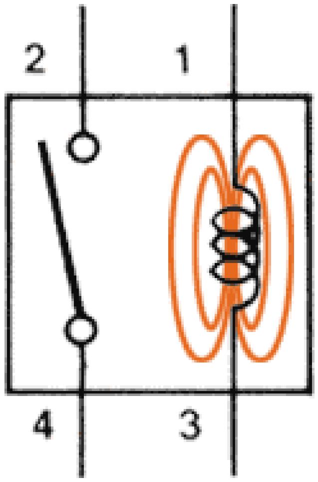
UNDERSTANDING RELAYS



This Automotive Series
UNDERSTANDING RELAYS
has been developed by

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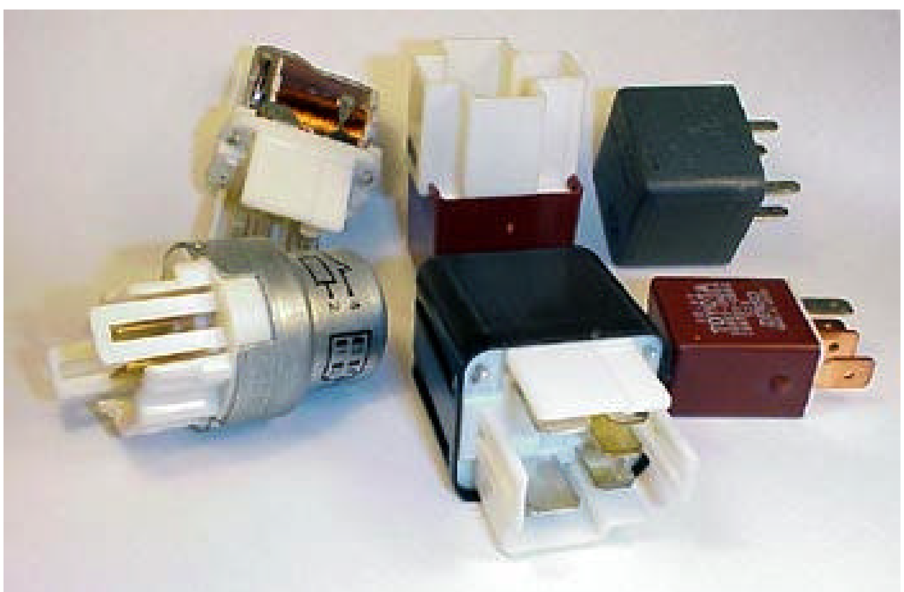
Professor of
Automotive Technology
Skyline College

RELAYS

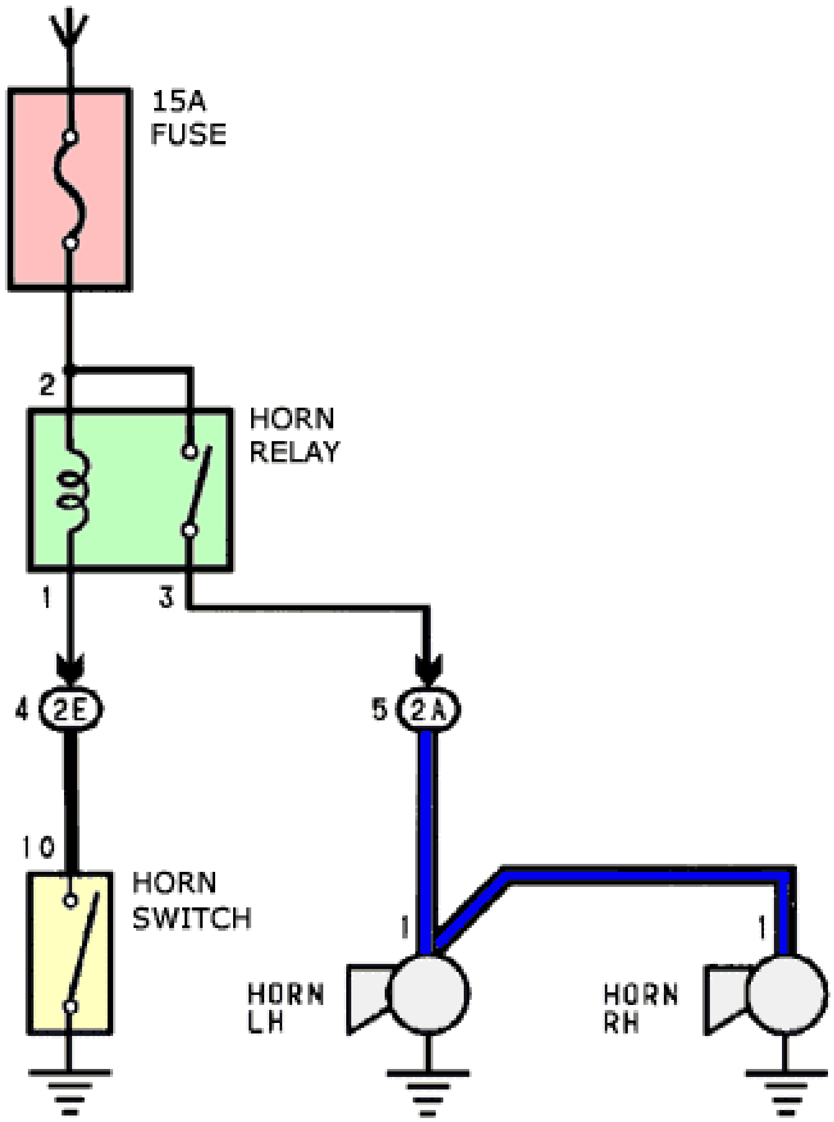
Relays are used throughout the automobile. Relays which come in assorted sizes, ratings, and applications, are used as remote control switches. A typical vehicle can have 20 relays or more.



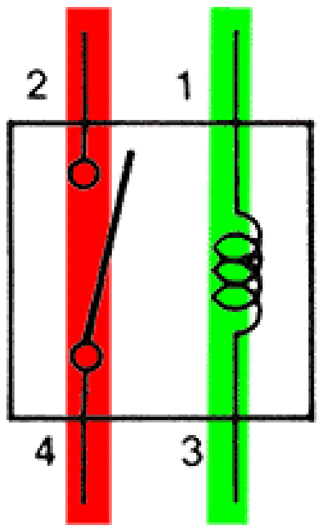
RELAY LOCATIONS
Relays are located throughout the entire vehicle. Relay blocks, both large and small, are located in the engine compartment; behind the left or right kick panels, or under the dash are common locations. Relays are often grouped together or with other components like fuses or placed by themselves.

RELAY POSITION IDENTIFICATION
Relay / Fuse block covers usually label the location and position of each fuse, relay, or fuse element contained within.

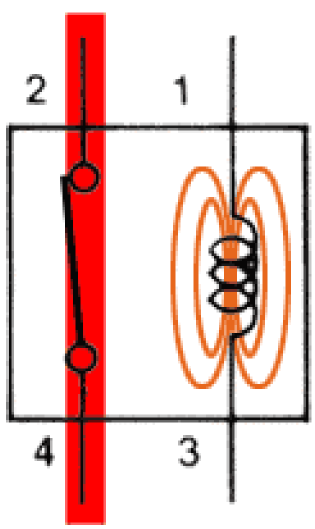
RELAY APPLICATIONS
Relays are remote control electrical switches that are controlled by another switch, such as a horn switch or a computer as in a power train control module. Relays allow a small current flow circuit to control a higher current circuit. Several designs of relays are in use today, 3-pin, 4-pin, 5-pin, and 6-pin, single switch or dual switches.



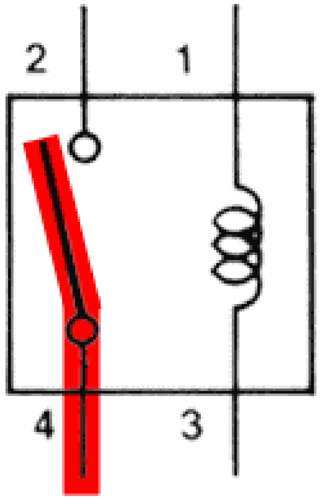
RELAY OPERATION
All relays operate using the same basic principle. Our example will use a commonly used 4 - pin relay. Relays have two circuits: A control circuit (shown in GREEN) and a load circuit (shown in RED). The control circuit has a small control coil while the load circuit has a switch. The coil controls the operation of the switch.



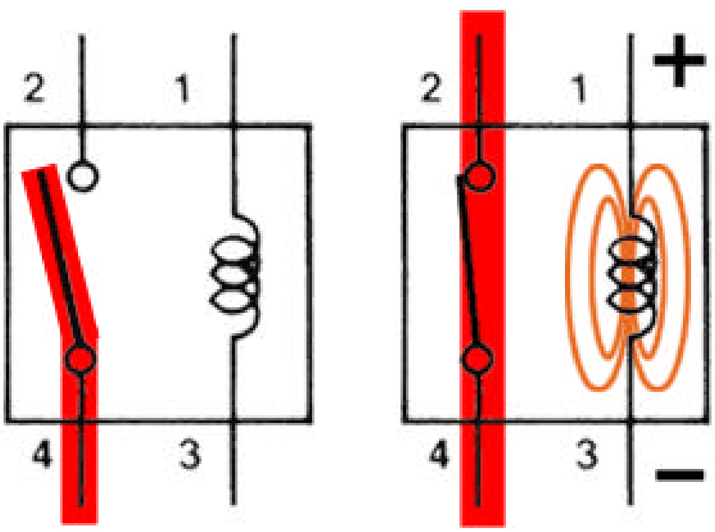
RELAY ENERGIZED (ON)
Current flowing through the control circuit coil (pins 1 and 3) creates a small magnetic field which causes the switch to close, pins 2 and 4. The switch, which is part of the load circuit, is used to control an electrical circuit that may connect to it. Current now flows through pins 2 and 4 shown in RED, when the relay in energized.



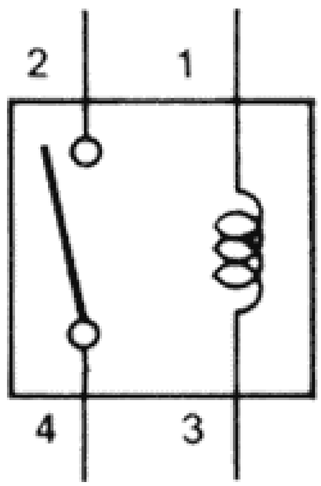
RELAY DE-ENERGIZED (OFF)
When current stops flowing through the control circuit, pins 1 and 3, the relay becomes de-energized. Without the magnetic field, the switch opens and current is prevented from flowing through pins 2 and 4. The relay is now OFF.



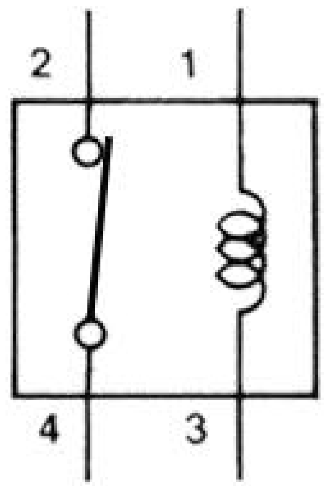
RELAY OPERATION
When no voltage is applied to pin 1, there is no current flow through the coil. No current means no magnetic field is developed, and the switch is open. When voltage is supplied to pin 1, current flow though the coil creates the magnetic field needed to close the switch allowing continuity between pins 2 and 4.



RELAY DESIGN ID
Relays are either Normally Open or Normally Closed. Notice the position of the switches in the two relays shown below. Normally open relays have a switch that remains open until energized (ON) while normally closed relays are closed until energized. Relays are always shown in the de-energized position (no current flowing through the control circuit - OFF). Normally open relays are the most common in vehicles; however either can be use in automotive applications.

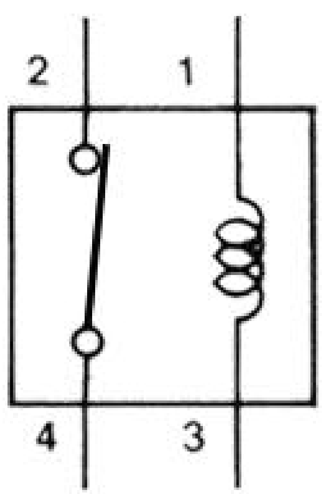


Normally Open (NO)

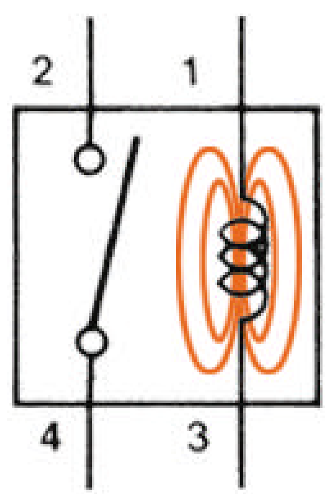


Normally Closed (NC)

NORMALLY CLOSED RELAYS
The operation of a Normally Closed relay is the same to that of a Normally Open relay, except backwards. In other words, when the relay control coil is NOT energized, the relay switch contacts are closed, completing the circuit through pins 2 and 4. When the control coil is energized, the relay switch contacts opens, which breaks the circuit open and no continuity exists between pins 2 and 4.

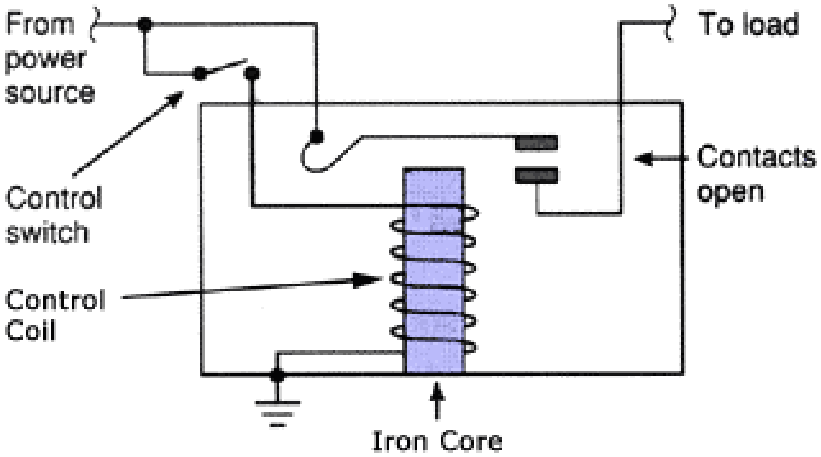


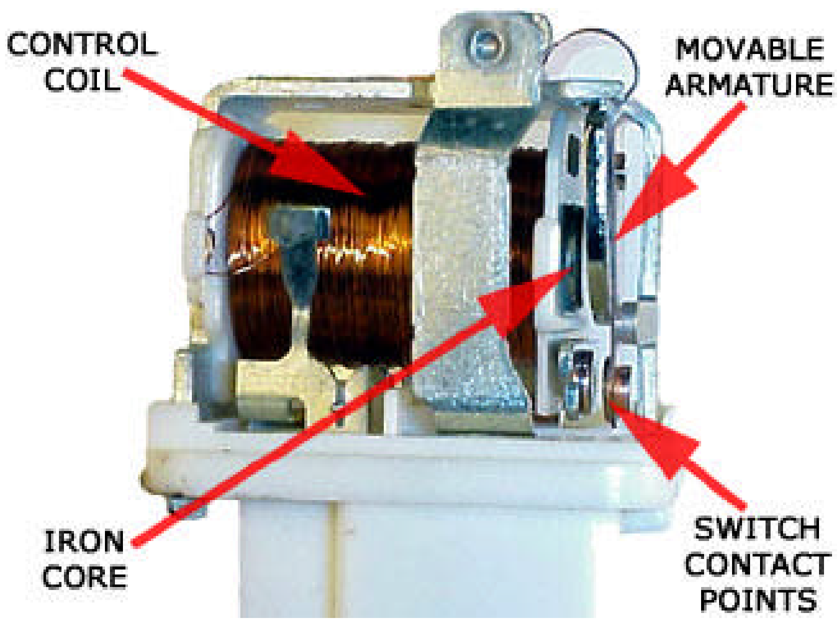
DE - ENERGIZED (OFF)



ENERGIZED (ON)

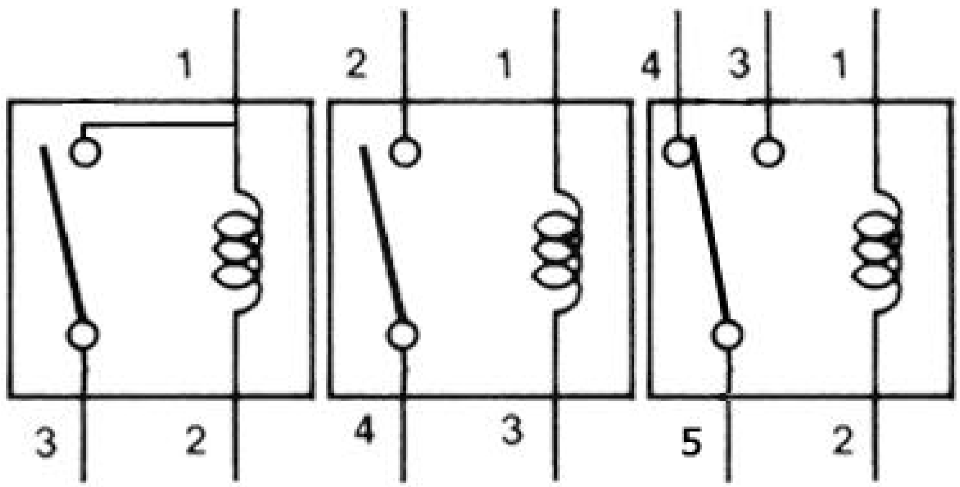
ACTUAL RELAY DESIGN
Current flows through the control coil, which is wrapped around an iron core. The iron core intensifies the magnetic field. The magnetic field attracts the upper contact arm and pulls it down, closing the contacts and allowing power from the power source to go to the load.





RELAY VARIATIONS

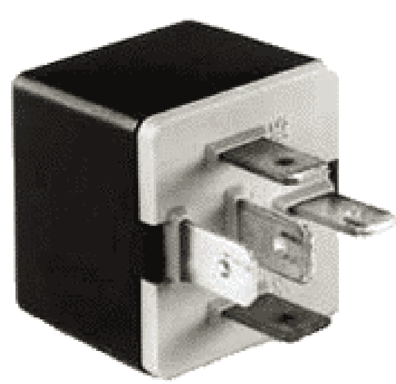
Other relay variations include three and five pin relays. A 3-PIN relay instead of two B+ input sources, this relay has one B+ input at pin 1. Current splits inside the relay, supplying power to both the control and load circuits. A 5-PIN relay has a single control circuit, but two separate current paths for the switch: One when the relay is de-energized (OFF - no current through the control coil) and the other the energized (ON - current is flowing through the control coil). When the 5-PIN relay is de-energized (OFF), pins 4 and 5 have continuity. When the relay is energized (ON), pins 3 and 5 have continuity.



3 - PIN **4 - PIN** **5 - PIN**

ISO STANDARDIZED RELAYS

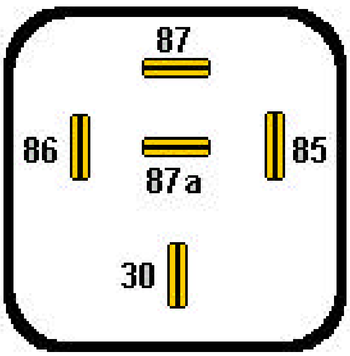
ISO relays were designed to try and standardize relay connections, making it easier to test and design systems. ISO relays are currently used by almost all automotive manufacturers today. Both 4 and 5 pin designs are used in both standard mini and micro sizes. FYI: ISO is short for International Standard Organization.

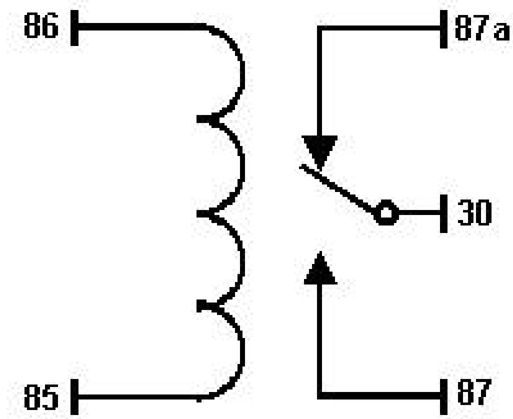


STANDARD MINI SHOWN

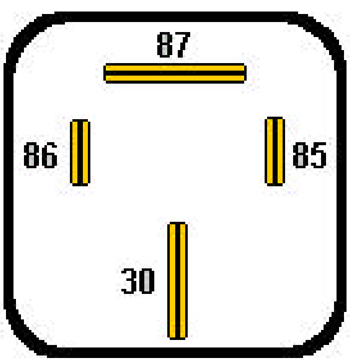
STANDARD MINI ISO RELAYS TYPES
Below are two popular standard MINI ISO relay configurations. The size of a ISO Standard MINI relay is a 1" square cube. Both 4 and 5 pins designs are used.

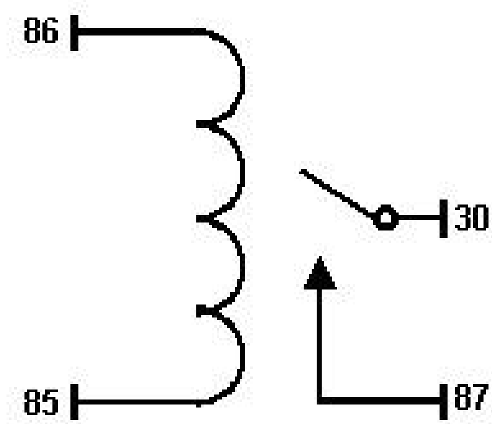
5 PIN
MINI RELAY





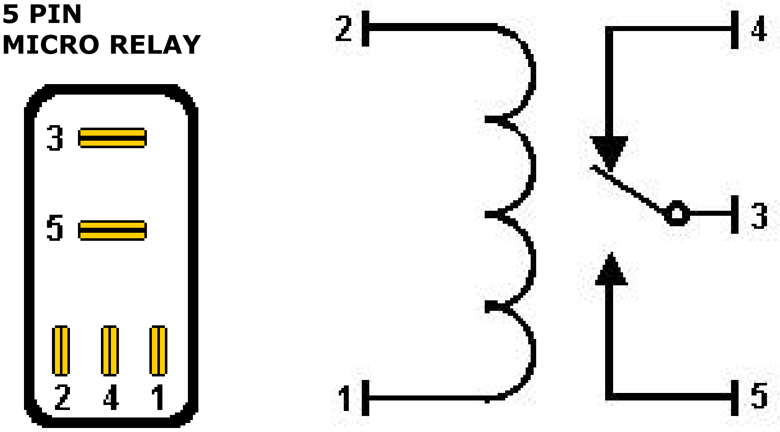
4 PIN
MINI RELAY



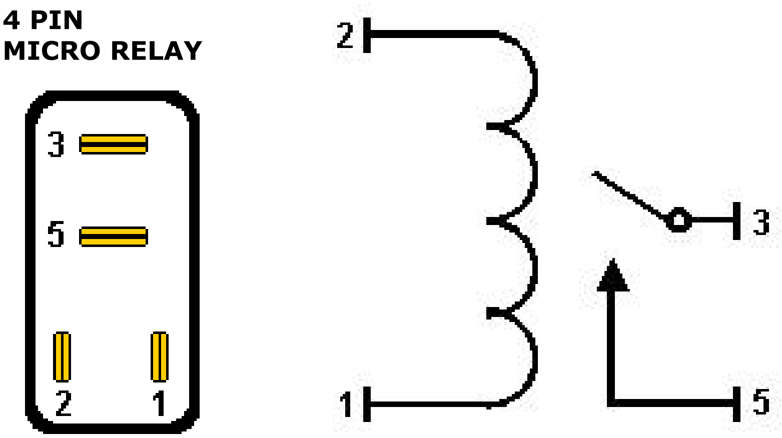


ISO MICRO RELAY TYPES
Below are two popular MICRO ISO relay configurations. The size of a ISO MICRO relay is a 1" x 1" x 1/2" square (1/2 as thick as a Mini relay). Both 4 and 5 pins designs are used.

5 PIN
MICRO RELAY

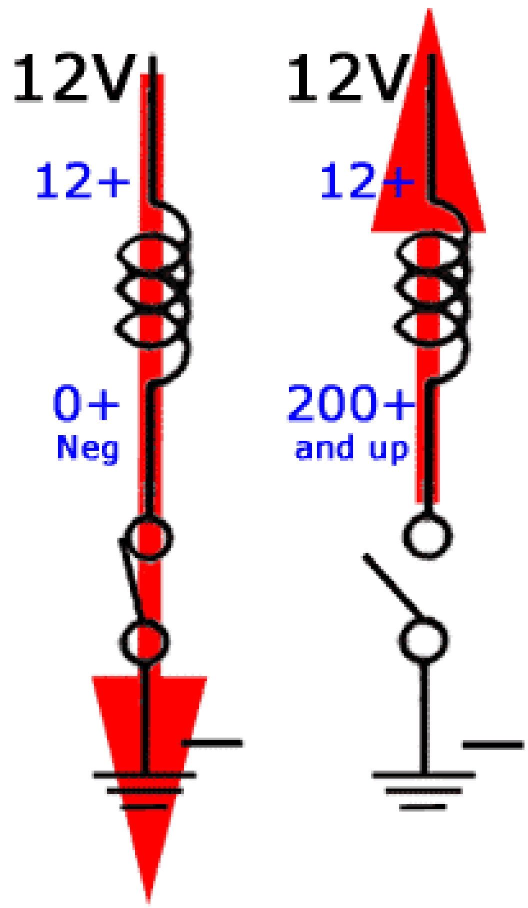


4 PIN
MICRO RELAY



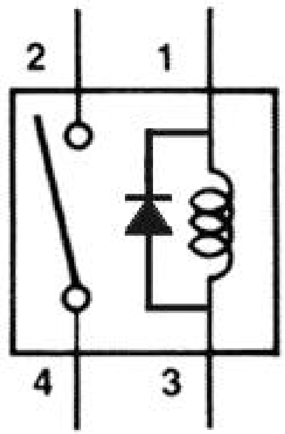
VOLTAGE SPIKES
When the switch is closed (shown left), current flows through the coil from positive to negative as shown in red. This current flow creates a magnetic field around the coil. The top of the coil is positive, and the bottom is negative.

When the switch is opened (shown on right), current stops flowing through the control circuit coil, and the magnetic field surrounding the coil cannot be maintained. As the magnetic field collapses across the coil, it induces a voltage into itself, creating a reverse polarity voltage spike of several hundred volts. Although the top of the coil is still 12 volts positive, the bottom of the coil produces several hundred positive volts (200+ volts or more); 200 is "more positive" and stronger than 12 volts, so current flows from the bottom of the coil up towards the top.



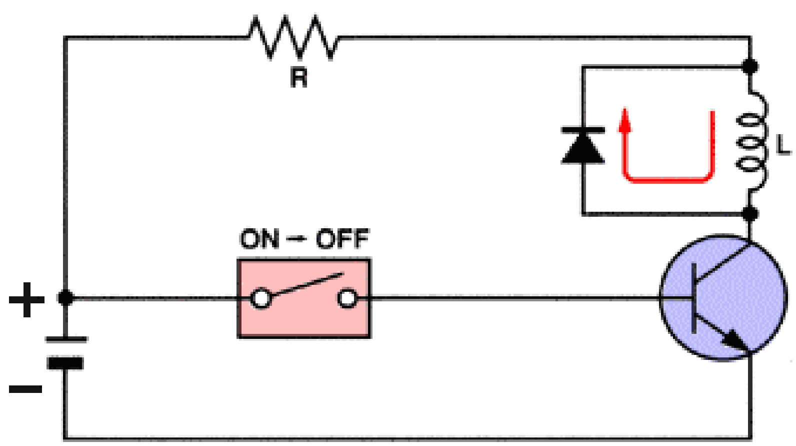
VOLTAGE SUPPRESSION RELAYS

Relays are often controlled by a computer. When relays are controlled by semiconductors such as transistors, they require some type of voltage suppression device. Solid state circuits are vulnerable to voltage spikes. Voltage spikes slam against transistors, destroying them. While some computer circuits have voltage suppression built inside the computer, others rely on voltage suppression from within the relay. High ohm resistors, diodes, or capacitors can be used for voltage suppression. Diodes and resistors are the most common. NOTE: Relays are usually clearly marked if a suppression diode or resistor are present.



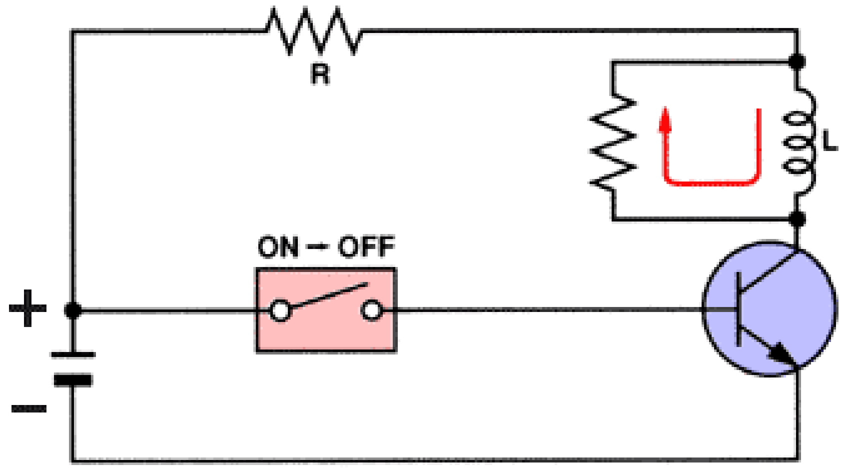
RELAYS WITH DE-SPIKING DIODES

A de-spiking (clamping) diode is connected in parallel with the relay coil. It is in the reverse biased position when the relay is turned on; therefore no current will flow through the diode. When the relay control circuit is opened (turned OFF), current stops flowing through the coil, causing the magnetic field to collapse. The magnetic lines of force cut through the coil and induce a counter voltage (a voltage in reverse polarity) into the winding. The counter voltage begins to raise. When the bottom side of the diode sees .7 volts more positive voltage than the top, the diode becomes forward biased, allowing the excess voltage to pass, completing the circuit to the other end of the coil. The current flows around in the diode and coil circuit until the voltage is dissipated.



RELAYS WITH DE-SPIKING RESISTORS

High ohm resistors are sometimes used instead of diodes. A resistor is more durable than a diode and can suppress voltage spikes similar to a diode, but the resistor will allow current to flow through it whenever the relay is on. Therefore resistance of the resistor must be fairly high (about 600 ohms) in order to prevent too much current flow in the circuit. High ohm resistors are not quite as efficient at suppressing a voltage spike as diodes.

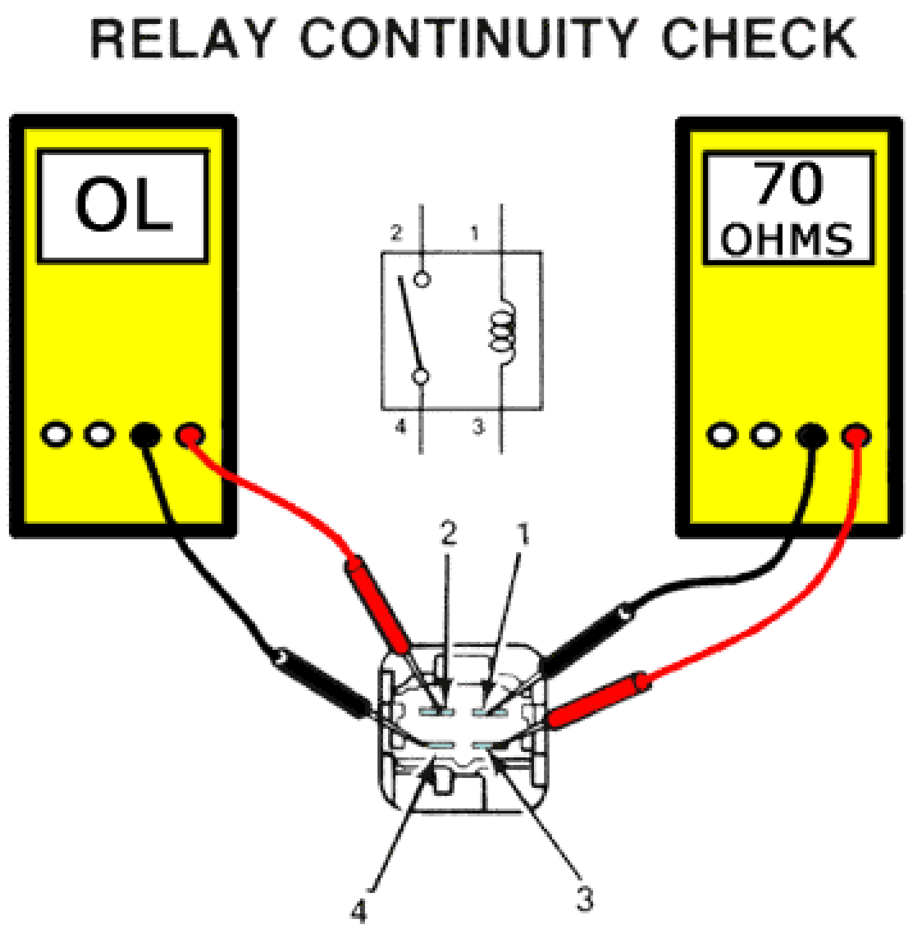


CIRCUIT IDENTIFICATION

Relays are easy to test but often misunderstood. Using a 4 pin relay for our example, we must first identify the pins. Some manufacturers place a diagram and pin ID on the outside of the relay case to show which pins are part of the control circuit and which pins are part of the load circuit.

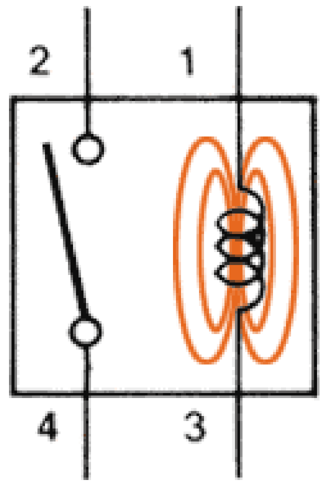
CONTINUITY CHECK FOR ID

If the relay is not labeled, use an ohmmeter and check to see which pins are connected to each other. You should typically find an ohm value of approximately 50 to 120 ohms between two of the pins. This is the control circuit. If the coil is less that 50 ohms it could be suspect. Refer to manual to verify reading. The remaining two pins should read OL (infinite) if it's a normally open relay, or 0 ohms (continuity) if it's a normally closed relay. If the readings are correct, proceed to the next test. Note: If none of the relay pins showed a coil value and all pins show OL or 0 ohms, the control coil is damaged and should be replaced.

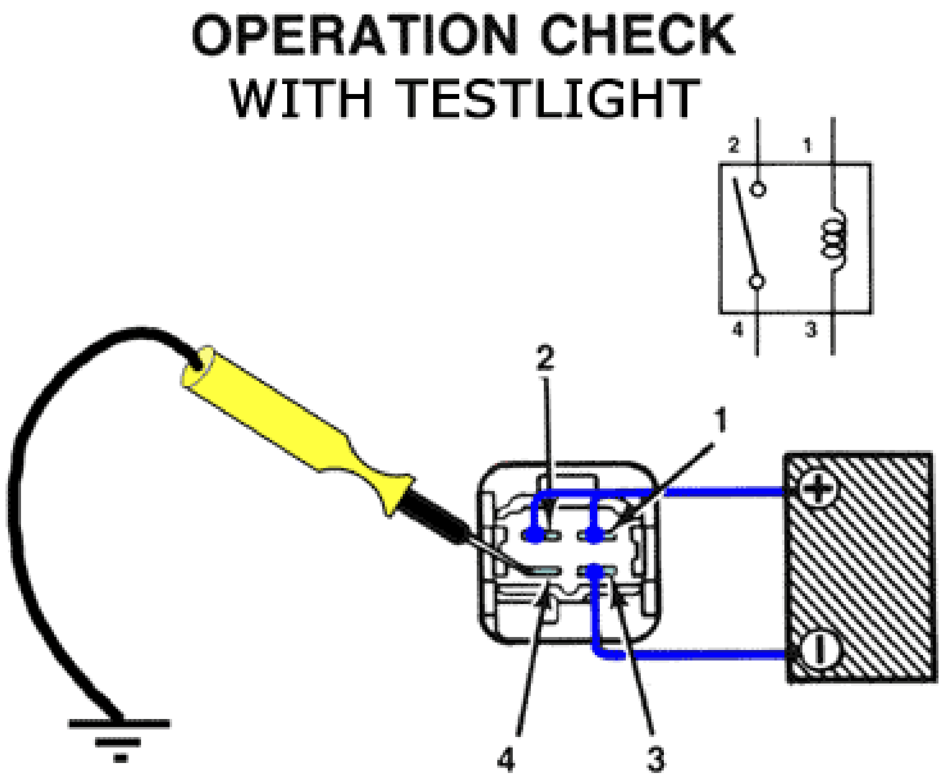


PRACTICAL TESTING

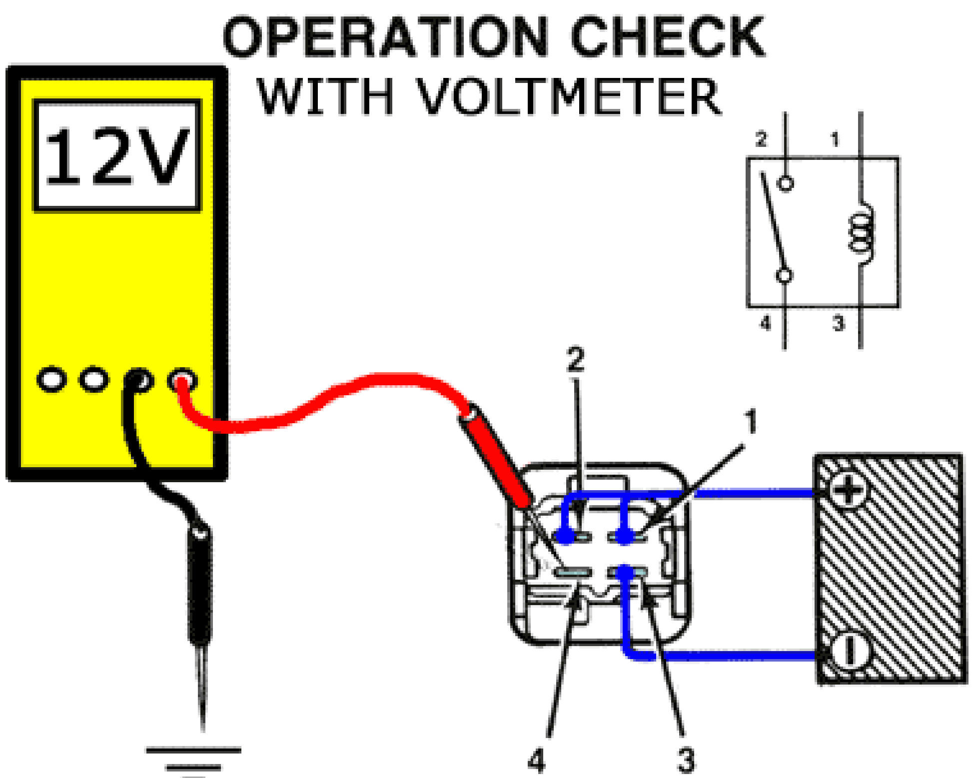
Once the pins have been identified, energize the control circuit by supplying B+ to pin 1 and a ground to pin 3. A faint "click" will be heard; although this "click" means the switch has moved (closed), it does not mean the relay is good. The load circuit switch contacts could still be faulty (high resistance), and further testing is required. A common mistake technicians make is they hear a "click" and assume the relay is good. Take the extra step and verify operation.



ATIONAL CHECK WITH TESTLIGHT
Now start the second part of the test. Energize the relay (control side) by supplying B+ to pin 1 and a ground to pin 3. A click should be heard. With the relay still energized, supply B+ pin 2 of the load circuit. The test light will be on. De-energize (remove B+) the control circuit at pin 1; the test light at pin 4 should go off. A test light is preferred because a test light will draw current through the switch.

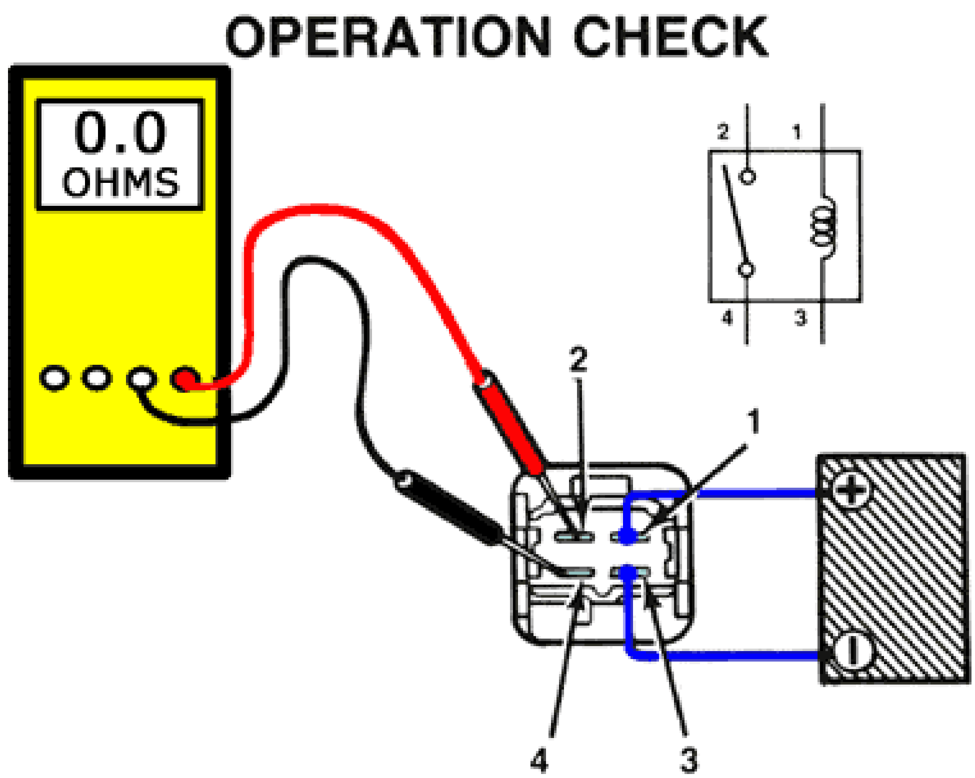


OPERATIONAL CHECK WITH VOLTMETER
A voltmeter can be substituted in place of a test light; however be aware if the contacts are partially burned, the voltmeter will show voltage indicating good contact even when bad. Remember high impedance digital voltmeters draw almost no current. Energize the relay (control side) by supplying B+ to pin 1 and a ground to pin 3. A click should be heard. With the relay still energized supply B+ to pin 2 of the load circuit. Connect the RED lead to pin 4 and the BLACK lead to ground. The voltmeter will indicate source voltage (12V). De-energize (remove B+) the control circuit at pin 1; the voltmeter should now read "zero". Re-energize the relay and the voltmeter should return to 12 volts.



CAUTION
Testing relays with built in clamping diodes require a special procedure. These relays are polarity sensitive; placing B+ to the wrong pin (backwards) while performing a practical test will forward bias the diode and damage the diode, thus destroying the protective quality of the diode.

OPERATIONAL CHECK WITH AN OHMMETER
An ohmmeter can also be used to test the load circuit, but the same problem as the voltmeter comes into play. Energize the relay (control side). Supply B+ to pin 1 and a ground (neg.) to pin 3. A click should be heard. Place the leads on an ohmmeter to across pin 2 and pin 4. Assuming it is a normally open relay the ohmmeter will indicate a complete circuit (close to zero -0 ohms). De-energize the control circuit at pin 1(remove B+). The ohmmeter should indicate OL (an open circuit - infinite). Re-energize the relay and the ohmmeter should return to "zero" ohms. Note: some manufactures provide a maximum ohm value when the switch contacts are closed, example 5 ohms max.



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OPERATIONAL CHECK FOR RELAY VOLTAGE SUPPRESSION DIODES
An ANALOG OHMMETER must be used. This test cannot be performed with a digital meter. The analog meter sends out a higher voltage which is required to forward bias the diode. Place the ohmmeter across the control circuit and record reading. Reverse the leads and check the control circuit again. A functioning diode will be indicated by have two different readings. A faulty diode will have the same reading in both directions.

Current from the ohmmeter flows through the control coil, in one direction. By reversing the leads, you send current in the opposite direction through the control coil. One of the two directions the diode will be forward biased(on), creating two paths for current thus lowering resistance. With the leads in the other direction, the diode in will be reversed biased (off) creating only one path, with higher resistance.

QUESTIONS

1. What are the several designs of relays used today?
2. Describe the two circuits within a relay.
3. What is meant when the relay is de-energized?
4. Describe what is meant by N.O. or N.C relays. Draw and example of each and indicate which is the most common.
5. Draw the three relay variations illustrated on page 12 or 27.
6. Describe what an ISO relay is and why it is used.
7. Draw both a 4 and a 5 - pin ISO relay. Be sure to indicate the correct circuit ID (pin numbers).
8. Why are voltage spikes a problem with relays? Be sure to indicate how the spike is created.
9. Explain how voltage suppression is controlled in a relay. Provide a drawing of each type.
10. Describe in detail the procedure to identify the relay type when it is not labeled on the outside of the relay.
11. Explain how to properly test a 4-pin relay for correct operation.
12. How many options for testing relays were provided in this training module.
13. Explain how to properly test a suppression diode inside the relay.
14. Please provide feedback on this training module. I am not looking for a kiss up answer but rather an honest response. Be sure to include what you liked and did not like about the training module.

