Capacitive Sensors

Functional principle

Capacitive proximity switches detect conductive and non-conductive materials that can be in a solid or liquid state. They serve the purpose of monitoring product levels in containers, checking contents in filling and packaging systems as well as detecting, positioning, monitoring and counting objects, e.g. in sequence control systems, conveyor belts.

Used for detecting media such as:

- ⌘ solid:
  wood, ceramic, glass, paper stacks, plastic, stone, rubber, ice, nonferrous metals, potatoes
- ⌘ liquid:
  water, oil, beverages, adhesives, paints
- ⌘ granular:
  plastic pellets, granulated products, grain, fodder, wood chip
- ⌘ powder:
  dyes, detergents, sand, cement, fertilizer, salt, sugar, flour, coffee

Technical description

The function of the capacitive proximity switch is based on evaluating the influence exerted by an actuator on the electrical field at the active face of the switch.
The approach of an influencing object increases the capacitance of the capacitor, which consists of a sensor electrode located behind the active face and the actuator connected to earth / mass.
This increase in capacitance is dependent on the conductance and the dielectric constant of the actuator as well as its mass, surface area and its distance from the sensor electrode. The capacitive limit switch is equipped with an RC oscillator with a gain factor that increases as a result of the rise in capacitance of the previously described capacitor to such an extent that oscillation is induced. In limit switches, the capacitance required to induce oscillation can be determined by the built-in potentiometer intervening in the feedback of the oscillator.

The response sensitivity, i.e. the sensing distance with a given actuator can be adjusted in this way. The oscillator output signal is fed to an evaluation circuit that actuates the switching amplifier.

In response to the approach of conductive material the actuating object and the active face of the sensor form the plates of a capacitor. The change in capacitance and the consequently achievable sensing distance are large.

In response to the approach of non-conductive material > 1 only the change in the dielectric constant is effective.
The increase in capacitance is less than is the case for conductive materials.
The resulting sensing distance is small.

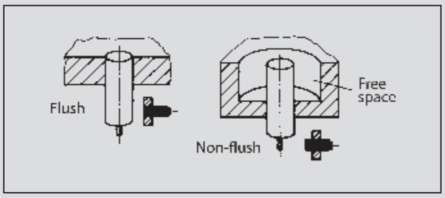
Sensitivity table	
St37 or other metals, earthed	1.00
Surface of water	1.00
St37 150 x 150 x 1 mm, not earthed	0.85
Marble 150 x 150 x 12.5 mm	0.65
Glass 150 x 150 x 7.5 mm	0.55
Stack of paper DIN A 4, 80 g/m², 500 sheets	0.55
Fibre board 150 x 150 x 16 mm	0.45
Ceramic tile 150 x 150 x 6 mm	0.25
PVC 150 x 150 x 4 mm	0.15

These values only indicate the expected magnitude of the response sensitivity as the specific properties of the actuating object and of the surroundings in actual applications have a considerable influence on the response distance. It is important to take into account the influence of moisture in order to ensure trouble-free operation. A high water content in the material to be detected, e.g. wood or paper, increases the sensing distance considerably.

In terms of capacitive proximity switches a distinction is made between

- ⌘ flush mount and
- ⌘ non-flush mount

limit switches.



In the case of non-flush mount limit switches a clearance that must contain no influencing material must be created about the switch. Due to the adjustment facility available in capacitive proximity switches, the installation of non-flush mount devices is not problematic in connection with reduced clearance. Non-flush mount capacitive proximity switches are characterised by low sensitivity to soiling or condensation.

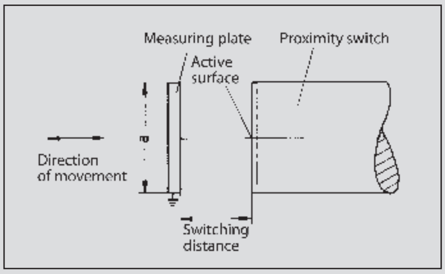
A screening electrode built into flush mount limit switches is connected to circuit ground. As both electrodes of the capacitor are now close together, flush mount capacitive proximity switches are particularly suitable for sensing dielectrics. The disadvantage is that this configuration has an increased sensitivity to condensation or soiling.

Capacitive proximity switches can mutually influence each other if they are mounted next to or opposite each other. In such configurations, the response of flush mount switches is considerably less sensitive than non-flush mount switches. Trials under actual application conditions should be carried out at distances from > 2x to <8x enclosure diameter. Arrangements with distances > 8x enclosure diameter are not problematic.

Active face: The active face of a capacitive proximity switch is the point at which the electrical field emerges. This point is located at the end face on types designed as threaded sleeves or smooth cylinders. Non-cylindrical limit switches are identified by a symbol on the corresponding face.

Influencing: In relation to a capacitive proximity switch the term influencing refers to the change in the switching status in response to the medium to be detected entering the electrical field.

Standard target: The standard target is defined as a square plate, 1 mm thick and made from FE 360.



The side length "a" of the square target corresponds to the diameter of the circle described by the active face. The length of its side is defined as the larger of either the active face diameter or three times the nominal sensing distance. The target must be earthed in order to ensure comparable sensing distances. The sensing distance of rectangular, capacitive proximity switches is determined by means of an earthed target with a size equal to the surface of the active side of the limit switch.

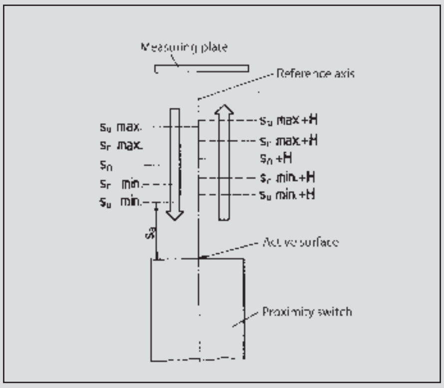
Sensing distance: The sensing distance, that changes the status of the output stage, is the distance of the influencing object in relation to the active face.

Nominal sensing distance (s_n): This is a device-specific characteristic value that does not take into account influences such as tolerance, temperature and changes in voltage.

Real sensing distance (s_r): The real sensing distance is measured at a rated voltage and an ambient temperature of 23 °C +/–5 °C. It must be between 90 % and 110 % of the nominal sensing distance.

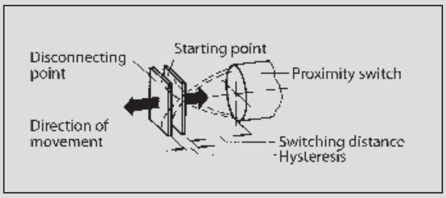
Useable sensing distance (s_u): The useable sensing distance is measured within the permissible temperature and voltage ranges and is 80 % – 120 % of the real sensing distance.

Assured sensing distance (s_a) (operational sensing distance): This is the distance that can be used effectively under the influence of temperature, voltage as well as tolerance variables. It is between 0 % and 72 % of the nominal sensing distance.

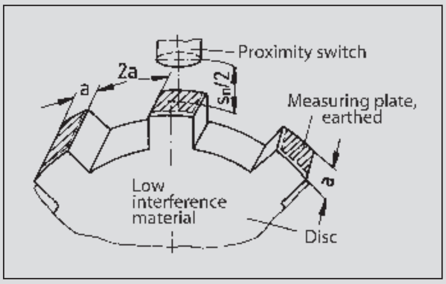


Reproducibility: The reproducibility of the switching distance is the repeat accuracy of the real sensing distance of two successive switching operations within a period of 8 hours at an ambient temperature between 18 °C and 28 °C and a supply voltage that may not deviate by more than 5 % from the rated voltage. The difference between any two measurements must not be more than 10 % of the real sensing distance.

Switching hysteresis: The switching hysteresis refers to the difference between the switch-on point as an object approaches the target and the switch-off point as the object moves away from the proximity switch. The value is specified as a percentage of the real sensing distance.



Switching frequency: The switching frequency is measured in accordance with EN 60947-5-2. The standard targets with the side length "a" are mounted on a plate that exerts minimum influence at "2a" intervals and are moved passed the proximity switch to be tested at half the nominal sensing distance. The maximum switching frequency is reached when the switch-on or switch-off time of the proximity switch is 50 µs. In the case of AC proximity switches, the maximum switching frequency is reached when the switch-on and switch-off time is equal to the half wave period of the supply frequency.



Temperature range: In accordance with DIN, the temperature range is from –25 °C to +70 °C. Reliable operation is ensured within this range.

Protection class

Corresponding to their ID code, the enclosures are dustproof and waterproof in accordance with IP 65 or IP 67 (DIN 40050).

Connection cable

A PVC-insulated connection cable is supplied as standard. Special versions with silicone sheathing, polyurethane sheathing, irradiation cross-linked PVC or Teflon insulation are also available.

Plug connection

Nowadays the plug connection is just as significant as the fixed cable on electronic proximity switches. The capacitive proximity switches in the BERNSTEIN range can be equipped with a wide variety of plug connections. As standard, this catalogue contains connector versions of virtually all types of limit switch.

Standards

All sensors conform to EN 60947-5-2

CE

Important information

Capacitive sensors are able to detect conductive and non-conductive materials in solid, liquid, granular or powder form. However, certain criteria must be taken into account in practical applications.

Sensing distance

The nominal sensing distances are specified and set at the factory in accordance with DIN EN 60947-5-2/98. The maximum sensing distance is achieved on approach of conductive materials of corresponding size.

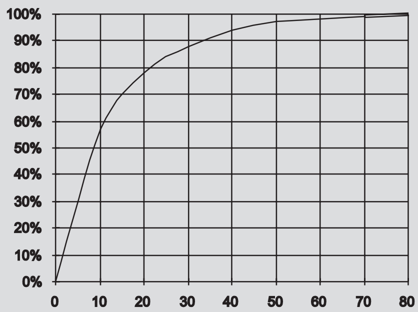
On approach of non-conductive materials, the dielectric constant of the material to be detected is of decisive significance. Depending on the application, the specified sensing distances vary by a certain factor in relation to the dielectric constant. The values determined according to the table only indicate the expected magnitude of the response sensitivity as the specific properties of the actuating object (diameter, thickness, moisture content etc.) and of the surroundings (earthing) in actual applications have a considerable influence on the response distance. In most cases adaptation to the specific application can be achieved by adjustment with the built-in potentiometer.

Clearance

In the case of non-flush mount capacitive sensors a clearance that must contain no influencing material must be created about the sensor. Non-flush mount capacitive sensors are characterised by low sensitivity to soiling or condensation. On account of their design, flush mount capacitive sensors are particularly suitable for sensing dielectrics. The increased sensitivity, however, may be detrimental in terms of the above mentioned parasitic effects.

If capacitive proximity switches are to be mounted opposite or next to each other, trials under actual application conditions should be carried out at distances between 2x and 8x enclosure diameter. Thanks to the adjustment facility, however, adaptation to specific applications is almost always possible.

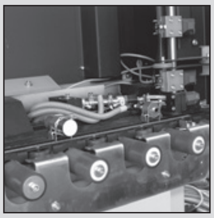
Examples of dielectric constants	
Glass	3 ... 14
Rubber	2.5 ... 3
Laminated paper	3.5 ... 6
Wood	2.5 ... 6.8
Marble	8.4 ... 14
Mineral oil	2.15
Epoxy resin	3.3 ... 3.6
Petroleum	2.2
Plexiglas	3.6
Polyamide	3 ... 8
PVC	3.3 ... 4.1
Porcelain	4.2 ... 6.5
Teflon PTFE	2
Air	1
Water	80.8
Paper (dry)	2



Variance of sensing distance as a function of

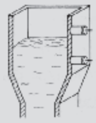
Application descriptions

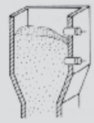
A particular application of capacitive proximity switches is to detect levels in non-metallic containers from the outside. Advantage: There is no need to make a hole in the container wall for the purpose of detecting product level. The medium to be detected does not come in contact with the limit switch. The prerequisite is that the dielectric constant and the mass of the material to be detected are greater than that of the container. The response sensitivity of the proximity switch must be reduced with the built-in potentiometer to such an extent that the limit switch does not respond to the container wall but rather to the medium to be detected.

Above: Insulation glass production lines equipped with BERNSTEIN capacitive sensors

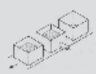
Further fields of application are illustrated below.

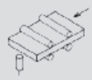

Level monitoring in non-metallic containers


Level monitoring of bulk material, e.g. granulated material, fodder


Stack height scanning, e.g. paper, chip board


Fill level monitoring in paint and adhesive containers


Registering, counting, sorting or monitoring in conveyor belt systems


Detecting, positioning in sequence control systems


Detection in woodworking applications


Belt breakage signalling


Level monitoring in packing systems