eSCOPE
Electronic Lab Scope

Training

eSCOPE ELITE4 Case Study - A Shift in Strategy
by Brandon Steckler

Understanding how vehicles' systems and/or components work is the essence of my job as a diagnostician, but it surely isn't the only challenge I face each day. Learning to utilize the tools at my disposal to prove or disprove a circuits functionality is equally as important. What isn't always discussed and is the basis for this case study is a computer's strategy, to determine if a circuit is functioning correctly. Some circuits are monitored for anticipated voltage potential dependent upon the state that the circuit is currently in (whether it is energized or not). Others look for a switched feedback like a pressure-switch for confirmation that a command was carried out. Some will perform action/reaction tests. The computer will monitor the output of another sensor to determine of a change was made, a rationality check. This response infers if the intended function was successful. This 2008 Dodge Grand Caravan (FIG A) has a yet another way of determining not only if a task was carried out, but just how "healthy" the circuits in question really is.

Fig. A

We begin with the subject vehicle arriving at the shop with and unrelated complaint of overheating and transmission fluid being spewed all over the engine compartment and chassis. The overheat and mess was due to a ruptured heater hose. The vehicle was repaired, and cooling system purged of air. Although the cooling system was tested (prior to repair) for the presence of combustion gasses in the cooling system, an extensive road test was carried out to further verify there was no underlying damage to the engine. At this point I pondered over what gave the customer the idea that "transmission fluid" was casted about. I realize some aren't familiar with all the fluids utilized in today's automobiles but in my mind, the unmistakable odor and color of vaporized antifreeze surely couldn't be mistaken for transmission fluid.

Post-repair and during the road test, proper operation of the thermostat and cooling fan was verified. I did however, notice that the engine exhibited what sounded like a higher than anticipated rpm (no tachometer in the cluster). I arrived back at the shop to top-off the cooling system and run a scan on the PCM (FIG B). A P0760 "Over Drive Solenoid circuit" was stored in memory. A second road test was carried out. To confirm my suspicions, I chose to monitor only four PIDs in a graphed format. This strategy allows me to enhance the loop speed of my scan tool as well as monitor only the PIDs I desire to see for comparative measure or action/reaction observation. It can be seen by the capture (FIG C) the engine rpm began to climb as the vehicle accelerated. At this point I noticed that the vehicle struggled to accelerate. The evidence is clear that the vehicle not only launched from a stop, from second gear but also maintained that gear ratio during the entire road test. I could also see that the PCM desired to keep the vehicle in the range. That trait right there, hints that the transmission is in a state of default or the PCM is not seeing a necessary input to command a taller gear and carry the transaxle through an upshift. I believe I just found the reason why the customer assumed the fluid spilled was from the transmission.

Fig. B

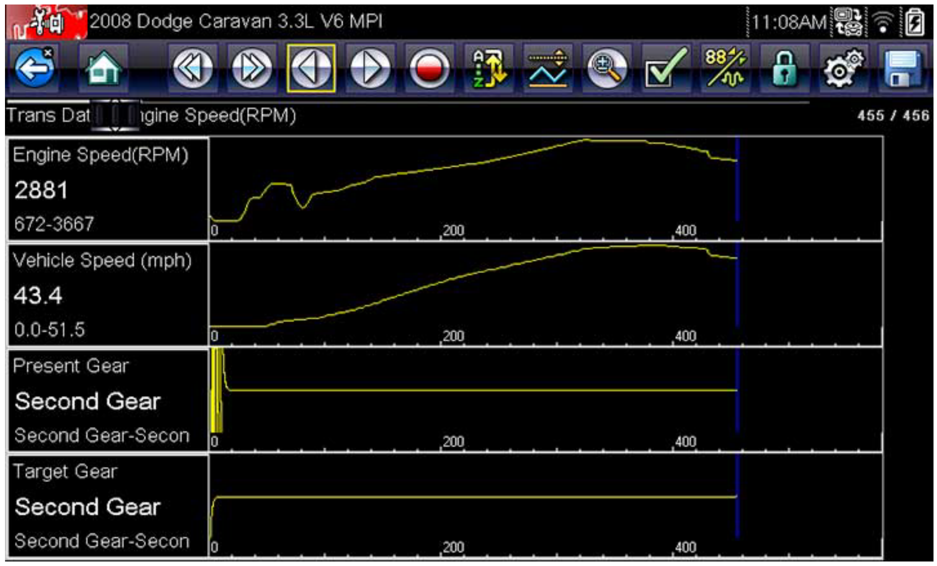


Fig. C

As I made my way back to the shop for a second time, I had started to develop a game plan to prove just why this PCM wouldn't allow an upshift to a more suitable gear ratio. I began with the first clue the PCM disclosed… "The DTC." I always begin with the description of the failure criteria as well as the theory and operation of the system. After all, there is certainly more than one way to skin a cat (FIG D). With this information in front of me, I'm allowed to think just like the PCM. I can then access a wiring diagram (FIG E) so that I may interface with the circuits necessary for carrying out the intended command as well as the circuits necessary to report the status of the circuit.

Theory of Operation

P0760-OD SOLENOID CIRCUIT

Four solenoids are used to control the friction elements (clutches). The continuity of the solenoid circuits is periodically tested. Each solenoid is turned on or off depending on its current state. An inductive spike should be detected by the PCM during this test. If no spike is detected, the circuit is tested again to verify the failure. In addition to the periodic testing, the solenoid circuits are tested if a gear ratio or pressure switch error occurs. In this case, one failure will result in the appropriate DTC being set. The MIL will illuminate and the transmission goes into neutral, if the DTC is set above 35 Km/h (22 mph), Limp-in mode when vehicle speed is below 35 Km/h (22 mph).

- **When Monitored:**

Initially at ignition on, then every 10 seconds thereafter. The solenoids will also be tested immediately after a gear ratio error or pressure switch error is detected.

- **Set Condition:**

Three consecutive solenoid continuity test failures, or one failure if test is run in response to a gear ratio or pressure switch error.

Fig. D

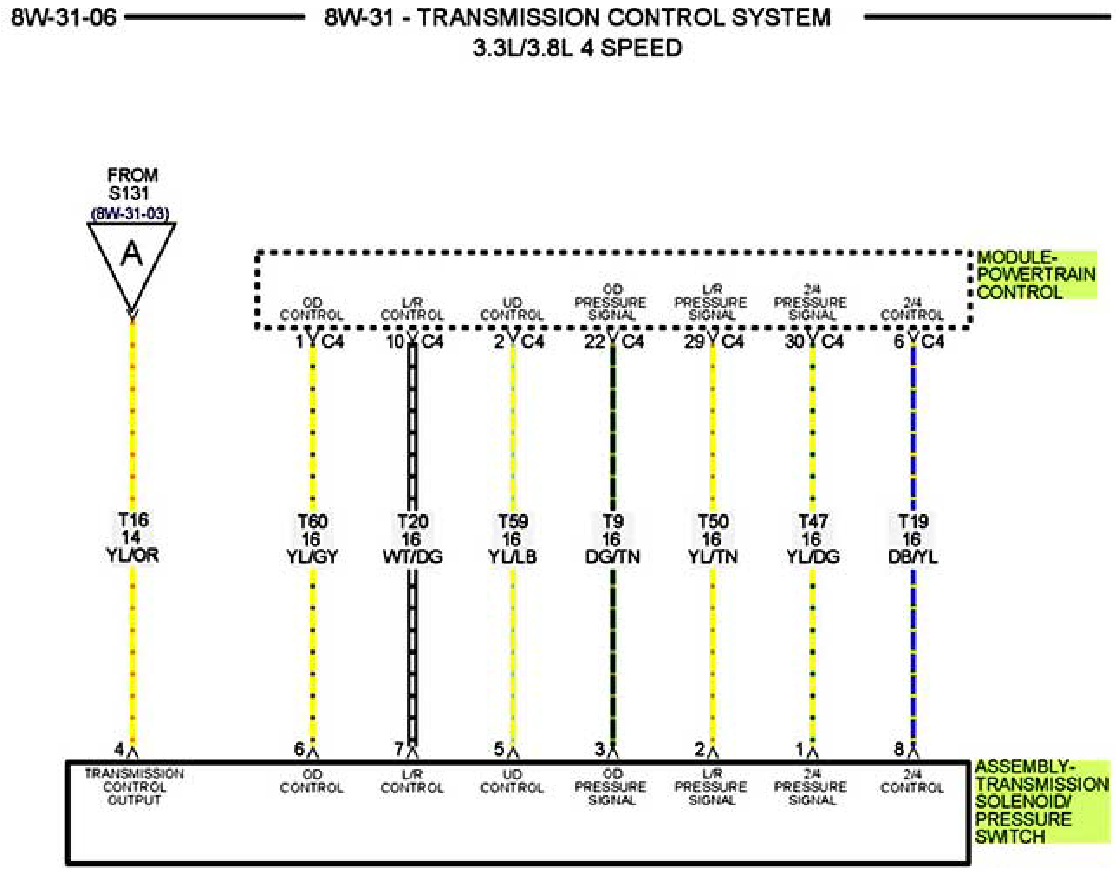


Fig. E

In theory, I can see if the PCM gave an order, see if the transmission intended to follow directions and watch for the confirmation the PCM needed to satisfy its desires. In this case, the circuits turn out to be one in the same. The same wires that are used to drive the solenoids are then being monitored to determine if the solenoids functioned or not…and we are going to discuss just how these tasks are performed. As can be seen in FIG D, the PCM watches for the inductive kick created by the transmission control solenoids. Let's step back for a moment. Solenoids work on the principal of ELECTROMAGNETISM. Said another way, when the circuit they lay in is energized, a magnetic field builds around the coil of wire contained within the solenoid. Centered within the coil of wire is a pintle, made of a ferrous metal, like iron. As the magnetic field builds, enough magnetic energy can be created to physically move the pintle off its seat, allowing to fluid to flow or preventing it from flowing. A by-product of a magnetic field occurs after the circuit is de-energized. This is what's known as an "inductive-kick". As the circuit is de-energized, the current flowing through the coil has now ceased. The magnetic field that was created, due to the current flow will begin to collapse. As it does so, the magnetic energy is converted back to electrical energy and a very large voltage is induced. The amount of voltage induced is proportional to the strength of the magnetic field. There are a few characteristics that will define this. Some of which include:

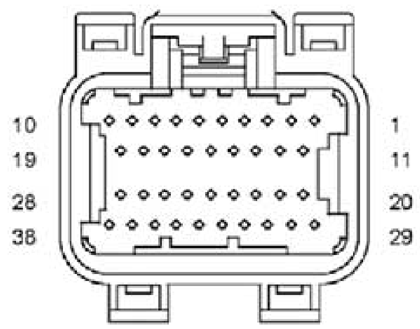
- resistance/current flowing through the circuit
- the amount of coil windings contained within the solenoid
- a fast turn-off speed (under 50uS) is considered sufficient to a good collapse

We capitalize on this very characteristic when the coil is used in an ignition system as this energy is multiplied and used to carry out the combustion process.

So, using a lab scope and an amp probe as the measuring devices (with suitable capture -capability), we can accurately detect if the circuits were energized, how much current was built upon each solenoid, the cleanliness of the turn-off (or de-energizing of the drive circuits) as well as the health of each individual solenoid's complete circuit… including the driver within the PCM. Here is the game plan…using the Pin-out of the PCM connect #C4, called out in the wiring diagram (FIG F), I will attach 4 channels of my lab scope to the drive circuits of all of the transaxle's control solenoids. I will cycle the ignition key and monitor the circuits simultaneously as the PCM carries out its self tests of the circuits. This is the same test carried out that initiated the MIL and DTC for the Over-Drive control solenoid circuit. The idea of watching all the solenoids has a lot to do with research. The fact that I haven't encountered these circuits before (at least not on this vehicle configuration) says I may not have the experience to notice subtle differences in the waveforms exhibited. That may mean the difference between not recognizing a "pass" from a "fail". Capturing not only the suspect circuit, but also the "good" ones allows for a comparison and is certainly a more fool-proof form of analysis.

Pin	Circuit	Description
1	T60 16YL/GY	OD CONTROL
2	T59 16YL/LB	UD CONTROL
3	T84 16DG/TN	EMC SOLENOID CONTROL
4	T82 16DG/OR	DC CONTROL
5	T83 16DG/GY	DC PRESSURE SIGNAL
6	T19 16DB/YL	2/4 CONTROL
7	-	-
8	T80 16DG/YL	LC CONTROL
9	-	-
10	T20 16DG/WT	L/R CONTROL
10	T20 16WT/DG	L/R CONTROL
11	T118 18DG	LP VFS CONTROL
11	T118 16DG	LP VFS CONTROL
12	Z901 16BK	GROUND
13	Z901 16BK	GROUND

Fig. F



MODULE-
POWERTRAIN
CONTROL C4

Referring to Figure G, I interfaced my scope to the circuits called out in FIG F, to the correlating color. The key was cycled, and the test was carried out by the PCM. Shown here (FIG H) is the test carried out with all solenoids' circuits displayed simultaneously. This is simply showing all of the circuits' activity superimposed upon one another. It certainly doesn't make for proper analysis. The next three subsequent FIGs will display the same test with the scope traces turned on, one at a time, for clarity. THEY ARE NOT DIFFERENT CAPTURES. All of these solenoid's circuits display similar activity (FIG I, J, K,). All are toggled to ground by the PCM very rapidly and when they are released, we can see that an inductive kick occurs.

Fig. G

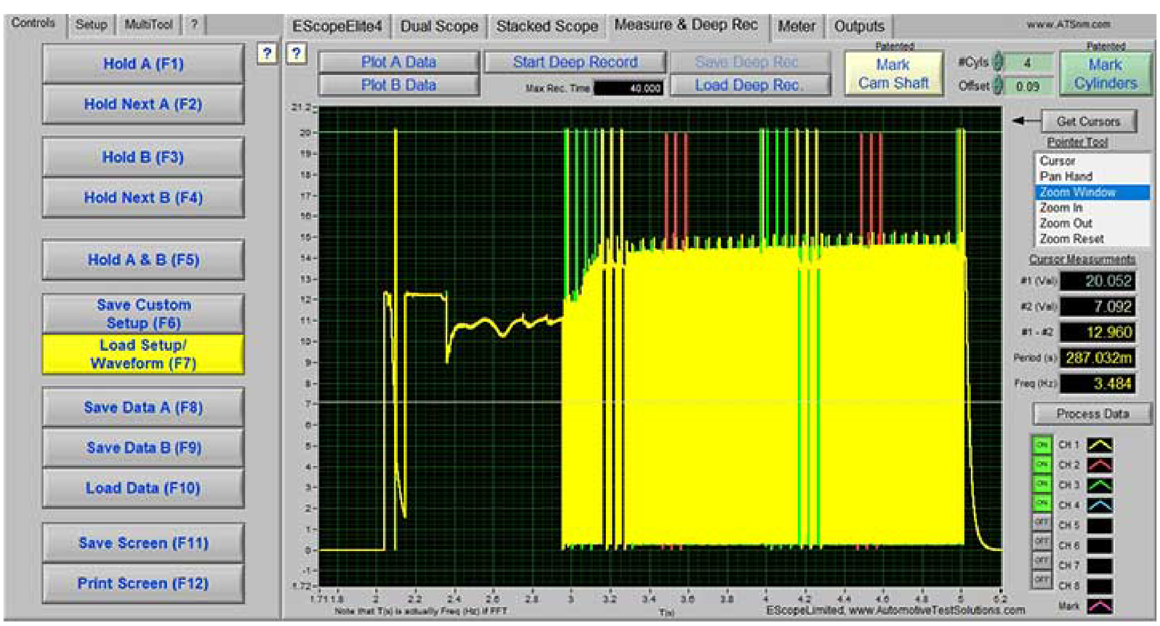


Fig. H

These three captures indicate:

-The circuits are complete (no "opens")
-The PCM can pull them low (to ground/energize them)
-The drivers as well as the solenoids are in good health (inductive kick that resulted at turn-off).

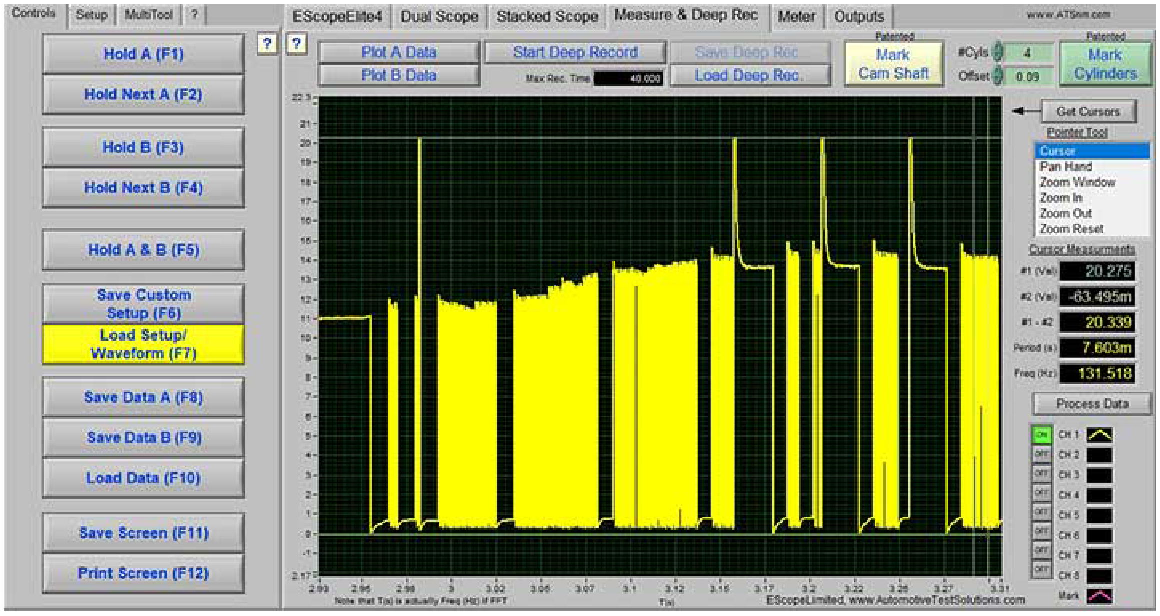


Fig. I

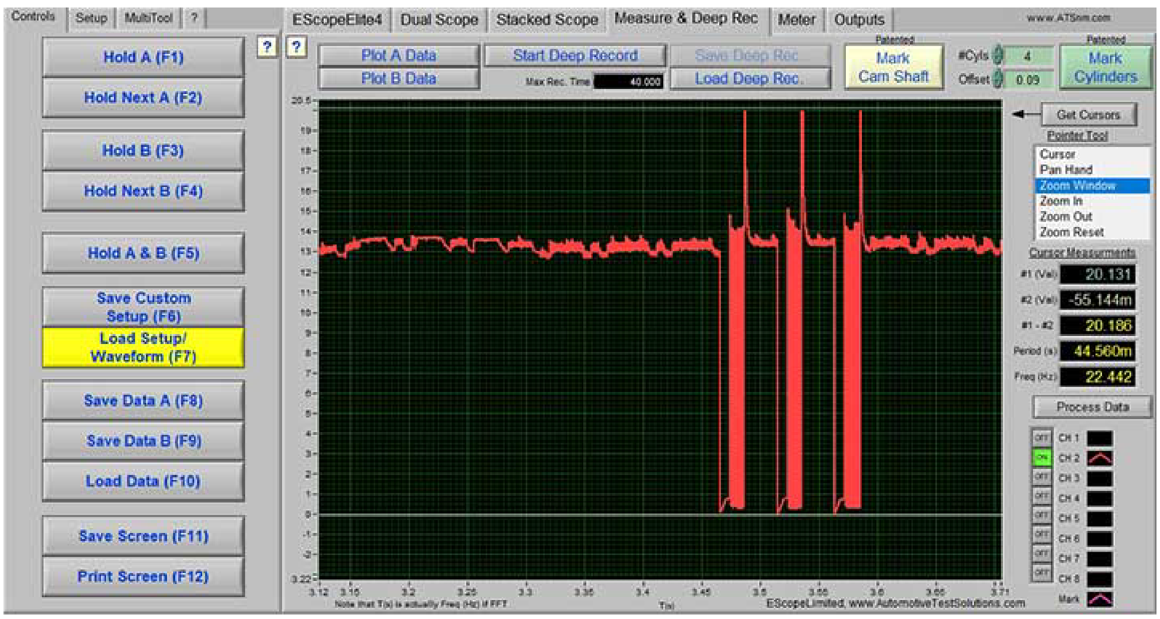


Fig. J

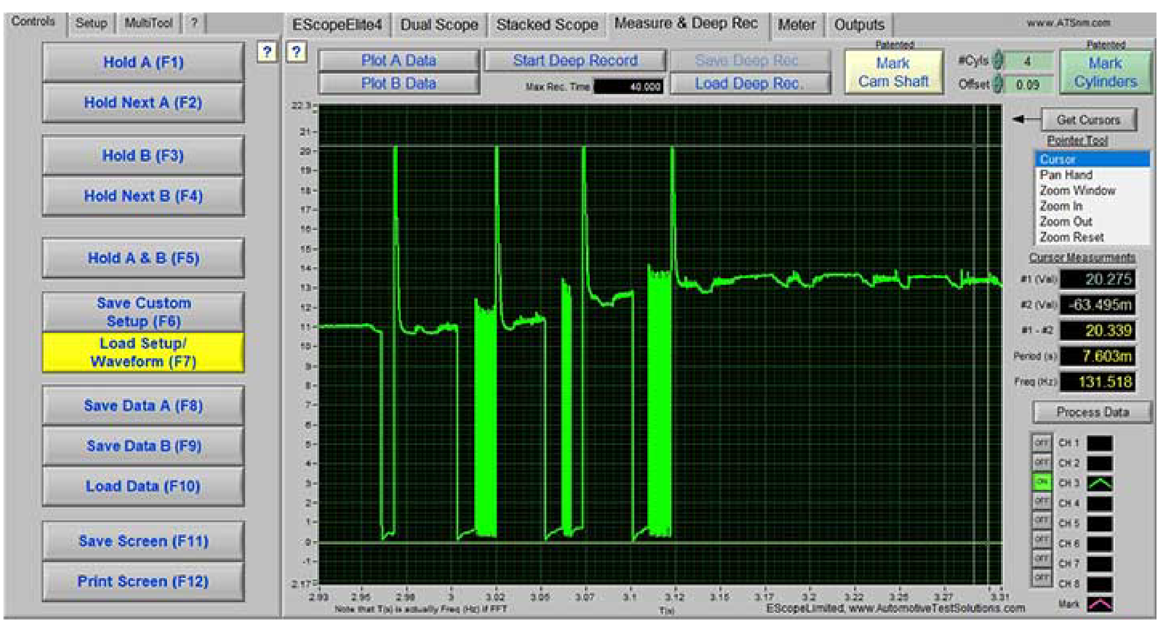


Fig. K

This final blue trace (FIG L) tells a slightly different tail. We can see after start-up that the blue trace remains close to system voltage. This indicates two things:

- The circuit is complete to the test-point (no "opens")
- There is no path to ground being created

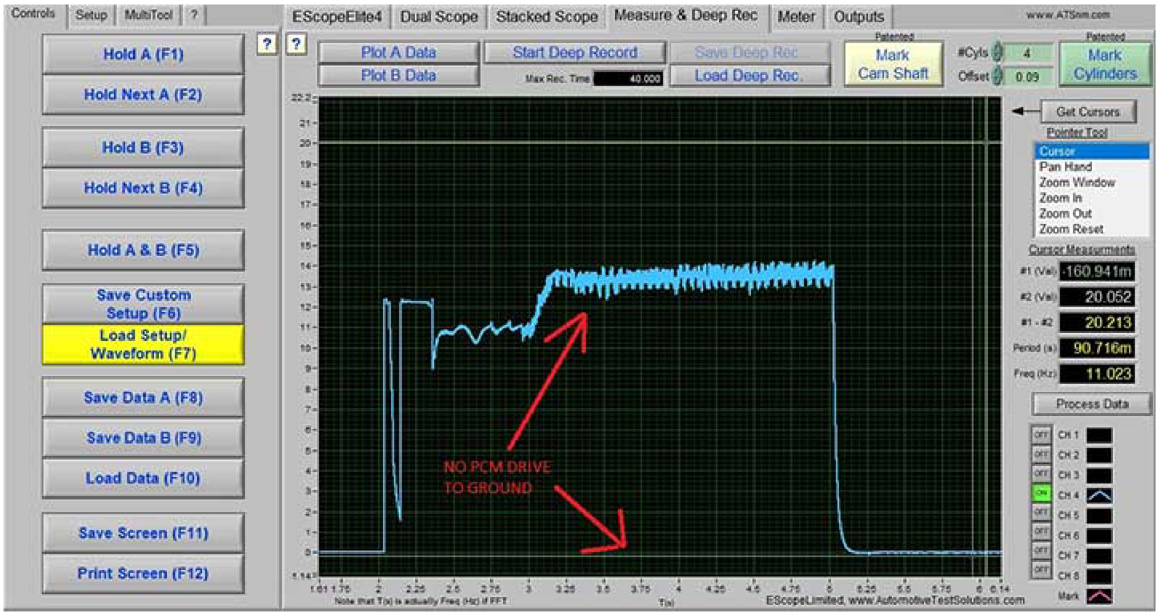


Fig. L

Of course, no inductive kick can be created if the PCM never energizes the circuit, right? So, assuming we are not dealing with terminal-fretting or poor pin-fitment the question then becomes "the chicken or the egg"? What I mean is … Is the PCM at fault or did a faulty solenoid (in the transaxle) short-circuit and overload the driver? Then the question becomes, how can we prove-out the solenoid without a functional driver or PCM to tell us "it's bad"?

Understanding the circuit functionality simply means the PCM creates the path to ground for each solenoid. So long as I have a clean path to ground, I can monitor the circuit as its energized /de-energized, allowing me to watch for inductive-kick of each solenoid for comparison. Simultaneously, I can monitor the circuit current flow during each solenoid event, to further compare each solenoid to one another. That will effectively allow me to cast a "GUILTY" or "NOT-GUILTY" call at my solenoid on the charge of murdering this Dodge's PCM.

Here I am, (FIG M) about ready to complete the path to ground for each solenoid being tested. Again, we will be looking for the circuits being:

- pulled to ground
- current flowing
- inductive kick as the ground path is removed

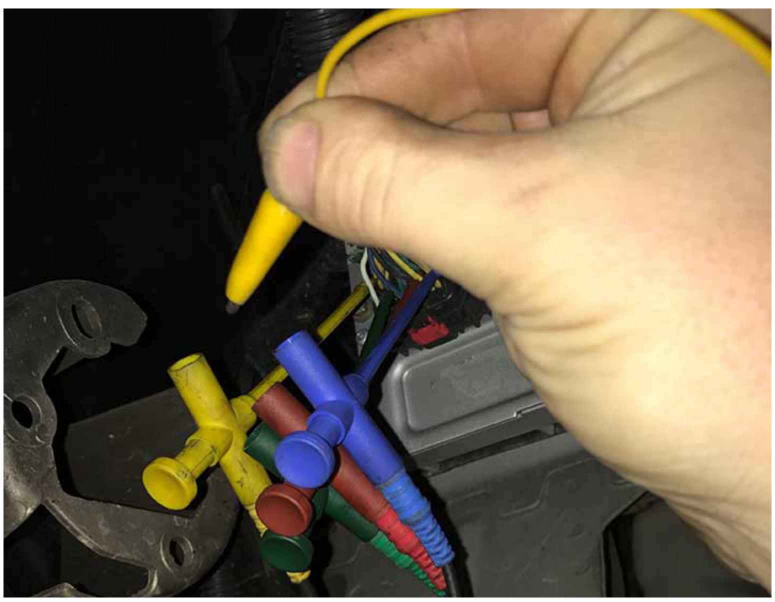


Fig. M

Here is a capture of a known-good solenoid (one that passed the PCMs self-test) as I provide a substitute ground-path (FIG N). We can see all the characteristics of a healthy solenoid, just as we should've anticipated seeing. Strong current flow and a decent inductive-kick. (FIG O). Here is a capture of the suspect-solenoid, under the same test conditions. It too, displays virtually the same characteristics. After confirming the terminals between my test point and the PCM were tested for integrity, a PCM was installed, programmed. A final road test was carried out (FIG P) and as you can see, the PCM is satisfied as proper shifting has been reinstated. This vehicle is repaired, and I can sleep comfortably knowing that the PCM solenoid driver was dead due to know fault of any other player in this game. It only has itself to blame.

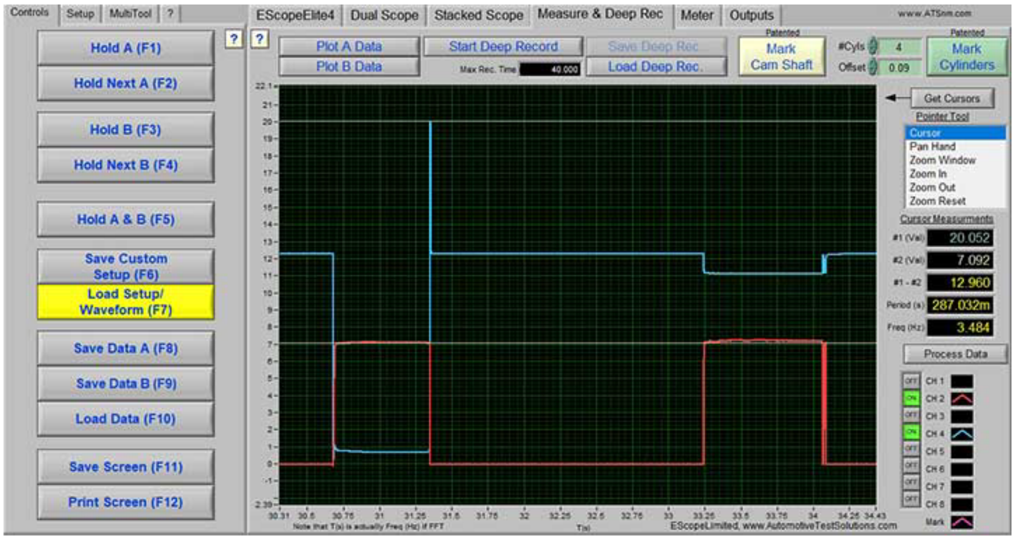


Fig. N

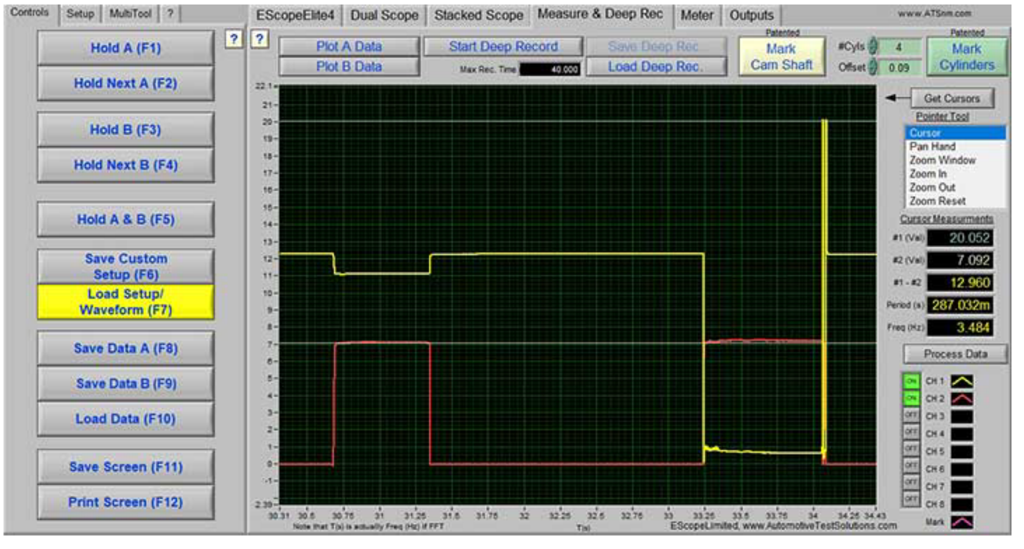


Fig. O

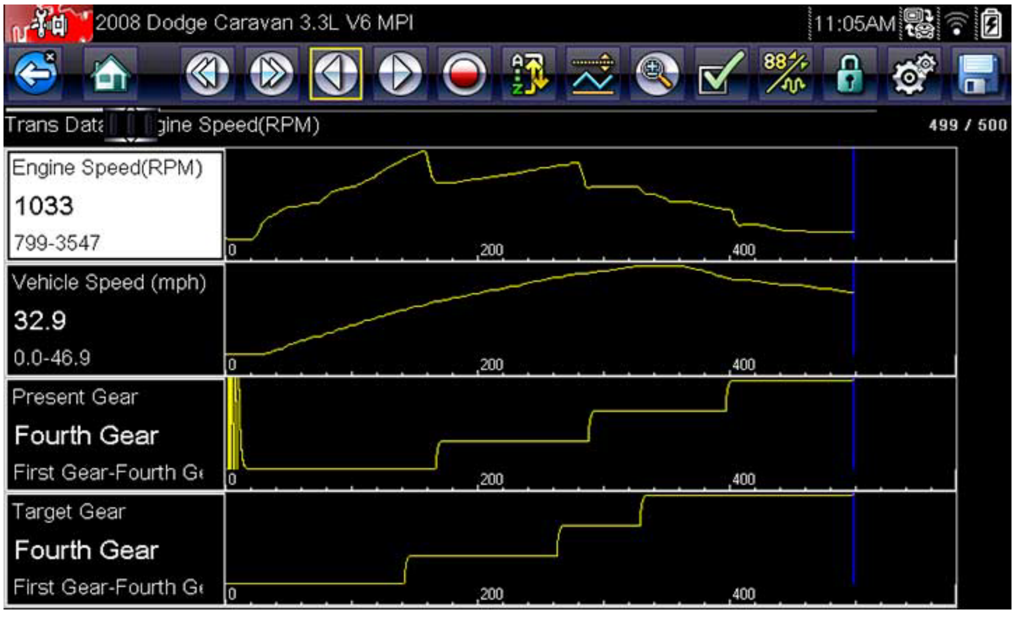


Fig. P

Using a combination of logic, testing technique as well as the capable tools, with a little bit of need-to know-info you can make comparative measures to determine if a PCM failure is truly the cause or effect…and THAT is difference between a satisfied customer and a comeback!