Repair Shop CONFIDENTIAL

Episode Two: *The Case of the Two-Stepping TPS*

When you are the world's greatest automotive detective, you meet all kinds of guys. Well, guys like Dave. That's *Dave* as in "Dave's Transmission City," formerly "Dave's Lifetime Brake & Muffler," still earlier "Dave's International Auto Repair," "Dave's Dependable Towing," "Dave's Quality Detailing" and so on back through a long chain of sequentially failed automotive businesses. Dave was a guy who scampered along the fine line between *ne'er-do-well* and *loser*. Our introduction had been a little strained, I guess — since I testified against him in a mechanical malpractice case that precipitated one of his many fundamental changes of business plan. I would never have expected him to become my client.

When he showed up on my doorstep I figured he had to be a very forgiving person. Or very forgetful. Or maybe really desperate. Turns out he was all of those things — the last, mostly. He'd been deep inside this transmission for nearly two weeks and still couldn't get a handle on its workings. Now a guy can make a mistake rebuilding an auto trans the first time he does it. Maybe make the same mistake the next time. But by the third time, he's got his dial indicator and service manual out and is really working them both. Dave was well beyond that third time. He was at the far deep end of *desperate.* That's why I call this:

The Case of the Two-Stepping TPS

Dave sounded more than a little frustrated. "I know you don't do transmissions, but I've got this Hyundai out here. I rebuilt the transmission myself, so I know it's mechanically *perfect* inside. In fact, I went through it a couple more times to check. But it's one of those computer-controlled trannies, and sometimes it shifts weird. *Must* be an electronic problem. Got any bright ideas?"

"Dave," I answered, "it could be dozens of things. The only way to find out is run tests and do some diagnostic thinking. My tests and diagnosis cost two cents a second — that's $72 an hour. There's no way to give you an answer from just what you've told me."

"Well," Dave said, "if you can figure it out and tell me what to do to fix it, I'll pay for your time."

Bingo! Dave had said the magic word. You can't buy me, but you can rent me — for $72 an hour. I explained to Dave we could stand around jawing all day if he wanted to — on his tab. Or we could take a drive in the car, and he could fill me in as we rode. He saw the wisdom (and the economy) in my suggestion. So I grabbed my Snap-on MT2500 Scanner and was ready to go.

The 'victim' was a '96 Hyundai Accent, white, four-door if that matters. The car looked good — no rust, no dents. Somebody had kept it clean, even waxed it once or twice. The fenders were straight.

The tires still had good tread on 'em. No keystripes, no illegible graffiti. Not even any bulletholes or stab wounds I could see. A nice little family car. Started right up. Sounded okay. The A/C kicked right in. I started off behind the wheel while Dave spilled his guts to explain how he ended up in my driveway.

Dave had bought the car cheap from somebody who told him it needed a trans. So first thing, Dave tore right into it. He had to admit he didn't find anything much wrong inside. "Just a couple worn clutches." He got it back together and gave it to his wife to drive. That's when everything started to unravel. He said she couldn't explain what was wrong, only that it wasn't right. He went into the trans again. This time there *really* was nothing wrong. But by then Dave had gotten himself behind the wheel of a Hyundai long-term because the wife grabbed his pickup and wasn't going to part with it until the Hyundai was fixed.

I listened while I drove. The Accent seemed a little flat on acceleration, but I didn't feel anything else terribly wrong. "Dave," I asked him flat-out, "What am I fixing? This car works."

"Just wait," he said, "It'll get all weird if you just drive it." We drove a couple more miles, and Dave kept talking. And my meter kept ticking over at two cents a second.

He had called some guys he knew at the local Hyundai dealership, and they suggested Dave look at the transmission's pulse generators. So he bought new ones and installed them. Which made no difference. Of course they made no difference: Pulse generators rarely go bad.

What the dealership guys had surely told Dave was to *look at* the pulse generators, not to *replace* them. The most common failure for transmission pulse generators is an open circuit caused by a gradual loosening of the connection to the main harness.

The fix is simple, and it works not just for pulse generators but also for a TPS, MAF, ISC or even for that electric drill you bought at the garage sale. Anything with a male-female electrical connector. Just twist the male terminal slightly. This makes the male terminal fit tightly against the sides of the female terminal, ensuring the electrical connection.

The trans computer uses pulse-generator data as inputs. This allows the computer to track the gear-speeds inside the trans. The computer uses this information as one factor in deciding which gear you get in a given set of circumstances. If the trans computer loses this information through a loose connection, it doesn't know what's going on with the gearsets, so it defaults to its failsafe program. On a Hyundai, failsafe is third gear. So an unexpected drop to third would point to the pulse generator connectors.

Finally, it acted up. We'd gone maybe ten miles when it downshifted. One minute we were cruising along at forty in fourth, then *Bang!* It felt like a downshift to second to me, which would rule out failsafe mode.

I asked Dave, "Did it do this before you rebuilt the trans?" He didn't know because he never bothered to test drive it before he tore into it. Ah! A long time ago, a really smart mechanic told me there are three things you *always* test drive *before* you start to fix 'em — alignments, carburetors and automatic transmissions. Dave should have met this guy and listened to him.

The transmission pulse generator. An iron core, copper windings, a plastic body with an O-ring and some connecting wires. No moving parts, nothing to wear out. Or so you would think. Sometimes the O-ring hardens and leaks. Sometimes the wires get cut in an accident. Once in a very great while, a winding will open or short, rendering the unit useless. The most common circuit failure is not a pulse-generator failure at all. The connection between the pulse generators and the main harness may deteriorate from vibration, so the transmission control unit loses contact with the pulse generators.

Here's an easy check if you suspect a loose wiring connection. Key-on/engine-off, pull up the pulse generators on your scan tool. Without removing the pulse generators from the trans, hold the body of an electric engraving tool against the exposed portion of a pulse generator. This should induce a voltage in the pulse generator's coil, which will in turn produce a reading on your scan tool. Now, wiggle the connector where it joins the main harness. A loose connection will make the scan tool reading drop in and out, as contact is made and broken. Repeat the process with the other pulse generator.

You don't have to use an engraving tool for this test, an electric soldering gun is just as effective, but it requires a finger on the trigger, is bulkier than an engraver, and it gets hot! For that matter, you don't even need a scan tool, a good voltmeter can usually display the a/c voltage pulses induced by a soldering gun or an engraving tool. Of course, if you are testing an inline connector, you would have to do the voltage meter checks at the PCM to avoid inadvertently repairing the connection by inserting the tester's probes.

This test also works on most antilock brake wheelspeed sensors, at least on the ones you can reach.

Left: *If only real life were this easy! The idea is to get the coil of the engraving pencil to induce a voltage through the windings of the component tested. An engraving pencil is a good choice because of its relatively small size, low temperature operation and hands-free on/off switch.*

Once you get everything lined up, you can follow the harness from one end to the other, wiggling wiring and connectors, watching the sensor output on a scan tool (or voltmeter or oscilloscope) probing for a signal dropout. This allows you to test without running the engine or driving down the street with one eye on the road and the other on the scanner display. This technique eliminates all the variables except for those related to the sensor circuit.

Here is one of the easy-to-see pulse generator connectors. Not the same as the one in the story — this one is actually on a Sonata. It is liable to suffer from the same 'loose-connector syndrome' because the wiring in the lower half (the pulse-generator side) hangs from the bracket. Over time and miles, vibration and transaxle movement may cause the male side of the connection to become loose inside the female side. An intermittent connection may develop.

I told Dave to take the wheel so I could hook up my scanner and scope things out. He laughed and told me he'd already scanned it and there weren't any codes. I told him to get us on the highway and hold it at a steady 50 while I worked. He was right; there weren't any codes — not in the engine or in the transmission control units. Still, I wasn't going to rule out the scanner data just yet. Scanners can do much more than just extract DTC's.

He got the car up to speed, and I hunkered down to the transmission data. Everything looked normal. As it should have — we were cruising along just fine. I decided to focus on only a couple of things while we waited for the trans to go berserk again. I called up the readings for vehicle speed (just to keep Dave honest and pinned at the 50 mph I wanted), TPS (so I could monitor the throttle and make sure he wasn't goofing things up with the pedal) and the two pulse-generator readings. I settled back and watched the numbers. Dave groused on and on about the many woes of his miserable life and luck, and I made a mental note to charge double the next time I went for a test drive with a depressed customer.

That's when I saw it. The TPS reading started bouncing. Instead of the steady 1.65 volts at a 50-mph cruise, I saw the voltage swing up to 3 and 4 volts, then back down again. Finally, it pegged at 3.9 and stayed there. *Bang!* The trans slammed down into second again.

Mystery solved! The TPS signal is a major input to the trans computer. If the computer suddenly receives a high TPS voltage signal, it thinks you've gone WOT, and so it (usually) commands a downshift. It doesn't matter a whit to the TCM whether that high TPS voltage is caused by a bona-fide, pedal-to-metal wide-open throttle or by a scabby potentiometer in the Throttle Position Sensor. It can't tell the difference, anyway. A sudden rise in TPS voltage *always* has the trans computer seriously considering a downshift, and most times you get it.

Dave didn't buy it. He had already scanned the car and knew it didn't have any codes stored. "No TPS code, no TPS problem, end of TPS story" was his settled judgement. I couldn't tell whether he was trying to 'cheap-out' on me or whether he was just too obtuse to learn anything new. I headed him back to the shop, so I could blow him away with technology. I grew up believing a real mechanic could fix anything using a flat rock, a sharp stick and half a roll of duct tape. But I'm out of duct tape; the Feds took away my sharp stick; and besides, nobody really *fixes* anything anymore. So I sprung for a Simutech. Dave was paying 2 cents a second, so he was going to see some electromechanical technotheater.

I already had the Hyundai interface cable, so I hooked the Simutech right into the PCM. Like every car I can think of other than a few exotics with drive-by-wire V12's, the Hyundai had only one TPS. The PCM shares the TPS signal input with the transmission control unit (TCM). On a car like this, you could check the TPS at the PCM, at the TCM or directly at the TPS itself. Dave's natural bent toward confusion being as strong as it was, I didn't want to puzzle him any more than I had to, so I monitored only the TPS waveform directly from the sensor. If the sensor itself were bad, the evidence should show up here.

I told Dave to lock the throttle steady with his hand and to be absolutely certain it did not move at all. Then I recorded the waveform you see in **Figure 1**. Dave swore the butterfly didn't budge, yet the oscilloscope pattern told a different story, as you see. During the roughly five seconds across the scope pattern, the TPS voltage was on the money for only one of the seconds. Part of the time it was high and steady; part of the time it bounced up and down as if someone were playing with the throttle. When the computers see the signal bounce, they assume the throttle plate is bouncing, too, and send commands to fit. The PCM goes to acceleration-enrichment mode, and the TCM may trigger a downshift.

Now that doesn't necessarily mean the throttle position sensor is the culprit. The anomalous voltage showing up at the PCM could come from a couple of crossed wires or electromagnetic interference of some other kind. But it was simple enough to unplug the TPS and watch the voltage fall to zero and stay there, *probably* indicating the problem was in the sensor itself (we should see the check-engine light, too, of course).

Some guys view this is an opportunity for the 'rap test.' No, not sullen, doggerel poetry set to thudding music — but, you know, when you tap the component with a hammer handle. A light tap shouldn't make the voltage jiggle like a dancer at the "Boom-Boom Room."

This one passed the 'rap test.' It also showed a smooth transition from 0.5 to 4.5 volts when opening the throttle Key-On, Engine-Off. But, hey!, we're dealing with an intermittent, right? Since the voltage was stable at zero with the TPS disconnected, I figured the sensor was the best suspect. I suggested we get this TPS off the street to see whether local property values improved.

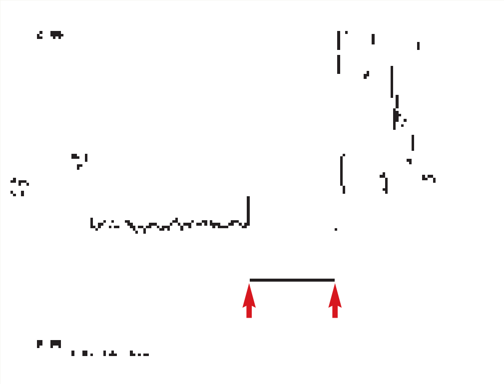

Figure 1

In simple terms, an oscilloscope pattern is a voltage trace over time, as you would get from a video camera focused on a really good voltmeter. This pattern is just such a recording. It shows several voltage changes at the TPS input for the PCM over a period of about five seconds.

The throttle was not moved during the recording, so the blips near the end of the pattern indicate a problem. Equally suspicious is the two-step voltage drop that starts the pattern. If you check the specs for this car, you find only the portion of the pattern between the arrows is actually correct at idle — about 0.5 volt.

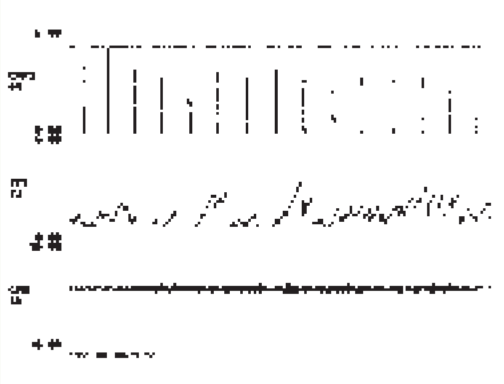

Figure 2

Another car, another scope pattern. This one displays about one second in the life of a TPS, along with the cam- and crank-sensor signals over the same period. The voltage output from this TPS changes almost constantly from 0.5 to 3.0 volts. Again, the throttle was immobile while the scope drew its juddering trace.

The complaint that brought this car in was "lack of power." It would intermittently run like the catalytic converter was plugged. The incorrect TPS input upset the fuel delivery, so the car ran like stink.

I printed up a copy of the TPS waveform for Dave — a little something to take home to the wife. Somehow he had to explain why he took that trans apart three times. He asked for a copy of a known-good waveform, so he could show her the difference. I printed up what you see in Figures 2 and 3. They were collected from another car for before-and-after evidence. **Figure 2** shows the same fluttering in the TPS voltage. **Figure 3** *(page 32)* is the same car after a new TPS was installed.

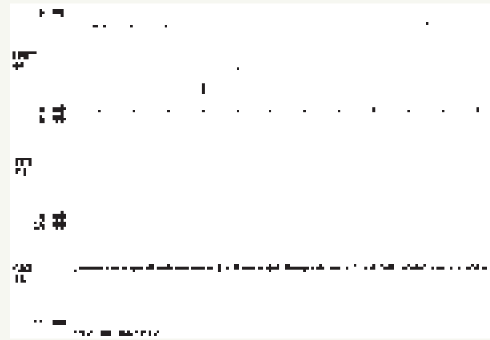

Figure 3

Same car as in Figure 2, same time and voltage ranges. If you only saw the TPS signal, you couldn't be sure the engine was running. It is dead flat at about 0.5 volt — just what you would expect from a stationary TPS in a key-on/engine-off situation.

This is a good indication that something has been fixed, maybe even the problem the owner was complaining about. Since, unlike Dave, you test drove the car to verify the complaint, all you have left to do is test drive it again to verify the repair.

Yep, it's a crank sensor. So, what's it doing in a story about TPS's? The three metal pins inside the connector have been twisted about fifteen degrees to restore a tight fit to the main harness. Doing this cured a 'no-start' problem.

Strange thing about the other car, though, was the original complaint was "no power." Its trans didn't downshift unexpectedly like Dave's did. But that was another case, another automotive mystery.

Dave took his waveforms, and I took his money. He figured he knew what to do next, so he could finish the fix himself. Probably figured he'd save a few bucks by not paying me a markup on a new TPS. That's fair, I guess. I guess it's also fair that I didn't tell him his TPS mounting screws were going to break. They almost always do, unless you heat them first. There were still a few things Dave would have to find out for himself. ■

CASE CLOSED

— By Bill Wheaton