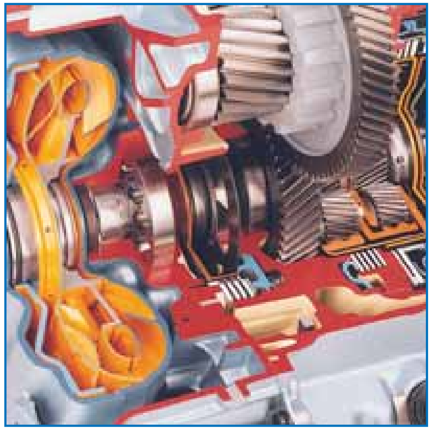


Chapter 14

Troubleshooting Electronic Control System Problems

After studying this chapter, you will be able to:

- ❑ Determine the exact nature of an electronic transmission/transaxle complaint.
- ❑ Determine whether the problem is in the electronic control system.
- ❑ Make visual checks for problems.
- ❑ Retrieve trouble codes and match codes to problem areas.
- ❑ Use scan tools and other test equipment to locate problem areas.
- ❑ Use test equipment to test individual components.
- ❑ Determine repair steps necessary to correct electronic transmission/transaxle defects.

Technical Terms

Pattern failures	Trouble codes
Limp-in mode	Snapshots
Gear skipping	Freeze frames
OBD I	Testing by substitution
OBD II	Zirconia-type oxygen sensor
Scan tool	Titania-type oxygen sensor

Introduction

To diagnose problems on electronically controlled transmissions and transaxles, the technician must be able to proceed logically, without randomly replacing expensive parts. This chapter covers the logical processes that must be used to diagnose electronic control systems. It also covers diagnosis of electronically controlled automatic transmission and transaxle components. Information on trouble code retrieval and other uses of scan tools is also presented.

Electronic Transmission and Transaxle Problems

Many of the problems that occur in an electronically controlled transmission or transaxle are the same as those that occur in hydraulically controlled transmissions. Other problems are unique to the electronic control system. The following section covers common electronic control system problems. **Figure 14-1** shows the possible sources of electronic control system problems in a modern transaxle.

Many computer control system problems are called ***pattern failures.*** A pattern failure is a problem that is common to a certain type of vehicle. The experienced technician will learn to spot pattern failures and quickly determine the defective part. The chart in **Figure 14-2** shows some common electronic control system failures that occur in one manufacturer's automatic transmissions and transaxles.

Limp-In Mode

If a major problem occurs in the computer control system, the ECM will place the system in ***limp-in mode.*** When the system is in the limp-in mode, the ECM ignores most input sensor readings and operates the engine and drive train output devices based on internal settings. The transmission or transaxle solenoids are energized in a way that gives the unit only one or two forward gears. Whenever the system goes into limp-in mode, the ECM it will illuminate the dashboard maintenance indicator light, or MIL. On older vehicles, the MIL is called the *service engine soon* light. An illuminated MIL is always an indication that the computer control system has a problem and that trouble codes should be retrieved.

Input Sensor Problems

In many cases, the transmission or transaxle reacts to problems in various vehicle sensors. Some sensors are located on the valve body, **Figure 14-3.** Other sensors are primarily monitor engine operation and are installed on the engine.

Faulty input sensors are the most common cause of electronic transmission or transaxle problems. A defective throttle position sensor (TPS) can cause improper shifting or erratic application of the converter lockup clutch. A failed TPS can also cause rough upshifts or a bump on closed throttle downshifts.

Speed sensors can cause problems by sending incorrect engine or output shaft information to the ECM. This usually affects shift speeds. A speed sensor located inside the case can collect metal filings that affect the signal. Some metal particles are produced as part of normal

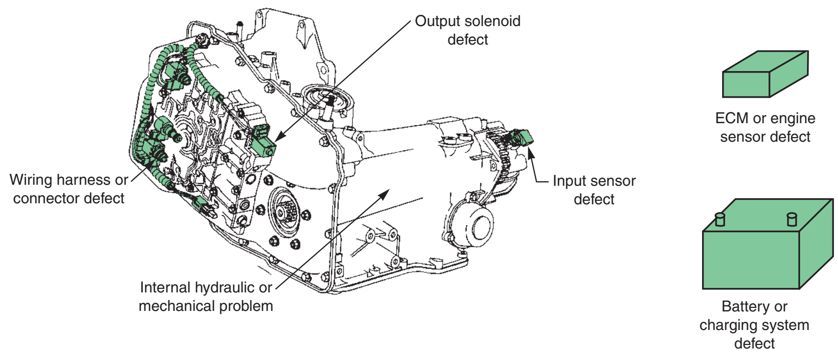


Figure 14-1. *Possible trouble spots on an electronically controlled transaxle. Remember that conventional problems, such as worn clutches or internal leaks, are just as likely as electronic component failure. (General Motors)*

Electronic Component Malfunctions	
Component/system	**Can affect**
Throttle position (TP) sensor	• Shift pattern (erratic) • Shift quality (firm or soft) • Engine (rough)
Automatic transmission output shaft speed (AT OSS) sensor	• Shift pattern (erratic) • TCC solenoid valve apply (at wrong time) • Shift quality (harsh or soft)
Transmission fluid pressure (TFP) manual valve position switch	• TCC solenoid valve apply (no apply if diagnostic code is set) • Shift pattern (no fourth gear in hot mode) • Shift quality (harsh) • Line pressure (high) • Manual downshift (erratic)
Automatic transmission fluid temperature (TFT) sensor	• TCC solenoid valve control (on or off) • Shift quality (harsh or soft)
Engine coolant temperature (ECT) sensor	• TCC solenoid valve control (no apply) • Shift quality (harsh)
Shift solenoid valves	• Gear application (wrong gear, only two gears, no shift)
Brake switch	• TCC apply (no apply) • No 4th gear if in hot mode
System voltage	• Line pressure (high) • Gear application (third gear only) • TCC control (no apply) • No 4th gear if in hot mode
3-2 control shift solenoid valve assembly	• Gear application (third gear only) • 3-2 downshifts (flare or tie-up)
Pressure control solenoid	• Line pressure (high or low) • Shift quality (harsh or soft)
TCC solenoid valve	• TCC solenoid valve apply (no apply) • No 4th gear if in hot mode
Cruise control	• Delays 3-4 upshift and TCC apply during heavy throttle
Acceleration slip regulation (ASR)	• Downshifts

Figure 14-2. *A manufacturer's list of possible problems for one electronic transmission. Symptoms will vary from one manufacturer to another, as well as from one type of transmission or transaxle to another. (General Motors)*

operation, and they often become stuck on the sensor magnet, affecting the production of the magnetic field. Wheel-mounted speed sensors can be damaged by road debris, or they can become coated with road tar.

Temperature sensors that are defective or produce out-of-range signals can cause hard or soft shifts. Some defective temperature sensors can keep the transmission from upshifting or prevent converter clutch apply. A common cause of engine temperature sensor problems is cooling system deposits that coat the sensor element. This causes the sensor to respond slowly or not at all to temperature changes.

Other sensors can indirectly affect shift speeds and shift quality. Most defects in engine sensors will show up first as engine-related problems. Defective pressure or temperature switches in the transmission or transaxle will usually not cause engine problems.

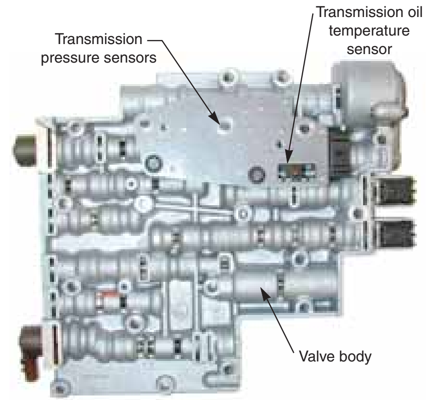


Figure 14-3. *Most transmission sensors are located inside the case, usually on the valve body. On this particular valve body, all the pressure sensors and the temperature sensor are installed in a plate. The plate is then attached to the valve body. Also note the pressure control solenoids on the outside edges of the valve body. (Sonnax)*

A loss of voltage to a sensor (usually called reference voltage) will result in an inoperative sensor. Reference voltage problems are usually caused by a defective ECM or a ground problem.

Solenoid Problems

Solenoid problems will vary depending on whether the solenoid is an on-off type or a pulsed type. On-off solenoids can stick open or closed. The usual result is the loss of some gears. In many cases, the transmission or transaxle will take off from a stop in a gear other than first. Other solenoid failures can cause ***gear skipping*** (shifting from first to third, for example), failure to shift into higher gears, or incorrect application of the converter lockup clutch. Occasionally, a solenoid will stick at times and work properly at other times. Typical causes of intermittent sticking include a high-resistance solenoid winding, a bad electrical connection, or buildup of sludge. Erratic shifting is a common symptom of an intermittently sticking solenoid. The transmission or transaxle may work well most of the time, with only occasional shift problems. In some cases, the transmission will shift improperly only when cold or only when hot.

Pulsed solenoids are generally used to control pressures. Therefore, instead of skipping gears, a failed pulsed solenoid can cause slipping or excessively hard or soft shifts. A defective line pressure solenoid will cause problems in any or all gears. Many pulsed solenoids control pressures of a specific operation, such as converter clutch apply feel or part throttle downshift. Defects in the related solenoid will cause problems during that process only.

Almost every solenoid has one or more small filters, **Figure 14-4.** If the filter becomes plugged, oil pressure will not be able to pass through the solenoid valve to the rest of the hydraulic system. Additionally, a torn filter can cause the solenoid to stick.

ECM Problems

Since it contains many complex circuits, a faulty ECM can cause a variety of problems, depending on which internal part or circuit has failed. Sometimes, the ECM will keep the transmission or transaxle from shifting. A defective ECM may cause the unit to stick in one gear. Another common ECM problem is erratic shifting. Examples include downshifting at cruising speeds or occasionally failing to upshift. The operation of the ECM is often affected by heat. A cold ECM may work well when the vehicle is first driven but cause problems as it heats up.

A defective ECM can hang up, or stick in one mode. Turning the ignition switch off and then back on may temporarily correct the problem. If the ECM controls pressures through a pulsed solenoid, failure may cause slipping, hard shifting, shudder during shifts, and other problems. In many cases, a failed ECM will also cause engine drivability problems.

A defective ECM can set false trouble codes and may sometimes set codes that do not exist. A failed ECM may illuminate the MIL when there is no problem, or it may fail to illuminate the MIL when a problem is present.

Figure 14-4. *The valves of a solenoid are machined to extremely small clearances and cannot tolerate the presence of even the smallest particle of dirt or metal. Most transmission solenoids are equipped with small filters to reduce the possibility of contamination. These filters can plug up, especially if other transmission or transaxle parts have failed.*

Wiring and Connector Problems

The voltages used to operate the sensors are usually much lower than battery voltage. Therefore, any wire damage or corrosion at the connectors greatly affects the sensor inputs to the ECM. Note that even slight resistance can cause incorrect sensor inputs, leading to improper or erratic shift points. A commonly overlooked wiring problem is a corroded ground connection or disconnected ground wires. Remember that the return path for the current is as important as the input path. Resistance through a ground circuit can affect several transmission control loops at once. Therefore, when a transmission/transaxle control system seems to have several unrelated or intermittent problems, look for a poor ground.

Another common wiring problem is a wire that has been chafed or broken by movement. This commonly occurs where wires must pass through confined spaces or small openings in the body or other sheet metal parts. Manufacturers often place electrical connectors near or under the vehicle's battery. The battery acid and hydrogen gas often cause corrosion inside the connector. Another common problem is a wire that is allowed to touch an exhaust system part. The insulation melts and the wire grounds against the exhaust component.

Battery Voltage and Computer System Operation

The voltage input to the computer control system must be at or near battery voltage (12.6 volts). Defects in the charging system or battery can pull voltage below 12 volts. Low voltage can confuse the ECM, causing computer control system problems. In many cases, the voltage will be only slightly below normal. Slightly low voltage will cause computer control system problems but not starting problems. Typical results of low voltage include intermittent engine and/or drive train problems, or an engine or drive train problem that cannot be isolated to a specific system or component. If any of the above situations occur, check the battery and charging system before performing further troubleshooting procedures. Begin by checking the tension and condition of the alternator drive belt, **Figure 14-5.** Also, check the belt pulley for wear or damage. If the drive belt is tight and appears to be in good condition, check the charging rate and battery condition using an electrical system tester, **Figure 14-6.**

The Seven-Step Troubleshooting Process

The seven-step troubleshooting process was discussed in Chapter 13. This process can be used to

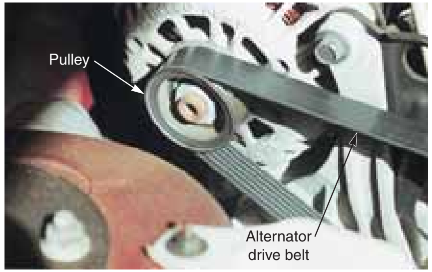


Figure 14-5. *Worn and slipping alternator drive belts are the source of many computer control system complaints. Inspect the belt for a glazed or cracked surface and for proper tension. Also check the alternator drive pulley for wear.*

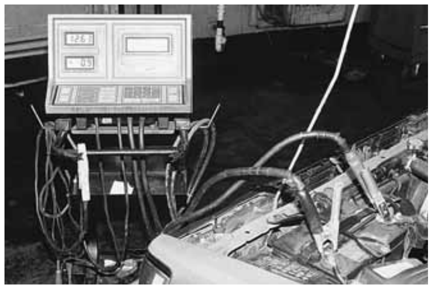


Figure 14-6. *Using an electrical system tester to conduct a battery load test. This unit will perform the test automatically.*

diagnose electronic transmissions and transaxles, as well as hydraulic models. The seven steps are as follows:

Step 1. Verify the problem—Interview the driver and make a road test to determine the exact problem.

Step 2. Check for obvious causes—Check for obvious faults, such as disconnected wires or misadjusted linkage.

Step 3. Determine which component or system is the most probable cause of the problem—Combine your knowledge and what you have learned in the previous steps to make a preliminary diagnosis of the problem.

Step 4. Perform pinpoint tests—Check all systems and components, eliminating them as possibilities.

Step 5. Check for related problems—Repeat test procedures, or perform new tests, to make sure that the problem identified in step 4 is the root cause of the problem.

Step 6. Correct the defect—Repair or replace the defective components as necessary.

Step 7. Recheck system operation—Road test the vehicle to make sure that the problem has been corrected and that no trouble codes have reappeared.

If necessary, review the detailed explanation of the seven-step process in Chapter 13. Remember that on modern vehicles, almost all systems are interconnected and affect each other.

Is the Trouble in the Electronic Control System?

Electronically controlled transmissions and transaxles may have problems caused by the mechanical and hydraulic components. Slipping and erratic shifting are as likely to be caused by hardened or damaged seals or burned holding members as by defects in the electronic control system components.

To isolate the problem to the mechanical, hydraulic, or electronic components, you must conduct some of the same tests used when checking hydraulic systems and components. Always begin any test procedure by removing the dipstick and checking fluid level and condition. As with a hydraulically controlled transmission or transaxle, this may give you all the information you need to diagnose a problem. Also check the manual linkage for looseness and proper positioning. On a few electronic transmissions, some of the shifts are hydraulically controlled. On these transmissions, check the adjustment and condition of the throttle linkage, and check governor operation.

When you perform a road test, note the condition of the engine and other vehicle systems, as well as the operation of the transmission or transaxle. A miss, surge, hesitation, or other problem may be mistaken for a defect in the transmission or transaxle. Engine missing and lockup torque converter shudder are often confused. Occasionally noises or roughness in the suspension may be blamed on the drive train.

If the preliminary checks lead you to believe that the problem is in the electronic control system, proceed with the diagnostic procedures outlined below.

Basic Electrical Checks

Before performing complex electronic tests, make some basic electrical checks. Begin by ensuring that the system fuses are not blown. Note that there may be more than one fuse protecting the system.

Note: Do not remove any fuses until you have retrieved trouble codes from the ECM.

Next, make a careful inspection for burned, chafed, and disconnected wires. In some cases, the wiring harness wrapping may have to be pulled back to expose damaged wires. Be sure to look carefully for burned insulation at any fusible link, **Figure 14-7.** Pull on the link to determine whether the wire has broken internally. Fusible links are usually located at the battery positive terminal, a nearby power relay, or the starter solenoid.

Check all vehicle ground wires. See **Figure 14-8.** On many vehicles, several ground wires are attached to one of the bolts on the engine thermostat housing. Slight coolant leaks can cause these wires to corrode. Often, the ground wires are removed during cooling system service and never reattached.

OBD II Computer Control Systems

Early computer control systems were designed to monitor the operation of computer system parts, such as

Figure 14-7. *Fusible links may be installed at the starter's positive terminal. A melted fusible link is sometimes hard to spot, since fusible links often melt open without damaging the insulation. Always tug at the fusible link to make sure it has not opened internally.*

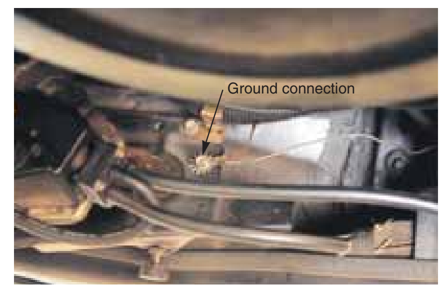


Figure 14-8. *Bad grounds are a common source of trouble. Always check grounds by visual inspection and by pulling on the connections. Also try to tighten the attaching bolt when applicable.*

sensors and output devices. If one of these parts failed, the ECM received an out-of-range electrical reading. The ECM would then set one or more trouble codes and turn on the dashboard-mounted warning light. These early systems are called on-board diagnostics, generation I, or ***OBD I,*** systems. OBD I was replaced in 1995-96 by an updated system called ***OBD II*** (on-board diagnostics, generation II) systems**.** The ECM in OBD II systems still detects failed parts, but it also monitors air-fuel ratio changes, engine misfires, temperature changes, and other operating conditions. From these inputs, the ECM can determine that a part is about to fail, or that excessive emissions will be produced in the near future. The ECM will then set one or more trouble codes and turn on the maintenance indicator light (MIL) in the dashboard. OBD I systems react to a problem that is already causing high emission or loss of performance. OBD II systems have the ability to catch potential problems *before* they begin to cause high emission or loss of performance. To accomplish this, the OBD II system has a misfire monitor, an extra oxygen sensor after the converter, and an evaporative emissions monitor.

Using Scan Tools

If the basic electrical tests do not reveal a problem, the next step is to check the unit using a ***scan tool***. The scan tool is a hand-held electronic device used to retrieve ***trouble codes*** and perform other diagnostic procedures. **Figure 14-9** shows a typical scan tool. The scan tool can be thought of as a portable computer that can communicate with the vehicle's on-board computer. While they are expensive, scan tools are becoming common because they save diagnostic time and reduce the chance of misdiagnosis. The scan tool also allows the technician to obtain information directly from the ECM. This information would not be available by any other means. Additionally, many scan tools can be used to reprogram the vehicle's computer.

Figure 14-9. *Scan tools can be used to retrieve trouble codes and obtain other information about the operation of an electronic transmission or transaxle.*

Caution: On OBD II–equipped vehicles, the proper scan tool *must* be used to retrieve trouble codes. Never attempt to retrieve trouble codes from an OBD II system by grounding one of the diagnostic connector terminals. Grounding any terminal will damage the ECM.

The scan tool must be connected to the system through the diagnostic connector. Always locate the proper diagnostic connector. On OBD II vehicles, a 16-pin connector called the data link connector (DLC) is used to access all vehicle computer systems. On older (non-OBD II) vehicles, there may be separate diagnostic connectors for the engine, drive train, anti-lock brakes, air conditioning, and suspension.

The power of the modern scan tool increases the amount of information available to the technician. Unfortunately, it also makes it easier to misinterpret the information. For instance, with hundreds of potential trouble codes, it is easy to look up the wrong code. Sometimes the amount of available scan tool information can cause the technician to miss the actual cause of a problem. For example, if the technician concentrates on differences in input and output shaft speeds in all gears (information that is available on modern scan tools), he or she may not notice that the torque converter clutch is not engaging. Much time could be wasted looking for slipping holding members when the actual problem is a defective converter control system.

For this reason, you must carefully interpret all trouble codes and other scan tool information before proceeding with diagnosis and repair.

Trouble Codes

OBD I computer systems have a two-digit trouble code system. The two-digit system limits the number of trouble codes to 100. OBD II systems use 5-character alphanumeric codes. Each code contains a letter and a four-digit number. See **Figure 14-10.** The letter identifies the general system causing the problem. The letter codes cover the three major vehicle subdivisions. They are B (body), C (chassis), P (power train), and U (internal computer communications network). The first number indicates whether the code is a standard code, which is assigned by SAE, or a non-uniform code, which is assigned by the vehicle manufacturer. The second number indicates the specific system in which the problem is occurring, and the final two numbers indicate which devices or circuits are causing the problem.

There are 8,000 possible OBD II codes. While all this capacity is not presently being used, a modern vehicle ECM may be programmed with several hundred trouble codes. **Figure 14-11** is a list of some current OBD II transmission trouble codes.

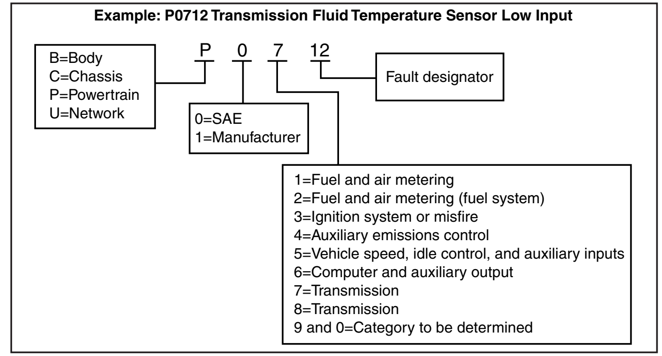


Figure 14-10. *Typical OBD II trouble code. This particular code indicates a low input signal to the transmission fluid temperature sensor.*

Other Scan Tool Functions

In addition to retrieving trouble codes, the scan tool can be used to retrieve other information from the vehicle computer. This information may include speeds at which shifts occur, converter clutch application speed, current gear, and transmission/transaxle temperatures and pressures. Some scan tools also display the desired gear for the particular engine and vehicle speed. This allows the technician to instantly determine whether the transmission is in the proper gear. Other scan tool readings give input and output shaft rpm, which can be used by the technician to diagnose slippage in a particular gear. **Figure 14-12** shows transmission-related data that can be obtained using a scan tool.

Other conditions that can be monitored by the scan tool include engine RPM and temperature, sensor inputs, vehicle speed, and outside air temperature. In OBD II systems, scan tools can also tell the technician whether or not there is an engine miss, and if so, which cylinder is causing the problem.

Some scan tools can interface with the ECU to provide ***snapshots,*** or ***freeze frames,*** of engine and transmission operation. The snapshot is a scan tool feature that records vehicle operating conditions immediately before and after a malfunction occurs. This information helps the technician determine exactly what happened to cause the problem. To record the snapshot information, the technician must drive the vehicle with the scan tool attached until the malfunction occurs. The technician can then access the readings through the scan tool. Some vehicle ECMs save snapshot information when a malfunction occurs during normal operation. The technician can retrieve this information using the scan tool. **Figure 14-13** shows typical snapshot information captured during one particular malfunction.

Scan tools can also be used to test output solenoids by bypassing the ECM and commanding the solenoids to operate. One of the most useful ways a scan tool can be used is during a road test. Attach the scan tool to the vehicle's diagnostic connector and observe readings as you drive the vehicle. Information on shift speeds, shift quality, slippage, and other data can be observed under actual driving conditions. The scan tool can be connected and then placed on the dashboard or seat for road testing.

The safest method of performing a road test while using a scan tool is to have someone else drive while you check the scan tool readings. Always use lightly traveled roads during the road test, and be alert for other drivers, traffic signals, and road conditions. The scan tool will display readings similar to those shown in **Figure 14-14.** These readings can be compared with actual transmission or transaxle operation as the malfunction occurs. This helps determine whether the problem is in the computer control system or another system. Actual scan tool displays vary widely. Scan tool instructions should be followed exactly to ensure that you obtain the proper readings.

Checking System and Component Operation

Once you have isolated the problem using the scan tool, you can proceed to test individual systems and components as outlined in the following sections.

Test Equipment

To test electronic components, you will need some or all of the following testers. This test equipment was

PO7XX OBDII Transmission/Transaxle Trouble Codes

PO700 Transmission Control System Malfunction
PO701 Transmission Control System Range/Performance
PO702 Transmission Control System Electrical
PO703 Torque Converter/Brake Switch B Circuit Malfunction
PO704 Clutch Switch Input Circuit Malfunction
PO705 Transmission Range Sensor Circuit Malfunction (PRNDL Input)
PO706 Transmission Range Sensor Circuit Range/Performance
PO707 Transmission Range Sensor Circuit Low Input
PO708 Transmission Range Sensor Circuit High Input
PO709 Transmission Range Sensor Circuit Intermittent
PO710 Transmission Fluid Temperature Sensor Circuit Malfunction
PO711 Transmission Fluid Temperature Sensor Circuit Range/Performance
PO712 Transmission Fluid Temperature Sensor Low Input
PO713 Transmission Fluid Temperature Sensor Circuit High Input
PO714 Transmission Fluid Temperature Sensor Circuit Intermittent
PO715 Input/Turbine Speed Sensor Circuit Malfunction
PO716 Input/Turbine Speed Sensor Circuit Range/Performance
PO717 Input/Turbine Speed Sensor Circuit No Signal
PO718 Input/Turbine Speed Sensor Circuit Intermittent
PO719 Torque Converter/Brake Switch B Circuit Low
PO720 Output Speed Sensor Circuit Malfunction
PO721 Output Speed Sensor Circuit Range/Performance
PO722 Output Speed Sensor Circuit No Signal
PO723 Output Speed Sensor Circuit Intermittent
PO724 Torque Converter/Brake Switch B Circuit High
PO725 Engine Speed Circuit Malfunction
PO726 Engine Speed Circuit Range/Performance
PO727 Engine Speed Circuit No Signal
PO728 Engine Speed Circuit Intermittent
PO730 Incorrect Gear Ratio
PO731 Gear 1 Incorrect Ratio
PO732 Gear 2 Incorrect Ratio
PO733 Gear 3 Incorrect Ratio
PO734 Gear 4 Incorrect Ratio
PO735 Gear 5 Incorrect Ratio
PO736 Reverse Incorrect Ratio
PO740 Torque Converter Clutch Circuit Malfunction
PO741 Torque Converter Clutch Circuit Performance or Stuck Off
PO742 Torque Converter Clutch Circuit Stuck On
PO743 Torque Converter Clutch Circuit Electrical
PO744 Torque Converter Clutch Circuit Intermittent
PO745 Pressure Control Solenoid Malfunction
PO746 Pressure Control Solenoid Performance or Stuck Off
PO747 Pressure Control Solenoid Stuck On
PO748 Pressure Control Solenoid Electrical
PO749 Pressure Control Solenoid Intermittent
PO750 Shift Solenoid A Malfunction
PO751 Shift Solenoid A Performance or Stuck Off
PO752 Shift Solenoid A Stuck On
PO753 Shift Solenoid A Electrical
PO754 Shift Solenoid A Intermittent
PO755 Shift Solenoid B Malfunction
PO756 Shift Solenoid B Performance or Stuck Off
PO757 Shift Solenoid B Stuck On
PO758 Shift Solenoid B Electrical
PO759 Shift Solenoid B Intermittent
PO760 Shift Solenoid C Malfunction
PO761 Shift Solenoid C Performance or Stuck Off
PO762 Shift Solenoid C Stuck On
PO763 Shift Solenoid C Electrical
PO764 Shift Solenoid C Intermittent
PO765 Shift Solenoid D Malfunction
PO766 Shift Solenoid D Performance or Stuck Off
PO767 Shift Solenoid D Stuck On
PO768 Shift Solenoid D Electrical
PO769 Shift Solenoid D Intermittent
PO770 Shift Solenoid E Malfunction
PO771 Shift Solenoid E Performance or Stuck Off
PO772 Shift Solenoid E Stuck On
PO773 Shift Solenoid E Electrical
PO774 Shift Solenoid E Intermittent
PO780 Shift Malfunction
PO781 1-2 Shift Malfunction
PO782 2-3 Shift Malfunction
PO783 3-4 Shift Malfunction
PO784 4-5 Shift Malfunction
PO785 Shift/Timing Solenoid Malfunction
PO786 Shift/Timing Solenoid Range/Performance
PO787 Shift/Timing Solenoid Low
PO788 Shift/Timing Solenoid High
PO789 Shift/Timing Solenoid Intermittent
PO790 Normal/Performance Switch Circuit Malfunction

Figure 14-11. *OBD II trouble codes for transmissions and transaxles. Older systems may also have transmission trouble codes.*

discussed in Chapter 2 and will be briefly reviewed here. Scan tools were discussed previously.

Voltmeters can be connected to read the voltage available at an electrical connection. The voltmeter in **Figure 14-15** is being used to measure voltage at a wire connector. The positive lead is placed on one of the connector terminals, and the negative lead is connected to a good ground. In **Figure 14-16,** the voltmeter is reading the voltage across a connection as current flows through it. If the connection has excessive resistance, current will try to flow through the meter, creating a voltage reading. The connection must be cleaned or replaced if the voltage is higher than the maximum specified.

Typical Scan Tool Data Values

Tech 1 Parameter	Units Displayed	Typical Scan Values
MAP	kPa	20-48 kPa, depending upon altitude
BARO	kPa	70-100kPa, depending upon altitude
TP sensor	Volts	0.3-0.9V
TP angle	Percent	0%
Engine speed	RPM	+/– 100 RPM from desired idle
Desired idle	RPM	+/– 100 RPM from engine speed
Current DTC set	Yes/no	No
ECT sensor	Volts	Varies
TFT	C° (F°)	Varies
TFT sensor	Volts	Varies
Trans. OSS	RPM	0
TCC duty cycle	Percentage	0%
TCC enable	Yes/no	No
TCC slip speed	RPM	+/– 50 RPM from the engine speed
Brake switch	Closed/open	Closed
TCC ramp	Seconds	0.00
TCC apply	Seconds	0.00
TCC out of range	Yes/no	No
TCC min. TP	Yes/no	No
TCC delta TP	Yes/no	No
TCC duty open	Yes/no	No
TCC duty shorted	Yes/no	No
TCC enable open	Yes/no	No
TCC enable short	Yes/no	No
Mph (km/h)	0-158 (0-255)	0
MAP sensor	Volts	1-2V, depending on altitude
Engine run time	Hr/min/sec	Varies
Ignition 1	Volts	Varies
ECT	C° (F°)	Varies
PC act. current	Amps	Varies (0.1-1.1 amps)
PC ref. current	Amps	Varies (0.1-1.1 amps)
PC duty cycle	Percentage	Varies
PC sol. low volts	Normal/low volts	Normal
TFP switch A/B/C	On/off	Off/on/off
Power enrichment	Yes/no	No
Cruise enables	Yes/no	No
A/C clutch	Yes/no	No
Kickdown enabled	Yes/no	No
4WD low	Yes/no	No

Figure 14-12. *Common data provided by the ECM through a scan tool. These readings can be used to quickly isolate a problem area. (General Motors)* *(Continued)*

Tech 1 Parameter	Units Displayed	Typical Scan Values
4WD	Yes/no	No
Current TAP	0-16	0
Hot mode	Yes/no	No
Adaptable shift	Yes/no	No
Long shift delay	Yes/no	No
Long shift time	Yes/no	No
TP range	Yes/no	Yes
TP delta	Yes/no	No
VSS delta	Yes/no	No
Max TAP	Yes/no	No
Trans. range	Error, rev, overdrive, drive 3 drive 2, low 1, P/N	P/N
Turbine speed	N/A	—
Input speed	N/A	—
Current gear	1,2,3,4	1
1-2 sol. 2-3 sol.	On/off	On/on
1-2 shift time	Seconds	Varies
2-3 shift time	Seconds	Varies
1-2 shift error	Seconds	Varies
2-3 shift error	Seconds	Varies
3-4 shift time	Seconds	Varies
3-4 shift error	Seconds	Varies
3-2 DS sol.	Yes/no	Yes
1-2 sol. open	Yes/no	No
1-2 sol. short	Yes/no	No
2-3 sol. open	Yes/no	No
2-3 sol. short	Yes/no	No
Shift delay	Seconds	0.00
Speed ratio	Ratio	8.00:1
Shift pattern	Number	8
Start of shift	Yes/no	Yes
End of shift	Yes/no	Yes
Upshift	Yes/no	No
Shift completed	Yes/no	Yes
Gear ratio	N/A	—

Figure 14-12. *Continued.*

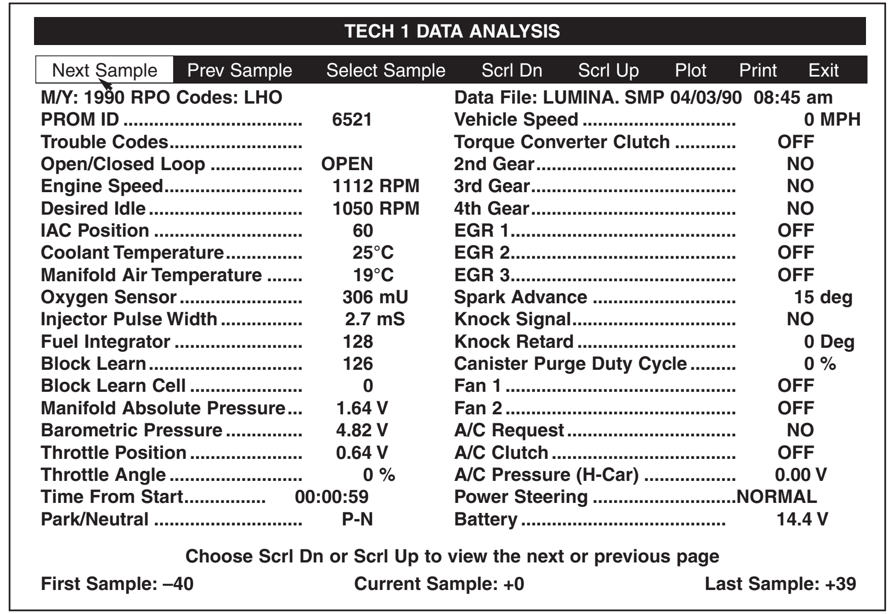


Figure 14-13. *Typical snapshot data. This information is saved at the time a malfunction occurs. (General Motors)*

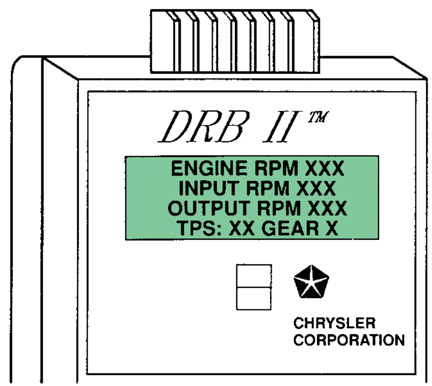


Figure 14-14. *Data displayed on the screen of a typical scan tool during a road test. The display shows engine, input shaft, and output shaft speeds, as well as the transmission gear and the throttle position (TPS reading). From this information, the technician can determine whether the transmission is slipping in a particular gear. (DaimlerChrysler)*

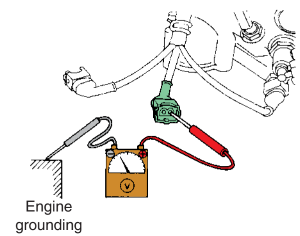


Figure 14-15. *A voltmeter will check for voltage at a terminal. The voltmeter can also be used to check for current flow between two terminals of a connector. (Subaru)*

Caution: Never use a test light to check any electronic circuit unless specifically recommended by the manufacturer. The current flow through a test light is great enough to damage most electronic circuits.

Ammeters, such as the one in **Figure 14-17,** can measure amperage flows up to 10 amps. More amperage will damage the ammeter, so most modern ammeters are equipped with an inductive pickup, **Figure 14-18.** This pickup is clamped over the current-carrying wire. The pickup reads the magnetic field created by current flowing through the wire and converts it to an amperage reading.

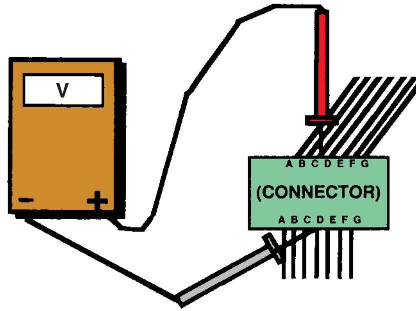


Figure 14-16. *Checking the voltage drop across a connector. More than a small voltage drop indicates a high-resistance connection. Actual maximum voltage drop varies from one circuit to another and depends on the amount of current flowing in the circuit. (General Motors)*

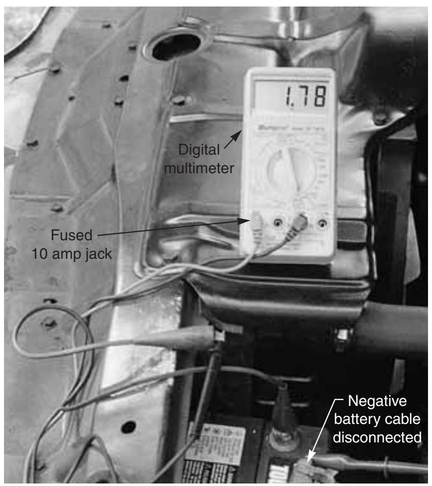


Figure 14-17. *Checking amperage draw. The ammeter will register the amount of current flowing in a circuit. Modern multimeters can read up to about 10 amps. (Fluke)*

Ohmmeters, **Figure 14-19,** are used to check for continuity or the presence of resistance. Wire resistance should be at or near zero. The resistance of an electronic part should be as specified in the service literature.

Modern voltmeters, ammeters, and ohmmeters are generally combined into a single unit called a multimeter. A multimeter used on any electronic system must have high impedance, or resistance to current flow. Many solid-state components, such as ignition modules and ECMs, can be severely damaged by careless use of test lights and multimeters. Specialized testers are often needed to check the operation of specific electronic devices or systems.

Waveform meters can be used to detect problems in sensors and solenoids. The technician connects the meter and observes the waveform produced by the operation of the suspected device. Then the technician compares the actual waveform with the standard waveform. The standard waveform is the waveform the device is supposed to produce when operating properly. If the waveforms do not

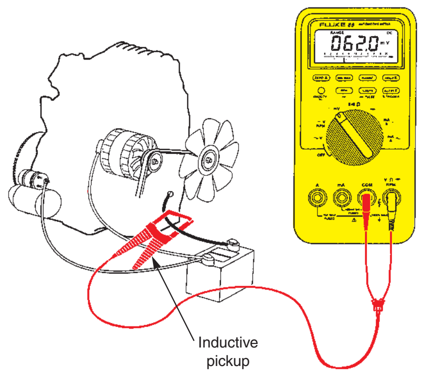


Figure 14-18. *An inductive pickup allows the meter to read a greater amount of amperage without subjecting the meter itself to high current. (Fluke)*

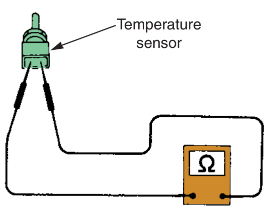


Figure 14-19. *Ohmmeters are commonly used to check temperature sensors. (Nissan)*

match, the device is usually defective. Occasionally, an incorrect waveform is caused by a related electrical problem instead of by the device itself. Therefore, even if the waveform is incorrect, it is important to make further checks before condemning the device. Many shops have lab scopes, which are similar to engine ignition oscilloscopes. Lab scopes perform the same functions as waveform meters. If you are unclear about the operation of waveform meters and lab scopes, refer to Chapter 3 for more information.

Temperature sensing tools can be used to determine the exact operating temperature of the engine or transmission. The actual temperature can be compared with the sensor readings recorded by the scan tool to determine whether the sensor is sending the correct signals to the ECM.

System Operation Testing

Once a suspect system has been isolated, the technician should determine whether that system and its components are working correctly. The easiest way to diagnose an electronic control system is by using the proper scan tool. If the transmission is operable, drive the vehicle and check the applicable scan tool readings. At the same time, observe transmission and transaxle operation.

During the test drive, note the transmission or transaxle shift pattern. Also note any slipping, harsh engagements, or noises. Try to match the malfunction with the scan tool readings. This will provide an indication of which gear has the problem and possible causes. With this information, you should be able to proceed to test the suspect components and systems.

Component Testing

This following section explains how to test individual electronic transmission and transaxle components. Before going on the individual component testing, be sure to read the general test information presented in the following section.

Types of Component Tests

There are three major ways to test electronic components: visual checks, electrical tests, and testing by substitution. General information on performing these tests is given in the following sections.

Making Visual Checks

You have already performed some visual checks as part of your preliminary diagnosis. If a problem is suspected in a specific system, check the system for disconnected or damaged wiring, obvious component defects, or problems in related areas. For instance, if your preliminary investigation indicates a problem with the MAP sensor, do not assume the sensor itself is bad. First, check the vacuum hoses to the sensor and all nearby vacuum connections for damage (splits, cracks), kinking, and clogging. Make sure that hoses are not disconnected or connected to the wrong parts. Next, look at the wiring connector and check the sensor for physical damage.

Making Electrical Tests

Caution: Some procedures call for energizing a solenoid or other device with battery power. Always consult the proper factory service manual to be sure that the device is designed to operate on full battery voltage. Some electrical devices will be destroyed if battery voltage is applied to them. When using jumper wires to operate a solenoid or other device, be sure that the wiring to the ECM is disconnected. Full battery voltage to some ECM connectors can destroy the ECM.

Note: Before making ohmmeter checks, be sure that the device or wiring is disconnected from all sources of electrical power. Ohmmeter readings taken on an energized device or wire are useless. Electrical power can also damage the ohmmeter.

Solenoids can be tested by making a continuity check, **Figure 14-20.** Additionally, jumper wires can be used to apply power to the solenoid while observing its

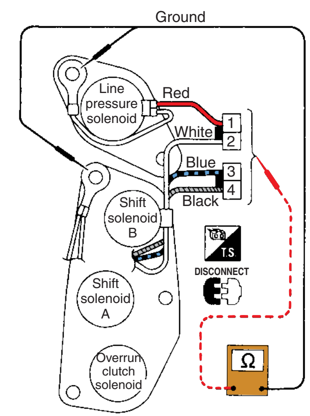


Figure 14-20. *Many solenoids can be checked with an ohmmeter. To accurately check a solenoid, you must know what the correct resistance reading should be. If the solenoid resistance does not match the specifications, the solenoid should be replaced. (Nissan)*

operation. Most solenoids do not have a visible plunger, and the technician must listen carefully for a click to determine whether the solenoid is operating. Some solenoids and other components can be checked through the wiring harness without removing the part from the transmission. Sometimes, the part can be checked though the transmission or transaxle wiring connector, and the oil pan does not need to be removed. However, you must refer to the service manual to determine which connector pin energizes which component, **Figure 14-21.**

Although most solid-state components require the use of specialized test equipment, basic checks can be made to some solid-state components. Common checks include using an ohmmeter to check a terminal for proper grounding. This check must be made very carefully to avoid damage to the unit. A few solid-state components can be checked for proper operation.

When checking any electrical component for proper voltage or resistance, consult the manufacturer's service literature to determine what the readings should be.

On some vehicles, the solenoid amperage draw can be read and compared to the manufacturer's specifications. Some pressure control solenoids can be checked by comparing amperage draw to the corresponding line pressure. A typical amperage-pressure chart is shown in **Figure 14-22.**

Testing by Substitution

In many cases, the only way to determine whether a component is defective is to replace it with a unit that is known to be in good working condition. When ***testing by substitution,*** however, the technician must keep the following things in mind:

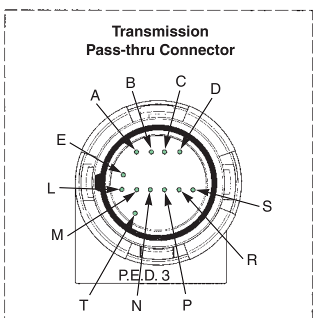
- Obtaining a known good part may be expensive and time-consuming. In many cases, especially when substituting an electrical or electronic part, the part will not be returnable.
- If the actual problem is a short or high amperage draw somewhere else in the related circuit, the heavy current flow may ruin the replacement part.
- If the part requires a great deal of labor (time) to replace, this time will be wasted if the suspect part is not the problem.

Be sure to eliminate all other sources of a problem before substituting parts. Always consult the manufacturer's manual to determine whether a part can be tested before replacing it. Technicians can partially offset the problem of obtaining substitute parts by acquiring a stock of commonly needed replacement parts.

Testing Manual Valve Position Sensors

Note: Some manual valve position sensors are called range sensors, PRNDL switches, or position switches.

An ohmmeter can be used to test the manual valve position sensor. Check the resistance at each switch position. Resistance should change as the shift lever is moved. See **Figure 14-23.** If resistance is not within specifications or does not change when the shifter is moved, the sensor should be replaced.



Cavity	Function
A	1-2 shift solenoid (low)
B	2-3 shift solenoid (low)
C	Pressure control solenoid (high)
D	Pressure control solenoid (low)
E	Both shift solenoids, TCC solenoid, and 3-2 control solenoid (high)
L	Transmission fluid temperature (high)
M	Transmission fluid temperature (low)
N	Range signal "A"
P	Range signal "C"
R	Range signal "B"
S	3-2 control solenoid (low)
T	TCC solenoid (low)

Figure 14-21. *To check an electronic transmission component through the case connector, you must know which connector pin goes to which component. A connector diagram, such as the one shown here, can be very helpful. (General Motors)*

Pressure control solenoid current (amp)	Approximate line pressure (psi)
0.02	170–190
0.10	165–185
0.20	160–180
0.30	155–175
0.40	148–168
0.50	140–160
0.60	130–145
0.70	110–130
0.80	90–115
0.90	65–90
0.98	55–65

Figure 14-22. *To make an amperage check of a solenoid on the vehicle, you must know what the current draw is supposed to be. Compare the correct reading in a table like this with actual current draw to determine whether the solenoid is good. (General Motors)*

Some manual valve position sensors can be checked with a scan tool. The sensor should be connected for this test. Follow the scan tool menu directions to test the sensor.

Testing Throttle Position Sensors

Before testing the throttle position sensor, determine what type of sensor it is. Most throttle position sensors are resistor types and can be tested with an ohmmeter. To make an ohmmeter check, disconnect the sensor wiring harness connector. Then attach an ohmmeter to the proper sensor leads. Operate the throttle and observe the ohmmeter readings. Many manufacturers specify checking the resistance at idle and wide open throttle positions. If the readings are incorrect, or if the ohmmeter readings do not change steadily as the throttle is opened, the sensor is defective.

Some throttle position sensors are transducers and must be checked with a voltmeter. A special adapter must be used to take readings with the wiring harness connected and the ignition switch in the *on* position. Testing procedures are similar to those for checking a resistor-type sensor.

Note: It is often easier to detect erratic throttle position sensor readings with an analog (needle-type) multimeter than with a digital meter. See Figure 14-24. The needle should move smoothly as the throttle is moved.

Transmission manual lever position	Resistance (ohms)	
	Min	Max
P	3770	4607
R	1304	1593
N	660	807
D	361	442
2	190	232
1	78	95

Figure 14-23. *Manual lever position sensors can usually be checked with an ohmmeter. One manufacturer's resistance specifications for various manual lever position sensor.*

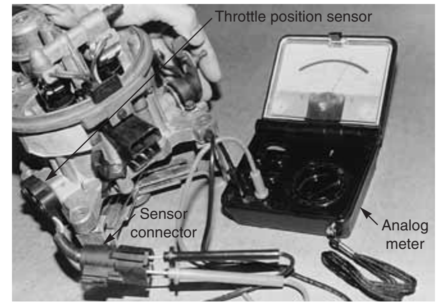


Figure 14-24. *While outdated for most automotive uses, an analog meter is useful for checking some throttle position sensors. Move the throttle while monitoring the meter.*

Some throttle position sensors can be adjusted if they are out of range. However, if the throttle position sensor gives erratic readings, it is defective and should be replaced.

Checking Speed Sensors

The simplest way to check a speed sensor is to use the proper scan tool. If the sensor is part of the distributor pickup assembly, the scan tool will be able to detect the ignition speed signal. Scan tools can also check the operation of speed sensors installed at the engine crankshaft or camshaft, as well as those located on the transmission or transaxle input shaft. Modern scan tools can read the speed sensor output as miles per hour. Comparing this to the actual speed of the vehicle will immediately tell the technician whether a vehicle speed sensor is operating properly. Some scan tools are designed to display speed sensor readings as drive shaft revolutions.

As was discussed in Chapter 12, speed sensors produce an alternating current (ac) output. Therefore, the operation of most vehicle speed sensors can be checked by measuring the output in ac volts. To make this test, raise the vehicle and disconnect the speed sensor at the transmission or transaxle.

Note: Vehicles with anti-lock brakes (ABS) or traction control may have speed sensors at each wheel. Consult the service manual to determine which speed sensors provide input to the transmission or transaxle.

Next, set the multimeter to the proper ac voltage range. With the drive wheels off the ground, shift the transmission or transaxle into drive and accelerate. The multimeter should read increasing ac voltage as the engine speed is increased. Some manufacturers call for checking the resistance of the speed sensor winding as shown in **Figure 14-25.** This should generally be done only after other tests have indicated a sensor problem.

Before condemning the speed sensor, check the tip of the sensor for a buildup of metal shavings. Often the sensor will operate properly when the shavings are removed. Because they are magnetized, both internal and external sensors can collect metal particles.

Testing Pressure Sensors

Since most pressure sensors are on-off devices, they can be easily tested with an ohmmeter. A typical procedure for testing a pressure sensor is shown in **Figure 14-26.** With no pressure supplied, the sensor will be in its normal position, either normally open (NO) or normally closed (NC). If a normally closed sensor reads infinite resistance, it is defective. If a normally open sensor has a low resistance reading, it too is defective.

However, even if a pressure sensor has the proper ohmmeter readings with no pressure applied, it may still be defective. It is always possible for a pressure sensor to fail and remain stuck in its normal (no pressure) position. If you suspect that a pressure sensor is not operating properly, the best way to check it is with a scan tool. Use the scan tool to access the pressure sensor signal. For example, if a pressure sensor should be closed in a particular gear but the scan tool does not indicate a closed signal when the unit is in that gear, the sensor is probably defective.

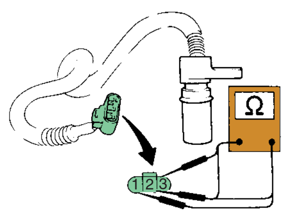


Figure 14-25. *Some speed sensors can be tested with an ohmmeter. You must have access to the proper resistance specifications. Other speed sensors can only be checked with a scan tool or an oscilloscope. (Nissan)*

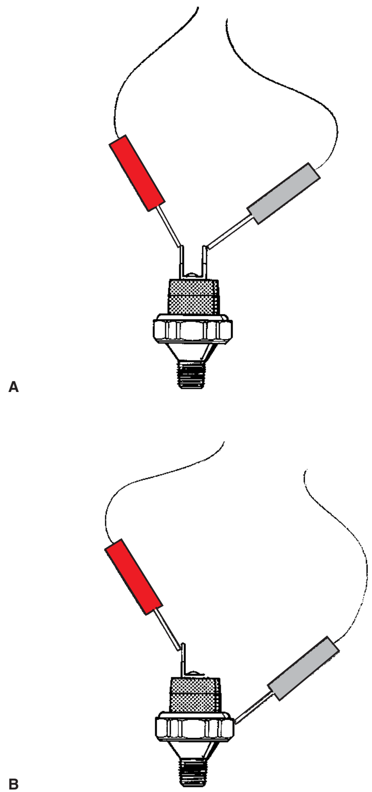


Figure 14-26. *An ohmmeter check of a pressure sensor. A normally open pressure sensor should have infinite resistance. A normally closed pressure sensor should have very low resistance. A—Connect the ohmmeter leads to the two terminals to obtain a reading. B—Connect the ohmmeter leads to the terminal and the sensor body.*

Testing Temperature Sensors

Temperature sensors make use of resistance changes to send a temperature signal to the ECU. Transmission temperature sensors are normally installed on the valve body or on the case inside the oil pan. Engine coolant temperature sensors are installed in such a way that they contact the engine coolant. They are located near the thermostat on many engines. Incoming air temperature sensors may be installed in the intake manifold, the plenum, or the ductwork connecting the air cleaner to the engine.

Checking temperature sensors with an ohmmeter is relatively simple. Unlike other common resistors, temperature sensors show a decrease in resistance as temperature increases. Therefore, both the resistance and temperature of this type of sensor must be monitored. **Figure 14-27** shows one method of checking a temperature sensor with an ohmmeter and a thermometer. The sensor has been removed from the vehicle and is being heated in a container of water. Sensor resistance should be checked at various temperatures. Another method involves using an infrared temperature gauge and observing the temperature of the sensor as the engine warms up. Check the resistance reading at various temperatures. Then compare the resistance and temperature readings to the manufacturer's specifications. If the readings do not closely match the specifications, the sensor is defective.

Another test can be made to check the temperature signal being sent to the ECM by the sensor. To make this test you must have a temperature tester and a scan tool. Use the temperature tester to measure the exact temperature at the sensor. Then use the scan tool to determine the temperature reading the sensor is sending to the ECM. If the readings do not match, the sensor is defective.

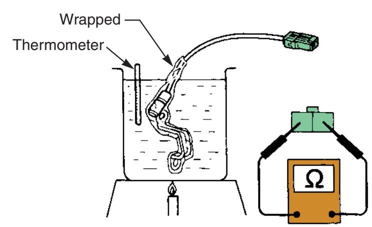


Figure 14-27. *Always test a temperature sensor at different temperatures. Place the sensor in water and gradually heat the water. Measure the resistance at different temperatures and compare the readings with factory specifications. (Nissan)*

Note: Be sure to make sensor tests over a range of temperatures. Many sensors will read incorrectly only in certain temperature ranges.

Checking Manifold Air Pressure (MAP) Sensors

To check a MAP sensor, attach a voltmeter to the MAP sensor connections or to the proper MAP sensor wires at the ECM. Turn the ignition switch to the *on* position and apply vacuum to the sensor vacuum port as shown in **Figure 14-28.** Observe the voltage reading as the vacuum is developed. If the voltage reading increases with increases in vacuum, the MAP sensor is probably working properly. Many manufacturers publish figures that specify the correct MAP sensor voltage at various vacuum levels. If the MAP sensor does not attain these voltages, it should be replaced.

A similar test can be made to the barometric pressure (BARO) sensor on some vehicles. Check the output voltage at the proper ECU terminals (ignition on, engine not running) and compare it to the specifications for the altitude in your area. See **Figure 14-29.**

Checking Mass Airflow (MAF) Sensors

Regardless of their design, all mass airflow, or MAF, sensors produce one of three types of outputs, depending

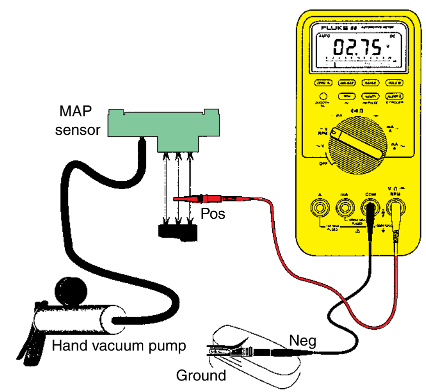


Figure 14-28. *One type of meter and vacuum pump setup for checking the output of a MAP sensor. Many MAP sensors can be checked with a scan tool. (Fluke)*

Altitude		Voltage range
Meters	Feet	
Below 305	Below 1000	3.8–5.5v
305–610	1000–2000	3.6–5.3v
610–914	2000–3000	3.5–5.1v
914–1219	3000–4000	3.3–5.0v
1219–1524	4000–5000	3.2–4.8v
1524–1829	5000–6000	3.0–4.6v
1829–2133	6000–7000	2.9–4.5v
2133–2438	7000–8000	2.8–4.3v
2438–2743	8000–9000	2.6–4.2v
2743–3048	9000–10,000	2.5–4.0v

Low altitude = high pressure = high voltage

Figure 14-29. *An altitude compensation chart is needed to ensure that MAP and BARO sensor readings are correct for the altitude in your area. (General Motors)*

on the manufacturer. These are analog dc voltage, low-frequency pulse, or high-frequency pulse. Older MAF sensors generally produce a dc voltage output, while many newer designs produce frequency pulse outputs.

It is sometimes possible to check the output of a dc voltage MAF sensor, but this must be done carefully to avoid damaging the electronic circuits. The safest way to do this is to use a scan tool to measure voltage changes while varying engine speed. Most MAF sensors have a voltage range of 0–5 volts. There are exceptions to this rule, however, and the technician should obtain the proper specifications before condemning the MAF sensor.

To avoid misdiagnosis and prevent damage to the MAF sensor and ECM, refer to the appropriate service manual for testing procedures. Always use a high impedance multimeter to avoid damaging the MAF or ECM.

The output of a frequency-type MAF sensor can be measured by most scan tools or by multimeters capable of reading RPM or duty cycles. Consult the multimeter manual to determine the exact meter settings. The frequency will be at a set value with the ignition on and the engine off. When the engine is started, increasing airflow through the MAF sensor will cause an increase in the frequency reading.

A variation of this procedure is shown in **Figure 14-30.** Disconnect the MAF sensor from the ducts. Then blow through the MAF sensor with the ignition on. Frequency should rise, indicating that the sensor is responding to air movement.

Note: Always determine the type of MAF sensor you are dealing with before performing tests, since frequency-type sensors closely resemble dc output types.

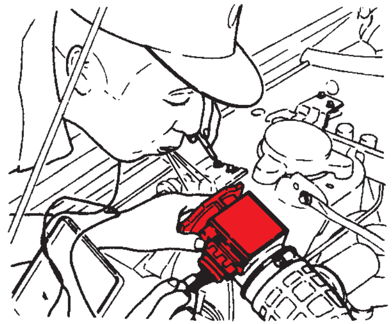


Figure 14-30. *Blowing through a MAF sensor will simulate the air that enters while the engine is running. (Nissan)*

Testing Oxygen Sensors

Caution: Oxygen sensors are sensitive to excess current. Improper grounding or the use of test lights and low-impedance multimeters can destroy them. Some manufacturers do not recommend meter tests of the oxygen sensor.

There are two basic types of oxygen sensors, the electrically heated and the non-heated. Oxygen sensors with one or two lead wires are non-heated types. If an oxygen sensor has three or more leads, it is a heated type.

Testing Oxygen Sensor Output

To test an oxygen sensor, it must be at a temperature of approximately 650° F (361° C). The sensor must be heated either by its heating element (when applicable) or by exhaust heat.

Begin by obtaining the correct specifications for the oxygen sensor that you are testing. Oxygen sensors use either Zirconia or Titania elements. A ***Zirconia-type oxygen sensor*** will produce a voltage reading, while a ***Titania-type oxygen sensor*** will produce a resistance reading.

After determining the type of sensor you are testing, set the multimeter to the proper range (usually 2V for a Zirconia sensor and 200KΩ for a Titania sensor). After the range is set, connect the positive (red) sensor lead to the sensor's signal wire and the negative (black) lead to ground. One- and three-wire sensors are grounded through the sensor housing. On two- and four-wire sensors, one of the wires is a ground wire. Be very careful to make the proper connections, as even slight voltage surges can ruin an oxygen sensor.

Make sure the sensor is at the correct operating temperature. Non-heated oxygen sensors should be heated by running the engine at high idle for at least 5 minutes. Then observe the multimeter readings. A rich mixture will cause a Zirconia sensor's voltage to increase, while causing a Titania sensor's resistance to decrease. A lean mixture, on the other hand, will cause a Zirconia sensor's voltage to decrease, while causing a Titania sensor's resistance to increase. If the sensor output responds quickly to changes in mixture ratio (within 1 to 3 seconds, depending on the manufacturer), the sensor is good.

Testing Oxygen Sensor Heater Circuit

The heater circuit of a heated oxygen sensor must be checked for proper resistance to ensure that the heater resistor is not burned out or shorted. To test the heater, set the multimeter to the 200KΩ range. Then connect the multimeter leads to the oxygen sensor heater terminals. Polarity is not important, but the leads must not contact the sensor signal terminal. If the resistance at the heater terminals is within specifications, the heater circuit is good.

Note: If the above tests are made while the oxygen sensor is installed on the vehicle, running the engine with the sensor disconnected will probably set false trouble codes. After all tests are complete, be sure to clear the ECM memory.

Testing Output Solenoids

Once the scan tool has isolated a solenoid as a potential problem, the solenoid can often be tested by one of three methods. One method is to use an ohmmeter to measure the resistance of the solenoid windings. Obtain a high-impedance ohmmeter and set it on the required range. Then remove the solenoid wiring harness and measure the resistance. The resistance should be within the manufacturer's specified range. A few solenoids will read very low resistance. Resistance should never be zero, as this indicates a shorted winding. Infinite resistance indicates an open winding.

Using jumper wires to apply power to solenoids is another way to test their operation. An operating solenoid will make at least one click when it is energized.

Caution: Some solenoids are not designed to operate on 12 volts. Full battery voltage may destroy the solenoid. Some solenoids can be tested if a voltage-dropping resistor is inserted in the jumper wire circuit. When testing a solenoid, attach the jumper cables just long enough to listen for a click.

A third method of testing a solenoid is to use an ammeter to check for excessive current draw. Most solenoids will draw one amp or less. Always check the manufacturer's specifications for exact current draw.

Checking Electric Motors

Most electric motors used on modern vehicles can be checked with the appropriate scan tool. Scan tool use was discussed earlier in this chapter. The windings of some motors can be checked with an ohmmeter. Connect the ohmmeter to the input and output connectors, or to the connector and the motor body. As a general rule:

- ❑ If the resistance reading is zero or very low, the winding is shorted.
- ❑ If the ohmmeter reads infinite resistance, the winding is open.

If winding specifications are available, check that the motor winding has the proper resistance. Specifications are usually given as a range of resistance, for instance 500 to 800 ohms.

Checking Wiring

When troubleshooting a wiring problem, remember that for any electrical device to operate properly there must be a complete circuit. This means that voltage must be available to the device, the device must be in operating condition, and the electrical circuit must be completed through a good ground.

Always obtain the proper wiring diagram when checking for a wiring problem. The correct wiring diagram will lead you to the most obvious connectors and trouble spots. See **Figure 14-31.**

Never assume that a connector is good just because it looks good on the outside. Separate any suspicious connectors and make a careful visual inspection for bent or corroded pins. Also, check for pins that have been pushed out of their holders. Make sure there are no signs of overheating on the connector. Also make ohmmeter checks for continuity. When using a diagnostic chart, such as the one in **Figure 14-32,** always follow procedures exactly.

Carefully inspect wire splices, **Figure 14-33.** Also, look for wires that are rubbing on moving parts or insulation that has melted on hot exhaust system components. Either of these conditions can cause a short that affects system operation and may destroy the ECM. The wiring harness in **Figure 14-34** must pass through a confined area between the body and the transmission. In this situation, even slight movement or incorrect positioning can cause a problem.

Testing the ECM

Some manufacturers have ECM testing procedures. Most of these procedures involve checking ECM voltage outputs. **Figure 14-35** shows an ECM being tested for proper voltage at the wiring harness. This procedure must be done very carefully to prevent ECM damage. It is usually safer to check for correct voltages at the sensors rather than at the ECM.

Most ECMs can only be tested by substitution. As was discussed earlier, this should be done after careful checking has determined that the ECM is the only possible source of the problem. Some manufacturers have special testers for checking the ECM. On most vehicles, however, the scan tool can be used to test the ECM.

Most modern ECMs have a provision for changing the information in the programmable read only memory

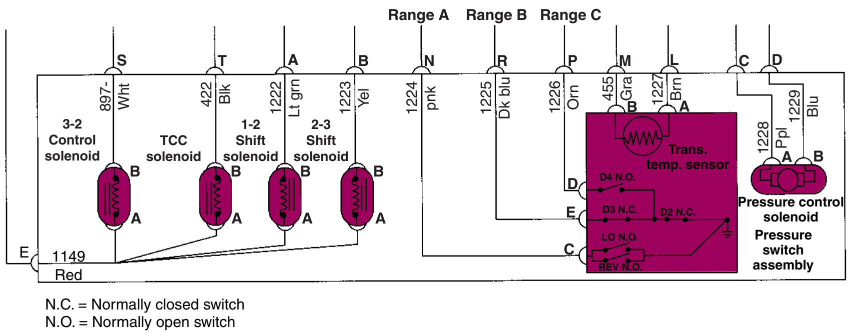


Figure 14-31. *To properly check the electrical system of an electronic transmission or transaxle, the technician must have access to the proper electrical schematic. (General Motors)*

<table>
<tr><td>C8 Check internal axode harness (continuity)
• Disconnect the internal harness from the soleniod (MCCC/CCC wire connector)
NOTE: Do not probe into connector terminals.
• Connect the positive lead from an ohmmeter to the tester MCCC/CCC jack and negative lead at the Black (91/92 MY) or Brown (93 MY) wire at the MCCC/CCC connector.
• Record resistance. Should be less than .5 ohms.
• Next, connect the positive lead from an ohmmeter to the tester VPWR jack and the negative lead at the Red (91/92 MY) or Green (93 MY) wire of the MCCC/CCC connector.
• Record resistance. Is the resistance less than .5 ohms?</td><td>Results
Yes
No</td><td>Action to take
Go to C9.
Replace internal harness. Go to C10.</td></tr>
<tr><td>C9 Check internal axode harness
• Check for continuity between BAT – (engine ground) and the appropriate wire with an ohmmeter or other low current tester (less than 200 milliamps).
<table><tr><td></td><td colspan="2">Wire color</td></tr><tr><td>Solenoid</td><td>91/92</td><td>93</td></tr><tr><td>MCCC/CCC
VPWR</td><td>Black
Red</td><td>Brown
Green</td></tr></table>• Connection should not show continuity (infinite).
• Is there continuity?</td><td>Yes
No</td><td>Replace internal harness. Go to C10.
Go to C10.</td></tr>
</table>

Figure 14-32. *This diagnostic chart is used when checking a wiring harness on a common automatic transaxle. Note that, even though the second procedure (C9) is a check for continuity (a complete circuit), an ohmmeter must be used. Using an ohmmeter instead of a test light ensures that the internal transaxle parts will not be damaged. (Ford)*

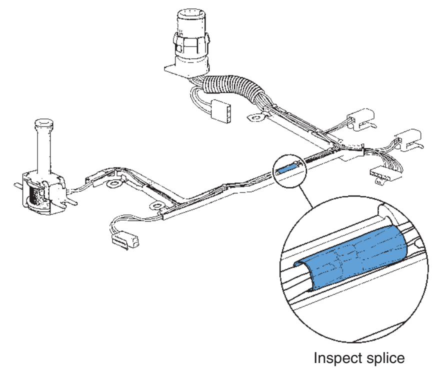


Figure 14-33. *Splices are a common source of problems. Carefully inspect the splice for looseness or signs of overheating. (General Motors)*

(PROM). Often, the original ECM programming was not perfectly calibrated to the vehicle. Sometimes actual operating conditions cause minor drivability problems with the original PROM programming. When this occurs, the manufacturer issues updated PROM information. The only way to determine whether updated information will cure a transmission or transaxle problem is to check the manufacturer's service bulletins or other update information.

Deciding on Work Needed

After locating a defective part, never assume that it is the root cause of the problem. Always try to determine what caused a part to fail. For example, if the ECM is defective, test all sensors and output solenoids for excessive current draw that could have caused the module to fail. Careless or incomplete diagnosis can allow further damage to the electronic components. Sometimes, a missed electronic defect can cause the transmission or transaxle to slip, destroying the holding members.

Summary

Many electronically controlled transmission or transaxle problems are the same as those encountered in hydraulically controlled transmissions. Other problems are unique to the electronic control system. Many computer control system problems are referred to as pattern failures, since they occur regularly on a particular system.

In many cases, the transmission or transaxle is reacting to problems in the engine. Sensors are the most common cause of electronic transmission/transaxle problems. Many sensor defects first show up as engine performance problems.

If a solenoid controls an entire system, failure may cause a transmission defect in all gears. If a defective solenoid controls only one gear, the problem will show up in that gear only.

A failed ECM can cause slipping, hard shifting, improper shift speeds, shudder during shifts, and other problems. A failed ECM may also cause engine drivability problems.

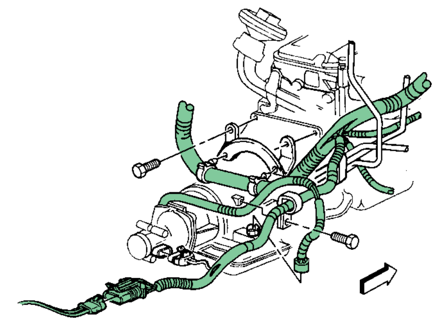


Figure 14-34. *A close-fitting wiring harness is subject to damage. Wiring harnesses should be inspected in areas where they pass through tight spots and near engine and exhaust system parts. (General Motors)*

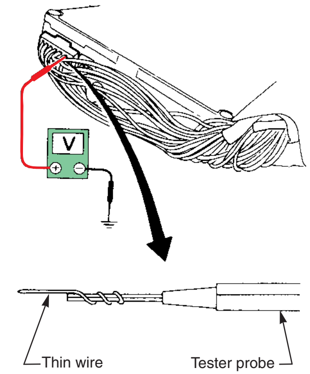


Figure 14-35. *One method of checking voltage output from the ECM. Be extremely careful when making checks like this, as the current flow through the meter could damage the ECM. (Nissan)*

Wiring and connector problems are common sources of computer system problems. The voltages used to operate the sensors are usually much lower than battery voltage, and a slight increase in resistance can cause problems. Defects in the ground circuit are commonly overlooked.

The seven-step diagnosis process is very helpful in determining the exact cause of a problem. It is sometimes difficult whether the problem is in the electronic control system or in the basic hydraulic and mechanical components. Always make the same preliminary checks that you would with hydraulically controlled transmission and transaxles when troubleshooting an electronically controlled transmission or transaxle.

Before performing complex electronic tests, make some basic electrical checks. Check fuses, wiring, and ground wires. If these checks do not reveal a problem, use a scan tool to check the system. The scan tool allows the technician to access trouble codes and obtain information on shift speeds, converter clutch application speed, and transmission/transaxle temperatures and pressures. The scan tool can also provide information on engine RPM and temperature readings.

Multimeters are used to read electrical values such as voltage, resistance, and amperage. Many multimeters can read the waveforms produced by the system components as they operate. Lab scopes can also produce these readings.

The easiest way to diagnose the operation of an electronic control system is by using the proper scan tool. If possible, drive the vehicle and observe the scan tool readings. During the test drive, note the transmission or transaxle shift pattern, as well as any slippage or noises.

To test individual electronic transmission and transaxle components, you should make visual checks, perform electrical tests, and test by substitution. Begin by looking for disconnected or damaged wiring, obvious component defects, or problems in related areas. Then make electrical tests to sensors and output devices as needed. As a last resort, test by substituting a known good part.

Most throttle position sensors can be tested with an ohmmeter. Some throttle position sensors are transducers and, therefore, must be checked with a voltmeter.

To check a speed sensor, use a multimeter to check for the presence of an ac waveform. Speed sensors can also be checked with a scan tool. Some manufacturers recommend checking the resistance of the speed sensor winding.

Pressure sensors can usually be checked with an ohmmeter. If a normally closed sensor reads infinite resistance with no pressure applied, the sensor is defective. If a normally open sensor reads low resistance with no pressure applied, it is defective.

To test temperature sensors, check the resistance reading at various temperatures. If the readings are not within specifications, the sensor is defective. Many sensors read incorrectly only in certain temperature ranges.

To check a MAP sensor, attach a voltmeter and vacuum pump to the sensor. If MAP sensor voltage reading increases with increases in vacuum, the MAP sensor is probably good. There are several types of mass airflow (MAF) sensors. Test procedures vary with each type. Always disconnect the MAF wiring to make readings.

Testing oxygen sensors requires care, since oxygen sensors are sensitive to excess current flow. Some manufacturers do not recommend meter tests of the oxygen sensor. Oxygen sensors use either Zirconia or Titania elements. Oxygen sensors with one or two lead wires are non-heated types. If an oxygen sensor has three or more leads, it is a heated type. The sensor must be at its operating temperature before testing it.

To test an output solenoid, remove the solenoid wiring harness and measure solenoid resistance. Some solenoids can be operated with jumper wires. Full battery voltage may destroy other solenoids, so always check the manufacturer's specifications before trying this test.

Schematics are useful when looking for defective wires, connections, and devices. Always obtain the proper wiring diagram when checking for a wiring problem.

Some manufacturers have procedures or equipment for testing for proper ECM voltage outputs. On most vehicles, a scan tool can be used to test the ECM. The ECM may have to be tested by substituting a known good unit and rechecking system operation.

Always double-check your results before replacing a defective component.

Review Questions—Chapter 14

Please do not write in this text. Place your answers on a separate sheet of paper.

1. Electronically controlled transmission or transaxle problems often resemble those that occur in _____ transmissions.
2. A pattern failure is a _____ type of problem.
3. _____ are the most common cause of electronic transmission/transaxle problems.
4. On-off _____ _____ can stick open or closed.
5. On a few electronic transmissions, some shifts are _____ controlled.
6. Engine missing is often confused for lockup torque converter _____.
7. Do not remove any _____ until you have retrieved trouble codes from the ECM.
8. Where are fusible links usually located?
9. Scan tools can be thought of as a portable _____ that can communicate with the vehicle's ECM.
10. OBD I computer systems can have a maximum number of ____ trouble codes. The OBD II system can have as many as _____ potential codes.

11. The snapshot is a scan tool feature that records vehicle operating conditions just before and just after a _____ occurs.
12. The three ways of checking computer control systems are _____ checks, _____ tests, and testing by _____.
13. Speed sensors produce a(n) _____ current output.
14. If a normally closed (NC) sensor reads zero resistance, it is _____.
15. If the MAP voltage reading increases with increases in _____, the sensor is probably OK.
16. The three types of MAF sensor outputs are analog ______ voltage, low _____ pulse, or high _____ pulse.

Matching

Match the following test equipment or testing method with the device that it is best at testing.

17. Jumper wires _____	(A) Temperature sensor
18. Ohmmeter _____	(B) Speed sensor
19. Substitution _____	(C) Output solenoid
20. Waveform meter _____	(D) ECM
	(E) Throttle position sensor

ASE-Type Questions—Chapter 14

1. Technician A says that electronically controlled transmission or transaxle problems are always caused by the electronic control system. Technician B says that an electronically controlled transmission or transaxle may have some of the same problems as a hydraulic unit. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
2. A defective throttle position sensor can cause all the following electronic transmission problems *except:*
   (A) harsh upshifts.
   (B) downshift bump.
   (C) converter vibration.
   (D) improper shift speeds.
3. Technician A says that a transaxle suffering from gear skipping may shift from first to third gear. Technician B says that erratic shifting is a symptom of an intermittently sticking solenoid. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
4. A problem thought to be in the transmission may actually be in the _____.
   (A) ignition system
   (B) fuel system
   (C) tires
   (D) All of the above.
5. All the following are OBD II trouble code letters *except:*
   (A) B (body).
   (B) T (transmission/transaxle).
   (C) C (chassis).
   (D) P (power train).
6. Each of the following statements about temperature sensor testing is true *except:*
   (A) temperature sensors show a decrease in resistance as temperature increases.
   (B) transmission temperature sensors are normally installed on case, outside of the oil pan.
   (C) temperature sensors are tested with a voltmeter.
   (D) the resistance and temperature of a temperature sensor must be monitored.
7. Testing a barometric pressure (BARO) sensor is similar to testing a _________ sensor.
   (A) MAF
   (B) MAP
   (C) speed
   (D) oxygen
8. Most ECMs can only be checked by:
   (A) using jumper wires to energize the ECM drivers.
   (B) checking ECM input with a test light.
   (C) checking ECM terminals with an ohmmeter.
   (D) substituting with a known good ECM.
9. Updated _____ information may cure some driveability problems.
   (A) PROM
   (B) RAM
   (C) speed sensor
   (D) solenoid winding
10. Technician A says the careful technician will not replace a part without checking for the cause of its failure. Technician B says that the only way to get rid of the vehicle is to replace the first thing that appears to correct the problem. Who is right?
    (A) A only.
    (B) B only.
    (C) Both A and B.
    (D) Neither A nor B.