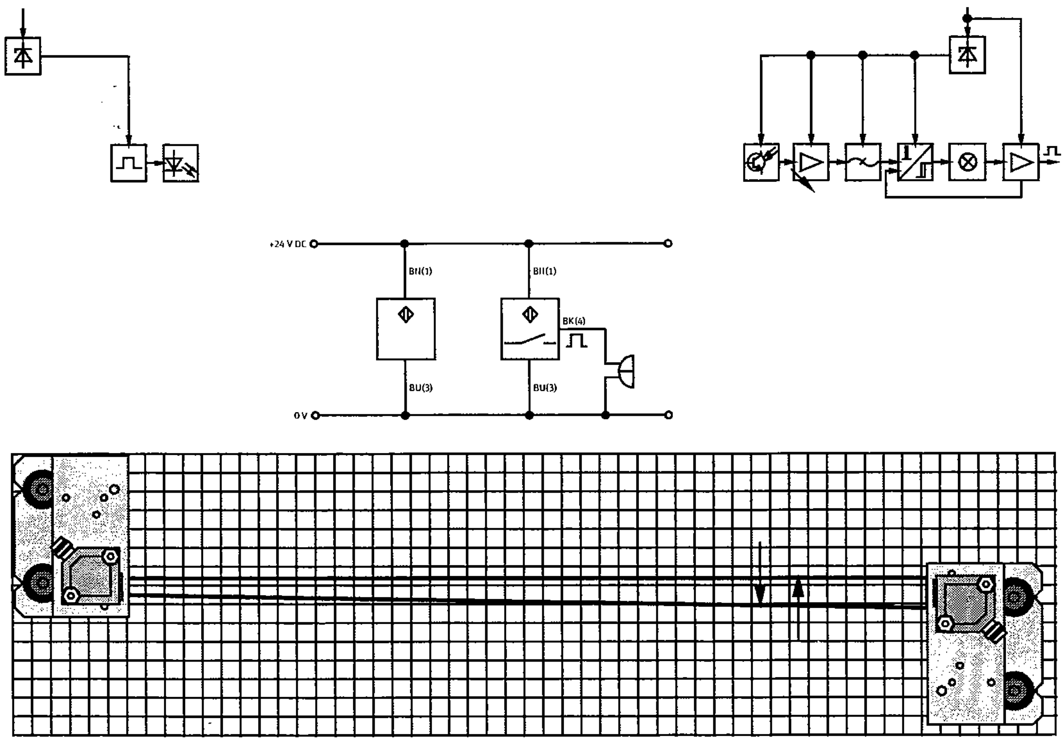
FESTO

Sensors for Handling and Processing Technology

Proximity Sensors

Workbook



529939

Order no.:	529939
Description:	ARBEITSBUCH
Designation:	D.LW-FP1110-GB
Edition:	11/01
Author:	Frank Ebel
Graphics:	Bärbel Böhland, Frank Ebel
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Contents

Preface

The workbook was designed for the equipment set of function package FP1110 - Proximity Sensors.

This workbook provides basic knowledge of proximity sensors in conjunction with textbook 'Proximity Sensors' (order no. 093046).

Technical data regarding the equipment used can be found in part D of the workbook.

You will find the order numbers of the individual components on the following pages.

Each exercise consists of exercise sheets and solution sheets. Each exercise sheet contains summarised details of:

- Training aim
- Exercise definition
- Problem description and further explanations for the practical assembly of the exercise
- Sample solution

To assist assembly, a practical layout is included. Special calculations and conclusions are provided in the sample solutions.

Warning
The positioning slide D.ER-VS-FP1110 and the set of test objects D.AS-OS contains strong magnets. Objects of magnetic sensitivity (i.e. floppy disks, cheque cards) should not be placed close to the magnets.

Equipment set FP1110
Order no.: 184474

Qty.	Description	Designation	Order no.
1	Sensor unit, magnetic 1, Reed contact	D:ER-SMEO-PP-SIBU	167056
1	Sensor unit, magnetic 2, contactless	D:ER-SMTO-PP-SIBU	167055
1	Sensor unit, inductive 1	D:ER-SIEH-M18B-PP-SIBU	177466
1	Sensor unit, inductive 2	D:ER-SIEH-M12B-PP-SIBU	177464
1	Sensor unit, optical RT 1, diffuse sensor	D:ER-SOE-RT-Q-PP-SIBU	167068
1	Sensor unit, optical RT 2, diffuse sensor	D:ER-SOE-RT-M18-PP-SIBU	167166
1	Sensor unit, optical RS, retro-reflective sensor	D:ER-SOE-RS-Q-PP-SIBU	167066
2	Sensor unit, optical LL 1 fibre-optic unit	D:ER-SOE-L-Q-PP-SIBU	167065
1	Sensor unit, optical ESS, through-beam sensor emitter	D:ER-SOE-S-Q-PP-SIBU	167064
1	Sensor unit, optical ESE, through-beam sensor receiver	D:ER-SOE-E-Q-PP-SIBU	167067
1	Sensor unit, capacitive	D:ER-SKE-M12-PP-SIBU	177470
1	Sensor unit, ultrasonic	D:ER-SUE-M18-PP-SIBU	184118
2	Fibre-optic cable unit SE, through-beam sensor design	D:ER-SOEZ-LK-SE-PP	150505
1	Fibre-optic cable unit RT, diffuse sensor design	D:ER-SOEZ-LK-RT-PP	150506
1	Reflector unit	D:ER-SOEZ-RFS20-PP	150504
1	Positioning slide *	D:ER-VS-FP1110-ST	034094
1	Distribution unit *	D:ER-VERT-SENSOR-SIBU	162248
1	Counting unit *	D:ER-ZE-FP1110-SIBU	162252
1	Rotary unit *	D:ER-DE-FP1110-SIBU	167097
1	Set of test objects	D:AS-OS	034083
1	Measuring scale 1020 mm	D:ER-LIN-1020	035697
1	Graph paper pad	D:AS-RK	034085
16	Plug-in adapters	D:MP-B-ME-AS	323571

* 4 plug-in adapters are necessary to mount this unit on the profile plate.

Accessories

The following elements are adapted to the equipment set:

Qty.	Description	Designation	Order no.
Courseware			
1	Textbook	D:LB-FP1110-D	093046
Accessories			
1	Vernier caliper	D:AS-MS	035653
1	Digital multimeter	D:AS-DMM	035681
Equipment			
1	Profile plate 1100 x 700 or Profile plate 550 x 700	D:DE-PP-1100 D:DE-PP-550	159411 159409
Power supply			
1	Power supply unit	D:AS-NG-D-115/230V	162417
1	Set of cables	D:AS-KS-4MM-UNI-SIBU	167091

Set of test objects components

Item no.	Material, Dimensions [mm]
1	Magnet 1
2	Magnet 2
3	Mild steel S 235 JR, 90 x 30
4	Stainless steel, 90 x 30
5	Aluminium, 90 x 30
6	Brass, 90 x 30
7	Copper, 90 x 30
8	Cardboard, 90 x 30
9*	Rubber, 90 x 30
10	Plastic, transparent, 90 x 30

Set of test objects components (continued)

Item no.	Material, Dimensions [mm]
11	Mild steel S 235 JR, 30 x 30
12	Mild steel S 235 JR, 25 x 25
13	Mild steel S 235 JR, 20 x 20
14	Mild steel S 235 JR, 15 x 15
15	Mild steel S 235 JR, 10 x 10
16	Mild steel S 235 JR, 5x 5
17	Kodak grey card, 100x 100
18	Plastic, transparent, 100x 100
19	Plastic, red, 100x 100
20	Plastic, blue, 100x 100
21	Plastic, black, 100x 100
22	Cardboard, white, 100 x100
23	Plastic, 2.0 mm thick, 90 x 30
24	Plastic, 3.0 mm thick, 90 x 30
25	Plastic, 5.0 mm thick, 90 x 30
26	Plastic, 8.0 mm thick, 90 x 30
27	Plastic, 11.0 mm thick, 90 x 30
28	Plastic, 14.0 mm thick, 90 x 30
29	Plastic, 17.0 mm thick, 90 x 30
30	Holder for fibre-optic cable
31	Housing (black), cover (blue)
32	Holding brackets for liquid level measurement, through-beam sensor (2)
33	Beaker
34	Test screws (2)
35	Workpiece ‚valve housing'
36	Screw driver

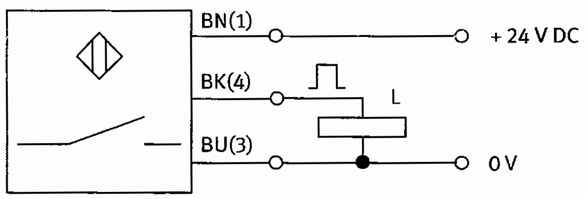
* Component part not identified with a number.

Proximity sensors

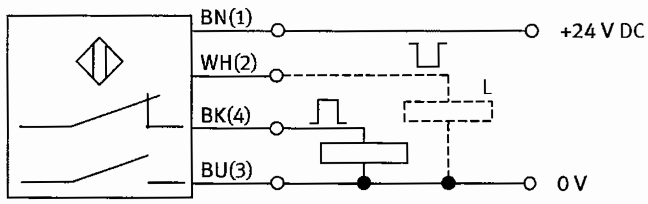
Except for the magnetic proximity sensor with Reed contact (D.ER-SMEO-..), all sensors in this function package are designed as positive switching proximity sensors with transistor output (PNP type). With this type of proximity sensor, the output line is with positive potential in the switched state. With a connected load, one terminal is thus connected to the proximity sensor signal output, while the other terminal is linked to 0 Volt (ground).

We are dealing here with proximity sensors of three and four wire technology. Outputs have either normally open or normally open and normally closed function.

Electrical connection diagram



Connection diagram of a three wire proximity sensor (L=load)



Connection diagram of a four wire proximity sensor (L=load)

Colour coding and connection identification

Operating voltage	
Positive pole	brown
Negative pole (0 V)	blue

Load output	
With three connecting wires	
irrespective of function	black
With four connecting wires	
Normally open function	black
Normally closed function	white

Colour coding for connecting wires of inductive proximity sensors according to Euronorm EN 50 044

The colour coding and the numerical identification of connecting wires is laid down only for inductive proximity sensors in Euronorm EN 50 044. For the other types of proximity sensor, colour coding and numerical identification of connecting wires are not standardised; however, identification codes are frequently based on the Euronorm for inductive proximity sensors.

Operating voltage	
Positive pole	1
Negative pole (0 V)	3

Load output	
Normally open function	4
Normally closed function	2

Numerical identification for connecting wires of inductive proximity sensors according to Euronorm EN 50 044

Colour abbreviations

Colour	Abbreviation
black	BK
brown	BN
blue	BU
red	RD
grey	GY
white	WH

Colour abbreviations according to DIN IEC 757

Further information on technical data concerning proximity sensors will be found in the data sheets.

Components/Exercises Table

Components (Description, Designation)	Exercises 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Profile plate 1100 x 700 D:DE-PP-1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Power supply unit D:AS-ND-D-115/230V	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Set of cables D:AS-KS-4MM-UNI-SIBU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Distribution unit D:ER-VERT-SENSOR-...	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Positioning slide D:ER-VS-FP1110-ST	1	1	1	1	1			1	1	1	1	1	1	1			1		
Counting unit D:ER-ZE-FP1110-SIBU													1	1					1
Rotary unit D:DE-DE-FP1110-SIBU														1					
Sensor unit, magnet. 1 D:ER-SMEO-...	1																		
Sensor unit, magnet. 2 D:ER-SMTO-...		1																	
Sensor unit, inductive 1 D:ER-SIEH-M18B-...			1	1	1													1	
Sensor unit, inductive 2 D:ER-SIEH-M12B-...			1											1					
Sensor unit, capacitive D:ER-SKE-M12-...										1	1					1		1	
Sensor unit, opt. RT 1, D:ER-SOE-RT-Q-...								1											

Components/Exercises
Table (continued)

Components (Description, Designation)	Exercises 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Sensor unit, opt. ESS D:ER-SOE-S-Q-...						1										1			
Sensor unit, opt. ESE D:ER-SOE-E-Q-...						1										1			
Sensor unit, opt. RS D:ER-SOE-RS-Q-...							1												
Reflector unit D:ER-SOEZ-RFS20-...							1												
Sensor unit, opt. LL 1 D:ER-SOE-L-Q-...									1				2	1	1	1	1		2
Fibre-optic cable unit SE D:ER-SOEZ-LK-SE-...													2						2
Fibre-optic cable unit RT D:ER-SOEZ-LK-RT-...									1					1	1	1	1		
Sensor unit, opt. RT 2 D:ER-SOE-RT-M18-...								1											
Sensor unit, ultrasonic D:ER-SUE-M18-...												1							
Measuring scale 1020 mm D:AS-LIN-1020								1				1							
Vernier caliper D:AS-MS	1	1	1	1	1				1	1	1		1	1					
Digital multimeter D:AS-DMM														1				1	
Set of test objects D:AS-OS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Graph paper pad D:AS-RK						1	1	1				1			1				

Notes on safety and operation

In the interest of your own safety you should observe the following:

- Observe general safety regulations!
  (DIN 58126 and VDE 100).
- Use only low voltages of ≤ 24 V.
- All components are provided with 4 mm safety sockets respectively safety plugs.
  For electical connections use only electrical cable with safety plugs.
- Switch off the voltage supply before connecting or disconnecting the circuit.
- The positioning slide D.ER-VS-FP1110 and the set of test objects D.AS-OS contains strong magnets. Objects of magnetic sensitivity (i.e. floppy disks, cheque cards) should not be placed close to the magnets.
- When the operating voltage is switched on, the motor starts up immediately with a rotational speed of about 2500 r.p.m.

Part A

Part A Exercises

Magnetic proximity sensors

Inductive proximity sensors

Optical proximity sensors

Capacitive proximity sensors

Exercise 1
Switching characteristics of a contacting magnetic proximity sensor

Training aim

To learn about the switching characteristics of a contact based magnetic proximity sensor (Reed contact) as a function of position and orientation of a magnet.

Exercise definition

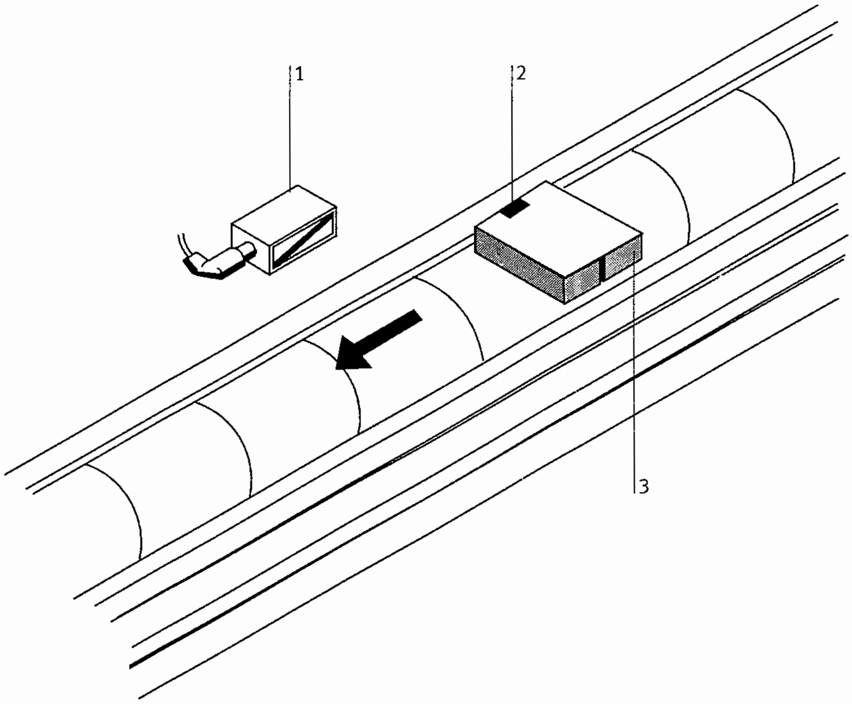
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

Metallic workpiece supports are transported on a conveyor. The position of a workpiece support is to be defined by means of a contact-based magnetic sensor (Reed contact). For this purpose, a permanent magnet is fitted to the workpiece support. Define the switching curve of this sensor.

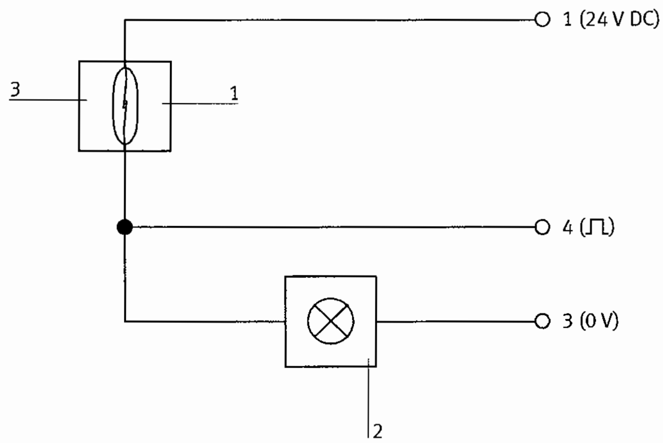
Positional sketch



Proximity sensor (1), Magnet (2), Workpiece support (3)

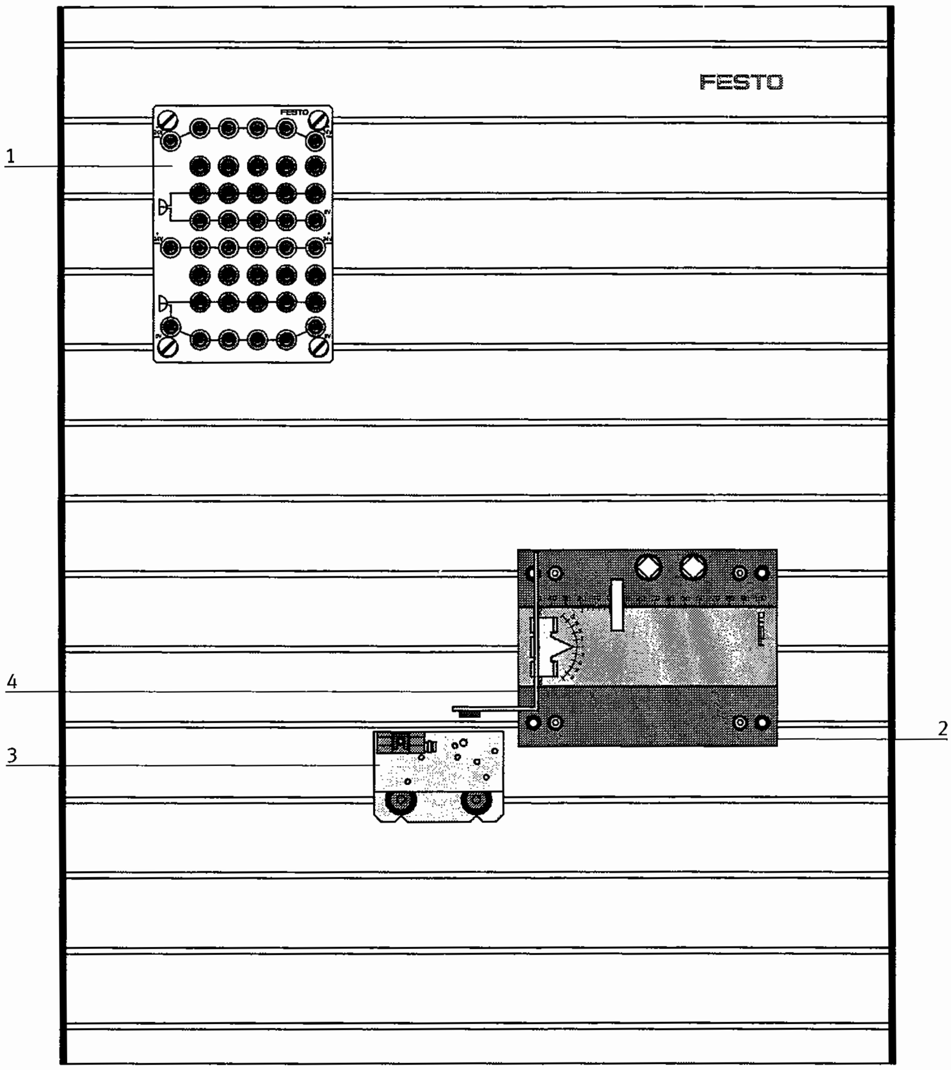
Function description

The magnetic field sensitive Reed contact is located behind a black plastic plate. The magnetic field of a permanent magnet switches the Reed contact by contactless means. The Reed contact consists of two separate flexible blades made from soft magnetic material, fitted in a hermetically sealed glass tube. When placed in an external magnetic field, these blades touch and establish an electrical contact.



Reed contact (1), Switching status indicator (LED) (2), Active zone (3)

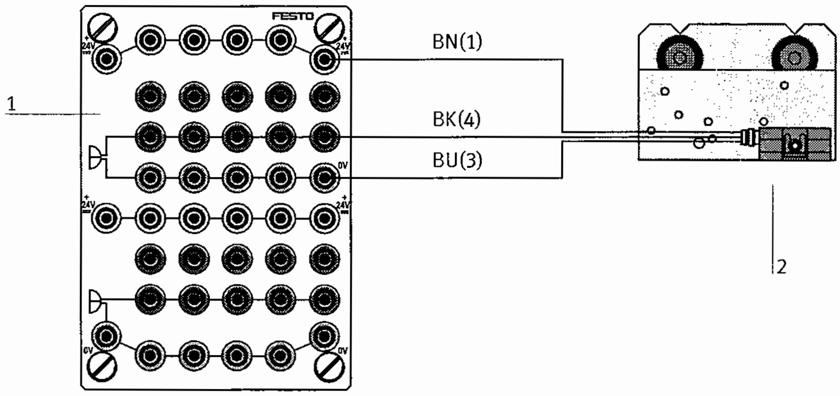
Layout



Components list

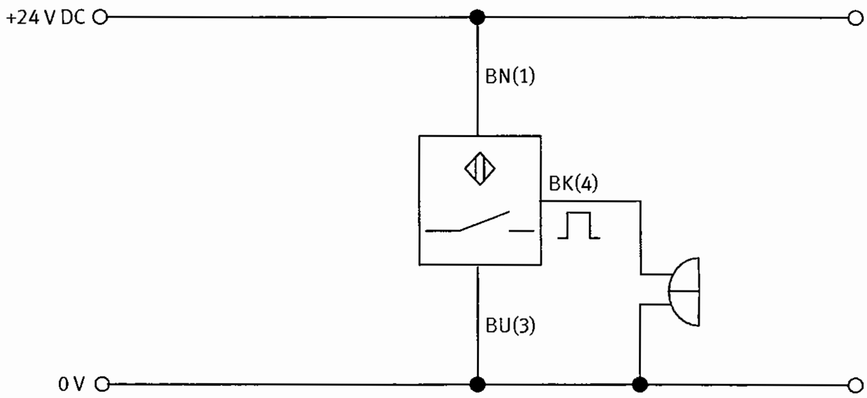
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Magnetic sensor unit 1, D:ER-SMEO-...
4	1	Set of test objects, magnet 1, part 1
	1	Set of test objects, magnet 2, part 2

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Magnetic sensor unit 1, D:ER-SMEO-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit, the positioning slide and the magnetic sensor unit 1 on the profile plate. Mount the magnetic sensor unit laterally offset by 5 cm in relation to the centre of the positioning slide (see fig. "Layout"). Connect the 24V electrical power supply and the magnetic proximity sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Experiment 1
Take magnet 1 (part 1) from the set of test objects and attach it to the material retainer of the positioning slide.

Move the magnet along the axis of the proximity sensor. Write down the points at which the proximity sensor responds to the magnet. You recognise this response by the illumination of the LED built into the proximity sensor and the sounding of the buzzer forming part of the distribution unit. Enter the response points into the diagram on the following page. The distance between magnet and proximity sensor is increased in 2 mm steps (in correspondence with the division on the magnet holder, starting from 0 mm; the displacement path of the positioning slide (stroke) is selected 50 mm in relation to the centre of the active area of the proximity sensor. The displacement path must be fully travelled for each measurement.

Mounting the vernier caliper
When mounting the vernier caliper, the slide unit of the positioning slide is set to "0". The two pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate flush with the edge in such a way, that the front pointer rests against the stop for the vernier caliper. The two retaining magnets retain the caliper body to the base plate of the positioning slide.

Experiment 2

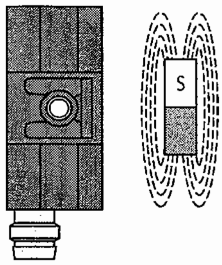
Now take magnet 2 (part 2) from the set of test objects and repeat the procedure described above. Again record the response points and mark the values in the diagram.

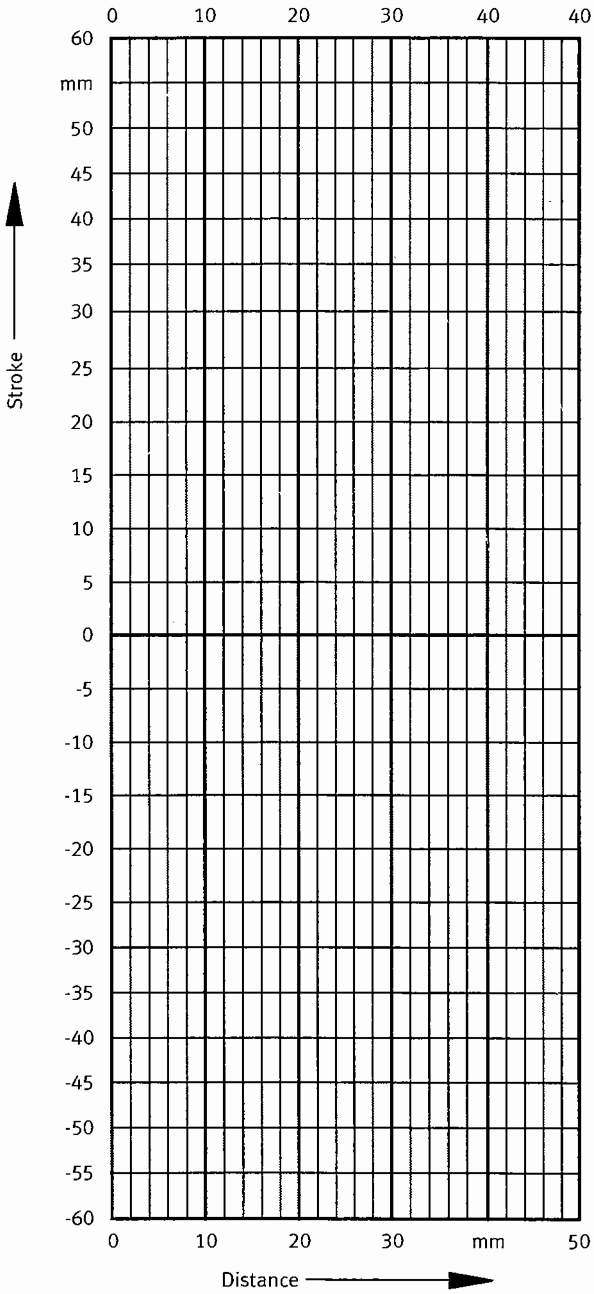
Note

When making your measurements, observe that the switch-on and switch-off points of the proximity sensor do not coincide: let the magnet approach the inactive proximity switch from the left, until this changes its switching status, thus obtaining its switch-on point. Now move the magnet away towards the left until the proximity sensor changes from the active to the inactive state, thus obtaining the switch-off point. The distance travelled between the two points is described as hysteresis.

Evaluation
Experiment 1

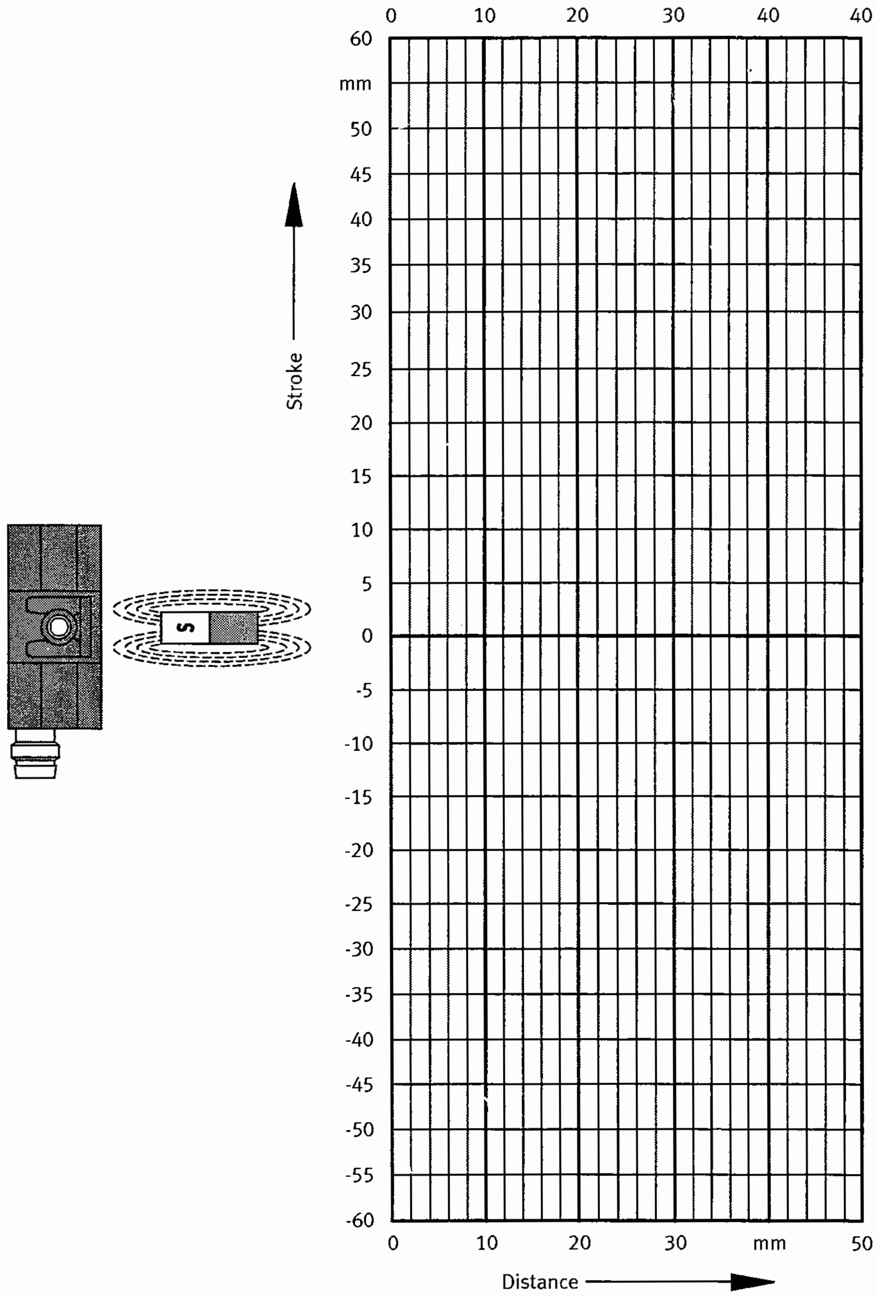
Magnet 1 (part1)





Evaluation
Experiment 2

Magnet 2 (part 2)



Exercise 2
Switching characteristics of a contactless magnetic proximity sensor

Training aim

To learn about the switching characteristics of a magnetic proximity sensor with electronic output dependent on position and orientation of a magnet.

Exercise definition

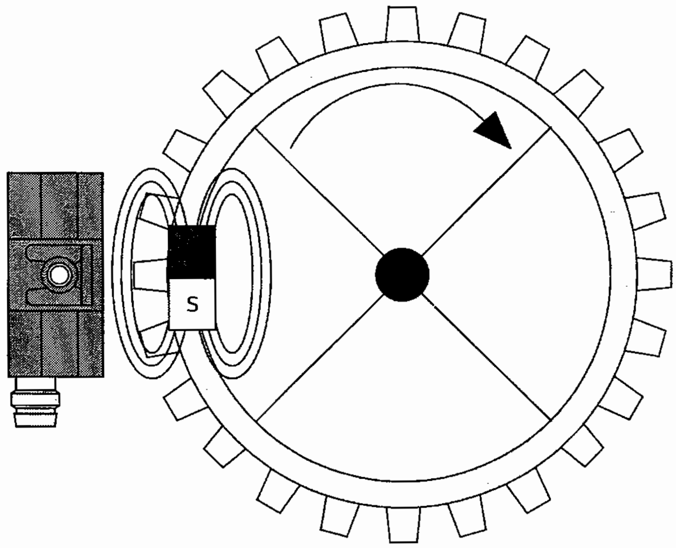
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

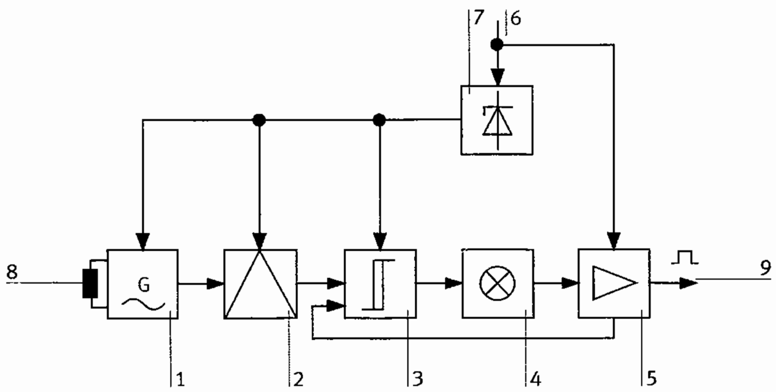
In order to measure the rotation rate of a non-metallic gear wheel, it is intended to use a contactless proximity sensor. For this purpose, a magnet is attached to a positon on the gear wheel. In order to achieve reliable switching, the switching curve of this proximity switch is to be recorded. The influence of the orientation of the axis of the magnetic poles is also to be investigated.

Positional sketch



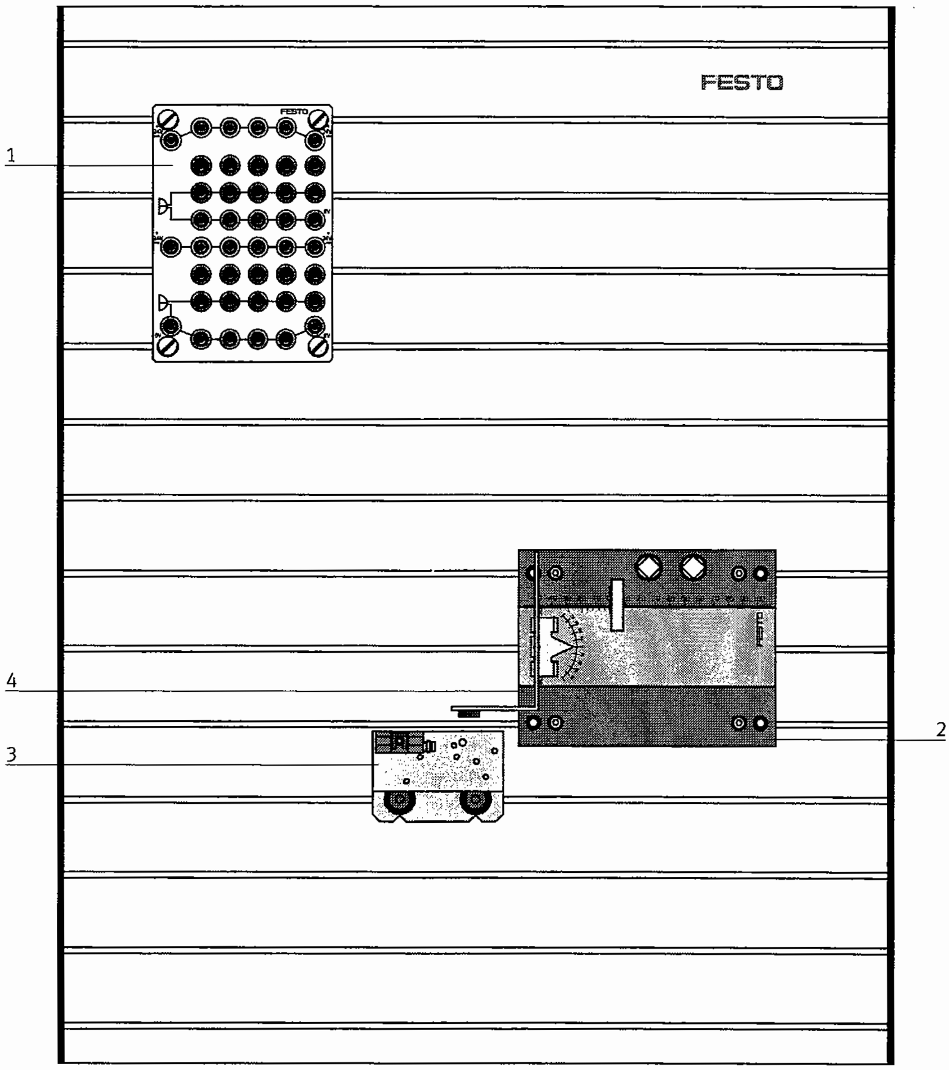
Function description

With this contactless sensor (D.ER-SMTO-..), the magnetic field sensitive area is identified with a blue dot. The detection of the magnetic field is achieved through the tuning of an oscillator which is built into the sensor. As the magnet approaches, the ferrite core of a high-frequency oscillator is saturated. This varies the current in the oscillator circuit. The current change is converted into an output signal by means of an amplifier circuit.



Oscillator (1), Demodulator (2), Triggering stage (3), Switching status indicator (LED) (4), Output stage with protective circuit (5), External voltage (6), Internal stabilised voltage (7), Active switching zone (coil) (8), Switching output (9)

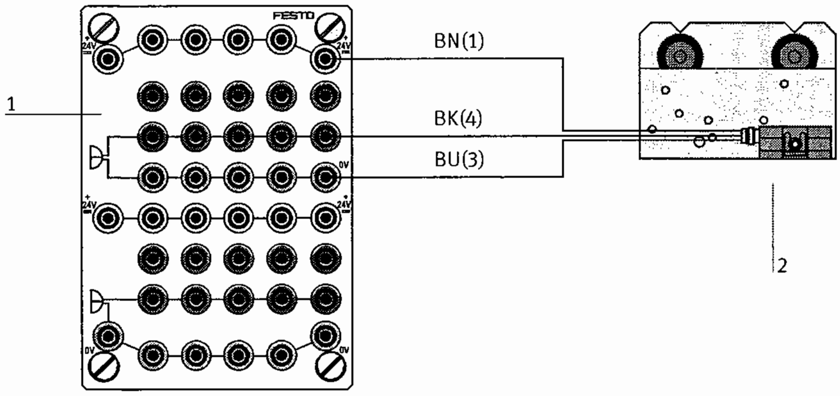
Layout



Components list

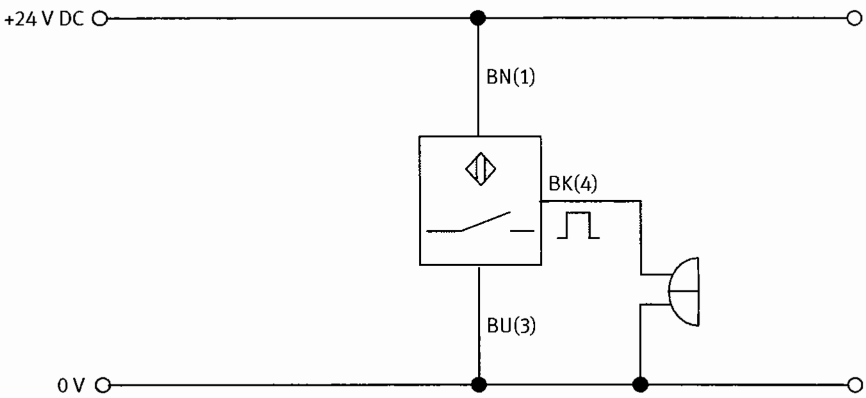
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Magnetic sensor unit 2, D:ER-SMTO-...
4	1	Set of test objects, magnet 1, part 1
	1	Set of test objects, magnet 2, part 2

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Magnetic sensor unit 2, D:ER-SMTO-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit, the positioning slide and the magnetic sensor unit 2 on the profile plate. Mount the magnetic sensor unit 5 cm offset from the centre of the positioning slide (see fig. "Layout"). Connect the 24V electrical power supply and the magnetic sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Experiment 1
Take magnet 1 (part 1) from the set of test objects and fit it into the material fixture of the positioning slide.

Move the magnet along the axis of the sensor. Make a note of the points where the sensor responds to the magnet. This response can be seen by illumination of the LED, which is built into the magnetic sensor, and by the sounding of the buzzer, which is built into the distribution unit. Record the results in the evaluation tables. The magnet-sensor distance starting from 0 mm increases in steps of 2 mm (in correspondence with the division of the magnet holder), the displacement path for the positioning slide (stroke) is selected 50 mm in relation to the centre of the active area of the sensor (blue dot). The displacement path must be fully travelled for each measurement.

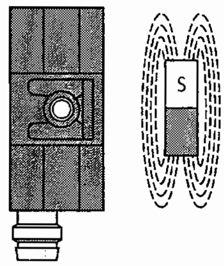
Mounting the vernier caliper
When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

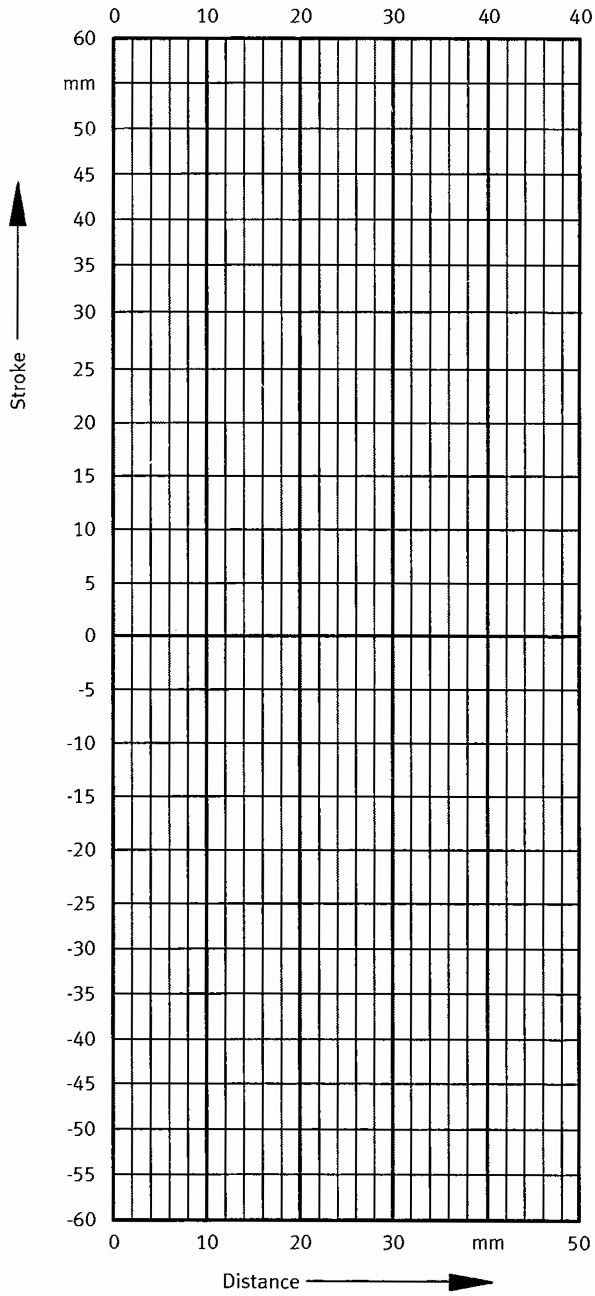
Experiment 2
Now take magnet 2 (part 2) from the set of test objects and repeat the above procedure. Again, make a note of the switching points.

Note
When making your measurement, observe that the switch-on and switch-off points of the proximity sensor do not coincide: let the magnet approach the inactive proximity switch from the left, until this changes its switching status, thus obtaining its switch-on point. Now move the magnet away towards the left until the sensor changes from the active to the inactive state, thus obtaining the switch-off point. The distance travelled between the two points is described as hysteresis.

Evaluation
Experiment 1

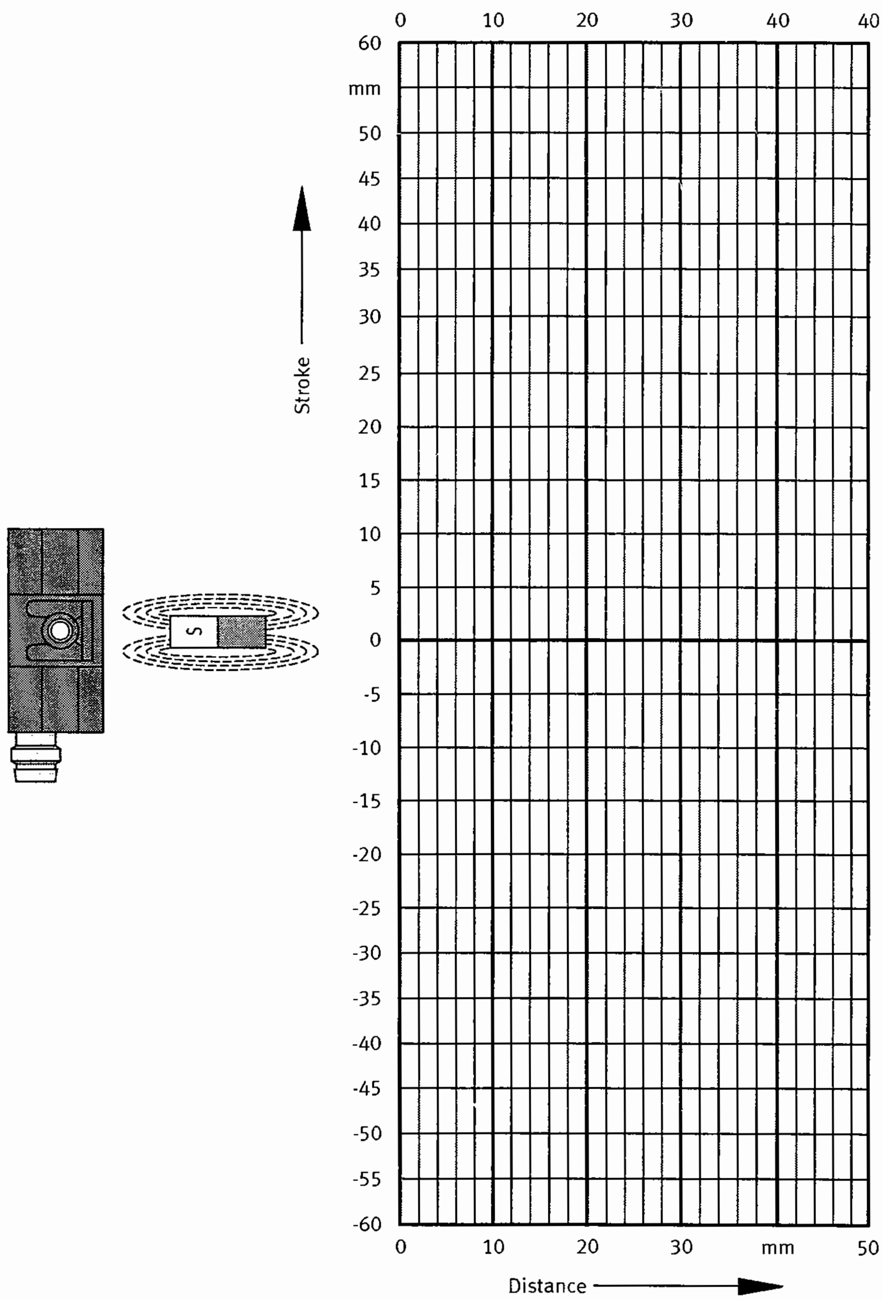
Magnet 1 (part 1)





Evaluation
Experiment 2

Magnet 2 (part 2)



Exercise 3
Switching distance of an inductive proximity sensor

Training aim

To learn about the switching characteristics of an inductive proximity sensor.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

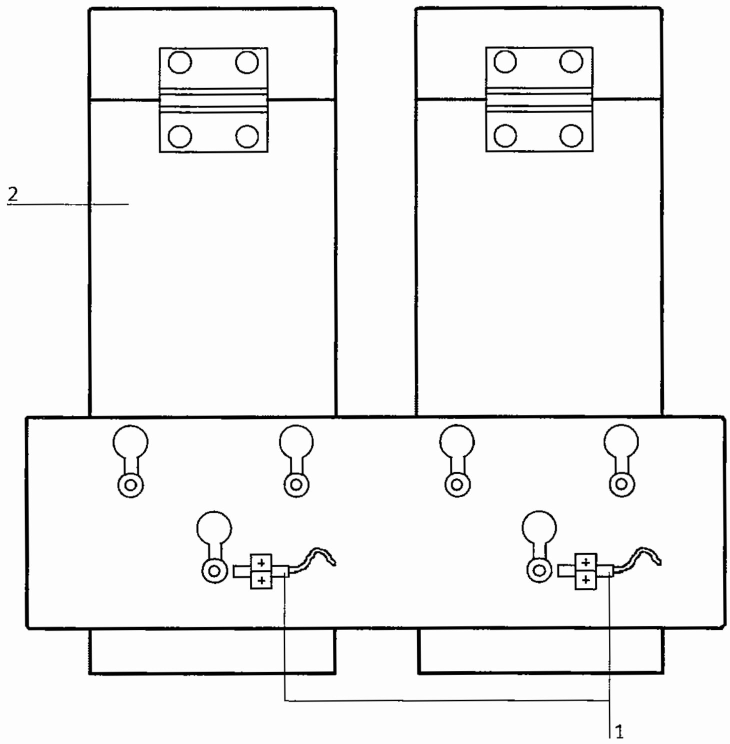
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

On an assembly station the presence of magazine shafts is monitored using inductive sensors. Measure the switching distance of various inductive sensors in order to determine the switching distance between a metal object and the sensor.

Positional sketch

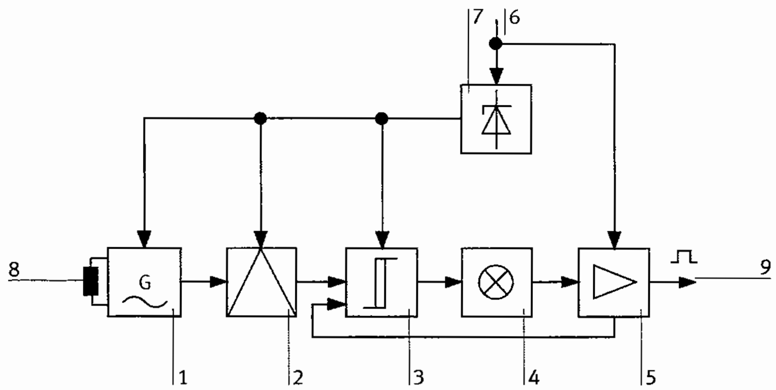


Inductive proximity switch (1), Magazine shaft (2)

Function description

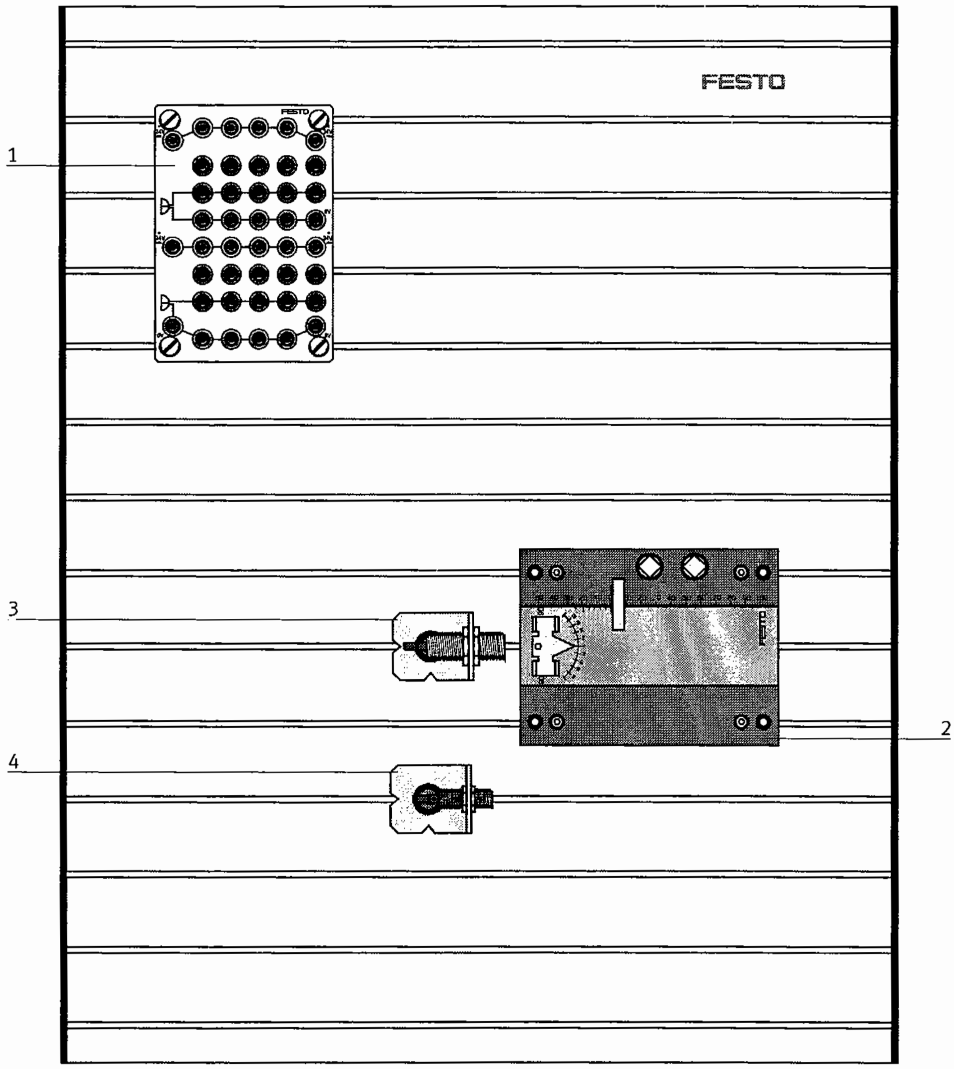
Inductive sensors contain an oscillator circuit, which consists of a parallel resonance circuit with inductance and capacitance as well as an amplifier. By means of a ferrite shell core of the inductance (coil), the electromagnetic field is directed towards the outside.

If an electrically conductive material is introduced into the electromagnetic stray field then, according to the laws of inductance, eddy currents are created, which attenuate oscillation. Depending on the conductivity, the dimensions and the distance of the approaching object, the oscillator can be attenuated to such an extent that oscillation stops. Attenuation of the oscillator is evaluated via subsequent electronic devices, and an output signal generated.



Oscillator (1), Demodulator (2), Triggering stage (3), Switching status indicator (LED) (4), Output stage with protective circuit (5), External voltage (6), Internal stabilised voltage (7), Active switching zone (coil) (8), Switching output (9)

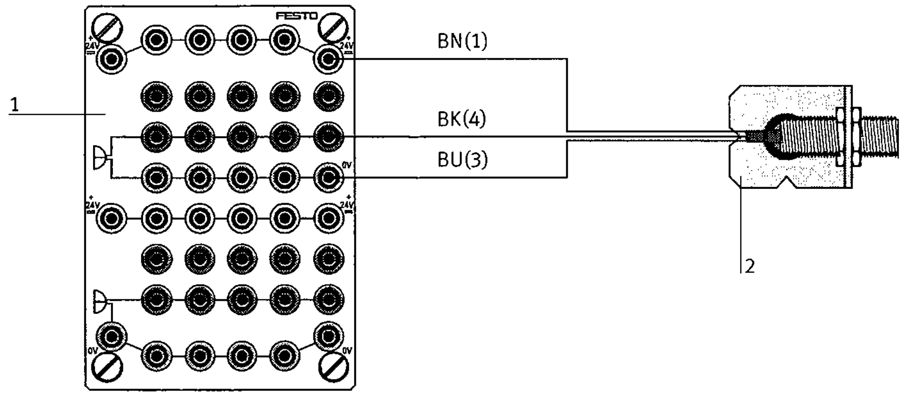
Layout



Components list

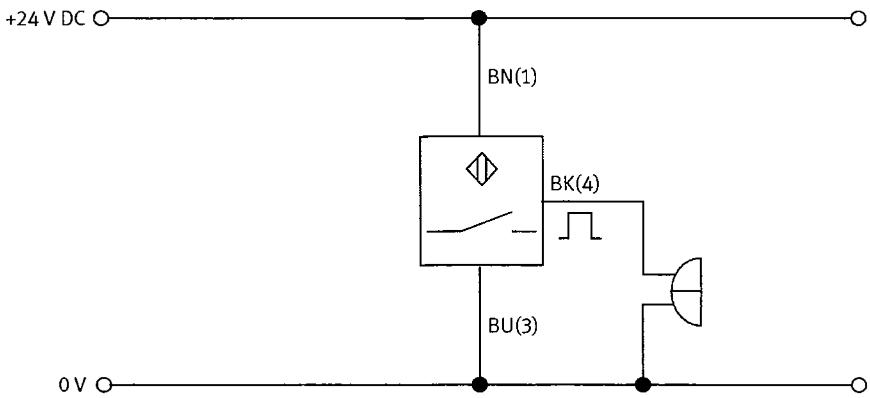
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Inductive sensor unit 1, D:ER-SIEH-M18B-...
4	1	Inductive sensor unit 2, D:ER-SIEH-M12B-...
	1	Set of test objects, mild steel S 235 JR, part 3

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Inductive sensor unit 1, D:ER-SIEH-M18B-... or Inductive sensor unit 2, D:ER-SIEH-M12B-...

Electrical circuit diagram



Practical assembly 1

Mount the distribution unit, the positioning slide and the inductive sensor unit 1 onto the profile plate. The inductive sensor is mounted centrally in front of the middle of the positioning slide (see fig. "Layout"). Connect the 24V electrical power supply and the inductive sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Now take the calibrating plate in mild steel (S 235 JR, part 3) from the set of test objects and fit it into the material fixture of the positioning slide.

Measure the switching distance of the sensor. Make a note of the point, at which the signal change occurs when the plate approaches the sensor, and also the point at which the signal change occurs when you move the plate away from the sensor. The difference between these two points is the hysteresis of the sensor.

Hysteresis (mm) = Switch-off point (mm) – Switch-on point (mm)

Practical assembly 2

Carry out the same measurements with the inductive sensor unit 2.

Repeat the measurements several times in order to check the reproducability of the switching distance.

Mounting the vernier caliper
When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Evaluation

Inductive sensor unit 1 (D:ER-SIEH-M18B-...)	
Switch-on point:	
Switch-off point:	
Hysteresis:	

Inductive sensor unit 2 (D:ER-SIEH-M12B-...)	
Switch-on point:	
Switch-off point:	
Hysteresis:	

Conclusions

Exercise 4
Sensing of different metals with inductive proximity sensors

Training aim

To learn that the switching distance of inductive proximity sensors is dependent on materials when sensing different metals.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

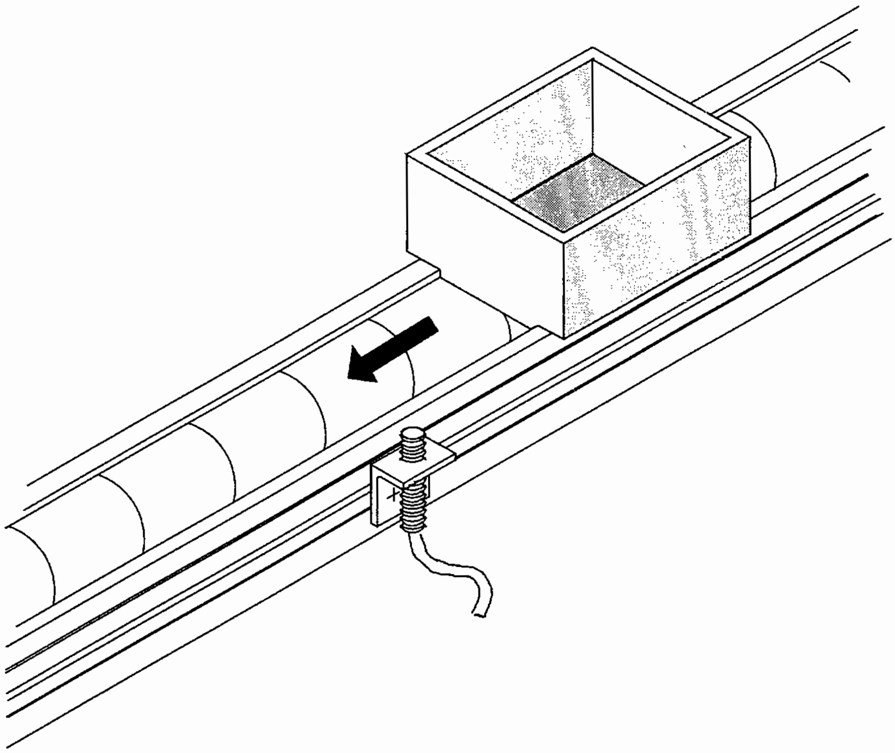
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

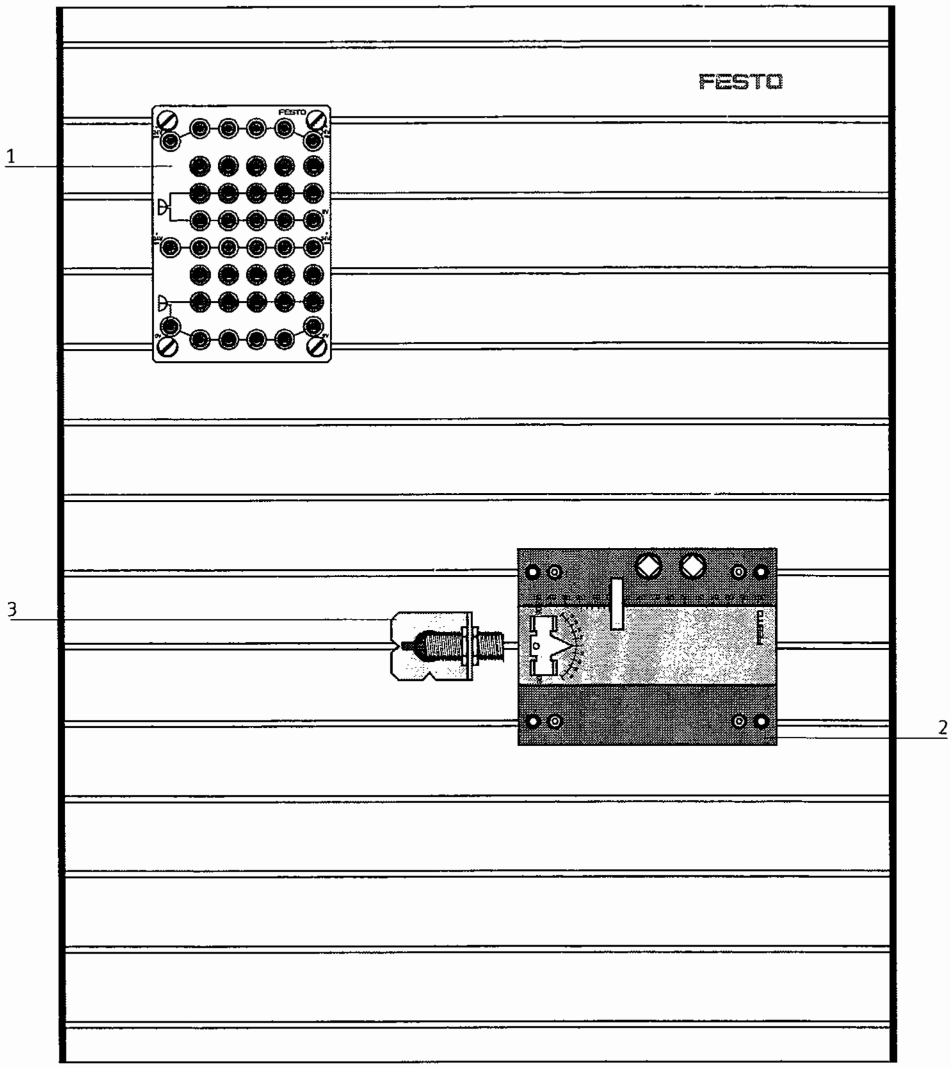
Problem description

On a conveyor, metal containers are used for the transport of assembly parts. The position of the containers on the individual station is defined by means of an inductive sensor. A selection of containers in different materials is available. The effect of the different materials on the switching distance is to be examined.

Positional sketch



Layout



Components list

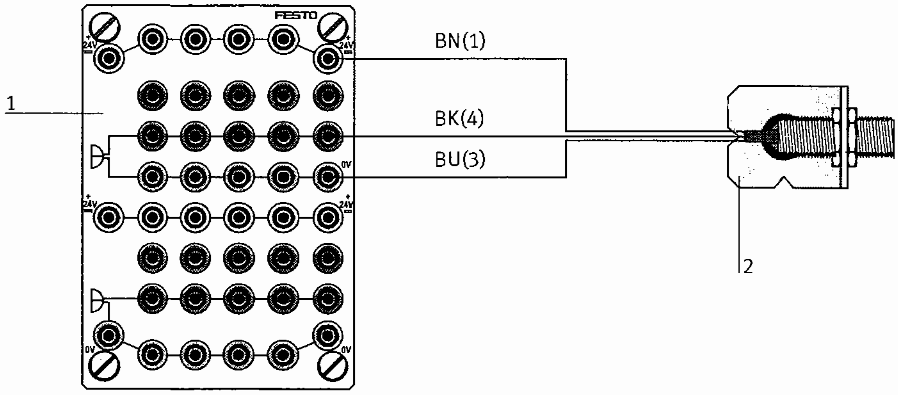
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Inductive sensor unit 1, D:ER-SIEH-M18B-...

The components list is continued on the following page.

Components list (continued)

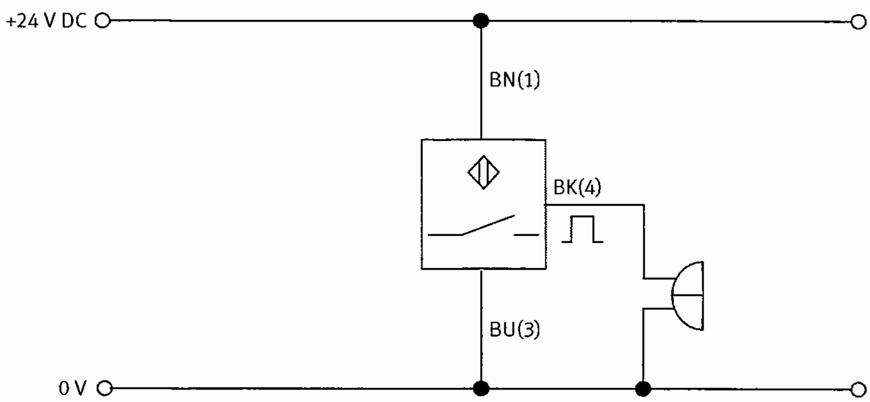
Item no.	Qty.	Designation
	1	Set of test objects, mild steel S 235 JR, part 3
	1	Set of test objects, stainless steel, part 4
	1	Set of test objects, aluminium, part 5
	1	Set of test objects, brass, part 6
	1	Set of test objects, copper, part 7

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Inductive sensor unit 1, D:ER-SIEH-M18B-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit, the positioning slide and the inductive sensor unit 1 on the profile plate. The inductive sensor is to be mounted centrally in front of the positioning slide (see fig. "Layout"). Connect the 24V electrical power supply and the inductive sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Measure the switching distance of the sensor for the different materials from the set of test objects. Make a note of the point at which the change-over occurs, when the plate approaches the sensor, as well as of the point of change-over when you move the plate away from the sensor.

Take the mild steel plate (S 235 JR, part 3) from the set of test objects and fit it into the material fixture of the positioning slide.

Take the various metal plates (stainless steel, aluminium, brass and copper) from the set of test objects and carry out the measurements.

Determine the reduction factor of the switching distance for the different materials. The reduction factor for mild steel (S 235 JR) is 1. With the other items, you can obtain their respective value by dividing the determined switching distance by the value of the switching distance for mild steel.

Mounting the vernier caliper

When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Evaluation

Material	Switch-on point [mm]	Switc-off point [mm]	Hysteresis [mm]	Reduction factor
Mild steel S 235 JR, part 3				1
Stainless steel, part 4				
Aluminium, part 5				
Brass, part 6				
Copper, part 7				

Conclusions

Exercise 5
Influence of the object surface on the switching distance

Training aim

To learn about the influence of objects of different size on the switching distance of an inductive proximity sensor.

Exercise definition

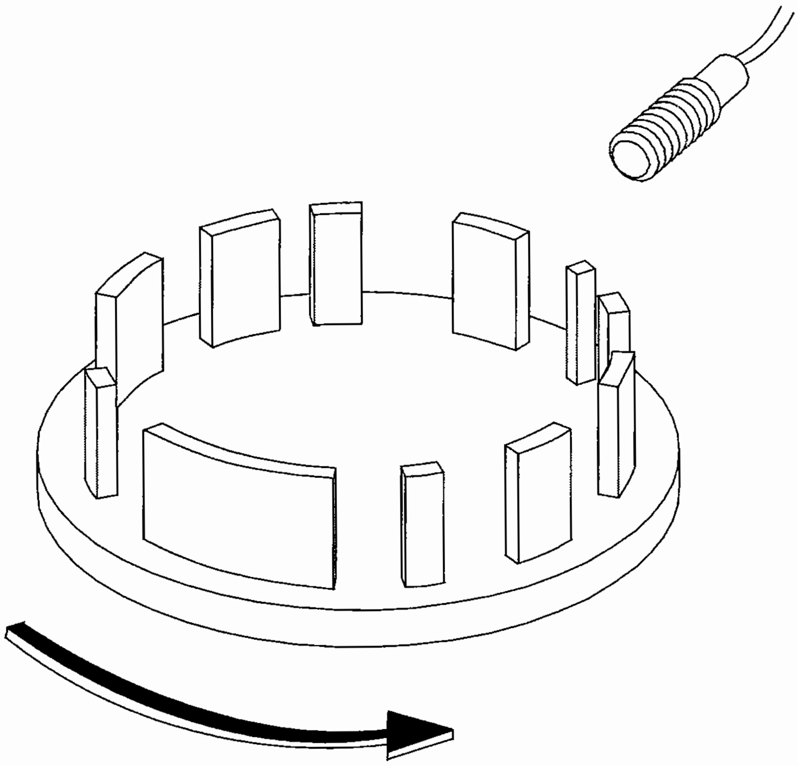
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

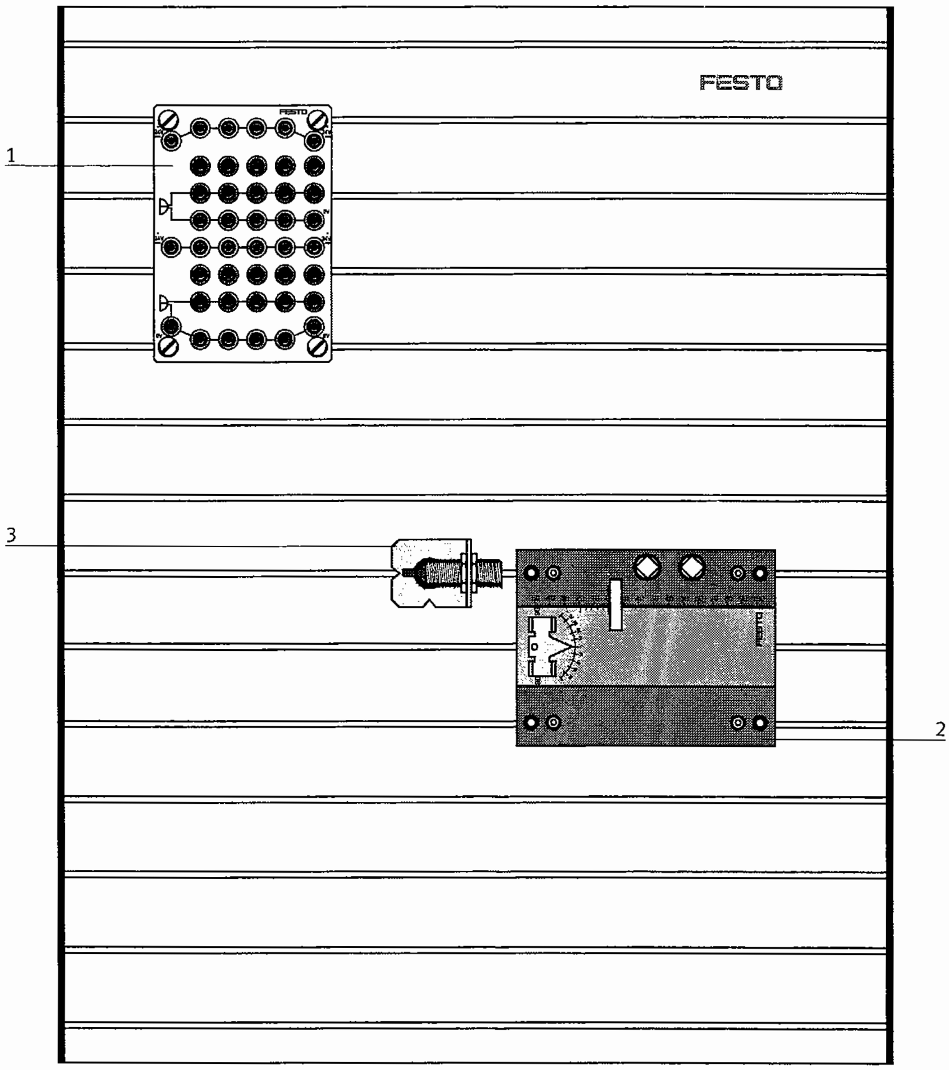
Problem description

Metallic objects of different size must be detected on a rotary indexing table by an inductive sensor. Only parts made from mild steel (S 235 JR) are to be detected. Investigate the influence of the object size on the switching distance of the sensor.

Positional sketch



Layout



Components list

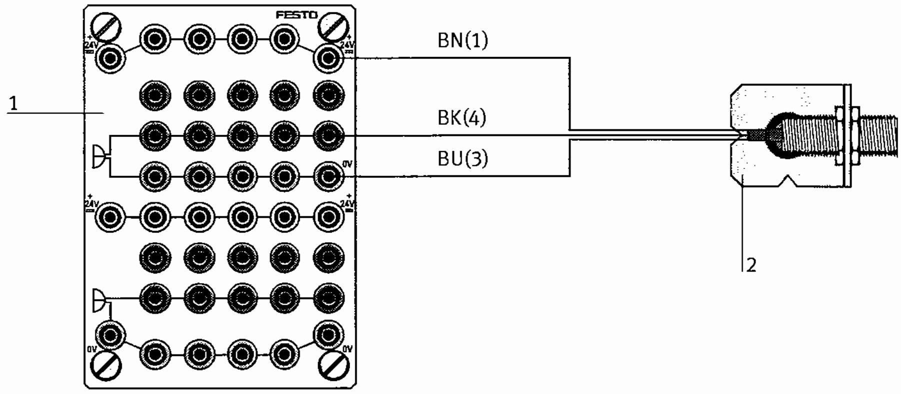
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Inductive sensor unit 1, D:ER-SIEH-M18B-...

The components list is continued on the following page.

Components list (continued)

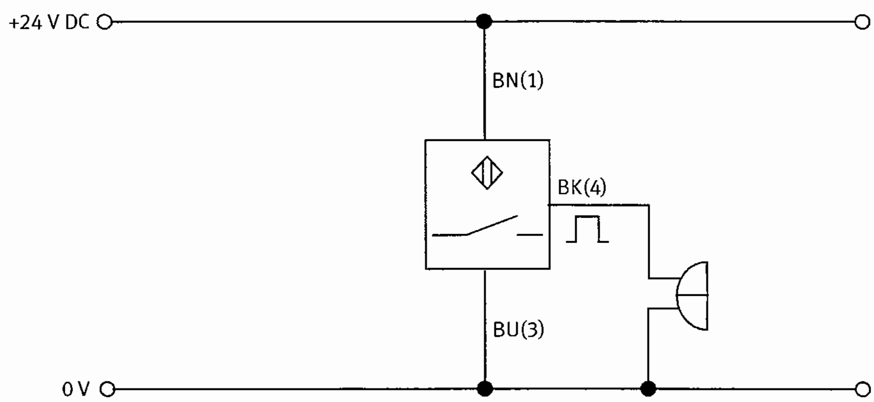
Item no.	Qty.	Designation
	1	Set of test objects, mild steel S 235 JR, 30 mm x 30 mm, part 11
	1	Set of test objects, mild steel S 235 JR, 25 mm x 25 mm, part 12
	1	Set of test objects, mild steel S 235 JR, 20 mm x 20 mm, part 13
	1	Set of test objects, mild steel S 235 JR, 15 mm x 15 mm, part 14
	1	Set of test objects, mild steel S 235 JR, 10 mm x 10 mm, part 15
	1	Set of test objects, mild steel S 235 JR, 5 mm x 5 mm, part 16

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Inductive sensor unit 1, D:ER-SIEH-M18B-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit, the positioning slide, and the inductive sensor unit 1 on the profile plate. The inductive sensor should be mounted offset by 5 cm against the centre of the positioning slide (see fig. "Layout"). Connect the 24V electrical power supply and the inductive sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Take the mild steel plates of different length (parts 11 - 16) from the set of test objects and carry out the measurements. Measure the switching distance of the proximity sensor for each of the plates. Make a note of the measurements at which a signal change occurs when the plates approach the sensor.

Mounting the vernier caliper

When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Note

The object of this exercise is to determine the relation between the switching distance and the size of the object. Standard EN 50 010 specifies a standard calibrating plate for defining the nominal switching distance. The standard calibrating plate for an inductive sensor is 1 mm thick and has an edge length either of the diameter of the inscribed circle of the active surface of the sensor or three times the length of the nominal switching distance of the sensor, whichever value is the larger.

For the sensor used, the nominal switching distance is 7 mm and the diameter of the active surface 16 mm. The standard calibrating plate sides must thus have a length of 21 mm.

Evaluation

Length of sides	Switching gap [mm]
Mild steelS 235 JR, part 11: 30 mm	
Mild steel S 235 JR, part 12: 25 mm	
Mild steel S 235 JR, part 13: 20 mm	
Mild steel S 235 JR, part 14: 15 mm	
Mild steel S 235 JR, part 15: 10 mm	
Mild steel S 235 JR, part 16: 5 mm	

Conclusions

Exercise 6
Response characteristics of a through-beam sensor

Training aim

To learn about the response of a through-beam sensor and how to determine the suitable materials for detection.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

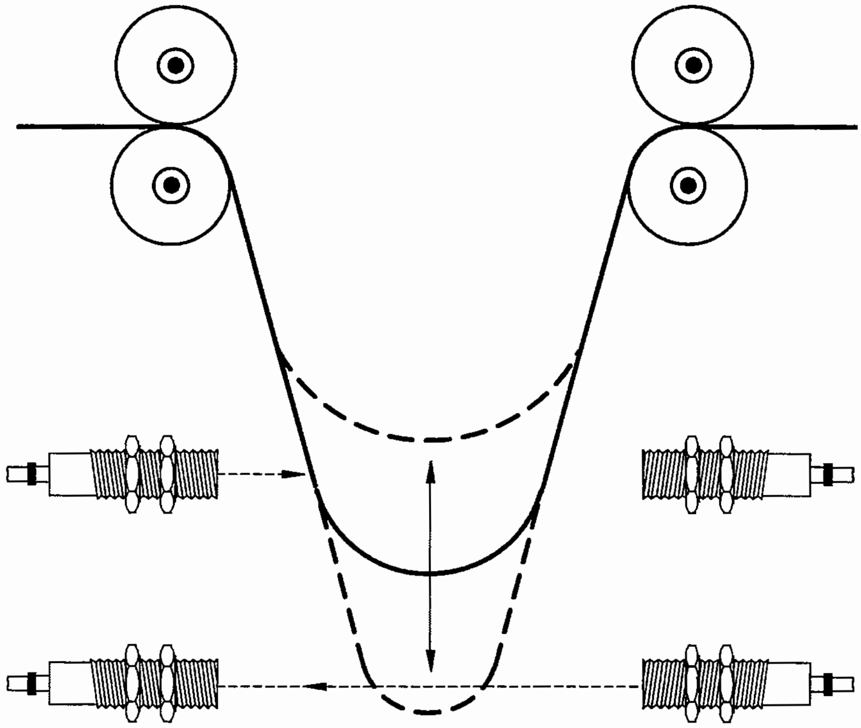
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

Two through-beam sensors are to be used for the loop control of a tape tensioning installation. Different materials have to be detected. Examine the response of a through-beam sensor to different materials.

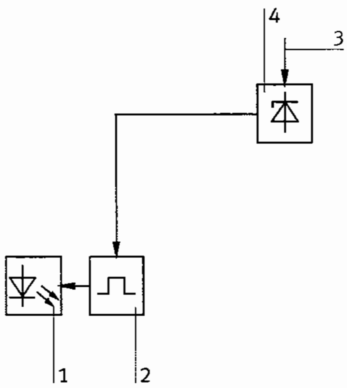
Positional sketch



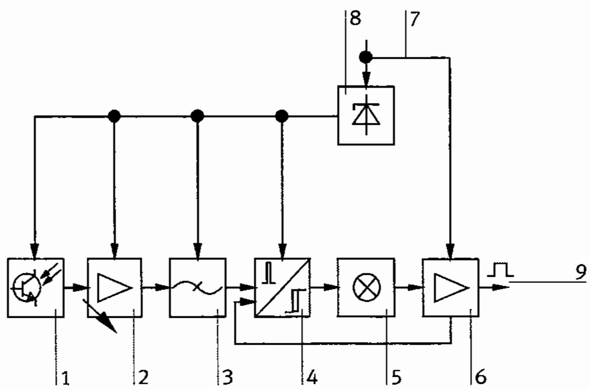
Function description

Optical sensors consist of two main parts, the emitter and the receiver. With through-beam sensors, these are housed separately.

The emitter consists of light emitting diodes. They emit in the red or infra-red range of wave length. This light is detected by means of suitable receivers. An object can break the existing light connection between emitter and receiver. The object to be detected should only let through a very small amount of the light beam, but may reflect any amount of light.

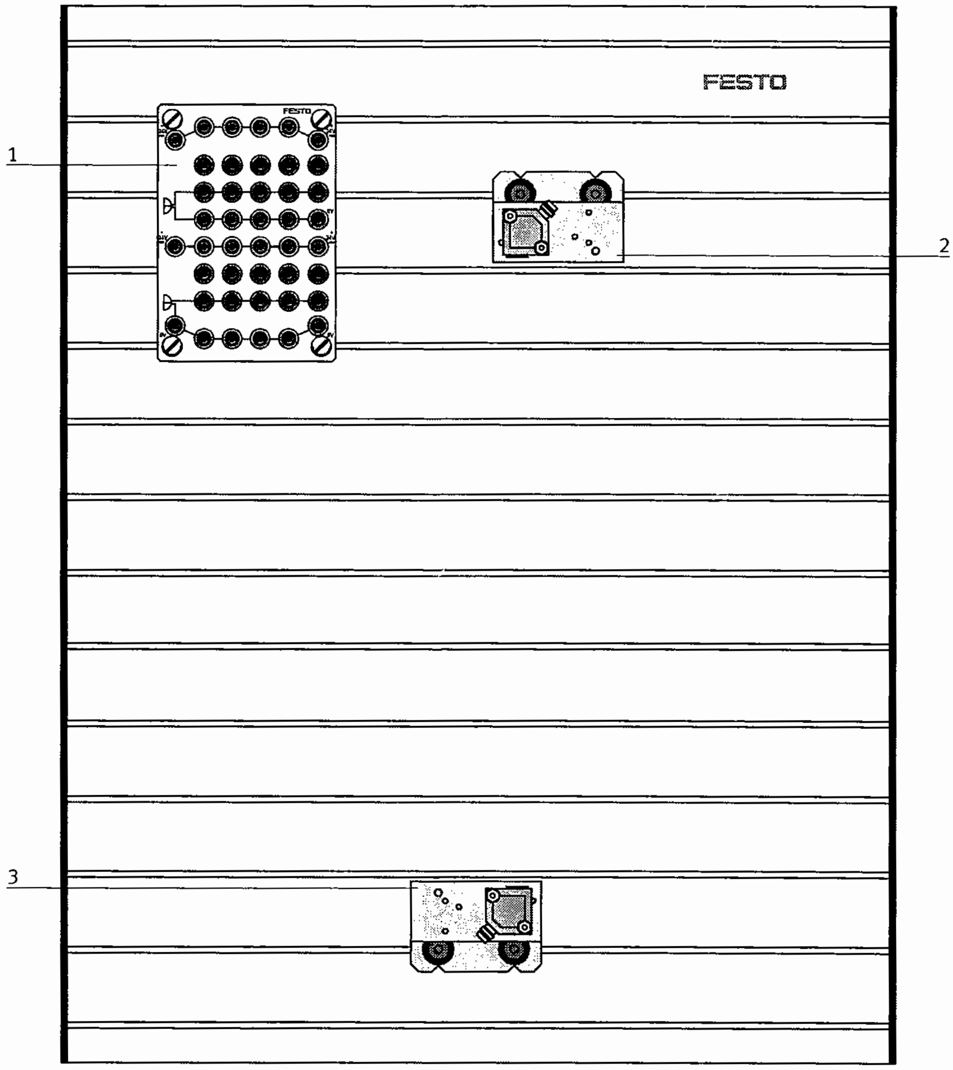


Photoelectric emitter (1), Oscillator (pulse generator) (2), External voltage (3), Internal stabilised voltage (4)



Photoelectric receiver (1), Preamplifier with potentiometer (2), Bandpass (filter) (3), Pulse level converter (4), Switching status indicator (LED) (5), Output stage with protective circuit (6), External voltage (7), Internal stabilised voltage (8), Switching output (9)

Layout



Components list

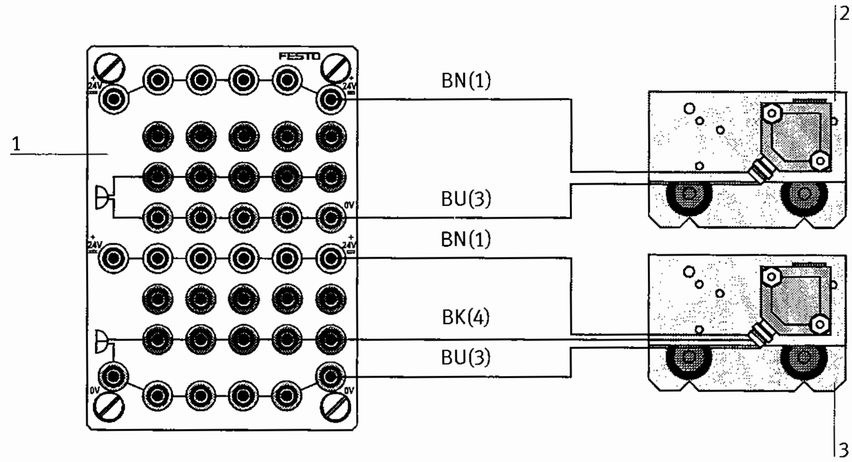
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit ESS, D:ER-SOE-S-Q-...
3	1	Optical sensor unit ESE, D:ER-SOE-E-Q-...

The components list is continued on the following page.

Components list (continued)

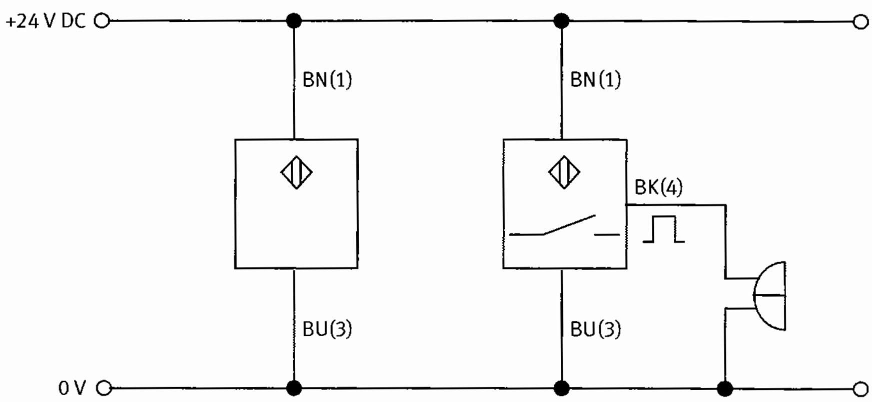
Item no.	Qty.	Designation
	1	Set of test objects, Kodak grey card, 100 mm x 100 mm, part 17
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, stainless steel, 90 mm x 30 mm, part 4
	1	Set of test objects, aluminium, 90 mm x 30 mm, part 5
	1	Set of test objects, cardboard, 90 mm x 30 mm, part 8
	1	Set of test objects, pubber, 90 mm x 30 mm, part 9
	1	Set of test objects, plastic, transparent, 90 mm x 30 mm, part 10
	1	Graph paper pad, D:AS-RK
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit ESS, D:ER-SOE-S-Q-...
3	1	Optical sensor unit ESE, D:ER-SOE-E-Q-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit and the optical sensor units ESS and ESE (through-beam sensor emitter and through-beam sensor receiver) on the profile plate. Select a distance of 40 cm between the emitter and the receiver. Connect the 24V electrical power supply and the emitter and the receiver to the distribution unit (see fig. "Electrical connections"). Connect the normally open output (black safety plug) of the receiver to a buzzer socket (see fig. "Electrical connections").

Examine the response to different materials: Set the adjustable potentiometer of the through-beam sensor receiver at the maximum value (turn the screw clockwise, max. 12 revolutions). Guide the objects into the light beam of the through-beam sensor. Enter your results in the table.

It may be necessary to adjust the potentiometer setting of the through-beam sensor receiver, in order to achieve the detection of certain materials.

Note
For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

Now test the response range of the through beam: Set the potentiometer at the maximum value. Insert graph paper pad under the emitter. Guide the Kodak grey card into the light beam from the side, with the white side facing the emitter, and make a note of the switch-on points on the graph paper pad. Measure in gaps of 2 cm along the optical axis. Introduce the Kodak grey card alternatively from the right and the left into the light beam.

Note
The emitter's black cable with black safety plug serves to simulate light beam interruption. The emitter's light source is deactivated by applying a 24 V DC control voltage to this plug.

When making your measurements, observe that the switch-on and switch-off points of the proximity sensor do not coincide. Bring the Kodak grey card towards the unactuated proximity sensor, e.g. from the left, until it changes its switching-on state. In this way, you obtain the switching-on point. Now move the Kodak grey card back to the left until the proximity sensor changes from the actuated to the unactuated state, thus obtaining the switch-off point. The difference between these two points is known as hysteresis.

Evaluation

Material	Detection yes/no
Mild steel S 235 JR, part 3	
Stainless steel, part 4	
Aluminium, part 5	
Cardboard, part 8	
Rubber, part 9	
Plastic, transparent, part 10	

Conclusions

Exercise 7
Response characteristics of a retro-reflective sensor

Training aim

To learn about the range of applications and the response characteristics of a retro-reflective sensor.

Exercise definition

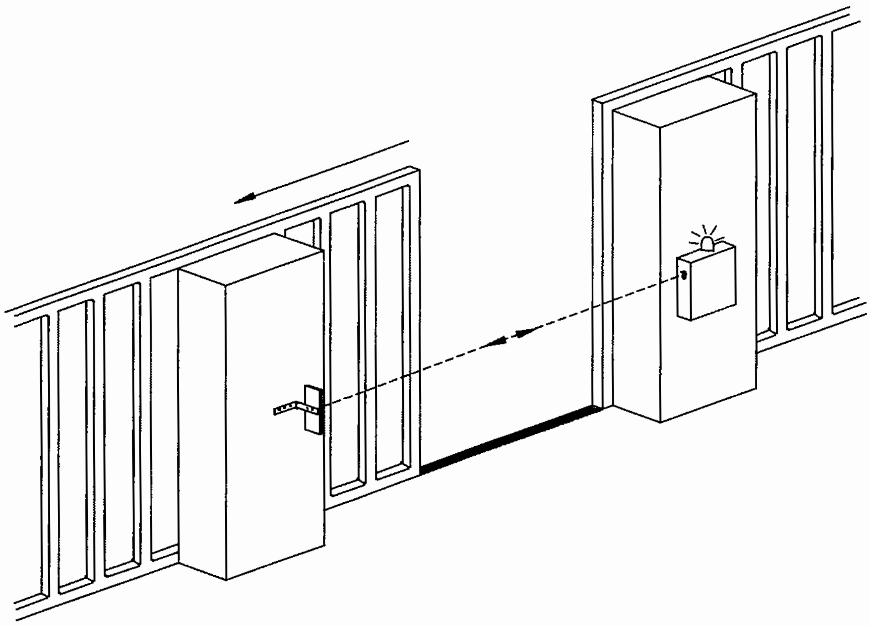
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

The gate to a yard is to be monitored by means of a retro-reflective sensor. Closure of the gate is to be prevented, as long as an object is present in the opening. Find out which objects can be detected by a retro-reflective sensor.

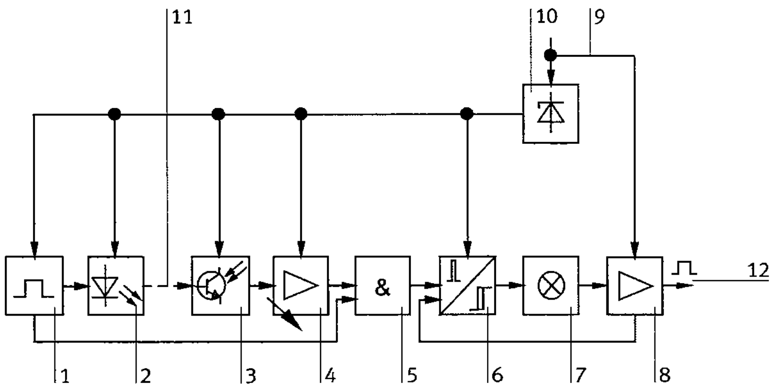
Positional sketch



Function description

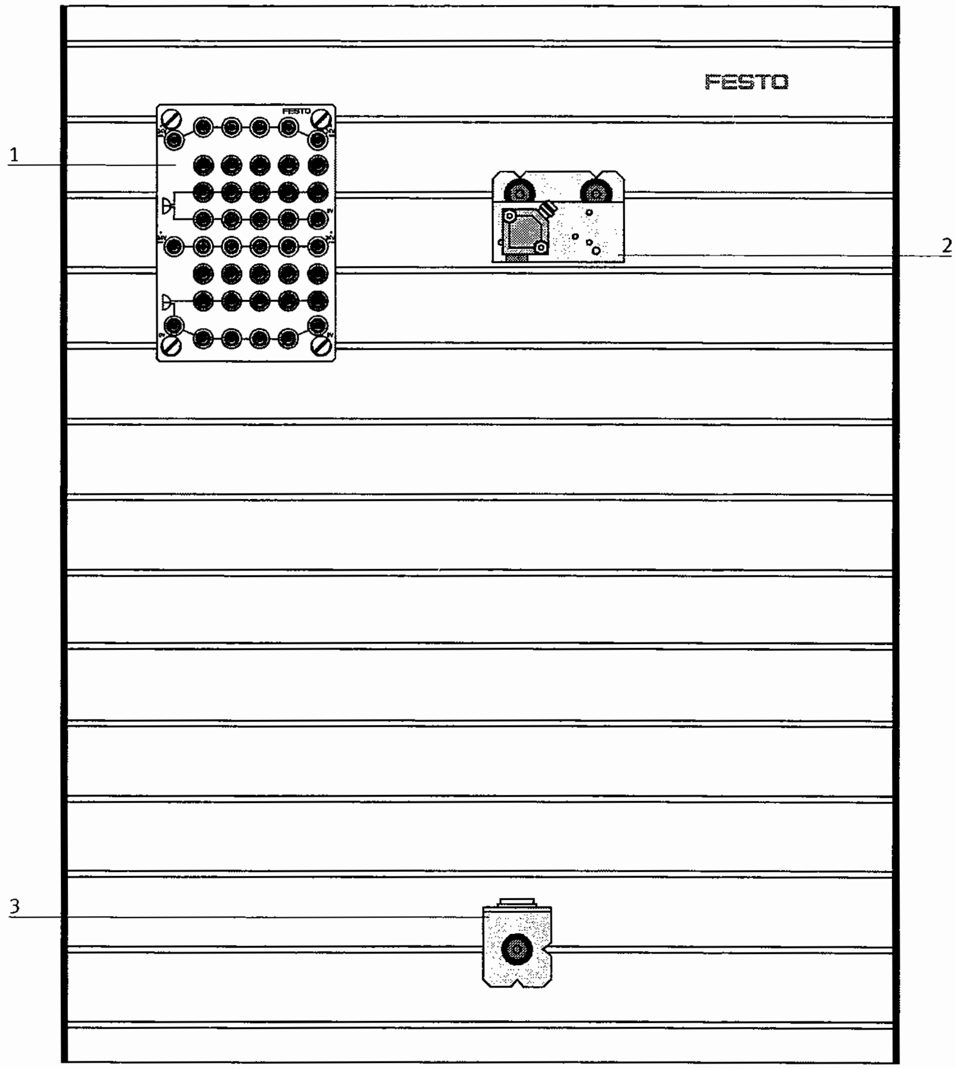
Optical proximity sensors consist of two principal modules, the emitter and the receiver. In the case of a retro-reflective sensor these two are mounted together in a common housing. An additional reflector is required.

Normally, LEDs emitting light in the red or infra-red wave length range are used as emitters. Suitable semi-conductor receivers detect this light inside the receiver module. The object interrupts the existing light beam connection between emitter and receiver. Reflecting objects can prevent this interruption.



Oscillator (1), Photoelectric emitter (2), Photoelectric receiver (3), Preamplifier with potentiometer (4), AND connection (5), Pulse level converter (6), Switching status indicator (LED) (7), Output stage with protective circuit (8), External voltage (9), Internal stabilised voltage (10), Optical path (11), Switching output (12)

Layout



Components list

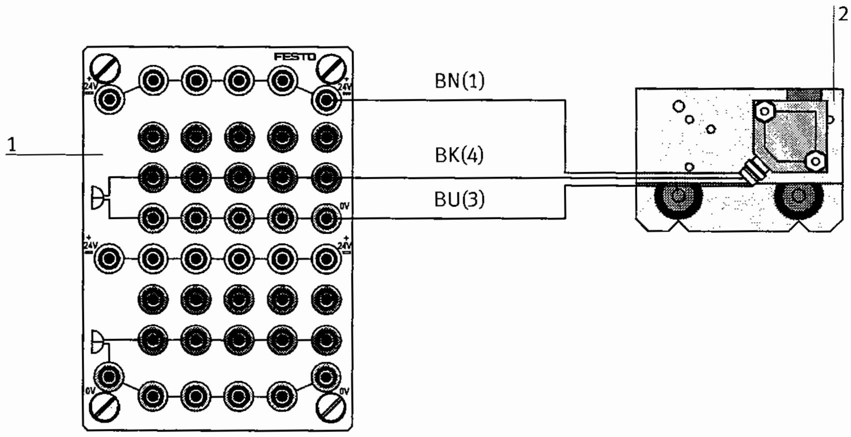
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit RS, D:ER-SOE-RS-Q-...
3	1	Reflector unit, D:ER-SOEZ-RFS20-...

The components list is continued on the following page.

Components list (continued)

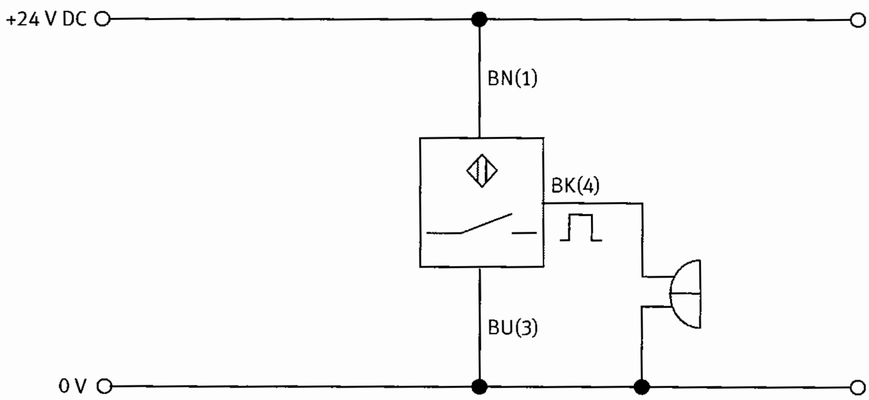
Item no.	Qty.	Designation
	1	Set of test objects, Kodak grey card, 100 mm x 100 mm, part 17
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, stainless steel, 90 mm x 30 mm, part 4
	1	Set of test objects, aluminium, 90 mm x 30 mm, part 5
		Set of test objects, brass, 90 mm x 30 mm, part 6
		Set of test objects, copper, 90 mm x 30 mm, part 7
	1	Set of test objects, cardboard, 90 mm x 30 mm, part 8
	1	Set of test objects, rubber, 90 mm x 30 mm, part 9
	1	Set of test objects, plastic, transparent, 90 mm x 30 mm, part 10
	1	Graph paper pad, D:AS-RK
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit RS, D:ER-SOE-RS-Q-...

Electrical circuit diagram



Practical assembly

Assemble the distribution unit and the optical sensor unit RS (retro-reflective sensor). Use the reflector as reflecting element. The nominal switching distance for this combination of units amounts to 1.5 m maximum. For your assembly, select a distance of 0.4 m. Connect the 24V electrical power supply to the distribution unit (see fig. "Electrical connections"). Connect the normally open output (black safety plug) to a buzzer socket (see fig. „Electrical connection“).

Turn the adjustment potentiometer of the retro-reflective sensor to its maximum value (turn the screw clockwise, max. 12 revolutions).

Introduce the different objects at a right angle into the path of the light beam and note whether the objects are detected.

What happens when you want to detect mirror-like objects? How can this effect be prevented? How do you position the object in relation to the retro-reflective sensor so that mirroring objects can be reliably detected? How can the presence of transparent objects be recorded under certain circumstances?

Now investigate the response range of the retro-reflective sensor: Reset the potentiometer to the maximum value. Fix the graph paper pad underneath the optical proximity sensor. From the side, introduce the Kodak grey card into the light path, with the grey face pointing towards the emitter, and record the switch-on points. Measure 2 cm distances along the optical axis. Introduce the card into the light beam alternatively from the right and from the left.

Note

For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

Evaluation

Material	Detection yes/no
Mild steel S 235 JR, part 3	
Stainless steel, part 4	
Aluminium, part 5	
Brass, part 6	
Copper, part 7	
Cardboard, part 8	
Rubber, part 9	
Plastic, transparent, part 10	

Conclusions

Exercise 8
Sensing range of a diffuse optical sensor

Training aim

To learn about the sensing range of a diffuse optical sensor depending on different surfaces and how to record the response curve.

Exercise definition

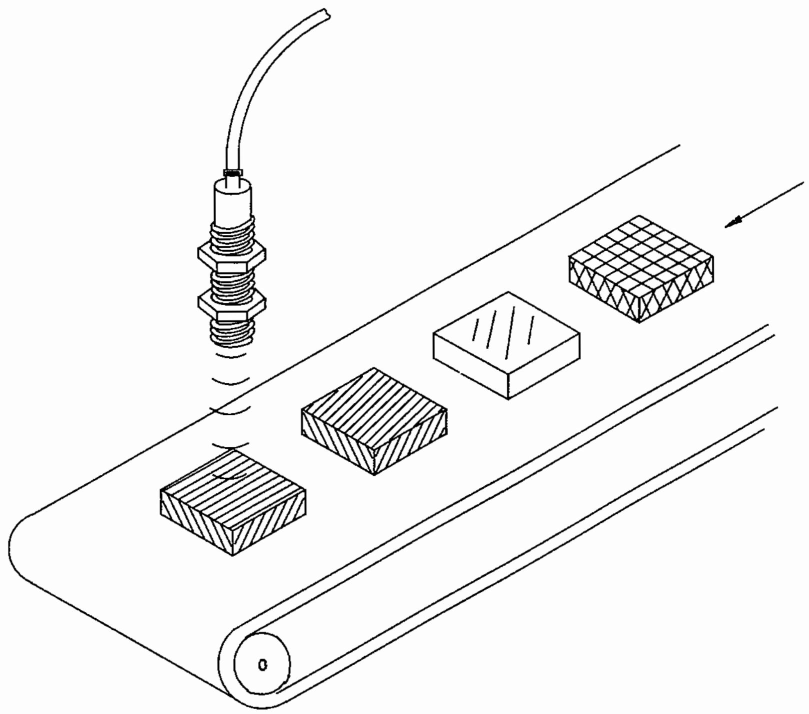
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

In a sorting station, materials of different surface characteristics and of different colours are to be detected by means of a diffuse sensor. Examine the switching characteristics and the range of the various diffuse sensors.

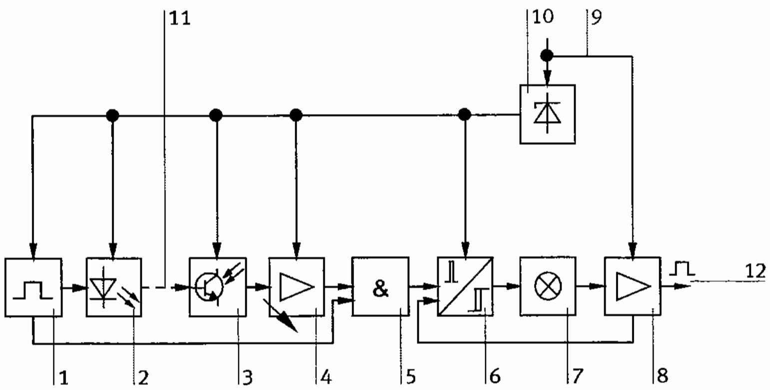
Positional sketch



Function description

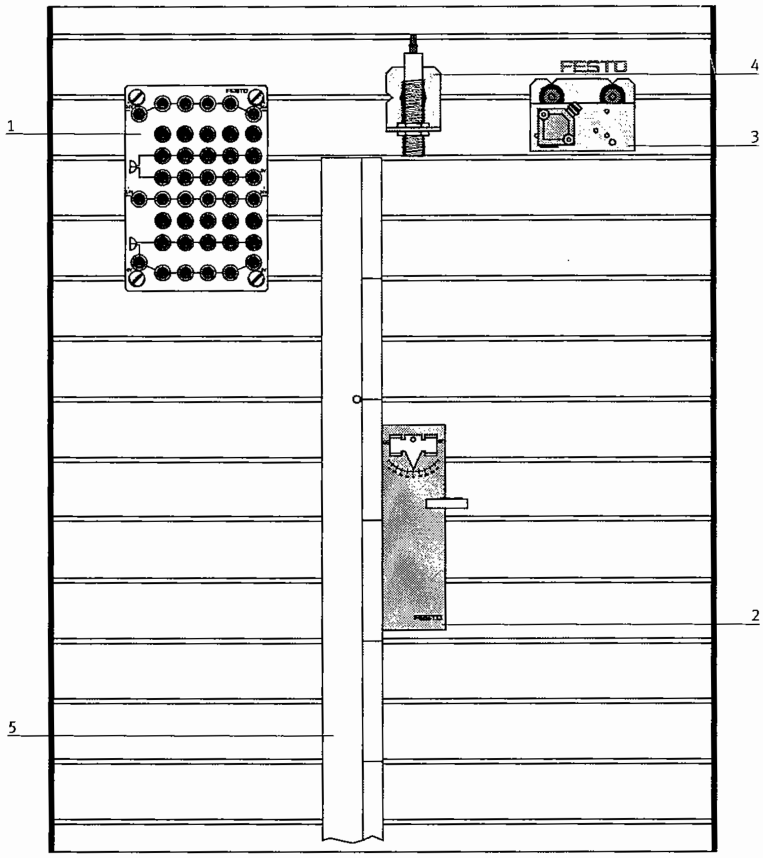
Optical proximity sensors consist of two main parts, i.e. the emitter and the receiver. In the case of diffuse sensors, these are installed in the same housing.

For the emitter, light emitting diodes are used, which emit mainly in the red or infrared range of wave length. This light is detected by the receiver via suitable semiconductor receivers. The object thus reflects back a part of the emitted light and activates the receiver. The object to be detected can be reflecting, matt, transparent or opaque, provided a sufficiently high part of the light is reflected directly or by diffusion.



Oscillator (1), Photoelectric emitter (2), Photoelectric receiver (3),
Preamplifier with potentiometer (4), AND connection (5), Pulse level converter (6),
Switching status indicator (LED) (7), Output stage with protective circuit (8),
External voltage (9), Internal stabilised voltage (10), Optical path (11),
Switching output (12)

Layout



Components list

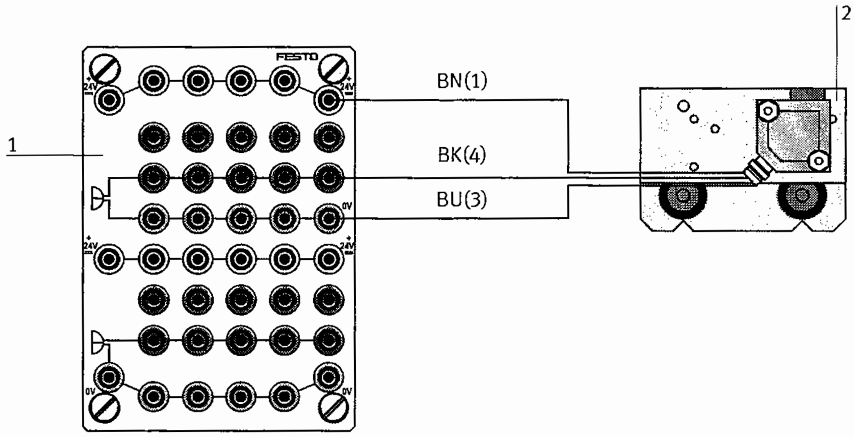
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
3	1	Optical sensor unit RT 1, D:ER-SOE-RT-Q-...
4	1	Optical sensor unit RT 2, D:ER-SOE-RT-M18-...
5	1	Measuring scale, D:AS-LIN-1020

The components list is continued on the following page.

Components list (continued)

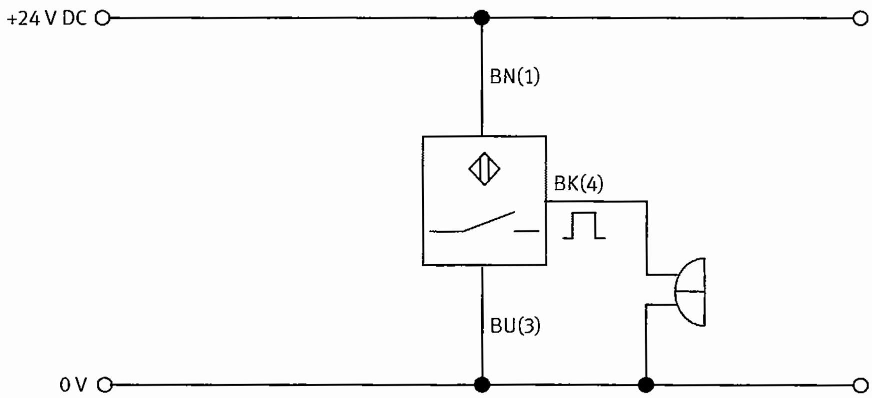
Item no.	Qty.	Designation
	1	Set of test objects, Kodak grey card, 100 mm x 100 mm, part 17
	1	Set of test objects, plastic, transparent, 100 mm x 100 mm, part 18
	1	Set of test objects, plastic, rot, 100 mm x 100 mm, part 19
	1	Set of test objects, plastic, blau, 100 mm x 100 mm, part 20
	1	Set of test objects, plastic, schwarz, 100 mm x 100 mm, part 21
	1	Set of test objects, cardboard, weiß, 100 mm x 100 mm, part 22
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, stainless steel, 90 mm x 30 mm, part 4
	1	Set of test objects, aluminium, 90 mm x 30 mm, part 5
	1	Set of test objects, brass, 90 mm x 30 mm, part 6
	1	Set of test objects, copper, 90 mm x 30 mm, part 7
	1	Set of test objects, rubber, 90 mm x 30 mm, part 9
	1	Graph paper pad, D:AS-RK
	1	Set of test objects, screw driver, part 36

Electrical connections
Experiment 1

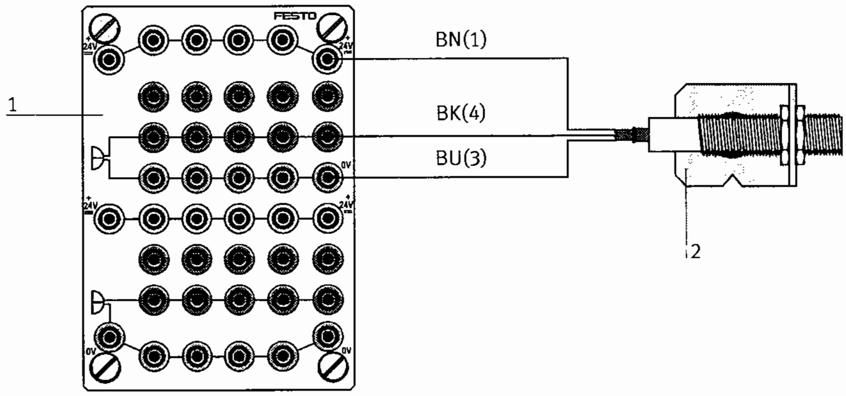


Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit RT 1, D:ER-SOE-RT-Q-...

Electrical circuit diagram

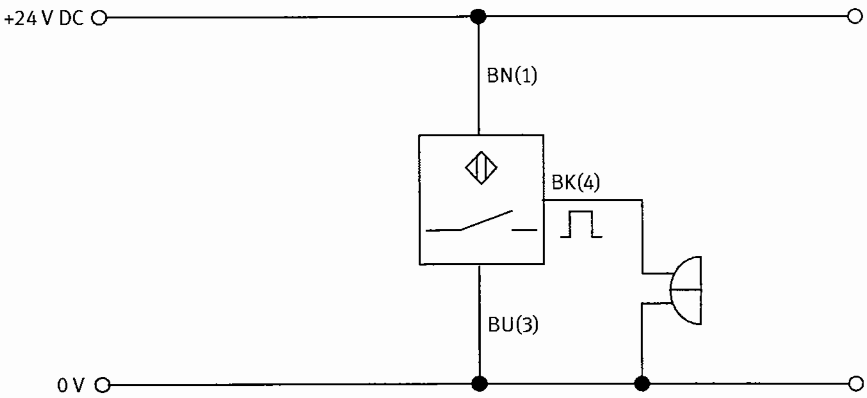


Electrical connections
Experiment 2



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit RT 2, D:ER-SOE-RT-M18-...

Electrical circuit diagram



Practical assembly
Experiment 1

Mount the distribution unit, the optical sensor unit RT 1 and the measuring scale on to the profile plate (see fig. "Layout"). Connect the 24V electrical power supply and the sensor to the distribution unit (see fig. "Electrical connections").

Calibrating the sensor

For your measurements, set the potentiometer of the diffuse optical sensor in such a way that the white side of the Kodak grey card registers at a distance of approximately 30 cm.

Note

For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

Now put materials with different reflectivity in front of the sensor and determine the switch-on point, the switch-off point and the hysteresis. The sliding part of the positioning unit, which can be removed from the base plate, is used for holding the materials. Use the measuring scale for lateral guiding and for measurement. Enter your measurements in the table.

Re-assemble the positioning slide again when you have completed the exercise.

Note

With the coloured plastic parts 100 mm x 100 mm, the matted side has to face the sensor.

To secure the rubber, part 9, use the mild steel plate as a clamping aid and support.

Practical assembly
Experiment 2

Now use the optical sensor unit RT 2. Mount the unit onto the aluminium bracket in such a way that the front end is flush with the zero point of the scale.

Calibrating the sensor
With this sensor, set the potentiometer in such a way that the white side of the Kodak grey card is registered at a distance of approximately 15 cm.

Note
For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

Carry out the same measurements as in experiment 1. Enter the measured value in the table.

Re-assemble the positioning slide again when you have completed the exercise.

Note
With the coloured plastic parts 100 mm x 100 mm, the matted side has to face the sensor.

To secure the rubber, part 9, use the mild steel plate as a clamping aid and support.

Practical assembly
Experiment 3

Now measure the response curves of the sensors. The potentiometer settings remain unchanged. Clamp the graph paper pad together with each sensor onto the assembly board.

Move the Kodak grey card, with the white side facing the sensor at a right angle, into the detection area of the sensor and mark the point at which the sensor recognises the card. Move the card closer from the right and from the left. Start your measurements approximately 1 cm away from the sensor and measure in gaps of approximately 2 cm.

Note
When carrying out your measurements, please note that the switch-on points and switch-off points for the sensor do not coincide. Move the Kodak grey card towards the unactuated sensor, e.g. from the left, until this changes its switching state, thus obtaining the switch-on point. Now remove the Kodak grey card back towards the left until the sensor changes from the actuated into the unactuated switching state, thus obtaining the switch-off point. The difference between these two points is known as hysteresis.

Evaluation

Experiment 1
Optical sensor unit RT 1 (D:ER-SOE-RT-Q-..)

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]
Kodak grey card, white side, part 17			
Kodak grey card, grey side, part 17			
Plastic, transparent, part 18			
Plastic, red, matted side, part 19			
Plastic, blue, matted side, part 20			
Plastic, black, matted side, part 21			
Cardboard, white, part 22			
Mild steel S 235 JR, part 3			
Stainless steel, part 4			
Aluminium, part 5			
Brass, part 6			
Copper, part 7			
Rubber, part 9			

Experiment 2
Optical sensor unit RT 2 (D:ER-SOE-RT-M18-..)

Material	**Switch-on point [mm]**	**Switch-off point [mm]**	**Hysteresis [mm]**
Kodak grey card, white side, part 17			
Kodak grey card, grey side, part 17			
Plastic, transparent, part 18			
Plastic, red, matted side, part 19			
Plastic, blue, matted side, part 20			
Plastic, black, matted side, part 21			
Cardboard, white, part 22			
Mild steel S 235 JR, part 3			
Stainless steel, part 4			
Aluminium, part 5			
Brass, part 6			
Copper, part 7			
Rubber, part 9			

Conclusions

Exercise 9
Sensing range of a diffuse optical sensor with fibre-optic cable

Training aim

To learn about the fields of application and the sensing range of a diffuse sensor equipped with a fibre-optic cable.

Exercise definition

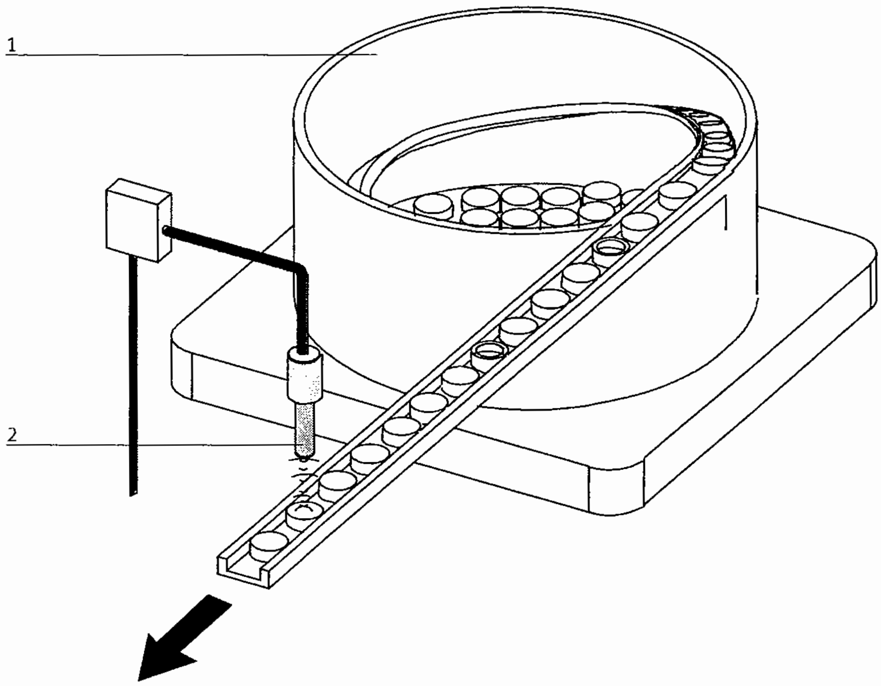
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

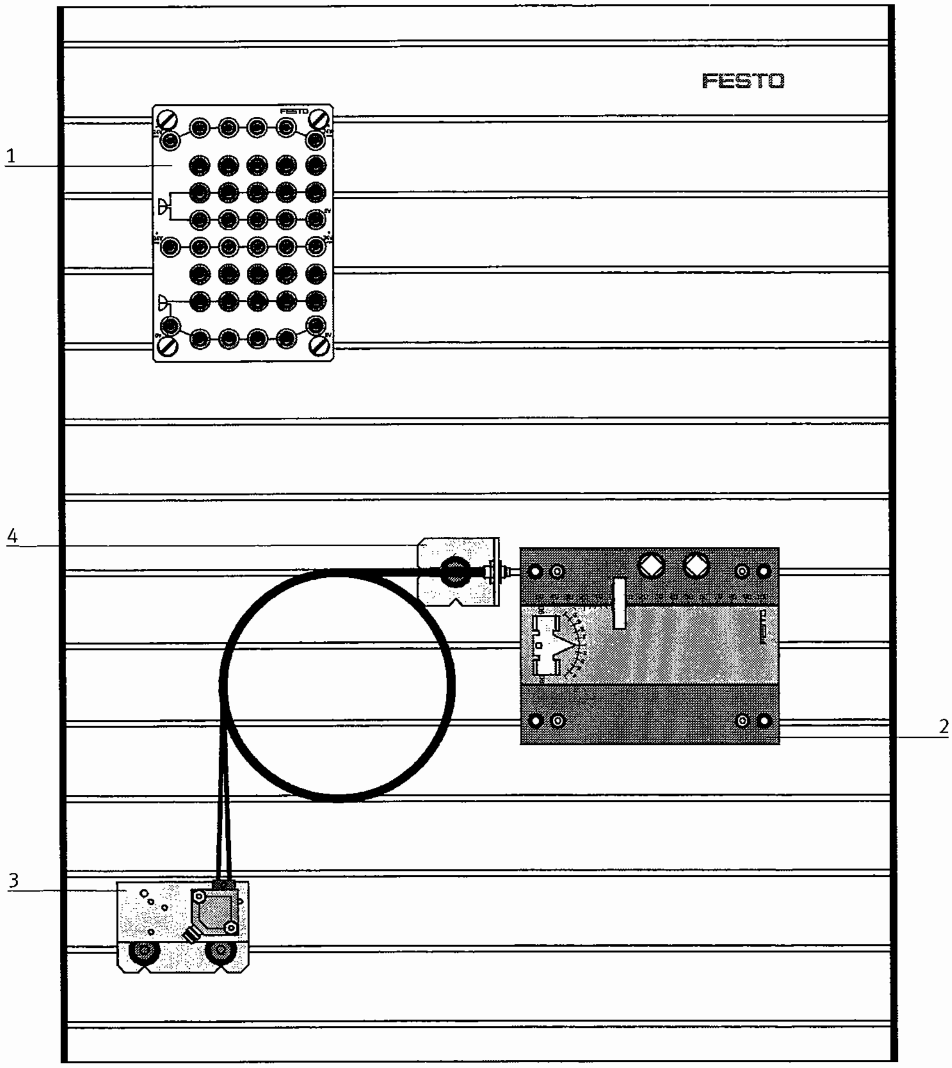
It is necessary to check the correct orientation of sealing caps fed from a vibrator hopper. Restricted space conditions allow only sensors fitted with fibre-optic cables to be used. Measure the sensitivity range of such an optical sensor.

Positional sketch



Vibrator hopper (1), Fibre-optic cable, diffuse sensor design (2)

Layout



Components list

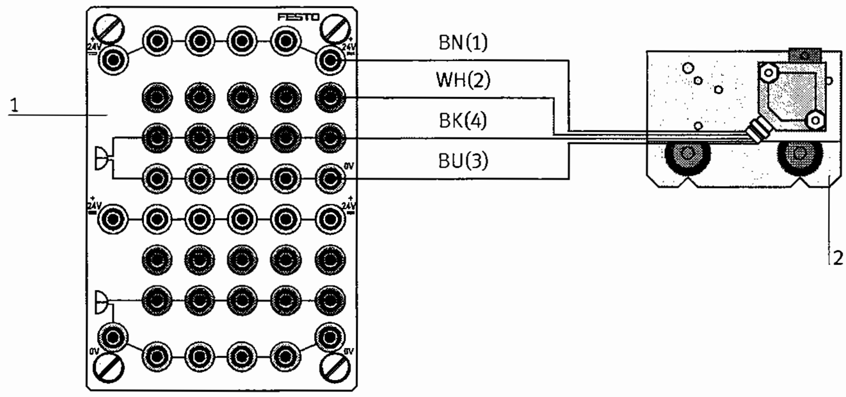
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Optical sensor unit LL1, D:ER-SOE-L-Q-...
4	1	Fibre-optic cable unit RT, D:ER-SOEZ-LK-RT-...

The components list is continued on the following page.

Components list (continued)

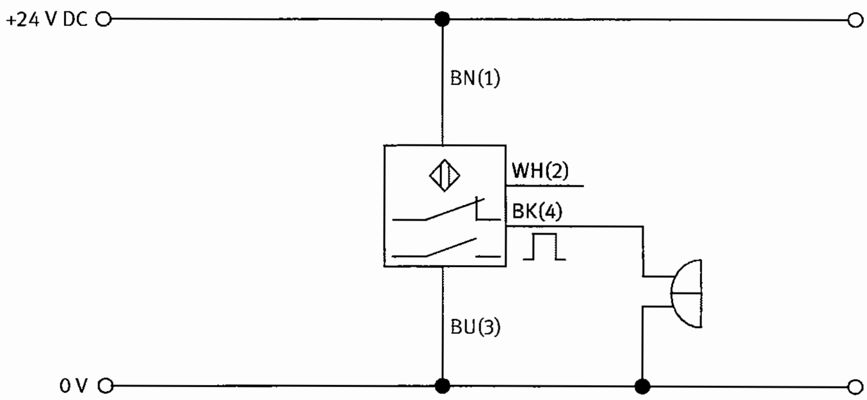
Item no.	Qty.	Designation
	1	Set of test objects, Kodak grey card, 100 mm x 100 mm, part 17
	1	Set of test objects, pastic, transparent, 100 mm x 100 mm, part 18
	1	Set of test objects, plastic, red, 100 mm x 100 mm, part 19
	1	Set of test objects, plastic, blue, 100 mm x 100 mm, part 20
	1	Set of test objects, plastic, black, 100 mm x 100 mm, part 21
	1	Set of test objects, cardboard, white, 100 mm x 100 mm, part 22
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, stainless steel, 90 mm x 30 mm, part 4
	1	Set of test objects, aluminium, 90 mm x 30 mm, part 5
	1	Set of test objects, brass, 90 mm x 30 mm, part 6
	1	Set of test objects, copper, 90 mm x 30 mm, part 7
	1	Set of test objects, rubber, 90 mm x 30 mm, part 9
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit on the profile plate. Assemble the optical sensor unit LL 1 (fibre-optic unit) with the fibre-optic cable unit RT. Insert the top part of the fibre-optic cable into the fixture of the mounting bracket and position the mounting bracket in front of the positioning slide. Mount the positioning slide 5 cm distant and 5 cm offset sideways (see fig."Layout"). Connect the 24 V power supply and the proximity sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Investigate the sensing range of this combination of units. Fix each material in turn to the positioning slide.

For the first measurement with the white side of the Kodak grey card, set the potentiometer for maximum range (turn the screw clockwise, max. 12 revolutions). Enter your results for the switch-on point, the switch-off point and the hysteresis in the table.

Note
For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

Mounting the fibre-optic cables
Insert the fibre-optic cables into the plugs of the fibre-optic unit up to stop. Securely tighten locking screw

Mounting the vernier caliper
When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Evaluation

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]
Kodak grey card, white side, part 17			
Kodak grey card, grey side, part 17			
Plastic, transparent, part 18			
Plastic, red, matted side, part 19			
Plastic, blue, matted side, part 20			
Plastic, black, matted side, part 21			
Cardboard, white, part 22			
Mild steel S 235 JR, part 3			
Stainless steel, part 4			
Aluminium, part 5			
Brass, part 6			
Copper, part 7			
Rubber, part 9			

Conclusions

Exercise 10
Switching distance of a capacitive sensor

Training aim

To learn about the switching characteristics of capacitive sensors.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

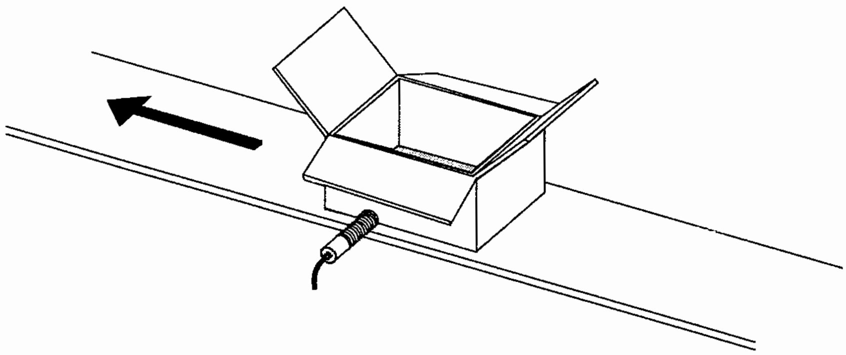
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

The presence of cardboard boxes in a packaging machine is to be monitored. A capacitive sensor is to be used for detection. Investigate whether this is suited for the purpose. In order to establish whether it would also be suitable for other packaging materials, you are asked to determine the switching distance for various materials.

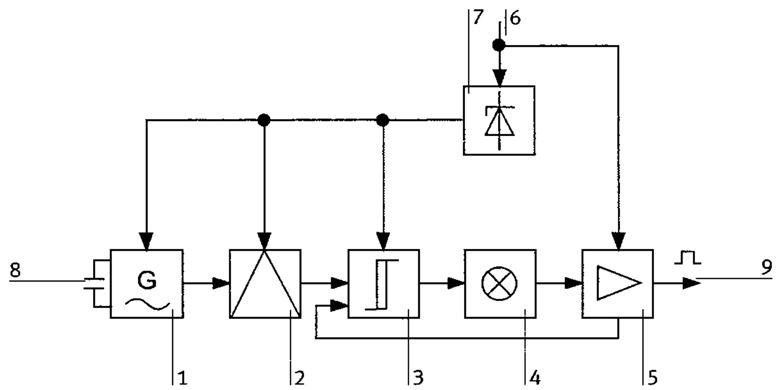
Positional sketch



Function description

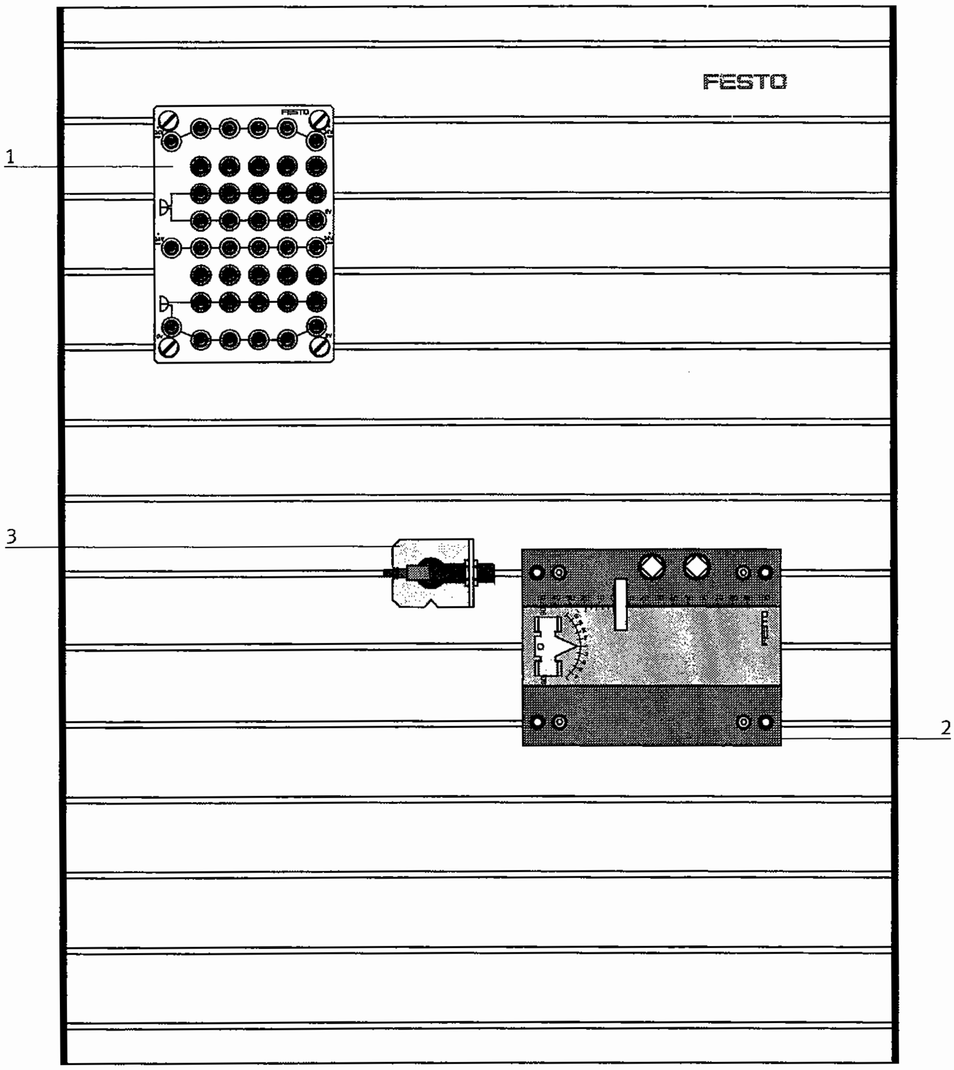
The operational principle of a capacitive proximity sensor is based on the capacitive change of a condenser in an RC resonant circuit, formed by a condenser (C) and a resistance (R).

If a substance is made to approach the proximity sensor, the capacity of the condensor increases. This causes a measurable change in the oscillatory characteristics of the RC circuit. Such change is converted by electronic evaluating circuitry into a usable output signal. The change in capacity depends largely on distance, dimensions and the dielectric constant of the substance in question.



Oscillator (1), Demodulator (2), Triggering stage (3), Switching status indicator (4), Output stage with protective circuit (5), External voltage (6), Internal stabilised voltage (7), Active switching zone (condensor) (8), Switching output (9)

Layout



Components list

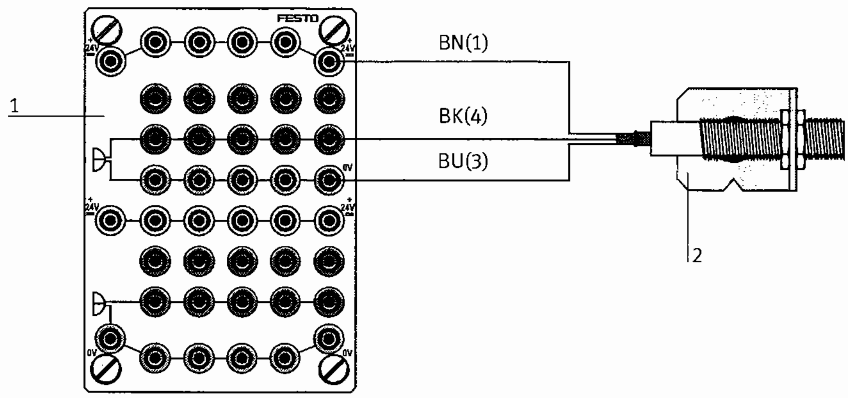
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Capacitive sensor unit, D:ER-SKE-M12-...

The components list is continued on the following page.

Components list (continued)

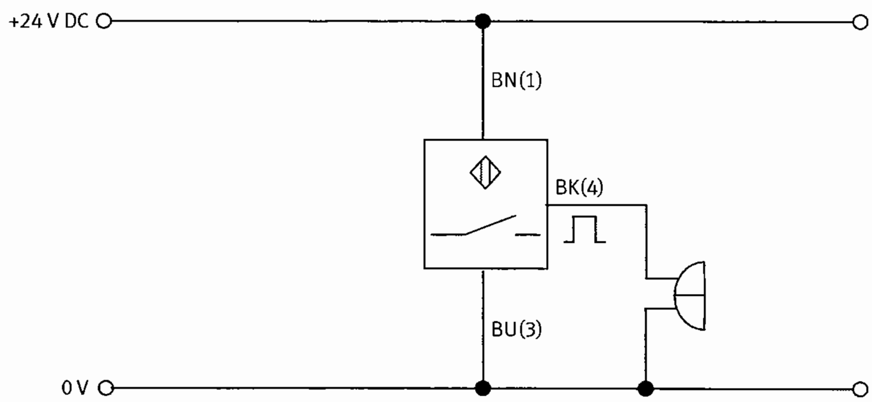
Item no.	Qty.	Designation
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, stainless steel, 90 mm x 30 mm, part 4
	1	Set of test objects, aluminium, 90 mm x 30 mm, part 5
	1	Set of test objects, brass, 90 mm x 30 mm, part 6
	1	Set of test objects, copper, 90 mm x 30 mm, part 7
	1	Set of test objects, cardboard, 90 mm x 30 mm, part 8
	1	Set of test objects, rubber, 90 mm x 30 mm, part 9
	1	Set of test objects, plastic, transparent, 90 mm x 30 mm, part 10
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Capacitive sensor unit, D:ER-SKE-M12-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit on the profile plate and also assemble the capacitive sensor unit. Mount the positioning slide offset sideways by 5 cm in relation to the sensor (see fig. "Layout"). Connect the 24V power supply and the sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Using the mild steel plate, part 3, set the switching distance of the proximity sensor at 8 mm via the adjusting screw. Carry out the switching distance measurement for the various test object materials. Enter your results for switch-on and switch-off point in a table. Calculate the hysteresis as the difference between switch-off and switch-on point and enter this likewise in the table.

Mounting the vernier caliper

When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Note

The capacitive proximity switch utilised is suitable only for non-flush mounting. This means that the active surface must not be surrounded by a material which leads to a change of switching status. There is no procedure laid down in a standard prescribing how to establish the switching distance.

Evaluation

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]
Mild steel S 235 JR, part 3			
Stainless steel, part 4			
Aluminium, part 5			
Brass, part 6			
Copper, part 7			
Cardboard, part 8			
Rubber, part 9			
Plastic, transparent, part 10			

Conclusions

Exercise 11
Influence of material thickness on the switching distance of a capacitive sensor

Training aim

To learn about the effect of the material thickness on the switching distance of a capacitive sensor.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

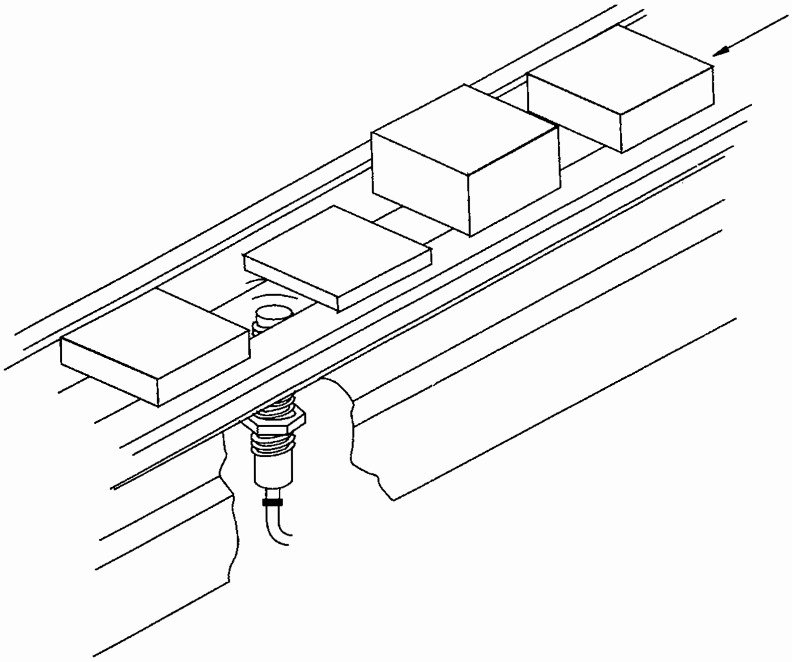
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

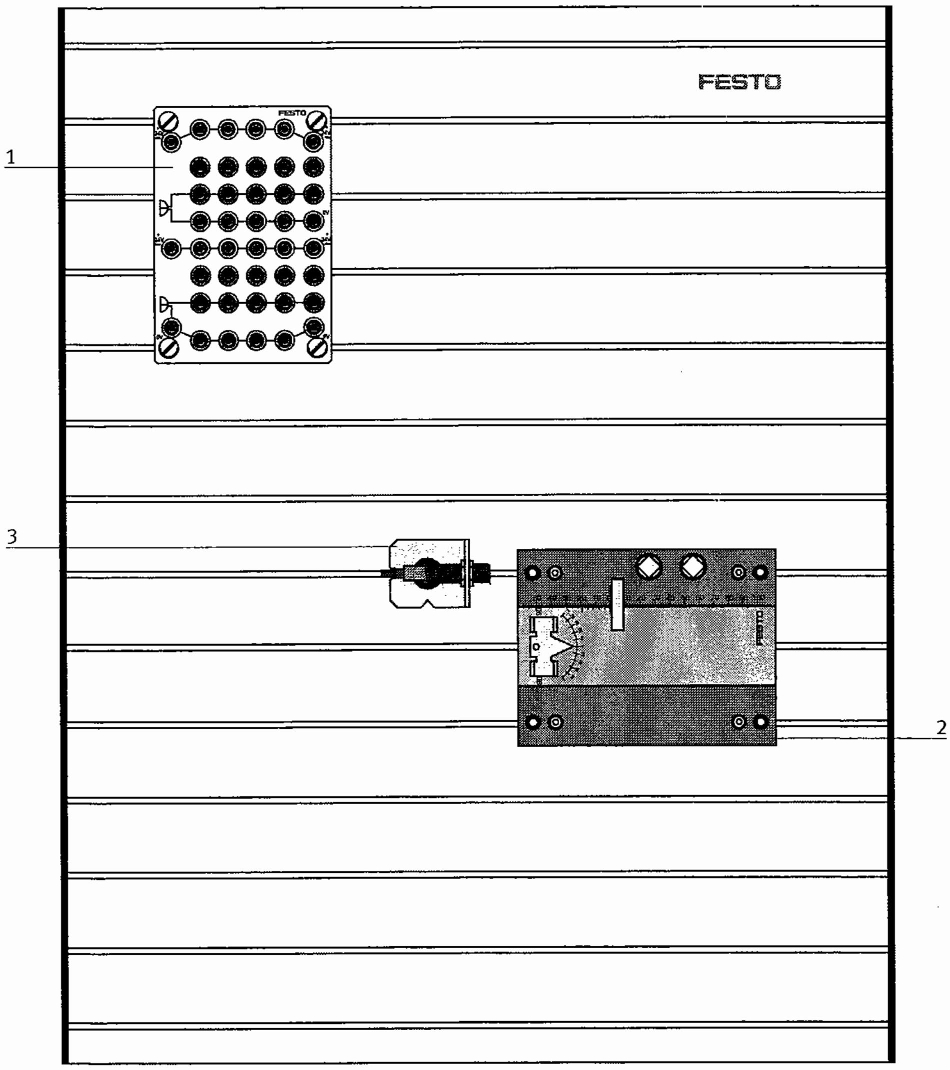
Problem description

On a conveyor, plastic parts of varying thickness are to be detected. A capacitive sensor is used for detection. Examine the effect of the material thickness on the switching distance of a sensor.

Positional sketch



Layout



Components list

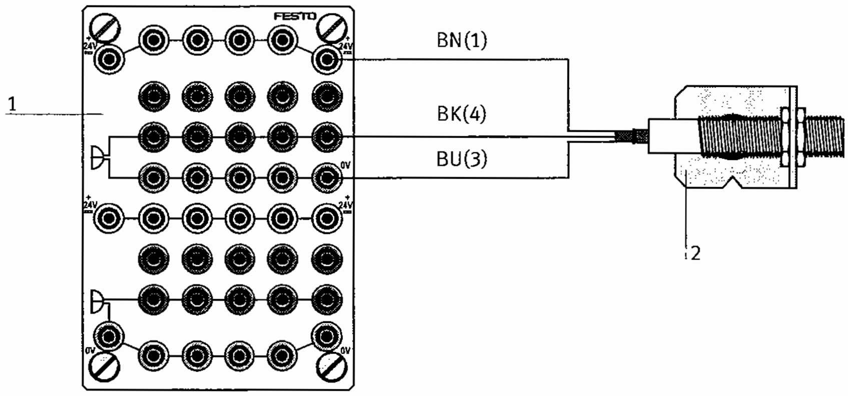
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
	1	Vernier caliper, D:AS-MS
3	1	Capacitive sensor unit, D:ER-SKE-M12-...

The components list is continued on the following page.

Components list (continued)

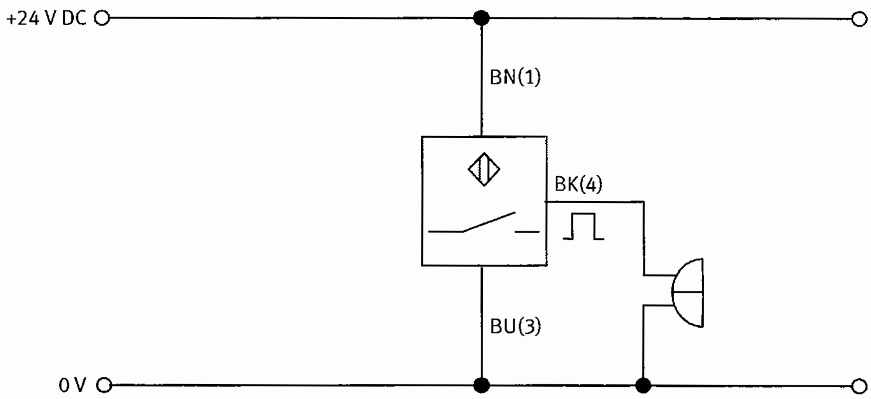
Item no.	Qty.	Designation
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, plastic, 2 mm thick, part 23
	1	Set of test objects, plastic, 3 mm thick, part 24
	1	Set of test objects, plastic, 5 mm thick, part 25
	1	Set of test objects, plastic, 8 mm thick, part 26
	1	Set of test objects, plastic, 11 mm thick, part 27
	1	Set of test objects, plastic, 14 mm thick, part 28
	1	Set of test objects, plastic, 17 mm thick, part 29
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Capacitive sensor unit, D:ER-SKE-M12-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit on the profile plate and also the capacitive sensor unit. Then mount the positioning slide 5 cm to the side of the sensor (see fig. "Layout"). Connect the 24V electrical power supply and the sensor to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

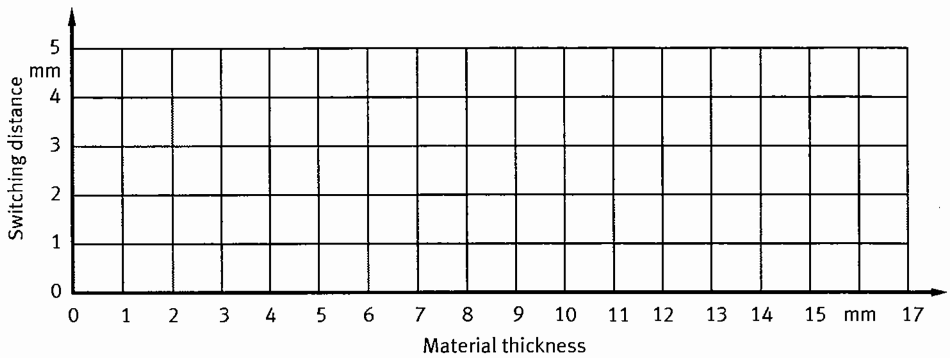
Next, use the mild steel plate, part 3, and set the switching distance at 8 mm. Then take the plastic plates of varying thicknesses from the set of test objects (parts 23 to 29) and determine the switching distance. Enter the measuring points in a table and draw a graph showing the switching distance depending on material thickness.

Mounting the vernier caliper

When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Evaluation

Material thickness [mm]	Switching distance [mm]
Plastic, part 23, 2.0 mm thick	
Plastic, part 24, 3.0 mm thick	
Plastic, part 25, 5.0 mm thick	
Plastic, part 26, 8.0 mm thick	
Plastic, part 27, 11.0 mm thick	
Plastic, part 28, 14.0 mm thick	
Plastic, part 29, 17.0 mm thick	



Conclusions

Exercise 12
Sound wave form and reflection characteristics of an ultrasonic sensor

Training aim

To determine the reflection characteristics and the response curve of an ultrasonic proximity sensor. Possibilities of application are investigated with the help of different materials.

Exercise definition

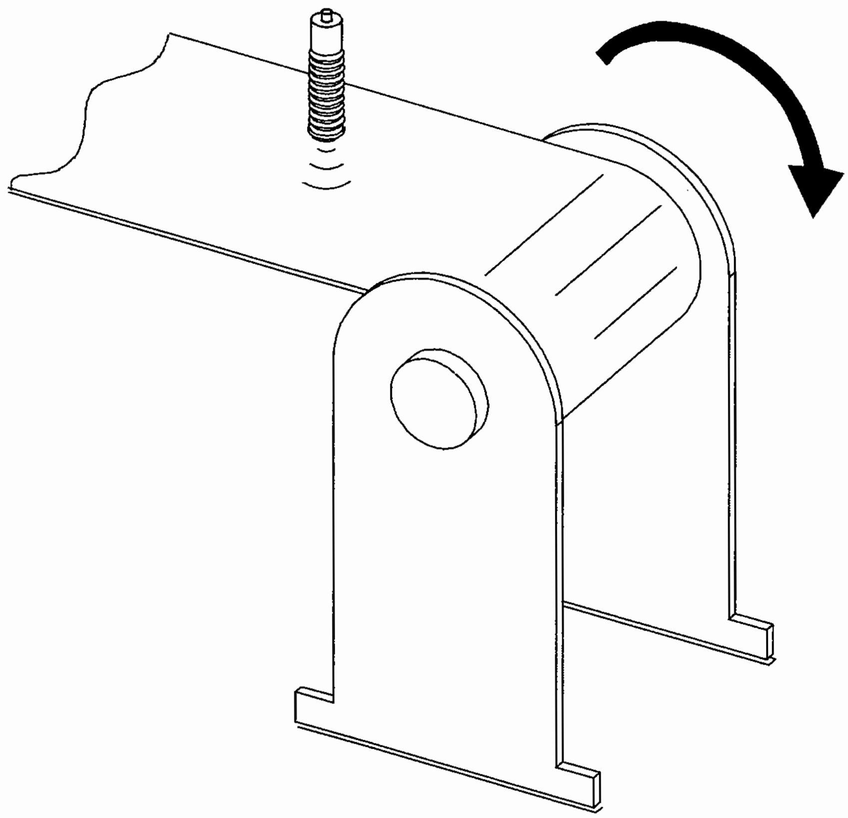
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

When producing film and foil, the winding of transparent plastic film and of thin metal foil is to be monitored by means of a proximity sensor. Investigate whether an ultrasonic proximity sensor is suitable for this purpose.

Positional sketch

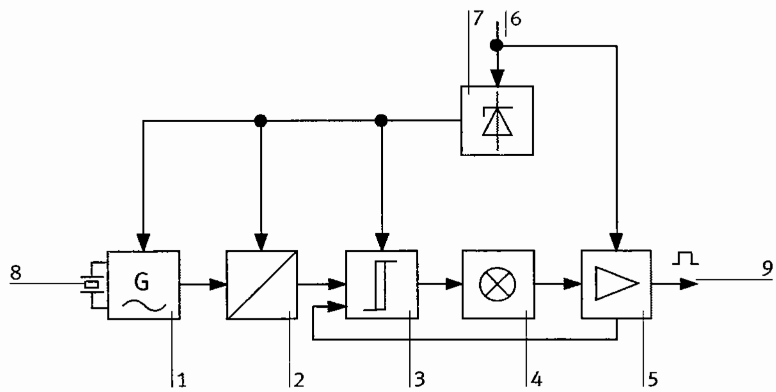


Function description

The operational principle of an ultrasonic proximity sensor is based on the generation, emission, and reception of sound waves in the non-audible range, mostly between 30 and 300 kHz.

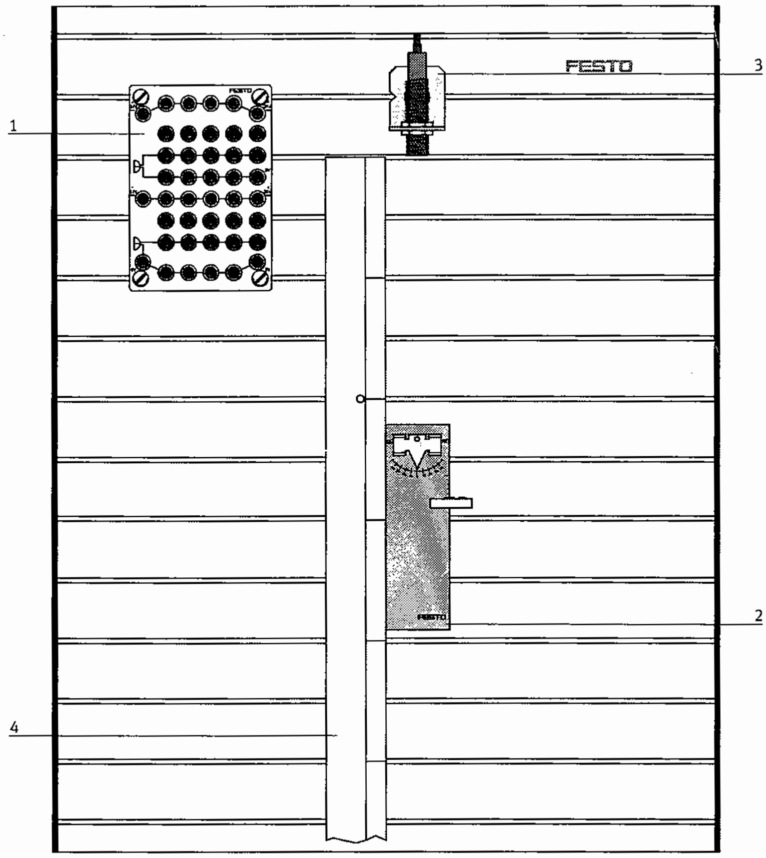
The ultrasonic proximity sensor is built up from three principal modules, the ultrasonic transducer, the evaluation unit, and the output stage. The ultrasonic transducer is usually a piezo-electric module, which is excited to generate vibrations in the range of 30 to 300 kHz by the application of a sinusoidal voltage.

The ultrasonic pulses are emitted with a frequency of between 1 Hz and 100 Hz. An evaluation is made of the time between the emission of an ultrasonic pulse and the reception of the pulse reflected by an object. If the object is located within the switching range of the ultrasonic sensor, an output signal is emitted.



Oscillator (1), Evaluation unit (2), Triggering stage (3), Switching status indicator (4), Output stage with protective circuit (5), External voltage (6), Internal stabilised voltage (7), Active switching zone (ultrasonic transducer) (8), Switching output (9)

Layout



Components list

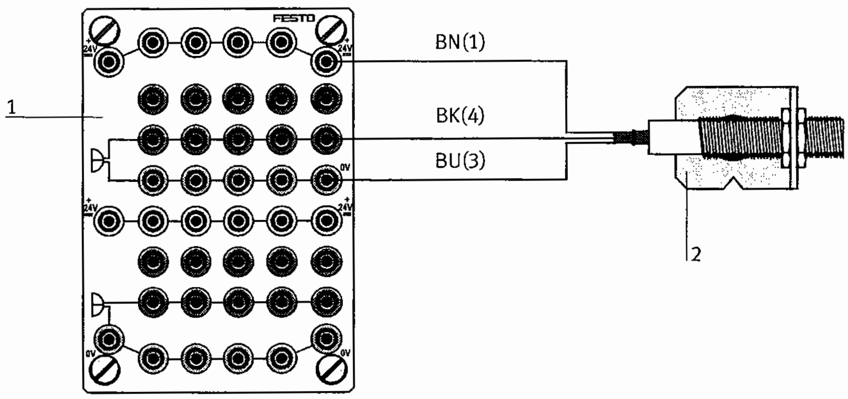
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
3	1	Sensor unit ultrasonic, D:ER-SUE-M18-...
4	1	Measuring scale, D:AS-LIN-1020

The components list is continued on the following page.

Components list (continued)

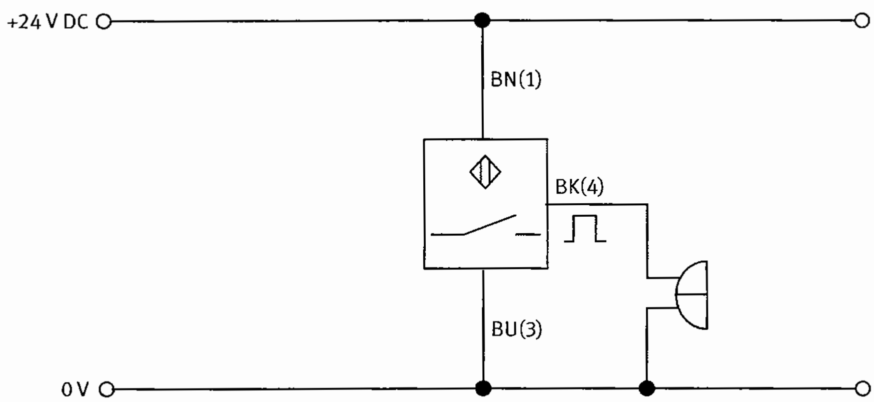
Item no.	Qty.	Designation
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, stainless steel, 90 mm x 30 mm, part 4
	1	Set of test objects, aluminium, 90 mm x 30 mm, part 5
	1	Set of test objects, brass, 90 mm x 30 mm, part 6
	1	Set of test objects, copper, 90 mm x 30 mm, part 7
	1	Set of test objects, cardboard, 90 mm x 30 mm, part 8
	1	Set of test objects, rubber, 90 mm x 30 mm, part 9
	1	Set of test objects, plastic, transparent, 90 mm x 30 mm, part 10
	1	Set of test objects, plastic, transparent, 100 mm x 100 mm, part 18
	1	Graph paper pad, D:AS-RK

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Sensor unit ultrasonic, D:ER-SUE-M18-...

Electrical circuit diagram



Practical assembly

Attach the distribution unit, the ultrasonic sensor unit and the measuring scale to the profile plate (see fig. "Layout"). Connect the 24V power supply and the proximity sensor to the distribution unit (see fig. "Electrical connections").

Introduce the various test objects into the path of emission at a distance of 15 cm and note whether and under what conditions these are detected. Use the separate sliding part of the positioning slide for mounting the objects, with the measuring scale as a lateral stop. Check the dependence of the sound reflection on the angle by means of the rotatable head of the sliding part.

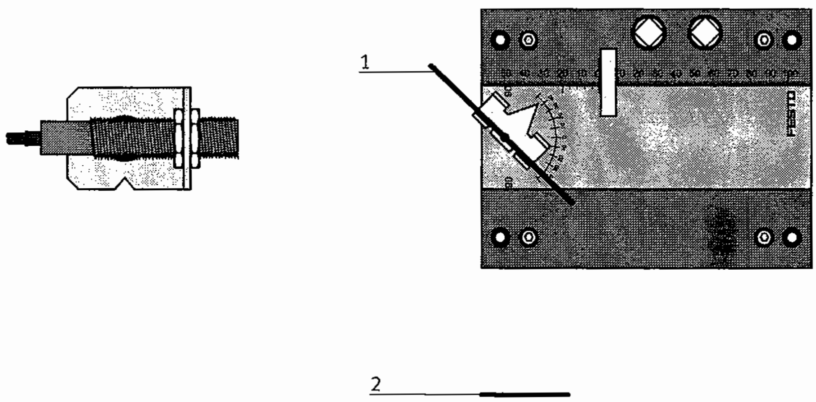
Fix the graph paper pad under the base of the proximity switch. Take the transparent plastic plate 100 mm x 100 mm, part 18, of the set of test objects, move it from the side (from the left and from the right) into the ultrasonic beam. Keep the plastic plate perpendicular to the ultrasonic beam axis. On the graph paper, mark the points, at which the ultrasonic sensor detects them (leading edge of the plate). Start your measurements 5 cm distant from the sensor and measure in steps of 2 cm.

Re-assemble the positioning slide again when you have completed the exercise.

Note

Observe that the switch-on and switch-off points of the sensor do not coincide when you take your measurements. For instance, let the plastic plate approach the inactive proximity sensor from the left until this changes its switching status, thus obtaining its switch-on point. Then move away the plastic plate towards the left until the proximity sensor changes from the active to the inactive state, thus obtaining its switch-off point. The distance travelled between these two points is described as hysteresis.

Hold a flat metal plate (from the set of test objects, e.g. the stainless steel plate) 10 cm distant from the proximity sensor and deflect the beam by 90°. Use the positioning slide and clamp a metal plate into the retaining fixture. Then turn it by 45°. Can you now detect a second metal plate (also from the set of test objects) with the deflected beam (see figure below)?



Part 1 (e.g. stainless steel plate) (1), Part 2 (e.g. copper plate) (2)

Evaluation

Material	Detection yes/no
Mild steel S 235 JR, part 3	
Stainless steel, part 4	
Aluminium, part 5	
Brass, part 6	
Copper, part 7	
Cardboard, part 8	
Rubber, part 9	
Plastic, transparent, part 10	
Plastic, transparent, part 18	

Conclusions

Exercise 13
Speed measurement

Training aim

To learn about the use of optical proximity sensors with fibre-optic cables for the measurement of speed.

Exercise definition

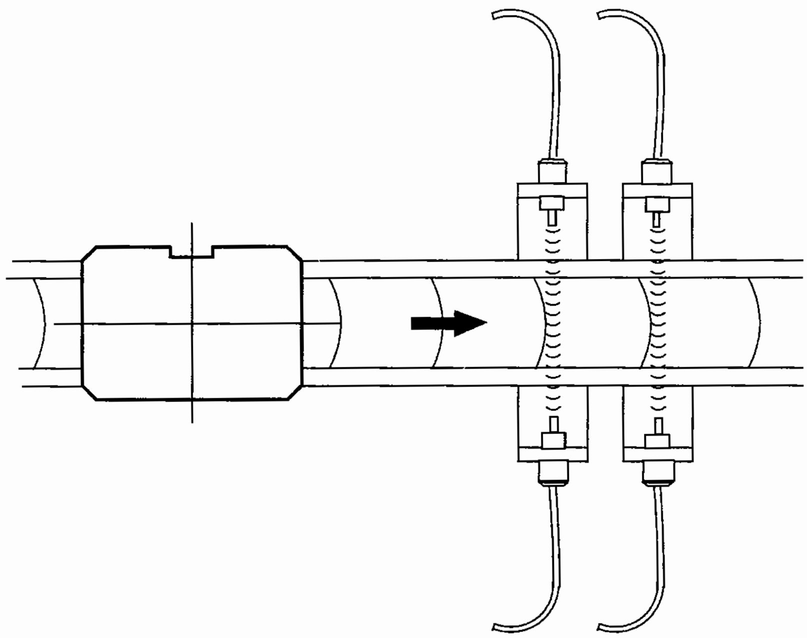
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

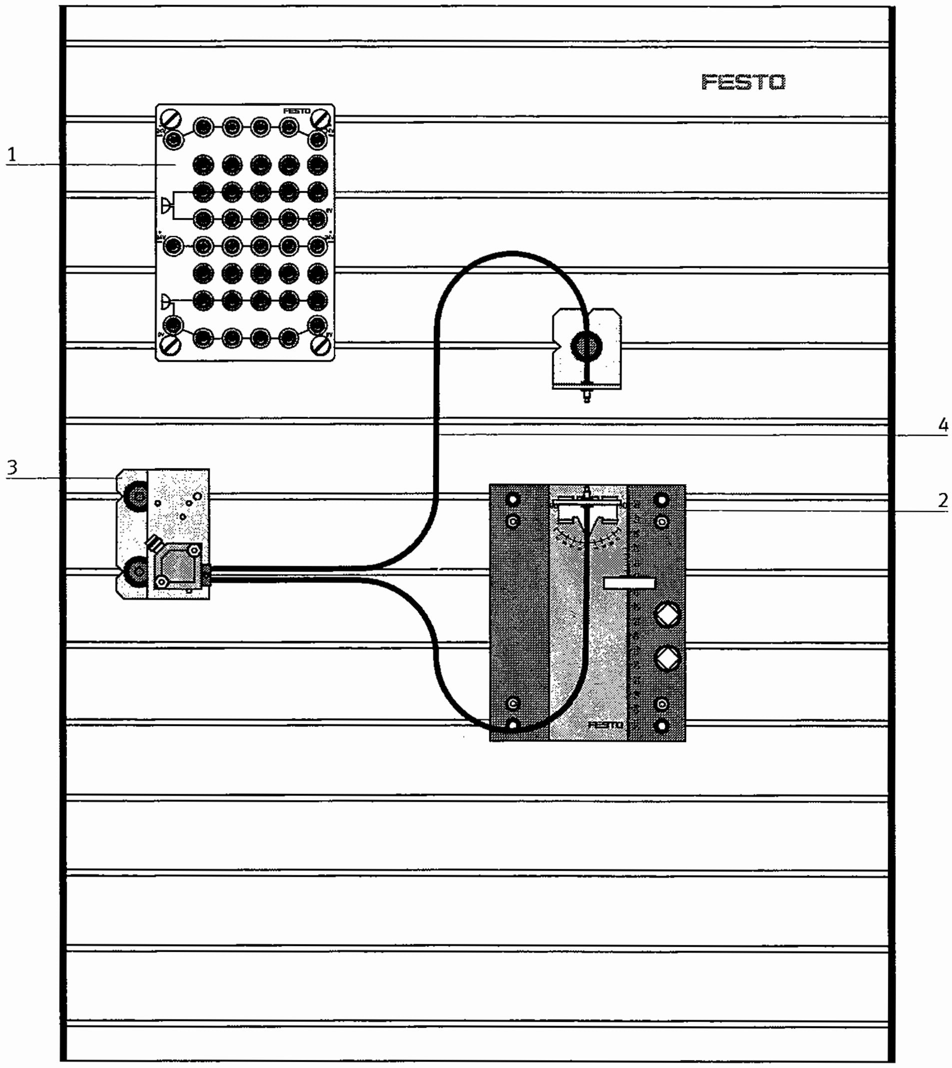
Problem description

On a conveyor, the speed of certain passing components is to be checked. Space for installing the sensors is restricted. Therefore, a sensor with fibre-optic cables is to be used.

Positional sketch



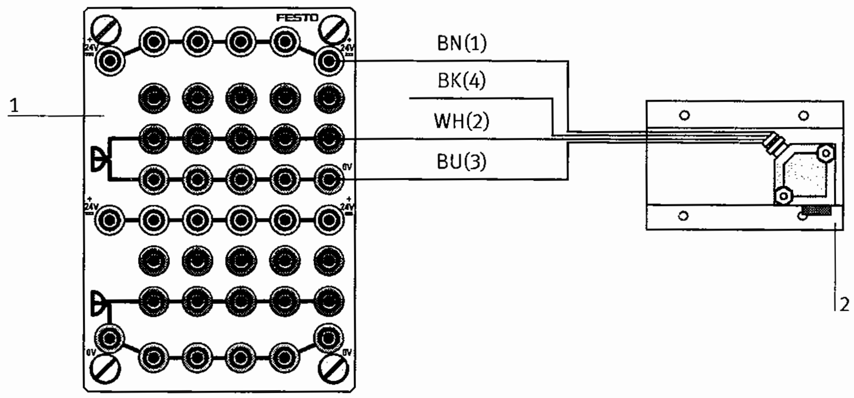
Layout 1



Components list

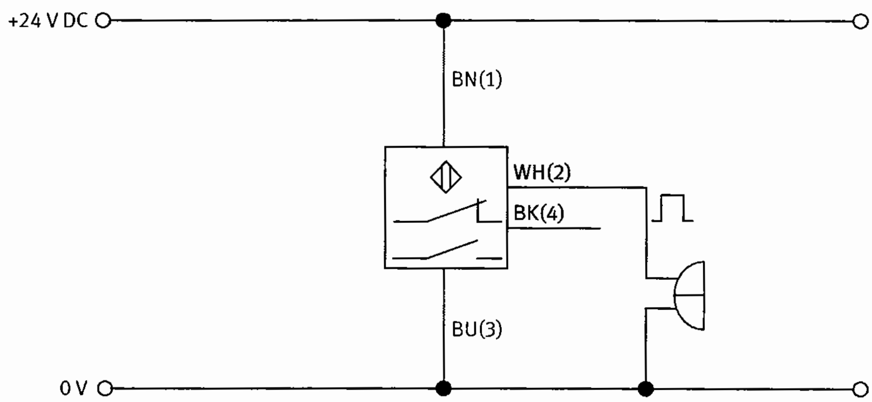
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP111-...0
	1	Vernier caliper, D:AS-MS
3	1	Optical sensor unit LL 1, D:ER-SEO-L-Q-...
4	1	Fibre-optic cable unit SE, D:ER-SOEZ-LK-SE-...
	1	Set of test objects, holder for fibre-optic cable, part 30
	1	Set of test objects, screw driver, part 36

Electrical connections

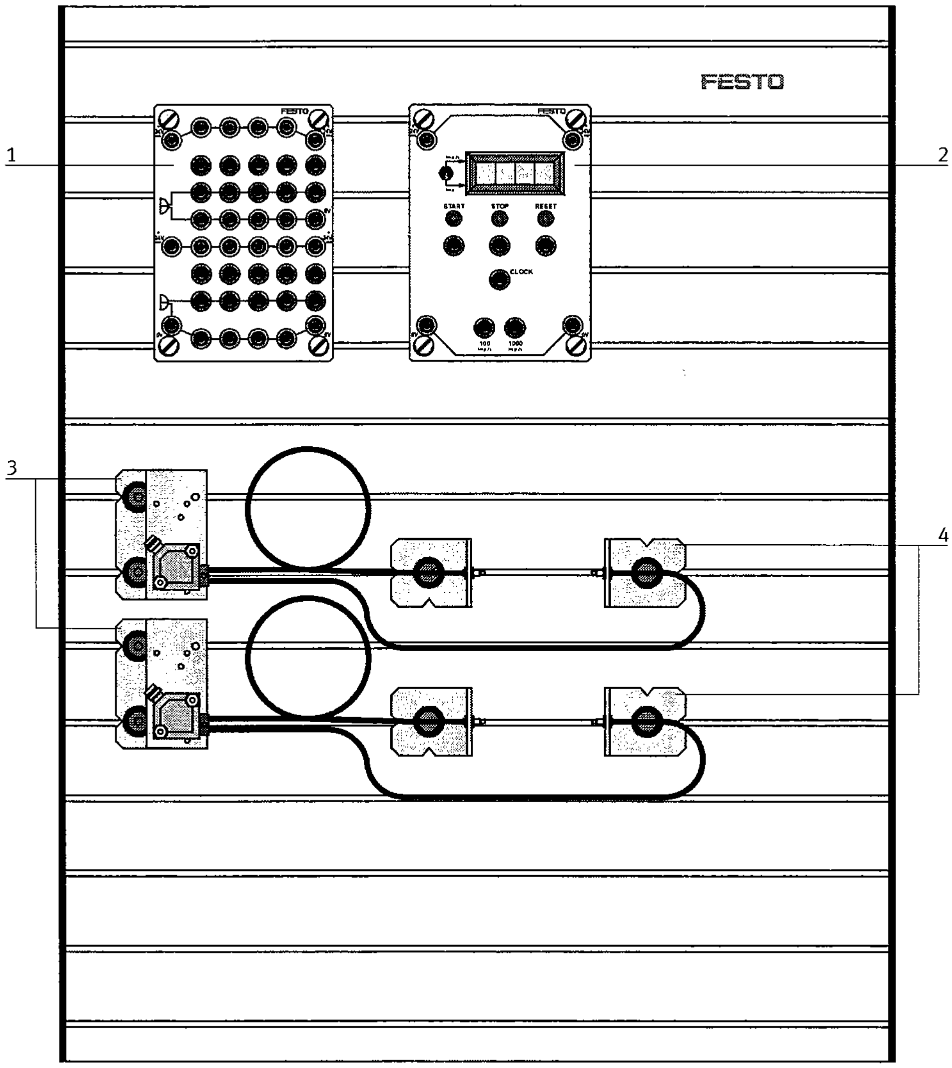


Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit LL 1, D:ER-SEO-L-Q-...

Electrical circuit diagram



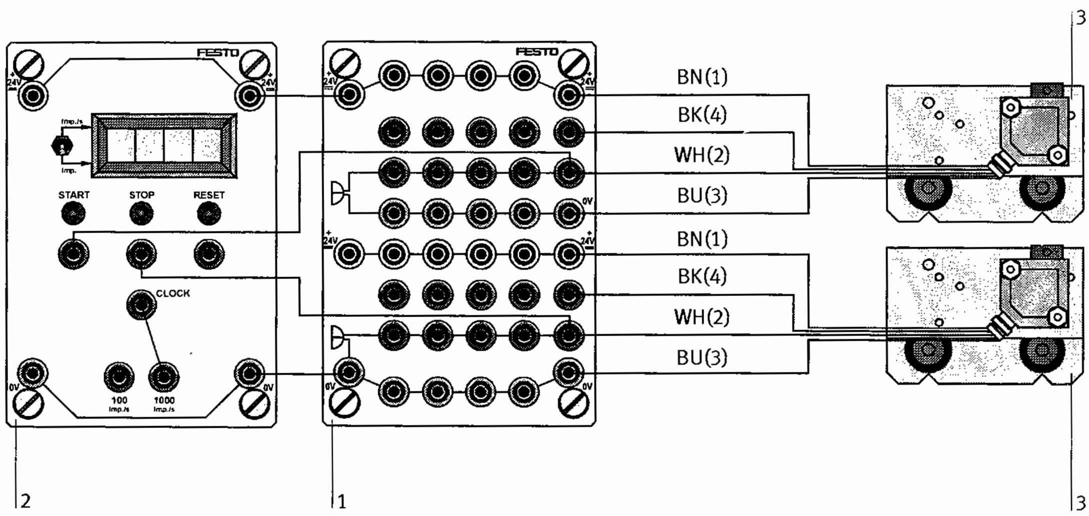
Layout 2



Components list

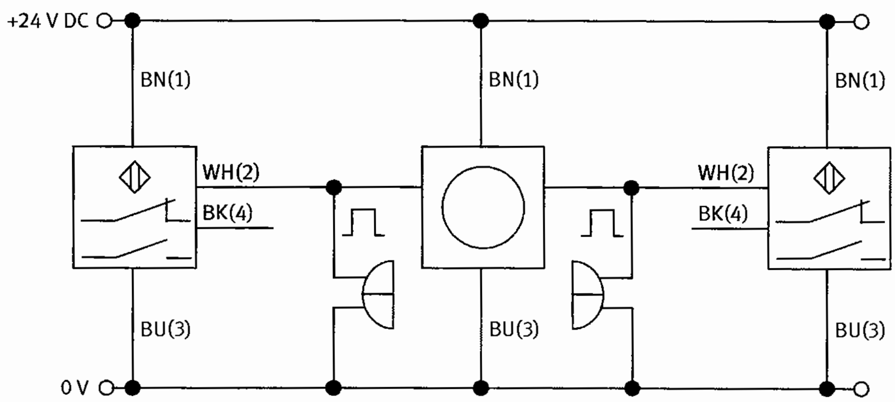
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Counting unit, D:ER-ZE-FP1110-...
3	2	Optical sensor unit LL 1, D:ER-SEO-L-Q-...
4	2	Fibre-optic cable unit SE, D:ER-SOEZ-LK-SE-...

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Counting unit, D:ER-ZE-FP1110-...
3	2	Optical sensor unit LL 1, D:ER-SEO-L-Q-...

Electrical circuit diagram



Practical assembly
Experiment 1

First of all, determine the maximum switching distance of the optical sensor unit LL 1. Mount the distribution unit, the positioning slide, and an optical sensor unit LL 1 on the profile plate (see fig. "Practical assembly 1"). Connect the 24V electrical power supply and the optical sensor unit LL 1 to the distribution unit (see fig. "Electrical connections").

Attach the vernier caliper to the positioning slide.

Set the potentiometer on the optical sensor unit LL 1 at maximum sensitivity (turn the screw clockwise, max. 12 revolutions).

Install the fibre-optic cable unit ES on the optical sensor unit LL1.

Screw one of the fibre-optic cables into its holder and mount it centrally 15 cm in front of the positioning slide. Secure the other fibre-optic cable in the material fixture of the positioning slide with the help of the holder for fibre-optic cables (set of test objects, part 30)

Move the receiver fibre-optic cable towards the emitter fibre-optic cable and make a note of the distance, at which the light emitting diode registers the change of the sensor switching state.

Mounting the fibre-optic cables
Insert the fibre-optic cables into the plugs of the fibre-optic unit up to stop. Securely tighten locking screw

Mounting the vernier caliper
When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Practical assembly
Experiment 2

Now choose a speed measuring distance of 10 cm. The distance between the emitter and the receiver fibre-optic cable should be 5 cm (see "Practical assembly 2"). Use the two optical sensor units LL 1 and the two fibre-optic cables ES. Connect these combined sensor units on the distribution unit (see fig. "Electrical connections").

The normally closed contact of the sensor is to be used in order to prevent a permanent signal from the distribution unit during the unactuated state. An output pulse should only be given when the object passes through the light beam.

Connect the counting unit to the distribution unit. Set the display mode switch 1 to 'Pulse' (Imp.). Connect the first light barrier to START socket 2 and the second to STOP socket 3. Use a short cable with safety plugs to connect the CLOCK socket 4 with the pulse output 10 '1000 Imp/s'.

Preparing the counting unit for measurement
Press the "Stop", "Reset" and "Start" buttons before the first measurement, in order to prepare the counting unit for measurement.

Now move an object (plate from set of test objects or your finger) through the barriers.

To determine the speed v:

$$v = s / t$$
$$s = 0.1 \text{ m}$$
$$t = (\text{Display} / 1000) \text{ s}$$
$$s = \text{path}$$
$$t = \text{time}$$

Evaluation

Switching distance **Potentiometer at maximum setting**	
Switch-on distance	
Switch-off distance	
Hysteresis	

Speed measurement	
Indicated value	
Corresponding time [s]	
Path [m]	
Speed [m/s]	

Conclusions

Exercise 14
Determining rotational speeds

Training aim

To learn about the differences and the application criteria of rotational speed detection with optical and inductive proximity sensors.

Exercise definition

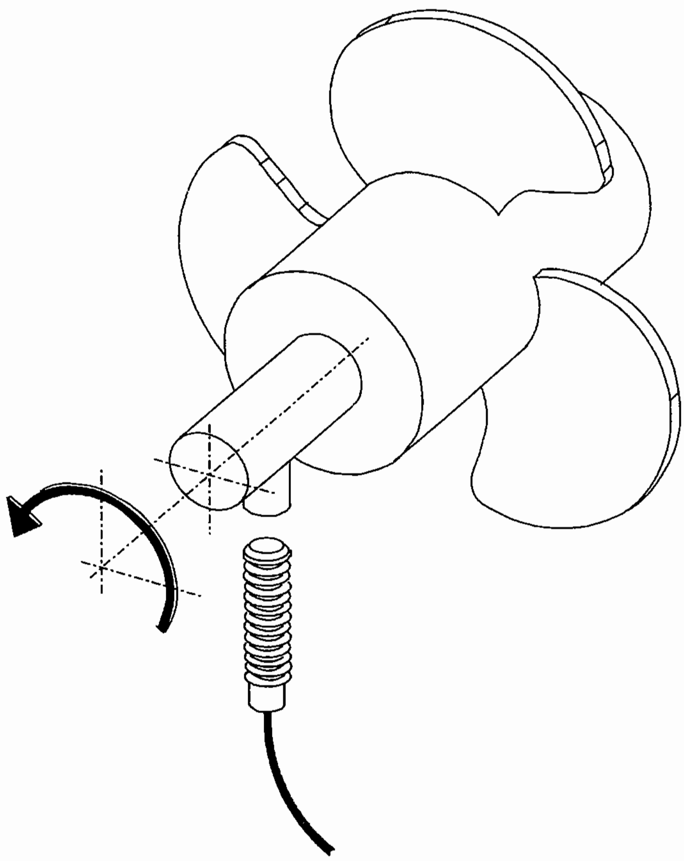
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

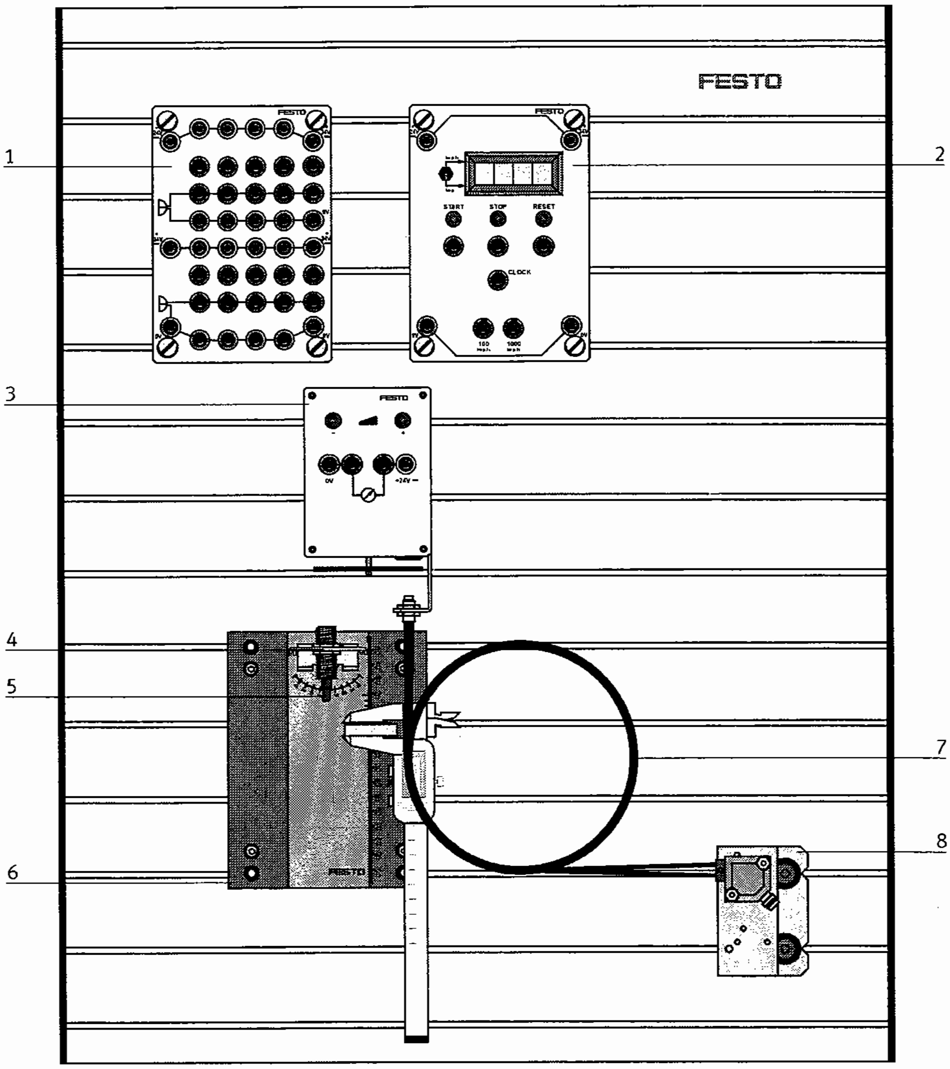
Problem description

In certain parts of a building a low pressure is to be permanently maintained. The monitoring of the speed of ventilator fans in a ventilating plant is carried out by means of sensors.

Positional sketch



Layout



Components list

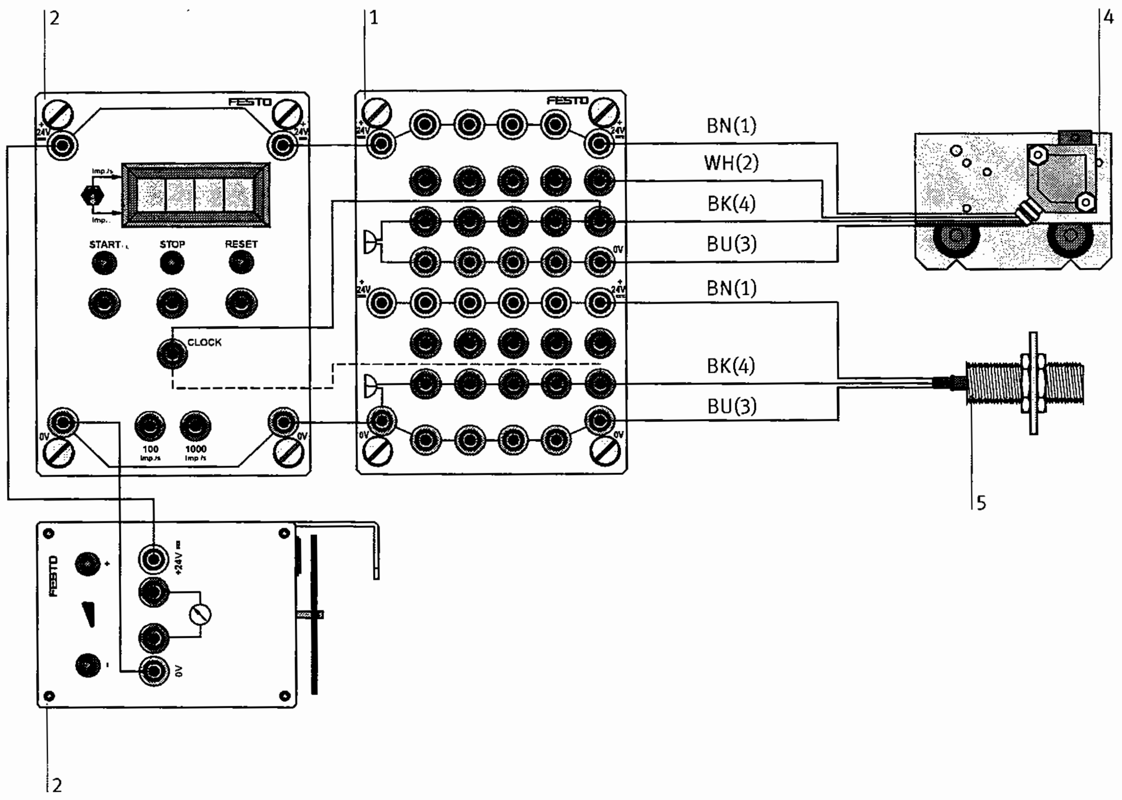
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Counting unit, D:ER-ZE-FP1110-...
3	1	Rotary unit, D:ER-DE-FP1110-...
	1	Digital multimeter, D:AS-DMM
4	1	Set of test objects, holder for fibre-optic cable, part 30
5	1	Inductive sensor unit 2, D:ER-SIEH-M12B-...
6	1	Positioning slide, D:ER-VS-FP1110-...

The components list is continued on the following page.

Components list (continued)

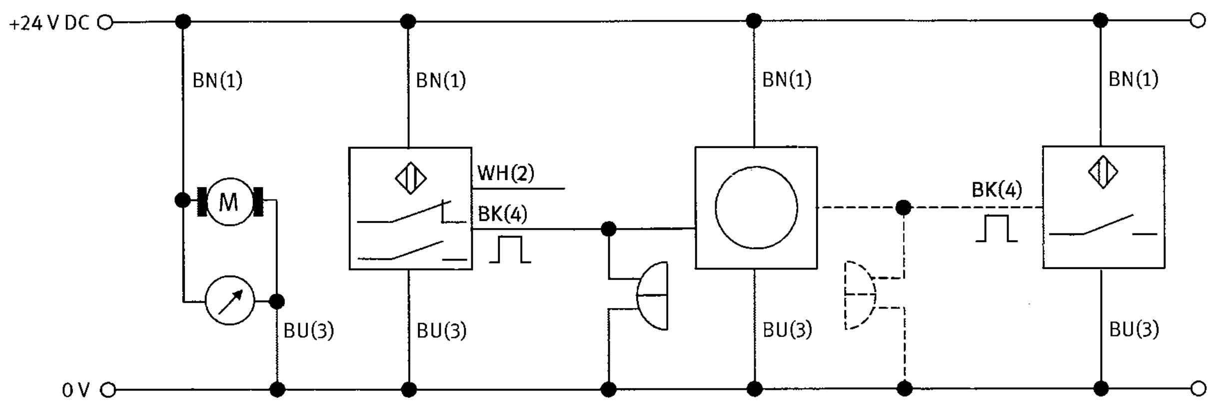
Item no.	Qty.	Designation
	1	Vernier caliper, D:AS-MS
7	1	Fibre-optic cable unit RT, D:ER-SOEZ-LK-RT-...
8	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...
	1	Set of test objects, screw driver, part 36
	1	17 mm spanner

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Counting unit, D:ER-ZE-FP1110-...
3	1	Rotary unit, D:ER-DE-FP1110-...
4	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...
5	1	Inductive sensor unit 2, D:ER-SIEH-M12B-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit, the rotary unit, the counting unit, and the positioning slide on the profile plate. Connect the rotary and the counting unit to the distribution unit. Mount the fibre-optic cable unit RT with the optical sensor unit LL 1 (Fibre-optic unit) on the reflector side of the rotary unit, and the inductive sensor unit 2 on the positioning slide. These sensors must also be connected to the distribution unit. Connect the 24V electrical power supply to the distribution unit.

Attach the vernier caliper to the positioning slide.

Adjusting the optical sensor D:ER-SOE-L-Q-...

The threaded part of the fibre-optic cable unit RT is fastened in the mounting hole on the right-hand side of the rotary unit's mountingbracket. Both ends of the fibre-optic cable are attached to the fibre-optic unit.

The potentiometer of the optical sensor unit LL 1 has to be set carefully for the sensor to switch reliably if the perforated disk is turned by hand. With the rotary unit at maximum speed, the potentiometer setting must be carefully adjusted until the position is discovered at which maximum rotational frequency is displayed at the connected counting unit (display within a range of approx. 520 Hz to 630 Hz).

Note

For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

Adjusting the inductive sensor D:ER-SIEH-M12B-...

The sensor included in the inductive sensor unit 2 must be removed from the retainer, and mounted to the holder for fibre-optic cables (set of test objects, part 30). Attach the mounted sensor to the material retainer of the positioning slide. A distance of approx. 3 mm between the perforated disc and the sensor should be used at first (set of test objects, plastic, part 23).

The speed of the rotary unit should be set with the help of the adjusted optical sensor such that a value of approximarely 200 Hz appears at the display. The inductive sensor must now be adjusted such that it measures the same value (i.e. approx. 200 Hz).

Mounting the vernier caliper
When mounting the vernier caliper, the slide unit of the positioning slide is set at "0". The two measuring pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate, flush with the edge, so that the front pointer is adjacent to the stop for the vernier caliper. The body of the caliper is attached to the base plate of the positioning slide by means of the two retaining magnets.

Mounting the fibre-optic cables
Insert the fibre-optic cables into the plugs of the fibre-optic unit up to stop. Securely tighten locking screw

Preparing the counting unit for measurement
Press the "Stop", "Reset" and "Start" buttons before the first measurement, in order to prepare the counting unit for measurement.

Connecting the sensors for measurement
The switching output of the optical or the inductive proximity sensor is now connected to the clock socket 4 at the counting unit. Display switch 1 is set to "Imp/s". Press the "Start" button. The current value of the output signals per second of the proximity sensor are displayed once per second.

Speed RS is determined thus:

$$RS = \frac{f_s}{\text{pulses/s}} \cdot \frac{60}{n} \cdot \text{r.p.m.}$$

f_s : Pulse frequency of output signal (unit: pulses per second)
n : Number of actuations per rotation

When using the rotary unit, n equals 8.

Note
The motor starts with a speed of approximately 2500 r.p.m. as soon as the operating voltage is switched on.

Let the motor run at low speed by pressing the touch control near the blue socket and watch the display. When the inductive sensor attains a value of approximately 200 pulses/s, check the potentiometer setting of the optical sensor, which should display the same value.

Start your series of measurements when the display reads approximately 80 pulses/sec. The operating voltage of the motor is then approximately 4.0 Volts. Measure the operating voltage of the motor and enter the value in the table. To measure the operating voltage connect the digital multimeter (D.AS-DMM) to the two black sockets of the rotary unit. Select the operating mode "Voltage Measurement" and a measuring range of at least 30 Volts. Start your measurement at a voltage of 4.0 Volts and increase the operating voltage initially by approximately 0.5 Volts, and after 14 Volts by 1.0 Volt at a time. After each measurement with the optical sensor, connect the inductive sensor and measure the speed with this sensor.

Enter each of the measured values in the table. Calculate the value for the speed from the value of the highest output pulse frequency and enter this in the right-hand column.

What are your findings about the switching frequency of the sensors?

Evaluation

Motor voltage [V]	Output-pulse-frequency SOE-L-Q-... [pulses/s]	Output-pulse-frequency SIEH-M12B-... [pulses/s]	Speed RS [r.p.m.]
4.0			
4.5			
5.0			
5.5			
6.0			
6.5			
7.0			
7.5			
8.0			
8.5			
9.0			
9.5			
10.0			
10.5			
11.0			
11.5			
12.0			
12.5			
13.0			
13.5			
14.0			
15.0			
16.0			
17.0			
18.0			
19.0			
20.0			

Conclusions

Exercise 15
Sensing the correct assembly of workpieces

Training aim

To learn about the application of proximity sensors for the checking of workpieces.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

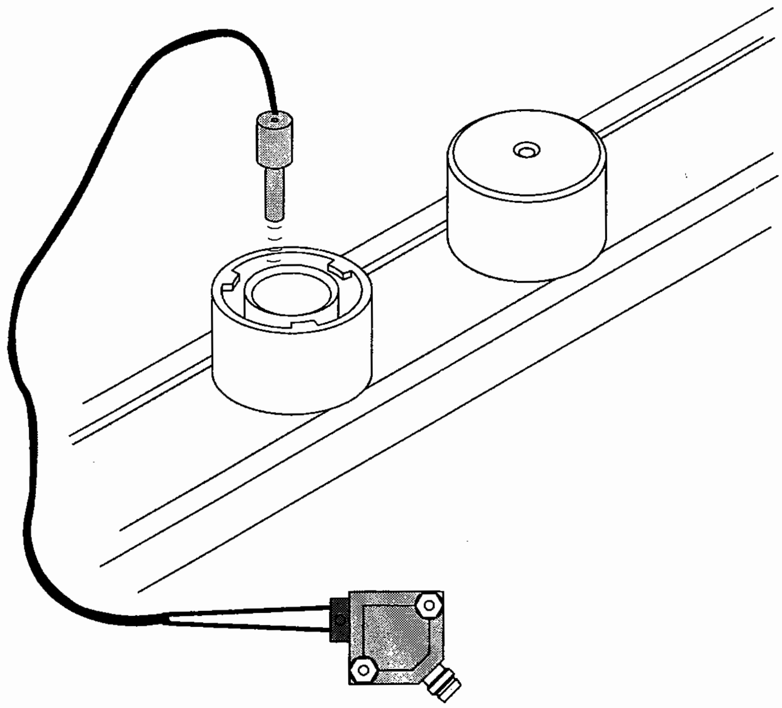
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

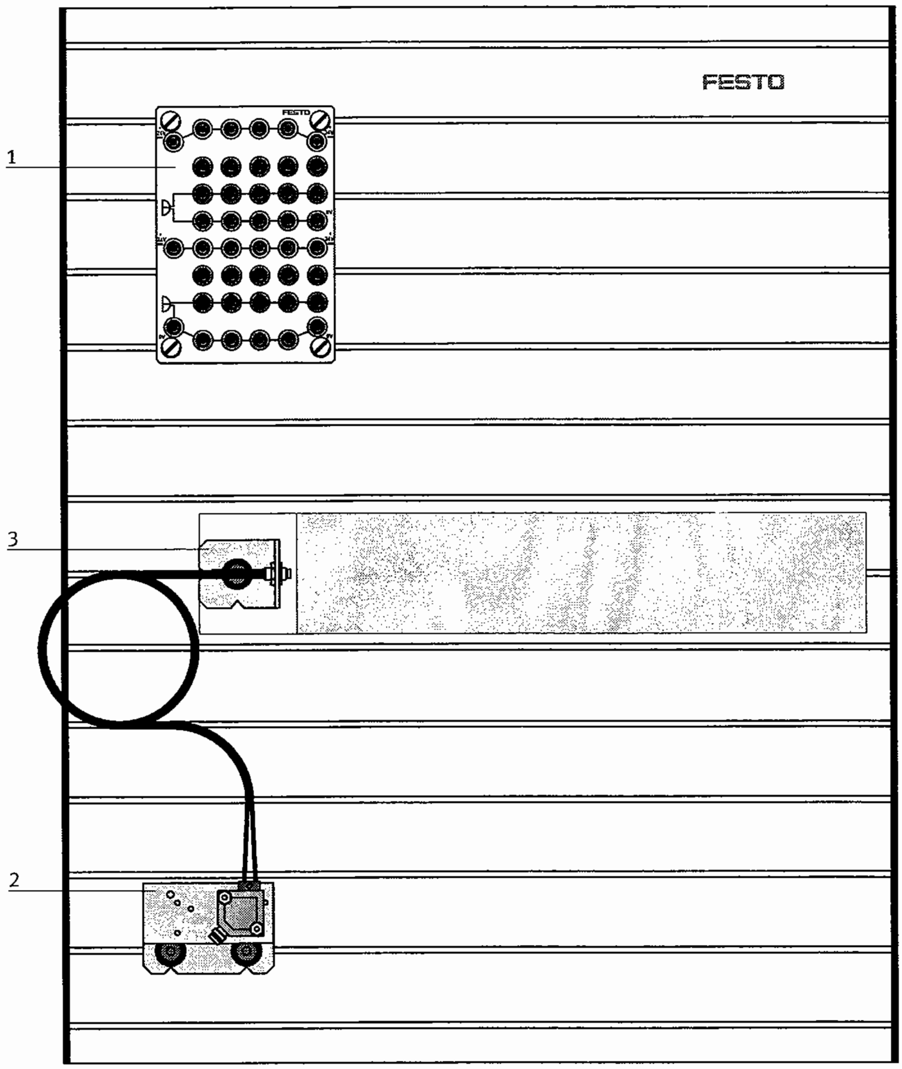
Problem description

Pre-assembled components are transported on a conveyor. The correct assembly of the components is to be checked. A diffuse sensor is used to check whether a cover has been mounted on the housing.

Positional sketch



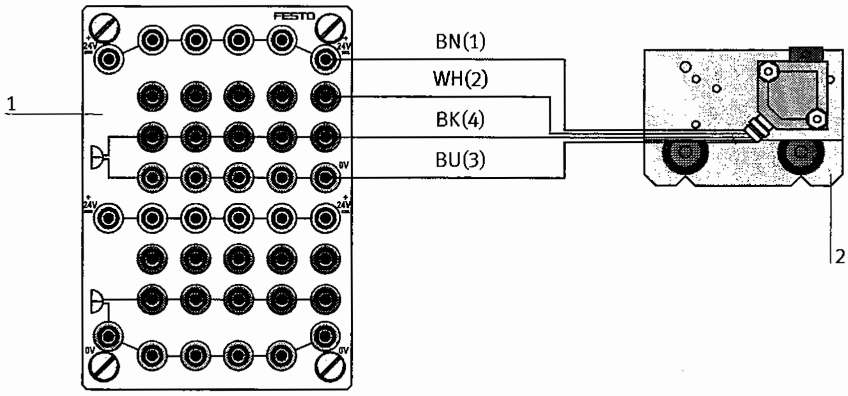
Layout



Components list

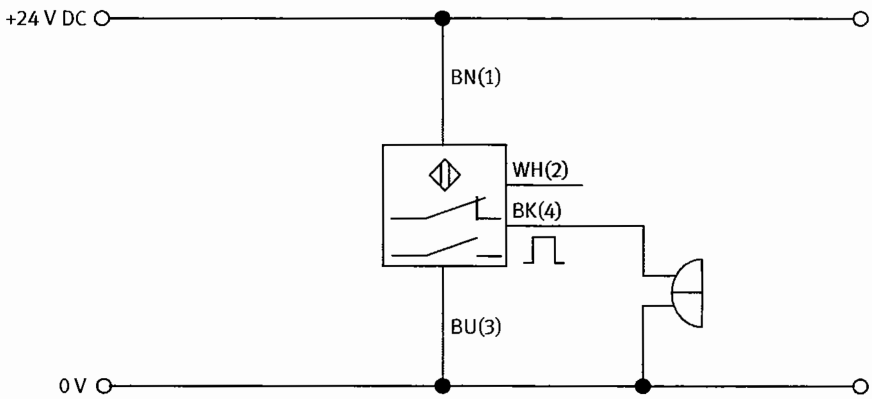
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...
3	1	Fibre-optic cable unit RT, D:ER-SOEZ-LK-RT-...
	1	Set of test objects, housing (black), cover (blue), part 31
	1	Graph paper pad, D:AS-RK
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit and the optical sensor unit LL 1 with the fibre-optic cable unit RT on the profile plate. During assembly, clamp the graph paper pad (see fig. "Layout") under the holder of the fibre-optic cable. Connect the 24V power supply and the sensor to the distribution unit (see fig. "Electrical connections").

Turn the potentiometer of the sensor unit to maximum range (turn the screw clockwise, max. 12 revolutions). Move the housing and the cover in various orientations toward the sensor (sensing of the housing takes place on the matte ring-shaped surface between the external diameter 40 mm and the internal diameter 20 mm) and note the distances, at which the object is detected. You can read the distances from the graph paper pad.

The optical proximity switch cannot detect the housing at a distance of 80 mm. Now mount the cover. Does the sensor now detect it?

Mounting the fibre-optic cables

Insert the fibre-optic cables into the plugs of the fibre-optic unit up to stop. Securely tighten locking screw

Evaluation

Object	Switching distance [mm]
Housing (black)	
Cover (blue)	

Conclusions

Exercise 16
Liquid level measurement

Training aim

To learn about the possibilities of using capacitive and optical sensors for measuring liquid levels.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

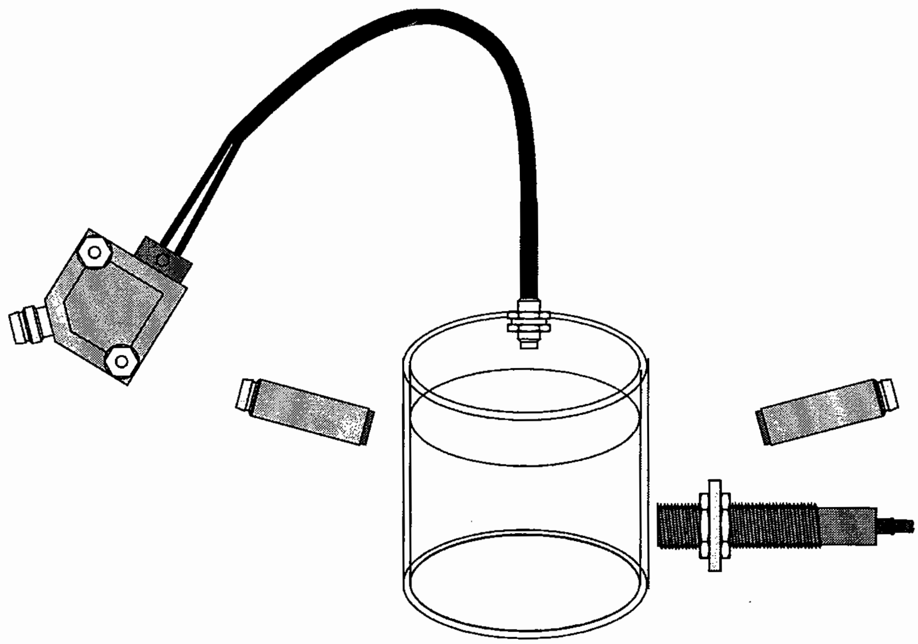
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

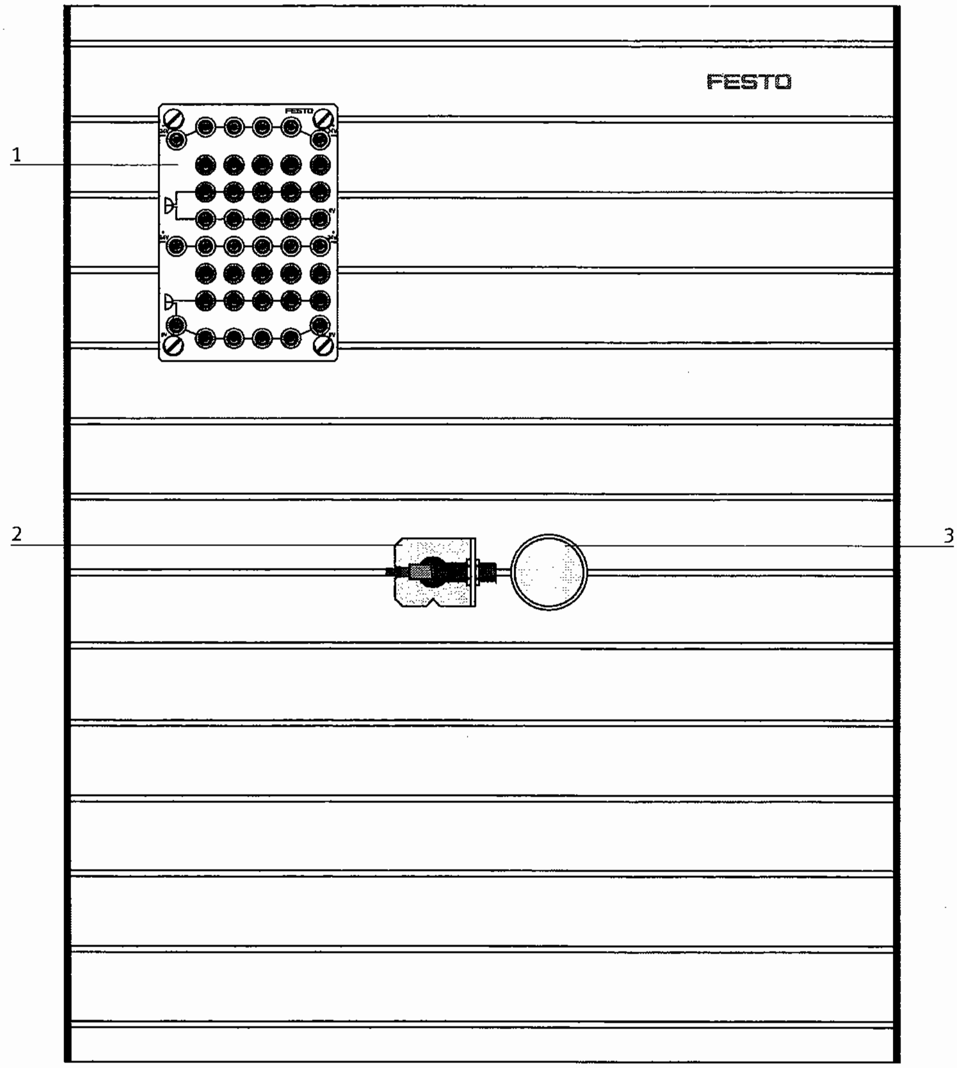
Problem description

The liquid level inside a transparent plastic container is to be ascertained through the wall of the container. For technical reasons, it is not possible to fit the sensor inside the container. Investigate the possibilities of using capacitive and optical proximity sensors.

Positional sketch



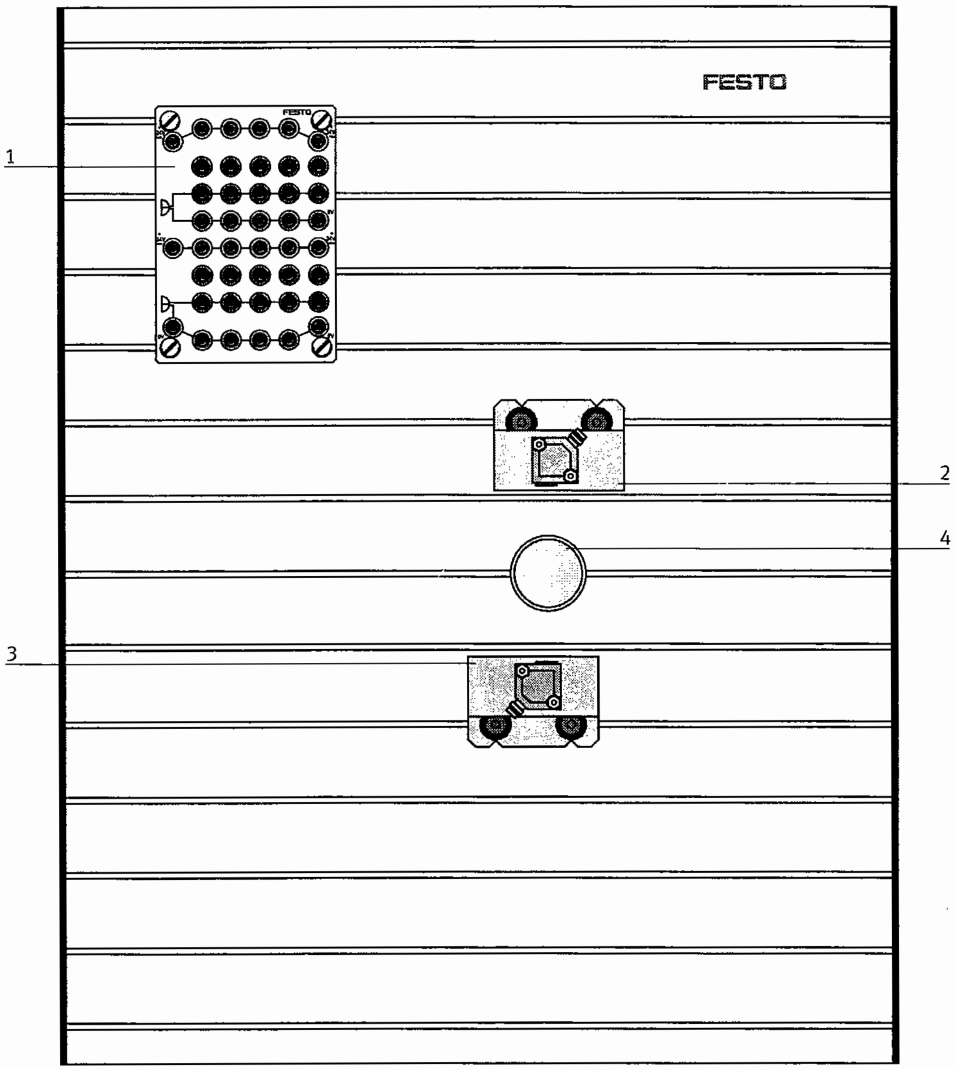
Layout 1



Components list

Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Capacitive sensor unit, D:ER-SKE-M12-...
3	1	Set of test objects, beaker, part 33
	1	Set of test objects, screw driver, part 36

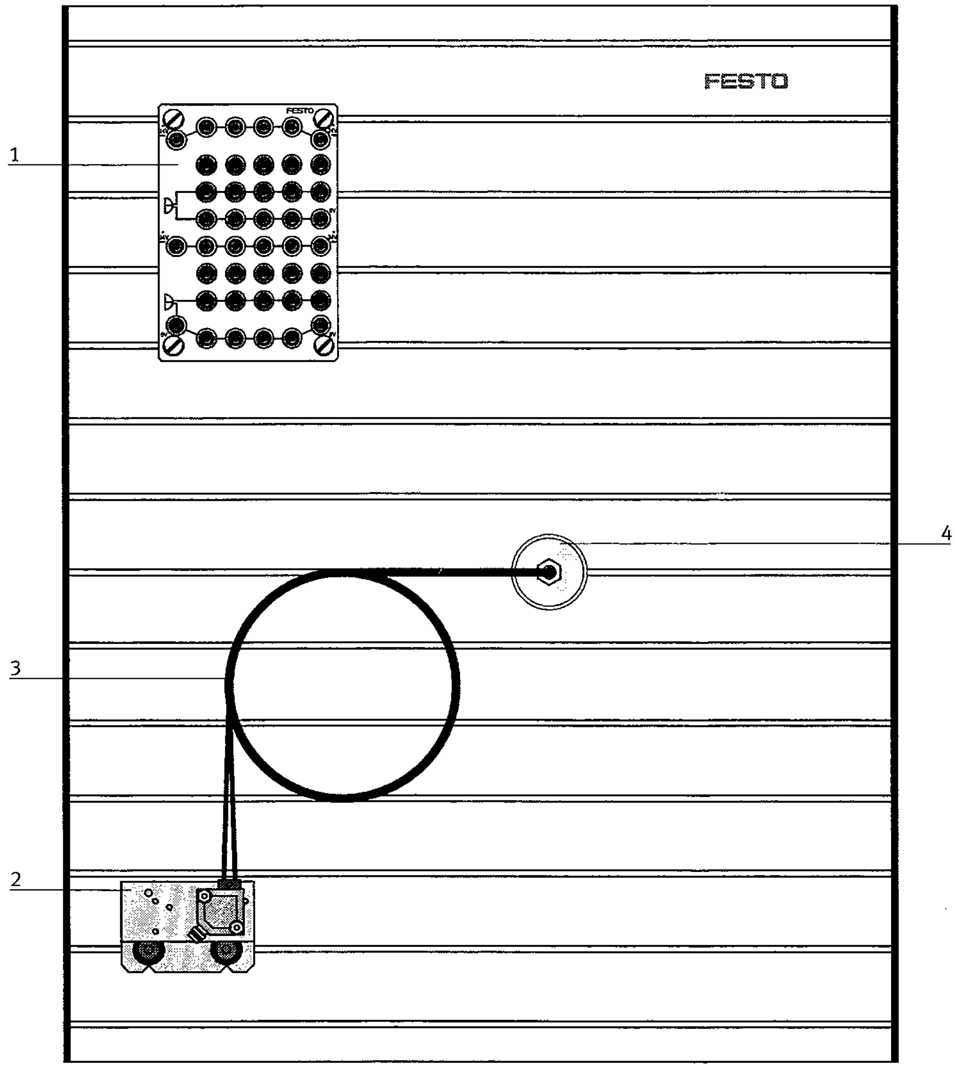
Layout 2



Components list

Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit ESS, D:ER-SOE-S-Q-...
3	1	Optical sensor unit ESE, D:ER-SOE-E-Q-...
	2	Set of test objects, holding bracket for liquid level measurement, part 32
4	1	Set of test objects, beaker, part 33
	1	Screw driver
	1	Allen key

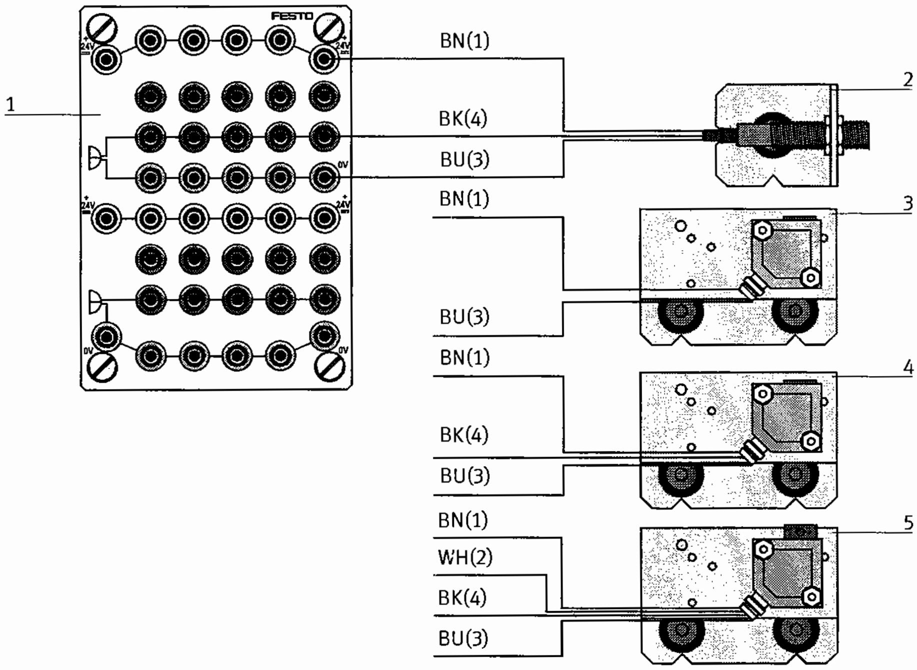
Layout 3



Components list

Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...
3	1	Fibre-optic cable unit RT, D:ER-SOEZ-LK-RT-...
4	1	Set of test objects, beaker, part 33
	1	Set of test objects, screw driver, part 36

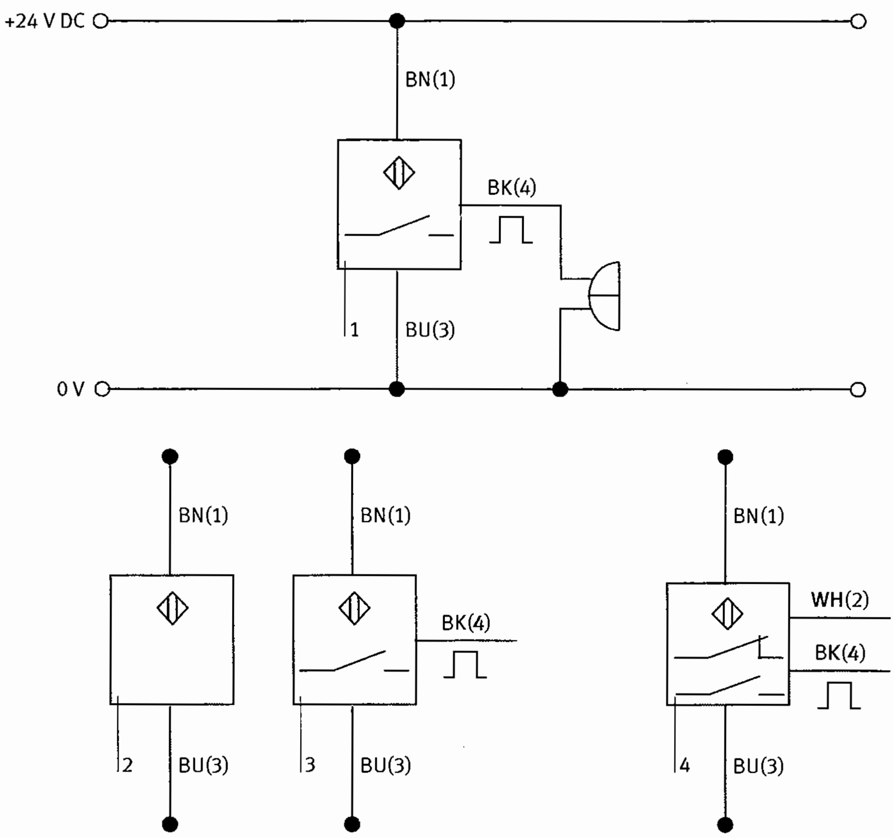
Electrical connections



Components list

Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Capacitive sensor unit, D:ER-SKE-M12-...
3	1	Optical sensor unit ESS, D:ER-SOE-S-Q-...
4	1	Optical sensor unit ESE, D:ER-SOE-E-Q-...
5	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...

Electrical circuit diagram



Components list

Item no.	Qty.	Designation
1	1	Capacitive sensor unit, D:ER-SKE-M12-...
2	1	Optical sensor unit ESS, D:ER-SOE-S-Q-...
3	1	Optical sensor unit ESE, D:ER-SOE-E-Q-...
4	1	Optical sensor unit LL 1, D:ER-SOE-L-Q-...

Practical assembly
Experiment 1

Mount the distribution unit and the capacitive sensor on the profile plate (see fig. "Layout 1"). Connect the 24V electrical power supply to the distribution unit (see fig. "Electrical connections").

Take the beaker and place it close to and in front of the active surface of the capacitive sensor. Connect the capacitive sensor to the distribution unit.

Using the potentiometer screw, adjust the sensitivity of the sensor to such a degree that it cannot detect the wall of the beaker. Slowly fill the beaker with water and observe the sensor's LED indicator.

Evaluation

Capacitive sensor unit	
Locate beaker directly at PS*)	water level __ mm, PS switches on __ mm, PS switches off
Locate beaker 3 mm from PS*)	water level __ mm, PS switches on __ mm, PS switches off

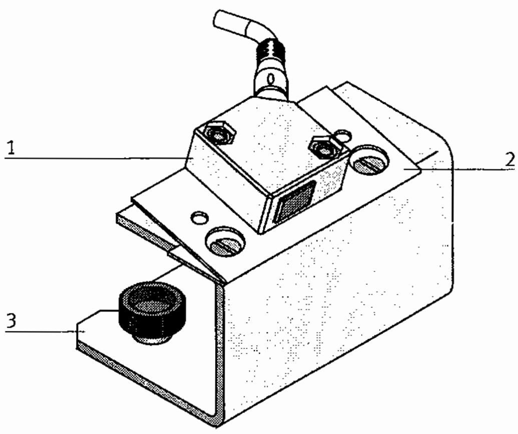
*) PS = Proximity sensor

Note
It is possible, in a similar manner, to detect objects through walls with the capacitive sensor (e.g. metallic objects through plastic partitions).

Practical assembly
Experiment 2

Liquid level measurement with optical sensor ESS/ESE is also possible.

Use the holding bracket (set of test objects, part 32). Mount this between aluminium bracket and proximity sensor so that the two sensors are inclined by an angle of 20°. Mount the sensor at a distance of 10 cm on the profile plate (see fig. "Layout 2"). Connect the 24V electrical power supply and the two optical sensor units to the distribution unit (see fig. "Electrical connections).



Optical sensor unit ESS or optical sensor unit ESE (1); Set of test objects, holding bracket for liquid level measurement, part 32 (2); Aluminium bracket (3)

Introduce the beaker between the elements of the through-beam sensor. Slowly fill it with water and watch the switching status indicator. Here, too, investigate the accuracy of liquid level monitoring.

Evaluation

Through-beam sensor	
Beaker placed between emitter and receiver	
water level	__ mm on
with further filling	__ mm off

Note
This arrangement is capable also of roughly detecting the height of objects.

Practical assembly
Experiment 3

With optical sensor unit LL 1 and with fibre-optic cable unit RT it is likewise possible to measure liquid levels.

Mount the sensor on the profile plate (see fig. "Layout 3"). Connect it to the distribution unit.

Adjust the sensor's potentiometer for maximum range (turn the screw clockwise, max. 12 revolutions). Bring the holder with fibre-optic cable unit RT above the filled beaker and watch for indication of switching status. Investigate the accuracy with which it is possible to detect a liquid level (hysteresis).

Mounting the fibre-optic cables
Insert the fibre-optic cables into the plugs of the fibre-optic unit up to stop. Securely tighten locking screw

Evaluation

Diffuse sensor with fibre-optic cable	
Distance PS*) – water level	__ mm on
Distance PS*) – water level	__ mm off

*) PS = Proximity sensor

Exercise 17
Checking of threads

Training aim

To learn about the use of optical proximity sensors with fibre-optic cables for checking threads.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

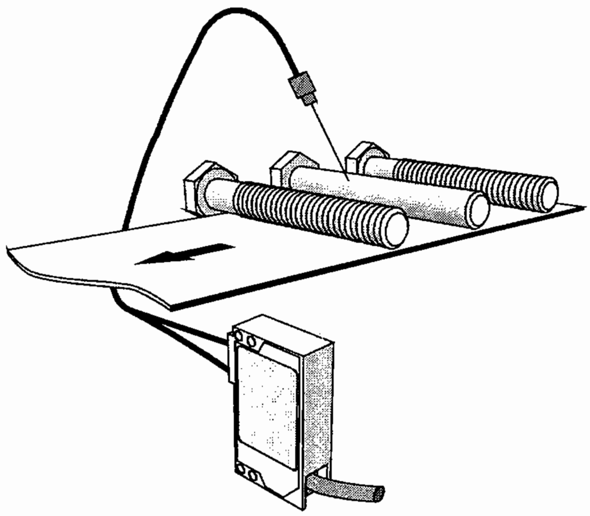
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

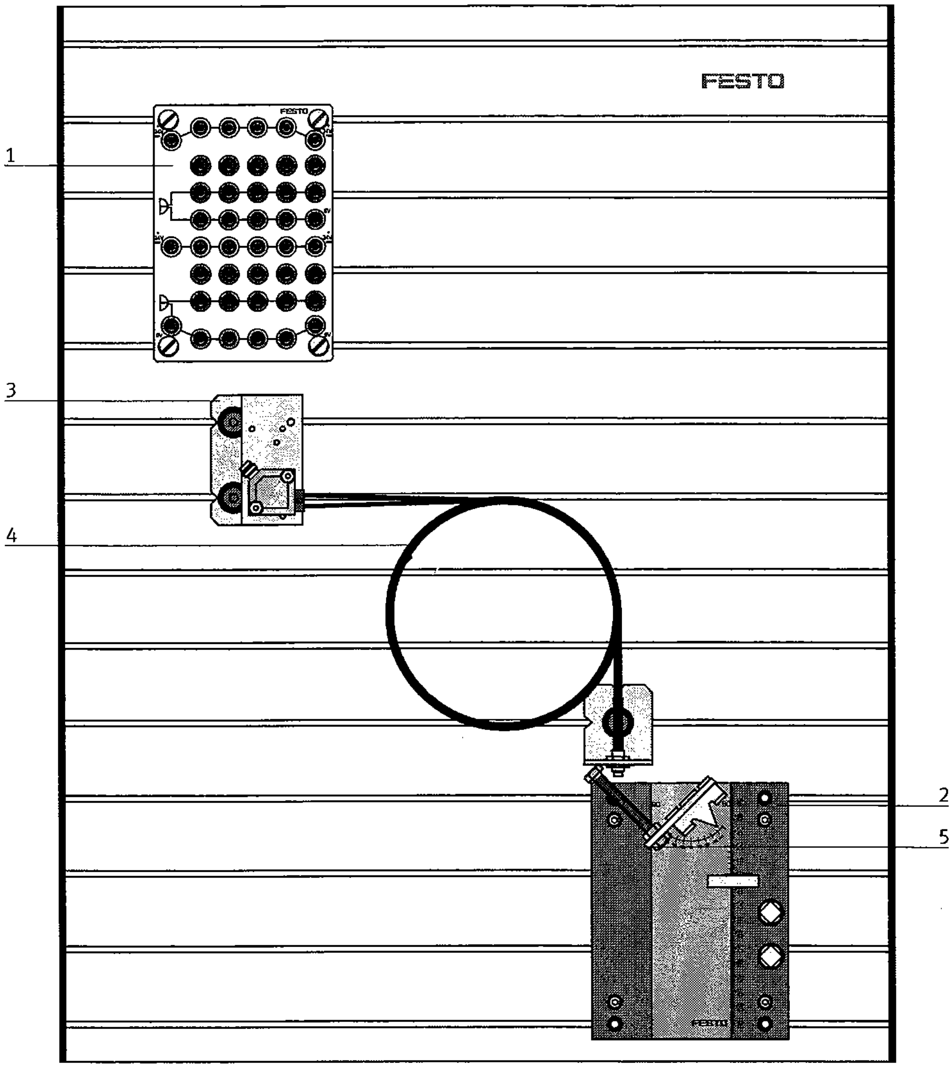
Problem description

During production, screws are to be checked for thread with an optical sensor.

Positional sketch



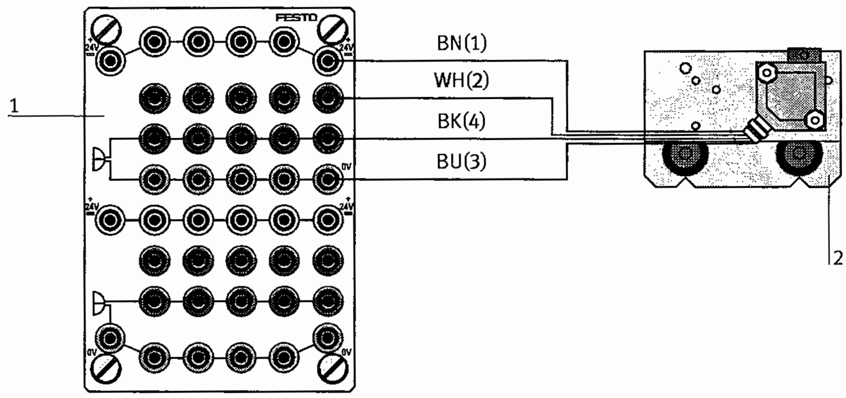
Layout



Components list

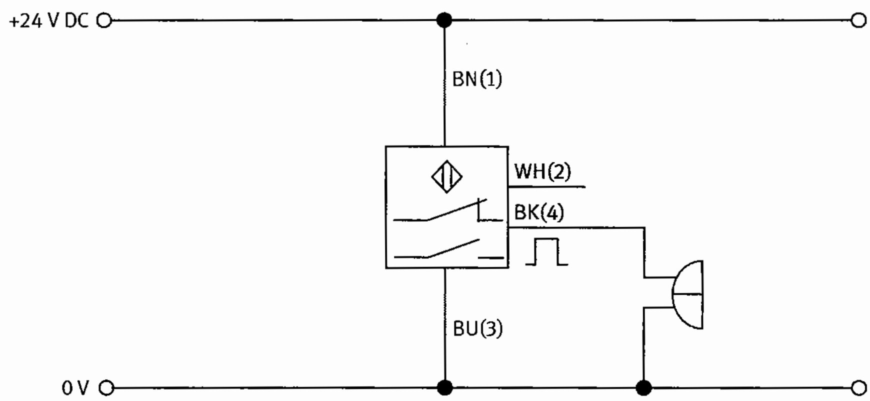
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Positioning slide, D:ER-VS-FP1110-...
3	1	Optical sensor unit LL1, D:ER-SOE-L-Q-...
4	1	Fibre-optic cable unit RT, D:ER-SOEZ-LK-RT-...
5	1	Set of test objects, holder for fibre-optic cables, part 30
	1	Set of test objects, 2 screws, part 34
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Optical sensor unit LL1, D:ER-SOE-L-Q-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit and the optical sensor unit LL 1 with the fibre-optic cable unit RT on the profile plate. Connect the 24V power supply and the sensor to the distribution unit (see fig. "Electrical connections").

Check the response to the test screws provided. Clamp the screw into the slide unit at an angle of 45°. Mount the screws one after the other into the holder for the fibre-optic cable (set of test objects, part 30). Move the screw in front of the sensing head of the fibre-optic cable, first with the thread facing the sensing head and then with the plain shank.

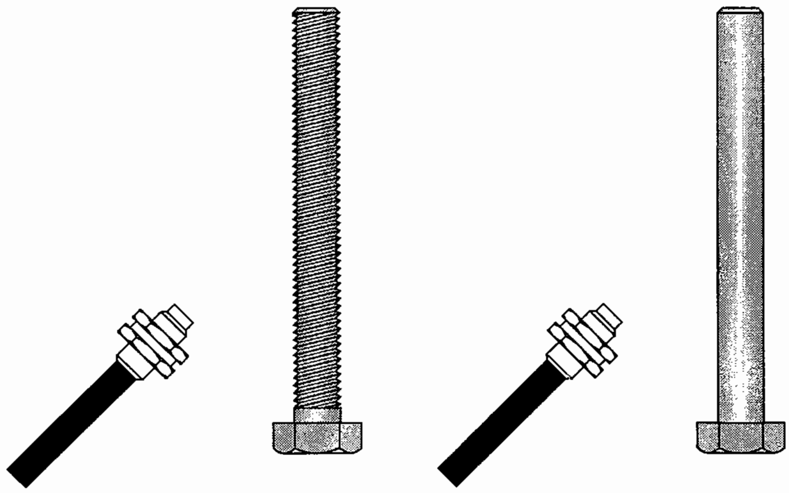
Enter the results of your measurements in the table. Sketch the lightbeam, which leads to the detection of the thread and the lightbeam which results in the bolt not being recognised.

Mounting the fibre-optic cables

Insert the fibre-optic cables into the plugs of the fibre-optic unit up to stop. Securely tighten locking screw

Evaluation

Mark the correct response	
a) Threaded screw	recognised / not recognised
b) Plain screw	recognised / not recognised



Conclusions

Exercise 18
Logic combinations of proximity sensor signals

Training aim

To learn how to establish logic connections with proximity sensors.

Exercise definition

- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

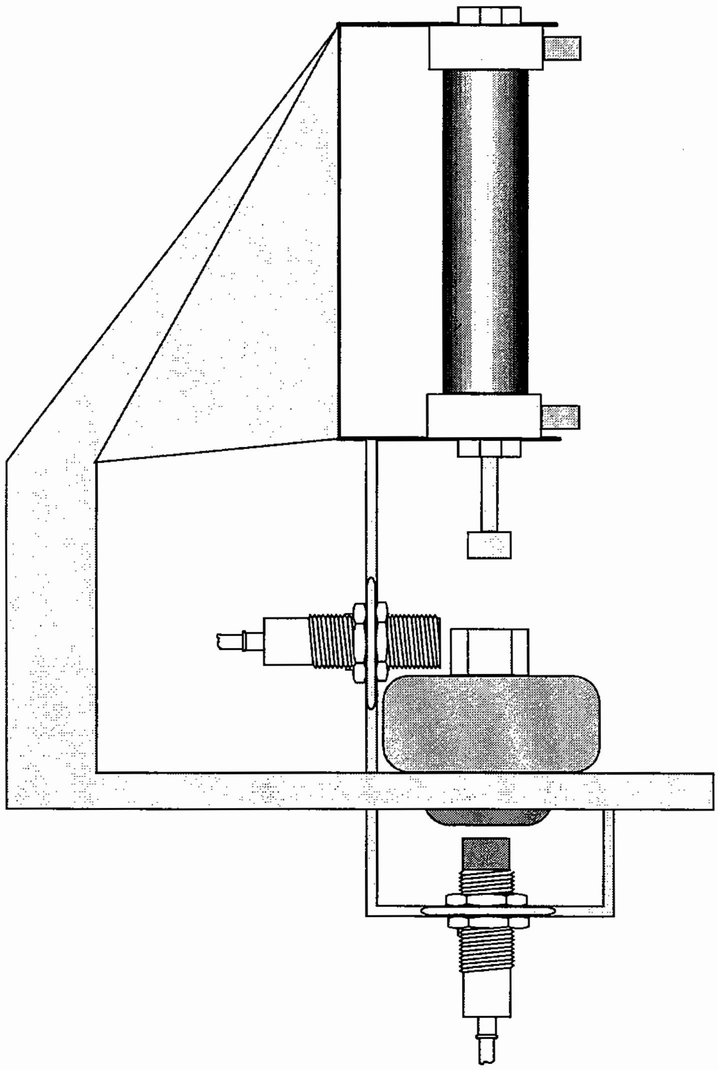
Warning

The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

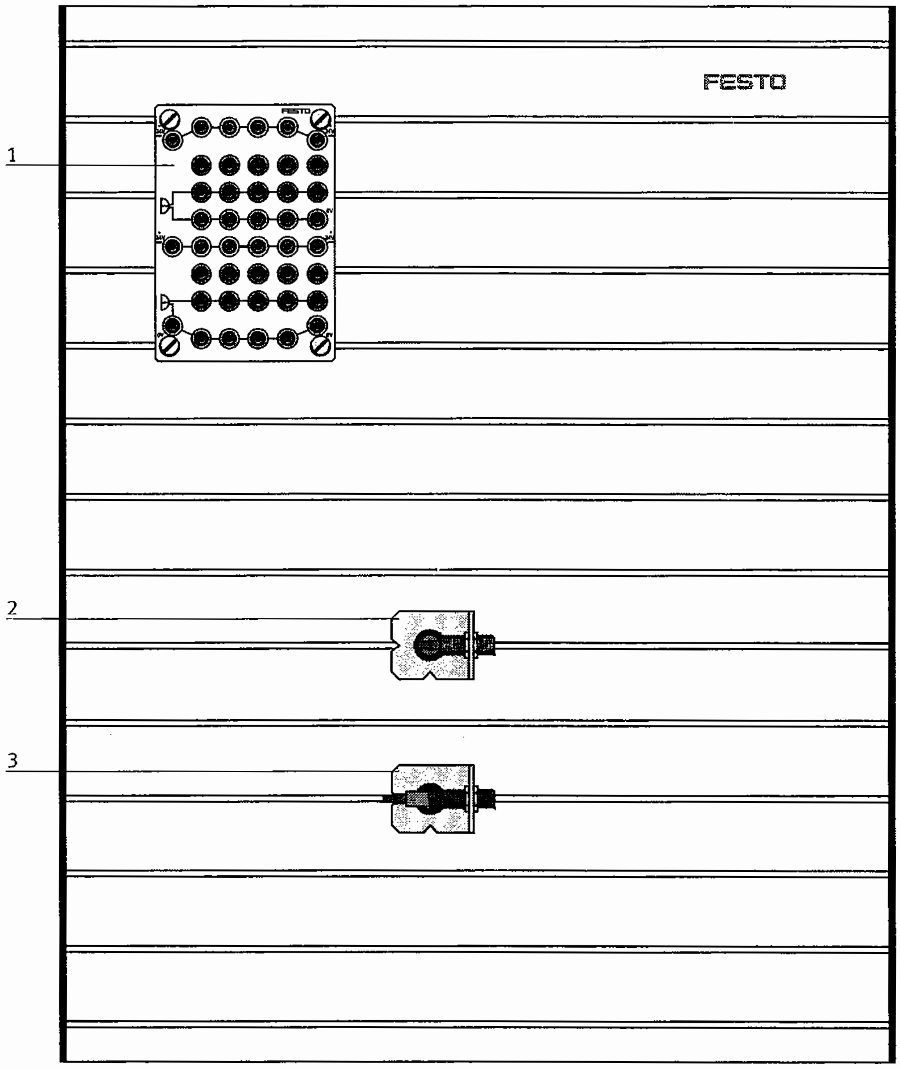
Problem description

In a pressing operation, metal inserts are pressed into plastic parts. Monitoring of material supply is carried out by means of a combination of sensors. The press is to operate only when the plastic part as well as the metal insert are in the correct position.

Positional sketch



Layout



Components list

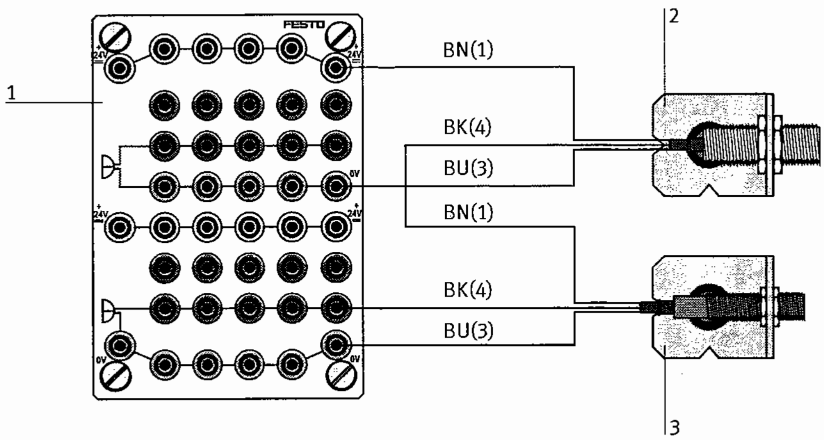
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Inductive sensor unit 1, D:ER-SIEH-M18B-...
3	1	Capacitive sensor unit, D:ER-SKE-M12-...
	1	Digital multimeter, D:AS-DMM

The components list is continued on the following page.

Components list (continued)

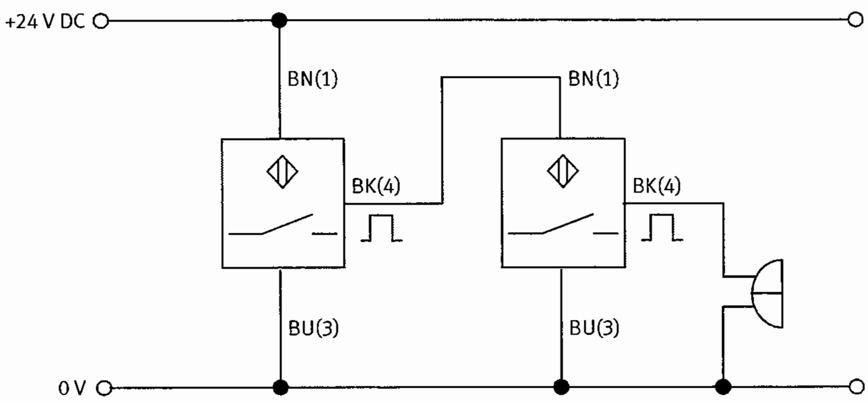
Item no.	Qty.	Designation
	1	Set of test objects, mild steel S 235 JR, 90 mm x 30 mm, part 3
	1	Set of test objects, cardboard, 90 mm x 30 mm, part 8
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Inductive sensor unit 1, D:ER-SIEH-M18B-...
3	1	Capacitive sensor unit, D:ER-SKE-M12-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit, the inductive sensor unit 1 and the capacitive sensor unit on the profile plate. Connect the 24V power supply to the distribution unit.

Measure the current consumption of the various proximity sensors in the attenuated and unattenuated state by connecting the switch output to the unconnected socket of the distribution unit and then to the buzzer socket. Make a note of the values in the table.

Now connect the switching output of the capacitive sensor with the positive operating voltage connection of the inductive sensor. To do this, plug the switching output of the capacitive sensor into the unconnected socket of the distribution unit and connect the positive connection of the inductive sensor to this. In this way, the inductive sensor receives its supply voltage only when an object has been detected by the capacitive sensor. The switching output of the inductive sensor is also plugged into an unconnected socket in the distribution unit.

Measure the individual voltages listed below:

- $\mathbf{V_{op}}$: Operating voltage
- $\mathbf{V_1}$: Voltage on the switched through output of the capacitive sensor (remaining operating voltage of the inductive sensor)
- $\mathbf{V_2}$: Voltage on the switched through output of the inductive sensor

Enter the measured values in the table.

Note

Inductive and capacitive proximity sensors are referred to as attenuated proximity sensors, when the proximity sensor detects an object.

Evaluation

Current consumption of a capacitive sensor	
a) Switching output in unconnected socket	
Switching status	Current consumption [mA]
unattenuated	
attenuated	
b) Switching output in buzzer socket	
Switching status	Current consumption [mA]
unattenuated	
attenuated	

Current consumption of an inductive sensor	
a) Switching output in unconnected socket	
Switching status	Current consumption [mA]
unattenuated	
attenuated	
b) Switching output in buzzer socket	
Switching status	Current consumption [mA]
unattenuated	
attenuated	

Voltage measurement with series connection	
	Voltage [V]
Operating voltage V_{op}	
Voltage V_1	
Voltage V_2	

Conclusions

Exercise 19
Position detection with proximity sensors

Training aim

To be acquainted with the use of optical proximity sensors with fibre-optic cables for the orientation of components.

Exercise definition

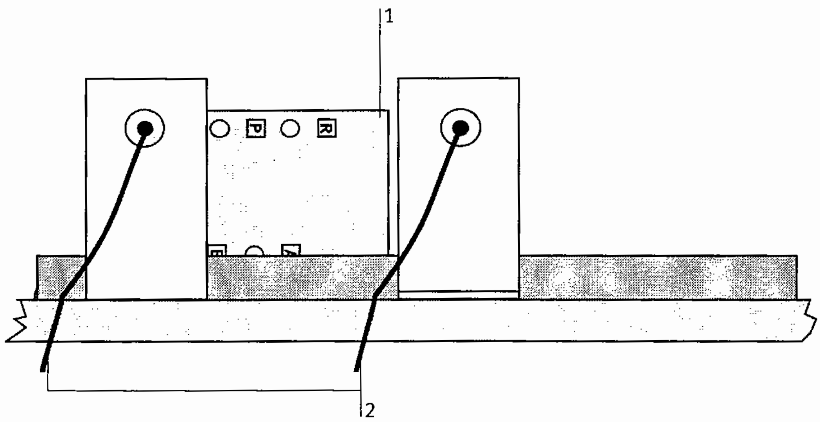
- Study the exercise. You will find hints and explanations in the textbook 'Proximity Sensors'.
- Before the practical construction of the exercise, read through the data sheets of the components required.
- Assemble the components.
- You can carry out the exercise in accordance with the description in paragraph "Practical assembly".
- Make a note of everything you consider of particular interest.

Warning
The electrical power supply must be switched on only after all connections have been established and checked. After completion of the exercise, the voltage supply must be switched off before the components are dismantled.

Problem description

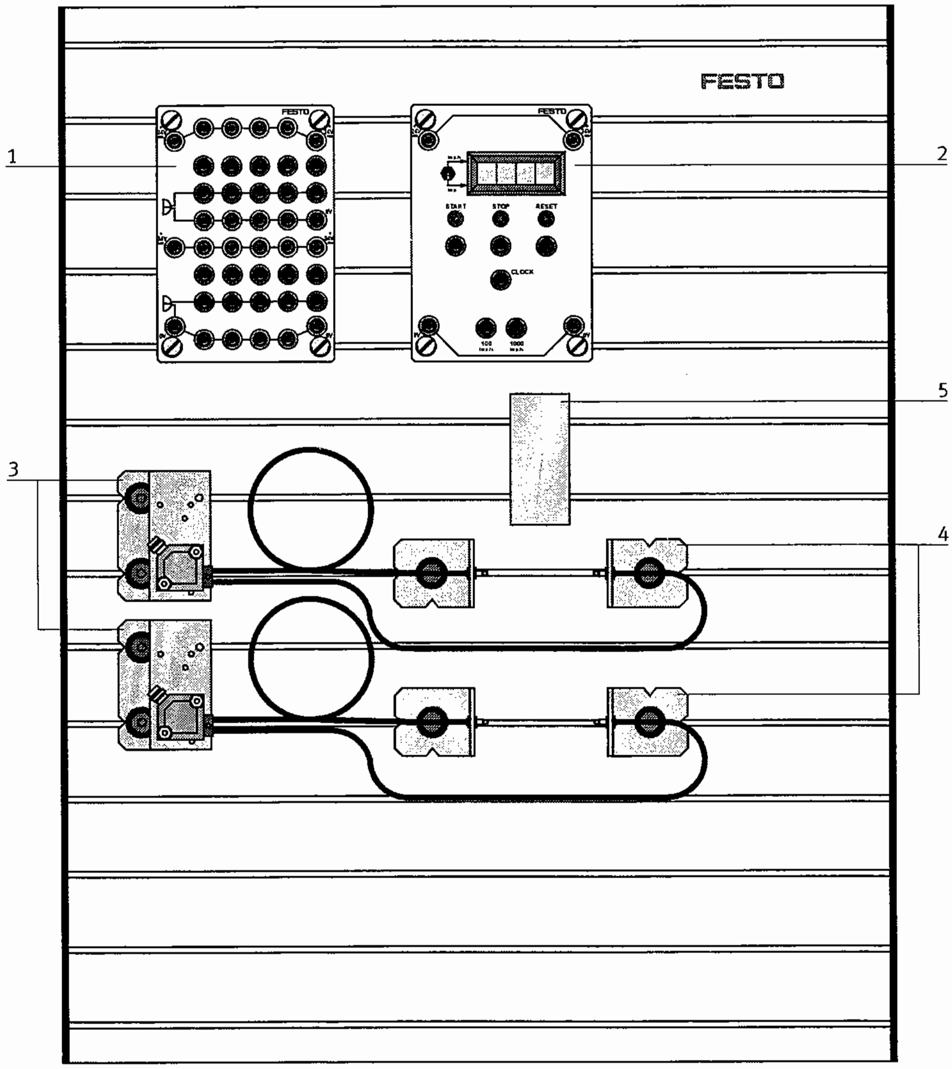
Valve housings are transported on a conveyor belt. The orientation of these housings is to be monitored by sensors. The fixing holes in the housings provide suitable distinguishing characteristics. Incorrectly orientated components are passed to the turning station.

Positional sketch



Valve housing (1), Fibre-optic cables (2)

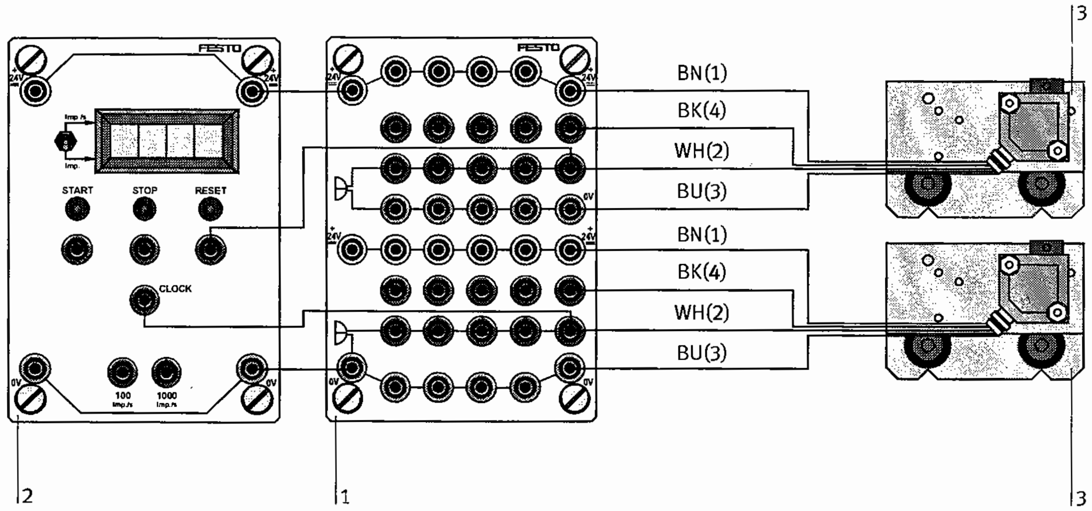
Layout



Components list

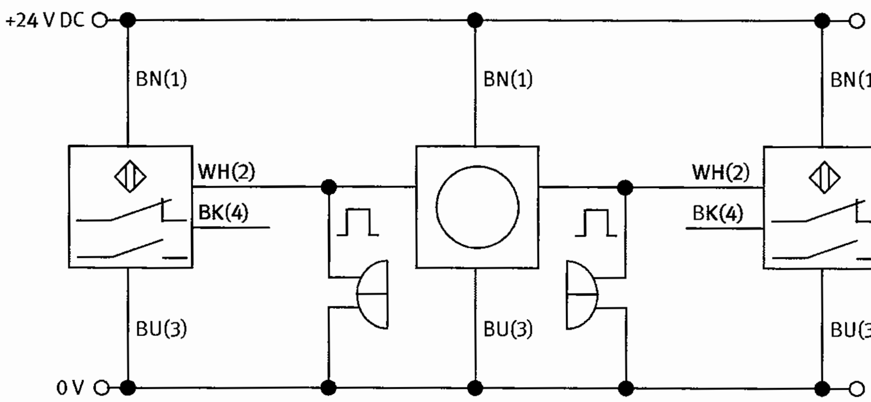
Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	1	Counting unit, D:ER-ZE-FP1110-...
3	2	Optical sensor unit LL 1, D:ER-SEO-L-Q-...
4	2	Fibre-optic cable unit SE, D:ER-SOEZ-LK-SE-...
5	1	Set of test objects, workpiece valve housing, part 35
	1	Set of test objects, screw driver, part 36

Electrical connections



Item no.	Qty.	Designation
1	1	Distribution unit, D:ER-VERT-SENSOR-...
2	2	Optical sensor unit LL 1, D:ER-SEO-L-Q-...
3	1	Counting unit, D:ER-ZE-FP1110-...

Electrical circuit diagram



Practical assembly

Mount the distribution unit and the two optical sensor units LL 1 with the fibre-optic cable units SE on the profile plate. Arrange a distance of 10 cm between the two light barriers and a distance of 5 cm between optical emitter and receiver unit. Connect the 24V electrical power supply and the two sensors to the distribution unit (see fig. "Electrical connections"). Connect the normally closed output of the first sensor unit to the RESET socket of the counting unit. The normally closed output of the second sensor is connected to the CLOCK socket of the counting unit. The indicating display mode switch is in position "Imp".

Move the valve housing, lying on its side, through the gap between the two light barriers in such a way that the fixing holes are on the level of the optical axis. Make a note of the result with both orientations.

Mounting the fibre-optic cables

Insert the fibre-optic cables into the plugs of the fibre-optic unit up to stop. Securely tighten locking screw

Preparing the counting unit for measurement

Press the "Stop", "Reset" and "Start" buttons before the first measurement, in order to prepare the counting unit for measurement.

Evaluation

Orientiation	Signals counted
1 upper hole	
2 upper holes	

Conclusions

Part B

Part B Fundamentals

The theoretical fundamentals for the function package Proximity Sensors are described in the textbook

Lerning system for Automation and Technology

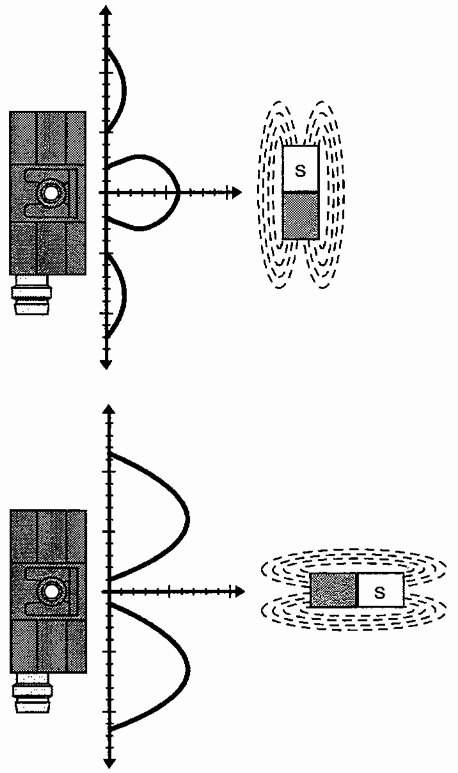
Proximity Sensors

Part C Solutions

Applications

Solution 1
Switching characteristics of a contacting magnetic proximity sensor

Evaluation



Switching characteristics for magnetic sensor unit 1 (D.ER-SMEO-..) with varying orientations of the axis of the magnetic poles

Conclusions

As can be seen from the figure above, two or even three switching areas may be observed, depending on the orientation of the axis of the magnetic poles. This ambiguity of the output signals can be prevented by attaching the magnet with the correct orientation of the axis and, given a specific field strength, at the correct distance.

In the case of sensor-magnet combinations which are obtained separately, it is important to check which switching characteristic is achieved. Only in this way can the effective application of the sensor be guaranteed.

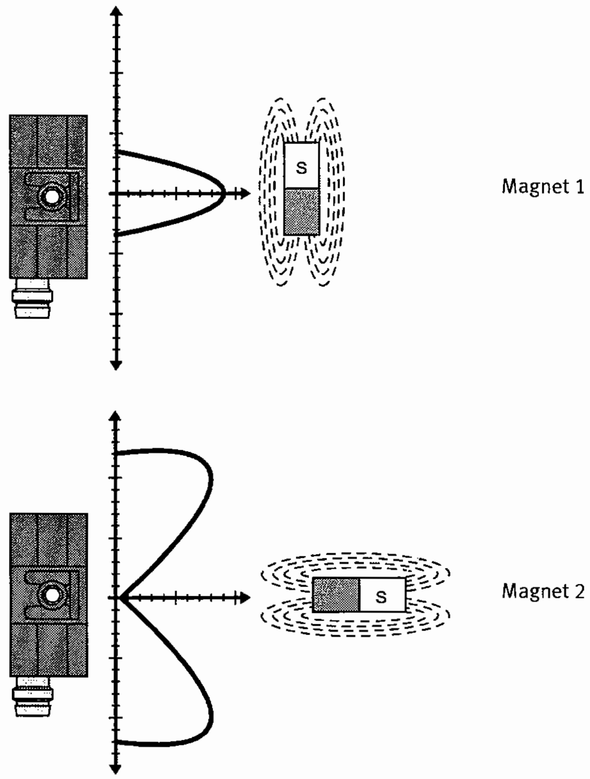
You will find further information and explanations in the textbook ‚Proximity Sensors'.

Solution

Solution 2

Switching characteristics of a contactless magnetic proximity sensor

Evaluation



Switching characteristics for magnetic sensor unit 2 (D.ER-SMTO-..) with varying orientations of the axis of the magnetic poles

Conclusions

As can be seen from the figure above, two switching areas may be observed, depending on the orientation of the axis of the magnetic poles. This ambiguity of the output signals can be prevented by attaching the magnet with the correct orientation of the axis and, given a specific field strength, at the correct distance.

In the case of sensor-magnet combinations which are obtained separately, it is important to check which switching characteristic is achieved. Only in this way can the effective application of the sensor be guaranteed.

With correctly orientated contactless magnetic sensors, a bounce-free output switching signal is obtained.

You will find further information and explanations in the textbook ‚Proximity Sensors'.

Solution

Solution 3
Switching distance of an inductive proximity sensor

Evaluation

Inductive sensor unit 1 (D:ER-SIEH-M18B-...)	
Switch-on point:	5.3 mm
Switch-off point:	5.6 mm
Hysteresis:	0.3 mm

Inductive sensor unit 2 (D:ER-SIEH-M12B-...)	
Switch-on point:	3.5 mm
Switch-off point:	3.7 mm
Hysteresis:	0.2 mm

Conclusions

With inductive sensors, the attainable switching distance is dependent on the diameter of the resonant circuit coil and therefore on the size of the cylindrical sensor. The larger the diameter, the larger the switching distance.

The difference between the switch-on point and the switch-off point is known as hysteresis. This is essential to guarantee reliable switching of the sensor. Should the switch-on point and switch-off point coincide, this would result in fluttering of the output signal.

The measured switching distances give an indication as to the required adjustment of inductive sensors.

Further information and explanations can be found in the textbook ‚Proximity Sensors'.

Solution

Solution 4
Sensing of different metals with inductive proximity sensors

Evaluation

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]	Reduction factor
Mild steel S 235 JR, part 3	5.9	6.2	0.3	1
Stainless steel, part 4	5.4	5.7	0.3	0.91
Aluminium, part 5	3.2	3.4	0.2	0.54
Brass, part 6	3.2	3.4	0.2	0.54
Copper, part 7	2.5	2.8	0.3	0.42

Conclusions

This exercise demonstrates that different metals result in different switching distances. With reduced switching distances the tolerances for the distances between containers are smaller, and the need for adjustment increases.

This effect depends on the difference in electric conductivity of the materials used.

Further information and explanations can be found in the textbook ‚Proximity Sensors'.

Solution

Solution 5
Influence of the object surface on the switching distance

Evaluation

Length of sides [mm]	Switching gap [mm]
Mild steel S 235 JR, part 11: 30	6.2
Mild steel S 235 JR, part 12: 25	6.1
Mild steel S 235 JR, part 13: 20	6.0
Mild steel S 235 JR, part 14: 15	5.8
Mild steel S 235 JR, part 15: 10	5.1
Mild steel S 235 JR, part 16: 5	3.1

Conclusions

The switching distance of an inductive sensor depends not only on the type of material (see exercise 4), but also on the size of the object to be detected.

In general, the switching distance of inductive sensors for objects which are smaller than the standard calibrating plate depends on the area of the object detected, i.e., for objects which are smaller than the standard calibrating plate, the achievable switching distance is smaller than the nominal switching distance.

Solution

Solution 6
Response characteristics of a through-beam sensor

Evaluation

Material	Detection yes/no
Mild steel S 235 JR, part 3	yes
Stainless steel, part 4	yes
Aluminium, part 5	yes
Cardboard, part 8	yes
Rubber, part 9	yes
Plastic, transparent, part 10	no

Conclusions

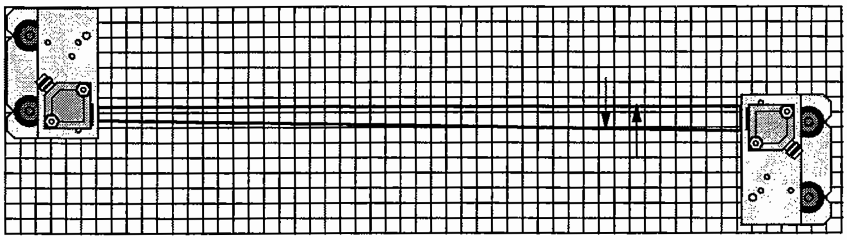
With a through-beam sensor, objects made of reflective materials can also be reliably detected. Transparent materials, however, present a problem.

If required, transparent materials can also be detected. Sensitivity must be reduced at the light barrier receiver with the potentiometer to this end. By further reducing the beam through the material, detection is possible. This, however, leads to a reduction in the switching distance. The transparent plastic object provided in the function package will not be detected, if it is clean and unscratched.

When guiding the objects into the light beam from the side, their position can be precisely detected.

Solution

In the illustration below, the switch-on points of the response curve of the through-beam sensor are shown. You will see, that the emitter emits light only through one lens, whereas the receiver receives light through both lenses.



Response curve of the through-beam sensor

Note
If the sensor emitter and sensor receiver are installed vertically to the profile plate, you obtain a response curve symmetrical in relation to the optical axis.

Solution 7
Response characteristics of a retro-reflective sensor

Evaluation

Material	Detection yes/no
Mild steel S 235 JR, part 3	yes* (no, if reflective and perpendicular to optical axis)
Stainless steel, part 4	no* (yes, if angle other than 90°)
Aluminium, part 5	no* (yes, if angle other than 90°)
Brass, part 6	no* (yes, if angle other than 90°)
Copper, part 7	yes* (no, if reflective and perpendicular to optical axis)
Cardboard, part 8	yes*
Rubber, part 9	yes
Plastic, transparent, part 10	yes *

* With these objects detection depends on the surface characteristics of the object, the angle and the distance between sensor and object.

Conclusions

Retro-reflective sensors function reliably if the light path is interrupted by opaque objects.

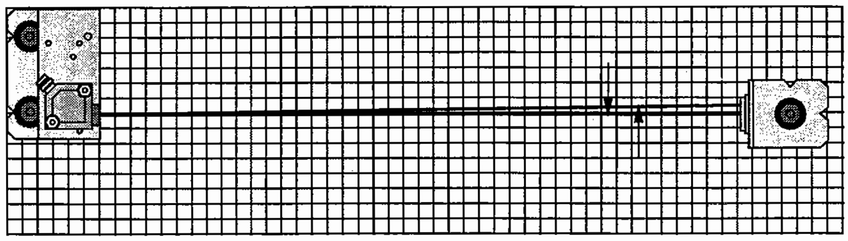
Yet, if an object with a reflecting surface enters the beam of emitted light at a 90° angle to the optical axis, there is no certainty that it will be detected by the retro-reflective sensor. This phenomenon may be avoided if the object is placed at an oblique angle to the optical axis.

Note
The use of retro-reflective sensors employing polarised light offers another possibility. These, too, provide reliable detection of reflecting objects. You will find further relevant explanations in the textbook ‚Proximity Sensors'.

Solution

The detection of transparent objects may sometimes be possible, if the sensitivity is reduced to such an extent that the attenuation through the twofold passage of the light beam through the object suffices.

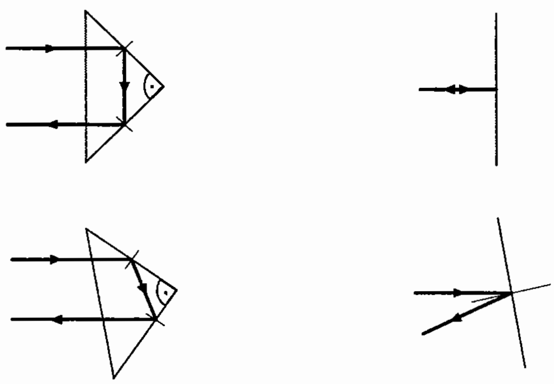
In the following illustration, the switch-on points are shown as the response curve of the optical retro-reflective sensor.



Response curve of the retro-reflective sensor

Note
There can be deviations from the shape of the response curves. Non-uniformity of the equipment parameters may be among the reasons. Slight dirt contamination may affect the shape of the curves. If the retro-reflective sensor is mounted vertically to the profil plate, it results in a response curve lying symmetrically to the optical axis.

Triple reflectors have the special characteristic of reflecting the light beam back to the emitter, even if their surface is not exactly normal to the light beam impinging on it. This simplifies the adjustment of the reflector. In accordance with the laws of optics, flat mirrors reflect the light beam away from the optical axis.



Reflection of a light beam from a triple reflector and a flat mirror

Solution 8
Sensing range of a diffuse optical sensor

Evaluation

Note
Your measured values may deviate from those given in the tables, because these values very much depend on the potentiometer setting and the nature of the surface of the objects selected from the set of test objects.

Experiment 1
Optical sensor unit RT 1 (D:ER-SOE-RT-Q-..)

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]
Kodak grey card, white side, part 17	300	340	40
Kodak grey card, grey side, part 17	175	210	35
Plastic, transparent, part 18	430	450	20
Plastic, red, matted side, part 19	220	250	30
Plastic, blue, matted side, part 20	190	230	30
Plastic, black, matted side, part 21	75	100	25
Cardboard, white, part 22	275	290	15
Mild steel S 235 JR, part 3	540	630	90
Stainless steel, part 4	520	610	90
Aluminium, part 5	550	570	20
Brass, part 6	660	690	30
Copper, part 7	370	430	60
Rubber, part 9	–	–	

Experiment 2
Optical sensor unit RT 2 (D:ER-SOE-RT-M18-..)

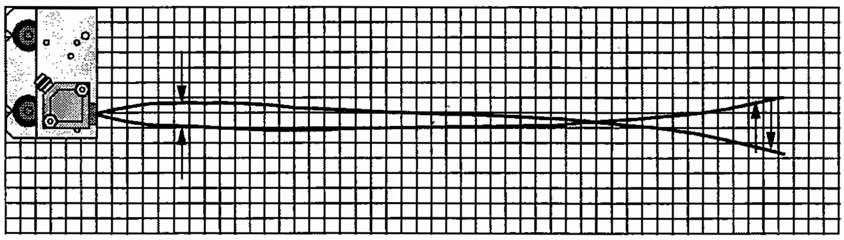
Material	**Switch-on point [mm]**	**Switch-off point [mm]**	**Hysteresis [mm]**
Kodak grey card, white side, part 17	150	185	35
Kodak grey card, grey side, part 17	90	120	30
Plastic, transparent, part 18	100	130	30
Plastic, red, matted side, part 19	110	140	30
Plastic, blue, matted side, part 20	105	130	25
Plastic, black, matted side, part 21	40	60	20
Cardboard, white, part 22	150	180	30
Mild steel S 235 JR, part 3	160	190	30
Stainless steel, part 4	170	200	30
Aluminium, part 5	200	240	40
Brass, part 6	280	300	20
Copper, part 7	180	200	20
Rubber, part 9	–	–	

Solution

Conclusions

It becomes apparent that the range of the sensor varies according to the reflectiveness of the material.

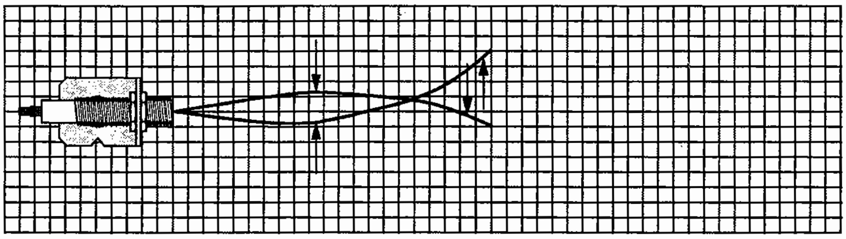
With the optical sensor unit RT 1 (diffuse sensor, D.ER-SOE-RT-Q-..) sensing ranges of up to approximately 800 mm (for reflecting surfaces) are achieved. As this sensor operates with infra-red light, the lightbeam is not visible. This can lead to difficulty with adjustments. The shape of the response curve is dependent on the potentiometer setting. The asymmetry is a result of the horizontal arrangement of the components (the emitter being adjacent to the receiver and the object approaching from the side).



Response curve of the diffuse sensor D:ER-SOE-RT-Q-...

Solution

With the sensor unit RT 2 (diffuse sensor, D.ER-SOE-M18-..) sensing ranges of approximately 500 mm (for reflecting surfaces) can be achieved. The asymmetry which is visible in the response curve is because the vertical alignment of the emitter and the receiver is not accurate.



Response curve of the diffuse sensor D:ER-SOE-RT-M18-...

Note
When detecting objects other than the Kodak grey card, which is 100 x 100 mm, this may create different response curves for the two diffuse sensors.

Solution 9
Sensing range of a diffuse optical sensor with fibre-optic cable

Evaluation

Note

Depending on the surface characteristics of the materials investigated, your measurements may reveal differences in sensing ranges. The cut edge of the fibre-optic cable and the optical transition from transmitter and receiver optics to the fibre-optic cable also influence measurement results.

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]
Kodak grey card, white side, part 17	8.3	10.5	2.2
Kodak grey card, grey side, part 17	4.1	5.5	1.4
Plastic, transparent, part 18	4.1	4.9	0.8
Plastic, red, matted side, part 19	6.2	8.0	1.8
Plastic, blue, matted side, part 20	–	–	
Plastic, black, matted side, part 21	–	–	
Cardboard, white, part 22	8.9	10	1.1
Mild steel S 235 JR, part 3	12.9	14.8	1.9
Stainless steel, part 4	10.4	12.2	1.8
Aluminium, part 5	13.0	15.0	2.0
Brass, part 6	14.2	16.6	2.4
Copper, part 7	13.1	14.6	1.5
Rubber, part 9	–	–	

Conclusions

Using fibre-optic cables, only small sensing ranges can be achieved. It is, therefore, necessary to approach the objects closely.

Their small overall size permits use in space saving applications. Application in inaccessible places is possible through the high flexibility of the fibre optics. They are capable of detecting the smallest objects and a high degree of sensing accuracy can be achieved. They can be used in surroundings subject to explosion risk, whereby the electrical components of the proximity sensor have to be hermetically separated.

Note
In locations with high temperature (e.g. 200 °C) glass fibre optic cables are preferable (see textbook ‚Proximity Sensors').

Solution 10
Switching distance of a capacitive sensor

Evaluation

Material	Switch-on point [mm]	Switch-off point [mm]	Hysteresis [mm]
Mild steel S 235 JR, part 3	8.0	9.0	1.0
Stainless steel, part 4	8.1	9.1	1.0
Aluminium, part 5	7.8	8.5	0.7
Brass, part 6	7.9	8.6	0.7
Copper, part 7	8.1	8.9	0.8
Cardboard, part 8	4.2	5.0	0.8
Rubber, part 9	6.5	7.4	0.9
Plastic, transparent, part 10	2.2	2.7	0.5

As the values given in the table are dependent on the potentiometer setting, your measurements may produce different figures, if the value achieved by the initial adjustment for the steel plate already deviates from the one in the table.

Conclusions

Metallic and non-metallic objects can be detected with capacitive proximity sensors. Compared, e.g. to optical diffuse sensors, they offer the advantage of being able to detect also materials with very low reflectivity (very dark surfaces). With materials of very low dielectric constants (e.g. many plastics), detection takes place only from a certain thickness and above (see exercise 11).

Note
The capacitive proximity sensor responds also to many liquids. It has, however, to be observed that an unintended wetting of the active surface of the proximity sensor, e.g. through water condensate, may lead to an output signal.

Solution

Solution 11
Influence of material thickness on the switching distance of a capacitive sensor

Evaluation

Material thickness [mm]	Switching distance [mm]
Plastic, part 23, 2,0	1.9
Plastic, part 24, 3,0	2.6
Plastic, part 25, 5,0	2.8
Plastic, part 26, 8,0	3.0
Plastic, part 27, 11,0	3.3
Plastic, part 28, 14,0	3.6
Plastic, part 29, 17,0	3.7

As the results depend on the potentiometer setting, the values of your measurements may deviate, if the initial adjustment for the steel plate does not result in a switching distance of precisely 8 mm.

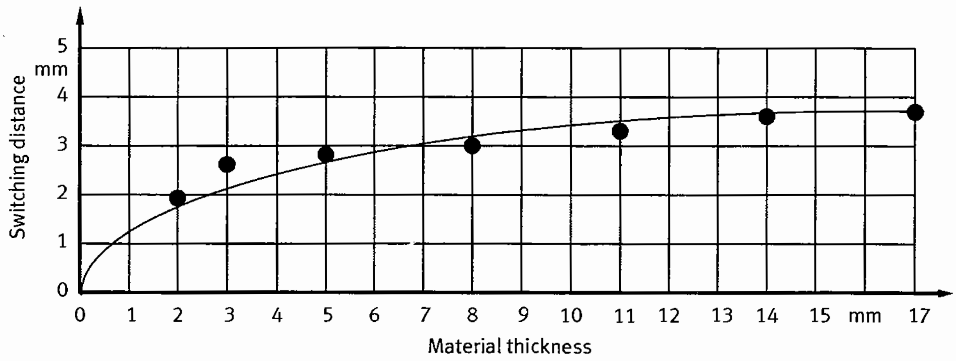
Conclusions

As can be seen from the graph, in the case of plastic, the switching distance of a capacitive sensor is dependent on the material thickness.

With a capacitive sensor, the capacitive change which results from the proximity of the object is measured. Therefore, a sufficiently large amount of the material has to be put before the sensor in order for it to react. The smaller the dielectric constant of the material, the more material needs to be brought into the active zone of the sensor in order for it to be detected (for numerical values of the dielectric constants for different materials see textbook ‚Proximity Sensors', for example).

The values for the reduction factor of the switching distance are indicated for those material thicknesses, for which the maximum possible switching distance for that material has been achieved.

Solution

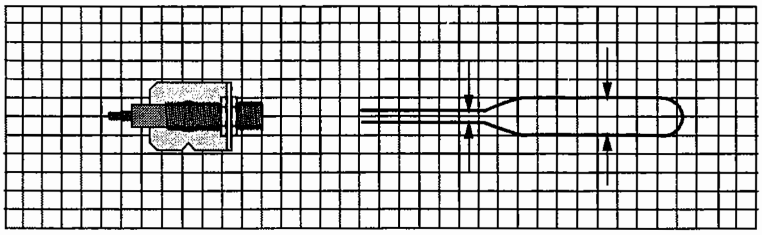


Switching distance of a capacitive sensor as a function of material thickness of plastic

Solution 12
Sound wave form and reflection characteristics of an ultrasonic sensor

Evaluation

Material	Detection yes/no
Mild steel S 235 JR, part 3	yes, ± 7°
Stainless steel, part 4	yes, ± 8°
Aluminium, part 5	yes, ± 5°
Brass, part 6	yes, ± 5°
Copper, part 7	yes, ± 4°
Cardboard, part 8	yes, ± 4°
Rubber, part 9	yes, ± 5°
Plastic, transparent, part 10	yes, ± 3°



Response curve of an ultrasonic sensor

The direction from which the object approaches the beam emitted by the sensor is marked by arrows in the illustration.

Conclusions

Ultrasonic sensors are capable of detecting all materials contained in the set of test objects within a specific range of angles. Even thin, transparent plastic film is reliably detected. Particularly with materials of smooth surface, one should note how the reflected beam is sensitive to angle. With coarse grained bulk materials, or when detecting textiles, this effect is not so pronounced.

Also after a double deflection of the beam by 90°, detection of a flat surface by an ultrasonic sensor is possible.

Note
In locations where intense external noise permeates the ultrasonic range, ultrasonic sensors can be used with reservations only. The external noise may be detected, resulting in faulty signals. Sources of such external noise can be e.g. metal saws, compressed air guns and similar appliances.

Solution 13
Speed measurement

Evaluation

Switching distance Potentiometer at maximum setting	
Switch-on distance	202 mm
Switch-off distance	215 mm
Hysteresis	13 mm

Speed measurement	
Indicated value	150
Corresponding time	0.150 s
Path	0.10 m
Speed	0.667 m/s (approx. 2.4 km/h)

Conclusions

With an optical sensor unit LL 1 it is possible to determine the handling speed of components on a conveyor even if the mounting area is restricted. Due to the optimum range of the through-beam sensor, a distance of approximately 100 mm can be reliably monitored.

Note
Due to light output reserves of the optical sensor unit, the actual range can be in excess of 200 mm.

Solution

Solution 14
Determining rotational speeds

Evaluation

Motor voltage [V]	Output-pulse frequency SOE-L-Q- [Imp./s]	Output-pulse frequency SIEH-M12B- [Imp./s]	Speed RS [r.p.m.]
4,0	84	84	630
4,5	95	95	712
5,0	107	108	802
5,5	119	119	892
6,0	131	131	982
6,5	144	144	1080
7,0	156	156	1170
7,5	168	168	1260
8,0	180	180	1350
8,5	193	192	1447
9,0	205	205	1537
9,5	216	216	1620
10,0	228	228	1710
10,5	241	240	1807
11,0	253	253	1897
11,5	265	265	1987
12,0	278	277	2085
12,5	289	254	2167
13,0	303	116	2272
13,5	315	49	2362
14,0	327	5	2452
15,0	352	–	2640
16,0	376	–	2820
17,0	401	–	3007
18,0	423	–	3172
19,0	448	–	3360
20,0	473	–	3547

The values given in this table are the results of a test measurement. The results of your measurements may deviate from this data. For the calculation of speed, the value of the optical sensor was used.

1. With the rotary unit, the limiting frequency of the inductive sensor is achieved. The interval times between the pulses become so short that the output signal cannot drop down to 0 V. This is why the counting unit shows less pulses per second beyond the limiting frequency.

2. With the rotary unit, the limiting frequency of the optical sensor is not achieved which is why the speed display accelerates steadily in this case.

Conclusions

When determining speed, ensure that the maximum switching frequency of the sensor used is higher than the expected maximum speed.

From the component data sheets of the sensor used, it can be seen that the maximum switching frequency for the inductive sensor (D:ER-SIEH-M12B-..) is approximately 400 Hz, and the maximum switching frequency for the optical sensor (D:ER-SOE-L-Q-..) approximately 1000 Hz. These values are confirmed by the measurements.

If inductive sensors are used, the speed of metallic perforated disks or gears can be determined. Due to the high switching frequencies, it is also possible to reliably determine fast rotations. Due to the small switching gap of the sensor, adjustment is, however, difficult.

With optical sensors, it is also possible to determine speed over larger distances. However, they often have a reduced switching frequency and the optical components can easily become contaminated.

Solution 15
Sensing the correct assembly of workpieces

Evaluation

Object	Switching distance [mm]
Housing (black)	–
Cover (blue)	60 mm

If a distance of 40 mm is selected between the fiber-optic unit and the housing, detection of the housing is not possible. If the cover is mounted, reliable detection occurs, that is, the proximity switch responds.

Conclusion

The fiber-optic unit with a diffuse sensor allows detection of whether a component (here the cover) has been mounted on an assembly. The sensor can be made insensitive to the background (the housing not being recognised) by appropriate adjustment of the potentiometer.

If the objects are brought too close towards the fibre-optic cable unit, then they are not detected because insufficient light is reflected into the receiver.

Solution

Solution 16
Liquid level measurement

Evaluation

Capacitive sensor unit	
Beaker directly at PS*)	water level 42 mm, PS switches on
Beaker 3 mm from PS*) On emptying the beaker	water level 58 mm, PS switches on the PS remains switched on upon further filling 54 mm, PS switches off

Through-beam sensor	
Beaker placed between emitter and receiver	
Water level	40 mm on
Upon further filling	58 mm off

Diffuse sensor with fibre-optic cable	
Distance PS*) – water level	11 mm on
Distance PS*) – water level	15 mm off

*) PS = Proximity sensor

The values in the table are the results of exemplary measurements.

Conclusions

Capacitive sensors

With a capacitive sensor, it is possible to detect a liquid level right through the walls of certain containers.

For this, the material of the container wall must be of a type undetectable by the proximity sensor, e.g. plastic. The thickness should not be more than 2 – 4 mm.

Hence the first step is to adjust the sensitivity so that the sensor does not react to the container wall. This is possible only if it is made from a material with a low dielectric constant.

If liquid is then introduced, the level can be detected by the sensor.

With capacitive sensors, there is no need for contact between sensor and the filling material to be detected, but one is usually limited to plastics as far as the container walls are concerned. If the proximity sensor is fitted inside the container, one has to select sensor designs not sensitive to corrosion or other attack by the substance used.

Optical sensors

With the optical methods, the liquid level must be directly visible. Depending on container material, one thus has to fit flanged transparent standpipes at suitable places on the container.

When sensing with a through-beam sensor fitted at an angle, one has to bear in mind that surface disturbances may lead to faulty detection.

With the diffuse sensor, wetting of the sensing head may lead to a false signal. If a liquid droplet remains suspended from the sensing head, light is reflected from emitter to receiver, even after the liquid level has fallen.
ert.

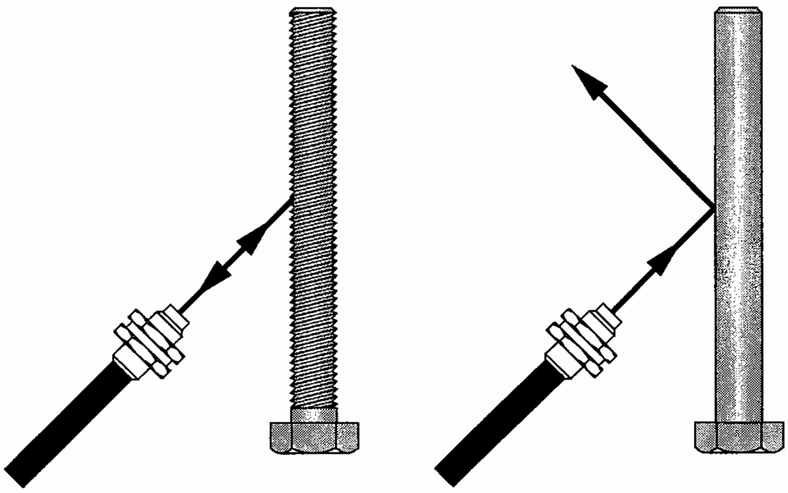
Note

When sensing filling levels, one is not limited to the application of detecting liquids. Other bulk materials, too, which are kept in a storage container, can be detected.

Solution 17
Checking of threads

Evaluation

Mark the correct response	
a) Threaded screw	recognised / ~~not recognised~~
b) Plain screw	~~recognised~~ / not recognised



Conclusions

The threaded screw is reliably recognised whereas the plain screw is not detected. Therefore, the checking for threads can easily be carried out.

However, faults in the thread itself cannot be detected by this method.

Solution

Solution 18
Logic combinations of proximity sensor signals

Evaluation

Current consumption of a capacitive sensor	
a) Switching output in unconnected socket	
Switching status	Current consumption [mA]
unattenuated	2.4
attenuated	7.2
b) Switching output in buzzer socket	
Switching status	Current consumption [mA]
unattenuated	2.4
attenuated	40 bis 55*

Current consumption of an inductive sensor	
a) Switching output in unconnected socket	
Switching status	Current consumption [mA]
unattenuated	15.8
attenuated	15.8
b) Switching output in buzzer socket	
Switching status	Current consumption [mA]
unattenuated	15.8
attenuated	40 bis 55*

* depending upon buzzer potentiometer setting

Voltage measurement with series connection	
	Voltage [V]
Operating voltage V_{op}	24.4
Voltage V_1	23.5
Voltage V_2	22.2

Conclusions

A simple logic connection of the output signals of sensors is possible without the use of programmable logic controls. With the series connection of sensors realised in this exercise, an AND connection has been achieved, i.e. the output signal is obtained only if all the series connected sensors switch through.

Note

Series connection of sensors is to be used only, if there are insufficient inputs for a programmable logic control (PLC), or a PLC is not used.

Please note the following with regard to this circuit type:

- The current consumption due to the load and the current consumption of the sensors connected in series is accumulative, i.e. the maximum current on contact of the first sensor has to be sufficient for current supply to all subsequent sensors and the load.
- In the switched through status each sensor has a voltage drop (in this instance approx. 1.3 V). The voltage available for the load reduces by the sum of the voltage drops.
- Because the subsequently switching sensors receive their operating voltage only when the previous sensor has switched through, the activating time delay has to be taken into account, i.e. the time which the sensor needs after actuation to be able to react to the objects.

Solution 19
Position detection with proximity sensors

Evaluation

Orientation	Signals counted
1 upper hole	2
2 upper holes	3

Conclusions

Using optical proximity sensors with fibre-optic cables, it is possible to check the orientation of components. In particular, the use of fibre-optic cables makes it possible to detect small structural features reliably.

In this exercise the counting unit is a substitute of a programmable logic controller (PLC).

Note
It is easy to set up an automated process sequence based on the evaluation of sensor output signals by a programmable logic controller. For this, the switching outputs of the sensors must be connected to the appropriate inputs of the controller. Suitable programming can bring about detection of orientation and an appropriate reaction to this.

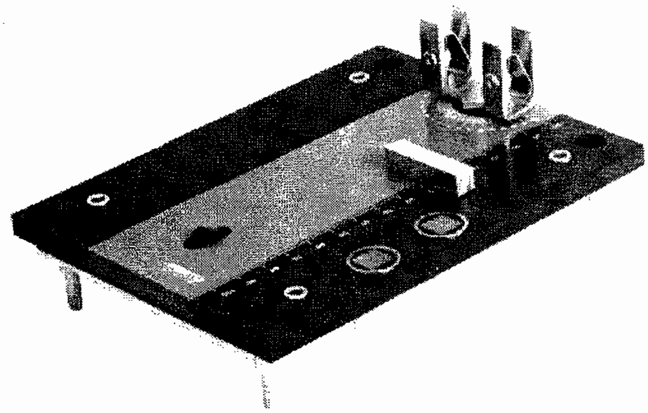
Solution

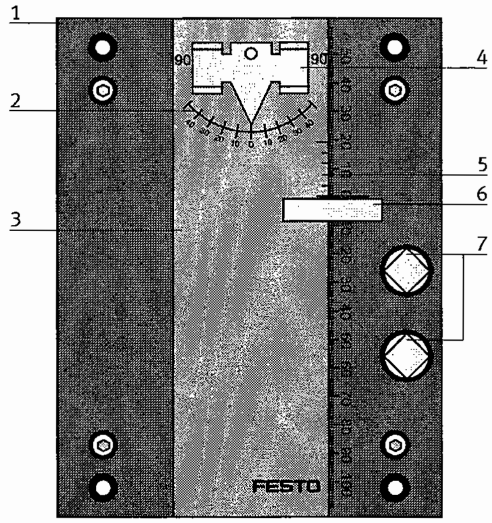
Part D

Part D **Data sheets**

034094

Positioning slide





1 Base plate
2 Angular position scale
3 Sliding plate
4 Rotatable material retainer
5 Vernier
6 Stop for vernier caliper
7 Retaining magnets for vernier caliper

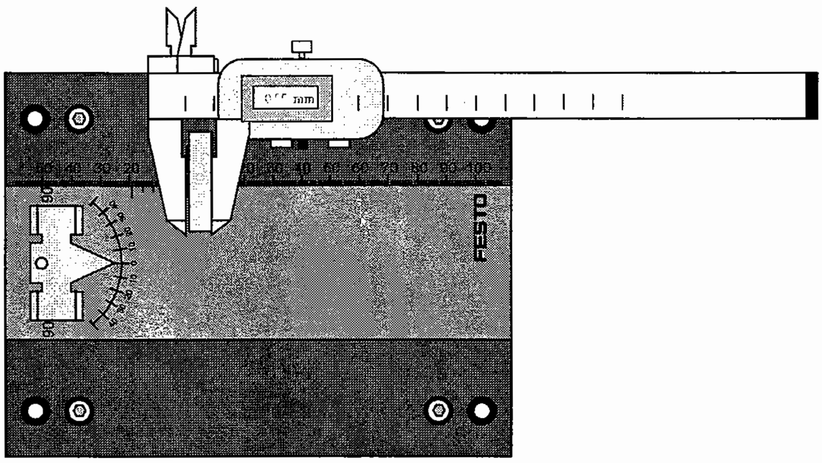
Design

The positioning slide consists of a plug-in base plate with four locating pins, a sliding plate and a rotatable material retainer. Attachment of this unit to the profile plate requires 4 plug-in adapters from the adapter set (Order no. 035651).

Positioning slide

Function

The positioning slide is used for carrying out the measurements which determine the switching distances and sensing ranges of different types of proximity sensors. For this, various test materials are held in the spring loaded retainer and then moved towards the proximity sensor along a central axis. A graduated scale on the sliding plate indicates the distance between the proximity sensor and object. The material retainer can be rotated, an angular scale for reading the rotary angle is marked on the sliding plate.
A vernier caliper can be fitted to the positioning slide by means of magnetic retainers. This increases the accuracy of measurement and simplifies the procedure for measuring hysteresis. When mounting the vernier caliper, the slide unit of the positioning slide is set to "0". The two pointers are moved apart by approximately 10 mm. The vernier caliper is placed parallel to the base plate flush with the edge in such a way, that the front pointer rests against the stop for the vernier caliper. The two retaining magnets retain the caliper body to the base plate of the positioning slide.



Note

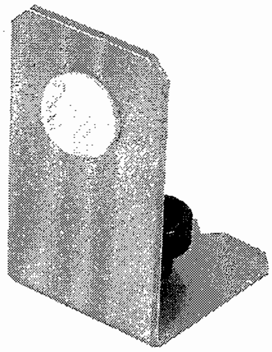
When using a vernier caliper for digital reading of measurements, the sliding plate supporting the test object is moved up to the proximity sensor, and the reading is set to "0". This provides a simple method of zero setting.
Avoid bringing objects sensitive to magnetic influence near the positioning slide.

Technical data

Mechanics	
Slide travel	150 mm
Graduation	1 mm
Angular scale	±90°
Graduation	2°
Vernier scale	0.2 mm
Max. clamping thickness	5 mm
Retaining force of stop magnets	each 5 N
Retaining force of retaining magnets	each 60 N
Max. operational temperature of magnets	+150 °C
Materials	Steel, zinc coated (base plate) Plastic (sliding plate, side pieces) Aluminium (stop) Samarium cobalt (magnets)
Weight	0.81 kg

150504

Reflector unit



Design

The reflector unit is bonded to an aluminium mounting bracket. The mounting bracket is attached to the profile plate by a T-head nut and a knurled screw.

Function

The prismatic reflector is used in conjunction with a retro-reflective sensor. This enables the light emitted by the emitter to be reflected in the direction of the receiver.

Note

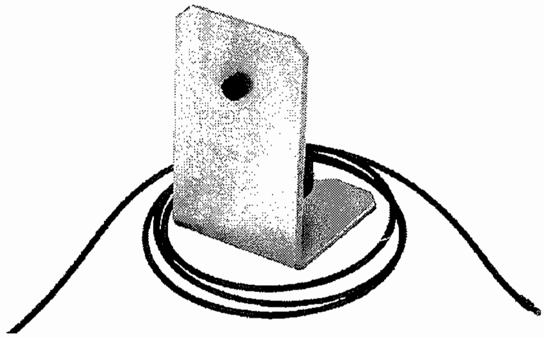
The sensing range that can be achieved with the sensor/reflector arrangement depends largely on the cleanliness of the reflector surface and the optical lenses.

Technical data

Mechanics	
Diameter	20 mm
Permissible ambient operating temperature	≤60 °C
Material	Aluminium (mounting bracket) Plastic, sealed (reflector)
Weight	0.06 kg

150505

Fibre-optic cable unit SE, through-beam sensor design



Design

The polymer fibre-optic cable is attached to an aluminium mounting bracket. The mounting bracket is attached to the profile plate with a T-head nut and a knurled screw. The free ends are to be connected to the appropriate proximity sensor.

Function

The emitter of the optical proximity sensor emits pulsating infrared light. The light is conducted to the sensing location through the emitting fibre-optic cable with separate sensing head. The receiver sensing head is arranged opposite the emitter sensing head. The light is conducted to the receiver of the optical proximity sensor via the receiving fibre-optic cable.

Note

The fibre-optic cables can be cut to the desired lengths (e.g. with a cutter or a scalpel). In order to achieve the full sensing range, it is important that the ends are cut square.

Assembling

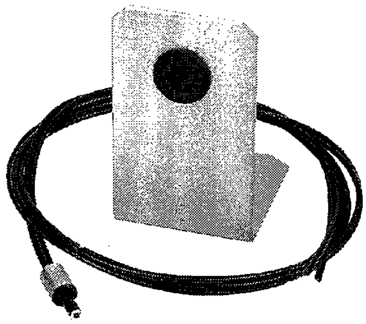
Insert fibre-optic cable into the plug of the fibre-optic unit up to stop. Securely tighten locking screw.

Technical data

Mechanics	
Diameter of fibre-optic cable	1 mm
Length	2000 m
Permissible ambient operating temperature	-40 °C to +70 °C
Bending radius	>25 mm
Max. detection range	400 mm
Mechanical connection	Thread M4
Material	Polymethylmethacrylate (PMMA) (fibre optic) Polyethylene (Outer casing)
Weight	0.13 kg

150506

Fibre-optic cable unit RT, diffuse sensor design



Design

The polymer fibre-optic cable can be supported in an aluminium mounting bracket or in the mounting bracket of the rotary unit. The mounting bracket is attached to the profile plate by a T-head nut and a knurled screw. The free ends are to be connected to the appropriate proximity sensor.

Function

The fibre-optic cable consists of two separate bundles of optical fibres, one for emitting and the other for receiving. The two optical fibres are attached to the sensing head. The emitter of the optical sensor unit emits pulsating infrared light. The light is conducted via the emitting fibre-optic cable to the sensing location. The light reflected from an object is conducted back to the receiver of the optical sensor via the receiving fibre-optic cable.

Note

The fibre-optic cables can be cut to desired lengths (e.g. with a cutter or scalpel). In order to achieve the full sensing range, it is important that the ends are cut square.

Assembling

Insert fibre-optic cable into the plug of the fibre-optic unit up to stop. Securely tighten locking screw.

150506

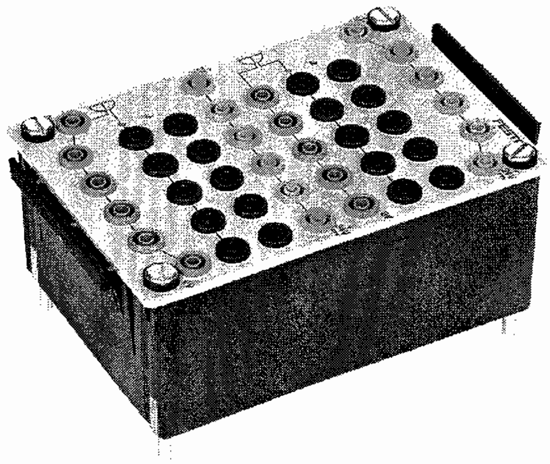
Fibre-optic cable unit RT, diffuse sensor design

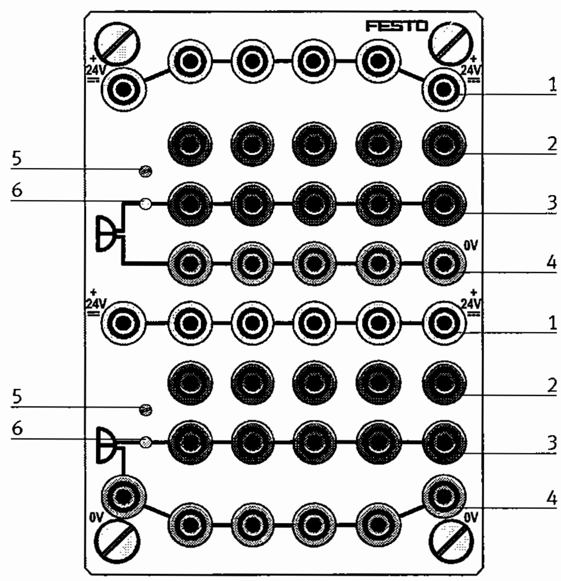
Technical data

Mechanics	
Diameter of fibre-optic cable	1 mm
Length	2000 mm
Permissible ambient operating temperature	-40 °C to +70 °C
Bending radius	>25 mm
Max. detection range	120 mm
Mechanical connection	Thread M6
Material	Polymethylmethacrylate (PMMA) (fibre optic) Polyethylene (outer casing)
Weight	0.07 kg

162248

Distribution unit





1 Operating voltage +24 VDC
2 Vacant sockets
3 Buzzer sockets
4 Operating voltage 0 VDC
5 Potentiometers for volume adjustment
6 Light emitting diodes

162248

Distribution unit

Design

The unit has four rows of sockets for supply voltage, two rows of sockets for connecting the proximity sensor signal outputs with two audible indicators (buzzers) and two vacant rows of sockets. The electrical connections to these various sockets is established by means of 4 mm safety plugs. The unit is retained via four locating pins. Attachment of this unit to the profile plate requires 4 plug-in adapters from the adapter set (Order no. 035651).

Function

The distribution unit connects the sensor units with the voltage supply. Operating voltage is supplied through the sockets of rows 1 (+24 V) and rows 4 (0 V). The switching outputs of the proximity sensors are plugged into rows 3 (fig. 1, rows 3). These sockets are decoupled via diodes. If a certain sensor switches, it is signalled acoustically via a built-in buzzer and optically via a built-in light emitting diode. The volume of the buzzer can be adjusted via the potentiometers. With sensor designs which have normally open, as well as normally closed outputs, the plug not in use at that time is pushed into one of the vacant sockets of rows 2.

Note

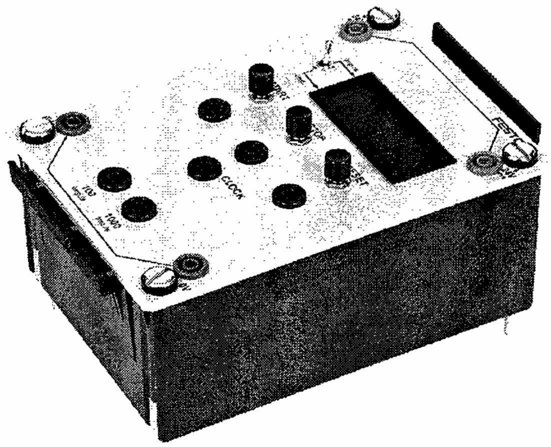
In order to avoid disturbing other working groups by the buzzer sound, its volume can be adjusted to zero via the potentiometers. The switching status display then takes place solely via the light emitting diode (LED), which is built into the sensor.

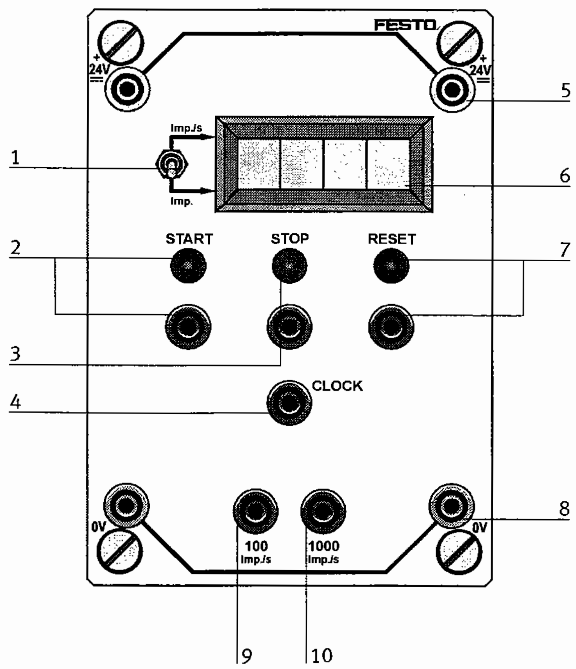
Technical data

Electrical	
Operating voltage	24 V DC
Contact set	10
Power consumption (Audible indicator)	1.2 W
Material	Aluminium (surface panel) Plastic (housing)
Weight	0.50 kg
Electrical connection	for 4 mm safety plugs

162252

Counting unit





1	Display mode switch
2	Start push button and socket
3	Stop push button and socket
4	CLOCK socket
5	Voltage supply +24 VDC
6	Digital display with four digits
7	Reset push button and socket
8	Voltage supply 0 VDC
9	Pulse output 100 pulses/s
10	Pulse output 1000 pulses/s

162252

Counting unit

Design

The counting unit is fitted inside a plug-in housing with four locating pins. The electrical connection of operating voltage and signal inputs is established by means of 4 mm safety plugs. Attachment of this unit to the profile plate requires 4 plug-in adapters from the adapter set (Part No. 035651).

Function

The counting unit facilitates the counting of output pulses from proximity sensors. In addition, it can also determine the time interval between two successive pulses by means of a start-stop circuit.
When the operating voltage has been connected, digital display 6 lights up. By pressing start push button 2, or by applying a voltage pulse (+24 V) to the start socket, the counting pulses can be recorded through CLOCK socket 4. After actuation of stop push button 3 or by applying a voltage pulse (+24 V) to the stop socket, the reading of counting pulses is interrupted.
Through actuation of reset push button 7, or by applying a voltage pulse (+24 V) to the reset socket, digital display 6 is reset to "0000".
CLOCK socket 4 is used to read voltage pulses from +15 V to +24 V. The two pulse outputs 9 and 10 supply a pulse train of 100 pulses/s or 1000 pulses/s respectively. By using a cable with safety plugs, the output signals of outputs 9 or 10 may be input to CLOCK input 4, (e.g. for time measurements).
Using the display mode switch 1, the display can either be made to count individual pulses, or the pulse frequency (pulses/second) can be displayed.

Examples

Three examples of the application of the counting unit are as follows:

Counting

If objects are to be counted, the output of a proximity sensor can be connected to CLOCK socket 4. Counting can be started, stopped, or reset to "0000" by using the push buttons or through sensors connected to sockets 2, 3, 7. Please make sure that the sensor is connected to the same reference potential (0 V terminals) as the counter. The display mode switch 1 must be set to position "IMP" (pulse).

Rotational speed measurement

If sensors are used for measuring rotational speed (by means of perforated disks or similar), the counting unit offers the possibility of determining the r.p.m. For this purpose, the switch output of the sensor must be connected to CLOCK socket 4. The display mode switch 1 must be set to position "Imp./s" (pulses/s). The value indicated is easily converted to the rotational speed by using the equation:

$$RS = \frac{f_s}{\text{pulses/s}} \times \frac{60}{n} \text{r.p.m.}$$

RS = rotational speed (r.p.m.)
f_s = pulse frequency (pulses/second)
pulses/s = indicated value
n = number of pulses per revolution

Time measurements

In order to measure times (or speeds), pulses of known frequency are continuously input to the CLOCK input 4. For this, a cable with safety plugs is used to connect CLOCK input 4 with socket 9 or 10 as required.
By means of the start, stop, reset push buttons, or start, stop, reset sockets, times can be measured manually or with proximity sensors. Display mode switch 1 must be set to position Imp. (Pulses).
By using socket 9, the time in seconds can be calculated by dividing the value displayed by 100. If socket 10 is used, the time in seconds is obtained by division of the value indicated by 1000.

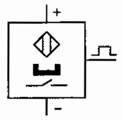
162252

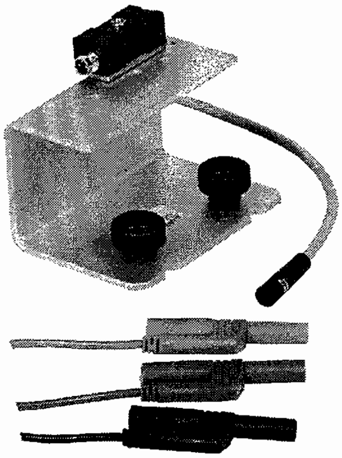
Counting unit

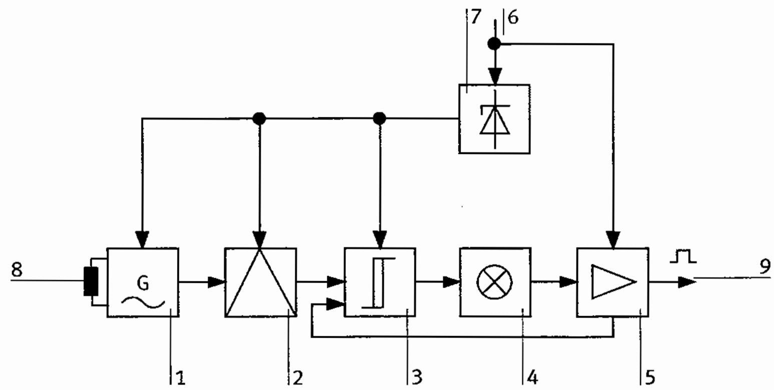
Technical data

Electrical	
Operating voltage	24 V DC
Input signal voltage	+15 V DC to +24 V DC
Power consumtion	1.2 W
Accuracy Pulse output 100 pulses/s Pulse output 1000 pulses/s Internal clock	 ±6% ±3% ±3%
Material	Aluminium (surface panel) Plastic (housing)
Weight	0.48 kg
Electrical connection	for 4 mm safety plugs

Magnetic sensor unit 2, contactless







1 Oscillator
2 Demodulator
3 Triggering stage
4 Switching status indicator
5 Output stage with protective circuit
6 External voltage
7 Internal stabilised voltage
8 Coil with active switching zone (external magnetic field)
9 Switching output

167055

Magnetic sensor unit 2, contactless

Design

The magnetic proximity sensor is mounted on an aluminium bracket. Attachment to the profile plate is effected by two T-headed nuts and two knurled screws. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

Function

With this contactless magnetic proximity sensor, detection of the magnetic field takes place through the detuning of an oscillator. When a magnet approaches, the core of an HF resonant circuit coil is saturated. This alters the oscillator current of the proximity sensor. This change is converted into an electrical switching signal. The proximity sensor has a PNP output, i.e. upon activation, the switch, which is designed as normally open, connects the signal line to the positive potential. The load is connected between the proximity sensor signal output and earth (0 V). The area sensitive to magnetic fields is marked by a blue dot on a black plastic plate. A yellow light emitting diode (LED) indicates the switching status.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output — black

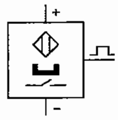
The sensor is protected against incorrect polarity, overload and short circuit.

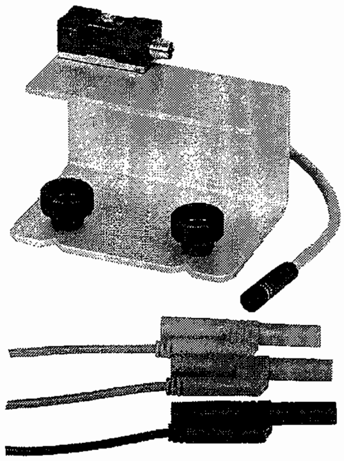
Technical data

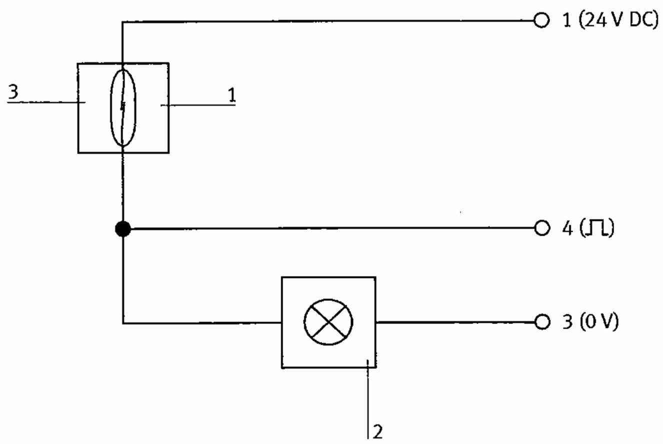
Electrical	
Operating voltage	10 V DC to 30 V DC
Switching output	PNP, normally open
Switching point accuracy	±0.1 mm
Switching point drift	±0.1 mm
Response travel (dependent on magnetic field)	7 mm to 17 mm
Response travel drift	≤1 mm
Hysteresis	0.1 mm to 5 mm
Maximum switching current	200 mA
Contact rating	6 Watt
Maximum switching frequency	1000 Hz
Current consumption (no load)	8 mA
Permissible ambient operating temperature	-25 °C to +70 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 67
Weight	0.20 kg
Electrical connection	Socket for cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

167056

Magnetic sensor unit 1, Reed contact







1 Reed contact
2 Switching status indicator
3 Active switching zone (external magnetic field)

Design

The magnetic proximity sensor is mounted on an aluminium bracket. Attachment to the profile plate is effected by two T-head nuts and two knurled screws. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

 Subject to change

167056

Magnetic sensor unit 1, Reed contact

Function

With this type of contacting sensor, magnetic field sensitive Reed contacts are used. The Reed contact is activated remotely by the magnetic field of an approaching permanent magnet. The contact consists of two flexible blades of soft magnetic material, separated by a gap, which are fitted inside a hermetically sealed glass tube. An external magnetic field causes the blades to touch and thus establish an electric contact. A yellow light emitting diode (LED) indicates the switching status.

Note

The cable terminals are colour coded.

- Operating voltage

Pin 1	brown (red plug)
Pin 3	blue

- Load output

Pin 4	black

Depending on the type of electrical load, the proximity sensor must be provided with a suitable protective circuit. One has to distinguish between ohmic, capacitive and inductive load.

Together with the switching status indicator, the proximity sensor contains a diode-resistance combination, which forms the protective circuit.

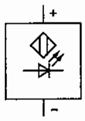
The switch is designed as normally open. When activated by a magnetic field under DC supply voltage, the positive potential is switched to the load output with the positive supply connected to terminal 1 and the negative to terminal 3.

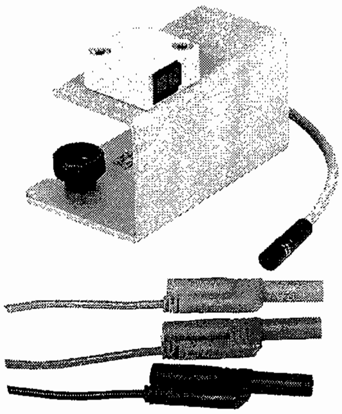
Technical data

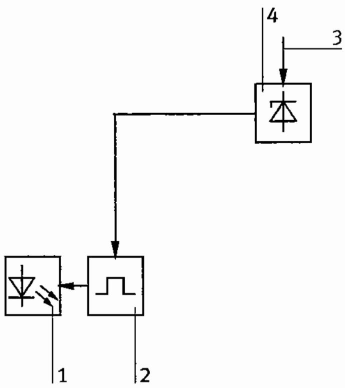
Electrical	
Operating voltage	12 V AC/DC to 27 V AC/DC (reduced brightness of the LED at E ≤ 18 V)
Switching point accuracy	±0.1 mm
Conductance	100 mΩ
Insulation resistance	10^{11} Ω
Switching time	≤2 ms
Maximum switching current	2.0 A
Maximum contact load	27 W / 27 VA
Maximum switching frequency	500 Hz
Permissible ambient operating temperature	-20 °C to +70 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 67
Weight	0.20 kg
Electrical connection	Socket for cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

167064

Optical sensor unit ESS, through-beam-sensor, emitter







1 Photoelectric emitter
2 Oscillator (pulse generator)
3 External voltage
4 Internal stabilised voltage

Design

The through-beam sensor emitter is mounted on an aluminium mounting bracket. Attachment to the profile plate is effected by two T-head nuts and two knurled screws. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

167064

Optical sensor unit ESS, through-beam-sensor, emitter

Function

Optical proximity sensors consist of two principal modules, the emitter and the receiver. In the case of the through-beam sensor, these are accommodated in two separate housings. The emitter emits pulsating infra red light from the invisible spectral range.
The object to be detected may reflect any amount of light but allow through only a minimal amount of light.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin brown (red plug)
  Negative pin(0 V) blue

The emitter's black cable with black safety plug serves to simulate light beam interruption. The emitter's light source is deactivated by applying a 24 V DC control voltage to this plug.

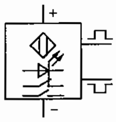
The sensor is protected against incorrect polarity.

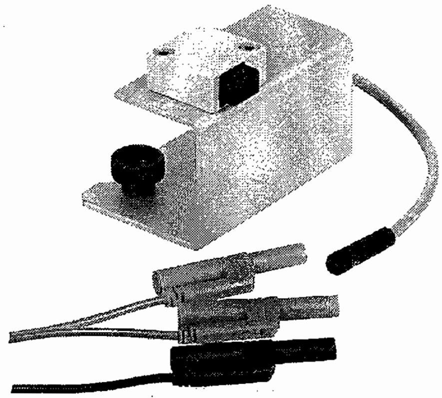
Technical data

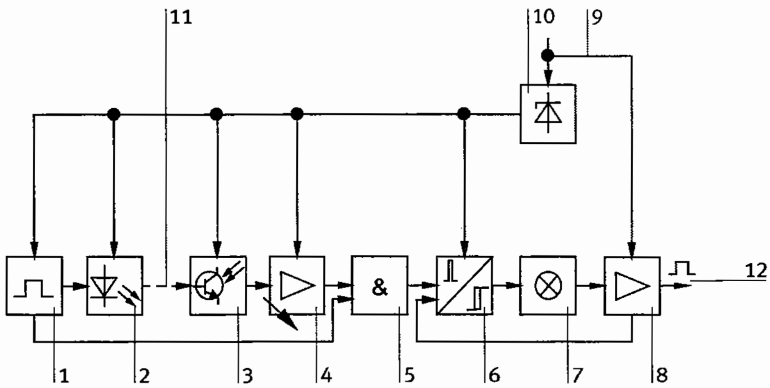
Electrical	
Operating voltage	10 V DC to 30 V DC
Type of light	Infrared
Nominal switching distance	6000 mm
Current consumption (no load)	25 mA
Permissible ambient operating temperature	-5 °C to +55 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 65
Weight	0.25 kg
Electrical connection	Socket for cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

167065

Optical sensor unit LL1, fibre-optic unit







1 Oscillator (pulse generator)
2 Photoelectric emitter
3 Photoelectric receiver
4 Preamplifier with potentiometer
5 AND connection
6 Pulse level converter
7 Switching status indicator
8 Output stage with protective circuit
9 External voltage
10 Internal stabilised voltage
11 Optical path
12 Switching output

167065

Optical sensor unit LL1, fibre-optic unit

Design

The optical proximity sensor with fibre-optic cable connections is fitted to an aluminium mounting bracket. Attachment to the profile plate is effected by two T-head nuts and two knurled screws. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

Function

Optical proximity sensors consist of two principal modules, the emitter and the receiver. In the case of the sensor unit LL1, both are accommodated in a single housing.
The emitter of the sensor unit emits pulsating red light in the visible spectral range. The light is conducted to the sensing area via the emitting fibre-optic cable on the sensing unit. Via the receiving fibre-optic cable, the light is led back to the receiver attached to the same housing.
Depending on the fibre-optic cable, the fibre-optic unit can be used as through-beam sensor or as diffuse sensor.

- When used as through-beam sensor, the following applies:
  The object to be detected may reflect any amount of light, but must not be fully transparent. A reduction of the emitting power can, within certain limits, be adjusted by means of a potentiometer. This can be useful for detecting partly transparent objects.
- When used as diffuse sensor, the following applies:
  The object to be detected may be mirror reflecting, matt, transparent or opaque. However, a sufficiently high proportion of the light must be reflected directly or diffusely.

The proximity sensor has PNP outputs, i.e. the signal line is switched to positive potential in the switched state. The load is connected between the proximity sensor output and earth (0 V). A yellow light emitting diode (LED) indicates the switching status.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage

Positive pin	brown (red plug)
Negative pin (0 V)	blue

- Load outputs

Normally open	black
Normally closed	white

For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

The sensor is protected against incorrect polarity, overload and short circuit.

If both outputs are actively used and short circuit and/or overload occurs at both outputs, the sensor is no longer resistant to short circuit or overload.

The switch is designed as normally open/normally closed. If it is used as a diffuse sensor, the following switching characteristics apply: If no object is detected, the white signal line is at positive potential, upon detection of an object, the positive potential is switched to the black signal line.

If it is used as through-beam sensor, the following switching characteristics apply: If no object is detected, the black signal line is at positive potential, upon detection of an object the positive potential is switched to the white signal line.

167065

Optical sensor unit LL1, fibre-optic unit

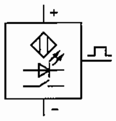
Technical data

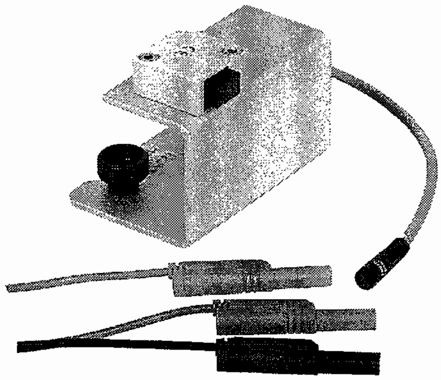
Electrical	
Permissible operating voltage	10 V DC to 30 V DC
Type of light	Red light
Switching output	PNP, Normally open/Normally closed
Nominal switching distance with fibre-optic cable unit SE	400 mm
Nominal switching distance with fibre-optic cable unit RT	120 mm
Hysteresis	≤10%
Reproducibility	±10%
Maximum switching current	200 mA
Maximum switching frequency	1000 Hz
Current consumption (no load)	25 mA
Permissible ambient operating temperature	-5 °C to +55 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 65
Weight	0.25 kg
Electrical connection	Socket for cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

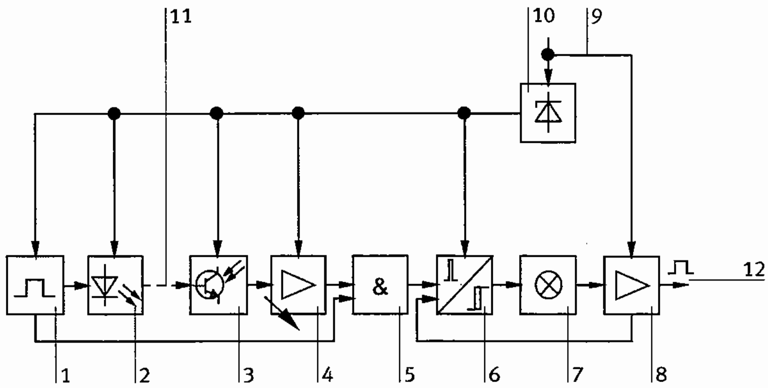
Subject to change

167066

Optical sensor unit RS, retro-reflective sensor







1 Oscillator (pulse generator)
2 Photoelectric emitter
3 Photoelectric receiver
4 Preamplifier with potentiometer
5 AND connection
6 Pulse level converter
7 Switching status indicator
8 Output stage with protective circuit
9 External voltage
10 Internal stabilised voltage
11 Optical path
12 Switching output

167066

Optical sensor unit RS, retro-reflective sensor

Design

The retro-reflective optical proximity sensor is mounted on an aluminium bracket. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

Function

Optical proximity sensors consist of two principal modules, the emitter and the receiver. In the case of retro-reflective sensors, both are accommodated in a single housing.
The emitter of the retro-reflective sensor emits pulsating infra red light from the invisible spectral range. The light is reflected back by an externally fitted reflector. This light is then detected by the receiver which is also housed in the retro-reflective sensor. If the path of emission is interrupted by an object, it causes a change in the switching status.
The object to be detected may be matt or transparent, provided that sufficient weakening of the emitted light beam occurs. With transparent, light permeable objects, the degree to which the emission is weakened can, within certain limits, be adjusted by means of the potentiometer. Mirror reflecting objects can not usually be detected if they are placed vertically to the optical axis.
The proximity sensor has a PNP output, i.e., the signal line is switched to positive potential in the switched state. The load is connected between the proximity sensor output and earth (0 V). A yellow light emitting diode (LED) indicates the switching status.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally closed — black

For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

The sensor is protected against incorrect polarity, overload and short circuit.

The switch is designed as normally closed. If no object is detected, the black signal line is at positive potential.

167066

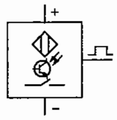
Optical sensor unit RS, retro-reflective sensor

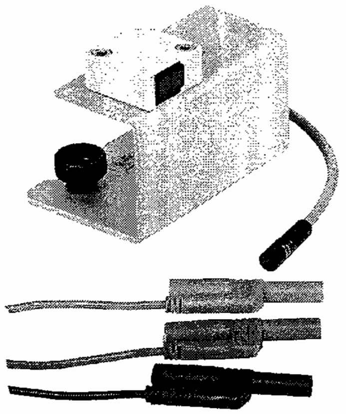
Technical data

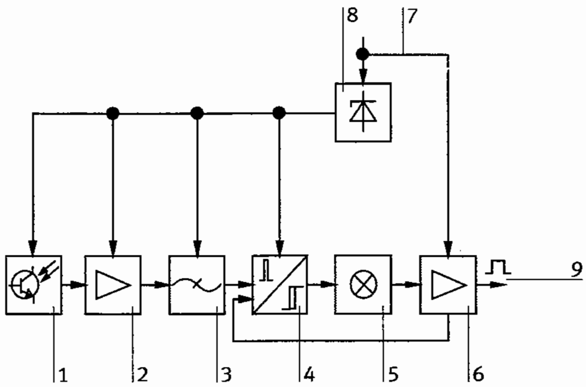
Electrical	
Permissible operating voltage	10 V DC to 30 V DC
Type of light	Infrared light
Switching output	PNP, normally closed
Nominal switching distance with reflector unit	2000 mm
Operational switching distance	100 mm to 1600 mm
Hysteresis	≤10%
Reproducibility	±10%
Maximum switching current	200 mA
Maximum switching frequency	1000 Hz
Current consumption (no load)	25 mA
Permissible ambient operating temperature	-5 °C to +55 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 65
Weight	0.25 kg
Electrical connection	Socket for cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

167067

Optical sensor unit ESE, through-beam-sensor, receiver







1 Photoelectric receiver
2 Preamplifier with potentiometer
3 Band-pass filter
4 Pulse level converter
5 Switching status indicator
6 Output stage with protective circuit
7 External voltage
8 Internal stabilised voltage
9 Switching output

167067

Optical sensor unit ESE, through-beam-sensor, receiver

Design

The through-beam sensor receiver is mounted on an aluminium mounting bracket. Attachment to the profile plate is effected by two T-head nuts and two knurled screws. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

Function

Optical proximity sensors consist of two principal modules, the emitter and the receiver. In the case of the through-beam sensor, these are accommodated in two separate housings.
The receiver receives the infra red light from the invisible spectral range, coming from the emitter. If the emitted light path is interrupted by an object, the switching status of the electrical output changes.
The object to be detected may reflect any amount of light, but allow through only a minimal amount of light. With translucent, light permeable objects, a reduction of the emission level can, within certain limits, be adjusted by means of the potentiometer at the receiver.
The proximity sensor has a PNP output, i.e., the signal line is switched to positive potential in the switched state. The load is connected between the proximity sensor output and earth (0 V). A yellow light emitting diode (LED) indicates the switching status.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally closed — black

For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

The sensor is protected against incorrect polarity, overload and short circuit.

The switch is designed as normally closed. If no object is detected, the black signal line is at positive potential.

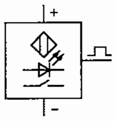
Optical sensor unit ESE, through-beam-sensor, receiver

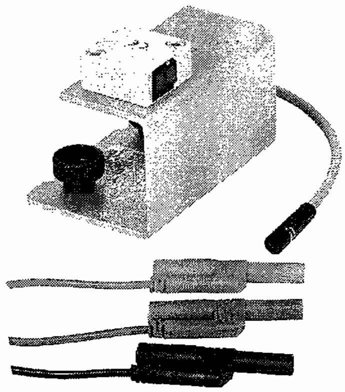
Technical data

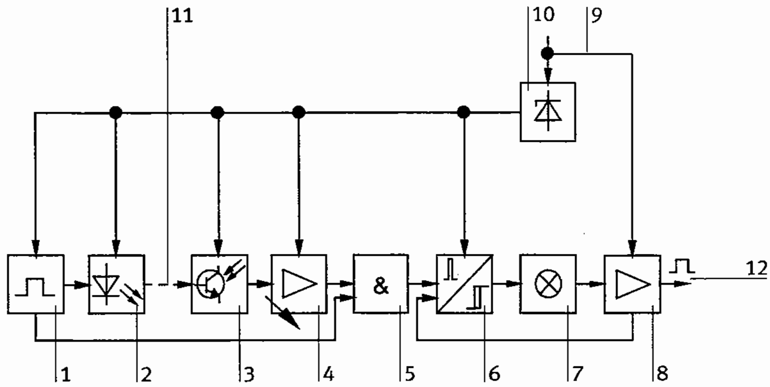
Electrical	
Permissible operating voltage	10 V DC to 30 V DC
Type of light	Infrared light
Switching output	PNP, normally closed
Nominal switching distance	6000 mm
Operational switching distance	100 mm to 4800 mm
Hysteresis	≤10%
Reproducibility	±10%
Maximum switching current	200 mA
Maximum switching frequency	1000 Hz
Current consumption (no load)	30 mA
Permissible ambient operating temperature	-5 °C to +55 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 65
Weight	0.25 kg
Electrical connection	Socket for cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

167068

Optical sensor unit RT 1, diffuse sensor







1 Oscillator (pulse generator)
2 Photoelectric emitter
3 Photoelectric receiver
4 Preamplifier with potentiometer
5 AND connection
6 Pulse level converter
7 Switching status indicator
8 Output stage with protective circuit
9 External voltage
10 Internal stabilised voltage
11 Optical path
12 Switching output

167068

Optical sensor unit RT 1, diffuse sensor

Design

The optical sensor unit RT 1is mounted on an aluminium bracket. Attachment to the profile plate is effected by two T-head nuts and two knurled screws. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

Function

Optical proximity sensors consist of two principal modules, the emitter and the receiver. In the case of diffuse sensors, both are accommodated in a single housing. The emitter of the diffuse sensor emits pulsating infra-red light from the invisible spectral range. The object to be detected reflects back part of the emitted light. By means of suitable semiconductor receivers, this light is dectected by the receiver which is also fitted in the sensor housing, and causes a change in the switching status.
The object to be detected may be mirror-reflecting, matt, transparent, or opaque. However, a sufficiently large proportion of the light must be reflected directly or diffusely. The operational switching distance can be varied by means of a potentiometer.
The proximity sensor has a PNP output, i.e., the signal line is switched to positive potential in the switched state. The load is connected between the proximity sensor output and earth (0 V). A yellow light emitting diode (LED) indicates the switching status.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally open — black

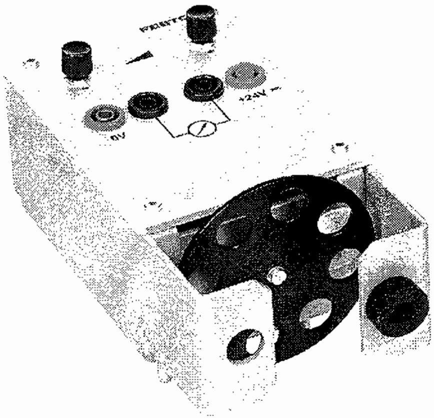
For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

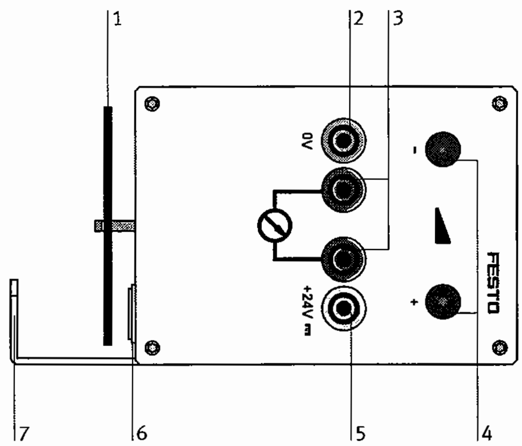
The sensor is protected against incorrect polarity, overload and short circuit.

The sensor is designed as normally open. When an object is detected, the positive potential is switched to the black signal line.

Technical data

Electrical	
Permissible operating voltage	10 V DC to 30 V DC
Type of light	Infrared light
Switching output	PNP, normally open
Nominal switching distance	600 mm
Operational switching distance	20 mm to 490 mm
Hysteresis	≤10%
Reproducibility	±10%
Maximum switching current	200 mA
Maximum switching frequency	1000 Hz
Current consumption (no load)	25 mA
Permissible ambient operating temperature	-5 °C to +55 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 65
Weight	0.25 kg
Electrical connection	Socket for cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1





1 Perforated disc
2 Voltage supply 0 V
3 Measuring sockets
4 Push buttons for rotational speed regulation
5 Voltage supply +24 V
6 Reflector
7 Mounting bracket for fibre optic cable, diffuse sensor design

167097

Rotary unit

Design

The rotary unit is fitted inside a plug-in housing with four locating pins. It has one integral retaining bracket for mounting the fibre-optic cable unit RT. Electrical connection is established by means of 4 mm safety plugs. Attachment of this unit to the profile plate is effected by four plug-in adapters of the adapter set.

Function

After connection to the operating voltage (red socket = +24 V, blue socket = 0 V), the rotational speed of the motor can be adjusted with the two black push buttons. A perforated disc is mounted on the axis of the rotary unit, which can be used for the repeated activation of sensors and rotational speed measurement. The perforated disc contains eight holes of equal size.

Note

- Increasing the rotational speed:
  – Press push button near red socket.
- Decreasing the rotational speed:
  – Press push button near blue socket.

When the operating voltage is switched on, the motor starts up immediately with a rotational speed of about 2500 r.p.m.

The rotational speed can be determined with suitable proximity sensors. When doing so, the limiting frequency of the proximity sensors used has to be observed.

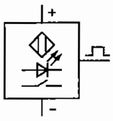
The operating voltage supplied to the motor can be tapped from the two black sockets.

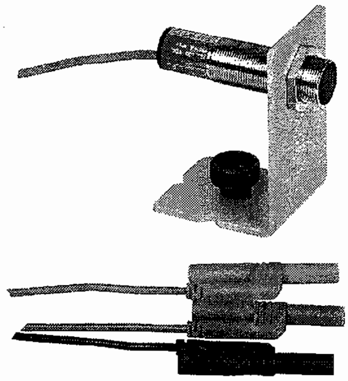
Technical data

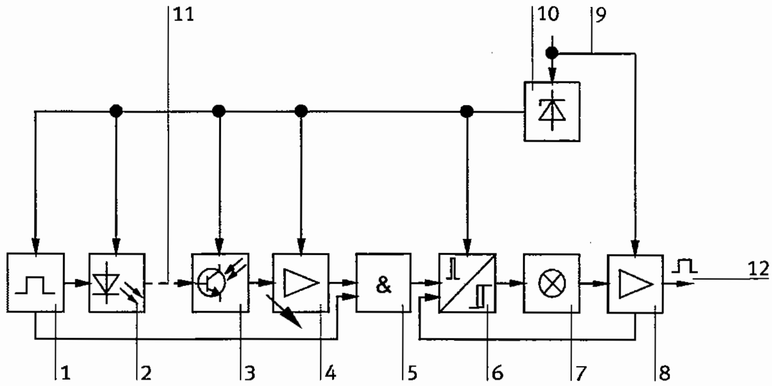
Electrical, mechanical	
Operating voltage	10 V DC to 30 V DC
Current consumption	100 mA
Rotational speed range	600 r.p.m. to 4900 r.p.m.
Materials	Aluminium (face plate and housing) Stahl S 235 JR (perforated disc)
Weight	0.50 kg
Electrical connection	for 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

Subject to change

Optical sensor unit RT 2, diffuse sensor







1 Oscillator (pulse generator)
2 Photoelectric emitter
3 Photoelectric receiver
4 Preamplifier with potentiometer
5 AND connection
6 Pulse level converter
7 Switching status indicator
8 Output stage with protective circuit
9 External voltage
10 Internal stabilised voltage
11 Optical path
12 Switching output

167166

Optical sensor unit RT 2, diffuse sensor

Design

The optical sensor unit RT 2is mounted on an aluminium bracket. Attachment to the profile plate is effected by two T-head nuts and two knurled screws. Electrical connection is established by means of the socket and the provided cable with 4mm safety plugs.

Function

Optical proximity sensors consist of two principal modules, the emitter and the receiver. In the case of diffuse sensors, both are accommodated in a single housing. The emitter of the diffuse sensor emits pulsating infra-red light from the invisible spectral range. The object to be detected reflects back part of the emitted light. By means of suitable semiconductor receivers, this light is dectected by the receiver which is also fitted in the sensor housing, and causes a change in the switching status.
The object to be detected may be mirror-reflecting, matt, transparent, or opaque. However, a sufficiently large proportion of the light must be reflected directly or diffusely. The operational switching distance can be varied by means of a potentiometer.
The proximity sensor has PNP outputs, i.e., the signal line is switched to positive potential in the switched state. The load is connected between the proximity sensor output and earth (0 V). A yellow light emitting diode (LED) indicates the switching status.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally open — black

For reliable operation, the green LED (function reserve indicator) must light up as well as the yellow LED (switching status indicator), when the sensor is detecting an object.

The sensor is protected against incorrect polarity, overload and short circuit.

The sensor is designed as normally open. When an object is detected, the positive potential is switched to the black signal line.

167166

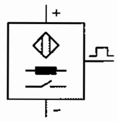
Optical sensor unit RT 2, diffuse sensor

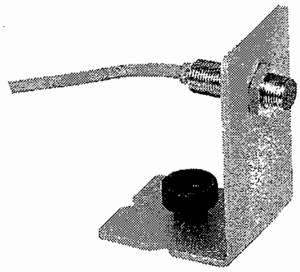
Technical data

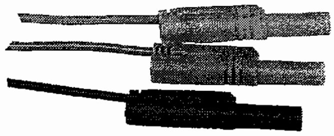
Electrical	
Permissible operating voltage	10 V DC to 30 V DC
Type of light	Infrared light
Switching output	PNP, normally open
Nominal switching distance	430 mm
Operational switching distance	20 mm to 350 mm
Hysteresis	≤10%
Reproducibility	±10%
Maximum switching current	200 mA
Maximum switching frequency	250 Hz
Current consumption (no load)	35 mA
Size of sensor	M18
Permissible ambient operating temperature	-5 °C to +55 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 65
Weight	0.19 kg
Electrical connection	Cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

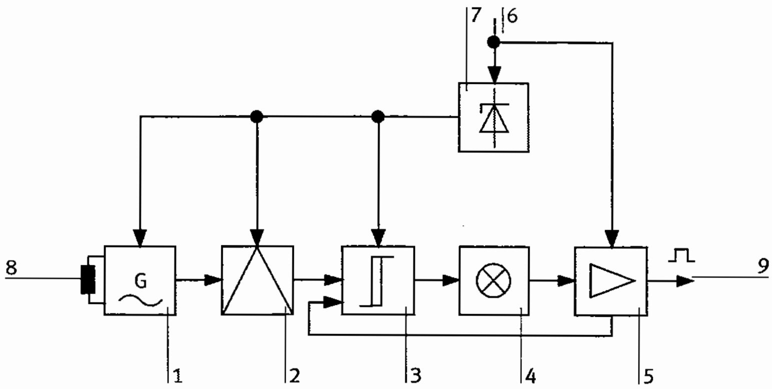
177464

Inductive sensor unit 2









1	Oscillator
2	Demodulator
3	Triggering stage
4	Switching status indicator
5	Output stage with protective circuit
6	External voltage
7	Internal stabilised voltage
8	Coil with active switching zone
9	Switching output

177464

Inductive sensor unit 2

Design

The inductive proximity sensor is mounted on an aluminium bracket. Attachment to the profile plate is effected by a T-head nut and a knurled screw. Electrical contact is established by a cable with 4 mm safety plugs.

Function

Inductive proximity switches contain an oscillator circuit, consisting of a parallel resonance circuit with coil and condenser, as well as an amplifier. The electromagnetic field is directed outwards from the ferrite core.
If an electrically conductive material penetrates into the area of the stray electromagnetic field, the law of induction causes eddy currents to be generated in the material, and results in the sensor field being attenuated. Depending on the conductivity, the dimensions, and the proximity of the conductive object, the resonant field may be attenuated to such an extent, that oscillation ceases. The damping of the oscillator is evaluated electronically (demodulator) and a switching signal is supplied by the triggering stage.
The proximity sensor has an PNP output, i.e. upon activation,the switch, which is designed as normally open, connects the signal line to the positive potential. The load is connected between the proximity sensor output and earth (0 V). The active switching surface is identified by a blue plastic disc. A yellow light emitting diode (LED) indicates the switching status. The proximity sensor is suitable for flush fitting in metals.

Note

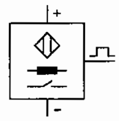
The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

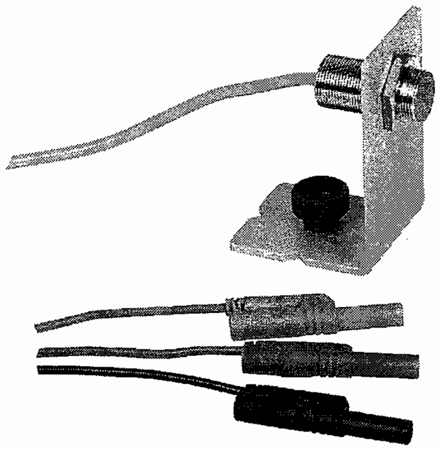
- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally open — black

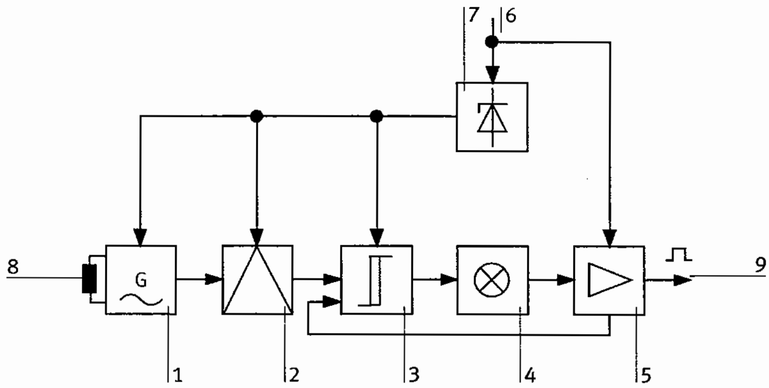
The sensor is protected against incorrect polarity, overload and short circuit.

Technical data

Electrical	
Permissible operating voltage	10 V DC to 30 V DC
Switching output	PNP, normally open
Nominal switching distance (mild steel)	4 mm
Hysteresis (ref. to nominal switching distance)	≤10%
Maximum switching current	150 mA
Maximum switching frequency	400 Hz
Current consumption (no load)	30 mA
Size of sensor	M12 x 1
Installation	flush-fitting
Permissible ambient operating temperature	-25 °C to +85 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 67
Weight	0.18 kg
Electrical connection	Cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1







1 Oscillator
2 Demodulator
3 Triggering stage
4 Switching status indicator
5 Output stage with protective circuit
6 External voltage
7 Internal stabilised voltage
8 Coil with active switching zone
9 Switching output

177466

Inductive sensor unit 1

Design

The inductive proximity sensor is mounted on an aluminium bracket. Attachment to the profile plate is effected by a T-head nut and a knurled screw. Electrical contact is established by a cable with 4 mm safety plugs.

Function

Inductive proximity switches contain an oscillator circuit, consisting of a parallel resonance circuit with coil and condènser, as well as an amplifier. The electro-magnetic field is directed outwards from the ferrite core.
If an electrically conductive material penetrates into the area of the stray electro-magnetic field, the law of induction causes eddy currents to be generated in the material, and results in the sensor field being attenuated. Depending on the conductivity, the dimensions, and the proximity of the conductive object, the resonant field may be attenuated to such an extent, that oscillation ceases. The damping of the oscillator is evaluated electronically (demodulator) and a switching signal is supplied by the triggering stage.
The proximity sensor has an PNP output, i.e. upon activation,the switch, which is designed as normally open, connects the signal line to the positive potential. The load is connected between the proximity sensor output and earth (0 V). The active switching surface is identified by a blue plastic disc. A yellow light emitting diode (LED) indicates the switching status. The proximity sensor is suitable for flush fitting in metals.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally open — black

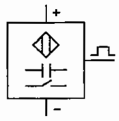
The sensor is protected against incorrect polarity, overload and short circuit.

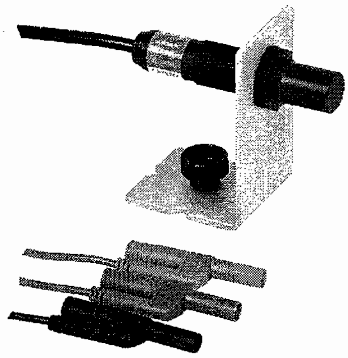
Technical data

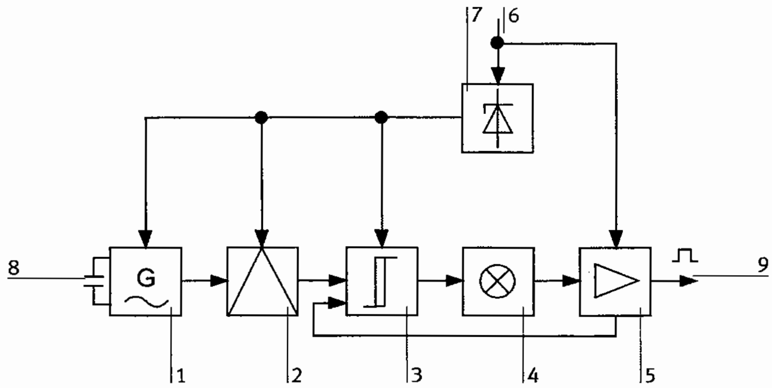
Electrical	
Permissible operating voltage	10 V DC to 30 V DC
Switching output	PNP, normally open
Nominal switching distance (mild steel)	7 mm
Hysteresis (ref. to nominal switching distance)	≤10%
Maximum switching current	150 mA
Maximum switching frequency	250 Hz
Current consumption (no load)	30 mA
Size of sensor	M 18 x 1
Installation	flush-fitting
Permissible ambient operating temperature	-25 °C to +85 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 67
Weight	0.18 kg
Electrical connection	Cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

177470

capacitive sensor unit







1	Oscillator
2	Demodulator
3	Triggering stage
4	Switching status indicator
5	Output stage with protective circuit
6	External voltage
7	Internal stabilised voltage
8	Condenser with active switching zone
9	Switching output

177470

capacitive sensor unit

Design

The inductive proximity sensor is mounted on an aluminium bracket. Attachment to the profile plate is effected by a T-head nut and a knurled screw. Electrical contact is established by a cable with 4 mm safety plugs.

Function

The operational principle of a capacitive proximity sensor is based on the evaluation of the change of capacitance of a condenser in an RC resonant circuit.
If any kind of material is introduced into the active field of the proximity sensor the capacitance of the condenser increases. This leads to a measurable change of the oscillatory behaviour of the RC resonant circuit. The change in capacitance depends substantially on the distance, the dimensions, and on the dielectric constant of the material in question.
The proximity sensor has a PNP output, i.e. upon activation, the switch, which is designed as normally open, connects the signal line to the positive potential. The load is connected between the proximity sensor signal output and earth (0 V). A yellow light emitting diode (LED) indicates the switching status. The capacitive proximity sensor cannot be flush mounted.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally open — black

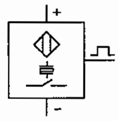
The sensor is protected against incorrect polarity, overload and short circuit.

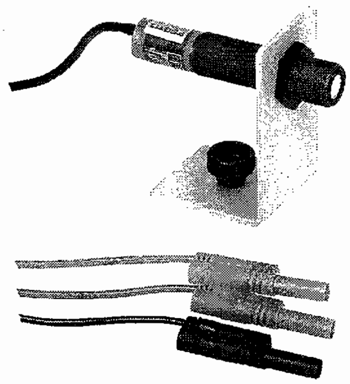
Technical data

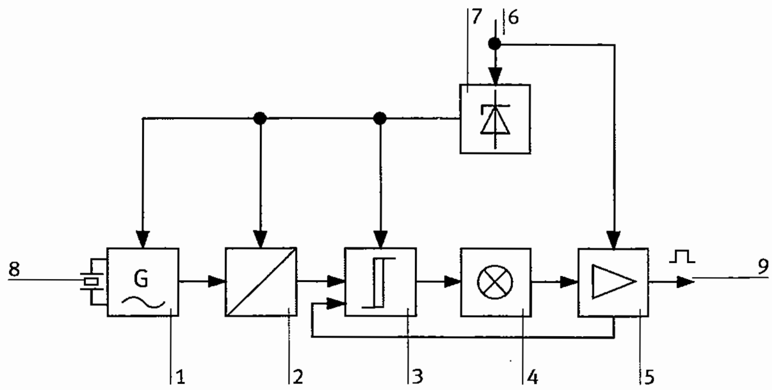
Electrical	
Permissible operating voltage	10 V DC to 36 V DC
Switching output	PNP, normally open
Nominal switching distance	4 mm
Hysteresis (ref. to nominal switching distance)	≤10%
Maximum switching current	200 mA
Maximum switching frequency	100 Hz
Current consumption (no load)	30 mA
Size of sensor	M12 x 1
Installation	not flush-fitting
Permissible ambient operating temperature	-25 °C to +85 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 67
Weight	0.18 kg
Electrical connection	Cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

184118

Ultrasonic sensor unit







1 Oscillator
2 Evaluation unit
3 Triggering stage
4 Switching status indicator
5 Output stage with protective circuit
6 External voltage
7 Internal stabilised voltage
8 Ultrasonic transducer with active switching zone
9 Switching output

184118

Ultrasonic sensor unit

Design

The ultrasonic proximity sensor is mounted in an aluminium bracket. The angle bracket is attached to the profile plate by a T-head nut and a knurled screw. Electrical connection is established by means of a cable with 4 mm safety plugs.

Function

The operational principle of an ultrasonic proximity sensor is based on the generation of sound waves and their detection after reflection by an object. The sound waves, generated by the sensor, are transmitted through the atmosphere.
A piezoelectric sound generator is excited to generate ultrasonic pulsations inaudible to the human ear. After emission, the sound emitter is switched to receiver mode, i.e. it now functions as a microphone. The time elapsed between the emission of an ultrasonic pulse and the reception of the pulse reflected by an object is evaluated. If an object is located within the range indicated, it causes a change in switching status.
Objects of various types of material can be detected. Shape, colour and form, i.e. whether solid, liquid or powder, have little or no influence on detection. Objects with a smooth, flat surface must be placed such that their surface is orientated at a right angle to the ultrasonic emission.
The proximity sensor has a PNP output, i.e. the signal line is switched to positive potential in the switched state. The switch is designed as normally open. The load is connected between the sensor output line and earth (0 V). A red LED indicates the switching status.

Note

The polarity of the applied voltage is critical for satisfactory operation. The cable terminals are colour coded.

- Operating voltage
  Positive pin — brown (red plug)
  Negative pin (0 V) — blue
- Load output
  Normally open — black

The sensor is protected against incorrect polarity, overload and short circuit.

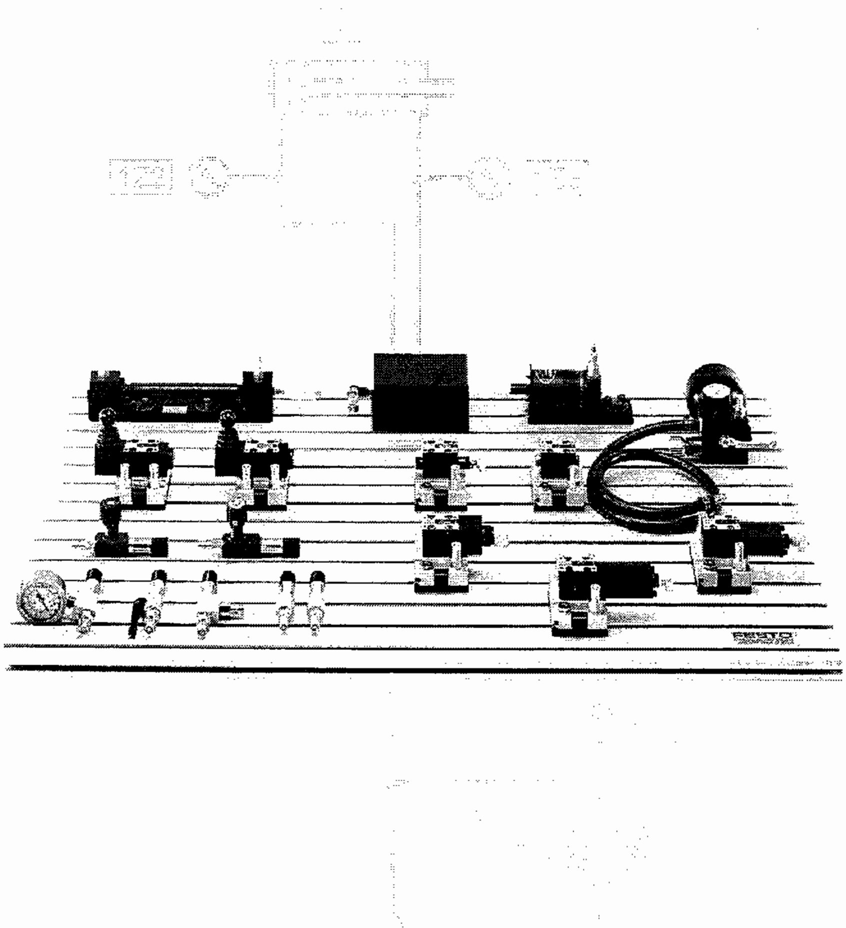
Technical data

Electrical	
Permissible operating voltage	19 V DC to 29 V DC
Switching output	PNP, normally open
Ultrasonic emitter frequency	215 kHz
Range	100 mm to 200 mm
Hysteresis	≤5%
Maximum switching current	100 mA
Maximum switching frequency	6 Hz
Current consumption (no load)	1 mA
Size of sensor	M18
Installation	flush-fitting
Permissible ambient operating temperature	0 °C to +70 °C
Protection against wrong polarity	integrated
Protection against short circuit	yes
Protection class	IP 67
Weight	0.20 kg
Electrical connection	Cable with 4 mm safety plugs
Electromagnetic compatibility	CE
Emitted interference	tested to EN 500 81-1
Noise immunity	tested to EN 500 82-1

Learning System for Automation and Technology

Hydraulics

Workbook Basic Level



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094468

Authorised applications and liability

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