Spinning your wheels

Wheel speed sensors are the eyes and ears of the systems that control ABS and ESP. Joe Clarke, of the Dublin Institute of Technology, explains how to diagnose a problem caused by a fault in the wheel speed sensor's input to the ECU.

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In the last decade, active vehicle safety has progressed significantly due to the technological advancements in anti-lock braking systems (ABS) and electronic stability control (ESP). The majority of motor vehicle manufacturers, tend to use the active type wheel speed sensor as opposed to the previous inductive type. These sensors are smaller in size, more accurate at lower speeds, can measure direction and produce a digital signal, which is interpreted directly by the vehicle's electronic control unit (ECU).

Operation

The active wheel speed sensor is typically mounted directly in the hub carrier opposite the wheel bearing. The wheel bearing contains a ring of magnets, commonly known as a phonic wheel, which rotates along with the wheel bearing as the road wheel turns. Hall-effect active wheel speed sensors consist of two wires: a battery voltage power supply from the ABS/ESP ECU and a return signal wire. In order for this sensor to function, it must receive it's power supply from the ECU. When the road wheel is rotated, the magnets pass by the sensor, resulting in the production of a square wave signal. The signal voltage and current, switches from a high state to a low state. The more times the signal goes from high to low, the faster the wheel is spinning. The voltage of the signal may vary in amplitude according to manufacturer.

Testing

In the event of a wheel speed sensor fault, the customer will be notified by the illumination of a malfunction indicator lamp (MIL) on the dash panel, along with a message on the multi-function display (MFD). To identify the fault, the technician's first step is to interrogate the ECU's fault log or memory bank using a diagnostic or scan tool. A fault description, manufacturer's fault code or a generic OBD C-code may be provided, according to the tool used. Another option is the observation of the vehicle's four wheel speeds in the live data or parameter measurement option while driving. All four wheel speed sensors should be indicating the same speed at all times.

Following fault area location, it is necessary to determine the actual faulty component i.e. sensor, ECU, phonic wheel or related wiring. The hall-effect active sensor must remain connected during all measurements. If the active sensor is disconnected, the ECU will interrupt the power supply to protect the system, which could lead to a faulty diagnosis. Measurements are therefore obtained by back probing or using a suitable break out box/connector.

When the ignition is switched on or the engine is running, battery voltage should be present on the supply line to the sensor. This may be measured using a DC voltmeter, or an oscilloscope as shown in Figure 1.

Although a DC voltmeter may be used to determine the sensor's signal high and low state as the road wheel is rotated, true signal verification is only possible with the oscilloscope. Connect the positive oscilloscope probe to the signal wire, while the negative probe is connected to a good chassis earth.

Figure 2 shows the signal produced when the road wheel is rotated slowly at constant speed.

As the distance between the magnets remains constant the duty cycle remains at 50%.

Figure 3 illustrates how the signal varies as the road wheel is accelerated from stand still. The 50% duty cycle remains, the amplitude is constant but the frequency of the waveform increases which is directly proportional to the wheel speed.

Conclusion

If the sensor produces no signal following verification of the wiring, the ECU, sensor or phonic wheel could be at fault. To eliminate the sensor or phonic wheel as the source of the fault, the sensor could be swapped with another location on the vehicle and re-checked. If the fault follows the sensor to it's new location, then the sensor is faulty.

A sticking phonic wheel can cause the signal to be interrupted (faulty) intermittently, causing the ECU to believe that a wheel is rolling at a different speed to the others. This may cause an involuntary ABS or ESP activation as the ECU might think that the vehicle is out of control i.e. in a yaw.

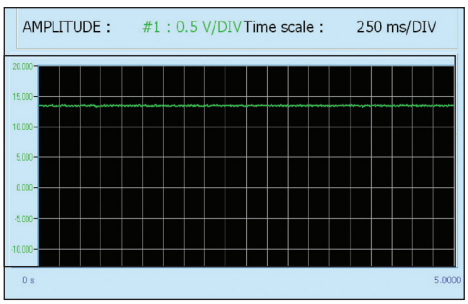

Figure 1: Oscilloscope trace of the supply voltage to the wheel speed sensor

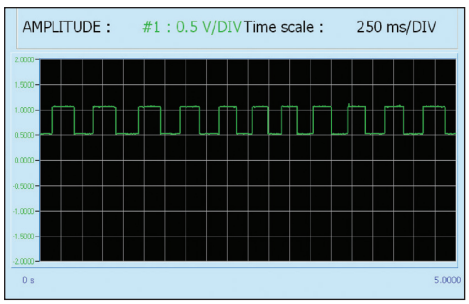

Figure 2: Oscilloscope trace of the signal voltage of the wheel speed sensor as the wheel rotates at constant speed

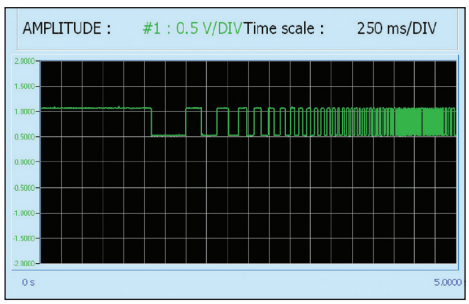

Figure 3: Oscilloscope trace of the signal voltage of the wheel speed sensor as the wheel accelerates from a stop position