Introduction to Capacitive Sensors

Capacitive sensors detect both metallic and nonmetallic targets such as glass, plastic, or wood. Depending on the size and material properties of the target as well as the size and mounting conditions of the sensor, detection distances of between 1 mm and 50 mm are possible.

Capacitive proximity sensors can be used as "penetrating sensors" to detect liquid or granular media. They react to the contents inside of a thin-walled and electrically nonconductive container made from glass or plastic. This function is performed by increasing the overall capacitance, consisting of the container wall and filling media (see also "Functional description of capacitive proximity sensors"). The "penetration" functionality of capacitive sensors enables fill level controls to be performed for liquid media and bulk goods without coming into direct contact with the material.

Special technical features of capacitive sensors:

- They react to both electrically conductive materials and insulating materials (ferrous metals, nonferrous metals, glass, wood, plastic, as well as oil and liquid solutions)
- The operating distance of the sensor can be adapted to the object and mounting properties
- They can be used as "penetrating" sensors through nontransparent and nonconductive container walls

Common applications for capacitive sensors:

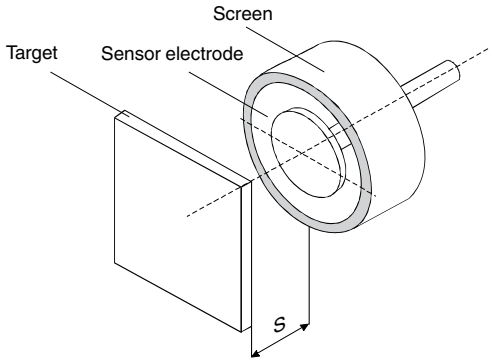
- Checks for the presence of paper, wood, glass, or plastic materials
- Fill level control for fluid media and bulk goods (pellets, tablets, granulate, toner)
- Detect presence of liquid in plastic piping and hoses

Common areas of application for capacitive sensors:

- Print and paper processing industry
- Packaging and food industry
- Pharmacy, chemical, and process technology
- Wood and plastic processing
- Automotive industry

Functional description

Capacitive proximity sensors have a sensor electrode (active area) and a shield ring. The sensor electrode is the active area of the sensor and emits an electric AC field that forms a capacitance with the surroundings acting as the counter potential (capacitor principle). If the target material moves closer to the active sensor electrode, the counter potential changes. The capacity between the sensor and the target increases. This change in external capacity is compared with an internal sensor reference value. If the reference value is exceeded, the sensor is actuated and delivers a transition signal to the sensor output. The external shield ring focuses the electric field of the sensor electrode and reduces the influence of the installation position upon the operating distance of the sensor.



The rated operating distance s_n of a capacitive proximity sensor is based on a grounded metal object of a particular size. In contrast, if the capacitance change for nonconductive actuator materials is lower, then the object must be moved closer to the sensor electrode in order to actuate the sensor. The length of the specific operating distance depends upon the electrode area, the size and the material (permittivity) of the object to be detected as well as the sensor's installed position. The lower the permittivity number of the respective target material under otherwise comparable physical mounting conditions, the shorter the achievable operating distance. With most capacitive proximity sensors, the sensitivity can be adjusted within limits using a potentiometer on the sensor. The factory-set operating distance can be adjusted in accordance with the object material, the installation position, and the application requirements.

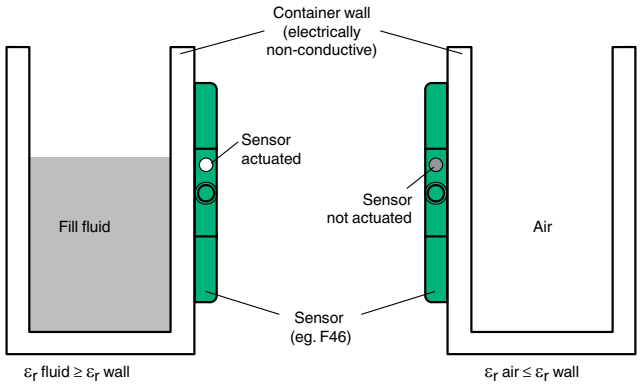
Correlation between material constants and operating distances

The rated operating distance s_n of a capacitive proximity sensor is preset at the factory using a grounded metal object of a particular size and under defined mounting conditions (flush, non-flush). If other materials are used with the otherwise unchanged object size and the mounting conditions of the sensor, the preset operating distance decreases. The table below illustrates the ranges of material-related dielectric constants and the expected reduction factors for the rated operated distance.

Material	Dielectricity ε_r	Reduction factor
Grounded metal plate	>100 to 10,000	1
Water	80	1
Alcohol	22	0.75
Glass	5 to 16	0.6
Ceramic	4 to 7	0.5
PVC	2.3 to 3.4	0.45
Wood (dry)	3 to 7	0.3
Oil	2.6 to 2.9	0.28
Paper (dry)	1.6 to 2.6	0.25
Air	1	0

The values in the table are reference values and therefore should not be referred to in terms of physical accuracy.

Special application–thru-wall sensing



The thru-wall sensing functionality of capacitive proximity sensors is based on the change in the total capacitance of the media to be detected. In this context, the sensor is not sensitive enough to detect the wall beacuse of a low relative dielectric constant component (right diagram, sensor does not react to container wall). If the filling media in the container now rises above the center of the sensor's electrode, the electric conductivity of the system changes and results in sensor actuation.