Appendix A

Circuit Inspection

Input Signals

Sensors produce different types of signals, that are either analog (variable voltage) or digital signal (on or off). The ECM will measure either voltage, amperage, or frequency of these signals.

Analog and Digital Signals

Fig. A-01
T852f363

Analog Signal

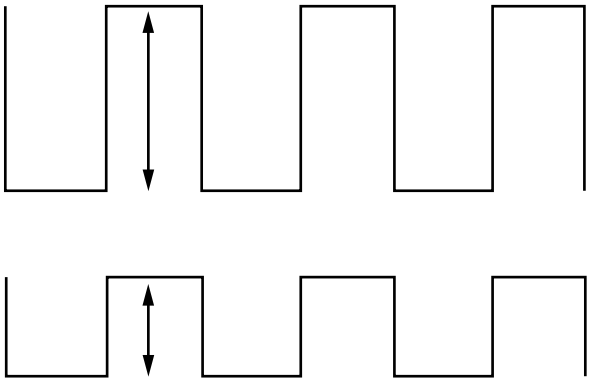
An analog signal is a variable signal and is usually measured by voltage or frequency. The voltage of the signal can be at any given point in a given range.

Digital Signal

A digital signal has only two states; high or low. This signal is often measured in volts or frequency. Digital signals are useful for indicating on/off, yes/no, high/low, or frequency. A digital signal is a signal that stays high or low for an extended period of time, sometimes called a discrete signal. Typically in circuits that involve switches, such as the Stop Lamp signal and Park/Neutral switch signal, the ECM is looking for a change in mode. Some sensors, such as the MRE speed sensor produce a digital signal and the ECM is measuring the frequency.

Amplitude

Amplitude is a measurement of strength, such as voltage. Amplitude can be measured from peak to peak, or from a reference point.



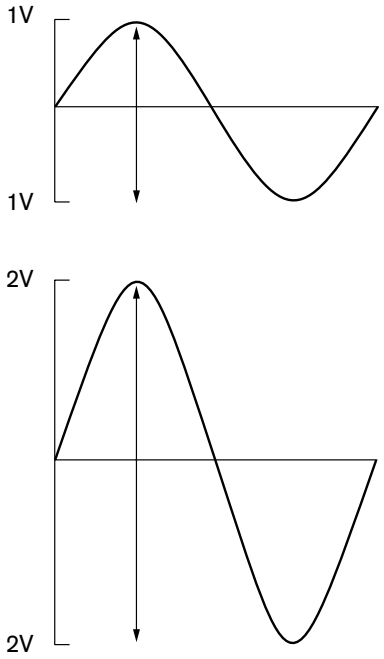


Fig. A-02

T852f364/T852f380

Frequency

Some signals are measured by frequency. A frequency is defined as the number of cycles per second. A cycle is a process that repeats from a common starting point. The unit for measuring frequency is called Hertz (Hz).

Frequency should not be confused with period. A period is the time it takes for the signal to repeat and is expressed as time. A 1 Hz signal lasts 1 second. A 2 Hz signal has a period of 0.5 seconds.

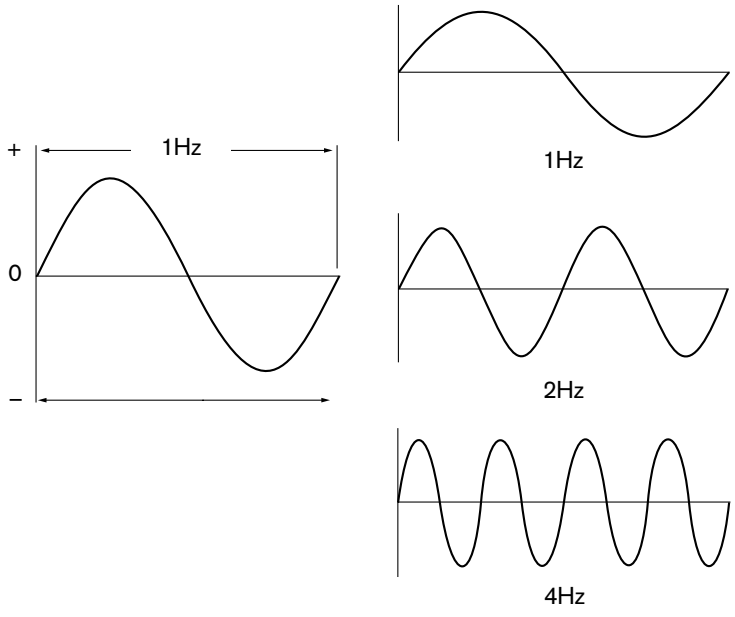
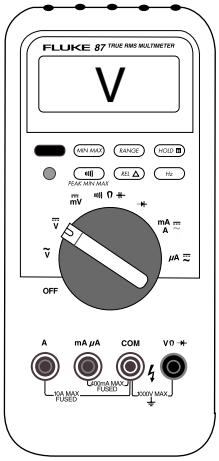


Fig. A-03

T852f365/T852f381

DC Voltage

Direct current is where the current flows in one direction. Though current flow and voltage can be variable, the direction always remains the same. The DVOM must be in the DC scale to measure DC voltage.



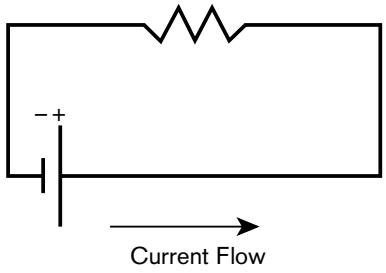
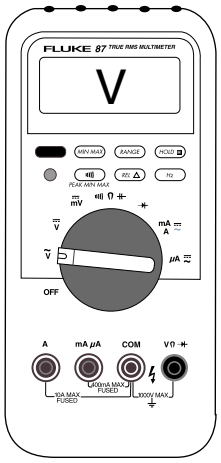


Fig. A-04
T852f380/T852f387

AC Voltage

Alternating current is where the direction of current flow changes. Current will travel from positive to negative, and then reverse course going to negative then positive. The DVOM must be in AC scale to measure AC voltage. There are different methods for measuring AC voltage and some DVOMs use what is known as a True RMS (Root Mean Square) to measure voltage. It is important for you to realize that the meter specified by the manufacturer must be used to obtain accurate results when compared to manufacturer's specifications.



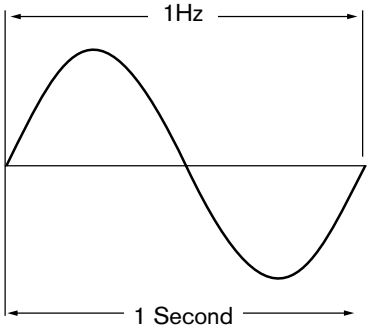


Fig. A-05
T852f388/T852f365

Output Signals and Circuits

To correctly interpret an oscilloscope pattern and DVOM reading, the technician needs to know the type of output circuit and how the test device is connected to the circuit.

Power Side Switched Circuit

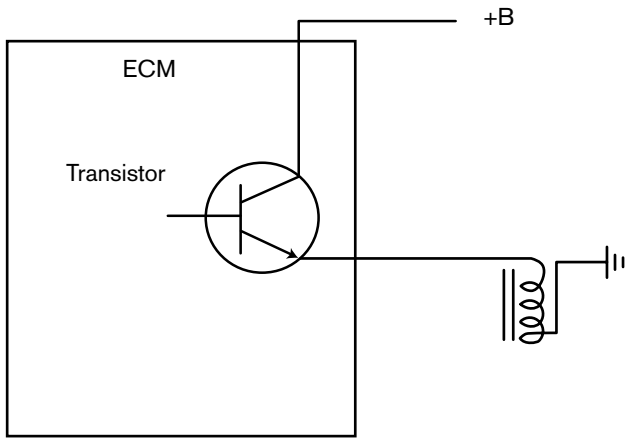


Fig. A-06
T852f366

Power Side Switched Circuit

A power side switch circuit will have voltage applied to the device when the circuit is switched on. When the transistor (think of the transistor as a switch) is turned on, current and voltage are applied to the device turning it on. The transistor is between power and the device. This is why they are commonly called power or power side switched circuits.

Ground Side Switched Circuit

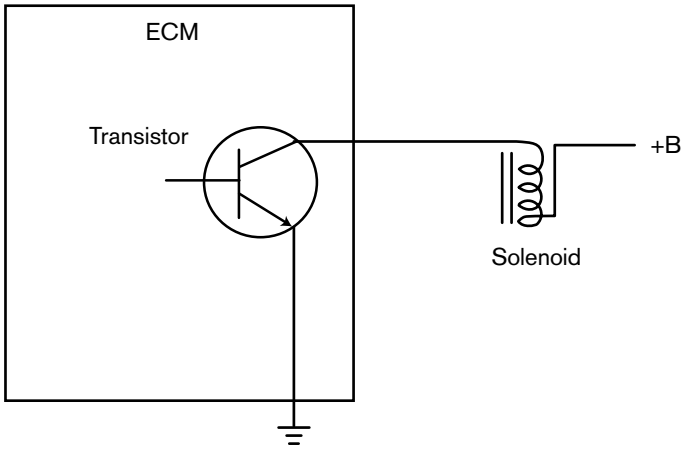


Fig. A-07
T852f367

Ground Side Switched Circuit

A ground side switched circuit has the transistor (switch) placed between the device and ground. When the transistor is turned on, the circuit now has a ground and current flows in the circuit. When the transistor is turned off current flow stops. Note that there is voltage present up to the transistor whenever the transistor is off.

Square Wave Duty Ratio Signals

When A and B are equal in length, the pulsewidth is 50%. This is a true square wave signal. A voltmeter connected to this circuit will measure half the supply voltage. The signal is said to have a low duty ratio when the on time is less than 50%.

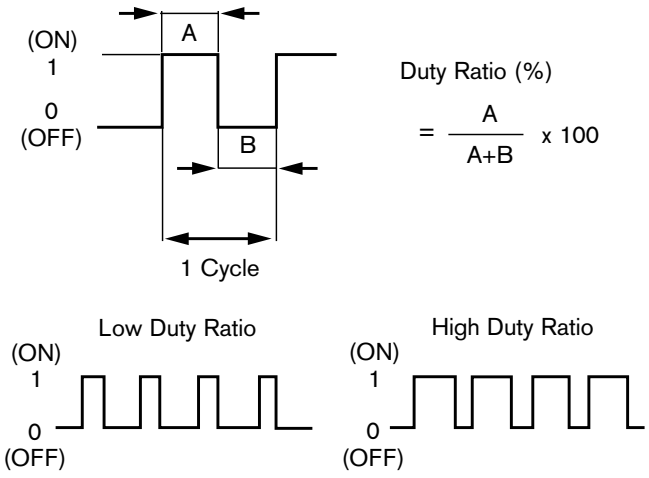


Fig. A-08
T852f368

Output Control Signals

Many devices, such as fuel injectors, EVAP purge, EGR VSV, rotary solenoid, alternator field circuit, etc. need to be modulated so that the desired output is achieved. There are a variety of control signals that can be used to regulate devices. Typically, the control signal changes the on/off time. This type of signal is often referred to as a pulse width modulated (PWM) signal and the on time is referred to as the pulsewidth. The duty cycle is the time to complete the on/off sequence. This can be expressed as a unit of time or as a frequency. The duty ratio is the comparison of the time the circuit is on versus the time the circuit is off in one cycle. This ratio is often expressed as a percentage or in milliseconds (ms).

PWM Signal

Each signal has the same frequency, only the pulsewidth has changed. The low duty ratio will have a lower current output.

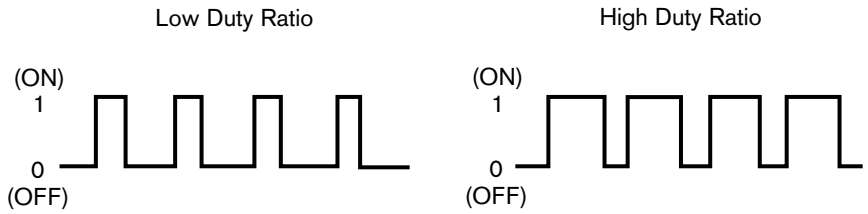
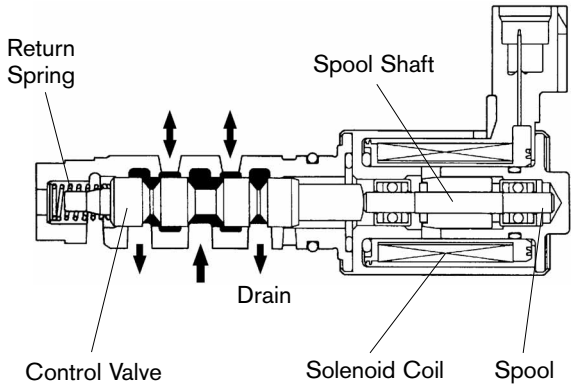


Fig. A-09

T852f368

Duty Ratio Solenoid

As the duty ratio (On time) increases, current flow through the solenoid increases moving the control valve. Oil pressure is then applied to the component that needs to be regulated, such as the variable valve timing mechanism, or lock-up control. In this example, Oil pressure increases as current increases. Other duty ratio solenoids can work in the opposite manner. Increasing current will decrease oil flow.



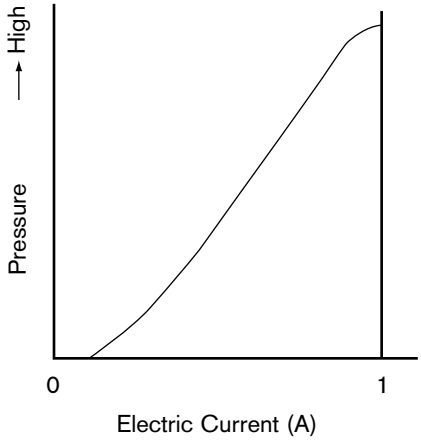


Fig. A-10
T852f370/T852f371

Fixed Duty Cycle Variable Duty Ratio (Pulse Width Modulated) Signal

This type of output control signal is defined by having a fixed duty cycle (frequency) with a variable duty ratio. With this type of signal only the ratio of on to off time varies. The ratio of on to off time modulates the output.

Variable Duty Cycle Variable Duty Ratio Signal

Duty cycle frequency has changed.
Duty ratio has changed.

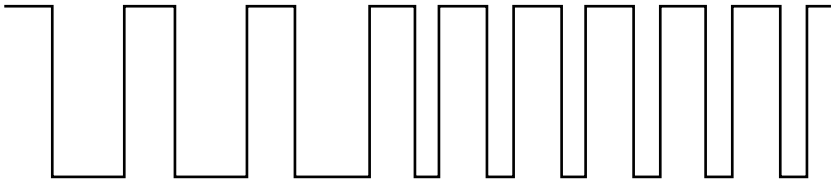


Fig. A-11
T852f372

Variable Duty Cycle/Variable Duty Ratio Signal

This signal varies the frequency of the duty cycle and the duty ratio. An excellent example is the signal used to control the fuel injector. As engine RPMs increase the fuel injector activation increases. As engine load increases, the duration of the fuel injector increases. It is easy to observe this type of control signal on the oscilloscope. With the oscilloscope connected to the fuel injector ECM terminal, as the engine RPMs (frequency) increase there will be more fuel injector cycles on the screen. As engine load increases, the on time (pulsewidth) also increases.

Measuring and Interpreting Signals

Oscilloscopes and many DVOMs can measure the pulsewidth, duty ratio, and frequency. For the technician to correctly interpret the reading oscilloscope line trace, the technician needs to know how the DVOM/oscilloscope is connected and the type of circuit.

Measuring Available Voltage On a Ground Side Switched Circuit

When the circuit is on, the DVOM will measure nearly 0 volts at the ECM.

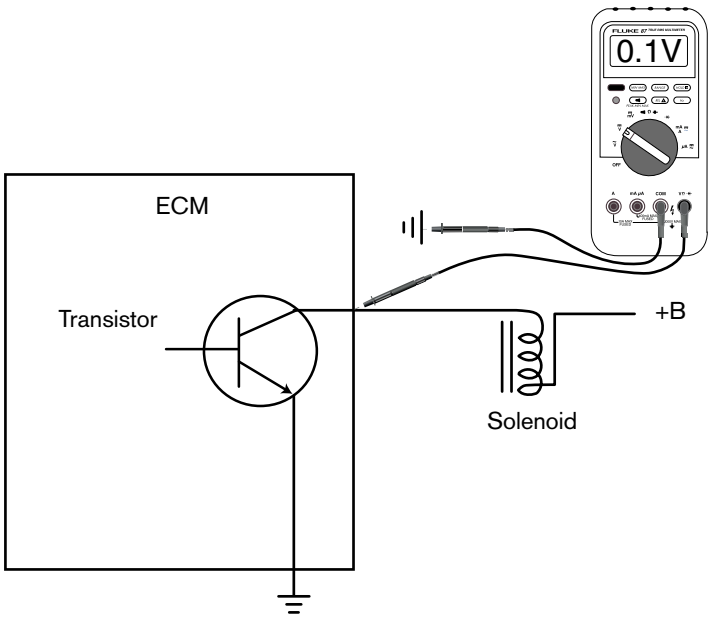


Fig. A-12
T852f382

Ground Side Switch Voltage Pattern Interpretation

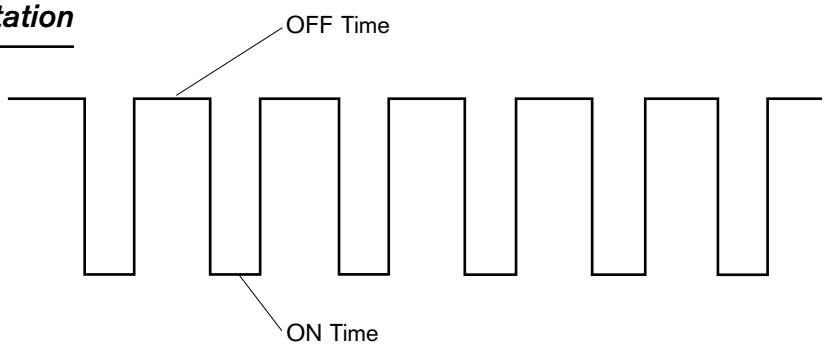


Fig. A-13
T852f373

Ground Side Switch Circuit Interpretation

With an oscilloscope connected at the ECM on a ground side switched circuit, the on time will be represented by the low (nearly 0 volts) voltage line trace. The voltage trace should be at supply voltage when the circuit is off and nearly 0 volts when the circuit is on. The on time (pulsewidth) is amount of time at 0 volts. If trace line does not go to nearly 0 volts, there may be a problem with the ground side of the circuit.

A DVOM in many cases can be substituted for the oscilloscope. When using a DVOM with a positive (+) or negative (-) trigger, select negative (-) trigger. Then the DVOM reading will represent the on time, usually as a percentage or in ms. On the voltage scale, the DVOM will read +B when the circuit is off and nearly 0 volts when the circuit is on.

Measuring Across the Load

Connecting at the ECM is the most common point used in the Repair Manual procedures. However, it is also possible to connect the oscilloscope or DVOM across the device. If this is done, the interpretation is different. The DVOM will read 0 volts when the circuit is off, and nearly +B when the circuit is on.

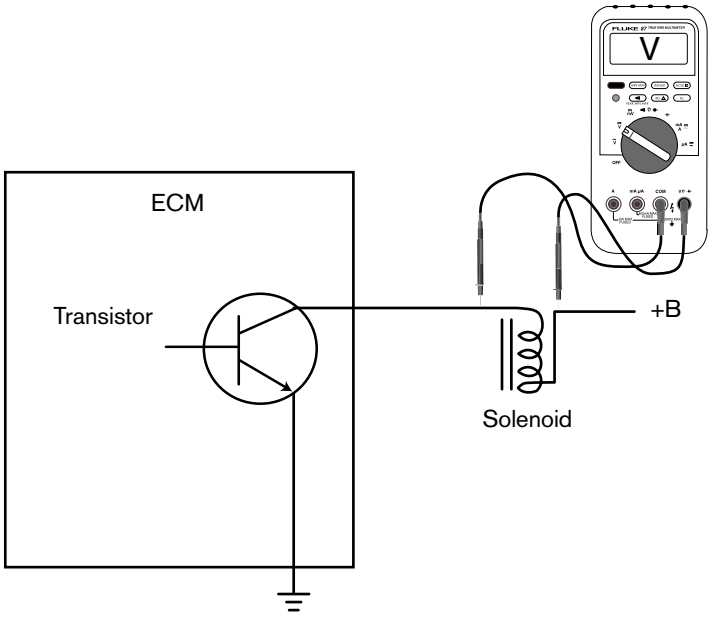


Fig. A-14
T852f383

Measuring Across the Load Pattern Interpretation

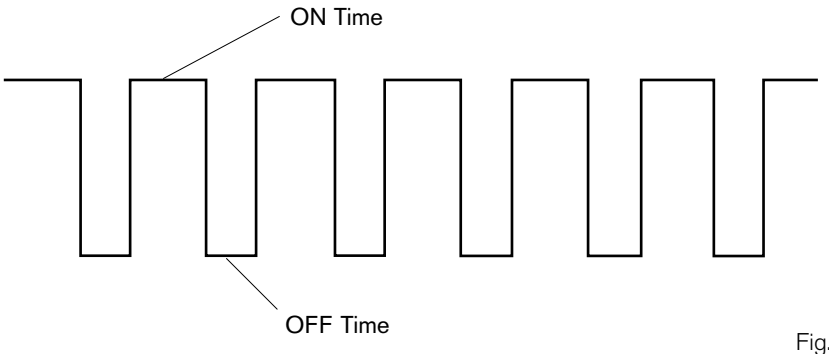


Fig. A-15
T852f373

Measuring Available Voltage on a Power Side Switched Circuit

When the circuit is on, the DVOM will measure +B at the ECM.

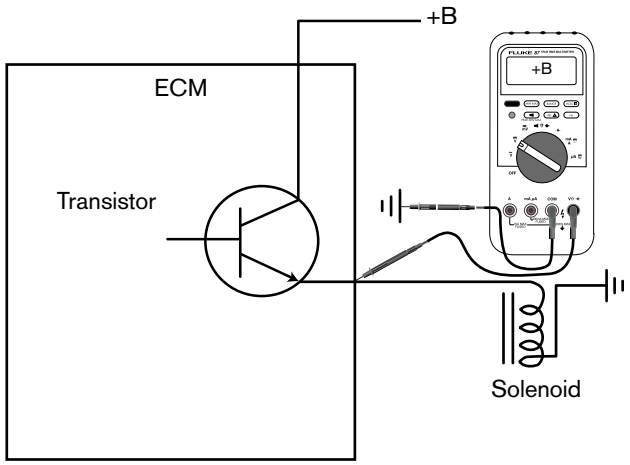


Fig. A-16
T852f384

Pattern Interpretation for a Power Side Switched Circuit

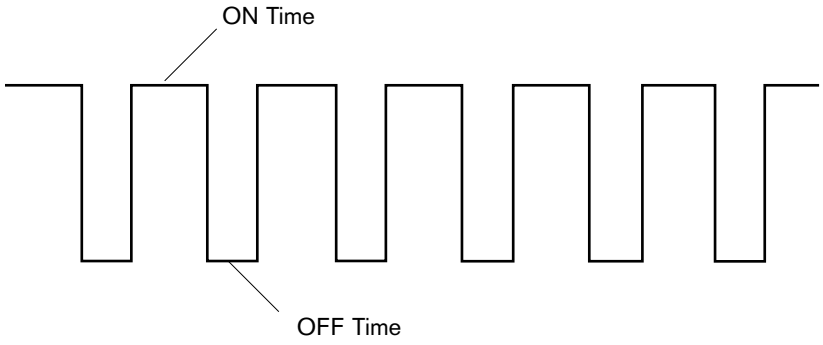


Fig. A-17
T852f373

Power Side Switch Circuit Interpretation

With an oscilloscope/DVOM connected at the ECM on a hot side switched circuit, the on time will be represented by the high (supply voltage) voltage line trace. The voltage trace should be at supply voltage when the circuit is on and at 0 volts when the circuit is off. The on time (pulsewidth) is the amount of time at supply voltage. If trace line does not go to supply voltage, there may be a problem with the supply side of the circuit.

When using a DVOM select positive (+) trigger. Then the DVOM reading will represent the on time, usually as a percentage or in ms.

Checking Circuit Operation Across The Load

The DVOM will measure nearly +B volts when the circuit is on.

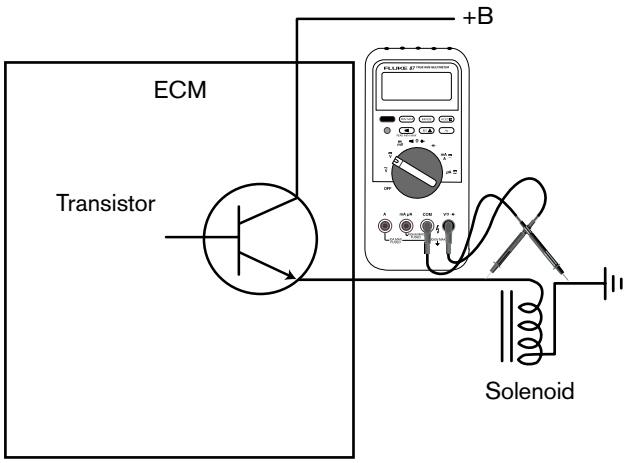


Fig. A-18
T852f369

Normally Closed Solenoid

Most solenoids are normally closed. This means that when they are off, they prevent the passage of fluid, air, vacuum, etc. When turned on, the passage opens.

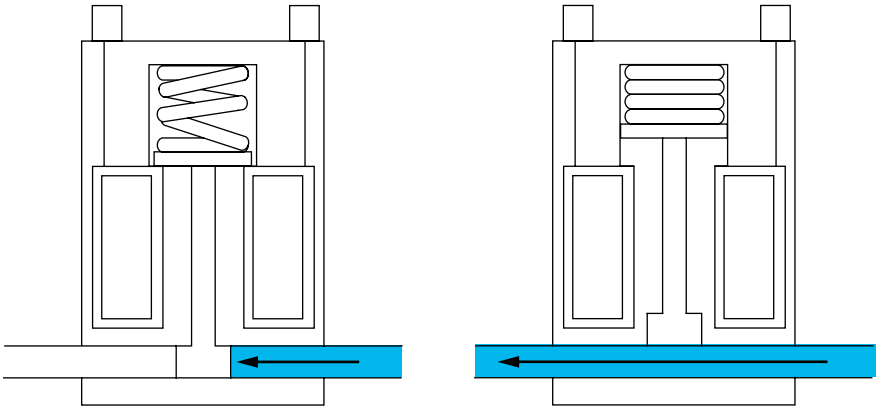


Fig. A-19
T852f374/T852f375

Normally Open Solenoid

When off, the passage in the solenoid is open.

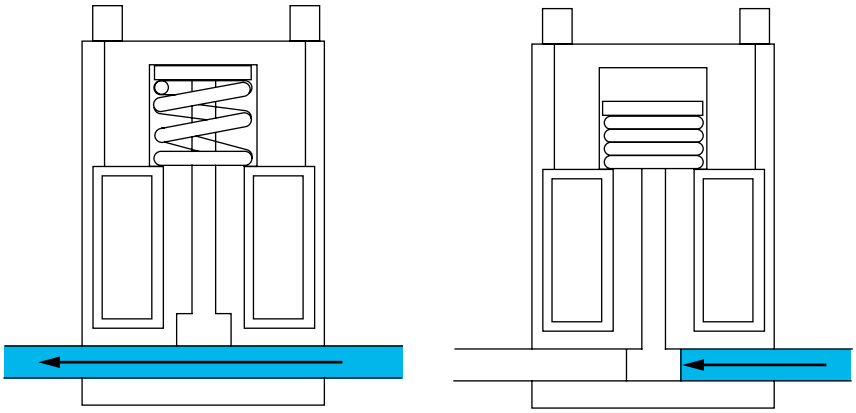


Fig. A-20
T852f376/T852f377

Solenoids

A solenoid is a component that is used to move something or control fluid flow. A solenoid consists of spring loaded valve, a coil, and housing. When the coil is energized, the magnetic field will pull the valve towards the center of the magnetic field. When the coil is turned off, the spring will return the valve to its resting position. There are a variety of solenoids used for engine control systems. It is important for the technician to know what type of solenoid is being used to determine operation and diagnosis. The following is explanation of the different types.

Two-Way VSV

Normally closed, Two-Way VSV.

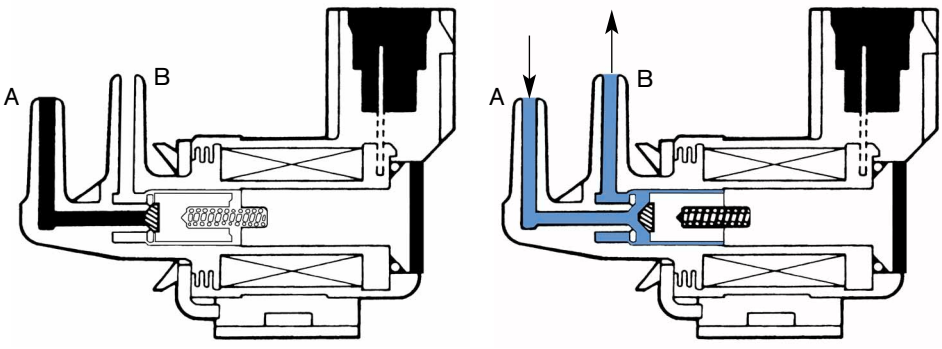


Fig. A-21
T852f378/T852f379

Vacuum Switching Valves (VSV)

VSVs are used in variety of applications. It is useful to know what type of VSV is being used for operational and diagnostic knowledge.

Two-way VSVs are commonly used in a variety of systems and can be of the normally open or normally closed type.

Two-way VSV	OFF	ON
Normally Closed	Closed	Open
Normally Open	Open	Closed

Two–Way VSV Operation Checks

For a normally closed VSV, air pressure is applied to a passage. Air flow should be greatly restricted. Next, the VSV is energized. Air should pass through freely. A restricted passage indicates the VSV has become plugged from debris or has failed.

For a normally open VSV air pressure is applied to a passage. Air should pass through freely. A restricted passage indicates the VSV has become plugged from debris or has failed. Next, the VSV is energized and air pressure is applied to the passage. Air flow should be greatly restricted.

For both VSVs, the coil resistance is checked with an ohmmeter.

Three-Way VSV

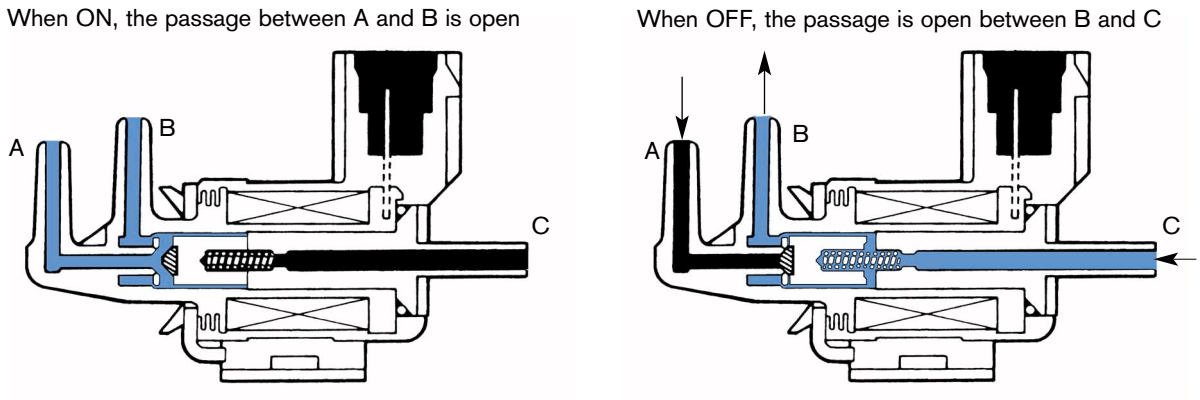


Fig. A-23
T852f089/T852f090

Three–Way VSV

A three-way VSV has three passages. When off, two passages are open and one is closed. When on, one passage will be closed and the other two opened.