



DID YOU KNOW #4

DO I NEED A HEAT SINK?

All too often customers complain that Solid State Relays “just blow too easily” .

IN TRUTH, MOST OF THE TIME, IT IS NOT THE RELIABILITY OF THE SOLID STATE RELAY THAT IS IN QUESTION HERE BUT, FAR TOO OFTEN IT IS THE INSTALLATION BY THE CLIENT THAT HAS NOT TAKEN INTO CONSIDERATION CORRECT FUSING AND OVERHEATING PROTECTION.

The use of Solid State Relays gives the best possible chance of really good control in any specific difficult applications and if installed correctly will have a long lifecycle. The “pro’s” far outweigh the “cons”

All Solid State Relays use semiconductor devices, normally triacs, to switch the load on and off. These semiconductor junctions generate heat as they switch the load on and off.

This “heat” needs to be dissipated and limited to the manufacturers maximum limit that the “triac” can withstand.

There are three main areas to watch when installing Solid State Relays:

Ambient Temperature and Load considerations
Electrical Fuse Protection
Heat Sink Calculations

Ambient Temperature and Load considerations

1. The temperature of the silicon junction (measured on the base) of the SSR limits the “Load Carrying Capacity” of all SSR’s.
2. The allowable load current for any specific SSR at a specified base temperature (panel ambient) can be determined from “Temperature De-rating Curves” published by manufacturers.
3. In practice we recommend that if you are drawing more than a few amps you should use a heat sink.
4. We supply din rail heat sinks with a footprint marginally bigger than the SSR base itself, which is easy to install, uses minimal panel space and is effective for most applications up to 75 % of maximum load current of the SSR.
5. This is simply a guideline, as in truth the actual load possible relies not solely on the maximum design load, but on other factors such as panel layout and duty cycle of the application etc.
6. Be advised though that if you are planning on using our 40 amp SSR’s in general the load should be limited to 30 ~ 33 amps or with special design factors possibly an amp or two higher. (See notes below)
7. When using our SSR’s above the 30 amp mark with a duty cycle of 60% or more it is advisable to install the heat sinks leaving a 2 mm gap between each to facilitate best natural air flow across the heat sink fins.
8. Depending on how many SSR’s you will have in one panel, in applications such as described above, it is always advisable to install a small extraction/ventilation fan at the top of the panel and have a vents at the bottom of the panel on both sides to allow maximum forced draft ventilation.
9. When installing any SSR on a heat sink, *you must use “Silicon Heat Transfer Paste” to fill the minute air gaps between the base of the SSR and the heat sink.*

Electrical Fuse Protection

1. The most common problem encountered when installing SSR's is the lack of adequate Electrical Short Circuit Protection for the device.
2. A circuit breaker or general fuse (GL) will not provide protection, as they are far too slow.
3. A SSR will fail in the first half cycle following a short circuit fault.
4. You must use an "Ultra High Speed" semiconductor fuse to protect the SSR.
5. For purposes of choosing the correct fuse to use, each SSR has an I²t rating against which the fuse must be matched.
6. Our 25 amp SSR has an I²t value of 450 and the 40 amp unit I²t = 1120
7. The fuse you use must have an I²t value that is less than this rated value at the operating voltage.
8. You may use any make of fuse but we recommend that our customers use the Ferraz make.
9. For the 25 amp Solid State Relay we suggest the Ferraz French Ferrule 660 gRB 25 amp 10 x 38 fuse. The I²t rating at 660 VAC is 470 which when reduced to 240 VAC operating voltage will be I²t = 225 or thereabouts.
10. For the 40 amp Solid State Relay we suggest that you use the French Ferrule 6.600-6.621 cp Ur 14 x 51 fuse which has an I²t = 700 at 660 VAC which is I²t = 336 at 240 VAC
11. As most heating applications are resistive in nature and therefore not prone to "overload" conditions, as long as you satisfy any statutory electrical wiring installation requirements applicable, you do not need a circuit breaker as well as the selected fuse to protect the Solid State Relay.
12. You must however, provide suitable isolation for each Solid State Relay circuit, so we recommend that you use a Modular Din Rail mount "clip open" Fuse Holder that provides isolation when you open the holder to inspect or change the fuse.

Heat Sink Calculations

When using our 40 amp SSR, as an example, the following may help in deciding on the maximum allowable load current relative to ambient temperature in the panel.

There are the following junctions in a heat sink application.

Symbol	Description	Unit	Value
T _j	Allowable triac junction temperature	°C	100
R _{jc}	Thermal resistance junction to SSR case	°C/watt	1.2
T _c	Case temperature	°C	100
R _{cs}	Thermal resistance case to sink	°C/watt	0.1
T _s	Heat sink temperature	°C	
R _{sa}	Thermal resistance heat sink to ambient	°C/watt	
T _a	Ambient air temp in panel	°C	

Each heat sink has a "Thermal resistance" rating that should be supplied by the manufacturer. You calculate an allowable thermal resistance for a suitable heat sink with two main given values:

T_a = Allowable max ambient air temp in the panel, which for this example we will assume is 50 °C

T_j = Maximum allowable triac junction temperature in the SSR, which in our case we have taken as 100 °C (allowing a small factor for safety).

V_{drop} = On state forward volt drop across the SSR which in our case is 1.6 volts for the 40 amp SSR.

R_{jc} = Thermal resistance junction to case which in our case is 1.0 °C

R_{cs} = Thermal resistance case to heat sink which we are taking as 0.1 °C/w

So the formulae (cutting it short) is

$$R_{sa} = (T_j - T_a) / ((V_{drop} \times \text{max current}) - (R_{jc} + R_{cs}))$$

$$R_{sa} = (100 - 50) / ((1.6 \times 40) - (1.2 + 0.1))$$

$$R_{sa} = 0.795 \text{ °C/watt}$$

This means that our heat sink with an estimated thermal resistance of 1.6 °C/watt (estimated for calculation purposes only) is not suitable. You need one with a thermal resistance of 0.75 °C/watt or lower.

In this example we would have to drop the maximum current down to 20 amps to reach a thermal resistance of 1.6 °C/watt or increase the cooling factor by forced draft keeping the ambient below 50 °C.

As an example if we could restrict the ambient to 30 °C and a maximum load current of 28 amps the formulae would give us a $R_{sa} = 1.6 \text{ }^\circ\text{C/watt}$ which is roughly suitable for our heat sink.

NOTE:

As you can see there are so many variables to consider (not forgetting the effect of duty cycle of the application or the number of SSR's to be mounted in one panel and ambient temperature in the panel etc) that the rule of thumb is to rate the SSR at about 75% of its maximum load capability when it is used in a panel mounted on our heat sinks but without forced draft cooling.

You can raise the design % load by installing forced draft cooling with an extraction cooling fan (or two) mounted at the top sides of the panel and cutting air vents in the bottom sides of the panel. When doing this you can raise the design load to about 85% ~ 87% of maximum rated load current of the SSR.

You can of course source a heat sink with a lower thermal resistance in the order of or below 1.0 °C/watt.

All these calculations are impacted on by the duty cycle of the control application. The lower the duty cycle the higher the allowable maximum current capacity will be. If you can estimate the duty cycle on and off time you can use the following formulae to estimate the RMS current loading and then use that in the above heat sink calculations.

$$I_{rms} = \sqrt{((I_{on})^2 \times T1)/(T1 + T2)}$$

I_{rms} = Average current loading to be used in the heat sink calculations.

$T1$ = Time current is on

$T2$ = Time current is off

I_{on} = RMS value of load current during the on period.

The above information is offered as a theoretical guide and is not necessarily to be taken as absolute in the design of your specific application. QIS scope of supply is limited to the sale only of the SSR's and is not responsible for the design and application engineering in which they are used.

QIS WILL BE HAPPY TO ANSWER ANY QUESTIONS YOU MAY HAVE. JUST CONTACT US WITH YOUR QUERIES.

**REMEMBER WE SUPPLY A FINE RANGE OF TEMPERATURE CONTROLLERS
AND SOLID STATE RELAYS AT VERY INEXPENSIVE PRICES**

QIS GREY SMITH 01244 539295