In the first part of this series on diagnosing ECUs, we went over some basic visual diagnosis of common failures. In this, the second part of the series, we’re going to go over some basic tests you can perform with a digital multimeter (DMM) that has a diode test function, and some more advanced testing using a lab scope. We’re going to focus mainly on testing for some of the common component failures on ECUs that control automatic transmissions.

CAUTION: If you don’t feel comfortable with testing or repairing an ECU, or aren’t confident using a digital multimeter or lab scope, consider sending the ECU to a company that specializes in testing and repairing them. Many can be found by doing a web search on “ECM rebuilding,” or “ECM repair.”

Before You Begin…

Remember to check the basics first. In the first part of this series we went over some visual checks; look for these failures before you start testing. A cracked solder joint can baffle you with an intermittent problem, and the crack may be so small you can barely see it. If you’re spending time checking for shorted transistors in the ECU, and the boss walks under the car and finds a harness that detours into the bell housing or is wrapped around the exhaust pipe, he won’t be very happy. The point is, make sure you’ve checked the circuits on the vehicle thoroughly before you go sniffing around inside the ECU.

When looking for a specific problem with an ECU, you need to have as much information as possible. This means looking at a vehicle wiring diagram or pin chart to determine which terminal on the ECU connects to the circuit in question:

• If it’s a solenoid circuit, what’s the problem? Is it energized all the time? Does it energize at all?
• If it’s a sensor circuit, do you have reference voltage to the sensor? Is the voltage too high?

And don’t forget to check all the power (battery +) and ground (battery –) pins, as well as ignition terminals that are only hot with the key on.

Testing Solenoid Driver Circuits

You may have heard the term driver mentioned in discussions about automotive electronic systems diagnosis. A driver is simply a power transistor inside the ECU that switches the power on and off to control a relay or solenoid. Driver transistors are like little solid-state relays: They use a small current to control a large current. The computer circuit inside the ECU can’t handle the higher current required to control the solenoid or relay directly. Instead, the computer circuit controls the driver transistor, and the transistor does the heavy work.

The driver transistor is part of the driver circuit. A driver circuit may also include a clamping diode or a current-
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Diagnosing ECUs, Part II

sensing resistor. These components are susceptible to damage or failure because they carry most of the current, and can be overloaded when a solenoid circuit’s resistance is too low or shorted. These components can fail and cause the ECU to energize the solenoid all the time, or keep it from energizing the solenoid at all. It’s more common for a transistor or diode to fail shorted than to fail open, so let’s look at the procedure to find shorted components.

Figures 1 and 2 show two simplified, generic solenoid driver circuits: one for a ground-controlled solenoid, and the other for a feed-controlled solenoid. An ECU may have either a clamping diode or a clamping zener diode, or it may have no internal diodes. Looking at these schematics, you can see that if a clamping diode or driver transistor shorted, the solenoid circuit would short to power or ground, depending on the circuit design and which type of clamping diode it has.

You can perform a quick test of a solenoid driver circuits at the ECU’s connector without opening the ECU:

- Get a wiring diagram or pin chart for the ECU so you can identify the pins.
- Unplug the ECU from the vehicle.
- Set your DMM to measure resistance, at the 1 megohm range or higher.
- Connect one lead to the suspect solenoid control pin.
- Connect the other lead to each of the battery + pins, one at a time.
- Measure the resistance for each pin.
- Repeat the test, with your probe still on the solenoid control pin, but now probe each ground (battery –) pin, and measure the resistance for each pin.

A normal reading will usually be 4000 ohms (4k ohms) or higher. The meter polarity — which terminal you probe with the positive or negative lead — doesn’t matter for this test. What you’re looking for is a low resistance reading; in many cases it can be less than 40 ohms. Shift solenoid driver circuits inside an ECU are usually identical, so test readings from one shift solenoid pin should be nearly identical to the others.

If you discover a low resistance reading, you can open the ECU to trace down the bad component. Follow the trace on the circuit board back from where it’s soldered to the pin until you come to the clamping diode or driver transistor. This is much like following a hydraulic passage through the case and separator plate in a transmission.

You can continue to trace the circuit through the board and continue on the other side, testing your concentration. Figure 3 shows an easy trace to follow: It stays on one side of the board and leads to the driver transistor and clamping zener diode.

The transistor has three terminals. When you find it, check the resistance between all three terminals. If only two terminals read shorted, the clamping diode is probably shorted. If all three terminals on the transistor read shorted, the transistor is probably shorted.

Next, carefully de-solder and remove the suspect component, to test it “out of circuit,” to verify that it’s failed.
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IMPORTANT: Before you remove any component from the board, always mark it or draw a diagram of it, so you can make sure you reinstall it facing the correct direction.

Testing a Diode or Transistor Out of Circuit

To test a diode:

- Set your DMM to the “Diode Test” function.
- Connect each meter test probe to a diode terminal and check the meter reading.
- Reverse the probes, and check the reading again.

A good diode will read about 0.5 to 0.8 volts (depending on the meter) with the negative probe on the “banded,” or cathode terminal (the one closest to the stripe on the diode body), and “OL” or open circuit with the positive probe on the cathode terminal. A shorted diode will read near zero volts both ways.

From a testing standpoint, a typical, bipolar transistor will look like two diodes connected together, as in figure 4. The base of a transistor would be the terminal that connects between the “diodes,” it isn’t always the center terminal on the transistor.

Set your DMM to the “Diode Check” function and measure between all three terminals of the transistor, reversing the test probes with each measurement. Any measurement should read either about 0.5 to 0.8 volts, or “OL” (out of limits). The main thing you are looking for is any reading that is zero, or near zero volts, indicating a shorted transistor.

It’s Alive!

In this last test, using a lab scope, we’ll check for a 5-volt supply and activity around the MCU (Microcontroller Unit). The MCU integrated circuit is a little computer itself; if it isn’t running, the ECU usually won’t function at all.

You’ll need a 20 MHz-or-higher lab scope and a 40 MHz-or-higher 10x probe. If your probe is selectable, make sure to set it to the 10x position; this will minimize the loading effect on the circuit. Next, you’ll need to power up the ECU. You can do this either by plugging it into the vehicle harness and turning the key on, or by connecting a 12-volt bench power supply to the ECU. If you use a power supply, make sure you connect to all of the battery positive pins, including those that are hot with the key on, and all of the power ground pins (battery –). Consult a wiring diagram or pin chart to be sure.

Next, identify the MCU on the circuit board. This is usually the largest or second largest integrated circuit on the board, and it has an oscillator crystal mounted close to it. The crystal will look like a little metal can, or a dipped component with two or three terminals. Figure 5 shows examples of both types of crystal. The crystal will usually have its frequency printed on it; most are between 1 and 20 megahertz.

Set your scope to 0.5 volts/division, DC. Set the time base to 0.5 microseconds/division. With a 10x probe, this will give you 5 volts per vertical division and 1 microsecond (1/1,000,000 second) per 2 horizontal divisions.

Connect the ground lead of your probe to a ground circuit on the board, or the power supply negative. Power up the ECU, and probe one of the pins on the MCU oscillator (figure 6). If the MCU oscillator is running, you should see a sinusoidal waveform about 4 to 5 volts high (figure 7). This is a good sign of life. This particular oscillator is running at 4 MHz, as there are 4 cycles of the waveform in 2 horizontal divisions. Probing random pins on the MCU, you should also find steady 5 volts or 5-volt logic on some pins. 5-volt logic will look like a scrambled, messy square wave on most oscilloscopes (figure 8).

If you don’t have access to a lab scope, a logic probe is a cheap alternative for looking for any activity on the MCU oscillator or pins. Radio Shack P/N 22-0303 will work just fine. A logic probe is also handy to check for data activity at the diagnostic connector and on the data busses.

If you don’t have 5 volts on any of the MCU pins, the 5-volt regulator circuit may be at fault. Some ECUs have a single 5-volt regulator that looks just like a transistor. It may have a “7805” or “78L05” part number printed on it. The regulator should have battery + (12 volts) on one terminal, 5 volts on another terminal, and 0 volts (ground) on the last. A bad 5-volt regulator or bad internal ECU ground can cause the voltage on 5-volt supply to be too high. Again, look carefully for cracked solder joints or burned traces on the circuit board.
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Where’s the 5-Volt Reference?

In some cases, the ECU will use the 5-volt reference from another module. This is common on Nissan vehicles. The transmission control module on a Nissan very often receives its 5-volt reference signal from the engine control module. This means that if the ECM is dead, or you power up a Nissan transmission controller by itself, it won’t have a 5-volt reference for the TPS and transmission temperature sensor circuits. The controller does have a separate 5-volt supply for its MCU and internal computer system.

As I mentioned in part one, remember to perform all ECU tests on a static dissipating service mat while wearing the attached wrist strap on your working hand. If you’re testing with a DMM, set it on the static mat, too.

That pretty much covers some of the basic testing you can do on an ECU. In the next issue of GEARS, we’ll look at how to diagnose and repair of a few common problems on a couple of transmission control modules, as well as what parts you need and where to get them. And after we’ve repaired one transmission controller in particular, it will be BETTER than new!