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WHEEL SPEED SENSORS OPERATING IN HARSH ENVIRONMENTS

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Introduction

Wheel speed sensors (WSS) operate in harsh environments with limited shielding and temperature control. WSS are required to provide correct speed and direction information for wheel speed, anti-lock braking, and traction control systems. Allegro Microsystems has developed innovative algorithms and high-performance sensors to operate in these environments. Modern Allegro Microsystems wheel speed parts have introduced SolidSpeed Technology which has moved much of the signal processing and detection to the digital domain. This allows the magnetic signal to be tracked in a way that previously was not possible. These sensor solutions are typically in a 2-wire package can utilize a pulse width protocol or AK protocol to provide speed, direction, relative air gap, and additional information. Modern Allegro WSS are designed with optional fault reporting for ASIL compliance.

Key Parameters

Throughout this document the air gap of the sensor in relation to the target is continuously referenced. This section is to discuss proper WSS alignment with the associated target. Determining this air gap requires two known mechanical features.

1. The branded face of the sensor is to point towards the target and be parallel with the face of the target.

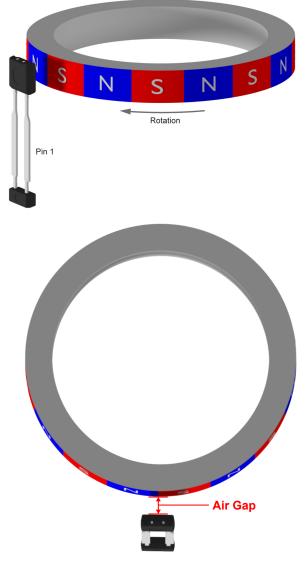2. The distance from the branded package face to target is considered the operating air gap of the sensor.

Figure 3: System mechanics

Environmental Factors

Due to the positional nature of wheel speed sensors temperature effects can play a large role in the sensor's performance. Wheel speed sensors are placed in non-temperature-controlled environments and depending on the daily vehicle usage these temperatures can vary from sub-zero to extreme heat due to placement near high-friction braking systems. The operational temperature range of a WSS can be found in its associated datasheet.

The WSS and sensed target can move independently, subjecting the sensor to cases where the air gap can change during operation. Allegro wheel speed sensors use SolidSpeed technology which allows the signal to be tracked throughout these dynamic air gap changes. If the air gap changes are large enough to be outside datasheet limits for allowable signal reduction such that signal tracking is momentarily lost, Allegro has advanced algorithms to recover signal tracking after several magnetic cycles.

Air Gap Range

Solid Speed technology allows Allegro's wheel speed sensors to be able to track the magnetic signals throughout a high range of air gap variation without missing an output event. The allowable signal variation is typically expressed in the datasheet along with the allowable differential peak to peak signal ranges. Allegro's wheel speed senosrs are designed to maintain a consistent performance over the air gap and temperature range for a given set of magnetic targets.
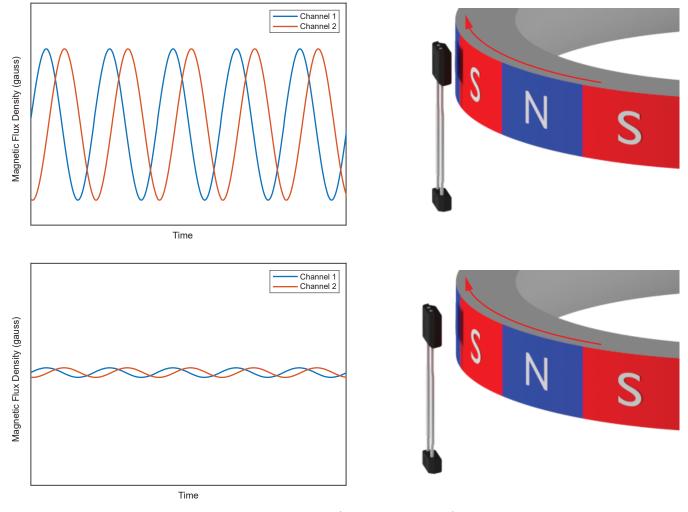

Figure 4: Air Gap Range (click images for animation)

Repeated and Sudden Air Gap

Wheel speed applications are also highly suspect to air gap deviations. Air gap deviations can be due to a multiple of reasons; change of velocity, the loading and unloading of a wheel, or an event that causes a wheel to change relative vertical location in a rapid motion with respect to the vehicle chassis. These events can cause the sensed magnetic signal to change in two ways. Gradual movement, where the air gap changes over a multiple of magnetic cycles known as a consecutive event ratio change (CERC). Or in a sudden movement, where the air gap changes over a fraction of a single magnetic cycle known as a spontaneous event ratio change (SpERC). The allowable event ratio change over a given number of teeth can be found in the datasheet of each device.
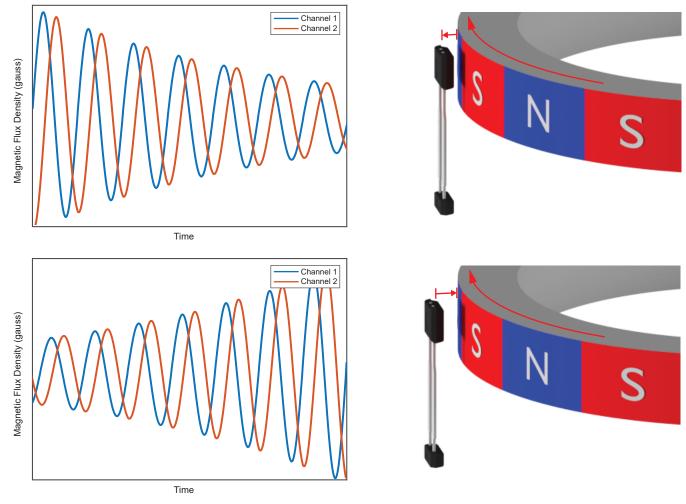

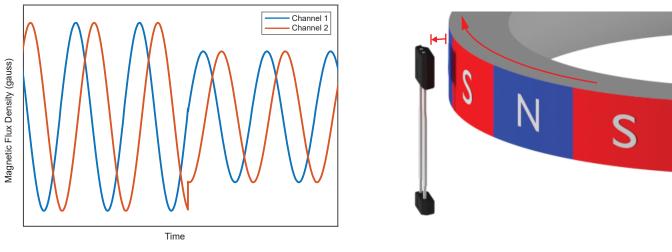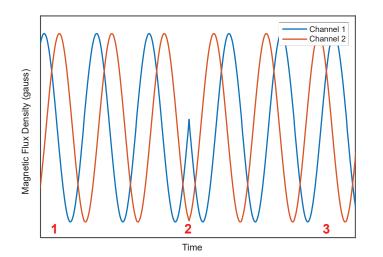*Figure 5: Gradual Air Gap (click image for animation)*

Figure 6: Sudden Air Gap (click image for animation)

Direction Change

Target direction of rotation detection is possible due to the physical location of sensing elements. This physical position of the sensitive elements creates multiple phase separated channels. This separation information is used to determine target direction of rotation. Since the phase separation of these channels is dependent on the pole-pair spacing of the sensed target, each target is to be analyzed to ensure compatibility. Each sensors datasheet has requirements and capabilities listed.
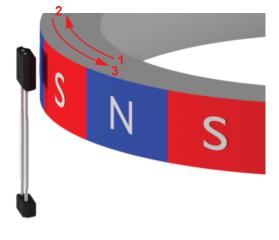

Figure 7: Direction Change (click image for animation)

Temperature Drift

Temperature change can vary the sensed target and sensor performance. One way the sensed signals can be altered is a magnetic drift, also considered a temperature drift, where the signal changes its zero-crossing location. Temperature drift occurs when nonuniform heating occurs on the WSS. Solid Speed technology has allowed for modern sensors to deal with signal variations in a robust fashion.
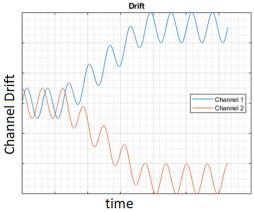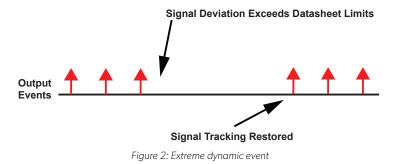

Figure 1: Temperature drift

Extreme Dynamic Event

If the magnetic signal variation exceeds datasheet limits, Allegro's wheel speed sensors use an advanced algorithm that will recover signal tracking using an event-based method. The sensor can detect if the signal tracking is lost for multiple magnetic cycles the sensors will automatically restore signal tracking.

Figure 2: Extreme dynamic event

Conclusion

All the above factors come in to play, often within a single application socket. Therefore, the industry leading, time-proven algorithms Allegro includes on their WSS ICs have been designed to handle the most stringent application conditions.

Revision History

Number	Date	Description	Responsibility
–	August 24, 2021	Initial release	S. Veilleux

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