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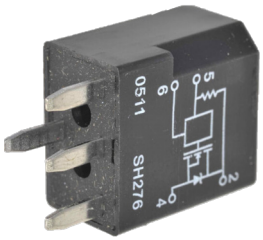
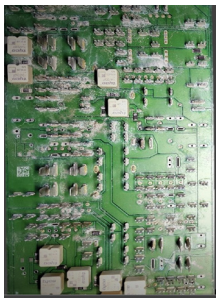


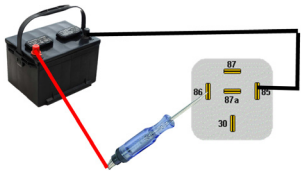
RELAYS

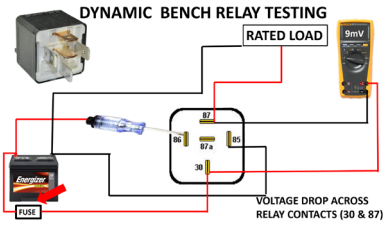
BASIC & NEW TYPES & OPERATION

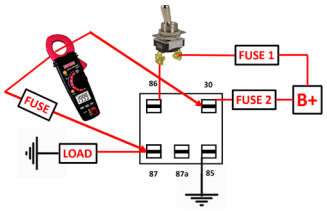
PCB – BISTABLE – HI PWR



BENCH & CIRCUIT TESTING







VERSION 2021-REV 1

RELAYS

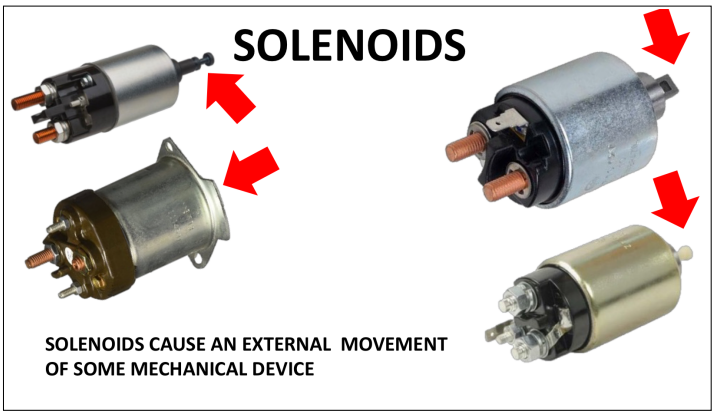
TYPES – OPERATION - TESTING




Today's vehicles have multiple relays installed in their electrical systems. Besides common locations like fuel pump, heater blower motor, A/C clutch, TCC, ABS and Lighting systems, vehicles now have many, many more relays and of many different sizes and styles. There are many new types of relays used on today's vehicles that must be understood by technicians, instructors and students. Among those covered in this class will be standard ISO, Mini, Micro, Solid State, Hi Pwr, and Bistable relays. The International Standards Organization (ISO) relays are still very common and now come in three basic sizes (Standard, Mini & Micro). The advantage of the ISO relays is that there is a standardized method of identifying relay terminals using either numbers or letters or both. Besides ISO type relays, today's vehicles can use specialized application relays, relays made as in integral part of a circuit board or power distribution center or can be made as an integral part of a single component.

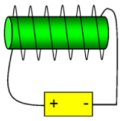
The importance of having a solid understanding of how relays operate is critical to being able to properly diagnose and repair relay systems. In the old days, a typical diagnostic approach to a relay circuit problem was to substitute the relay with a known good one and hope the problem was fixed. If not, you knew that you have to "get into the circuit" a bit more to identify the problem. Today, with so many different types of relays available, it is critical to fully understand how the affected circuit operates, any inter-connected circuits using the relay and more importantly, having the vehicle specific service information available to assist you in your diagnosis.

- **What is a relay?**
- **Solid State relays**
- **GM Hi-Power & PCB relays**
- **Bi-Stable relays**
- **Relay Spike Suppression**
- **Relay Testing Procedures**
- **Relay Circuit Testing Procedures**
- **Specialized Relay Testing Equipment**

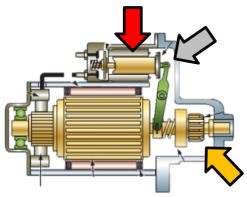


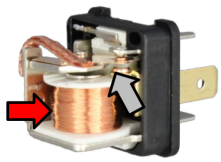
Solenoids are like relays in that they both have coil windings that establish a strong magnetic field which causes a plunger inside the coil to move when energized. A solenoid also has an external connection from the plunger that moves another device outside of the solenoid. The most common application of a solenoid is the starter solenoid which causes the starter gear to move and engage with the engines flywheel.

WHAT IS THE DIFFERENCE BETWEEN A RELAY AND A SOLENOID??
THEY BOTH HAVE A COIL OF WIRE THAT DEVELOPS A MAGNETIC FIELD
THEY BOTH HAVE A PLUNGER THAT MOVES WHEN ENERGIZED



A SOLENOID HAS AN EXTERNAL MOVEMENT OF THE PLUNGER AND A RELAY DOES NOT





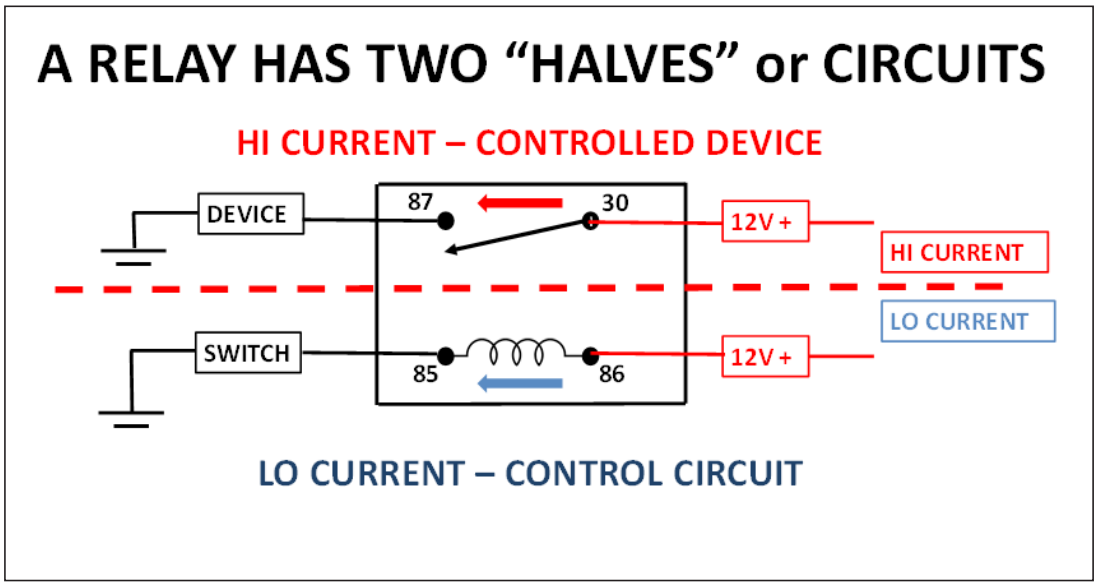
Is this a relay or a solenoid. Although commonly called a solenoid in the trade, it is technically a relay as there are no external moving parts.

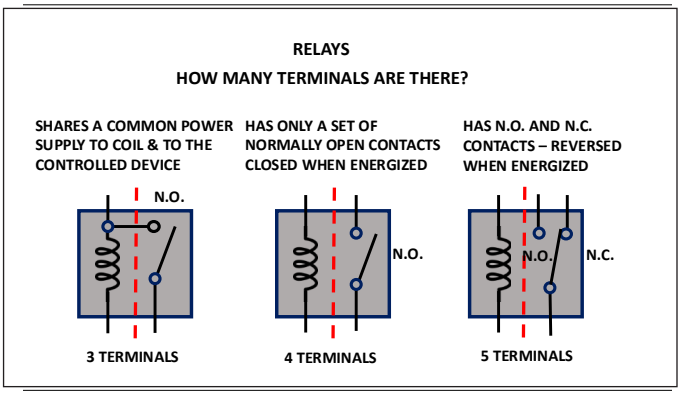
RELAYS

RELAYS ARE A HIGH CURRENT PASSING SWITCH THAT IS CONTROLLED BY A LOW CURRENT CIRCUIT – NO EXTERNAL MOVEMENT IS AVAILABLE

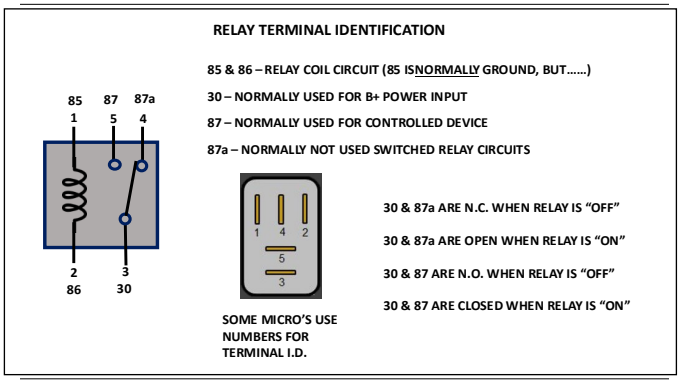
Relays are very common in today's vehicles are becoming more so with each vehicle model year that is released. It is extremely important that technicians have a strong understanding of relays and relay circuits to properly diagnose and repair vehicle systems.

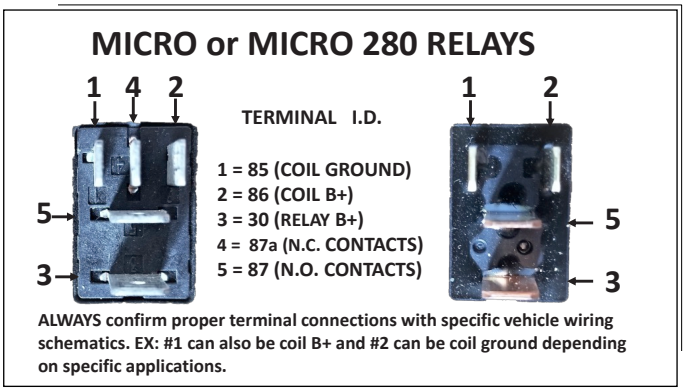
Relays are relatively reliable components, but can create system problems that will require proper diagnosis and replacement/repair. What is more important is the fact that technicians must also understand and be able to diagnose the entire circuit that the relay operates. These skills require proper understanding and use of correct service information, wiring schematics, proper diagnostic tools to perform efficient repair of relay systems used in the vehicle. Eliminating expensive guesswork will improve efficiency and develop great working relationships with customers.





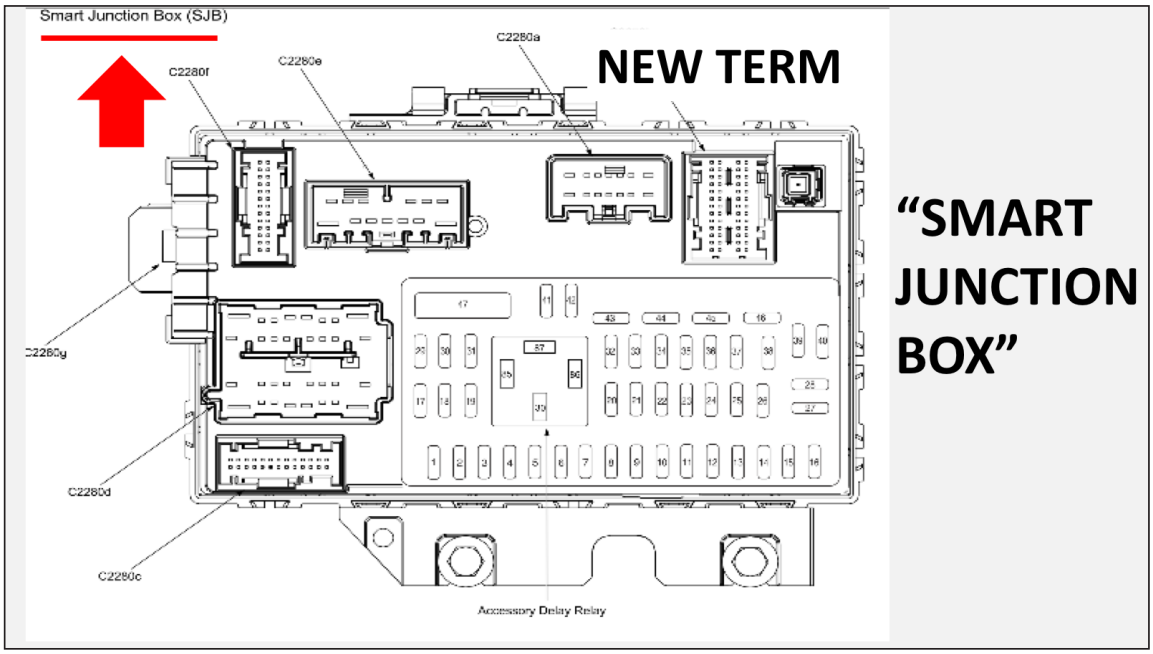
ISO (International Standards Organization) relays are very commonly used in today's vehicles of all types and brands. There are also many different types of non-ISO relays used, but it is fair to say that the majority of relays used today are ISO types. Relays can commonly have 3, 4 or 5 electrical terminals. The terminals each are identified with either numbers, letters or a combination of both.





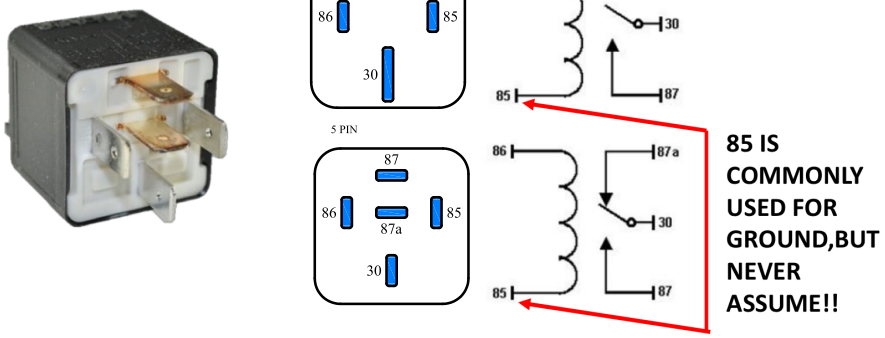
As relays get smaller in size, a different numbering system is used for terminal identification. These terminal numbers are often displayed on wiring schematics and it is necessary to have a clear understanding of this system. Micro or Micro 280 relays are about 5/8" (15.85mm) X 7/8" (22mm) in size. They are available in both a 4-terminal and a 5-terminal design with terminal #4 being the 87a of other ISO standard relays. See above chart for terminal identification. Remember also that specific vehicle manufacturers can often change how terminals 85 & 86 are used for control and feed to the relay coil. Terminal 85 or 86 can be the B+ power feed and the other terminal would be the ground. It is imperative to always check the vehicle specific circuit schematic to properly identify the relays terminals and how they are used in the circuit.

Many cars now use relays and other components that are integrated into one non-serviceable assembly. These can be called “Smart Junction Boxes” (Ford), or Power Distribution Centers (GM) and others. If the relay fails, the entire assembly must be replaced.



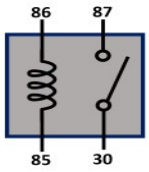
Proper diagnosis of relay controlled circuits requires that vehicle specific information is available. NEVER assume that all vehicles are the same from year to year as this often is not the case. Always learn the entire circuit before attempting to diagnose or repair it. Many times relays fail due to excessive current flowing through them. Defective controlled components can cause this such as bad cooling fans, fuel pumps, and other shorted or defective conditions. It is recommended that a current flow check be made of the controlled device prior to replacing only the relay. Voltage drop testing of the circuit can also identify other conditions that can cause negative performance issues.

I.S.O. STANDARD RELAYS (4 and 5 TERMINAL)

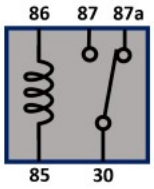


ISO (International Standards Organization) relays are extremely common in today's vehicles. The advantage to them is that they use a standardized method of identifying the electrical terminals. See below diagrams for specific terminal configuration and identification of all types of ISO relays.

RELAY SCHEMATICS

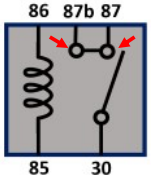


COMMON RELAY– 4 POLE – 30 TO 87 N.O.
SPECIAL APPLICATIONS CAN BE N.C., BUT IS RARE.
85 & 86 IS COIL CIRCUIT
IS CALLED A "MAKE & BREAK" RELAY – SIMPLEST FORM



COMMON RELAY– 5 POLE – 30 TO 87a N.C. 30 TO 87 N.O .

CALLED A "CHANGE OVER " RELAY 87a IS NOT ALWAYS USED- IF NOT, IT IS A "MAKE & BREAK" RELAY – 85 & 86 IS COIL CIRCUIT



RARE RELAY– 5 POLE – 30 TO 87 & 87b N.O.

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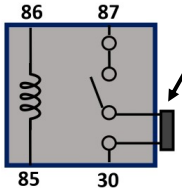
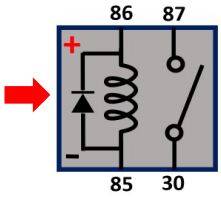
SWITCHES TWO CIRCUITS FROM A COMMON FEED – GERMAN CARS (BMW)
CLASSIFICATION IS A DIN/EN TYPE A RELAY



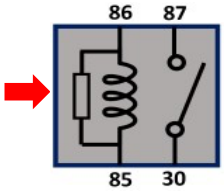
RELAY WITH REPLACEABLE FUSE– USUALLY PART OF MOLDED HOUSING-

OEM RARE – NORMALLY FOUND IN AFTERMARKET APPLICATIONS, RV, MARINE, ALARMS, SNOW PLOWS, OFF ROAD LIGHTING, CAR OPTIONS-ADD-ON'S, ETC. CAN BE USED ON CARS FOR AUXILIARY CIRCUITS



RELAY WITH DIODE ACROSS COIL FOR SPIKE SUPPRESSION

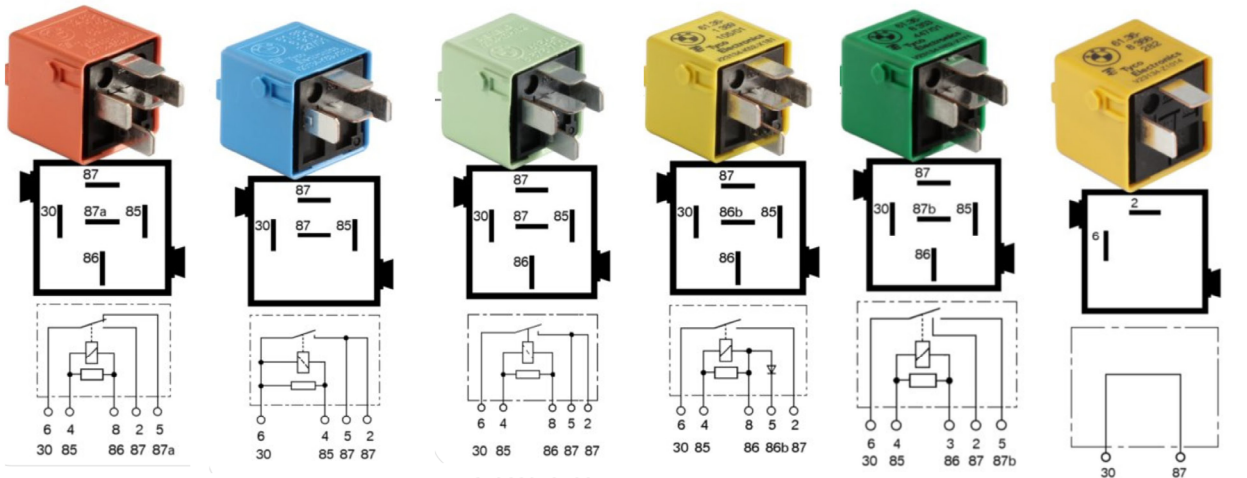
Diodes are always installed with the band of the diode facing to terminal 85 (if positive-reverse biased) & is critical that 12V+ be connected here and NOT 85 to prevent permanent diode damage!

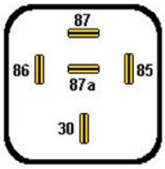


RELAY WITH RESISTOR ACROSS COIL FOR SPIKE SUPPRESSION
(OFTEN CALLED A SHUNT RESISTOR)

Not as efficient at blocking spikes as diodes, but is not polarity sensitive. Either 85 or 86 can be positive or negative.

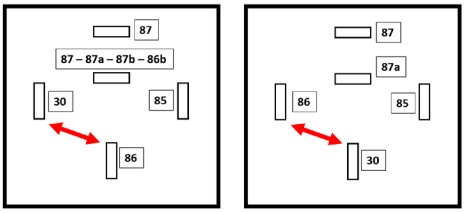
BMW - TYCO & SIEMENS (DIN/EN) RELAYS





STANDARD ISO 5-PIN RELAY

The vehicle manufacturer BMW (Germany) has always used innovative and in some cases complex technologies in their vehicle offerings. Using relay circuits is no exception. The above chart displays relay circuit configurations that are different than standard DIN/ISO relay organization and more importantly, standardization. These relays are compliant with DIN/EN standards which are not exactly the same as DIN/ISO. There are two different types (A & B). Type B are identical to DIN/ISO relays. Type A has different terminal identification layout and should be understood by technicians. DIN/EN is an older German/European standard whereas DIN/ISO is international. These BMW relays have been in use for many years and continue today. Technicians can be familiar with the terminal identification of a standard ISO 5-pin relay and often test the relay or relay circuits without much thought because "they are all the same". After understanding this information, it is hoped that you will be aware of the differences between BMW DIN/EN (Tyco & Siemens) relays and if by chance, you have some of them laying around in your shop, you would be able to recognize them and know that the terminals are very different. Refer to the drawing below: You can see that terminals 30 and 86 configuration are "reversed". As 30 is usually B+ on ISO relays and 86 is usually coil positive, you could envision some weird or even potentially harmful outcomes if the relays were switched. This would especially be true on diode suppressed relays. The diode would be instantly "blown" in this case. Terminals 85 and 87 are consistent with both relays. However, BMW often controls two different circuits on with the one relay. **Terminal 87a** is where most of the differences can occur. With an ISO relay, terminal 87a are the normally closed set of contacts. BMW uses this terminal for 87 (two circuits on), 87a (N.C. contacts), 87b (another circuit "on") and 86b (two circuits can control the relay). Always refer to the vehicle specific wiring schematic for proper identification.



BMW – TYCO & SIEMENS TYPE "A" RELAYS

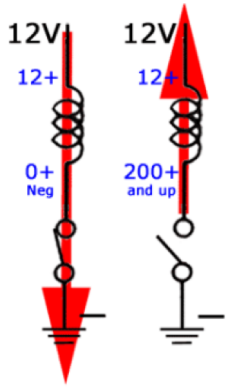
STANDARD DIN/ISO 5-PIN RELAY

Although becoming rare, some ISO and other relays use suppression diodes in the relay coil circuit. It is very important that technicians know how to determine if the relay has a diode and if so, how to properly test the relay both in and out of the circuit. Suppression is needed in the relay coil due to an induced voltage that is generated each time the relay coil is turned off. This induced voltage if allowed to leave the relay can cause serious damage to sensitive electronic components such as modules, computers and other devices. This induced voltage is often referred to as “voltage kick”.

Relay induced voltages are controlled today by either using a diode or a resistor in parallel with the relay coil winding. These components keep the induced voltage within the coil as it dissipates after each coil on/off cycle. It is important to note that if a relay has a diode in the coil, the relay is extremely sensitive to the proper polarity hookup of the relay coil circuit. Reversing terminals # 85 & # 86 will INSTANTLY damage the diode beyond use. The problem is that if this happens due to improper testing, oftentimes, the technician doesn’t realize this has happened and the relay in installed back into the circuit which can create damage to other components. Sometimes, the relay housing will have the relay schematic which MAY indicate that a diode is used. If not, always check the specific wiring diagram for the relay’s circuit or perform a “check test” of the relay to determine if it has a diode or not.

RELAY COIL SPIKE SUPPRESSION

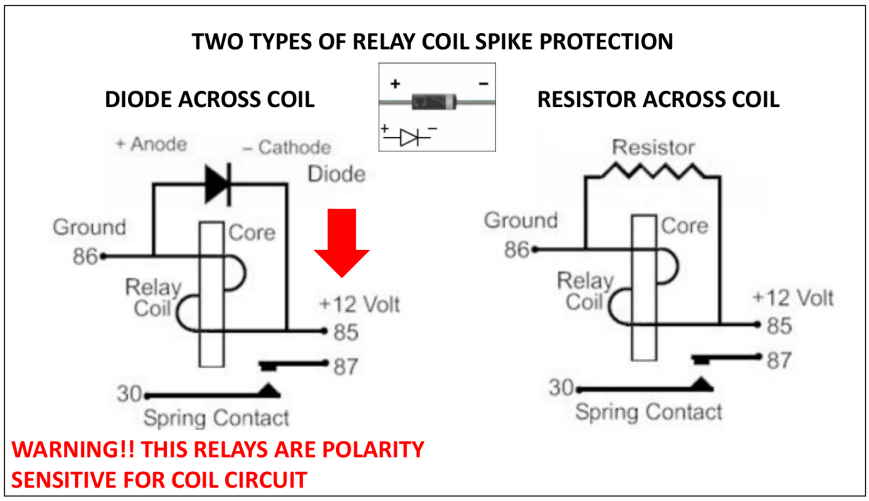
Anytime current is flowing in a coil of wire and the circuit is turned OFF, there is an induced spike of increased voltage generated in the coil. (INDUCTION) If that voltage is allowed to escape the relay, it can damage sensitive electronic components. (Computers, sensors, etc)



CALLED “INDUCTIVE KICK”

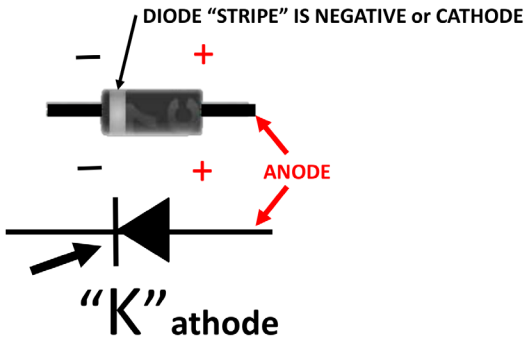
Induced voltages can be higher than 200-400 volts!!

The diode will always be installed in the relay coil circuit with the cathode (-) band of the diode body facing towards terminal #86 (if it is connected to a positive source). This is called “reverse biased” and it is important that +12V is connected to this terminal and NOT terminal #85. In the example shown above, terminal #85 is connected to a positive source (which is rare). ALWAYS check vehicle specific wiring schematics for this information. Diodes are excellent for suppression of induced voltages, but due to their fragility and increased internal protection of the computer and module electronics, most relays today use resistors to perform this function.



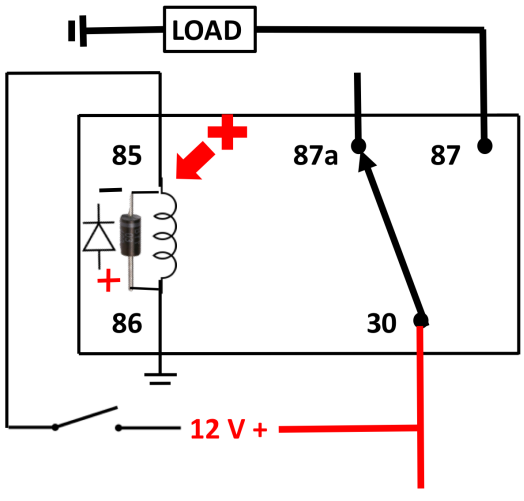
The diode "stripe" must ALWAYS face towards the "positive" connection of the coil relay winding. Connecting the relay coil "backwards" will result in the immediate destruction of the diode and loss of spike suppression.

CAUTION: The relay may continue to operate normally with the diode destroyed, but could result in damage to external components due to the loss of the diode's suppression operation.



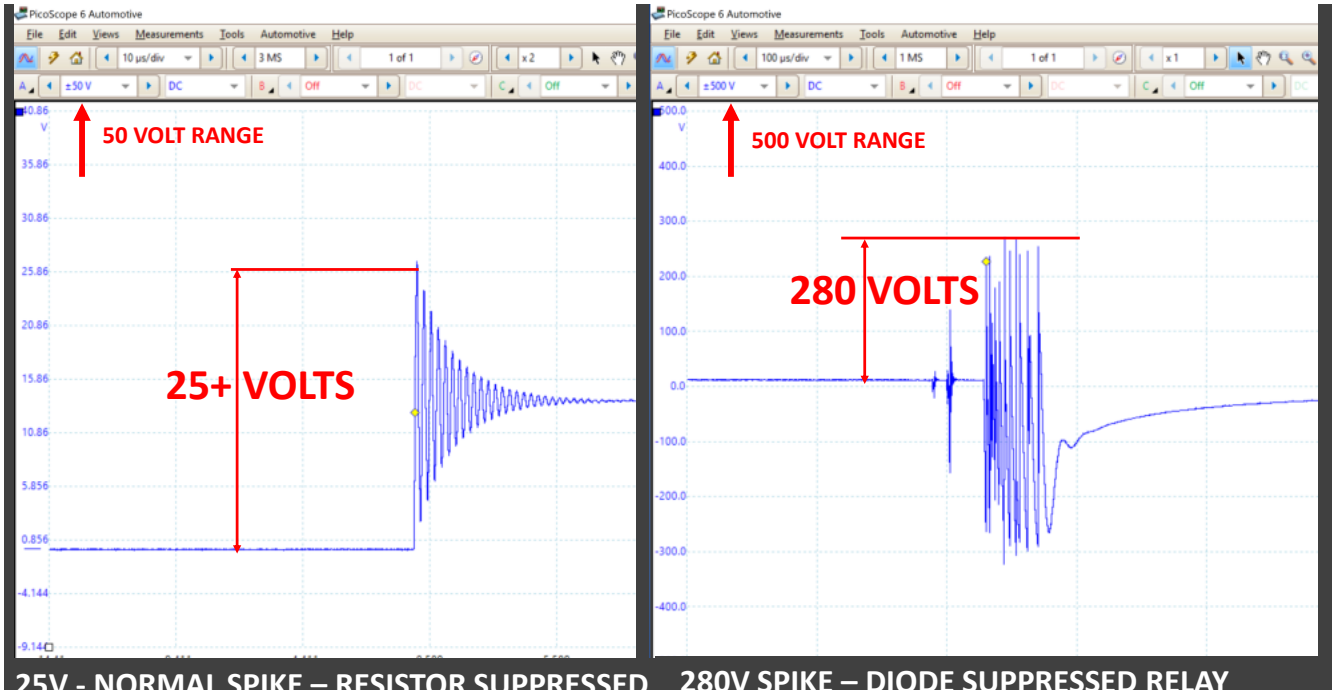
MENTAL TRICKS FOR REMEMBERING DIODE POLARITY MARKINGS

IF YOU SUSPECT THAT THE RELAY MAY HAVE A SUPPRESSION DIODE or THE SCHEMATIC SHOWS ONE, ALWAYS USE A TEST LIGHT TO ENERGIZE THE RELAY (#85 & #86) ON THE BENCH. NEVER USE JUST JUMPER WIRES!!!



Relay coil spike suppression is a very important design to prevent damage to sensitive electronic components such as computers, controllers, modules, etc. There are two methods of accomplishing this protection. One is by using a resistor connected across the relay's coil. This resistor is typically called a "shunt resistor" and is normally trouble-free in operation and longevity. The other method is by installing a diode across the relay coil. The diode is often called a "flyback diode". A relay with a diode is POLARITY sensitive when testing with B+ and ground, whereas, a resistor protected relay is not polarity sensitive. Not knowing the difference between a diode and resistor suppressed relay commonly causes a technician to unknowingly destroy the suppression diode by improper bench testing the relay and the relay will operate normally after the diode has been mistakenly destroyed, but will no longer have the ability to protect sensitive electronic devices in the circuit. This could be the cause of damaging computers, modules and controllers without realizing the actual cause of the problem.

Checking for the presence of a diode is covered in detail in the TESTING RELAY section. Below are two oscilloscope pattern captures showing a normal pattern of a resistor suppressed relay. The inductive "kick" is about 25 volts which is well within accepted tolerances. The pattern on the right was taken from a diode suppressed relay with a blown diode. Notice that the inductive "kick" is about 280 volts which could easily damage electronic components.



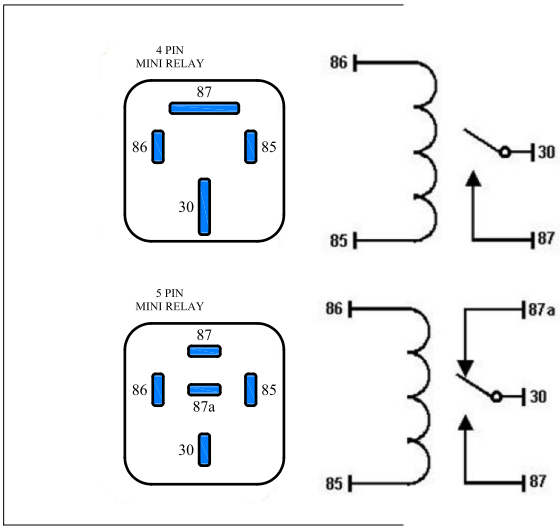
25V - NORMAL SPIKE – RESISTOR SUPPRESSED 280V SPIKE – DIODE SUPPRESSED RELAY

I.S.O. STANDARD RELAYS (4 and 5 TERMINAL)

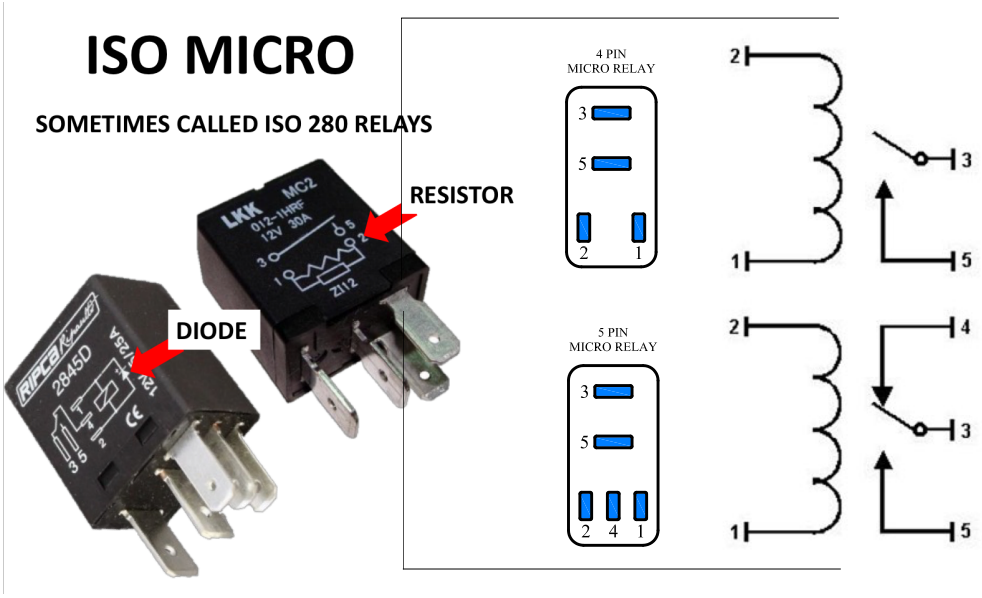
SOMETIMES CALLED "ICE CUBE" RELAYS - THEY ARE ABOUT 1" SQUARE

ISO "standard" relays have been used for years in vehicles, but with improvements in technology, they are being replaced with ISO "mini" relays primarily for their smaller sizes.

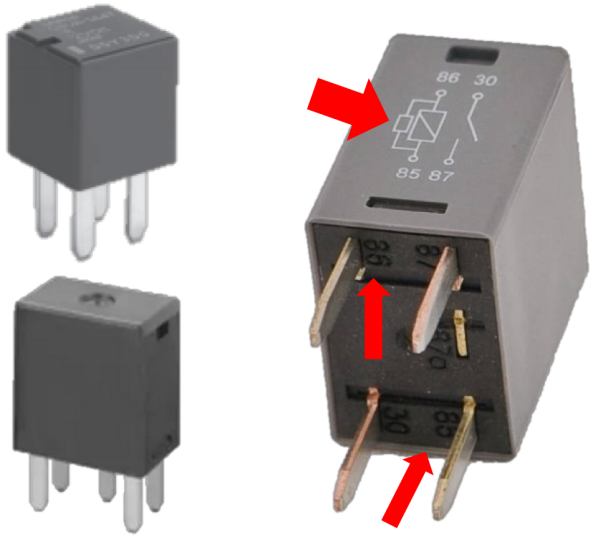
ISO MINI



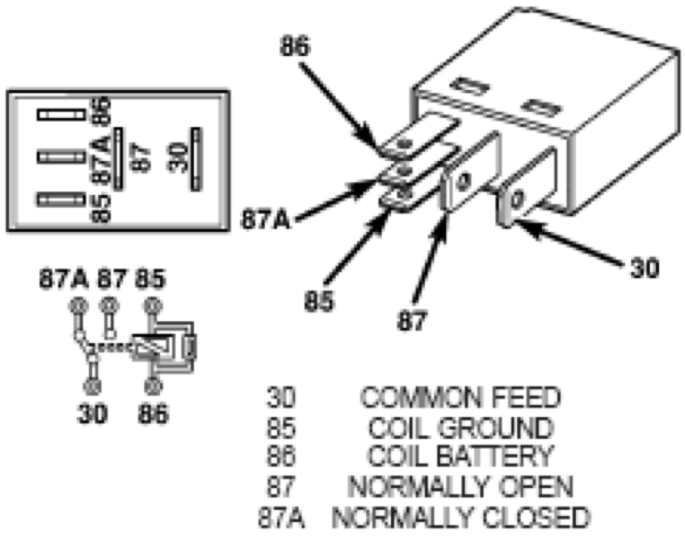
ISO relays are also available in a "mini" size which are smaller than the full-sized ISO relays. Terminal identification can be the same or may use numbers. Their advantage is simply to save space in the vehicle.

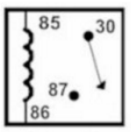


ISO relays also come in the MICRO size which are shaped somewhat rectangular and usually use numbers to identify electrical terminals. Notice in the examples shown, that one micro relay has a suppression diode and one uses a resistor.

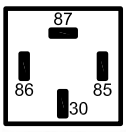


Note that on the four-terminal relay shown above, terminals # 85 & # 86 are on opposite corners of the relay's housing. This is a typical layout for micro relays and is important to note for purposes of bench testing. Always check the relay housing for a relay schematic or obtain vehicle specific wiring diagrams. Another reliable source of relay information is to obtain a document called a manufacturers BUYERS GUIDE. Buyers guides can be requested at any auto parts jobber store or can often be downloaded from the manufacturers website. An example would be Standard Motor Products. They have downloadable buyers guides and catalogs available. Buyers guides show pictures of the relay (and other components), gives the specific vehicle application and in most cases, shows a wiring diagram of the relay. This is a good resource for teaching and learning electrical components.





Schematic

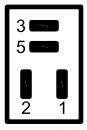


4 Pin View

Basic 4 Pin Mini Relay

- **Case size:** 1 inch x 1 inch x 1 inch
- **Pin 30:** Power into the relay for the accessory device
- **Pin 87:** Relay switched power out to the accessory device
- **Pin 85:** Positive hot line to activate the relay coil
- **Pin 86:** Ground line to the relay

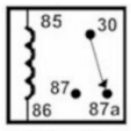
Schematic



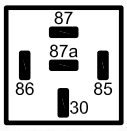
4 Pin View

Basic 4 Pin Micro Relay

- **Case size:** 1 inch x 1 inch x 1/2 inch
- **Pin 3:** Power into the relay for the accessory device
- **Pin 5:** Relay switched power out to the accessory device
- **Pin 2:** Positive hot line to activate the relay coil
- **Pin 1:** Ground line to the relay



Schematic

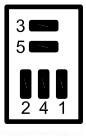


5 Pin View

Basic 5 Pin Mini Relay

- **Case size:** 1 inch x 1 inch x 1 inch
- **Pin 30:** Power into the relay for the accessory device
- **Pin 87:** Relay switched power out to the accessory device
- **Pin 87a:** Powered hot when relay is at rest. Open when relay is activated
- **Pin 85:** Positive hot line to activate the relay coil
- **Pin 86:** Ground line to the relay

Schematic



5 Pin View

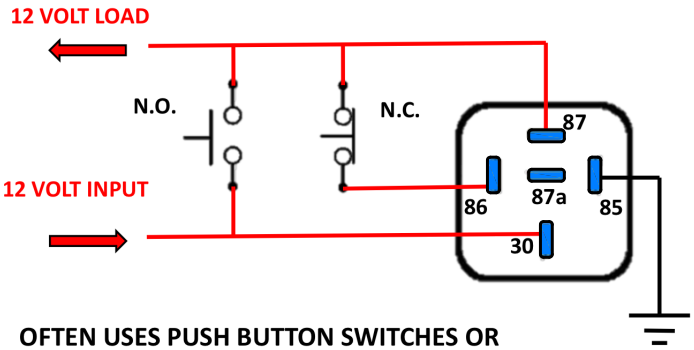
Basic 5 Pin Micro Relay

- **Case size:** 1 inch x 1 inch x 1/2 inch
- **Pin 3:** Power into the relay for the accessory device
- **Pin 5:** Relay switched power out to the accessory device
- **Pin 4:** Powered hot when relay is at rest. Open when relay is activated
- **Pin 2:** Positive hot line to activate the relay coil
- **Pin 1:** Ground line to the relay

The above diagrams show the terminal configuration and identification of common ISO relays.

LATCHING RELAYS AND LATCHING RELAY CIRCUITS

SIMPLE LATCHED RELAY CIRCUIT

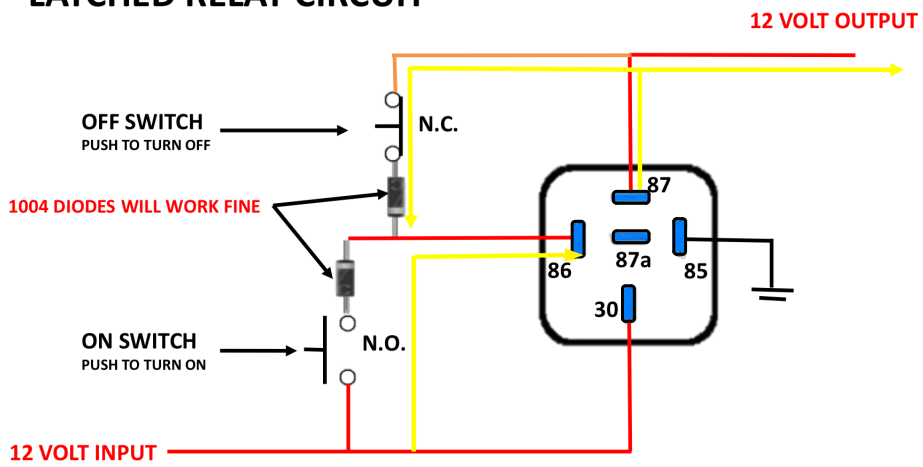


OFTEN USES PUSH BUTTON SWITCHES OR OTHER TYPES OF MOMENTARY CONTACT INPUT DEVICES

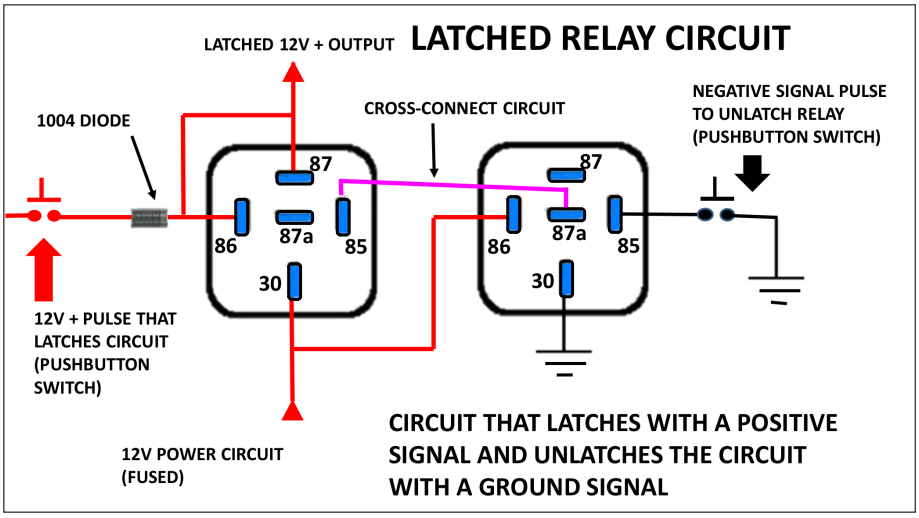
Some cars use relay "latching" circuits. Latching means that the relay stays in the switched position even after the switch is not long used. Most latched circuits use momentary switches of some kind with the most common being push buttons or momentary inputs from other modules, computers or processors. Many after-market custom system installers use latching relay circuits to accomplish their goals with add-on alarm, extra lighting and audio systems. There is a LATCHING relay available that without any external modifications will stay in the switched position even though the switch input is removed. The relay would have to receive an additional switch input to change back to its original position. These relays are somewhat rare in vehicles, but relay latching circuits are not.

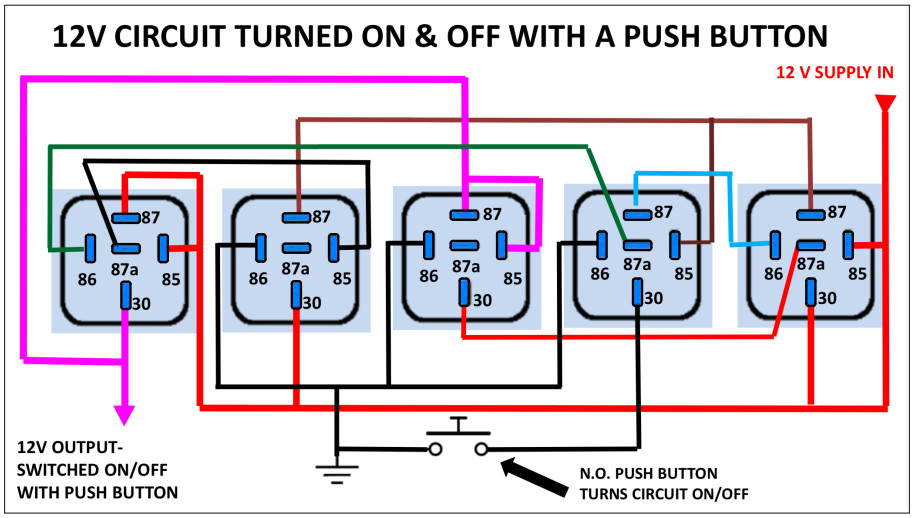
View the diagrams for common types of "custom" relay latching circuits that can be customized to any specific need or objective.

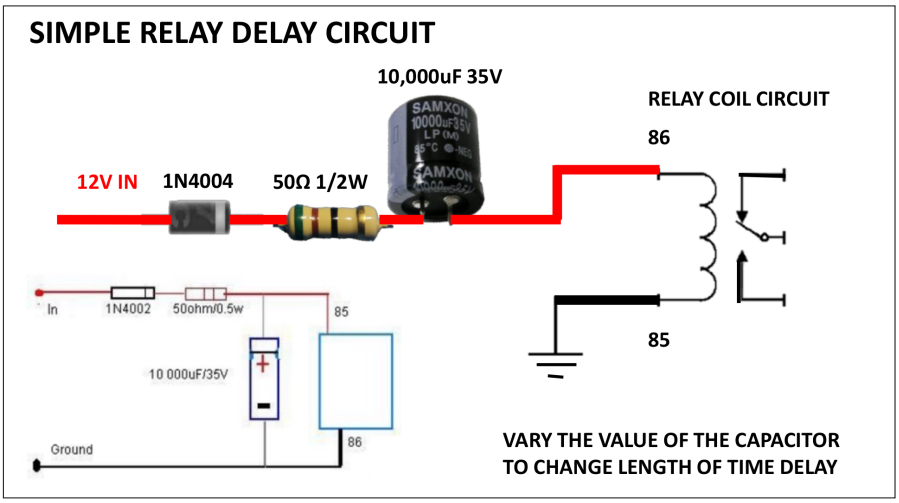
LATCHED RELAY CIRCUIT



Switches can be push buttons, toggle, or other types used as switching devices to momentarily break the relay coil circuit.





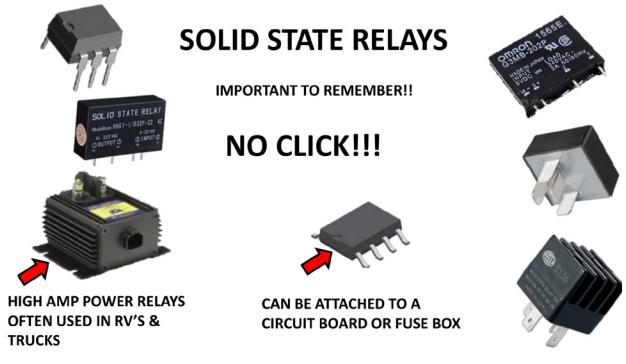


It is possible to build a custom relay “timing circuit” by following the schematic above. Change to value of the capacitor to change the amount of switching time.

REMEMBER THAT NOT ALL AUTOMOTIVE RELAYS ARE ISO TYPES

IF NOT, ALWAYS CHECK SCHEMATIC TO IDENTIFY TERMINALS BEFORE TESTING CIRCUIT OR RELAY

Not all relays used in vehicles today are the ISO type. If you come across a non-ISO relay, be sure to obtain the vehicle specific wiring diagram for the relay before you test or diagnose the circuit. Some ISO relays or others can have dedicated fuses attached to the relay housing.



WHAT ARE SOLID-STATE RELAYS?

MOSFET'S -(metal oxide semiconductor -field effect transistor)

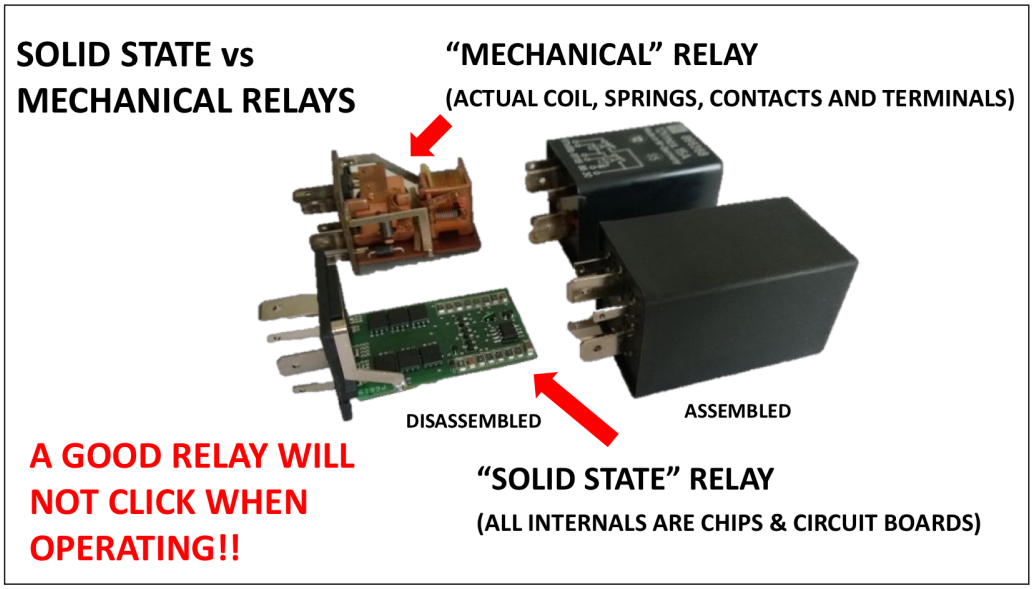
ADVANTAGES -

SILENT -NO ARCING ISSUES -CAN SUPPORT PWM CIRCUITS - NO VOLTAGE SPIKE ISSUES - CAN BE USED TO CONTROL VOLTAGES (EX: DAYTIME RUNNING LIGHTS) -VERY FAST SWITCHING-INTERNAL CIRCUIT PROTECTION W/O FUSES

DISADVANTAGES -

MORE COSTLY -CAN BE DIFFICULT TO DIAGNOSE - NON SERVICEABLE

Some of the newest types of relays are solid-state in design. Non-solid state relays have coils, mechanical contacts, springs, levers and other devices. Solid-state relays do not have the mechanical components inside that traditional relays have. They use circuit boards and electronic components to perform the same switching function in a circuit as a mechanical relay does. It is important to remember that solid-state relays do not typically have the "clicking" sound that is a common trait of standard relays. Be sure to follow OEM diagnostic routines to properly determining if the solid-state relay is functioning normally or not.



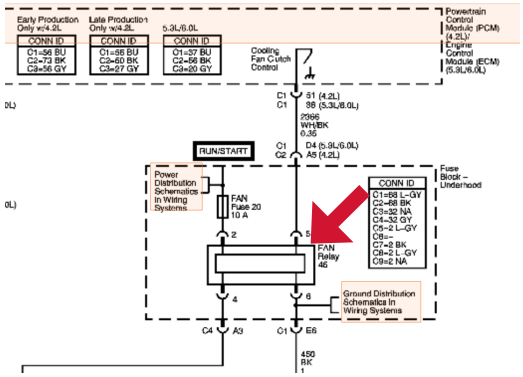
GM PCB SOLID STATE RELAYS

A recent new relay has appeared on vehicles used especially by GM. It is a solid-state relay that GM calls a "PCB" or printed circuit board relay. It has no internal mechanical parts. It also uses a unique terminal configuration that was designed to prevent the relay from being installed in a conventional ISO relay receptacle. Look at picture below to observe the different terminal configuration: **GM Part # 15016745**

SOMETHING KIND OF "NEW"

STANDARD ISO –
MICRO 5-PIN RELAY

SOLID STATE ISO –
MICRO 4-PIN RELAY
GM CALLS THEM A
"PCB" RELAY – 2005+

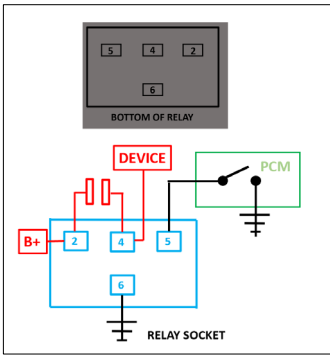


This relay is used in many GM vehicles for blower motors, cooling fans and other applications. The schematic does not show any internal relay parts (just a blank box). This relay is solid-state and does not contain a coil or physical contacts. Instead, it is a Mosfet transistor.

CONFUSING TERMINOLOGY

PCB – (MOUNTED ON A CIRCUIT BOARD)
NOT SERVICEABLE – ENTIRE BOARD REPLACED

PCB – (ELECTRONIC RELAY) GM'S TERM.
REMOVABLE & SERVICEABLE – EXCHANGE WITH A NEW ONE



BISTABLE RELAYS

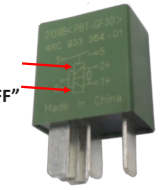
BISTABLE RELAY:

ONCE RELAY COIL IS ENERGIZED – THE RELAY STAYS IN WHAT EVER POSITION WAS COMMANDED EITHER "ON" or "OFF" EVEN WHEN COIL IS TURNED OFF

COIL ENERGIZATION IS ONLY MOMENTARY – NOT CONSTANT

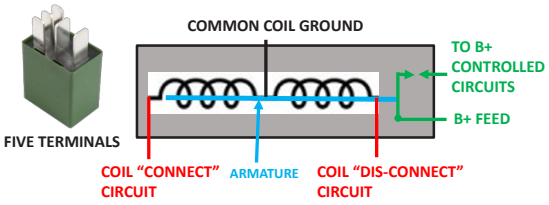
RELAY COIL(s) MUST BE ENERGIZED AGAIN TO "SWITCH" RELAY

NO CURRENT FLOW IN COIL CIRCUIT ONCE COIL CIRCUIT IS ACTIVATED

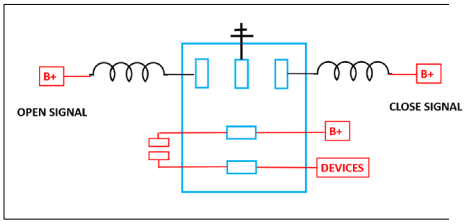


CAN HAVE "ONE" OR "TWO" COILS
(MOST LIKELY ALL SOLID STATE DESIGN)

"TWO COIL" BISTABLE RELAY – CIRCUIT THEORY EXPLANATION (BUT MOST RELAYS ARE LIKELY SOLID STATE)



BISTABLE RELAY – MOST OPERATED BY MODULES & QUAD-DRIVERS. NOT MECHANICAL SWITCHES



GM HI-POWER RELAYS

In recent years, GM has redesigned some of their ISO relays to handle higher circuit load currents for such components as fuel pumps, blower motors, etc. They call the high power or (HI PWR) relays. They are physically the same size as other ISO Mini types. It is important to note that there is an "older" version and a "newer" version, and they do not have the same specifications for testing.

OLD VERSION: GM PART# 13500126 or 13500127

This relay has heavy duty contacts (30, 87a and 87) to handle loads up to 35A. The coil resistance is the same as most other similar and specifications is around 80Ω ±. This relay is totally interchangeable with other relay applications.

NEW VERSION: GM PART# 13502751

This relay has been redesigned with a different relay coil. The new coil has a normal resistance specification of 200Ω ±. This is a very important factor to remember when testing the coil resistance. Most ISO relays always have had a normal coil resistance in the range of 80Ω ±. If one does not know about the new version of the high-power relay, they could condemn a good relay.

Another big factor has to do with the control circuit of this relay. With the coil having 210Ω ± of resistance, the amount of control current from a PCM/BCM or other control modules is much less that a relay having a coil resistance of 80Ω ±. The 210Ω ± coil draws about 60mA of current compared to an 80Ω ± coil which draws about 160mA. If a "regular" relay is installed in place of the new version, the higher control current could possibly damage the computer or module. Be aware of the differences.

GM "HI-POWER" RELAY – (OLD & NEW VERSIONS)

ON "NEW" VERSION - COIL RESISTANCE IS HIGHER THAN MOST ALL OTHERS – HANDLES HIGHER CURRENTS WITH LOWER CONTROL CURRENT BY PCM-BCM

OLD VERSION - #13500126 & 13500127

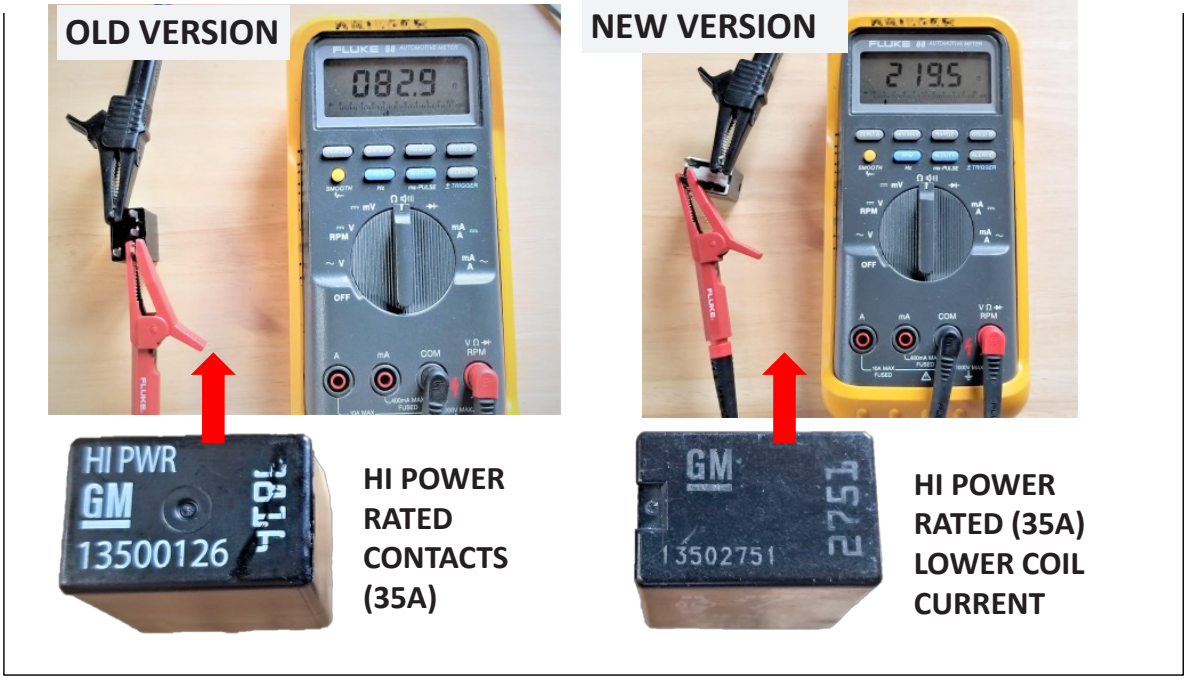
NEW VERSION - #13502751

(AND, DOESN'T HAVE "HI PWR" ON IT!)

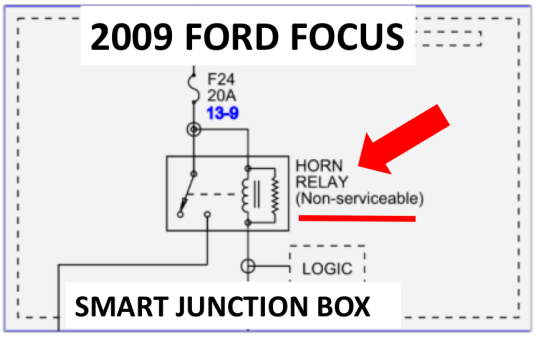
WARNING !!!

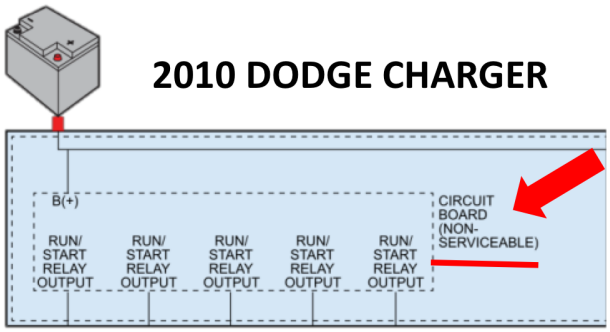
PWM CIRCUITS

SPEC'S –	COIL RESISTANCE	COIL CURRENT
OLD & COMMON ISO –	80Ω	160mA
NEW - GM HI-POWER –	210Ω ←	60mA ←



Testing the old and new versions of the GM Hi Power relays.



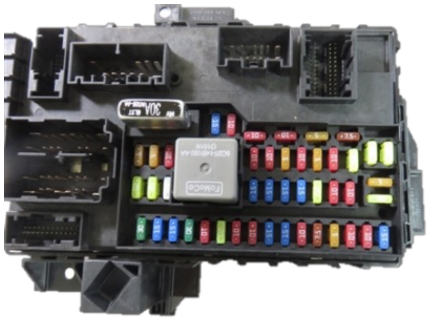


TIPM (TOTALLY INTEGRATED POWER MODULE)

INTEGRAL RELAYS

RELAYS HANDOUT

Many vehicles today use “integrated relays” installed in fuse boxes, power centers or other modules. These relays are identified as “non-serviceable” and replacement of the entire assembly is the only method of repair. These units are expensive and often must be programmed to the specific vehicle they are installed in.



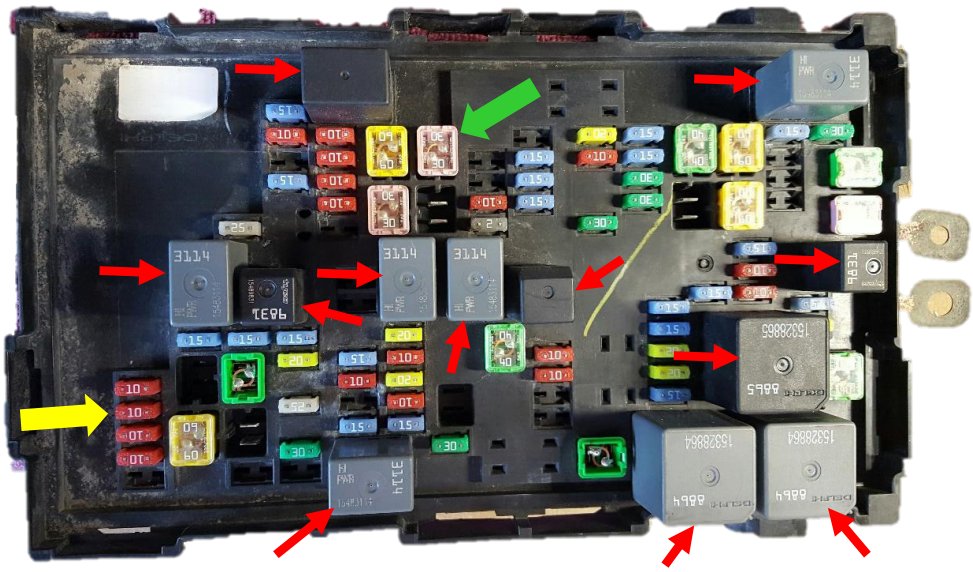
SMART JUNCTION BOX

$205.00 PLUS PROGRAMMING CHARGES

TIPM (TOTALLY INTEGRATED POWER MODULE)

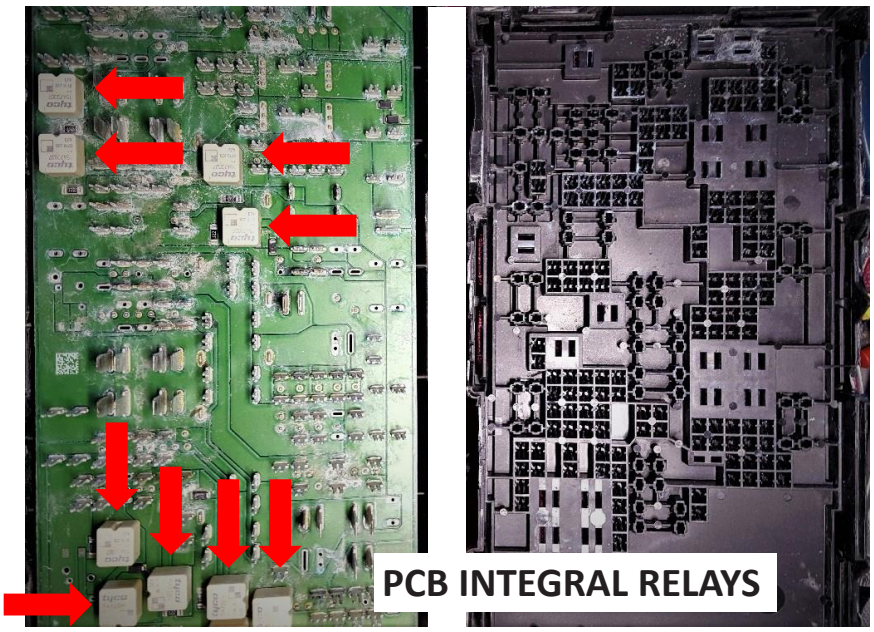
$300.00+ PLUS PROGRAMMING CHARGES

DORMAN IS ONE AFTERMARKET MANUFACTURER THAT NOW CARRIES THESE COMPONENTS

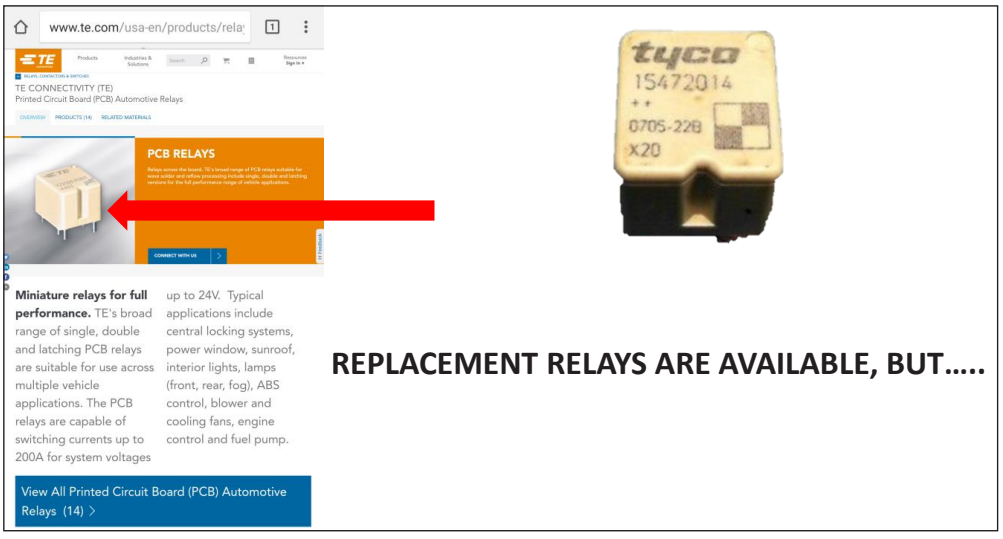


GM POWER DISTRIBUTION CENTER (VERY COMMON)

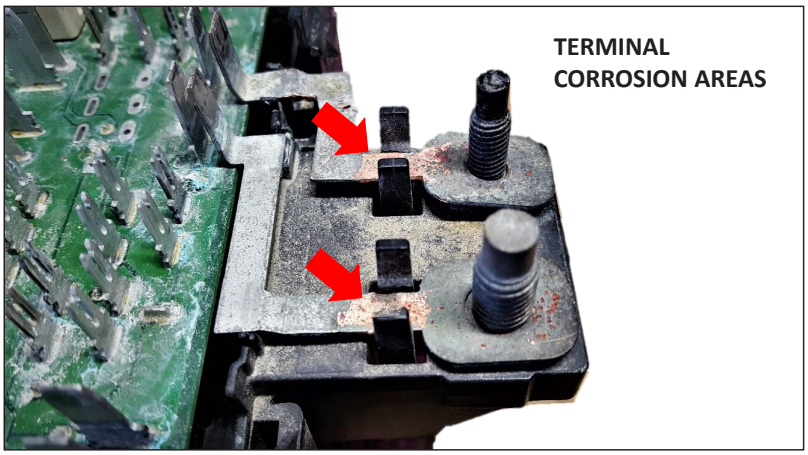
A typical Power Distribution Center on a GM product primarily used from 2007 and newer vehicles. The assembly is fed by B+ power and ground by the two large terminals (shown on right-side of picture) The **GREEN** arrow identifies cartridge fuses (30A, 40A, 60A), **RED** arrows identify all types of relays (replaceable) and **YELLOW** arrow identifies mini-fuses. This assembly also has integral relays on the under-side of the circuit board that are non-serviceable. (See below picture).



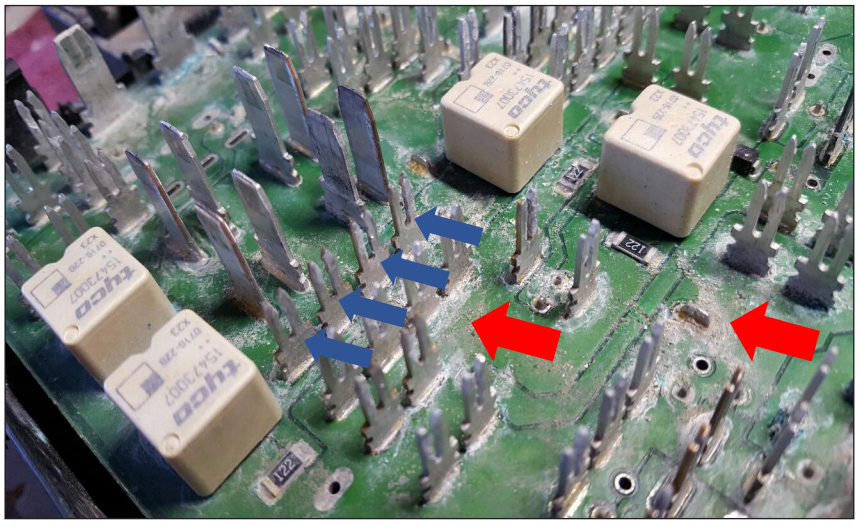
This picture shows the location of nine integral non-serviceable relays soldered onto the circuit board. This assembly is NOT designed to be taken apart and perform service on the relays. It is shown taken apart only for instructional purposes. The non-serviceable relays are classified as “PCB” relays which indicates that they are soldered on the “Printed Circuit Board”.



Although, the actual PCB relays can be located and purchased, GM does not recommend that this particular component be serviced. Some circuit boards (like FCA) can have the integral relays replaced, but this procedure takes a high degree of expertise, requires very detailed soldering work and often isn’t worth the financial savings considering the issues of customer warranties and support. Most commonly, if the component needs replacing, the entire assembly is exchanged.

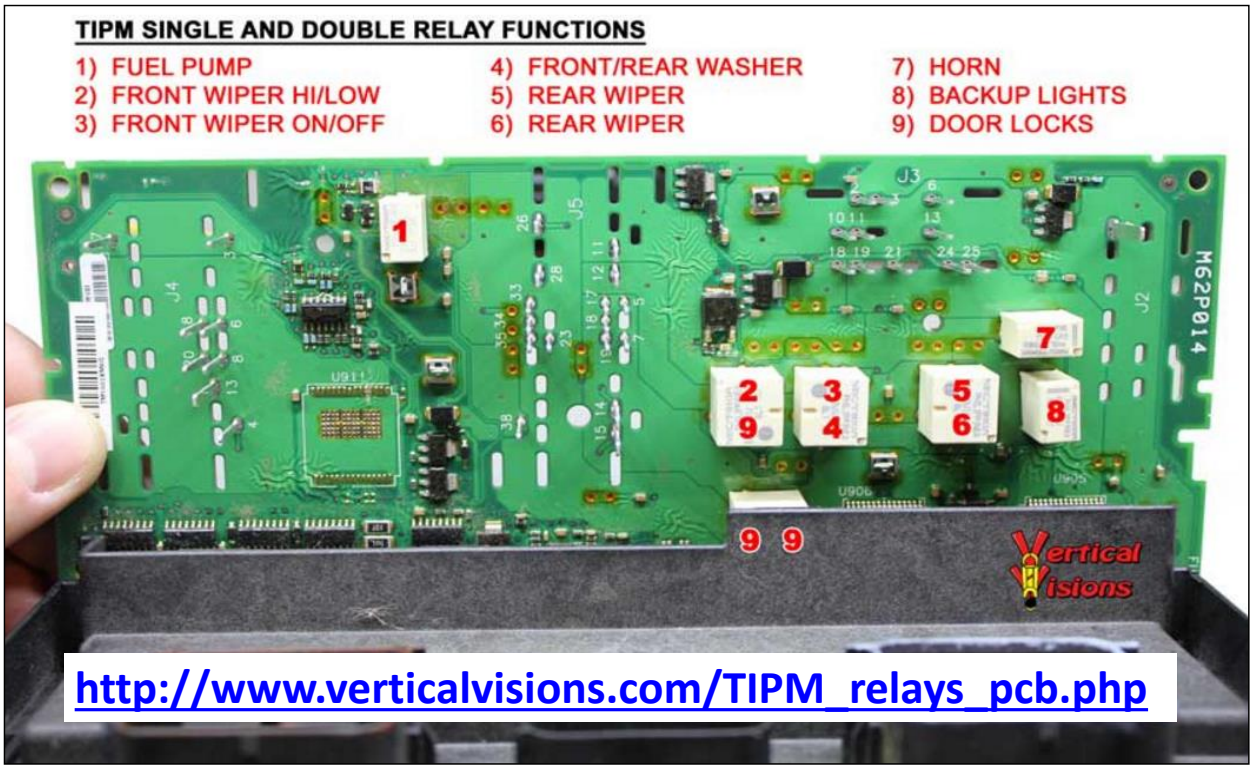


One of the biggest problems and concerns with sealed assemblies like power distribution centers is moisture intrusion. OEM components are carefully sealed and protected from moisture. However, oftentimes the incorrect removal and assembly of covers, weather-pack connectors, grommets, etc. can result in corrosion and internal electrical problems requiring replacement of the entire assembly. The main diagnostic issue with these conditions is that the damage cannot be viewed from the outside of the assembly and because disassembly is often not recommended, the only clue to this possible condition is improper component or circuit performance. It is extremely important that all covers are properly reinstalled when checking or servicing these components.



The red arrows point to circuit board corrosion caused from water intrusion. Normally, this portion of the circuit board is not visible to technicians as it is under non-serviceable assemblies. In this case, the notches or slots on the terminals identified by the blue arrows where the mini-fuses attach from above the circuit board cover.

Careful inspection and service procedures must be followed in order to prevent moisture intrusion and subsequent damage to fuse boxes, power distribution centers and other similar components. Failure to do can result in expensive repairs.



Integrated and solid state relays are tested differently than common mechanical relays. Always refer to OEM service information, but common diagnostic procedures of these components include:

1. Scan tool bi-directional control tests of relay function.
2. Scope testing of relay commands from input source.
3. Substitution of relay's controlled load with an equal sized load to check function of relay and control circuits.

If a defective integrated relay is diagnosed and confirmed, replacement of the entire component (fuse box, Power Distribution Center, TIPM or other component) is often required. Check with other sources as to the other availability of alternative repair and replacement procedures for individual relays.

Be aware that this process often requires complicated disassembly and re-assembly of the circuit boards including the requirement of de-soldering and soldering of very small electrical connections and terminals. These procedures may not be suitable for every case.

RELAY TESTING

ABSOLUTELY NEED ACCURATE AND VEHICLE SPECIFIC SERVICE INFORMATION FOR PROPER DIAGNOSIS

IDENTIFI

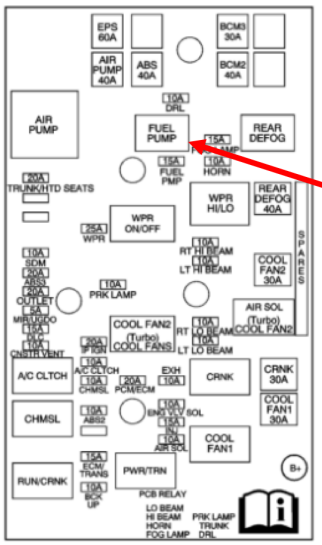
OnDemand5

SHOPKEY

ALLDATA

Relays and relay circuits often require accurate testing to identify the cause of a circuit malfunction. It is necessary for technicians to have a thorough understanding and ability to properly diagnose these components. One of the most important factors is to have accurate vehicle service information applied to a specific vehicle. Never assume that all relays and relay circuits are the same. They may be, but often can vary by model year and specific vehicle application.

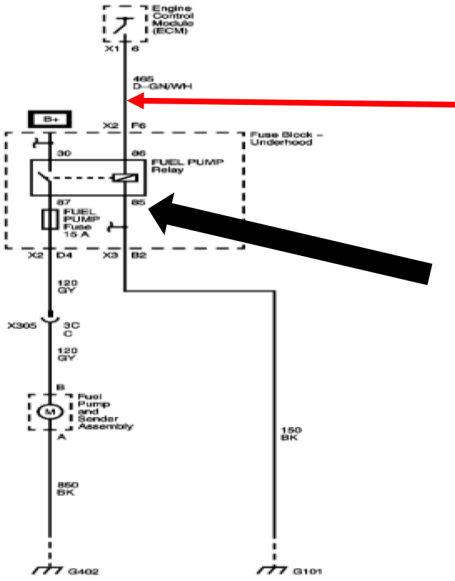
It is important to have a full understanding of how a relay circuit operates, what input turns the relay on, the power and coil power ground circuits and when the relay operates. This information is available for OEM and some aftermarket service information resources.



PROPER DIAGNOSIS REQUIRES ACCURATE SERVICE INFORMATION

COMPONENT LOCATOR

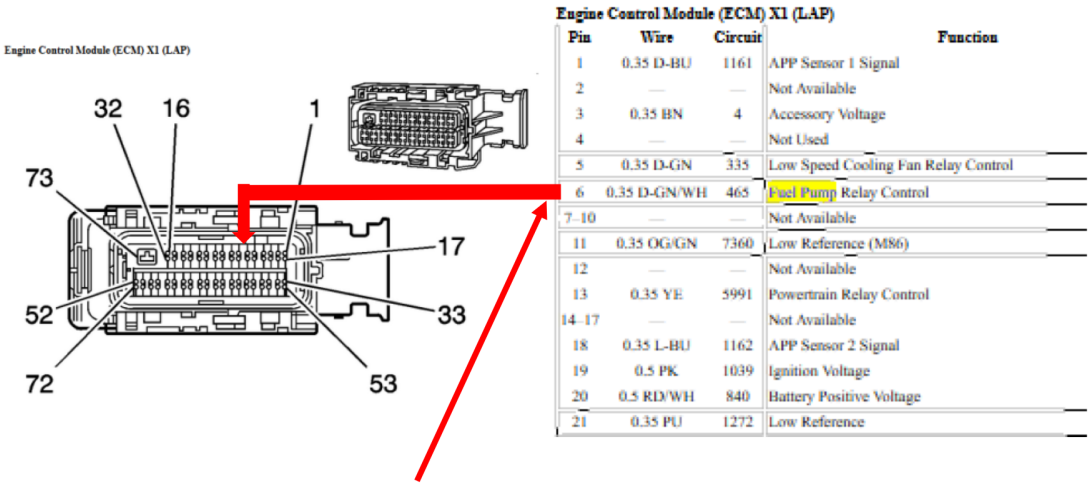
WHERE IS THE RELAY LOCATED?



VEHICLE SPECIFIC WIRING DIAGRAM

REMEMBER THAT #85 IS THE GROUND CIRCUIT FOR THE RELAY IN THIS EXAMPLE

Having the correct wiring diagram is critical for correct repair of electrical circuits.



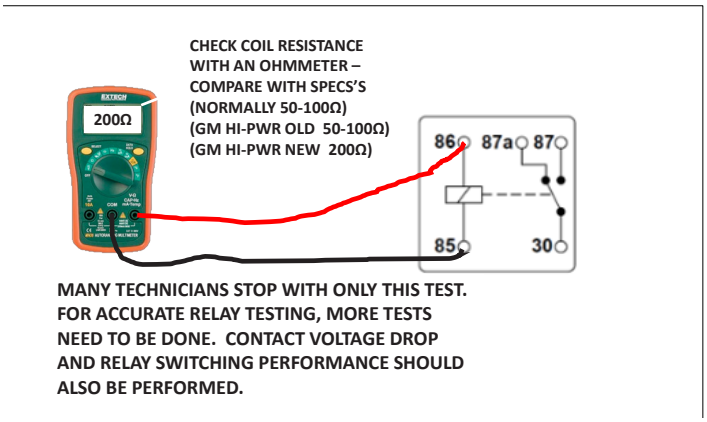
Engine Control Module (ECM) X1 (LAP)

Pin	Wire	Circuit	Function
1	0.35 D-BU	1161	APP Sensor 1 Signal
2	—	—	Not Available
3	0.35 BN	4	Accessory Voltage
4	—	—	Not Used
5	0.35 D-GN	335	Low Speed Cooling Fan Relay Control
6	0.35 D-GN/WH	465	Fuel Pump Relay Control
7–10	—	—	Not Available
11	0.35 OG/GN	7360	Low Reference (M86)
12	—	—	Not Available
13	0.35 YE	5991	Powertrain Relay Control
14–17	—	—	Not Available
18	0.35 L-BU	1162	APP Sensor 2 Signal
19	0.5 PK	1039	Ignition Voltage
20	0.5 RD/WH	840	Battery Positive Voltage
21	0.35 PU	1272	Low Reference

KNOW THE CIRCUIT AND WHAT CAUSES IT TO "TURN ON" AND WHEN

Understanding the circuit is also very important for the correct diagnosis to be revealed. You must understand what turns the relay on. What conditions have to be met before the relay is energized?

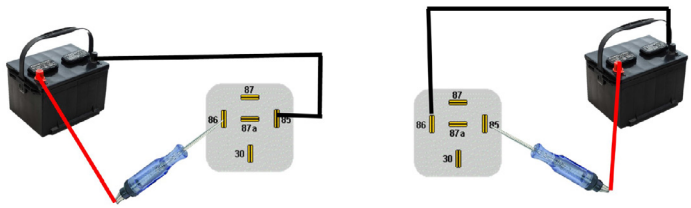
The above pictures show a typical fuel pump circuit from a GM vehicle. It is important to understand how the entire circuit operates before attempting to perform any testing. Use service information to identify the location of the relay circuit wires in all connecters.



Test the relay coil resistance by hooking up an ohmmeter on LOW scale to terminals 85 & 86 of the relay. It doesn't make any difference about polarity. The reading should be between 50-100Ω for standard relays and between 195-210Ω for GM Hi-Pwr relays

MANY TECHNICIANS STOP WITH ONLY THIS TEST. FOR ACCURATE RELAY TESTING, MORE TESTS NEED TO BE DONE. CONTACT VOLTAGE DROP AND RELAY SWITCHING PERFORMANCE SHOULD ALSO BE PERFORMED.

TESTING FOR A DIODE IN RELAY COIL



Relays with an internal diode used for spike suppression, MUST be bench tested in only one specific polarity hookup of B+ and ground to relay terminals 85 & 86. If a relay with a diode is energized with reverse polarity, the diode will be instantly destroyed and you will not know it because the relay coil will still be energized and the relay will operate "normally", but without spike suppression.

TESTING PROCEDURE:

Connect a 12V test light that draws at least 200mA or a #194 bulb and socket to terminals 85 and 86 of the relay. The light bulb will do one of the following two things:

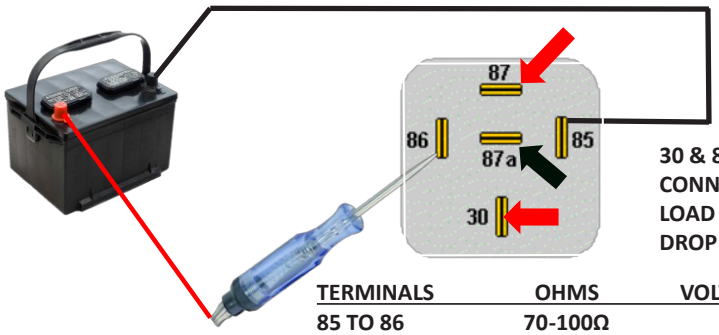
1. It will come on dim and the relay will "click". (The current flowing through the test light is still sufficient to energize the relay coil. This is one-half of the test to determine if there is a diode in the relay coil circuit.
2. It will come on bright and the relay will not click". (This indicates that there is a diode in the relay coil circuit and that it is functioning properly.)

Now, reverse the polarity of the test light or bulb connected to the relay coil terminals.

1. If the test light comes on dim and the relay "clicks" again, you have confirmed that there is a resistor in the coil circuit OR if there is supposed to be diode in the circuit, the diode is "blown" and is not protecting the circuit from voltage spikes.
2. If the test light comes on bright and the relay does not "click", there is a diode in the relay coil circuit and it is functioning properly.

SUMMARY:
If the relay coil clicks with both polarity hookups, there is either a suppression resistor in the coil circuit OR if there is a diode in the relay coil, it is blown and is not protecting the circuity. NOTE- the relay will still function normally, but there will be no spike protection.

RELAY BENCH TESTING
(FOR COILS WITH 80Ω COIL RESISTANCE)
(MUST USE A TEST LIGHT OR #194 BULB THAT DRAWS ABOUT .250A)



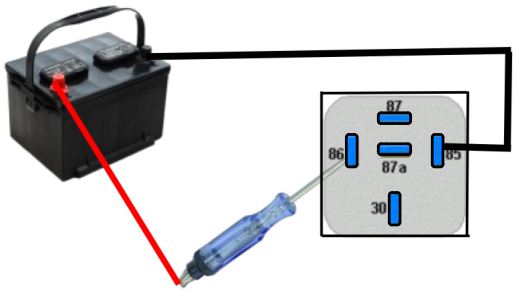
30 & 87 MUST BE CONNECTED TO AN EQUAL LOAD BEFORE VOLTAGE DROP TESTING.

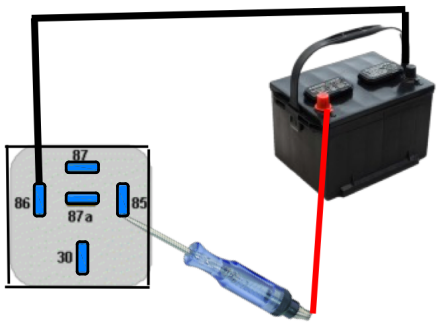
TERMINALS	OHMS	VOLTAGE DROP
85 TO 86	70-100Ω	12 VOLT
30 TO 87	OFF - ∞ ON - 0Ω	ON .1 V or 100mV
30 TO 87a	OFF - 0Ω ON - ∞	OFF .1 V or 100mV

DOES RELAY HAVE A DIODE OR RESISTOR INSIDE???

REVERSE POLARITY OF TEST LIGHT HOOKUP
IF RELAY CLICKS IN ONE DIRECTION, BUT NOT THE OTHER, IT HAS A DIODE

IF RELAY CLICKS IN BOTH DIRECTIONS, IT HAS A RESISTOR

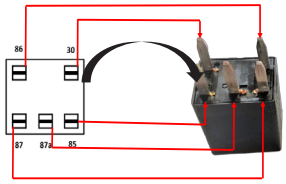




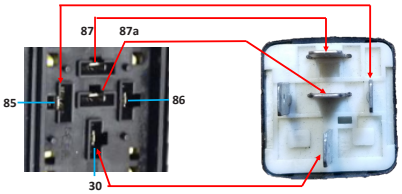
USE A .250A DRAW TEST LIGHT **#194 BULB WORKS WELL**

RELAY DYNAMIC SOCKET TESTING

With the relay removed from its socket, there is valuable testing that can be done at the socket. The first test discussed here will be to measure the current of the controlled component circuit. See below drawing

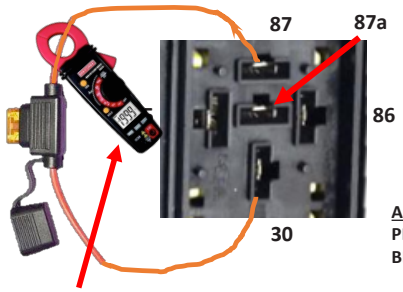


IDENTIFYING SOCKET TERMINALS



IDENTIFYING SOCKET TERMINALS

After removing the relay from its socket, it is very important to correctly identify the terminal receptacles. Some service information documents provide this information and others may not. Turn relay over in your hands and carefully observe the terminal numbers and mentally transfer those to the socket. It's helpful to make a sketch of the socket if you don't have correct service information.



CURRENT DRAW OF DEVICE CIRCUIT

NEVER ASSUME THAT ALL RELAYS ARE THE SAME

DYNAMIC TESTING
(ENTIRE CIRCUIT INCLUDING ALL WIRING,GROUND, CONNECTERS AND DEVICE)

ALWAYS, ALWAYS, ALWAYS CHECK PROPER WIRING DIAGRAM FIRST BEFORE JUMPERING ANYTHING.

IN THIS CASE, INSTALL A FUSED JUMPER WIRE BETWEEN #30 & #87 - CONTROLLED DEVICE SHOULD OPERATE

After properly identifying all terminals 30, 87 and 87a for the relay socket you are testing, connect a FUSED jumper wire from terminal 87 to terminal 30. Either use an inductive ammeter (as shown) or connect a properly sized ammeter in series with the jumper lead. NOTE: On some circuits, it may be necessary to supply a fused B+ power supply to the socket if terminal 30 is switched by some other circuit. However, if it is switched, it is a good diagnostic strategy to test the switch portion of the circuit also. As soon as the ammeter is connected, the reading obtained is defined as the DEVICE CIRCUIT current. DO NOT assume that it is the current draw of the device (such as a fuel pump or blower motor) A distinct advantage of performing this test is that any excessive resistance anywhere in either the B+ positive side or the ground side will reduce the amount of current flowing in the circuit. The only factor that would missing would be any voltage drop existing between the relay contacts of the relay you removed to perform this test. EXAMPLE: If the measured current was 15 amps and the circuit tested was a blower motor. Do you know if this is the correct current for this circuit? To confirm, disconnect the ammeter and connect a fused jumper wire from a known good B+ source (Battery) directly to the device. Also, to eliminate the ground circuit, you can also run a known good ground path. Now, measure the current flowing to the device. In reality, it should be very close to what was measured at the socket. If the socket current is substantially lower than the direct wired direct current, there is unwanted resistance in the circuit wires, connecters, ground connections or other problems. This is good confirmation test that the circuit has good integrity without having to disassemble components to gain access to wiring and connecters.

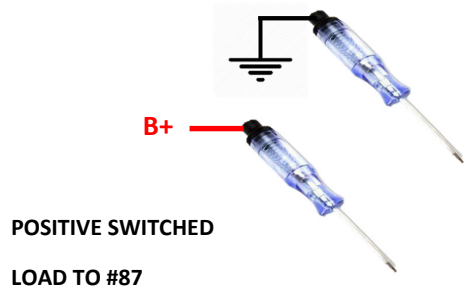
If the relay also uses terminal 87a for operation, be sure to test that circuit also.

RELAY SOCKET TERMINAL TESTING

Important diagnosis for relay controlled circuits can effectively be done at the relay socket. Many times, the portion of the entire circuit which is causing problems can be identified at the relay socket before any disassembly needs to be completed. It is extremely important that before completing any tests at the relay socket, one MUST completely and thoroughly understand how the circuit is constructed and operates. This can only be done by using a VEHICLE SPECIFIC wiring schematic that shows the circuit in detail. Many of today's schematics can be difficult to interpret. Be sure you are familiar with the circuit you are testing.

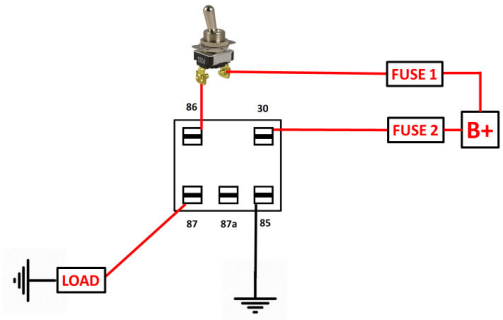
PROCEDURE:

1- Obtain a vehicle specific wiring schematic for the circuit being tested and gain a complete understanding of how it functions.
2- Identify the location of the relay being tested and remove. Inspect relay for any abnormal conditions.
3- Carefully and accurately identify each terminal of the relay socket. Make a sketch of the terminal numbers.
4- Using a 12 volt test light (250mA or less), begin testing the relay socket and corresponding circuits.



POSITIVE SWITCHED

LOAD TO #87

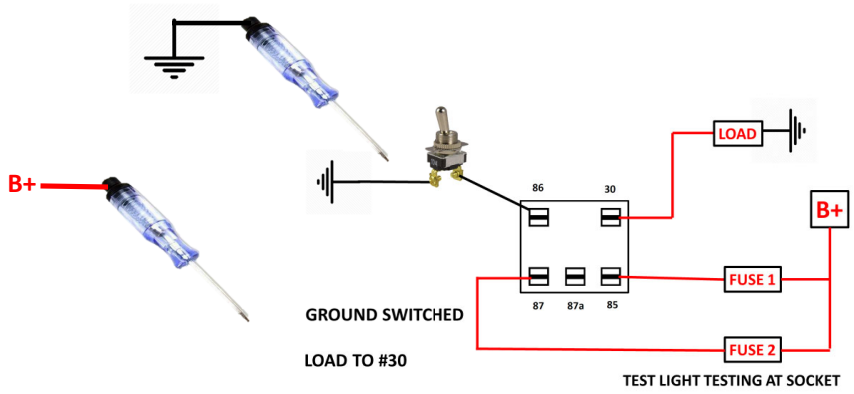


CIRCUIT EXAMPLE – COIL CIRCUIT IS B+ SWITCHED AND LOAD IS CONNECTED TO TERMINAL 87

TEST LIGHT CONNECTED FROM GROUND TO:		EXPECTED RESULTS OF TEST
1-	86	"OFF" (control switch is defective or open or there is an open in that circuit)
2-	86	"ON" (control switch is closed (switch test- open & close switch)(or a short to B+)
3-	30	"ON" (Fuse #1 is good)
4-	30	"OFF" (Fuse #1 is open or circuit is open)
5-	85	"OFF" (there is no B+ feed to terminal 85)
6-	85	"ON" (there is a short between B+ and circuit 85 with an open ground)
7-	87	"OFF" (relay removed, there is no B+ to this termina)l
8-	87	"ON" (there is a short between B+ and this circuit)
9-	87a	"OFF" (no B+ on this terminal with this specific circuit although there could be in others)

TEST LIGHT CONNECTED FROM B+ TO:		EXPECTED RESULTS OF TEST
10-	86	"OFF" (no path to ground is available)
11-	86	"ON" (there is a short to ground in the circuit & fuse 1 would be open)
12-	85	"ON" (circuit 85 path to ground has continuity)
13-	85	"OFF" (circuit path to ground has an open)
14-	30	"OFF" (there is no path to ground in this circuit)
15-	30	"ON" (there is a short to ground in the circuit and fuse #2 is open)
16-	87	"DIM or BRIGHT" (depending the resistance of the load, test light may come on dim if load circuit is high. If load has low resistance, test light will be BRIGHT)
17-	87	"OFF" (there is an open in the controlled device B+ circuit or device is open)
18-	87a	"OFF" (test light results could vary depending on if 87a terminal is used on other circuits

The below circuit is **GROUND** switched and the LOAD is connected to terminal #30. See test results below:



CIRCUIT EXAMPLE – COIL CIRCUIT IS GROUND SWITCHED AND LOAD IS CONNECTED TO TERMINAL 30

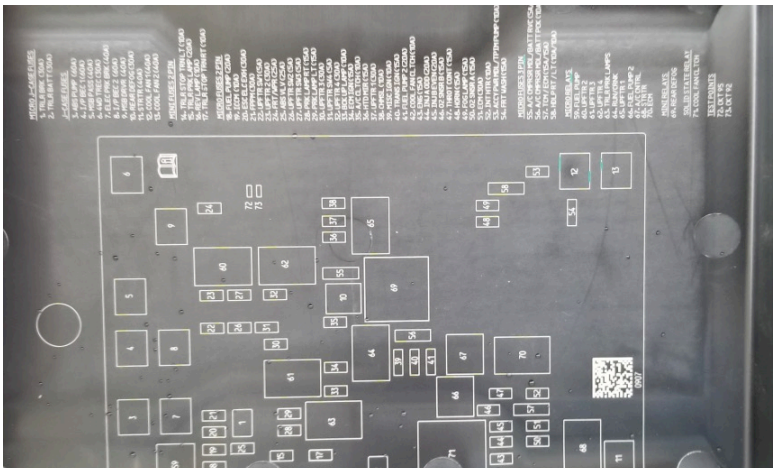
TEST LIGHT CONNECTED FROM GROUND TO:		EXPECTED RESULTS OF TEST
1-	86	"OFF" (there is no B+ available to turn on test light)
2-	86	"ON" (there is a short to B+ somewhere in the circuit)
3-	30	"OFF" (there is no B+ available to turn on test light))
4-	30	"ON" (there is a short to B+ somewhere in the circuit)
5-	85	"ON" (Fuse 1 is good and circuit has continuity)
6-	85	"OFF" (Fuse 1 is open or there is an open in that circuit)
7-	87	"ON" (Fuse 2 is good and circuit has continuity)
8-	87	"OFF" (Fuse 2 is open or there is an open somewhere in that circuit)
9-	87a	"OFF" (no B+ on this terminal with this specific circuit although there could be in others)

TEST LIGHT CONNECTED FROM B+ TO:		EXPECTED RESULTS OF TEST
10-	86	"OFF" (if switch is open, is defective or there is an open in that circuit)
11-	86	"ON" (If switch is closed or there is a short to B+ in the circuit)(switch test ON/OFF)
12-	85	"OFF" (there is no path to ground for test light)
13-	85	"ON" (Fuse 1 is open and there is a short to ground in that circuit)
14-	30	"DIM or BRIGHT" (depending on the resistance of the load, test light may come on dim if load resistance is high. If load has low resistance, test light will be BRIGHT))
15-	30	"OFF" (there is an open in the circuit to load) or load is open)
16-	87	"OFF" (there is no path to ground for the test light)
17-	87	"ON" (Fuse 2 is open and there is short to ground in that circuit)
18-	87a	"OFF" (test light results could vary depending on if 87a terminal is used on other circuits)

All of t he above tests can save significant amounts of time when diagnosing a non-functional relay controlled circuit. This is also a great assignment to make to your students or technicians to confirm proper understanding of how the circuit functions.

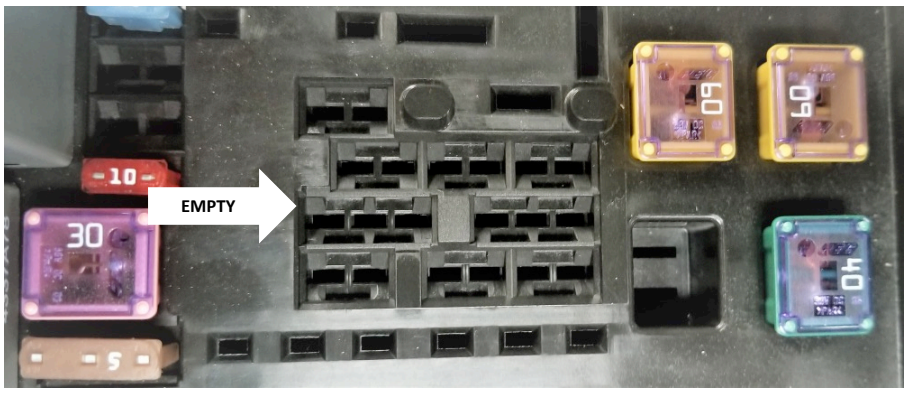
TESTING AT THE VEHICLE PDC (POWER DISTRIBUTION CENTER) or FUSE BOX

There are several tests that can be performed for relays and relay circuits at the vehicles PDC (Power Distribution Center or Fuse Box). Be sure to use correct vehicle service information to locate the correct fuse box or PDC for the relay circuit you are working on. Use the service information or the cover for correct relay, fuse and circuit breaker identification.



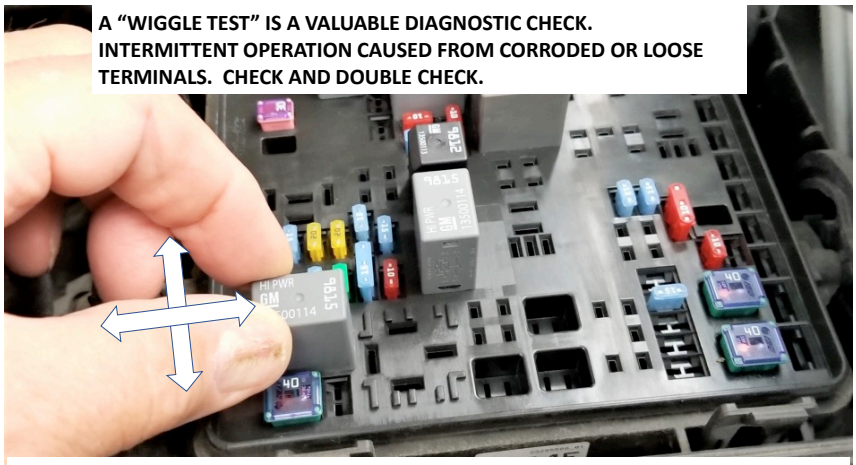
THE IMPORTANCE OF KNOWING THE CORRECT RELAY……

It is important to note that not all relay sockets are used in each vehicle. If the relay socket does not have electrical terminals in it, it usually means that the vehicle being worked on does not have that specific relay circuit option. Disregard all “empty” relay sockets.

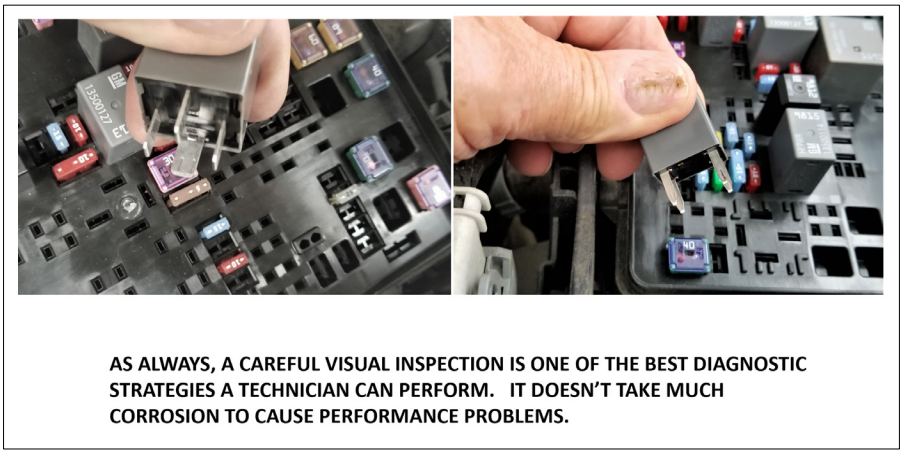


NOT ALL VEHICLES USE ALL AVAILABLE RELAY SOCKET POSITIONS IN PDC (POWER DISTRIBUTION CENTER) or FUSE BOX

It can be good diagnostic test to “wiggle” the relay back and forth in its socket while monitoring the circuit performance. Corroded or dirty relay terminals or sockets (green) can dramatically affect the circuit. Some manufacturers mention to NOT perform this test as their concern is that by doing so, the tendency is to enlarge or stretch out the relay connecter terminals which they say can cause loose connections. If this test is performed carefully, it can be done without damage.



Another valuable test to be performed at the PDC is to complete a very careful visual inspection of both the relay and socket terminals. Look for signs of corrosion, green deposits, water intrusion and overheating. These conditions can cause relay circuit to malfunction or not operate at sll. VISUAL INSPECTION is a critical part of any diagnostic procedure.

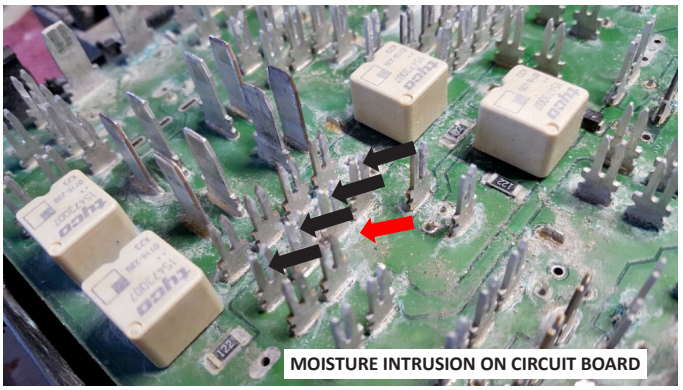


If an abnormal condition is discovered during the visual inspection, it will be necessary to repair or replace the PDC or fuse box. In some cases, it may be possible to install a separate relay outside of the PDC, but this should be done only with your supervisor's and the customers awareness and permission. Other causes of these conditions can be having too many electrical devices on the relay circuit that was not designed to handle the extra current. Vehicle owners who add additional non-stock devices to existing relay circuits are a common cause of this condition. Snow plow trucks, RV add-on devices, high power audio systems and others are common causes of this condition.

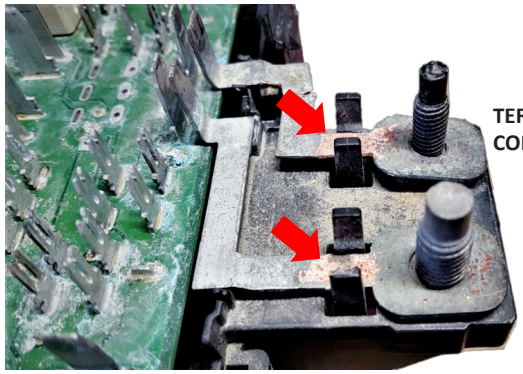
OVERHEATED RELAY SOCKETS CAN BE TYPICALLY CAUSED FROM:

1- EXCESSIVE CURRENT CAUSED FROM DEVICE SHORTED OR PARTIALLY SHORTED
2- TESTING RELAY CIRCUITS & NOT USING A FUSED JUMPER WIRE
3- UNWANTED SHORT OF B+ TO GROUND IN THE CIRCUIT
4- ADDING TOO MANY DEVICES TO AN EXISTING CIRCUIT (OFF-ROADERS, SNOW PLOWS & EXTRA LIGHTING DEVICES)

In many cases, where there is visible external relay socket damage, there may also be significant internal damage and corrosion that cannot be seen. Moisture intrusion is a common cause of having to replace the entire PDC or fuse box. Causes of moisture intrusion can be from power washing the engine compartment, damaged or missing weather pack sealing gaskets or loose or poorly connected covers. See below pictures for examples of water intrusion that required the PDC to be replaced.

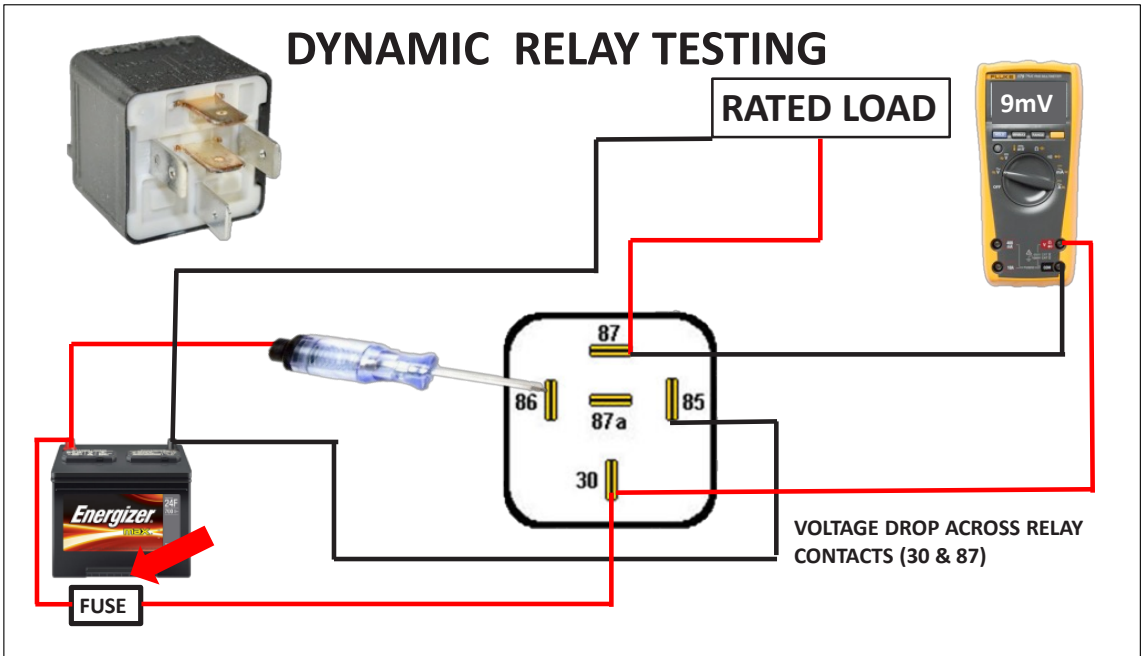


MOISTURE INTRUSION ON CIRCUIT BOARD



TERMINAL CORROSION AREAS

DYNAMIC BENCH TESTING OF TERMINALS 30 & 87

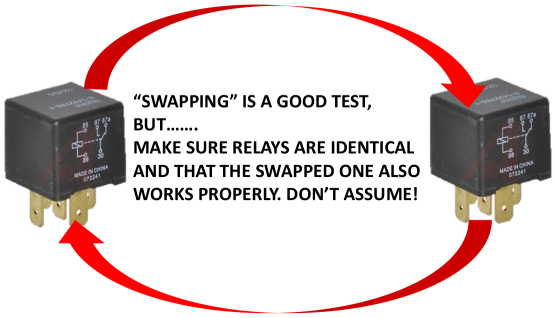


A very necessary test of any relay is to measure how much voltage drop is lost through the relay contacts when energized. Relays can have corroded or pitted contacts which negatively affects the ability to conduct current. Many technicians do not conduct this test, but it is extremely important to do so. This can be done both in the vehicle or on the bench. If testing on the bench, create an electrical load equal to the circuit load that the relay controls in the vehicle. Hooking head lights in parallel or blower motors are simple methods of doing this. Set up the test circuit on the workbench and energize the relay with the correct polarity. Using a voltmeter set to read milli-volts, measure the voltage drop between terminals 30 and 87 of the relay. If the N.C. set of contacts are used (30 to 87a) be sure to test those contacts also. The amount of voltage drop across the contacts is dependent on the current flow through the relay. Typical readings are:

CURRENT	VOLTAGE DROP
40.0A	900mV
18.5A	410mV
15.0A	375mV
12.5A	320mV
10.0A	250mV
8.0A	180mV
6.6A	150mV
4.0A	100mV
2.5A	51mV
2.0A	40mV
1.3A	26mV
650mA	13mV
320mA	5.6mV
NO LOAD	0.0mV

NOTE- THESE VALUES MAY BE A BIT HIGHER OR LOWER FOR YOUR SPECIFIC RELAY

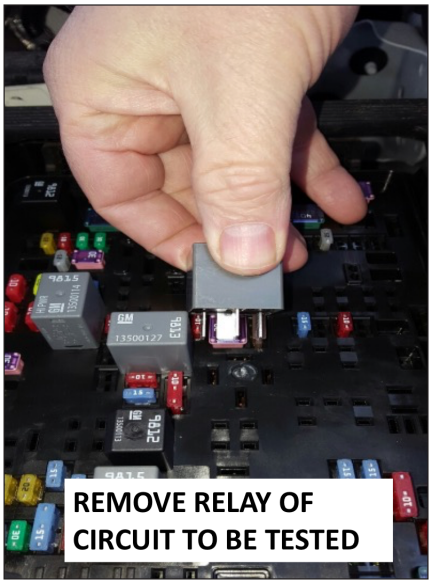
RELAYS HANDOUT



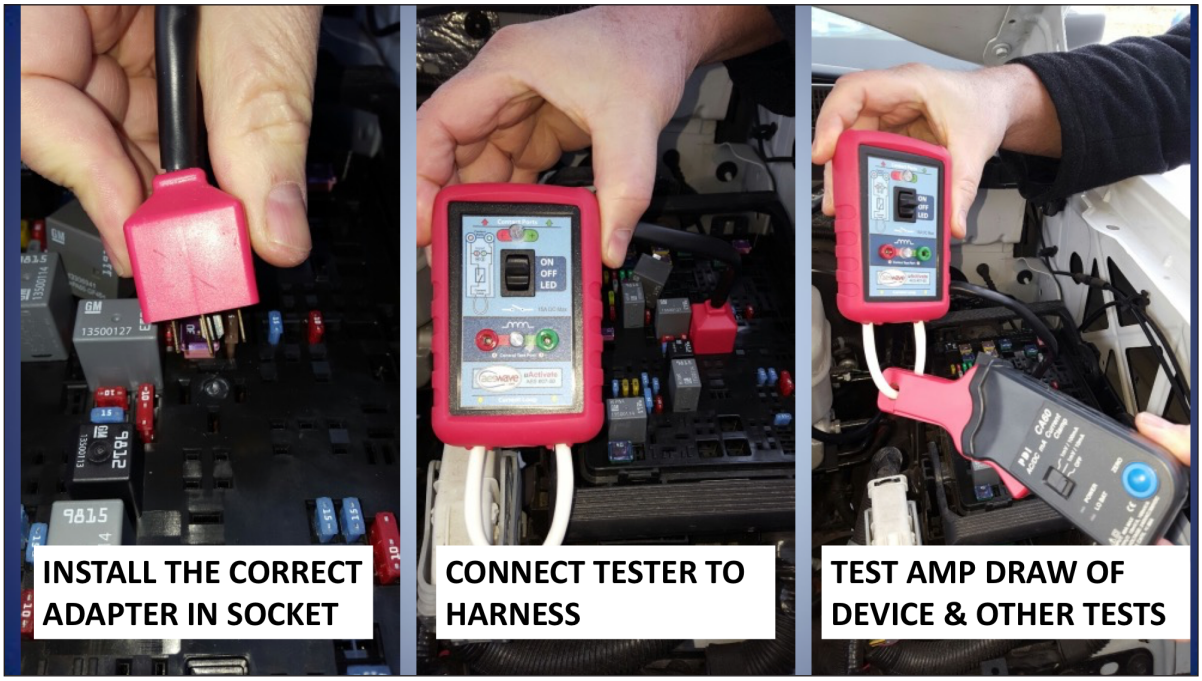
"SWAPPING" IS A GOOD TEST, BUT.....
MAKE SURE RELAYS ARE IDENTICAL AND THAT THE SWAPPED ONE ALSO WORKS PROPERLY. DON'T ASSUME!

RELAY CIRCUIT TEST TOOL – DOES NOT TEST RELAY'S, BUT TESTS THE CIRCUIT

GAIN ACCESS TO POWER DIST. CENTER



REMOVE RELAY OF CIRCUIT TO BE TESTED



SPECIALIZED RELAY CIRCUIT TEST TOOLS CAN PERFORM:

TESTS FUNCTIONALITY OF THE RELAY COIL CIRCUIT-RESISTANCE AND SWITCHING

TESTS FUNCTIONALITY CIRCUIT LOAD INCLUDING VOLTAGE DROPS, TOTAL CURRENT AND SCOPE PATTERNS IF DESIRED

IDENTIFIES POSITIVE AND NEGATIVE POLARITY OF COIL AND LOAD CIRCUITS

EASY ACCESS TO ALL RELAY CIRCUIT ELEMENTS FROM ONE LOCATION

EASY TEST ACCESS POINTS FOR OHMMETER, VOLTMETER, TEST LIGHT AND SCOPES

COVERS THE "WHAT IF'S" WHEN REPLACING THE RELAY DOESN'T FIX THE PROBLEM

LISLE LIS56810

LISLE LIS69300

Electronic Specialties ESI-191 Relay Buddy Pro Test Kit

PLUS QUIP EQP-018 EQP-109

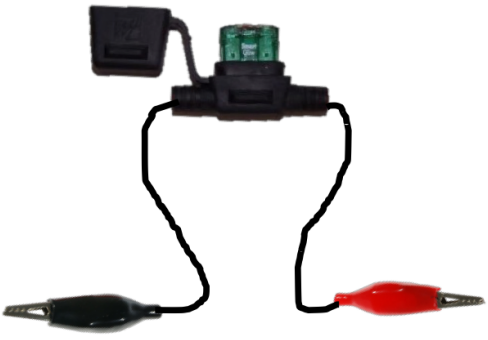
EXTECH AUT-100

IPA #9038A

Lisle 69300 MASTER RELAY CIRCUIT TEST KIT

Electronic Specialties 191 Relay Buddy Pro Test Kit

ALBA ALB30933 4 & 5 PIN RELAY TESTER



PLEASE, ALWAYS USE FUSED JUMPER WIRES WHEN TESTING, JUMPING or BYPASSING ANY COMPONENT

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Voltage Drop Testing:

Voltage Drop – Part 3 — 9:42 min
https://www.youtube.com/watch?v=WONhgSxeZ2s

Voltage Drop – Part 4 — 9:38 min
https://www.youtube.com/watch?v=H8rl5w51fNo

Voltage Drop Test – Delco Remy TECH TIP (HD Truck) — 5:54 min
https://www.youtube.com/watch?v=UhT2cNCfTXc

Voltage drop testing with the Power Probe Hook — 3:28 min
https://www.youtube.com/watch?v=4EjwMpXBjKk

Relays, Operation, Wiring, Diagnosis & Testing:

VEHICLE RELAYS - Operation & Diagnosis - Dan Sullivan — 12:37 min
https://www.youtube.com/watch?v=Mru8BbTGDwM

VEHICLE RELAYS - Testing from the relay base – Dan Sullivan — 7:19 min
https://www.youtube.com/watch?v=6eZg3wLYsr0

DIY: How to Test a Relay BASIC LEVEL — 9:51 min
https://www.youtube.com/watch?v=clSSwXeezDo

Electrical Series: How To Test A Relay — 3:45 min
https://www.youtube.com/watch?v=GtWmYffMido

How to test a 4-pin Relay (Electronic on/off Switch) also with connector & led light — 10:40 min
https://www.youtube.com/watch?v=67fU_QrN0gg

How to wire up a relay — 16:39 min
https://www.youtube.com/watch?v=bb9rCtB_2HU

How to wire a relay – Tutorial — 3:11 min
http://cumminsengines.com/assets/pdf/4971166.pdf

What is a Relay? How a Relay works! (non-automotive) — 3:35 min
https://www.youtube.com/watch?v=hhYWEh4Dfoc

What is a Relay? How does a Relay works! (Silent) — 3:31 min
https://www.youtube.com/watch?v=1_YfuH_AcxQ

Understanding 12v DC Switches, Relays, Solenoids - Part 1 — 20:14 min
https://www.youtube.com/watch?v=jZoGC0BUk5c

Testing relays with the Power Probe — 6:00 min
https://www.youtube.com/watch?v=dsUm2INjURE

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Relays, Operation, Wiring, Diagnosis & Testing:

Pete Meier Motor Age – Using the Uactivate relay tester — 4:22 min
https://www.youtube.com/watch?v=5Tx1rQn-K10

How to use Switches, Relays, Solenoids in your 12v Wiring Harness – Part 2 (Custom app.) — 21:58 min
https://www.youtube.com/watch?v=7vOVSst-SoY

How Does A Relay Work - Automotive Relay SPDT — 12:39 min
https://www.youtube.com/watch?v=xvFvJiiDD7w

Testing relay with and without a diagram (ohmmeter based only) — 14:10 min
https://www.youtube.com/watch?v=dsUm2INjURE

Wiring Products - How to Wire an Automotive Relay — 2:03 min
https://www.youtube.com/watch?v=Tw9QkkT2ptU

Basic Automotive Relay Operation and Simple Wiring
(Not perfect video quality and narrative, but good fundamentals) — 8:04 min
https://www.youtube.com/watch?v=hhduYLhUeK0

RELAYS - How to wire and how they work TUTORIAL !!
(Poor narration, but good fundamentals) — 20:52 min
https://www.youtube.com/watch?v=F1SGyN6Yp64

Switches, Relays and Wiring Diagrams 2 - ADP Training — 5:21 min
https://www.youtube.com/watch?v=Fxl1B0tpq6U

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Youtube & Other Channels for Resources:

ADP VIDEO TRAINING YOUTUBE CHANNEL
https://www.youtube.com/user/ADPTraining

AESWAVE VIDEO YOUTUBE CHANNEL
https://www.youtube.com/user/AESwave

SCANNER DANNER (PAUL DANNER) YOUTUBE BASIC CHANNEL (OVER 100 FREE VIDEOS) (DETAILED)
https://www.youtube.com/results?q=scannerdanner+YOUTUBE

SCANNER DANNER PREMIUM YOUTUBE CHANNEL (HIGHLY RECOMMEND)
https://www.youtube.com/results?search_query=scannerdanner+premium

VINCE FISCHELLI YOUTUBE CHANNEL
https://www.youtube.com/results?search_query=vince+fischelli+

VIDEO – DAVE HOBBS – COMPREHENSIVE TESTING OF PARASITIC DRAW – 190 MINUTE VIDEO FOR PURCHASE AT: https://www.aeswave.com/Parasitic-Current-Draw-p9220.html $124.95

Other Resources:

ARTICLE: How to Locate a Parasitic Drain – Motor Magazine
https://www.motor.com/magazine-summary/proven-techniques-for-battery-drain-diagnosis/#

ARTICLE: Inductive Ammeter Conducting Parasitic Draw test
http://www.hotrod.com/articles/matco-tools-parasitic-drain-tester-and-low-current-probe/

WEBSITE: Complete online course on basic electrical systems. 10 major sections of content including one on relays. Author – Kevin Sullivan – San Bruno College – After getting to homepage, click on ONLINE INSTRUCTION
www.autoshop101.com

ARTICLE: JORGE MENCHU – AESWAVE – WIRE COLOR CODING PDF
http://resources.aeswave.com/articles/Jorge/2008_12_Motor_WDcolorCoding.pdf

ARTICLE: A New Approach to Parasitic Draw Testing – Motor Age
http://www.searchautoparts.com/motorage/technicians/scope-scan-service-repair/new-approach-testing-parasitic-draw

ARTICLE: Parasitic Load Testing at fuses using a voltmeter
http://www.gonzostoolbox.com/KnowledgeFolder/ParasiticDrawHunting.html

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Multimeters — Types, Operation and Use:

How to Use a Multimeter 8:07 min
https://www.youtube.com/watch?v=TdUK6RPdIrA

Beginners Guide to Using Multimeter 19:04 min
https://www.youtube.com/watch?v=RtNMhCzq72M

How to Use a Multimeter to Diagnose Common Problems 14:08 min
https://www.youtube.com/watch?v=aDy9-IGNeQM

"The Best Multimeter in The World (How to Use Them)" Generic – Non-Automotive 41:28 min
https://www.youtube.com/watch?v=Io8MWr3NuuM

Mastering Meters & Advanced Electrical Diagnostics Dave Hobbs-Delphi 1:13:43 min
https://www.youtube.com/watch?v=QPI7gIijjNo

How to Use a Multimeter to Troubleshoot Common Problems BBB Industries 14:08 min
https://www.youtube.com/watch?v=aDy9-IGNeQM

How to use a Multimeter for beginners: Part 1 - Voltage measurement / Multimeter tutorial 32:56 min
https://www.youtube.com/watch?v=ZBbgiBU96mM

How to use a multimeter for advanced measurements: Part 2 - Current Probes / clamps / transducers 29:00 min
https://www.youtube.com/watch?v=Kqa51Femytw

How to use a Multimeter for beginners: Part 2a - Current measurement 42:35 min
https://www.youtube.com/watch?v=EVFkKBFJsZg

How to use a Multimeter for beginners: Part 3 - Resistance and Continuity 27:10 min
https://www.youtube.com/watch?v=InJhgwmj2So

How To Use a Clamp Meter 5:48 min
https:/ /www.youtube.com/watch?v=WDTVE7IxJQ8

Tutorial: How to use a clamp meter / current clamp 19:52 min
https://www.youtube.com/watch?v=nxhUwH70F_4

Multimeter Review / buyers guide: GTC CM100 1 mA to 100 A Low Current Clamp Meter 26:52 min
https://www.youtube.com/watch?v=1sq2WRGPABw

Multimeter basics, voltage and resistance tests (a free SD Premium video) Scanner Danner 39:42 min
https://www.youtube.com/watch?v=w0PpLTnKKZg

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Understanding Electrical Diagrams & Schematics:

Eric The Car Guy – Electrical Troubleshooting – Part II — 24:03 min
https://www.youtube.com/watch?v=GVSvA0y-peA

How to Read a Wiring Diagram – Part I — 6:16 min
https://www.youtube.com/watch?v=KbvM5Tkc-UA

Electrical Diagrams – Part 2 — 1:33 min
https://www.youtube.com/watch?v=TFD8ZqXujsE

Electrical Diagrams – Part 3 — 13:54 min
https://www.youtube.com/watch?v=qXWhQxQXvsY

Electrical Diagrams – Part 4 — 14:46 min
https://www.youtube.com/watch?v=VXhMh9IOqMU

Electrical Diagrams – Part 5 — 16:39 min
https://www.youtube.com/watch?v=Sv1wO3qdRZI

Electrical Diagrams – Part 6 — 9:52 min
https://www.youtube.com/watch?v=DWRi_h251XA

How to Read an Electrical Block Diagram Motor Age — 23:20 min
https://www.youtube.com/watch?v=oww3zm8fGJU

Jorge Menchu – AESwave – Wire Color Coding — 30:59 min
https://www.youtube.com/watch?v=oC480VSLjBg

Electrical and Schematic Troubleshooting-based Diagnostics with Bill Fulton — 2:28:35 min
https://www.youtube.com/watch?v=D6k9ACOJ9sw

Electrical Diagnostics with “G” Jerry Truglia and Rich Peterson Part I — 2.57:16 min
https://www.youtube.com/watch?v=UgH8FtQZhNU

Electrical Diagnostics with “G” Jerry Truglia and Rich Peterson Part II — 2.33:57 min
https://www.youtube.com/watch?v=qnlJViS9M4A

Basic Electricity for Service Techs: Ohm’s law, Current Flow, Opens & Shorts BBB Ind. — 13:53 min
https://www.youtube.com/watch?v=WoN1nou5t1Q

Understanding Electrical Circuits and How To Test Them – Motor Age — 12:00 min
https://www.youtube.com/watch?v=SO-eKuhCOqc

Advanced Electrical Troubleshooting – Jerry Truglia — 24:26 min
https://www.youtube.com/watch?v=kZ5LaFaTDNc

Electrical Testing and Troubleshooting Tips With Vince Fischelli — 53:42 min
https://www.youtube.com/watch?v=mVJWuZ6XrwA

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Understanding Electrical Diagrams & Schematics:

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Electrical and Schematic Troubleshooting-based Diagnostics with Bill Fulton 2.28:35 min
https://www.youtube.com/watch?v=D6k9ACOJ9sw

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Electrical Diagnostics with "G" Jerry Truglia and Rich Peterson Part II 2.33:57 min
https://www.youtube.com/watch?v=qnlJViS9M4A

Basic Electricity for Service Techs: Ohm's law, Current Flow, Opens & Shorts BBB Ind. 13:53 min
https://www.youtube.com/watch?v=WoN1nou5t1Q

Test Lights:

Eric The Car Guy - Basic Test Light Use 29:52 min
https://www.youtube.com/watch?v=wLVu2HYtOhA

How to Test Automotive Grounds 1:56 min
https://www.youtube.com/watch?v=LGWhzTuJroQ&list=PLRmBBuJTdDw0Pi4SEjzQV9nKQEjfEIWhH

Test Light - regular vs logic probe 8:31 min
https://www.youtube.com/watch?v=vNe3E5ncZgA&index=5&list=PLRmBBuJTdDw0Pi4SEjzQV9nKQEjfEIWhH

How to use a automotive test light – (DIY & Basic, but good info) 20:14 min
https://www.youtube.com/watch?v=BjCjmwUxUSU&list=PLRmBBuJTdDw0Pi4SEjzQV9nKQEjfEIWhH&index=12

HOW TO USE AN AUTOMOTIVE TEST LIGHT TO FIND PROBLEMS!! 3:08 min
https://www.youtube.com/watch?v=Hlna_kUt7As

How to test for a short to ground (ohmmeter vs test light) (Scanner Danner) 39:23 min
https://www.youtube.com/watch?v=WVPFOru17-Q

How to Make an LED Test Light 18:04 min
https://www.youtube.com/watch?v=tDUJDVGyzrQ

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Test Lights:

How to make your own short circuit detector — 10:06 min
https://www.youtube.com/watch?v=6aSClicvo6M&feature=youtu.be

How to measure the current draw of your test light (Incandescent vs. LED) (Scanner Danner) — 4:50 min
https://www.youtube.com/watch?v=gEQnKNLlcFQ

How to Make Your Own Test Light — 4:12 min
https://www.youtube.com/watch?v=sbzBFyn6V2c

Logic Probe Testing — 1:58 min
https://www.youtube.com/watch?v=QH8W6-U23vk

How to Make Your Own Logic Probe — 48:39 min
https://www.youtube.com/watch?v=4TH6zSdFIhA

Homemade Logic Probe Test Light — 11:28 min
https://www.youtube.com/watch?v=4TH6zSdFIhA

DIY LOGIC PROBE – Schematic — 3:35 min
https://www.youtube.com/watch?v=6CMeyYYGsaM

Not all test lights are created equal — 4:49 min
https://www.youtube.com/watch?v=ZPvJF7RP-yY

Battery Parasitic Load Testing:

How to Find a Battery Drain — 25:17 min
https://www.youtube.com/watch?v=tRYgzM3G8N4

Basic draw test using a multimeter. Very basic content — 7:53 min
https://www.youtube.com/watch?v=eXX8TfzRAKk

Parasitic Draw testing — 14:26 min
https://www.youtube.com/watch?v=jTECmj78ZOU

Pete Meier Motor Age - Parasitic draw test methods — 18:00 min
https://www.youtube.com/watch?v=P-wxG6U5TuY

Pete Meier Motor Age Voltage Drop testing across fuses — 6:19 min
https://www.youtube.com/watch?v=T6rDTtxaeJ4

Improved Methods of Battery Drain Testing — 18:12 min
https://www.youtube.com/watch?v=QRso1A0VScw

How To Locate and Identify a Parasitic Drain — 12:34 min
https://www.youtube.com/watch?v=YhC8xj5vHUg

RESOURCES FOR ELECTRICAL DIAGNOSTIC STRATEGIES CLASS

VIDEOS

Battery Parasitic Load Testing:

Eric the Car Guy parasitic load testing with multimeter (no battery saver used) 16:50 min
https://www.youtube.com/watch?v=KF1gijj03_0

Parasitic Current Draw: AMP Clamp Tech Tip – Dave Hobbs – Delphi 4:14 min
https://www.youtube.com/watch?v=EcFo35tyev0

Battery keeps going dead (what to test before replacing) – Scanner Danner 17:35 min
https://youtube.com/AA-vHbE1IA8

BATTERY DRAINS TECH TIP - Dave Hobbs 9:16 min
https://www.youtube.com/watch?v=M7fcj_R-2kY

How to test an Alternator (alternator not charging from a blown fuse) Scanner Danner Pt 1 29:38 min
https://www.youtube.com/watch?v=--AdY8z1QfU

How to find a short to ground (blown fuse) Part II - Scanner Danner 21:36 min
https://youtu.be/FK9STP4G9-I

How to locate a battery drain (parasitic drain test) Part 1 50:41 min
https://youtu.be/h06xb6SC7Yc

How to locate a battery drain (parasitic drain test) Part 2 - Scanner Danner 44:44 min
https://youtu.be/dgvIicgZRcQ

Voltage Drop Testing:

Voltage Drop Testing - Complete Topic Motor Age – Pete Meier & Jerry Truglia 1:23:51 min
https://www.youtube.com/watch?v=n7-YSsWXVq8

Voltage Drop Testing – Pete Meier & Jerry Truglia 1:26:45 min
https://www.youtube.com/watch?v=YaYtCVBodpw

Basic Voltage Drop Testing for Automotive Electrical Testing 13:56 min
https://www.youtube.com/watch?v=9aioZN33xsA

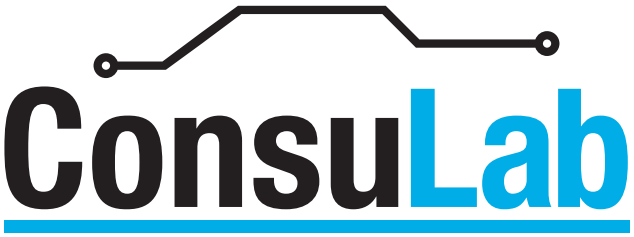
Understanding Voltage Drop 33:14 min
https://www.youtube.com/watch?v=DfLyh43iihM

What is Voltage Drop? Dan Sullivan 14:54 min
https://www.youtube.com/watch?v=ggKnH-95ty0

Voltage Drop – Part 1 3:40 min
https://www.youtube.com/watch?v=6Sqk_Gai59I

Voltage Drop – Part 29:28 min
https://www.youtube.com/watch?v=a1vR2BxJ9jQ

NOTES



TRAINING AIDS

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