GUIDELINES FOR MAPPING SPEED SENSOR TARGETS

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INTRODUCTION

Speed sensor targets have various application-specific forms, such as ring magnets with different magnetic properties, diameters, and numbers of pole pairs, and ferrous gears with different sizes and features. For each target, it is important to determine if they are compatible with the speed sensor that will be used and the air gap range over which the sensor will operate. This requires finding and analyzing the magnetic input signal over several placements of the sensor relative to the target—for example, over rotation of the target and over air gap. The set of magnetic input signal values over target rotation and sensor position is known as a target map, and the method to measure, simulate, or calculate these signals is known as target mapping. This application note describes the various techniques that can be used to map customer targets for speed sensors.

MAPPING SPEED SENSOR TARGETS USING MAGNETIC SIMULATIONS

If a 3D model or a technical drawing of the target is available, Allegro can perform magnetic simulations to map the target. These simulations are performed in Ansys Maxwell or in MATLAB by creating a sensor and target system, defining movement parameters, and solving them to find the magnetic fields at the sensing elements of the sensor.

To perform these simulations, Allegro requires the following information from customers:

- A 3D model of the target, usually available as a STEP file. For less complex ferrous targets or ring magnets, a technical drawing with target dimensions may be sufficient.
- Allegro speed sensor under consideration for the application.
- Any special placement requirements for example any twist or tilt in the sensor placement.
- Material properties of the target, for example, the type of ferrous material and the permeability (U_r) for ferrous targets, or the magnetic material, remanence flux density, (B_r), and temperature coefficients for ring magnets.
- Dimensions and motion of any nearby ferrous or magnetic materials that may influence the magnetic field.

Magnetic simulations can be characterized into two types: ring magnets with Allegro front-biased sensors and ferrous targets with Allegro back-biased sensors.

Ring Magnets with Allegro Front-Biased Sensors

Figure 1 shows the steps required to determine the maximum air gap on a ring magnet model. The ring magnet in the figure is created from information provided by the customer. A simulation is run for rotation over one pole pair (or one T_{CYCLE}) and over several air gaps, and the peak-to-peak of the differential magnetic signal is plotted versus air gap. The air gap at which the peak-to-peak crosses the datasheet-specified minimum peak-to-peak differential signal value (30 G in Figure 1) is the maximum operating air gap of the sensor.

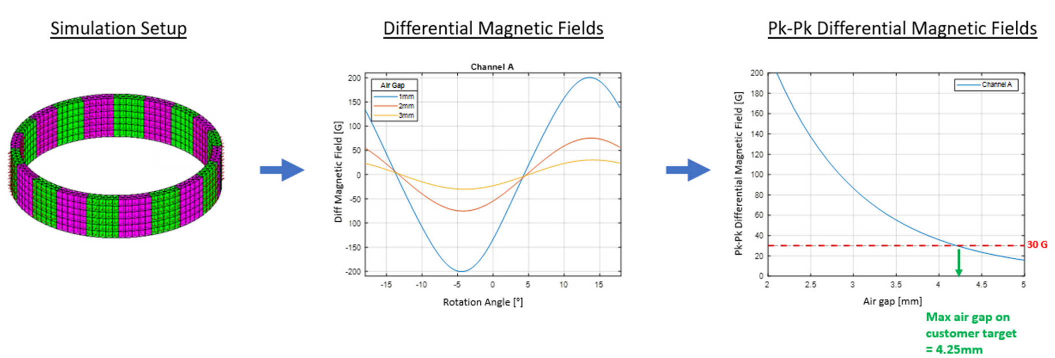

Figure 1: Ring magnet mapping through simulations

Similarly, several operating characteristics and limits described in the datasheets of Allegro front-biased sensors can be calculated from the input magnetic fields. These include:

- Operating differential magnetic input
- Operating single-ended field magnitude
- Signal cycle-cycle variation
- Switch point separation
- Phase shift

These operating characteristics depend on the Allegro sensor under consideration, and it is important to determine if the specifications for these operating characteristics will be met to ensure the correct operation of the sensor in the application.

Ferrous Targets with Allegro Back-Biased Sensors

For back-biased speed sensors, Allegro datasheets define specifications such as the maximum air gap on a standard Allegro ferrous target. Therefore, a customer target mapping must be compared to a mapping of the Allegro target. Figure 2 shows the procedure to find the maximum air gap on a customer target through simulations. Both the customer target and the Allegro standard target are imported into the simulation environment, the material properties are defined, and a simulation is performed over one tooth valley period and over air gap. The maximum air gap on the customer target is determined by finding the air gap where the peak-to-peak of the differential magnetic signal on the customer target is equal to the peak-to-peak of the differential magnetic signal on the Allegro target at the datasheet-defined maximum air gap. For example, in Figure 2, the maximum air gap is determined to be 2 mm on the customer target.

Several operating characteristics and limits described in the datasheets of Allegro front-biased sensors can be calculated from the simulated input magnetic fields. These include:

- Switch point separation
- Cycle-to-cycle variation
- Signature amplification ratio for targets with signature regions
- Dynamic and sudden air gap range
- Phase shift

These operating characteristics depend on the Allegro sensor under consideration, and it is important to determine if the specifications for these operating characteristics will be met to ensure the correct operation of the sensor in the application.

MAPPING SPEED SENSOR TARGETS ON THE TEST BENCH

If physical targets are available, Allegro labs can perform measurements to map the target on the test bench. Mapping a physical target has the advantage that it considers any small variations that might be present on the actual target that may be missed by the ideal environment in simulations. Additionally, the fields measured from a test bench mapping more closely represent the actual fields the sensor will sense in the application.

Like magnetic simulations, test bench mappings can be characterized into two types.

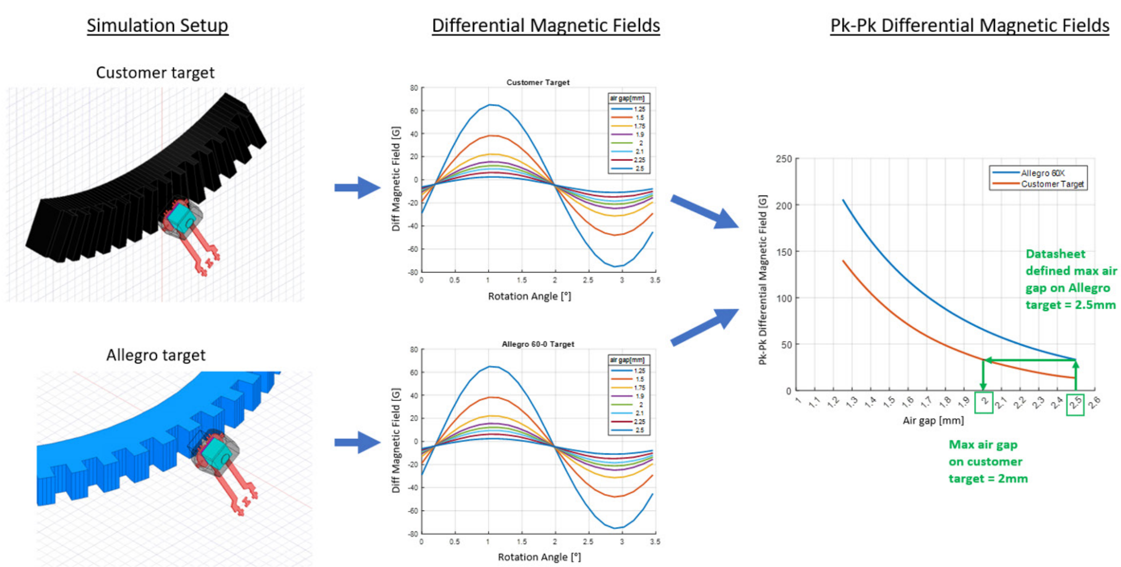

Figure 2: Ferrous target mapping through simulations

Mapping Ring Magnets with Allegro Front-Biased Sensors

Figure 3 shows the bench setup for a ring magnet mapping measurement. Ring magnets can be mapped using an Allegro linear sensor to measure the magnetic fields. The setup requires a rotational stage to rotate the ring magnet at precise angles and a 3D linear stage set to control the placement of the linear sensor so that it passes through all air gaps and all sensing element placements in the speed sensor. The linear sensor must be placed so that it measures the magnetic field in the direction that the speed sensor will sense (since Hall parts and GMR parts sense fields in different directions). The magnetic field over rotation, air gap, and sensing element placements can be acquired using a data acquisition device or read digitally depending on the linear sensor being used. Once the fields are found, differential signals can be calculated, and the maximum air gap can be determined from the peak-to-peak differential signal as described in the magnetic simulations section.

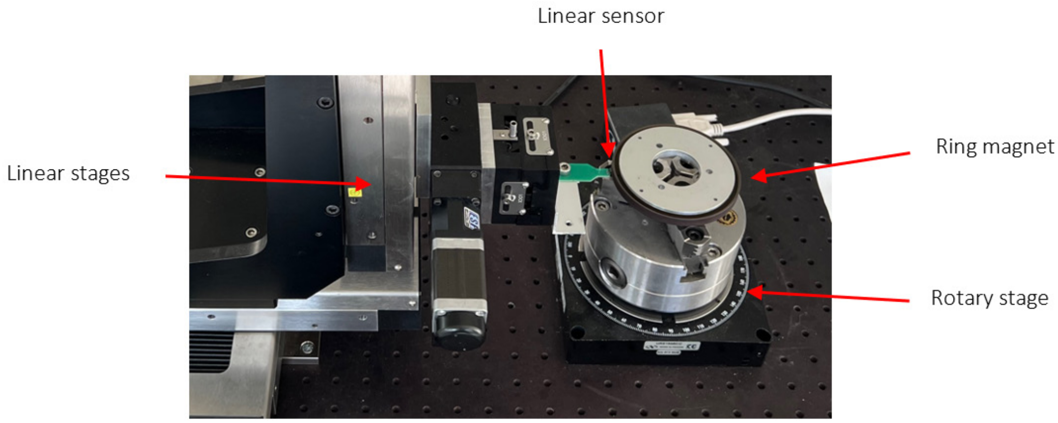

Figure 3: Ring magnet mapping bench setup

Mapping Ferrous Targets with Allegro Back-Biased Sensors

The method for mapping a ferrous target is different from that of ring magnets such that normally a linear sensor is not required. Ferrous targets may be mapped using the actual back-biased Allegro speed sensor that will be used in the application. The magnetic differential signals can be read out as an analog signal on the pins of the IC or digitally in LSBs. The physical setup (shown in Figure 4) is the same as described for ring magnet mappings. However, to find the maximum air gap on a customer ferrous target, an Allegro standard target must be mapped at the datasheet-defined maximum air gap to find the peak-to-peak differential magnetic signals. The customer target can then be mapped over rotation and over air gap, and maximum air gap can be determined by finding the air gap at which the peak-to-peak differential signal on the customer target is equal to the peak-to-peak differential signal value on the Allegro target at the datasheet-defined maximum air gap.

For a physical mapping, in most cases, it may be sufficient to map just one pole-pair or one tooth valley period. However, it is recommended to map the full 360° rotation of the target—at least at one nominal air gap—to ensure that there are no defects in the target creating undesired magnetic signal shapes.

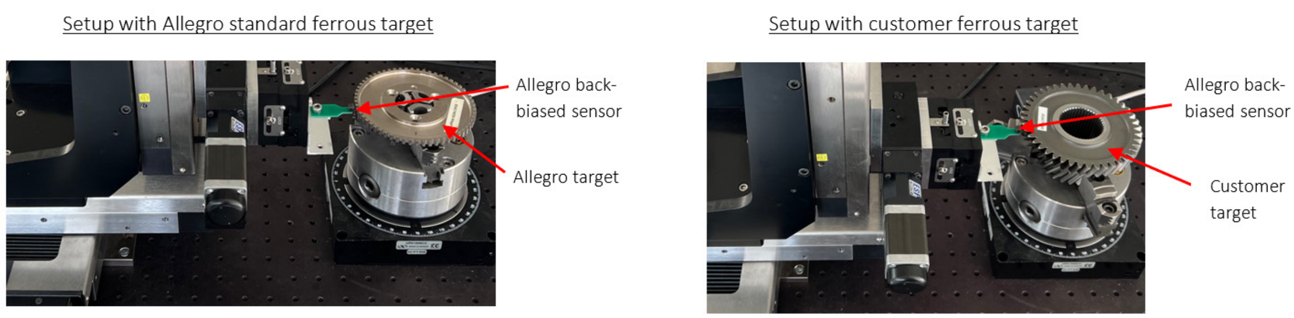

Figure 4: Ferrous target mapping bench setups

CONCLUSION

Mapping techniques may be used to evaluate customer targets for speed sensor applications. Depending on the information that is available, Allegro has the possibility to both simulate and measure the magnetic signals sensed by the speed sensors. These magnetic signals can then be analyzed to determine the compatibility of the speed sensor to the customer target.

Revision History

Number	Date	Description
–	May 8, 2023	Initial release

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