SUBSYSTEMS

DATABOOK

1st EDITION

SGS-THOMSON
MICROELECTRONICS

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4662

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JUNE 1994

TABLE OF CONTENTS

INTRODUCTION

SGS-THOMSON MICROELECTRONICS has always been sensitive to environmental protection, directly and indirectly.

Directly, because the Company has banned hazardous chemical products or materials in its manufacturing processes, indirectly, because our policy is to design and implement processes that are pollution free and that minimize any kind of waste in physical resources.

Within the SGS-THOMSON MICROELECTRONICS, the Subsystems Products Group, have as a stated goal and constant objective the design and manufacture of products capable of handling electrical power with the least possible power waste. This is achieved by adopting switch mode technologies.

All the products described in this databook, be them power supplies, DC-DC converters, regulators, battery chargers or stepping motor drivers, utilize the switch mode approach. They thus achieve efficiencies that are unmatched by the linear mode technology.

Efficiencies in the order of 85% and above can be achieved by SGS-THOMSON modules, while linear technology can barely deliver efficiencies in the range of 50% and below. For example a FAX, a telephone with integrated voice mail, needs about 6,5 W to operate.
By using a switch mode power supply, with an efficiency of 80%, the wasted power is 1.62W. This corresponds to 14 kWh per year (about $1 per year at the current energy price).
By using a linear mode power supply, with an efficiency of 30% the wasted power is 15W, that corresponds to 131 kWh annually.

The energy and cost saving offered by the switch mode is increased by a factor of 10 and the initial major cost of the switch mode solution can be paid back in less than one year.

Throw-away batteries if not properly disposed of, can constitute a severe hazard to the environment. This is another area where SGS-THOMSON has made a contribution to protecting the environment. A well-designed battery charger can recharge the same battery more than 500 times (although 1000 times is more typical). This means that a single battery can replace 500 (or 1000) throw-away batteries.

An evaluation can easily be made; the solution from SGS-THOMSON Microelectronics is at the same time more economical and is also an investment in environmental protection.

ALPHANUMERICAL INDEX

SELECTION GUIDE

DC / DC CONVERTERS

INDUSTRIAL APPLICATIONS

Single Output Type	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt / mA	Dimensions L • W • H (mm)	Page Number
GS1T5-5	1	4.5 to 5.5	5 / 250	35.6 • 21.6 • 14	21
GS2T5-5	2	4.5 to 5.5	5 / 400	35.6 • 21.6 • 14	33
GS2T5-12	2	4.5 to 5.5	12 / 200	35.6• 21.6 • 14	39
GS3T5-3.3	3	4.75 to 5.25	3.3 / 750	33 • 33 • 16.5	55
GS25T24-5	25	18 to 36	5 / 5000	116 • 65 • 21.1	77
GS30T24-12	30	18 to 36	12 / 2500	116 • 65 • 21.1	77
GS30T24-15	30	18 to 36	15 / 2000	116 • 65 • 21.1	77

Dual Output Type	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt / mA	Dimensions L • W • H (mm)	Page Number
GS2T5-D5	2	5	± 5 / 200	50.8 • 25.4 • 12	41
GS2T5-D12	2	5	± 12 / 100	50.8 • 25.4 • 12	43

Triple Output Type	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt / mA	Dimensions L • W • H (mm)	Page Number
GS1T5-5D15	1	4.7 to 5.3	+5 / 3 to 20 ± 15 / 5 to 15	33 • 33 • 16.5	23
GS2T5-5D15	2	4.7 to 5.3	+5 / 3 to 50 ± 15 / 5 to 70	33 • 33 • 16.5	35
GS5T24-5D15	5	17.5 to 30	+ 5 / 200 ± 15 / 125	50.8 • 38.1 • 19	61

HIGH INPUT VOLTAGE APPLICATIONS (UL AND TUV APPROVED)

Type Number	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt (*) / A	Dimensions L • W • H (mm)	Page Number
GS70T300-3.5	100	200 to 400	3.5 / 20	50.8 • 101.6 • 20	87
GS100T300-5	100	200 to 400	5.2 / 20	50.8 • 101.6 • 20	87
GS100T300-12	100	200 to 400	12.0 / 8.3	50.8 • 101.6 • 20	87
GS100T300-15	100	200 to 400	15.0 / 6.6	50.8 • 101.6 • 20	87
GS100T300-24	100	200 to 400	24.0 / 4.2	50.8 • 101.6 • 20	87
GS100T300-48	100	200 to 400	48.0 / 2.0	50.8 • 101.6 • 20	87

(*) Output voltage can be adjusted from about 1/2 V_{out} to 1.1 V_{out}. See data sheet for more details

ECL APPLICATIONS (-5.2 V_{DC} OUTPUT)

Type Number	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt / mA	Dimensions L • W • H (mm)	Page Number
GS3T5-5.2	3	4.75 to 5.25	5.2 / 600	33 • 33 • 16.5	57
GS15T5-5.2	15	4.75 to 5.35	5.2 / 3000	50.8 • 50.8 • 14.7	69

DC / DC CONVERTERS (cont'd)

ISDN APPLICATIONS

Type Number	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt / mA	Dimensions L • W • H (mm)	Page Number
GS1T70-D540	1	25 to 99	5 / 2 to 90 40 / 10.5	50.8 • 50.8 • 18	25
GS1T70-D540F	1	25 to 115	5 / 2 to 90 40 / 10.5	56 • 56 • 18	29

TELECOM APPLICATIONS (48 V_{DC} INPUT)

Single Output Type	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt / mA (A)	Dimensions L • W • H (mm)	Page Number
GS4T48-5	4	38 to 60	5 / 50 to 800	33 • 33 • 16.5	59
GS5T48-5	5	40 to 60	5 / 50 to 1000	50.8 • 50.8 • 14.7	63
GS5T48-12	5	38 to 60	12 / 50 to 420	33 • 33 • 16.5	65
GS5T48-15	5	38 to 60	15 / 50 to 330	33 • 33 • 16.5	67
GS15T48-5	15	40 to 60	5 / 3000	50.8 • 50.8 • 14.7	71
GS24T48-12	24	36 to 72	12 / 2000	50.8 • 50.8 • 12.5	75
GS25T48-5	25	36 to 72	5 / 5000	116 • 65 • 21.1	81
GS30T48-5	30	36 to 72	5 / 50 to 6000	50.8 • 50.8 • 12.5	85
GS30T48-12	30	36 to 72	12 / 2500	116 • 65 • 21.1	85
GS30T48-15	30	36 to 72	15 / 2000	116 • 65 • 21.1	85
GS120T48-3.3	120	38 to 60	3.35 / 35 A	125 • 66.5 • 19	97
GS175T48-5	175	38 to 60	5.075 / 35 A	125 • 66.5 • 19	97
GS175T48-12	175	38 to 60	12 / 15 A	125 • 66.5 • 19	97
GS175T48-15	175	38 to 60	15 / 12 A	125 • 66.5 • 19	97
GS300T48-5	300	38 to 60	5.075 / 60 A	125 • 66.5 • 20	107
Double Output Type	**Output Power (W)**	**Input Voltage Range (V_{DC})**	**Output Volt / mA**	**Dimensions L • W • H (mm)**	**Page Number**
GS2T48-D12	2	38 to 60	± 12 / 100	50 • 38 • 19	51

LAN APPLICATIONS (-9 V_{DC} OUTPUT)

Single Output Type	Output Power (W)	Input Voltage Range (V_{DC})	Output Volt / mA	Dimensions L • W • H (mm)	Page Number
GS2T5-9	2	4.5 to 5.5	9 / 250	35.6 • 21.6 • 14	37
GS2T12-9	2	11.28 to 15.75	9 / 70 to 250	33 • 33 • 12.7	45
GS2T12-9A	2	9.50 to 15.75	9 / 250	35.6 • 21.6 • 14	47
GS2T12-9S	2	9.50 to 15.75	9 / 250	35.6 • 21.6 • 14	49
GS2TX-9	2	4.15 to 15.75	9 / 250	35.6 • 21.6 • 14	53

BATTERY CHARGERS AND ACCESSORIES

Type	Description	Package	Page Number
GSCC-8.507BC-A	In-Car Battery Charger (USA Version)	Cigar Lighter	121
GSCC-8.507BC-E	In-Car Battery Charger (European Version)	Cigar Lighter	121
GSCC-7.007BS-A	In-Car Battery Saver (USA Version)	Cigar Lighter	117
GSCC-7.007BS-E	In-Car Battery Saver (European Version)	Cigar Lighter	117
GS-R28.0BE-A	In-Car Battery Eliminator (USA Version)	Cigar Lighter	261
GS-R28.0BE-E	In-Car Battery Eliminator (European Version)	Cigar Lighter	261
GSAC-8.507BC-1	Indoor Use Battery Charger (European Version)	Mains Adaptor	113
GSAC-8.507BC-2	Indoor Use Battery Charger (UK Version)	Mains Adaptor	113
GS20AC-12-1	Indoor Use Power Supply (European Version)	Mains Adaptor	73
GS20AC-12-2	Indoor Use Power Supply (UK Version)	Mains Adaptor	73

PROTECTION CONNECTORS

Single Output Type	Description	Page Number
GS-P8-A	Bidirectional data line protector	253
GS-P8-E	Bidirectional data line protector	253
GS-P15-A	Bidirectional data line protector	257

AUTOMOTIVE

Type	Description	Package	Page Number
GSCC-8.507BC-A	In-Car Battery Charger (USA Version)	Cigar Lighter	121
GSCC-8.507BC-E	In-Car Battery Charger (European Version)	Cigar Lighter	121
GSCC-7.007BS-A	In-Car Battery Saver (USA Version)	Cigar Lighter	117
GSCC-7.007BS-E	In-Car Battery Saver (European Version)	Cigar Lighter	117
GS-R28.0BE-A	In-Car Battery Eliminator (USA Version)	Cigar Lighter	261
GS-R28.0BE-E	In-Car Battery Eliminator (European Version)	Cigar Lighter	261
GS-R218	18 V - 1.5 A DC-DC Converter for Automotive Application	Cigar Lighter	263

SWITCHING VOLTAGE REGULATORS

Type Number	Description	Dimensions L • W • H (mm)	Page Number
GS-R1005	5V / 10A Fixed Output; V_{in} = 18 to 36V	101.6 • 50.8 • 19	281
GS-R1012	12V / 10A Fixed Output; V_{in} = 18 to 36V	101.6 • 50.8 • 19	289
GS-R218	18V / 1.5A In Car - Cigar Lighter Case	103 • 28 • 28	263
GS-R400V	Adjustable 4A, 5.1 to 40 V Output ; V_{in} up to 46V	85.5 • 67.0 • 21.3	265
GS-R400VB	Like GS-R400V with Adjustable Current, Syncro Module	85.5 • 67.0 • 21.3	265
GS-R400V/2	Adjustable 2A, 5.1 to 24V Output; V_{in} up to 40V; Small size	50.8 • 50.8 • 14.7	271
GS-R405	5V / 4A Fixed Output	85.5 • 67.0 • 21.3	265
GS-R405/2	5V / 4A Fixed Output; Small size	50.8 • 50.8 • 14.7	271
GS-R405S	5V / 4A Fixed Output with Reset; V_{in} up to 46V	85.5 • 67.0 • 21.3	265
GS-R412	12V / 4A Fixed Output	85.5 • 67.0 • 21.3	265
GS-R412/2	12V / 3A Fixed Output; Small Size	50.8 • 50.8 • 14.7	271
GS-R415	15V / 4A Fixed Output	85.5 • 67.0 • 21.3	265
GS-R415/2	15V / 3A Fixed Output; Small Size	50.8 • 50.8 • 14.7	271
GS-R424	24V / 4A Fixed Output	85.5 • 67.0 • 21.3	265
GS-R424/2	24V / 2A Fixed Output ; Small Size	50.8 • 50.8 • 14.7	271
GS-R4840N	40V / 1A Negative Output Regulator	85.5 • 67.0 • 21.3	275
GS-R4840NV	Digital Adjust. 0.6 A / -22 to -60V Negative Output Regulator	109 • 65 • 21	277
GS-R51212	Triple Outputs: 5V / 3.5A ; ±12V / 0.1A	85.5 • 67.0 • 21.3	297
GS-R51212S	Like GS-R51212 with ±12V Adjustable Output (±4.25 to ±12.45V); Reset Output	101.6 • 50.8 • 19	301
GS-R51515S	Like GS-R51212 with ±15V Adjustable Output (±4.5 to ±15.25V); Reset Output	101.6 • 50.8 • 19	301

POWER CONTROLLER & MOTOR DRIVE MODULES

Type Number	Description	Dimensions L • W • H (mm)	Page Number
GS-D050	0.5 A Chopped Bipolar Stepper Motor Driver	50.8 • 50.8 • 147	157
GS-D200	2.0 A Chopped Bipolar Stepper Motor Driver	85.5 • 67.0 • 21.3	173
GS-D200S	2.5 A Chopped Bipolar Stepper Motor Driver Fully Protected Outputs	85.5 • 67.0 • 21.3	173
GS-D200M	2.5 A Microstep Driver	85.5 • 67.0 • 21.3	189
GS-C200	Programmable Intelligent Stepper Motor Controller with 25 different Commands	85.5 • 67.5 • 22.0	125
GS-C200S	Programmable Intelligent Stepper Motor Controller with 29 different Commands	85.5 • 67.5 • 22.0	125

POWER CONTROLLER & MOTOR DRIVE BOARDS

Type Number	Description	Dimensions L • W • H (mm)	Page Number
GS-D250M	2.5 A Microstep Motor Driver	160 • 100 • 28	203
GS-D350M	5.6 A Microstep Motor Driver	160 • 100 • 48	211
GS-D500A	5 A Step and Microstep Drive Board	160 • 100 • 28	223
GS-D550	5.6 A Chopped 2 and 5 phases Stepper Motor Driver	160 • 100 • 48	233
GS-DC200	Board with a GS-C200 Controller and a GS-D200 Driver	160 • 100 • 24	245
GS-DC200S	Board with a GS-C200 Controller and a GS-D200S Driver	160 • 100 • 24	245
GS-DC200SS	Board with a GS-C200S Controller and a GS-D200S Driver	160 • 100 • 24	245

GLOSSARY

Symbol	Parameter	Unit	Description
f_c	Clock Pulse Frequency	kHz	A stepper or microstepper motor controller permits to switch the angular position of the motor with a certain number of steps per second. This rate is defined "Clock Pulse Frequency" or fc.
f_s	Switching Frequency	kHz	The "switching frequency" is the working frequency at which the DC voltage is switched in a DC-DC converter or switching power supply.
I_i	Average Input Current or Input Current	A	The average input current or simply the input current is the value of the input current which is sinked by the device by its input terminals.
I_{inh}	Inhibit input current	mA	When an Inhibit Voltage V_{iinh} is applied to the relevant pin, a corresponding Iinh current is sinked by the converter. See also V_{iinh}.
I_{ien}	Enable Input Current	mA	When an enable voltage V_{ien} is applied to the apposite enable input of the module, a corresponding current Iien is sinked from the input itself (depending on the circuit configuration).
I_{ipk}	Inrush Transient Peak Current	A^2s	The peak instantaneous input current sinked by the power supply at Power-On.
I_{ir}	Reflected Input Current	mA	The AC current generated at the input of a switching power supply.
I_{isc}	Average Input Current	A	This parameter is related to those converters which are provided by a FOLDBACK protection at the output. When the output is in short circuit condition (V_o = 0V), a current Iisc is sinked by the device from its input terminals.
I_o	Output Current	A	This parameter identifies the allowed range for the output current.
I_{ol}	Overcurrent Limit Initiation	A	It defines the output current value at which the output protection circuit starts the current limitation.
I_{osc}	Shortcircuit Output Current	A	Output current value when output is in short-circuit condition. I_{osc} is a predetermined value in order to prevent damage of the power supply.
I_{ph}	Phase Current per Output	A	This parameter gives the allowed range of the output current of a stepper (or microstepping) motor driver for every phase of the motor.
I_{rt}	Reset Output Sink Current	mA	Some modules, after the power ON, generates a RESET signal through an Open-Collector output, which can sink a I_{rt} current.
I_s	Quiescent Supply Current	mA	The quiescent supply current is the input current sinked when no output power is delivered.
P_I	Input Power	W	It is the input power to the device.
R_{th}	Thermal Resistance Case to ambient	°C/W	It defines the temperature increase due to power dissipation generated inside the device. If, for example, a device has a R_{th} = 6.5 °C/W, a dissipation of 1 W causes a temperature increment of 6.5 °C.
SVR	Supply Voltage Rejection	mV/V	It defines the residual AC voltage at the output compared to the residual AC voltage eventually present at the input.
t_{cd}	Crowbar Delay Time	µs	The Crowbar protection has an intervention time which is called t_{cd}.
T_{cop} or T_{hop}	Operating Case Temperature or Operating Heatsink Temperature	°C	This parameter is related to devices with metal case and it defines the allowed temperature range.

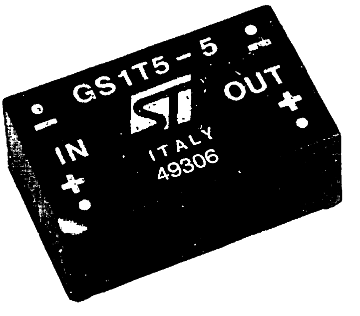
Symbol	Parameter	Unit	Description
t_{on}	Turn-on Time	ms	Time required by the output voltage to reach its nominal value at power ON.
T_{op}	Operating Ambient Temperature Range	°C	The parameter is related to devices with plastic case and it defines the allowed temperature range.
t_{rd}	Reset Delay Time	ms	It defines the delay of the Reset signal availability after the power ON operation
t_s	Load Transient Settling Time	µs	The Load Transient Settling Time identifies the time to settle the output voltage within the output limits.
t_{ss}	Soft Start Time	ms	It defines the time that is necessary to reach the nominal output voltage after the power-on for inhibit/enable operation.
T_{stg}	Storage Temperature Range	°C	It defines the allowed temperature range with no operating condition.
V_i	Input Voltage	V	This parameter specifies the allowed voltage range that can be applied at the input of the device.
V_{ien}	Enable Input Voltage	V	It specifies the required voltage to enable the module.
V_{iinh}	Inhibit Voltage	V	It specifies the required voltage to inhibit the module.
V_{is}	Isolation Voltage	V	It defines the maximum AC or DC voltage which may be applied from input to output and/or case of a power supply.
V_{iuv}	Input Undervoltage Lockout	V	It defines the limits of the input voltage which are necessary for Power-On condition.
V_o	Output Voltage	V	It defines the nominal value of the DC output voltage.
V_o	Logic Output Voltage	V	It is the voltage range of the digital outputs of the device.
V_{ol} or V_{cth}	Output Overvoltage Limit Initiation or Crowbar Intervention Threshold	V	It defines the voltage at which the power supply shuts down the output.
V_{on}	Output Noise Voltage	mV	V_{on} is the output voltage variation which takes in account of three noise components: - The ripple. - The switching noise. - The random noise which is not related to the switching PWM noise.
V_{or} or V_r	Output Ripple Voltage	mV	V_{or} is the output voltage variation due to Pulse Width Modulation (PWM) used to obtain the required output.
V_{ost}	Short-term Output Voltage Regulation	V	V_{ost} defines a voltage deviation range from the nominal value that takes into account these following causes: - Initial tolerance - Line and load regulation - Short term drift - Warm up See also V_o and V_{ots}
V_{ots}	Total Static Tolerance	V	V_{ots} defines a voltage deviation range from the nominal value that takes into account these following causes: - Aging - Long term ambient temperature drifts - Short Term Output Voltage Regulation (V_{ost}).
V_s	DC Supply Voltage	V	This parameter gives to the user the allowed range of DC Supply voltage
W_i	Input Energy	W•s	It is the energy absorbed by the device.
δIo	Current Sharing Deviation	%	Difference bethween output currents when two or more modules are connected in parallel.

Symbol	Parameter	Unit	Description
$\Delta V_O/\Delta T$	Temperature Stability	mV/°C	Output voltage variation caused by temperature variation.
ΔV_O	Total Remote Sense Compensation	V	It defines what is the maximum voltage drop, for the connection to the load, that can be compensated by the power supply.
δV_{OL}	Line Regulation	mV	Output voltage variation caused by input voltage variation.
δV_{OO}	Load Regulation	mV	Output voltage variation caused by output current variation.
δV_O	Peak Load Transient Response	mV	It defines the maximum peak of the output voltage if a step variation of the output load occurs.
η	Efficiency	%	The Efficiency is the ratio of output power to input power.

DATASHEETS

1W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS1T5-5	5 V	5 V	250 mA



DESCRIPTION

The GS1T5-5 is a 1W DC-DC converter designed to provide an isolated 5V/250mA power source.

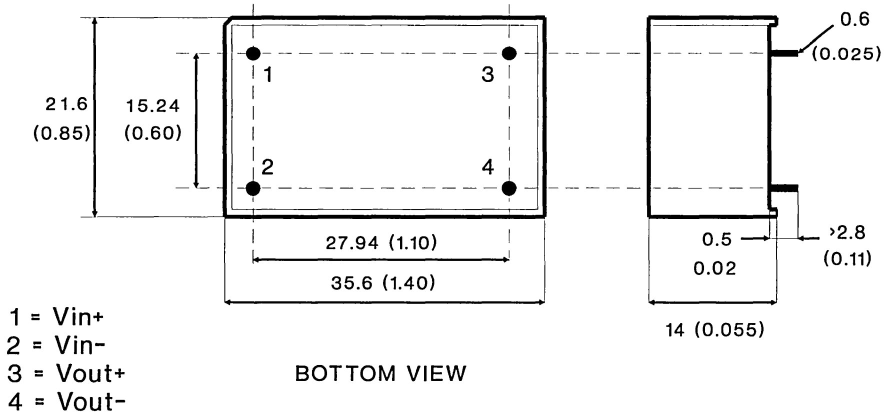
The module operates from a 5V input source and it offers 2500V_{DC} isolation.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5V	I_O = 0 to 250mA	4.50	5	5.50	V
I_{ir}	Input Reflected Current	V_i = 5V V_O = 5V	I_O = 0 to 250mA		15	30	mApp
V_O	Output Voltage	V_i = 4.5 to 5.5V	I_O = 0 to 250mA	4.75	5	5.25	V
I_O	Output Current*	V_i = 4.5 to 5.5V	V_O = 5V	0		250	mA
δV_{OL}	Line Regulation	V_i = 4.5 to 5.5V	I_O = 250mA			5	mV
δV_{OO}	Load Regulation	V_i = 5V	I_O = 20 to 250mA			5	mV
V_{or}	Output Ripple Voltage	V_i = 5V V_O = 5V	I_O = 40 to 250mA		60	80	mVpp
V_{is}	Isolation Voltage	Input to Output		2500			VDC
η	Efficiency	V_i = 5V V_O = 5V	I_O = 250mA	70	73		%
T_{op}	Operating Ambient Temperature Range			– 25		+75	°C
T_{stg}	Storage Temperature Range			– 40		+85	°C

* Note: when output current is less than 20mA, output ripple voltage increases due to discontinuous operation.

CONNECTION DIAGRAM AND MECHANICAL DATA



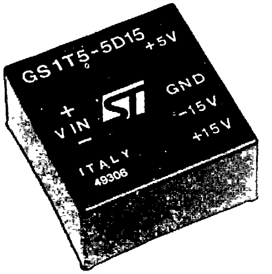
Package B. Dimensions in mm (inches)

SGS-THOMSON MICROELECTRONICS

GS1T5-5D15

1 W TRIPLE OUTPUT DC-DC CONVERTER

Type	V_i	V_o	I_o
GS1T5-5D15	5 V	+ 5 V	+ 20 mA
		+ 15 V	+ 15 mA
		– 15 V	– 15 mA



DESCRIPTION

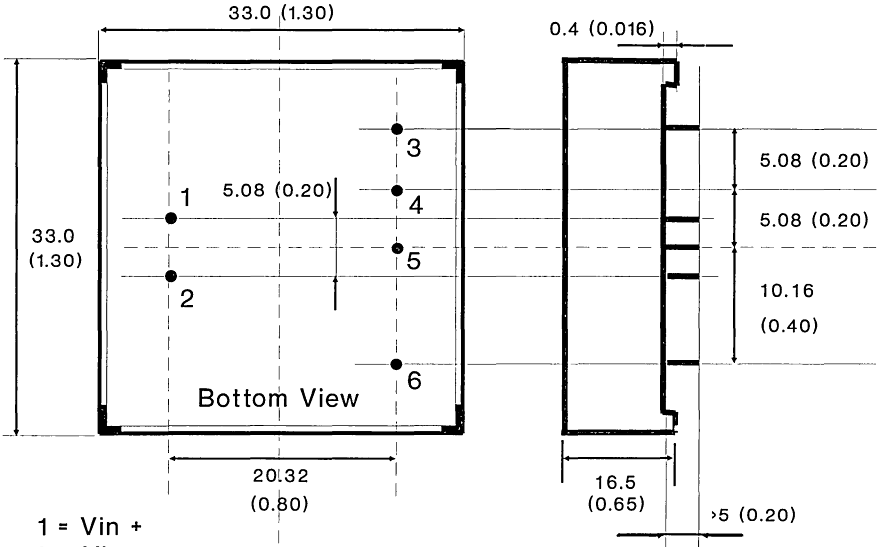
The GS1T5-5D15 is a 0.6W DC-DC converter designed to provide an isolated 5V/20mA, +15V/15mA and -15V/15mA power source.

The module operates from a 5V input source and offers 2500V_{DC} isolation.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_{o1} = +5V I_{o1} = 3 to 20mA V_{o2} = +15V I_{o2} = 5 to 15mA V_{o3} = – 15V I_{o2} = – 5 to – 15mA	4.7	5.0	5.3	V
I_{ir}	Input Reflected Current	V_i = 4.7 to 5.3V Full Load			10	mApp
V_{o1}	Output Voltage 1	V_i = 4.7 to 5.3V I_{o1} = 3 to 20mA	4.75	5.00	5.25	V
V_{o2}	Output Voltage 2	V_i = 4.7 to 5.3V I_{o2} = 5 to 15mA	14.25	15.00	15.75	V
V_{o3}	Output Voltage 3	V_i = 4.7 to 5.3V I_{o3} = – 5 to – 15mA	– 14.25	– 15.00	– 15.75	V
I_{o1}	Output Current 1	V_i = 4.7 to 5.3V V_{o1} = 5V	3		20	mA
I_{o2}	Output Current 2	V_i = 4.7 to 5.3V V_{o2} = +15V	5		15	mA
I_{o3}	Output Current 3	V_i = 4.7 to 5.3V V_{o3} = – 15V	– 5		– 15	mA
V_{or1}	Output Ripple Voltage 1	V_i= 4.7 to 5.3V I_{o1}= 20mA			30	mVpp
V_{or2}	Output Ripple Voltage 2	V_i = 4.7 to 5.3V I_{o2} = 15mA			70	mVpp
V_{or3}	Output Ripple Voltage 3	V_i = 4.7 to 5.3V I_{o3} = – 15mA			70	mVpp
V_{is}	Isolation voltage		2500			Vdc
η	Efficiency	V_i = 5V Full Load	68	73		%
f_s	Switching Frequency	V_i = 5V Full Load		150		kHz
T_{op}	Operating Ambient Temperature Range		0		+80	°C
T_{stg}	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = Vin +
2 = Vin -
3 = Vout +15V
4 = Vout -15V
5 = Out Common Ground
6 = Vout +5V

Package C. Dimensions in mm (inches)

ISDN DC-DC CONVERTER

Type	V_I	V_O	I_O
GS1T70-D540	25 to 115 V	5 V	90 mA
		40 V	10,5 mA

FEATURES

- Wide operating line termination voltage
- Peak input overvoltage withstand: 1kV for 1.2/50µs
- Peak overvoltage withstand on Output 2 (40V): 250V for 10/700µs
- Positive or negative input voltage polarity
- Input and output filtering
- Short-circuit protection on both outputs
- Input power during shortcircuit within specification
- Minimum current drain during stand-by condition: 10µA for Vi<18V
- Input-output isolation voltage: 2000V_{RMS} for 60 seconds
- Output1-output2 isolation voltage: 2000V_{RMS} for 60 seconds
- Mechanical dimensions (L x W x H): 50.8 mm x 50.8 mm x 18 mm (2" x 2" x 0.71")

DESCRIPTION

The GS1T70-D540 converter has been designed for the "U" interface of an ISDN-NTBA (Network Termination Basic Access) system with either 4B3T or 2B1Q standard trasmission.

It meets the requirements of the following specifications:

EN 60950

CCITT I.430

CCITT G.960

CCITT G.961

ETS 300 002

ETS 300 012

ETS 300 047 (ISDN BASIC ACCESS, Safety and Protection)

Two isolated outputs, 5V/90mA and 40V/10.5mA are supplied. The converter offers short-circuit protection (short-circuit on 40V output doesn't affect 5V output and the input power never exceeds the limit of the specification), input either voltage polarity, 80% minimum efficiency at maximum load, input and output filtering to meet very stringent noise requirements.

The input and the output 2 (40V) stages are protected against differential overvoltage up to 1kV (1.2/50µs) and 250V (10/700µs) respectively.

When the input voltage is below 18V, the converter offers a very high input impedance and a maximum quiescent current of 10µA.

These features allow the converter to operate directly connected to the telephone line without any external components.

In addition, the wide operating input voltage range allows it to operate within the whole range of LT (Line Termination) battery voltage and its relevant line resistance.

2000V_{RMS} isolation voltage for 60 second is provided between input to outputs and between output 1 and output 2.

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Std. Conditions:

Line Termination voltage: 47 to 71V
87 to 99V

Line Resistance (Rs): 10 to 560 Ω
550 to 1400 Ω

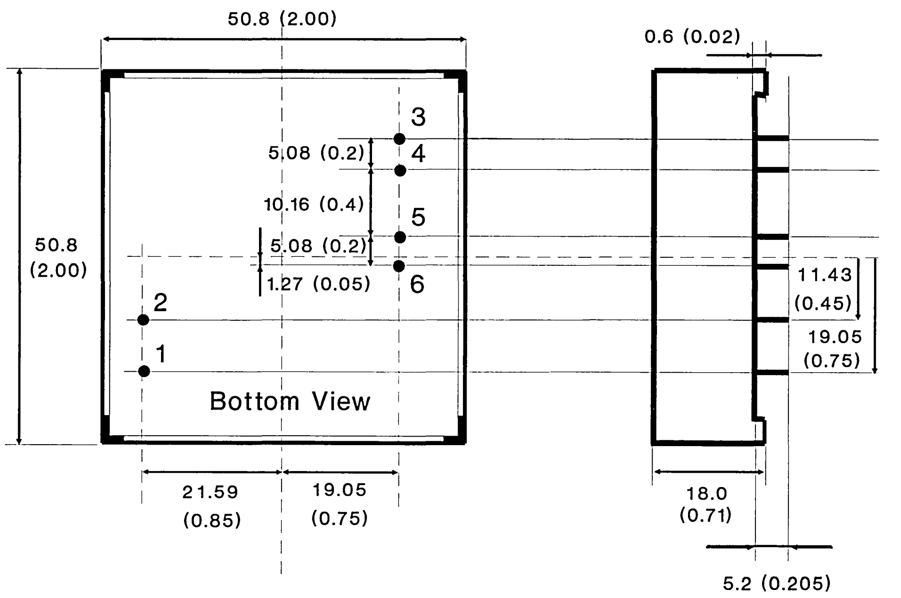
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	Std. Conditions	25		115	V
V_{ipk}	Input Transient Overvoltage	t = 1.2/50µs (pulse)			1	kV
V_{ist}	Start Up Input Voltage	See fig. 2	28		44	V
V_{o1}	Output Voltage 1	Std. Conditions	4.75	5	5.25	V
V_{o2}	Output Voltage 2	Std. Conditions	34	40	42	V
V_{or1}	Output Ripple Voltage 1	Std. Conditions BW = 0 to 20MHz		5	20	mVpp
V_{or2}	Output Ripple Voltage 2	Std. Conditions BW = 0 to 20MHz		10	30	mVpp
eN	Input Noise Voltage	Std. Conditions BW = 0 to 20MHz		10	30	mVpp
I_{o1}	Output Current 1	Std. Conditions I_{o2} = 0 to 10.5 mA V_{o1} = 5V	2		90	mA
I_{o1l}	Output Current 1 Limit Initiation	Std. Conditions V_{o1} = 4.75 to 5.25V	110		130	mA
I_{o2}	Output Current 2	Std. Conditions I_{o1} = 2 to 90 mA V_{o2} = 40V	0		10.5	mA
I_{osc2}	Output 2 Short Circuit Current	Std. Conditions Output Shorted (Indefinite time)	9		14	mA
V_{is}	Isolation Voltage (pulse)	Input to Output 1 Input to Output 2 Output 1 to Output 2	2000			VRMS
T_{op}	Operating Ambient Temperature Range		0		+80	°C
T_{stg}	Storage Temperature Range		– 40		+85	°C

OUTPUT POWER CHARACTERISTICS

LT (Line Termination Voltage) = **47V to 71V** **Rs** (Line Resistance) = 10 to 560 Ω				**LT** (Line Termination Voltage) = **87V to 99V** **Rs** (Line Resistance) = 550 to 1400 Ω			
Max Input Power (mW)	**NT Status**	**Min Output Power 1 (5V)[mW]**	**Min Output Power 2 (40V)[mW]**	**Max Input Power (mW)**	**NT Status**	**Min Output Power 1 (5V)[mW]**	**Min Output Power 2 (40V)[mW]**
450	Activated	320	0	450	Activated	320	0
950	Activated Emergency	330	410	950	Activated Emergency	330	410
90	Deactivated	25	0	90	Deactived	25	0
180	Deactivated Emergency	25	45	180	Deactivated Emergency	25	45
950	Activated with 40 V Short circuit	330	Short circuit	950	Activated with 40V Short circuit	330	Short circuit

CONNECTION DIAGRAM AND MECHANICAL DATA

Figure 1.



Package V. Dimensions in mm (inches).

PIN DESCRIPTION

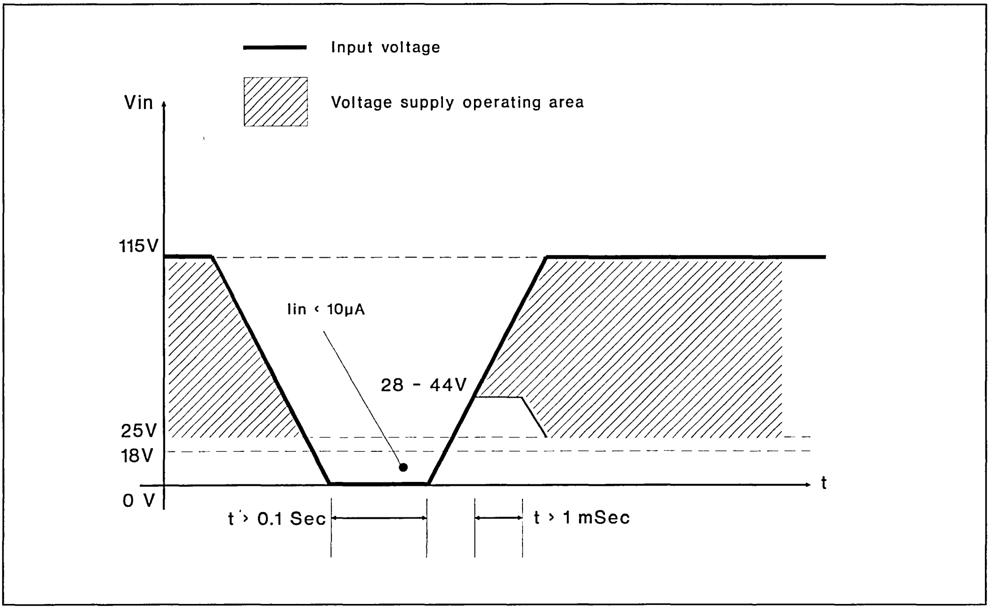
Pin	Description
1	Input (either polarity).
2	Input (either polarity).
3	+5V Output.
4	Return for +5V Output.
5	+40V Output.
6	Return for +40V Output.

VOLTAGE SUPPLY OPERATING AREA

Figure 2 shows the Voltage Supply Operating area during a switching OFF-ON sequence.

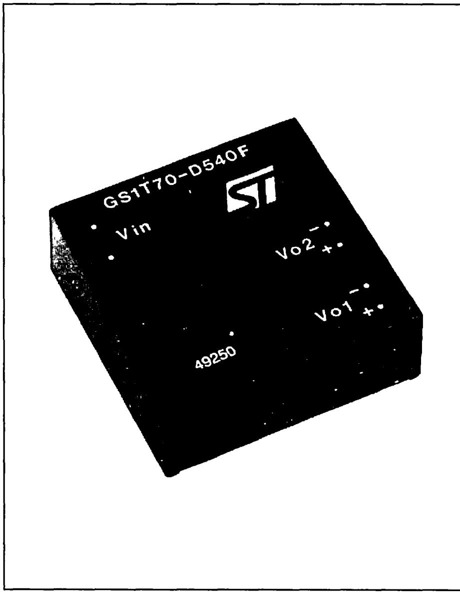
The start-up voltage is 44V maximum. When the input voltage is below 18V the maximum quiescent current is lower than 10µA.

Figure 2.



ISDN DC-DC CONVERTER (FRENCH VERSION)

Type	V_i	V_o	I_o
GS1T70-D540F	25 to 115 V	5 V	90 mA
		40 V	10,5 mA



FEATURES

- Wide operating line termination battery voltage
- Peak input overvoltage withstand: 1kV for 1.2/50µs
- Peak overvoltage withstand on Output 2 (40V): 250V for 10/700µs
- Positive or negative input voltage polarity
- Input and output filtering
- Short-circuit protection on both outputs
- Input power during shortcircuit within specification
- Minimum current drain during stand-by condition: 10µA for Vi<18V
- Undervoltage lock out at 10V
- Input-output isolation voltage: 10 kV pulse 1,2/50 µseconds
- Output1-output2 isolation voltage: $2000V_{RMS}$ for 60 seconds
- Mechanical dimensions (L x W x H): 56 mm x 56 mm x 18 mm (2.2" x 2.2" x 0.71")

DESCRIPTION

The GS1T70-D540F converter has been designed for the "U" interface of an ISDN-NTBA (Network Termination Basic Access) system with either 4B3T or 2B1Q standard trasmission.

It meets the requirements of the following specifications:

EN 60950

CCITT I.430

CCITT G.960

CCITT G.961

ETS 300 002

ETS 300 012

ETS 300 047 (ISDN BASIC ACCESS, Safety and Protection)

Two isolated outputs, 5V/90mA and 40V/10.5mA are supplied. The converter offers short-circuit protection (short-circuit on 40V output doesn't affect 5V output and the input power never exceeds the limit of the specification), input either voltage polarity, 80% minimum efficiency at maximum load, input and output filtering to meet very stringent noise requirements.

The input and the output 2 (40V) stages are protected against differential overvoltage up to 1kV (1.2/50µs) and 250V (10/700µs) respectively.

When the input voltage is below 18V, the converter offers a very high input impedance and a maximum quiescent current of 10µA.

These features allow the converter to operate directly connected to the telephone line without any external components.

In addition, the wide operating input voltage range allows it to operate within the whole range of LT (Line Termination) battery voltage and its relevant line resistance.

$2000V_{RMS}$ isolation voltage for 60 second is provided between input to outputs and between output 1 and output 2.

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Std. Conditions:

Line Termination voltage: 90 to 110V / 105 to 115V

Line Resistance (Rs): 50 to 1400 Ω / 500 to 1900 Ω

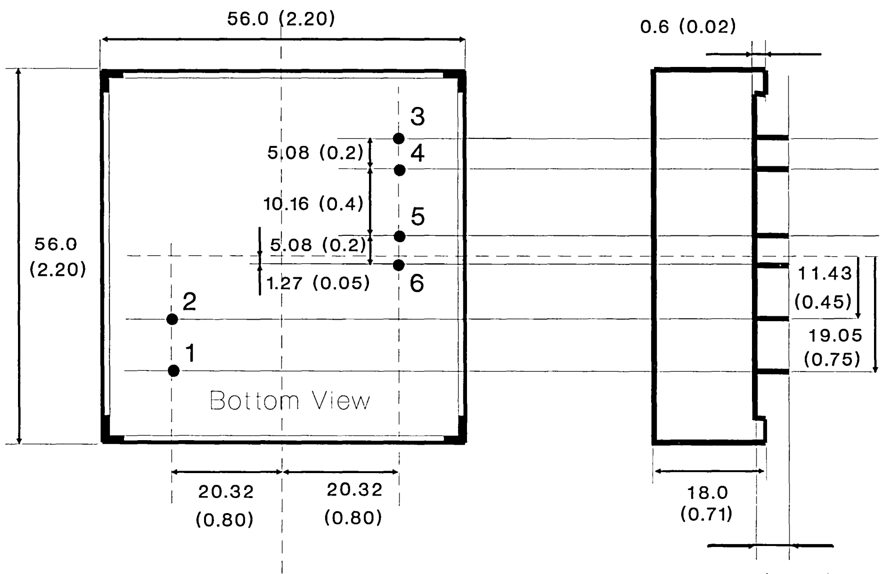
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	Std. Conditions	25		115	V
V_{ipk}	Input Transient Overvoltage	t = 1.2/250µs (pulse)			1	kV
V_{ist}	Start Up Input Voltage	See fig. 2	28		44	V
V_{iuv}	Input Undervoltage Lockout		10			V
V_{o1}	Output Voltage 1	Std. Conditions	4.75	5	5.25	V
V_{o2}	Output Voltage 2	Std. Conditions	34	40	42	V
V_{or1}	Output Ripple Voltage 1	Std. Conditions BW = 0 to 20MHz		5	20	mVpp
V_{or2}	Output Ripple Voltage 2	Std. Conditions BW = 0 to 20MHz		10	30	mVpp
eN	Input Noise Voltage	Std. Conditions BW = 0 to 20MHz		10	30	mVpp
I_{o1}	Output Current 1	Std. Conditions I_{o2} = 0 to 10.5 mA V_{o1} = 5V	2		90	mA
I_{o1l}	Output Current 1 Limit Initiation	Std. Conditions V_{o1} = 4.75 to 5.25V	110		130	mA
I_{o2}	Output Current 2	Std. Conditions I_{o1} = 2 to 90 mA V_{o2} = 40V	0		10.5	mA
I_{osc2}	Output 2 Short Circuit Current	Std. Conditions Output Shorted (Indefinite time)	9		14	mA
V_{is}	Isolation Voltage (pulse)	Input to Output 1 t = 1.2/50 µs Input to Output 2 t = 1.2/50 µs Output 1 to Output 2 t = 1.2/50 µs	10000 10000 4000			VRMS
T_{op}	Operating Ambient Temperature Range		0		+75	°C
T_{stg}	Storage Temperature Range		– 40		+85	°C

OUTPUT POWER CHARACTERISTICS

LT (Line Termination Voltage) = **90V to 110V** **Rs** (Line Resistance) = 50 to 1400 Ω				**LT** (Line Termination Voltage) = **105V to 115V** **Rs** (Line Resistance) = 500 to 1900 Ω			
Max Input Power (mW)	**NT Status**	**Min Output Power 1 (5V)[mW]**	**Min Output Power 2 (40V)[mW]**	**Max Input Power (mW)**	**NT Status**	**Min Output Power 1 (5V)[mW]**	**Min Output Power 2 (40V)[mW]**
600	Activated	420	0	600	Activated	420	0
1150	Activated Emergency	450	420	1150	Activated Emergency	450	420
200	Deactivated	110	0	200	Deactivated	110	0
270	Deactivated Emergency	110	60	270	Deactivated Emergency	110	60
1150	Activated with 40 V Short circuit	450	Short circuit	1150	Activated with 40V Short circuit	450	Short circuit

CONNECTION DIAGRAM AND MECHANICAL DATA

Figure 1.



Package V. Dimensions in mm (inches).

PIN DESCRIPTION

Pin	Description
1	Input (either polarity).
2	Input (either polarity).
3	+5V Output.
4	Return for +5V Output.
5	+40V Output.
6	Return for +40V Output.

VOLTAGE SUPPLY OPERATING AREA

Figure 2 shows the Voltage Supply Operating area during the switch ON-OFF and OFF-ON sequence.

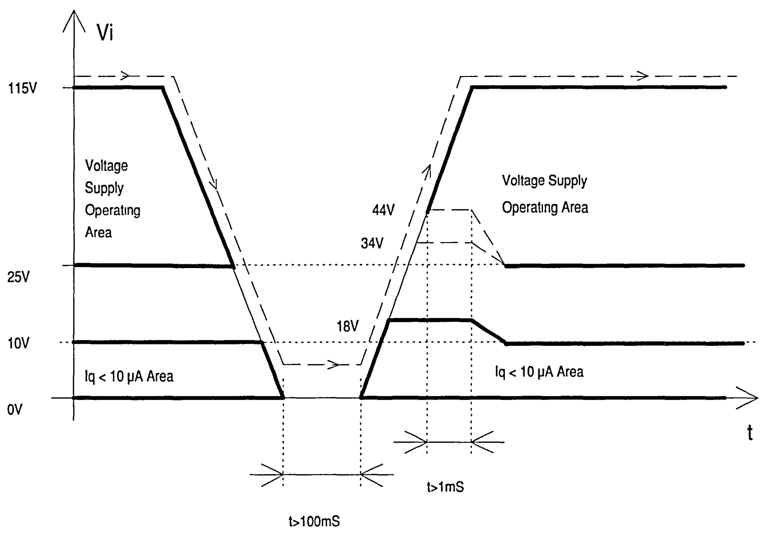
- Switch ON-OFF sequence:

For an Input Voltage Vi > 25V, the circuit operates correctly, because it lies in the Voltage Supply Operating Area.
The converter goes in High Input Impedance mode (I_q < 10µA) when the V_i is lower than 10V. If V_i remains between 0 -10V range for almost for almost 100 ms, the converter is in OFF condition.

- Switch OFF-ON sequence:

The quiescent current Iq remains below 10µA if Vi is lower than 18V.
The start-up voltage is between 34 to 44V. After 1 ms in this condition, the converter is in Voltage Supply Operating Area (V_{in} = 25 to 115V).

Figure 2.



SGS-THOMSON
MICROELECTRONICS

GS2T5-5

2 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2T5-5	5 V	5 V	400 mA

DESCRIPTION

The GS2T5-5 is a 2W DC-DC converter designed to provide an isolated 5V/400mA power source.

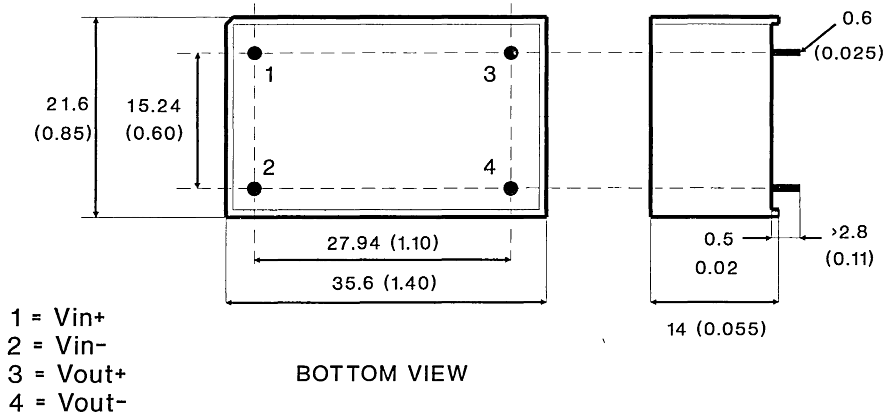
The module operates from a 5V input source and it offers 1500V_{DC} isolation.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5V	I_O = 0 to 400mA	4.50	5	5.50	V
I_{ir}	Input Reflected Current	V_i = 5V V_O = 5V	I_O = 400mA		25	40	mApp
V_O	Output Voltage	V_i = 4.5 to 5.5V	I_O = 0 to 400mA	4.75	5	5.25	V
V_{or}	Output Ripple Voltage	V_i = 5V V_O = 5V	I_O = 40 to 400mA		90	120	mVpp
δV_{OL}	Line Regulation	V_i = 4.5 to 5.5V	I_O = 400mA			5	mV
δV_{OO}	Load Regulation	V_i = 5V	I_O = 40 to 400mA			10	mV
I_O	Output Current*	V_i = 4.5 to 5.5V V_O = 5V		0		400	mA
V_{is}	Isolation Voltage	Input to Output		1500			VDC
η	Efficiency	V_i = 5V V_O = 5V	I_O = 400mA	67	70		%
Top	Operating Ambient Temperature Range			0		+70	°C
Tstg	Storage Temperature Range			– 40		+85	°C

* Note: when output current is less than 40mA, output ripple voltage increases due to discontinuous operation.

CONNECTION DIAGRAM AND MECHANICAL DATA



Package B. Dimensions in mm (inches)

2 W TRIPLE OUTPUT DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2T5-5D15	5 V	+ 5 V	+ 50 mA
		+ 15 V	+ 70 mA
		– 15 V	– 70 mA

DESCRIPTION

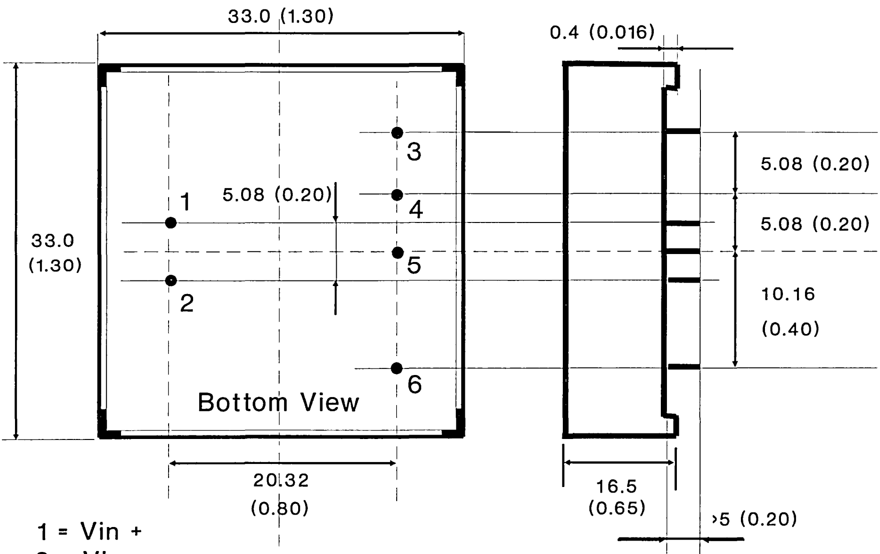
The GS2T5-5D15 is a 2.3W DC-DC converter designed to provide an isolated 5V/50mA, +15V/70mA and -15V/70mA power source.

The module operates from a 5V input source and offers 2500V_{DC} isolation.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_{o1} = +5V I_{o1} = 3 to 50mA V_{o2} = +15V I_{o2} = 5 to 70mA V_{o3} = – 15V I_{o2} = – 5 to – 70mA	4.7	5.0	5.3	V
I_{ir}	Input Reflected Current	V_i = 4.7 to 5.3V Full Load			150	mApp
V_{o1}	Output Voltage 1	V_i = 4.7 to 5.3V I_{o1}= 3 to 50mA	4.75	5.00	5.25	V
V_{o2}	Output Voltage 2	V_i = 4.7 to 5.3V I_{o2} = 5 to 70mA	14.25	15.00	15.75	V
V_{o3}	Output Voltage 3	V_i = 4.7 to 5.3V I_{o3} = – 5 to – 70mA	– 14.25	– 15.00	– 15.75	V
V_{or1}	Output Ripple Voltage 1	V_i = 4.7 to 5.3V I_{o1} = 50mA			50	mVpp
V_{or2}	Output Ripple Voltage 2	V_i = 4.7 to 5.3V I_{o2} = 70mA			100	mVpp
V_{or3}	Output Ripple Voltage 3	V_i = 4.7 to 5.3V I_{o3} = – 70mA			100	mVpp
I_{o1}	Output Current 1	V_i = 4.7 to 5.3V V_{o1} = 5V	3		50	mA
I_{o2}	Output Current 2	V_i = 4.7 to 5.3V V_{o2} = +15V	5		70	mA
I_{o3}	Output Current 3	V_i = 4.7 to 5.3V V_{o3} = – 15V	– 5		– 70	mA
V_{is}	Isolation Voltage		2500			V_{DC}
f_s	Switching Frequency	V_i = 5V Full Load		50		kHz
η	Efficiency	V_i = 5V Full Load	70	75		%
T_{op}	Operating Ambient Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = Vin +
2 = Vin -
3 = Vout +15V
4 = Vout -15V
5 = Out Common Ground
6 = Vout +5V

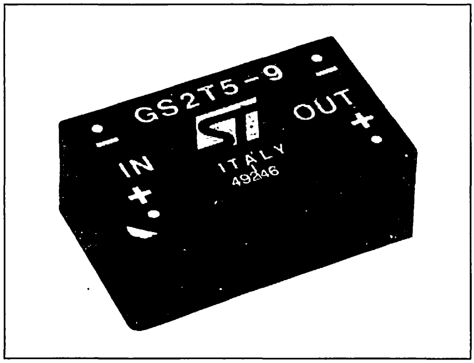
Package C. Dimensions in mm (inches).

SGS-THOMSON MICROELECTRONICS

GS2T5-9

2 W LAN DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2T5-9	5 V	– 9 V	– 250 mA



DESCRIPTION

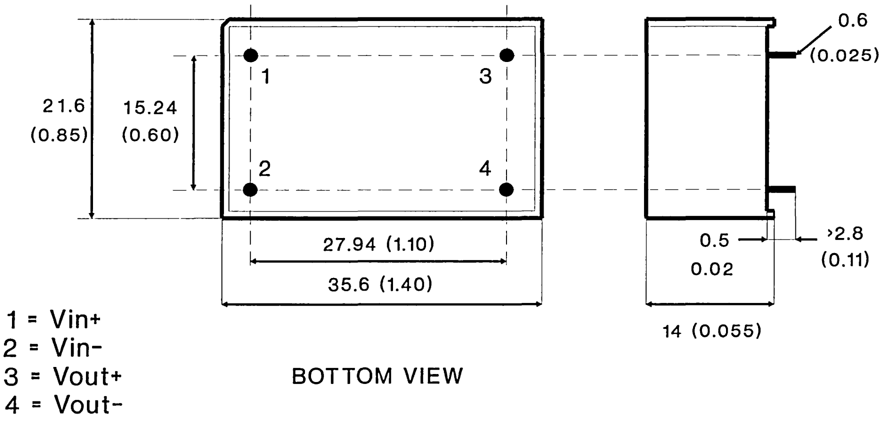
The GS2T5-9 is a 2.25W DC-DC converter designed to provide power, voltage regulation and isolation for Local Area Network (CHEAPERNET and ETHERNET) transceivers from a standard 5V input voltage, according to IEEE 802.3 Standard.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
V_i	Input Voltage	V_O = – 9V	I_O = 0 to – 250mA	4.5	5	5.5	V
I_{ir}	Input Reflected Current	V_i = 5V V_O = – 9V	I_O = – 250mA		25	30	mApp
V_O	Output Voltage	V_i = 4.5 to 5.5V	I_O = 0 to – 250mA	– 8.55	– 9.00	– 9.45	V
V_{or}	Output Ripple Voltage	V_i = 5V	I_O = – 250mA		.7	10	mV_{RMS}
δV_{OL}	Line Regulation	V_i = 4.5 to 5.5V	I_O = – 250mA			5	mV
δV_{OO}	Load Regulation	V_i = 5V	I_O = – 20 to – 250mA			5	mV
I_O	Output Current*	V_i = 4.5 to 5.5V	V_O = – 9V	0		– 250	mA
V_{is}	Isolation Voltage			2500			V_{DC}
η	Efficiency	V_i = 5V	I_O = – 250mA	70	73		%
Top	Operating Ambient Temperature Range			0		+70	°C
Tstg	Storage Temperature Range			– 40		+85	°C

* Note: when output current is less than 20mA, the output ripple voltage increases due to discontinuous operation.

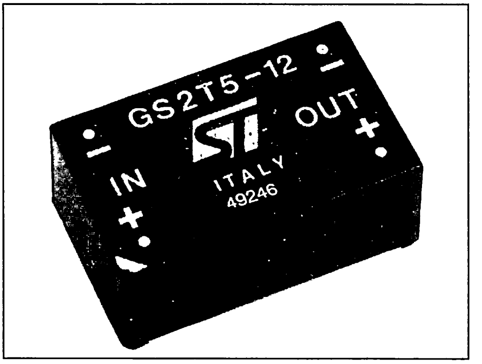
CONNECTION DIAGRAM AND MECHANICAL DATA



Package B. Dimensions in mm (inches)

2 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2T5-12	5 V	12 V	200 mA



DESCRIPTION

The GS2T5-12 is a 2.4W DC-DC converter designed to provide an isolated 12V/200mA power source.

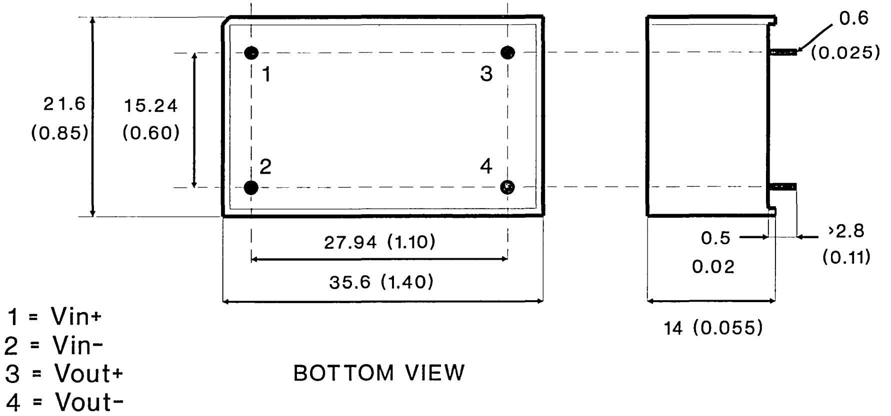
The module operates from a 5V input source and features continuous short-circuit protection.

An input filter minimizes the reflected input current.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 12V I_O = 0 to 200mA	4.5	5	5.5	V
I_{ir}	Input Reflected Current	V_i = 5V V_O = 12V I_O = 200mA		20	30	mApp
V_O	Output Voltage	V_i = 4.5 to 5.5V I_O = 0 to 200mA	11.4	12.0	12.6	V
V_{or}	Output Ripple Voltage	V_i = 5V I_O = 200mA		5	10	mV_{RMS}
δV_{OL}	Line Regulation	V_i = 4.5 to 5.5V I_O = 200mA			10	mV
δV_{OO}	Load Regulation	V_i = 5V I_O = 50 to 200mA			10	mV
I_O	Output Current	V_i = 4.5 to 5.5V V_O = 12V	50		200	mA
V_{is}	Isolation Voltage		2500			V_{DC}
η	Efficiency	V_i = 5V I_O = 200mA	65	70		%
Top	Operating Ambient Temperature Range	Still air	0		+60	°C
Top	Operating Ambient Temperature Range	Forced ventilation air speed = 100 LFM	0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package B. Dimensions in mm (inches)

2W DUAL OUTPUT DC-DC CONVERTER

Type	V_i	V_o	Io
GS2T5-D5	5 V	±5 V	±200 mA

DESCRIPTION

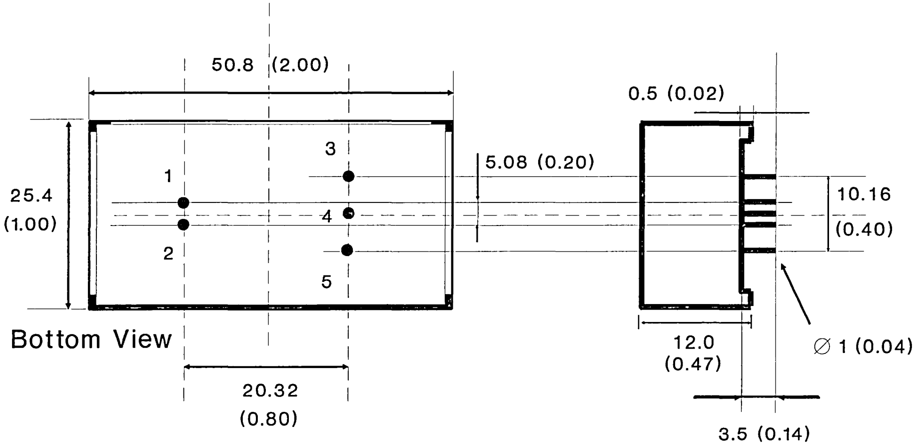
The GS2T5-D5 is a 2W DC-DC converter designed to provide an isolated +5V/200mA and – 5V/200mA power source.

The module operates from a 5V input source and offers 2500V_{DC} isolation.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_{o1} = +5V I_{o1} = 0 to 200mA V_{o2} = – 5V I_{o2} = 0 to – 200mA	4.75	5.00	5.25	V
I_{ir}	Input Reflected Current	V_i = 4.75 to 5.25V Full Load		25	40	mApp
V_{o1}	Output Voltage 1	V_i = 4.75 to 5.25V I_{o1} = 0 to 200mA	4.75	5.00	5.25	V
V_{o2}	Output Voltage 2	V_i = 4.75 to 5.25V I_{o2} = 0 to – 200mA	– 4.75	– 5.00	– 5.25	V
V_{or1}	Output Ripple Voltage 1	V_i = 4.75 to 5.25V I_{o1} = 200mA			20	mV_{RMS}
V_{or2}	Output Ripple Voltage 2	V_i = 4.75 to 5.25V I_{o2} = – 200mA			20	mV_{RMS}
I_{o1}	Output Current 1	V_i = 4.75 to 5.25V V_{o1} = 5V	0		200	mA
I_{o2}	Output Current 2	V_i = 4.75 to 5.25V V_{o2} = – 5V	0		– 200	mA
V_{is}	Isolation Voltage		2500			V_{DC}
f_s	Switching Frequency	V_i = 5V Full Load		20		kHz
η	Efficiency	V_i = 5V Full Load	55	62		%
Top	Operating Ambient Temperature Range	Still air	0		+55	°C
Top	Operating Ambient Temperature Range	Forced ventilation air speed = 100 LFM	0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = Vin +
2 = Vin -
3 = Vout +
4 = Out Common Ground
5 = Vout -

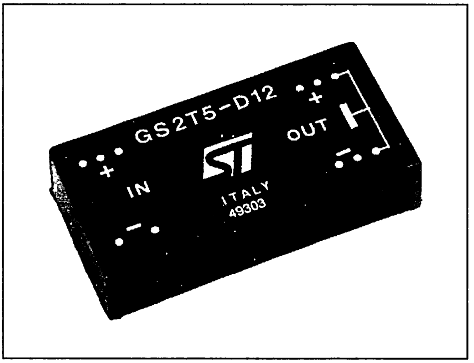
Package D. Dimensions in mm (inches)

SGS-THOMSON MICROELECTRONICS

GS2T5-D12

2W DUAL OUTPUT DC-DC CONVERTER

Type	V_i	V_o	Io
GS2T5-D12	5 V	±12 V	±100mA



DESCRIPTION

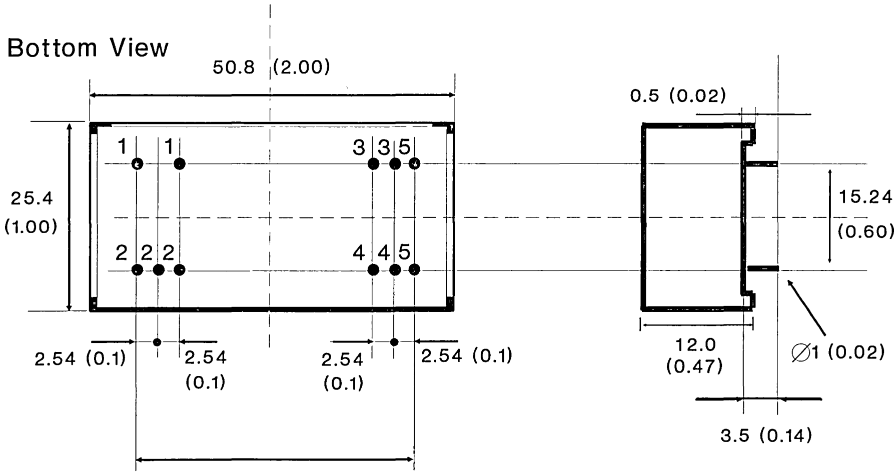
The GS2T5-D12 is a 2W DC-DC converter designed to provide an isolated +12V/100mA and –12V/100mA power source.

The module operates from a 5V input source and offers 2500V_{DC} isolation.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_{o1} = +12V I_{o1} = 0 to100mA V_{o2} = – 12V I_{o2} = 0 to – 100mA	4.75	5.00	5.25	V
I_{ir}	Input Reflected Current	V_i = 4.75 to 5.25V Full Load		50	75	mApp
V_{o1}	Output Voltage 1	V_i = 4.75 to 5.25V I_{o1} = 0 to 100mA	10.8	12.0	13.2	V
V_{o2}	Output Voltage 2	V_i = 4.75 to 5.25V I_{o2} = 0 to – 100mA	– 10.8	– 12.0	– 13.2	V
V_{or1}	Output Ripple Voltage 1	V_i = 4.75 to 5.25V I_{o1} = 100mA			100	mV_{RMS}
V_{or2}	Output Ripple Voltage 2	V_i = 4.75 to 5.25V I_{o2} = – 100mA			100	mV_{RMS}
I_{o1}	Output Current 1	V_i = 4.75 to 5.25V V_{o1} = 12V	0		100	mA
I_{o2}	Output Current 2	V_i = 4.75 to 5.25V V_{o2} = – 12V	0		– 100	mA
V_{is}	Isolation Voltage		2500			V_{DC}
η	Efficiency	V_i = 5V Full Load	70	75		%
Top	Operating Ambient Temperature Range		0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = Vin -
2 = Vin +
3 = Vout -
4 = Vout +
5 = Out Common Ground

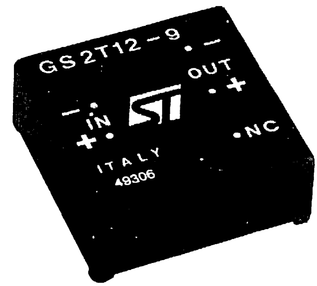
Package D. Dimensions in mm (inches)

2W LAN DC-DC CONVERTER

Type	V_i	V_o	Io
GS2T12-9	12 V	– 9 V	– 250 mA

DESCRIPTION

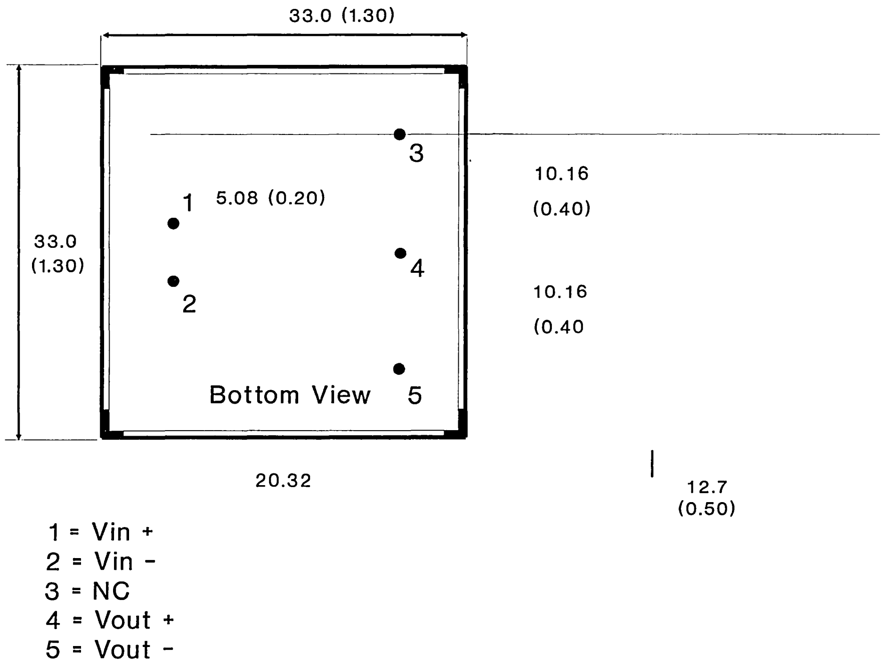
The GS2T12-9 is a 2.25W DC-DC converter designed to provide power, voltage regulation and isolation for Local Area Network (CHEAPERNET and ETHERNET) transceivers from a wide range of input voltage, according to IEEE 802.3 Standard.



ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = -9V I_O = – 70 to – 250mA	11.28	12.00	15.75	V
I_{ir}	Reflected Input Current	V_i = 11.28 to 15.75V I_O = – 250mA V_O = – 9V			100	mApp
V_O	Output Voltage	V_i = 11.28 to 15.75V I_O = – 70 to – 250mA	– 8.55	– 9.00	– 9.45	V
V_{or}	Output Ripple Voltage	V_i = 11.28 to 15.75V I_O = – 250mA			50	mV_{RMS}
V_{on}	Output Noise Voltage	V_i = 11.28 to 15.75V I_O = – 250mA			75	mVpp
δV_{OL}	Line Regulation	V_i = 11.28 to 15.75V I_O = – 250mA			5	mV
δV_{OO}	Load Regulation	V_i = 12V I_O = – 70 to – 250mA			5	mV
I_O	Output Current	V_i = 11.28 to 15.75V V_O = – 9V	70		250	mA
V_{is}	Isolation Voltage	Input to Output	2500			V_{DC}
η	Efficiency	V_i = 11.28 to 15.75V I_O = – 250mA	70	71		%
Top	Operating Ambient Temperature Range		0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



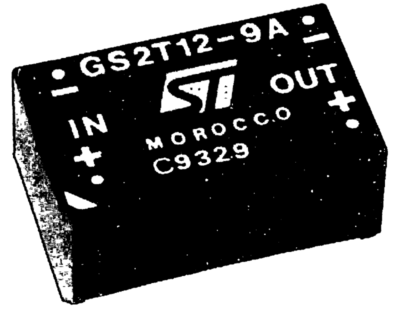
Package A. Dimensions in mm. (inches)

SGS-THOMSON
MICROELECTRONICS

GS2T12-9A

2 W LAN DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2T12-9A	9,5 to 15,7 V	– 9 V	– 250 mA



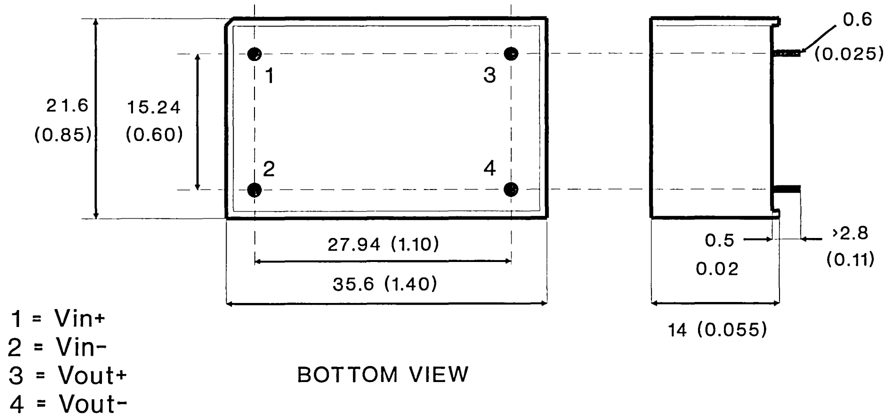
DESCRIPTION

The GS2T12-9A is a 2.25W DC-DC converter designed to provide power, voltage regulation and isolation for Local Area Network (CHEAPERNET and ETHERNET) transceivers from a wide range of input voltage, according to IEEE 802.3 Standard.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = – 9V I_O = 0 to – 250mA	9.50		15.75	V
I_{ir}	Input Reflected Current	V_i = 9.50 to 15.75V V_O= – 9V I_O = – 250mA		2	5	mApp
V_O	Output Voltage	V_i = 9.50 to 15.75V I_O= 0 to – 250mA	– 8.55	– 9.00	– 9.45	V
V_{or}	Output Ripple Voltage	V_i = 9.50 to 15.75 V I_O = – 250mA		2	5	mV_{RMS}
δV_{OL}	Line Regulation	V_i = 9.50 to 15.75V I_O = – 250mA			5	mV
δV_{OO}	Load Regulation	V_i = 12V I_O = 0 to – 250mA			5	mV
I_O	Output Current	V_i = 9.50 to 15.75V V_O = – 9V	0		– 250	mA
V_{is}	Isolation Voltage		2500			V_{DC}
η	Efficiency	V_i = 9.50V to 15.75V I_O = – 250mA	75	80		%
Top	Operating Ambient Temperature Range		0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package B. Dimensions in mm (inches)

2 W LAN DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2T12-9S	9,5 to 15,75 V	– 9 V	– 250 mA

DESCRIPTION

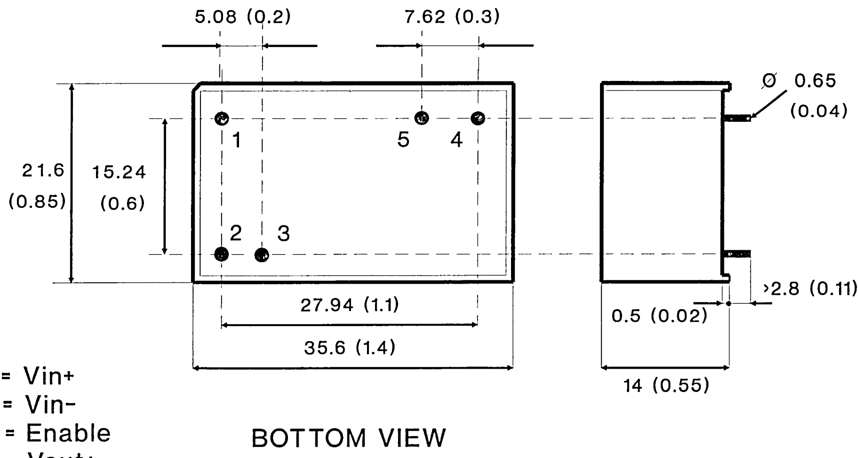
The GS2T12-9S is a 2.25W DC-DC converter designed to provide power, voltage regulation and isolation for Local Area Network (CHEAPERNET and ETHERNET) transceivers from a wide range of input voltage, according to IEEE 802.3 Standard.

Enable function, active high, is available with CMOS/TTL logic operation compatibility.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = – 9V I_O = 0 to – 250mA	9.50	12	15.75	V
V_{ir}	Input Ripple	V_i = 12V I_O = – 250mA		45	75	mVpp
I_{ir}	Reflected Input Current	V_i = 12V I_O = – 250mA		10	20	mApp
I_{ien}	Enable Input Current	V_i = 9.50 to 15.75V			0.2	mA
V_O	Output Voltage	V_i = 9.50 to 15.75V I_O = 0 to – 250mA	– 8.55	– 9.00	– 9.45	V
V_{or}	Output Ripple Voltage	V_i = 12V I_O = – 250mA		30	70	mVpp
V_{is}	Isolation Voltage	Input to Output	2500			V_{DC}
η	Efficiency	V_i = 12V I_O = – 250mA	68	71		%
T_{op}	Operating Ambient Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA

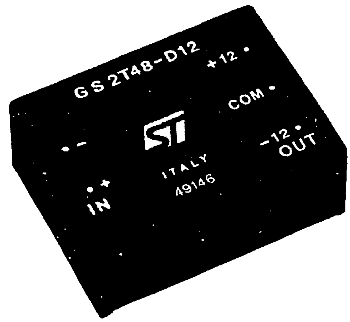


1 = Vin+
2 = Vin-
3 = Enable
4 = Vout+
5 = Vout-

Package B. Dimensions in mm (inches)

2W DUAL OUTPUT DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2T48-D12	38 to 60 V	±12 V	±100mA



DESCRIPTION

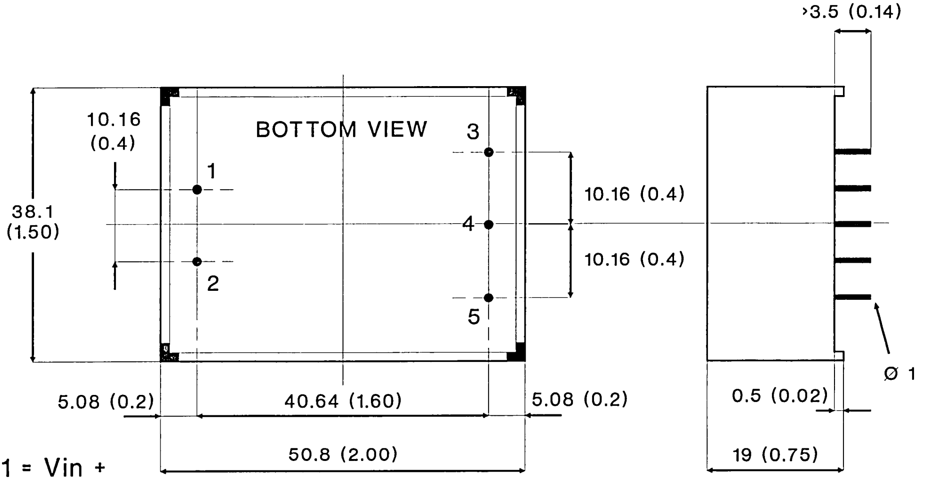
The GS2T48-D12 is a 2.4W DC-DC converter designed to provide an isolated +12V/100mA and -12V/100mA power source.

The module operates from wide input range (38 to 60V) and offers low reflected input current and continuous short-circuit protection.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_{o1} = +12V I_{o1}= 0 to 100mA V_{o2} = – 12V I_{o2} = 0 to – 100mA	38	48	60	V
I_{ir}	Input Reflected Current	V_i = 38 to 60V Full Load		3	5	mApp
V_{o1}	Output Voltage 1	V_i = 38 to 60V I_{o1} = 0 to 100mA I_{o2} = 0 to – 100mA	11.2	12.0	12.8	V
V_{o2}	Output Voltage 2	V_i = 38 to 60V I_{o2} = 0 to – 100mA I_{o1} = 0 to 100mA	– 11.2	– 12.0	– 12.8	V
V_{or1}	Output Ripple Voltage 1	V_i = 38 to 60 I_{o1} = 100mA		30	50	mV_{RMS}
V_{or2}	Output Ripple Voltage 2	V_i = 38 to 60 I_{o2} = – 100mA		30	50	mV_{RMS}
I_{o1}	Output Current 1	V_i = 38 to 60V V_{o1} = 12V	0		100	mA
I_{o2}	Output Current 2	V_i = 38 to 60V V_{o2} = – 12V	0		– 100	mA
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency	V_i = 48V	50	100	150	kHz
η	Efficiency	V_i = 48V Full Load	70	73		%
Top	Operating Ambient Temperature Range		0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = Vin +
2 = Vin -
3 = Vout -
4 = Out Common Ground
5 = Vout +

Package E. Dimensions in mm (inches)

SGS-THOMSON MICROELECTRONICS

GS2TX-9

2 W LAN DC-DC CONVERTER

Type	V_i	V_o	I_o
GS2TX-9	4,5 to 15,75 V	– 9 V	– 250 mA

DESCRIPTION

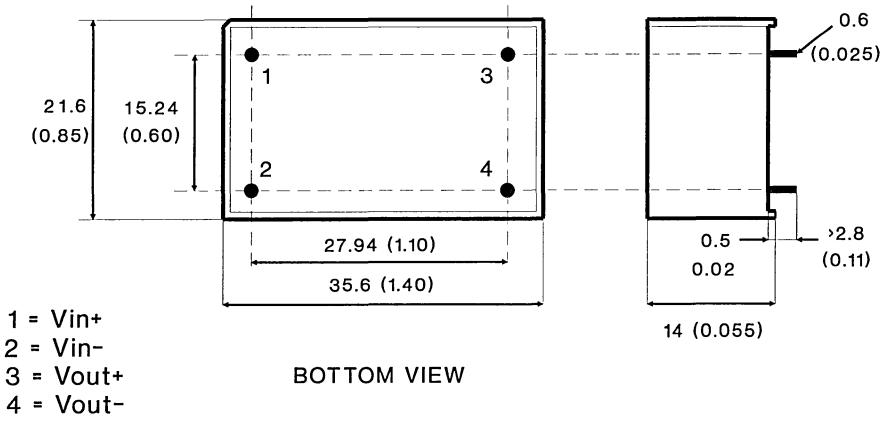
The GS2TX-9 is a 2.25W unregulated DC-DC converter designed to provide power, voltage regulation and isolation for Local Area Network (CHEAPERNET and ETHERNET) transceivers from a wide range of input voltage, according to IEEE 802.3 Standard.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 9V I_O = 0 to – 250mA	4.5		15.75	V
I_{ir}	Input Reflected Current	V_i = 5V V_O = – 9V I_O = – 250mA		25	30	mApp
I_{ir}	Input Reflected Current	V_i = 12V V_O = – 9V I_O = – 250mA		2	5	mApp
V_O	Output Voltage	V_i = 4.5 to 15.75V I_O = 0 to – 250mA	– 8.55	– 9.00	– 9.45	V
V_{Or}	Output Ripple Voltage	V_i = 5V I_O = – 250mA		7	10	mV_{RMS}
V_{Or}	Output Ripple Voltage	V_i = 12V I_O = – 250mA		2	5	mV_{RMS}
δV_{OL}	Line Regulation	V_i = 4.5 to 5.5V I_O = – 250mA			5	mV
δV_{OO}	Load Regulation	V_i = 4.5 to 15.75V I_O = – 20 to – 250mA			5	mV
I_O	Output Current*	V_i = 4.5 to 15.75V V_O = – 9V	0		– 250	mA
V_{is}	Isolation Voltage		2500			V_{DC}
η	Efficiency	V_i = 5V I_O = – 250mA	70	73		%
η	Efficiency	V_i = 12V I_O = – 250mA	75	80		%
Top	Operating Ambient Temperature Range		0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

* When the input voltage is <5V and the output current is less than 20mA, the output ripple voltage increases due to discontinuous operation.

CONNECTION DIAGRAM AND MECHANICAL DATA



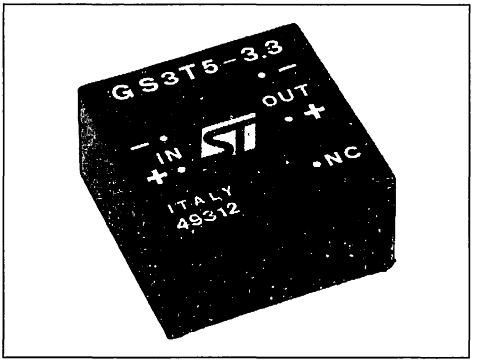
Package B. Dimensions in mm.

SGS-THOMSON MICROELECTRONICS

GS3T5-3.3

3 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS3T5-3.3	5 V	3,3 V	750 mA



DESCRIPTION

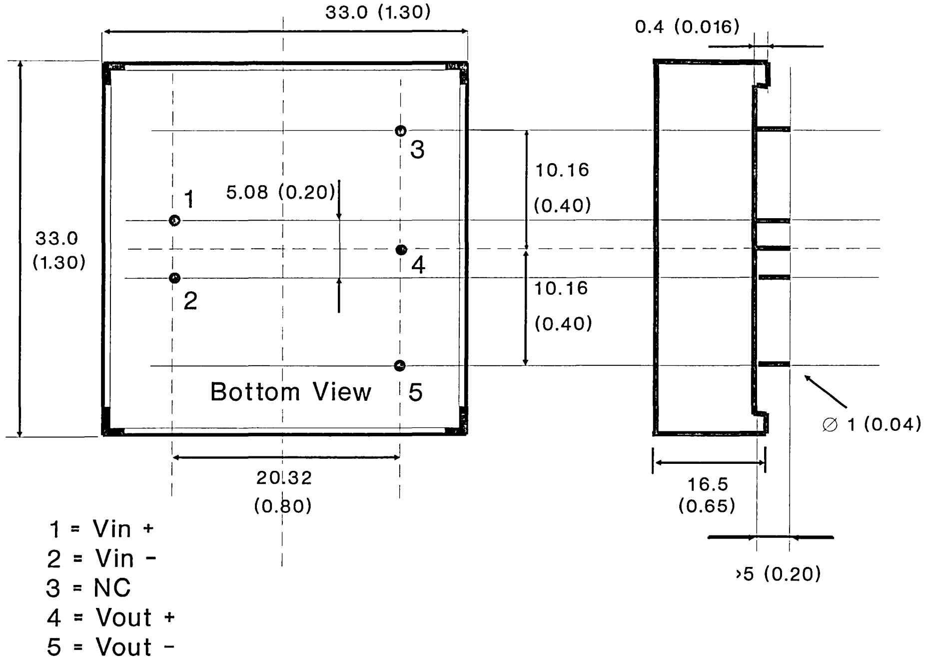
The GS3T5-3.3 is a 2.5W DC-DC converter designed to provide an isolated 3.3V/750mA power source.

The module operates from a 5V input source and features continuous short-circuit protection.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 3.3V I_O = 0 to 750mA	4.75	5.00	5.25	V
I_{ir}	Reflected Input Current	V_i = 5V V_O = 3.3V I_O = 750mA		25	50	mApp
V_O	Output Voltage	V_i = 4.75 to 5.25V I_O = 0 to 750mA	3.2	3.3	3.4	V
V_{or}	Output Ripple Voltage	V_i = 5V I_O = 750mA		7	15	mV_{RMS}
δV_{OL}	Line Regulation	V_i = 4.75 to 5.25V I_O = 750mA		2	10	mV
δV_{OO}	Load Regulation	V_i = 5V I_O = 50 to 750mA		20	50	mV
I_O	Output Current	V_i = 4.75 to 5.25V V_O = 3.3V	0		750	mA
I_{osc}	Output Short-circuit Current	V_i = 5V		1200	1500	mA
V_{is}	Isolation Voltage		750			V_{DC}
f_s	Switching Frequency	V_i = 5V I_O = 750mA		70		kHz
η	Efficiency	V_i = 5V I_O = 750mA	70	75		%
T_{op}	Operating Ambient Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package C. Dimensions in mm (inches)

SGS-THOMSON
MICROELECTRONICS

GS3T5-5.2

3 W DC-DC CONVERTER FOR ECL

Type	V_i	V_o	Io
GS3T5-5.2	5 V	5,2 V	600 mA

DESCRIPTION

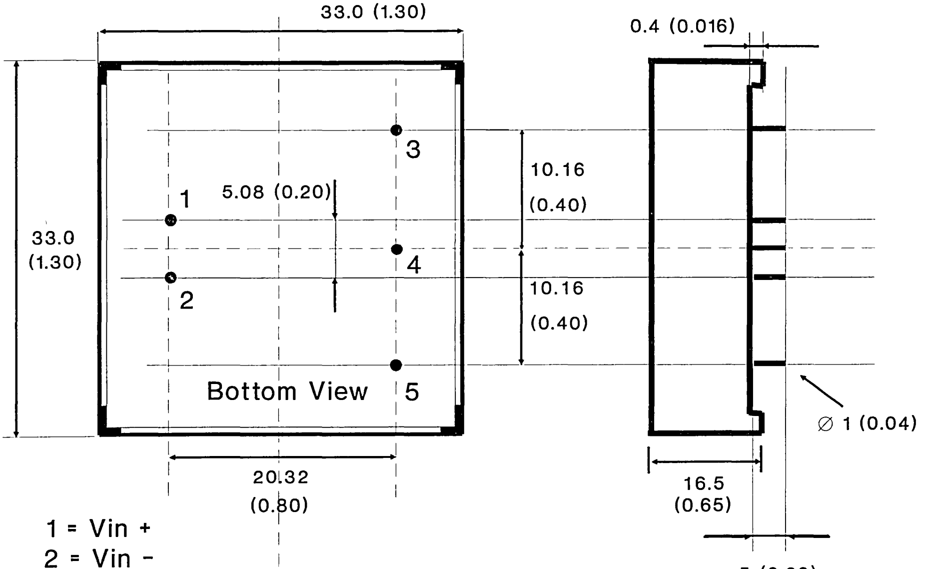
The GS3T5-5.2 is a 3.12W DC-DC converter designed to provide an isolated 5.2V/600mA power source.

The module operates from a 5V input source and features continuous short-circuit protection.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5.2V I_O = 0 to 600mA	4.75	5.00	5.25	V
I_{ir}	Reflected Input Current	V_i = 5V V_O = 5.2V I_O = 600mA		25	50	mApp
V_O	Output Voltage	V_i = 4.75 to 5.25V I_O = 0 to 600mA	5.04	5.20	5.36	V
V_{or}	Output Ripple Voltage	V_i = 5V I_O = 600mA		5	15	mV_{RMS}
V_{orn}	Total Output Ripple and Noise Voltage	V_i = 5V I_O = 600mA			70	mVpp
δV_{OL}	Line Regulation	V_i = 4.75 to 5.25V I_O = 600mA		2	10	mV
δV_{OO}	Load Regulation	V_i = 5V I_O = 50 to 600mA		10	15	mV
I_O	Output Current	V_i = 4.75 to 5.25V V_O = 5.2V	0		600	mA
I_{osc}	Output Short-circuit Current	V_i = 5V		900	1500	mA
V_{is}	Isolation Voltage		750			V_{DC}
f_s	Switching Frequency	V_i = 5V I_O = 600mA		70		kHz
η	Efficiency	V_i = 5V I_O = 600mA	70	75		%
Top	Operating Ambient Temperature Range	Still Air	0		+60	°C
Top	Operating Ambient Temperature Range	Forced Ventilation, air speed = 100 LFM	0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA

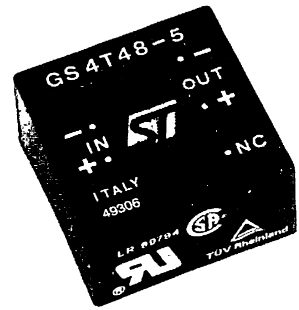


1 = Vin +
2 = Vin -
3 = NC
4 = Vout +
5 = Vout -

Package C. Dimensions in mm (inches)

4 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS4T48-5	38 to 60 V	5 V	800 mA



DESCRIPTION

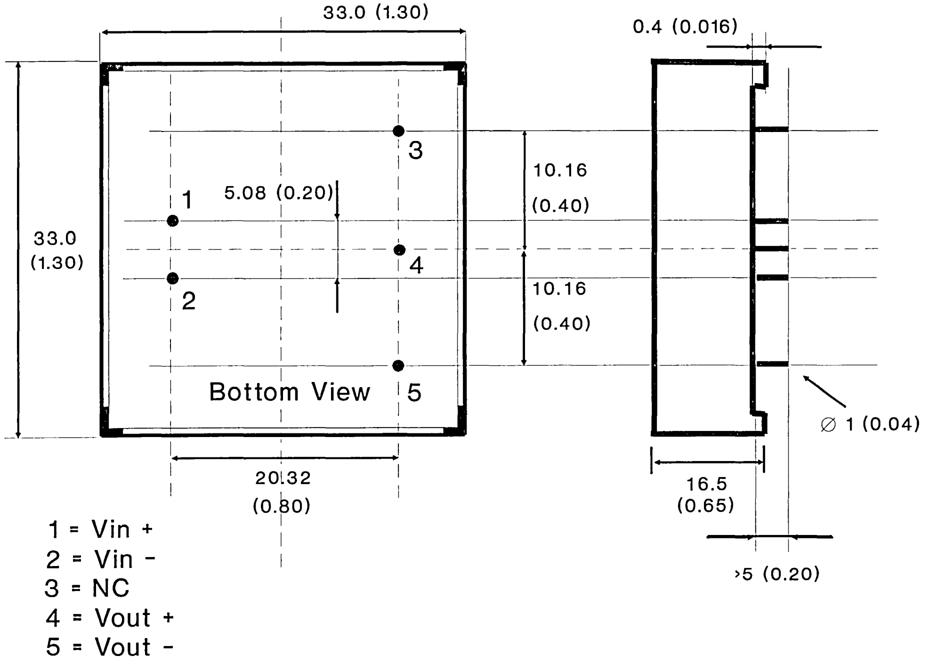
The GS4T48-5 is a 4W DC-DC converter designed to provide a 5V/800mA isolated power source.

The module features a wide input voltage range (38 to 60V), low reflected input current and continuous short-circuit protection. It is certified by UL, CSA (level 3) and TUV as having SELV output when provided with a SELV input.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5V I_O = 50 to 800mA	38	48	60	V
I_i	Input Current	V_i = 38 to 60V I_O = 800mA			140	mA
I_{ir}	Input Reflected Current	V_i = 48V V_O = 5V I_O = 800mA		20	30	mApp
V_O	Output Voltage	V_i = 38 to 60V I_O = 50 to 800mA	4.8	5	5.2	V
V_{or}	Output Ripple Voltage	V_i = 48V I_O = 800mA BW = 5Hz to 20MHz		30	50	mVpp
δV_{OL}	Line Regulation	V_i = 38 to 60V I_O = 800mA		1	2	mV/V
δV_{OO}	Load Regulation	V_i = 48V I_O = 50 to 800mA		50	75	mV/A
I_O	Output Current	V_i = 38 to 60V V_O = 5V	50		800	mA
I_{osc}	Output Short-circuit Current	V_i = 48V			2	A
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency	V_i = 38 to 60V I_O = 50 to 800mA	50		200	kHz
η	Efficiency	V_i = 48V I_O = 800mA	70	73		%
Top	Operating Ambient Temperature Range	Still Air	0		+55	°C
Top	Operating Ambient Temperature Range	Forced ventilation, air speed = 100 LFM	0		+65	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package C. Dimensions in mm (inches)

SAFETY APPROVALS

The converter is agency certified to the following safety requirements:

Agency	Requirements	File Number
UL	UL-STD-1950	E141284
CSA	CSA-STD-C22.2 No. 234	LR 99794-3
TUV	EN 60950 DIN VDE 0805	R 9172410

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SGS-THOMSON MICROELECTRONICS

GS5T24-5D15

5W TRIPLE OUTPUT DC-DC CONVERTER

Type	V_I	V_O	I_O
GS5T24-5D15	17,5 to 30	+ 5 V	200 mA
		+ 15 V	125 mA
		- 15 V	– 125 mA

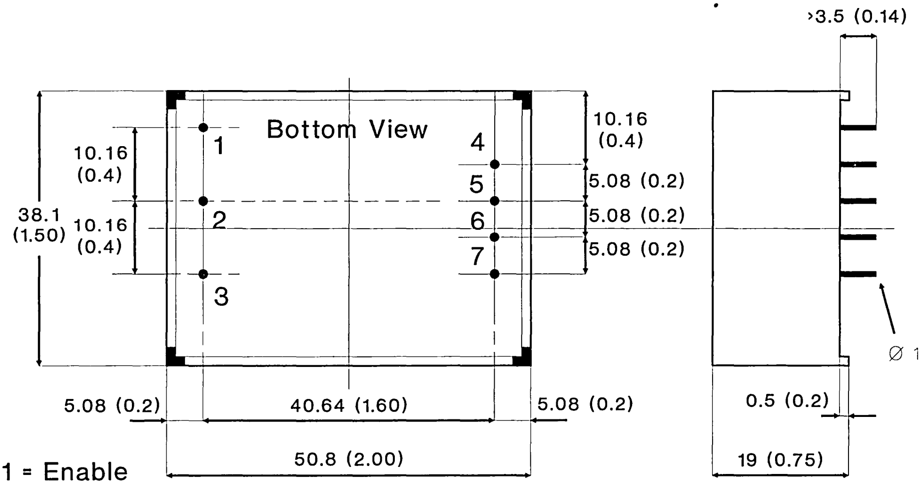
DESCRIPTION

The GS5T24-5D15 is a 5W DC-DC converter designed to provide three isolated outputs: 5V/200mA and a dual ±15V/±125mA.
The module operates from a 24V input source and offers 2500V_{DC} isolation voltage. A high level TTL/CMOS compatible input will enable the unit; a low input will inhibit it.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
V_i	Input Voltage	V_{o1} = 5V V_{o2} = 15V V_{o3} = – 15V	I_{o1} = 0 to 200mA I_{o2} = 0 to 125mA I_{o3} = 0 to – 125mA	17.5	24.0	30.0	V
I_{ir}	Input Reflected Current	Vi = 17.5 to 30V	Full Load on All Outputs			75	mApp
V_{o1}	Output Voltage 1	V_i = 17.5 to 30V	I_{o1} = 0 to 200mA	4.75	5.00	5.25	V
V_{o2}	Output Voltage 2	V_i = 17.5 to 30V	I_{o2} = 0 to 125mA	14.25	15.00	15.75	V
V_{o3}	Output Voltage 3	V_i = 17.5 to 30V	I_{o3} = 0 to – 125mA	– 14.25	– 15.00	– 15.75	V
V_{or1}	Output Ripple Voltage 1	Vi = 24V	Full Load on All Outputs			30	mVpp
V_{or2}	Output Ripple Voltage 2	Vi = 24V	Full Load on All Outputs			90	mVpp
V_{or3}	Output Ripple Voltage 3	Vi = 24V	Full Load on All Outputs			90	mVpp
I_{o1}	Output Current 1	V_i = 17.5 to 30V V_{o1} = 5V		0		200	mA
I_{o2}	Output Current 2	V_i = 17.5 to 30V V_{o2} = 15V	I_{o3} = 0 to 125mA	0		125	mA
I_{o3}	Output Current 3	V_i = 17.5 to 30V V_{o3} = – 15V	I_{o2} = 0 to – 125mA	0		125	mA
V_{is}	Isolation Voltage			2500			V_{DC}
f_s	Switching Frequency				120		kHz
η	Efficiency	V_i = 24V	Full Load on All Outputs	65	70		%
Top	Operating Ambient Temperature Range	Still air		0		+40	°C
Top	Operating Ambient Temperature Range	Forced ventilation, air speed = 100 LFM		0		+60	°C
Tstg	Storage Temperature Range			– 20		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = Enable
2 = Vin -
3 = Vin +
4 = Vout -15V
5 = Vout +15V
6 = Out Common Ground
7 = Vout +5V

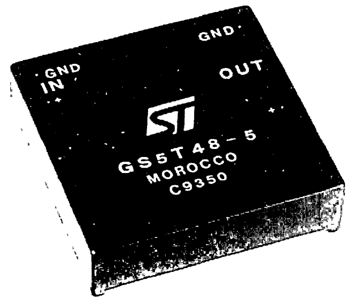
Package E. Dimensions in mm (inches)

SGS-THOMSON MICROELECTRONICS

GS5T48-5

5 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS5T48-5	40 to 60 V	5 V	1 A



DESCRIPTION

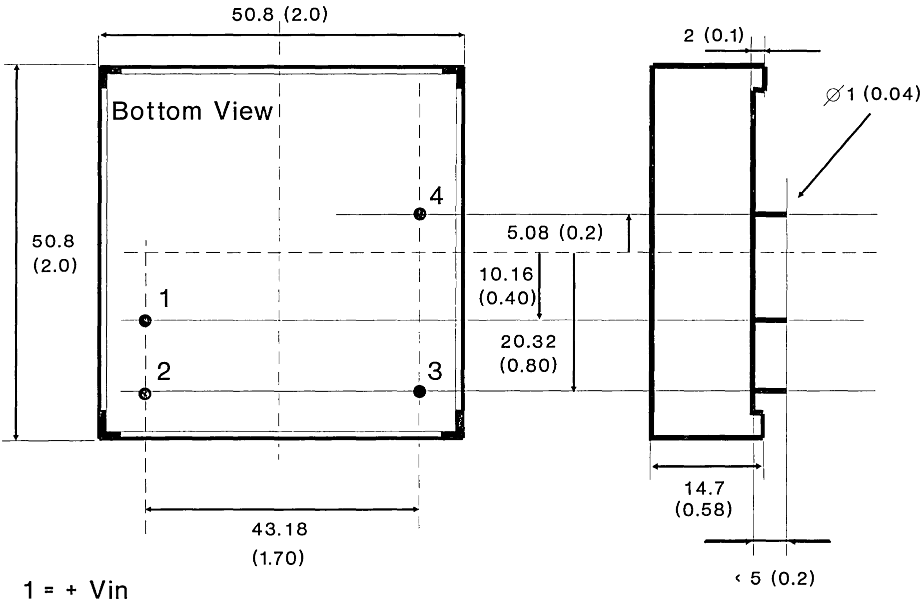
The GS5T48-5 is a 5W DC-DC converter designed to provide a 5V/1A isolated power source in a metal package.

The module features a wide input voltage range (40 to 60V), low reflected input current and continuous short-circuit protection.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5V I_O = 50 to 1000mA	40	48	60	V
I_i	Input Current	V_i = 40 to 60V I_O = 1000mA			115	mA
I_{ir}	Input Reflected Current	V_i = 48V V_O = 5V I_O= 1000mA		10	15	mApp
V_O	Output Voltage	V_i = 40 to 60V I_O = 50 to 1000mA	4.85	5.00	5.15	V
V_{or}	Output Ripple Voltage	V_i = 48V I_O = 1000mA BW = 5Hz to 20MHz		20	35	mVpp
I_O	Output Current	V_i = 40 to 60V V_O = 5V	50		1000	mA
I_{osc}	Output Short-circuit Current	V_i = 48V			2.3	A
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency	V_i = 40 to 60V I_O = 50 to 1000mA		100		kHz
η	Efficiency	V_i = 48V I_O = 1000mA	70	72		%
Top	Operating Case Temperature Range		– 25		+85	°C
Tstg	Storage Temperature Range		– 40		+105	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = + Vin
2 = - Vin
3 = - Vout
4 = + Vout

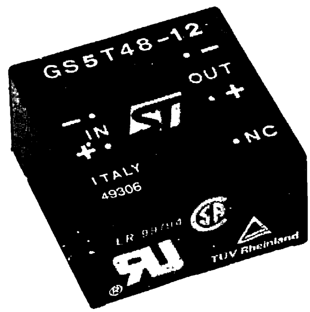
Package G. Dimensions in mm (inches)

SGS-THOMSON MICROELECTRONICS

GS5T48-12

5 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS5T48-12	38 to 60 V	12 V	420 mA



DESCRIPTION

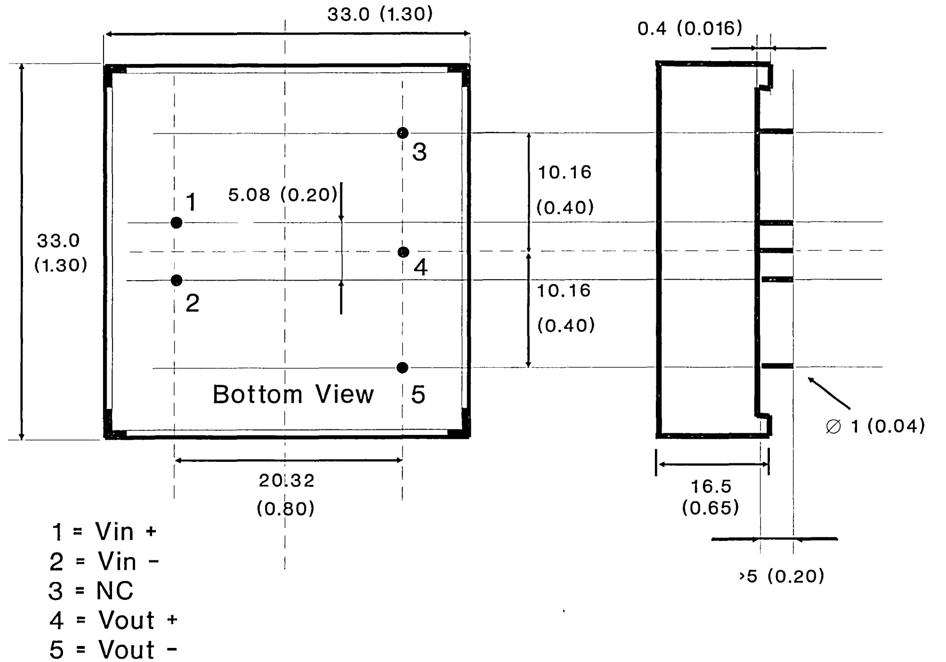
The GS5T48-12 is a 5W DC-DC converter designed to provide a 12V/420mA isolated power source.

The module features a wide input voltage range (38 to 60V), low reflected input current and continuous short-circuit protection. It is certified by UL, CSA (level 3) and TUV as having SELV output when provided with a SELV input.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 12V I_O = 50 to 420mA	38	48	60	V
I_i	Input Current	V_i = 38 to 60V I_O = 420mA			500	mA
I_{ir}	Input Reflected Current	V_i = 48V V_O = 12V I_O = 420mA		25	40	mApp
V_O	Output Voltage	V_i = 38 to 60V I_O = 50 to 420mA	11.5	12	12.5	V
V_{or}	Output Ripple Voltage	V_i = 48V I_O = 420mA BW = 5Hz to 20MHz		50	100	mVpp
δV_{OL}	Line Regulation	V_i = 38 to 60V I_O = 420mA		1	2	mV/V
δV_{OO}	Load Regulation	Vi = 48V I_O = 50 to 420mA		100	150	mV/A
I_O	Output Current	V_i = 38 to 60V V_O = 12V	50		420	mA
I_{osc}	Output Short-circuit Current	V_i = 48V			1.8	A
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency	V_i = 38 to 60V I_O = 50 to 420mA	30		200	kHz
η	Efficiency	V_i = 48V I_O = 420mA	78	80		%
Top	Operating Ambient Temperature Range	Still air	0		+60	°C
Top	Operating Ambient Temperature Range	Forced ventilation, air speed = 100 LFM	0		+70	°C
Tstg	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package C. Dimensions in mm (inches)

SAFETY APPROVALS

The converter is agency certified to the following safety requirements:

Agency	Requirements	File Number
UL	UL-STD-1950	E141284
CSA	CSA-STD-C22.2 No. 234	LR 99794-3
TUV	EN 60950 DIN VDE 0805	R 9172410

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® TUV is a registered trademark of TUV Rheinland.

SGS-THOMSON MICROELECTRONICS

GS5T48-15

5 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS5T48-15	38 to 60 V	15 V	330 mA

DESCRIPTION

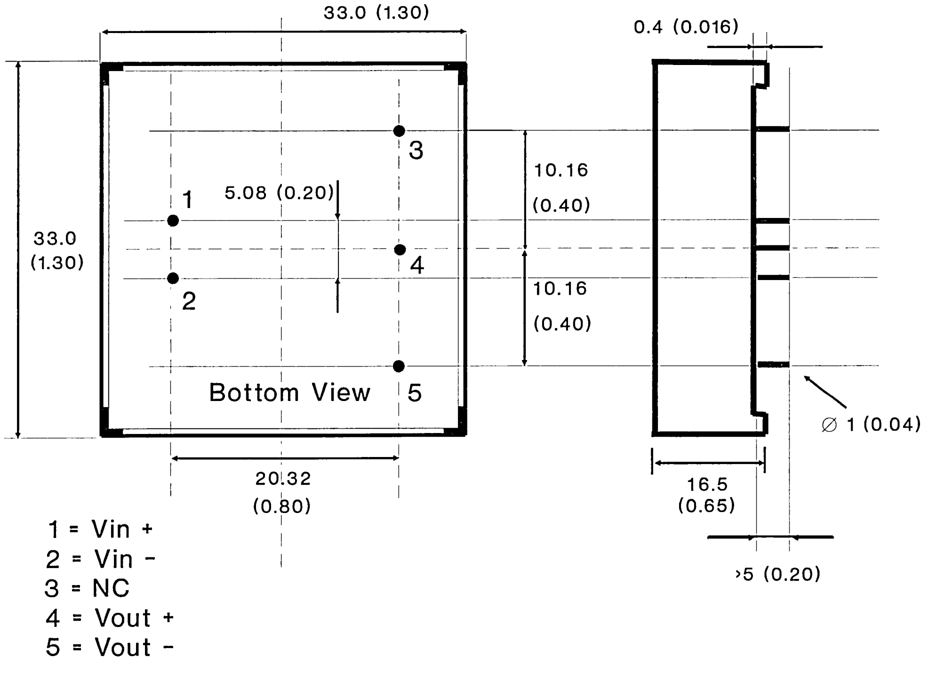
The GS5T48-15 is a 5W DC-DC converter designed to provide a 15V/330mA isolated power source.

The module features a wide input voltage range (38 to 60V), low reflected input current and continuous short-circuit protection. It is certified by UL, CSA (level 3) and TUV as having SELV output when provided with a SELV input.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 15V I_O = 50 to 330mA	38	48	60	V
I_i	Input Current	V_i = 38 to 60V I_O = 330mA			500	mA
I_{ir}	Input Reflected Current	V_i = 48V V_O = 15V I_O = 330mA		25	40	mApp
V_O	Output Voltage	V_i = 38 to 60V I_O = 50 to 330mA	14.5	15	15.5	V
V_{or}	Output Ripple Voltage	V_i = 48V I_O = 330mA BW = 5Hz to 20MHz		50	100	mVpp
δV_{OL}	Line Regulation	V_i = 38 to 60V I_O = 330mA		1	2	mV/V
δV_{OO}	Load Regulation	V_i = 48V I_O = 50 to 330mA		100	150	mV/A
I_O	Output Current	V_i = 38 to 60V V_O = 15V	50		330	mA
I_{osc}	Output Short-circuit Current	V_i = 48V			1.8	A
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency	V_i = 38 to 60V I_O = 50 to 330mA	30		200	kHz
η	Efficiency	V_i = 48V I_O = 330mA	80	82		%
T_{op}	Operating Ambient Temperature Range	Still air	0		+60	°C
T_{op}	Operating Ambient Temperature Range	Forced ventilation, air speed = 100 LFM	0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package C. Dimensions in mm (inches)

SAFETY APPROVALS

The converter is agency certified to the following safety requirements:

Agency	Requirements	File Number
UL	UL-STD-1950	E141284
CSA	CSA-STD-C22.2 No. 234	LR 99794-3
TUV	EN 60950 DIN VDE 0805	R 9172410

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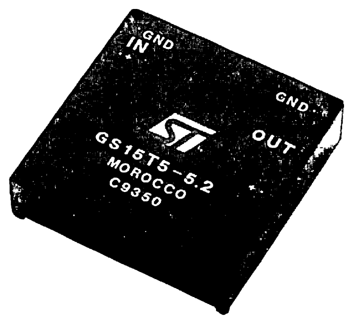
SGS-THOMSON MICROELECTRONICS

GS15T5-5.2

15 W DC-DC CONVERTER FOR ECL

Type	V_{in}	V_{out}	I_{out}
GS15T5-5.2	5 V	5,2 V	3 A



DESCRIPTION

The GS15T5-5.2 is a 15W DC-DC converter designed to provide a 5.2V isolated output from a 5V input.

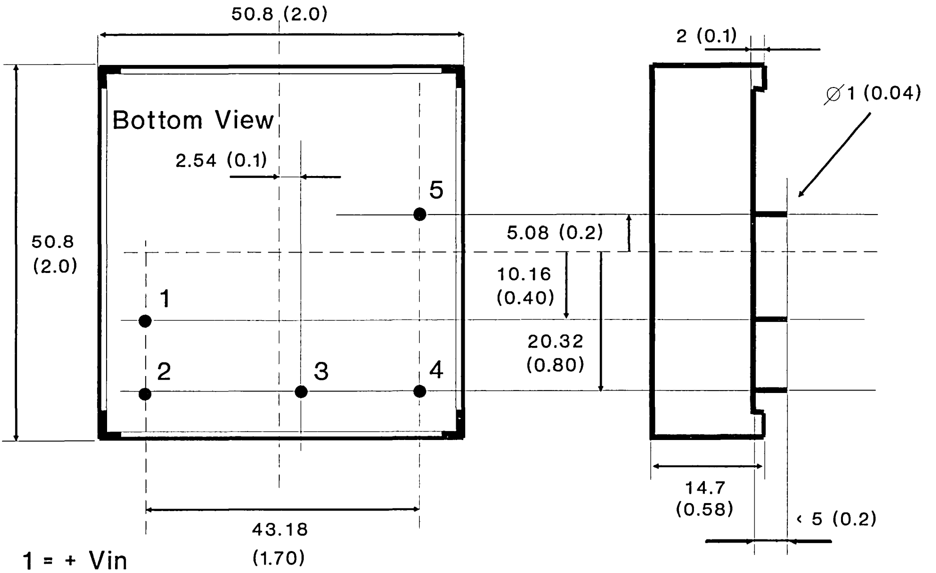
The device can operate with an output current in the range of 0.0 to 3.0A without any intermittent operation (packet switching).

It offers short-circuit protection and input-output isolation of 750V_{DC} minimum. The integral heatsink allows a large power handling capability and it provides also an effective shielding to minimize EMI.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5.2V I_O = 0.0 to 3.0A	4.75	5.0	5.35	V
I_{ir}	Input Reflected Current	V_i = 5.0V V_O = 5.2V I_O = 3.0A		40	50	mApp
I_{iq}	Input Quiescent Current	V_i = 5.0V V_O = 5.2V I_O = 0.0A		87	95	mA
V_O	Output Voltage	V_i = 4.75 to 5.25V I_O = 0.0 to 3.0A	5.04	5.2	5.36	V
I_O	Output Current	V_i = 4.75 to 5.25V	0.0		3.0	A
δV_{OL}	Line Regulation	V_i = 4.75 to 5.25V I_O = 3.0A		1	10	mV
δV_{OO}	Load Regulation	V_i = 5.0V I_O = 0.0 to 3.0A		10	15	mV
V_{or}	Output Ripple Voltage	V_i = 5.0V I_O = 3.0A		20	30	mVpp
V_{or}	Output Ripple Voltage	V_i = 5.0V I_O = 3.0A		8		mV_{RMS}
I_{osc}	Output Short-circuit Current	V_i = 5.0V			4.75	A
V_{is}	Isolation Voltage		750			V_{DC}
f_s	Switching Frequency	V_i = 4.75 to 5.25V I_O = 0.0 to 3.0A		100		kHz
η	Efficiency	V_i = 5.0V I_O = 3.0A	77	79		%
R_{thc}	Thermal Resistance Case to Ambient	$T_{amb.}$= 25°C V_i = 5.0V I_O = 3.0A		8		°C/W
T_c	Maximum Case Temperature				90	°C
T_{stg}	Storage Temperature Range		– 40		+105	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



1 = + Vin
2 = - Vin
3 = Case
4 = - Vout
5 = + Vout

Package G. Dimensions in mm (inches)

USER NOTES

Thermal Characteristics

Worst case power dissipation at full load is less than 5W.

To operate the device at an ambient temperature of 60 °C the thermal resistance case-to-ambient must be lower than 6.5 °C/W.

This can be accomplished by adding an external heatsink or by forced ventilation with air speed of about 100 linear feet/minute.

MTBF Calculations

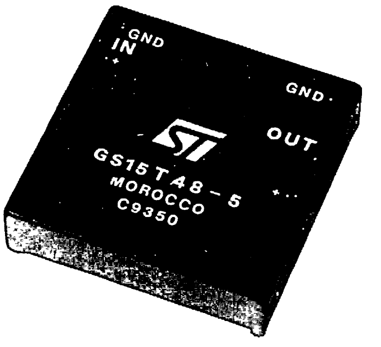
The MTBF according to MIL HDBK-217E calculation for a ground benign environment is:

- 216k hours for a case temperature of 91 °C.
- 379k hours for a case temperature of 60 °C.

This last condition can be obtained at $T_{amb.}$= 40 °C and forced ventilation of 100 feet/minute.

15W DC-DC CONVERTER

Type	V_i	V_o	Io
GS15T48-5	40 to 60 V	5 V	3 A



DESCRIPTION

The GS15T48-5 is a 15W DC-DC converter designed to provide a 5V/3A isolated output from a 48V input in a metal package.

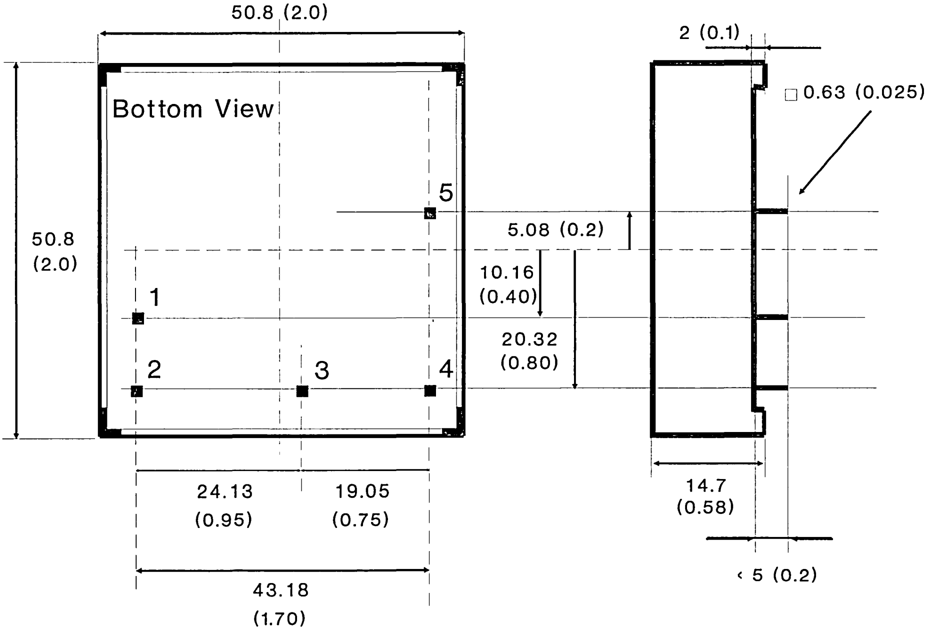
High frequency forward switching configuration ensures high efficiency (80% typ.); input filter minimizes reflected input current and continuous short-circuit protection is provided.

The integral heatsink allows a large power handling capability and it features also an effective shielding to minimize EMI.

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5V I_O = 0 to 3A	40	48	60	V
I_i	Input Current	V_i = 48V I_O = 3A		400		mA
I_{ir}	Input Reflected Current	V_i = 48V V_O = 5V I_O = 3A		50	80	mApp
I_{iq}	Input Quiescent Current	V_i = 48V V_O = 5V I_O = 0A		20		mA
V_O	Output Voltage	V_i = 40 to 60V I_O = 0 to 3A	4.75	5	5.25	V
δV_{OL}	Line Regulation	V_i = 40 to 60V I_O = 3A		10	20	mV
δV_{OO}	Load Regulation	V_i = 48V I_O = 0 to 3A		10	20	mV
V_{or}	Output Ripple Voltage	V_i = 48V I_O = 3A		20	50	mVpp
I_O	Output Current	V_i = 40 to 60V	0		3	A
I_{osc}	Output Short-circuit Current	V_i = 48V		5	6	A
V_{is}	Isolation Voltage		750			V_{DC}
f_s	Switching Frequency	V_i = 40 to 60V I_O = 0 to 3A		250		kHz
η	Efficiency	V_i = 48V I_O = 3A		80		%
R_{thc}	Thermal Resistance Case to Ambient	Tamb = 25°C V_i = 48V I_O = 3A		8		°C/W
T_{cmax}	Maximum Case Temperature				+85	°C
T_{stg}	Storage Temperature Range		– 40		+105	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package G. Dimensions in mm (inches)

PIN DESCRIPTION

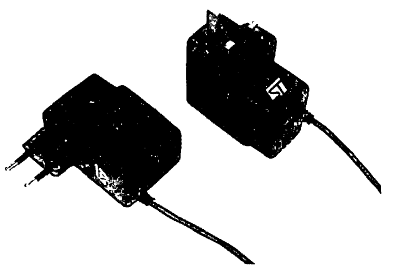
Pin	Function	Description
1	+ Input	DC input voltage (48V nom.)
2	- Input	Return for input voltage
3	Case	Case connection
4	- Output	Negative isolated output voltage
5	+ Output	Positive isolated output voltage

SGS-THOMSON MICROELECTRONICS

GS20AC-12

20 WATT AC-DC CONVERTER

Type	V_i	V_o	I_o
GS20AC-12	230 VRMS	12 V	1,7 A



DESCRIPTION

The GS20AC-12 is an AC-DC switching power supply able to deliver 20W output power (12V/1.7A).

Two versions of the INPUT PLUG ADAPTOR are available:

EUROPEAN VERSION:
GS20AC-12-1 (ORDERING NUMBER)

UK VERSION:
GS20AC-12-2 (ORDERING NUMBER)

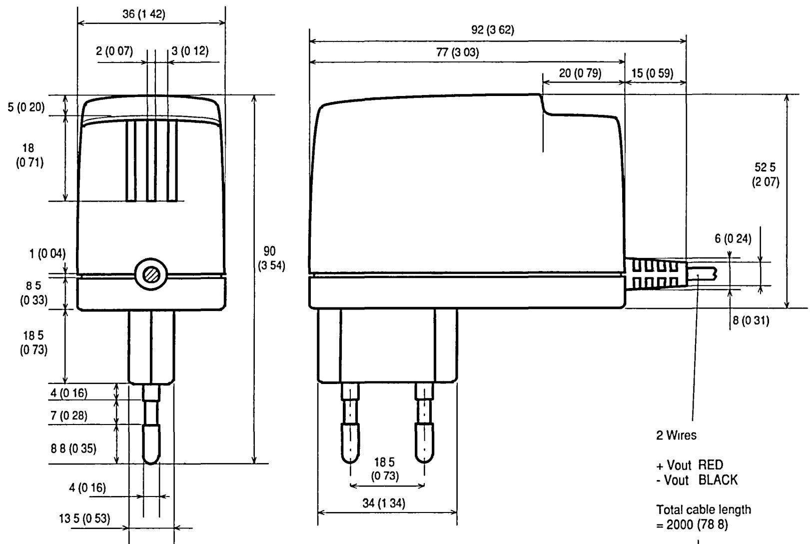
(See page 2 for mechanical drawings)

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

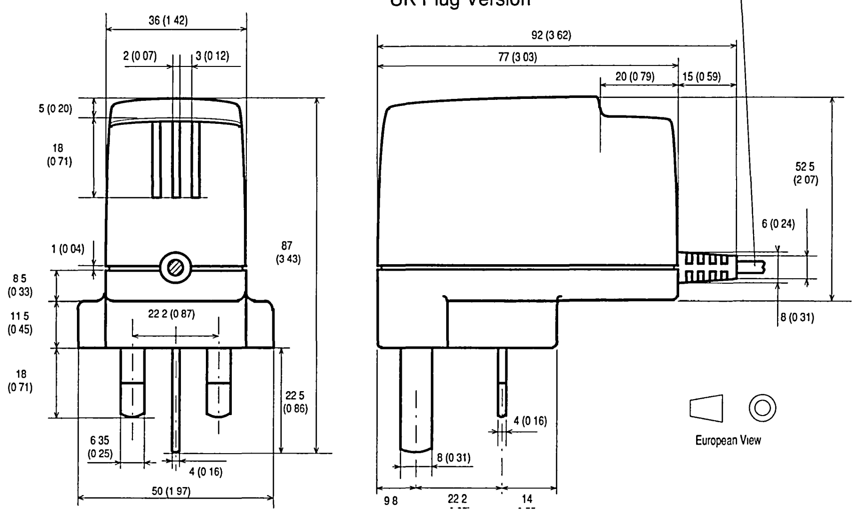
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage		187	230	264	V_{RMS}
V_o	Output Voltage	V_i = 187V to 264V_{RMS} I_o = 0 to 1.7A	11	12	13	V_{DC}
I_o	Output Current	V_i = 187V to 264V_{RMS} V_o = 11 to 13V	0		1.7	A
I_{ol}	Overcurrent Limit Initiation	V_i = 187V to 264V_{RMS}		2		A
I_{osc}	Short Circuit Output Current	V_i = 187V to 264V_{RMS}		0.7		A
η	Efficiency	V_i = 187V to 264V_{RMS} I_o = 1.7A		75		%
T_{op}	Operating Ambient Temperature Range		– 20		+45	°C
T_{stg}	Storage Temperature Range		– 25		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA

European Plug Version



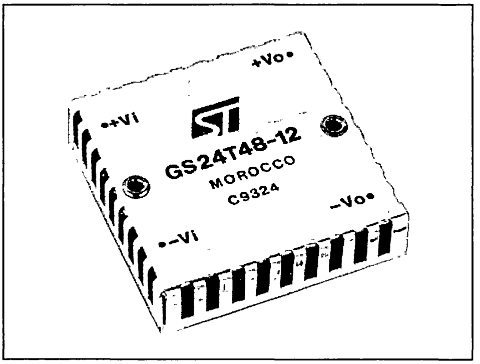
UK Plug Version



Output connector to be defined according to customer specifications
Dimensions in mm (inches).

24 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS24T48-12	36 to 72 V	12 V	2 A



DESCRIPTION

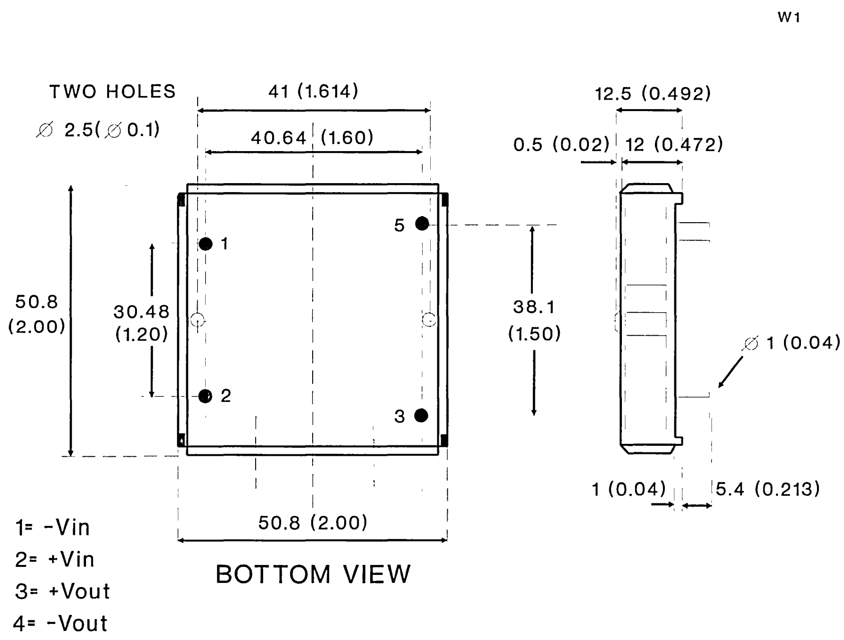
The GS24T48-12 is a 24W DC-DC converter designed to provide a 12V/2A isolated power source.

The module features a wide input voltage range (36 to 72V), low reflected input currend and short-circuit protection.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 12V I_O = 0.1 to 2A	36	48	72	V
I_i	Input Current	V_i = 48V V_O = 12V I_O = 2A		0.58	0.60	A
I_{ir}	Input Reflected Current	V_i = 48V V_O = 12V I_O = 2A		90	120	mApp
I_{iinr}	Input Inrush Current	V_i = 48V V_O = 12V I_O = 2A		18	22	Ap
I_{isc}	Input Shortcircuit Current	V_i = 48V V_O = 0V		100	150	mA
V_o	Output Voltage	V_i = 36 to 72V I_O = 0.1 to 2A	11.4	12	12.6	V
V_{or}	Output Ripple Voltage	V_i = 48V V_o = 12V I_O = 2A		30	60	mVpp
V_{on}	Output Noise Voltage	V_i = 48V V_O = 12V I_O = 2A BW = 100MHz			500	mVpp
δV_{OL}	Line Regulation	V_i = 36 to 72V I_O = 2A		20	30	mV
δV_{OO}	Load Regulation	V_i = 48V I_O = 0.1 to 2A		20	30	mV
I_o	Output Current	V_i = 36 to 72V V_O = 12V	0.1		2	A
I_{osc}	Output Short-circuit Current	V_i = 48V V_O = 0V		1.0	1.5	A
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency	V_i = 36 to 72V I_O = 0.1 to 2A		450		kHz
η	Efficiency	V_i = 48V V_O = 12V I_O = 2A	84	86		%
R_{th}	Thermal Resistance	Case-to-Ambient		13		°C/W
T_{cop}	Operating Case Temperature Range		0		+85	°C
T_{stg}	Storage Temperature Range		– 20		+105	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package W. Dimensions in mm. (inches)

SGS-THOMSON MICROELECTRONICS

GS25/30T24 Family

25/30 W DC-DC CONVERTER FAMILY

Type	V_i	V_o	I_o
GS25T24-5	18 to 36 V	5 V	5 A
GS30T24-12	18 to 36 V	12 V	2,5 A
GS30T24-15	18 to 36 V	15 V	2 A

FEATURES

- MTBF in excess of 1M hours at +45°C ambient temperature
- Wide input voltage range (18 to 36V)
- No external component required
- High efficiency (see data)
- Non latching permanent short-circuit protection
- Overvoltage protection
- Redundant operation
- Remote output voltage sense
- Remote INHIBIT/ENABLE
- Soft-start
- Minimized reflected input current
- Reverse input polarity protection
- Peak input overvoltage withstand
- No derating over the temperature range
- 500V_{DC} minimum isolation between input and output
- PCB or chassis mountable

DESCRIPTION

The GS25T24-5, GS30T24-12 and GS30T24-15 are isolated DC-DC converters designed for general purpose application.

The output power is in the range of 25W to 30W. To ensure very long life, these converters do not use electrolytic aluminum capacitors or optoelectronic feedback systems.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	17 to 38V	V
V_{ipk}	Input Transient Overvoltage (t ≤ 1sec.)	45	V
V_{ir}	Input Reverse Voltage	– 50	V
T_{stg}	Storage Temperature Range	– 55 to +105	°C
T_{op}	Operating Temperature Range	– 25 to +71	°C

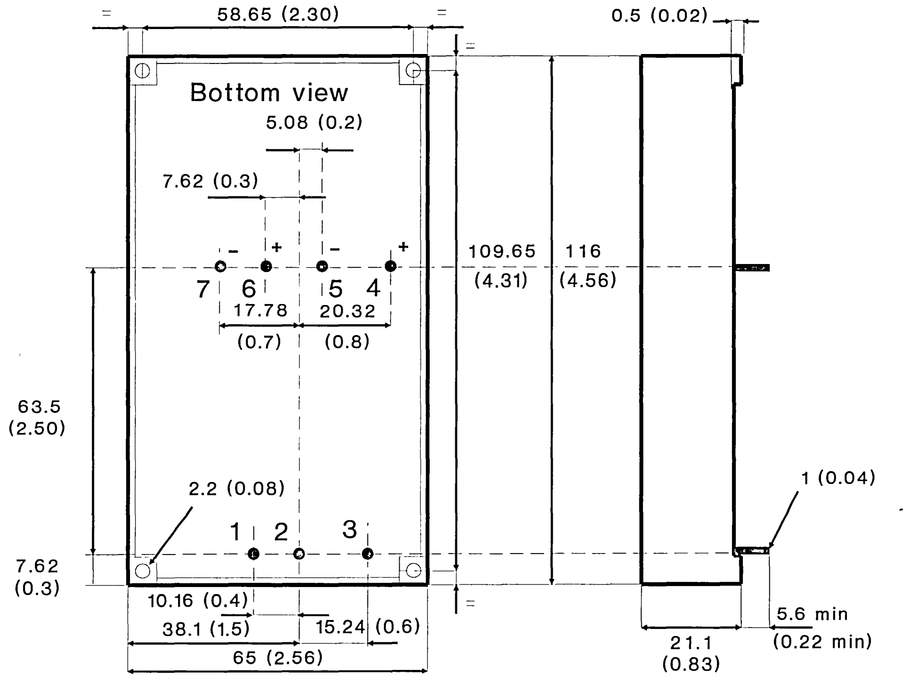
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	Full Load	18	24	36	V
I_i	Input Current	GS25T24-5 Full Load		1370		mA
		GS30T24-12 Full Load GS30T24-15		1600		
I_{ir}	Input Reflected Current	V_i = 24V Full Load		40		mApp
I_{isc}	Input Short-circuit Current	GS25T24-5 V_i = 24V		360		mA
		GS30T24-12 V_i = 24V		220		
		GS30T24-15 V_i = 24V		200		
I_{iq}	Input Quiescent Current	V_i = 24V Converter OFF		5		mA
V_{inhl}	Low Inhibit Voltage	V_i = 24V Full Load			1.2	V
V_{enh}	High Enable Voltage	V_i = 24V Full Load	1.8 (open)			V
I_{inh}	Input Inhibit Current	V_i = 24V Full Load		1		mA
V_o	Output Voltage	GS25T24-5 V_i = 24V Full Load	4.95	5.00	5.05	V
		GS30T24-12 V_i = 24V Full Load	11.88	12.00	12.12	
		GS30T24-15 V_i = 24V Full Load	14.85	15.00	15.15	
V_{or}	Output Ripple and Noise Voltage	V_i = 24V Full Load		10		mVpp
δV_{OL}	Line Regulation	V_i = 18 to 36V Full Load		±0.001		%
δV_{OO}	Load Regulation	V_i = 24V Full Load to No Load		±0.05		%
V_{oov}	Output Overvoltage Protection	GS25T24-5 Full Load V_i = 24V			6.8	V
		GS30T24-12 Full Load V_i = 24V			15	
		GS30T24-15 Full Load V_i = 24V			18	
ΔV_o	Total remote sense compensation	V_i = 18V			1	V
Tc	Temperature Coefficient	V_i = 24V Full Load Operating Temperature Range			+0.02	%/°C

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified) (cont'd)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I_o	Output Current	GS25T24-5 V_i = 18 to 36V	0		5	A
		GS30T24-12 V_i = 18 to 36V	0		2.5	
		GS30T24-15 V_i = 18 to 36V	0		2	
I_{osck}	Output Current Limit	GS25T24-5 V_i = 24V Overload			5.5	A
		GS30T24-12 V_i = 24V Overload			2.75	
		GS30T24-15 V_i = 24V Overload			2.2	
t_{ss}	Soft-start Time	V_i = 24V Full Load		30		ms
t_{rt}	Transient Recovery Time	V_i = 24V Step Load Change δI_o = 25%		75		µs
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency			150		kHz
η	Efficiency	GS25T24-5 V_i = 24V Full Load	75	78		%
		GS30T24-12 V_i = 24V Full Load	79	82		
		GS30T24-15 V_i = 24V Full Load	80	83		
R_{is}	Isolation Resistance		10^9			Ω
R_{thc}	Thermal Resistance Case to Ambient			4		°C/W

CONNECTION DIAGRAM AND MECHANICAL DATA



Package F. Dimensions in mm. (inches)

PIN DESCRIPTION

Pin	Function	Description
1	- IN	Negative input voltage.
2	+ IN	Positive input voltage. Unregulated input voltage (typically 24V) must be applied between pin 1-2. The input section of the DC-DC converter is protected against reverse polarity by a series diode. No external fuse is required. Input is filtered by a Pi network.
3	ON/OFF	Logically compatible with CMOS or open collector TTL. The converter is ON (Enable) when the voltage applied to this pin with reference to pin 1 is higher than 1.8V. The converter is OFF (Inhibit) for a control voltage lower than 1.2V. When the pin is unconnected the converter is ON (Enable).
4	+ SENSE	Senses the remote load high side. To be connected to pin 6 when remote sense is not used.
5	- SENSE	Senses the remote load return. To be connected to pin 7 when remote sense is not used.
6	+ OUT	Output voltage.
7	- OUT	Output voltage return.

25/30 W DC-DC CONVERTER FAMILY

Type	V_i	V_o	I_o
GS25T48-5	36 to 72 V	5 V	5 A
GS25T48-12	36 to 72 V	12 V	2,5 A
GS25T48-15	36 to 72 V	15 V	2 A

FEATURES

- MTBF in excess of 1M hours at +45°C ambient temperature
- Wide input voltage range (36 to 72V)
- No external component required
- High efficiency (see data)
- Non latching permanent short-circuit protection
- Overvoltage protection
- Redundant operation
- Remote output voltage sense
- Remote INHIBIT/ENABLE
- Soft-start
- Minimized reflected input current
- Reverse input polarity protection
- Peak input overvoltage withstand
- No derating over the temperature range
- $500V_{DC}$ minimum isolation between input and output
- PCB or chassis mountable

DESCRIPTION

The GS25T48-5, GS30T48-12 and GS30T48-15 are isolated DC-DC converters designed for general purpose application.

The output power is in the range of 25W to 30W. To ensure very long life, these converters do not use electrolytic aluminum capacitors or optoelectronic feedback systems.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	34 to 72V	V
V_{ipk}	Input Transient Overvoltage (t ≤ 1sec.)	90	V
V_{ir}	Input Reverse Voltage	– 100	V
T_{stg}	Storage Temperature Range	– 55 to +105	°C
T_{op}	Operating Temperature Range	– 25 to +71	°C

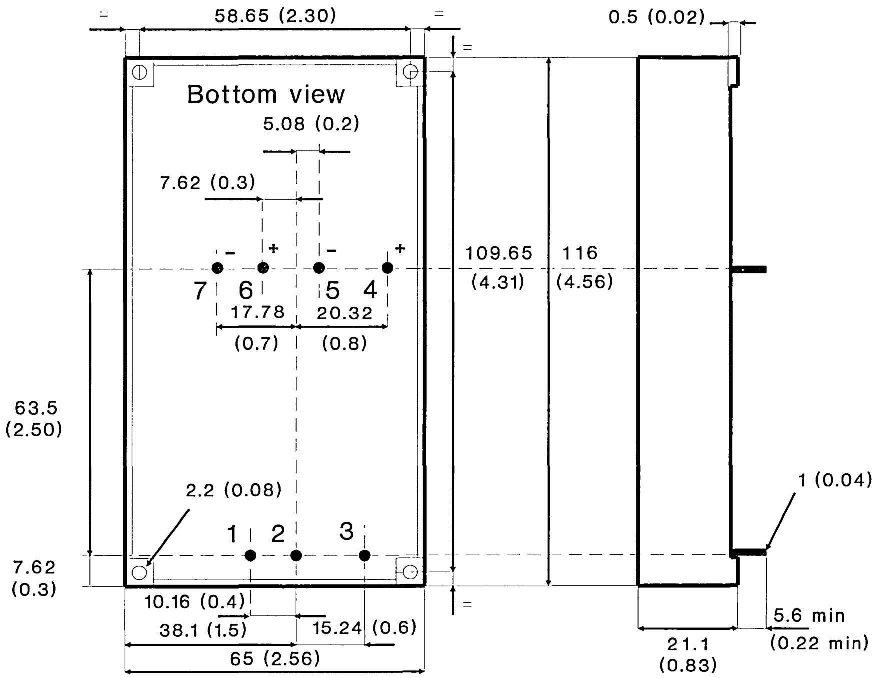
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	Full Load	36	48	72	V
I_i	Input Current	GS25T48-5 Full Load		640		mA
		GS30T48-12 Full Load		730		
		GS30T48-15 Full Load		730		
I_{ir}	Input Reflected Current	V_i = 48V Full Load		50		mApp
I_{isc}	Input Short-circuit Current	GS25T48-5 V_i = 48V		710		mA
		GS30T48-12 V_i = 48V		820		
		GS30T48-15 V_i = 48V		820		
I_{iq}	Input Quiescent Current	V_i = 48V Converter OFF		5		mA
V_{inhl}	Low Inhibit Voltage	V_i = 48V Full Load			1.2	V
V_{enh}	High Enable Voltage	V_i = 48V Full Load	1.8 (open)			V
I_{inh}	Input Inhibit Current	V_i = 48V Full Load		1		mA
V_o	Output Voltage	GS25T48-5 V_i = 48V Full Load	4.95	5.00	5.05	V
		GS30T48-12 V_i = 48V Full Load	11.88	12.00	12.12	
		GS30T48-15 V_i = 48V Full Load	14.85	15.00	15.15	
V_{or}	Output Ripple and Noise Voltage	V_i = 48V Full Load		10		mVpp
δV_{OL}	Line Regulation	V_i = 36 to 72V Full Load		±0.001		%
δV_{OO}	Load Regulation	V_i = 48V Full Load to No Load		±0.05		%
V_{oov}	Output Overvoltage Protection	GS25T48-5 Full Load V_i = 48V			6.8	V
		GS30T48-12 Full Load V_i = 48V			15	
		GS30T48-15 Full Load V_i = 48V			18	
ΔV_o	Total remote sense compensation	V_i = 36V			1	V
Tc	Temperature Coefficient	V_i = 48V Full Load Operating Temperature Range			+0.02	%/°C

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified) (cont'd)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I_o	Output Current	GS25T48-5 V_i = 36 to 72V	0		5	A
		GS30T48-12 V_i = 36 to 72V	0		2.5	
		GS30T48-15 V_i = 36 to 72V	0		2	
I_{osck}	Output Current Limit	GS25T48-5 V_i = 48V Overload			5.5	A
		GS30T48-12 V_i = 48V Overload			2.75	
		GS30T48-15 V_i = 48V Overload			2.2	
t_{ss}	Soft-start Time	V_i = 48V Full Load		30		ms
t_{rt}	Transient Recovery Time	V_i = 48V Step Load Change δI_o = 25%		75		µs
V_{is}	Isolation Voltage		500			V_{DC}
R_{is}	Isolation Resistance		10^9			Ω
f_s	Switching Frequency			150		kHz
η	Efficiency	GS25T48-5 V_i = 48V Full Load		81		%
		GS30T48-12 V_i = 48V Full Load		86		
		GS30T48-15 V_i = 48V Full Load		86		
R_{thc}	Thermal Resistance Case to Ambient			4		°C/W

CONNECTION DIAGRAM AND MECHANICAL DATA



Package F. Dimensions in mm. (inches)

PIN DESCRIPTION

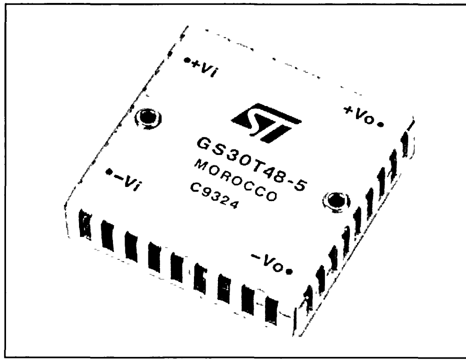
Pin	Function	Description
1	- IN	Negative input voltage.
2	+ IN	Positive input voltage. Unregulated input voltage (typically 48V) must be applied between pins 1-2. The input section of the DC-DC converter is protected against reverse polarity by a series diode. No external fuse is required. Input is filtered by a Pi network.
3	ON/OFF	Logically compatible with CMOS or open collector TTL. The converter is ON (Enable) when the voltage applied to this pin with reference to pin 1 is higher than 1.8V. The converter is OFF (Inhibit) for a control voltage lower than 1.2V. When the pin is unconnected the converter is ON (Enable).
4	+ SENSE	Senses the remote load high side. To be connected to pin 6 when remote sense is not used.
5	- SENSE	Senses the remote load return. To be connected to pin 7 when remote sense is not used.
6	+ OUT	Output voltage.
7	- OUT	Output voltage return.

SGS-THOMSON MICROELECTRONICS

GS30T48-5

30 W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS30T48-5	36 to 72 V	5 V	6 A



DESCRIPTION

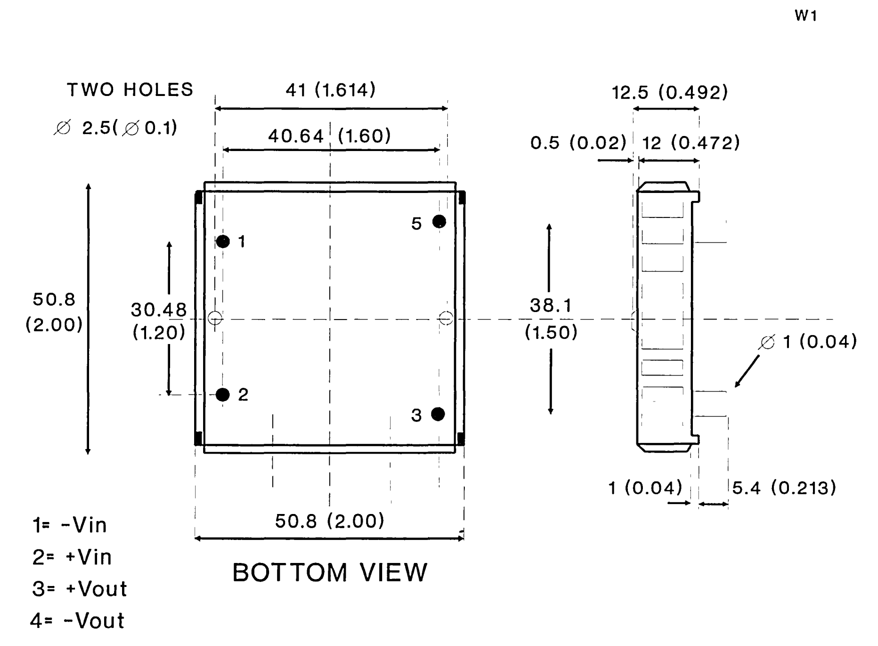
The GS30T48-5 is a 30W DC-DC converter designed to provide a 5V/6A isolated power source.

The module features a wide input voltage range (36 to 72V), low reflected input current and short-circuit protection.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5V I_O = 0.05 to 6A	36	48	72	V
I_i	Input Current	V_i = 48V V_O = 5V I_O = 6A		0.79	0.82	A
I_{ir}	Input Reflected Current	V_i = 48V V_O = 5V I_O = 6A		250	300	mApp
I_{iinr}	Input Inrush Current	V_i = 48V V_O = 5V I_O = 6A		18	22	Ap
I_{isc}	Input Shortcircuit Current	V_i = 48V V_O = 0V		45	70	mA
V_O	Output Voltage	V_i = 36 to 72V I_O = 0.05 to 6A	4.75	5.00	5.25	V
V_{or}	Output Ripple Voltage	V_i = 48V V_o = 5V I_O = 6A		150	200	mVpp
δV_{OL}	Line Regulation	V_i = 36 to 72V I_O = 6A		2	10	mV
δV_{OO}	Load Regulation	V_i = 48V I_O = 0.05 to 6A		2	10	mV
I_O	Output Current	V_i = 36 to 72V V_O = 5V	0.05		6	A
I_{osc}	Output Short-circuit Current	V_i = 48V V_O = 0V		0.85	1.1	A
V_{is}	Isolation Voltage		500			V_{DC}
f_s	Switching Frequency	V_i = 36 to 72V I_O = 0.05 to 6A		450		kHz
η	Efficiency	V_i = 48V V_o = 5V I_O = 6A	77	80		%
R_{th}	Thermal Resistance	Case-to-Ambient		13		°C/W
T_{cop}	Operating Case Temperature Range		0		+85	°C
T_{stg}	Storage Temperature Range		– 20		+105	°C

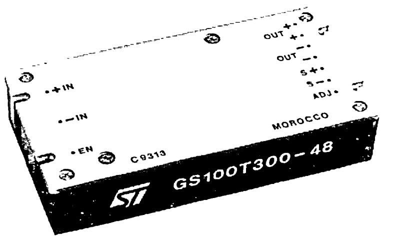
CONNECTION DIAGRAM AND MECHANICAL DATA



Package W. Dimensions in mm (inches)

70W/100W DC-DC CONVERTERS FAMILY

Type	V_i	V_o	I_o
GS70T300-3.5	200 to 400 V	3,5 V	20 A
GS100T300-5	200 to 400 V	5,2 V	20 A
GS100T300-12	200 to 400 V	12,0 V	8,3 A
GS100T300-15	200 to 400 V	15,0 V	6,6 A
GS100T300-24	200 to 400 V	24,0 V	4,2 A
GS100T300-48	200 to 400 V	48,0 V	2,0 A



FEATURES

- High input voltage range bus: 200 to 400Vdc
- UL, TUV approved
- High output power (up to 100W)
- High efficiency (80% min. on GS100T300-5 module)
- Output voltages range: 3.5-5.2-12-15-24 and 48V
- Output voltage adjustable by external pin
- Remote load voltage sense compensation
- Output short-circuit protection
- Output overvoltage protection
- Undervoltage lock-out
- Minimal overshoot during load transients
- 3750V_{RMS} input to output isolation voltage
- Internal input and output filtering
- Softstart
- PCB or chassis mountable
- Mechanical Dimensions 101,6 • 50,8 • 20 mm (4,00 • 2,00 • 0,79 inches)

DESCRIPTION

The GS70/100T300 family includes 70/100W DC-DC converters used to generate isolated output voltages with an output current up to 20A from a wide range input voltage (200 to 400Vdc).
All the GS70/100T300 family modules require an external fuse (1 Amps.) on the input side.

GS70T300-3.5 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 3.5V I_O = 0 to 20A (Operating Conditions)	200	300	400	V_{DC}
Q_i	Inrush Charge	V_i = 400V I_O = 20A		$40 \cdot 10^{-6}$		C
P_i	Input Power	V_i = 300V I_O = 0A (No Load)		2.5		W
V_O	Output Voltage	V_i = 200 to 400V I_O = 0 to 20A	3.43	3.5	3.57	V
V_O	Output Voltage Range	V_i = 200 to 400V I_O = 0 to 20A (see fig. 2)	1.75		3.5	V
V_{orn}	Output Ripple and Noise Voltage	V_i = 300V I_O = 20A BW = 0 to 20Mhz		35	40	mVpp
V_{ol}	Output Overvoltage Limit Initiation	V_i = 200 to 400V I_O = 0 to 20A		$1.2 \cdot V_O$		V
δV_{OL}	Line Regulation	V_i = 200 to 400V I_O = 20A			±0.1	%
δV_{OO}	Load Regulation	V_i = 300V I_O = 0 to 20A			±0.1	%
ΔV_O	Total Remote Sense Compensation	V_i = 200 to 400V			0.6	V
δV_O	Peak Load Transient Response	V_i = 300V δI_O = 10A		500		mVp
SVR	Supply Voltage Rejection	f = 100Hz		55		dB
I_O	Output Current	V_i = 200 to 400V V_O = 3.3V	0		20	A
I_{ol}	Overcurrent Limit Initiation	V_i = 300V	21	23	25	A
I_{osc}	Shortcircuit Output Current	V_i = 300V	18	23	28	A
t_s	Load Transient Settling Time	V_i = 300V δI_O = 10A		300		µs
t_{on}	Turn-on Time	V_i = 200V I_O = 20A		6	10	ms
V_{is}	Isolation Voltage	Input to Output	3750			V_{RMS}
		Input to Baseplate	2500			
		Output to Baseplate	500			
f_s	Switching Frequency	V_i = 200 to 400V I_O = 0 to 20A		150		kHz
η	Efficiency	V_i = 300V I_O = 20A	78	79		%
R_{th}	Thermal Resistance	Baseplate to Ambient		7.5		°C/W
T_{cop}	Operating Case Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+100	°C

GS100T300-5 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5V I_O = 0 to 20A (Operating Conditions)	200	300	400	V_{DC}
Q_i	Inrush Charge	V_i = 400V I_O = 20A		$40 \cdot 10^{-6}$		C
P_i	Input Power	V_i = 300V I_O = 0A (No Load)		2.5		W
V_O	Output Voltage	V_i = 200 to 400V I_O = 0 to 20A	5.09	5.20	5.30	V
V_O	Output Voltage Range	V_i = 200 to 400V I_O = 0 to 20A (see fig. 2)	2.6		5.20	V
V_{orn}	Output Ripple and Noise Voltage	V_i = 300V I_O = 20A BW = 0 to 20Mhz		40	50	mVpp
V_{ol}	Output Overvoltage Limit Initiation	V_i = 200 to 400V I_O = 0 to 20A		$1.2 \cdot V_O$		V
δV_{OL}	Line Regulation	V_i = 200 to 400V I_O = 20A			±0.1	%
δV_{OO}	Load Regulation	V_i = 300V I_O = 0 to 20A			±0.1	%
ΔV_O	Total Remote Sense Compensation	V_i = 200 to 400V			0.6	V
δV_O	Peak Load Transient Response	V_i = 300V δI_O = 1A		500		mVp
SVR	Supply Voltage Rejection	f = 100Hz		55		dB
I_O	Output Current	V_i = 200 to 400V V_O = 5V	0		20	A
I_{ol}	Overcurrent Limit Initiation	V_i = 300V	21	23	25	A
I_{osc}	Shortcircuit Output Current	V_i = 300V	18	23	28	A
t_s	Load Transient Settling Time	V_i = 300V δI_O = 1A		300		µs
t_{on}	Turn-on Time	V_i = 200V I_O = 20A		6	10	ms
V_{is}	Isolation Voltage	Input to Output	3750			V_{RMS}
		Output to Baseplate	500			
		Input to Baseplate	2500			
f_s	Switching Frequency	V_i = 200 to 400V I_O = 0 to 20A		150		kHz
η	Efficiency	V_i = 300V I_O = 20A	80	81		%
R_{th}	Thermal Resistance	Baseplate to Ambient		7.5		°C/W
T_{cop}	Operating Case Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+100	°C

GS100T300-12 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 12V I_O = 0 to 8.3A (Operating Conditions)	200	300	400	V_{DC}
Q_i	Inrush Charge	V_i = 400V I_O = 8.3A		$40 \bullet 10^{-6}$		C
P_i	Input Power	V_i = 300V I_O = 0A (No Load)		2.5		W
V_O	Output Voltage	V_i = 200 to 400V I_O = 0 to 8.3A	11.76	12.00	12.24	V
V_O	Output Voltage Range	V_i = 200 to 400V I_O = 0 to 8.3A (see fig. 2)	6.0		13.2	V
V_{orn}	Output Ripple and Noise Voltage	V_i = 300V I_O = 8.3A BW = 0 to 20Mhz		100	120	mVpp
V_{ol}	Output Overvoltage Limit Initiation	V_i = 200 to 400V I_O = 0 to 8.3A		$1.2 \bullet V_O$		V
δV_{OL}	Line Regulation	V_i = 200 to 400V I_O = 8.3A			±0.1	%
δV_{OO}	Load Regulation	V_i = 300V I_O = 0 to 8.3A			±0.1	%
ΔV_O	Total Remote Sense Compensation	V_i = 200 to 400V			0.6	V
δV_O	Peak Load Transient Response	Vi = 300V δI_O = 4A		500		mVp
SVR	Supply Voltage Rejection	f = 100Hz		45		dB
I_O	Output Current	V_i = 200 to 400V V_O = 12V	0		8.3	A
I_{ol}	Overcurrent Limit Initiation	Vi = 300V	8.8	9.1	11.0	A
I_{osc}	Shortcircuit Output Current	Vi = 300V	7.5	9.0	11.0	A
t_s	Load Transient Settling Time	Vi = 300V δI_O = 4A		300		µs
t_{on}	Turn-on Time	Vi = 200V I_O = 8.3A		6	10	ms
V_{is}	Isolation Voltage	Input to Output	3750			V_{RMS}
		Input to Baseplate	2500			
		Output to Baseplate	500			
f_s	Switching Frequency	V_i = 200 to 400V I_O = 0 to 8.3A		150		kHz
η	Efficiency	V_i = 300V I_O = 8.3A	83	84		%
R_{th}	Thermal Resistance	Baseplate to Ambient		7.5		°C/W
T_{cop}	Operating Case Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+100	°C

GS100T300-15 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 15V I_O = 0 to 6.6A (Operating Conditions)	200	300	400	V_{DC}
Q_i	Inrush Charge	V_i = 400V I_O = 6.6A		$40 \cdot 10^{-6}$		C
P_i	Input Power	V_i = 300V I_O = 0A (No Load)		2.5		W
V_O	Output Voltage	V_i = 200 to 400V I_O = 0 to 6.6A	14.7	15.0	15.3	V
V_O	Output Voltage Range	V_i = 200 to 400V I_O = 0 to 6.6A (see fig. 2)	7.5		16.5	V
V_{orn}	Output Ripple and Noise Voltage	V_i = 300V I_O = 6.6A BW = 0 to 20Mhz		110	150	mVpp
V_{OI}	Output Overvoltage Limit Initiation	V_i = 200 to 400V I_O = 0 to 6.6A		$1.2 \cdot V_O$		V
δV_{OL}	Line Regulation	V_i = 200 to 400V I_O = 6.6A			±0.1	%
δV_{OO}	Load Regulation	V_i = 300V I_O = 0 to 6.6A			±0.1	%
ΔV_O	Total Remote Sense Compensation	V_i = 200 to 400V			0.6	V
δV_O	Peak Load Transient Response	V_i = 300V δI_O = 3.3A		500		mVp
SVR	Supply Voltage Rejection	f = 100Hz		45		dB
I_O	Output Current	V_i = 200 to 400V V_O = 15V	0		6.6	A
I_{OI}	Overcurrent Limit Initiation	V_i = 300V	7.1	7.5	8.0	A
I_{osc}	Shortcircuit Output Current	V_i = 300V	6.5	8.0	10.0	A
t_s	Load Transient Settling Time	V_i = 300V δI_O = 3.3A		300		µs
t_{on}	Turn-on Time	V_i = 200V I_O = 6.6A		6	10	ms
V_{is}	Isolation Voltage	Input to Output	3750			V_{RMS}
		Input to Baseplate	2500			
		Output to Baseplate	500			
f_s	Switching Frequency	V_i = 200 to 400V I_O = 0 to 6.6A		150		kHz
η	Efficiency	V_i = 300V I_O = 6.6A	84	85		%
R_{th}	Thermal Resistance	Baseplate to Ambient		7.5		°C/W
T_{cop}	Operating Case Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+100	°C

GS100T300-24 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

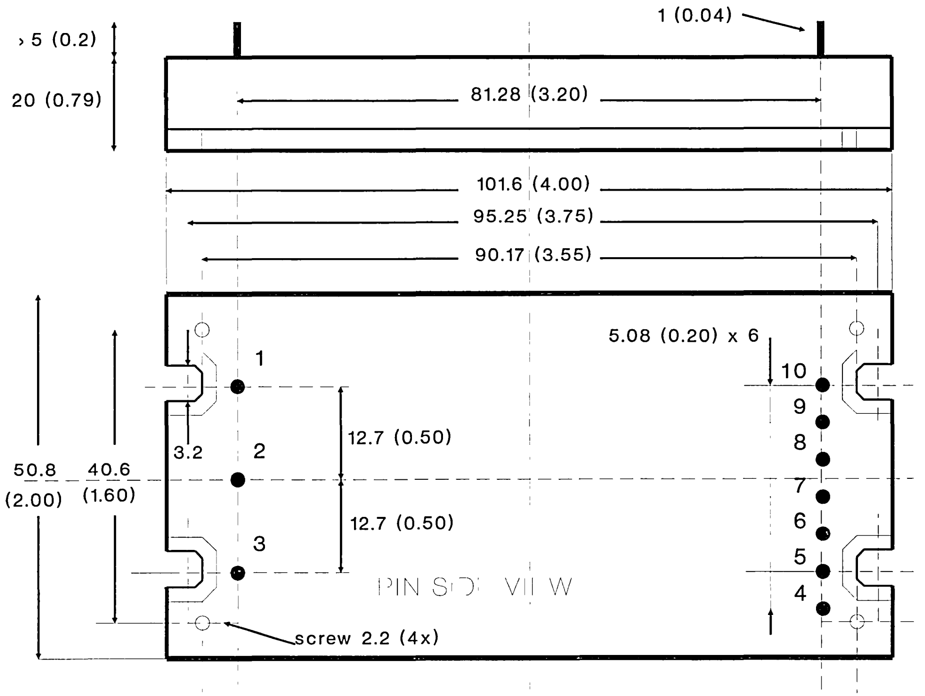
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 24V I_O = 0 to 4.2A (Operating Conditions)	200	300	400	V_{DC}
Q_i	Inrush Charge	V_i = 400V I_O = 4.2A		$40 \bullet 10^{-6}$		C
P_i	Input Power	V_i = 300V I_O = 0A (No Load)		2.5		W
V_O	Output Voltage	V_i = 200 to 400V I_O = 0 to 4.2A	23.5	24.0	24.5	V
V_O	Output Voltage Range	V_i = 200 to 400V I_O = 0 to 4.2A (see fig. 2)	12.0		26.4	V
V_{orn}	Output Ripple and Noise Voltage	V_i = 300V I_O = 4.2A BW = 0 to 20Mhz		200	240	mVpp
V_{ol}	Output Overvoltage Limit Initiation	V_i = 200 to 400V I_O = 0 to 4.2A		$1.2 \bullet V_O$		V
δV_{OL}	Line Regulation	V_i = 200 to 400V I_O = 4.2A			±0.1	%
δV_{OO}	Load Regulation	V_i = 300V I_O = 0 to 4.2A			±0.1	%
ΔV_O	Total Remote Sense Compensation	V_i = 200 to 400V			0.6	V
δV_O	Peak Load Transient Response	V_i = 300V δI_O = 2.1A		500		mVp
SVR	Supply Voltage Rejection	f = 100Hz		40		dB
I_O	Output Current	V_i = 200 to 400V V_O = 24V	0		4.2	A
I_{ol}	Overcurrent Limit Initiation	V_i = 300V	4.5	5.0	5.5	A
I_{osc}	Shortcircuit Output Current	V_i = 300V	3.8	4.5	6.0	A
t_s	Load Transient Settling Time	V_i = 300V δI_O = 2.1A		300		µs
t_{on}	Turn-on Time	V_i = 200V I_O = 4.2A		6	10	ms
V_{is}	Isolation Voltage	Input to Output	3750			V_{RMS}
		Input to Baseplate	2500			
		Output to Baseplate	500			
f_s	Switching Frequency	V_i = 200 to 400V I_O = 0 to 4.2A		150		kHz
η	Efficiency	V_i = 300V I_O = 4.2A	84	85		%
R_{th}	Thermal Resistance	Baseplate to Ambient		7.5		°C/W
T_{cop}	Operating Case Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+100	°C

GS100T300-48 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 48V I_O = 0 to 2.1A (Operating Conditions)	200	300	400	V_{DC}
Q_i	Inrush Charge	V_i = 400V I_O = 2.1A		$40 \cdot 10^{-6}$		C
P_i	Input Power	V_i = 300V I_O = 0A (No Load)		2.5		W
V_O	Output Voltage	V_i = 200 to 400V I_O = 0 to 2.1A	47.04	48.00	48.96	V
V_O	Output Voltage Range	V_i = 200 to 400V I_O = 0 to 2.1A (see fig. 2)	24.0		52.8	V
V_{orn}	Output Ripple and Noise Voltage	V_i = 300V I_O = 2.1A BW = 0 to 20Mhz		400	500	mVpp
V_{ol}	Output Overvoltage Limit Initiation	V_i = 200 to 400V I_O = 0 to 2.1A		$1.2 \cdot V_O$		V
δV_{OL}	Line Regulation	V_i = 200 to 400V I_O = 2.1A			±0.1	%
δV_{OO}	Load Regulation	V_i = 300V I_O = 0 to 2.1A			±0.1	%
ΔV_O	Total Remote Sense Compensation	V_i = 200 to 400V			0.6	V
δV_O	Peak Load Transient Response	Vi = 300V δI_O = 1A		500		mVp
SVR	Supply Voltage Rejection	f = 100Hz		35		dB
I_O	Output Current	V_i = 200 to 400V V_O = 48V	0		2	A
I_{ol}	Overcurrent Limit Initiation	Vi = 300V	2.1	2.3	2.5	A
I_{osc}	Shortcircuit Output Current	Vi = 300V	1.8	2.3	2.8	A
t_s	Load Transient Settling Time	V_i = 300V δI_O = 1A		300		µs
t_{on}	Turn-on Time	V_i = 200V I_O = 2.1A		6	10	ms
V_{is}	Isolation Voltage	Input to Output	3750			V_{RMS}
		Input to Baseplate	2500			
		Output to Baseplate	500			
f_s	Switching Frequency	V_i = 200 to 400V I_O = 0 to 2.1A		150		kHz
η	Efficiency	V_i = 300V I_O = 2.1A	84	85		%
R_{th}	Thermal Resistance	Baseplate to Ambient		7.5		°C/W
T_{cop}	Operating Case Temperature Range		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+100	°C

CONNECTION DIAGRAM AND MECHANICAL DATA

Figure 1.



Package R; dimensions in mm (inches)

PIN DESCRIPTION

Pin	Function	Description
1	ENABLE	The converter is ON (Enable) when the voltage applied to this pin with reference to pin 2 is lower than 1.2V. The converter is OFF (Inhibit) for a control voltage in the range of 2.1 to 5V. When the pin is unconnected the converter is OFF (Inhibit).
2	- Vin	Negative input voltage.
3	+ Vin	Positive input voltage. Unregulated input voltage in the range of 200 to 400Vdc must be applied between pin 2-3.
4,5	+ Vo	+Vo output voltage.
6,7	- Vo	+Vo output voltage return.
8	+ SENSE	Senses the remote load high side. To be connected to pins 4,5 when remote sense is not used.
9	- SENSE	Senses the remote load return. To be connected to pins 6,7 when remote sense is not used.
10	ADJ	Adjust output voltage pin. A voltage generator between the ADJ. pin and -SENSE pin sets the Vo. When unconnected Vo is at nominal value (see fig. 2).

ADJUSTMENT OF THE OUTPUT VOLTAGE

The output voltage can be fixed following the indications given in fig. 2. The external reference voltage Vadj can be calculated using the following formula:

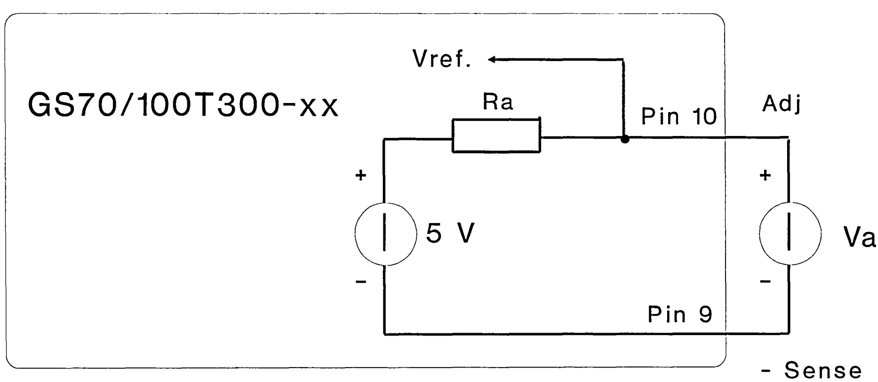
$$V_{adj} = 5 \bullet \frac{V_o}{V_{nom}}$$

The Vout and Vadj ranges are given in the following table:

Table 1: Output voltage generation with external voltage generator

Type	Nominal Output Voltage (V)	Output Voltage Range (V_{out})	External Voltage Generator allowed Range (V_{adj})
GS70T300-3.5	3.5	1.75 to 3.50	2.5 to 5.0
GS100T300-5	5.2	2.60 to 5.20	2.5 to 5.0
GS100T300-12	12.0	6.00 to 13.20	2.5 to 5.5
GS100T300-15	15.0	7.50 to 16.50	2.5 to 5.5
GS100T300-24	24.0	12.00 to 26.40	2.5 to 5.5
GS100T300-48	48.0	24.00 to 52.80	2.5 to 5.5

Figure 2. Output voltage adjustment



Safety approvals

The converter is agency certified to the following safety requirements.

Agency	Requirements	License Number
UL	UL-STD-1950	E141284
TUV	EN 60950	R 9371740.1

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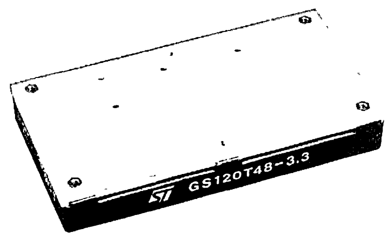
SGS-THOMSON MICROELECTRONICS

GS120/175T48 Family

120W/175W DC-DC CONVERTERS FAMILY

Type	V_i	V_o	I_o
GS120T48-3.3 GS120T48-3.3E	38 to 60 V	3,35 V	35 A
GS175T48-5 GS175T48-5E	38 to 60 V	5,075 V	35 A
GS175T48-12 GS175T48-12E	38 to 60 V	12,0 V	15 A
GS175T48-15 GS175T48-15E	38 to 60 V	15,0 V	12 A



FEATURES

- UL, CSA, TUV approved
- High output power (up to 175W)
- High efficiency (82% typ. on GS175T48-5 module)
- Parallel operation with equal current sharing
- Synchronization pin
- Remote ON/OFF
- Remote load voltage sense compensation
- Output short-circuit protection
- Undervoltage lock-out
- Minimal overshoot during load transients
- Output overvoltage protection
- 500V_{DC} input to output isolation voltage
- Internal input and output filtering
- Softstart
- PCB or chassis mountable
- Optional additional finned heatsink
- Mechanical dimensions 125 • 66,5 • 19 (4,92 • 2,62 • 0,75)

DESCRIPTION

The GS120/175T48 family includes 120/175W DC-DC converters used to generate fixed isolated output voltages with an output current up to 35A from a wide range input voltage (38 to 60V).
The suffix E Identifies the metric threading on the planar heatsink (see fig. 1).

OPTION

Type Ordering Number	Description	Thermal Resistance	Dimensions L • W • H mm (inches)
HS01	Additional finned heatsink (See fig. 7)	2.8°C/W	125 • 66.5 • 15 (4.92 • 2.62 • 0.59)

GS120T48-3.3 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 3.35V I_O = 0 to 35A (Operating Conditions)	38	48	60	VDC
Viuv	Input Undervoltage Lockout	Vo = 3.35V I_O = 0 to 35A	32	34	36	VDC
I_i	Average Input Current	V_i = 0 to 60V I_O = 35A			4.2	A
Iipk	Inrush Transient Peak Current	V_i = 60V I_O = 35A			0.2	A^2s
Iir	Reflected Input Current	V_i = 38 to 60V BW = 5Hz to 20MHz I_O = 35A (See fig. 2)			20	mApp
Vien	Enable Input Voltage	V_i = 38 to 60V I_O = 0 to 35A	0		1.2	V
Iien	Enable Input Current	V_i = 38 to 60V I_O = 0 to 35A Vien = 0V			-1	mA
Viinh	Inhibit Voltage	V_i = 38 to 60V I_O = 0 to 35A Vien = open	8		18	V
P_i	Input Power	V_i = 38 to 60V I_O = 0A (No Load)		1.5	2	W
V_O	Total Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 35A	3.25	3.35	3.45	V
Vost	Short-term Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 35A	3.30	3.35	3.40	V
Vots	Total Static Tolerance	V_i = 38 to 60V I_O = 0 to 35A	3.28	3.35	3.42	V
Vol	Output Overvoltage Limit Initiation	V_i = 38 to 60V I_O = 0 to 35A	4	4.5	5.2	VDC
Vor	Output Ripple Voltage	V_i = 38 to 60V I_O = 35A		20	30	mVpp
Von	Output Noise Voltage	V_i = 38 to 60V I_O = 35A		50	80	mVpp
ΔV_O	Total Remote Sense Compensation	V_i = 38 to 60V			0.6	V
δV_O	Peak Load Transient Response	V_i = 48V δI_O = 5A slope = 0.1A/µs			60	mVp
I_O	Output Current	V_i = 38 to 60V V_O = 3.35V	0		35	A
Iol	Overcurrent Limit Initiation	V_i = 48V	36		39	A
Iosc	Shortcircuit Output Current	V_i = 48V V_O = 0.2 to 0.5V			51	A
ts	Load Transient Settling Time	V_i = 48V δI_O = 5A slope = 0.1A/µs			200	µs
ton	Turn-on Time	V_i = 48V I_O = 35A Vien = from high to low			5	ms
		V_i = 0 to 60V I_O = 35A Vien = low	3		10	
Vis	Isolation Voltage		500			V
fs	Switching Frequency	V_i = 38 to 60V I_O = 0 to 35A	160	175	200	kHz
η	Efficiency	V_i = 38 to 60V I_O = 35A	76	77		%
Rth	Thermal Resistance	Case to Ambient		5.2		°C/W
Tcop	Operating Case Temperature Range		– 10		+85	°C
Tstg	Storage Temperature Range		– 40		+105	°C

GS175T48-5 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5.075V I_O = 0 to 35A (Operating Conditions)	38	48	60	VDC
V_{iuv}	Input Undervoltage Lockout	V_O = 5.075V I_O = 0 to 35A	32	34	36	VDC
I_i	Average Input Current	V_i = 0 to 60V I_O = 35A			6.1	A
I_{ipk}	Inrush Transient Peak Current	V_i = 60V I_O = 35A			0.2	A^2s
I_{ir}	Reflected Input Current	V_i = 38 to 60V BW = 5Hz to 20MHz I_O = 35A (See fig. 2)			30	mApp
V_{ien}	Enable Input Voltage	V_i = 38 to 60V I_O = 0 to 35A	0		1.2	V
I_{ien}	Enable Input Current	V_i = 38 to 60V I_O = 0 to 35A V_{ien} = 0V			-1	mA
V_{iinh}	Inhibit Voltage	V_i = 38 to 60V I_O = 0 to 35A V_{ien} = open	8		18	V
P_i	Input Power	V_i = 38 to 60V I_O = 0A (No Load)		1.5	2	W
V_O	Total Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 35A	4.94	5.075	5.21	V
V_{ost}	Short-term Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 35A	5.002	5.075	5.148	V
V_{ots}	Total Static Tolerance	V_i = 38 to 60V I_O = 0 to 35A	4.97	5.075	5.18	V
V_{ol}	Output Overvoltage Limit Initiation	V_i = 38 to 60V I_O = 0 to 35A	6	6.3	7	VDC
V_{or}	Output Ripple Voltage	V_i = 38 to 60V I_O = 35A		20	30	mVpp
V_{on}	Output Noise Voltage	V_i = 38 to 60V I_O = 35A		50	80	mVpp
ΔV_O	Total Remote Sense Compensation	V_i = 38 to 60V			0.6	V
δV_O	Peak Load Transient Response	V_i = 48V δI_O = 5A slope = 0.1A/µs			100	mVp
I_O	Output Current	V_i = 38 to 60V V_O = 5.075V	0		35	A
I_{ol}	Overcurrent Limit Initiation	V_i = 48V	36		39	A
I_{osc}	Shortcircuit Output Current	V_i = 48V V_O = 0.2 to 0.5V			51	A
t_s	Load Transient Settling Time	V_i = 48V δI_O = 5A slope = 0.1A/µs			250	µs
t_{on}	Turn-on Time	V_i = 48V I_O = 35A V_{ien} = from high to low			5	ms
		V_i = 0 to 60V I_O = 35A V_{ien} = low	3		10	
V_{is}	Isolation Voltage		500			V
f_s	Switching Frequency	V_i = 38 to 60V I_O = 0 to 35A	160	175	200	kHz
η	Efficiency	V_i = 38 to 60V I_O = 35A	81	82		%
R_{th}	Thermal Resistance	Case to Ambient		5.2		°C/W
T_{cop}	Operating Case Temperature Range		– 10		+85	°C
T_{stg}	Storage Temperature Range		– 40		+105	°C

GS175T48-12 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

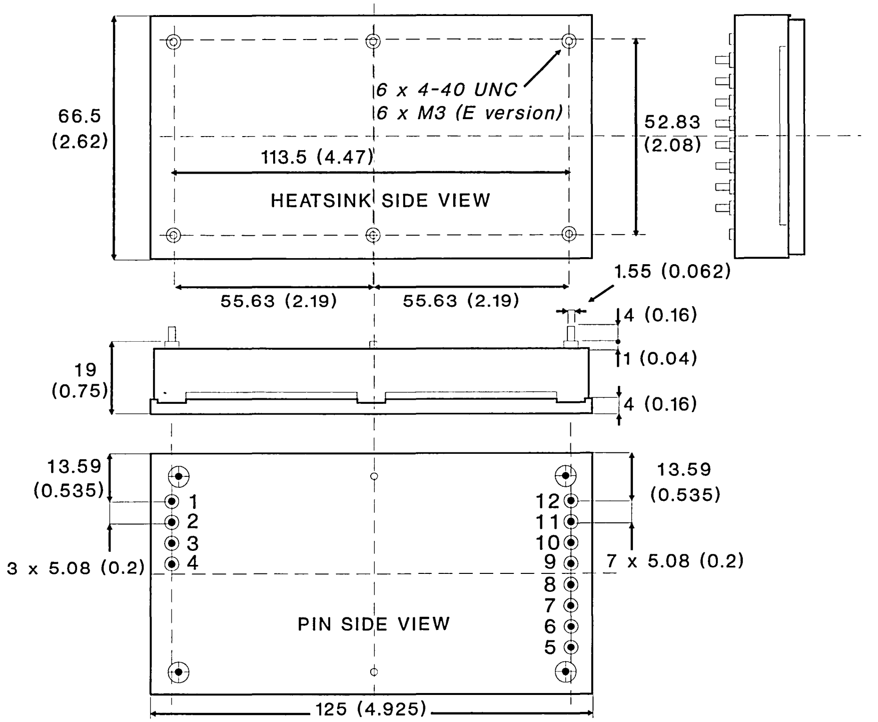
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Vi	Input Voltage	Vo = 12V Io = 0 to 15A (Operating Conditions)	38	48	60	VDC
Viuv	Input Undervoltage Lockout	Vo = 12V Io = 0 to 15A	32	34	36	VDC
Ii	Average Input Current	Vi = 0 to 60V Io = 15A			5.5	A
Iipk	Inrush Transient Peak Current	Vi = 60V Io = 15A			0.2	A^2s
Iir	Reflected Input Current	Vi = 38 to 60V BW = 5Hz to 20MHz Io = 15A (See fig. 2)			20	mApp
Vien	Enable Input Voltage	Vi = 38 to 60V Io = 0 to 15A	0		1.2	V
Iien	Enable Input Current	Vi = 38 to 60V Io = 0 to 15A Vien = 0V			-1	mA
Viinh	Inhibit Voltage	Vi = 38 to 60V Io = 0 to 15A Vien = open	8		18	V
Pi	Input Power	Vi = 38 to 60V Io = 0A (No Load)		1.5	2	W
Vo	Total Output Voltage Regulation	Vi = 38 to 60V Io = 0 to 15A	11.4	12.0	12.6	V
Vost	Short-term Output Voltage Regulation	Vi = 38 to 60V Io = 0 to 15A	11.76	12.0	12.24	V
Vots	Total Static Tolerance	Vi = 38 to 60V Io = 0 to 15A	11.64	12.0	12.36	V
Vol	Output Overvoltage Limit Initiation	Vi = 38 to 60V Io = 0 to 15A	13.2	14	15	VDC
Vor	Output Ripple Voltage	Vi = 38 to 60V Io = 15A		35	70	mVpp
Von	Output Noise Voltage	Vi = 38 to 60V Io = 15A		60	120	mVpp
ΔVo	Total Remote Sense Compensation	Vi = 38 to 60V			0.6	V
δVo	Peak Load Transient Response	Vi = 48V δIo = 3A slope = 0.2A/µs			200	mVp
Io	Output Current	Vi = 38 to 60V Vo = 12V	0		15	A
Iol	Overcurrent Limit Initiation	Vi = 48V	16		19	A
Iosc	Shortcircuit Output Current	Vi = 48V			25	A
ts	Load Transient Setting Time	Vi = 48V δIo = 3A slope = 0.2A/µs			300	µs
ton	Turn-on Time	Vi = 48V Io = 15A Vien = from high to low			5	ms
		Vi = 0 to 60V Io = 15A Vien = low	3		10	
Vis	Isolation Voltage		500			V
fs	Switching Frequency	Vi = 38 to 60V Io = 0 to 15A	160	175	200	kHz
η	Efficiency	Vi = 38 to 60V Io = 15A	84	86		%
Rth	Thermal Resistance	Case to Ambient		5.2		°C/W
Tcop	Operating Case Temperature Range		– 10		+85	°C
Tstg	Storage Temperature Range		– 40		+105	°C

GS175T48-15 ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 15V I_O = 0 to 12A (Operating Conditions)	38	48	60	VDC
V_{iuv}	Input Undervoltage Lockout	V_O = 15V I_O = 0 to 12A	32	34	36	VDC
I_i	Average Input Current	V_i = 0 to 60V I_O = 12A			5.5	A
I_{ipk}	Inrush Transient Peak Current	V_i = 60V I_O = 12A			0.2	A^2s
I_{ir}	Reflected Input Current	V_i = 38 to 60V I_O = 12A			20	mApp
V_{ien}	Enable Input Voltage	V_i = 38 to 60V I_O = 0 to 12A	0		1.2	V
I_{ien}	Enable Input Current	V_i = 38 to 60V I_O = 0 to 12A V_{ien} = 0V			-1	mA
V_{iinh}	Inhibit Voltage	V_i = 38 to 60V I_O = 0 to 12A V_{ien} = open	8		18	V
P_i	Input Power	V_i = 38 to 60V I_O = 0A (No Load)		1.5	2	W
V_O	Total Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 12A	14.25	15.0	15.75	V
V_{Ost}	Short-term Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 12A	14.7	15.0	15.3	V
V_{Ots}	Total Static Tolerance	V_i = 38 to 60V I_O = 0 to 12A	14.55	15.0	15.45	V
V_{OI}	Output Overvoltage Limit Initiation	V_i = 38 to 60V I_O = 0 to 12A	16.5	17	18	VDC
V_{Or}	Output Ripple Voltage	V_i = 38 to 60V I_O = 12A		45	90	mVpp
V_{On}	Output Noise Voltage	V_i = 38 to 60V I_O = 12A		75	150	mVpp
ΔV_O	Total Remote Sense Compensation	V_i = 38 to 60V			0.6	V
δV_O	Peak Load Transient Response	V_i = 48V δI_O = 3A slope = 0.2A/µs			200	mVp
I_O	Output Current	V_i = 38 to 60V V_O = 15V	0		12	A
I_{OI}	Overcurrent Limit Initiation	V_i = 48V	13		16	A
I_{Osc}	Shortcircuit Output Current	V_i = 48V V_O = 0.2 to 0.5V			21	A
ts	Load Transient Settling Time	V_i = 48V δI_O = 3A slope = 0.2A/µs			300	µs
ton	Turn-on Time	V_i = 48V I_O = 12A V_{ien} = from high to low			5	ms
		V_i = 0 to 60V I_O = 12A V_{ien} = low	3		10	
V_{is}	Isolation Voltage		500			V
fs	Switching Frequency	V_i = 38 to 60V I_O = 0 to 12A	160	175	200	kHz
η	Efficiency	V_i = 38 to 60V I_O = 12A	86	88		%
Rth	Thermal Resistance	Case to Ambient		5.2		°C/W
Tcop	Operating Case Temperature Range		– 10		+85	°C
Tstg	Storage Temperature Range		– 40		+105	°C

CONNECTION DIAGRAM AND MECHANICAL DATA

Figure 1.



Package T. Dimensions in mm (inches).

PIN DESCRIPTION

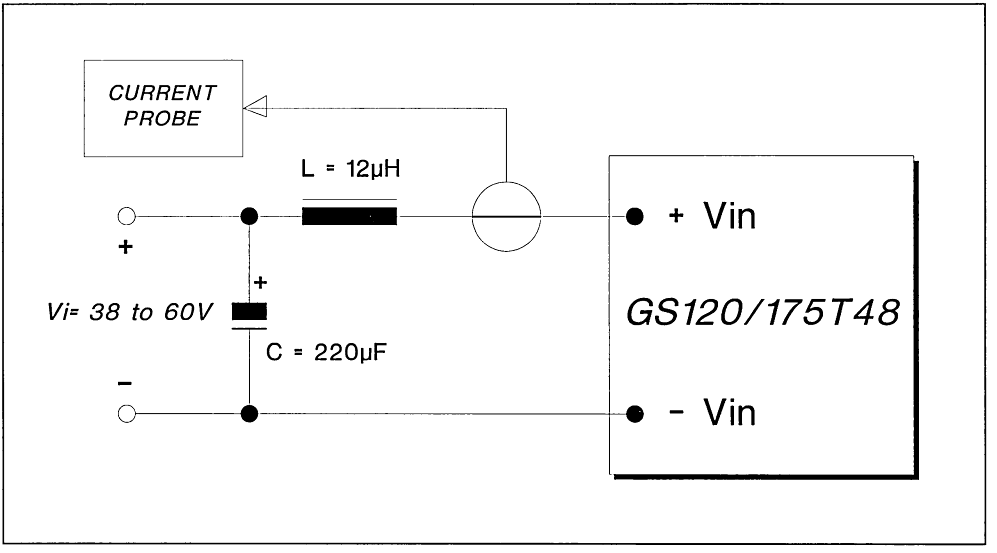
Pin	Function	Description
1	- IN	Negative input voltage.
2	+ IN	Positive input voltage. Unregulated input voltage (typically 48V) must be applied between pin 1-2.
3	ON/OFF	The converter is ON (Enable) when the voltage applied to this pin with reference to pin 1 is lower than 1.2V (see Vien). The converter is OFF (Inhibit) for a control voltage in the range of 8 to 18V. When the pin is unconnected the converter is OFF (Inhibit).
4	CASE	Case connection pin.
5	SYNC	Synchronization pin. See figures 3, 4, 5, 6. Open when not used.
6	PARALLEL	Parallel output. See figures 3, 4, 5, 6. Open when not used.
7	+ SENSE	Senses the remote load high side. To be connected to pin 11,12 when remote sense is not used.
8	- SENSE	Senses the remote load return. To be connected to pin 9,10 when remote sense is not used. In parallel configuration, take care to connect all -S pins together (see figures 3,4,5,6).
9,10	- OUT	Fixed output voltage return.
11,12	+ OUT	Fixed output voltage.

USER NOTES

Reflected Input Current

The reflected input current measurement (Iir, see Electrical Characteristics) is performed according to the test set-up of fig. 2.

Figure 2.



Softstart

To avoid heavy inrush current the output voltage rise time is 10ms maximum in any condition of load.

Remote Sensing

The remote voltage sense compensation range is for a total drop of 0.6V equally shared between the load connecting wires.

It is a good practice to shield the sensing wires to avoid oscillations.

See the connection diagram on figures 3, 4, 5, 6.

Remote ON/OFF

The module is controlled by the voltage applied between the ON/OFF pin and -IN pin.

The converter is ON (Enable) when the voltage applied is lower than 1.2 V (see Vien on Electrical Characteristics).

The converter is OFF (Inhibit) for a control voltage in the range of 8 to 18V (see Viinh).

When the pin is unconnected the converter is OFF. Maximum sinking current is 1mA.

Module Protection

The module is protected against occasional and permanent shortcircuits of the output pins to ground, as well as against output current overload. It uses a current limiting protection circuitry, avoiding latch-up problems with certain type of loads.

A crowbar output overvoltage protection is activated when the output voltage exceeds the specified values (see Electrical Characteristics).

Parallel Operation

To increase available output regulated power, the module features the parallel connection possibility with equal current sharing and maximum deviation of 10% (two modules in parallel).

See the connection diagram on figures 3, 4, 5, 6.

Figure 3.

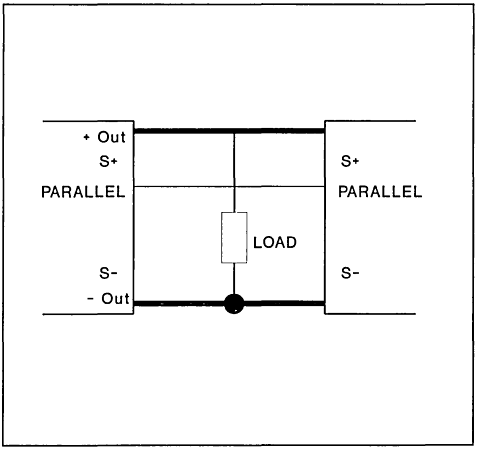


Figure 4.

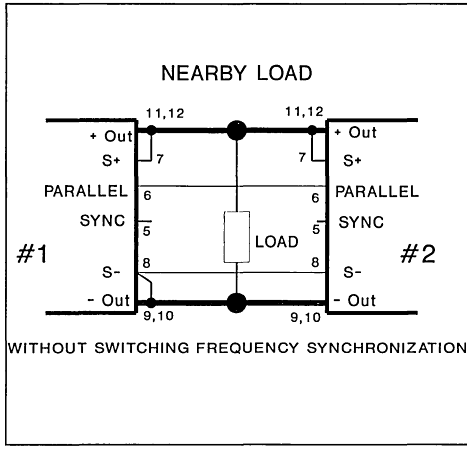


Figure 5.

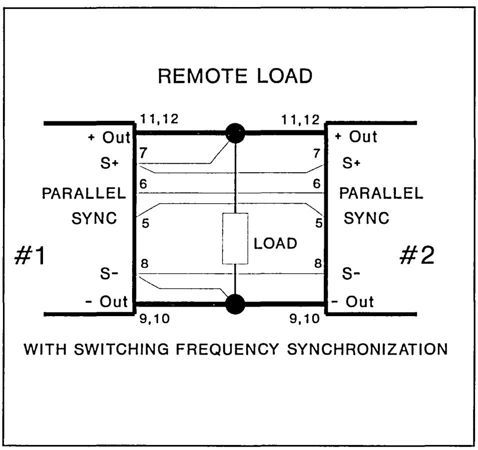
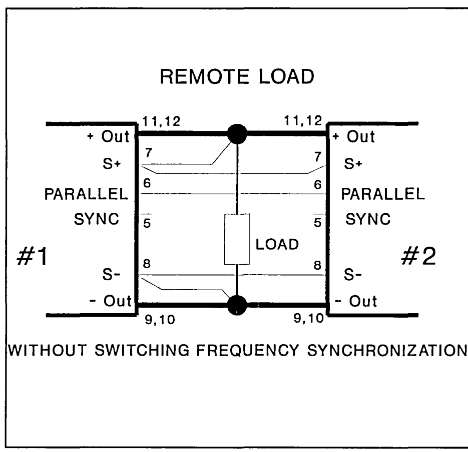


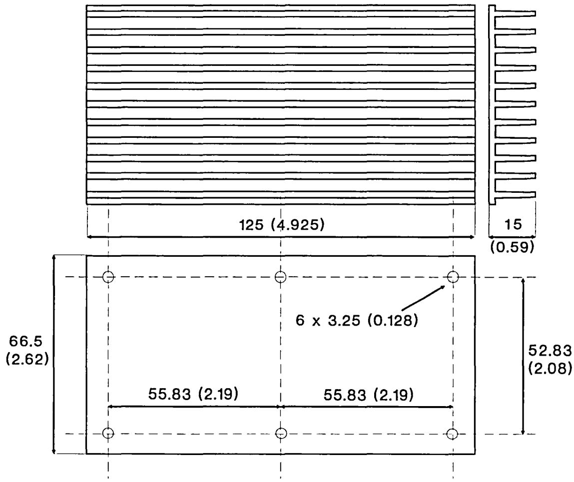
Figure 6.



Finned heatsink option

An additional finned heatsink is available (type ordering number HS01) to allow the user to decrease the total thermal resistance of the module to a typical value of 2.8 °C/W. The heatsink is suitable both for standard (4-40 UNC threading) and E version (M3 threading); screw length in the range of 6 to 8 mm (0.24 to 0.32"). See fig. 7.

Figure 7. - HS01 Heatsink.



Dimensions in mm (inches).

Thermal Characteristics

Following figures show the behaviour at still air and forced ventilation operation of the GS175T48-5 module (typical efficiency 82%) without (fig. 8) and with the additional finned HS01 heatsink (fig. 9)

Figure 8. - GS175T48-5 with stadard flat heatsink.

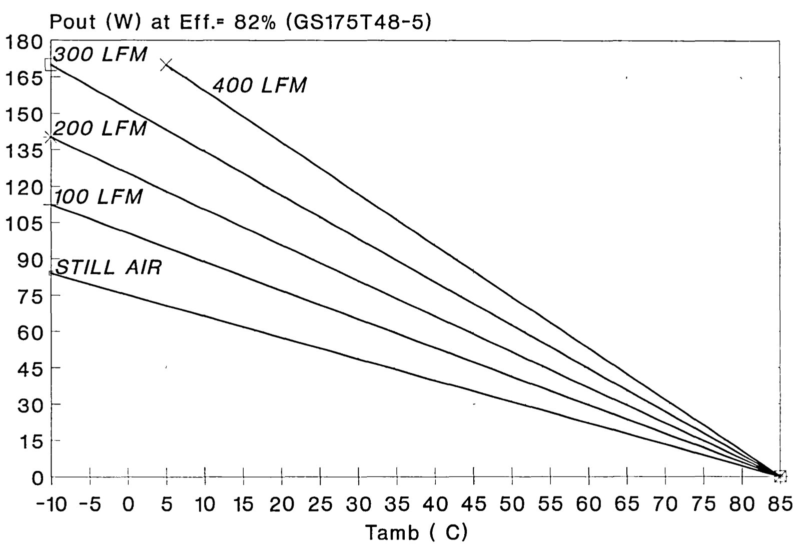
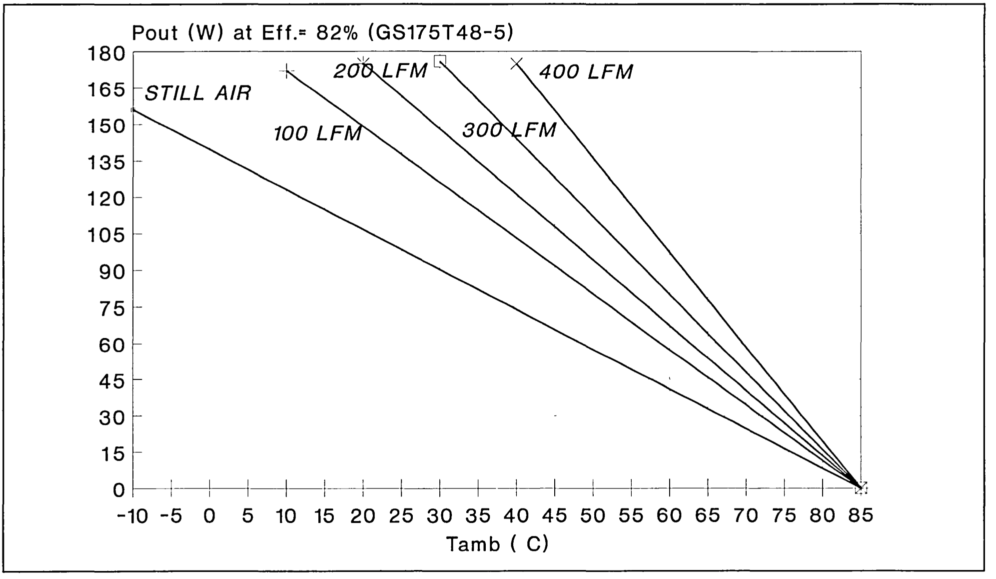


Figure 9. - GS175T48-5 with additional HS01 finned heatsink



Safety approvals

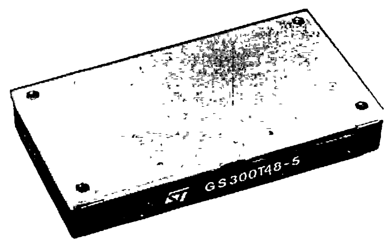
The converter is agency certified to the following safety requirements.

Agency	Requirements	License Number
UL	UL-STD-1950	E141284
CSA	CSA-STD-C22.2 No.234 (level 3)	LR 99794-2
TUV	EN 60950 DIN VDE 0805	R 9272137

® UL is a registered trademark of UNDERWRITERS LABORATORIES inc.
® CSA is a registered trademark of CANADIAN STANDARDS ASSOCIATION.
® TUV is a registered trademark of TUV Rheinland.

300W DC-DC CONVERTER

Type	V_i	V_o	I_o
GS300T48-5	38 to 60 V	5,075 V	60 A



FEATURES

- Very high output power (300W)
- High efficiency (80% min.)
- Parallel operation with current sharing
- Synchronization pin
- Remote ON/OFF
- Remote load voltage sense compensation
- Output short-circuit protection
- Output overvoltage protection
- Thermal protection
- Undervoltage lock-out
- Minimal overshoot during load transients
- 500 V_{DC} input to output isolation
- Internal input and output filtering
- Softstart
- PCB or chassis mountable

DESCRIPTION

The GS300T48-5 is a 300W DC-DC converters used to generate a 5.075V isolated output with a current of 60A from a wide range input voltage (38 to 60V).

SELECTION GUIDE

Type Ordering Number	Input Voltage (V)	Output Voltage (V)	Output Current (A)	Dimensions L • W • H mm (inches)
GS300T48-5 GS300T48-5E	38 to 60	5.075	60	125 • 66.5 • 20 (4.92 • 2.62 • 0.79) **The suffix E identifies the metric threading on the planar heatsink (see fig. 1).**

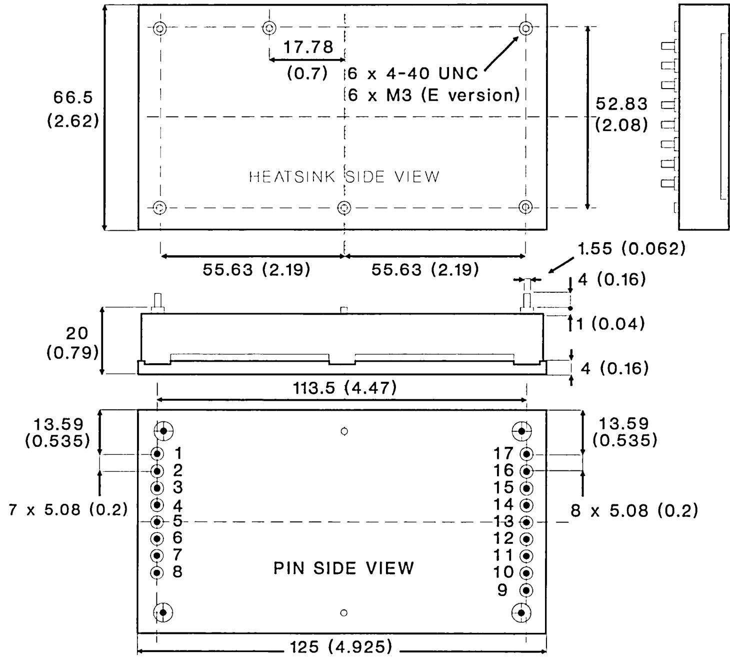
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5.075V I_O = 0 to 30A (Operating Conditions)	38	48	60	VDC
V_{iuv}	Input Undervoltage Lockout	I_O = 0 to 60A	29		36	V
I_i	Average Input Current	V_i = 48V I_O = 60A			7.8	A
I_{ipk}	Inrush Transient Peak Current	V_i = 60V I_O = 60A			0.3	A^2s
I_{ir}	Reflected Input Current	V_i = 48V I_O = 60A BW = 5Hz to 20MHz (see fig. 2)			30	mApp
V_{ien}	Enable Input Voltage	V_i = 38 to 60V I_O = 0 to 60A	0		1.2	V
I_{ien}	Enable Input Current	V_i = 38 to 60V I_O = 0 to 60A V_{ien} = 0V			– 1	mA
V_{iinh}	Max Inhibit Voltage	V_i = 38 to 60V I_O = 0 to 60A V_{ien} = open	8		18	V
P_i	Input Power	V_i = 38 to 60V I_O = 0A (No Load)		1.5	2	W
V_O	Total Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 60A	4.490	5.075	5.210	V
V_{Ost}	Short-term Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 60A	5.002	5.075	5.148	V
V_{Ots}	Total Static Output Voltage Regulation	V_i = 38 to 60V I_O = 0 to 60A	4.970	5.075	5.180	V
V_{Ol}	Output Overvoltage Limit Initiation	V_i = 38 to 60V I_O = 0 to 60A		6.3		V
V_{Or}	Output Ripple Voltage	V_i = 38 to 60V I_O = 60A BW = 0 to 20 Mhz			50	mVpp
V_{On}	Output Noise Voltage	V_i = 38 to 60V I_O = 60A BW = 0 to 20 Mhz			100	mVpp
ΔV_O	Total Remote Sense Compensation	V_i = 38 to 60V			0.6	V
δV_O	Peak Load Transient Response	V_i = 48V δI_O = 10A slope = 0.1A/µs			100	mVp
I_O	Output Current	V_i = 38 to 60V V_O = 5V	0		60	A
I_{Ol}	Overcurrent Limit Initiation	V_i = 48V		63		A
I_{Osc}	Shortcircuit Output Current	V_i = 48V		69		A
t_s	Load Transient Setting Time	V_i = 48V δI_O = 10A slope = 0.1A/µs			250	µs
t_{on}	Turn-on Time	V_i = 38 to 60V I_O = 0 to 60A V_{ien} = from high to low			10	ms
		V_i = 0 to 60V I_O = 0 to 60A V_{ien} = low			10	
V_{is}	Isolation Voltage		500			V
f_s	Switching Frequency	V_i = 38 to 60V I_O = 0 to 60A	160	180	200	kHz
η	Efficiency	V_i = 38 to 60V I_O = 60A	80	81		%
R_{th}	Thermal Resistance	Case to Ambient		5.2		°C/W
T_{cop}	Operating Case Temperature Range*		0		+70	°C
T_{stg}	Storage Temperature Range		– 40		+105	°C

* Thermal intervention @ T_{cop} = 85°C

CONNECTION DIAGRAM AND MECHANICAL DATA

Figure 1.



Package U. Dimensions in mm (inches)

PIN DESCRIPTION

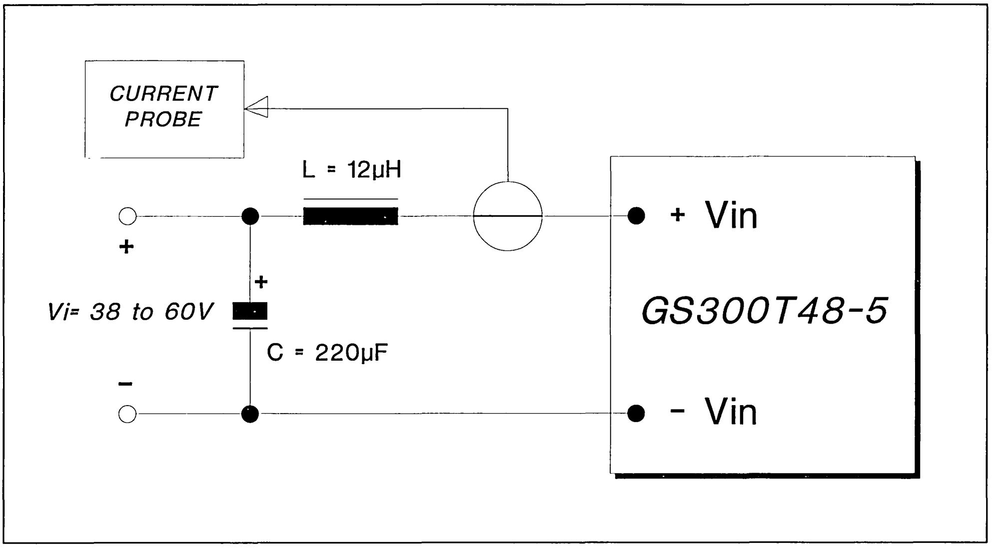
Pin	Function	Description
1,2	- Vin	Negative input voltage.
3,4	+ Vin	Positive input voltage. Unregulated input voltage (typically 48V) must be applied between pin 1,2-3,4.
5	SYNC	Synchronization pin. See figures 3, 4, 5, 6. Open when not used.
6	PARALLEL	Parallel output. See figures 3, 4, 5, 6. Open when not used.
7	ON/OFF	The converter is ON (Enable) when the voltage applied to this pin with reference to pin 1,2 is lower than 1,2 V (see Vien). The converter is OFF (Inhibit) for a control voltage in the range of 8 to 18V. When the pin is unconnected the converter is OFF (Inhibit).
8	CASE	Case connection pin
9	+ SENSE	Senses the remote load high side. To be connected to pin 15,16,17 when remote sense is not used.
10	- SENSE	Senses the remote load return. To be connected to pin 11,12,13,14 when remote sense is not used. In parallel configuration, take care to connect all -SENSE pins together (see figures 3,4,5,6).
11,12, 13,14	- OUT	-5V voltage return.
15,16, 17	+ OUT	+5V output voltage.

USER NOTES

Reflected Input Current

The reflected input current measurement (Iir, see Electrical Characteristics) is performed according to the test set-up of fig. 2.

Figure 2.



Softstart

To avoid heavy inrush current the output voltage rise time is 10ms maximum in any condition of load.

Remote Sensing

The remote voltage sense compensation range is for a total drop of 0.6V equally shared between the load connecting wires.

It is a good practice to shield the sensing wires to avoid oscillations.

See the connection diagram on figures 3, 4, 5, 6.

Remote ON/OFF

The module is controlled by the voltage applied between the ON/OFF pin and -IN pin.

The converter is ON (Enable) when the voltage applied is lower than 1.2 V (see Vien on Electrical Characteristics).

The converter is OFF (Inhibit) for a control voltage in the range of 8 to 18V (see Viinh).

When the pin is unconnected the converter is OFF. Maximum sinking current is 1mA.

Module Protection

The module is protected against occasional and permanent shortcircuits of the output pins to ground, as well as against output current overload. It uses a current limiting protection circuitry, avoiding latch-up problems with certain type of loads.

A latching crowbar output overvoltage protection is activated when the output voltage exceeds the typical value of 6.3V (see Electrical Characteristics). A thermal non-latching protection disables the module whenever the heatsink temperature reaches about 85°C.

Parallel Operation

To increase available output regulated power, the module features the parallel connection possibility with equal current sharing and maximum deviation of 10% (two modules in parallel).

See the connection diagram on figures 3, 4, 5, 6.

Figure 3.

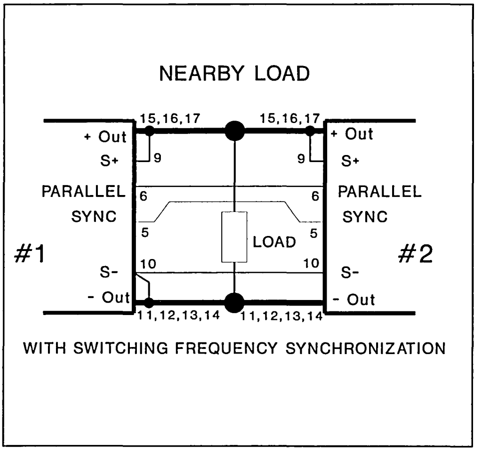


Figure 4.

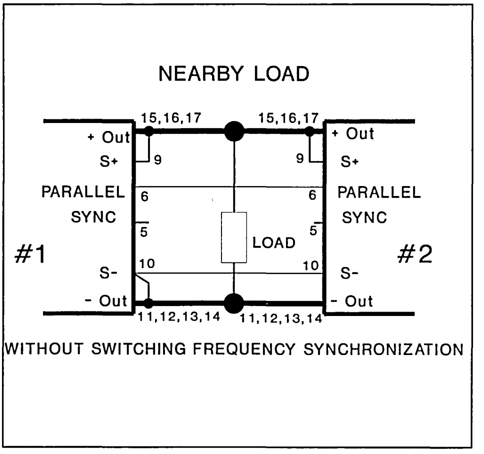


Figure 5.

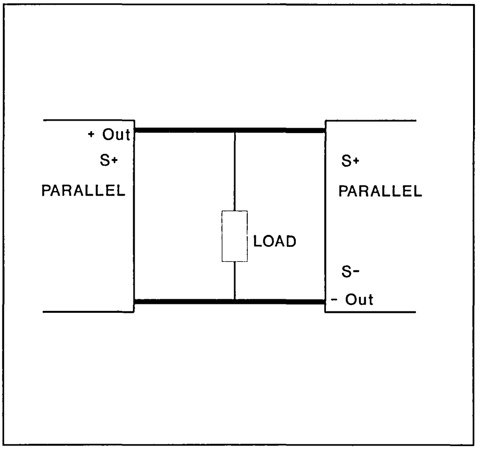
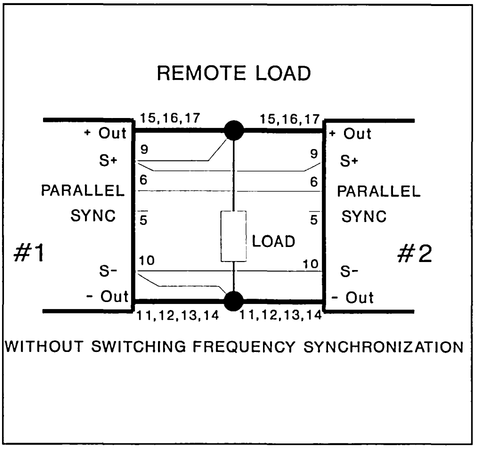


Figure 6.



Thermal Characteristics

The case-to-ambient thermal resistance of the GS300T48-5 module is 5.2°C/W typical. It may be decreased, improving the convection cooling, by mounting an external heatsink to the top of the unit heatsink (fig. 9).

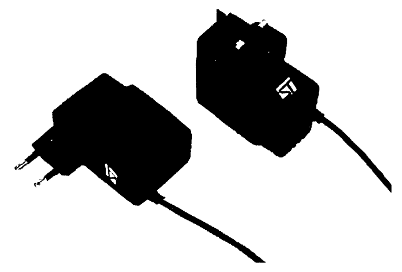
Six threaded holes, # 4-40 UNC on the standard or # M3 on the E version, 5 mm (0,2") maximum deep, are provided for this purpose (see fig. 1).

SGS-THOMSON MICROELECTRONICS

GSAC-8.507BC

BATTERY CHARGER

Type	V_i	V_o	Io
GSAC-8.507BC	230 V_{RMS}	8.5 V	700 mA



FEATURES

- Charge of NiCd or NiMH batteries
- Switch mode constant current generation
- Three level charging current (fast, trickle, zero charging current)
- Overcharge detection by - Δ V and $\Delta T/\Delta t$ under internal microprocessor control
- No discharge of the battery when charger is turned off
- Initial trickle charge for deeply discharged batteries
- Maximum battery voltage protection
- Maximum battery temperature protection
- Timer back up protection
- Output short circuit protection
- Detection of fault battery
- Charge status displayed by LED
- European or UK plug

DESCRIPTION

The GSAC-8.507BC is a high efficiency battery charger for connection to the mains and to be used with 5 cells NiCd and NiMH batteries.

Two versions of the INPUT PLUG ADAPTOR are available:

EUROPEAN VERSION : GSAC-8.507BC-1 (Ordering Number)

UK VERSION : GSAC-8.507BC-2 (Ordering Number)

(See pag. 3 for mechanical data)

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	AC Input Voltage	I_{ch} = 0 to 0.7A	187	230	264	V_{RMS}
I_{chf}	Fast Charge Current	V_i = 187 to 264 V_{RMS} $V_{battery}$ = 5 to 8.2V	0.65	0.70	0.75	A
I_{cht}	Trickle Charge Current	V_i = 187 to 264 V_{RMS} $V_{battery}$ = 1 to 5V or 0°C < T_{batt} < 10°C or charge completed	20	30	40	mA
C	Returned Charge	V_i = 187 to 264 V_{RMS}		95		%
V_{batt}	Maximum Battery Voltage Protection	V_i = 187 to 264 V_{RMS} I_{ch} = 0.7A	8.2	8.5	8.7	V
T_{co}	Battery Temperature Cut Off	V_i = 187 to 264 V_{RMS} I_{ch} = 0.0A		50		°C
t_{out}	Time Out Protection Duration	V_i = 187 to 264 V_{RMS} I_{ch} = 0.7A	·	2		hours
f_s	Switching Frequency	V_i = 187 to 264 V_{RMS} I_{ch} = 0.03 to 0.7A		100		kHz
T_{op}	Operating Ambient Temperature Range		– 20		+60	°C
T_{stg}	Storage Temperature Range		– 25		+85	°C

Status	Condition
Red ON	- Fast charge (I_{ch} = 0,7A)
Green ON	- Charge Completed (I_{ch} = 0.03A) - Timer elapsed
Red Flashing	Anomalous battery conditions (I_{ch} = 0.0A) - Initial $T_{battery}$ < 0 °C - Initial $T_{battery}$ > 40 °C - $T_{battery}$ > 50 °C - Faulty battery
Green Flashing	(I_{ch} = 0.03A) - Initial charge of deeply discharged batteries - 0 °C < T_{batt} < 10 °C
OFF	Battery not connected

NOTES

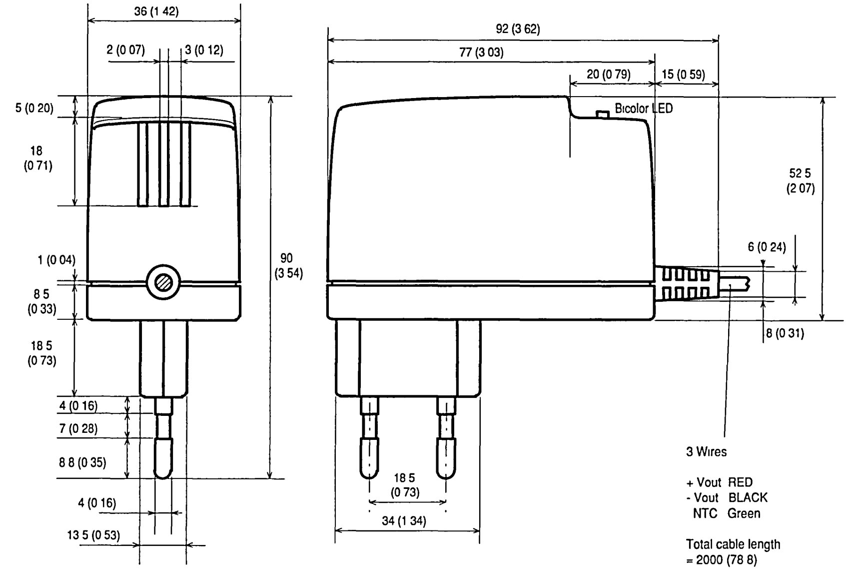
1 - The battery temperature detection is a function of the characteristics of the NTC resistor used inside the battery pack. Please consult factory.

2 - Different fast charge and trickle charge currents, and different time out are available on request (Maximum charge current cannot exceed 1A).

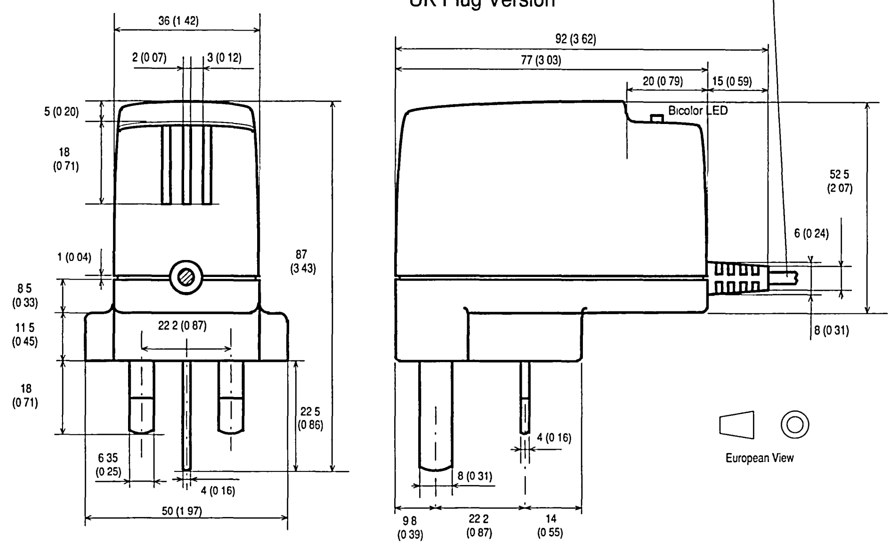
3 - For connector to the battery pack please consult factory.

CONNECTION DIAGRAM AND MECHANICAL DATA

European Plug Version



UK Plug Version

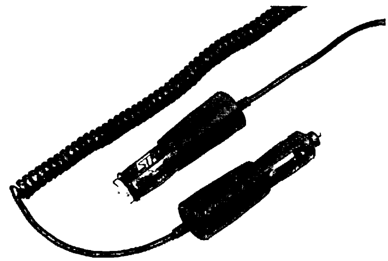


Output connector to be defined according to customer specifications
Dimensions in mm (inches).

GSCC-7.007BS

BATTERY SAVER

Type	V_i	Vo	Io
GSCC-7.007BS	10,5 to 16,0V	6,75 V	700 mA



DESCRIPTION

The GSCC-7.007BS is a switch mode constant current battery saver for 5 cell NiCd or NiMH batteries. The input energy is supplied by the car cigar lighter plug and the battery is charged by 0.7A constant current.

Two versions of the INPUT PLUG ADAPTOR are available:

WASHER TIP VERSION:
GSCC-7.007BS-E (Ordering Number)

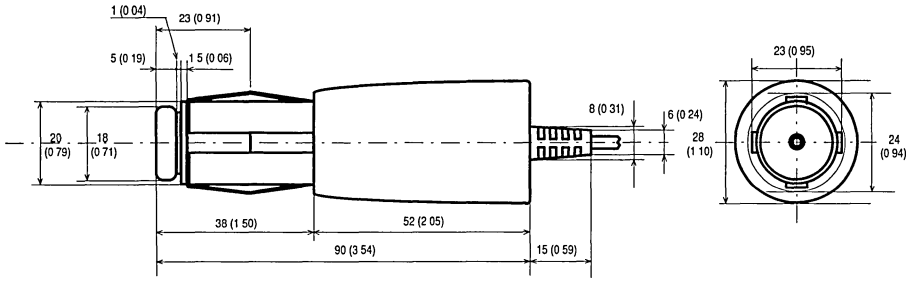
SPRING-LOADED TIP VERSION:
GSCC-7.007BS-A (Ordering Number)
(See page 2 for mechanical data)

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

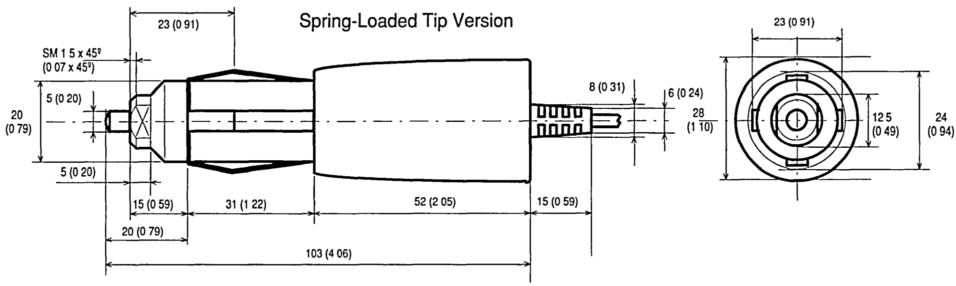
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	I_o = 0.7A Vbatt = 5 to 6.75V	10.5		16.0	V
I_o	Output Charge Current	V_i = 10.5V to 16V V_{batt} = 5.0 to 6.75V	650	700	750	mA
V_o	Output Limiting Voltage	V_i = 10.5 to 16V	6.5	6.75	7.00	V
T_{op}	Operating Ambient Temperature Range		– 20		+70	°C
T_{stg}	Storage Temperature Range		– 25		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA

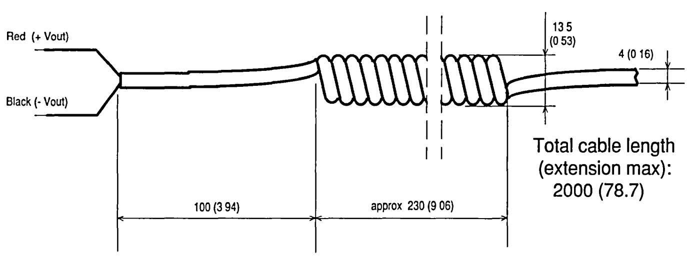
Washer Tip Version



Spring-Loaded Tip Version



Coiled cable (both versions)

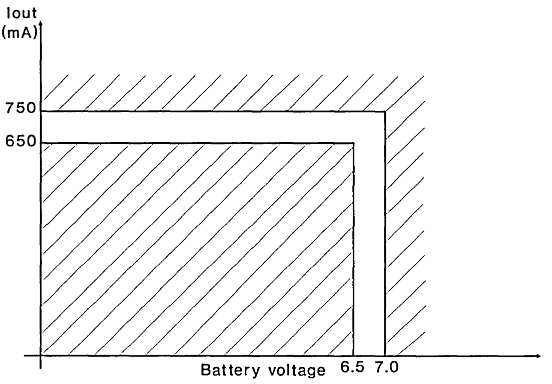


Total cable length (extension max): 2000 (78.7)

European View

Output connector to be defined according to customer specifications
Dimensions in mm (inches).

CHARGE CHARACTERISTICS



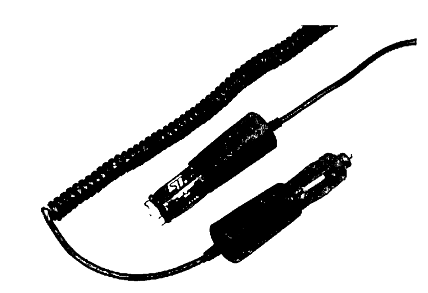
CHARGE CHARACTERISTICS

SGS-THOMSON MICROELECTRONICS

GSCC-8.507BC

BATTERY CHARGER

Type	V_i	V_o	I_o
GSCC-8.507BC	10.8 to 16 V	8.5 V	700 mA



FEATURES

- Charge of NiCd or NiMH batteries
- Switch mode constant current generation
- Three level charging current (fast, trickle, zero charging current)
- Overcharge detection by - Δ V and $\Delta T/\Delta t$ under internal microprocessor control
- No discharge of the battery when charger is turned off
- Initial trickle charge for deeply discharged batteries
- Maximum battery voltage protection
- Maximum battery temperature protection
- Timer back up protection
- Output short circuit protection
- Detection of fault battery
- Charge status displayed by LED

DESCRIPTION

The GSCC-8.507BC is a high efficiency battery charger for IN CAR application to be used with 5 cell NiCd or NiMH batteries.

Two versions of the INPUT PLUG ADAPTOR are available:

WASHER TIP VERSION: **GSCC-8.507BC-E** (Ordering Number)

SPRING-LOADED TIP VERSION: **GSCC-8.507BC-A** (Ordering Number)

(See pag. 3 for mechanical data)

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	I_{ch} = 0 to 0.7A	10.8	14.4	16	V
I_{chf}	Fast Charge Current	V_i = 10.8 to 16V $V_{battery}$ = 5 to 8.2V	0.65	0.70	0.75	A
I_{cht}	Trickle Charge Current	V_i = 10.8 to 16V $V_{battery}$ = 1 to 5V or 0°C < T_{batt} < 10°C or charge completed	20	30	40	mA
C	Returned Charge	V_i = 10.8 to 15V		95		%
V_{batt}	Maximum Battery Voltage Protection	V_i = 10.8 to 16V I_{ch} = 0.7A	8.2	8.5	8.7	V
T_{co}	Battery Temperature Cut Off	V_i = 10.8 to 16V I_{ch} = 0.0A		50		°C
t_{out}	Time Out Protection Duration	V_i = 10.8 to 16V I_{ch} = 0.7A		2		hours
f_s	Switching Frequency	V_i = 10.8 to 16V I_{ch} = 0.03 to 0.7A		100		kHz
T_{op}	Operating Ambient Temperature Range		– 20		+60	°C
T_{stg}	Storage Temperature Range		– 25		+85	°C

Status	Condition
Red ON	- Fast charge (Ich = 0,7A)
Green ON	- Charge Completed (Ich = 0.03A) - Timer elapsed
Red Flashing	Anomalous battery conditions (Ich = 0.0A) - Initial $T_{battery}$ < 0 °C - Initial $T_{battery}$ > 40 °C - $T_{battery}$ > 50 °C - Faulty battery
Green Flashing	(Ich = 0.03A) - Initial charge of deeply discharged batteries - 0 °C < Tbatt < 10 °C
OFF	Battery not connected

NOTES

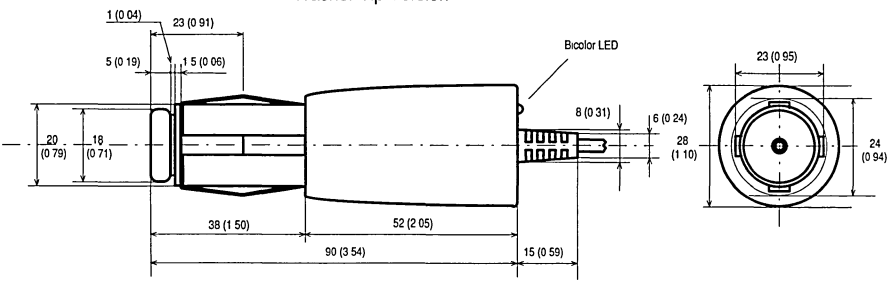
1 - The battery temperature detection is a function of the characteristics of the NTC resistor used inside the battery pack. Please consult factory.

2 - Different fast charge and trickle charge currents, and different time out are available on request (Maximum charge current cannot exceed 1A).

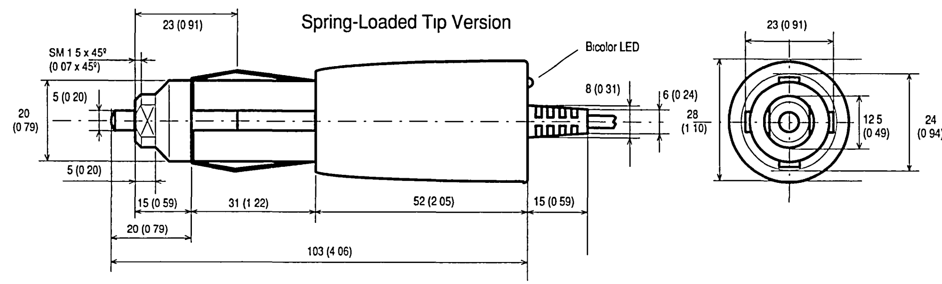
3 - For connector to the battery pack please consult factory.

CONNECTION DIAGRAM AND MECHANICAL DATA

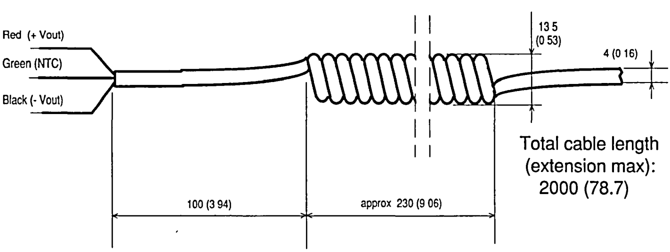
Washer Tip Version

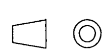


Spring-Loaded Tip Version



Coiled cable (both versions)





European View

Output connector to be defined according to customer specifications
Dimensions in mm (inches).

INTELLIGENT STEPPER MOTOR CONTROLLERS

FEATURES

- Absolute and incremental positioning
- Up to 999,999 step per move
- Speed range to 10,000 steps/s
- Ramp lenght to 999 steps
- Single unregulated supply voltage
- Index and velocity mode
- Automatic and Home positioning
- Loops and Delay execution
- Conditional start and stop
- Status feedback to the host
- RS232 communication port
- Point to point and Multipoint protocol
- Closed loop operation
- Counter preset (GS-C200S only)
- Jump to (GS-C200S only)
- Jump to on-condition (GS-C200S only)
- Initialization during execution (GS-C200S only)
- Auxiliary output voltages +5V, ± 12V

DESCRIPTION

The GS-C200 and GS-C200S are powerful stepper motor control modules that interface every power sequencer/driver available on the market.

A sophisticated hardware and an easy to learn programming language result in minimal development and debugging time of motion control systems. The modules are supported by dedicated software that includes both an on-screen editor and a debugger that greatly improve the module ease of use.

The instruction sets comprise respectively 25 (GS-C200) and 29 (GS-C200S) different commands which can be executed either under host control or in a stand alone environment. An on board EE-PROM is used for program saving and retrieving.

The availability of three User inputs and three programmable User outputs, each of which can be tested or set under program control, assures to the designer a high level of system power and flexibility.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	42	V
T_{stg}	Storage Temperature Range	– 40 to + 85	°C
T_{op}	Operating Temperature Range	0 to + 50	°C
	Humidity (non condensing)	0 to 90	%

ELECTRICAL CHARACTERISTICS (T_A = 25C and V_s=24V unless otherwise specified)

Symbol	Parameter		Min	Typ	Max	Unit
V_S	DC Supply Voltage		12		40	V
I_S	Quiescent Supply Current			80		mA
V_i	Logic Input Voltage (TTL compatible)	Low High	 2		0.8 5	V V
V_o	Logic Output Voltage (TTL compatible)	Low High	 2		0.8 5	V V
tcpw	Clock Pulse Width				5	µs
trpw	Reset Pulse Width (Internal)				500	µs

MOTION CHARACTERISTICS

SPEED RANGE	10 to 10000 steps
SPEED RESOLUTION	10 steps
RAMP LENGHT	1 to 999 steps
RAMP RESOLUTION	1 step
POSITIONING RANGE(C200) (C200S)	0 to 9999999 – 8388608 to + 8388607
SINGLE MOVEMENT RANGE	1 to 999999 steps
POSITIONING RESOLUTION	1 step
POSITIONING REPEATIBILITY	+/– 0 step
PROGRAM STORAGE CAPABILITY	119 bytes

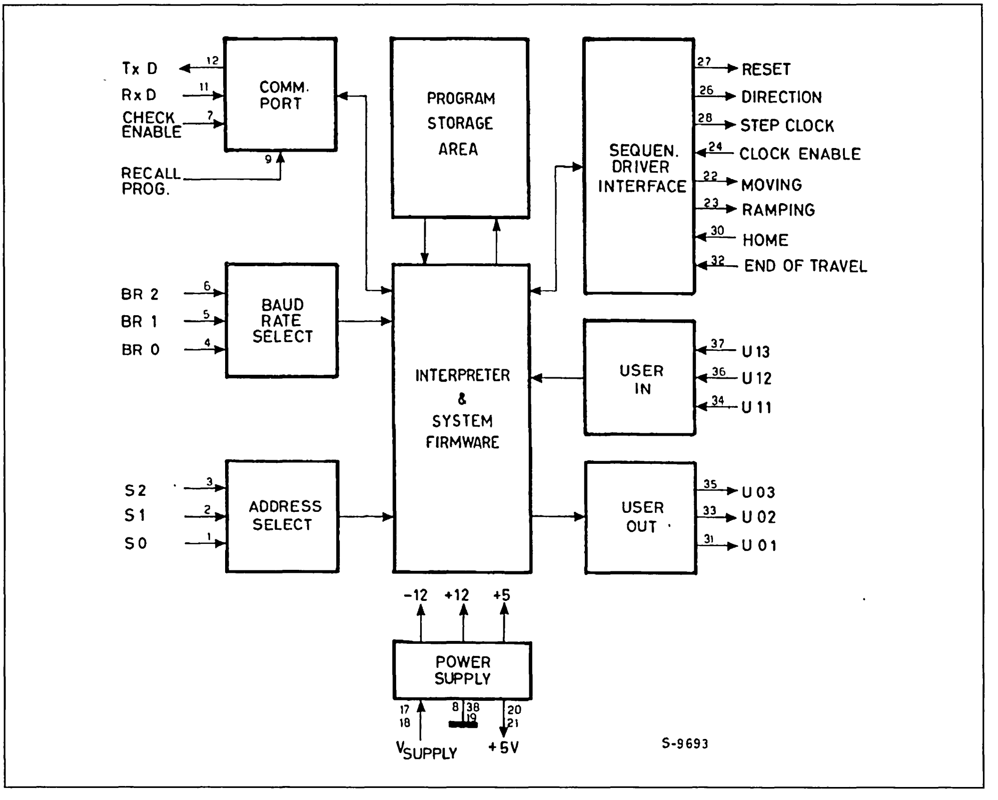
COMMUNICATION PORT CHARACTERISTICS

SIGNAL LINES	3 (TxD, RxD, GND)
BAUD RATE RANGE	110 to 9600
FORMAT	1 Start Bit 7 Data Bit 2 Stop Bit Odd parity

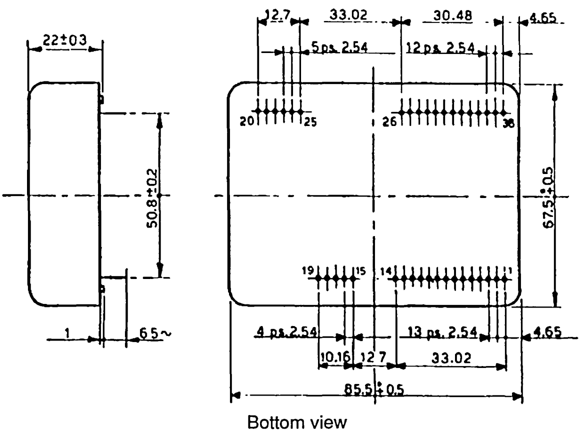
STORAGE CAPACITY

MINIMUM NUMBER OF COMMANDS	30
MAXIMUM NUMBER OF COMMANDS	45

Figure 1. Block Diagram



CONNECTION DIAGRAM AND MECHANICAL DATA



Dimensions in mm.

Bottom view

PIN DESCRIPTION

Pin	Function	Description
1	SEL0	Protocol/address LSB select input
2	SEL1	Protocol/address SSB select input
3	SEL2	Protocol/address MSB select input
4	BR0	Baud rate LSB select input
5	BR1	Baud rate SSB select input
6	BR2	Baud rate MSB select input
7	CHS	Checksum enable input
8	GND	Ground
9	REC	Program autorecall input
10		Must be connected to pin 8
11	RXD	RS232 received data input
12	TXD	RS232 transmitted data output
13	TXPD	Transmitted data pull-down resistor
14	RDY	Status logic output
15	–VSL	Unregulated –12V supply output (note 1)
16	+VSL	Unregulated +12V supply output (note 1)
17	V_S	Supply voltage input
18	V_S	Supply voltage input
19	GND	Ground
20	5V	5V Auxiliary output (note 2)
21	5V	5V Auxiliary output (note 2)
22	MOV	Motor moving logic output
23	RAMP	Motor ramping logic output
24	ENABLE	Stop enable logic input
25		Not connected
26	DIR	Direction selection logic output
27	RESET	Power driver Reset logic output
28	CLOCK	Step clock logic output
29		Not connected
30	HOME	Home position logic input
31	UO1	User 1 logic output
32	EOT	End of travel switch logic input
33	UO2	User 2 logic output
34	UI1	User 1 logic input
35	UO3	User 3 logic output
36	UI2	User 2 logic input
37	UI3	User 3 logic input
38	GND	Ground

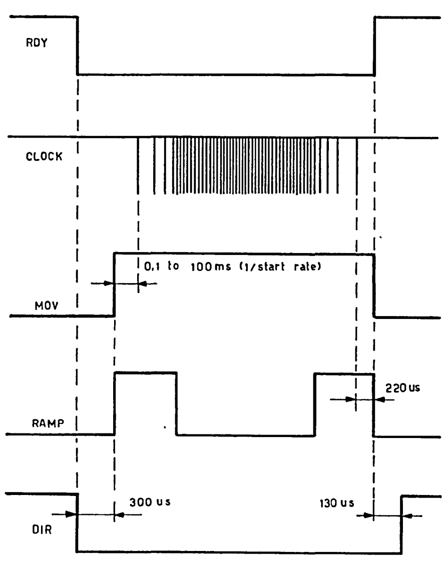
Notes: 1 – Maximum available current is 10mA
2 – Maximum available current is 100mA

The various signals that characterize the GS-C, their function and the active level are described in detail in the following:

Pin	Function
1 - 2 - 3	The SEL0 (pin1), SEL1 (pin2) and SEL2 (pin3) inputs are used to select the communication protocol and the module address. They have an internal pull-up and when unconnected they are at the 1 logic level.
4 - 5 - 6	The BR0 (pin4), BR1 (pin5) and BR2 (pin6) inputs are used to select the Baud rate of the communication port. They have an internal pull-up and when unconnected they are at the 1 logic level.
7	The CHS checksum generation conditioning input enables the user to include or exclude the checksum character from the data exchange string. A "zero" logic level applied to this input disables the control and the generation of the checksum character thus allowing the GS-C to be connected to a video terminal.
8	This pin is the common terminal for all logic signals and for the power supply return path.
9	The REC Recall Program Enable input pin, when brought to "zero", enables the automatic recall of the program stored in the EEPROM and its immediate execution.
10	This pin is for testing purpose only and it must be grounded for normal operation.
11	The RxD input of the serial communication port is used by the module to receive commands from the Host Computer. The input logic levels are compatible with the RS232 and V24 standards.
12	The TxD output of the serial communication port is used by the module to send data to the Host Computer. The logic levels of this output are compatible with the RS232 and V24 standards.
13	The TxPD Transmitted data pull-down resistor pin must always be connected to the TxD output (pin 12) when the Point-to-Point protocol is used. When the Multipoint protocol is selected, this pin must be left open on all modules except the chain terminator unit, in order to avoid the TxD output overload.
14	The RDY hardware status output (open collector) signal pin is used as the controller status flag. RDY assumes a "zero" logic level when a command or a program is in execution
15	–12V unregulated output. A maximum of 10mA can be sinked from this pin.
16	+12V unregulated output. A maximum of 10mA can be sinked from this pin.
17 - 18	Module supply input. For correct operations a supply voltage ranging from 12 to 40 Volt is required.
19	See pin 8.
20 - 21	5 Volt regulated output, available either for the Sequencer-Driver logic section or for a custom interface logic supply. The maximum current that can be sinked from this pin is 100mA.
22	The MOV Motor moving output becomes the logic level "one" when the GS-C is executing a movement. This output can be used to program the phase current level when the motion is running at a level higher than for the rest condition.
23	The RAMP Ramp in execution output is rised to the logic level "one" when the GS-C is executing an acceleration or a deceleration ramp. This output can be used to program the phase current level when the motion is ramping at a level higher than for the rest or slewing condition.
24	The ENABLE input pin allows the user to control the Step clock logic output to avoid the motor being stepped if the previous step was not correctly executed. A "zero" logic level applied to this pin stops the generation of the step pulses. This input can be used to stop the system when an emergency occurs, to execute the motion according to externally generated timing, or to implement a closed loop control system.
25, 29	Not connected.
26	The DIR Direction selection output is used to inform the Sequencer-Driver on the direction of rotation. The logic level "one" determines a clockwise rotation, but of course the rotation depends on the motor phases connection to the Sequencer-Driver.
27	The RESET Power driver Reset output is brought to the "zero" logic state for 400µs when the unit is powered-on, or when the GS-C receives the "Initialize position counter" command. This output is normally used to assure the correct start-up of the Sequencer-Driver or any other external custom logic.

Pin	Function
28	The CLOCK Step clock output is used to inform the Sequencer-Driver to perform a step. The direction (clockwise or counterclockwise) is defined by the logic status of the DIR output. In steady conditions, the CLOCK is at the "one" logic level, and the step is represented by a negative going pulse with a 1.7µs duration.
30	The HOME Home position input allows the system to find its reference point. This input can be driven by a mechanically activated contact indicating the "zero" position. It is normally used together with the EOT End-of-travel signal.
31	The UO1 User output 1 is intended for user purposes. The status of this output can be set and cleared under program control and it can be used for various functions. It is normally used for the control of external devices, the selection of the Sequencer-Driver operating mode, or the synchronization of complex movements.
32	The EOT End-of-travel input allows, in combination with the HOME input, the correct mechanical initialization of the system. For this purpose it must be brought to the "zero" logic level when the system reaches the run end position.
33	The U02 User output 2 is intended for user purposes. See pin 31 description.
34	The UI1 User input is intended for user purposes. The status of this input can be read by the Host Computer or tested during the program execution, and used to condition the start of a movement, the execution of a specific portion of a program (GS-C200S only), or any other similar operation.
35	The UO3 User output 3 is intended for user purposes. See pin 31 description.
36	The UI2 User input 2 input is intended for user purposes. See pin 34 description.
37	The UI3 User input 3 input is intended for user purposes. See pin 3 and pin 4 description.
38	See pin 8.

Figure 2. GS-C Timing Diagram



S.I.M.P.L.E. Interpreter Command and Functions
(**S**GS-THOMSON **I**nteractive Stepper **M**otor **P**rogramming **L**anguage and **E**xecutor)

Command	Byte Length	Function
Ax	2	Activate the specified (x) User output.
Cx	2	Clear the specified (x) User output.
Dxxx	2	Delay for the specfied number (xxx) of tenth of second.
E	–	Start executing the program currently stored into RAM memory.
F	–	Feedback the GS-C status (i.e. Ready or Busy).
f+/–xxxxxxx	4	Preset the position counter to the specified absolute value (C200S).
G+/–xxxxxxx	4	Go to the specified target position (C200S).
g(+/–)	4	Move the motor indefinitely in the specified direction.
g(+/–)x	4	Move the motor in the specified direction until the specified (x) input is brought to zero.
H(+/–)	–	Find Home position moving clockwise (+), or moving counterclockwise (–).
Ix	2	Initialize the position counter (x=1), the user outputs (x=2), or both (x=3).
jx	2	Jump to memory location (x). Location (x) ranges between 0 and 118 (C200S).
jcy, x	2	Jump to memory location (x) if the binary value of the user inputs matches (y) value (C200S).
K	–	Kill the program in execution.
Lx	2	Loop for the specified (x) number of times.
M	–	Transfer the RAM memory content to EEPROM.
P	–	Enter the programming mode (C200).
Po	–	Enter the programming mode (C200S).
Px	–	Exit the programming mode (C200S).
Q	–	List to the host the program currently in RAM memory.
Rxxx	4	Set the Ramp length to the specified (xxx) value.
Sxxx	4	Set the start-stop speed to the specified (xxx) value.
Txxx	4	Set the slew rate speed to the specified (xxx) value.
Ux	2	Execute the program until the specified (x) user input is brought to a low level.
Vx	–	Read back the current position (x=1) or the user I/O status (x=2).
X	–	Transfer the program from EEPROM to RAM.
Wx	2	Wait until the specified (x) user input is raised to a logic one level.
Z	–	Stop through a deceleration ramp.
+/–xxxxxx	4	Move clockwise (+) or counter-clockwise (–) for the specified (xxxxxx) number of steps.

GS-C200 AND GS-C200S DESCRIPTION

The increasing popularity of microprocessors and their very low cost, have contributed to a fast growth of stepper motors usage in a large numbers of application previously covered by more complex, bulk and expensive DC motors servo loops. The GS-C200 and the GS-C200S modules have been conceived to help the industrial designer in designing the stepper motor applications based on microprocessor control.

These modules are programmable intelligent stepper motor controllers that coordinate highly complex movements and sequential operations. This capability is performed through the integration of sophisticated hardware and an easy to learn and very functional and powerful programming language.

Thanks to this high level programming language, the power of the instruction set and the ability to condition and control the program execution through the USER inputs and outputs, the GS-C200 and GS-C200S drastically reduce the design time and start-up manufacturing phase of very complex systems. The GS-C200S offers an advanced and powerful instruction set that includes also the conditional jump which allows for more efficient program-ming. The GS-C200, the GS-C200S and their companion modules, the GS-D200 and the GS-D200S, can be used to drive in chopped mode of bipolar stepper motor with a 2/2.5A maximum phase current rating.

The two modules (GS-C and GS-D) are available also on a single Eurocard board named respectively GS-DC200, GS-DC200S and GS-DC200SS according to the various modules combination (see the relevant data sheet). In the following the modules will be generically named GS-C. The specific module part number will be used when the feature is unique to that module.

A MOTION SYSTEM ARCHITECTURE

A complete motion system controlled by a host computer is normally configured as per fig. 3.

The GS-C logical and functional architecture is shown in fig. 1 and it includes the following basic blocks:

- Interface to the Host Computer via an RS232 communication port.
- Address and baud rate selection.
- Interface to the Sequencer-Driver (in particular but not exclusively, to the GS-D200 or GS-D200S) via 5 output and 3 input lines
- Command Interpreter and Executor.
- Program storage area
- Power Supply.

The above mentioned functions are performed by the GS-C without the addition of any external component, and the module flexibility is further enhanced by the use of only one unregulated supply voltage that can be the same used to supply the Sequencer-Driver (from 12V up to 40V).

Commands are sent to the module by a Host Computer or by a simple video terminal during the programming/debugging phase through an RS232 serial port. They are interpreted and validated by the command interpreter and executed through the Sequencer-Driver interface.

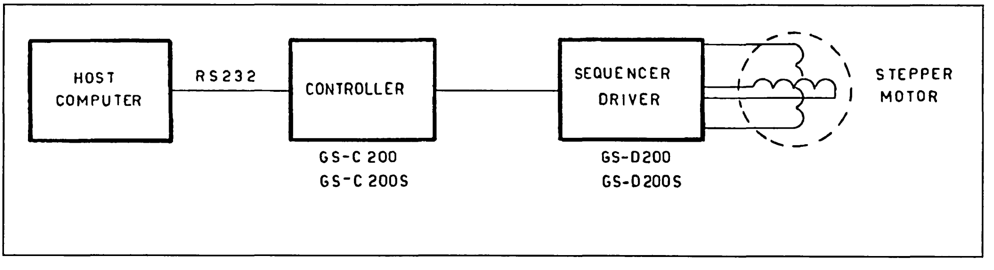
Command execution can be conditioned and controlled by the status of the USER IN-OUT interface.

A program storage area has been added to permanently store a program in an on-board EEPROM; this is particulary beneficial to obtain a low cost stand-alone controller that does not need any connection to an external computer or to store programs frequently used in complex motion sequencies thus reducing the host computer burden and speeding up the system processing.

Particular attention has been given to the simplicity of the instruction set to allow an easy design of the system to those designers that are not very familiar with microprocessor software and programming.

In the following a detailed description of the various functional blocks is given.

Figure 3. A Motion System Block Diagram



INTERFACE TO THE HOST COMPUTER AND DATA PROTOCOL

The interface to the Host Computer is through an RS232 or V24 serial communication port.

Baud Rate Programming

The Baud rate is programmed between 110 and 9600 bit/sec by using the BR0, BR1 and BR2 inputs according to the following table:

BR0 (p4)	BR1 (p5)	BR2 (p6)	Baud Rate
0	0	0	9600
1	0	0	4800
0	1	0	2400
1	1	0	1200
0	0	1	600
1	0	1	300
0	1	1	150
1	1	1	110

This setting is obtained by connecting the pins 4, 5, and 6 to ground (0 status) or by leaving them open (1 status). The communication port does not use any control line but just the transmit and receive signals. The host computer must handle the data excange in the proper way.

Module Address Programming

The communication protocol can be either Point to Point or Multipoint. In the first case a single communication line is required for each module, while in the latter more than one module (up to seven) can share the same communication line.

The Multipoint protocol as well as the peripheral device address are selected through SEL0, SEL1 and SEL2 inputs. The Point-to-Point protocol is selected by connecting all the SEL inputs to the 5V output pin (pin 20) or by leaving them open.

The following table defines the protocol and the address setting:

SEL2	SEL1	SEL0	Address	Protocol
0	0	0	7	Multipoint
1	0	0	6	Multipoint
0	1	0	5	Multipoint
1	1	0	4	Multipoint
0	0	1	3	Multipoint
1	0	1	2	Multipoint
0	1	1	1	Multipoint
1	1	1	–	Point-to-Point

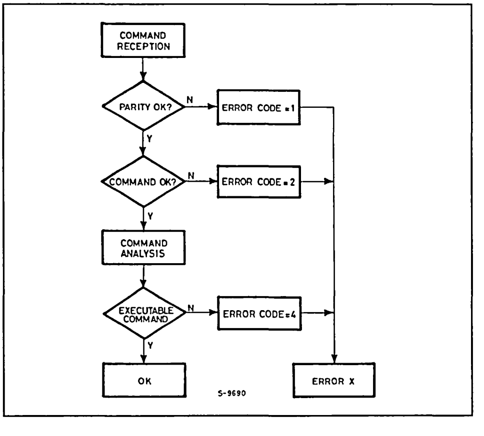
When the multipoint connection is chosen, the address of each module is obtained by connecting the various SEL pin (1, 2, 3) to ground (0 status) or by leaving them open (1 status).

The basic difference between the two protocols is represented by the sytem wiring complexity and the data throughput. The Point-to-Point offers the higher throughput data rate but it requires a connecting cable for each unit, while the Multipoint minimizes the connecting cables but at reduced throughput rate. When this latter protocol is chosen, the command must always be preceeded by the address of the unit.

Data Exchange Protocol

The dialogue is always driven by the Host Computer which sends the string containing the command or the request to be implemented. The GS-C module stores the instruction sent by the Host and then it checks if the string has been correctly received by analyzing the parity bit. It then analyzes the consistency of the received instructions by verifying the presence and correctness of the argument, and finally, it checks whether the request can be processed or not (for example, an attempt to move outside the system limits, etc.) reporting to the Host the analisys result. If no error is detected, the GS-C replies to the Host by a "Y" message. In case of error, the message will be "Error X" requesting the Host to send the message again or to modify some parameters of the previous message to fix the error detected by the GS-C. The actual value of X (see fig. 4 and error code table) gives the Host the information on the type of detected error. The procedure implemented for the dialogue with the Host is shown on the flowchart of fig. 4.

Figure 4. Controller-Host Dialogue Flowchart.



The general format of a command string is the following:

ADDRESS	COMMAND	ARGUMENT	CHECKSUM	CAR.RETURN

The **Address** must be the first transmitted character and it is present only if the Multipoint protocol is used (at least one of SEL0, SEL1, SEL2 is different from zero).

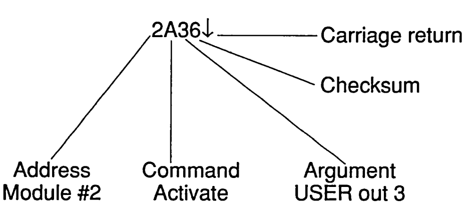
The **Command** is the second character(s) of the string, in the Multipoint protocol, but it becomes the transmission opening character when the Point-to-Point protocol is used (SEL0, SEL1 and SEL2 = 0).

The **Argument**, if required, is specified immediately after the command and its length depends on the command type.

The **Checksum** character verifies the correctness of the received string; its value is determined by the sum of the binary values of the preceding characters. The result is cut at the seventh least significant bit and ORed with exadecimal 10 (C200S/C200 from V2.2) to make the result compatible with the transmission system. The last character, the string ending character, is always a **Carriage Return** that will be identified in the following by the symbol (↓).

By connecting the pin CHS (pin 7) to ground, the checksum character is not anymore requested, and the task of guaranteeing the correctness of the message is left to the parity bit. It should be noted that by using this dialogue mode, the data integrity confidence level is reduced. Because motion systems normally operate in manufacturing premises subjected to heavy electro-magnetic noise, and because any communication problem may have catastrophic effects on the system actions, it is a good practice to use the checksum character whenever possible. The checksum character is normally not used (pin CHS connected to ground) when the GS-C is connected to a video-terminal, i.e. during the initial programming and debugging phase. In the following, three examples of command strings sent to a GS-C module are given.

Example 1 - MULTIPOINT PROTOCOL. The Host Computer wants to set the USER output 3 of the module #2. The command will have the following format:



The checksum character **6** results from the binary sum of the character **2** (ASCII value = 32) + character **A** (ASCII value = 41) + character **3** (ASCII value = 33) truncated at the seventh bit.

Example 2 - POINT-TO-POINT PROTOCOL.

The same instruction is given by the Host to a Point to Point connected module.

The command will have the following format:

A3t↓

The checksum character has an ASCII value **t** that derives from the sum of the ASCII code A+3 = 41+33 = 74 in binary weighted code or **t** in ASCII code.

Example 3 - POINT-TO-POINT PROTOCOL WITHOUT CHECKSUM.

For the same instruction, the command format will be:

A3↓

The string consists of command and argument only.

The GS-C feeds back information to the Host every time it receives a command, therefore it has not to identify itself to the Host when answering in a Multipoint connection.

The format of the string answered back by the GS-C is the following:

ANSW.CODE	ARGUMENT	CHECKSUM	CAR.RETURN

The first character, which always identifies the answer type, may assume one of the following values:

Y The command string has been correctly received.

B The controller is Busy and cannot process commands.

R The controller is Ready to process commands.

E An error has been detected. The type of error is specified by the number following the "E".

V A controller status (a position or an USER input/output status) is sent back and its value is specified by the characters following the "V".

The length of the Argument, present only for "E" and "V" answers, can range between 1 and 7 characters, and it is a function of the received command. The number following the "E" code, i.e. the error argument, specifies the detected error type according to the following table:

Error code	Type of error
1	Parity error when receiving one or more characters, checksum error, or too long a command string.
2	Command argument out of limit or not requested.
3	Storage capacity overflow.
4	Not allowed or not executable command.
5	Overflow error during program execution (GS-C200 only).
6	EEPROM programming error.

The number following the "V" code depends on the type of the received command.

When the GS-C answers to a "V1" request (feedback the actual absolute position against the Home position), the answer will be:

Vxxxxxxx↓

where the xxxxxxx represent the absolute position.

When the GS-C answers to a "V2" request (feedback the USER input/output status), the answer will be:

Vxy↓

where the x and y meaning is:

x = 1	User Input 1 = 1
x = 2	User Input 2 = 1
x = 4	User Input 3 = 1
y = 1	User Output1 = 1
y = 2	User Output 2 = 1
x = 4	User Output 3 = 1

The logic values of the inputs and outputs are added together. For example the answer:

V36↓

indicates the following USER I/O status:

UI1 =	1	UO1 =	0
UI2 =	1	UO2 =	1
UI3 =	0	UO1 =	1
	3		6

The presence of Checksum character, whose value is calculated by using the method described in the previous example, is conditioned by the CHS pin status.

When CHS is grounded (either by a logic signal or by a strap to ground) the checksum is deleted.

The string terminator is, as in the previous case, a Carriage Return.

THE SEQUENCER-DRIVER INTERFACE

The interface to the Sequencer-Driver and, through it, to the mechanical environment, consists of eight logic signals (5 outputs and 3 inputs) which enable the GS-C intelligent controller to interface the GS-D200 or the GS-D200S modules as well as any Sequencer Drivers currently available. The eight signals can be divided into two groups, named respectively:

PRIMARY SIGNALS

UTILITY SIGNALS

The primary signals are those necessary for the correct system operation:

RESET	Output to reset the Sequencer-Driver.
CLOCK	Step clock output.
DIR	Direction output.
ENABLE	Step enable input.

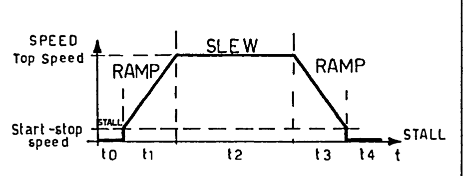
The function of each signal is described in detail in section **PIN DESCRIPTION** on page 4/31; it will be shown later that the Step Enable Input in conjunction with the position sensor of the motor, allows the implementation of closed loop systems (see paragraph **Closed Loop Operation** on pag. 27). The Utility signals allow the optimization of the driving system and the minimization of the hardware. They are:

MOV	Movement in execution output.
RAMP	Ramp in execution output.
EOT	Mechanical End of Travel input.
HOME	Electrical Home Position input.

By using these signals it is possible to correctly define the system starting point or reference position, or to change the current in the motor windings during the acceleration and deceleration phases in order to optimize the motor performance.

A typical example of the utility signals implementation is given here. Let's suppose that the required speed profile is as shown in fig. 5.

Figure 5. Speed-Time Profile.



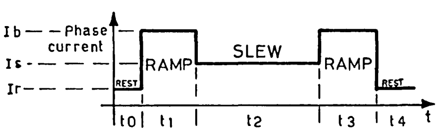
To optimize the motor torque during the acceleration and deceleration (t_1 and t_3) it is convenient to use a phase current profile as shown in fig. 6. During the SLEW phase (t_2) when the motor rotates at constant speed, the current is reduced to the minimum value necessary to compensate the system losses (friction) and the load inertia. During the STALL phase (t_0 and t_4) the current is further reduced to the bare value necessary to maintain the load in the right mechanical position. By using this current profile the power dissipation of the Sequencer-Driver and motor is optimized.

This profile can easily be implemented by using the utility signals:

MOV   Movement in execution.

RAMP   Ramp in execution.

Figure 6. Phase Current-Time Profile.



The status of these two outputs can be used to set the appropriate phase current value for the power driver, by a simple but effective interface circuit that is described in detail in fig. 11 of paragraph **PHASE CURRENT PROGRAMMING** on page 24.

THE USER INTERFACE

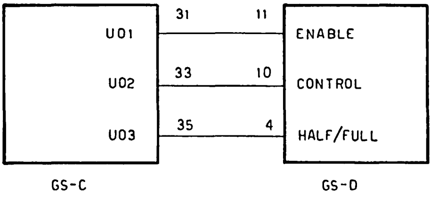
The USER interface consists of three inputs and three outputs which are TTL compatible. They can be read and/or activated during the execution of a program under the complete user control; therefore they condition a program execution.

These signals allow the implementation of complex movements, minimizing the program length and the use of external hardware. The start of a movement or of a sequence can be conditioned by a logic level applied to one or more inputs, thus performing the "mechanical tree" function.

The USER outputs logic state is set by program instructions and this information can be used by other controllers to synchronize multiple movements or to control external drivers.

By using only these signals, it is possible to build up simple systems which implement cyclic movements and create a true stand-alone system. The example reported in figure 7 shows one of the possible utilization of USER output. The example

Figure 7. USER Output Applicative Example



refers to a complete motion control system implemented by using the GS-C200 controller and the GS-D200 Sequencer-Driver. The USER output UO1 is used to enable the GS-D200 (UO1 High) or to inhibit it (UO1 Low).

The USER output UO2 is used to select the motor current decay inherent to the chop mode control of GS-D200. When UO2 is high a slow decay is imposed to the phase current during recirculation; when UO2 is low a fast decay is selected.

The USER output UO3 allows the selection between the half and full-step mode of operation of the GS-D200. Half-step occurs when UO3 is high.

The GS-C200S is capable of executing a jump command either direct or conditioned by the logic status of the USER inputs. This capability is very useful because it allows complex programs to be written by using a limited number of instructions. This feature makes also possible to have a segmented program contained in the internal memory; the selection and the subsequent execution of the needed program segment is started by a specific logic status applied to the USER inputs.

THE S.I.M.P.L.E. COMMAND INTERPRETER AND EXECUTOR AND THE PROGRAMMING LANGUAGE

The GS-C modules contain an interpreter program named S.I.M.P.L.E., acronym for **S**GS-THOMSON **I**nteractive **S**tepper **M**otor **P**rogram **L**anguage and **E**xecutor, that recognizes simple mnemonic commands, verifies the correctness of the received commands and executes the instruction sequences of each command or a complete command sequence by translation into complex executable instructions. The interpreter recognizes three different types of commands:

DIRECT EXECUTION COMMAND

DELAYED EXECUTION COMMAND

UTILITY COMMANDS

Direct execution commands are immediately actuated. They include: start and stop the program execution, set the programming mode, check position, check I/O, etc...

Delayed execution commands are run when requested by the sequence currently stored in memory. By using a combination of these commands, it is possible to perform very complex movements including also the conditioning by external stimulus, the iteration of a specific sequence for a defined number of times.

Utility commands allow the GS-C modules to perform several additional functions such as the detection of the position, phase current optimization etc... These commands, when properly used, speed up the system debugging phase and they increase the system efficiency.

Note: To easily learn how to program the GS-C and to minimize development time, a P.C. based self explaining and interactive program named **F.A.S.T.** (**F**irst **A**dvanced **S**tepper motor **T**raining program), able to communicate with the module by using the Point-to-Point protocol, has been developed and it is available to the end user. (See GS-C200PROG data sheet).

Command strings can be easily implemented also by using a high level language such as BASIC, or they can be generated by a dedicated microcontroller programmed in machine language. The dialogue speed is limited by the time required to construct the command string and to analyze the GS-C data, and it results noticeabily reduced when a "machine language" program is used.

The program, after testing, can be stored in the EEPROM included in the GS-C module and then loaded and automatically executed at power-up, resulting in a low cost stand-alone system. It is also possible to save the program as a DOS file on a floppy disk for future retrieval, or to ease the field update of the program itself.

Every command is identified by one or two characters and by a variable length argument (from 0 to 7 characters). If the Multipoint communication protocol is used, the address is specified by the number that preceeds the command. All the commands sent by the Host, as well as the data generated by the GS-C, are terminated by a Carriage Return (ASCII value = 0D).

In the following pages all the commands which may be executed by the GS-C200 and the GS-C200S are detailed, as well as their format. A practical example of the command usage is also given. The presence of an asterisk at the end of the command denotes that the command is executable only by the GC-C200, while two asterisk denote a command executed only by the GS-C200S.

Each command is shown in the same format used during the programming phase, i.e. the command identifier plus the argument:

Gsxxxxxxx

The argument can be single, double or missing according to the various command types.

The various argument are identified by different letters according to the particular type i.e.:

s = sign	+ or –
x = figure	1 to 3
y = figure	0 to 7
v = value	1 to 999 depending on command
p = position	1to 999999 incremental or the absolute position

Apart the different number of executable commands and functions, the GS-C200S and the GS-C200 look very similar each other. The only foundamental difference is the way they manage the position counter.

The position counter is the reference ruler for the microprocessor to move correctly from the actual position to the targeted one, executing the proper number of steps in the right direction.

The GS-C200 position counter allows a maximum of ten million steps to be executed, and the home position corresponds to the 0 count position. When a movement is larger than the position ruler limits an Error 5 is reported to the Host.

The GS-C200S position counter allows a maximum total count of 2^{24} step ranging from –8388608 to +8388607 steps. When the maximum count is exceeded the counter wraps-around. For example if the position counter is +8388606 and a +5 steps movement is executed, the final position will be:

+8388606	Initial position
+8388607	After 1 step execution
–8388608	After 2 steps execution
–8388607	After 3 steps execution
–8388606	After 4 steps execution
–8388605	Final position

Of course no error is reported.

Command	Description
Ax	The **Activate** command sets a User output to the active logic level "one". The command is always followed by an argument whose value ranges between 1 and 3, and that specifies the User output to be activated. The command string: A2↓ causes the UO2 output to be set to the logic level "one". The **Activate** command is of the delayed execution type and it occupies 2 memory locations.
Cx	The **Clear** command clears a User output, i.e it forces the logic level to "zero". The command is always followed by an argument whose value ranges between 1 and 3, and that specifies the User output to be cleared. The command string: C3↓ cleares the UO3 output by forcing it to the logic level "zero". The three USER outputs are automatically cleared at power-up. The **Clear** command is of the delayed execution type and it occupies 2 memory locations.
Dvvv	The **Delay** command allows the execution of a delay. The instruction is always followed by an argument whose value ranges between 1 and 255, and that specifies the duration in tenth of sec. of the delay to be executed. The command string: D15↓ causes a 1.5 seconds delay to be executed before the next instruction is considered. The **Delay** command is of the delayed execution type and it occupies 2 memory locations.
E	The **Execute** command starts the execution of the program stored in memory. It is also used to terminate the GS-C200 programming session and no argument is required. The **Execute** command is of the immediate execution type.
F	The **Feedback** command allows the host computer to know whether the controller is ready to receive a command or not. To comply with this request, the GS-C replies by: B↓ (Busy) in case it is executing a program, or: R↓ (Ready) if it is ready to receive a command, or: E5↓ (Error) This latter answer, used only by the GS-C200, indicates that during the program execution the position counter has reached the overflow condition (i.e. > 9999999). The feedback command is of the immediate execution type.
fsxxxxxxx **	The **force** command, executable only by the GS-C200S, allows the user to preset the position counter to the desired value. This command is always followed by the sign and the value of the position that spans from – 8388608 to + 8388607. The **force** command is of the delayed/immediate execution type and it occupies 4 memory locations.
Gxxxxxxx *	The **Goto** command forces the motor to reach the specified target position. This command, executed exclusively by the GS-C200, is always followed by an argument whose value ranges between 0 and 9999999, and it defines the position to be reached. The 0 position coincides with the Home position or with the position where an Initialize command has been sent. The **Goto** command is of the delayed execution type and it occupies 4 memory locations.

Command	Description
Gs *	The "velocity mode" **Goto** command allows to move the motor continuously, i.e. the motor is accelerated to the programmed speed and then it slews indefinitely in the selected direction until a "stop" command is received. The command is always followed by the direction information. The command string : G+↓ move the motor in the clockwise direction while: G–↓ move the motor in the counterclockwise direction. To stop the motor either the Z or the K command can be used. The "velocity mode" **Goto** command is of the delayed execution type and it occupies 4 memory locations.
Gsx *	A further possibility offered by the Goto command, that greatly improves the GS-C200 flexibility, is the "controlled velocity mode" operation. This command is followed by the direction information and by the User input to be tested to stop the operation. This occurs when a "zero" level is applied to the specified User input. For example the command string: G+2↓ causes the motor to ramp to the programmed slew speed and to move at this speed until the UI2 input is brought to "zero". The "controlled velocity mode" **Goto** command is of the delayed execution type and it occupies 4 memory locations.
Gsxxxxxxx **	The Goto command forces the motor to reach the specified target position. This command, executed exclusively by the GS-C200S, is always followed by an argument whose value ranges from – 8388608 and + 8388607, and it defines the position to be reached. The 0 position coincides with the Home position or with the position where an Initialize command has been sent. The **Goto** command is of the delayed execution type and it occupies 4 memory locations.
gs **	The "velocity mode" **Goto** command allows to move the motor continuously, i. e. the motor is accelerated to the programmed speed and then it slews indefinitely in the selected direction until a "stop" command is received. g+1↓ move the motor in the clockwise direction while: g–↓ move the motor in the counterclockwise direction. To stop the motor either the Z or the K command can be used. The "velocity mode" **Goto** command is of the delayed execution type and it occupies 4 memory locations.
gsx **	An additional possibility offered by the **Goto** command, further improving the GS-C200S flexibility, is the "controlled velocity mode" operation. This command is followed by the direction information and by the User input to be tested to stop the operation. This occurs when a "zero" level is applied to the specified User input. For example the command string: gt1↓ causes the motor to ramp to the programmed slew speed and to move at this speed until the UI1 input is brought to "zero". The "controlled velocity mode" **Goto** command is of the delayed execution type and it occupies 4 memory locations.

Command	Description
Hs	The **Home** command allows the GS-C to find the mechanical reference position. The command is followed by the argument that specifies the searching direction of the End Of Travel switch. The argument can be omitted and in such a case the GS-C will execute the command: H+↓ As soon as the GS-C receives the **Home** command, it moves the motor in the selected direction at the Start-Stop speed (defined as the first instruction at the beginning of the program) until the End Of Travel input is brought to "zero". When this condition is reached the direction is reversed and the movement continues until the Home input reaches the "zero" logical level. The position counter is then cleared as well as the program contained in the RAM memory, and the controller is ready to process a new command. In the GS-C200S, the position is also cleared, but the previous program, present in the RAM is saved. When the Home and the End Of Travel inputs are tied toghether the system reference point will correspond to the End Of Travel position. To allow the system homing also in a stand alone application, an **Home** command is automatically executed at start-up after the program recall. The Home direction is defined by the logic state of the RxD input (pin 11) that when unconnected is equivalent to a **H+** command, while when connected to the +5V pin it forces a **H–** command. In a stand-alone environment, when the **Home** command is not needed, it is mandatory to ground the End od Travel and the Home inputs (pins 32 and 30). The **Home** command is of the immediate execution type.
Ix	The **Initialize** command forces the GS-C module to be selectively inizialized. The command is followed by an argument whose value ranges between 1 and 3, and that specifies where the action is addressed according to the following table: 1 = Position counter is cleared 2 = User outputs are cleared 3 = Position counter and User outputs are cleared. The **Initialize** command is used to create a logic Home position for the GS-C200 if the 9999999 steps are not enough for the specific application. This function is better performed by the force command in the GS-C200S, for which it is also possible to insert this command into the program. The **Initialize** command is of the immediate execution type for the GS-C200, while it results of the delayed/immediate execution type for the GS-C200S and it occupies 2 memory locations.
jv **	The **jump** command, executed only by the GS-C200S, allows the user to move inside the program and to repeat indefinitely a portion of the program itself. The argument specifies the memory location to be reached and it ranges from 0 (that is the program starting point) to 118. The **jump** command is of the delayed execution type and it occupies 2 memory locations.
jcv,y **	The **conditional jump** command, executed only by the GS-C200S module, allows the user to move inside the program as a function of the logic state of the User inputs. The argument specifies both the memory location to be reached (**v**), that must range between 0 and 118, and the User input condition to be matched (**y**) in order to execute the **conditional jump.** The following example shows how powerful this command is: jc0,40↓ jc1,52↓ jc2,74↓ When the first command is encountered the module tests the status of the User input pins and if their value is 0 a jump to the memory location 40 is executed. If the condition is not met the jump is not executed and the following instruction is examined, and so on. The **conditional jump** command is of the delayed execution type and it occupies 2 memory locations.
K	The **Kill** command aborts the program execution. The program can be restarted just by issuing the Execute instruction which will start the sequence from the first program instruction and not from the interrupt point; it is therefore advisable to always send a Home instruction after a **Kill** instruction in order to allow the system to start from a known position. The **Kill** command is of the immediate execution type.

Command	Description
Lo	The **Loop start** command marks the memory location where the portion of a repeatedly executed command sequence begins. This command is normally used together with the Loop repetition number command. The **Loop start** command is of the delayed execution type and it occupies 2 memory locations.
Lxxx	The **Loop repetition number** command allows an instruction, a sequence or a whole program to be repeated for the specified number of times. The command must be followed by an argument ranging from 1 to 255, that specifies how many times the portion of the program contained between the Loop start command and the **Loop repetition number** has to be executed. The sequence: L0↓ • • • L10↓ forces the command sequence included between L0 and L10 to be repeated ten times. This command in normally used togheter with the Loop start command. If the loop starting point is not specified, the interpreter repeats the sequence starting from the beginning of the program. The **Loop repetition number** command is of the delayed execution type and it occupies 2 memory locations.
M	The **Memory save** command allows the program currently stored in the RAM memory to be permanently saved in the EEPROM. The program can then be reloaded both automatically or under command. In the first case, it is executed automatically at power on, while in the latter the X command must be issued. The **Memory save** command is of the immediate execution type.
P *	The **Program enter** command sets the GS-C200 in the programming mode and it allows a new program to be entered in the memory. The instruction doesn't require any argument and it causes the cancellation of the program contained in the RAM memory The programming session is terminated by the Execute command. The **Program enter** command is of the immediate execution type.
Po **	The **Program enter** command sets the GS-C200S in the programming mode and it allows a new program to be entered in the memory. The instruction doesn't require any argument and it causes the cancellation of the program contained in the RAM memory. The programming session is terminated either by the program exit or the Execute command. The **Program enter** command is of the immediate execution type.
Px **	The **Program exit** command sets the GS-C200S in the execution mode and it allows the unit to wait for a command. The instruction doesn't require any argument. The **Program exit** command is of the immediate execution type.
Q	The **Query** command instructs the GS-C to send to the Host computer the program currently stored in the RAM memory. Every program instruction is separated by a carriage return (ASCII 13), and the program end is evidenced by the transmission of a message "END" that is the sequence terminator and it must be recognized by the Host. The instruction does not require any argument. The **Query** command is of the immediate execution type.

Command	Description
Rvvv	The **Ramp** command allows the user to define the length of the acceleration and deceleration ramps that are always identical. The command is followed by an argument whose value ranges from 1 to 999 and it determines the number of steps necessary to pass from the Start-Stop speed to Slew speed. The instruction: R50↓ specifies an acceleration or deceleration ramp 50 steps long. When the number of steps to be executed is lower than the length of the two ramps (acceleration and deceleration), the ramping is reversed before the maximum speed is reached to guarantee the correctness of the final position. More than one ramp length can be used during the program execution just by introducing an R command in the proper sequence place. R25↓ 3000↓ • • R85↓ –800↓ • This program executes a 25 steps ramp length for the movements until the R85 command is encountered; from that moment all the movements are executed with a 85 steps ramp length. This feature allows the user to optimize the motion system to adapt for different friction and load conditions. The **Ramp** command is of the delayed execution type and it occupies 4 memory locations.
Svvv	The **Start-Stop** command allows the user to choose the step rate at which the motion is started. The command is always followed by an argument whose value ranges between 1 and 1000 and it corresponds to a **Start-Stop** step rate of 10 to 10,000 steps/second (a by 10 multiplier is used). The range normally used is from 1 to 50 corresponding to a 10 to 500 steps/second rate. The command: S30↓ indicates a 300 step/sec or 300Hz Start-Stop frequency. A **Start-Stop** command must initiate any program to be executed in stand alone environment. More than one **Start-Stop** rate can be used during the program execution just by introducing a new **Start-Stop** command when needed, as shown in the following program sequence: S20↓ T200↓ • • S35↓ • T300↓ • The **Start-Stop** command is of the delayed execution type and it occupies 4 memory locations.
Tvvv	The **Top-speed** command allows the user to choose the motion system Slew speed. The command is always followed by an argument whose value ranges between 1 and 1000 that correspond to a **Top-speed** step rate of 10 to 10000 steps/second (a by 10 multiplier is used). The range normally used is from 30 to 500, corresponding to a 300 to 5000 steps/second rate. The command: T300 indicates a 3000 steps/sec or 3kHz rate (equivalent to 900 turns/minute for a motor with 200 steps/turn). More than one **Top-speed** rate can be used during the program execution just by introducing a new **Top-speed** command in the proper sequence place as per the example reported in the Start-stop speed command description. The **Top-speed** command is of the delayed execution type and it occupies 4 memory locations.

Command	Description
Ux	The **Until** command allows the program currently stored in RAM memory to be continuously executed until a specific USER input is brought to "zero". The command is always followed by an argument whose value ranges between 1 and 3, and it specifies the User input to be tested. The command: U2↓ states that the program, once started, will be continuously executed as long as the User input UI2 is at the logic level "one". Just after User Input UI2 is set to "zero", the program processes the next command after U2. The **Until** command is of the delayed execution type and it occupies 2 memory locations.
Vx	The **Verify** command allows the Host to know the current absolute position of the motor versus the Home position or the status of the USER inputs and outputs. The instruction is always followed by an argument whose value, 1 or 2, specifies the type of requested information. The request for the current absolute position is obtained by issuing the instruction: V1↓ the GC-C200 answer can be 1234567↓ while the GS-C200S answer can be: +1234↓ The request of the USER outputs status is obtained by using the instruction: V2↓ the GS-C answer can be: 25↓ that denotes the following Input/Output status: UI1 = 0 UO1 = 1 UI2 = 1 UO2 = 0 UI3 = 0 UO1 = 1 2 5 The **Verify** command is of the immediate execution type.
X	The **eXchange** command allows the user to transfer the program currently stored in the EEPROM into the RAM. This command is used either during the program debugging phase when the F.A.S.T. program is utilized, or when the fast execution of a frequently used program is needed. In this latter case the Host recalls the program from the EEPROM by simply issuing the following command string: E↓ X↓ The **eXchange** command is of the immediate execution type.
Wx	The **Wait-for** command allows the program start or a portion of program execution to be conditioned by the rising edge of an external signal applied to the a USER input. The command is always followed by an argument whose value ranges between 1 and 3, and it specifies the User input to be tested in order to conditions the next command execution. The instruction: W2↓ states that the program execution is conditioned by the presenoe of a "one" logic level at the User Input UI2. The **Wait-for** command is of the delayed execution type and it occupies 2 memory locations.

Command	Description
Z	The **Zero the speed** command allows a smooth stop of the motion system. When the GS-C receives this command it reduces the stepping rate to "zero" through a deceleration ramp and it stops the program execution. If there is no motion when activated, the program execution is immediately stopped. By using this command it is possible to stop the motor still maintaining trace of the system position. The program can be subsequentely restarted through an E command.
±XXXXXX	The **incremental positioning** command allows the user to perform a movement referenced to the actual position. The command can be issued either with a + or – sign that defines the direction of the motion, and it is followed by an argument ranging from 1 and 999999 that defines the number of steps to be executed. The **Incremental position** command can be mixed to the Goto absolute positioning command in a program, and it is normally used in a subroutine. The **Incremental position** command is of the delayed execution type and it occupies 4 memory locations.

During the program execution, the GS-C accepts only the **F**, **Z** and **K** commands. Any other command sent to the GS-C during the program execution has no effect, and the module will respond to the Host Computer by sending the answer B (Busy).

The GS-C200S programming requires a specific attention because, when a program includes a jump command, it is mandatory to address the proper memory position to correctly execute the sequence.

For this purpose it is mandatory to define the jump memory location by adding, for each program instruction, the proper bytes length that is specified in the command description. The program starts from memory address 0.

THE PROGRAM STORAGE AREA

The GS-C contains two storage areas reserved to the User. The first is the microprocessor Random Access Memory from where the motion program is executed, the second is an EEPROM where the programs are saved. The EEPROM contains a program or a command sequence programmed by the user that can be transferred into the RAM memory by using the X command.

The RAM contains either a program or a command sequence sent by the Host computer or transferred from the EEPROM. In any case the program that is executed when an E or Goto command is issued. is the one contained in the RAM.

If the program is sent by the Host, it is checked to verify if the logical and physical correctness has been respected and if the storage capability is not exceeded. In case an error is detected, it is notified to the Host through an appropriated error message.

The number of instructions that can be stored depends on the type of instruction, and typically it ranges between 30 and 60, for a total of 119 memory locations.

THE POWER SUPPLY

The GS-C module contains a high efficiency switch mode power supply. It generates the various regulated voltages required for the proper operation of the internal logic and the communication port, starting from an unregulated input voltage that can range from 12 to 40 Volt. The module also features a 5V output capable of delivering up to 100mA, which can be used to supply external devices or the logic port of a GS-D module. This output is protected against short circuit to ground. Two outputs at ±12V are available with a current capacity of 10mA.

PROGRAM EXAMPLES

After the description of the communication protocol, of the various commands and of the various messages, some simple programs examples are given in the following.

Example 1

The required action is to run a motor at 1000 steps/sec. rate, with a start-stop rate of 100 steps/sec., and a ramp length of 50 steps. The target position to be reached is the step 500000.

The operative sequence is the following:

1) Connect the GS-C200 to an Host Computer equipped with the advanced Basic program.
2) Power-on the GS-C200.
3) Enter the DOS operating system and then run the F.A.S.T. program (see the **GS-C200PROG** datasheet).
4) Start the programming session by typing the following command sequence:

F↓	Read the controller status. A Ready is answered by the GS-C.
I3↓	Clear the position counter and the USER outputs.

P↓	Enter the programming mode
S10↓	Set the Start-stop rate to 100 steps/sec.
T100↓	Set the Slew speed rate to 1000 steps/sec.
R50↓	Set the Ramp length to 50 steps.
G500000↓	Goto the target position
E↓	End of the programming session. The GS-C starts the program execution.

The G500000 command can be substituted by the +500000 command. The program can also be stored in the GS-C EEPROM by typing an M↓ command before the E↓ command.

Example 2

The program chosen for this example drills 5 equidistant holes on a metal bar. A GS-C and GS-D motion system is used to control the vertical position of the drill, while a second GS-C and GS-D motion system is used for the proper bar loading and positioning. To better clarify the operations to be executed and to show the program simplicity, the two command sequences and the relative process flowcharts are also reported.

The programming session is entered following the points 1 to 4 of the previous example. The first command sequence, used to correctly position the metal bar, is the following:

S10↓	Set the Start-stop speed to 100 steps/sec
T100↓	Set the Slew speed to 1000 steps/sec
R40↓	Set the ramp length to 40 steps
W1↓	Wait for the external Start
+250↓	Reach the first drilling position
L0↓	Loop starting point
A2↓	Activate the unit 2 forcing UO2 = 1
D1↓	Wait 0.1 sec
C2↓	Then reset UO2
W2↓	Wait until drilling completion
+120↓	Reach the drilling position 120 steps CW
L4↓	Repeat the loop 4 times
A2↓	Activate the unit 2 forcing UO2 = 1
C2↓	Then reset UO2
W2↓	Wait until drilling completion
+250↓	Reach the cutting position 250 steps CW
A1↓	Activate the cutting blade forcing UO1 = 1
D5↓	Wait 0.5 sec
C1↓	Clear cutting command resetting UO1

The second command sequence, used to drill the metal bar, is the following:

S15↓	Set the Start-stop rate to 150 steps/sec
T200↓	Set the Slew rate to 200 steps/sec
R25↓	Set the Ramp length to 25 steps
W1↓	Wait for start
W2↓	Wait for a drilling command from unit 1
A2↓	Activate the drill motor forcing UO2 = 1
+150↓	Pull down the drill
D1↓	Wait 0.1 sec
G0↓	Lift the drill up
C2↓	Stop the drill motor
A1↓	Notify drilling completion to unit 1 forcing UO1 = 1
D1↓	Wait 0.1 sec
C1↓	Then clear UO1

The combination of these two programs operates only on one bar, then the two GS-C become available again to the Host both for the repetition of the program or for the entering of a new command sequence.

If the operation has to be repeated till the exhaustion of bars, it will be sufficient to add, at the beginning of the first sequence, the command;

U3↓	execute until UI3 = 1

which allows the drilling cycle to continue until the controller which takes care of the bar positioning, is notified to stop the operations.

This notification is accomplished by clearing the User input UI3 of GS-C devoted to the positioning.

To demonstrate the efficiency of the GS-C programming language it is worth to mention that the program for the bar positioning uses 50 memory locations, while the program for the drill control needs only 36 memory locations. The two programs can be contained in the GS-C memory thus making the system simpler and easier to maintain.

Figure 8. Automatic Drilling And Positioning System Block Diagram.

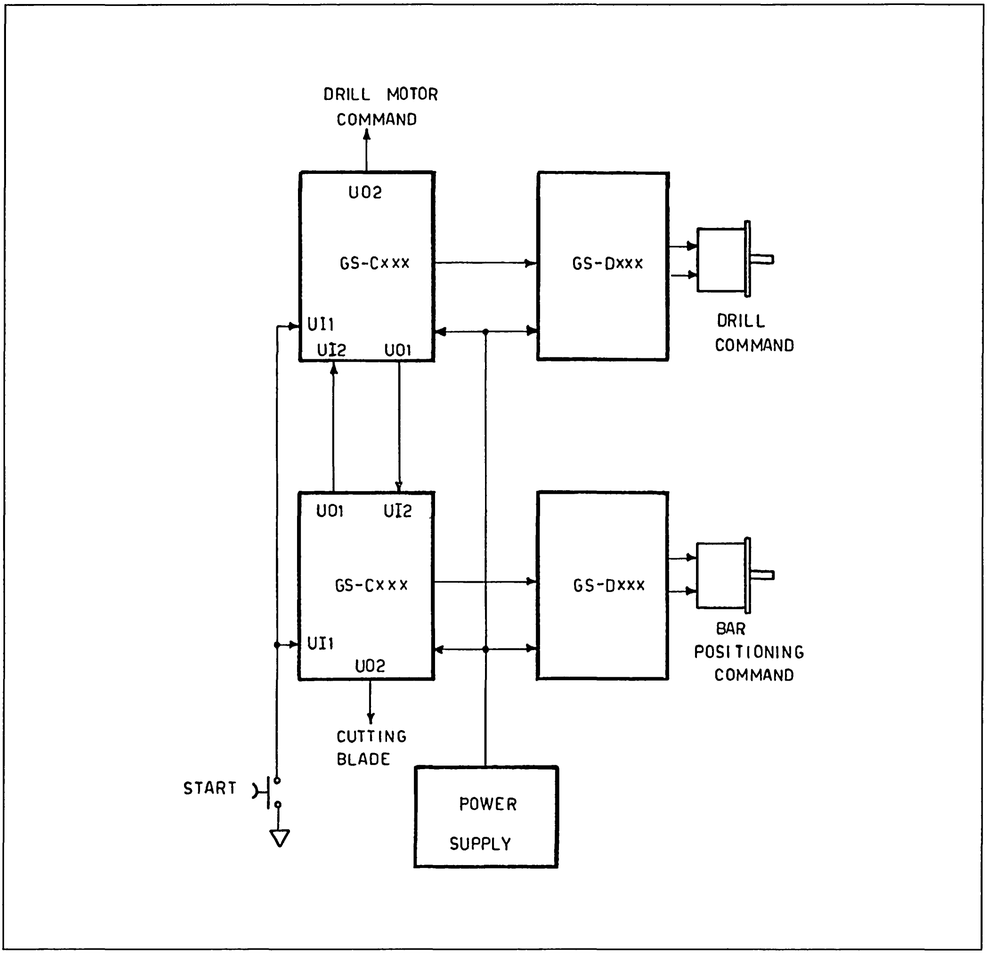
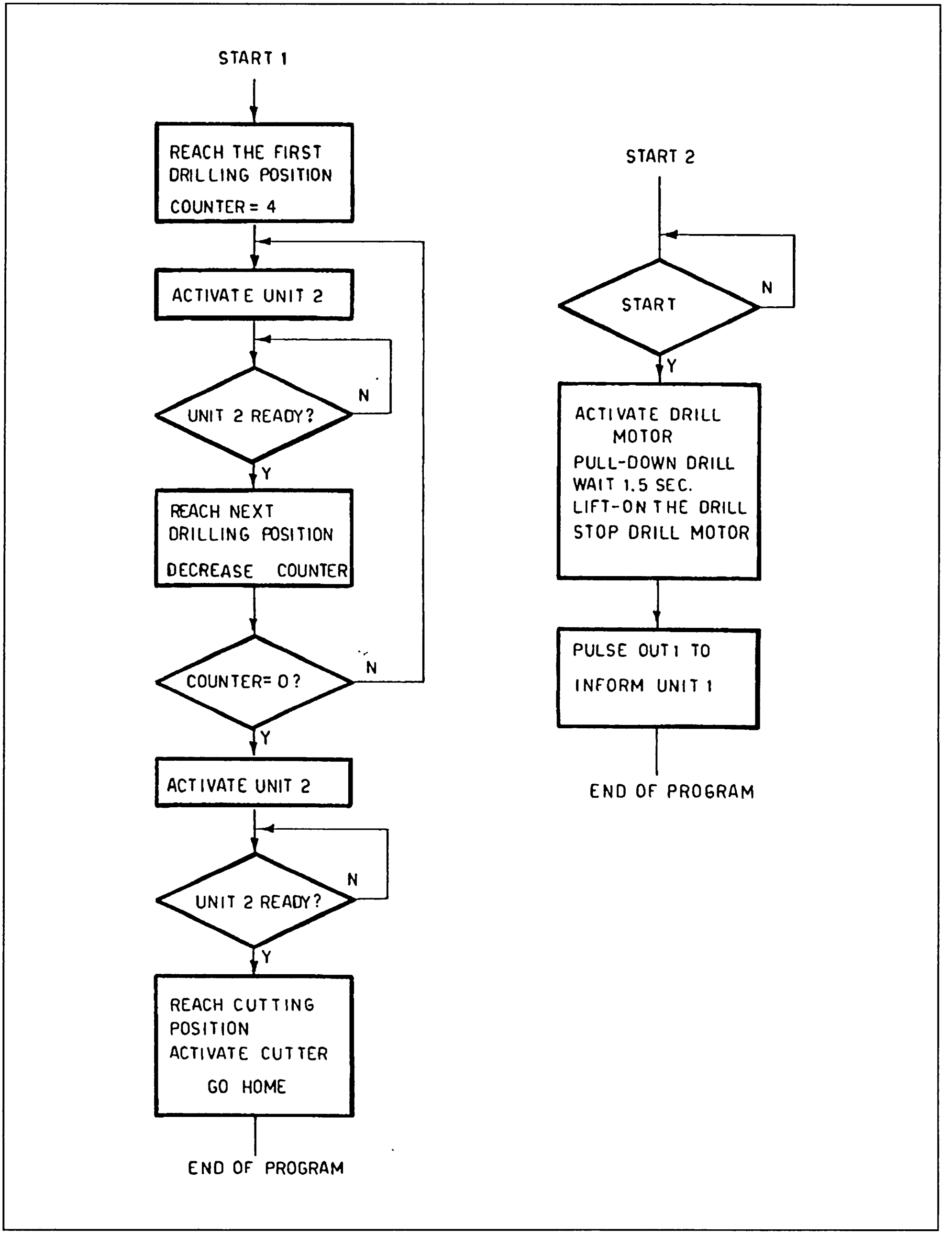


Figure 9. Programs Flow-charts.



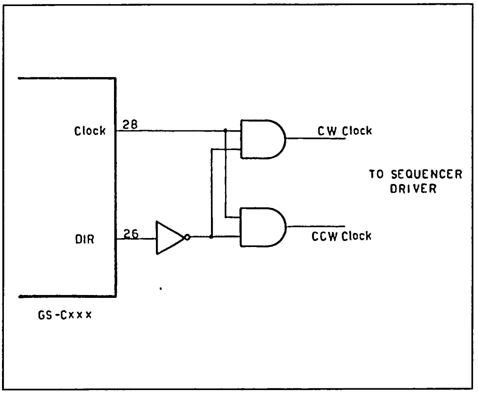
GS-C200 AND GS-C200S APPLICATION

THE SEQUENCER-DRIVER INTERFACE

The GS-C is a general purpose stepper motor controller capable to drive any type of motor, i.e. two, three and five phases motors, by just interfacing it to the right Sequencer-Driver.

Sometime the available Sequencer-Driver requires two separate Clock lines, one for each direction, and this requirement is easily fulfilled by the circuit of figure 10.

Figure 10. Alternative Sequencer-Driver driving.



PHASE CURRENT PROGRAMMING

As already explained, the possibility to modify the phase current of a stepper motor according to different operating conditions, gives substantial improvements in term of efficiency and system reliability because it minimizes the resonance effects and the dissipated power.

The phase current programming can be implemented in various modes, either via a software command by changing the status of the USER output lines, or by hardware. Of course, the Sequencer-Driver must have the current programming capability. An example of a hardware solution, implemented around a GS-C and GS-D200/200S module, is shown in fig.11.

The application utilizes the two outputs:

MOV	Movement in execution output (pin 22)
RAMP	Ramp in execution (pin 23)

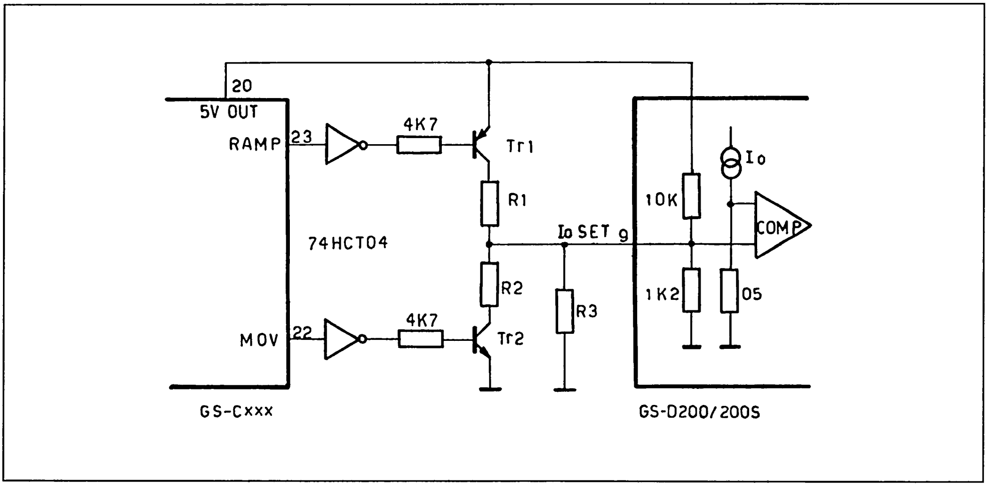
of the GS-C module and the

I_{oset}	Current programming input (pin 9)

of the GS-D module.

The phase current has the shape shown in fig.6, i.e. it is minimized when the motor is stopped, it has its maximum value during the acceleration/deceleration ramps, and an intermediate value during the slew phase.

Figure 11. Phase Current Programming of the GS-D200/200S



Let's assume the following values are needed:

$I_{rest} = 0.25A$

$I_{ramp} = 1.5A$

$I_{slew} = 0.5A$

The logic condition of the RAMP and MOV outputs in the various states is:

During the ramping phase both pins 22 and 23 are high: Tr1 is ON and Tr2 is OFF.

During the slew phase pin 23 is low and pin 22 is high: Tr1 and Tr2 are OFF.

In stall condition Tr1 is OFF and Tr2 is ON.

The value of R1, R2, R3 is determined as follows (for further details please see the GS-D200/200S data sheet). The value of R3, that fixes the I_{slew} = = 0.5A (Tr1 and Tr2 OFF), is easily calculated by referring to the GS-D data sheet:

$$R3 = \frac{I_{slew}}{1 - 0.933 \cdot I_{slew}}$$

$$R3 = 937\ \Omega$$

The value of the R2 resistor, when paralleled to R3, fixes the value of I_{rest} = 0.25A (Tr1 OFF, Tr2 ON).

$$R2 // R3 = \frac{I_{rest}}{1 - 0.933 \cdot I_{rest}}$$

$$R2 // R3 = 326\Omega$$

$$R2 = 500\Omega$$

The value of R1, that depends on the value of R3 and the resistors contained in the GS-D200/200S module, fixes I_{ramp} = 1.5A (Tr1 ON, Tr2 OFF).

The values of the internal resistors are:

1.2kΩ to ground and 10kΩ to V_{SS} for the GS-D200

750Ω to ground and 10kΩ to V_{SS} for the GS-D200S

Assuming the GS-D200S is used, after some straightforward calculations, it results:

$$R1 = 4245\Omega$$

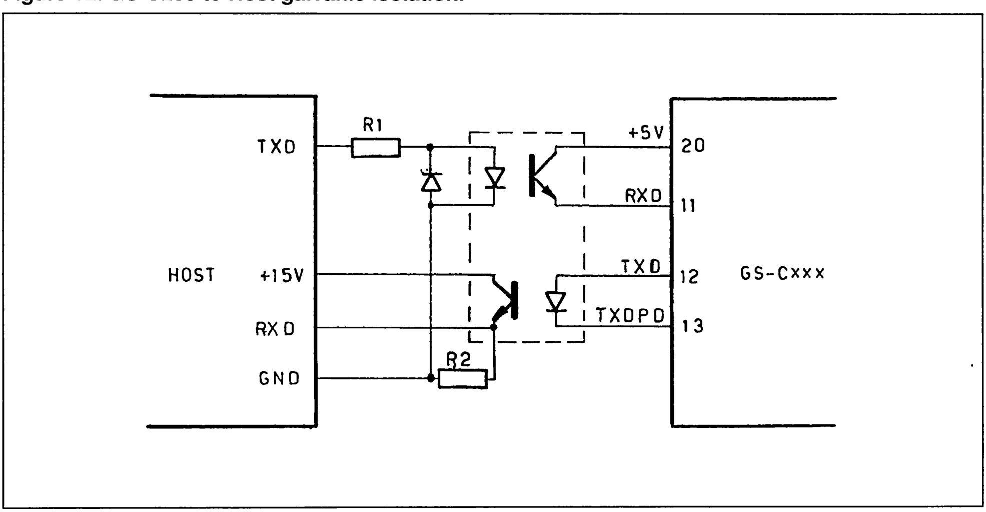
of course all these values do not take into account the transistors saturation losses and in some cases, when a very precise current is needed, a trimming is required.

GALVANIC ISOLATION

The industrial environment, where normally a stepper motor and its driving system operate, is very noisy and for this reason it is often advisable to have a galvanic isolation between the Host computer and the motion system. Because the connection between the Host and the GS-C module requires only three wires (TxD, RxD and ground), the galvanic isolation can be implemented as per fig. 12 that uses only two optocouplers and two resistors, one protection diode and a +12 or +15V source.

A +12 or +15V source is normally available on the pin 6 and 8 of any RS232 connector. The source impedance is quite high (in the range of 220 to 600Ω) and for this reason the value of R2 must be greater than 1000Ω to avoid the source overload.

Figure 12. GS-C200 to Host galvanic isolation.



COMPLEX MOVEMENTS SYNCHRONIZATION

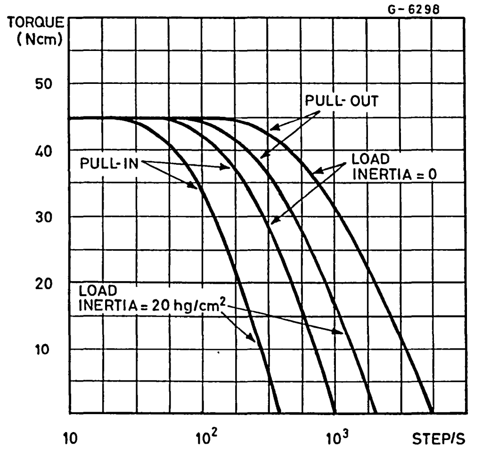
In many applications the synchronization of several movements is quite often required and the GS-C allows this function to be easily implemented either by using the Step Enable input or the User input/output pins. In fig.13A and fig.13B the block diagrams relative to the two solutions are reported.

The solution **A** is the simplest but it has some limitations, i.e. it can be used only when the whole system has to move synchronously. The solution **B** is more complex but also more flexible and it allows the program to control where and when the synchronization must be implemented.

THE START-STOP SPEED (S command) SELECTION

A typical Start-Stop curve (as shown on Fig. 14), shows that for a given driving voltage and phase current, the highest drive frequency allowed at the start (Pull-In Rate) is much lower than the one allowed for the stop (Pull-Out Rate) and that both are influenced by the load value. Of course the higher the current level the higher is the available torque, and the system can be started at a greater speed. A significant increase of the start-stop speed is obtained when the supply voltage is increased but in both cases the problem related to the mechanical resonance must be considered. It is advisable to maintain a significant safety margin against the system torque limit in order to avoid any problem due to the friction variation. A commonly accepted rule fixes the Start-Stop speed equal to the 50% of the maximum theoretical value reported on the motor data sheet; this takes into account friction, load inertia variations as well as motor parameter differences and power supply fluctuations.

Figure 14. Start-Stop Characteristic.



SLEW SPEED (T command) SELECTION

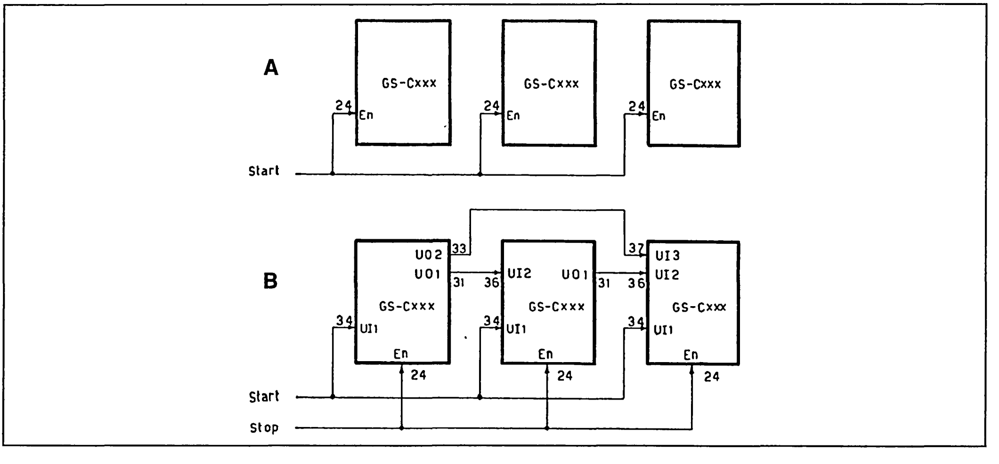
The Slew speed is roughly determined by the load and it can be evaluated by using the following relation:

$$\frac{F \cdot L}{6000 \cdot t} = \frac{T \cdot N}{10}$$

where

F = Strength in Pounds
T = Torque in Ounce/Inch
L = Length in Inches
N = Speed in turn/min.
t = Time in seconds

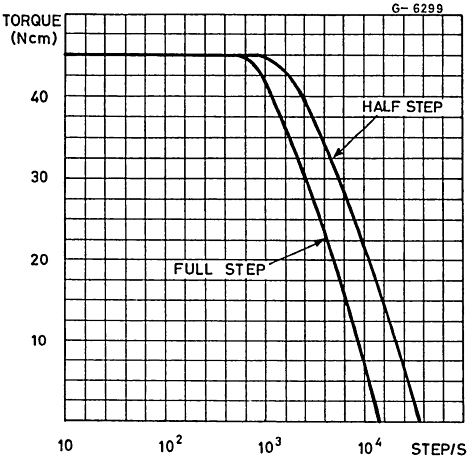
Figure 13. Complex Movements Synchronization



The Slew speed is also limited by the motor electrical and physical characteristics, as shown on Fig. 15 where the behaviour of the minimum available torque versus the driving frequency is reported.

It can be noted that the torque decreases almost linearly starting from a certain frequency, and this frequency depends on the motor windings impedance and the rotor inertia.

Figure 15. Torque/Frequency Characteristic.

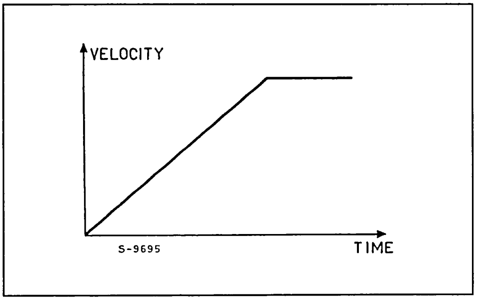


RAMP LENGHT (R command) SELECTION

The acceleration and deceleration ramps are not likely to be calculated and they shall be optimized during the system debugging and testing phase. The testing may start with very conservative ramp gradients, i.e. very long ramps, that will be gradually shortened until the first positioning error is detected.

The acceleration and deceleration ramps generated by the GS-C have the trend shown in fig. 16.

Figure 16. The GS-C200 Acceleration Ramp.



It is important to note that, when the number of steps to be executed does not allow to reach the Slew speed, the GS-C moves to the target position performing a partial acceleration ramp linked to a shortened deceleration ramp. This represents the minimum time consuming way to reach the specified position.

CLOSED LOOP OPERATION

The stepper motor is a device normally driven in an open loop mode and there is no direct control between the cause and the effect. In adverse conditions an issued step may not be performed mechanically because the driving conditions do not match the required torque and speed. In addition, the resonance phenomenon, common to all the stepper motors, can also affect the correct positioning.

In some particular applications, when the load has a very large spread of values and the torque margin is limited, it is sometimes necessary to implement an external electronic circuitry to guarantee the correct system positioning

To this purpose three different methods can be adopted:

a) Digital encoding of the absolute position.

b) Recognition that a step has been executed by the usage of a slotted disk, two optocouplers and some logic.

c) The same as above by the usage of velocity coils and some logic.

The first solution is very expensive and the digitalized position value must be read by the computer through a parallel port by using a specifically written program. A further limitation arises from the fact that every shaft encoder provides just the information relative to the position but it does not take care if more than one turn has been performed by the motor shaft, and an external logic is also required to detect and save this condition.

The second solution is less expensive but it requires a tedious trimming of the mechanical positioning of the optical sources and detectors to be effective. The major drawback of this solution is its sensitivity to dust, and the whole position sensing system must be contained in a dust free box.

The last solution is probably the best under every point of view because it does not require any mechanical positioning adjustement that has been previously made by the motor manufacturer; moreover it is dust insensitive beeing based on flux variation across an air gap and finally no mechanical hardware must be added to the system.

In fig. 17 the block diagram of a closed loop system is reported.

If the step execution is recognized by a movement detector that uses either a slotted disk or the motor velocity coils, two logic signals (x,y) like those reported in fig. 18 are available.

It is possible, by using these two signals as inputs (x, y) of the very simple and inexpensive logic circuit reported in fig. 19, to detect the direction of rotation and the step execution. The output of the circuit is then used to condition the step enable input of the GS-C module allowing the step clock pulse to be issued only if the previous step has been executed.

Figure 17. Closed Loop System.

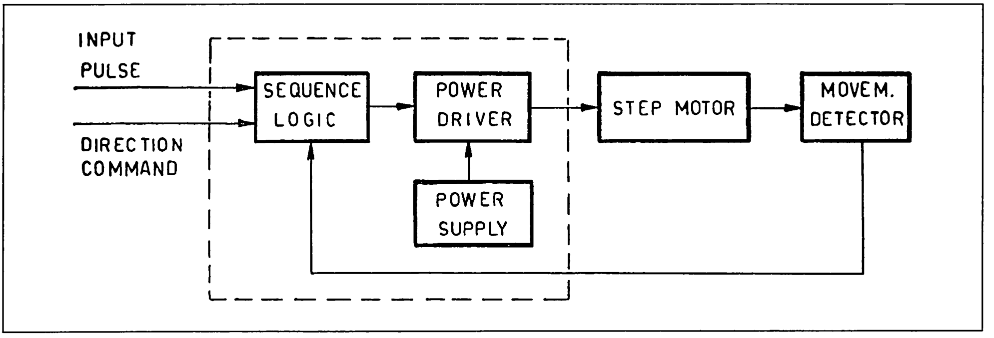


Figure 18. Signal Output of the Movement Detector.

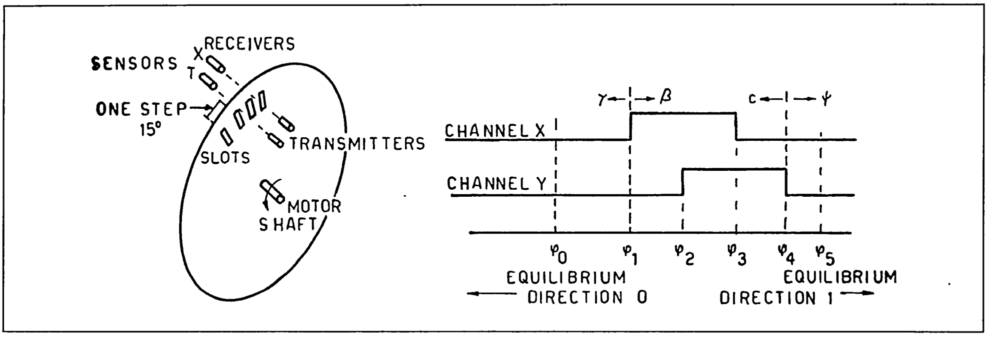
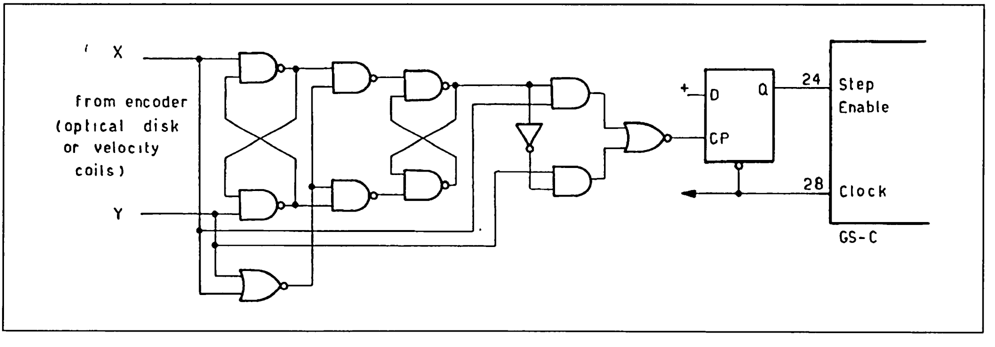


Figure 19. Suggested Logic to Close the Loop.



ELECTRONIC DAMPING

Any stepper motor system when driven at very low stepping rates, has an oscillatory step response as shown in fig. 20.

This oscillatory behaviour is due to fact that the motor reaches the stall position after each excitation change through an acceleration and a successive deceleration. This causes the motor shaft to rotate with jumps instead of uniform motion.

Another consequence of this oscillatory single step response is that the long system settling time can cause mechanical stresses to the driven load.

A second tedious effect is the enhancement of the rotor oscillation when the driving step rate approaches the natural resonance frequency of the motor. If the step rate is lower than this frequency, the motor is behind the equilibrium position and the velocity is near to zero when the next excitation change occurs.

When the step rate is increased to a value close to the natural resonance frequency, an increase of the oscillations also occurs, and as soon as the oscillation amplitude exceeds the step amplitude, the corrispondence between the rotor position and the excitation sequence is lost and any subsequent rotor movement is erratic as shown in fig. 21.

A simple method to reduce the oscillations problem is to use the half step driving, but this also limits the maximum speed of the system.

When this limitation is not acceptable, other two basic techniques may be adopted to damp the system oscillations:

1. A mechanical damper
2. An electronic damping circuit.

Figure 21. Slow Speed Step Response.

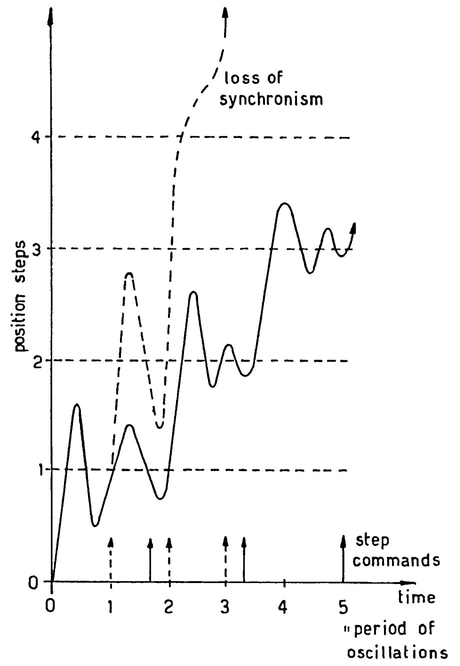
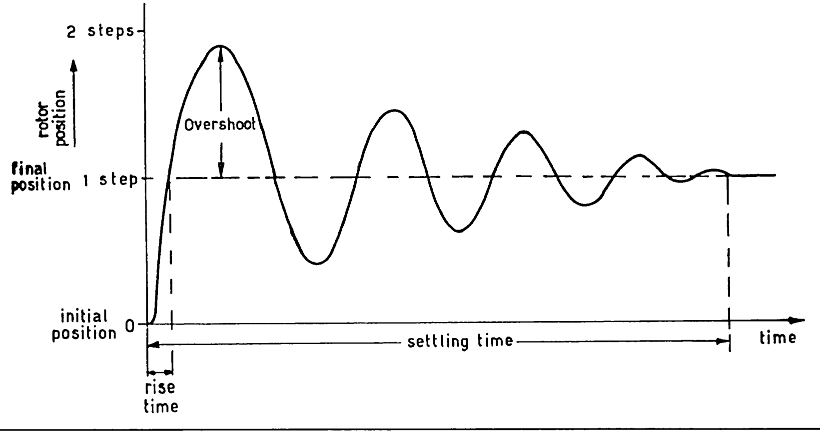


Figure 20. Typical Single Step Response.



The mechanical damping is obtained by the introduction of a viscous friction between the motor shaft and the load. The friction system must be elastic and it will recover the original relative angular shaft alignement to assure the correct final positioning.

The response time of the damping system must be quite fast, and it must be active just for rapid speed changes otherwise a severe limitation in the maximum speed will occur.

The electronic damping is obtained by the proper driving of the motor phases that are switched on and off in such a way to generated a negative torque to decelerate and stop the rotor smoothly. Let's assume the motor is moving from position 1 to the detent position 2, i.e. the phase A is switched OFF and the phase B is switched ON.

The rotor starts moving at t_0 instant (see fig. 22), and after a time t_1, the phase driving is reversed (phase A ON and phase B OFF) generating a braking torque that will allow the rotor to approach the final detent position at a very limited speed. Before the zero speed is reached, (t_2) it is necessary to switch back the phase driving to its original condition in order to stop the system at its target position.

Leaving the phase driving unchanged will cause the motor to stop a step earlier of the correct position because the motor, after the zero speed is reached, will accelerate in the reverse direction returning to the starting position.

The deceleration time as well the damping level is easily adjusted by changing the timing i.e. t_1 and t_2, but it can be quite complicate to compensate a system where large load variation occurs.

In fact, an heavy load variation causes a large variation of the single step response time of the system, and it could be that a system compensated in a no load condition will stop one step behind when fully loaded, while another compensated at full load will probably exibits erratic positioning at no load.

If the load condition is known it is possible to introduce a compensation circuit that can be conveniently driven by one or more User outputs. Fig. 22 shows the motor response to a single step pulse with electronic damping and the relative phase driving. This phase switching reversal method is also known as the bang-bang damping method, and it can be easily implemented by using the GS-C module.

The RAMP and MOV signals allow the user to detect when the last pulses are issued, and to generate, by a simple logic circuit, the delayed phase reversal commands necessary to implement the sequence of fig. 23.

The circuit uses a last pulse detector (G1), and on the falling edge of the A signal (synchronous to the last step command), a timing generator is triggered. The various delays can be trimmed to the values requested by the operating conditions, and the pulse sequence reported in figure 23 (A, B and C signals) in generated.

The A and B signals are used to reverse the motion direction (G_2) while the C signal steps twice the motor (backward and forward).

Figure 22. Single Step Response with Damping.

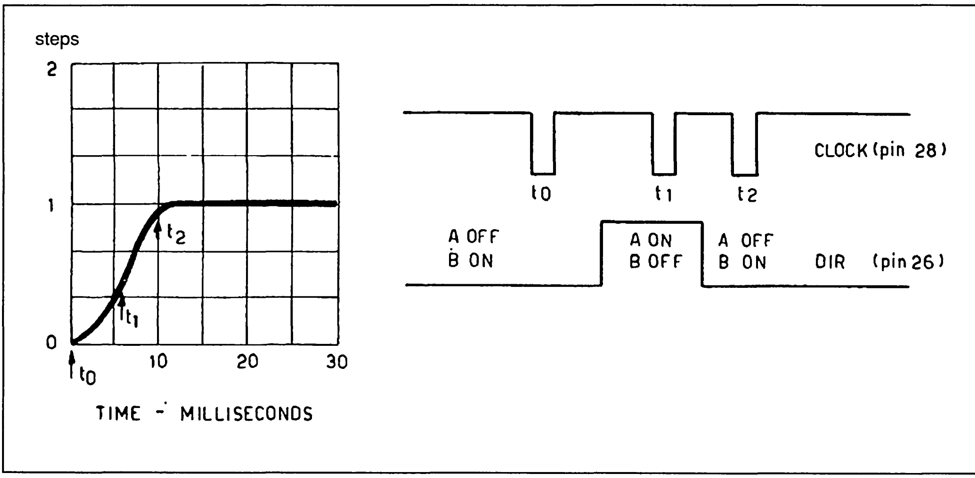
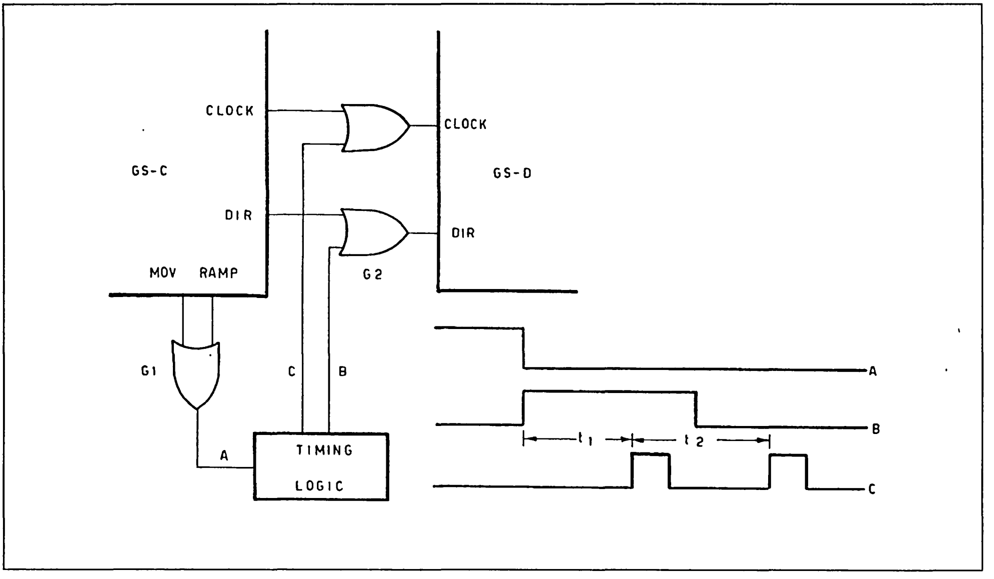


Figure 23. Practical Implementation of the Phase Reversal Damping with the GS-C Module.



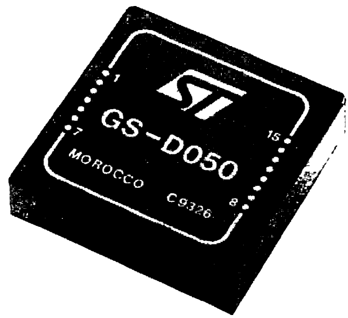
SGS-THOMSON MICROELECTRONICS

GS-D050

0.5A BIPOLAR STEPPER MOTOR DRIVE MODULE

FEATURES

- Inputs TTL/CMOS compatible
- Logic Inhibit/Enable
- Chopper regulation of motor bipolar current
- Programmable motor current (0.5 A max) (by steps or continuously)
- Wide voltage range (10-46 V)
- Full-step (wave and normal drive), Half-step, Quarter-step operations
- Overtemperature protection



DESCRIPTION

The GS-D050 is a driver for bipolar stepper motors that directly interfaces a microprocessor and two phase permanent magnet motors.

The motor current is controlled in a chopping mode up to 0.5 A. The small outline makes the GS-D050 ideal when space is a premium.

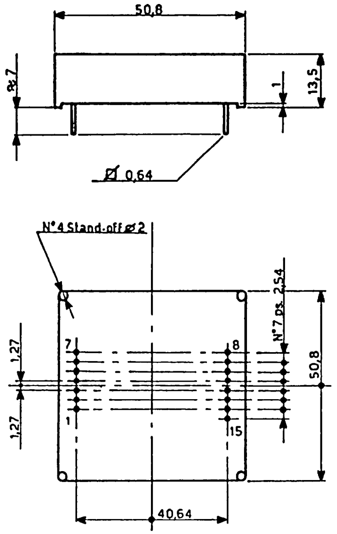
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	46	V
V_{SS}	DC Logic Supply Voltage	7	V
V_i	Logic Input Voltage	6	V
I_o	Peak Output Current	1.2	A
V_{ref}	Reference Input Voltage	5	V
T_{stg}	Storage Temperature Range	– 40 to +105	°C
T_{cop}	Operating Case Temperature Range	– 20 to + 85	°C

THERMAL DATA

$R_{th(ca)}$	Case-ambient Thermal Resistance	Max	8.0	°C/W

MECHANICAL DATA



Dimension in mm

Bottom view

PIN DESCRIPTION

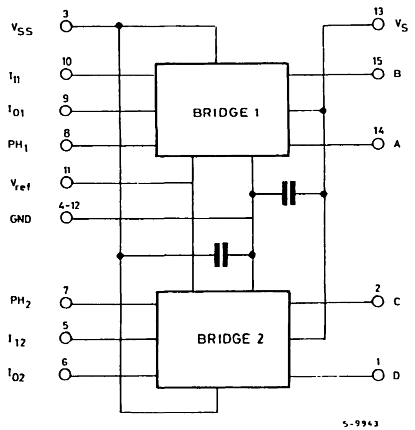
Pin	Function	Description
1	D	Bridge Output D. This output has a phase opposite to the driving signal PH2
2	C	Bridge Output C. This output has the same phase of the driving signal PH2.
3	V_{SS}	Logic Supply Voltage. Maximum applicable voltage is 7 V.
4	GND	See Pin 12
5	I_{12}	Input pin for current level and operating mode selection (see pin 10 - I11 description)
6	I_{O2}	Input pin for current level and operating mode selection (see pin 10 - I11 description)
7	PH2	Phase 2 Logic Input
8	PH1	Phase 1 Logic Input
9	I_{O1}	Input pin for current level selection (see pin 10 - I11 description)
10	I_{11}	Input pin used, together with IO1, to select the current level according to the following table.

I_{11}/I_{12}	I_{01}/I_{02}	Phase Current
0	0	I_{ph} = 100 % I_{set}
0	1	I_{ph} = 60 % I_{set}
1	0	I_{ph} = 19% I_{set}
1	1	No Current

PIN DESCRIPTION (Cont'd)

Pin	Function	Description
11	Vref	Reference Input Voltage for the Chopper Comparators. The voltage applied to this pin settles the phase current to the desired value. A 5 V ref sets a 0.5 A phase current when full-step drive is selected.
12	GND	Ground Connection. Motor and logic supply voltage as well as the logic signals, must be referenced to this pin.
13	V_S	Motor Unregulated Supply Voltage. Maximum Applicable Voltage is 46 V.
14	A	Bridge Output A. This output has the same phase of the driving signal PH1.
15	B	Bridge Output B. This output has a phase opposite to the driving PH1.

Equivalent Block Diagram of GS-D050



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

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	DC Supply Voltage	Pin 13	10		46	V
V_{SS}	DC Logic Supply Voltage	Pin 3	4.75	5	5.25	V
I_S	Quiescent Supply Current	Pin 13 V_S = 35V Iout = 0		15	30	mA
I_{SS}	Quiescent DC Supply Current	Pin 3. All Inputs High Iout = 0 V_{SS} = 5 V		15		mA
V_i	Input Voltage	Pin 5, 6, 7, 8, 9, 10 Low High	 2.0		0.8 V_{SS}	V V
I_i	Input Current	Pin 5, 6, 7, 8, 9, 10 Low High			0.4 10	mA µA
Vsat	Source Saturat. Voltage	Pin 1, 2, 14, 15 I_O = 0.5 A Conduction Period			2.1	V
Vsat	Source Saturat. Voltage	Pin 1, 2, 14, 15 Io = 0.5 A Recirculation Period			1.4	V
Vsat	Sink Saturat. Voltage	Pin 1, 2, 14, 15 Io = 0.5 A			1.4	V

MODULE OPERATION

The module consists of two identical sections each of them driving one winding of a bipolar permanent magnet stepper motor.

A brief description is given for one section.

An H bridge output stage (fig. 1) drives the winding of the motor by a constant current up to 0.5 A. The direction of the current depends on which diagonal of the H bridge is activated.

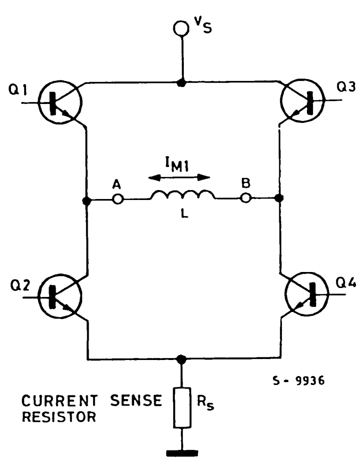
The input signal PH1 selects the diagonal. (See block diagram). When PH1 is high the two transistors Q_1 and Q_4 are switched ON and the current is sourced by the A pin and sinked by the B pin. When PH1 is low, Q_3 and Q_2 are switched ON. At switch ON the current through the winding increases almost linearly according to the equation :

$$\frac{\delta I_{M1}}{\delta t} = \frac{V_S}{L}$$

being L the inductance of the winding.

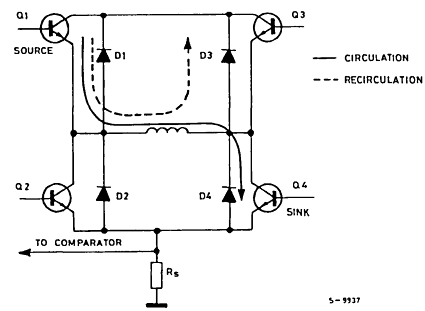
This current is sensed by a current sense resistor R_S and the voltage drop is compared to a reference voltage.

Figure 1. Output Bridge Circuit.



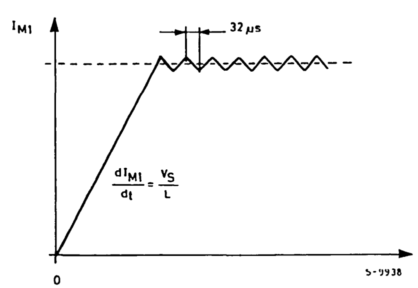
When the voltage drop is higher than reference the sink transistor (for example Q_4) is switched off and the current decays through the source transistor and the recirculating diode D3 (fig. 2).

Figure 2. Current Paths During Current Level Control.



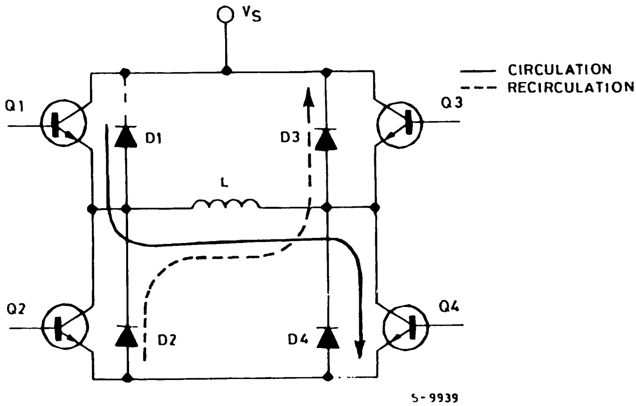
The module contains a monostable circuit that keeps OFF Q_4 for a fixed period of time (t_{OFF} = 32 µs). After t_{OFF}, Q_4 is switched on again and the cycle is repeated as long as PH1signal is high (fig 3).

Figure 3. Output Current Waveform



When the signal PH1 changes state (from high to low), both Q_1 and Q_4 are switched OFF and Q_2 and Q_3 are switched ON. The current recirculates through D2 and D3 until it decays to zero and then it reverses the direction (fig. 4).

Figure 4. Current Paths During Phase Reversal.



The current phase reversal is therefore obtained by a four quadrant operation while the current level control is by a two quadrant operation. The current decay by a four quadrant is faster being the total voltage applied to the winding almost equal to supply voltage.

The decay time during chopping control of the current level is internally fixed (t_{OFF}), the applied voltage to the inductance is also fixed (about 3 V) and, therefore, the amplitude of current decay or the current ripple depends exclusively on the value of L.

The level of the maximum current is fixed and controlled by a set of voltage dividers and comparators. Four current levels can be digitally selected according to the status of I_{11} and I_{01} (See block diagram and fig. 5).

When $I_{11} = I_{01} = 1$ the H-bridge is disactivated and no current can circulate.

For $I_{11} = 0$; $I_{01} = 0$ the comparator 1 is enabled. The maximum current is allowed to flow through the bridge and the value of the current is given by

$$I_M = \frac{0.042 V_{ref}}{R_S} = 100\%$$

$R_S = 0.47\ \Omega$ is internally fixed. For $V_{ref} = 5$ V the maximum allowed current is 0.45 A.

For $I_{11} = 0$; $I_{01} = 1$ the comparator 2 is enabled and the current is reduced to 60% of the maximum value.

For $I_{11} = 1$; $I_{01} = 0$ the comparator 3 is enabled and the current is reduced to 19%. When in Wave or Half Step mode, the signals I_{11} and I_{01} are used also for the correct timing. The following paragraphs show the mode operation of the GS-D050 making reference to the schematic of fig. 6. The current is considered positive when flowing from A to B or from C to D.

Figure 5. Current Level Setting.

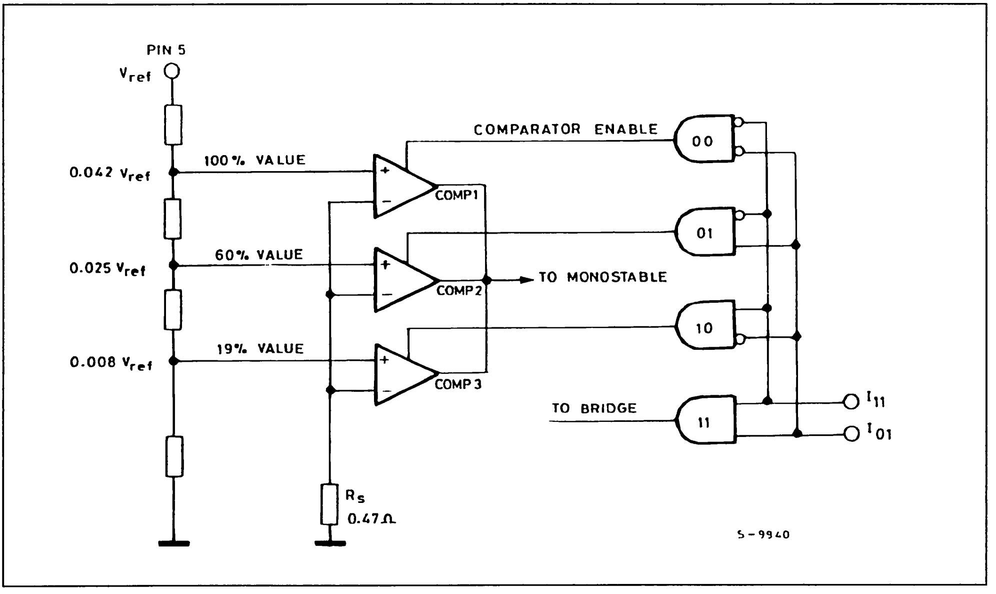
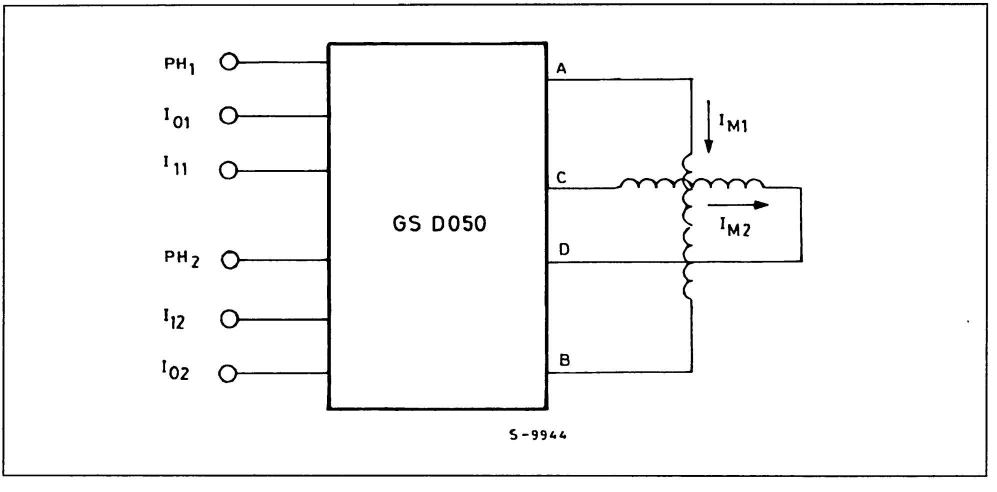


Figure 6. Basic GS-D050 Inputs and Outputs.



ONE PHASE ON or WAVE CURRENT

Only one winding is energized at any given time according to the sequence (for FWD direction)

AB ; CD ; BA ; DC ;

(BA means a negative current flowing from B to A).

Fig. 7 and 8 show the timing of the input signals and of the output currents.

Figure 7. Wave Drive FWD Direction.

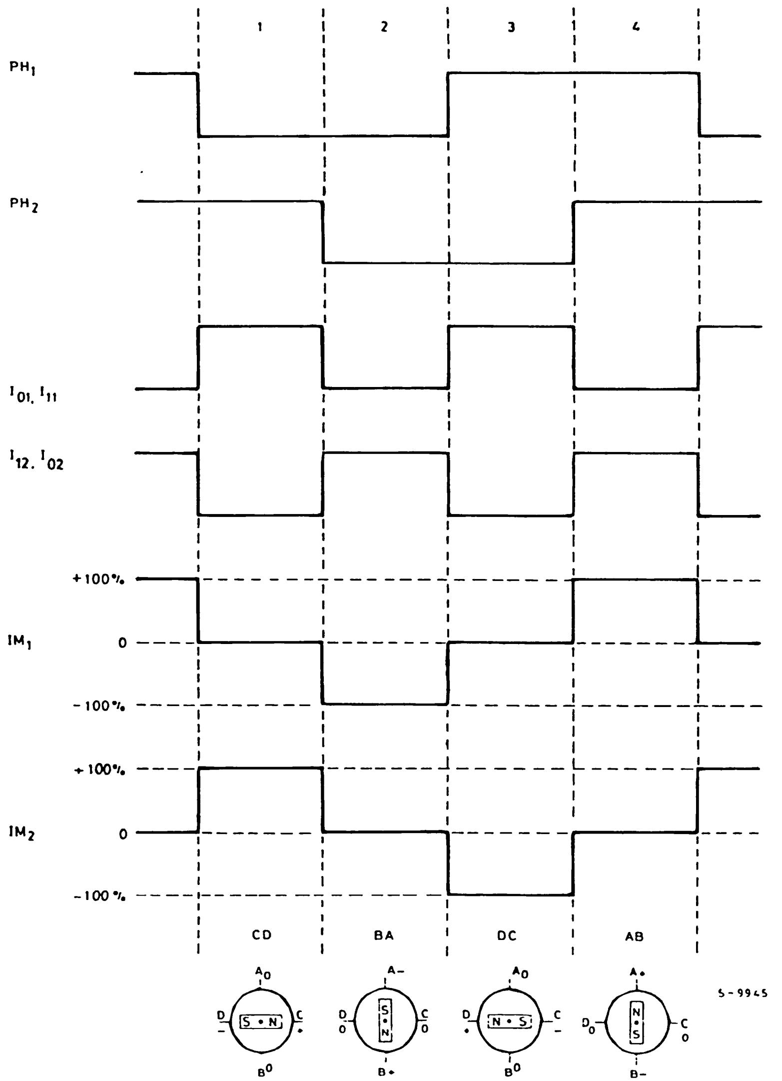
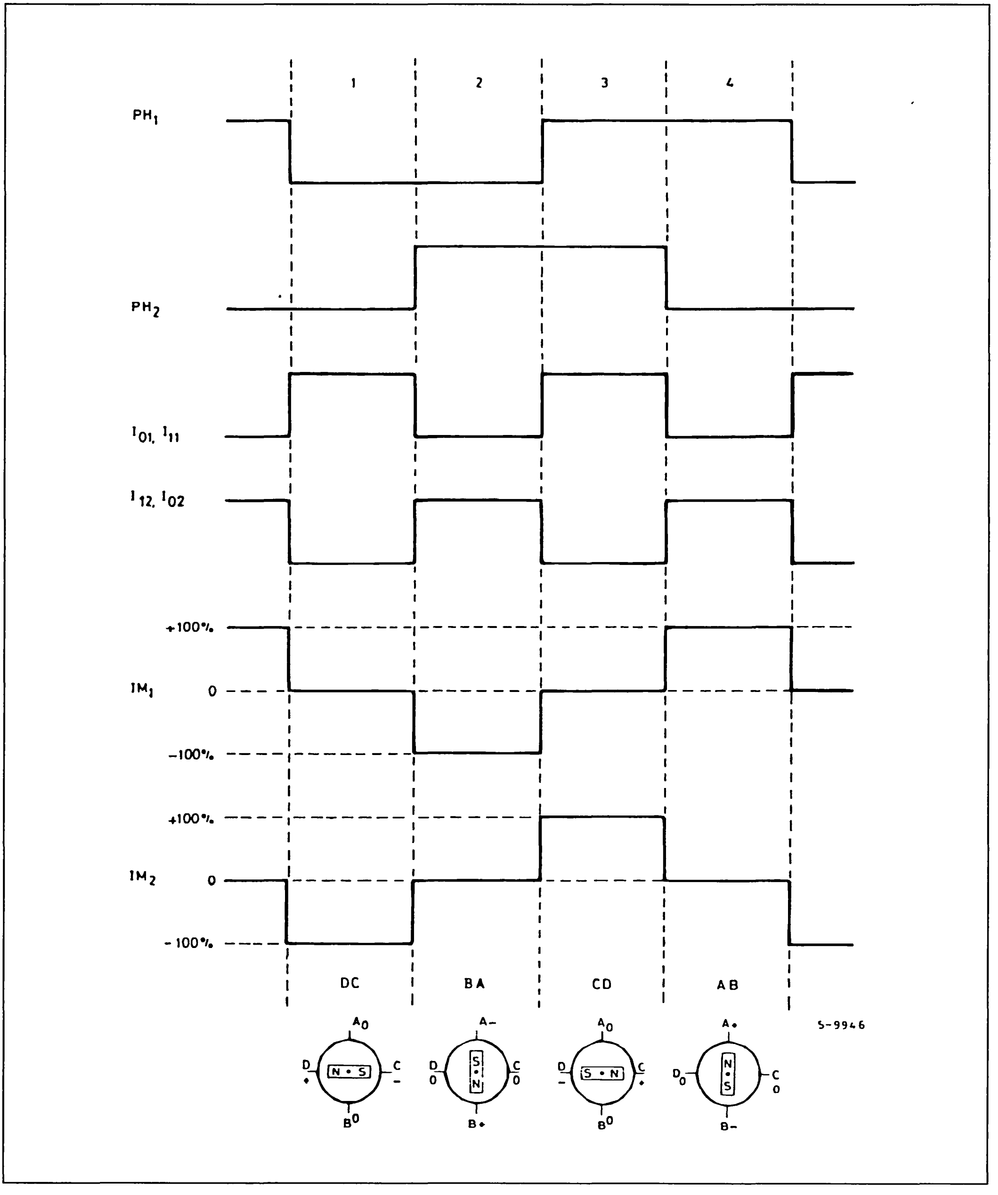


Figure 8. Wave Drive REV Direction.



TWO-PHASE-ON or NORMAL DRIVE

Two windings are energized at any given time according to the sequence (FWD direction).

AB & CD ; CD & BA ; BA & DC ; DC & AB

In this case I_{01}, I_{11} signals are used just for current level set.

Fig. 9 and 10 show the timing or various signals.

Figure 9. Two-Phase-on FWD Direction.

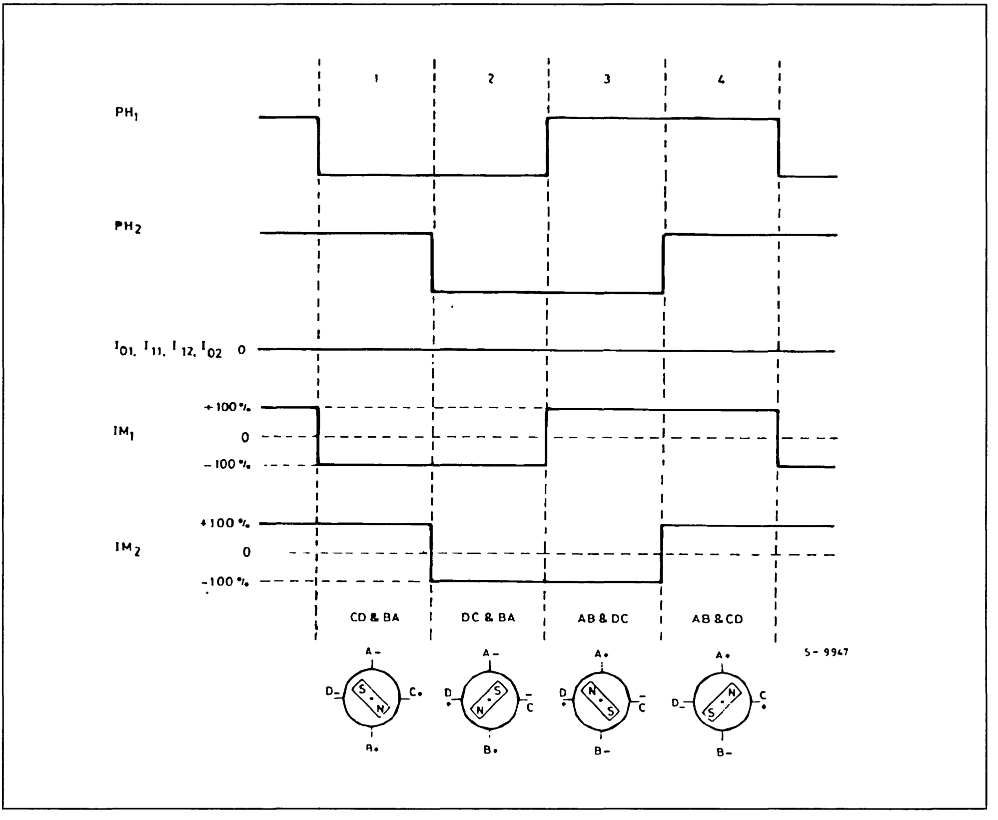
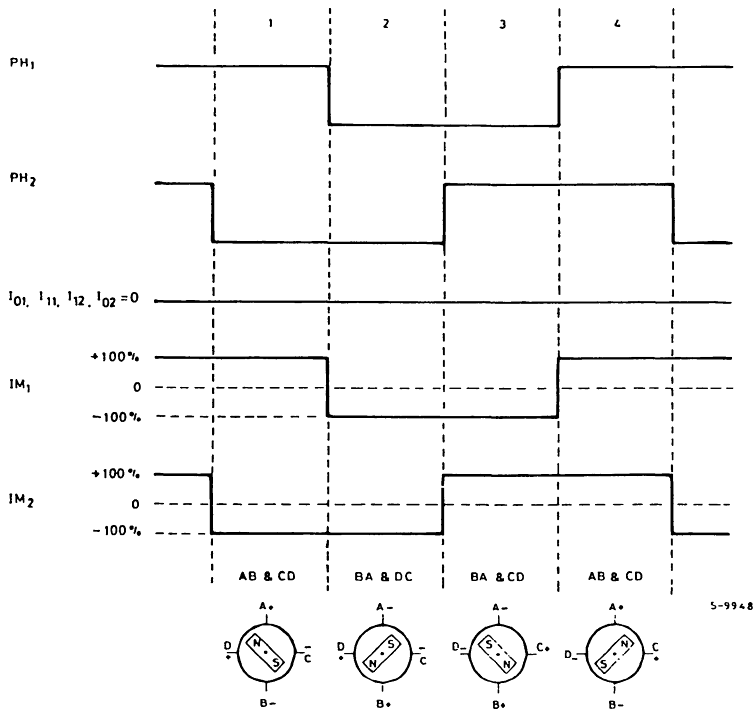


Figure 10. Two-Phase-on REV Direction.



HALF STEP DRIVE

By this mode one winding or two windings are alternatively energized. Eight steps are required for a complete revolution of the rotor.

For FWD direction the sequence is :

AB ; AB & CD ; CD & BA ; BA ; BA & DC ; DC ; DC & AB

Fig. 11 and 12 show the timing of various signals.

Figure 11. Half Step FWD Direction.

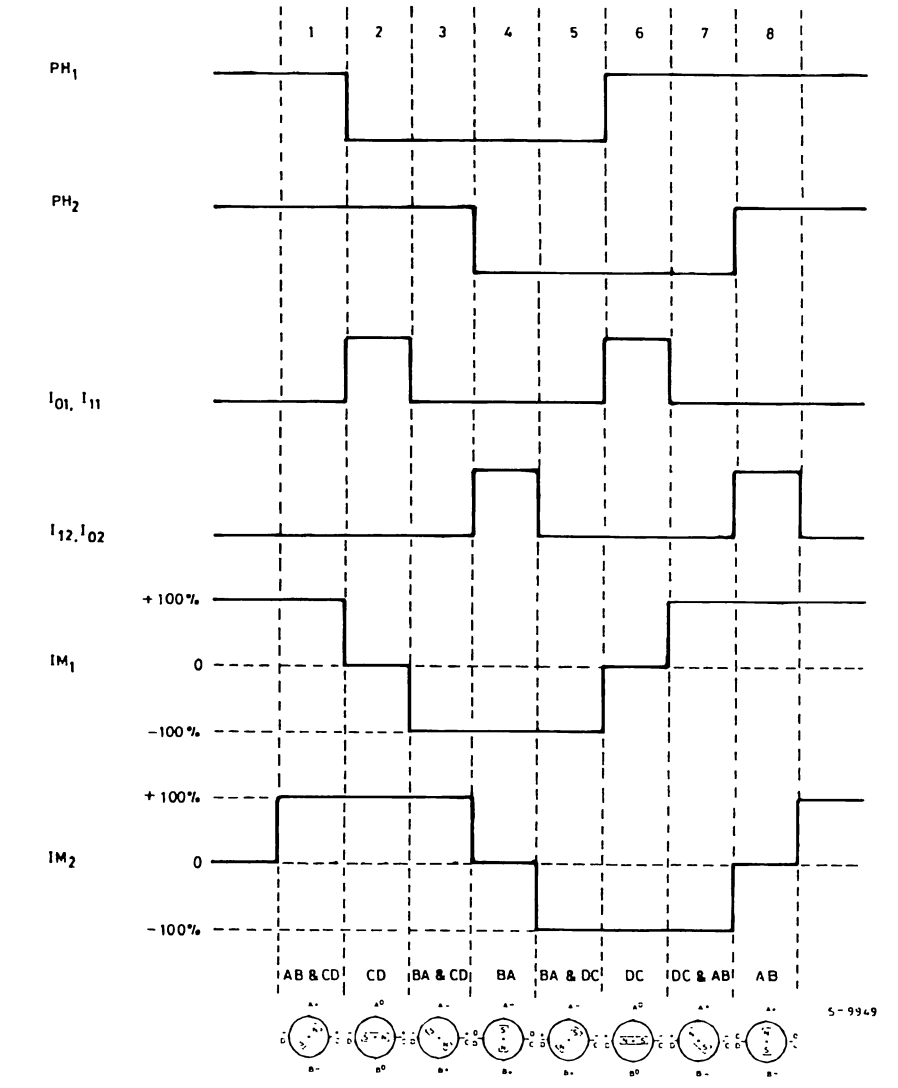


Figure 12. Half Step REV Direction.

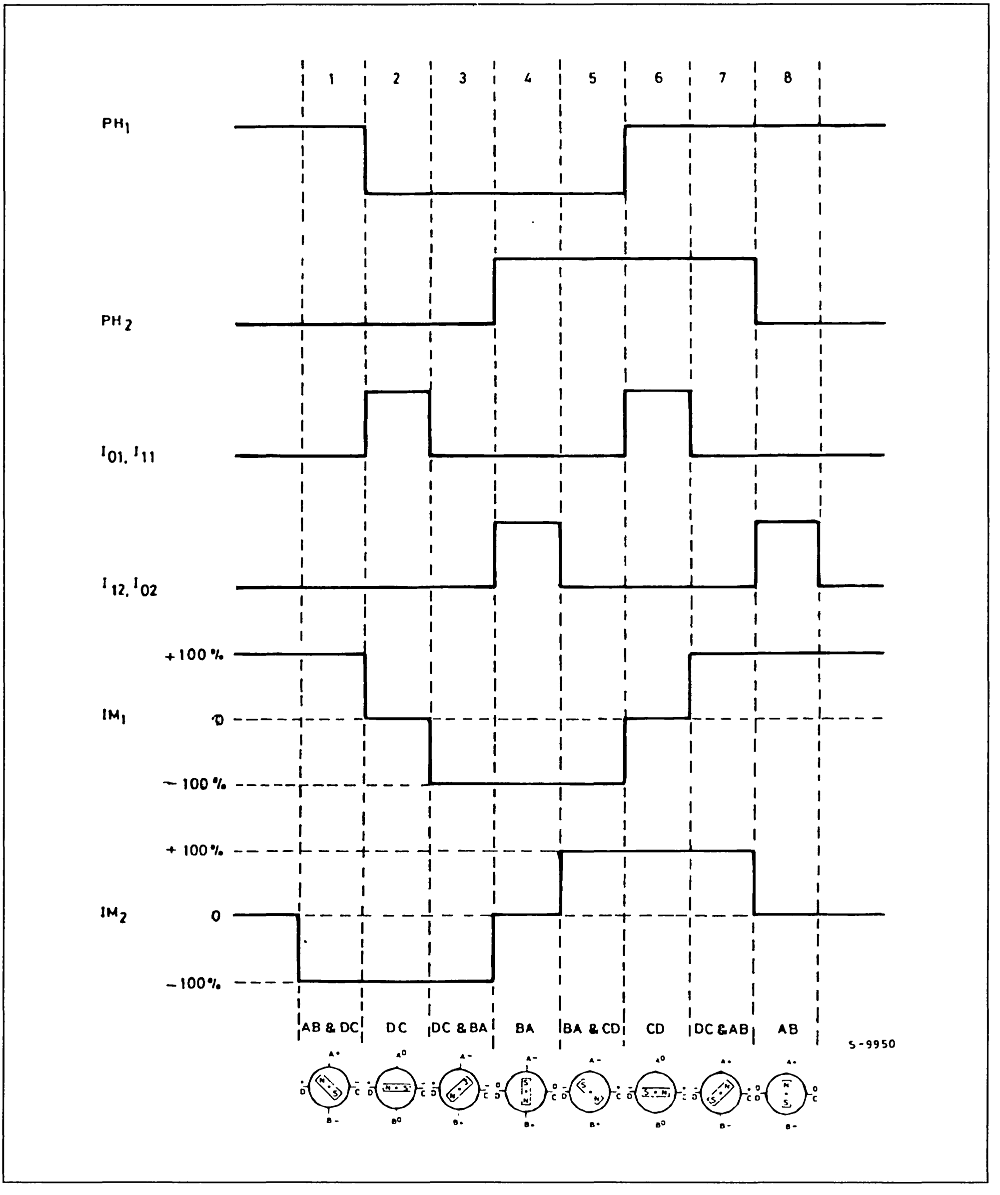


Figure 13. Quarter Step FWD Direction.

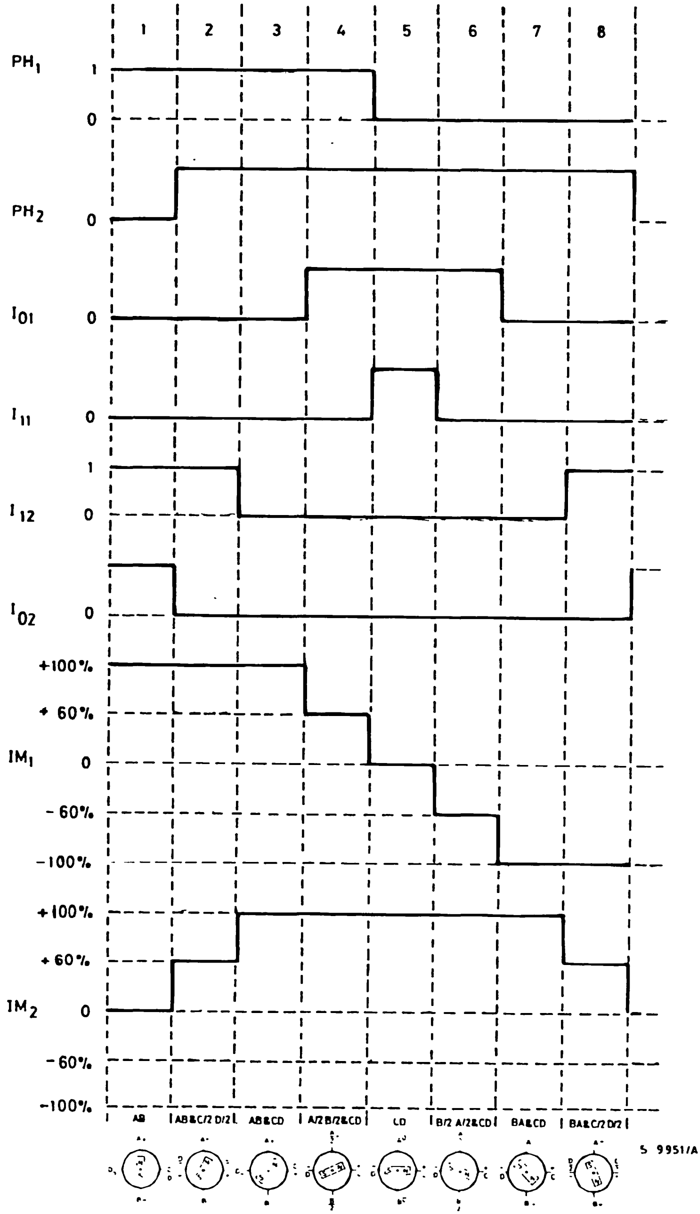
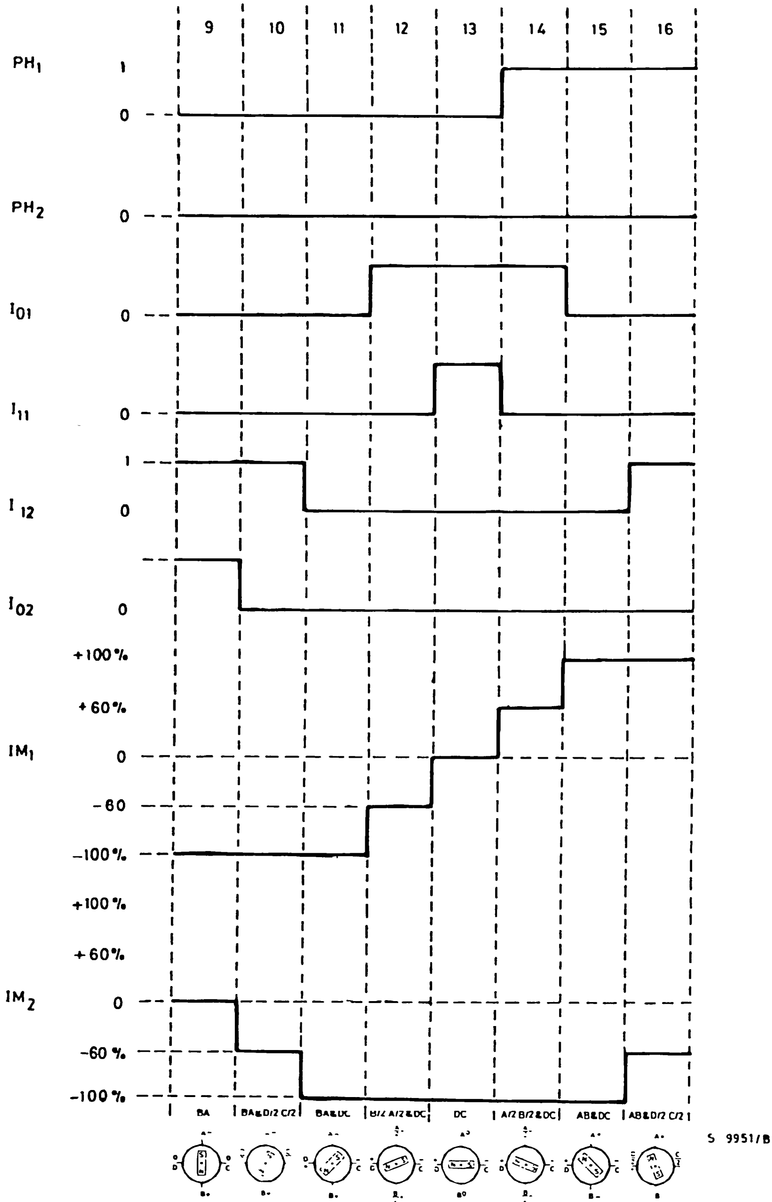


Figure 13. Quarter Step FWD Direction. (Continued)



For wave, normal, half step, the driving can be made at any current level : for simplicity the previous diagrams refer to a condition where 100 % of the motor current is used, as set by the equation.

$$I_H = \frac{0.042\ V_{ref}}{R_S}$$

In half step mode it is advisable to reduce the current level to 60 % of the maximum when two windings are energized and to use the maximum value when one winding is energized : this allows a less irregular torque.

This operation can be simply performed by selecting the proper status of I_{01} and I_{02}.

QUARTER STEP DRIVE

It is preferable to perform the quarter step drive at full power to have a more regular torque.

The extra quarter steps are added to the half step sequence by putting one winding at half current according to the sequence.

$$AB\ ;\ AB\ \&\ \frac{CD}{2}\ ;\ AB\ \&\ CD\ ;\ \frac{AB}{2}\ \&\ CD\ ;\ CD\ ;$$

$$CD\ \&\ \frac{BA}{2}\ ;\ CD\ \&\ BA\ ;\ \frac{CD}{2}\ \&\ BA\ ;\ BA\ ;$$

$$BA\ \&\ \frac{DC}{2}\ ;\ BA\ \&\ DC\ ;\ \frac{BA}{2}\ \&\ DC\ ;\ DC\ ;$$

$$DC\ \&\ \frac{AB}{2}\ ;\ DC\ \&\ AB\ ;\ \frac{DC}{2}\ \&\ AB.$$

The timing for forward direction is shown on fig. 13. 16 steps are required for one complete revolution.

APPLICATION CIRCUIT

A typical application is shown on fig. 14 for a maximum winding current of about 0.5 A.

As shown, no external component is needed to drive the motor.

Signals I_{01}, I_{11}, I_{02}, I_{12} may be used to inhibit the module when they are permanently kept at high level. If they are left open, the GS-D050 treats them as at high logic level.

The case of the GS-D050 is electrically connected to ground : radiated EMI caused by chopping operation is therefore shielded by the case itself.

To reduce further EMI a low pass filter can be inserted across the outputs of the GS-D050 as shown on fig. 15.

L, C, components should be selected according to

$$L \cong \frac{L_M}{10} \qquad C = \frac{4 \cdot 10^{-10}}{L}$$

The module is protected against thermal overload.

If by any reasons (very high ambient temperature or high power dissipation or both) the junction temperatures of active components inside the GS-D050 reach 150° C the module automatically reduces the output power and the power dissipa -tion.

Even if the module controls the maximum output current, a short circuit of the outputs can damage the device.

Figure 14. GS-D050 Basic Application Circuit.

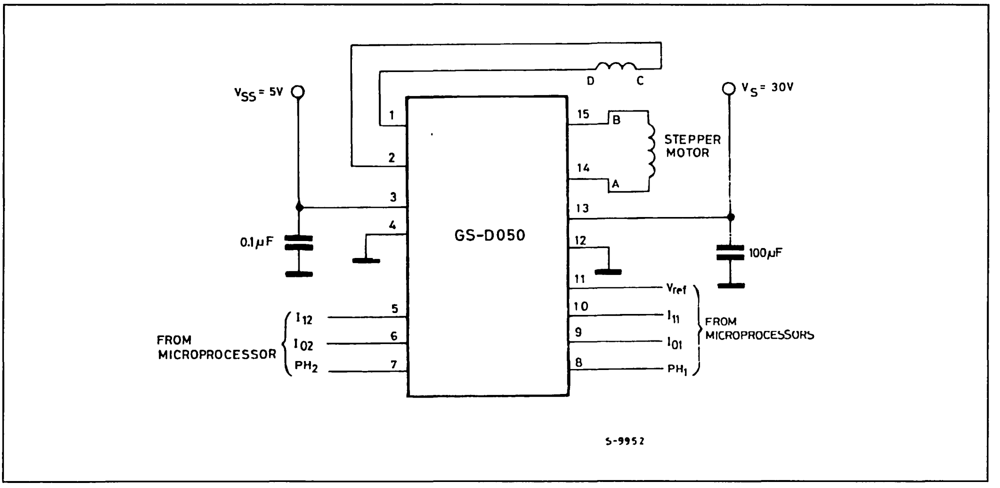
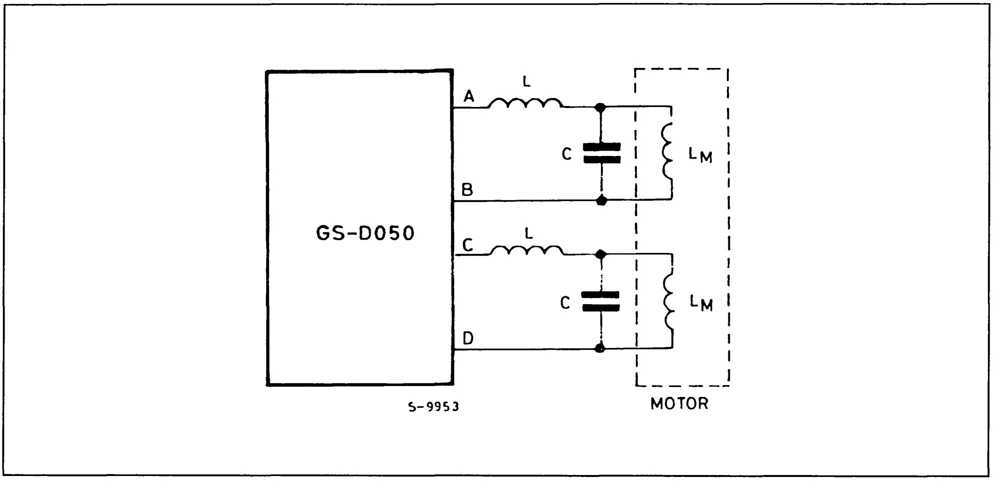


Figure 15. Circuit for EMI Reduction.



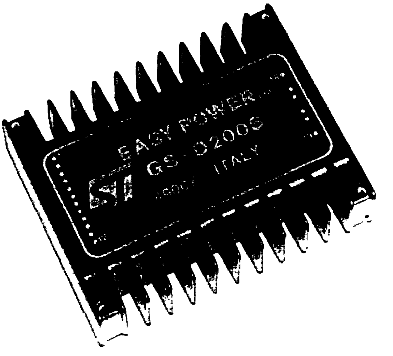
2/2.5A BIPOLAR STEPPER MOTOR DRIVE MODULES

FEATURES

- Wide supply voltage range
- Full/Half step drive capability
- Logic signals TTL/CMOS compatible
- Programmable motor phase current and chopper frequency
- Selectable Slow/Fast current decay
- Synchronization for multimotor applications
- Remote shut-down
- Home position indication

DESCRIPTION

The **GS-D200** and the **GS-D200S** are drive modules that directly interface a microprocessor to a two phase, bipolar, permanent magnet stepper motors. The phase current is chopper controlled, and the internal phase sequence generation reduces the burden of the controller and it simplifies software development.
The **GS-D200** uses bipolar power outputs while the **GS-D200S** has powermos outputs to significantly reduce both commutation and conduction losses. A further benefit offered by the **GS-D200S** is the complete protection of the outputs against any type of shorts.



SELECTION CHART

Type Ordering Number	Phase Current (A)	Voltage Drop (V)	Supply Voltage (V)
GS-D200	1.0 nom. (0.5 to 2.0)	4.1 max.	10 to 46 5.0±5%
GS-D200S	2.0 nom. (0.5 to 2.5)	2.5 max.	12 to 40 5.0±5%

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value	Unit
V_S	DC Supply Voltage (pin 18)	GS-D200 GS-D200S	48 42	V V
V_{SS}	DC Logic Supply Voltage (pin 12)		7	V
T_{stg}	Storage Temperature Range		– 40 to +105	°C
T_{cop}	Operating Case Temperature Range		– 20 to +85	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C and V_S=24V unless otherwise specified)

Symbol	Parameter	Test Conditions		Value			Unit
				Min	Typ	Max	
I_S	Quiescent Supply Current	Pin 18				20	mA
I_{SS}	Quiescent Logic Supply Current	Pin 12 V_{SS}=5V			60		mA
V_i	Input Voltage	Pin 3,4,6,7,10,11	Low High	2		0.8 V_{SS}	V V
I_i	Input Current	Pin 3,4,6,7,10,11	V_i=Low V_i=High			0.6 10	mA µA
V_{sat}	Source/Sink Saturation Voltage(GS-D200)	Pin 14,15,16,17	I_O=1A			1.8	V
V_{sat}	Source/Sink Saturation Voltage(GS-D200S)	Pin 14,15,16,17	I_O=2A			1.8	V
I_{OL}	Current Limit Intervention	GS-D200S		5			A
f_C	Chopper Frequency				17		kHz
t_{clk}	Stepckl Width	Pin 6 (See fig. 1)		0.5			µs
t_S	Set Up Time	"		1			µs
t_h	Hold Time	"		1			µs
t_r	Reset Width	"		1			µs
t_{rclk}	Reset to Clock Set Up Time	"		1			µs

Figure 1: Signals Timing

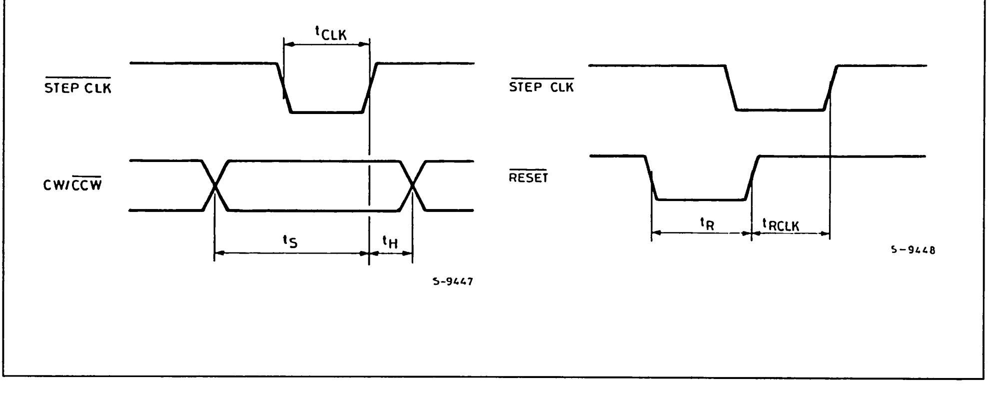


Figure 2: GS-D200 and GS-D200S Block Diagram

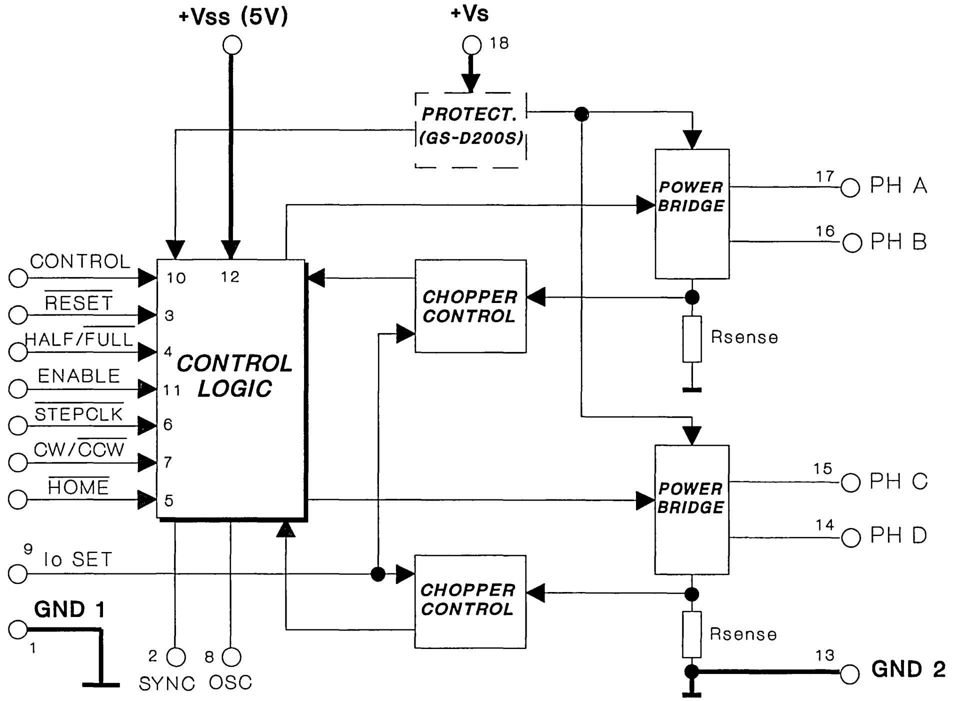


Figure 3: GS-D Modules Typical Application

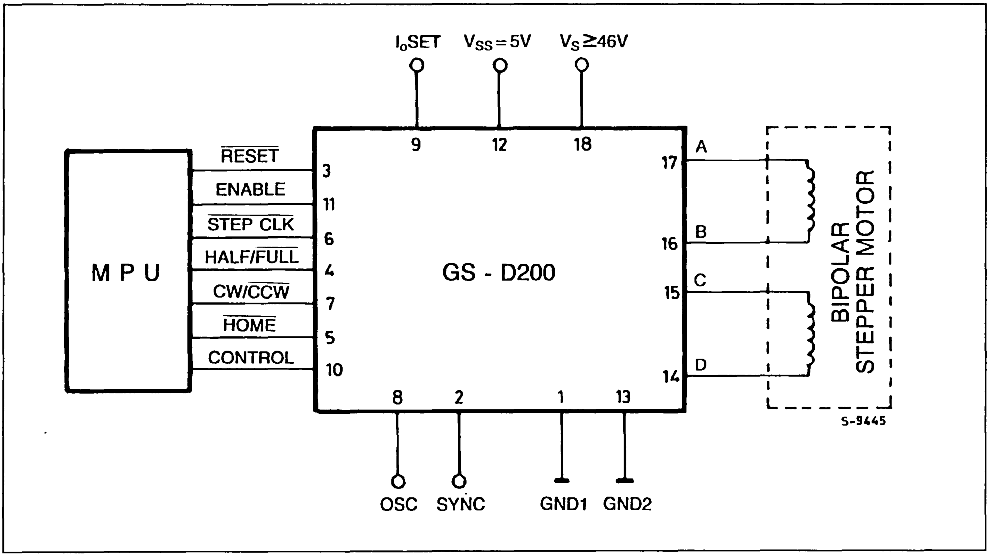
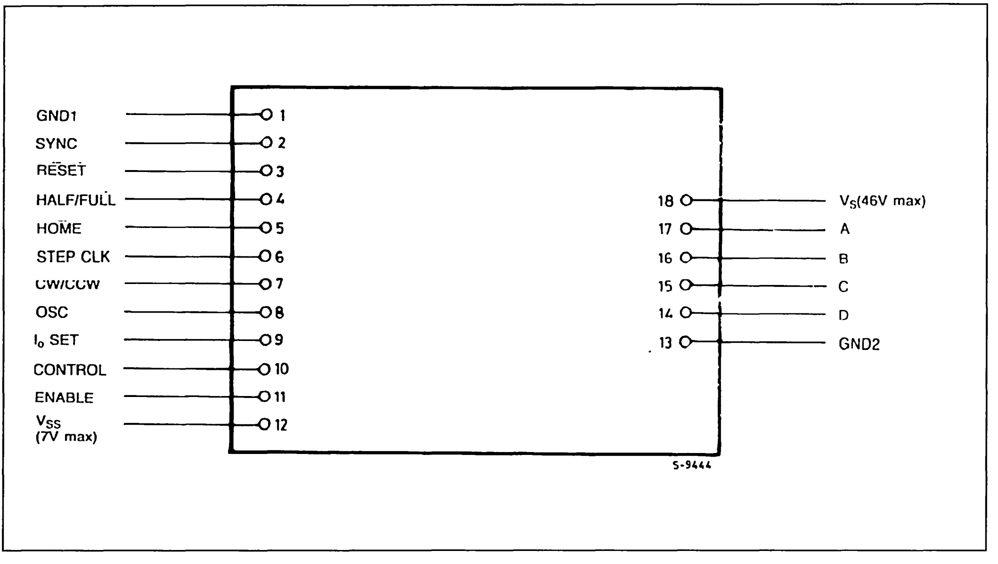


Figure 4: GS-D200 and GS-D200S Connection Diagram (Top view)



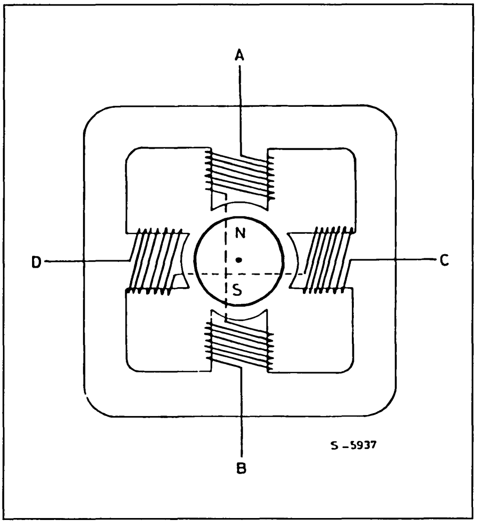
PIN DESCRIPTION

Pin	Function	Description
1	GND1	Return path for the logic signals and 5V supply.
2	Sync	Chopper oscillator output. Several modules can be synchronized by connecting together all Sync pins. This pin can be used as the input for an external clock source.
3	$\overline{\text{Reset}}$	Asynchronous reset input. An active low pulse on this input preset the internal logic to the initial state (ABCD=0101).
4	Half/$\overline{\text{Full}}$	Half/Full step selection input. When high or unconnected the half step operation is selected.
5	Home	When high, this output indicates that the internal counter is in its initial state (ABCD=0101). This signal may be used in conjunction with a mechanical switch to ground or with open collector output of an optical detector to be used as a system home detector.
6	$\overline{\text{Stepclk}}$	The motor is moved one step on the rising edge of this signal.
7	CW/$\overline{\text{CCW}}$	Direction control input. When high or unconnected clockwise rotation is selected. Physical direction of motor rotation depends also on windings connection.
8	Oscillator	The chopper oscillator timing, internally fixed at 17kHz, can be modified by connecting a resistor between this pin and V_{SS} or a capacitor between this pin and Gnd1. The oscillator input must be grounded when the unit is externally synchronized.
9	Ioset	Phase current setting input. A resistor connected between this pin and Gnd1 or V_{SS}, allows the factory setted phase current value (1A for GS-D200 and 2A for GS-D200S) to be changed.
10	Control	Logic input that allows the phase current decay mode selection. When high or unconnected the slow decay is selected.
11	Enable	Module enable input. When low this input floats the outputs enabling the manual positioning of the motor. Must be LOW during power-up and down sequence, HIGH during normal operation.
12	V_{SS}	5V supply input. Maximum voltage must not exceed 7V.
13	GND2	Return path for the power section.
14	D	D output.
15	C	C output.
16	B	B output.
17	A	A output.
18	V_S	Module and motor supply voltage. Maximum voltage must not exceed the specified values.

BIPOLAR STEPPER MOTOR BASICS

Simplified to the bare essentials, a bipolar permanent magnet motor consists of a rotating-permanent magnet surrounded by stator poles carrying the windings (fig. 5).

Figure 5: Simplified Bipolar Two Phase Motor



Bidirectional drive current is imposed on windings A-B and C-D and the motor is stepped by commutating the voltage applied to the windings in sequence. For a motor of this type there are three possible drive sequences.

One-Phase-on or Wave Drive

Only one winding is energized at any given time according to the sequence :

AB - CD - BA - DC

(BA means that the current is flowing from B to A).

Fig. 6 shows the sequence for a clockwise rotation and the corresponding rotor position.

Two-Phase-on or Normal Drive

This mode gives the highest torque since two windings are energized at any given time according to the sequence (for clockwise rotation).

AB & CD ; CD & BA ; BA & DC ; DC & AB

Fig. 7 shows the sequence and the corresponding position of the rotor.

Half Step Drive

This sequence halves the effective step angle of the motor but gives a less regular torque being one winding or two windings alternatively energized. Eight steps are required for a complete revolution of the rotor.
The sequence is:

AB ; AB & CD ; CD ; CD & BA ; BA ; BA & DC ; DC ; DC & AB

as shown in fig. 8.

By the configurations of fig. 6, 7, 8 the motor would have a step angle of 90 ° (or 45 ° in half step). Real motors have multiple poles pairs to reduce the step angle to a few degrees but the number of windings (two) and the drive sequence are unchanged.

Figure 6: One-Phase-on (Wave Mode) Drive

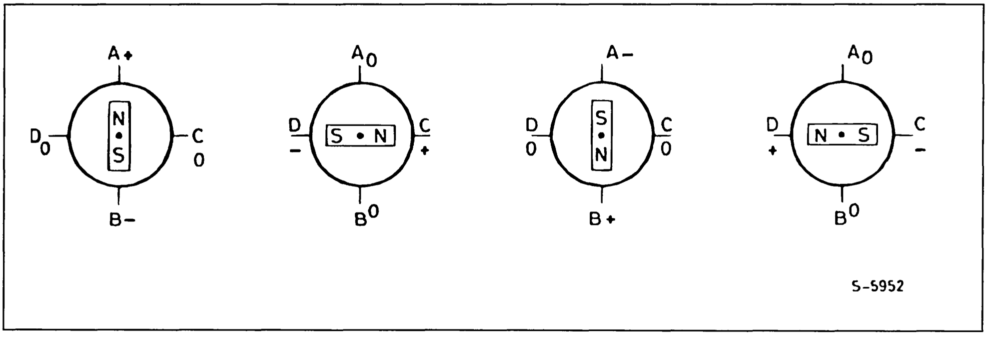


Figure 7: Two-Phase-on (Normal Mode) Drive

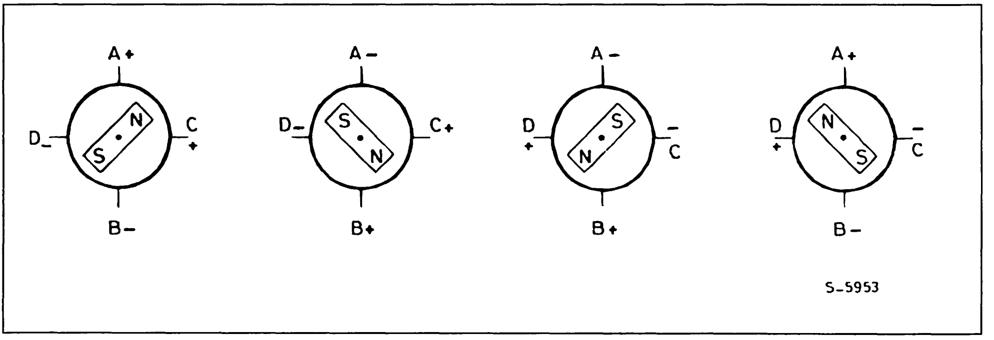
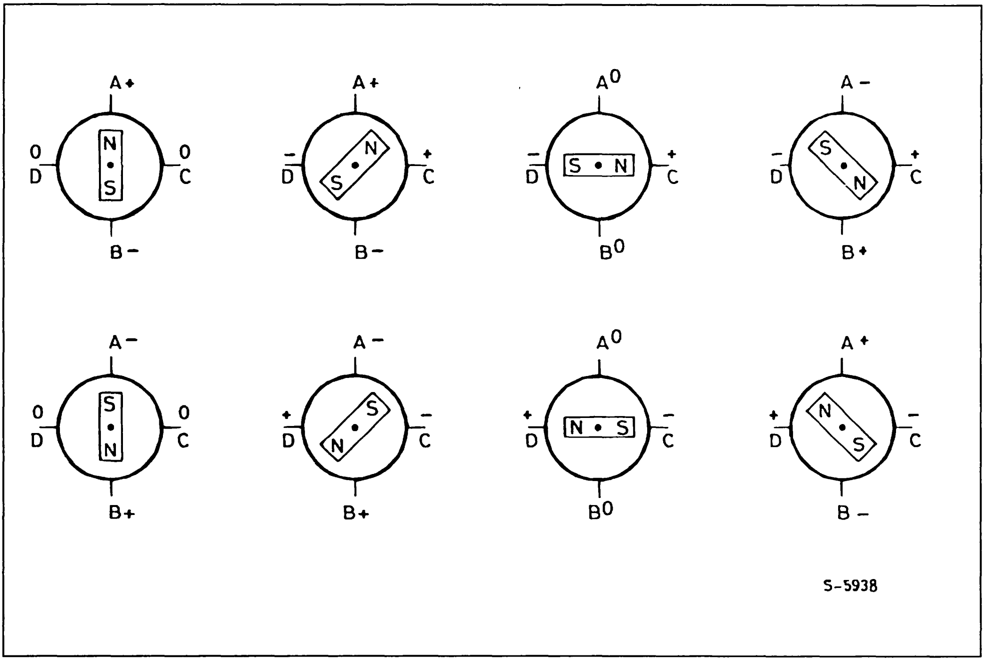


Figure 8: Half Step Sequence



PHASE SEQUENCE GENERATION INSIDE THE GS-D200/GS-D200S

The modules contains a three bit counter plus some combinational logic which generate suitable phase sequences for half step, wave and normal full step drive. This 3 bit counter generates a basic eight-step Gray code master sequence as shown in fig. 9. To select this sequence, that corresponds to half step mode, the HALF/$\overline{\text{FULL}}$ input (pin 4) must be kept high or unconnected.
The full step mode (normal and wave drive) are both obtained from the eight step master sequence by skipping alternate states. This is achieved by forcing the step clock to bypass the first stage of the 3 bit counter. The least significant bit of this counter is not affected and therefore the generated sequence depends on the state of the counter when full step mode is selected by forcing pin 4 (HALF/$\overline{\text{FULL}}$) low. If full step is selected when the counter is at any odd-numbered state, the two-phase-on (normal mode) is implemented (see fig. 10).
On the contrary, if the full mode is selected when the counter is at an even-numbered state, the one-phase-on (wave drive) is implemented (see fig. 11).

Figure 9: The Eight Step Master Sequence corresponding to Half Step Mode.

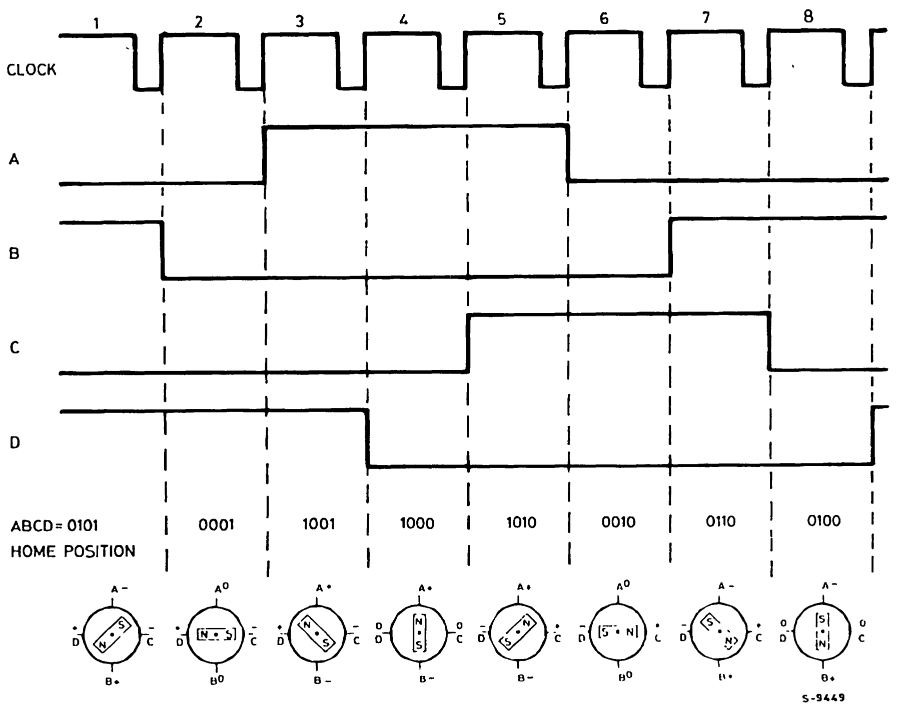


Figure 10: Two-Phase-on (Normal Mode) Drive

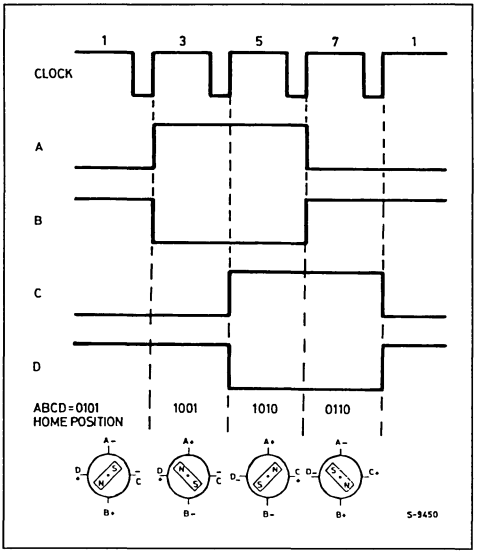
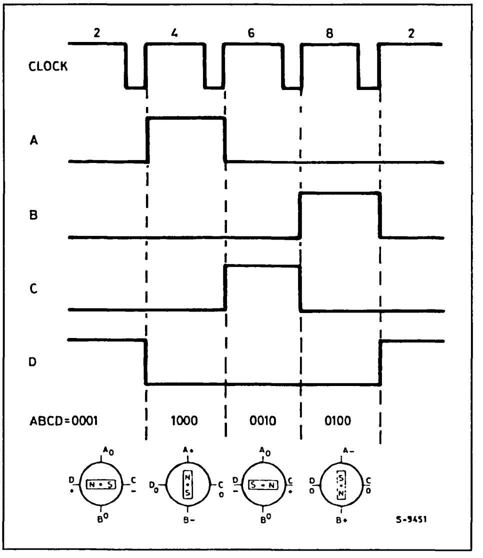


Figure 11: One-Phase-on (Wave Mode) Drive



RESET, ENABLE AND HOME SIGNALS

The $\overline{\text{RESET}}$ is an asynchronous reset input which restores the module to the home position (state 1 : ABCD = 0101). Reset is active when low.

The $\overline{\text{HOME}}$ output signals this condition and it is intended to be ANDed with the output of a mechanical home position sensor.

The ENABLE input is used to start up the module after the system initialization. ENABLE is active when high or unconnected.

MOTOR CURRENT REGULATION

The two bipolar winding currents are controlled by two internal choppers in a PWM mode to obtain good speed and torque characteristics.
An internal oscillator supplies pulses at the chopper frequency to both choppers.

When the outputs are enabled, the current through the windings raises until a peak value set by I_{oset} and R_{sense} (see the equivalent block diagram) is reached. At this moment the outputs are disabled and the current decays until the next oscillator pulse arrives.

The decay time of the current can be selected by the CONTROL input (pin 10). If the CONTROL input is kept high or open the decay is slow, as shown in fig. 12, where the equivalent power stage of GS-D200, the voltages on A and B are shown as well as the current waveform on winding AB.

When the CONTROL input is forced low, the decay is fast as shown in fig. 13.

The CONTROL input is provided on GS-D200 and GS-D200S to allow maximum flexibility in application.

If the modules must drive a large motor that does not store much energy in the windings, the chopper frequency must be decreased: this is easily obtained by connecting an external capacitor between OSC pin and GND1.

In these conditions a fast decay (CONTROL LOW) would impose a low average current and the torque could be inadequate. By selecting CONTROL HIGH, the average current is increased thanks to the slow decay.

When the GS-D200S is used in the fast-decay mode it is recommended to connect external fast recovery, low drop diodes between each phase output and the supply return (GND). The slow-decay should be the preferred operating recirculation mode because of the lower power dissipation and low noise operations.

Figure 12: Chopper Control with Slow Decay

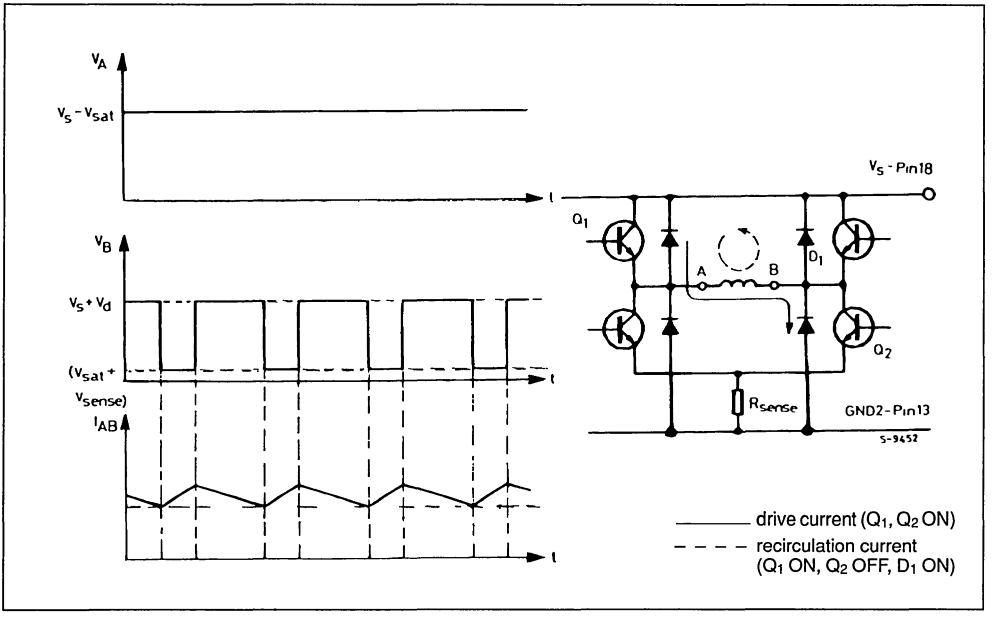
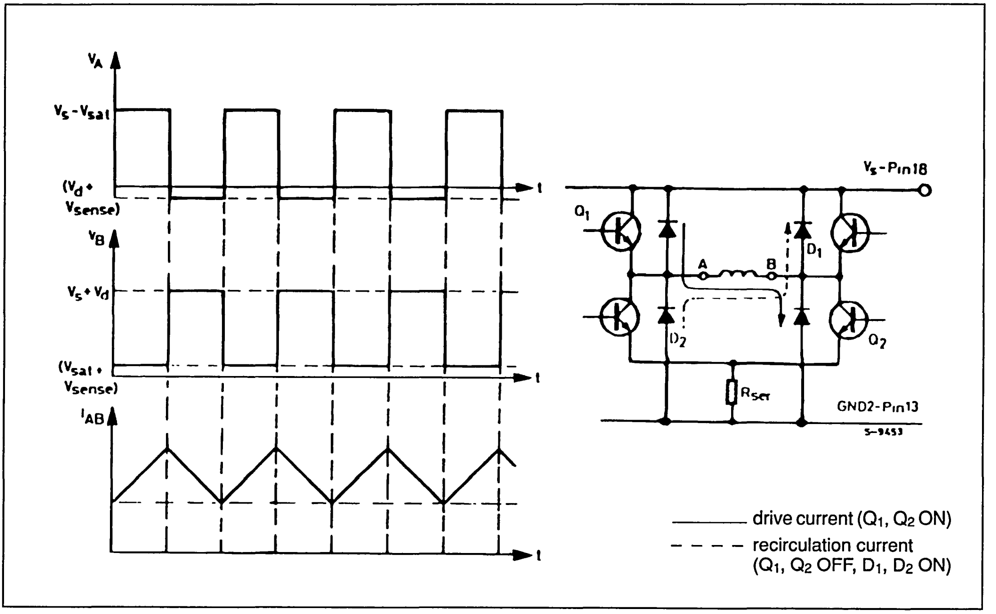


Figure 13: Chopper Control with Fast Decay



USER NOTES

Supply Voltage

The recommended operating maximum supply voltage must include the ripple voltage for the V_S rail, and a 5V±5% for the V_{SS} line is required.
The two supply voltages must to be correctly sequenced to avoid any possible erroneous positioning of the power stages. The correct power-up and power-down sequences are:

Power-up
1) V_{SS} (5V) is applied with Enable = Low
2) Vs (the motor supply voltage) is applied
3) Enable is brougth High

Power-down
1) Enable is brougth Low
2) V_S is switched off
3) V_{SS} is switched off.

Case Grounding

The module case is internally connected to pin 1 and 13. To obtain additional effective EMI shield, the PCB area below the module can be used as an effective sixth side shield.

Thermal Characteristics

The case-to-ambient thermal resistance of the GS-D modules is 5°C/W. This produces a 50°C temperature increase of the module surface for 10W of internal dissipation.
According to ambient temperature and/or to power dissipation, an additional heatsink or forced ventilation may be required. (See derating curves).

Supply Line Impedance

The module has an internal capacitor connected accross the supply pins (18 and 13) to assure the circuit stability. This capacitor cannot handle high values of current ripple, and would be permanently damaged if the primary energy source impedance is not adequate.
The use of a low ESR, high ripple current 470µF capacitor located as close to the module as possible is recommended. Suitable units are the SPRAGUE type 672D, the SPRAGUE 678D, the RIFA type PEG 126 or any equivalent unit. When space is a limitation, a 22µF ceramic multilayer capacitor connected across the module input pins must be used.

Module Protections

The GS-D200 outputs are protected against occasional and permanent short-circuits of the output pin to the supply voltage. The GS-D200S outputs are also protected against short circuits to ground and to another output. When the current exceeds the maximum value, the output is automatically disabled.

The GS-D200S protection is of the latching type, i.e. when an overload condition is detected the unit outputs are disabled. To restart the operations it is necessary to disable the unit (pin 11=Low) or to switch off the supply voltage for at least 100ms.

Motor Connection

The motor is normally quite far from the module and long cables are needed for connection. The use of a twisted pair cable with appropriate cross section for each motor phase is recommended to minimize DC losses and RFI problems.

Unused Inputs

All the GS-D200 and GS-D200S logic inputs have an internal pull-up, and they are high when unconnected.

Phase Current Programming

The output current of the GS-D200 is factory set to 1A while the GS-D200S has a standard 2A value. The phase current value can be changed by connecting an appropriate resistor between pin 9 and ground or V_{SS} (see fig. 14). In the first case the phase current will decrease, in the latter it will increase.
The maximum phase current must be limited to 2A for the GS-D200 and 2.5A for the GS-D200S to avoid permanent damage to the module.

GS-D200 phase current programming:

I>1A $\quad Ri = \dfrac{10 - I}{0.993 \cdot I - 1} = k\Omega \quad Ri \geq 8.2\ k\Omega$

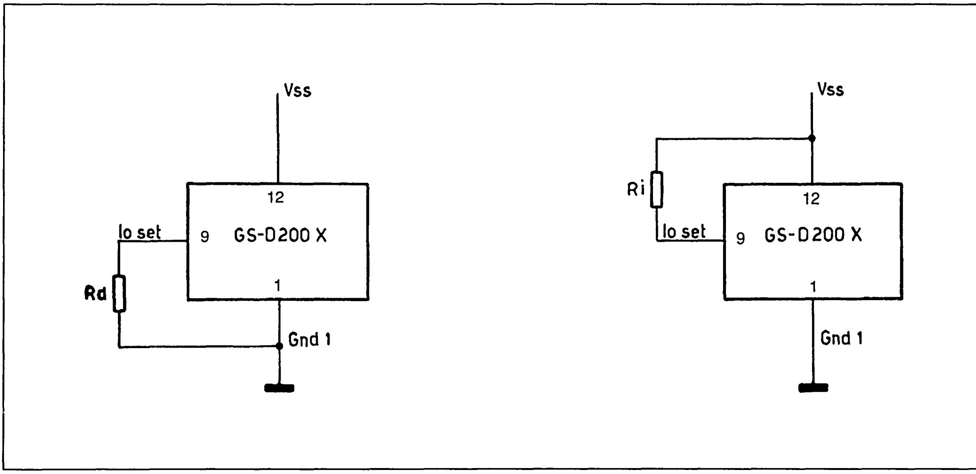
I<1A $\quad Rd = \dfrac{I}{1 - 0.993 \cdot I} = k\Omega$

GS-D200S phase current programming:

I>2A $\quad Ri = \dfrac{10 - 0.33 \cdot I}{0.473 \cdot I - 1} = k\Omega \quad Ri \geq 50\ k\Omega$

I<2A $\quad Rd = \dfrac{I}{3.03 - 1.43 \cdot I} = k\Omega$

Figure 14: GS-D200 and GS-D200S Phase Current Programming



Chopper Frequency Programming

The chopper frequency is internally set to 17kHz, and it can be changed by addition of external components as follows. To increase the chopper frequency a resistor must be connected between Oscillator (pin 8) and V_{SS} (pin 12, see fig. 15).
The resistor value is calculated according to the formula:

$$Rf = \frac{306}{fc - 17} = k\Omega \qquad \text{where } fc = kHz \quad Rf \geq 18k\Omega$$

To decrease the chopper frequency a capacitor must be connected between Oscillator (pin 8) and Gnd1 (pin 1). The capacitor value is calculated according to the formula:

$$Cf = \frac{80.5 - 4.7fc}{fc} = nF \quad \text{where } fc = kHz$$

Figure 15: Chopper Frequency Programming

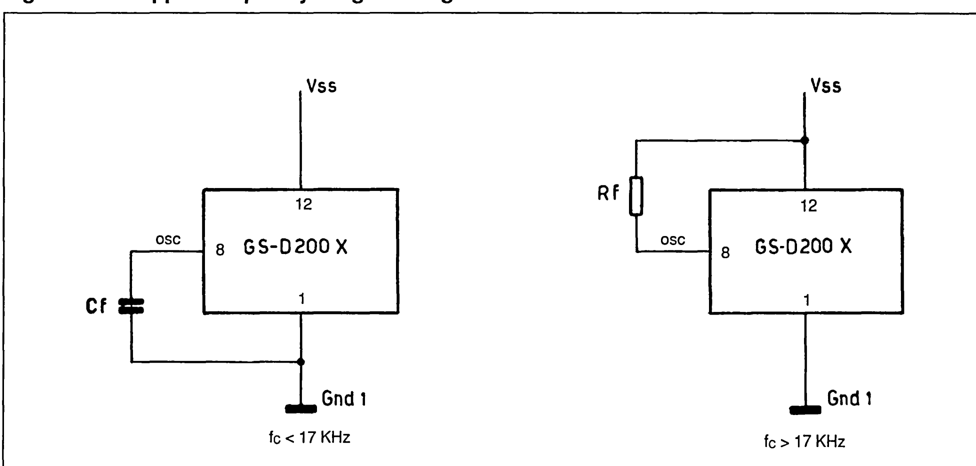


Figure 16: GS-D200 Free Air Derating Curve

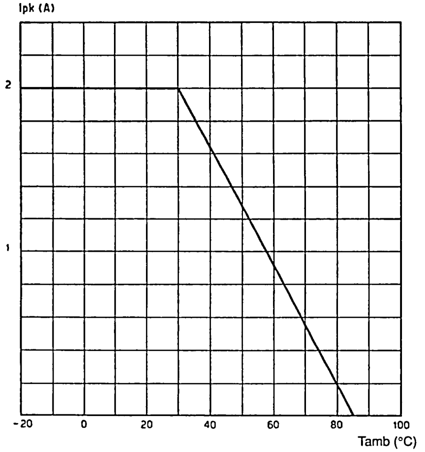
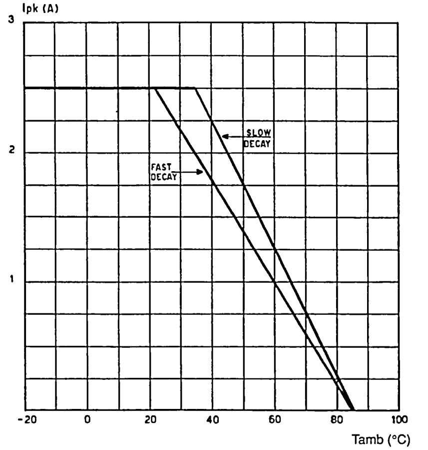


Figure 17: GS-D200S Free Air Derating Curve



MULTI MODULES APPLICATION

In complex systems, many motors must be controlled and driven. In such a case more than one GS-D200 or GS-D200 S must be used.
To avoid chopper frequencies noise and beats, all the modules should be synchronized.
If all the motors are relatively small, the fast decay may be used, the chopper frequency does not need any adjustement and fig. 18 shows how to synchronize several modules.

When at least one motor is relatively large a lower chopper frequency and a slow decay may be required: In such a case the overall system chopper frequency is determined by the largest motor in the system as shown in fig. 19.

Figure 18: Multimotor Synchronization. Small Motor and Fast Current Decay

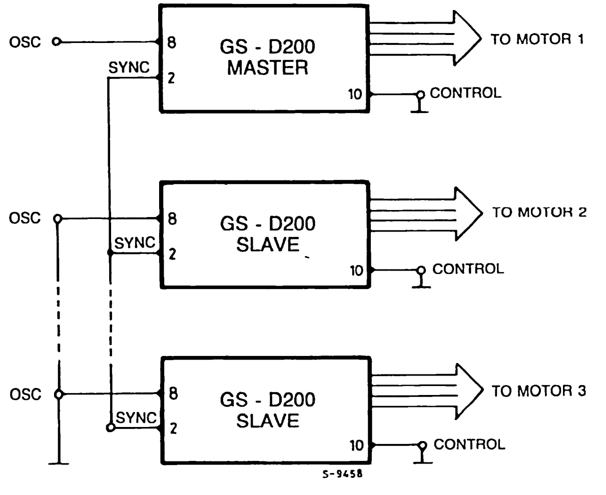
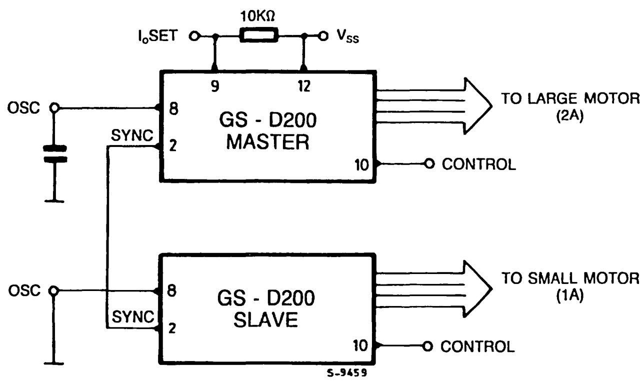


Figure 19: Multimotor Synchronization. Large and Small Motor. Slow Current Decay



THERMAL OPERATING CONDITIONS

In many cases the modules do not require any additional cooling because the dimensions and the shape of the metal box are studied to offer the minimum possible thermal resistance case-to-ambient for a given volume.

It should be remembered that these modules are a power device and, depending on ambient temperature, an additional heath-sink or forced ventilation or both may be required to keep the unit within safe temperature range. ($T_{casemax}$ < 85 °C during operation).

The concept of maximum operating ambient temperature is totally meaningless when dealing with power components because the maximum operating ambient temperature depends on how a power device is used.

What can be unambiguously defined is the case temperature of the module.

To calculate the maximum case temperature of the module in a particular applicative environment the designer must know the following data:

– Input voltage

– Motor phase current

– Motor phase resistance

– Maximum ambient temperature

From these data it is easy to determine whether an additional heath-sink is required or not, and the relevant size i.e. the thermal resistance.

The step by step calculation is shown for the following example (GS-D200).

V_{in} = 40 V, I_{phase} = 1 A, R_{ph} Phase resistance = =10Ω, max. T_A = 50 °C

● Calculate the power dissipated from the indexer logic and the level shifter (see electrical characteristics):

$$P_{logic} = (5\text{ V} \bullet 60\text{ mA}) + (40\text{ V} \bullet 20\text{ mA}) = 1.1\text{ W}$$

● Calculate the average voltage across the winding resistance:

$$V_{out} = (R_{ph} \bullet I_{out}) = 10\Omega\ \zeta\ 1\text{ A} = 10\text{ V}$$

● Calculate the required ON duty cycle (D.C.) of the output stage to obtain the average voltage (this D.C. is automatically adjusted by the GS-D200):

$$D.C. = \frac{V_{out}}{V_{in}} = \frac{10}{40} = 0.25$$

● Calculate the power dissipation of the GS-D200 output power stage. The power dissipation depends on two main factors:

– the selected operating mode (FAST or SLOW DECAY)

– the selected drive sequence (WAVE, NORMAL, HALF STEP)

FAST DECAY. For this mode of operation, the internal voltage drop is $V_{satsource} + V_{satsink}$ during the ON period i.e. for 25 % of the time.
During the recirculation period (75 % of the time), the current recirculates on two internal diodes that have a voltage drop V_d = 1 V, and the internal sense resistor (0.5 Ω). For this example, by assuming maximum values for conservative calculations, the power dissipation during one cycle is:

$$P_{pw} = 1.1 \bullet [2\ V_{sat} \bullet I_{ph} \bullet D.C. + 2\ V_d \bullet I_{ph} \bullet (1 - D.C.) + 0.5 \bullet I_{ph}]$$

$P_{pw} = 1.1 \bullet [2 \bullet 1.8 \bullet 1 \bullet 0.25 + 2 \bullet 1 \bullet 1 \bullet 0.75 + 0.5 \bullet 1]$

$P_{pw} = 1.1 \bullet [0.9 + 1.5 + 0.5] = 3.19\ W$

The factor 1.1 takes into account the power dissipation during the switching transient.

SLOW DECAY. The power dissipation during the ON period is the same. The RECIRCULATION is made internally through a power transistor ($V_{satsink}$) and a diode. The power dissipation is, therefore:

$P_{pw} = 1.1 \bullet [2\ V_{sat} \bullet I_{ph} \bullet D.C. + (V_{sat} + V_d) \bullet I_{ph} \bullet (1 - D.C.)]$

$P_{pw} = 1.1 \bullet [2 \bullet 1.8 \bullet 1 \bullet 0.25 + (1.8 + 1) \bullet 1 \bullet 0.75]$

$P_{pw} = 1.1 \bullet [0.9 + 2.1] = 3.3\ W$

WAVE MODE. When operating in this mode the power dissipation is given by values of FAST and SLOW DECAY mode, because one phase is energized at any given time.

NORMAL MODE. At any given time, two windings are always energized. The power dissipation of the power output stage is therefore multiplied by a factor 2.

HALF STEP. The power sequence, one-phase-on, two-phase-on forces the power dissipation to be 1.5 times higher than in WAVE MODE when the motor is running. In stall condition the worst case for power dissipation is with two-phase-on i.e. a power dissipation as in NORMAL MODE.

The following table summarizes the power dissipations of the output power stage of the GS-D200 when running for this example:

	Wave	Normal	Half Step
Fast Decay	3.19 W	6.38 W	6.38 W
Slow Decay	3.30 W	6.60 W	6.60 W

- Calculate the total power dissipation for the GS-D200 :

$P_{tot} = P_{logic} + P_{pw}$

In this example, for slow decay and normal mode

$P_{tot} = 1.1 + 6.6 = 7.7\ W$

- The case temperature can now be calculated:

$T_{case} = T_{amb} + (P_{tot} \bullet R_{th}) = 55 + (7.7 \bullet 5) = 93.5\ °C$

- If the calculated case temperature exceeds the maximum allowed case temperature, as in this example, an external heat-sink is required and the thermal resistance can be calculated according to:

$$Rth_{tot} = \frac{T_{cmax} - T_{amb}}{P_{tot}} = \frac{85 - 55}{7.7} = 3.9\ °C$$

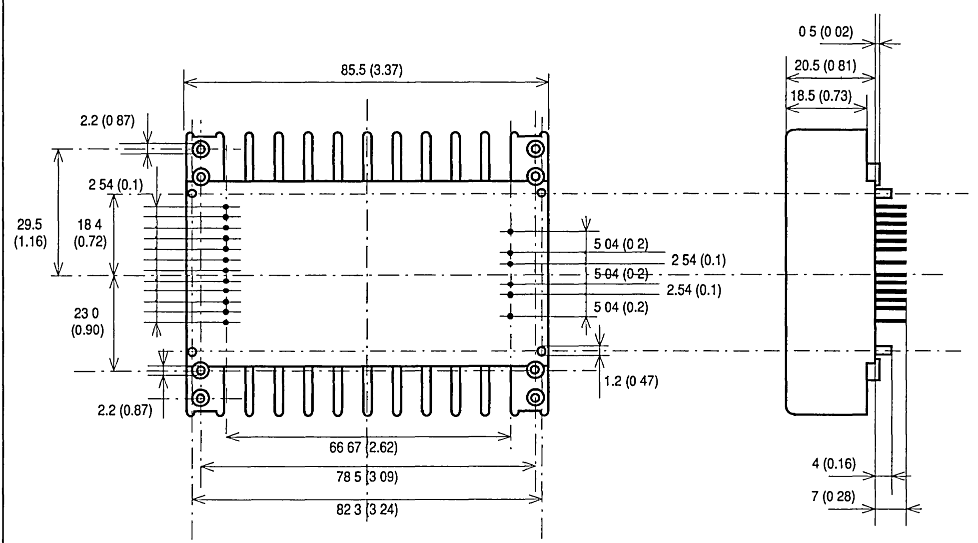
and then

$$Rth_{hs} = \frac{Rth \cdot Rth_{tot}}{Rth - Rth_{tot}} = \frac{5 \cdot 3.9}{5 - 3.9} = 17.7°C$$

The following table gives the thermal resistance of some commercially available heath-sinks that fit on the GS-D200 module.

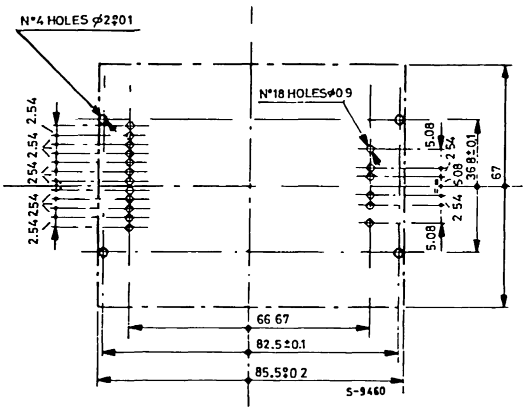
Manufacturer	Part Number	R_{th} (°C/W)	Mounting
Thermalloy	6177	3	Horizontal
Thermalloy	6152	4	Vertical
Thermalloy	6111	10	Vertical
Fischer	SK18	3	Vertical
Assman	V5440	4	Vertical
Assman	V5382	4	Horizontal

MECHANICAL DATA



Dimensions in mm

MOTHER BOARD LAYOUT



SGS-THOMSON
MICROELECTRONICS

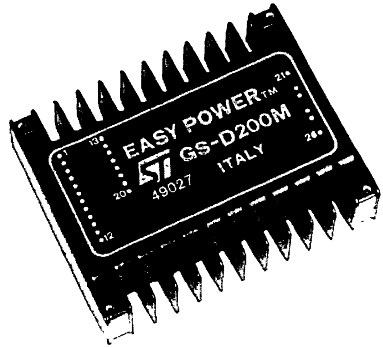
SGS-THOMSON MICROELECTRONICS

GS-D200M

2.5A MICROSTEP DRIVE MODULE FOR STEPPER MOTORS

FEATURES

- Wide supply voltage range (12 to 40V)
- High peak phase current (2.5Apk)
- 1/128 phase current resolution
- Logic signals TTL/CMOS compatible
- Direct interface to microprocessors
- Chopping regulation of the phase current
- Programmable peak motor phase current
- Remote inhibit/enable
- Thermal protection



DESCRIPTION

The GS-D200M is a module specifically designed to drive bipolar stepper motors in the microstep mode.
The unit interfaces the microprocessor as a parallel port and two phase, bipolar, permanent magnet stepper motor.
The phase current (up to 2.5Apk) is controlled in a chopping mode by using a mixed recirculation method that allows the best overall system performance.
The microstep per step rate is determined by the microprocessors software according to the application requirement: the maximum resolution of the phase current is 1/128 of the peak value.
The two phases of the motor are driven by two internal and separate H-bridges made of powerfets to minimize the commutation and conduction losses.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	42	V
V_{SS}	DC Logic Supply Voltage	7	V
T_{stg}	Storage Temperature Range	– 40 to +105	°C
T_{cop}	Operating Case Temperature Range	– 20 to +85	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C and V_S=24V unless otherwise specified)

Symbol	Parameter	Test Conditions	Value			Unit
			Min	Typ	Max	
V_S	DC Supply Voltage		12		40	V
V_{SS}	DC Logic Supply Voltage		4.75	5	5.25	V
I_S	Quiescent Supply Current			20		mA
I_{SS}	Quiescent Logic Supply Current	V_{SS} = 5V		60		mA
I_{ph}	Phase Peak Current				2.5	A
V_{dr}	Voltage Drop	I_{ph} = 2A			2.5	V
V_i	Logic Input Voltage	Low High	 2		0.8 V_{SS}	V
V_o	Logic Output Voltage	Low High	 2		0.8 V_{SS}	V
t_{off}	Recirculation Time			32		µs
D_s	Select and Data to Strobe Set Up Time		100			ns
D_h	Select and Data to Strobe Hold Time		600			ns
Stpw	Strobe Pulse Width		700			ns
Csrt	Data Uptdating Frequency				400	kHz
Rth	Case to Ambient Thermal Resistance			5		°C/W

Figure 1. Signals Timing

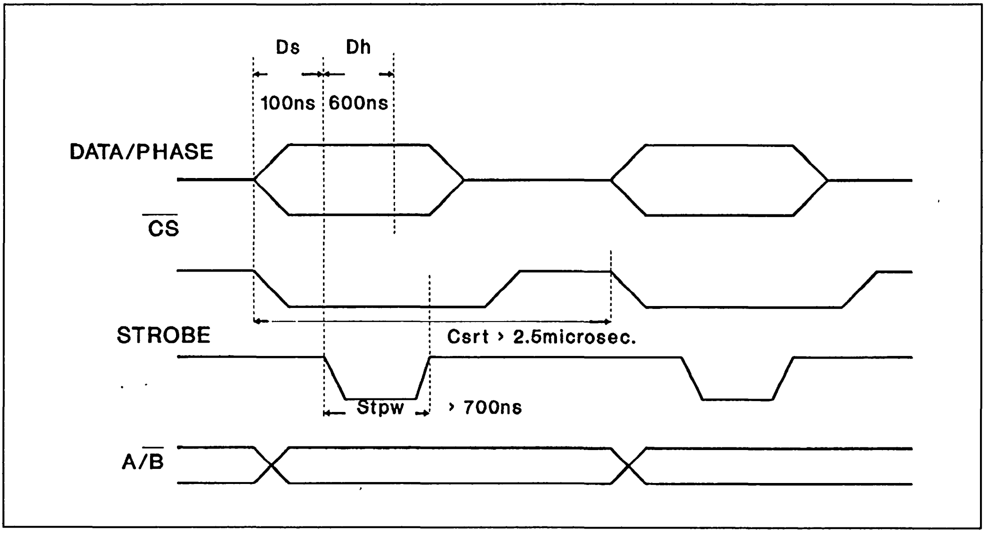


Figure 2. GS-D200M Equivalent Block Diagram

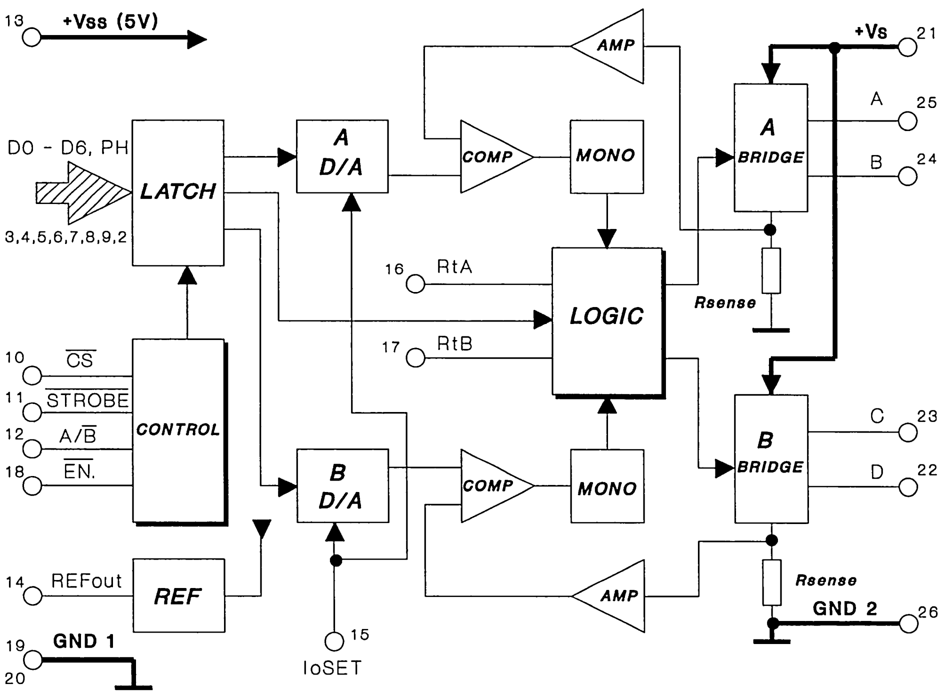
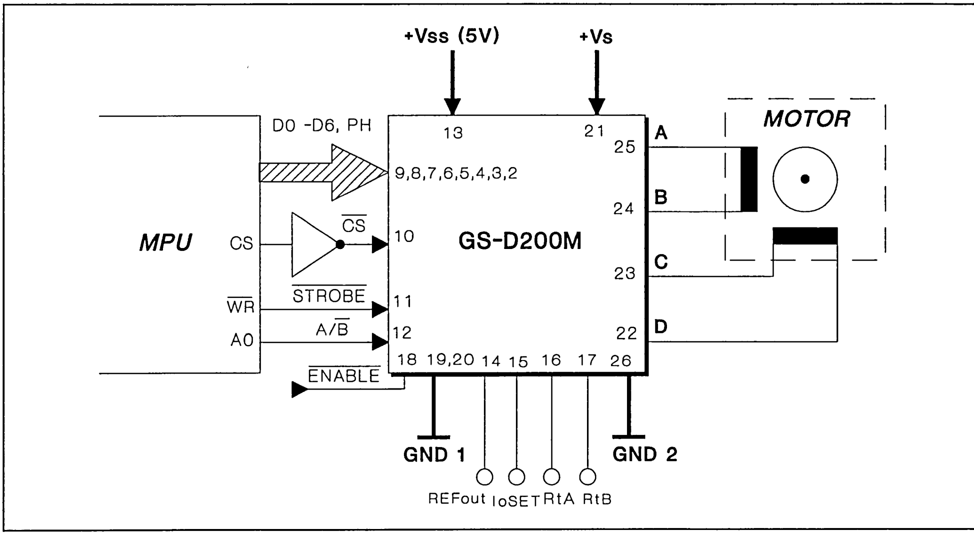


Figure 3. Interfacing the GS-D200M to a Microprocessor and to Stepper Motor.



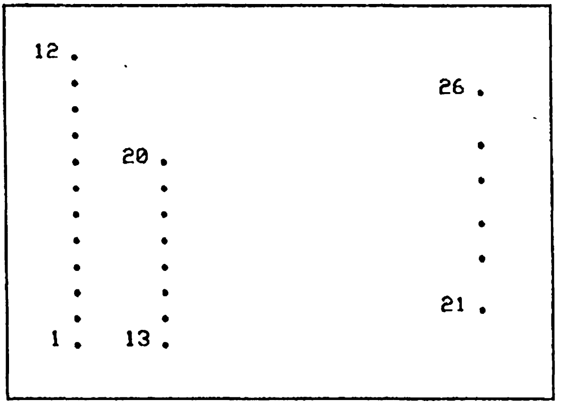
PIN DESCRIPTION

Pin	Function	Description
1	Vss	5V supply input. Maximum voltage must not exceed 7V.
2	Phase	Phase logic information. This input, normally connected to bit7 of the data bus, determines the direction of conduction for the addressed power driver.
3	D6	Data inputs. The value present on these inputs is stored into the addressed DAC latch during the high-to-low transition of the STROBE input.
4	D5	
5	D4	
6	D3	
7	D2	
8	D1	
9	D0	
10	CS	Chip select input. Data can be stored into DAC latches only when CS is low.
11	STROBE	Latches strobe command. The data present on the bus is transferred to the addressed DAC latch on the high-to-low transition of this input.
12	A/B	DAC latch selection input. When high the A DAC is addressed.
13	Vss	5V supply input. Maximum voltage must not exceed 7V.
14	REFout	Reference output. A 2.5V reference voltage is available on this pin for phase current setting.
15	Ioset	Current setting input. A resistor connected between pin 14 and this pin sets the phase current peak value.
16	RtA	Phase A ripple current setting resistor.

PIN DESCRIPTION (Cont'd)

17	RtB	Phase B ripple current setting resistor.
18	DISABLE	Power driver disable logic input. When high or unconnected causes the output power stages to float.
19	GND	Return path for the logic.
20	GND	Return path for the logic.
21	Vs	Module and motor supply voltage. Maximum voltage must not exceed 40V.
22	D	D output. A motor winding is connected between D and C outputs.
23	C	C output. A motor winding is connected between C and D outputs.
24	B	B output. A motor winding is connected between B and A outputs.
25	A	A output. A motor winding is connected between A and B outputs.
26	GND1	Ground path for the motor current.

Figure 4. Connection Diagram (Bottom view)



MICROSTEPPING BASICS

Stepping motors have the advantage to be usable in an open-loop system's architecture that controls speed and positioning.
However, they exibit also two major limitations on achievable resolution and mechanical resonance.
The microstepping mode of operation can pratically eliminate these two limitations.

Resolution Improvement Through Microstepping

Basically, microstepping is achieving finer electrical resolution than is offered by conventional full-step and half-step driving.
A typical and simplified two-phase-on (normal mode) drive of a stepping motor is shown in fig. 5.

Figure 5. Two-Phase-on (Normal mode) Drive.

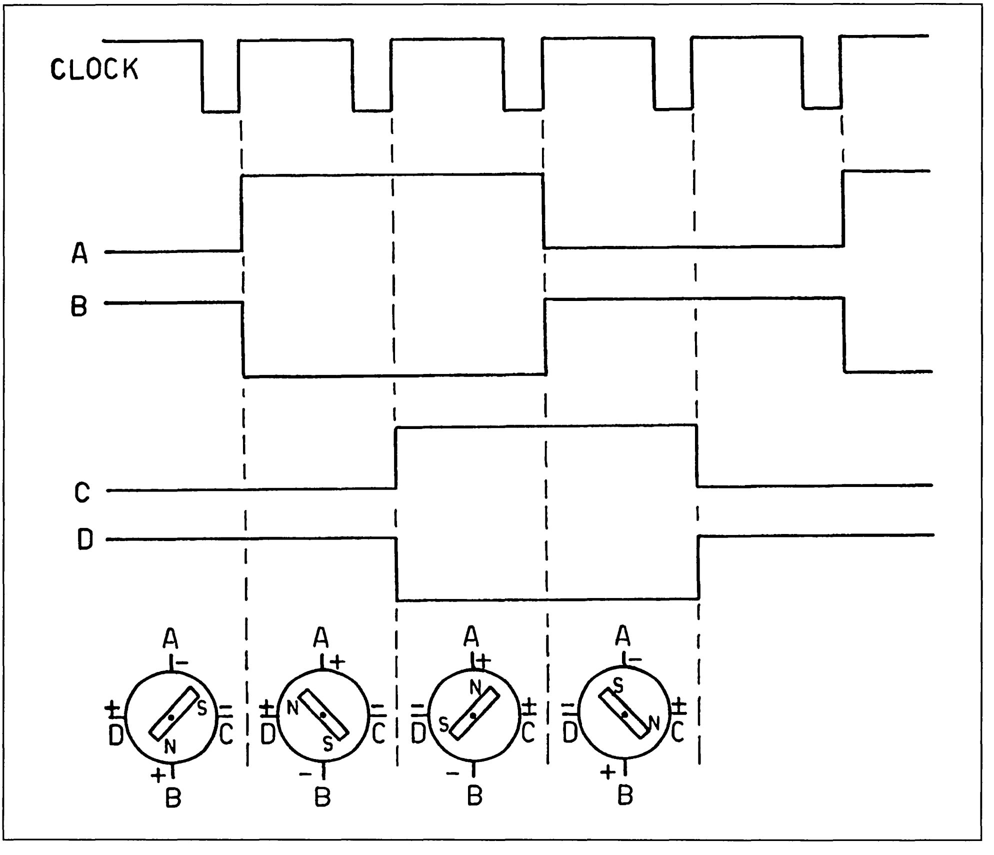


Figure 6. Phase Current for Four Full Step.

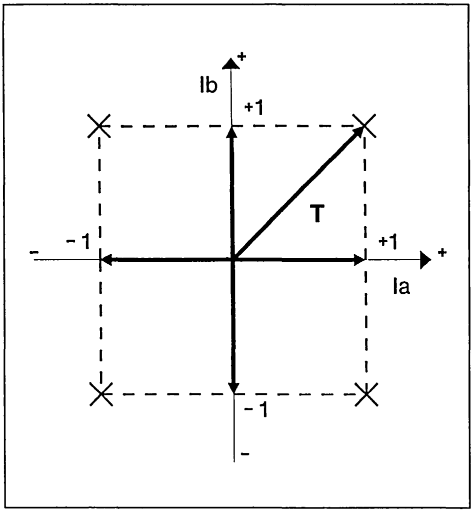
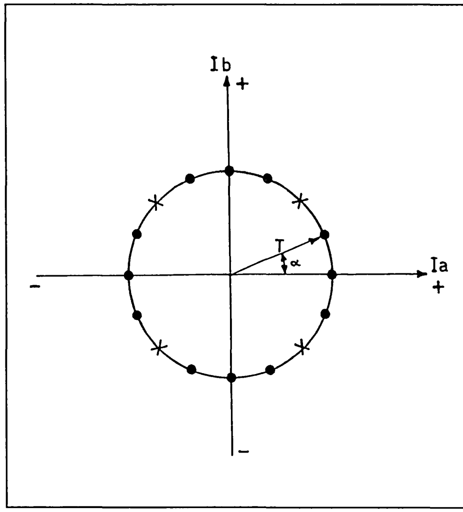


Figure 7. Microstepping



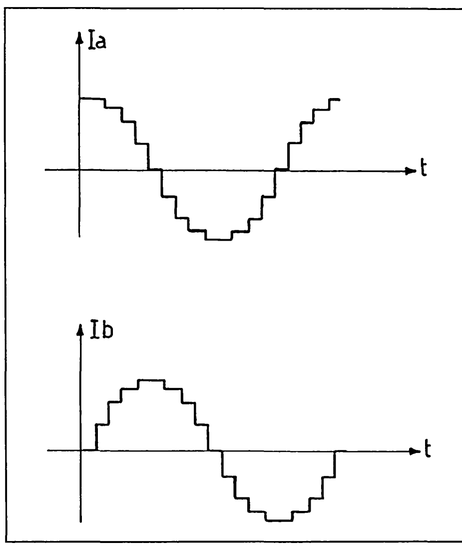
A full cycle (360 electrical degrees) of the driving signals generate exactly four full steps (one torque cycle).
One full step is, therefore, equivalent to 90° of electrical signal.
This is equivalent to have two windings with current I_a and I_b mechanically placed at 90° along x, y, axis as shown in fig. 6. The two currents have discrete values: 0, +1, –1.

The torque T is proportional to the current in the motor winding and the resultant torque is the vector sum of the individual torques produced by phase a and phase b current. The motion direction is determined by the direction of the current flow.
From fig. 6, it is evident that to reduce the mechanical step angle, the torque vector should have more than the 4 position indicated by the crosses.
The ideal situation would be for the resultant torque vector to fall in a unit circle for all positions as shown in fig. 7.

This would occur if the winding current rather than square waves as shown in fig. 5 are orthogonal functions, such as sine and cosine.

In fig. 7 four microsteps/step are shown. The correspondent phase currents are shown in fig. 8.

Figure 8. Phase Current Profile for 4 microsteps/step



Substantially, the microstepping mode is obtained by subdividing each full step into a fixed number of microsteps; this, in turns, is obtained by driving the motor winding with intermediate current levels.

The higher the number of intermediate levels, the closer the torque vector will follow the unity circle of fig. 7. However, the mechanical characteristics of the motor in response to these intermediate levels will make useless a very high number of levels: in the GS-D200M, the maximum number of microsteps/step is fixed at 128.
Real motors have multiple poles pairs to reduce the step angle to a few mechanical degrees for a full step.
Most steppers have resolution of 200 steps/revolution i.e. 1.8° per full step.
The finer electrical resolution obtained by 128 microsteps/step is more than adequate for practical application.

Mechanical Resonance Improvement

Microstepping can help smooth out the mechanical motion of a stepper motor.
Large pulse drive waveforms encountered in full step mode create mechanical forces that may translate into mechanical resonances in a positioning system.

These resonances are also depending on load characteristics and they are difficult to control because of low damping capability of stepper motors.
Resonance may cause loss of synchronization i.e. the motor can skip or gain a step.
Microstepping reduces large current transients and it is beneficial in reducing or eliminating the resonance problem.

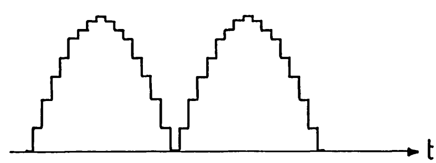
GS-D200M DESCRIPTION

The block diagram of the module is shown in fig. 2.
The GS-D200M implements all the functions needed to achieve intelligent power drive of a stepper motor in a microstep mode.

The two functions, sine and cosine, are digitized, stored in a look-up-table of the external microprocessor and supplied to the module.
The magnitude only of the two signals is sufficient since the software can take into account the sign i.e. the direction.
The typical waveform has the form of a rectified sine wave as shown in fig. 9.

The current waveform can also be modified, via software, to take into account motor resonance and damping.

Figure 9. Digitized, Rectified Sine Wave



The GS-D200M includes two data latches that can be easily interfaced to a microprocessor, either to an I/O port or directly on the data bus of the system. Using these two latches, the microprocessor can indipendently set both the level and the direction of the current flow in each winding of the stepper motor.

In the 8 bit word of the microprocessor, 7 bits can be used to digitize the sine, cosine functions so achieving 128 levels while the Most Significant Bit can be used as a sign bit (direction).
The 7 bits are indicated as D0.....D6 while the MSB is named phase (Ph).

Three additional pins are present on the GS-D200M for the micro data processing. The data of the microprocessor can be stored into the latches just when the Chip Select pin (CS) is low. The data transfer into the selected modules occurs during the high-to-low transition of the STROBE pin.
The proper latch inside the GS-D200M is selected by the A/B pin: when high the A latch is addressed.
The conversion of the digital information in the latch into an analog signal that sets the current level is performed by a couple of 7-bit D/A converters.
The two analog signals, after proper conditioning for current control, drive two H-powerfet bridges that can directly interface the two motor windings.

CURRENT CONTROL INSIDE THE GS-D200M.

The peak current delivered by the H-bridges can be programmed externally up to 2.5Apk max.
To this purpose a resistor must be connected between the pins REF_{out} and I_{oset}. This resistor fixes the current to voltage conversion of the two D/A converters that employ a current switch approach to reach a setting time of less than 2µs.
The value of the current programming resistor is given by:

$$R_i = (3.2/Ipk - 1)\ k\Omega.$$

where Ipk = phase peak current.

The minimum value of Ri is 280Ω that corresponds to the maximum current of 2.5Apk.
The phase current level control of the GS-D200M is achieved by a chopping mode.
The Pulse Width Modulation (PWM) that could be used to achieve a chopping mode can exhibit some stability problems if the switching duty-cycle exceeds 50%.
For this reason the GS-D200M uses Frequency Modulation switching control.
This techniques uses fixed off duration from the moment the output current exceeds the reference level established by the D/A converters.

Referring to the block diagram of fig. 2, the phase current of each bridge is sensed by R_{sense}, amplified and fed to one input of a comparator, being the other input connected to the D/A output.
When the phase current exceeds the level fixed by the D/A, a monostable pulse generator is triggered by the comparator and it disables the H-bridge for a time duration of 32µs that is fixed inside the module. During the off-time the current decays. At the end of the off-time, a new cycle is started, the H-bridge is enabled again and the phase current starts to rise again according to the L/R time constant of the motor winding. The on-time depends on the supply voltage, the L/R constant and the Electromotive force of the motor.
Therefore the total time (on+off) is never constant and the switching frequency is self adapting to the dynamic behaviour requested by microstepping.

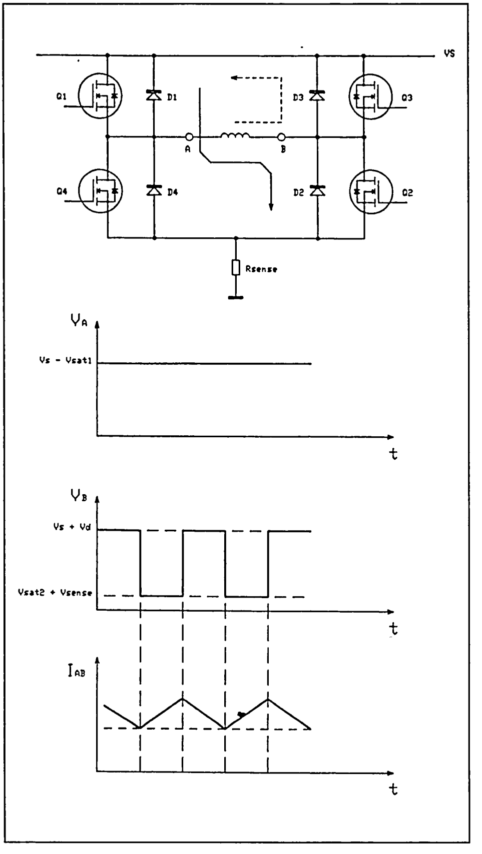
The amount of current decay during the fixed off-time depends on the method used to recirculate the current: slow or fast.

The method for slow decay is shown in fig. 10. During the on-time both Q1 and Q2 are on. The total voltage V_{AB} applied to the winding is:

$$(V_S - V_{sat1}) - (V_{sat2} + V_{sense})$$

where V_S = supply voltage, V_{sat1} = saturation voltage of Q1, V_{sat2} = saturation voltage of Q2, V_{sense} = voltage drop on the sensing resistor.
The current flow is indicated by the solid line of fig. 10.

Figure 10. Chopper Control with Slow Decay

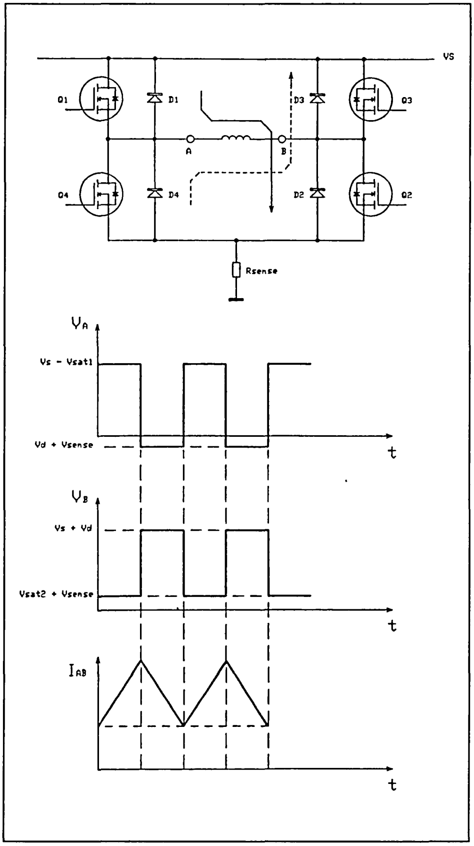


If, during the off-time, Q2 is switched off, the current stored in the winding will flow through D_3 (see dotted line of fig. 10) and V_B will raise the V_S+V_d being V_d the voltage drop of D_3.
The total voltage applied to the winding during the off-time is, therefore, $V_{sat1}+V_d$ and the current decay is slow. The method for fast decay is shown in fig. 11.

During the on-time both Q1 and Q2 are ON as in the previous case.
During the off-time both Q1 and Q2 are switched OFF and the current flows through D_4 and D_3 (dotted line of fig. 11).
During the off-time the voltage applied to the winding is:

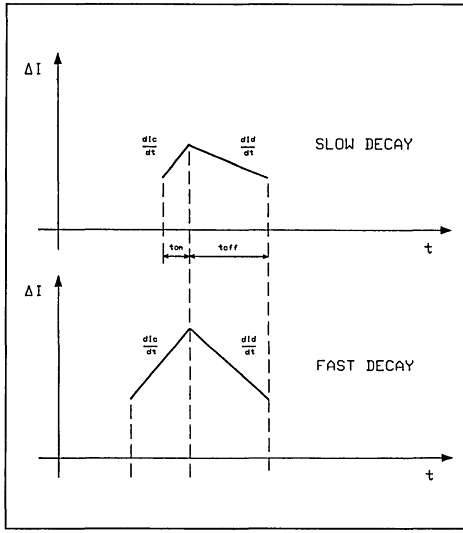
$$(V_S + V_d) - (V_d + V_{sense})$$

Figure 11. Chopper Control with Fast Decay



If the V_d and V_{sense} are negligible compared to V_s, the slope of the current decay is practically equal to the slope of the current rise during the on-time.
The decay can be very fast depending on the value of V_s, R, L and EMF.
Both methods (slow, fast decays) have advantages and disadvantages.
The disadvantage of the fast decay is a higher ripple current due to the chopping action.
The disadvantage of slow decay is the reduced on-time.
In steady state conditions, the amount of decay during off-time is equal to the amount of current rise during the on-time.
Fig. 12 shows a qualitative behaviour of the ripple current in the two cases.
During the off-time the slope dI_d/dt are different because of the different voltage applied to the winding during recirculation.

Figure 12. On-time for Slow and Fast Decay



During the on-time the slope dI_c/dt is the same on both the cases. Being the ripple lower in the slow decay, it takes a shorter time during the on-phase to reach the peak current.

In some application where there is a low back EMF, as it will occur when trying to hold a position and V_{emf} becomes zero, or high supply voltage, the minimum achievable on-time for a slow decay can set a current level that is above the desired current set by the D/A converter.

For a given minimum average phase current I_m, the dutycycle (t_{on}/t = D) is given by the following formula:

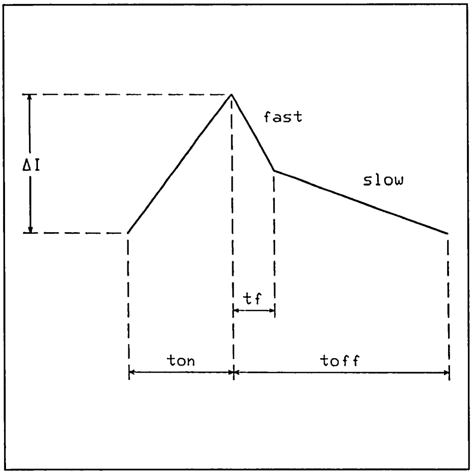
$$I_m = \frac{(V_s - V_{sat1})\,D + (D-1)\,V_d - V_{emf} - V_{sat2} - V_{rsense}}{R_{motor} + R_{sense}}$$

If I_m is very low, D may be prevented to be very low by various delays, etc.
To overcome these problems and to add flexibility to the GS-D200M a mixed decay (recirculation) method as been adopted.

During the off-time, initially a fast decay is imposed on the phase current. The off-time is then completed by a slow decay.
The ripple current behaviour is shown in fig. 13.

An internal monostable is triggered when the current reaches the peak current.
This monostable switches off both Q1 and Q2 (see fig. 11) so forcing a fast decay for a time t_f.

Figure 13. Mixed Decay Method



After t_f, Q1 is turned on again to complete the off-time in a slow mode.

The fast decay time t_f can be programmed by two resistor connected between the R_{tA} and R_{tB} pins to V_{SS} (+5V).
The value of these resistors is given by:

$$R_{tA}, R_{tB} = \left(\frac{t_f}{0.7} - 0.1 \right) k\Omega$$

where t_f is in microseconds.

The GS-D200M User is therefore free to select the proper current ripple value that best fits to his/her needs.

USER NOTES

GS-D200M - DAC Operation

GS-D200M has two internal DACs used to set the current in phase AB and in phase CD. The internal DACs are named A and B:

- DAC A set the current in phase CD (pins 23,22)
- DAC B set the current in phase AB (pins 25,24).

To load a digital word, present on D0 - D6 inputs, on DAC A you have to:

- set D0 - D6 inputs, on DAC A (D0 is LSB)
- set input A/B to logic level high
- set CS input to logic level low
- give a STROBE signal.

The digital word set the current at a value given by the relation:

$$I_{out} = I_{pk} \times \frac{N}{127}$$

where N is the digital value (0 to 127) and Ipk is the maximum current set by means the resistor Ri with the relation:

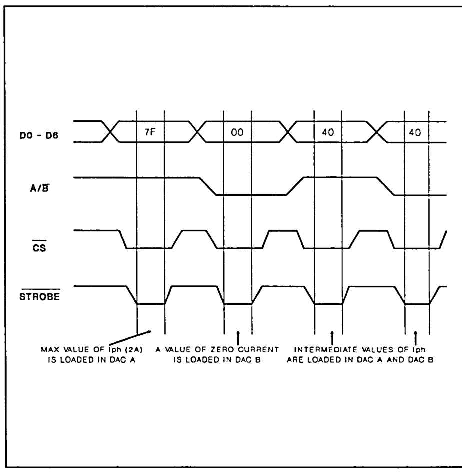
$$Ri = \frac{3.2}{I_{pk}} - 1 (k\Omega)$$

This means:

- if D0 -D6 are all zeros the phase current is 0 (zero)
- if D0 - D6 are all ones the phase current is the maximum value set by Ri
- other combinations on D0 - D6 give a phase current proportional to the digital value.

Example: Iph= 2A, Ri= 0.6kΩ

Figure 14.

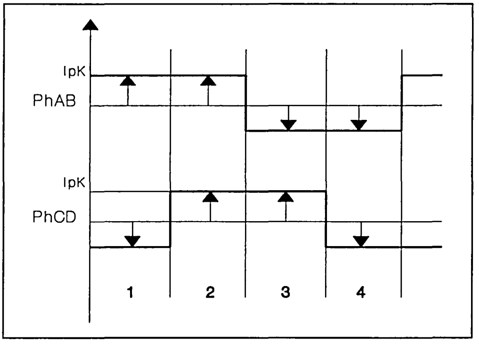


Phase Input (pin 2)

This pin is used to set the direction of the current in the addressed power driver. Usually this pin is connected to the data bus pin named D7. When this input is at logical high level, the current flows from B to A (phase AB) and from C to D (phase CD); when it is at logical low level the current flows from A to B (phase AB) and from D to C (phase CD).

Example: suppose to simulate a full-step moving. The current waveforms present on the phase outputs are shown in fig. 15.

Figure 15.



The arrows show the direction of the current in the phases:

- when phase (D7) = 1

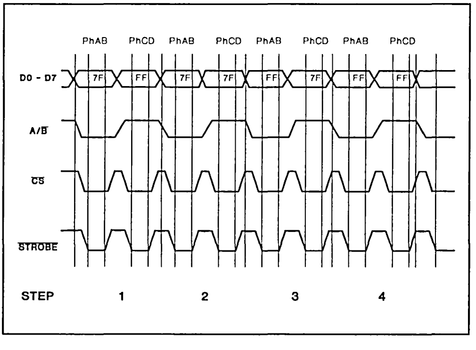
- when phase (D7) = 0

As you can see, the current changes from the maximum value in one way to the maximum value in the opposite way: so the digital inputs D0-D6 will be always at logic level high (7F).

The sequence the user has to load to have the full step mode is:

step	Ph AB			Ph CD		
	D7	D6-D0	D7-D0	D7	D6-D0	D7-D0
1	0	7F	7F	1	7F	FF
2	0	7F	7F	0	7F	7F
3	1	7F	7F	0	7F	7F
4	1	7F	7F	1	7F	FF

Figure 16.



GS-D200M Inhibit/Enable

One pin (DISABLE) is provided to put the two H-bridges in a floating mode.
To operate the GS-D200M this pin must be pulled down.

Supply Voltage

The recommended operating maximum supply voltage V_S is 40V inclusive of the ripple voltage, while for V_{SS} the voltage is 5V±5%.
The two supply voltages must be correctly sequenced to avoid erroneous conditions of the power stages.

The power-up and power-down sequences are:

Power-up
1) V_{SS} (5V) is applied with Disable = High
2) V_S (the motor supply voltage) is applied
3) After 50 ms (power-on reset time) the phase current level can be programmed to the proper level
4) Disable input is brougth low.

Power-down
1) Disable is brougth High
2) V_S is switched off
3) V_{SS} is switched off.

Case Grounding

The module case is internally connected to pin 19, 20 and 26. To obtain an effective EMI shield, the PCB area below the module can be used as a sixth side shield.

Thermal Characteristics

The case-to-ambient thermal resistance of the module is 5°C/W. This produces a 50°C temperature increase of the module surface for a 10W of internal power dissipation. According to ambient temperature and/or to power dissipation, an additional heatsink or forced ventilation may be required.

Supply Line Impedance

The module has an internal capacitor connected accross the supply pins to assure the circuit stability. This capacitor cannot handle large values of high frequency ripple current, and it is permanently damaged if the primary voltage source impedance is not adequate.

The use of a low ESR, high ripple current 470µF capacitor located as close to the module as possible is recommended. Suitable capacitors should have a RMS current capability of 2.5 A_{RMS} with a working voltage of 50 V_{DC} and an ESR of 0,1Ω at 100 kHz. When space is a limit, a 22µF ceramic multilayer capacitor connected across the module input pins must be used.

Module Protection

The GS-D200M outputs are protected against occasional and permanent short circuits of the output pins to the supply voltage.
The thermal protection is activated when, for any reason, the internal junction temperature reaches 150°C. The unit restarts to operate as soon as the junction temperature falls below 130°C.

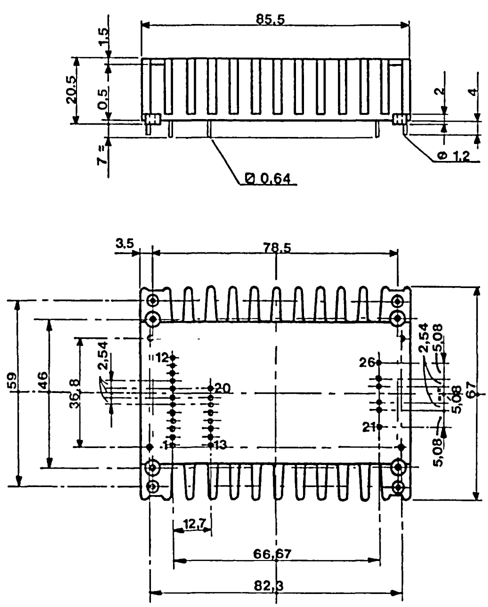
Motor Connection

The motor is usually quite far from the module and long cables are needed to connect the two. The use of a twisted pair cable with appropriate cross section for each motor phase is recommended to minimize DC losses and RFI problems.

Unused Inputs

All the GS-D200M logic inputs, excluding the databus, have a resistive pull-up, and they are in a high logic state when unconnected.

CONNECTION DIAGRAM AND MECHANICAL DATA



Dimensions in mm

Bottom view

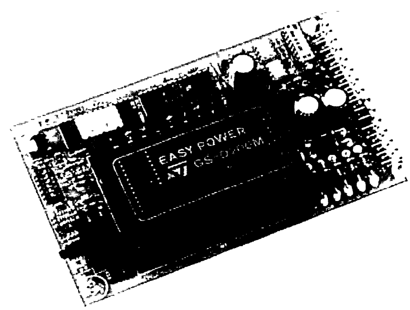
SGS-THOMSON
MICROELECTRONICS

GS-D250M

2.5A MICROSTEP DRIVE BOARD FOR STEPPER MOTORS

FEATURES

- 2.5A/phase peak current
- 5, 10, 25, 45, 90, 100, 127, microsteps/step selection
- Full step selection possibility
- User programmable phase current
- User programmable phase current ripple
- Automatic ripple reduction at rest
- 4/8 wires motor drive
- Step clock in excess of 200kHz
- Single unregulated supply voltage
- TTL, 12V, 24V programmable input level
- Input signal galvanic isolation
- Thermal protection



DESCRIPTION

The GS-D250M is a single-Europe board for microstepping drive of 4/8 wires stepping motors.
Thanks to a very large number of embedded functions, the interfaces to the external environment are reduced to a minimum: just three commands are needed as inputs (step clock, direction, enable) and the outputs can drive directly the stepping motor windings.
The availability of user's selectable hardware allows a very high flexibility to meet all possible application needs.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	42	V
I_i	Logic Input Current	30	mA
I_o	Logic Output Current	10	mA
T_{stg}	Storage Temperature Range	– 20 to +85	°C
T_{hop}	Max Operating Heatsink Temperature (GS-D200M)*	+85	°C

* Thermal protection intervention @ T_h 90°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C and V_S=24V unless otherwise specified)

	Parameter	Min	Typ	Max	Unit
V_S	DC Supply Voltage	12		40	V
I_i	Logic Input Current**		10		mA
V_O	Logic Output Voltage (TTL compatible) Low High	 2	 2	0.8 5	V
I_{ph}	Phase Peak Current*		0.5	2.5	Apk
f_C	Clock Pulse Frequency			140	kHz
V_{is}	Isolation Voltage	500			Vdc

Note: The unit requires an input filtering capacitor 4700µF/50V, with low ESRand located as close as possible to the board

* Output shorts protection phase-to-phase and phase-to-supply
** TLL, 12V, 24V Programmable input voltage level.

Figure 1. Signal Timing

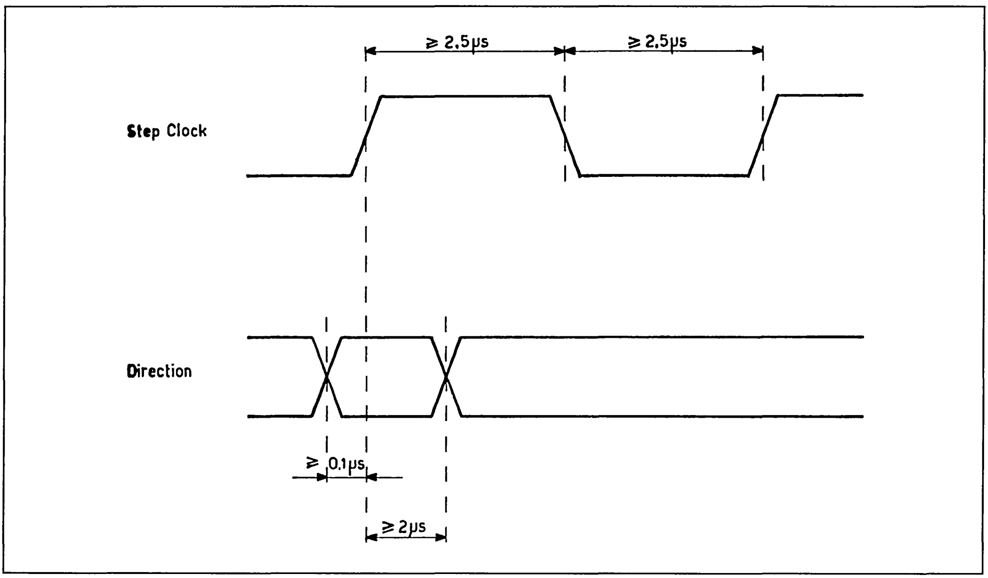
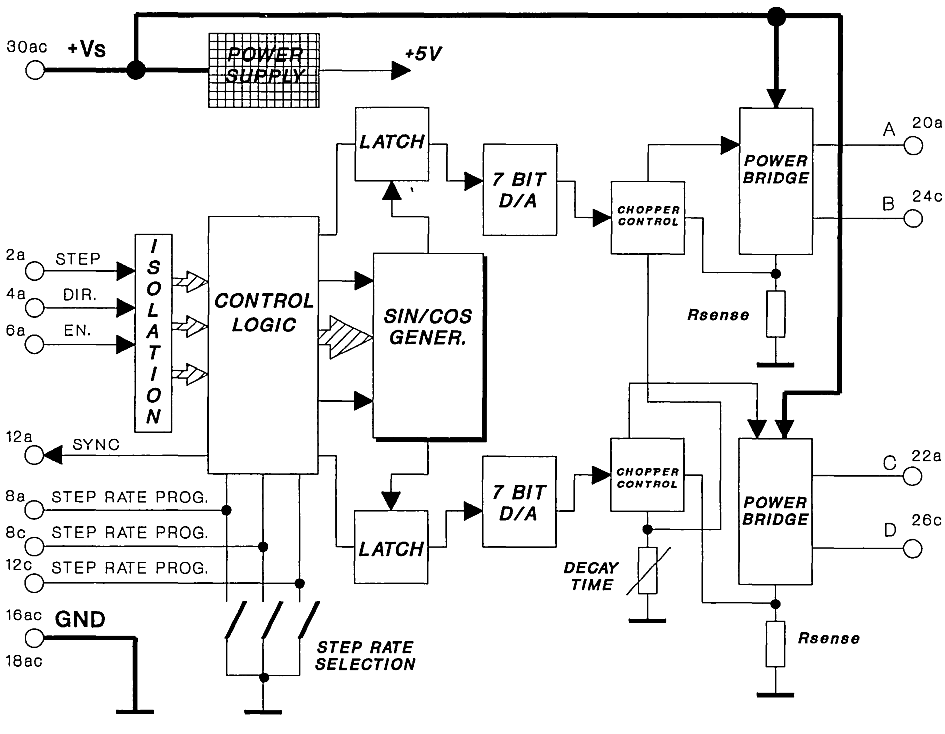
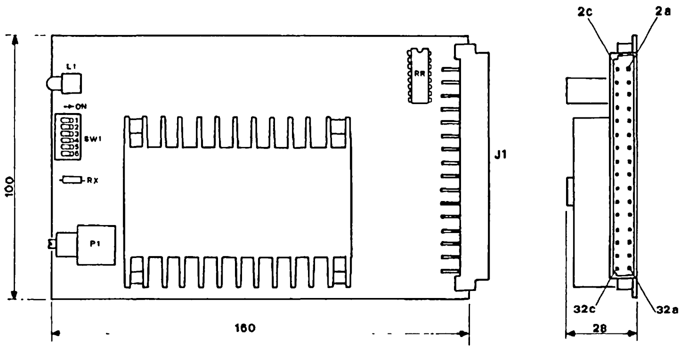


Figure 2. GS-D250M Block Diagram



CONNECTION DIAGRAM AND MECHANICAL DATA



Dimensions in mm

GS-D250M BUS CONNECTOR PINS DESCRIPTION

The GS-D250M uses a 32 pins (16+16) DIN 41612 - VG95324 male connector

Row a	Pin	Row c
Step pulse input	2	Step pulse return
Direction input	4	Direction return
Disable input	6	Disable return
Microsteps/step programming	8	Microsteps/step programming
Not used	10	Not used
Sync Output	12	Microsteps/step programming
Not used	14	Not used
Supply ground	16	Supply ground
Supply ground	18	Supply ground
Phase A output	20	Not used
Phase C output	22	Not used
Not used	24	Phase B output
Not used	26	Phase D output
Not used	28	Not used
Supply voltage	30	Supply voltage
Not used	32	Not used

GS-D250M hardware available commands.

SW1, SW2, SW3	Microsteps/step programming
SW4	Selection of step clock transition
SW5	Direction polarity selection
SW6	Current ripple reduction at rest
Rx	Maximum peak current setting
P1	Phase current ripple programming
RR	Resistor array for logic level setting

GS-D250M DESCRIPTION

The GS-D250M single-Europe board has been designed by taking into account the maximum semplicity and flexibility in use.
It is based around the GS-D200M (microstep drive module, see the relevant data sheet) and it implements all the functions needed for a microstepping signal generation, so reducing the burden of external microprocessors, and the power stage to drive the stepper motor windings.
In its simplest application, the GS-D250M needs just three commands inputs: step clock, direction, disable.
Because this extreme semplicity could prevent the adaptability to different types of application, hardware selectable options are offered to the user to best program the board to his/her needs.
The various functions are described in the following.

Supply Voltage

The supply voltage can have any value between 12V and 40V maximum. No well regulated DC voltage is needed.
The supply voltage must be connected between pins 30a, 30c (positive rail) and 16a, 16c, 18a, 18c (negative rail).
The GS-D250M is permanently damaged by a supply voltage larger than 42V. The recommended maximum supply voltage is 40V.

During the phase current control by chopping method, the phase current is returned to supply voltage at each fast recirculation period. These current pulses can bring the supply voltage well above the recommended 40V max if the output impedance of the power supply feeding the GS-D250M is not adequately low.
A 1000µF/50V capacitor with low ESR at high frequency should be connected as close as possible to the supply voltage pins to provide a low impedance path for the recirculating current pulses.

An internal step-down switch mode regulator provides the 5V/± 5% requested by the internal logic blocks and it provides an automatic reset at POWER ON.
The POWER ON is indicated by on LED available of the front edge of the board.

Microstep Programming

The microsteps/step can be programmed by the user.
The digitized sine and cosine functions required for a microstepping control are stored in Lock-Up-Table inside the board. The user has two options to select the adequate number of microsteps/step.

Microstep programming by hardware

Three switches (SW1, SW2, SW3) are available on the front edge of the board.
The following table defines the microsteps/step rate.

SW1	SW2	SW3	Microsteps/step
OFF	OFF	OFF	127
ON	OFF	OFF	100
OFF	ON	OFF	90
ON	ON	OFF	45
OFF	OFF	ON	25
ON	OFF	ON	10
OFF	ON	ON	5
ON	ON	ON	1

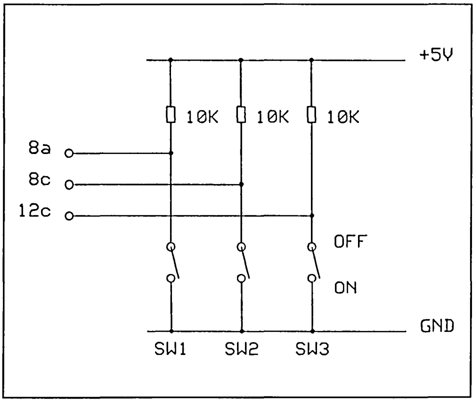
The last condition defines a full step operation of the board.
The switches are in the OFF condition when the knob is pulled versus the board edge.

Microstep programming by microprocessor software

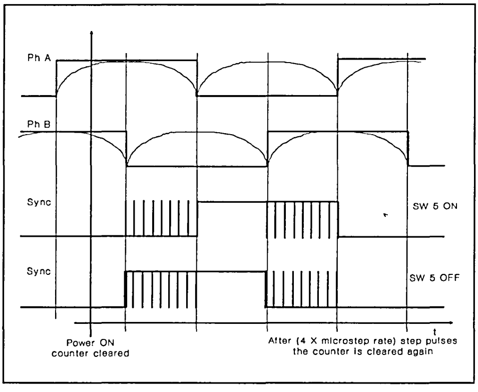
The microsteps/step rate can also be changed on-the-fly by using the three logic inputs available on the bus connector (pin 8a, 8c, 12c).
These pins correspond, respectively, to SW1, SW2, SW3.
If the selection is performed remotely, the switches SW1, SW2, SW3 must be in the OFF position.

Fig. 3 clarifies the interaction between internal switches and external command signals.

Figure 3. Remote Microstepping Programming



The remote change from one rate to another cannot be implemented asynchronously by it must be forced only when the phase currents are respectively at 45 electrical degrees.
That corresponds to have the internal microstep counter to zero.
This counter is zeroed at power on and then cleared again at every (4 x microstep rate) step pulses.



To change the pulses ratio:

- The system controlling GS-D250M must take in count the pulses
- Every 4 x microstep rate pulses respect to the power on it can change the microstep rate
- The changing must take place more than 5 microseconds after the active edge of the clock pulse and before the next step pulse.

Setting of the Active Step Clock Transition

The step clock applied between pins 2a and 2c can be active i.e. advancing the motor by one step on the rising or falling edge of the clock pulse.
The user can select the proper transition condition by setting the SW4 switch according to the following table:

SW4	TRANSITION
ON	Low-to-high active step clock transition
OFF	High-to-low active step clock transition.

Setting of the Direction Polarity

The rotation direction signal must be applied between pin 4a and 4c. To add flexibility to the GS-D250M board the proper direction signal is combined with the position of an internal switch (SW5) according to the following table:

DIR SIGNAL	SW5	ROTATION
HIGH	ON	CCW
HIGH	OFF	CW
LOW	ON	CW
LOW	OFF	CCW

Phase Current Programming

The GS-D250M can be used to drive 4 wires motors or 8 wires motors. The phase peak current level can be programmed by a resistor according to the following formula:

$$R_X = \frac{3.2}{I_{pk}} - 1 \quad (k\Omega)$$

where I_{pk} is expressed in Amperes.
The factory setting is for a peak current of 1.6A.
The user can replace R_X (located close to the front edge of the board) by a new resistor according to the desired current level. The minimum value of R_X is 270Ω that corresponds to I_{pk} = 2.5A.

Phase Current Ripple Programming

The phase current control is performed by a chopping method with fixed off-time (about 32μs).
Therefore the chopping uses Frequency Modulation to keep the phase current at a desired level.
Being the off-time fixed, the amount of current decay i.e. of current ripple depends on the supply voltage, the back EMF, the L/R constant of the motor and on the method used for current recirculation (fast or slow, see the GS-D200M data sheet).

The GS-D250M board uses a mixed recirculation method:
fast recirculation for a time t_f, slow recirculation for the remaining period ($t_{off} - t_f$) of the off-time.
The time t_f and, therefore, the amount of phase

current ripple can be adjusted by the proper setting of the potentiometer P1 provided on the front edge of the board.

Current ripple programming allows the optimization of the electromechanical characteristics of the system and the reduction of power dissipation inside the motor.

To further improve the performance of the GS-D250M board, the current ripple can be automatically reduced at rest.
The user can select this option by setting the switch SW6 in the ON position. When SW6 is OFF this feature is eliminated and normal operation restored.

Input Commands

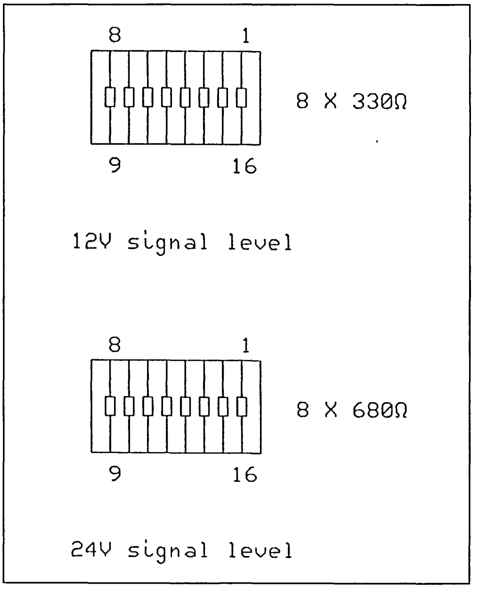
In the most straightforward application the GS-D250M board needs just three commands: step clock, direction, disable.
The module is disable when pin 6a is at high level.
To reduce the noise sensitivity, the three signals are applied to the board through internal optocouplers.
The pins 8a, 8c, 12c (optional commands for remote microsteps/step programming) are not galvanically isolated.
The signal level can have TTL compatibility (factory setted) or voltage levels of 12V or 24V, by changing the resistor array RR as shown in fig. 4.

Environmental Data

The GS-D250M board uses powerfet transistors in the two H-bridges that drive the motor windings.
This allows reduced conduction and switching power dissipation inside the GS-D200M.

Nevertheless, according to the application and to the ambient temperature, the GS-D200M case temperature can eventually increase to above 85°C. In such a case, cooling by forced ventilation is needed.

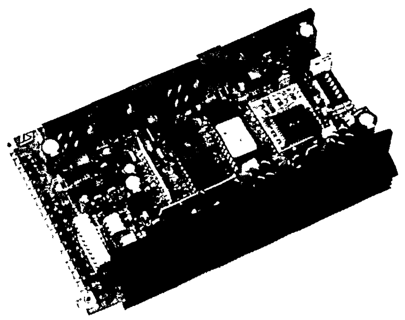
Figure 4. Input Signal Level Programming



5.6A MICROSTEP DRIVE BOARD FOR STEPPER MOTOR

FEATURES

- 5.6A/phase peak current
- 5, 10, 25, 45, 90, 100, 127 microsteps/step
- Full step operation
- User selectable phase current
- Automatic two quadrant chopping at rest
- Programmable phase current ripple
- 4/8 wires motors drive
- Galvanic isolation
- Full output protection against short circuits
- Thermal, under and overvoltage protection
- Step clock in excess of 140kHz
- Isolated Fault output



DESCRIPTION

The GS-D350M is a member of the SGS-THOMSON family of stepper motor drive modules and boards. It drives the 4/8 wires motor in a microstep mode thus assuring smooth and resonance free operations. On top of that it offers an unusually large number of features that allow a complete control of the electromechanical characteristics of the motion system to obtain optimum performance.
The powermos output stages offer both low conduction and commutation losses for increased efficiency; this, combined with an exclusive protection scheme, results in an extremely rugged unit suitable for harsh environment operation.
The GS-D350M single-Europe board is the simplest and most cost effective solution to any stepper motor drive requirements, thanks to the high number of embedded extra features.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	42	V
Iph	Output Current per Bridge	3.3	Apk
Idis	Supply Bus Discharge Current	4	A
I_i	Logic Input Current	30	mA
I_o	Logic Output Current	10	mA
V_{is}	Logic to Supply Isolation Voltage	500	V
Tstg	Storage Temperature Range	– 20 to +85	°C
Thop	Max Operating Heatsink Temperature*	+85	°C

* Thermal protection intervention @ Th > 90°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ and V_s=24V unless otherwise specified)

Symbol	Parameter	Min	Typ	Max	Unit
V_S	DC Supply Voltage	18		40	V
I_{ph}	Phase Current per Output*	0.5		2.8	A
I_i	Logic Input Current**		10		mA
V_O	Logic Output Voltage (TTL compatible) Low High	 2		0.8 5	V
fc	Clock pulse frequency			140	kHz

* Output shorts protection phase-to-phase, phase-to-supply and phase-to-ground.
** TTL, 12V, 24V Programmable input voltage level.

Note: The unit requires an input filtering capacitor 4700µF/50V, with low ESR and located as close as possible to the board.

Figure 1. Signals Timing

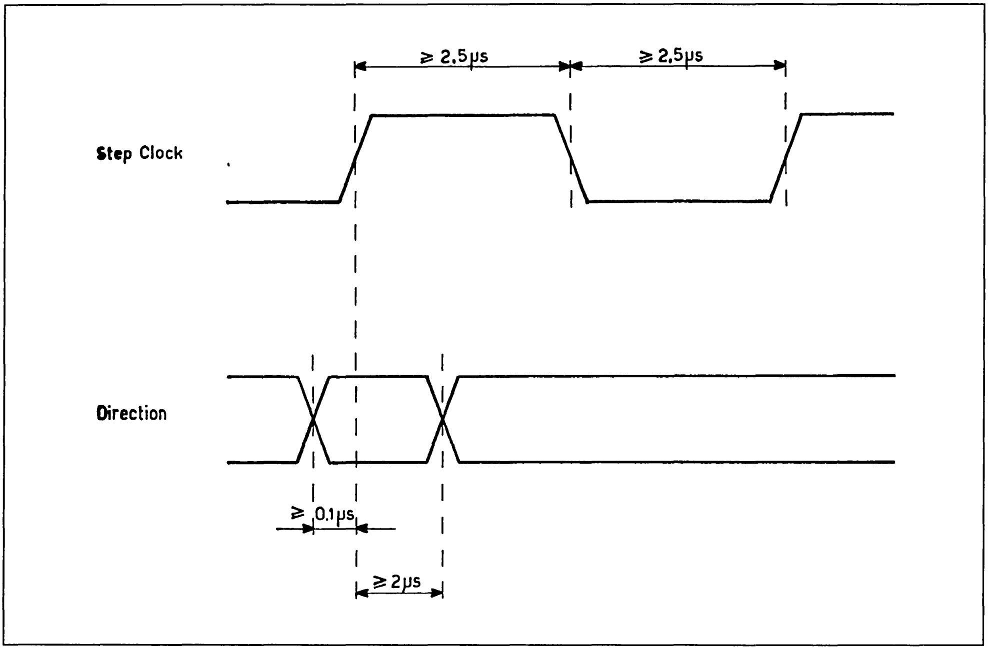
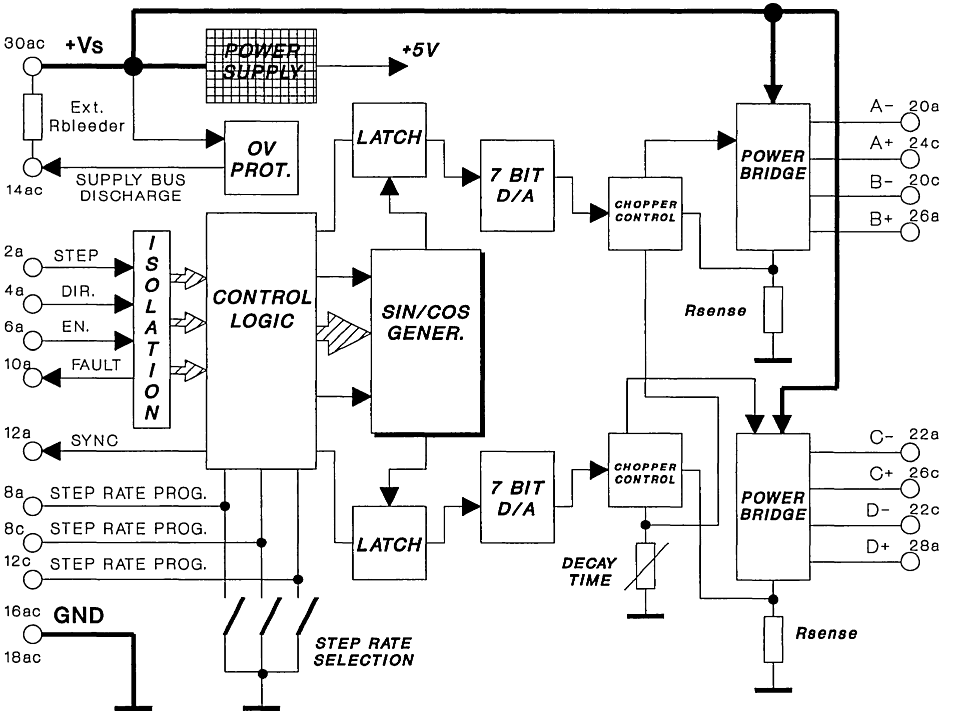
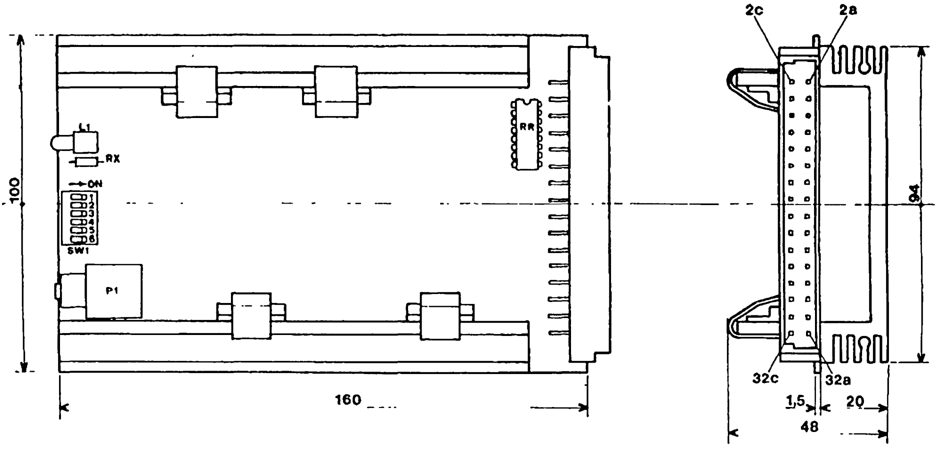


Figure 2. GS-D350M Block Diagram



CONNECTION DIAGRAM AND MECHANICAL DATA



Dimension in mm

GS-D350M Hardware available commands

SW1, SW2, SW3	Microsteps/step programming
SW4	Step clock transition selection
SW5	Direction polarity selection
SW6	Current ripple reduction at rest
R_X	Maximum peak current setting
P_1	Phase current ripple programming
RR	Resistor array for logic level setting

GS-D350M BUS CONNECTOR PINS DESCRIPTION

The GS-D350M uses a 32 pins (16+16) DIN 41612-VG95324 male connector.

Pin	Function
2a	Step clock input: this is a logic input that performs the step function, i.e. on every transition of this input the motor is moved one step in the proper direction. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
2c	Return path for the Step clock input.
4a	Direction input; the logic state applied to this pin decides the rotation direction of the motor shaft. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
4c	Return path for the Direction input.
6a	Enable input; a logic high level applied to this input causes the power driver outputs to float. This condition allows the manual positioning of the system. Care must be used when this input is activated because the detention torque is lost. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
6c	Return path for the Enable input.
8a	Microsteps/step rate remote programming
8c	Microsteps/step rate remote programming
10a	Fault logic output. This isolated output is at a low logic level whenever an anomalous condition is detected. The output is open collector, i.e. a pull-up resistor is required.
10c	Fault output return path. Must be connected to the driven logic ground.
12a	Synchronization signal for Microsteps/step logic programming.
12c	Microsteps/step rate remote programming.
14a-c	Supply bus discharge output; this output is activated when an overvoltage condition is detected. A resistive load connected between this pin and the supply bus can be used to sink power to limit the maximum supply voltage to safe conditions.
16a-c	Power supply ground
18a-c	Power supply ground
20a	Phase A– output.
20c	Phase B– output.
22a	Phase C– output.
22c	Phase D– output.
24c	Phase A+ output.
26a	Phase B+ output.
26c	Phase C+ output.
28a	Phase D+ output.
30a-c	Module supply voltage; hazardous voltages may be present on these pins.

GS-D350M DESCRIPTION

The GS-D350M is a complete subsystem to drive stepper motors either in full step or microstep mode. A very large number of auxiliary functions has been included to allow extreme simplicity and flexibility in use.

Particular care has been devoted to protections, so that the GS-D350M can be safely used in very harsh environments. In addition to the obvious function to drive the motor phases in a chopping mode, the following functions have been implemented:

- Sine/cosine generation
- Selection of seven different microsteps/step rates
- Selection of full step drive
- Programming of peak phase current to optimize the torque
- Automatic phase current ripple reduction at rest
- Full protection against short circuits between phase-to-phase, phase-to-ground and phase-to-supply
- Thermal, undervoltage, overvoltage protection
- Galvanic isolation of input signals and of fault indication output
- On board auxiliary voltages generation.

As a result, the GS-D350M can provide up to 5.6A per phase and, in its simplest application, just three command signals are required: step clock, direction, enable.

SUPPLY VOLTAGE

A single, unregulated supply voltage is requested to operate the board.

THE POWER SUPPLY MUST BE TURNED OFF WHEN PLUGGING OR UNPLUGGING THE BOARD.

The supply pins are: 30a, 30c positive rail
16a, 16c, 18a, 18c ground rail.

The other supply voltages needed by the board are internally generated by a high efficiency step-down switch mode regulator that provides also the subsystem reset at power on. The supply voltage range is between 18V and 42V: it is recommended to operate the board at a maximum voltage of 40V. If an undervoltage condition is detected ($V_s < 18V$) the GS-D350M is automatically disabled and an LED is activated.

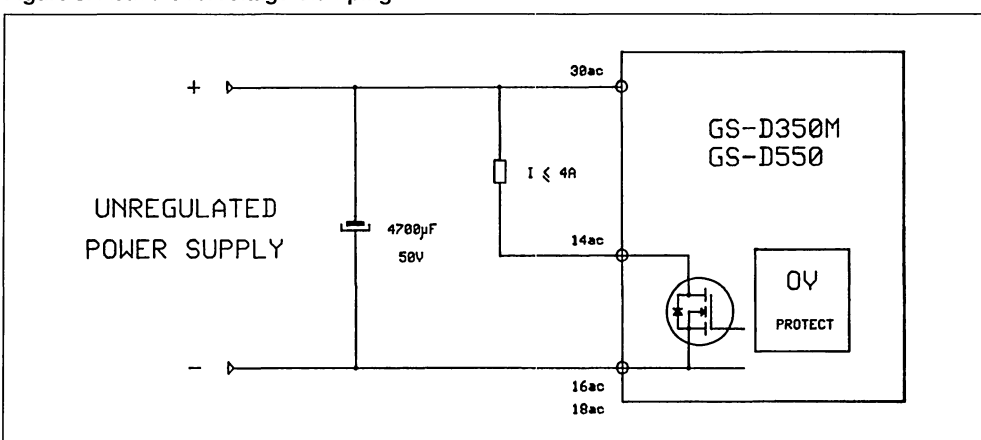
If a voltage above 42V is applied to the board, the following features are activated:

- An LED is turned on.
- An automatic overvoltage active clamping is turned on.

The active clamping system is implemented as shown in fig. 3.
The active overvoltage clamping is mainly intended to clamp transient overvoltages.

In case of permanent overvoltage, excessive power dissipation can occur. Therefore, if the supply voltage is derived from a rectified and filtered secondary winding of a main transformer, this voltage at no load and at maximum main AC voltage must be lower than 42V (50/60 Hz ripple included). Overvoltages may occur during fast deceleration because of transient spikes on the AC main supply during very fast deceleration cycles and when the output bridges are in the fast decay recirculation mode.

Figure 3. Active Overvoltage Clamping



During this mode, the phase current pulses are returned to the supply voltage: if the supply voltage impedance is not adequately low, the current pulse can raise the voltage well above the nominal level.

To avoid that the overvoltage clamping is activated at a chopping mode switching frequency, a 4700µF/50V capacitor must be connected as close as possible to the supply pins.
The ESR of the capacitor at the switching frequency (about 20÷30 kHz) must be very low.

The power rating of the external bleeder resistor can range from 10 to 50W depending on AC main supply condition (overvoltage transients frequency). The resistor must be of a low inductance type to allow fast discharge of the bus voltage.

This value varies according to the operating conditions, but in first approximation it can be calculated according to the following formula:

$$R_{bleeder} \geq \frac{V_S}{4} \, [\Omega]$$

This is the minimum usable value.

MICROSTEP PROGRAMMING

The number of microsteps per step is field programmable. The digitized sine and cosine functions, required by a microstepping control, are stored in a Lock-Up-Table inside the GS-D350M.

Two options are provided for the proper microsteps/step rate selection.

Microstep Programming by Hardware

Three switches (SW1, SW2, SW3) are available on the front edge of the board.

The microsteps/step rate is defined by the following table.

SW1	SW2	SW3	MICROSTEPS/STEP
OFF	OFF	OFF	127
ON	OFF	OFF	100
OFF	ON	OFF	90
ON	ON	OFF	45
OFF	OFF	ON	25
ON	OFF	ON	10
OFF	ON	ON	5
ON	ON	ON	1

The switches are in OFF condition when the knob is pulled versus the board edge. The last condition (ON, ON, ON) defines a full step operation.

Microstep Programming by Host Computer

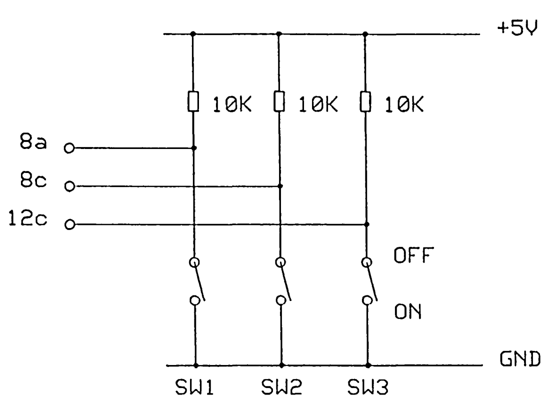
The microsteps/step rate can also be changed on-the-fly by using the three logic inputs available on the bus connector (8a, 8c, 12c) that correspond, respectively, to SW1, SW2, SW3.

This mode of operation may be requested during the motor operation to obtain, as an example, smooth start up and maximum top speed to reduce the time-to-move.

The interaction between logic signals and hardware switches is shown in fig. 4.

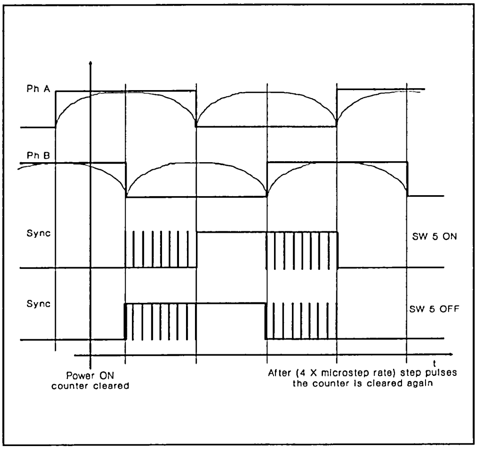
To operate the logic pins of the bus, the three internal switches must be in the OFF state (state 1).

Figure 4. Remote Microstepping Programming



The remote programming of the microsteps/step rate cannot be implemented asynchronously: it must be made only when the phase currents are at 45 electrical degrees.

That corresponds to have the internal microstep counter to zero. This counter is zeroed at power on and then cleared again at every (4 x microstep rate) step pulses.



To change the pulses ratio:

- The system controlling GS-D350M must take in count the pulses
- Every 4 x microstep rate pulses respect to the power on it can change the microstep rate
- The changing must take place more than 5 microseconds after the active edge of the clock pulse and before the next step pulse.

SETTING OF THE ACTIVE EDGE OF THE STEP CLOCK

The step clock active edge (i.e. the edge that advances the motor by one step) can be the rising or the falling edge depending on the position of the switch SW4.
The following table allows the proper setting:

SW4	ACTIVE TRANSITION
ON	Low-to-high
OFF	High-to-low

SETTING OF THE DIRECTION POLARITY

The rotation direction signal must be applied between pin 4a and 4c.
The direction (CW or CCW) depends on the status of the direction signal and of the position of the switch SW5 as shown in the following table:

DIR SIGNAL	SW5	ROTATION
HIGH	ON	CCW
HIGH	OFF	CW
LOW	ON	CW
LOW	OFF	CCW

PHASE CURRENT PROGRAMMING

The GS-D350M can be used to drive both four-wires and eight-wires motors.
Particular care must be paid to connect the wires with the correct polarity.

The GS-D350M uses four powerfet H-bridges (PHA, PHB, PHC, PHD outputs respectively)
PHA and PHB are energized in parallel as well PHC and PHD.

The possible connections of a motor are shown in fig. 5 and fig. 6.

Figure 5. Four Wires Motor Connection

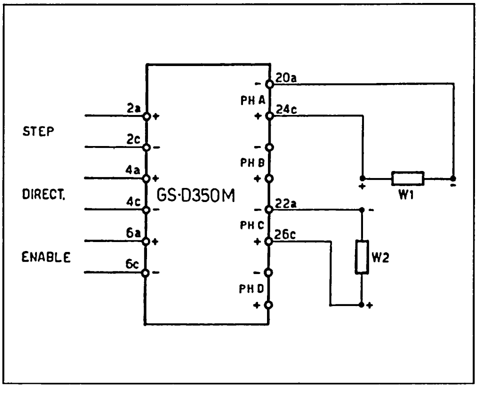
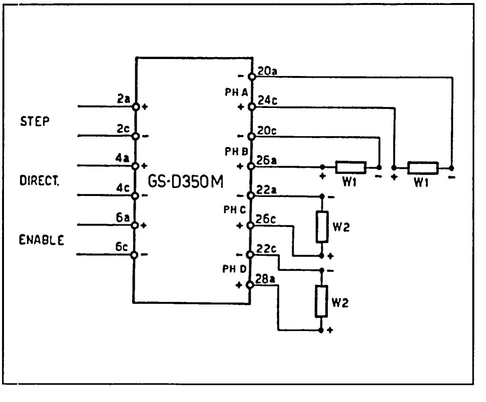


Figure 6. Eight Wires Motor Connection



In case of a four-wires motor, PHA and PHC only must be used.

Each H-bridge can deliver up to 2.8 Apk that is also the maximum current for a winding.

Therefore a four-wires motor can have a maximum phase current of 2.8 A.

In the case of an eight-wires motor the maximum phase current is 2 x 2.8 = 5.6 Apk.

The output peak current level can be programmed by a single resistor Rx that acts on all the four H-bridges.

The value of Rx for a given I_{pk} is

$$R_x = [\frac{3.2}{I_{pk}} - 1]\ k\Omega$$

The maximum value of I_{pk} is 2.8 Apk and the minimum value of Rx is 143 Ω.

The factory setting is for 1.6 Apk current for each output.

The user can modify the peak current by a proper substitution of Rx.

PHASE CURRENT RIPPLE PROGRAMMING

The phase current level control is performed by a chopping method with fixed off-time (about 32 µs) i.e. by Frequency Modulation technique.
By definition, a chopping control imposes a certain ripple on the average current. Being the off-time fixed, the amount of the current decay during the off-time, i.e. the current ripple, depends on many variables such as:

- Supply voltage
- Motor winding inductance L and resistance R
- Maximum step rate
- Microsteps/step rate.

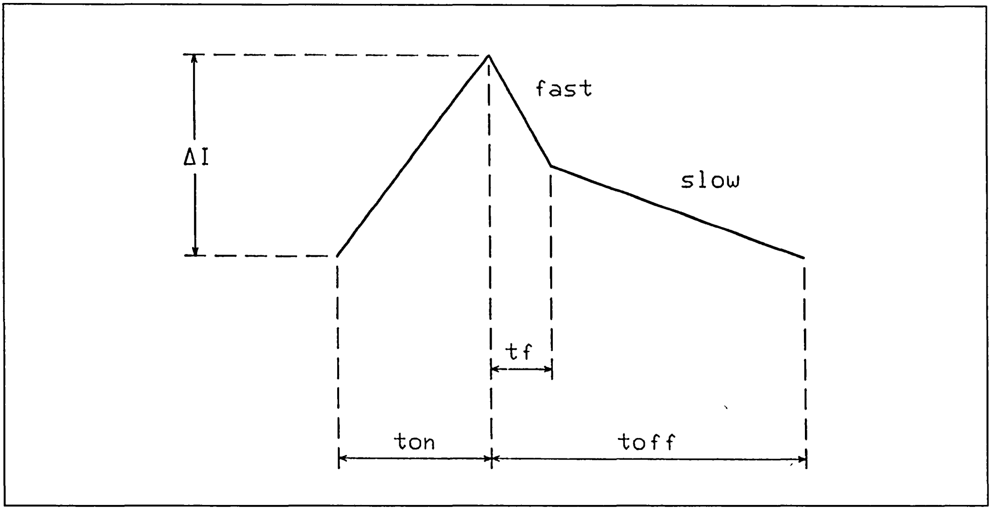
It depends also on the method used to recirculate the phase curent during the off-time (slow decay i.e. two quadrants operation or fast decay i.e. four quadrants operation).

The amplitude of the phase current ripple is a very important parameter for every microstepping drive mode because it contributes to the electromechanical performance of the system.

A low current ripple offers noiseless operation and reduced power dissipation in the motor.

The GS-D350M uses a mixed recirculating method: fast and slow decay as shown qualitatively in fig. 7.

Figure 7. Mixed Decay Method



During the time t_f, a fast decay (four quadrants operation) is imposed. The off-time is then completed in a slow decay (two quadrants operation). The current ripple is, therefore, a function of t_f too. The fast decay time t_f can be continuously adjusted by acting on potentiometer P1 (R36) provided on the front edge of the board.

The proper setting of P1 (R36) can be made by monitoring the phase current under the worst case operation and by adjusting P1 (R36) until a sinusoidal current waveform is reached.

When the motor is at rest, no back EMF is generated and the current ripple might increase.
To prevent this phenomenon, the automatic ripple reduction feature at rest has been implemented in the GS-D350M.

By putting the switch SW6 in the ON position, the phase current recirculates in a slow decay for all the off-time ($t_f = 0$), so giving the minimum possible ripple current determined, only, by the supply voltage and the L/R constant of the motor.

The user could eventually reduce the external supply voltage at rest to further reduce the current ripple. If the SW6 is in the OFF position there is no ripple reduction at rest.

INPUT COMMANDS

In its most straightforward application, the GS-D350M requires just three input commands as shown in fig. 5 (STEP CLOCK, DIRECTION, ENABLE).

The module is disabled when pin 6a is at high logic level versus pin 6c.

These three signals are galvanically isolated by internal optocouplers. (Isolation voltage: 500V).

The level of the input signal is field programmable. The factory setting is for TTL signals.

In case the signals level is 12V or 24V, a DIL resistor array must be changed as shown in fig. 8.

THERMAL PROTECTION

The GS-D350M board has an integral heatsink that allows continuous operation up to 50°C ambient temperature if the phase current is limited to 4 Apk.

At higher ambient temperature and/or higher phase current levels additional cooling must be provided by forced ventilation or by additional heatsink.

The maximum allowable winding current for an eight-wires motor versus the ambient temperature is shown in fig. 9 while fig. 10 shows maximum current level at rest.

To protect the system against unforeseen odd events, a thermal protection is activated whenever the heatsink temperature reaches about 90°C.
The thermal protection disables the module and the condition is signaled by the FAULT signal.

OUTPUT OVERLOAD AND SHORT CIRCUIT PROTECTION

To prevent permanent damage to the GS-D350M, three protections have been implemented against overload and short circuits between:

- output to supply voltage
- output to output
- output to ground.

When one of these adverse conditions occurs, the drive of the output H-bridges in disabled and the condition is signaled by the FAULT signal.

FAULT SIGNAL

The FAULT signal is available at pin 10a and 10c. When a fault is present, pin 10a goes low versus pin 10c.

This output is a galvanically isolated TTL signal.
Whenever the FAULT signal is activated, the LED provided in the front edge of the module is switched ON.

Figure 8. Input Signal Level Programming

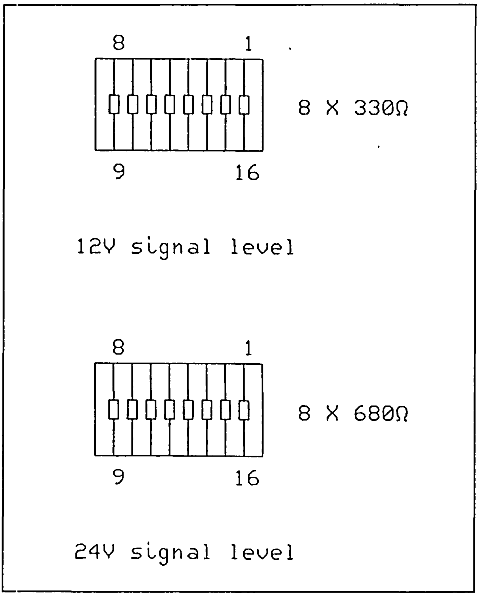


Figure 9. Thermal behaviour when stepped

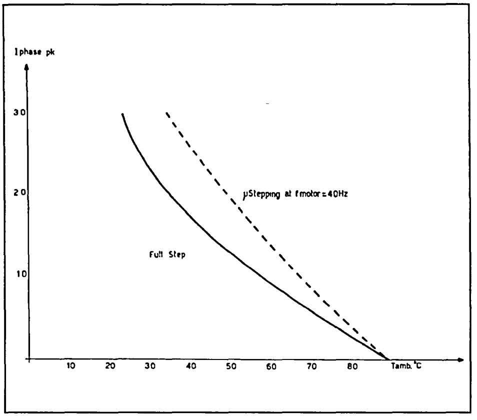
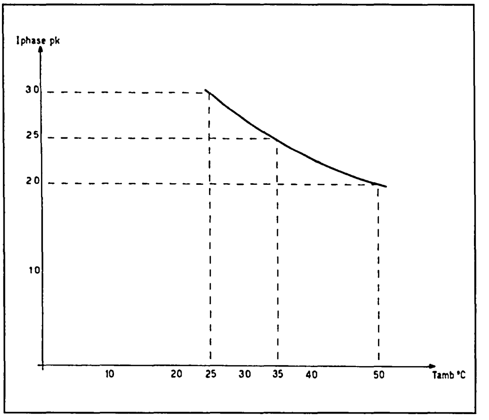


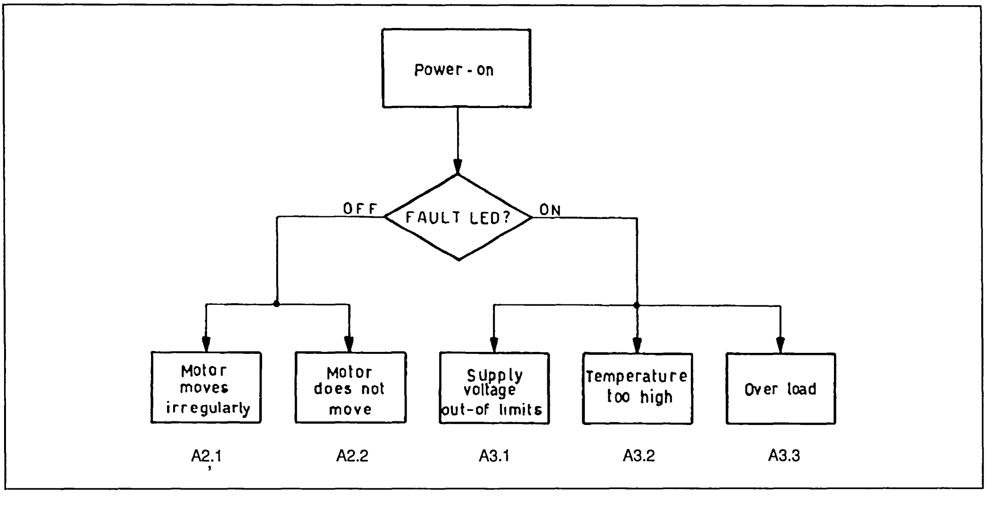
Figure 10. Thermal behaviour at rest



The FAULT signal is active (low) when:
- the supply voltage is lower than 18V
- the supply voltage is higher than 42V
- the heatsink temperature is higher than 90°C
- an output overload is present.

A - TROUBLE SHOOTING

A1 - Troubleshooting Sequence



A2 - FAULT SIGNAL INACTIVE

A2.1 - The motor moves irregularly if:

a) there is an error in the motor connection;
b) the step rate is close to the resonance frequency or too high;
c) the load plus friction torque is close to motor torque;
d) the motor is defective.

The corrective actions are:

a) check and correct the motor connections;
b) change the step rate;
c) increase the phase current or decrease the step rate;
d) substitute the motor.

A2.2 - The motor doesn't move if:

a) there is an error in the motor connection;
b) the Step-clock signal is not present, wrongly connected or badly timed;
c) the load plus friction torque is too high;
d) the motor is defective.

The corrective actions are:

a) check and correct the motor connections;
b) verify the step-clock connection and the timing;
c) increase the phase current or use a larger motor;
d) substitute the motor.

A3 - FAULT SIGNAL ACTIVE

The fault output is active when:

a) the supply voltage is lower than 18V;
b) the supply voltage is higher than 42V;
c) the heatsink temperature is higher than 90°C;
d) there is an output overload condition.

A3.1 - An anomalous supply voltage condition occurs if:

a) the power supply is incorrectly set or a power supply fault has occurred;
b) the motor is used as a generator;
c) very fast deceleration is used.

The corrective actions are:

a) check and correct the power supply setting;
b) use the bus discharge circuit and limit the motor speed to safe values;
c) use the bus discharge circuit and longer deceleration times.

A3.2 - The heatsink temperature is higher than 90°C if:

a) the ambient temperature (around the board) is too high.

The corrective actions are:

a) provide an adequate heatsink, space and ventilation to the board.

A3.3 - An output overload condition is detected if:

a) an accidental short circuit phase-to-phase, phase-to-ground or phase-to-supply has occurred;
b) the motor has an internal short circuit.

The corrective actions are:

a) check the integrity of the connections between the board and the motor;
b) substitute the motor.

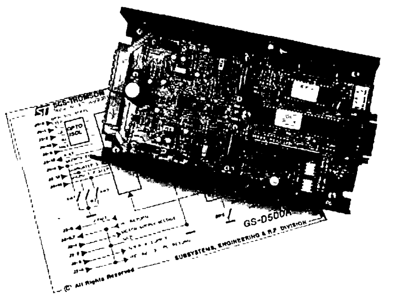
SGS-THOMSON MICROELECTRONICS

GS-D500A

100V/5A STEP AND MICROSTEP DRIVE BOARD FOR STEPPER MOTORS

FEATURES

- 100V Operating Supply Voltage
- 5A/phase peak current
- 5, 25, 125 microsteps/step
- Full step and half step operation
- User selectable phase current
- 90° out of phase chopping to save power consumption
- Galvanic isolation
- Full output protection against short-circuits
- Thermal and undervoltage protection
- Step clock in excess of 200kHz
- Fault indication output
- Special circuit to reduce midrange instability



DESCRIPTION

The GS-D500A is a member of the SGS-THOMSON family of stepper motor driver modules and boards. It drives motors in full step, half step and microstep mode.
On top of that if offers an unusually large number of features that allow a complete control of the electromechanical characteristics of the motion system to obtain optimum performance.
The powermos output stages offer both low conduction and commutation losses for increased efficiency; this, combined with a complete protection scheme, results in an extremely rugged unit suitable for harsh environment operation.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	110	V
V_{SS}	DC Logic Supply Voltage	13	V
I_{ph}	Output Current per Bridge	6	Apk
I_i	Logic Input Current	30	mA
V_{is}	Isolation Voltage	500	V
T_{stg}	Storage Temperature Range	– 20 to +85	°C
T_{hop}	Operating Heatsink Temperature	+85	°C

Note: Absolute maximum ratings are limit values above which the unit can be permanently damaged
* Thermal protection intervention @ Th > 90°C

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C and V_s = 24V unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_S	DC Supply Voltage		12		100	V
V_{SS}	DC Logic Supply Voltage		11.5	12	12.5	V
I_{ph}	Phase Current per Output*		0.5		5	A
I_i	Logic Input Current			10		mA
V_{Sl}	On board Logic Supply Output		4.75	5	5.25	V
I_{osl}	On board Logic Supply Current Output				100	mA
fc	Clock Pulse Frequency				200	kHz

* Output Shorts Protection phase-to-phase, phase-to-ground.
Note: the unit requires an input filtering capacitor in the range of 4700 to 10000 µF/100V, with low ESR and located as close as possible to the board.

Figure 1. Signals timing

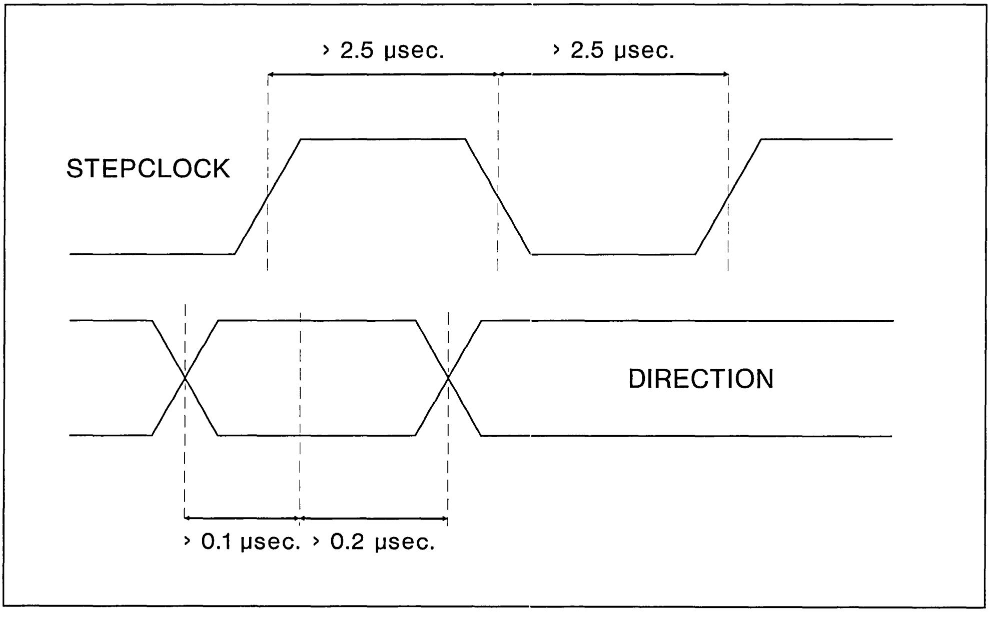
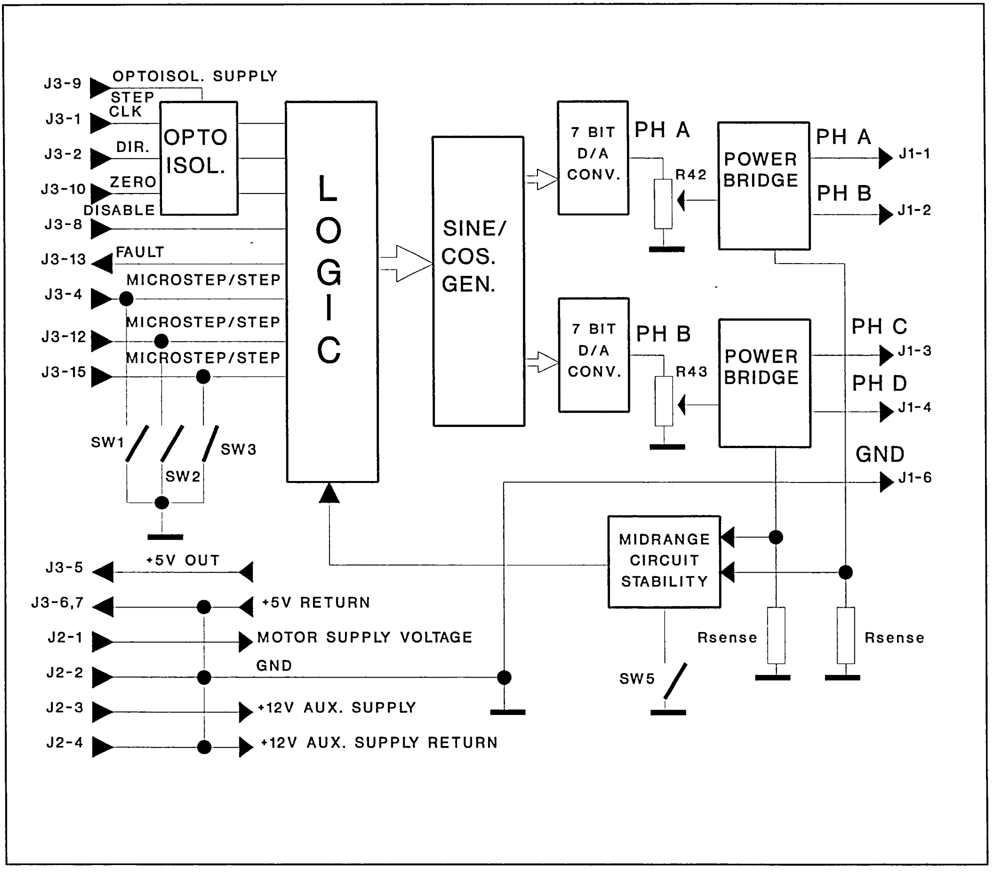
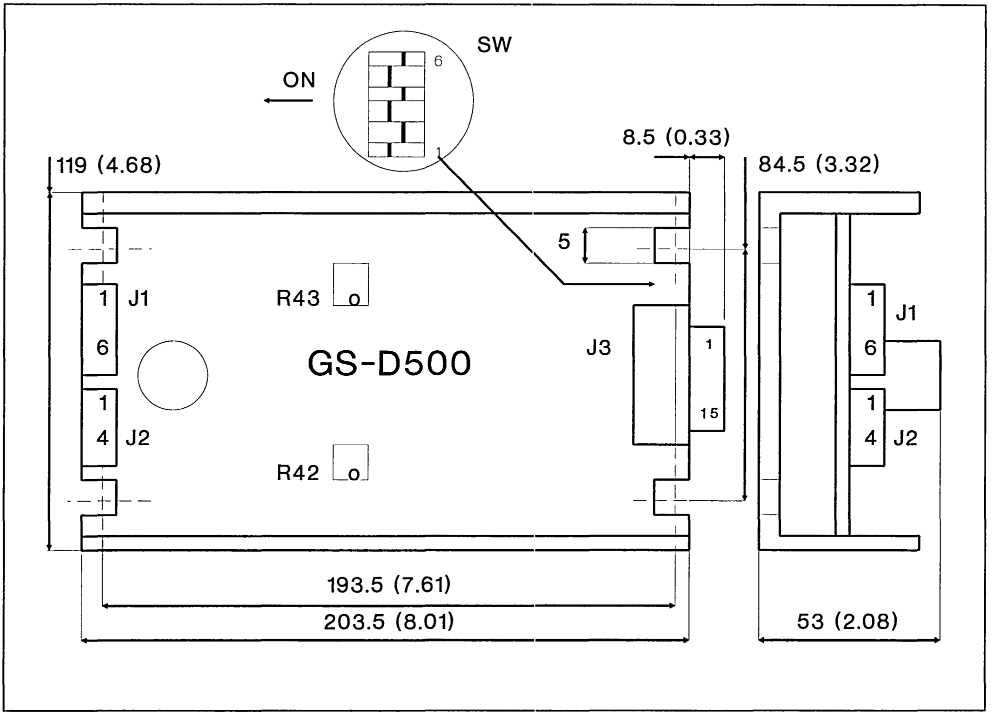


Figure 2. Block diagram



MECHANICAL DATA (dimensions are in millimeters)



GS-D500A HARDWARE AVAILABLE COMMANDS

SW1, SW2, SW3	Microsteps/step programming
SW4	Phase peak current selection
SW5	Midrange stabilization ON/OFF
SW6	Current reduction at rest
R42	Phase **AB** current programming
R43	Phase **CD** current programming

GS-D500A CONNECTORS PINS DESCRIPTION

CONNECTOR J1

J1-1	Phase A output
J1-2	Phase B output
J1-3	Phase C output
J1-4	Phase D output
J1-6	Ground

CONNECTOR J2

J2-1	Motor Supply Voltage
J2-3	Auxiliary Supply Voltage (+12V)
J2-2,4	Ground

CONNECTOR J3

Pin	Function
J3-1	Step clock isolated input (see fig. 3): this is a logic input that performs the step function, i.e. on every transition of this input the motor is moved one step in the proper direction.
J3-2	Direction isolated input (see fig. 4): the logic state applied to this pin decides the rotation direction of the motor shaft.
J3-4	Microsteps/step rate remote programming (SW1).
J3-5	On board +5V output
J3-6,7	Return path for on board +5V output
J3-8	Disable input (see fig. 6): a logic high level applied to this input causes the power driver outputs to float. This condition allows the manual positioning of the system. Care must be used when this input is activated because the detention torque is lost.
J3-9	Optocoupler supply voltage
J3-10	Zero current control isolated input (see fig. 5): when activated the phase current is reduced to zero
J3-12	Microsteps/step rate remote programming (SW2)
J3-13	Fault logic output (see fig. 9): this ouput is at a low logic level whenever an anomalous condition is detected.
J3-15	Microsteps/step rate remote programming (SW3)

Figure 3. Stepclock input circuit

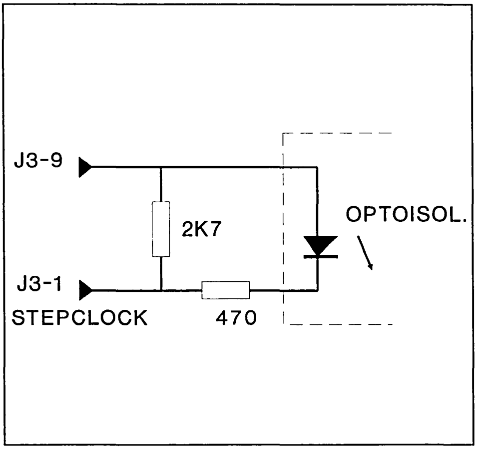


Figure 4. Direction input circuit

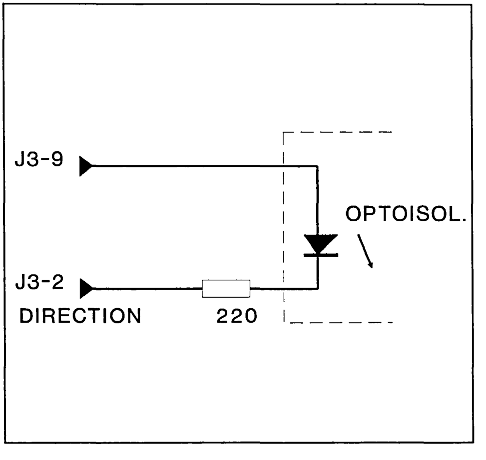


Figure 5. Zero current input circuit

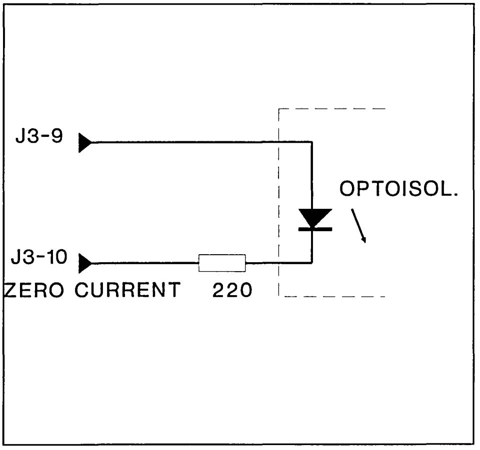
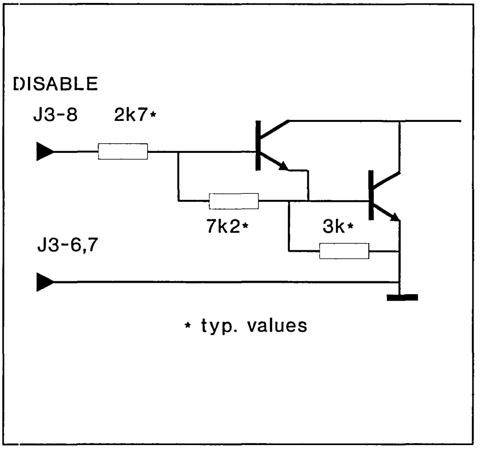


Figure 6. Disable input circuit



A - GS-D500A DESCRIPTION

The **GS-D500A** is a complete subsystem to drive stepper motors either in full step or microstep mode. A very large number of auxiliary functions has been included to allow extreme simplicity and flexibility in use.

Particular care has been devoted to protections, so that the **GS-D500A** can be safely used in very harsh environments.
In addition to the obvious function to drive the motor phases in a chopping mode, the following functions have been implemented:

- Sine/cosine generation
- Selection of three different microsteps/step rates
- Selection of full/half step drive
- Programming of peak phase current to optimize the torque
- Automatic phase current reduction at rest (selectable)
- Full protection against short-circuit between phase-to-phase and phase-to-ground
- Thermal and undervoltage protection
- Galvanic isolation of 3 input signals (**clock, direction, zero current**).
- Fault indication output
- On board auxiliary voltages generation
- Midrange stability circuitry (selectable)

As a result, the **GS-D500A** can provide up to 5A per phase and, in its simplest application, just three command signals are required: **step clock, direction, disable.**

A1 - SUPPLY VOLTAGE

THE POWER SUPPLY MUST BE TURNED OFF WHEN PLUGGING OR UNPLUGGING THE BOARD

The supply pins are:

J2-1 for Motor Supply Voltage

J2-3 for Auxiliary Voltage

J2-2,4 for Ground rail

The other supply voltages needed by the boards are internally generated.

If an undervoltage condition is detected (Vs < 10V) the GS-D500A is automatically disabled and a led is activated.

The Motor Supply voltage is in the range from 12 to 100V, the Auxiliary voltage from 11 to 13V.

At power-on the Auxiliary Supply voltage must be applied before the Motor Supply voltage, while at power-off the Motor Supply voltage must be removed before the Auxiliary voltage.

A2 - FULL-STEP/HALF-STEP/MICROSTEP PROGRAMMING BY HARDWARE

The number of microsteps per step is field programmable. The digitized sine and cosine functions, required by a microstepping control, are stored in a Lock-Up-Table inside the GS-D500A.

Two options are provided for the proper microsteps/step rate selection.

Three switches (SW1, SW2, SW3) are available on the front edge of the board.

The full-step/half-step/microstep mode is defined by the following table.

SW1	SW2	SW3	MODE
OFF	ON	OFF	Half step
ON	ON	OFF	125 microsteps/step
ON	OFF	ON	25 microsteps/step
OFF	ON	ON	5 microsteps/step
ON	ON	ON	Full step

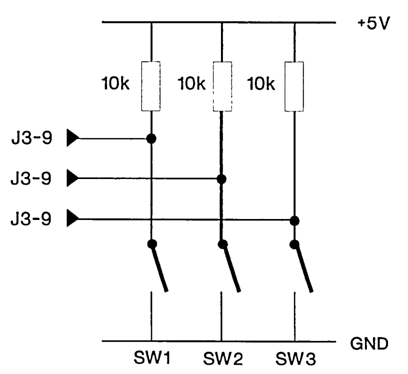
The switches are in OFF condition when the knob is pulled versus the board edge. Invalid combinations disable the board.

A2.1 - MICROSTEP PROGRAMMING BY HOST COMPUTER

The microsteps/step rate can also be remotely changed by using the three logic inputs available on the J3 connector (pins 4,12 and 15) that corresponds, respectively, to SW1, SW2, SW3.

The interaction between logic signals and hardware switches is shown in fig. 4.

Figure 7. Remote microstepping programming



To operate the logic pins of the J3 connector, the three internal switches must be in the OFF state.

A3 - CURRENT REDUCTION AT REST

Phase current can be reduced when the motor is stopped if SW6 is open.
Current reduction is operative about 1 second after the last clock pulse.

A4 - SETTING OF THE DIRECTION POLARITY

The rotation direction signal must be applied at pin J3-3.

The direction (CW or CCW) depends on the status of the direction signal as shown in the following table:

DIR. SIGNAL	ROTATION
HIGH	CCW
LOW	CW

A5 - PHASE CURRENT PROGRAMMING

The phase current can be programmed by means two on-board trimmer called R42 and R43 (see mechanical drawing).

R42 programs the current in phase AB, while R43 programs the current in phase CD.

A6 - MIDRANGE STABILITY

A particular circuitry is implemented on the board to avoid midrange oscillations.
This circuit is inserted on the current control loop when SW5 is OFF.

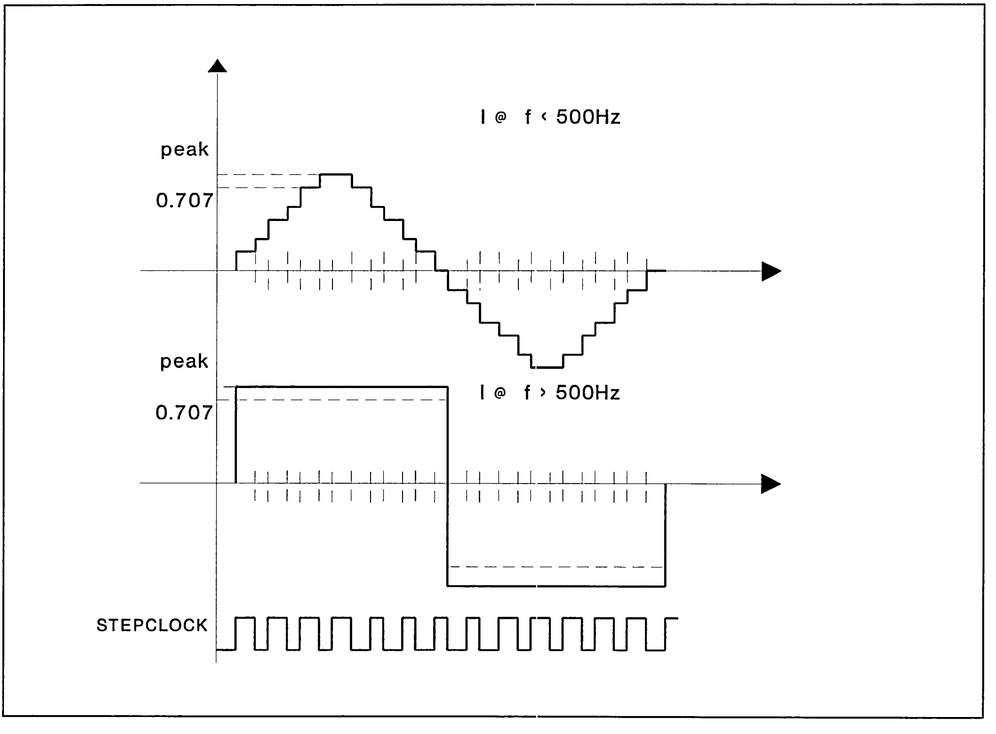
A7 - CURRENT SELECTION IN MICROSTEP/CONSTANT CURRENT SWITCHING (SW4)

When the board is used to drive a motor in microstep mode, an automatic switching from sinusoidal/cosinusoidal current to constant current is performed when the sinusoidal output waveform exceeds 500Hz. The constant output current can be chosen to be 0.707 of the peak current or the peak current: this possibility is given by SW4. (See fig. 8).

SW4 OFF	0.707 x Ipeak
SW4 ON	Ipeak

An histeresys is inserted on the 500Hz threshold to avoid unwanted oscillations.

Figure 8. Current selection by SW4



A8 - OUTPUT OVERLOAD AND SHORT CIRCUIT PROTECTION

To prevent permanent damage to the GS-D500A, three protections have been implemented against overload and short circuits between:

- output to output
- output to ground

When one of these adverse conditions occurs, the driver of the output H-bridges is disabled for about 500ms and the condition is signaled by the FAULT signal.

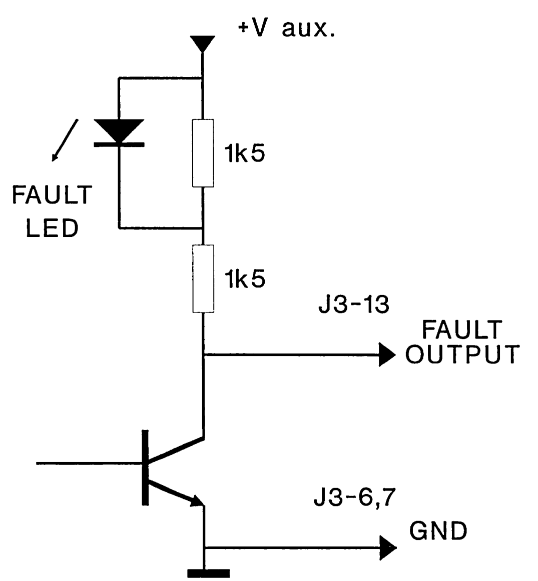
A9 - FAULT SIGNAL

The FAULT signal is available at pin J3-13. When a fault is present, pin 13 goes low versus pins 6,7.

Whenever the FAULT signal is activated, the led provided in the front edge of the module is switched ON.
The FAULT signal is active (low) when:

- the supply voltage is lower than 12V
- the heatsink temperature is higher than 90°C
- an output overload is present
- a disable is active.

Figure 9 - FAULT signal output circuit



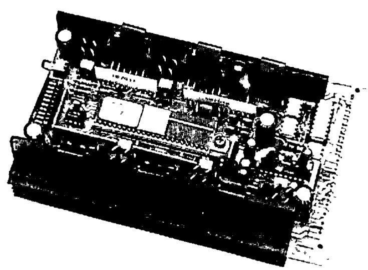
SGS-THOMSON MICROELECTRONICS

GS-D550

2/5 PHASE STEPPING MOTOR DRIVE BOARD

FEATURES

- Two and five phase motor drive
- Half and full step operation
- User programmable phase current during acceleration, slewing, rest
- Two/four quadrant current chopping
- Programmable phase current ripple
- Step clock frequency up to 100 kHz
- Galvanic isolation of input/output signals
- Thermal, undervoltage, overvoltage protection
- Single unregulated supply voltage
- On-board auxiliary voltages generation



DESCRIPTION

The GS-D550 is a board designed to drive stepper motors with 2 or 5 phases and with a current per phase up to 2.8A.
A very large number of auxiliary functions have been designed in, so that the interface to the microprocessor or host computer is reduced to a minimum.
The five output stages use powerfet H-bridges to ensure low conduction and switching losses; full protection against short circuits results in an extremely rugged unit suitable for harsh environment operation.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	42	V
I_{ph}	Continuous Phase Current per Output	2.8	Apk
I_{dis}	Supply Bus Discharge Current	4	A
I_i	Logic Input Current	30	mA
I_o	Logic Output Current	10	mA
V_{is}	Logic to Supply Isolation Voltage	500	V
T_{stg}	Storage Temperature Range	– 20 to +85	°C
T_{hop}	Operating Heatsink Temperature Range*	+85	°C

* Thermal protection intervention @ Th> 90°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ and $V_s = 24V$ unless otherwise specified)

Symbol	Parameter	Min	Typ	Max	Unit
V_S	DC Supply Voltage	18		40	V
I_{ph}	Phase Current per Output* (5 phase)	0.5		2.8	A
I_{ph}	Phase Current per Output* (2 phase, eight wires)	1.0		5.6	A
I_i	Logic Input Current**		10		mA
V_O	Logic Output Voltage (TTL compatible) Low High	 2		0.8 5	V
fc	Clock Pulse Frequency			100	kHz
fs	Chopping Frequency		20		kHz

Note: The unit requires an input filtering capacitor 4700µF/50V, with low ESR and located as close as possible to the board.
* Output shorts protection phase-to-phase, phase-to-supply and phase-to-ground.
** TTL, 12V, 24V Programmable input voltage level.

Figure 1. Signals Timing

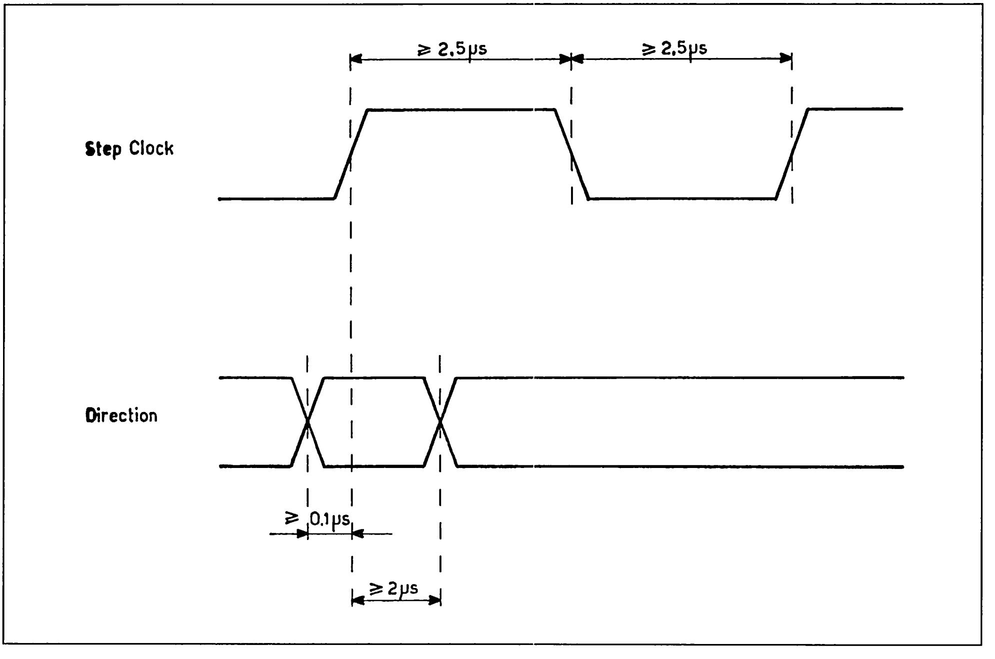
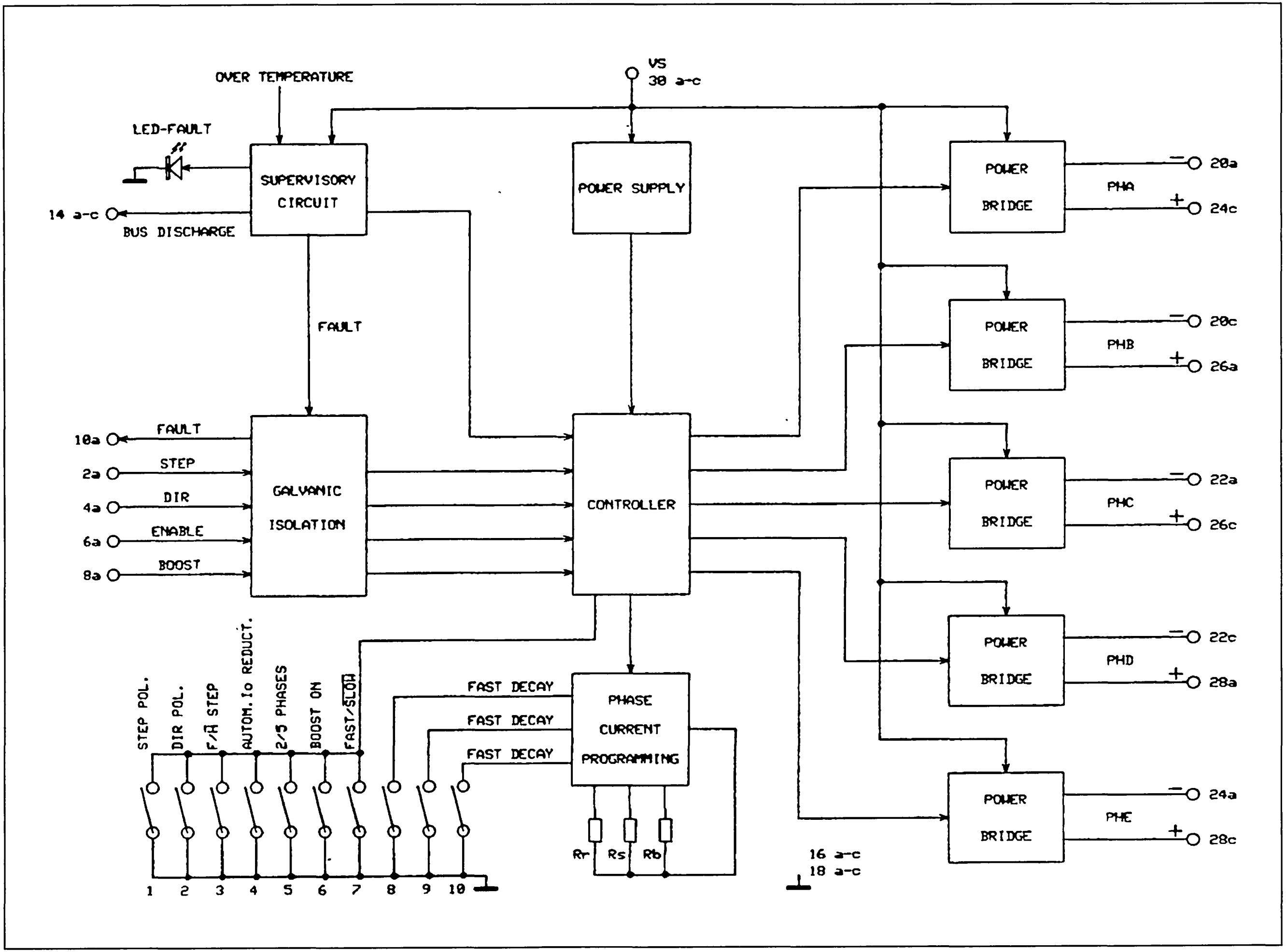
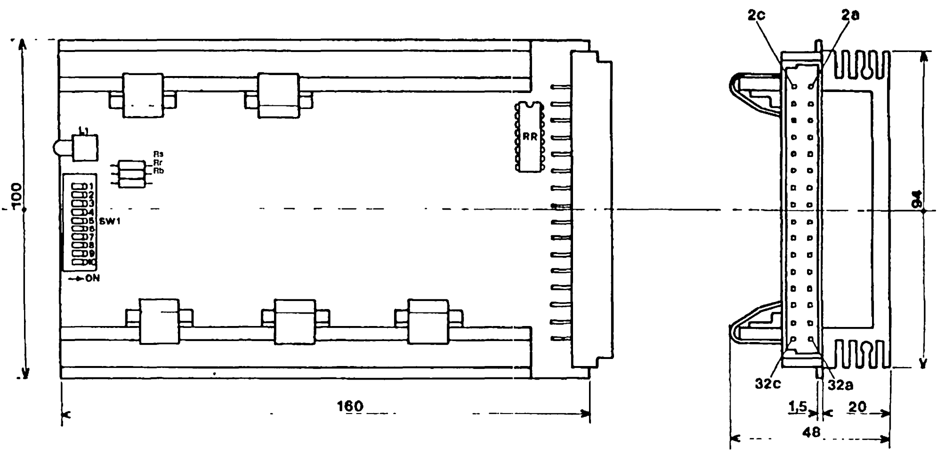


Figure 2. GS-D550 Block Diagram



CONNECTION DIAGRAM AND MECHANICAL DATA



Dimensions in mm

GS-D550 Hardware available commands

SW1	Step clock transition selection
SW2	Direction polarity selection
SW3	Half/full step mode selection
SW4	Automatic current reduction at rest
SW5	2/5 phases drive selection
SW6	Boosted phase current selection
SW7	Fast/slow decay phase current recirculation selection
SW8	Fast recirculation time duration
SW9	Fast recirculation time duration
SW10	Fast recirculation time duration
R_r	Rest current resistor
R_S	Slew current resistor
R_b	Boost current resistor
RR	Resistor array for logic level setting

GS-D550M BUS CONNECTOR PINS DESCRIPTION

The GS-D550M uses a 32 pins (16+16) DIN 41612-VG95324 male connector.

Pin	Function
2a	Step clock input: this is a logic input that performs the step function, i.e. on every transition of this input the motor is moved one step in the proper direction. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
2c	Return path for the Step clock input.
4a	Direction input; the logic state applied to this pin decides the rotation direction of the motor shaft. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
4c	Return path for the Direction input.
6a	Enable input; a logic high level applied to this input causes the power driver outputs to float. This condition allows the manual positioning of the system. Care must be used when this input is activated because the detention torque is lost. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
6c	Return path for the Enable input.
8a	Current Boost input; a logic high level applied to this input causes the phase current value to rise to a predetermined level. In a particular condition of a DIP switch setting, the activation of this pin has the same effect as the ENABLE input. The input is isolated and its logic level can be selected between TTL, 12V, 24V.
10a	Fault logic output. This isolated output is at a low logic level whenever an anomalous condition is detected. The output is open collector, i.e. a pull-up resistor is required.
10c	Fault output return path. Must be connected to the driven logic ground.
12a	Return path for BOOST input.
14a-c	Supply bus discharge output; this output is activated when an overvoltage condition is detected. A resistive load connected between this pin and the supply bus can be used to sink power to limit the maximum supply voltage to safe conditions.
16a-c	Power supply ground.
18a-c	Power supply ground.
20a	Phase A- output.
20c	Phase B- output.
22a	Phase C- output.
22c	Phase D- output.
24a	Phase E- output.
24c	Phase A+ output.
26a	Phase B+ output.
26c	Phase C+ output.
28a	Phase D+ output.
28c	Phase E+ output.
30a-c	Module supply voltage; hazardous voltages may be present on these pins.

GS-D550 DESCRIPTION

The GS-D550 is a complete sybsystem to drive stepper motors in half/full step mode.
A very large number of auxiliary functions has been included to allow extreme simplicity and flexibility in use. Particular care has been devoted to protections, so that the GS-D550 can be safely used in very harsh environments.

MOTOR CONNECTION

The GS-D550 can be used to drive both two phases and five phases motors, therefore five output H-bridges power stages are present.
Particular care must be used to connect the motor windings so that they can be energized by the correct sequence and polarity.

To obtain the best overall performances it is recommended to respect the following common sense rules.

The connectors to the motor must be made by using low resistance twisted wires in order to minimize both losses and radiated noise.

If the distance is greater than 3 meters (10 feet) it's good practice to shield the cables and connect the shield to the supply voltage return pin of the board. This is only to meet the international rules for radiated noise.

Connection of two-phase, 4 wires motor

Two windings only are available so that the maximum phase current is the maximum current a H-bridge can deliver, i.e. 2.8 A.
The connection must be made as shown in fig. 3. PHA and PHC must be mandatorily used.

Connection of two-phases, 8 wires motors

Two windings are available for a single phase. The maximum current per winding is still 2.8 A and the maximum phase current is, therefore, 5.6A.
The connection must be made as shown in fig. 4. PHE output is not used. The use of 8 wires motors is recommended to achieve higher torque and tighter control of the phase current.

Connection of five-phase motors

A five-phase motor must be connected to the GS-D550 as shown in fig. 5.

Figure 3. Two-phase, Four Wires Stepper Motor Connection

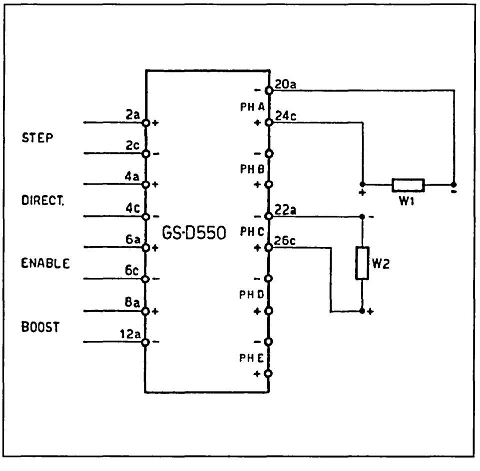


Figure 4. Two-phase, Eight Wires Stepper Motor Connection

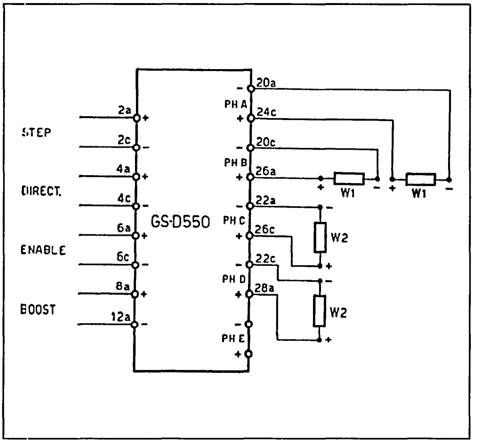
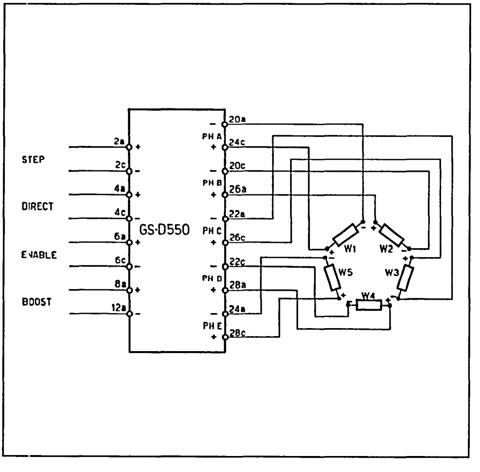


Figure 5. Five-Phase, Stepper Motor Connection



SUPPLY VOLTAGE

A single, unregulated supply voltage is requested to operate the board.

THE POWER SUPPLY MUST BE TURNED OFF WHEN PLUGGING OR UNPLUGGING THE BOARD.

The supply pins are: 30a, 30c positive rail
16a, 16c, 18a, 18c ground rail.

The other supply voltages needed by the board are internally generated by a high efficiency step down switch mode regulator that provides also the subsystem reset at power on.
The supply voltage range is between 18V and 42V: it is recommended to operate the board at a maximum voltage of 40V.
If an undervoltage condition is detected (V_S < 18V) the GS-D550 is automatically disabled and an LED is activated.

If a voltage above 42V is applied to the board, the following features are activated:

- An LED is turned on.
- An automatic overvoltage active clamping is turned on.

The active clamping system is implemented as shown in fig. 6.
The active overvoltage clamping is mainly intended to clamp transient overvoltages.

In case of permanent overvoltage, excessive power dissipation can occur. Therefore, if the supply voltage is derived from a rectified and filtered secondary winding of an AC main transformer, this voltage at no load and at maximum main AC voltage must be lower than 42V (50/60 Hz ripple included).
Overvoltages may occur because of transient spikes on the AC main supply, during very fast deceleration cycles and when the output bridges are in the fast decay recirculation mode. During this mode, the phase current pulses (up to 5.6 A) are returned to the supply voltage (four quadrant operation): if the impedance of the voltage supply is not adequately low, these current pulses can raise the voltage well above the nominal level.

To avoid that the overvoltage clamping is activated at a chopping mode switching frequency, a 4700µF/50V capacitor must be connected as close as possible to the supply pins.
The ESR of the capacitor at the switching frequency (about 20÷30 kHz) must be very low.

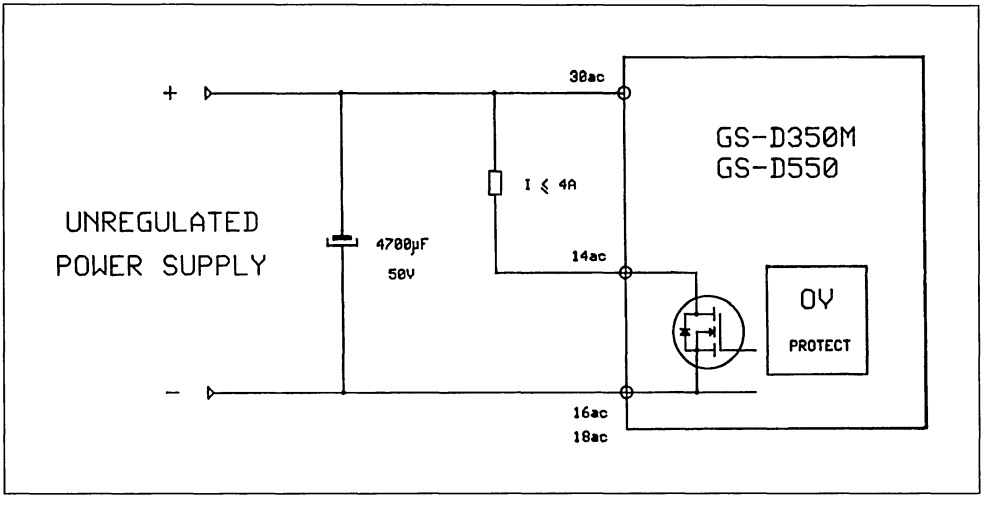
The power rating of the external bleeder resistor can range from 10 to 50W depending on AC main supply condition (overvoltage transients frequency). The resistor must be of a low inductance type to allow fast discharge of the bus voltage.

This value varies according to the operating conditions, but in first approximation it can be calculated according to the following formula:

$$R_{bleeder} \geq \frac{V_S}{4} \; [\Omega]$$

This is the minimum usable value.

Figure 6. Active Overvoltage Clamping



PHASE CURRENT PROGRAMMING

The maximum output current of each output bridge can be programmed according to the various tasks to be performed. This feature is particularly useful to drive the motor phase by a current that optimizes the torque value.

A typical movement of a positioning system has the speed profile shown in fig. 7.

To optimize the torque during the various conditions it is convenient to adopt a phase current profile as shown in fig. 8.

The phase current is boosted to the maximum value compatible with the motor cahacteristics during the positive and negative acceleration periods to reach as fast as possible the slew condition. This current is shown as I_b.

When the top speed is reached, the motor rotates at constant SLEW speed and the phase current can be reduced to the minimum value necessary to overcome the system losses (friction) and the load inertia. This current is shown as I_s.

During the STALL period the motor is at rest and the phase current can be further reduced to the bare minimum necessary to maintain the load in the right mechanical position. This current is shown as I_r.

The GS-D550 board allows the independent programming of the three values of I_r, I_s, I_b by the proper setting of resistors R_r, R_s, R_b. (See the mechanical drawing).
To calculate the proper values the following formulas apply:

$$K_r = \frac{5}{0.33 \cdot I_r} - 1$$ Rest current factor

$$K_s = \frac{5}{0.33 \cdot I_s} - 1$$ Slew current factor

$$K_b = \frac{5}{0.33 \cdot I_b} - 1$$ Boost current factor

then the three resistor values can be defined

$R_r = K_r$ Rest current setting resistor

$$R_s = \frac{K_r \cdot K_s}{K_r - K_s}$$ Slew current setting resistor

$$R_b = \frac{K_s \cdot K_b}{K_s - K_b}$$ Boost current setting resistor

where I_r, I_s, I_b are expressed in Ampere (A),
R_r, R_s, R_b are expressed in kohm (kΩ).

If, for example, the following set of currents are required:

I_r = 1.16 A
I_s = 2.0 A
I_b = 2.5 A

the formulas give

$$K_r = \frac{5}{0.33 \cdot 1.16} - 1 = 12.0$$

$$K_s = \frac{5}{0.33 \cdot 2.0} - 1 = 6.57$$

Figure 7. Speed versus Time Profile

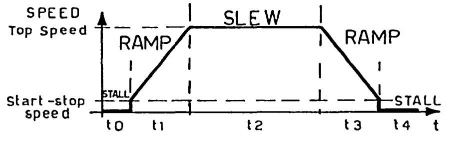
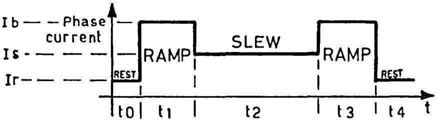


Figure 8. Phase Current versus Time Profile



SGS-THOMSON MICROELECTRONICS

$$K_b = \frac{5}{0.33 \cdot 2.5} - 1 = 5.06$$

Therefore

$$R_b = K_r = 12\ k\Omega$$

$$R_s = \frac{12 \cdot 6.57}{12 - 6.57} \approx 15\ k\Omega$$

$$R_b = \frac{6.57 \cdot 5.06}{6.57 - 5.06} = 22\ k\Omega$$

This example reports values that are the factory setting for R_r, R_b, R_s.

The three levels of phase current at rest, ramp and slew are actuated by internal and external commands conditioned by hardware commands setting as follows:

I_r Actuation

The actuation is automatically executed by the GS-D550 and it is conditioned by the position of the hardware command SW4 as per the following table.

SW4	STATUS
ON	No automatic reduction at rest
OFF	Automatic current reduction at rest.

I_s Actuation

No signal is needed and the condition is reached whenever the motor runs at top speed.

I_b Actuation

To boost the phase current during the ramps an external signal must be applied to pin 8a. The command is conditioned by the position of the hardware command SW6 as per the following table.

BOOST	SW6	PHASE CURRENT
ON	ON	BOOSTED
OFF	ON	NORMAL
ON	OFF	ZERO
OFF	OFF	NORMAL

PHASE CURRENT RIPPLE PROGRAMMING

The chopping control of the phase current implies automatically some amount of current ripple that depends on many parameters such as:

- supply voltage
- inductance L and resistance R of the motor windings
- back EMF
- method adopted for phase current recirculation during off-time (two quadrants or four quadrants)
- duration of the off-time when the current is allowed to decay.

The phase current ripple generates additional power dissipation inside the board (switching losses) and inside the motor.

A two quadrant recirculation mode (slow decay) causes the minimum current ripple, being all the other conditions equal and the minimum power dissipation. However the braking characteristics of the motor are impaired because of the high energy stored into the motor windings.

The four quadrant recirculation improves these braking characteristics, but it generates higher current ripple i.e. higher power dissipation.
It is quite important, therefore, to have the possibility to control the amount of current ripple.
The GS-D550 allows the user to program the ripple to a value that best fits to her/his needs.

Four hardware commands are provided to this purpose:

SW7, SW8, SW9, SW10

The conditions generated by these commands are shown by the following tables.

SW7	RECIRCULATION MODE
ON	Four quadrants
OFF	Two quadrants.

The first condition allows a fast decay but the current ripple is at its maximum for a given supply voltage, L/R time constant of the motor back EMF. Because the current ripple depends also on the off-time this maximum value can be decreased by reducing the off-time that is conditioned by the status of SW8, SW9, SW10 as follows:

SW8	SW9	SW10	OFF-TIME
OFF	OFF	OFF	12.6 μs
ON	OFF	OFF	11.0 μs
OFF	ON	OFF	9.4 μs
ON	ON	OFF	7.8 μs
OFF	OFF	ON	6.2 μs
ON	OFF	ON	4.6 μs
OFF	ON	ON	3.0 μs
ON	ON	ON	1.4 μs

STEP MODE SELECTION

The GS-D550 can drive the stepper motor according to two possible step modes:

- Full step
- Half step

To reduce the burden of the Host computer to a minimum just the clock signal must be provided externally to pin 2a: the driving signal sequence is generated inside the board and the stepping mode is defined by the hardware command SW3 as follows:

SW3	STEP MODE
ON	Half step
OFF	Full step

2/5 PHASE STEPPING MOTOR SELECTION

The connection of the motor windings is described on page 6 (MOTOR CONNECTION).

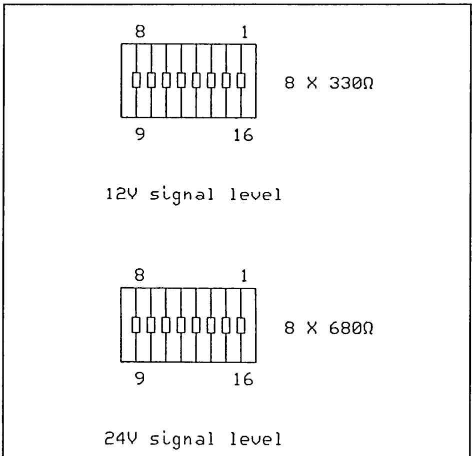
To drive motors with two or five phases, the GS-D550 must be properly set by acting on the hardware command SW5 according to the following table:

SW5	MOTOR
ON	Five phases
OFF	Two phases.

SETTING OF THE INPUT SIGNALS POLARITY

The flexibility of the GS-D550 is further enhanced by the availability of two additional hardware commands SW1, SW2, that allow to select the proper polarity of the input signals.

Figure 9. Input Signal Level Programming



SETTING OF THE ACTIVE EDGE OF THE STEP CLOCK

The step clock active edge i.e. the edge that advances the motor by one step, can be the rising or the falling edge depending on the position of the hardware command SW1.

SW1	ACTIVE TRANSITION
ON	Low-to-High
OFF	High-to-Low.

SETTING OF THE DIRECTION POLARITY

The rotation direction signal must be applied between pin 4a and 4c.

The direction (CW or CCW) depends on the status of the direction signal and on the position of the SW5 command as shown in the following table:

DIR SIGNAL	SW1	ROTATION
HIGH	ON	CCW
HIGH	OFF	CW
LOW	ON	CW
LOW	OFF	CCW

SETTING OF INPUT SIGNALS LEVEL

The input signals to the GS-D550 board are:

- Step clock
- Direction
- Enable
- Boost.

These four signals are galvanically isolated by internal opto couplers (isolation voltage: 500 V).

The board is enabled when pin 6a is low versus pin 6c. The input driving signals logic level can be selected according to the following options:

- TTL compatible
- 12 V
- 24 V

The factory setting is for TTL compatible signals. To modify the level, a DIL resistor array must be changed as shown in fig. 9.

BOARD PROTECTIONS

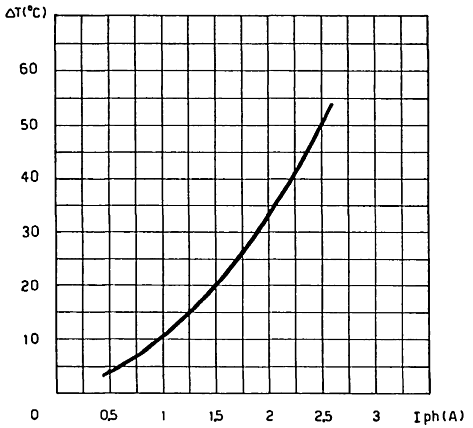
The board is protected against:

- Supply overvoltage
- Supply undervoltage
- Output short circuits: phase-to-supply
phase-to-phase
phase-to-ground
- Overtemperature

The thermal protection is activated when the temperature of the integral heatsink reaches about 90°C. In such a case the board is automatically disabled and the FAULT signal is activated.

The heatsink temperature depends on the ambient temperature and the internal power dissipation. Fig. 10 and 11 show the increase of heatsink temperature versus the phase current. The GS-D550 can be operated at a phase current up to 2A if the ambient temperature is less than 50°.

Figure 10. Two-phase mode thermal

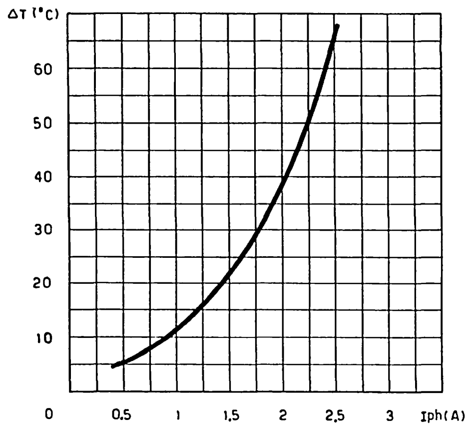


In case of out of range supply voltage and/or overloads the board is automatically disabled and the condition is signaled by an LED and by the FAULT signal.

FAULT SIGNAL

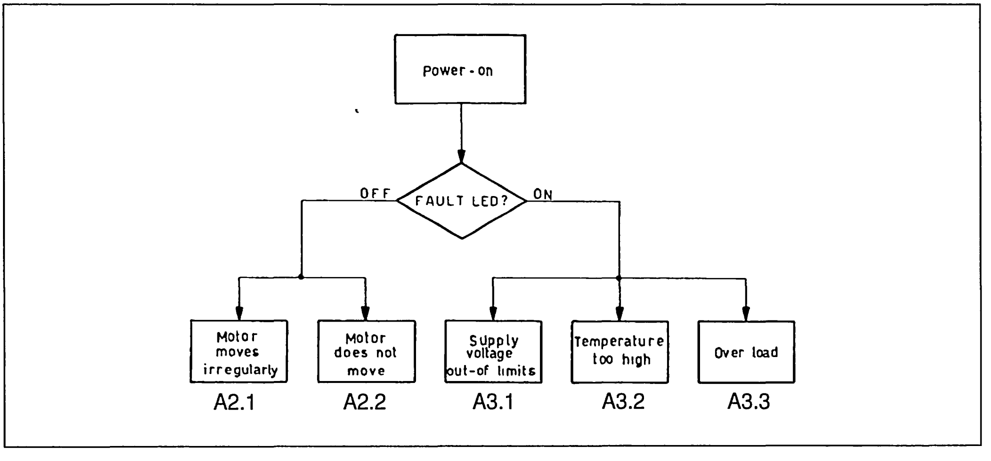
The FAULT signal is available at pin 10a and pin 10c. When a FAULT is present, pin 10a goes low versus pin 10c. This output is a galvanically isolated TTL signal.

Figure 11. Five-phase mode thermal



A-TROUBLE SHOOTING

A.1-Troubleshooting sequence



FAULT SIGNAL INACTIVE

A2.1-The motor moves irregularly if:

a) there is an error in the motor connection;

b) the step rate is close to the resonance frequency or too high;

c) the load plus friction torque is close to motor torque;

d) the motor is defective.

The corrective actions are:

a) check and correct the motor connections;

b) change the step rate;

c) increase the phase current or decrease the step rate;

d) substitute the motor.

A2.2-The motor doesn't move if:

a) there is an error in the motor connection;

b) the step-clock signal is not present, wrongly connected or badly timed;

c) the load plus friction torque is too high;

d) the motor is defective.

The corrective actions are:

a) check and correct the motor connections;

b) verify the Step-clock connection and the timing;

c) increase the phase current or use a larger motor;

d) substitute the motor.

A3-FAULT SIGNAL ACTIVE

The fault output is active when:

a) the supply voltage is lower than 18V;

b) the supply voltage is higher than 42V;

c) the heatsink temperature is higher than 90°C;

d) there is an output overload condition.

A3.1-An anomalous supply voltage condition occurs if:

a) the power supply is incorrectly set or a power supply fault has occurred;

b) the motor is used as a generator;

c) very fast deceleration is used.

The corrective actions are:

a) check and correct the power supply setting;

b) use the bus discharge circuit and limit the motor speed to safe values;

c) use the bus discharge circuit and longer deceleration times.

A3.2-The heatsink temperature is higher than 90°C if:

a) the ambient temperature (around the board) is too high.

The corrective actions are:

a) provide an adequate heatsink, space and ventilation to the board.

A3.3-An output overload condition is detected if:

a) an accidental short circuit phase-to-phase, phase-to-ground or phase-to-supply has occurred,

b) the motor has an internal short circuit.

The corrective actions are:

a) check the integrity of the connections between the board and the motor;

b) substitute the motor.

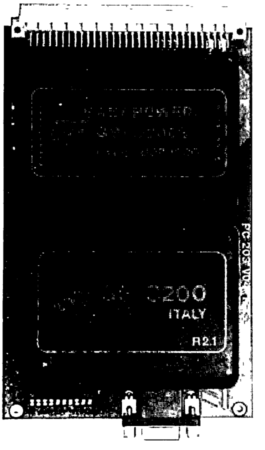
STEPPER MOTOR CONTROL AND DRIVE SYSTEM FAMILY

DESCRIPTION

The **GS-DC200** series is a family of single Eurocard boards that contain all the logic necessary to operate a stepper motor, including the instructions decoding, the step timing generation, the storage of the program to be executed. The motor interface can deliver phase current up to 2.5A.

The boards can be used as a stand alone complete motion control system or they can be driven by a central host computer.

The **GS-DC200** family is built around the **GS-C200, GS-C200S, GS-D200, GS-D200S** modules, (see the relevant data sheet) and it retains all the features of these modules.



SELECTION CHART

Ordering Number	Controller Sequencer Driver	Instruction Set Commands	Phase Current (A)
GS-DC200	GS-C200+GS-D200	25	2.0
GS-DC200S	GS-C200+GS-D200S	25	2.5
GS-DC200SS	GS-C200S+GS-D200S	29	2.5

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	42	V
Tstg	Storage Temperature Range	–40 to +105	°C
Thop	Max Operating Heatsink Temperature (GS-D200/200S)	+85	°C

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C and V_S=24V unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_S	DC Supply Voltage		12		40	V
I_S	Quiescent Supply Current			150		mA
V_i	Logic Input Voltage	Low High	 2		0.8 5	V V
V_o	Logic Output Voltage	Low High	 2		0.8 5	V V
I_{ph}	Programmable Phase Current	GS-DC200 GS-DC200S/SS			2 2.5	A A
f_c	Chopper Frequency			17		kHz
t_{cpw}	Clock Pulse Width				5	µs
t_{rpw}	Reset Pulse Width (Internal)				500	µs

MOTION CHARACTERISTICS

Speed Range	10 to 10000 steps
Speed Resolution	10 steps
Ramp Length	1 to 999 steps
Ramp Resolution	1 step
Positioning Range (GS-DC200/S)	0 to 9999999
Positioning Range (GS-DC200SS)	–8388608 to +8388607
Single Movement Range	1 to 999999 steps
Positioning Resolution	1 step
Positioning Repeatibility	± 0 step
Program Storage Capability	119 Bytes

COMMUNICATION PORT CHARACTERISTICS

SIGNAL LINES	3(TXD, RXD, GND)
BAUD RATE RANGE	110 to 9600
FORMAT	1 Start Bit 7 Data Bit 2 Stop Bit Odd Parity

Figure 1. GS-DC200, GS-DC200S and GS-DC200SS Block Diagram

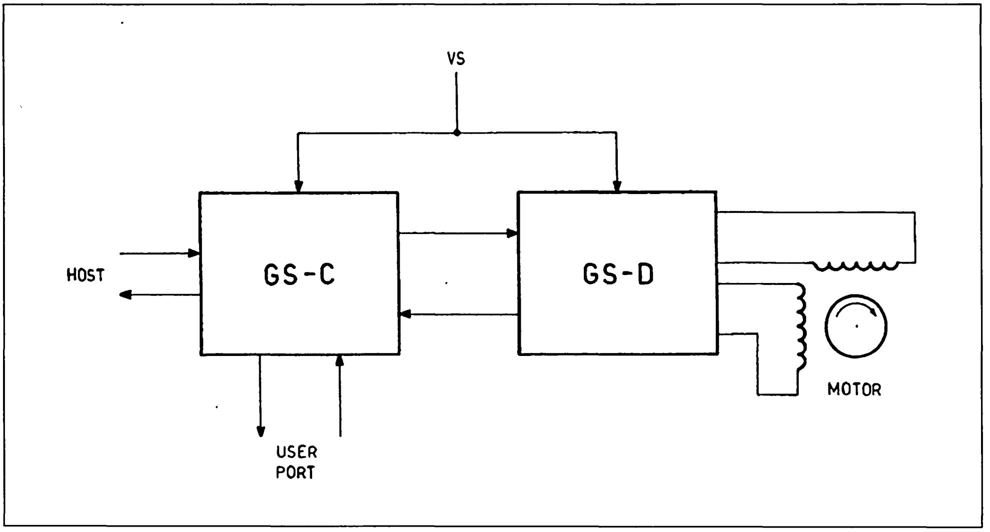
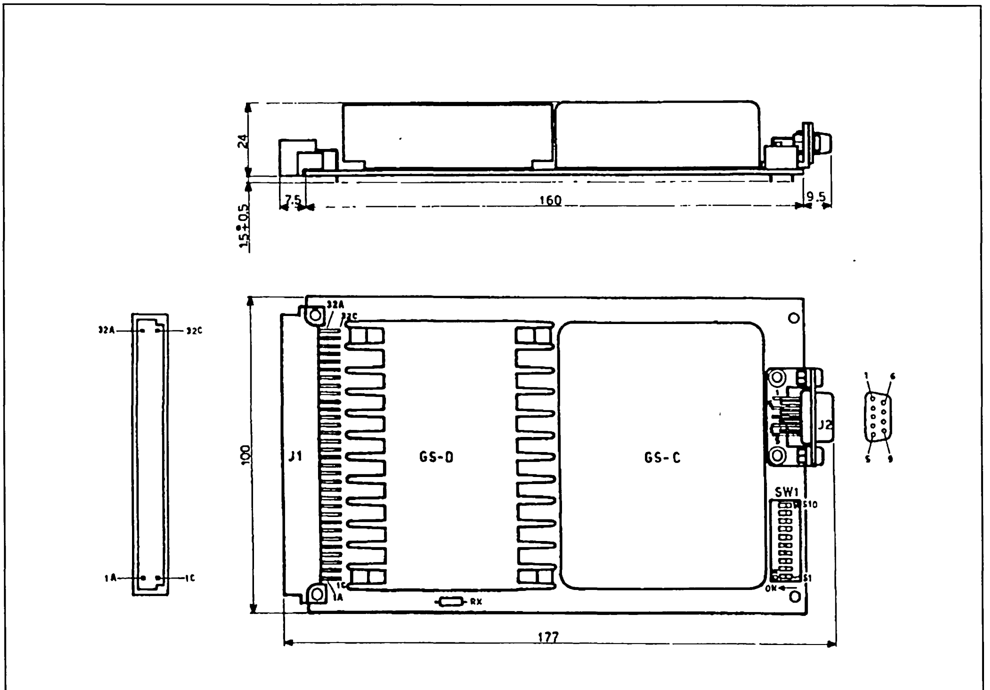
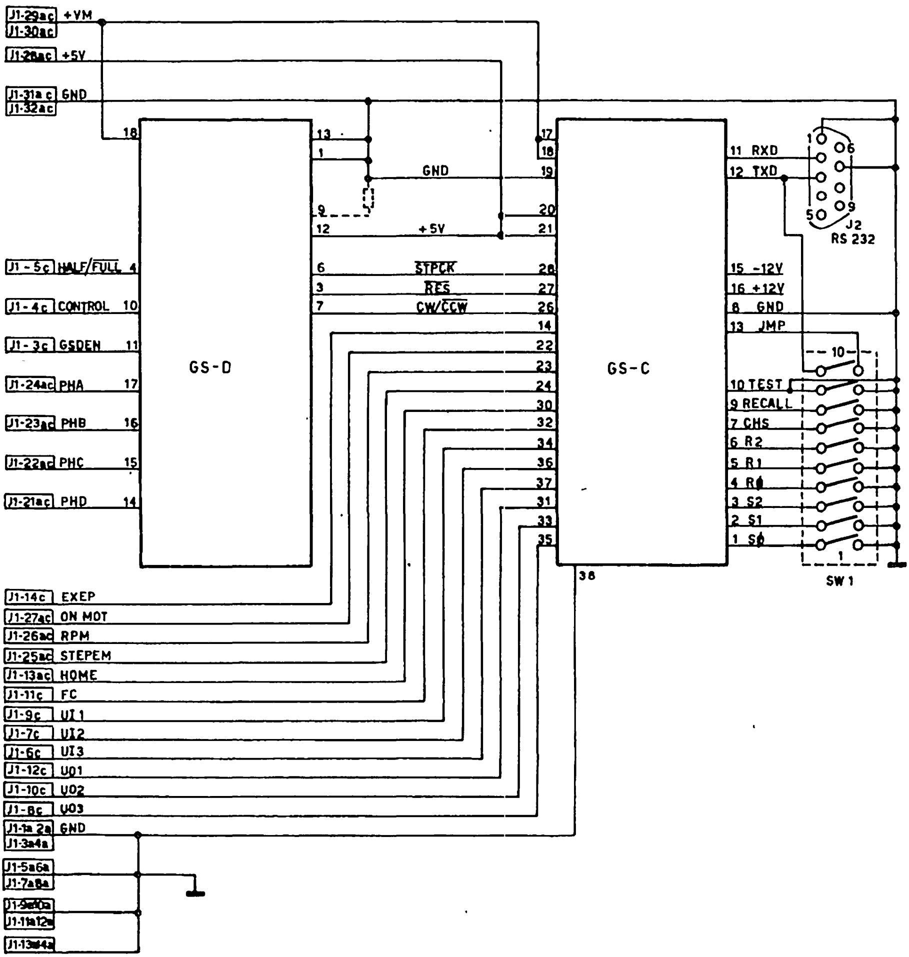


Fig. 2 - GS-DC Stepper Motor Driver/Controller Board



Dimensions in mm

Fig. 3 - GS-DC200, GS-DC200S and GS-DC200SS Schematic Diagram



GS-DC FAMILY BUS CONNECTOR PINS DESCRIPTION

The GS-DC family uses a 32 pin (16+16) DIN 41612-VG 95324 male connector and a RS-232 connector.

DIN BUS CONNECTOR (J1)

Pin	Row a Signal	Row c Signal
1	Ground	Not used
2	Ground	Not used
3	Ground	Power driver enable input
4	Ground	Power driver control input
5	Ground	Half/Full step select
6	Ground	User input 3
7	Ground	User input 2
8	Ground	User output 3
9	Ground	User input 1
10	Ground	User output 2
11	Ground	End-of-travel switch
12	Ground	User output 1
13	Ground	Home switch
14	Ground	Prog. under execution output
15	Not used	Not used
16	Not used	Not used
17	Not used	Not used
18	Not used	Not used
19	Not used	Not used
20	Not used	Not used
21	Phase D output	Phase D output
22	Phase C output	Phase C output
23	Phase B output	Phase B output
24	Phase A output	Phase A output
25	Step enable input	Stop enable input
26	Ramp in execution logic output	Ramp in execution logic output
27	Motor moving	Motor moving
28	+5V output	+5V output
29	Supply voltage	Supply voltage
30	Supply voltage	Supply voltage
31	Supply ground	Supply ground
32	Supply ground	Supply ground

RS-232 CONNECTOR (J2 - DB9)

Pin 1	Ground
Pin 2	Received data input
Pin 3	Transmitted data output
Pin 7	Ground

GS-DC FAMILY HARDWARE AVAILABLE COMMANDS

Dip switch configuration selection (0=OFF 1=ON)

S1	S2	S3	Address	Protocol
0	0	0	–	Point-to-point
1	0	0	1	Multipoint
0	1	0	2	Multipoint
1	1	0	3	Multipoint
0	0	1	4	Multipoint
1	0	1	5	Multipoint
0	1	1	6	Multipoint
1	1	1	7	Multipoint

S4	S5	S6	Baud rate
0	0	0	110
1	0	0	150
0	1	0	300
1	1	0	600
0	0	1	1200
1	0	1	2400
0	1	1	4800
1	1	1	9600

S7	Checksum
1	Disable
0	Enable

S8	Stand alone operation
1	Enable
0	Disable

Note: Switch position 9 is not used.

S10	RS232 TXD pull-down
0	Not connected
1	Connected

Rx	Phase peak current programming

USER NOTES

To correctly operate the GS-DC boards family, it is recommended to read the following data sheets: GS-C200/200S; GS-D200/200S; GS-C200 PROG.

Supply Voltage

The recommended operating maximum supply voltage must include the ripple voltage on the V_S supply rail and it must not exceed 40V to avoid permanent damage to the board.

The boards have internal capacitors connected between the supply and ground pins to assure the electrical stability. These capacitors cannot handle high values of current ripple and they would be permanently damaged if the voltage source impedance is not adequately low.

The use of a low ESR, high current ripple, 470µF/50V capacitor located as close as possible to the board is recommended. Suitable units are the Sprague type 672 D or 678 D, the RIFA type PEC 126 or any equivalent unit.

Board Protections

The GS-DC200 board is protected against occasional or permanent short circuits to the supply voltage of the phase output pins.

The GS-DC200S and GS-DC200SS are protected also against short circuits to ground or to another phase output.

For the GS-DC200S and GS-DC 200SS the protection is of the latching type i.e. when an overload occurs, the board is automatically disabled. To restart the operations, the supply voltage must be switched off for at least 100 ms.

Motor Connection

When long wires are needed to connect a remote motor, it is recommended to use twisted pair cables with a proper cross section to minimize DC losses and RFI problems.

Phase Current Programming

The maximum output current/phase can be programmed by changing the value of the R_X resistor. The factory setting is for maximum current of

1 A GS-DC 200

2 A GS-DC200S / GS-DC200SS.

The new value of R_X resistor for a different value of maximum phase current I (A) can be calculated according to the following formulas:

GS-D200

I > 1,07

$$Rx = \left[\frac{10 - I}{(0.993 * I) - 1}\right] k\Omega \quad Rx \geq 8.2K\Omega$$

I < 1,07

$$Rx = \left[\frac{I}{1 - (0.993 * I)}\right] k\Omega$$

GS-D200S

I > 2,11

$$Rx = \left[\frac{10 - (0.33 * I)}{(0.473 * I) - 1}\right] k\Omega \quad Rx \geq 50K\Omega$$

I < 2,11

$$Rx = \left[\frac{I}{3.03 - (1{,}43\, I)}\right] k\Omega$$

The maximum programmed current must not exceed 2.0A for the GS-DC200 and 2.5A for the GS-DC200S/GS-DC200SS.

Thermal Characteristics

The maximum power dissipation occurs on the GS-D200/GS-D200S modules used on the boards. The thermal resistance case-to-ambient of the integral heatsink of these modules is 5°C/W. This means a 50°C temperature increase of the heatsink if the internal power dissipation is 10W.
The maximum allowed heatsink temperature is 85°C. Therefore, according to the ambient temperature and/or the internal power dissipation, forced ventilation may be required.

Programming

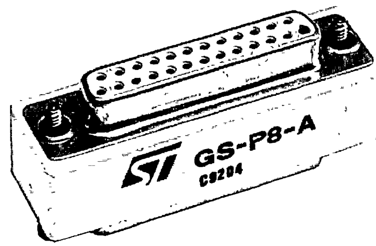
To correctly program motion sequences, see the GS-C200/200S and/or GS-C200 PROG data sheets.

BIDIRECTIONAL DATA LINE PROTECTOR

DESCRIPTION

The GS-P8-A and GS-P8-E are Bidirectional Data Line Protection systems against EOS (Electrical Over Stress) and ESD (Electrical Static Discharge).

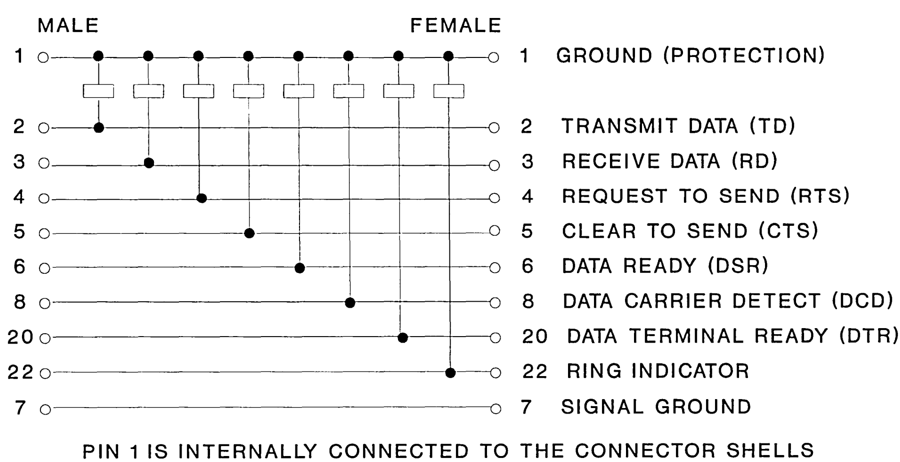
These subminiature male/female connector, designed both for EIA RS232C and V24 with 8 lines, shunts to ground hazardous overvoltages induced on an EIA cable.



ORDERING TYPE NUMBER

Type	Description
GS-P8-A	American version (female screws 4.40 UNC)
GS-P8-E	European version (female screws M3)

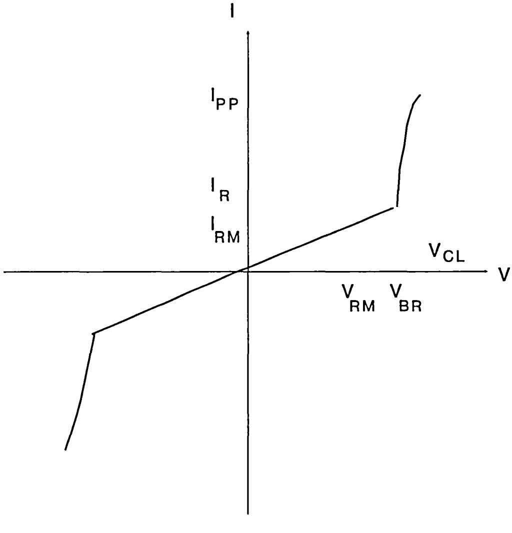
Figure 1. Block diagram of GS-P8-A and GS-P8-E



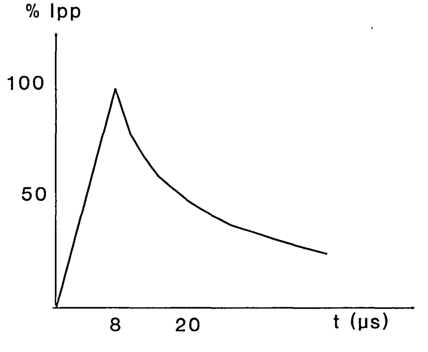
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified 8/20µS pulse waveform)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Vrm	Stand-off voltage	Pin 2, 4, 20		± 6		V
Vrm	Stand-off voltage	Pin 3, 5, 6, 8, 22		± 24		V
Vbr	Breakdown voltage	Pin 2, 4, 20 Ir = 10 mA	± 7,7			V
Vbr	Breakdown voltage	Pin 3, 5, 6, 8, 22 Ir = 1 mA	± 24			V
Vcl	Clamping Voltage	Pin 2, 4, 20 Ipp = 40A			± 12	V
Vcl	Clamping Voltage	Pin 3, 5, 6, 8, 22 Ipp = 40A			± 35	V
Pp	Peak Power Rating	Pin 2, 4, 20	500			W
Pp	Peak Power Rating	Pin 3, 5, 6, 8, 22	800			W
Irm	Leakage Current	Pin 2, 4, 20 Vrm = ± 6V			25	µA
Irm	Leakage Current	Pin 3, 5, 6, 8, 22 Vrm = ± 24V			5	µA
Ci	Input Capacitance	All pins to pin 1.7 5V bias			680	pF
Top	Operating Temperature Range		– 65		+100	°C
Tstg	Storage Temperature Range		– 65		+125	°C

Figure 2: Symbols definition

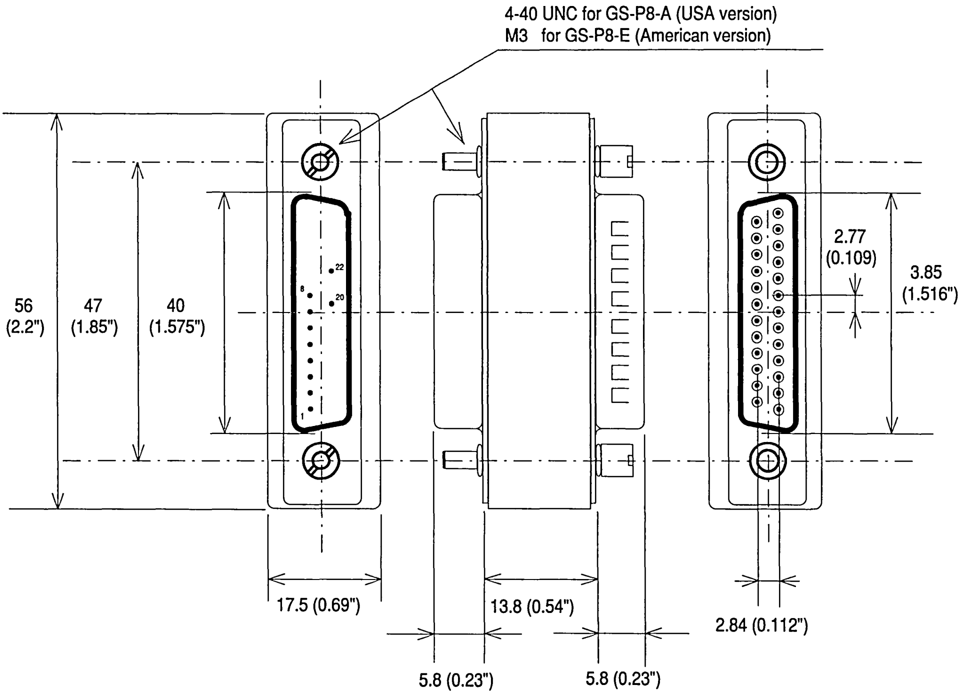


SYMBOLS DEFINITION



PULSE WAVEFORM 8/20 µs

Figure 3.



Dimensions in mm (inches).

BIDIRECTIONAL DATA LINE PROTECTOR

DESCRIPTION

The GS-P15-A is a Bidirectional Data Line Protection System against EOS (Electrical Over Stress) and ESD (Electrical Static Discharge).

This subminiature male/female connector, designed both for EIA RS232C and V24 with 15 lines, shunts to ground hazardous overvoltages induced on an EIA cable.

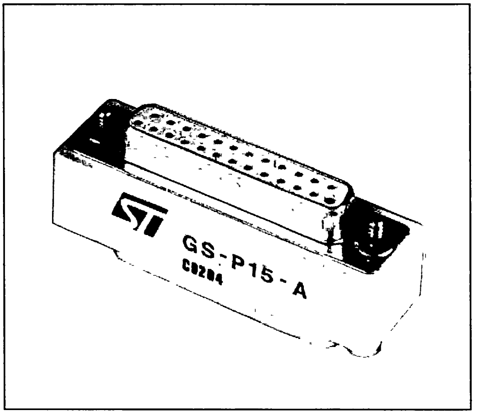
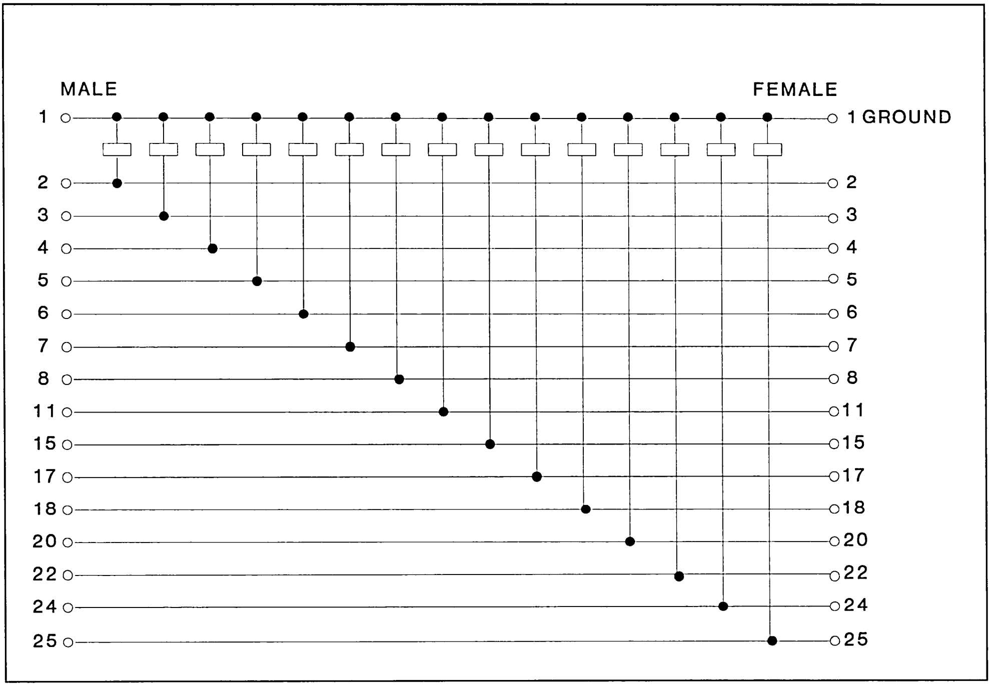


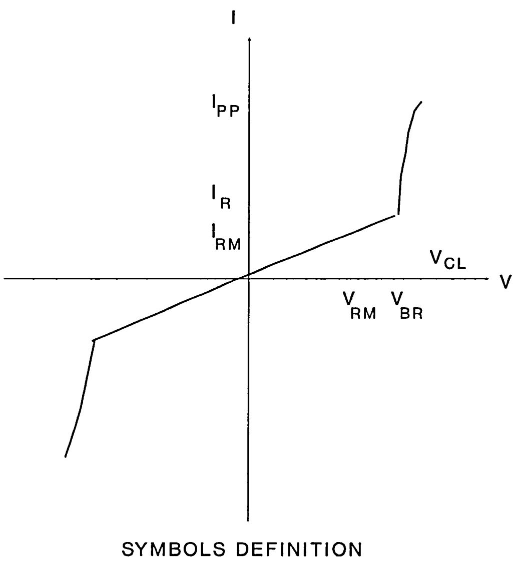
Figure 1. Block diagram



ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified 8/20µS pulse waveform)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{rm}	Stand-off voltage	Irm = 4 mA I/O pin ground		± 24		V
V_{rr}	Breakdown voltage	Ir = 1 mA I/O pin ground		± 25		V
V_{cl}	Clamping voltage	Ipp = 10A			± 31	V
V_{cl}	Clamping voltage	Ipp = 25A			± 36	V
C1	Capacitance	Between two input pins at 0V bias			420	pF
C2	Capacitance	Between one pin at 0V and one at Vrm			140	pF
Top	Operating Ambient Temperature Range		– 65		+100	°C
Tstg	Storage Temperature Range		– 65		+125	°C

Figure 2: Symbols definition



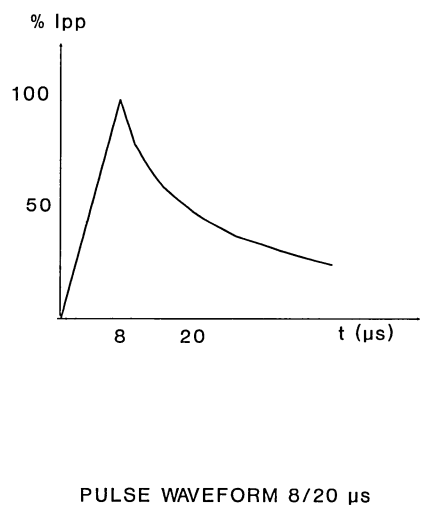
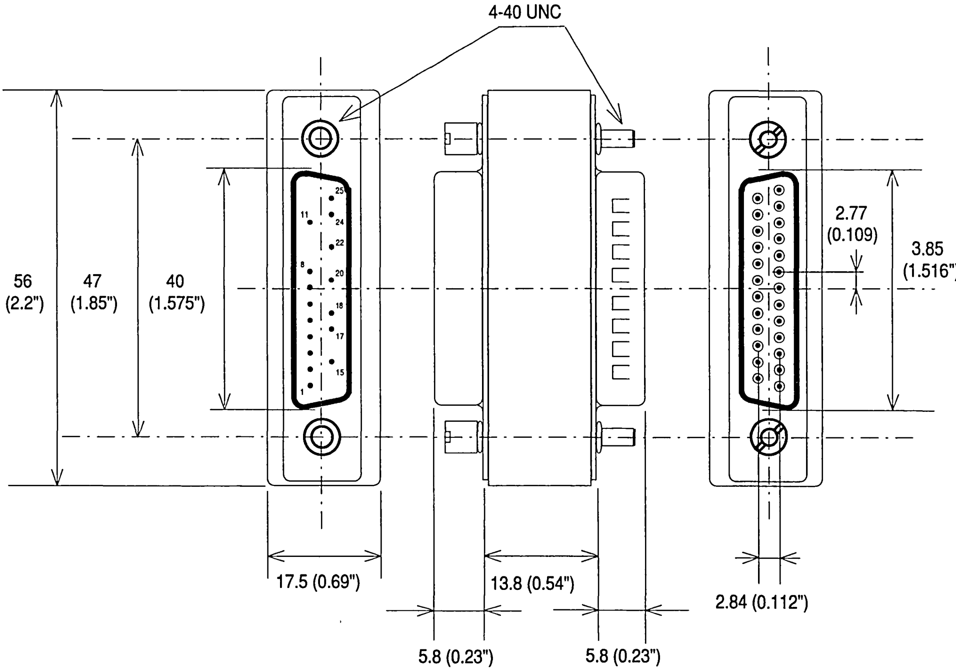


Figure 3.



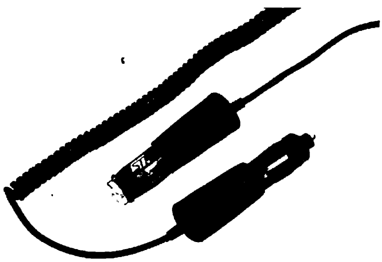
Dimensions in mm (inches).

SGS-THOMSON MICROELECTRONICS

GS-R28.0BE

BATTERY ELIMINATOR

Type	V_i	V_o	I_o
GS-R28.0BE	10,5 to 16 V	7,5 V	750 mA



DESCRIPTION

The GS-R28.0BE is a switch mode constant voltage BATTERY ELIMINATOR that can deliver an output voltage of 7.5 V at 0,75 A of DC output current (Peak output current = 1.8 Ap).

Two versions of the INPUT PLUG ADAPTOR are available:

WASHER TIP VERSION:
GS-R28.0BE-E (Ordering Number)

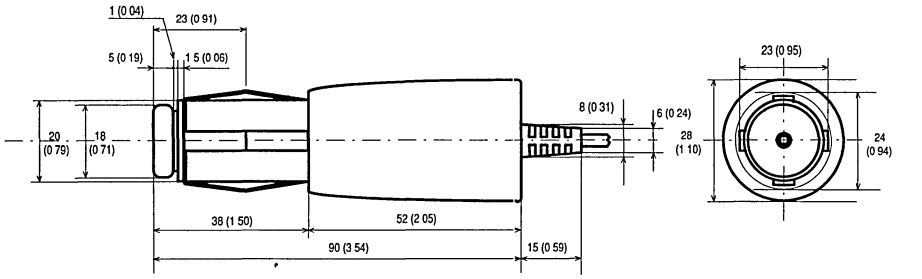
SPRING-LOADED TIP VERSION:
GS-R28.0BE-A (Ordering Number)
(See page 2 for mechanical data)

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

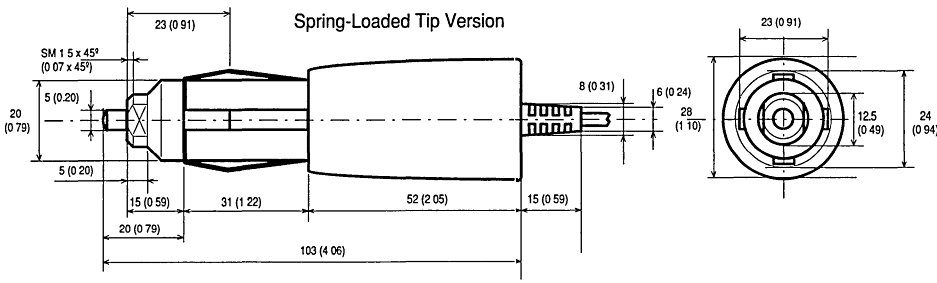
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 7 to 8V	10.5		16	V
I_{iq}	Input Quiescent Current	V_{in} = 13.2V I_O = 0A		20	30	mA
V_O	Output Voltage	V_i = 10.5 to 16V I_O = 0 to 1.8Ap	7.0	7.5	8.0	V
I_O	Output Current	Continuous output current V_i = 10.5 to 16V V_O = 7.5V			750	mA
I_{op}	Peak Output Current	Duration: 0.6 ms every 4.8 ms V_i = 10.5 to 16V V_O = 7.5V			1.8	Ap
V_{or}	Output Ripple Voltage	V_i = 10.5 to 16V V_O = 7.5V I_O = 750 mA			100	mVpp
η	Efficiency	V_i = 13.2V I_O = 750 mA		70		%
f_s	Switching Frequency	V_{in} = 10.5 to 16V I_O = 0A to 1.8 Ap		100		kHz
T_{op}	Operating Ambient Temperature Range		– 20		+60	°C
T_{stg}	Storage Temperature Range		– 25		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA

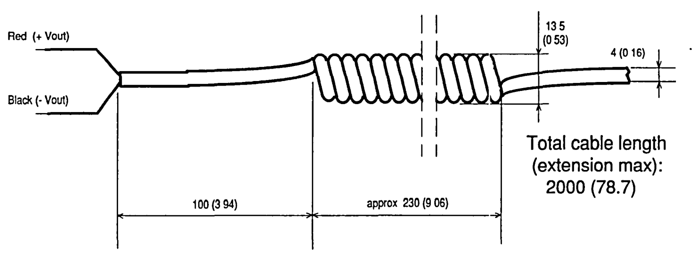
Washer Tip Version

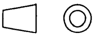


Spring-Loaded Tip Version



Coiled cable (both versions)





European View

Output connector to be defined according to customer specifications
Dimensions in mm (inches).

27W SWITCHING REGULATOR FOR AUTOMOTIVE APPLICATION

Type	V_i	V_o	I_o
GS-R218	10,5 to 16,0 V	18 V	1,5 A

DESCRIPTION

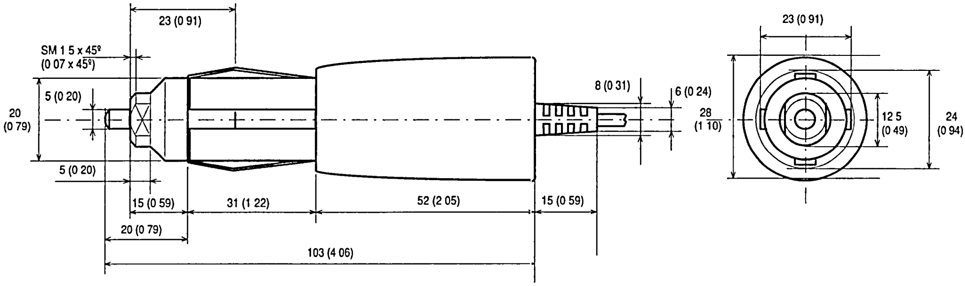
The GS-R218 is a switching voltage regulator that can deliver an output current of 1,5 A at 18 V when supplied by a car battery.

The regulator uses a cigar lighter case with a coiled cord and it is protected against overloads and short circuits at the output (latching overload protection: to restart the regulator after the intervention of the overload protection, the input voltage must be switched OFF and ON again).

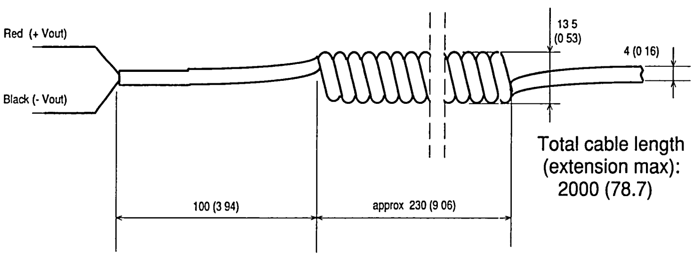
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_o = 18 V I_o = 0 to 1.5 A	10.5		16	V
I_{iq}	Input Quiescent Current	V_i = 13 V I_o = 0 A		17		mA
V_o	Output Voltage	V_i = 10.5 to 16 V I_o = 0 to 1.5A	16.6	18	18.7	V
I_o	Output Current	V_i = 10.5 to 16V	0.0		1.5	A
I_{ol}	Output Overload Current	V_i = 10.5 to 16 V	1.6			A
V_{or}	Output Ripple Voltage	V_i = 13 V I_o = 1.5A		200		mVpp
η	Efficiency	V_i = 13 V I_o = 1.5A		90		%
f_s	Switching Frequency			300		kHz
T_{op}	Operating Ambient Temperature Range		– 20		+60	°C
T_{stg}	Storage Temperature Range		– 20		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Coiled cable



European View

Output connector to be defined according to customer specifications
Dimensions in mm (inches).

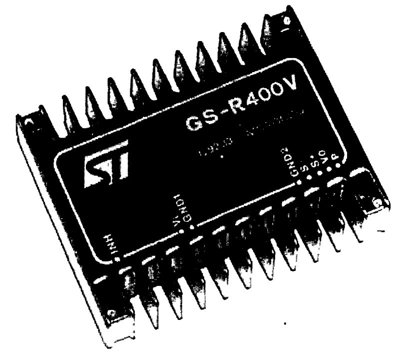
SGS-THOMSON MICROELECTRONICS

GS-R400 Family

20W TO 140W STEP-DOWN SWITCHING REGULATOR FAMILY

FEATURES

- MTBF in excess of 200,000 hours
- 4A max output current
- 46V max input voltage
- 4V max drop-out voltage
- Soft start
- Remote logic inhibit/enable
- Remote output voltage sense
- Non-latching overload and short circuit protection
- Crow-bar output overvoltage protection



DESCRIPTION

The GS-R400 series is a versatile family of high current, high voltage step-down switching voltage regulators.

The integral heatsink allows a large power handling capability and it provides also an effective shielding to minimize EMI.

SELECTION CHART

Type Ordering Number	Output Voltage (V)	Input Voltage (V)	Output Ripple (mVpp)	Regulation Line (mV/V)	Regulation Load (mV/A)	Efficiency (%)	Notes
GS-R405	5.1 ± 2%	9 to 46	25	2	20	70	Fixed output voltage
GS-R412	12.0 ± 4%	16 to 46	50	5	40	80	"
GS-R415	15.0 ± 4%	19 to 46	65	5	60	85	"
GS-R424	24.0 ± 4%	28 to 46	100	6	90	90	"
GS-R405S	5.1 ± 2%	9 to 46	25	2	20	70	Reset output
GS-R400V	5.1 to 40	Vo+4 to 46	25 to 100	6	20 to 90	70 to 90	Progr. output voltage
GS-R400VB	5.1 to 40	Vo+4 to 46	25 to 100	6	20 to 90	70 to 90	Progr. output voltage and current. Frequency synchr.

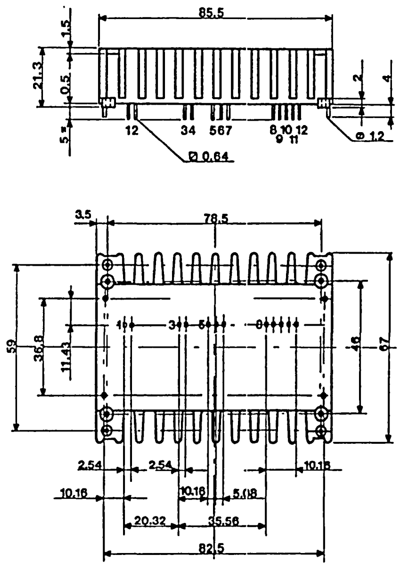
Note: The line regulation is measured at I_{out}=1A
The load regulation is measured at $V_{in}=V_o$+8V and I_{out}=1 to 3A
For $V_O \geq 36V$ and I_o = 4A an external heatsink or forced ventilation are required.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	48	V
I_{rt}*	Reset Output Sink Current	20	mA
T_{stg}	Storage Temperature Range	– 40 to +105	°C
T_{cop}	Operating Case Temperature Range	– 20 to +85	°C

* GS-R405S only

CONNECTION DIAGRAM AND MECHANICAL DATA



Pin 2 GS-R405S only
Pin 5,6,7 GS-R400VB only
Pin 12 GS-R400V/VB only

Dimensions in mm

Bottom view

PIN DESCRIPTION

Pin	Function	Description
1	Inhibit	The module is disabled by a high logic level applied to this pin.
2	Reset	Reset output (GS-R405S only).
3	+ Input	DC input voltage. Recommended maximum voltage is 46V.
4	Input GND	Return for input voltage source.
5	Oscillator	100kHz oscillator output. To be connected to Sync (pin 6) input if the unit is a master and left open if it is a slave (GS-R400VB only). See fig. 5.
6	Sync	Synchronization input. To be connected to the Oscillator output (pin 5) of the master (GS-R400VB only). See fig. 5.
7	Current limiting	A resistor (≥ 2.2kΩ) connected from this pin to pin 9 sets the current limiting level (GS-R400VB only).
8	Output GND	Return for output current path. Internally connected to pin 4.
9	– Sense	Senses the remote load return. Must be tied to pin 8 when the remote sensing feature is not used. See fig. 1.
10	+ Sense	Senses the remote load high side. Must be tied to pin 11 when the remote load sensing feature is not used. See fig. 1.
11	+ Output	Regulated DC output voltage.
12	Program	A resistor (≤ 18kΩ) connected between this pin and pin 10 sets the output voltage (GS-R400V and GS-R400VB only).

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$\Delta V_O/\Delta T$	Temperature Stability	$V_i = V_O+8V$ $I_O = 1A$		0.2/1.6		mv/°C
I_O	Output Current	$V_i = V_O+8V$	0.2		4	A
I_{OL}	Current Limit	$V_i = V_O+8V$		5	8	A
I_{isc}	Average Input Current	V_i = 46V Output Shorted		0.1	0.2	A
f_s	Switching Frequency	I_O = 1A		100		KHz
SVR	Supply Voltage Rejection	f_O = 100Hz I_O =1A		4/12		mV/V
V_r	Ripple Voltage	I_O = 2A		25/150		mV_{pp}
t_{ss}	Soft Start Time	$V_i = V_O+8V$		10/35		ms
V_{inhl}	Low Inhibit Voltage				0.8	V
V_{inhh}	High Inhibit Voltage		2		5.5	V
I_{inhh}	High Inhibit Input Current	V_{inh} = 5V			500	µA
t_{cb}	Crow-bar Delay Time			5		µs
V_{rh}*	Reset High Level			5		V
V_{rl}*	Reset Low Level	I_{rl} = 5mA I_{rl} = 10mA			0.2 0.4	V
t_{rd}*	Reset Delay Time			100		ms
V_{cth}	Crowbar Intervention Threshold			V_O•1.25		V
ΔV_O	Total Remote Sense Compensation				500	mV
R_{th}	Thermal Resistance	Case to ambient		5		°C/W

* GS-R405S only

USER NOTES

Input Voltage

The recommended operating maximum DC input voltage is 46V inclusive of the ripple voltage.

Remote Sensing

The remote voltage sense compensation range is for a total drop of 500mV equally shared between the load connecting wires. It is a good practice to shield the sensing wires to avoid oscillation.
Each sense input must be connected to its companion output power pin when the remote sense capability is not used (see fig. 1).

Case Grounding

The module case is isolated from the electrical circuit of the switching regulator. It can be grounded using the 4 corner pins.
The PCB area below the module can be used as an effective sixth side shield against EMI.

Thermal Characteristics

The case-to-ambient thermal resistance of all the GS-R400 modules is about 5°C/W. This produces a 50°C temperature increase of the module surface for 10W of internal power dissipation.
Depending on the ambient temperature and/or on the power dissipation, an additional heatsink or forced ventilation may be required.

Input Impedance

The module has an internal capacitor connected between the input pins in order to assure PWM stability. This capacitor cannot handle large values of high frequency ripple current and it can be permanently damaged if the primary energy source impedance is not adequate. The use of an external low ESR, high ripple current capacitor located as close the module as possible is recommended.
Suitable capacitors should have a RMS current capability of $2.5A_{RMS}$ with a working voltage of 50 V_{DC} and an ESR of 0,1Ω at 100 kHz. When space

is a limitation, a 22µF ceramic multilayer capacitor must be connected to the module input pins.

Output Voltage Programming

The GS-R400V and GS-R400VB output voltage is programmed by using a resistor (see pin function table and fig. 4). The resistor must be located very close the module and the PCB layout must mimimize injected noise. The value of the resistor is calculated by using the following formula:

$$R_V = 2.67\left(\frac{V_O}{5.1} - 1\right) k\Omega$$

V_O can be adjusted between 5.1 and 40V.

Current Limiting Programming

The GS-R400VB current limiting is programmed by using a resistor (see pin function table and fig. 4). The value of the resistor is calculated by using the following formula:

$$R_i = [2.2 + (5 \bullet I_O)]\ k\Omega$$

Module Protection

The modules are protected against occasional and permanent short circuits of the output pin to ground, as well as against output current overload.
When the output current exceeds the maximum value, the output is automatically disabled. After a fixed time the module starts again in a soft mode. The cycle is repeated until the overload condition is removed.
A crowbar output overvoltage protection is activated whenever the output voltage exceeds the nominal output voltage by more than 25%.

Figure 1. Load Connection

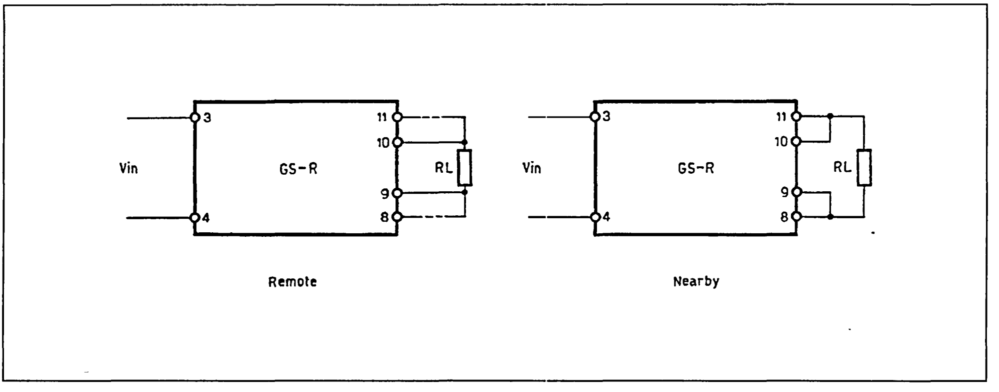


Figure 2. Remote Inhibit Operation

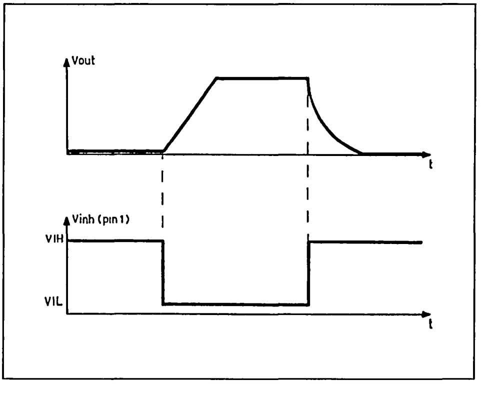


Figure 3. Reset Operation

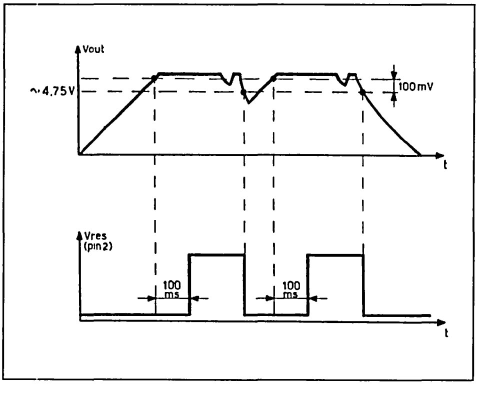


Figure 4. Voltage and Current Programming

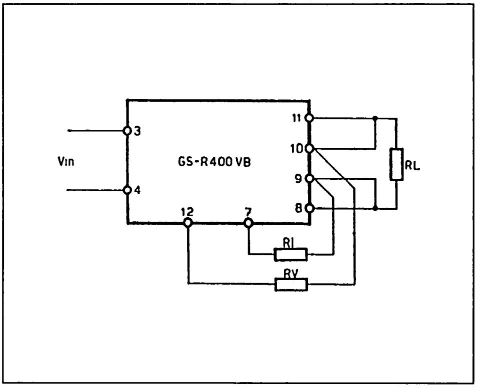
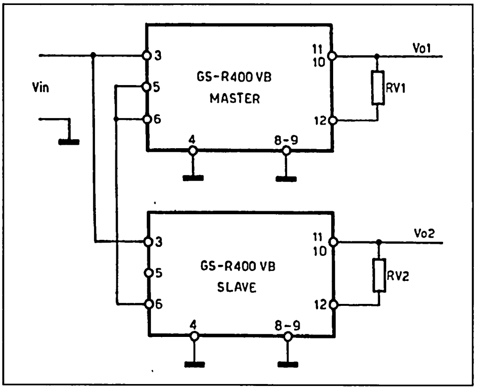


Figure 5. Multiple Units Synchronization



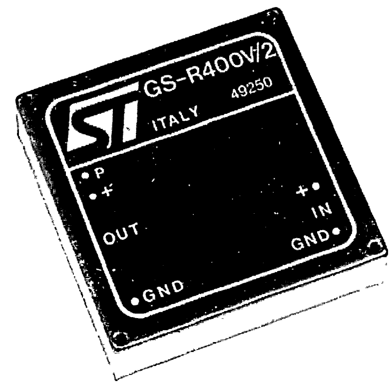
SGS-THOMSON MICROELECTRONICS

GS-R400/2 Family

SMALL SIZE STEP-DOWN SWITCHING REGULATOR FAMILY

FEATURES

- MTBF in excess of 500,000 hours
- 4A max output current
- 40V max input voltage
- 4V max drop-out voltage
- Soft start
- Non-latching short circuit protection
- Crow-bar output overvoltage protection



DESCRIPTION

The GS-R400/2 series is a family of small sized high current, high voltage step-down switching regulators.

The integral heatsink allows a large power handling capability and it provides also an effective shielding to minimize EMI.

SELECTION CHART

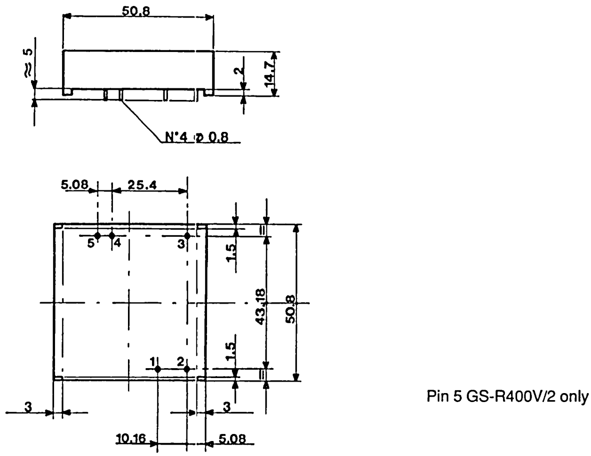
Type Ordering Number	Output Voltage (V)	Input Voltage (V)	Output Ripple (mVpp)	Regulation Line (mV/V)	Regulation Load (mV/A)	Efficiency (%)	Notes
GS-R405/2	5.1 ± 2%	9 to 40	25	2	20	80	Fixed output voltage
GS-R412/2	12.0 ± 4%	16 to 40	50	5	40	85	"
GS-R415/2	15.0 ± 4%	19 to 40	65	6	60	87	"
GS-R424/2	24.0 ± 4%	28 to 40	100	6	80	90	"
GS-R400V/2	5.1 to 24	Vo+4 to 40	25 to 100	2 to 6	20 to 80	80 to 90	Progr. output voltage

Note : Line regulation is measured at I_{out}=1A.
Load regulation is measured at $V_{in}=V_o+8V$ and I_{out}=0.5 to 1.5A.
Case temperature must be kept below 85° C

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	42	V
I_o	Output Current	4	A
T_{stg}	Storage Temperature Range	– 40 to +105	°C
T_{cop}	Operating Case Temperature Range	– 20 to +85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Dimensions in mm   Bottom view

PIN DESCRIPTION

Pin	Function	Description
1	+ Input	DC input voltage. Recommended maximum voltage is 40V.
2	Input GND	Return for input voltage source.
3	Output GND	Return for output current path. Internally connected to pin 2.
4	+ Output	Regulated DC output voltage.
5	Program	A resistor (<10kΩ) connected between this pin and pin 4 sets the + output voltage of the GS-R400V/2.

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$\Delta V_O/\Delta T$	Temperature Stability	$V_i = V_O$+8V I_O = 1A		0.2/0.6		mV/°C
I_O	Output Current	$V_i = V_O$+8V	0.1		4	A
I_{OL}	Current Limit	$V_i = V_O$+8V		5	8	A
I_{isc}	Average Input Current	V_i = 40V Output Shorted		0.1	0.2	A
f_S	Switching Frequency	I_O = 1A		100		kHz
SVR	Supply Voltage Rejection	f_O = 100Hz I_O = 1A		4/12		mV/V
V_r	Ripple Voltage	I_O = 1A		25/100		mVpp
t_{ss}	Soft Start Time			10/35		ms
t_{cb}	Crowbar Delay Time			5		µs
V_{cth}	Crowbar Intervention Threshold			V_O•1.25		V
R_{th}	Thermal Resistance	Case to ambient		8		°C/W

USER NOTES

Input Voltage

The recommended operating maximum DC input voltage is 40V inclusive of the ripple voltage.

Case Grounding

The module case is internally connected to pin 2 and pin 3.
The PCB area below the module can be used as an effective sixth side shield against EMI.

Thermal Characteristics

The case-to-ambient thermal resistance of all the GS-R400/2 modules is about 8°C/W. This produces a 32°C temperature increase of the module surface for 4W of internal power dissipation.
Depending on the ambient temperature and/or on the power dissipation, an additional heatsink or forced ventilation may be required.

Input Impedance

The module has an internal capacitor connected between the input pins in order to assure PWM stability. This capacitor cannot handle large values of high frequency ripple current and it can be permanently damaged if the primary energy source impedance is not adequate.
The use of an external low ESR, high ripple current capacitor located as close the module as possible is recommended.
Suitable capacitors should have a RMS current capability of 2.5 A_{RMS} with a working voltage of 50 V_{DC} and an ESR of 0,1Ω at 100kHz. When space is a limitation a 22μF ceramic multilayer capacitor must be connected to the module input pins.

Output Voltage Programming

The GS-R400V/2 output voltage is programmed by using a resistor.
The resistor must be located very close the module and the PCB layout must minimize injected noise. The value of the resistor is calculated by using the following formula:

$$R_V = 2.67\left(\frac{V_O}{5.1} - 1\right) k\Omega$$

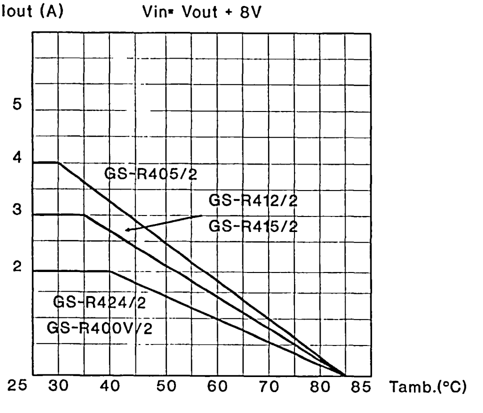
V_O can be adjusted between 5.1 and 24V.

Module Protection

The modules are protected against occasional and permanent short circuits of the output pins to ground. During short circuit (when the output current exceeds the maximum value) the output is automatically disabled. After a fixed time the module starts again in a soft mode. The cycle is repeated until the short circuit condition is removed.

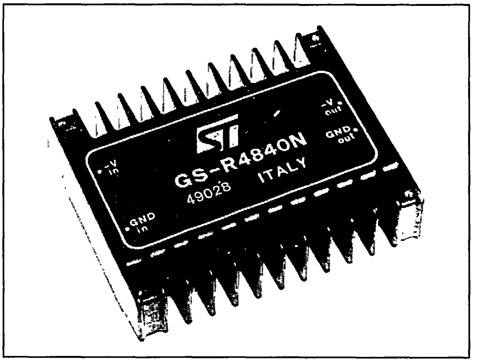
The module can be permanently damaged if the case temperature exceeds 85° C

Power Derating Curve



44W NEGATIVE SWITCHING REGULATOR

Type	V_i	V_o	I_o
GS-R4840N	– 43 to – 60 V	– 40 V	1,08 A



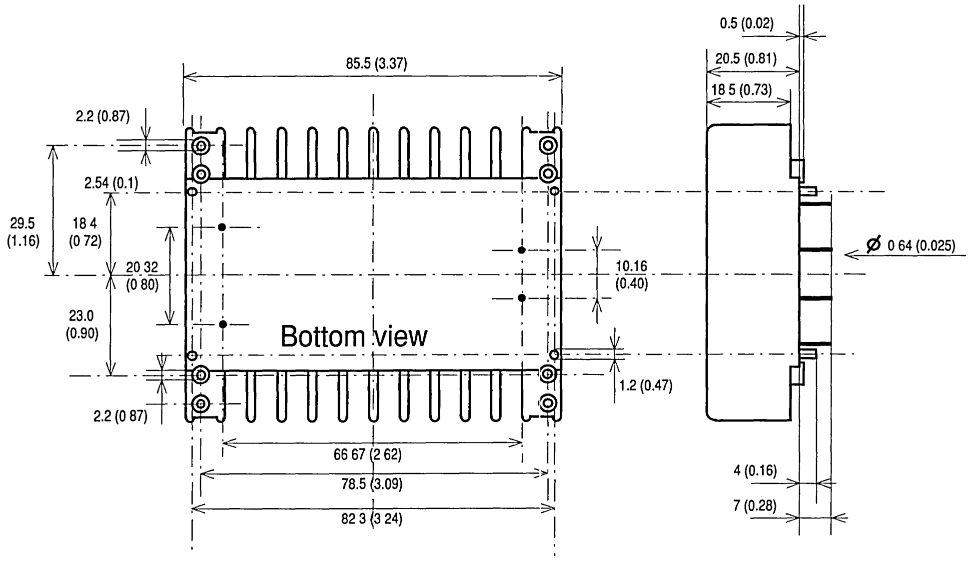
DESCRIPTION

The GS-R4840N is a negative input, negative output switching voltage regulator that can provide up to 44W output power without input to output isolation.

ELECTRICAL CHARACTERISTICS ($T_{amb.}$= 25° C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	I_O = 1.08A	– 43	– 48	– 60	V
V_{ni}	Input noise (CCITTP53)	V_i = – 48V I_O = – 1A			1	mV
I_i	Input Current	V_i = – 48V I_O = – 1.08A			– 1	A
V_O	Output Voltage	V_i = – 43 to – 60V I_O = 0 to – 1.08A	– 38.5	– 40.5	– 42.5	V
V_{or}	Output Ripple Voltage	V_i = – 48V I_O = – 1.08A			100	mVpp
V_{on}	Output noise Voltage (CCITTP53)	V_i = – 48V I_O = – 1A			1	mV
Iosc	Output Current Limit	V_i = – 48V		– 1.6		A
f_s	Switching Frequency			50		kHz
η	Efficiency	V_i = – 48V I_O = – 1.08A		93		%
Top	Operating Case Temperature Range		0		+70	°C
Tstg	Storage Temperature Range		– 20		+85	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



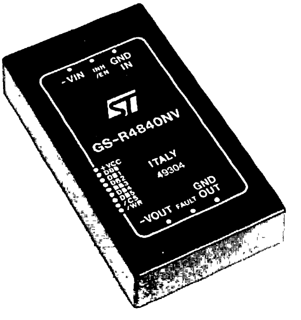
Package H. Dimensions in mm.
Note: Pins 1 and 4 are internally connected

SGS-THOMSON
MICROELECTRONICS

GS-R4840NV

36 W NEGATIVE SWITCHING REGULATOR

Type	V_i	V_o	I_o
GS-R4840NV	– 40 to – 60 V	–22 to –60 V	– 600 mA



FEATURES

- Digital input for voltage selection
- Short-circuit protection
- Overvoltage protection
- Thermal protection
- Softstart
- Fault signal indication output
- High efficiency (>80%)

DESCRIPTION

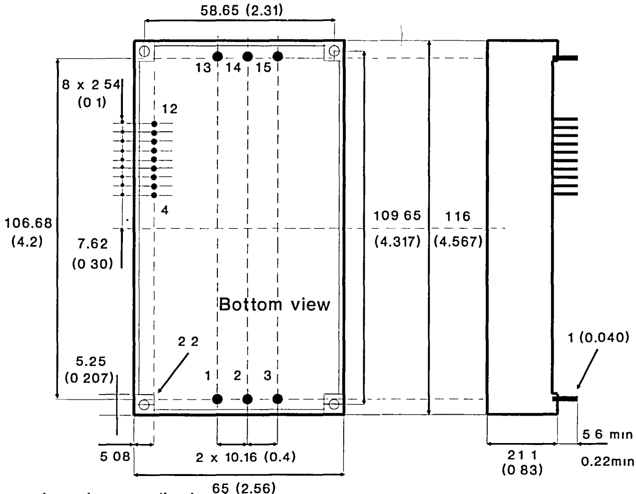
The GS-R4840NV is a negative input, negative output switching voltage regulator that provides up to 36W output power without input-output isolation.

The output voltage is programmable by input logic signals that allow 64 steps (6 bit) of regulated output, from –22 to –60V.

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = – 22 to – 60V I_O = – 10 to – 600mA	– 40	– 48	– 60	V
V_{ir}	Input Ripple Voltage	V_i = – 40 to – 60V I_O = – 600mA			20	mVpp
V_O	Output Voltage	V_i = – 40 to – 60V I_O = – 10 to – 600mA	– 22		– 60	V
V_{or}	Output Ripple Voltage	V_O = – 22 to – 60V I_O = – 600mA		4	10	mVpp
V_{oov}	Output Overvoltage Protection	V_i = – 40 to – 60V I_O = – 10 to – 600mA	Vo+5%		Vo+10%	V
I_O	Output Current	V_i = – 40 to – 60V V_O = – 22 to – 60V	– 10		– 600	mA
I_{ol}	Current Limit	V_i = – 40 to – 60V Overload Condition			– 900	mA
I_{osc}	Output Average Short Circ. Current	V_i = – 40 to – 60V			– 80	mA
f_s	Switching Frequency			100		kHz
η	Efficiency	V_i = – 48V I_O = – 600mA V_O = – 48V	80	82		%
R_{th}	Thermal Resistance	Case to Ambient		4		°C/W
T_{cop}	Operating Case Temperature Range		0		+85	°C
T_{stg}	Storage Temperature Range		– 20		+105	°C

CONNECTION DIAGRAM AND MECHANICAL DATA



Package F. Dimensions in mm. (inches)

PIN DESCRIPTION

Pin	Function	Description
1	-Vin	Negative input voltage.
2	Inhibit/ $\overline{\text{Enable}}$	Remote Inhibit/Enable logically compatible with CMOS or open collector TTL. The converter is OFF (Inhibit) when this pin is unconnected or the voltage applied is in the range of 2 to 5V (referred to GND). The converter is ON (Enable) for a control voltage in the range of 0 to 0.8V maximum.
3	GND IN	Return for input voltage source and +5V logic supply voltage. Internally connected to pin 15.
4	+5V IN	+5V logic supply voltage. Maximum voltage must not exceed 7V.
5	DB0	Data bit 0 (LSB).
6	DB1	Data bit 1.
7	DB2	Data bit 2.
8	DB3	Data bit 3.
9	DB4	Data bit 4.
10	DB5	Data bit 5 (MSB).
11	$\overline{\text{CS}}$	Chip select. An active low input control which is the device enable input terminal.
12	$\overline{\text{WR}}$	Write control. An active low control which enables the microprocessor to write data to the DAC.
13	-Vout	Negative output voltage.
14	FAULT	FAULT indication output (referred to GND). The FAULT signal is high (TTL compatible level) when: - the INHIBIT is ON (high) - an output overload is present (Vo < 18V typ.) - an overtemperature is present - an overvoltage is present (Vo > Vo+5%)
15	GND OUT	Return for output voltage source. Internally connected to pin 3.

Note: Case internally connected to Ground.

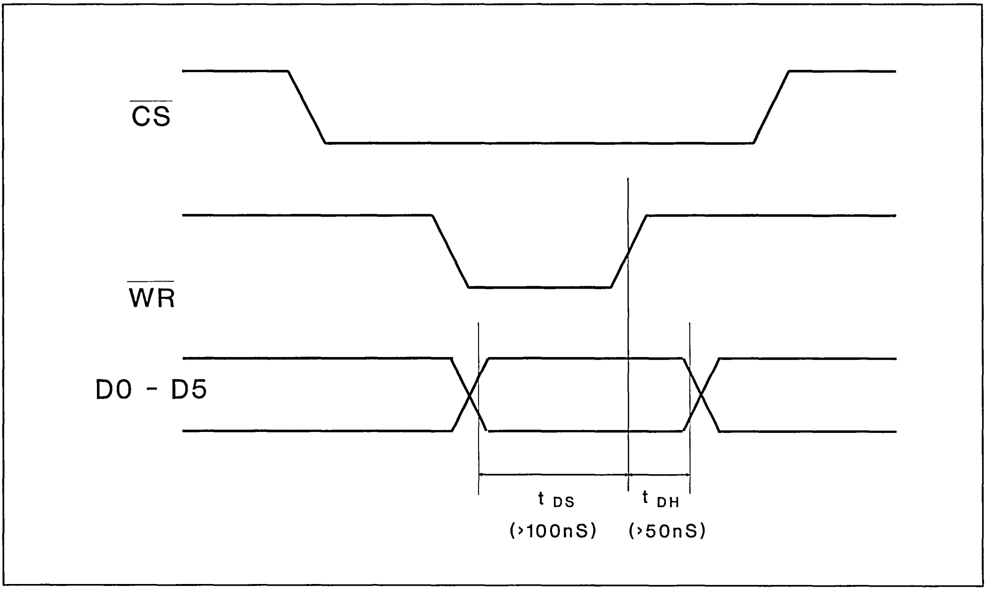
USER NOTES

Digital Information

The GS-R4840NV accepts 6 bit binary at the data inputs DB0 to DB5. Data are transferred when CS is low and during the rising edge of WR signal.

t_{DS} and t_{DH} have to be 100ns and 50ns minimum respectively (see fig. 1).

Figure 1 - Signals Timing.

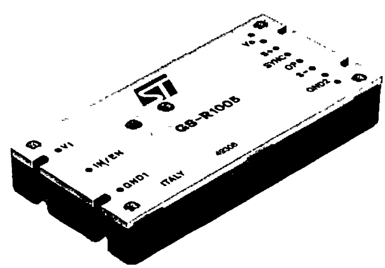


SGS-THOMSON
MICROELECTRONICS

GS-R1005

50W STEP-DOWN SWITCHING REGULATOR

Type	V_i	V_o	I_o
GS-R1005	12 to 36 V	5 V	10 A



FEATURES

- Wide input voltage range (12 to 36V)
- High efficiency (80% min.)
- Parallel operation with current sharing
- Synchronization
- Remote inhibit/enable
- Remote load voltage sense
- Output short-circuit protection
- Soft-start
- PCB or chassis mountable

DESCRIPTION

The GS-R1005 is a step-down switching voltage regulator suitable to provide 5V/10A output voltage from a wide input voltage range (12 to 36V).

ABSOLUTE MAXIMUM RATINGS

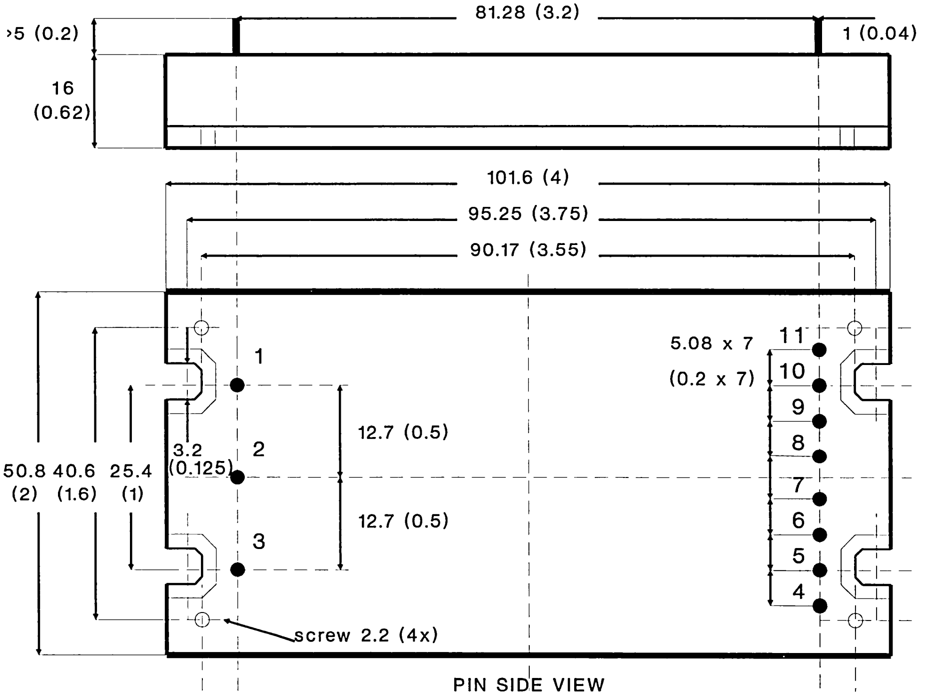
Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	40	V
V_{iinh}	High Inhibit voltage	28	V
T_{cop}	Operating Case Temperature Range	0 to +75	°C
T_{stg}	Storage Temperature Range	– 20 to +105	°C

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 5.05V I_O = 1.2 to 10A	12	24	36	V
I_i	Input Current	V_i = 24V I_O = 10A		2.5		A
I_{ir}	Reflected Input Current	V_i = 24V I_O = 10A with external filter (C = 470μF)		200	220	mApp
V_{ien}	Enable Input Voltage	V_i = 12 to 36V I_O = 1.2 to 10A	0		1.2	V
V_{iinh}	Inhibit Input Voltage	V_i = 12 to 36V I_O = 1.2 to 10A	2		24	V
I_{iinh}	Inhibit Input Current	V_i = 12 to 36V I_O =1.2 to 10A V_{iinh} = 5V		0.3	0.5	mA
V_O	Output Voltage	V_i = 12 to 36V I_O = 1.2 to 10A	4.9	5.05	5.2	V
V_{or}	Output Ripple Voltage	V_i = 24V I_O = 10A		100	120	mVpp
δV_{OL}	Line Regulation	V_i = 12 to 36V I_O = 10A			0.5	%
δV_{OO}	Load Regulation	V_i = 24V I_O = 1.2 to 10A			1	%
ΔV_O	Total Remote Sense Compensation	V_i = 24V I_O = 10A			0.5	V
I_O	Output Current*	V_i = 12 to 36V V_O = 5.05V	0		10	A
I_{ol}	Output Current Limiting	V_i = 12 to 36V	12.5		13.7	A
I_{osc}	Short-circuit Output Current	V_i = 24V			16	A
δI_O	Current Sharing Deviation	V_i = 24V I_O = 2 to 10A two modules in parallel			10	%
t_{ss}	Soft-start Time	V_i = 24V I_O = 10A		15		ms
t_{r1}	Line Transient Recovery Time	V_i = 12 to 36V I_O = 5A		60		μs
t_{r2}	Load Transient Recovery Time	V_i = 24V I_O = 1.2 to 10A		100		μs
f_s	Switching Frequency	V_i = 24V I_O = 1.2 to 10A		100		kHz
η	Efficiency	V_i = 12 to 36V I_O = 10A	80	83		%
R_{thc}	Thermal Resistance Case-to-ambient			7.5		°C/W

* Note: when output current is less than 1.2A, output ripple voltage increases due to discontinuous operation.

CONNECTION DIAGRAM AND MECHANICAL DATA



Package R. Dimensions in mm (inches).

PIN DESCRIPTION

Pin	Function	Description
1	GND Input	Return for input voltage source. Internally connected to pin 10,11.
2	Inhibit	The converter is ON (Enable) when this pin is unconnected or the voltage applied is lower than 1.2V. The converter is OFF (Inhibit) for a control voltage in the range of 2 to 24V.
3	+ Vin	DC Input voltage; recommended maximum voltage is 36V. External capacitor between pin 3 and pin 1 is mandatory; recommended value is 470µF/50V for switching application.
4,5	+ Vout	+5V output voltage.
6	+ Sense	Senses the remote load high side. To be connected to pin 4,5 when remote sense is not used.
7	Sync	Synchronization output. See figures 1,2,3,4. Open when not used.
8	Parallel	Parallel output. See figures 1,2,3,4. Open when not used.
9	- Sense	Senses the remote load return. To be connected to pin 10,11 when remote sense is not used. In parallel configuration, take care to connect all -S pins together (see figures 1,2,3,4).
10,11	GND Output	Return for output current path. Internally connected to pin 1.

USER NOTES

Input Voltage

The recommended operating maximum DC input voltage is 36V inclusive of the ripple voltage. The use of an external low ESR, high ripple current capacitor located as close the module as possible is mandatory; recommended value is 470µF/50V.

Softstart

To avoid heavy inrush current the output voltage rise time is typically 15ms in any condition of load.

Remote Sensing

The remote voltage sense compensation range is for a total drop of 500mV equally shared between the load connecting wires. It is a good practice to shield the sensing wires to avoid oscillations. See the connection diagram on figures 1, 2, 3, 4.

Parallel Operation

To increase available output regulated power, the module features the parallel connection possibility with equal current sharing and maximum deviation of 10% (two modules in parallel). See the connection diagram on figures 1, 2, 3, 4.

Module Protection

The module is protected against occasional and permanent shortcircuits of the output pins to ground, as well as against output current overload. It uses a current limiting protection circuitry, avoiding latch-up problems with certain types of loads.

Figure 1.

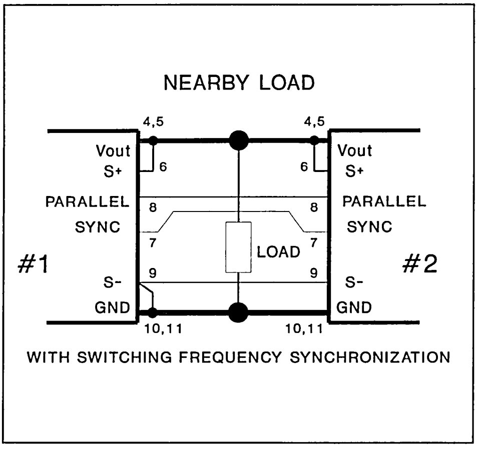


Figure 2.

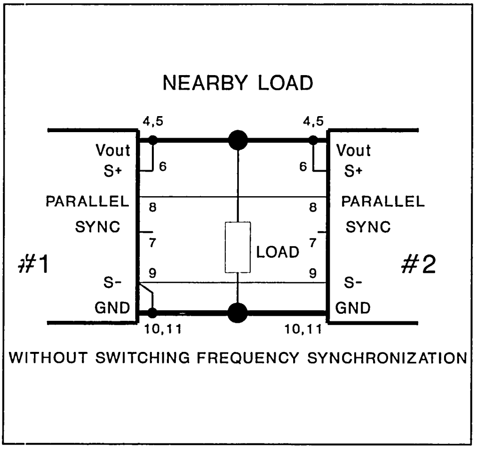
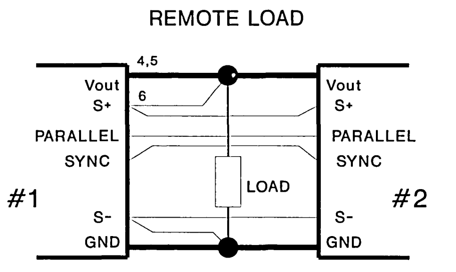
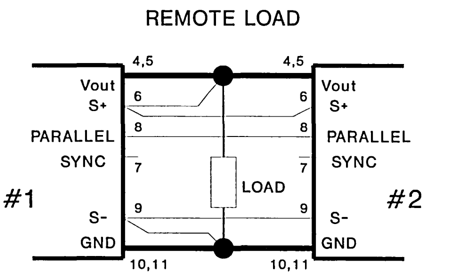


Figure 3.



WITH SWITCHING FREQUENCY SYNCHRONIZATION

Figure 4.



WITHOUT SWITCHING FREQUENCY SYNCHRONIZATION

Thermal characteristics: how to choose the heat-sink

Sometimes the GS-R1005 requires an external heat-sink depending on both operating temperature conditions and power.

Before entering into calculations details, some basic concepts will be explained to better understand the problem.

The thermal resistance between two points is represented by their temperature difference in front of a specified dissipated power, and it is expressed in Degree Centigrade per Watt (°C/W).

For GS-R1005 the thermal resistance case to ambient is 7.5°C/W. This means that an internal power dissipation of 1W will bring the case temperature at 7.5°C above the ambient temperature.

The maximum case temperature, at which the module provides 10A, is 75°C (see fig. 6).

Let's suppose to have a GS-R1005 that delivers a load current of 10A at an ambient temperature of 40°C.

The dissipated power in this operating condition is about 10.2W (at typical efficiency of 83%), and the case temperature of the module will be:

$$T_{Case} = T_{Amb} + P_d \times R_{th} = 40 + 10.2 \times 7.5 = 116.8\ °C$$

This value exceeds the maximum allowed temperature and an external heat-sink must be added. To this purpose four holes (see mechanical drawing) are provided on the metal surface of the module.

To calculate this heat-sink, let's first determine what the total thermal resistance should be.

$$R_{th} = \frac{T_{CaseMAX} - T_{amb}}{P_d} = \frac{75 - 40}{10.2} = 3.42°C / W$$

This value is the resulting value of the additional heatsink thermal resistance.

Figure 5. - Efficiency vs. Output Current.

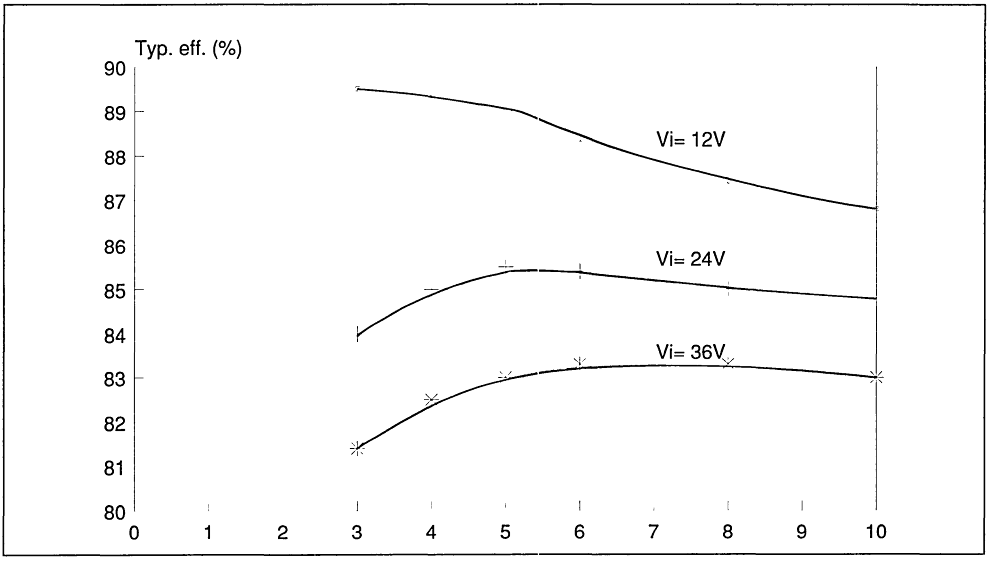
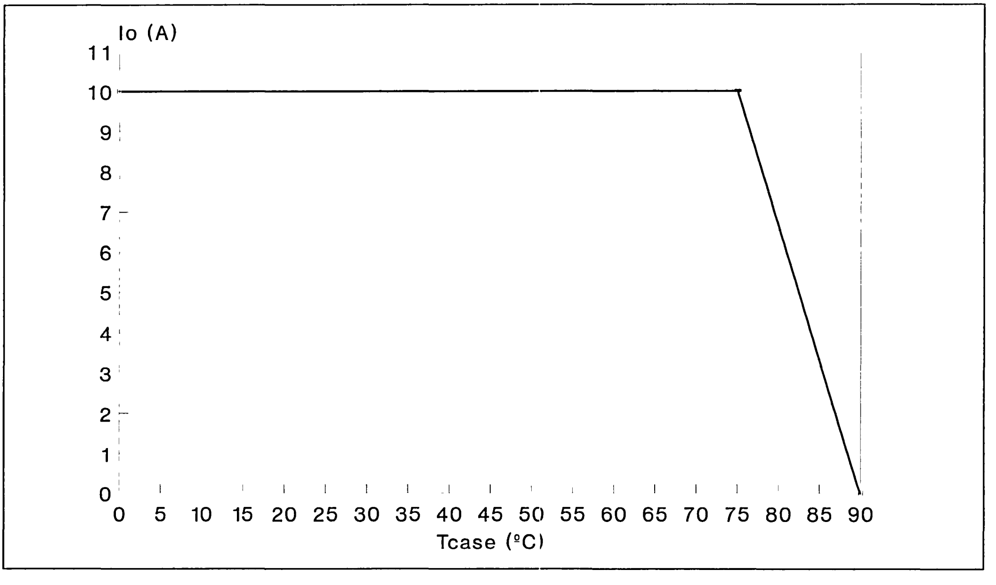


Figure 6. - Output Current vs. T case.



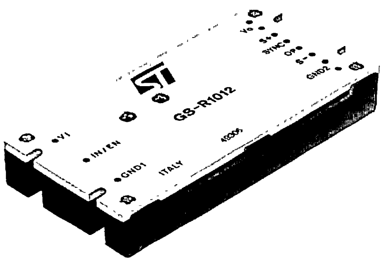
The following list may help the designer to select the proper commercially available heat-sink. Sometimes it can be more convenient to use a custom made heat-sink that can be experimently designed and tested.

Manufacturers	Type	Height (mm)	Rth (°C/W)
ALUTRONIC	PR139	20	3
	PR140	19	2
	PR159	20	2.5
ASSMAN	V5440	19	3
	V5805	15	2
	V5280	19	2
AAVID	60885	14	4.5
	60660	25.5	1.5
	62355	33.5	3
AUSTERLITZ	KS50	12	3
	KS100.3	15	2.5
FISCHER	SK16	25.5	1.5
	SK52	19	2
SGE BOSARI	L30	21	3
	LZ50	24	3
THERMALLOY	6155	14	4.5
	6601	14	5
	6176	24	4.5
	6320	30	1.5

GS-R1012

120W STEP-DOWN SWITCHING REGULATOR

Type	V_i	V_o	I_o
GS-R1012	18 to 36 V	12 V	10 A



FEATURES

- Wide input voltage range (18 to 36V)
- High efficiency (90% min.)
- Parallel operation with current sharing
- Synchronization
- Remote inhibit/enable
- Remote load voltage sense
- Output short-circuit protection
- Soft-start
- PCB or chassis mountable

DESCRIPTION

The GS-R1012 is a step-down switching voltage regulator suitable to provide 12V/10A output voltage from a wide input voltage range (18 to 36V).

ABSOLUTE MAXIMUM RATINGS

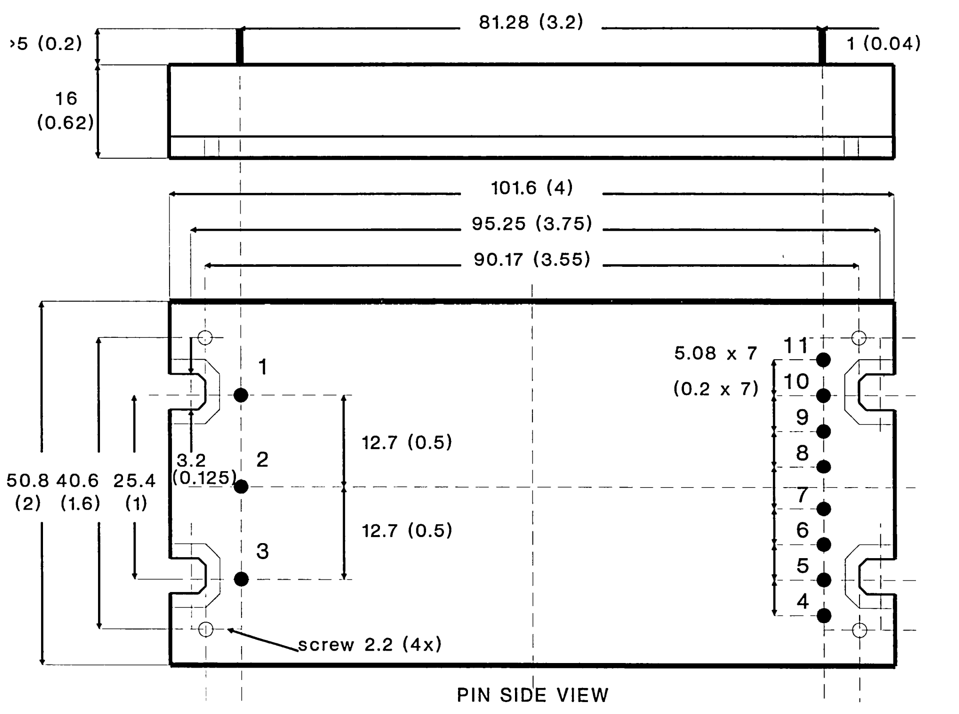
Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	40	V
V_{iinh}	High Inhibit voltage	28	V
T_{stg}	Storage Temperature Range	– 20 to +105	°C
T_{cop}	Operating Case Temperature Range	0 to +75	°C

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage	V_O = 12V I_O = 1.5 to 10A	18	24	36	V
I_i	Input Current	V_i = 24V I_O = 10A		5,6		A
I_{ir}	Reflected Input Current	V_i = 24V I_O = 10A with external filter (C = 1000µF)		400	500	mApp
V_{ien}	Enable Input Voltage	V_i = 18 to 36V I_O = 1.5 to 10A	0		1.2	V
V_{iinh}	Inhibit Input Voltage	V_i = 18 to 36V I_O = 1.5 to 10A	2		24	V
I_{iinh}	Inhibit Input Current	V_i = 18 to 36V I_O =1.5 to 10A V_{iinh} = 5V		0.3	0.5	mA
V_O	Output Voltage	V_i = 18 to 36V I_O = 1.5 to 10A	11.4	12	12.6	V
V_{or}	Output Ripple Voltage	V_i = 24V I_O = 10A		150		mVpp
δV_{OL}	Line Regulation	V_i = 18 to 36V I_O = 10A			0.5	%
δV_{OO}	Load Regulation	V_i = 24V I_O = 1.5 to 10A			1	%
ΔV_O	Remote Sense Compensation	V_i = 24V I_O = 10A			0.5	V
I_O	Output Current*	V_i = 18 to 36V V_O = 12V	0		10	A
I_{OL}	Output Current Limiting	V_i = 18 to 36V	10.5		11.5	A
I_{OSC}	Short-circuit Output Current	V_i = 24V			16	A
δI_O	Current Sharing Deviation	V_i = 24V I_O = 2 to 10A two modules in parallel			10	%
t_{ss}	Soft-start Time	V_i = 24V I_O = 10A		15		ms
t_{r1}	Line Transient Recovery Time	V_i = 15 to 36V I_O = 5A		60		µs
t_{r2}	Load Transient Recovery Time	V_i = 24V I_O = 1.5 to 10A		100		µs
f_s	Switching Frequency	V_i = 24V I_O = 1.5 to 10A		100		kHz
η	Efficiency	V_i = 18 to 36V I_O = 10A	90	92		%
R_{thc}	Thermal Resistance Case-to-ambient			7.5		°C/W

* Note: when output current is less than 1.5A, output ripple voltage increases due to discontinuous operation.

CONNECTION DIAGRAM AND MECHANICAL DATA



Dimensions in mm (inches).

PIN DESCRIPTION

Pin	Function	Description
1	GND Input	Return for input voltage source. Internally connected to pin 10,11.
2	Inhibit	The converter is ON (Enable) when this pin is unconnected or the voltage applied is lower than 1.2V. The converter is OFF (Inhibit) for a control voltage in the range of 2 to 24V.
3	+ Vin	DC Input voltage; recommended maximum voltage is 36V. External capacitor between pin 3 and pin 1 is mandatory; recommended value is 1000µF/50V for switching application.
4,5	+ Vout	+12V output voltage.
6	+ Sense	Senses the remote load high side. To be connected to pin 4,5 when remote sense is not used.
7	Sync	Synchronization output. See figures 1,2,3,4. Take care to leave the pin open when is not used.
8	Parallel	Parallel output. See figures 1,2,3,4. Take care to leave the pin open when is not used.
9	- Sense	Senses the remote load return. To be connected to pin 10,11 when remote sense is not used. In parallel configuration, take care to connect all -S pins together (see figures 1,2,3,4).
10,11	GND Output	Return for output current path. Internally connected to pin 1.

USER NOTES

Input Voltage

The recommended operating maximum DC input voltage is 36V inclusive of the ripple voltage. The use of an external low ESR, high ripple current capacitor located as close the module as possible is mandatory; recommended value is 1000µF/50V.

Softstart

To avoid heavy inrush current the output voltage rise time is typically 15ms in any condition of load.

Remote Sensing

The remote voltage sense compensation range is for a total drop of 500mV equally shared between the load connecting wires. It is a good practice to shield the sensing wires to avoid oscillations. See the connection diagram on figures 1, 2, 3, 4.

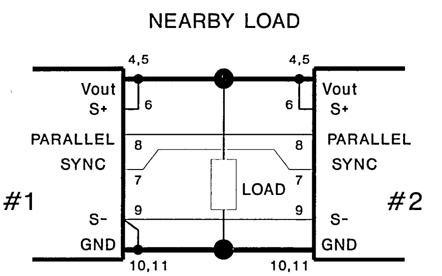
Parallel Operation

To increase available output regulated power, the module features the parallel connection possibility with equal current sharing and maximum deviation of 10% (two modules in parallel). See the connection diagram on figures 1, 2, 3, 4.

Module Protection

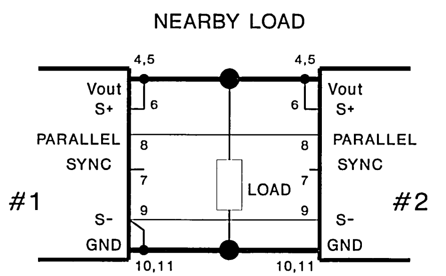
The module is protected against occasional and permanent shortcircuits of the output pins to ground, as well as against output current overload. It uses a current limiting protection circuitry, avoiding latch-up problems with certain types of loads.

Figure 1.



WITH SWITCHING FREQUENCY SYNCHRONIZATION

Figure 2.



WITHOUT SWITCHING FREQUENCY SYNCHRONIZATION

Figure 3.

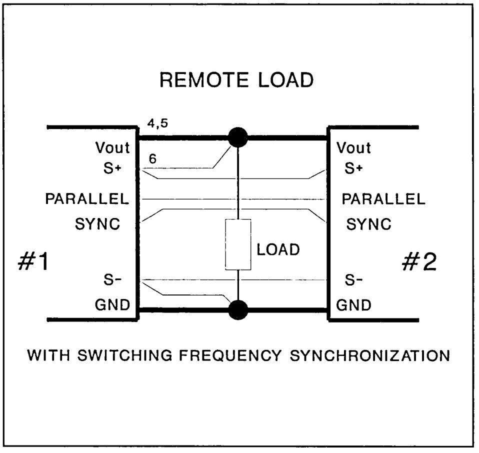
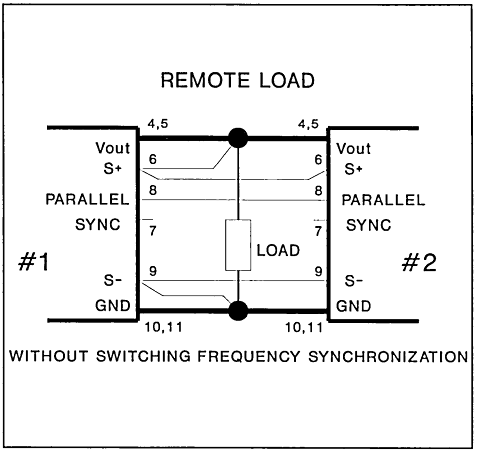


Figure 4.



Thermal characteristics: how to choose the heat-sink

Sometimes the GS-R1012 requires an external heat-sink depending both operating temperature conditions and power.

Before entering into calculations details, some basic concepts will be explained to better understand the problem.

The thermal resistance between two points is represented by their temperature difference in front of a specified dissipated power, and it is expressed in Degree Centigrade per Watt (°C/W).

For GS-R1012 the thermal resistance case to ambient is 7.5°C/W. This means that an internal power dissipation of 1W will bring the case temperature at 7.5°C above the ambient temperature.

The maximum case temperature to which the module provides 10A is 75°C (see fig. 6).

Let's suppose to have a GS-R1012 that delivers a load current of 10A at an ambient temperature of 40°C.

The dissipated power in this operating condition is about 10.4W (at typical efficiency of 92%), and the case temperature of the module will be:

$$T_{Case} = T_{Amb} + P_d \times R_{th} = 40 + 10.4 \times 7.5 = 118°C$$

This value exceeds the maximum allowed temperature and an external heat-sink must be added. To this purpose four holes (see mechanical drawing) are provided on the metal surface of the module.

To calculate this heat-sink, let's first determine what the total thermal resistance should be.

$$R_{th} = \frac{T_{CaseMAX} - T_{amb}}{P_d} = \frac{75 - 40}{10.4} = 3.37°C / W$$

This value is the resulting value of the additional heatsink thermal resistance.

Figure 5. - Efficiency vs. Output Current.

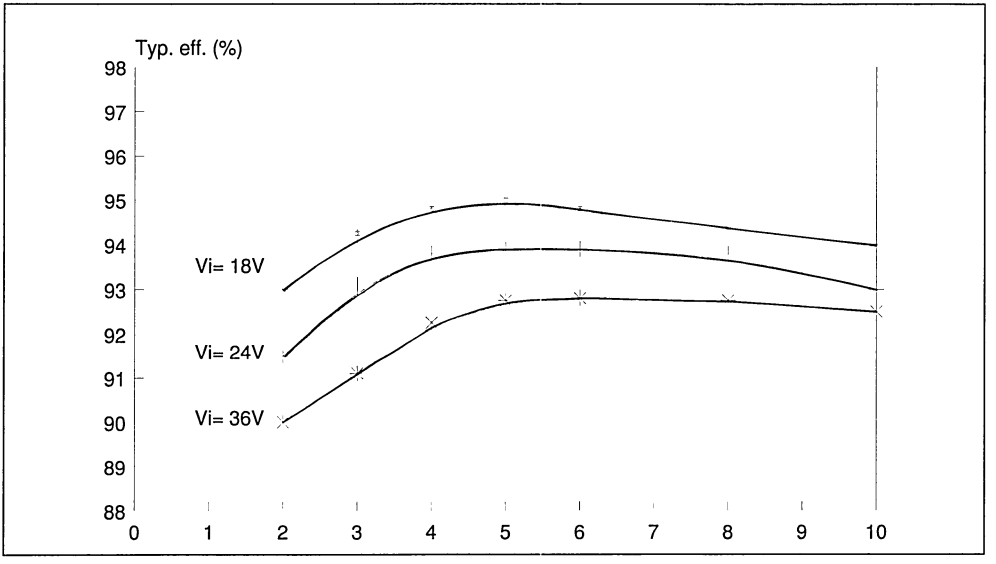
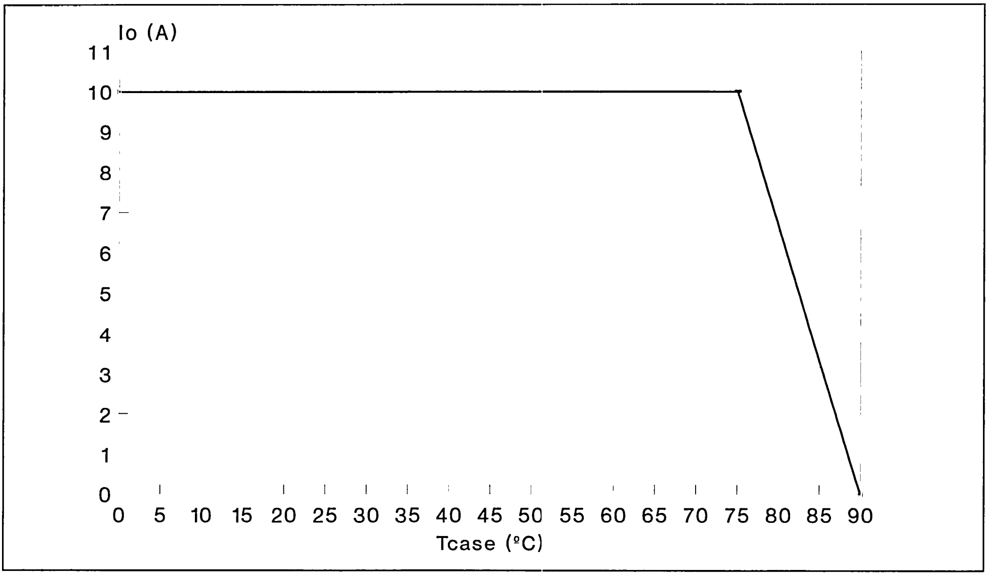


Figure 6. - Output Current vs. T case.



The following list may help the designer to select the proper commercially available heat-sink. Sometimes it can be more convenient to use a custom made heat-sink that can be experimently designed and tested.

Manufacturers	Type	Height (mm)	Rth (°C/W)
ALUTRONIC	PR139	20	3
	PR140	19	2
	PR159	20	2.5
ASSMAN	V5440	19	3
	V5805	15	2
	V5280	19	2
AAVID	60885	14	4.5
	60660	25.5	1.5
	62355	33.5	3
AUSTERLITZ	KS50	12	3
	KS100.3	15	2.5
FISCHER	SK16	25.5	1.5
	SK52	19	2
SGE BOSARI	L30	21	3
	LZ50	24	3
THERMALLOY	6155	14	4.5
	6601	14	5
	6176	24	4.5
	6320	30	1.5

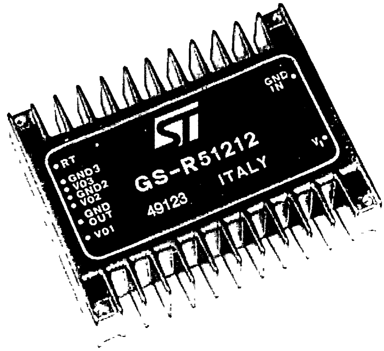
SGS-THOMSON MICROELECTRONICS

GS-R51212

20W TRIPLE OUTPUT STEP-DOWN SWITCHING REGULATOR

FEATURES

- MTBF in excess of 200,000 hours
- 4V max drop-out voltage
- Soft start
- Reset output
- Non-latching short circuit protection
- Crow-bar output overvoltage protection



DESCRIPTION

The GS-R51212 is a versatile triple output, high current, high voltage step-down switching regulator module that provides a +5V and two isolated 12V outputs. It is ideal for microprocessor based boards because it powers the logic and the communication ports and it has a Reset output for the correct system start-up.

The integral heatsink allows a large power handling capability and it provides also an effective shielding to minimize EMI.

MAIN CHARACTERISTICS

V_i	Input Voltage	9 to 40V
V_{o1} I_{o1}	Output Voltage Output Current	5.1V 3.5A
V_{o2} I_{o2}	Output Voltage Output Current	12V 0.1A
V_{o3} I_{o3}	Output Voltage Output Current	12V 0.1A

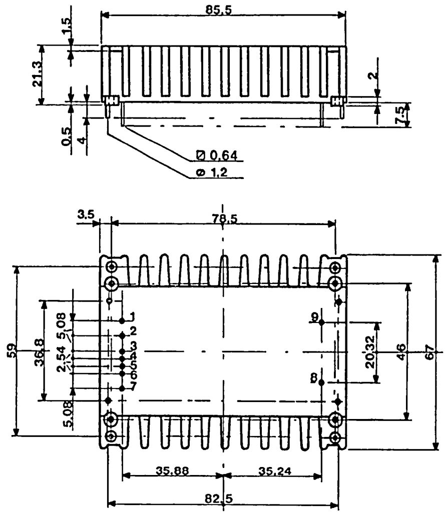
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	42	V
I_{rt}	Reset Output Sink Current	20	mA
T_{stg}	Storage Temperature Range	– 40 to +105	°C
T_{cop}	Operating Case Temperature Range	– 20 to +85	°C

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_o1	Output Voltage	V_i = 24V I_o1 = 2.5A	4.95	5.1	5.2	V
V_o2	Output Voltage	V_i=24V I_o2 = 0.1A	11.5		12.5	V
V_o3	Output Voltage	V_i = 24V I_o3 = 0.1A	11.5		12.5	V
$\Delta V_o/\Delta T$	Temperature Stability	All Outputs		0.2		mV/°C
V_i	Input Voltage		9		40	V
I_o1	Output Current	V_i = 24V	0.5		3.5	A
I_o2	Output Current	V_i = 24V			0.1	A
I_o3	Output Current	V_i = 24V			0.1	A
I_{isc}	Average Input Current	V_i = 40V V_o1 = 0V		0.1	0.2	A
I_{isc}	Average Input Current	V_i = 40V $V_o1/2/3$ = 0V		0.1	0.2	A
I_{ir}	Reflected Input Current	V_i = 24V I_o1 = 2.5A $I_o2,3$ = 0.1A		200		mApp
V_{is}	5V to 12V Isolation Voltage		200			VDC
f_s	Switching Frequency			100		kHz
η	Efficiency	V_i = 24V I_o1 = 2.5A $I_o2,3$ = 0.1A		70		%
ΔV_o	Line Regulation	I_o1 = 2.5A V_i = 15 to 25V $I_o2,3$ = 0.1A		2		mV/V
ΔV_o	Load Regulation	V_i = 24V I_o1 = 0.5 to 2.5A V_i = 24V I_o2,I_o3 = 0.05 to 0.1A		35 600		mV/A
SVR	Supply Voltage Rejection	50/60Hz		4		mV/V
V_{or}	Output Ripple Voltage	V_i = 24V I_o1 = 2.5A		30		mVpp
V_{on}	Output Noise Voltage	V_i = 24V I_o1 = 2.5A		40		mVpp
I_{rh}	Reset Leakage Current			100		µA
V_{rl}	Reset Low Level	I_{reset} = 5mA		0.2		V
t_{rd}	Reset Delay Time			100		ms
t_{r1}	Line Transient Recovery Time	I_o1 = 2.5A V_i = 15 to 35V		500		µs
t_{r2}	Load Transient Recovery Time	V_i = 24V I_o = 0.5 to 2.5A		200		µs
t_{ss}	Soft Start Time			10		ms
t_{cd}	Crowbar Delay Time			5		µs
V_{cth}	Crowbar Intervention Threshold			6.37		V
R_{th}	Thermal Resistance	Case to ambient		5		°C/W

CONNECTION DIAGRAM AND MECHANICAL DATA



Dimensions in mm

Bottom view

PIN DESCRIPTION

Pin	Function	Description
1	Output 1	Regulated 5.1V output.
2	Output GND	Return for output1 current path. Internally connected to pin 8.
3	Output 2	Regulated 12V output.
4	Ground 2	Return of output 3 current path.
5	Output 3	Regulated 12V output.
6	Ground 3	Return of output 3 current path.
7	Reset	Open collector Reset output.
8	Input GND	Return of input voltage source. Internally connected to pin 2.
9	+ Input	DC input voltage. Recommended maximum voltage is 40V.

USER NOTES

Input Voltage

The recommended operating maximum DC input voltage is 40V inclusive of the ripple voltage.

Case Grounding

The module case is internally connected to pin 2 and pin 8.
The PCB area below the module can be used as an effective sixth side shield against EMI.

Thermal Characteristics

The case-to-ambient thermal resistance of the GS-R51212 module is about 5°C/W. This produces a 50°C temperature increase of the module surface for a 10W of internal power dissipation.
Depending on the ambient temperature and/or on the power dissipation, an additional heatsink or forced ventilation may be required.

Input Impedance

The module has an internal capacitor connected between the input pins in order to assure PWM stability. This capacitor cannot handle large values of high frequency ripple current, and it can be permanently damaged if the primary energy source impedance is not adequate.
The use of an external low ESR, high ripple current capacitor located as close to the module as possible is recommended. Suitable capacitors should have a RMS current capability of 2,5 A_{RMS} with a working voltage of 50 V_{DC} and an ESR of 0,1Ω at 100 kHZ. When space is a limitation, a 22μF ceramic multilayer capacitor must be connected to the module input pins.

Module Protection

The module is protected against occasional and permanent short circuits of the output pins to ground, as well as against output current overload. When the output current at 5V output exceeds the maximum value, the output is automatically disabled. After a fixed time the module starts again in a soft mode. The cycle is repeated until the overload condition is removed.
A crow-bar output overvoltage protection is activated when the output voltage on V_{o1} exceeds 6.37V.

Output Current

The output current of the main output is 3.5A. The max output current of the two 12V outputs is a function of the input voltage and of the main output current as shown in fig. 1.
If the main current is zero, no voltage will be available on the 12V outputs.

Figure 1. Output Current Capability vs. Operating Conditions

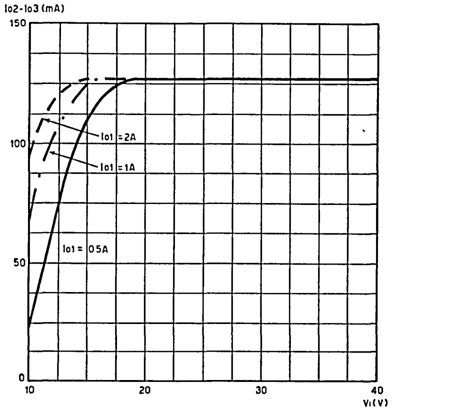


Figure 2. Reset Operation

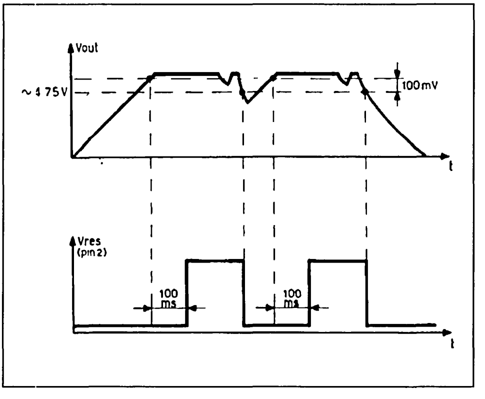
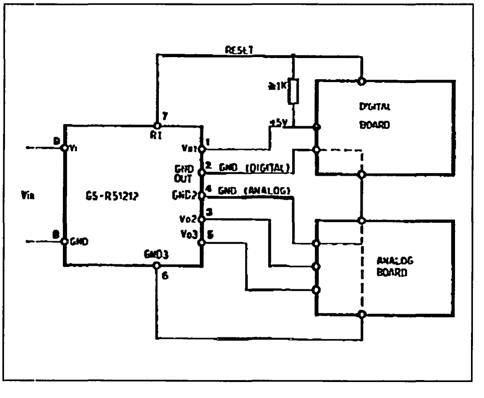


Figure 3. Typical application



SGS-THOMSON MICROELECTRONICS

SGS-THOMSON MICROELECTRONICS

GS-R51212S
GS-R51515S

31W TRIPLE OUTPUT STEP-DOWN SWITCHING REGULATORS

Type	V_i	V_o	I_o
GS-R51212S	15 to 40 V	+ 5,1 V	4,5 A
		± 12 V	0,35 A
GS-R51515S	15 to 40 V	+ 5,1 V	4,5 A
		± 15 V	0,3 A

FEATURES

- 5.1V/4.5A and ±12V/0.35A or ±15V/0.3A output voltages
- ±12 or ±15V externally adjustable
- High efficiency (81% typ.)
- Short-circuit protection
- Reset output
- Power Fail programmable input
- Inhibit/Enable control input
- Soft-start
- PCB or chassis mounting

DESCRIPTION

The GS-R51212S and GS-R51515S are versatile triple output, high current step-down switching regulators that provide +5.1V/4.5A output voltage and an isolated ±12V/0.35A or ±15V/0.3A dual output voltage.
They are ideal for microprocessor based boards because power the logic and the communication ports and have Reset output and Power Fail programmable input for the correct system start-up.

The Inhibit/Enable pin allows the ON/OFF logic function with TTL/CMOS compatible input signal.
The auxiliary outputs (±12V or ±15V) are externally adjustable in a very wide range, i.e. from ±4.25V to ±12.45V on GS-R51212S and from ±4.50V to ±15.25V (typical values) on GS-R51515S.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC Input Voltage	44	V
I_{rs}	Reset Output Sink Current	20	mA

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

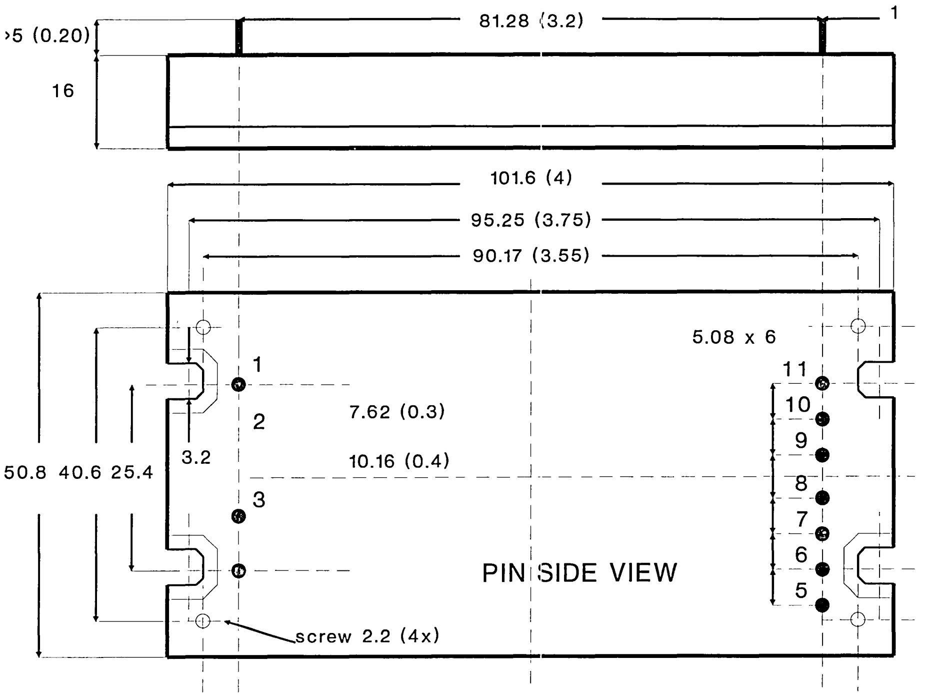
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_i	Input Voltage GS-R51212S	V_{o1} = +5.1V I_{o1} = 4.5A V_{o2} = +12V I_{o2} = 0.35A V_{o3} = – 12V I_{o3} = – 0.35A	15		40	V
V_i	Input Voltage GS-R51515S	V_{o1} = +5.1V I_{o1} = 4.5A V_{o2} = +15V I_{o2} = 0.3A V_{o3} = – 15V I_{o3} = – 0.3A	15		40	V
I_{ir}	Input Reflected Current	V_i = 24V $I_{o1,2,3}$ = Full Load No external input capacitor		0.5		App
I_{ir}	Input Reflected Current	V_i = 24V $I_{o1,2,3}$ = Full Load Ci (external) = 100µF/50V		0.15		App
V_{ien}	Enable Input Voltage	V_i = 15 to 40V	0		0.8	V
I_{ien}	Enable Input Current	V_i = 15 to 40V			– 1	mA
V_{iinh}	Inhibit Input Voltage	V_i = 15 to 40V	1.2		+Vi	V
V_{o1}	Output Voltage 1	V_i = 15 to 40V I_{o1} = 0 to 4.5A I_{o2} = 0 to 0.35/0.3A I_{o3} = 0 to – 0.35/– 0.3A	+5	+5.1	+5.2	V
V_{o2}	Output Voltage 2 GS-R51212S	V_i = 15 to 40V I_{o1} = 0 to 4.5A I_{o2} = 0 to 0.35A I_{o3} = 0 to – 0.35A	+11.5	+12	+12.5	V
V_{o2}	Output Voltage 2 GS-R51515S	V_i = 15 to 40V I_{o1} = 0 to 4.5A I_{o2} = 0 to 0.3A I_{o3} = 0 to – 0.3A	+14.5	+15	+15.5	V
V_{o3}	Output Voltage 3 GS-R51212S	V_i = 15 to 40V I_{o1} = 0 to 4.5A I_{o2} = 0 to 0.35A I_{o3} = 0 to – 0.35A	– 11.5	– 12	– 12.5	V
V_{o3}	Output Voltage 3 GS-R51515S	V_i = 15 to 40V I_{o1} = 0 to 4.5A I_{o2} = 0 to 0.3A I_{o3} = 0 to – 0.3A	– 14.5	– 15	– 15.5	V
V_{or1}	Output Ripple Voltage 1	V_i = 24V I_{o1} = 4.5A		30	50	mVpp
$V_{or2,3}$	Output Ripple Voltage 2,3	V_i = 24V $I_{o2,3}$ = 0.35/0.3A		50	100	mVpp
δV_{OL1}	Line Regulation 1	V_i = 15 to 40V I_{o1} = 2.5A $I_{o2,3}$ = 0.35/0.3A		0.5		mV/V
$\delta V_{OL2,3}$	Line Regulation 2,3	V_i = 15 to 40V I_{o1} = 2.5A $I_{o2,3}$ = 0.35/0.3A		1		mV/V
δV_{OO1}	Load Regulation 1	V_i = 24V I_{o1} = 0.5 to 4.5A $I_{o2,3}$ = 0.35/0.3A		2		mV/A
$\delta V_{OO2,3}$	Load Regulation 2,3	V_i = 24V I_{o1} = 2.5A I_{o2},I_{o3} = 0.05 to 0.35/0.3A		500		mV/A
I_{o1}	Output Current 1	V_i = 15 to 40V V_{o1} = 5.1V $I_{o2,3}$ = 0 to 0.35/0.3A	0		4.5	A
I_{o2}	Output Current 2* GS-R51212S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o2} = +12V I_{o3} = 0 to – 0.35A	0		0.35	A
I_{o2}	Output Current 2* GS-R51515S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o2} = +15V I_{o3} = 0 to – 0.3A	0		0.3	A
I_{o2}	Output Current 2* GS-R51212S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o2} = +12V I_{o3} = 0A	0		0.7	A
I_{o2}	Output Current 2* GS-R51515S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o2} = +15V I_{o3} = 0A	0		0.6	A
I_{o3}	Output Current 3* GS-R51212S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o3} = – 12V I_{o2} = 0 to 0.35A	0		– 0.35	A

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified) (cont'd)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I_{o3}	Output Current 3* GS-R51515S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o3} = – 15V I_{o2} = 0 to 0.3A	0		– 0.3	A
I_{o3}	Output Current 3* GS-R51212S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o3} = – 12V I_{o2} = 0A	0		– 0.7	A
I_{o3}	Output Current 3* GS-R51515S	V_i = 15 to 40V I_{o1} = 0 to 4.5A V_{o3} = – 15V I_{o2} = 0A	0		– 0.6	A
I_{osck1}	Output Current Limit 1	V_i = 15 to 40V Overload		5.5		A
I_{osc1}	Output Short-circuit Current 1	V_i = 15 to 40V		3		A
$I_{osc2,3}$	Output Short-circuit Current 2,3	V_i = 15 to 40V		0.8		A
t_{ss}	Soft-start time			10		ms
t_{dr}	Reset Time Delay			100		ms
f_s	Switching Frequency	V_i = 15 to 40V V_{o1} = 5.1V I_{o1} = 0.5 to 4.5A V_{o2} = +12/+15V V_{o3} = – 12/– 15V I_{o2}, I_{o3} = – 0.05 to – 0.35/– 0.3A		100		kHz
η	Efficiency	V_i = 24V $I_{o1,2,3}$ = Full Load	78	81		%
R_{th}	Thermal Resistance			7.5		°C/W
T_{cop}	Operating Case Temperature Range		0		+85	°C
T_{stg}	Storage Temperature Range		– 40		+105	°C

* Note: when output current is less than 50mA, output ripple voltage increases due to discontinuous operation.

CONNECTION DIAGRAM AND MECHANICAL DATA



Package R. Dimensions in mm (inches).

PIN DESCRIPTION

Pin	Function	Description
1	GND IN	Return for input voltage source. Internally connected to pin 7.
2	$\overline{EN}$.	Inhibit/Enable control input. The converter is ON (ENABLE) when the voltage applied to this pin is lower than 0.8V. The converter is OFF (INHIBIT) when this pin is unconnected or the input voltage is in the range of 1.2 to Vi.
3	P.F.	Power Fail programmable input. If unconnected the Power Fail threshold voltage is 11V with 1V hysteresis (factory setting).
4	+ Vin	DC input voltage. Recommended maximum voltage is 40V.
5	RT	Reset output (active high). When the supply voltage +Vin and the regulated output voltage +Vo1 are in the correct range this signal is generated after a delay time of 100ms typical.
6	Vo + 5V	Regulated +5.1V output voltage.
7	GND 1	Return for output 1 current path. Internally connected to pin 1.
8	Vo + 12/15V	Regulated +12 or +15V output.
9	Vo – 12/15V	Regulated – 12 or – 15V output.
10	ADJ.	External adjustment for output voltages ±12 and ±15V.
11	GND Aux.	Return for ±12 and ±15V output current path.

USER NOTES

Input Voltage

The recommended operating maximum DC input voltage is 40V inclusive of the ripple voltage. The use of an external low ESR, high ripple current capacitor located as close the module as possible is recommended; suggested value is 100µF/50V.

Soft-start

To avoid heavy inrush current the output voltage rise time is typically 10ms in any condition of load.

Power Fail-Reset Circuit

The module include a voltage sensing circuit that may be used to generate a power-on/power-off reset signal for a microprocessor system.
The circuit sense the input supply voltage and the output generated voltage Vo1 (+5V) and will generate the required reset signal only when both the sensed voltages have reached the required value for correct system operation.
When both the supply voltage and the regulated voltage are in the correct range the output Reset signal is generated after a delay time t_{DR} of 100ms typical.
A latch assures that if a spike is present on the sensed voltage the delay time circuit discharges completely before initialization of a new reset cycle.
Reset output has internal pull-up resistor of 10kOhm connected to Vo +5V pin.
Maximum sink output current is 20mA at $V_{RESET(sat)}$ = 200mV.
Fig. 1 and fig. 2 show reset waveforms.

Power Fail Programmable Input

This pin is internally connected via a divider to the +Vin pin for Power Fail function.
The factory setting is for a value of 11V with 1V hysteresis.
It is possible to program a different value of Power Fail threshold by connecting a resistor (Rpf) between pin 3 (Power Fail Input) and pin 1 (GND Input). The value of Rpf must be calculated according to the following formula:

$$R_{pf} = \frac{5.1}{\frac{V_{pf} - 5.1}{34} - 0.191} = (k\Omega)$$

where Vpf is the desired value of Power Fail threshold voltage.
Exampe: Vpf = 24V (must not be lower than 12V):

$$R_{pf} = \frac{5.1}{\frac{24 - 5.1}{34} - 0.191} = 14k\Omega$$

Figure 1 - Reset and Power Fail waveforms.

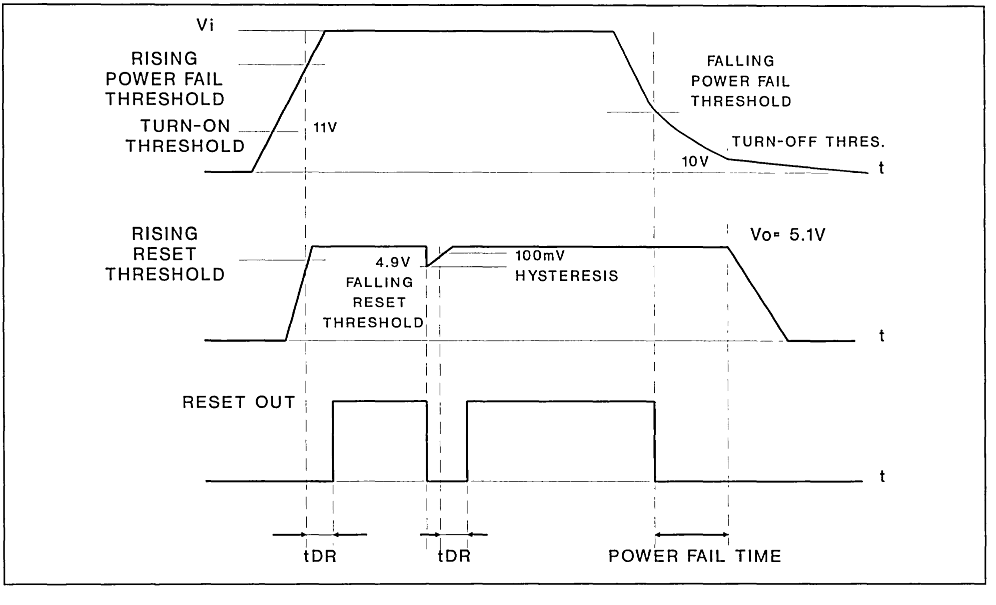
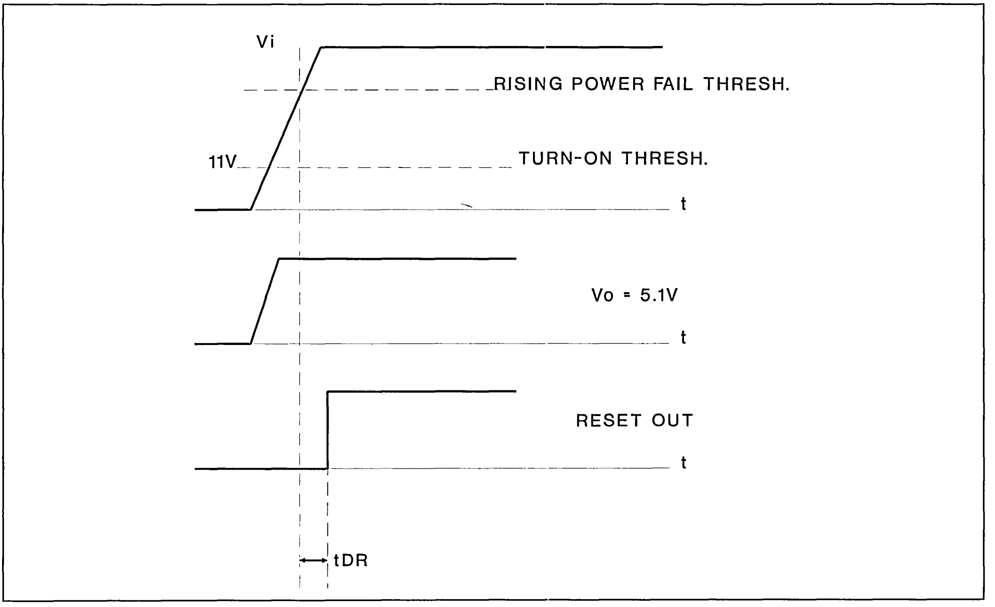


Figure 2 - Reset and Power Fail waveforms.



Auxiliary Outputs

The auxiliary outputs (±12V or ±15V) are externally adjustable in symmetric way by connecting a resistor Ra between pin 10 (ADJ.) and pin 8 (Vo + 12/+15V), according to the following formula:

GS-R51212S $$R_a = 32.66 \times \frac{V_o - 4.229}{12.485 - V_o}$$

GS-R51515S $$R_a = 38.66 \times \frac{V_o - 4.39}{15.252 - V_o}$$

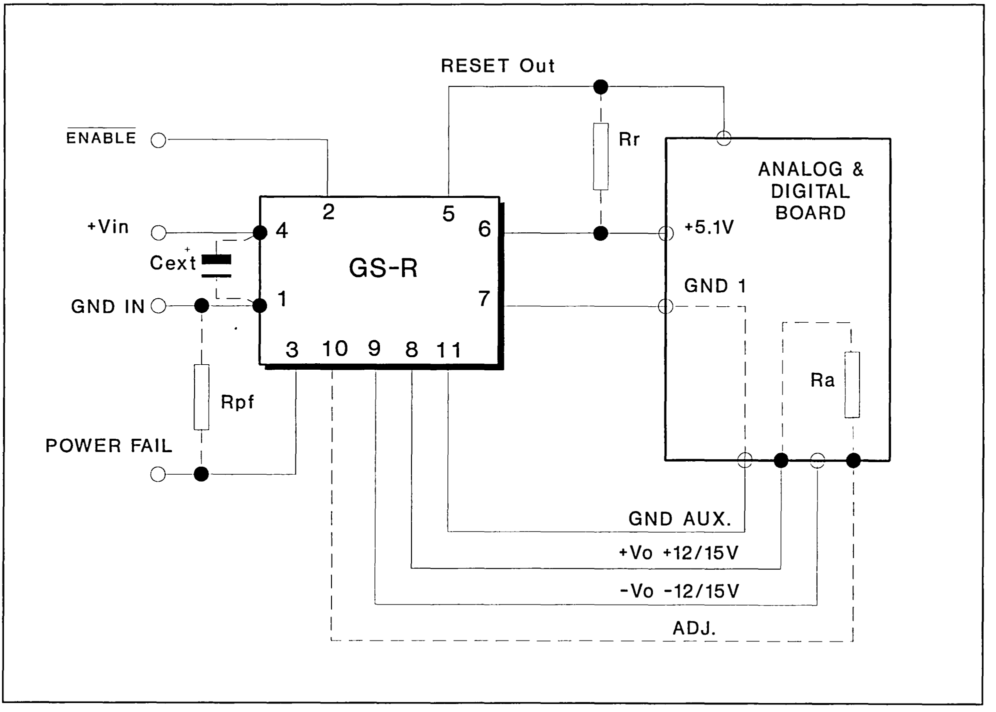
where V_O is the desired dual output voltage.
Example: $V_O = \pm 5V$.

R_a (GS-R51212S) = 3.36kΩ
R_a (GS-R51515S) = 2.3kΩ

Example: $V_O = \pm 10V$.

R_a (GS-R51212S) = 75.8kΩ
R_a (GS-R51515S) = 41.3kΩ

Figure 3 - Typical Application.



Inhibit/Enable Input

The Inhibit/Enable function allows the ON/OFF logic control of the module.
The converter is ON (Enable) when the voltage applied to pin 2 (EN.) and referred to pin 1 (GND IN) is lower than 0.8V (TTL, CMOS, open collector compatible level).
The converter is OFF (Inhibit) when pin 2 is unconnected or the voltage applied is in the range of 1.2V to +Vin. Maximum sinking current is 1mA.

Module Protection

The module is protected against occasional and permanent short-circuits of the output pins to ground, as well as against output current overload. The main output (+5.1V) uses a foldback current limiting; the output current decreases with increasing overload, reaching a minimum at short-circuit condition.
This solution minimizes internal power dissipation. The auxiliary outputs (±12V or ±15V) use a current limiting protection circuitry.

Thermal characteristics

Sometimes the GS-R51212S and GS-R51515S require an external heat-sink depending on both operating temperature conditions and power.
Before entering into calculations details, some basic concepts will be explained to better understand the problem.

The thermal resistance between two points is represented by their temperature difference in front of a specified dissipated power, and it is expressed in Degree Centigrade per Watt (°C/W).
For the modules the thermal resistance case to ambient is 7.5°C/W. This means that an internal power dissipation of 1W will bring the case temperature at 7.5°C above the ambient temperature.
The maximum case temperature is 85°C.
Let's suppose to have a GS-R51515S that delivers the maximum output power of 31.4W at an ambient temperature of 40°C.

The dissipated power in this operating condition is about 7.4W (at typical efficiency of 81%), and the case temperature of the module will be:

$$T_{case} = T_{amb} + P_d \times R_{th} = 40 + 7.4 \times 7.5 = 95.5\ °C$$

This value exceeds the maximum allowed temperature and an external heat-sink must be added. To this purpose four holes (see mechanical drawing) are provided on the metal surface of the module. To calculate this heat-sink, let's first determine what the total thermal resistance should be:

$$R_{th} = \frac{T_{case(max)} - T_{amb}}{P_d} = \frac{85 - 40}{7.4} = 5.40\ °C/W$$

This value is the resulting value of the parallel connection of GS-R thermal resistance and of the additional heatsink thermal resistance.

$$\frac{R_{th}\ (GSR) \times R_{th}\ (Heatsink)}{R_{th}\ (GSR) + R_{th}\ (Heatsink)} = 5.40°C / W$$

To calculate the thermal resistance of the additional heat-sink the following equation may be used:

$$R_{th}\ (Heatsink) = \frac{5.40 \times R_{th}\ (GSR)}{R_{th(GSR)} - 5{,}40} = \frac{5.40 \times 7.5}{7.5 - 5.40} = 19.3\ °C / W$$

In instead of or in addition to the external heatsink, a forced ventilation with an air speed of about 200 linear feet/minute can be used reducing the thermal resistance of the module at the specified value.

APPLICATION NOTES

SGS-THOMSON SYSTEMS FOR RECHARGEABLE BATTERIES

1 - FOREWORD

In casual language a battery pack is anything that supplies electrical power through a chemical reaction whose description is beyond the scope of this note and it is normally built by a combination (series, parallel, or both) of cells that are the basic electrochemical building blocks.
In the following a battery pack will be simply named battery.
Batteries can be grouped into two distinct categories:

- Disposable Primary Batteries
- Rechargeable Secondary Batteries

This note deals with the SGS-THOMSON systems for rechargeable batteries but it is worth to mention some typical characteristics of primary batteries too.

Primary batteries

The variety of types, based on different chemistries, is very high (for lithium batteries alone there are more than 30 different types).
However these types of batteries share some common characteristics:

- Primary batteries offer significantly higher energy density, i.e. for a given volume more watts per hour are available when compared with secondary batteries.
- Primary batteries offer a lower self-discharge rate
- Primary batteries are less expensive than secondary
- Primary batteries have higher internal impedance so that they have less current sourcing capability.
- Thanks to standardization, replacement is easy world wide.

Secondary batteries

Despite the advantages mentioned above, there is a growing demand on secondary batteries because of:

- Increased electrical power drain of portable equipment that would exhaust very rapidly the energy stored into a primary battery.
- Increased sensitivity to the environment protection: primary batteries must be disposed of and they contain materials that are hazardous for the environment.

Some types of rechargeable batteries contains hazardous materials too but they exhibit a much longer usable life so that one secondary battery can replace more than 500 disposable batteries.
The most popular secondary batteries can be divided into three major groups:

- Lead-acid
- Nickel-cadmium
- Nickel-Metal hydride

A fourth technology, Lithium-Jon, is now reaching the market even if the number of manufacturers as well as the volumes are still limited. This new technology is quite promising because it will offer a significant leap in energy density.

The table 1 shows some typical values for primary and secondary batteries that, however, can vary with manufacturer and battery size.

SGS-THOMSON have developed various families of products for the specific application in the field of secondary batteries. These families are briefly described in the data book. It must be noted that the large variety of:

- battery types and sizes.
- available energy source (mains or car batteries).
- connections to the final sets where batteries are employed.
- etc.

does not allow an appropriate product standardization. Therefore the following descriptions deal mainly with the basic principles of SGS-THOMSON products.

For specific application, please contact the local SGS-THOMSON organization or the Division Product Marketing:

SUBSYSTEMS PRODUCTS GROUP
SGS-THOMSON MICROELECTRONICS
20041 AGRATE BRIANZA - ITALY
CENTRO DIREZIONALE COLLEONI
PALAZZO ANDROMEDA, 3
Tel: 0039-39-635574 Fax: 0039-39-635582

Table 1: Typical battery performance at 20 °C

Type : PRIMARY	Nominal Voltage	Energy Density W•h / Kg
Alkaline - MnO2	1.4	130
Carbon - Zinc	1.3	65
Lithium - MnO2	2.7	230
Mercury - Zinc	1.3	110
Silver - Oxide *	1.5	130
Zinc - Air *	1.3	300
Type : SECONDARY		
Lead - Acid	2	35
Nickel - Cadmium	1.2	35
Nickel - Metal Hydride	1.2	55
Lithium - Jon	3.6	130

* For button cells

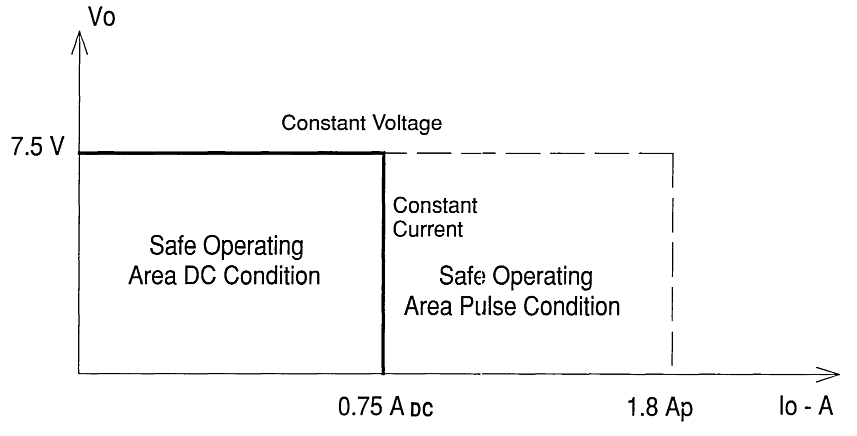
2 - BATTERY ELIMINATORS

Whenever another power source is available, it may be convenient to preserve the battery by providing an alternate method to deliver the power required by the electronic equipment.

In this case the battery is replaced by a battery eliminator that is, essentially, a constant voltage regulator. As typical example, a battery eliminator can be used to supply a handheld phone from a car battery thus avoiding the use of the phone battery during travels.

For replacement of a 5/6 cell battery pack, the GS-R28.0BE switch mode battery eliminator can be used. See the corresponding data sheet.

Figure 1. Output characteristics of GS-R28.0BE
Peak current duration: 0,6 ms with 0,13 duty cycle



3. BATTERY SAVERS

While a battery eliminator replaces completely the battery pack, a battery saver is used together with the battery pack. The battery is charged in a float mode and it is maintained in a ready-to-serve condition.
The principle is shown in fig. 2

Figure 2. Battery Saver

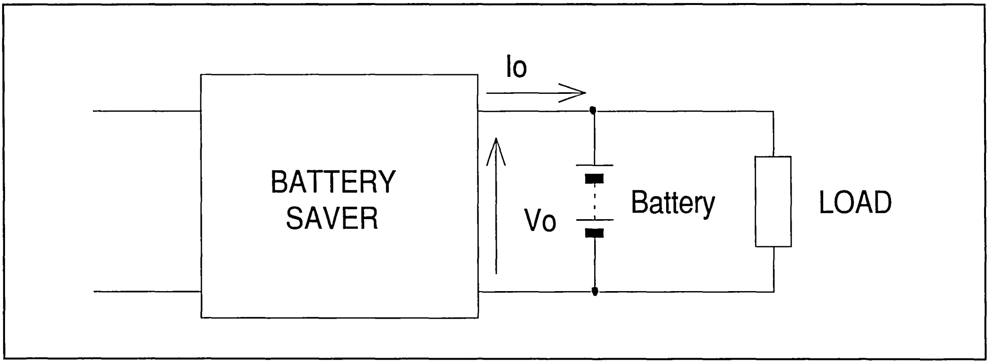


Figure 3.

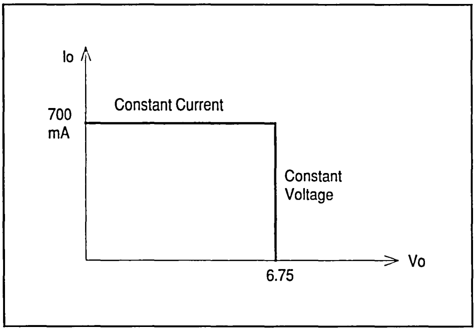
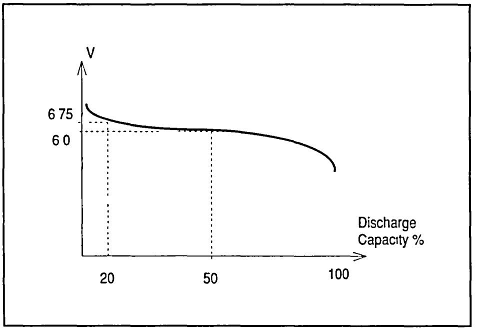


Figure 4.



The output electrical characteristics of a battery saver is shown in fig. 3.
The indicated values are relevant to a 5 cell battery pack.
If the initial battery voltage is greater than 6.75V, the battery will supply the load and no current is delivered by the battery saver. Therefore the battery is discharged by the load until its voltage reaches 6.75 V. At this point, the battery saver, working in a voltage mode (vertical line of the characteristic of fig. 3), supplies the current required by the load and the battery can save its stored energy. After removal of the battery saver, the battery is still retaining more than 80 % of its capacity (for a 5 cell battery, 50 % of capacity correspond to about 5 x 1,2 = 6.0 V as shown on the discharge curve of fig. 4).

If the initial battery voltage is lower than the preset value of 6.75 V, the battery saver works in constant current mode (horizontal line of the characteristics of fig. 3) by delivering a constant current of 700 mA that charges the battery to about 80 % of its capacity until the battery voltage reaches 6.75 V. Clearly if the load is ON, just the net difference between 700 mA and the load current is available to charge the battery.
As a typical example, a battery saver can be used to supply a handheld phone from a car battery thus providing the current needed by the phone and maintaining, in the mean time, about 80% of the battery capacity.
For utilization together with a 5 cell battery pack, the GSCC-7.007BS switch mode battery saver can be used. See the corresponding data sheet.

4. BATTERY CHARGERS

The SGS-THOMSON battery chargers are high-quality systems particularly designed to charge NiCd and NiMH batteries (for Lead-Acid and Lithium-Jon batteries, please consult SGS-THOMSON).

Proper charging is a key to success with any battery application since improper charging methodology can be detrimental to the battery life. Depending on the accuracy of this charging methodology, a NiCd or a NiMH battery can withstand more than 500 recharging cycles (typically 1000 cycles) before being disposed off.

The basic charging process consists in returning to the battery the electrons that were delivered during the discharge.

In all the SGS-THOMSON battery chargers, the electrons are returned as a constant DC current of proper polarity and magnitude.

While it could be desirable to reduce the time to completely recharge a battery by increasing the magnitude of the charging DC current, it must be clearly understood that the maximum charge rate is normally specified by the manufacturer for every specific battery type.

Four different charge rates (expressed in terms of C) are defined in industry as shown in the Table 1.

METHOD OF CHARGING	CHARGE RATE
Trickle	0.01 C to 0.02 C
Standard	0.05 C to 0.1 C
Quick	0.2 C to 0.33 C
Fast & Ultra Fast	1 C to 4 C

The C rate is the charging current in Amperes numerically equivalent to the capacity given in Ah. For example, a battery with a capacity C=1.2 Ah is charged at 1C if the charging current is1,2 A.

The variety of different battery types (standard, quick, fast and each one with a different capacity C), the variety of available energy for charge (DC or AC), the variety of mechanical constraints and the variety of economical considerations do not allow the conception of a unique, universal and economic battery charger to be used under all the circumstances.

Therefore SGS-THOMSON has developed a product strategy by a differentiated approach specific for each type of battery pack and for each customer.

However SGS-THOMSON battery chargers share some common features as outlined in the following:

- fast charge by a constant current to allow a perfect control of the current level.
- constant current generation by a switch mode approach to allow very high efficiency i.e. reduction of power dissipation and waste.
- constant monitoring of charge status by microprocessors to allow the shortest charging time without reaching hazardous conditions of overcharge and so ensuring several hundreds recharge cycles.
- common software algorithm for NiCd and NiMH batteries to allow freedom to the user in the adoption of battery types.
- continuous display of charge status by LEDs driven directly by microprocessors.
- back up protection by timers to stop the fast charge even under anomalous conditions.
- possibility to use the electronic system even when its battery is under charge.
- stop of fast charge when the battery temperature is outside the allowed range (T_{batt} <0°C or T_{batt} >50°C)
- charging current level adjusted according to the battery temperature (trickle mode is imposed if 0 ° < T_{batt} < 10 ° C or 40 ° C < T_{batt} < 50 ° C).
- sensing of the battery presence (if the battery is not connected to the charger, the output voltage of the charger is automatically switched off).
- sensing of one or more default cells inside the battery pack (if this condition occurs the charger is switched off and the condition is signaled by LED status).
- sensing of the maximum battery voltage to stop the charge in case of anomalous conditions
- initial trickle charge followed by fast charge in case of deeply discharged batteries
- minimum current drain (less than 100 µA) in case the charger is left connected to the battery even when it is not used.

The a.m. features are performed by continuous monitoring of battery absolute voltage and battery voltage variation in time, of battery absolute temperature and battery temperature variation in time, of elapsed time.

Depending on the type of available power source and on the application, the SGS- THOMSON battery chargers can be grouped into four different categories:

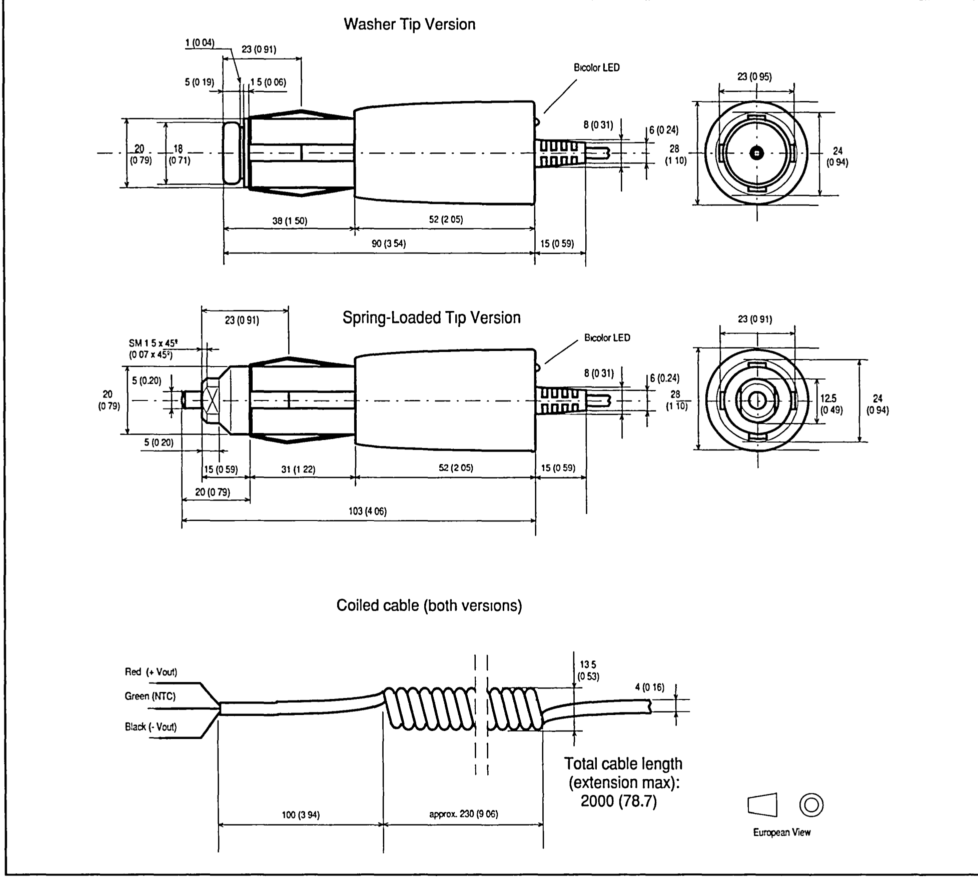
- in-car battery chargers (cigar lighter types): **GSCC-8.507BC**
- wall-mount battery chargers (for mains plug) : **GSAC-8.507AC**
- desk top battery chargers
- in car battery chargers with hands free operation (cradle types).

4.1 IN-CAR BATTERY CHARGERS (GSCC-8.507BC).

These chargers can be used in a car when the battery pack consists of no more than 6 cells (either NiCd or NiMH).

They are assembled into a cigar lighter package as shown in fig 5.

Figure 5.



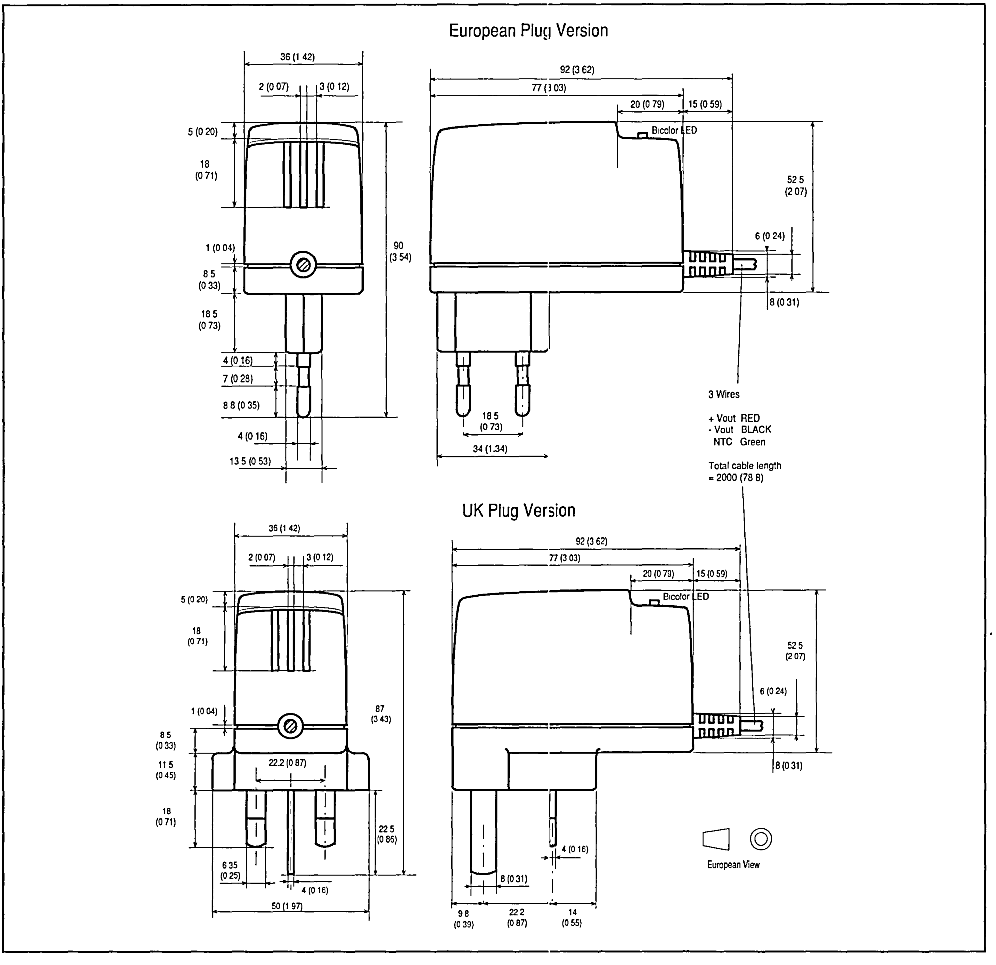
The package has been particularly designed to avoid mechanical interferences with other mechanical part of a car when the charger is inserted into the car cigar lighter plug.
All the used materials are non flammable and UL recognized.
A dual color LED is used to display different charge status or anomalous battery conditions by continuous or flashing green and red colors or both off so that five different messages can be sent to the user. ST can assist the customer in assigning the proper color (green or red) and condition (continuous or flashing or off) according to different battery status. For optimum charger performance, customers should specify the NTC type. These cigar lighter types retain all the feature common to ST battery chargers.
This charger can deliver a maxim charge current of 1A. The actual value depends on the battery charge status and temperature. Trickle charge is normally 5% of the maximum fast charge current.

4.2 WALL MOUNT BATTERY CHARGERS (GSAC-8.507BC).

These chargers can be used when the available energy source is the mains.

Thanks to the adoption of a switch mode technology, these chargers are housed in a small and light package as shown in fig 6.

Figure 6. Wall-Mount battery chargers (European and UK Versions).



The American and the Australian version of the input plug will be available in 1994.
A dual color LED is used to display different charge status or anomaly battery conditions by continuous or flashing green and red colors or both off so that five different messages can be sent to the user.

ST can assist the customer in assigning the proper color (GREEN or RED) and condition (continuous or flashing) according to different battery status. For optimum charger performance, customers should specify the NTC type. The wall-mount types retain all the feature common to ST battery chargers.

4.3 DESKTOP BATTERY CHARGERS FOR HANDHELD PHONES.

SGS-THOMSON design and manufacture many types of desktop battery chargers for handheld phones application. These chargers are designed under contracts for specific customers because no standardization exists for this type of application.
These contracts are covered by NON DISCLOSURE AGREEMENTS so that no mechanical information can be provided.
Nevertheless the following information can be provided here.
Mechanically the Desk top chargers are divided into two groups:

- Single slot desk top chargers. The phone is inserted inside this slot. Electrically the phone may be in OFF status, stand by or receiving mode. If the status of the phone is available on one or more phone pins, the desk top charger can accommodate the charging current to supply the additional current requested by the phone without affecting the charging time for the battery.
  Upon request ST can provide an additional feature to allow the charge of the battery and an additional power supply for the phone regardless of its status (OFF, stand-by, receiving or transmitting mode). ST Patent.
- Dual slot desk top chargers.
  In these type of chargers the front slot is normally used to charge the battery that is directly connected to the phone while the rear slots is used to charge a spare battery pack.
  ST can offer versions for simultaneous charging of the two battery packs or for sequential charging: in this last case the charging priority is assigned to the front slot.
  In all the cases, ST use separate current generation and overcharge detection by microprocessors for each slot.

The ST Desk Top chargers are normally powered by an external power supply: depending on the total power available by this external supply, the simultaneous or sequential charge can be adopted.

For simultaneous charge with a maximum current of 1 A per slot, ST can provide the relevant external off line power supply.

Alternatively ST may consider the inclusion of an AC-DC switch mode power supply inside the Desk top charger.

As said previously, ST can deliver an AC-DC off-line power supply to be used in combination with dual or single slot desk top chargers.

This off-line power supply is assembled into a wall mount package. See GS20AC-12 data sheet.

DESK TOP CHARGERS (SINGLE OR DUAL SLOT)

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit	Note
V_i	Input Voltage	V_O = 0 to max I_O = 0 to max	12		22	V	1
V_O	Output Voltage	Determined by number of cells	0		9.8	V	2
I_O	Output Current per slot	V_i = 12 to 22 V	0		1	A	3
η	Efficiency	V_i = 12 V I_O = 0.7 A per slot		75		%	
f_S	Switching frequency	V_i = 12 V to 22 V any value for V_O and I_O		100		kHz	4
Top	Operating Ambient Temperature		0		35	°C	

Note 1: The wide input voltage range allows the use of an unregulated external power supply.

Note 2: The output voltage depends on the number of cells in the battery pack and on the battery charge status. The reported maximum value is for a 6 cell battery pack.

Note 3: The reported value (1 A) is the maximum charging current for a battery pack of 6 cell. For a higher number of cells, the max charging current must be scaled down accordingly. The real value of fast charge current depends on the actual type of battery. Trickle charge current is normally 5% of the maximum fast charge current.

Note 4: For the dual slot version, the switching frequency is synchronized for the two slots to avoid frequency beats and interference.

4.4 IN CAR BATTERY CHARGERS WITH HANDS FREE OPERATION FOR HAND HELD PHONES (CRADLE TYPES).

SGS-THOMSON design and manufacture cradle type battery chargers for in car hands free operation.
These products are so peculiar in their application (battery charge is just one of the several function performed) that no general description can be provided here.
Nevertheless it is worth to mention that the battery charge is performed along the same feature already described.
Even if ST use a switch mode approach for constant current generation, no interference is induced on the phone (radiated or conducted noise).

5. CONCLUSION

The range of ST products devoted to battery charge is very broad and each product is designed specifically according to customer requests.
This note is intended as a general description of these products to outlight some specific (and in many case unique) feature of ST chargers.
In this domain, the best results are obtained by a close cooperation between ST and the customers and ST is available to customize any type of application for any type of battery.

APPLICATION NOTE

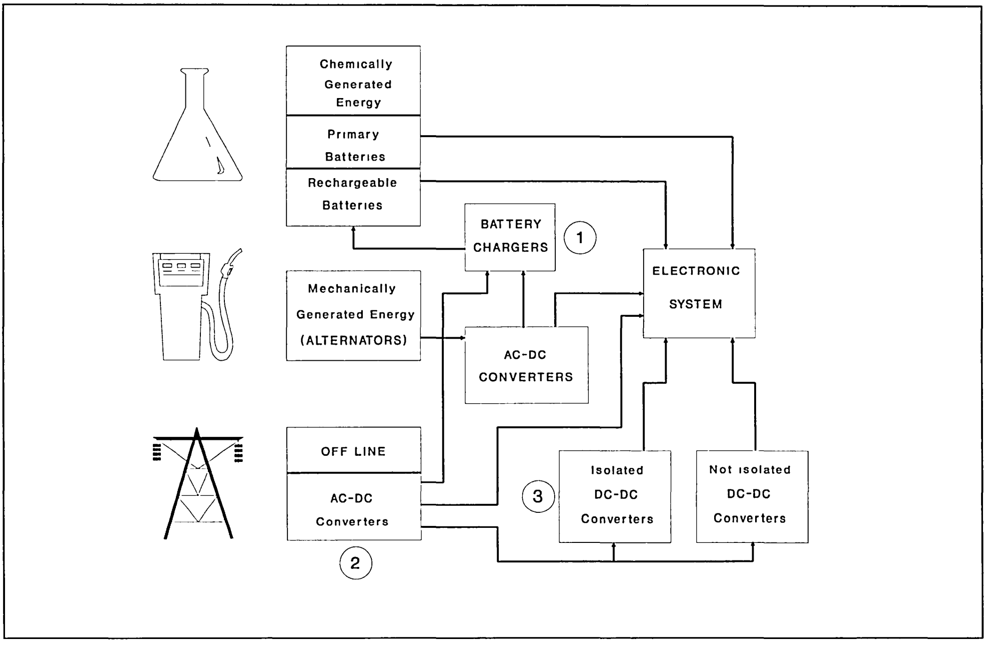
SGS-THOMSON AND POWER SUPPLY SYSTEMS

Every electronic system must be supplied by electrical power to operate and the source of this electrical power may be of different kinds, some of which are shown generically in fig. 1

The Subsystems, Engineering and Back-End Division of SGS-THOMSON is very active in the domain of power supplies and the various product families have been designed by keeping in mind the general approach outlined in the conceptual block diagram shown in fig. 1.
One section of this data book is dedicated to block 1 - Battery chargers. In this field SGS-THOMSON can supply state-of-the-art products thanks to a deep know-how on the batteries behavior during charge, availability of excellent semiconductor components and mechanical design ability.
Block 2 covers the field of OFF LINE power supplies.

SGS-THOMSON manufacture customized products only for this type of application i.e. products designed according to a customer specification. Therefore these products are not included into this data book. The variety of OFF LINE power supplies is so large that no standardization is possible and customers that buy off- the-shelf products have, necessarily, to accept compromises in terms of electrical performance, size and price.
SGS-THOMSON policy of "customized products only" allows the better performance and optimization from these points of view.
The problem of lack of standardization is partially compensated by a family of high voltage DC-DC converters, the GS100T300-xx covered in this book. These converters have a high and wide input voltage range (from 200 V_{DC} to 400 V_{DC}) so that a complete off line power supply can be easily build by the adoption of these converters complemented by the mains rectifier and filter.

Figure 1.

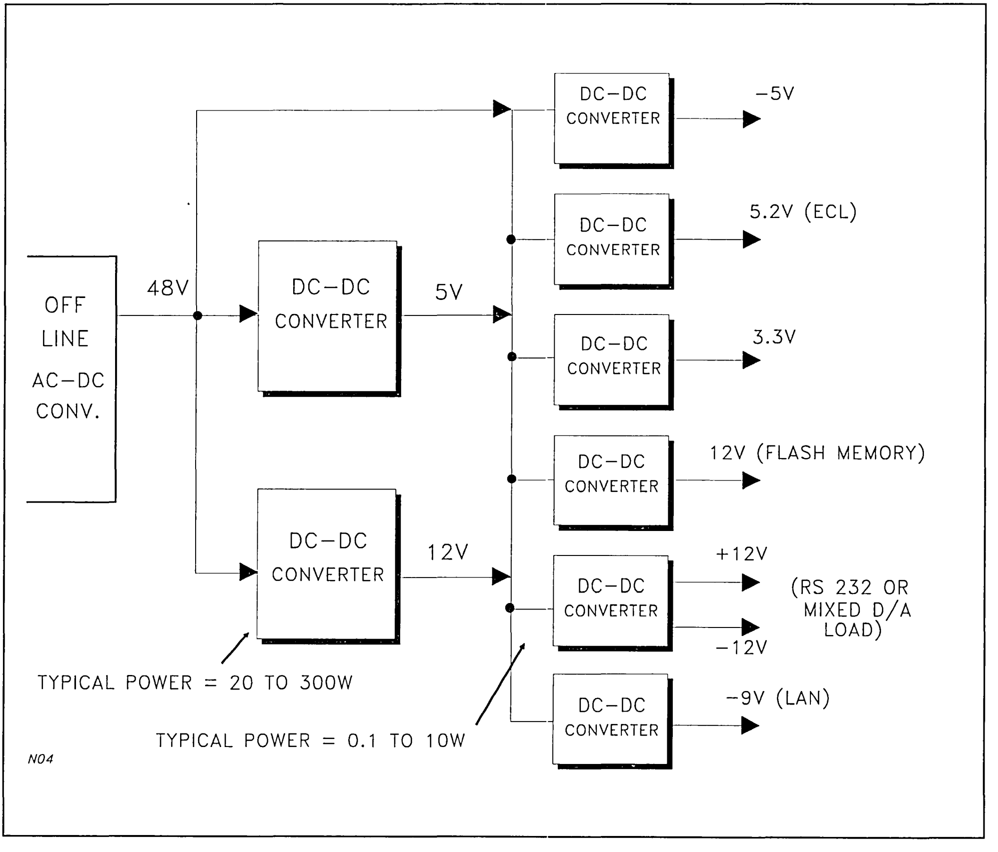


Block 3 Isolated DC-DC converters and block 4 Non Isolated DC-DC Converters have been designed according to a strategy of distributed power architecture as shown in fig. 2

When an electronic equipment requires many different supply voltages, a central power supply system is not the best approach because of poor load regulation (long connecting cables will show significant voltage drops at high current), and because in a multiple outputs power supply just one output voltage is well controlled against line and load variations.

In this case it is preferable to generate the required DC voltage just at the point of its utilization by local regulation (on card or bus regulation).
This concept is shown in fig. 2 and a variety of families (GS-T families for isolated DC-DC converters and GS-R families of non isolated DC-DC regulators) are described in this data book.
The range of output power of these modules is quite large (from 0,1 W to 300 W) and many different output voltages are available.
The architecture of fig. 2 allows also the implementation of an easy back-up solution by connecting the 48 V bus to an adequate battery.

Figure 2.



APPLICATION NOTE

MAINS RECTIFICATION FOR THE GS100T300-x

The GS100T300-x is a family of DC-DC converters with different output voltages (x), that can deliver an output power of 100 Watt when an unregulated DC voltage source of 300 V typical is available.
The key data for GS100T300-x are:

P_o = Output power = 100 Watt
V_o = Output voltage = from 3.3 to 48 V_{DC}
η = Efficiency = 80 % min.
V_{in} = Input voltage = 200 to 400 V_{DC}
I_{inRMS} = Input RMS current = 0.88 A_{RMS}

The following note describes how to obtain an unregulated DC input voltage from the mains.
Four examples are considered: the Europe and Usa mains, and, for each of them, with and without the hold-on characteristic.

The hold-on characteristic is the ability of the input voltage source to mantain a DC voltage higher than the minimum input voltage of the DC-DC converter, even in case of a mains interruption of 1 cycle.

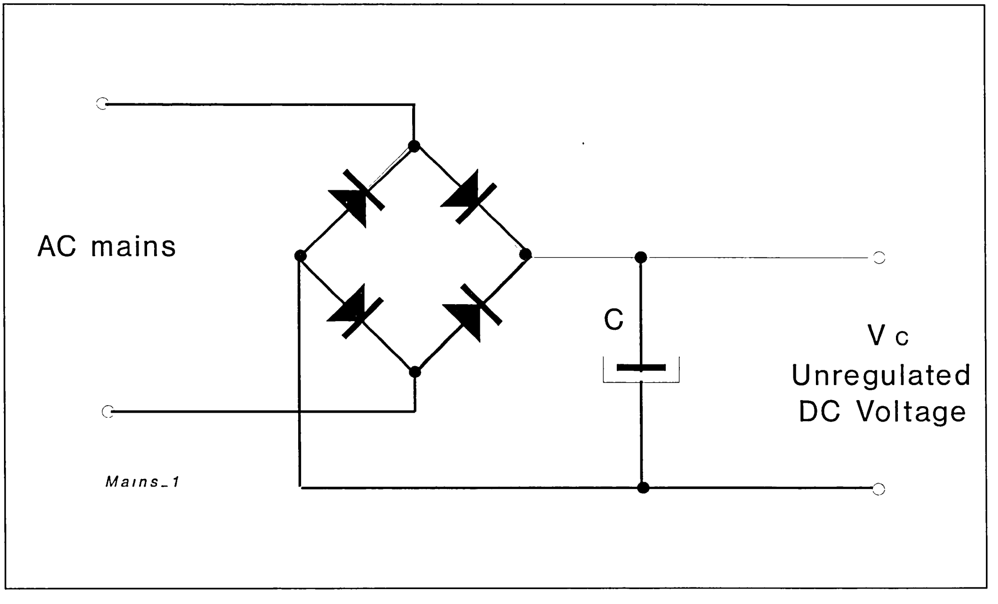
1. European mains without the hold on characteristic.

The European mains characteristics are:

V_{inac} = 230 V_{RMS} ± 15 %
240 V_{RMS} ± 10 %
f = 50 Hz

The minimum AC voltage is, therefore, 195 V_{RMS} while the maximum AC voltage is 264 V_{RMS}. A bridge rectifier as shown in fig. 1 can be used to obtain the required unregulated DC voltage.

Figure 1: AC-DC converter for Europe Mains.



The typical waweform for this type of rectifier is shown in fig. 2 where:

- V_c = Voltage across capacitor C.
- V_{pk} = peak value of the input AC voltage.
- V_{min} = minimum voltage across capacitor C.
- t_{ch} = charging time of the capacitor C
- t_{dch} = discharging time of the capacitor C
- i_{ch} = peak charge current for the capacitor C
- I_{dc} = average input current
- T = total time for one complete cycle

The total energy Win to be supplied by the capacitor C during one full cycle of the mains is:

$$W_{in} = \frac{P_{in}}{f} = \frac{P_o}{\eta \bullet f} \quad (1)$$

where P_{in} is the input power in Watt of the GS100T300-x and f is the mains frequency in Hz. In this case:

$$W_{in} = \frac{100}{0.8 \bullet 50} = 2.5 \ W \bullet s$$

During each half cycle, the capacitor has to deliver 1/2 Win and its voltage will drop from V_{pk} to V_{min}. The following equation applies:

$$\frac{1}{2} W_{in} = \frac{1}{2} C (V^2_{PK} - V^2_{min}) \quad (2)$$

therefore

$$C = \frac{W_{in}}{V^2_{pk} - V^2_{min}} \quad (3)$$

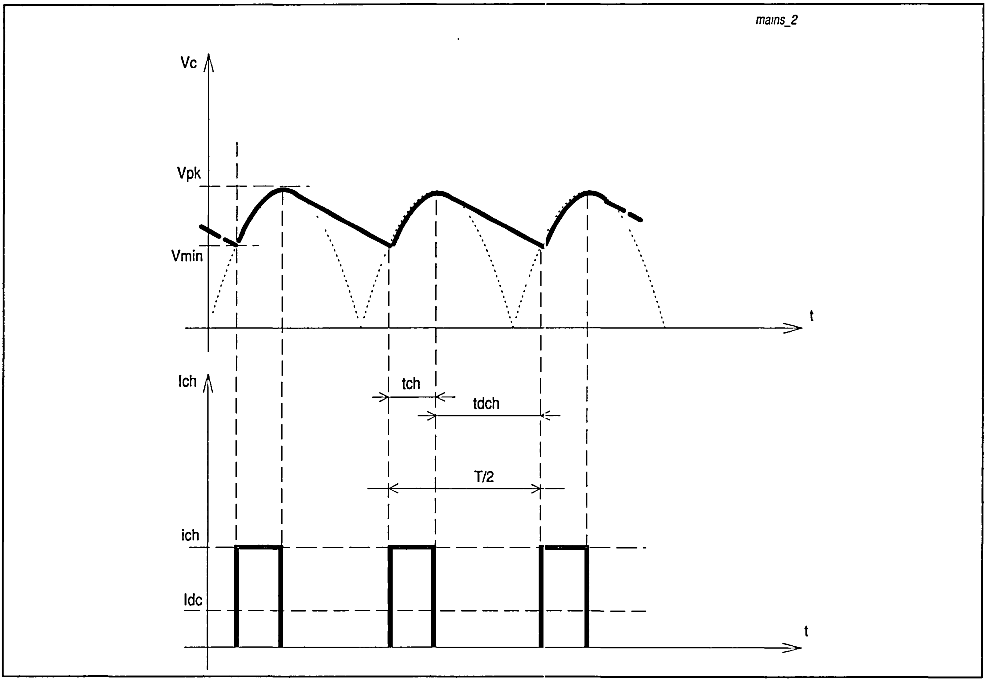
In this case:

$$V_{pk} = \sqrt{2} \bullet V_{inRMSmin} - 4 = 1.41 \bullet 195 - 4 = 271 \text{ V}$$

Where 4 V is a good assumption for the voltage drop across the rectifying diodes and the input filter. According to the GS100T300-x data, V_{min}=200 V. Therefore, from equation (3):

$$C = \frac{2.5}{271^2 - 200^2} = 75 \ \mu F$$

Figure 2. Typical waveform for the circuit of fig. 1



The nearest available value is 82µF. By using this value, the new Vmin is given by:

$$V_{min} = \sqrt{V_{pk}^2 - \frac{W_{in}}{C}} \qquad (4)$$

and so:

$$V_{min} = \sqrt{271^2 - \frac{2.5}{82 \cdot 10^{-6}}} = 207\ V$$

The ripple voltage across the capacitor is:

$$V_{ripple} = V_{pk} - V_{min} \qquad (5)$$

$$V_{ripple} = 271 - 207 = 64\ V_{p-p}$$

The maximum voltage across C is obtained when the AC input voltage is at its maximum and the DC-DC converter does not deliver power. In this case the voltage drop across the diodes and the filter is about 2 V so that the maximum voltage is:

$$V_{PKmax} = \sqrt{2} \cdot V_{inRMSmax} - 2 =$$
$$= 1.41 \cdot 264 - 2 = 370\ V$$

From fig. 2, it may be assumed that the charging current is flowing during the time t_{ch} and with a rectangular shape with a peak value of i_{ch}.
The charging time is given by:

$$t_{ch} = \frac{T}{2\pi} \cos^{-1} \frac{V_{min}}{V_{pk}} \qquad (6)$$

$$t_{ch} = \frac{20 \cdot 10^{-3}}{2\pi} \cos^{-1} \frac{207}{271} = 2.23\ ms$$

The charging peak current is given by:

$$i_{ch} = C\,\frac{V_{pk} - V_{min}}{t_{ch}} \qquad (7)$$

therefore:

$$i_{ch} = 82 \cdot 10^{-6}\,\frac{271 - 207}{2.23 \cdot 10^{-3}} = 2.35\ A_p$$

The RMS value of the input current is given by:

$$I_{in(RMS)} = i_{ch}\sqrt{\delta} \qquad (8)$$

where δ is the duty cycle i.e. the diodes conduction time (t_{ch}) divided by T/2:

$$\delta = \frac{2\,t_{ch}}{T} \qquad (9)$$

The average value of the input current is given by:

$$I_{in(AVG)} = i_{ch} \cdot \delta \qquad (10)$$

From equations (8), (9) and (10):

$$\delta = \frac{2 \cdot 2.23 \cdot 10^{-3}}{20 \cdot 10^{-3}} = 0.223$$

$$I_{in(RMS)} = 2.35\,\sqrt{0.223} = 1.11\ A_{RMS}$$

$$I_{in(AVG)} = 2.35 \cdot 0.223 = 0.524\ A_{DC}$$

The RMS current across the capacitor is the difference between the input RMS current and the input average current that is not flowing through the capacitor:

$$I_{cap(RMS)} = \sqrt{I_{in(RMS)}^2 - I_{in(AVG)}^2} \qquad (11)$$

$$I_{cap(RMS)} = \sqrt{1.11^2 - 0.524^2} = 0.978\ A_{RMS}$$

The equation (11) is valid if the circuit of fig. 1 is connected to a DC load. The GS100T300-x is a switch mode DC-DC converter so that also the input RMS current of the converter (0,88 A_{RMS}) is flowing through the capacitor.
Therefore

$$I_{capTOT(RMS)} = \sqrt{I_{cap(RMS)}^2 + I_{DC-DC(RMS)}^2} \qquad (12)$$

$$I_{capTOT(RMS)} = \sqrt{0.978^2 + 0.88^2} = 1.31\ A_{RMS}$$

2. European mains with hold-on characteristics

In this case the capacitor C must be able to deliver the whole energy during one complete mains cycle-failure.
The input waveform is shown in fig. 3, where:

V_{pf} = Voltage across the capacitor after one cycle of power fail.

The worst case is when the mains interruption happens when the capacitor voltage is already at V_{min}; the following equation applies:

$$W_{in} = \frac{1}{2} C \left(V_{min}^2 - V_{pf}^2\right) \qquad (13)$$

Equation (2) is still valid. By combining equation (2) and (13)

$$V_{PK}^2 - V_{min}^2 = \frac{1}{2}\left(V_{min}^2 - V_{pf}^2\right)$$

therefore

$$V_{min} = \sqrt{\frac{1}{3}\,(2 \bullet V_{pk}^2 + V_{pf}^2)} \qquad (14)$$

from equation (13)

$$C = \frac{2W_{in}}{V_{min}^2 - V_{pf}^2} \qquad (15)$$

By combining eq. (14) and eq. (15)

$$C = \frac{3W_{in}}{V_{pk}^2 - V_{pf}^2} \qquad (16)$$

By assuming $V_{pk} = 271$ V and $V_{pf} = 200$ V

$$C = \frac{3 \bullet 2.5}{271^2 - 200^2} = 224\ \mu F$$

The nearest higher value is 270 µF. By adopting this value

$$V_{pf} = \sqrt{V_{pk}^2 - \frac{3W_{in}}{C}} \qquad (17)$$

$$V_{pf} = \sqrt{271^2 - \frac{3 \bullet 2.5}{270 \bullet 10^{-6}}} = 214\ V$$

$$V_{min} = \sqrt{\frac{1}{3}\,(2 \bullet 271^2 + 214^2)} = 254\ V$$

$$V_{Fripple} = V_{pk} - V_{min} = 271 - 254 = 17\ V_{p-p}$$

$$t_{ch} = \frac{20 \bullet 10^{-3}}{2\pi} \cos^{-1}\frac{254}{271} = 1.14\ ms$$

$$i_{ch} = 270 \bullet 10^{-6} \bullet \frac{271 - 254}{1.14 \bullet 10^{-3}} = 4.03\ A_p$$

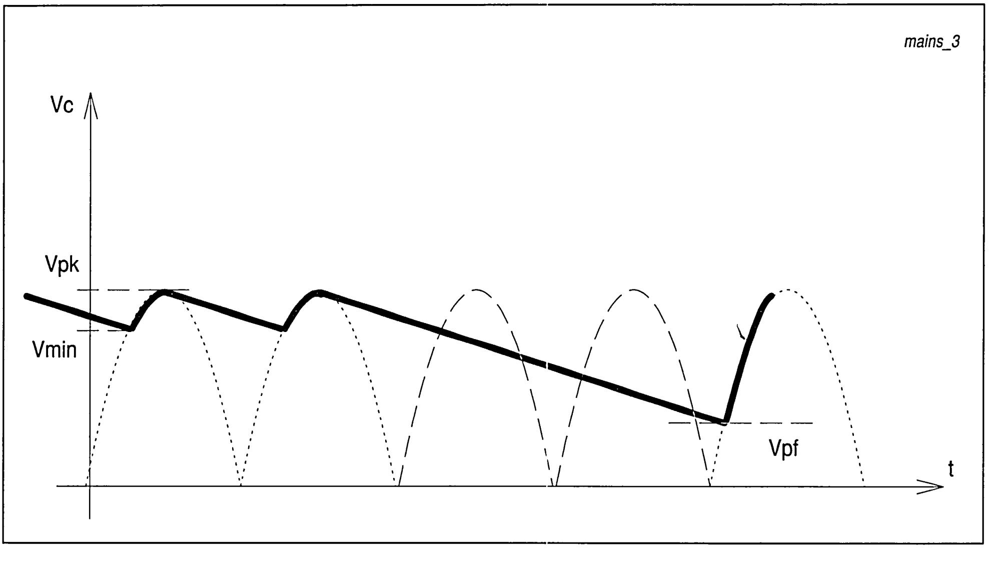
$$I_{in(RMS)} = 4.03\sqrt{\frac{1.14}{10}} = 1.36\ A_{RMS}$$

$$I_{in(AVG)} = 4.03 \bullet \frac{1.14}{10} = 0.46 A_{DC}$$

$$I_{cap(RMS)} = \sqrt{1.36^2 - 0.46^2} = 1.28\ A_{RMS}$$

$$I_{capTOT(RMS)} = \sqrt{1.28^2 + 0.88^2} = 1.55\ A_{RMS}$$

Figure 3. Typical waveform with one cycle of power failure



The key results are summarized in the following table:

European mains: **V_{inac}=195V_{RMS} min; f=50Hz** **230 V_{RMS} typ; Win = 2.5 W x Sec.** **264 V_{RMS} max**

Parameter	Without hold-on	With hold-on	Unit
C	82	270	µF
Vmin	207	254	V
Vpf	-	214	V
VRipple	64	17	Vp-p
Vmax	370	370	V
ich	2,35	4,03	Ap
tch	2,23	1,14	ms
Iin(RMS)	1,11	1,36	ARMS
Iin(AVG)	0,524	0,46	ADC
IcapTOT(RMS)	1,32	1,55	ARMS

3. Usa mains without the hold-on characteristics

The USA mains characteristics are:

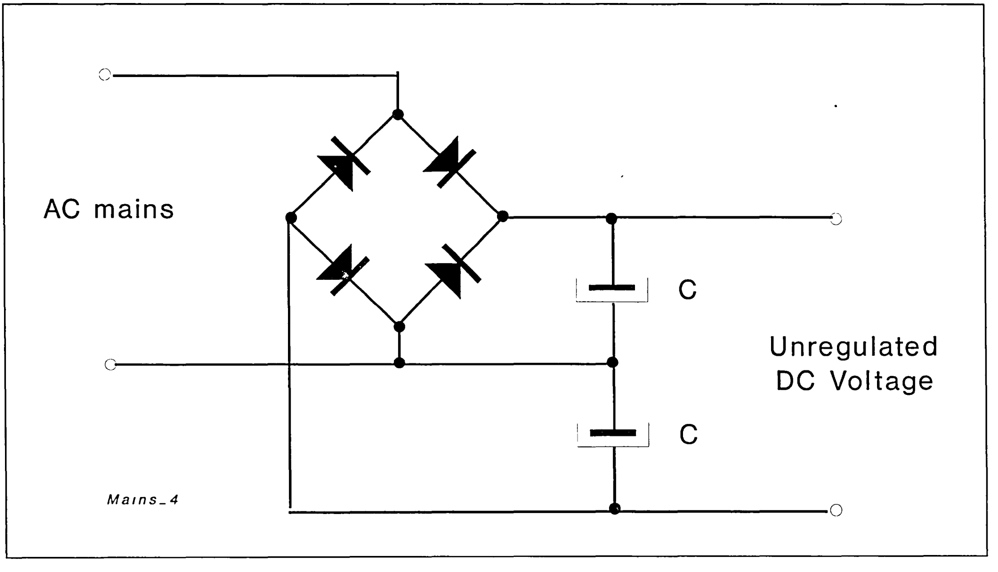
V_{INAC} =117 V_{RMS} ± 15 % 60 Hz

To reach the minimum input voltage required by the GS100T300-x, a voltage doubler configuration is required as shown in fig. 4.

C1 and C2 are alternatively charged to peak line voltage minus the voltage drop across the input filter and one diode of the rectifying bridge so that a voltage drop of 2V may be assumed.
The waveforms are shown on fig. 5.

By assuming a linear discharge of the capacitors, when the capacitor C1 reaches its minimum (Vc1min), the voltage of the capacitor C2 is half way between Vpk and Vc2min.

Figure 4. AC-DC converter for USA mains.



Therefore:

$$V_{min} = V_{C1min} + \frac{V_{PK} + V_{C2min}}{2}$$

If C1=C2=C

$$V_{min} = \frac{3\,V_{Cmin} + V_{PK}}{2} \qquad (18)$$

Each capacitor has to supply one half of the energy required by the GS100T300-x for an entire line cycle.
Therefore:

$$\frac{1}{2}\,W_{in} = \frac{1}{2}\,C\,(V_{PK}^2 - V_{Cmin}^2)$$

$$C = \frac{W_{in}}{V_{PK}^2 - V_{Cmin}^2} \qquad (19)$$

From equation (18)

$$V_{Cmin} = \frac{2\,V_{min} - V_{PK}}{3} \qquad (20)$$

In the case of the USA mains:

$$V_{PK} = \sqrt{2} \bullet 117 \bullet 0.85 - 2 = 138\ V_p$$

$$W_{in} = \frac{P_{in}}{f} = \frac{P_0}{\eta \bullet f} = \frac{100}{0.8 \bullet 60} = 2.08\ W \bullet s$$

By imposing V_{min} = 200V, from equation (20)

$$V_{Cmin} = \frac{2 \bullet 200 - 138}{3} = 87\ V$$

and from equation (19)

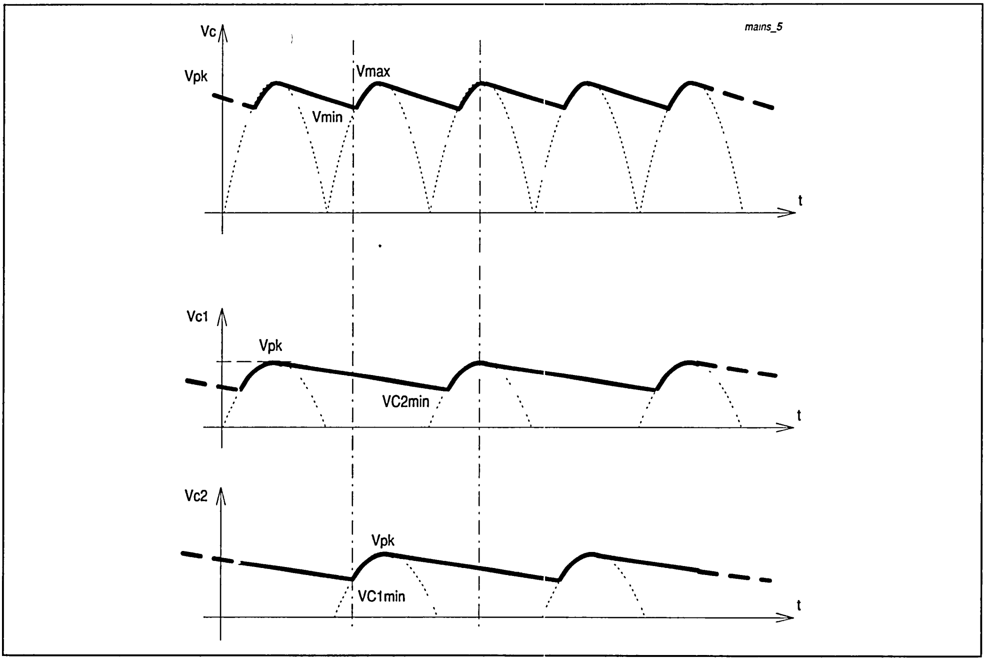
$$C = \frac{2.08}{138^2 - 87^2} = 181\ \mu F$$

The nearest higher value is C=220µF. By adopting this value, from equation (19)

$$V_{Cmin} = \sqrt{V_{pk}^2 - \frac{W_{in}}{C}} \qquad (21)$$

$$V_{Cmin} = \sqrt{138^2 - \frac{2.08}{220 \bullet 10^{-6}}} = 98\ V$$

Figure 5. Waveform for the voltage doubler configuration



and from equation (18)

$$V_{min} = \frac{3 \bullet 98 + 138}{2} = 216\ V$$

From fig. 5

$$V_{max} = V_{PK} + \frac{V_{PK} + V_{Cmin}}{2} = 138 + \frac{138 + 98}{2} = 256V$$

$$V_{Ripple} = V_{max} - V_{min} = 256 - 216 = 40\ V_{p-p}$$

Equations (6),(7),(8),(9),(10),(11),(12) are still valid. However, since the capacitors are charged every other half cycle, the duty cycle is given by:

$$\delta = \frac{t_{ch}}{T}$$

$$t_{ch} = \frac{1}{2 \bullet \pi \bullet 60} \cos^{-1} \frac{98}{138} = 2.07\ ms$$

$$i_{ch} = 220 \bullet 10^{-6} \bullet \frac{138 - 98}{2.07 \bullet 10^{-3}} = 4.25\ A_p$$

$$\delta = 2.07 \bullet 10^{-3} \bullet 60 = 0.124$$

$$I_{inRMS} = 4.25\ \sqrt{0.124} = 1.49\ A_{RMS}$$

$$I_{inAVG} = 4.25 \bullet 0.124 = 0.53\ A_{DC}$$

$$I_{capRMS} = \sqrt{1.49^2 - 0.53^2} = 1.39\ A_{RMS}$$

$$I_{cap\ totRMS} = \sqrt{1.39^2 + 0.88^2} = 1.64\ A_{RMS}$$

When the AC mains is at its maximum (134 V_{RMS})

$$V_{pk} = \sqrt{2} \bullet 134 - 2 = 187V$$

$$V_{Cmin} = \sqrt{187^2 - \frac{2.08}{220 \bullet 10^{-6}}} = 160\ V$$

$$V_{min} = \frac{3 \bullet 160 + 187}{2} = 333\ V$$

$$V_{max} = 187 + \frac{187 + 160}{2} = 360.5\ V$$

$$V_{Ripple} = 360.5 - 333 = 27.5\ V_{p-p}$$

4. USA mains with hold-on characteristics

From fig. 5, during a mains failure of one cycle, the two capacitors in series must provide all the energy required by the GS100T300-x for the same period.

By supposing that the power fail occurs when the total voltage is V_{MIN}, the voltage at the end of 1 cycle failure (V_{pf}) is obtained by

$$W_{in} = \frac{1}{2} C_{eq} \bullet (V^2_{min} - V^2_{pf}) \qquad (22)$$

where: $C_{eq} = \frac{1}{2} C$

$$C = \frac{4\ W_{in}}{V^2_{min} - V^2_{pf}}$$

Equation (18), (21) and (23) must be valid at the same time. After some straightforward calculations the value of C is 406 µF. The nearest higher value is 470 µF. From equation (21)

$$V_{Cmin} = \sqrt{138^2 - \frac{2.08}{470 \bullet 10^{-6}}} = 120.9\ V$$

From equation (18)

$$V_{min} = \frac{3 \bullet 120.9 + 138}{2} = 250.36\ V$$

The voltage after 1 cycle of power fail is given by

$$V_{pf} = \sqrt{V^2_{min} - \frac{4\ W_{in}}{C}} \qquad (24)$$

$$V_{pf} = \sqrt{250.36^2 - \frac{4 \bullet 2.08}{470 \bullet 10^{-6}}} = 212\ V$$

By applying equations (6), (7), (8), (9), (10), (11) and (12) the following values are obtained:

$$t_{ch} = \frac{1}{2 \bullet \pi \bullet 60} \cos^{-1} \frac{120.9}{138} = 1.33\ ms$$

$$i_{ch} = 470 \bullet 10^{-6} \bullet \frac{138 - 120.9}{1.33 \bullet 10^{-3}} = 6.02\ A_p$$

$$\delta = 1.33 \bullet 10^{-3} \bullet 60 = 0.08$$

$$I_{inRMS} = 6.02 \bullet \sqrt{0.08} = 1.7\ A_{RMS}$$

$$I_{inAVG} = 6.02 \bullet 0.08 = 0.48\ A_{DC}$$

$$I_{capRMS} = \sqrt{1.7^2 - 0.48^2} = 1.63\ A_{RMS}$$

$$I_{capTOT\ (RMS)} = \sqrt{1.63^2 + 0.88^2} = 1.85\ A_{RMS}$$

$$V_{max} = 138 + \frac{138 + 120.9}{2} = 267.4\ \text{V}$$

$$V_{Ripple} = 267.4 - 250.4 = 17\ \text{V}_{p-p}$$

When the AC main is at its maximum (134V_{RMS})

$$V_{pk} = \sqrt{2} \bullet 134 - 2 = 187\ \text{V}$$

$$V_{Cmin} = \sqrt{187^2 - \frac{2.08}{470 \bullet 10^{-6}}} = 175\ \text{V}$$

$$V_{min} = \frac{3 \bullet 175 + 187}{2} = 355.6\ \text{V}$$

$$V_{max} = 187 + \frac{187 + 175}{2} = 368\ \text{V}$$

$$V_{Ripple} = 368 - 355.6 = 12.4\ \text{V}_{p-p}$$

The key results are summarized in the following table:

USA Mains **V_{inAC}=99 V_{RMSmin}; 117 V_{RMStyp}; 134 V_{RMSmax};**
f=60 Hz Win=2.08 W x Sec.

The following values are calculated for V_{inAC}=99V_{RMS} exception made for Vmax that is calculated for V_{inAC} = 134V_{RMS}

Parameter	Without hold-on	With hold-on	Unit
C	220	470	µF
V_{min}	216	250.36	V
V_{pf}	-	212	V
V_{Ripple}	40	17	V_{p-p}
V_{max}	360.5	368	V
i_{ch}	4.25	6.02	Ap
t_{ch}	2.07	1.33	ms
$I_{in(RMS)}$	1.49	1.7	ARMS
$I_{in(AVG)}$	0.53	0.48	ADC
$I_{capTOT(RMS)}$	1.64	1.85	ARMS

The four configurations are shown in fig. 6a and 6b

Figure 6a. Different AC-DC converter configurations (European versions)

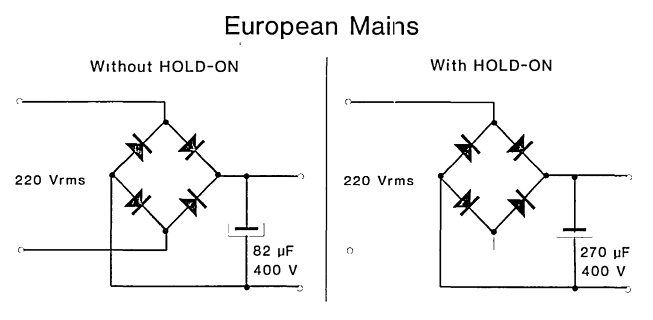
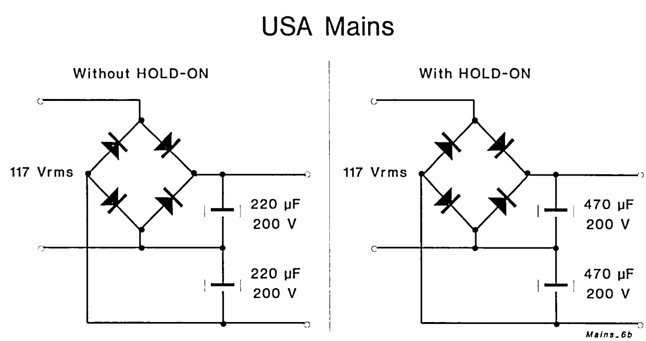


Figure 6b. Different AC-DC converter configurations (USA versions)



5. Ripple current of the filtering capacitor

The previous calculations don't take into account that the capacitance value and the maximum ripple current are not independent. In other words available capacitors of a given capacitance may not meet the requirements for ripple current.
For example, in the case of the European Mains without hold-on, the minimum required capacitance is 82 µF and the maximum ripple current is 1.32 A_{RMS}. While the calculation is correct, such a capacitor doesn't exist: available capacitors of 82 µF / 400 V have a ripple current capability that is 1/3 of the required value at the best.
The designer has to repeat the calculation according to the available capacitors that meet the ripple current requirement, the allowed value for a given application, the cost, etc.
An example is reported in the following.
An available series of capacitors has the following data:

C (µF)	Ripple Current - A_{RMS} @ 85 °C
47	0.71
68	0.84
100	1.04
150	1.23
220	1.50
330	1.80

From the table, the increase in ripple current capability is not proportional to the increase of capacitance. For the two extreme values, the increase of capacitance is 330 / 47 = 7.02 while the increase in ripple current capability is 180 / 0.71 = 2.53.
Therefore it is more convenient to use smaller capacitors in parallel rather than one single capacitor at high value of capacitance.

For this example, 2 capacitors of 68 µF are used in parallel, therefore C = 2 x 68 µF = 136 µF. The calculated values are modified as follows.

$$V_{min} = \sqrt{V_{PK}^2 - \frac{W_{in}}{C}} = \sqrt{271^2 - \frac{2.5}{136 \bullet 10^{-6}}} = 235\ \text{V}$$

$$V_{Ripple} = V_{PK} - V_{min} = 271 - 235 = 36\ V_{p-p}$$

$$t_{ch} = \frac{1}{2\pi f}\cos^{-1}\frac{V_{min}}{V_{PK}} =$$

$$\frac{1}{2\pi 50}\cos^{-1}\frac{235}{271} = 1.66\ \text{ms}$$

$$i_{ch} = C\,\frac{V_{PK} - V_{min}}{t_{ch}} =$$

$$= 136 \bullet 10^{-6} \bullet \frac{271 - 235}{1.66 \bullet 10^{-3}} = 2{,}94\ A_p$$

$$\delta = \frac{2\,t_{ch}}{T} = \frac{2 \bullet 1.66}{20} = 0.166$$

$$I_{inRMS} = i_{ch} \bullet \sqrt{\delta} = 2.95 \bullet \sqrt{0.166} = 1.20\ A_{RMS}$$

$$I_{inAVG} = i_{ch} \bullet \delta = 2.95 \bullet 0.166 = 0.490\ A_{DC}$$

$$I_{cap\ totRMS} = \sqrt{I^2_{inRMS} - I^2_{inAVG} + I_{inDC-DCRMS}} =$$

$$= \sqrt{1.20^2 - 0.49^2 + 0.88^2} = 1.40\ A_{RMS}$$

The parallel of 2 capacitors has a current capability of 2 x 0.84 = 1.68 A_{RMS} so that the capacitors are not overstressed. The impedance of the two capacitors in parallel is about 0.1 Ohms at f = 100 kHz. The designer can repeat the calculations according to the application (European/USA mains, with or without hold-on) to different size and cost targets, etc.

HEATSINK CALCULATION AND EXAMPLES

In many cases, GS-Rx and GSxTy-z modules don't require any additional cooling methods because the dimensions and the shape of the metal boxes were studied to offer the minimum possible thermal resistance case to ambient for a given module.
It should be remembered, that GS-R and GS-T modules are power devices i.e. products that deliver power and dissipate power and, depending on ambient temperature, an additional heat-sink or forced ventilation or both may be required to keep the unit within safe temperature range.
We would like here to eliminate a wrong parameter that has been plaguing the technical literature of power devices for 30 years: the operating ambient temperature specified among Absolute Maximum Rating.
The concept of operating ambient temperature is totally meaningless when we deal with power components, because the operating ambient temperature depends on how a power device is used.
What can be unambiguously defined is the maximum junction temperature of a power semiconductor device or the case temperature of a module. To prove this, let's consider the following example:

GS-R1005 at :
$V_{in} = 24V$ $I_o = 10$ A $P_o = 50$ W $T_{casemax} = 75$ °C
GS100T300-12 at :
$V_{in} = 300$ V $I_o = 8$ A $P_o = 96$ W $T_{casemax} = 70$ °C

From data sheets we can get the respective efficiencies η and power dissipations

$$P_d = P_o \left(\frac{1}{\eta} - 1\right)$$

GS-R1005	$\eta = 0.83$	$P_d = 10.2$ W
GS100T300-12	$\eta = 0.84$	$P_d = 18.3$ W

In case of natural convection (no heat-sink or forced ventilation) the thermal resistance case to ambient and the maximum ambient temperature ($T_{ambMAX} = T_{Cmax} - R_{th} \bullet P_d$) will be:

GS-R1005
$R_{th} = 7.5$ °C/W $T_{ambMAX} = 75\text{-}7.5\bullet 10.2 = \text{-}1.5$°C
GS100T300-12
$R_{th} = 7.5$°C/W $T_{ambMAX} = 70\text{-}7.5\bullet 18.3 = \text{-}62.25$°C

As data show, the maximum operating ambient temperatures are a "non-sense" in the two cases, due to the fact that both devices are for use with an external heatsink.

In practice a designer must fix four preliminary values such as:

V_{in} = Input voltage

V_{out} = Output voltage

I_{out} = Output current

T_{amb} = Maximum ambient temperature at which the system must operate.

From these data, it is easy to determine whether an additional heat-sink is required or not and the relevant size i.e. the required thermal resistance. The step by step calculation is as follows:

1. Calculate output power:

$$P_O = V_O \bullet I_O$$

2. On data sheet, from V_o, V_{in}, I_o, the efficiency is obtained directly or by calculation:

$$\eta = \frac{P_O}{P_{IN}}$$

3. The actual power dissipation is given by:

$$P_d = P_O \left(\frac{1}{\eta} - 1\right)$$

4. The case temperature is calculated:

$$T_{CASE} = T_{AMBmax} + R_{th} \bullet P_d$$

(Rth is shown on data sheet)

5. If $T_{case} < T_{caseMAX}$ no external heat-sink is required

If Tcase > $T_{caseMAX}$ then proceed as follows.

6. Let's calculate what thermal resistance case to ambient is needed:

$$T_{TH(tot)} = \frac{T_{CASEmax} - T_{AMBmax}}{P_d}$$

This is the total thermal resistance i.e. the parallel of the module and external heat- sink thermal resistances.

7. The thermal resistance of the additional heat-sink is calculated:

$$R_{TH(HS)} = \frac{R_{THmodule} \bullet R_{TOT}}{R_{THmodule} - R_{TOT}}$$

As an example, let's consider two cases.
Conditions:

GS-R1005	GS100T300-12
$V_{in1} = 24$ V	$V_{in2} = 300$ V
$V_{o1} = 5$V	$V_{o2} = 12$ V
$I_{o1} = 2$A	$I_{o2} = 5$A
$R_{th1} = 7.5$ °C/W	$R_{th2} = 7.5$ °C/W
$T_{caseMAX}$=75°C	$T_{caseMAX}$=70°C

$T_{ambMAX} = 55$°C

1. Output powers:

$$P_{O1} = 5 \bullet 2 = 10 \text{ W} \quad P_{O2} = 12 \bullet 5 = 60 \text{ W}$$

2. From data sheet:

$$\eta_1 = 0.83 \quad \eta_2 = 0.84$$

3. Power dissipations:

$$P_{d1} = 10 \ (\frac{1}{0.83} - 1) = 2.0 \text{ W}$$

$$P_{d2} = 60 \ (\frac{1}{0.84} - 1) = 11.4$$

4. Case temperatures:

$$T_{C1} = 55 + 2.0 \bullet 7.5 = 70 \text{ °C}$$

$$T_{C2} = 55 + 11.4 \bullet 7.5 = 140.5 \text{ °C}$$

5. The GS-R1005 does not require heat-sink that is, on the contrary, required for GS100T300-12.

6. Total thermal resistance for GS100T300-12

$$R_{TH(TOT)} = \frac{70 - 55}{11.4} = 1.31 \text{ °C / W}$$

7. Required thermal resistance of heat-sink:

$$R_{TH(HS)} = \frac{7.5 \bullet 1.31}{7.5 - 1.31} = 1.58 \text{ °C / W}$$

The following table gives the thermal resistance of commercially available heat-sinks.

Manufacturer	Part Number	Rth °C/W	Mounting	Fastening
SGS-THOMSON	HS01	2.8	Vert.	Screw
THERMALLOY	6177	3	Horiz.	Screw
THERMALLOY	6152	4	Vert.	Screw
THERMALLOY	6111	10	Vert.	Adeshive
THERMALLOY	6155	4.5	Vert.	Screw
THERMALLOY	6601	5	Vert.	Screw
THERMALLOY	6176	4.5	Vert.	Screw
THERMALLOY	6320	1.5	Horiz.	Screw
ALUTRONIC	PR139	3	Vert.	Screw
ALUTRONIC	PR140	2	Horiz.	Screw
ALUTRONIC	PR159	2.5	Vert.	Screw
AAVID	60885	4.5	Vert.	Screw
AAVID	60660	1.5	Horiz.	Screw
AAVID	62355	3	Vert.	Screw
AUSTERLITZ	KS50	3	Vert.	Screw
AUSTERLITZ	KS100.3	2.5	Horiz.	Screw
FISCHER	SK18	3	Vert.	Screw
FISCHER	SK48	3	Vert.	Screw
FISCHER	SK16	1.5	Horiz.	Screw
FISCHER	SK52	2	Horiz.	Screw
FISCHER	SK07	4	Vert.	Adeshive
SGE Bosari	L30	3	Horiz.	Screw
SGE Bosari	LZ50	3	Vert.	Screw
SGE Bosari	SR50	6	Vert.	Adeshive
ASSMAN	V5280	2	Horiz.	Screw
ASSMAN	V5805	2	Vert.	Screw
ASSMAN	V5440	4	Vert.	Adeshive
ASSMAN	V5382	4	Horiz.	Screw
ASSMAN	V5460	3	Vert.	Screw
ASSMAN	V5510	3	Vert.	Screw

SGS-THOMSON MICROELECTRONICS

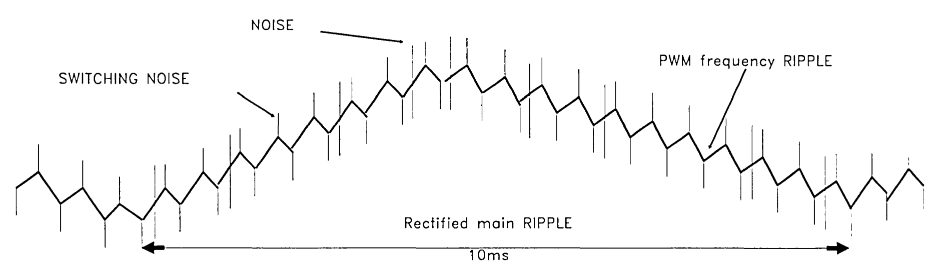
APPLICATION NOTE

HOW TO TEST OUTPUT RIPPLE AND NOISE OF POWER SUPPLIES

The switching power supplies (either step-down regulators, or isolated DC-DC converters, or OFF-LINE power supplies) have the fundamental advantage of high efficiency i.e. low power dissipation when compared to linear voltage regulation.

However the switching technique, that is beneficial to raise the efficiency, has an associated weakness i.e. the output voltage has always an AC content. The typical output ripple and noise of a switching power supply is as shown in fig. 1.

Figure 1. Output ripple and noise of a switching power supply



Four AC components can be identified:

- low frequency ripple at 2f being f the AC mains frequency
- high frequency ripple due to Pulse Width Modulation (PWM) to obtain the required line and load regulation.
- the switching noise that has the same frequency of the switching PWM
- the aperiodic random noise that is not related to the AC source frequency and/or the switching frequency.

The above mentioned parameters are normally specified by the peak to peak amplitude so that the best method for testing is by an oscilloscope with a bandwidth of 20 MHz.

Care must be taken when using the scope probe.

Fig. 2 shows a wrong method because the ground wire of the probe can collect radiated noise and the scope display is strongly dependent on the probe position.

Fig. 3 shows a better method because the collection of the radiated noise is minimized.

Figure 2. Wrong output ripple and noise test

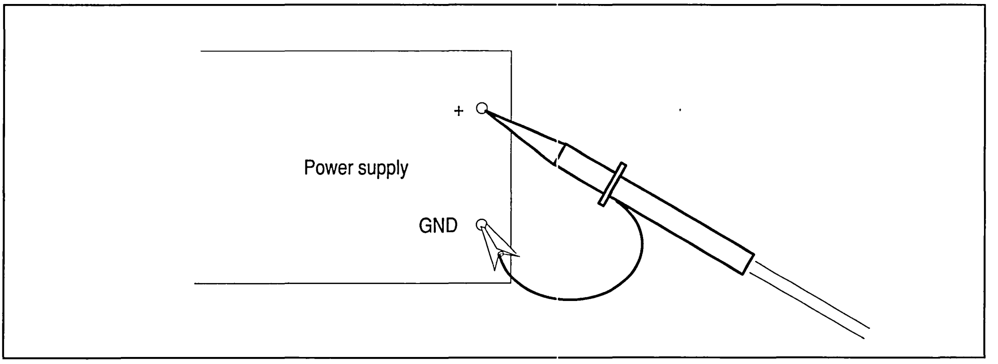
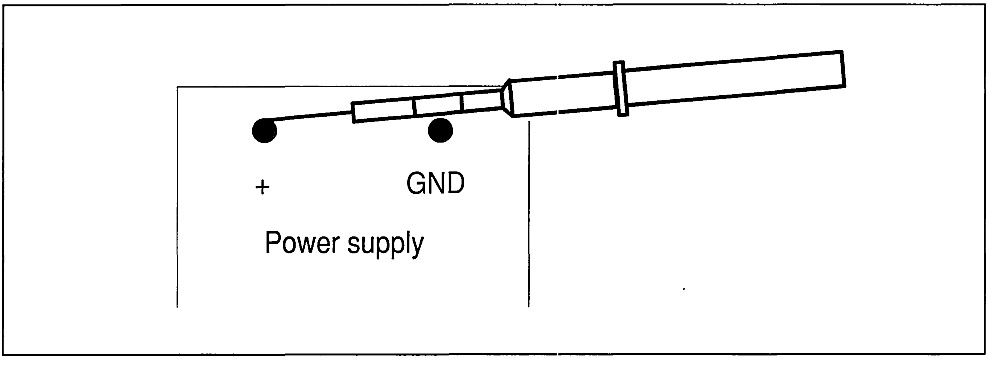


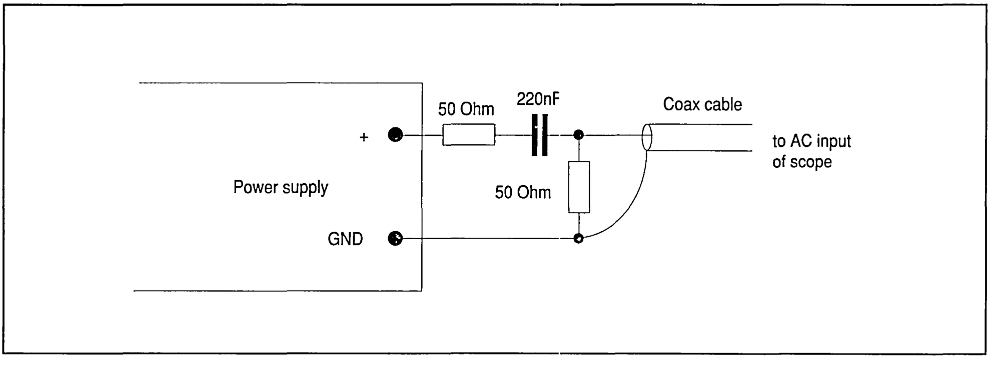
Figure 3. Correct output ripple and noise test



The ground ring of the probe is pressed directly against the output ground of the power supply and the tip is in contact with the output voltage pin.

A preferred method is shown in fig. 4: the waveform displayed on the scope must be multiplied by a factor 2.

Figure 4. Preferred method to test output noise and ripple



RELIABILITY REPORT

INTRODUCTION

Following our tradition of publishing official and detailed Quality and to meet the ambitious quality goals of SGS-THOMSON, a company quality policy has been implemented by top management, with the purpose of defining the course of actions and to state what is going to be done.

Our primary goal is to create an environment for continuous improvement in quality, in order to achieve zero defects in our products and services. The improvement rate must be at least a factor of ten every four years.

Our quality policy is as follows:

- Customers' needs and requirements must be met (through a market driven approach to business)
- Quality must be built-in (to be prevention driven instead of correction driven)
- Processes must be "capable" (Cp≥2 both for manufacturing and business processes)
- Processes must be kept under strict control (SPC as the basic tool)
- Investment for quality improvement must be equal or greater than a defined percentage of sales
- Training on quality is a basic motivation and improvement tool
- Managers must be measured on quality results
- Quality system must meet ISO 9000 / EN 29000 requirements.

Each division / group in the company must issue its plans in conformance with this corporate policy.

CHAPTER 1 - SGS-THOMSON PRODUCTS QUALITY ASSURANCE

1.1 SGS-THOMSON QUALITY AND RELIABILITY POLICY

The product Quality and Reliability proceeds from the design and development process of each new product, through the production and shipment up to the service supplied to the customer.

It is well known that Reliability is part of the product itself.

SGS-THOMSON has a Total Quality Control policy to manufacture consistently reliable high quality products. Everyone in the company must recognize the importance of maintaining and improving Quality and Reliability levels.

SGS-Thomson policy allows the problem solving as they arise. Total Quality Control prevents quality problems rather than simply eliminating defective finished products.

This policy gives to the customer many advantages because it guarantees a better Quality and Reliability and cost reduction.

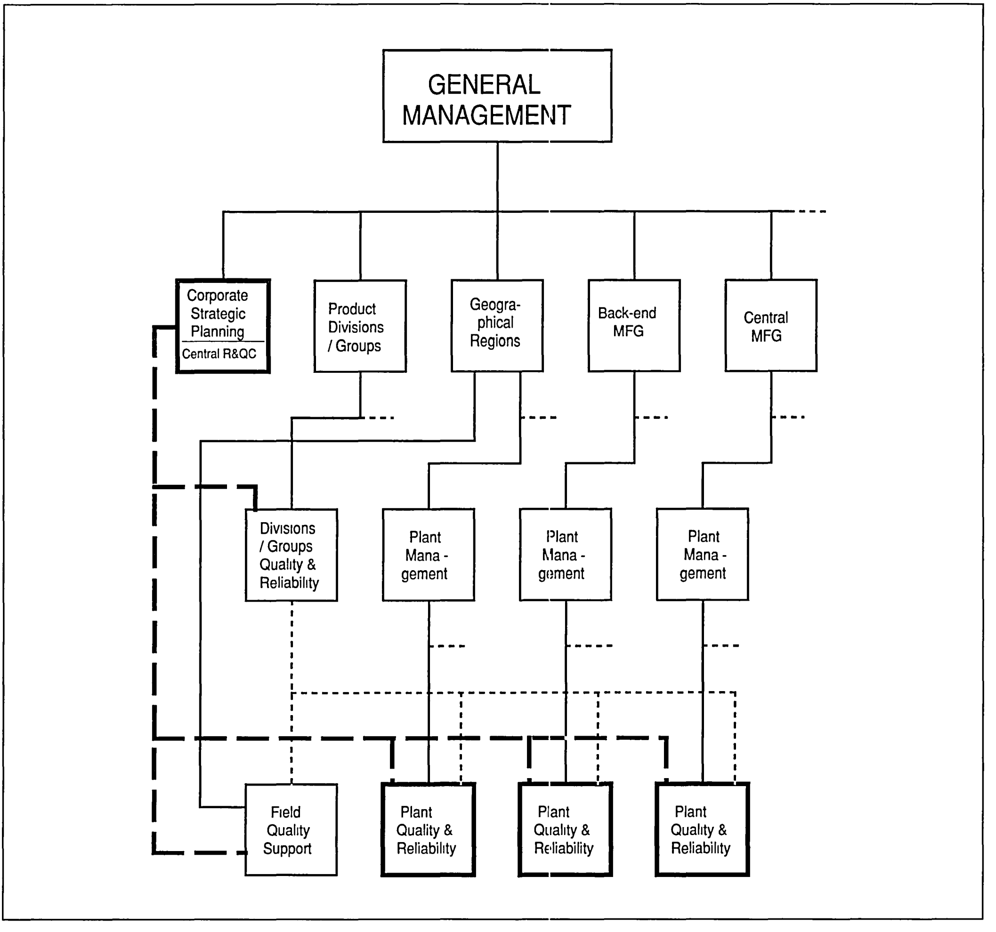
1.2 SGS-THOMSON ORGANIZATION AND MANAGEMENT

Quality Organization

SGS-THOMSON is organized in a matrix structure with product divisions/groups, geographical sales regions and corporate level support functions.

Within this structure the Quality and Reliability activities are managed and performed at both strategic and operative levels.

Figure 1. SGS-THOMSON quality organization chart and main activities.



Central R & QC

- Managing the company's Quality and Reliability departments oriented to TQM and ISO 9000 / EN 29000 concepts.
- Establishing quality strategies, targets and Q&R programs for the whole Group.
- Generating and enforcing quality policies and procedures,
- Collecting, analyzing and disseminating Q&R data from customers and local quality control departments. Summarizing the results for top management to emphasize corrective actions required or in progress.
- Coordinating the Company-wide program for Statistical Process Control through a steering committee.
- Managing incoming materials through supplier's audits, data collection and analysis.
- Assisting the Corporate Human Resources Department (CHRD) in quality and excellence training and education programs.
- Quality system auditing to verify the adequacy of the Q&R management and activities.
- Evaluating customers' general Q&R specifications or contracts in cooperation with divisional Q&R departments.
- Supporting customers in order to understand their quality needs, requirements and trends.
- Managing the Corporate Unified Document Control System (UDCS)
- Evaluating Cost Of Non Quality (CONQ)

Divisions / Groups Q & R

- Assuring the Quality and Reliability of their products regardless of production location.
- Qualifying new materials and new products. Certifying new processes prior to volume production.
- Creating customer satisfaction by directly interfacing with customers from design phase to approval of new products to insure compliance with their specifications and needs.
- Reliability testing and collecting results necessary for assessing process and product reliability and issuing reports to provide our customers with the correct image of our product reliability.
- Coordinating corrective actions needed to improve Q&R of products and processes as planned in quality budgets, taking into account also Failure Analysis results and other Customer Feedbacks.
- Assuring the quality of purchased material through partnership with vendors, certification and Ship To Stock programs.
- Coordinating and approving all the quality specifications regarding the division/group's products and processes.
- Regular Self-auditing on processes, SPC, specifications and standard operating procedures application.
- Updating divisional quality manuals.
- Assuring a uniform quality approach throughout the company under the direction of central R & QC.

Plant Q & R

- Assuring the quality and reliability of all manufactured products.
- Regular self-auditing on processes, SPC, specifications and standard operating procedures application.
- Achieving Q&R targets and uniform quality approach throughout the company, maintaining a close liaison with Central and Divisional/Group Quality departments.
- Coordinating corrective and preventive actions in the plant based on the feedback from Quality and Reliability tests, field data and Failure Analysis results.
- Assuring that adequate Q&R inspections and controls are performed at the plants including incoming, SPC, outgoing , reliability testing and failure analysis.
- Assuring the correct distribution and updating of specifications received through the central document control system.
- Updating the Plant Quality Manual.
- Liaising with the other plants in order to assure common quality approaches, under the direction of Central R & QC
- Interfacing with customers for audits, certifications, etc.

1.3 DESIGN-IN FOR QUALITY AND RELIABILITY

Since the Quality and Reliability depend on a large extent on the basic structure, SGS-Thomson pays much attention to Quality and Reliability features just from the design phase. The most important points are the user reliability requirements, the operating conditions and the reliability checkpoints for components, materials and process.

The design review consists of a study of design documents, the choice of reliability tests and methods, a check on the process compatibility to achieve the design goals, and the review of past failures in similar products.

New products and processes qualification consist of four activities:

1. New production process technical qualification
2. New production process production qualification
3. New materials qualification
4. New product qualification.

Technical qualification is performed on a small product sample at the pre-production phase. Production qualification is performed on the large-scale production process.

CHAPTER 2 - QUALITY AND RELIABILITY ACTIVITIES

2.1 QUALITY IN PROCUREMENT

The Quality approach with our suppliers is described in the diagram of Fig. 2.
Another important element of Quality in Procurement is "Source Certification for Ship To Stock". Selected materials suppliers, considered as strategic, will be requested to enter for a certification program on a base of partnership.

The suppliers completing the program with a satisfactory result will become preferred sources for the certified materials.

SGS-THOMSON Quality Department is responsible for establishing a close relationship with each supplier and for maintaining continuous feedback from them along with all appropriate documentation and information as shown below.

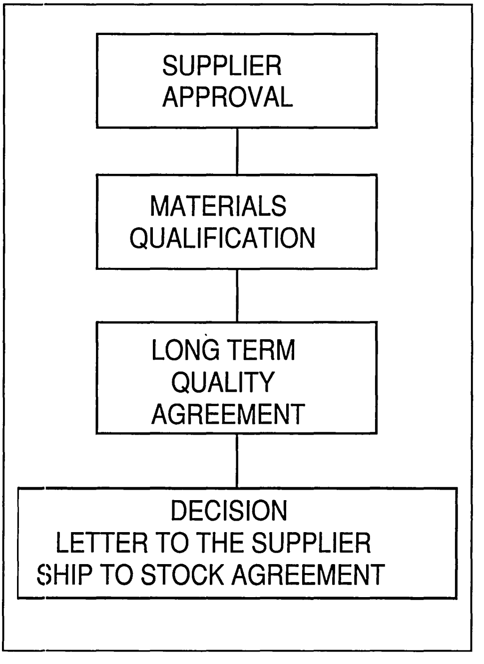
This includes:

- Certificate of conformity for each lot received, giving statistical data on golden parameters.
- Documentation on achievement of Cp-Cpk figures in line with our internal targets.
- Trends for suppliers' process parameters.

The Quality Department is also responsible for ensuring that suppliers receive all the data they need from SGS-THOMSON. This includes:

- Information on rejected or waived lots.
- Comparative supplier ratings.
- Information on production results were appropriate.
- Yearly quality objectives.

Figure 2. Quality improvement program for purchased materials



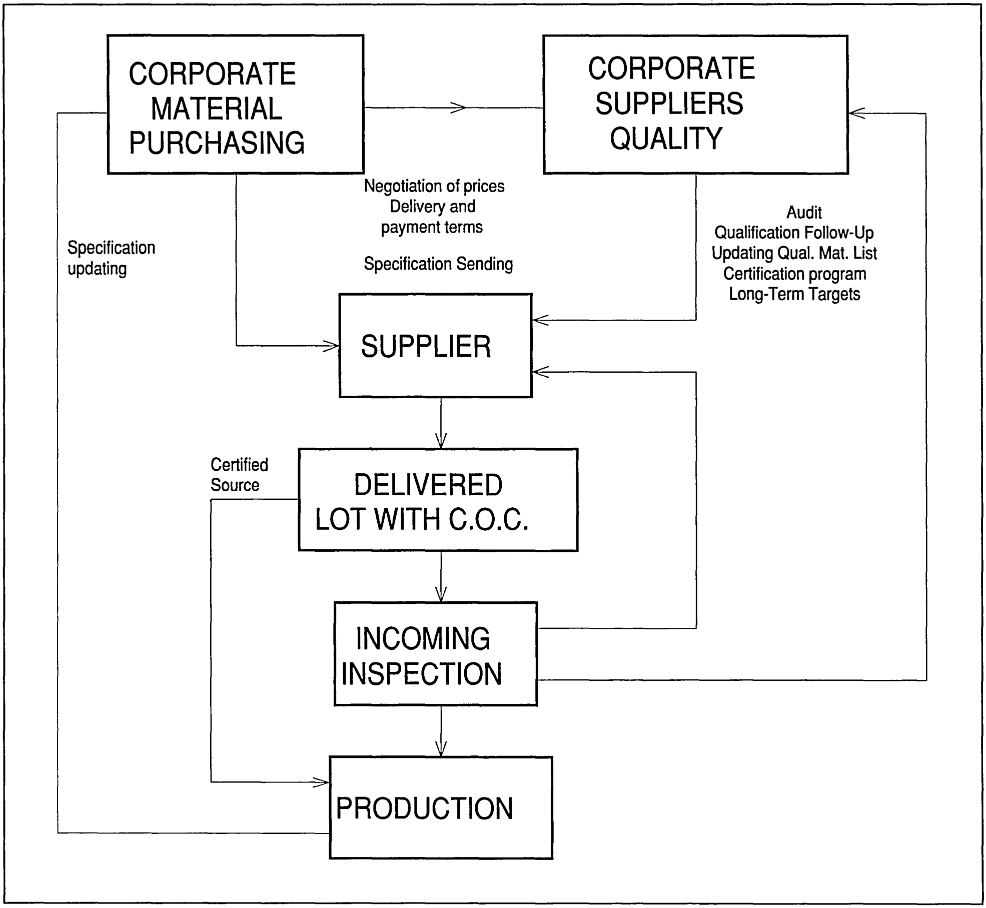
2.2 THE RELIABILITY APPROACH

SGS-Thomson pays particular attention during the design and manufacturing stages and it studies the various factors that affect the products Reliability both in operational and environmental conditions.

Subsystems reliability is described in quantitative terms by measuring the failure rate as a function of time. The failure rate distribution of a product follows the familiar bathtub curve shown in Fig. 3.

This curve is divided into three time zones, as shown in the figure.

Figure 3. Relationship Supplier - SGS-THOMSON



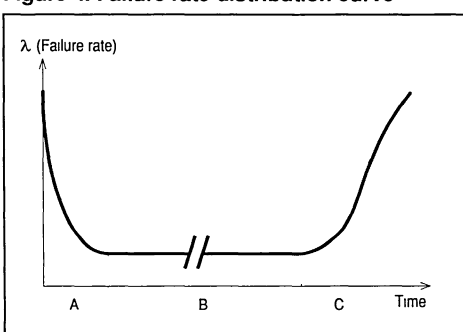
The length of each zone depends on the various components used in the products and operating stresses.

Zone A covers the infant mortality period where failure modes are usually open and short circuits that causes complete functional failures and seriously degraded performances.

Zone B represents the random failure part of the distribution curve related to the useful life. This period, generally very long, depends on the stress (temperature, applied voltage, applied power, circuit complexity etc.).

Failures in zone C are wear out failures consisting of catastrophic failures and degraded parameters.

Figure 4. Failure rate distribution curve



2.3 THE RELIABILITY TESTS

These are two types of reliability tests:

- tests executed during the product design and development
- tests executed during the production phase.

The first type is usually executed on a small sample but for a long time, or under very accelerated conditions to investigate worn out failures and to determine tolerances and limits of the design.

The second type is executed periodically during the production to check, maintain and improve the assured Quality and Reliability levels.

All reliability tests performed by SGS-THOMSON are under more severe conditions than those met in the field. These conditions, although accelerated, are chosen to simulate stress conditions of the current operation and care is taken to ensure that the failure modes and mechanism are unchanged.

2.4 THE FAILURE ANALYSIS

The failure analysis is the investigation made on products that fail during laboratory testing or in field, to determine the failure cause. Failures may be caused by production defects or by using the product outside the absolute maximum rating limits.

In the first case, failure analysis helps SGS-Thomson to improve the production process, in the second, it helps the customer to eliminate design errors that overstress the product.

Failure analysis involves more than simply opening the package or remove some screw and looking inside. The failure mechanisms are complex and varied so it is necessary to perform a logical sequence of operations and examinations to discover the origin of the problem. To identify the failure, mechanism requires an understanding of manufacturing process, a sound knowledge of the technology plus the knowledge of the working conditions during applications.

SGS-THOMSON sophisticated failure analysis facilities allow to identify rapidly the corrective actions to improve the production quality and to gauge the performance of manufacturing processes, so that they can be better adapted to the new products development.

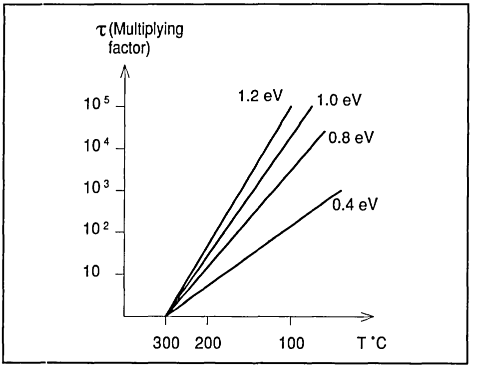
2.5 THE RELIABILITY PREVISION

The reliability prevision is essential in the development and maintenance of electronic equipments. But to actually prove reliability figures is so expensive and time spending that it is normally unused. Fortunately, data obtained from accelerated simulated conditions give the relationship between applied stress and failure rate that is supported by data collected in the field.

To predict reliability, data collected from accelerated tests and operating life tests performed at high temperature are related to normal operating conditions and the failure rate estimated with sufficient accuracy. Reliability prevision is very interesting during the design phase to give an early estimation of equipment reliability and to provide data for design analysis and reliability growth monitoring.
Fig. 5 shows the temperature derating curves and the multiplying factors for temperature reduction. The various lines correspond to the activation energies associated with the different involved failure mechanisms.

Current reliability prediction models, such as MIL HDBK 217D, give useful predictions for a wide range of components.
These models are derived from accelerated life tests, screening, burn-in, reliability tests, field experience, product characterization and failure data.
In the following table the values of FITs (failure in time or (failure/hour) x 10E-9) extracted from the MIL HDBK 217D are reported.

Figure 5. Arrhenius plot



The MIL HDBK 217D predicted failure rates are conservative values. They result from historical data and cannot take into consideration the continuous technological improvements in the semiconductor field.

In the following table an example of the failure rate prediction for various active and passive components is reported for different operating temperatures.

Table 1. Failure rate prevision example

Component or Family of components	Failure Rate Prediction at T = 25°C	Failure Rate Prediction at T = 50°C	Failure Rate Prediction at T=75°C	Failure Rate Prediction at T=100°C
Signal Diode - Glass Device - 50 % rated voltage	24	38	66	160
Signal Diode - Glass Device - 100 % rated Voltage	35	54	94	228
Power Diode - Plastic Device - 50 % rated Power	31	50	80	123
Power Diode - Plastic Device - 100 % rated Power	104	161	280	685
Zener Diode - Glass device - 50 % rated Current	35	42	52	70
Zener Diode - Glass device - 100 % rated Current	50	64	94	181
Signal Transistor - Hermetic Device 100 % rated Voltage *	<1	<1	2	10
Signal Transistor - Plastic Device 100 % rated Voltage *	<1	2	20	100
Power Transistor - Hermetic Device 100 % rated Voltage *	<1	<1	1	6
Power Transistor - Plastic Device 100 % rated Voltage *	<1	5	50	500
Power LIC - Multiwatt - 100 % Rated Voltage *	<1	<1	2	10,
Signal LIC - Plastic minidip - 100% rated voltage *	<1	2	15	120
MOS Logic - Plastic microprocessor *	2	15	130	650
MOS Memory - Ceramic EPROM 64 k *	10	55	230	2100
CMOS - Plastic Gate/MSI - 100 % rated voltage *	1	10	120	1200
CMOS - Ceramic gate/MSI - 100 % rated voltage *	<1	2	20	200
Resistor Composition - ≤1 MOhm 50 % Rated Power	18	47	120	311
Resistor Composition - ≤1 MOhm 100 % Rated Power	45	124	325	-
Metallic Resistor ≤1 MOhm - 50 % Rated Power	44	55	67	91
Metallic Resistor ≤1 MOhm - 100 % Rated Power	75	95	130	-
Wirewound Resistor ≤1 MOhm 50 % Rated Power	265	297	362	500
Wirewound Resistor ≤1 MOhm 100 % Rated Power	540	702	918	1405
Resistor Network (for any internal resistor)	5	14	34	73
Aluminum Capacitor <47µF low leakage 50 % rated voltage	68	120	272	800
Aluminum Capacitor <47 µF low leakage 100 % rated voltage	300	560	1240	3800
Aluminum Capacitor <1500 µF low leakage 50 % rated voltage	480	1104	3840	18000
Aluminum Capacitor <1500 µF low leakage 100 % rated voltage	1870	4320	14880	75000
Ceramic Capacitor <100 nF - 50 % rated voltage	75	79	83	89
Ceramic Capacitor <100 nF 100 % rated voltage	500	540	562	603
Mylar Capacitor <200 nF - 50% rated voltage	20	20	24	41
Mylar Capacitor <200 nF - 100 % rated voltage	468	487	580	1030
Tantalum Capacitor ≤10 µF TAG 50% rated voltage	405	500	749	1467
Tantalum Capacitor ≤10 µF TAG 100% rated voltage	2370	2900	4370	-
Transformer 130 °C max operating temperature	308	376	513	890
Inductor 130 °C max operating temperature	62	75	103	178
Printed Boards Dual side wave soldered -any hole	0.015	0.015	0.015	0.015
Connectors for boards Diallyphtalate - any pin	7	16	29	48

Note: For semiconductors, the temperature is to be intended as junction temperature. For the asterisk marked components, the reported figures are historical data measured and collected by SGS- Thomson.

2.6 RELIABILITY AND USER APPLICATION

The reliability heavily depends on the electrical and mechanical stresses encountered in the use application. Designers must therefore pay much attention to electrical circuit design, mounting techniques and environmental conditions to exploit the inherent reliability of the components.

2.6.1 Maximum ratings

The "Absolute Maximum Ratings" found on SGS-Thomson data sheets are limit values of the operating and environmental conditions that must never be exceeded, even temporarily, otherwise the component may be degraded o destroyed.

Even if the device works correctly outside these limits, its lifetime can be greatly reduced.

2.6.2 Derating

Temperature is one of the main factors affecting the reliability of almost every component.

I.e. for semiconductor devices, the failure rate increases rapidly with the junction temperature following the Arrhenius law:

$$\lambda = A \bullet e^{-\frac{E_a}{kT_j}}$$

where
A = constant
K = Boltzmann's constant
Ea = activation energy
Tj = junction temperature

Taking the typical activation energy for random failure as 1 eV this gives a six fold increase in failure rate for a temperature rise of 20 °C.

Activation energies are in the range of 0.3 to 0.6eV (typically 0.44eV) for infant mortality failures and 0.6 to 1.4eV for random failures.

These considerations can be extended, using different coefficients, to the majority of the components and then to maximize reliability, designers should keep the temperature as low as possible.

2.6.3 Electrical loading

During normal operation, voltage, current and power dissipation all affect the useful component life. Excessive power dissipation raises the temperature with a consequent increase of failure rate; voltages and currents outside the recommended working conditions may cause degradation or premature failure.

2.6.4 Performance limits relaxation

During the component life some degradation of the performance characteristics is possible. Circuit designers can therefore increase the electronic equipment reliability at very little cost by relaxing the performance limits specified. Therefore adding an extra safety margin allows the equipment to keep on working even if the component performance shows little shifts.

2.6.5 Mechanical stresses.

SGS-Thomson performs a variety of reliability tests to check the resistance to mechanical stresses, vibration, shocks, etc. during the transport and the use.
Care should still be taken by use to avoid excessive mechanical stress on the product.

2.6.6 Mounting on heatsinks

External heatsinks are often required to prevent excessive temperature rises. The user must be careful to avoid mechanical damage during mounting and to ensure adequate heat flow.
The heatsink should be flat, the screws (of a suitable type) tightened to the correct torque and silicon grease used when necessary.

2.6.7 Soldering

Soldering must be done at controlled temperature and for the possible shortest time.
After soldering operations, residual flux must be removed to ensure good reliability. If ultrasonic cleaning is used, take care to avoid resonance effects.

Do not use trichloroethilene solvent.
To avoid deterioration of the solderability, parts should be stored in an environment free from dust and reactive gas with temperature in the range 5-30 °C and humidity from 40 to 60%.
Rapid temperature changes should be avoided because they may cause condensation.

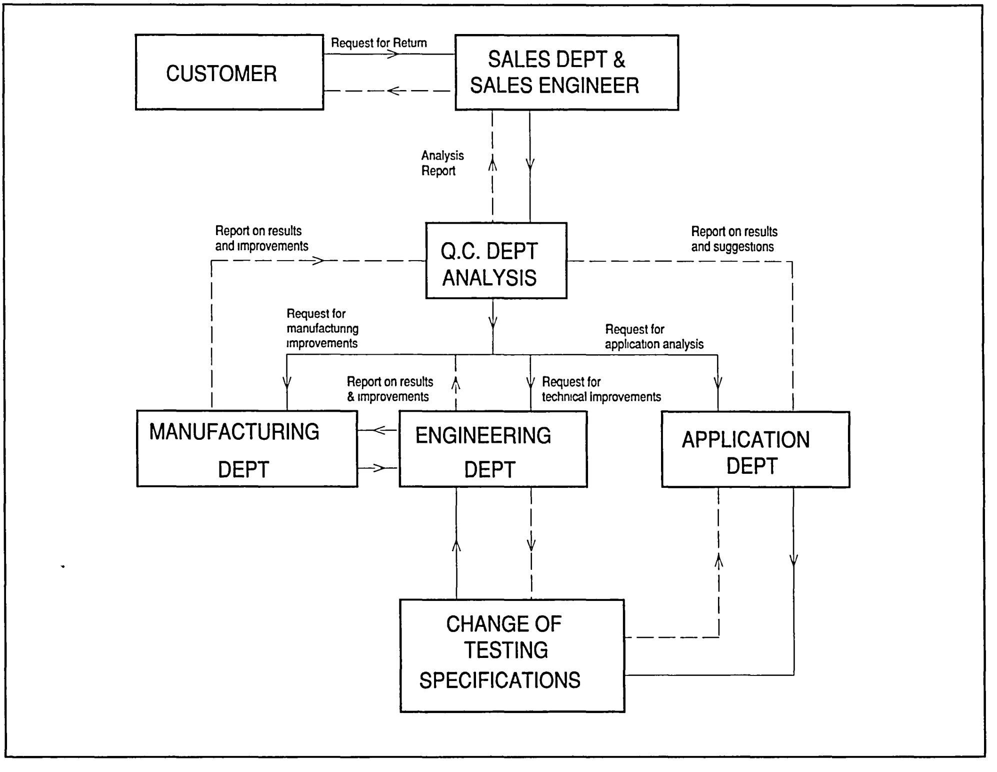
2.7 THE SPECIFICATION SYSTEM

Quality and reliability are measurable parameters. The measurements to be meaningful must be carried out in strict accordance with written procedures and test methods.
Similarly, production processes must be managed repeatedly. This means that detailed instructions and descriptions of every process step must be prepared and updated.
This information is formalized in the company specifications that cover all the Quality and Reliability procedures and the process instructions.

Table 3. The Specification System

SGS-THOMSON Internal Specifications	Purchasing Materials	Production	Testing & Finishing
Material Specifications	X		
Process Specifications		X	
Quality in process specifications		X	
Quality Acceptance Specifications		X	
Reliability Specifications			X
Reliability Methods Specifications			X

Figure 6. Example of customer return process



CHAPTER 3 - THE SGS-THOMSON STANDARD PRODUCT ASSURANCE PROGRAM

3. GENERAL INFORMATION

The following information is valid for all products ordered from SGS-THOMSON without any special agreement.

3.1.1 Marking

Each part will be marked using a contrasting ink with the following standard information:

1. Company logo
2. Device type (as detailed in the specification)
3. Serial number (where applicable)
4. Lot code (production lot, including manufacturing plant designator, where applicable)

3.1.2 Packaging

Devices will be packed in the SGS-Thomson standard package. The following information will be marked on the first package:

1. Company logo
2. Device type as shown on the order confirmation
3. Quantity in the package
4. Shipment number
5. Optional warning label.

3.1.3 Testing and Finishing

All the parts will be submitted to a 100% electrical testing according to SGS-Thomson datasheet.

3.1.4 External Visual and Mechanical Inspection Criteria Definitions

Inoperative Mechanical Defects (critical) i.e. wrong pin indication, broken or weakened leads and connectors, missing or broken cover, mixed package, etc.

Visual Defects (significant mechanical defects but not functional defects) i.e. deformed pin, unmarked packages or with illegible marking, cosmetic defects, package dimensions.

3.1.5 Certification

Certificate of conformance will be enclosed when requested and agreed. This is a document issued with a delivery lot stating that the components have been accepted under requirements of the particular specification.

3.1.6 Reference specifications

Basic sampling procedure and tables for inspection by attributes are the same foreseen by MIL-STD-105D.

In general the single sampling plan will be used but the customer may use other sampling plans (with, of course the same AQLs and inspection levels).

3.1.7 Precedence of documents

For the purpose of contractual interpretation, in case of conflict, documents shall take the following order of precedence:

1. Purchase order
2. Detail specification (agreed bethween customer and SGS-THOMSON)
3. SGS-THOMSON specifications (including this document)
4. Reference specifications.

3.1.8 Essential terms and specifications

For the purpose of interpretation of this general specification, the following terms and definitions are applied:

Detail specification

A specification which covers a particular component or range of components, and which describes that component including rated and/or limiting electrical, thermal and dimensional values and characteristics. The detail specification will also give the inspection requirements or appropriate reference to this general specification.

Production lot

A production lot shall consist of devices manufactured on the same production line, technique, materials, controls and design within a given period (generally one month).

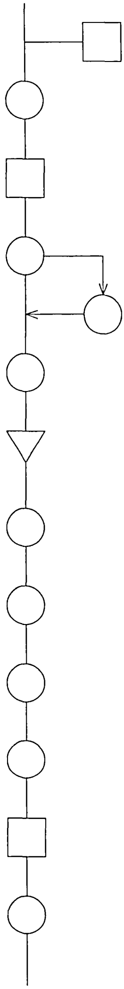
Delivery lot

A quantity of components delivered to an order at one time. One delivery lot may consist of one or more production lots or parts thereof.

Structurally similar devices

Structurally similar devices are those devices produced through final seal by the same fabrication techniques, using the same type of machines and apparatus and having the same basic design rules and the same package. Details of structural similarity for various components will be defined, when required, by the SGS- THOMSON Quality Assurance Manager(s).

Figure 7. Standard modules manufacturing process flow chart



1 - Material inspection - Raw materials are inspected following written specs and records are maintained for traceability

2 - Board assembling - mounting, soldering , etc. to produce semifinished parts

3 - Visual inspection - Parts are ispected and corrected if necessary

4 - Electrical test - Each part is electrically tested and identified if it doesn't meet electrical requirements

5 Failure analysis/repair - Each failed part is tested and repaired, and records are maintained

6 - Final assembly - The parts are assembled to metal case (if applicable)

7 - Visual inspection - Assembled but unsealed units are individually inspected

8 - Sealing - The parts are sealed (if possible)

9 - Final electrical test - Parts are tested for operational characteristics and limits

10 - Lead finish - The leads are tested for mechanical dimensions and solderability

11 - Marking - The parts are marked as for specification

12 - Group A inspection - A sample is tested to verify AQL

13 - Packaging and shipping

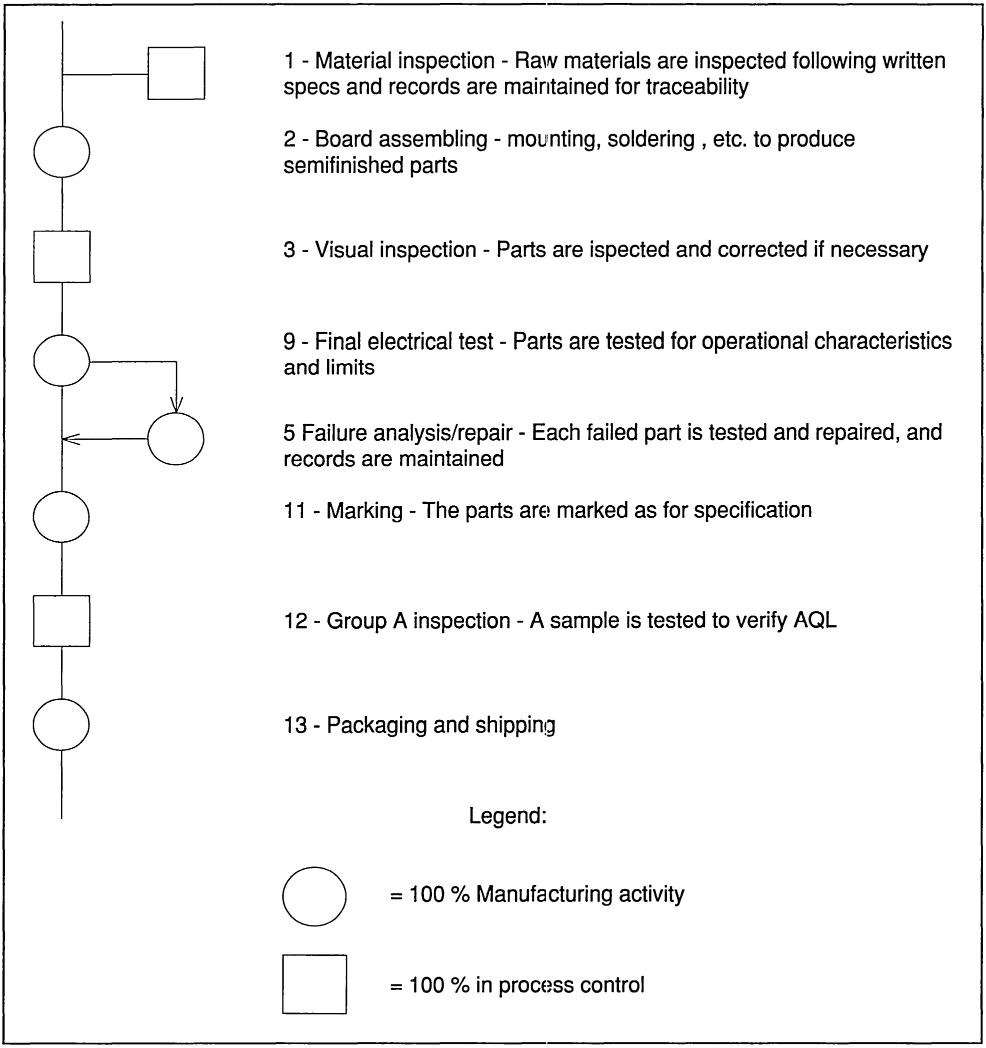
Legend:

○ = 100 % Manufacturing activity

□ = 100 % in process control

▽ = Gate inspection (sample acceptance)

Figure 8. Subassembly and boards manufacturing process flow chart



3.2 IN PROCESS CONTROL DURING MANUFACTURING

PROCESS STEPS	Tests	Description
3	Visual	Check for short between adjacent pins and for right components orientation
4	Electrical	Test right operational characteristics and limits / test
7	Visual	Check right final assembly, I.C. orientation etc.
9	Electrical	Test exhaustive operational characteristics and limits
10	Mechanical	Test for pin size and alignment and absence of potting material
11	Visual	Marking orientation and readability
12	Various	See paragraph 3.3
13	Various	Verify quantity, type, boxing labeling, documentation etc.

3.3 GROUP A INSPECTION

The quality guarantees specified here are the minimum quality levels.

Subgroup	Parameter	Insp.Level	AQL
A1	Visual and mechanical inspection	I	0.40
A2	Inoperative failures electrical/mechanical	I	0.40
A3	DC parameters	II	0.1
A4	AC parameters	II	0.1

The sample size per lot to be tested can be chosen using the following table:

Lot size range	General inspection levels		
	I	II	S4
16 - 25	3	5	3
26 - 50	5	8	5
51 - 90	5	13	5
91 - 150	8	20	8
151 - 280	13	32	13
281 - 500	20	50	13
501 - 1200	32	80	20
1201 - 3200	50	125	32
3201 - 10000	80	200	32
10001 - 35000	125	315	50
35001 - 150000	200	500	80

The acceptance criteria to be used are reported in the following table where:

Acc = Acceptance number
Re = Rejection number

Sample size	Acceptance Quality Level					
	0.15 Acc Re		0.25 Acc Re		0.40 Acc Re	
3	0	1	0	1	0	1
5	0	1	0	1	0	1
8	0	1	0	1	0	1
13	0	1	0	1	0	1
20	0	1	0	1	0	1
32	0	1	0	1	0	1
50	0	1	0	1	0	1
80	0	1	0	1	0	2
125	0	1	1	2	1	2
200	1	2	1	2	2	3
315	1	2	2	3	3	4
500	2	3	3	4	5	6

3.4 TRACEABILITY

The ability to access historical records of a manufacturing process is a vitally important tool in support of identifying causes and corrective actions for problems, and in support of continuous process improvements. This is commonly referred to as "traceability". It could be defined as both the ability to trace any individual product sample back to the time, place and condition of its manufacture, as well as the ability to trace the present whereabouts of all product samples produced at a given time, place and condition of manufacture. In addition, a traceability procedure must provide a "key" to unlock the pathway into the archived manufacturing records.

SGS-THOMSON has established procedures which provide excellent traceability for all its products.

To access the traceability system, SGS-THOMSON marks its products with a topside trace code which is the "key" to the archived manufacturing records. This trace code can be easily used to support investigation of any manufacturing issues.

3.5 CONTROL OF MEASURING AND TEST EQUIPMENT (CALIBRATION)

No matter how good a piece of measuring equipment is, its results will always be subject to some error. This is due to the ability of the instrument to resolve small changes, its repeatability, its closeness to an accepted standard and the accuracy of the standard employed. All these factors together form the uncertainty of the measurement. Determining and, where appropriate, reducing this uncertainty, is called calibration.

A schedule of internal audits, vendor (external calibration agency) audits and of course customer audits, ensure the probity of the calibration system.

Skilled engineers, high quality standards and computerized recall systems are utilized maintaining the integrity of all measurements critical to the performance and reliability of the product.

CHAPTER 4. QUALITY CONTROL

In SGS-THOMSON the term "Quality Control" embraces all actions performed to keep the various processes under control. To do this it is necessary to assess and to reduce the process variability and to initiate and accomplish actions to improve it.
The main tools used are:

- Statistical process control (SPC)
- Defect Density
- Production Environment Control (PEC)

4.1 Statistical Process Control (SPC)

The goal of the SPC program in SGS-THOMSON, is to bring each critical step of each process to 6 Sigma capability (i.e. to achieve a Cp $\geq$ 2.0). The program is drive by a Corporate Steering Committee and implemented by local steering committees for Groups, Plants or major support departments. SPC training is supplied at all levels from top management to operators, tailored according to the specific needs and uses.

Standard operating procedures and SPC manuals detail the principles and methods of applying SPC (consistent with CECC specification number 0016).

In addition, as a guide for our customers, we have published an information document entitled "Statistical Process Control. Its application in the Semiconductor Industry", which can be obtained from your local Sales office.

At SGS-THOMSON we extend the concept of SPC beyond the conventional aspect of "control" to include prevention via Failure Modes and Effects Analysis (FMEA) and improvement via Design of Experiments (DOE).

4.2 Failure Mode and Effect Analysis (FMEA)

FMEA is a disciplined methodology to anticipate and evaluate potential failure modes and to define preventive actions that can be incorporated during development of a product or process. Thus costly field failures and redesigns can be avoided, resulting in:

- higher reliability
- more robustness & fewer defects
- shorter effective time to market

three factors are associated with each potential failure mode:

- Severity (S):
  impact on the customer
- Occurrence (O):
  probability of the potential failure mode
- Detection (D):
  effectiveness of the control to prevent transfer of failure further in the process

Under SGS-THOMSON's FMEA, remedies are addressed with this order of priority:

- reduction of occurrence
- avoidance of failure mode
- increase of detection effectiveness

4.3 Design of Experiments (DOE)

Designed Experiments are the most effective means of process step optimization. Because of the complexity and interactivity of semiconductor processing it is not possible to use "one variable at a time" methods; so complex statistical methods are employed to design a minimum set of experiments that can evaluate several variables and their interactions simultaneously.

Successful designed experiments usually result in higher yield, lower variability and reduced cycle time. Improvements as large as a factor of two to ten in one or more of these variables are not uncommon.

APPENDIX 1 - MTBF CALCULATION EXAMPLES

This appendix contains two examples of MTBF calculation, made according to MIL-HDBK-217D.

For this exercise, performed on GS-R405 and GS-R412 modules, the following load and environmental operating condition have been chosen:

Cond. 1	$V_{in} = 20V$	$V_{out} = 5V$	
	$I_{out} = 3A$	$T_a = 40°C$	GS-R405
Cond. 2	$V_{in} = 20V$	$V_{out} = 5V$	
	$I_{out} = 3A$	$T_a = 55°C$	GS-R405
Cond. 3	$V_{in} = 30V$	$V_{out} = 12V$	
	$I_{out} = 3A$	$T_a = 55°C$	GS-R412

The class of environmental operating conditions, chosen to correctly evaluate the components stresses, as foreseen by MIL-HDBK-217D, is the following:

Ground-Fixed

Like installation in permanent racks with adequate cooling andinstallation in unheated buildings; includes permanent installation of air traffic control, radar and communication facilities, and missile silo ground support equipment.

Ground-Benign

Non mobile, laboratory environment readily accessible to maintenance; it includes laboratory instruments and test equipment, medical electronic equipment, business and scientific computer complexes.

First of all the power dissipated on the module and on the various components is calculated obtaining the following results:

Operating Condition	1	2	3
Output Power (W)	15.0	15.0	36.0
Efficiency (%)	74.0	74.0	80.0
Diss. Power (W)	5.3	5.3	9.0
Diode Power (W)	3.0	3.0	5.0
LIC Power (W)	2.0	2.0	3.6
Comp. Power (W)	0.3	0.3	0.4

Then the case temperature is calculated by knowing that the module to ambient thermal resistance is 5°C/W:

Cond. 1 $40 + (5.3 \times 5) = 66.5°C$
Cond. 2 $55 + (5.3 \times 5) = 81.5°C$
Cond. 3 $55 + (9 \times 5) = 100.0°C$

As shown above, condition 2 is out of the spec limits and it is necessary to add an external heat-sink to lower the case temperature. The standard available parts show a thermal resistance in the range 3-10°C/W and selecting a 6°C/W unit, for conditions. 2 and 3 a module to ambient thermal resistance of 2.8°C/W is obtained and the new values of case temperature are:

Cond. 2 $55 + (5.3 \times 2.8) = 70°C$
Cond. 3 $55 + (9 \times 2.8) = 80°C$

Now it is possible to estimate the junction temperature by knowing that the junction to case thermal resistance, for the two power devices, are respectively 3°C/W for the LIC and 4°C/W for the diode.

Operating Condition	1	2	3
Case Temperature (°C)	66.5	70.0	80.0
Component Temperature (°C)	70.0	74.0	86.0
Diode Junction Temp. (°C)	81.5	78.5	95.0
LIC Junction Temp. (°C)	73.0	77.0	91.0

The next step foresees the definition of the number, by type, the operating condition in terms of percentage of the rated power/voltage of the various components and materials used in the module.

Component Description	GS-R405	GS-R412
Resistor Carbon Film	6	6
Resistor Metal Film	-	2
Capacitor Ceramic	3	3
Capacitor Aluminum Elect. low-leakage	1	1
Capacitor Al. Elect.	2	2
Power Plastic LIC	1	1
Power plastic Diode	1	1
Power plastic SCR	1	1
Toroidal inductor	1	1
PCB dual side (holes)	60	64

Component Description	Operating Conditions
Resistor Carbon Film	≤ 10% Rated Power
Resistor Metal Film	≤10% rated power
Capacitor Ceramic	≤ 36 nF ≤ 10 % rated voltage
Capacitor Aluminum Elect. low-leakage	≤ 2.5 μF ≤ 20 % rated voltage
Capacitor Al. Elect.	≤ 100 μF ≤ 50 % rated voltage
Power Plastic LIC	Multiwatt 50% rated voltage
Power plastic Diode	≤ 10 A ≤ 60 % rated voltage
Power plastic SCR	≤ 10 A ≤ 10 % rated voltage
Toroidal inductor	130° max operating temperature
PCB dual side (holes)	not applicable

By using the tables and the appropriate coefficients reported in the MIL-HDBK-217D, it is possible to define the FIT for the Ground-Fixed environmental operating condition:

Ground-Fixed	Cond. 1	Cond. 2	Cond. 3
Resistor carbon film	72	72	86
Resistor metal film	24	24	29
Capacitor ceramic	15	15	18
Cap. Aluminum Electr. low-leakage	280	335	490
Cap. Al. Electrolytic	2735	3265	4800
Power plastic LIC	70	90	200
Power plastic Diode	65	60	86
Power plastic SCR	25	33	45
Toroidal inductor	80	85	103
PCB dual side	1	1	1
Total FIT (x 10^{-9})	**3367**	**3980**	**5858**

The same calculation is now repeated for the Ground-Benign operating environment:

Ground-Benign	Cond. 1	Cond. 2	Cond. 3
Resistor carbon film	25	25	30
Resistor metal film	8	8	10
Capacitor ceramic	9	9	11
Cap. Aluminum Electr. low-leakage	117	140	205
Cap. Al. Electrolytic	1140	1360	2000
Power plastic LIC	18	23	51
Power plastic Diode	17	15	22
Power plastic SCR	7	8	12
Toroidal inductor	14	15	18
PCB dual side	1	1	1
Total FIT (x 10^{-9})	**1356**	**1604**	**2360**

It is possible now to calculate the MTBF both for continuous operations and for a well defined mission profile that foresees a 30 % operative time against a 70 % inoperative time, and the Reject Rate percentage (x 1000 hours x 1000 pcs.) by using the formula:

$$\text{MTBF} = \frac{1}{\text{FIT}} \qquad \text{Reject rate} = \text{FIT} \times 10^{6}$$

MTBF and Rejects for continuous operations Ground-Fixed environment

	MTBF(hours)	Rej Rate (% x1000 hours)
Condition 1	297.000	3.3
Condition 2	251.000	4.0
Condition 3	170.000	5.9

MTBF and Rejects for a 30% on - 70 % off mission Ground Fixed environment

	MTBF(hours)	Rej Rate (% x 1000 hours)
Condition 1	737.000	1.4
Condition 2	623.000	1.6
Condition 3	423.000	2.4

In the same way it is possible to calculate the MTBF and the rejects percentage for the Ground-benign condition.

MTBF and Rejects for continuous operations Ground-Benign environment:

	MTBF(hours)	Rej Rate (0/00 x 1000 hours)
Condition 1	2.456.000	0.4
Condition 2	2.076.000	0.5
Condition 3	1.410.000	0.7

The same exercise has been performed on the GS-R405/2 for a Ground-Fixed 100% operating environment using the following selected operating conditions:

Cond. 1	$V_{in} = 24V$	$I_{out} = 1A$	$T_a = 25°C$	Eff=74°
Cond. 1	$V_{in} = 24V$	$I_{out} = 2A$	$T_a = 25°C$	Eff=78°
Cond. 1	$V_{in} = 24V$	$I_{out} = 3A$	$T_a = 25°C$	Eff=80°
Cond. 1	$V_{in} = 24V$	$I_{out} = 1A$	$T_a = 55°C$	Eff=74°
Cond. 1	$V_{in} = 24V$	$I_{out} = 2A$	$T_a = 55°C$	Eff=78°
Cond. 1	$V_{in} = 24V$	$I_{out} = 3A$	$T_a = 55°C$	Eff=80°

By knowing that in these operating conditions the percentage of conduction of the power switch is about 20%, the dissipated power on the main components can be estimated obtaining the following figures:

Operating Condition	1	2	3	4	5	6
Output Power (W)	5	10	15	5	10	15
Efficiency (%)	74	78	80	74	78	80
Diss. Power (W)	1.75	2.82	3.75	1.75	2.82	3.75
Diode Power (W)	0.72	1.45	2.16	0.72	1.45	2.16
LIC Power (W)	0.93	1.22	1.39	0.93	1.22	1.39
Comp. Power (W)	0.10	0.15	0.20	0.10	0.15	0.20

It is possible now to define the main components temperature:

Operating Condition	1	2	3	4	5	6
Case Temperature (°C)	39	47.5	55	69	77.5	85
Diode Junct. temp. (°C)	47	63.5	78.7	77	93.5	108.7
LIC Junct. Temp. (°C)	41.5	51.2	59.2	71.5	81.2	89.2
Components Temp. (°C)	41	50.5	59	71	80.5	89

Condition "6" shows a case temperature at the limit stated as "Absolute Maximum Rating" so it is not applicable unless an external heatsink is added.

The components used in the module and the relative operating conditions are:

Quantity.	Component description	Operating conditions
2	Resistor Metal-film	< 10% rated power
3	Capacitor ceramic	≤ 36 nF ≤ 10 % rated voltage
1	Elect. Cap. Tantalum	≤ 2.5 µF ≤ 30 % rated voltage
1	Elect. Cap. Tantalum	≤ 500 µF ≤ 40 % rated voltage
1	Elect. Cap. Aluminum	≤ 50 µF ≤ 50 % rated voltage
1	Power plastic LIC	Multiwatt 60% rated voltage
1	Power plastic Diode	≤ 10 A ≤ 50% rated voltage
1	Power hermetic SCR	≤ 10 A ≤ 10% rated voltage
1	Toroidal inductor	130 °C max operating temp.
1	PCB dual side	50 holes

It is possible now to find the FITs for any component and for the selected operating conditions:

Operating Condition	1	2	3	4	5
Resistor metal film	19	20	23	24	26
Capacitor ceramic	13	13	14	14	15
Elect. cap. Tantalum 2.5 µF	225	247	328	345	405
Elect. cap. Tantalum 500 µF	528	580	765	792	950
Elect. cap. Aluminum 50 µF	386	504	924	957	1394
Power plastic LIC	30	40	70	70	100
Power plastic diode	45	56	80	86	116
Power Hermetic SCR	11	14	20	21	24
Toroidal inductor	57	63	78	80	94
PCB dual side	1	1	1	1	1
Total FIT ($x10^{-9}$)	**1315**	**1538**	**2303**	**2390**	**3125**

It is possible now to calculate both MTBF and Reject percentage and the results are the following:

Cond. 1
V_{in} = 24V I_{out} = 1A T_a = 25 °C
Eff = 74%
MTBF = 760.400 hours
Rejects Rate = 1.28 ‰ x 1000 hours

Cond. 2
V_{in} = 24V I_{out} = 2A T_a = 25 °C
Eff = 78%
MTBF=650.100 hours
Rejects Rate=1.51 ‰ x 1000 hours

Cond. 3
V_{in} = 24V I_{out} = 3A T_a = 25 °C
Eff = 80%
MTBF=434.200 hours
Rejects Rate=2.28 ‰ x 1000 hours

Cond. 4
V_{in} = 24V I_{out} = 1A T_a = 55 °C
Eff = 74%
MTBF=418.400 hours
Rejects Rate=2.37 ‰ x 1000 hours

Cond. 5
V_{in} = 24V I_{out} = 2A T_a = 55 °C
Eff = 78%
MTBF=320.000 hours
Rejects Rate=3.12 ‰ x 1000 hours

By using this method, it is possible to calculate the MTBF and the Reject for any other more complex module, subassembly or board by simply choosing the right figures for the various components or active devices.

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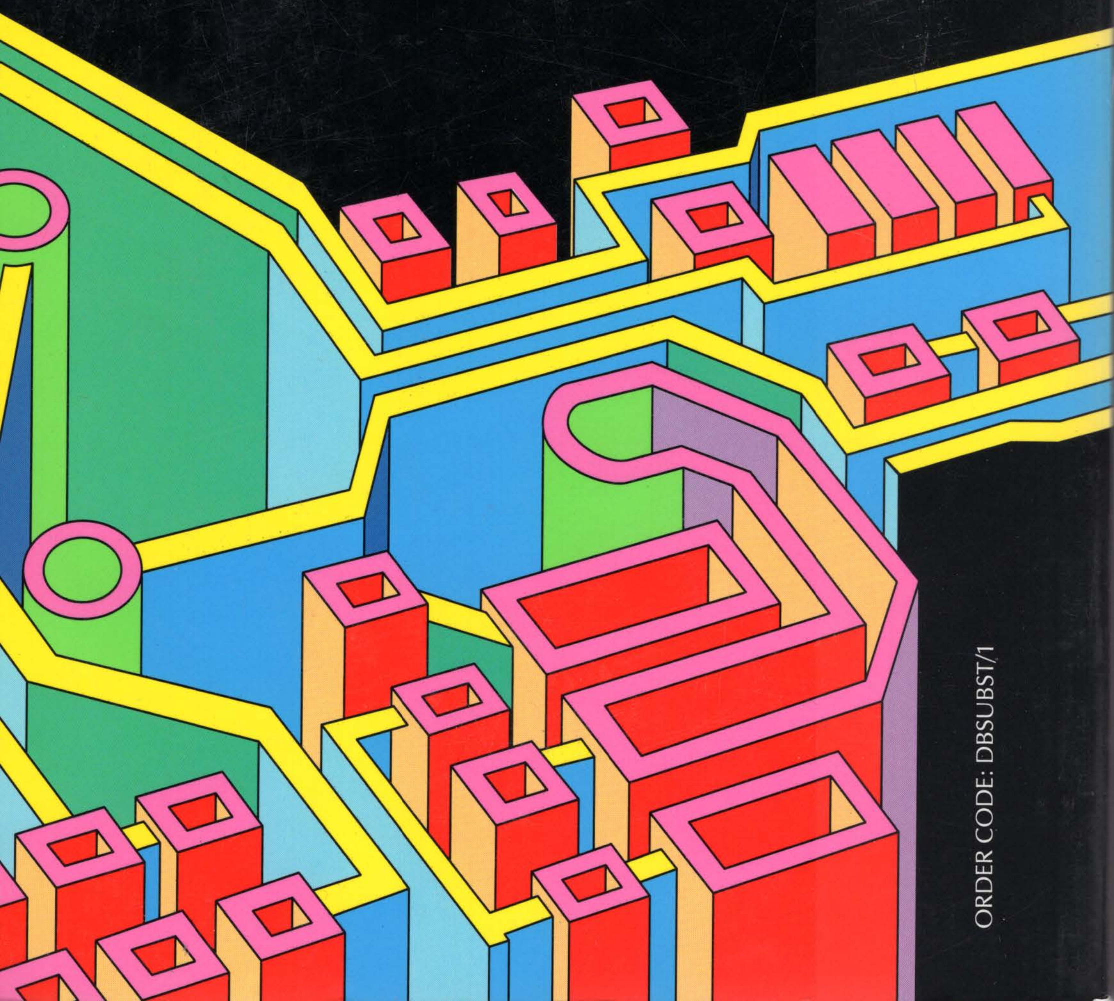

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