

## DC Output Solid State Relays

### Introduction

DC output solid state relays are being used more and more widely. One of the major reasons for the use of solid state relays for switching dc is the fact that as there are no moving parts there is no contact arcing or wear out mechanism. However, there are some precautions which have to be taken when using solid state relays with inductive dc loads.

### Relay Connections

Because the input and output terminals of dc solid state relays are electrically isolated by up to 3,750 Vrms the relative positions of the input signal and load connections are irrelevant. As shown in Fig 1, the input can be supplied either from a source or sink configuration and the load can be connected to either the relay positive or negative output terminals. The solid state relay can be used as a level shifter because no electrical relationship is required between the control and power output sections of the relay.

### Inductive Load Considerations

When a DC load is inductive, special precautions have to be taken to protect the solid state relay at turn off. Energy is stored in the magnetic flux created by the current flowing through the inductive load. When the solid state relay is turned off the collapse of the magnetic flux creates an electro-magnetic force with a polarity that tries to maintain the pre-existing current flow. This is shown schematically in Fig 2.

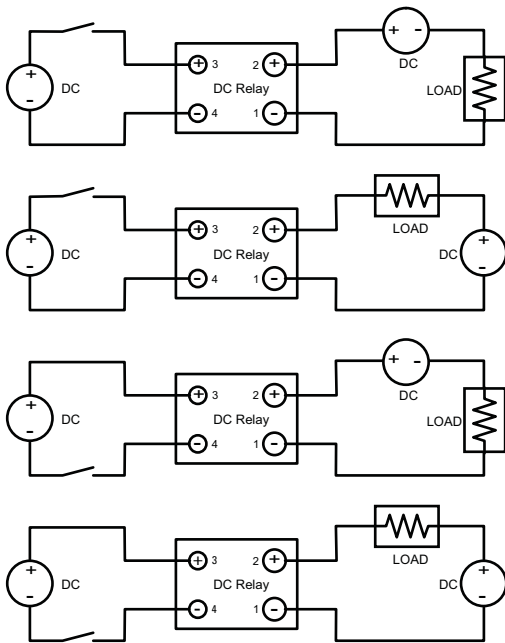


Fig. 1 - Connecting Solid State Relays

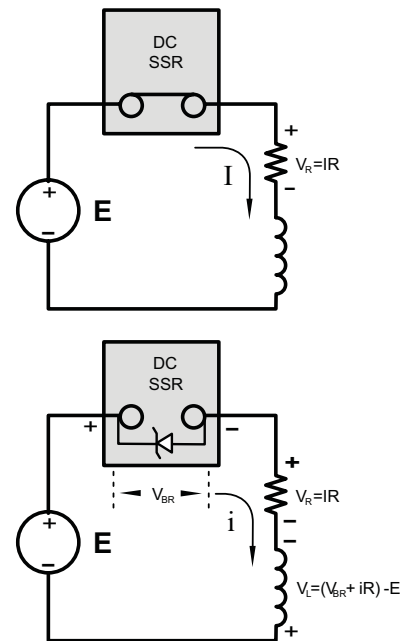


Fig. 2

If no electrical path is provided for the inductive load current to flow, the collapse of magnetic flux will generate a voltage high enough to break over any limiting voltage element in the circuit, one element is usually the solid state relay, shown schematically as  $V_{BR}$ . In the case of a solid state relay, either the output power semiconductor device or one of the driving semiconductors will be broken over into conduction. In many cases this break over will permanently damage the semiconductor resulting in a relay with a permanently shorted output.

It is fairly straightforward to provide a circulating path for the inductive current in most circuits. This is usually accomplished by the addition of a freewheel diode as shown in Fig A.

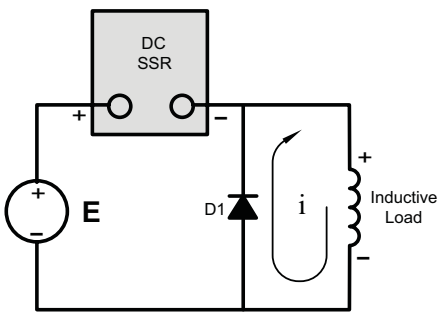


Fig A

Unless the solid state relay is to be turned on while current is still flowing in the freewheel diode, the diode can be a standard recovery type. If, however, the solid state relay can be turned on before the load current has been completely discharged, then a fast recovery diode must be used in the freewheel position. The use of a fast recovery diode reduces the instantaneous inrush current amplitude and duration when the relay is turned on into an existing freewheel diode current.

In some applications it is necessary to discharge the inductive current rapidly (for example to open a solenoid as quickly as possible). If rapid current discharge is a requirement, then, the discharge path must be designed to require a high voltage to be generated. This follows from the fact  $E = L di/dt$ , where  $E$  is the voltage generated by the collapse of magnetic flux,  $L$  is the inductance of the load and  $di/dt$  is the rate of change of current. Obviously for a fixed value of  $L$  the greater the value of  $E$ , then the greater the  $di/dt$  and the more rapidly the load current is reduced to zero. Increasing the voltage which has to be generated to create a freewheel path can be accomplished by changing the standard diode shown in Fig 3(a) to a zener or TVS diode as shown in Fig 3(b).

It must be recognized that the voltage appearing across the solid state relay is the sum of the supply voltage and the zener or TVS diode voltage. So for a system using a 48 Vdc supply and a 100 volt rated solid state relay, the voltage across the freewheel components cannot be greater than 52volts at maximum load current.

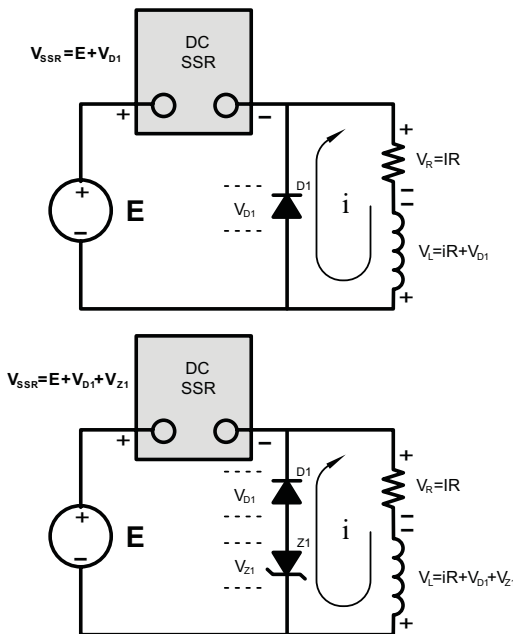


Fig 3 (a - b)

An alternate method to create the same inductor voltage is to connect the zener or TVS diode across the output terminals of the solid state relay, as shown in figure 3(c), in this case the clamping voltage can be 100 volts.

However, as this voltage is in series with the 48 Vdc supply the end result is the same as putting the clamping component across the load, a voltage of 52 volts has to be generated by the inductive load.

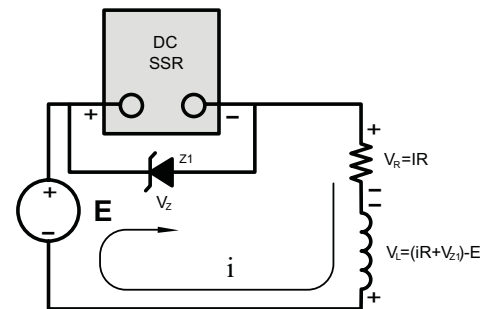


Fig 3 (c)

Conclusion

DC output solid state relays give designers a great deal of flexibility in the relative connections of control and load voltages.

Care must be taken when a solid state relay is used to control and inductive load, to ensure that at turn off, the voltage rating of the solid state relay is not exceeded. This is normally accomplished by the use of a freewheel diode but in some circumstances it is necessary to force the load to generate a high voltage for rapid discharge of the load current. In these cases a zener or TVS diode is used to increase the voltage necessary to provide the inductive load with a freewheel path.