PMM Plastics Machinery & Manufacturing

MachineDesign

Top Tips

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).

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).

Dielectric Value Chart (Capacitive Sensors can detect anything 1.2 or over)

Material	Dielectric Constant
ABS pellet	1.5 - 2.5
Acetone	19.5 - 20
Acrylic resin	2.7 - 6.0
Air, vacuum	1
Alcohol, Industrial	16 - 31
Aluminum powder	1.6 - 1.8
Aluminum sulphate	6
Asphalt	2.5 - 3.2
Bakelite	3.6
Calcium carbonate	1.8 - 2.0
Calcium oxide	11.8
Calcium sulphate	5.6
Carbon dioxide	1.6
Celluloid	3
Cement	1.5 - 2.1
Coffee, powder	2.4 - 2.6
Coke	1.1 - 2.2
Corn, refuse	2.3 - 2.6
Epoxy resin	2.5 - 6.0
Ethyl alcohol	24
Flour	2.5 - 3.0
Fly ash	1.5 - 1.7
Glass	5

Material	Dielectric Constant
Grain	3 - 8
Hexane, liquid	5.8 - 6.3
Hydrochloric acid	4 - 12
Iron oxide	14.2
Kerosene	2.8
Marble	8
Mica	6
Nitrogen, liquid	1.4
Nylon	4 - 5
Oil, heavy	2.6 - 3.0
Oil, mineral	2.1
Oil, vegetable	2.5 - 3.5
PE pellet	1.5
Perspex	3.2
Petroleum	2.2
Polyamide	5
Polyethylene	2.3
Polypropylene	2.3
Polystyrene	3
Polyvinyl chloride	2.9
Porcelain	4.4
Potassium chloride	4.6
PP pellet	1.5 - 1.8

Material	Dielectric Constant
Paraffin	2.2
PVC powder	1.4
Quartz glass	3.7
Quartz sand	4.5
Rice	3 - 8
Rubber, hard	4
Rubber, raw	3 - 5
Sand	3 - 5
Silicon	2.8
Soap powder	1.2 - 1.5
Sodium sulphite	5
Soft rubber	2.5
Starch	2 - 5
Sugar	3
Sugar, granulated	1.5 - 2.2
Sulphuric acid	84
Teflon	2
Toluene, liquid	2.0 - 2.4
Urethane	6.5 - 7.1
Water	48 - 80
Water, chlorine	2
Wheat, powder	2.5 - 3

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.

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 IO-Link communication.

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 OPERATING 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 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, phone, video conference, in person, or by using international distribution partners.