With capacitive sensors from Baumer you can complete almost any task.
Innovative all-rounders.

Capacitive sensors can detect metallic, non-metallic, transparent, opaque, liquid and solid substances reliably without the need for contact. These properties make them true «all-rounders», which are used in a many different industrial applications. The ability of the measuring field to penetrate non-conductive materials is particularly advantageous for measuring filling levels. Capacitive sensors can be installed outside of a container to detect a filling level inside. This protects the sensor from aggressive media and prevents contamination of high-quality materials by the sensor at the same time.

Years of production and development know-how and our proximity to the market, allow us to offer our standard portfolio but also to develop application-optimized solutions and innovations as well as unique mounting concepts.
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Sensor solutions.

Whether for object or position recognition, measuring, a miniaturized or exceptionally robust design – Baumer has the right sensor for every application. Different sensor functions in standard housings ease assembly for the user and limit the setup time to a minimum. Baumer can supply a wide range from inductive to vision sensors and advise you comprehensively.
Solutions customized for each customer

No range of products will ever be large enough to provide the optimal solution for every application. Often within an application, there are requirements that move in a completely new direction and cannot be fulfilled to the extent desired by the existing solutions in the market. This is why our development engineers work closely with our customers. Sensors customized for each customer are continuously being created while searching for the optimal solution to specific requirements.

The range extends from special mechanical housings all the way to completely new types of sensor systems. An innovative sensor solution may also help you achieve a substantial competitive advantage.

We would be happy to answer your questions!
Material-independent object and filling level detection – capacitive sensors.

Contactless
- Reliable object detection with sensing distances up to 30 mm
- No sensor damage due to aggressive media
- Medium is not contaminated by the sensor

No matter what material
- Reliable detection of conductive and non-conductive materials
- Failure-free detection of highly transparent and opaque materials
- Reliable detection even on optically reflecting surface

Durable
- Protected installation outside the container possible
- Closed sensor front increases lifetime in case of contact with liquids
- High wear resistance of the housing increases sensor lifetime in case of contact with granules

Applications
- Machine tools
- Graphic machinery
- Packaging machinery
- Food and beverages
- Installation/handling
- Medical devices
- Laboratory automation

Granule level detection in injection molding plants
- Robust design protects the sensors from mechanical wear
- Surface-independent detection
- Fast and easy installation

Wafer detection in solar cell manufacturing facilities
- Reliable wafer detection thanks to large sensing distances
- Flush mounting possible thanks to flat design
- Detection regardless of transparency and brightness of the objects

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Liquid level monitoring of return flow tanks in laboratory automation

- Fast and easy sensor installation outside the tanks
- Long lifetime thanks to robust housing
- Several self-definable monitoring areas thanks to easy cascading

Filling level monitoring in bottling plants

- Detection through packaging
- Quality control of closed packaging at the end of the process possible
- Color-independent detection increases process safety

Ink level detection in offset printing machines

- Level detection in direct contact with the liquid
- Dirt and drop retention is suppressed by the sensor
- Easy and safe functional principle
Admissible lead lengths
For proximity switches large lead lengths signify load capacitance of the output and increased influence of interference signals. Lead lengths >5 m should, if possible, be avoided.

Connection cable
Most capacitive sensors come standard with a highly flexible PVC cable. If higher resistance to grease and oil is required, they can also be supplied with a PUR cable. The standard cable length is 2 m.

Current consumption
Current maximally consumed by the circuit at nominal voltage (no load).

Dimension
This specification usually refers to the diameter of the sensing face. The following applies: the larger the sensing face, the greater the sensing distance (Sn).

Electrical conductivity
Electrical conductivity is the ability of a medium to conduct an electrical current. It is specified in Siemens per meter.

Hysteresis
Hysteresis is the difference between the operating and switching-off point as an object approaches and moves away from the sensor.

Output indicator
The LED indicates the current output.

Oil resistance
Sensors with all-metal housing and PUR cable are suitable for applications in oily environments.

Output protection
The sensors are protected against voltage peaks, short circuits and reverse polarity.

Residual ripple
It is assumed for sensor operation that the specified voltage supply range is not exceeded or undershot at any time. A residual ripple VR of max. 10% of the direct current average value is tolerated by the sensor within these limits.

Repeat accuracy
Repeat accuracy is the maximum deviation of the sensing distance during 2 arbitrary measurements within 8 hours under constant conditions.

Reverse polarity protection
The sensors are protected against voltage peaks, short circuits and reverse polarity.

Sensing face
The size of the sensing face is defined by the electrodes. The larger the measuring electrode, the larger the electrical field and the greater the sensing distance.

Sensor standard
The sensor standard is described in EN 60947-5-2:2007.

Short circuit protection
The sensors are protected against voltage peaks, short circuits and reverse polarity.

Load current
Specifies the maximum current that may flow through the output for an unlimited period.

Switching frequency
The highest possible number of switching operations per second is defined in the sensor standard EN 60947.

Temperature drift
Within the specified temperature range, the effective sensing distance Sr can change in relation to the nominal sensing distance Sn by the specified range.

Operating temperature range
The sensors are designed and tested for function in the specified temperature range.

Voltage drop Vd
This specification indicates the maximally dropping voltage via the controlled output.

Voltage supply range +VS
At a maximum residual ripple of 10%, the voltage supply must not exceed and/or fall below the specified minimum and maximum values.
Definition of sensing distance

Sensing distance

The international standard EN 60947-5-2 defines sensing distance as follows: sensing distance is the distance at which a standard target moving toward the sensing face of a proximity switch causes a signal change.

The sensing distance of capacitive sensors depends on the following factors:
- Sensor diameter
- Sensor design (with/without GND electrode)
- Material of the medium to be detected
- Size of the approached body

Standard target

Predefined part used for comparative measurement of sensing distances and scanning ranges. The standard target is square, 1 mm thick and made of Fe 360 (ST 37). The side length corresponds to either the diameter of the sensing face or the triple nominal sensing distance $S_r$, the respectively higher value being definitive. The target must be grounded.

Nominal sensing distance $S_n$

Nominal sensing distance $S_n$ is a type classification parameter and does not take into account tolerances during machining or changes due to external conditions such as voltage or temperature.

Usable sensing distance $S_u$

Sensing distance of an individual proximity switch measured over the temperature range and at a supply voltage of 85% and 110% of the rated value. For capacitive proximity switches it must be between 80% and 120% of the effective sensing distance.

Effective sensing distance $S_e$

Effective sensing distance of an individual proximity switch which is measured at a defined temperature, voltage and installation conditions. For capacitive proximity switches it must be between 90% and 110% of the nominal sensing distance at 23 ±5 °C.

Assured sensing distance $S_a$

Distance from the sensing face at which the operation of the proximity switch is ensured under defined conditions. For capacitive proximity switches the assured sensing distance is between 0% and 72% of the nominal switching distance.
Protection classes

1) Protection from ingress of dust and complete protection against electric shock.

2) Protection from water jets from any direction.

IP 67 includes the IP 65 specification. In addition this class offers protection against water when the housing is immersed in water under defined pressure and time conditions (30 minutes in 1 meter deep water).

Water must not enter in a quantity that will produce harmful effects if the housing is continuously immersed in water and if conditions which are specified between the manufacturer and user are fulfilled. The conditions must however be more difficult than in IP 67.

Protection from ingress of water during high-pressure cleaning with pure water at a water pressure of 8,000 bis 10,000 kPa and a water temperature of +80 °C. The pressurization period is 30 seconds per position. Because this test procedure distinctly differs from the other IP tests, devices with the test seal IP 69K do not automatically have protection class IP 67 or IP 68. Solely devices with protection class IP 67 also have the underlying protection classes as well.
To rule out unintentional interference of the measuring field and to achieve maximum sensing distances, it is required to follow the mounting instructions and to maintain the specified minimum distances. If the minimum distances are undercut, a reduction of the sensing distances is expectable. A sensor test directly at the application is recommended.

### Mounting arrangement

**Flush mounting**

Flush mounting of flush-mountable capacitive sensors is possible in all materials. The minimum distance between the sensors must be observed.

### Mounting arrangement

**Non-flush mounting**

For non-flush-mountable capacitive sensors a free zone must be created around the sensor head which must not contain any damping material.

### Max. installation torques

To avoid damage during sensor installation, the specified installation torques must not be exceeded.

#### Cylindrical housing with external thread

<table>
<thead>
<tr>
<th>Material</th>
<th>M8</th>
<th>M12</th>
<th>M30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass</td>
<td>7,0 Nm</td>
<td>15 Nm</td>
<td>200 Nm</td>
</tr>
<tr>
<td>Nickel-plated</td>
<td>1,5 Nm</td>
<td>3,0 Nm</td>
<td>15 Nm</td>
</tr>
<tr>
<td>Plastic</td>
<td>1,5 Nm</td>
<td>3,0 Nm</td>
<td>15 Nm</td>
</tr>
</tbody>
</table>

#### Rectangular housing

<table>
<thead>
<tr>
<th>Material</th>
<th>M3</th>
<th>M4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass</td>
<td>0,9 Nm</td>
<td>2,1 Nm</td>
</tr>
<tr>
<td>Nickel-plated</td>
<td>0,5 Nm</td>
<td>1,0 Nm</td>
</tr>
<tr>
<td>Plastic</td>
<td>0,5 Nm</td>
<td>1,0 Nm</td>
</tr>
</tbody>
</table>
Connection diagrams

Explanatory notes on the connection diagrams

The specified diagrams indicate the undamped output. A sensor is in a damped state when an object is located in within its scanning range. In the diagrams Z denotes the typical load resistance position; Uz denotes the voltage applied to this load resistance. If Uz = high (≈ +Vs), then current flows; if Uz = low (≈ 0 V), then no current flows via the load resistance. Load resistance between output and +Vs is referred to as pull-up resistance, load resistance between output and 0 V as pull-down resistance.

PNP or NPN output

Sensors with a PNP or NPN output have a 3-wire design (+Vs, output and 0 V) and operate with direct current (DC). The load resistance of PNP sensors is between output and 0 V (pull-down resistance), while load resistance of NPN sensors is between +Vs and output (pull-up resistance). As a result, the PNP output is connected to the positive voltage supply during switching (positive switching output), whereas the NPN output is connected to the negative voltage supply during switching (negative switching output).

Normally open contacts and/or normally closed contacts define the switching function. Normally open contacts are referred to as normally open (NO), normally closed contacts as normally closed (NC). During damping with an object, sensors with normally open function establish contact connections (Uz = high), while sensors with normally closed function disconnect connections (Uz = low).

<table>
<thead>
<tr>
<th>State</th>
<th>Uz</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>undamped</td>
<td>low</td>
<td>off</td>
</tr>
<tr>
<td>damped</td>
<td>high</td>
<td>on</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State</th>
<th>Uz</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>undamped</td>
<td>high</td>
<td>on</td>
</tr>
<tr>
<td>damped</td>
<td>low</td>
<td>off</td>
</tr>
</tbody>
</table>
Push-pull output (push-pull)

Sensors with a push-pull output have a 3-wire design like PNP or NPN sensors (+Vs, output and 0 V) and also operate with direct current (DC). Because this output is designed as a change-over, it can be used as a positive or as a negative switching output depending on the wiring. Therefore it is compatible with PNP or NPN outputs and is universally usable. If the load is connected to 0 V, the behavior of the output potential is identical to that of a sensor with a PNP output; when the load is connected to +Vs, the behavior of the output potential is identical to that of a sensor with an NPN output. The switching function active low means that during damping with an object approx. 0 V (low) are over the load resistance; at active high approx. +Vs (high) are over the load resistance during damping. Parallel connection of push-pull sensors is possible only with corresponding wiring.

<table>
<thead>
<tr>
<th>State</th>
<th>Uz1</th>
<th>Uz2</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>undamped</td>
<td>low</td>
<td>high</td>
<td>off</td>
</tr>
<tr>
<td>damped</td>
<td>high</td>
<td>low</td>
<td>on</td>
</tr>
</tbody>
</table>

Push-pull active high

Push-pull active low

Compatibility of push-pull and PNP/NPN

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PNP normally open (NO)</td>
<td>push-pull active high with pull-down load</td>
</tr>
<tr>
<td>PNP normally closed (NC)</td>
<td>push-pull active low with pull-down load</td>
</tr>
<tr>
<td>NPN normally open (NO)</td>
<td>push-pull active high with pull-up load</td>
</tr>
<tr>
<td>NPN normally closed (NC)</td>
<td>push-pull active low with pull-up load</td>
</tr>
</tbody>
</table>
The capacitive sensor basically functions like an open capacitor. An electrical field is formed between the measuring electrode and the GND electrode. If a material with a dielectric constant $\varepsilon_r$ greater than air enters the electrical field, the capacity of the field increases depending on the $\varepsilon_r$ of this material. The electronics measure this capacity increase, the generated signal is conditioned during subsequent signal processing and causes output switching at a corresponding magnitude.

**Sensor type**

*Sensors with GND electrode*

These sensors can be flush-mounted with the sensing face in a material. Because the measuring field of these sensors extends from the measuring to the integrated GND electrode, a defined measuring field is created. They are particularly suitable for detecting non-conductive materials such as oils, glass, wood or plastics, but can also detect conductive materials just as well. To prevent undesired switching and moisture on the sensor surface, a compensating electrode was integrated to suppress undesired objects.

*Sensors without a GND electrode*

Generally these sensors cannot be flush mounted. Since they do not have a GND electrode, the object to be detected performs the function of a GND electrode. Sensors without a GND electrode feature low sensitivity to soiling and condensation and are suitable especially for level tasks. To achieve long sensing distances, the medium to be detected should be conductive and optimally grounded.
Detectable media

Dielectric constant

Capacitive sensors detect conductive as well as non-conductive media with a dielectric constant $\varepsilon_r > 1$. The dielectric constant $\varepsilon_r$ (also relative permittivity or inductive capacitance) of a material indicates how many times greater the electric flux density will become if instead of vacuum (air) the corresponding material enters the measuring field.

Conductive media

Conductive media typically has an electrical conductivity $> 20 \, \mu\text{S/cm}$. Conductive material can easily be detected by all sensor types whether they have a GND electrode or not. In conductive media the dielectric constant is irrelevant for the sensing distance. The sensing distance is influenced by the size of the object and its grounding.

Conductive media include:
- Water
- Blood
- Ink
- Milk
- Acetone
- Metals

Non-conductive media

Non-conductive media typically has an electrical conductivity $< 20 \, \mu\text{S/cm}$. In general sensors with a GND electrode are recommended for non-conductive media. If a non-conductive object is moved into the sensor field, the field increases depending on the dielectric constant and the size of the material to be detected, increasing the capacity of the measuring field. The lower $\varepsilon_r$ is, the harder it is to detect the medium. Generally it can be said that e.g. for plastics with $\varepsilon_r = 3$ the effective sensing distance $S_r$ corresponds to approximately 50% of the nominal sensing distance $S_n$. 

![Graph showing dielectric constant and sensing distance depending on $\varepsilon_r$]

<table>
<thead>
<tr>
<th>Material</th>
<th>$\varepsilon_r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>80</td>
</tr>
<tr>
<td>Methanol</td>
<td>33</td>
</tr>
<tr>
<td>Alcohol</td>
<td>25</td>
</tr>
<tr>
<td>Stoneclay</td>
<td>8.4</td>
</tr>
<tr>
<td>Glass</td>
<td>2.2</td>
</tr>
<tr>
<td>Wood</td>
<td>1</td>
</tr>
<tr>
<td>PVC</td>
<td>2</td>
</tr>
<tr>
<td>Rapeseed oil</td>
<td>3</td>
</tr>
<tr>
<td>Gear</td>
<td>3</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>2.2</td>
</tr>
<tr>
<td>Coffee beans</td>
<td>1.5</td>
</tr>
<tr>
<td>Paper</td>
<td>1.2</td>
</tr>
<tr>
<td>Synthetic granules</td>
<td>1.2</td>
</tr>
<tr>
<td>Air, vacuum</td>
<td>1</td>
</tr>
</tbody>
</table>
Level detection in direct contact

Capacitive sensors in especially robust plastic and metal housings are very suitable for level detection in direct contact with the medium. The sensors feature high chemical and mechanical resistance. They are installed through an opening in the container wall or inside the container. The internal compensating electrode prevents switching errors caused by sediments and moisture on the sensing face. Sensors with a fully enclosed housing are preferable for applications with direct media contact.

Level detection through container walls

Capacitive sensors can detect media through non-conductive container walls without any problems. This is a big benefit particularly in closed containers, chemically aggressive media or in media which must not be contaminated. The higher the dielectric constant or conductivity of the medium to be detected, the better it can be detected by the sensor through the container wall.

Object detection / bulk goods

Capacitive sensors can detect all kinds of objects without any problems. The better the level of conductivity and grounding of an object is, the higher is the level of signal reserves and detection reliability. Because many capacitive sensors can be flush mounted, they are suitable for protected, space-saving installation.