Electrical Relays 101

Electrical relays are used extensively in modern buses, trucks, and cars. In addition, they are used for energizing large AC loads in factories. They can be used for an amazing number of applications. For example, I wrote an article on trailer wiring conversions (5 wire to 4 wire and 24V to 12V) for the March 2009 Bus Conversions Magazine. It made use of relays to manufacture a robust system. I am preparing an article on upgrading headlights on buses and it will discuss using relays to improve the headlight system. With that in mind, let's jump right in and talk about these wonderful devices.

JIM SHEPHERD

WHAT IS A RELAY?

Simply stated, a relay is a switch. Unlike the switch on the wall that you use to turn on lights, a relay uses an electronic signal to turn on the switch. The fundamental concept of a relay is to be able to switch relatively high current circuits with a very low current signal. For example the Mini ISO cube relay (Fig. 1) requires less than 1/2 amp (12V) to switch a circuit capable of transmitting 30 amps.

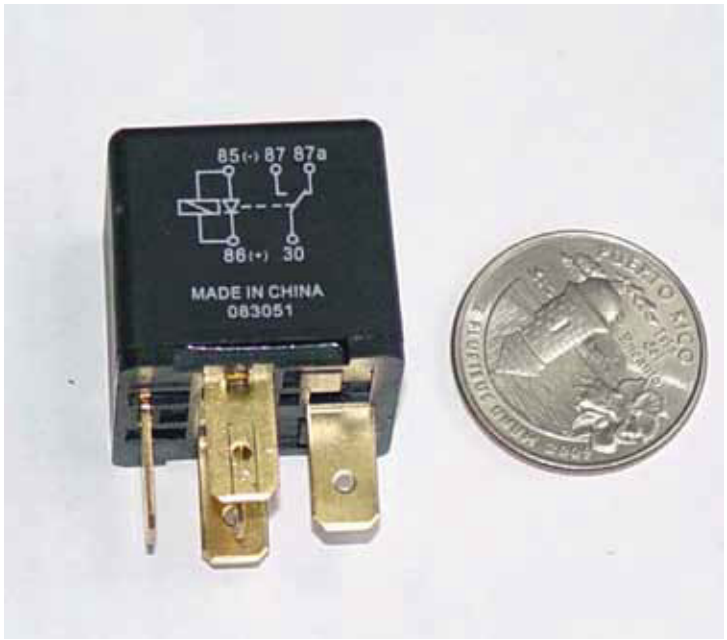

Fig. 1 Automotive Mini ISO relay

WHY DO WE USE RELAYS?

In modern truck, bus, and automotive applications, they are used to control virtually all of the circuits in the vehicle. These relays allow the design engineer to use fairly low current switches to control devices that require significant current. For example, a semi truck can have many clearance lights that, in total, can draw a fairly high current. A low current toggle switch is used to trigger the relay that, in turn, provides power for the lights.

Back in the mid '80s, I built a 1956 Chevy (still have it). I wired every circuit with a relay (see Fig 2). Some of the circuits did not require a relay, but that did not stop me from making Radio Shack richer. I had installed a late model steering column and used the push button which originally controlled the cruise control to flash the bright lights. The push button was a very low-current device, but with the relay, it could control the high current bright lights. I also installed a relay to shut off the headlights if the ignition switch was turned off. To this day, the relays and circuits still work very well.

Fig. 2 Relay System in '56 Chevy

TYPES OF RELAYS

Relays come in all shapes and sizes. For example, we use a relay on our fire detection system board that is extremely small (shown in Fig. 3 next to a dime for comparison). It is capable of transmitting 0.7 amps which we use to trigger a fire suppression system, or a Mini ISO relay that controls several functions in the motorhome in the event of a fire. Some AC relays are the size of the proverbial bread box (or larger). The large AC relays are often called contactors. Fig. 4 shows a relay used to start my 5 HP compressor with a low-current signal from the pressure switch.

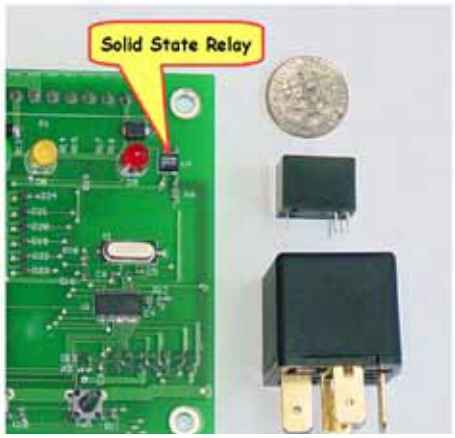

Fig. 3 Solid State Relay on PC Board. Also shown are other relays for comparison.

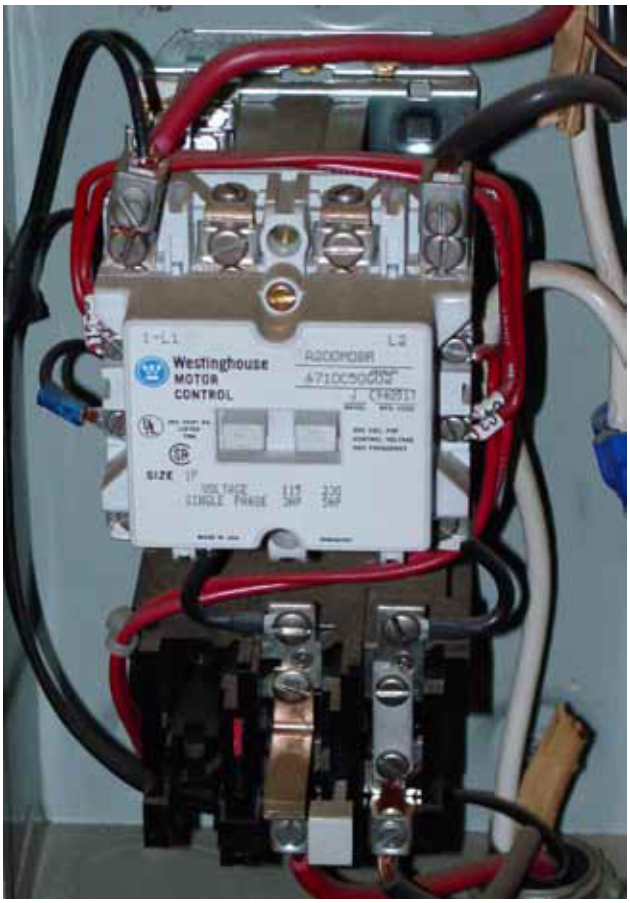

Fig. 4 Air Compressor Contactor

Relays are available in two formats: solid state and electromechanical. Solid state relays use electronic circuitry to turn on the switch, while electromechanical relays use a coil and armature to pull contacts together to complete the high current circuit.

Solid state relays (SSR) have no moving parts and are very reliable. A simplistic description of their operation is that the control circuit turns on an LED and that is used to generate a voltage via miniature "solar panel". That voltage generated by the "solar panel" operates a special form of a transistor to do the switching. All of that is accomplished in a very small, enclosed package. Most solid state relays have relatively low current capability – generally less than 10 amps at 12V.

As stated earlier, relays come in all shapes and sizes. Fig. 3 show the SSR on our board, a second SSR that is a part of our house alarm system and the Mini ISO electromechanical relay along with a dime for size comparison. These relays have current capacities varying from .7 to 30 amps at 12 volts.

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There are also special versions of relays. For example, we use a timer relay in our system that activates upon a signal of a fire detection and then shuts off after 10 seconds. We use this relay to simulate pressing the shut down button for the generator. Thus we shut down the generator if a fire is detected. The relay we use is actually a part of a multifunction circuit board (Fig 5).

Within a given class of relay, there can be a large number of variations. For example, they can have a resistor or diode across the coil connections to minimize current surges that can be significant. In most applications this current is not an issue, but we use relays with diodes to provide a measure of protection for our circuit boards. This same class of relay can have various physical characteristics to facilitate mounting options. Some can be obtained in a sealed version for operation in a moist environment.

Relays with capacities up to 30 amps at 12/24 volts are relatively inexpensive. Using the relays shown in Fig. 3 for cost comparison; our system relay is less than a dollar, the SSR for the alarm system is less than two dollars, and the Mini ISO is in the $5 range depending on configuration.

Relays are rated for intermittent and continuous duty. The application dictates the duty cycle. Continuous duty relays must be able to disperse the heat generated by the coil current. All of the relays shown in Fig. 3 are continuous duty.

Virtually all automotive relays are electromechanical. We will concentrate on that version for the remainder of the article.

HOW DO WE USE RELAYS?

The best example of a relay is the starter solenoid. Granted, it is a special version that uses the coil and armature to not only connect the very high current source to the starter motor but to also pull in the bendix. However, it is the perfect example of the relay concept. It uses very low current hardware (starter switch on the dash) to activate a circuit that demands 300-400 amps. Starter solenoids are rated as intermittent duty cycle.

The control and the application of relays is only limited by the imagination. As we explore how relays are used, we will first look at signal or control wiring and then the high current wiring. Fig. 6 shows the Mini ISO relay schematic which is typical of many electromechanical relays. It is drawn to emphasize the "signal" and power circuits. The signal or control circuits on these relays is designated terminals 85 and 86. The power circuit typically has the supply connected to terminal 30, while the output terminals are either 87 for the "normally open" circuit or 87a for the "normally closed" circuit. We will give examples for each in a minute, but let's talk about the signal side of the relay first.

Fig. 5 Timer Relay System

The signal side of the relay requires a voltage to energize

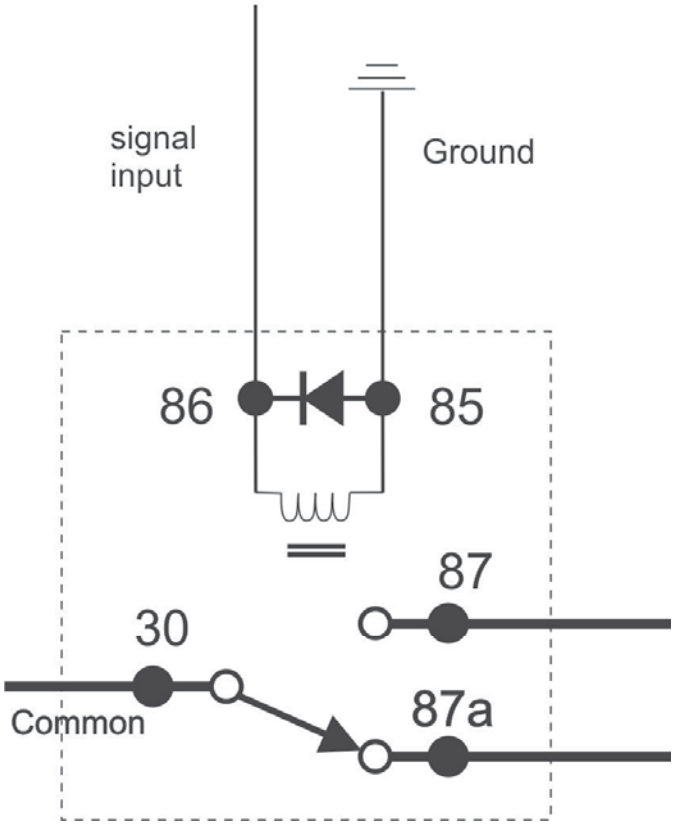

Fig. 6 Mini ISO Schematic. Drawing by Geoff Probert

the coil. For the typical vehicle that would be the 12V (or 24V) supply and ground connections. In the typical application, there would be a switch in the supply circuit such as an ignition switch, toggle switch, headlight switch, etc.. However, the switch could also be in the ground circuit. An example would be the horn relay where the horn button completes the grounds circuit. Indeed, there can be switches on both sides of the signal circuit. An example would be a fuel pump relay where the main control signal is the switched power side of the ignition switch and then an additional hidden switch on the ground side could be turned off to prevent car theft.

The signal and power sides of the relay are completely separate. For example, the signal could be 12 volts DC and the power side could be 24 volts DC or 120 volts AC or any other AC or DC voltage within the capability of the relay. The signal side of the relay has a specific voltage rating.

Now let's get back to the power output circuits of the Mini ISO relay. As stated earlier, the two circuit options are "normally open" (NO) and "normally closed" (NC). Those terms refer to the condition where the coil is not energized. In that condition, the circuit from the supply (30) to the NO (87) terminal is not connected – it is "open". Conversely, the NC (87a) circuit is connected – it is "closed". The typical application is to use the NO terminal. Here, when the signal is applied to the coil, terminals 30 and 87 are connected and power

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is sent to the device powered by the relay. In the energized condition 87a is no longer connected to terminal 30.

While the NC option is not used as frequently, it is a very useful circuit. We install a Mini ISO relay, wired in the NC condition, in the propane solenoid valve circuit of a motorhome. When the coil is not energized, the power is supplied to the solenoid valve so that propane can flow. However, if our fire detection system senses a fire, it applies power to the coil of the propane relay and that causes the circuit to open, turning off the power to the solenoid valve – thus shutting off the propane in the event of a fire.

There are also applications that make use of multiple relays. One of the main applications in the automotive market is the electric winch. The circuit uses four high-current relays to reverse the polarity to the DC winch motor so the winch drum can be powered in either direction.

THE MINI ISO RELAY

I have mentioned the Mini ISO relay several times in this article. It is used extensively in the truck and bus markets as well as several automotive manufacturers. In addition, it is the relay of choice for most automotive aftermarket applications. It is often referred to as the "Bosch" relay, but it is manufactured by several companies. The "footprint" of the connecting spades is standardized by ISO.

Technically, it is described as a SPDT Relay: (Single Pole Double Throw). Fig. 6 shows the schematic of the relay wiring. The connection numbers are standardized. The operation and terminal definitions were discussed earlier in this article.

The spade terminals on this relay can be connected with standard 1/4 inch female spade connectors. When I wire a system, I use a pre-wired socket that is shown in Fig. 7.

There are a very large number of variations of this relay. The basic relay physical configuration is shown in Fig. 7. Fig. 8 shows three physical versions of this relay: sealed/shielded, "standard" and tab for mounting. As noted earlier, there are also electrical variations with resistors or diodes in the signal side of the relay.

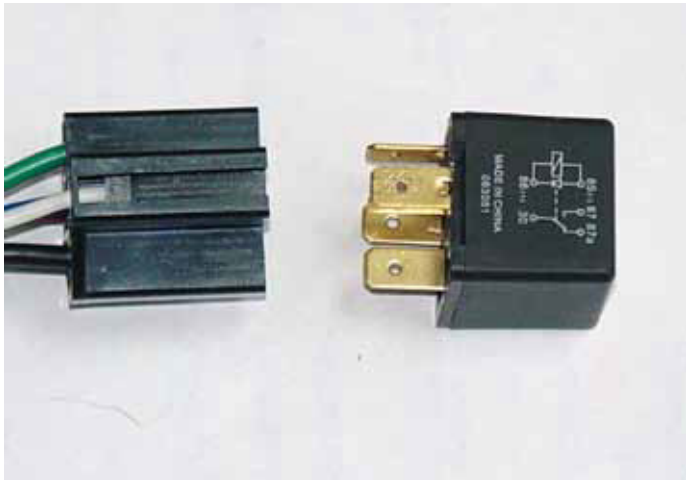

Fig. 7 Mini ISO Relay with Wired Socket

Reliability of Mini ISO relays is reported by the manufacturers to be very good. My experience is that they display the typical "infant mortality" type of distribution common to most electrical products. In the very early life, some will fail quickly. After that phase, they can last a long time. Both of the major suppliers rate their relays for a million mechanical cycles. That sounds good. The "fine print" clarifies that that is a no electric load condition, but it illustrates the level of reliability that the OEMs come to expect.

Fig. 8 Types of Mini ISO Relays

There are several manufacturers of Mini ISO relays. The relays carried by the major distributors are Omron, Panasonic, and Tyco. As I photographed the relay

with the diode, I realized that it was made in China. It is a relay sold by a well respected manufacturer (Tyco). I am concerned about the quality of Chinese electronic products, but there are times that specific configurations are not available from other sources.

Table 1 lists some relay/socket options and possible suppliers. In that table, I recommend Digi-Key as the vendor for the relays. We get most of our components from Digi-Key and we are very satisfied with their selection and service. They will sell to individuals in small quantities. I have listed the manufacturer part number in case the reader wants to look for another source.

Part	Manufacturer	Part No	Supplier	Product No.
Basic 12V	Omron	G8JN-1C7T-DC12	http://www.digikey.com	Z981-ND
12 V with diode	Tyco	1432790-1	http://www.digikey.com	PB682-ND
12V sealed/shield	Omron	G8JN-1C6T-DC12	http://www.digikey.com	Z983-ND
Basic 24V	Could not find source			
24V with diode	Tyco	1432795-1	http://www.digikey.com	PB684-ND
24V diode shielded	Panasonic	CB1-D-24V	http://www.digikey.com	255-2160-ND
Socket with wires	NA	NA	http://www.delcity.net/	73570

Table 1 Mini ISO Relay Source Information