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SAMPLE CHAPTER 11

Automotive Automatic Transmission and Transaxles

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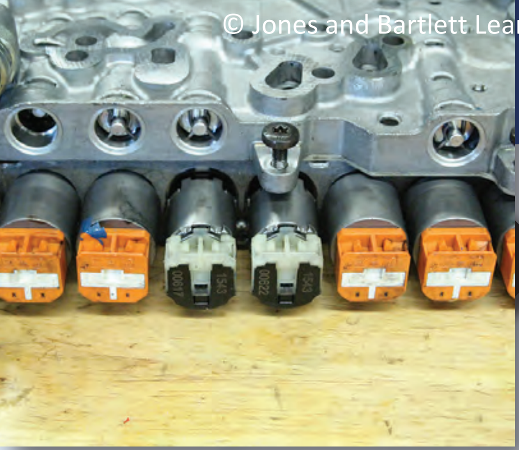


CHAPTER 11

Electronically Controlled Transmission

NATEF Tasks

There are no NATEF tasks for this chapter.

Knowledge Objectives

After reading this chapter, you will be able to:

- **K11001** Describe the purpose and function of electronically controlled transmission components.
- **K11002** Describe the purpose and function of transmission sensors.
- **K11003** Describe the purpose and function of the vehicle speed sensor.
- **K11004** Describe the purpose and function of the input shaft speed sensor.
- **K11005** Describe the purpose and function of the transmission oil temperature sensor.
- **K11006** Describe the purpose and function of transmission pressure switches.
- **K11007** Describe the purpose and function of the line pressure sensor.
- **K11008** Describe the purpose and function of the clutch pressure sensor.
- **K11009** Describe the purpose and function of the throttle position sensor.
- **K11010** Describe the purpose and function of the accelerator pedal position sensor.
- **K11011** Describe the purpose and function of the engine coolant temperature sensor.
- **K11012** Describe the purpose and function of the manifold absolute pressure sensor.
- **K11013** Describe the purpose and function of the mass airflow sensor.
- **K11014** Describe the purpose and function of the crankshaft position sensor.
- **K11015** Describe the purpose and function of the brake on/off switch.
- **K11016** Describe the purpose and function of the manual lever position switch.
- **K11017** Describe the purpose and function of the overdrive switch.
- **K11018** Describe the purpose and function of the electronic actuators.
- **K11019** Describe the purpose and function of the electronic pressure control solenoid.
- **K11020** Describe the purpose and function of the shift solenoids.
- **K11021** Describe the operation of the electronically controlled transmission system.
- **K11022** Describe the purpose and operation of the powertrain control module/transmission control module.
- **K11023** Describe the purpose and function of electronic shift programs.

Skills Objectives

There are no Skills Objectives for this chapter.

You Are the Automotive Technician

A customer brings her vehicle into the transmission shop and indicates that it is not shifting properly. The customer is concerned that she may need to have the transmission replaced, which can be an expensive repair. After gathering all of the customer's information, you review the service history and service bulletins for the vehicle. You then tell the customer that you need to perform further diagnostics and recommend taking the vehicle for a test drive to verify the problem. The diagnostic test you perform is to observe the speedometer and make sure it is working. After the diagnostic test, you discuss the speedometer performance with the customer and discuss service options.

1. What type of problems could the vehicle have if the speedometer is not working?
2. Why is it important to verify service history and service bulletins prior to working on any vehicle?
3. What type of sensor is similar to a vehicle speed sensor?

Introduction

Transmissions began changing from hydraulically controlled to electronically controlled during the late 1980s and early 1990s. Currently, there are no auto manufacturers in the United States still producing hydraulically controlled transmissions for use in new vehicles. This change is partially because of the increased need for greater fuel economy and the additional gears required to achieve it. More accurate control of vehicles' emissions is another reason why manufacturers use electronically controlled transmissions. When the vehicle computer is in charge of the shift timing, it can better predict load changes. This keeps emissions under better control by adjusting the engine settings in preparation for the shift. On a conventional hydraulically controlled transmission, the computer can react to the increased load only *after* the transmission shifts.

Fully computer-controlled transmissions have also allowed manufacturers to install lighter transmissions into vehicles because the computer controls can be used to reduce the amount of torque flowing through a transmission as it shifts (**FIGURE 11-1**). Note that computer-controlled means that the computer is controlling hydraulic valves in most cases, thereby directing hydraulic pressure to activate the various clutches and bands within the transmission.

Electronically Controlled Transmission Components

Electronic Control

K11001 Describe the purpose and function of electronically controlled transmission components.

K11002 Describe the purpose and function of transmission sensors.

As discussed in the Hydraulically Controlled Transmission chapter, in a fully hydraulically controlled transmission, the shift points are controlled by hydraulic and mechanical devices such as springs and valves. In the fully electronically controlled transmission, the shift points are controlled by the vehicle's **powertrain control module (PCM)** or a **transmission control module (TCM)**. Most vehicle manufacturers have integrated the TCM into the construction of the PCM, so we use the abbreviation PCM for this chapter. The PCM receives various inputs from the engine and transmission to determine the shift timing and the firmness of the shift. We come back to the PCM after we learn about some of the inputs and outputs that the PCM uses **FIGURE 11-2**.

Vehicle Speed Sensor (VSS)

K11003 Describe the purpose and function of the vehicle speed sensor

In a hydraulically controlled transmission, vehicle speed, or ground speed, is measured by the governor. The governor produces a hydraulic pressure that moves shift valves inside the transmission. In a computerized transmission, the governor is replaced by a **vehicle speed sensor (VSS)**. This VSS is sometimes called an output shaft speed sensor (**FIGURE 11-3**).

FIGURE 11-1 A typical electronically controlled transmission removed from a vehicle.

FIGURE 11-2 A typical vehicle PCM that has been removed from a vehicle.

The VSS is often also responsible for sending the vehicle speed information to the vehicle speedometer. Sometimes this information is sent to the PCM and the PCM relays the information, or they may both receive the same signal. On early electronically controlled transmissions, sometimes the manufacturer would use an electronic VSS *and* a mechanical speedometer cable because the vehicle was still using a mechanical speedometer in the instrument panel.

Most VSSs fall into the category of sensor called a magnetic pickup, or magnetic reluctance, sensor. The sensor assembly consists of an iron core wrapped with fine copper wiring. There is also a reluctor wheel, which has raised “teeth” located around the circumference of the wheel. **FIGURE 11-4** shows the parts of the magnetic pickup sensor. The reluctor wheel is attached to the output shaft of the transmission and spins with the output shaft. As the teeth of the reluctor wheel get closer to the iron core, a positive voltage is produced. As the teeth move away, the voltage becomes negative. This process repeats over and over again as the reluctor wheel spins, creating an AC voltage.

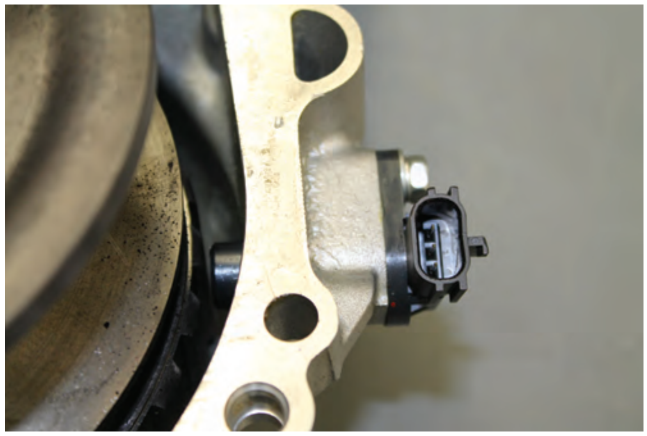


FIGURE 11-3 A VSS installed in a transmission. The case on the transmission has been disassembled to show the sensor through the case and the reluctor wheel.

This signal is sent to the PCM, where the vehicle speed can be determined from the signal frequency. The magnetic pickup sensor produces its own voltage while the reluctor wheel is spun. These sensors do not need a separate wire to supply them with a reference voltage, until a maximum value is reached.

Another type of VSS is called a **reed switch**. There is a thin movable blade switch inside the sensor and a magnet installed in a rotating part, called the rotor, on the output shaft (**FIGURE 11-5**). As the output shaft spins, the rotor spins.

When the magnet comes near the reed switch, the switch closes, allowing current to flow through the switch. When the magnet moves away from the switch, the switch opens, breaking the current flow. This opening and closing of the switch creates a DC square wave pattern that the PCM can use to determine vehicle speed. Reed switches need to be supplied with electricity to operate. The amount of voltage that the sensor is supplied with varies among vehicle manufacturers. Some of these switches apply a ground to a wire coming from the PCM; others simply allow a voltage to pass from a voltage source, through the reed switch, to the PCM.

Input Shaft Speed Sensor

Many transmissions also incorporate an **input shaft speed sensor**, also called a turbine speed sensor because the input shaft is splined to the turbine of the torque converter

▶ TECHNICIAN TIP

When a customer states that the automatic transmission will not shift, perform some basic diagnostic tests before replacing a transmission. A simple diagnostic test is to observe whether the speedometer is working. If the speedometer is not working, there is probably a problem with the VSS or its wiring.

▶ TECHNICIAN TIP

Magnetic pickup sensors do not need to be installed in the vehicle to be tested. If you place a voltmeter on the leads of a magnetic pickup sensor and spin the output shaft of a transmission, you should get an AC voltage reading. The faster the shaft is spun, the higher the voltage, until a maximum value is reached.

K11004 Describe the purpose and function of the input shaft speed sensor.

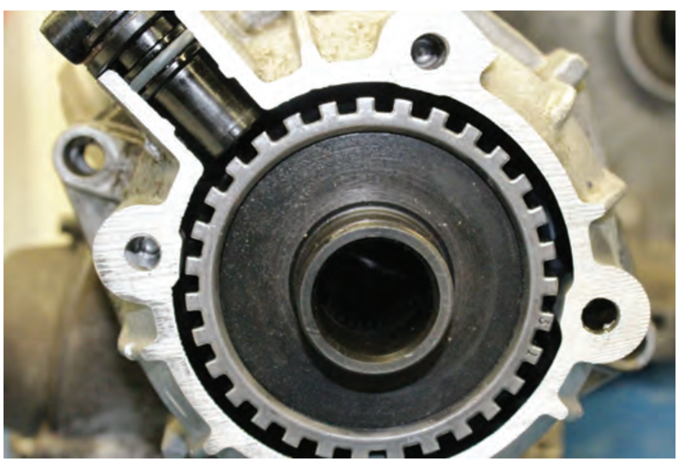
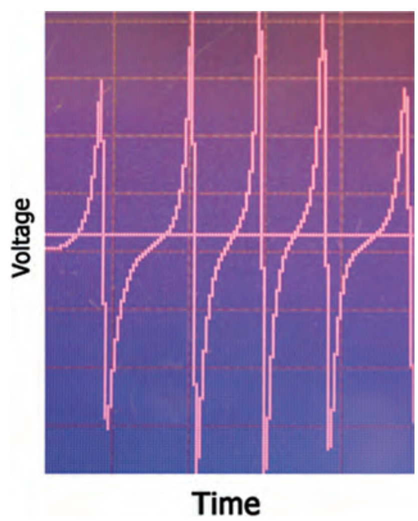


FIGURE 11-4 A typical VSS magnetic pickup sensor diagram.



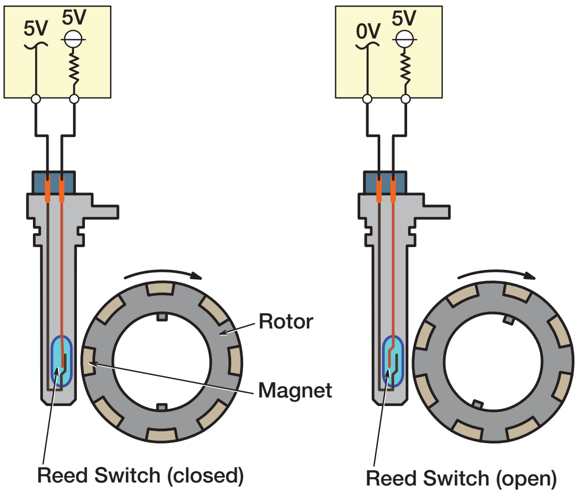


FIGURE 11-5 A reed switch VSS. As the magnet in the rotor passes the reed switch, the switch closes, allowing current to flow.

FIGURE 11-6 An input shaft speed sensor on an Allison 1000 transmission. This sensor will measure the speed of the Power Take Off (PTO) gear that is part of the input shaft of this transmission. You can see the teeth of the PTO gear through the hole in the case.

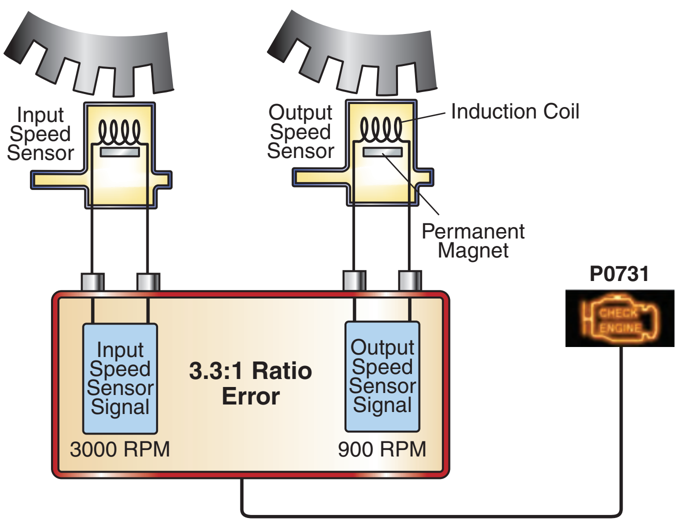


FIGURE 11-7 Input shaft speed sensor versus output shaft speed sensor.

(**FIGURE 11-6**). The input shaft speed sensor is very similar to a VSS. These sensors can also be a magnetic pickup type or a reed switch type. Both types send their signal as an input to the PCM.

Some PCMs compare the input shaft speed sensor to the output shaft speed sensor to determine gear ratios. For example, if the input shaft is spinning at 3000 rpm and the transmission is in first gear (3:1 reduction), then the output shaft should be spinning at 1000 rpm. The PCM can also use this information to determine if a clutch or band is slipping. For example, if the output shaft speed sensor is only reading 900 rpm, the PCM knows that first gear is slipping (**FIGURE 11-7**) and will trigger a diagnostic trouble code (DTC) such as a P0731 gear ratio error in first gear.

Some manufacturers compare the input shaft speed sensor to the output shaft speed sensor to measure the amount of time required to complete the shift from one gear to another. Chrysler vehicles often use this information and list it as the clutch volume index (CVI). This CVI number can be used by the PCM to determine how worn the clutch or band is and to adjust shift timing and pressures accordingly. These adaptive systems are covered later in the chapter.

Transmission Oil Temperature Sensor

K11005 Describe the purpose and function of the transmission oil temperature sensor.

Another input the PCM uses when controlling the shifting of an electronically controlled transmission is the **transmission fluid temperature (TFT) sensor**. Most TFT sensors are a type of resistor called a thermistor. A thermistor changes its resistance based upon its temperature. The PCM will supply a reference voltage to the sensor and measure the amount of voltage returned to the PCM through the TFT sensor (**FIGURE 11-8**).

The PCM varies shift timing and pressures based upon the TFT sensor because cold transmission oil is thicker than hot transmission oil and does not flow as easily through small orifices and passages in the transmission. So, if the transmission oil is cooler, the PCM will allow higher engine rpm before shifting the transmission and will also allow more time for the transmission to complete the shift. If the transmission oil is hot, the PCM may increase line pressure to compensate for internal leaks, as thinner oil flows past valves and seals more easily. The TFT sensor's temperature can typically be viewed using a scan tool. If the vehicle has completely cooled down overnight, the TFT should be fairly close to ambient temperature, engine coolant temperature, and intake air temperature. This means that

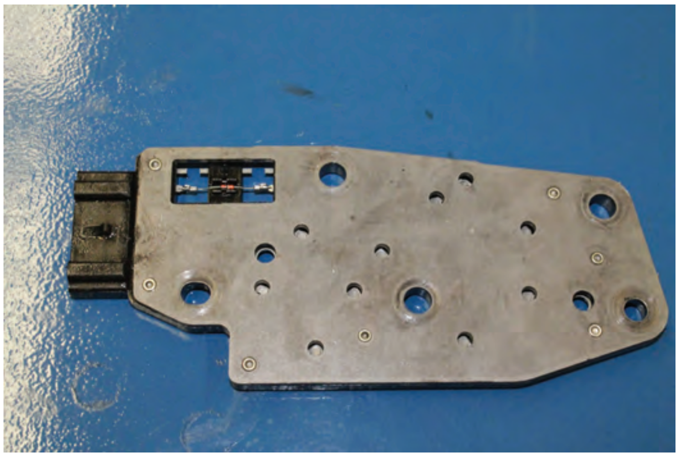


FIGURE 11-8 A General Motors TFT sensor and pressure switch assembly.

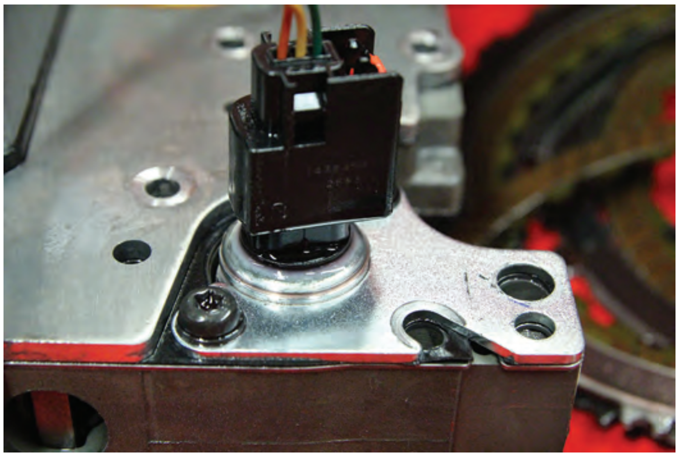


FIGURE 11-9 A typical line pressure sensor.

if the temperature of the air around the vehicle was 60°F (16°C) for most of the night, the TFT, and other temperature sensors, should be reading close to 60°F (16°C).

Transmission Pressure Switches

K11006 Describe the purpose and function of transmission pressure switches.

Inside many transmissions, there are small pressure switches. The switches are a simple open or closed type. When there is no pressure in a hydraulic circuit, the switch is open. When pressure is applied, it closes. The PCM uses this information to determine if a particular hydraulic circuit of the transmission has pressure, such as the circuit for the **torque converter clutch (TCC)** lock-up system. The pressure switches can also be used to determine in what gear range the transmission is operating. Figure 11-11 shows a common General Motors pressure switch used to verify which gear the transmission is operating in.

Line Pressure Sensor

K11007 Describe the purpose and function of the line pressure sensor.

The PCM receives voltage signals on some transmissions from a **line pressure sensor** (**FIGURE 11-9**). The line pressure sensor is a pressure transducer, which is a type of resistor that changes its resistance based upon pressure. The sensor is supplied with reference voltage from the PCM. The sensor varies the voltage based upon the line pressure and sends the signal back to the PCM. The PCM can then interpret the signal and vary the line pressure inside the transmission in order to adapt the shift timing based upon line pressure.

Clutch Pressure Sensor

K11008 Describe the purpose and function of the clutch pressure sensor.

Some transmissions utilize a clutch pressure sensor to determine when a clutch has completed its shift. If a pressure sensor is installed in a hydraulic circuit for a clutch, servo, or dog clutch, the PCM can observe the pressure reading inside the clutch. Many transmission reduce engine power as they complete a shift. The PCM senses the pressure stabilize in the clutch pack, which means that the shift is complete, and then reapplies engine power (**FIGURE 11-10**).

Throttle Position Sensor

K11009 Describe the purpose and function of the throttle position sensor.

The **throttle position sensor (TPS)** is a critical sensor for an electronically controlled transmission (**FIGURE 11-11**). The TPS is a type of variable resistor called a **potentiometer**, which varies its resistance based on its position. A volume knob on a stereo is another example of a potentiometer.

The TPS is mounted on the side of an engine throttle body assembly, and the inside of the TPS moves with the position of the throttle valve. The PCM supplies the TPS with a steady reference voltage and monitors the voltage returned through the potentiometer. Most TPSs have a relatively high resistance at closed throttle, dropping the reference

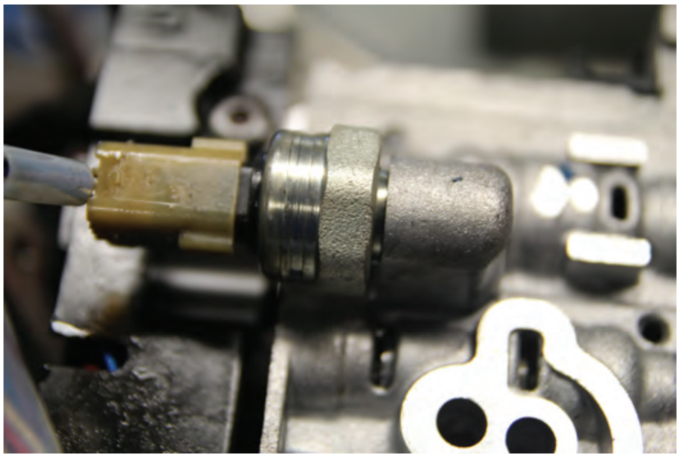


FIGURE 11-10 A pressure sensor installed on the valve body for a ZF 9HP transmission. This pressure sensor measures pressure in the dog clutch apply circuit to determine when the dog clutch has been engaged.

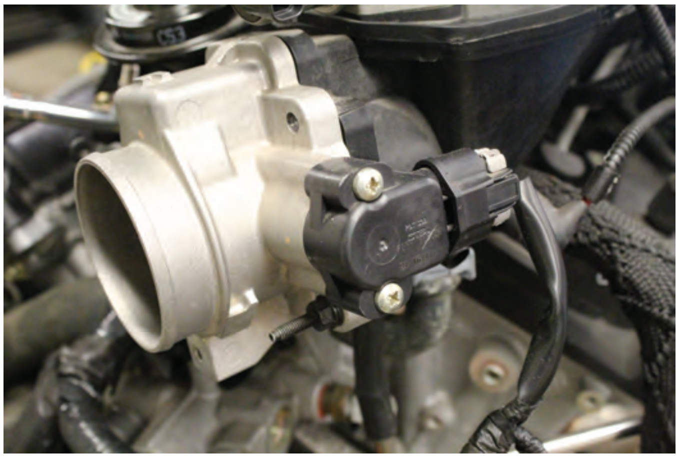


FIGURE 11-11 A TPS mounted on the side of a throttle body assembly.

voltage, which results in a low-voltage signal being returned to the PCM through the signal return wire. Usually this voltage is around 0.5 volts at closed throttle. The sensor's resistance steadily drops as the throttle valve is opened. This drop causes the voltage signal returned to the PCM to increase to approximately 4.5 volts at wide-open throttle.

Although TPS voltage can be monitored using a scan tool, it is recommended that the operation of the sensor be verified using a digital storage oscilloscope (DSO), as the scan tool's data rate is relatively slow and cannot display the TPS voltage quickly enough to find flaws in the sensor. To test a TPS sensor, measure the voltage on the signal return wire with the vehicle in key on, engine off (KOEO) mode. Using the throttle pedal, slowly open the throttle all the way and release it. The voltage should rise steadily and return to the closed-throttle level. **FIGURE 11-12** shows a good sensor pattern measured with a DSO on the left, and a bad pattern on the right. The sensor on the right is from a vehicle that exhibited a severe hesitation and erratic shifting. The sensor on the left is from the same vehicle after the sensor was replaced, fixing the problem.

On modern drive-by-wire vehicles, there is no longer a dedicated TPS sensor. Drive-by-wire vehicles are ones in which there is no physical connection between the accelerator pedal and the throttle on the engine. The throttle opening is operated by a throttle motor that is controlled by the PCM. Inside this throttle motor assembly, there are one or two throttle position sensors, depending on the vehicle manufacturer. These sensors are used by the PCM to verify that the throttle is in the correct, commanded position (**FIGURE 11-13**).

▶ TECHNICIAN TIP

If a customer brings a vehicle in and complains about erratic shifting and a vehicle hesitation problem, it is a good idea to check the TPS first. A PCM often will fail to detect a problem with a TPS because the sensor is directly tied to human reaction. Often, if the PCM senses the voltage drop out on a TPS signal, it assumes the driver released the accelerator. This makes it difficult to determine sensor failure unless the sensor fails completely, resulting in either 0 volts or reference voltage being returned to the PCM.

Accelerator Pedal Position Sensor

K11010 Describe the purpose and function of the accelerator pedal position sensor.

A sensor that is similar to the TPS is the accelerator pedal position sensor (**FIGURE 11-14**). It is used on drive-by-wire vehicles to determine the driver's intent as related to acceleration/

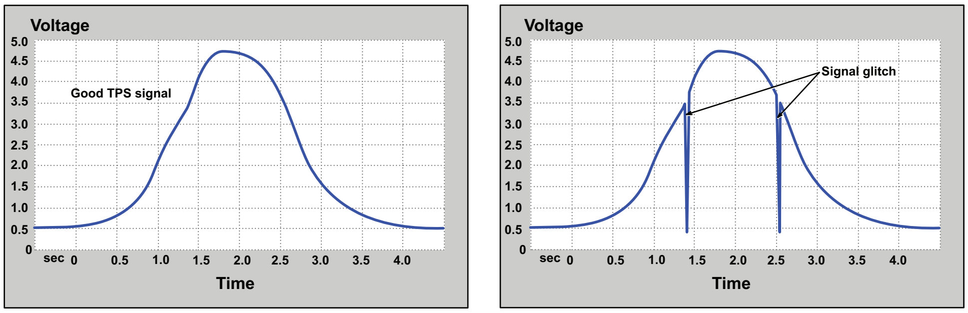


FIGURE 11-12 Two TPS sensor patterns from a DSO. A good sensor pattern is on the left and a bad pattern is on the right.

deceleration. Beyond indicating the position of the accelerator pedal, the signal can also be used to determine how quickly or slowly the pedal is being pressed or released. Quick application of the pedal can indicate the need for more engine power and the corresponding need for a downshift and a delay of the upshifts. Quick release of the pedal can indicate the start of a panic stop. This way, the PCM prepare to take actions that would help avoid an accident, such as downshifting and applying the brakes.

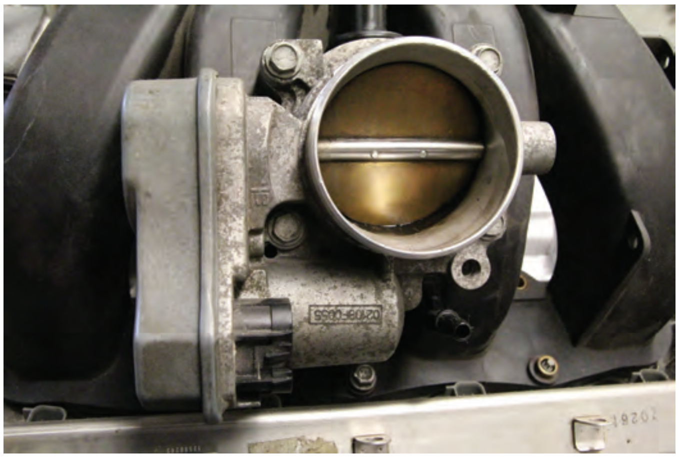


FIGURE 11-13 An electronic throttle installed on a Chevrolet Cobalt.

Engine Coolant Temperature Sensor

The PCM utilizes the **engine coolant temperature (ECT) sensor** not only for starting the engine but also for transmission operation. An ECT sensor is another thermistor, a resistor that varies its resistance based upon temperature, like the TFT sensor. The ECT sensor is installed in an engine coolant passage, often near the thermostat housing on an engine (**FIGURE 11-15**). The PCM sends out reference voltage to the ECT sensor, which varies the voltage returned to the PCM through the thermistor, allowing the PCM to determine the temperature of the engine from the voltage.

K11011 Describe the purpose and function of the engine coolant temperature sensor.

The PCM varies shift timing and pressures based upon engine temperature. When the engine is cold, the PCM delays transmission shifts to allow the engine to warm up faster and allow for more consistent engine and transmission operation.

ECT temperature can be seen using a scan tool. If the temperature seems extremely low, around – 40°F (– 40°C), or extremely high, exceeding 280°F (138°C), a bad sensor or faulty wiring are possible culprits. A quick test to determine if you have a bad sensor or bad wiring is to turn the vehicle off and unplug the sensor. Turn the vehicle back on KOEO and look at the scan tool data. Did the data change? Next turn the vehicle off again. Insert a fused jumper wire into the ECT connector to short across the two terminals going back to the PCM. (Be sure you are on the proper connector!) Turn the vehicle back on KOEO. Did the value change? The reading should have gone from the lowest possible reading to the highest possible reading (or the other way around, depending on the vehicle). If there was no change in the reading, you have a wiring problem on the vehicle. If it did change, your problem may lie with the ECT sensor. Note that vehicles may have more than one sensor to read coolant temperature. Some vehicles use a separate sensor for the temperature gauge on the instrument cluster, and possibly another one to control the radiator fan. Make sure you are testing the correct sensor. Also, the current flow through the ECT sensor is very small. If the sensor terminals are corroded, dirty, or loose, it is possible that by disconnecting the ECT sensor and reconnecting it, it will start reading properly again. If so, this is not likely to be a permanent fix. You may have to clean or repair the terminals, or replace the sensor, to repair it permanently.

▶ TECHNICIAN TIP

An ECT sensor cannot accurately read engine temperature when the coolant level is low. Before condemning the ECT sensor, make sure the coolant level is up to the proper level and that the thermostat is operating properly on the vehicle.

FIGURE 11-14 Accelerator pedal position sensor.

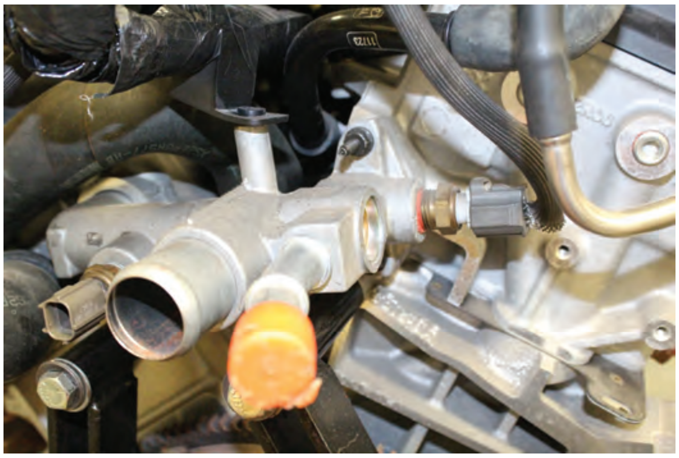


FIGURE 11-15 An ECT sensor installed near the thermostat housing.

FIGURE 11-16 A common MAP sensor installed on an intake manifold.

Some engines use a cylinder head temperature (CHT) sensor instead of an ECT sensor. The CHT sensor is a thermistor that measures the cylinder head temperature to accomplish the same thing as the ECT, but it can always accurately measure temperature because it does not rely on the level of coolant to touch the sensor. Thus, its readings are not affected by low coolant. Check the vehicle's service information to determine which type of sensor is used on the vehicle.

Manifold Absolute Pressure Sensor

K11012 Describe the purpose and function of the manifold absolute pressure sensor.

The PCM needs to know how much load the engine and transmission are under. One method of determining engine load is through the use of a **manifold absolute pressure (MAP) sensor**. The MAP sensor can be either directly bolted to the intake manifold or connected through a vacuum hose (**FIGURE 11-16**). Most modern MAP sensors use a type of flexible silicon chip within a sealed chamber; the chip changes resistance when manifold pressure flexes the chip. The varying resistance then changes the output signal based on the manifold pressure. When the engine has more vacuum, the chip is pulled down, changing its resistance. The PCM supplies a reference voltage to the sensor, which is reduced as it travels through the potentiometer and is then returned to the PCM. Because manifold pressure is an indication of engine load, the PCM can use this voltage signal to monitor engine load.

Manifold pressure is a good indicator of engine load and was used by the vacuum modulator on our hydraulically controlled transmission. When an engine is operating under light load, engine manifold pressure is low. When the engine is operating under heavy load, engine manifold pressure is high. As the manifold pressure changes, so do the shift points. When the engine is under heavy load, the shifts are delayed, and vice versa. The engine load is also used to determine when the TCC should be applied and released. The TCC cannot transmit very much torque without slipping, which would burn it up quickly. Thus, when the engine is under more load than the TCC is designed for, the PCM turns the TCC off.

Although many vehicles still have a MAP sensor on the intake manifold, most of these sensors on vehicles built after 1996 are not the primary sensor used for determining engine load, as you will see in the next section. MAP sensors are now used to test if certain emissions-related components are functioning properly, as they will cause changes in manifold pressure if they are.

▶ TECHNICIAN TIP

MAP sensors were originally connected to the intake manifold through a vacuum hose. Over time these hoses deteriorate and can develop small holes and cracks in the lines, or they get soft and collapse. Vacuum hoses should be replaced periodically as they start to show signs of deterioration. A vacuum hose that has deteriorated will typically affect fuel economy and result in a late, harder shift, as the PCM thinks the vehicle is under greater load than it really is.

Mass Airflow Sensor

K11013 Describe the purpose and function of the mass airflow sensor.

To meet more stringent emission standards, most vehicles come equipped with a **mass airflow (MAF) sensor**, rather than a MAP sensor, to measure engine load. MAF sensors are a much more accurate and faster means of measuring engine load. The MAF sensor actually measures the mass of the air coming into the engine, so the PCM can accurately inject the proper amount of fuel. MAF sensors measure airflow in grams per second (gps). The more airflow, the harder the engine is working. As engine speed increases, so does airflow. The MAF sensor is typically installed in the air intake hose leading to the throttle body assembly. Although some MAF sensors are built into the throttle body assembly, others are mounted on the air cleaner assembly (**FIGURE 11-17**).

Many different types of MAF sensors are currently being installed on vehicles, and you need to check the specific vehicle's service information for testing methods. It is important to check that all of the air intake hoses are tightly secured to the engine so that the MAF sensor will measure all of the air entering the engine. Any air leaks *after* the sensor will result in an inaccurate reading by the MAF sensor, resulting in early shifting and poor vehicle drivability. Some MAF sensors require periodic cleaning, as dirt and contaminants can build up on the sensing surface inside the sensor. Clean these components carefully, using a cleaner recommended for MAF sensor cleaning. Note that some manufacturers specifically say not to clean their MAF sensors and to instead replace them if they are

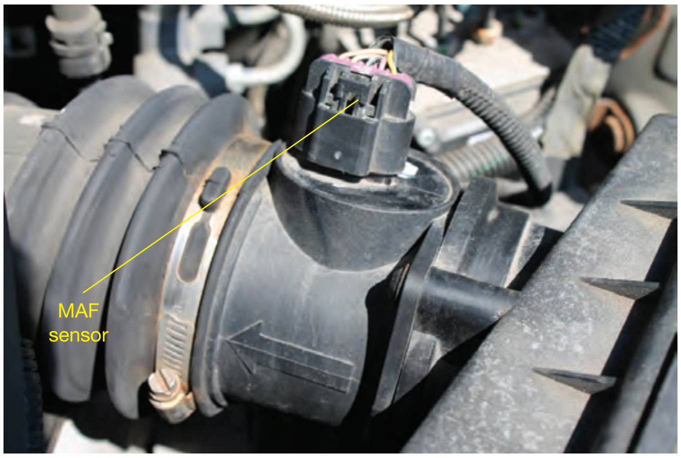


FIGURE 11-17 A MAF sensor installed in the air intake tube on a vehicle. It is important to make sure all of the clamps are securely fastened.

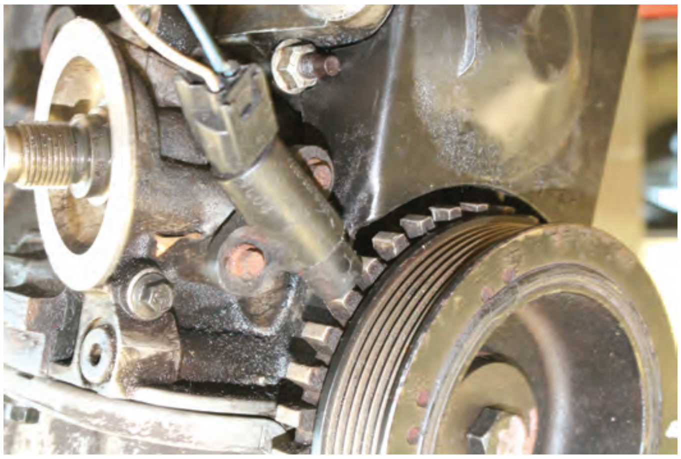


FIGURE 11-18 A crankshaft position (CKP) sensor installed on the front of a crankshaft.

not reading correctly. Be careful to check the manufacturer's recommendation regarding whether the MAF sensor can be cleaned. If it can, follow the manufacturer's directions precisely.

Crankshaft Position Sensor

K11014 Describe the purpose and function of the crankshaft position sensor.

The PCM uses the **crankshaft position (CKP) sensor** to determine engine speed (**FIGURE 11-18**). CKP sensors can be a magnetic pickup-style sensor, a Hall-effect sensor, or an optical-style sensor. All three types of sensors serve the same function: to send a pulsed signal to the vehicle PCM to determine engine speed.

The PCM compares the CKP sensor signal to the input shaft speed sensor in the transmission to determine torque converter slippage between the impeller and the turbine. It is also used as the PCM operates the TCC to monitor the engagement and slippage of the TCC. Most TCCs are pulsed on slowly to prevent a harsh engagement that drivers might complain about. By observing the difference in speed, the PCM can precisely control how long it takes for the TCC to become fully locked.

Brake On/Off Switch

K11015 Describe the purpose and function of the brake on/off switch.

Another input the PCM monitors is the brake on/off switch (**FIGURE 11-19**). The brake switch is used to control the brake lights on the vehicle when the driver applies the brakes, but the PCM also uses this information for transmission control. The brake on/off switch is a normally open switch that closes when the driver applies the brake pedal, allowing current to flow to the stop lamps and to the PCM. In some vehicles, the brake on/off switch is separate from the brake light switch, so always check the service information to make sure you are testing the correct switch.

The PCM uses the brake on/off switch input to disengage the TCC. As soon as the driver applies any pressure to the brake pedal, the TCC must be released to prevent excessive drag on the engine and a possible stall. On some newer vehicles, the brake switch is also used to put the transmission into neutral while idling at a stoplight. As long as the driver has the brake pedal applied, the vehicle will remain in neutral to save fuel. As soon as the driver releases the brake pedal, the transmission reengages into gear (**FIGURE 11-20**).

Manual Lever Position

K11016 Describe the purpose and function of the manual lever position switch.

The **manual lever position (MLP) switch** is sometimes called a transmission range switch or a neutral safety switch. It is a simple multi-position switch that sends a signal to the PCM regarding which gear the manual lever is in. This information is used to prevent the vehicle from starting in any gear except Park or Neutral. The PCM also uses this information to turn on the reverse lights and to control the selection of gears and automatic shifting.

FIGURE 11-19 BOO sensor.

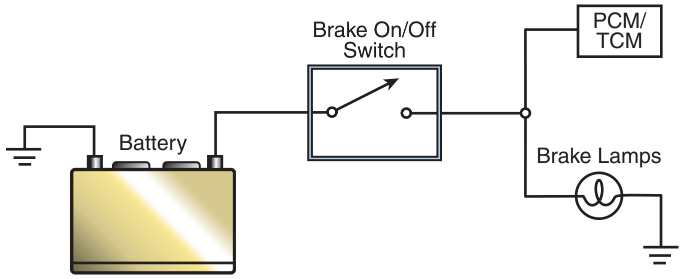


FIGURE 11-20 A common brake on/off switch wiring diagram.

The MLP is often mounted directly on the transmission case where the shift linkage connects to the transmission (**FIGURE 11-21**). On some vehicles, this switch is adjustable and will have to be adjusted after replacing the transmission, the shift cable, or the switch.

K11017 Describe the purpose and function of the overdrive switch.

Overdrive Switch

The overdrive switch is operated by the driver to manually select or deselect overdrive (**FIGURE 11-22**). Many manufacturers recommend not using overdrive when pulling a trailer or heavy loads because doing so can overload the transmission. Therefore, the driver can activate the overdrive switch (sometimes labeled as "Tow/Haul"), which sends a simple on/off signal to the PCM indicating that the driver wants to disable overdrive. The PCM then modifies the shifting pattern accordingly, locking out overdrive. The driver activates the overdrive switch again when overdrive is desired. The PCM then allows shifting into overdrive when appropriate. Some vehicles automatically reset the overdrive switch to allow overdrive when the vehicle is restarted.

▶ TECHNICIAN TIP

After replacing a transmission, make sure the MLP switch is adjusted correctly *before* starting the vehicle. If the switch has not been adjusted properly, when the technician continues to add hydraulic oil to top off the transmission, the vehicle may suddenly have enough transmission fluid to engage the clutches and begin moving.

Manual Shift Buttons

On many late-model electronically controlled transmissions, the driver can command the transmission to upshift or downshift manually. There are several types of manual shift control systems in production. The first type has a plus and a minus button on the gear shift lever. If the transmission is shifted into the manual position, the driver can press the plus button in order to cause the transmission to upshift. Pressing the minus button will cause the transmission to downshift (**FIGURE 11-23**).

The second type of manual shift system allows a floor-mounted gear shift lever to be operated in a manual position. Once the shifter is moved over to the manual position, it can be pushed forward to upshift the transmission and moved backward to downshift the transmission (**FIGURE 11-24**).

FIGURE 11-21 A manual lever position (MLP) switch mounted on the outside of the transmission. Note the manual lever linkage passing through the middle of the switch.

FIGURE 11-22 An overdrive switch used by the driver to manually select or deselect overdrive.

FIGURE 11-23 Manual transmission control buttons installed on the shift lever on a late-model pickup truck.

FIGURE 11-24 A floor-mounted gear shift that allows manual operation.

Both systems will still automatically shift the transmission, and override the driver, to prevent the engine from over-revving and damaging itself. They will also automatically downshift when the vehicle slows down, so the vehicle is not in a high gear ratio that would cause excessive wear and tear on both the engine and transmission. The most common reason for using the manual control function of an automatic transmission is when the vehicle is towing a heavy trailer. The driver can downshift the transmission before reaching a hill. Even though transmissions have come a long way with their advancements, they still cannot see the road ahead to know when a hill is coming.

▶ Powertrain Control Module Outputs

K11018 Describe the purpose and function of the electronic actuators.

K11019 Describe the purpose and function of the electronic pressure control solenoid.

Electronic Pressure Control Solenoid

On electronically controlled transmissions, line pressure is controlled using an **electronic pressure control (EPC) solenoid** (**FIGURE 11-25**). Most EPC solenoids are controlled by a digital signal that rapidly cycles on and off to control pressure. This on / off cycling can be classified in two ways; pulse-width modulation and duty cycle. Pulse width is generally measured in milliseconds (mS) of on-time per cycle, and duty cycle is generally measured in percent of on-time per second. A pulse width of 25 mS means that the solenoid would be activated for 25 mS for one cycle. A duty cycle of 50% means the solenoid is on 50% of a second and off the other 50% of the second. If we were to look at the voltage to the EPC solenoid using a DSO, we would see a square wave pattern like that shown in **FIGURE 11-26**.

EPC solenoids are installed in the line pressure circuit and exhaust some of the line pressure back to the transmission pan (**FIGURE 11-27**). If the line pressure is 200 pounds per square inch (psi) and we have an EPC duty cycle of 50%, the line pressure will be approximately 100 psi. Roughly 50% of the line pressure will be exhausted back to the pan. If higher line pressure is required, the PCM will reduce the duty cycle. At a 25% duty cycle, the line pressure would be approximately 150 psi, or 75% of the available line pressure in this example.

Most EPC solenoids are designed so that if there is a problem with the PCM, the wiring, or the EPC solenoid, the vehicle will default to maximum line pressure. The EPC solenoid will be forced closed by an internal spring, and no line pressure will be exhausted to the pan. When using a scan tool, you will notice that some manufacturers give you the amount of amperage being used by the EPC solenoid, rather than the duty cycle. This

FIGURE 11-25 EPC solenoid.

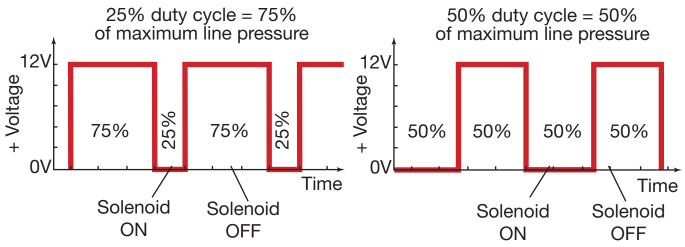


FIGURE 11-26 A duty cycle pattern of an electronic pressure control (EPC) solenoid.

amperage will change as the duty cycle of the solenoid is changed. **FIGURE 11-28** shows an EPC solenoid electrical diagram.

Shift Solenoids

K11020 Describe the purpose and function of the shift solenoids.

Shift solenoids are typically an electromagnetic type of valve that is either open or closed. These solenoids can directly control line pressure to an application device, such as a clutch or band, or they may control a shift valve, which in turn directs fluid to the clutch or band. Many four-speed automatic transmissions use two shift solenoids to control the transmission. **TABLE 11-1** lists the shift solenoid operation on a typical four-speed automatic transmission. By turning the different solenoids on and off, all of the gears needed can be hydraulically applied. With the addition of more gear ratios, more shift solenoids have to be added to the transmission. The principles remain the same as the simpler four-speed transmission. Each manufacturer will publish shift solenoid charts for their transmission models.

Based on the information in Table 11-1, what gear would the vehicle start in if both solenoids failed? Notice that only third gear does not use either shift solenoid. If the vehicle has a problem with the PCM, the shift solenoids, or the wiring, the customer may complain about a very poor-performing vehicle that will only start in third gear. This is often called limp-in mode, as the vehicle would still be drivable with a shift solenoid failure.

▶ Electronically Controlled Transmission Operation

FIGURE 11-29 is a simplified diagram for a common Chrysler 41TE transmission, found in many of the Chrysler minivans. In this transmission, the solenoids directly operate the clutches to control the shifting of gears. This particular transmission has four solenoids. They are labeled 1, 2, 3, and 4 on the diagram. Solenoid 1 controls the underdrive clutch, solenoid 2 controls the overdrive clutch, solenoid 3 controls the low reverse clutch, and

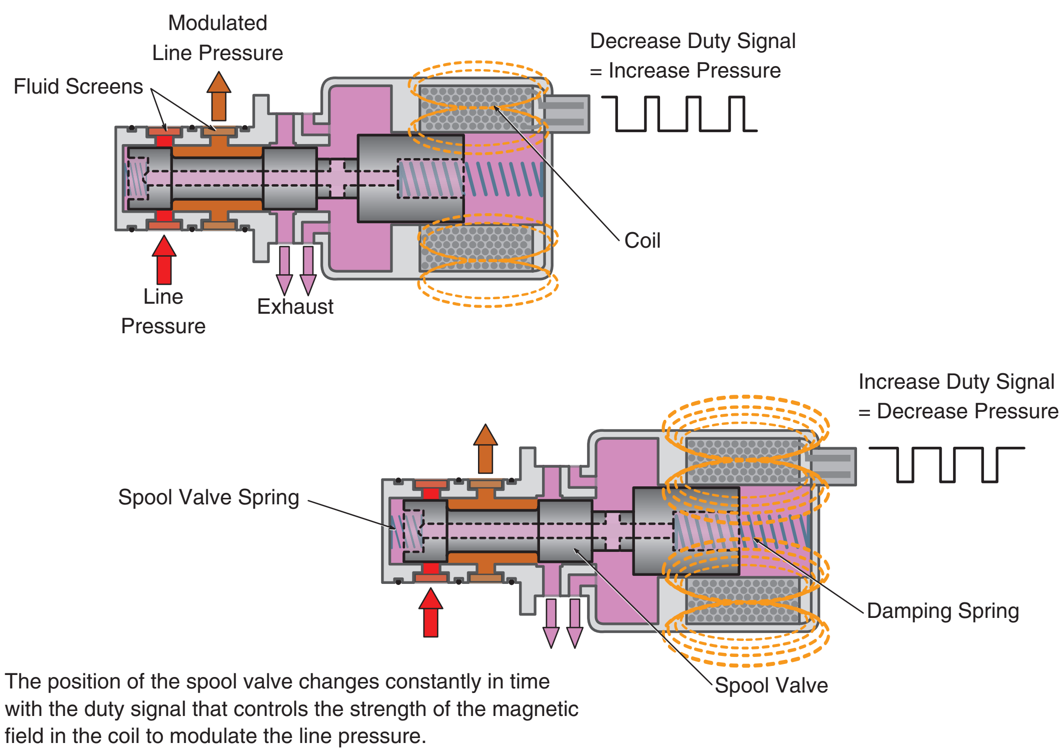


FIGURE 11-27 An EPC solenoid controls how much fluid is exhausted back to the pan to control line pressure.

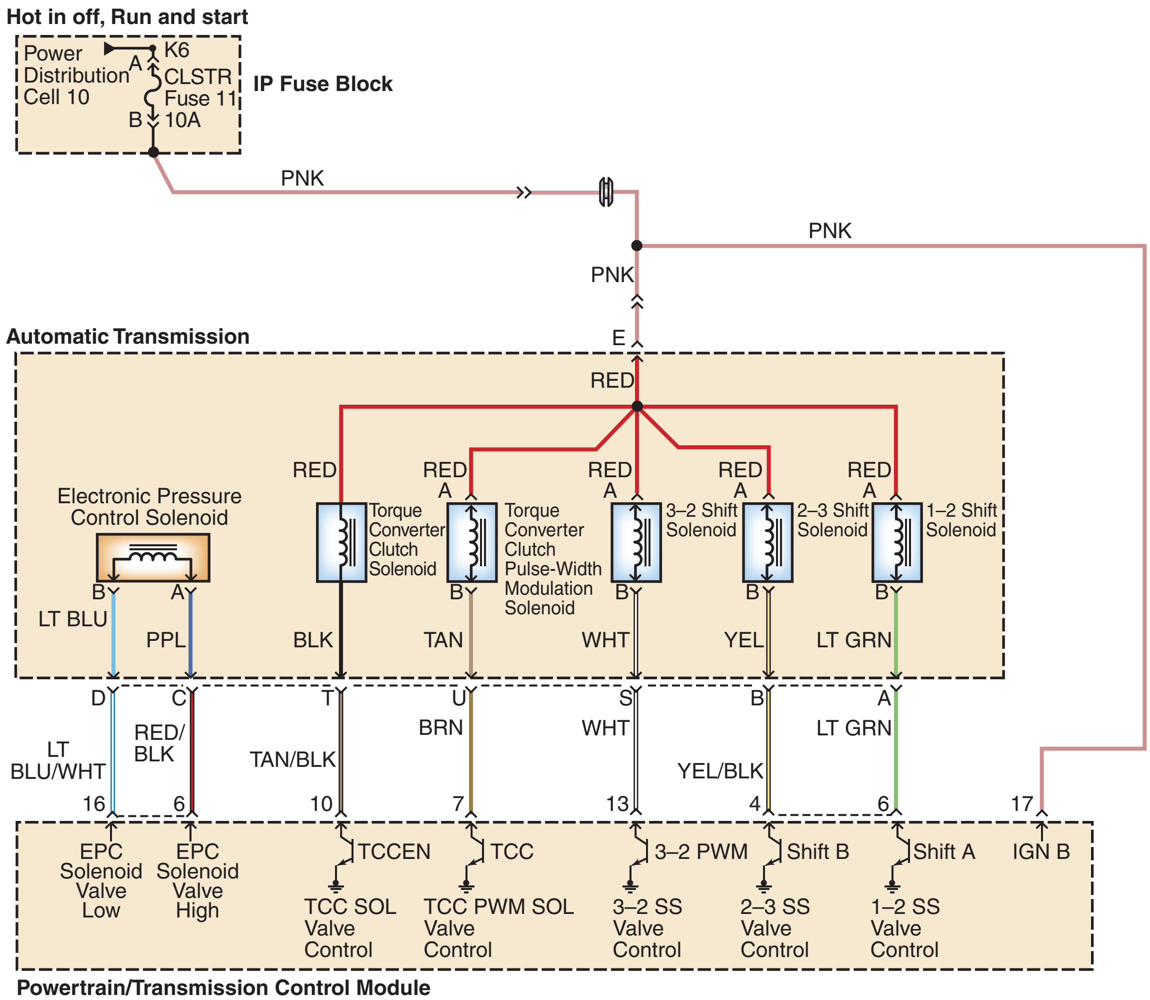


FIGURE 11-28 An EPC solenoid electrical diagram.

TABLE 11-1: Shift Solenoid Operation on a Typical Four-Speed Automatic Transmission

PCM Commanded Gear	1–2 Shift Solenoid	2–3 Shift Solenoid
Park, neutral, reverse	On	On
First	On	On
Second	Off	On
Third	Off	Off
Fourth	On	Off

solenoid 4 controls the 2–4 clutch. Looking at **FIGURE 11-29**, you can see that solenoids 1 and 3 are being used. Line pressure is being routed through the solenoids to the underdrive clutch and the low reverse clutch to engage first gear.

In **FIGURE 11-30**, you can see the transmission in second gear. For this transmission to operate in second gear, the PCM commands solenoids 1 and 4 on. This allows line pressure to flow to the underdrive clutch through solenoid 1. Line pressure is allowed to flow through solenoid 4 to the 2–4 clutch. With both the underdrive clutch and the 2–4 clutch engaged, the vehicle is in second gear.

FIGURE 11-31 shows the same transmission in third gear. In third gear on this vehicle, the PCM commands solenoids 1 and 2 on. Solenoid 1 again supplies line pressure to the

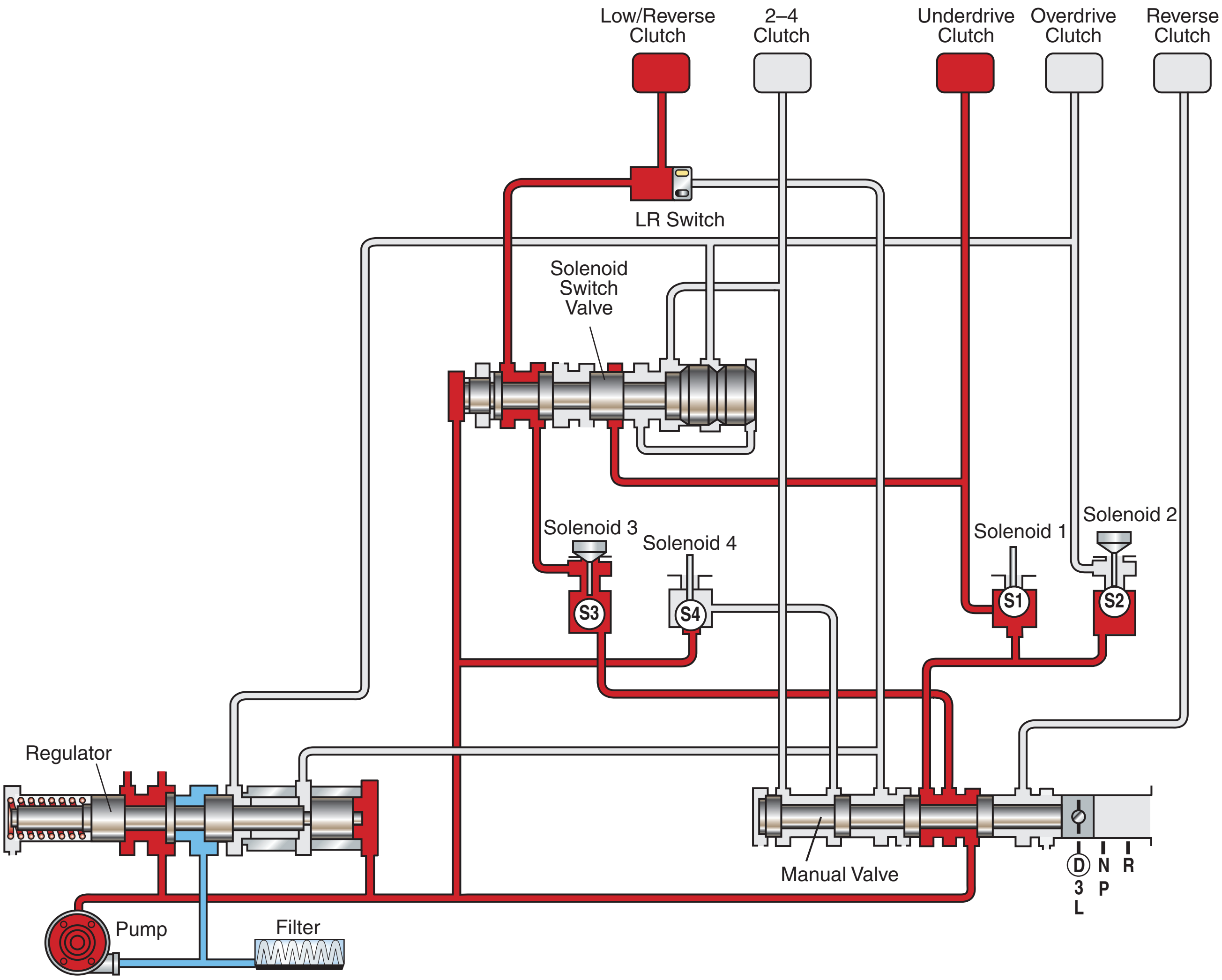


FIGURE 11-29 A simplified diagram of a Chrysler 41 TE transmission in first gear.

underdrive clutch, and solenoid 2 supplies line pressure to the overdrive clutch. With both the underdrive clutch and the overdrive clutch engaged, the vehicle is in third gear.

FIGURE 11-32 shows fourth gear operation. For fourth gear in this transmission, solenoids 2 and 4 need to be engaged by the PCM. Solenoid 2 allows line pressure to flow to the overdrive clutch, and solenoid 4 allows line pressure to flow to the 2–4 clutch. When both the 2–4 clutch and the overdrive clutch are engaged, the vehicle is in fourth gear.

In many transmissions, the solenoids do not directly operate the clutches and bands. Rather, the solenoid allows hydraulic oil to flow to a spool valve. The spool valve then moves, allowing line pressure to flow past and engage the clutch or band. **FIGURE 11-33** is a simplified hydraulic diagram for a Mitsubishi transmission. In the figure, the transmission is in first gear. The manual valve allows line pressure to flow to all four of the pressure control valves, and to the four shift solenoids. The PCM has energized solenoids 1 and 3. Solenoid 1 is now able to flow line pressure to pressure control valve 1, causing the spool valve to move to the left. When the spool valve moves to the left, line pressure is allowed to flow to the low reverse band. Solenoid 3 allows line pressure to flow to shift valve 3, causing the spool valve to move to the left. As this valve moves to the left, line pressure is allowed to flow to the underdrive clutch. When the low/reverse band and the underdrive clutch are engaged, the vehicle is in first gear.

FIGURE 11-34 shows the same transmission in second gear. For second gear, the PCM energizes solenoids 2 and 3 The manual valve allows line pressure to flow to all four shift valves and all four solenoids. Opening solenoid 2 allows line pressure to be applied to shift

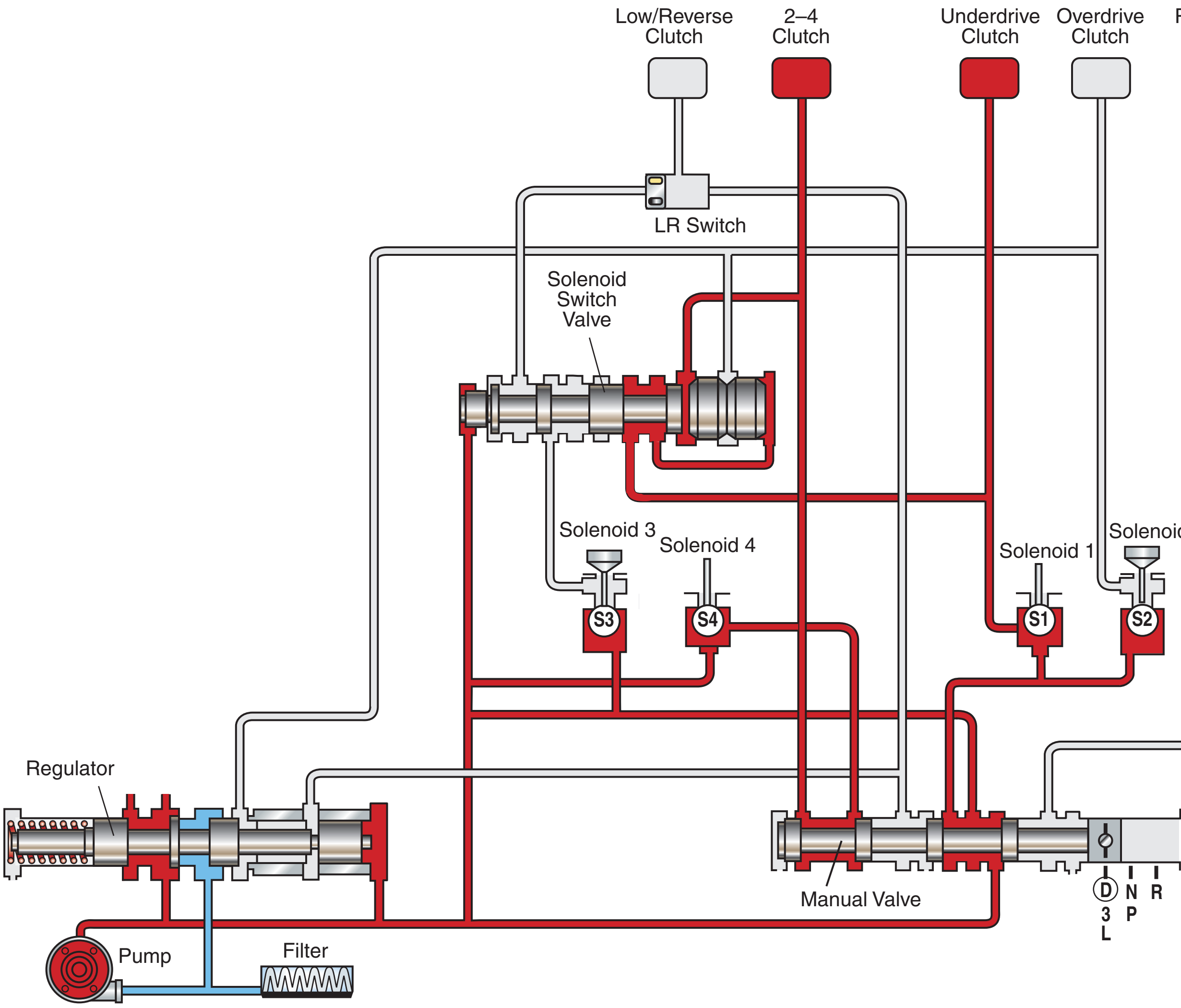


FIGURE 11-30 A simplified diagram of a Chrysler 41TE transmission in second gear.

valve 2, causing the spool valve to move to the left. This movement allows line pressure to flow past shift valve 2 and to the second band. Opening solenoid 3 allows line pressure to be applied to the right side of shift valve 3, causing the valve to move to the left. As the spool valve moves to the left, line pressure is allowed to flow through the shift valve to the underdrive clutch. When the underdrive clutch and the second band are applied, the vehicle is in second gear.

The same generic transmission, this time in third gear, is shown in **FIGURE 11-35**. Looking at the diagram, we can see that the PCM has energized solenoids 3 and 4. Again, line pressure has been supplied to all four shift solenoids and the four shift valves. Opening solenoid 3 allows line pressure to flow to the right side of shift valve 3, causing the spool valve to move to the left. When the valve moves to the left, line pressure is allowed to flow through the spool valve to the underdrive clutch. When solenoid 4 is engaged by the PCM, line pressure flows to the right side of shift valve 4, again moving the spool valve to the left. Line pressure is then allowed to flow to the overdrive clutch. When both the underdrive clutch and the overdrive clutch are engaged, this transmission is in third gear.

In **FIGURE 11-36**, we have the same transmission once more. This time the PCM has commanded operation of fourth gear. The PCM has energized solenoids 2 and 4. Each of these solenoids then allows line pressure to its respective shift valve. The line pressure causes the spool valve to move to the left, allowing line pressure to flow from shift valve 2 to

▶ TECHNICIAN TIP

Always test drive a vehicle to verify the reported problem. One customer brought in a turbocharged vehicle he had recently purchased, complaining that the turbocharger was not functioning correctly. After a quick test drive, it was determined that the turbocharger was not the cause of the poor performance; rather, the transmission solenoids had failed and the vehicle only had third gear. Replacing the solenoids fixed the problem and the customer was happy. If the technician had listened to the customer and replaced the turbo unit, the vehicle would still have had very poor performance.

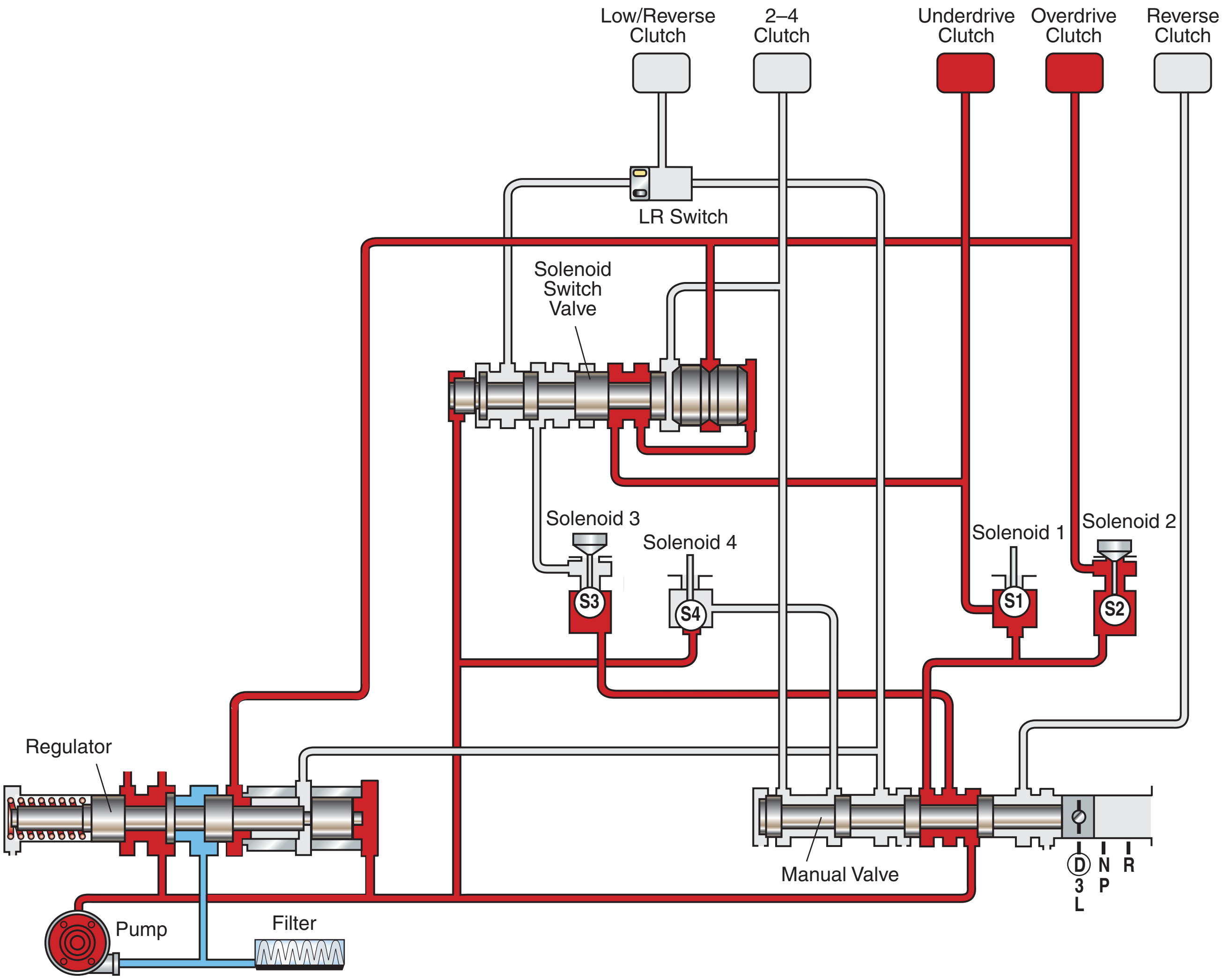


FIGURE 11-31 A simplified diagram of a Chrysler 41TE transmission in third gear.

the second band, and from shift valve 4 to the overdrive clutch. When both the second band and the overdrive clutch are engaged, this transmission is in fourth gear.

In the hydraulic diagrams for these examples, the direct solenoid shift type and the indirect solenoid shift type have been simplified to ease understanding. Having grasped the basic concept of how these systems control the transmission, you can follow a more complicated hydraulic diagram. On many transmissions, the manufacturers will use multiple valves to ensure proper operation of the clutches and bands, and to prevent the transmission from being in two gears at once. If a transmission were allowed to be in two gears at once, the results would be disastrous for the transmission, as it would tend to lock up and the weakest part would burn out or break. Take a look at **FIGURE 11-37**. This is the actual hydraulic diagram for the Chrysler 41TE transmission. What valves did we remove from the simplified diagram? Are you able to determine how it would operate with the additional valves?

K11021 Describe the operation of the electronically controlled transmission system.

K11022 Describe the purpose and operation of the powertrain control module/transmission control module.

▶ Powertrain Control Module/Transmission Control Module

The PCM or the TCM is the brain in the system. In basic terms, it comprises a storage memory section, a data processor section, an input sensor control and processing section, and a section for output drivers. The storage memory contains the software for the computer, as well as a place to retain DTCs, freeze-frame data, and learned data. Software

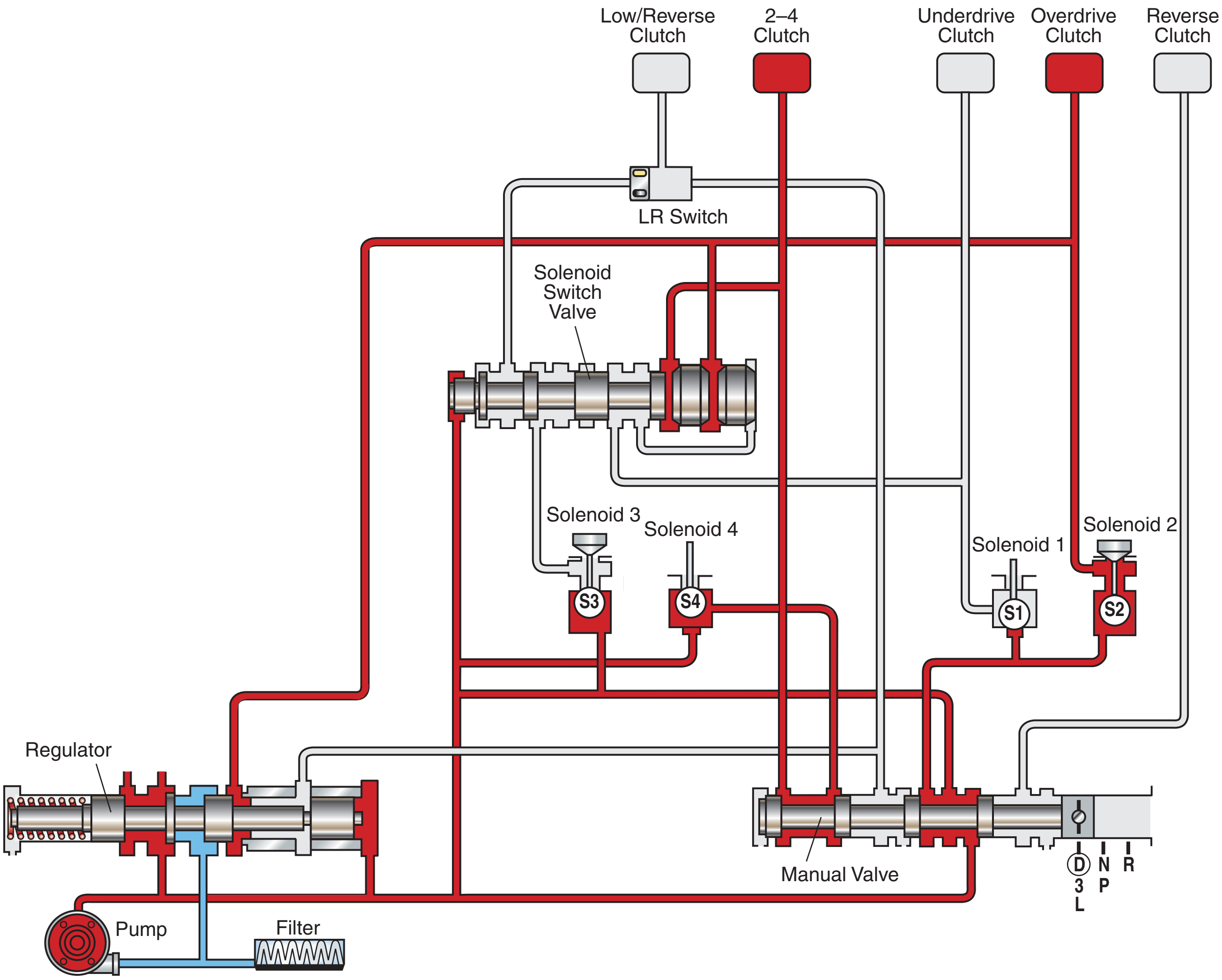


FIGURE 11-32 A simplified diagram of a Chrysler 41TE transmission in fourth gear.

is loaded into the memory, which is the basis for processing data. The software contains all of the information needed for the processor to interpret the sensor information and make decisions based on the programmed information. It also contains the instructions for performing diagnostic tests on the circuits and PCM itself. In many cases, the software can be updated by uploading software updates, called a reflash process. With software that can be updated, manufacturers can design fixes for many of the issues that may arise once their vehicles go into operation. This makes it easier, quicker, and less expensive to resolve some common customer or drivability issues rather than replacing the PCM with an updated part.

If a vehicle has a separate PCM and TCM, the two computers will share data from each other's sensors through a communication network. Most late-model vehicles will use a communication system called CAN (Controller Area Network). This network will connect most, if not all, of the different computer modules found in the vehicle through a set of twisted pair wires.

The processor and drivers are hardware related, so they make up the physical portion of the PCM. The input sensor section is responsible for sending the proper reference voltage to many of the sensors. It also receives the sensor signals and processes them into information that the main computer processor can use. The processor's function is to receive the data and compare them to data maps in the memory. Once the sensor data has been analyzed, the processor looks up the appropriate data map and determines the necessary actions. The processor then sends the appropriate commands to each of the drivers, which

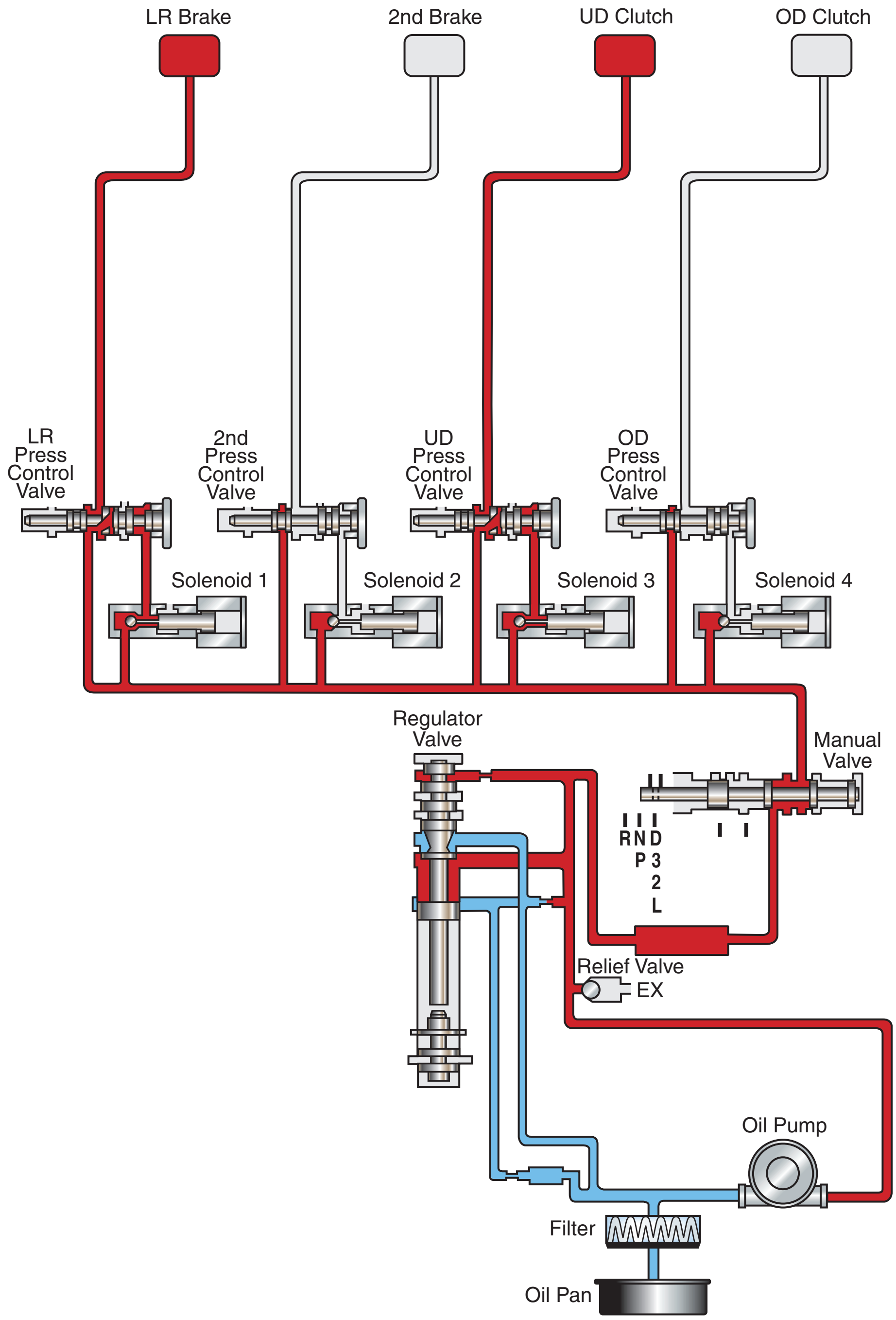


FIGURE 11-33 A simplified hydraulic diagram for a transmission in which the shift solenoids indirectly operate the clutches or bands in first gear.

are electronic switching or control devices that control each of the actuators in the transmission. The processor also commands the diagnostic tests on the system and evaluates the results compared to the information stored in memory. The output drivers typically send either simple on/off signals or pulse-width–modulated signals to the actuators, depending on the actuator being controlled.

Electronic Shift Programs

K11023 Describe the purpose and function of electronic shift programs.

Most vehicles can identify and adapt to a driver's individual style and to environmental conditions. In time, the PCM learns how a particular driver uses the vehicle. For example, does the driver always accelerate hard or more gradually?

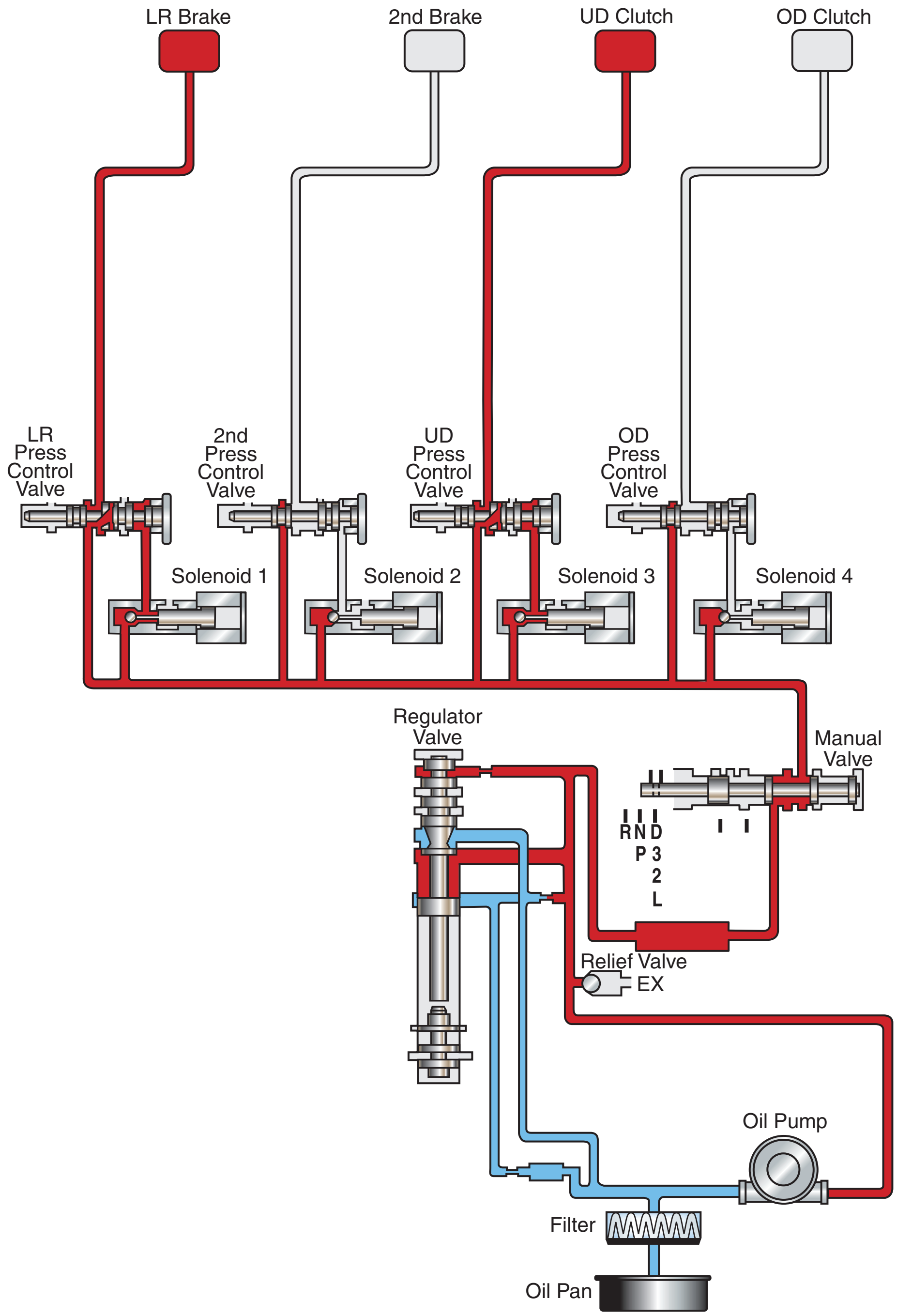


FIGURE 11-34 A simplified hydraulic diagram of a transmission in second gear that uses indirect solenoids to control the shifts.

The PCM monitors the TPS sensor along with the VSS to determine a driver's driving pattern. For a driver who has a more aggressive driving pattern, the PCM will delay the shift points to allow the engine to operate closer to its peak rpm range. The PCM will also increase the line pressure to give firmer, quicker shifts. During deceleration, the transmission will downshift at a higher rpm so the engine will be at an ideal rpm for maximum performance after the downshift.

For a more conservative driver, the PCM will allow the transmission to shift earlier to keep the engine's rpm lower and help improve fuel economy. The PCM will also reduce the line pressure to soften the shifts and allow for a more comfortable drive.

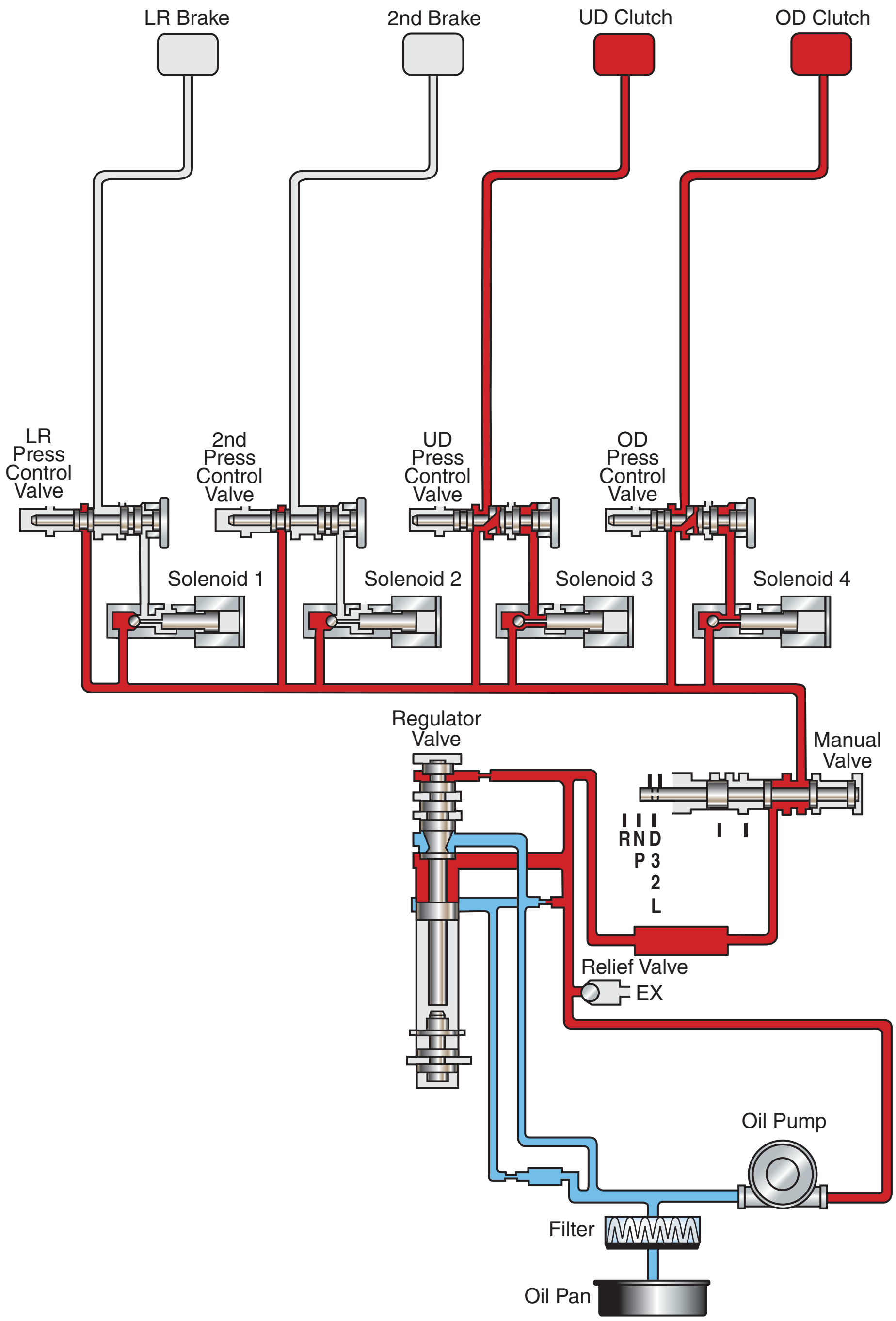


FIGURE 11-35 A simplified hydraulic diagram of a transmission in third gear that uses indirect solenoids to control the shifts.

Some vehicles have a mode selection switch on, or near, the gearshift lever to change the shift characteristics. The mode selector might have modes such as sport or normal, or sport or economy (**FIGURE 11-38**). On some hybrid vehicles, a brake mode, or regenerative braking mode, is available (**FIGURE 11-39**). This mode is used when going down steeper hills and increases the amount of regeneration that is commanded. It provides greater braking power than in the normal mode.

Because a driver's driving responses can vary considerably within a short time, depending on traffic and road conditions, response patterns are analyzed continuously. If a driver's requirements change suddenly after a stop, the driving style identification circuits within the control unit must be able to adapt.

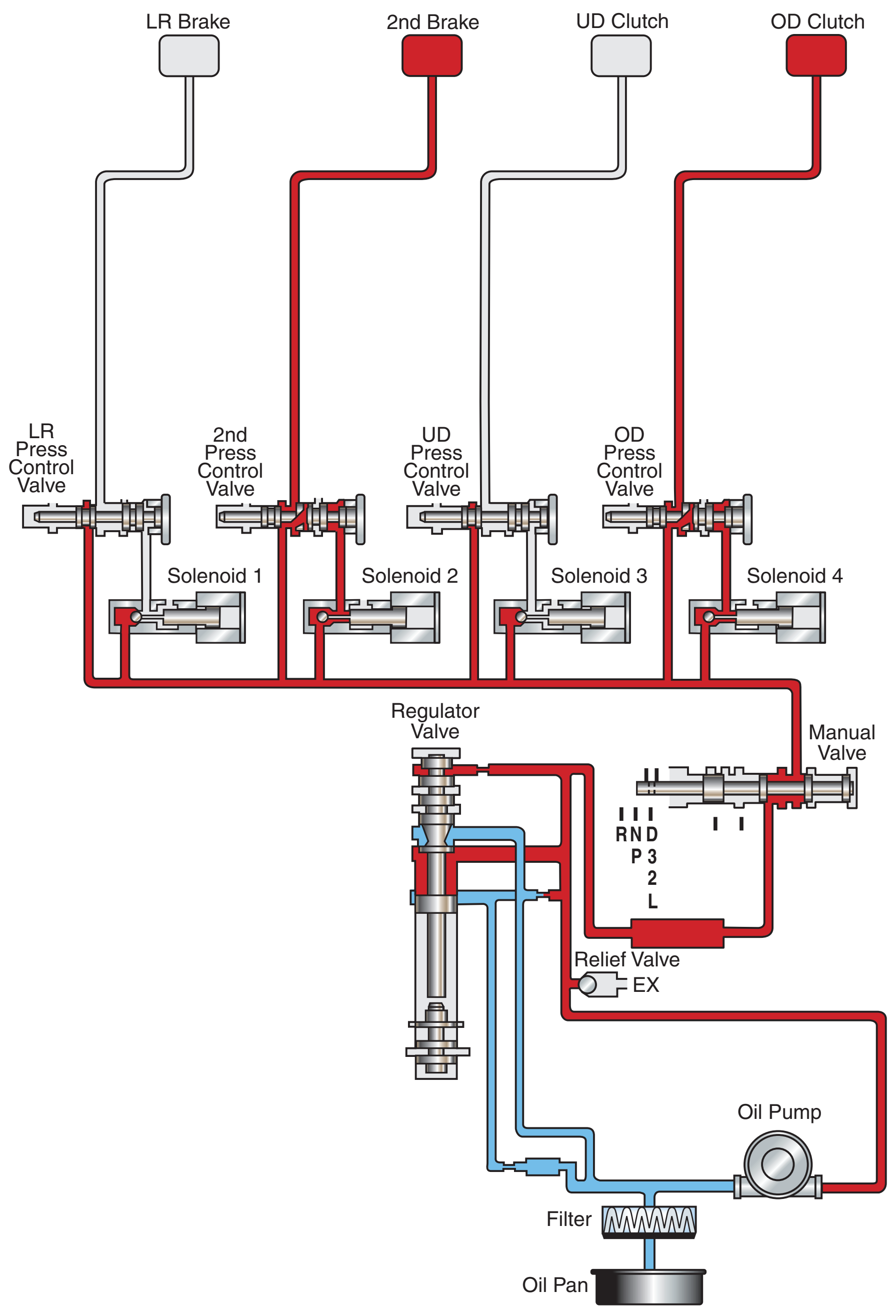


FIGURE 11-36 A simplified hydraulic diagram of a transmission in fourth gear that uses indirect solenoids to control the shifts.

Environment Identification

Identification of environment means identifying unusual ambient conditions in which the vehicle is operating. Slippery conditions require a gear ratio that enhances traction and the stability of motion of the vehicle. On vehicles equipped with traction control, one method of providing improved traction is to change the gear ratio of the transmission. Wheel slip monitoring via the anti-lock braking sensors may confirm poor tire grip, and a winter shift program can be initiated by the PCM on a vehicle with traction control. When traction control is activated, if a tire starts to spin, the PCM will command the brake for that wheel to apply in order to slow down the wheel so power can be given to the other wheel. The PCM typically commands a higher transmission gear, and thus reduced engine torque, when the vehicle is just starting from a stop. This helps to prevent the tires from losing traction.

▶ TECHNICIAN TIP

If the adaptive memory is lost due to clearing of the memory, or disconnection of the battery on some vehicles, the customer may come back and complain, "What did you do to my transmission? It doesn't work the same as before!" To prevent this, you can either use a memory minder while the battery is disconnected, or you can test drive the vehicle to help it relearn a driving style. The other alternative is to educate drivers and tell them that they will have to drive the vehicle for a few days for it to relearn their driving style.

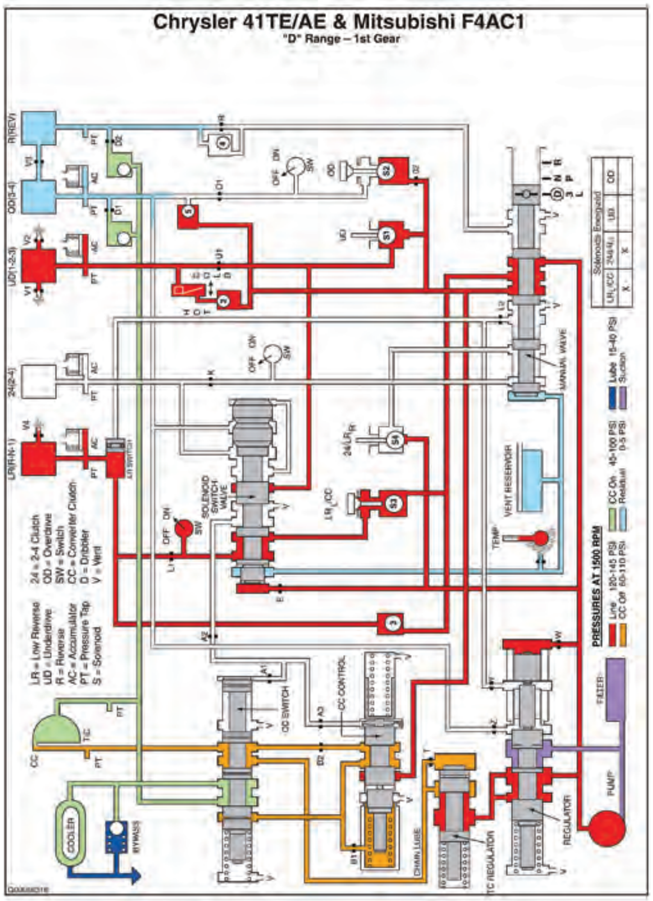


FIGURE 11-37 A non-simplified hydraulic diagram for a Chrysler 41TE Transmission.

FIGURE 11-38 An Economy/Power button located on the shifter handle.

FIGURE 11-39 Regeneration Mode on this Prius Hybrid vehicle is activated by the shift selector.

Electronic Transmission Fault Detection

On electronically controlled transmissions, the PCM must be able to monitor the transmission for proper operation. One of the first methods of fault detection is a basic circuit test. On solenoids and switches, the PCM can test the continuity of those circuits and tell whether they are open, shorted to ground, or shorted to power. If the test value is out of range, the PCM will set a DTC and turn the malfunction indicator lamp (MIL) on.

A more sophisticated type of fault detection is when the PCM monitors the input shaft speed sensor and compares it to the VSS to determine gear ratios. If the ratio is not correct, the PCM will set a DTC for a ratio error and turn the MIL on.

Newer PCMs also have logic programmed into them. No longer will the PCM only look for opens, shorts, and ratio errors. It will now also apply logic to the operating conditions it sees. For example, suppose the PCM is sent a signal from the CKP sensor of 650 rpm, an MLP signal of neutral, and a TPS signal of 75% throttle. The PCM has the logic built into its programming to realize that it is not possible to have the vehicle in neutral, an engine speed of only 650 rpm, and the throttle at 75% open. The PCM would trigger a code for the TPS. Before PCMs were programmed with this type of logic, the PCM could not make these kinds of determinations.

Torque Management

On many modern electronically controlled transmissions, the PCM can manage the torque output of the engine and vary the amount of torque being sent to the transmission. By having a completely electronically controlled transmission and engine, the PCM is able to reduce the amount of torque being produced by the engine right before the transmission shifts. Much of the wear and tear in an automatic transmission occurs during the relatively short time that the transmission is shifting between gears. By reducing the amount of torque being transmitted to the transmission during this time, transmission wear is greatly reduced, and smoother shifting is experienced. Manufacturers have also found that by using torque management to reduce the amount of torque during shifting, they can install a smaller transmission in the vehicle. For example, a manufacturer might be able to install a transmission that was designed to handle less torque than otherwise would be necessary, without affecting the transmission's longevity.

To manage the engine torque, the PCM might be programmed to cut back on the ignition timing of the engine right before the transmission shifts. As soon as the transmission has completed the shift, the PCM returns the ignition timing to normal. During normal operation, the spark plug is fired anywhere between about 10 degrees and 45 degrees of crankshaft revolution *before* the piston reaches top dead center. By retarding the ignition timing, the engine torque is dramatically decreased, reducing the strain on the transmission. All of this happens in less than 1 second, so the driver rarely feels any loss of power. If anything, the driver might notice that the transmission shifts more smoothly than a vehicle without torque management.

Limp-in Mode

Most electronically controlled transmissions have a fail-safe, or **limp-in mode**. Limp-in mode means that even if the computer for the transmission or the part of the PCM that controls the transmission fails, the vehicle will still be drivable. The transmission will have only one forward gear. Whichever gear does not require any shift solenoids will be the limp-in gear. On many transmissions, third gear is designed to be the limp-in gear. However as vehicle manufacturers have started adding more gear ratios to automatic transmissions, this fail-safe mode has been disappearing. Some vehicle manufacturers will prevent the vehicle from moving at all if the PCM/TCM detects a problem with the transmission.

Also, on most transmissions, if the PCM fails, the EPC solenoid will mechanically default to maximum line pressure to prevent clutch and band slippage, which would severely damage the transmission. This results in additional holding power for the clutches and bands. Failure of the transmission in any of these ways should turn on the MIL, notifying the driver of the failure and allowing him or her to safely drive the vehicle to a repair facility.

Adaptive Transmission Control (ATC)

Modern, electronically controlled transmissions automatically adapt their programming as the transmission wears and learns how the driver operates the vehicle. In this section, we will take a deeper look at how two different manufacturers perform the adaptive learning to compensate for wear. By studying the General Motors and Chrysler methods, the principles of adaptive learning will become clear. Most other manufacturers operate adaptive learning in a similar way to either the General Motors style or the Chrysler style.

General Motors Transmission Adaptive Pressure (TAP)

On most late-model General Motors (GM) transmissions, adaptation to transmission shifts will be made by varying the line pressure in the transmission. Remember, as with all manufacturers, not all vehicle transmissions used in GM vehicles are produced by GM. Also, some of the newer 6-speed transmissions, such as the 6L80 transmission, use a system similar to the Chrysler style. GM calls their adaptive control TAP. The PCM first analyzes the time it takes to complete an upshift. The PCM, however, will only analyze certain upshifts. If the driver is operating the vehicle erratically, the PCM will not attempt to analyze the shift because there is too great of a chance that the shift could be adapted incorrectly. The PCM also ignores any shifts that occur during other events that can cause a change in the shift quality. For example, the PCM will not analyze a shift occurring during cycling of an A/C compressor (**FIGURE 11-40**).

On some vehicles, the transmission will not analyze a shift if the malfunction indicator light (MIL) is illuminated for certain codes, such as lean air-fuel ratio codes.

Other parameters that the PCM will consider are engine load, throttle position, engine temperature, and transmission temperature. It is also important to note that the author has found some vehicles that will not perform adaptive functions if the percentage of ethanol in the fuel is above 40%. This is a greater concern if you are in an area in which E-85 fuel is available.

Once the PCM has decided that a shift met all of its predetermined requirements, it will analyze the time that it took to complete the shift and determine if any corrections

FIGURE 11-40 A scan tool displaying the time it took to perform the 1-2 shift.

need to be made to the TAP program. TAP can be viewed and reset on some scan tools. TAP is broken down into cells for each shift (**FIGURE 11-41**).

There are 13 TAP cells numbered 4–16. Each cell corresponds to a calculated amount of engine output. Cell 4 is a light throttle, light load shift, while cell 16 is a much more "spirited" acceleration shift. The cells are broken down evenly between cell 4 and 16 to correspond to different levels of engine load.

Every transmission has an upper and lower limit built into the adaptive shift program that will trip a P1811 trouble code in the PCM/TCM. This code means that the transmission cannot increase the shift pressure (or decrease the shift pressure) any more than it already has. A beginning technician may automatically decide that the transmission must come out and be rebuilt because the clutch packs must be worn. This may or may not be the case. An actual line pressure test is needed to confirm that the transmission pressure actually corresponds to what the PCM/TCM has read. If the pump is worn, or the pressure control solenoid is faulty, the pressure will not be the same as the PCM/TCM has determined, possibly tripping the P1811 code.

After a transmission repair or replacement, always reset the transmission adaptive pressure memory using a scan tool. Not all scan tools will allow you to reset the adaptive memory. If this is the case, the adaptive memory can be reset by disconnecting the battery for an extended period of time, typically about 30 minutes (**FIGURE 11-42**).

Chrysler Clutch Volume Index (CVI)

Starting with the A604/41TE transmission, Chrysler introduced the world to Clutch Volume Index, or CVI. The 41TE transmission has electrical solenoids that directly send hydraulic pressure to the various clutches in the transmission, rather than the solenoids moving a separate hydraulic shift valve. Each clutch (or servo) will have its own CVI number. This number is a calculation of the volume of fluid required to apply the clutch. The CVI number can be any number between 0 and 255. A lower number means that the clutch requires less volume, and a higher number means the clutch requires more volume (**FIGURE 11-43**).

As clutches wear, the volume of fluid needed will increase slightly. In reality, a high CVI number may not mean that the clutch has failed. It simply means that the *time* it took for the clutch to fill is greater. High numbers can mean a clutch is worn, or it can mean there are internal leaks, or other hydraulic problems. As with the TAP system, the PCM/TCM will only analyze shifts when certain requirements are met. Some of the clutches are

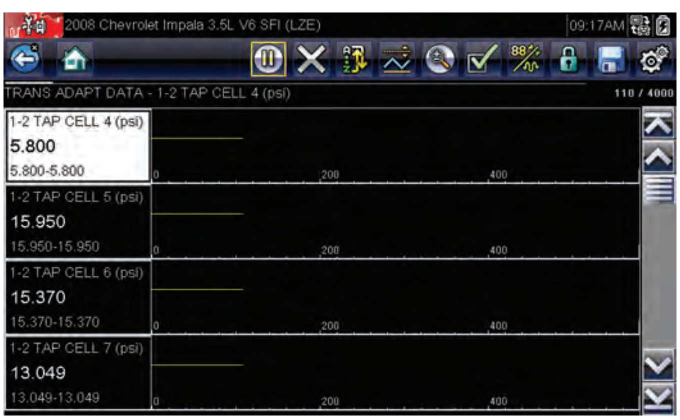


FIGURE 11-41 The GM TAP data display from a Chevrolet Impala.

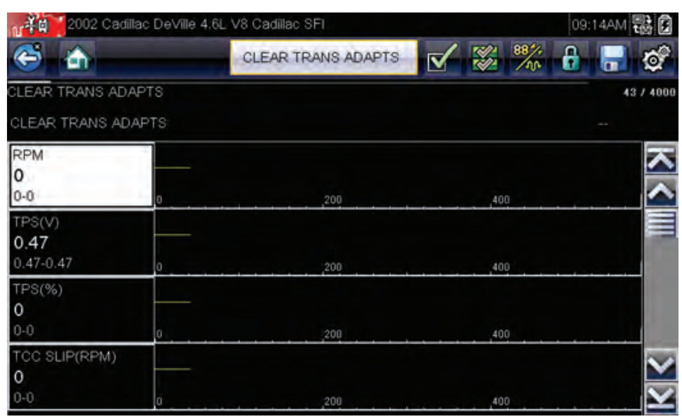


FIGURE 11-42 Transmission adaptive pressure being reset after a transmission repair.

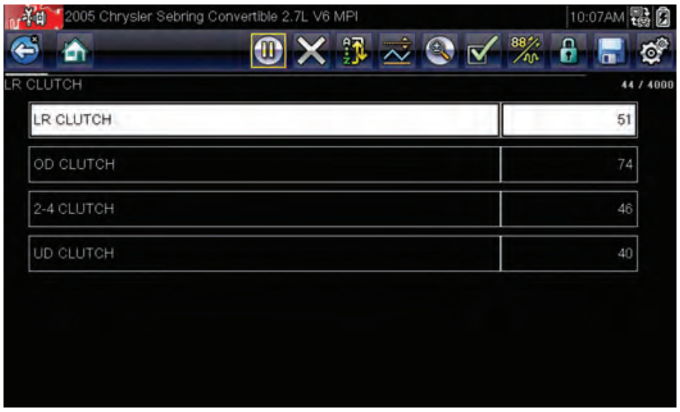


FIGURE 11-43 CVI numbers shown on a scan tool for a 2005 Chrysler Sebring with 60,000 miles and a recent transmission repair of the valve body and replacement of the solenoid pack. The customer was told by a repair facility that the vehicle needed a complete transmission. The actual repair was significantly cheaper because the transmission did not need to be removed and overhauled.

FIGURE 11-44 CVI numbers shown on a scan tool for a 2005 Chrysler Town and Country with 110,000 miles. Note the significantly higher CVI numbers for the overdrive clutch than in Figure 11-43.

only tested during downshifts, such as the low/reverse clutch on the 41TE. If you have a transmission that is not adapting the CVI numbers after a reset, it will be necessary to look up in the service information exactly what parameters need to be met in order for the PCM/TCM to analyze the shift. Every transmission has recommended CVI numbers, and it is necessary to check the service information for the correct specifications for the transmission you are working on (**FIGURE 11-44**).

Using the CVI number, the PCM/TCM anticipates a shift and begins applying the shift solenoid earlier or later than normal to compensate for a longer clutch fill time. Again, verifying the correct pressures with an actual transmission pressure gauge can be very helpful in the diagnosis of the transmission. If the CVI exceeds the amount to which the PCM/TCM can adapt, the transmission will typically switch to a fail-safe mode, preventing transmission shifts. After transmission repairs or replacement, the CVI must be reset. Remember that the CVI will cause the PCM/TCM to begin applying the clutch earlier. If the clutch no longer needs this extra time, you may have very harsh, bumpy shifts that could damage the repaired transmission (**FIGURE 11-45**).

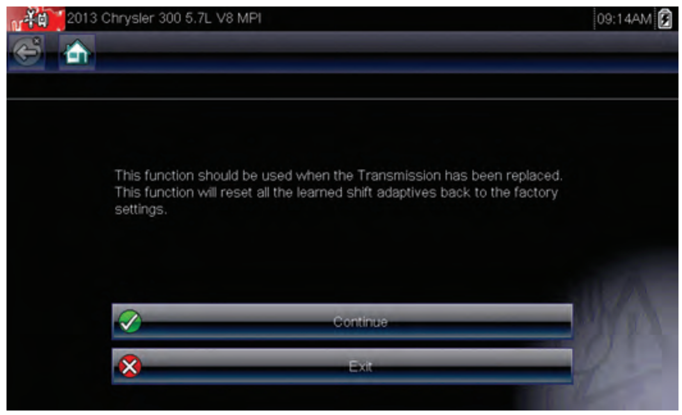


FIGURE 11-45 Resetting the CVI on a 2013 Chrysler 300C transmission after an overhaul.

▶ Wrap-Up

Ready for Review

- US auto manufacturers switched to electronically controlled transmissions by the late 1980s.
- Shift oints in an electronically controlled transmission are controlled by the powertrain control module (PCM) or transmission control module (TCM).
- A vehicle speed sensor (VSS) relays vehicle speed information to the speedometer
- Types of VSS are magnetic pickup and reed switch.
- An input shaft peed sensor is similar to a VSS and relays its signal to the PCM.
- Shift iming and pressure are regulated based on input from the transmission fluid temperature (TFT) sensor.
- Transmission pressure switches are used to determine when pressure is in a particular circuit.
- Transmission line pressure is adjusted based on feedback from the line pressure sensor.

- The throttle position sensor (TPS) is a variable resistor (potentiometer) that moves with the position of the throttle.
- The engine coolant temperature (ECT) sensor relays information to the PCM, enabling the PCM to vary shift iming and pressures based on engine temperature.
- The manifold absolute pressure (MAP) sensor allows the PCM to monitor how much load the engine and transmission are under.
- Modern MAP sensors (installed after 1996) are primarily used to determine functionality of emissions-related components.
- Mass airflow (MAF) sensors measure the mass of air (in
- grams per second) entering the engine, enabling the PCM to inject the correct amount of fuel.
- Types of crankshaft osition (CKP) sensors are magnetic pickup, Hall effect, and optical.
- The PCM relies on the CKP sensor to determine engine speed.
- The PCM reads signals from the brake on/off witch to know when the driver has applied the brake pedal.
- The manual lever position (MLP) switch may be referred to as the transmission range switch or a neutral safety switch.
- The PCM reads the manual lever position to prevent the vehicle from starting unless it is in park or neutral.
- An electronic pressure control (EPC) solenoid is used to control line pressure.
- Shift olenoids, sometimes in conjunction with shift valves, are used to direct line pressure to an application device.
- Shift olenoids may allow hydraulic oil to flow to a spool valve rather than directly operate clutches and bands.
- A torque converter clutch (TCC) lock-up solenoid is engaged once vehicle speed has stabilized.
- The PCM is designed to adapt to a driver's individual driving pattern.
- The PCM can also identify and adapt to environmental conditions.
- The fi st step in a PCM's fault detection system is a basic circuit test.
- The PCM monitors gear ratios as a method of fault detection.
- The PCM can reduce transmission wear by torque reduction during gear shifting.
- The PCM manages engine torque via retarding engine ignition timing prior to transmission shifts
- Limp-in mode refers to the ability of the vehicle to function in the event of a failure of the transmission computer or part of the PCM that controls the transmission.
- GM uses the TAP system on most modern automatic transmissions to adapt the shift uality.
- Chrysler uses a volume-based system to vary shift iming called CVI.

Key Terms

crankshaft position (CKP) sensor A sensor used by the PCM to monitor engine speed. It can be one of three types of sensors—Hall effect, magnetic pickup, or optical.

engine coolant temperature (ECT) sensor A sensor that changes resistance based upon coolant temperature; also known as a thermistor.

input shaft speed sensor A sensor inside the transmission that measures the rpm of the input shaft; also called a turbine shaft sensor.

limp-in mode A transmission operating mode in which limited computer controls are needed for the purpose of getting the vehicle to a shop.

line pressure sensor A variable resistor sensor used to monitor line pressure. It sends a signal back to the PCM where it can be translated into a psi reading.

manifold absolute pressure (MAP) sensor A vacuum sensor that is attached to the intake manifold by a passageway or vacuum hose. The sensor measures engine intake manifold pressure to determine engine load and sends a corresponding signal to the PCM.

manual lever position (MLP) switch A switch that is used by the PCM to determine which gear range the driver has selected with the shift lever.

mass airflow (MAF) sensor A sensor located in the air intake system that is used to measure the mass of the air flowing into the engine.

potentiometer A type of variable resistor that increases or decreases its resistance as it is turned, which creates a varying voltage signal.

reed switch A type of speed sensor that uses a magnetic field to open and close a movable set of contacts. It is used with a rotating magnet to measure rpm of a shaft and send the signal to the PCM.

shift solenoid An electromechanical device used to control oil flow to bands and clutches in an automatic transmission to help shift the transmission.

throttle position sensor (TPS) A type of potentiometer used by the PCM to measure throttle angle.

torque converter clutch (TCC) A hydraulically operated clutch located inside the torque converter that applies at predetermined conditions and stops torque converter slippage.

transmission control module (TCM) A computer module that controls the transmission operation. It may be integrated into the PCM.

transmission fluid temperature (TFT) sensor A type of variable resistor used inside the transmission to monitor oil temperature.

vehicle speed sensor (VSS) A sensor used by the PCM to measure vehicle speed. It is often located in the transmission extension housing.

Review Questions

1. All of the following statements are true with respect to the vehicle speed sensor (VSS) *except*:
   a. It is responsible for sending the vehicle speed information to the vehicle speedometer.
   b. It is sometimes called an output shaft speed sensor.
   c. It is often also responsible for sending the vehicle speed information to the vehicle speedometer.
   d. It can never replace a governor in a computerized transmission.
2. All the following statements are true *except*:
   a. In a fully hydraulically controlled transmission, the shift points are controlled by the vehicle's power train control module (PCM).
   b. In a fully electronically controlled transmission, the shift points are controlled by the vehicle's power train control module (PCM).
   c. In a fully electronically controlled transmission, the shift points are controlled by the vehicle's transmission control module (TCM).
   d. On a hydraulically controlled transmission, the computer can react to the increased load only *after* the transmission shifts.
3. Transmission pressure switches are:
   a. open when there is pressure.
   b. used to determine what gear range the transmission is operating in.
   c. present in the dashboard.
   d. used to determine the pressure of the transmission fluid.
4. Which of the following is a pressure transducer?
   a. Electric-only propulsion
   b. Manual lever position (MLP) switch
   c. Overdrive switch
   d. Line pressure sensor
5. Which of the following is installed in an engine coolant passage, often near the thermostat housing on an engine?
   a. MAF sensor
   b. ECT sensor
   c. MAP sensor
   d. CKP sensor
6. All of the following statements are true *except*:
   a. The PCM or the TCM is the brain in the system.
   b. The PCM monitors the TPS sensor along with the VSS to determine a driver's driving pattern.
   c. Slippery conditions require a gear ratio that enhances traction and the stability of motion of the vehicle.
   d. Increasing the amount of torque being transmitted to the transmission reduces transmission wear.
7. Which of the following is used by the PCM to tell which gear range the driver has selected with the shift lever?
   a. Manual lever position switch
   b. Reed switch
   c. Line pressure sensor
   d. Throttle position sensor
8. Choose the correct statement with respect to limp-in mode.
   a. It refers to the event of failure of the transmission computer, where the vehicle still functions.
   b. It is a sensor used by the PCM to monitor engine speed.
   c. It is a sensor that changes resistance based upon coolant temperature.
   d. It is a type of speed sensor that uses a magnetic field to open and close a movable set of contacts.
9. An electromechanical device used to control oil flow to bands and clutches in an automatic transmission to help shift the transmission is the:
   a. torque converter clutch.
   b. throttle position sensor.
   c. shift solenoid.
   d. potentiometer.
10. All the following statements describing the VSS are true *except*:
    a. The types of VSS are magnetic pickup and reed switch.
    b. An input shaft speed sensor is similar to a VSS and relays its signal to the PCM.
    c. It relays vehicle speed information to the speedometer.
    d. It is primarily used to determine functionality of emissionsrelated components.

ASE-Type

1. Tech A says that electronically controlled automatic transmissions have improved fuel efficiency. Tech B says that more gears with electronically controlled automatic transmissions have improved fuel efficiency. Who is correct?
   a. Tech A
   b. Tech B
   c. Both A and B
   d. Neither A nor B
2. Tech A says that electronic transmissions today are smaller and lighter than hydraulically controlled transmissions. Tech B says that electronic transmissions are beefier today to withstand higher torques. Who is correct?
   a. Tech A
   b. Tech B
   c. Both A and B
   d. Neither A nor B
3. Tech A says that reed switches produce air-conditioning voltage. Tech B says that a magnetic VSS can be troubleshot by checking to see if the sensor is producing a DC voltage when the output shaft is turning. Who is correct?
   a. Tech A
   b. Tech B
   c. Both A and B
   d. Neither A nor B
4. Tech A says that transmissions with an input shaft speed sensor and a vehicle speed sensor (VSS) can use this information to determine shift solenoid failure. Tech B says

the input shaft speed sensor is also called a turbine speed sensor. Who is correct?

- **a.** Tech A
- **b.** Tech B
- **c.** Both A and B
- **d.** Neither A nor B

5. Tech A says that when troubleshooting a TPS at WOT, the return voltage should not exceed 12 volts. Tech B says that when using a digital storage oscilloscope to troubleshoot a TPS up to WOT, KOEO voltage should rise steadily up to WOT. Who is correct?

- **a.** Tech A
- **b.** Tech B
- **c.** Both A and B
- **d.** Neither A nor B

6. Tech A says that the ECT and the TFT will delay transmission shifting. Tech B says that the ECT and the TFT could cause the transmission to shift sluggishly or way too soon. Who is correct?

- **a.** Tech A
- **b.** Tech B
- **c.** Both A and B
- **d.** Neither A nor B

7. Tech A says that all MAP sensors send a signal to the PCM to determine engine load. Tech B says that all MAF sensors send a signal to the PCM to determine engine load. Who is correct?

- **a.** Tech A
- **b.** Tech B
- **c.** Both A and B
- **d.** Neither A nor B

8. Technician A says that a CVI number of 190 indicates that the transmission is slipping. Technician B says that CVI numbers range from 0 to 255. Who is correct?

- **a.** Tech A
- **b.** Tech B
- **c.** Both A and B
- **d.** Neither A nor B

9. Tech A says that the PCM uses the brake switch information to hold the transmission in gear during braking, no shifts allowed. Tech B says that when troubleshooting an ECT sensor, using a paper clip to jump the connector will help determine if the problem is the sensor or the wiring. Who is correct?

- **a.** Tech A
- **b.** Tech B
- **c.** Both A and B
- **d.** Neither A nor B

10. Tech A says that automatic transmissions will change gear ratios based upon winter weather conditions. Tech B says that on a vehicle with traction control, the transmission will change shift programming to assist. Who is correct?

- **a.** Tech A
- **b.** Tech B
- **c.** Both A and B
- **d.** Neither A nor B

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SAMPLE CHAPTER 11

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Keith Santini
Kirk VanGelder

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