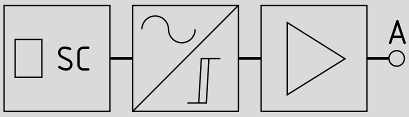
Capacitive sensors

System description

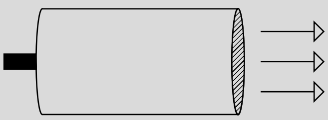
Method of function



The non-contact capacitive sensor converts a value of interest for production purposes (distance or filling level) to a signal that can be further evaluated. Function is based on the change in the electrical field in the area of its active face. The basic structure of the device consists of an RC oscillator as a sensor, a demodulator and an output level.

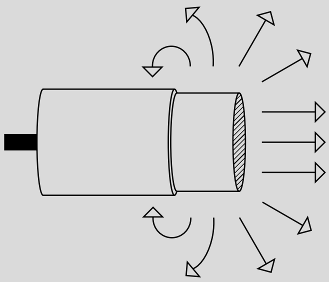
The approach of metals or non-metals to the active face of the capacitive sensor results in a change in capacity, whereby the RC oscillator begins to oscillate. This causes the trigger level downstream from the oscillator to tip, and the switching amplifier changes its output state. The switching function at the output is N.O., N.C. or change-over contact depending on the device type.

Installation



Flush version

Sensors with a linear electrical field. These devices scan solid bodies (e.g. wafers, components, circuit boards, hybrids, cartons, stacks of paper, bottles, plastic blocks and sheets) for distance, or liquids through a partition made of glass or plastic (max. thickness 4 mm).



Non-flush version

Sensors with a spherical electrical field. The active face of these devices should be in contact with the target product to be actively scanned (e.g. granulate, sand, oil or water).

Size correction factor

With objects that are not flat and are smaller compared to the active face one obtains the following switching distances depending on the standardised surface F/F0 with F0 = sensor face surface (active face) and F = face surface of the target object. The data relate to flush sensors and objects in the form of long thin rods.

Standardised object area	Switching distance, S in %	ø – object in mm	F in mm^2	S in mm
1.50	100	22	380	8
1.24	100	20	314	8
0.8	100	16	201	8
0.61	100	14	154	8
0.31	94	10	79	7.5
0.20	85	8	50	6.8
0.15	82.5	7	38	6.6
0.05	67.5	4	13	5.4
0.03	57.5	3	7	4.6

Table 1

Applications

Capacitive proximity switches are suitable for controlling and monitoring machine processes and for providing signals for counting tasks where metals and non-metals are available, as well as for signalling levels in containers and through container walls where liquid, pulverised or grainy materials require detection.

Types of interaction

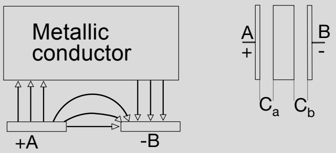


Fig. 1

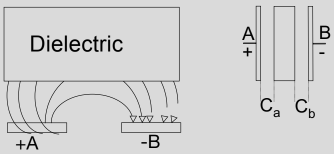


Fig. 2

Capacitive sensors are actuated by both conductive and non-conductive objects. Objects made of conductive materials form a counter-electrode to the sensor's active face. This forms two capacities, C_A and C_B connected in series, with the electrode surfaces A and B (Fig. 1). The capacity of this serial connection is always greater than the capacity of the uncovered electrodes A and B.

Metals achieve the highest switching distances due to their very high conductivity. Reduction factors for differing metals – like those of inductive sensors – must be taken into account.

Actuation by objects made of non-conductive materials (insulators): when one places an insulator between the electrodes of a condenser the capacity increases with the dielectric constant ε (Fig. 2) of the insulator.

The dielectric constant of all solids and liquids is greater than air (ε_{air} = 1; see Table 2). Similarly, objects made of non-conductive materials have an effect on the active face of a capacitive sensor by increasing the coupling capacity. Materials with greater dielectric constants achieve longer switching distances. When scanning organic materials (wood, grain, etc.) it should be noted that the achievable switching distance is very strongly influenced by the water content (ε_{water} = 80!)

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The effect of differing materials

Switching distance and dielectric constants

The switching distance (S_r) is dependent on the dielectric constant (ε_r) of the target object. The maximum switching distance (100 %) is achieved with metallic objects while it is reduced with other materials in proportion to the dielectric constant of the target object.

Table 2 (below) shows the dielectric constants of some important materials. As a result of the high dielectric constant value of water, wood exhibits relatively large fluctuations. Damp wood is therefore considerably better detected by capacitive sensors than dry wood.

Dielectric constants (ε_r) of various materials			
Air. vacuum	1	Perspex	3.2
Teflon	2	Araldite	3.6
Wood	2 … 7	Bakelite	3.6
Paraffin	2.2	Quartz glass	3.7
Petroleum	2.2	Hard rubber	4
Terpentine oil	2.2	Oiled paper	4
Transformer oil	2.2	Pressboard	4
Paper	2.3	Porcelain	4.4
Polyethylene	2.3	Laminated paper	4.5
Polypropylene	2.3	Quartz sand	4.5
Cable compound	2.5	Glass	5
Soft rubber	2.5	Polyamide	5
Silicone rubber	2.8	Mica	6
PVC	2.9	Marble	8
Polystyrene	3	Alcohol	25.8
Celluloid	3	Water	80

Table 2

Object detection

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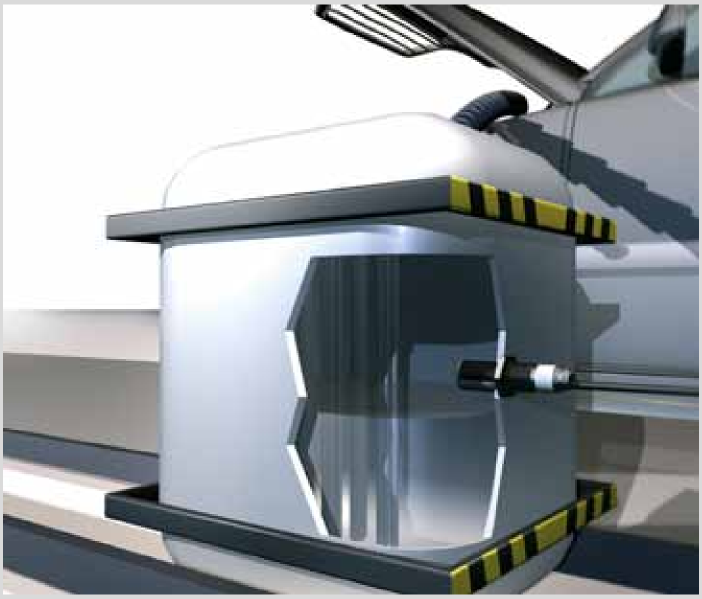
Capacitive sensors (e.g. KL 18) detect the quantity of the isolated bulk material through container walls with a thickness of up to 4 mm.



Level measuring

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The capacitive sensor (e.g. KL 08) detects the level of a reservoir for liquid refrigerant.

Level measuring

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For level control in a transparent container filled with pills, a capacitive sensor (e.g. KD 12) is used.