



# Monitoring of relevant process parameters using fluid sensors

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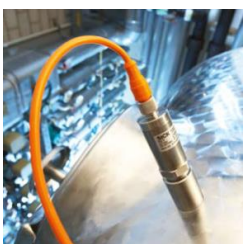
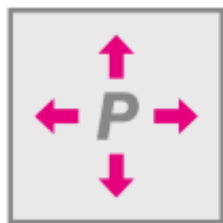
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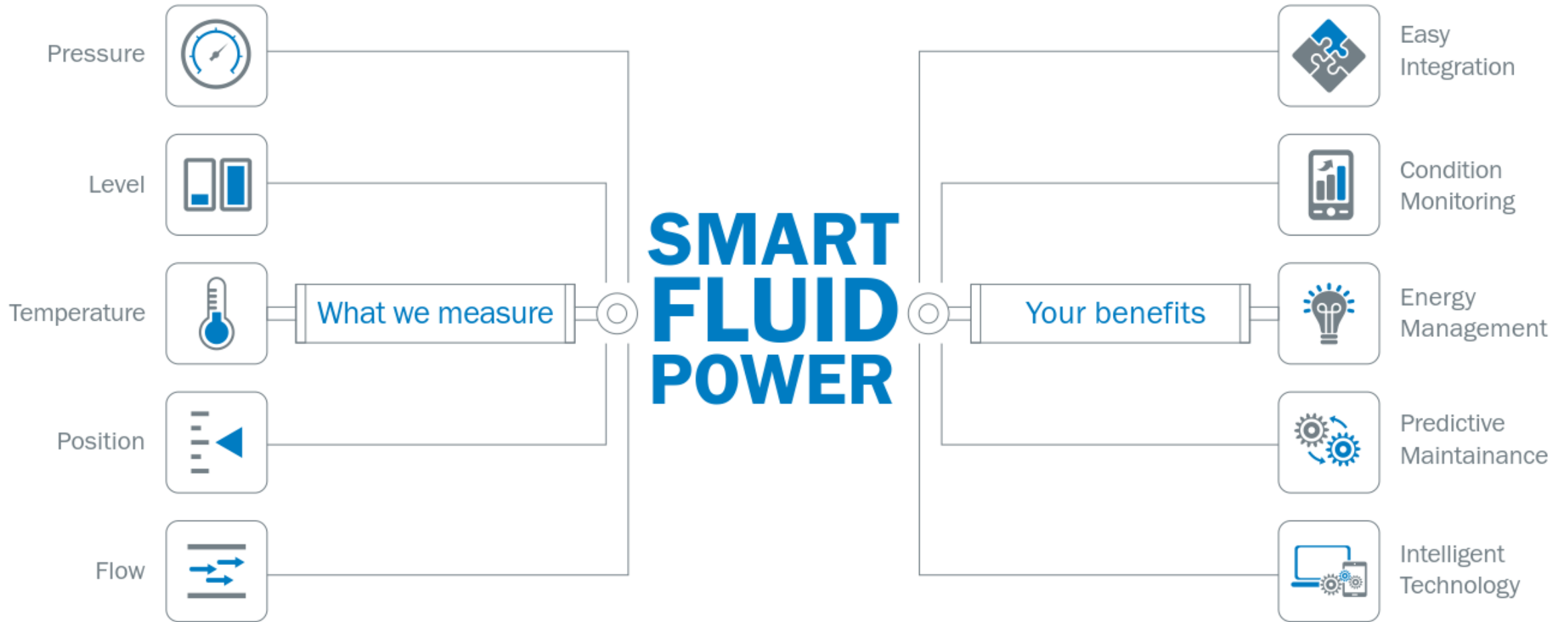
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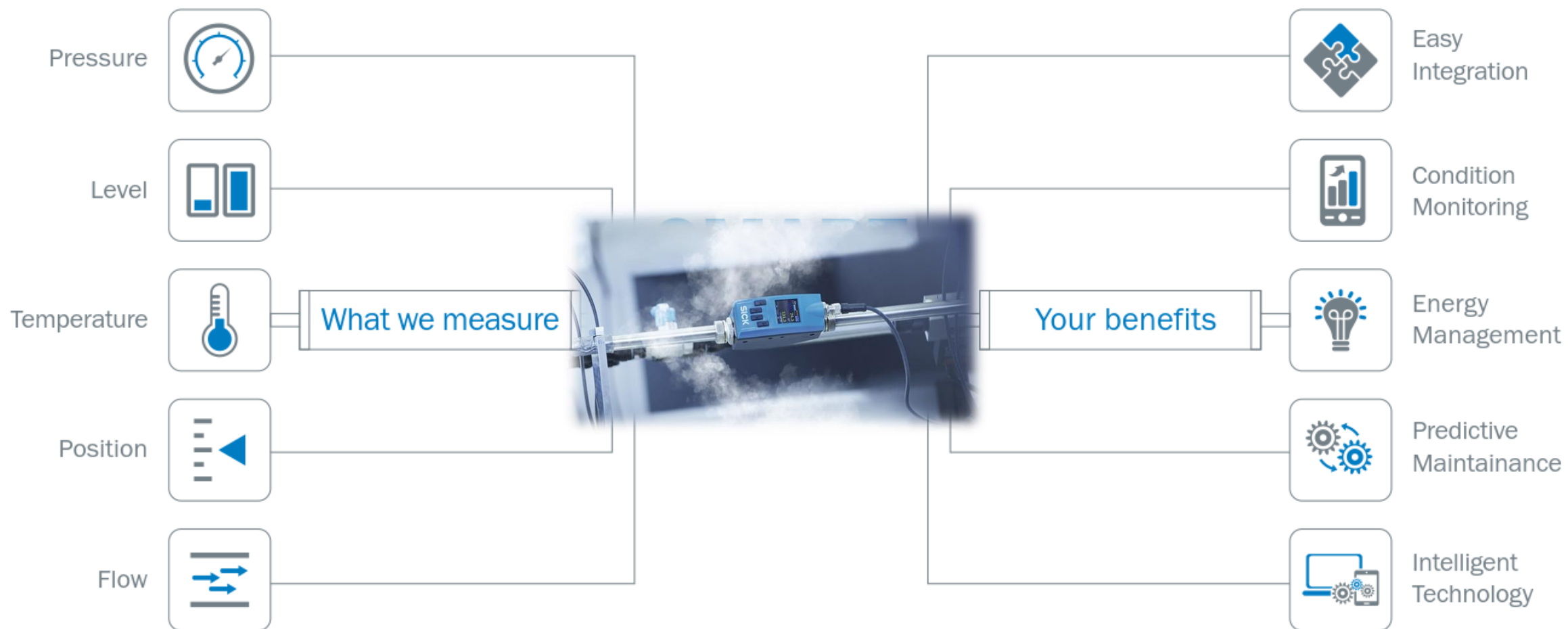


- **Technology update as the basis for increasing efficiency for the relevant process parameters:**
  - Level and point level measurement
  - Universal pressure measurement in liquids and gases
  - Flow measurement technology
  - Temperature measurement for liquids and gases
- **Technology selection**
- **Process connections**
- **Outlook 80 Ghz radar technology**









# Level and point level measurement

## Overview of technologies



Level measurement for all possibilities of liquids and bulk goods:

- Guided Radar Wave (TDR)

- Ultrasonic

- Capacitive

- Hydrostatic

- Free space radar (e.g. 80 GHz)

Point level measurement:

- vibration

- Visually

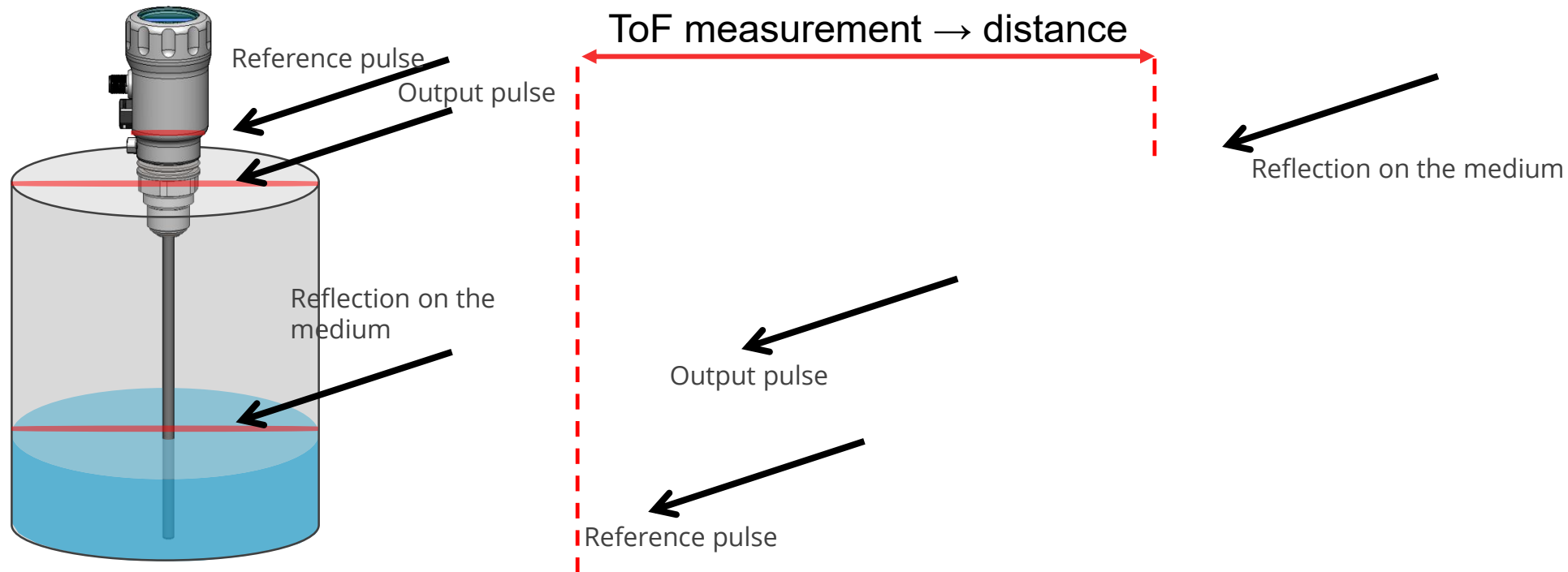
- Capacitive impedance spectroscopy

# Level measurement

Guided Radar Wave (TDR)



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# Level measurement

Guided Radar Wave (TDR)



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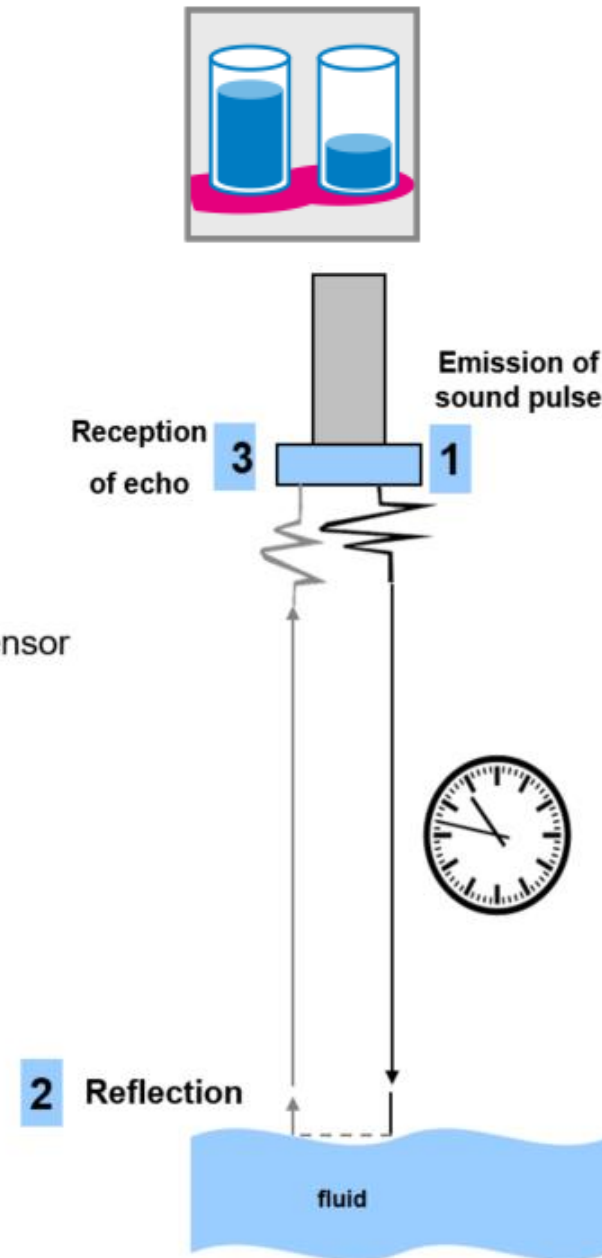
# Level measurement

## Ultrasonic

Ultrasonic sensors work based on time of flight principle

1. Emission of sound pulse
2. Reflection
3. Reception of echo

Based on the run time of the emitted sound pulse the sensor determines the distance between the fluid and the sensor



# Level measurement

Ultrasonic



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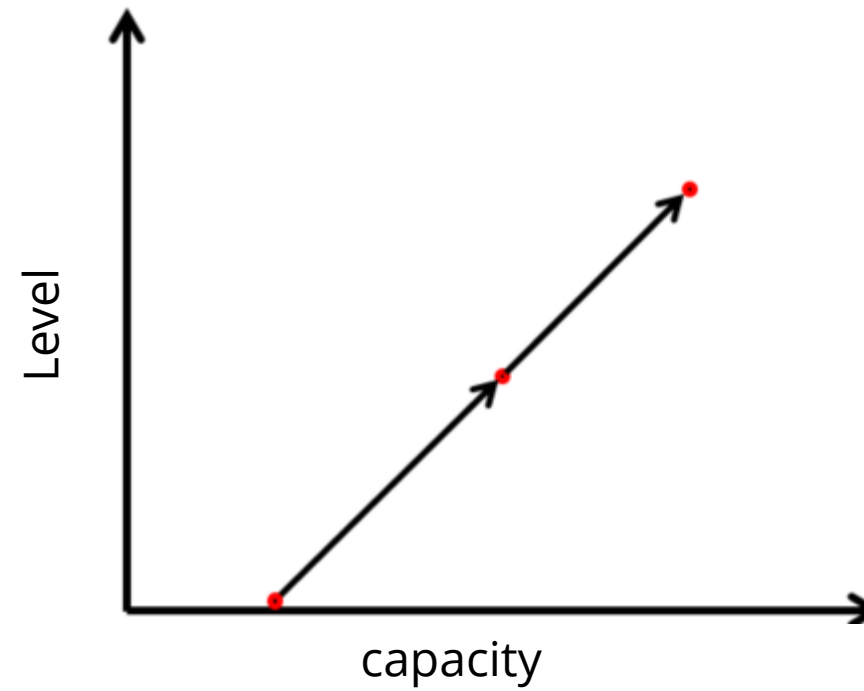
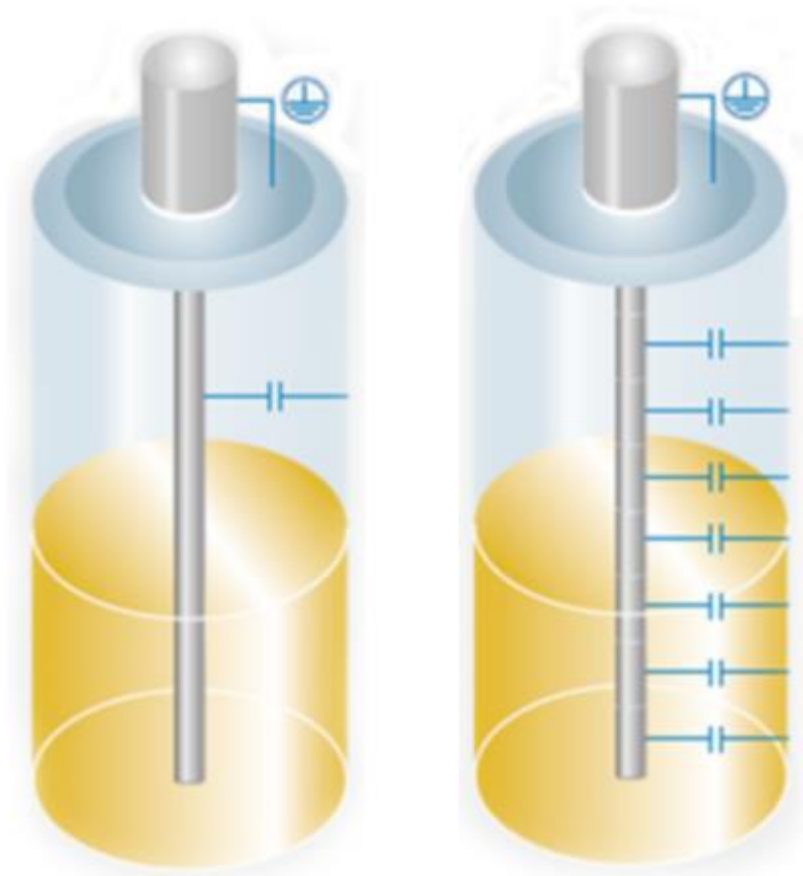


# Level measurement

Capacitive



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# Level measurement

Capacitive



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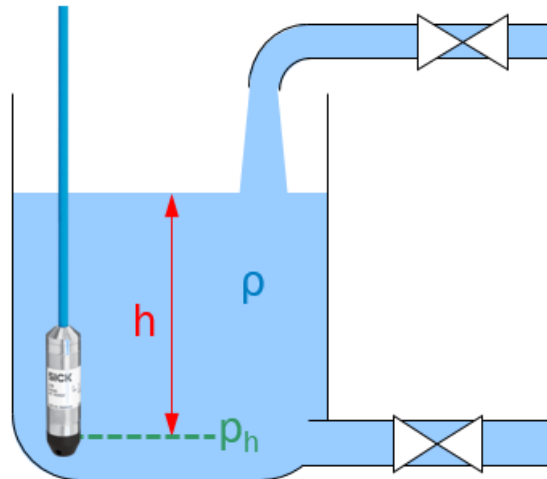
# Level measurement

## Hydrostatic open tank



Because of its mass any liquid is creating pressure. This pressure depends on the height of the liquid level and it can be used for level measurement.

Open tank



$$h = \frac{p_h}{\rho \cdot g}$$

$h$  height of level above pressure sensor

$p_h$  gauge pressure in depth  $h$

$\rho$  density of liquid

$g$  acceleration of gravity (9,81 m/s<sup>2</sup>).

Rule of thumb

$$h [\text{m}] \approx p [\text{bar}] * 10$$

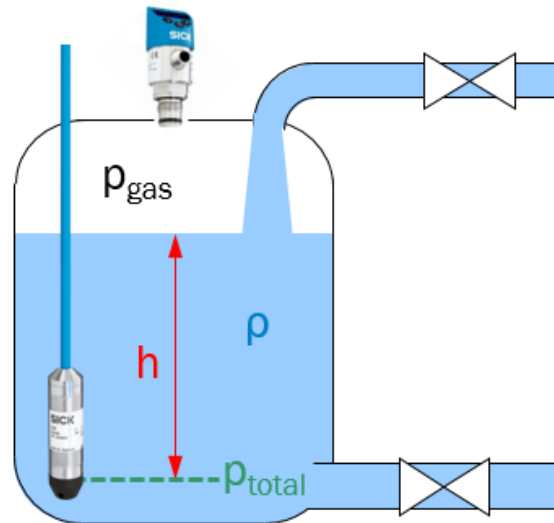
# Level measurement

Hydrostatic closed/pressurized tank



In a pressurised tank the pressure of the gas above the liquid exerts pressure on the liquid's level. For the calculation of the level this pressure must be subtracted to obtain the hydrostatic pressure.

Closed/Pressurized tank



$$h = \frac{p_{\text{total}} - p_{\text{gas}}}{\rho \cdot g}$$

$h$  height of level above pressure sensor

$p_{\text{total}}$  total gauge pressure in depth  $h$

$p_{\text{gas}}$  gauge pressure of gas above level

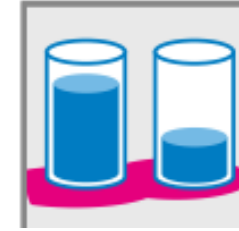
$\rho$  density of liquid

$g$  acceleration of gravity (9,81 m/s<sup>2</sup>).



# Level measurement

Hydrostatic closed/pressurized tank



Attention:

The accuracy of hydrostatic level measurement in pressurized tanks is higher than in open tanks. This is because in pressurized tanks the combined accuracy of 2 pressure sensors has to be taken into account.

Open tank:

One pressure sensor

$$h = \frac{p_h}{\rho \cdot g}$$

Pressurized tank:

Two pressure sensors

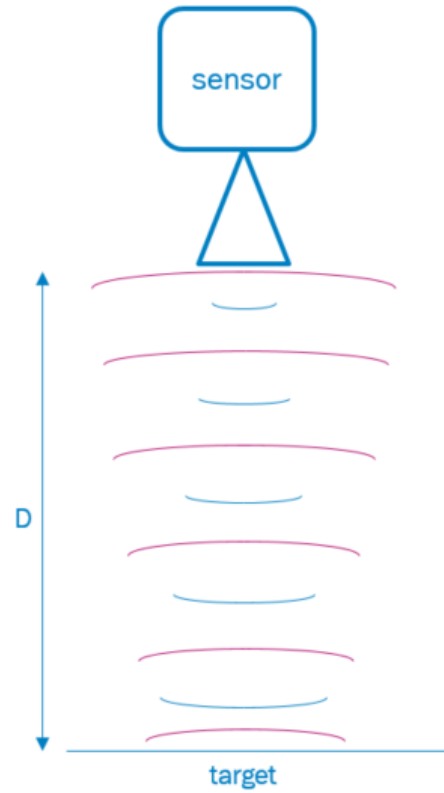
$$h = \frac{p_{\text{total}} - p_{\text{gas}}}{\rho \cdot g}$$

# Level measurement

Radar free space (e.g. 80 GHz)



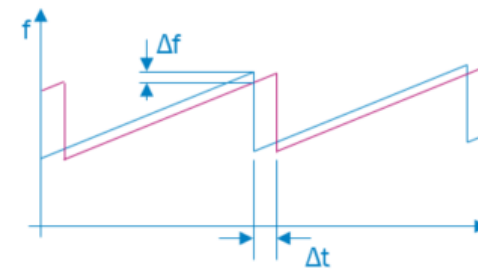
- FMCW (Frequency Modulated Continuous Wave) radar technology



1. Radar signal gets emitted by antenna
2. Radar signal gets reflected by target back to antenna
3. Time between emitting and receiving the signal (travel time) is directly proportional to distance to target

$$D = \frac{c_{\text{gas phase}} \cdot \Delta t}{2}$$

4. Since such short times are difficult to measure accurately FMCW uses Frequency Modulation and mixes both signals



$$\Delta f \sim \Delta t$$

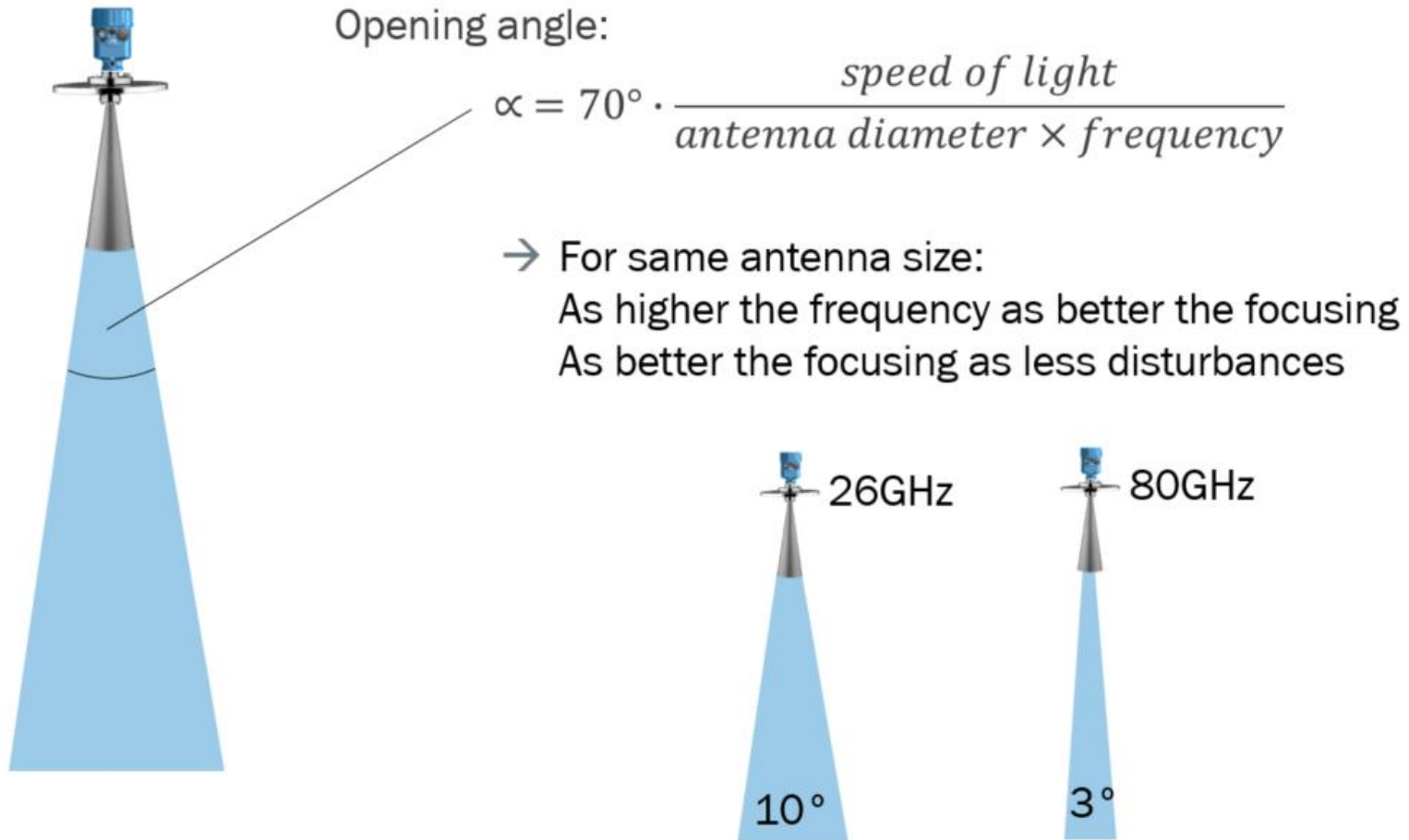
5. The resulting frequency is the difference of the frequency of both signals and indirectly corresponds to the time difference which indicates the distance

# Level measurement

Radar free space (e.g. 80 GHz)



- 80GHz – the meaning of the frequency



# Level measurement

Radar free space (e.g. 80 GHz)



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# Level and point level measurement

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Point level measurement:

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- Visually

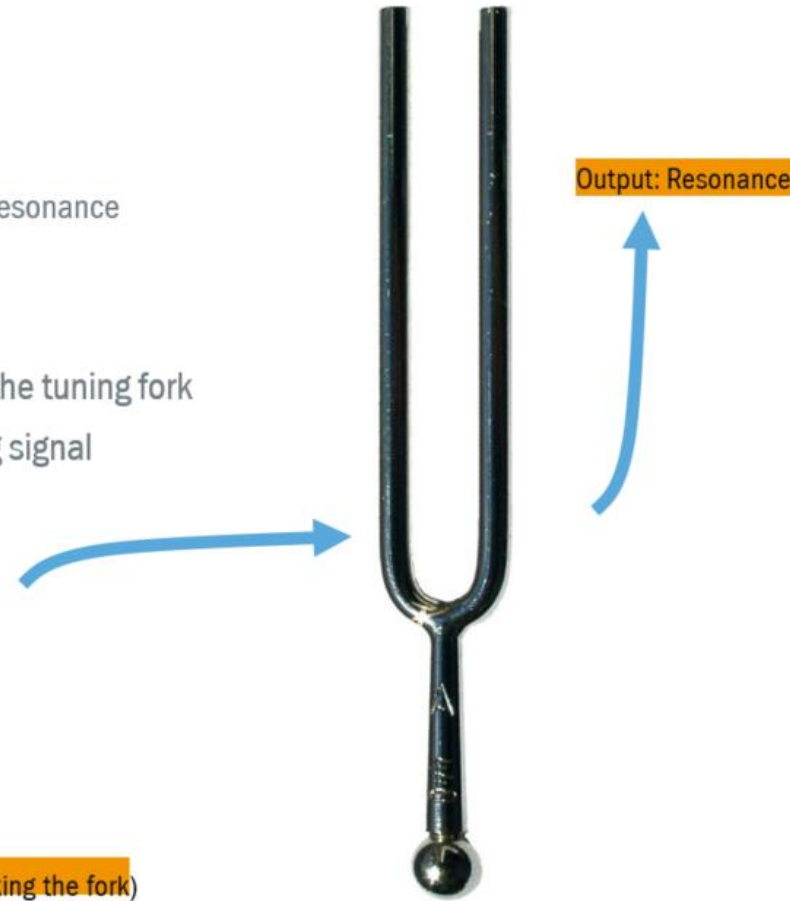
- Capacitive impedance spectroscopy

# Point level measurement:

## Vibration



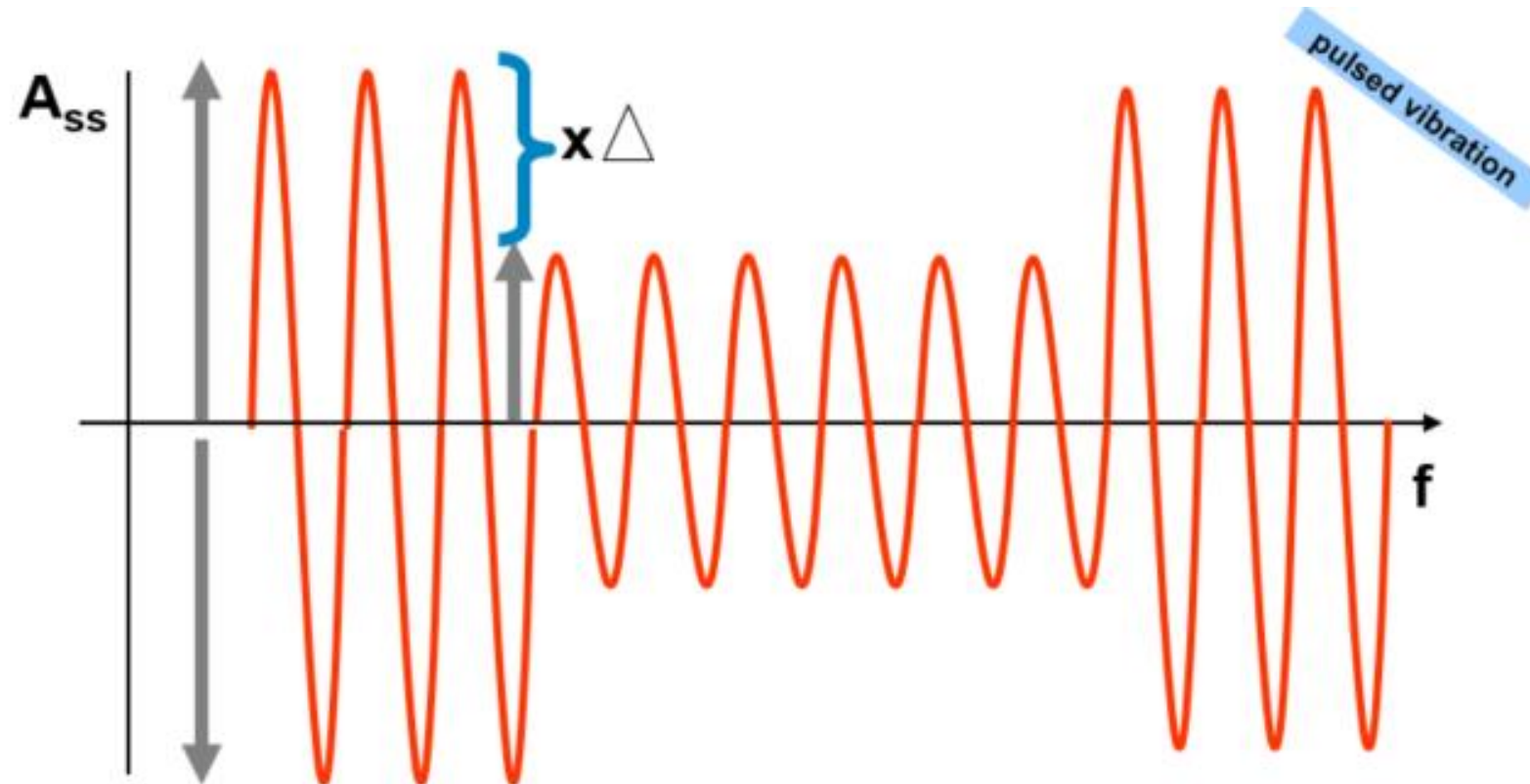
- Tuning fork technology
  - ▶ Acoustic technology
    - A fork vibrates in resonance frequency
    - Immersing the fork in substance changes the resonance
- Background
  - ▶ Liquids or solids influence the resonance of the tuning fork
  - ▶ Changes to the resonance trigger a switching signal
- Structure with piezo elements





# Point level measurement:

Vibration

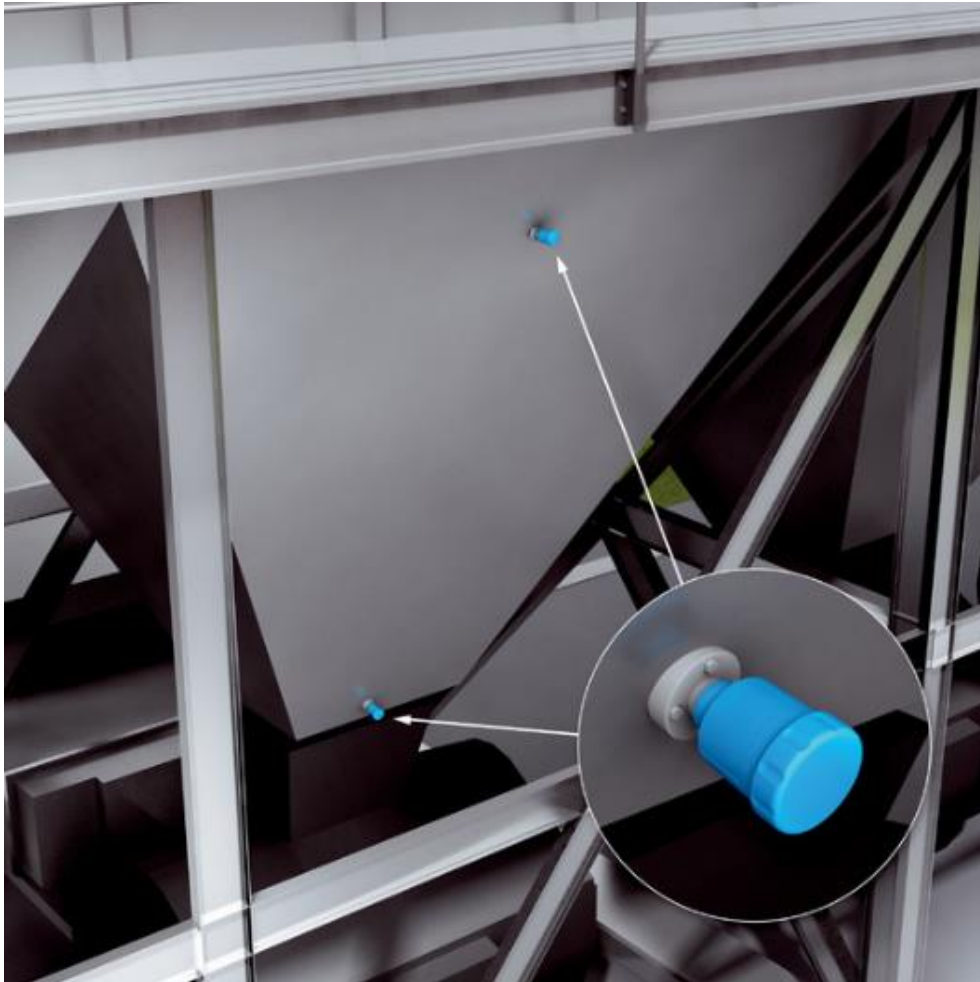


# Point level measurement:

Vibration



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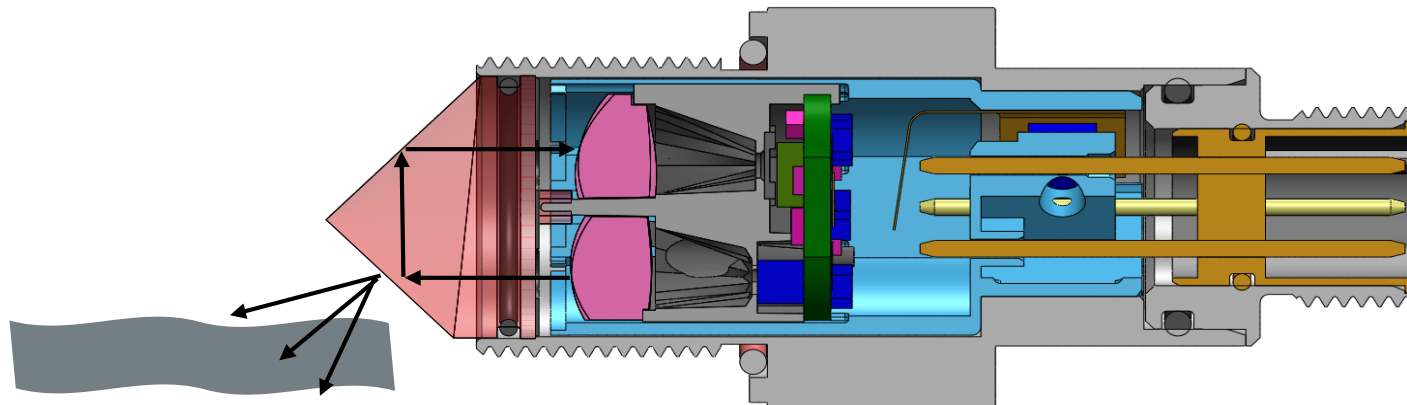


# Point level measurement:

Optical



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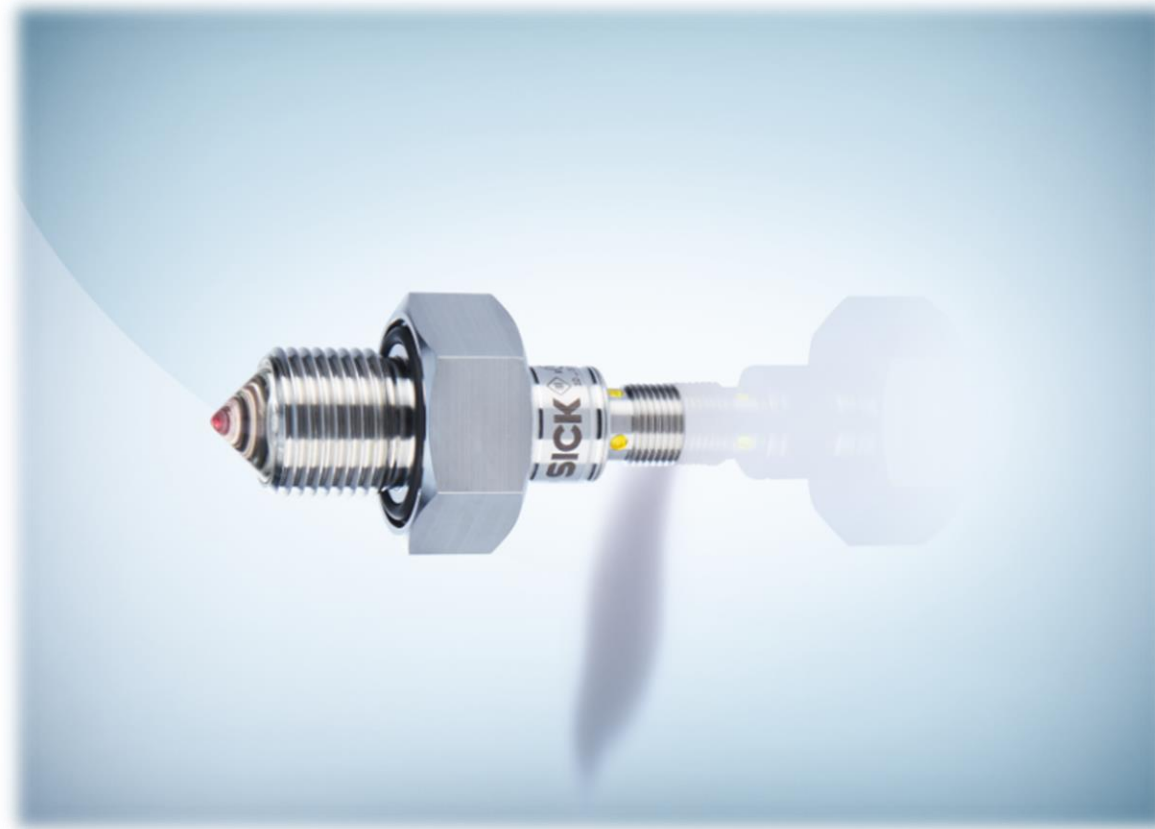


# Point level measurement:

Optical

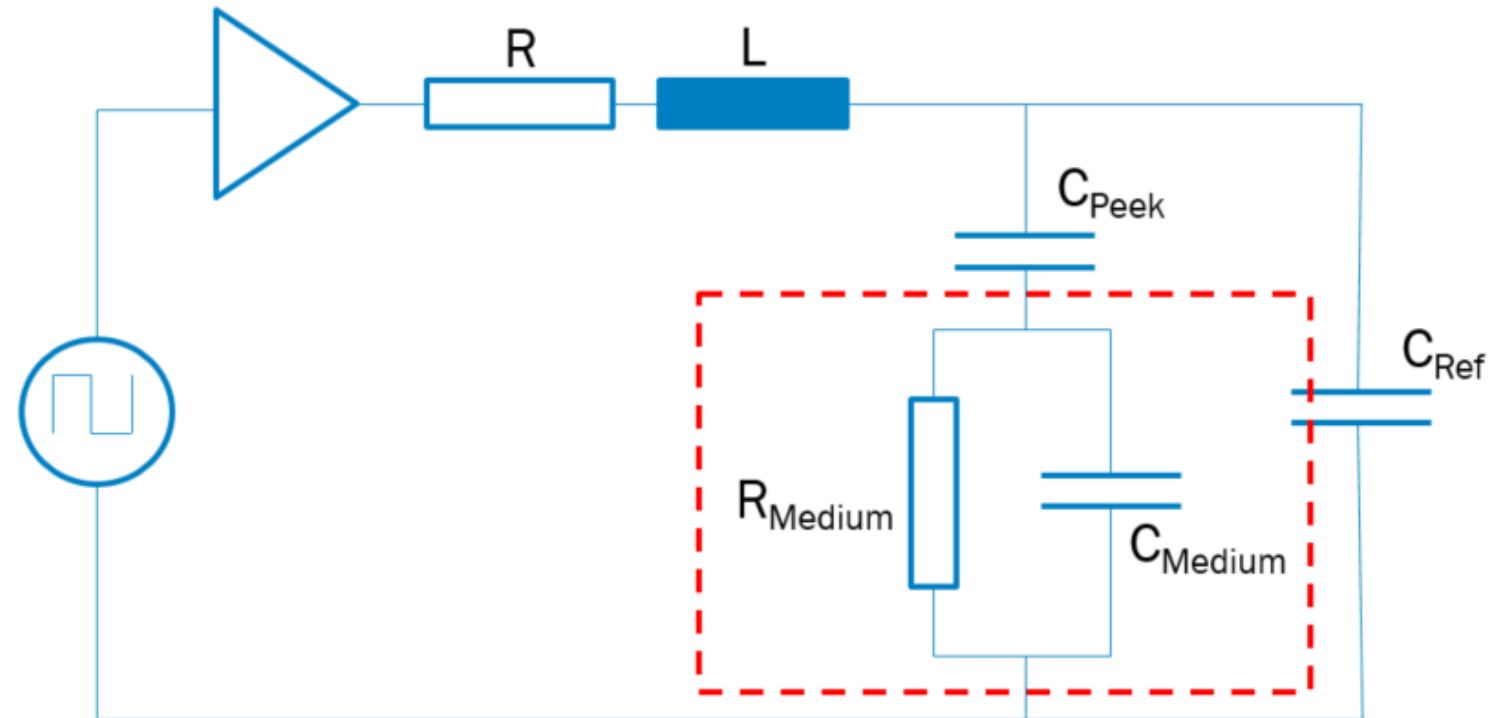


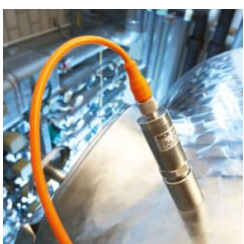
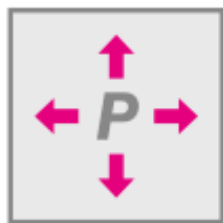
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# Point level measurement:

Capacitive impedance spectroscopy



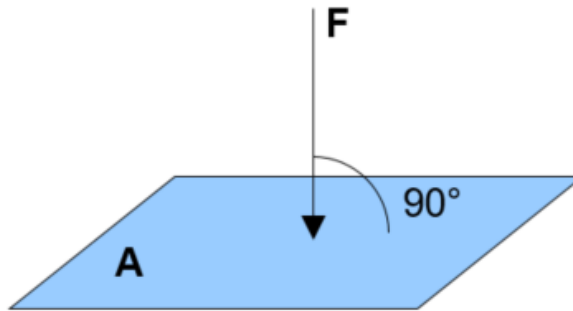
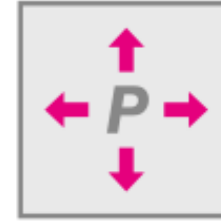


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# Pressure



$$p = \frac{F}{A}$$

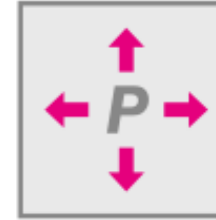
$$[p] = \frac{N}{m^2} = \text{Pa (Pascal)}$$



French scholar Blaise Pascal  
(June 19, 1623 to Aug. 19, 1662)

# Pressure

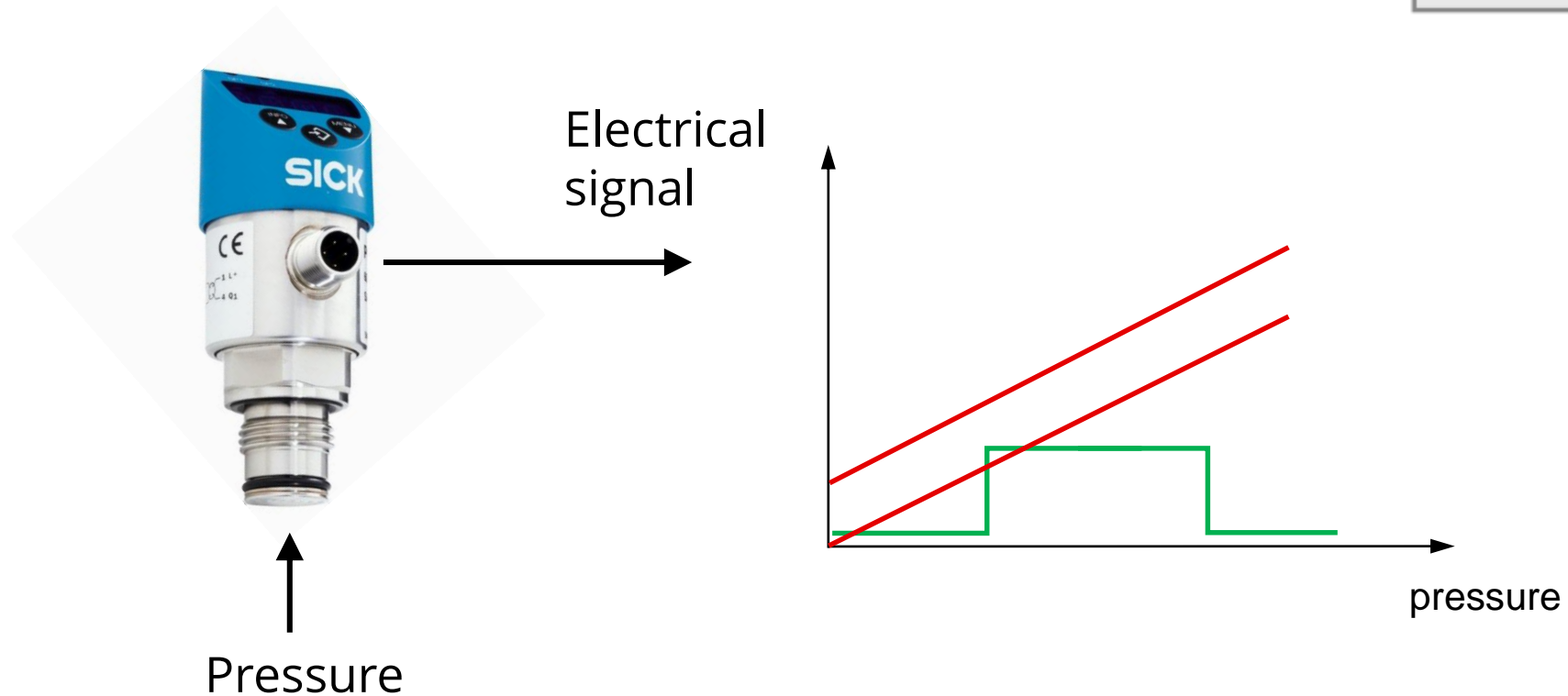
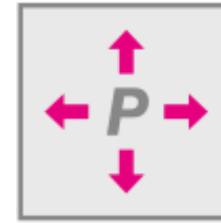
## Unit



- 1 bar = **100 000 Pa**
- 1 psi = 1 lbf / in<sup>2</sup> = **6.895 Pa**
- 1 MPa = **1 000 000 Pa** = 10 bar
- 1 kg(f)/cm<sup>2</sup> = **98067 Pa** = 0,981 bar

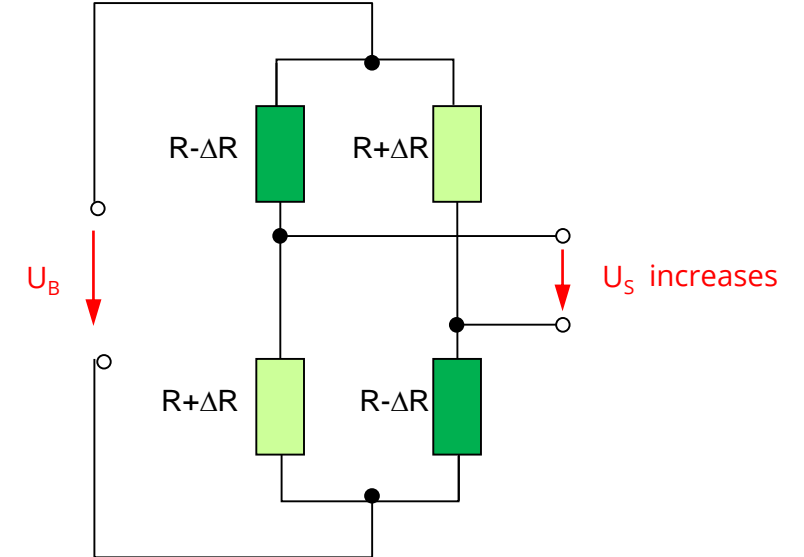
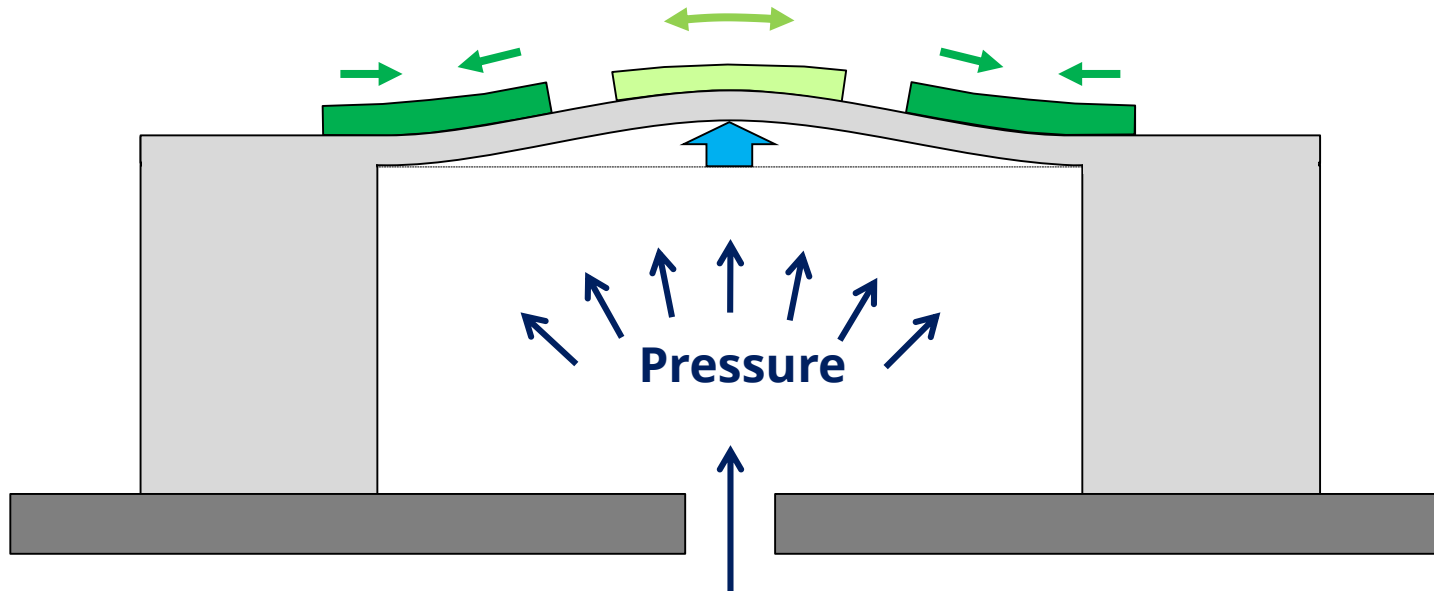
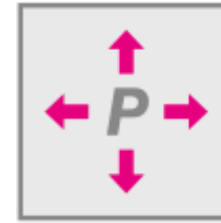


# Pressure



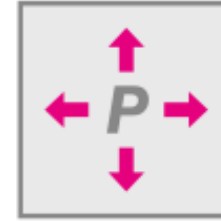
- Pressure transmitter → analog output signal
- Pressure switch → digital output signal

# Pressure



# Pressure

Processconnection

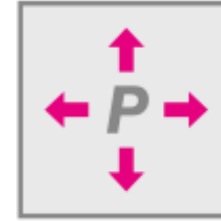


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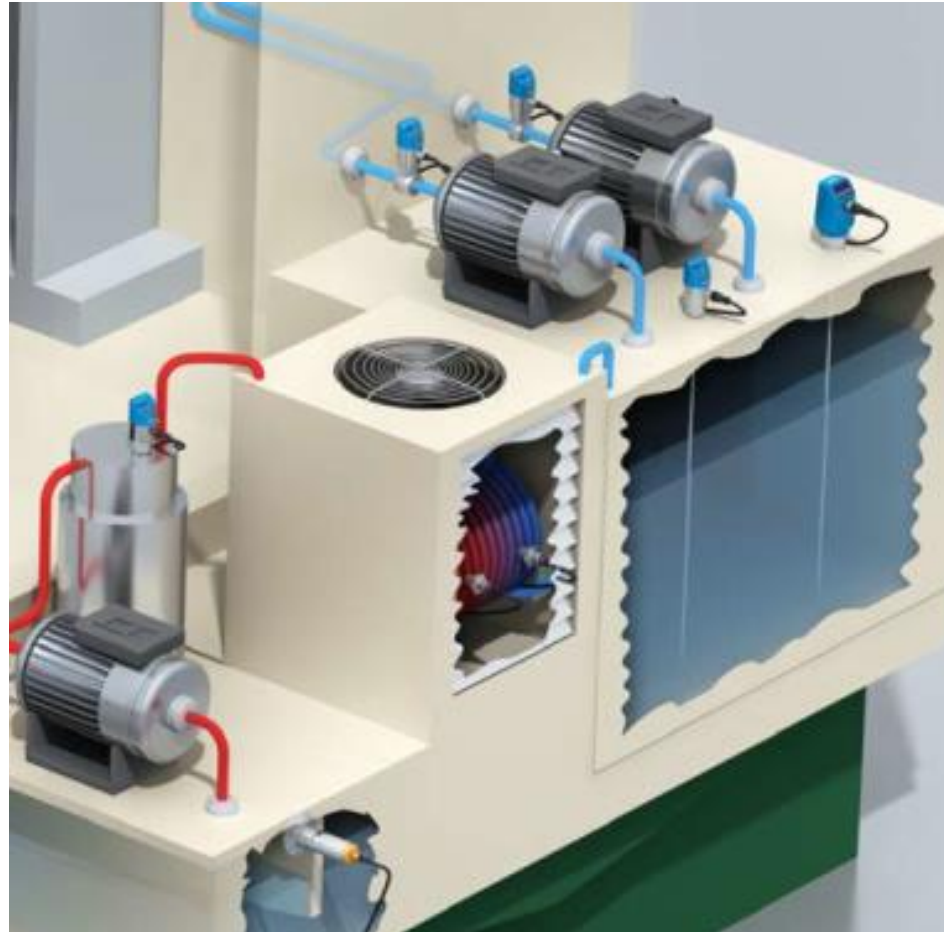


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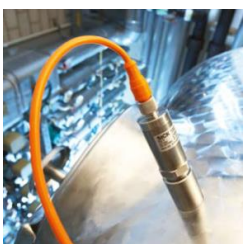
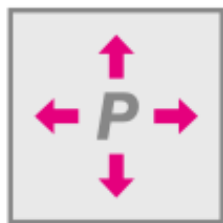
Application control of workpiece clamping



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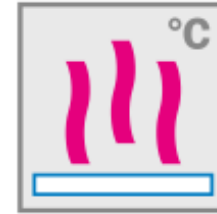




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# Temperature



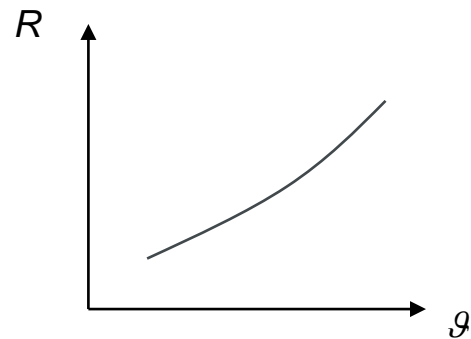
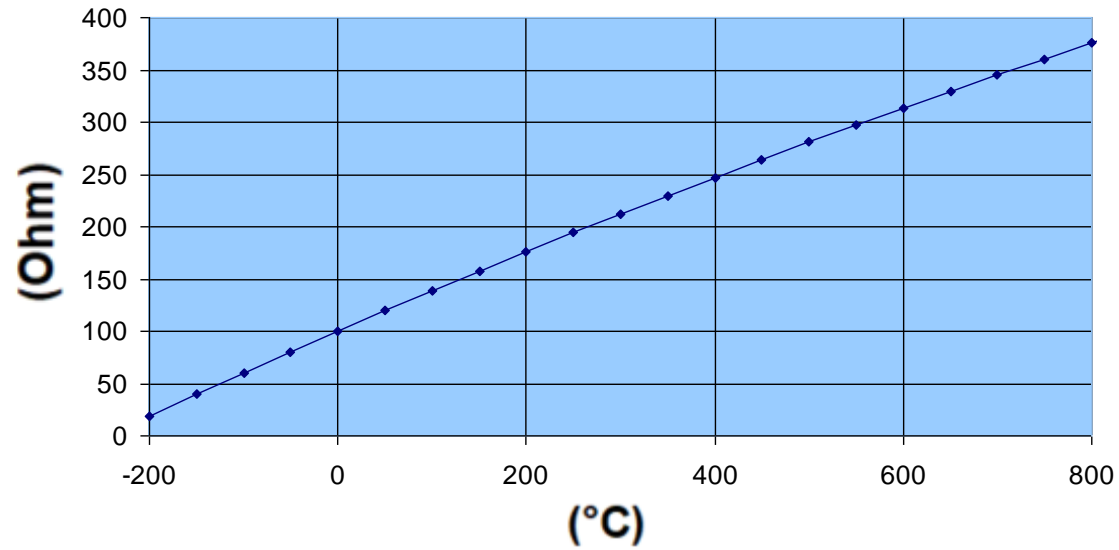
Anders Celsius

# Temperature

Platinum resistance

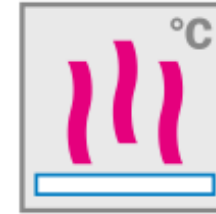


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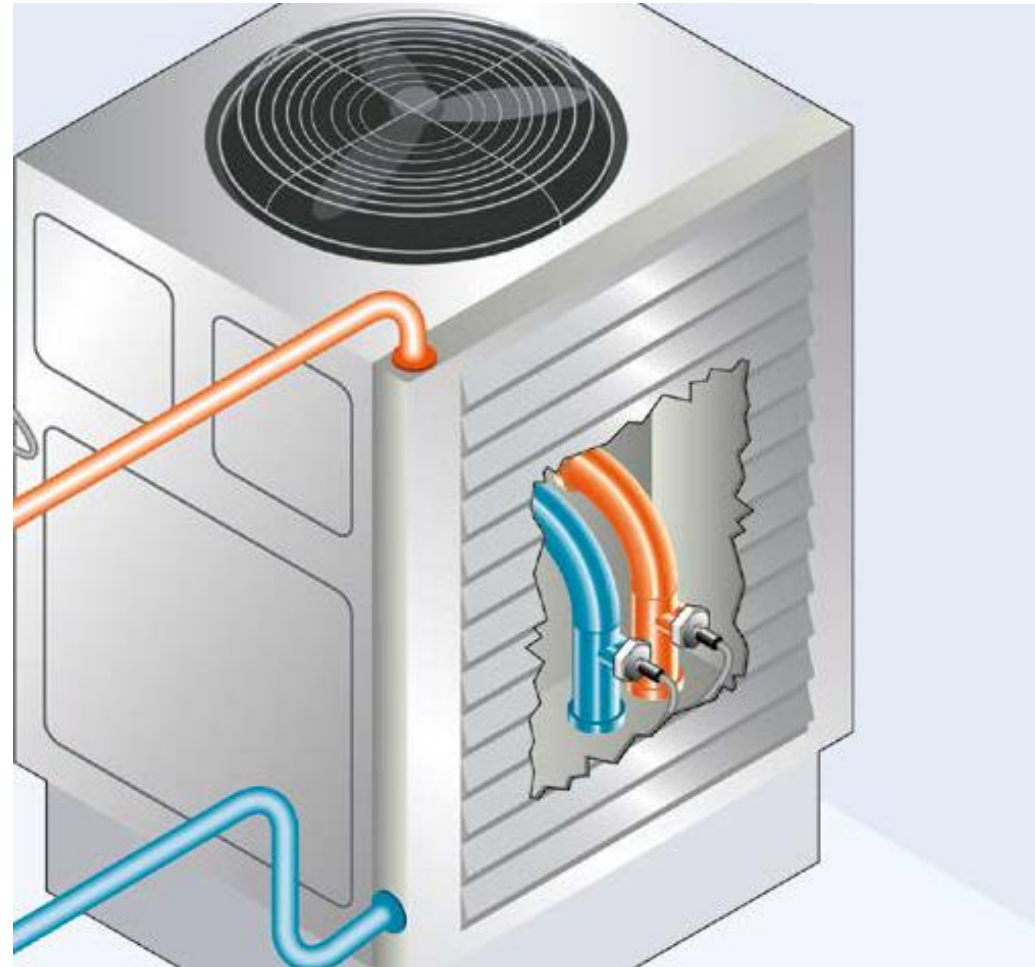


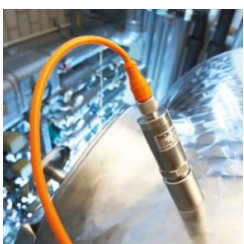
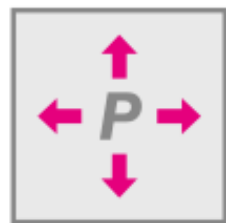
# Temperature

Application coolant temperature control



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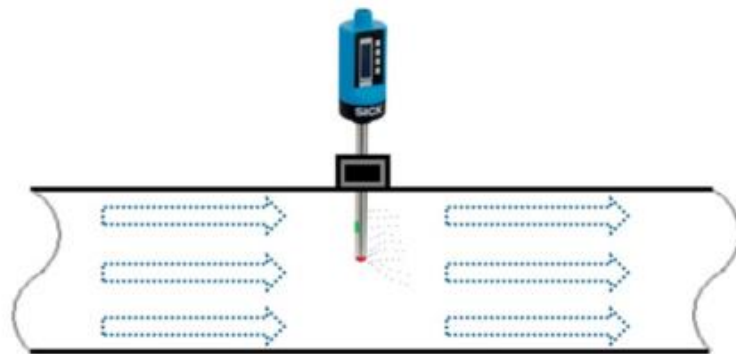
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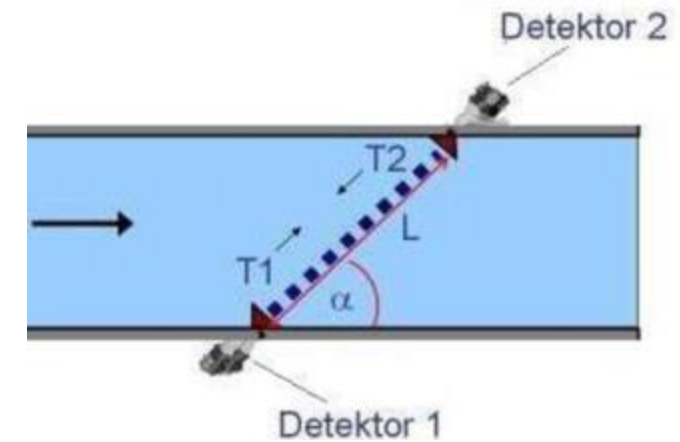
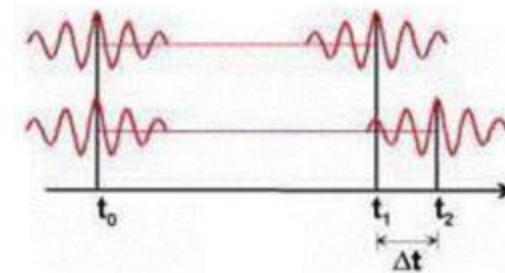
# Flow



$$\Delta T = T_H - T_M = \text{Constant}$$



## Physics



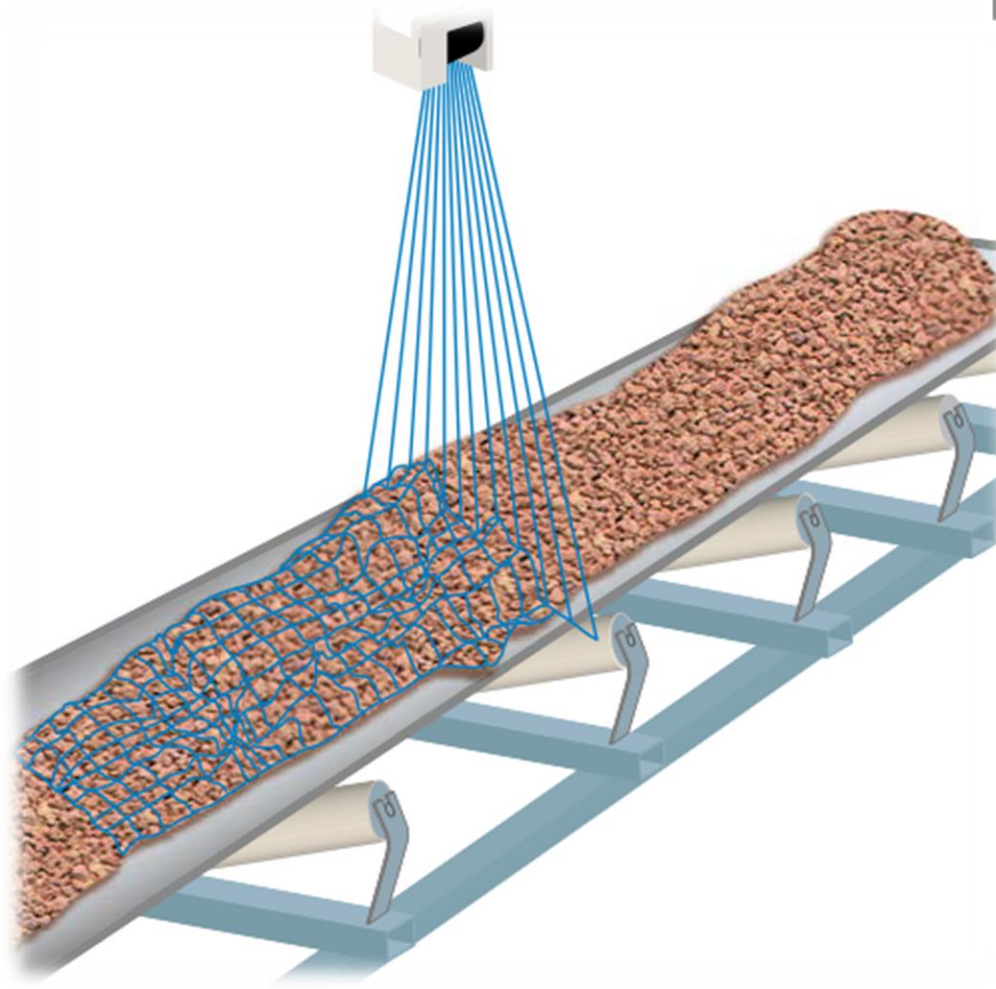


# Flow

Application volume information



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# Flow

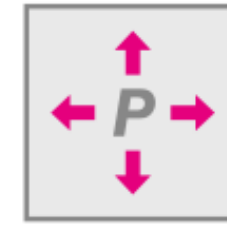
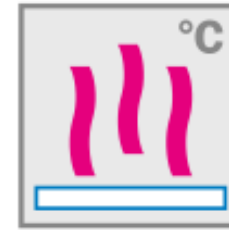
## Application volume information



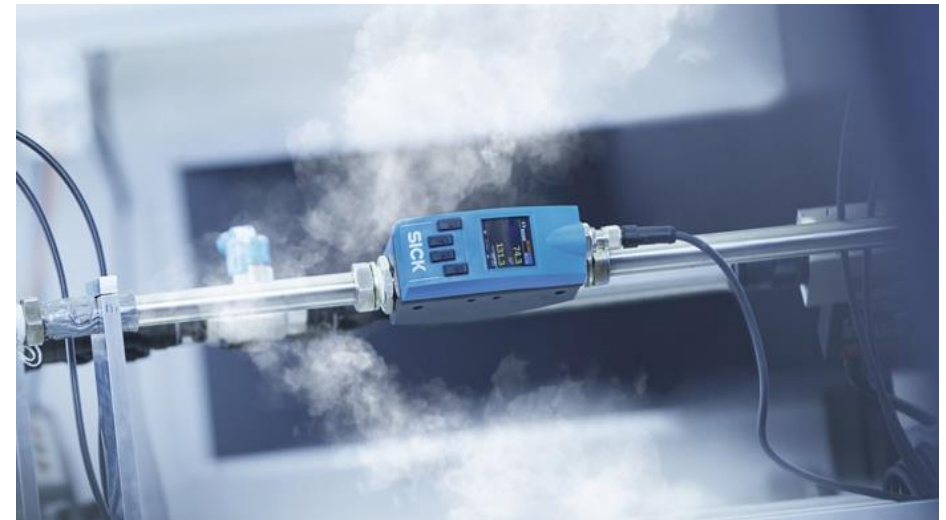


# Good energy management

New Innovation

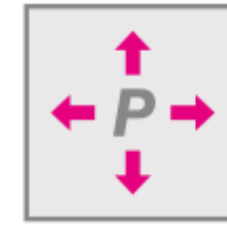
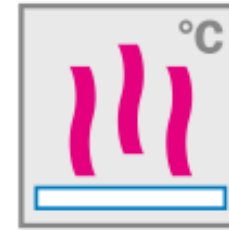


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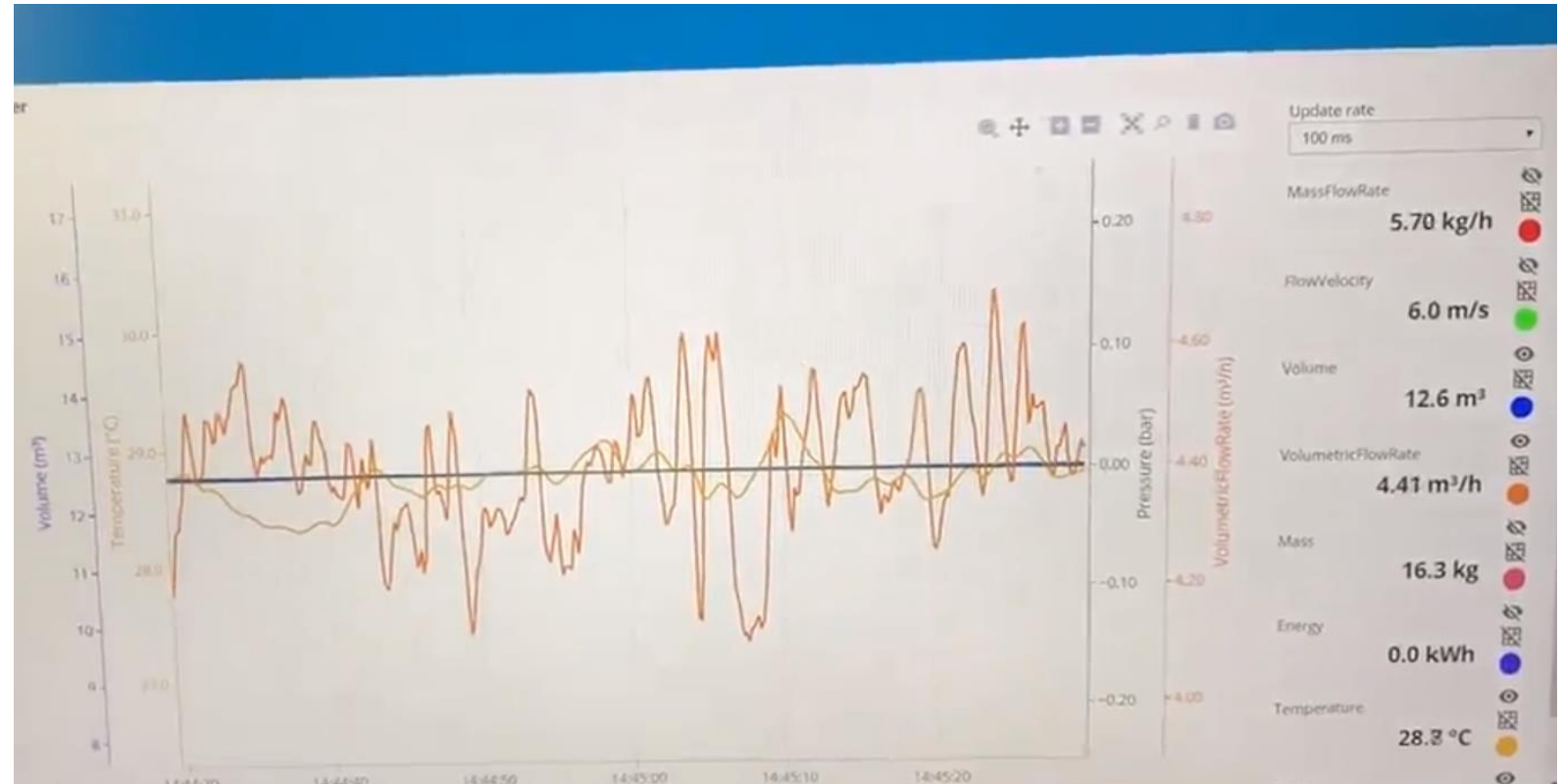


# Good energy management

New Innovation → FTMg

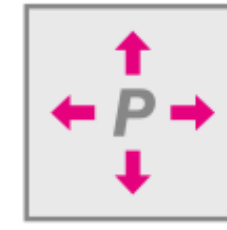
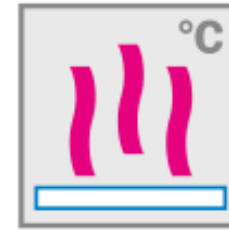


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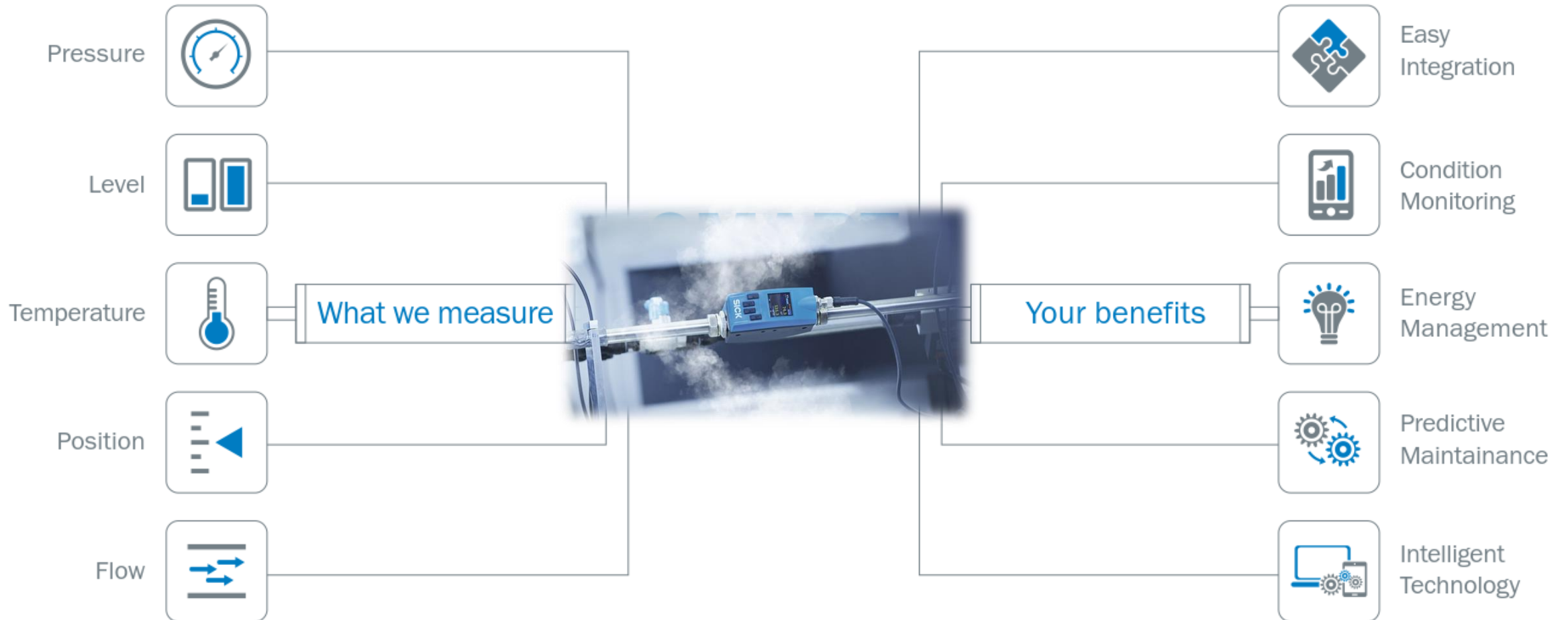


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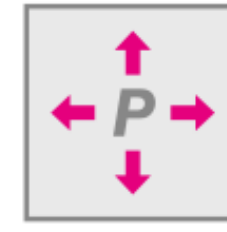


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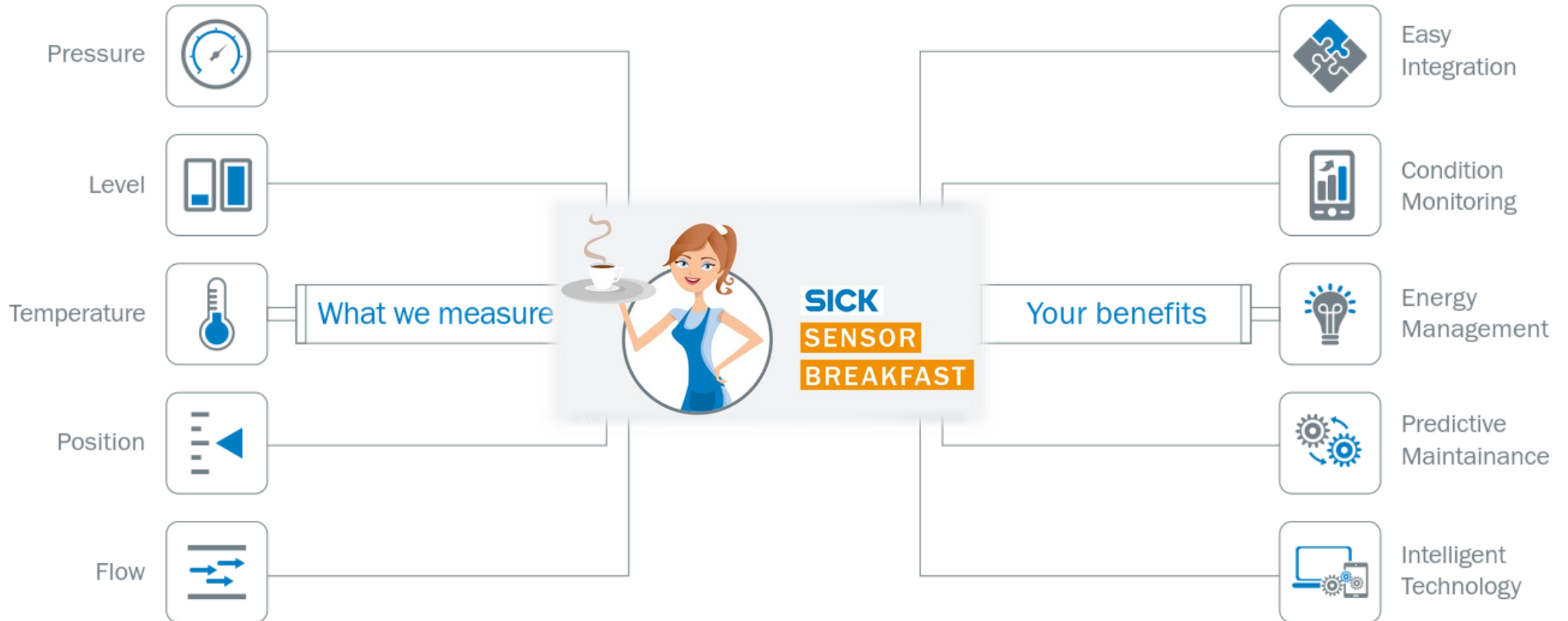


# Good energy management

Sensor breakfast




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# Online configurator

<https://www.sick.com/>




### Fluid sensors

Optimized control of process parameters is the main driver for increasing efficiency and reducing input of valuable resources. Whether it's pressure measurement, temperature measurement, level control or flow metering – SICK offers a wide range of solutions for measuring process variables for liquids, gases and bulk solids and protecting against overflow and dry run. SICK devices are rugged and easy to use. Innovative sensor technology enables accurate, universal measurement independent of material type.



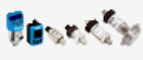
### Level sensors

Whether for continuous level measurement, point level measurement or both – SICK offers a wide range of solutions for process engineering, storage, and protection. Based on the installation ...




### Pressure sensors

SICK offers a portfolio of electronic pressure measurement transmitters and switches that can be adapted to individual customer requirements because of intelligent and varied configuration ...




### Flow sensors

SICK provides innovative sensor solutions for flow measurement technology which combine flexible measuring methods and rugged equipment design with cost-efficient connection concepts to ...




### Temperature sensors

With its product portfolio of screw-in and insertion thermometers as well as temperature switches SICK offers high-quality solutions for contact temperature measurement in liquids and gases. The



### Level and point level measurement using efficient technology

The innovative offer comprises, for example, guided wave radar sensors (TDR), ultrasonic equipment, capacitive sensors, vibrating equipment and various optical technologies. With SICK, the focus is on the optimum solution for your application. To achieve this, we can refer to our broad sensor portfolio.

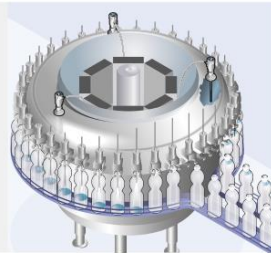


**Level measurement with LFP Inox**

LFP Inox detects the level of storage containers in order to guarantee the supply to the filling machine. Besides the aseptic design, the most important feature of this application is fast, precise measurement.


**Benefits:**

- Fast response time
- High reproducibility
- Hygienic design
- High enclosure rating IP69
- Simple installation



### Pressure measurement for liquids and gases

In many branches of machine and plant engineering, the production industry, machine tool construction, process technology, and the manufacture and refinement of foodstuffs and beverages, measurement of variable state pressure plays a central role.




**Monitoring of the workpiece clamping by PBS plus with IO-Link**

In CNC machines, the workpieces are often clamped hydraulically. Electronic pressure switches like the PBS make sure that the clamping pressure is correct.


**Benefits:**

- Pressure switch, pressure transmitter and display in one device
- Quick product changes through switching point setting via IO-Link
- Ergonomic: clearly legible display, large push-buttons and rotating housing
- Rugged and reliable
- Wide range of installation variants



### Universal temperature measurement

Whether it is the monitoring of operating conditions in machine and plant engineering or the control and regulation of sensitive processes, the reliable and accurate determination of temperature is of fundamental importance in many industries.

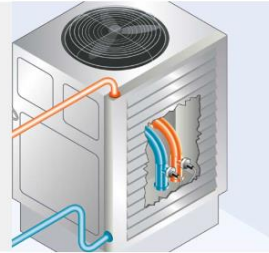


**Cooling lubricant temperature control with TSP**

Temperature sensors are used in many areas. One example is the machine tool industry. Reliability and long-term stability of the thermometers are indispensable for reliable plant operation. The temperature of the cooling lubricant is regulated in order to guarantee high quality machining of the workpiece.


**Benefits:**

- Reliable
- Small dimensions
- Simple installation
- Inexpensive



### Flow and throughput measurement with modern technologies

SICK flow rate sensor systems rely on innovative run-time measurement processes based on ultrasonic and laser technology. These non-contact technologies are particularly notable for their flexible fields of application and their great variety.

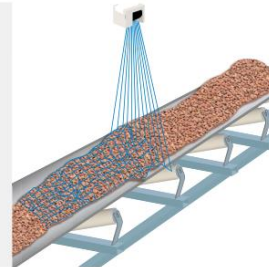


**Bulkscan®**

The non-contact measuring Bulkscan® device detects the profile of the bulk material on the conveyor belt. The flow rate is calculated using the belt speed and the bulk material profile. This makes it possible to create a feedback control system that provides optimal belt speed and ensures economic belt utilization.

**Benefits:**

- Low maintenance throughput measurement
- Flexible use
- Optimum belt usage
- Belt monitoring to reduce belt wear (Bulkscan® LMS511)





# Thank you for your attention!

**Bernhard Wieser**

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[www.sick.at](http://www.sick.at)

