Industrial Maintenance

Sensors

Courseware Sample

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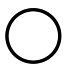
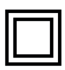
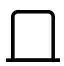
Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

Symbol	Description
⚠ DANGER	**DANGER** indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
⚠ WARNING	**WARNING** indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
⚠ CAUTION	**CAUTION** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
CAUTION	**CAUTION** used without the *Caution, risk of danger* sign ⚠, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger
	Caution, lifting hazard
	Caution, hand entanglement hazard
	Notice, non-ionizing radiation
⎓	Direct current
∿	Alternating current
≂	Both direct and alternating current
3∿	Three-phase alternating current
⏚	Earth (ground) terminal

Safety and Common Symbols

Symbol	Description
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

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Preface

The Sensors Training System, Model 8036-4, introduces the use of sensors.

The Sensors Training System is part of the Industrial Controls Training Program, which includes the following systems:

- Basic Controls;
- Programmable Logic Controller;
- Motor Drives;
- Sensors.

We hope that your learning experience will be the first step of a successful career.

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.

About This Manual

The exercises in this manual, *Sensors,* complement the exercises contained in the manuals *Basic Controls,* and *Programmable Logic Controller.*

Each exercise is divided into the following :

- A clearly defined Exercise Objective;
- A Discussion of the theory involved in the exercise;
- A Procedure Summary which provides a bridge between the theoretical Discussion and the laboratory Procedure;
- A step-by-step laboratory Procedure where important principles covered in the Discussion are observed and quantified;
- A Conclusion to summarize the material presented in the exercise;
- Review Questions to verify that the material has been well assimilated.

Optional equipment

Exercises 7 and 8 require the use of the optional Reversible AC Motor.

Safety considerations

Safety symbols that may be used in this manual and on the equipment are listed in the Safety Symbols table at the beginning of the manual.

Safety procedures related to the tasks that you will be asked to perform are indicated in each exercise.

Make sure that you are wearing appropriate protective equipment when performing the tasks. You should never perform a task if you have any reason to think that a manipulation could be dangerous for you or your teammates.

Reference material

Refer to the component data sheets for detailed information on how to use the devices. These data sheets are included on the CD supplied with the manual *Basic Controls*, Model 39163 (or 87774).

Prerequisite

To perform the exercises in this manual, you should have completed the manual *Basic Controls*, Model 39163 (or 87774). You should have also completed the manual *Programmable Logic Controller*, Model 39436, to perform Exercise 8.

About This Manual

Systems of units

Units are expressed using the International System of Units (SI) followed by the units expressed in the U.S. customary system of units (between parentheses).

To the Instructor

You will find in this Instructor Guide all the elements included in the Student Manual together with the answers to all questions, results of measurements, graphs, explanations, suggestions, and, in some cases, instructions to help you guide the students through their learning process. All the information that applies to you is placed between markers and appears in red.

Accuracy of measurements

The numerical results of the hands-on exercises may differ from one student to another. For this reason, the results and answers given in this manual should be considered as a guide. Students who correctly performed the exercises should expect to demonstrate the principles involved and make observations and measurements similar to those given as answers.

- Before a student begins an exercise, ensure that the equipment is in good condition and does not represent any risk when used.

- This guide provides you with the answers to questions.

- Make sure that the students understand the objectives of the work to be done.

Sample Exercise

Extracted from

the Student Manual

and the Instructor Guide

Polarized Retroreflective Photoelectric Switch

EXERCISE OBJECTIVE

- Introduce the Polarized Retroreflective Photoelectric Switch;
- Become familiar with its operation using the Reflective Block.

DISCUSSION

Retroreflective or retroflective sensing, is the most popular sensing mode. Retroreflective sensors can be used to detect most objects, including shiny objects. They contain both the emitter and receiver in the same housing. The light beam emitted by the light source is reflected by a special reflective surface and detected by the receiver, as shown in Figure 12. They are intended primarily for use in applications where an opaque target will completely block the light beam between the sensor and the reflective surface. Therefore, retroreflective sensors are not well suited to detect small and translucent objects.

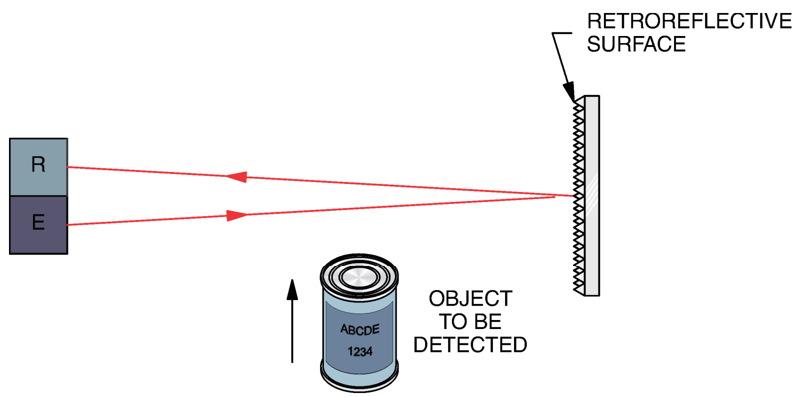

Figure 12. Retroreflective sensing.

Special reflectors or reflective tapes are used for retroreflective sensing. Unlike mirrors or other flat reflective surfaces, these reflective objects do not require perfect alignment. Misalignment of a reflector or reflective tape of up to 15° will typically not significantly reduce the operating margin of the sensing system. A wide selection of reflectors and reflective tapes is available. Some examples are shown in Figure 13.

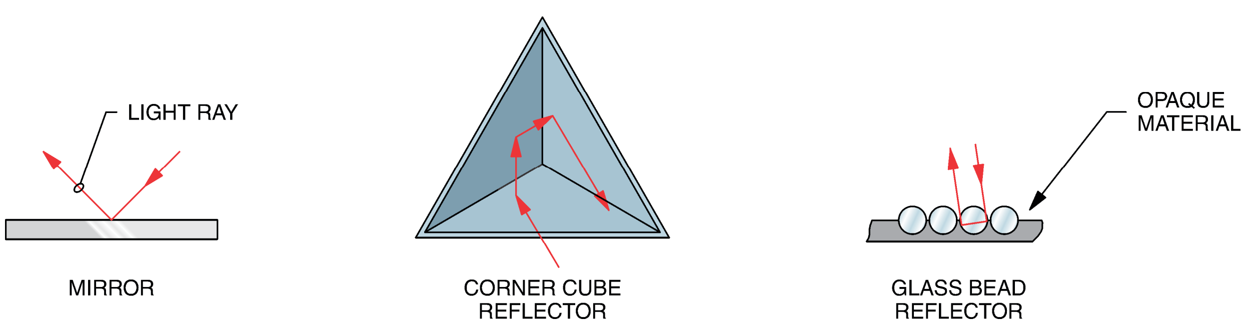

Figure 13. Retroreflective materials.

Occasionally, standard retroreflective sensors can be falsely triggered by reflections from shiny or highly reflective targets. To avoid this, polarized retroreflective sensing offers a better solution.

Polarized retroreflective sensors contain polarizing filters in front of the emitter and receiver. These filters are perpendicular, or 90° out of phase with each other, as shown in Figure 14. A depolarizing reflector is used to reflect the light.

In the absence of a target, the light emitted from the sensor is depolarized and reflected from the depolarizing reflector. Some of the reflected light passes through the polarizing filter in front of the receiver and is detected by the sensor, as shown in Figure 14 (a).

However, the light reflected by most targets is returned to the sensor with the same polarity, and cannot pass through the polarizing filter in front of the receiver, as shown in Figure 14 (b).

Polarized retroreflective sensors offer shorter sensing range than standard retroreflective sensors. Instead of infrared LEDs, they must use a less efficient visible red LED. They also have additional light losses caused by the polarizing filters.

Many standard reflectors depolarize light and are suitable for polarized retroreflective sensing. However, corner cube retroreflectors provide the highest signal return to the sensor. They have 2000 to 3000 times the reflectivity of white paper. For this reason, they are used to make safety reflectors for bicycles, cars, and signs.

As Figure 13 shows, corner cube reflectors consist of three adjoining sides arranged at right angles. When a light ray hits one of the adjoining sides, it is reflected to the second side, then to the third, and then back to its source in a direction parallel to its original course. You can experiment with the corner cube reflection by throwing a tennis ball into the corner of a room. The ball will return to you after bouncing off the three surfaces. Because of their high level of reflectivity, corner cube reflectors were placed on the moon by the Apollo astronauts and are still used today to measure the distance to the moon by timing laser light pulses reflected from Earth.

Polarized retroreflective sensors are often used to detect shiny objects. However, because the light may be depolarized as it passes through plastic film or stretch wrap, shiny objects may create detectable reflections (depolarized light) by the receiver if they are wrapped in clear plastic film.

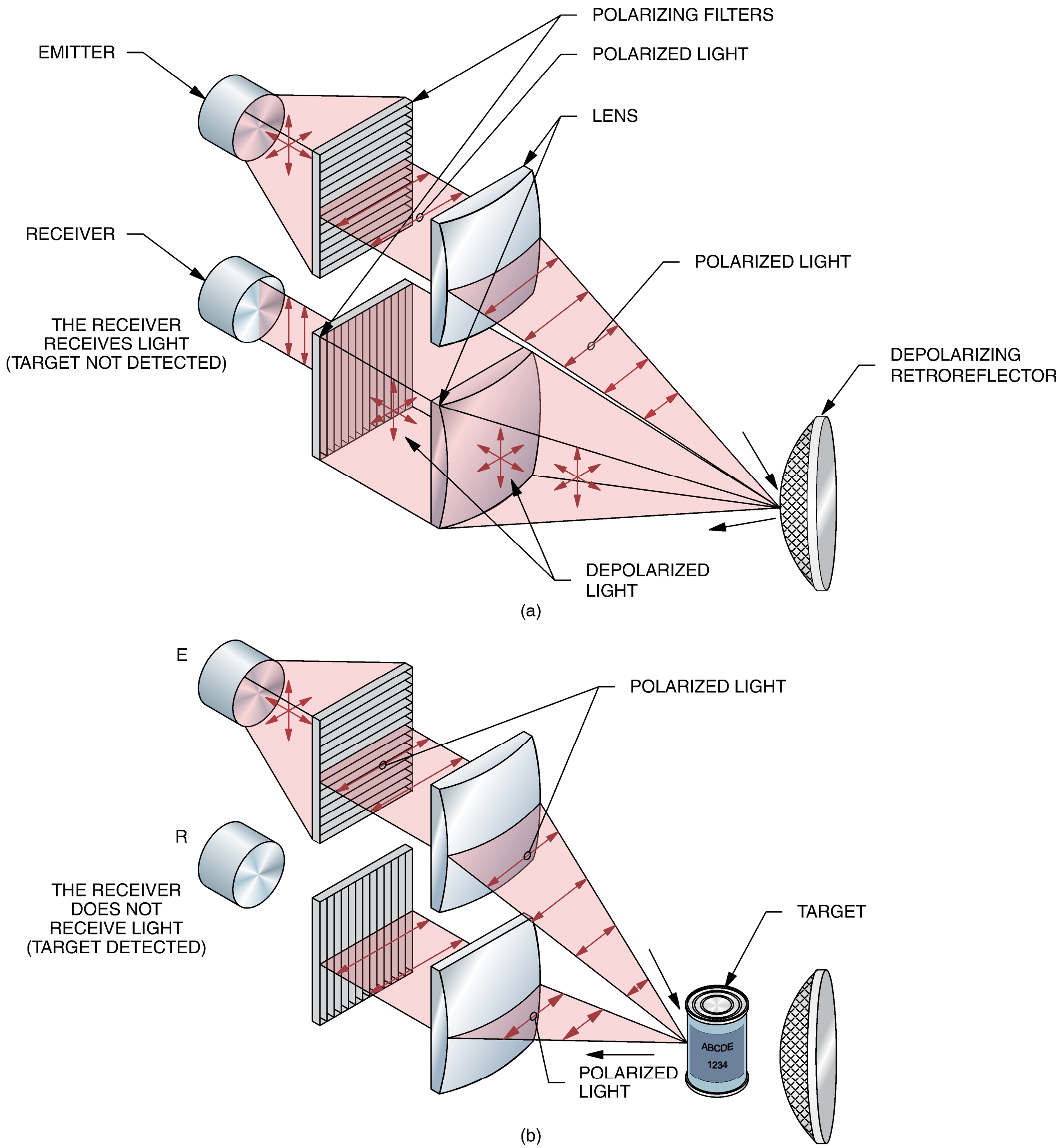

Figure 14. Polarized retroreflective sensing.

Most reflective tapes, like glass bead retroreflectors, do not depolarize light and are suitable only for use with standard retroreflective sensors.

The Polarized Retroflective Photoelectric Switch of your training system is shown in Figure 15. The sensor has a power indicator (green LED), an output indicator (yellow LED) that lights when the output is activated, and a stability indicator (orange LED) that lights when the excess gain exceeds 2.5. There is no sensitivity adjustment on this sensor. Other characteristics of the Polarized Retroflective Photoelectric Switch are shown in Table 4.

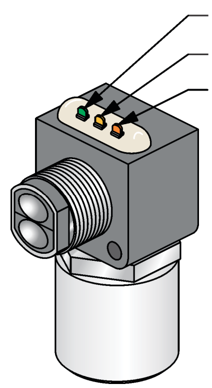

Figure 15. Polarized Retroflective Photoelectric Switch.

Table 4. Characteristics of the Polarized Retroflective Photoelectric Switch.

Characteristics of the polarized retroflective photoelectric switch	
Type	Polarized retroretlective
Transistor output type	Sourcing (PNP)
Sensing distance — Maximum	3 m (9.8 ft)
Light source — Type Wavelength	Visible red 660 nm (26.0 micro-inch)
Response time (sensor only)	1 ms
Light beam detection modes	Light operate/Dark operate (1)
Sensor output type	Relay output

(1) The sensor has light operate and dark operate outputs. The output relay coil is connected to the light operate output. The dark operate output is not used.

PROCEDURE OUTLINE

The Procedure is divided into the following sections:

- Set up and connections
- Equipment required
- Setup
- Characteristics
- Detection of various objects

PROCEDURE

Set up and connections

In the first part of the exercise, you will observe the ability of the Polarized Retroflective Photoelectric Switch to detect each surface of the Reflective Block.

In the second part, you will observe the ability of the Polarized Retroflective Photoelectric Switch to detect the presence of opaque, transparent, and small objects.

Equipment required

Refer to the Equipment Utilization Chart in Appendix A to obtain the list of equipment required to perform this exercise.

Setup

1. Set up the circuit shown in Figure 16.

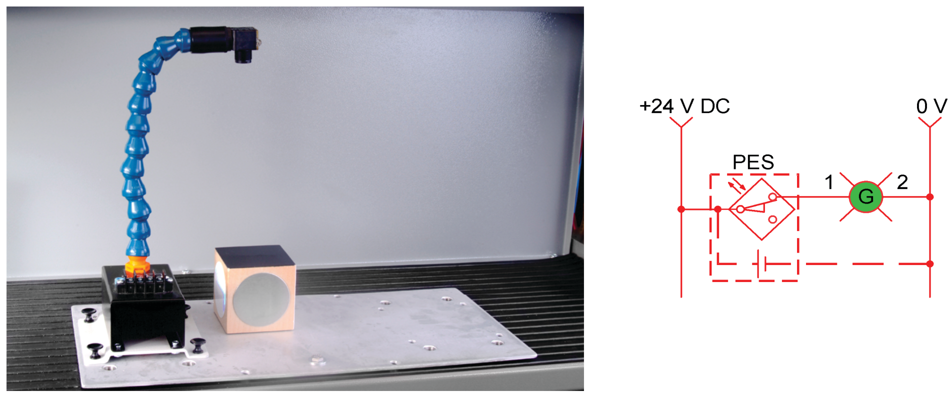

Figure 16. Circuit using the Polarized Retroflective Photoelectric Switch.

2. Perform the Energizing procedure.

3. Position the Reflective Block so the black plastic surface is parallel to the sensor sensing face at a distance of 200 mm (8 in), as shown in Figure 16.

Characteristics

4. Determine which surfaces are detected by the sensor. Note your observations in Table 5.

Table 5. Surfaces detected by the Polarized Retroreflective Photoelectric Switch.

Surface	Detected	Not detected
Black plastic surface		
White plastic surface		
Matte black metallic surface		
Shiny metallic surface		
Depolarizing retroreflective surface		

Surface	Detected	Not detected
Black plastic surface		✓
White plastic surface		✓
Matte black metallic surface		✓
Shiny metallic surface		✓
Depolarizing retroreflective surface	✓	

5. What can you conclude from your observations? Try with other distances between the sensor sensing face and the Reflective Block surfaces.

The Polarized Retroflective Photoelectric Switch triggers only with the depolarizing retroreflective surface. The other surfaces of the Reflective Block do not depolarize the light beam.

Detection of various objects

6. Position the Reflective Block so the depolarizing retroreflective surface is on top.

Yes. The Polarized Retroflective Photoelectric Switch detects the presence of fingers because they are large enough to break the entire light beam emitted by the photoelectric switch.

7. Is the green pilot light lit when an object is inserted between the sensing face and the depolarizing retroreflective surface? Explain why.

Yes. The object prevents the depolarizing retroreflective surface from returning depolarized light to the sensor. The sensor remains untriggered. The NC contact remains closed and the green pilot light is powered.

8. Pass a transparent object (plastic film) between the sensor and the Reflective Block. Does the photoelectric switch detect its presence? What does this mean?

No (if so, suggest that the student uses a more transparent object). The Polarized Retroflective Photoelectric Switch does not detect the presence of transparent objects. The target must be opaque to break the entire light beam to activate the photoelectric switch.

9. Pass a small object like an electrical lead between the sensor and the Reflective Block. Does the photoelectric switch detect its presence? What does this mean?

No. The Polarized Retroflective Photoelectric Switch does not detect the presence of an electrical lead. The target object must break the entire light beam to activate the photoelectric switch.

10. Without modifying the sensor position, take the Reflective Block in your hand and hold the depolarizing retroreflective surface in front of the sensing face with an angle of approximately 45°. Does the photoelectric switch detect its presence in this position? What does this indicate?

Yes. Unlike mirrors or other flat reflective surfaces, retroreflectors do not have to be perfectly aligned to return sufficient light to be detected by the sensor.

11. Turn the individual power switch of the AC Power Supply off, disconnect the circuit, and return the equipment to the storage location.

Conclusion

In this exercise, you were introduced to the Polarized Retroreflective Photoelectric Switch.

You observed how the Polarized Retroflective Photoelectric Switch detects the presence of various objects placed between the sensor and the depolarizing retroreflective surface of the Reflective Block. You saw that this sensor does not detect transparent objects. You also observed that it does not detect objects smaller than the light beam.

Review Questions

1. For which applications are the retroreflective photoelectric sensors designed?

Retroreflective photoelectric sensors are intended primarily for use in applications where an opaque target will completely block the light beam between the sensor and the depolarizing retroreflective surface. They can detect most objects including shiny objects.

2. Name two reasons why polarized retroreflective sensors offer a shorter detection distance than standard retroreflective sensors.

They use a less efficient visible red LED, and they have additional light losses caused by the polarizing filters.

3. What are the purposes of the filters in a polarized retroreflective sensor?

Filter and polarize the light

4. Name the type of retroreflector that provides the highest signal return.

Corner cube retroreflectors

5. Explain why retroreflective sensors are not well suited to detect small objects.

Because the light beam must be completely blocked for the sensor to be deactivated.

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