SCAN TOOLS, O-SCOPES AND TOOTHPICKS

Comprehensive PCM operating strategy outlines aren't written down anywhere, but it would help if they were.

BY RICHARD MCCUISTIAN, CONTRIBUTING EDITOR

Those who have been following *Motor Age* Garage articles for the past few years may remember this red Jeep Cherokee from the August 2003 issue (page 14). The 4.0L had an oil pressure problem, and two of my students repaired it by replacing the cam bearings. That was 47,000 miles ago, and the oil pressure problem is ancient history. However, I got a call from my buddy at the tire store about the Jeep.

The concern was that the Jeep was misfiring on a couple of cylinders, but the problem was intermittent. The tire store tech and I didn't discuss it as extensively as we could have, but in the end, he swapped the crank sensor and the spark plugs and sent the owner on his way.

The tire store guys I know are very good at brakes, suspension, vibrations and front-end work, but they really don't have the time or inclination to chase an intermittent drivability concern. So when the Jeep came wheeling back in, he called me to see if I was willing to tackle the problem. It sounded interesting, so I told the serviceman to bring the Cherokee by and I would try to duplicate the problem myself.

DROPPING COMPANIONS

I couldn't give the Jeep an in-depth exam because my primary scan tool was at the repair center to have the software reloaded. Thus, the only tool I had on hand that would communicate with the vehicle wasn't my tool of choice and had only limited functionality at best on that platform.

The pilot said the Jeep had run just fine during the 30-mile drive to the college and that he wasn't sure we would be able to duplicate the concern when he got there. While we talked, I took a quick look under the hood.

One thing I pay particular attention to on 4.0L Jeeps is the cam sensor synchronizer. If anybody has moved it, the previous marks of the anchor area are apparent. However, sometimes the shaft will try to gall and turn the cam sensor synchronizer as well, and when that happens, you can generally see a short scratch on the anchor area that was made when the synchronizer movement occurred. In most cases, the shaft locks completely, destroying the driven gear, and the engine won't even start. I saw none of that, so we drove the Jeep. In only a short distance, the concern appeared. At first, the Jeep began bucking like it had a spark leaking past a plug boot, but the further we went, the worse it ran.

"All you have to do in order to correct this is switch the Jeep off and restart it," he told me.

I didn't want to do that because I was anxious to see what was going on, so I carefully limped the Jeep back to the shop and popped the hood. The 4.0L had dropped four cylinders. The fact that it would even run on two cylinders was astounding. I began disconnecting injectors to determine which cylinders were silent, and I found that the only ones popping were numbers 3 and 4.

In the midst of my testing, the engine stalled, and when it was restarted, the problem had evaporated. Another test drive failed to reproduce the anomaly, although I did manage to use a cheap generic scan tool to squeeze a coil primary circuit code (P0353) and a (P1391) "loss of cam or crank signal" code out of it. This appeared to be heat-related, which conjures up a host of possibilities. If the cam sensor is dead or disconnected, the engine won't start. But the engine will keep running if the cam signal is lost.

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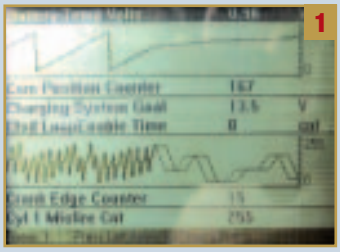
All photos: Richard McCuistian

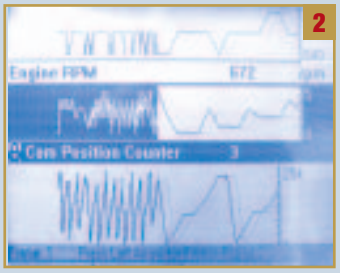
A PREVIOUS GARAGE VEHICLE RETURNS

VEHICLE: 2000 Jeep Cherokee
MILEAGE: 86,453 miles
DRIVETRAIN: 4.0L engine, automatic transmission
COMPLAINT: "Sputters" while driving.

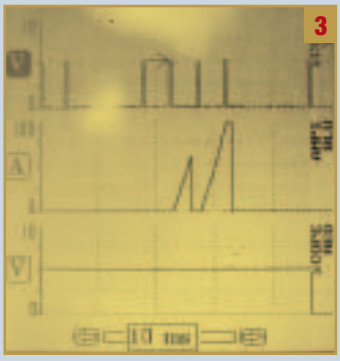
A LOOK AT THE NUMBERS



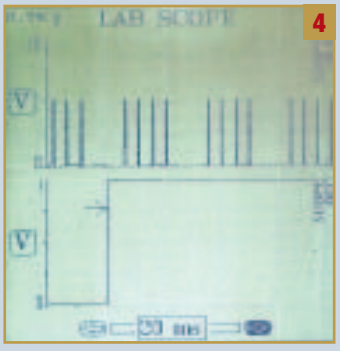
1. These are normal cam and crank counter graphs as fed to the scan tool by the PCM. The seeming double trace on the right side of the lower graph is a photo anomaly due to the rapidly moving lines on that part of the graph. The left side of the graph on the scan tool compresses the data automatically.



2. This Cam Position Counter pattern (center graph) eventually deteriorated and went completely flat, in spite of the fact that I had a good clean square wave signal present at the PCM terminal in question. To further complicate my thinking, this PCM did the same thing on my personal vehicle later that day.



3. The top graph pattern on this oscilloscope is the crank sensor signal. Graph number two is a current ramp picture of what the PCM was doing with one of the primary circuits. The bottom trace is the cam signal. Pay close attention to where the cam signal is in relation to the crank signal on the top graph. The Jeep 4.0L flywheel ring has three sets of four holes spaced 120 degrees apart; thus, there are three groups of four like this in a complete revolution.



4. This is what the cam sync signal (bottom trace) should look like in relation to the crank signal. It should correspond with a point about halfway between two of the sets of four in the flat spot. I turned the cam synchronizer just like you'd turn a distributor to set the timing, but was watching the scope instead of a timing light.

My students were trickling in, so I told the Cherokee's owner that if I was going to make a wild guess, I'd say the rail coil assembly was going sour, based on the fact that the dead cylinders were all companions (1/6, 2/5). You may be asking, "What about the fact that the engine skip disappeared on restart?" The Jeep's powertrain control module (PCM) kills injectors on misfiring cylinders in an attempt to preserve the catalyst and leaves them offline until the engine is restarted. Thus a malfunctioning coil rail could cause the injectors to drop out in companion pairs the way this 4.0L was doing.

NEW RAIL COIL, NO CHANGE

I was tired of not having a serviceable scan tool, so I requisitioned and bought two scan tools that week. It was a good thing I did. I bumped into the Apache pilot and got his report on the Jeep: "I drove it around quite a bit with the new coil rail on it. I thought it was fixed, but it started sputtering again."

I decided that an auto mechanics instructor needs to tangle with one of these jobs once in a while to stay sharp and remain professionally developed. We filled out the proper paperwork, and he left the Jeep with me.

I studied the scan tool cam and crank counters on my new scan tool's screen to get a feel for what I was looking at, but saw no concern. On Friday, I let it idle all morning to get it good and hot, then drove it to lunch. I've learned that, frequently, a vehicle

will be more prone to exhibit an intermittent concern when you aren't driving the vehicle just for the purpose of finding it; I drove it like it was my own. Well, it ran great all the way to the burger place that day. I allowed the Jeep to hot soak while I ate my lunch. The Jeep ran great almost all the way back to the college before it started misfiring and then stalled.

Knowing that the students leave just before noon on Fridays, I spent my free time fiddling with it. With the new scan tool connected and peering into the OEM datastream, I noticed the cam sensor counter appeared erratic and then flattened out completely while I was watching it.

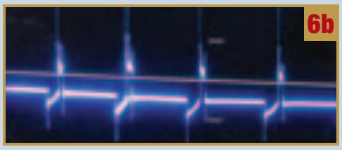
Remembering the loss of cam sensor code, I wasn't surprised. I had another cam sensor on hand, but installing the new sensor did nothing to produce anything less flat on the datastream. Connecting my PDA handheld scope to the cam sensor signal wire (I had to split the tape at the PCM connector), I found a good square wave cam signal all the way to the PCM. The signal was making it to the PCM, but the PCM wasn't sending counter information out to the scan tool.

It was time for me to leave for the week, so I plugged the problem Jeep's PCM into the harness on my personal vehicle along with the scan tool. (I left my PCM mounted for easy reconnection.) About 10 miles into my journey home, the scan tool showed a flat cam sensor signal. This seemed to indicate a PCM concern, but for the entire weekend, that was the only time I saw a flat cam signal and my Jeep never ran badly or stalled.

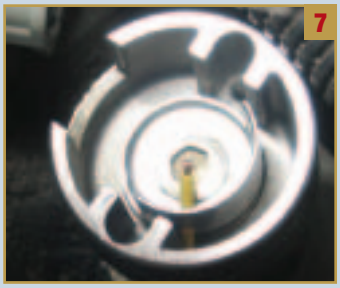
I wasn't at all satisfied. I didn't want to throw an expensive part at the problem before I was sure. Too many PCMs have been changed for no good reason, and I didn't want to go there.

DEEPER INTO THE SYSTEMS

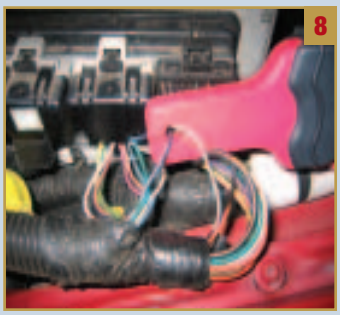
5. This was my "thinking outside the box" way of getting a secondary signal: Because I had already clipped the primary wires at the PCM and run a temporary overlay using a spare connector that would plug into the original coil rail, I simply put a different connector on that same overlay harness. I did some checking to find out which coil was which, plugged it into the Explorer's coil pack and fired the Jeep up on the Explorer's coil pack.



6A & 6B. The top scope pattern (6a) showed double spark lines and looked pretty regular, so I initially drew the false conclusion that the Jeep was designed for repetitive spark at idle like some other vehicles. One caveat was that this double pattern would come and go on its own and the sound of the engine would change. Adjusting the cam sensor made an immediate difference in the pattern (6b) and solved all the Jeep's problems. Kudos to Glenn Young!



7. Whenever you're working on a Cherokee or a Grand Cherokee and you want to eliminate one possible cause of a peculiar drivability complaint, it doesn't cost much to put the crank on zero TDC compression and turn the cam synchronizer so the hole in the housing lines up with the hole in the vane, just as illustrated. After performing the scope procedure, I rolled the 4.0L to zero and found that these holes were perfectly aligned. I could have done this when the Jeep first arrived and fixed the problem, but I wouldn't have had such an interesting story to tell.



8. One more thing: If you want a nice parade pattern on your single-trace scope of either coil or injector current ramps on a problem engine, give this little trick a try. Run all the wires through the inductive lead, and the scope will sort them out across its time scale. This inductive probe is available from most automotive electronics tool suppliers for about $150 and can be used with either an o-scope or a multimeter.

DIGGING DEEPER

By Monday afternoon, the Jeep had deteriorated to the point that the problem was almost always present, even with the engine cold. The engine would idle just fine but as soon as the throttle was opened, the PCM would drop injector pulse to first one pair of cylinders, then another. Then it would stall. What was interesting is that it didn't always throw the Cam/Crank code, but it virtually always threw ignition coil primary circuit codes and I cleared them each time.

What was I supposed to think? Aren't those codes there to give us some direction? If that wasn't enough,

All photos: Richard McCuistian

I kept getting a transmission fault code – a development that muddied the water even more. Having experienced shorts in transmission circuits (the same reference voltage wire that feeds the cam and crank sensors goes to the Vehicle Speed Sensor), I disconnected the transmission wire harness but to no avail. The problem was still there. I quickly clipped the coil primary wires at the PCM and ran a new wiring overlay to the rail coil but accomplished nothing.

I inspected the crank sensor wiring but found nothing pinched, chafed or lying against a hot pipe. I used my PDA to check the current ramping pattern on the coils; all three circuits can be passed through the probe for a nice parade pattern on the scope. I found that each coil was intermittently giving two current ramps.

Was the Jeep actually supposed to have repetitive spark at idle? I didn't know, but the Ford Crown Victoria and Escort do. It makes the engine idle smoother and cleaner, but the repetitive spark evaporates as soon as the throttle is cracked. This was new information. However, the fact that the current ramps remained strong even as the engine was dropping cylinders indicated that the primary circuits were still intact: An open circuit provides no current ramp, although a shorted circuit might provide one. But this harness was short, easy to inspect and pristine, so I discarded the primary circuit short idea for the time being.

I decided to install a different type of ignition coil pack. I removed the coil rail, put a different coil primary connector on my overlay, and wired a 1998 Ford Explorer coil pack so the Jeep could start and run on the Explorer coil. I connected a set of secondary leads to the plugs. Now I could access the secondary with my ignition oscilloscope.

The vehicle ran the same way, which eliminated the new coil rail he had purchased as a possible source of the problem. But now I was able to connect the ignition o-scope and watch the secondary pattern while the stall-stumble was under way. The o-scope agreed with the PDA: There were indeed two firing spikes per spark plug. But the second spike

seemed to come and go, and when it did, the sound of the engine would change. This was getting downright weird. Did the Jeep have repetitive spark or didn't it? The book didn't say so, but as far as I've been able to tell, the Ford shop manuals don't mention it on those cars either.

BREAKTHROUGH

While I was fighting with the scopes and scan tools, my friend Glen Young called. Glen also has a shop of his own and teaches technical classes.

"Glen," I broached, "let me run something by you." I described my trouble with the Jeep and his answer was simple.

"When I reach the end of my thought processes on something like that, I check the cam sensor synchronization with the scope," he said.

Well, that was fine, but short of splitting the wire harness on my own Jeep and making a comparison, which I could do if necessary, I had no idea what to look for.

"I haven't seen anything on that [problem] on paper anywhere. What is it supposed to look like?" I asked.

Glen described what I should be looking for, and when I went back to the Jeep and adjusted the cam synchronizer to match the pattern, every one of the engine's problems went away, including the bogus repetitive spark pattern. I felt silly.

Bringing the crankshaft around to zero degrees top dead center (TDC) compression, I removed the cam sensor and checked the hole in the vane where it was supposed to line up with the hole in the housing by inserting a toothpick through both holes. I've performed that operation dozens of times and never even thought about doing it on this Jeep because the cam synchronizer hadn't been touched for 47,000 miles. There is a utility in the DRB III scan tool for synchronizing the sensor, but I've found that the toothpick method works best – believe it or not.

Normal timing chain stretch must have allowed the cam sensor to work itself slightly out of line, and the rest is history. It was a perfect match. I had gone through fire and flood all week long, and the whole time I could have fixed it with a toothpick. MA

MOTOR AGE GARAGE TEST 499 7/05

2000 Jeep Cherokee that sputters while driving

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Have you ever taken a *Motor Age* Garage test prior to this one? ☐ Yes ☐ No

1. Technician A says that, as a general rule, there is no direct electrical connection between the primary and secondary windings on distributorless ignition system coil packs. Technician B says that if one spark plug wire is disconnected from a distributorless ignition coil, the companion tower on that coil will not fire. Who is correct?

a. Tech A **b.** Tech B **c.** Both **d.** Neither

2. Which of the following reasons for a cylinder misfire is least likely to raise hydrocarbon emissions?

a. A fouled spark plug. **b.** A shorted spark plug wire. **c.** An injector that is stuck open. **d.** Low fuel pressure.

3. On the 4.0L straight-six engine, when cylinder #1 is on its compression stroke, cylinder #6 is on:

a. Compression **b.** Intake **c.** Exhaust **d.** Power

4. Technician A says the cam sensor signal is necessary for the 4.0L to start, but that the vehicle will run with the sensor unplugged. Technician B says the crank sensor produces an analog rather than a digital signal. Who is correct?

a. Tech A **b.** Tech B **c.** Both **d.** Neither

5. A PCM is believed to have a burned-out injector driver. Technician A says a known-good PCM from a similar vehicle should be connected to the problem vehicle to solidify the diagnosis. Technician B says the circuit controlled by the burned-out driver should be checked for a short. Who is correct?

a. Tech A **b.** Tech B **c.** Both **d.** Neither

6. Technician A says there is no reason to check the ignition timing on an engine with no timing adjustment. Technician B says that if the crank sensor reluctor wheel is mounted on the harmonic balancer, a loose harmonic balancer retainer bolt can adversely affect ignition timing, even if the timing is not adjustable. Who is correct?

a. Tech A **b.** Tech B **c.** Both **d.** Neither

7. Engine vacuum reads 13 inches at a no-load idle on a 318 Dodge pickup engine. The engine starts a little hard and runs somewhat sluggish, but doesn't smoke. The ignition timing has been properly adjusted and the cylinders have an average compression of 130 pounds with very little variation between cylinders. Technician A says retarded valve timing due to a stretched timing chain may be the problem. Technician B says timing chain stretch can be checked without removing the timing cover. Who is correct?

a. Tech A **b.** Tech B **c.** Both **d.** Neither

8. Advanced ignition timing can cause:

a. Hard-starting.
b. Ping/detonation.
c. Piston damage.
d. Any or all of the above.

9. Which of the following is least likely to cause poor fuel economy?

a. Low fuel pressure.
b. Late ignition timing.
c. Running boards, a luggage rack and a bug shield.
d. A cell phone mounted too near the PCM.

10. Technician A says some vehicles with an unreliable cam sensor may actually run better with the sensor connector unplugged. Technician B says some vehicles may use a different fuel strategy and illuminate the MIL but may run just fine with the cam sensor disconnected. Who is correct?

a. Tech A **b.** Tech B **c**. Both **d.** Neither

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