V8 driveability case study

Brendan Sorenson

This is a recent case from my shop that includes a couple wrong turns as the diagnostic path is not always as straightforward as some case studies would have you believe.

This highly modified, supercharged Holden VE Series II Commodore V8 was a trade job for a performance shop. It went through a large rebuild with them around six months ago and had since gone in and out of different periods of perfect running at 1000hp-plus track days, dead misfires, fuel-cut type symptoms and, for good measure, a new flywheel and bellhousing from an exploded clutch.

These changing symptoms were accompanied by an extensive list of parts they (and sometimes the owner) had replaced, including leads, aftermarket coils, genuine coils, injectors and even donor ignition-coil wiring looms (short loom from each coil to the main junction connector for that bank's coil wires).

Tests they had completed were also quite in-depth – compression testing, valve-spring visual inspection, fuel pressure, injector bench testing, dyno data-logging – and certainly not two-minute jobs.

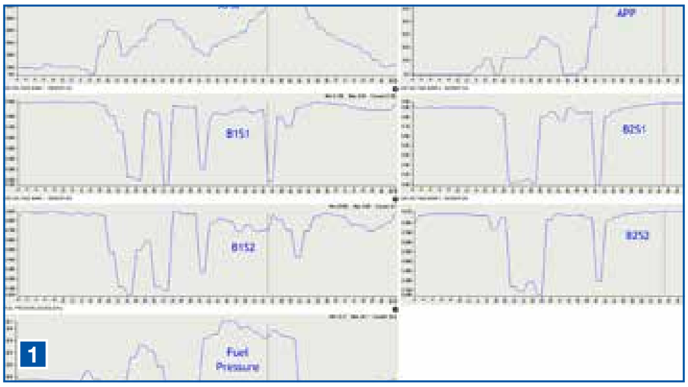
The vehicle presented with a repeatable mid-to-high load driveability problem. It could idle perfectly, free-rev no problem at standstill and push you back in your seat under 20 per cent throttle on the road but as soon as you pushed any higher in the load range it surged, knocked, misfired, backfired and hesitated terribly.

I was happy it was repeatable. I wasn't so happy about how difficult it was to test a 1000hp car on the street at higher loads, each time waiting for the possibility of it really going bang during my data-logging pulls.

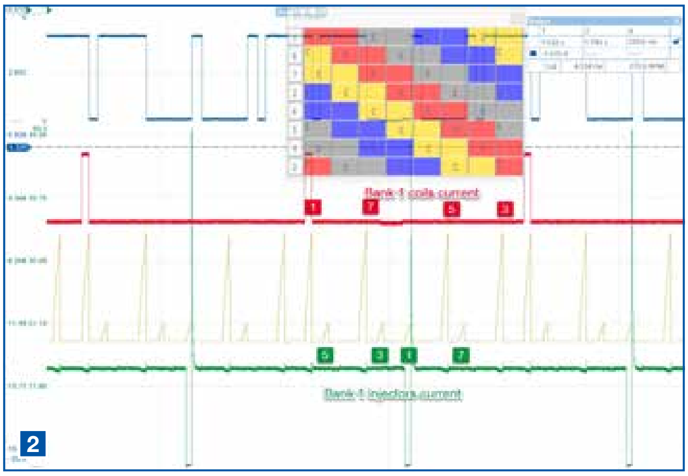
I started with my Snap-on Solus, which is my favourite scan tool for data-logging for deep analysis later on the PC. Midway into the wide-open throttle (WOT) pull, around 3500RPM, I dropped a cursor at the point the engine RPM started to falter (i.e. the point it started faulting) and clear as day I could immediately see that B1S1 sharply dropped lean while B2S1 remained rich as it should on a WOT pull (pic 1). So it seemed likely the fault related to bank one.

Taking the first wrong turn, I also couldn't help but notice the low-side fuel pressure (this system has a low-side fuel pressure sensor) was dropping during the pull, starting around 35 kilopascals (kPa) and dropping to 32kPa during the fault.

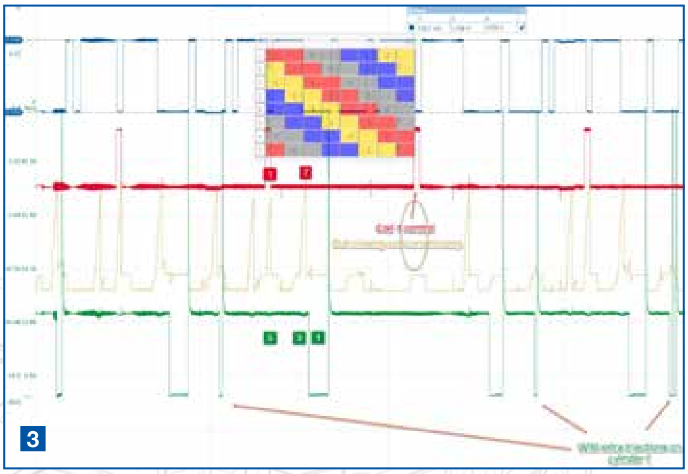
I'm no LS engine expert but that sounded terribly low to me, so I pulled up some standard LS engine specs and, sure enough, it was terribly low.



1



2



3

Here's where everyone finds out I'm more comfortable around a Camry than a Corvette. I spoke to the performance shop and they assured me this highly modified fuel system was achieving the correct target numbers for the tune.

The system consisted of dual-stage fuel pumps, so just to satisfy myself I bypassed the boost-pressure activated second-stage pump control by manually activating the relays and running both pumps constantly, which gave no change in symptoms.

With no other data parameter IDs (PIDs) giving any further clear direction, no fault codes and even all misfire monitors reading zero when it clearly had some terrible misfires, it was time to move on from the scan tool to some more hands-on, non-intrusive testing.

With four scope channels at my disposal (Santa didn't bring me an eight-channel Pico), I needed to gather as much data as possible on each short test run. A good place to start on petrol driveability is monitoring cam, crank, coils and injectors. Any intermittent test-equipment poor connection would not be acceptable, so for any voltage readings on these high-vibration test drives I used my Pomona wire piercers instead of my more favoured back-probing pins, which might have wriggled out under vibration.

The crank sensor was buried, so for now I made a voltage connection on the accessible cam sensor (blue). The wiring diagram showed me the coils and injectors for each bank all run through their own bank-specific fuse, so with one Fuse Buddy and one current clamp I was able to see all bank-one coil and injection current events on one channel (yellow).

For this first test I used my two remaining channels to connect into the control wire of cylinder-one coil (red) and injector (green).

Pic 2 shows perfect running at idle, with the large yellow coil ramps being the coils and the smaller yellow coil ramps being the injectors on bank one.

Roll on the load down the road and it bucked and kicked as repeatably as ever and the waveforms gathered were astonishing (pic 3).

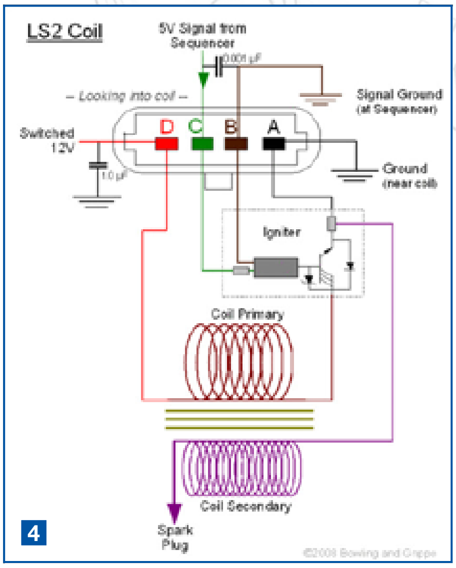
Coil control remained steady but there were clearly some missing coil-current ramps when there was good control. Injection control was chaotic; some good longer duration high-load injections, some missing injection controls and even some random, non-rhythmic multiple injections on the same cylinder. *(cont. p10)*

In hindsight now, the steady coil control should have led me elsewhere but, intrigued, I let the car cool overnight and returned to waste half an hour making solid connection on the crank sensor, only to find my cam and crank sensors reported steadily throughout the fault.

After a cup of coffee mulling over some wiring diagrams, I focused on a Haynes Pro earth-point location diagram. Engine running, I ensured all earth points in the engine bay had no excessive voltage drop by measuring between it and battery earth, all giving a good reading under 50 millivolts (mV). Those that I couldn't physically access via the ground lug, I tested at the wiring-loom connectors further up the circuit where more accessible.

To up the ante, I also used my high-current test light – a H4 headlight with low and high beam bridged to give a decent 10A current draw – with the engine running to ensure all earth points in the engine bay could light my bulb brightly. Engine off, I also used the H4 test light to confirm my coil power and earth. The injector power could also light the bulb brightly.

Here's your first hint. Content with the bright bulb, I skipped carrying out voltage-drop testing with my multimeter on these circuits. Could this have changed my path?



4

Running over the facts so far with the guys in the shop, there is always one who says those all too familiar words – 'Maybe it's the ECU.'

It didn't sit right with me. It was such a load-dependant fault, with the engine able to function logically at other loads. When you think of the ECU on a circuit-board level, it's not the way an ECU fails. Couldn't hurt to check, though, so I wasted another hour or so digging the ECU out to brightly light my H4 bulb on all the power and ground supply circuits on the unplugged ECU connector.

I remembered the scope capture showing a coil-control event with no current ramp. That seemed like the lowest hanging fruit to chase at this point, particularly given the list of previous ignition-system component replacements that apparently gave temporary relief to whatever symptom it had that chosen month.


5

Remembering my oxygen (O2) sensors were alluding to the fault being on bank one, I wanted to see if anything was different between a coil on bank one and bank two since each bank on this engine has its own circuit, basically making it a known good to compare.

The four wire coils on this GM engine are a little different to others (pic 4). Left to right they have a power (D), a 5V transistor trigger (C), a dedicated transistor earth wire (B) – running a wire all the way back to the ECU to give a filtered ground, much like a sensor ground does – and a coil ground (A) to carry the hefty 10A or so of actual coil current. Three of the wires are shared by all coils on its respective bank, aside from pin C, the 5V transistor trigger, which is individual to each coil to fire at the correct time.

Not exactly sure what I was looking for, or what I might find, I made voltage connections into pin B on a bank-two coil (bank-two shared transistor earth, channel A), a bank-two coil trigger (channel B), pin B on a bank-one coil (bank-one shared transistor earth, channel C) and this time monitored bank-two coil and injector current for any abnormality with an amp clamp at its fuse to confirm if the fault truly was only on bank one (channel D).

Focusing on channel A (blue) and channel C (green), there wasn't much activity on each bank's transistor earth during idle and low load. However, during the fault, large peaks started to form, particularly on the bank-one shared transistor earth, with some of the voltage drops (deviation from true earth zero volts) rising to more than 600mV (pic 5).

Such was the duration and shape of these voltage-drop ramps on the green trace, they could be mistaken for coil-current ramps if you hadn't been told what you were looking at.

While activity increased on the bank-two transistor earth during the fault, the ramps it displayed were predominantly mini versions of what was happening on bank one during bank-one coil events – I would suggest these were actually bank-one fault events making their way electrically onto the bank-two circuit.

Multiple facts so far pointed to something being amiss on this bank-one coil circuit. I thought it through while the car cooled itself and did a brake job to cool my mind. I had good coil control, I had tested the power and the ground with a 10A test light but I had not tested them flying down the road during the fault, with heat, vibration and movement.

My thoughts turned to ground point four, the bank-one coil main ground, bolted to the rear of the cylinder head. It was inaccessible, so I had proved it could flow 10A up at the bank-one main wiring connector. I hooked the same test light up to this pin again, then shook as much loom as I could reach – and the light dulled!

With direction now, I used a borescope to follow the loom down behind the engine and – bullseye! – out of the thick wiring loom at this point exited one single-inch long wire, with an exposed wire end, resting on an empty thread in the head where a crimped earth lug should obviously be. The wire was making a decent earth connection at idle but when 1000 horses tried to rip the motor off its mounts the connection was compromised.

I'd love to say I could explain the knock-on effects of this poor coil earth but my knowledge only extends so far. It looked like the current went looking for a different path, finding its way into the coil transistor earth, causing the large voltage drops as the tiny wire struggled to deal with far more current than it was intended to.

The odd extra injections also raised some questions – was the ECU using this transistor earth wire in a Toyota ignition-failure sensor (IGF) style monitoring and could it possibly have some contribution to injection timing? Surely not?

In hindsight, I would have loved to have spent some more time gathering money shots like what would have been an extreme voltage drop on the bank-one coil main earth during the fault but I had all I needed to take this job to the bank.

With a back probe in the accessible bank-one harness connector main coil-earth pin, I ran a jumper wire and alligator clip to the engine block. Rolling on the throttle, for the first time I felt the full output of this engine, which prompted a passing pedestrian to seemingly ruin his undies as he mimed what must have been a plunger on his forehead while yelling something along the lines of 'Banker!'… all as he disappeared in the rear-view mirror.