Threaded Body

Smooth Body

Unless otherwise noted, the products contained in this section should not be used for functional safety applications. These products were not designed or tested to IEC 60947-5-3 or recommended for functional safety.

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Revision notes

Volume 8—Sensing Solutions, CA08100010E

Tab 4—Capacitive Proximity Sensors

Revision date	Section	Change page(s)	Description
09/08/2017	4.0	V8-T4-5	Content edit
09/08/2017	4.1	V8-T4-6	Content edit
09/08/2017	4.2	V8-T4-10	Content edit
09/08/2017	All	All	Revision date changed to September 2017

Powering Business Worldwide

Technical Reference

Capacitive Proximity Sensors

Capacitive proximity sensors are designed to detect both metallic and nonmetallic targets. They are ideally suited for liquid level control and for sensing powdered or granulated material.

Strengths and Weaknesses

Consider these strengths and weaknesses of the capacitive proximity sensor:

Capacitive Proximity Sensor Attributes

Attributes
Strengths
Can detect both metallic and nonmetallic objects at greater ranges than inductive sensors
High switching rate for rapid response applications (counting)
Can detect liquid targets through non-metallic barriers (glass, plastic)
Long operation life, solid-state output for "bounce free" signals
Weaknesses
Affected by varying temperature, humidity and moisture conditions
Not as accurate as inductive proximity sensors

Applications

Here are some examples showing how the detection power of capacitive proximity sensors is used:

- **Liquid level detection applications**, such as preventing overfilling or underfilling, are common in the packaging industry
- **Material level control applications**, such as assuring that a sleeve of labels on a labeling line is not empty
- **Counting applications**, such as tracking units passing a point on a conveyor
- **Induction molding process**, detection of level of plastic pellets in feed hopper

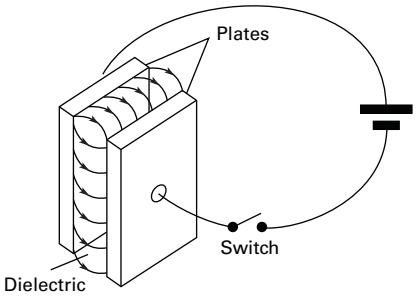
Operation of the Capacitive Proximity Sensor

A capacitor consists of two metal plates separated by a insulator (called a **dielectric**). **The operation of this type of sensor is based on dielectric capacitance**, which is the ability of a dielectric to store an electrical charge.

The distance between the plates determines the ability of the capacitor to store a charge.

Measuring the change in capacitance as an object enters the electrical field can be used as an ON/OFF switching function.

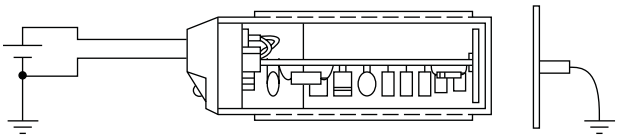
Capacitor Operation



When this principle is applied to the capacitive proximity sensor, **one capacitive plate is part of the switch, the enclosure (the sensor face) is the insulator. The target is the other "plate."** Ground is the common path.

Capacitive proximity sensors can detect any target that has a dielectric constant greater than air. Liquids have high dielectric constants. Metal also makes a good target.

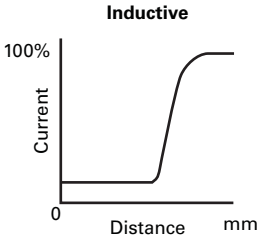
Capacitive Proximity Sensor Operation

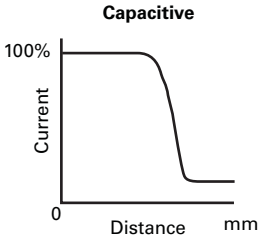


The capacitive proximity sensor has four basic elements: a sensor (which is a dielectric), an oscillator circuit, a detector circuit and an output circuit.

As an object approaches the sensor, the **dielectric constant of the capacitor changes.** The oscillator circuit's **oscillation begins when feedback capacitance is detected.** This is just the opposite in the inductive proximity sensor, where the oscillation is damped when the target is present.

Oscillator Damping





The **detector circuit** monitors the oscillator's output. When it detects sufficient change in the field, it switches on the output circuit.

The **output circuit** remains active until the target leaves the sensing field. The oscillator responds with a decrease in amplitude, and when it is no longer receiving sufficient capacitance feedback, the detector circuit switches OFF.

There is a built-in **difference between the operate and release amplitudes to provide hysteresis.**

Capacitive Proximity Sensor Influences

Many of the same factors that influence the sensing range of inductive proximity sensors, also influence the sensing range of capacitive proximity sensors.

Typically, capacitive sensors have a greater sensing range than inductive sensors.

Sensing distance for capacitive proximity sensors is dependent on plate diameter. With inductive proximity sensors, the size of the coil is the determining factor.

Typical Proximity Sensing Ranges

Sensor with a Tubular Diameter of:	Inductive Unshielded Sensor	Capacitive Unshielded Sensor
18 mm	8 mm	15 mm
30 mm	15 mm	25 mm
34 mm	—	35 mm

Sensitivity Adjustment

Most capacitive proximity sensors are equipped with sensitivity adjustment potentiometers. Because the sensor measures a dielectric gap, it is important to be able to compensate for target and application conditions and adjust the sensing range.

Target Material and Size

A capacitive sensor should not be hand-held during set up. Because your hand has a dielectric constant greater than air, the sensor may detect your hand rather than the intended target.

Capacitive sensors can detect both ferrous and non-ferrous materials equally well. **There is no derating factor to be applied when sensing metal targets.** But, other materials do affect the sensing range.

Because they can be used to detect liquid through a nonmetallic material such as glass or plastic, you need to ensure that the sensor detects just the liquid, not the container. **The transparency of the container has no effect on the sensing.**

Environment

Many of the same factors that affect inductive proximity sensors, also affect capacitive sensors, only more so.

- Embeddable mounting—capacitive sensors are generally treated as **non-shielded devices**, and therefore, **are not embeddable**
- Flying chips—they are **more sensitive to both metallic and nonmetallic chips** and residue
- Adjacent sensors—**more space between devices is required** due to the greater, non-shielded sensing range
- Target background—because of both the greater sensing range, and its ability to sense metallic and nonmetallic materials, **greater care in applying these sensors is needed when background conditions are present**
- Ambient atmosphere—the **amount of humidity in the air may cause a capacitive sensor to operate** even when no target is present
- Welding magnetic fields—capacitive sensors **are generally not applied in a welding environment**
- Radio Frequency Interference (RFI)—in the same way that inductive proximity sensors are affected, **RFI interferes with capacitive sensor circuitry**
- Showering arc (EFT)—**induced electrical noise affects these sensors** in the same way it does for an inductive sensor

Product Selection Guide

Threaded Body Capacitive Proximity Sensors

Page V8-T4-6

Overview

These self-contained devices will detect both metallic and nonmetallic targets. A full threaded housing provides ease of mounting.

Applications

Liquid level control

Nonmetallic targets

Product Features

18 and 30 mm diameters with threaded housing

Shielded and unshielded sensing

Two-wire AC—20 to 250V
Three-wire DC—10 to 30V, NPN and PNP

2-meter PVC cable or 4-pin micro-connector

Short circuit and reverse polarity protected (DC models)

LED indicator

Sensitivity adjustment

Technical Data and Specifications

Contact ratings—
AC: 300 mA
DC: 300 mA

Enclosure ratings—
NEMA® 1, 2, 3, 3S, 4, 12, 13
IP65

Construction—
POM
Nuts, nylon 66

Approvals

CE
RoHS Compliant

Smooth Body Capacitive Proximity Sensors

Page V8-T4-10

Overview

Smooth body capacitive models feature longer ranges than our threaded body models and include a convenient mounting bracket.

Applications

Liquid level control

Nonmetallic targets

Product Features

34 mm diameter

Shielded and unshielded sensing

Two-wire AC—20 to 250V
Three-wire DC—10 to 30V, NPN and PNP

2-meter PVC cable or 4-pin micro-connector

Short circuit and reverse polarity protected (DC models)

LED indicator

Sensitivity adjustment

Includes mounting bracket

Technical Data and Specifications

Contact ratings—
AC: 300 mA
DC: 300 mA

Enclosure ratings—
NEMA 1, 2, 3, 3S, 4, 12, 13
IP65

Construction—
POM
Nuts, nylon 66

Approvals

CE
RoHS Compliant

Threaded Body Sensors

Contents

Threaded Body Sensors

Product Description

Type E53 Capacitive Proximity Sensors from Eaton's electrical sector are self-contained devices designed to detect both metallic and nonmetallic targets. They are ideally suited for liquid level control and for sensing powdered or granulated material. For best operation, they should be used in an environment having relatively constant temperature and humidity.

Features

- Detect liquids, powders and other materials that are difficult or impossible to detect with other sensor types
- Plastic body is corrosion resistant
- Sensitivity adjustment
- Output indicator LED

Standards and Certifications

- CE
- RoHS Compliant

CE RoHS COMPLIANT

⚠ DANGER

THIS SENSOR IS NOT A SAFETY DEVICE AND IS NOT INTENDED TO BE USED AS A SAFETY DEVICE. This sensor is designed only to detect and read certain data in an electronic manner and perform no use apart from that, specifically no safety-related use. This sensor product does not include self-checking redundant circuitry, and the failure of this sensor product could cause either an energized or de-energized output condition, which could result in death, serious bodily injury, or property damage.

For the most current information on this product, visit our Web site: www.eaton.com

For Customer Service in the U.S. call 1-877-ETN CARE (386-2273), in Canada call 1-800-268-3578.
For Application Assistance in the U.S. and Canada call 1-800-426-9184.

Product Selection

E53 Threaded Body Sensors

Two-Wire Sensors

Operating Voltage	Sensing Range (Sn)	Shielding	Connection Type	NO Output Catalog Number	NC Output Catalog Number
18 mm Diameter					
					
20–250 Vac	0.31 in (8 mm)	Shielded	2-meter cable	**E53KAL18A2**	**E53KBL18A2**
			3-pin micro AC connector	**E53KAL18A2SA** (A)	**E53KBL18A2SA** (A)
	0.59 in (15 mm)	Unshielded	2-meter cable	**E53KAL18A2E**	**E53KBL18A2E**
			3-pin micro AC connector	**E53KAL18A2EA** (A)	**E53KBL18A2EA** (A)
30 mm Diameter					
					
20–250 Vac	0.79 in (20 mm)	Shielded	2-meter cable	**E53KAL30A2**	**E53KBL30A2**
			3-pin micro AC connector	**E53KAL30A2SA** (A)	**E53KBL30A2SA** (A)
	0.98 in (25 mm)	Unshielded	2-meter cable	**E53KAL30A2E**	**E53KBL30A2E**
			3-pin micro AC connector	**E53KAL30A2EA** (A)	**E53KBL30A2EA** (A)

Three-Wire Sensors

Operating Voltage	Sensing Range (Sn)	Shielding	Connection Type	NO Output Catalog Number	NC Output Catalog Number
18 mm Diameter					
					
10–30 Vdc	0.31 in (8 mm)	Shielded (NPN)	2-meter cable	**E53KAL18T110**	**E53KBL18T110**
			4-pin micro DC connector	**E53KAL18T110SD** (B)	**E53KBL18T110SD** (B)
		Shielded (PNP)	2-meter cable	**E53KAL18T111**	**E53KBL18T111**
			4-pin micro DC connector	**E53KAL18T111SD** (B)	**E53KBL18T111SD** (B)
	0.59 in (15 mm)	Unshielded (NPN)	2-meter cable	**E53KAL18T110E**	**E53KBL18T110E**
			4-pin micro DC connector	**E53KAL18T110ED** (B)	**E53KBL18T110ED** (B)
		Unshielded (PNP)	2-meter cable	**E53KAL18T111E**	**E53KBL18T111E**
			4-pin micro DC connector	**E53KAL18T111ED** (B)	**E53KBL18T111ED** (B)
30 mm Diameter					
					
10–30 Vdc	0.79 in (20 mm)	Shielded (NPN)	2-meter cable	**E53KAL30T110**	**E53KBL30T110**
			4-pin micro DC connector	**E53KAL30T110SD** (B)	**E53KBL30T110SD** (B)
		Shielded (PNP)	2-meter cable	**E53KAL30T111**	**E53KBL30T111**
			4-pin micro DC connector	**E53KAL30T111SD** (B)	**E53KBL30T111SD** (B)
	0.98 in (30 mm)	Unshielded (NPN)	2-meter cable	**E53KAL30T110E**	**E53KBL30T110E**
			4-pin micro DC connector	**E53KAL30T110ED** (B)	**E53KBL30T110ED** (B)
		Unshielded (PNP)	2-meter cable	**E53KAL30T111E**	**E53KBL30T111E**
			4-pin micro DC connector	**E53KAL30T111ED** (B)	**E53KBL30T111ED** (B)

Note

(A)(B) See listing of compatible connector cables on **Page V8-T4-8**.

Compatible Connector Cables

Micro-Style Straight Female

Standard Cables ①②

Current Rating at 600V	Voltage Style	Number of Pins	Gauge	Length	Pin Configuration/Wire Colors (Face View Female Shown)	Catalog Number
Micro-Style, Straight Female						
13A	Vac	3-pin, 3-wire	22 AWG	6 ft (2m)	 1-Green 2-Red/Black 3-Red/White	**CSAS3F3CY2202**
10A	Vdc	4-pin, 3-wire	22 AWG	6 ft (2m)	 1-Brown 2-No Wire 3-Blue 4-Black	**CSDS4A3CY2202**
		4-pin, 4-wire	22 AWG	6 ft (2m)	 1-Brown 2-White 3-Blue 4-Black	**CSDS4A4CY2202**

Technical Data and Specifications

Threaded Body Sensors

Description	AC Models	DC Models
AC residual	2.5 mA maximum	—
Maximum load current	300 mA	300 mA
Switching rate	15 operations per second	250 operations per second
Circuit protection	—	Short circuit and reverse polarity
Output indicator LED	Lights when output is ON	Lights when output is ON
Ambient temperature range	–13° to 158°F (–25° to 70°C)	–13° to 158°F (–25° to 70°C)
Enclosure ratings	NEMA 1, 2, 3, 3S, 4, 12, 13 (IEC IP65)	NEMA 1, 2, 3, 3S, 4, 12, 13 (IEC IP65)
Sensitivity adjustment	Included	Included
Housing material	Polyoxymethylene (POM) plastic mounting nuts molded of nylon 66 (PA66)	Polyoxymethylene (POM) Plastic mounting nuts molded of nylon 66 (PA66)

Notes

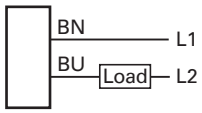
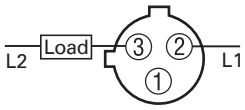
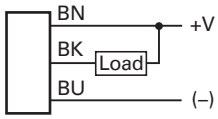
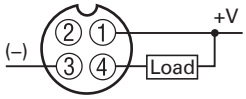
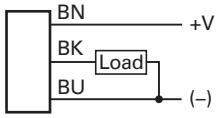
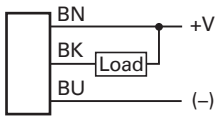
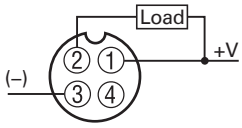
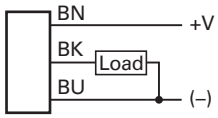
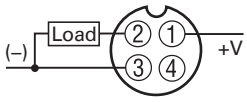
① For a full selection of connector cables, see **Tab 10**, **section 10.1**.

② Use four-wire connector cable on NC output versions.

Wiring Diagrams

Pin numbers are for reference, rely on pin location when wiring.

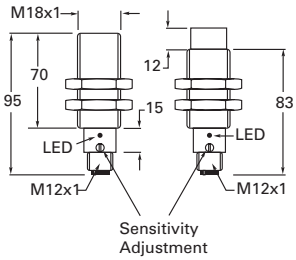
Threaded Body Sensors

Operating Voltage	Output	Cable Models	Micro-Connector Models (Face View Male Shown)
Two-Wire Sensors			
20–250 Vac	NO and NC		
Three-Wire Sensors			
10–30 Vdc	NO (NPN)		
	NO (PNP)		—
	NC (NPN)		
	NC (PNP)		

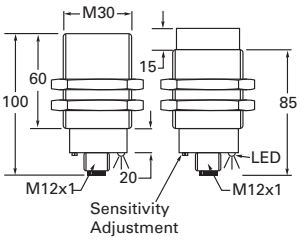
Dimensions

Approximate Dimensions in mm

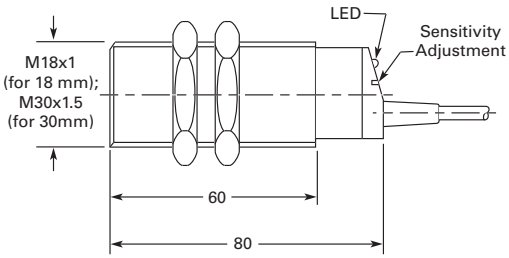
18 mm Diameter Threaded Body Sensor



30 mm Diameter Threaded Body Sensor



18 and 30 mm Cable



Smooth Body Sensors

Contents

Smooth Body Sensors

Product Description

Type E53 Capacitive Proximity Sensors from Eaton's electrical sector are self-contained devices designed to detect both metallic and nonmetallic targets. They are ideally suited for liquid level control and for sensing powdered or granulated material. For best operation, they should be used in an environment having relatively constant temperature and humidity.

Features

- Detect liquids, powders and other materials that are difficult or impossible to detect with other sensor types
- Plastic body is corrosion resistant
- Sensitivity adjustment

Standards and Certifications

- CE
- RoHS Compliant

CE RoHS COMPLIANT

⚠ DANGER

THIS SENSOR IS NOT A SAFETY DEVICE AND IS NOT INTENDED TO BE USED AS A SAFETY DEVICE. This sensor is designed only to detect and read certain data in an electronic manner and perform no use apart from that, specifically no safety-related use. This sensor product does not include self-checking redundant circuitry, and the failure of this sensor product could cause either an energized or de-energized output condition, which could result in death, serious bodily injury, or property damage.

For the most current information on this product, visit our Web site: www.eaton.com

For Customer Service in the U.S. call 1-877-ETN CARE (386-2273), in Canada call 1-800-268-3578.
For Application Assistance in the U.S. and Canada call 1-800-426-9184.

Product Selection

E53 Smooth Body Sensors

Two-Wire Sensors

34 mm Diameter

Operating Voltage	Sensing Range (Sn)	Shielding	Connection Type	NO Output Catalog Number	NC Output Catalog Number
34 mm Diameter ①					
20–250 Vac	1.38 in (35 mm)	Unshielded	2-meter cable	**E53KAL34A2E**	**E53KBL34A2E**
			3-pin micro AC connector	**E53KAL34A2EA** ㉂	**E53KBL34A2EA** ㉂

Three-Wire Sensors

34 mm Diameter

Operating Voltage	Sensing Range (Sn)	Shielding	Connection Type	NO Output Catalog Number	NC Output Catalog Number
34 mm Diameter ①					
10–30 Vdc	0.98in (25 mm)	Shielded (NPN)	2-meter cable	**E53KAL34T110**	**E53KBL34T110**
			4-pin micro DC connector	**E53KAL34T110SD** ㉄	**E53KBL34T110SD** ㉄
		Shielded (PNP)	2-meter cable	**E53KAL34T111**	**E53KBL34T111**
			4-pin micro DC connector	**E53KAL34T111SD** ㉄	**E53KBL34T111SD** ㉄
	1.38 in (35 mm)	Unshielded (NPN)	2-meter cable	**E53KAL34T110E**	**E53KBL34T110E**
			4-pin micro DC connector	**E53KAL34T110ED** ㉄	**E53KBL34T110ED** ㉄
		Unshielded (PNP)	2-meter cable	**E53KAL34T111E**	**E53KBL34T111E**
			4-pin micro DC connector	**E53KAL34T111ED** ㉄	**E53KBL34T111ED** ㉄

Compatible Connector Cables

Standard Cables ②

Micro-Style Straight Female

Current Rating at 600V	Voltage Style	Number of Pins	Gauge	Length	Pin Configuration/Wire Colors (Face View Female Shown)	Catalog Number
Micro-Style, Straight Female						
13A	AC	3-pin, 4-wire	22 AWG	6 ft (2m)	 1-Green 2-Red/Black 3-Red/White	**CSAS3F3CY2202**
10A	DC	4-pin, 3-wire	22 AWG	6 ft (2m)	 1-Brown 2-No Wire 3-Blue 4-Black	**CSDS4A3CY2202**
		4-pin, 4-wire	22 AWG	6 ft (2m)	 1-Brown 2-White 3-Blue 4-Black	**CSDS4A4CY2202**

Notes

㉂㉄ See listing of compatible connector cables above.

① Includes mounting bracket.

② For a full selection of connector cables, see **Tab 10**, **section 10.1**.

Technical Data and Specifications

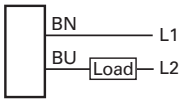
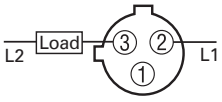
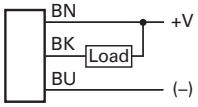
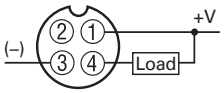
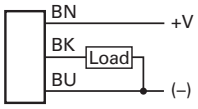
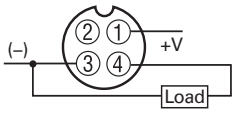
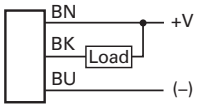
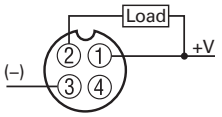
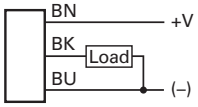
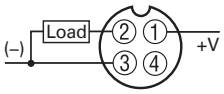
Smooth Body Sensors

Description	AC Models	DC Models
Residual current	2.5 mA maximum	—
Maximum load current	300 mA	300 mA
Switching rate	15 operations per second	250 operations per second
Circuit protection	—	Short circuit and reverse polarity
Output indicator LED	Lights when output is ON	Lights when output is ON
Ambient temperature range	–13° to 158°F (–25° to 70°C)	–13° to 158°F (–25° to 70°C)
Enclosure ratings	NEMA 1, 2, 3, 3S, 4, 12, 13 (IEC IP65)	NEMA 1, 2, 3, 3S, 4, 12, 13 (IEC IP65)
Sensitivity adjustment	Included	Included

Wiring Diagrams

Pin numbers are for reference, rely on pin location when wiring.

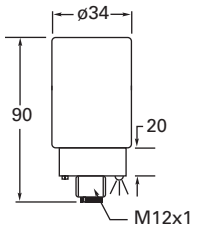
Smooth Body Sensors

Operating Voltage	Output	Cable Models	Micro-Connector Models (Face View Male Shown)
Two-Wire Sensors			
20–250 Vac	NO and NC		
Three-Wire Sensors			
10–30 Vdc	NO (NPN)		
	NO (PNP)		
	NC (NPN)		
	NC (PNP)		

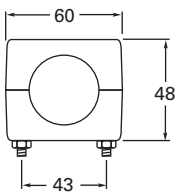
Dimensions

Approximate Dimensions in mm

34 mm Diameter Smooth Body Sensor



Mounting Bracket (Included with Sensor)



34 mm Cable