# APPLE SOLID STATE RELAYS

## Principle of Operation

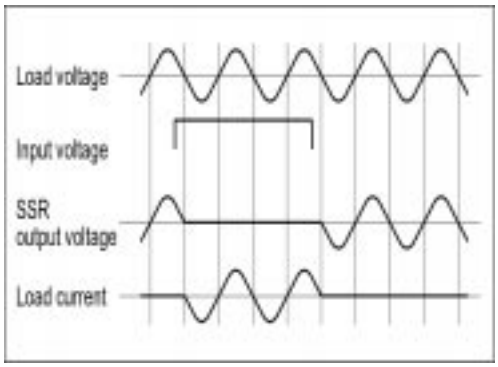
### SSR for AC Loads

### Zero-crossing SSR

The zero-crossing SSR uses a photo transistor or photo triac coupler to isolate the input from the output (see the circuit configuration on the previous page). When the input signal is activated, the internal zero-crossing detector circuit triggers the triac to turn on as the AC load voltage crosses zero.The load current is maintained by the triac's latching effect after the input signal is deactivated, until the triac is turned off when the load voltage crosses zero. The following describes voltage and current wave forms for ***different types of loads:***

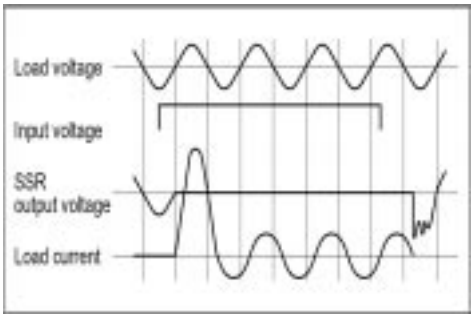
**• Resistive loads**

Since resistive loads cause no phase shift between the voltage and current, the triac turns on when the AC load voltage crosses zero after the input signal is activated. The SSR turns off when the AC load voltage crosses zero and the load current is turned off after the input signal is subsequently deactivated.




**• Inductive loads**

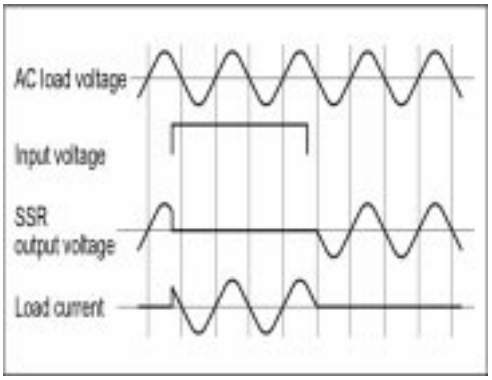
The SSR turns on when the load voltage crosses zero after the input signal is activated. It turns off when the load current subsequently crosses zero after the input signal is deactivated. A phase difference between the voltage and current may supply a transient spike to the SSR when it is turned off. While the snubber circuit absorbs this spike, an excessively large spike may result in a dv/dt error in the SSR's internal triac.




### Non zero-crossing SSR

The non zero-crossing SSR uses a phototriac coupler to isolate the input from the output. When the input signal is activated, the output immediately turns on, since there is no zero-crossing detector circuit. The load current is maintained by the triac's latching effect after the input signal is deactivated, until the AC load voltage crosses zero.

**• Resistive loads**




### SSR for DC Loads

The SSR for DC loads uses a phototransistor coupler to isolate the input from the output. The output immediately responds to the input, since the phototransistor coupler directly turns the output transistor ON or OFF.

MOSFET are other preferd switching device , which are in position to offer more VOLTAGE operations of DC & higher current upto 200VDC & 40ADC.
IGBT is another solution for higher voltages upto 1200 VDC & currents up to 100Amps.

### I/O Relays

Essentialy used to communicate from PLC based systems to outside loads (out modules), & from sensors such as microswitches , proximity sensors back to PLC ( Input modules)

***Input modules*** **(Types I-AC and I-DC)**
Interface SSRs have an input which is completely isolated from the output with a phototransistor coupler. This type of SSR outputs a logic signal that corresponds to the input signal. Two basic types are available:
an I-AC with an AC input, and an I-DC with a DC input.

***Output modules*** ***(Types O-AC and O-DC)***
The O-AC type output module employs a circuit configuration identical to that of the zero-crossing SSR for AC loads; the O-DC type output module employs a circuit configuration identical to that of the SSR for DC loads.

## SAFETY CONSIDERATIONS

### SAFETY WARNINGS:

>>Do not use the product under conditions that exceed the range of its specifications.It may cause overheating, smoke, or fire. Always design the SSR rating with guidlines from the LOAD charts.

>> Do not touch the recharging unit while the power is on. There is a danger of electrical shock. Be sure to turn off the power when performing mounting, maintenance, or repair operations on the relay (including connecting parts such as the terminal board and socket).

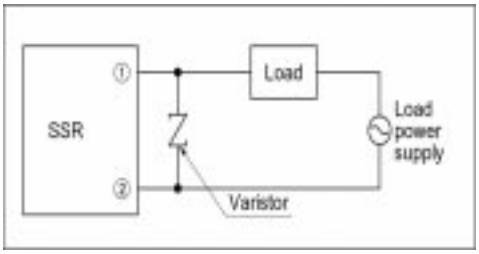
>> Check the connection diagrams in the catalog and be sure to connect the terminals correctly. Erroneous connections could lead to unexpected operating errors, overheating, or fire.

**>> When the input terminals are connected with reverse polarity**
Reversing the polarity will not cause damage to the device, due to the presence of a protection diode, but the device will not operate.

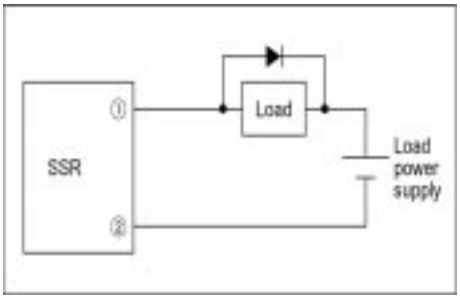
**>> In the case of operating voltage containing ripple** If the SSR control voltage contains ripple, the peak of the ripple should not exceed the maximum rated control voltage, and the bottom of the ripple should exceed the minimum rated control voltage.

## Cautions for Use of SSR

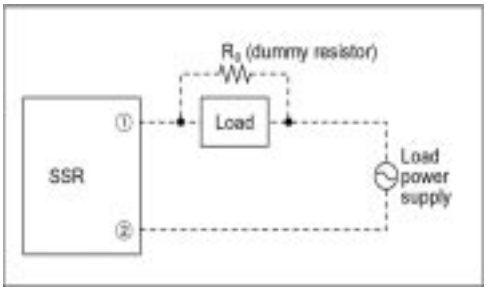
**1. Regarding output noise surge protection**
(1) AC Output Type
A high noise surge voltage applied to the SSR load circuit can cause malfunction or permanent damage to the device. If such a high surge is anticipated, use a varistor across the SSR output.



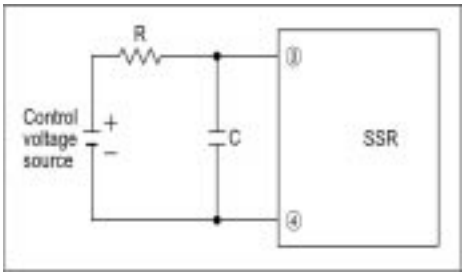

(2) DC Output Type
When the SSR is loaded with an inductive load, such as a solenoid contactor, motor, or solenoid valve, use a counter-EMF suppression diode across the load.




**2. When used for the load less than rated**
An SSR may malfunction if it is used below the specified load. In such an event, use a dummy resistor in parallel with the load.

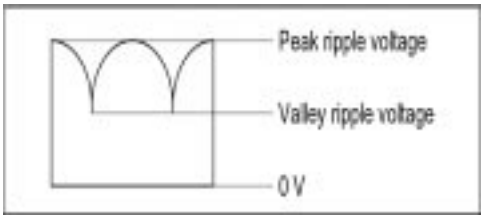



**3. Noise and surge protection at the input side**
A high noise surge voltage applied to the SSR input circuit can cause malfunction or permanent damage to the device. If such a high surge is anticipated, use C or R noise absorber in the input circuit.




**4. When the input terminals are connected with reverse polarity**
Reversing the polarity will not cause damage to the device, due to the presence of a protection diode, but the device will not operate.

**5. In the case of operating voltage containing ripple**
If the SSR control voltage contains ripple, the peak of the ripple should not exceed the maximum rated control voltage, and the bottom of the ripple should exceed the minimum rated control voltage.




**6. Others**

(1) If an SSR is used in close proximity to another SSR or heat-generating device, its ambient temperature may exceed the allowable level. Carefully plan SSR layout and ventilation.
(2) Soldering to SSR terminals should be completed within 5 seconds at 260 Deg. C.
(3) Terminal connections should be made by referring to the associated wiring diagram.
(4) For higher reliability, check device quality under actual operating conditions.
(5) Heat sink paste is necessary in case of Higher current SSR , while mounting on the Bigger heat sinks (refer Heat sink designing)
(6) Proper tightning of the Heat sink mounting screws is necessary. Heat sink Paste & proper tightning ensures the proper heat transfer to the ambient. This could be the main cause of failure for long run.

## Snubber Circuit

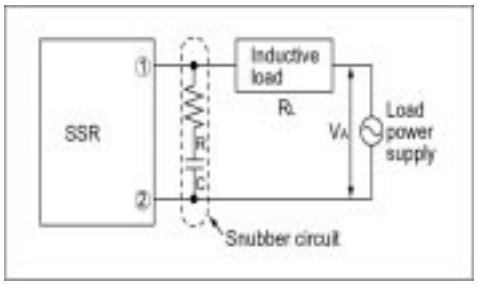
**1. Reduce dv/dt**
An SSR used with an inductive load can accidentally fire due to a high load voltage rise rate (dv/dt), even though the load voltage is below the allowable level (inductive load firing).
Our SSRs contain a snubber circuit designed to reduce dv/dt. But for heavy Inductive Loads external Snubbers could be added

**2. Selecting the snubber constants**
**1) C selection**
The charging coefficient tau for C of the SSR circuit is shown in formula ( i )

$$t = (R_L + R) * C \quad \text{---------- ( i )}$$

$$(C * t) / (R_L + R) = (0.632 * V_A) / ((dv/dt) * (R_L + R)) \quad \text{---------- ( ii )}$$

By setting C = 0.1 to 0.2 F, dv/dt can be controlled to between nV/ ms and n+V / ms or lower. For the condenser, use either an MP condenser metallized polyester film.
For the 100 V line, use a voltage between 250 and 400 V, and for the 200 V line, use a voltage between 400 and 600 V.




**2) R selection**
If there is no resistance R (the resistance R controls the discharge current from condenser C), at turn-on of the SSR, there will be a sharp rise in dv/dt and the high peak value discharge current will begin to flow. This may cause damage to the internal elements of the SSR.
Therefore, it is always necessary to insert a resistance R. In normal applications, for the 100 V line, have R = 10 to 100 W and for the 250 V line, have R = 50 to 150 W .
The allowable discharge current at turn-on will differ depending on the internal elements of the SSR.)
( The power loss from R, written as P, caused by the discharge current and charging current from C, is shown in formula (iii) below:
For the 100 V line, use a power of 1/2 W, and for the 200 V line, use a power above 2 W.

$$P = (C * (V_A)^2 * f) / 2 \quad \text{---------- (iii)}$$

f = Power supply frequency

Also, at turn-off of the SSR, a ringing circuit is formed with the capacitor C and the circuit inductance L, and a spike voltage is generated at both terminals of the SSR. The resistance R serves as a control resistance to prevent this ringing. Moreover, a good non-inductive resistance for R is required. Carbon film resistors or metal film resistors are often used.For general applications, the recommended values are C = 0.1m F and R = 20 to 100 W . There are cases of resonance in the inductive load, so the appropriate care must be taken when making your selections.

## Protection Circuit

High-reliability SSR circuits require an adequate protection circuit, as well as careful study of the characteristics and maximum ratings of the device.

**1. Over-Voltage Protection**

The SSR load power supply requires adequate protection against over-voltage errors from various causes. The methods of over-voltage protection include the following:

(1) Use devices with a guaranteed reverse surge withstand voltage (controlled avalanche devices, etc.)

(2) Suppress transient spikes

Use a switching device in the secondary circuit of a transformer or use a switch with a slow opening speed.

(3) Use a surge absorption circuit

Use a CR surge absorber or varistor across the load power supply or SSR.

Special care must be taken so power on/off surges or external surges do not exceed the device's rated load voltage. If a surge voltage exceeding the device's rated voltage is anticipated, use a surge absorption device and circuit (e.g. a ZNR from Matsushita Electronic Components).

Choosing the Rated Voltage of the ZNR

(1) Peak supply voltage

(2) Supply voltage variation

(3) Degradation of ZNR characteristic (1 mA ± 10%)

(4) Tolerance of rated voltage (10%)

For application to 100 V AC lines, choose a ZNR with the following rated voltage:

**2. Over-Current Protection**

An SSR circuit operated without over-current protection may result in damage to the device. Design the circuit so the device's rated junction temperature is not exceeded for a continuous overload current. (e.g. Surge current into a motor or light bulb)

The surge-on current rating applies to over-current errors which occur less than several tens of times during the service life of a semiconductor device. A protection coordination device is required for this rating.

Methods of over-current protection include the following:

(1) Suppressing over-currents

Use a current limiting reactor in series with the load power supply.

(2) Use a current shut-off device

Use a current limiting fuse or circuit breaker in series with the load power supply.

Refer Other SSR documents

1. Load selection criteria
2. Heat sink calculation ,

## SSR I/O modules

**16 and 8 Channel Models Direct Connection to the Digital I/O Plug-in Boards On-Board Buffers Powered by 5 Vdc**