Speed Sensors

McLaren Electronic Systems offers four types of speed sensor for automotive applications:

- Inductive
- Differential Hall Effect (DHE)
- Zero Speed Hall Effect
- True Position Zero Speed

All types give an output when subjected to a changing magnetic field. The field is provided by a permanent magnet inside the sensor body and is modified by the motion of a ferromagnetic toothed wheel. Magnets are not required in the target wheel. As each edge of a tooth passes the sensor, the magnetic field changes causing a change in the sensor output.

Comparison of Inductive and DHE Sensors

Although they measure similar parameters and are a similar size and shape, these sensors are not interchangeable. The DHE and Zero Speed Hall Effect sensors give an open collector switched output while the inductive sensor gives a voltage pulse output with a magnitude which changes with speed over a large range.

In practice, the three sensors may be used in similar applications. Where the precise timing of a pulse, rather than the pulse rate is important, for example, in engine timing applications, an inductive sensor gives more accurate results. With appropriate packaging, inductive sensors can be used at very high temperatures and we can supply a version able to operate at up to 290℃ (designed for turbochargers).

For other applications, the DHE or Zero Speed sensors may be used. They are less expensive that the inductive sensors, and the electrical interface is easier to implement. However, Hall sensors include active electronics that place a practical limit on the maximum operating temperature.

Speed, Angular Position and Torque

Speed is measured by counting the number of times that a target wheel tooth edge passes the sensor in a given time period. Since the number of teeth on the wheel is fixed, it is easy to calculate the average speed over the period.

To measure the relative position of two shafts, or the twist in a shaft (which is a measure of torque), two target wheels and two sensors are used. Each wheel has its own sensor and the relative rotational angle of the wheels is measured in terms of the time delay between the sensor pulses. To avoid ambiguity, at least one of the wheels must have either only one tooth or a “missing tooth” to act as a reference.

The sensor can also be used to measure the absolute angle of the target wheel on, for example, a crankshaft. In high speed 4 stroke engine timing applications it is important to use a wheel with a number of teeth equal to half the number of cylinders (e.g. a 5 tooth wheel for a 10 cylinder engine). The pulse from the sensor gives the ECU a timing reference for each cylinder. To ensure that the ECU timing is in phase with the mechanical timing, a single tooth wheel is placed on the cam shaft, and its position is measured by a separate sensor.

Cut in Speed

The Zero Speed Hall Effect sensor can be used for low speed measurement, whereas the Inductive and DHEs have minimum detection frequencies. This is discussed in the following notes for each type.

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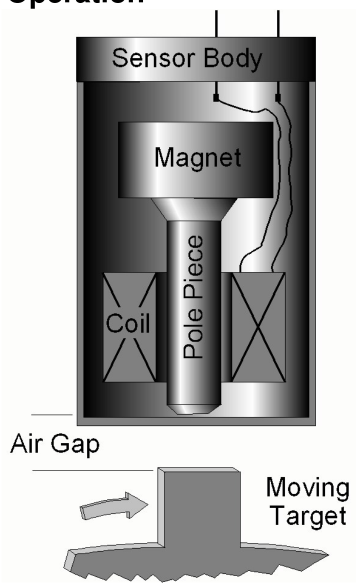
Speed Sensors

Inductive Sensors

Inductive (magnetic reluctance) speed sensors are lightweight and very robust, which makes them particularly suited to demanding motorsport applications. Typical applications are cam and crank shaft position/speed and wheel and turbo shaft speed measurement.

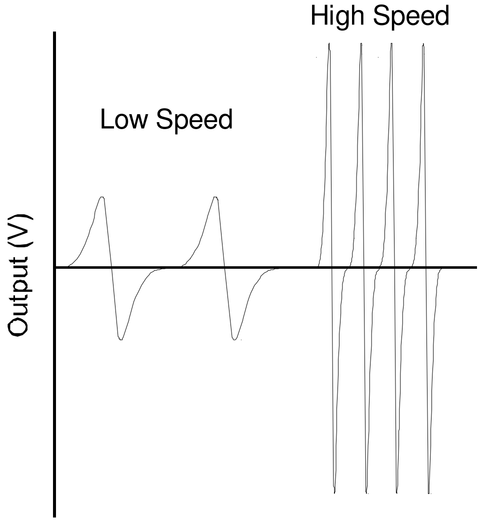
In-house design and manufacture allows our sensor design team to provide very cost effective customised parts to suit even the most demanding application. We have optimized the magnetic circuit, formed by the sensor and its target, to achieve high sensitivity in a very small package.

Principle of Operation



In an inductive sensor, the magnetic field around a permanent magnet changes if a ferrous target (e.g. a toothed wheel) is moved in front of the sensor. The change is sensed by the voltage generated in a coil of wire in the magnetic field. The coil and magnet are integrated in the sensor body for ease of installation.

The magnitude of the induced voltage increases with the speed of movement of the ferrous object (i.e. the target wheel speed). The voltage decreases as the distance (air gap) between the end of the sensor and the moving target gets larger.



Typical output signal of an inductive sensor

Our interface circuits accept the voltage output and convert it to produce a switched pulse output suitable for speed and position measurement. These circuits trigger when the voltage output passes through a threshold (typically 200mV). The detection level can be set lower, but the sensor would be more susceptible to noise. The output of the sensor has to exceed the detection voltage before motion can be detected. Since this voltage depends on the speed of the target, inductive sensors are unable to detect very low speeds.

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Speed Sensors

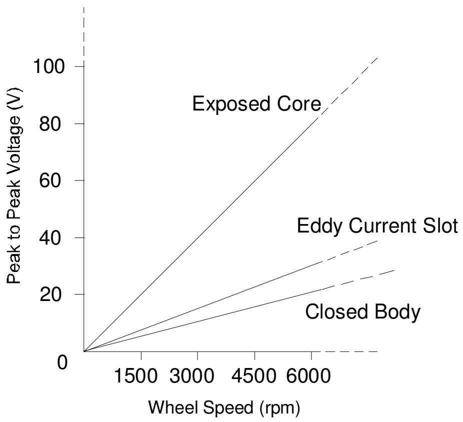
Selecting the Sensor, Target Wheel and Interface Electronics

McLaren Electronic Systems design and manufacture a wide range of inductive sensors and can assist in selecting the right part and defining the most suitable target wheel. We can estimate the cut-in speed (i.e the lowest detectable speed) and confirm the estimate by testing with a sample target wheel.

As a complete system supplier, we can advise on suitable electronic interfaces as well as offering fully integrated interface solutions. We can also offer a discrete interface to condition the sensor signal to provide a TTL compatible output. This can be packaged as an encapsulated unit integrated into the sensor cable.

Sensor Design

Our inductive sensors are available in a range of engine mounting configurations and special versions are available to operate up to 290℃ (for high temperature applications such as turbo speed measurement)



Output of Different Types of Inductive Speed Sensor

The connecting cables on our sensors are not screened. This is because, if not correctly installed, the screen can act as an antenna and can increase the noise level rather than suppressing electromagnetic interference. However, any sensor can be supplied with a screened cable, if required.

Three types of sensor body are offered to suit the most demanding applications:

A. A totally closed design that ensures that the electromechanical assembly is fully encased, masking it particularly suitable for very high temperature applications.

B. A design with a small slot introduced into the body to suppress eddy currents. Eddy currents impede the rate of change of magnetic flux through the sensor. By suppressing them, high speed sensitivity and position measurement accuracy are significantly improved.

C. A body with the magnetic core exposed through the end-face of the sensor body. The air gap between the sensor and the target can be reduced, yielding greater low speed sensitivity and position measurement accuracy, whilst maintaining the improved high speed performance gained from an eddy current reduction slot.

If the sensor is installed in such a way that it is surrounded by metal (e.g. when inserted into a casting) the eddy current reduction slot will have little effect and the closed body type is recommended.

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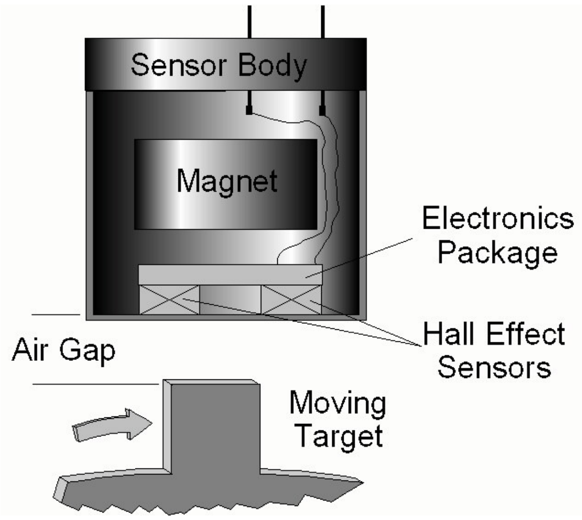
Speed Sensors

Hall Effect Sensors (Differential, Zero Speed and TPZS)

Hall Effect speed sensors are lightweight, reliable and very robust which makes them particularly suitable for demanding motorsport applications. Typical applications are wheel speed and camshaft position measurement. Under special circumstances relative shaft positions can also be measured (please contact our technical consultancy department if you wish to do this).

As the design and manufacture is in-house we can provide very cost effective customised parts to suit even the most demanding application.

Principle of Operation for the DHE



A Hall effect element is a small sheet of semiconductor material arranged with a constant current flowing across it. In a magnetic field, a voltage, which is proportional to the field strength and at right angles to the current flow, is generated across the element. The magnetic field is supplied by a permanent magnet in the sensor, a magnetised wheel is not needed.

Differential Hall Effect

The differential version has two Hall effect elements and only responds to changes in magnetic field strength. This arrangement is relatively immune to interference, but it cannot detect static fields. This limits its operation to speeds which give a switching frequency greater than the minimum operating frequency quoted in the Product Summary. This design allows for relatively large operating air gaps.

The sensor has an open collector output with a 10nF filter capacitor between output and ground. Typically an external pull up resistor is used on the sensor output but a 2kohm “pull up” resistor can be included on some models to convert to TTL output levels.

This resistor and capacitor give an R/C charge characteristic on the rising edge of the sensor output. If the resistor is too large, especially in higher frequency applications, the signal may not reach the threshold levels required to trigger the control unit. For this reason we recommend triggering on the falling edge which is not subject to the same R/C characteristic.

The output switches to “high” as the leading edge of the tooth passes the sensor and remains high until the trailing edge passes, when it switches “low”. If the sensor is rotated through 180°, the switching polarity is reversed.

Zero Speed Hall Effect

The Zero Speed Hall Effect incorporates a single hall probe. This means that the sensor is not orientation dependent with regard to the target wheel. Furthermore, it can detect wheel rotation down to 0Hz. However, this design is less tolerant of large operating air gaps between the sensor and the target wheel than the differential Hall effect version. The recommended air gap is 0.8mm (1.0mm maximum).

The sensor has an open collector output with a 2.2nF filter capacitor between output and ground. The sensor shows a low output in the presence of a tooth.

The cables on our sensors are not screened. This is because, if fitted incorrectly, the screen can act as an antenna and can increase the noise level rather than suppressing electromagnetic interference. However, all models can be supplied with a screen, if required.

True Position Zero Speed

Designed for use with the F1 Standard ECU for quadrature measurement, speed and position can be derived for gearbox applications.

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