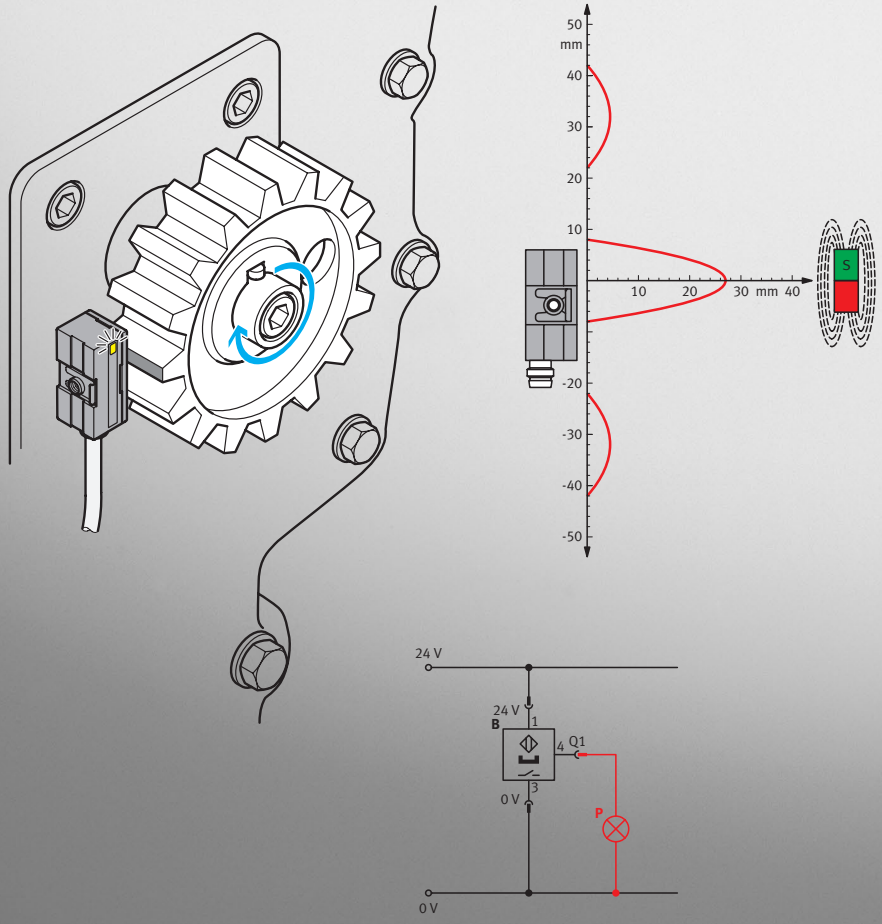
Sensors for object detection



FESTO

Workbook
TP 1311

With CD-ROM

Festo Didactic
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Exercises and worksheets

Use for intended purpose

The training package “Sensors for Object Detection” may only be used:

- For its intended purpose in teaching and training applications
- When its safety functions are in perfect condition

The components included in the training package are designed in accordance with the latest technology as well as recognised safety rules. However, life and limb of the user and third parties may be endangered, and the components may be impaired if they are used improperly.

The training system from Festo Didactic has been developed and produced for training and vocational education in the field of automation technology. The respective training companies and/or trainers must ensure that all trainees observe the safety precautions which are described in this workbook.

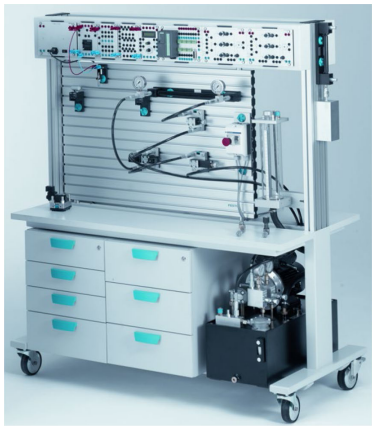
Festo Didactic hereby excludes any and all liability for damages suffered by trainees, the training company and/or any third parties, which occur during use of the equipment in situations which serve any purpose other than training and/or vocational education, unless such damages have been caused by Festo Didactic due to malicious intent or gross negligence.

Preface

Festo Didactic's training system for automation and technology is geared towards various educational backgrounds and vocational requirements. The training packages are therefore broken down as follows:

- Technology training modules
- Mechatronics and factory automation
- Process automation and control technology
- Robotino® – training and research with mobile robots
- Hybrid learning factories

The technology modules deal with various technologies including pneumatics, electro-pneumatics, hydraulics, electro-hydraulics, proportional hydraulics, programmable logic controllers, sensor technology, electrical engineering and electric drives.



The modular design of the training system makes it possible to focus on applications above and beyond those covered in the individual modules, such as, for example, PLC actuation of pneumatic, hydraulic and electrical drives.

All training modules have the same structure:

- Hardware
- Courseware
- Software
- Seminars

The hardware is comprised of industrial components and systems that are specially designed for training purposes.

The structure of the courseware corresponds to that of the training hardware. It includes:

- Textbooks (with exercises and examples)
- Workbooks (with practical exercises, supplementary instructions and solutions)
- Books of exercises (with practical exercises and supplementary explanations)
- Transparencies and videos (for dynamic instruction)

The teaching and learning media are available in several languages. They're intended for use in classroom instruction, but are also suitable for self-study.

Where software is concerned, computer training programs, as well as simulation, visualisation, project engineering, design engineering and programming software, are made available.

A wide range of seminars covering the contents of the training packages round off the programme for training and vocational education.

Do you have tips, feedback or suggestions for improving this workbook?

If so, please send us an e-mail at did@de.festo.com.
The authors and Festo Didactic look forward to your feedback.

Introduction

This workbook is part of the training system for automation and technology from Festo Didactic. The system provides a solid basis for practical training and vocational education. Training package TP 1311 deals with the subject of sensors for object detection.

Special emphasis is placed on the design, function, connection, range of applications and selection of sensors on the basis of the requirements for the respective application.

A permanent workstation equipped with a Festo Didactic profile plate and a short-circuit proof power supply unit with an output voltage of 24 V DC is a prerequisite for setting up the circuits.

All the circuits for the 15 exercises are set up using the TP 1311 equipment set. The theoretical fundamentals for understanding these exercises are included in the textbook:

- Proximity sensors (order number 093046)

Data sheets for the individual components are also available (sensors, measuring instruments etc.).

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Work instructions and safety precautions

General

- Trainees should only work with the circuits under the supervision of a trainer.
- Observe the specifications included in the data sheets for the individual components and in particular all safety instructions!
- Faults which may impair safety must not be generated in the training environment and must be eliminated immediately.

Mechanical setup

- Mount all the components securely onto the profile plate.
- Adhere to the instructions regarding positioning of the components.

Electrical setup

- Use low voltage only (max. 24 V DC).
- Electrical connections must only be established and interrupted in the absence of voltage!
- Only use connecting cables with safety plugs for electrical connections.
- Only pull the plug when disconnecting connecting cables – never pull the cable.

Mounting technology

The mounting boards for the components are equipped with mounting variant A, B or C:

- Variant A, snap-in system
  Lightweight components that are not load-bearing (e.g. directional control valves and sensors). Simply clip the component into the slot on the profile plate. Release the component from the slot by turning the blue lever.
- Variant B, bolt system
  Components with medium load capacity (e.g. pneumatic cylinders). These components are clamped onto the profile plate using T-head bolts. The blue, knurled nut is used for clamping and loosening.
- Variant C, screw system
  For components with high load capacity and components which are seldom removed from the profile plate (for example on-off valve with filter regulator). The components are secured with socket head screws and T-head bolts.

Recommended accessories

A ruler and a digital multimeter are required in order to evaluate the circuits which have been set up.

- Layout dimensions and scanning widths are measured with the ruler.
- Operating voltages, output voltages and output current values are measured with the digital multimeter.

Training package Sensors for Object Detection (TP 1311)

The TP 1311 training package consists of a multitude of training materials. The subject matter is sensors for object detection. Individual components included in the TP 1311 training package can also be included in other modules.

Important TP 1311 components

- Permanent workstation with Festo Didactic profile plate
- Sets of components or individual components (e.g. sensors, indicators, set of objects, positioning slide)
- Complete laboratory setups

Media

The courseware for the TP 1311 training package consists of a textbook and a workbook. The textbook contains basic physical and technical knowledge regarding sensors for object detection. The workbook includes exercise sheets for each exercise, the solutions to each individual worksheet and a CD-ROM. A set of ready-to-use exercise sheets and worksheets is included in each workbook for all of the exercises.

Data sheets for the hardware components are made available along with the training package.

Media	
Textbook	Proximity switches
Workbook	Sensors for object detection
Set of transparencies	Sensor technology
Digital training program	Web-based training for sensor technology 2 – Sensors for object detection

Overview of media for the TP 1311 training package

A digital training program (web-based training for sensor technology 2 – Sensors for object detection) is available as software for the training package. This training program takes an in-depth look at sensors for object detection in automated systems. With the help of a complex example based on actual industrial practice, the student works through the basic principles of sensor technology and is able to select suitable sensors.

You'll find further training materials in our catalogue and on the Internet. The training system for automation and technology is continuously updated and expanded. Transparency sets, videos, CD-ROMs, DVDs and training programs, as well additional courseware, are offered in several languages.

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Learning objectives

Magnetic proximity switches

- Become familiar with the setup and function of a magneto-resistive proximity switch.
- Become familiar with the switching performance of a magneto-resistive proximity switch.
- Become familiar with the influence of position and orientation of a magnet on switching performance.
- Become familiar with the basic principles of connection and circuit technology.

Inductive proximity switches

- Become familiar with the setup and function of an inductive proximity switch.
- Become familiar with the terminology used to describe the switching performance of an inductive proximity switch.
- Become familiar with the influence of various physical designs and workpiece materials on the switching performance of inductive sensors.
- Learn how the material used affects the switching distance of inductive proximity switches when detecting various types of metal.
- Become familiar with the setup of logic operations using proximity switches.
- Be able to select a suitable sensor based on prevailing conditions.

Optical proximity switches

- Become familiar with the terminology used to describe the switching performance of optical proximity switches.
- Become familiar with the response characteristics of a through-beam sensor.
- Be able to determine which materials can be detected with the sensor.
- Become familiar with the range of applications and the response characteristics of a retro-reflective sensor.
- Become familiar with the setup and function of an optical diffuse light sensor.
- Become familiar with the range of applications and the scanning width of a diffuse light sensor with fibre-optic adaptor.
- Become familiar with the range of applications of optical proximity switches with fibre-optic cable.
- Be able to select a suitable sensor based on prevailing conditions.

Capacitive proximity switches

- Become familiar with the setup and function of a capacitive proximity switch.
- Become familiar with the influence of the type of material used on the switching distance of a capacitive proximity switch.
- Become familiar with the setup of logic operations using proximity switches.

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Allocation of learning objectives to exercises

Exercise / Learning objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Become familiar with the setup and function of a magneto-resistive proximity switch.	•														
Become familiar with the switching performance of a magneto-resistive proximity switch.	•														
Become familiar with the basic principles of connection technology and circuit technology for proximity switches.	•	•													
Become familiar with the setup and function of an inductive proximity switch.		•													
Become familiar with the terminology used to describe the switching performance of an inductive proximity switch.		•													
Learn how the material used affects the switching distance of inductive proximity switches when detecting various types of metal.			•												
Become familiar with the influence of variously sized object on the switching distance of an inductive proximity switch.				•											
Become familiar with the response characteristics of an inductive sensor with analogue output.					•										
Be able to determine the characteristic curve of an inductive sensor with analogue output.					•										
Be able to determine the responsivity of an inductive sensor with analogue output.					•										
Be able to evaluate measurement reproducibility, linearity and hysteresis error.					•										
Become familiar with the dependence of output current on material and distance from the object to be measured.						•									
Become familiar with the dependence of output current on the size of the cross-sectional area and distance from the object to be measured.						•									

Exercise / Learning objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Become familiar with the setup and function of a through-beam sensor.							•								
Become familiar with the response characteristics of a through-beam sensor.							•								
Become familiar with the materials which can be detected with a through-beam sensor.							•								
Become familiar with the setup and function of a retro-reflective sensor.								•							
Become familiar with the switching performance of a retro-reflective sensor.								•							
Become familiar with the range of applications of a retro-reflective sensor.								•							
Become familiar with the setup and mode of operation of a diffuse light sensor.									•						
Become familiar with the influence of workpiece surfaces on the scanning width of a diffuse light sensor.									•						
Become familiar with the setup and function of fibre-optic cables.										•					
Become familiar with the range of applications of fibre-optic cables.										•					
Become familiar with the setup and function of a capacitive proximity switch.											•				
Become familiar with the switching performance of a capacitive proximity switch.											•				
Become familiar with the range of applications of capacitive proximity switches.												•			
Be able to detect fill levels with capacitive and optical proximity switches.												•			
Be able to use proximity switches to inspect workpieces.													•		
Be able to select suitable proximity switches.													•		
Become familiar with the range of applications of optical proximity switches.														•	
Become familiar with the basic principles of connection technology and circuit technology for proximity switches.	•	•													•
Be able to setup logic operations using proximity switches.															•

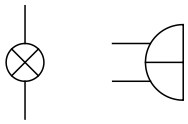
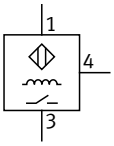
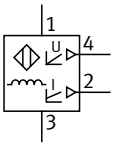
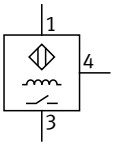
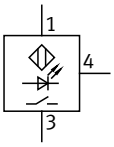
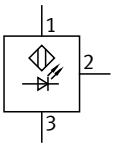
Equipment set

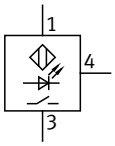
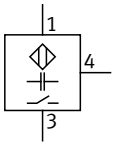
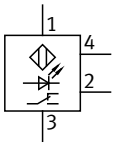
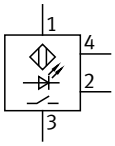
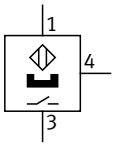
The equipment set is used to convey knowledge about the basic principles and the use of magneto-resistive, inductive, capacitive and optical proximity switches. It includes all the components that are necessary for mastering the specified learning objectives and can be supplemented with any other equipment sets. A profile plate, a power supply unit and a digital multimeter are also required in order to set up functional circuits.

Equipment set TP 1311 (order no. 566918)

Component	Order no.	Quantity
Indicator unit and distributor, electrical	162244	1
Proximity switch, inductive, M12	548643	1
Proximity sensor, inductive, with analogue output, M12	548644	1
Proximity switch, inductive, M18	548645	1
Through-beam sensor, receiver	548647	1
Through-beam sensor, transmitter	548648	1
Retro-reflective sensor	548649	1
Reflector (triple mirror), 20 mm	548650	1
Proximity switch, capacitive, M12	548651	1
Fibre-optic unit	548655	1
Diffuse sensor with background suppression	548656	1
Fibre-optic cable	548659	1
Set of objects	549830	1
Positioning slide	549842	1
Proximity switch, magneto-resistive	566199	1

Graphic symbols, equipment set

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

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

Allocation of components per exercise

Exercise / Component	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Indicator unit and distributor, electrical	1	1	1	1			1	1	1	1	1	1	1	1	1
Proximity switch, inductive, M12		1													1
Proximity sensor, inductive, with analogue output, M12					1	1									
Proximity switch, inductive, M18		1	1	1											
Through-beam sensor, receiver							1					1			
Through-beam sensor, transmitter							1					1			
Retro-reflective sensor								1							
Reflector (triple mirror), 20 mm								1							
Proximity switch, capacitive, M12											1	1			1
Fibre-optic unit									1						
Diffuse sensor with background suppression										1				1	
Fibre-optic cable									1					1	
Set of objects	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Positioning slide	1	1	1	1	1	1			1	1	1	1	1		1
Proximity switch, magneto-resistive	1														
Ruler									1	1		1		1	
Digital multimeter					1	1									1
Power supply unit, 24 V DC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Notes for the teacher/trainer

Learning objectives
The basic learning objective of this workbook is to become familiar with sensors for object detection, as well as the practical setup of circuits on the profile plate. This direct interaction involving both theory and practice assures faster, longer-lasting learning progress. The more specific learning objectives are documented in the matrix. Concrete, individual learning objectives are assigned to each exercise.

Required time
The time required for working through the exercises depends on the student's previous knowledge of the subject matter. Apprentices in the field of metalworking or electrical installation: approx. 2 weeks. With training as a skilled labourer: approx. 1 week

Equipment set components
The workbook, the book of exercises and the equipment set all match each other. All the components required for the 15 exercises are included in the TP 1311 equipment set.

Each exercise can be set up on a slotted mounting plate or a profile plate with a width of at least 350 mm.

Standards
The following standards are used in this workbook:

EN 60617-7:	Graphic symbols for circuit diagrams
EN 60947-5-2:	Low-voltage switchgear and control gear – Control circuit components and switching elements – Proximity switches
EN 81346-2:	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations

Identification within the workbook
Solutions and supplements in graphics or diagrams are in red.

Identification within the book of exercises
Texts which require completion are identified with blank lines or grey table cells.
Graphics which require completion include a grid.

Training notes
These notes provide additional information about the individual proximity switches. These notes are not included in the worksheets.

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Solutions

The solutions provided in the workbook are the results of test measurements. Your measurement results may deviate.

This is particularly true for adjustable proximity switches. In the case of optical proximity switches, additional deviation may also be caused by the surface characteristics of the examined materials. The cut edge of the fibre-optic cable and the optical transition from the optics of the transmitter/receiver to the fibre-optic cable also influence measurement results.

Learning areas

Below is an overview of the different learning areas of "sensors for object detection" allocated by profession.

Profession	Topic
Electrician for automation technology	Controllers, analysis and adaptation
	Systems analysis and safety testing
	Programming and implementing controllers for systems
	Selecting and integrating drive systems
	Commissioning and approving automation systems
	Maintaining and optimising automation systems
Mechatronics technician	Implementing mechatronic subsystems
	Commissioning, troubleshooting and repair
Industry mechanic	Installing and commissioning control systems

Structure of the exercises

All 15 exercises have the same structure and are broken down into:

- Title
- Learning objectives
- Presentation of the problem
- Layout
- Project assignment
- Work tools
- Worksheets

The solutions for all 15 exercises are included in the workbook.

Component designations

The components are designated in circuit diagrams in accordance with EN 81346-2. Letters are assigned depending on the component type. Consecutive numbers are assigned if several components of the same type are included within a single circuit.

Sensors: B, B1, B2 etc.
Signal generators: P, P1, P2 etc.

CD-ROM contents

Included on the CD-ROM are the workbook (in PDF format) as well as additional media.

The CD-ROM contains the following folders:

- Operating instructions
- Images
- Data sheets
- Presentations
- Product information

Operating instructions
Operating instructions for various components included in the training package are available. These instructions are helpful with regard when using and commissioning the equipment.

Images
Photos and graphics of components and industrial applications are made available. These can be used to illustrate individual tasks. Project presentations can also be supplemented with these illustrations.

Data sheets
The data sheets for the components included in the training package are available as PDF files.

Presentations
Contains short presentations of components included in the training module. They can be used, for example, for the creation of project presentations.

Product information
The manufacturer's product information is provided for selected components. The representations and descriptions of the components are intended to demonstrate how they are presented in an industrial catalogue. Additional information regarding the components is also included.

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Exercise 1:

Detecting the speed of a gear

Learning objectives

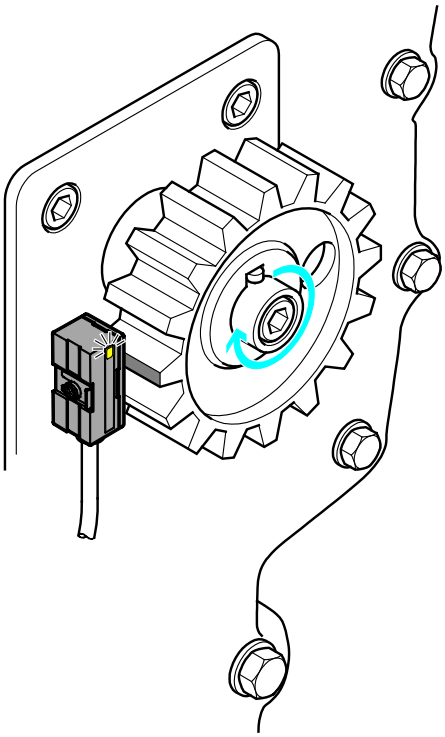
After completing this exercise:

- You'll be familiar with the setup and function of a magneto-resistive proximity switch.
- You'll be familiar with the switching performance of a magneto-resistive proximity switch.
- You'll be familiar with the basic principles of connection technology and circuit technology for proximity switches.

Presentation of the problem

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

Layout



Magnetic proximity switch for recording speed

Assignments

1. Describe the setup and function of a magneto-resistive proximity switch.
2. Examine the switching performance of the magneto-resistive proximity switch.
3. Examine the influence of the orientation of the magnetic axis.
4. Answer the questions about magnetic proximity switches.

Work tools

- Data sheets
- Textbook Proximity switches

Note

Do not switch electrical power supply on until all the connections have been completed and inspected. After completing this exercise, switch the electrical power supply back off again before dismantling the components.

Training notes

Operating instructions, images, data sheets, presentations, and product information for individual components from the equipment set can be found on the included CD-ROM.

1. Description of the function

a) Describe the function of the magneto-resistive proximity switch.

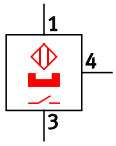
The magneto-resistive proximity switch detects a magnetic field by means of resistors which are influenced by it. A bridge circuit for the resistors generates a voltage when a magnet approaches the sensor without making contact. The voltage is processed by the integrated electronic evaluation unit and is converted into an output signal.

The surface which is sensitive to the magnetic field is identified with a blue dot on the contactless proximity switch used.

b) Complete the circuit symbol for the magneto-resistive proximity switch.

Requirements

- The proximity switch is contactless,
- reacts when a magnet approaches it, and
- its switching output has a normally open function.

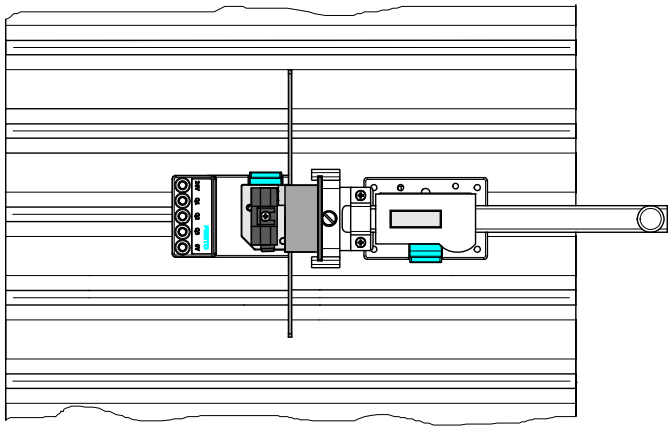


c) Complete the table below. The required data are included in the data sheet for the magneto-resistive proximity switch.

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

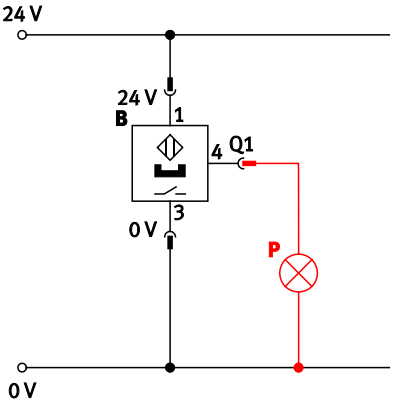
2. Determine switching performance

a) Mount the indicator unit, the positioning slide and the magneto-resistive proximity switch on the profile plate.



Setup

b) Connect the 24 V power supply unit and the magneto-resistive proximity switch to the indicator unit. Complete the circuit diagram.



Electrical circuit diagram

c) Complete the equipment list. Enter all the components you'll require in order to examine switching performance.

Quantity	Component
1	Proximity sensor, magneto-resistive
1	Positioning slide
1	Indicator unit and distributor, electrical
1	Power supply unit, 24 V DC

Item	Part
1	Workpiece holder
2	Magnet 1, on support plate
3	Magnet 2, on support plate

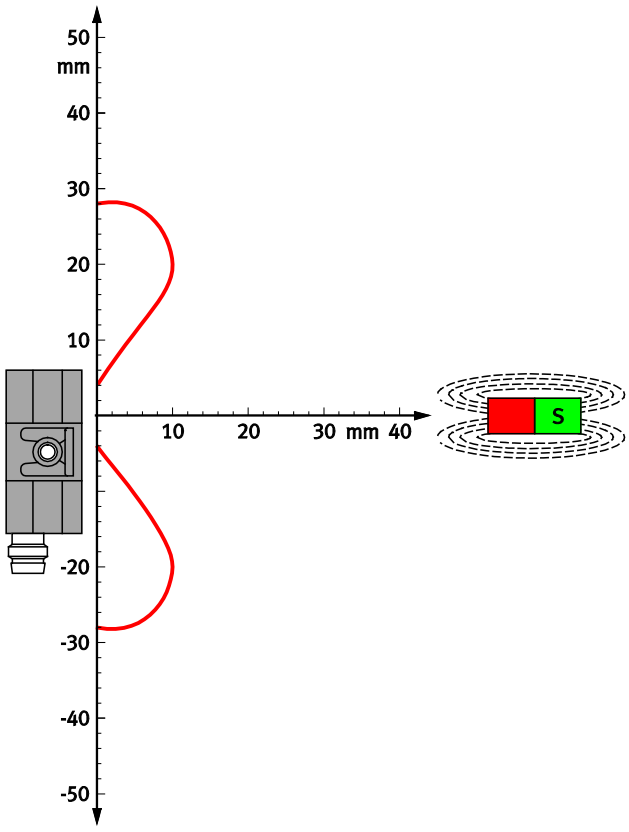
Individual parts from the set of objects

Test procedure "Magnet 1"

- Insert the workpiece holder from the set of objects into the workpiece receiver on the positioning slide.
- Take magnet 1 from the set of objects and insert it into the workpiece holder.
- Push the workpiece receiver on the positioning slide all the way up to the limit stop (scale value: "0 mm"). Position the proximity switch and the positioning slide so that the distance between the magnet and the proximity switch is as small as possible.
- Move the magnet along the longitudinal axis of the proximity switch. Add the points at which the proximity switch reacts to the magnet to the diagram. You'll know when the proximity switch responds, because the integrated LED lights up at. The LED integrated in the indicator also lights up.
- The distance between the magnet and the proximity switch is increased in steps of 2 mm each. The magnet carrier is moved 50 mm relative to the middle of the active surface of the proximity switch (blue dot). Travel must be fully completed for each measurement.

Note

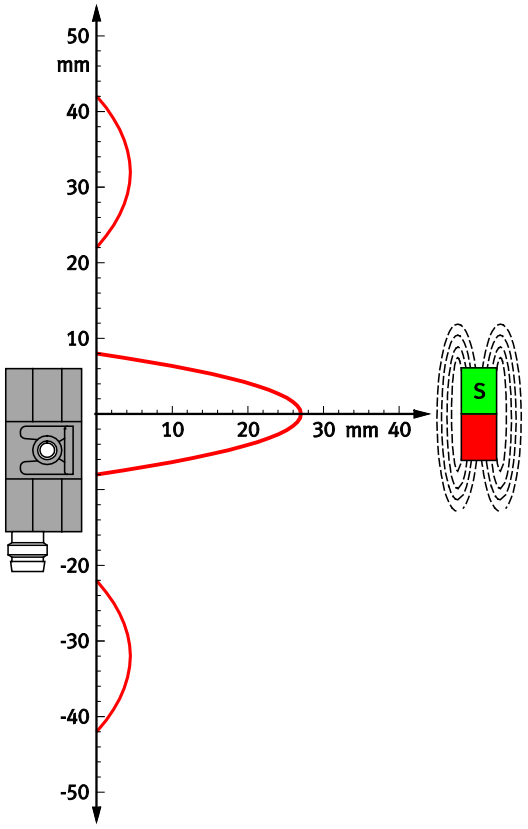
While performing measurements, make sure that the switch-on and switch-off points for the proximity sensor do not coincide. If the unactuated proximity switch is approached by the magnet from, for example, the left until its switching status changes, the switch-on point is detected. If the magnet continues to move to the left until the proximity switch changes from the actuated to the unactuated state, the switch-off point is detected. The distance between these two points is known as hysteresis.



Switching curve, magnet 1

Test procedure “Magnet 2”

– Using magnet 2 from the set of objects, repeat the above described procedure.
– Add the points at which the proximity switch reacts to this magnet to the diagram.



Switching curve, magnet 2

3. Influence of the orientation of the magnetic axis

– Describe the influence of the orientation of the magnetic axis.

As is demonstrated by the characteristic switching curves, two or three switching ranges are apparent depending on orientation of the magnetic axis. One of these three ranges can be plainly identified as the primary switching range. Any ambiguity of the output signal can be avoided by mounting the magnet with the correct magnetic axis orientation and, in the case of fixed field strengths, at the correct distance.

Where proximity switch/magnet combinations are used which are purchased as individual parts, achieved switching performance must always be tested. This is the only way to ensure reliable use of these proximity switches.

4. Questions about magnetic proximity sensors

a) Explain the term **magneto-resistive**.

The term magneto-resistive designates the change in resistance of ferromagnetic materials when exposed to a magnetic field. The resistors consist of, for example, nickel-iron alloys and are connected in Wheatstone bridge circuits. Bridge voltage changes under the influence of an external magnetic field. This change is evaluated.

b) Describe two further possibilities for substantiating the presence of a magnetic field. Briefly explain how these proximity switches function.

Reed switch – Contact blades made of ferromagnetic materials are fused into a glass bulb. The contact blades are magnetised when exposed to a magnetic field. They pull in and the contact is closed.

Inductive-magnetic proximity switch – The state of a resonant circuit is evaluated. The resonant circuit's coil is equipped with a ring core. The ring core material is saturated by a magnetic field and the resonant circuit current is changed. This change is evaluated.

Table of contents

Exercises and worksheets

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Exercise 1:

Detecting the speed of a gear

Learning objectives

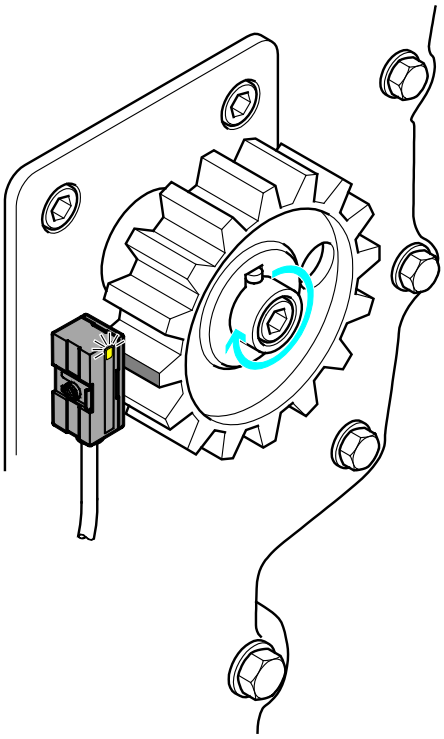
After completing this exercise:

- You'll be familiar with the setup and function of a magneto-resistive proximity switch.
- You'll be familiar with the switching performance of a magneto-resistive proximity switch.
- You'll be familiar with the basic principles of connection technology and circuit technology for proximity switches.

Presentation of the problem

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

Layout



Magnetic proximity switch for recording speed

Assignments

1. Describe the setup and function of a magneto-resistive proximity switch.
2. Examine the switching performance of the magneto-resistive proximity switch.
3. Examine the influence of the orientation of the magnetic axis.
4. Answer the questions about magnetic proximity switches.

Work tools

- Data sheets
- Textbook Proximity switches

Note

Do not switch electrical power supply on until all the connections have been completed and inspected. After completing this exercise, switch the electrical power supply back off again before dismantling the components.

1. Description of the function

a) Describe the function of the magneto-resistive proximity switch.

_____

_____

_____

_____

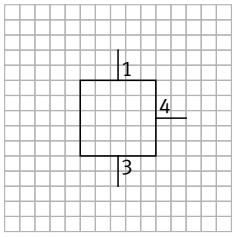
_____

_____

b) Complete the circuit symbol for the magneto-resistive proximity switch.

Requirements

- The proximity switch is contactless,
- reacts when a magnet approaches it, and
- its switching output has a normally open function.

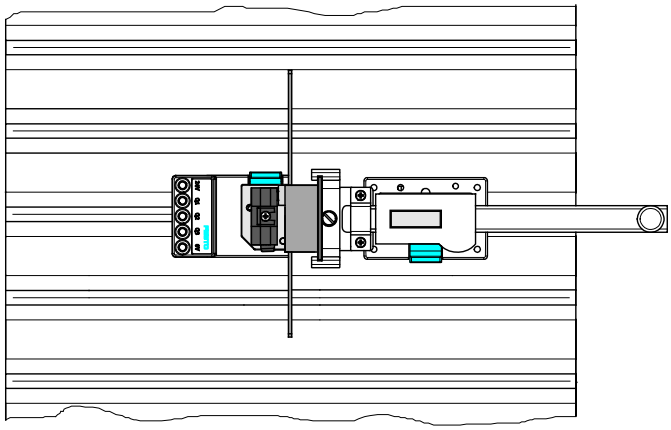


c) Complete the table below. The required data are included in the data sheet for the magneto-resistive proximity switch.

Parameter	Value
Operating voltage (DC)	
Switching current	
Switching frequency	
Switching output	
Switching status display	
Switching point reproducibility	

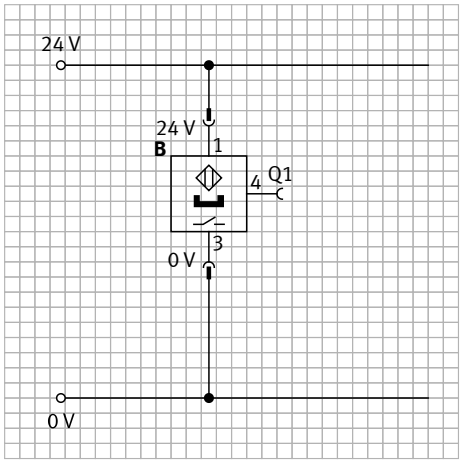
2. Determine switching performance

a) Mount the indicator unit, the positioning slide and the magneto-resistive proximity switch on the profile plate.



Setup

b) Connect the 24 V power supply unit and the magneto-resistive proximity switch to the indicator unit. Complete the circuit diagram.



Electrical circuit diagram

Name: _____ Date: _____

c) Complete the equipment list. Enter all the components you'll require in order to examine switching performance.

Quantity	Component
1	
1	
1	
1	Power supply unit, 24 V DC

Item	Part
1	Workpiece holder
2	Magnet 1, on support plate
3	Magnet 2, on support plate

Individual parts from the set of objects

Test procedure "Magnet 1"

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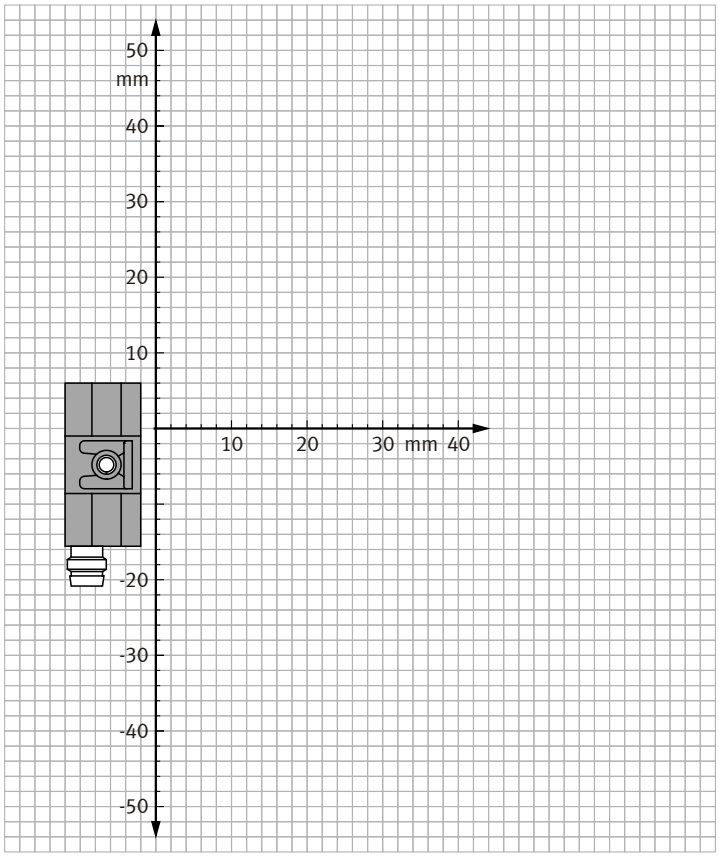
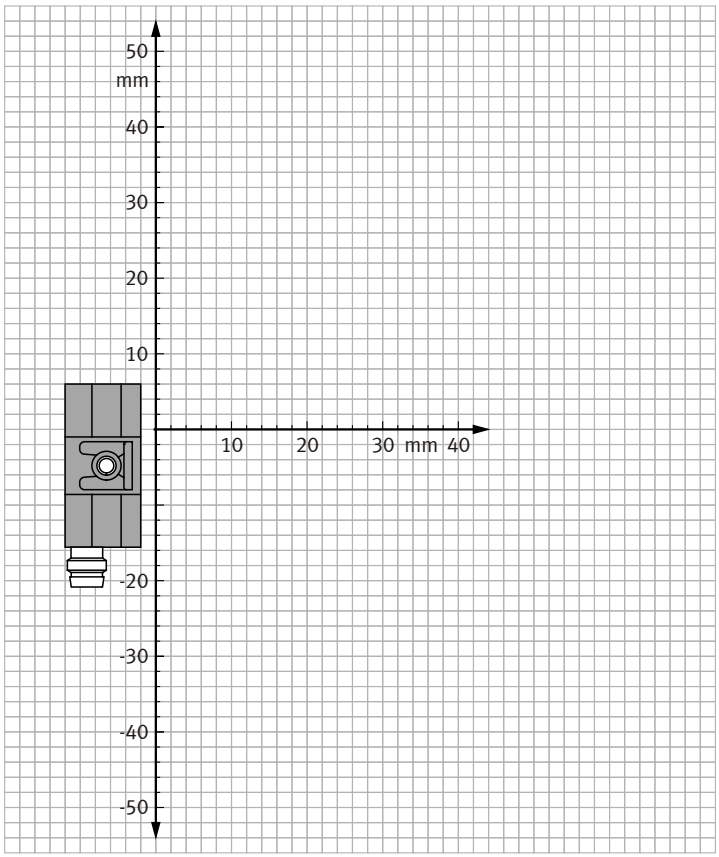


Switching curve, magnet 1

Test procedure “Magnet 2”

– Using magnet 2 from the set of objects, repeat the above described procedure.
– Add the points at which the proximity switch reacts to this magnet to the diagram.



Switching curve, magnet 2

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3. Influence of the orientation of the magnetic axis

– Describe the influence of the orientation of the magnetic axis.

4. Questions about magnetic proximity sensors

a) Describe two further possibilities for substantiating the presence of a magnetic field. Briefly explain how these proximity switches function.

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