Capacitive proximity sensors

Presentation

Advantages

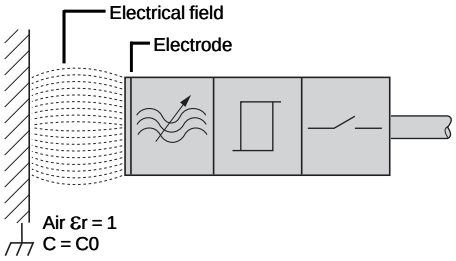
■ No physical contact with the object to be detected.

■ High operating rates.

■ Solid-state product, no moving parts (service life not related to number of operating cycles).

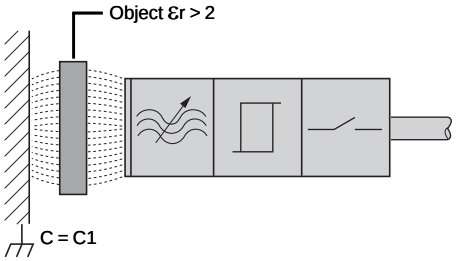
■ Detection of any object irrespective of material or conductivity, for example: metals, minerals, wood, plastic, glass, cardboard, leather, ceramic, fluids, etc.

Operating principle



An electrical field is created between 2 electrodes on the front face of the sensor.
These electrodes constitute a capacitor with a capacitance of:
C = ε0 * εr * A/d where:
ε0 = 8.854187 pF/m (permittivity in free space)
εr: relative permittivity of the material present between the 2 electrodes
A: dimensions of electrodes
d: distance between electrodes

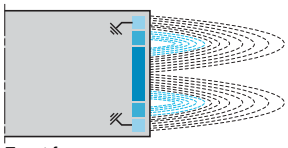
All materials where εr > 2 will be detected



When an object of any material (εr > 2) passes the sensing face of the sensor, it modifies the coupling capacitance (C1).
This variation in capacitance (C1 > C0) instigates the starting of the oscillator which, in turn, causes the output driver to operate and provides an output signal.

Types of sensor

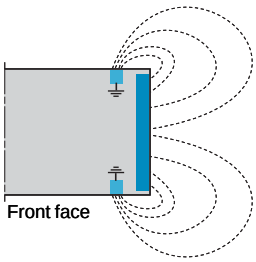
Sensors flush mountable in support


Front face

The special feature of these versions is the shape of the electrical field which is rectilinear and confined within the dimensions of the product.
Cylindrical and block type models used for the detection of insulated materials (wood, plastic, cardboard, glass…) or liquid through an insulated partition (glass, plastic…) with a maximum thickness of 4 mm:

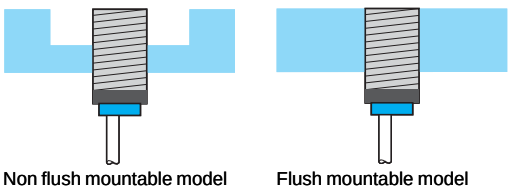
These products are recommended for:
- comparatively short detection distances,
- applications requiring flush mounting of the sensor,
- detection through a partition (example: detection of glass through cardboard),
- side by side mounting.

Sensors non flush mountable in support


Front face

Cylindrical models (plastic case)
The spherical shape of the electrical field enables detection of any type of material whether it be solid, liquid, granular… (metal, water, oil, plastic pellets, powder, flour…). Detection can be achieved through a partition or by direct contact (immersion) of the active surface with the object to be detected.
Distances to be adhered to around the sensing face. (See characteristics, pages 31157/5 and 31157/7).

Mounting precautions

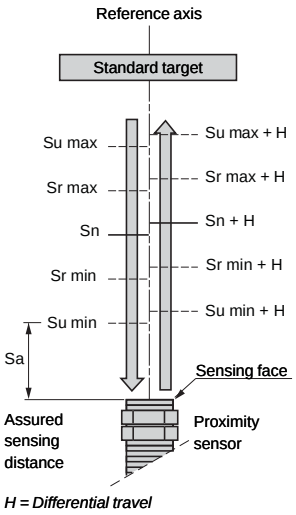

Non flush mountable model

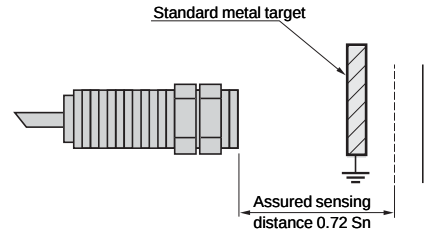
Flush mountable model

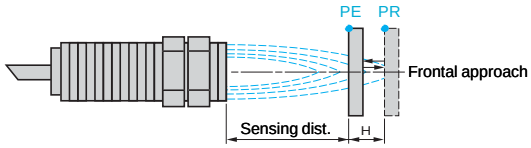
Non flush mountable models cannot be flush mounted in their support.
The non flush mountable models require a free zone around the active head. (See page 31158/5).

Capacitive proximity sensors

Terminology







PE = pick-up-point, the target is detected
PR = drop-out point, the target is no longer detected

Definitions

In order to ensure that customers can make reliable product comparisons and selection, the standard IEC 60947-5-2 defines various sensing distances, such as:

Nominal sensing distance (Sn)
The rated operating distance for which the sensor is designed. It does not take into account any variations (manufacturing tolerances, temperature, voltage).

Effective sensing distance (Sr)
The effective sensing distance is measured at the rated voltage (Un) and the rated ambient temperature (23 °C ±5 °C)
It must be between 90% and 110% of Sn.

Usable sensing distance (Su)
The usable sensing distance is measured at the limits of the permissible variations in the ambient temperature and at a supply voltage equal to 85% and 110% of the rated voltage.
It must be between 80% and 120% of Sr.

Assured sensing distance (Sa)
This is the operating zone of the sensor.
The assured sensing distance is between 0 an 72% of Sn.

Standard metal target

The standard IEC 60947-5-2 defines the standard metal target as a square mild steel (Fe 360) plate, 1 mm thick.
The side dimension of the plate is either equal to the diameter of the circle engraved on the sensing face of the sensor or 3 times the nominal sensing distance (Sn).

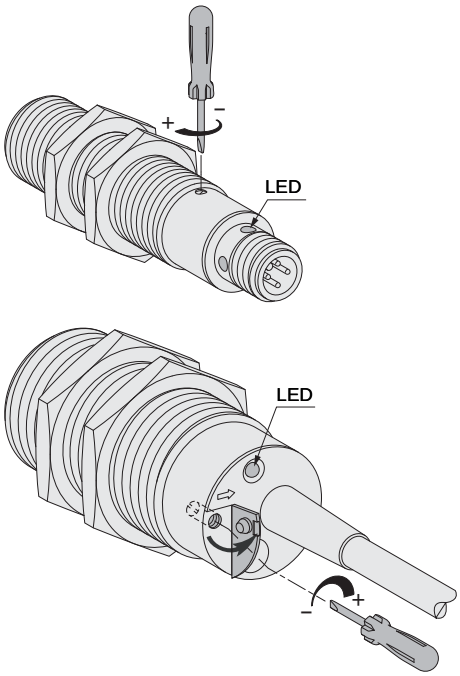
Repeat accuracy

The repeat accuracy (R) is the repeatability of the sensing distance between successive operations. Readings are taken over a period of time whilst the sensor is subjected to voltage and temperature variations: 8 hours, 10 to 30 °C, Un ± 5%.
It is expressed as a percentage of the effective sensing distance Sr.

Differential travel

The differential travel (H) or hysteresis, is the distance between the operating point, as the standard metal target moves towards the sensor, and the release point, as it moves away.
This hysteresis is essential for the stable operation of the sensor.

Terminology (continued)



Sensitivity of the sensor

All our sensors incorporate a sensitivity adjustment potentiometer. This enables the sensitivity of the sensor to be adjusted to suit the type of object to be detected.

Depending on the sensor version, the sensitivity adjustment potentiometer is either mounted on the side or the rear.

The sensors are factory preset for nominal sensitivity.

Depending on the application, adjustment of the sensitivity could be necessary as follows:
- increasing the sensitivity for objects which have a weak influence (low εr): paper, cardboard, glass, plastic,
- decreasing the sensitivity for objects which have a strong influence (strong εr): metals, liquids.

However, in the event of severe variations in the ambient conditions, do not increase the sensitivity of the sensor such that it is set to its maximum operating limits.

An increase in sensitivity causes an increase in the switching hysteresis.

Terminology (continued)

Operating distances

The operating distance of the sensor is related to the dielectric constant (εr) of the object material
The higher the value of εr the easier the detection of the object will be.

The assured sensing distance depends on the object material: S = Sn x Fc
S = assured sensing distance,
Sn = nominal sensing distance of the sensor,
Fc = correction factor related to the object material.

Example: sensor XT1 M30PA372 used to detect a rubber object.
Sn = 10 mm, Fc = 0.3.
Assured sensing distance S = 10 x 0.3 = 3 mm.

The list below indicates the dielectric constant values of the most common object materials, together with their correction factors (Fc) for the nominal sensing distance of the sensor.

Material	εr	Fc
Acetone	20	0.8
Air	1	0
Alcohol	24	0.85
Ammonia	15…25	0.75…0.85
Cement (powder)	4	0.35
Cereals	3…5	0.3…0.4
Epoxy resin	4	0.36
Ethylene glycol	38	0.95
Flour	2.5…3	0.2…0.3
Glass	3...10	0.3...0.7
Marble	6...7	0.5...0.6
Mica	6…7	0.5…0.6
Nylon	4…5	0.3…0.4
Oil	2.2	0.2
Paper	2…4	0.2…0.3
Paraffin	2…2.5	0.2

Material	εr	Fc
Petrol	2.2	0.2
Plexiglass	3.2	0.3
Polyester resin	2.8…8	0.2…0.6
Polystyrene	3	0.3
Porcelain	5…7	0.4…0.5
Powdered milk	3.5...4	0.3...0.4
Rubber	2.5…3	0.3
Salt	6	0.5
Sand	3...5	0.3...0.4
Sugar	3	0.3
Teflon	2	0.2
Vaseline	2...3	0.2...0.3
Water	80	1
Wood (damp)	10…30	0.7…0.9
Wood (dry)	2…7	0.2…0.6

Environment

■ **Electromagnetic interference**

The sensors undergo electromagnetic interference testing in accordance with the recommendations of standard IEC 60947-5-2 (electrostatic discharges, radiated electromagnetic fields, fast transients, impulse voltages).

■ **Thermal influences**

It is advisable to remain within the values stated on the characteristic pages so as to avoid sensing distance drift and possible incorrect operation of the sensor.

■ **Chemical agents**

To ensure a long service life, it is essential that any chemicals coming into contact with the case of the sensor are non corrosive.

■ **Earthing**

Earthing of an object that has high conductivity increases the sensing distance.

Additional information relating to outputs

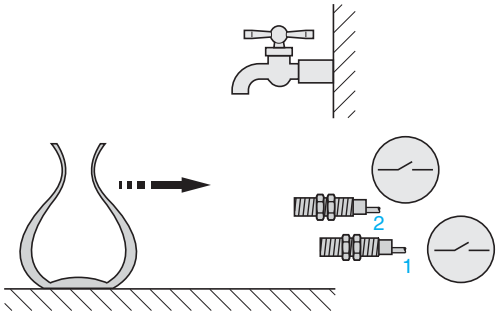
Refer to corresponding pages relating to inductive proximity sensors for:

■ Terminology.

■ Details and specific aspects of 2-wire and 3-wire type connection.

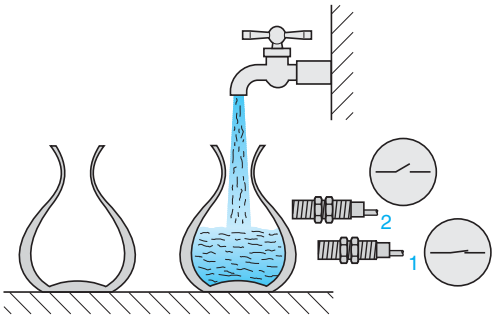
■ Connecting several sensors in series or parallel.

Application example: “Bottle filling”



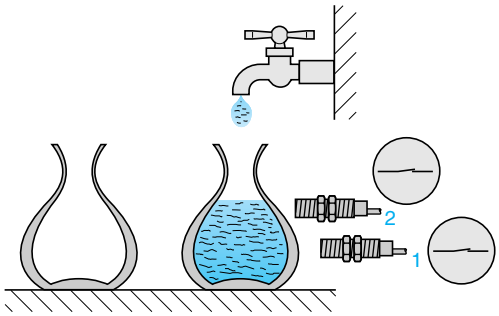
■ **Bottle arrival**

Bottles are fed on a conveyor for filling.
The sensors 1 (for insulated object materials) and 2 (for conductive object materials) are in an unoperated state.



■ **Bottle filling**

As soon as the bottle enters the detection zone of sensor 1, the filling operation commences.
Sensor 2 remains in the unoperated state.



■ **Filling complete**

Sensor 2 detects that the required level has been reached and stops further filling.

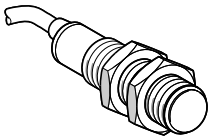
Reminder: the wall of the container must be non metallic and its thickness ≤ 4 mm.

Capacitive proximity sensors

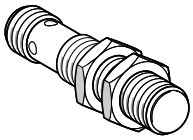
For detection of insulated materials

Cylindrical, flush mountable. Metal case

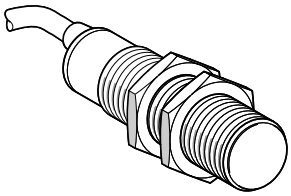
d.c. or a.c. supply



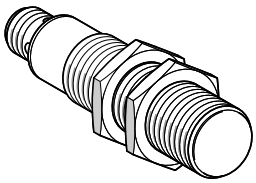
XT1 12S1●●L2



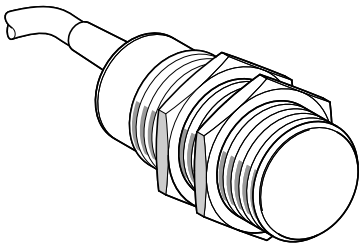
XT1 12S1PCM12



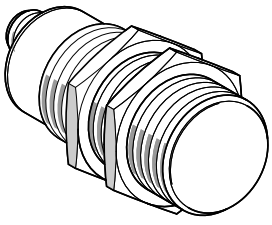
XT1 18B1●●L2



XT1 18B1PCM12



XT1 30B1●●L2



XT1 30B1PCM12

Ø 12, threaded M12 x 1, stainless steel

Sensing distance (Sn) mm	Function	Output	Connection	Reference	Weight kg
Four-wire ⎓ 24 V					
2	NO/NC	PNP	Pre-cabled (L = 2 m)	**XT1 12S1PCL2**	0.070
			M12 connector	**XT1 12S1PCM12**	0.040
Three-wire ⎓ 24 V					
2	NO	PNP	Pre-cabled (L = 2 m)	**XT1 12S1PAL2**	0.070
		NPN	Pre-cabled (L = 2 m)	**XT1 12S1NAL2**	0.040

Ø 18, threaded M18 x 1, nickel plated brass

Sensing distance (Sn) mm	Function	Output	Connection	Reference	Weight kg
Four-wire ⎓ 24 V					
5	NO/NC	PNP	Pre-cabled (L = 2 m)	**XT1 18B1PCL2**	0.150
			M12 connector	**XT1 18B1PCM12**	0.075
Three-wire ⎓ 24 V					
5	NO	PNP	Pre-cabled (L = 2 m)	**XT1 18B1PAL2**	0.150
		NPN	Pre-cabled (L = 2 m)	**XT1 18B1NAL2**	0.150
Two-wire ∿ 24-240 V					
5	NO	–	Pre-cabled (L = 2 m)	**XT1 18B1FAL2**	0.150
	NC	–	Pre-cabled (L = 2 m)	**XT1 18B1FBL2**	0.150

Ø 30, threaded M30 x 1.5, nickel plated brass

Sensing distance (Sn) mm	Function	Output	Connection	Reference	Weight kg
Four-wire ⎓ 24 V					
10	NO/NC	PNP	Pre-cabled (L = 2 m)	**XT1 30B1PCL2**	0.270
			M12 connector	**XT1 30B1PCM12**	0.150
Three-wire ⎓ 24 V					
10	NO	PNP	Pre-cabled (L = 2 m)	**XT1 30B1PAL2**	0.270
		NPN	Pre-cabled (L = 2 m)	**XT1 30B1NAL2**	0.270
Two-wire ∿ 24-240 V					
10	NO	–	Pre-cabled (L = 2 m)	**XT1 30B1FAL2**	0.270
	NC	–	Pre-cabled (L = 2 m)	**XT1 30B1FBL2**	0.270

Capacitive proximity sensors
For detection of insulated materials
Cylindrical, flush mountable. Metal case
d.c. or a.c. supply

Characteristics

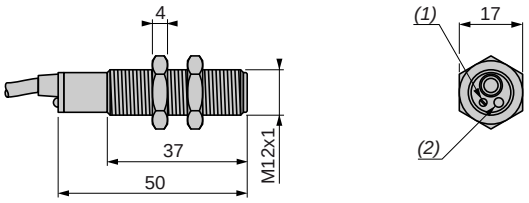
Sensor type			M12 XT1 12●	M18 XT1 18●		M30 XT1 30●	
			3-wire ⎓ 4-wire ⎓	3-wire ⎓ 4-wire ⎓	2-wire ∿	3-wire ⎓ 4-wire ⎓	2-wire ∿
Product certifications			CE, IEC 60947-5-2				
Connection	Pre-cabled, length **2 m**		●	●	●	●	●
	Connector, **M12**		●	●	–	●	–
Main characteristics							
Nominal sensing distance Sn	Conforming to IEC 60947-5-2	**mm**	2	5		10	
Assured sensing distance Sa	Conforming to IEC 60947-5-2	**mm**	0…1.44	0…3.60	0…3.60	0…7.2	0…7.2
Adjustment zone		**mm**	0.5…5	1…8	1…5	2…20	2…15
Repeat accuracy			< 0.1 Sr				
Differential travel			< 0.2 Sr				
Output characteristics							
Output state indication			Yellow LED				
Switching capacity		**mA**	200	200	330	200	330
Maximum switching frequency		**Hz**	300	200	25	150	25
Protection against short-circuit			Yes	Yes	–	Yes	–
Voltage drop, closed state		**V**	⩽ 2	⩽ 2	⩽ 6	⩽ 2	⩽ 6
Residual current, open state		**mA**	< 0.1	< 0.1	< 5	< 0.1	< 5
Delays	First-up	**ms**	⩽ 30	⩽ 30	⩽ 100	⩽ 30	⩽ 100
	Response	**ms**	⩽ 5	⩽ 5	⩽ 20	⩽ 5	⩽ 20
	Recovery	**ms**	⩽ 5	⩽ 5	⩽ 20	⩽ 5	⩽ 20
Supply							
Rated supply voltage		**V**	⎓ 24	⎓ 24	∿ 24 - 240 50/60 Hz	⎓ 24	∿ 24 - 240 50/60 Hz
Voltage limits (including ripple)		**V**	⎓ 12 - 30	⎓ 12 - 30	∿ 20 - 264 50/60 Hz	⎓ 12 - 30	∿ 20 - 264 50/60 Hz
Current consumption, no-load		**mA**	< 15	< 15	< 3	< 15	< 3
Protection against reverse polarity			Yes	Yes	–	Yes	–
Environment							
Materials	Case		Stainless steel 303	Nickel plated brass			
	Cable		PVC				
	Number and c.s.a. of wires		3 x 0.14 mm² or 4 x 0.14 mm²	3 x 0.34 mm² or 4 x 0.34 mm²	3 x 0.34 mm²	3 x 0.75 mm² or 4 x 0.5 mm²	3 x 0.75 mm²
Degree of protection	Conforming to IEC 60529 & IEC 60947-5-2		IP 67 *(1)* IP65 for **XT1 12S1PCM12** and **XT1 18B1PCM12** sensors				
Storage and operating temperature		**°C**	- 25…+ 70				
Vibration resistance	Conforming to IEC 60068-2-6		10 gn, ± 1 mm (f = 10…55 Hz)				
Shock resistance	Conforming to IEC 60068-2-27		30 gn, 11 ms				
Resistance to electromagnetic interference							
Electrostatic discharges	Conforming to IEC 61000-4-2	**kV**	8 (air) / 4 (contact)				
Radiated electromagnetic fields	Conforming to IEC 61000-4-3	**V/m**	3				
Fast transients	Conforming to IEC 61000-4-4	**kV**	2				

(1) With adjustment potentiometer sealing screw

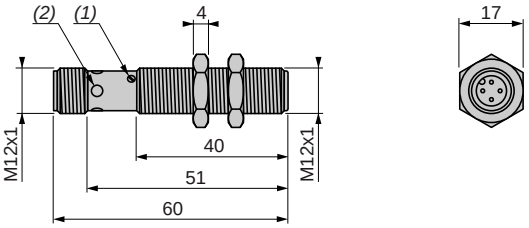
Capacitive proximity sensors
For detection of insulated materials
Cylindrical, flush mountable. Metal case
d.c. or a.c. supply

Dimensions

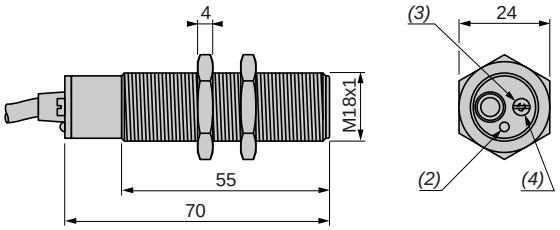
M12, pre-cabled
XT1 12S1●●L2



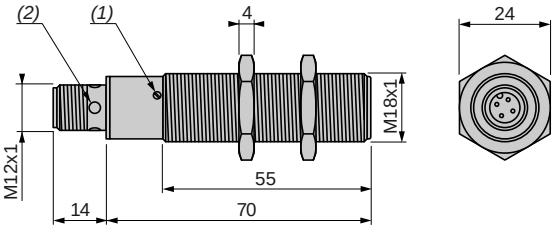
M12, M12 connector
XT1 12S1PCM12



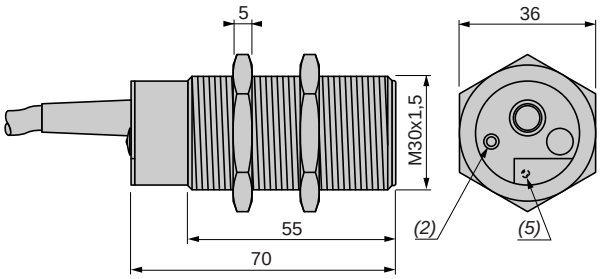
M18, pre-cabled
XT1 18B1●●L2



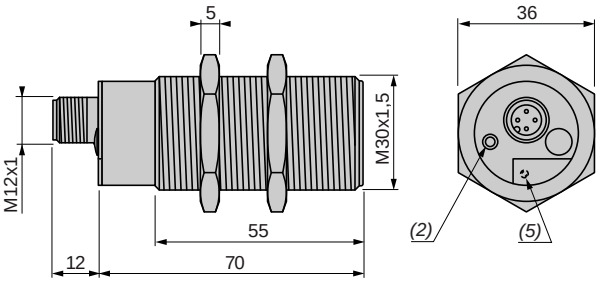
M18, M12 connector
XT1 18B1PCM12



M30, pre-cabled
XT1 30B1●●L2



M30, M12 connector
XT1 30B1PCM12



(1) Adjustment potentiometer
(2) LED
(3) Sealing screw
(4) Potentiometer beneath sealing screw
(5) Potentiometer beneath protective flap

Capacitive proximity sensors
For detection of insulated materials
Cylindrical, flush mountable. Metal case
d.c. or a.c. supply

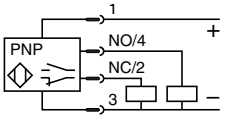
Wiring schemes

Connector version

M12 connector

4-wire ⎓, PNP
NO + NC output, M12

XT1 12/18/30●●●●M12



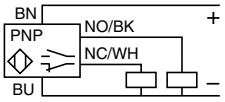
Pre-cabled version

Cable

BU: Blue
BN: Brown
BK: Black
WH: White
YE/GN: Yellow/green

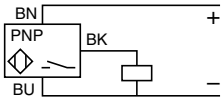
4-wire ⎓, PNP
NO + NC output, pre-cabled

XT1 12/18/30PC●●L2



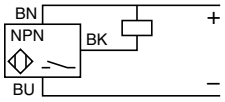
3-wire ⎓, PNP
NO output, pre-cabled

XT1 12/18/30PA●●L2



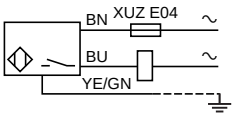
3-wire ⎓, NPN
NO output, pre-cabled

XT1 12/18/30NA●●L2



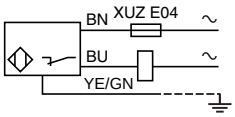
2-wire ∿
NO output

XT1 18/30B1FAL2



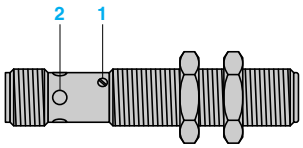
2-wire ∿
NC output

XT1 18/30B1FBL2

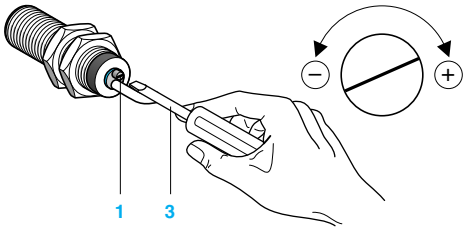


Adjustment

Sensitivity adjustment

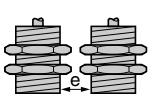
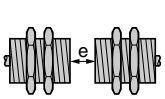
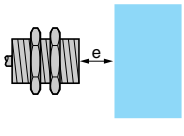
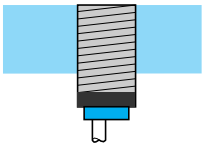


Adjustment from the side for	**XT1 12●●●●M12** **XT1 18●●●●M12**
Adjustment from the rear for	**XT1 ●●●●●L2** **XT1 30●●●●M12**



1 Adjustment potentiometer
2 LED
3 Adjustment using suitable screwdriver (included with sensor)

Setting-up

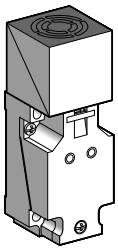
Minimum mounting distances (mm)	**Side by side**	**Face to face**	**Facing a metal object**	**Mounted in support**
				
XT1 M12 flush mountable	e ⩾ 0	e ⩾ 2.2 x Sn	e ⩾ 2 x Sn	–
XT1 M18 flush mountable	e ⩾ 0	e ⩾ 2.2 x Sn	e ⩾ 2 x Sn	–
XT1 M30 flush mountable	e ⩾ 0	e ⩾ 2.2 x Sn	e ⩾ 2 x Sn	–

***Fixing nut tightening torque: XT1 12** : 10 N.m, **XT1 18** : 28 N.m, **XT1 30** : 40 N.m*

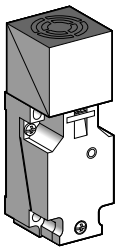
Capacitive proximity sensors

For detection of insulated materials

Block type, form C.
Plastic case, plug-in. Turret head
d.c. or a.c. supply



XT7 C40●C440



XT7 C40FP262

Sensors flush mountable in support

3-wire ⎓ 12…48 V flush mountable

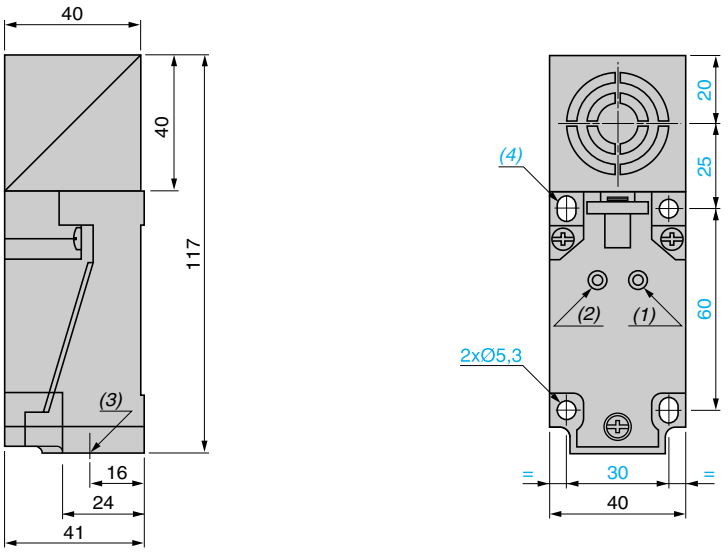
Sensing distance (Sn) mm	Function	Output	Reference	Weight kg
15	NO + NC	PNP	**XT7 C40PC440**	0.220
		NPN	**XT7 C40NC440**	0.220

2-wire ∿ 24…240 V (50/60 Hz) flush mountable

Sensing distance (Sn) mm	Function	Reference	Weight kg
15	NO or NC via programming	**XT7 C40FP262**	0.220

Dimensions

XT7 C40●●●●●



(1) Output LED
(2) Supply LED (depending on model)
(3) 1 tapped entry for n° 13 plastic cable gland
(4) 2 elongated holes Ø 5.3 x 7

Capacitive proximity sensors

For detection of insulated materials
Block type, form C.
Plastic case, plug-in. Turret head
d.c. or a.c. supply

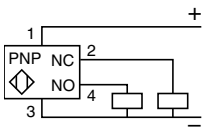
Characteristics

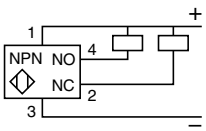
Sensor type			XT7 C40●C440	XT7 C40FP262
Connection			Screw terminals, clamping capacity 4 x 1.5 mm² *(1)*	Screw terminals, clamping capacity 3 x 1.5 mm² *(1)*
Degree of protection	Conforming to IEC 60529		IP 67	
Operating zone		**mm**	0…10.8	
Repeat accuracy			⩽ 0.1 Sr	
Product certifications			UL, CSA, CE	
Differential travel			⩽ 0.2 Sr	
Operating temperature		**°C**	- 25…+ 70	
Output state/supply indication			Yellow LED: output Green LED: supply	Yellow LED: output
Rated supply voltage		**V**	⎓ 12…48	∿ 24…240 (50/60 Hz)
Voltage limits (including ripple)		**V**	⎓ 10…58	∿ 20…264
Switching capacity		**mA**	0…200 with overload and short-circuit protection	5…350 (2 A inrush) *(2)*
Voltage drop, closed state		**V**	⩽ 2	⩽ 5.5
Residual current, open state		**mA**	–	⩽ 1.5
Current consumption, no-load		**mA**	⩽ 10	–
Maximum switching frequency		**Hz**	100	25
Delays	First-up	**ms**	⩽ 30	⩽ 150
	Response	**ms**	⩽ 5	⩽ 20
	Recovery	**ms**	⩽ 5	⩽ 30

(1) Cable gland not included with sensor. For suitable n° 13 plastic cable gland (XSZ PE13), see page 37317/2.
(2) These sensors do not incorporate overload or short-circuit protection and therefore, it is essential to connect a "quick-blow" fuse in series with the load (see page 37317/2).

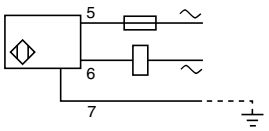
Wiring schemes

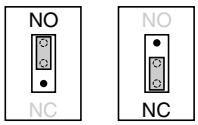
3-wire ⎓
NO + NC output





2-wire ∿ programmable
NO or NC output, depending on position of link

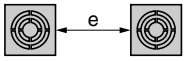




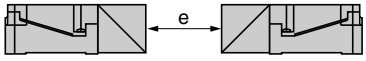
Setting-up

Minimum mounting distances (mm)

Side by side

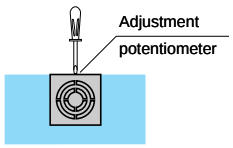


Face to face



	Side by side	Face to face
XT7 flush mountable	e ⩾ 40	e ⩾ 120

Flush mounting



To avoid interference by the immediate surroundings, it may be necessary to reduce the sensitivity when flush mounting the sensor.