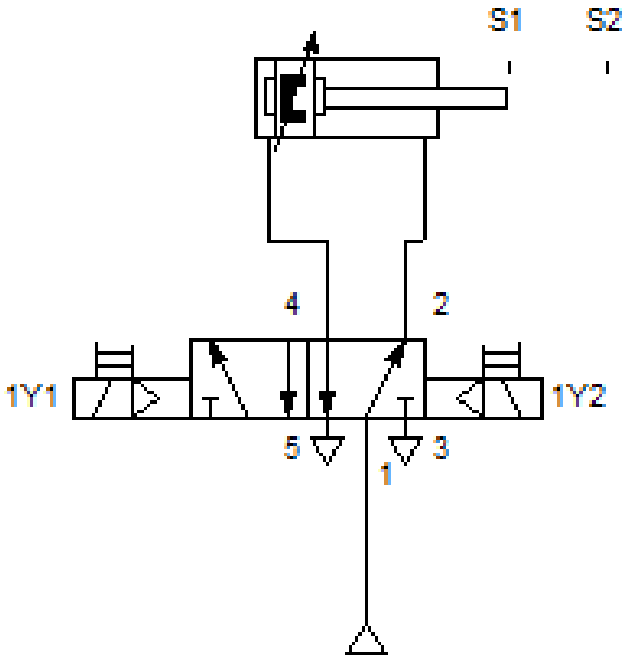
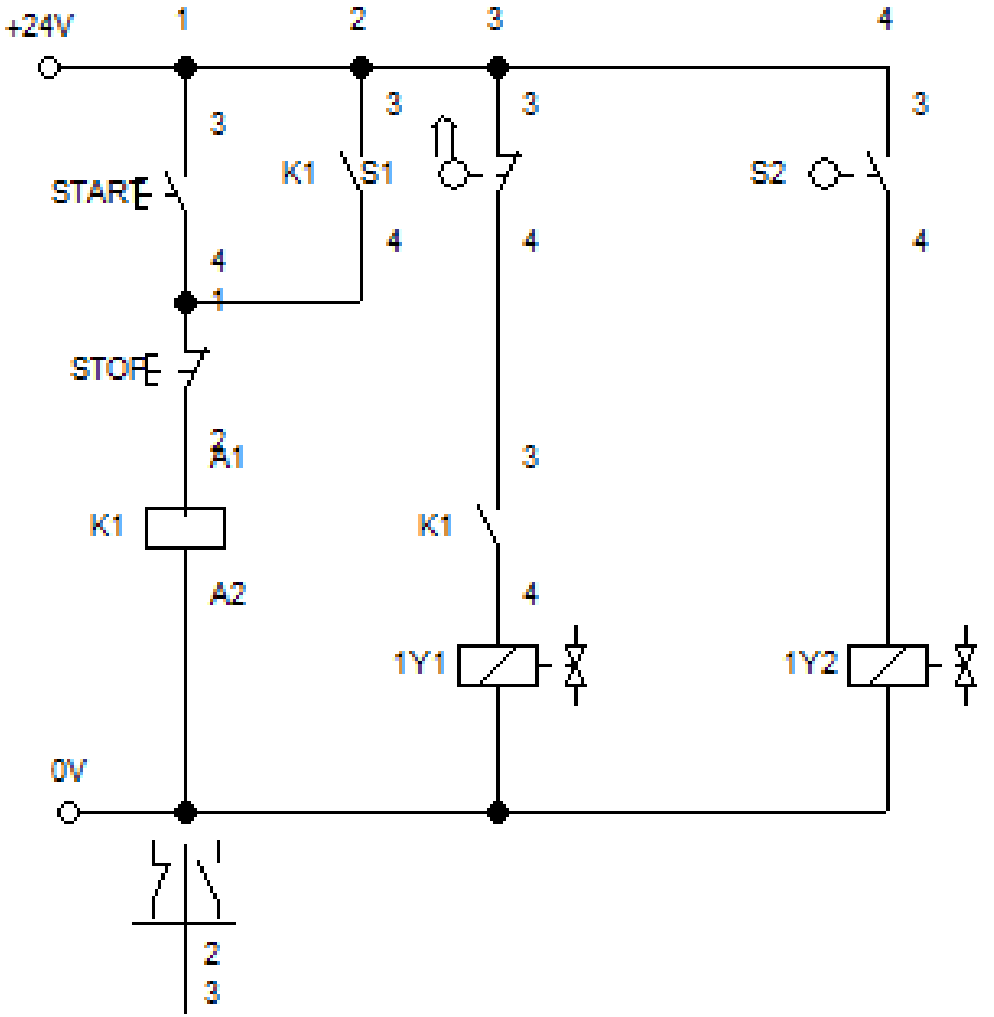
Topic 3

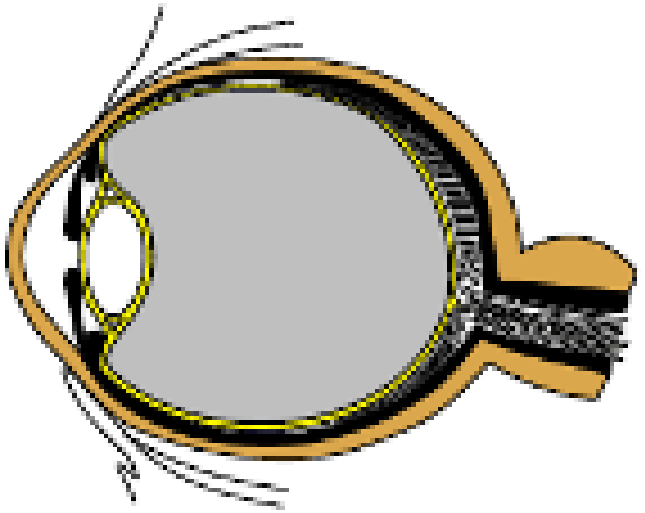
Introduction to sensor in mechatronics

Author：Gao Haihua

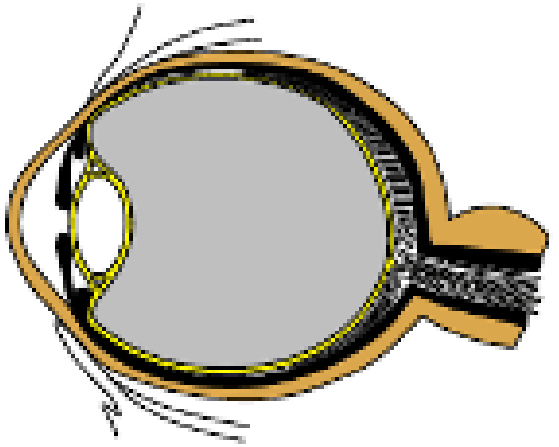
Task Checking







Technically, a sensor is a converter that converts physical signals, such as temperature, distance, or pressure into other signals, which makes it easier to make evaluations. This signal is usually an electronic signal, such as electricity Voltage, current, impedance, or oscillation frequency.



Sensors are used in the field of automation because they:

- In automation systems, errors such as tool damage can be signaled in advance.
- Locate the source of errors.
- Detection of wear tools.
- Provides measured values that can be continuously improved by control and regulation.
- For automated quality control.
- Monitor material management and assist in the automation of material flows.
- Product identification, which is the essence of automation.
- Signals of danger in the workpiece, e.g. increased contamination.
- Provide a more user-friendly working environment, such as monotonous and fatigued visual monitoring work, in hazardous environments monitoring and measurement work.

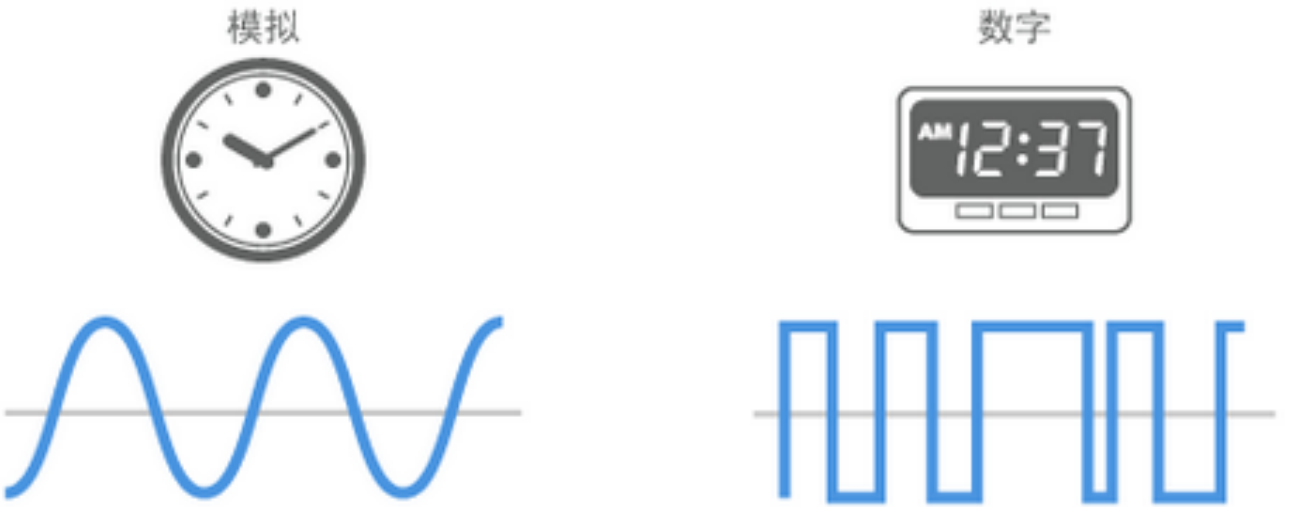
Sensor classification

Geometric values	Position, distance, length, stroke, tension, slope, speed, acceleration, rotation Rotation angle, rotation of the workpiece
Force-dependent properties	Force, weight, pressure, torque and mechanical efficiency
Material Quantity	Flow and filling degree of gaseous, liquid and solid materials
Heat and temperature	
The amount of photoelectric radiation evaluated	Radiant current, radiant energy, radiant intensity, emissivity, and brightness, such as luminous energy Quantity, luminous intensity, luminous rate. However, this category includes image processing for all systems
Sonic characteristics	Sound pressure, sound energy, sound level, and sound frequency
Electromagnetic quantities	General electronic identification components are based on voltage, current and electrical energy. These elements are also packaged Including in the field of electronic and electromagnetic quantities. The latter is limited by wavelengths greater than -3 m10
High-energy radiation	X-ray radiation, gamma radiation. High energy radiation due to wavelengths less than 10-10 m and be restricted. Particle radiation sensors such as electrons, alpha particles, elementary particles, and nuclear fragments
Chemical substances	Gas, ion, water, dew and freezing point sensors
Physical Material Attributes	Mechanical, electronic, photoelectric, thermal and acoustic properties
Object and form recognition	This category generally includes sensor systems, such as optoelectronic characteristic readers, obstacle code readers, electromagnetic strip readers, and image processing systems, which also includes a previous category, but as a separate group due to their application areas

Sensor signals

Typically, a sensor converts a physical value into an electronic signal. The sensor can be based on the class of the output signal .

Types are divided into binary signals, also known as switching signals, and analog sensors.



Binary sensors

Binary sensors generate only two different output signals, such as the switching state "on" and "off". different values of physical variables can cause the sensor to transition from one switching state to another; This switch value usually set. In many cases, the switching points of the characteristic curves are different. At two switching points or the difference between the critical values is the hysteresis. In many applications, hysteresis is advantageous because of closed-loop control

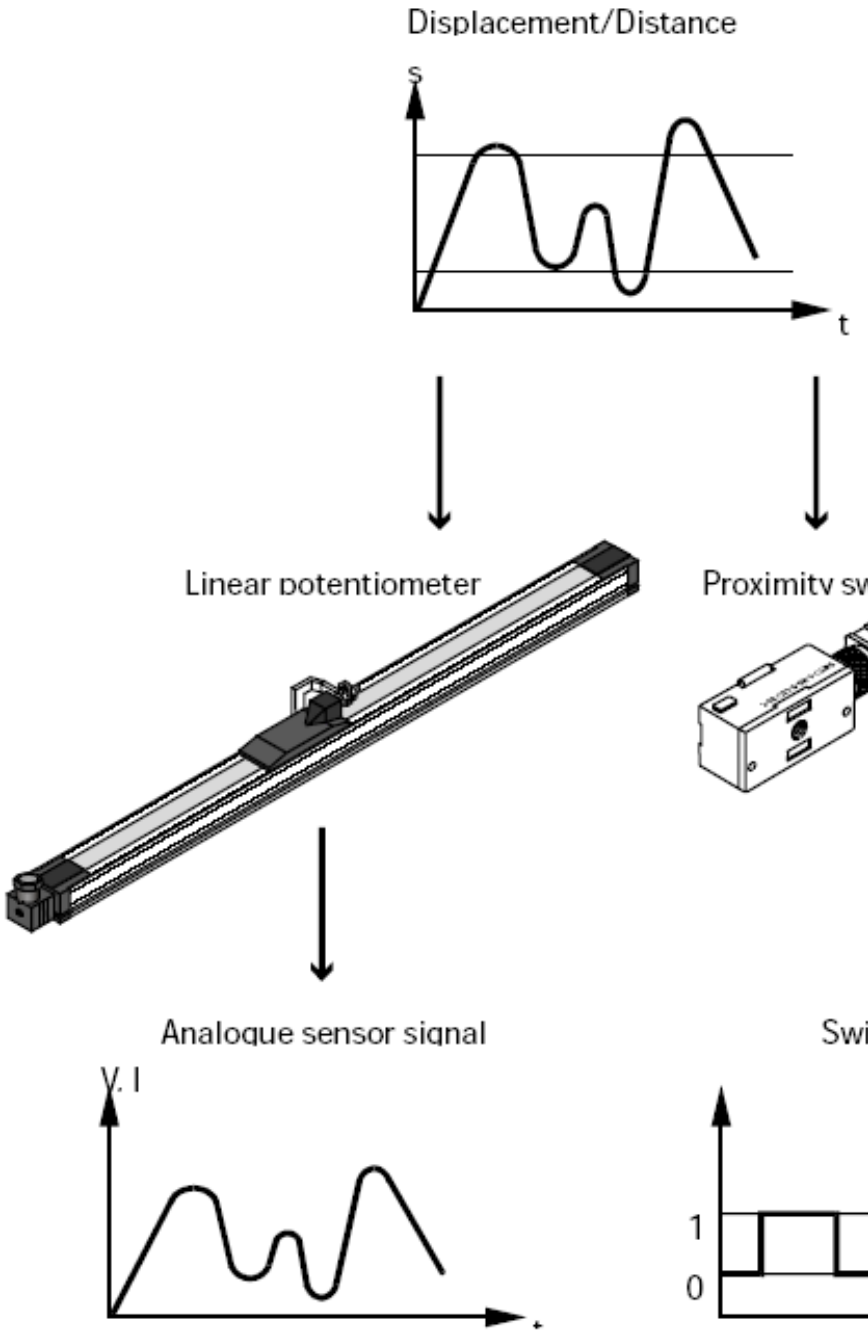
It reduces the switching frequency and improves system stability.

Analog sensors

Analog sensors generate an electronic signal that constantly changes according to changes in physical values.

This one Correlation is not linear, whereas binary sensors always show actual changes in physical values.

Analog sensing device provides more information than the binary sensor; But signal processing is a bit more expensive.

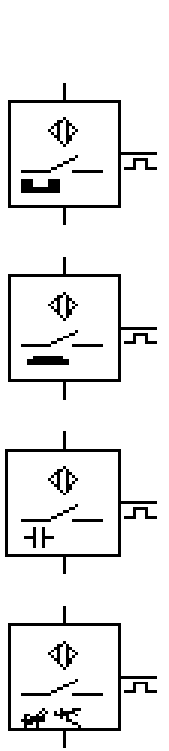

Displacement/Distance
s
t
Linear potentiometer
Proximity switch
Analogue sensor signal
Switching signal
V, I
1
0

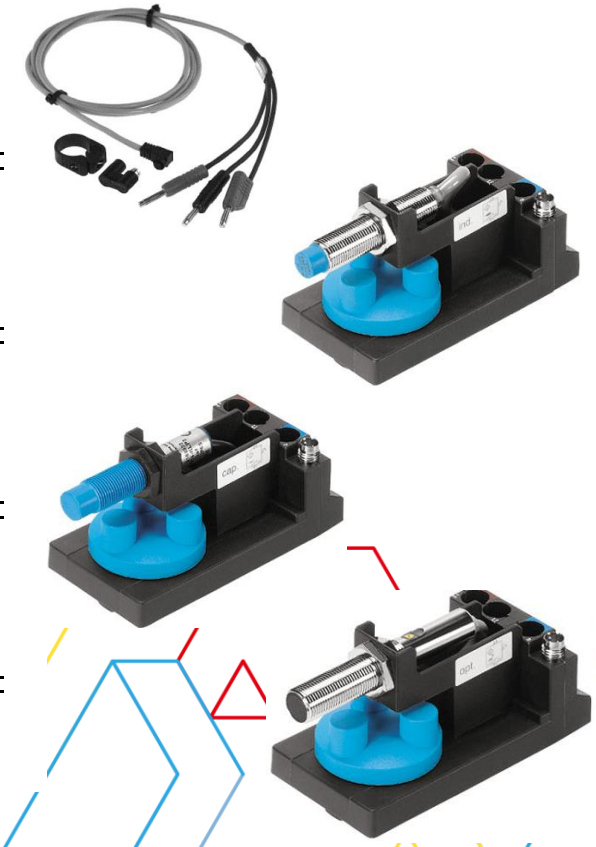
Normal sensors

reed switches

Non-contact type

- •Magnetic induction proximity switch： Used for detecting magnetic fields
- •inductive sensor： used for detecting metal
- •Capacitive sensor： Used to detect any object
- •Optical sensor： Used to detect any object





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Process industry

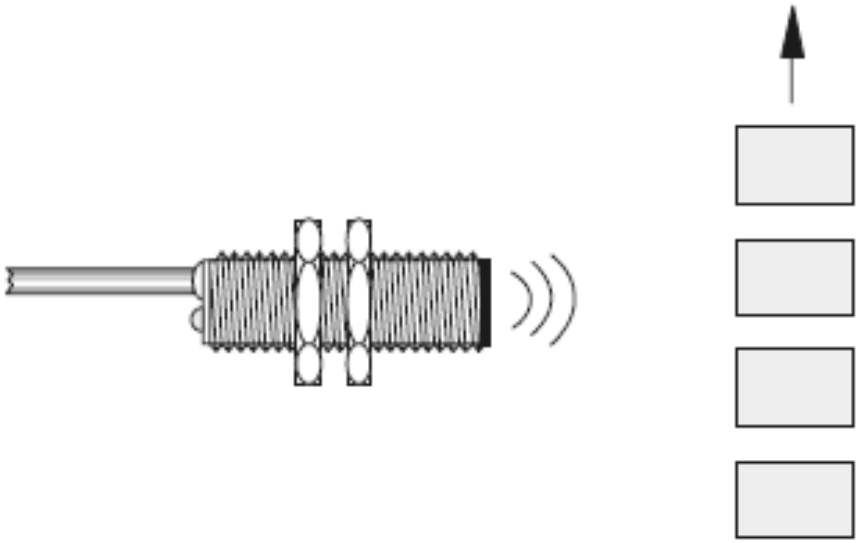
Hybrid industry

Discrete industry

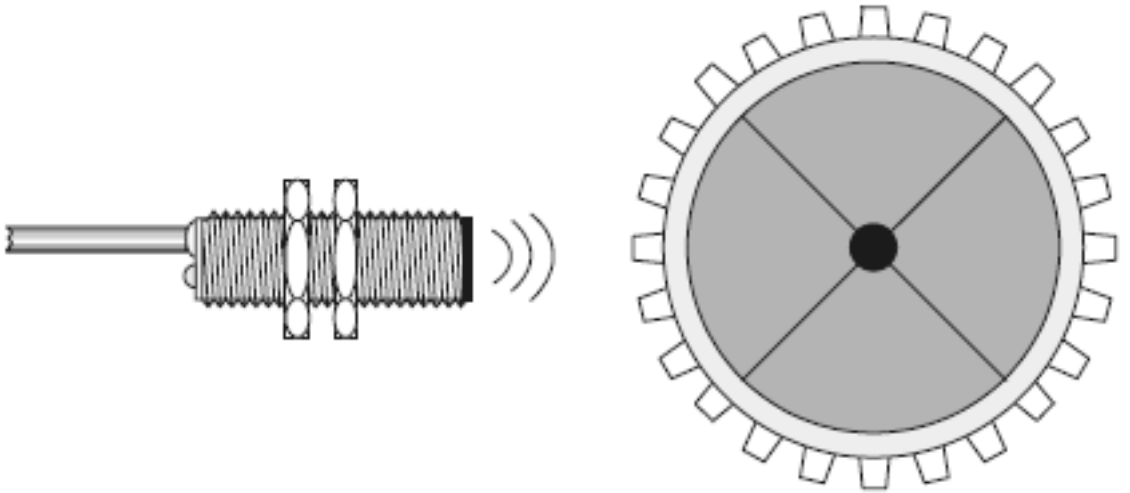
Discrete industries / Factory automation

Application capabilities of the sensor

Product count

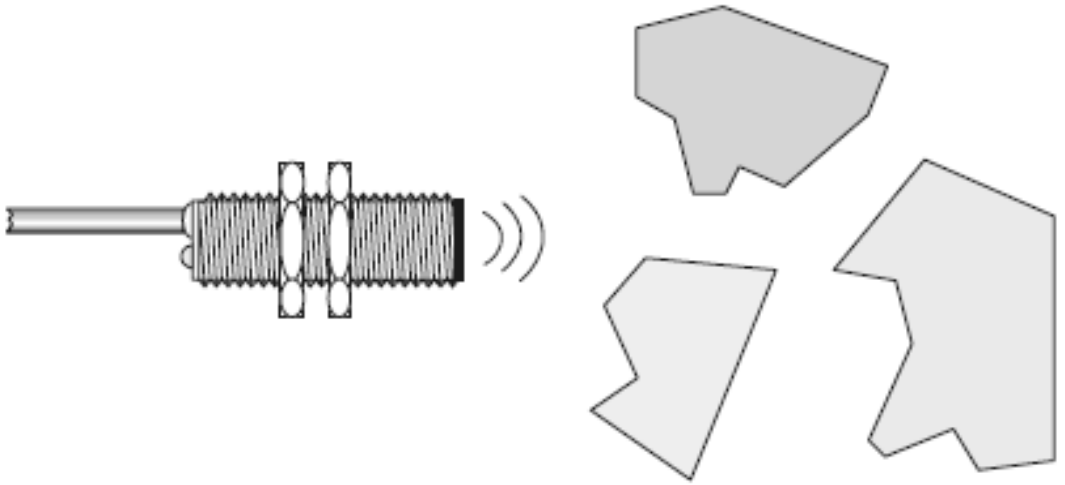


Measure the rotational speed

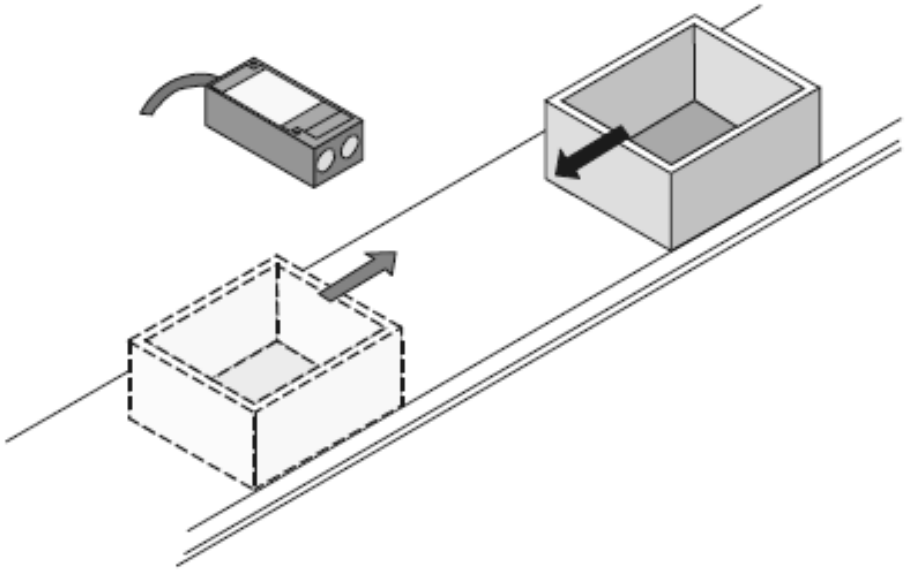


Application capabilities of the sensor

Detect materials

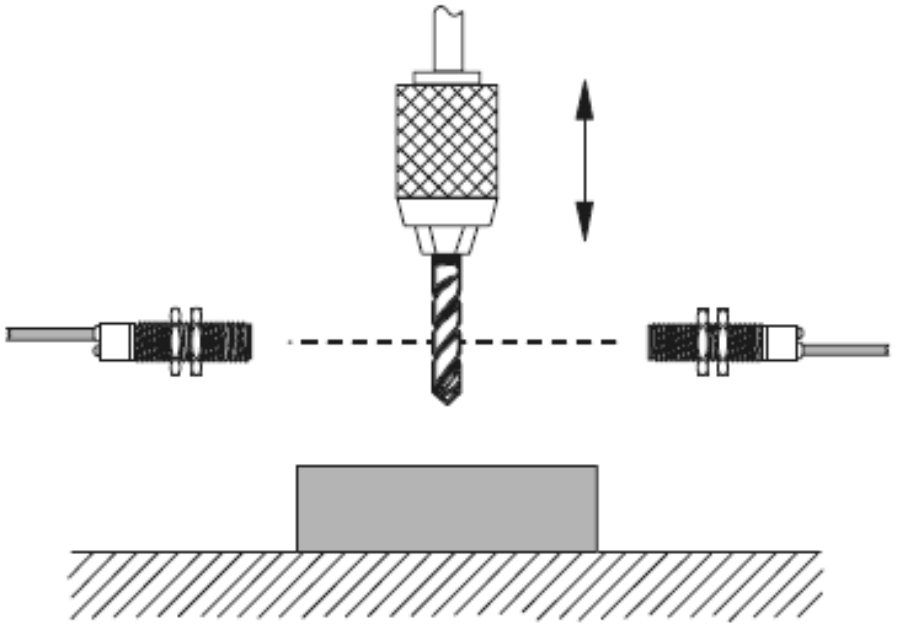


Define the direction

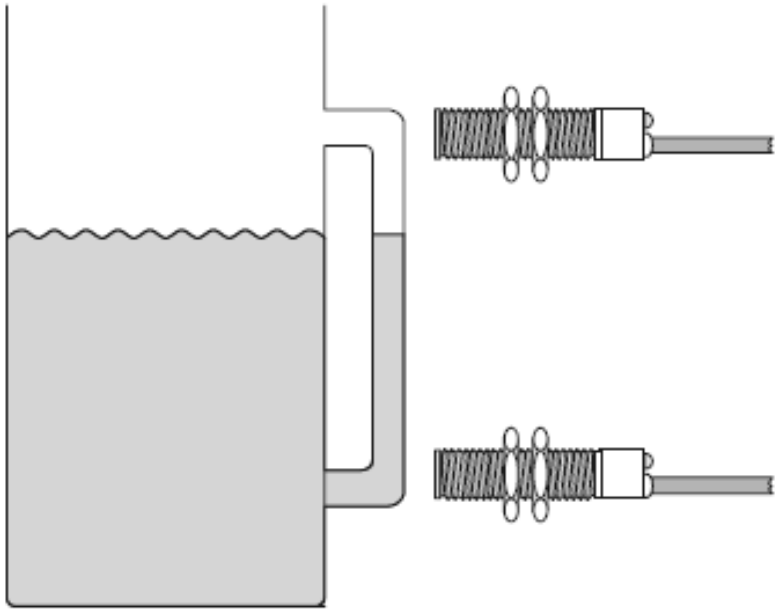


Application capabilities of the sensor

Tool monitoring

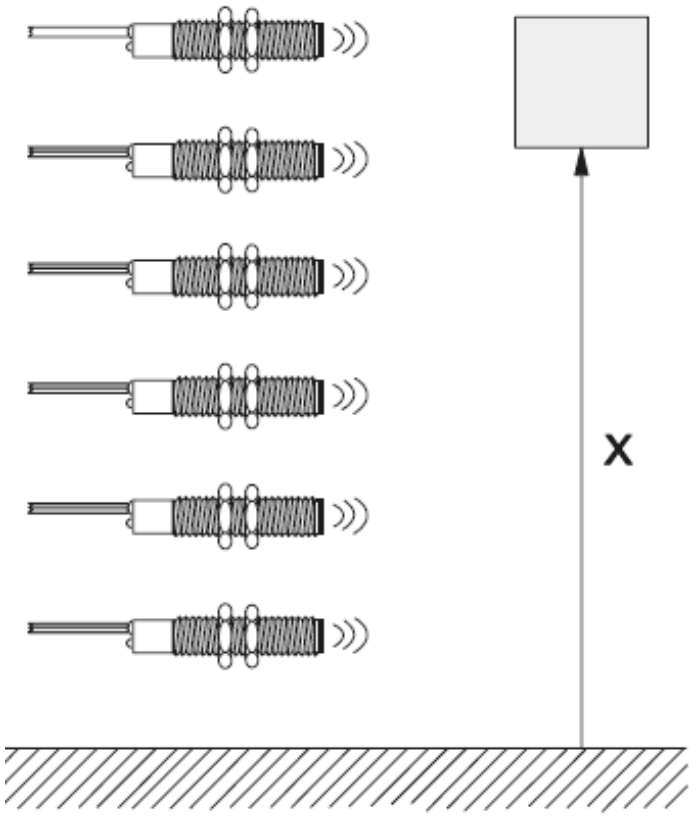


Monitor liquid levels

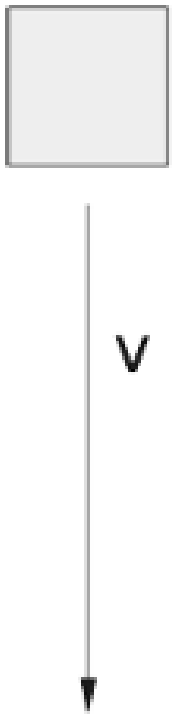


Application capabilities of the sensor

Distance monitoring

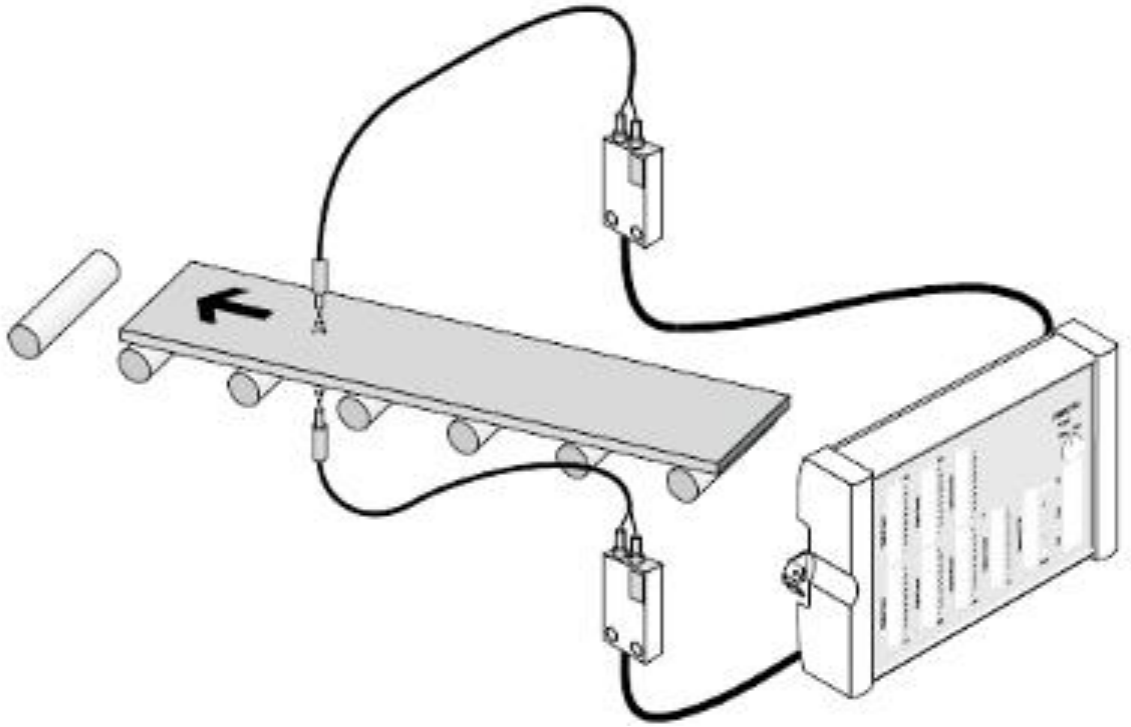


Speed measurement

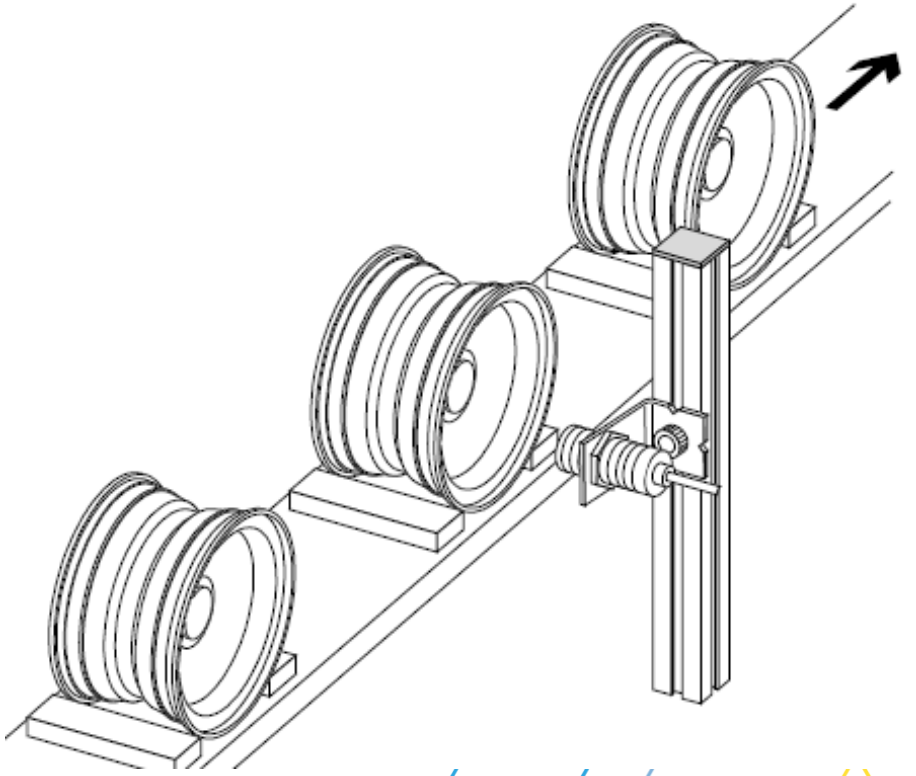


Application capabilities of the sensor

Detection of workpiece thickness

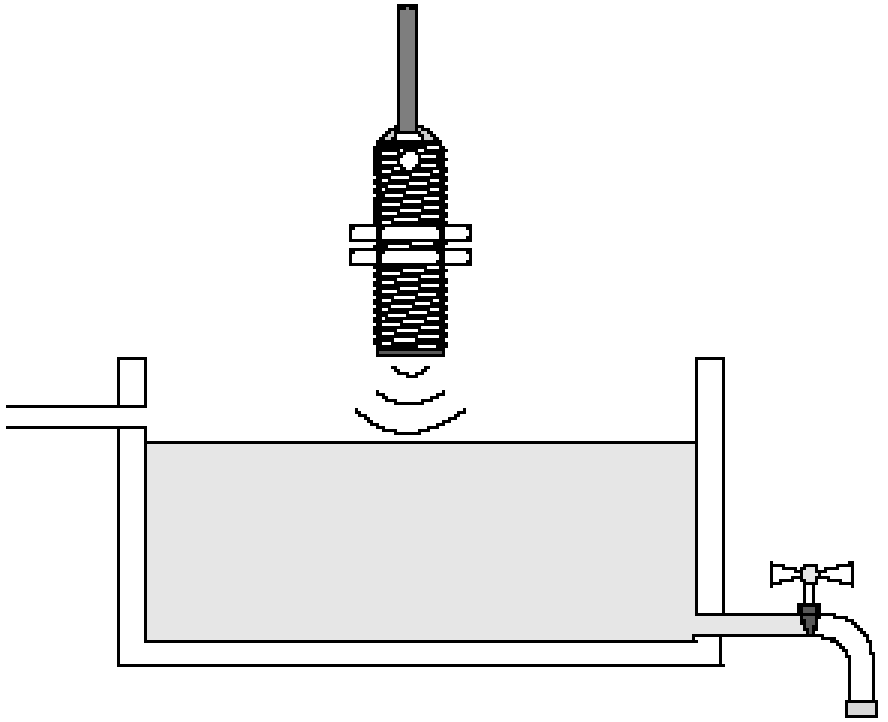


Automotive wheel inspection

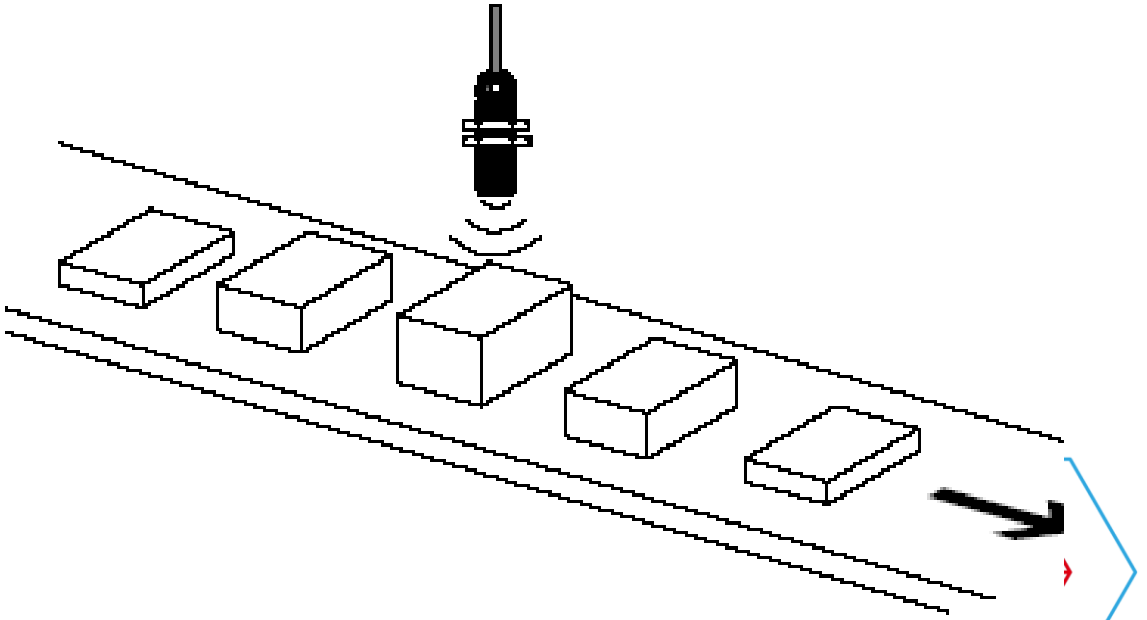


Application capabilities of the sensor

Detect liquid level

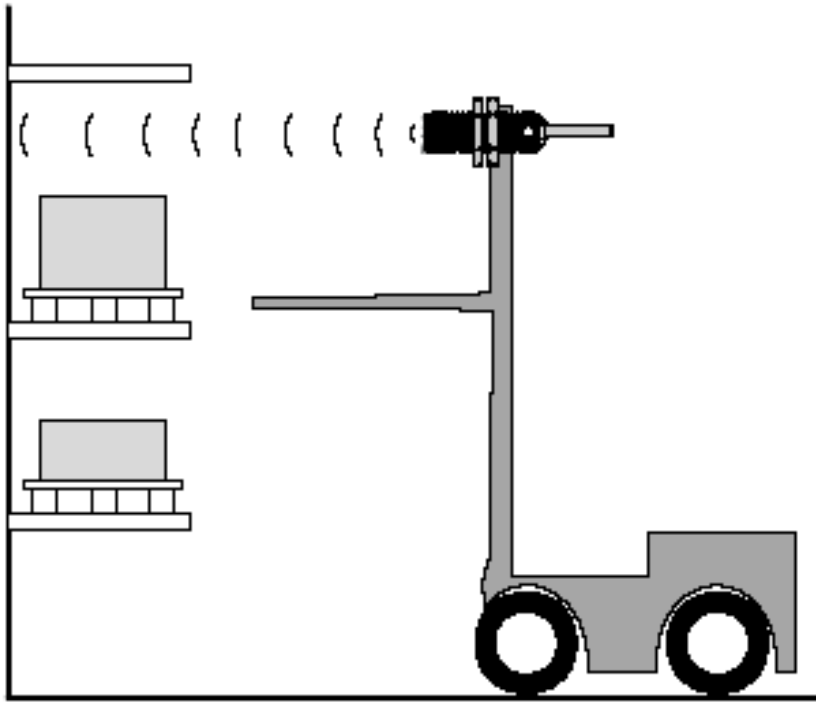


Classify according to height

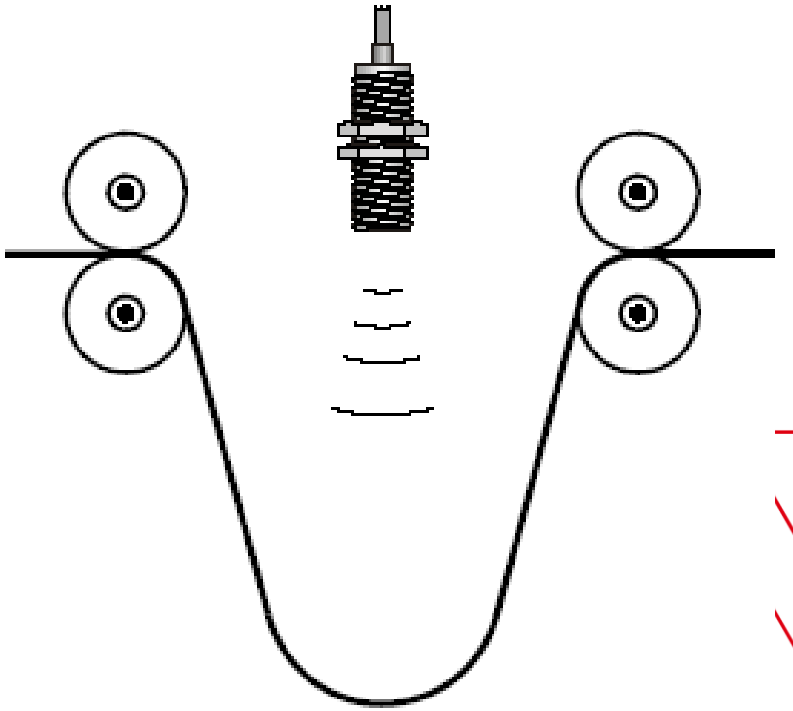


Application capabilities of the sensor

Control the lifting device

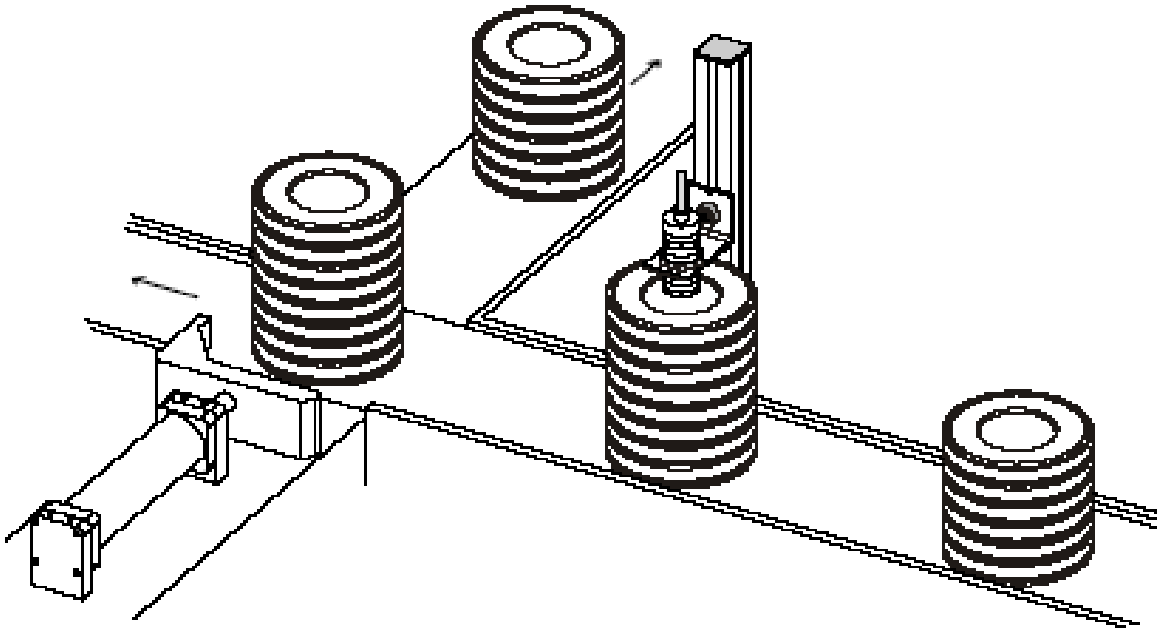


Detects tension

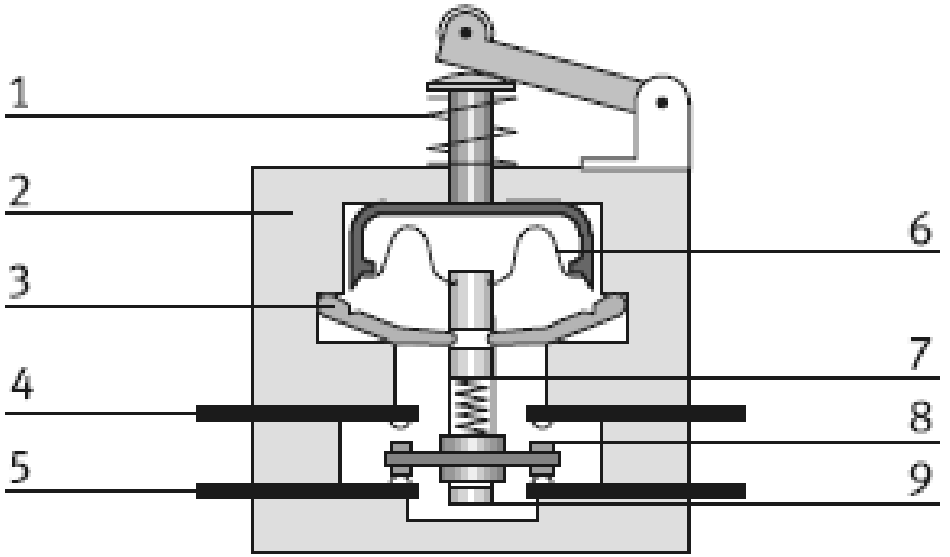


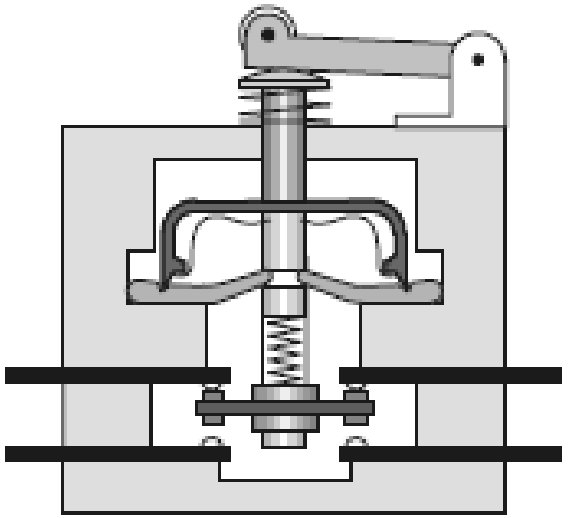
Application capabilities of the sensor

Classification according to the height of the stack



Electro-mechanical switches





Compression spring (1)

Housing (2)

Detent lever (3)

Normally open contacts (4)

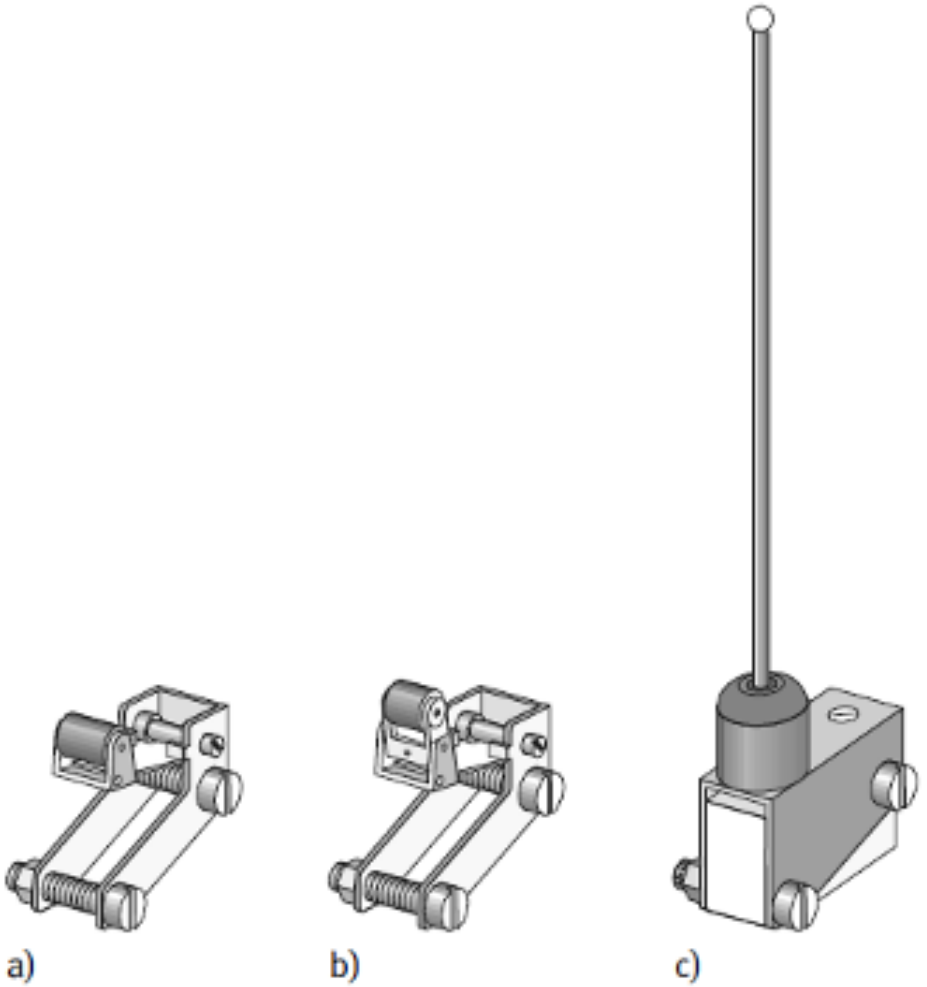
Normally closed contacts (5)

Arched spring (6)

Contact pressure spring (7)

Contact blade (8)

Guide bolt (9)



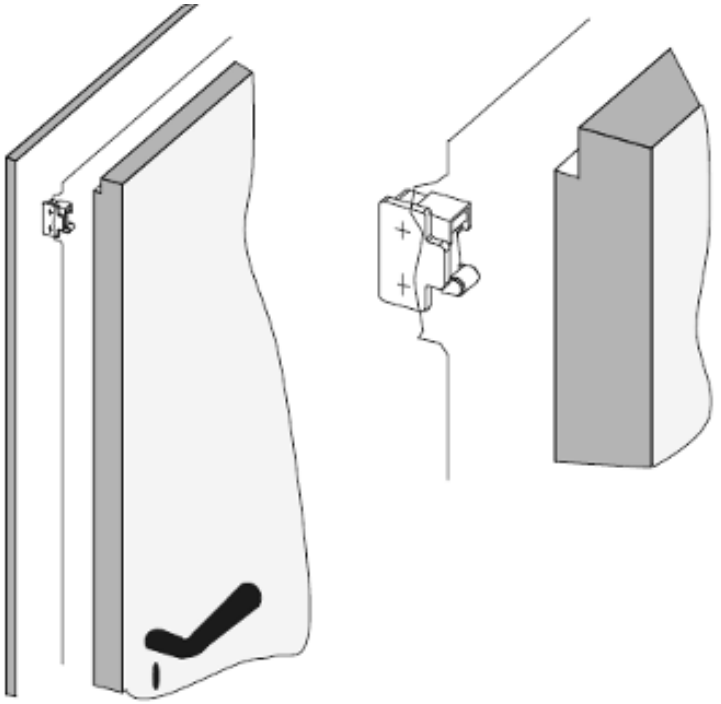
a) Roller lever

b) Roller lever with idle return

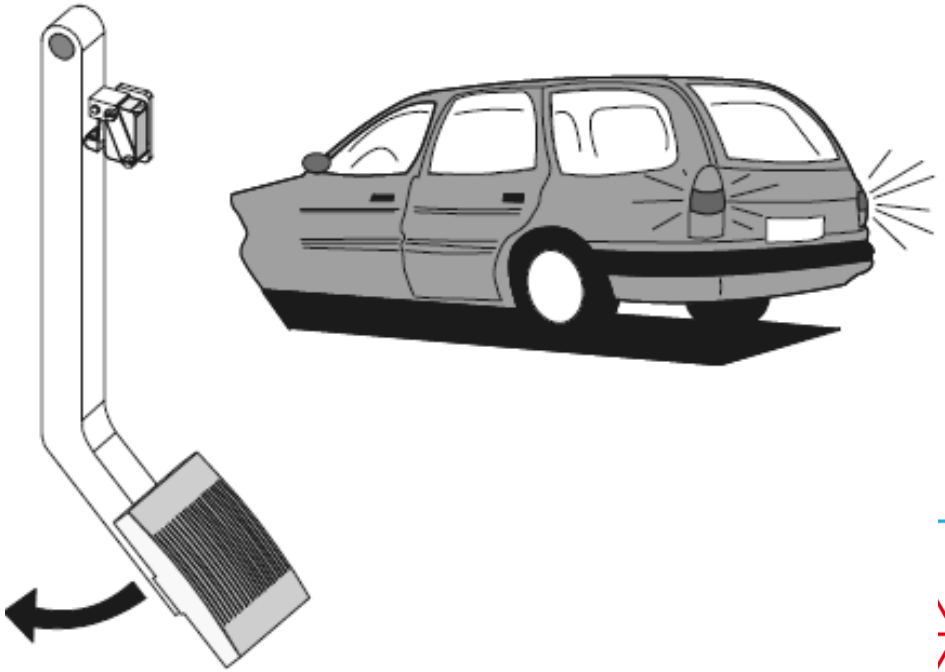
c) Whisker actuator

Parameter	Value
Switching capacity (resistive load)	24 V DC, 6 A 250 V AC, 6 A
Switching point accuracy	0.01 – 0.1 mm (Precision switch up to 0.001 mm)
Switching frequency	Approx. 60 – 400 switching operations/min.
Service life	10 Million switching cycles
Protection class (IEC 529, DIN40050)	IP00 – IP67

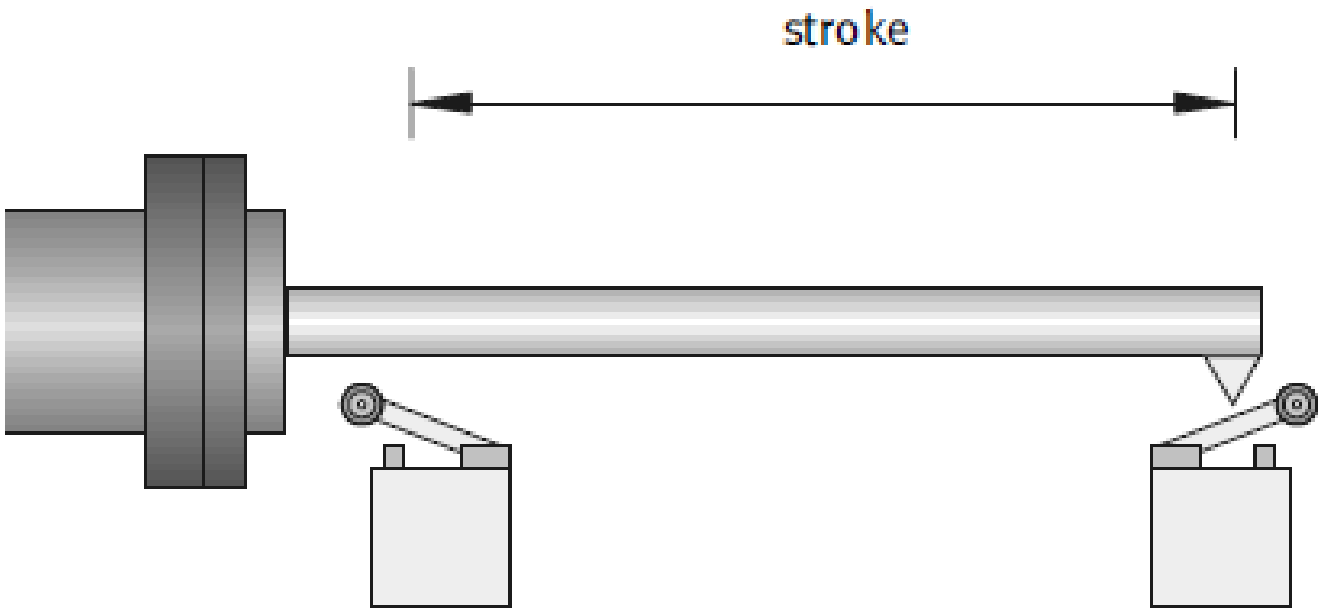
Monitoring of doors



Brake switch

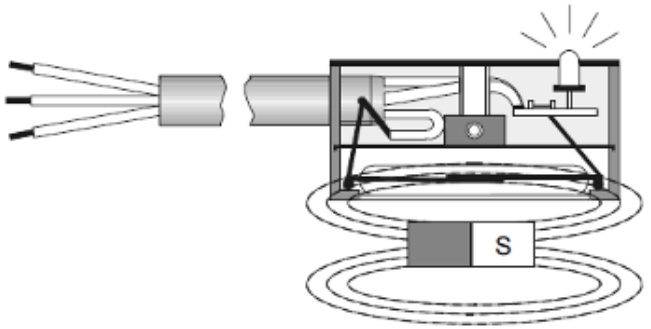


Double-acting cylinder end position sensor

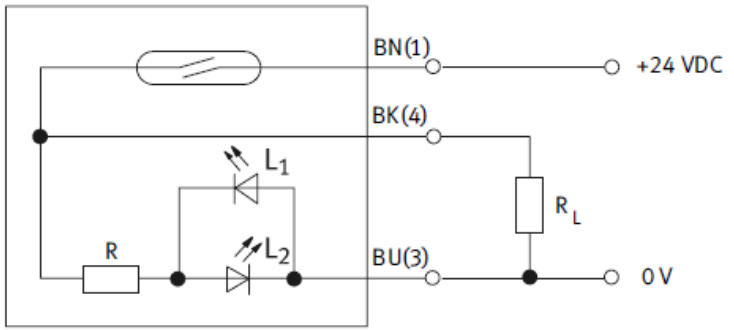


Electromagnetic proximity sensors:

Reed type

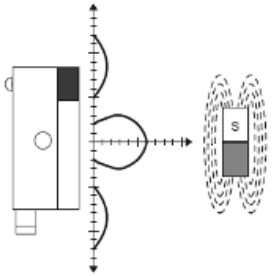


circuit

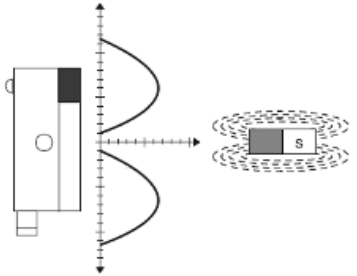


Parameter	Value
Switching voltage	12 – 27 V DC or AC
Switching accuracy	±0.1 mm
Maximum contact rating	40 W
Maximum magnetic interference induction	0.16 mT
Maximum switching current	2 A
Maximum switching frequency	500 Hz
Switching time	≤2 ms
Conductance	0.1 Ω
Contact service life (with protective circuit)	5 Million switching cycles
Protection class (IEC 529, DIN 40050)	IP66
Ambient operating temperature	-20 – +60 °C

"Cylinder sensor"

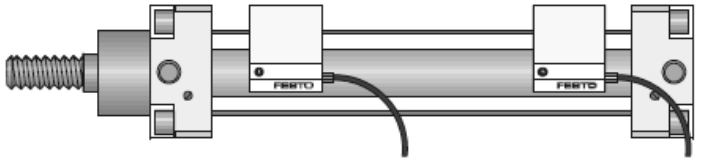


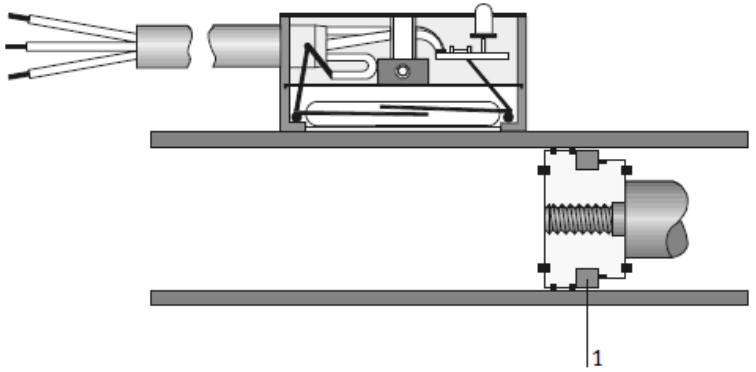
Sensing range



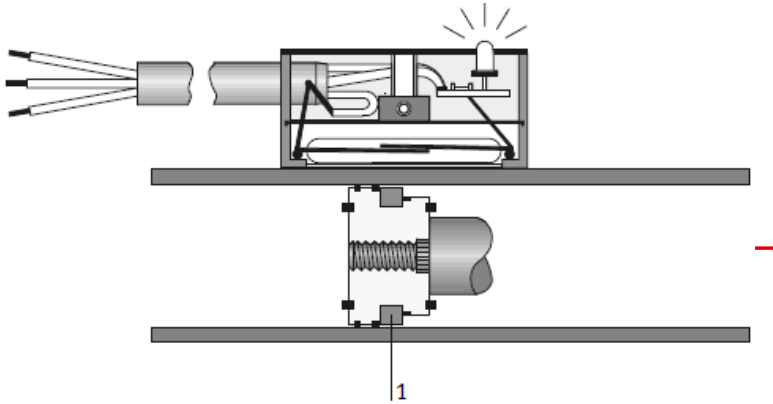
Note;
60mmCylinder-to-cylinder spacing

Applied to cylinder end-position detection



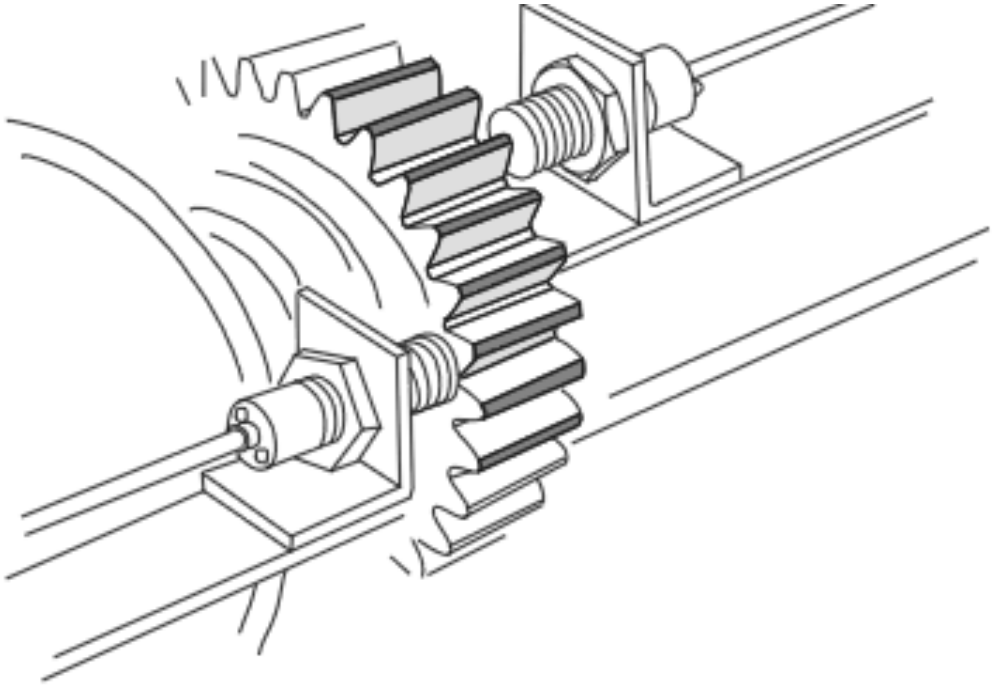


The sensor is not activated

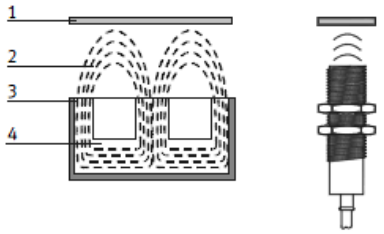


The sensor is activated

Detection of speed and direction of rotation



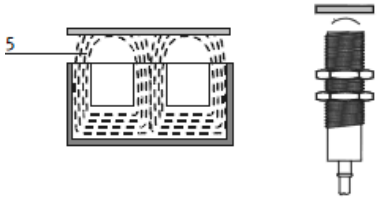
Inductive sensors



The effect of different materials on the detection distance

Material	Reduction factor
Steel S 235 JR (old: St37)	1.0
Chrome nickel	0.70 – 0.90
Brass	0.35 – 0.50
Aluminium	0.35 – 0.50
Copper	0.25 – 0.40

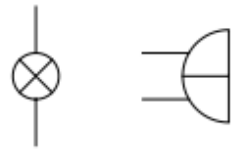
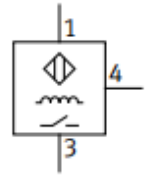
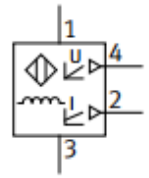
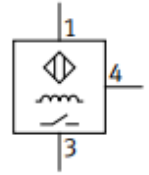
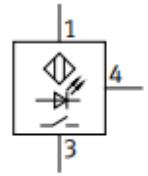
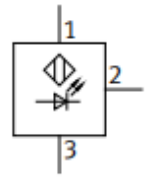
Note: Only materials with electrical conductivity can be detected with it

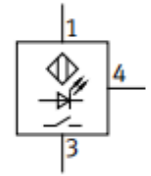
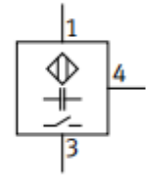
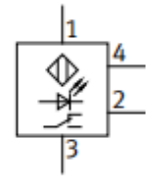
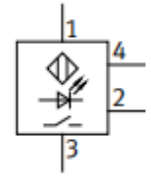
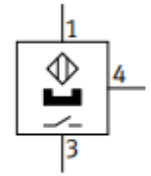


Parameter	Value
Object material	Metals
Operating voltage	10 – 30 V
Nominal switching distance	0.8 – 10 mm, maximal 250 mm
Maximum switching current	75 – 400 mA
Vibration	10 – 50 Hz, 1 mm amplitude
Sensitivity to dirt	insensitive
Service life	very long
Switching frequency	10 – 5000 Hz, maximal 20 kHz
Design	cylindrical, block-shaped
Size (examples)	M8x1, M12x1, M18x1, M30x1, Ø 4 – 30 mm, 25 mm x 40 mm x 80 mm
Protection class to IEC 529 (DIN 40050)	up to IP67
Ambient operating temperature	-25 – +70 °C

The detection distance is the farthest 250mm

Graph symbols

Component	Graphic symbol
Indicator unit and distributor, electrical	
Proximity switch, inductive, M12	
Proximity sensor, inductive, with analogue output, M12	
Proximity switch, inductive, M18	
Through-beam sensor, receiver	
Through-beam sensor, transmitter	

Component	Graphic symbol
Retro-reflective sensor	
Proximity switch, capacitive, M12	
Fibre-optic unit	
Diffuse sensor with background suppression	
Proximity switch, magneto-resistive	

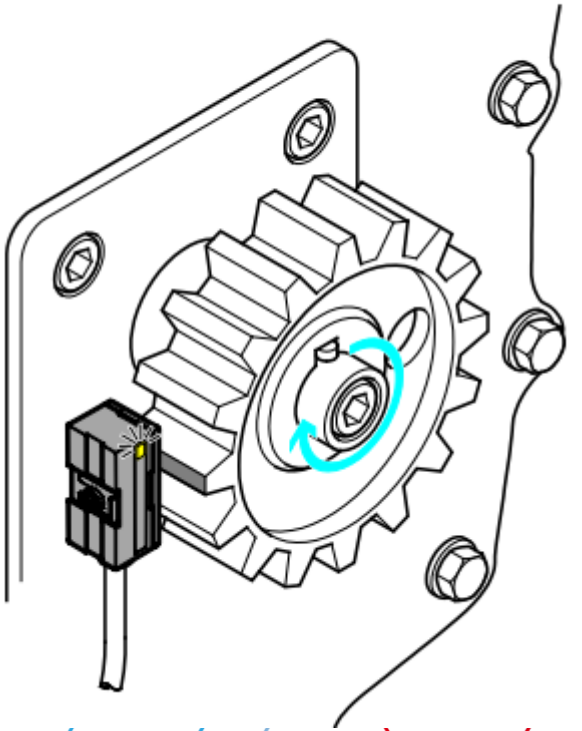
Detecting the speed of a gear

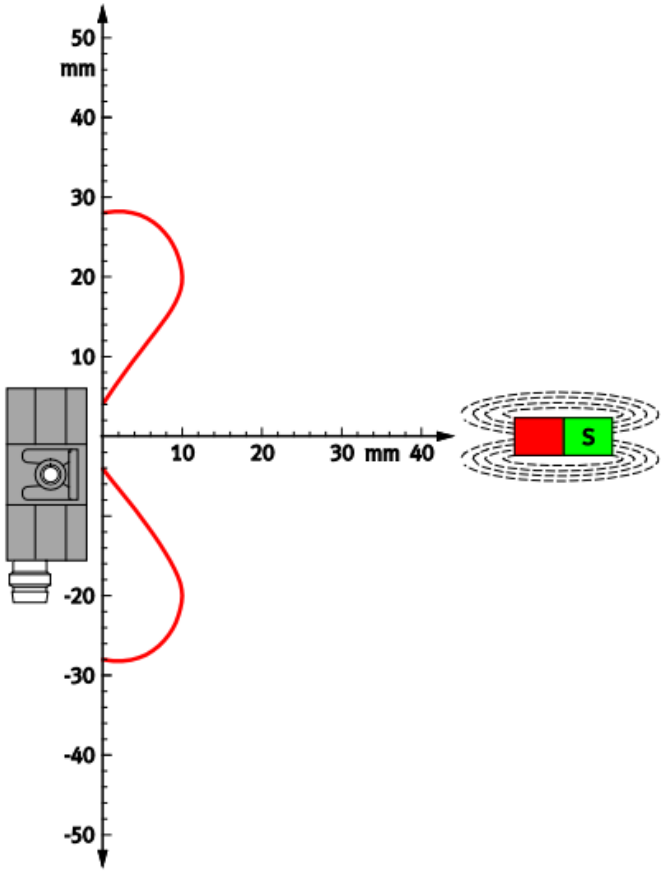
Presentation of the problem

The use of a contactless proximity switch has been planned in order to record the speed of a non-metallic gear. A magnet is mounted on one of the gear's teeth to this end. Reliable switching must be ensured. The proximity switch's characteristic switching curve needs to be determined. The influence of the orientation of the magnetic axis must also be examined.

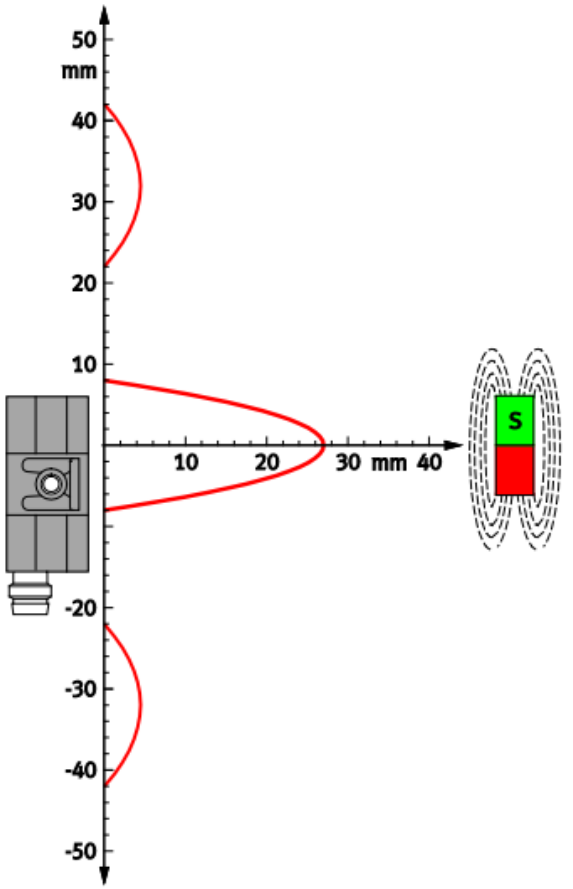
Parameter	Value
Operating voltage (DC)	10 to 30 V DC
Switching current	Max. 200 mA
Switching frequency	Max. 500 Hz
Switching output	PNP, NO contact
Switching status display	Yellow LED
Switching point reproducibility	±0.1 mm

Layout





Switching curve, magnet 1



Switching curve, magnet 2

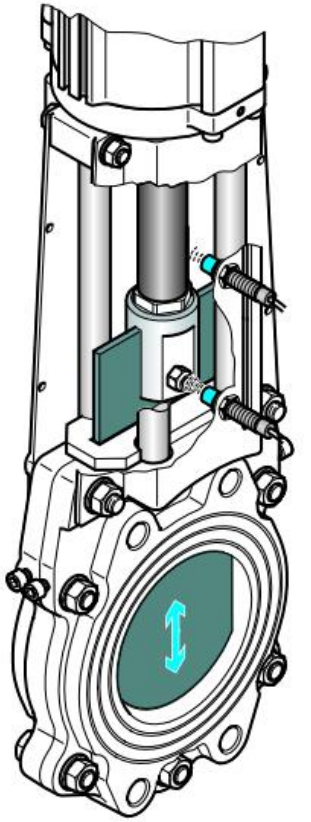
Sensing the position of a valve slide

Presentation of the problem

The position of a valve slide in a length of pipe is sensed by means of limit switches. A test setup will be used to determine whether or not inductive proximity switches can be used for position sensing.

Parameter	Value	Value
Size	M18 x 1	M12 x 1
Sensing range	0 to 8 mm	0 to 4 mm
Repetition accuracy	0.2 mm	0.2 mm
Type of mounting	Non-flush	Non-flush
Operating voltage	15 to 34 V DC	10 to 30 V DC
No-load current	≤ 30 mA	≤ 30 mA
Switching output	PNP, NO contact	PNP, NO contact
Switching status display	Yellow LED	Yellow LED
Output current	Max. 200 mA	Max. 200 mA
Switching frequency	Max. 300 Hz	Max. 2000 Hz

Layout



Position sensing, valve slide

Parameter	Measured value 1 (mm)	Measured value 2 (mm)	Measured value 3 (mm)	Mean value (mm)
Switch-on point:	8.0	8.0	8.0	8.0
Switch-off point:	8.3	8.5	8.5	8.4
Hysteresis:	0.3	0.5	0.5	0.4

Measured values, inductive proximity switch M18

Parameter	Measured value 1 (mm)	Measured value 2 (mm)	Measured value 3 (mm)	Mean value (mm)
Switch-on point:	4.5	4.5	4.5	4.5
Switch-off point:	4.75	4.75	5.0	4.8 mm
Hysteresis:	0.25	0.25	0.5	0.3 mm

Measured values, inductive proximity switch M12

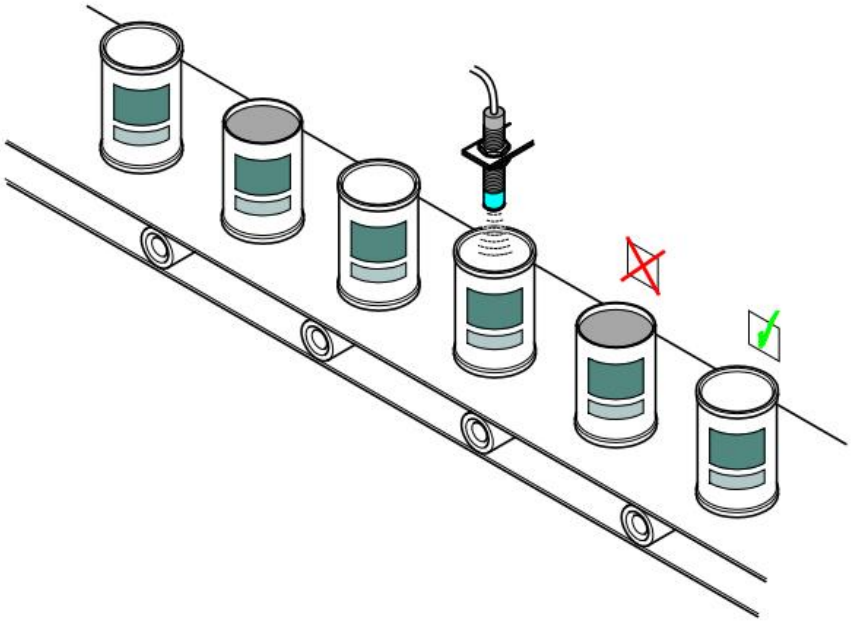
Inspecting food tins

Presentation of the problem

Filled tins of food are sealed, and are then transported to a palletising unit via a conveyor belt. An inductive proximity switch is used to determine whether or not the tins have been closed with a lid. Ever since the material used for the lids was changed, errors occur frequently during inspection. Find out whether or not the lid material has an effect on the switching performance of the inductive proximity switch.

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]
Galvanised steel (5)	8.0	8.3	0.3
Stainless steel (6)	6.0	6.25	0.25
Aluminium (7)	4.0	4.25	0.25
Brass (8)	4.5	4.75	0.25
Copper (9)	3.0	3.25	0.25

Layout



Lid inspection

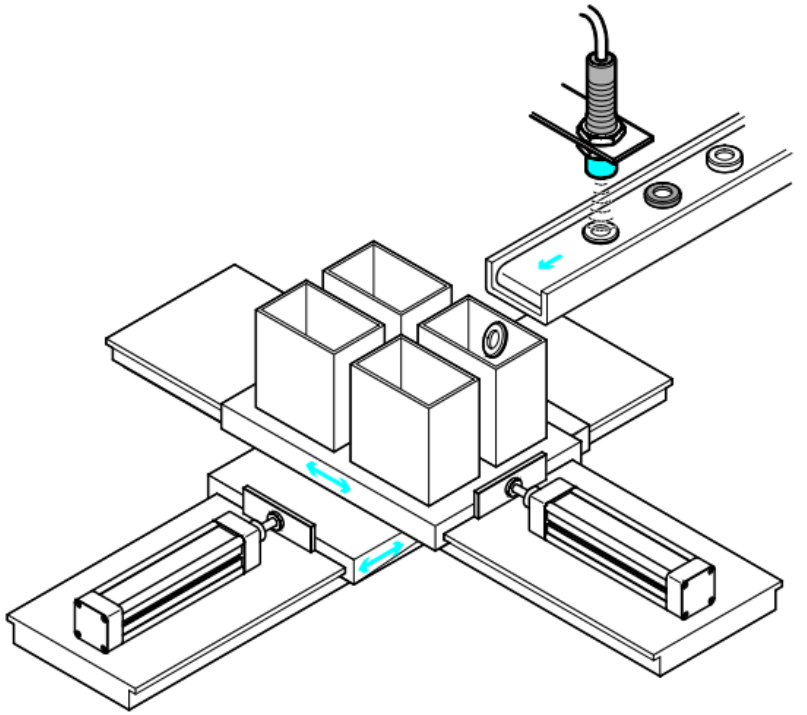
Sorting washers

Presentation of the problem

Washers of varying size are sorted into magazines in a sorting device. These metallic washers need to be detected with an inductive proximity switch. Only parts made of steel need to be detected. Examine the influence of object size on the switching distance of an inductive proximity switch.

Length [mm]	Switching distance [mm]
Steel, 30 x 30	8.0
Steel, 25 x 25	7.75
Steel, 20 x 20	7.5
Steel, 15 x 15	7.0
Steel, 10 x 10	5.5
Steel, 5 x 5	3.0

Layout

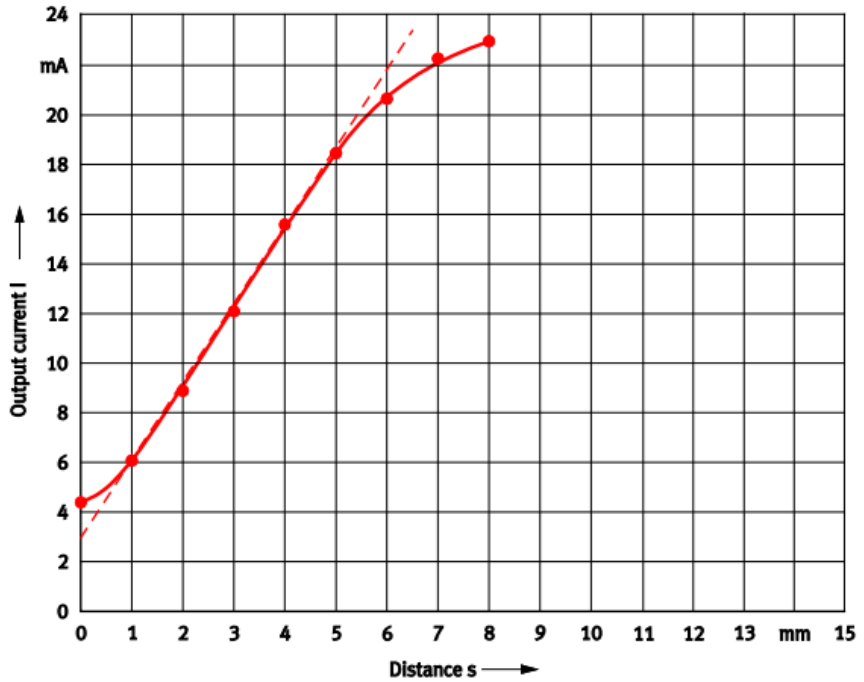


Sorting device

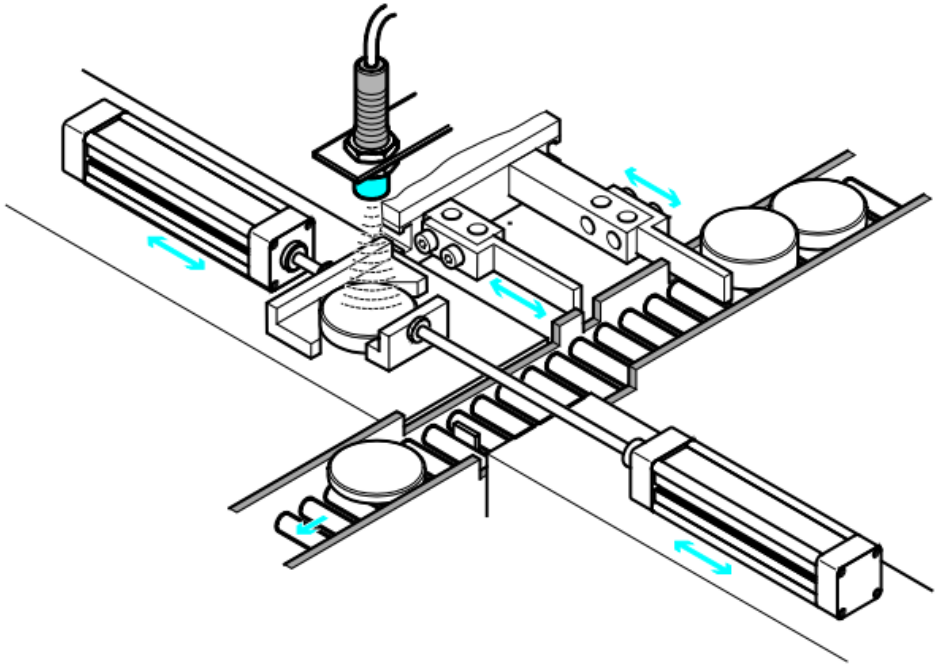
Measuring the thickness of steel discs

Description of the problem

The thickness of steel discs needs to be determined using an inductive sensor with analogue output before further machining takes place. Establish whether or not the sensor is suitable for this purpose and which level of accuracy can be ensured during measurement of the discs on a measuring table. The steel discs are lying flat on a non-metallic base.



Characteristic curve of the inductive sensor



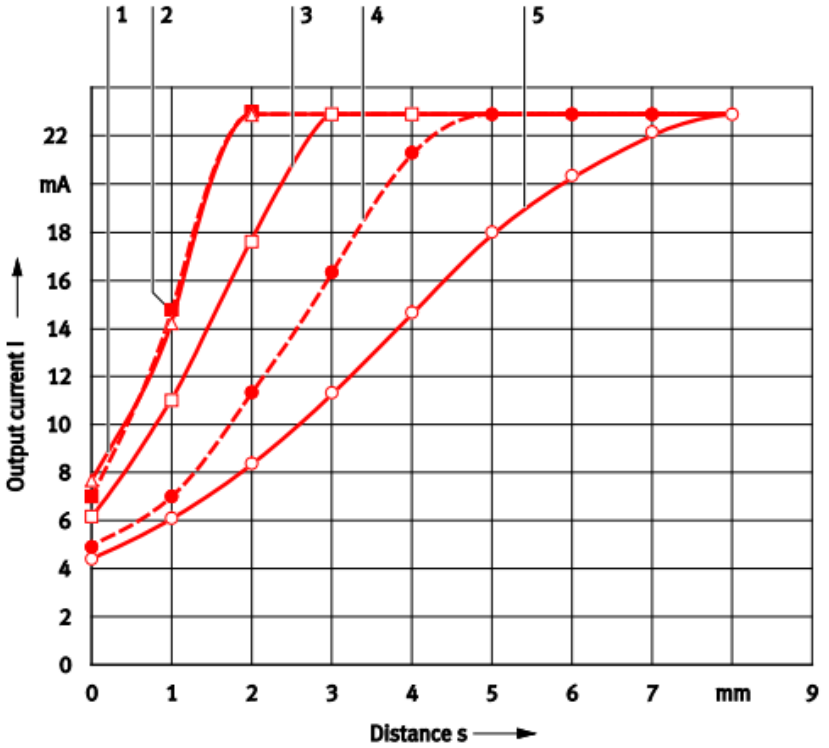
Workpiece thickness measurement

The inductive sensor with analogue output doesn't have any hysteresis within the specified range of measuring accuracy.

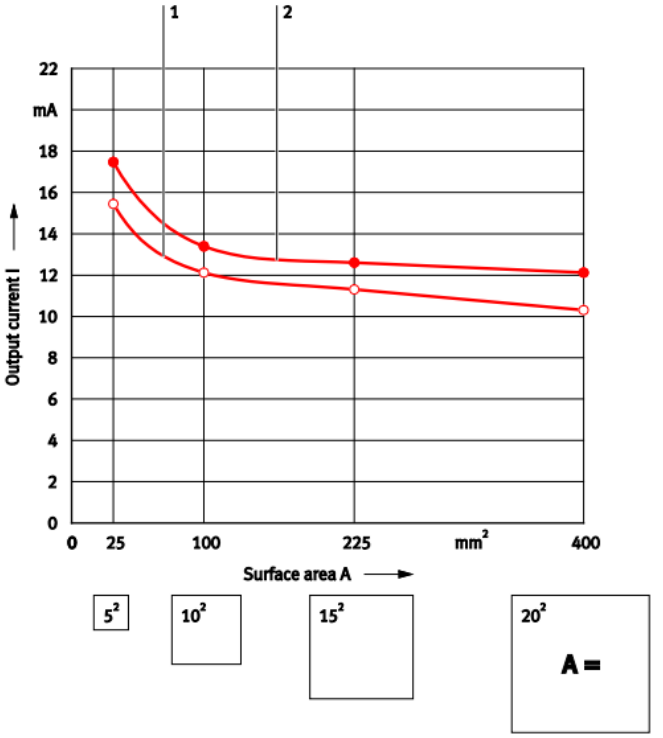
Sorting flat seals

Description of the problem

Welted flat seals made of various metals in sizes R 1/4" and R 3/8" are detected by an inductive sensor with analogue output, and then sorted. Determine whether or not the sensor is suitable for this task.

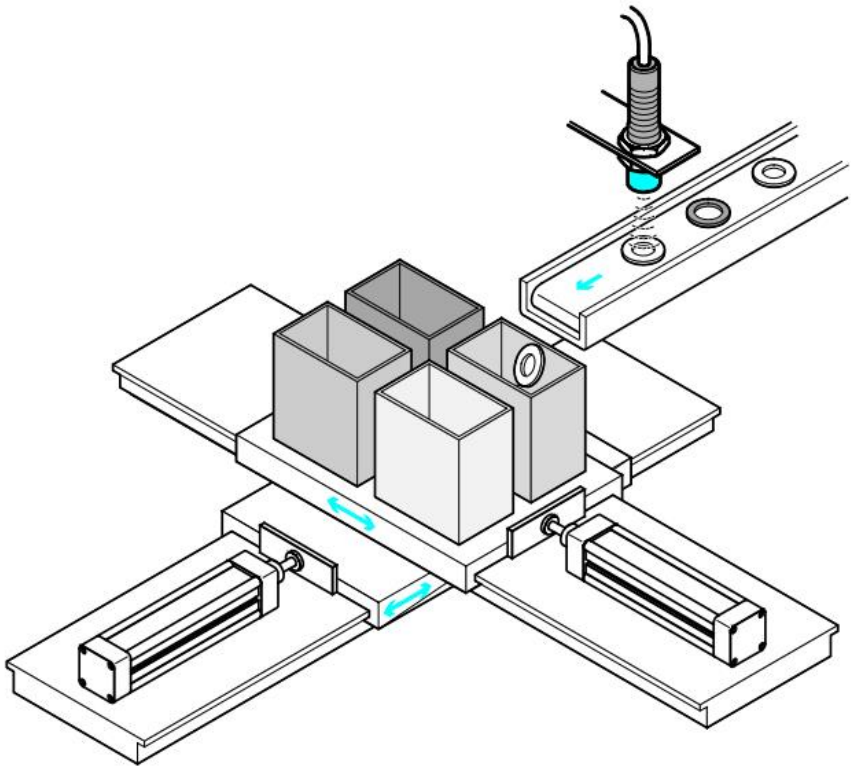


1: copper, 2: aluminium, 3: brass, 4: stainless steel, 5: steel



1: sensor-to-object distance of 3 mm; 2: sensor-to-object distance of 4 mm

Layout



Sorting device

Author: Gao Haihua

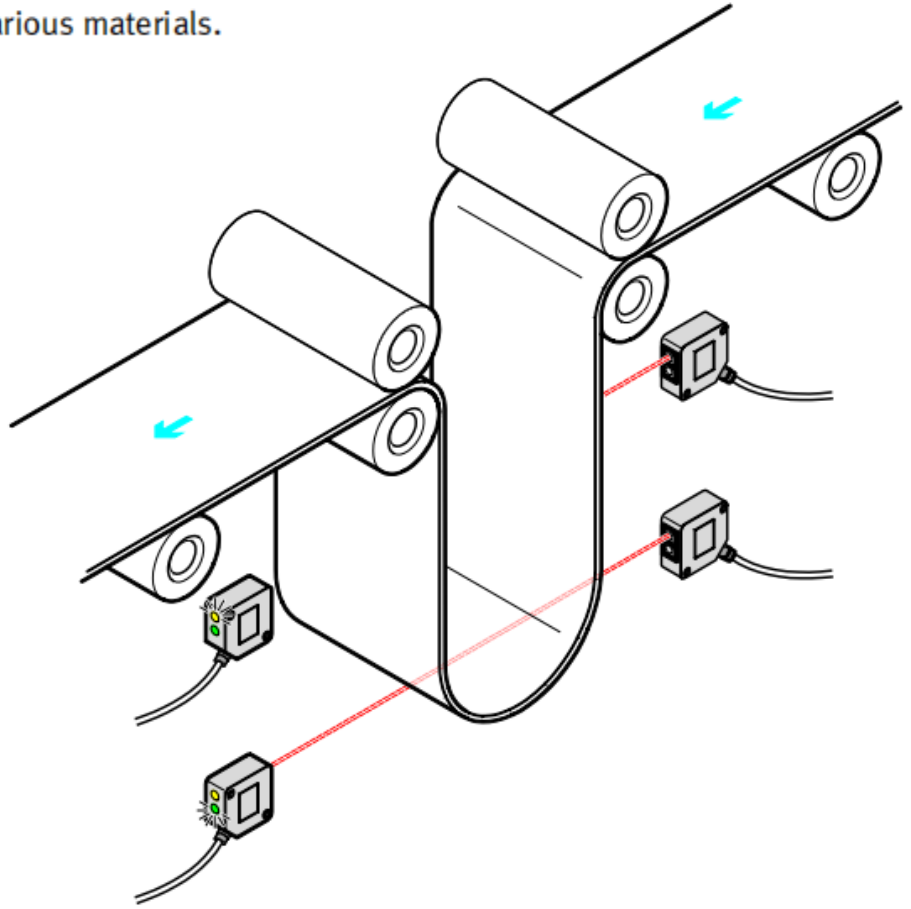
Controlling a dip at a belt tensioner

Description of the problem

Two through-beam sensors are used for dip control at a belt tensioner. Various materials need to be detected. Examine the response characteristics of a through-beam sensor using various materials.

Parameter	Value
Light type	Infrared
Adjustment device	Potentiometer
Operating voltage	10 to 36 V DC
No-load current	≤ 15 mA
Switching output	PNP, NO contact
Switching status display	Yellow LED
Switching element function	Dark switching
Output current	Max. 200 mA
Switching frequency	Max. 1000 Hz
Operating reserve display	Green LED

Through-beam sensor – receiver



Belt tensioner

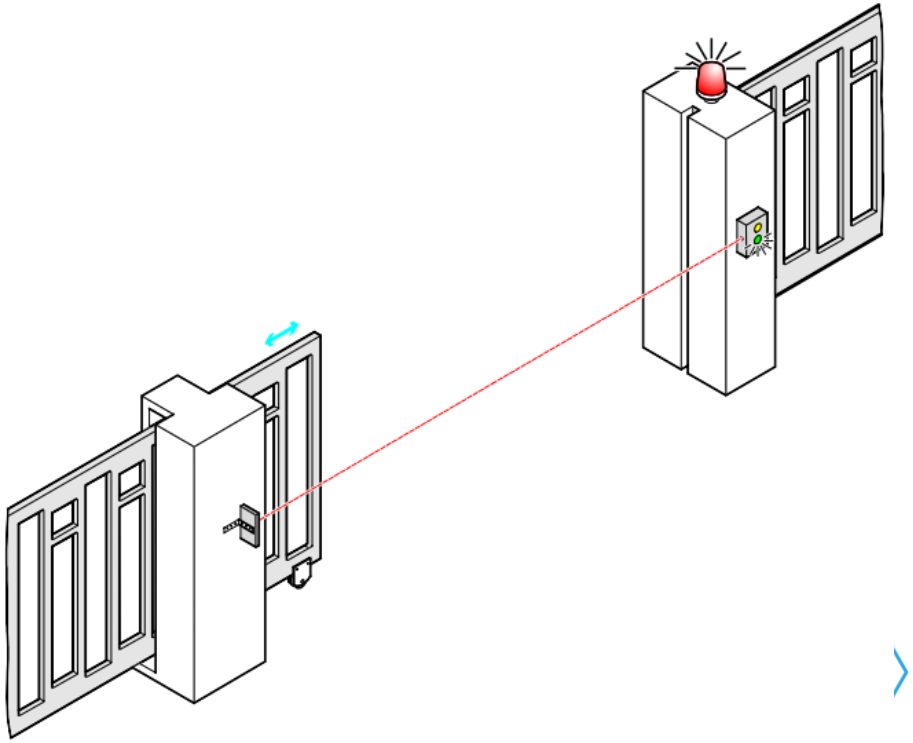
Monitoring an electrically operated gate

Description of the problem

A gate is to be monitored with a retro-reflective sensor. The gate should be prevented from closing as long as people or vehicles are located within its opening. Determine which objects can be detected with retro-reflective sensors.

Parameter	Value
Working range	0 to 2000 mm
Light type	Red, polarised
Adjustment device	Potentiometer
Operating voltage	10 to 30 V DC
No-load current	≤ 25 mA
Switching output	PNP, NO contact
Switching status display	Yellow LED
Switching element function	Dark switching
Output current	Max. 200 mA
Switching frequency	Max. 1000 Hz
Operating reserve display	Green LED
Protection	IP 65

Layout



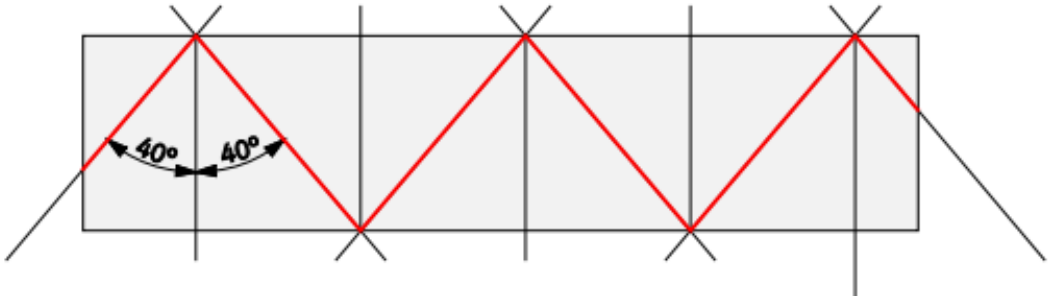
Monitoring a gate

Feeding crown caps

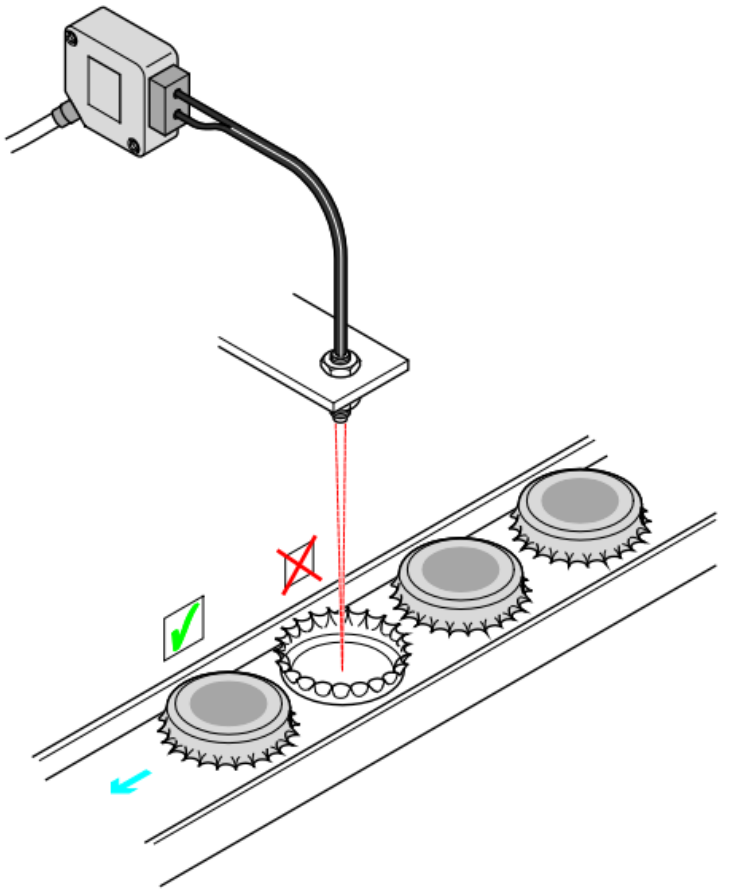
Description of the problem

Feeding of correctly oriented crown caps, which are fed by a vibrator conveyor, will be examined. As space is tight, proximity switches with fibre-optic cable will have to be used. Determine whether or not the scanning width of these optical proximity switches is adequate.

– Inside the fibre-optic cable, light strikes the edges of its core and jacket at an angle of 40°. Sketch transmission of the light beam through the fibre-optic cable.



Layout



Feed unit for crown caps

– Complete the table below. The required data are included in the data sheet for the fibre-optic cable.

Parameter	Value
Fibre-optic bundle diameter	1 mm
Length	2000 mm
Sensing range	Max. 0 to 120 mm Min. 0 to 24 mm
Protection	IP 65

– Complete the table below. The required data are included in the data sheet for the fibre-optic unit.

Parameter	Value
Light type	Red
Adjustment device	Potentiometer
Operating voltage	10 to 30 V DC
No-load current	≤ 25 mA
Switching output	PNP, NC/NO, antivalent
Switching status display	Yellow LED
Output current	Max. 200 mA
Switching frequency	Max. 1000 Hz
Operating reserve display	Green LED
Protection	IP 65

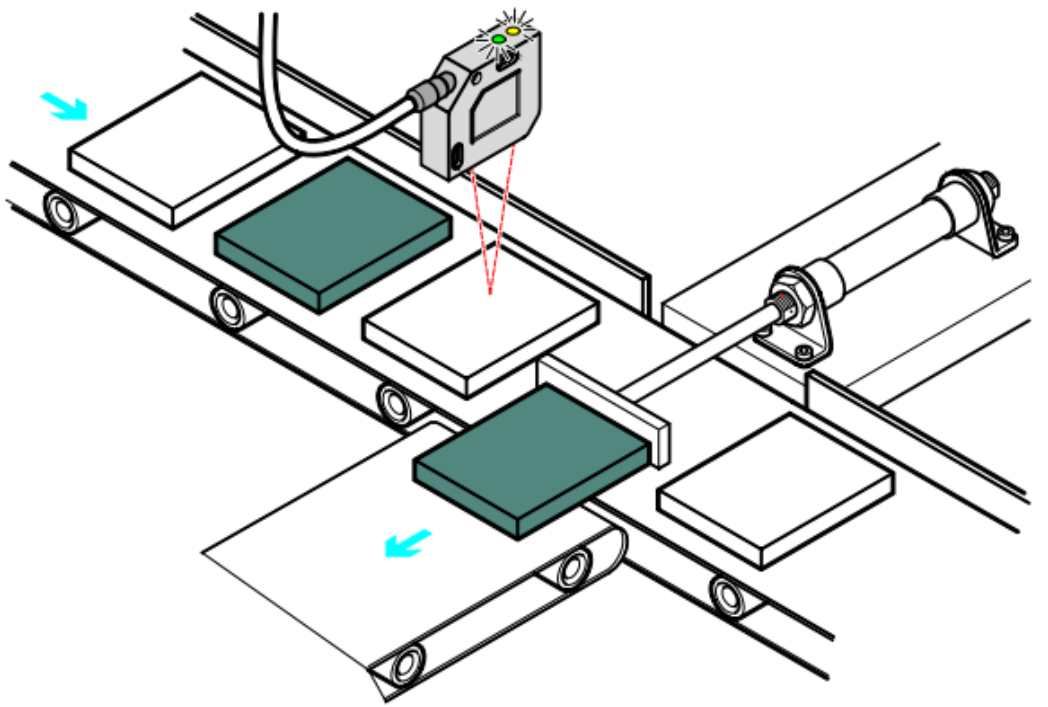
Sorting workpieces

Description of the problem

Materials with different surface characteristics and colours need to be detected by a sorting device with the help of a diffuse sensor. Examine the switching performance and the range of the diffuse sensor.

Parameter	Value
Working range	25 to 100 mm
Light type	Red
Adjustment device	Teach-in, teach-in via electrical connection
Operating voltage	10 to 30 V DC
No-load current	≤ 35 mA
Switching output	PNP, NC/NO, switchable
Switching status display	Yellow LED
Output current	Max. 100 mA
Switching frequency	Max. 1000 Hz
Operating reserve display	Green LED
Protection	IP 67

Layout

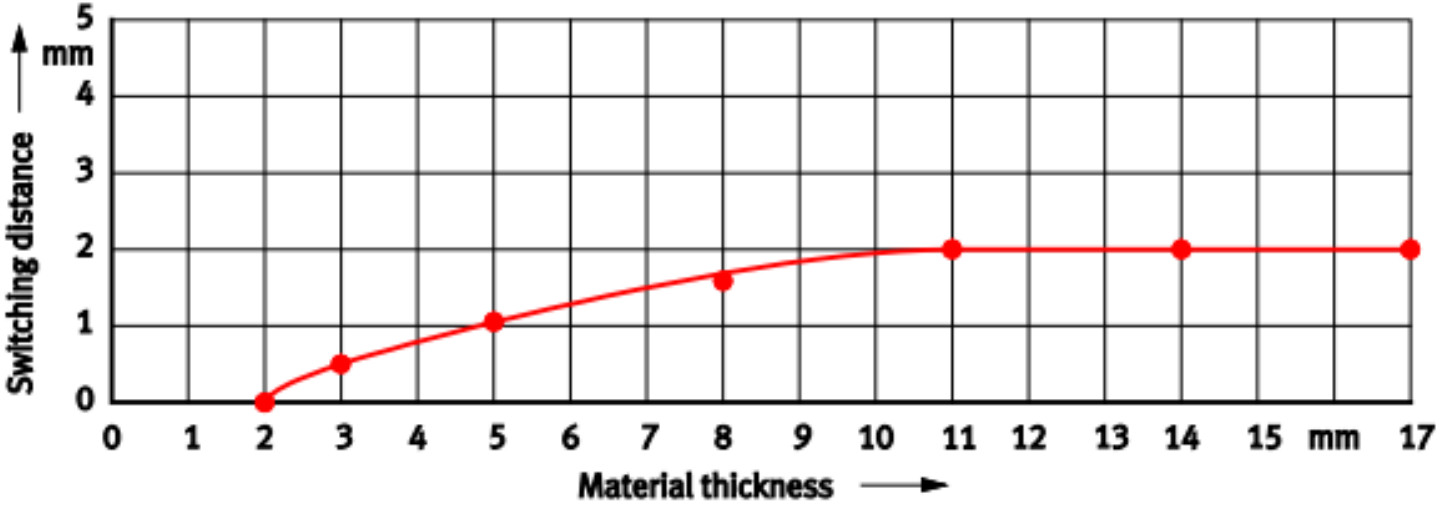


Sorting device

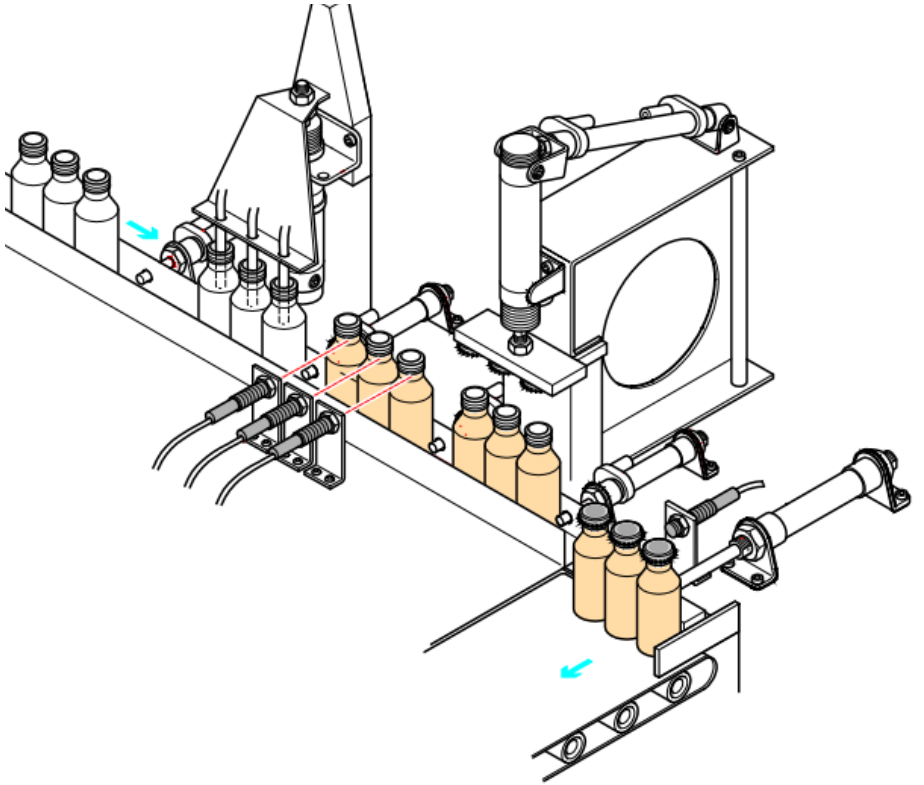
Monitoring fill levels

Description of the problem

Fill levels must be detected while filling beverage bottles. The fill level has to be sensed through the bottle. Examine capacitive and optical proximity switches for their suitability for this task. As bottles with various wall thicknesses are used, any effects due to wall thickness must also be examined.



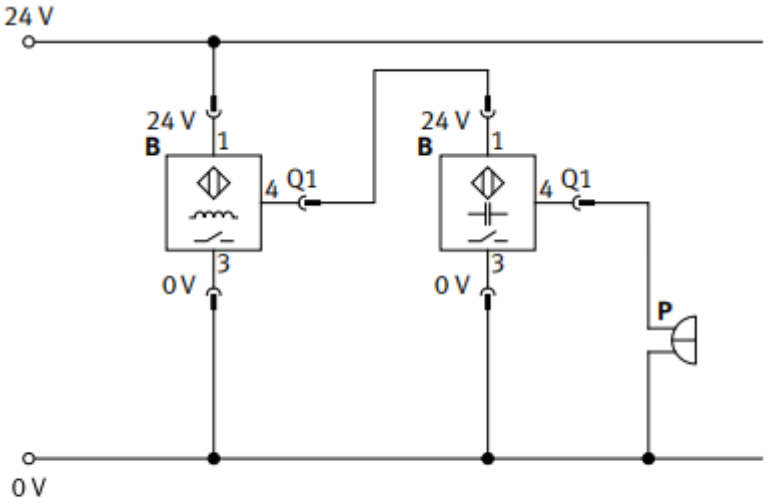
Switching distance of the capacitive proximity switch relative to the material thickness of the plastic



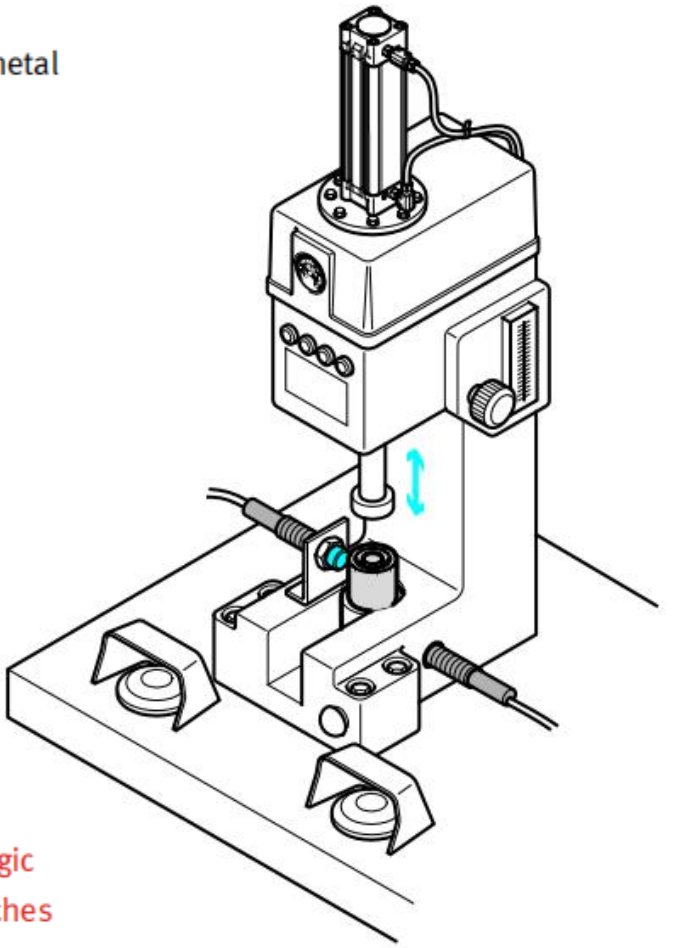
Monitoring material feed at a press

Description of the problem

Metal inserts are pressed into plastic parts at a press. Material feed will be monitored by means of a combination of proximity switches. The press should only be enabled when the plastic part and the metal insert are both in their correct positions.



Electrical circuit diagram



Simple logical linking of proximity switch output signals is possible even without programmable logic controllers. In this exercise an AND operation has been implemented by connecting proximity switches in series, i.e. an output signal is only generated if all of the proximity switches connected in series are actuated.

Discrete industries sensors

- Optic sensor
- Inductive sensor
- Capacitive sensor
- Electro-mechanical switches
- Magnetic sensor

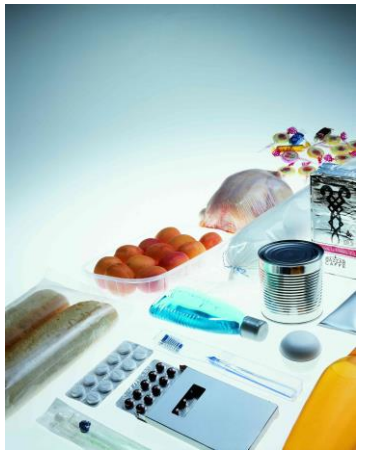
Process industries / Process automation

Process industries / Process automation

Branches of process automation

Fascinating

- water supply and wastewater disposal
- food processing industry
- the bulk goods industry
- chemicals and petrochemicals
- biotechnology and pharmaceuticals
- Paper, a.s.o.



New learning system – MPS PA complete system

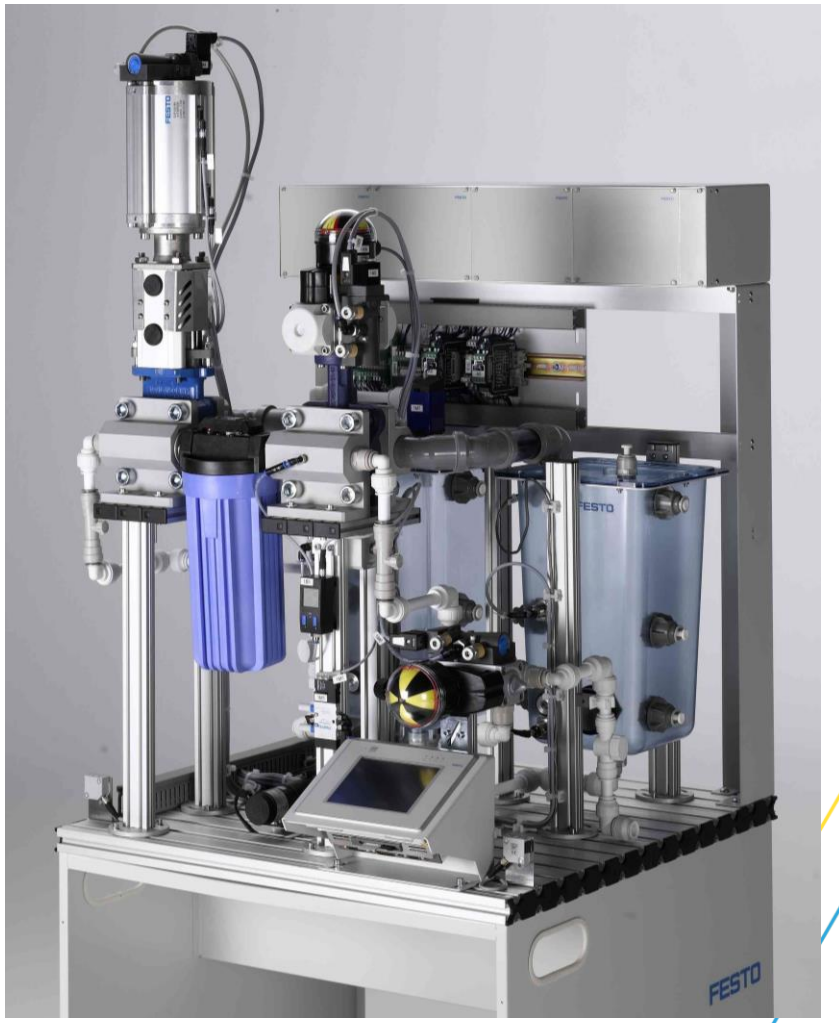
Here is our new learning system for the process industry and closed loop control:

4 work stations:

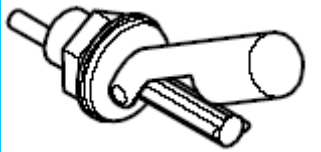
- **Filtration**
- **Mixing**
- **Reactor**
- **Bottling**

Our solution – MPS PA single work stations

Filtration work station



Liquid level monitoring

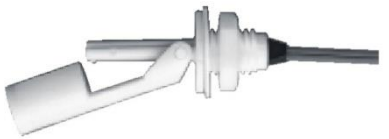


Float switch
(Check if the water tank overflows)

Capacitive sensor
(Upper and lower limits of water tank)

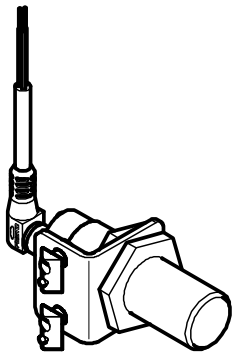
Float limit switch sensor: installed inside the water tank wall

- Depending on the installation height, the float switch can be used both during the process of water level rise and during the process of water level decrease
- The sensor outputs a 24V switching value, which is introduced into the input port of the workstation I/O board
- Convenient disassembly and assembly



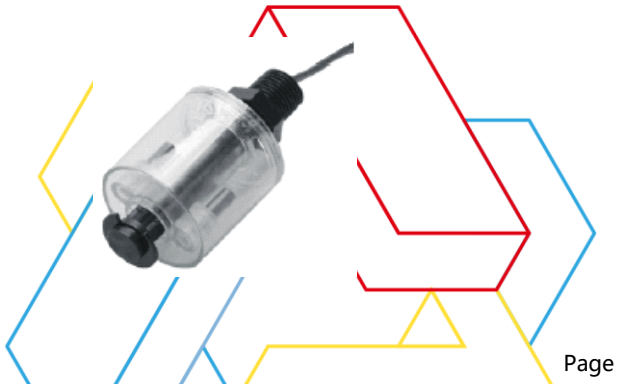
Capacitive sensor: detects liquid level through the water tank

- Two capacitive sensors located behind the low water tank can monitor the water level. The position of the sensor fixed on the aluminum profile can be adjusted
- Sensors detect water level through the water tank wall
- The sensor outputs a 24V switching value and is introduced into the input port of the workstation I/O board



Float limit switch placed on top of water tank

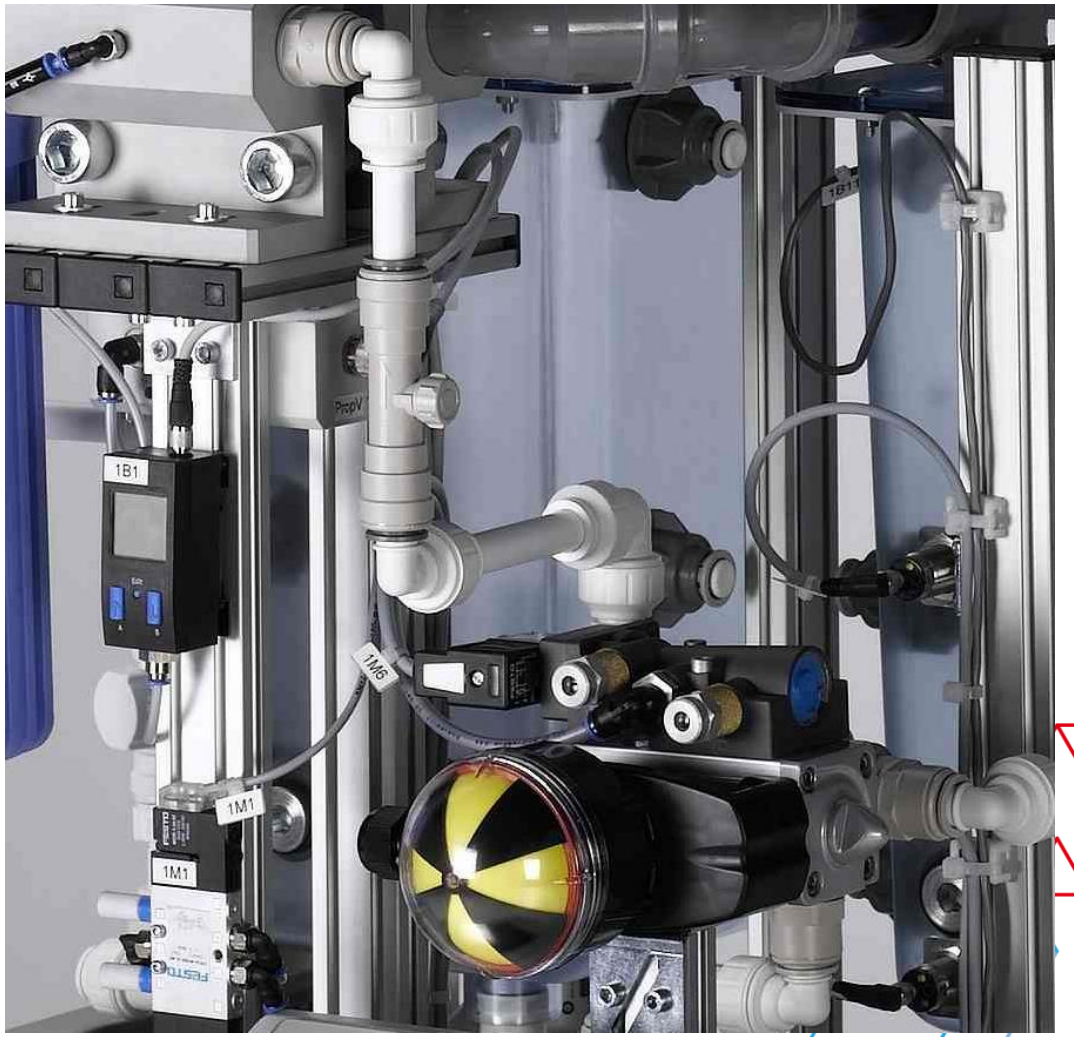
- The sensor outputs a 24V switching signal, which is introduced into the input port of the workstation I/O port
- The switch is connected to the control circuit through a safety relay, and automatically cuts off the power supply of the water pump when the water level exceeds the upper limit
- Encapsulated with transparent material, with visible internal coils



Our solution – MPS PA single work stations

Open and closed loop control of different typical process values:

Pressure control.



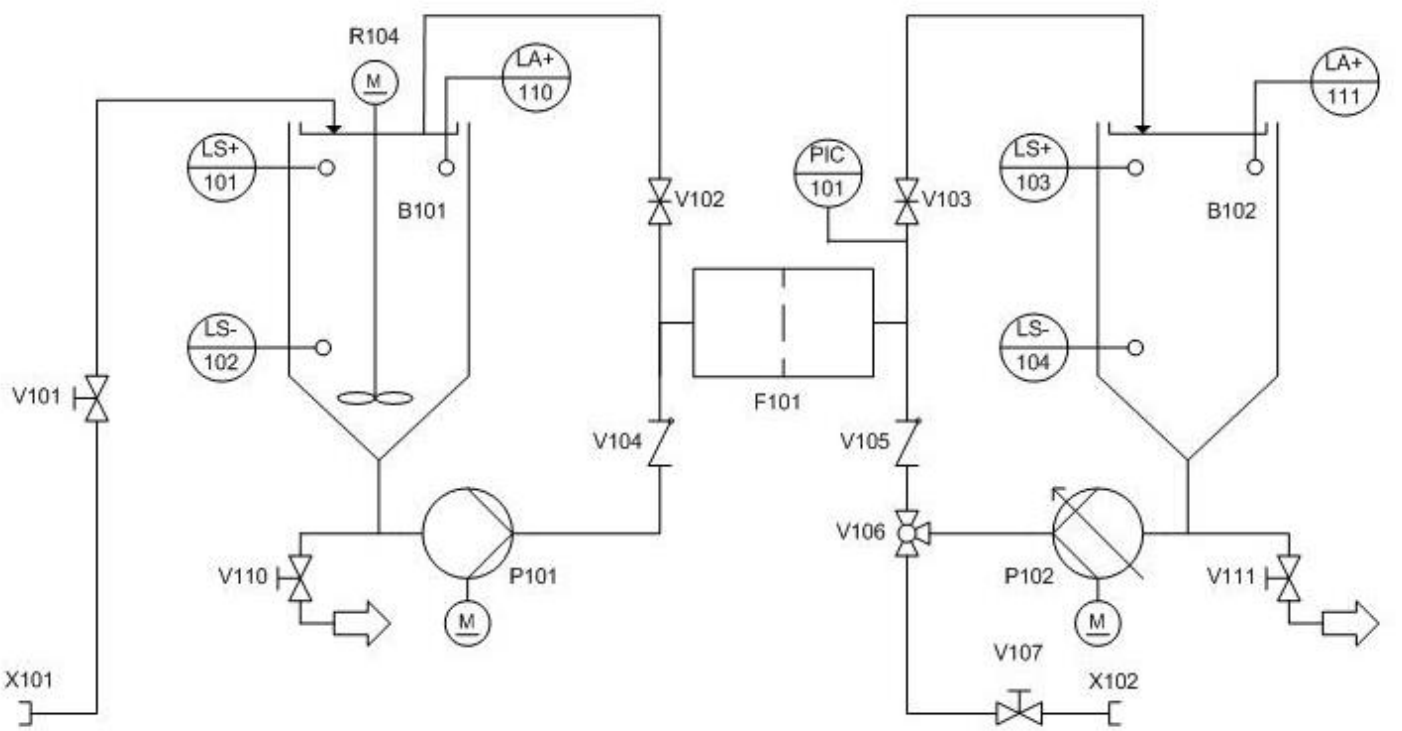
“PID” “Piping and Instrumentation Diagram

Our solution – MPS PA single work stations

Master different and complex technology.

Process technology like:

Filtration and waste water recycling

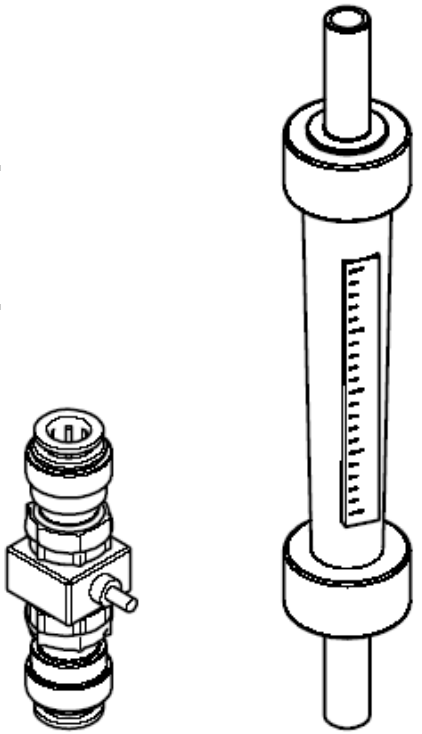


EN ISO 10 628 und DIN 19227-1

Our solution – MPS PA single work stations

Mixing work station

Flow control system



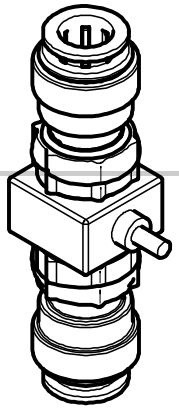
Flow sensor with floating ball

Flow sensor with impeller

Our solution – MPS PA single work stations

Open and closed loop control of different typical process values:

Flow-rate control,



- The photoelectric blade sensor can measure the flow rate
- Frequency signal
  0.3-9.0 l/min 40-1200Hz
- Signal amplitude 0~24 V DC
  sent to PLC Fast counter input port
- Power supply range 8-24V DC
- Frequency to voltage converter
  0-1000 Hz 0 – 10 V DC

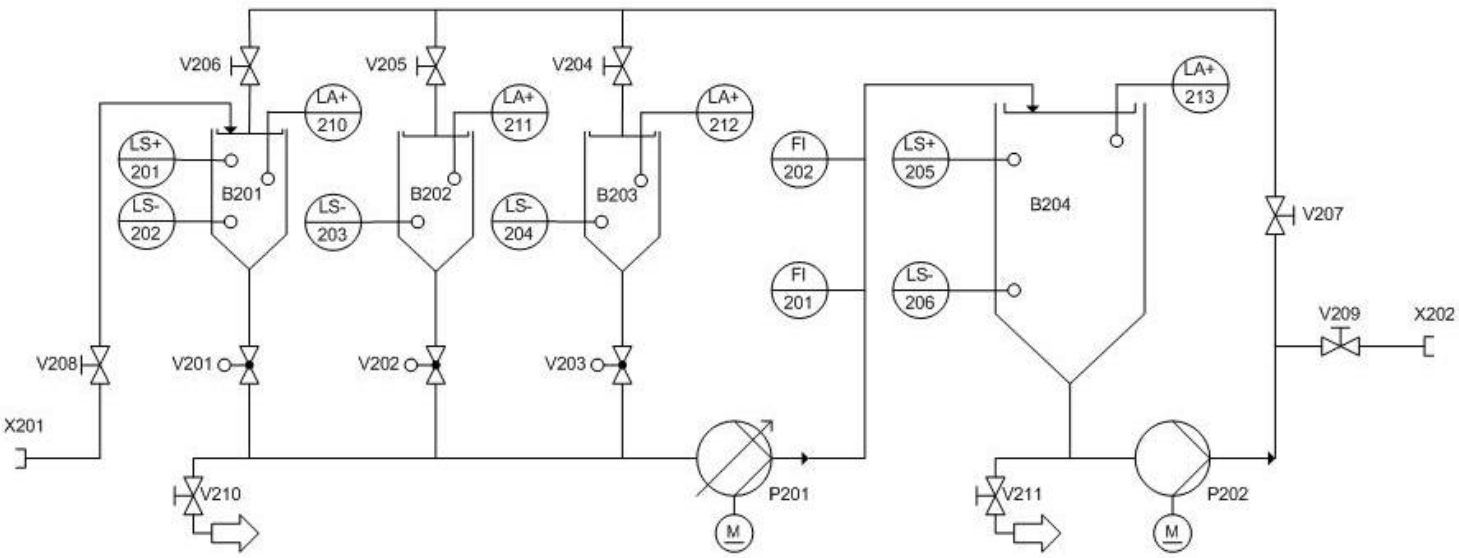
Our solution – MPS PA single work stations

Master different and complex technology.

Process technology like:

Mixing of raw materials,

"PID" "Piping and Instrumentation Diagram



EN ISO 10 628 und DIN 19227-1

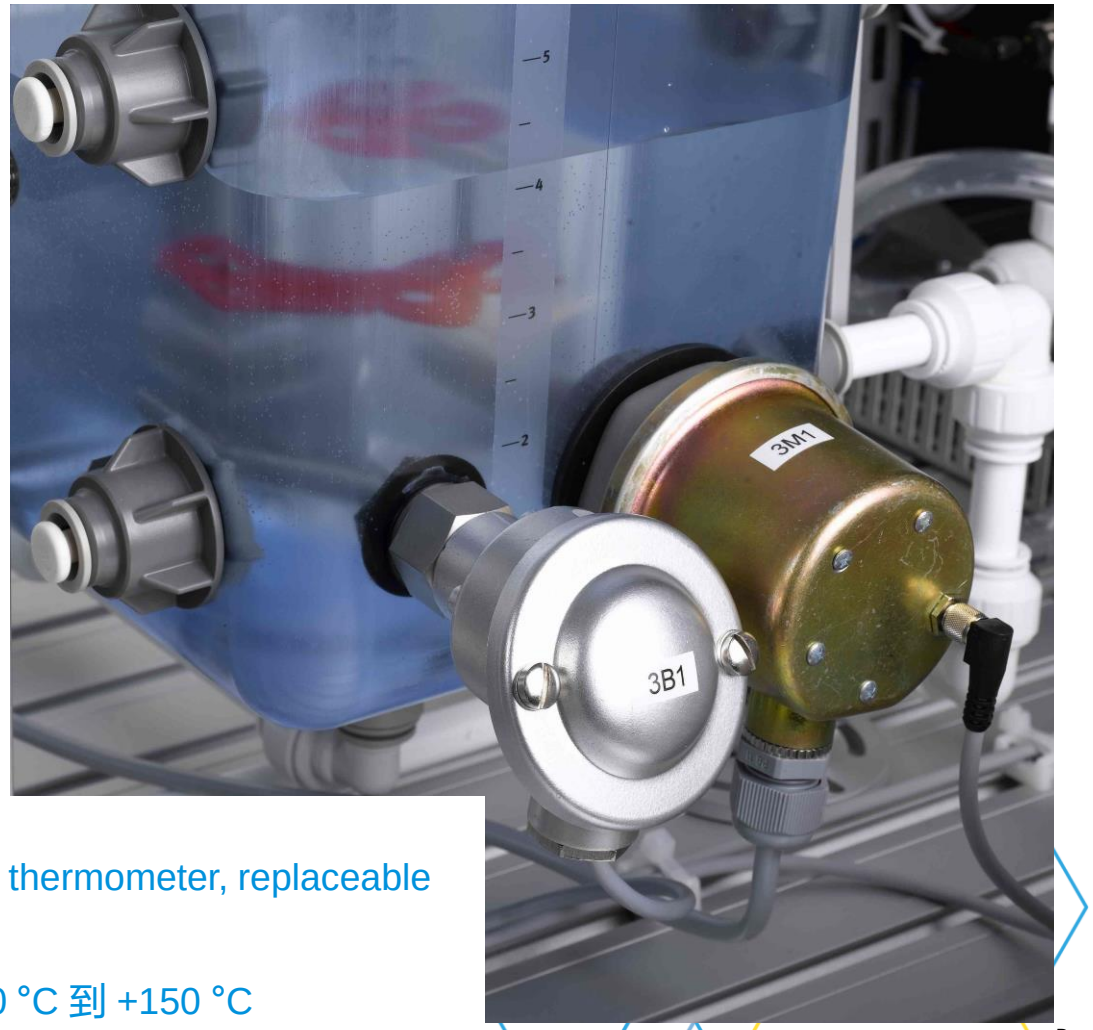
Our solution – MPS PA single work stations

Reactor work station

Our solution – MPS PA single work stations

Open and closed loop control of various typical process values:

Temperature control



- PT100 sensor
  Platinum resistance thermometer, replaceable thermistor
- measuring range-50 °C 到 +150 °C

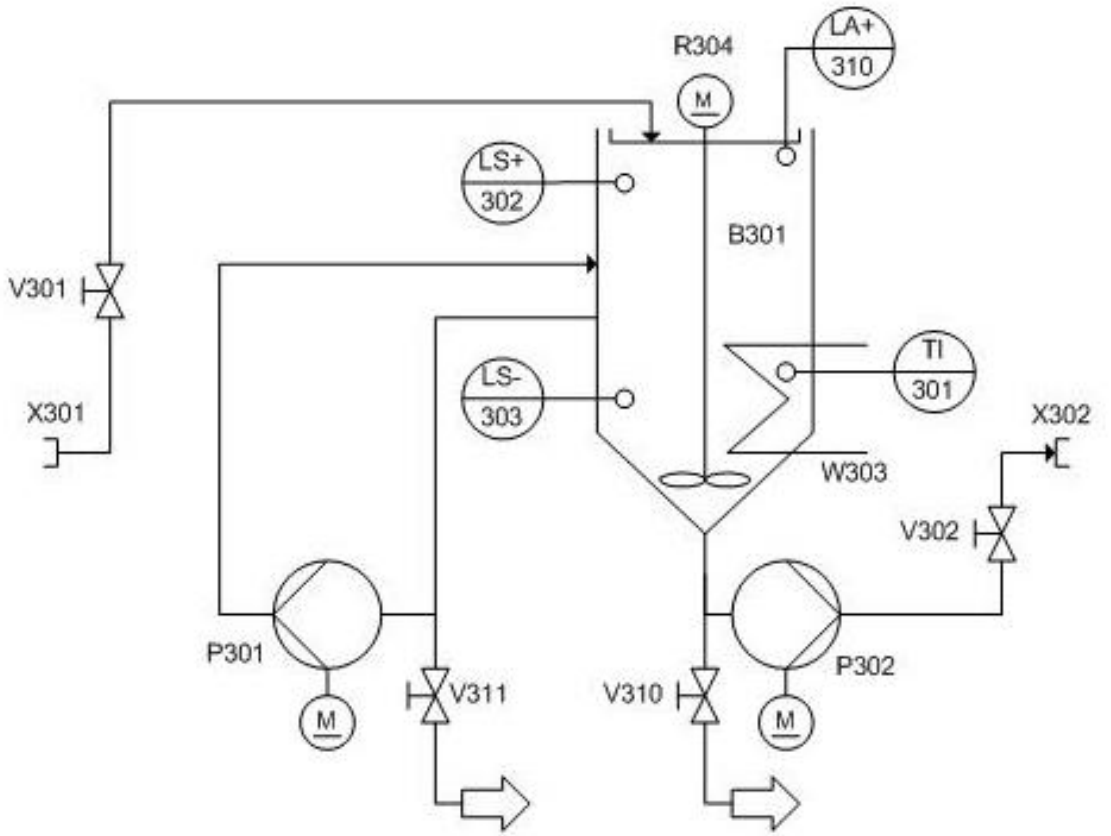
Our solution – MPS PA single work stations

Master different and complex technology.

Process technology like:

Tempering

“PID” “Piping and Instrumentation Diagram



EN ISO 10 628 und DIN 19227-1

Our solution – MPS PA single work stations

Bottling work station

Our solution – MPS PA single work stations

Open and closed loop control of different typical process values:

Level control

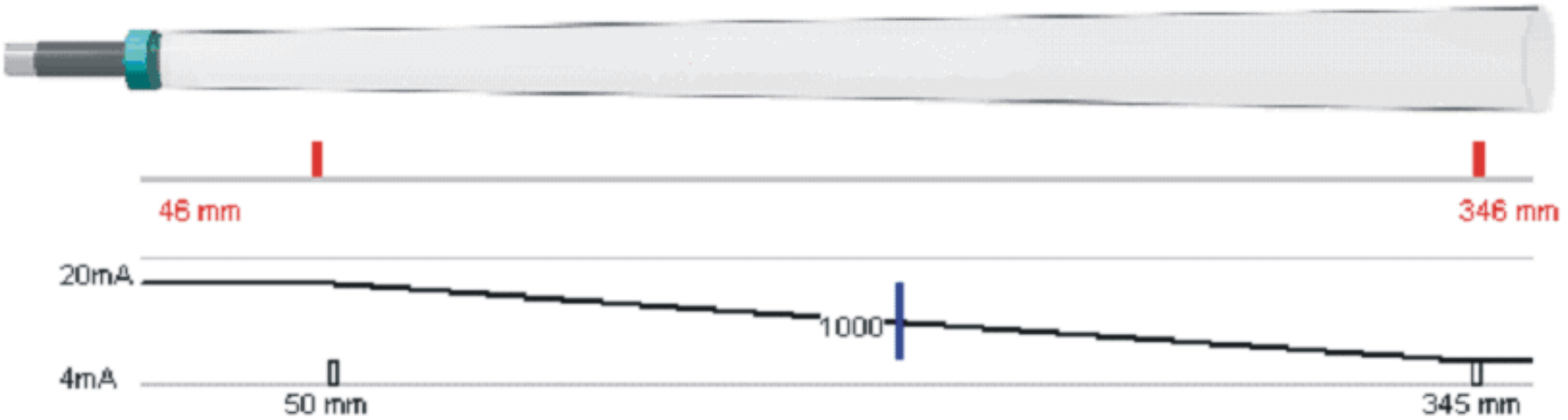
ultrasonic sensor： Continuous measurement of liquid level

Ultrasonic sensors

- Detection range 50-300 mm corresponds to standard current signal 4-20 mA
- The sensor detects the distance from the liquid surface, and the signal characteristic curve shows a decreasing curve (i.e. negative slope, the larger the distance, the smaller the current signal)
- The blind spot detection is within 50 mm, and the signal is invalid within this range
- Current to voltage conversion

  4-20 mA　　0-10 DC

ultrasonic sensor： Continuous measurement of liquid level



The negative slope characteristic curve of the ultrasonic sensor (because the liquid level is opposite to the distance), which is linear

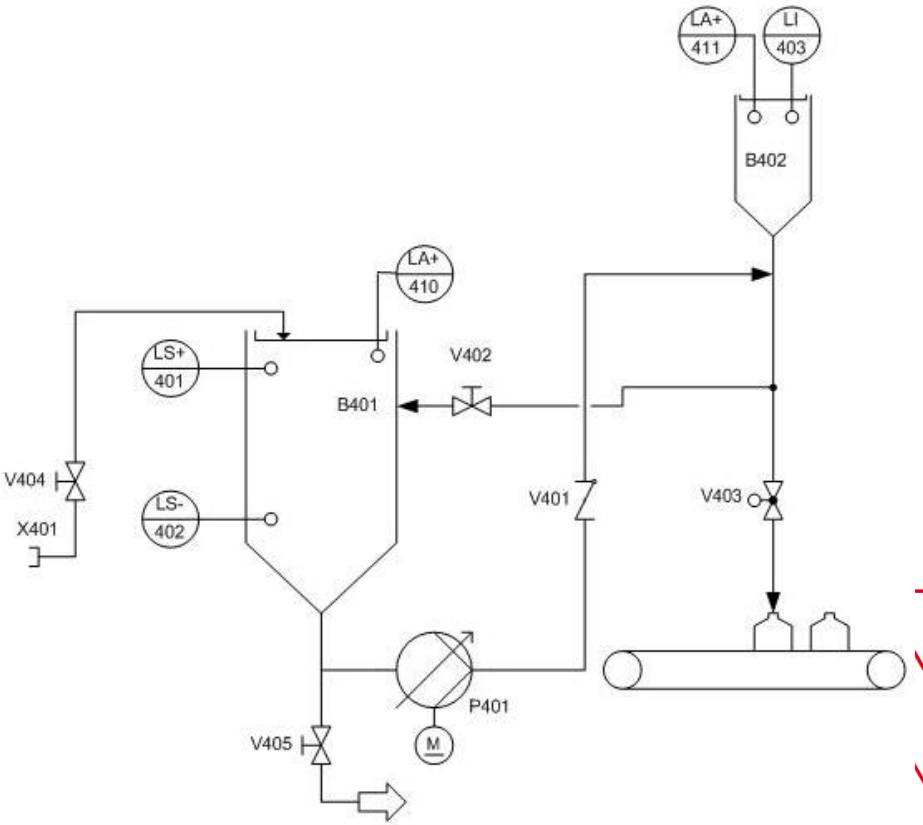
“PID” “Piping and Instrumentation Diagram

Our solution – MPS PA single work stations

Master different and complex technology.

Process technology like:

Dosing and bottling



EN ISO 10 628 und DIN 19227-1

Process industries sensors

Pressure sensor

Flow sensor

Temperature sensor

Ultrasonic sensor

Float limit switch

Thank You !