

Application Notes

Featured Products: SR75 Series

Description:



Short Circuit Protected COTS Solid State Relays

Application note describing the application and technical benefits of the following features:

- Short Circuit and Overload Current Protection: prevents damage to system components, assemblies and system wiring from overload current or short circuit conditions
- Optical Isolation: isolates signals and logic circuits from load transients, and eliminates ground loops and signal ground noise
- Broad Switching Range: SR75-1- 60 Vdc @ 1.5 Adc, SR75-2- 300 Vdc @ 0.75 Adc or 120 Vrms @ 0.5 Amps
- Power FET Output: No voltage offset with a linear on-resistance for low voltage drop reducing power dissipation
- Low Off-State Leakage and High Dielectric Strength: for high off-state impedance and safety and protection of circuits

Introduction:

The SR75 is a DC solid state relay with built-in short circuit and overload current protection. The operating voltage range is from zero to 60 Vdc (SR75-1), zero to 300 Vdc or 120 Vrms AC (SR75-2) when connected with a diode bridge. This series provides protection of AC or DC loads against damage from overload currents. The SR75 offers protection against short circuit and overload currents by continuously monitoring the instantaneous load current and the output switch junction temperature. If either condition exceeds predetermined limits the relay will turn-off and remain off until it is reset by removing the overload condition and cycling the input control voltage. This action mimics a resettable circuit breaker but with a turn-off time of micro-seconds (ms) in the presence of short circuit currents. The SR75 can respond to large excess currents fast enough to prevent serious damage to the relay, system wiring, or other system components. This application note describes the operational considerations when using this relay and the technical benefits of the features offered.

Input/Control

The SR75 is an optically isolated solid state relay that uses light emitting diodes (LED's) to generate light. The light from the LEDs is detected by light sensitive devices creating a voltage that powers an isolated output switching device. The light generated from the LED is directly proportional to the current that flows through the LED. Figure 1 is a simplified functional diagram of an optically isolated solid state relay. This diagram shows the input drive and the output Field Effect Transistor (FET) switch. With optical isolation, loads can be connected to the output with no electrical reference to the input. The loads can float and be switched in the ground buss, the power buss or anywhere in between. Optical isolation prevents conduction of electrical noise from the output to the input which can cause false signals.

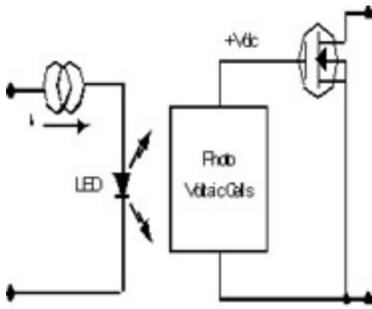


Figure1

The input LED is driven by a current source for consistency of the switch performance over temperature. Figure 2 is a family plot of the voltage current transfer characteristic curves for an LED shown at three different temperatures. If the drive source for the LED were a voltage source, and the LED were driven at 1.25 Vdc at 25_C, the current would be about 12.5 mA. Now if the temperature were to change to - 40_C and the drive voltage remained at 1.25 Vdc the LED current would change to about 5 mA. An additional change of temperature to 100_C would change the LED current to about 24 mA. This example illustrates how a change in operating temperature of the LED could cause large changes in the light emitted from the LED and the voltage generated for the output switch, affecting the FET turn-on characteristics. Attempting to overdrive the LED with a large input voltage/current to always ensure adequate drive to the output switch would then result in excessive power dissipation in the relay input circuit and would decrease the allowable power that could be used to drive the load.

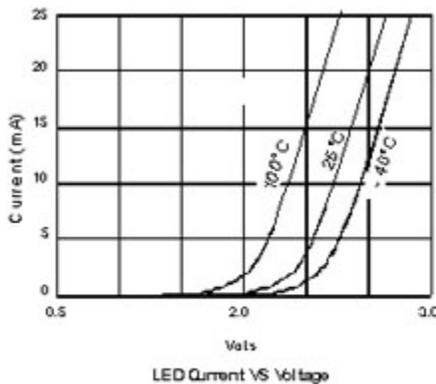


Figure2

If, however, the drive source for the LED were a current source, then voltage changes caused by temperature effects would reflect only small input drive demand as the temperature changed but the LED current would remain fixed. The input drive current would always be adequate and input power dissipation would be fixed and consistent with load requirements.

Teledyne's SR75 series is designed with a current regulator input drive circuit to optimize the relay operation over temperature. A plot of the input transfer function is shown in Figure 3. The current as a function of voltage rises quickly around 3.0 volts and is relatively flat as the voltage increases. For input voltages between 3.8 and 6.0 volts the relay can be driven directly from a voltage source (TTL) with no external components. If the input drive is greater than 6.0 Vdc, the current source would still maintain the LED current but power would increase rapidly as the input drive voltage increased. Since the power dissipated is

finite, the power consumed in the input must be subtracted from the allowable power switched in the load. Input drive voltages greater than 6.0 volts requires a series input resistor to limit the power dissipation on the input.

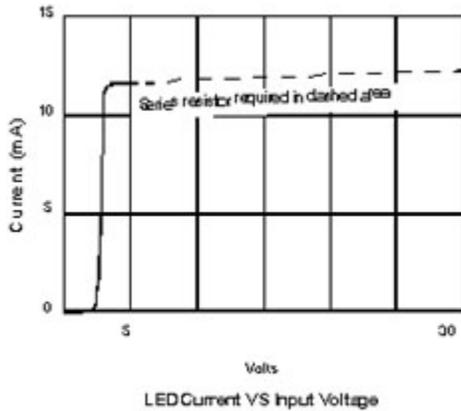


Figure 3

Figure 4 is a nomograph that allows quick determination of the value of the required series resistor when the input drive voltage exceeds 6.0 Volts. Alternatively, use the following formula to calculate the series resistor value:

$$R_s = (V - 6) / 11 \text{ mA}$$

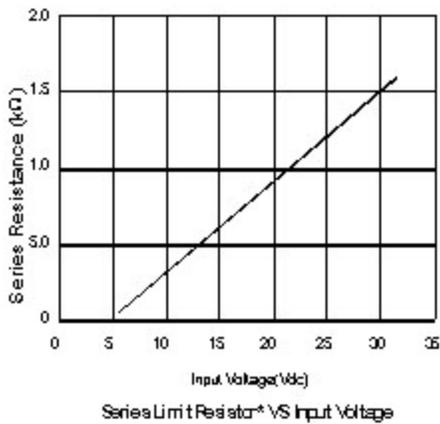


Figure 4

* Use the standard resistor value equal to or less than the value found in Fig.

Short Circuit Protection

The short circuit and overload current protection is implemented with a current sense and with a junction temperature monitor for maximum effectiveness. Figure 5 is a block diagram of the SR75-1 and the SR75-2 showing the protection circuit implementation.

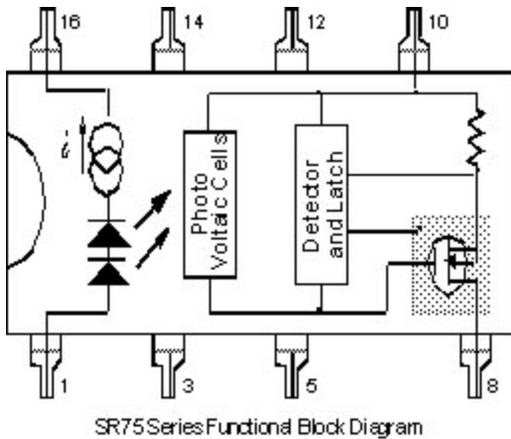
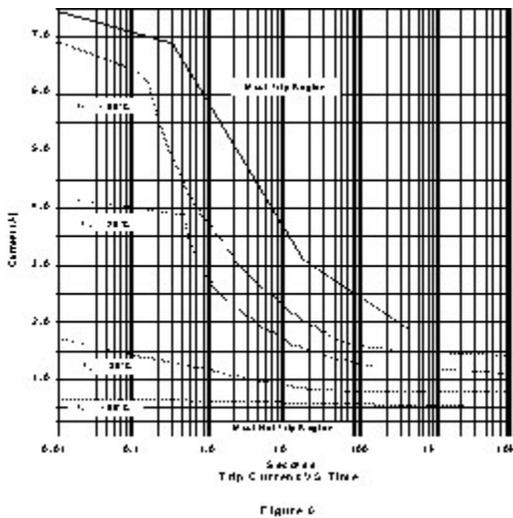


Figure 5

The instantaneous load current is monitored and the protection will be triggered if the load current exceeds a predetermined value for a specified time duration. The higher the current the shorter the time for the protection to be activated. Figure 6 is a plot of the overload current response transfer function.



This curve displays the current level and time duration that will trigger a turn-off from the overload circuit. It also shows different curves for 25_C, 85_C, 105_C and -55_C operations. The response is completely controlled by the current sense in the very short time response area. As time increases on the response curve, the importance of the junction temperature intensifies. This is true until in the area where time is long the response is equally controlled by the junction temperature measurement and the current monitor. When the junction temperature reaches a predetermined value the relay will turn-off. The trip point of the junction temperature is set such that it would only be reached if the output load conditions were abnormal. The trip point is low enough that there is a reasonable margin before electrical damage to the switch could occur. The curve in Figure 6 covers overload response times from 0.01 seconds to basically infinity. For very large short circuit currents different response curves apply.

There are two different conditions of short circuit current flow that can exist each with a different response. One condition is when the SR75 solid state relay is off and is turned on into a short with no current limiting. This condition is shown in Figure 7(a). The initial conditions for this response is that the voltage is set at 300 Vdc and is applied to the output. The relay is then turned-on with no limiting impedance. It takes the SR75

relay approximately 120 ms to respond to the short circuit current and turn-off. During that time the peak current rises to about 5.0 Amps. The turn-off after that is very quick (in the order of a few microseconds).

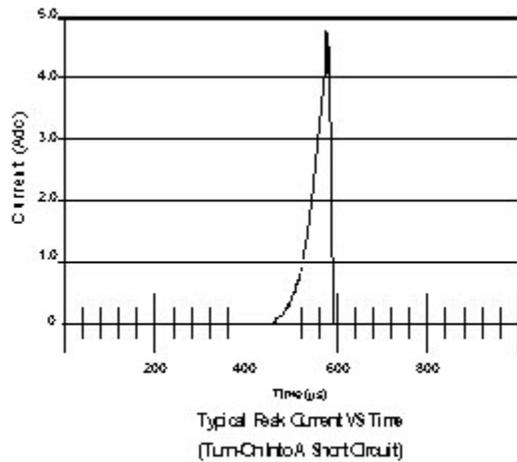


Figure 7(a)

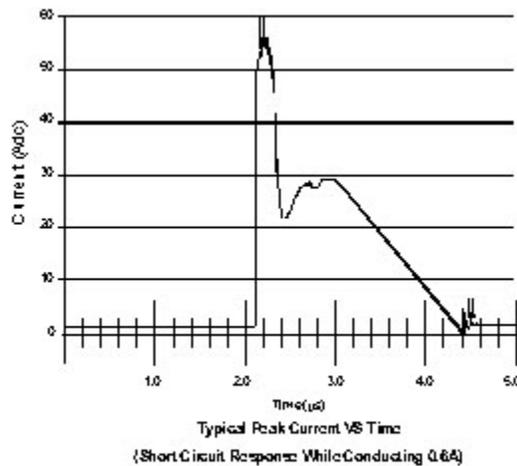


Figure 7(b)

The second condition for a short circuit current is where the SR75 series is on and is conducting up to the rated load current when a short circuit occurs. The transient response for this condition is shown in Figure 7(b). The initial conditions for this plot is 300 Vdc is switched directly across the output with no current limiting impedance while the SR75 is on and conducting 0.6 Adc. In the Figure 7(a) response, the peak current is in the area of 5 Adc. In the case of a short circuit occurring while the relay is conducting, the peak current is more than 10 times that value; but the time duration of the transient current is approximately 2 ms. Neither of these conditions will cause permanent damage to the SR75. Figures 7(a) and 7(b) data are intended to show typical response times and current magnitudes to instantaneous, short circuit currents. Actual responses would depend on circuit conditions, load parameters, current flow and applied voltage. When the SR75-1 or the SR75-2 detect a short circuit or current overload, a latch is triggered in the output drive circuit that turns the output FET off. The latch will remain set until the turn-on voltage to the output FET is removed. Removal of the input drive voltage will reset the latch off. Reapplying an input turn-on voltage will then turn the SR75 solid state relay back on.

Typical SR75-1, SR75-2 Applications:

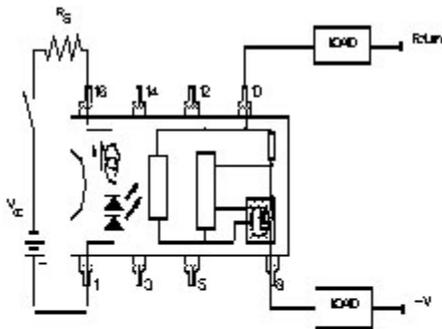
- Servo Systems
- Instrumentation
- Robots and Drones
- Control Systems
- Alarm/Warning Systems
- Liquid & Gas Pumps
- Thermal Control Systems
- Automated Test
- Light Control Systems
- Control Panels
- Programmable Controllers
- Defrosters
- Audio Visual Controls & Displays

Typical SR75-1, SR75-2 Loads:

- Motors DC or AC
- Transducers
- Solenoids
- Lights
- Relays
- Power FETs For DC or Bi-Directional Loads
- Heaters
- Power Triacs, or SCRs For AC Loads

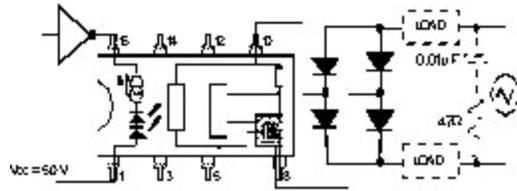
SR75 Series Wiring Configuration

Below are typical connections for interfacing the SR75-1 and the SR75-2 into either AC or DC Loads.



SHORT CIRCUIT PROTECTED DC LOADS (SR75-1, SR75-2)

- Diode suppression is required for individual loads
- Loads may be switched on either the high or the low side of the power source
- The SR75 may be driven directly from an open collector TTL gate or inverter



SHORT CIRCUIT PROTECTED AC LOADS (SR75-2)

- Diodes in the bridge circuit must have a minimum average current rating of 1.0A per diode and should have a peak transient current rating consistent with the diode current values shown in Figures 6 and 7.
- Loads may be switched in and out of the power source.
- The SR75-2 may be driven from an open collector TTL gate or inverter.

There are no electrical connections to pins 3, 5, 6, and 4. These pins are provided for mechanical support in high vibration environments and for conducting heat away when operating at maximum switching power.