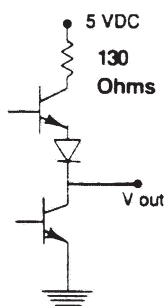
One of the primary advantages of SSR's and I/O modules is their compatibility with low-level, solid state logic. Any logic gate, buffered or not, capable of delivering the required current and voltage within its maximum power dissipation rating can be used to control an SSR or I/O module.

Many TTL gates, for example will safely dissipate 40 mW or more; and the total package will dissipate up to one watt. This gate power must not be confused with relay input power. Whereas a SSR whose input requires 11 mA at 5V DC consumes 55 mW of power, the TTL gate sinking this 11 mA may have a voltage drop of only 0.2 volt, and power consumption of just 2.2 mW.

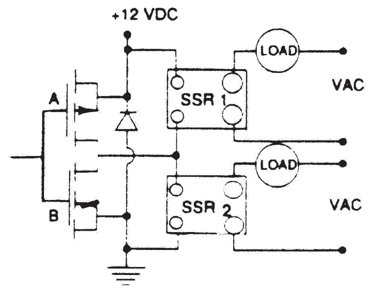
TTL gates can only sink relay input current, not source it. This is because as shown, the sourcing transistor has a pullup resistance in its collector circuit. Pulling 11 mA through this resistance, in this case 130 Ohms, would leave insufficient input voltage to operate the relay. For example, a SSR requiring a nominal 5VDC may not operate on less than 4 volts. Typically, the drop across the transistor



and diode at 11 mA would approximate 0.8 volt; and the drop across 130 Ohms is 1.4 volt. This 2.2 volt drop would leave only about 1.8 volts for the relay to operate, not enough for relay turn-on.

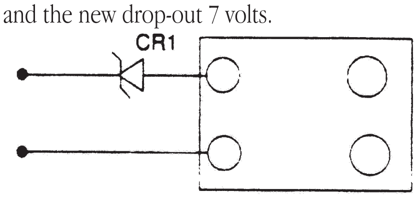
Since TTL gates can only sink current to the relay, and since current sinking is done from a "zero" logic signal, the relay can only be turned on from a "zero" signal. This is contrary to normal relay operation, which prefers that the relay be turned on as a result of a "one" signal. To obtain relay actuation from a logical "one" signal, it is necessary to use an inverting gate. With such a gate, when a "one" signal is received, the sink transistor will turn on and conduct relay input current.

CMOS gates can both source and sink current. As shown, a single gate may even be used to drive two Solid State Relays.

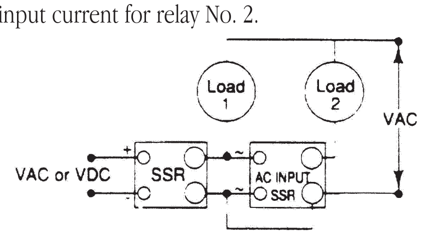


When sourcing transistor A is on, it conducts current to SSR2. When sinking transistor B is on, it conducts to SSR1.

By using a zener diode in series with the input, the pick up and drop-out voltage of a Solid State Relay or an I/O Module can be increased by the value of the zener. For example, a typical SSR has a maximum pick-up voltage of 3 VDC and a minimum drop-out of 1 VDC. By adding a 6 volt zener as shown, the new pick-up will be 9 volts and the new drop-out 7 volts.



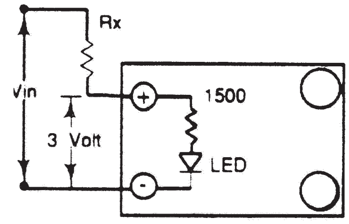
Two SPST AC SSR's controlled from a single DC source, can be connected to operate as a SPDT relay to switch AC power to either of two loads. Note that one of the SSR's must be an AC input type. Because of overlap (make-before break), the power source must be capable of supporting both loads for approximately two cycles. Offstate leakage in load No. 1 will be equal to the off-state leakage of relay No. 1 plus the input current for relay No. 2.



All WRC Solid State Relays with DC input and AC output have a control circuit consisting of 1500 Ohms in series with the Opto-coupler LED. At 3 Volt input the relay will turn on with 1.33 mA (3 volts-1 volt dropped across the LED = 2 Volts / 1500 Ohms = 1.33 mA).

$$\frac{\text{Input voltage} - 1}{1500} = \text{Input Current (Amps)}$$

At higher voltages obviously, the current will be correspondingly higher. Since no more than 1.4 mA are required to turn on the relay and increasing the input voltage will unnecessarily increase this current, an external resistor can be added in series with the input, creating a voltage divider, so that the voltage seen at the input will be approximately 3 volts.



$$Rx = \frac{(Vin - 3)}{.0014}$$

If odd value, pick the next lower resistance value then calculate wattage required as:

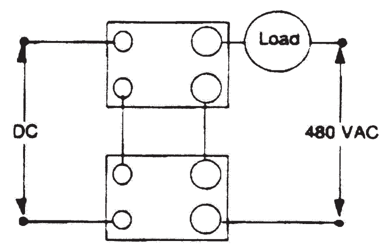
$$W = \frac{(Vin-3)2}{Rx}$$

Under all conditions, the SSR will draw:

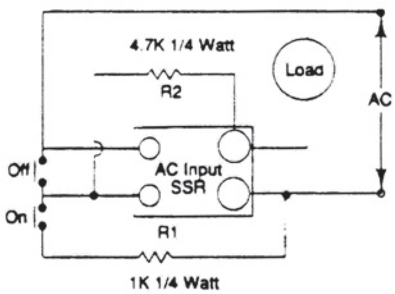
$$Amps = \frac{(Vin - 1)}{Rx + 1500}$$

Example: For a 60 VDC input, you will need an external resistor Rx=(60-3)/.0014= 40,7140hms. Using the next lower standard value of 40K, the wattage will be $(60\ 8)^2/40{,}000$=.08 watts.

If a higher voltage is required, two Solid State Relays can be connected with their outputs in series and their inputs either in series or parallel, for example if two 25 Amp SSR's with 600 P.I.V. rating are connected in series they will have a rating of 25 Amps and a Peak Inverse Voltage capability of 1200V, quite suitable for 480VAC ($680V_{PEAK}$) operation.



An AC SSR can be made to self latch (at the sacrifice of input-output isolation), thus pemmitting the use of momentary action switches for on/ off or stop/start operation. It may be necessary to insert an RC filter across the relay input to prevent the relay from turning on due to switching transients upon application of system power. Note that the SSR employed here must be an AC input type.



Transformer loads can have **severe in-rush current** problems depending on the state of the transformer flux at turn-off. The in-rush current is created when the transformer saturates during the first half of the next applied voltage cycle. A relay must be selected to handle the surge current for 1/2 cycle. As a rule of thumb, the relay should have a 1/2 cycle surge current rating greater than the maximum applied line voltage divided by the transformer primary resistance. (Roughly 12 times the rated current).

Recommended Transformer Loads

SSR Rating	at 120VAC	at 240VAC
10A	200VA	400VA
25A	400VA	800VA
40A	600VA	1.2KVA
75A	1 KVA	2KVA

Solid State Relays are well suited for driving heaters, however, in some temperature control applications the load is rapidly and almost continuously switched on and off, creating a severe thermal stress on the the SCR chips. In those cases it is recommended to use the SSR at no more than 75% of rating.

Recommended Heater Loads

SSR Rating	at 120VAC	at 240VAC
10A	900W	1.8KW
25A	2.0KW	4.0KW
40A	3.6KW	7.2KW
75A	6.5KW	13 KW

All of WRC's Power SSR's use high noise immunity circuitry in addition to a snubber network to handle the electrical noise generated by inductive loads.

Recommended Solenoid Loads

SSR Rating	at 120VAC	at 240VAC
10A	900W	1.8KW
25A	2.1 KW	4.2KW
40A	3.6KW	7.2KW
75A	6.5KW	13 KW

Since all of our SSR's are zero voltage switched, they are the ideal device for driving incandescent lamps. An electro-mechanical relay can turn on a lamp at any point of the AC cycle, causing a large in-rush of current through the cold filament. A zero switched SSR will instead drive the lamp with a gradually increasing current, reducing the in rush current and prolonging lamp life.

Recommended Lamp Loads

SSR Rating	at 120VAC	at 240VAC
10A	1 KW	2KW
25A	2KW	4KW
40A	3KW	6KW
75A	5.5KW	11 KW

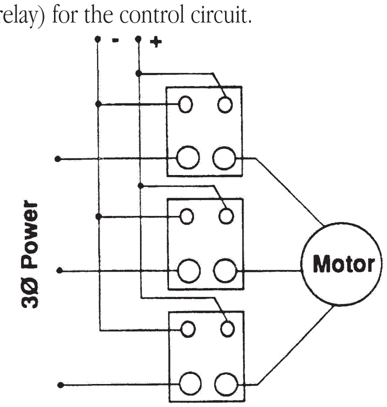
CAUTION: *Using SSRs for driving mercury, fluorescent, or HID lamps should be avoided. If they must be used, the SSR must be severly derated and thoroughly tested in the specific application.*

The following table gives guidelines for selecting relays for single phase non-reversing motors. *Driving reversing motors is not recommended due to the potentially destructive voltage doubling and capacitive discharge that they create.*

Recommended Loads

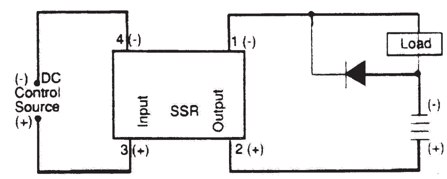
SSR Rating	at 1 20VAC	at 240VAC
4A	2A	2A
10A	1/4 Hp	1/3 Hp
25A	1/3 Hp	1/2 Hp
40A	3/4 Hp	1-1/2 Hp
75A	1-1/4Hp	3 Hp

Three phase motors can be controlled as shown. Note that only two SSR's are required, the third is optional. The inputs are shown in a parallel arrangement, but they can also be connected in series as long as at least 9VDC is available (3VDC/relay) for the control circuit.



Screws are prevented from self-loosening by design. The automatic progressive locking principle generates an increasing thread friction as the screw is tightened. Repeated tightening and loosening does not cause fatigue of the locking components. Recommended torque is 5-7 in/lbs. Care should be taken not to overtighten screws.

Most loads are inductive, even ones that are not so labeled. An inductive load will produce harmful transient voltages when it is turned off. Power MOSFET outputs can be susceptible to the transient voltages produced by seemingly "non-inductive" loads and can be damaged if not properly protected. A protection diode across the load is recommended.



Input and output polarity must be observed. Inductive loads must be diode suppressed.

The diode used should be of the fast-recovery type with a reverse voltage rating at least equal to the supply voltage. Examples of fast-recovery diodes that may be used for transient suppression:

RELAY MODEL	MOTOROLA DIODES	GE DIODES
RSDC	MR851	A11 5A

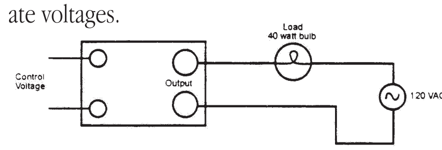
These diodes are suitable for most applications. For fast repetition rates consult factory for further information.

WRC Solid State Relays and Input/Output Modules can (as is possible with any electronic component) fail without warning.

For this reason WRC cannot recommend, condone or warrant any application of our products that could cause harm or injury, in any manner, to any person upon such failure of the product.

Please contact the factory if you have any doubts or questions as to whether this caution applies to your application.

A solid state relay can be quickly and easily tested. To evaluate whether or not it is operative, connect the relay as follows using the appropriate voltages.



The lamp bulb should not turn "On" until the control voltage is applied (and "Off" when control voltage is removed). If the lamp comes "On" with no control voltage, the output is shorted.

Shown is an AC output solid state relay. DC units can be checked the same way with appropriate DC voltages and load.

Adequate heatsinking, including consideration of air temperature and flow, is essential to the proper operation of a solid state relay. Units should not be mounted in an enclosed area without proper air flow. Units should also never be mounted to a plastic base or to painted surfaces. Failure to provide adequate heatsinking will cause a solid state relay to fail. We recommend mounting our units on the heatsinks listed in this catalog. However, when this is not possible, and units are to be mounted to some other heatsinking object, material heat conductivity should be kept in mind. Our heatsinks are 1/8" thick and provide adequate heat dissipation given proper ventilation and ambient temperature. In comparison, twice the amount of steel and four times the amount of stainless steel would be needed to achieve the same effect.

Using electromechanical relays in conjunction with solid state relays is not recommended. Electromechanical relays produce a significant amount of electrical noise which could cause a solid state relay to mistrigger. If these two types of relays are used together, surge voltage protection is required.

When using either Ring or Spade type terminals with the S505, SS- or RSDC lines, do not use the Saddle Clamps that are provided. It is sufficient to secure the Ring or Spade **type connectors** with the enclosed screws.

All solid-state **relays have** an 1^2T rating. This rating is the bench mark for their ability to handle a shorted output condition. WRC advocates circuit protection through the use of a properly selected 1^2T (semiconductor fuse).

Devices such as electromechanical circuit breakers and slow blow fuses **cannot react quickly** enough to protect the SSR in a shorted condition and are not recommended!! Fast blow type fuses may be appropriate for some applications.

For Fuses I^2t is the measure of let-through energy in terms of current versus time. For solid state relays, I^2t is based directly on the output thrysistor's single-cycle peak surge current determined by:

$$I^2t \left(\frac{I^2pk(surge)}{2} \right) .0083 \text{ (seconds)}$$

The procedure is to select a fuse with an I^2 let-through rating that is less than the I^2t capability of the solid state relay for the same duration.

System designers who are considering using I^2t fuses should consult a good technical manual dealing with the application of I^2t's when designing their systems. Eg: Littlefuse's semiconductor fuse catalog.

The WRC 3-Phase solid state relay is designed for switching power to 3-phased asynchronous motors and to resistive loads. For guidance in its application, refer to the following notes:

(380 Volt. 50/60 HZ Motors - Direct Start)	Motor Size (KW)	Start Current (ARMS)	Operabng Current (ARMS)
2-Pole- 3000 RPM	3	43.4	6.2
4-Pole- 1500 RPM	3	38.0	6.9
6-Pole- 1000 RPM	4	47.7	9.0
8-Pole - 750 RPM	3	36.6	8.7
(220 Volt. 50/60 HZ Motors - Direct Start)			
2-Pole - 3000 RPM	2.2	45.0	7.0

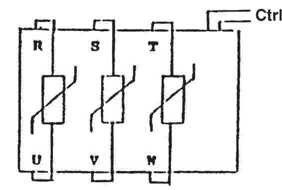
The relay can be short-circuit protected with an appropriate semiconductor fuse. The load integral of the relay (I^2t) determines which size of fuse is to be used. The relay load integral of the 3-phase relay is 1,035 A^2 Sec. The fuse load integral must be below that of the relay for the appropriate protection. Be certain to analyze the fuse currenVtime curve to insure that the fuse can withstand the motor starting current (if applicable).

NOTE: Overload protection should be provided by another slow-acting fuse in series with the short circuit protection fuse. (An overload being an over-current condition that is not of high enough amplitude to be considered a short circuit).

There is a possibility that an overload condition could occur that is not of sufficient magnitude to open the overload fuse, but can overheat the relay, creating a constant "on" status.

To protect the load from damage in this event, it is necessary to insert some type of upper-limit device (e.g. thermal) in series with the relay output to cause discontinuance of current to the load. Additionally, it is advisable to have a mechanical disconnect in the load circuit for service purposes.

When operating the relay in an electrically noisy environment, large voltage transients may damage the relay. To protect against this occurrence, it is advisable to install appropriate varistors across the respective supply and load terminals of the relay output.



In the event that a load completely or partially short circuits, the following table indicates the absolute maximum current that the relay can withstand for various time limits:

Time (Sec)	Current (ARMS)	Time (Sec)	Current (ARMS)
.2	275	8.0	80
.4	228	10.0	75
.6	188	12.0	72
.8	161	14.0	71
1.0	150	16.0	70
2.0	124	18.0	69
4.0	95	20.0	67
6.0	86	40.0	58