Most vehicle dynamics control systems are activated by wheel speed signals. The Anti-lock Braking System (ABS) and the Anti-Slip Regulation (ASR) deriving from it are almost entirely based on such wheel speed measurements.

Precise wheel speed measurement under any environmental condition is also vital when it comes to systems such as Electronic Stability Control (ESC), Electronic Stabilisation Program (ESP) and many others.

**System description and signal generation**

Sensors and encoders form a system where the encoder delivers the measured values which are then read by the sensor and converted into an electronic signal for the Engine Control Unit (ECU).

All wheel speed sensors used to date are based on the measurement of magnetic fields that vary depending on the wheel speeds. The connection between the encoder and sensor is a magnetic field situated in an air gap. (Figure 1)

The first encoders were made of ferritic metal and installed on the axle journal. Unfortunately, the axle vibration often interfered with the speed signal and also the design was very susceptible to contamination. To avoid this, the encoders were integrated into the wheel bearings, initially outside the seal and later actually in the seal itself.

**Passive sensors**

A magnet in the sensor is absolutely necessary for ferritic encoders. Initially, passive sensors with integrated magnets were used for this purpose. They do not require current and work according to the induction principle. Containing a coil wound around a permanent magnet, the ferritic metal of the encoder causes a change in the magnetic flow through the coil, so that a voltage is generated in proportion to the rotational speed of the encoder.

Therefore, the speed signal frequency of these inductive sensors is dependent on the speeds, which is a desired measurement effect. However, the speed signal amplitude is also speed dependent and this is an undesirable side effect that results in signal loss when driving at lower speeds.

**Active sensors**

Following on from passive sensors came the introduction of active sensors with integrated magnet. Their encoders still consist of ferritic material but, in contrast to passive sensors, these active speed sensors require a current in order to generate an ECU signal. However, they are able to record driving speeds from 0.1 km/h upwards. Some designs have the additional ability to distinguish between forward and reverse motion.

**Multipole encoders**

The refinement of the entire system brought about the creation of the magnetic multipole encoder which led to the elimination, or significant reduction, of magnets in active speed sensors. Passive speed sensors have completely fallen by the wayside.

The development of multipole encoders was undertaken in cooperation with seal and sensor suppliers. Wheel bearing variants range from types with integrated encoders and sensors, as well as multipole encoders with either axial or radial reading capabilities, through to open and clean systems.

**Sensor position**

While today’s encoders are typically integrated into the bearing in order to minimise interference factors such as rotational vibration, the sensors are installed at different positions. The table below shows the advantages and disadvantages of various sensor positions.

<table>
<thead>
<tr>
<th>Sensor position</th>
<th>Mounted inside the wheel bearing</th>
<th>Mounted on the wheel bearing</th>
<th>Mounted on the wheel carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>Sensor head and encoder are protected against contamination and mechanical wear</td>
<td>Maximum precision of the speed signal</td>
<td>Easy replacement of the speed sensor</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>Risk of bearing contamination during sensor replacement resulting in bearing failure</td>
<td>Sensor replacement normally not possible</td>
<td>Lower precision of speed signal</td>
</tr>
</tbody>
</table>

Today most new vehicles incorporate wheel bearings with integrated multipole encoders. FAG-branded wheel bearings are currently sold for serial production to car makers such as Ford, BMW, Rover, VW, Audi, Volvo and GM.

**Small part – great effect**

Workshop understanding of the entire system is becoming increasingly important for any repair, especially with safety relevant components such as wheel bearings. Technicians should be aware that vehicle dynamic control systems can fail due to incorrect repairs. FAG, as one of the leading wheel bearing suppliers, delivers not only the suitable original brand spare parts but also the technical information for correct handling and mounting. This ensures that the entire system will function properly and, above all, safely.

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