The Variable Load-Current Rating of Solid-State Relays and Power Controllers

There are many features and benefits to solid-state relays that make them a preferred alternative to electromechanical relays and contactors. Chief amongst them is their long-life expectancy, but life-expectancy for an SSR is dependent upon how well the relay can dissipate the heat it generates during normal operation. Lack of proper heat management is one of the primary reasons SSRs fail prematurely, and improper heat management is often a result of a simple misunderstanding in how the specified load-current rating of the relay applies in the real world.

A decent, SCR-based solid-state relay will dissipate power at a rate of about 1 Watt per ampere of load current. Once the load current exceeds five to seven amps, an external heat sink is required to ensure that the relay doesn't overheat. Therefore, for example, a 50-amp rated SSR is *only* rated for 50 amps when mounted to a heat sink that can adequately dissipate 50 Watts of power. Failure to provide an adequate heat sink will result in excessive temperatures and, ultimately, relay failure.

Knowing that solid-state relays require heat sinks in order to operate reliably is half the battle. Knowing how to select an adequate heat sink is the other half, and often where the battle is lost. Fortunately, selecting the right heat sink only requires a basic understanding of the application and a bit of simple math.

As a general rule-of-thumb, the base plate temperature of an SSR should be kept below 100°C. It's also important to know the ambient temperature in the panel where the SSR will be used as this will be the baseline for calculating the maximum baseplate operating temperature. In the examples below we'll assume a 40°C ambient temperature and that adequate ventilation is provided for convection airflow through the panel.

The formula for calculating baseplate temperature is; Tbp = Tamb + (P x (Rhs + 0.2°C/W)), where Tamb is the ambient temperature in the panel, P is the power being dissipated (load current) and Rhs is the thermal impedance of the heat sink. We're adding 0.2°C/W to the impedance of the heat sink as a safety margin to account for the impedance of the thermal compound or thermal pad used when mounting the SSR to the heat sink.

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Using the formula above we can reliably estimate the heat sink requirement for an SSR to carry 50A in a 40°C ambient:

Tbp = Tamb + (P x (Rhs + 0.2°C/W))
100°C = 40°C + (50A x (X + 0.2°C/W))
100°C - 40°C = 50X + 10°C
50°C = 50X
X = 1.0°C/W heat sink

Therefore, a 1.0°C/W heat sink is required for an SSR to carry 50 amps of load current in a 40°C ambient.

Using the same calculations, you can easily see how the actual maximum load-current rating of the SSR changes depending upon the impedance of the heat sink to which it's mounted. The SSR is still rated to 50 amps, but the maximum *allowable* rating can be quite different.

1.5°C/W heat sink; 100°C = 40°C + (Xamps x (**1.5°C/W** + 0.2°C/W)) = **35.3 Amps**
2.0°C/W heat sink; 100°C = 40°C + (Xamps x (**2.0°C/W** + 0.2°C/W)) = **27.3 Amps**
3.0°C/W heat sink; 100°C = 40°C + (Xamps x (**3.0°C/W** + 0.2°C/W)) = **18.8 Amps**
5.0°C/W heat sink; 100°C = 40°C + (Xamps x (**5.0°C/W** + 0.2°C/W)) = **11.5 Amps**

In addition to selecting an adequate heat sink, care must be given to the torque specifications for the SSR and the amount of thermal compound used in the assembly. Improper mounting torque, and too much or too little thermal compound can also result in a premature SSR failure.

The simplest method for determining the maximum load-current rating of a solid-state relay is to use a pre-assembled power controller solution from HBControls. Each power controller assembly is derated to provide the maximum allowable load current in a 40°C ambient temperature, eliminating the need to perform any thermal calculations or heat sink selection. Furthermore, since the SSRs are already assembled onto specific, custom-designed heat sinks, mounting torque and the application of thermal compound are no longer concerns.

For additional information or support, please visit us at www.hbcontrols.com or contact our support team @ 800.879.7918 / support@hbcontrols.com.