Oscilloscopes & Labscopes Part III

"Although digital storage oscilloscopes or "labscopes" have now become more acceptable and used in our modern automotive workshops, many a good mechanic can still be bewildered or confused by how to use this tool. I suspect the humble labscope tends to intimidate many technicians."

By Maurice Donovan (MD)

As we continue our journey in the world of oscilloscopes or "labscopes" I want to illustrate how within a matter of a week, I had two VZ Commodore's come to my workshop and both cars had misfiring issues. One Commodore had a random misfiring only when hot and under load. We were able to locate this misfire to one bank of the engine, and the other had random misfiring issues with total engine breakdown whilst under load.

I also had a third Commodore come in. This one was a VE and also had similar misfiring complaints on one engine bank.

Each of these vehicles had different causes to what initially seemed similar symptoms, and each vehicle was correctly diagnosed within a reasonable timeframe without the need to replace parts that were not necessary. The only way each of these cars was able to be diagnosed correctly was by using the labscope.

Before we start let's do some revision!

What is a oscilloscopes or labscope?

A labscope is basically a voltmeter that displays voltage signals along a time base. The vertical scale measures the amplitude or amount of the voltage and the horizontal scale measures an incremental timeline along which the signals are displayed.

With electronics it is all about voltage and what happens with the voltage. No scantool can show you this. All a scantool can do is guide you to a problem. The labscope can verify the problem, so without a labscope a mechanic is just guessing.

My first VZ commodore had a misfire that only happened on a very hot engine and only while the engine was under load conditions. It took a while before we felt the misfire. Always remember rule number one, if we are going to diagnose a car we must experience the problem ourselves. Rule number 2 if we do not experience the problem, we do not attempt to fix the car.

Why? Because to guess or assume is simply not acceptable! We must see, hear or feel the problem personally, otherwise we could spend valuable time fixing other problems WE FEEL, WE DIAGNOSE, otherwise we could fix something but is it the actual problem which caused the customer to come to you in the first place. Potentially you can have a cranky customer.

Now that we had experienced the VZ commodore misfire under load, we hooked up our scantool to make sure we did not have any crank sensor codes etc. It was time to hook up our labscope to inspect the integrity of the ignition system.

Diagnostics is all about logic and time.

Thinking logically I still suspected I may have had an intermittent problem with the coil trigger caused by a malfunction in the crank sensor. But I knew I could also have a problem with my secondary ignition. As was the case with this car, hooking up to the primary voltage is not possible in the majority of modern cars because newer model cars have the ignition module built into the coil, making the negative control terminal impossible to access. (you need the negative terminal to hook up your labscope when checking primary voltage on a coil.) A lot of the time even the secondary voltage is difficult or near to impossible to access.

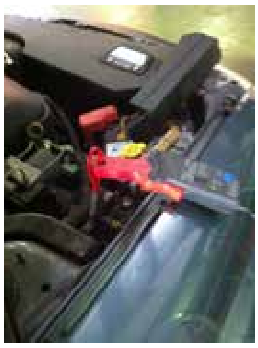
I was having trouble picking up a good signal using my COP pick wand.

The built in transistor is triggered by the ECM with a small voltage that turns on the transistor, which switches the coil to ground so as to allow the primary current to flow. Because we cannot hook up to voltage doesn't stop us from hooking up to the primary current. We can access the primary current through the positive side of the coil.

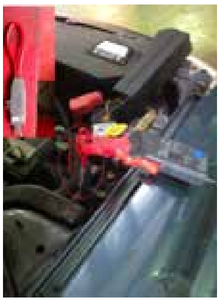
Most coils now are Coil on Plug (COP) or Waste spark where one coil is COP with a lead going to its companion cylinder. An oscilloscope secondary wand is ideal but with some coils it still hard to get a good signal from the wand. A lot of coils are buried under the manifolds so these days while it is possible to access secondary voltage it is not always easy.

While current along with primary voltage or secondary voltage is by far the most thorough way of inspecting the primary and secondary ignition integrity, primary current on its own is still very valuable.

I mentioned that I was suspicious about the ignition triggering, so logically wouldn't you think I would go for the crank angle sensor first which signals the Engine Control Module (ECM) to trigger the coil? Well, remember I said diagnostics is all about logic and time. It would take me a good 30 minutes or so to unbolt the ECM off the front of the engine, then I would have to look up my wiring diagram to find the right terminals to do a back probe, and then later would have to put the ECM back on the engine. To slow.



Logically, it makes perfect sense to remove an ignition coil powerfuse and plug in my fuse wire loop tool and simply clamp my low amp probe around my looped wire. When you think about it, if my trigger is the problem I am going to lose my primary current. If this turns out to be the case then yes I would



then unbolt the ECM and back probe the terminals that connect to the crank angle sensor.

My logic paid off as it turned out I was not losing my trigger, the coil driver (within the ECM) was partially grounding the coil when there should have clearly been no current flowing. I also noted that the coil amp peak was considerably lower than expected. **(see pic 1 on page 12).**

Taking out the numerous road testings we had to take before we actually experienced the misfire, the whole diagnostic procedure only took 20 minutes (excluding the road testing).

It took a while before we could get the vehicle to misfire under load conditions as the fault only showed up on the labscope when the car was misfiring. The other option would have been to take the car on the road with my labscope hooked up and then I would have "captured" the misfire on my labscope.

The power of a labscope is evident when I picked up the 2 faults in my primary current capture **(see pic 1 on page 12)).**

If our amps were a bit low on one coil,one could suspect a coil problem. But the entire bank of coils were all low so you would not expect all 3 coils to fail at once. (I was only hooked up to one bank, and each bank has its own fuse for that bank of coils.) So the evidence to the problem laid in the fact we had current flowing when the coil should have been turned off. Therefore the cause must be a faulty coil driver which is located within the ECM.

A new ECM was fitted. Then we needed to program the new ECM. We can do it here in my workshop. We need security codes and a Tech 2 or as I have a pass-through J2534 device and a subscription to AC Delco GMH factory website to assist this process.

The vehicle was retested and now has no more issues and we have a happy customer.

Now we turn our attention to the other VZ Commodore.

The second VZ Commodore was also misfiring and was breaking down badly under load. Again after checking scan data it was decided to again check the primary coil current in the same way we checked the first Commodore.

This time we had good amps, but it was noted ramp drop-off (coil turn off) had a ringing. This ringing is not normal **(see pic 3 on page 12)** The current stops flowing and we see this with a sharp and sudden line drop in our current ramp pattern. Our labscope revealed that when the coil is switched off we have a lot of hash ringing out.

What is Hash? Instead of a nice clean straight cut off line we had a ringing of lines that followed after the straight cut off line. This indicates there is a secondary leak, either the coil, the coil boot, or the spark plugs.

The coils and plugs were removed and inspected. The plugs needed replacing, but the coils and boots all looked in good shape. After fitting new spark plugs this car was like new to drive. Problem solved. **(see pic 2 on page 12 is what we now have a good cut off without any hash or ringing)**

We have to remember if our ignition system starts to misfire the ECM will turn off the injectors to save the Catalytic Convertor. This would explain the severe breaking down of the engine while under load. **(see pic 3 on page 12)**

The third Commodore was a VE and it had an entire engine bank misfiring similar but much more evident than on our first VZ Commodore. Our scantool revealed codes P0302, P0304, P0306 which are misfire codes pointing to the entire left hand bank 2 side of the engine.

We hooked up our low amp probe to check the primary coil current and to my surprise I had a good pattern even while under load and while the misfire was happening. So this proved I had a good ignition system.

Remember I said the key to diagnostics was logic and time. My logic directed me to want to check the valve timing, so this directed me to do a running compression test using my oscilloscope hooked to a pressure transducer. The reason being that if I was to hook up to my cam and crank sensors, it would take a lot more time and this would only show me if the intake cam was in correlation to the crank. If my intake was okay but my exhaust was out, I would not see this. But by using a pressure transducer I could see so much more and I could see if the intake and exhaust were correctly timed.

Pressure Transducer

My compression pattern is a reflection of the combustion process. Viewing the pressure waveforms from inside the cylinder of a running engine can provide a great deal of diagnostic information.

Understanding these waveforms will help you spot valve issues, blocked catalytic converters and restricted air intakes and much more.

For this test we remove the spark plug from the cylinder head (be sure to ground the spark), then install a compression test metal tube adaptor (it is vital with any adaptors we use that they are reinforced so that intake vacuum will not suck in the pipe or hose.) This compression test doesn't use a one way valve as is the case with our conventional dynamic compression test. In my running compression test I am using a 500 psi transducer on the end of my compression tube adaptor.

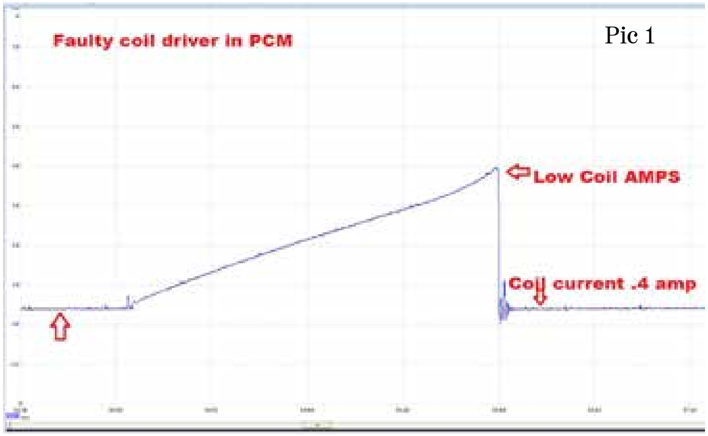
As you can see, the compression test that we have captured has a major problem. If you look at the capture in **picture 4** and compare it with the good capture in the **picture 5** (which is a good known wave pattern), then you will notice I have a huge hump in the middle of my 2 towers. **(Refer to pictures on page 12)**

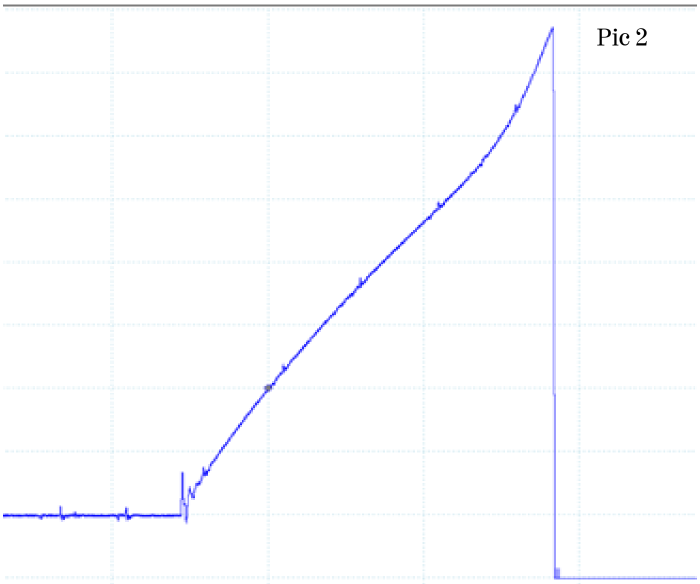
This hump **(in Pic 4)** is caused by the exhaust gases not escaping from the combustion chamber.

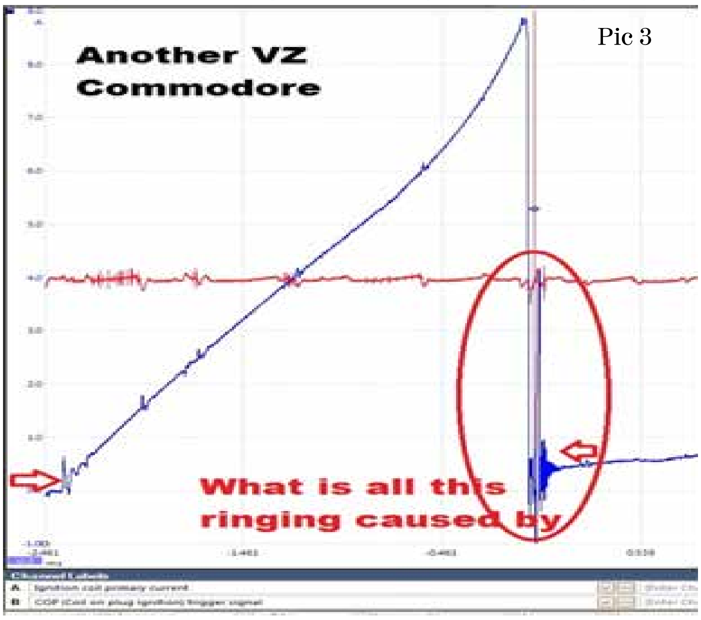
After analysing the wave pattern we can determine that the exhaust valve is opening too early, therefore it is also closing too early. When an exhaust valve closes too early there is not enough time to get rid of all the exhaust gases. The build-up of exhaust gas is evident with the hump we see in between the two compression humps. (**Refer to Pic 4)**

Using my cursers and measuring the time between both compression towers and then dividing 720 degrees of crankshaft rotation (we know there is 2 full rotations of the crankshaft to complete a 4 stroke cycle, so two rotations is what happens between each compression tower) we need to know how many degrees the crank will turn in one millisecond of time.

The time between the towers is 201 milliseconds, there is 720



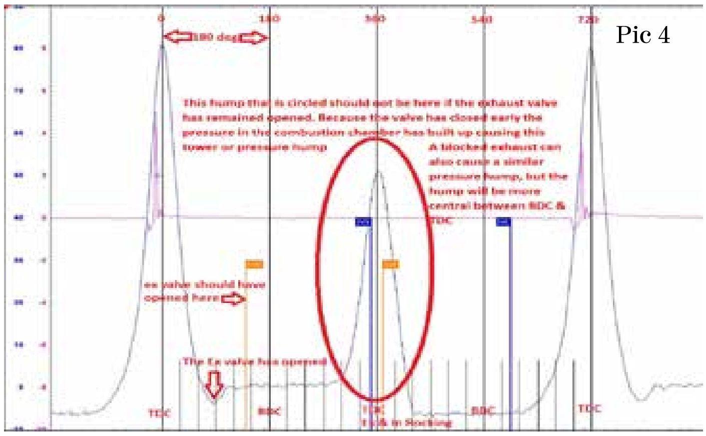




Faulty spark plugs - see the ringing after the amps stop, and after new spark plugs no ringing after the amps stop.

degrees between the two towers (2 crank shaft revolutions) so we need to divided 720 / 201 = 3.58 degrees per each millisecond of time.

We can clearly see where the exhaust valve has opened and by moving the cursor on this point we can see this event happened



The flags indicates when the valves should be opening and closing. Yellow is the exhaust and the first yellow is when the exhaust valve should be opening but where the red arrow is when the exhaust valve opened way too early.

Yellow flags is the exhaust valve first opens and second yellow flag closes. The blue flag is the intake valve, first again is the opening and the second is the intake closing .

at 24ms of time which we then multiply by 3.58 = 85.92 degrees (so 86 degrees). We know when the exhaust valve should have opened at about 45 degrees before bottom dead centre(BBDC)and; Bottom Dead Centre (BDC)happens at 180 degrees of crankshaft revolution. So we simply take 180 – 86 = 94 degrees BBDC. So it should have opened at 45 degrees BBDC but it actually opened at 94 Degrees BBDC that makes the exhaust opening and closing 49 degrees early.

So, without a labscope and the right accessories it would be very difficult to efficiently diagnose the 3 problem vehicles in this case study.

HANDY TIP: If you want to learn more on labscope diagnostics, I recommend you buy the elearning series called Autonerdz by Tom Roberts http://www.autonerdz.com/n1.htm You will find this handy.

Until next time, happy diagnosing, MD.

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