Machine Design

Electronic Design

TOP TIPS

How to Properly Select an Inductive Proximity Sensor

Inductive proximity sensors detect metallic objects (both ferrous and non-ferrous metals). There are three primary parts to an inductive sensor: inductive coil with oscillator, evaluation circuit, and output circuit. When an oscillating signal is applied to the coil, a magnetic field is created. The presence of metal disrupts the magnetic field and is detected by the evaluation circuit, which energizes an output signal. Inductive sensing technology allows targets to be detected without contact while ignoring most environmental influences such as reflected light, dirt, debris, and oil.

Typical applications for inductive proximity sensors include gear tooth detection (RPM), speed monitoring, end of travel detection, and positioning/closure in various industries including plastics, packaging, food and beverage, agriculture, transportation, mining, and mobile equipment.

Some key characteristics of inductive proximity sensors include:

- **Maintenance free and wear-resistant**
- **Non-contact detection**
- **Solid state output for bounce-free switching and long lifetime**
- **Excellent resistance to shock and vibration**
- **Insensitive to moderate dust and dirt collection**
- **Waterproof**
- **Widely resistant to chemicals**

There are several factors to consider when selecting the best inductive proximity sensor for your application. These considerations can be broken down into five categories:

1 DETAILS OF THE DETECTION TARGET

It is critical to identify the physical size and material properties of the target to determine the sensing range required.

Target Size: Even though inductive sensors detect metal, the target must be large enough to disrupt the sensing field. The minimum target size is defined according to EN 60947-5-2 with a 1 mm thick square target with the length of each side equal to whichever is greater:

1) The diameter of the circle inscribed on the active surface sensing face, or
2) Three times the rated operating distance.

Target Material: The target material is important to identify since most metals are compounds and not pure. Technical data and specifications for inductive sensors are based on ferrous steel according to EN 60947-5-2. If the target material is stainless steel, aluminum, brass, copper, etc., a reduction factor will need to be applied to the sensing range (see Figure 1, Sensing Range Derating Factor Chart).

1

SENSING RANGE DERATING FACTOR

Material	Derating Factor	Type of Metal
Steel (Fe360)	1.0	Ferrous
Chrome-nickel (CrNi)	0.6 to 0.8	Non-Ferrous
Brass (CuZn)	0.35 to 0.5	Non-Ferrous
Aluminum (Al)	0.3 to 0.5	Non-Ferrous
Copper (Cu)	0.25 to 0.3	Non-Ferrous

Figure 1

Sensing Distance: Sensing distance of inductive sensors typically ranges from 1 mm to 40 mm. Inductive sensors can detect both ferrous and non-ferrous metals, but not necessarily at the same sensing range. For example, a standard inductive sensor technical specification lists a 10 mm sensing range (this would be using a ferrous steel target). That same sensor would only have a range between 2.5 mm to 10 mm, depending on the composition of the metal.

There are a few options to overcome these real-world application challenges:

- Use an extended range model such as a double (2x) or triple (3x) sensing range version. Most applications require some amount of sensing range reduction due to target size, material, and environment. A conservative determination of the required sensing range would be to double the actual sensing distance. For example, if the target will be 4 mm from the sensor face, select a sensor with an 8 mm sensing range. Of course, the surrounding environment must be considered, as well
- If possible, use a non-flush/non-shielded sensor (see Sensor Installation section below in Tip 2), which provides longer sensing ranges than flush/shielded sensors.
- Many sensor manufacturers offer an advanced inductive technology (also more expensive) that can detect ferrous and non-ferrous targets at the same distance—i.e., Factor 1, universal sensing, etc.

Speed: Inductive sensors offer faster switching speeds compared to capacitive proximity sensors and can be just as fast as some photoelectric sensors. Generally, the larger the sensor size the slower the sensor speed/switching frequency. Additionally, the switching frequency for AC SCR outputs (25 Hz or 25 times per second) are significantly slower than DC solid state outputs (up to 6 kHz or 6,000 times per second). For a high-level overview of typical sensing ranges and switching frequency per housing size, refer to Figure 2, Common Inductive Sensor Performance. There are many specialized inductive sensors to consider, but the chart provides an initial guideline for selection.

COMMON INDUCTIVE SENSOR PERFORMANCE

Sensor Diameter	Sensing Distance from Target to Sensor						Switching Frequency [Hz]
	Standard range (1x) Sensor		Double range (2x) Sensor		Triple range (3x) Sensor		
	Flush	Non flush	Flush	Non flush	Flush	Non flush	
M5	0.8 mm	1.5 mm	1.5 mm	2 mm	NA	NA	6,000 Hz
M8	1.5 mm	2.5 mm	2 mm	4 mm	3 mm	6 mm	2,000 Hz
M12	2 mm	4 mm	4 mm	8 mm	6 mm	10 mm	2,000 Hz
M18	5 mm	8 mm	8 mm	14 mm	12 mm	20 mm	1,500 Hz
M30	10 mm	15 mm	15 mm	22 mm	22 mm	40 mm	1,000 Hz

Figure 2

2 UNDERSTAND THE INTEGRATION REQUIREMENTS

Integration requirements are typically determined by the other components and setup of the application. Often these requirements cannot be changed and, therefore, are important to understand early in the process of selecting an inductive sensor.

Supply Voltage: Inductive sensors are available for use with input supply voltages of AC, DC, or even AC/DC applications.

Sensor Output: Common output options available include Normally Closed (NC) and/or Normally Open (NO), NPN and/or PNP (DC), SCR (AC), MOSFET (AC), analog (DC) output, NAMUR, or IO-Link communication.

Sensor Installation: Inductive sensors are available in threaded cylinder, smooth cylinder, and rectangular housings. The most common body style is threaded cylindrical in M8, M12, M18, and M30. These cylindrical housings are often offered in short and long bodies, referring to the length of the sensor. Some sensors are designed for flush mounting (also referred to as shielded), but others are designed for non-flush (also referred to as non-shielded) mounting, allowing additional sensitivity on the side of the sensing face. If more than one inductive sensor will be installed, research the operating instructions since the sensors can interfere with each other. There are inductive sensors available which can be programmed to operate without interference for this type of application.

Termination Style: Typically, inductive sensors will only have two connection options to input power and output signal—quick disconnect (M8 or M12) or a cable with flying leads. The quick disconnect options are popular due to faster sensor replacement and easier connectivity troubleshooting. For larger inductive sensors, occasionally terminal connections are offered.

3 CONSIDER THE OPERATING ENVIRONMENT

The operating environment of an inductive proximity sensor can greatly narrow the selection options. Exposure to oils, chemicals, washdown conditions, noise, extreme shock or vibrations, or presence of hazardous materials might require specialized sensor capabilities.

Housing Material: Inductive sensor housing materials are nickel-plated brass, stainless steel, or plastic (such as polycarbonate). Metal housings are the most common due to durability and protection against potential contact with the target. Plastic housings can be beneficial when considering exposure to specific chemicals or for a more cost-effective solution.

Operating Temperature Range: The minimum and maximum temperature which the sensor will experience during operation and storage need to be considered.

Environmental or Explosion Proof Ratings: Technical standards such as IP and NEMA ratings are now industry norms providing insight into the conditions a sensor can operate for indoor/outdoor use, presence of dust/debris, and exposure to water. Another environmental consideration is for hazardous materials. Similarly, technical standards from OSHA and the National Fire Protection Association provide industry standard ratings (Class, Division, Group) for operation in hazardous environments. For mobile equipment and automotive applications, often an E1-type approval is required due to the extreme conditions and public road safety. If the sensor could be exposed to high voltage peaks (i.e., a battery disconnecting from a generator), consider a sensor with SAEJ1113-11 load dump protection rating.

3

External Noise Protection: Advanced noise protection will reduce false detections caused by vibration shocks, electrical surges, electrostatic discharge, electrical transients/bursts, wire conducted disturbances, power-frequency magnetic fields, and radiated RF electromagnetic fields. These types of interferences are increasingly more common in applications. Selecting an inductive sensor with E1-type approval, even if the application is not mobile equipment, will provide additional noise protection.

4

PLAN FOR THE FUTURE

Some manufacturers offer sensors with IO-Link communication, which provide unparalleled capabilities compared to traditional sensors. The user can program the sensor output, implement custom time delays, and use logic functions. These basic benefits reduce inventory and allow immediate, flexible customization to your application using standard sensors.

Beyond that, there are many other capabilities. Data logging—detection counter, switching frequency, low temperature, high temperature—provides visibility to potential operational inefficiencies. Customizable alarms (temperature or sensing range) allow scheduled maintenance to occur before the sensor fails. Specialty functions such as Rotational Speed Monitoring can calculate frequency detection to check overspeed and underspeed conditions. The RPM Counter function allows the user to enter the number of activations required to change the output (i.e., number of teeth on a gear) so the sensor provides an output once per revolution. Using the analog over IO-Link capability, the sensor can give position information of a target or provide quality control to ensure the correct metal is being used. As digitalization allows data to be transferred into valuable information, all companies are on a journey to implement "smart" features. Sensor selection is the right time to consider these capabilities.

5

SELECT A REPUTABLE RESOURCE OR SENSOR MANUFACTURER

It can be challenging to select the best technology for an application and then select the best sensor. Partnering with a sensor manufacturer and experienced automation expert, such as Carlo Gavazzi, allows you to leverage their 50+ years of global application experience and sensor knowledge. Carlo Gavazzi offers product overviews, detailed data sheets, selection guides, application examples, videos, and more for your own independent research. Application engineers, product managers, and a technical sales team are eager to learn about your specific applications and assist finding the best technology and sensor to fit your needs. If Carlo Gavazzi does not offer a sensor today to fit your needs, customization options are available to develop that perfect sensor for your application (custom cable/connector options, custom packing and labeling, and more.)

Support is available by email (sensors@carlogavazzi.com), phone, video conference, in person, or using international distribution partners.