How To Use Advanced Angle Sensor Technologies

A white paper by

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This white paper describes advantages of using advanced angle sensor technologies and focuses on best practices for correctly implementing non-contacting and touchless angle sensors. These best practices will help users get reliable and precise measurements while minimizing or avoiding inaccuracies that could be introduced by users.

Technology Advantages

Touchless sensors often offer distinct advantages over potentiometric track-and-wiper components and noncontact sensors. They're the more suitable technology when:

- An application requires measurements through a nonmagnetic wall or plate
- The application is in an extreme environment, necessitating a sensor shaft and/or sensor to be sealed or not even exposed to the environment
- The drive shaft has a lot of play or vibrates
- Applications with very low friction-torque requirements
- Applications in which drive-shaft misalignment is problematic

Definitions

"Non-contacting" stands for the position measurement technology being one without mechanical- electrical contacts, e.g. wipers or switches and "touchless" means that there is no mechanical connection between the rotating shaft on the machine side and the static sensor housing. Almost all "touchless" technologies are "non-contacting" (or "contactless").

Components and Usage

All Hall-Effect based non-contacting touchless sensors are made of two parts: the sensor housing itself, consisting of electronics including the Hall-Effect chip, the power supply and circuitry for digital or analog outputs and a magnetic marker, which is mounted on the rotating shaft of the machine. The magnet marker provides a directional magnetic field orientation over 360° rotation, which is detected and translated into a defined output signal with the help of the electronics in the sensor housing.

Hall-Effect sensors detect the magnetic field orientation to obtain a physical position value and not the field strength. These sensors also come with smart adjustment electronics to compensate for all kinds of magnetic field variations, which include temperature variations and mechanical tolerances of shafts and mounting plates included in the design.

FIgure 1 - Basic setup.

<u>Mounting Sensors and magnets</u>

Mounting touchless rotary sensors involve four steps: (1) securing the sensing component (sensor) and the magnet properly, (2) selecting a magnet size based on the proximity the magnet is to be mounted to the sensor, (3) taking into account if your application is measuring with a material/surface between magnet and sensor when selecting magnet size and (4) ensuring proper alignment between magnet and sensor.

<u>Securing the Sensor and Magnet</u>

Hall – Effect sensor chipsneed to be mounted **on-axis** with the rotating drive shaft of the machine. There are **centering features** included in the housings, that should be used as references to features on the mounting surface. These include the round circumference of the housing itself, locating pin holes or – somewhat less precise – the mounting screw holes.

These sensors also need to be mounted **perpendicular to the shaft** referencing usually the top or the bottom of the sensor housing. Many sensors can nowadays be mounted on both surfaces, allowing for measurements through non-magnetic walls mounting the sensor on the front, on a plate or a specially dimensioned hole in a mounting plate.

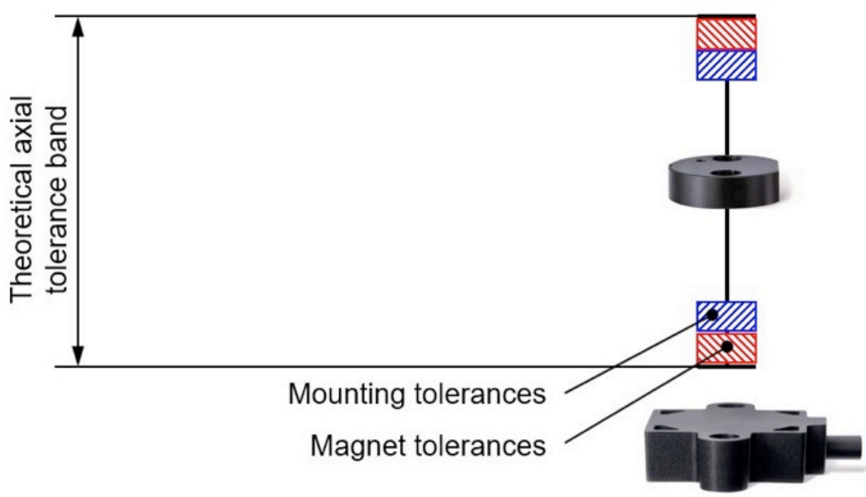


Figure 2 - Correct mounting distance.

The correct **distance range** between magnet marker and sensor housing is specified in the data sheets, however, as sensors can be combined with all kinds of sizes of magnet markers, it is important to follow the manufacturer's recommendation.

Selecting The Magnet

The distance range is defined by the strength of the individual magnet used. In general, **bigger is better for a better linearity in spite of radial misalignment**, but bigger magnets are more expensive.

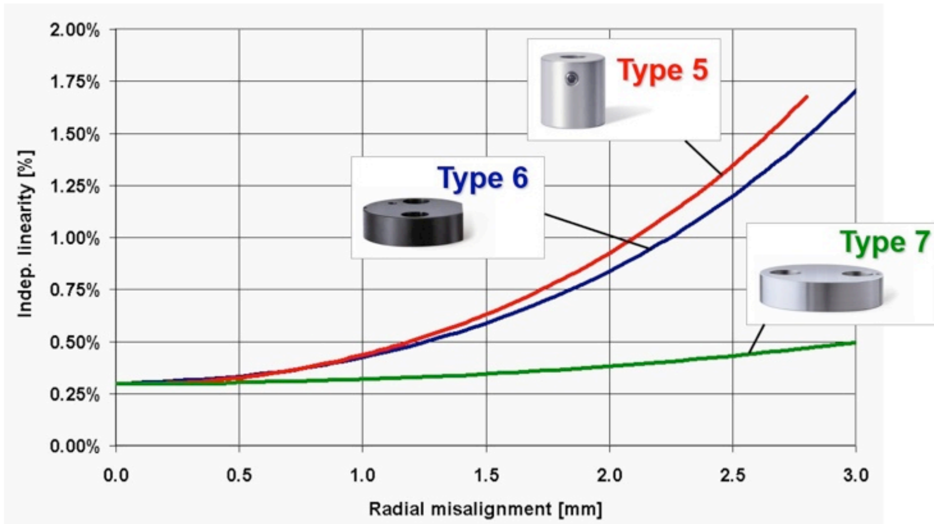


Figure 3 - Size vs. linearity error and radial misalignment.

The larger size of the magnet also allows for a larger maximum distance between sensor and magnet marker and with a stronger magnet the axial tolerance range increases as well.

Magnet strength limits the usable distance range and permissible radial misalignment.

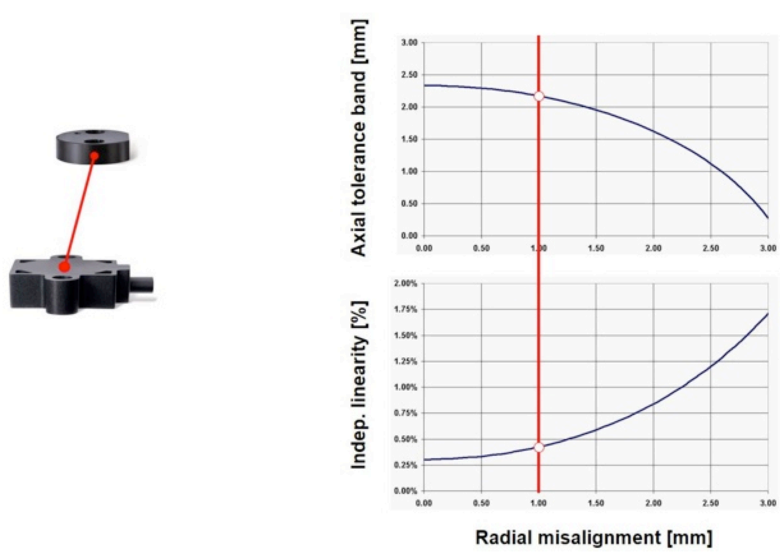
There are many ways to mechanically mount a magnet to a rotating part or shaft, and in consequence there are many different types of magnet markers. Mounting methods include screwing a bolt onto the end of your application's rotating part being measured, sliding a hollow shaft magnet over it, adhering with a permanent adhesive and fastening it using a coupling device.

The choice depends on the size, features like flats on the shaft and accessibility of the shaft end for setting the mounting screws. 6 mm, 8 mm, 10 mm and ⅛", ¼" shaft sizes on the customer side are most common. With those, magnet markers with a hole on the back end are easy to mount with a set screw. (See figure 4, Types 2, 3 and 5). With larger shaft ends, holding the magnet marker with two screws can provide a cost effective mounting method (See figure 4 , Types 6 and 7).

The type of mounting also depends on how the angular index point is set during installation. If the angular adjustment is done with rotating the sensor itself or using an sensor with an electronic offset adjustment, simple threaded magnet markers are a safe option (Types 1 and 4). Custom solutions are feasible with aluminum magnet markers or – for larger quantities – with cost effective injection molded types. Customers can also choose from a variety of bare magnets (Types 8 and 9) with the correct field strength. They can be mounted on non-magnetic surfaces only.

Figure 4 - Magnet type overview.

<u>Alignment</u>
Touchless sensors specify a maximum misalignment distance from center-vertical to remain with specifications. With increasing radial misalignment (due to mechanical play and/or mechanical tolerances) the linearity error increases and the axial tolerance decreases, an example is shown in the next graph:



General Mounting Remarks

Some of the sensors come with **mounting hardware** like clamps and screws, some do not. It is important to check for manufacturer's recommendations on screw size and **screw mounting torque** to prevent over torquing - or, conversely, a loosening mechanical connection - especially with some of the plastic housings. Screws might be metric, depending on the location of the manufacturer. Switching to english sizes if required is usually not an issue. Securing mounting hardware with a **thread locker** is always recommended. Mounting surfaces can be made of magnetic steel. However, when measuring through walls with the magnet marker on the other side, only non-magnetic wall materials will work.

When integrating a sensor into an application, **cable routing** needs attention as well. The direction of the cable exit is sometimes flexible, e.g. axial or radial, which helps to overcome dimensional restrictions in the application. Manufacturers also specify bending radiuses for their cables, partly for one-time bending and sometimes also for multiple bending operations. Sensors with individual wires will allow for smaller bending radiuses than cables, however, depending on the shielding requirements individual wires might not be an option. Cable clamps in 2 to 3 inch distance will keep down vibration and wear.

Conclusion

Advanced technology touchless angle sensors are beneficial in several types of applications where a sensor using track/wiper technology or even a shaft, in some applications, could mean degraded performance or even non-performance. By paying attention to manufacturers specifications for magnet size, type and position as well as mounting instructions, touchless angle sensors can be a reliable and accurate solution for many applications. An added benefit from using this technology is that it is inherently wear-free, providing very long sensor life.