $V_{GS}=10V$
	IRF822/IRFP422/IRF422 IRF823/IRFP423/IRF423	2.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF820/IRFP420/IRF420 IRF821/IRFP421/IRF421	—	2.5	3.0	Ω	$V_{GS}=10V$, $I_D=1.4A$
	IRF822/IRFP422/IRF422 IRF823/IRFP423/IRF423	—	3.0	4.0	Ω	
g_{fs}	Forward Transconductance (2)	1.5	2.3	—	℧	$V_{DS}\geqslant 50V$, $I_D=1.4A$
C_{iss}	Input Capacitance	—	390	—	pF	$V_{GS}=0V$, $V_{DS}=25V$, f=1.0MHz
C_{oss}	Output Capacitance	—	52	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	22	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	10	15	ns	$V_{DD}=0.5BV_{DSS}$, $I_D=2.5A$, $Z_O=18\Omega$ (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	12	18	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	28	42	ns	
t_f	Fall Time	—	12	18	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	13	19	nC	$V_{GS}=10V$, $I_D=2.5A$, $V_{DS}=0.8$ Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.2	3.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	6.8	10	nC	

THERMAL RESISTANCE

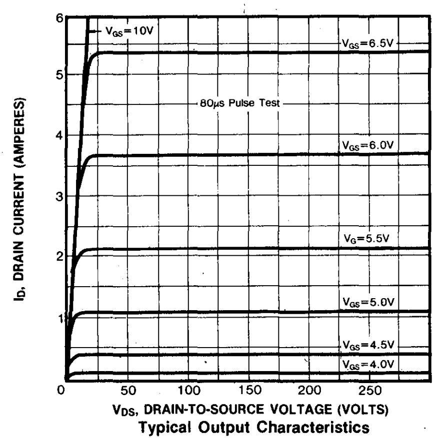
Symbol	Characteristic		IRF820-3	IRFP420-3	IRF420-3	Unit	
R_{thJC}	Junction-to-Case	MAX	2.5	2.5	2.5	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) $T_J=25°C$ to 150°C
(2) Pulse test: Pulse width⩽300μs, Duty Cycle⩽2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

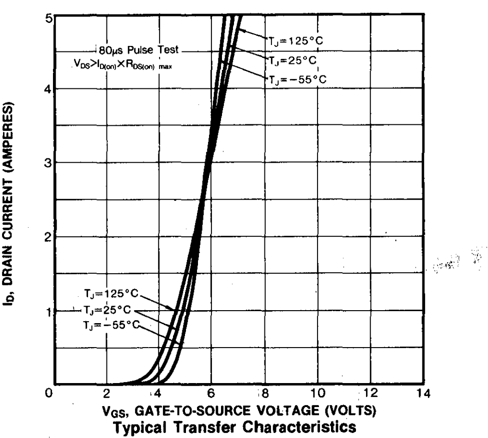
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF820/IRFP420/IRF420 IRF821/IRFP421/IRF421	—	—	2.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF822/IRFP422/IRF422 IRF823/IRFP423/IRF423	—	—	2.2	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF820/IRFP420/IRF420 IRF821/IRFP421/IRF421	—	—	8.0	A	
	IRF822/IRFP422/IRF422 IRF823/IRFP423/IRF423	—	—	7.0	A	
V_{SD}	Diode Forward Voltage (2) IRF820/IRFP420/IRF420 IRF821/IRFP421/IRF421	—	—	1.6	V	T_C=25°C, I_S=2.5A, V_{GS}=0V
	IRF822/IRFP422/IRF422 IRF823/IRFP423/IRF423	—	—	1.5	V	T_C=25°C, I_S=2.2A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	270	540	ns	T_j=25°C, I_F=2.5A, dI_F/dt=100A/μS

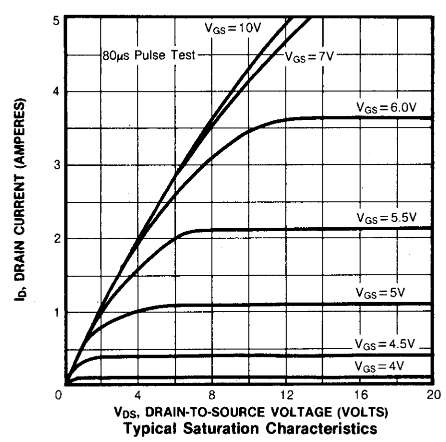
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



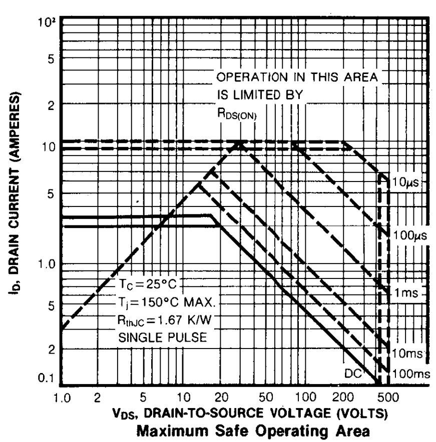
Typical Output Characteristics



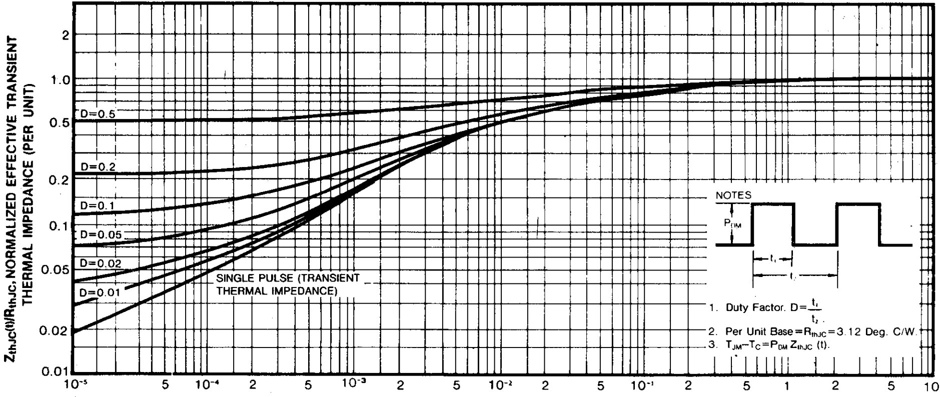
Typical Transfer Characteristics



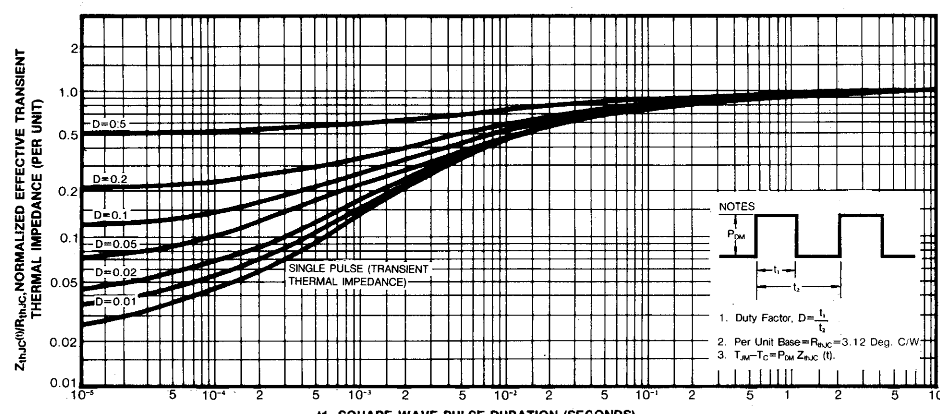
Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF820-3 And IRF420-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP420-3

Typical Transconductance Vs. Drain Current

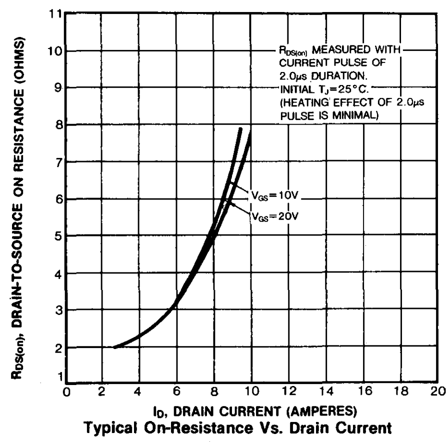
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

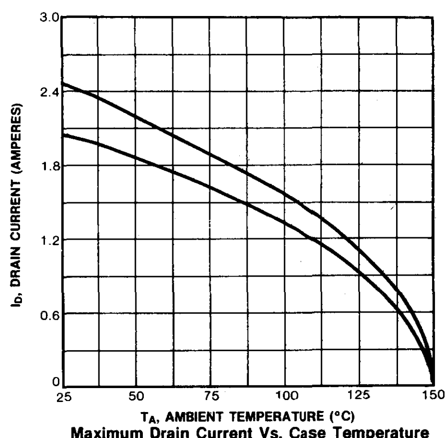
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

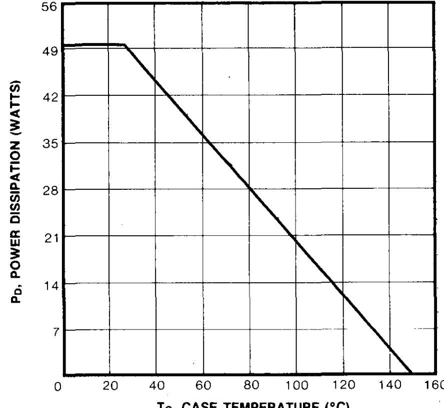
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

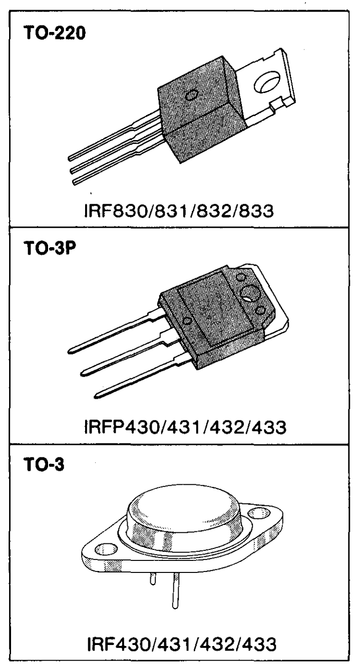
4

IRF830/831/832/833
IRFP430/431/432/433
IRF430/431/432/433

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF830/IRFP430/IRF430	500V	1.5Ω	4.5A
IRF831/IRFP431/IRF431	450V	1.5Ω	4.5A
IRF832/IRFP432/IRF432	500V	2.0Ω	4.0A
IRF833/IRFP433/IRF433	450V	2.0Ω	4.0A

MAXIMUM RATINGS

Characteristics	Symbol	IRF830 IRFP430 IRF430	IRF831 IRFP431 IRF431	IRF832 IRFP432 IRF432	IRF833 IRFP433 IRF433	Unit
Drain-Source Voltage (1)	V_{DSS}	500	450	500	450	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	500	450	500	450	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	4.5	4.5	4.0	4.0	Adc
Continuous Drain Current T_C=100°C	I_D	3.0	3.0	2.5	2.5	Adc
Drain Current—Pulsed (3)	I_{DM}	18	18	16	16	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy(4)	E_{AS}	280				mJ
Avalanche Current	I_{AS}	4.5				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=25 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF830/IRFP430/IRF430 IRF832/IRFP432/IRF432	500	—	—	V	V_{GS}=0V I_D=250μA
	IRF831/IRFP431/IRF431 IRF833/IRFP433/IRF433	450	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF830/IRFP430/IRF430 IRF831/IRFP431/IRF431	4.5	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRF832/IRFP432/IRF432 IRF833/IRFP433/IRF433	4.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF830/IRFP430/IRF430 IRF831/IRFP431/IRF431	—	0.95	1.5	Ω	V_{GS}=10V, I_D=2.5A
	IRF832/IRFP432/IRF432 IRF833/IRFP433/IRF433	—	1.4	2.0	Ω	
g_{fs}	Forward Transconductance (2)	2.5	3.2	—	℧	V_{DS}≥50V, I_D=2.5A
C_{iss}	Input Capacitance	—	780	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	86	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	38	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	11	17	ns	V_{DD}=0.5BV_{DSS}, I_D=4.5A, Z_O=12Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	15	23	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	35	53	ns	
t_f	Fall Time	—	15	23	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	21	32	nC	V_{GS}=10V, I_D=4.5A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	3.2	4.8	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	11	17	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRF830-3	IRFP430-3	IRF430-3	Unit	
R_{thJC}	Junction-to-Case	MAX.	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.50	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

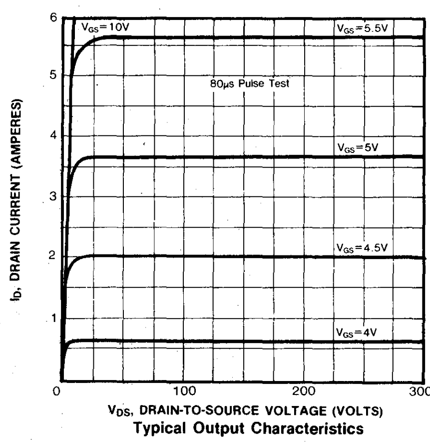
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

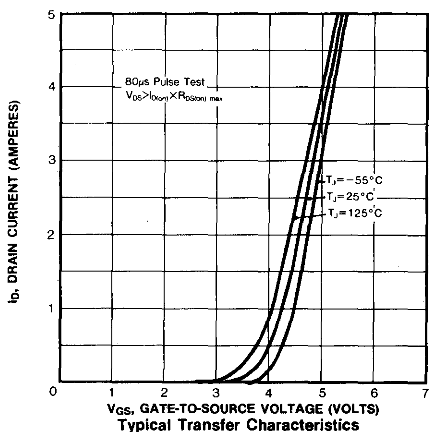
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF830/IRFP430/IRF430 IRF831/IRFP431/IRF431	—	—	4.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF832/IRFP432/IRF432 IRF833/IRFP433/IRF433	—	—	4.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF830/IRFP430/IRF430 IRF831/IRFP431/IRF431	—	—	18	A	
	IRF832/IRFP432/IRF432 IRF833/IRFP433/IRF433	—	—	16	A	
V_{SD}	Diode Forward Voltage (2) IRF830/IRFP430/IRF430 IRF831/IRFP431/IRF431	—	—	1.6	V	T_C=25°C, I_S=4.5A, V_{GS}=0V
	IRF832/IRFP432/IRF432 IRF833/IRFP433/IRF433	—	—	1.5	V	T_C=25°C, I_S=4.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	370	760	ns	T_j=25°C, I_F=4.5A, dI_F/dt=100A/μS

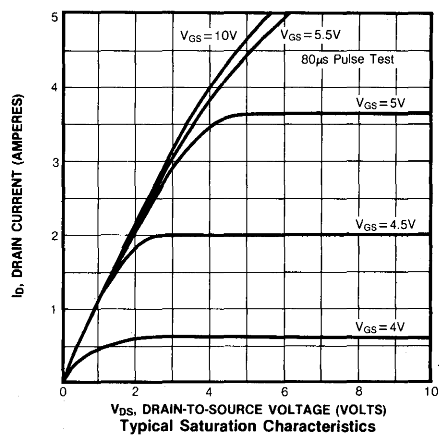
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



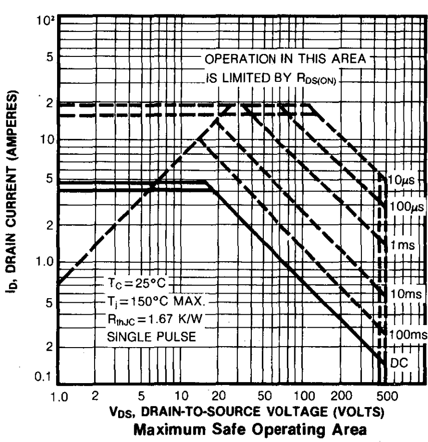
Typical Output Characteristics



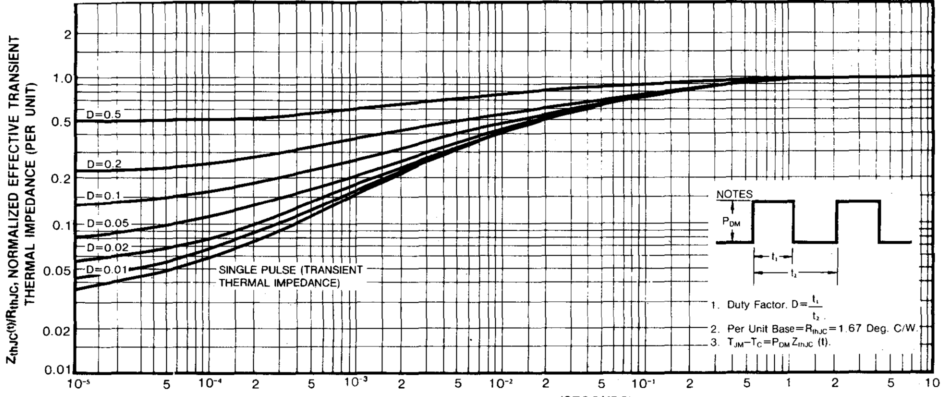
Typical Transfer Characteristics



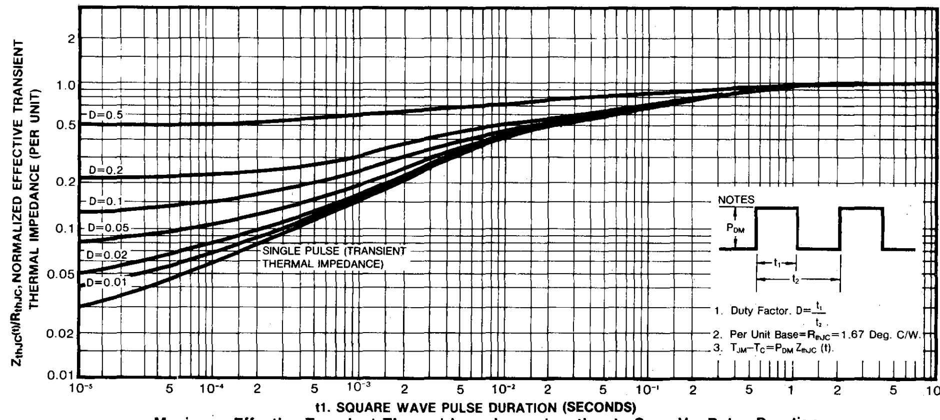
Typical Saturation Characteristics



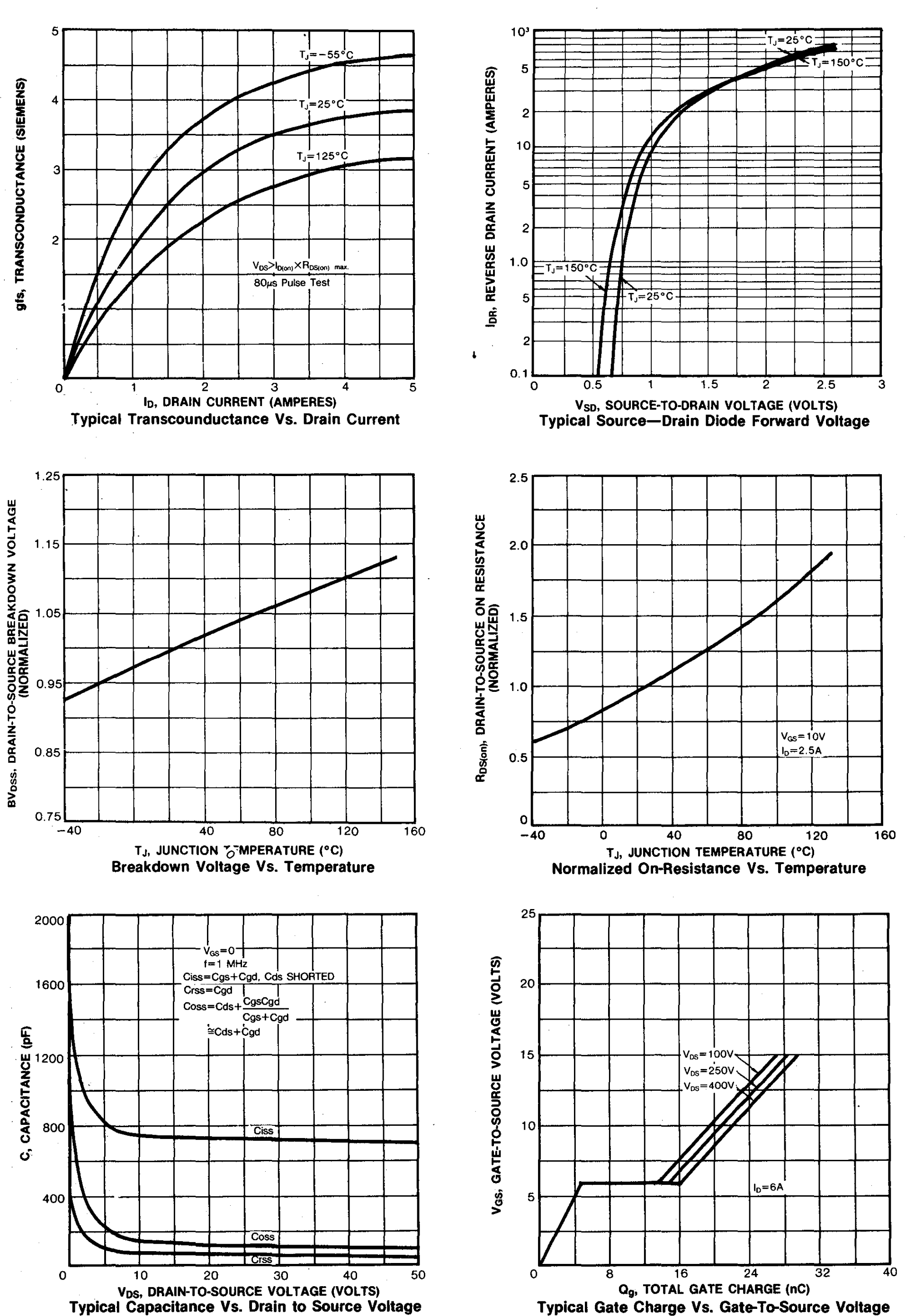
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF830-3 And IRF430-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP430-3



Typical Transcounductance Vs. Drain Current

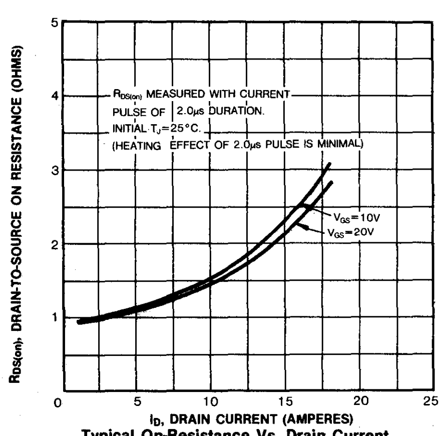
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

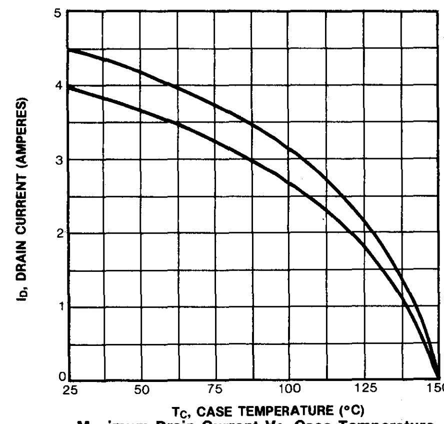
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

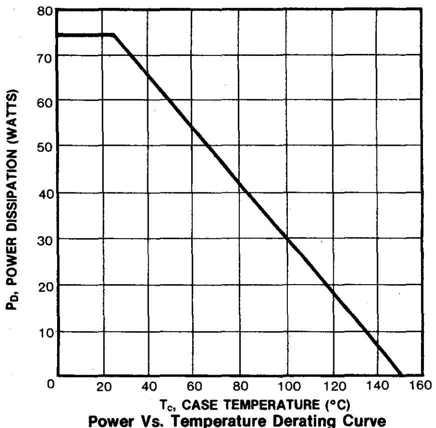
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

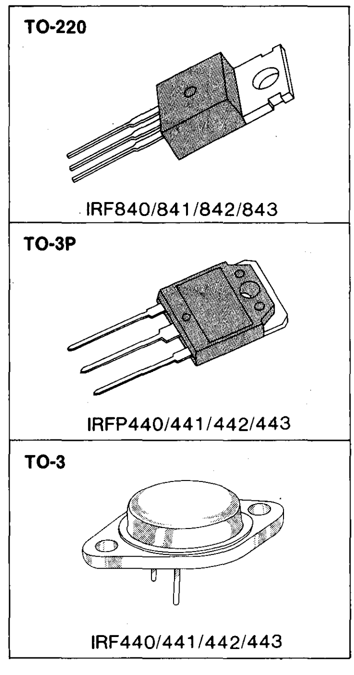
4

IRF840/841/842/843
IRFP440/441/442/443
IRF440/441/442/443

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF840/IRFP440/IRF440	500V	0.85Ω	8.0A
IRF841/IRFP441/IRF441	450V	0.85Ω	8.0A
IRF842/IRFP442/IRF442	500V	1.10Ω	7.0A
IRF843/IRFP443/IRF443	450V	1.10Ω	7.0A

MAXIMUM RATINGS

Characteristics	Symbol	IRF840 IRFP440 IRF440	IRF841 IRFP441 IRF441	IRF842 IRFP442 IRF442	IRF843 IRFP443 IRF443	Unit
Drain-Source Voltage (1)	V_{DSS}	500	450	500	450	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	500	450	500	450	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	8.0	8.0	7.0	7.0	Adc
Continuous Drain Current T_C=100°C	I_D	5.0	5.0	4.0	4.0	Adc
Drain Current—Pulsed (3)	I_{DM}	32	32	28	28	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	510				mJ
Avalanche Current	I_{AS}	8.0				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.44 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF840/IRFP440/IRF440 IRF842/IRFP442/IRF442	500	—	—	V	V_{GS}=0V I_D=250μA
	IRF841/IRFP441/IRF441 IRF843/IRFP443/IRF443	450	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF840/IRFP440/IRF440 IRF841/IRFP441/IRF441	8.0	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max.}$ V_{GS}=10V
	IRF842/IRFP442/IRF442 IRF843/IRFP443/IRF443	7.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF840/IRFP440/IRF440 IRF841/IRFP441/IRF441	—	0.76	0.85	Ω	V_{GS}=10V, I_D=4.0A
	IRF842/IRFP442/IRF442 IRF843/IRFP443/IRF443	—	0.85	1.1	Ω	
g_{fs}	Forward Transconductance (2)	4.0	6.5	—	℧	V_{DS}≥50V, I_D=4.0A
C_{iss}	Input Capacitance	—	1510	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	154	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	66	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	14	21	ns	$V_{DD}=0.5BV_{DSS}$, I_D=8.0A, Z_O=19Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	23	35	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	49	74	ns	
t_f	Fall Time	—	20	30	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	42	63	nC	V_{GS}=10V, I_D=8.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	6.2	9.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	22	32	nC	

THERMAL RESISTANCE

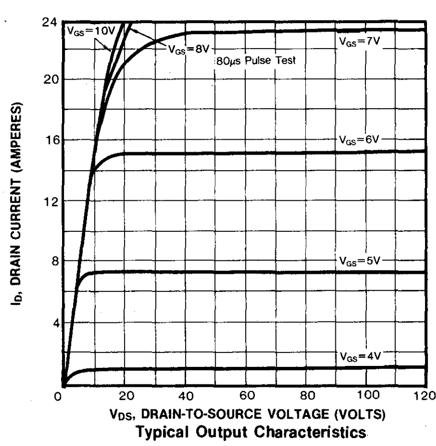
Symbol	Characteristic		IRF840-3	IRFP440-3	IRF440-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

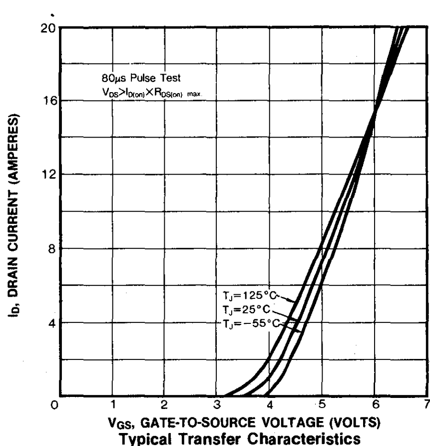
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF840/IRFP440/IRF440 IRF841/IRFP441/IRF441	—	—	8.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF842/IRFP442/IRF442 IRF843/IRFP443/IRF443	—	—	7.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF840/IRFP440/IRF440 IRF841/IRFP441/IRF441	—	—	32	A	
	IRF842/IRFP442/IRF442 IRF843/IRFP443/IRF443	—	—	28	A	
V_{SD}	Diode Forward Voltage (2) IRF840/IRFP440/IRF440 IRF841/IRFP441/IRF441	—	—	2.0	V	T_C=25°C, I_S=8.0A, V_{GS}=0V
	IRF842/IRFP442/IRF442 IRF843/IRFP443/IRF443	—	—	1.9	V	T_C=25°C, I_S=7.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	460	970	ns	T_j=25°C, I_F=8.0A, dI_F/dt=100A/μS

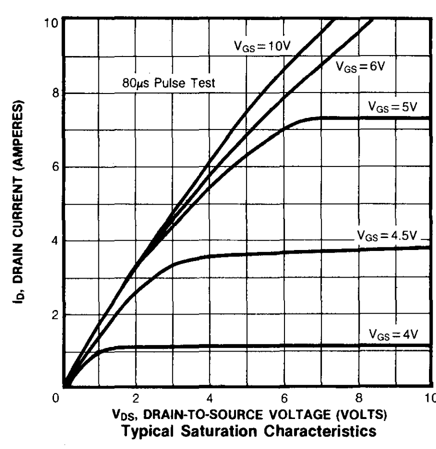
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



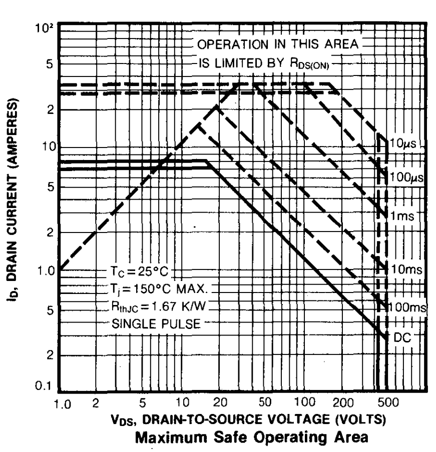
Typical Output Characteristics



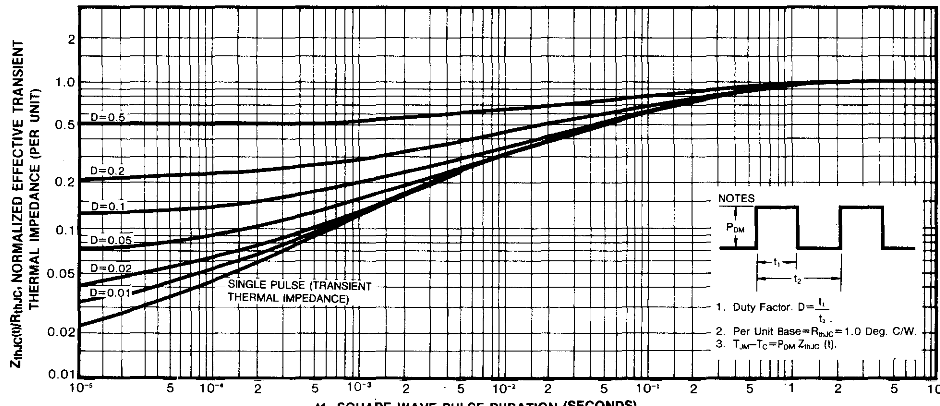
Typical Transfer Characteristics



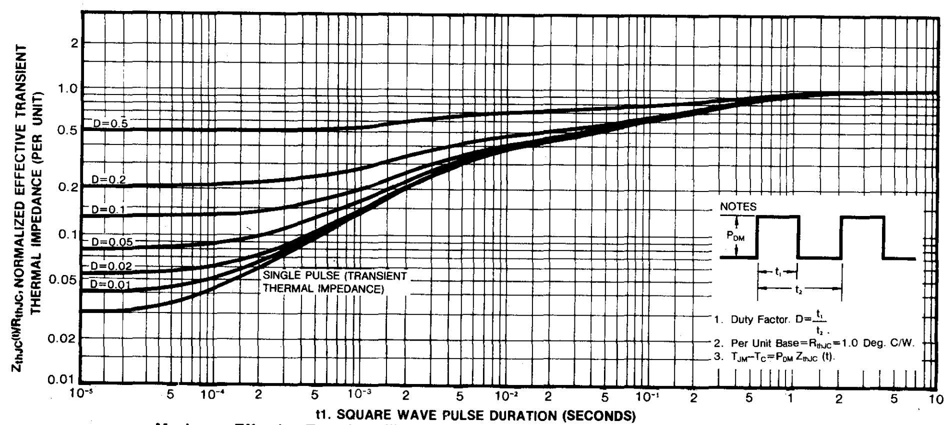
Typical Saturation Characteristics



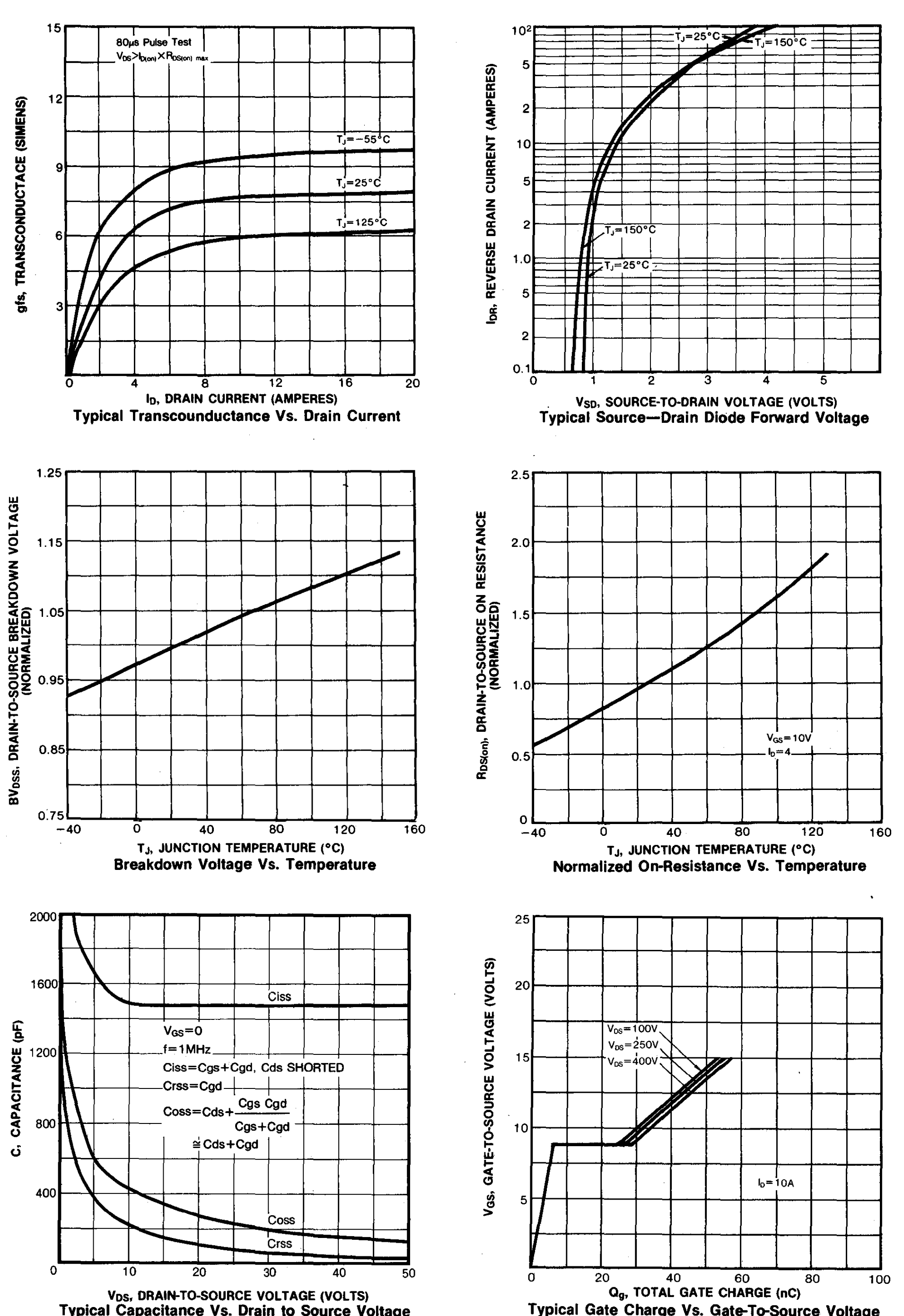
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration
For IRF840-3 For IRF440-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration
For IRFP440-3



Typical Transcounductance Vs. Drain Current

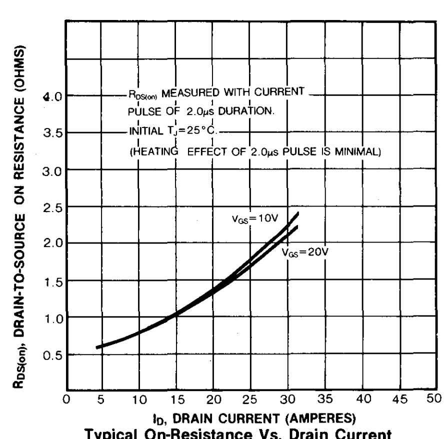
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

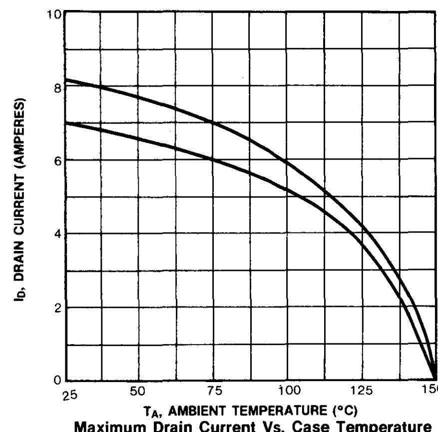
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

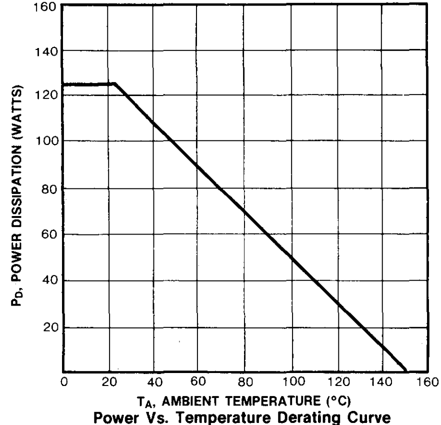
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

4

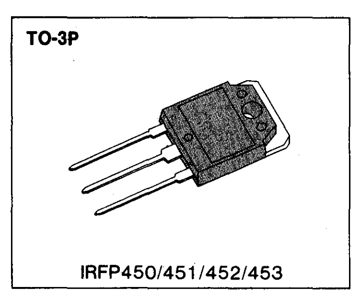
IRFP450/451/452/453

N-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS\ (ON)}$**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**

TO-3P



IRFP450/451/452/453

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFP450	500V	0.4Ω	14A
IRFP451	450V	0.4Ω	14A
IRFP452	500V	0.5Ω	12A
IRFP453	450V	0.5Ω	12A

MAXIMUM RATINGS

Characteristic	Symbol	IRFP450	IRFP451	IRFP452	IRFP453	Unit
Drain-Source Voltage (1)	V_{DSS}	500	450	500	450	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	500	450	500	450	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	14	14	12	12	Adc
Continuous Drain Current T_C=100°C	I_D	8.8	8.8	7.9	7.9	Adc
Drain Current—Pulsed (3)	I_{DM}	56	56	48	48	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy	E_{AS}	760				mJ
Avalanche Current	I_{AS}	14				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	180 1.4				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=7.0mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C.

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFP450/452	500	—	—	V	V_{GS}=0V
	IRFP451/453	450	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFP450/451	14	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFP452/453	12	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFP450/451	—	0.35	0.4	Ω	V_{GS}=10V, I_D=7.9A
	IRFP452/453	—	0.4	0.5	Ω	
g_{fs}	Forward Transconductance (2)	9.3	10.8	—	℧	V_{DS}≥50V, I_D=7.9A
C_{iss}	Input Capacitance	—	2950	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	290	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	118	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	V_{DD}=0.5BV_{DSS}, I_D=13A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	50	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	150	ns	
t_f	Fall Time	—	—	70	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	77	120	nC	V_{GS}=10V, I_D=13A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	11	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	60	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRFP450-3	Unit	
R_{thJC}	Junction-to-Case	MAX	0.70	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	K/W	Free Air Operation

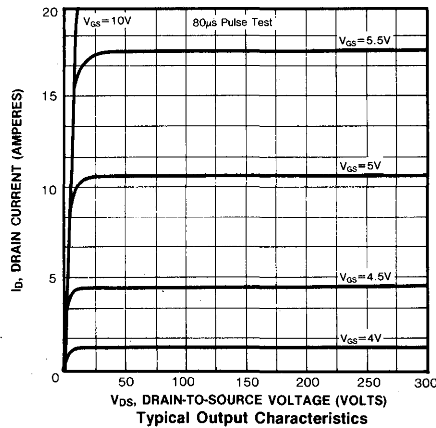
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

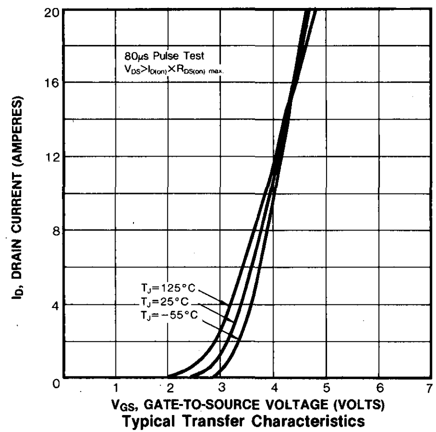
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF450/451/IRFP450/451	—	—	14	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF452/453/IRFP450/451	—	—	12	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF450/451/IRFP450/451	—	—	56	A	
	IRF452/453/IRFP452/453	—	—	48	A	
V_{SD}	Diode Forward Voltage (2) IRF450/451/IRFP450/451	—	—	1.4	V	$T_C=25°C$, $I_S=14A$, $V_{GS}=0V$
	IRF452/453/IRFP452/453	—	—	1.3	V	$T_C=25°C$, $I_S=12A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	580	1200	ns	$T_j=25°C$, $I_F=13A$, $dI_F/dt=100A/\mu S$

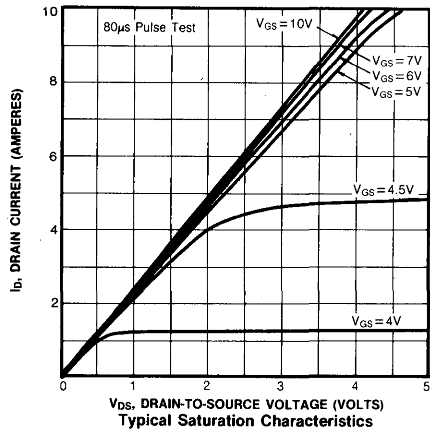
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



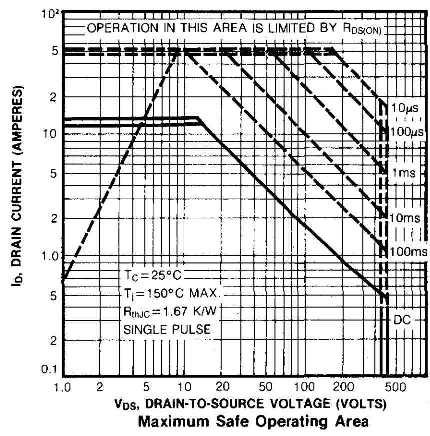
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Output Characteristics



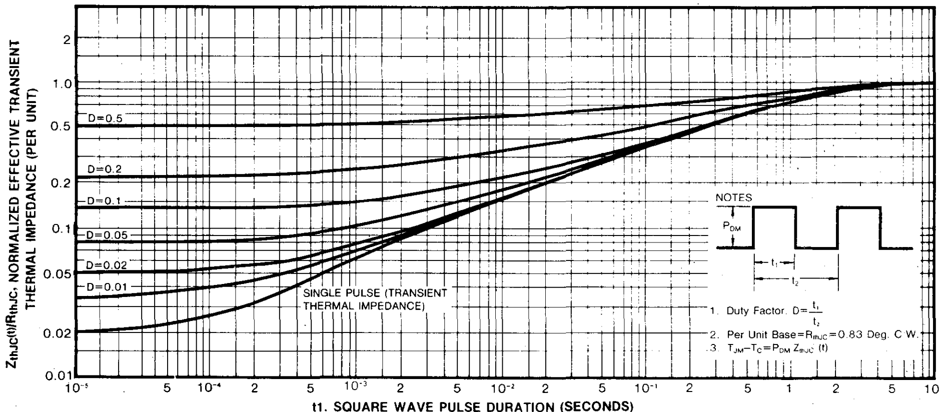
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
Typical Transfer Characteristics



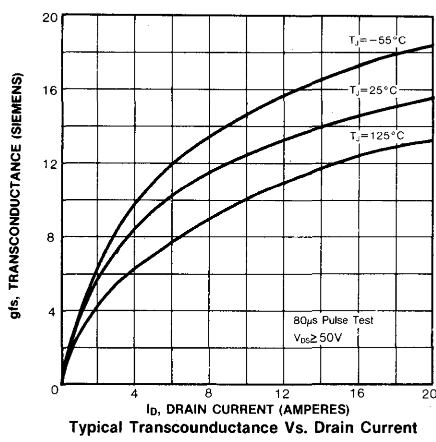
Typical Saturation Characteristics



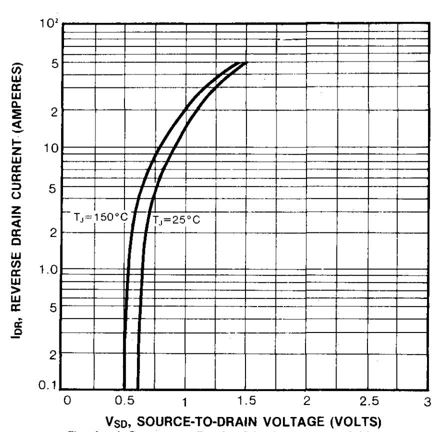
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP450-3



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

V_{GS}=10V
I_D=7A

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

V_{GS}=0
f=1 MHz
Ciss=Cgs+Cgd,
Crss=Cgd
$Coss=Cds+\frac{CgsCgd}{Cgs+Cgd}$
≅Cds+Cgd

Ciss
Coss
Crss

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

V_{DS}=100V
V_{DS}=250V
V_{DS}=400V
I_D=16A

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

V_{GS}=10V
V_{GS}=20V

$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL T_J=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

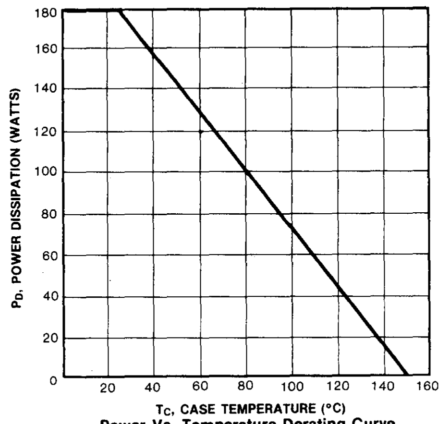
I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

I_D, DRAIN CURRENT (AMPERES)

T_C, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

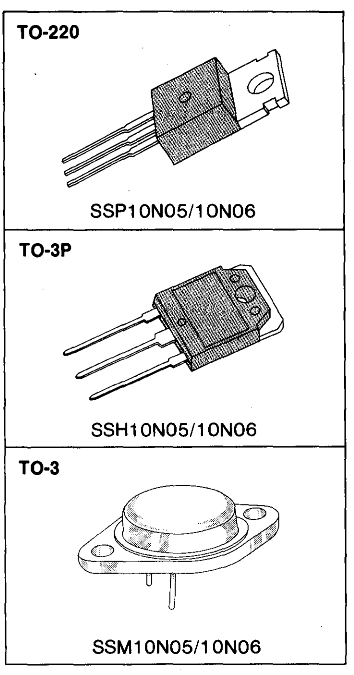
4

SSP10N05/10N06
SSH10N05/10N06
SSM10N05/10N06

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP10N05/SSH10N05/ SSM10N05	50V	0.28Ω	10A
SSP10N06/SSH10N06/ SSM10N06	60V	0.28Ω	10A

MAXIMUM RATINGS

Characteristic	Symbol	SSP10N05 SSH10N05 SSM10N05	SSP10N06 SSH10N06 SSM10N06	Unit
Drain-Source Voltage (1)	V_{DSS}	50	60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	50	60	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	10	10	Adc
Continuous Drain Current T_C=100°C	I_D	6	6	Adc
Drain Current—Pulsed (3)	I_{DM}	28	28	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	35.2		mJ
Avalanche Current	I_{AS}	10		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.53 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

SSP10N05/10N06
SSH10N05/10N06
SSM10N05/10N06

N-CHANNEL POWER MOSFETS

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP10N05/SSH10N05/ SSM10N05	50	—	—	V	V_{GS}=0V I_D=250μA
	SSP10N06/SSH10N06/ SSM10N06	60	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	$V_{DS}=V_{GS}$, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	10	—	—	A	$V_{DS}>I_{D(on)}\times R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.28	Ω	V_{GS}=10V, I_D=5.0A
g_{fs}	Forward Transconductance (2)	2.5	—	—	℧	V_{DS}≥50V, I_D=5.0A
C_{iss}	Input Capacitance	—	—	400	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	350	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	100	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=5.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	120	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	50	ns	
t_f	Fall Time	—	—	60	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	13	26	nC	V_{GS}=10V, I_D=10A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	6.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7.0	—	nC	

THERMAL RESISTANCE

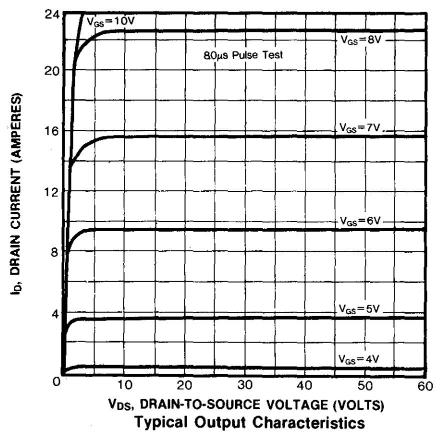
Symbol	Characteristic		SSP10N05/06	SSH10N05/06	SSM10N05/06	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	62.5	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

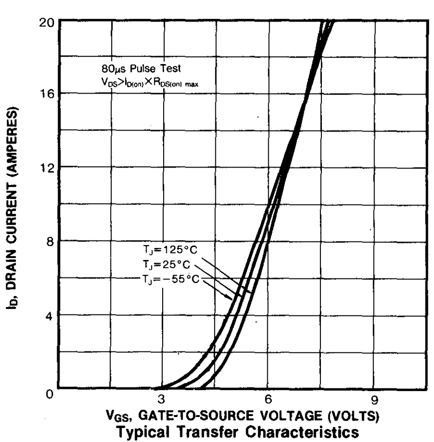
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	10	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	28	A	
V_{SD}	Diode Forward Voltage (2)	—	1.7	3.0	V	T_C=25°C, I_S=10.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	—	ns	T_j=150°C, I_F=10.0A, dI_F/dt=100A/μS

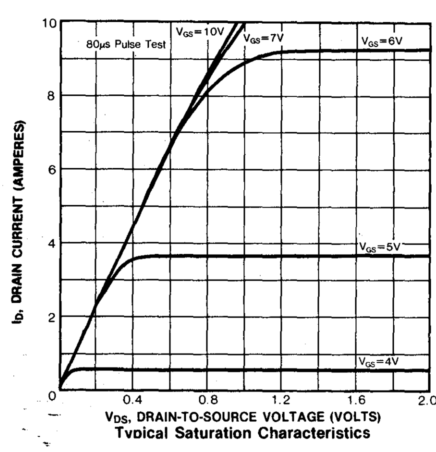
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



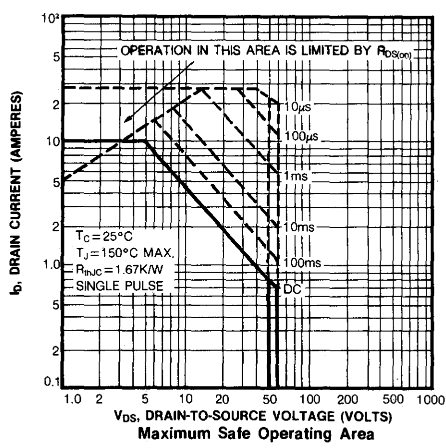
Typical Output Characteristics



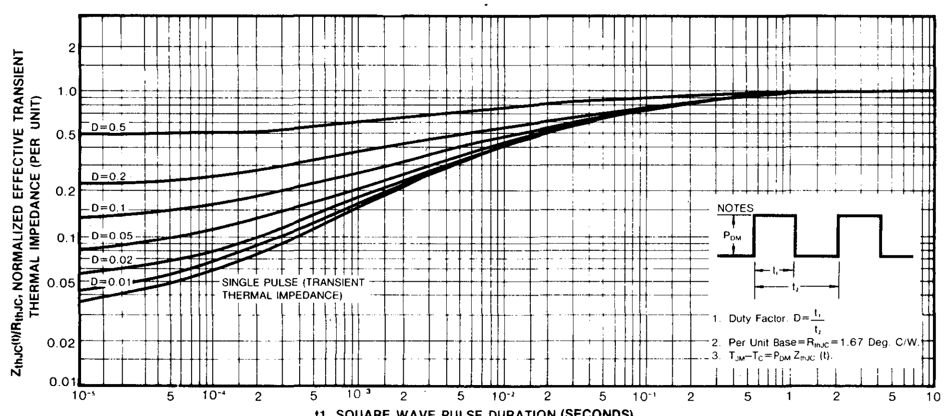
Typical Transfer Characteristics



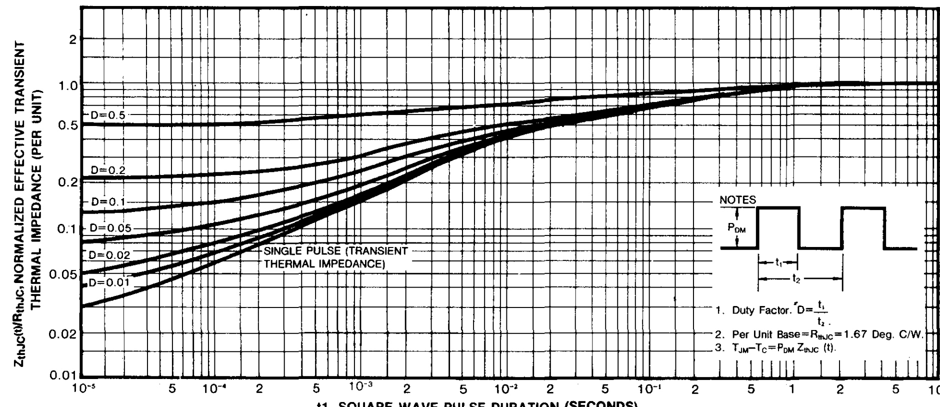
Typical Saturation Characteristics



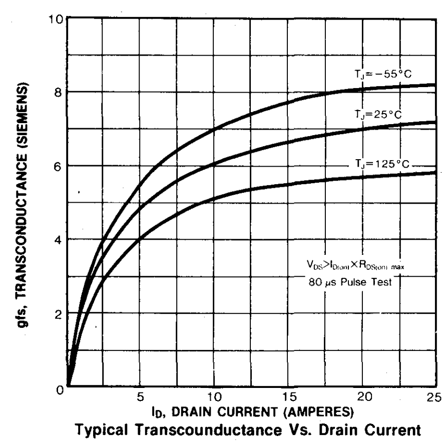
Maximum Safe Operating Area



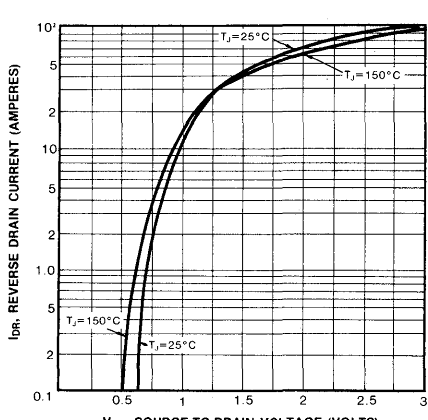
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP10N05/06 And SSM10N05/06



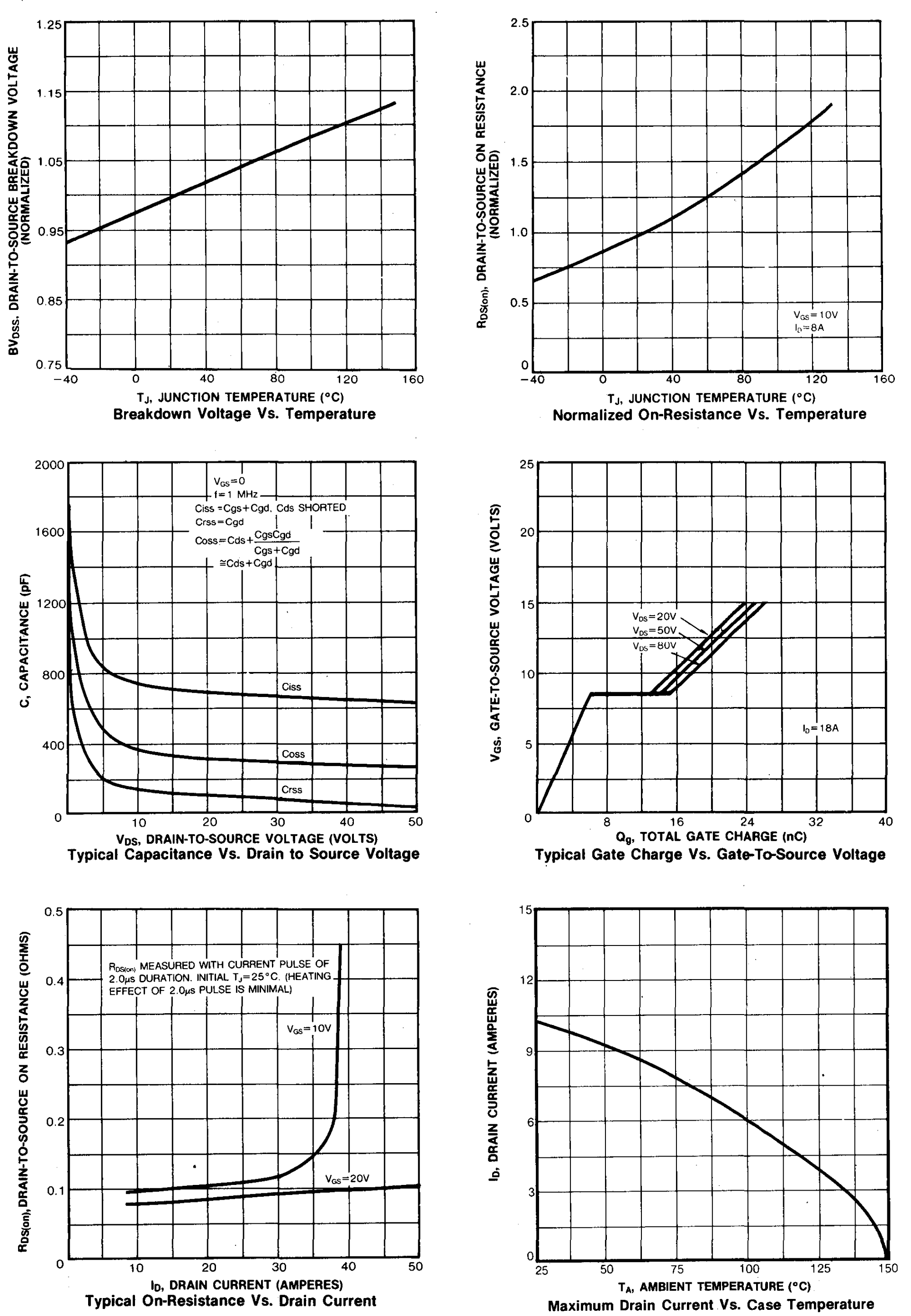
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH10N05/06

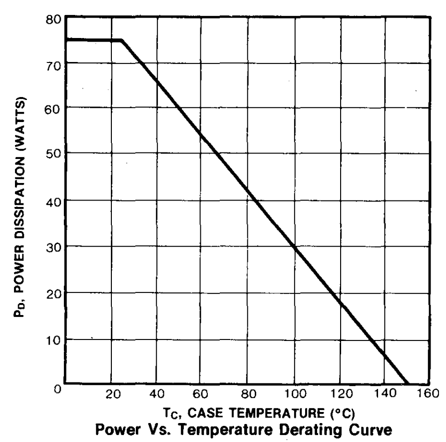


Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

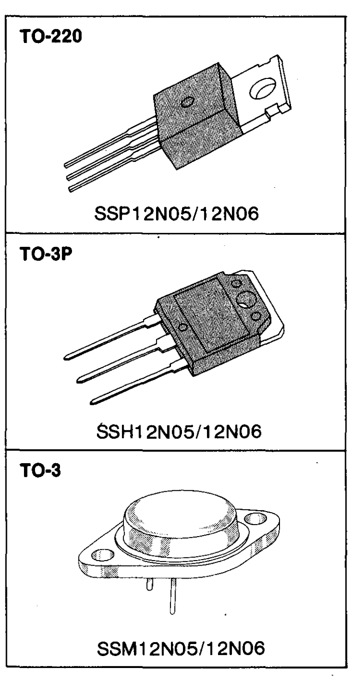

BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=8A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss=Cds+CgsCgd/(Cgs+Cgd)
≅Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS=20V
VDS=50V
VDS=80V
ID=18A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
RDS(on) MEASURED WITH CURRENT PULSE OF 2.0µs DURATION. INITIAL TJ=25°C. (HEATING EFFECT OF 2.0µs PULSE IS MINIMAL)
VGS=10V
VGS=20V
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

SSP12N05/12N06
SSH12N05/12N06
SSM12N05/12N06

N-CHANNEL POWER MOSFETS



FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP12N05/SSH12N05/ SSM12N05	50V	0.2Ω	12.0A
SSP12N06/SSH12N06/ SSM12N06	60V	0.2Ω	12.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP12N05 SSH12N05 SSM12N05	SSP12N06 SSH12N06 SSM12N06	Unit
Drain-Source Voltage (1)	V_{DSS}	50	60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	50	60	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	12	12	Adc
Continuous Drain Current T_C=100°C	I_D	7	7	Adc
Drain Current—Pulsed (3)	I_{DM}	30	30	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	51		mJ
Avalanche Current	I_{AS}	12		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.53 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP12N05/SSH12N05/ SSM12N05	50	—	—	V	V_{GS}=0V I_D=250μA
	SSP12N06/SSH12N06/ SSM12N06	60	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	12	—	—	A	V_{DS}>$I_{D(on)}$×$R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.2		V_{GS}=10V, I_D=6.0A
g_{fs}	Forward Transconductance (2)	4.0	—	—	℧	V_{DS}≥50V, I_D=6.0A
C_{iss}	Input Capacitance	—	—	400	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	300	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	100	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	60	ns	V_{DD}=0.5BV_{DSS}, I_D=6.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	160	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	80	ns	
t_f	Fall Time	—	—	110	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	13	26	nC	V_{GS}=10V, I_D=12A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	6.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7.0	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP12N05/06	SSH12N05/06	SSM12N05/06	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	62.5	40	30	K/W	Free Air Operation

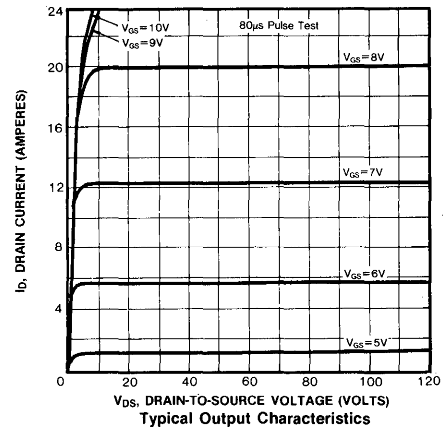
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

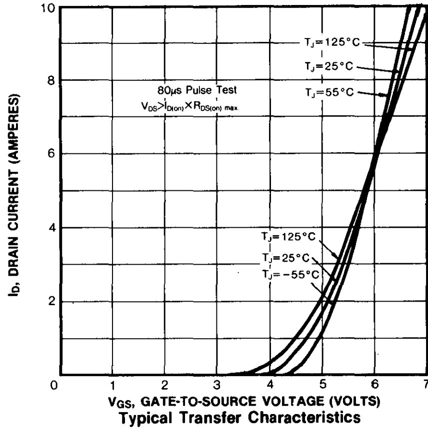
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	12	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	30	A	
V_{SD}	Diode Forward Voltage (2)	—	1.8	3.2	V	T_C=25°C, I_S=12.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	—	ns	T_j=150°C, I_F=12.0A, dI_F/dt=100A/μS

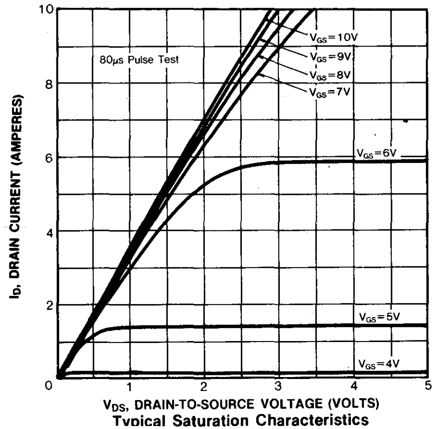
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



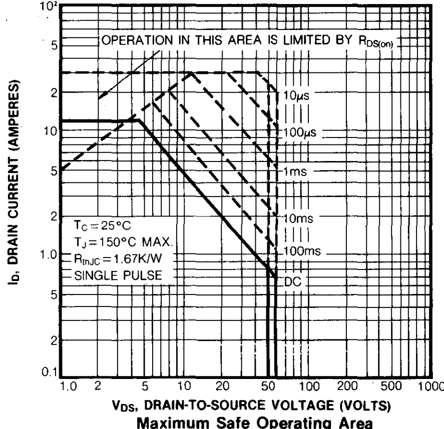
Typical Output Characteristics



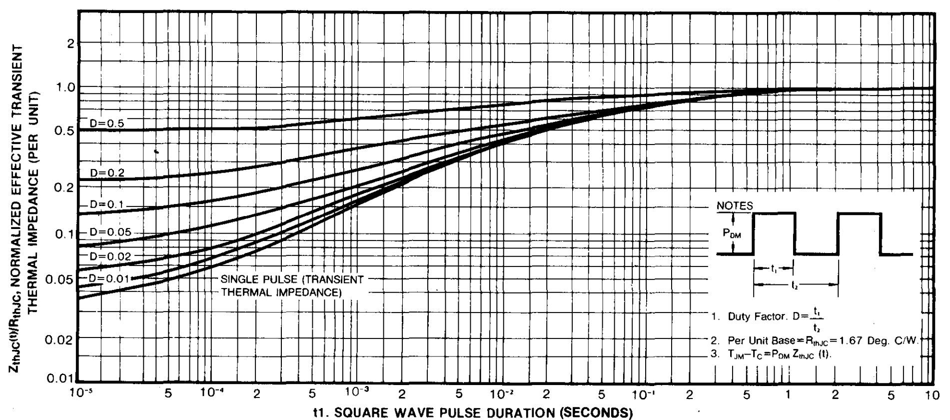
Typical Transfer Characteristics



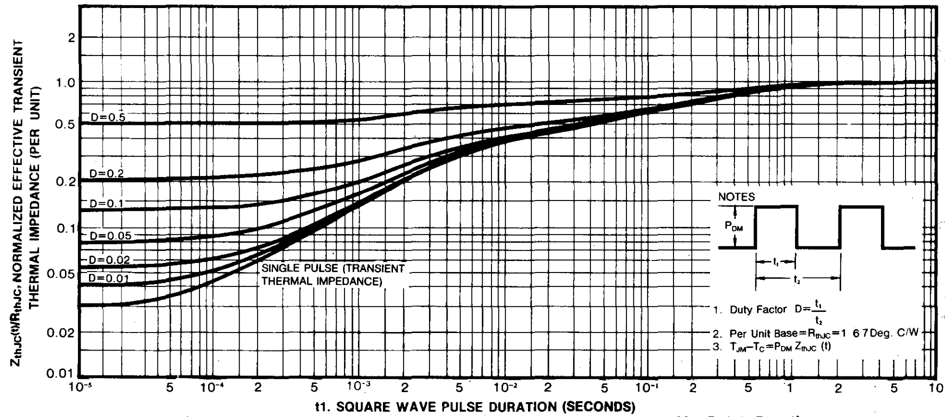
Typical Saturation Characteristics



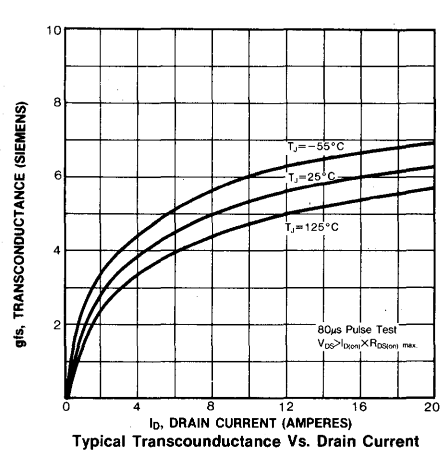
Maximum Safe Operating Area



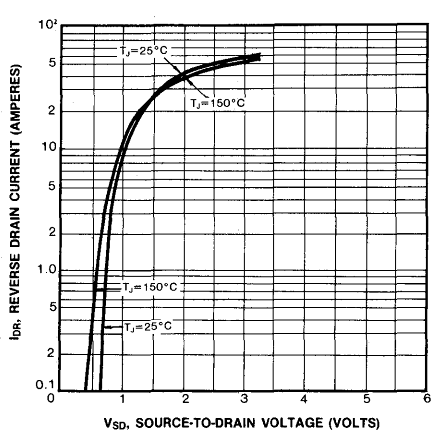
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP12N05/06 And SSM12N05/06



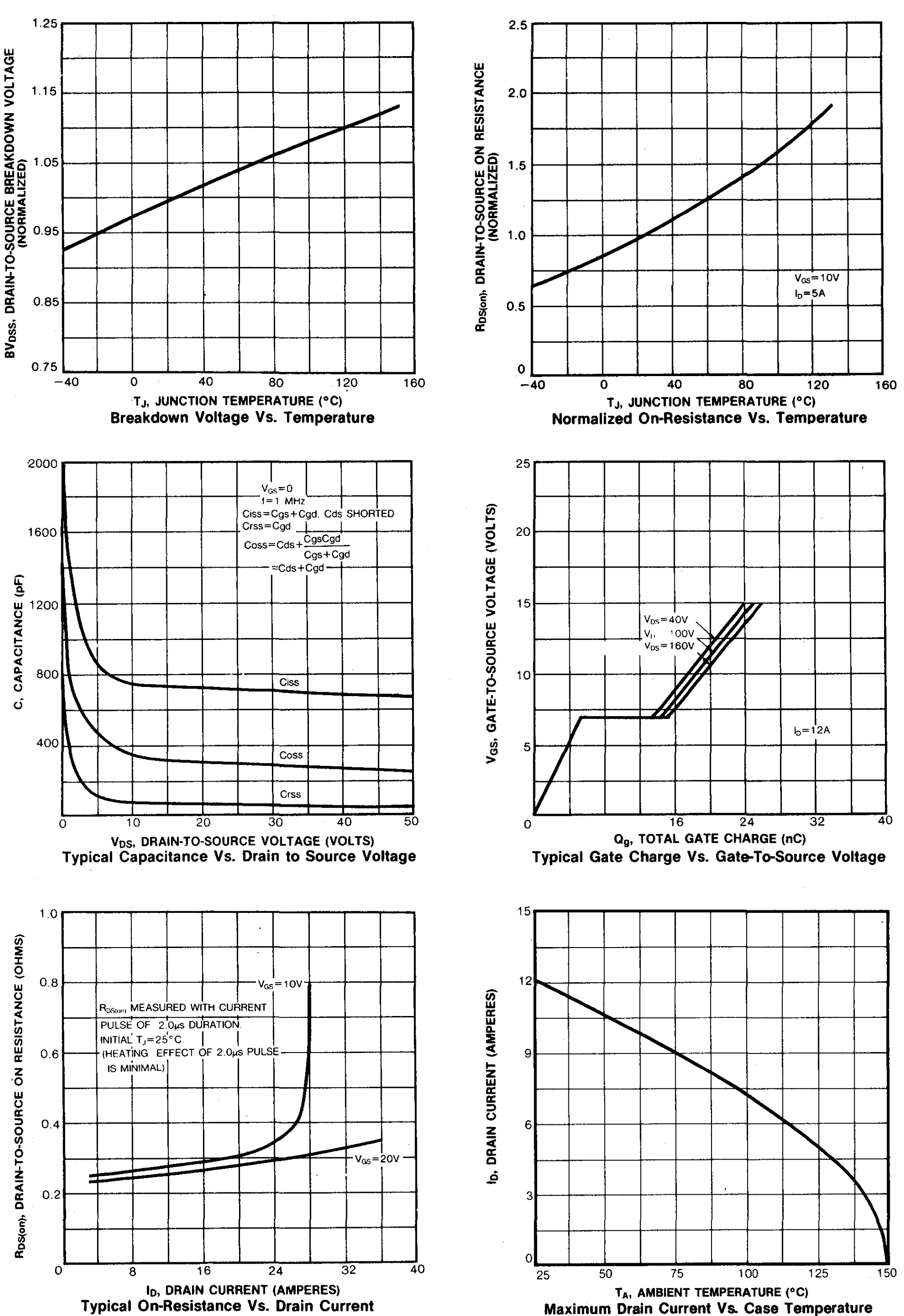
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH12N05/06

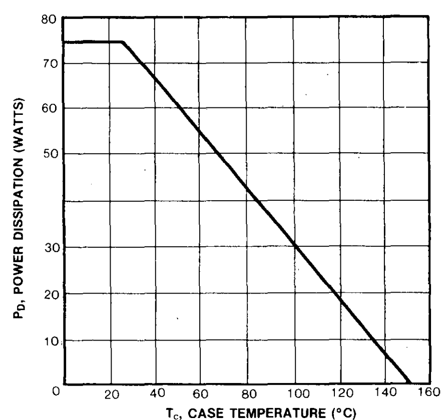


Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage


BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=5A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss=Cds+CgsCgd/(Cgs+Cgd)
≈Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS=40V
VDS=160V
ID=12A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
VGS=10V
RDS(on) MEASURED WITH CURRENT
PULSE OF 2.0μs DURATION.
INITIAL TJ=25°C.
(HEATING EFFECT OF 2.0μs PULSE
IS MINIMAL)
VGS=20V
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



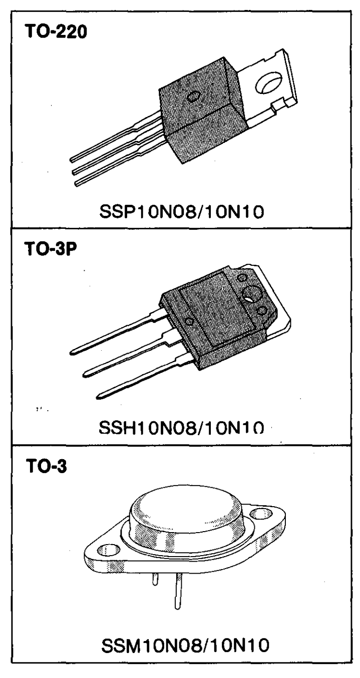
Power Vs. Temperature Derating Curve

SSP10N08/10N10
SSH10N08/10N10
SSM10N08/10N10

N-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS\,(ON)}$**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP10N08/SSH10N08/ SSM10N08	80V	0.33Ω	10A
SSP10N10/SSH10N10/ SSM10N10	100V	0.33Ω	10A

MAXIMUM RATINGS

Characteristic	Symbol	SSP10N08 SSH10N08 SSM10N08	SSP10N10 SSH10N10 SSM10N10	Unit
Drain-Source Voltage (1)	V_{DSS}	80	100	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	80	100	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	10	10	Adc
Continuous Drain Current T_C=100°C	I_D	6	6	Adc
Drain Current—Pulsed (3)	I_{DM}	30	30	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	35.2		mJ
Avalanche Current	I_{AS}	10		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.5		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.53 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP10N08/SSH10N08 SSM10N08	80	—	—	V	V_{GS}=0V I_D=250μA
	SSP10N10/SSH10N10/ SSM10N10	100	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	$V_{DS}=V_{GS}$, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	10	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)\,max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.33	Ω	V_{GS}=10V, I_D=5.0A
g_{fs}	Forward Transconductance (2)	2.5	—	—	℧	V_{DS}≥50V, I_D=5.0A
C_{iss}	Input Capacitance	—	—	600	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	400	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	80	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=5.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	100	ns	
t_f	Fall Time	—	—	50	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	13	—	nC	V_{GS}=10V, I_D=10A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	6.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7.0	—	nC	

THERMAL RESISTANCE

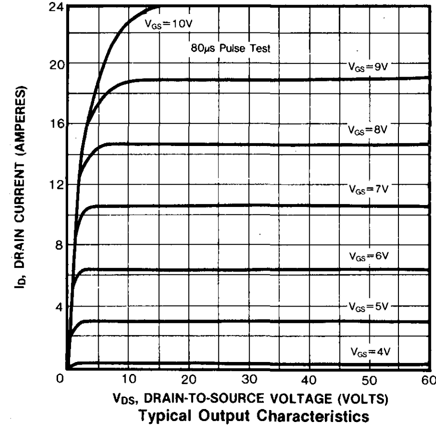
Symbol	Characteristic		SSP10N08/10	SSH10N08/10	SSM10N08/10	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	62.5	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

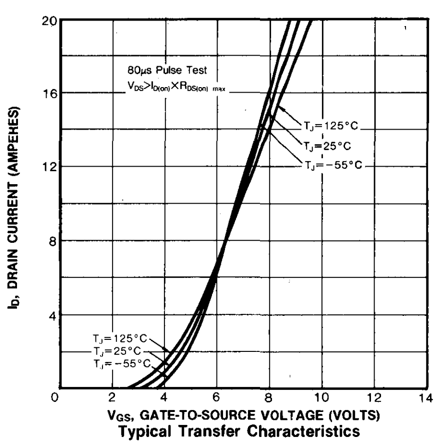
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	10.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	30	A	
V_{SD}	Diode Forward Voltage (2)	—	1.4	3.0	V	T_C=25°C, I_S=10.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	700	—	ns	T_j=150°C, I_F=10.0A, dI_F/dt=100A/μS

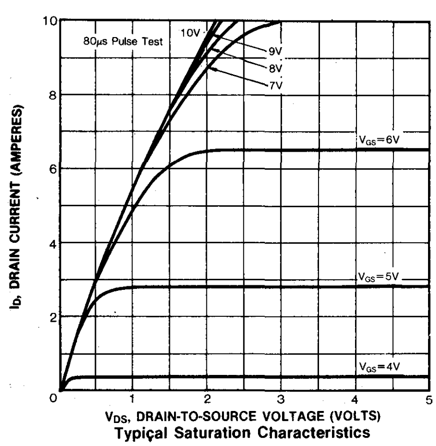
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



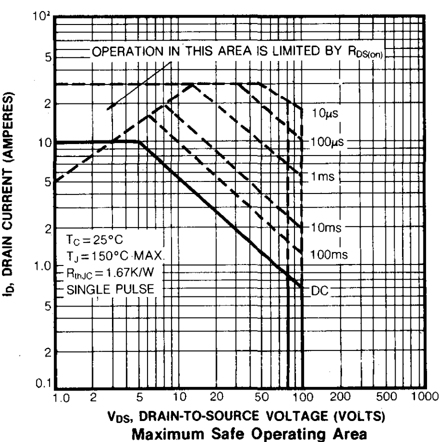
Typical Output Characteristics



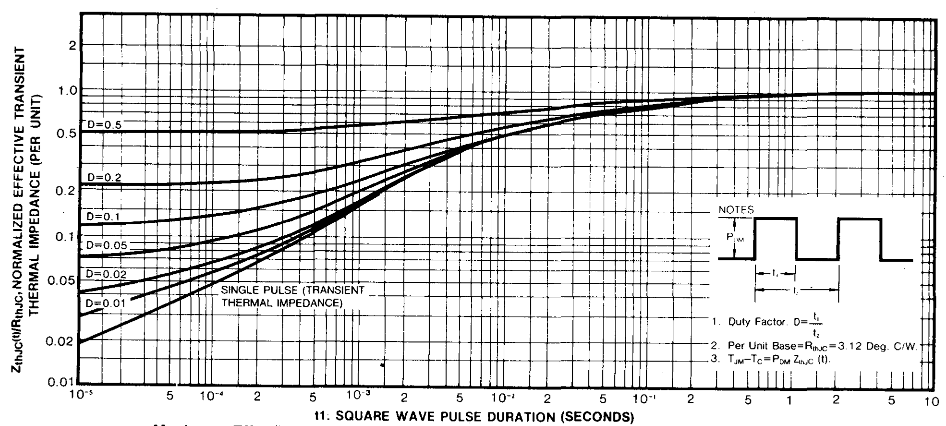
Typical Transfer Characteristics



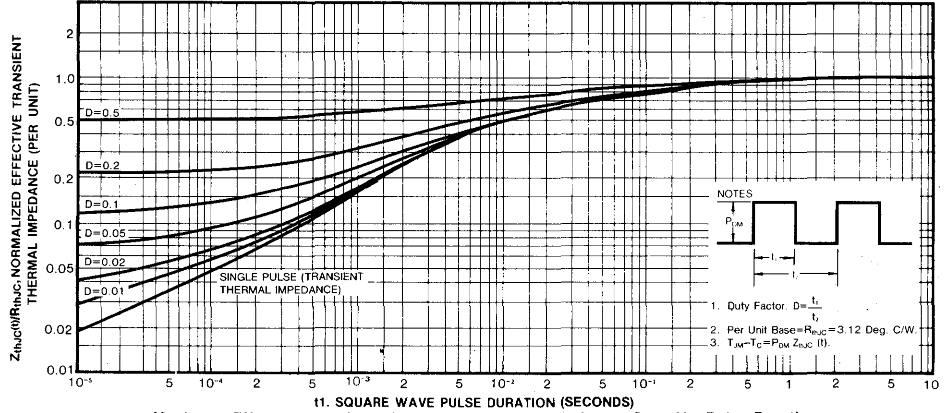
Typical Saturation Characteristics



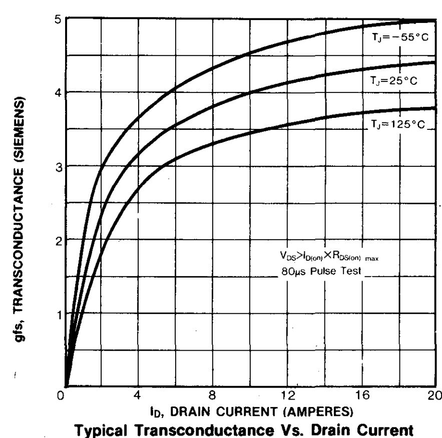
Maximum Safe Operating Area



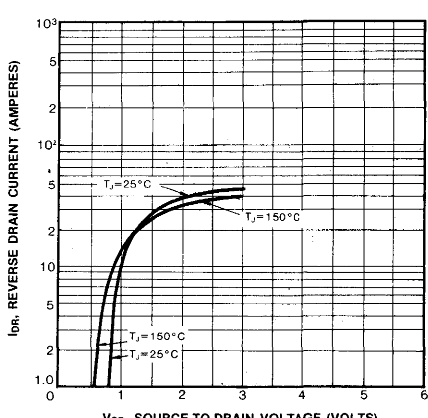
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP10N08/10 And SSM10N08/10



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH10N08/10



Typical Transconductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

1.25, 1.15, 1.05, 0.95, 0.85, 0.75

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

2.5, 2.0, 1.5, 1.0, 0.5, 0

$V_{GS}=10V$
$I_D=4A$

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

1000, 800, 600, 400, 200

$V_{GS}=0$
f=1 MHz
Ciss=Cgs+Cgd, Cgd SHORTED
Crss=Cgd
$Coss=Cds+\frac{CgsCgd}{Cgs+Cgd}$
≅ Cds + Cgd

Ciss
Coss
Crss

0, 10, 20, 30, 40, 50

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

25, 20, 15, 10, 5

$V_{DS}=20V$
$V_{DS}=50V$
$V_{DS}=80V$

$I_D=10A$

0, 4, 8, 12, 16, 20

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

1.0, 0.8, 0.6, 0.4, 0.2

$V_{GS}=10V$
$V_{GS}=20V$

$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL $T_J=25°C$. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

0, 10, 20, 30, 40, 50

I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

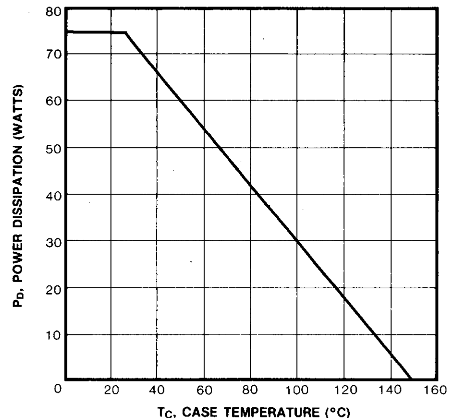
I_D, DRAIN CURRENT (AMPERES)

15, 12, 9, 6, 3, 0

25, 50, 75, 100, 125, 150

T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

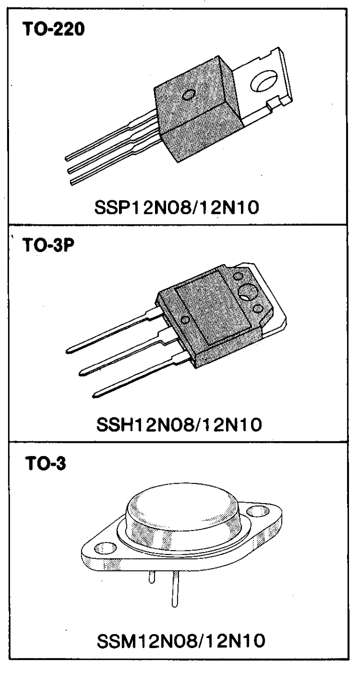
4

SSP12N08/12N10
SSH12N08/12N10
SSM12N08/12N10

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP12N08/SSH12N08/ SSM12N08	80V	0.18Ω	12A
SSP12N10/SSH12N10/ SSM12N10	100V	0.18Ω	12A

MAXIMUM RATINGS

Characteristic	Symbol	SSP12N08 SSH12N08 SSM12N08	SSP12N10 SSH12N10 SSM12N10	Unit
Drain-Source Voltage (1)	V_{DSS}	80	100	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	80	100	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	12	12	Adc
Continuous Drain Current T_C=100°C	I_D	7	7	Adc
Drain Current—Pulsed (3)	I_{DM}	30	30	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	51		mJ
Avalanche Current	I_{AS}	12		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.53 mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP12N08/SSH12N08/ SSM12N08	80	—	—	V	V_{GS}=0V I_D=250μA
	SSP12N10/SSH12N10/ SSM12N10	100	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	12	—	—	A	V_{DS}>$I_{D(on)}$×$R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.18	Ω	V_{GS}=10V, I_D=6.0A
g_{fs}	Forward Transconductance (2)	4.0	—	—	℧	V_{DS}≥50V, I_D=6.0A
C_{iss}	Input Capacitance	—	—	800	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	400	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	100	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=6.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	200	ns	
t_f	Fall Time	—	—	100	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	17	26	nC	V_{GS}=10V, I_D=12A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	8	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	9	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP12N08/10	SSH12N08/10	SSM12N08/10	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

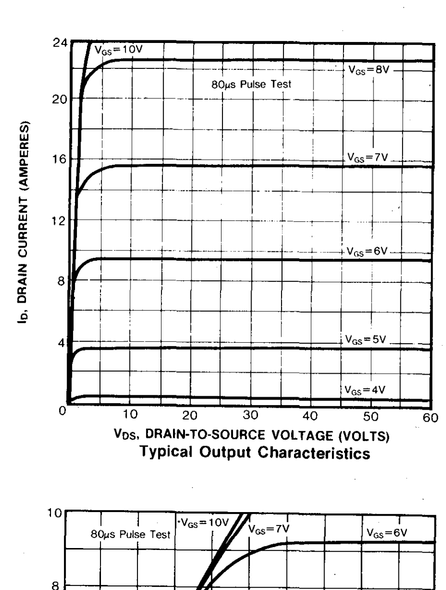
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

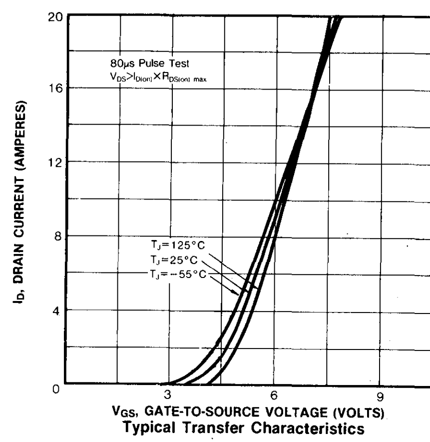
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	12	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	30	A	
V_{SD}	Diode Forward Voltage (2)	—	1.2	2.5	V	$T_C=25°C$, $I_S=12.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	325	—	ns	$T_j=150°C$, $I_F=12.0A$, $dI_F/dt=100A/\mu S$

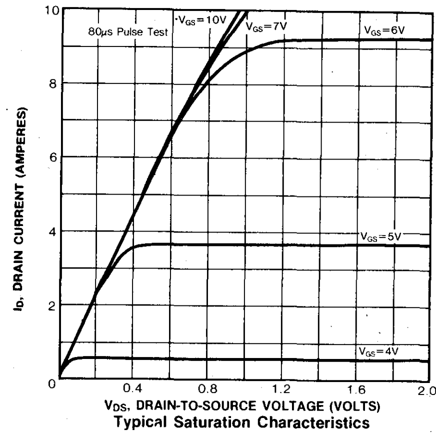
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq300\mu s$, Duty Cycle$\leq2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature



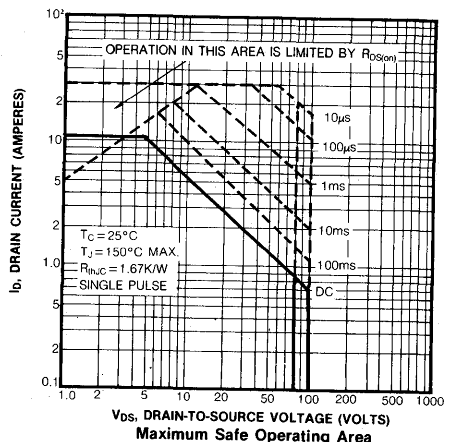
Typical Output Characteristics



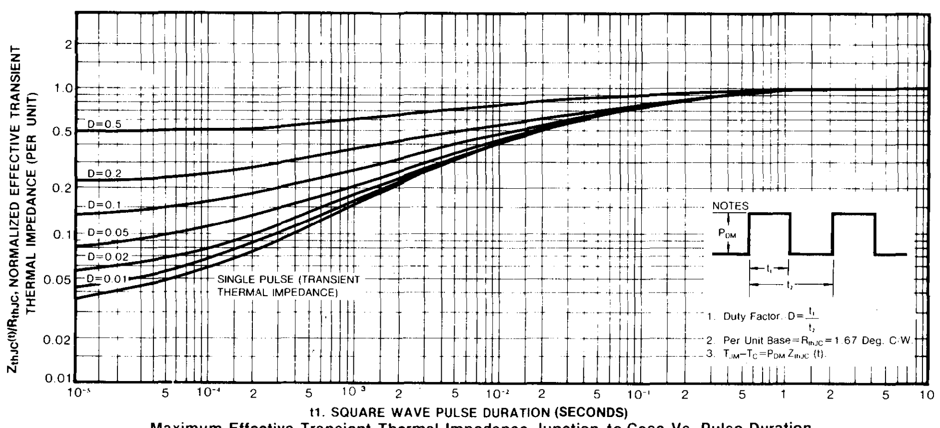
Typical Transfer Characteristics



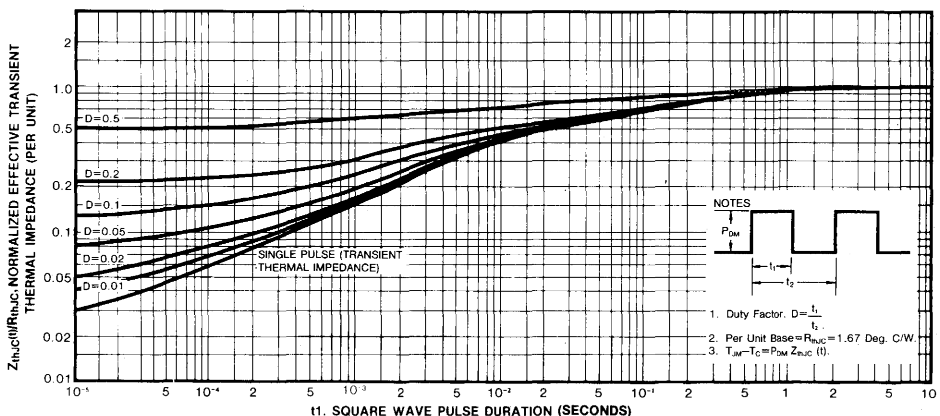
Typical Saturation Characteristics



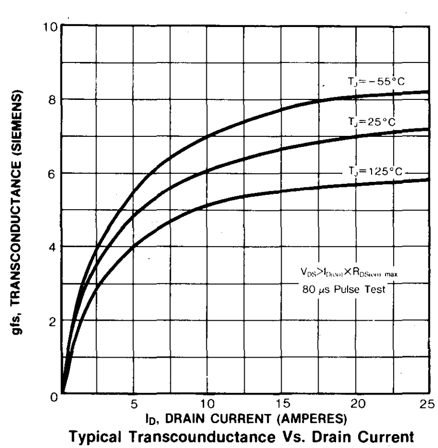
Maximum Safe Operating Area



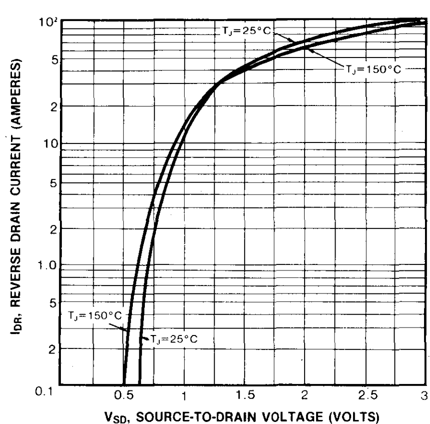
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP12N08/10 And SSM12N08/10



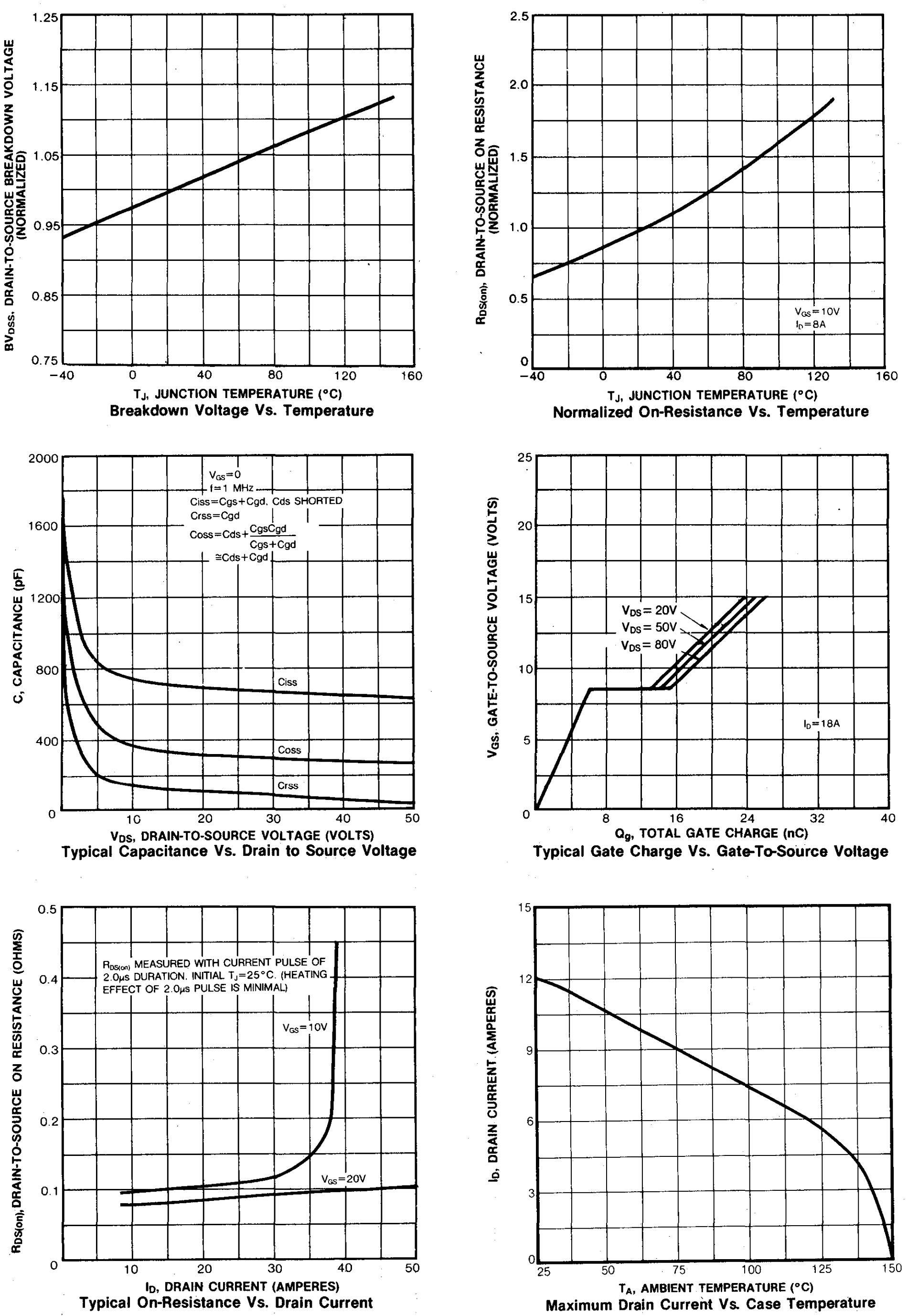
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH12N08/10

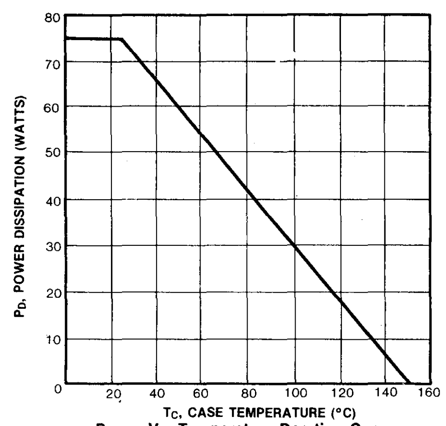


Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage


BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=8A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss=Cds+CgsCgd/(Cgs+Cgd)
≅Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS= 20V
VDS= 50V
VDS= 80V
ID=18A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
RDS(on) MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL TJ=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)
VGS=10V
VGS=20V
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

SSH60N06/60N10
SSM60N06/60N10

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability
- TO-220 package

TO-3P

SSH60N06/60N10

TO-3

SSM60N06/60N10

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSH60N06 SSM60N06	60V	0.025	0.03	60A
SSH60N10 SSM60N10	100V	0.025	0.03	60A

MAXIMUM RATINGS

Characteristic	Symbol	SSH60N06 SSM60N06	SSH60N10 SSM60N10	Unit
Drain-Source Voltage (1)	V_{DSS}	60	100	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	60	100	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	60		Adc
Continuous Drain Current T_C=100°C	I_D	40		Adc
Drain Current—Pulsed (3)	I_{DM}	180		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	790		mJ
Avalanche Current	I_{AS}	60.0		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150/200 (5) 1.2/1.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.33mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C
(5) TO-3P/TO-3

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSH60N06/SSM60N06	60	—	—	V	V_{GS}=0V
	SSH60N10/SSM60N10	100	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	60	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	0.025	Ω	V_{GS}=10V, I_D=30A
	STD	—	—	0.03	Ω	
g_{fs}	Forward Transconductance (2)	7.0	—	—	℧	V_{DS}≥50V, I_D=30A
C_{iss}	Input Capacitance	—	4800	—	pF	V_{GS}=0V, V_{DS}=25V, f=1MHz
C_{oss}	Output Capacitance	—	950	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	395	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	126	ns	V_{DD}=0.5BV_{DSS}, I_D=30A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	280	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	630	ns	
t_f	Fall Time	—	—	210	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	80	nC	V_{GS}=10V, I_D=60A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	28	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	14	nC	

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature
(4) For ultra low "A" $R_{DS(on)}$, device add "A" suffix to part number

THERMAL RESISTANCE

Symbol	Characteristic		SSH60N06/10	SSM6006/10	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.63	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

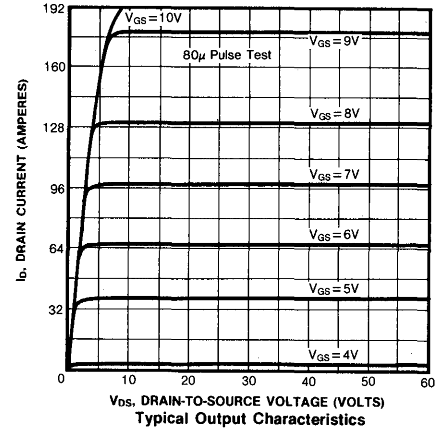
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

4

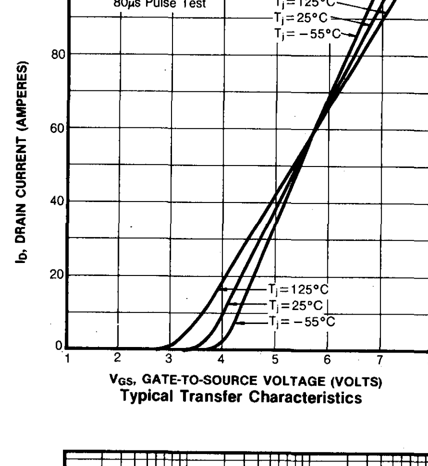
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	60	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	180	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.5	V	$T_C=25°C$, $I_S=60A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	1200	—	ns	$T_j=150°C$, $I_F=60A$, $dI_F/dt=100A/\mu S$

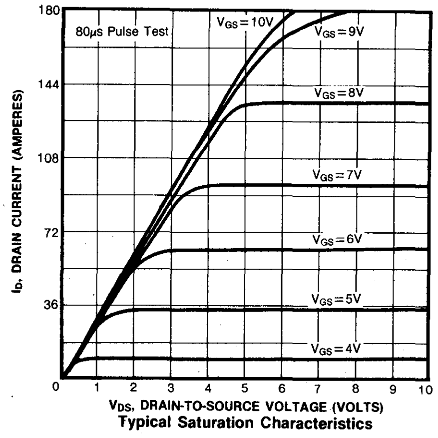
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



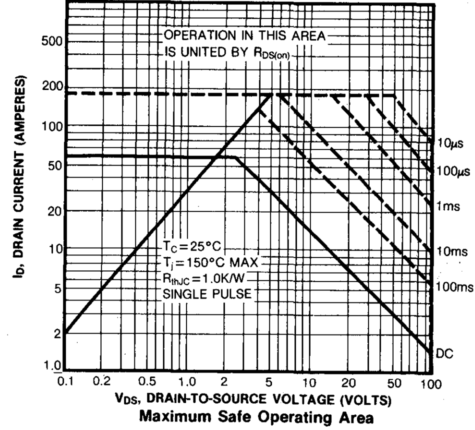
Typical Output Characteristics



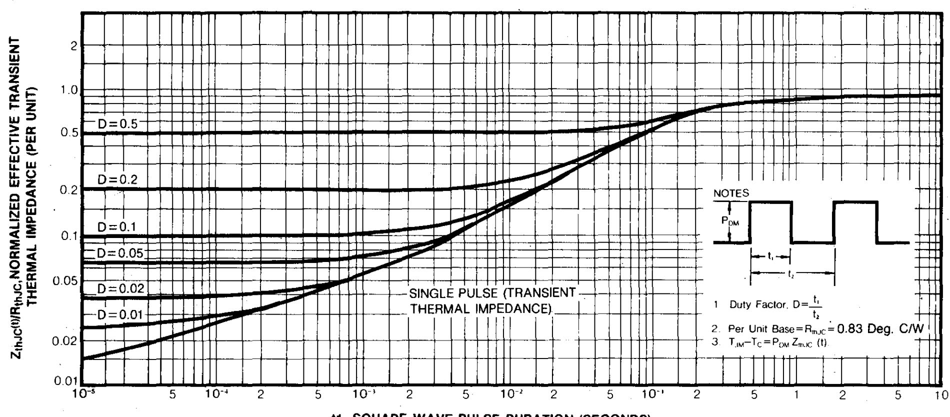
Typical Transfer Characteristics



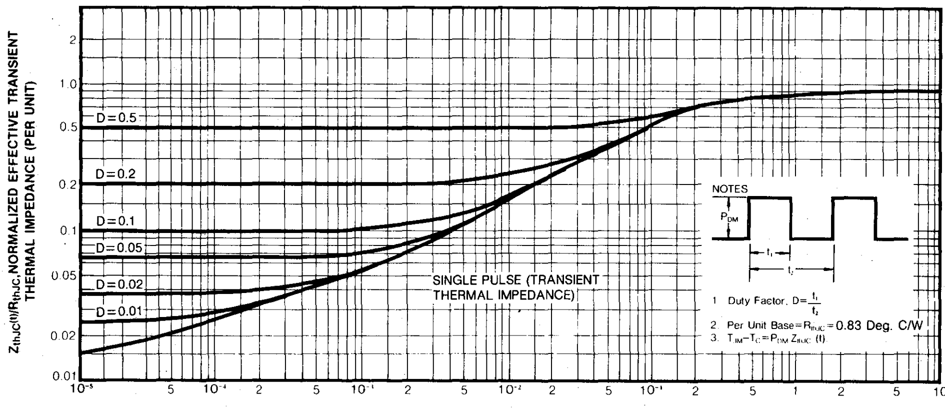
Typical Saturation Characteristics



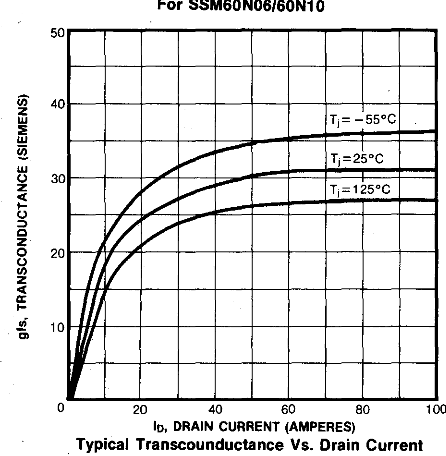
Maximum Safe Operating Area



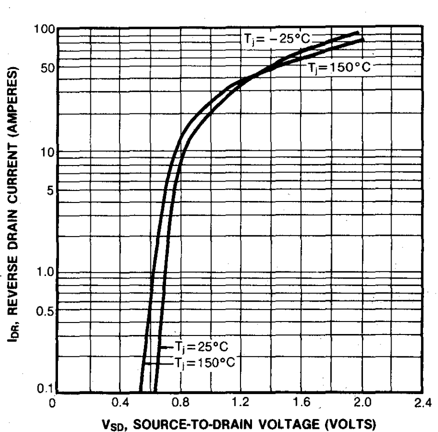
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH60N06/60N10



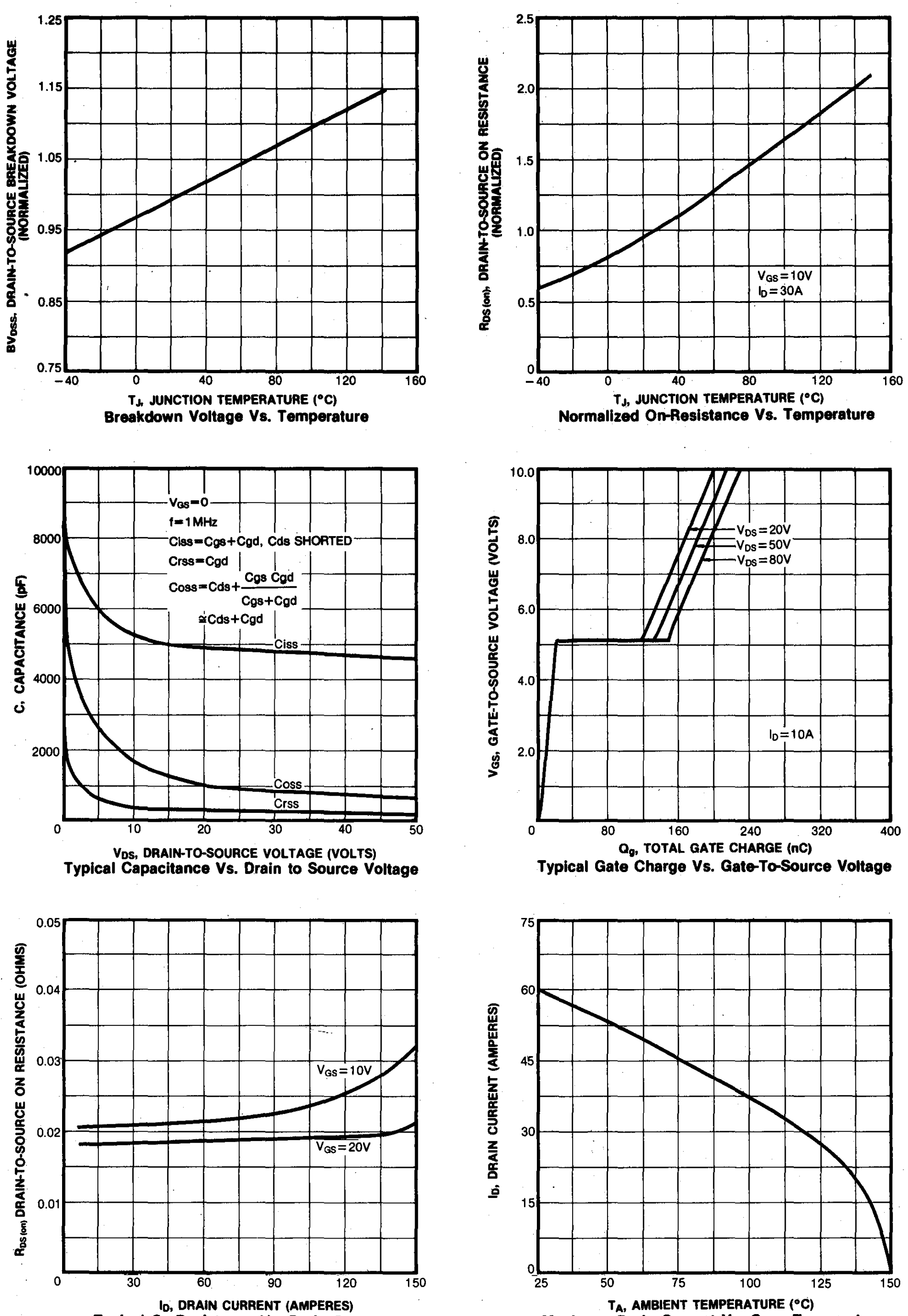
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSM60N06/60N10

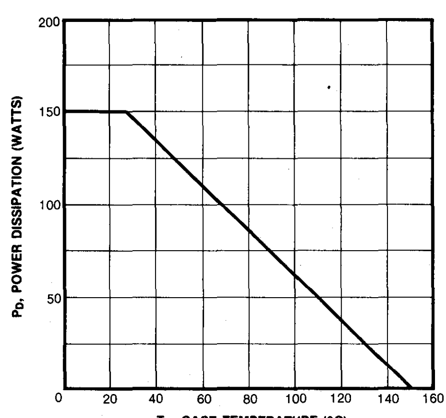


Typical Transcounductance Vs. Drain Current

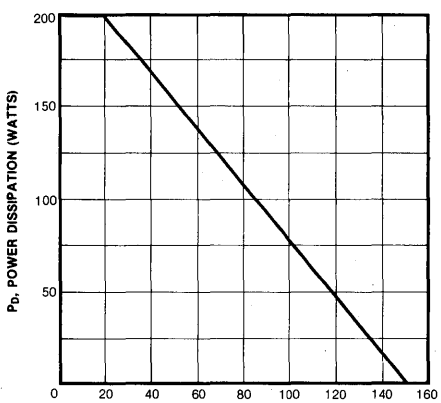


Typical Source—Drain Diode Forward Voltage


BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=30A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss=Cds+Cgs Cgd/Cgs+Cgd
≅Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS=20V
VDS=50V
VDS=80V
ID=10A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on) DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
VGS=10V
VGS=20V
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve
For SSH60N06/60N10



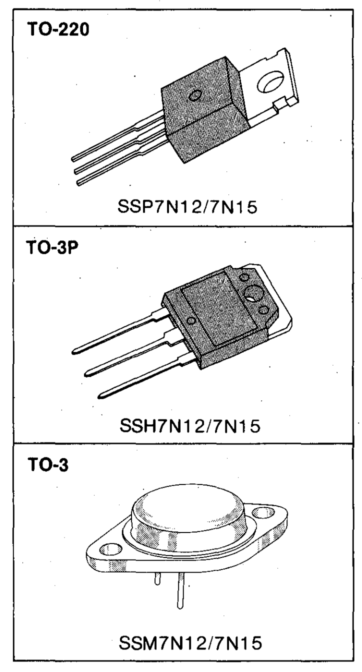
Power Vs. Temperature Derating Curve
For SSM60N06/60N10

SSP7N12/7N15
SSH7N12/7N15
SSM7N12/7N15

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP7N12/SSH7N12/ SSM7N12	120V	0.7Ω	7.0A
SSP7N15/SSH7N15/ SSM7N15	150V	0.7Ω	7.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP7N12 SSH7N12 SSM7N12	SSP7N12 SSH7N12 SSM7N12	Unit
Drain-Source Voltage (1)	V_{DSS}	120V	150V	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	120V	150V	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	7.0	7.0	Adc
Continuous Drain Current T_C=100°C	I_D	4.0	4.0	Adc
Drain Current—Pulsed (3)	I_{DM}	18	18	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	102		mJ
Avalanche Current	I_{AS}	7		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS ($T_C=25°C$ unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP7N12/SSH7N12/ SSM7N12	120	—	—	V	$V_{GS}=0V$ $I_D=250\mu A$
	SSP7N/15/SSH7N/15/ SSM7N/15	150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	$V_{DS}=V_{GS}$, $I_D=1mA$
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	$V_{GS}=20V$
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	$V_{GS}=-20V$
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating $V_{GS}=0V$
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, $V_{GS}=0V$, $T_C=125°C$
$I_{D(on)}$	On-State Drain-Source Current (2)	7	—	—	A	$V_{GS}>I_{D(on)}\times R_{OS(on)\ max}$, $V_{GS}=10V$
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.7	Ω	$V_{GS}=10V$, $I_D=3.5A$
g_{fs}	Forward Transconductance (2)	1.5	—	—	℧	$V_{DS}\geq 50V$, $I_D=3.5A$
C_{iss}	Input Capacitance	—	—	600	pF	$V_{GS}=0V$, $V_{DS}=25V$, f=1.0MHz
C_{oss}	Output Capacitance	—	—	250	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	100	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	20	ns	$V_{DD}=0.5BV_{DSS}$, $I_D=3.5A$, $Z_O=50\Omega$ (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	50	ns	
t_f	Fall Time	—	—	50	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	11	—	nC	$V_{GS}=10V$, $I_D=7.0A$, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	5.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	6.0	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP7N12/15	SSH7N12/15	SSM7N12/15	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

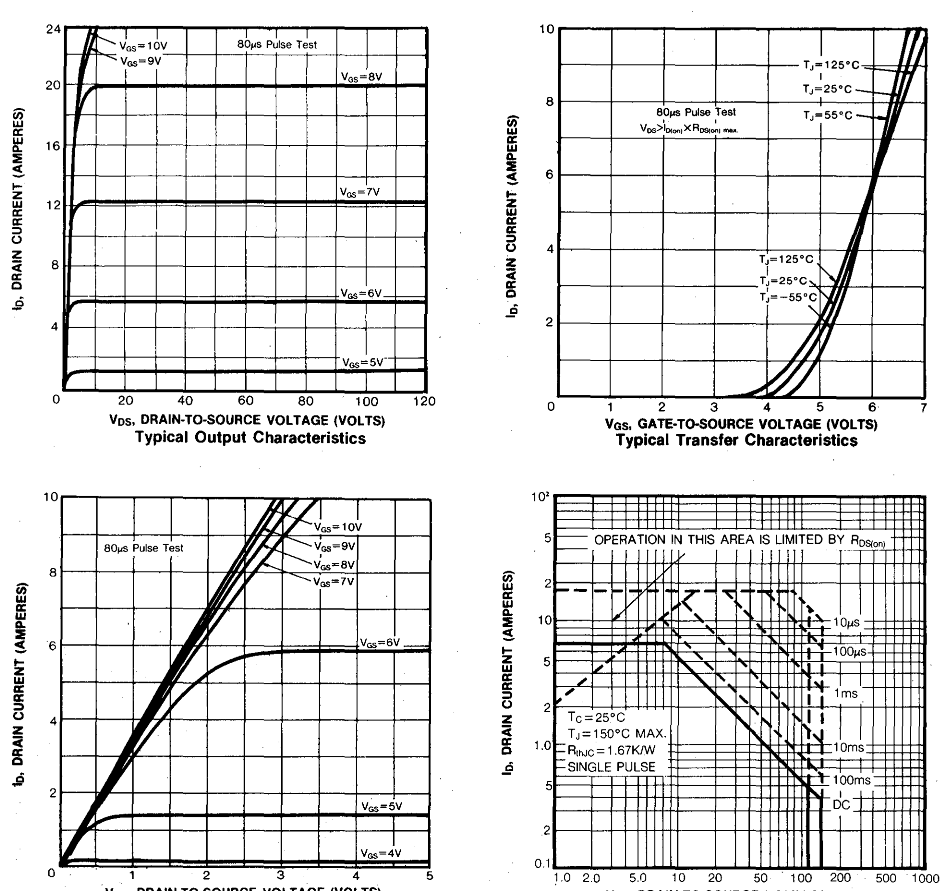
Notes: (1) $T_J=25°C$ to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	7.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	18	A	
V_{SD}	Diode Forward Voltage (2)	—	1.3	2.5	V	$T_C=25°C$, $I_S=7.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	300	—	ns	$T_j=150°C$, $I_F=7.0A$, $dI_F/dt=100A/\mu S$

Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq 300\mu s$, Duty Cycle$\leq 2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature

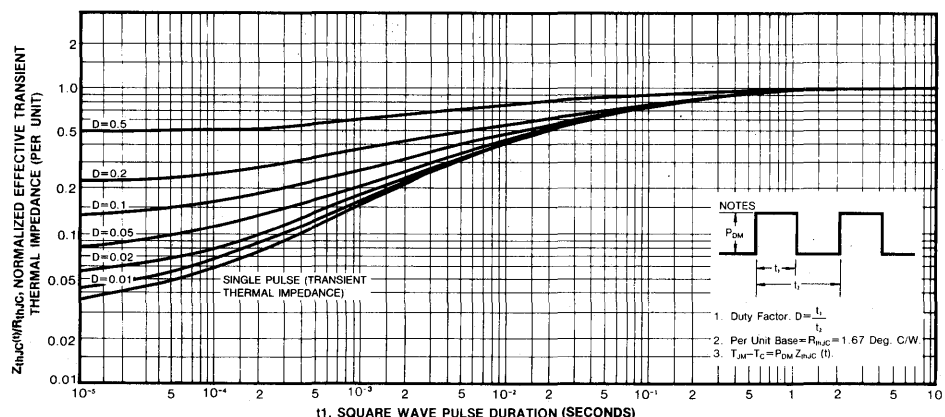


Typical Output Characteristics

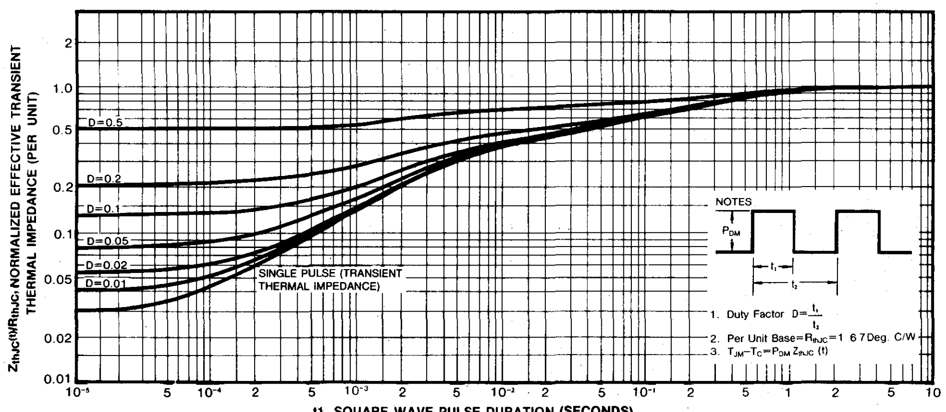
Typical Transfer Characteristics

Typical Saturation Characteristics

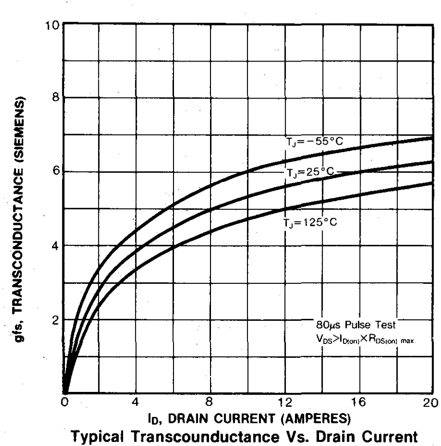
Maximum Safe Operating Area



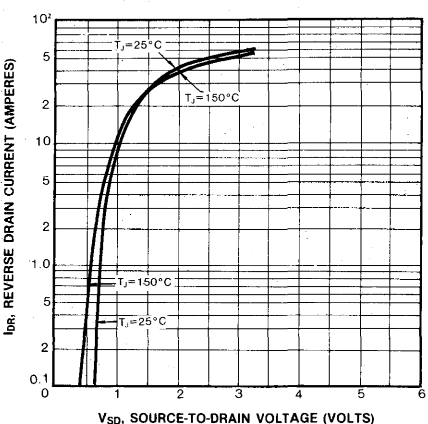
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP7N12/15 And SSM7N12/15



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH7N12/15

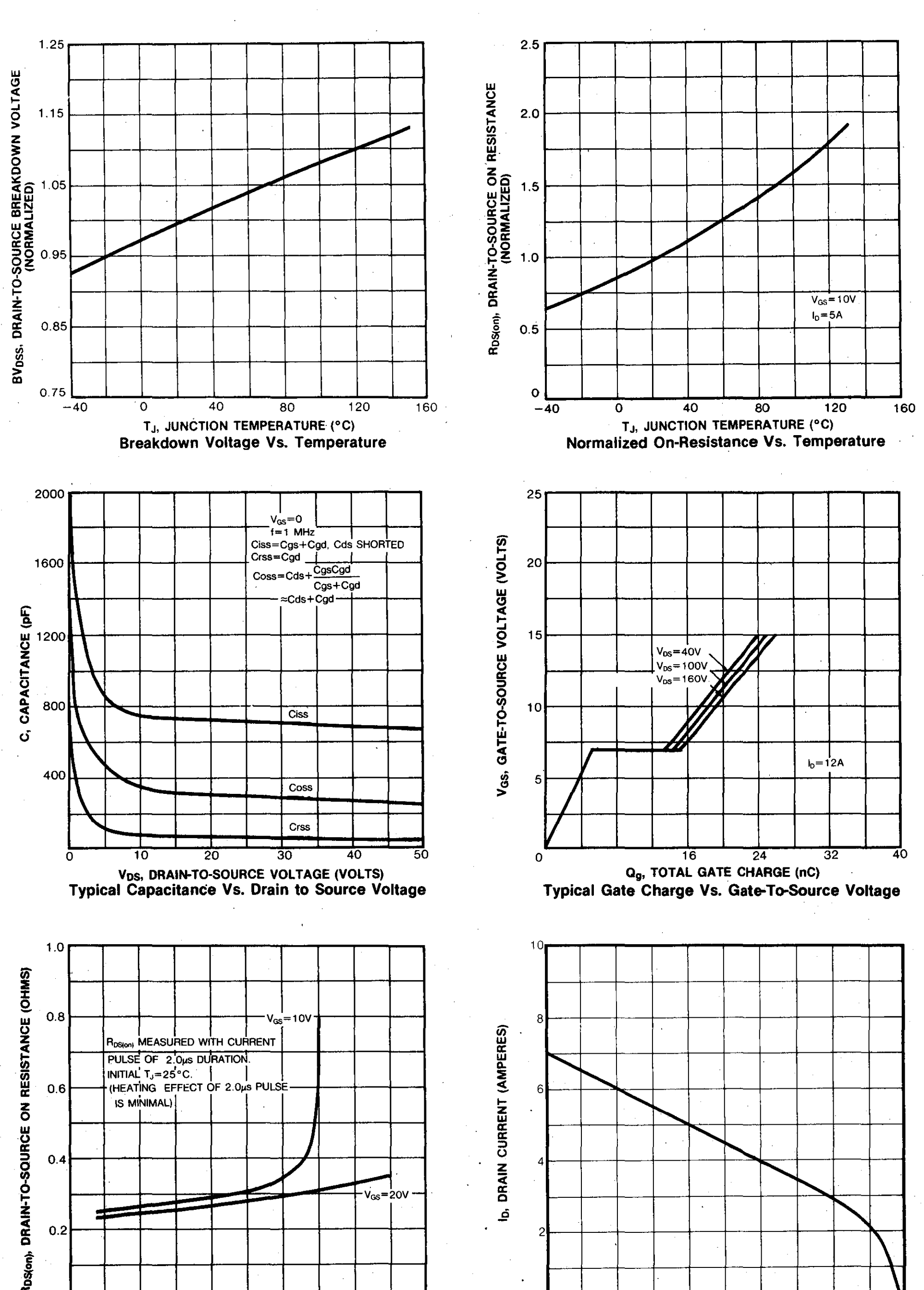


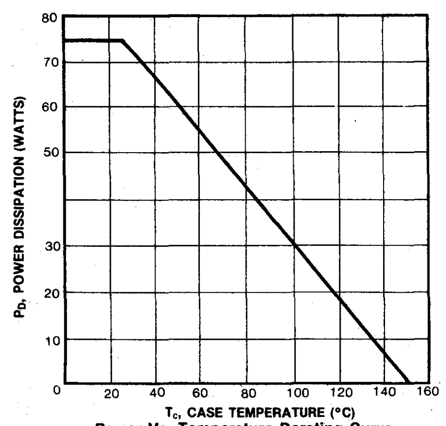
Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

4


BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=5A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss=Cds+CgsCgd/Cgs+Cgd
≈Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS=40V
VDS=100V
VDS=160V
ID=12A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
VGS=10V
RDS(on) MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL TJ=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)
VGS=20V
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



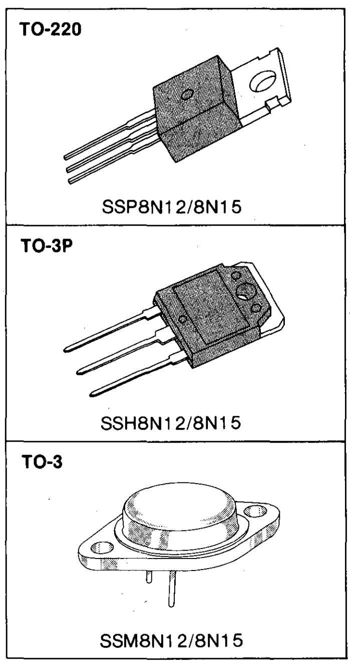
Power Vs. Temperature Derating Curve

SSP8N12/8N15
SSH8N12/8N15
SSM8N12/8N15

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP8N12/SSH8N12/ SSM8N12	120V	0.5Ω	8.0A
SSP8N15/SSH8N15/ SSM8N15	150V	0.5Ω	8.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP8N12 SSH8N12 SSM8N12	SSP8N15 SSH8N15 SSM8N15	Unit
Drain-Source Voltage (1)	V_{DSS}	120	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	120	150	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	8	8	Adc
Continuous Drain Current T_C=100°C	I_D	5	5	Adc
Drain Current—Pulsed (3)	I_{DM}	25	25	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	134		mJ
Avalanche Current	I_{AS}	8		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP8N12/SSH8N12/SSM8N12	120	—	—	V	V_{GS}=0V I_D=250μA
	SSP8N15/SSH8N15/SSM8N15	150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	8.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.5	Ω	V_{GS}=10V, I_D=4A
g_{fs}	Forward Transconductance (2)	6.0	—	—	℧	V_{DS}≥50V, I_D=4.0A
C_{iss}	Input Capacitance	—	—	600	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	250	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	100	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=4.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	100	ns	
t_f	Fall Time	—	—	50	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	11.0	—	nC	V_{GS}=10V, I_D=8.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	5.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	6.0	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP8N12/15	SSH8N12/15	SSM8N12/15	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

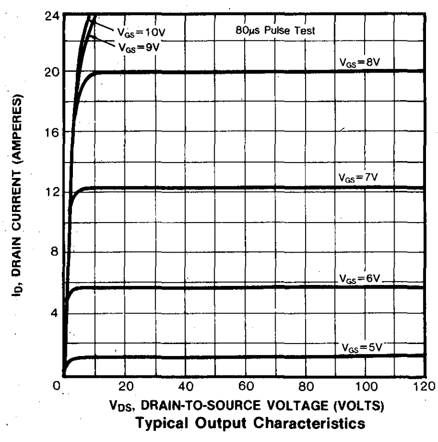
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

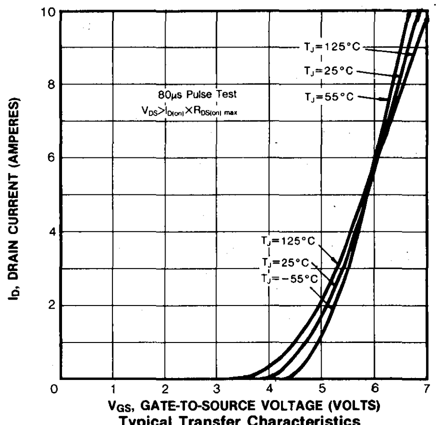
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	8.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	25	A	
V_{SD}	Diode Forward Voltage (2)	—	1.4	3.0	V	$T_C=25°C$, $I_S=8.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	300	—	ns	$T_j=150°C$, $I_F=8.0A$, $dI_F/dt=100A/\mu S$

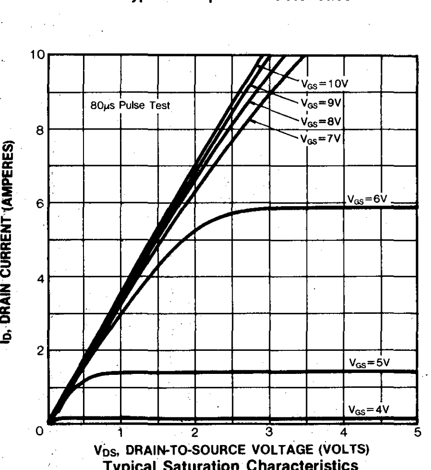
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



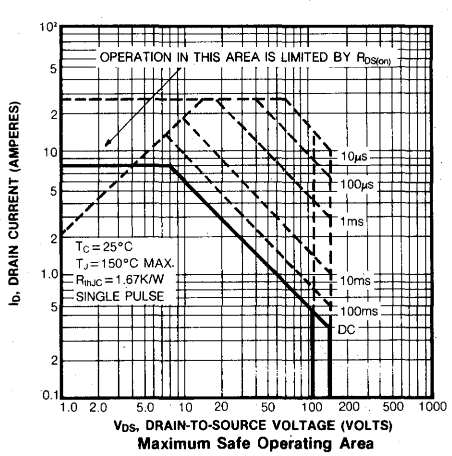
Typical Output Characteristics



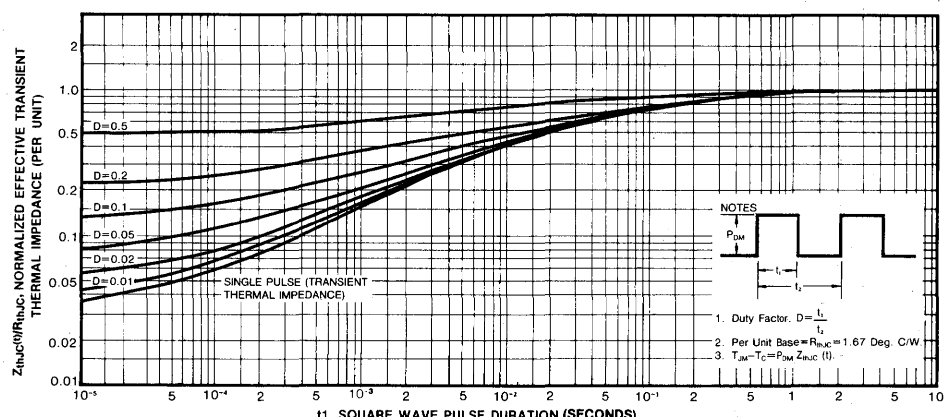
Typical Transfer Characteristics



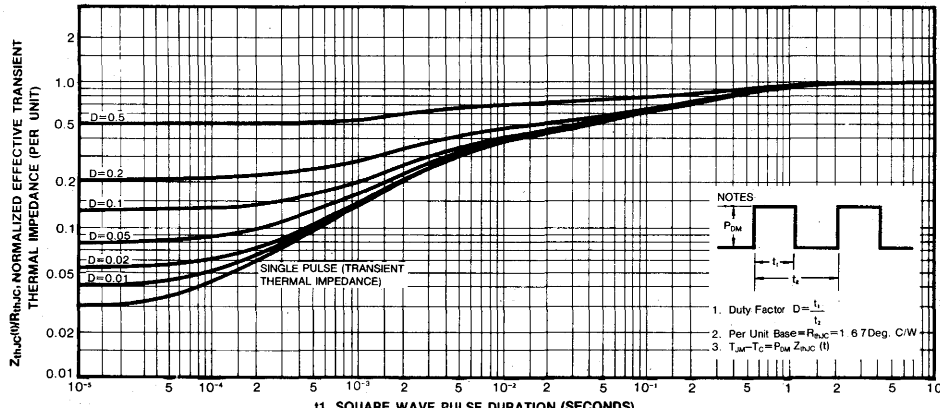
Typical Saturation Characteristics



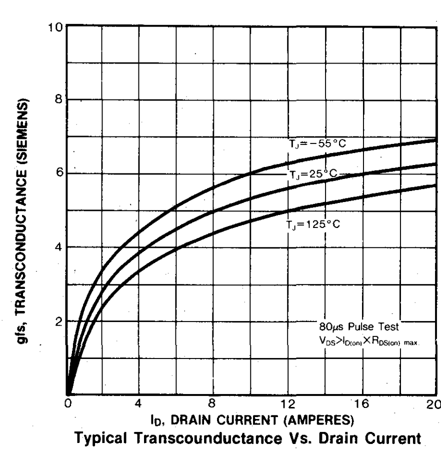
Maximum Safe Operating Area



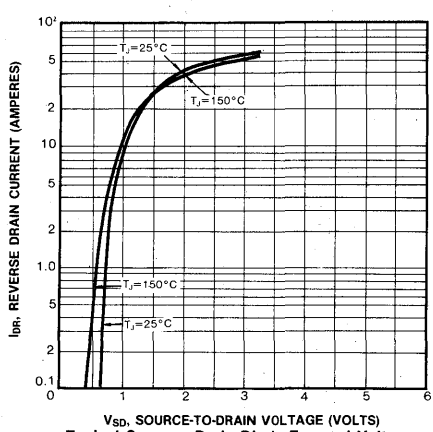
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP8N12/15 and SSM8N12/15



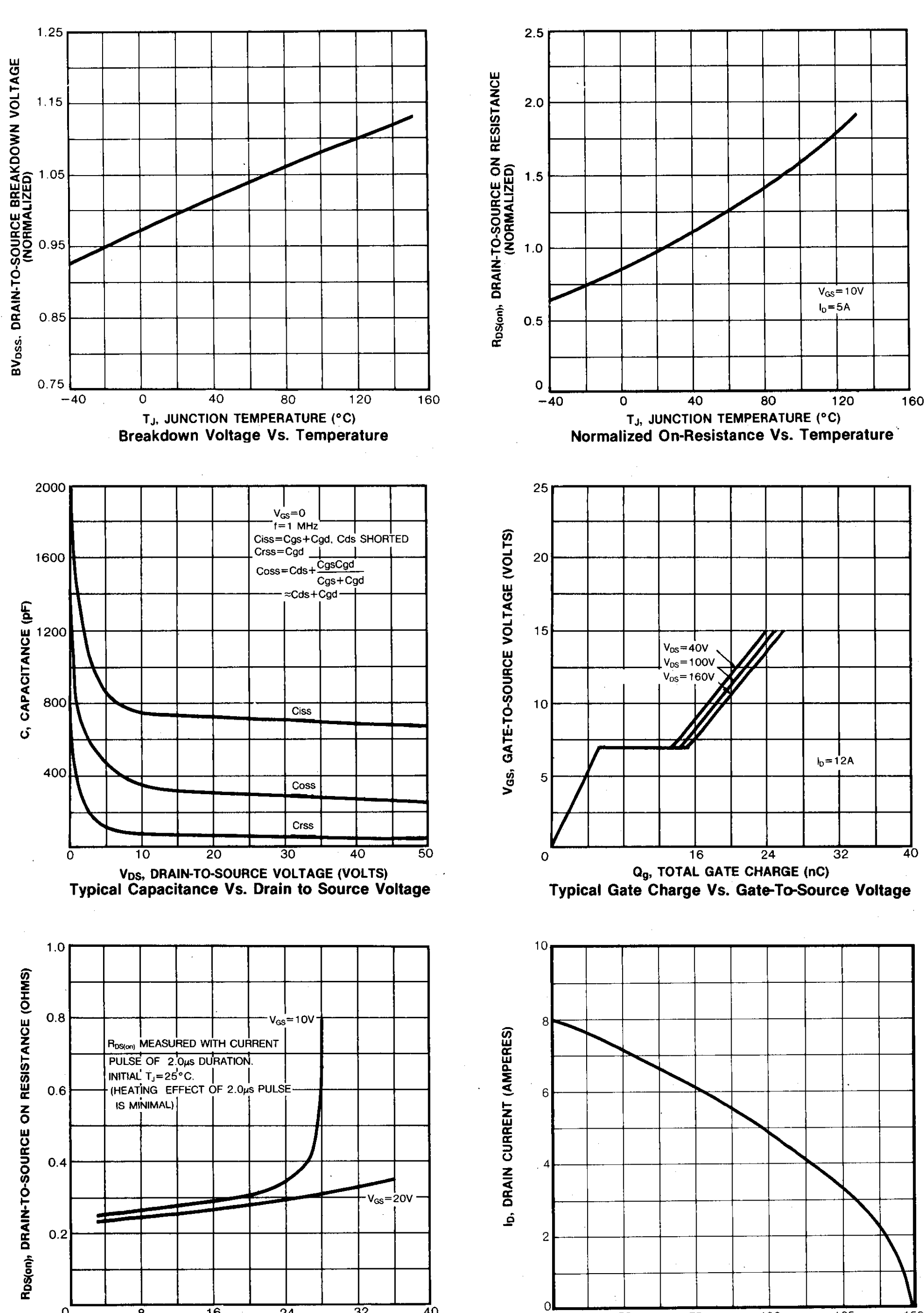
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH8N12/15



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage



Breakdown Voltage Vs. Temperature

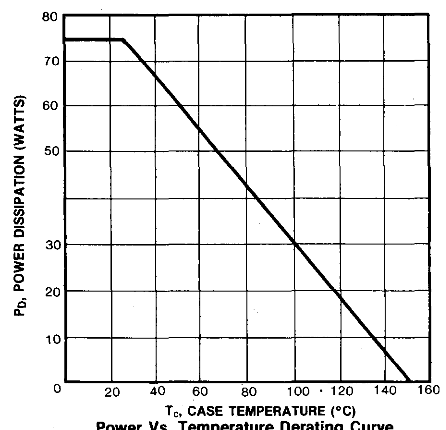
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

Typical Gate Charge Vs. Gate-To-Source Voltage

Typical On-Resistance Vs. Drain Current

Maximum Drain Current Vs. Case Temperature



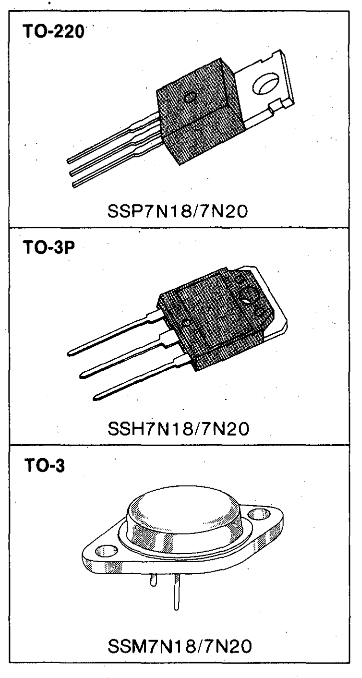
Power Vs. Temperature Derating Curve

SSP7N18/7N20
SSH7N18/7N20
SSM7N18/7N20

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP8N18/SSH8N18/ SSM8N18	180V	0.4Ω	7.0A
SSP8N20/SSH8N20/ SSM8N20	200V	0.4Ω	7.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP8N18 SSH8N18 SSM8N18	SSP8N20 SSH8N20 SSM8N20	Unit
Drain-Source Voltage (1)	V_{DSS}	180	200	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	180	200	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	7	7	Adc
Continuous Drain Current T_C=100°C	I_D	4	4	Adc
Drain Current—Pulsed (3)	I_{DM}	18	18	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy	E_{AS}	103		mJ
Avalanche Current	I_{AS}	7.0		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP7N18/SSH7N18/SSM7N18	180	—	—	V	V_{GS}=0V I_D=250μA
	SSP7N20/SSH7N20/SSM7N20	200	—	—	V	
$V_{GS(m)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	7.0	—	—	A	V_{GS}>$I_{D(on)}$×$R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.7	Ω	V_{GS}=10V, I_D=3.5A
g_{fs}	Forward Transconductance (2)	3.0	—	—	Ω	V_{DS}≥50V, I_D=3.5A
C_{iss}	Input Capacitance	—	—	700	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	300	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	80	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DO}=0.58V_{DSS}, I_D=3.5A, Z_O=50Ω (MCSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	100	ns	
t_f	Fall Time	—	—	50	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	9.0	—	nC	V_{GS}=10V, I_C=7.0A, V_{DS}=0.8, Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	4.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	5.0	—	nC	

THERMAL RESISTANCE

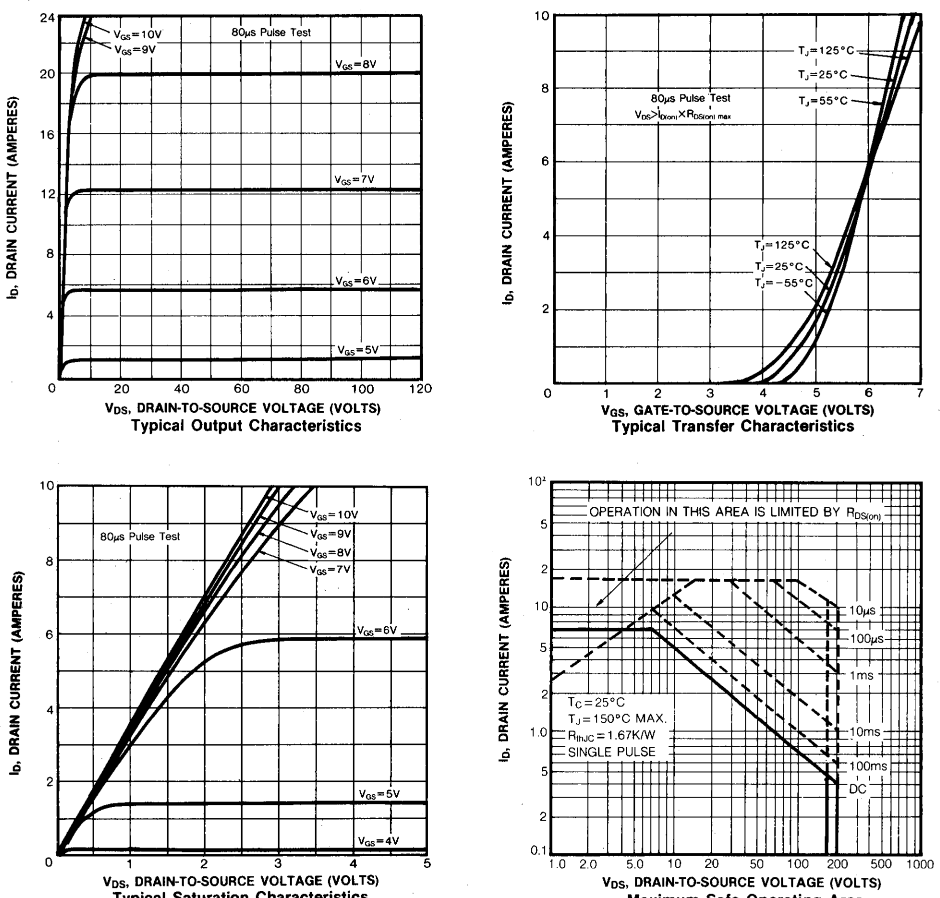
Symbol	Characteristic		SSP8N18/20	SSH8N18/20	SSM8N18/20	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.63	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.26	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	7.0	A	—	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	18	A	
V_{SD}	Diode Forward Voltage (2)	—	1.5	3.0	V	$T_C=25°C$, $I_S=7.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	300	—	ns	$T_j=150°C$, $I_F=7.0A$, $dI_F/dt=100A/\mu S$

Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq 300\mu s$, Duty Cycle$\leq 2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature

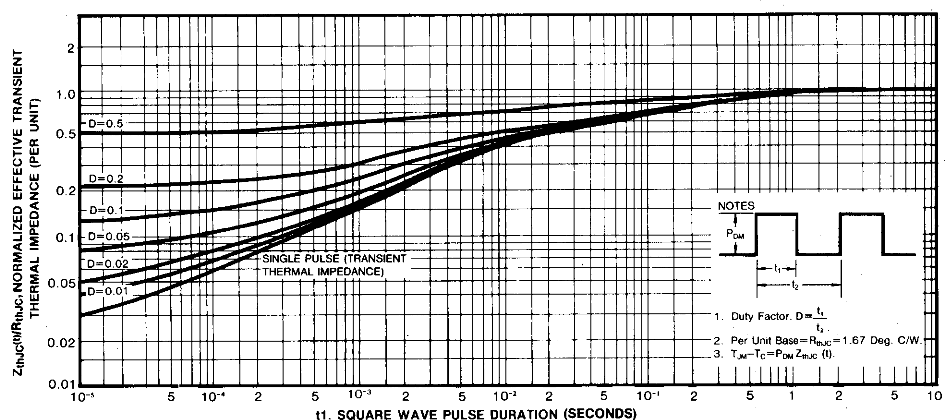


Typical Output Characteristics

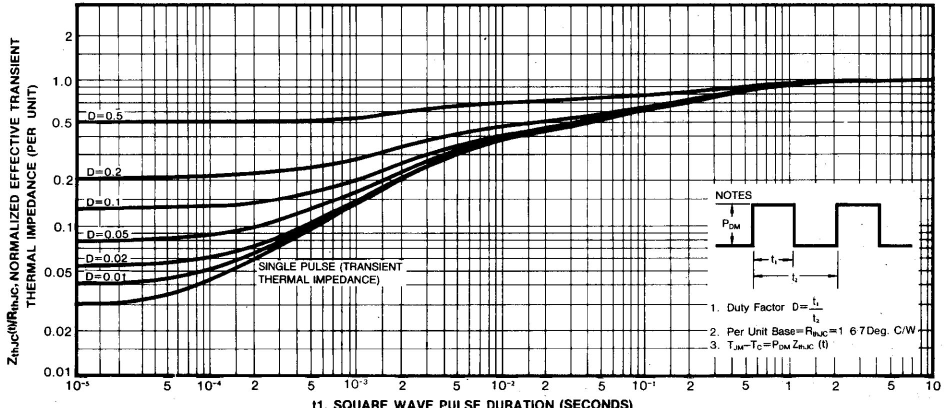
Typical Transfer Characteristics

Typical Saturation Characteristics

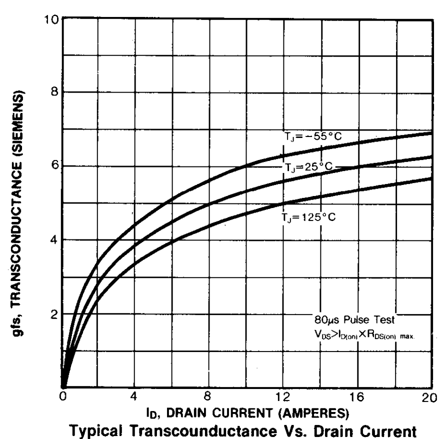
Maximum Safe Operating Area



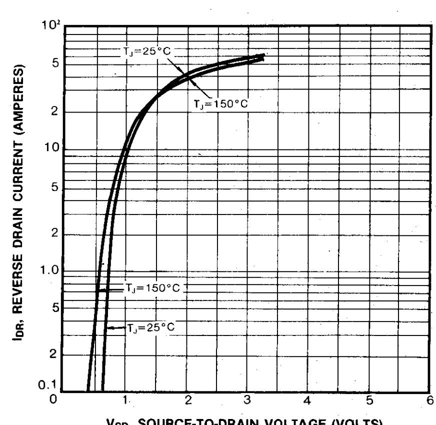
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP7N18/20 And SSM7N18/20



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH7N18/20



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

1.25, 1.15, 1.05, 0.95, 0.85, 0.75

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

2.5, 2.0, 1.5, 1.0, 0.5, 0

V_{GS}=10V
I_D=5A

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

2000, 1600, 1200, 800, 400

V_{GS}=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
$Coss=Cds+\frac{CgsCgd}{Cgs+Cgd}$
≈Cds+Cgd

Ciss
Coss
Crss

0, 10, 20, 30, 40, 50

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

25, 20, 15, 10, 5

V_{DS}=40V
V_{DS}=100V
V_{DS}=160V

I_D=12A

0, 16, 24, 32, 40

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

1.0, 0.8, 0.6, 0.4, 0.2

V_{GS}=10V

$R_{DS(on)}$ MEASURED WITH CURRENT
PULSE OF 2.0μs DURATION.
INITIAL T_J=25°C.
(HEATING EFFECT OF 2.0μs PULSE
IS MINIMAL)

V_{GS}=20V

0, 8, 16, 24, 32, 40

I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

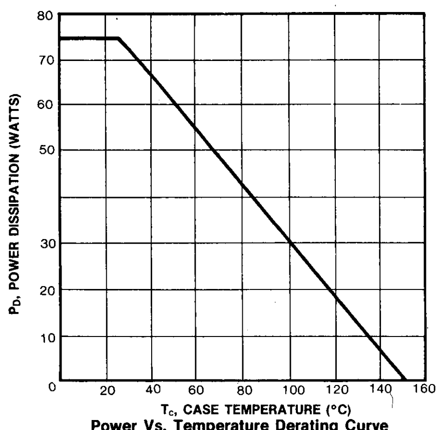
I_D, DRAIN CURRENT (AMPERES)

10, 8, 6, 4, 2, 0

25, 50, 75, 100, 125, 150

T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



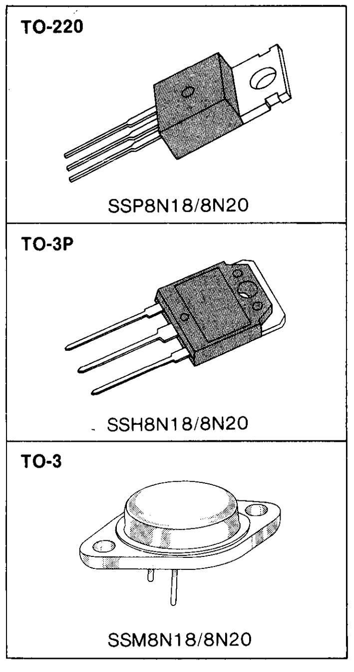
Power Vs. Temperature Derating Curve

SSP8N18/8N20
SSH8N18/8N20
SSM8N18/8N20

N-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS\ (ON)}$**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP8N18/SSH8N18/ SSM8N18	180V	0.4Ω	8.0A
SSP8N20/SSH8N20/ SSM8N20	200V	0.4Ω	8.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP8N18 SSH8N18 SSM8N18	SSP8N20 SSH8N20 SSM8N20	Unit
Drain-Source Voltage (1)	V_{DSS}	180	200	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	180	200	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	8	8	Adc
Continuous Drain Current T_C=100°C	I_D	4.8	4.8	Adc
Drain Current—Pulsed (3)	I_{DM}	25	25	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	135		mJ
Avalanche Current	I_{AS}	8		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP8N18/SSH8N18/SSM8N18	180	—	—	V	V_{GS}=0V I_D=250μA
	SSP8N20/SSH8N20/SSM8N20	200	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	8.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.4	Ω	V_{GS}=10V, I_D=4A
g_{fs}	Forward Transconductance (2)	3.0	—	—	℧	V_{DS}≥50V, I_D=4.0A
C_{iss}	Input Capacitance	—	—	800	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	300	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	100	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	40	ns	V_{DD}=0.5BV_{DSS}, I_D=4.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	200	ns	
t_f	Fall Time	—	—	100	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	15	—	nC	V_{GS}=10V, I_D=8.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	8	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP8N18/20	SSH8N18/20	SSM8N18/20	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.26	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	8.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	25	A	
V_{SD}	Diode Forward Voltage (2)	—	1.4	3.0	V	T_C=25°C, I_S=8.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	—	ns	T_j=150°C, I_F=8.0A, dI_F/dt=100A/μS

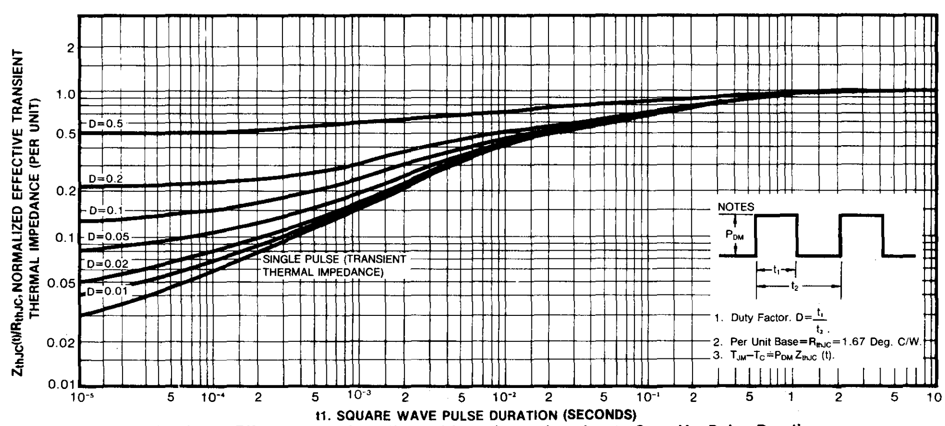
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Output Characteristics

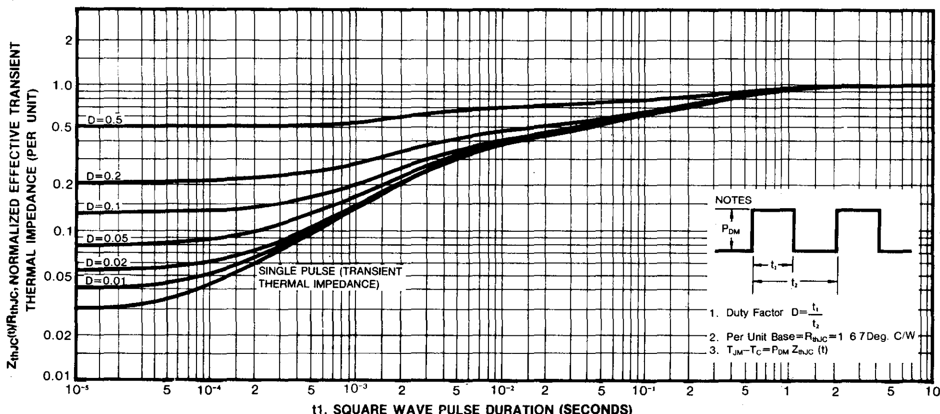
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
Typical Transfer Characteristics

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Saturation Characteristics

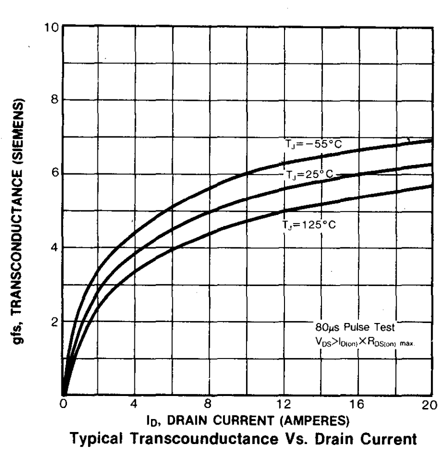
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Maximum Safe Operating Area



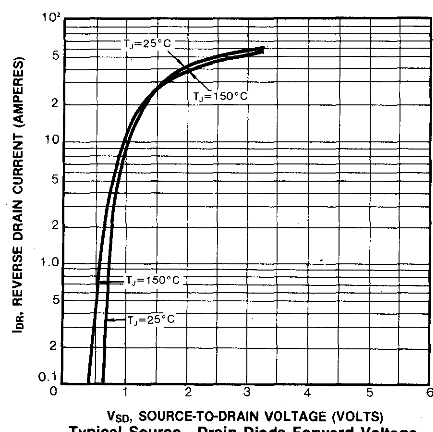
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP8N18/20 and SSM8N18/20



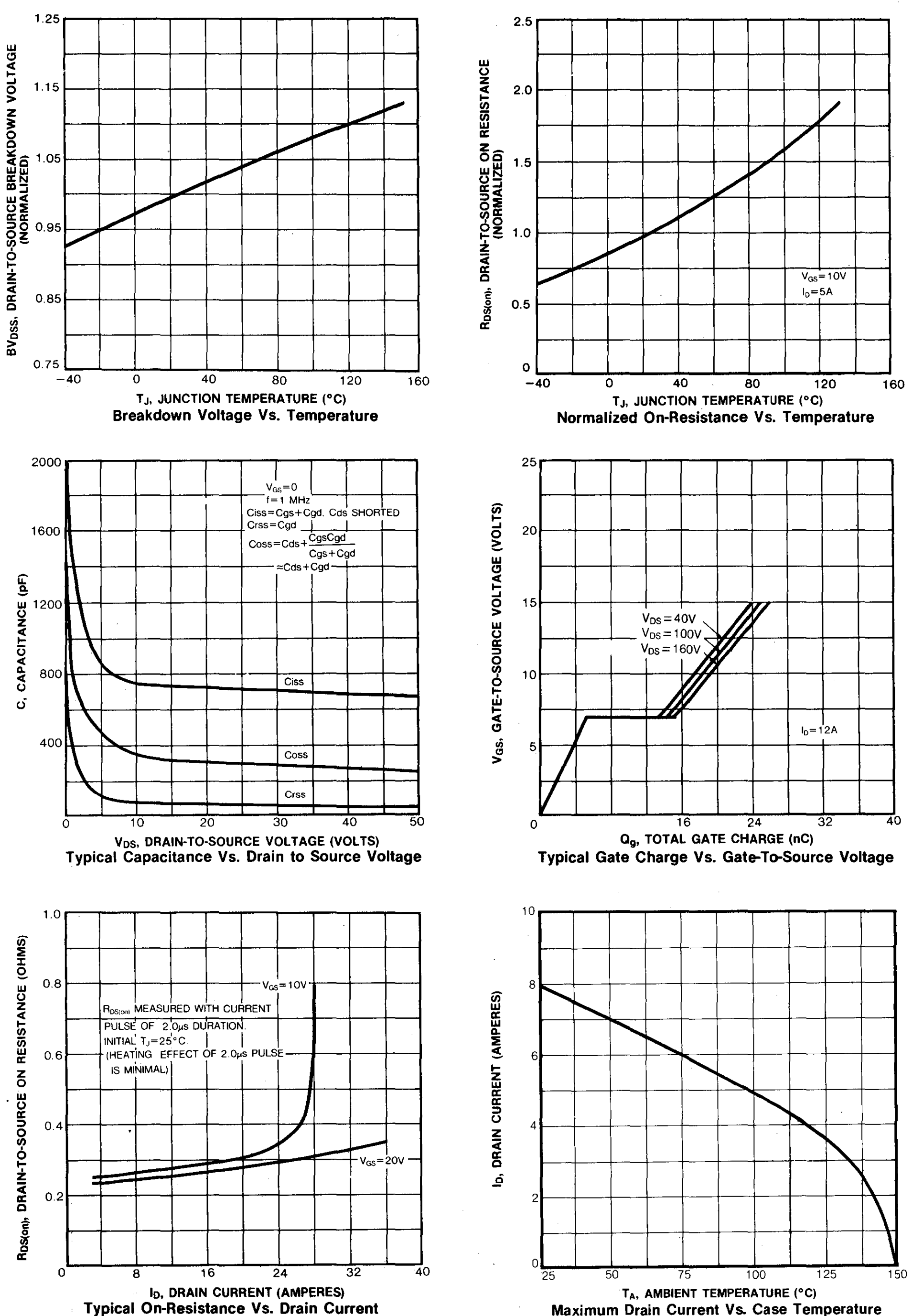
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH8N18/20

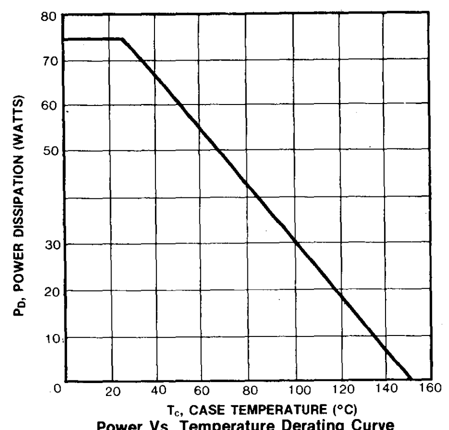


Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

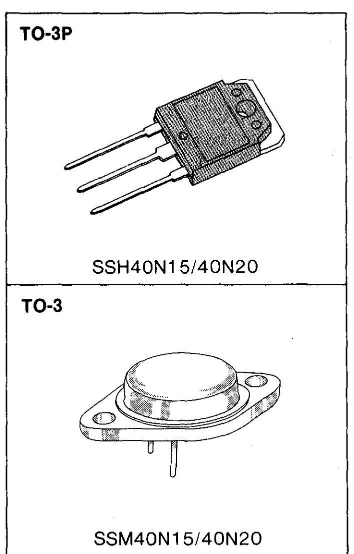

BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=5A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1 MHz
Ciss=Cgs+Cgd. Cds SHORTED
Crss=Cgd
Coss=Cds+CgsCgd/Cgs+Cgd
≈Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS=40V
VDS=100V
VDS=160V
ID=12A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
VGS=10V
RDS(on) MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL TJ=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)
VGS=20V
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

SSH40N15/40N20
SSM40N15/40N20

N-CHANNEL POWER MOSFETS



FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$ A	$R_{DS(on)}$ STD	I_D
SSH40N15 SSM40N15	150V	0.065Ω	0.08Ω	40A
SSH40N20 SSM40N20	200V	0.065Ω	0.08Ω	40A

MAXIMUM RATINGS

Characteristic	Symbol	SSH40N15 SSM40N15	SSH40N20 SSM40N20	Unit
Drain-Source Voltage (1)	V_{DSS}	150	200	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	150	200	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	40		Adc
Continuous Drain Current T_C=100°C	I_D	25		Adc
Drain Current—Pulsed (3)	I_{DM}	120		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	840		mJ
Avalanche Current	I_{AS}	40		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150/200 (5) 1.2/1.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=1 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C
(5) TO-3P/TO-3

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSH40N15/SSM40N15	150	—	—	V	V_{GS}=0V
	SSH40N20/SSM40N20	200	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	40	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	0.065	Ω	V_{GS}=10V, I_D=20A
	STD	—	—	0.08	Ω	
g_{fs}	Forward Transconductance (2)	10	—	—	℧	V_{DS}≥50V, I_D=20A
C_{iss}	Input Capacitance	—	4440	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	771	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	301	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	130	ns	V_{DD}=0.5BV_{DSS}, I_D=20A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	280	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	630	ns	
t_f	Fall Time	—	—	210	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	240	nC	V_{GS}=10V, I_D=50A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	80	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	160	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSH40N15/20	SSM40N15/20	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.63	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

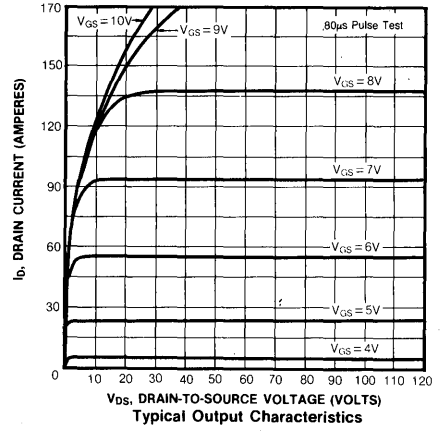
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

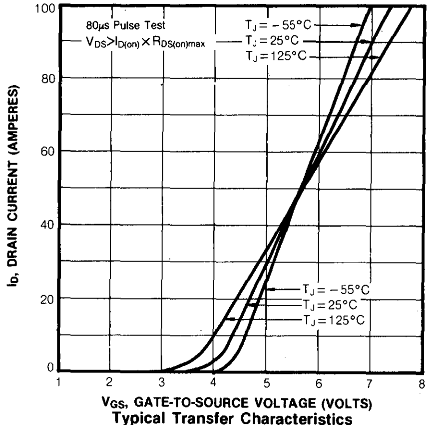
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	15.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	60	A	
V_{SD}	Diode Forward Voltage(2)	—	—	2.5	V	$T_C=25°C$, $I_S=15A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	900	—	ns	$T_j=150°C$, $I_F=15.0A$, $dI_F/dt=100A/\mu S$

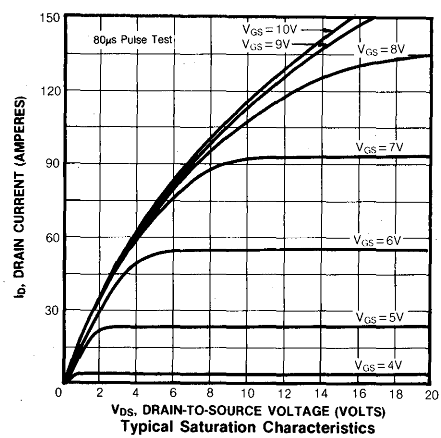
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



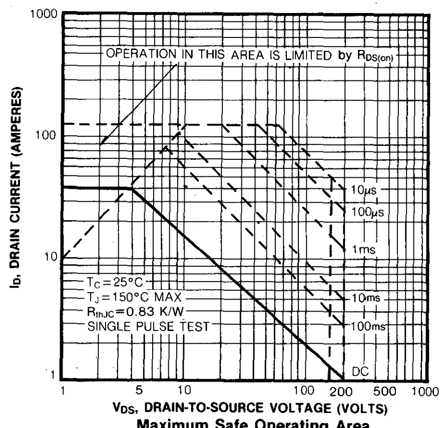
Typical Output Characteristics



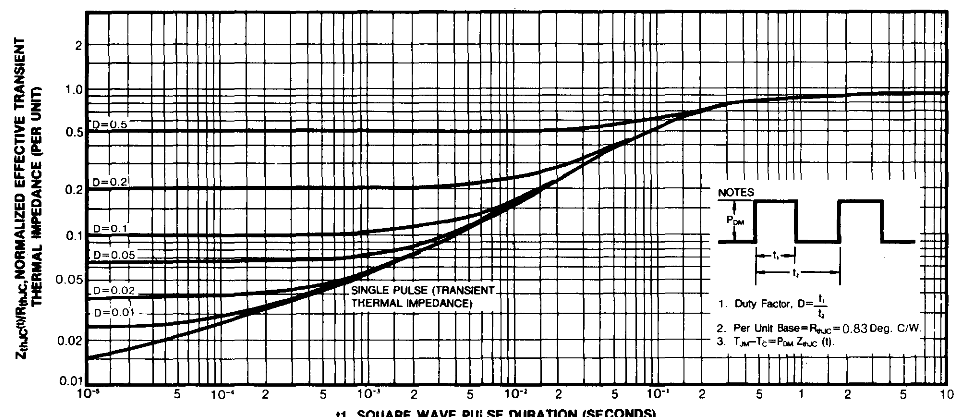
Typical Transfer Characteristics



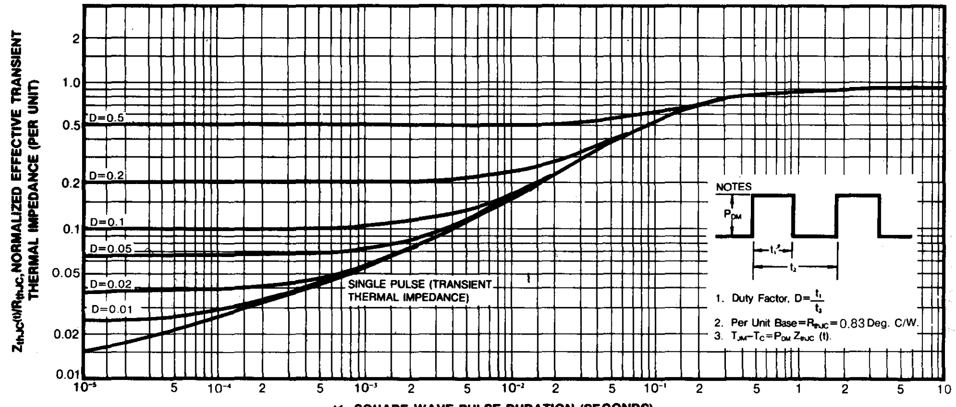
Typical Saturation Characteristics



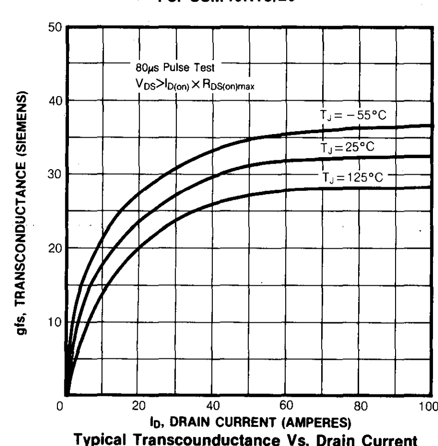
Maximum Safe Operating Area



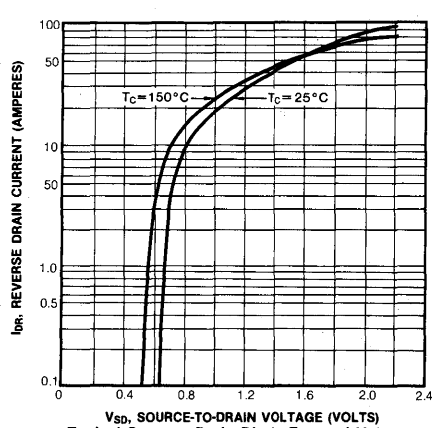
Maximum Effective Transient Thermal Impedance Junction- to-Case Vs. Pulse Duration For SSH40N15/20



Maximum Effective Transient Thermal Impedance Junction- to-Case Vs. Pulse Duration For SSM40N15/20



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

4

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

$V_{GS}=10V$
$I_D=20A$

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

$V_{GS}=0$
$f=1MHz$
Ciss= Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss= Cds+ $\frac{Cgs\ Cgd}{Cgs+Cgd}$
≈Cds+Cgd

C_{iss}, C_{oss}, C_{rss}

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

$V_{DS}=160V$
$V_{DS}=100V$
$V_{DS}=80V$
$I_D=40A$

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$ DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

$V_{GS}=10V$
$V_{GS}=20V$

$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION − INTIAL $T_J=25°C$ (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

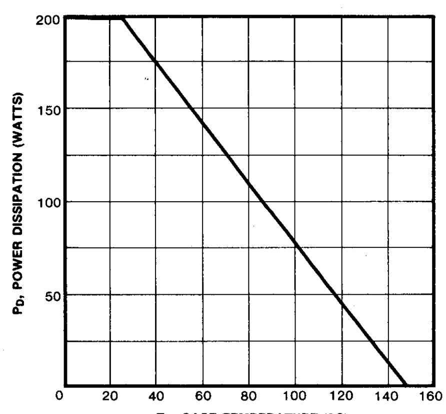
I_D, DRAIN CURRENT (AMPERES)

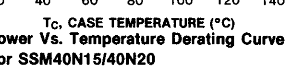
Typical On-Resistance Vs. Drain Current

I_D, DRAIN CURRENT (AMPERES)

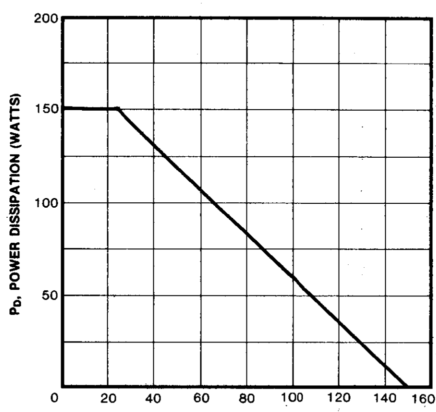
T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature





Power Vs. Temperature Derating Curve For SSM40N15/40N20



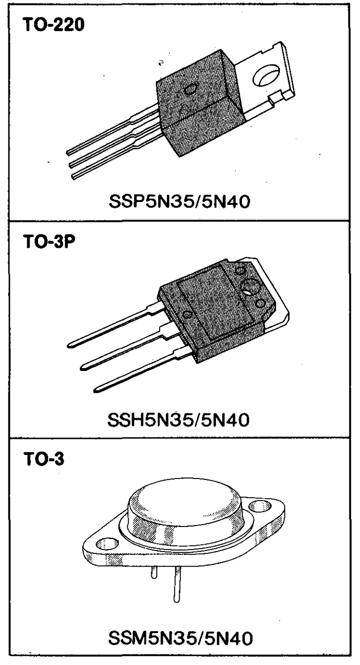
Power Vs. Temperature Derating Curve For SSH40N15/40N20

SSP5N35/5N40
SSH5N35/5N40
SSM5N35/5N40

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP5N35/SSH5N35/ SSM5N35	350V	1.0Ω	5.0A
SSP5N40/SSH5N40/ SSM5N40	400V	1.0Ω	5.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP5N35 SSH5N35 SSM5N35	SSP5N40 SSH5N40 SSM5N40	Unit
Drain-Source Voltage (1)	V_{DSS}	350	400	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	350	400	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	5	5	Adc
Continuous Drain Current T_C=100°C	I_D	25	25	Adc
Drain Current—Pulsed (3)	I_{DM}	12	12	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	240		mJ
Avalanche Current	I_{AS}	5		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=17 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP5N35/SSH5N35/SSM5N35	350	—	—	V	V_{GS}=0V I_D=250μA
	SSP5N40/SSH5N40/SSM5N40	400	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	5.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	1.0	Ω	V_{GS}=10V, I_D=2.5A
g_{fs}	Forward Transconductance (2)	2.0	—	—	℧	V_{DS}≥50V, I_D=2.5A
C_{iss}	Input Capacitance	—	—	1200	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	300	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	80	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=2.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	200	ns	
t_f	Fall Time	—	—	100	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	27	—	nC	V_{GS}=10V, I_D=5.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	17	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	10	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP5N35/40	SSH5N35/40	SSM5N35/40	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

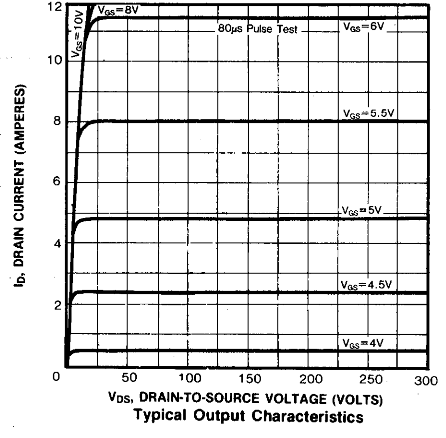
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

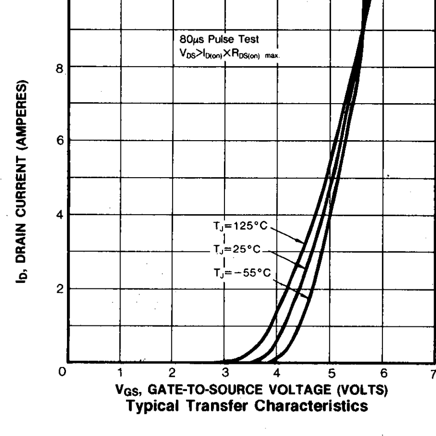
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	5.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	12	A	
V_{SD}	Diode Forward Voltage (2)	—	1.1	1.4	V	T_C=25°C, I_S=5.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	210	—	ns	T_j=150°C, I_F=5.0A, dI_F/dt=100A/μS

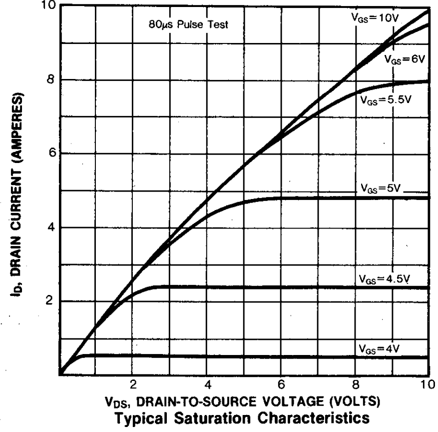
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs. Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



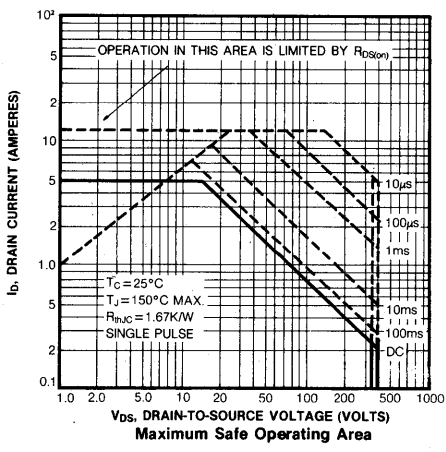
Typical Output Characteristics



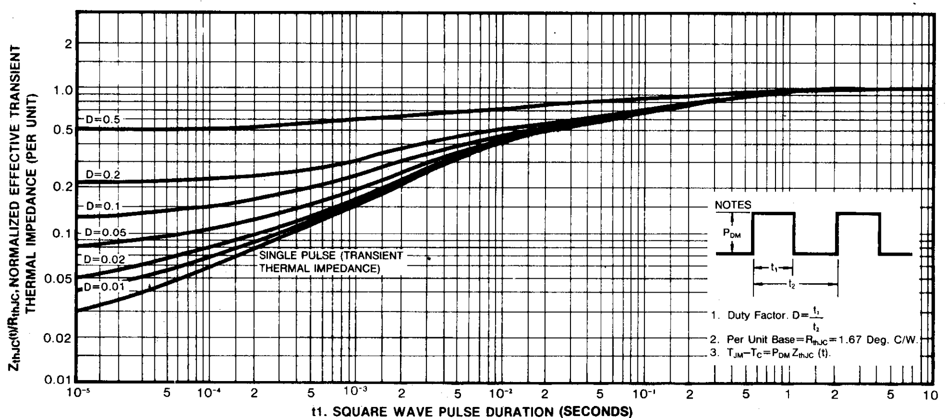
Typical Transfer Characteristics



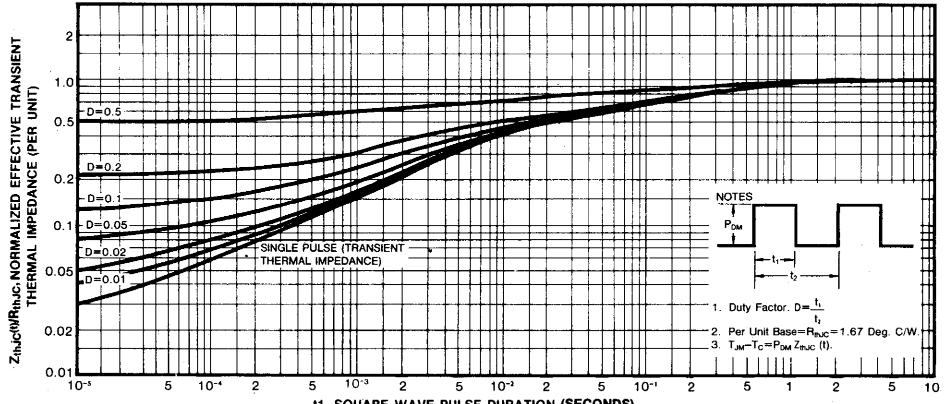
Typical Saturation Characteristics



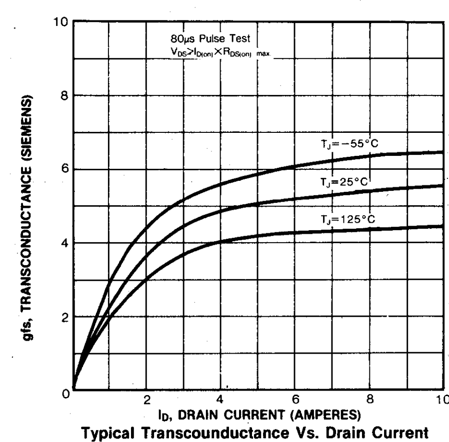
Maximum Safe Operating Area



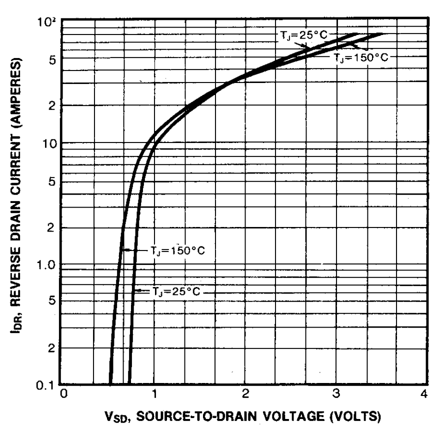
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP5N35/40 and SSM5N35/40



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH5N35/40

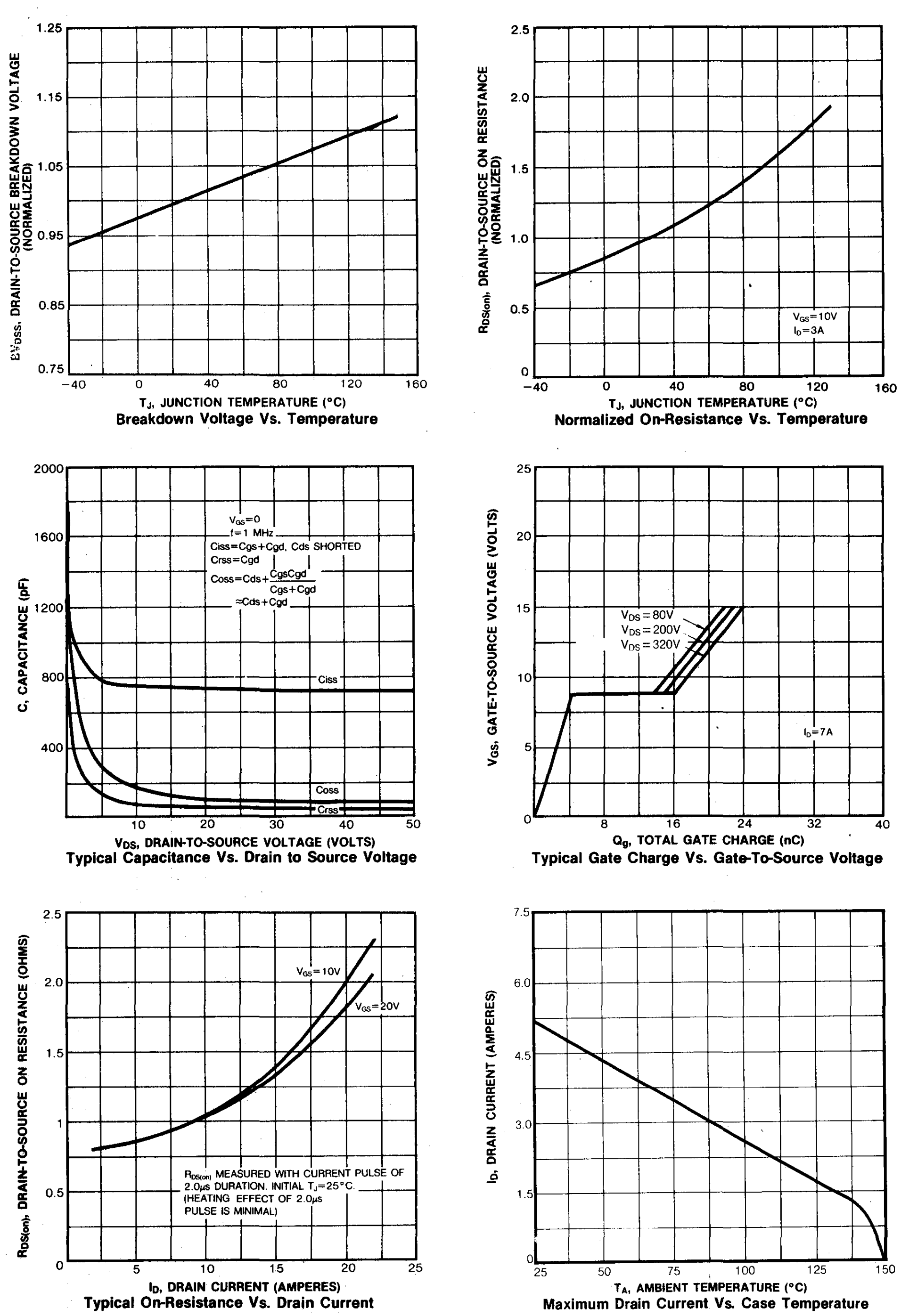


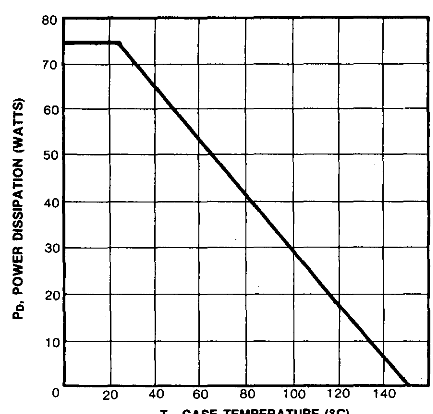
Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

4


BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=3A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss=Cds+CgsCgd/(Cgs+Cgd)
≈Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS=80V
VDS=200V
VDS=320V
ID=7A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
VGS=10V
VGS=20V
RDS(on) MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL TJ=25°C.
(HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



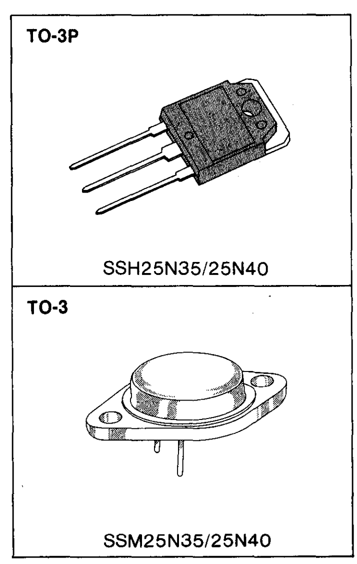
Power Vs. Temperature Derating Curve

SSH25N35/25N40
SSM25N35/25N40

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSH25N35 SSM25N35	350V	0.20Ω	0.25Ω	25A
SSH25N40 SSM25N40	350V	0.20Ω	0.25Ω	25A

MAXIMUM RATINGS

Characteristic	Symbol	SSH25N35 SSM25N35	SSH25N40 SSM25N40	Unit
Drain-Source Voltage (1)	V_{DSS}	350	400	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	350	400	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	25		Adc
Continuous Drain Current T_C=100°C	I_D	16		Adc
Drain Current—Pulsed (3)	I_{DM}	100		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	1310		mJ
Avalanche Current	I_{AS}	25		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150/200 (5) 1.2/1.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C
(5) TO-3P/TO-3

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSH25N35/SSM25N35	350	—	—	V	V_{GS}=0V
	SSH25N40/SSM25N40	400	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	25	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	0.2	Ω	V_{GS}=10V, I_D=13A
	SSH25N35/SSM25N35 SSH25N40/SSM25N40	—	—	0.25	Ω	
g_{fs}	Forward Transconductance (2)	7.0	—	—	℧	V_{DS}≥50V, I_D=13A
C_{iss}	Input Capacitance	—	4287	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	500	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	160	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	130	ns	V_{DD}=0.5BV_{DSS}, I_D=13A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	280	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	630	ns	
t_f	Fall Time	—	—	210	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	240	nC	V_{GS}=10V, I_D=30A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	80	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	160	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSH25N35/40	SSM25N35/40	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.63	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

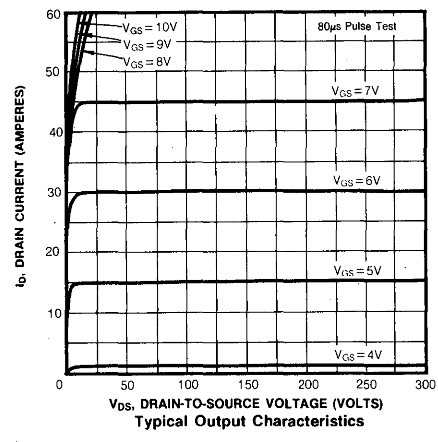
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

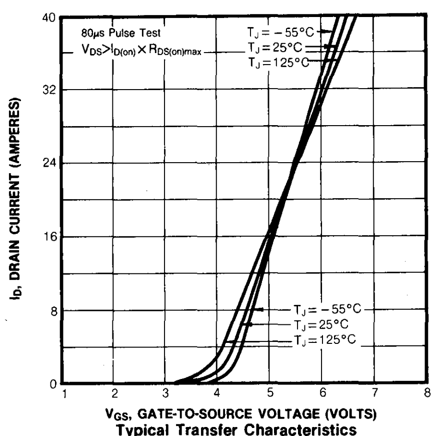
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	25	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	100	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.5	V	T_C=25°C, I_S= A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	1200	—	ns	T_j=150°C, I_F=25A, dI_F/dt=100A/μS

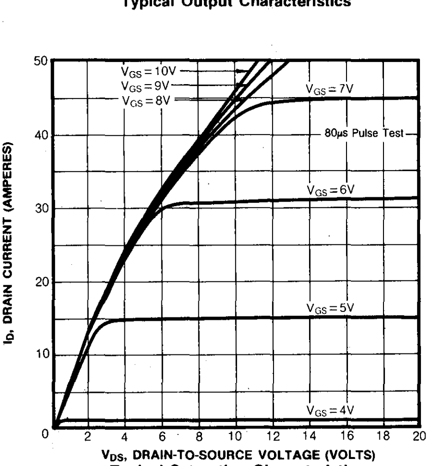
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



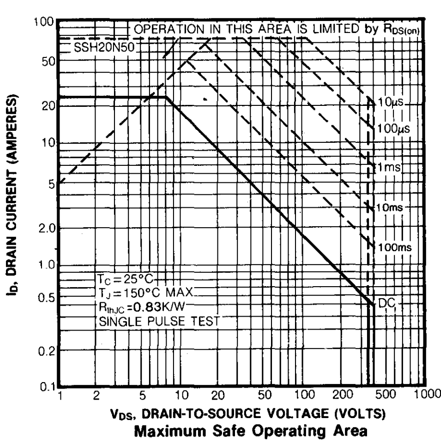
Typical Output Characteristics



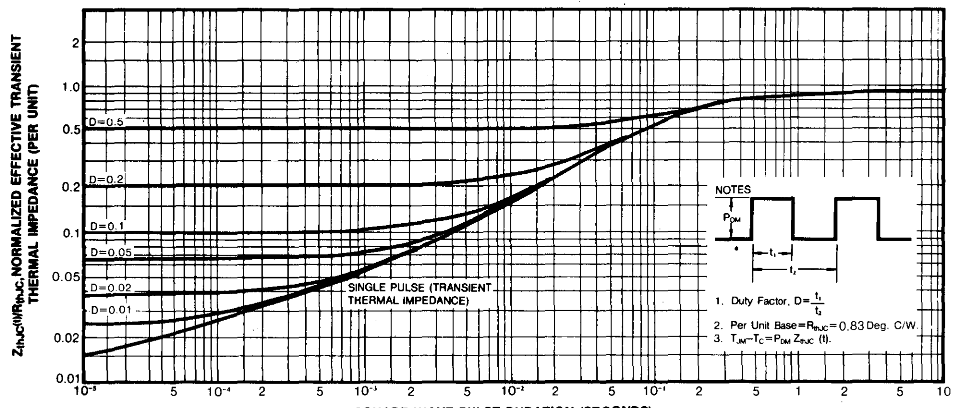
Typical Transfer Characteristics



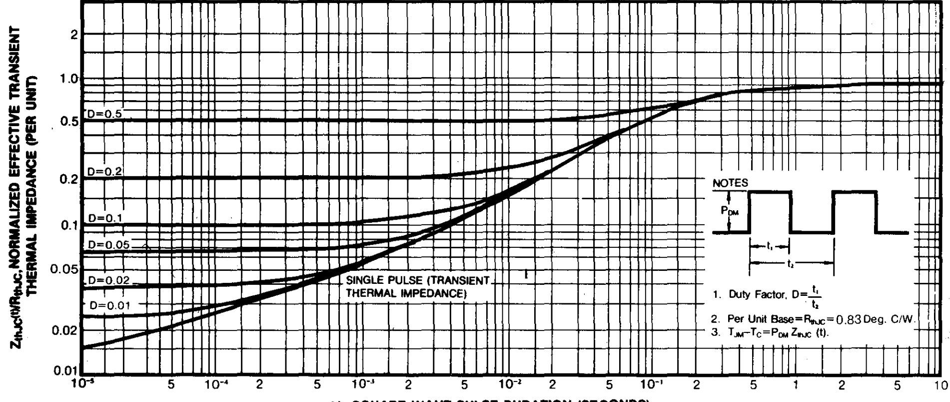
Typical Saturation Characteristics



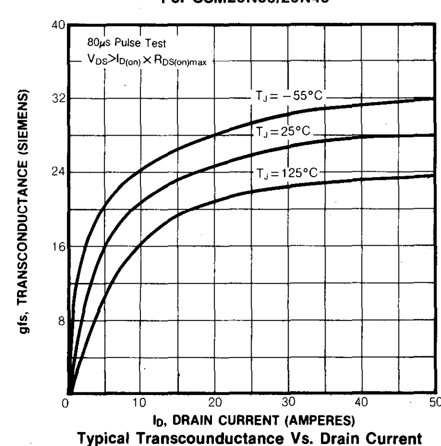
Maximum Safe Operating Area



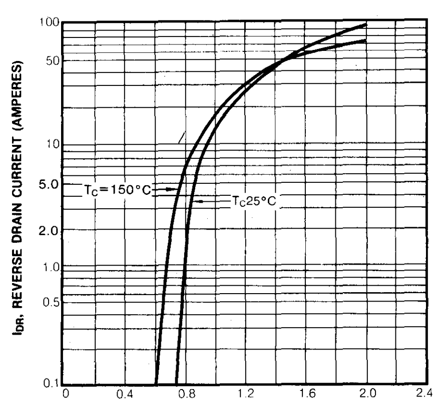
Maximum Effective Transient Thermal Impedance Junction- to-Case Vs. Pulse Duration For SSH25N35/25N40



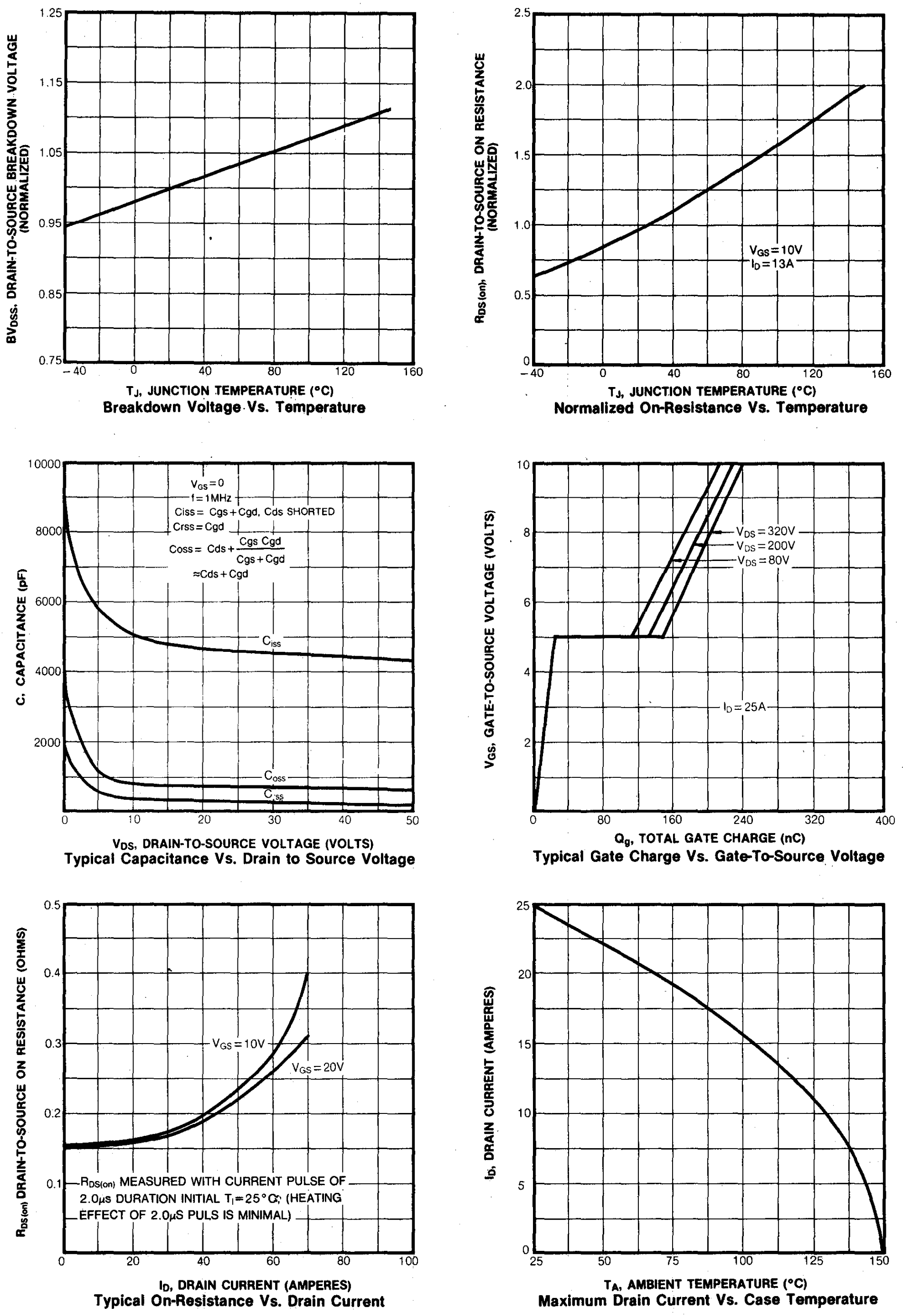
Maximum Effective Transient Thermal Impedance Junction- to-Case Vs. Pulse Duration For SSM25N35/25N40



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage



Breakdown Voltage Vs. Temperature

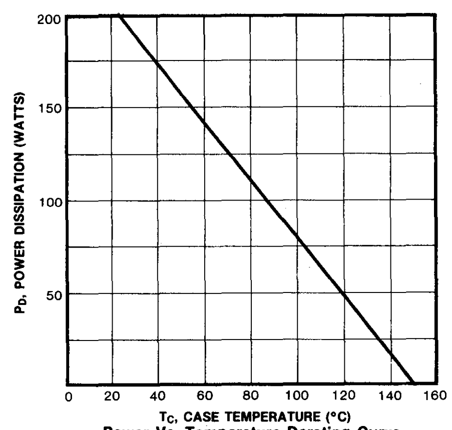
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

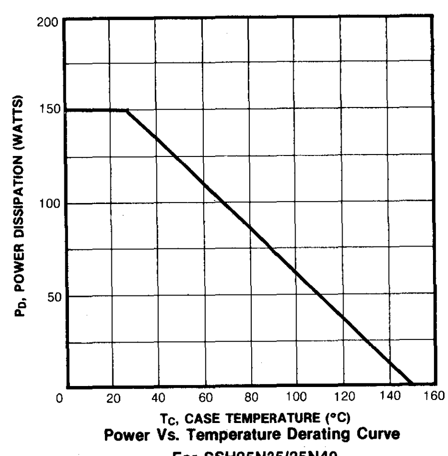
Typical Gate Charge Vs. Gate-To-Source Voltage

Typical On-Resistance Vs. Drain Current

Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve For SSM25N35/25N40



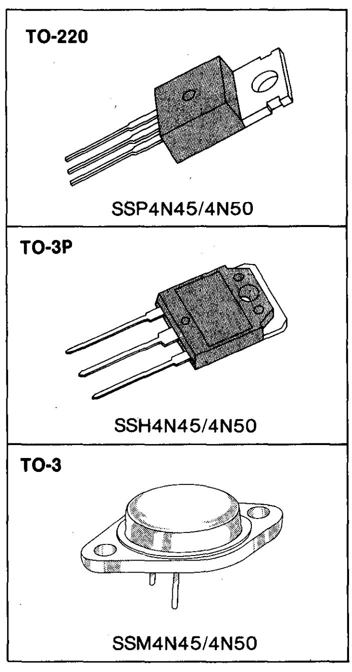
Power Vs. Temperature Derating Curve For SSH25N35/25N40

SSP4N45/4N50
SSH4N45/4N50
SSM4N45/4N50

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP4N45/SSH4N45/ SSM4N45	450V	1.5Ω	4.0A
SSP4N50/SSH4N50/ SSM4N50	500V	1.5Ω	4.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP4N50 SSH4N50 SSM4N45	SSP4N50 SSH4N50 SSM4N50	Unit
Drain-Source Voltage (1)	V_{DSS}	450	500	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	450	500	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	4	4	Adc
Continuous Drain Current T_C=100°C	I_D	2.5	2.5	Adc
Drain Current—Pulsed (3)	I_{DM}	10	10	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	268		mJ
Avalanche Current	I_{AS}	4		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=25 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP4N45/SSH4N45/SSM4N45	450	—	—	V	V_{GS}=0V I_D=250μA
	SSP4N50/SSH4N50/SSM4N50	500	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	4.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	1.5	Ω	V_{GS}=10V, I_D=2.0A
g_{fs}	Forward Transconductance (2)	6.0	—	—	℧	V_{DS}≥50V, I_D=2.0A
C_{iss}	Input Capacitance	—	—	1200	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	300	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	80	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=2.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	200	ns	
t_f	Fall Time	—	—	100	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	27	—	nC	V_{GS}=10V, I_D=4.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	17	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	10	—	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP4N45/50	SSH4N45/50	SSM4N45/50	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

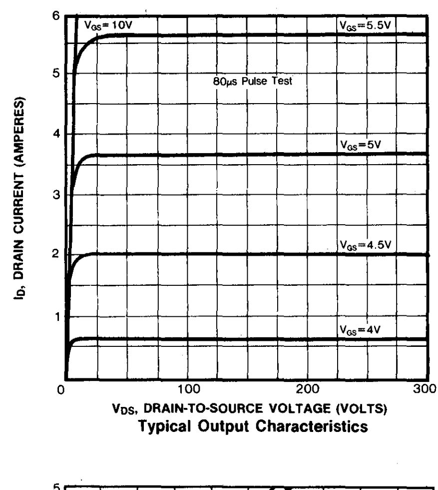
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

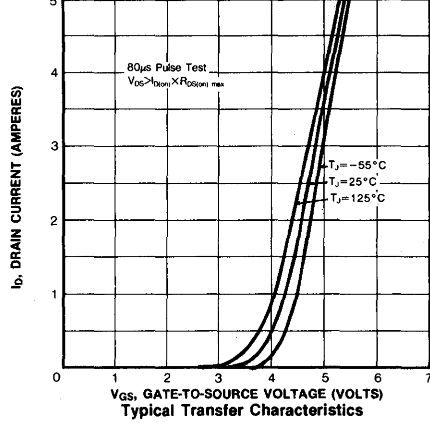
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	4.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	16	A	
V_{SD}	Diode Forward Voltage (2)	—	1.1	1.4	V	$T_C=25°C$, $I_S=4.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	210	—	ns	$T_j=150°C$, $I_F=8.0A$, $dI_F/dt=100A/\mu S$

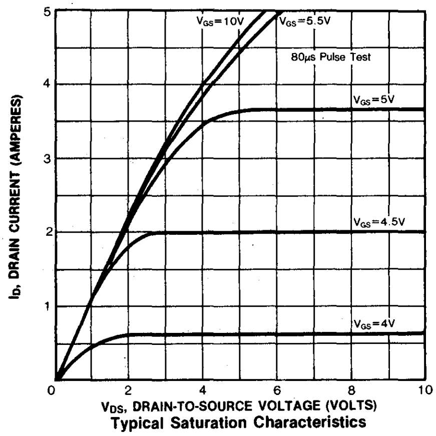
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



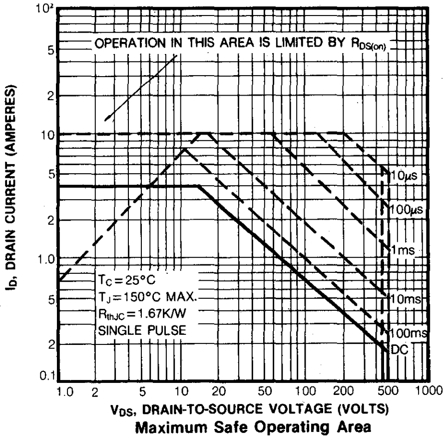
Typical Output Characteristics



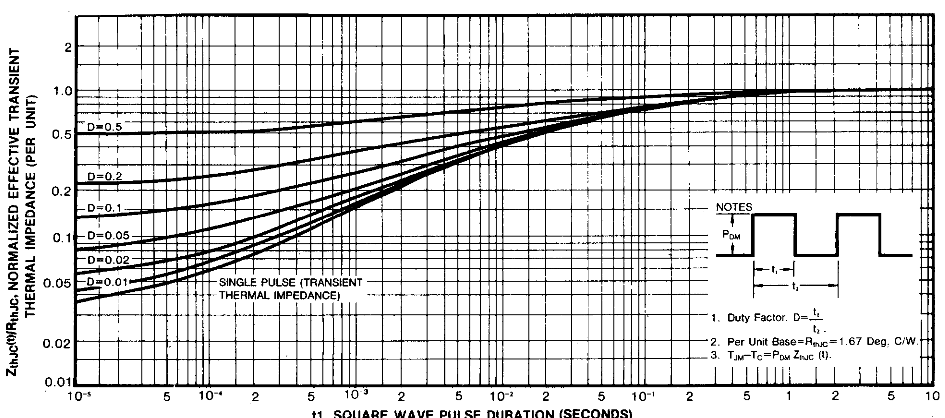
Typical Transfer Characteristics



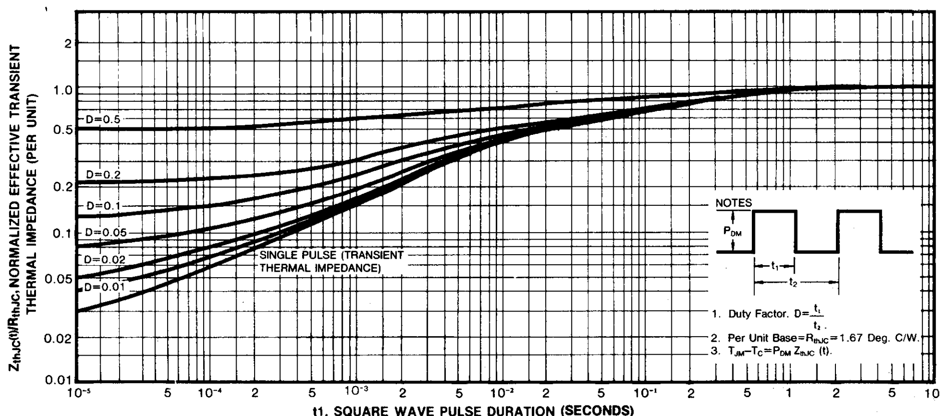
Typical Saturation Characteristics



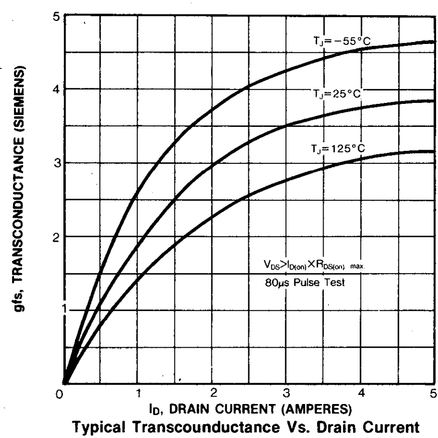
Maximum Safe Operating Area



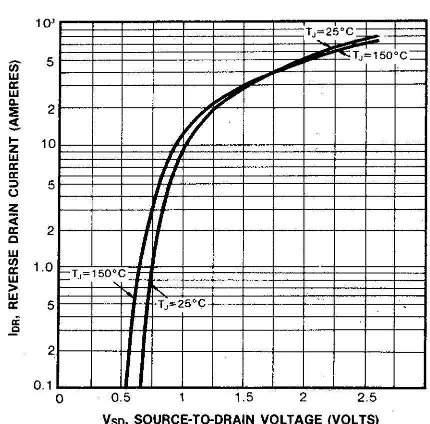
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP4N45/50 and SSM4N45/50



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH4N45/50



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

1.25, 1.15, 1.05, 0.95, 0.85, 0.75

−40, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

2.5, 2.0, 1.5, 1.0, 0.5, 0

V_{GS}=10V
I_D=2.5A

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

2000, 1600, 1200, 800, 400

V_{GS}=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
$Coss=Cds+\frac{CgsCgd}{Cgs+Cgd}$
≅Cds+Cgd

Ciss
Coss
Crss

0, 10, 20, 30, 40, 50

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

25, 20, 15, 10, 5

V_{DS}=100V
V_{DS}=250V
V_{DS}=400V

I_D=6A

0, 8, 16, 24, 32, 40

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

5, 4, 3, 2, 1

$R_{DS(on)}$ MEASURED WITH CURRENT
PULSE OF 2.0μs DURATION.
INITIAL T_J=25°C.
(HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

V_{GS}=10V
V_{GS}=20V

0, 5, 10, 15, 20, 25

I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

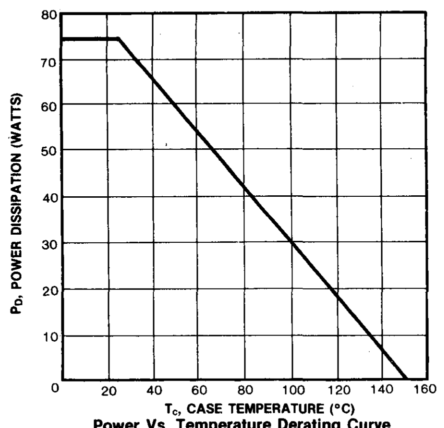
I_D, DRAIN CURRENT (AMPERES)

5, 4, 3, 2, 1, 0

25, 50, 75, 100, 125, 150

T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



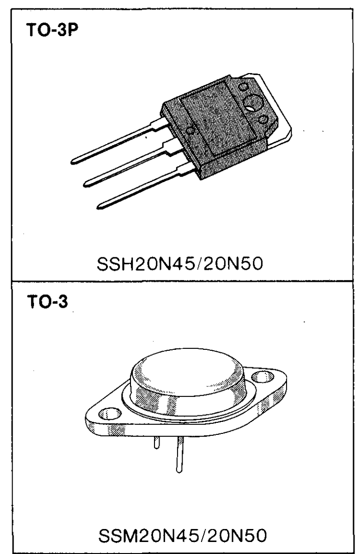
Power Vs. Temperature Derating Curve

SSH20N45/20N50
SSM20N45/20N50

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSH20N45 SSM20N45	450V	0.25Ω	0.35Ω	20A
SSH20N50 SSM20N50	500V	0.25Ω	0.35Ω	20A

MAXIMUM RATINGS

Characteristic	Symbol	SSH20N45 SSH20N45	SSM20N50 SSM20N50	Unit
Drain-Source Voltage (1)	V_{DSS}	450	500	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	450	500	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	20		Adc
Continuous Drain Current T_C=100°C	I_D	13		Adc
Drain Current—Pulsed (3)	I_{DM}	80		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	960		mJ
Avalanche Current	I_{AS}	20		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150/200 1.2/1.6 (5)		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4.3mH, V_{dd}=50V, R_G=25Ω, starting T_j=25°C
(5) TO-3P/TO-3

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSH20N45/SSM20N45	450	—	—	V	V_{GS}=0V
	SSH20N50/SSM20N50	500	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	20	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	0.25	Ω	V_{GS}=10V, I_D=13A
	STD	—	—	0.35	Ω	
g_{fs}	Forward Transconductance (2)	7.0	—	—	℧	V_{DS}≥50V, I_D=13A
C_{iss}	Input Capacitance	—	4260	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	438	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	125	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	130	ns	V_{DD}=0.5BV_{DSS}, I_D=10A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	280	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	630	ns	
t_f	Fall Time	—	—	210	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	240	nC	V_{GS}=10V, I_D=25A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	80	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	160	nC	

THERMAL RESISTANCE

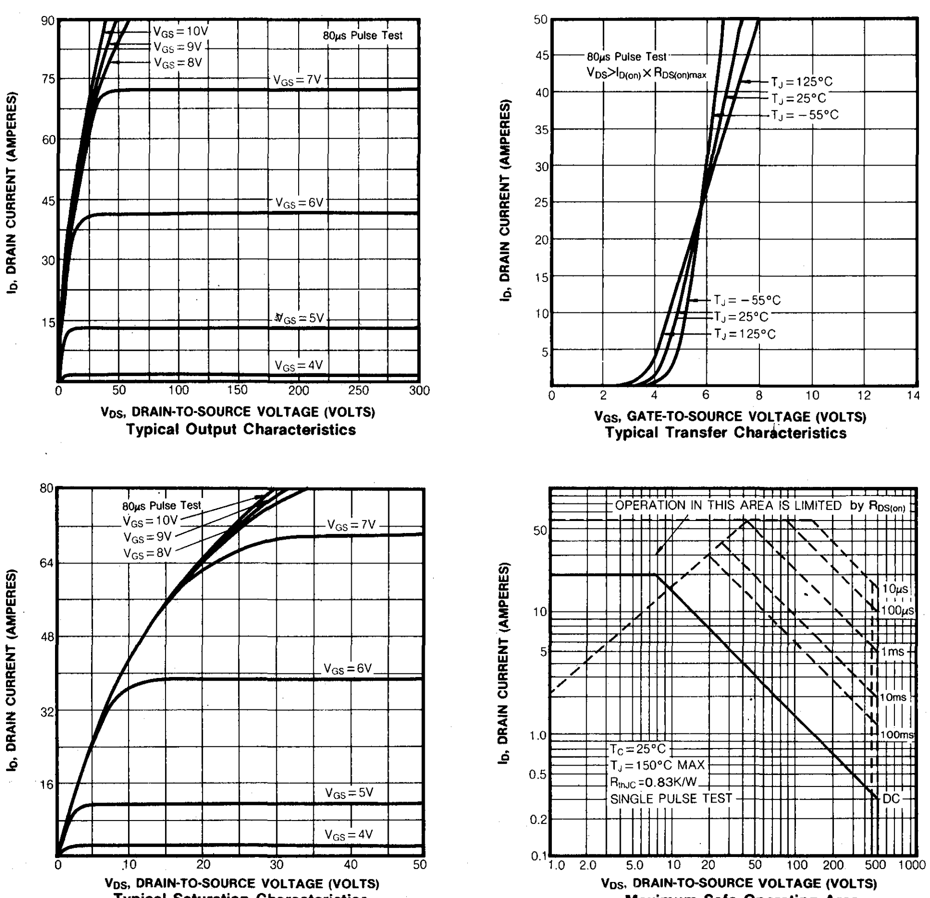
Symbol	Characteristic		SSH20N45/50	SSM20N45/50	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.63	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	20	A	Modified MOSFET showing the integral reverse P-N junction rectifier (G, D, S)
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	80	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.5	V	T_C=25°C, I_S=20A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	900	—	ns	T_j=150°C, I_F=20A, dI_F/dt=100A/μS

Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

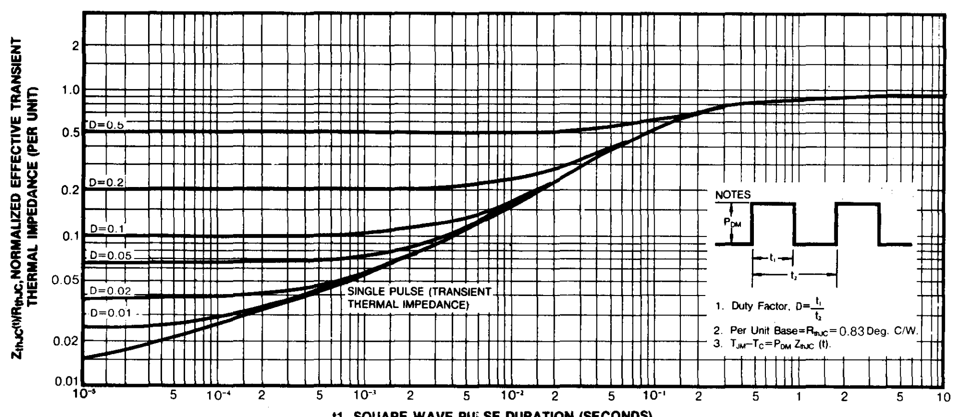


Typical Output Characteristics

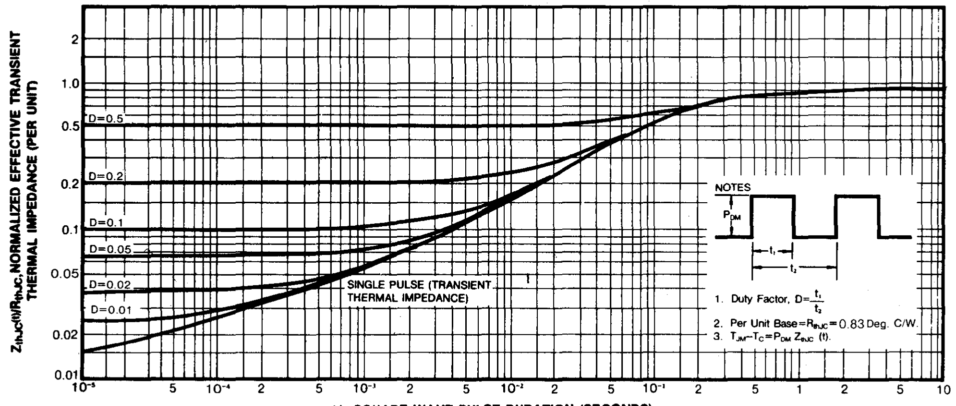
Typical Transfer Characteristics

Typical Saturation Characteristics

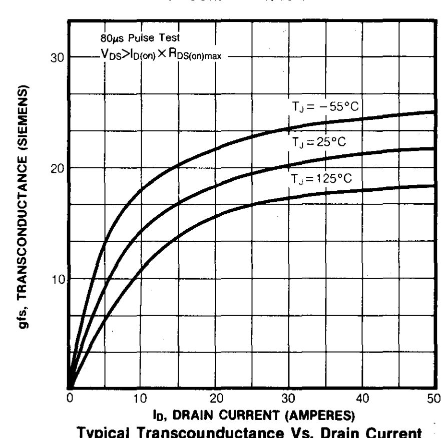
Maximum Safe Operating Area



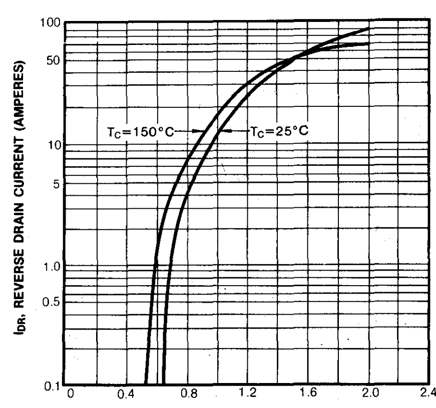
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH20N45/20N50



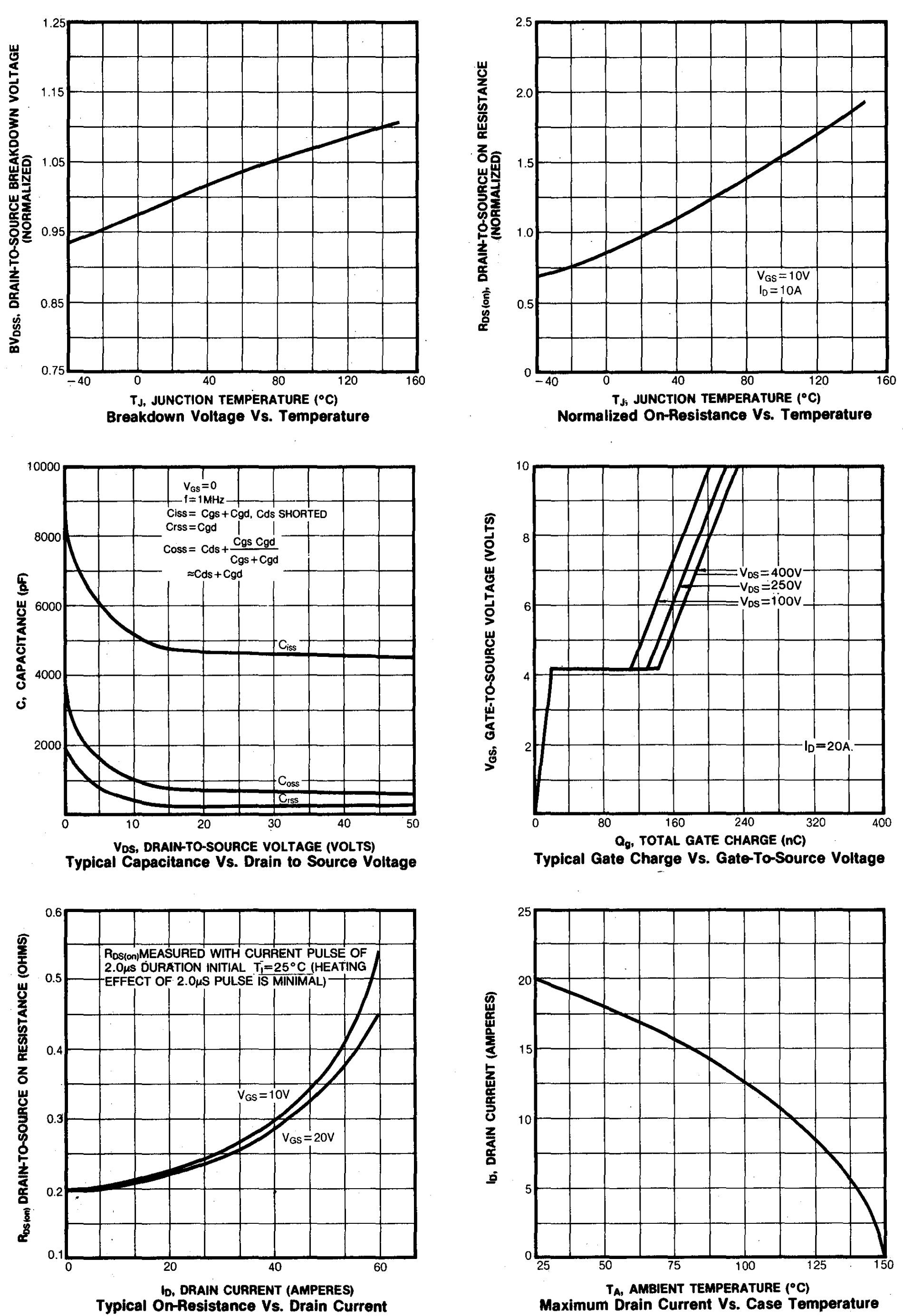
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSM20N45/20N50



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage



Breakdown Voltage Vs. Temperature

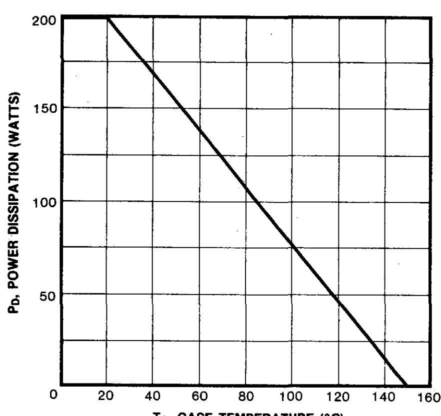
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

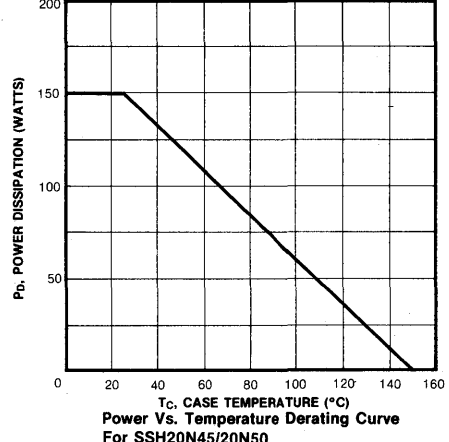
Typical Gate Charge Vs. Gate-To-Source Voltage

Typical On-Resistance Vs. Drain Current

Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve For SSM20N45/20N50



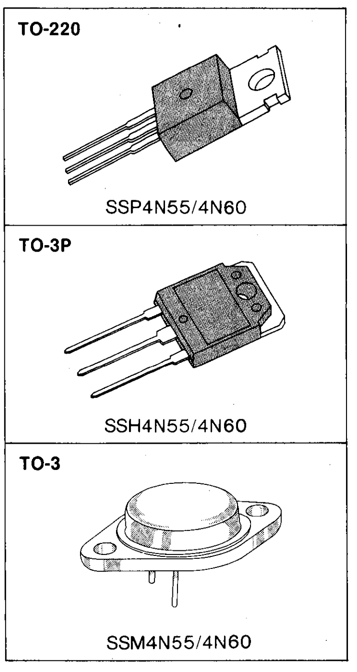
Power Vs. Temperature Derating Curve For SSH20N45/20N50

SSP4N55/4N60
SSH4N55/4N60
SSM4N55/4N60

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP4N55/SSH4N55/ SSM4N55	550V	3.0Ω	4A
SSP4N60/SSH4N60/ SSM4N60	600V	3.0Ω	4A

MAXIMUM RATINGS

Characteristic	Symbol	SSP4N55 SSH4N55 SSM4N55	SSP4N60 SSH4N60 SSM4N60	Unit
Drain-Source Voltage (1)	V_{DSS}	550	600	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	550	600	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	4	4	Adc
Continuous Drain Current T_C=100°C	I_D	2.5	2.5	Adc
Drain Current—Pulsed (3)	I_{DM}	16	16	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	358		mJ
Avalanche Current	I_{AS}	4		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=42 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP4N60/SSH4N60/SSM4N60	600	—	—	V	V_{GS}=0V I_D=250μA
	SSP4N55/SSH4N55/SSM4N55	550	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	4	—	—	A	V_{DS}>$I_{D(on)}$×$R_{OS(on)\ max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	2.0	3.1	Ω	V_{GS}=10V, I_D=2.0A
g_{fs}	Forward Transconductance (2)	2.0	3.1	—	℧	V_{DS}≥50V, I_D=2.0A
C_{iss}	Input Capacitance	—	720	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	40	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	40	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	40	ns	V_{DD}=0.5BV_{DSS}, I_D=2.0A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	100	ns	
t_f	Fall Time	—	—	60	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	25	—	nC	V_{10}=10V, I_D=8.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—		15	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	6.0	—	nC	

THERMAL RESISTANCE

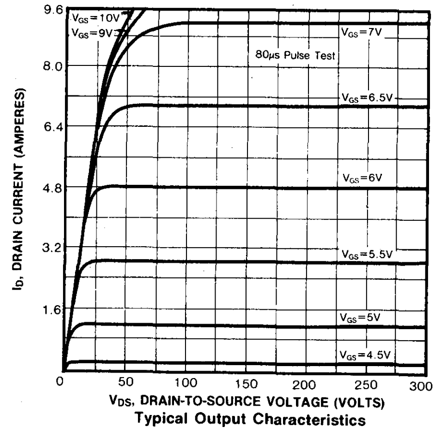
Symbol	Characteristic		SSP4N50/60	SSH4N55/60	SSN4N55/60		
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

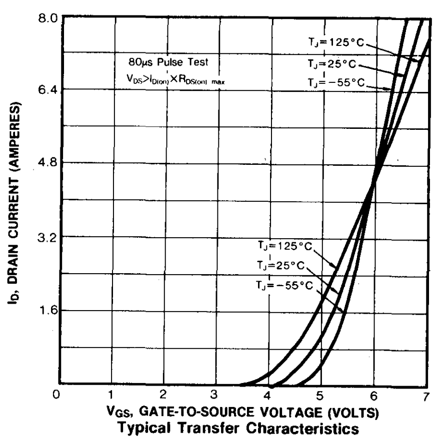
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	4.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	16.0	A	
V_{SD}	Diode Forward Voltage (2)	—	—	1.5	V	$T_C=25°C$, $I_S=4.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	600	—	μs	$T_j=150°C$, $I_F=8.0A$, $dI_F/dt=100A/\mu S$

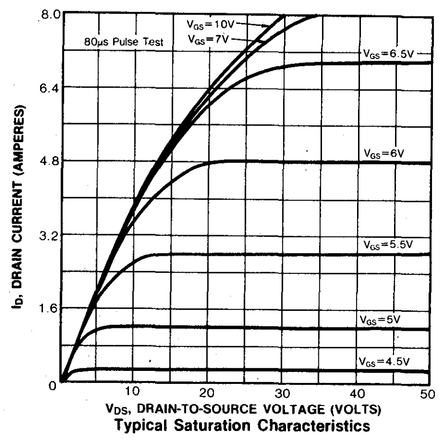
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



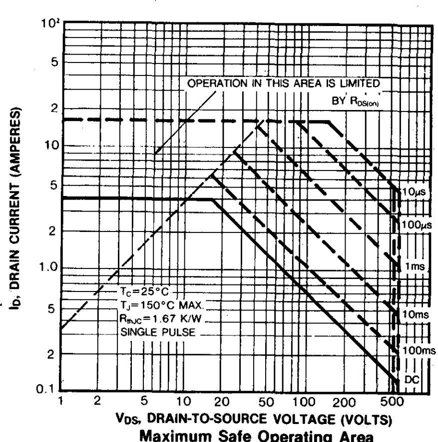
Typical Output Characteristics



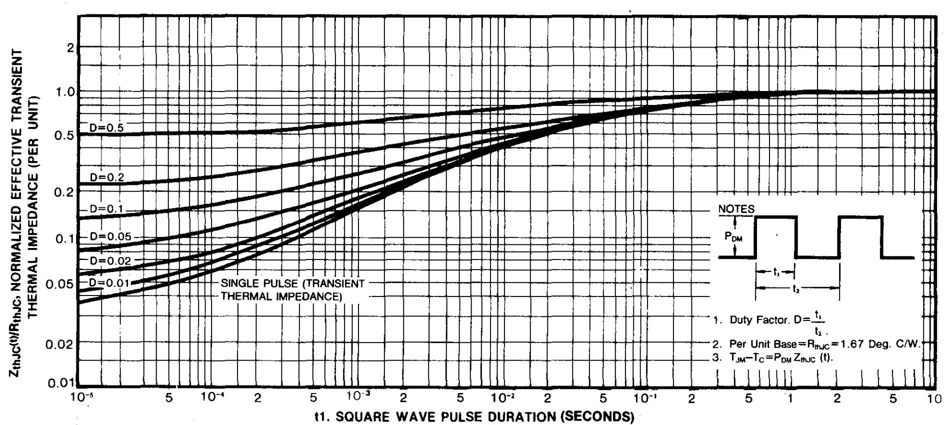
Typical Transfer Characteristics



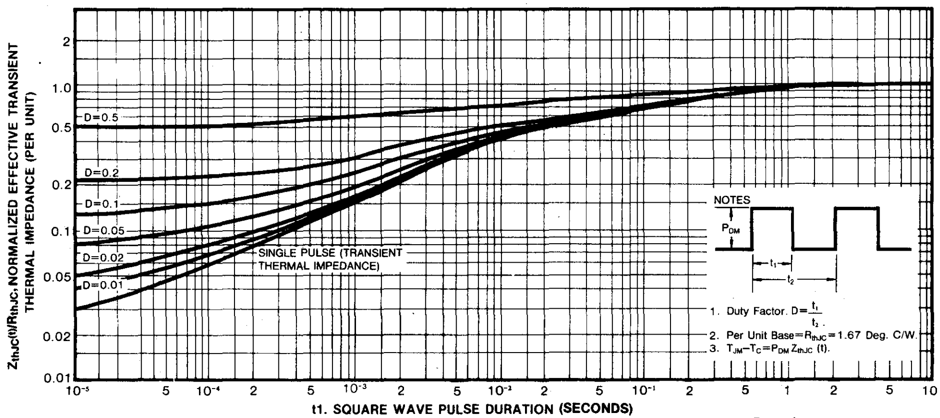
Typical Saturation Characteristics



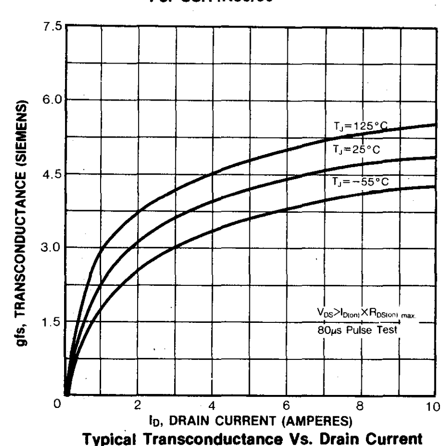
Maximum Safe Operating Area



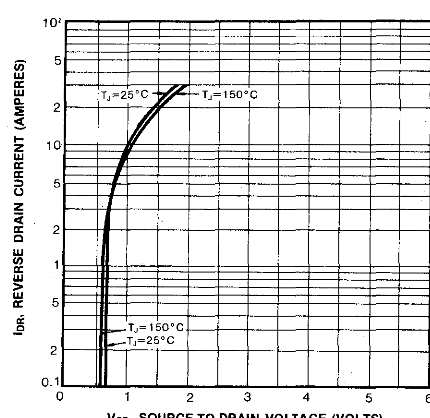
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP4N55/60 and SSM4N55/60



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH4N55/60

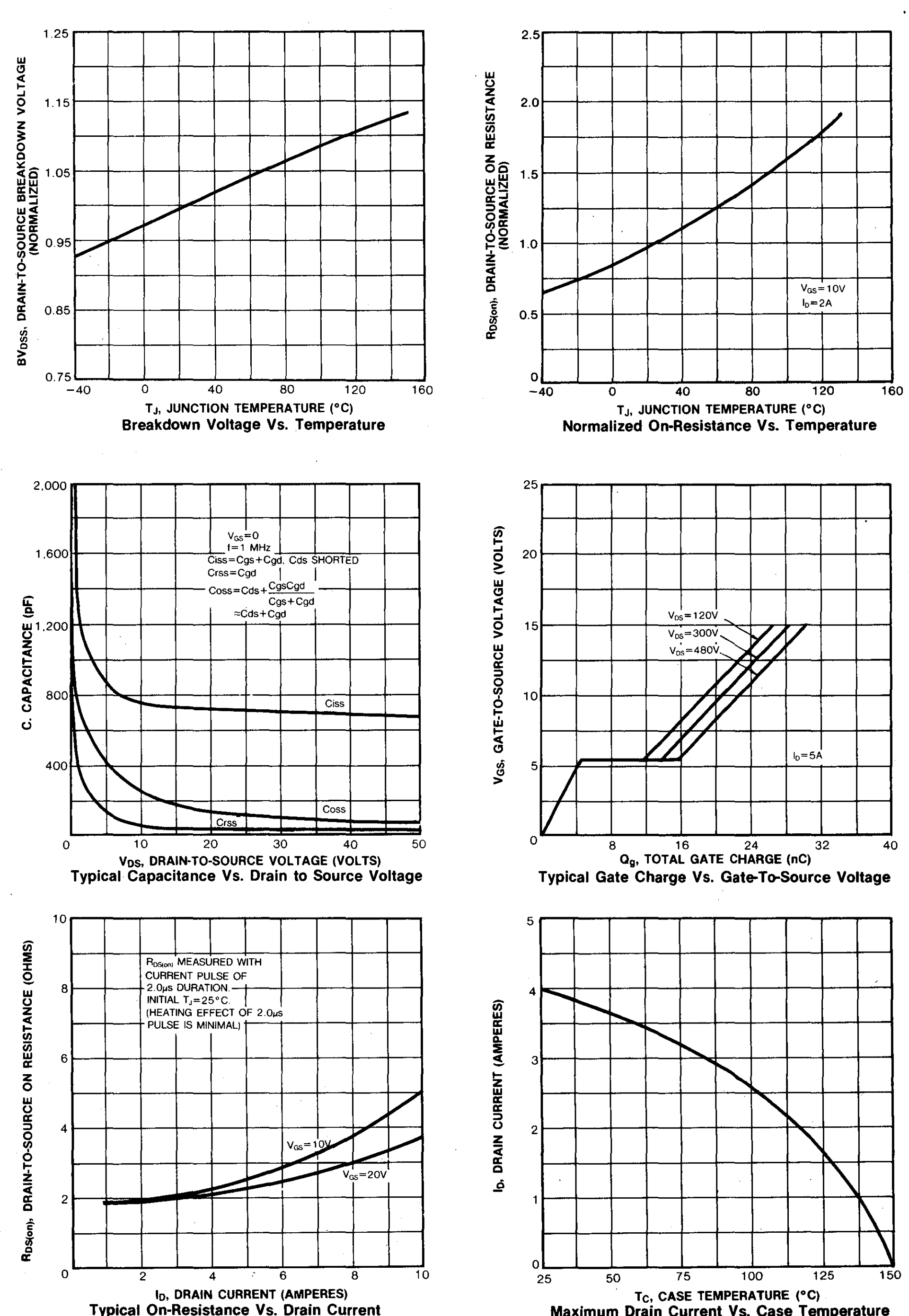


Typical Transconductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

4



Breakdown Voltage Vs. Temperature

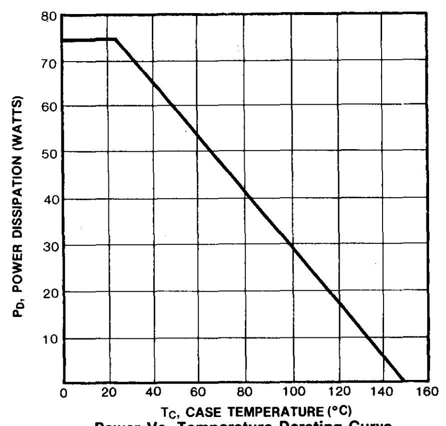
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

Typical Gate Charge Vs. Gate-To-Source Voltage

Typical On-Resistance Vs. Drain Current

Maximum Drain Current Vs. Case Temperature



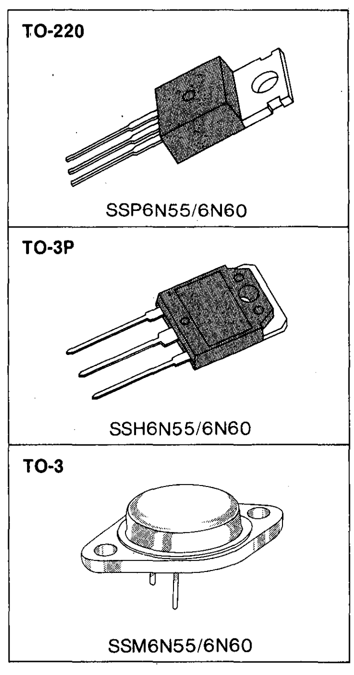
Power Vs. Temperature Derating Curve

SSP6N55/6N60
SSH6N55/6N60
SSM6N55/6N60

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSP6N55/SSH6N55/ SSM6N55	550V	1.8Ω	6.0A
SSP6N60/SSH6N60/ SSM6N60	600V	1.8Ω	6.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP6N55 SSH6N55 SSM6N55	SSP6N60 SSH6N60 SSM6N60	Unit
Drain-Source Voltage (1)	V_{DSS}	550	600	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	550	600	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	6.0	6.0	Adc
Continuous Drain Current T_C=100°C	I_D	4.0	4.0	Adc
Drain Current—Pulsed (3)	I_{DM}	24	24	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	570		mJ
Avalanche Current	I_{AS}	6.0		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=27mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSP6N55/SSH6N55/ SSM6N55	550	—	—	V	V_{GS}=0V I_D=250μA
	SSP6N60/SSH6N60/ SSM6N60	600	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	$V_{DS}=V_{GS}$, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	6.0	—	—	A	$V_{GS}>I_{D(on)}\times R_{OS(on)\,max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	1.8	Ω	V_{GS}=10V, I_D=3.0A
g_{fs}	Forward Transconductance (2)	3.0	4.8	—	℧	V_{DS}≥50V, I_D=3.0A
C_{iss}	Input Capacitance	—	—	1800	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	—	350	pF	
C_{rss}	Reverse Transfer Capacitance	—	—	150	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	60	ns	V_{DD}=0.5BV_{DSS}, I_D=3.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	200	ns	
t_f	Fall Time	—	—	120	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	40	nC	V_{GS}=10V, I_D=7.5A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	15	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	25	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSP6N55/60	SSH6N55/60	SSM6N55/60	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

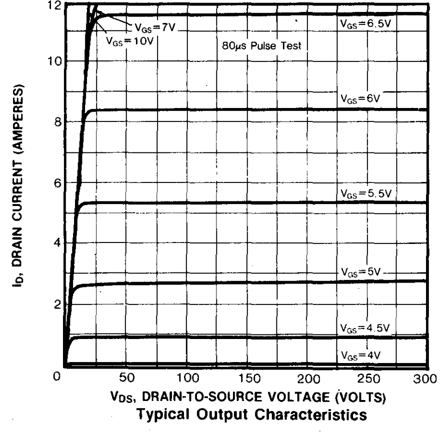
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

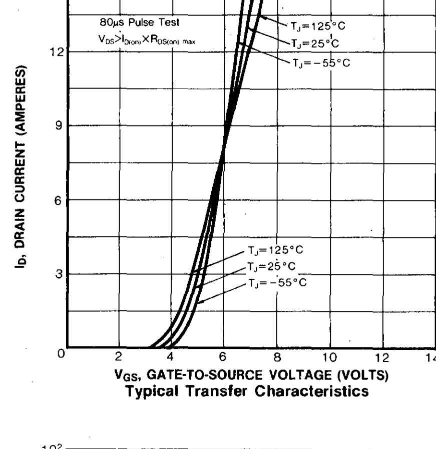
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	6.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	24.0	A	
V_{SD}	Diode Forward Voltage (2)	—	—	1.5	V	T_C=25°C, I_S=10.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	450	940	ns	T_j=150°C, I_F=10.0A, dI_F/dt=100A/μS

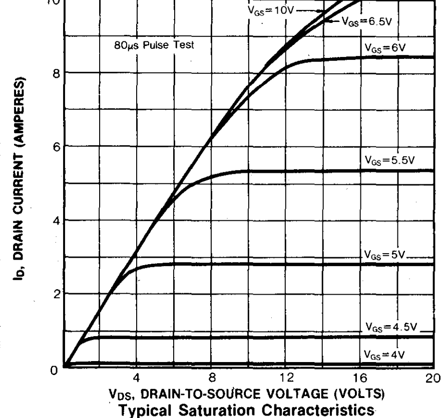
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



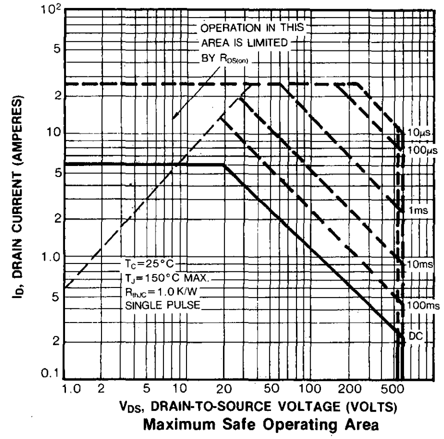
Typical Output Characteristics



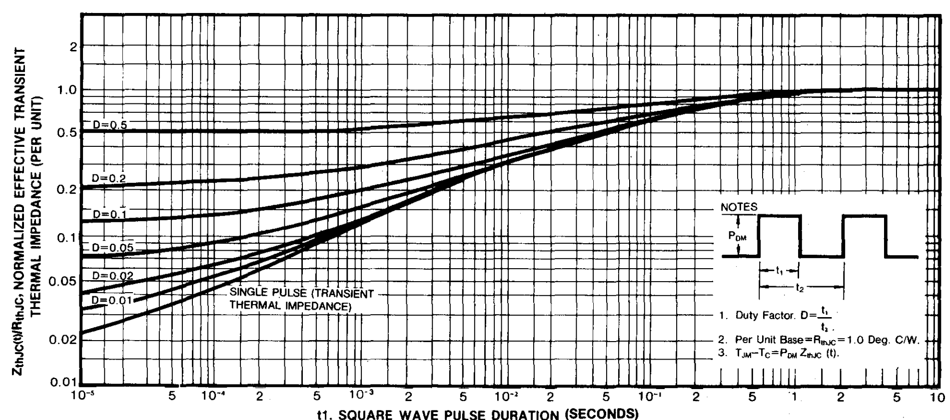
Typical Transfer Characteristics



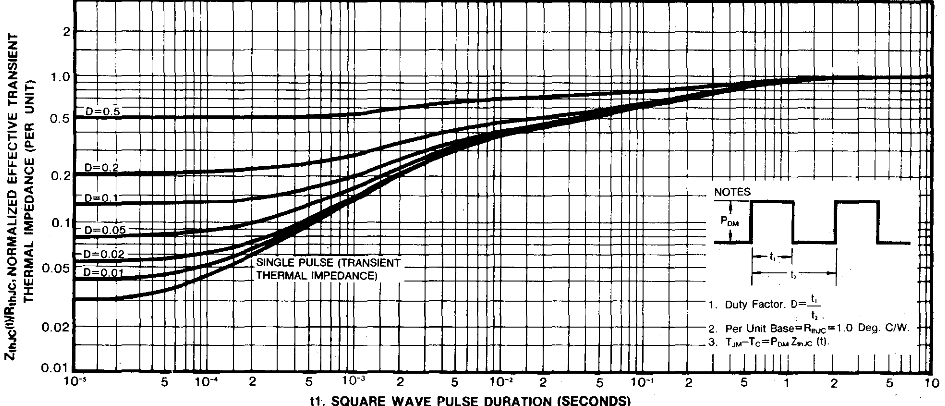
Typical Saturation Characteristics



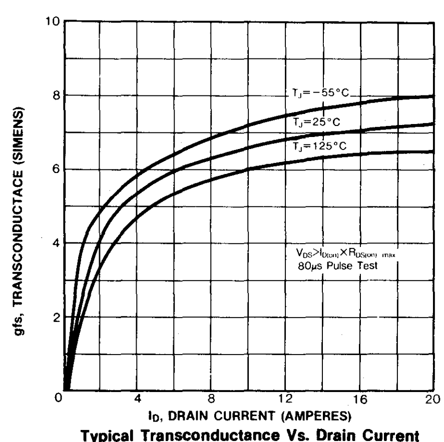
Maximum Safe Operating Area



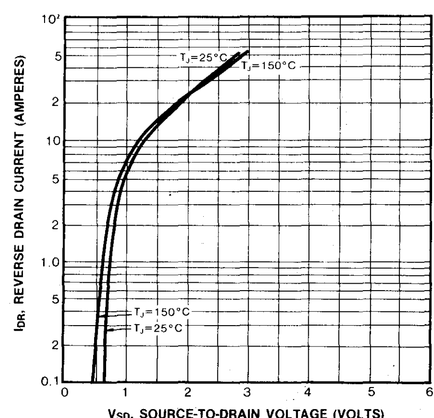
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP6N55/60 And SSM6N55/60



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH6N55/60



Typical Transconductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

1.25, 1.15, 1.05, 0.95, 0.85, 0.75

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

2.5, 2.0, 1.5, 1.0, 0.5, 0

V_{GS}=10V
I_D=3A

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

3,000, 2,400, 1,800, 1,200, 600, 0

V_{GS}=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
$\text{Coss}=\text{Cds}+\frac{\text{CgsCgd}}{\text{Cgs}+\text{Cgd}}$
≈Cds+Cgd

Ciss
Coss
Crss

10, 20, 30, 40, 50

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

25, 20, 15, 10, 5, 0

V_{DS}=120V
V_{DS}=300V
V_{DS}=480V

I_D=7.5A

20, 40, 60, 80, 100

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

5, 4, 3, 2, 1, 0

$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL T_J=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

V_{GS}=10V
V_{GS}=20V

5, 10, 15, 20, 25

I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

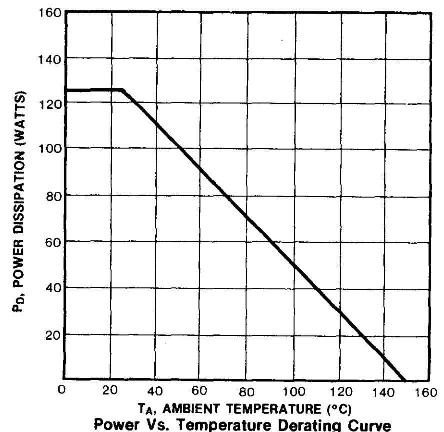
I_D, DRAIN CURRENT (AMPERES)

10, 8, 6, 4, 2, 0

25, 50, 75, 100, 125, 150

T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



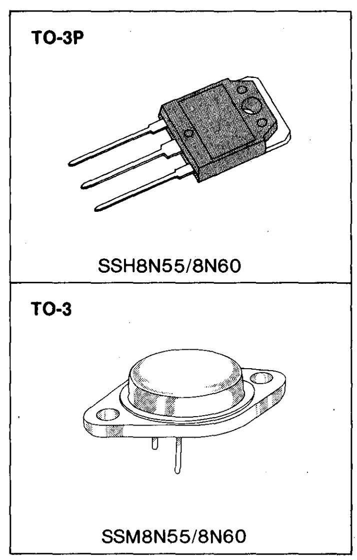
Power Vs. Temperature Derating Curve

SSH8N55/8N60
SSM8N55/8N60

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
SSH8N55/SSM8N55	550V	1.0Ω	8A
SSH8N60/SSM8N60	600V	1.0Ω	8A

MAXIMUM RATINGS

Characteristic	Symbol	SSH8N55 SSM8N55	SSH8N60 SSM8N60	Unit
Drain-Source Voltage (1)	V_{DSS}	550	600	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	550	600	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	8.0	8.0	Adc
Continuous Drain Current T_C=100°C	I_D	5.0	5.0	Adc
Drain Current—Pulsed (3)	I_{DM}	32	32	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	492		mJ
Avalanche Current	I_{AS}	8		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150 1.4/1.2		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=14 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSH8N55/SSM8N55	550	—	—	V	V_{GS}=0V
	SSH8N60/SSM8N60	600	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	8.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	0.7	1.0	Ω	V_{GS}=10V, I_D=4A
g_{fs}	Forward Transconductance (2)	5.0	5.6	—	℧	V_{DS}≥50V, I_D=4.0A
C_{iss}	Input Capacitance	—	2570	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	216	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	63	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	90	ns	V_{DD}=0.5BV_{DSS}, I_D=4.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	200	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	450	ns	
t_f	Fall Time	—	—	150	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	120	nC	V_{GS}=10V, I_D=10A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	40	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	80	nC	

THERMAL RESISTANCE

Symbol	Characteristic		SSH8N55/60	SSM8N55/60	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.83	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

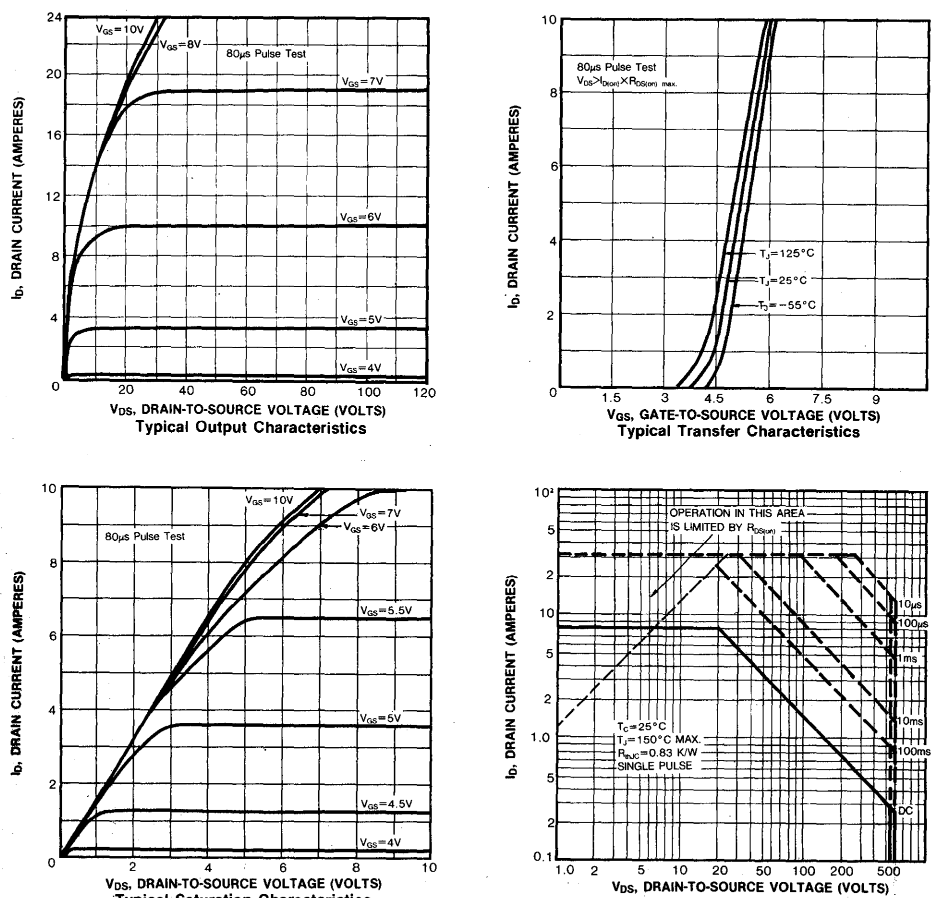
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	8.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	32.0	A	
V_{SD}	Diode Forward Voltage (2)	—	—	1.5	V	$T_C=25°C$, $I_S=8.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	800	—	ns	$T_j=150°C$, $I_F=8.0A$, $dI_F/dt=100A/\mu S$

Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

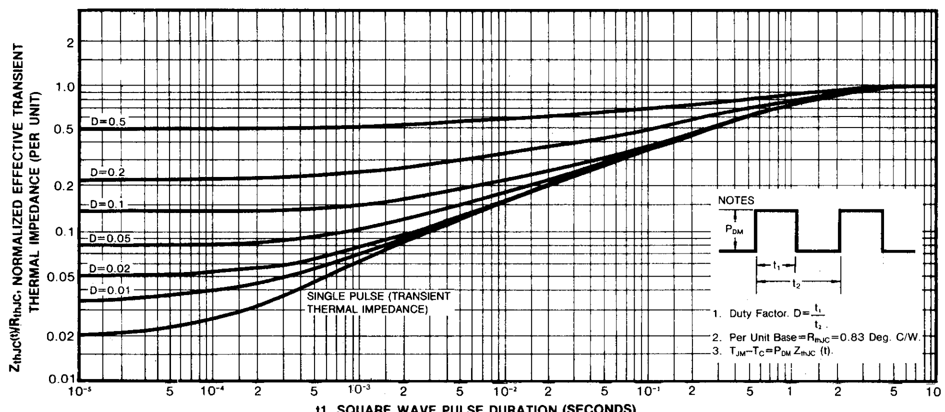


Typical Output Characteristics

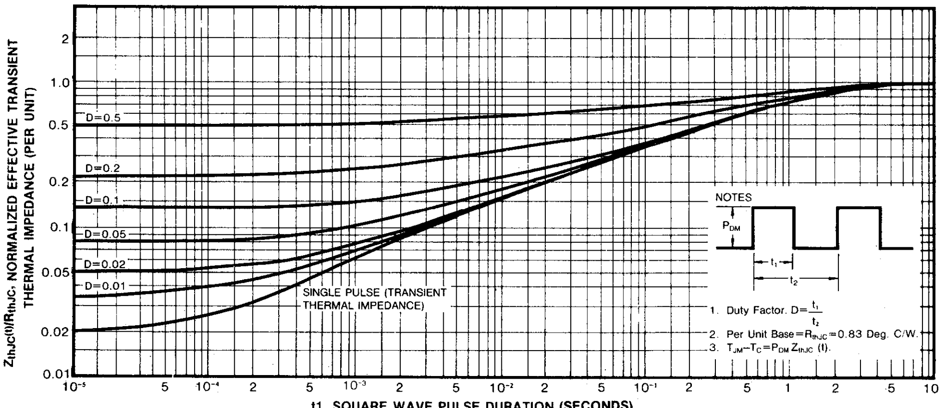
Typical Transfer Characteristics

Typical Saturation Characteristics

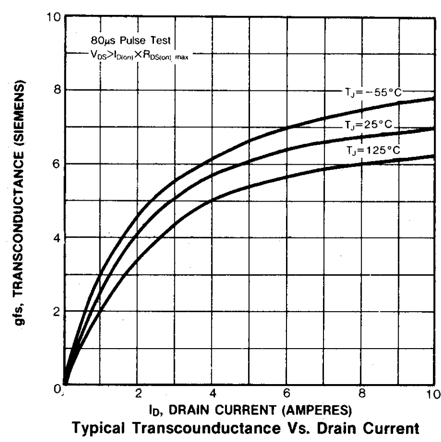
Maximum Safe Operating Area



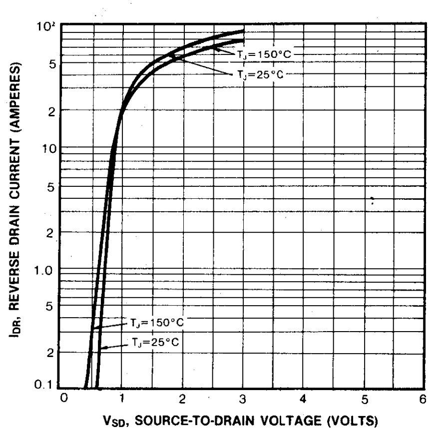
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH8N55/60



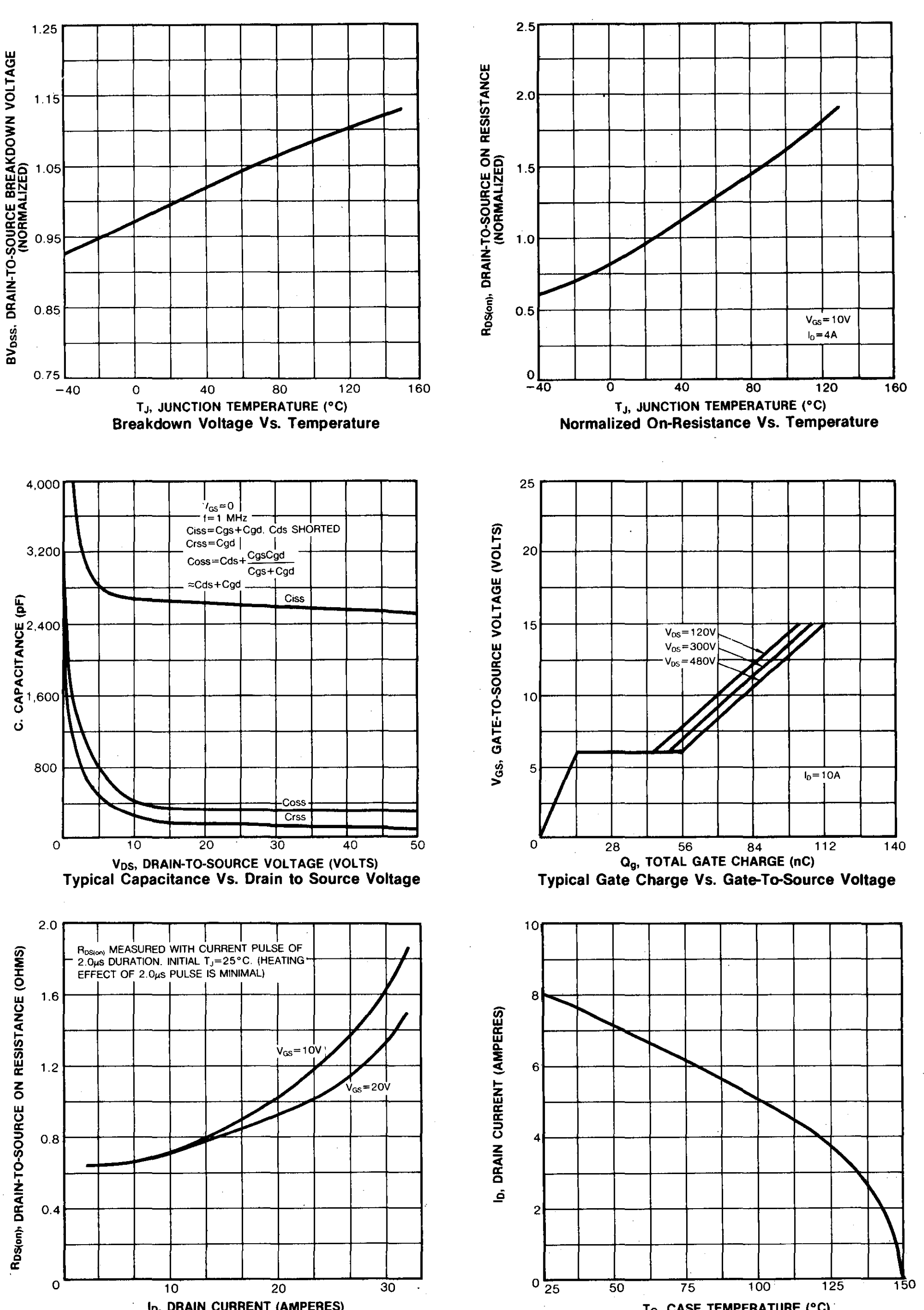
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSM8N55/60



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage



Breakdown Voltage Vs. Temperature

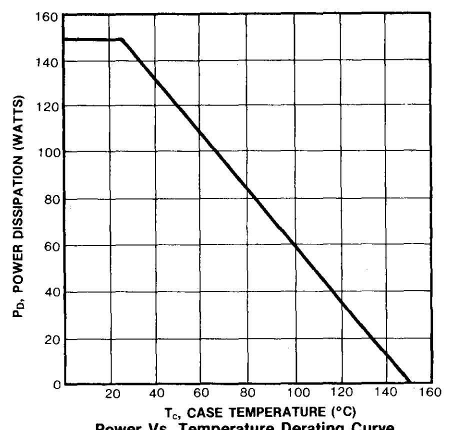
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

Typical Gate Charge Vs. Gate-To-Source Voltage

Typical On-Resistance Vs. Drain Current

Maximum Drain Current Vs. Case Temperature



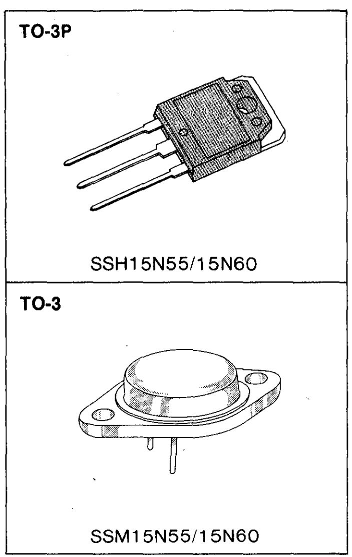
Power Vs. Temperature Derating Curve

SSH15N55/15N60
SSM15N55/15N60

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSH15N55 SSM15N55	550V	0.45Ω	0.50Ω	15.0Ω
SSH15N60 SSM15N60	600V	0.45Ω	0.50Ω	15.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSH15N55 SSH15N55	SSM15N60 SSM15N60	Unit
Drain-Source Voltage (1)	V_{DSS}	550	600	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	550	600	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	15		Adc
Continuous Drain Current T_C=100°C	I_D	10		Adc
Drain Current—Pulsed (3)	I_{DM}	60		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	1060		mJ
Avalanche Current	I_{AS}	15		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150/200 (5) 1.2/1.6		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=9mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C
(5) TO-3P/TO-3

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage SSH15N55/SSM15N55	550	—	—	V	V_{GS}=0V
	SSH15N60/SSM15N60	600	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	15	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max}$, V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	0.45	Ω	V_{GS}=10V, I_D=8.0A
	STD	—	—	0.50	Ω	
g_{fs}	Forward Transconductance (2)	7.0	—	—	℧	V_{DS}≥50V, I_D=8.0A
C_{iss}	Input Capacitance	—	4417	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	738	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	967	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	130	ns	V_{DD}=0.5BV_{DSS}, I_D=8.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	280	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	630	ns	
t_f	Fall Time	—	—	210	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	240	nC	V_{GS}=10V, I_D=18A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	80	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	160	nC	

THERMAL RESISTANCE

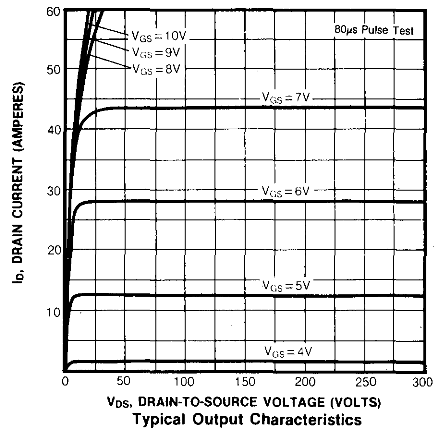
Symbol	Characteristic		SSH15N55/60	SSM15N55/60	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.63	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

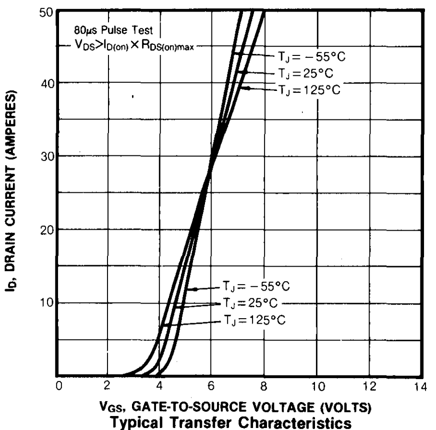
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	15.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	60	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.5	V	$T_C=25°C$, $I_S=15A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	900	—	ns	$T_j=150°C$, $I_F=15.0A$, $dI_F/dt=100A/\mu S$

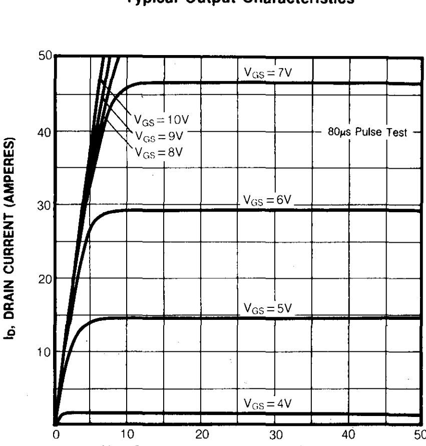
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



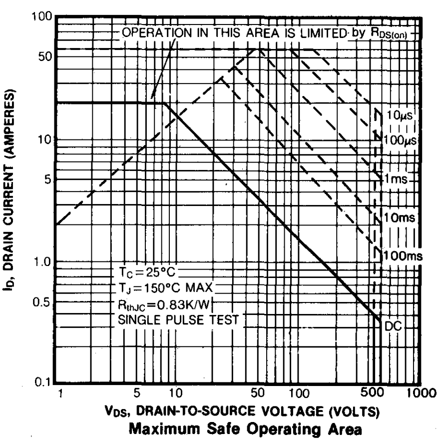
Typical Output Characteristics



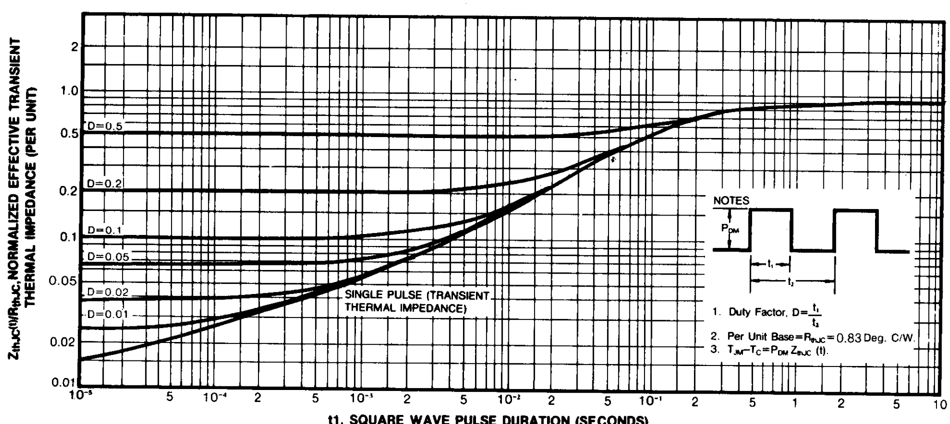
Typical Transfer Characteristics



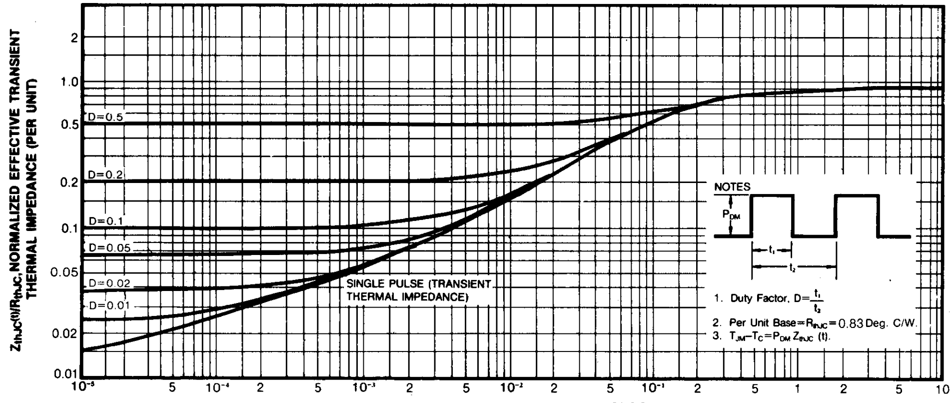
Typical Saturation Characteristics



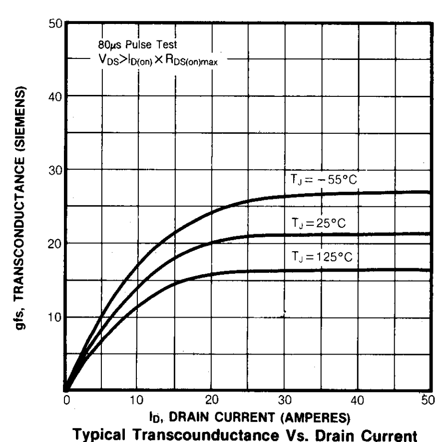
Maximum Safe Operating Area



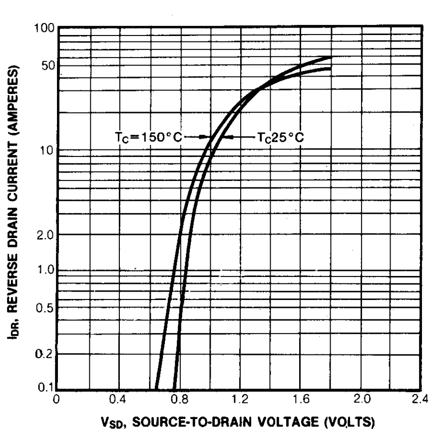
Maximum Effective Transient Thermal Impedance Junction- to-Case Vs. Pulse Duration
For SSH15N55/15N60



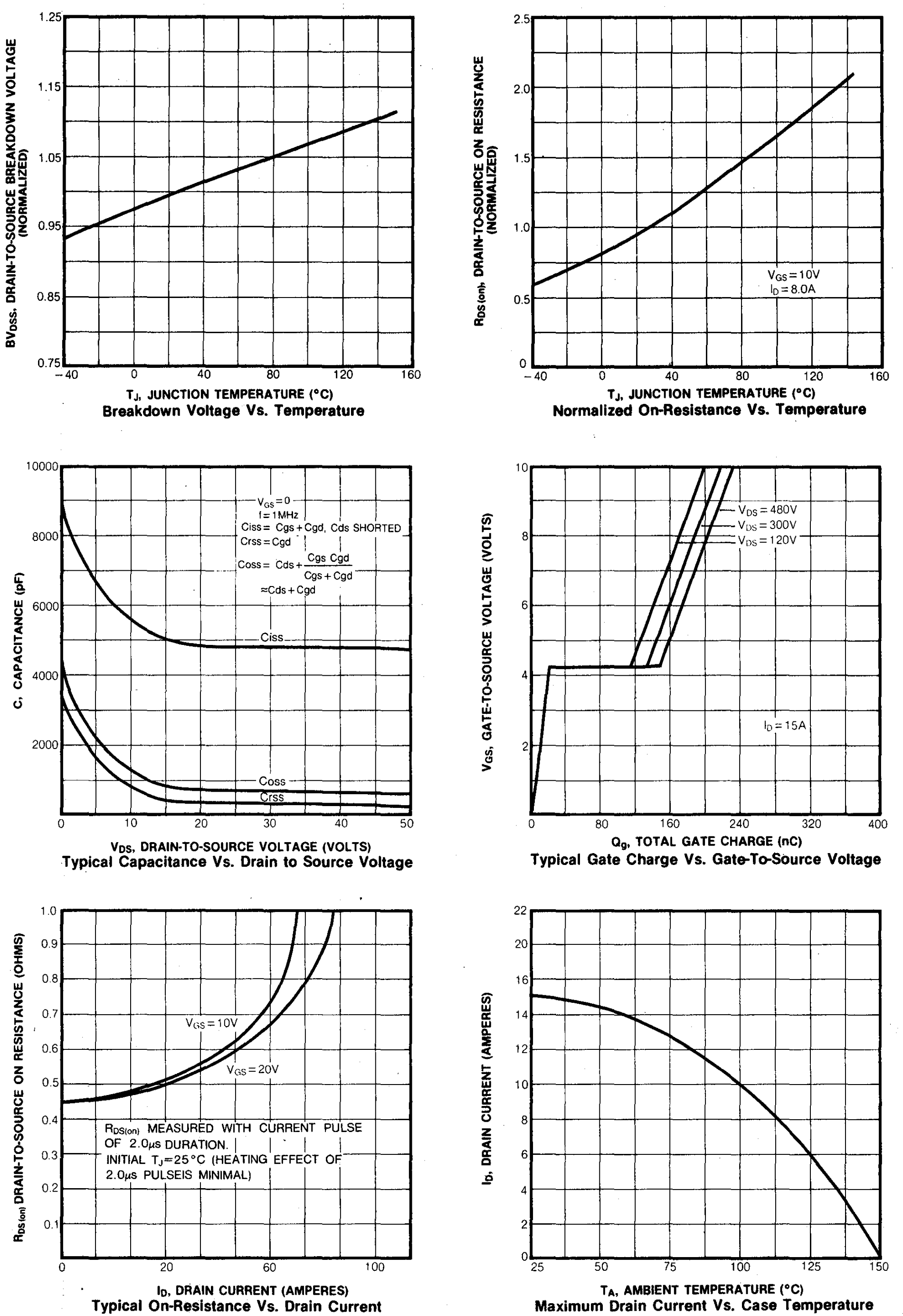
Maximum Effective Transient Thermal Impedance Junction- to-Case Vs. Pulse Duration
For SSM15N55/15N60

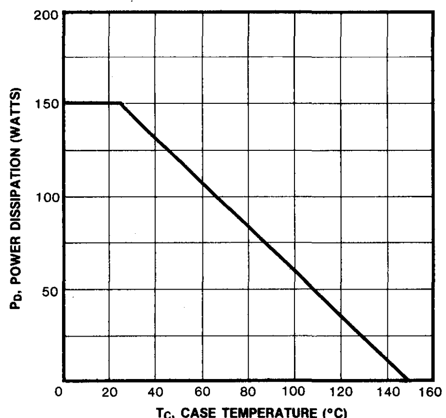


Typical Transcounductance Vs. Drain Current

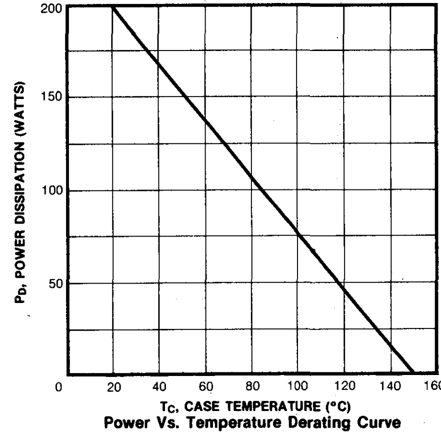


Typical Source—Drain Diode Forward Voltage


BVDSS, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
TJ, JUNCTION TEMPERATURE (°C)
Breakdown Voltage Vs. Temperature
RDS(on), DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
VGS=10V
ID=8.0A
TJ, JUNCTION TEMPERATURE (°C)
Normalized On-Resistance Vs. Temperature
C, CAPACITANCE (pF)
VGS=0
f=1MHz
Ciss= Cgs+Cgd, Cds SHORTED
Crss=Cgd
Coss= Cds+ Cgs Cgd / Cgs+Cgd
≈Cds+Cgd
Ciss
Coss
Crss
VDS, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage
VGS, GATE-TO-SOURCE VOLTAGE (VOLTS)
VDS=480V
VDS=300V
VDS=120V
ID=15A
Qg, TOTAL GATE CHARGE (nC)
Typical Gate Charge Vs. Gate-To-Source Voltage
RDS(on) DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
VGS=10V
VGS=20V
RDS(on) MEASURED WITH CURRENT PULSE OF 2.0μs DURATION.
INITIAL TJ=25°C (HEATING EFFECT OF 2.0μs PULSEIS MINIMAL)
ID, DRAIN CURRENT (AMPERES)
Typical On-Resistance Vs. Drain Current
ID, DRAIN CURRENT (AMPERES)
TA, AMBIENT TEMPERATURE (°C)
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve For SSH15N55/15N60



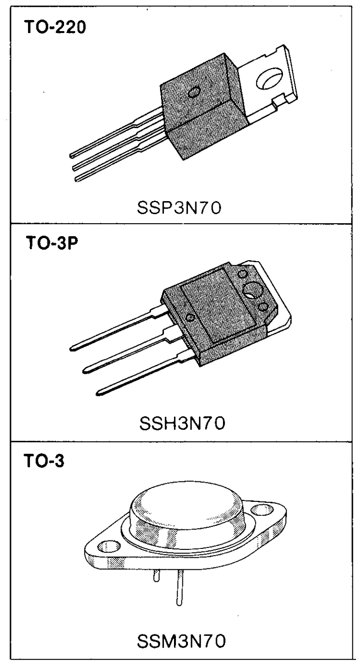
Power Vs. Temperature Derating Curve For SSM15N55/15N60

SSP3N70
SSH3N70
SSM3N70

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSP3N70 SSH3N70 SSM3N70	700V	5.00Ω	6.00Ω	3A

MAXIMUM RATINGS

Characteristic	Symbol	SSP3N70 SSH3N70 SSM3N70	Unit
Drain-Source Voltage (1)	V_{DSS}	700	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	700	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Continuous Drain Current T_C=25°C	I_D	3.0	Adc
Continuous Drain Current T_C=100°C	I_D	2.0	Adc
Drain Current—Pulsed (3)	I_{DM}	12	Adc
Gate Current—Pulsed	I_{GM}	±1.5	Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	243	mJ
Avalanche Current	I_{AS}	3	A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150	°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300	°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=51mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	700	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	3	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	5.0	Ω	V_{GS}=10V, I_D=1.5A
	STD	—	—	6.0	Ω	
g_{fs}	Forward Transconductance (2)	1.5	2.5	—	℧	V_{DS}≥50V, I_D=1.5A
C_{iss}	Input Capacitance	—	779	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	75.6	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	24.9	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	40	ns	V_{DD}=0.5BV_{DSS}, I_D=1.5A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	95	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	150	ns	
t_f	Fall Time	—	—	60	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	25	nC	V_{GS}=10V, I_D=4.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	10	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	15	—	nC	

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature
(4) For ultra low "A" $R_{DS(on)}$, device add "A" suffix to part number

THERMAL RESISTANCE

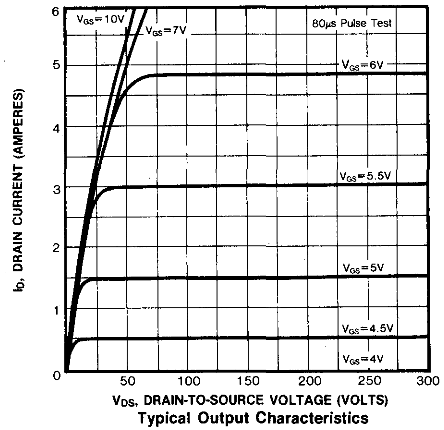
Symbol	Characteristic		SSP3N70	SSH3N70	SSM3N70	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	HEW	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

4

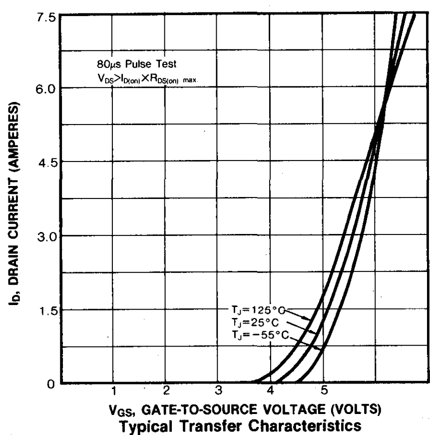
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	3.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	12	A	
V_{SD}	Diode Forward Voltage(2)	—	—	1.5	V	$T_C=25°C$, $I_S=3.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	500	—	ns	$T_j=150°C$, $I_F=3.0A$, $dI_F/dt=100A/\mu S$

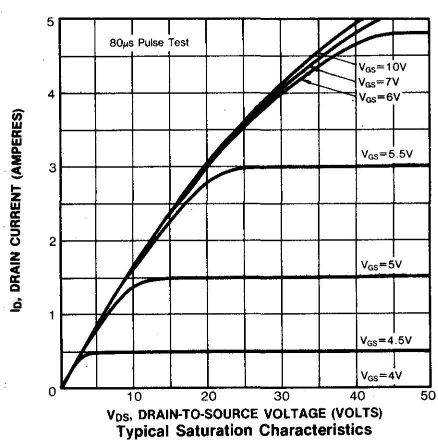
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



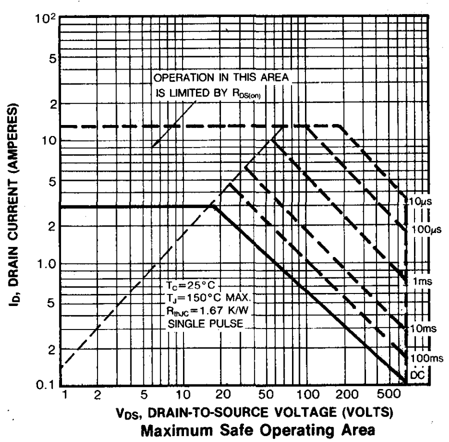
Typical Output Characteristics



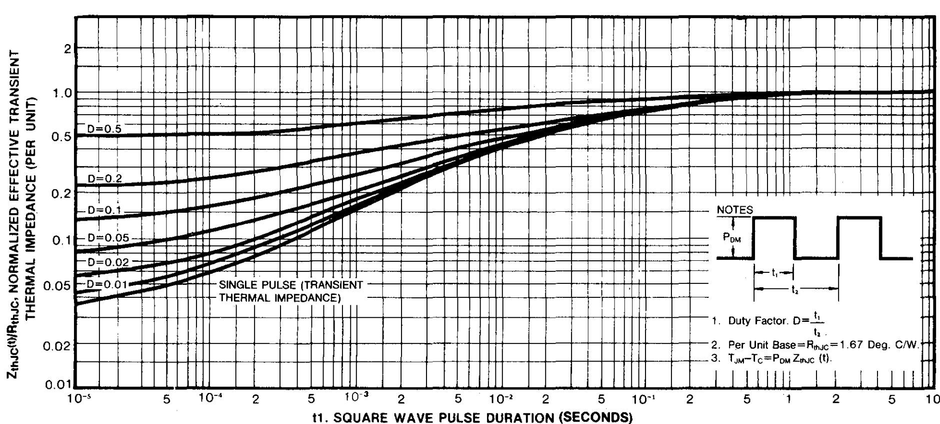
Typical Transfer Characteristics



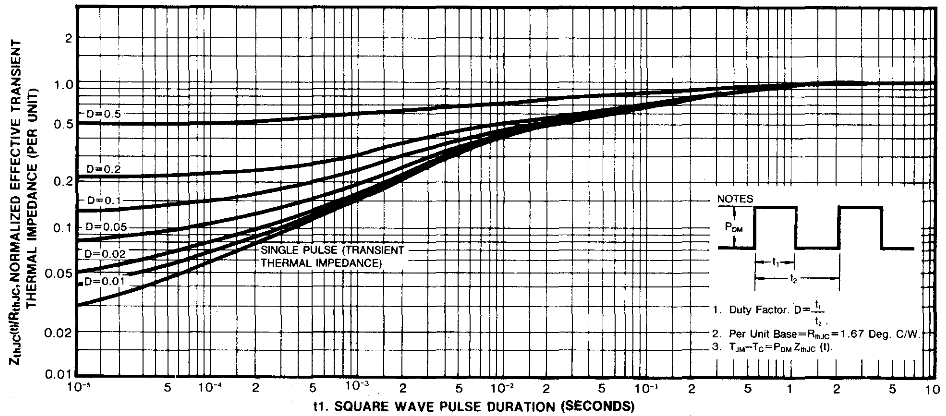
Typical Saturation Characteristics



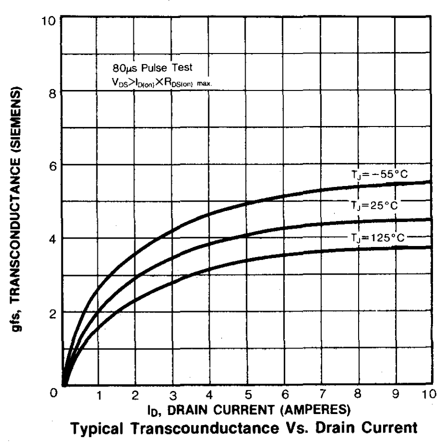
Maximum Safe Operating Area



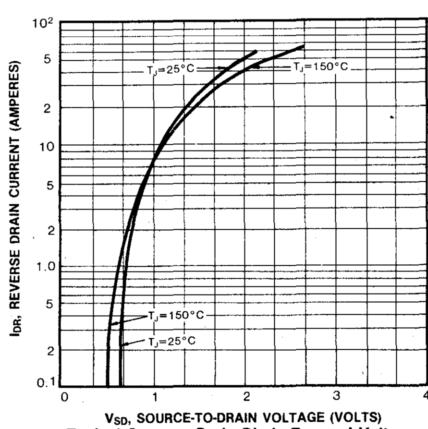
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP3N70/SSM3N70



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH3N70

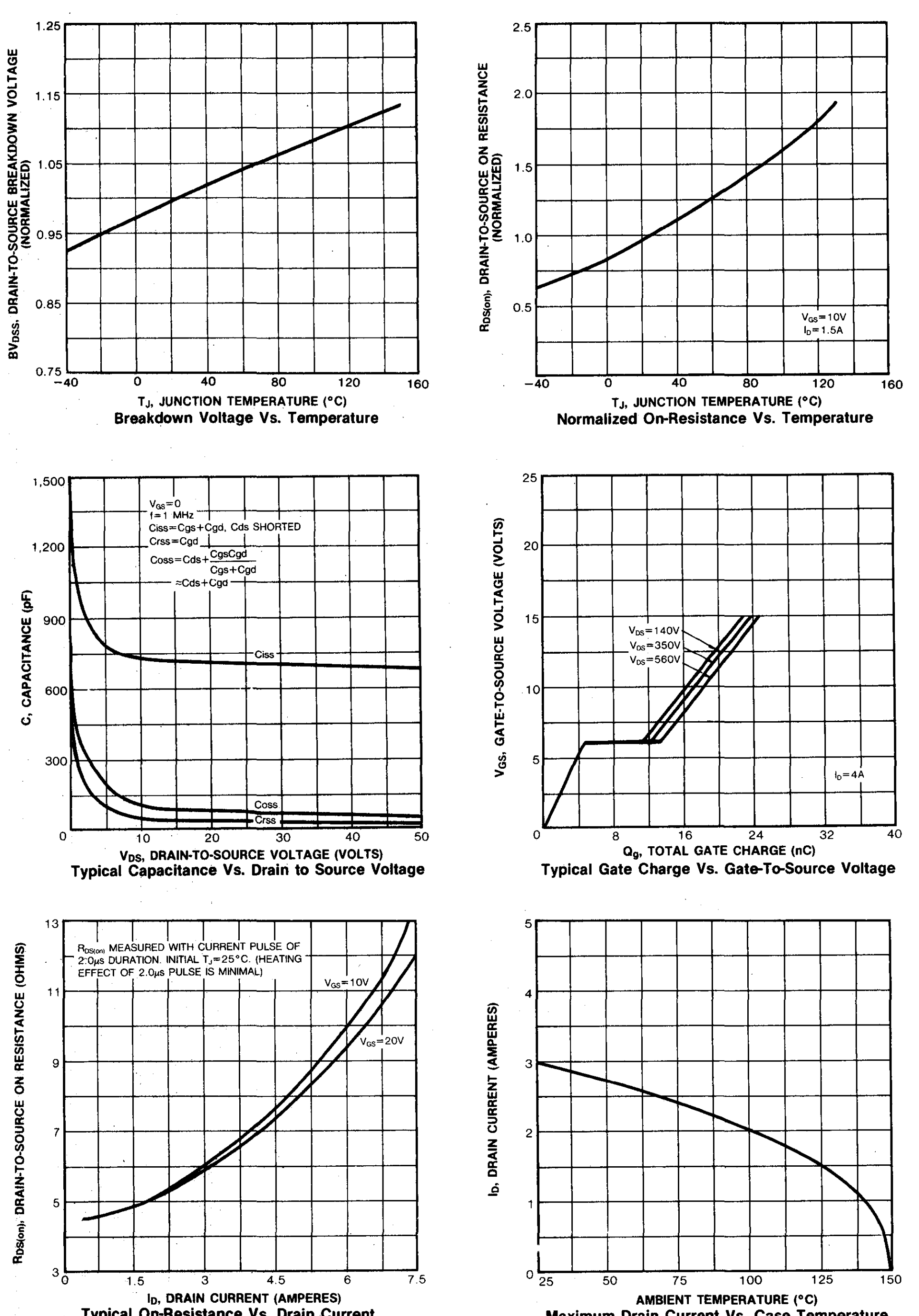


Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

4



Breakdown Voltage Vs. Temperature

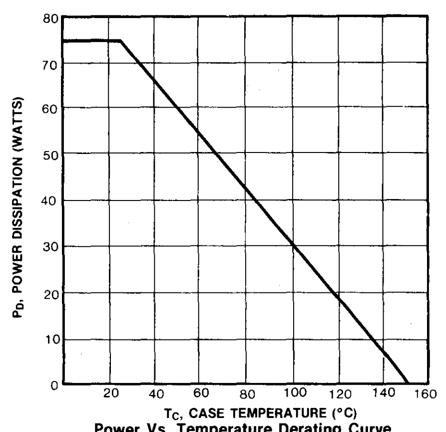
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

Typical Gate Charge Vs. Gate-To-Source Voltage

Typical On-Resistance Vs. Drain Current

Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

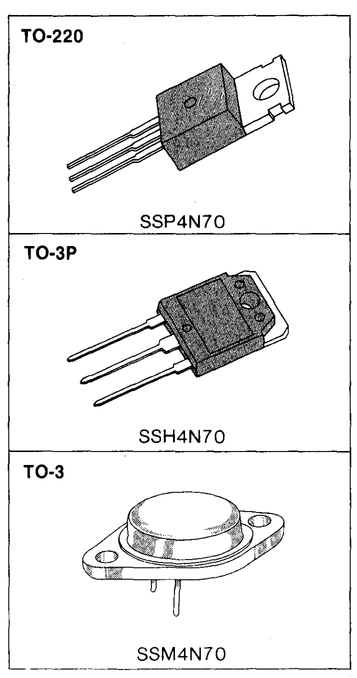
4

SSP4N70
SSH4N70
SSM4N70

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSP4N70 SSH4N70 SSM4N70	700V	2.5Ω	3.5Ω	4.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSP4N70 SSH4N70 SSM4N70	Unit
Drain-Source Voltage (1)	V_{DSS}	700	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	700	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Continuous Drain Current T_C=25°C	I_D	4.0	Adc
Continuous Drain Current T_C=100°C	I_D	4.0	Adc
Drain Current—Pulsed (3)	I_{DM}	2.5	Adc
Gate Current—Pulsed	I_{GM}	±1.5	Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	280	mJ
Avalanche Current	I_{AS}	4	A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150	°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300	°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=33mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	700	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	4	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	2.5	Ω	V_{GS}=10V, I_D=2.0A
	STD	—	—	3.5	Ω	
g_{fs}	Forward Transconductance (2)	2.5	3.6	—	℧	V_{DS}≥50V, I_D=2.0A
C_{iss}	Input Capacitance	—	1457	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	130	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	38.8	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	60	ns	V_{DD}=0.5BV_{DSS}, I_D=2.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	150	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	300	ns	
t_f	Fall Time	—	—	130	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	40	nC	V_{GS}=10V, I_D=5.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	15	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	25	—	nC	

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature
(4) For ultra low "A" $R_{DS(on)}$, device add "A" suffix to part number

THERMAL RESISTANCE

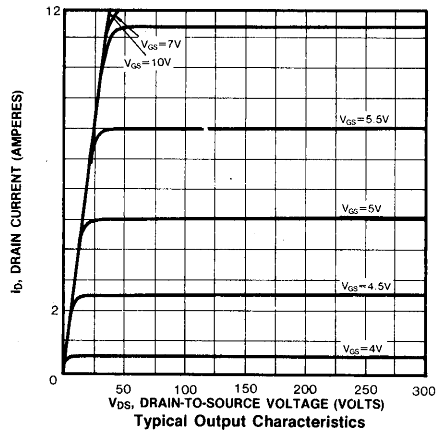
Symbol	Characteristic		SSP4N70	SSH4N70	SSM4N70	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	HEW	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

4

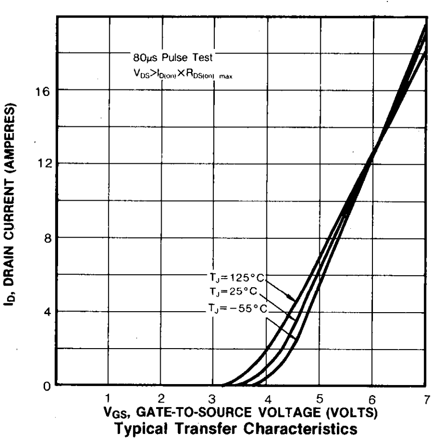
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	4.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	16	A	
V_{SD}	Diode Forward Voltage(2)	—	—	1.5	V	$T_C=25°C$, $I_S=4.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	600	—	ns	$T_j=150°C$, $I_F=4.0A$, $dI_F/dt=100A/\mu S$

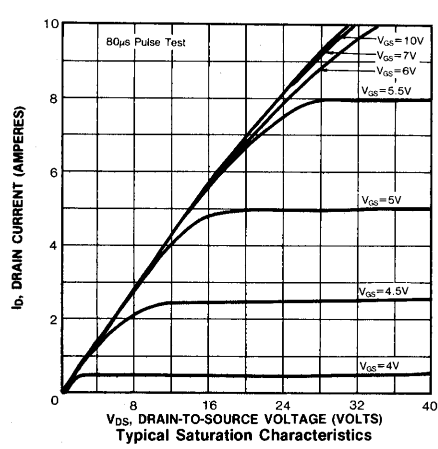
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



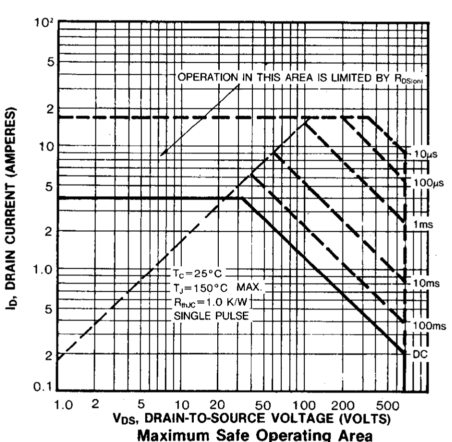
Typical Output Characteristics



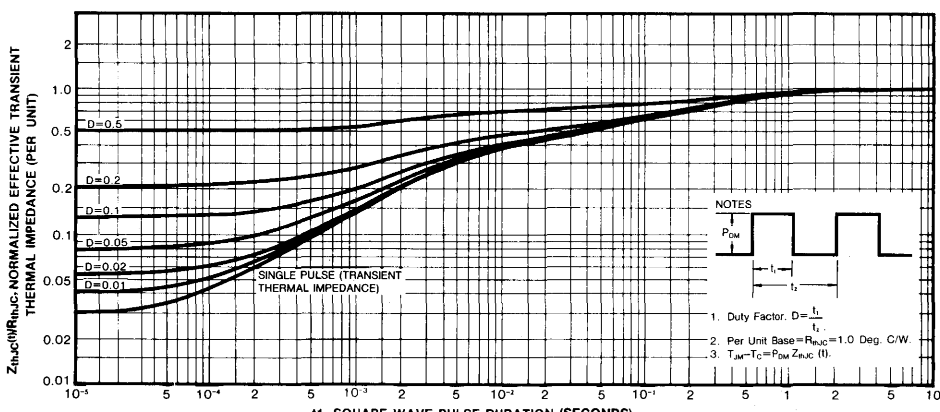
Typical Transfer Characteristics



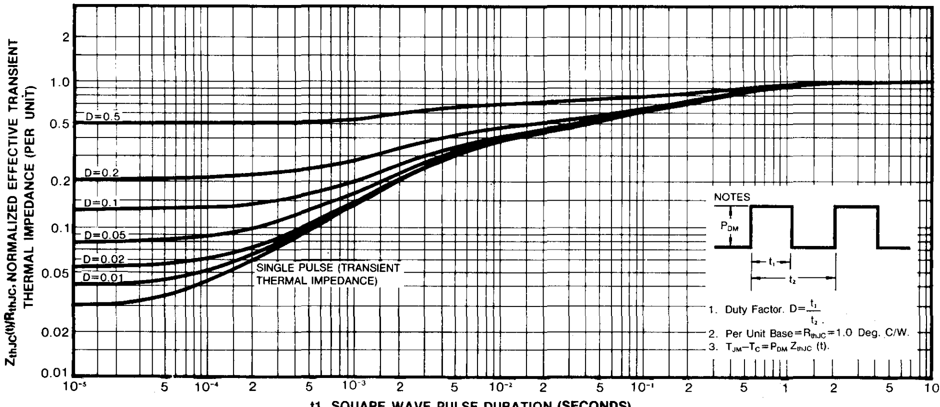
Typical Saturation Characteristics



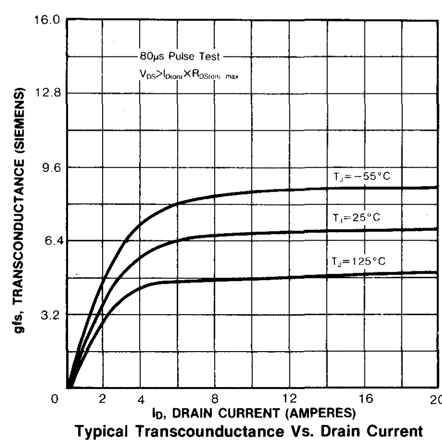
Maximum Safe Operating Area



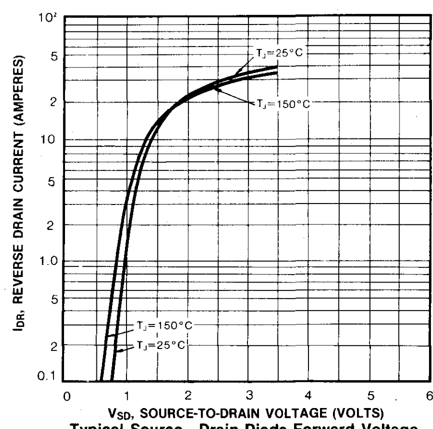
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSP4N70 and SSM4N70



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH4N70



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

1.25
1.15
1.05
0.95
0.85
0.75
BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
−40 0 40 80 120 160
T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

2.5
2.0
1.5
1.0
0.5
0
$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
V_{GS}=10V
I_D=2A
−40 0 40 80 120 160
T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

2000
1600
1200
800
400
0
C, CAPACITANCE (pF)
$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL T_J=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)
Ciss
Coss
Crss
10 20 40 50
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

25
20
15
10
5
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
V_{DS}=140V
V_{DS}=350V
V_{DS}=560V
I_D=5A
0 20 40 60 80 100
Q_g, TOTAL GATE CHARGE (nC)

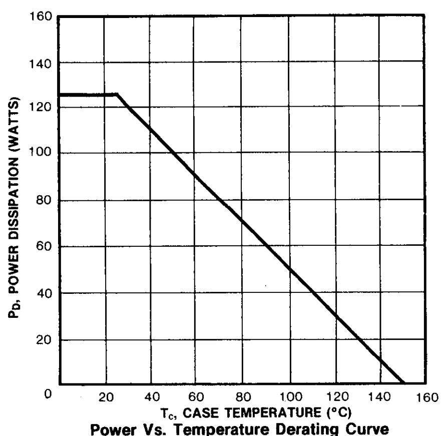
Typical Gate Charge Vs. Gate-To-Source Voltage

5.0
4.4
3.8
3.2
2.6
2.0
$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (OHMS)
$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL T_J=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)
V_{GS}=10V
V_{GS}=20V
0 4 8 12 16 20
I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

5
4
3
2
1
0
I_D, DRAIN CURRENT (AMPERES)
25 50 75 100 125 150
T_C, CASE TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

SSH6N70
SSM6N70

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-3P

SSH6N70

TO-3

SSM6N70

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSP6N70 SSH6N70 SSM6N70	700V	1.4Ω	1.9Ω	6.0A

MAXIMUM RATINGS

Characteristic	Symbol	SSH6N70 SSM6N70	Unit
Drain-Source Voltage (1)	V_{DSS}	700	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	700	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Continuous Drain Current T_C=25°C	I_D	6.0	Adc
Continuous Drain Current T_C=100°C	I_D	4.0	Adc
Drain Current—Pulsed (3)	I_{DM}	24	Adc
Gate Current—Pulsed	I_{GM}	±1.5	Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	455	mJ
Avalanche Current	I_{AS}	6.0	A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150 1.2	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150	°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300	°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=51mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	700	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	6.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	1.4	Ω	V_{GS}=10V, I_D=3.0A
	STD	—	—	1.9	Ω	
g_{fs}	Forward Transconductance (2)	5.0	7.0	—	℧	V_{DS}≥50V, I_D=3.0A
C_{iss}	Input Capacitance	—	2460	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	2.10	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	63.4	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	90	ns	V_{DD}=0.5BV_{DSS}, I_D=3.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	200	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	450	ns	
t_f	Fall Time	—	—	150	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	60	nC	V_{GS}=10V, I_D=7.5A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	20	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	40	—	nC	

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature
(4) For ultra low "A" $R_{DS(on)}$, device add "A" suffix to part number

4

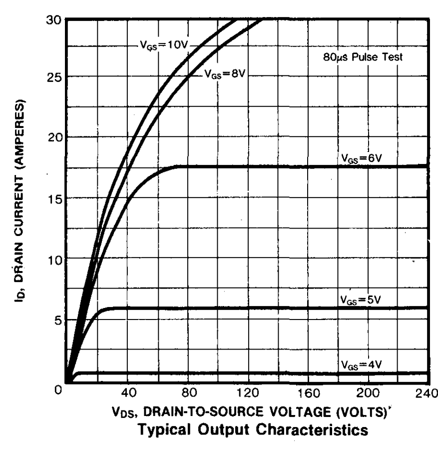
THERMAL RESISTANCE

Symbol	Characteristic		SSH6N70	SSM6N70	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.83	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

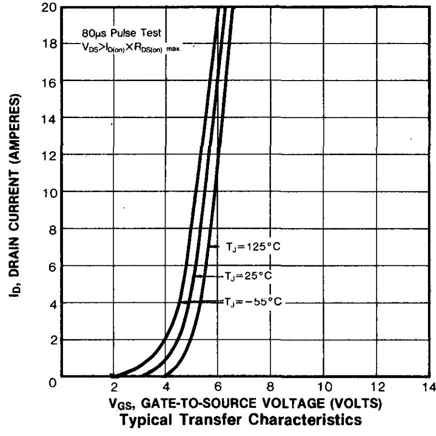
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	6.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	24	A	
V_{SD}	Diode Forward Voltage(2)	—	—	1.5	V	$T_C=25°C$, $I_S=6.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	800	—	ns	$T_j=150°C$, $I_F=6.0A$, $dI_F/dt=100A/\mu S$

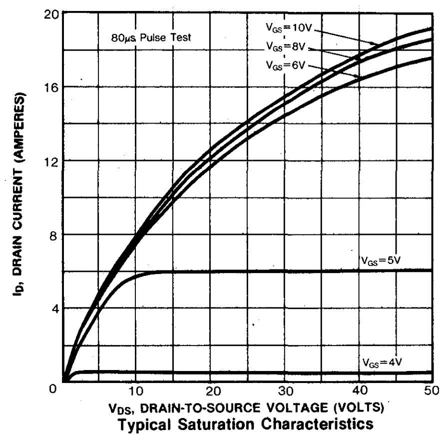
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



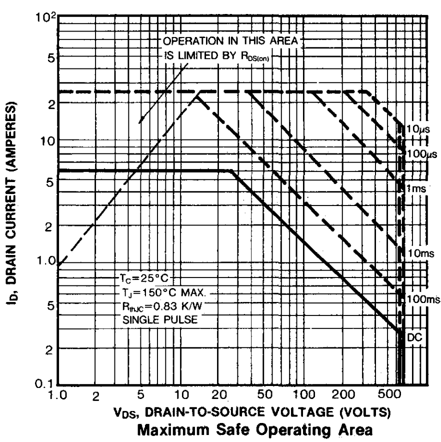
Typical Output Characteristics



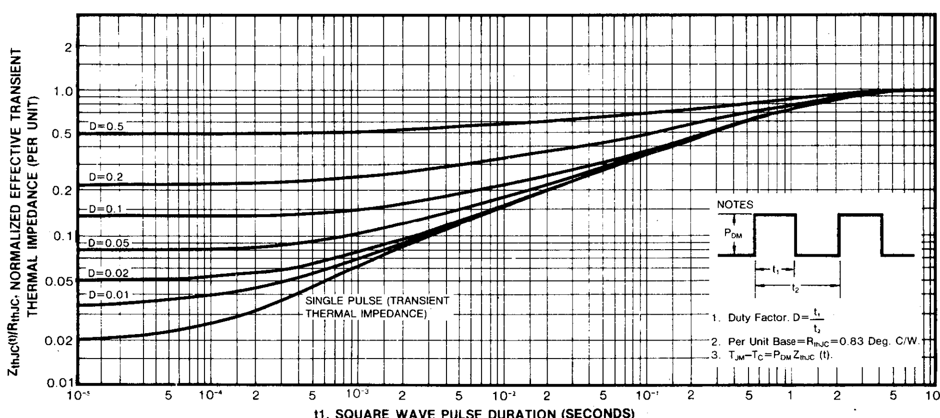
Typical Transfer Characteristics



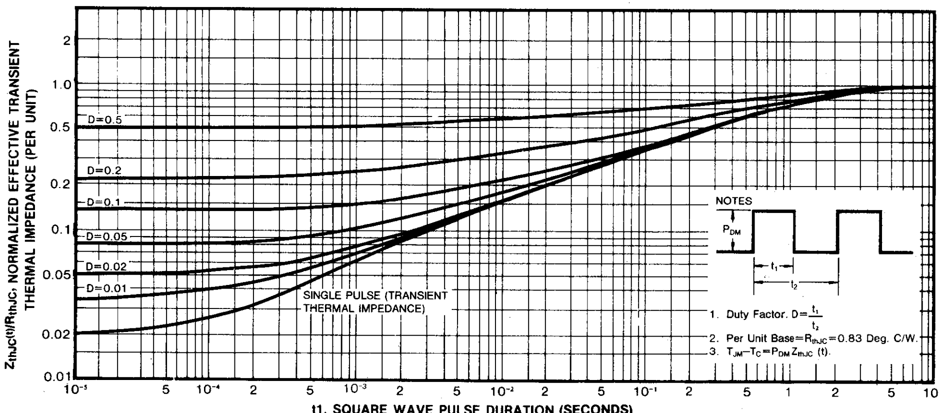
Typical Saturation Characteristics



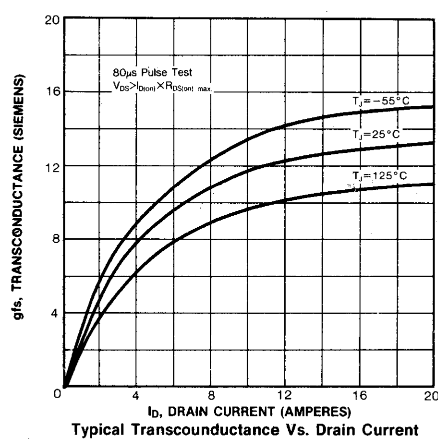
Maximum Safe Operating Area



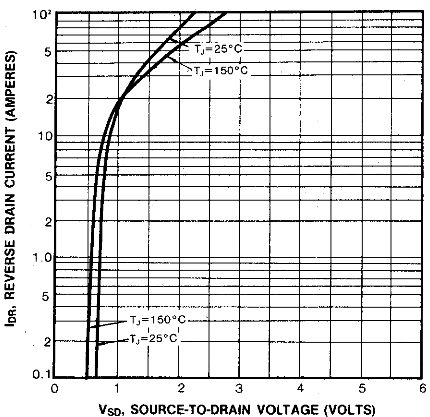
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH6N70



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSM6N70



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

1.25, 1.15, 1.05, 0.95, 0.85, 0.75

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

2.5, 2.0, 1.5, 1.0, 0.5, 0

V_{GS}=10V
I_D=3A

−40, 0, 40, 80, 120, 160

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

4,000, 3,200, 2,400, 1,600, 800, 0

V_{GS}=0
f=1 MHz
Ciss=Cgs+Cgd, Cds SHORTED
Crss=Cgd
$Coss=Cds+\frac{CgsCgd}{Cgs+Cgd}$
≈Cds+Cgd

Ciss
Coss
Crss

10, 20, 30, 40, 50

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

I_D, DRAIN CURRENT (AMPERES)

25, 20, 15, 10, 5, 0

$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL T_J=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

V_{DS}=140V
V_{DS}=350V
V_{DS}=560V SSH6N70

I_D=7.5A

28, 56, 84, 112, 140

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$ DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

5, 4, 3, 2, 1, 0

$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL T_J=25°C. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

V_{GS}=10V
V_{GS}=20V

2, 4, 6, 8, 10, 12, 14, 16, 18, 20

I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

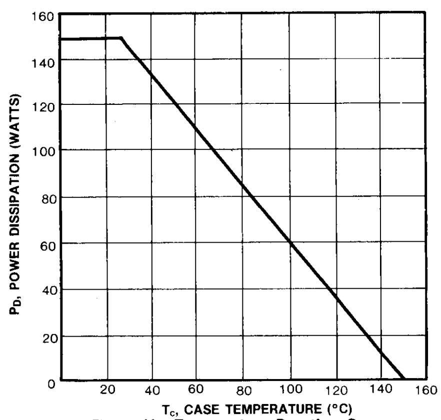
I_D, DRAIN CURRENT (AMPERES)

10, 8, 6, 4, 2, 0

25, 50, 75, 100, 125, 150

T_C, CASE TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



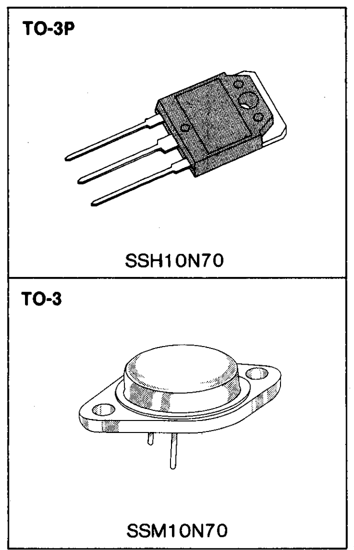
Power Vs. Temperature Derating Curve

SSH10N70
SSM10N70

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$		I_D
		A	STD	
SSH10N70 SSM10N70	700V	0.9Ω	1.2Ω	10A

MAXIMUM RATINGS

Characteristic	Symbol	SSH10N70 SSM10N70	Unit
Drain-Source Voltage (1)	V_{DSS}	700	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	700	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Continuous Drain Current T_C=25°C	I_D	10	Adc
Continuous Drain Current T_C=100°C	I_D	6.5	Adc
Drain Current—Pulsed (3)	I_{DM}	40	Adc
Gate Current—Pulsed	I_{GM}	±1.5	Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	795	mJ
Avalanche Current	I_{AS}	10	A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	150/200 (5) 1.2/1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150	°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300	°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=15mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C
(5) TO-3P/TO-3

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	700	—	—	V	V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.5	V	V_{DS}=V_{GS}, I_D=1mA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	10.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) A	—	—	0.9	Ω	V_{GS}=10V, I_D=5.0A
	STD	—	—	1.2	Ω	
g_{fs}	Forward Transconductance (2)	7.0	—	—	℧	V_{DS}≥50V, I_D=5.0A
C_{iss}	Input Capacitance	—	3678	—	pF	V_{GS}=0V, V_{DS}=25V, f=1MHz
C_{oss}	Output Capacitance	—	293	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	816	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	130	ns	V_{DD}=0.5BV_{DSS}, I_D=5.0A, Z_O=4.7Ω (MCSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	280	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	630	ns	
t_f	Fall Time	—	—	210	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	240	nC	V_{GS}=10V, I_D=13A, V_{DS}= 0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	80	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	160	nC	

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature
(4) For ultra low "A" $R_{DS(on)}$, device add "A" suffix to part number

THERMAL RESISTANCE

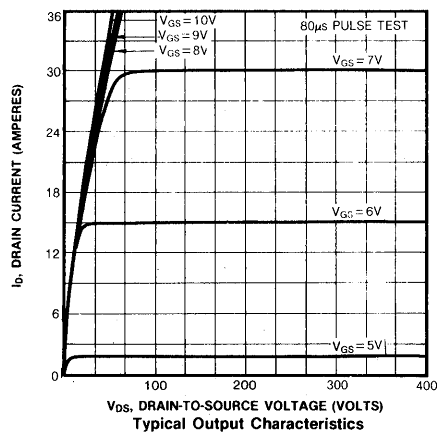
Symbol	Characteristic		SSH10N70	SSM10N70	Unit	
R_{thJC}	Junction-to-Case	MAX	0.83	0.63	K/W	
R_{thCS}	Case-to-Sink	TYP	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

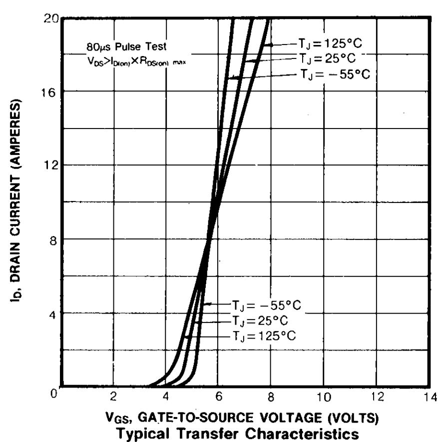
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	10	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	40	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.5	V	$T_C=25°C$, $I_S=10A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	900	—	ns	$T_j=150°C$, $I_F=10A$, $dI_F/dt=100A/\mu S$

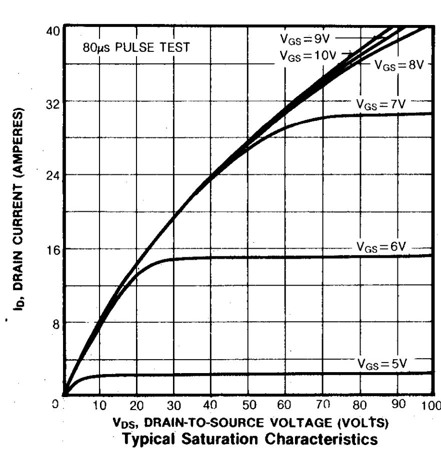
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq 300\mu s$, Duty Cycle$\leq 2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature



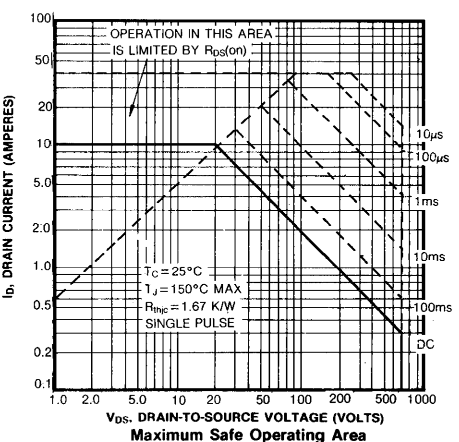
Typical Output Characteristics



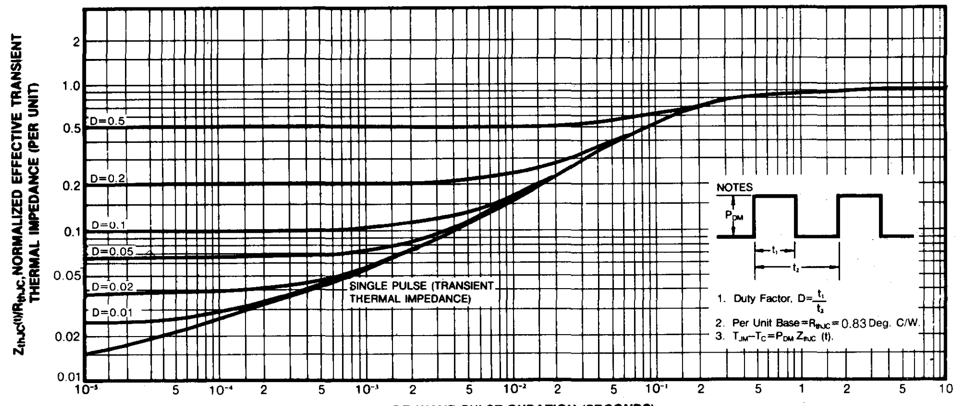
Typical Transfer Characteristics



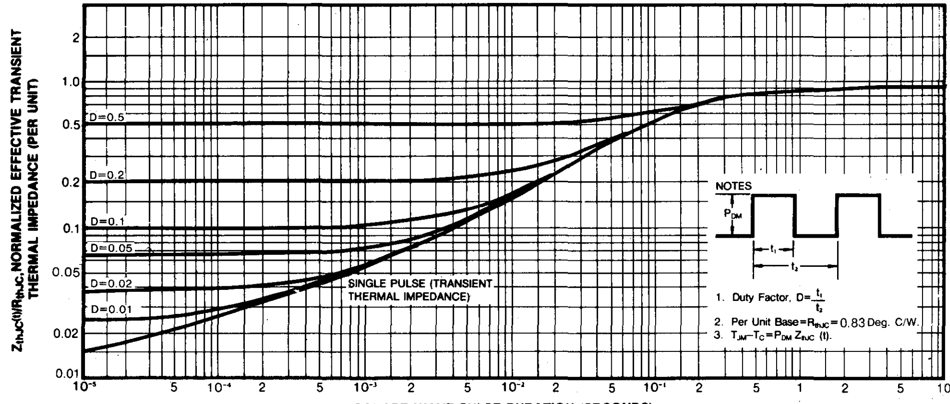
Typical Saturation Characteristics



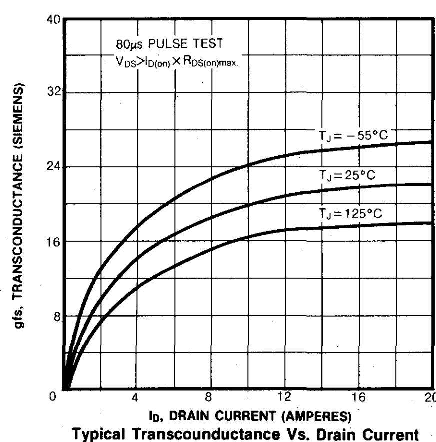
Maximum Safe Operating Area



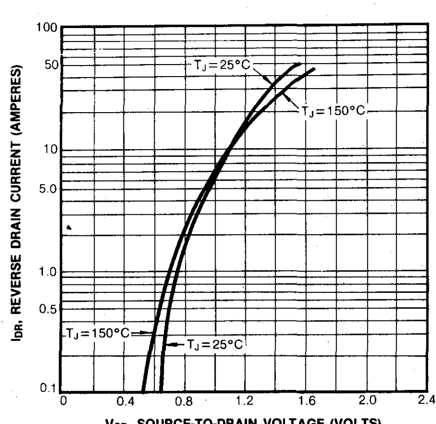
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSH10N70



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For SSM10N70



Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

1.25 1.15 1.05 0.95 0.85 0.75

−40 0 40 80 120 160

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

2.5 2.0 1.5 1.0 0.5 0

$V_{GS}=10V$
$I_D=5.0A$

−40 0 40 80 120 160

T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

C, CAPACITANCE (pF)

10000 8000 6000 4000 2000 0

$V_{GS}=0$
$f=1MHz$
Ciss = Cgs + Cgd, Cds SHORTED
Crss = Cgd
$Coss = Cds + \frac{Cgs\ Cgd}{Cgs + Cgd}$
$\approx Cds + Cgd$

Ciss
Coss
Crss

0 10 20 30 40 50

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage

V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)

25 20 15 10 5 0

$V_{DS}=160V$
$V_{DS}=400V$
$V_{DS}=640V$

$I_D=10A$

0 20 40 60 80 100

Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

$R_{DS(on)}$ DRAIN-TO-SOURCE ON RESISTANCE (OHMS)

2.5 2.0 1.5 1.0 0.5

$V_{GS}=10V$
$V_{GS}=20V$

$R_{DS(on)}$ MEASURED WITH CURRENT PULSE OF 2.0μs DURATION. INITIAL $T_J=25°C$. (HEATING EFFECT OF 2.0μs PULSE IS MINIMAL)

0 8 16 24 32 40

I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current

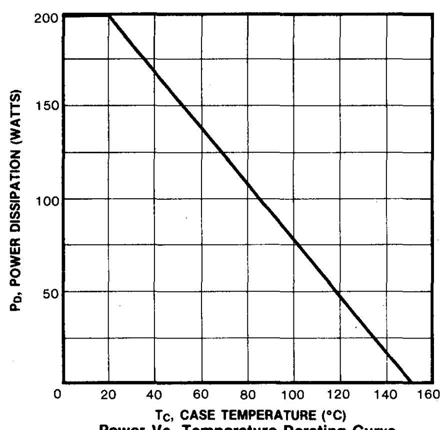
I_D, DRAIN CURRENT (AMPERES)

10 8 6 4 2

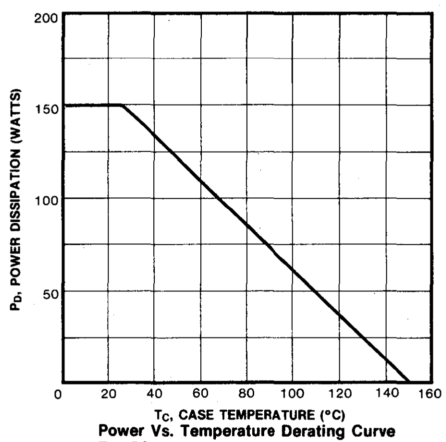
25 50 75 100 125 150

T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve For SSM10N70



Power Vs. Temperature Derating Curve For SSH10N70

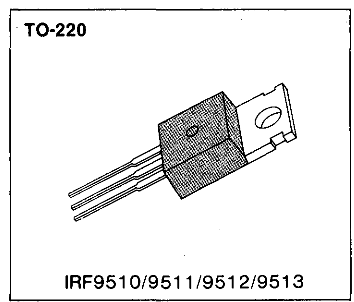
IRF9510/9511/9512/9513

P-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-220



IRF9510/9511/9512/9513

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9510	−100V	1.2Ω	−3.0
IRF9511	−60V	1.2Ω	−3.0
IRF9512	−100V	1.6Ω	−2.5A
IRF9513	−60V	1.6Ω	−2.5A

MAXIMUM RATINGS

Characteristic	Symbol	IRF9510	IRF9511	IRF9512	IRF9513	Unit
Drain-Source Voltage (1)	V_{DSS}	−100	−60	−100	−60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−60	−100	−60	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−6.0	−6.0	−5.0	−5.0	Adc
Continuous Drain Current T_C=100°C	I_D	−4.0	−4.0	−2.5	−3.5	Adc
Drain Current—Pulsed (3)	I_{DM}	−24	−24	−20	−20	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	20 0.16				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C

(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%

(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9510/9512	-100	—	—	V	V_{GS}=0V I_D=−250μA
	IRF9511/9513	-60	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9510/9511	-3.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)\ max}$, V_{GS}=−10V
	IRF9512/9513	-2.5	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	—	1.2	Ω	V_{GS}=−10V, I_D=−1.5A
		—	—	1.6	Ω	
g_{fs}	Forward Transconductance (2)	0.76	—	—	℧	V_{DS}≤−50V, I_D=−1.5A
C_{iss}	Input Capacitance	—	250	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	92	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	51	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	15	39	ns	V_{DD}=0.5BV_{DSS}, I_D=−1.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	30	60	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	20	40	ns	
t_f	Fall Time	—	20	40	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	11	—	nC	V_{GS}=−15V, I_D=−4.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	4.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7.0	—	nC	

THERMAL RESISTANCE

R_{thJC}	Junction-to-Case	—	—	6.4	K/W	
R_{thCS}	Case-to-Sink	—	1.0	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

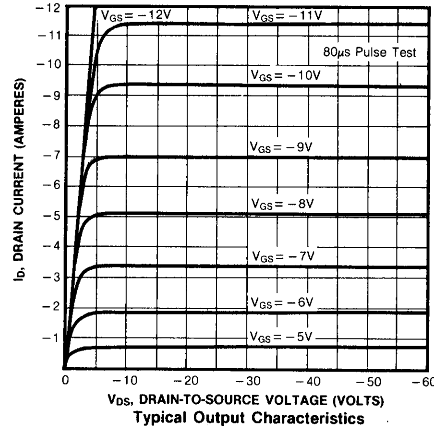
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

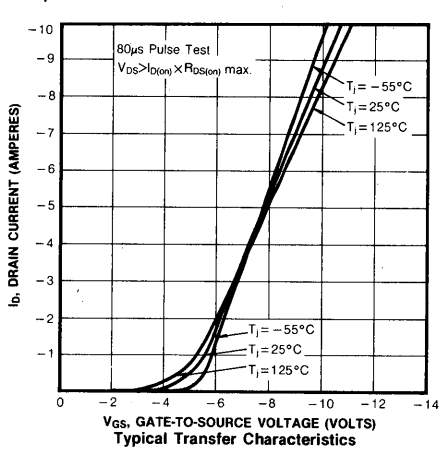
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9510/9511	—	—	−3.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
	IRF9512/9513	—	—	−2.5	A	
I_{SM}	Pulse Source Current (Body Diode)(3) IRF9510/9511	—	—	12	A	
	IRF9512/9513	—	—	10	A	
V_{SD}	Diode Forward Voltage (2) IRF9510/9511	—	—	−5.5	V	T_C=25°C, I_S=−3.0A, V_{GS}=0V
	IRF9512/9513	—	—	−5.3	V	T_C=25°C, I_S=−2.5A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	120	—	ns	T_j=150°C, I_F=−3.0A, dI_F/dt=100A/μS

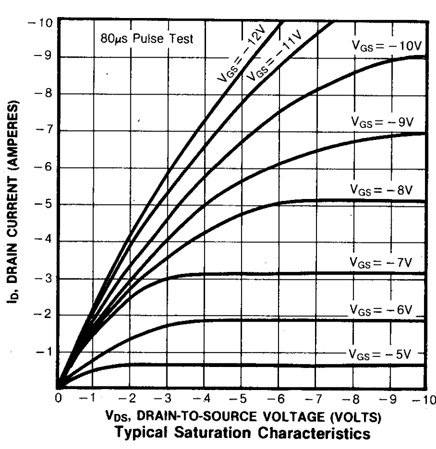
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



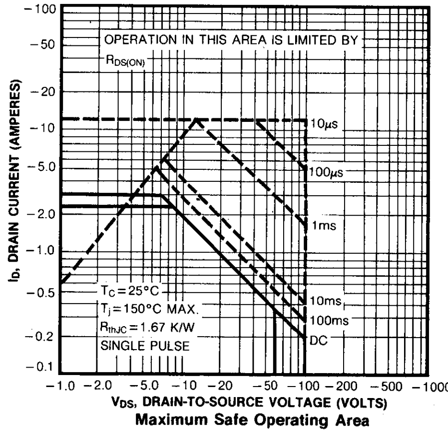
Typical Output Characteristics



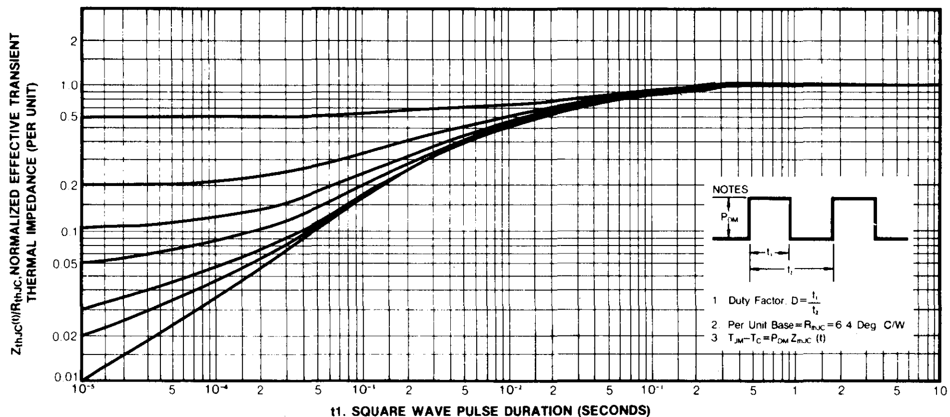
Typical Transfer Characteristics



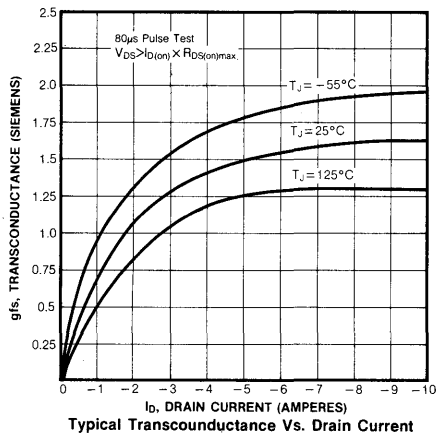
Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



Typical Transcounductance Vs. Drain Current

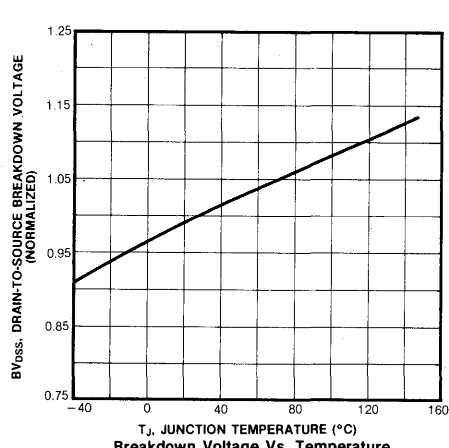
I_{DR}, REVERSE DRAIN CURRENT (AMPERES)

$T_C = 25°C$

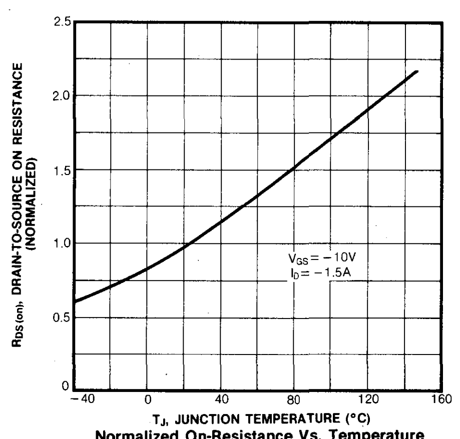
$T_C = 150°C$

V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

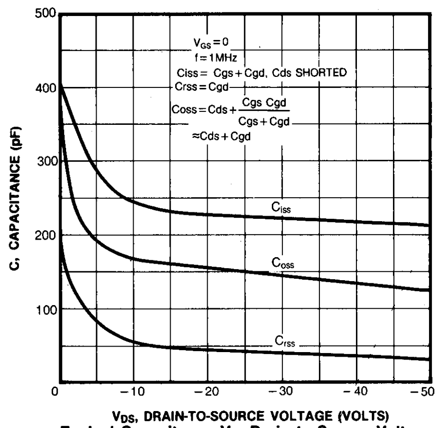
Typical Source—Drain Diode Forward Voltage



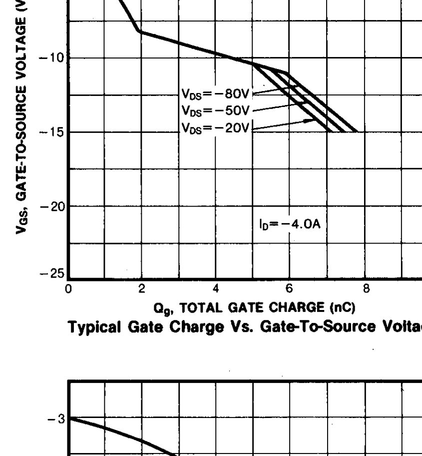
Breakdown Voltage Vs. Temperature



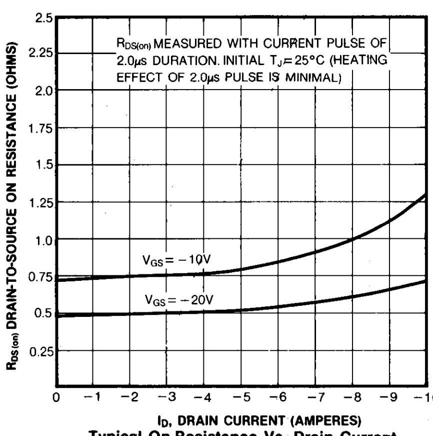
Normalized On-Resistance Vs. Temperature



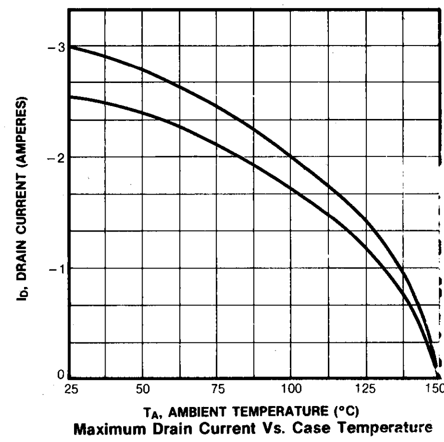
Typical Capacitance Vs. Drain to Source Voltage



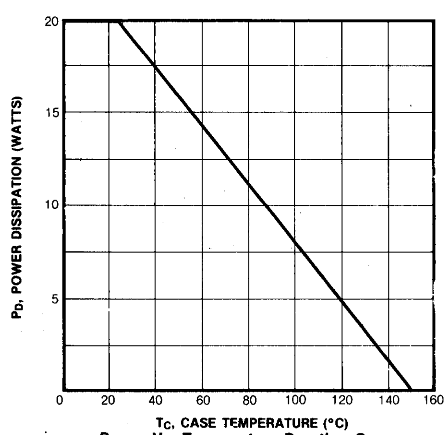
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



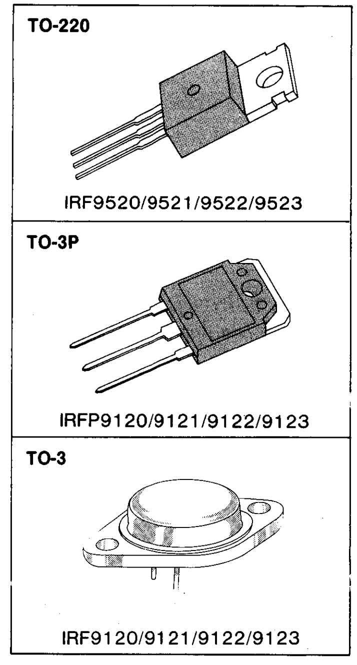
Power Vs. Temperature Derating Curve

IRF9520/9521/9522/9523
IRFP9120/9121/9122/9123
IRF9120/9121/9122/9123

P-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9520/IRFP9120/ IRF9120	−100V	0.6Ω	−6.0A
IRF9512/IRFP9121/ IRF9121	−60V	0.6Ω	−6.0A
IRF9522/IRFP9122/ IRF9122	−100V	0.8Ω	−5.0A
IRF9523/IRFP9123/ IRF9123	−60V	0.8Ω	−5.0A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRF9520 IRF9120 IRF9120	IRF9521 IRF9121 IRF9121	IRF9522 IRFP9122 IRF9122	IRF9523 IRFP9123 IRF9123	Unit
Drain-Source Voltage (1)	V_{DSS}	−100	−60	−100	−60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−60	−100	−60	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−6.0	−6.0	−5.0	−5.0	Adc
Continuous Drain Current T_C=100°C	I_D	−4.0	−4.0	−3.5	−3.5	Adc
Drain Current—Pulsed (3)	I_{DM}	−24	−24	−20	−20	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	40 0.32				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

IRF9520/9521/9522/9523
IRFP9120/9121/9122/9123
IRF9120/9121/9122/9123

P-CHANNEL POWER MOSFETS

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9520/IRF9120/IRF9120 IRF9522/IRFP9120/IRF9122	-100	—	—	V	V_{GS}=0V I_D=−250μA
	IRF9521/IRFP9121/IRF9121 IRF9523/IRF9123/IRF9121	−60	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}= 20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9520/IRFP9120/IRF9120 IRF9522/IRFP9122/IRF9122	-6.0	—	—	A	V_{DS}>$I_{D(on)}$x$R_{DS(on)}$max, V_{GS}=−10V
	IRF9521/IRF9121/IRF9121 IRF9523/IRFP9123/IRF9123	-5.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF9520/IRFP9120/IRF9120 IRF9522/IRFP9120/IRF9122	—	—	0.6	Ω	V_{GS}=−10V, I_D=−3.0A
	IRF9521/IRFP9121/IRF9121 IRF9523/IRFP9123/IRF9121	—	—	0.8	Ω	
g_{fs}	Forward Transconductance (2)	0.9	—	—	℧	V_{DS}≤−50V, I_D=−3.0A
C_{iss}	Input Capacitance	—	427	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	128	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	44.5	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=−3.0A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	100	ns	
t_f	Fall Time	—	—	15	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	12	nC	V_{GS}=−15V, I_D=−8.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	9	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	7	nC	

THERMAL RESISTANCE

Symbol	Characteristic		IRF9520-3	IRFP9120-3	IRF9120-3	Unit	
R_{thJC}	Junction-to-Case	MAX	3.12	3.12	3.12	K/W	
R_{thCS}	Case-to-Sink	TYP	1.0	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

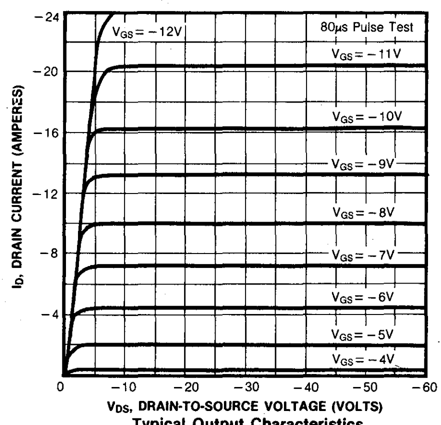
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

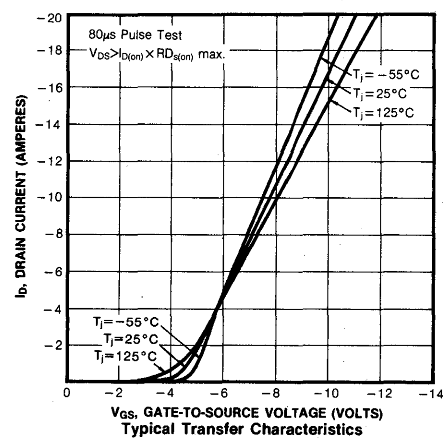
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9520/IRFP9120/IRF9120 IRF9521/IRFP9121/IRF9121	—	—	−60	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF9522/IRFP9122/IRF9122 IRF9523/IRFP9123/IRF9123	—	—	−5.0	A	
I_{SM}	Pulse Source Current (Body Diode) (3) IRF9520/IRFP9120/IRF9120 IRF9521/IRFP9121/IRF9121	—	—	−24	A	
	IRF9522/IRFP9122/IRF9122 IRF9523/IRFP9123/IRF9123	—	—	−20	A	
V_{SD}	Diode Forward Voltage (2) IRF9520/IRFP9120/IRF9120 IRF9521/IRFP9121/IRF9121	—	—	−6.3	A	T_C=25°C, I_S=−6.0A, V_{GS}=0V
	IRF9522/IRFP9122/IRF9122 IRF9523/IRFP9123/IRF9123	—	—	−6.0	A	T_C=25°C, I_S=−5.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	230	—	ns	T_j=150°C, I_F=−6.0A, dI_F/dt=100A/μS

Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

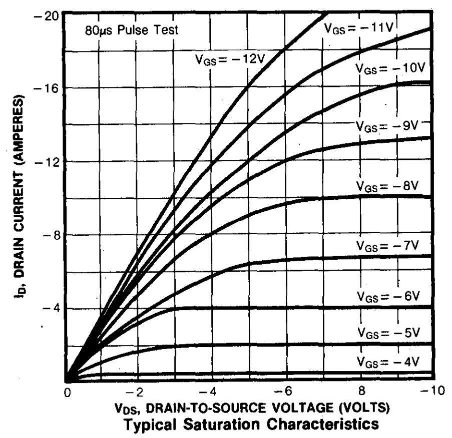
4



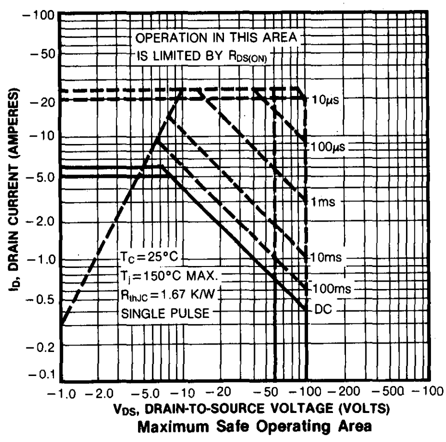
Typical Output Characteristics



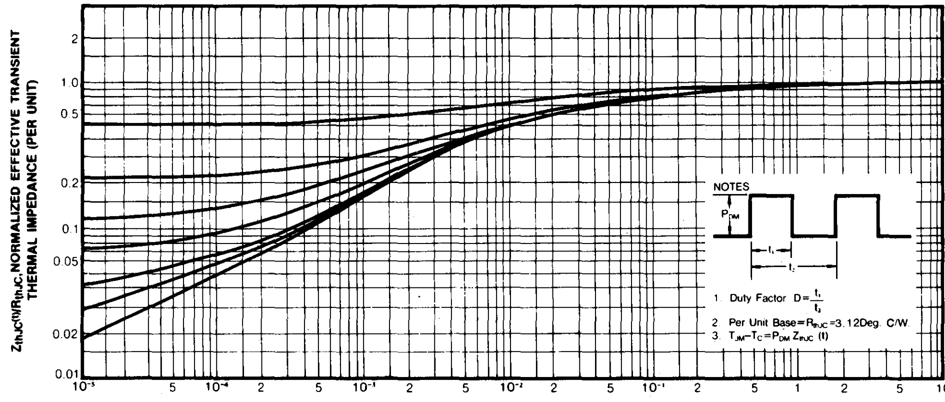
Typical Transfer Characteristics



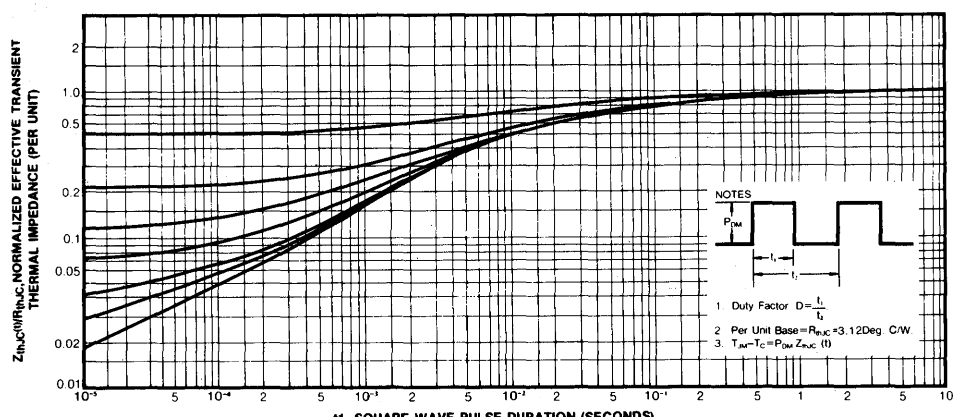
Typical Saturation Characteristics



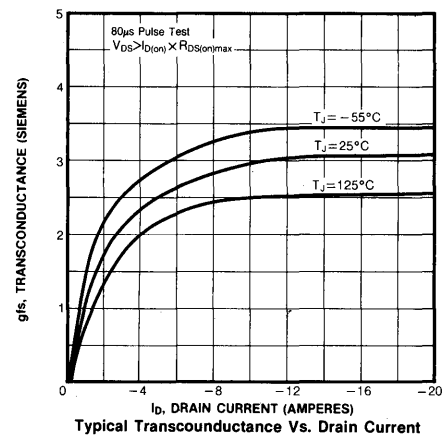
Maximum Safe Operating Area



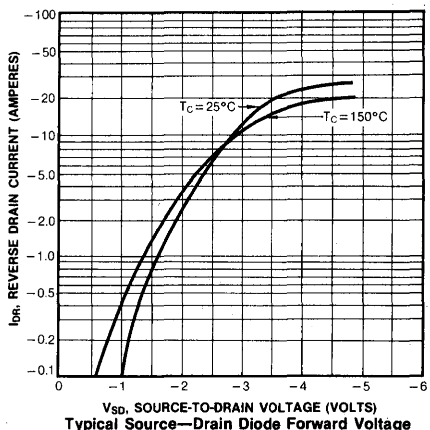
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF9520-3 And IRF9120-3



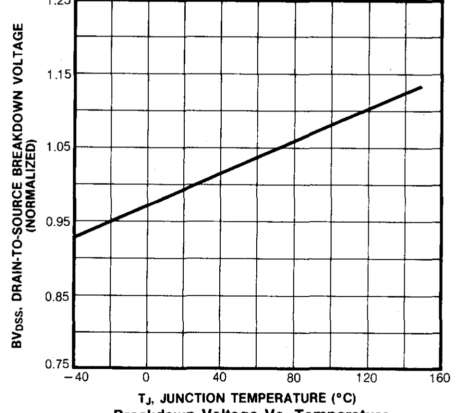
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP9120-3



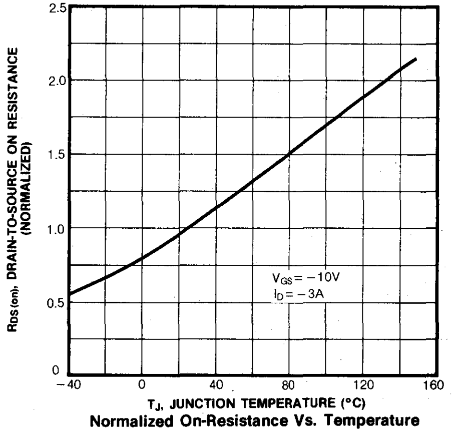
Typical Transcounductance Vs. Drain Current



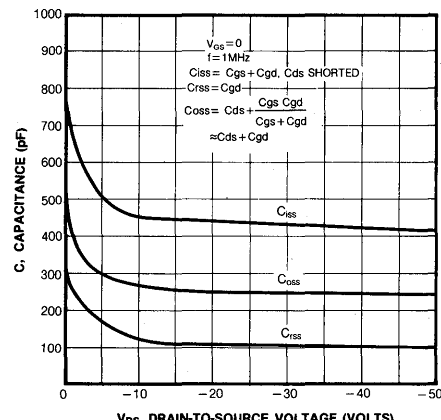
Typical Source—Drain Diode Forward Voltage



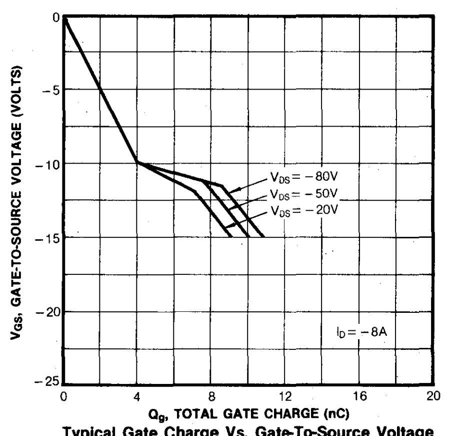
Breakdown Voltage Vs. Temperature



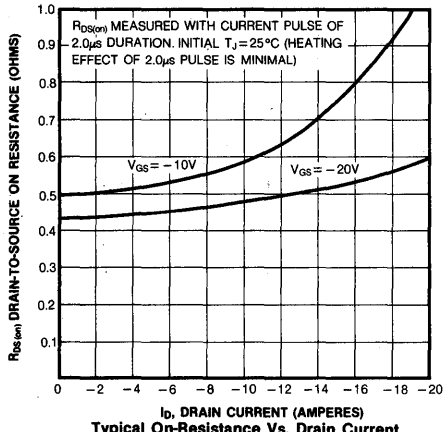
Normalized On-Resistance Vs. Temperature



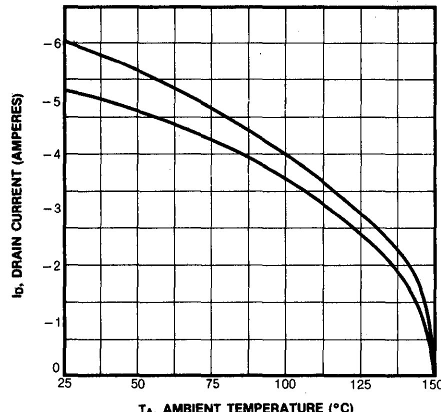
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

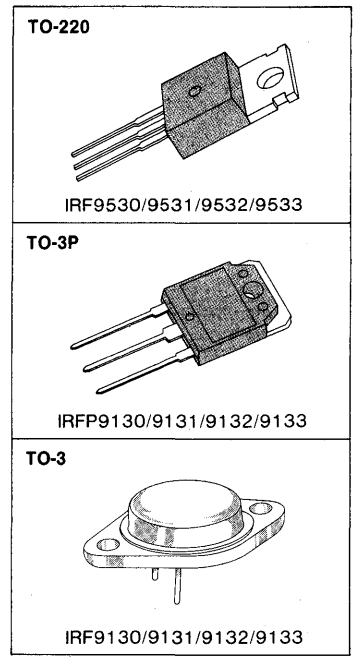
P_D, POWER DISSIPATION (WATTS)

T_C, CASE TEMPERATURE (°C)

Power Vs. Temperature Derating Curve

IRF9530/9531/9532/9533
IRFP9130/9131/9132/9133
IRF9130/9131/9132/9133

P-CHANNEL POWER MOSFETS



FEATURES

- **Lower $R_{DS\ (ON)}$**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9530/IRFP9130/ IRF9130	−100V	0.30Ω	−12A
IRF9531/IRFP9131/ IRF9131	−60V	0.30Ω	−12A
IRF9532/IRFP9132/ IRF9132	−100V	0.40Ω	−10A
IRF9533/IRFP9133/ IRF9133	−60V	0.40Ω	−10A

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MAXIMUM RATINGS

Characteristic	Symbol	IRF9530 IRF9130 IRF9130	IRF9531 IRF9131 IRF9131	IRF9532 IRFP9132 IRF9132	IRF9533 IRFP9133 IRF9133	Unit
Drain-Source Voltage (1)	V_{DSS}	−100	−60	−100	−60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−60	−100	−60	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−12	−12	−10	−10	Adc
Continuous Drain Current T_C=100°C	I_D	−7.5	−7.5	−6.5	−6.5	Adc
Drain Current—Pulsed (3)	I_{DM}	−48	−48	−40	−40	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9530/IRF9130/IRF9130 IRF9532/IRFP9132/IRF9132	-100	—	—	V	V_{GS}=0V I_D=−250μA
	IRF9531/IRFP9131/IRF9132 IRF9533/IRF9133/IRF9133	−60	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9530/IRFP9130/IRF9130 IRF9531/IRFP9131/IRF9131	-12	—	—	A	V_{DS}<$I_{D(on)}$×$R_{DS(on)max}$, V_{GS}=−10V
	IRF9532/IRFP9132/IRF9132 IRF9533/IRFP9133/IRF9133	−10	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF9530/IRFP9130/IRF9130 IRF9531/IRFP9131/IRF9131	—	—	0.3	Ω	V_{GS}=−10V, I_D=−6.5A
	IRF9532/IRFP9132/IRF9132 IRF9533/IRFP9133/IRF9133	—	—	0.4	Ω	
g_{fs}	Forward Transconductance (2)	2.0	—	—	℧	V_{DS}⩽−50V, I_D=−6.5A
C_{iss}	Input Capacitance	—	835	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	357	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	94	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	60	ns	V_{DD}=0.5BV_{DSS}, I_D=−6.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	140	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	140	ns	
t_f	Fall Time	—	—	140	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	45	nC	V_{GS}=−15V, I_D=−15A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	20	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	25	nC	

THERMAL RESISTANCE

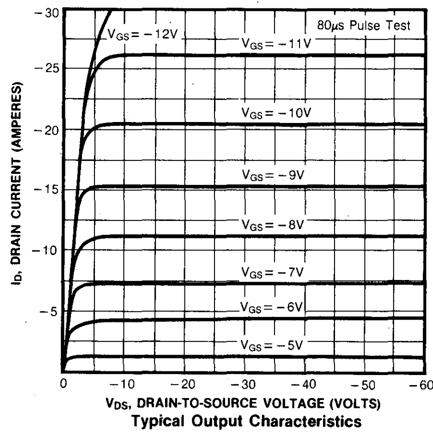
Symbol	Characteristic		IRF9530-3	IRFP9130-3	IRF9130-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	1.0	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width⩽300μs, Duty Cycle⩽2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

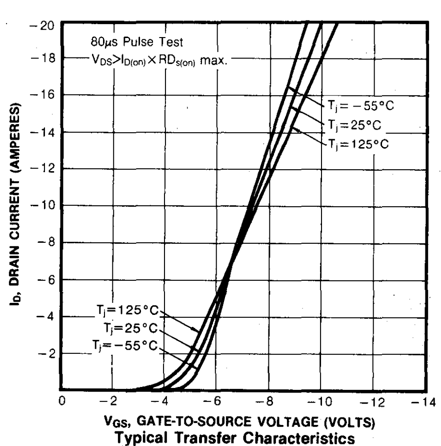
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9530/IRF9130/IRF9130 IRF9531/IRFP9131/IRF9131	—	—	−12	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier (symbol: G, D, S)
	IRF9532/IRFP9132/IRF9132 IRF9533/IRF9133/IRF9133	—	—	−10	A	
I_{SM}	Pulse Source Current (Body Diode) (3) IRF9530/IRFP9130/IRF9130 IRF9531/IRFP9131/IRF9131	—	—	−48	A	
	IRF9532/IRFP9132/IRF9132 IRF9533/IRFP9133/IRF9133	—	—	−40	A	
V_{SD}	Diode Forward Voltage (2) IRF9530/IRFP9130/IRF9130 IRF9531/IRFP9131/IRF9131	—	—	−6.3	A	T_C=25°C, I_S=−12A, V_{GS}=0V
	IRF9532/IRFP9132/IRF9132 IRF9533/IRFP9133/IRF9133	—	—	−6.0	A	T_C=25°C, I_S=−10A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	—	ns	T_j=150°C, I_F=−6.0A, dI_F/dt=100A/μS

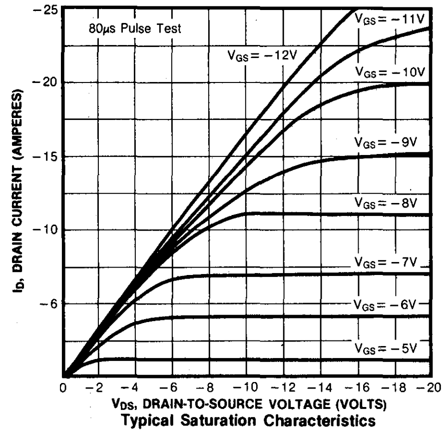
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



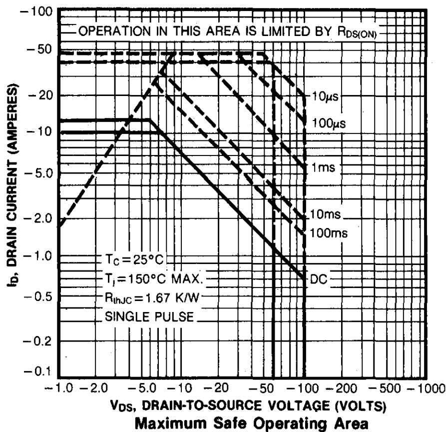
Typical Output Characteristics



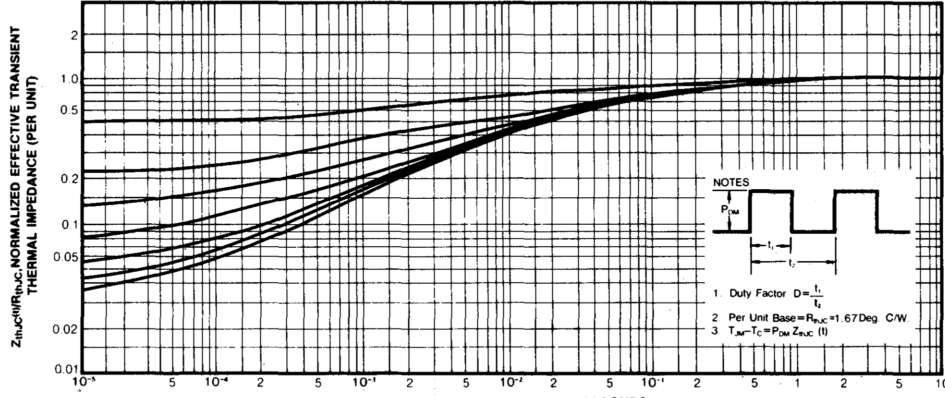
Typical Transfer Characteristics



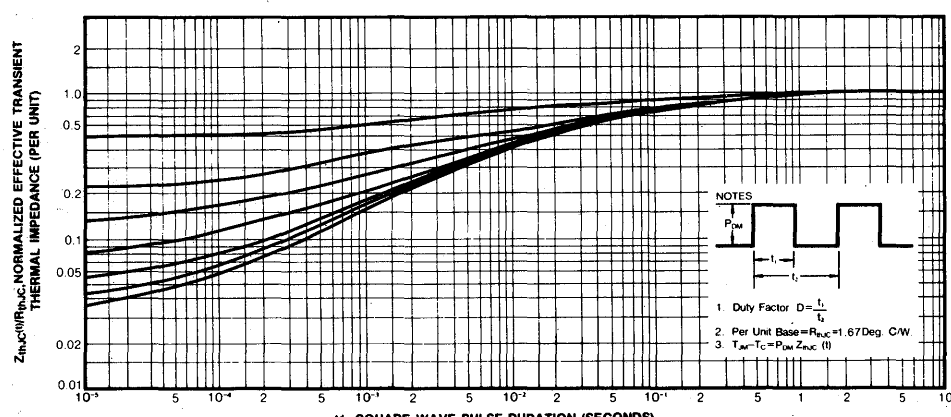
Typical Saturation Characteristics



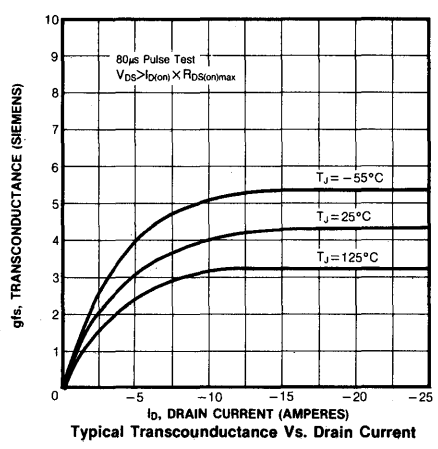
Maximum Safe Operating Area



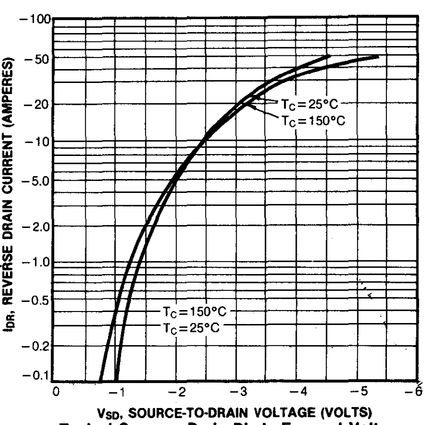
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF9530-3 And IRF9130-3



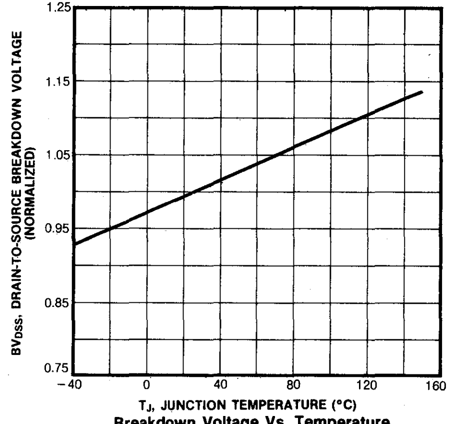
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP9130-3



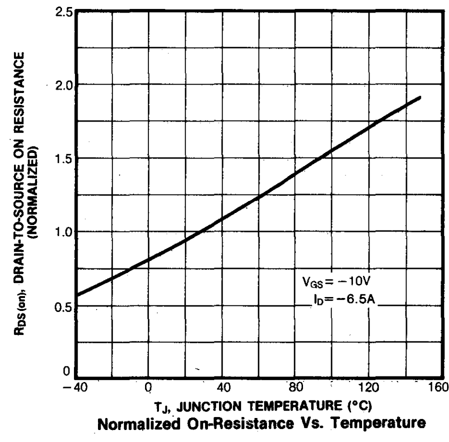
Typical Transcounductance Vs. Drain Current



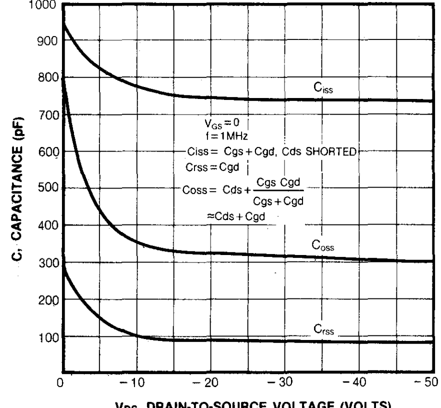
Typical Source—Drain Diode Forward Voltage



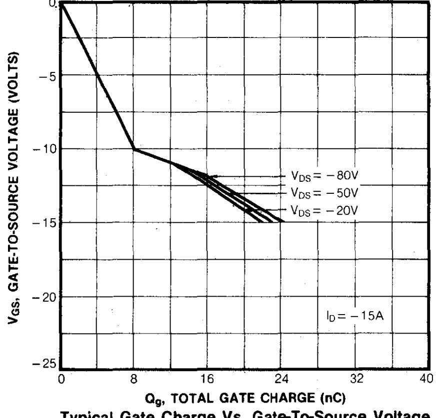
Breakdown Voltage Vs. Temperature



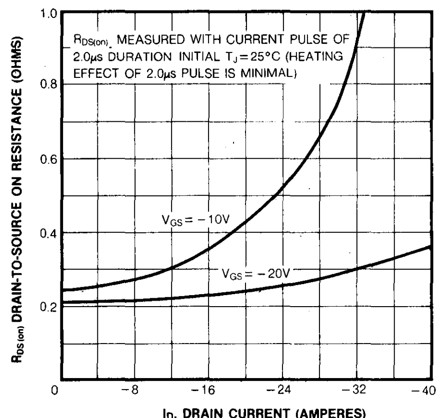
Normalized On-Resistance Vs. Temperature



Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current

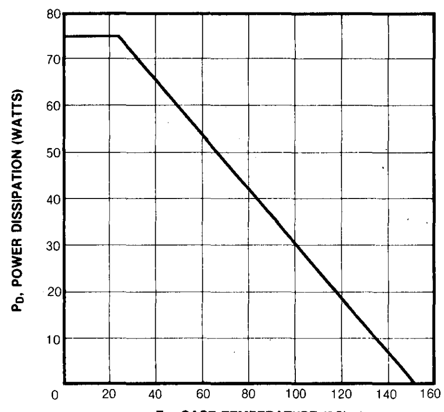
ID, DRAIN CURRENT (AMPERES)

−15
−12
−9
−6
−3

25 50 75 100 125 150

TA, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



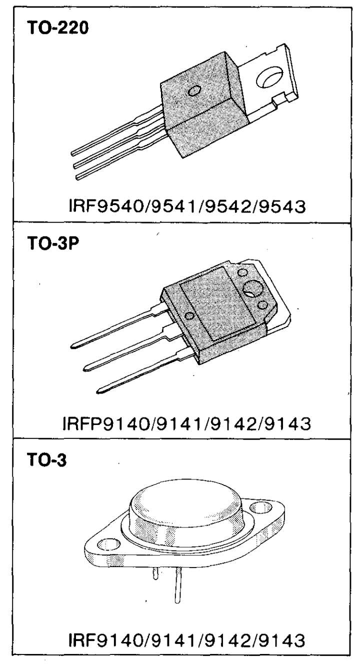
Power Vs. Temperature Derating Curve

IRF9540/9541/9542/9543
IRFP9140/9141/9142/9143
IRF9140/9141/9142/9143

P-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9540/IRFP9140/ IRF9140	−100V	0.2Ω	−19A
IRF9541/IRFP9141/ IRF9141	−60V	0.2Ω	−19A
IRF9542/IRFP9142/ IRF9142	−100V	0.3Ω	−15A
IRF9543/IRFP9143/ IRF9143	−60V	0.3Ω	−15A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRF9540 IRFP9140 IRF9140	IRF9541 IRFP9141 IRF9141	IRF9542 IRFP9142 IRF9142	IRF9543 IRFP9143 IRF9143	Unit
Drain-Source Voltage (1)	V_{DSS}	−100	−60	−100	−60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−60	−100	−60	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−19	−19	−15	−15	Adc
Continuous Drain Current T_C=100°C	I_D	−12	−12	−10	−10	Adc
Drain Current—Pulsed (3)	I_{DM}	−70	−70	−60	−60	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

IRF9540/9541/9542/9543
IRFP9140/9141/9142/9143
IRF9140/9141/9142/9143

P-CHANNEL POWER MOSFETS

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9540/IRF9140/IRF9140 IRF9542/IRFP9142/IRF9142	-100	—	—	V	V_{GS}=0V I_D=−250μA
	IRF9541/IRFP9141/IRF9141 IRF9543/IRFP9143/IRF9143	-60	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9540/IRFP9140/IRF9140 IRF9543/IRFP9143/IRF9143	-19	—	—	A	V_{DS}>$I_{D(on)}$x$R_{DS(on)}$max, V_{GS}=−10V
	IRF9541/IRFP9141/IRF9141 IRF9543/IRFP9143/IRF9143	-15	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF9540/IRFP9140/IRF9140 IRF9542/IRFP9142/IRF9142	—	—	0.2	Ω	V_{GS}=−10V, I_D=−10A
	IRF9541/IRFP9141/IRF9141 IRF9543/IRFP9143/IRF9143	—	—	0.3	Ω	
g_{fs}	Forward Transconductance (2)	5.0	—	—	℧	V_{DS}≤−50V, I_D=−10A
C_{iss}	Input Capacitance	—	1560	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	240	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	120	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	20	30	ns	V_{DD}=0.5BV_{DSS}, I_D=−10A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	10	15	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	13	20	ns	
t_f	Fall Time	—	8.0	12	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	70	90	nC	V_{GS}=−15V, I_D=−24A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	30	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	60	nC	

THERMAL RESISTANCE

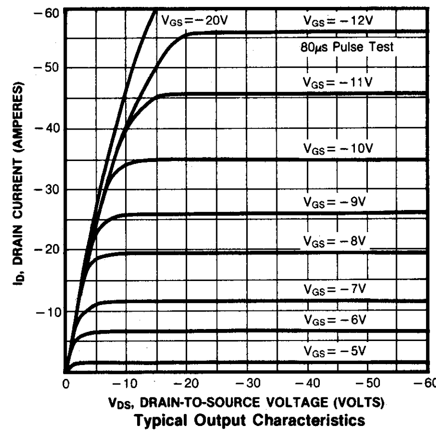
Symbol	Characteristic		IRF9540-3	IRFP9140-3	IRF9140-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

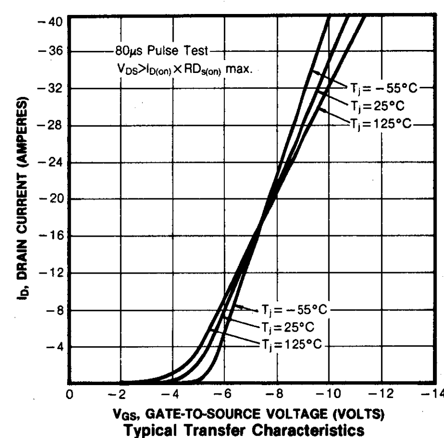
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9540/IRFP9140/IRF9140 IRF9541/IRFP9141/IRF9141	—	—	−19	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF9542/IRFP9142/IRF9142 IRF9543/IRFP9143/IRF9143	—	—	−15	A	
I_{SM}	Pulse Source Current (Body Diode) (3) IRF9540/IRFP9140/IRF9140 IRF9541/IRFP9141/IRF9141	—	—	−76	A	
	IRF9542/IRFP9142/IRF9142 IRF9543/IRFP9143/IRF9143	—	—	−60	A	
V_{SD}	Diode Forward Voltage (2) IRF9540/IRFP9140/IRF9140 IRF9541/IRFP9141/IRF9141	—	—	−4.2	A	T_C=25°C, I_S=−19A, V_{GS}=0V
	IRF9542/IRFP9142/IRF9142 IRF9543/IRFP9143/IRF9143	—	—	−4.0	A	T_C=25°C, I_S=−15A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	170	—	ns	T_j=150°C, I_F=−19A, dI_F/dt=100A/μS

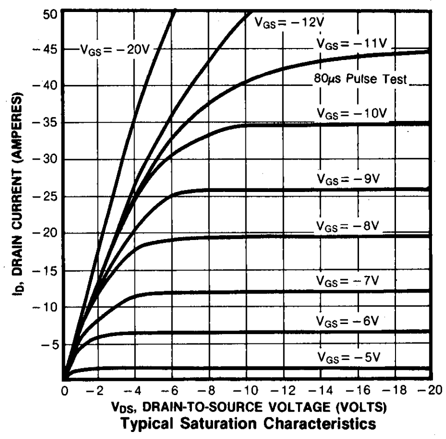
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



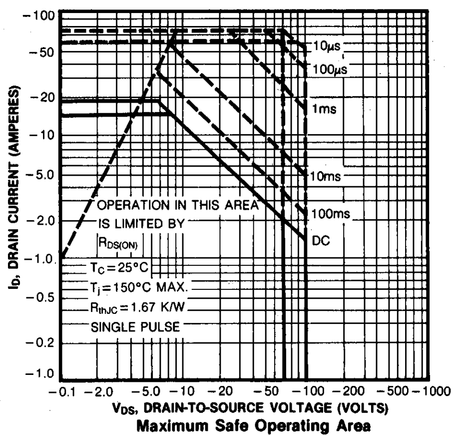
Typical Output Characteristics



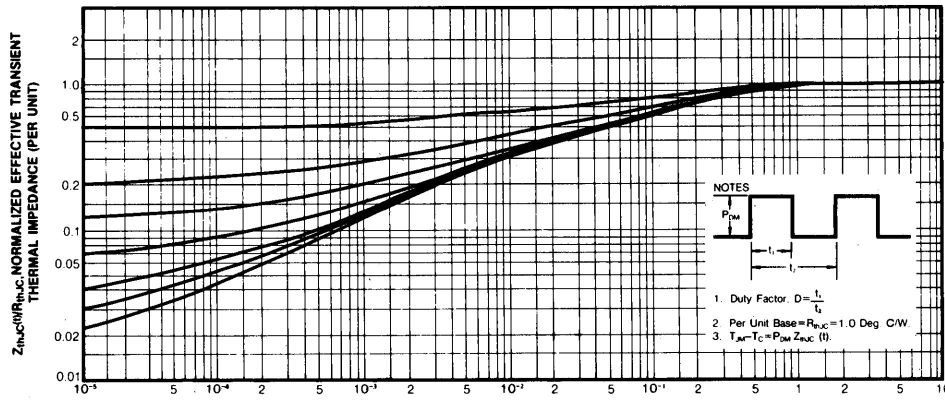
Typical Transfer Characteristics



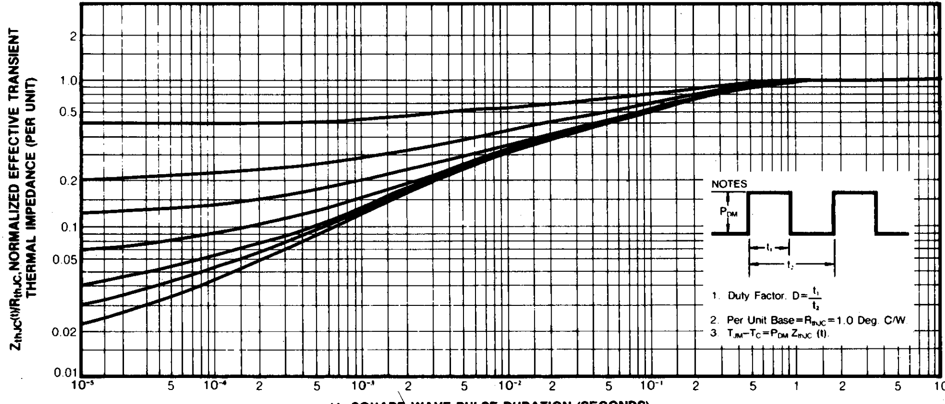
Typical Saturation Characteristics



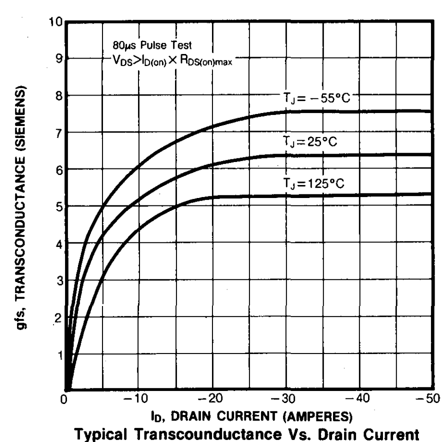
Maximum Safe Operating Area



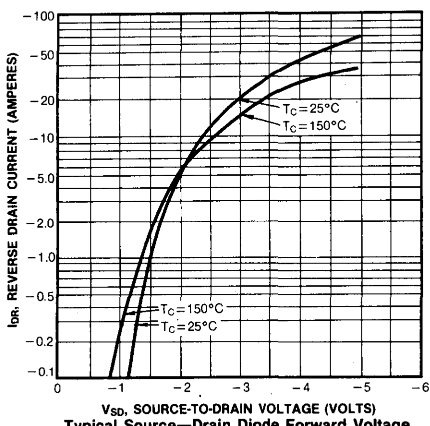
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration
For IRF9540-3 And IRF9140-3



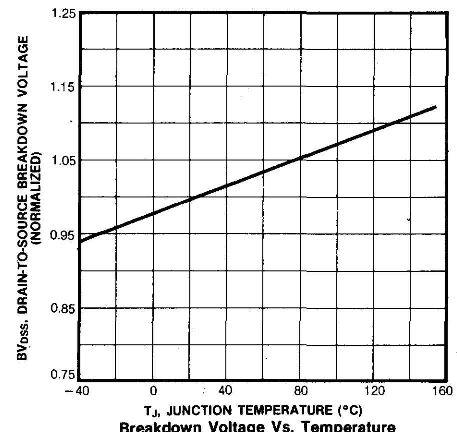
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration
For IRFP9140-3



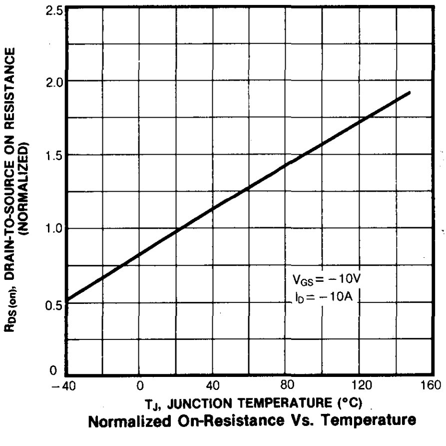
Typical Transcounductance Vs. Drain Current



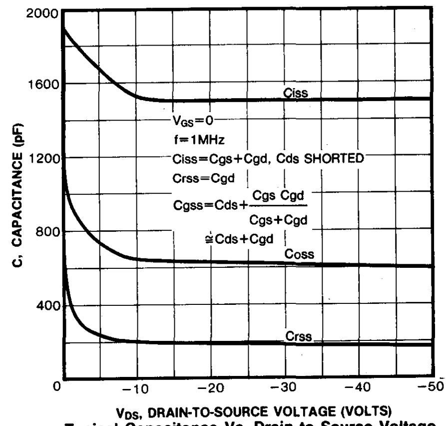
Typical Source—Drain Diode Forward Voltage



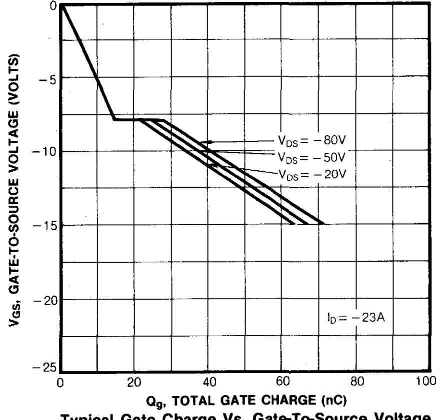
Breakdown Voltage Vs. Temperature



Normalized On-Resistance Vs. Temperature

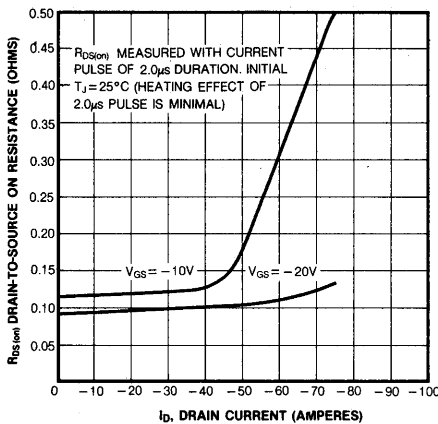


Typical Capacitance Vs. Drain to Source Voltage

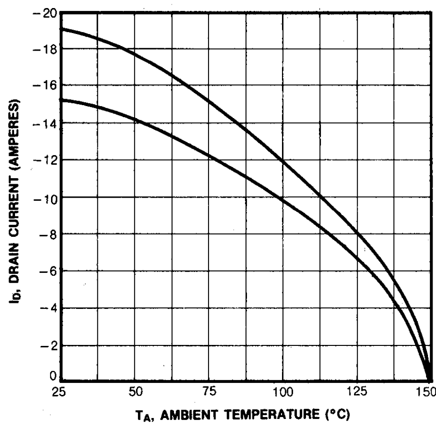


Typical Gate Charge Vs. Gate-To-Source Voltage

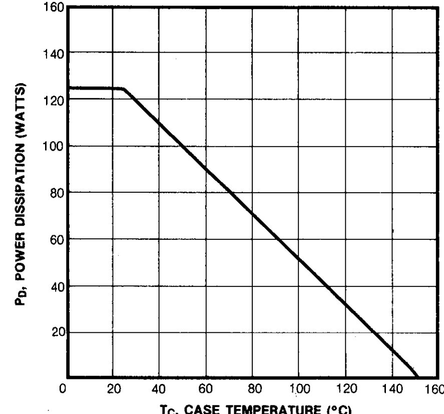
4



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

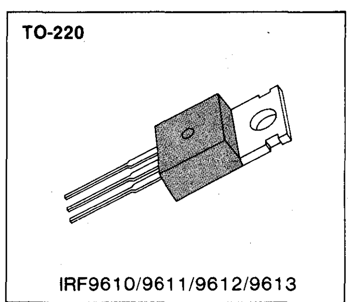
IRF9610/9611/9612/9613

P-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

TO-220



IRF9610/9611/9612/9613

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9610	−200V	3.0Ω	−1.75A
IRF9611	−150V	3.0Ω	−1.75A
IRF9612	−200V	4.5Ω	−1.5A
IRF9613	−150V	4.5Ω	−1.5A

MAXIMUM RATINGS

Characteristic	Symbol	IRF9610	IRF9611	IRF9612	IRF9613	Unit
Drain-Source Voltage (1)	V_{DSS}	−200	−150	−200	−150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200	−150	−200	−150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−1.75	−1.75	−1.5	−1.5	Adc
Continuous Drain Current T_C=100°C	I_D	−1.0	−1.0	−0.9	−0.9	Adc
Drain Current—Pulsed (3)	I_{DM}	−7.0	−7.0	−6.0	−6.0	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	20 0.16				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9610/9612	-200	—	—	V	V_{GS}=0V, I_D=−250μA
	IRF9611/9613	-150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9610/9611	-1.75	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)\ max}$, V_{GS}=−10V
	IRF9612/9613	-1.5	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF9610/9611	—	—	3.0	Ω	V_{GS}=−10V, I_D=−0.9A
	IRF9612/9613	—	—	4.5	Ω	
g_{fs}	Forward Transconductance (2)	0.7	—	—	℧	V_{DS}≤−50V, I_D=−0.9A
C_{iss}	Input Capacitance	—	227	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	52.7	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	29.6	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	15	ns	V_{DD}=0.5BV_{DSS}, I_D=−1.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	25	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	15	ns	
t_f	Fall Time	—		15	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	11	—	nC	V_{GS}=−15V, I_D=−4.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	4	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7	—	nC	

THERMAL RESISTANCE

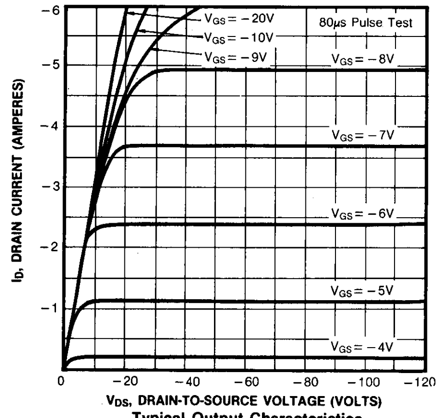
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	6.4	K/W	
R_{thCS}	Case-to-Sink	—	1.0	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	80	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

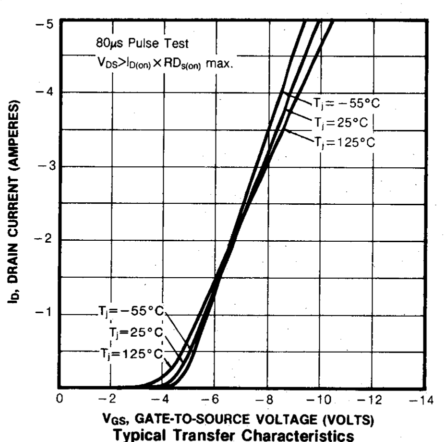
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9610/9611	—	—	−1.75	A	Modified MOSFET showing the integral reverse P-N junction rectifier
	IRF9612/9613			−1.5	A	
I_{SM}	Pulse Source Current (Body Diode)(3) IRF9610/9611	—	—	−7.0	A	
	IRF9612/9613	—	—	10	A	
V_{SD}	Diode Forward Voltage (2) IRF9610/9611	—	—	−5.8	V	$T_C=25°C$, $I_S=-1.75A$, $V_{GS}=0V$
	IRF9612/9613	—	—	−5.5	V	$T_C=25°C$, $I_S=-1.5A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	240		ns	$T_j=150°C$, $I_F=-3.0A$, $dI_F/dt=100A/\mu S$

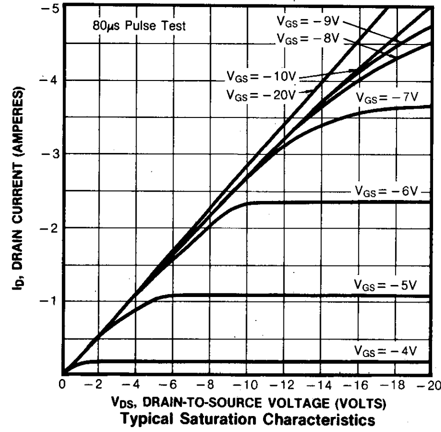
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



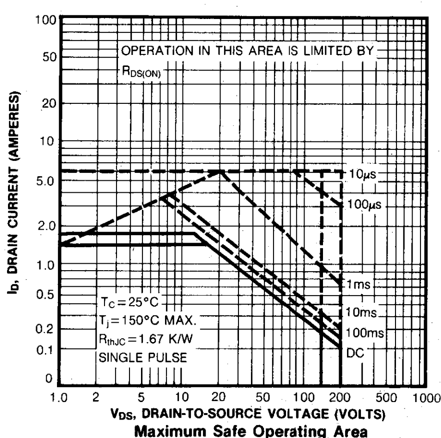
Typical Output Characteristics



Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area

t_1, SQUARE WAVE PULSE DURATION (SECONDS)

Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

NOTES

1. Duty Factor, $D = \frac{t_1}{t_2}$
2. Per Unit Base $= R_{thJC} = 6.4$ Deg C/W
3. $T_{JM} - T_C = P_{DM} Z_{thJC}$ (t)

80μs Pulse Test
$V_{DS} > I_{D(on)} \times R_{DS(on)max.}$

I_D, DRAIN CURRENT (AMPERES)

Typical Transcounductance Vs. Drain Current

V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

Typical Source—Drain Diode Forward Voltage

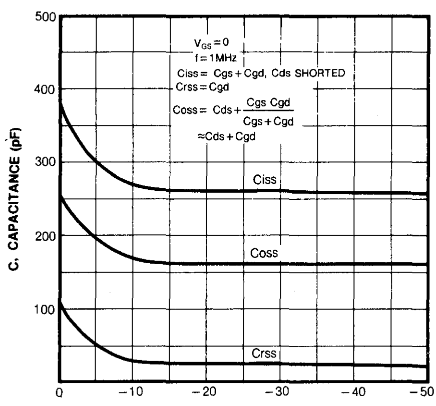
T_J, JUNCTION TEMPERATURE (°C)

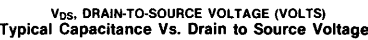
Breakdown Voltage Vs. Temperature

$V_{GS} = -10V$
$I_D = -0.9A$

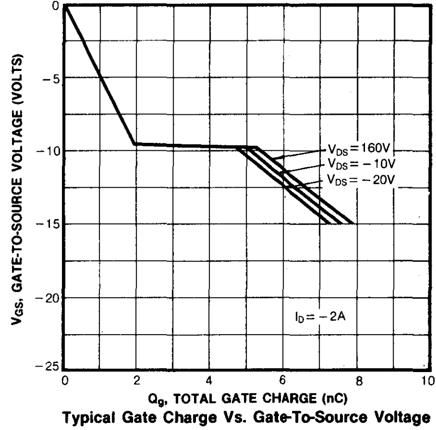
T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature

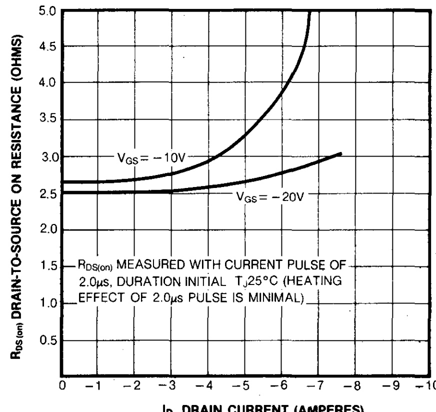




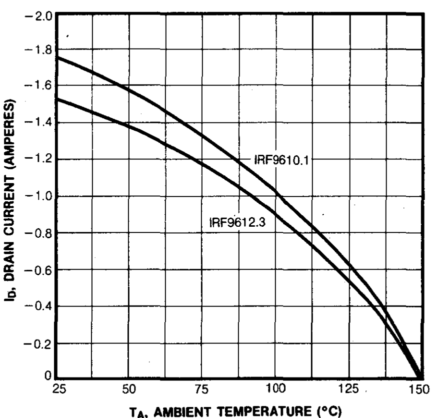
Typical Capacitance Vs. Drain to Source Voltage



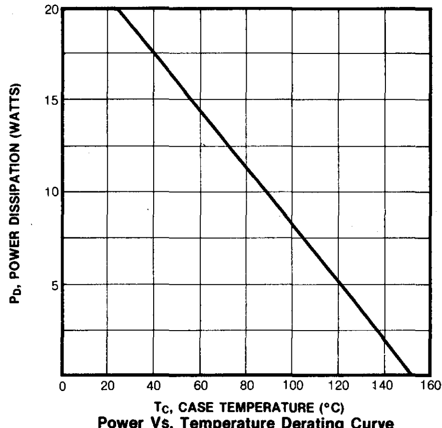
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

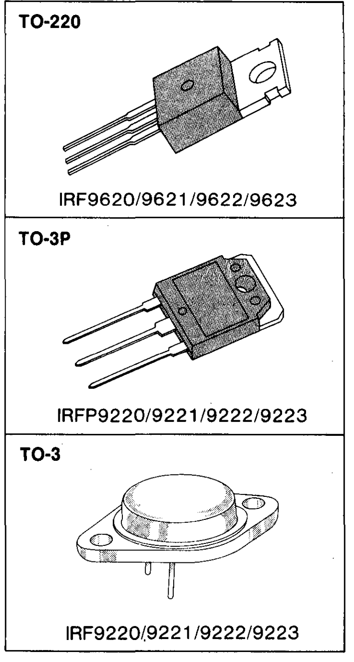
4

IRF9620/9621/9622/9623
IRFP9220/9221/9222/9223
IRF9220/9221/9222/9223

P-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9620/IRFP9220/ IRF9220	−200V	1.5Ω	−3.5A
IRF9621/IRFP9221/ IRF9221	−150V	1.5Ω	−3.5A
IRF9622/IRFP9222/ IRF9222	−200V	2.4Ω	−3.0A
IRF9623/IRFP9223/ IRF9223	−150V	2.4Ω	−3.0A

MAXIMUM RATINGS

Characteristics	Symbol	IRF9620 IRFP9220 IRF9220	IRF9621 IRFP9221 IRF9221	IRF9622 IRFP9222 IRF9222	IRF9623 IRFP9223 IRF9223	Unit
Drain-Source Voltage (1)	V_{DSS}	−200	−150	−200	−150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200	−150	−200	−150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−3.5	−3.5	−3.0	−3.0	Adc
Continuous Drain Current T_C=100°C	I_D	−2.0	−2.0	−1.5	−1.5	Adc
Drain Current—Pulsed (3)	I_{DM}	−14	−14	−12	−12	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	40 0.32				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

IRF9620/9621/9622/9623
IRFP9220/9221/9222/9223
IRF9220/9221/9222/9223

P-CHANNEL POWER MOSFETS

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9620/IRFP9220/IRF9220 IRF9622/IRFP9222/IRF9222	-200	—	—	V	V_{GS}=0V I_D=−250μA
	IRF9621/IRFP9221/IRF9221 IRF9623/IRFP9223/IRF9223	-150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9620/IRFP9220/IRF9220 IRF9621/IRFP9221/IRF9221	-3.5	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=−10V
	IRF9622/IRFP9222/IRF9222 IRF9623/IRFP9223/IRF9223	-3.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF9620/IRFP9220/IRF9220 IRF9621/IRFP9221/IRF9221	—	—	1.5	Ω	V_{GS}=−10V, I_D=−1.5A
	IRF9622/IRFP9222/IRF9222 IRF9623/IRFP9223/IRF9223	—	—	2.4	Ω	
g_{fs}	Forward Transconductance (2)	1.0	—	—	℧	V_{DS}≤−50V, I_D=−1.5A
C_{iss}	Input Capacitance	—	405	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	85.5	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	27	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	40	ns	V_{DD}=0.5BV_{DSS}, I_D=−1.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	50	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	50	ns	
t_f	Fall Time	—	—	40	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	22	nC	V_{GS}=−15V, I_D=−4.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	9	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	13	nC	

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THERMAL RESISTANCE

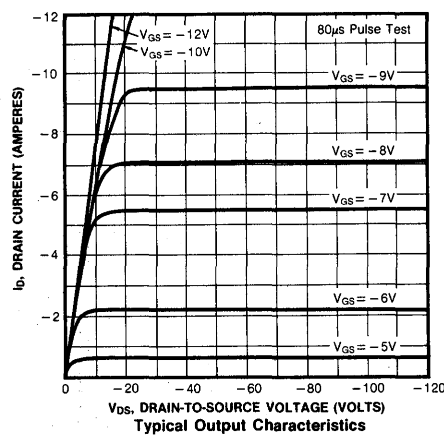
Symbol	Characteristic		IRF9620-3	IRFP9620-3	IRF9620-3	Unit	
R_{thJC}	Junction-to-Case	MAX	3.12	3.12	3.12	K/W	
R_{thCS}	Case-to-Sink	TYP	1.0	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

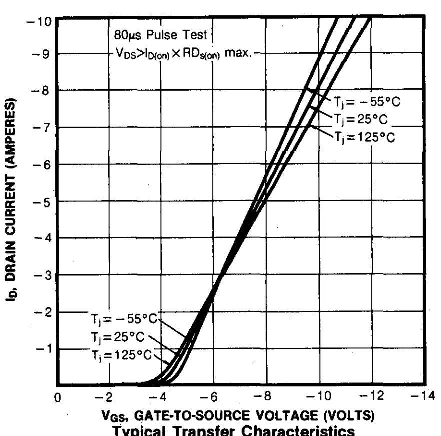
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9620/IRFP9220/IRF9220 IRF9621/IRFP9221/IRF9221	—	—	−3.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF9622/IRFP9222/IRF9222 IRF9623/IRFP9223/IRF9223	—	—	−3.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRF9620/IRFP9220/IRF9220 IRF9621/IRFP9221/IRF9221	—	—	−14	A	
	IRF9622/IRFP9222/IRF9222 IRF9623/IRFP9223/IRF9223	—	—	−12	A	
V_{SD}	Diode Forward Voltage (2) IRF9620/IRFP9220/IRF9220 IRF9621/IRFP9221/IRF9221	—	—	−7.0	V	T_C=25°C, I_S=−3.5A, V_{GS}=0V
	IRF9622/IRFP9222/IRF9222 IRF9623/IRFP9223/IRF9223	—	—	−6.0	V	T_C=25°C, I_S=−3.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	—	ns	T_j=150°C, I_F=−3.5A, dI_F/dt=100A/μS

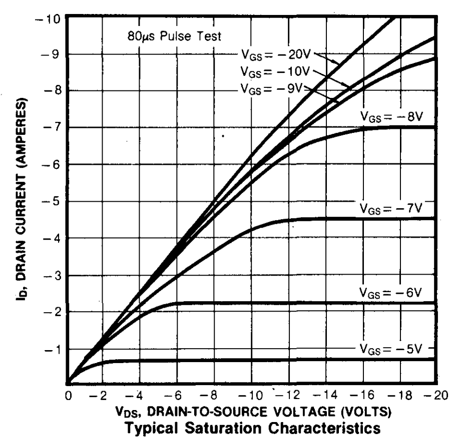
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



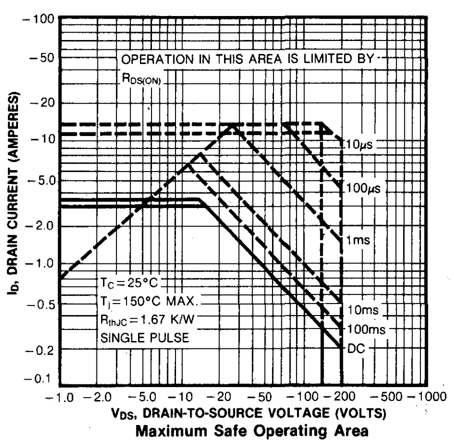
Typical Output Characteristics



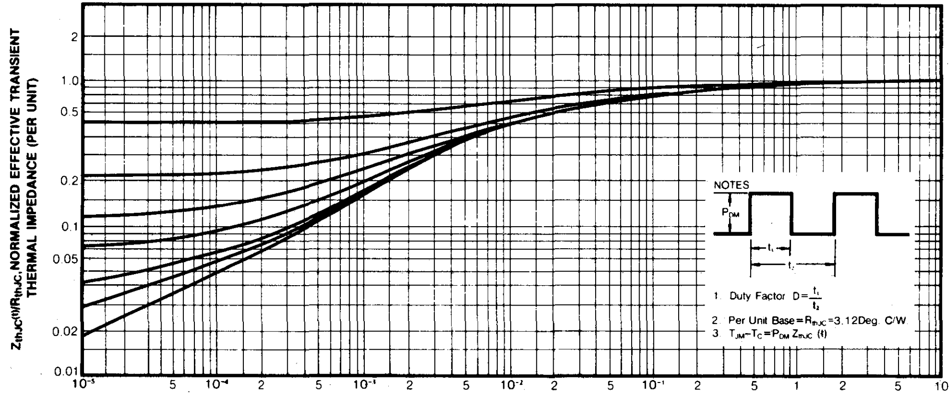
Typical Transfer Characteristics



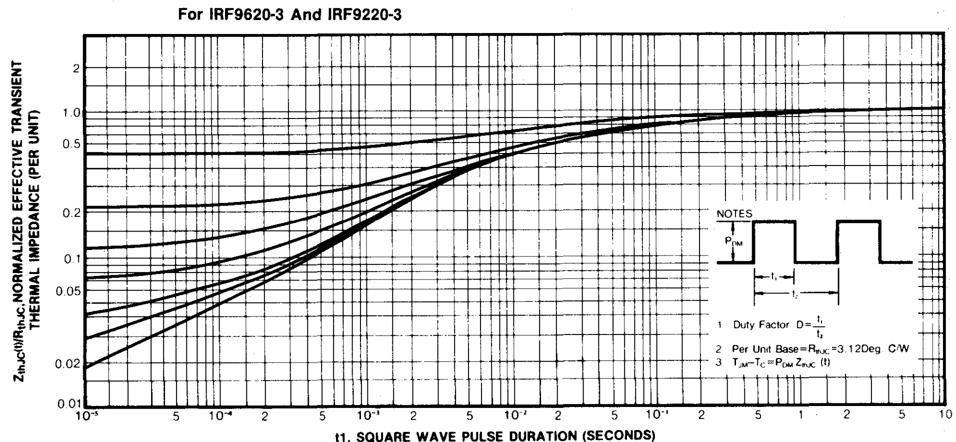
Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF9620-3 And IRF9220-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP9220-3

80μs Pulse Test
$V_{DS} > I_{D(on)} \times R_{DS(on)max}$
$T_J = -55°C$
$T_J = 25°C$
$T_J = 125°C$
gfs, TRANSCONDUCTANCE (SIEMENS)
0.5, 1.0, 1.5, 2.0, 2.5, 3.0
0, −1, −2, −3, −4, −5, −6, −7, −8, −9, −10
I_D, DRAIN CURRENT (AMPERES)

Typical Transcounductance Vs. Drain Current

$T_C = 25°C$
$T_C = 150°C$
$T_C = 150°C$
$T_C = 25°C$
I_{DR}, REVERSE DRAIN CURRENT (AMPERES)
−0.1, −0.2, −0.5, −1.0, −2.0, −5.0, −10, −20, −50, −100
0, −1, −2, −3, −4, −5, −6, −7, −8, −9, −10, −11, −12
V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)
0.75, 0.85, 0.95, 1.05, 1.15, 1.25
−40, 0, 40, 80, 120, 160
T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

$V_{GS} = -10V$
$I_D = -1.5A$
$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)
0, 0.5, 1.0, 1.5, 2.0, 2.5
−40, 0, 40, 80, 120, 160
T_J, JUNCTION TEMPERATURE (°C)

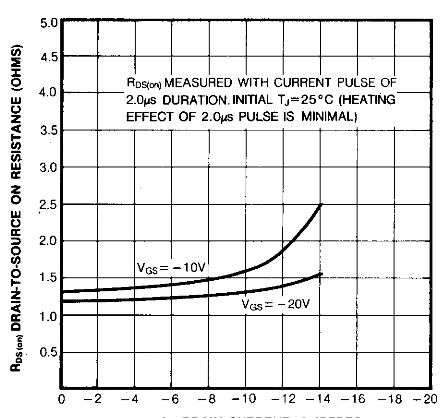
Normalized On-Resistance Vs. Temperature

$V_{GS} = 0$
f = 1MHz
Ciss = Cgs + Cgd, Cds SHORTED
Crss = Cgd
$Coss = Cds + \frac{Cgs\ Cgd}{Cgs + Cgd}$
≈ Cds + Cgd
C_{iss}
C_{oss}
C_{rss}
C, CAPACITANCE (pF)
100, 200, 300, 400, 500
0, −10, −20, −30, −40, −50
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

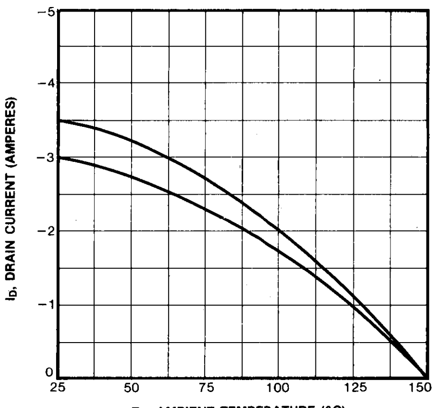
Typical Capacitance Vs. Drain to Source Voltage

$V_{DS} = -160V$
$V_{DS} = -100V$
$V_{DS} = -40V$
$I_D = -4.0A$
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
0, −5, −10, −15, −20, −25
0, 4, 8, 12, 16, 20
Q_g, TOTAL GATE CHARGE (nC)

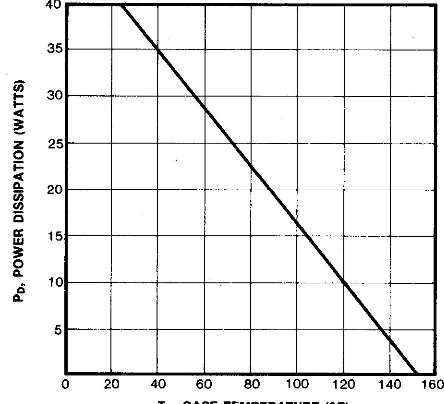
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

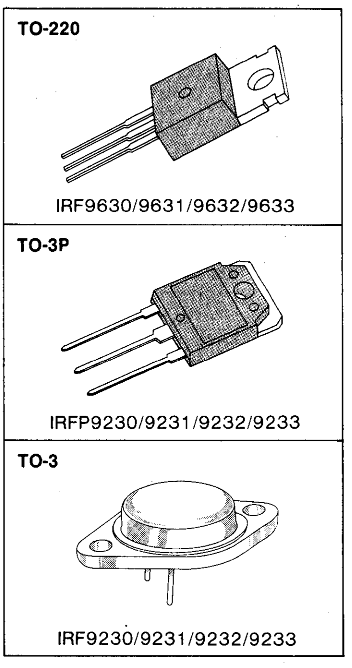
4

IRF9630/9631/9632/9633
IRFP9230/9231/9232/9233
IRF9230/9231/9232/9233

P-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS\ (ON)}$**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9630/IRFP9230/ IRF9230	−200V	0.8Ω	−6.5A
IRF9631/IRFP9231/ IRF9231	−150V	0.8Ω	−6.5A
IRF9632/IRFP9232/ IRF9232	−200V	1.2Ω	−5.5A
IRF9633/IRFP9233/ IRF9233	−150V	1.2Ω	−5.5A

MAXIMUM RATINGS

Characteristic	Symbol	IRF9630 IRF9230 IRF9230	IRF9631 IRF9231 IRF9231	IRF9632 IRFP9232 IRF9232	IRF9633 IRFP9233 IRF9233	Unit
Drain-Source Voltage (1)	V_{DSS}	−200	−150	−200	−150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200	−150	−200	−150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−0.5	−6.5	−5.5	−5.5	Adc
Continuous Drain Current T_C=100°C	I_D	−4.0	−4.0	−3.5	−3.5	Adc
Drain Current—Pulsed (3)	I_{DM}	−26	−26	−22	−22	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	75 0.6				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9630/IRFP9230/IRF9230 IRF9632/IRFP9232/IRF9232	-200	—	—	V	V_{GS}=0V I_D=−250μA
	IRF9631/IRFP9231/IRF9231 IRF9633/IRFP9233/IRF9233	-150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9630/IRFP9230/IRF9230 IRF9631/IRFP9231/IRF9231	-6.5	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max}$, V_{GS}=−10V
	IRF9632/IRFP9232/IRF9232 IRF9633/IRFP9233/IRF9233	-5.5	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF9630/IRFP9230/IRF9230 IRF9631/IRFP9231/IRF9231	—	—	0.8	Ω	V_{GS}=−10V, I_D=−3.5A
	IRF9632/IRFP9232/IRF9232 IRF9633/IRFP9233/IRF9233	—	—	1.2	Ω	
g_{fs}	Forward Transconductance (2)	2.2	—	—	℧	V_{DS}≤−50V, I_D=−3.5A
C_{iss}	Input Capacitance	—	812	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	318	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	72.6	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	V_{DD}=0.5BV_{DSS}, I_D=−3.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	100	ns	
t_f	Fall Time	—	—	80	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	45	nC	V_{GS}=−15V, I_D=−8.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	20	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	25	nC	

THERMAL RESISTANCE

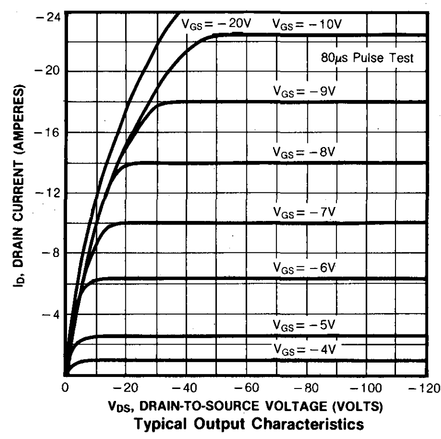
Symbol	Characteristic		IRF9630-3	IRFP9230-3	IRF9230-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.67	1.67	1.67	K/W	
R_{thCS}	Case-to-Sink	TYP	1.0	0.24	0.1	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

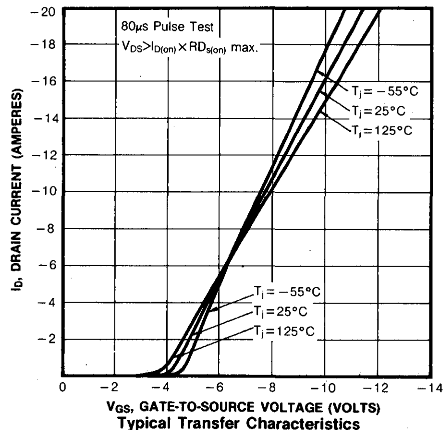
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9630/IRFP9230/IRF9230 IRF9631/IRFP9231/IRF9231	—	—	−6.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF9632/IRFP9232/IRF9232 IRF9633/IRFP9233/IRF9233	—	—	−5.5	A	
I_{SM}	Pulse Source Current (Body Diode) (3) IRF9630/IRFP9230/IRF9230 IRF9631/IRFP9231/IRF9231	—	—	−26	A	
	IRF9632/IRFP9232/IRF9232 IRF9633/IRFP9233/IRF9233	—	—	−22	A	
V_{SD}	Diode Forward Voltage (2) IRF9630/IRFP9230/IRF9230 IRF9631/IRFP9231/IRF9231	—	—	−6.5	A	T_C=25°C, I_S=−6.5A, V_{GS}=0V
	IRF9632/IRFP9232/IRF9232 IRF9633/IRFP9233/IRF9233	—	—	−6.3	A	T_C=25°C, I_S=−5.5A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	—	ns	T_j=150°C, I_F=−6.5A, dI_F/dt=100A/μS

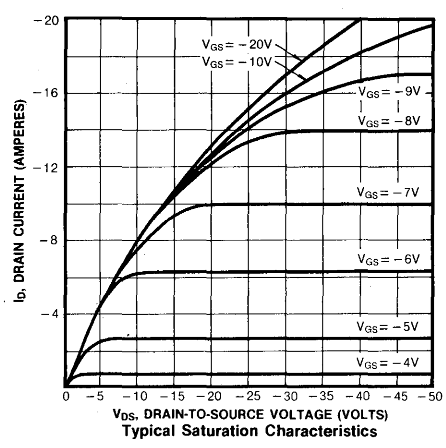
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



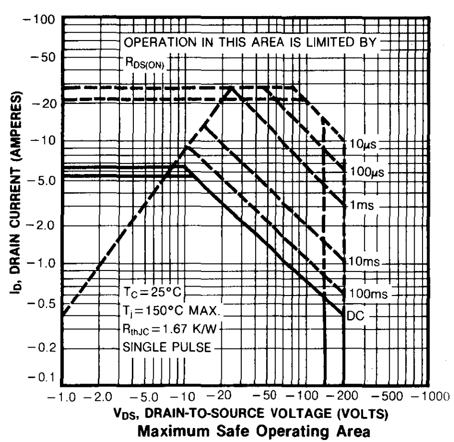
Typical Output Characteristics



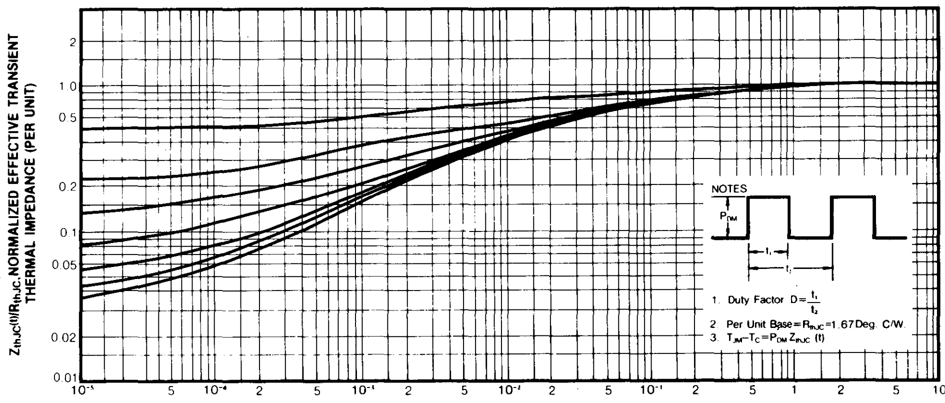
Typical Transfer Characteristics



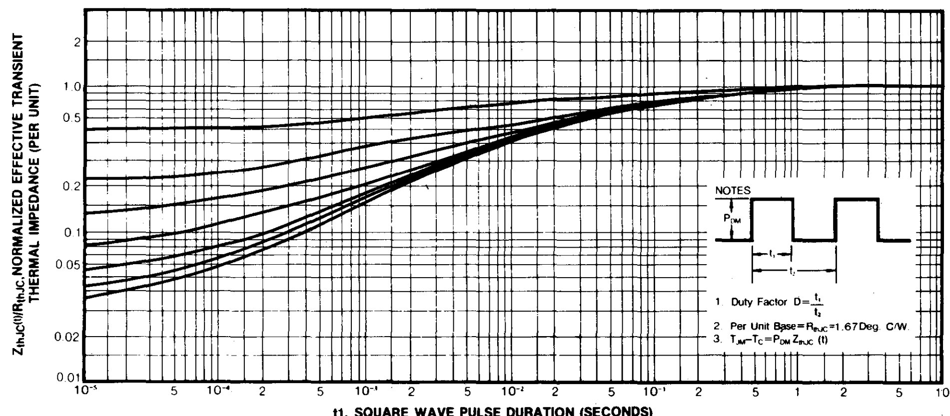
Typical Saturation Characteristics



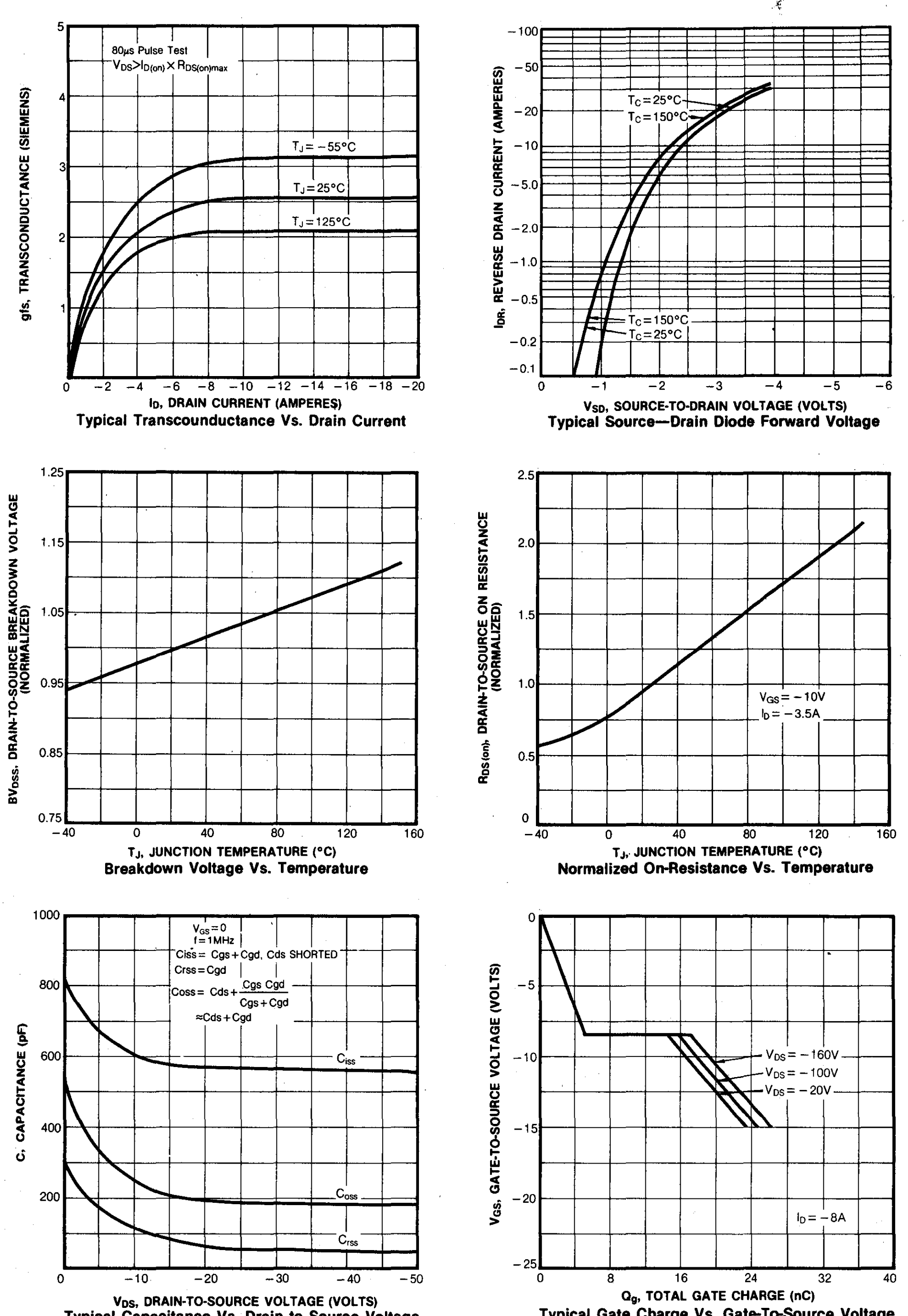
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration
For IRF9630-3 And IRF9230-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration
For IRFP9230-3



Typical Transcounductance Vs. Drain Current

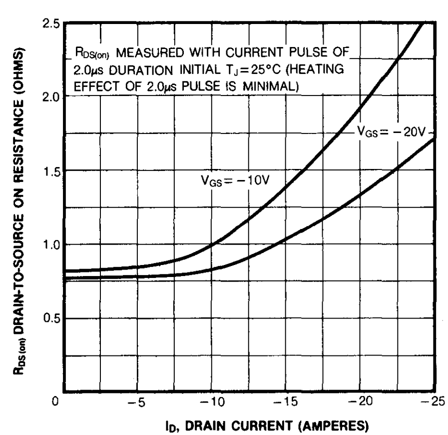
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

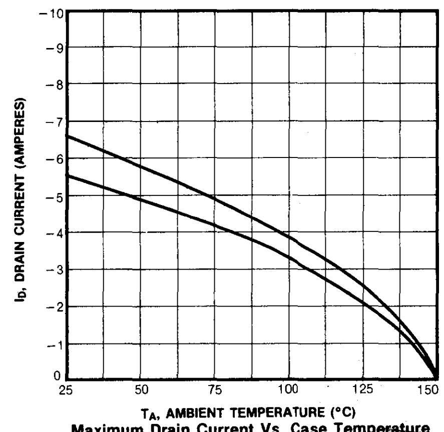
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

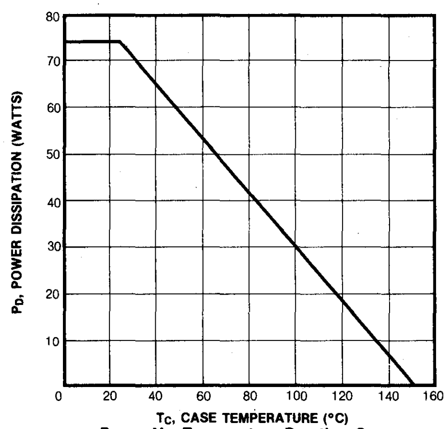
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

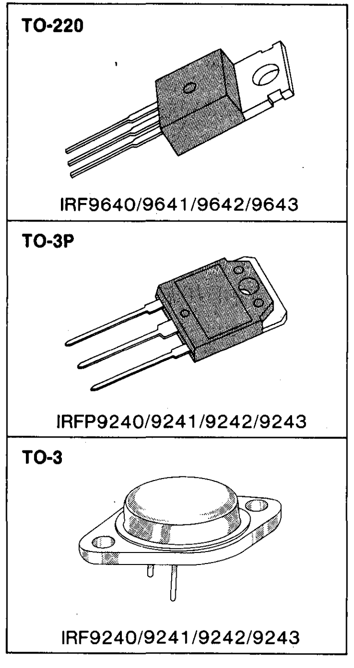
4

IRF9640/9641/9642/9643
IRFP9240/9241/9242/9243
IRF9240/9241/9242/9243

P-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRF9640/IRFP9240/ IRF9240	−200V	0.5Ω	−11A
IRF9641/IRFP9241/ IRF9241	−150V	0.5Ω	−11A
IRF9642/IRFP9242/ IRF9242	−200V	0.7Ω	−9.0A
IRF9643/IRFP9243/ IRF9243	−150V	0.7Ω	−9.0A

MAXIMUM RATINGS

Characteristic	Symbol	IRF9640 IRFP9240 IRF9240	IRF9641 IRFP9241 IRF9241	IRF9642 IRFP9242 IRF9242	IRF9643 IRFP9243 IRF9243	Unit
Drain-Source Voltage (1)	V_{DSS}	−200	−150	−200	−150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200	−150	−200	−150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−11	−11	−9.0	−9.0	Adc
Continuous Drain Current T_C=100°C	I_D	−7.0	−7.0	−6.0	−6.0	Adc
Drain Current—Pulsed (3)	I_{DM}	−44	−44	−36	−36	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	125 1.0				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRF9640/IRFP9240/IRF9240 IRF9642/IRFP9242/IRF9242	-200	—	—	V	V_{GS}=0V I_D=−250μA
	IRF9641/IRFP9241/IRF9241 IRF9643/IRFP9243/IRF9243	-150	—	—	V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRF9640/IRFP9240/IRF9240 IRF9641/IRFP9241/IRF9241	−11	—	—	A	V_{DS}>$I_{D(on)}$x$R_{DS(on)}$max, V_{GS}=−10V
	IRF9642/IRFP9242/IRF9242 IRF9643/IRFP9243/IRF9243	-9.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRF9640/IRFP9240/IRF9240 IRF9642/IRFP9241/IRF9241	—	0.44	0.5	Ω	V_{GS}=−10V, I_D=−6.0A
	IRF9642/IRFP9242/IRF9242 IRF9643/IRFP9243/IRF9243	—	0.5	0.7	Ω	
g_{fs}	Forward Transconductance (2)	4.0	4.7	—	℧	V_{DS}≤−50V, I_D=−6.0A
C_{iss}	Input Capacitance	—	1542	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	230	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	115	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD}=0.5BV_{DSS}, I_D=−6.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	15	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	18	ns	
t_f	Fall Time	—	—	12	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	90	nC	V_{GS}=−15V, I_D=−22A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	30	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	60	nC	

THERMAL RESISTANCE

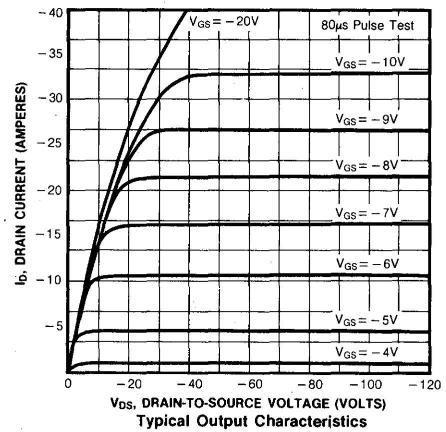
Symbol	Characteristic		IRF9640-3	IRFP9240-3	IRF9240-3	Unit	
R_{thJC}	Junction-to-Case	MAX	1.0	1.0	1.0	K/W	
R_{thCS}	Case-to-Sink	TYP	0.5	0.24	0.12	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	80	40	30	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

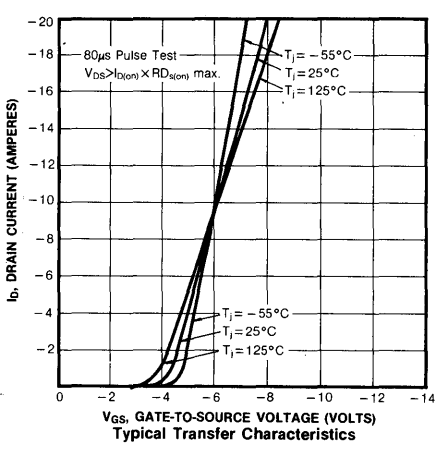
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRF9640/IRFP9240/IRF9240 IRF9641/IRFP9241/IRF9241	—	—	−11	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRF9642/IRFP9242/IRF9242 IRF9643/IRFP9243/IRF9243	—	—	−9	A	
I_{SM}	Pulse Source Current (Body Diode) (3) IRF9640/IRFP9240/IRF9240 IRF9641/IRFP9241/IRF9241	—	—	−44	A	
	IRF9642/IRFP9242/IRF9242 IRF9643/IRFP9243/IRF9243	—	—	−36	A	
V_{SD}	Diode Forward Voltage (2) IRF9640/IRFP9240/IRF9240 IRF9641/IRFP9241/IRF9241	—	—	−4.6	A	$T_C=25°C$, $I_S=-11A$, $V_{GS}=0V$
	IRF9642/IRFP9242/IRF9242 IRF9643/IRFP9243/IRF9243	—	—	−4.4	A	$T_C=25°C$, $I_S=-9.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	270	—	ns	$T_j=150°C$, $I_F=-11A$, $dI_F/dt=100A/\mu S$

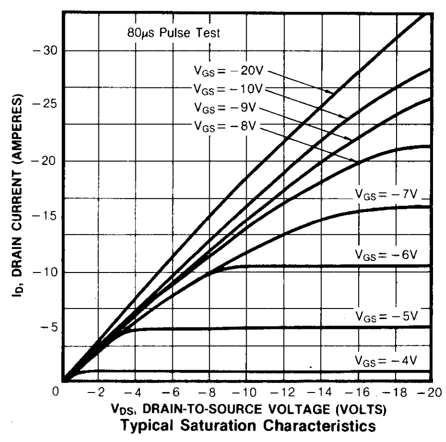
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



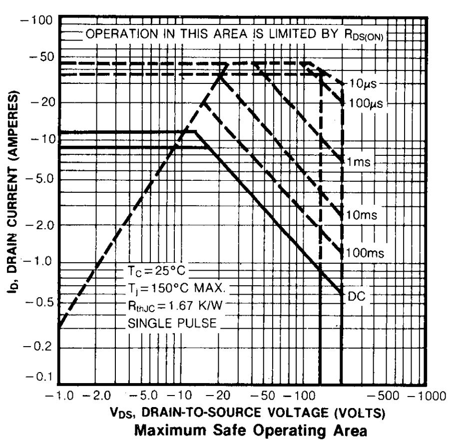
Typical Output Characteristics



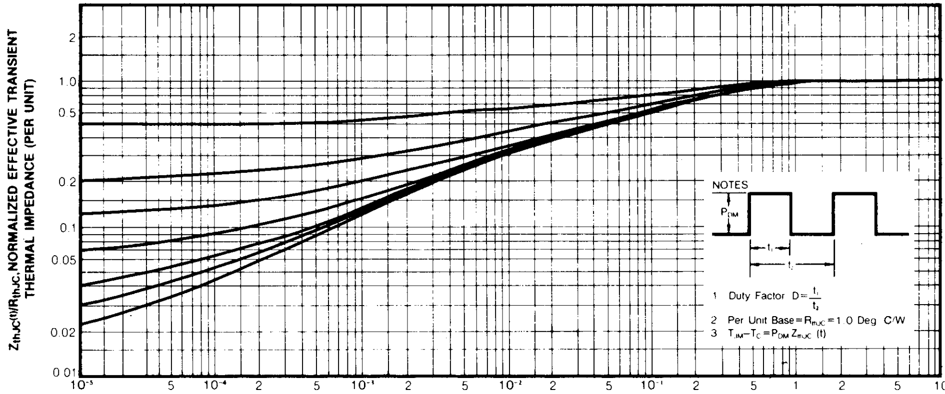
Typical Transfer Characteristics



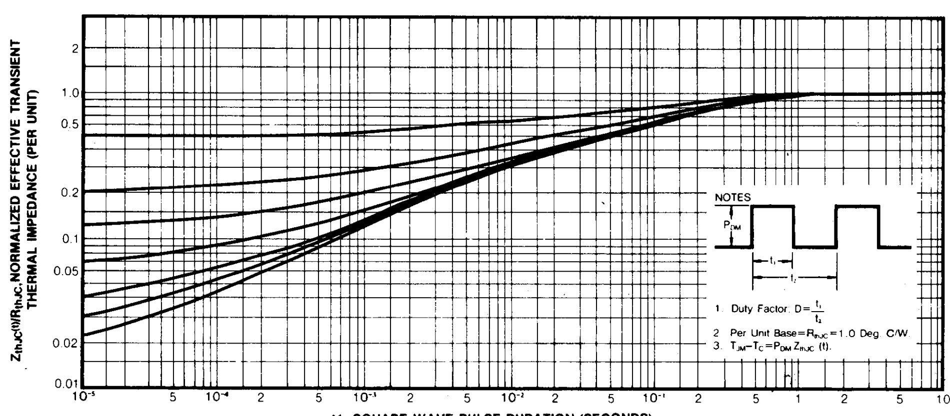
Typical Saturation Characteristics



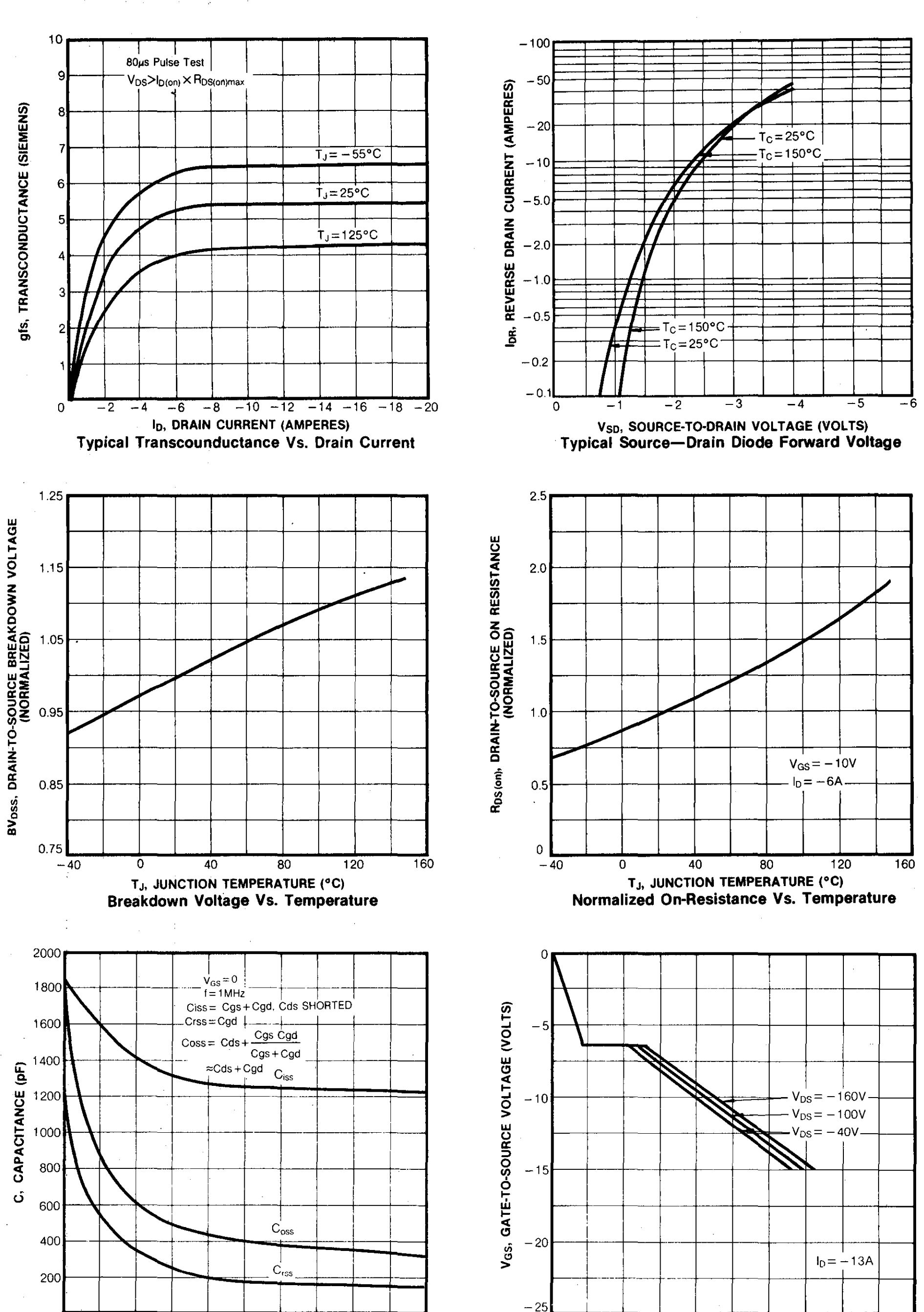
Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRF9640-3 And IRF9240-3



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration For IRFP9240-3



Typical Transcounductance Vs. Drain Current

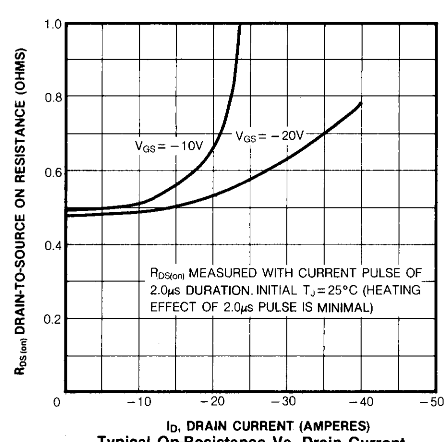
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

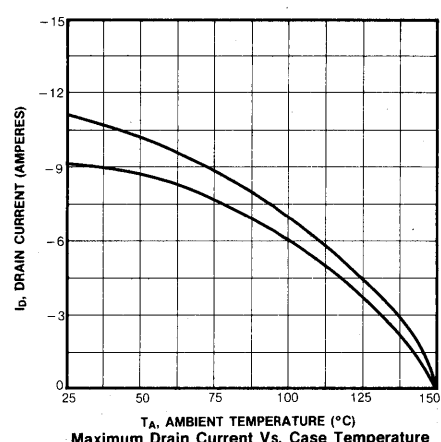
Normalized On-Resistance Vs. Temperature

Typical Capacitance Vs. Drain to Source Voltage

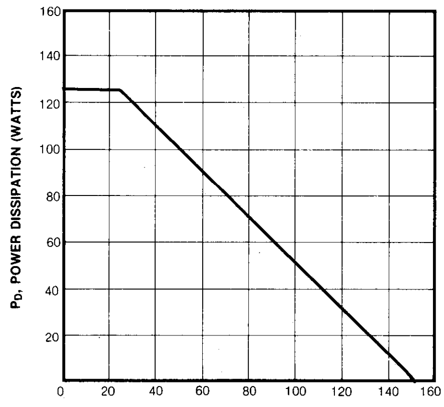
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



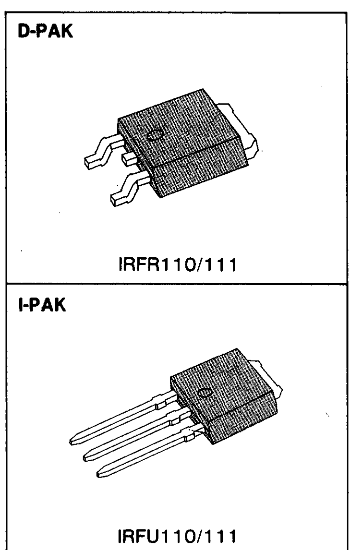
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR110/U110	100V	0.54Ω	4.7A
IRFR111/U111	80V	0.54Ω	4.7A

MAXIMUM RATINGS

Characteristic	Symbol	IRFR110/U110	IRFR111/U111	Unit
Drain-Source Voltage (1)	V_{DSS}	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	4.7		Adc
Continuous Drain Current T_C=100°C	I_D	3.3		Adc
Drain Current—Pulsed (3)	I_{DM}	17		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	13		mJ
Avalanche Current	I_{AS}	4.7		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	25 0.20		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.91mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFR110/U110	100	—	—	V	V_{GS}=0V
	IRFR111/U111	80	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	4.7	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	0.37	0.54	Ω	V_{GS}=10V, I_D=3.3A
g_{fs}	Forward Transconductance (2)	1.3	1.8	—	℧	V_{DS}≥50V, I_D=3.3A
C_{iss}	Input Capacitance	—	180	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	67	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	29	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	7.6	11	ns	V_{DD}=0.5BV_{DSS}, I_D=5.6A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	24	36	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	14	21	ns	
t_f	Fall Time	—	14	21	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	5.2	7.7	nC	V_{GS}=10V, I_D=10A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	1.5	2.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	2.2	3.2	nC	

THERMAL RESISTANCE

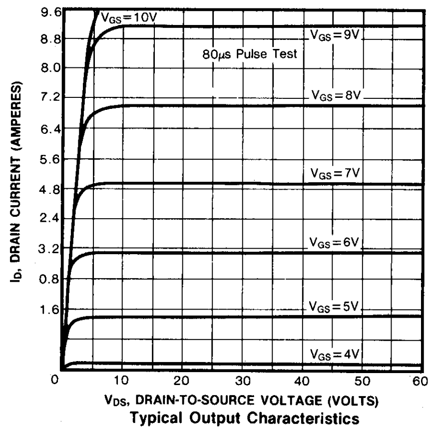
R_{thJC}	Junction-to-Case	MAX	5.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

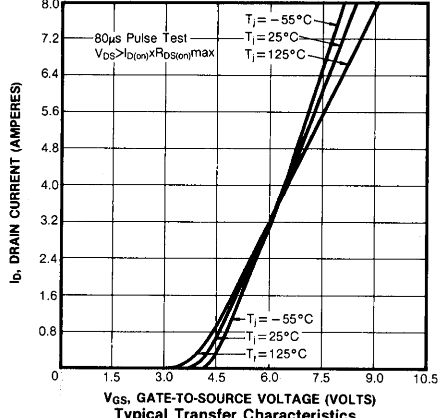
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	4.7	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	17	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.5	V	$T_C=25°C$, $I_S=4.7A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	96	200	ns	$T_j=150°C$, $I_F=5.6A$, $dI_F/dt=100A/\mu S$

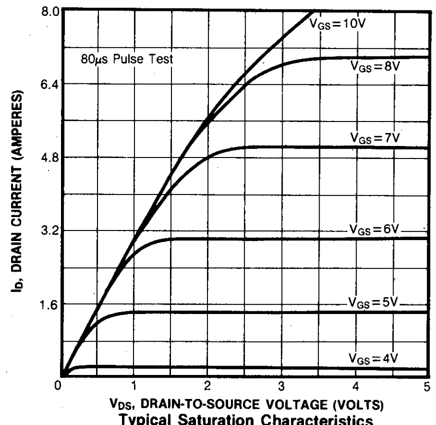
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



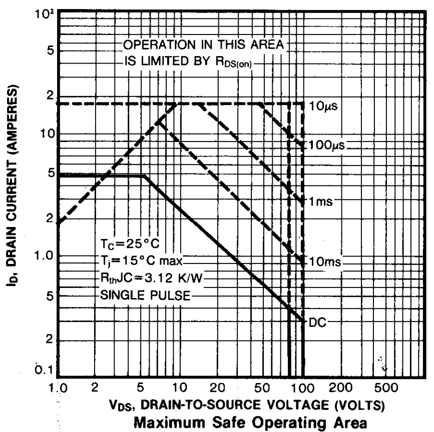
Typical Output Characteristics



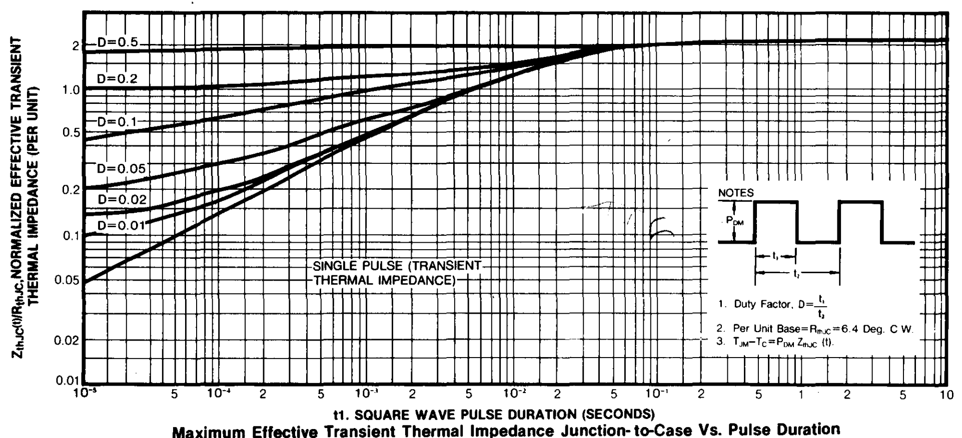
Typical Transfer Characteristics



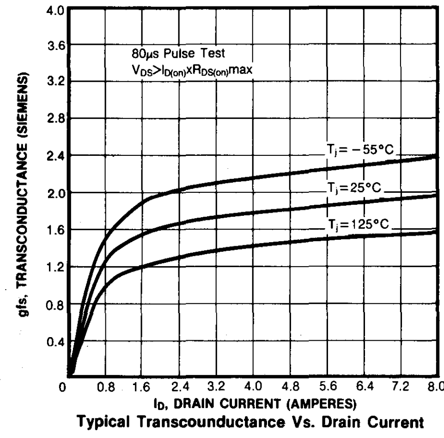
Typical Saturation Characteristics



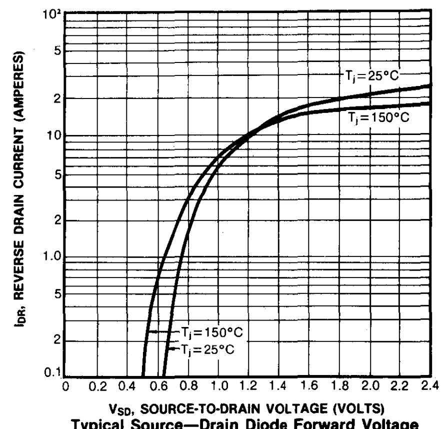
Maximum Safe Operating Area



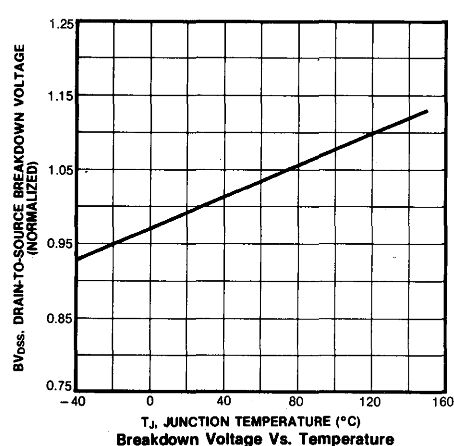
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



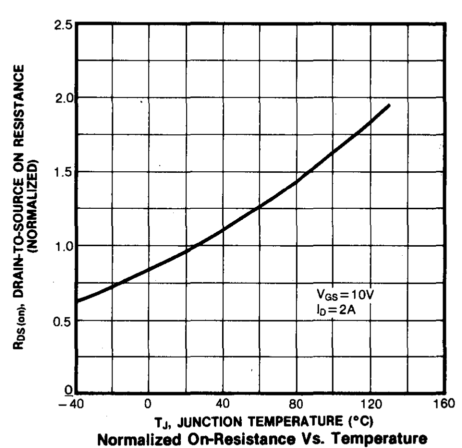
Typical Transcounductance Vs. Drain Current



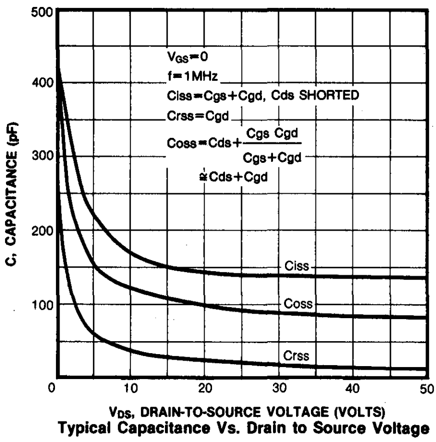
Typical Source—Drain Diode Forward Voltage



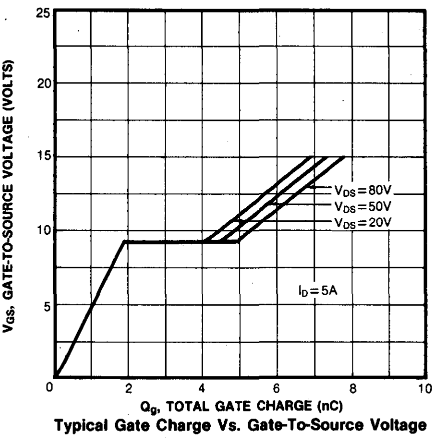
Breakdown Voltage Vs. Temperature



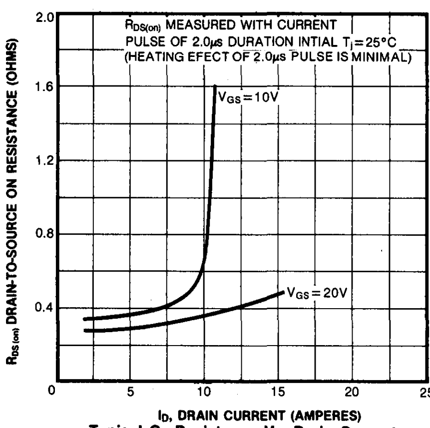
Normalized On-Resistance Vs. Temperature



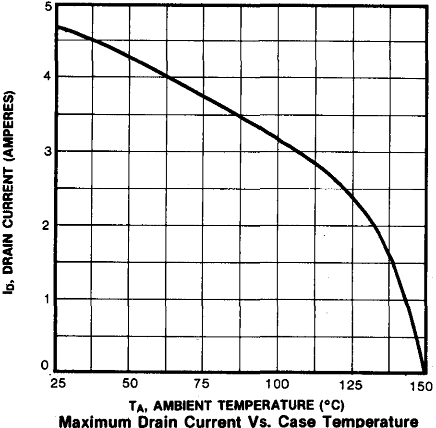
Typical Capacitance Vs. Drain to Source Voltage



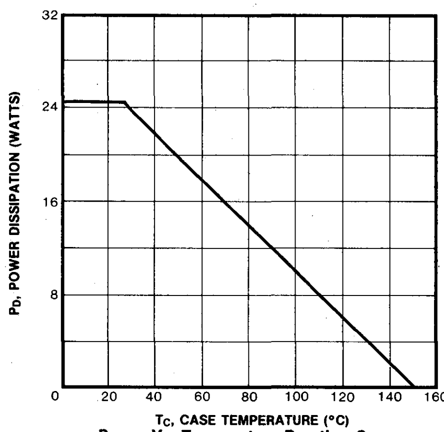
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



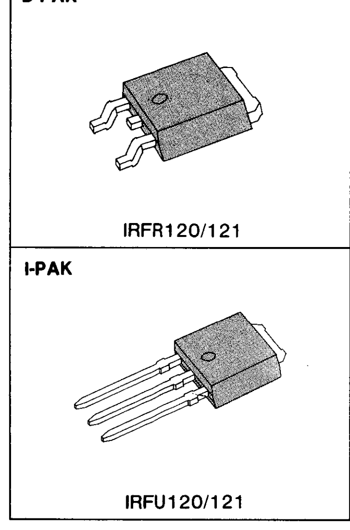
Power Vs. Temperature Derating Curve

IRFR120/121
IRFU120/121

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR120/U120	100V	0.27Ω	8.4A
IRFR121/U121	80V	0.27Ω	8.4A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRFR120/U120	IRFR121/U121	Unit
Drain-Source Voltage (1)	V_{DSS}	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	8.4		Adc
Continuous Drain Current T_C=100°C	I_D	5.9		Adc
Drain Current—Pulsed (3)	I_{DM}	34		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	30		mJ
Avalanche Current	I_{AS}	8.4		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.33		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.64mH, V_{dd}=25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFR120/U120	100	—	—	V	V_{GS}=0V
	IRFR121/U121	80	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	8.4	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	0.214	0.27	Ω	V_{GS}=10V, I_D=5.7A
g_{fs}	Forward Transconductance (2)	2.8	3.3	—	℧	V_{DS}≥50V, I_D=5.9A
C_{iss}	Input Capacitance	—	416	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	111	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	43	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.8	13	ns	V_{DD}=0.5BV_{DSS}, I_D=9.2A, Z_O=18Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	30	45	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	19	29	ns	
t_f	Fall Time	—	20	30	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	9.7	15	nC	V_{GS}=10V, I_D=9.2A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.2	3.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	2.3	3.4	nC	

THERMAL RESISTANCE

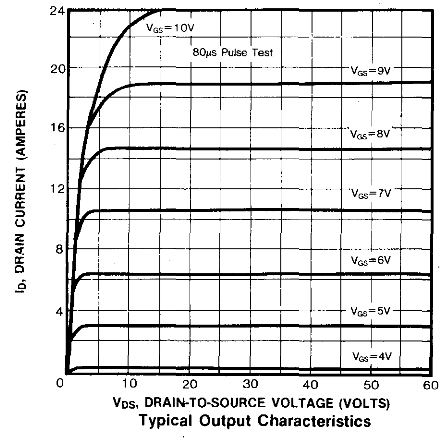
R_{thJC}	Junction-to-Case	MAX	3.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

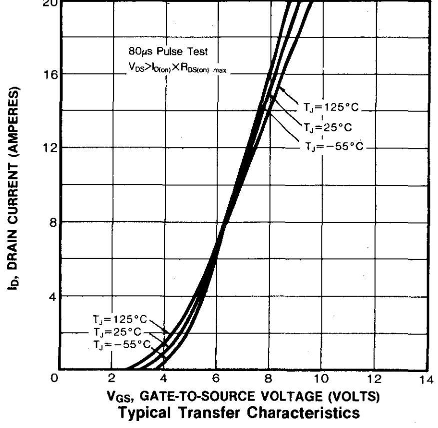
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	8.4	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	34	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.5	V	$T_C=25°C$, $I_S=8.4A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	110	240	ns	$T_j=150°C$, $I_F=9.2A$, $dI_F/dt=100A/\mu S$

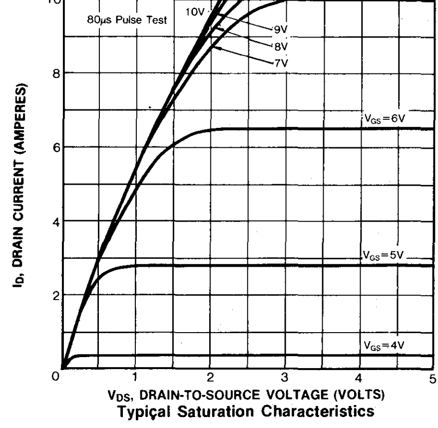
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



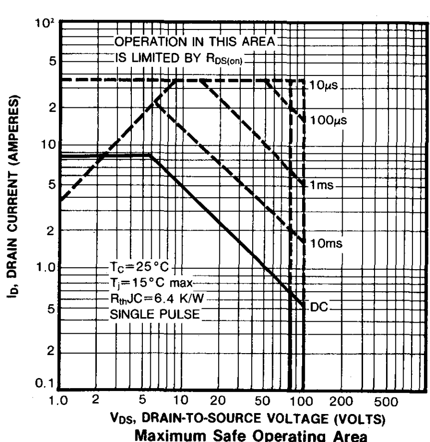
Typical Output Characteristics



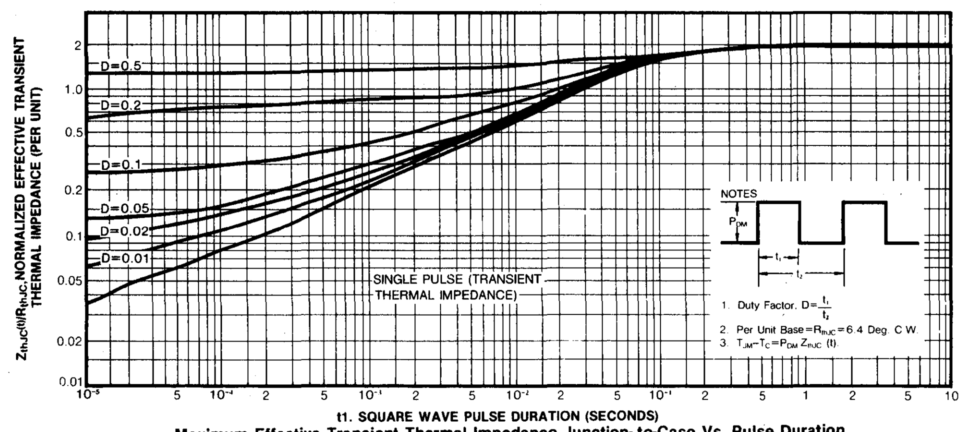
Typical Transfer Characteristics



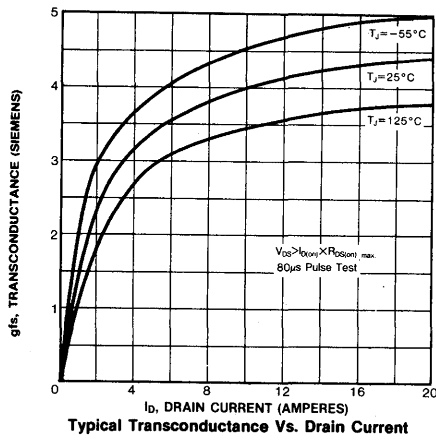
Typiçal Saturation Characteristics



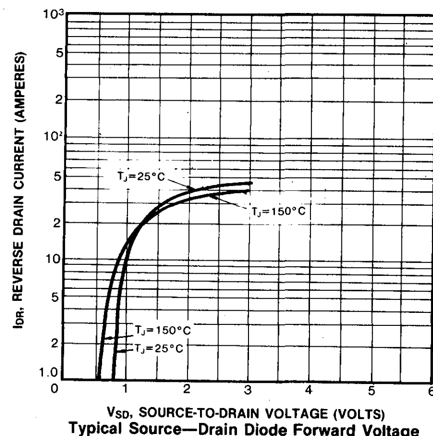
Maximum Safe Operating Area



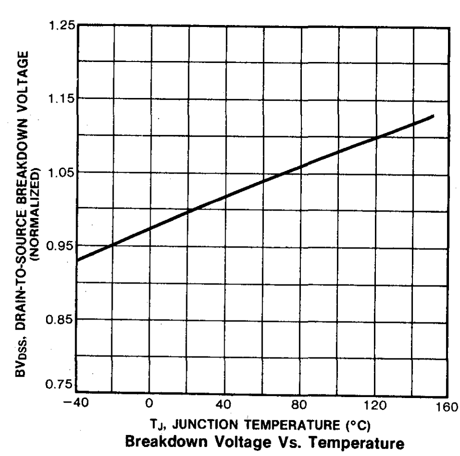
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



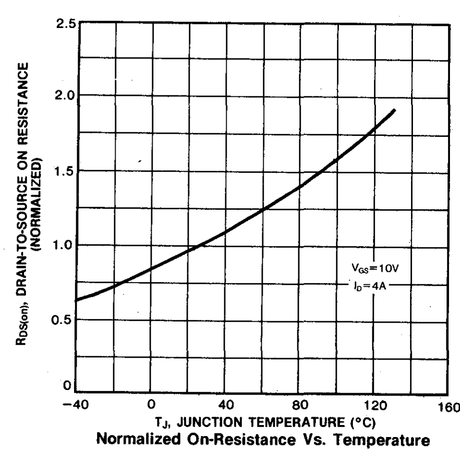
Typical Transconductance Vs. Drain Current



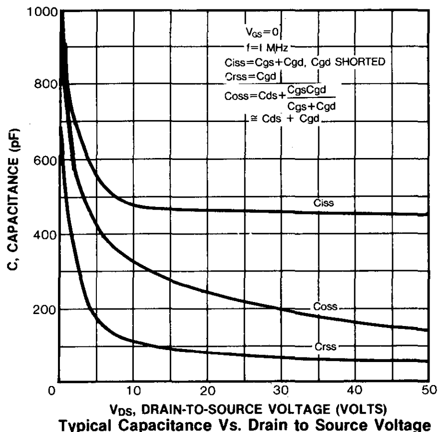
Typical Source—Drain Diode Forward Voltage



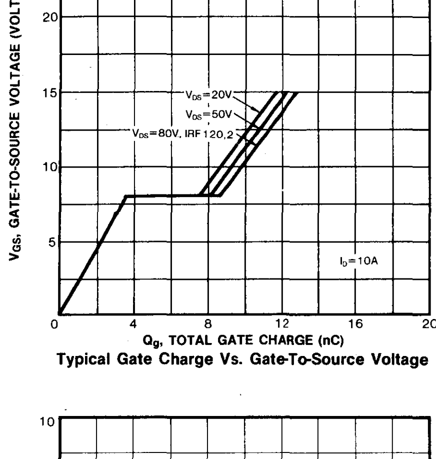
Breakdown Voltage Vs. Temperature



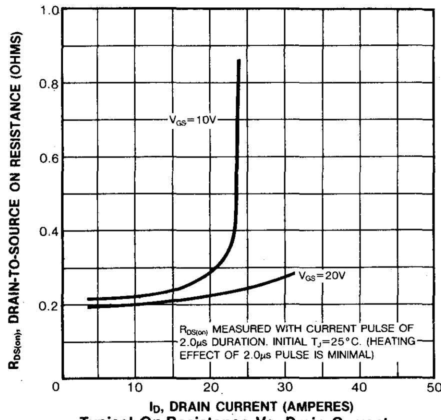
Normalized On-Resistance Vs. Temperature



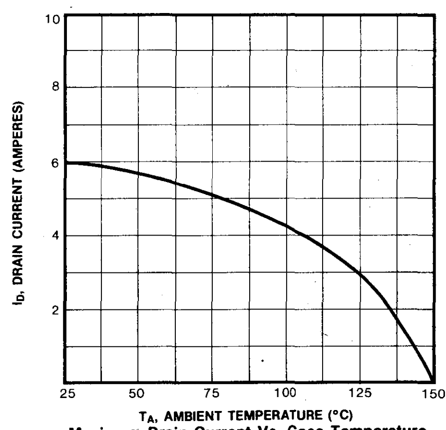
Typical Capacitance Vs. Drain to Source Voltage



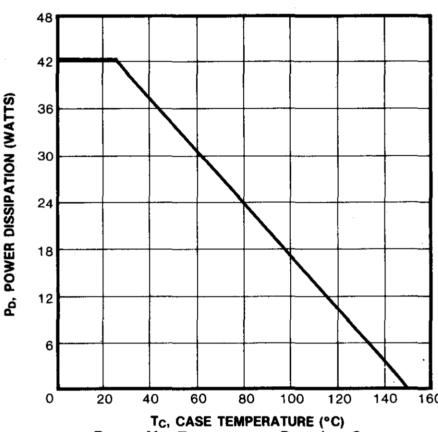
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



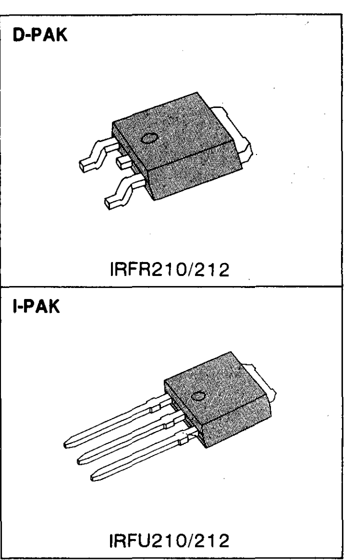
Power Vs. Temperature Derating Curve

IRFR210/212
IRFU210/212

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR210/U210	200V	1.5Ω	2.7A
IRFR122/U212	200V	2.4Ω	2.1A

MAXIMUM RATINGS

Characteristic	Symbol	IRFR210/U210	IRFR212/U212	Unit
Drain-Source Voltage (1)	V_{DSS}	200	200	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	200	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	2.7	2.1	Adc
Continuous Drain Current T_C=100°C	I_D	1.7	1.3	Adc
Drain Current—Pulsed (3)	I_{DM}	11	8.4	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	31		mJ
Avalanche Current	I_{AS}	2.7		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	25 0.20		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.64mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	200	—	—		V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFR210/U210	2.7	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFR212/U212	2.1	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFR210/U210	—	0.91	1.5	Ω	V_{GS}=10V, I_D=1.3A
	IRFR212/U212	—	1.5	2.4	Ω	
g_{fs}	Forward Transconductance (2)	0.83	1.3	—	℧	V_{DS}≥50V, I_D=1.3A
C_{iss}	Input Capacitance	—	180	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	40	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	18	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.0	12	ns	V_{DD}=0.5BV_{DSS}, I_D=3.2A, Z_O=24Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	20	30	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	17	26	ns	
t_f	Fall Time	—	20	30	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	11	17	nC	V_{GS}=10V, I_D=3.2A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	1.3	2.0	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	4.1	6.1	nC	

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THERMAL RESISTANCE

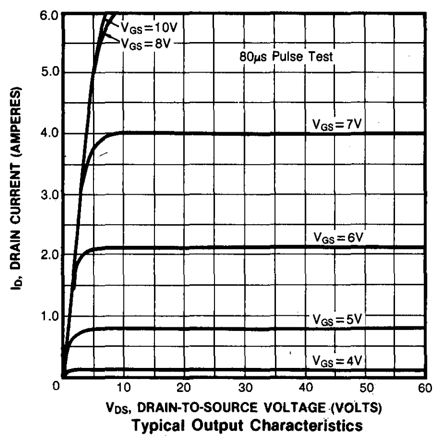
R_{thJC}	Junction-to-Case	MAX	5.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

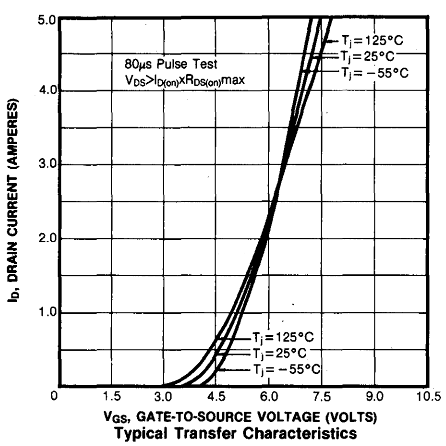
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	2.7	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	11	A	
V_{SD}	Diode Forward Voltage (2)	—	—	2.0	V	T_C=25°C, I_S=2.7A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	170	400	ns	T_j=150°C, I_F=3.2A, dI_F/dt=100A/μS

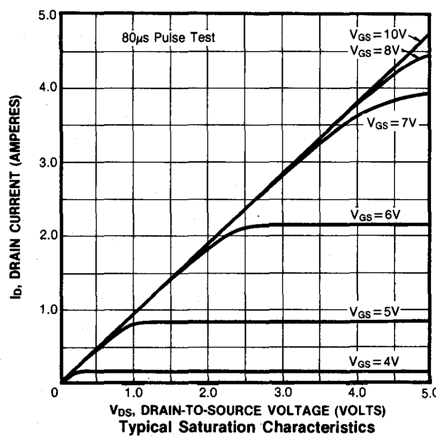
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



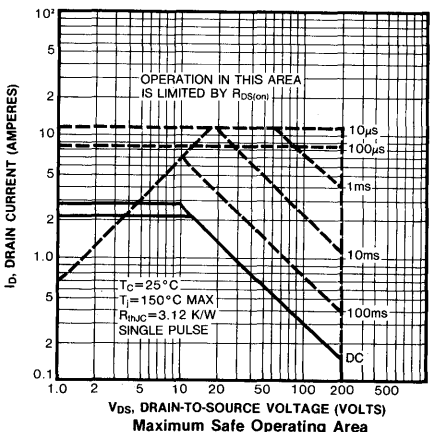
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Output Characteristics



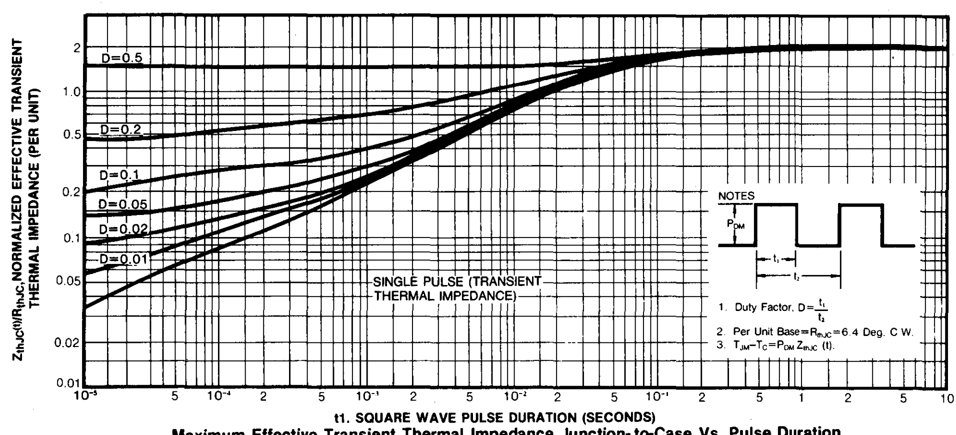
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
Typical Transfer Characteristics



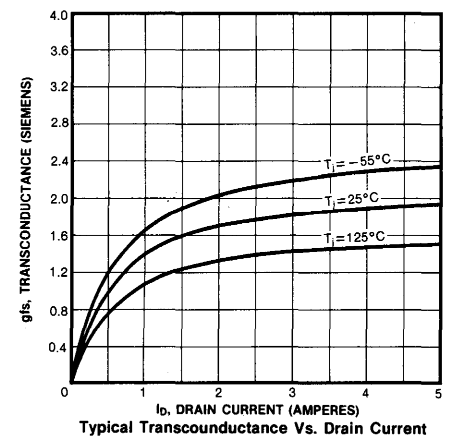
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Saturation Characteristics



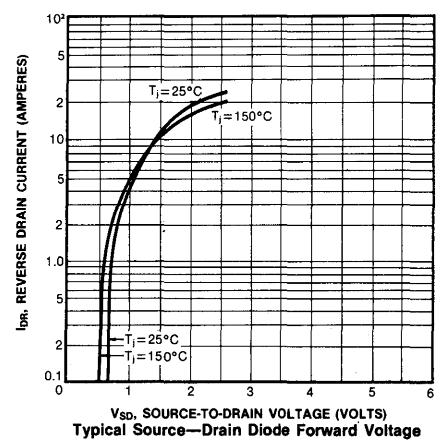
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Maximum Safe Operating Area



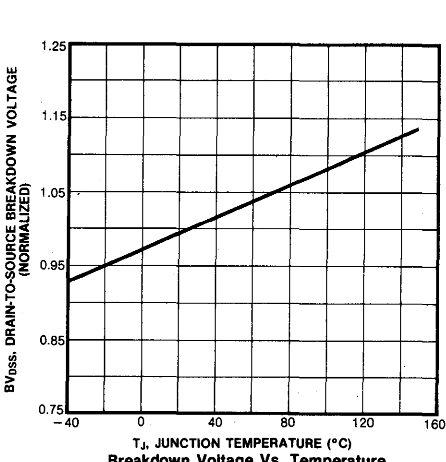
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



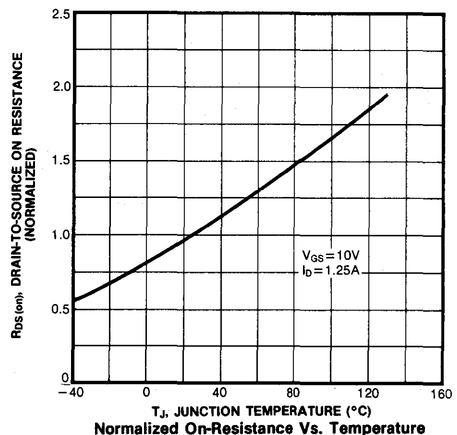
Typical Transcounductance Vs. Drain Current



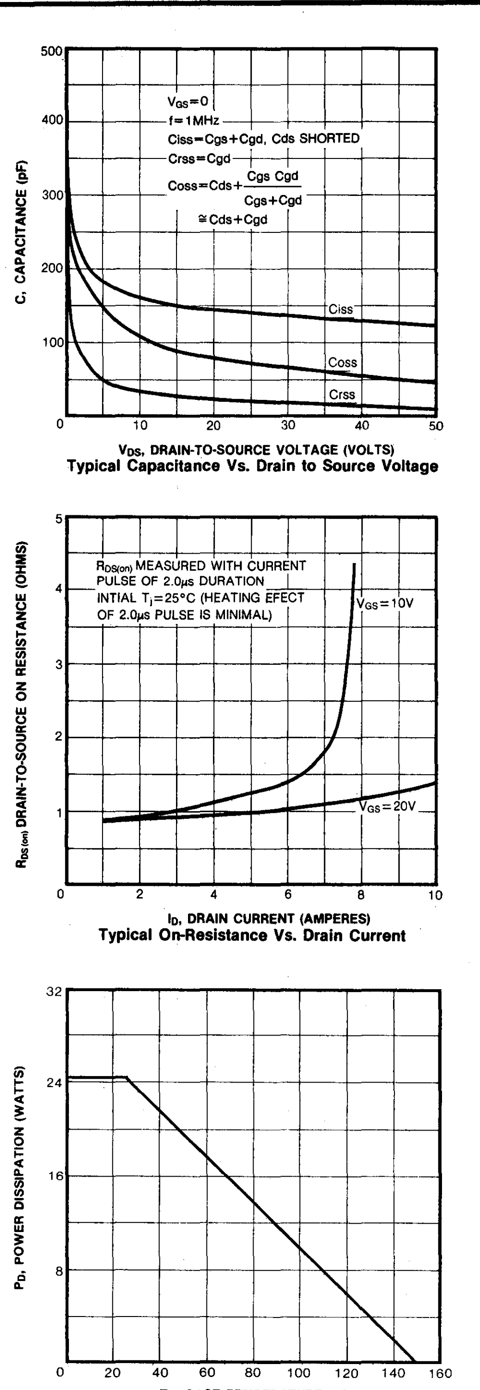
Typical Source—Drain Diode Forward Voltage



Breakdown Voltage Vs. Temperature



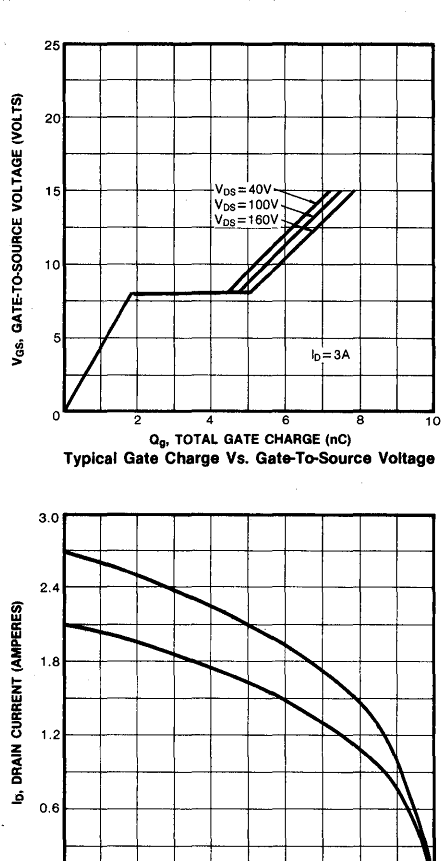
Normalized On-Resistance Vs. Temperature



Typical Capacitance Vs. Drain to Source Voltage

Typical On-Resistance Vs. Drain Current

Power Vs. Temperature Derating Curve



Typical Gate Charge Vs. Gate-To-Source Voltage

Maximum Drain Current Vs. Case Temperature

IRFR220/222
IRFU220/222

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

D-PAK

IRFR220/222

I-PAK

IRFU220/222

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR220/U220	200V	0.80Ω	4.6A
IRFR222/U222	200V	1.2Ω	3.8A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRFR220/U220	IRFR222/U222	Unit
Drain-Source Voltage (1)	V_{DSS}	200		Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200		Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	4.6	3.8	Adc
Continuous Drain Current T_C=100°C	I_D	2.9	2.4	Adc
Drain Current—Pulsed (3)	I_{DM}	18	15	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	50		mJ
Avalanche Current	I_{AS}	4.6		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.33		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4.5mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	200	—	—		V_{GS}=0V I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFR220/U220	4.6	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFR222/U222	3.8	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFR220/U220	—	—	0.8	Ω	V_{GS}=10V, I_D=2.4A
	IRFR222/U222	—	—	1.2	Ω	
g_{fs}	Forward Transconductance (2)	1.7	2.6	—	℧	V_{DS}≥50V, I_D=2.4A
C_{iss}	Input Capacitance	—	400	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	82	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	32	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.8	13	ns	V_{DD}=0.5BV_{DSS}, I_D=5.1A, Z_O=18Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	27	41	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	21	32	ns	
t_f	Fall Time	—	14	21	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	12	18	nC	V_{GS}=10V, I_D=5.1A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.3	3.4	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	4.5	6.8	nC	

THERMAL RESISTANCE

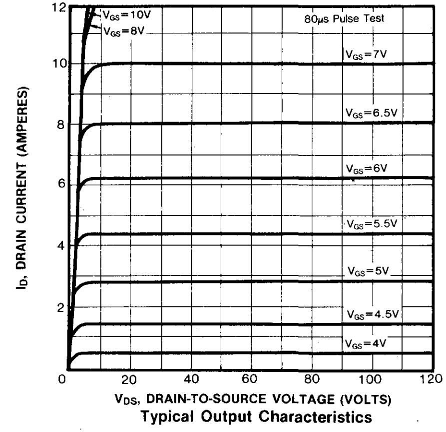
R_{thJC}	Junction-to-Case	MAX	3.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

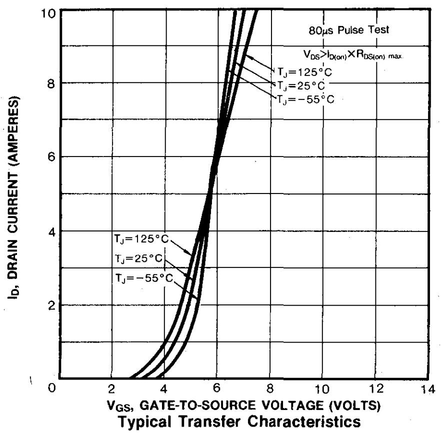
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	4.6	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	18	A	
V_{SD}	Diode Forward Voltage (2)	—	—	1.8	V	$T_C=25°C$, $I_S=4.6A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	170	400	ns	$T_j=150°C$, $I_F=5.1A$, $dI_F/dt=100A/\mu S$

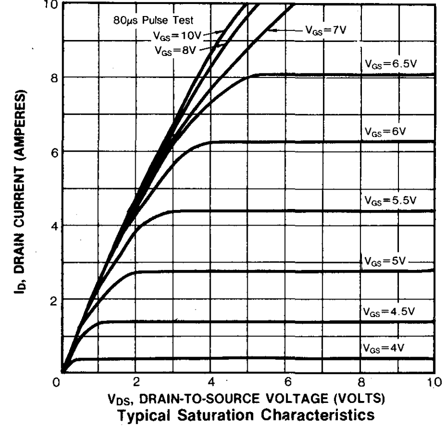
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq 300\mu s$, Duty Cycle$\leq 2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature



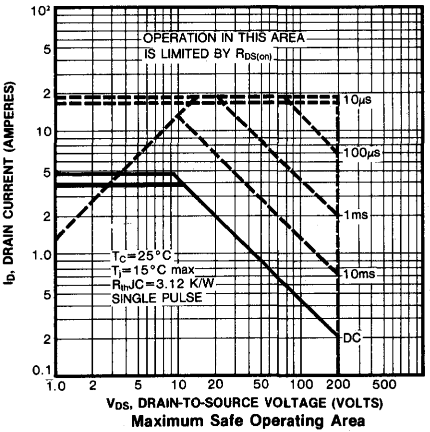
Typical Output Characteristics



Typical Transfer Characteristics

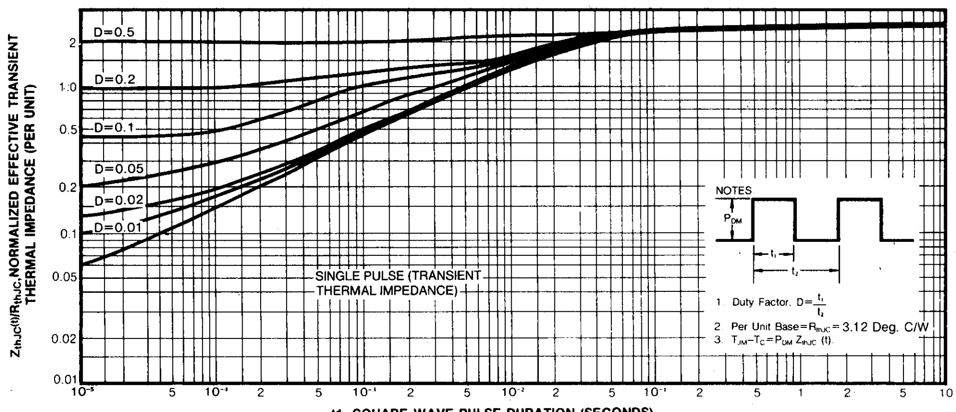


Typical Saturation Characteristics

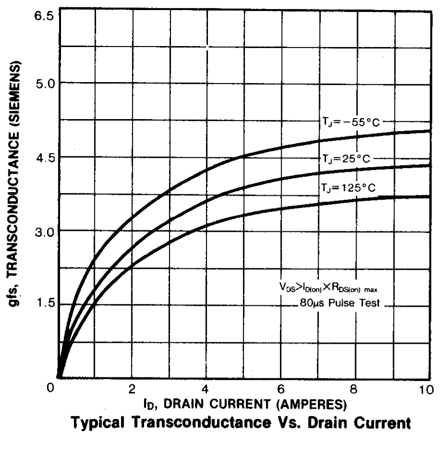


Maximum Safe Operating Area

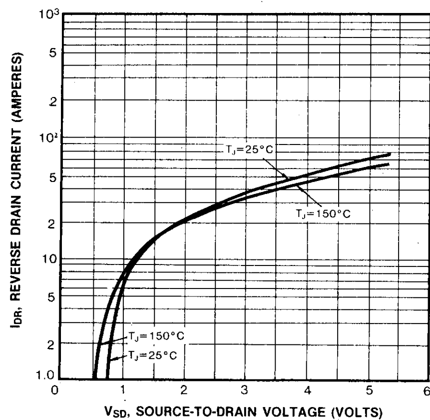
4



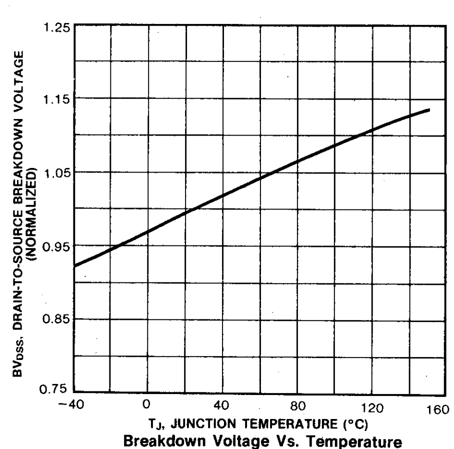
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



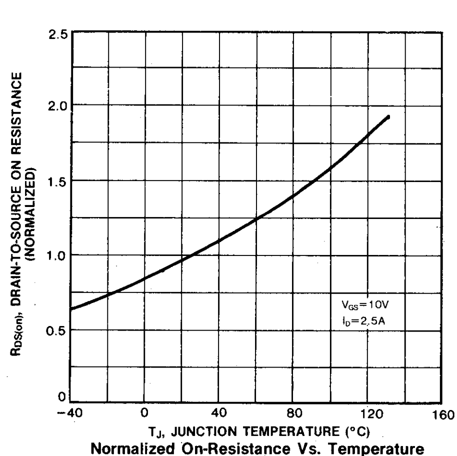
Typical Transconductance Vs. Drain Current



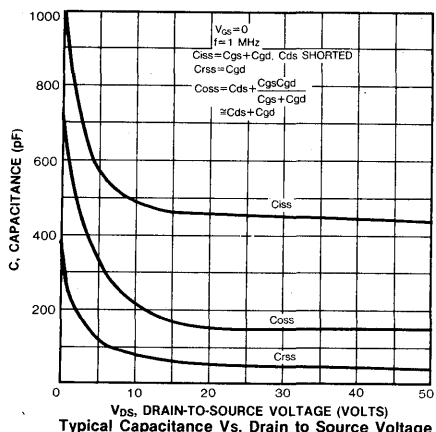
Typical Source—Drain Diode Forward Voltage



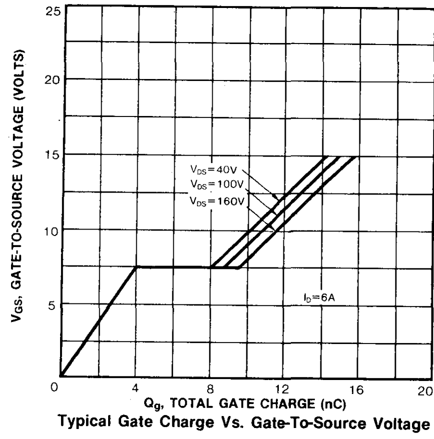
Breakdown Voltage Vs. Temperature



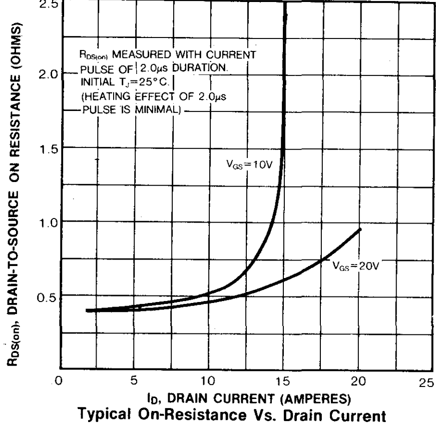
Normalized On-Resistance Vs. Temperature



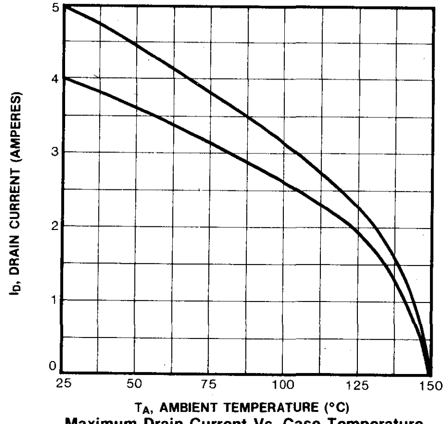
Typical Capacitance Vs. Drain to Source Voltage



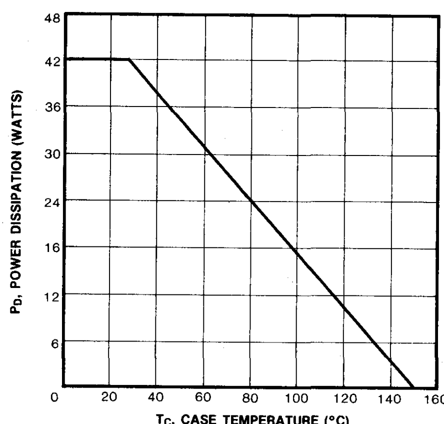
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

4

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability

D-PAK

IRFR9110/9111

I-PAK

IRFU9110/9111

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR9110/U9110	−100V	1.2Ω	−3.2A
IRFR9111/U9111	−80V	1.2Ω	−3.2A

MAXIMUM RATINGS

Characteristic	Symbol	IRFR9110/U9110	IRFR9111/U9111	Unit
Drain-Source Voltage (1)	V_{DSS}	−100	−80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−80	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	−3.2		Adc
Continuous Drain Current T_C=100°C	I_D	−2.0		Adc
Drain Current—Pulsed (3)	I_{DM}	−13		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	190		mJ
Avalanche Current	I_{AS}	−3.2		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	25 0.20		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=29 mH, V_{dd}=50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFR9110/U9110	-100	—	—	V	V_{GS}=0V
	IRFR9111/U9111	-80	—	—	V	I_D=−250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}= 20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	-3.2	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	1.1	1.2	Ω	V_{GS}=10V, I_D=−2.0A
g_{fs}	Forward Transconductance (2)	0.7	—	—	℧	V_{DS}≤−50V, I_D=−2.0A
C_{iss}	Input Capacitance	—	250	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	92	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	51	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	7.9	12	ns	V_{DD}=0.5BV_{DSS}, I_D=−3.8A, Z_O=24Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	33	50	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	8.3	12	ns	
t_f	Fall Time	—	14	21	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	75	11	nC	V_{GS}=−10V, I_D=−3.8A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	1.5	2.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	4.1	6.1	nC	

THERMAL RESISTANCE

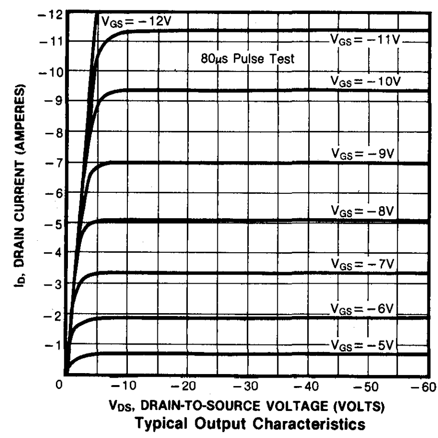
R_{thJC}	Junction-to-Case	MAX	5.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

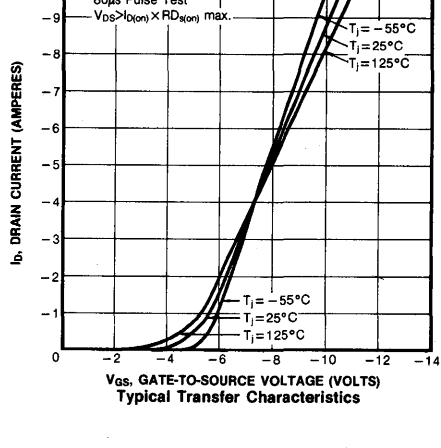
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	−3.2	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	13	A	
V_{SD}	Diode Forward Voltage (2)	—	—	−5.5	V	$T_C=25°C$, $I_S=-3.2A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	86	180	ns	$T_j=150°C$, $I_F=-3.8A$, $dI_F/dt=100A/\mu S$

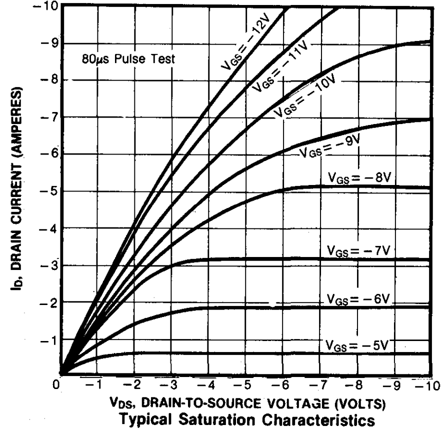
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



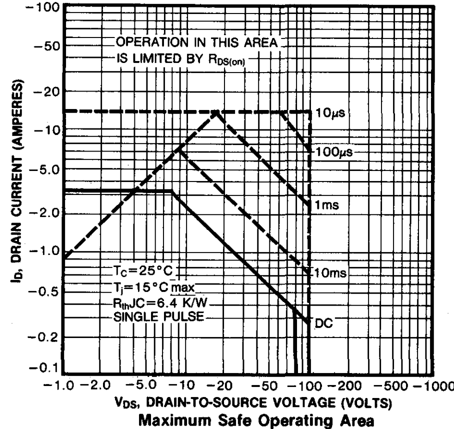
Typical Output Characteristics



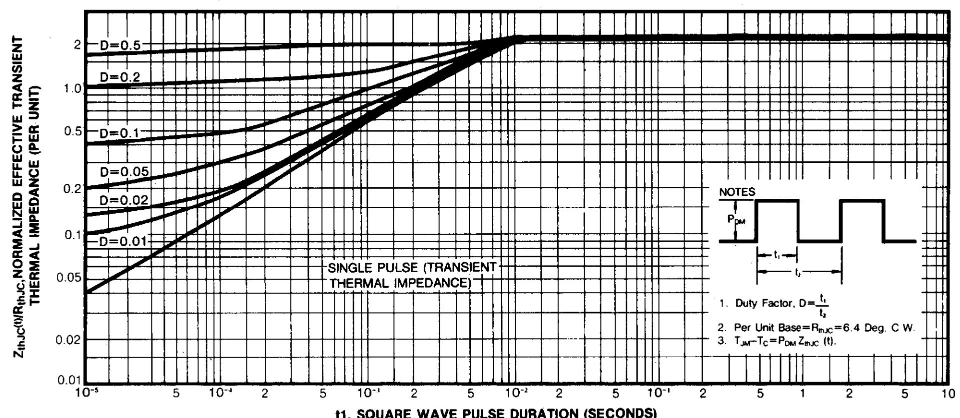
Typical Transfer Characteristics



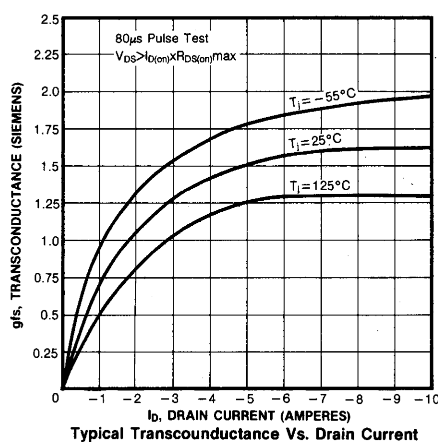
Typical Saturation Characteristics



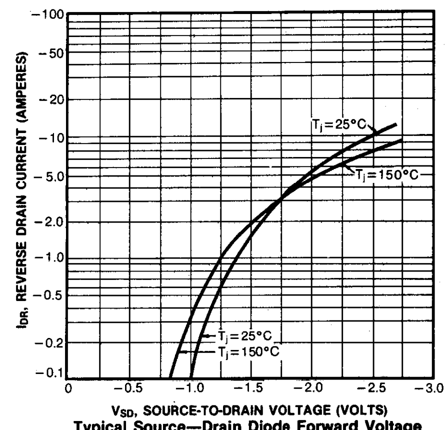
Maximum Safe Operating Area



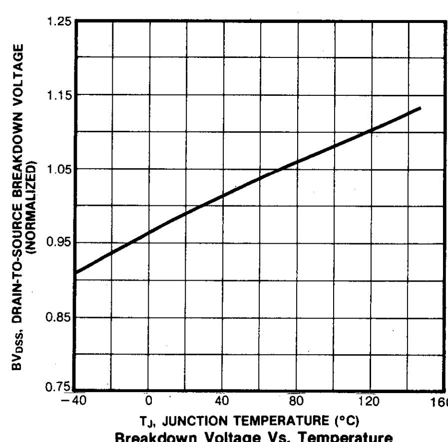
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



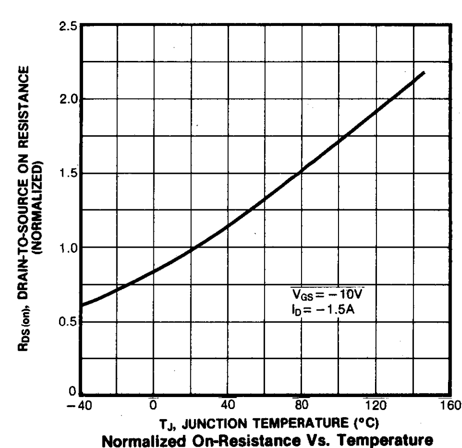
Typical Transcounductance Vs. Drain Current



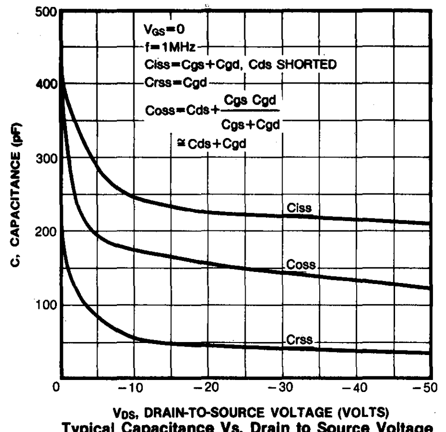
Typical Source—Drain Diode Forward Voltage



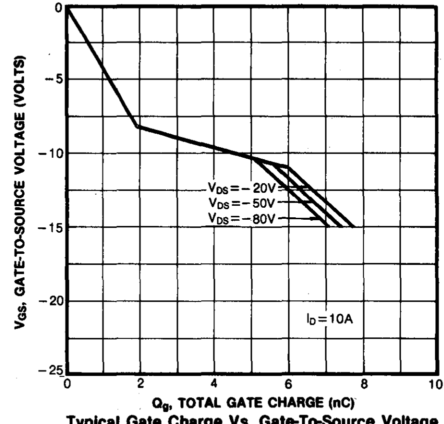
Breakdown Voltage Vs. Temperature



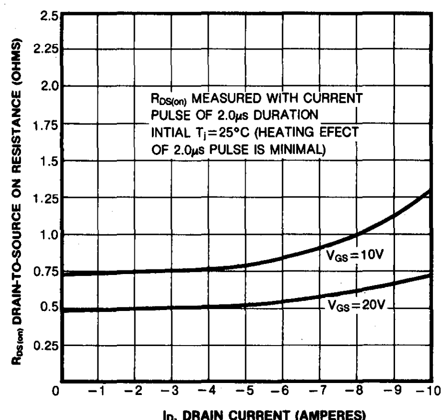
Normalized On-Resistance Vs. Temperature



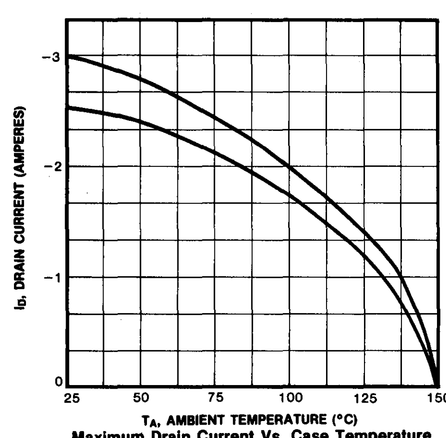
Typical Capacitance Vs. Drain to Source Voltage



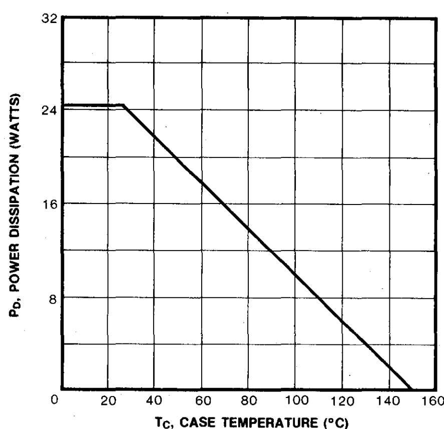
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



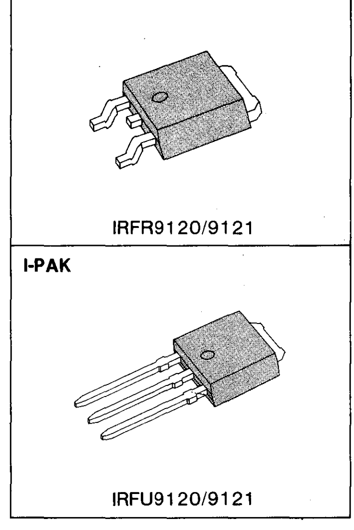
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR9120/U9120	−100V	0.60Ω	−5.9A
IRFR9121/U9121	−80V	0.60Ω	−5.9A

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MAXIMUM RATINGS

Characteristic	Symbol	IRFR9120/U9120	IRFR9121/U9121	Unit
Drain-Source Voltage (1)	V_{DSS}	−100	−80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−80	Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	−5.9		Adc
Continuous Drain Current T_C=100°C	I_D	−3.7		Adc
Drain Current—Pulsed (3)	I_{DM}	−24		Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	370		mJ
Avalanche Current	I_{AS}	−5.9		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.33		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=18mH, V_{dd}=−25V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFR9120/U9120	-100	—	—	V	V_{GS}=0V
	IRFR9121/U9121	−80	—	—	V	I_D=−250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}= 20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2)	-5.9	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max}$, V_{GS}=−10V
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2)	—	0.50	0.60	Ω	V_{GS}=−10V, I_D=−3.7A
g_{fs}	Forward Transconductance (2)	1.5	—	—	℧	V_{DS}≤−50V, I_D=−3.7A
C_{iss}	Input Capacitance	—	427	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	128	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	44.5	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	9.0	13	ns	V_{DD}=0.5BV_{DSS}, I_D=−6.4A, Z_O=18Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	44	66	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	10	15	ns	
t_f	Fall Time	—	22	33	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	13	20	nC	V_{GS}=−10V, I_D=−6.4A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.0	3.0	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	6.8	10	nC	

THERMAL RESISTANCE

R_{thJC}	Junction-to-Case	MAX	3.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	−5.9	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	−24	A	
V_{SD}	Diode Forward Voltage (2)	—	—	−6.3	V	T_C=25°C, I_S=−5.9A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	—	—	ns	T_j=150°C, I_F=−6.4A, dI_F/dt=100A/μS

Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

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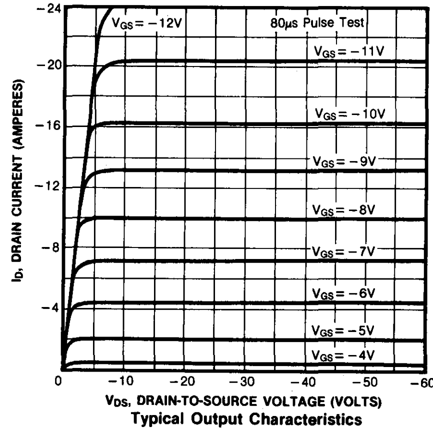
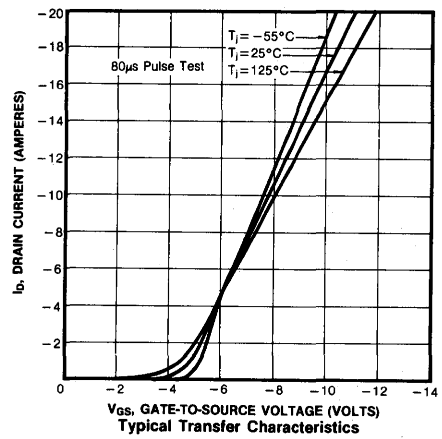
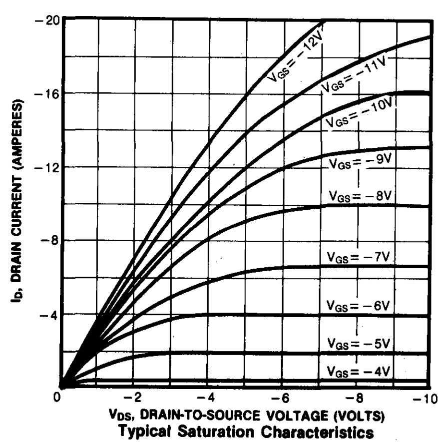


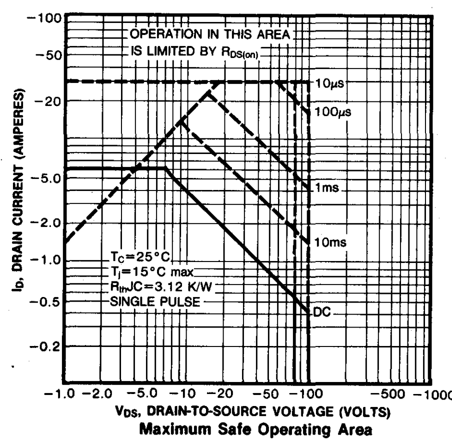
Typical Output Characteristics



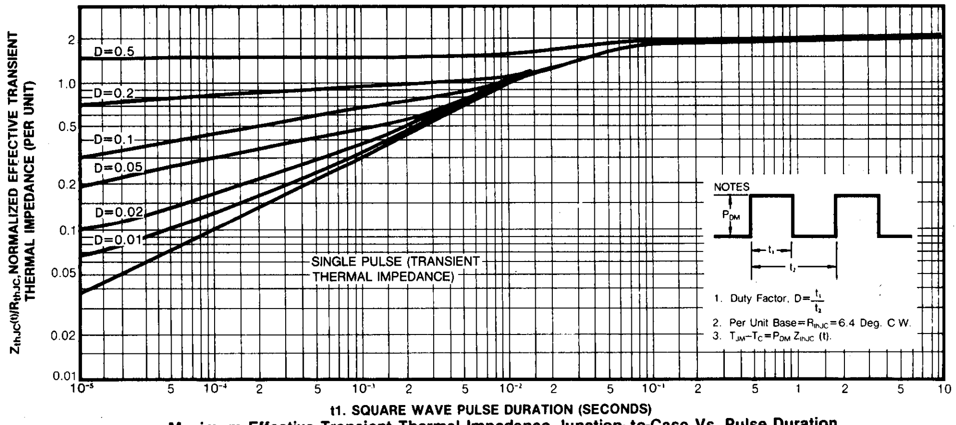
Typical Transfer Characteristics



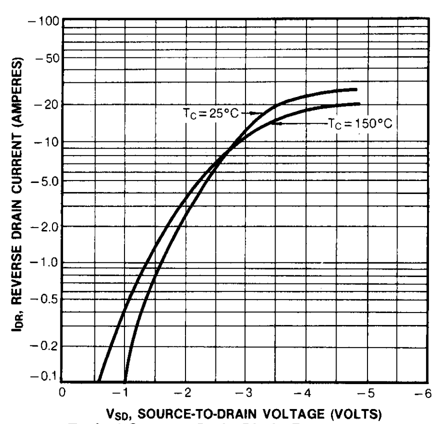
Typical Saturation Characteristics



Maximum Safe Operating Area

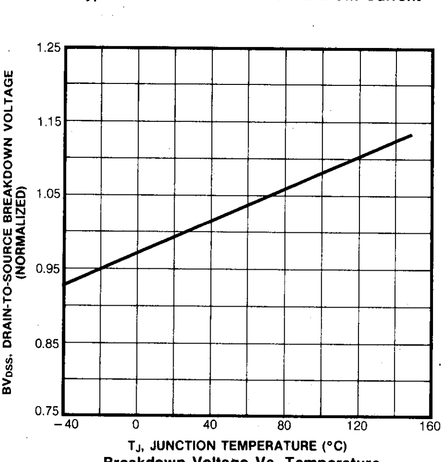


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

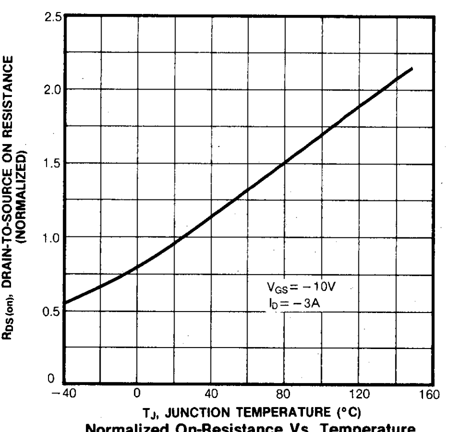


Typical Transcounductance Vs. Drain Current

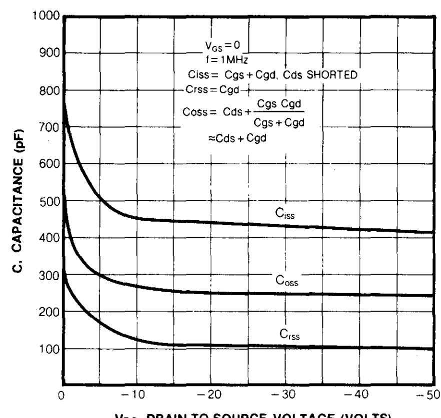
Typical Source—Drain Diode Forward Voltage



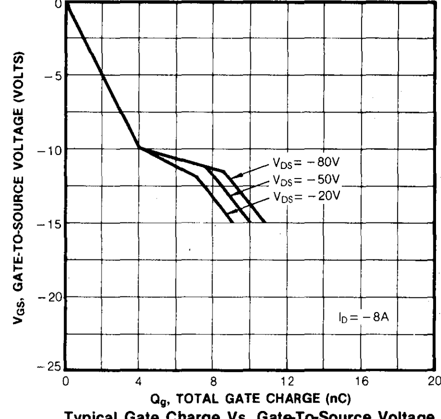
Breakdown Voltage Vs. Temperature



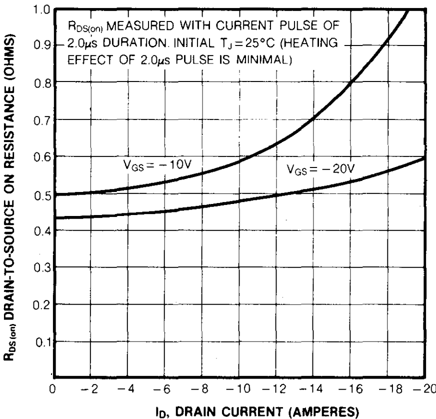
Normalized On-Resistance Vs. Temperature



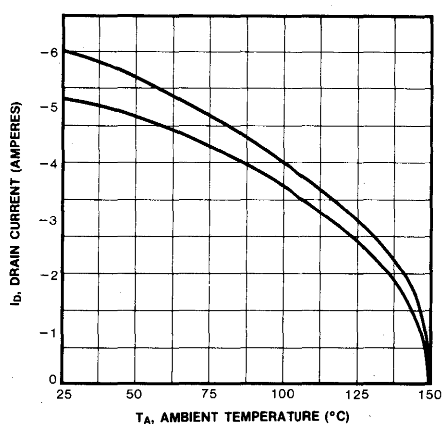
Typical Capacitance Vs. Drain to Source Voltage



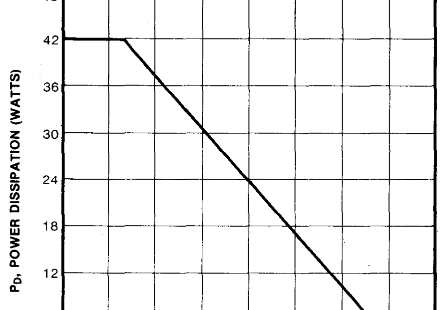
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

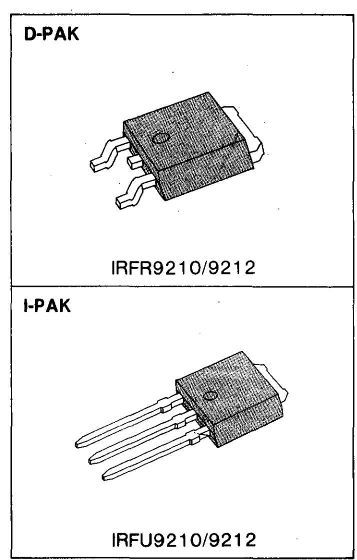


Power Vs. Temperature Derating Curve

4

FEATURES

- Lower $R_{DS\,(ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR9210/U9210	−200V	3.0Ω	−2.0A
IRFR9212/U9212	−200V	4.5Ω	−1.6A

MAXIMUM RATINGS

Characteristic	Symbol	IRFR9210/U9120	IRFR9212/U9212	Unit
Drain-Source Voltage (1)	V_{DSS}	−200		Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200		Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	−2.0	−1.6	Adc
Continuous Drain Current T_C=100°C	I_D	−1.2	−1.0	Adc
Drain Current—Pulsed (3)	I_{DM}	−8.0	−6.4	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	150		mJ
Avalanche Current	I_{AS}	−2.0		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	25 0.20		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=59mH, V_{dd}=−50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage	-200	—	—		V_{GS}=0V I_D=−250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFR9210/U9210	-2.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=−10V
	IRFR9212/U9212	-1.6	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFR9210/U9210	—	—	3.0	Ω	V_{GS}=−10V, I_D=−1.0A
	IRFR9212/U9212	—	—	4.5	Ω	
g_{fs}	Forward Transconductance (2)	0.61	—	—	℧	V_{DS}≤−50V, I_D=−1.0A
C_{iss}	Input Capacitance	—	180	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	53	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	17	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.0	12	ns	V_{DD}=0.5BV_{DSS}, I_D=−2.3A, Z_O=24Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	12	18	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	11	17	ns	
t_f	Fall Time	—	13	20	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	6.5	9.7	nC	V_{GS}=−10V, I_D=−2.3A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	1.4	2.2	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	3.3	5.7	nC	

THERMAL RESISTANCE

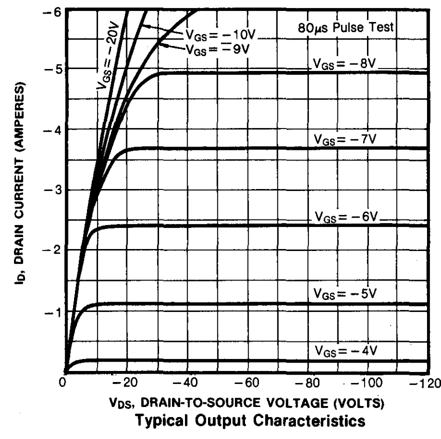
R_{thJC}	Junction-to-Case	MAX	5.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

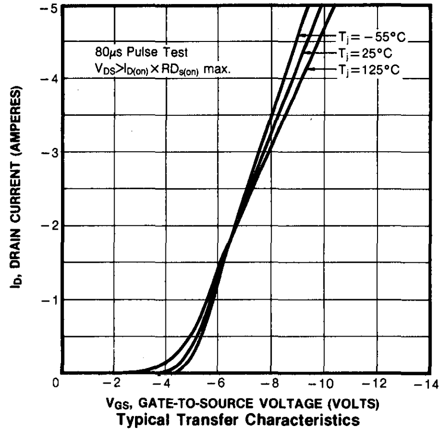
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	−2.0	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	−8.0	A	
V_{SD}	Diode Forward Voltage (2)	—	—	−5.8	V	T_C=25°C, I_S=−2.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	99	214	ns	T_j=150°C, I_F=−2.3A, dI_F/dt=100A/μS

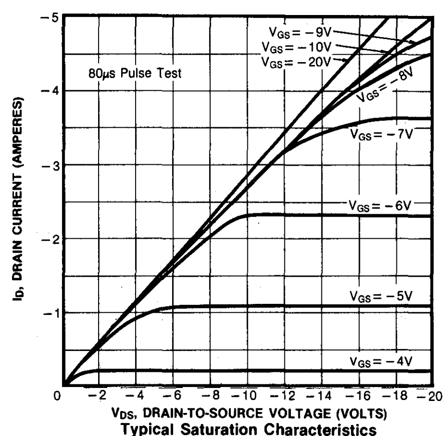
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



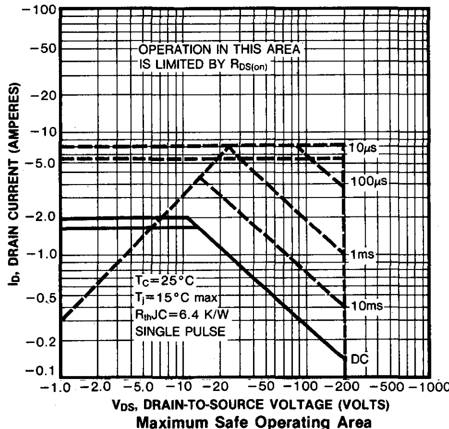
Typical Output Characteristics



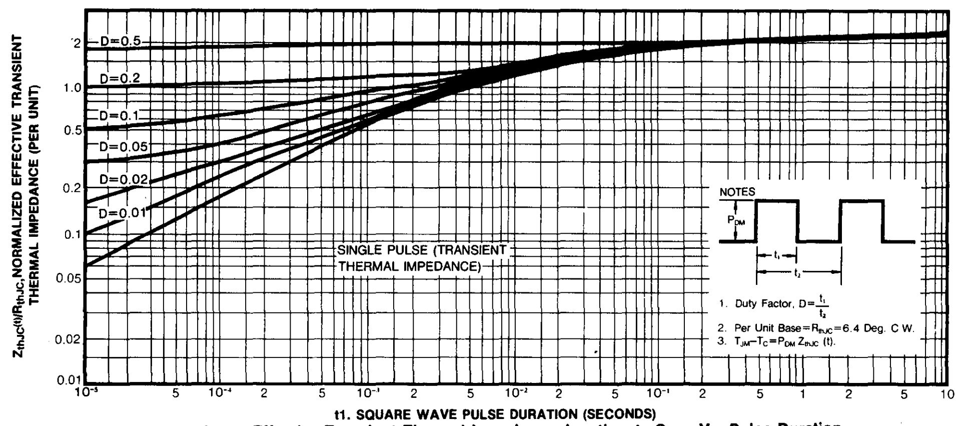
Typical Transfer Characteristics



Typical Saturation Characteristics

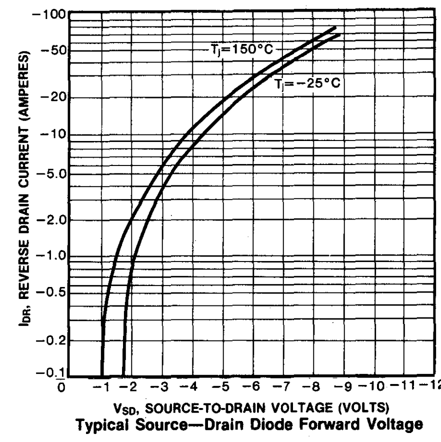


Maximum Safe Operating Area

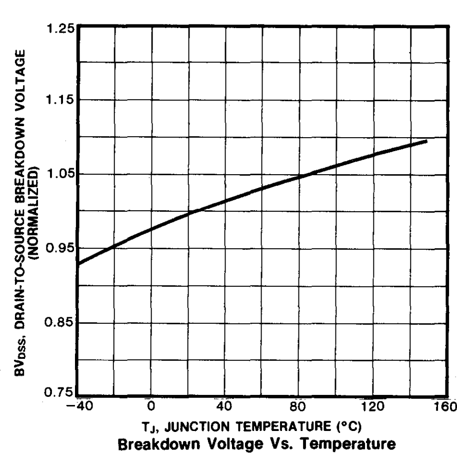


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

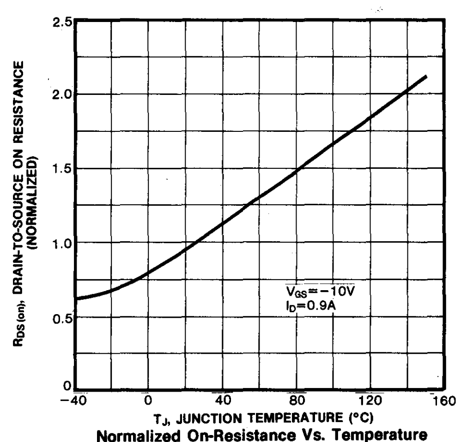
Typical Transcounductance Vs. Drain Current



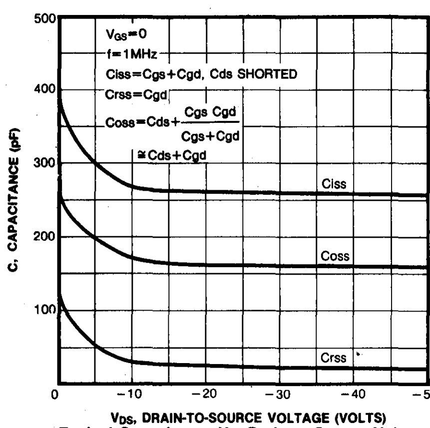
Typical Source—Drain Diode Forward Voltage



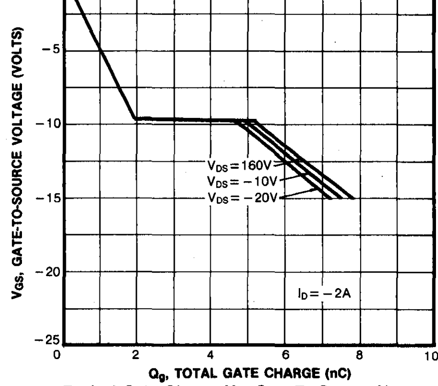
Breakdown Voltage Vs. Temperature



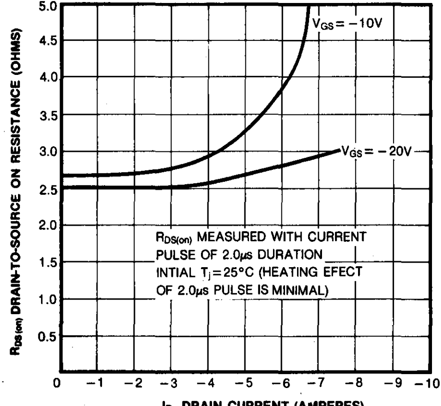
Normalized On-Resistance Vs. Temperature



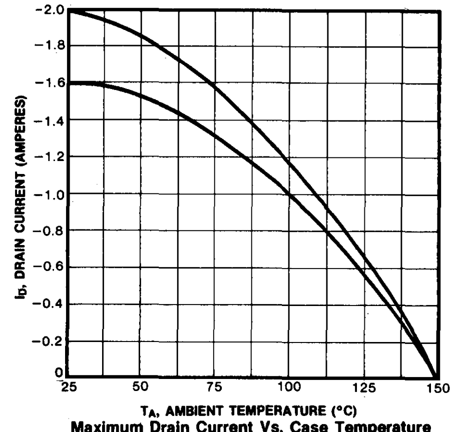
Typical Capacitance Vs. Drain to Source Voltage



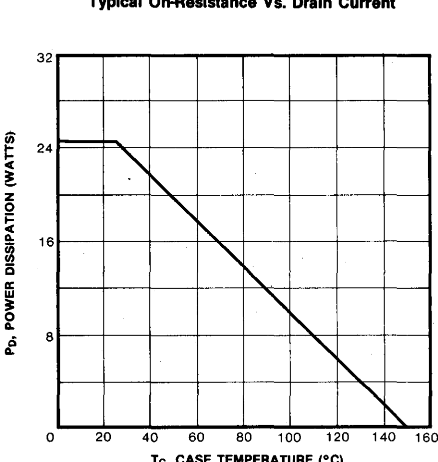
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



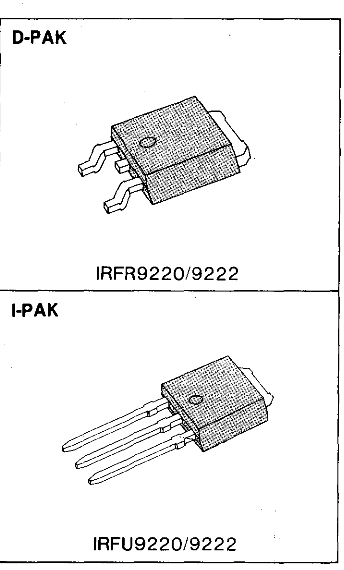
Power Vs. Temperature Derating Curve

IRFR9220/9222
IRFU9220/9222

P-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFR9220/U9220	−200V	1.5Ω	−3.6A
IRFR9222/U9222	−200V	2.4Ω	−2.8A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRFR9220/U9220	IRFR9222/U9222	Unit
Drain-Source Voltage (1)	V_{DSS}	−200		Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200		Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Continuous Drain Current T_C=25°C	I_D	−3.6	−2.8	Adc
Continuous Drain Current T_C=100°C	I_D	−2.3	−1.8	Adc
Drain Current—Pulsed (3)	I_{DM}	−14	−11	Adc
Gate Current—Pulsed	I_{GM}	±1.5		Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	290		mJ
Avalanche Current	I_{AS}	−3.6		A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.33		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, Tstg	−55 to 150		°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300		°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=35mH, V_{dd}=−50V, R_G=25Ω, Starting T_j=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage		—	—	V	V_{GS}=0V I_D=−250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFR9220/U9220	−3.6	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=−10V
	IRFR9222/U9222	−2.8	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFR9220/U9220	—	1.0	1.5	Ω	V_{GS}=−10V, I_D=−1.8A
	IRFR9222/U9222	—	1.5	2.4	Ω	
g_{fs}	Forward Transconductance (2)	1.1	—	—	℧	V_{DS}≤−50V, I_D=−1.8A
C_{iss}	Input Capacitance	—	405	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	85.5	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	30	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	8.8	13	ns	V_{DD}=0.5BV_{DSS}, I_D=−3.9A, Z_O=18Ω (MCSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	27	41	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	7.3	11	ns	
t_f	Fall Time	—	19	29	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	12	18	nC	V_{GS}=−10V, I_D=−3.9A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	2.0	3.0	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	7.1	1.1	nC	

THERMAL RESISTANCE

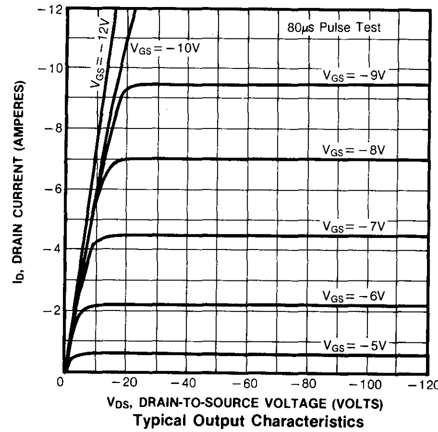
R_{thJC}	Junction-to-Case	MAX	3.0	K/W	
R_{thCS}	Case-to-Sink	TYP	1.7	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	MAX	110	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

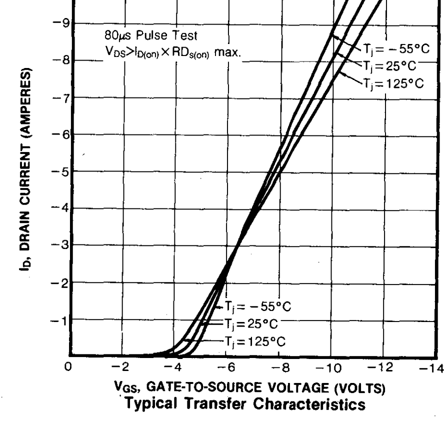
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	−3.6	A	Modified MOSFET showing the integral reverse P-N junction rectifier
I_{SM}	Pulse Source Current(Body Diode)(3)	—	—	−14	A	
V_{SD}	Diode Forward Voltage (2)	—	—	−7.0	V	$T_C=25°C$, $I_S=-3.6A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	140	290	ns	$T_j=150°C$, $I_F=-3.9A$, $dI_F/dt=100A/\mu S$

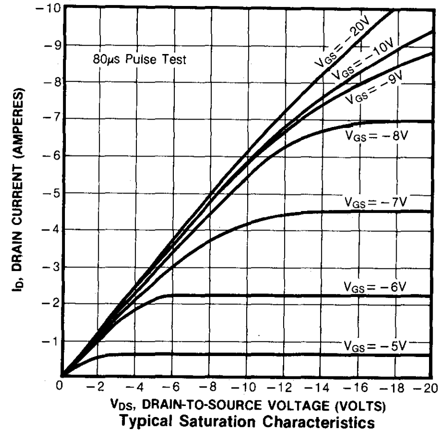
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



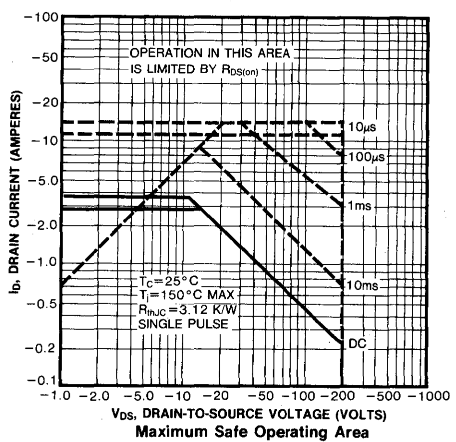
Typical Output Characteristics



Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area

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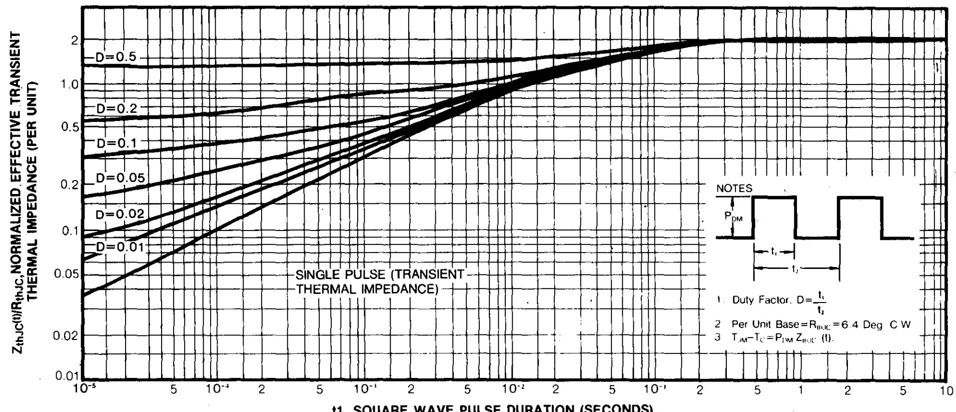
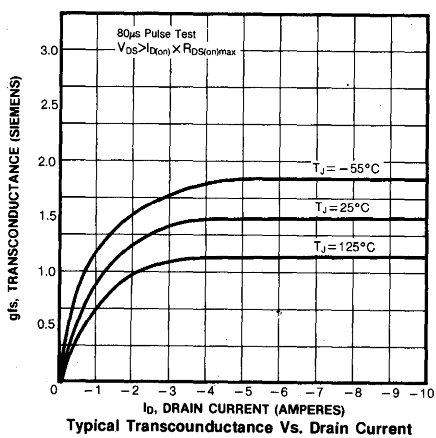
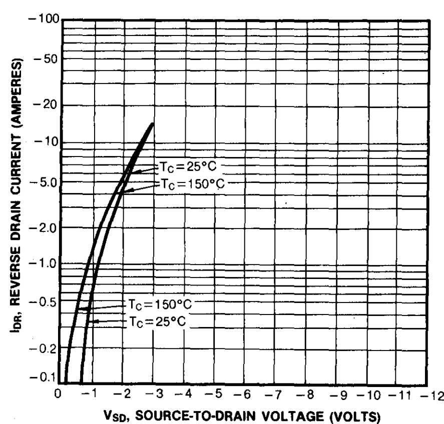


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



Typical Transcounductance Vs. Drain Current

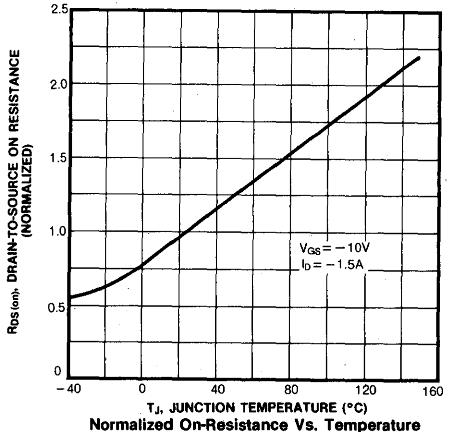


Typical Source—Drain Diode Forward Voltage

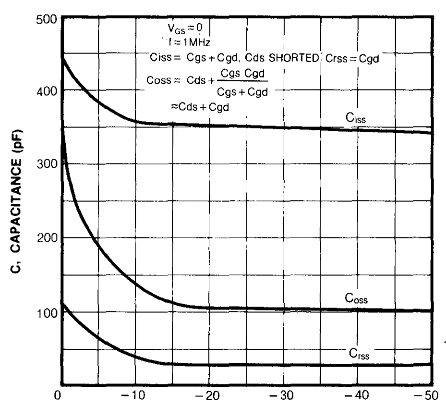
BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

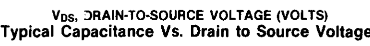
T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

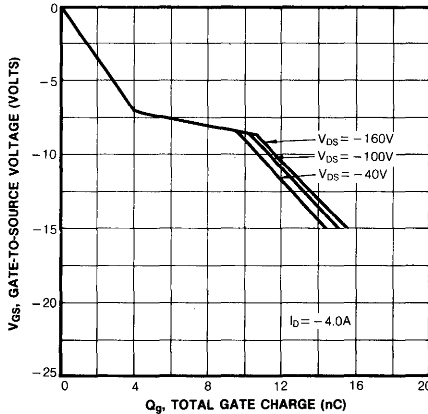


Normalized On-Resistance Vs. Temperature

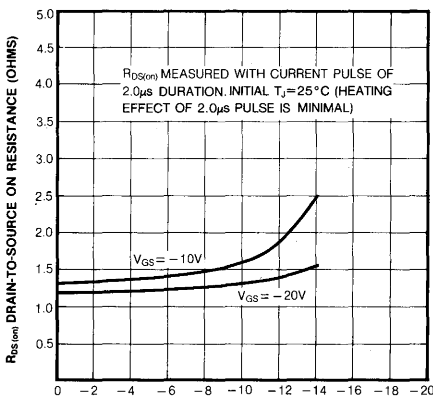




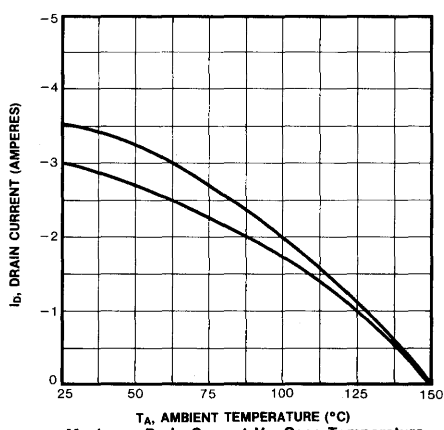
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage

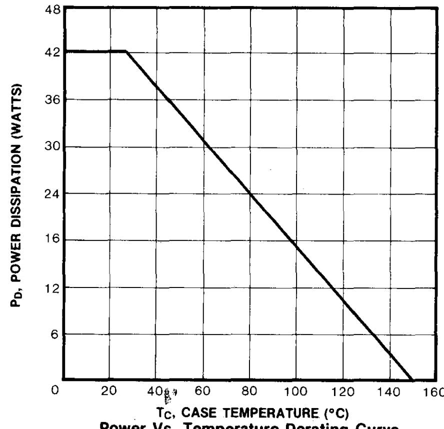


Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

4



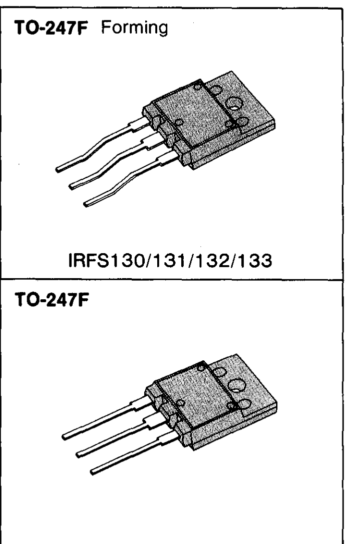
Power Vs. Temperature Derating Curve

IRFS130/131/132/133

N-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS\ (ON)}$ at high voltage**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS130	100V	0.16Ω	9.7A
IRFS131	80V	0.16Ω	9.7A
IRFS132	100V	0.22Ω	8.3A
IRFS133	80V	0.22Ω	8.3A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS130	IRFS131	IRFS132	IRFS133	Unit
Drain-Source Voltage	V_{DSS}	100	80	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	9.7	9.7	8.3	8.3	Adc
Continuous Drain Current T_C=100°C	I_D	6.2	6.2	5.5	5.5	Adc
Drain Current—Pulsed (3)	I_{DM}	56	56	48	48	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	33				mJ
Avalanche Current	I_{AS}	9.7				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.34				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.53mH, V_{dd}=25V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS130/IRFS132	100	—	—	V	V_{GS}=0V
	IRFS131/IRFS133	80	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS130/IRFS131	14	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS132/IRFS130	12	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS130/IRFS131	—	0.10	0.16	Ω	V_{GS}=10V, I_D=8.3A
	IRFS132/IRFS133	—	0.20	0.23	Ω	
g_{fs}	Forward Transconductance (2)	5.1	—	—	℧	V_{DS}≥50V, I_D=8.3A
C_{iss}	Input Capacitance	—	640	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	240	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	72	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	15	ns	V_{DD}=0.5BV_{DSS}, I_D=8.0A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	51	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	35	ns	
t_f	Fall Time	—	—	36	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	26	nC	V_{GS}=10V, I_D=18A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	5.5	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	11	nC	

THERMAL RESISTANCE

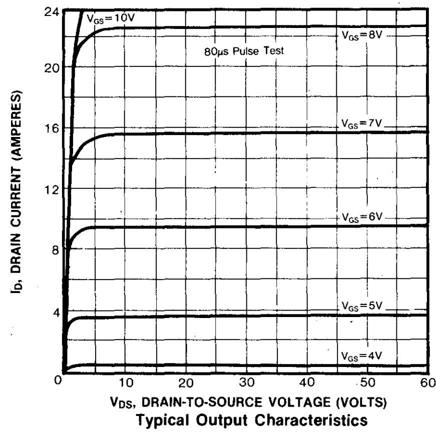
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	2.97	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

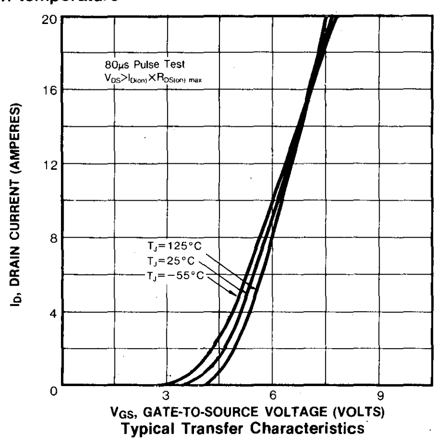
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS130/131	—	—	14	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS132/133	—	—	12	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS130/131	—	—	56	A	
	IRFS132/133	—	—	48	A	
V_{SD}	Diode Forward Voltage (2) IRFS130/131	—	—	2.5	V	T_C=25°C, I_S=14A, V_{GS}=0V
	IRFS132/133	—	—	2.3	V	T_C=25°C, I_S=12A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	120	—	ns	T_j=25°C, I_F=9.7A, dI_F/dt=100A/μS

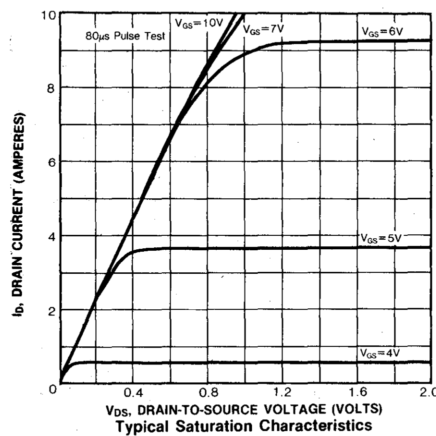
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



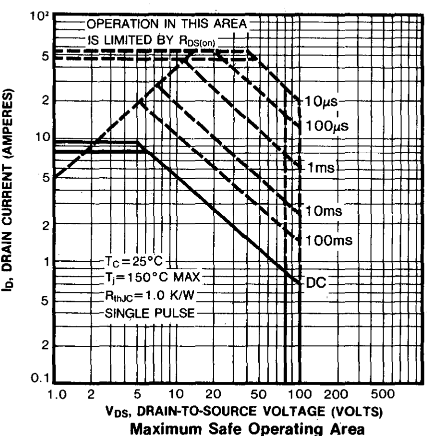
Typical Output Characteristics



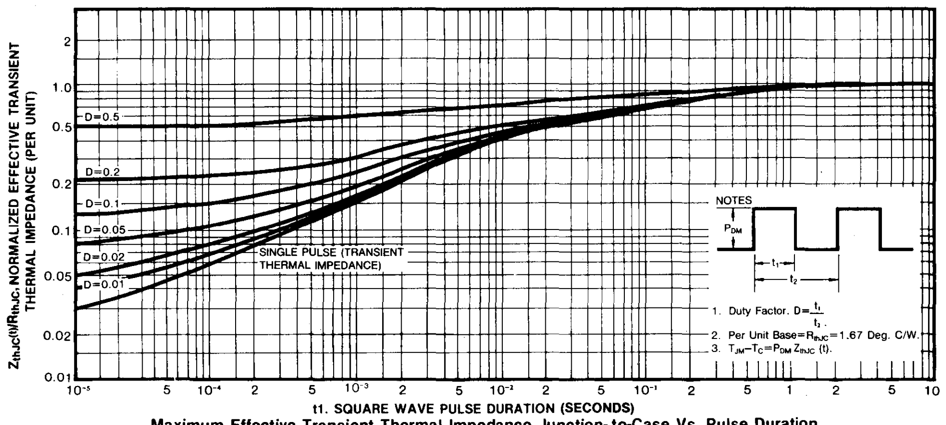
Typical Transfer Characteristics



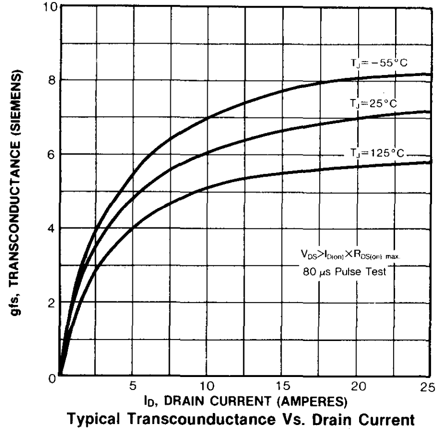
Typical Saturation Characteristics



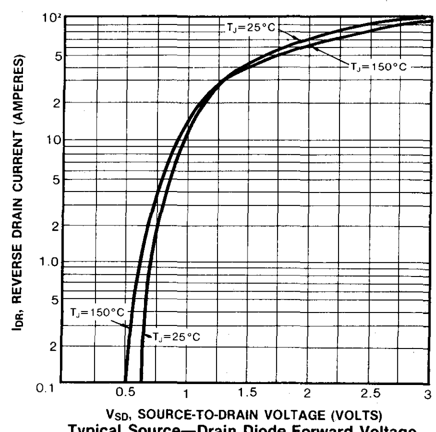
Maximum Safe Operating Area



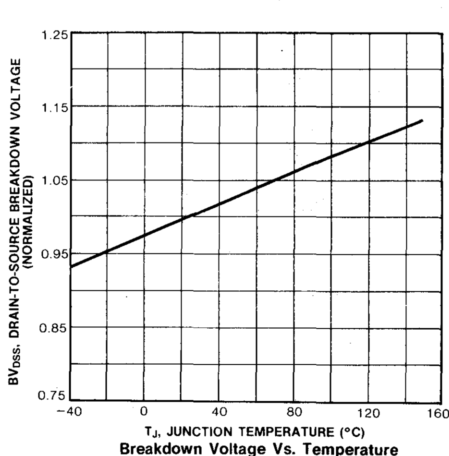
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



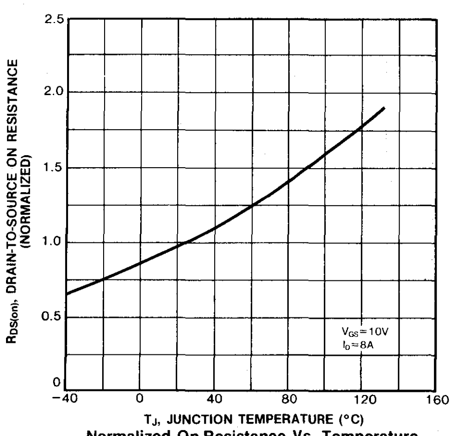
Typical Transcounductance Vs. Drain Current



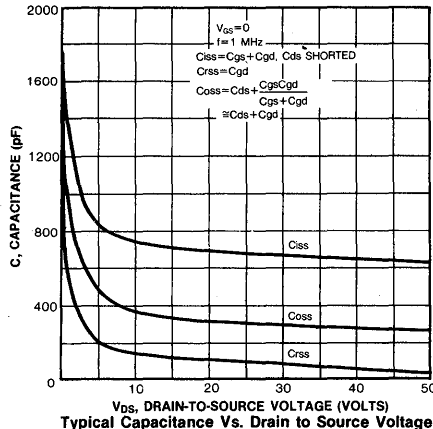
Typical Source—Drain Diode Forward Voltage



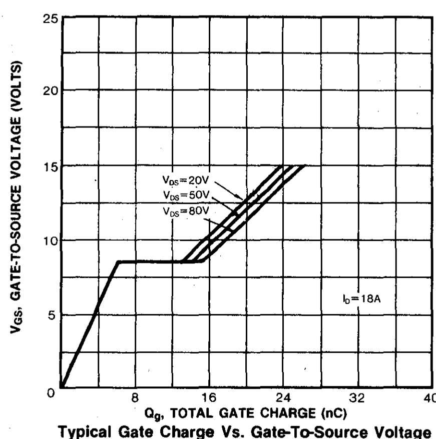
Breakdown Voltage Vs. Temperature



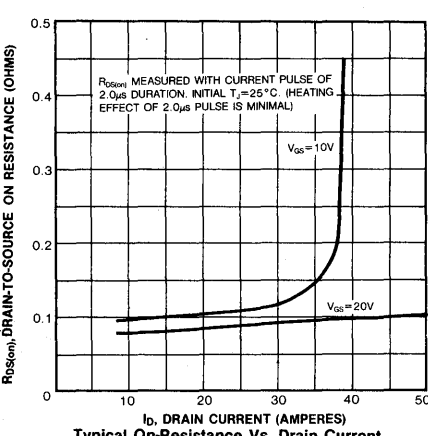
Normalized On-Resistance Vs. Temperature



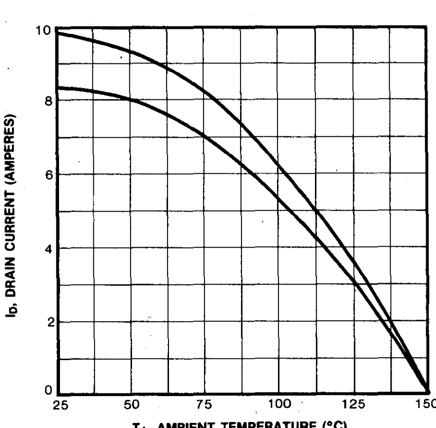
Typical Capacitance Vs. Drain to Source Voltage



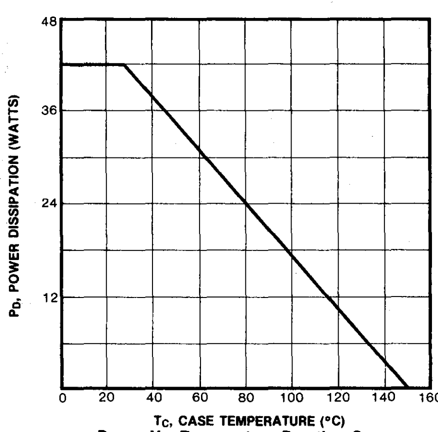
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



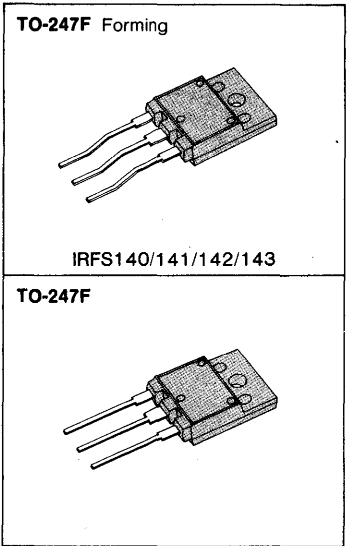
Power Vs. Temperature Derating Curve

IRFS140/141/142/143

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS140	100V	0.077Ω	19.4A
IRFS141	80V	0.077Ω	19.4A
IRFS142	100V	0.10Ω	17.3A
IRFS143	80V	0.10Ω	17.3A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRFS140	IRFS141	IRFS142	IRFS143	Unit
Drain-Source Voltage	V_{DSS}	100	80	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	19.4	19.4	17.3	17.3	Adc
Continuous Drain Current T_C=100°C	I_D	13.8	13.8	11.7	11.7	Adc
Drain Current—Pulsed (3)	I_{DM}	110	110	100	100	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	108				mJ
Avalanche Current	I_{AS}	19.4				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	65 0.52				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.53mH, V_{dd}=25V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS140/IRFS142	100	—	—	V	V_{GS}=0V
	IRFS141/IRFS143	80	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS140/IRFS141	28	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS142/IRFS140	25	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS140/IRFS141	—	—	0.077	Ω	V_{GS}=10V, I_D=17A
	IRFS142/IRFS143	—	—	0.10	Ω	
g_{fs}	Forward Transconductance (2)	8.7	—	—	℧	V_{DS}≥50V, I_D=17A
C_{iss}	Input Capacitance	—	1500	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	500	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	90	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	23	ns	V_{DD}=0.5BV_{DSS}, I_D=15A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	10	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	60	ns	
t_f	Fall Time	—	—	75	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	59	nC	V_{GS}=10V, I_D=34A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	12	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	38	nC	

THERMAL RESISTANCE

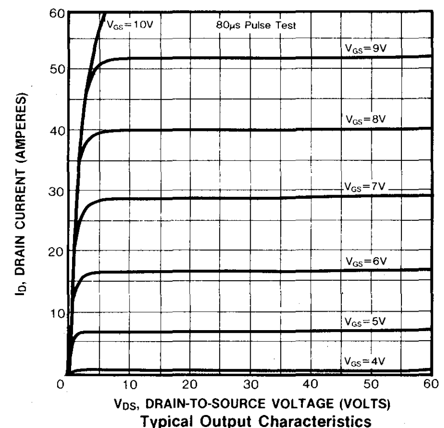
R_{thJC}	Junction-to-Case	—	—	1.92	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

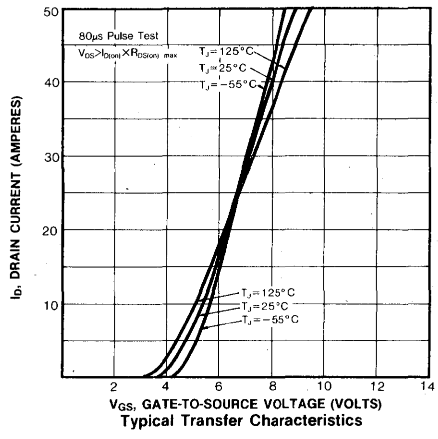
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS140/141	—	—	28	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS142/143	—	—	25	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS140/141	—	—	110	A	
	IRFS142/143	—	—	100	A	
V_{SD}	Diode Forward Voltage (2) IRFS140/141	—	—	2.5	V	$T_C=25°C$, $I_S=28A$, $V_{GS}=0V$
	IRFS142/143	—	—	2.3	V	$T_C=25°C$, $I_S=25A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	150	—	ns	$T_j=25°C$, $I_F=9.7A$, $dI_F/dt=100A/\mu S$

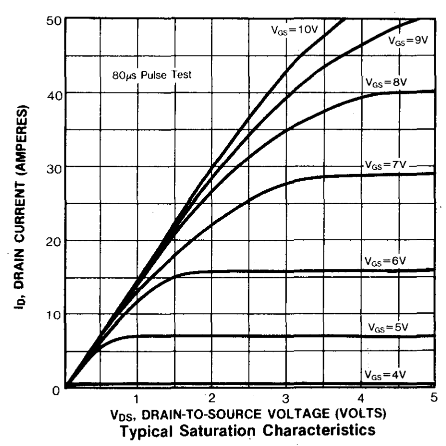
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



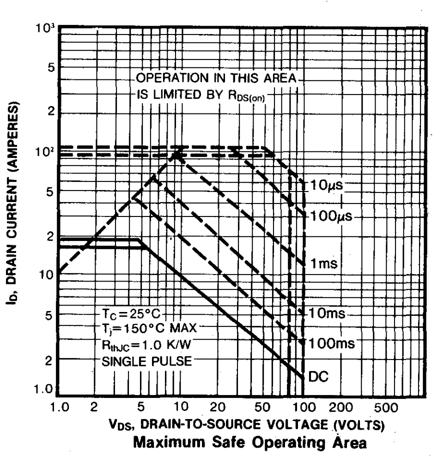
Typical Output Characteristics



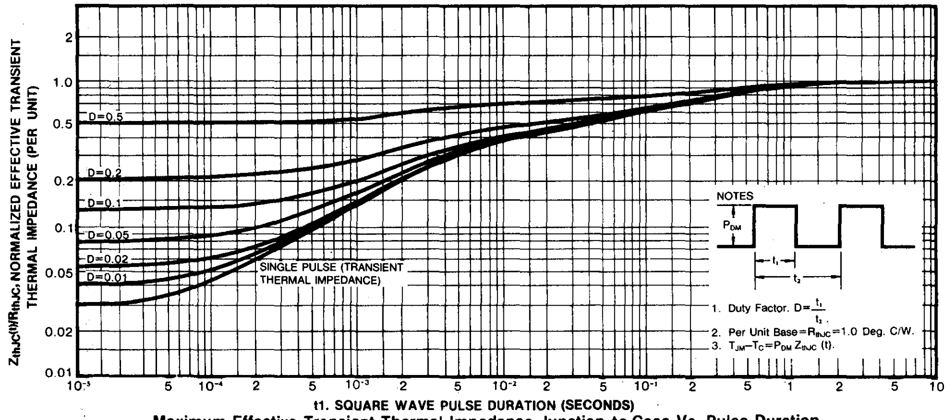
Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

gfs, TRANSCONDUCTANCE (SIEMENS)

0, 3, 6, 9, 12, 15

$T_J=-55°C$

$T_J=25°C$

$T_J=125°C$

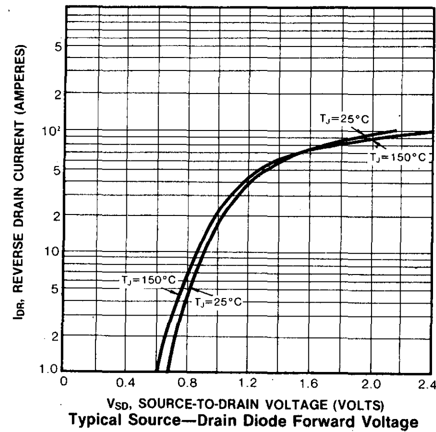
80μs Pulse Test

$V_{DS}>I_{D(on)}\times R_{DS(on)\,max}$

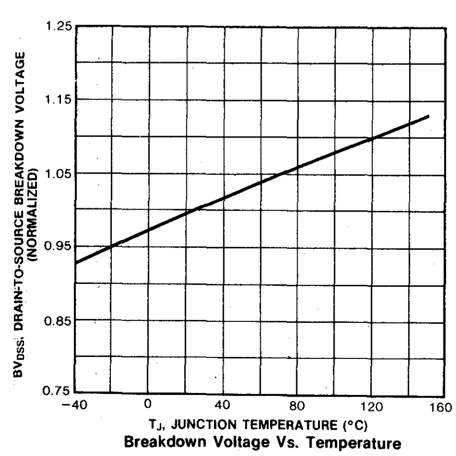
10, 20, 30, 40, 50

I_D, DRAIN CURRENT (AMPERES)

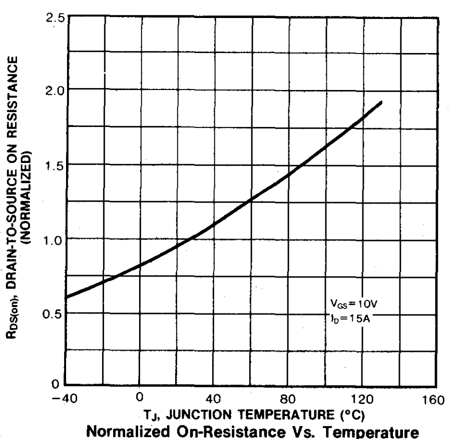
Typical Transconductance Vs. Drain Current



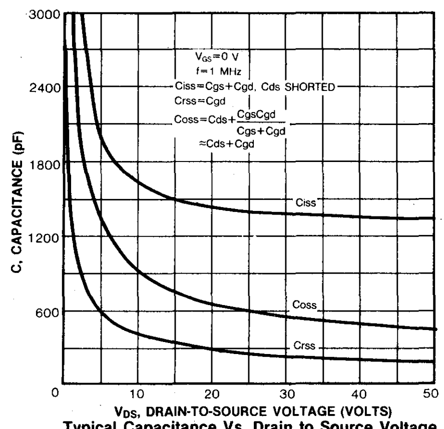
Typical Source—Drain Diode Forward Voltage



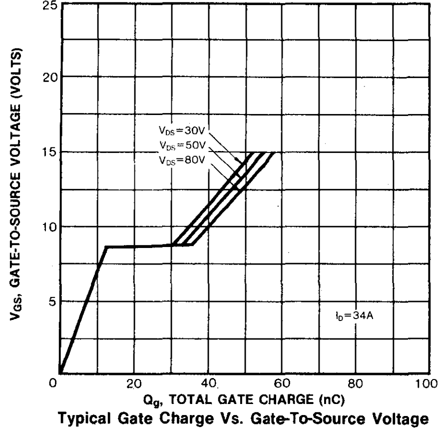
Breakdown Voltage Vs. Temperature



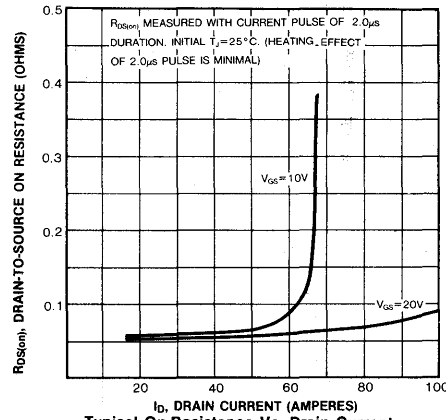
Normalized On-Resistance Vs. Temperature



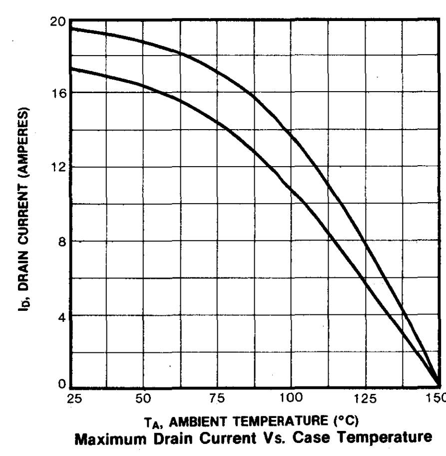
Typical Capacitance Vs. Drain to Source Voltage



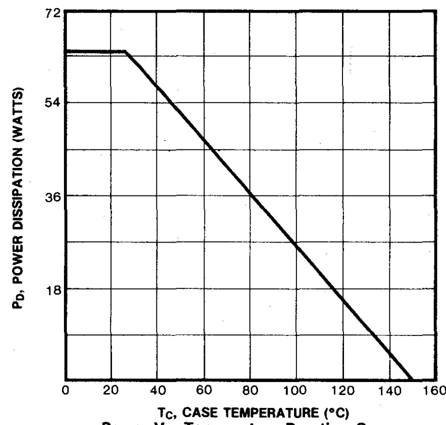
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

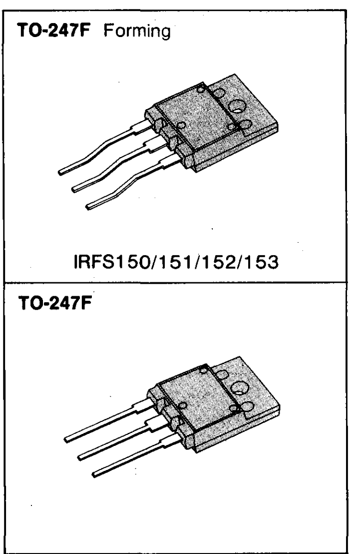
4

IRFS150/151/152/153

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS\ (ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS150	100V	0.055Ω	27.7A
IRFS151	80V	0.055Ω	27.7A
IRFS152	100V	0.080Ω	23.5A
IRFS153	80V	0.080Ω	23.5A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS150	IRFS151	IRFS152	IRFS153	Unit
Drain-Source Voltage	V_{DSS}	100	80	100	80	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	100	80	100	80	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	27.7	27.7	23.5	23.5	Adc
Continuous Drain Current T_C=100°C	I_D	17.3	17.3	14.2	14.2	Adc
Drain Current—Pulsed (3)	I_{DM}	160	160	132	132	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	180				mJ
Avalanche Current	I_{AS}	27.7				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	70 0.56				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=0.36mH, V_{dd}=25V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS150/IRFS152	100	—	—	V	V_{GS}=0V
	IRFS151/IRFS153	80	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS150/IRFS151	40	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS152/IRFS150	34	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS150/IRFS151	—		0.055	Ω	V_{GS}=10V, I_D=22A
	IRFS152/IRFS153	—		0.08	Ω	
g_{fs}	Forward Transconductance (2)	13.0	—	—	℧	V_{DS}≥50V, I_D=20A
C_{iss}	Input Capacitance	—	2400	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	1000	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	200	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	24	ns	V_{DD}=0.5BV_{DSS}, I_D=20A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	210	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	84	ns	
t_f	Fall Time	—	—	140	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	1.0	nC	V_{GS}=10V, I_D=50A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	18		nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	27		nC	

THERMAL RESISTANCE

R_{thJC}	Junction-to-Case	—	—	1.78	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

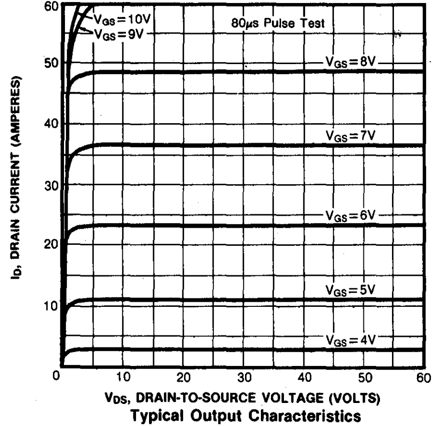
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

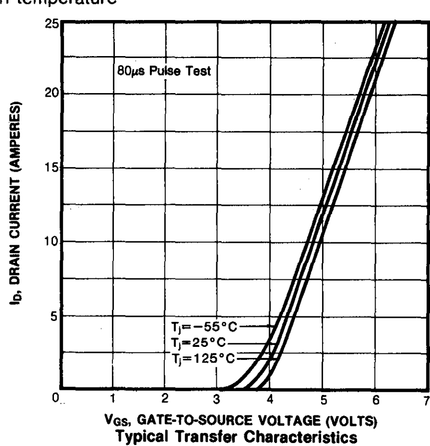
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS150/151	—	—	40	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS152/153	—	—	34	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS150/151	—	—	160	A	
	IRFS152/153	—	—	132	A	
V_{SD}	Diode Forward Voltage (2) IRFS150/151	—	—	2.5	V	$T_C=25°C$, $I_S=40A$, $V_{GS}=0V$
	IRFS152/153	—	—	2.3	V	$T_C=25°C$, $I_S=34A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	600	—	ns	$T_j=25°C$, $I_F=27.7A$, $dI_F/dt=100A/\mu S$

Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%

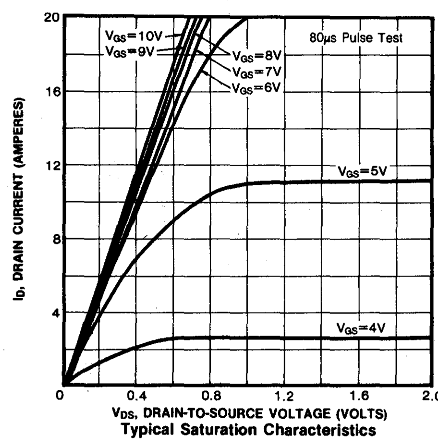
(3) Repetitive rating: Pulse with limited by max. junction temperature



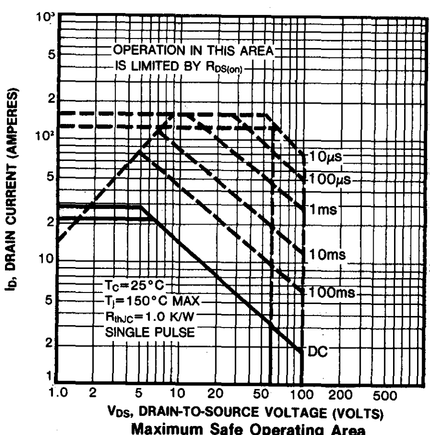
Typical Output Characteristics



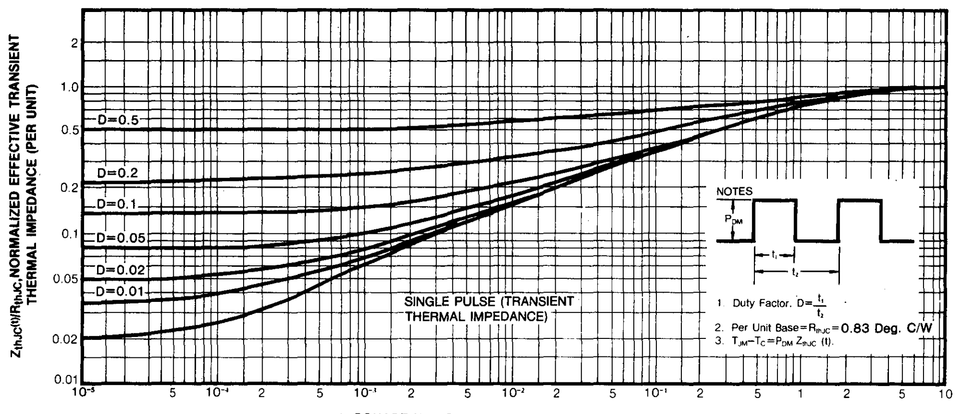
Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area



Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

gfs, TRANSCONDUCTANCE (SIEMENS)

$T_j=-55°C$

$T_j=25°C$

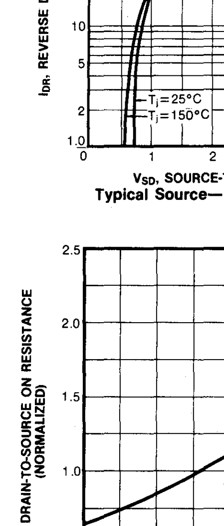
$T_j=125°C$

80μs Pulse Test

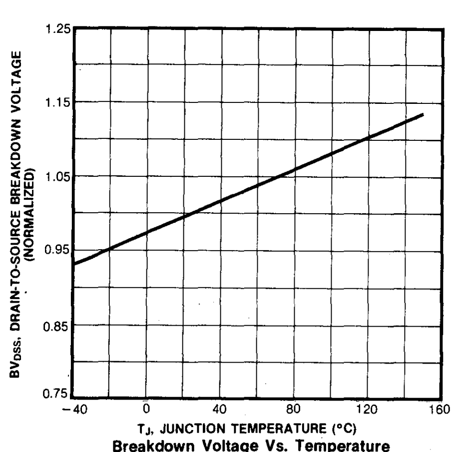
$V_{DS}>I_{D(on)}xR_{DS(on)}max$

I_D, DRAIN CURRENT (AMPERES)

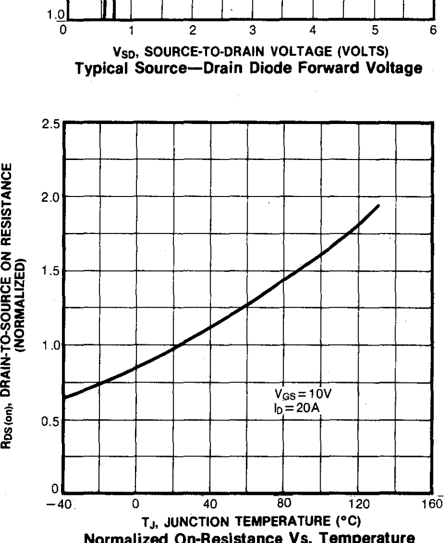
Typical Transcounductance Vs. Drain Current



Typical Source—Drain Diode Forward Voltage

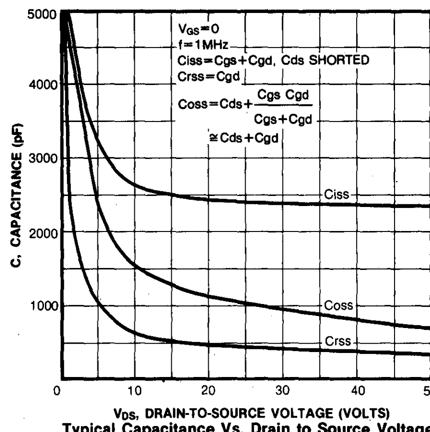


Breakdown Voltage Vs. Temperature

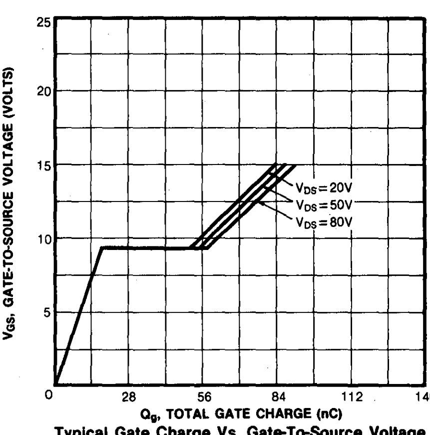


Normalized On-Resistance Vs. Temperature

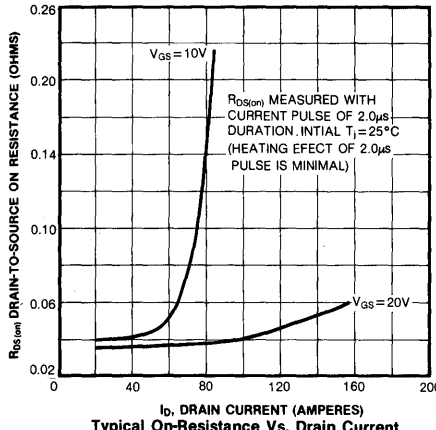
4



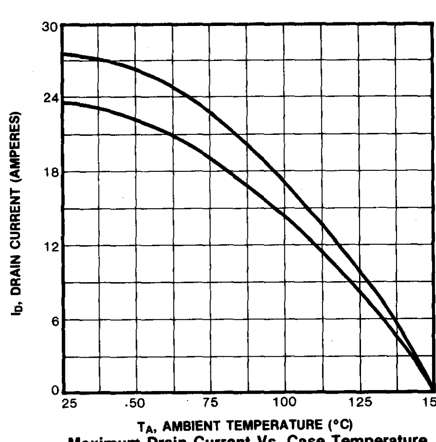
Typical Capacitance Vs. Drain to Source Voltage



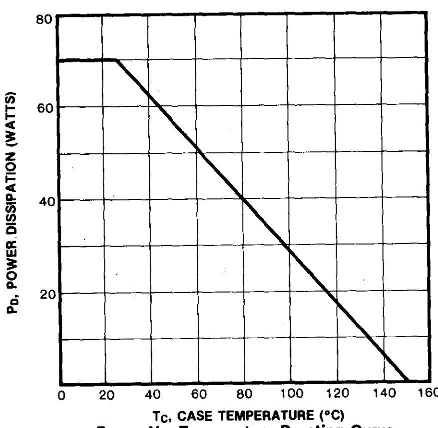
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



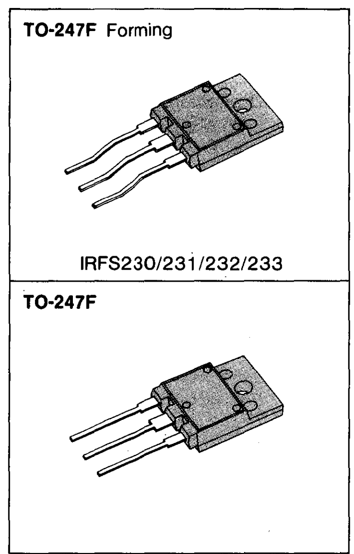
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\,(ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS230	200V	0.40Ω	6.2A
IRFS231	150V	0.40Ω	0.2A
IRFS232	200V	0.60Ω	5.5A
IRFS233	150V	0.60Ω	5.5A

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MAXIMUM RATINGS

Characteristic	Symbol	IRFS230	IRFS231	IRFS232	IRFS233	Unit
Drain-Source Voltage	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	6.2	6.2	5.5	5.5	Adc
Continuous Drain Current T_C=100°C	I_D	4.4	4.4	32	32	Adc
Drain Current—Pulsed (3)	I_{DM}	36	36	32	32	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	80				mJ
Avalanche Current	I_{AS}	6.2				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.34				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS230/IRFS232	150	—	—	V	V_{GS}=0V
	IRFS231/IRFS233	200	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS230/IRFS231	9.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS232/IRFS230	8.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS230/IRFS231	—	0.25	0.4	Ω	V_{GS}=10V, I_D=5.0A
	IRFS232/IRFS233	—	0.4	0.6	Ω	
g_{fs}	Forward Transconductance (2)	3.0	—	—	℧	V_{DS}≥50V, I_D=5.0A
C_{iss}	Input Capacitance	—	750	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	120	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	45	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD}=0.5BV_{DSS}, I_D=5.0A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	50	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	50	ns	
t_f	Fall Time	—	—	40	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	30	nC	V_{GS}=10V, I_D=12A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	50	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	14	nC	

THERMAL RESISTANCE

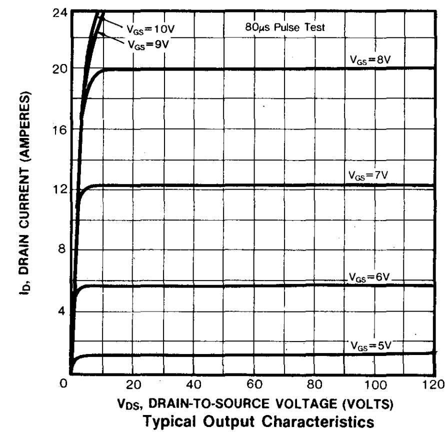
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	2.97	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

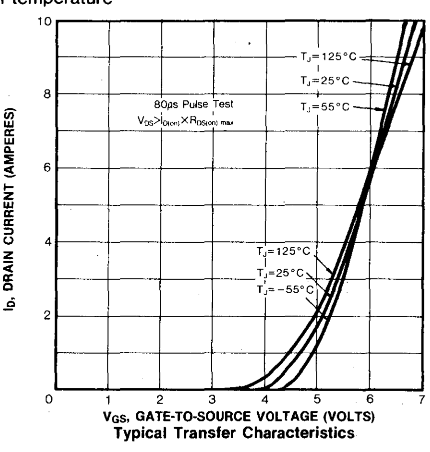
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS230/231	—	—	9.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS232/233	—	—	8.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS230/231	—	—	36	A	
	IRFS232/233	—	—	32	A	
V_{SD}	Diode Forward Voltage (2) IRFS230/231	—	—	2.0	V	$T_C=25°C$, $I_S=9.0A$, $V_{GS}=0V$
	IRFS232/233	—	—	1.8	V	$T_C=25°C$, $I_S=8.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	450	—	ns	$T_j=25°C$, $I_F=6.2A$, $dI_F/dt=100A/\mu S$

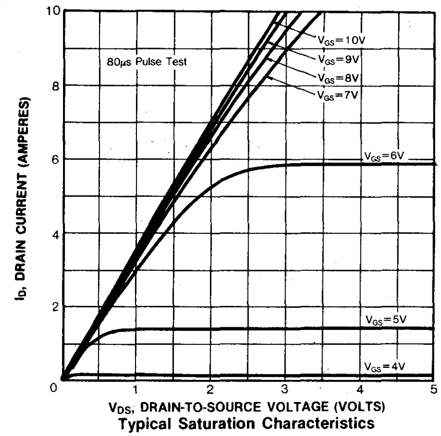
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq 300\mu s$, Duty Cycle$\leq 2\%$
(3) Repetitive rating: Pulse with limited by max. junction temperature



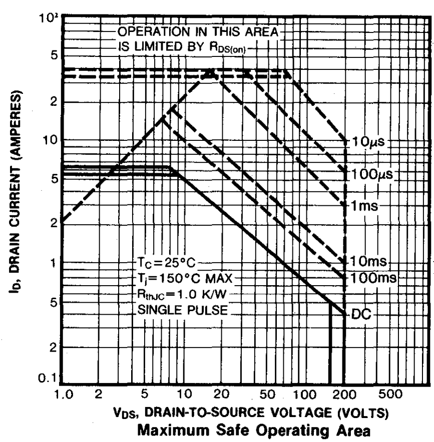
Typical Output Characteristics



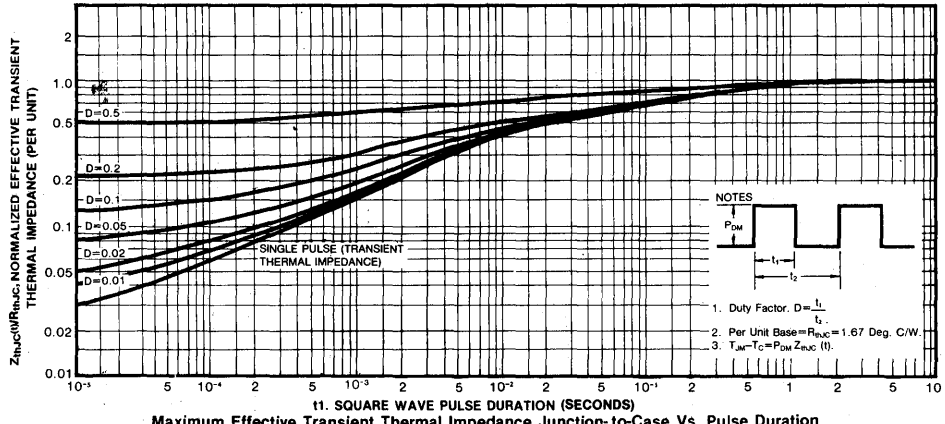
Typical Transfer Characteristics



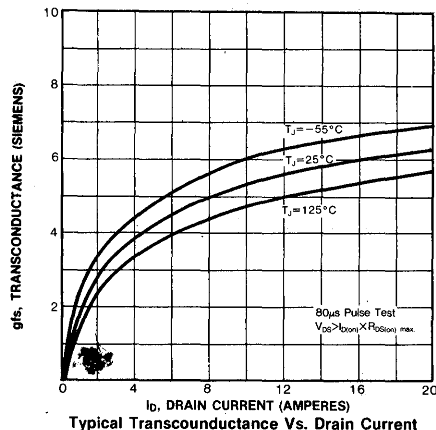
Typical Saturation Characteristics



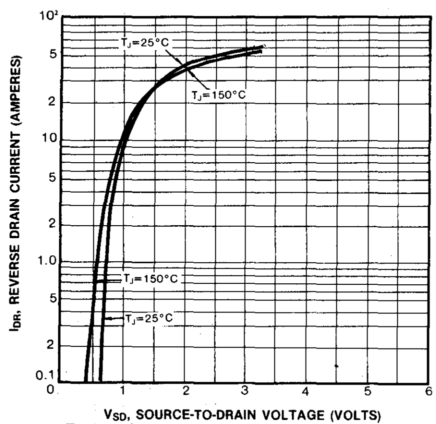
Maximum Safe Operating Area



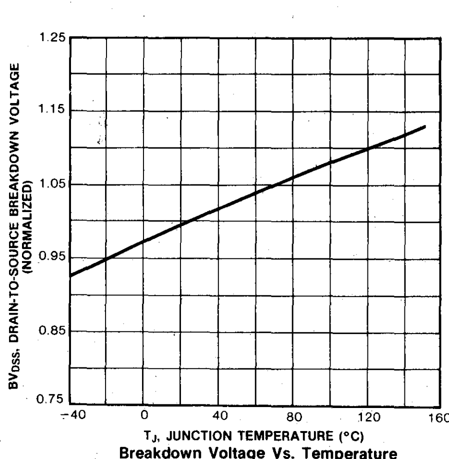
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



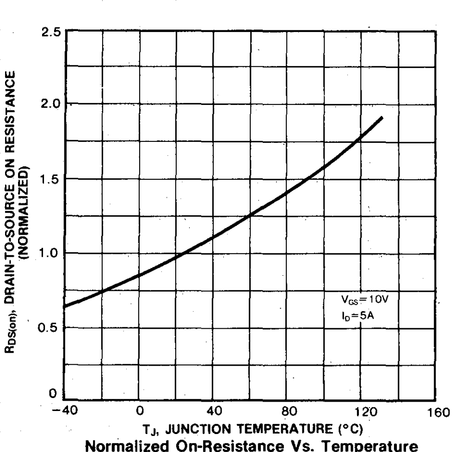
Typical Transcounductance Vs. Drain Current



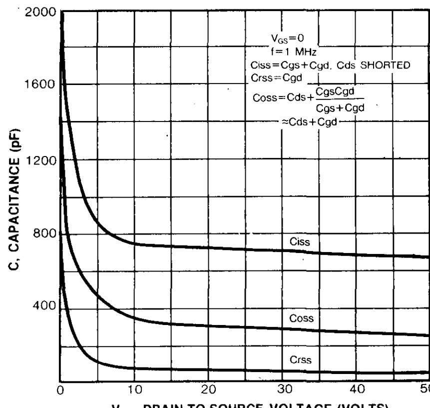
Typical Source—Drain Diode Forward Voltage

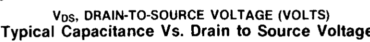


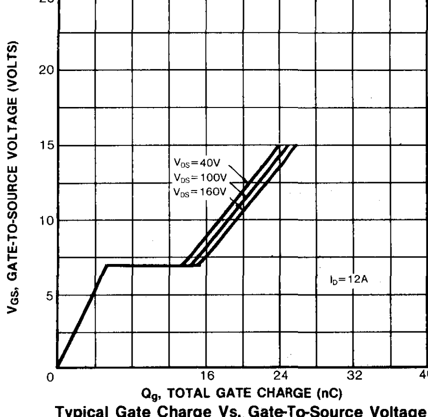
Breakdown Voltage Vs. Temperature



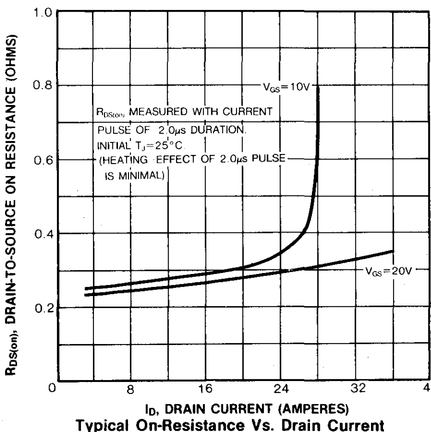
Normalized On-Resistance Vs. Temperature



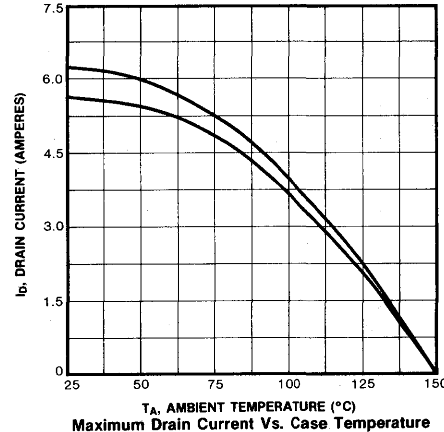

V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)
Typical Capacitance Vs. Drain to Source Voltage



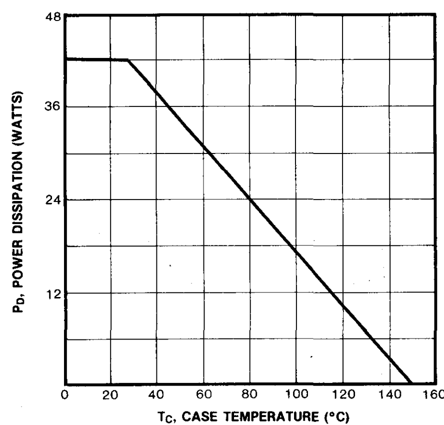
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

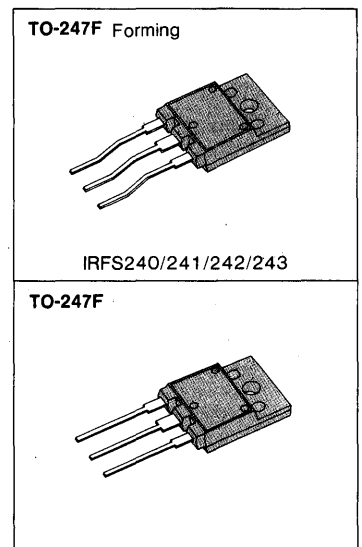
4

IRFS240/241/242/243

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS240	200V	0.18Ω	12.5A
IRFS241	150V	0.18Ω	12.5A
IRFS242	200V	0.22Ω	11.0A
IRFS243	150V	0.22Ω	11.0A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS240	IRFS241	IRFS242	IRFS243	Unit
Drain-Source Voltage	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	12.5	12.5	11.0	11.0	Adc
Continuous Drain Current T_C=100°C	I_D	7.6	7.6	6.8	6.8	Adc
Drain Current—Pulsed (3)	I_{DM}	72	72	64	64	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	230				mJ
Avalanche Current	I_{AS}	12.5				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	65 0.52				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=2.7mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS240/IRFS242	200	—	—	V	V_{GS}=0V
	IRFS241/IRFS243	150	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS240/IRFS241	18	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS242/IRFS240	16	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS240/IRFS241	—	—	0.18	Ω	V_{GS}=10V, I_D=10A
	IRFS242/IRFS243	—	—	0.22	Ω	
g_{fs}	Forward Transconductance (2)	6.0	—	—	℧	V_{DS}≥50V, I_D=10A
C_{iss}	Input Capacitance	—	1400	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	240	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	95	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD}=0.5BV_{DSS}, I_D=10A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	60	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	80	ns	
t_f	Fall Time	—	—	60	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	44	60	nC	V_{GS}=10V, I_D=22A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	9	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	35	nC	

THERMAL RESISTANCE

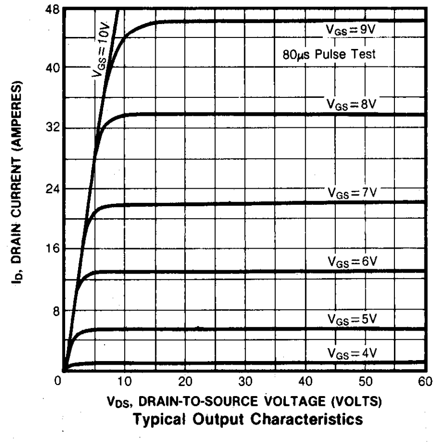
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	1.92	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

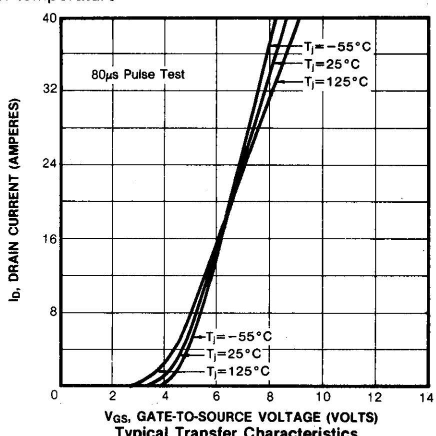
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS240/241	—	—	18	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS242/243	—	—	16	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS240/241	—	—	72	A	
	IRFS242/243	—	—	64	A	
V_{SD}	Diode Forward Voltage (2) IRFS240/241	—	—	2.0	V	T_C=25°C, I_S=18A, V_{GS}=0V
	IRFS242/243	—	—	1.9	V	T_C=25°C, I_S=16A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	650	—	ns	T_j=25°C, I_F=6.2A, dI_F/dt=100A/μS

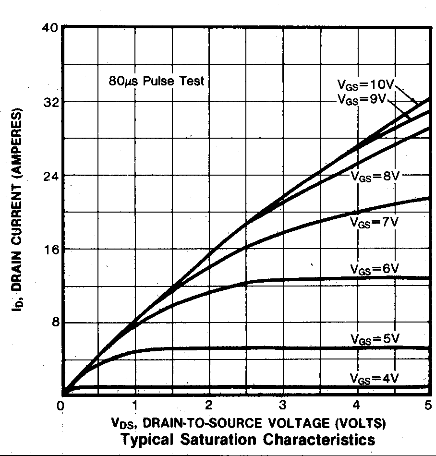
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



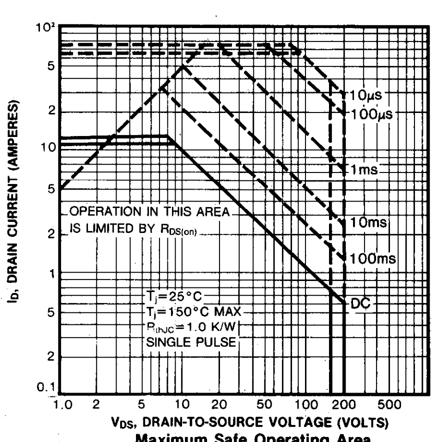
Typical Output Characteristics



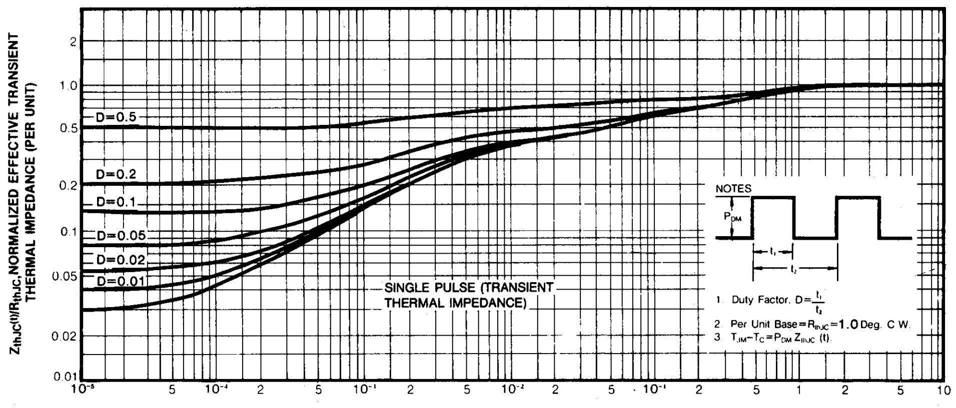
Typical Transfer Characteristics



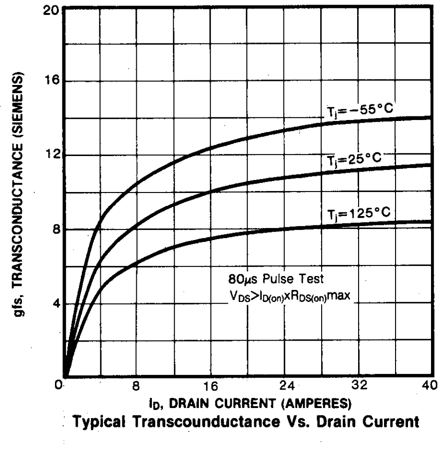
Typical Saturation Characteristics



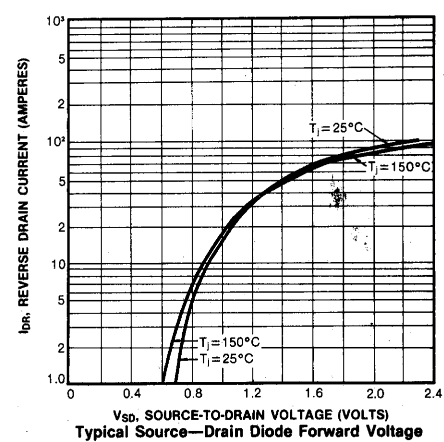
Maximum Safe Operating Area



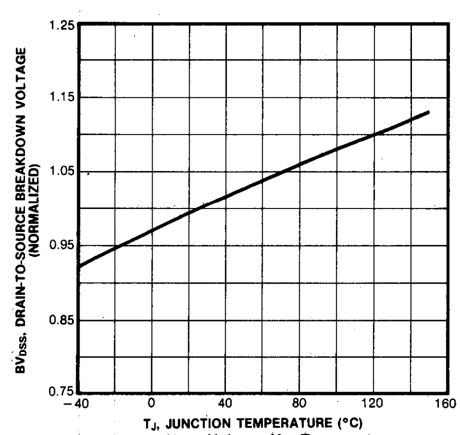
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



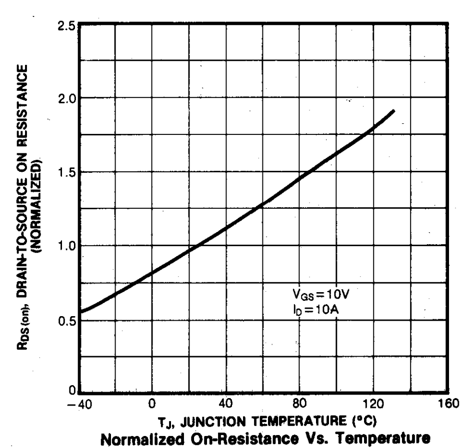
Typical Transcounductance Vs. Drain Current



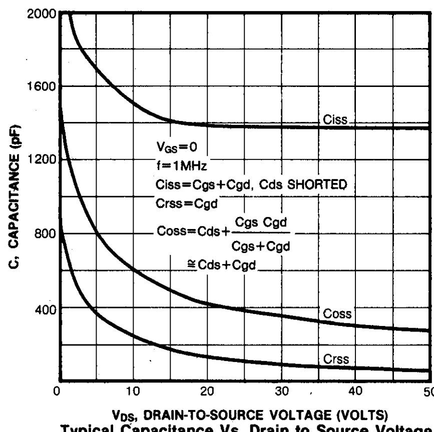
Typical Source—Drain Diode Forward Voltage



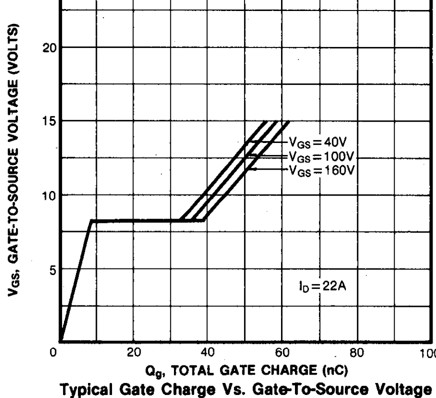
Breakdown Voltage Vs. Temperature



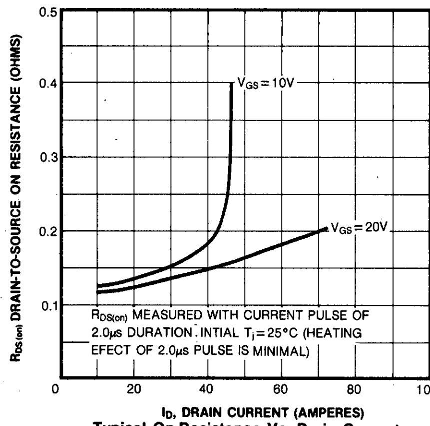
Normalized On-Resistance Vs. Temperature



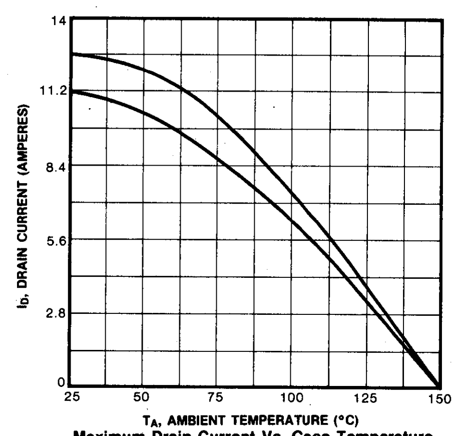
Typical Capacitance Vs. Drain to Source Voltage



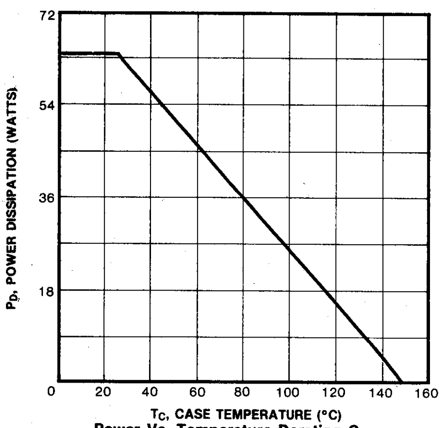
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



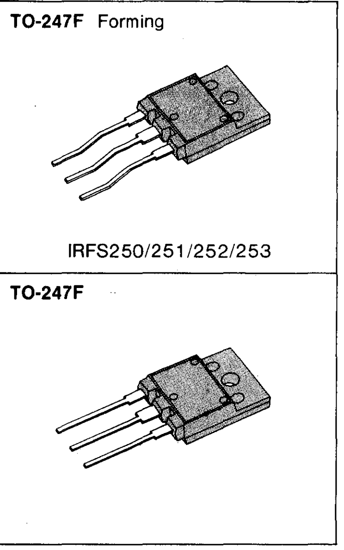
Power Vs. Temperature Derating Curve

IRFS250/251/252/253

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS250	200V	0.085Ω	20.7A
IRFS251	150V	0.085Ω	20.7A
IRFS252	200V	0.12Ω	17.3A
IRFS253	150V	0.12Ω	17.3A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS250	IRFS251	IRFS252	IRFS253	Unit
Drain-Source Voltage	V_{DSS}	200	150	200	150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	200	150	200	150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	20.7	20.7	17.3	17.3	Adc
Continuous Drain Current T_C=100°C	I_D	13	13	11	11	Adc
Drain Current—Pulsed (3)	I_{DM}	120	120	100	100	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	247				mJ
Avalanche Current	I_{AS}	20.7				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	70 0.56				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=1.1mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS250/IRFS252	200	—	—	V	V_{GS}=0V
	IRFS251/IRFS253	150	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS250/IRFS251	30	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max.}$ V_{GS}=10V
	IRFS252/IRFS250	25	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS250/IRFS251	—			Ω	V_{GS}=10V, I_D=16A
	IRFS252/IRFS253	—			Ω	
g_{fs}	Forward Transconductance (2)	8.0	—	—	℧	$V_{DS}\geqslant$50V, I_D=16A
C_{iss}	Input Capacitance	—	2500	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	533	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	228	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	V_{DD}=0.5BV_{DSS}, I_D=16A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	125	ns	
t_f	Fall Time	—	—	100	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	120	nC	V_{GS}=10V, I_D=38A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	18		nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	50		nC	

THERMAL RESISTANCE

R_{thJC}	Junction-to-Case	—	—	1.78	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS250/251	—	—	30	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS252/253	—	—	25	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS250/251	—	—	120	A	
	IRFS252/253	—	—	100	A	
V_{SD}	Diode Forward Voltage (2) IRFS250/251	—	—	2.0	V	T_C=25°C, I_S=30A, V_{GS}=0V
	IRFS252/253	—	—	1.8	V	T_C=25°C, I_S=25A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	300	—	ns	T_j=25°C, I_F=20.7A, dI_F/dt=100A/μS

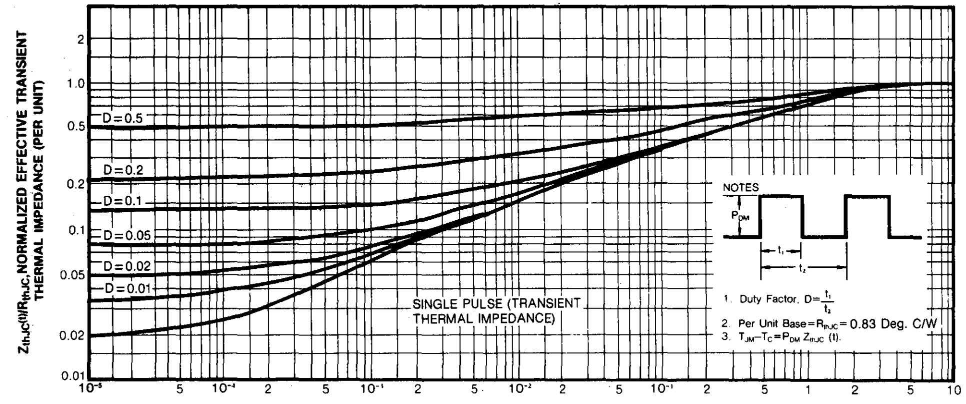
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

Typical Output Characteristics

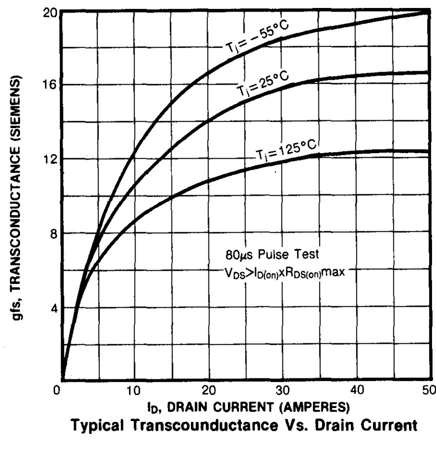
Typical Transfer Characteristics

Typical Saturation Characteristics

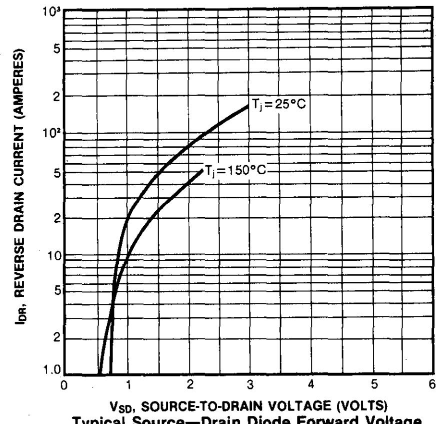
Maximum Safe Operating Area



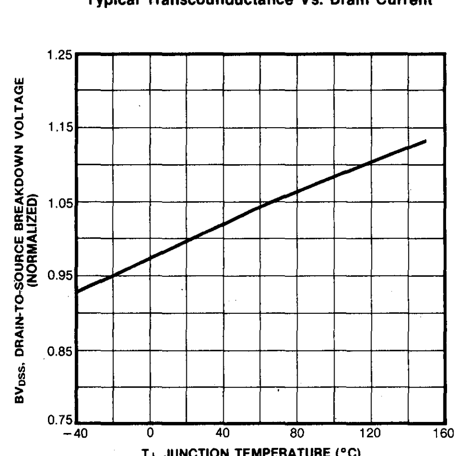
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



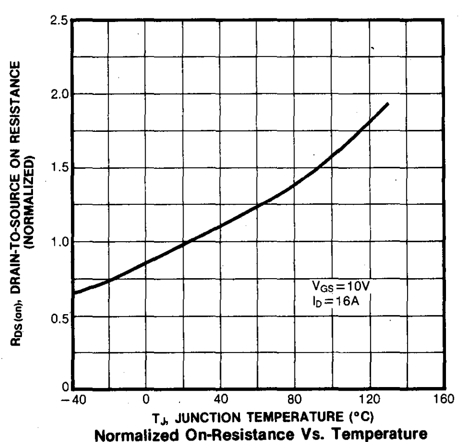
Typical Transcounductance Vs. Drain Current



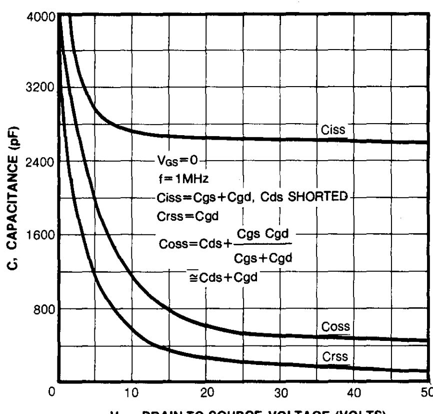
Typical Source—Drain Diode Forward Voltage



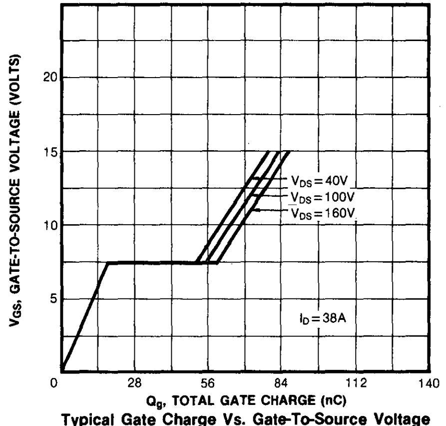
Breakdown Voltage Vs. Temperature



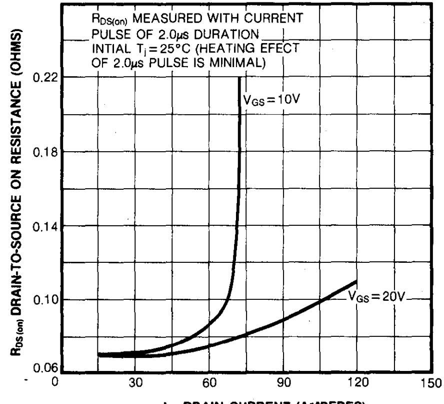
Normalized On-Resistance Vs. Temperature



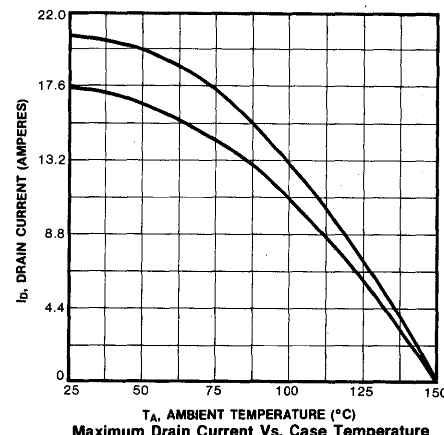
Typical Capacitance Vs. Drain to Source Voltage



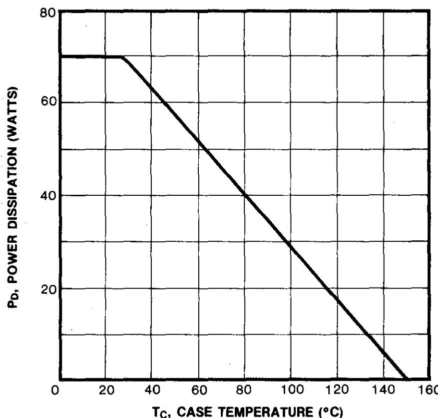
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



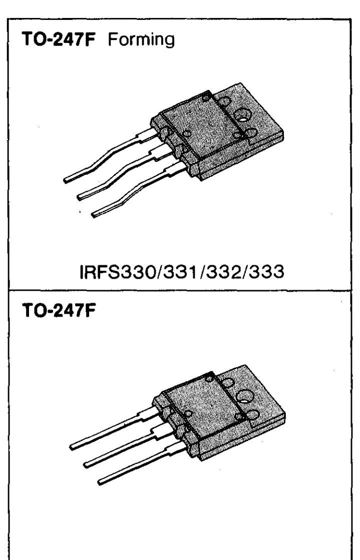
Power Vs. Temperature Derating Curve

IRFS330/331/332/333

N-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS(ON)}$ at high voltage**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS330	400V	1.0Ω	3.8A
IRFS331	350V	1.0Ω	3.8A
IRFS332	400V	1.5Ω	3.5A
IRFS333	350V	1.5Ω	3.5A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS330	IRFS331	IRFS332	IRFS333	Unit
Drain-Source Voltage	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	3.8	3.8	3.5	3.5	Adc
Continuous Drain Current T_C=100°C	I_D	2.4	2.4	2.3	2.3	Adc
Drain Current—Pulsed (3)	I_{DM}	32	32	18	18	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	128				mJ
Avalanche Current	I_{AS}	3.8				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.34				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=17mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS330/IRFS332	400	—	—	V	V_{GS}=0V
	IRFS331/IRFS333	350	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS330/IRFS331	5.5	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS332/IRFS330	4.5	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS330/IRFS331	—	—	1.0	Ω	V_{GS}=10V, I_D=3.0A
	IRFS332/IRFS333	—	—	1.5	Ω	
g_{fs}	Forward Transconductance (2)	2.9	—	—	℧	V_{DS}≥50V, I_D=3.0A
C_{iss}	Input Capacitance	—	780	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	99	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	43	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	17	ns	V_{DD}=0.5BV_{DSS}, I_D=3.0A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	29	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	56	ns	
t_f	Fall Time	—	—	24	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	18	30	nC	V_{GS}=10V, I_D=7.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	40	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	14	nC	

THERMAL RESISTANCE

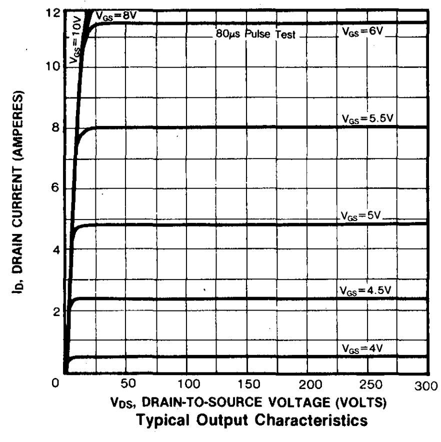
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	.	2.97	K/W	
R_{thCS}	Case-to-Sink	—	0.24		K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—		40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

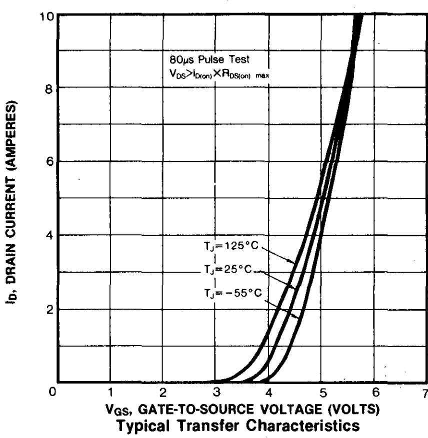
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS330/331	—	—	5.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS332/333	—	—	4.5	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS330/331	—	—	22	A	
	IRFS332/333	—	—	18	A	
V_{SD}	Diode Forward Voltage (2) IRFS330/331	—	—	1.8	V	$T_C=25°C$, $I_S=5.5A$, $V_{GS}=0V$
	IRFS332/333	—	—	1.6	V	$T_C=25°C$, $I_S=4.5A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	310	—	ns	$T_j=25°C$, $I_F=3.8A$, $dI_F/dt=100A/\mu S$

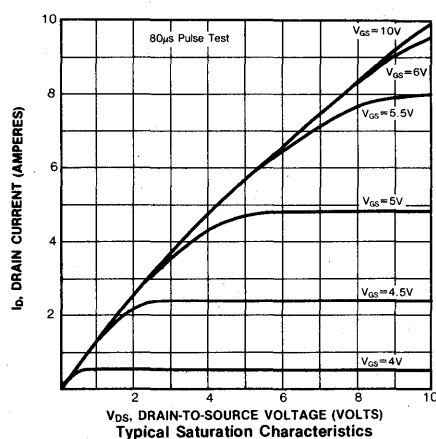
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



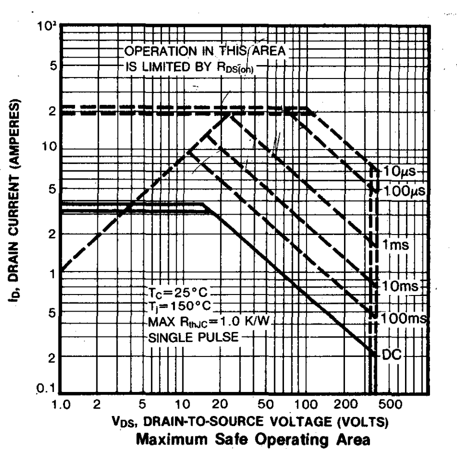
Typical Output Characteristics



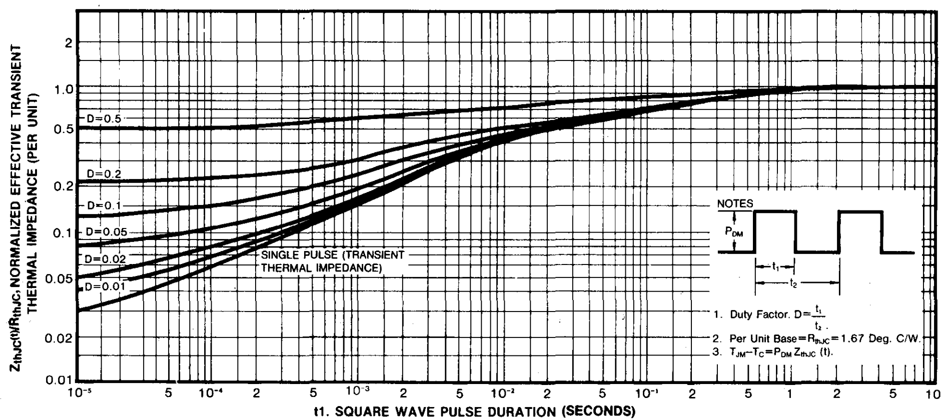
Typical Transfer Characteristics



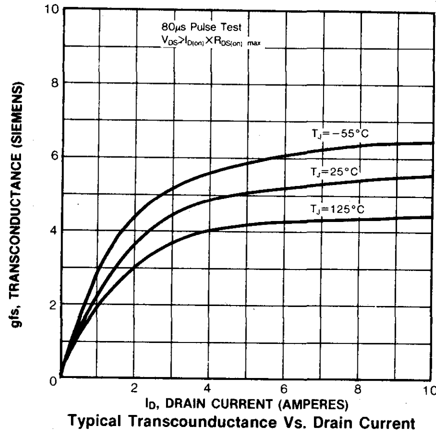
Typical Saturation Characteristics



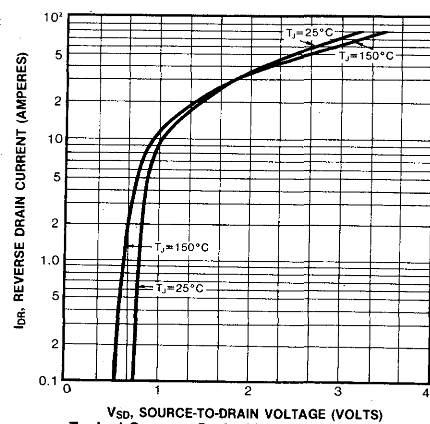
Maximum Safe Operating Area



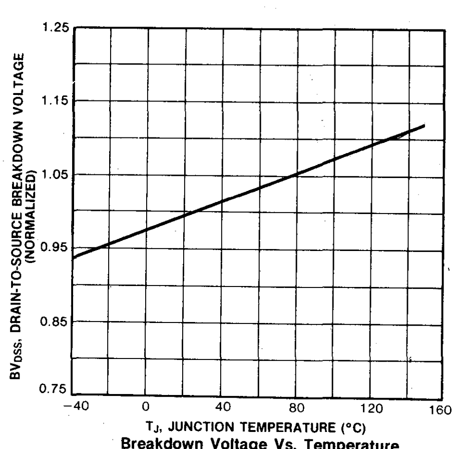
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



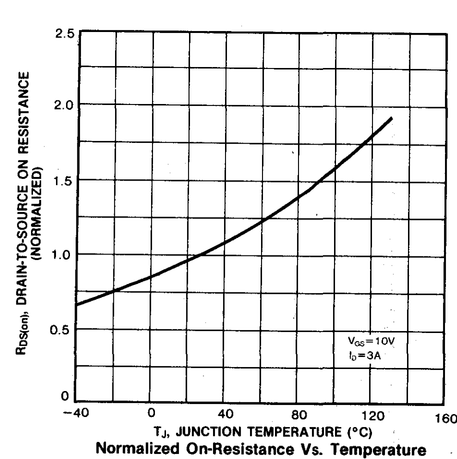
Typical Transcounductance Vs. Drain Current



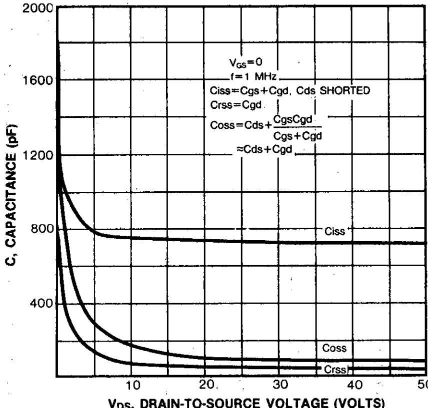
Typical Source—Drain Diode Forward Voltage



Breakdown Voltage Vs. Temperature



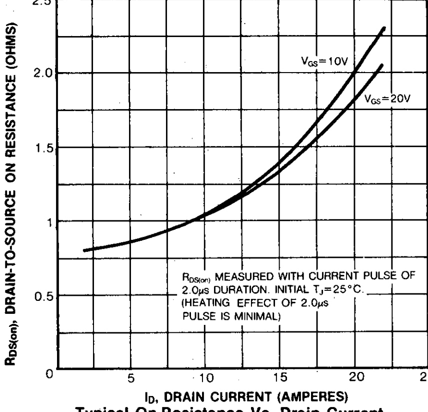
Normalized On-Resistance Vs. Temperature



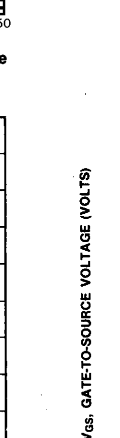
Typical Capacitance Vs. Drain to Source Voltage

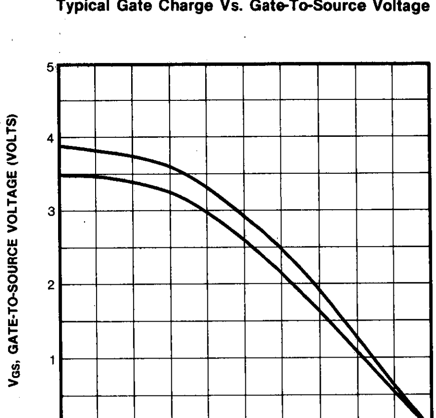
25
20
15
10
5
0
V_{GS}, GATE-TO-SOURCE VOLTAGE (VOLTS)
V_{DS}=80V
V_{DS}=200V
V_{DS}=320V
I_D=7A
8
16
24
32
40
Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage

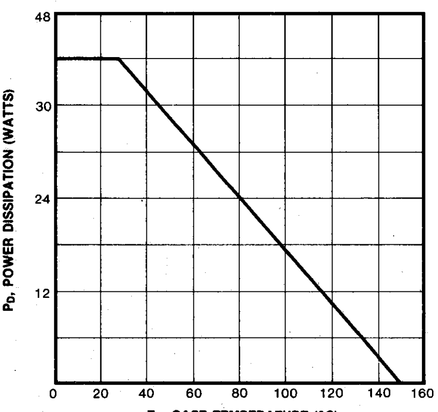


Typical On-Resistance Vs. Drain Current





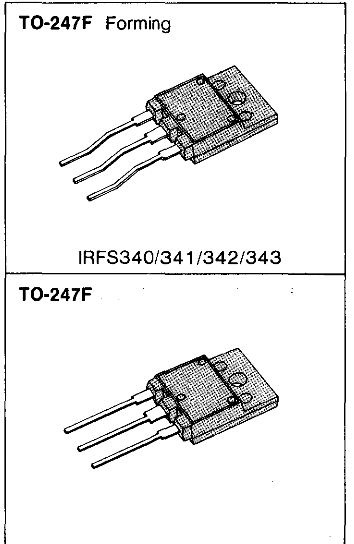
Typical Gate Charge Vs. Gate-To-Source Voltage



Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\,(ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS340	400V	0.55Ω	6.9A
IRFS341	350V	0.55Ω	6.9A
IRFS342	400V	0.80Ω	5.5A
IRFS343	350V	0.80Ω	5.5A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRFS340	IRFS341	IRFS342	IRFS343	Unit
Drain-Source Voltage	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	6.9	6.9	5.5	5.5	Adc
Continuous Drain Current T_C=100°C	I_D	4.3	4.3	3.4	3.4	Adc
Drain Current—Pulsed (3)	I_{DM}	40	40	33	33	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	227				mJ
Avalanche Current	I_{AS}	6.9				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	65 0.52				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=9.1mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS340/IRFS342	400	—	—	V	V_{GS}=0V
	IRFS341/IRFS343	350	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS340/IRFS341	10	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max}$. V_{GS}=10V
	IRFS342/IRFS340	83	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS340/IRFS341	—	—	0.55	Ω	V_{GS}=10V, I_D=5.2A
	IRFS342/IRFS343	—	—	0.80	Ω	
g_{fs}	Forward Transconductance (2)	5.8	—	—	℧	V_{DS}≥50V, I_D=5.2A
C_{iss}	Input Capacitance	—	1500	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	178	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	75	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	21	ns	V_{DD}=0.5BV_{DSS}, I_D=5.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	41	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	75	ns	
t_f	Fall Time	—	—	36	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	63	nC	V_{GS}=10V, I_D=12A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	9.0	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	32	nC	

THERMAL RESISTANCE

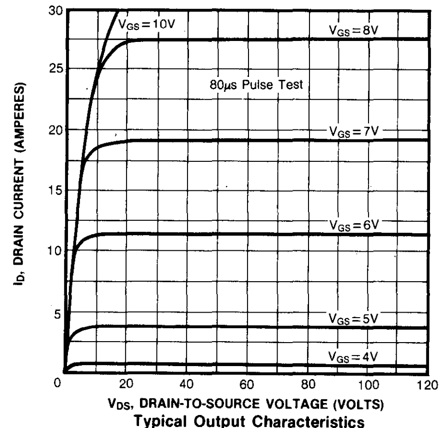
R_{thJC}	Junction-to-Case	—	—	1.92	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

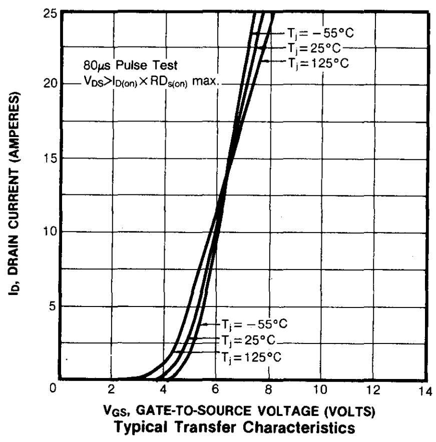
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS340/341	—	—	10	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS342/343	—	—	8.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS340/341	—	—	8.0	A	
	IRFS342/343	—	—	40	A	
V_{SD}	Diode Forward Voltage (2) IRFS340/341	—	—	2.0	V	T_C=25°C, I_S=10A, V_{GS}=0V
	IRFS342/343	—	—	1.9	V	T_C=25°C, I_S=8.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	370	—	ns	T_j=25°C, I_F=6.9A, dI_F/dt=100A/μS

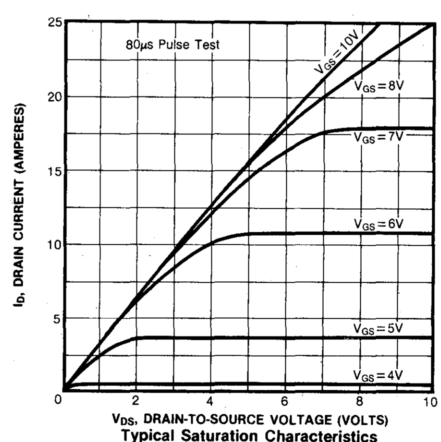
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



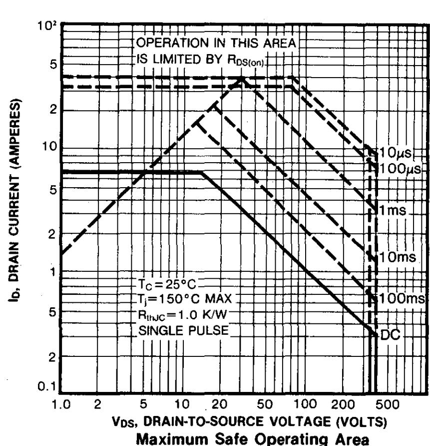
Typical Output Characteristics



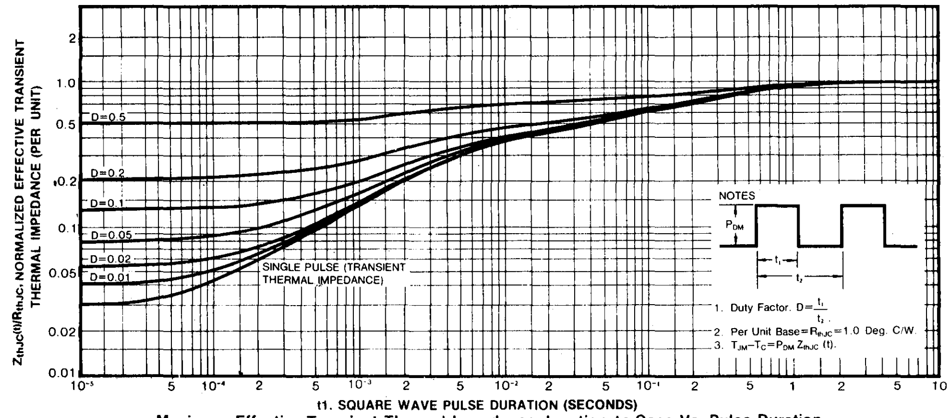
Typical Transfer Characteristics



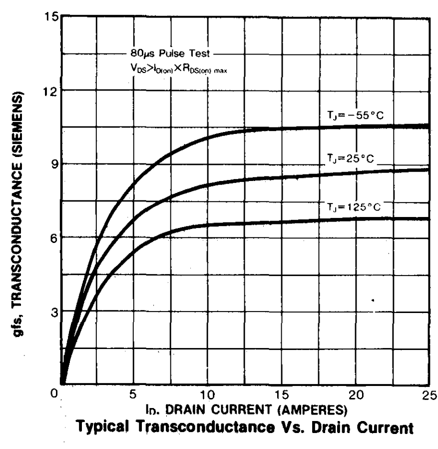
Typical Saturation Characteristics



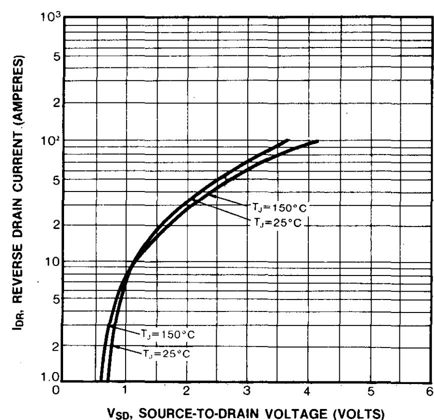
Maximum Safe Operating Area



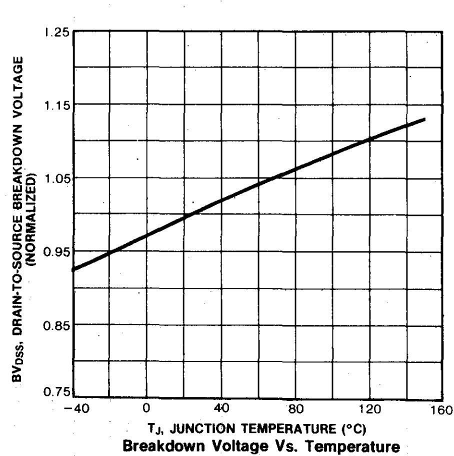
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



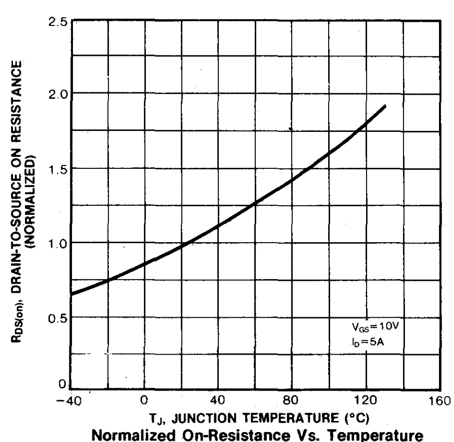
Typical Transconductance Vs. Drain Current



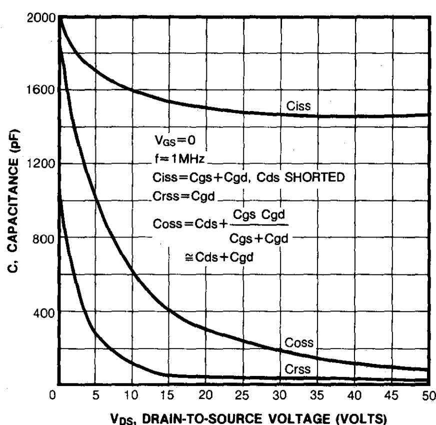
Typical Source—Drain Diode Forward Voltage



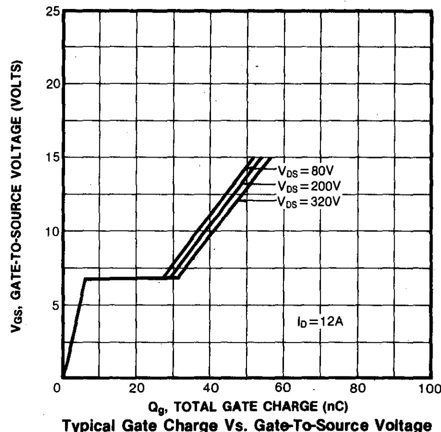
Breakdown Voltage Vs. Temperature



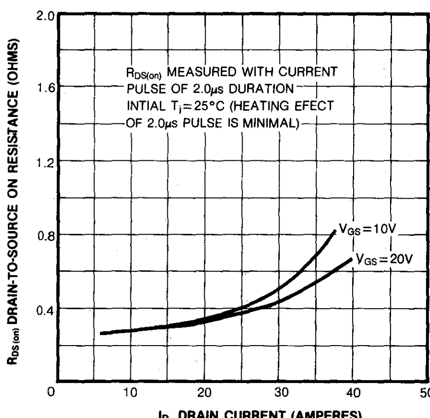
Normalized On-Resistance Vs. Temperature



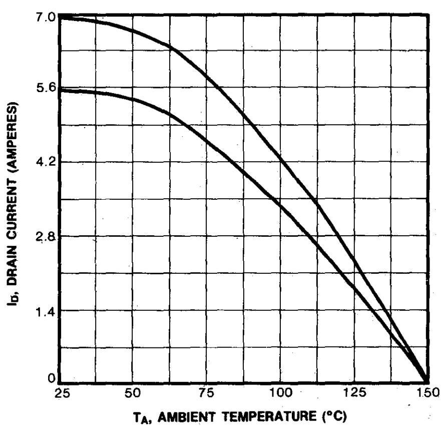
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage

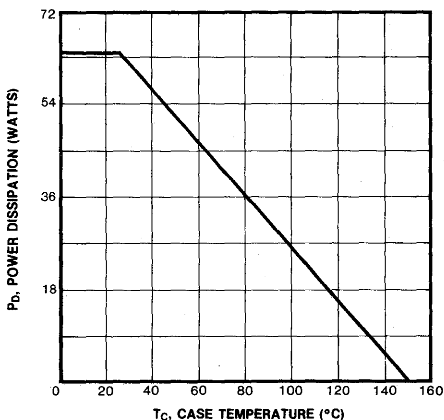


Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

4



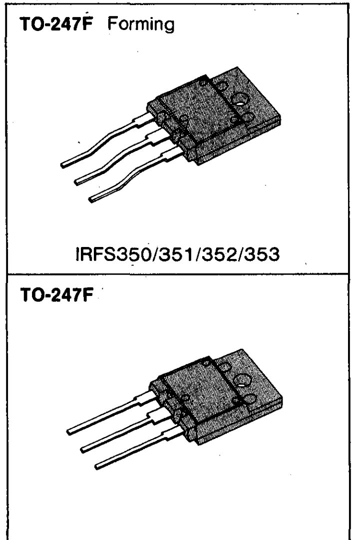
Power Vs. Temperature Derating Curve

IRFS350/351/352/353

N-CHANNEL POWER MOSFETS

FEATURES

- Lower $R_{DS(ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS350	400V	0.3Ω	10.4A
IRFS351	350V	0.3Ω	10.4A
IRFS352	400V	0.4Ω	9.0A
IRFS353	350V	0.4Ω	9.0A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS350	IRFS351	IRFS352	IRFS353	Unit
Drain-Source Voltage	V_{DSS}	400	350	400	350	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	400	350	400	350	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	10.4	10.4	9.0	9.0	Adc
Continuous Drain Current T_C=100°C	I_D	6.2	6.2	5.5	5.5	Adc
Drain Current—Pulsed (3)	I_{DM}	60	60	52	52	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	227				mJ
Avalanche Current	I_{AS}	10.4				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	70 0.56				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=17mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS350/IRFS352	400	—	—	V	V_{GS}=0V
	IRFS351/IRFS353	350	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS350/IRFS351	15	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS352/IRFS350	13	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS350/IRFS351	—	—	0.3	Ω	V_{GS}=10V, I_D=8.0A
	IRFS352/IRFS353	—	—	0.4	Ω	
g_{fs}	Forward Transconductance (2)	8.0	—	—	℧	V_{DS}≥50V, I_D=8.0A
C_{iss}	Input Capacitance	—	2980	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	338	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	150	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	V_{DD}=0.5BV_{DSS}, I_D=8.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	65	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	150	ns	
t_f	Fall Time	—	—	75	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	120	nC	V_{GS}=10V, I_D=18A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	14	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	59	—	nC	

THERMAL RESISTANCE

R_{thJC}	Junction-to-Case	—	—	1.78	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

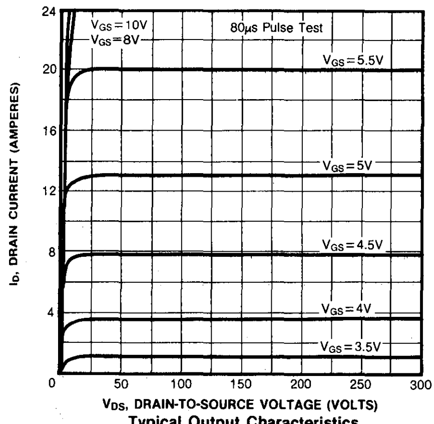
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

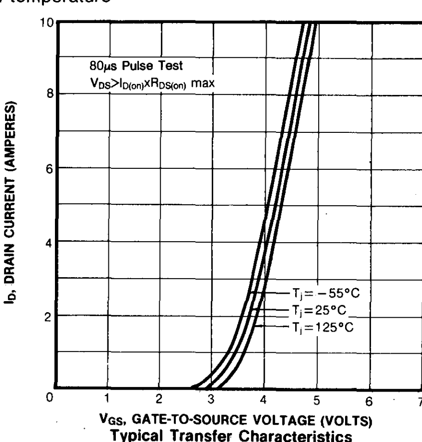
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS350/351	—	—	15	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS352/353	—	—	13	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS350/351	—	—	60	A	
	IRFS352/353	—	—	52	A	
V_{SD}	Diode Forward Voltage (2) IRFS350/351	—	—	1.6	V	$T_C=25°C$, $I_S=15A$, $V_{GS}=0V$
	IRFS352/353	—	—	1.5	V	$T_C=25°C$, $I_S=13A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	1000	—	ns	$T_j=150°C$, $I_F=10.4A$, $dI_F/dt=100A/\mu S$

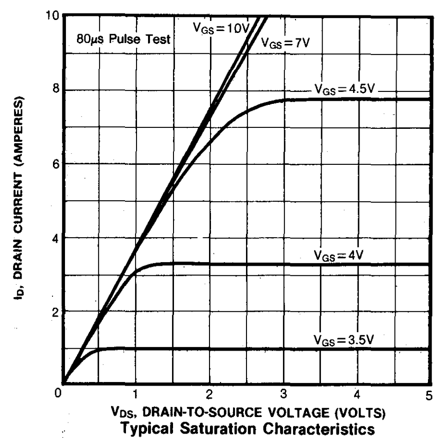
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



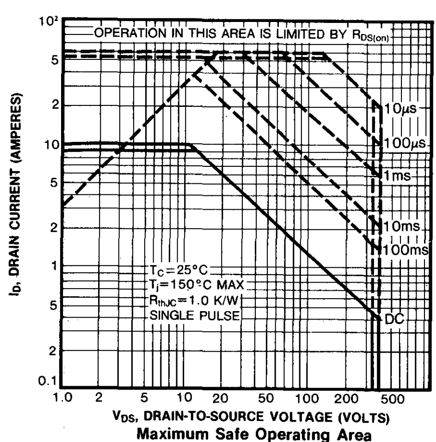
Typical Output Characteristics



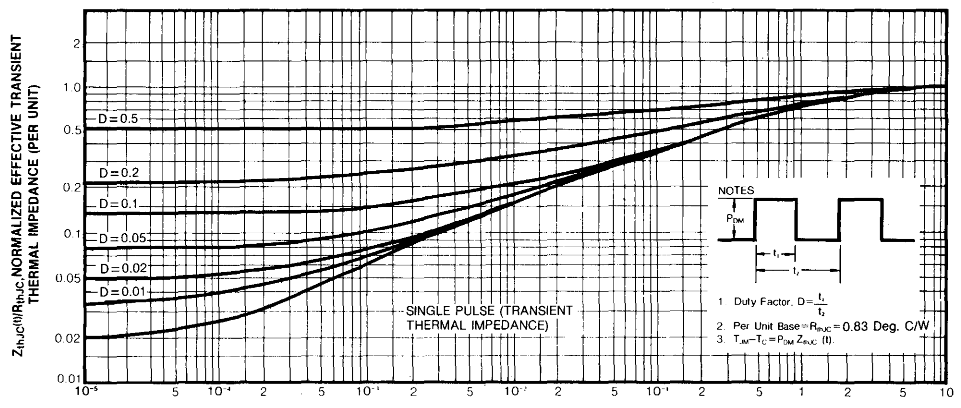
Typical Transfer Characteristics



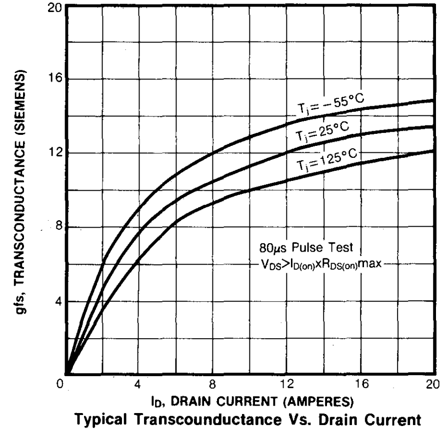
Typical Saturation Characteristics



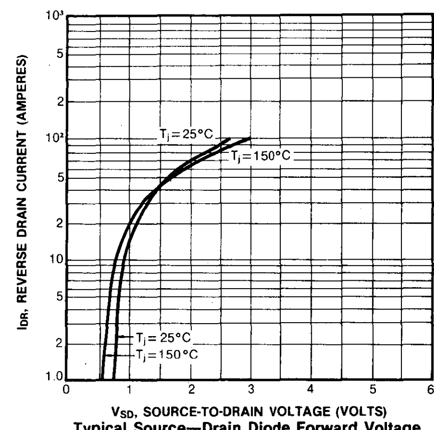
Maximum Safe Operating Area



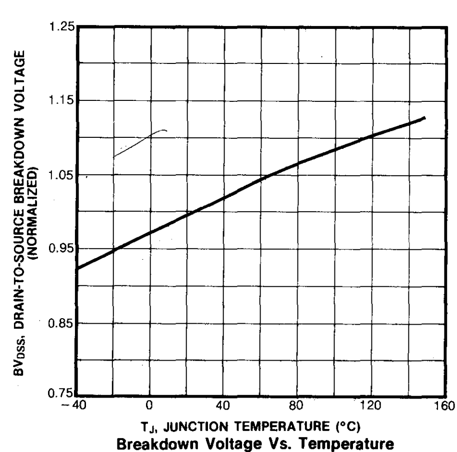
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



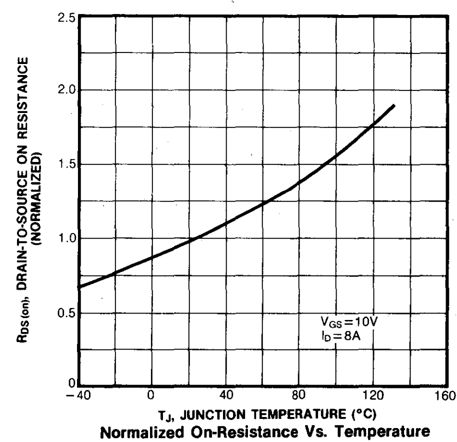
Typical Transcounductance Vs. Drain Current



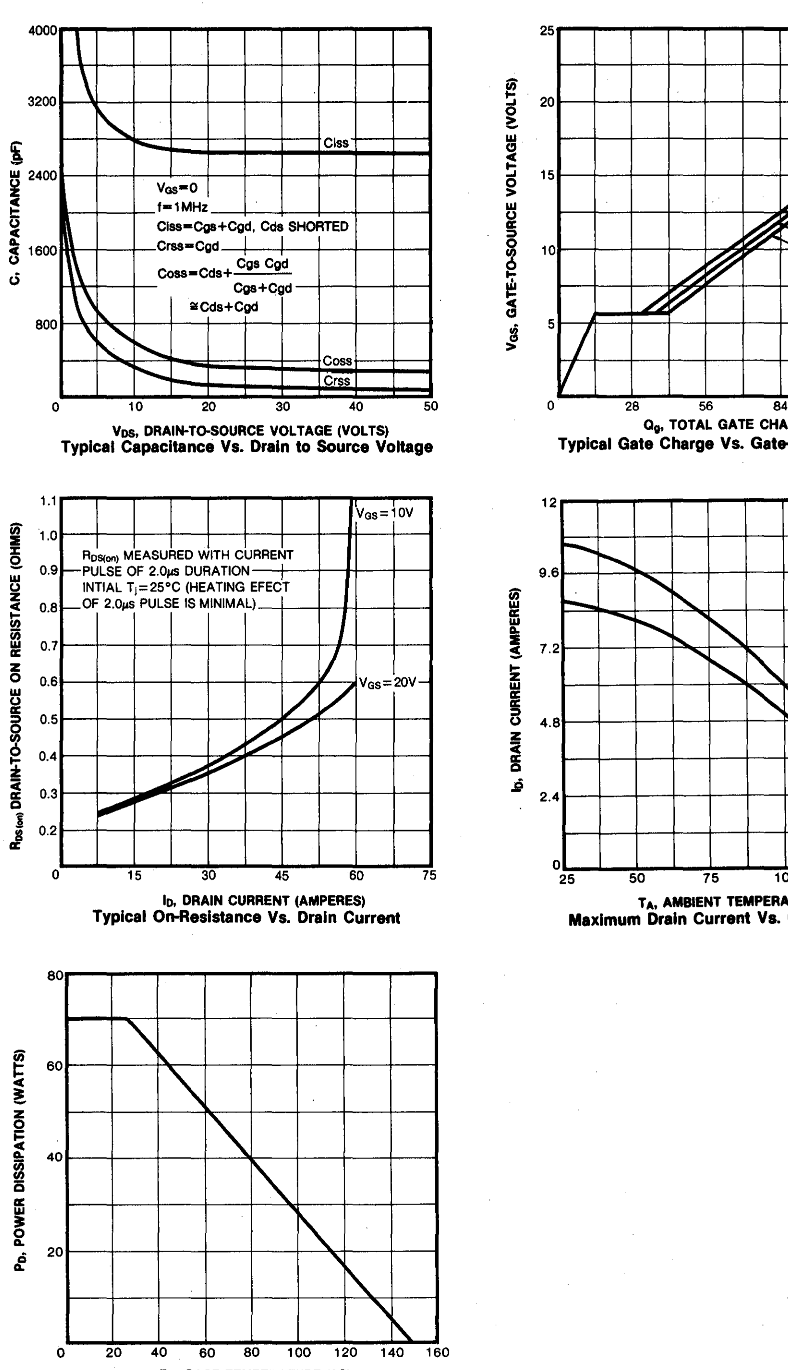
Typical Source—Drain Diode Forward Voltage



Breakdown Voltage Vs. Temperature



Normalized On-Resistance Vs. Temperature



Typical Capacitance Vs. Drain to Source Voltage

Typical Gate Charge Vs. Gate-To-Source Voltage

Typical On-Resistance Vs. Drain Current

Maximum Drain Current Vs. Case Temperature

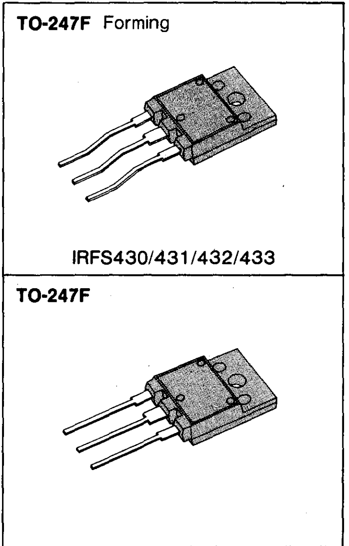
Power Vs. Temperature Derating Curve

IRFS430/431/432/433

N-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS(ON)}$ at high voltage**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS430	500V	1.5Ω	3.1A
IRFS431	450V	1.5Ω	3.1A
IRFS432	500V	2.0Ω	2.8A
IRFS433	450V	2.0Ω	2.8A

4

MAXIMUM RATINGS

Characteristic	Symbol	IRFS430	IRFS431	IRFS432	IRFS433	Unit
Drain-Source Voltage	V_{DSS}	500	450	500	450	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	500	450	500	450	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	3.1	3.1	2.8	2.8	Adc
Continuous Drain Current T_C=100°C	I_D	2.0	2.0	1.7	1.7	Adc
Drain Current—Pulsed (3)	I_{DM}	18	18	16	16	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	132				mJ
Avalanche Current	I_{AS}	3.1				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.34				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS430/IRFS432	500	—	—	V	V_{GS}=0V
	IRFS431/IRFS433	450	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS430/IRFS431	4.5	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS432/IRFS430	4.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS430/IRFS431	—	—	1.5	Ω	V_{GS}=10V, I_D=2.5A
	IRFS432/IRFS433	—		2.0	Ω	
g_{fs}	Forward Transconductance (2)	2.5	—	—	℧	V_{DS}≥50V, I_D=2.5A
C_{iss}	Input Capacitance	—	780	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	86	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	38	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	17	ns	V_{DD}=0.5BV_{DSS}, I_D=2.5A, Z_O=15Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	23	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	53	ns	
t_f	Fall Time	—	—	23	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	32	nC	V_{GS}=10V, I_D=6.0A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	4.8	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	17	nC	

THERMAL RESISTANCE

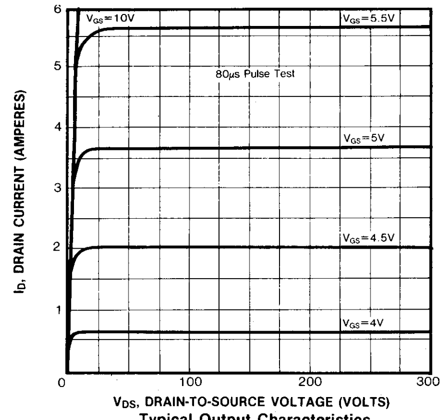
R_{thJC}	Junction-to-Case	—	—	2.97	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

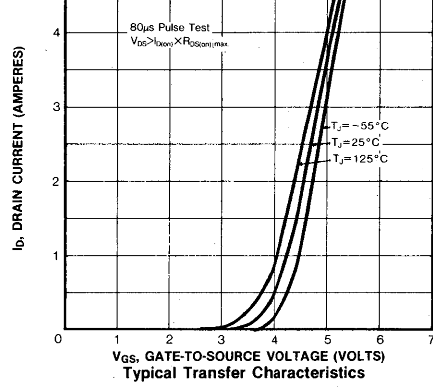
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS430/431	—	—	4.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS432/433	—	—	4.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS430/431	—	—	18	A	
	IRFS432/433	—	—	16	A	
V_{SD}	Diode Forward Voltage (2) IRFS430/431	—	—	1.6	V	$T_C=25°C$, $I_S=4.5A$, $V_{GS}=0V$
	IRFS432/433	—	—	1.5	V	$T_C=25°C$, $I_S=4.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	370	—	ns	$T_j=25°C$, $I_F=3.1A$, $dI_F/dt=100A/\mu S$

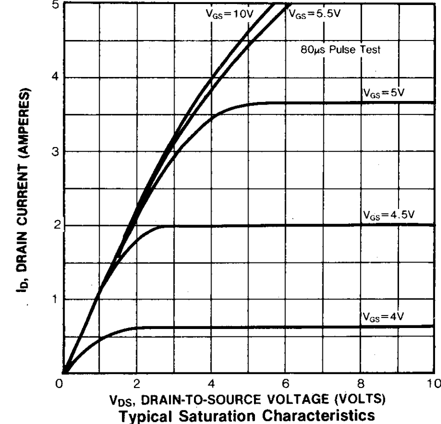
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



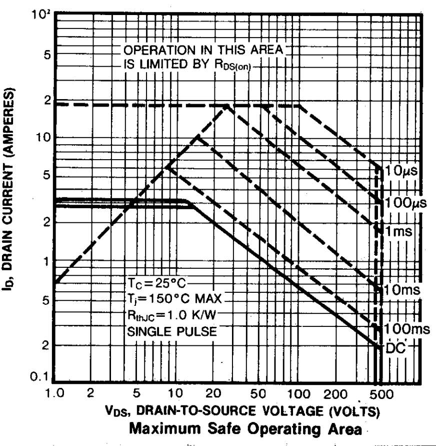
Typical Output Characteristics



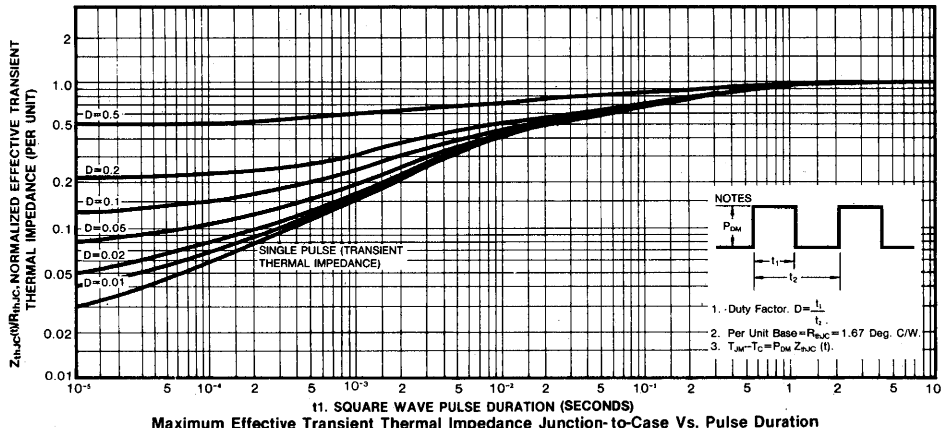
Typical Transfer Characteristics



Typical Saturation Characteristics

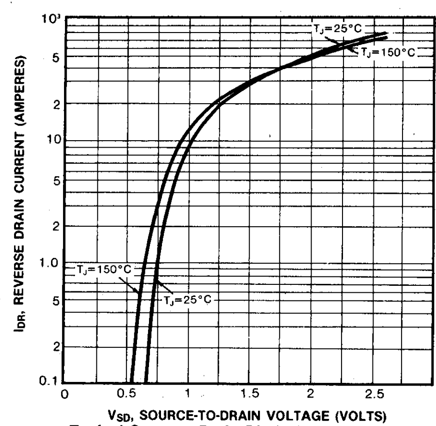


Maximum Safe Operating Area

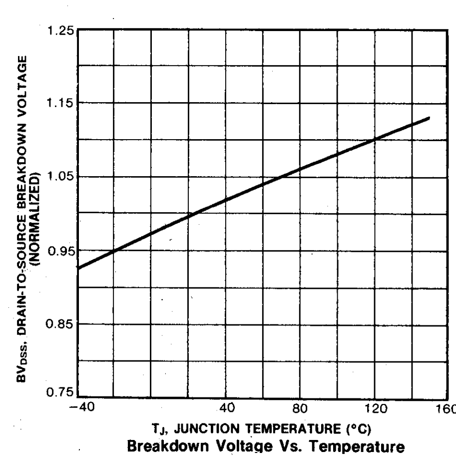


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

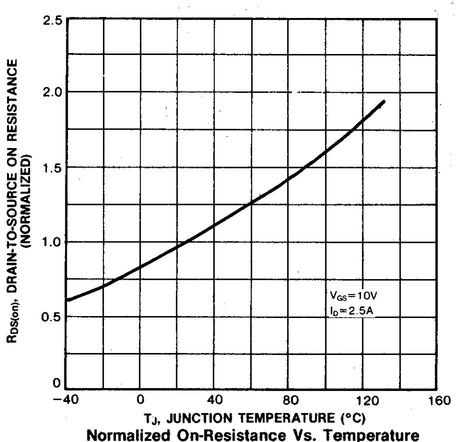
Typical Transcounductance Vs. Drain Current



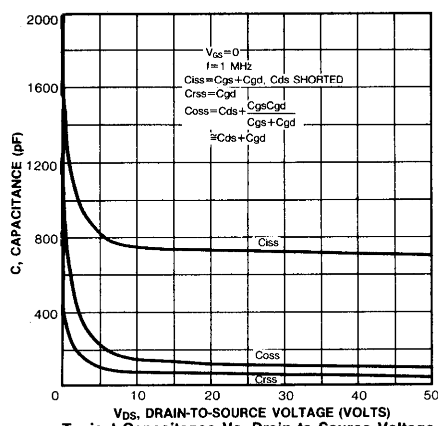
Typical Source—Drain Diode Forward Voltage



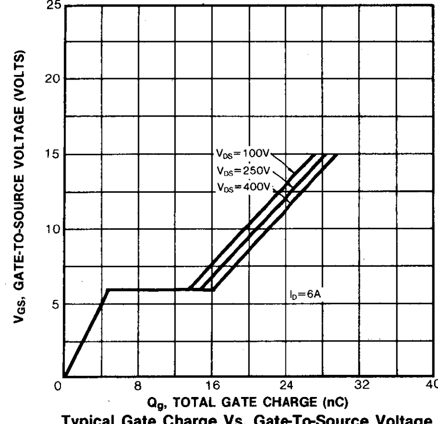
Breakdown Voltage Vs. Temperature



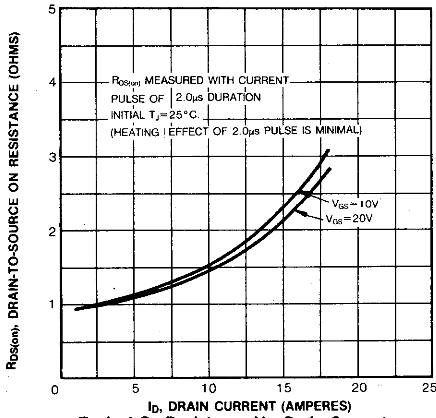
Normalized On-Resistance Vs. Temperature



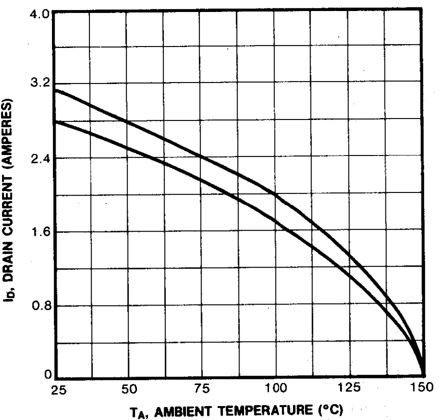
Typical Capacitance Vs. Drain to Source Voltage



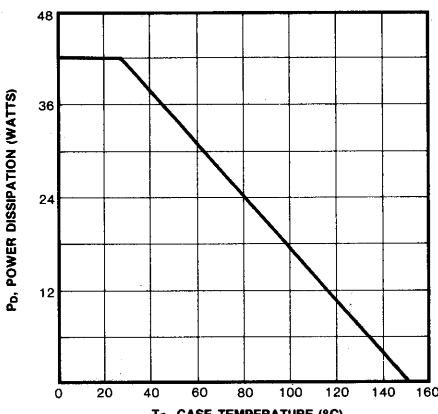
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



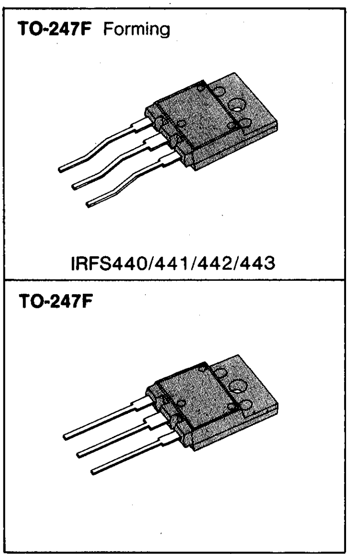
Power Vs. Temperature Derating Curve

4

IRFS440/441/442/443

FEATURES

- Lower $R_{DS\ (ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS440	500V	0.85Ω	5.5A
IRFS441	450V	0.85Ω	5.5A
IRFS442	500V	1.10Ω	4.8A
IRFS443	450V	1.10Ω	4.8A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS440	IRFS441	IRFS442	IRFS443	Unit
Drain-Source Voltage	V_{DSS}	500	450	500	450	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	500	450	500	450	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	5.5	5.5	4.8	4.8	Adc
Continuous Drain Current T_C=100°C	I_D	3.4	3.4	2.7	2.7	Adc
Drain Current—Pulsed (3)	I_{DM}	32	32	28	28	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	222				mJ
Avalanche Current	I_{AS}	5.5				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	65 0.52				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=4mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS440/IRFS442	500	—	—	V	V_{GS}=0V
	IRFS441/IRFS443	450	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS440/IRFS441	8.0	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS442/IRFS440	7.0	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS440/IRFS441	—		0.85	Ω	V_{GS}=10V, I_D=4.0A
	IRFS442/IRFS443	—		1.1	Ω	
g_{fs}	Forward Transconductance (2)	4.0	—	—	℧	V_{DS}≥50V, I_D=4.0A
C_{iss}	Input Capacitance	—	1510	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	154	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	60	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	21	ns	V_{DD}=0.5BV_{DSS}, I_D=40A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	35	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	74	ns	
t_f	Fall Time	—	—	30	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	63	nC	V_{GS}=10V, I_D=10A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	9.3	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	34	nC	

THERMAL RESISTANCE

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	1.92	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

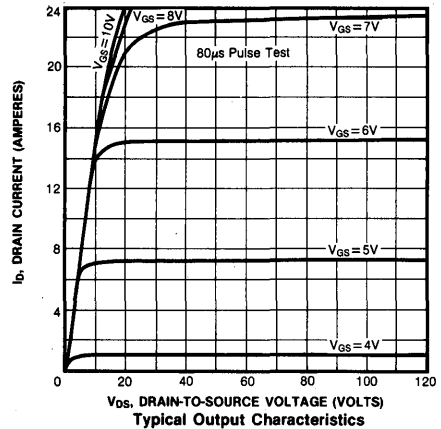
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

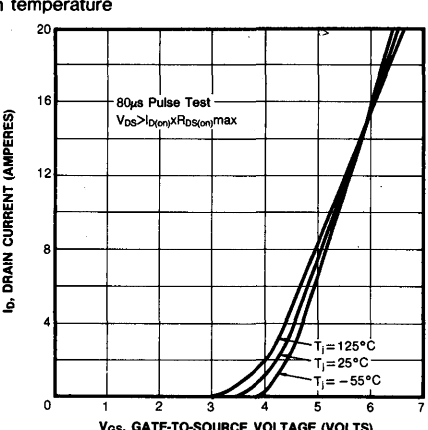
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS440/441	—	—	8.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS442/443	—	—	7.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS440/441	—	—	32	A	
	IRFS442/443	—	—	28	A	
V_{SD}	Diode Forward Voltage (2) IRFS440/441	—	—	2.0	V	T_C=25°C, I_S=8.0A, V_{GS}=0V
	IRFS442/443	—	—	1.9	V	T_C=25°C, I_S=7.0A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	460	—	ns	T_j=25°C, I_F=55A, dI_F/dt=100A/μS

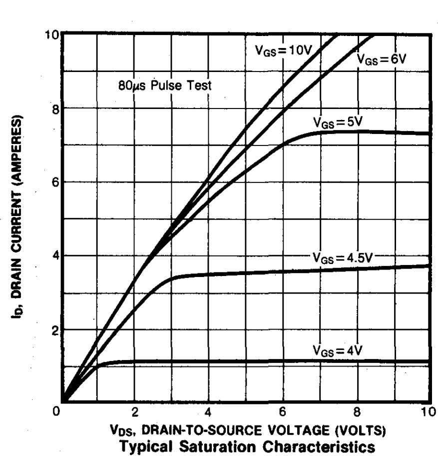
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



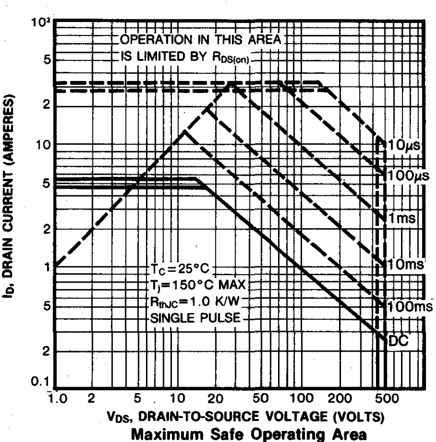
Typical Output Characteristics



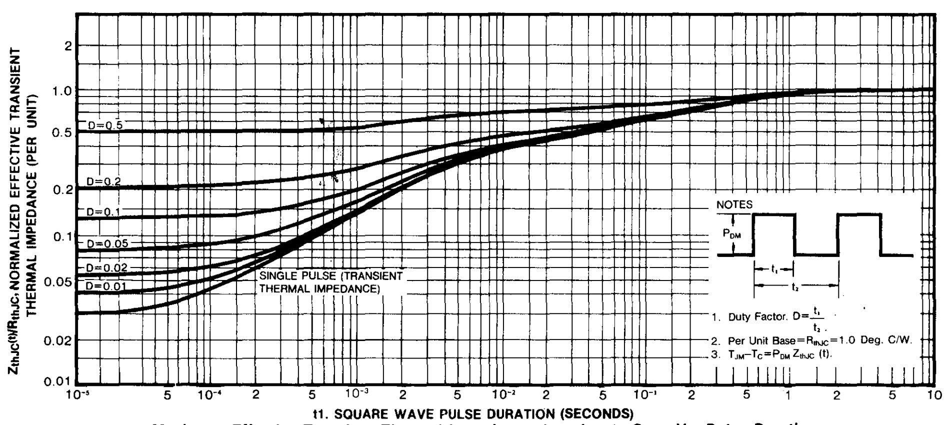
Typical Transfer Characteristics



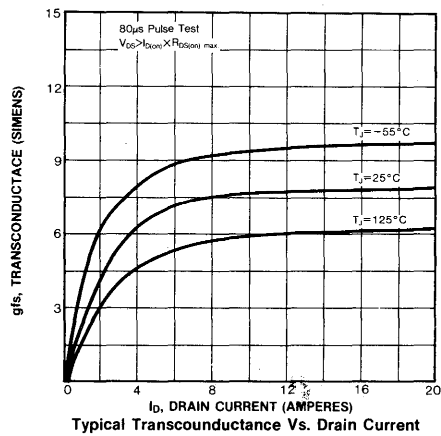
Typical Saturation Characteristics



Maximum Safe Operating Area

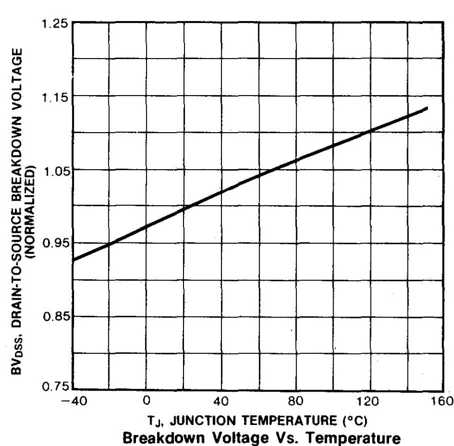


Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

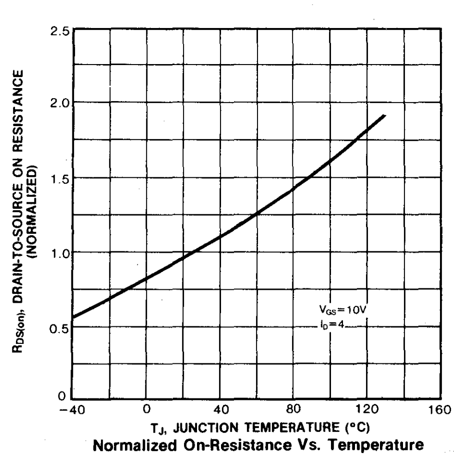


Typical Transcounductance Vs. Drain Current

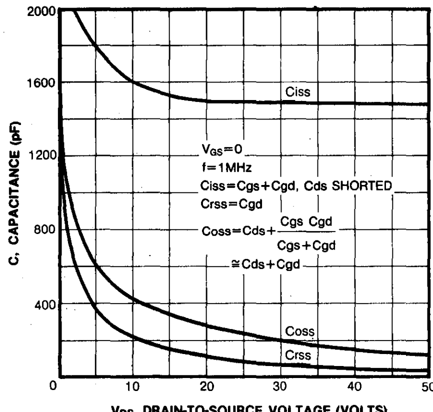
Typical Source—Drain Diode Forward Voltage



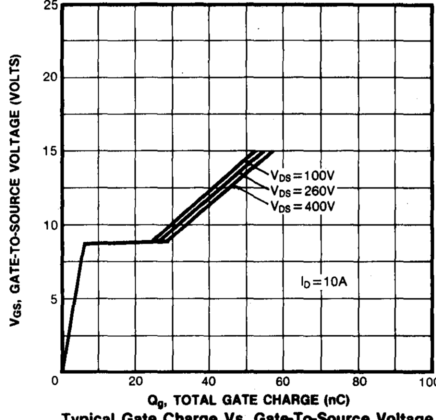
Breakdown Voltage Vs. Temperature



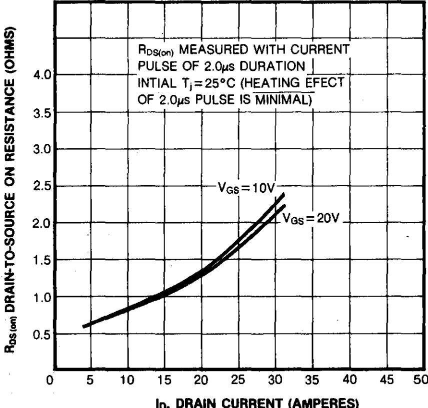
Normalized On-Resistance Vs. Temperature



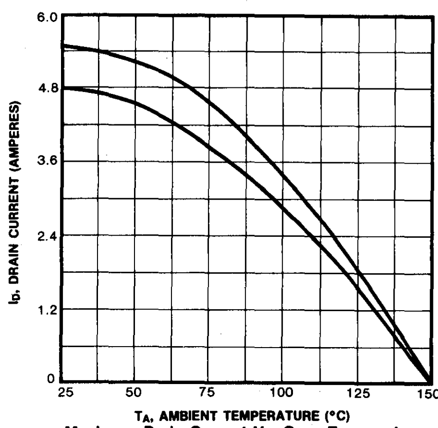
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

P_D, POWER DISSIPATION (WATTS)

72 54 36 18

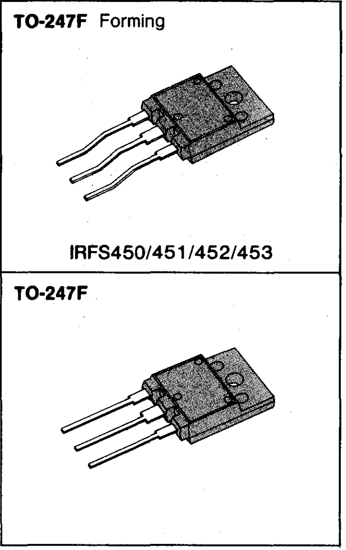
0 20 40 60 80 100 120 140 160

T_C, CASE TEMPERATURE (°C)

Power Vs. Temperature Derating Curve

FEATURES

- Lower $R_{DS\ (ON)}$ at high voltage
- Improved inductive ruggedness
- Fast switching times
- Rugged polysilicon gate cell structure
- Lower input capacitance
- Extended safe operating area
- Improved high temperature reliability



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS450	500V	0.40Ω	9.0A
IRFS451	450V	0.40Ω	9.0A
IRFS452	500V	0.50Ω	8.3A
IRFS453	450V	0.50Ω	8.3A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS450	IRFS451	IRFS452	IRFS453	Unit
Drain-Source Voltage	V_{DSS}	500	450	500	450	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	500	450	500	450	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	9.0	9.0	8.3	8.3	Adc
Continuous Drain Current T_C=100°C	I_D	5.5	5.5	4.8	4.8	Adc
Drain Current—Pulsed (3)	I_{DM}	52	52	48	48	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Single Pulsed Avalanche Energy (4)	E_{AS}	297				mJ
Avalanche Current	I_{AS}	9.0				A
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	70 0.56				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature
(4) L=7.0mH, V_{dd}=50V, R_G=25Ω, starting Tj=25°C

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS450/IRFS452	500	—	—	V	V_{GS}=0V
	IRFS451/IRFS453	450	—	—	V	I_D=250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=−20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS450/IRFS451	13	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=10V
	IRFS452/IRFS450	12	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS450/IRFS451	—	—	0.4	Ω	V_{GS}=10V, I_D=7.0A
	IRFS452/IRFS453	—		0.5	Ω	
g_{fs}	Forward Transconductance (2)	6.0	—	—	℧	V_{DS}≥50V, I_D=7.0A
C_{iss}	Input Capacitance	—	2950	—	pF	V_{GS}=0V, V_{DS}=25V, f=1.0MHz
C_{oss}	Output Capacitance	—	290	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	118	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	V_{DD}=0.5BV_{DSS}, I_D=7.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	50	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	150	ns	
t_f	Fall Time	—	—	70	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	120	nC	V_{GS}=10V, I_D=16A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	11	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	66	—	nC	

THERMAL RESISTANCE

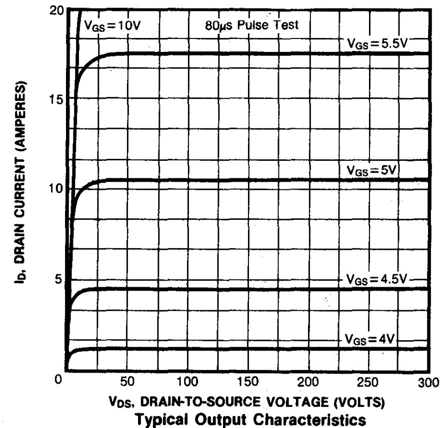
R_{thJC}	Junction-to-Case	—	—	1.78	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

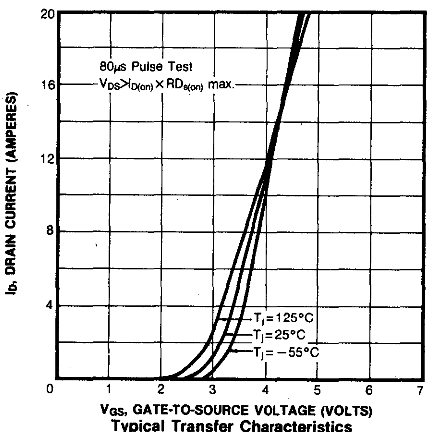
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS450/451	—	—	13	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS452/453	—	—	12	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS450/451	—	—	52	A	
	IRFS452/453	—	—	48	A	
V_{SD}	Diode Forward Voltage (2) IRFS450/451	—	—	1.4	V	T_C=25°C; I_S=13A, V_{GS}=0V
	IRFS452/453	—	—	1.3	V	T_C=25°C, I_S=12A, V_{GS}=0V
t_{rr}	Reverse Recovery Time	—	1300	—	ns	T_j=25°C, I_F=9.0A, dI_F/dt=100A/μS

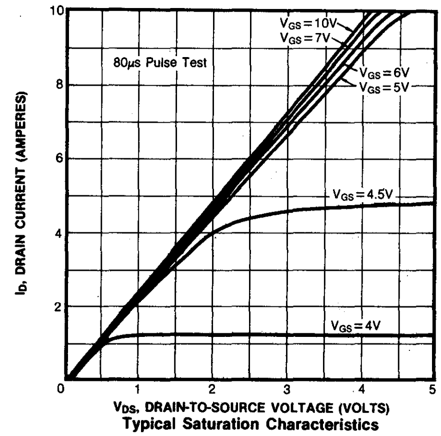
Notes: (1) T_J=25°C to 150°C (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



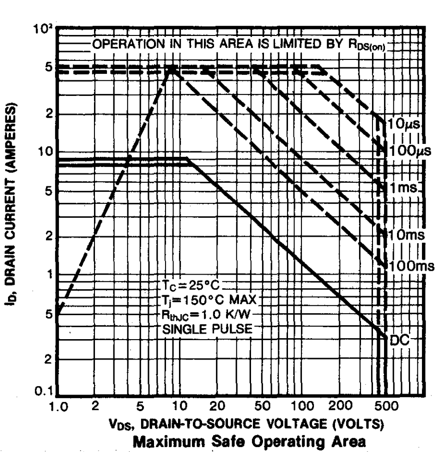
Typical Output Characteristics



Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area

t1. SQUARE WAVE PULSE DURATION (SECONDS)

Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

NOTES

1. Duty Factor, $D = \frac{t_1}{t_2}$
2. Per Unit Base $= R_{thJC} = 0.83$ Deg. C/W
3. $T_{JM} - T_C = P_{DM} Z_{thJC}(t)$.

I_D, DRAIN CURRENT (AMPERES)

Typical Transcounductance Vs. Drain Current

V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

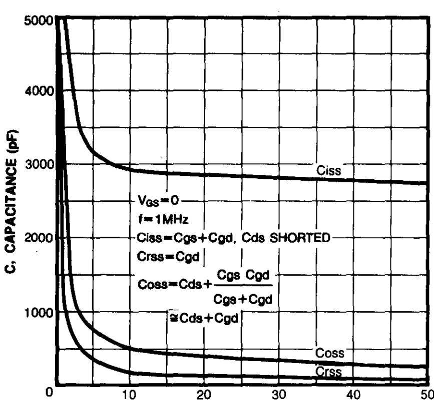
Typical Source—Drain Diode Forward Voltage

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

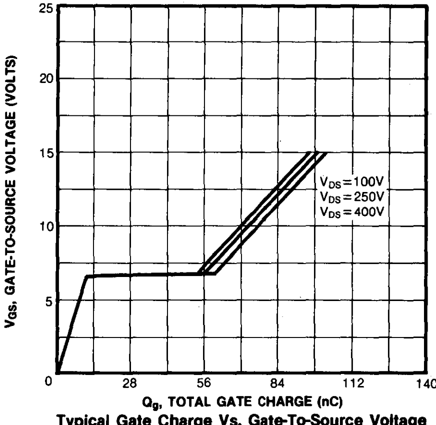
T_J, JUNCTION TEMPERATURE (°C)

Normalized On-Resistance Vs. Temperature



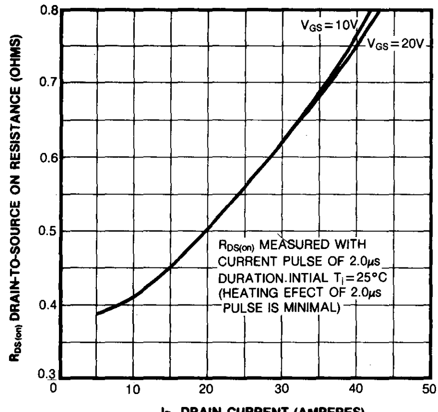
V_{DS}, DRAIN-TO-SOURCE VOLTAGE (VOLTS)

Typical Capacitance Vs. Drain to Source Voltage



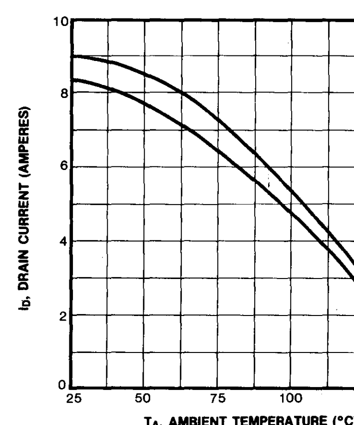
Q_g, TOTAL GATE CHARGE (nC)

Typical Gate Charge Vs. Gate-To-Source Voltage



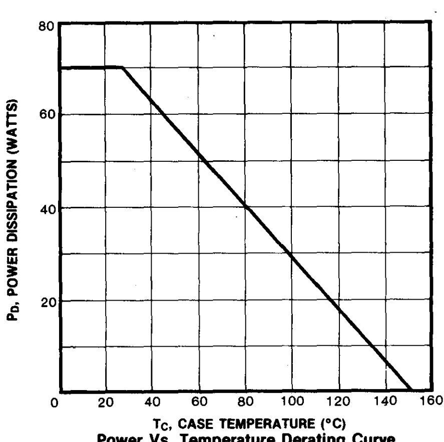
I_D, DRAIN CURRENT (AMPERES)

Typical On-Resistance Vs. Drain Current



T_A, AMBIENT TEMPERATURE (°C)

Maximum Drain Current Vs. Case Temperature



T_C, CASE TEMPERATURE (°C)

Power Vs. Temperature Derating Curve

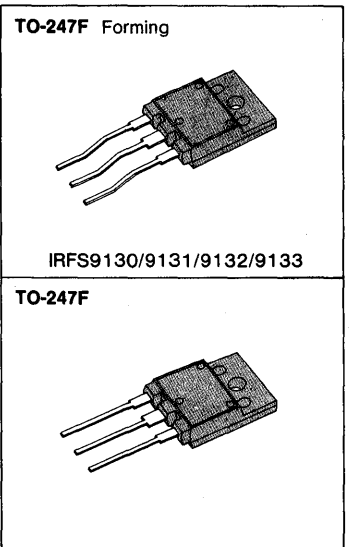
4

IRFS9130/9131/9132/9133

P-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS\,(ON)}$ at high voltage**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS9130	−100V	0.30Ω	−8.3A
IRFS9131	−60V	0.30Ω	−8.3A
IRFS9132	−100V	0.40Ω	−6.9A
IRFS9133	−60V	0.40Ω	−6.9A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS9130	IRFS9131	IRFS9132	IRFS9133	Unit
Drain-Source Voltage	V_{DSS}	−100	−60	−100	−60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−60	−100	−60	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−8.3	−8.3	−6.9	−6.9	Adc
Continuous Drain Current T_C=100°C	I_D	−5.0	−5.0	−4.4	−4.4	Adc
Drain Current—Pulsed (3)	I_{DM}	−48	−48	−40	−40	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.34				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS9130/IRFS9132	-100	—	—	V	V_{GS}=0V
	IRFS9131/IRFS9133	-60	—	—	V	I_D=−250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS9130/IRFS9131	−12	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=−10V
	IRFS9132/IRFS9130	−10	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS9130/IRFS9131	—	—	0.3	Ω	V_{GS}=−10V, I_D=−6.5A
	IRFS9132/IRFS9133	—	—	0.4	Ω	
g_{fs}	Forward Transconductance (2)	2.0	—	—	℧	V_{DS}⩽−50V, I_D=−6.5A
C_{iss}	Input Capacitance	—	670	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	357	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	94	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	60	ns	V_{DD}=0.5BV_{DSS}, I_D=−6.5A, Z_O=50Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	140	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	140	ns	
t_f	Fall Time	—	—	140	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	45	nC	V_{GS}=−15V, I_D=−15A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	20	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	25	nC	

THERMAL RESISTANCE

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	2.97	K/W	
R_{thCS}	Case-to-Sink	—	2.97	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

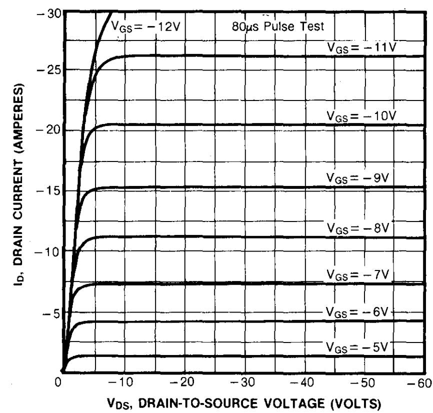
Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width⩽300μs, Duty Cycle⩽2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

4

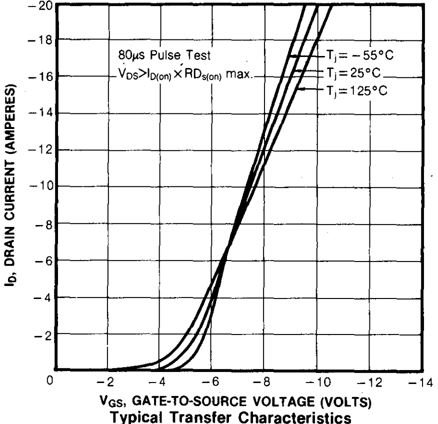
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS9130/9131	—	—	−12	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier (G, D, S)
	IRFS9132/9133	—	—	−10	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS9130/9131	—	—	−48	A	
	IRFS9132/9133	—	—	−40	A	
V_{SD}	Diode Forward Voltage (2) IRFS9130/9131	—	—	−6.3	V	$T_C=25°C$, $I_S=-12A$, $V_{GS}=0V$
	IRFS9132/9133	—	—	−6.0	V	$T_C=25°C$, $I_S=-10A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	300	—	ns	$T_j=150°C$, $I_F=-8.3A$, $dI_F/dt=100A/\mu S$

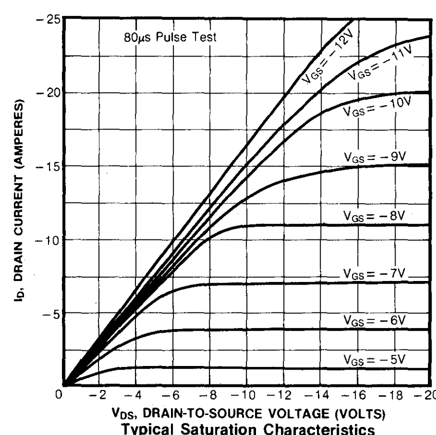
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



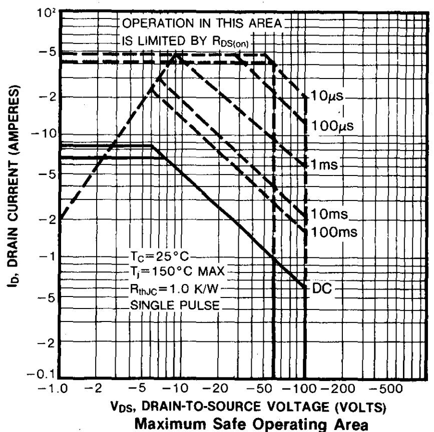
Typical Output Characteristics



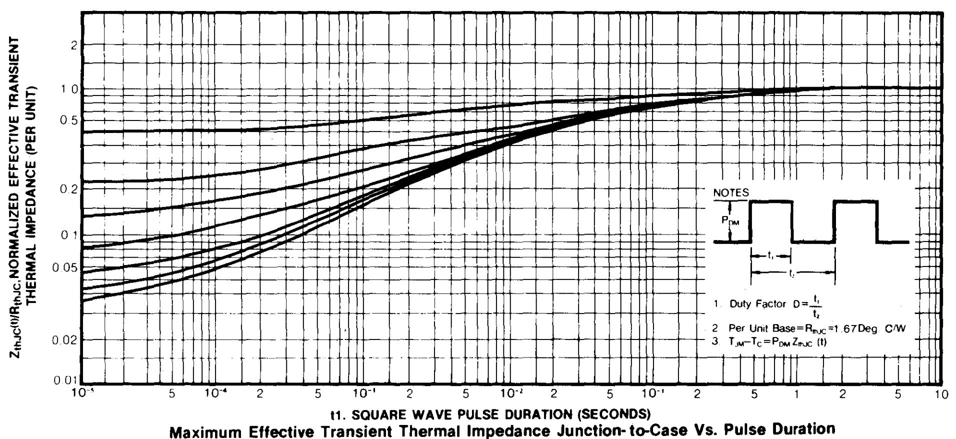
Typical Transfer Characteristics



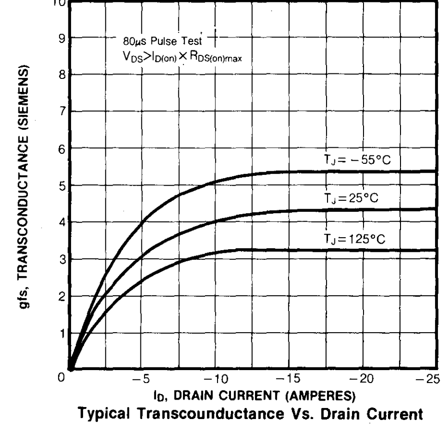
Typical Saturation Characteristics



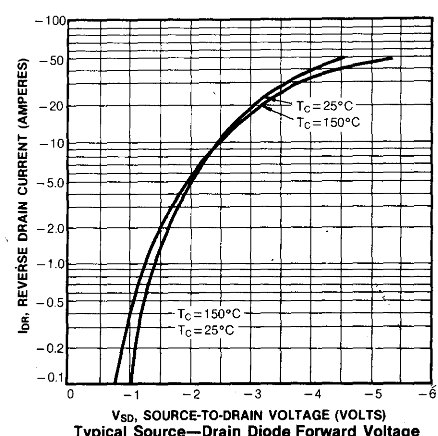
Maximum Safe Operating Area



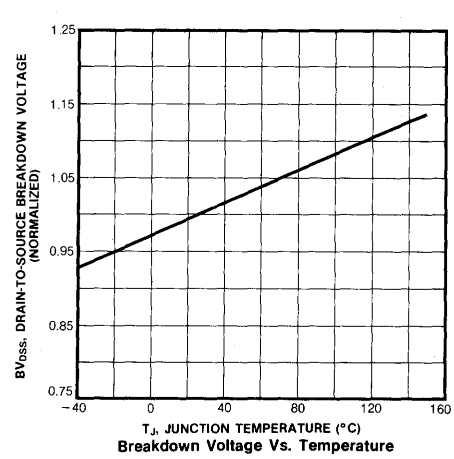
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



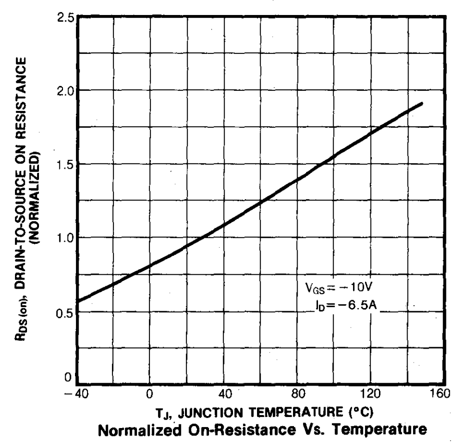
Typical Transcounductance Vs. Drain Current



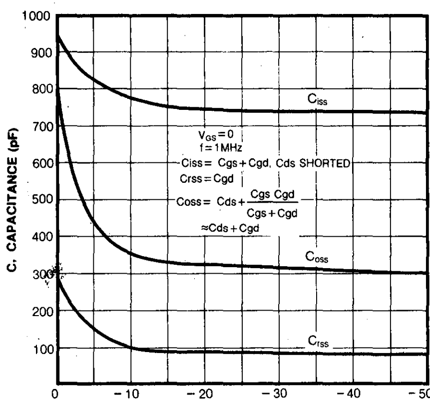
Typical Source—Drain Diode Forward Voltage



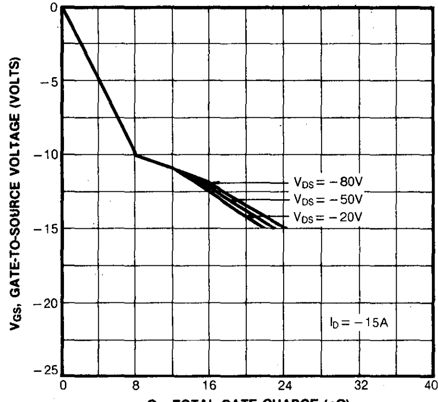
Breakdown Voltage Vs. Temperature



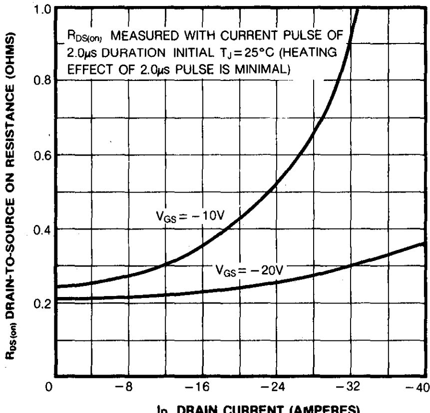
Normalized On-Resistance Vs. Temperature



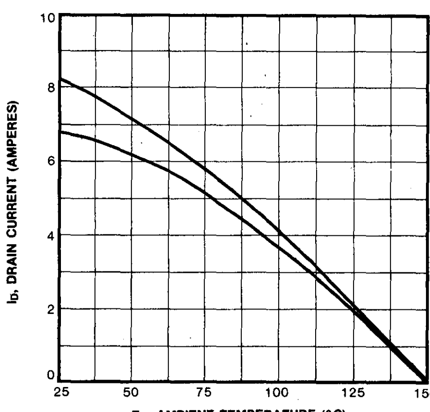
Typical Capacitance Vs. Drain to Source Voltage



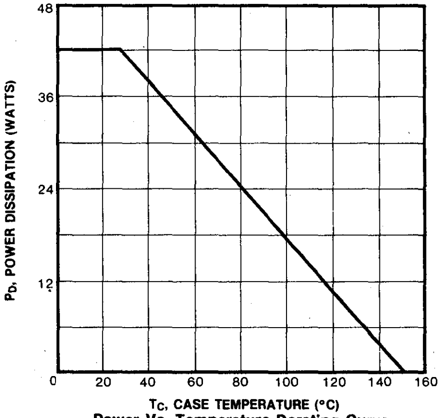
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



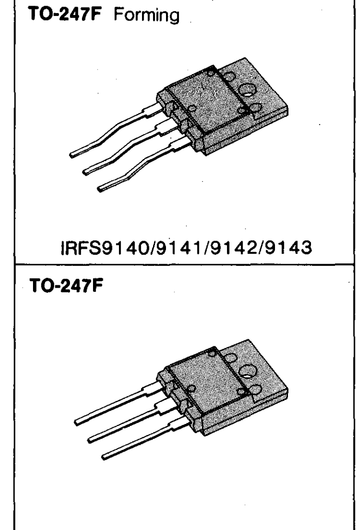
Power Vs. Temperature Derating Curve

IRFS9140/9141/9142/9143

P-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS(ON)}$ at high voltage**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS9140	−100V	0.2Ω	−13.2A
IRFS9141	−60V	0.2Ω	−13.2A
IRFS9142	−100V	0.3Ω	−10.4A
IRFS9143	−60V	0.3Ω	−10.4A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS9140	IRFS9141	IRFS9142	IRFS9143	Unit
Drain-Source Voltage	V_{DSS}	−100	−60	−100	−60	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−100	−60	−100	−60	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−13.2	−13.2	−10.4	−10.4	Adc
Continuous Drain Current T_C=100°C	I_D	−8.3	−8.3	−6.9	−6.9	Adc
Drain Current—Pulsed (3)	I_{DM}	−76	−76	−60	−60	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	65 0.52				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS9140/IRFS9142	-100	—	—	V	V_{GS}=0V
	IRFS9141/IRFS9143	-60	—	—	V	I_D=-250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=-250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	-100	nA	V_{GS}=-20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS9140/IRFS9141	-19	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=-10V
	IRFS9142/IRFS9140	-15	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS9140/IRFS9141	—	—	0.2	Ω	V_{GS}=-10V, I_D=-10A
	IRFS9142/IRFS9143	—	—	0.3	Ω	
g_{fs}	Forward Transconductance (2)	5.0	—	—	℧	V_{DS}≤-50V, I_D=-10A
C_{iss}	Input Capacitance	—	1552	—	pF	V_{GS}=0V, V_{DS}=-25V, f=1.0MHz
C_{oss}	Output Capacitance	—	232	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	120	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD}=0.5BV_{DSS}, I_D=-10A, Z_O=4.7Ω (MCSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	15	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	20	ns	
t_f	Fall Time	—	—	12	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	90	nC	V_{GS}=-15V, I_D=-24A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	30	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	60	nC	

THERMAL RESISTANCE

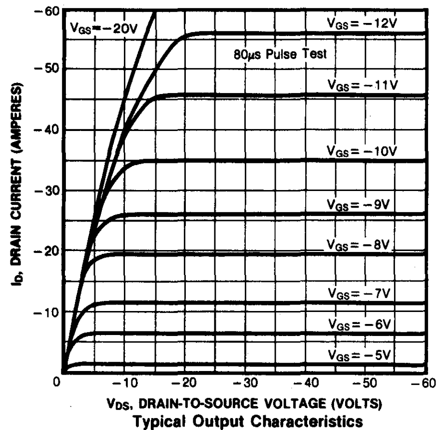
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	1.92	K/W	
R_{thCS}	Case-to-Sink	—	2.97	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

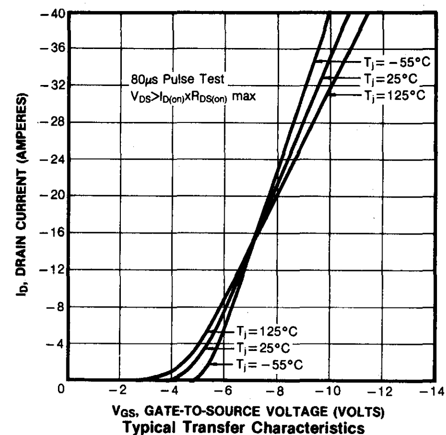
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS9140/9141	—	—	−19	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS9142/9143	—	—	−15	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS9140/9141	—	—	−76	A	
	IRFS9142/9143	—	—	−60	A	
V_{SD}	Diode Forward Voltage (2) IRFS9140/9141	—	—	−4.2	V	$T_C=25°C$, $I_S=-19A$, $V_{GS}=0V$
	IRFS9142/9143	—	—	−4.2	V	$T_C=25°C$, $I_S=-15A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	170	—	ns	$T_j=150°C$, $I_F=13.2A$, $dI_F/dt=100A/\mu S$

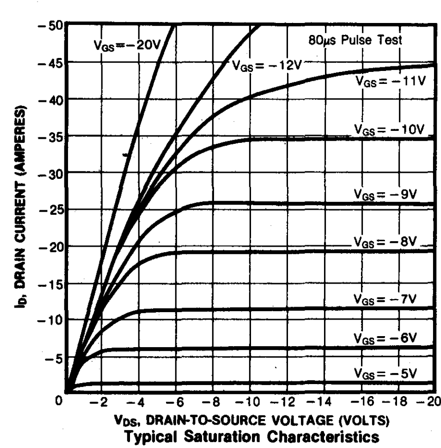
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



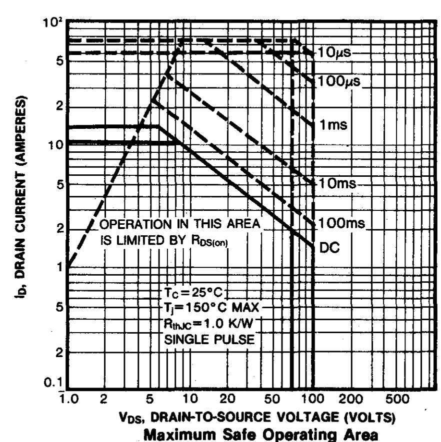
Typical Output Characteristics



Typical Transfer Characteristics

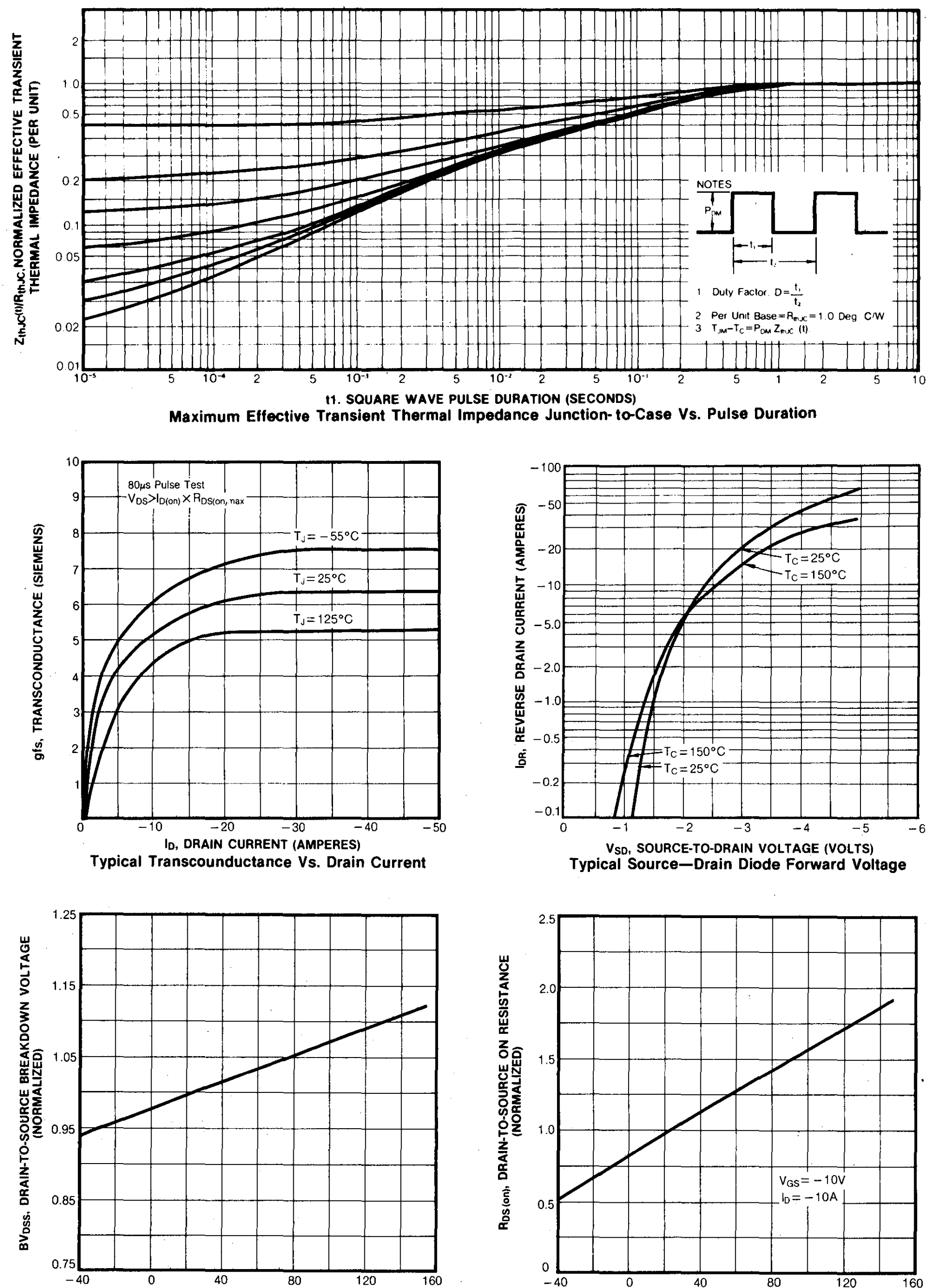


Typical Saturation Characteristics



Maximum Safe Operating Area

4



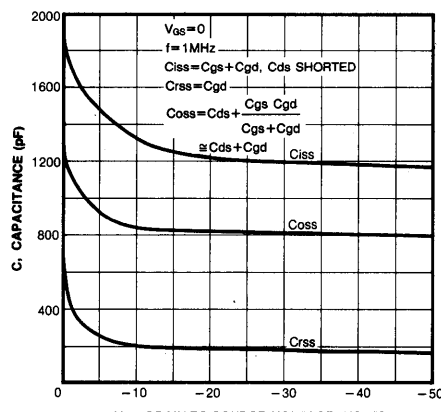
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

Typical Transcounductance Vs. Drain Current

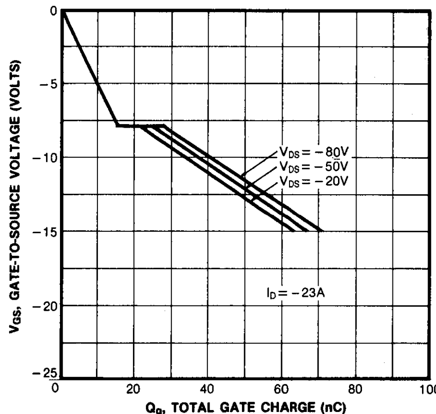
Typical Source—Drain Diode Forward Voltage

Breakdown Voltage Vs. Temperature

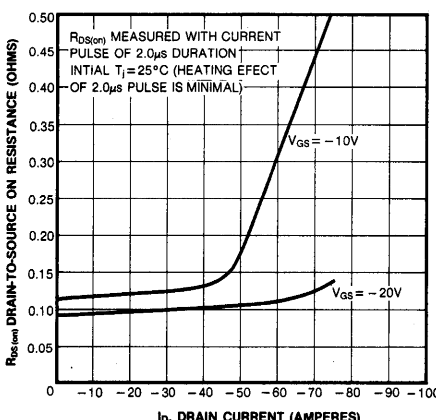
Normalized On-Resistance Vs. Temperature



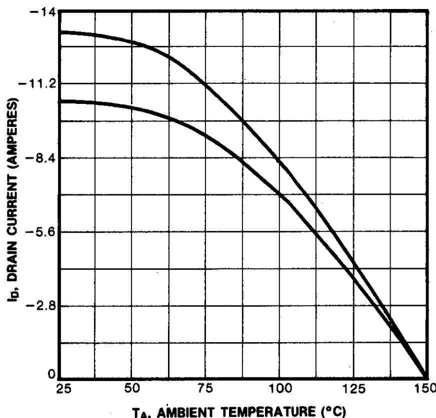
Typical Capacitance Vs. Drain to Source Voltage



Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature

PD, POWER DISSIPATION (WATTS)

72

54

36

18

0 20 40 60 80 100 120 140 160

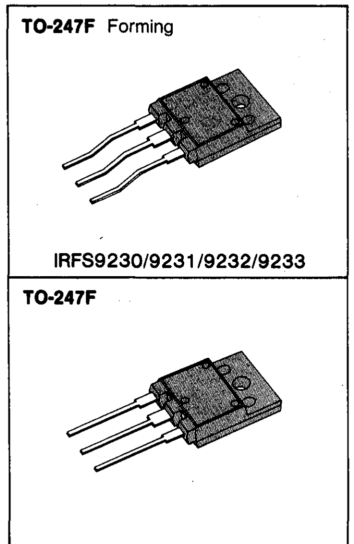
TC, CASE TEMPERATURE (°C)

Power Vs. Temperature Derating Curve

4

IRFS9230/9231/9232/9233

P-CHANNEL POWER MOSFETS



FEATURES

- **Lower $R_{DS(ON)}$ at high voltage**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS9230	−200V	0.8Ω	−4.5A
IRFS9231	−150V	0.8Ω	−4.5A
IRFS9232	−200V	1.2Ω	−3.8A
IRFS9233	−150V	1.2Ω	−3.8A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS9230	IRFS9231	IRFS9232	IRFS9233	Unit
Drain-Source Voltage	V_{DSS}	−200	−150	−200	−150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200	−150	−200	−150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−4.5	−4.5	−3.8	−3.8	Adc
Continuous Drain Current T_C=100°C	I_D	−2.7	−2.7	−2.4	−2.4	Adc
Drain Current—Pulsed (3)	I_{DM}	−26	−26	−22	−22	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	42 0.34				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS ($T_C=25°C$ unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS9230/IRFS9232	-200	—	—	V	$V_{GS}=0V$
	IRFS9231/IRFS9233	-150	—	—	V	$I_D=-250\mu A$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS}=V_{GS}$, $I_D=-250\mu A$
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	$V_{GS}=20V$
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	$V_{GS}=-20V$
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating $V_{GS}=0V$
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, $V_{GS}=0V$, $T_C=125°C$
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS9230/IRFS9231	-6.5	—	—	A	$V_{DS}>I_{D(on)}\times R_{DS(on)max.}$ $V_{GS}=-10V$
	IRFS9232/IRFS9233	-5.5	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS9230/IRFS9231	—	—	0.8	Ω	$V_{GS}=10V$, $I_D=-3.5A$
	IRFS9232/IRFS9233	—	—	1.2	Ω	
g_{fs}	Forward Transconductance (2)	2.2	—	—	℧	$V_{DS}\leqslant-50V$, $I_D=-3.5A$
C_{iss}	Input Capacitance	—	610	—	pF	$V_{GS}=0V$, $V_{DS}=-25V$, f=1.0MHz
C_{oss}	Output Capacitance	—	204	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	55	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	50	ns	$V_{DD}=0.5BV_{DSS}$, $I_D=-3.5A$, $Z_O=50\Omega$ (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	100	ns	
t_f	Fall Time	—	—	80	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	45	nC	$V_{GS}=-15V$, $I_D=-8.0A$, $V_{DS}=0.8$ Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	20	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	25	nC	

THERMAL RESISTANCE

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	2.97	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

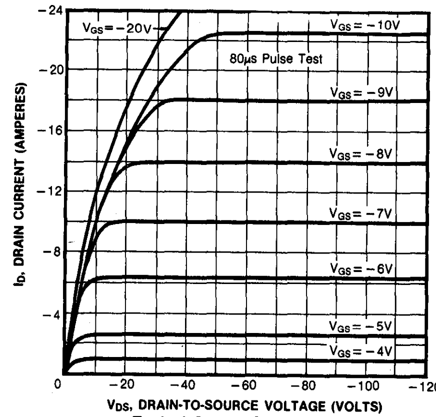
Notes: (1) $T_J=25°C$ to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

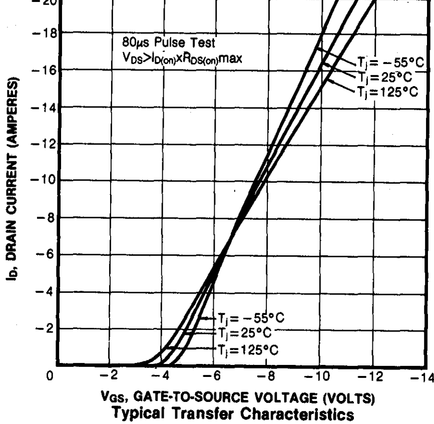
Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS9230/9231	—	—	−6.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS9232/9233	—	—	−5.5	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS9230/9231	—	—	−26	A	
	IRFS9232/9233	—	—	−22	A	
V_{SD}	Diode Forward Voltage (2) IRFS9230/9231	—	—	−6.5	V	$T_C=25°C$, $I_S=-6.5A$, $V_{GS}=0V$
	IRFS9232/9233	—	—	−6.3	V	$T_C=25°C$, $I_S=-5.5A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	400	—	ns	$T_j=150°C$, $I_F=-4.5A$, $dI_F/dt=100A/\mu S$

Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width$\leq 300\mu s$, Duty Cycle$\leq 2\%$

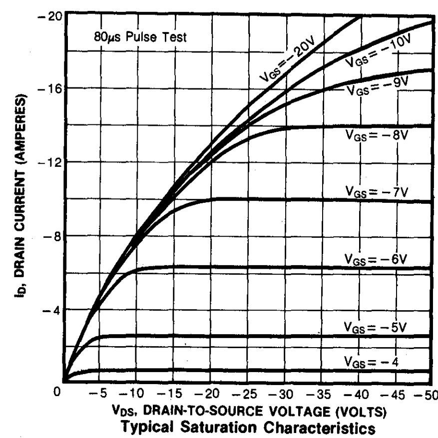
(3) Repetitive rating: Pulse with limited by max. junction temperature



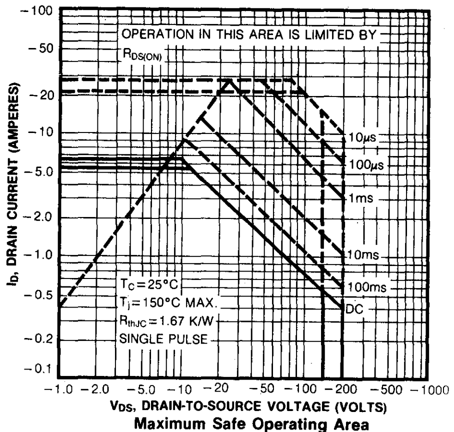
Typical Output Characteristics



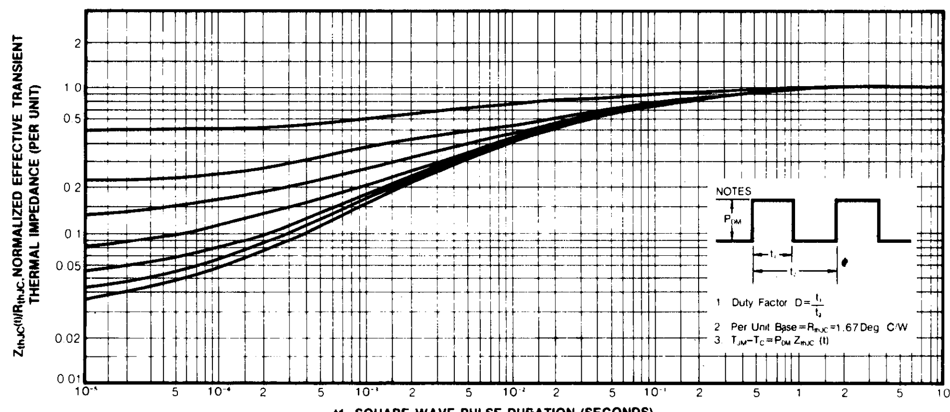
Typical Transfer Characteristics



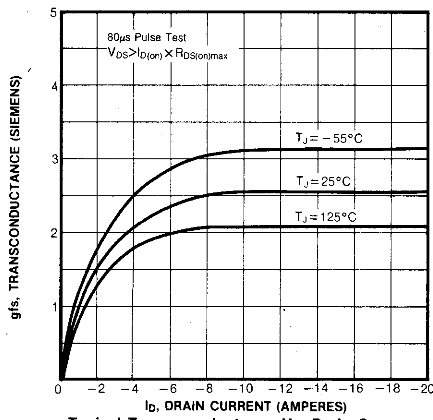
Typical Saturation Characteristics



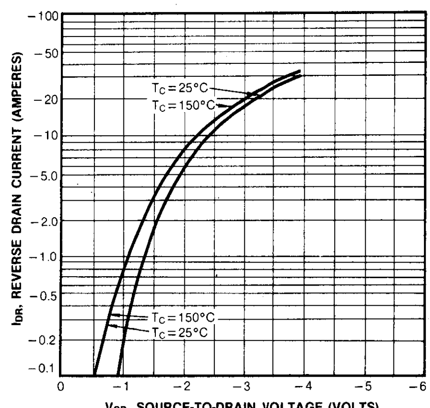
Maximum Safe Operating Area



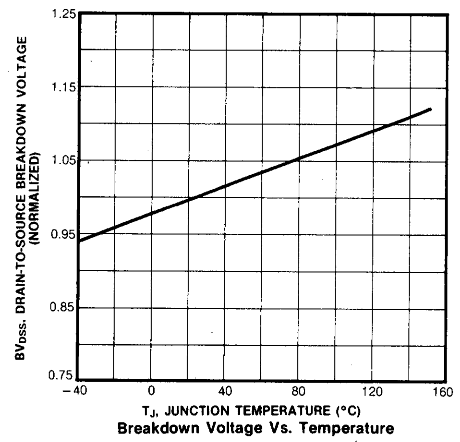
Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration



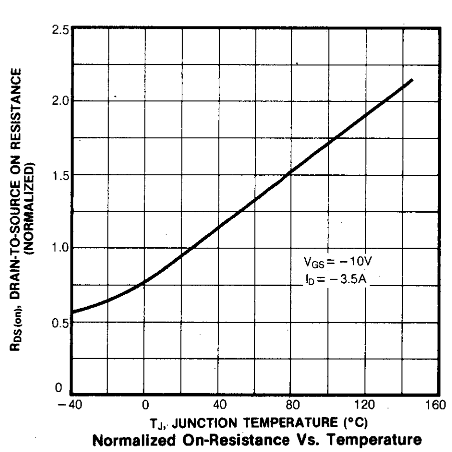
Typical Transcounductance Vs. Drain Current



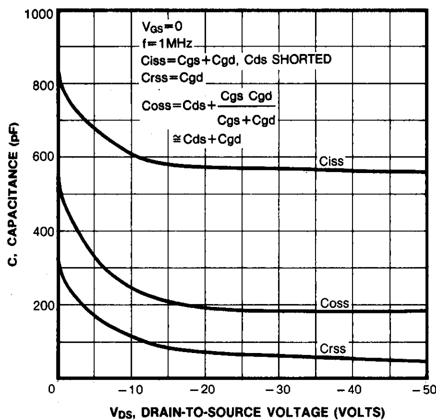
Typical Source—Drain Diode Forward Voltage



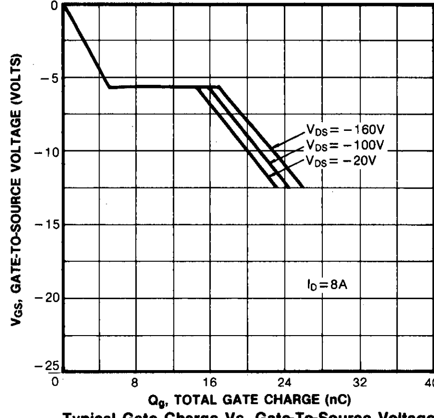
Breakdown Voltage Vs. Temperature



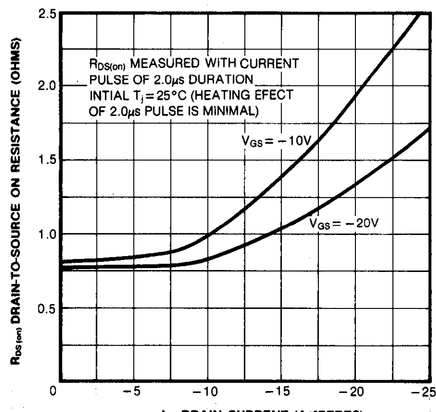
Normalized On-Resistance Vs. Temperature



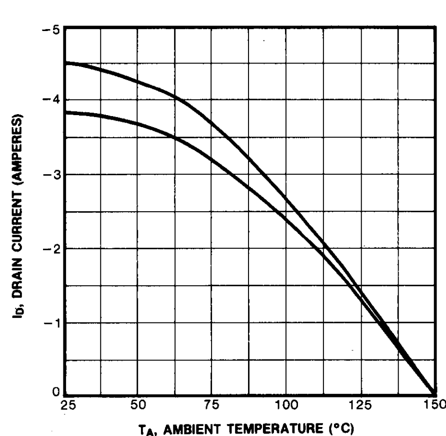
Typical Capacitance Vs. Drain to Source Voltage



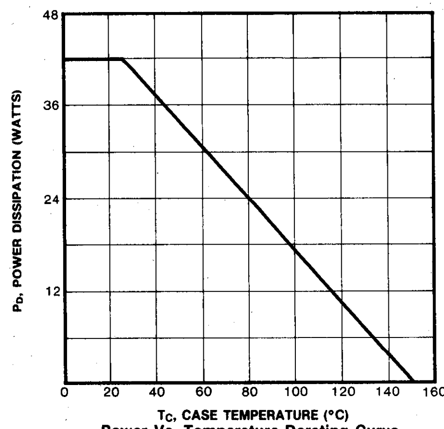
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current



Maximum Drain Current Vs. Case Temperature



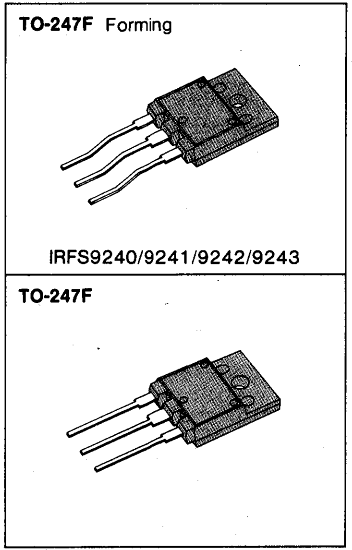
Power Vs. Temperature Derating Curve

IRFS9240/9241/9242/9243

P-CHANNEL POWER MOSFETS

FEATURES

- **Lower $R_{DS\ (ON)}$ at high voltage**
- **Improved inductive ruggedness**
- **Fast switching times**
- **Rugged polysilicon gate cell structure**
- **Lower input capacitance**
- **Extended safe operating area**
- **Improved high temperature reliability**



PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFS9240	−200V	0.5Ω	−7.6A
IRFS9241	−150V	0.5Ω	−7.6A
IRFS9242	−200V	0.7Ω	−6.2A
IRFS9243	−150V	0.7Ω	−6.2A

MAXIMUM RATINGS

Characteristic	Symbol	IRFS9240	IRFS9241	IRFS9242	IRFS9243	Unit
Drain-Source Voltage	V_{DSS}	−200	−150	−200	−150	Vdc
Drain-Gate Voltage (R_{GS}=1.0MΩ)(1)	V_{DGR}	−200	−150	−200	−150	Vdc
Gate-Source Voltage	V_{GS}	±20				Vdc
Continuous Drain Current T_C=25°C	I_D	−7.6	−7.6	−6.2	−6.2	Adc
Continuous Drain Current T_C=100°C	I_D	−4.8	−4.8	4.0	4.0	Adc
Drain Current—Pulsed (3)	I_{DM}	−44	−44	−36	−36	Adc
Gate Current—Pulsed	I_{GM}	±1.5				Adc
Total Power Dissipation @ T_C=25°C Derate above 25°C	P_D	65 0.52				Watts W/°C
Operating and Storage Junction to Case	T_J, Tstg	−55 to 150				°C
Maximum Lead Temp. for Soldering Purposes, 1/8″ from case for 5 seconds	T_L	300				°C

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature

ELECTRICAL CHARACTERISTICS (T_C=25°C unless otherwise specified)

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-Source Breakdown Voltage IRFS9240/IRFS9242	-200	—	—	V	V_{GS}=0V
	IRFS9241/IRFS9243	-150	—	—	V	I_D=−250μA
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D=−250μA
I_{GSS}	Gate-Source Leakage Forward	—	—	100	nA	V_{GS}=−20V
I_{GSS}	Gate-Source Leakage Reverse	—	—	−100	nA	V_{GS}=20V
I_{DSS}	Zero Gate Voltage Drain Current	—	—	250	μA	V_{DS}=Max. Rating V_{GS}=0V
		—	—	1000	μA	V_{DS}=Max. Rating×0.8, V_{GS}=0V, T_C=125°C
$I_{D(on)}$	On-State Drain-Source Current (2) IRFS9240/IRFS9241	−11	—	—	A	V_{DS}>$I_{D(on)}$×$R_{DS(on)max.}$ V_{GS}=−10V
	IRFS9242/IRFS9243	−9	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance (2) IRFS9240/IRFS9241	—	—	0.5	Ω	V_{GS}=−10V, I_D=−6.0A
	IRFS9242/IRFS9243	—	—	0.7	Ω	
g_{fs}	Forward Transconductance (2)	4.0	—	—	℧	V_{DS}≤−50V, I_D=−6.0A
C_{iss}	Input Capacitance	—	1570	—	pF	V_{GS}=0V, V_{DS}=−25V, f=1.0MHz
C_{oss}	Output Capacitance	—	272	—	pF	
C_{rss}	Reverse Transfer Capacitance	—	142	—	pF	
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD}=0.5BV_{DSS}, I_D=−6.0A, Z_O=4.7Ω (MOSFET switching times are essentially independent of operating temperature)
t_r	Rise Time	—	—	15	ns	
$t_{d(off)}$	Turn-Off Delay Time	—	—	18	ns	
t_f	Fall Time	—	—	12	ns	
Q_g	Total Gate Charge (Gate-Source Plus Gate-Drain)	—	—	90	nC	V_{GS}=−15V, I_D=−13A, V_{DS}=0.8 Max. Rating (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	—	—	30	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	—	—	60	nC	

THERMAL RESISTANCE

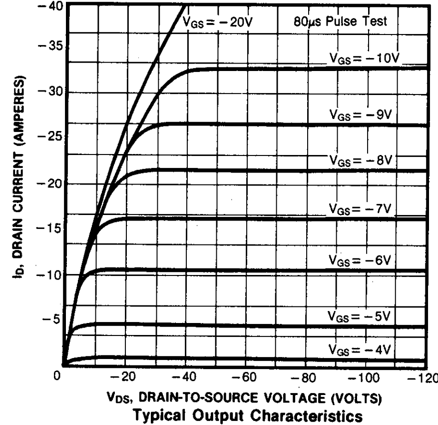
R_{thJC}	Junction-to-Case	—	—	1.92	K/W	
R_{thCS}	Case-to-Sink	—	0.24	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	40	K/W	Free Air Operation

Notes: (1) T_J=25°C to 150°C
(2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse width limited by max. junction temperature

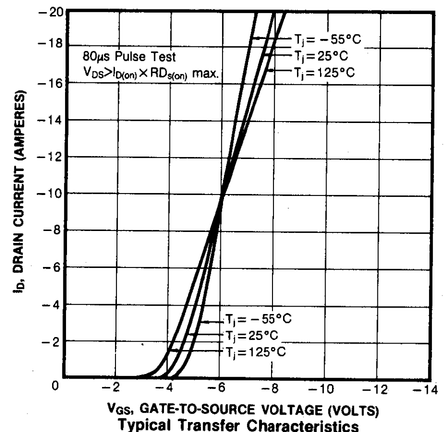
SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

Symbol	Characteristic	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode) IRFS9240/9241	—	—	−11	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier
	IRFS9242/9243	—	—	−9.0	A	
I_{SM}	Pulse Source Current(Body Diode)(3) IRFS9240/9241	—	—	−44	A	
	IRFS9242/9243	—	—	−36	A	
V_{SD}	Diode Forward Voltage (2) IRFS9240/9241	—	—	−4.6	V	$T_C=25°C$, $I_S=-14A$, $V_{GS}=0V$
	IRFS9242/9243	—	—	−44	V	$T_C=25°C$, $I_S=-9.0A$, $V_{GS}=0V$
t_{rr}	Reverse Recovery Time	—	270	—	ns	$T_j=150°C$, $I_F=-7.6A$, $dI_F/dt=100A/\mu S$

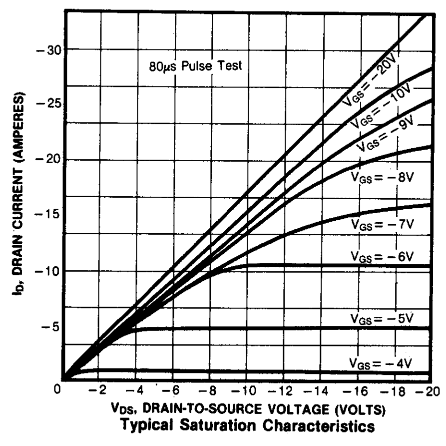
Notes: (1) $T_J=25°C$ to $150°C$ (2) Pulse test: Pulse width≤300μs, Duty Cycle≤2%
(3) Repetitive rating: Pulse with limited by max. junction temperature



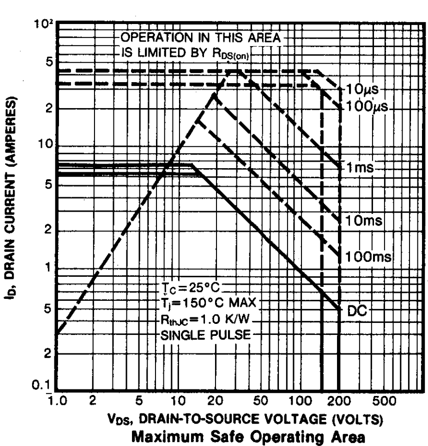
Typical Output Characteristics



Typical Transfer Characteristics



Typical Saturation Characteristics



Maximum Safe Operating Area

$Z_{thJC}(t)/R_{thJC}$, NORMALIZED EFFECTIVE TRANSIENT THERMAL IMPEDANCE (PER UNIT)

NOTES

1 Duty Factor $D = \frac{t_1}{t_2}$

2 Per Unit Base $= R_{thJC} = 1.0$ Deg. C/W

3 $T_{JM} - T_C = P_{DM} Z_{thJC}$ (t).

t1. SQUARE WAVE PULSE DURATION (SECONDS)

Maximum Effective Transient Thermal Impedance Junction-to-Case Vs. Pulse Duration

gfs, TRANSCONDUCTANCE (SIEMENS)

80μs Pulse Test

$V_{DS} > I_{D(on)} \times R_{DS(on)max}$

$T_J = -55°C$

$T_J = 25°C$

$T_J = 125°C$

I_D, DRAIN CURRENT (AMPERES)

Typical Transcounductance Vs. Drain Current

I_{DR}, REVERSE DRAIN CURRENT (AMPERES)

$T_C = 25°C$

$T_C = 150°C$

V_{SD}, SOURCE-TO-DRAIN VOLTAGE (VOLTS)

Typical Source—Drain Diode Forward Voltage

BV_{DSS}, DRAIN-TO-SOURCE BREAKDOWN VOLTAGE (NORMALIZED)

T_J, JUNCTION TEMPERATURE (°C)

Breakdown Voltage Vs. Temperature

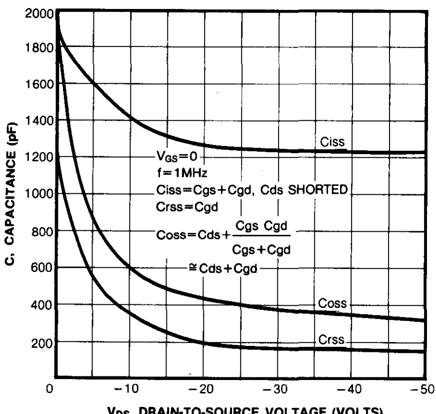
$R_{DS(on)}$, DRAIN-TO-SOURCE ON RESISTANCE (NORMALIZED)

$V_{GS} = -10V$

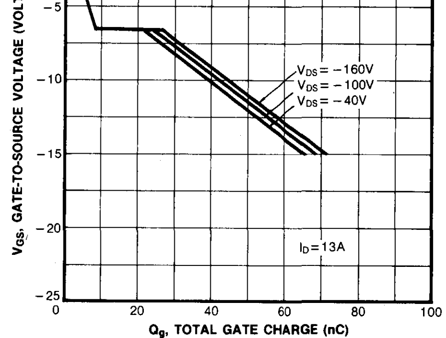
$I_D = -6A$

T_J, JUNCTION TEMPERATURE (°C)

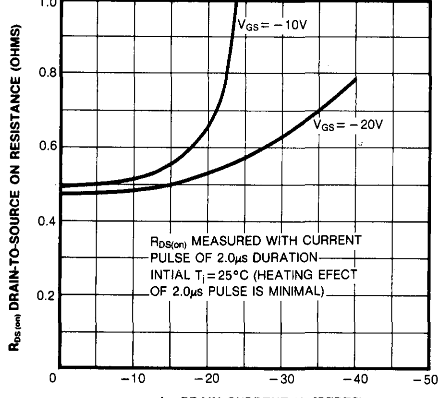
Normalized On-Resistance Vs. Temperature



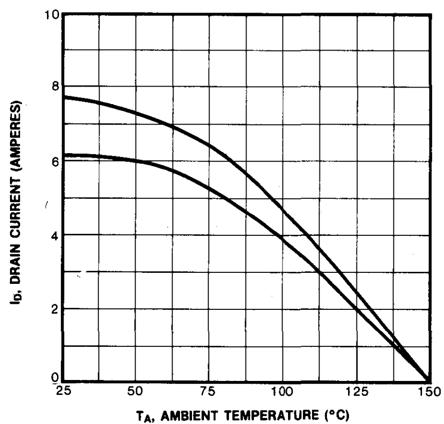
Typical Capacitance Vs. Drain to Source Voltage



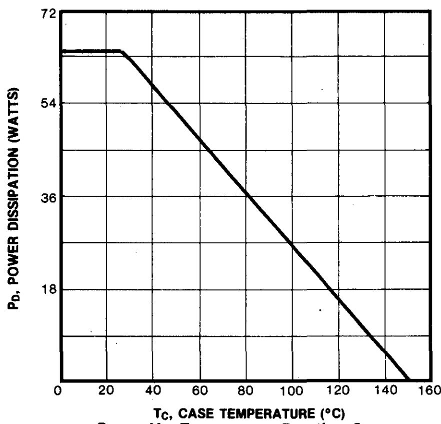
Typical Gate Charge Vs. Gate-To-Source Voltage



Typical On-Resistance Vs. Drain Current

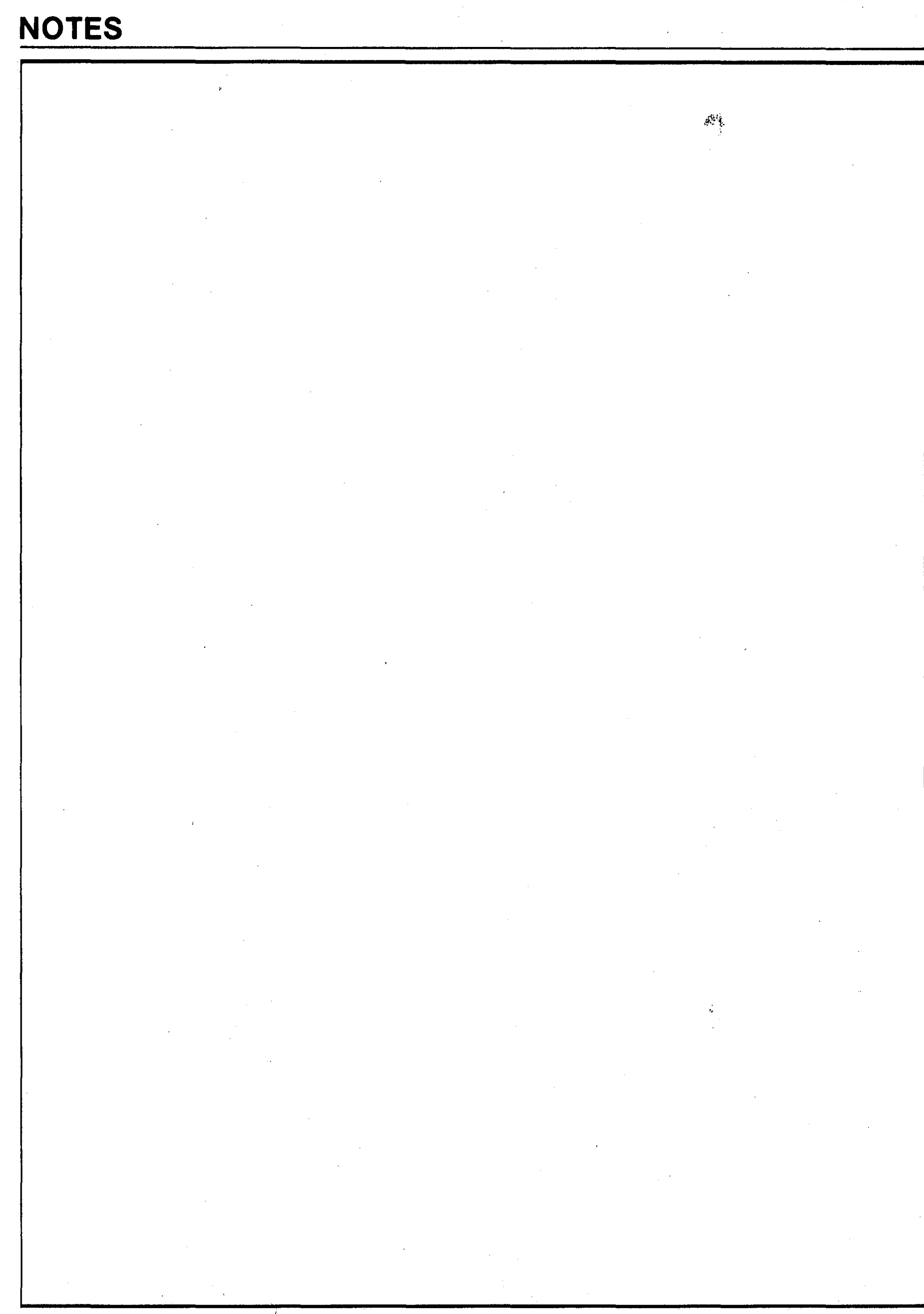


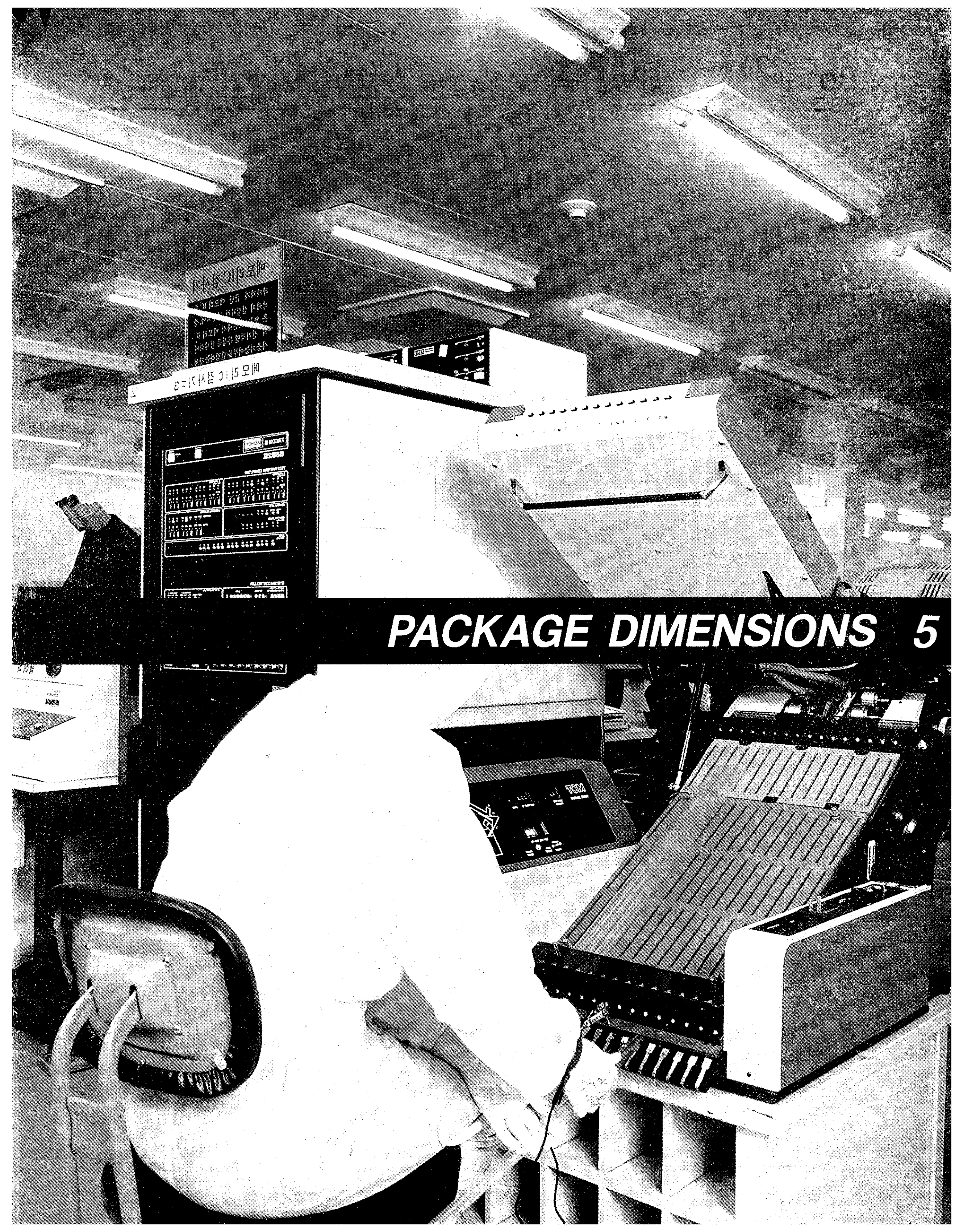
Maximum Drain Current Vs. Case Temperature



Power Vs. Temperature Derating Curve

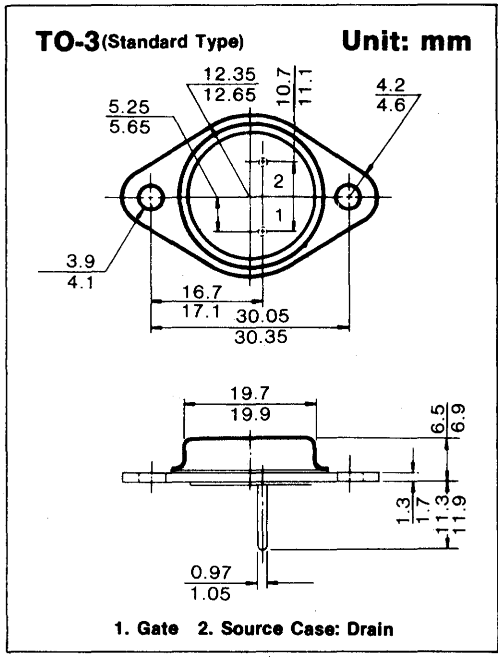
NOTES

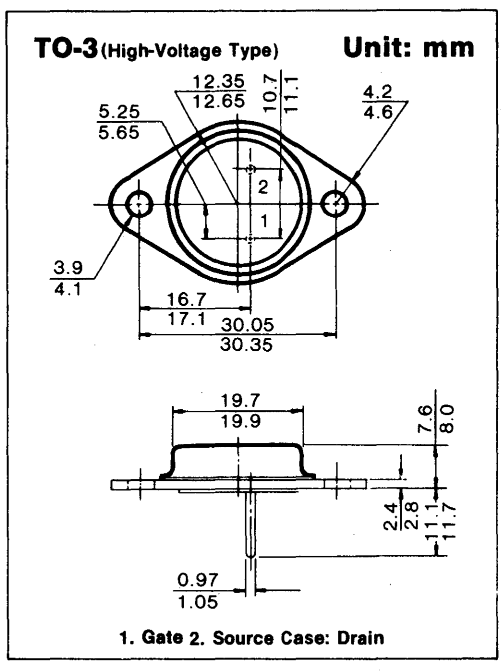


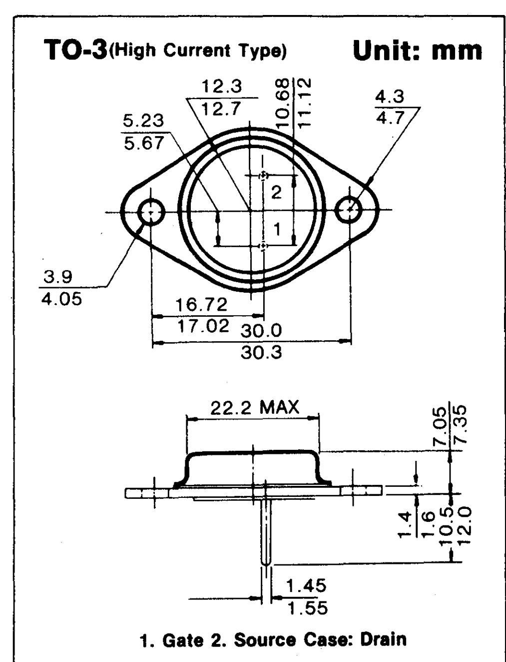


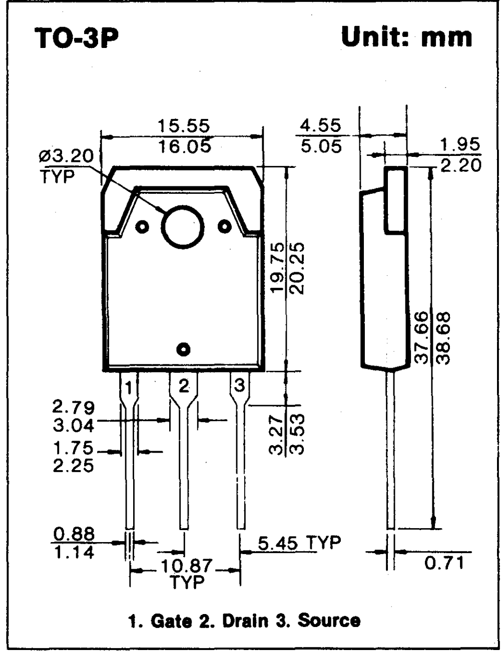
PACKAGE DIMENSIONS 5

PACKAGE DIMENSIONS









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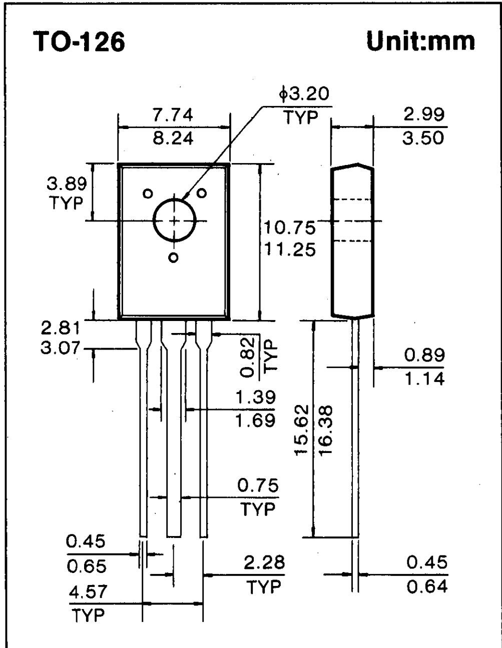

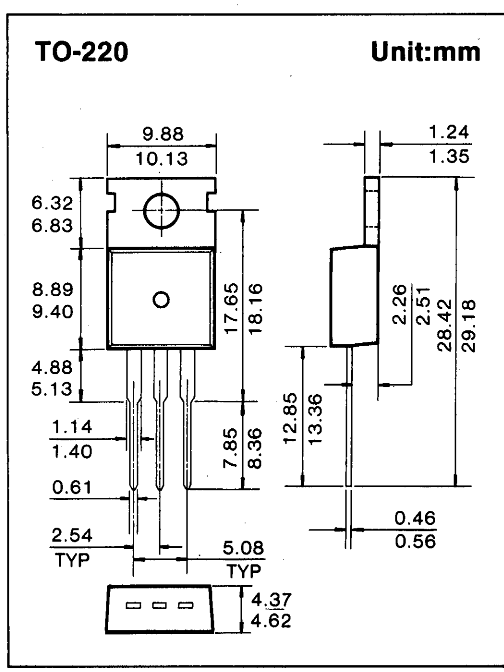

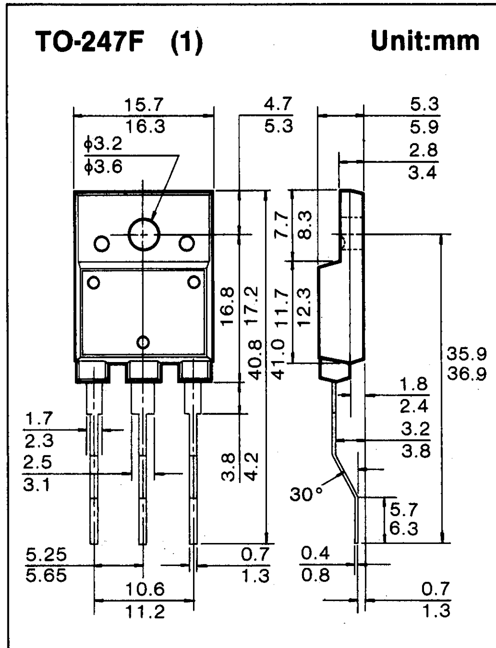

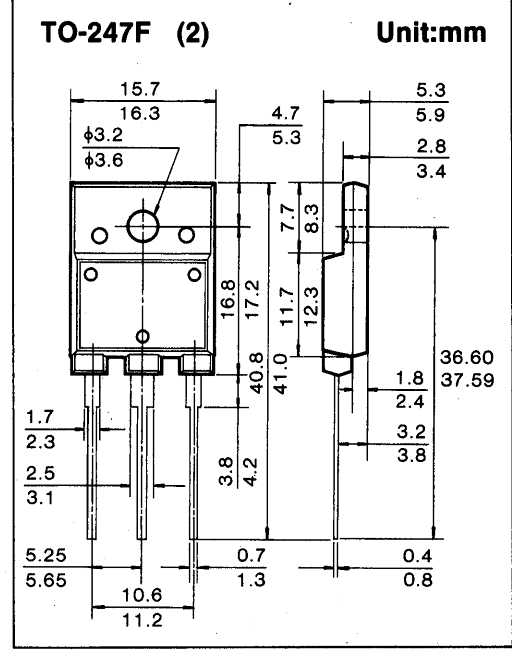

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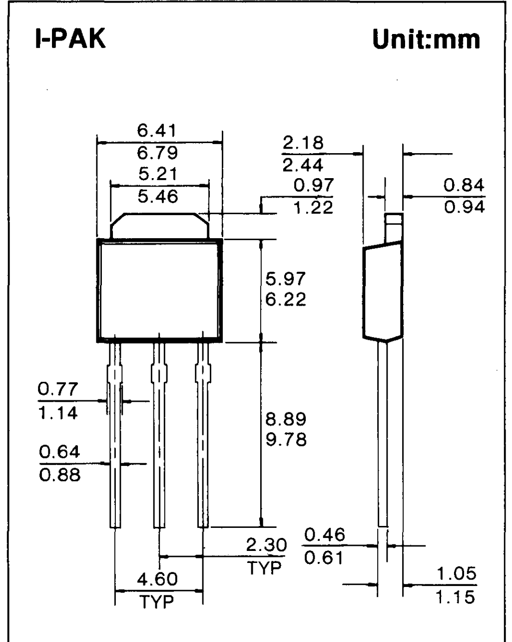

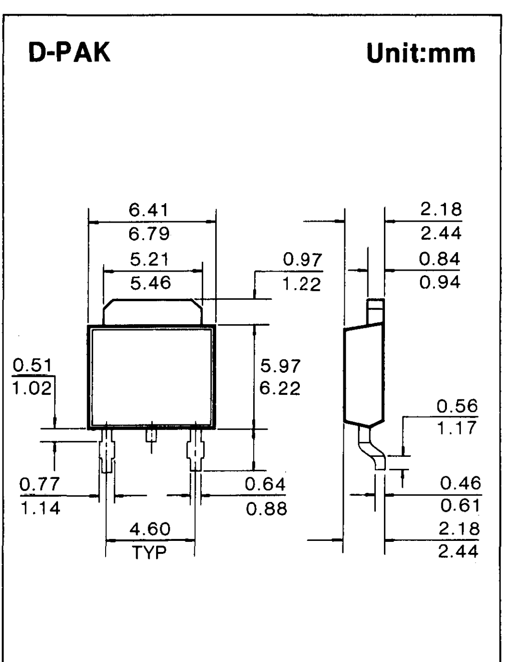

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