WELLS Counter Point

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THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Engine Knock Sensors

Part Two

We continue our investigation of engine knock sensors with a look at one- and two-wire sensors.

In the previous issue of *Counter Point*, we discussed the various causes of engine knock. Prior to the age of electronic engine control, an engine designer had a limited number of effective tools to guard against engine knock. Principle among these were combustion chamber design, the octane of the fuel used and mapping of the spark advance curve. The designer couldn't risk the possibility of engine damage caused by knock, so it was always necessary to keep the engine well short of the point where it might begin. This assured engine longevity, but hurt performance.

Modern engines are now fully controlled by electronics. Engineers no longer have to settle for a conservative preset spark advance curve. Spark advance can now be controlled dynamically. This dynamic control allows the engine control module (ECM) to take into account changing engine operating conditions as well as the available octane of the fuel, then use that information to extract the maximum amount of engine performance without running the risk of damaging spark knock.

The key sensor used to maintain dynamic control of spark advance and extract maximum performance is the engine knock sensor. For any given operating situation, the ECM attempts to deliver the maximum available performance by advancing the ignition. If this advance were unchecked, it would inevitably lead to engine knock.

The control unit needs a sentinel to report knock as soon as it begins. Ignition timing is then retarded by the ECM, and the knock stops. The ECM repeats the process by steadily advancing the timing until knock is detected, then retarding the timing until the knock stops. This closed loop process allows the engine to deliver maximum performance under all conditions, without the risk of damage or lost performance caused by knock.

Two major knock sensor designs are used today: *broadband single-wire* and *flat response two-wire knock sensors*. Both sensor designs use piezoelectric crystals to produce and send voltage signals to the ECM. The amplitude and frequency of this signal varies, depending upon the vibration levels within the engine. Broadband and flat response knock sensor signals are processed differently by the PCM.

Broadband sensors use a single-wire circuit. This sensor type can respond to knock frequencies up to 1000 Hz from the design frequency value. This allows the sensor to accommodate shifts in engine knock frequency with changing engine operating conditions. The sensor's high voltage output allows the use of a single, non-shielded output wire and a low impedance measuring circuit, while providing reduced susceptibility to electromagnetic interference (EMI).

Some PCMs output a bias voltage on the knock sensor signal wire. The bias voltage creates a voltage drop that the PCM monitors and uses to diagnose knock sensor faults. The knock sensor noise signal rides along this bias voltage. Due to the constantly fluctuating frequency and amplitude of the signal, it will always be outside the bias voltage parameters. The PCM in many applications will learn the knock sensor's normal noise output. The PCM uses the noise channel and the knock sensor signal that rides along the noise channel similar to bias voltage systems. Both systems constantly monitor the sensor output, watching for a missing signal or one that falls within the noise frequency channel.

Flat response knock sensors use a two-wire circuit. This is a self-generating piezoelectric design that requires no power to the sensor. The sensor has a flat frequency response over the range of 5 to 18 kHz. This allows the sensor to be used on different engines by adjusting the filter frequency of the signal processing electronics to match the knock frequency of the engine. The sensor responds to knock frequencies that are higher than the primary knock frequency, allowing the higher knock frequencies to be used by a control system, either individually or combined with the primary knock frequency.

The signal rides within a noise channel which is learned by the PCM. The noise

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Fine Tuning

Fine Tuning questions are answered by Mark Hicks, Technical Services Manager. Please send your questions to: Mark Hicks c/o ***Wells Manufacturing, L.P., P.O. Box 70, Fond du Lac, WI 54936-0070*** *or e-mail him at* ***technical@wellsmfgcorp.com.*** *We'll send you a very nice Wells golf shirt if your question is published. So please include your shirt size with your question.*

Q: I am working on a 2002 Nissan Sentra GXE with a 1.8L engine. It has a code P0335 stored in the computer. My reference says the P0335 code means a crankshaft (CKP) sensor fault. I have replaced the PCM twice with a Nissan factory unit and I have also installed the updated sensor kit. I have also tested the CKP signal at both the sensor and at PCM pin 75. I was able to obtain examples of the Nissan factory waveforms for the crank and cam sensors and the ones I am getting on this vehicle match the examples perfectly. I checked voltage drop on both the feed and ground sides of the circuit and they are well within specs at .005 volts. I cleared the code after doing all this, but it immediately returns after start-up. I am lost; where do I go from here?

Tom Evans
Fixer Right Repairs
San Antonio, TX

A: There's been an increase in the frequency of this problem in the past few years. To get a better understanding, let's take a quick tour through the computer system's calculating process on this Nissan. A P0335 DTC is set by the PCM when one or more of the following conditions occur:

• The CKP sensor signal is not detected by the PCM during the first few moments of cranking,
• The proper signal from the CKP sensor is not sent to the PCM during engine running,
• The CKP sensor signal is not in the normal pattern during engine running.

With the testing you have already performed, it would be reasonable to assume that the PCM is receiving the CKP sensor signal. So the first two scenarios are not the issue. When I see the third condition, my question is this: How does the PCM know what is normal and what is not? In this case the PCM compares the signal from the CKP and camshaft position sensors to each other.

This is the key to this repair. Look at these two signals superimposed on your scope, as shown in the diagram. This testing technique will take longer to explain than the available space. We will discuss this issue in greater detail in the near future. But for today, if your scope pattern does not match the synchronization of this pattern, your timing chain and tensioner will most likely need replacement.

Result: Tom ended up replacing the timing chain, gears and tensioners to repair the problem.

I have to apologize for throwing such an off-the-wall question at you in our last issue. I think it was worth it, because the answer to the problem will give us all a better understanding of GM computer strategy. I hope you agree.

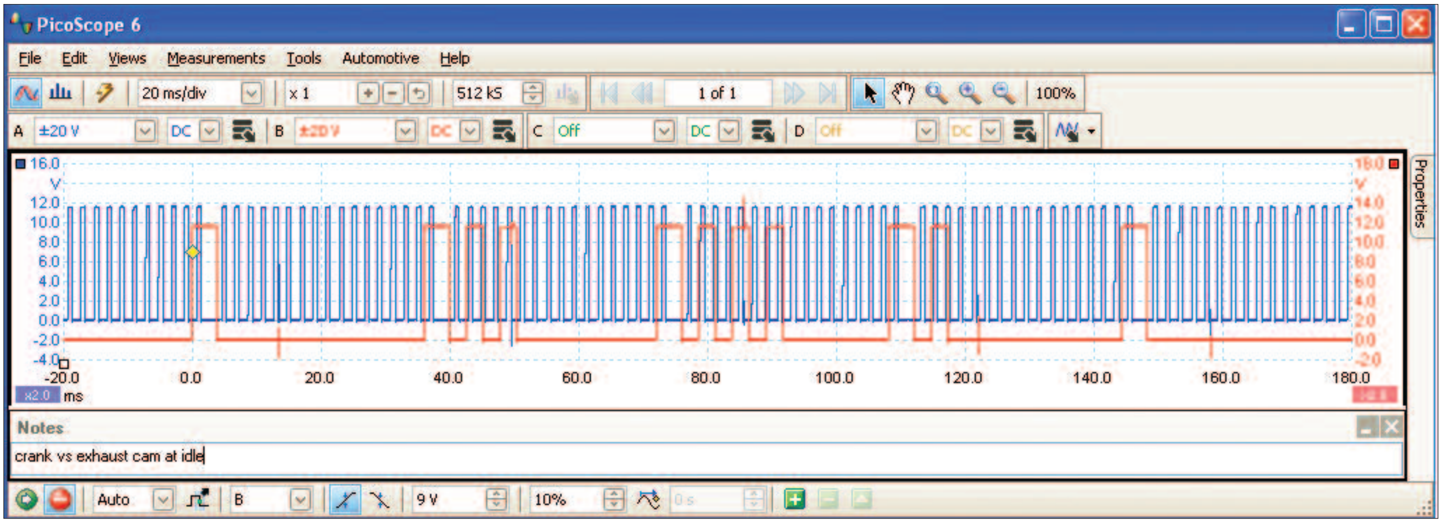
Last time we were working on a 2001 Chevrolet pickup with a 4.3L engine. It had a P0300 code stored and the scan tool showed number 4 cylinder had multiple misfires. It has previously been checked for vacuum leaks and the intake gaskets were replaced. The plugs, wires, distributor, MAP, EGR valve, fuel injectors, PCM and number 4 cylinder's valve springs have all been replaced. But guess what? The P0300 and number 4 misfire were still there and cylinder number 1 showed some misfires above 1200 RPM.

The first thought was a possible problem with the distributor. Yes, it had been replaced. But remember, this is the type with the odd ventilation problems. We found a technical service bulletin (TSB), number 03-06-04-041A, which talks about setting code P0300. Chuck checked out the new distributor. The cap and rotor looked good and the vents were clear. He also put a timing light on the number 4 ignition wire and found it would intermittently lose spark. Okay, we know all the parts that send the high voltage are good. It must be a trigger problem.

The secondary ignition is triggered by the PCM on this vehicle. The PCM determines when to trigger the module based on the signals it receives from the cam and crank sensors. Could there be something interrupting the synchronization? The crankshaft sensor is triggered by a reluctor on the end of the crankshaft and the camshaft sensor is triggered by the distributor rotation. What is in between the two? You guessed it, the timing chain.

Chuck checked the timing chain tension and sure enough there was all kinds of slop.

We did a little more research and found a service bulletin on it. Funny, the bulletin was not listed under misfires or timing chain issues. It was under timing chain tensioner, which this vehicle does not come with from the factory. The TSB number is 03-06-01-024C. It says nothing about misfires, but it does talk about rattling and spark noise, which of course points to a loose chain. The bulletin also suggests installing tensioners when the chain is replaced.



Screen capture courtesy John Thornton

Replacing the chain and installing the tensioners took care of the Check Engine light, codes and misfires. This tells me the synchronization was being skewed due to a loose chain. It also raises a question: Does the factory know more about this type of problem than they are letting on?

Diagnose The Problem Win A Shirt

I am working on a 2002 Chevrolet Suburban K1500 with a 5.3L VIN T engine. Five DTCs have set in the computer's memory. I have cleared the codes twice but they return after 15 minutes of driving. The transmission goes into safe mode and seems to be in third gear as soon as the Check Engine light illuminates.

The codes are:
P0740 - Torque converter clutch enable circuit
P0753 - 1-2 shift solenoid valve performance
P0758 - 2-3 shift solenoid valve performance
P0785 - Transmission 3-2 shift solenoid
P1860 - Torque converter clutch pulse width modulated solenoid electrical fault

The other unusual problem is the instrument panel. It will go out intermittently and pop back "on" with no rhyme or reason. Any ideas?

Sigurd Peterson

Editor's Hint: The instrument panel and transmission controls are electrically fed by the same IGN 0 fuse.

If you have the answer, please use the following contact information:

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For certified (no fee) diagnostic assistance, call 1-800-558-9770 between 7:00 AM and 7:00 PM CST.

Important Dates To Remember

The National Institute for Automotive Service Excellence (ASE) will offer its Fall 2008 paper and pencil-based certification tests on November 13th, 18th and 20th. The Winter 2009 computer-based testing will take place between January 16th and February 23rd, at 230 designated test centers. Additional information can be found at *www.ase.com.*

Wells Manufacturing. L.P. encourages professionalism through technician certification. WELLS

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Engine Knock Sensors - Part Two

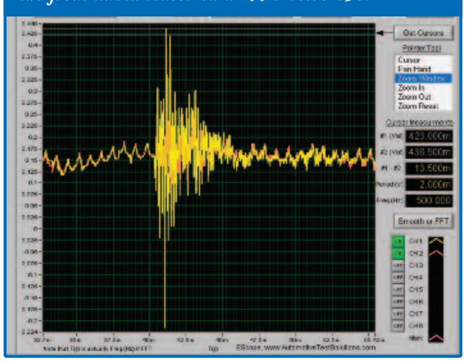
channel is based upon the normal noise input from the knock sensor and is known as background noise. As engine speed and load change, the noise channel upper and lower parameters will change to accommodate the knock sensor signal, keeping the signal within the channel. When there is knock, the signal will move outside the noise channel frequency and the PCM will reduce spark advance until the signal moves back inside the noise channel frequency.

It's very difficult to make an engine knock when you want it to. Here, an air chisel and a blunt bit are used to temporarily mislead the knock sensor.

Photo and sccreen captures courtesy Bernie Thompson

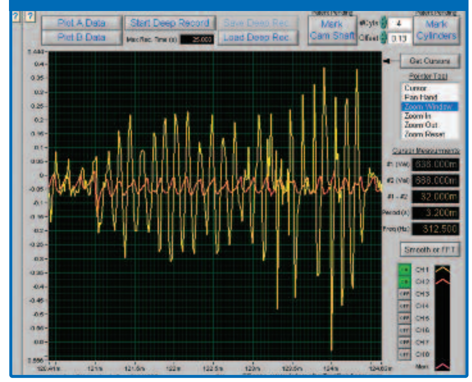
Both the number and position of the knock sensors must be carefully selected so that knock from any cylinder or cylinders can be recognized under all conditions, with special emphasis on high loads and engine speeds. The knock sensor mounting position is generally on the side of the engine block or under the intake manifold. Four cylinder engines are normally equipped with one sensor, five and six cylinder engines with two and eight, ten and twelve cylinder engines with two or more knock sensors.

Using your oscillosope to check patterns produced by good components will help you identify defective components. The air chisel produced this signal from the front knock sensor on a 1996 Volvo 850.



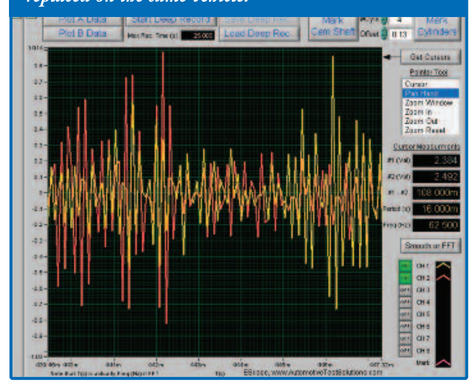
The sensor signals are evaluated by the PCM. A reference level is formed for each cylinder, which is continuously and automatically adapted to operating conditions. A comparison with the useful signal obtained from the sensor signal for every combustion process in every cylinder allows the PCM to determine whether knocking is occurring. If so, the ignition point is retarded by a fixed amount, 3° of crankshaft rotation for example, for the cylinder involved. This process is repeated for every cylinder for every combustion process that has been recognized as knocking. Once the knock subsides, the ignition point is advanced in small steps until it has returned to its spark advance map value.

A defective knock sensor on a 2000 Toyota Avalon engine produced the waveform below during a snap throttle test.



Since the knock limit varies from cylinder to cylinder within an engine and changes dramatically within the operating range, the result is an individual ignition point for every cylinder. Cylinder-selective knock recognition and control makes possible the best optimization of engine efficiency and fuel consumption. If the vehicle is designed for operation with unleaded premium fuel, it can also be operated with regular unleaded fuel with slightly reduced performance and without the risk of internal engine damage.

You can see quite a bit more scope activity during a snap throttle test after the knock sensor had been replaced on the same vehicle.



In dynamic operation, knock frequency will increase under such conditions. To reduce knock, an individual spark advance map can be stored in the electronic control unit for the two fuel types. After start-up, the engine operates with the "premium" map. The PCM is switched to the "regular" map if the knock frequency exceeds a predetermined limit. The driver is not aware of this switchover; only power and fuel consumption will be slightly reduced. WELLS

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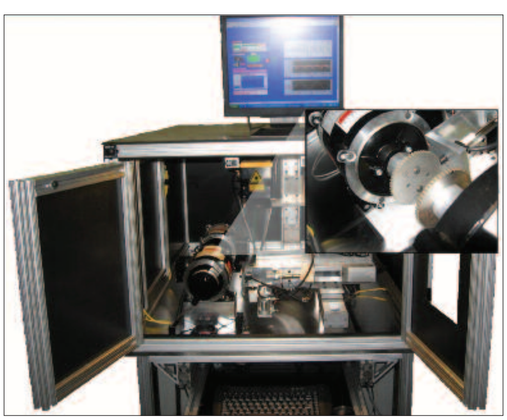
Quality Points

Wells ABS Sensors

Today's tires, suspensions and brakes have dramatically improved vehicle safety. The antilock braking system (ABS) has made the largest single safety improvement in this area. Wells recognizes that ABS speed sensors must be manufactured to precision standards, to assure that the system will always function properly. For this reason we manufacture state-of-the-art ABS wheel speed sensors, and every sensor is fully function-tested before it is boxed.



The first step in this process is to test inductance and impedance with an inductance (L), capacitance (C), and impedance (R) LCR meter and record the results. The sensors are tested next at two speeds: a very low 50 rpm and a very high 2000 rpm. These signals are captured by a 14-bit analog device, then sent to the integral computer system (shown here) for analysis. Rejected sensors are scrapped and passing sensors are laser date coded.

Your customers can rest easy knowing they will stop in the shortest distance and straightest line possible using our ABS sensors. WELLS

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