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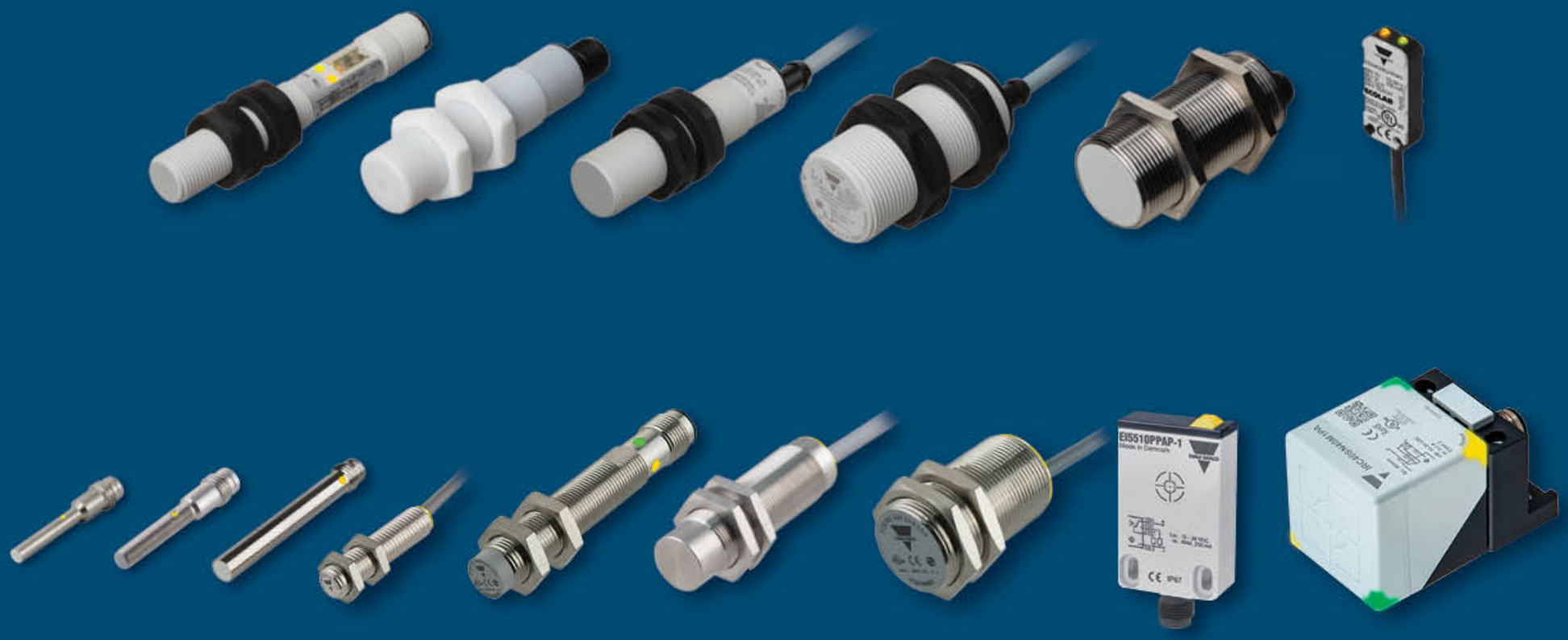

How to Properly Select a Proximity Sensor

This downloadable ebook on How to Properly Select a Proximity Sensor, provides a roadmap for people to properly determine which type of proximity sensor they'll need for their application. Both types of proximity sensors are also available with IO-Link communications, so implementation to the IIoT / Industry 4.0 is fairly seamless. Learn about properly selecting and specifying a proximity sensor today, by reading this information laden ebook today.

WHAT'S INSIDE

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How to Properly Select a Capacitive Proximity Sensor

Capacitive proximity sensors detect nearly all materials—both metal and non-metal objects—and can even sense through wood or plastic. This is due to the technology being activated by the dielectric constant of a material. If the target material's dielectric constant is significantly higher than another material, often wood or plastic, a capacitive sensor can ignore the lower dielectric material and still detect the target material. This unique functionality allows capacitive sensors to detect fill levels of liquids, pellets, and powders through container walls.

Typical markets and applications for capacitive proximity sensors include: plastics (dryers, vacuum systems, hopper level), agriculture (grain silos, automatic feeding systems, irrigation systems), food and beverage (level detection in bottles and packages, pallet detection, object presence detection) and the wood industry (sawdust and wood chip level detection, pallet production).

Some key characteristics of capacitive proximity sensors include:

- Maintenance-free and wear-resistant
- Contact or non-contact with the target
- Solid state output for bounce-free switching and long lifetime
- Insensitive to vibrations
- Insensitive to moderate dust and dirt collection
- Waterproof
- Widely resistant to chemicals

There are several factors to consider when selecting the best capacitive 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 of the target and dielectric value of the material to determine the sensing range required.

Target Description: Capacitive sensors are used to detect solid objects or liquid/granulate objects. The size of the target and dielectric value are the most critical features to identify. If the sensor is detecting liquid or granulates, the dielectric value of both the target material and container material are important; please reference the Dielectric Value Chart (see next page).

How to Properly Select a **Capacitive Proximity Sensor** | continued

Sensing Distance: The adjustable sensing distance of capacitive sensors typically ranges from 0.5 to 40mm. Several reduction factors apply to capacitive sensing ranges, such as the size of the target, dielectric value of the target material, and mounting and grounding of metal targets.

Speed: Capacitive sensors offer slower switching speeds compared to many photoelectric or inductive proximity sensors. However, capacitive applications typically do not require fast responses. As a rule of thumb, the typical sensing speed for a relay output type (1Hz or 1 time per second) or AC SCR output type (10Hz or 10 times per second) are slower than DC types, which can switch up to 50Hz (50 times per second).

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 when selecting a capacitive sensor.

DIELECTRIC VALUE CHART (CAPACITIVE SENSORS CAN DETECT ANYTHING OVER 1.2)

Material	Dielectric Constant	Material	Dielectric Constant	Material	Dielectric Constant	Material	Dielectric Constant
ABS pellet	1.5-2.5	Com, refuse	2.3 - 2.6	Oil, turpentine	2.2	Rice	3 - 8
Acetone	19.5-20	Epoxy resin	2.5-6.0	Oil, vegetable	2.5-3.5	Rubber, hard	4
Acrylic resin	2.7-6.0	Ethyl alcohol	24	PE pellet	1.5	Rubber, raw	3-5
Air, vacuum	1	Flour	2.5-3.0	Perspex	3.2	Sand	3-5
Alcohol, industrial	16-31	Fly ash	1.5-1.7	Petroleum	2.2	Silicon	2.8
Aluminum Powder	1.6-1.8	Glass	5	Polyamide	5	Soap powder	1.2-1.5
Aluminum Sulphate	6	Grain	3-8	Polyethylene	2.3	Sodium sulphite	5
Araldit	3.6	Hexane, liquid	5.8-6.3	Polypropylene	2.3	Soft rubber	2.5
Asphalt	2.5-3.2	Hydrochloric acid	4-12	Polystyrene	3	Starch	2-5
Bakelite	3.6	Iron oxide	14.2	Polyvinyl chloride	2.9	Sugar	3
Calcium carbonate	1.8-2.0	Kerosene	2.8	Porcelain	4.4	Sugar, granulated	1.5.-2.2
Calcium oxide	11.8	Marble	8	Potassium chloride	4.6	Sulfuric acid	84
Calcium sulphate	5.6	Mica	6	PP pellet	1.5-1.8	Teflon	2
Carbon dioxide	1.6	Nitrogen, liquid	1.4	Presipan	4	Toluene, liquid	2.0-2.4
Celluloid	3	Nylon	4-5	Paraffin	2.2	Urethane	6.5-7.1
Cement	1.5-2.1	Oil, heavy	2.6-3.0	PVC powder	1.4	Water	48-80
Coffee, powder	2.4-2.6	Oil, mineral	2.1	Quartz glass	3.7	Water, chlorine	2
Coke	1.1-2.2	Oil, transformer	2.2	Quartz sand	4.5	Wheat, powder	2.5-3

How to Properly Select a **Capacitive Proximity Sensor** | continued

Supply Voltage: Capacitive 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/DC) output, relay or analog (DC) output, or with IO-Link communications.

Sensor Installation: The most common capacitive sensor body styles include square or rectangular housings, or smooth or threaded barrel type housings. Some sensors are designed for flush mounting, but others are designed for non-flush mounting, allowing additional sensitivity on the side of the sensing face.

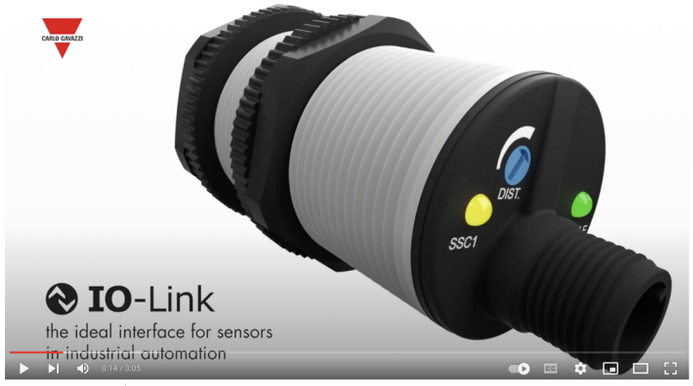
Termination Style: Typically, capacitive sensors will only have two connection options to input power and output signal—quick disconnect (M8 or M12) or a cable with flying leads. The quick disconnect options are popular due to faster sensor replacement and easier connectivity troubleshooting.

3. Consider the operation environment
The operating environment of a capacitive proximity sensor can greatly narrow the selection options. Exposure to oils, chemicals, washdown conditions, noise, or presence of hazardous materials might require specialized sensor capabilities.

Housing Material: Common capacitive sensor body materials are polymers such as ABS, PA, PBT, PP, PTFE, PVC, or metals such as aluminum, brass, nickel-plated brass, or stainless steel. Metal housings are durable and beneficial if potential contact with the sensor could occur. Polymers are preferred if there is potential exposure to specific chemicals.

Operating Temperature Range: The minimum and maximum temperatures the sensor will experience during operation and storage must be considered.

Environmental or Explosion Proof Ratings: Technical standards such as IP and NEMA ratings are now industry standard to provide insight into the conditions a sensor can operate in 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



WATCH THE VIDEO:

IO-Link Capacitive Sensors from Carlo Gavazzi

An informative video on Carlo Gavazzi's Capacitive Proximity Sensors featuring IO-Link communications.

WATCH NOW

How to Properly Select a **Capacitive Proximity Sensor** | continued

standard ratings (Class, Division, Group) for operation in hazardous environments.

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.

4. Plan for the future

Some manufacturers offer sensors with IO-Link communication, which provides 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—power cycles, operating hours, operating cycles, low temperature, high temperature—provides visibility to potential operational inefficiencies. Customizable alarms, temperature or dust, allow scheduled maintenance to occur before the sensor fails. Functions such as Quality of Run (QoR) give real-time indication of the sensor performance and Quality of Teach (QoT) provides confidence of the quality and repeatability of the sensors' set points. As digitalization allows data to be transferred into valuable information, all companies are on a journey to implement these "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 choose the best sensor. Partnering with a sensor manufacturer and experienced automation expert, such as Carlo Gavazzi, allows you to leverage their global application experience and sensor knowledge. For your own independent research, Carlo Gavazzi offers product overviews, detailed data sheets, selection guides, application examples, videos, and more. Application engineers, product managers, and a technical sales team are eager to learn about your specific applications and assist in finding the best technology and sensor to fit your needs. Support is available by email (sensors@carlogavazzi.com), phone, video conference, in person, or by using international distribution partners. ▲

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 and while ignoring most environmental influences such as reflected light, dirt, debris, oil, etc.

Typical applications for inductive proximity sensors include gear tooth detection (RPM), speed monitoring, end of travel detection, positioning/closure in various industries including Plastics, Packaging, Food & 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 & long lifetime
- Excellent resistance to shock and vibration
- Insensitive to moderate dust & 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 5 categories outlined here:

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 1mm 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 Sensing Range Derating Factor Chart.)

SENSING RANGE DERATING FACTOR

Material	Derating Factor	Type of Metal
Steel (Fe360)	1.0	Ferrous
Chrome-nickel (CrNi)	0.6-0.8	Non-Ferrous
Brass (CuZn)	0.35-0.5	Non-Ferrous
Aluminum (Al)	0.30-0.5	Non-Ferrous
Copper (Cu)	0.25-0.3	Non-Ferrous

How to Properly Select an **Inductive Proximity Sensor** | continued

Sensing Distance: Sensing distance of inductive sensors typically range from 1mm to 40mm. 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 specifications lists a 10mm sensing range (this would be using a ferrous steel target.) That same sensor would only have a range between 2mm to 4.5mm, depending on the composition of the aluminum.

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, environment, etc. A conservative determination of the required sensing range would be to double the actual sensing distance. For example, if the target will be 4mm from the sensor face, select a sensor with an 8mm 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) which provide longer sensing ranges than flush / shielded sensors.

COMMON INDUCTIVE SENSOR PERFORMANCE

Sensor Diamter	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	0.8mm	1.5mm	1.5mm	2mm	NA	NA	6,000Hz
M8	1.5mm	2.5mm	2mm	4mm	3mm	6mm	2,000Hz
M12	2mm	4mm	4mm	8mm	6mm	10mm	2,000Hz
M18	5mm	8mm	8mm	14mm	12mm	20mm	1,500Hz
M30	10mm	15mm	15mm	22mm	22mm	40mm	1,000Hz

- 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 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 (25Hz or 25 times per second) are significantly slower than DC solid state outputs (up to 6kHz or 6,000 times per second.) For a high level overview of typical sensing ranges and switching frequency per housing size, refer to the Common Inductive Sensor Performance chart. There are many specialized inductive sensors to consider but the chart provides an initial guideline for selection.

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),

How to Properly Select an **Inductive Proximity Sensor** | continued

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 National Fire Protection Association provide industry standard ratings (Class, Division, Group)

How to Properly Select an **Inductive Proximity Sensor** | continued

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 (ie a battery disconnecting from a generator), consider a sensor with SAEJ1113-11 load dump protection rating.

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 radiate 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 noise protection.

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 so 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) allows 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 (ie 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.

Select a reputable resource or sensor manufacturer

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