INTRODUCTION

The purpose and function of gears in a transmission include the following:

- Low/first gear must provide enough torque to get the vehicle moving.
- High gear should provide an engine speed for fuel-efficient operation at highway speeds.
- The intermediate ratios should be spaced to provide adequate acceleration while minimizing the potential of overrevving the engine before the shift or lugging the engine after the shift.

The majority of vehicles up to the 1970s used three-speed transmissions while some added an overdrive unit for a fourth gear ratio to lower engine RPM at cruise speeds. As the need to improve fuel economy and reduce exhaust emissions has improved, four-, five-,six-speed (or more) transmissions have been introduced to provide lower first gears, overdrive, and/or smaller steps between gear ratios.

An automatic transmission provides the forward and reverse gear ratios needed without requiring the driver to make the change in gearing as with a manual transmission. Most automatic transmissions and transaxles include the following shift modes:

- Park (P). In the park position, the output shaft is locked to the case of the transmission/transaxle which keeps the vehicle from moving. In the park position the engine can be started by the driver.
- Reverse (R). The reverse gear selector position is used to move the vehicle in reverse.
- Neutral (N). In the neutral position no torque is being transmitted through the automatic transmission/transaxle. In this position the engine can be started by the driver.
- Drive (D). The D position includes the overdrive ratios in most vehicles. Use this position when driving on the highway.
- Manual (M). Electronic range select (ERS) or manual mode allow the driver to select the range of gear ratios.

Torque converter. A torque converter replaces the manual transmission clutch. It is a type of fluid coupling that can release the power flow at slow engine speeds and also multiply the engine torque during acceleration. The torque converter includes a friction clutch that locks up to eliminate slippage at cruising speeds, improving fuel economy and reducing exhaust emissions. Figure 1.

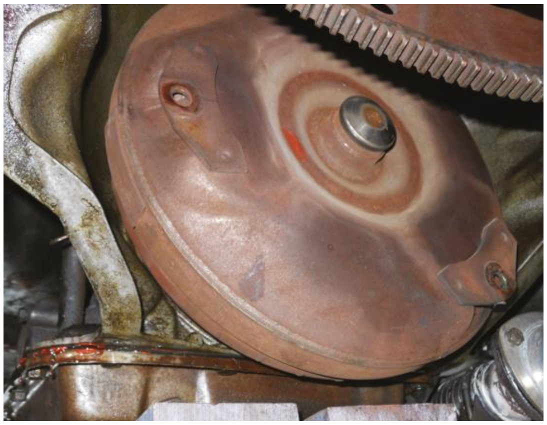

Figure 1. Torque converter

Planetary gear sets. Most automatic transmissions use planetary gear sets, which are a combination of gears. Planetary gear sets are used and combined in a complex manner so that transmissions with seven or eight speeds forward plus reverse are possible. Figure 2.

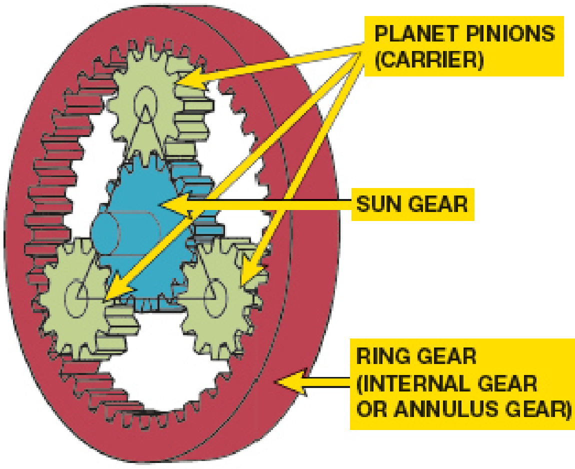

Figure 2. Planetary gear set.

Shifts are made by engaging or releasing one or more internal clutches that drive a gear set member, or by engaging or releasing other clutches or bands that hold a gear set member stationary. An automatic transmission might have as many as seven of these power control units (clutches or bands). One-way clutches are also used that self-release.

One or more clutches will control the power coming to a planetary member and one or more reaction members can hold a gear set member stationary. The third planetary member will be the output.

Transaxle. A transaxle is a compact combination of a transmission, the final drive gear reduction, and the differential. It can be either a manual, automatic, or continuously variable transaxle. Transaxles are used in nearly all front-wheel-drive vehicles.

A transmission normally has one output shaft that couples to the rear axle through the driveshaft. A transaxle has two output shafts that couple to the two front wheels through a pair of driveshafts. The differential used in transaxles or drive axles is a torque-splitting device that allows the two axle shafts to operate at different speeds so that a vehicle can turn corners. Figure 3.

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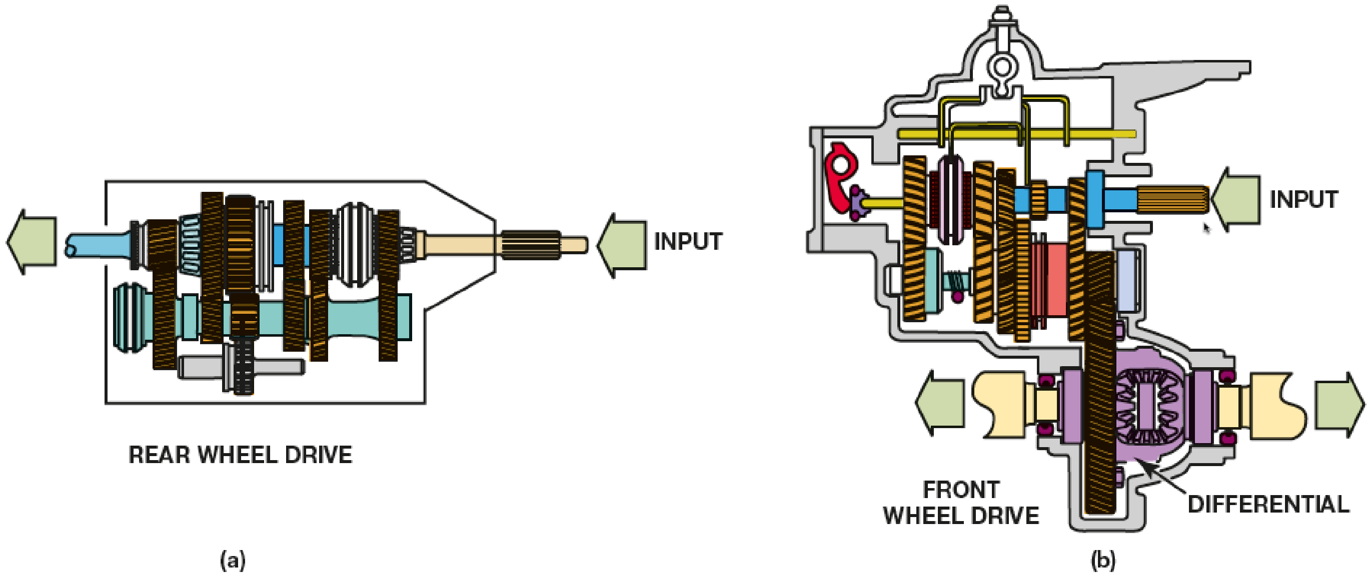

Figure 3. Transmission (a) compared to a transaxle (b).

ASE TEST TOPICS

A1 Mechanical/Hydraulic Systems

1. Road test the vehicle to verify mechanical/hydraulic system problems based on driver's concern; research vehicle service history.

2. Diagnose noise, vibration, harshness, and shift quality problems.

A road test is used to verify the customer's concern and check the general overall condition of the transmission. The vehicle should be road tested at the start of the diagnosis and after the repair. A road test may involve simply driving the vehicle and mentally reviewing the transmission operation. The following points are normally checked during a road test:

- Quality of each upshift and downshift at various loads
- Timing of each upshift and downshift at various loads
- Any hunting between gear ranges
- Operation of the torque converter and torque converter clutch (TCC)
- Slipping in any gear range
- Binding or tie-up in any gear range
- Noise or vibration in any gear range

3. Diagnose fluid loss, type, level, and condition problems.

Most transmission dipsticks are marked for both cold and hot fluid temperatures. It is never a good idea to operate a transmission with the fluid level too high (an overfill condition) or too low (an underfill condition). Figure 4.

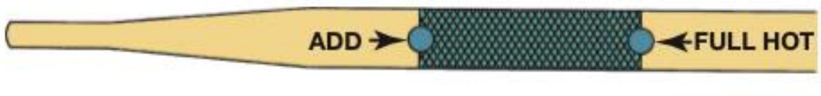

Figure 4. Dipstick markings.

To check transmission fluid with a dipstick, check the procedure stamped on the dipstick. The usual procedure includes the following steps:

- Park the vehicle on a level surface, apply the parking brake securely, and place the gear selector in park or neutral as recommended by the manufacturer.
- Clean any dirt from the dipstick cap and remove the dipstick.
- Wipe the dipstick clean and return it to the filler pipe, making sure that it is fully seated.
- Pull the dipstick out again and read the fluid level.

Some units do not use dipsticks. Fluid level is checked by following the procedure stated in the service information. A general procedure is to bring the transmission to operating temperature and then remove the fluid level plug. Fluid will trickle or weep out of the plug if the level is correct. Figure 5.

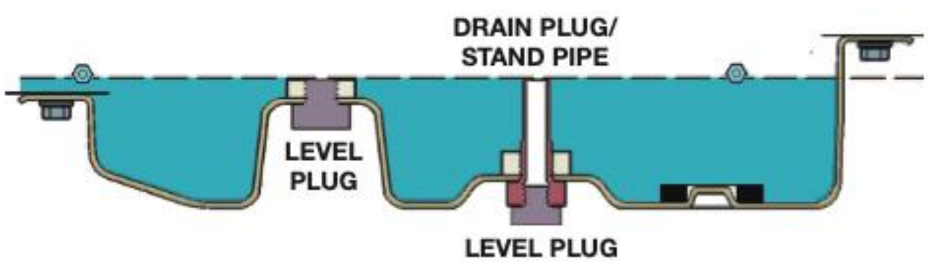

Figure 5. Transmission pan showing two types of level plugs.

Some manufacturers require a special procedure or tool in order to check the fluid level of their sealed transmissions, so it is wise to review their fluid-checking procedures.

Fluid condition should always be checked when checking fluid level. A transmission technician will normally smell the fluid and check the color for unusual characteristics. The fluid should be a bright reddish color with a smell that is similar to new fluid. Fluid condition can be checked by placing a sample on clean, white, absorbent paper. Clean fluid will spread out and leave only a wet stain. Dirty fluid will leave deposits of foreign material. Figure 6.

Figure 6. Checking fluid condition.

4. Perform pressure tests; determine necessary action.

The operation of an automatic transmission is dependent on hydraulic pressure. A pressure gauge is used to check the condition of the hydraulic system. All transmissions have a pressure test port, and some have more than one. If there is only one port, it will usually be for line pressure. The additional ports provide the apply or release pressure of a particular clutch. Service information includes illustrations to identify these test ports. Figures 7 and 8.

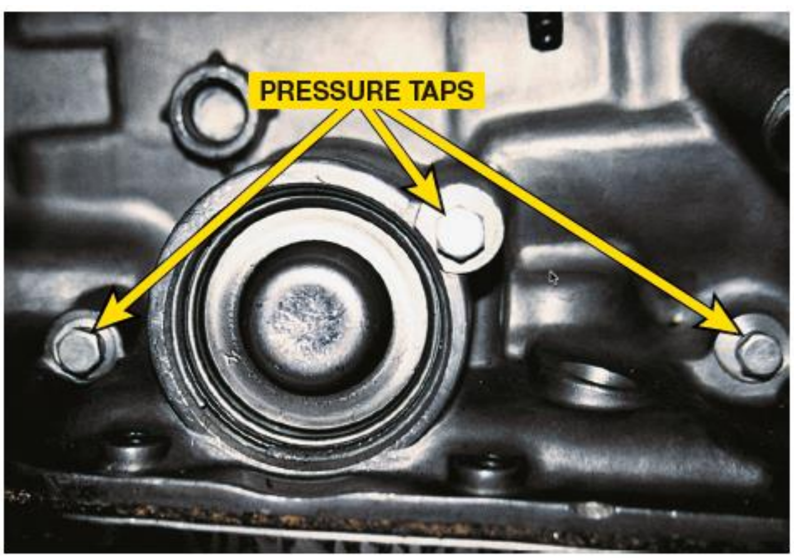

Figure 7. Taps for pressure testing.

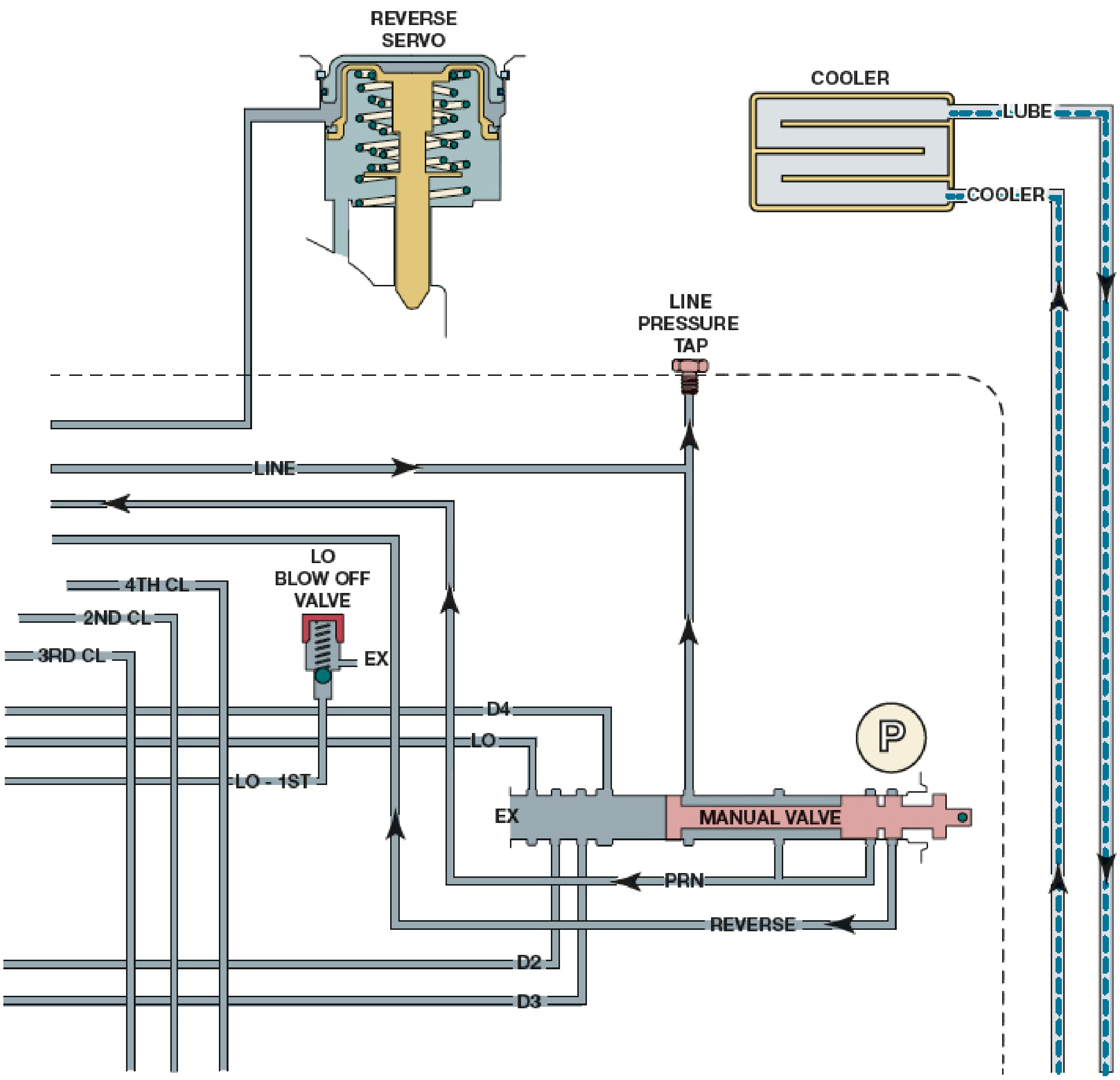

Figure 8. A partial hydraulic schematic showing the line pressure tap.

When using a hydraulic pressure gauge, it is recommended that the range of the gauge be 0 to 300 PSI (0–2 kPa) to prevent gauge damage while testing reverse gear pressure. The approximate pressures in most transmissions will be as follows:

- Neutral, park, and drive at idle: 50 to 60 PSI (350 to 400 kPa)
- Reverse: 150 to 250 PSI

5. Diagnose torque converter stator/one-way clutch failure.

The three major parts of the torque converter include:

- Impeller. The impeller is the driving member and rotates with the engine and is located on the transmission side of the converter. When the engine is running, the flexplate and converter rotate with the crankshaft.

- Turbine. The turbine is located on the engine side of the converter. The impeller vanes pick up fluid in the converter housing and direct it toward the turbine. The turbine rotates and turns the transmission input shaft. The turbine is the converter's output member. The center hub of the turbine is splined to the transmission input shaft.
- Stator. A torque converter also contains the stator, or reactor, which is mounted on a one-way clutch. The stator is the reaction member of the torque converter. The one-way clutch allows the stator to rotate clockwise but blocks counterclockwise rotation. Figure 9.

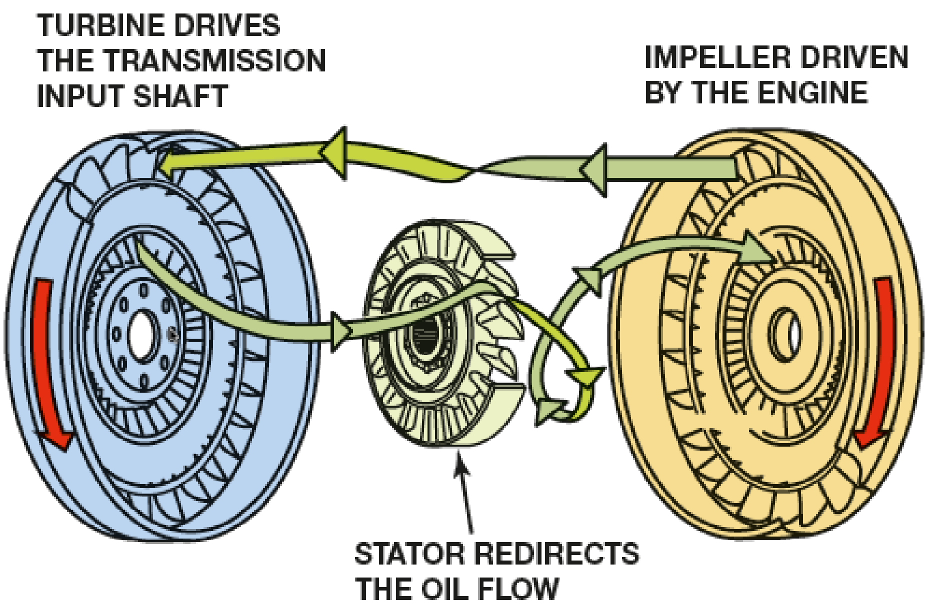

Figure 9. Basic torque converter (no clutch shown).

A stall test is used to check the stator one-way clutch inside the torque converter. This test should be performed with caution because it operates the vehicle in a potentially dangerous situation: The vehicle is in gear with the throttle wide open. It is recommended that both the parking brake and the service brake be firmly applied, the wheels blocked, and the throttle be held open for a maximum of 5 seconds.

Apply the brakes firmly, move the gear selector to reverse, move the throttle to wide open, and watch the tachometer. The speed should increase to somewhere between 1500 and 3000 RPM. As soon as the speed stops increasing or goes higher than 3500 RPM, quickly note the reading and close the throttle. Record the speed.

- If the stall speed is too low. The engine is weak, out of tune, or the stator one-way clutch is slipping.
- If the stall speeds are normal, but the vehicle has normal acceleration and has reduced performance at higher speeds. The stator one-way clutch could be seized in a locked-up condition.

6. Perform torque converter clutch (lock-up converter) mechanical/hydraulic system tests.

The torque converter clutch (TCC) is applied to eliminate the slippage during the coupling phase, which improves fuel economy. When the TCC applies, the converter locks up, connecting the transmission input shaft directly to the engine, much like a vehicle with a manual transmission and clutch.

The torque converter clutch (TCC) is PCM controlled. The PCM determines when the TCC is to be applied based on sensor information, such as throttle position (TP), engine load (MAP), and engine temperature. The TCC can applied in almost any gear, depending on the transmission/transaxle design, and can be monitored using a scan tool. Figure 10.

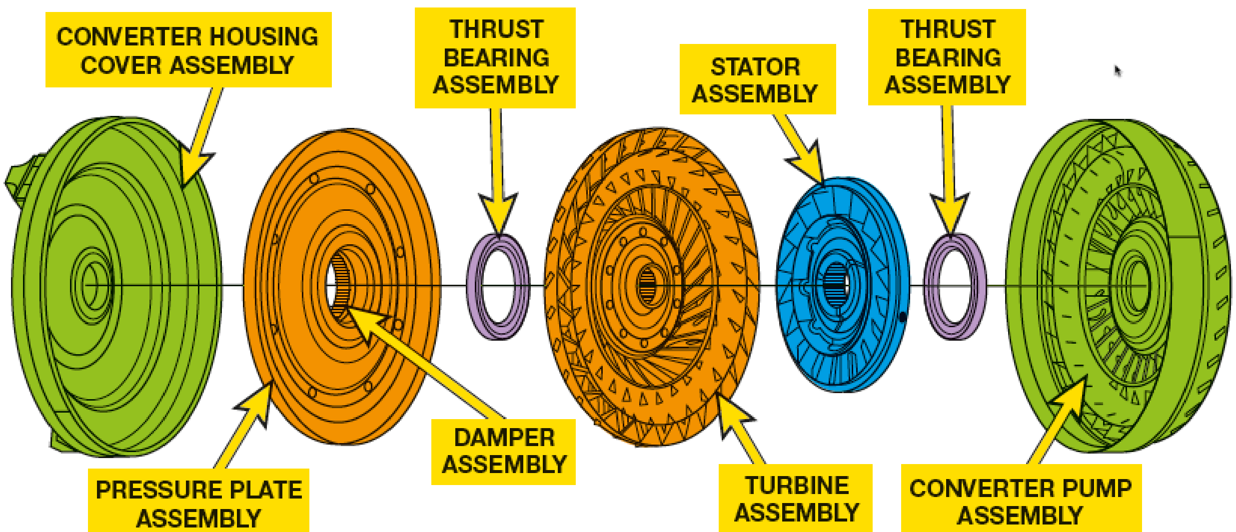

Figure 10. Torque converter and torque converter clutch (pressure plate).

7. Diagnose mechanical/hydraulic systems using appropriate test equipment, service information, technical service bulletins, flow charts, and hydraulic diagrams.

The most comprehensive and accurate service information is the service information from the vehicle manufacturer. The manufacturer provides this information in a digital format.

A technical service bulletin (TSB) is issued by the vehicle manufacturer to notify service technicians of a potential problem or other critical information. The TSB may include diagnostic procedures and the necessary corrective action.

Manufacturers provide hydraulic schematics/fluid diagrams of the fluid passages and valves. This example shows the pump and line pressure lines. Figure 11.

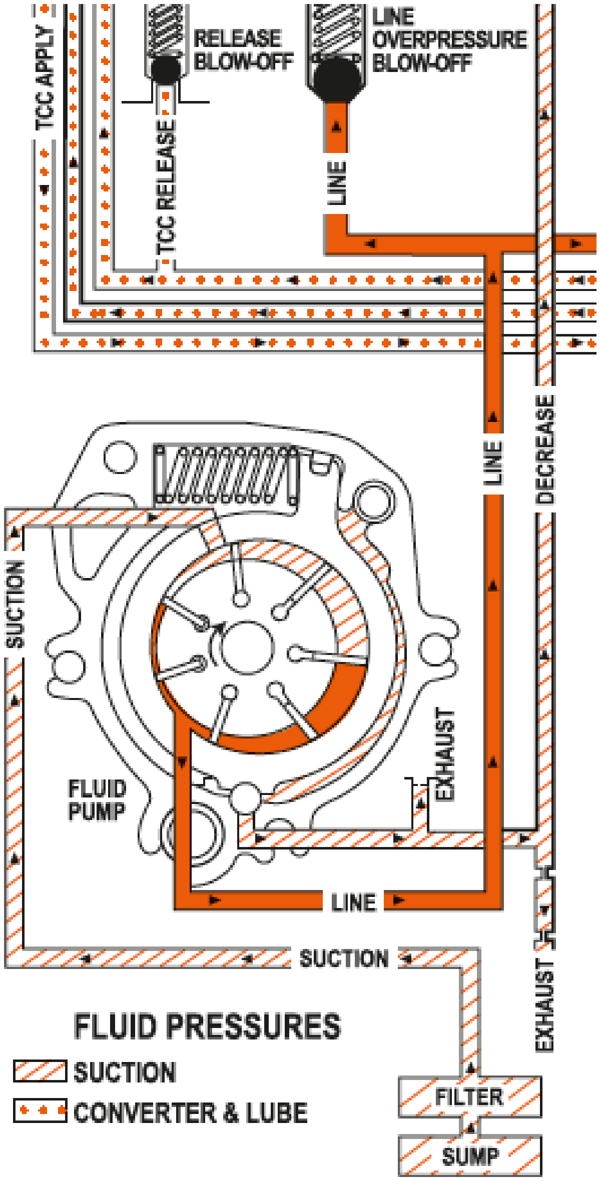

Figure 11. A hydraulic schematic/fluid diagram (sample).

8. Identify transmission type including torque converter automatic, dual-clutch automatic (DCT), CVT, and Hybrid/EV drive.

A dual clutch automatic transmission/transaxle uses two clutches that are mounted together. One clutch drives the odd number gears (first, third, fifth, and seventh). The other clutch drives the even number gears (second, fourth, and sixth).

The shifts occur without interrupting the torque from the engine by applying torque to the clutch while at the same time disconnecting the other clutch. Each successive gear is pre-selected by servos that engage the shift the synchronizers prior to engaging the clutch. Figure 12.

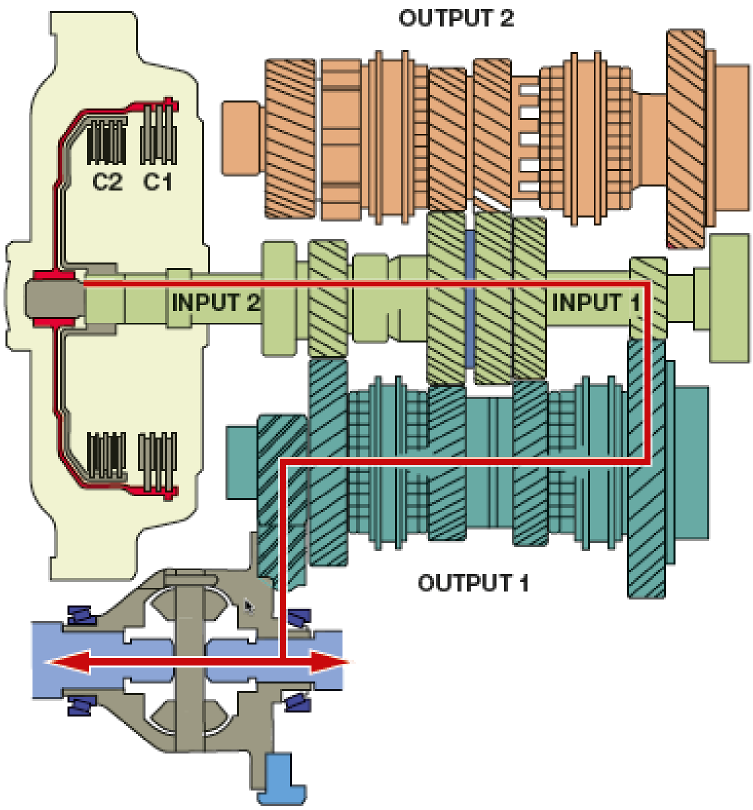

Figure 12. A dual clutch transmission, showing power flow in first gear, clutch 1 (C1) engaged.

HEV transmissions are different based on the level of the hybrid vehicle in which they are installed. A mild hybrid with stop–start system typically contains a transmission with a single electric motor. A full hybrid generally contains a transmission with two electric motors. Figure 13

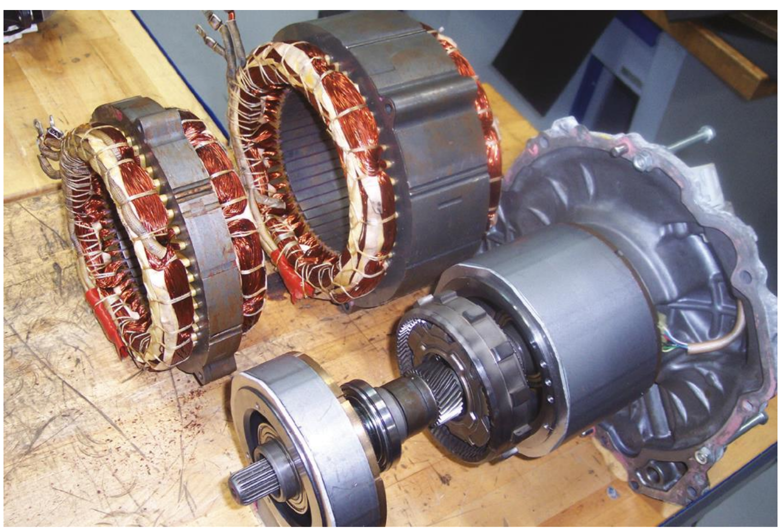

Figure 13. Hybrid vehicle transmission.

In order to adapt a conventional automatic transmission to a hybrid powertrain, an electric auxiliary pump is used to maintain fluid pressure in the transmission during ICE idle-stop. Some vehicles use a hydraulic impulse storage accumulator to provide fluid pressure as the ICE restarts after the idle-stop mode. Figure 14.

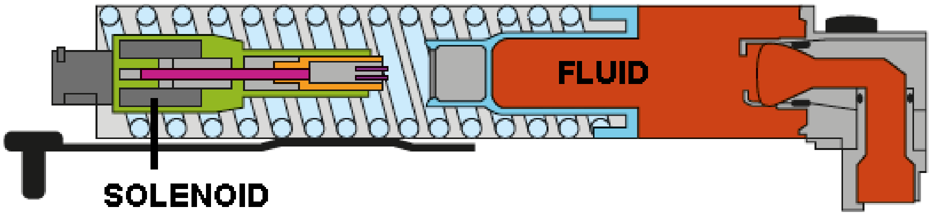

Figure 14. Storage accumulator. The solenoid is de-energized when fluid pressure is needed.

Currently, 5-, 6-, 7-, 8-, and 10-speed automatic transmissions are becoming common. With more emphasis being placed on fuel economy and lower emissions, the continuously variable transmission (CVT) is becoming more popular as it provides infinite gear ratios and the best opportunity to maximize engine efficiency.

A continuously variable transmission (CVT) is usually found on some front-wheel-drive vehicles that use a transaxle. A CVT varies the gear ratio in a continuous manner instead of in a series of steps or fixed gear ratios. The power flow is through a steel belt between two pulleys that change their width and effective diameter. As the speed increases, the diameter of the driving pulley increases as the sides of the pulley move together. While this happens, the driven pulley is made wider. Figure 15.

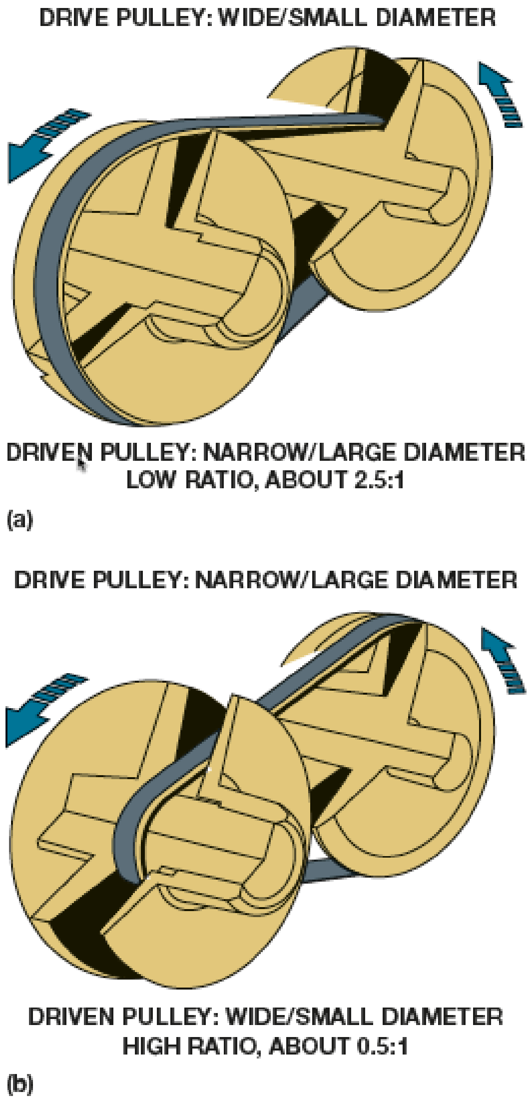

Figure 15. Principle of a CVT transmission.

Most all-electric vehicles are equipped with just a single speed transmission/transaxle yet are capable of delivering outstanding performance and acceptable range with motor torque of up to 230 lb-ft (315 Nm) and peak power of 188 HP (140 kW). Figure 16.

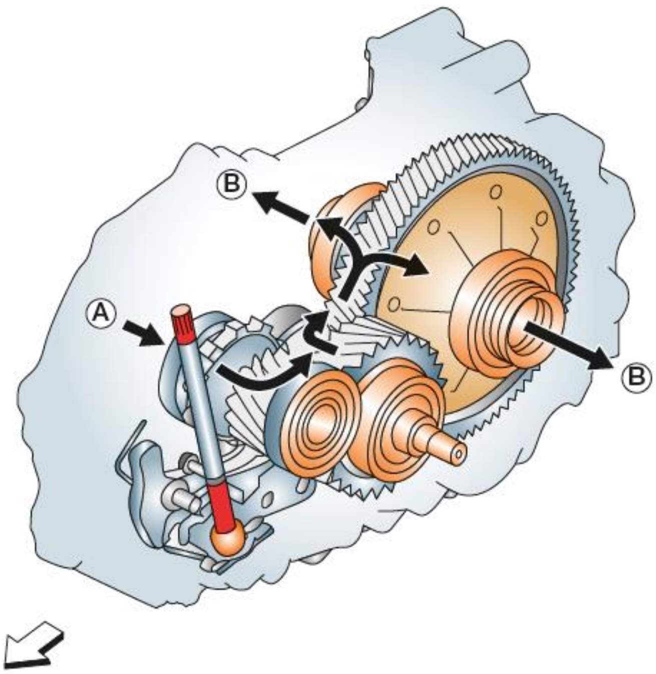

Figure 16. An electric vehicle one-speed transmission.

9. Diagnose the auxiliary transmission fluid pump(s) and/or pressure accumulator found in stop/start (idle stop)-adapted automatic transmissions.

Many newer non-hybrid vehicles are equipped with a stop-start system. In these vehicles, the engine stops running when the vehicle is stopped and restarts when the driver releases the brake. When the engine stops, the hydraulic pump inside the transmission/transaxle also stops and pressure would drop preventing the clutches from holding. Some automatic transmissions/transaxles use an auxiliary electric driven pump to maintain line pressure when the engine stops during a stop-start event. Figure 17.

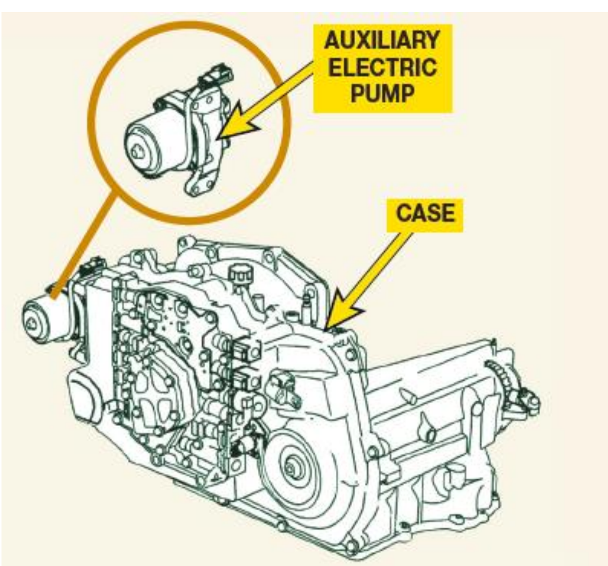

Figure 17. Auxiliary pump maintains fluid pressure during engine-stop.

A2 Electronic Systems

1. Road test the vehicle to verify electronic system problems based on driver's concern; research vehicle service history.

A road test is used to verify the customer's concern and check the general overall condition of the transmission. The vehicle should be road tested at the start of the diagnosis and after the repair. A road test may involve simply driving the vehicle and mentally reviewing the transmission operation.

A scan tool is used during the test drive to check for the proper voltage and current of the shift solenoids. Figure 18.

Figure 18. Scan tool.

Observe the operation of the command for the shift solenoids and the TCC solenoid while driving the vehicle. This information confirms that the PCM is commanding the operation, and it does not mean that the solenoids are working correctly. Therefore, if the scan data indicate that a particular solenoid is being commanded on and nothing occurs, then the problem could be caused by a defect with the following:

- Hydraulic component (clutch, band, etc.)
- Solenoid
- Fault in the wiring to the solenoid or from the solenoid to the PCM or TCM

2. Diagnose pressure concerns on transmissions equipped with electronic pressure control.

The transmission's hydraulic pump pressure regulator valve is controlled by the pressure regulator valve that is controlled by a pulse-width-modulated (PWM) solenoid, called an electronic pressure control (EPC) solenoid. The pressure control valve is normally closed, which results in high regulated pressure. Current (a maximum of about 1 ampere) energizes the solenoid, which reduces the regulated pressure. EPC current can be monitored using a scan tool. Figure 19.

- The higher the pulse width, the more current and the lower the pressure.
- The lower the pulse width, the less the current and the higher the pressure.

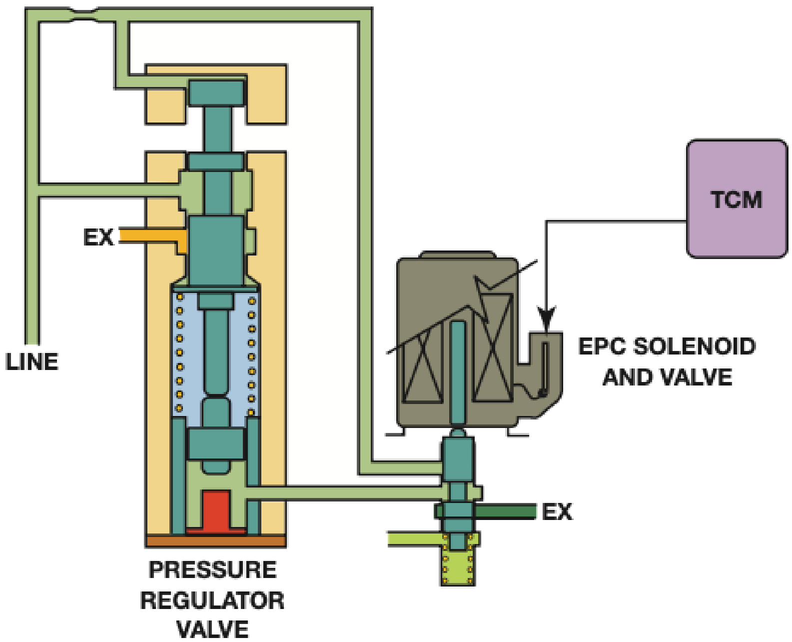

Figure 19. Line pressure is controlled by the EPC solenoid.

3. Perform torque converter clutch (lock-up converter) electronic system tests.

A scan tool can display information about the various sensors and components that can assist the service technician in determining the cause of many automatic transmission/transaxle problems. Observe the operation of the command for the shift solenoids and the TCC solenoid while driving the vehicle. The scan tool can also be used to command the TCC on or off for testing.

4. Diagnose electronic transmission control systems using appropriate test equipment, service information, technical service bulletins, and schematics; diagnose problems in electrical/electronic circuits (including data communications).

A digital voltmeter (DVM) measures the pressure or potential of electricity in units of volts. A voltmeter is connected to a circuit in parallel. Voltage can be measured by selecting either AC or DC volts. The DC volts (DCV) setting is the most common for automotive testing. Use this setting to measure battery voltage and voltage to all lighting and accessory circuits. Figure 20.

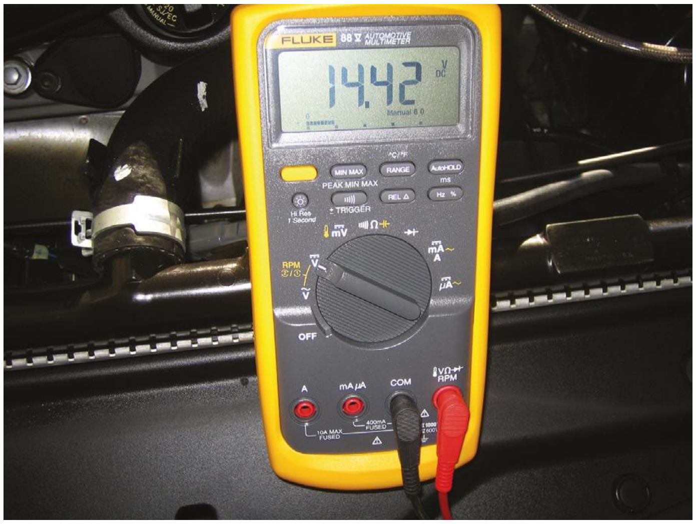

Figure 20. A digital voltmeter measuring battery voltage.

After checking for stored diagnostic trouble codes (DTCs), refer to service information for any technical service bulletins (TSBs) that may relate to the vehicle being serviced. DTCs must be known before searching for service bulletins, because bulletins often include information on solving problems that involve a stored diagnostic trouble code.

Since the 1990s, vehicles have used modules to control the operation of most electrical components. A typical vehicle will have 10 or more modules, and they communicate with each other over data lines or hard wiring, depending on the application. Faults in these systems can cause transmission concerns. Figure 22.

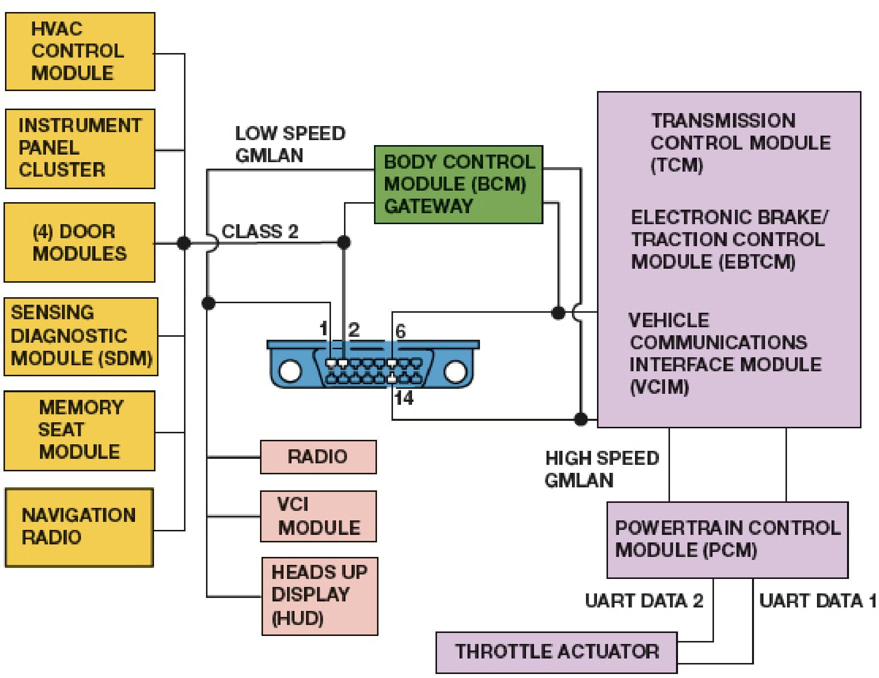

Figure 22. A typical network system shows the transmission control module (TCM)communicates with the PCM over the high speed GMLAN bus.

5. Verify proper operation of charging system; check battery(s) (type, size, ratings), sensors, connections, and power/ground circuits.

Charging system voltage tests should be performed on a vehicle with a battery at least 75% charged. If the battery is discharged (or defective), the charging voltage may be below specifications. To measure charging system voltage, a scan tool or digital voltmeter can be used.

- Connect the voltmeter or scan tool.
- Set the meter to read DC volts or set the scan tool to engine data.
- Start the engine and raise to a fast idle (about 2,000 RPM).
- Read the voltmeter or scan tool and compare with specifications.
- This voltage should be between 13.5 and 15.0 volts (or within manufacturer's specifications).

An electronic system cannot function without adequate power or a good ground. The power and ground connections are often overlooked. After determining there is a problem in the electronic system, check B+ voltage at the battery and then at the TCM and transmission power relay if there is one. There should be at least 12.6 volts with the engine off and 13.6 to 15 volts with the engine running. Figure 21.

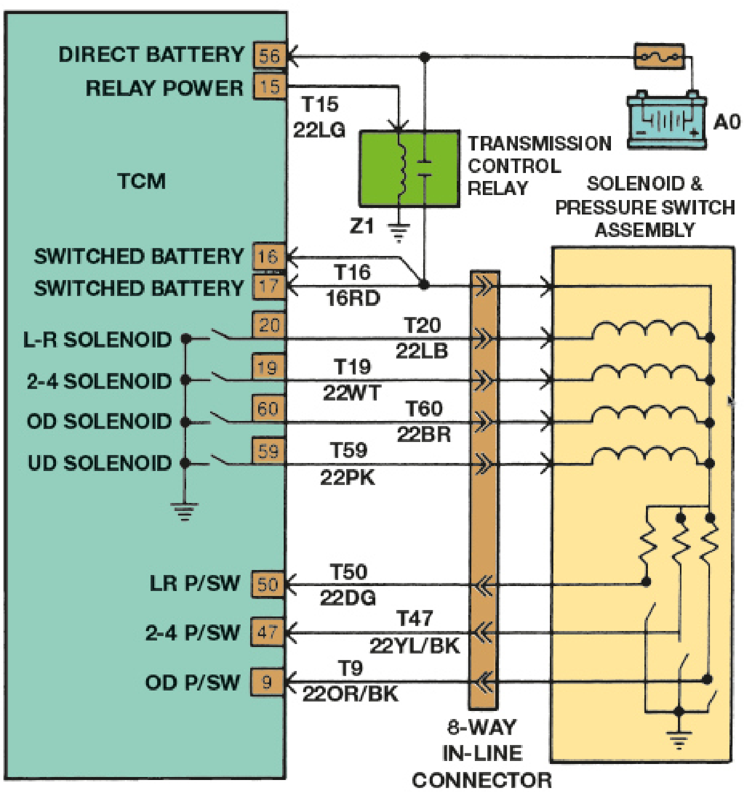

Figure 21. TCM terminals 16 and 17 receive B+ when the transmission relay is energized.

6. Differentiate between engine performance, powertrain, transfer case, or other vehicle systems, and transmission/transaxle-related problems.

At times, concerns about transmission operation mat be caused by other vehicle components.

- Check for obvious faults such as damaged or worn driveshafts or U-joints.
- Check for evidence of recent transmission or drivetrain service work.
- Check the body and frame for evidence of a collision or recent collision repairs.
- Perform a road test and listen for noise changes as the transmission shifts through the gear ranges. A transmission gear set problem is indicated if the noise changes depending on the gear range.
- Engine-speed-related vibrations occur during particular engine speed ranges and these vibrations change when the transmission shifts gears. There are several causes leading to this, for example, belt-driven accessories such as the fan, alternator, air-conditioning compressor, or internal engine unbalance.

7. Diagnose shift quality concerns resulting from problems in the electronic transmission control system.

8. Use scan tool data, bidirectional controls, and/or diagnostic trouble codes (DTCs) to diagnose electronic systems.

During diagnosis the technician can command shifts electrically by providing the proper electrical signal to operate the solenoids using a factory level scan tool and then observe the operation of the shift solenoids and the TCC solenoid while driving the vehicle.

One of the roles of the powertrain control module (PCM) and/or the transmission control module (TCM) is to monitor transmission operation and determine if malfunctions may be occurring. The PCM/TCM will run frequent self-tests of the electrical circuitry and will also analyze the sensor data to look for transmission slippage, overheating, or other problems. When a problem has been detected, the PCM will generate a diagnostic trouble code (DTC) and may also place the transmission in limp-home mode, depending on what sort of problem has been detected. Figure 22.

P0765	Shift solenoid D problem
P0766	Shift solenoid D performance or stuck off
P0767	Shift solenoid D stuck on
P0768	Shift solenoid D electrical
P0770	Shift solenoid E problem
P0771	Shift solenoid E performance or stuck off
P0772	Shift solenoid E stuck on
P0773	Shift solenoid E electrical

Figure 22. Some examples of DTCs generated by the PCM related to solenoid faults.

9. Connect diagnostic scan tool to vehicle; access, verify, and update software calibration settings and solenoid/valve body calibration codes; perform control module re-learn and adaptation (basic settings) procedures as needed.

Flashing a module is the updating of the programming of an electronic control module such as the PCM or TCM to solve an issue or customer concern. Flashing a PCM/TCM, also called programming, reprogramming, and calibrating, can be done to correct possible software problems.

Adaptive learning keeps shift duration within a certain time period as determined by the driver's habits. Transmissions use input and output speed sensors, allowing the TCM to determine the gear ratio and how long it takes to make the shift. Some manufacturers refer to the adaptive control as the clutch volume index (CVI), which is the length of time it takes to fill the clutches with fluid.

For an electronic transmission/transaxle to operate correctly, a "fast learn" or a "quick learn" should be performed with a scan tool before the vehicle is driven. This action will get the adaptive settings close to what they should be and will help prevent damage to the unit if this procedure is not done.

One example of the process:

- Use a scan tool capable of performing the fast-learn procedure.
- Select the fast learn or "Adapts (clear)" process from the scan tool menu. Figure 23.
- Place the transmission in "drive" with the vehicle stationary. The TCM will individually apply the clutches and calculate the clutch volume index.
- Place the transmission in "reverse" with the vehicle stationary. The TCM will individually apply the clutches and calculate the clutch volume index.
- Shut off the engine for at least 30 seconds.

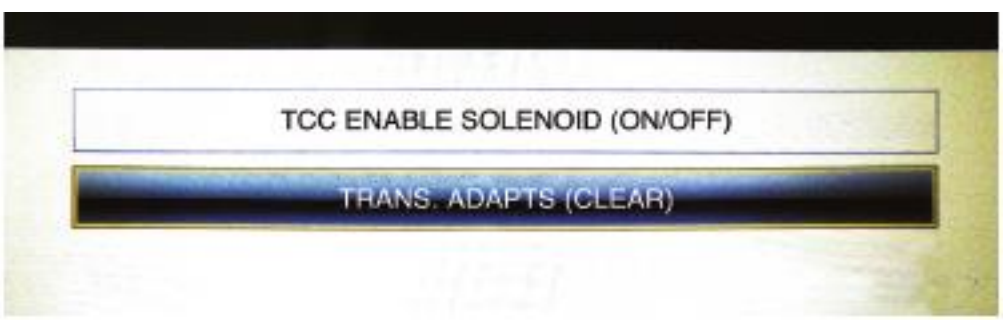

Figure 23. Clearing the adaptive settings.