How to Choose a Solid State Relay

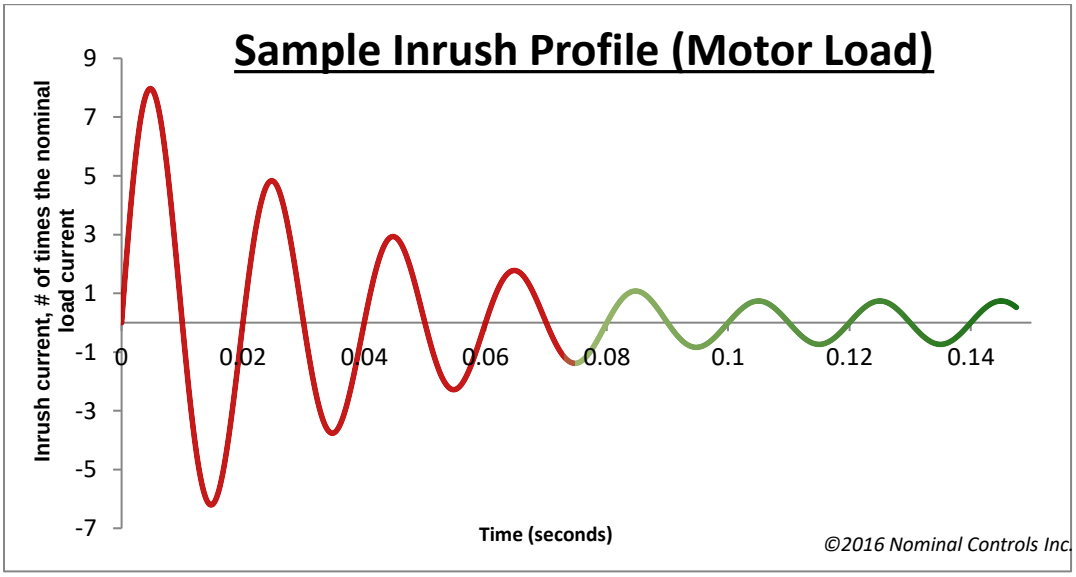
There are 4 steps in choosing a suitable solid state relay (SSR):

1. Input and Output Selection

There are 3 common SSR input-output variations, VDC in-VAC out, VAC in-VAC out, and VDC in-VDC out. In order to achieve the desired control outcomes, ensure the control input parameters (voltage & current) satisfies the relay's guaranteed turn-on and turn-off parameters. For VDC inputs under 50V, no reverse diode is needed.

1. Current Rating Selection

Selecting the correct current rating is a crucial aspect in determining solid state relays' reliability. SSR's current rating corresponds to the maximum current that should pass through the relay before possible damages occur to SSR's internal components. Most common SSR failures are the result of insufficient current capacity against inrush current, which is capable of being many magnitudes greater than continuous operating current illustrated below:



The effect of inductive reactance, power grid variables and other tolerances also need to be considered while choosing the SSR's current rating. However a lower SSR current rating may be permitted if the load's start-up current follows a lower and gradual increasing inrush current profile such as motor soft-start. As a rule of thumb, choose SSR rated 50% of the expected peak inrush current. The following table shows the respective inrush current profiles of different types of loads:

Inrush Current of Different Loads					
Resistor	**Resistive Heating**	**Relay**	**3-phase AC Motor (hardstart)**	**Single phase AC Motor (hardstart)**	**DC Motor (hardstart)**
1x	1.6x	3x	5-7x	5-10x	10-12x
Solenoid	**Incandescent, Halogen Lamp**	**Transformer (Live/Empty)**	**Capacitor**	**ELV (12-24V) Halogen Lamp**	**LED Lamp**
10x	10-15x	10x / 10-20x	20-50x	50-75x	50-100x

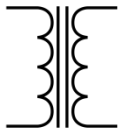
*Rule of thumb: Choose relays rated ~50% the peak inrush current

Load Specific Details:

Heater Load

Resistors are not affected by inrush current. However in resistive heating applications, an inrush current up to 1.6x the continuous current could be generated under cold-start conditions.

Transformer Load

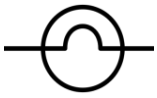


Without a live-load, a transformer would experience an initial inrush current surge of up to 20 times within the first 10-500ms. With a live-load attached, this inrush current surge drops to about 10 times its continuous operating current.

Motors

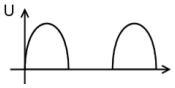
AC motors may generate an initial inrush current 5-10 times the operating current without soft-start protocols; for three phase AC motor it is 5-7 times; for a DC motor it is as high as 10-12 times. The duration of motor's inrush current is expected to last longer than most other loads. The user must also ensure implement adequate protection against long and intense current surges as well as against motor induced counter EMF to prevent damages.

Lighting Loads



Lamp loads of all types generally have very high inrush currents. Incandescent and halogen lamps have inrush current 10-15 times the actual operating current. For low voltage halogen lightings this value is between 50-75 times. A relay current rating at least 70 times the continuous operating current is necessary for LED light applications, where the inrush current can peak between 50-100 times.

Rectified Half-Wave

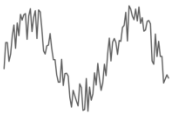


Rectified half AC waves will not reach the SSR output. Since the 0 amplitude is never crossed, solid state relays with zero-crossing switching mode will not be turned on. The solution is to use solid state relay with instant-on switching more or alternatively connect a bleeder resistance with 20% the SSR load current.

Rectified Full-Wave

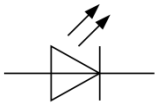
Some rectified waves such as square wave can cause the internal triac of the SSR to malfunction. Therefore in applications where the AC wave is fully rectified, choose solid state relay with an internal MOSFET instead of a triac.

Inverted Wave



Inverted waves are subject to unpredictable spikes and surges. Solid state relays should not be used for control applications following an inverted wave.

Small Capacity Loads



Without any control signal input, there would still be a leakage currents originating from the SSR's output end. If this leakage current exceeds the load release current then the SSR may fail to be controlled properly. To resolve this issue, the magnitude of the SSR switching current should be increased by connecting a bleeder resistance in parallel.

2. Zero-cross or Instant-On Mode Selection

There are two main SSR switching output modes, zero-cross or instant-on/random-turn-on.

Zero-Cross

With this switching mode, SSR's first output conduction cycle only starts when the AC sine wave crosses the next immediate 0 amplitude. Since it's unlikely that the control signal start coincide with a 0 point of the AC main, this implies there is usually a short delay before solid state relay's output fully conducts. This delay can be beneficial as it reduces initial surge current, and lessens the electrical noise to the grid.

Zero-Cross relays are suitable for most industrial applications with loads that are resistive in nature. Examples include heating applications, lighting applications, programmable controls and other low inductance applications.

Instant-On/Random-turn-on

With this switching mode, SSR's first output conduction cycle starts within 100μs or immediately following an on signal; ideal for applications where the load is required to be in sync with the signal. However there is a trade off, as instant-on also implies that the SSR will likely be subject to the peaks of inrush currents.

For most resistive applications, both zero-crossing and instant-on relays may be used interchangeably. For inductive applications, instant-on relays are usually the preferred option because of signal sync requirements.

3. Heatsink Requirement

Solid state relays are known to generate excessive heat during their operation. In order to maintain their reliability and performance, SSR's operating temperature must be kept under 80°C / 176°F by using heatsinks or other heat dissipation protocols.

Heatsinks should be selected on the basis of continuous operating current which is independent of the relay's current rating. The following conventions of heatsink selection should be applied:

1) Heat dissipation is required for solid state relays operating nominally at greater than 5 amps load current.
2) As a rule of thumb, the heatsink for the SSR should weigh 15 grams for every 1 ampere of nominal load current (Ex: a SSR operating at 30A continuously should be equipped with a heatsink that weighs 500g).

Feel free to contact us about your solid state relay and heatsink needs.