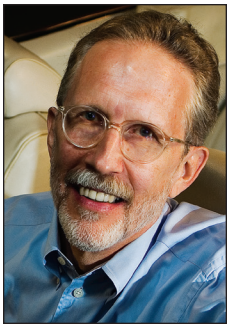
Trouble Shooter



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Vehicle systems that rely on wheel speed sensors for their operation have been with us for some time. The systems and the sensors continue to evolve, requiring new service techniques.

Magnetic Attraction

I'm working on a 2013 Nissan Pathfinder. The customer said she was driving the vehicle and everything seemed normal until the ABS, traction control and stability control warning lights came on and a four-wheel drive error message appeared on the instrument cluster.

This vehicle is equipped with active ABS wheel speed sensors. A DTC for the right front wheel speed sensor signal was stored in memory. I connected my lab scope to the wires at the sensor and observed a flatline at almost 11V while rotating the tire. The wheel speed sensor on the other side of the vehicle produced a square wave output in the same voltage range when I repeated the test.

I replaced the right front wheel speed sensor, but the new sensor is still producing a flatline signal at 10.75V. I can generate a square wave on the scope if I remove the sensor from the spindle and pass a magnet over it. For a final test, I installed the new sensor on the left side of the vehicle. It produced a normal square wave in that location.

It would appear that all that's left is the tone wheel, which is integral to the wheel bearing on this vehicle. It doesn't seem to be working, although there's no play or noise in the wheel bearing. You would think that even a damaged tone wheel would allow the wheel speed sensor to generate some kind of signal, instead of a flatline. I would expect to at least see missing pulses. It also seems strange that all systems that rely on the wheel speed sensor stopped working so abruptly. I haven't removed the hub yet, but from what I can see by looking through the wheel speed sensor hole in the spindle and by looking at the back of the hub bearing, there doesn't appear to be any damage.

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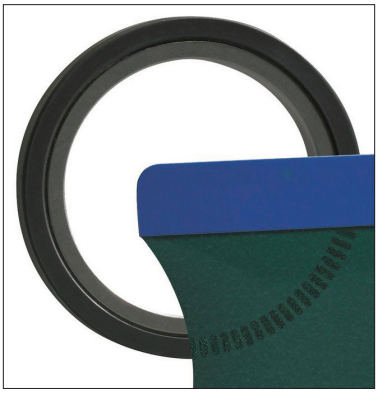

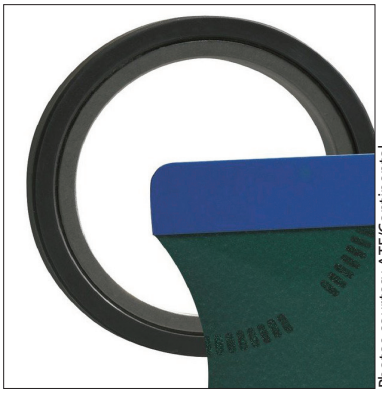

Photos courtesy ATE/Continental

This magnetic sensor ring test card (Part No. 760130) contains a sheet of film that's sensitive to magnetic fields. Placing it next to a wheel bearing that includes an integrated rubber seal that has been enriched with iron dust will reveal the seal's magnetic fields. The image on the left shows a bearing with an unbroken, even pattern that can be easily detected by the adjacent wheel speed sensor. The image on the right reveals a large gap where no fields are detected, possibly caused by physical damage to the seal.

To date, there have been four types of wheel speed sensors installed on vehicle ABS and traction control systems. The earliest was the inductive sensor, which produced an alternating current sine wave output and had two wires. The amplitude of these inductive sensors increased along with the frequency as vehicle speed increased. They also weren't able to produce a useable signal below a certain vehicle speed. Inductive sensors were replaced by two- and three-wire Hall effect sensors. These sensors produce a square wave output but, once again, their ability to produce a useable signal below a certain vehicle speed is limited, which is what led to the development of the fourth sensor type—the two-wire magnetoresistive sensor.

The magnetoresistive, or "active," sensor must have an opposite-pole magnetic tone ring present to produce a signal. The tone ring is embedded in the wheel or hub bearing seal. These sensors can generate a useable signal output down to a very low vehicle speed, which has allowed for vehicle features like adaptive cruise control. If you're in doubt about which type of sensor a vehicle is equipped with, a simple test will tell you whether it's a Hall effect or a magnetoresistive. Place a screwdriver tip next to the sensor tip.

Hall effect sensors feature a built-in magnet that will attract the screwdriver tip; the magnetoresistive sensor does not have a magnet and will not attract the tip.

Active ring speed sensors work with magnetic sensor rings, which are integrated into the rubber sealing ring of the wheel bearing. To accomplish this, the rubber is enriched with iron dust and then given magnetic fields which are highly sensitive. Unlike the iron tone rings we're used to seeing on the backs of brake rotors, it's not possible to visually inspect the magnetic sensor rings. If the seal ring is in place, there's not much more to check.

On vehicles equipped with self-contained hub bearings, it's not possible to install a new hub bearing assembly with the magnetic sensor ring facing the wrong way. The bearing is already in place and the sensor ring will automatically align with the wheel speed sensor once the hub bearing assembly is installed. However, on vehicles that feature separate wheel bearings with embedded magnetic sensor rings, it may be possible to incorrectly install the bearing.

To avoid installation error, some bearing manufacturers have incorporated a stepped outer bearing race. The diameter is smaller in one section of the outer bearing diameter and larger on the remainder. The bearing must be pressed into place beginning with smaller diameter, as it won't fit in the other direction. This orients the magnetic sensor ring properly.

If the bearing does not have a stepped diameter, there's another method to identify the magnetic sensor ring's location. A piece of transparent film sensitive to magnetic fields will reveal the presence of the evenly spaced iron material embedded in the bearing's rubber sealing ring. Flip the bearing over and the film will not show a pattern. The film can also be used to diagnose a break in the magnetic sensor ring caused by damage, as seen in the photos on page 6. ATE and other manufacturers offer test cards with a protective sleeve that are designed for this purpose.

Back to your customer's wheel speed sensor, magnetic sensor ring and the related diagnostic trouble codes. If the wheel speed sensor is able to produce a signal when it's installed in one location but not in another, there are only a few remaining possible causes. First, the magnetic sensor ring may be damaged. But as you mentioned, you would expect to see at least a partial or erratic signal in this case. Second, the bond between the seal ring containing the magnetic sensor ring and the hub bearing may be damaged. On a very rusted bearing, the seal may be present but no longer rotate with the internal bearing race. So while the vehicle is moving, the sensor ring remains stationary along with the outer bearing race. Lastly, the sensor ring may be missing entirely, again due to rust or external damage. It's not going to be easy to get a clear view of what's going on back there until the hub bearing has been removed, which is something it looks like you're going to have to do anyway.

There are several things you can do (or not do) to extend the service life of the new wheel bearing and sensor ring. Never place a wheel bearing with a magnetic sensor ring on a dirty workbench. Never place a permanent magnet anywhere near the magnetic sensor ring. Never insert sharp-edged or pointed tools in the wheel speed sensor bore, as this can result in damage to the magnetic sensor ring. Fit the wheel bearings as instructed by the wheel bearing or vehicle manufacturer. Don't drive the wheel bearing into place with a hammer and drift; use a press or other tool designed for that purpose to install the wheel bearing. Once the bearing is installed, make sure the magnetic sensor ring and the wheel speed sensor are positioned opposite each other, with the proper gap.