AIRTEX® ENGINE MANAGEMENT COMPONENTS

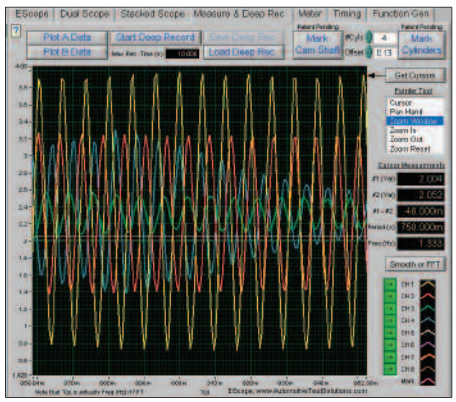
Counter Point

Volume 3 Issue 4, Fall/Winter 2007

THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

ABS Speed Sensors

This article focuses on the operation and diagnosis of the variable-reluctance ABS speed sensor.



The most commonly used antilock brake system (ABS) wheel speed sensor is the variable-reluctance type. Magneto-resistive is the other sensor type. Also called "active" speed sensors, they are a relatively recent development. The function and diagnostics involved are different from those of variable-reluctance sensors. This article will focus on the more common variable-reluctance type. We will investigate the magneto-resistive type in a future article.

At the center of a variable-reluctance wheel speed sensor is a permanent magnet. A thin copper wire is wrapped around the magnet to form a coil, allowing the wheel speed sensor to function as a small AC voltage generator. The wheel speed sensor is mounted adjacent to a toothed ring, also called a tone ring. The tone ring is attached to a part (like a drive axle or hub) that rotates as the wheel turns and the vehicle moves.

As the tone ring rotates, the wheel speed sensor generates a small AC voltage. When viewed on an oscilloscope, this voltage is shown as a sine wave that increases in frequency and amplitude as wheel speed increases. Both frequency and amplitude are proportional to the vehicle wheel speed.

A growing number of vehicles have the wheel speed sensor and tone ring contained inside a sealed wheel bearing hub assembly, unlike other wheel speed sensor setups where the tone ring is on the outside of the outer CV joint housing, axle or hub. This sealed environment is intended to protect the sensor and make it less vulnerable to damage or contamination. The first of these applications dates back to 1999 Chevy/GMC and Ford trucks. Since then, sealed wheel bearing hub assemblies with integral ABS wheel speed sensors have also been used on a growing number of GM, Ford, Chrysler and other vehicles.

Regardless of the design, speed sensors at each wheel allow the ABS control unit to monitor wheel speed independently. If a wheel has lost traction under braking, it will slow more quickly than the other wheels that still have normal traction. If a wheel speed sensor indicates that one or more of the wheels is slowing more rapidly than the others, the ABS control unit will activate the ABS system to restore traction to the slipping wheel or wheels. The ABS control unit also tests the wheel speed sensors statically for circuit integrity, as well as dynamically for signal strength.

These are the basics of ABS operation. Our major focus in this article is the wheel speed sensor. Wheel speed sensor failures and sensor signal problems represent the most common types of ABS failures. Knowing how to diagnose the various types of failures related to wheel-speed sensors is a critical part of the ABS diagnostic process.

Wheel speed sensor failures generally fall into two categories: code-related failures and those that result in a false activation of the ABS system. Code-related failures can be further divided in either current codes or history codes.

Current codes are those that indicate the system has experienced a hard failure and the problem responsible for the code is still present. A history code indicates the system experienced the problem in the past, set the code associated with it, but is now operating normally.

An example of a history would be a wheel speed sensor with an intermittent wiring harness problem. The wheel speed sensor signal might haved dropped out some time in the past, long enough to store a code. If the intermittent problem "fixed itself," the ABS light would go out but a history code would stay in memory for a computer-determined number of key cycles. Checking the control unit's memory for history codes may give you a head start on diagnosing intermittent problems.

An ABS system may also experience what is referred to as "false activation." This occurs when the ABS system engages, even though none of the vehicle's wheels are experiencing excessive slip as a result of a tire losing grip with the road. In most cases, false activation

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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 **Airtex Engine Management, P.O. Box 70, Fond du Lac, WI 54936-0070** or e-mail him at **mhicks@airtexproducts.com**. We'll send you a very nice golf shirt if your question is published. So please include your shirt size with your question.*

Q: The 2003 Jeep Liberty with a 3.7L engine and about 50,000 miles was brought to our shop with a crank but no start problem. The customer claimed the engine started misfiring, the Check Engine light came on, the tachometer went very high and then the engine died and would not restart.

When I got the vehicle into the shop, the engine started and ran pretty good. I put the scan tool on it and pulled a code P0320, which means a problem with the crank sensor circuit. I also looked at the freeze frame and the code had set at about 7500 RPM. I checked the wiring from the crank sensor to the PCM and it tested okay. I scoped the crank sensor and found a perfect pattern, but I decided to replace it anyway.

I wasn't convinced the problem was fixed, so I decided to run the engine for my own assurance. After about a half hour of running, it stalled. Four of the six coils were burnt out. I replaced them, restarted the engine and took it for a road test. After a short drive the fifth coil burned so I replaced the remaining two. I tested it for another two hours and about 45 miles and it ran well.

I called the customer and he came in about two hours later and picked up the Jeep. He got about two miles down the road, then the engine quit and it would not restart. Back in the shop I found three of the new coils were smoked and, you guessed it, the P0320 had returned. I again checked all the wiring from the all the coils and the crank sensor, to no avail. I am thinking the PCM or the new crank sensor may be defective. What do you think?

Robert Ojeda
Sharp Auto
Benicia, CA

A: The parameters to set a code P0320 on a Jeep are interesting. The code set conditions are: no crankshaft position sensor signal present during cranking, and at least three camshaft position sensor signals have occurred. The second half of these conditions can be a little misleading and lead you down the wrong path of diagnostics. For example, what if the cam sensor is generating signals that are not correct?

When the grounding circuit of the cam sensor becomes defective, this is exactly what occurs. The cam sensor will generate multiple signals and the PCM will interpret this as camshaft revolutions. In the meantime, the crankshaft sensor has not generated any signals because the crankshaft has not rotated far enough. The PCM calculates this as a problem with the crankshaft position sensor circuit, not the cam sensor circuit. This will very likely lead you down the dark and wooded diagnostic path of no return.

The faulty cam sensor would explain the high tachometer reading, as well as the coils that were damaged by excessive triggering. To diagnose this failure, attach your lab scope to both the crank and cam sensor outputs. Start the engine. Lightly tapping on the cam sensor will also help to unmask a sensor ground problem.

Result: Robert rechecked the system as instructed and found the cam sensor to be defective.

Thank you for all the great responses to the high idle question from reader Fred Ludden that was included in the previous *Counter Point*. To bring you up to speed, the problem vehicle is a 1994 Olds 98 with an idle speed of 2800 rpm. The AIS motor, intake gaskets and throttle body base gasket have been replaced and no vacuum leaks are present.

Several readers commented they needed more information. Kudos to all who take this approach to diagnosis. If you don't have enough information to make an informed diagnosis, don't guess. Continue your research until you have all of the facts.

If you were diagnosing this problem, what would you do next? Or better yet, what would you have done long before getting this far? If you said plug in the scan tool and take a look at the parameters, I am with you. This is what Fred did next, and he found the IAC counts were low and the TPS voltage over specifications.

When he replaced the TPS, he noticed there was coolant leaking out of it. Aha! Now we are getting to the root of the problem. The TPS on this application is mounted under the throttle body and it had been seeping antifreeze for a while. The leaking antifreeze found its way into the TPS and caused a short circuit and a high voltage output to the computer. The computer interpreted this as a partial throttle and of course turned the idle speed up by adjusting the IAC.

Results: Fred replaced the TPS as well as all the throttle body gaskets and the idle returned to normal.

The first reader with the correct answer was:

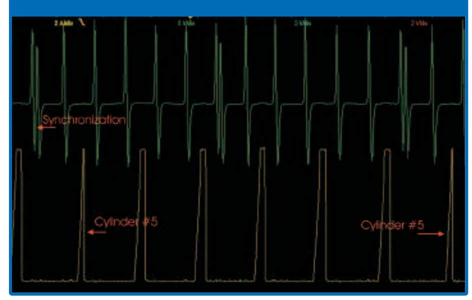
Robert Downes
Westampton, NJ

Diagnose The Problem Win A Shirt

This is a problem on a 1995 Pontiac with a 3.1L engine that we diagnosed in our shop. The owner complained of a lack of power and engine shake. Our first step was to verify the complaint. It was obvious that the engine had a misfire, and our scan tool indicated the culprit was cylinder number 5.

Next, we backprobed the feed wire from the crankshaft position sensor to the control module and amp clamped the battery feed wire to the ignition control module. The labscope waveforms shown in the illustration below are the results of the test. The crank sensor produced the green waveform at the top of the screen capture, and the yellow waveform at the bottom represents the amperage draw to the control module.

This screen capture illustrates the relationship between the crankshaft sensor signal and ignition module current draw.



Question: What could cause this type of amperage draw pattern on cylinder number 5?

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

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ABS Speed Sensors

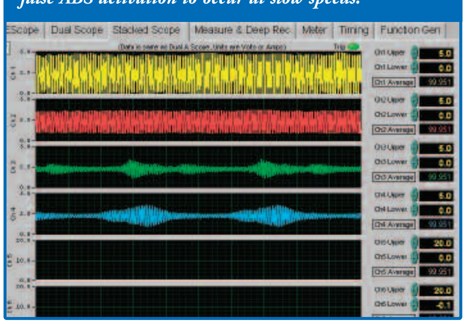
does not result in a trouble code being stored because the control unit thinks the system is operating as designed.

The false activation frequently occurs at the end of the stop cycle; usually at speeds below 10 mph. When this occurs, the speed sensor produces a signal that mimics a signal that should occur during normal wheel slip. When the control unit receives the bogus speed sensor signal, it goes into its wheel slip control mode and cycles the ABS at the affected wheel to control a wheel slip condition which does not currently exist.

False activation of the ABS usually occurs as a result of one of two types of sensor problems. The first involves how the signals from the system's speed sensors compare with one another. The control unit uses this comparison along with how the signals look when compared to a preprogrammed memory to determine if excessive wheel slip is occurring.

For example, if the frequency of the signal from one front sensor falls off before the other front sensor, the control unit will interpret this as a valid wheel slip and engage that wheel's pressure control circuit. This type of problem generally takes place at low speeds, when the difference between the sensor signals shows up as the greatest. The second common cause of false ABS activation is due to an erratic signal. An erratic signal is one that doesn't change smoothly over time. Following are a few examples of how an erratic signal can occur.

Both rear axles had been replaced on this 1998 Lincoln Town Car. The trigger wheels were approximately .060-in. smaller in diameter than OE. This can be seen on channel 3 (green) and channel 4 (blue). There were no DTCs set, however this caused a false ABS activation to occur at slow speeds.



All screen captures courtesy Automotive Test Solutions.

A variable-reluctance wheel speed sensor can be checked by measuring its resistance with a DMM (digital multimeter). Always consult your service information, because the exact specifications can vary significantly from vehicle to vehicle.

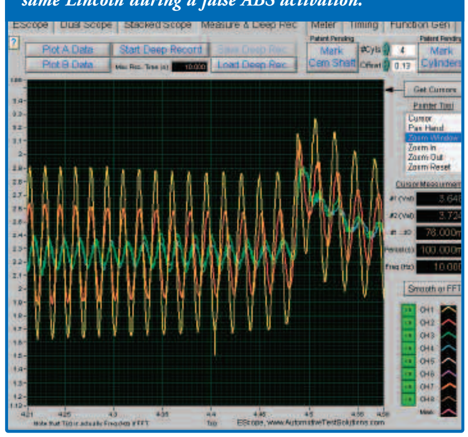
If the wheel speed sensor resistance is out of specification, it will not produce an accurate signal. To verify sensor outputs, compare them using an oscilloscope or AC volt meter.

Don't forget the wiring between the speed sensor and the control unit. If there is excessive resistance in the wiring, the signal will be affected. The most common causes of excessive resistance are water intrusion and corrosion inside the connector between the sensor and the main wiring harness. Water intrusion can also occur at the sensor. A failed seal at the sensor can cause erratic, intermittent or inoperative sensor problems.

The distance or air gap between the end of the wheel speed sensor and the tone ring is also critical. A precise gap is necessary to produce a strong, reliable signal. But if the gap is too close, metal-to-metal contact between the sensor and tone ring would damage both. Conversely, an air gap that's too wide may produce a weak or erratic signal, or no signal at all.

If a wheel speed sensor is adjustable, refer to your service information for the required air gap and adjust it to specs. Insert a nonmagnetic brass or plastic feeler gauge between the end of the sensor and ring, then tighten the set screw that locks the sensor in place.

This screen capture illustrates the speed signals on the same Lincoln during a false ABS activation.

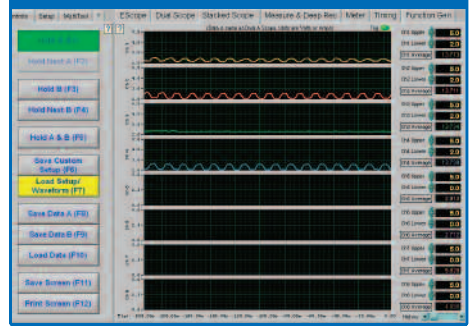


Some sensors come with a piece of paper or a plastic sleeve over the end that provides the proper gap when the sensor is installed. To install this type of sensor, insert it until it just touches the tone ring, tighten the set screw to lock it in place. The sensor ring will either wear a groove in the spacer or tear it off completely. Either way, the gap remains perfect.

Even a properly adjusted speed sensor air gap can be affected by a loose wheel bearing. Any excessive looseness in the wheel bearing will result in a change in air gap and signal strength as the wheel rotates, and must be corrected. The ABS control unit monitors the signal strength and frequency. A speed sensor with a low voltage output should set a code if the output falls below the cut point established in the control unit's operating software.

The sensors are magnetic and will attract metallic debris from semi-metallic brake linings and rotors. If too much metal debris collects on the outer casing, the signal can also be adversely affected.

During a routine brake job, one of the wheel speed sensors on this 1999 Subaru was hit and moved away from the tone wheel. This reduced the signal amplitude and caused false ABS activation. The fix was to readjust the sensor air gap at the right rear wheel.



A code may not set if the sensor is producing sufficient voltage, even though there is noise present. Noise, as indicated by hash in the waveform, may cause the control unit to misinterpret the signal and cause erratic ABS operation that may not be accompanied by a trouble code. The control unit may or may not have the sophistication to identify a signal that's compromised by noise. Instead of identifying the signal problem, the control unit could see it as a wheel speed variation and activate the ABS.

Even a tiny nick in the tone ring may be enough to disrupt the signal. The tone ring can be damaged if a prybar and/or hammer are improperly used to separate a halfshaft from the steering knuckle, or if the halfshaft has been dropped on the floor. A difference of only a few thousandths of an inch in the height of the teeth on the tone ring can affect the wheel speed sensor signal, especially at lower speeds.

Sealed hub assemblies, with the wheel speed sensor and tone ring safely inside, are supposed to provide protection against external corrosion. But if moisture seeps into the hub and corrodes the tone ring, the result will be an uneven wheel speed sensor signal that confuses the ABS system. Road salt may also work its way into the hub assembly at the sensor hole and attack the tone ring. The problem may not be bad enough to set a fault code and turn on the ABS warning light. Yet it may cause misleading wheel speed sensor readings that trick the ABS system into pulsing the brakes when ABS is not needed. AIRTEX

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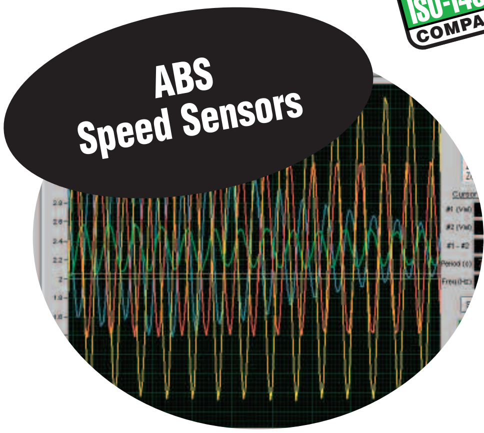

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