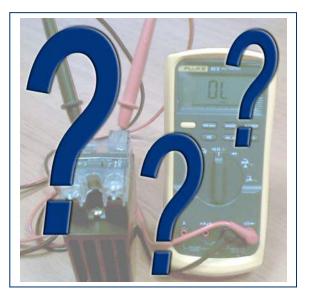## How to Bench Test a Solid State Relay

Many companies have processes in place to bench test products before they are released to production. In most cases these tests are very straight forward and simply verify the functionality of a component before it is installed in their equipment. However, even the most simplistic of test setups requires a basic understanding of how the component operates with regards to the function it is designed to perform. Otherwise the process is doomed to failure before it is ever implemented. Accordingly, how to bench test a solid state relay is one of the more common questions submitted to our technical support team.

Solid State Relays; Theory of Operation

For all practical purposes a solid state relays is basically nothing more than an electronic switch. And, as with any switch, it is used in systems where the user has a need to control the application and subsequent removal of power to an electric load. Therefore, they are often associated with more common mechanical devices, such as push button and toggle switches, and electromechanical relays (EMR). These types of switches have mechanical contacts that physically close or open when a "command" is given to the input (coil) or they are manually actuated. The functionality of such devices can be easily verified on a test bench with a simple digital multimeter. The impedance across their normally-open terminals will be very high (open circuit) in the off-state, and very low (short circuit) when it is actuated (or energized).

However, unlike mechanical / electromechanical relays, the output of a SSR contains no moving parts. Instead, two SCRs in inverse parallel, or "back to back", are used to switch load current. When an input signal is applied to the SSR, a small amount of current (150mA max, typically) flows from the AC mains, through the optical isolator (and trigger circuit, in some designs) and into the gate of the forward-biased SCR. This turns on the SCR and allows load current to flow for that half of the AC cycle. When the polarity of the AC mains reverses, the first SCR turns off
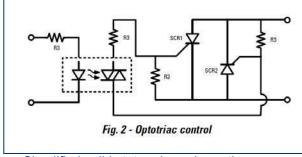
and the second one conducts load current for the next half of the AC cycle. This operation is continually repeated until the input signal is removed from the relay.

The absence of moving parts in a solid state relay is what makes them so advantageous over electromechanical relays. No moving parts mean that there is no bouncing or arcing of contacts every time the relay switches current to the load. Therefore, a typical solid state relay has a lifetime of 50x to 500x operations (or more!) than an equivalent rated EMR, depending upon application conditions and temperature gradients. Moreover, no moving parts mean no acoustical noise when the relay switches. This feature makes SSRs appealing to many engineers designing panels or equipment for use in residential or commercial applications.

However, no moving parts also means that a solid state relay cannot be bench tested with a multimeter in the same manner as an EMR or mechanical switch!

Fig. 2 - Optotriac control

Simplified solid state relay schematic

Bench Testing a Solid State Relay

A multimeter determines impedance by injecting a small amount of voltage through its probes into the circuit being tested. It then measures the current flowing through the probes and calculates resistance. Easy enough; Resistance = Voltage / Current!

However, as we just discussed above, a solid state relay's output turns on by "stealing" a bit of voltage from the AC mains in order to supply current to the gate of the SCRs. Simply put, if the AC mains is not connected to the relay then the output cannot turn on. Since the voltage and current produced by a multimeter is not sufficient enough to turn on the SCRs, the output of a solid state relay will remain in the off state; even with the input signal applied. As a result, SSRs will sometimes fail an incoming inspection because the engineer expects to see a significant change in the output impedance when they turn on the relay.

The most effective way to bench test a solid state relay is to construct a simple test circuit consisting of a DC power supply or battery (a 9Vdc battery will work fine in most cases) and a 60W or 100W light bulb. Fig. 1 below shows the basic wiring diagram for testing a DC input solid state relay. When the AC mains is applied to the output of the SSR, the light bulb should not illuminate. When S1 is actuated, the DC supply will energize the input of the SSR and the output will turn on, illuminating the light bulb. Opening S1 will again turn off the load. Note that the output of the SSR is

not polarity sensitive, so the load can be connected to either terminal #1 or #2.
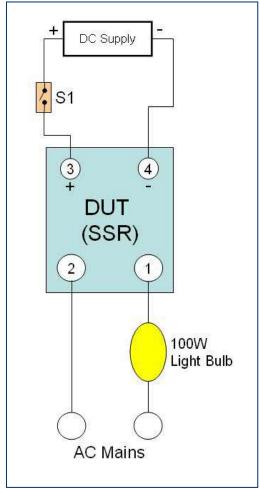

Fig 1; SSR bench test wiring diagram for a DC input / AC output SSR

"Since the voltage and current produced by a multimeter is not sufficient enough to turn on the SCRs, the output of a solid state relay will remain in the off state; even with the input signal applied."

The same test setup can also be used to verify the functionality of AC input SSRs. We only need to replace the DC source with a connection to the AC mains through S1, as shown in Fig. 2. As with the output, the input is not polarity sensitive. However, this setup can only be used where the AC mains voltage is less than the maximum input voltage rating of the solid state relay. Applying a voltage to the input that exceeds its maximum rating will damage the SSR.
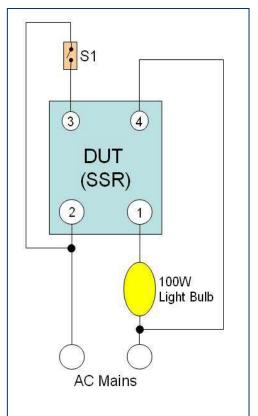

Fig 2; SSR bench test wiring diagram for an AC input / AC output SSR

It is also possible to use the test setup in Fig. 1 to evaluate the functionality of a DC output solid state relay. This can be done by using a second DC power supply to switch the output instead of the AC mains. However, the supply must be of sufficient voltage to illuminate a 40W or 60W light bulb (or lower wattage if the DC supply does not sufficiently illuminate the bulb). In most cases a 60Vdc supply capable of delivering 1 amp of load current will suffice. Also, unlike AC output SSRs, the output of a DC SSR is polarity sensitive. The "+" & "-" terminals of the power supply must be connected to the corresponding "+" & "-" of the SSRs output.

While a light bulb load provides an easy visual confirmation of the relay's operation, we must also consider that in some cases engineers might prefer to use a different type of load to bench test a solid state relay. In most cases this is not a problem as long as the voltage & current rating of the SSR is not exceeded. However, with DC SSRs we have to be a bit more careful. If the customer decides to use a motor, fan, EMR coil, or any other type of inductive load, then a suppression diode (such as a ON Semiconductor 1N4937RLG) must be placed in reverse-parallel with the load. This will prevent the back EMF from damaging the SSR when the load is de-energized.

More information can be found on this subject in the Tech Library section of the Crydom website.

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