

## Application Note: Relay Selection and Design

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A solid state relay is a means to controlling the signal path of a large signal with a very small signal, such as an output signal from a microcontroller. This achieves the same purpose as an electromechanical relay; however there are some functional differences. Knowing these differences and thinking about the requirements of a circuit will help in selecting the appropriate relay type.

### Electromechanical Relays

The electromechanical relay relies on the magnetic field generated from a control signal's current going through a coil, which pulls on a magnetic lever that makes a connection between separate electrical contacts. This type of relay will only activate when the magnetic field from the coil is strong enough, meaning that there is a minimum amount of current required from the control signal. Typical non-ideal resistances in the coil can sometimes be as high as  $1\text{k}\Omega$  or more, leading to at least  $12\text{mA}$  needed to turn on the relay if the specified turn-on voltage was  $12\text{V}$ .

If a microcontroller were used to supply the control signal, one would have to make sure that the minimum output current the microcontroller can supply can meet these requirements; sometimes, as with ultra-low power microcontrollers, this is not the case. This can be alleviated with a simple transistor current buffer, as shown below in Figure 1. When the base of the transistor receives the output current of the microcontroller, the transistor saturates and provides a path for current to flow from another supply source through the coil.

There are a few considerations to make when using this type of setup. First of all, an appropriate relay must be chosen for the load. If the load requires  $10\text{A}$  of current, then the contact ratings for the relay should be rated at least that much. Coil limitations must also be taken into consideration, where excessive coil resistance should be accounted for in buffer design. If the relay needs a significant amount of current, a larger buffer transistor may be needed.

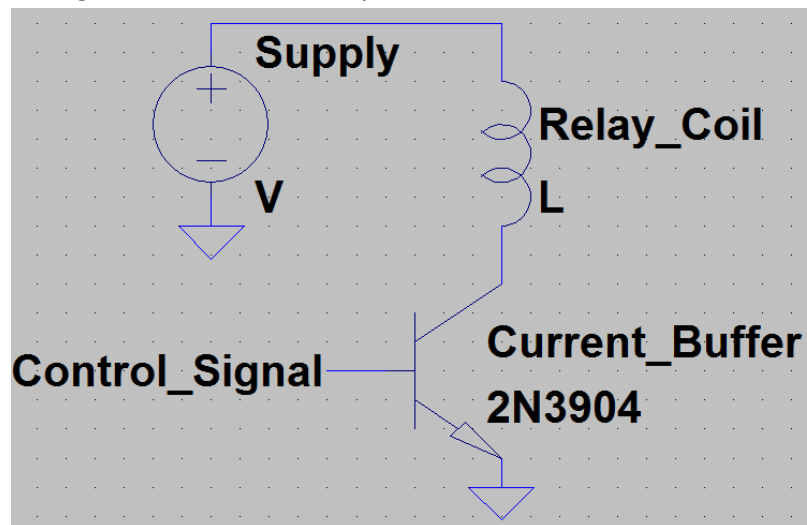


Figure 1. Simple current buffer circuit

## Solid State Relays

The solid state relay achieves the switching motion in a different way. The basic schematic for a solid state relay is shown below in Figure 2. First, a control signal is fed into a photocoupler that consists of an LED and a stack of photovoltaic diodes. These photovoltaic diodes act like a solar cell; converting light energy from the lit LED on the control side into a voltage potential. This voltage potential is used to drive the gates of two MOSFETs. The drain and source of each of these MOSFETs are then used as paths for current for higher-power systems.

There are two MOSFETs in this design to allow for bi-directional current flow. If there were only one MOSFET, then current could flow through it can only be controlled from drain to source. This is because of the protection diodes that are typically installed in MOSFETs; these protection diodes are off when current flows from drain to source, but turn into a short circuit around the MOSFET when current flows from source to drain. This means that current flow can be controlled in one direction, but not the other. If two MOSFETs are placed with their sources connected, current through them can be controlled in either direction.

There are some limits to consider when using the solid state relay as well. When choosing which photocoupler to use, it is important to note the turn-on voltage of the LED within; if the control voltage cannot overcome this voltage, then the photovoltaic cells will not activate and neither will the MOSFETs. Photocouplers such as these typically have varying output voltages that depend on the amount of input current through the LED; the datasheet should supply these plots. One should also be careful of which MOSFETs are chosen. Some of the most important factors to consider when choosing MOSFETs are threshold voltage and power dissipation. The threshold voltage should be lower than the output voltage of the photocoupler; otherwise the MOSFETs will not turn on when prompted. Power dissipation ratings are also critical, as the MOSFET may become damaged if it was not designed to handle the voltage and current desired by the relay load.

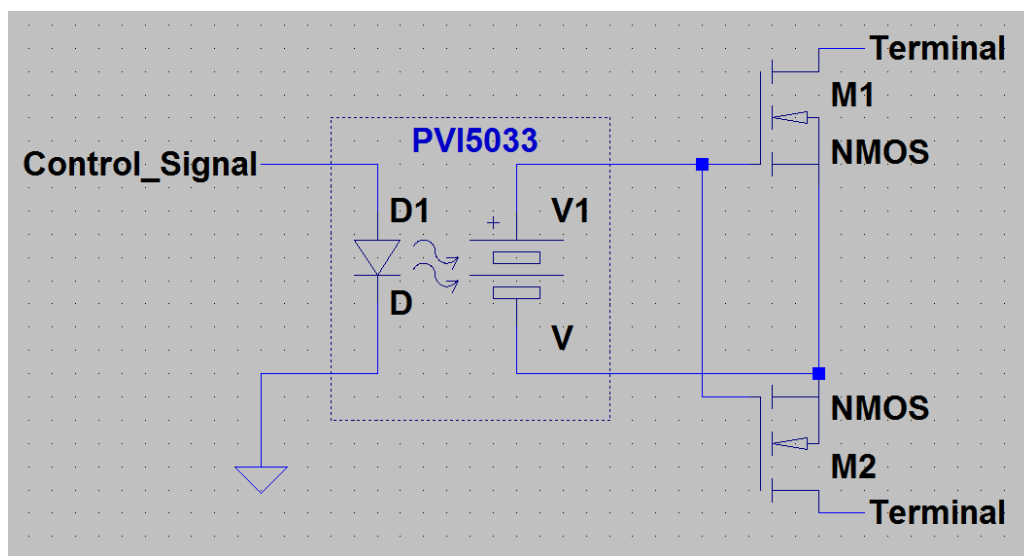


**Figure 2.** Solid state relay circuit