General Application Notes

Heat Sinking

Heat is generated by all Solid State Relays in direct relation to the amount of current being switched. Approximately 0.8-1.4 Watts will be generated by the SSR for every Amp switched. This heat must be dissipated as fast as generated otherwise the temperature will increase until the relay fails. Approximately 90% of all problems with relays are directly related to heat.

Adequate heat sinking, including consideration of air temperature and flow, is essential to the proper operation of a solid state relay. Units should never be mounted in an enclosed area without proper air flow. Units should also never be mounted to a plastic base or to a painted surface. Failure to provide adequate heat sinking will cause a solid state relay to fail. We recommend mounting our units on the heat sinks listed on page E12 of this catalog. However, when this is not possible, and the units are to be mounted to some other heat sinking object, material heat conductivity should be kept in mind. In heat dissipation, our heat sinks are approximately equivalent to a sheet of aluminum 1/8" thick by the dimensions shown:

SAS-HTSK-1.6	10" x 10"	(254 x 254mm)
SAS-HTSK-1.0	14" x 14"	(355.6 x 55.6mm)

(Given proper ventilation and ambient temperature.)

In comparison, twice the amount of steel and four times the amount of stainless steel would be needed to achieve the same effect.

Any panel mount Solid State Relay must be mounted to a clean, bare (non-painted) surface that is free of oxidation.

Since even the best heat sink surfaces have some imperfections, there will be many air pockets between the base of the relay and the heat sink (or panel) surface.

Air is a very poor conductor of heat and will cause the relay to run hotter than it should. To fill these pockets, Thermal Transfer Pads (see pg E12) should be placed on the metal base of the relay before mounting to a metal surface. We suggest torque of 10 inch-pounds on both of the SSR mounting screws.

Alternately, an evenly applied 0.002" thick layer of Dow Corning 340 (or equivalent) can be used. Note that a thicker layer of thermal compound actually decreases heat transmission.

Since airflow will affect its performance, a heat sink should be mounted in a manner that assures unrestricted airflow over its surface. Recommended mounting is on a vertical metal surface, with the fins oriented vertically so that air can flow unimpeded along the surfaces of the heat sink. Horizontal or inverted mounting is possible but not recommended, and the SSR must be derated accordingly.

Care must be taken when mounting multiple SSRs in a confined area. SSRs should be mounted on individual heat sinks whenever possible. Panel mount SSRs should never be operated without proper heat sinking or in free air as they will THERMALLY SELF DESTRUCT UNDER LOAD.

A simple method for monitoring temperature is to slip a thermocouple under a mounting screw. If the base temperature does not exceed the "max heat sink temperature" (shown on pg E14) under normal operating conditions, the SSR is operating in an optimal thermal environment. If this temperature is exceeded, the relays current handling ability must either be thermally improved by the use of a larger heat sink, or greater air flow must be provided over the device through the use of a fan. Some cases may require the selection of a higher current output SSR and thermally derating the device accordingly.

Remember that the heat sink removes the heat from the Solid State Relay and transfers that heat to the air in the electrical enclosure. In turn, this air must circulate and transfer its heat to the outside ambient. Providing vents and/or forced ventilation is a good way to accomplish this.

80% Power Rule

All Solid State Relays are capable of running at full rated power (with proper heat sinking). However, it is strongly suggested that they be used at no more than 80% power to provide a safety margin in case of higher than expected voltage, temperature, or dust on the heat sink, etc. Additionally, voltage can vary up to +/-10%, and a heating element up to +/-10% over its life—two main reasons for the 80% rule.

Din Mounted Single and Three Phase Relays

The SAR series are provided with integral heat sinks. The SAR50-100A units should be mounted so as to provide 1" (25mm) of space between the units, for best air flow (the 80% of power rule described above still applies). They can be mounted against each other if the end units in a row are derated by 10% and the middle units are derated 10% more than the end ones.

On the other hand, the SAR-25/40A units can be installed on a DIN-rail with only 0.18 inches between relays, "Fin-to-Fin"! The SAR-25/40A family provides more amps per square inch than other brands of industrially hardened SCR controllers and

SSNA9000

General Application Notes *(continued)*

will perform better in installations with higher ambient temperatures.

For proper airflow, the SAR units should both be mounted in a manner leaving space above and below the heat sink equal to or greater than the height of the heatsink. Since airflow will affect performance, relays with integral heat sinks should be mounted in a manner providing unrestricted airflow over their surfaces. Recommended mounting is on a vertical surface, with the fins oriented vertically, so that air can flow unimpeded along the surfaces of the heat sink.

Heat Sink Calculations for SAS Family of Solid State Relays

Sprecher + Schuh SAS Power Dissipation

SAS3-10	**SAS3-25**
10 Amp Relays	25 Amp Relays
10A/11W	25A/31W
8A/9W	20A/23W
6A/6W	15A/16W
4A/4W	10A/10W
2A/2W	5A/5W
Max heat sink=90ºC	Max heat sink=85ºC
Pwr Ref: V_0=0.80V_0	Pwr Ref: V_0=0.80V_0
Rt=0.038 Ω	Rt=0.021 Ω
SASx-50	**SASx-75**
50 Amp Relays	75 Amp Relays
50A/59W	75A/84W
40A/44W	60A/63W
30A/30W	45A/44W
20A/18W	30A/27W
10A/9W	15A/13W
Max heat sink=105ºC	Max heat sink=105ºC
Pwr Ref: V_0=0.80V_0	Pwr Ref: V_0=0.85V_0
Rt=0.0092 Ω	Rt=0.0046 Ω

All calculations are in ºC. See derating curves on next page. Sprecher + Schuh provides three ways to calculate the heat sink for your application.

1) Heat Sink Calculation Method

Maximum heat sink temperature minus maximum ambient temperature divided by the power dissipation (use the chart above for power dissipation at desired current).

(Max Heat Sink Temp - Max Ambient Temp) / Watts = ___

For Example, use an

- SAS3-25-1D running at 20 Amps in a 45ºC ambient
- From the chart, at 20 Amps it dissipates 23 Watts
- A 25A unit can have an 85ºC heat sink
- (85-45 ambient) = 40ºC temp rise is allowed
- 40ºC/23W = 1.74ºC/W heat sink rating or less (less temperature rise per watt is better)
- Therefore, the recommended heat sink would be part number: SAS-HTSK-1.6 (rated at 1.6ºC/W) or any equivalent heat sink that is 1.74 or LESS. Remember, the lower the heat sink value, the better it dissipates the heat. The relay must be connected to the heat sink using an appropriate thermal conduction grease or thermal pad.

2) De-Rating Calculation Method

Maximum heat sink temperature minus maximum ambient temperature divided by the heat sink rating (use the previous chart for power dissipation).

(Max Heat Sink Temp - Max Ambient Temp) /
Heat sink rating = ___(Max allowed Watts)

For Example, use an

- SAS3-10-1D is a 60ºC ambient with a 2.0ºC/W heat sink.
- 90ºC - 60ºC = 30ºC heat sink Temperature rise is allowed.
- 30ºC divided by 2.0ºC/W =15W.
- From the table, full load current of 10A only dissipates 11W.
- Thus, an SAS3-10-1D mounted on a 2.0ºC/W heat sink can switch 10A at 60ºC.

3) Power Calculation in Place of the Charts

Heat rise calculation of an SAS solid state relay based upon amperage switched "ON" 100% of the time. Please note, the Sprecher + Schuh "SAS" SSR uses engineering techniques that provide maximum surge survivability while generating a low temperature rise.

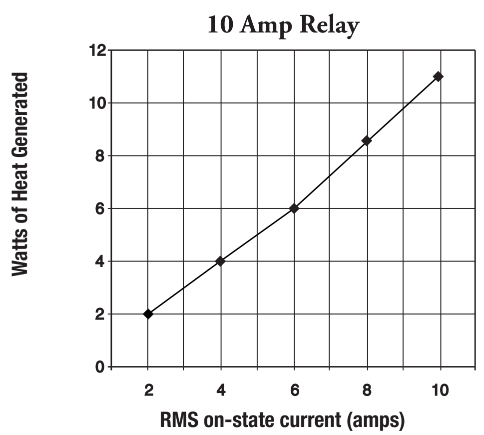
$(0.9 \times I_{rms} \times V_o) + (I^2_{rms} \approx \times R_t)$ = Power

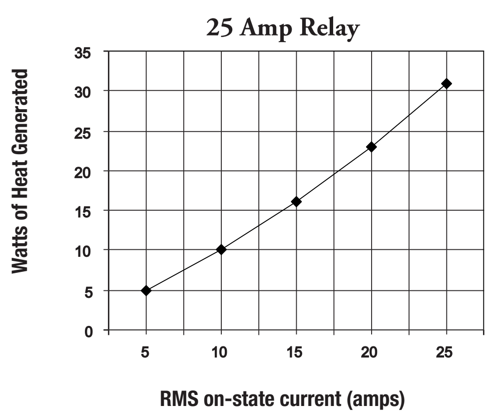
For Example, use an

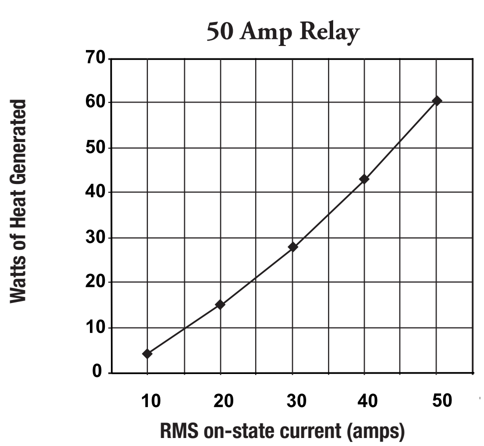
- SAS3-25-1D for a 21A application.
- $(0.9 \times 21A \times 0.80V) + (21^2 \times 0.021\Omega) = 24.4$ W

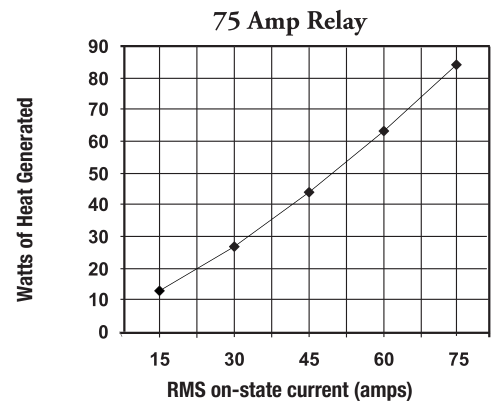
General Application Notes *(continued)*

SAS Family Solid State Relay Power Curves









Motor Applications (SAR - 3 Phase Unit)

The Sprecher + Schuh 3 phase solid state relay is designed for switching power to 3 phased asynchronous motors and to resistive loads. For guidance in its application, refer to the following notes:

(380 Volt, 50/60Hz Motors - Direct Start)

	Motor Size (KW)	Start Current (A_{rms})	Operating Current (A_{rms})
2-Pole - 3000 RPM	3	43.4	6.2
4-Pole - 1500 RPM	3	38.0	6.9
6-Pole - 1000 RPM	4	47.7	9.0
8-Pole - 750 RPM	3	36.6	8.7
(220 Volt, 50/60Hz Motors - Direct Start)			
2-Pole - 3000 RPM	2.2	45.0	7.0

Overload Capacities

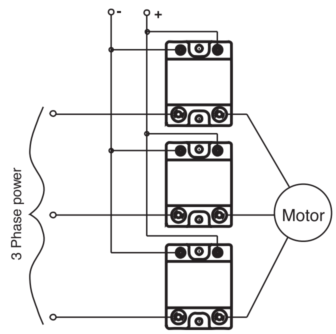
In the event that a load completely or partially short circuits, the following table indicates the absolute maximum current that the 3 Phase SAR-Unit relay can withstand for various time limits:

Time (Sec)	Current (A_{rms})	Time (Sec)	Current (A_{rms})
.2	275	8.0	80
.4	228	10.0	75
.6	188	12.0	72
.8	161	14.0	71
1.0	150	16.0	70
2.0	124	18.0	69
4.0	95	20.0	67
6.0	86	40.0	58

General Application Notes *(continued)*

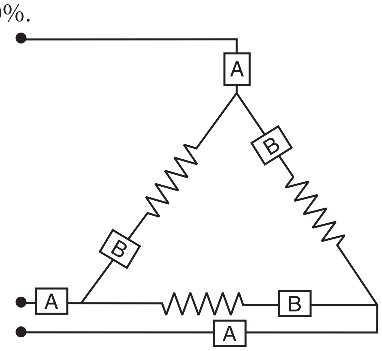
Three Phase Motor Control (SAS Series)

Three phase motors can be controlled as shown. Note that only two SSRs are required (the third is optional). The inputs are shown in parallel, but they can also be connected in series as long as the minimum control voltage is provided to power each relay.

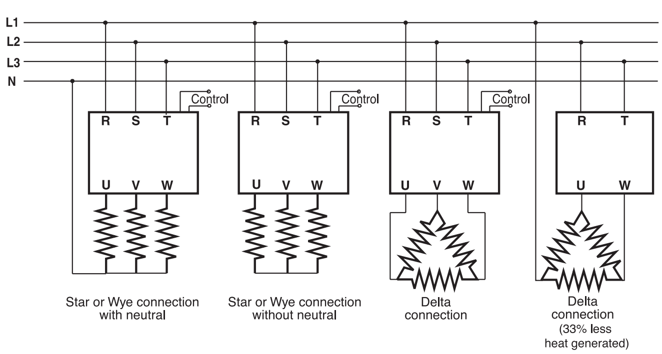


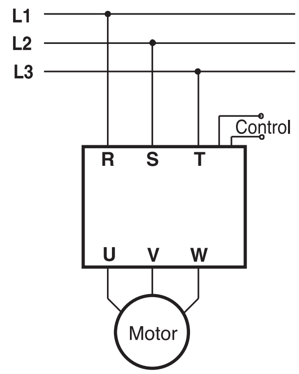
Three Phase Wiring Suggestions

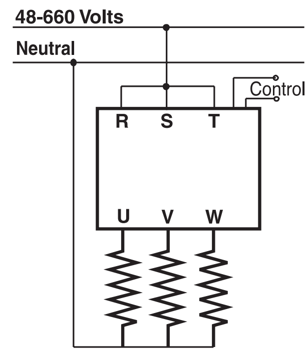
Relay positioning in a three-phase circuit impacts the current draw and therefore the amount of heat generated. When positioned in location "A", as indicated below, a relay will draw 73.2% more current than position "B". Using position "B" will enable the use of a smaller relay or will provide an increased safety margin. Additionally, by drawing less current, heat generation is reduced by 40%.



Example Wiring (SAR-3 Phase Unit)





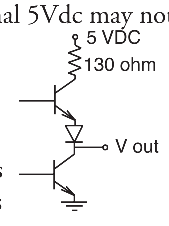


Logic Signal (TTL) Operation

One of the primary advantages of SSRs and I/O modules is their compatibility with low level, solid state logic. Any logic gate, buffered or not, capable of delivering the required current and voltage within its maximum power dissipation rating can be used to control an SSR or I/O module.

Many TTL gates, for example, will safely dissipate 40mW or more; and the total package will dissipate up to one Watt. (This gate power must not be confused with relay input power.) Whereas an SSR in which the input requires 6mA at 5Vdc consumes 30mW of power, the TTL gate sinking this same 6mA may have a voltage drop of only 0.2 volt, and power consumption of just 1.2 mW!

TTL gates can only sink relay input current, not source it. This is because the sourcing transistor has a pull-up resistance in its collector circuit. Pulling 11mA through this resistance, in this case 130 ohms, would leave insufficient input voltage to operate the relay. For example, an SSR requiring a nominal 5Vdc may not operate on less than 4 volts.



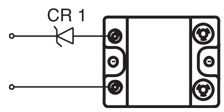
Typically, the drop across the transistor and diode at 11mA would approximate 0.8 volt; and the drop across 130 ohms is 1.4 volt. This 2.2 volt drop would leave only about 1.8 volts for the relay to operate, not enough for relay turn-on.

Since TTL gates can only sink current to the relay, and since current sinking is done from a "zero" logic signal, the relay can only be turned on from a "zero" signal. This is contrary to normal relay operation, which prefers that the relay be turned on as a result of a "one" signal. To obtain relay actuation from a logical "one" signal, it is necessary to use an inverting gate. With such a gate, when a "one" signal is received, the sink transistor will turn on and conduct relay input current.

General Application Notes *(continued)*

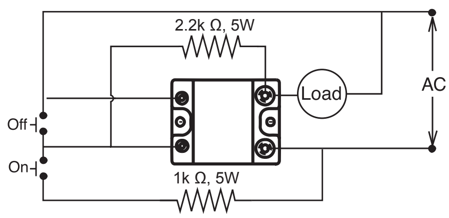
Changing Pickup and Dropout Voltage

By using a zener diode in series with the input, the pick up and drop out voltage of a Solid State Relay or an I/O Module can be increased by the value of the zener. For example, a typical SSR has a maximum pick up voltage of 4 Vdc and a minimum drop out of 1 Vdc. By adding a 6 volt zener as shown, the new pick up will be 10 volts and the new drop out 7 volts.



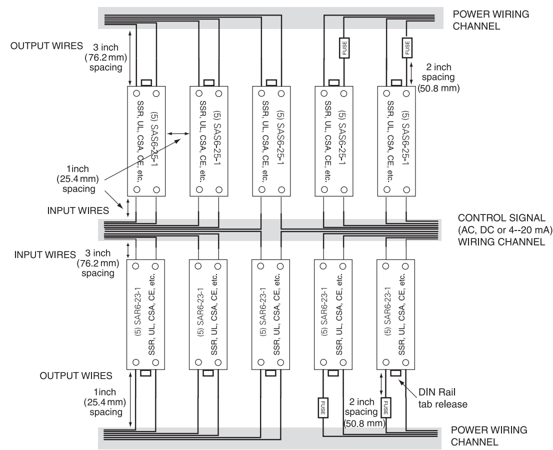
Latching SSR

An AC SSR can be made to self latch (at the sacrifice of input-output isolation), thus permitting the use of momentary action switches for on/off or stop/start operation. It may be necessary to insert an RC filter across the relay input to prevent the relay from turning on due to switching transients upon application of system power. Note that the SSR employed here must be an AC input type.



Installation Density

To achieve maximum installation density and to provide separate wiring channels for the high voltage/high current wires vs the control signal wires, Sprecher + Schuh's SAR family of 25 or 40 amp products can be installed as shown below. Please ensure that you observe the wire terminal numbers. The spacing shown is the minimum requirement for most industrial applications. Unrestricted airflow is needed for the Sprecher + Schuh product to perform at its rated capacity.



Crimped-on Wire Terminals

When using either Ring or Spade crimped terminals with the SAS relays, do not use the saddle clamps that are provided. It is sufficient to secure the Ring or Spade Connectors with the enclosed screws.

When using electrical wire that is larger than #10 AWG with the SAR relays, 25-40 amp models, use a crimped lug, such as Amp# 790368-1 or equivalent.

DIN Rail Sizes

All DIN Rail mountable relays and modules will fit on any standard 35mm rail.

General Application Notes *(continued)*

Heater Loads

Solid State Relays are well suited for driving heaters, however, in some temperature control applications the load is rapidly and almost continuously switched on and off. This is ideal for purely resistive loads (0.9-1.0 power factor). For loads of power factor 0.8-0.9 Sprecher + Schuh recommends increasing the controller cycle time to 5 sec. minimum. Loads with a power factor <0.8 should be derated for inductive load.

Recommended Heater Loads:

SSR Rating	at 120Vac	at 240Vac	at 480 Vac
10A	960W	1.9KW	3.8KW
25A	2.4KW	4.8KW	9.6KW
50A	4.8KW	9.6KW	19.2KW
75A	7.2KW	14.4 KW	28.8KW

Low cold resistance elements such as Tungsten or Short Wave Infrared have special design considerations due to high inrush currents. Please consult the factory.

Solenoid Valves and Contactors

All of Sprecher + Schuh power SSRs use high noise immunity circuitry in addition to a snubber network to handle the electrical noise generated by inductive loads.

However, the cycling of a solenoid load will generate large current spikes which will decrease the power capability of the SSR. The power rating of the SSR will be reduced by the power rating percentage shown.

Cycle Time	Power Rating
20 sec.	80%
5 sec.	65%
1 sec.	40%

Recommended Solenoid Loads = V x I x (Power Rating)

Recommended Solenoid at 5 sec. cycle time.

SSR Rating	at 120Vac	at 240Vac
10A	780W	1.9KW
25A	2.0KW	3.9KW
50A	3.8KW	7.6KW
75A	5.8KW	14KW

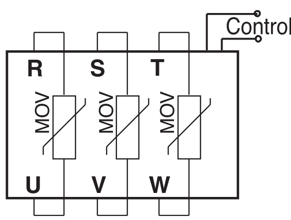
Short Circuit Protection

The relay can be short circuit protected with an appropriate semiconductor fuse. The load integral of the relay (I^2t) determines which size of fuse is to be used. The fuse load integral must be below that of the relay for the appropriate protection. Be certain to analyze the fuse current/time curve to insure that the fuse can withstand the motor starting current (if applicable).

NOTE: Overload protection should be provided by another slow-acting fuse in series with the short circuit protection fuse. (An overload being an overcurrent condition that is not of high enough amplitude to be considered a short circuit).

Transient Voltage Protection

When operating a relay in an electrically noisy environment, large voltage transients may damage the relay. To protect against this occurrence, it is advisable to install appropriate varistors across the respective supply and load terminals of the relay output.



Model SAR6-30-3 shown with customer-installed MOVs.

If your application is located near inductive loads, or shares power sources with large inductive loads that are creating transients in excess of the blocking voltage of the Sprecher + Schuh solid state relay, then you must install a metal oxide varistor (MOV) to protect the solid state relay. It is up to the installation company to properly size the MOV to the application! Ideally, the MOV protection is near the noise generating inductive load (such as a motor, drive, or other large inductive coil) or you can place MOVs directly across the output terminals of the SSR. Some "typical" MOVs include:

600 volt application - Harris V660 LA80B
480 volt application - Harris V575 LA80B
300 volt application - Harris V320 LA40B

The new SAS and SAR families of solid state relays include technology that dramatically reduces your need to install an external MOV except in extremely noisy environments or inductive load applications.

General Application Notes *(continued)*

Single Phase Motor Control

The following table gives guidelines for selecting relays for single phase non-reversing motors. Driving reversing motors is not recommended due to the potentially destructive voltage doubling and capacitive discharge that they create.

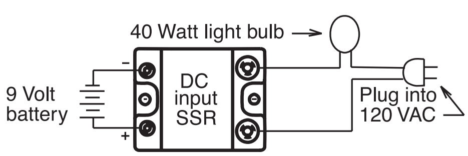
Recommended Loads:

SSR Rating	at 120Vac	at 240Vac	at 480Vac
10A	1/4 Hp	1/2 Hp	-
25A	1/3 Hp	1 Hp	2 Hp
50A	3/4 Hp	2 Hp	3 Hp
75A	1-1/4Hp	3 Hp	7-1/2 Hp

Lamp Test

An AC output solid state relay can be quickly and easily tested. To evaluate whether or not it is operative, connect the relay as follows using the appropriate voltages. The lamp bulb should not turn "On" until the control voltage is applied (and "Off" when control voltage is removed). If the lamp comes "On" with no control voltage, the output is shorted.

Shown is an AC output solid state relay. DC units can be checked the same way with appropriate DC voltages and load.



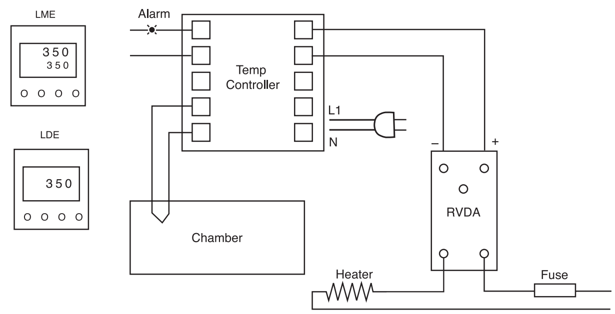
Safety

Due to their leakage current Solid State Relays are NOT open circuits, even when in the off-state. Safety can only be achieved by a mechanical disconnect between the solid state relay and the power lines.

Typical Temperature Control Installation

Electrically heated chamber application:

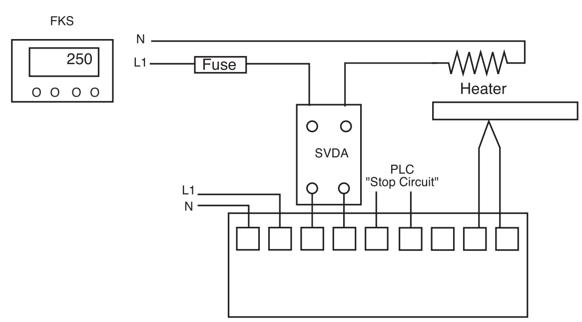
- DC activated SAR6 solid state relay
- Thermocouple input
- Alarm for operator warning



Typical Temperature Control Application

Packaging or food processing application:

- SAS DC activated solid state relay
- Analog sensor input
- Alarm circuit to stop PLC or related equipment



Locking Screws - SAR Units

Screws are prevented from self-loosening by a special design. The automatic progressive locking principle generates an increasing thread friction as the screw is tightened. Repeated tightening and loosening does not cause fatigue of the locking components. Recommended torque is 7-9 in/lbs. Care should be taken not to overtighten screws.

General Application Notes *(continued)*

Fusing Considerations

Circuit Breakers and slow blow fuses offer no protection to Solid state relays. Fast, "I^2T Semiconductor Fuses" are the only reliable way to protect SSRs.

All solid state relays have an I^2T rating. This rating is the bench mark for their ability to handle a shorted output condition. Sprecher + Schuh advocates circuit protection through the use of a properly selected I^2T (semiconductor fuse).

Devices such as electromechanical circuit breakers and slow blow fuses cannot react quickly enough to protect the SSR in a shorted condition and are not recommended!!

For fuses, I^2T is the measure of let-through energy in terms of current versus time. For solid state relays, I^2T is based directly on the output thyristor's single-cycle peak surge current determined by:

$$I^2T = \frac{I^2pk(surge)}{2} \times 0.0083 \text{ (sec)}$$

The procedure is to select a fuse with an I^2T let-through rating that is less than the I^2T capability of the solid state relay for the same duration.

An I^2T fuse protects the solid state relay. You still need a regular fuse or circuit breaker to protect the complete installation, in accordance with your local electrical code.

Leakage - Effect on Input

Many temperature controllers and PLC's use triacs as output devices and most manufacturers place a ".022 microfared snubber" across their triacs for their own protection. This snubber can produce enough leakage when the controller is "off" to cause the solid state relay connected to it to go "on" or at least to not turn "off" properly.

A solution to this problem is to place a 10K ohm, 2 Watt resistor (for 120 Volt control), across the input (control) of the solid state relay.

The SAS and SAR AC input family typically do NOT need the additional burden resistor. This saves you installation time and cost.

Output Leakage

Solid state relays typically have 8mA leakage current, even in their off-state. The only safe way to prevent shock is to have a mechanical disconnect between the line and the relay.

Direct Copper Bonding

Sprecher + Schuh employs the proven reliability of direct copper bonding technology to all of its SCR chip assemblies. This direct bonding provides a more reliable mechanical connection between the SCR and the heat sink, by reducing the physical stress on the chips and also provides for better heat dissipation by reducing the layers heat must travel through to the ambient. This results in a more durable relay and a longer usable relay lifetime.

Using SSRs with Electromechanical Relays

Using an SAS or SAR relay to activate an electromechanical or mercury contactor is possible. Electromechanical relays produce a significant amount of electrical noise which could cause a solid state relay to mistrigger. If these two types of relays are used together, surge voltage protection may be required.

Caution

Sprecher+Schuh Solid State Relays can fail without warning (as is possible with any electronic component).

For this reason Sprecher+Schuh cannot recommend, condone or warrant any application of our products that could cause harm or injury, in any manner, to any person upon such failure of the product.

Please contact the factory if you have any doubts or questions as to whether this caution applies to your application.