

# Capacitive sensors – general description

## Functional principle

The proximity-action capacitive sensor converts a variable of interest in technical production terms (e.g. distance or level) into a signal which can be processed further. The function is based on the alteration in the electrical field around its active zone. The sensor basically consists of an oscillator, an electrode assembly as the pick-up, a demodulator and an output stage.

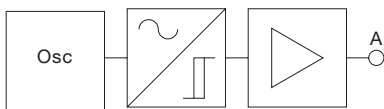


Fig. 1.02

The approach of metals or non-metals into the active zone of the capacitive sensor causes a change in capacitance, which in turn causes the RC oscillator to begin to vibrate.


This causes the trigger stage downstream of the oscillator to flip, and the switching amplifier to change its output status. The switching function at the output is either an N.O., N.C. or changeover contact, depending on the type of unit involved.

The function of the capacitive sensor can be explained in terms of variation in all parameters of the equation for capacitance:

$$C = \epsilon_0 \times \epsilon_r \times F \times (1/S)$$

- $\epsilon_r$ : as the relative dielectric coefficient (property of the medium being scanned)
- $\epsilon_0$ : as absolute dielectric coefficient = const.
- F: as surface
- S: as distance.

From the formula above it follows that objects which have a sufficiently large relative dielectric coefficient ( $\epsilon_r$ ) and surface will be detected by the capacitive sensor. Besides the **standard (multi-purpose) sensor technology**, in which the pick-up is a constituent part of the oscillator circuit, there are also more modern processes designed to meet special application requirements.

 Sensors using the patented **clock frequency modulation process**. Here, the sensor is not part of an oscillator circuit, but is activated by an oscillator's output. This entails significantly higher levels of interference immunity, above and beyond the product standard, meeting the requirements of the German Basic Standard for Industrial Applications.



Sensors using the patented **FSA process**. Here, the sensor consists of several sensor electrodes, appropriately integrated into an oscillator circuit. This process has been specially developed for detecting the fill levels of aqueous solutions, and scores in terms of special compensation characteristics for coping with different tank walls and media adhesion levels.



**ESD-proof sensors**. In addition, a selection of M30 and Ø30 standard sensors are specially protected against high ESD voltages (electrostatic discharge). This enables them to be used in plastic granule conveyor systems.

The **S I E SENSORIK** company manufactures capacitive sensors in 2 versions:

### 1. Version SK

Here, only the oscillator or a capacitive pick-up is accommodated in the sensor housing. The evaluation electronics are located in a separate housing. The sensor can be separated from the evaluation electronics.

### 2. Version SK1

Here, the oscillator and the evaluation electronics are accommodated in a single sensor housing. Electronic circuits and relays can be directly actuated by signal pre-processing inside the device.

Typical applications:

- ▶ controlling and monitoring machine processes
- ▶ sensor for counting tasks
- ▶ fill level detection in tanks and through non-metallic tank walls

## Application

A distinction is drawn between two different application categories for capacitive sensors:

### 1. S I E designation: Proximity Sensor (sensor version flush-mounted)


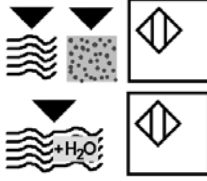
 Sensors with a rectilinear electrical field. These devices scan solids (e.g. wafers, components, PCBs, hybrids, cartons, stacks of paper, bottles, plastic blocks and sheets) from a distance or liquids through a partition wall (glass or plastic, thickness max. 4 mm), and should in each individual case be tested beforehand with samples. See also the section on adjustment.



Fig. 1.03

### 2. S I E designation: Level Sensor (sensor version non-flush mounted)

Sensors with a spherical electrical field.

 These units are designed to detect the product, bulk goods or liquids (e.g. granulate, sugar, flour, corn, sand, or oil and water) with their active surface, by touching the medium or through tank wall.

The choice of the appropriate sensor depends on the operating conditions and the kind of medium and should in each case be tested beforehand with samples. See also the section on adjustment.

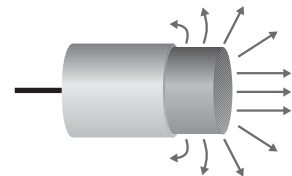


Fig. 1.04

## Sensing distance S

This is the distance between the active sensor surface and the product being scanned at the moment of output-signal change as the object is approached. It depends on shape, size and nature of the object concerned.

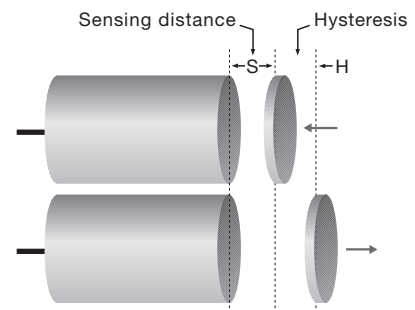


Fig. 1.05

# Capacitive sensors – general description

## Hysteresis

Hysteresis is the distance differential between the switch-on point (as the object approaches) and the switch-off point (as the object recedes again).

## Repeatability

- is the maximum sensing distance differential between any two measurements, measured within 8 hours with multiple „approaches“ to the object being scanned.

## Material correction factor

If the material of the object concerned is not a metal or water, the sensing distance  $S$  will be reduced. Table 1.06 provides a guide to the reduction factors applying for the different materials involved. The precise values must be individually determined with the sensor actually being used.

| Material                                     | Thickness d/mm | $\epsilon_r$      | Reduction factor     |
|--|----------------|-------------------|----------------------|
| Steel ST-37                                  | 1,5            |                   | 1,0                  |
| Brass Ms                                     | 1,5            |                   | 1,0                  |
| Water  |                | approx. 81        | 1,0                  |
| Mikanit 132 (Mica)                           | 2<br>4<br>6    | 4,5               | 0,35<br>0,41         |
| UP (Polyester, glass-fibre-reinforced)       | 2<br>4<br>6    | 4,0               | 0,47<br>0,47         |
| Polyamide A (Nylon 6.6)                      | 2<br>4<br>6    | 4,2 atm. humidity | 0,69<br>0,22         |
| Polyamide B (Nylon 6)                        | 3<br>6<br>9    | 5,3 atm. humidity | 0,25                 |
| Melamin Fabric base laminate (HGW 2271)      | 2<br>4<br>6    | 7                 | 0,53<br>0,62<br>0,66 |
| Paper base laminate (HP 2061)                | 2<br>4<br>6    | 5                 | 0,56<br>0,62<br>0,68 |
| Polystyrene (PS)                             | 2<br>4<br>6    | 2,5 DIN 53483     | 0,24<br>0,31<br>0,36 |
| Polycarbonate (PC)                           | 2<br>4<br>6    | 2,92 DIN 53484    | 0,26<br>0,36<br>0,40 |
| Polymethylmethacrylate (Acrylic glass, PMMA) | 5<br>10<br>15  | 2,9 DIN 53483     | 0,39<br>0,45<br>0,47 |
| Polyvinyl chloride (PVC)                     | 6<br>12        | 2,9               | 0,41<br>0,47         |
| PVC foamed                                   | 3<br>6         | 1,5-2,5           | 0,22<br>0,25         |

Fig. 1.06

## Sensing distance range or detection range ( $S_d$ )

- is the range in which the sensing distance can be adjusted.

## Effective sensing distance ( $S_r$ )

- is the sensing distance measured for a sensor aimed at an earthed metal plate in accordance with IEC 60947-5-2. It is sized so as to ensure that the edge

length (m) of the square metal plate equals the sensor's diameter or corresponds to three times the nominal sensing distance  $S_r$ , whichever is greater.

If the plate is made from a different material, is of smaller dimensions, not earthed or features a different shape or different characteristics, this will entail shorter sensing distances.

## Installation: flush-mounted

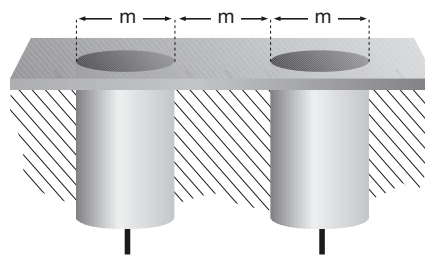


Fig. 1.07

For flush-mountable sensors in plastic housings, the sensing distance must be adjusted after installation.

## Installation: non-flush-mounted

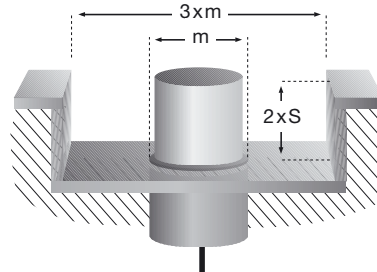


Fig. 1.08

## Installation: opposite

- applies for flush and non-flush-mountable sensors.

### Important!

The clearance for non-flush-mountable sensors (Fig. 1.08) must be complied with.

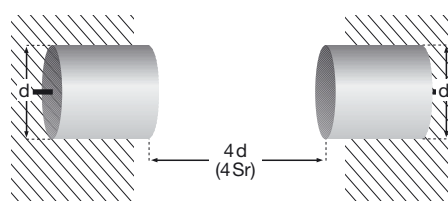


Fig. 1.09

## Mounting torques

To ensure that the sensors are not mechanically destroyed during installation, make sure that you comply with the following torque figures.

Housing made of metal, approx.:

|                       |       |
|-----------------------|-------|
| M5x0,5 / V2A          | 3 Nm  |
| 8x1 / V2A             | 15 Nm |
| M12x1 / V2A           | 40 Nm |
| M12x1 / MS            | 10 Nm |
| M18x1 / V2A           | 60 Nm |
| M18x1 / MS            | 25 Nm |
| M30x1,5/M32x1,5 / V2A | 90 Nm |
| M30x1,5/M32x1,5 / MS  | 65 Nm |

## Housing materials

By choosing and combining the appropriate housing materials, sensors can be supplied for almost all environmental conditions.



PTFE is a special case among housing materials, by virtue of its outstanding resistance to chemicals. The S I E company offers a wide choice of sensors entirely in PTFE (cPTFE).

The following housing materials are standard for capacitive sensors:

|           |   |
|-----------|---|
| PVC       | (=Polyvinyl chloride)                                   |
| PTFE      | (=Polytetrafluoroethylene)                              |
| FEP       | (=Tetrafluoroethylene-Perfluoropropylene)               |
| PUR       | (=Polyurethane)   |
| PBT/PET   | (=Polybutyleneterephthalate/ Polyethyleneterephthalate) |
| POM       | (=Polyoxymethylene)                                     |
| PA        | (=Polyamide)  |
| PSU       | (=Polysulfone)  |
| PC        | (=Polycarbonate)  |
| MS/Cr     | (=Brass) chrome plated                                  |
| Stahl/V2A | (=Stainless steel)                                      |

## Laying the leads

The control leads to the sensors should be laid separately or shielded from the main power lines.

### Please note!

The sensor lead for the SK mini-sensors with a 2-mm-Ø housing, M3, and a 10-mm-Ø / 2.5-high housing, must not exceed an overall length of max. 3 m.

The sensor lead for the SK mini-sensors from a housing  $\varnothing \geq 4$  mm and a housing  $\varnothing \geq 18/4$  high, must not exceed an overall length of max. 10 m.

## EMC Directive and CE labelling

The sensors, sensor amplifiers and sensor secondary switchgear we produce comply with the statutory provisions of the European EMC Directive No. 89/336 EEC and thus with the Low-Voltage Directive No. 73/23 EEC.

The limit values stipulated in the Product Standard IEC 60947-5-2 are complied with.

In addition, we also supply sensors that meet the EMC specification laid down in the German Basic Standard for Industrial Applications.

## Voltage drop $U_d$

The voltage drop is the voltage measured across the active output of the proximity switch when carrying the operational current flows under specified conditions.

## Core identification

The individual cores of the sensor cables are colour-coded.

### DC-units:

brown (br/bn) = +  
blue (bl/bu) = -  
black (sw/bk) = output

### AC-units:

black (sw/bk) or brown (br/bn) = L1  
blue (bl/bu) = N  
green/yellow (gr/ge, gn/ye) = earth

## IP degree of protection

The degrees of protection IP 20, IP 40, IP 54, IP 64 up to IP 68 are in accordance with IEC 60529.

Code letters IP (International Protection) designate protection against shock hazard, ingress of solid foreign bodies, and water, for electrical equipment.

### 1<sup>st</sup> digit:

- 2 protection against penetration of solid foreign bodies larger than 12 mm, shielding from fingers or similar objects.
- 4 protection against penetration of solid bodies larger than 1 mm, shielding from tools or wires.
- 5 protection against harmful dust deposits, complete shock-hazard protection.
- 6 protection against penetration of dust, complete shock-hazard protection.

### 2<sup>nd</sup> digit:

- 0 no special protection

- 4 protection against water spraying from all directions against the piece of equipment concerned.
- 5 protection against a water jet from a nozzle, directed from all directions against the piece of equipment concerned.
- 7 protection against water, when the piece of equipment concerned (housing) is immersed in water under specified pressure and time conditions.
- 8 Protection against water during continuous submersion



IPX4..x6



IPX7..x8

Housings for a multitude of applications are labelled with the appropriate code number for jet-water and submersion.

## Switching frequency

The switching frequency is a succession of periodically repeated activation and de-activation of the sensors during one second. Measuring method in conformity with IEC 60947-5-2.

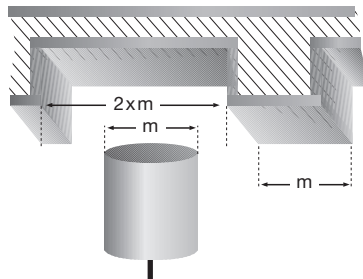


Fig. 1.10

## Standby current

This is the current the sensor consumes at maximum supply voltage without a connected load.

## Operating voltage ( $U_B$ ) or supply voltage

- is the voltage range in which flawless functioning of the sensor is assured. It subsumes all voltage tolerances and residual ripples.

## Operating current ( $I_e$ ) or output current

- is the maximum current with which the sensor may be loaded at its output in continuous operation.

## Smallest operating current ( $I_m$ )

- is the minimum current that has to flow

through the load in order to assure flawless functioning of the switching output stage. Stated for 2-wire AC/DC or AC devices.

## Residual current ( $I_r$ )

- is the current that can flow in the load circuit in the blocked state of the switching output stage.

## Residual ripple

This is the maximum permissible AC voltage which may be superimposed on the supply voltage without affecting the function of the sensor.

## Short-circuit protection and overload protection

The sensors normally contain this protective feature. In the event of overload or short-circuit at the output, the output transistor is automatically switched off. As soon as the malfunction has been corrected, the output stage is reset to normal functioning.

## Polarity reversal protection

The sensor electronics are protected against possible polarity reversal or interchanging of the connection wires.

## Ambient temperature

- specifies the temperature range at which the sensor may be operated.

**SIE SENSORIK** manufactures both sensors for the standard temperature range of  $-30 \dots +70^\circ\text{C}$  and sensors for more stringent temperature requirements up to max.  $+250^\circ\text{C}$ .



## Temperature drift

This states the amount by which the sensing distance may change in dependence on temperature.

## Switching function

N.O. contact: the switching output of the sensor is not switched through in its deactivated state.



Fig. 1.11

N.C. contact: the switching output of the sensor is switched through in its deactivated state.



Fig. 1.12

# Capacitive sensors – general description

## Type code and pictograms

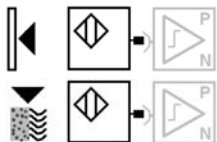
Chapter

|              |     |   |            |    |    |          |   |       |   |    |   |   |   |   |     |    |
|--------------|-----|---|------------|----|----|----------|---|-------|---|----|---|---|---|---|-----|----|
| 0200<br>0300 | SK  | - | -          | 4  | -  | M12      | - | -     | b | -  | - | - | - |   |     |    |
| 0400         | SV  | - | -          | -  | -  | 45/30/15 | - | P     | - | -  | S | - | - |   |     |    |
| 0600<br>0700 | SK1 | - | -          | 3  | -  | M8/46    | - | N     | - | nb | - | Ö | - | - | Y1  |    |
| 0650         | SK1 | - | -          | 20 | -  | M30      | - | AC/DC | - | b  | - | X | - | - | PBT | Y2 |
| 0710         | SK1 | - | FSA        | -  | -  | 50/10    | - | P     | - | b  | - | X | - | - | POM | -  |
| 0900         | SK  | - | HT180      | -  | FS | R3/8     | - | -     | - | -  | - | - | - | - | -   | -  |
| 1200         | SNG | - | 230AC/24DC | -  | -  | -        | - | -     | - | -  | - | - | T | - | -   | -  |

|           |                          |                  |                   |              |          |                 |        |          |            |
|-----------|--------------------------|------------------|-------------------|--------------|----------|-----------------|--------|----------|------------|
| Pos<br>1  | 2                        | 3                | 4                 | 5            | 6        | 7               | 8      | 9        | 10         |
| Unit code | Subgroup                 | Sensing distance | Dimensions Figure | Output stage | Mounting | Output polarity | Option | Material | Connection |
| SK        | A                        | Figure           | M12/60            | P            | b        | S               | T      | PVC      | Y2         |
| SK1       | HT125, HT250, HT180      | FS               | 30/4              | N            | nb       | Ö               | MinMax | PTFE     | Y1         |
| SV        | TM                       |                  | JM18              | AC/DC        |          | X               | K      | MS       | KL         |
| SVD       | FSA                      |                  | 45/30/15          | 4I20         |          |                 | K-T    | V2A      |            |
| SNG       | 2VX                      |                  | LDG12             | X            |          |                 |        | PBT      |            |
| SLK       | X2L                      |                  | R3/8              |              |          |                 |        | POM      |            |
|           | 230AC/24DC<br>115AC/24DC |                  |                   |              |          |                 |        | cPTFE    |            |
|           | 230AC<br>115AC           |                  |                   |              |          |                 |        |          |            |

### Product line:

Mini-sensor **SK**, proximity type and level switch



Flexible **SKF** version available.

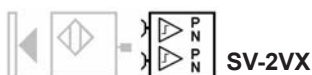
SK sensors require a sensor amplifier to function.



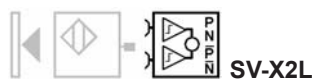
Standard amplifier



Dynamic process amplifier. Not for general use. Self adjusts for highest possible sensitivity

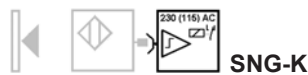


Double amplifier contains 2 independent SV units with both PNP and NPN output.

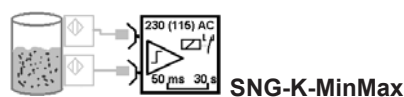


Logic amplifier with built in AND / OR / FF / MinMax functionality for 2x SK-type sensor.

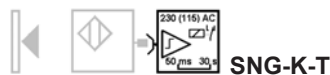
All SNG amplifiers in opposite to SNG power packs are marked with a „-K-“ in the type code.



Standard amplifier for AC use. Contains potentiometer for sensitivity adjustment.



As before but with MinMax level control circuitry.



Sensor amplifier for AC use with timer functionality. Switch-on and switch-off delay are user programmable

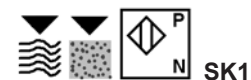
The **SK1** series sensors are self-contained having a semiconductor output stage. **DC**-3-wire units having a PNP or NPN output . **AC/DC** type sensors are 2-wire units.



Proximity sensor for DC use.



Proximity switch , 2-wire AC or DC supplied.



Standard Level switch DC are non flush mountable units.



AC/DC 2-wire level switch version.

SK1- sensors for particular applications



**SK1-TM**  
High-noise immune sensors. This sensors are specially marked with our RF-symbol. The type designation contains a „-TM-“ marking.



**SK1-FSA**  
SK1 liquid level switch.

Beside those detection type sensors (proximity and level switches) **measuring devices** are also available.

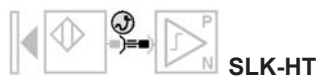


**SK1-A**  
Capacitive proximity sensor supplying an analogue current output signal (4..20mA).

Proximity and level units for high temperature use. Self contained and passive probe versions are available.



**SK-HT**  
The „active“ supply line cable (contains the oscillator housed in the customized amplifier-end connector)

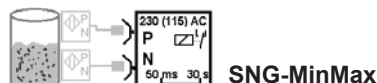


**SLK-HT**  
drives a standard or any other amplifier out of our product range.

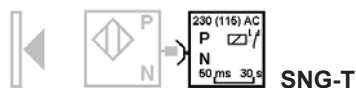
The product range is completed by the power packs for SK1-sensors



**SNG**  
Standard power pack (plain unit without any additional functionality). Supplies one sensor with the standardized 24V.



**SNG-MinMax**  
Power pack contains electronics for minimum maximum level control.



**SNG-T**  
Power pack contains user adjustable switch-on and switch-off delay.

**Function pictograms:**



NO/NC user selectable



PNP/NPN user selectable



Input automatically detects for PNP or NPN.



User adjustable switch-on delay.



User adjustable switch-off delay.



Relais output (SPDT). Available for power packs only.

**Connection:**



Sensor with lead



Sensor with built in connector.



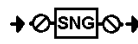
Sensor with lead and connector.



Input connector, output lead connection



Clamp terminal



Input and output clamp terminal

**Stress care identifier:**



Sensor with highest chemical resistance.



Sensor for high temperature use



Sensor with improved ESD noise immunity



Sensor with improved RF noise immunity (radiated and conducted)

**Application identifier:**



Proximity switch



In touch level detection



Through wall level detection



Through wall level detection with compensation for residues,adhesion and filming

>> **Smart Level**



**Safety note:**

The products of **S I E SENSORIK** must not be used in areas in which a technical defect or any failure of the devices would endanger people's health or lives.

**S I E SENSORIK** does not give any guarantee for the products' use.