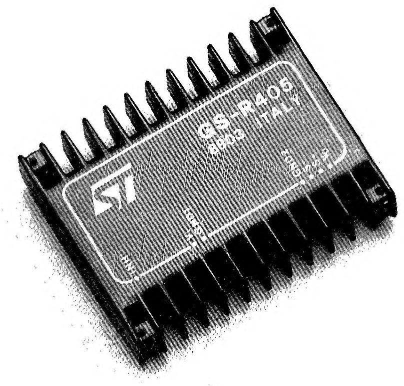
140W SWITCHING VOLTAGE REGULATOR MODULES

- MTBF IN EXCESS OF 200.000 HOURS
- NO EXTERNAL COMPONENTS REQUIRED
- PC CARD OR CHASSIS MOUNTABLE
- HIGH OUTPUT CURRENT (4 A)
- HIGH INPUT VOLTAGE (48 V)
- FIXED OR ADJUSTABLE OUTPUT VOLTAGE
- HIGH EFFICIENCY (UP TO 90%)
- SOFT START
- REMOTE INHIBIT/ENABLE
- REMOTE OUTPUT VOLTAGE SENSE
- RESET OUTPUT (GS–R405S ONLY)
- NON-LATCHING SHORT CIRCUIT PROTECTION
- THERMAL PROTECTION
- CROW BAR PROTECTION FOR THE LOAD



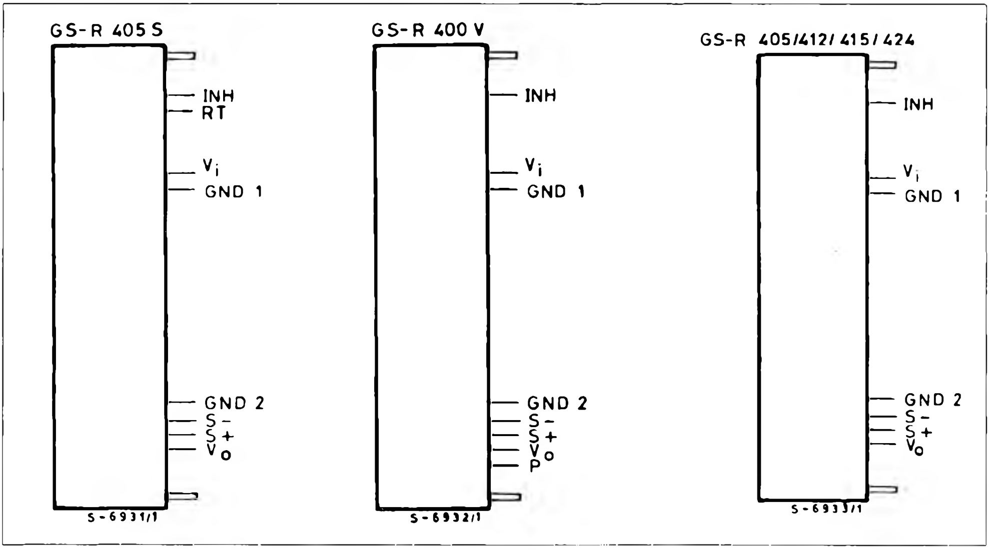
DESCRIPTION

The GS–R400 series is a complete family of HIGH CURRENT HIGH VOLTAGE SWITCHING VOLTAGE REGULATORS available in several output voltages from 5.1 to 40 V.
These step down regulators shielded for EMI, can provide local on-card regulation, or be used in central power supply systems, in both professional and industrial applications.

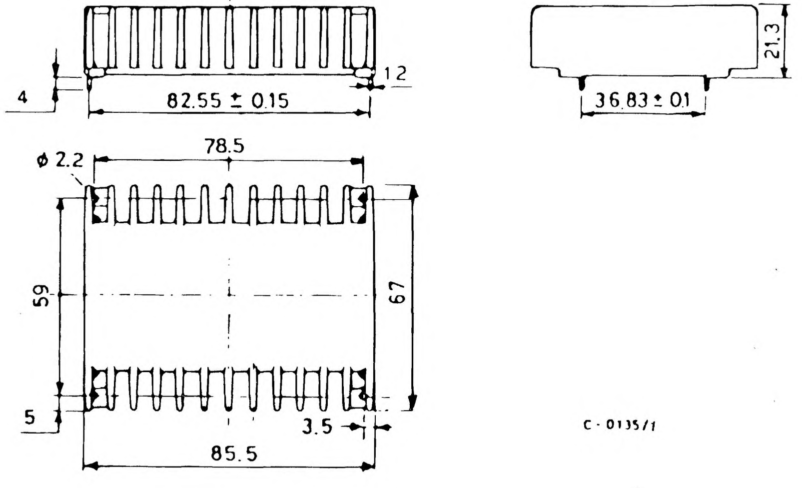
PRODUCTS FAMILY

Order Number	Output Voltage	Reset Output
GS-R405S	5.1 V	Yes
GS-R405	5.1 V	—
GS-R412	12 V	—
GS-R415	15 V	—
GS-R424	24 V	—
GS-R400V	Adjustable 5.1 to 40 V	—

CONNECTION DIAGRAM (side view)



MECHANICAL DATA (dimensions in mm)



PIN FUNCTIONS

Symbol	Pin	Function
INH	- Inhibit	TTL compatible input. A logic high level signal applied to this pin disables the module. To be connected to GND_2 when not used.
RT	- Reset Output	Available on GS-R405S only. Reset voltage is high (5.1 V) when output voltage reaches nominal value (5.1 V) and it is generated with a fixed 100 ms delay.
V_i	- Input Voltage	Unregulated DC voltage input. Maximum voltage must not exceed 48 V. Recommended maximum operating voltage is 46 V.
GND_1	- Ground	Common ground for input voltage.
GND_2	- Ground	Common ground of high current path.
S^-	- Sensing Negative	For connection to remote load, this pin senses the actual ground of the load itself. To be connected to GND_2 when not used. This pin is connected to case.
S +	- Sensing Positive	For connection to remote loads this pin allows voltage sensing on the load itself.To be connected to V_0 when not used.
V_o	- Output Voltage	Regulated and stabilized DC voltage is available on this pin. Max output current is 4 A. The device is protected against short circuit of this pin to ground or to supply.
P	- Output Voltage Programming	Available on GS-R400V only. A variable resistor (18 KΩ max) connected between this pin and S^+ adjusts the output voltage.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_i	DC input voltage	48	V
I_{RT}	Reset output sink current	20	mA
V_{INH}	Inhibit voltage	15	V
T_{stg}	Storage temperature range	– 40 to + 105	°C
T_{cop}	Operating case temperature range	– 20 to + 85	°C

Recommended maximum operating input voltage is 46V.

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

Type			GS-R 405 S			GS-R 405			GS-R 4012 V			Unit
Symbol	Parameter	Test Condit.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_O	Output Voltage	$V_i = V_O + 8V$, $I_O = 1A$	5	5.1	5.2	5	5.1	5.2	11.5	12	12.5	V
V_O	Temperature Stability	$V_i = V_O + 8V$, $I_O = 1A$		0.2			0.2			0.5		mV/°C
V_i	Input Voltage	$I_O = 1A$	8		46	8		46	15		46	V
I_O	Output Current	$V_i = V_O + 8V$	0.2		4	0.2		4	0.2		4	A
I_{OL}	Current Limit	$V_i = V_O + 8V$		5	8		5	8		5	8	A
I_{isc}	Average Input Current	Vi = 46V Output Shorted		0.1	0.2		0.1	0.2		0.1	0.2	A
f_s	Switching Frequency	$I_O = 1A$		100			100			100		KHz
η	Efficiency	$V_i = V_O + 8V$ $I_O = 1A$		75			75			85		%
ΔV_O	Line Regulation	$I_O = 1A$ $V_i = V_O + 3V$ to 46V		2			2			2		mV/V
SVR	Supply Voltage Rejection	f = 100Hz $I_O = 1A$		4			4			6		mV/V
ΔV_O	Load Regulation	$\Delta I_O = 2A$ (1 to 3 A)		20			20			40		mV/A
V_r	Ripple Voltage	$I_{out} = 2A$		25			25			50		mV
t_{ss}	Soft Start Time	$V_{in} = V_{out} + 10V$		15			15			25		ms
V_{INHL}	Low Inhibit Voltage				0.8			0.8			0.8	V
V_{INHH}	High Inhibit Voltage		2.0		5.5	2.0		5.5	2.0		5.5	V
I_{INH}	Input Current High	$V_{INH} = 5V$			500			500			500	µA
t_{CB}	Crow Bar Delay Time			5			5			5		µS
V_{RH}	Reset High Level			5			–			–		V
V_{RL}	Reset Low Level	$I_{RL} = 5mA$ $I_{RL} = 15mA$			0.2 0.4			–			–	V V
t_R	Reset Delay Time			100			–			–		ms
V_{SD}	Max Differential Sense Voltage	$S^- - GND2$ $V_O - S^+$			100			100			100	mV

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

Type			GS-R 415			GS-R 424			GS-R 400 V			Unit
Symbol	**Parameter**	**Test Condit.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	
V_O	Output Voltage	$V_i = V_O + 8V$	14.3	15	15.6	23	24	25	5.1	–	40*	V
V_O	Temperature Stability	$V_i = V_O + 8V$, $I_O = 1A$		0.2			0.6			0.2/1.6		mV/°C
V_i	Input Voltage	$I_O = 1A$	18		46	27		46	8		46	V
I_O	Output Current	$V_i = V_O + 8V$	0.2		4	0.2		4	0.2		4*	A
I_{OL}	Current Limit	$V_i = V_O + 8V$		5	8		5	8		5	8	A
I_{isc}	Average Input Current	Vi = 46V Output Shorted		0.1	0.2		0.1	0.2		0.1	0.2	A
f_s	Switching Frequency	$I_O = 1A$		100			100			100		KHz
η	Efficiency	$V_i = V_O + 8V$ $I_O = 1A$		90			90			75/90		%
ΔV_O	Line Regulation	$I_O = 1A$ $V_i = V_O + 3V$ to 46V		5			6			6		mV/V
SVR	Supply Voltage Rejection	f = 100Hz $I_O = 1A$		8			12			12		mV/V
ΔV_O	Load Regulation	$\Delta I_O = 2A$ (1 to 3A)		60			90			20/90		mV/A
V_r	Ripple Voltage	$I_{out} = 2A$		60			100			25/150		mV
t_{ss}	Soft Start Time	$V_{in} = V_{out} + 10V$		25			35			15/35		ms
V_{INHL}	Low Inhibit Voltage				0.8			0.8			0.8	V
V_{INHH}	High Inhibit Voltage		2.0		5.5	2.0		5.5	2.0		5.5	V
I_{INH}	Input Current High	$V_{INH} = 5V$			500			500			500	µA
t_{CB}	Crow Bar Delay Time			5			5			5		µS
V_{RH}	Reset High Level			–			–			–		V
V_{RL}	Reset Low Level				– –			– –			– –	V V
t_R	Reset Delay Time			–			–			–		ms
V_{SD}	Max Differential Sense Voltage	$S^- - GND2$ $V_O - S^+$			100			100			100	mV

* Maximum Output Current is guaranteed up to V_o = 36V and derated linearly to 3A at V_o = 40V.

MODULE OPERATION

The GSR400 series is a family of step down switching mode voltage regulators.

Unregulated DC input voltage must be higher than nominal output voltage by, at least, 3 V. Minimum input voltage is therefore 8 V for GS-R405S and GS-R405; maximum input voltage is 48 V for all types.

Output voltage is fixed or adjustable (GS-R400V). The maximum current delivered by the output pin is 4 A. A minimum output current of 200 mA is required for proper module operation. In no-load condition, the module still works, but the electrical characteristics are slightly modified vs. specifications.

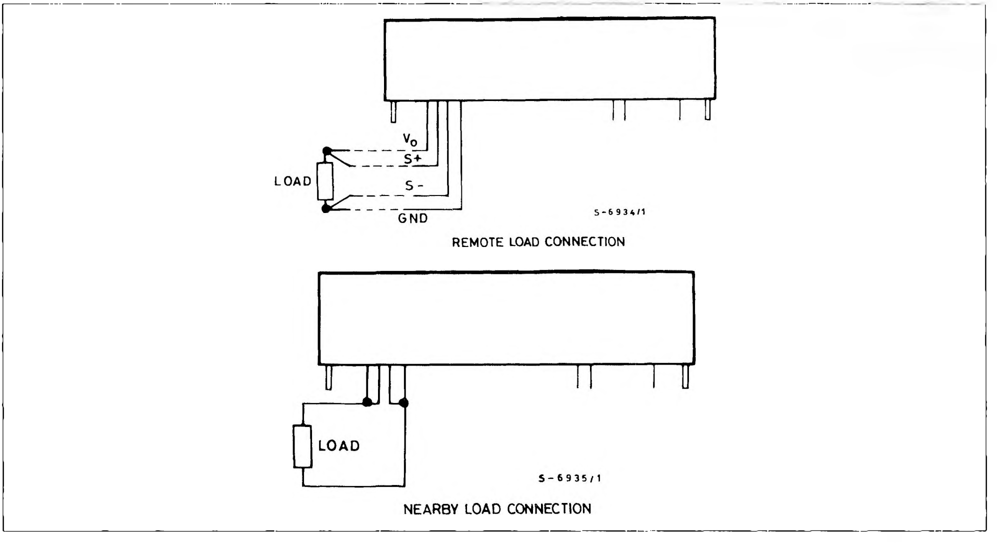
To prevent excessive over current at switch on, a soft start function is provided. Nominal output voltage is approached gradually in about 15 ms.

The module can be inhibited by a TTL, N MOS or C MOS compatible voltage applied to the INH pin. When this voltage is at high level, the module is switched off : if the inhibit signal goes from high to low level, the module restarts softly. Maximum DC voltage applicable to this pin is 15 V. When remote control (inhibit) of the module is not used, the INH pin must be connected to GND_2.

The remote load sensing is another feature provided in all the models.

This function is performed by two pins (S^+, S–) that can monitor the voltage directly across the load when this load is connected to the module by long wires : voltage drop on these wires is automatically compensated. Maximum drop compensation must not exceed 100mV. The case of the module is internally connected to S–. Therefore, the case must be always isolated from ground if the sensing function is used. The switching frequency of the module is 100 KHz. To prevent EMI, the module is contained in a metal box that provides shielding and heatsink.

Figure 1 : Module connection to remote or nearby loads.

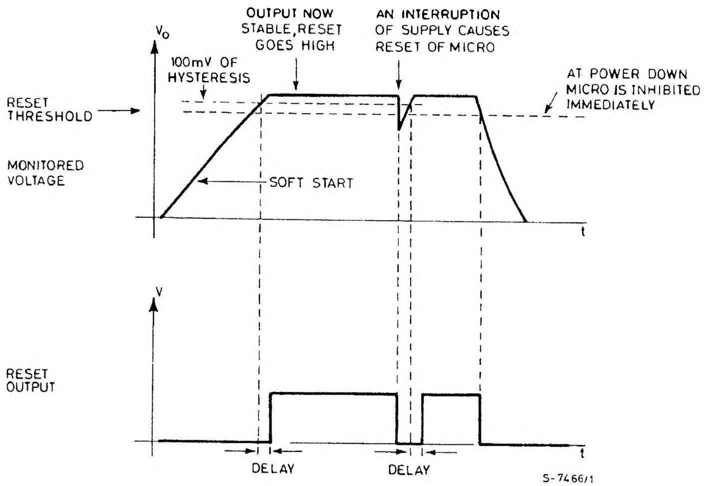


GS-R405S

The RESET output is provided on GS-R405S only as an auxiliary function to reset or inhibit microprocessors when the output voltage, at switch on and off, reaches a prefixed value of 4.9 to 5.1 V or when the output voltage, for any reason, drops below nominal value by more than 100 mV. In any case the minimum falling threshold value is 4.75 V or higher and the reset output voltage is generated with a fixed delay of 100 ms.

Time delay of the reset function also rejects wrong information caused by occasional spikes generated during switch on and off.

Figure 2 : Output voltages reset as a function of output voltage and time.



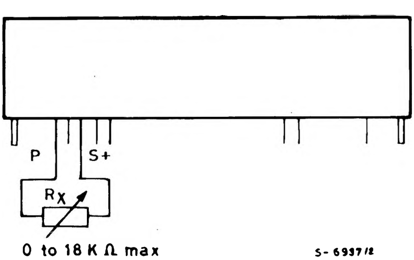
GS-R400V

The output voltage of this model can be adjusted in a range from 5.1 to 40 V by use of an external variable resistor as shown in Fig.3.
The variable resistor can be substituted by a fixed value Rx to obtain a fixed output voltage V_0 according to the formula :

$$Rx = 2.67 \cdot \left(\frac{V_o}{5.1} - 1 \right) K\Omega$$

where V_0 can vary from 5.1 to 40 V.

Figure 3 : Output voltage adjustment on GS-R400V.



MODULE PROTECTIONS

THERMAL PROTECTION

The module has inside a thermal protection. When ambient temperature reaches prohibitive values, so that internal junction temperature of active components reaches 150 °C, the module is switched off. Normal operation is restored when internal junction temperature falls below 130 °C : this large hysteresis allows an extremely low frequency intermittent operation (ON - OFF) caused by thermal overload.

SHORT CIRCUIT PROTECTION

The module is protected against occasional and permanent short circuits of the output pin to ground or against output current overloads.
When output current exceeds the maximum allowed value for safe operation, the output is automaticaly disabled. After a fixed time, the module starts again in a soft mode : if the overload is still present, the module switches off and the cycle is repeated until the overload condition is removed. The average overload current is limited to a safe value for the module itself. Input current during output short circuit is always lower than in regular operation.

LOAD PROTECTION

The module protects, by a crow bar circuit, the load connected to its output against overvoltages.
This circuit senses continuously the output voltage : if, for any reason,the output voltage of the module exceeds by + 20 % the nominal value (fixed or adjustable), the crow bar protection is activated and it short circuits the output pin to ground. This protection prevents also damages to module if output pin is wrongly connected to supply voltage.

THERMAL DATA

The thermal resistance module to ambient is about 5 °C/W. This means that if the internal power dissipation is 10 W, the temperature on the surface of the module is about 50°C over ambient temperature.

According to ambient temperature and/or to power dissipation, an additional heatsink may be required.

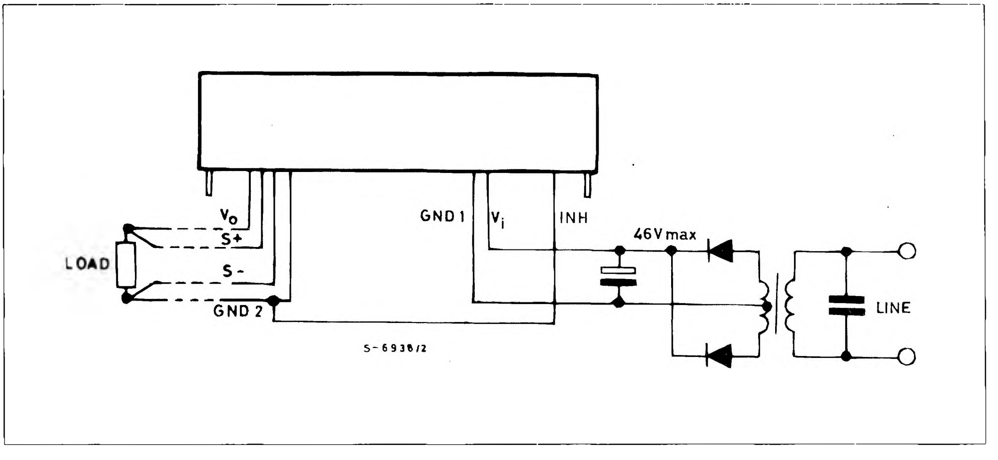
Four holes are provided on the metal box of the module to allow the mounting of this optional external heatsink.

It is recommended to keep the metal box temperature below 85 °C.

TYPICAL APPLICATIONS

The high input voltage range allows both cost saving on 50/60 Hz transformer when the module is supplied from the main and the possibility to supply the module with batteries that, according to their charge status, can show large spread on voltage.

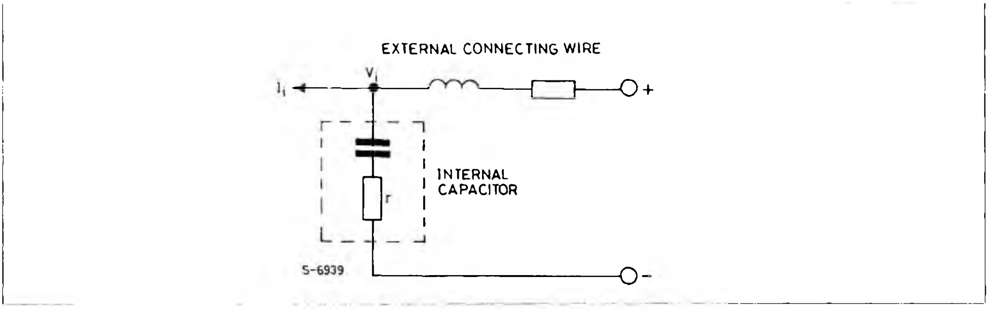
Figure 4 : A typical application of GS-R400 family.



TYPICAL APPLICATIONS (continued)

The module has, internally, an input filtering capacitor between pin V_I and GND_1. At the switching frequency therefore the equivalent input circuit is as shown in Fig. 5.

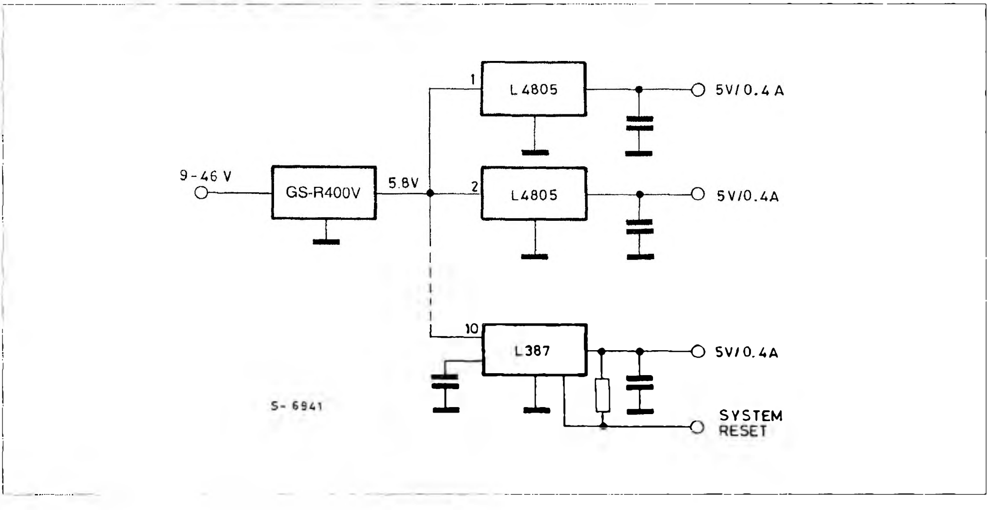
Figure 5 : Equivalent input circuit of GS-R400 voltage regulator.



Since I_I is a high frequency alternating current, the inductance associated to long input connecting wire can cause a voltage ripple on point V_I that produces a ripple current across internal capacitor and a power dissipation on r.

When very long connecting wires are used, the input capacitor may be damaged by this power dissipation. For this reason it is suggested to keep input connecting wires as short as possible.

Figure 6 : Preregulators for Distributed Supplies.



The fixed voltage regulators shown on Fig.6 are available from SGS-THOMSON Microelectronics. An over-all low power dissipation is achieved due to the high efficiency of the GS-R400V and inherent low voltage drop of fixed regulators. Up to 10 different points can be supplied, using L4805 or L387.

TYPICAL APPLICATIONS (continued)

Figure 7 : 24 V to 12 V Power Conversion for Trucks.

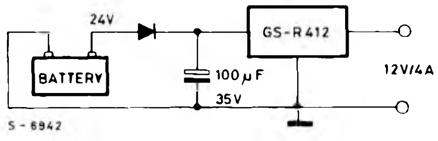


Figure 8 : Multiple output supply using preregulator.

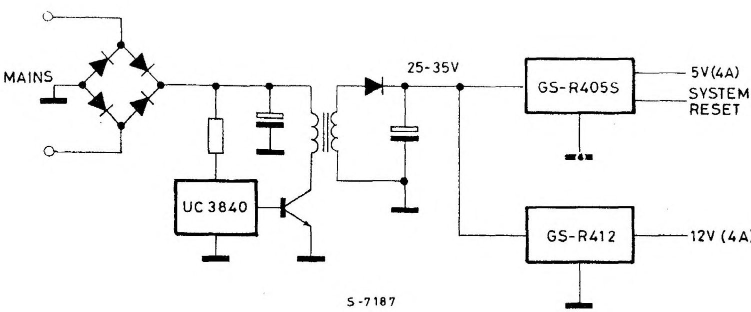
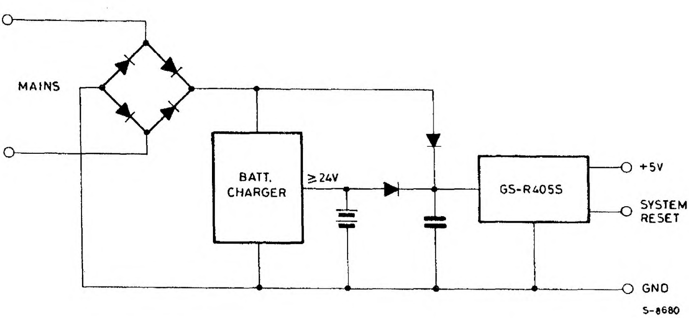
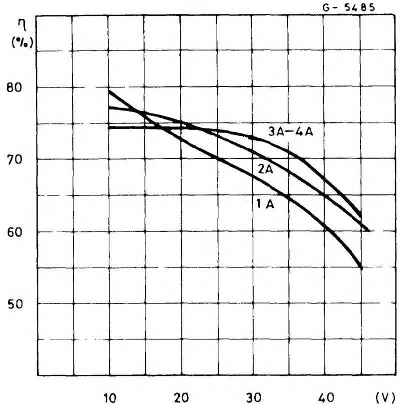


Figure 9 : Uninterruptable power supply.

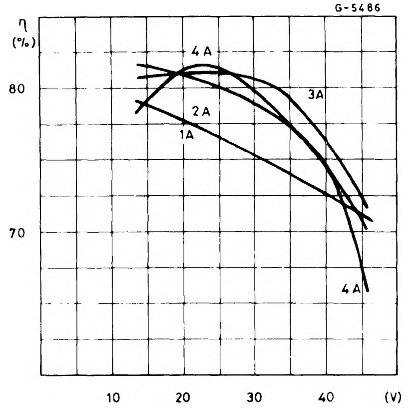


EFFICIENCY VS. INPUT VOLTAGE & OUTPUT CURRENT

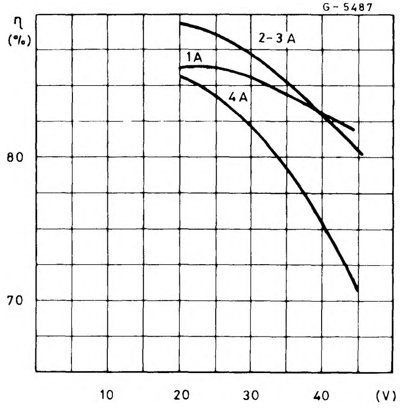
GS-R405



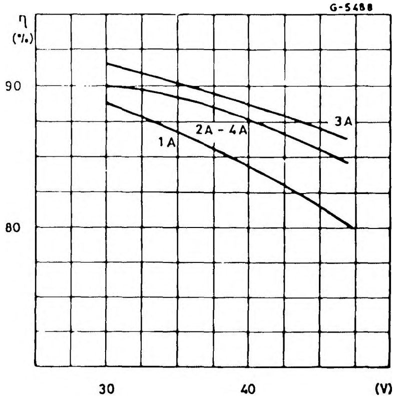
GS-R412



GS-R415

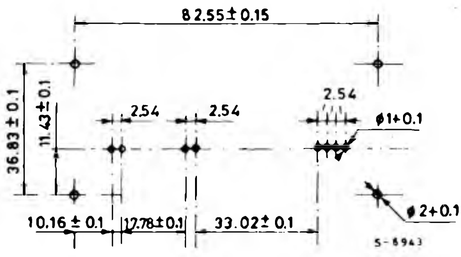


GS-R424

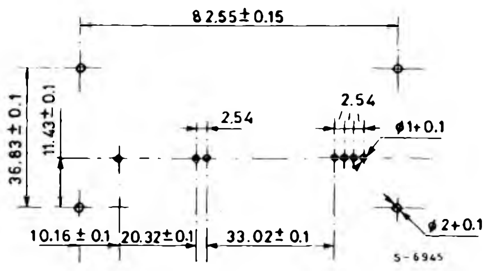


MOTHER BOARD LAYOUT

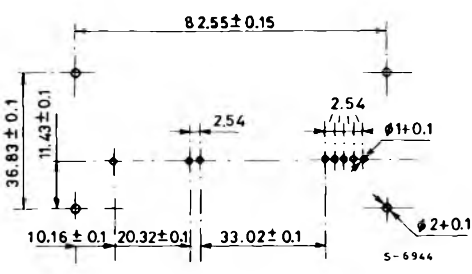
GS-R405S



GS-R405
GS-R412
GS-R415
GS-R424



GS-R400V



Printed Circuit Driling (Components side)

Required holes pattern to be drilled on the mother boards to allow correct mounting.

DESIGN HINTS

The hints provide a pratical guideline for the selection of the transformer, the rectifying diodes and the filtering capacitor of a power supply based on GS-R400 family.

Let's consider the application shown in the Figure 10. The rectifier circuit configurations suitable for medium to high current applications, are the Full Wave Center Tapped and the Full Wave Bridge. (See fig.11)

Both configurations offer the advantage of a smaller surge current in the winding of the transformer and the doubling of ripple frequency that allows the filtering capacitor reduction.

In the following we will consider the full wave bridge only, that allows the best transformed utilization.

The output power of the power supply is, respectively :

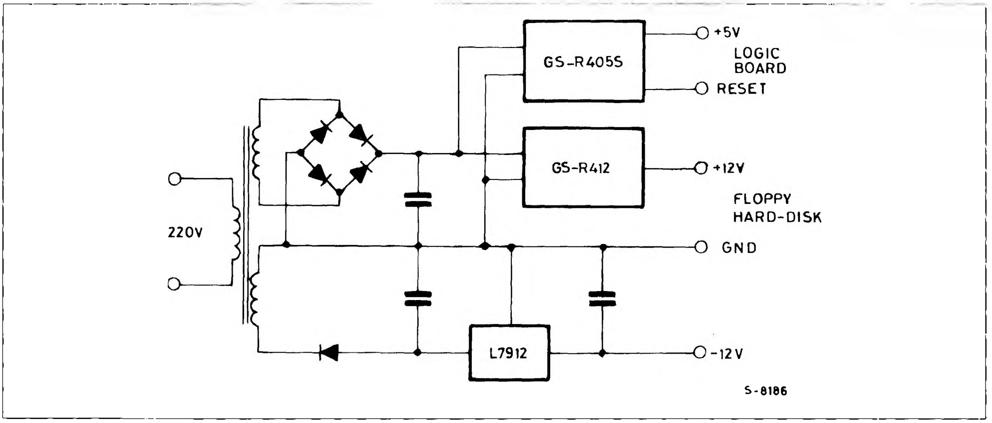
5 V · 4 A = 20 W for GS-R405S
12 V · 2.5 A = 30 W for GS-R412.

The total input power is, therefore

$$P_i = \frac{P_0}{Eff.} = \frac{20}{.75} + \frac{30}{.85} = 62W$$

The two values for efficiency are derived from GS-R electrical characteristics.

Figure 10 : Microcomputer supply using GS-R400.



The maximum input voltage to the module is set up to 40 V to work well below the Absolute Maximum Rating (48V).

$$V_i\,(pk) = 40\ V$$

The minimum input voltage is set uo to 16 V to allow a minimum drop-out of 4 V on the GS-R412.

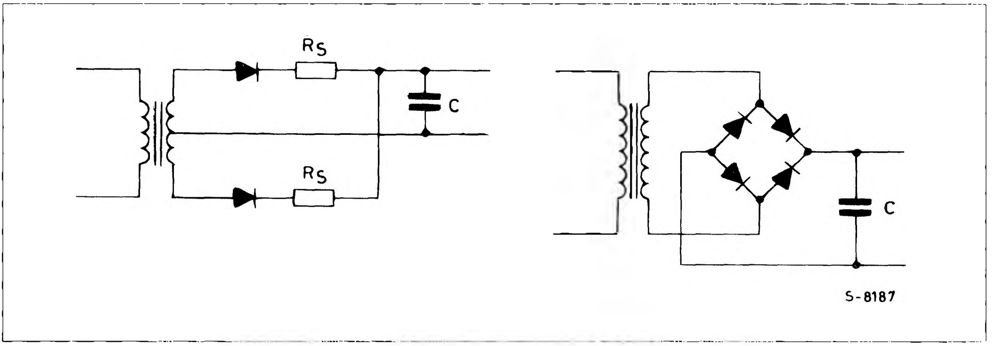
$$V_i\,(min) = 16\ V$$

The nominal input voltage is set up at the middle of this range to allow a larger input ripple voltage and line voltage variations.

$$V_i\,(DC) = \frac{40 - 16}{2} + 16 = 28\ V$$

DESIGN HINTS (continued)

Figure 11 : Rectifying circuits.



Let's assume a maximum 100 (120) Hz output ripple of the two regulators of 20 mVpp. Since the ripple rejection of the two modules is, at least 50 dB (316 times), the maximum allowed input ripple is

$$20\ \text{mV} \cdot 316 = 6.32\ V_{ripple(pp)}$$

Let's definite rf(in) as the ratio of RMS ripple to DC voltage

$$rf(in) = \frac{6.32}{2 \cdot \sqrt{2} \cdot 28} .100 = 8\ \%$$

The input current is calculated from the input power and voltage :

$$I_i = \frac{P_i}{V_i(DC)} = \frac{62W}{28\ V} = 2.2\ A$$

The equivalent load for the transformer + rectifier + capacitor is therefore

$$R_L = \frac{28V}{2.2A} = 12.73\ \text{Ohm}$$

$V_i(pk)$ must correspond to the nominal value of the mains plus the allowed variations. Let's assume that the AC voltage at the primary of the transformer may vary of ± 15 %.

At nominal AC voltage the corresponding secondary maximum DC voltage is :

$$V_i(pk)nom = 40 - 15\ \% = 34\ V$$

Then we calculate

$$\frac{V_i(DC)}{V_i(pk)} = \frac{28V}{34V} = 0.82$$

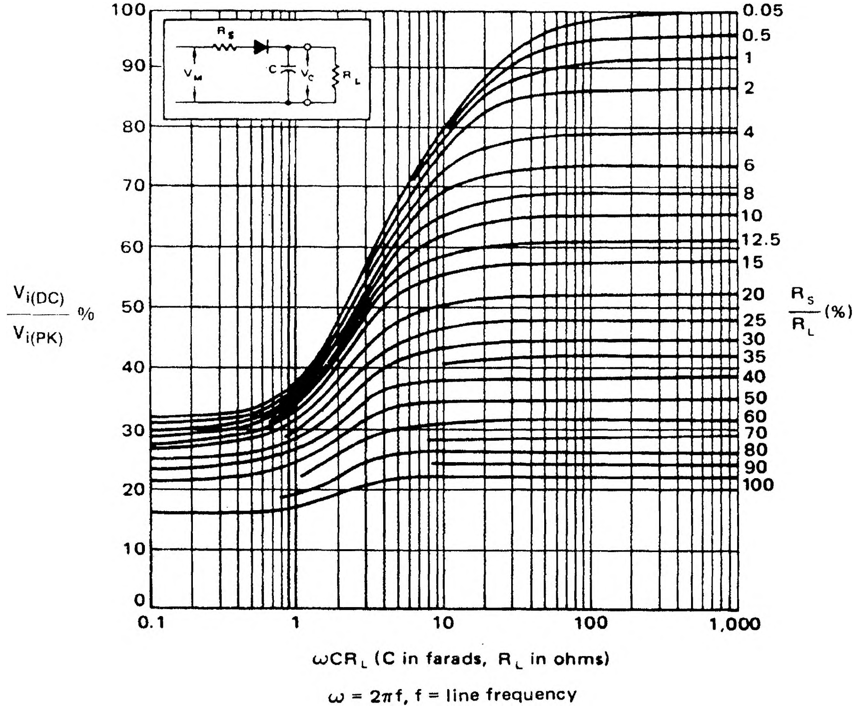
From the graph of fig. 12b we obtain,

$$\text{for } \frac{V_i(DC)}{V_i(pk)} = 0.82$$

$$\omega C R_L = 8 \text{ and } \frac{R_S}{R_L} = 4\%$$

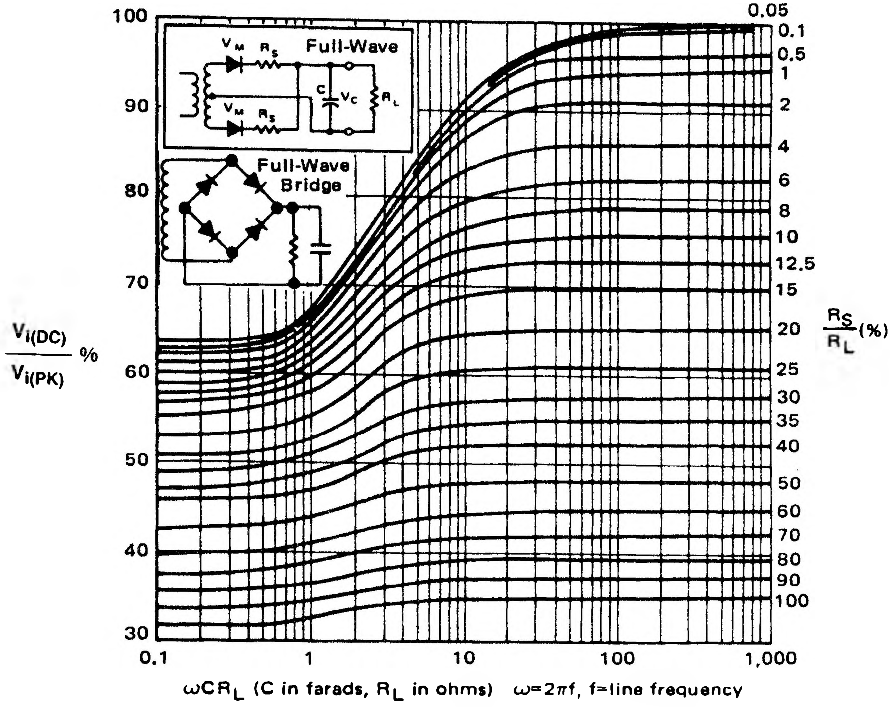
DESIGN HINTS (continued)

Figure 12a : Input Voltage (DC/pk) Ratio Half Wave.



DESIGN HINTS (continued)

Figure 12b : Input Voltage (DC/pk) Ratio Full Wave.



Therefore

$$C = \frac{8}{2\pi f \cdot R_L} = \frac{8}{6.28 \cdot 100 \cdot 12.73} = 1000\ \mu F$$

To take into account the spread of commercially available capacitors, this value is doubled : 2200 µF / 50 V.

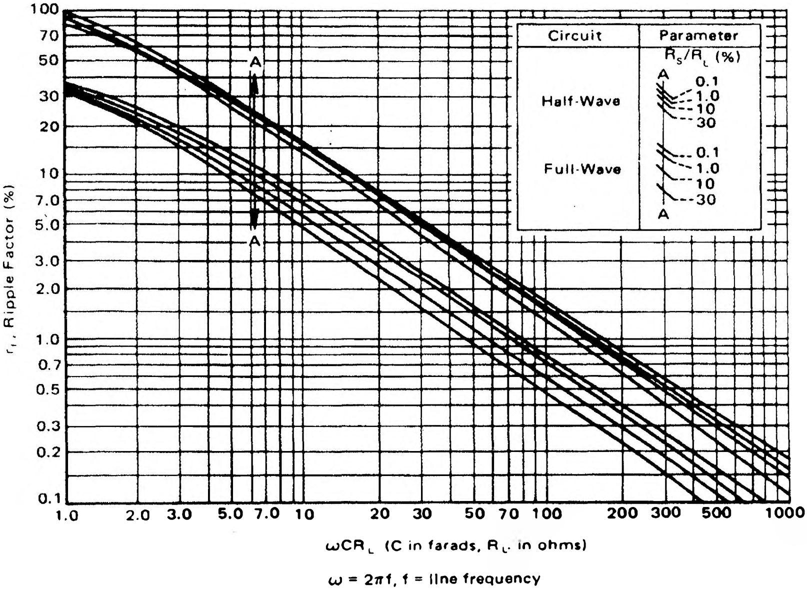
We procede now assuming that :

$$R_S = 4\ \%\ R_L = 0.04 \cdot 12.73 = 0.51\ \text{Ohm}$$

It represents the total series resistance of the transformer and the rectifying bridge.

DESIGN HINTS (continued)

Figure 13 : Ripple Voltage vs. Input Capacitance and Rs/RL.



From the figure 13 for $\omega CR_L = 8$ and $R_S/R_L = 4$ % it results :

$$rf = 7.5\ \%$$

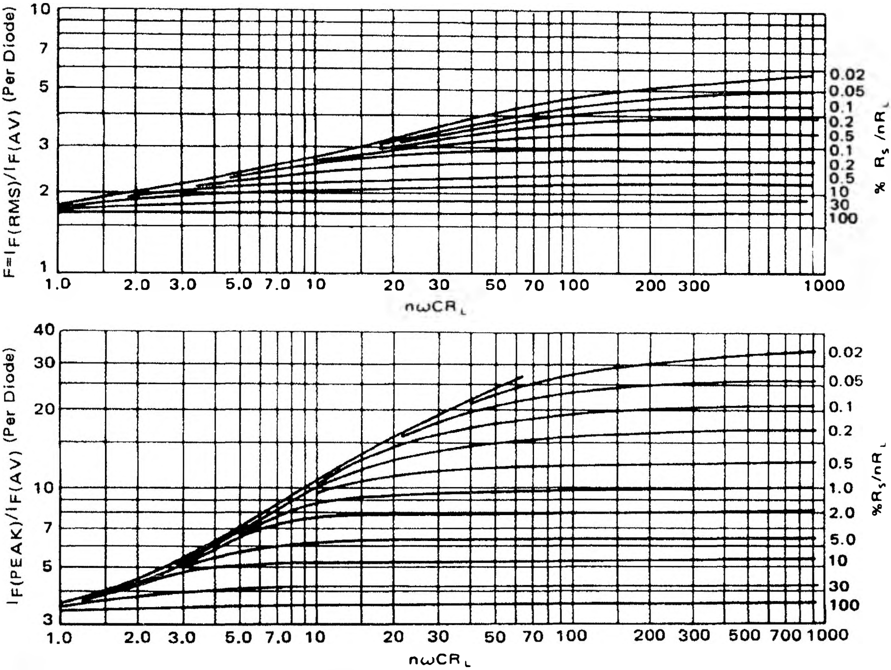
Therefore the peak to peak value of the resulting input ripple will be :

$$V_{ripple(pp)} = 2\sqrt{2} \cdot rf \cdot V_i(DC) = 5.9\ V_{pp}$$

This value is lower than the maximum allowed (6.32 V_{pp}).

DESIGN HINTS (continued)

Figure 14 : RMS/Average Peak/Average Diode Current relation.



$n = \begin{cases} 1 & \text{For Half-Wave Single-Phase Rectifier Circuits} \\ 2 & \text{For Full-Wave Single-Phase Rectifier Circuits} \end{cases}$

$\omega = 2\pi f$ where f = Line Frequency

C in Farads

R_L in Ohms

R_S = RMS Equivalent Source Resistance

The minimum input DC voltage will correspond to the minimum input AC voltage, i.e. the nominal value minus 15 %, therefore

$$V_i(DC)min = V_i(DC)nom - 15\,\%$$
$$= 28 - 15\% = 23.8\ V$$

The minimum peak voltage present at the input of the regulators will be the minimum DC voltage minus the peak of ripple voltage :

$$V_i(pk)min = 23.8 - \frac{5.9}{2} = 20.85V$$

well above the minimum allowed (16 V).

As shown on figure 14 for $2\omega CR_L = 16$ and $R_S/2R_L = 2\ \%$ we obtain :

$$\frac{If(RMS)}{If(Av)} = 2$$

Therefore :

$$Isec\ (RMS) = \frac{I_i(DC) \cdot 2}{\sqrt{2}}$$
$$= \frac{2.2 \cdot 2}{\sqrt{2}} = 3.12\ A\ (RMS)$$

DESIGN HINTS (continued)

The secondary voltage must be :

$$Vsec\ (RMS) = \frac{V_i(pk) + 1.4}{\sqrt{2}} = 25.1\ V\ (RMS)$$

where 1.4V takes into account the voltage drop on diodes.

Then the transformer rating is calculated :

$$VA = 25.1 \cdot 3.12 = 78.3\ VA$$

To select the rectifying bridge of diodes, the following considerations applies.

The forward average current is one half the total input DC current since the configuration is a bridge :

$$If(Av) = \frac{I_i(DC)}{2} = \frac{2.2}{2} = 1.1\ A$$

As shown on figure 13 for $2\omega CR_L = 2 \cdot 8 = 16$ and $Rs/2R_L = 1/2 \cdot 4\% = 2\%$ we get

$$\frac{If\ (pk)}{If\ (Av)} = 8 \text{ i.e. } If\ (pk) = 8 \cdot If\ (Av) = 8.8\ A$$

and

$$\frac{If\ (RMS)}{if\ (Avg)} = 2 \text{ i.e. } If\ (RMS) = 2 \cdot If\ (Av) = 2.2\ A$$

The surge current occurs at the maximum secondary voltage

$$Isurge = \frac{V_i\ (pk)}{R_S} = \frac{40}{0.51} = 78.4\ A$$

HOW TO CHOOSE THE HEAT SINK

Sometimes the GS-R400 requires an external heat sink depending both operating temperature conditions and power.

Before entering into calculation 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.

For GS-R400 the thermal resistance case to ambient is 5 °C/W. This means that an internal power dissipation of 1 Watt will bring the case temperature at 5 °C above the ambient temperature.

The maximum allowed case temperature of the module is 85 °C.

Let's suppose to have a GS-R412 that delivers a load current of 4 A at an ambient temperature of 40 °C.

The dissipated power in this operating condition is about 13W, and the case temperature of the module will be :

$$T_{case} = T_{amb} + Pd \cdot Rth = 40 + 13 \cdot 5 = 105\ °C$$

This value exceeds the maximum allowed temperature and an external heat sink must be added. To this purpose four holes are provided on top of the case.

To calculate this heat sink, let's first determine what the total thermal resistance should be.

$$Rth = \frac{T_{case(max)} - T_{amb}}{Pd} = \frac{85 - 40}{13} = 3.46°C/W$$

This value is the resulting value of the parallel connection of the GS-R thermal resistance and of the additional heatsink thermal resistance.

$$\frac{R_{th}(GSR) \cdot R_{th}(Heatsink)}{R_{th}(GSR) + R_{th}(Heatsink)} = 3.46°C/W$$

To calculate the thermal resistance of the additional heat sink the following equation may be used :

$$R_{th}(Hs) = \frac{3.46 \cdot R_{th}(GSR)}{R_{th}(GSR) - 3.46} = \frac{3.46 \cdot 5}{5 - 3.46} = 10.54°C/W$$

HOW TO CHOOSE THE HEAT SINK (continued)

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	Rth	Mounting	Fastening
Thermalloy	6177	3	Horiz.	Screw
	6152	4	Vert.	Screw
	6111	10	Vert.	Adhes.
Fischer	SK18	3	Vert.	Screw
	SK48	3	Vert.	Screw
	SK07	4	Vert.	Adhes.
SGE Borsari	SR50	6	Vert.	Adhes.
Assmann	V5440	4	Vert.	Adhes.
	V5382	4	Horiz.	Screw
	V5460	3	Vert.	Screw
	V5510	3	Vert.	Screw

HOW TO CHOOSE THE PROTECTING FUSE

The GS-R400 family protects the load against overvoltage, by an internal crow-bar that continuously senses the output voltage and fires a thyristor when the voltage is higher than the nominal + 20%. Thyristor current capability is 150 A.

The crowbar can be activated either by an overvoltage generated by an external injected voltage, or by a failure of the module itself.

In the first case the module provides to limit the input current to a safe value, and to recover the normal operations it is sufficient to switch off the input voltage for a time greater than the discharge time of the input filter capacitor.

In the second case the failure is pratically a module input-output short circuit, the input current is no more limited by the module, and it is necessary to provide a method for disconnecting the module from the input voltage in a very short time to avoid failures of the board where the module is mounted.

The simplest method foresees the use of a fuse in the input path to limit the fault current to a safe value.

The proper fuse should be selected with some criteria :

- the fuse must handle the steady state current
- the fuse must handle the inrush current that occurs at turn-on
- the fuse must blow if the module has an input to output short circuit.

To this purpose, it is usual to select a fuse whose rated current is between 150 and 250 % of the rated full-load input current.

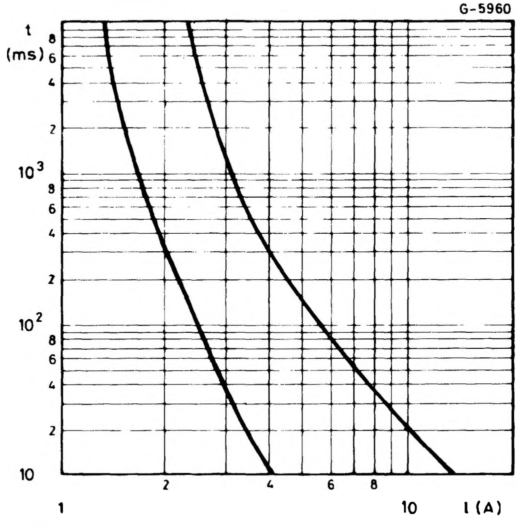
This usually provides enough overload capability to prevent fuse blowing from aging and fatigue due to repeated turn-on overload.

It is also necessary to examine the opening time versus the fuse overload characteristics, and the best choice is the high reliability, low cost, standard commercial units like 3AG, 3AB or DIN41661.

All the units must be of the fast type with fusing characteristics as depicted in dashed area of fig. 15.

HOW TO CHOOSE THE PROTECTING FUSE (continued)

Figure 15 : Fast fusing intervention curve.



As an example, for a GS-R405 unit supplied by a 24 Volt minimum input voltage, the fuse rating can be calculated as follows.

At a maximum delivered power of 20 Watt, assuming a 70 % efficiency, the input power will be 28.5 Watt and the input current 1.2 A.

The fuse rating will be 2A that guarantees a maximum fusing time of 20 ms (typical 2 ms) for a current of 20A that can be generally accepted without board problem.