**Department of Electrical Engineering**

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| **Semester:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** | **Section: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** |

**EE-383**-**Instrumentation and Measurements**

**Experiment # 8**

**Fiber-Optic Photoelectric Switches**

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|  |  | **PLO4/**  **CLO3** | | **PLO4/ CLO4** | **PLO8/ CLO5** | **PLO9/ CLO6** |
| **Name** | **Reg. No** | **Viva / Quiz / Lab Performance** | **Analysis of data in Lab Report** | **Modern Tool Usage** | **Ethics and Safety** | **Individual and Teamwork** |
|  |  | **5 Marks** | **5 Marks** | **5 Marks** | **5 Marks** | **5 Marks** |
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**Lab no. 8**

**Fiber-Optic Photoelectric Switch**

# OBJECTIVE

In this lab, you will be introduced to Fiber-Optic photoelectric switches; and you will learn

• Uses of Fiber-optic photoelectric switches

• Advantages and Disadvantages of Fiber-optic switches

• Their operations using reflective block

# Introduction

# Fiber-optic sensors are designed for applications where the sensor cannot be placed at the actual sensing position. Fiber-optics is not a sensing technique but a method of transmitting light energy. Fiber-optic cables use transparent fibers of glass, or plastic, to conduct and guide light energy. They are used in photoelectric controls as light "pipes" as shown in Figure 8-1

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# Figure 8-1. Light energy is transmitted through fiber-optic cables.

# Light from the emitter is transmitted through a fiber-optic cable and emerges at the end of the cable. The reflected beam is then carried back to the receiver through a separate fiber optic cable combined either in the cable assembly (bifurcated) or within a separate cable assembly. Fiber-optic cables can be mounted in locations that would otherwise be inaccessible to photoelectric sensors.

# A typical optical fiber consists of an inner core and outer cladding. The inner core is composed of either glass or plastic. Figure 8-2 shows how an optical fiber transmits light. The inner core has a higher index of refraction than the cladding. Light entering the fiber is reflected by the boundary between the core and cladding. Light rays travel the entire length of the cable because of internal reflections.

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# Figure 8-2. Light propagation in an optical fiber

# Imperfections in optical fibers cause a loss of light intensity between one end of cable and the other end. Figure 8-3 shows how imperfections can affect light propagation. Impurities, bubbles and irregularities in fiber construction and density will deflect or absorb some light. Uneven fiber ends caused by improper cutting will increase light losses. Because of the losses inherent to fiber construction, fiber -optic cables are rated by their light power loss (in dB) over a length of 1.6 km (1 mi). An inexpensive cable loses as much as 500 dB/km (800 dB/mi), while a communication grade cable loses only 10 dB/km (16 dB/mi).

# 

# Figure 8-3. Optical fiber imperfections.

# Because of their small size, typically 0.05 mm (0.0019 in), optical fibers are grouped

# in bundles containing as many as several hundred individual fibers. Depending on the type of cable selected, fiber-optic cables can be used in the diffuse-reflective, through-beam, and retroreflective sensing modes.

# Since light, rather than current, travels through the fiber-optic cables, the signal is unaffected by electromagnetic interference and vibration. Due to their small sensing area, fiber-optic photoelectric sensors are well suited for small part detection and high temperature sensing. However, they can be easily obstructed by dirt or other opaque substances.

# The Fiber-Optic Photoelectric Switch of your training system comes either with LED indicators (see Figure 8-4a) or with a digital display (see Figure 8-4b). The two following subsections describe each model.

# As Figure 8-4a shows, this sensor has an output indicator (orange LED) that lights when the output is activated, a stability indicator (green LED), a TEACH indicator (red/green LED), a TEACH button, a TEACH/RUN selector, and an L.ON/D.ON (light operate/dark operate) selector.

# Some Important characteristics of fiber-optic switches are listed below:

# 

# Table 8-1a. Characteristics of the Fiber-Optic Photoelectric Switch with LED Indicators

# Fiber-Optic Photoelectric Switch with Digital Display

# As Figure 8-4b shows, this sensor has a digital display that indicates the incident light level or threshold value, as well as the contents of functions during operation. This sensor also has sensitivity adjustment buttons (UP and DOWN buttons), an L/D (light operate/dark operate) button, and a TEACH button. Finally, this sensor has an output indicator (orange) that lights when the output is activated, a TEACH indicator (orange), and an L/D (light operate/dark operate) button.

# Other characteristics of the Fiber-Optic Photoelectric Switch with digital display are

# listed in Table 8-1b.

# Table Description automatically generated

# Table 8-1b. Characteristics of the Fiber-Optic Photoelectric Switch with Digital Display

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# Figure 8-4a. Fiber-Optic Photoelectric Switch with LED Indicators.

# Diagram, schematic Description automatically generated

# Figure 8-4b. Fiber-Optic Photoelectric Switch with Digital Display

# Sensitivity Adjustments

# There are different procedures, called *teaching methods*, to adjust the sensitivity of a fiber-optic photoelectric switch:

# • *Maximum sensitivity setting* is used to detect the presence of objects that completely block the sensor light beam, and to detect the presence of objects with no background.

# • *With/without object teaching* is used for detection of a slight difference in reflection, color discrimination, background objects with unstable reflection, detection of object surface irregularities, and for elimination of background object influence. This method is used with both photoelectric switch models.

# • *No-object/Automatic teaching* is used when teaching is impossible by stopping the movement of sensing objects, for detection of bright/dark objects by teaching only with background objects, and for elimination of background object influence. Changes in the incident light level are detected within a certain time interval and the operating point is set at the midpoint between the maximum and minimum detected levels. This method,

# described in Appendix D, is used with both photoelectric switch models.

# Procedure Summary

# In the first part of the exercise, *Sensitivity Adjustment*, you will adjust the sensitivity of the Fiber-Optic Photoelectric Switch using the *With/without object teaching* method.

# In the second part of the exercise, *Characteristics*, you will observe the ability of the Fiber-Optic Photoelectric Switch to detect each surface of the Reflective Block. You will also experiment with the light operate/dark operate modes of the photoelectric switch.

# In the third part of the exercise, *Sensitivity Adjustment Using the Retroreflective Surface of the Reflective Block*, you will adjust the sensitivity of the Fiber-OpticPhotoelectric Switch using the *With/without object teaching* method using theretroreflective surface of the Reflective Block.

# EQUIPMENT REQUIRED

# Refer to the Equipment Utilization Chart, in Appendix A of this manual, to obtain the list of equipment required to perform this lab.

# PROCEDURE

# Sensitivity Adjustment

# *With/without object teaching*

# Connect the circuit as shown in figure below to DC supply and turn on DC power supply

# \*

# Figure 8-5. Circuit using the Fiber-Optic Photoelectric Switch.

1. Adjust the sensitivity of the Fiber-Optic Photoelectric Switch as follow:

• Put the Reflective Block on a white sheet of paper and position the block so the white plastic surface is on top.

• Aim the sensor sensing face toward the white plastic surface of the Reflective Block at a distance of 75 mm (3 in) as shown in Figure 8-5.

• Remove the protective cover of the photoelectric switch.

If you are using the photoelectric switch model with LED indicators, proceed with the steps in 3.a. If you are using the photoelectric switch model with digital display, proceed with the steps in 3.b.

**3.a.** **Photoelectric switch model with LED indicators**

• Set the photoelectric switch detection mode to Light operate by setting its L.ON/D.ON selector to the L.ON position.

• Set the TEACH/RUN selector to the TEACH position.

• The output indicator and the stability indicator should turn off.

• Depress the TEACH button once. The TEACH indicator (red) is lit and the built-in buzzer beeps once.

• Remove the Reflective Block and depress the TEACH button once. If the teaching is correct, the TEACH indicator (red) turns green and the built-in buzzer beeps once.

• If the teaching is not correct, the TEACH indicator (red) starts flashing and the built-in buzzer beeps 3 times. Change the position of the target and the detection distance that have been set and repeat from the beginning.

• Set the TEACH/RUN selector to RUN to complete the setting. The TEACH indicator (green) turns off. Replace the protective cover and go to step 3.

**3.b. Photoelectric switch model with digital display**

• Set the photoelectric switch detection mode to Light operate by pressing the L/D button so that the L (Light) indicator is lit.

• Depress the TEACH button once. This sets the first detection point (point with a workpiece).

• Remove the Reflective Block and depress the TEACH button once. This sets the second detection point (point without a workpiece).

• Verify that the teaching is correct: the output (orange) indicator turns on when the Reflective Block is moved past the sensor, while the output (orange) indicator turns off when the Reflective Block is removed.

• Replace the protective cover and go to step 3

**Characteristics**

Test the ability of the Fiber-Optic Photoelectric Switch to detect the various surfaces of the Reflective Block. Leave the photoelectric switch detection mode set to Light operate. Position the photoelectric switch and the Reflective Block as shown in Figure 8-5 and determine which surfaces are detected by the sensor. Note your observations in Table 8-2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Surfaces** | **LO (light Operate)** | | **DO (Dark Operate)** | |
| **Detected** | **Not Detected** | **Detected** | **Not Detected** |
| Black Plastic Surface |  |  |  |  |
| White Plastic Surface |  |  |  |  |
| Matte Black Metallic Surface |  |  |  |  |
| Shiny Metallic Surface |  |  |  |  |
| Retroreflective Surface |  |  |  |  |

***Table 8-2***

4. What can you conclude from your observations?

1. Set the Photoelectric switch to the Dark operate mode: if you are using the photoelectric switch model with LED indicators, set its L.ON/D.ON selector to the D.ON position; if you are using the photoelectric switch model with digital display, press the L/D button so that the D (Dark) indicator is lit.
2. Repeat your observations for each surface of the Reflective Block and determine which surfaces are detected by the sensor. Note your observations in Table 8-2.
3. Compare result obtained in light operate, dark operate mode. What can you conclude from these results?

**Sensitivity Adjustment Using the Retroreflective Surface of the Reflective Block**

1. Set the Photoelectric switch to the Light operate mode. Repeat the sensitivity adjustment procedure, With/without object teaching, indicated in step 2, using the retroreflective surface of the Reflective Block instead of the white plastic surface. Determine which surfaces are detected by the sensor. Note your observations in Table 8-3.

|  |  |  |
| --- | --- | --- |
| **Surfaces** | **Detected** | **Not Detected** |
| Black Plastic Surface |  |  |
| White Plastic Surface |  |  |
| Matte Black Metallic Surface |  |  |
| Shiny Metallic Surface |  |  |
| Retroreflective Surface |  |  |

***Table 8-3***

# Compare the results obtained for each sensitivity setting indicated in Table 8-2 and Table 8-3. Are the results similar? Explain why.

# Turn off DC power supply and remove all the leads.

# CONCLUSION

In this lab, you were introduced to fiber-optic photoelectric switches. You learned how and when they are used, their advantages and disadvantages. You adjusted the sensitivity of the Fiber-Optic Photoelectric Switch using the *With/without object teaching* method. You observed its ability to detect the presence of various reflective surfaces in the light operate and dark operate modes of operation. By adjusting the sensitivity using the retroreflective surface of the Reflective Block instead of the white plastic surface, you observed that this photoelectric switch is capable of discrimination.

# REVIEW QUESTIONS

1. For which applications are the fiber-optic photoelectric switches designed for?
2. Explain why fiber-optic photoelectric switches can be easily obstructed by dirt or other opaque substances
3. Which teaching method should be used to adjust the sensitivity of the Fiber-Optic Photoelectric Switch to detect the presence of objects with no background?.
4. Explain why the signal transmitted by fiber-optic cables is unaffected by electromagnetic interference and vibration.
5. What cause the losses in light intensity in fiber-optic cables?