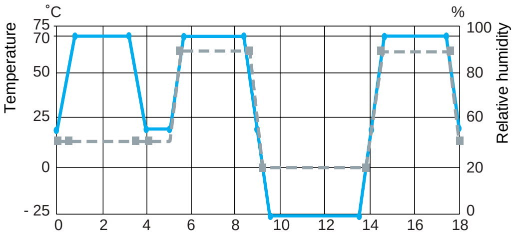
Inductive proximity sensors

Recommendations

The sensors described in this catalogue are designed to be used in standard industrial presence detection applications.
These sensors do not have a redundant electrical circuit as would be needed to allow them to be used in safety applications.
For safety applications, consult our "Safety solutions using Preventa" catalogue No. 36223.

Standards and certifications
Parameters related to the environment



- 25° + 70°C cycle, 95% RH

Temperature °C
Humidity as a %

Quality controls

Our inductive proximity sensors are subject to specific precautions guaranteeing their reliability in the harshest industrial environments.

■ **Qualification**
□ The product characteristics stated in this catalogue are subject to a **qualification procedure** carried out in our laboratories.
□ The products are notably subjected to **climatic cycle** tests for 3000 hours with their supply on to check their ability to hold their characteristics over time.
■ **Production**
□ The electrical characteristics and detection distances at both ambient temperature and extreme temperatures are 100% checked.
□ Products are sampled at random during production and are subjected to **monitoring tests** relating to all their qualified characteristics.
■ **Customer returns**
If, in spite of all these precautions, defective products are returned to us, they are subject to **systematic analysis** and **corrective actions** are taken to eliminate the risks of the fault reoccurring.

Conforming to standards

All Telemecanique brand proximity sensors conform to the standard IEC 60947-5-2

Mechanical shock resistance

The sensors are tested in accordance with the standard IEC 60068-2-27, 50 gn, duration 11 ms.

Vibration resistance

The sensors are tested in accordance with the standard IEC 60068-2-6, amplitude ± 2 mm, f = 10…55 Hz, 25 gn at 55 Hz.

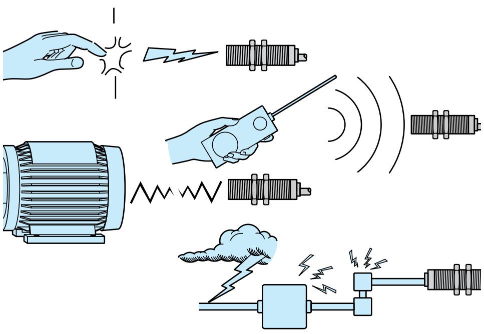
Resistance to the environment: IP

■ Please refer to the characteristics pages for the various sensors.
■ **IP 67**: protection against the effects of immersion.
Test conforming to IEC 60529: sensor immersed for 30 minutes in 1 m of water.
No deterioration in either operating or insulation characteristics is permitted.
■ **IP 68**: protection against prolonged immersion.
The test conditions are subject to agreement between the manufacturer and the user (e.g. machine-tool applications or other applications on any other machine drenched in cutting fluids).

Resistance to magnetic interference

Telemecanique inductive proximity sensors are tested in accordance with the recommendations of the standard IEC 60947-5-2.

Resistance to electromagnetic interference



■ Electrostatic discharges	Versions ∼ and ≂: level 4 immunity (15 kV). **IEC 61000-4-2**
■ Radiating electromagnetic fields (electromagnetic waves)	Versions ⎓, ∼ and ≂ : level 2 immunity (3 V/m) or level 3 immunity (10 V/m). **IEC 61000-4-3**
■ Fast transients (motor start/stop interference)	Version ⎓: level 3 immunity (1 kV). Versions ∼ and ≂: level 4 immunity (2 kV) except Ø 8 mm model (level 2). **IEC 61000-4-4**
■ Impulse voltage	Versions ⎓, ∼ and ≂ : level 3 immunity (2.5 kV) except Ø 8 mm and smaller models (1 kV level). **IEC 60947-5-2**

Resistance to chemicals in the environment

■ Owing to the very wide range of chemicals encountered in modern industry, it is very difficult to give general guidelines common to all sensors.
■ To ensure lasting efficient operation, it is essential that the chemicals coming into contact with the sensors will not affect their casings and, in doing so, prevent their reliable operation.
■ Cylindrical and flat plastic case sensors offer an excellent overall resistance to:
□ chemical products such as salts, aliphatic and aromatic oils, fuel oils, acids and diluted bases. For alcohols, ketones and phenols, preliminary tests should be made relating to the nature and concentration of the liquid.
□ agricultural and food industry products such as animal or vegetable based food products (vegetable oils, animal fat, fruit juice, dairy proteins, etc.).
In all cases, the materials selected (see product characteristics) provide satisfactory compatibility in most industrial environments (for further information, please consult your Regional Sales Office).

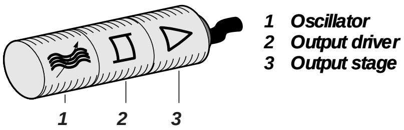
Insulation

Class 2 devices ⧈

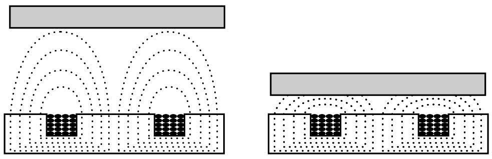
Electrical insulation conforming to the standards IEC 61140 and NF C 20-030 concerning electric shock protection means.

Inductive proximity sensors

Principle of inductive detection



Composition of an inductive proximity sensor



Detection of a metal object

Operating principle

■ Inductive proximity sensors are solely for the detection of metal objects.
They basically comprise an oscillator whose windings constitute the sensing face.
An alternating magnetic field is generated in front of these windings.

■ When a metal object is placed within the magnetic field generated by the sensor, the resulting currents induced form an additional load and the oscillation ceases.
This causes the output driver to operate and, depending on the sensor type, a normally open (NO) or normally closed (NC) output signal is produced.

Inductive proximity detection

■ Inductive proximity sensors enable the detection, without contact, of metal objects.
■ Their range of application is very extensive, and includes:
□ the monitoring of machine parts (cams, stop, etc.),
□ monitoring the flow of metal parts, counting, etc.,

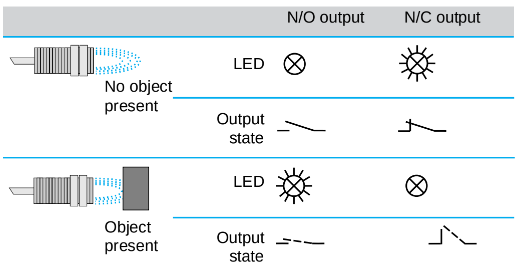
Advantages of inductive detection

■ No physical contact with the object to be detected, thus avoiding wear and enabling fragile or freshly painted objects to be detected.
■ High operating rates. Fast response.
■ Excellent resistance to industrial environments (robust products fully encapsulated in resin).
■ Solid-state technology: no moving parts, therefore service life of sensor independent of the number of operating cycles.

Osiconcept

■ **Osi**concept sensors are suitable for all metal environments (flush mountable or non flush mountable) as they provide for a maximum sensing distance even in the presence of a metal background. Precision detection of the object's position can be provided by means of the teach mode. For further information, see page 37316/2

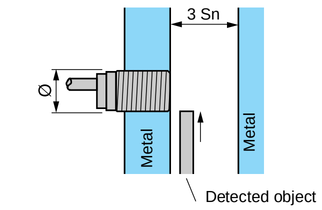
Output LED



Output LED

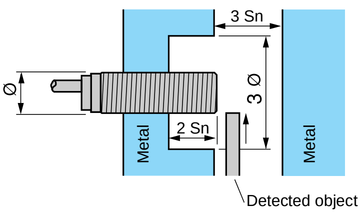
All Telemecanique brand inductive proximity sensors incorporate an output state LED indicator.
Osiconcept sensors are provided with a green LED which indicates the presence of the voltage and guides the user during setting-up (teach mode)

Mounting of sensors on a metal support



Sensors suitable for flush mounting in metal

■ No side clearance required.
■ All models using the **Osi**concept system are flush mountable in the metal without reducing the sensing distance and even allow an object to be detected against a metal background. For further information, see page 37316.

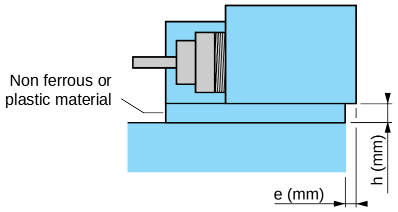


Sensors not suitable for flush mounting in metal

■ Side clearance required
Sensing distance greater than a standard flush mountable model.
■ The **Osi**concept system eliminates the side clearance requirement. For further information, see page 37316.

Inductive proximity sensors

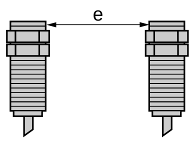
Mounting of sensors on a metal support



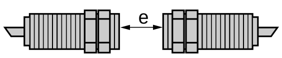
Mounting in conjunction with fixing bracket

- Standard flush mountable models: e = 0, h = 0
- Standard non flush mountable models
  - Ø 6.5 / 8 / 12 mm: e = 0, h = 0
  - Ø 18 mm: if h = 0, e ⩾ 5; e = 0, h ⩾ 3.
  Ø 30 mm: if h = 0, e ⩾ 8; e = 0, h ⩾ 4.
- **Osi**concept models: e = 0, h = 0

Mounting distance between sensors



Mounting side by side
e ⩾ 2 Sn



Mounting face to face
e ⩾ 10 Sn

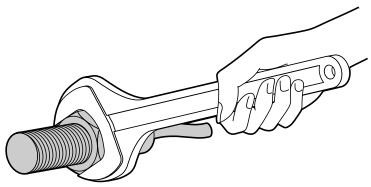
Standard sensors

Two sensors mounted too close to each other are likely to lock in the "detection state", due to interference between their respective oscillating frequencies.
To avoid this condition, minimum mounting distances given for the sensors should be adhered to or sensors with staggered oscillating frequencies used.

Staggered frequency sensors

For applications where the minimum recommended mounting distances for standard sensors cannot be achieved, it is possible to overcome this restraint by mounting a staggered frequency sensor adjacent or opposite to each standard sensor. For information on staggered frequency sensors, please consult your Regional Sales Office.

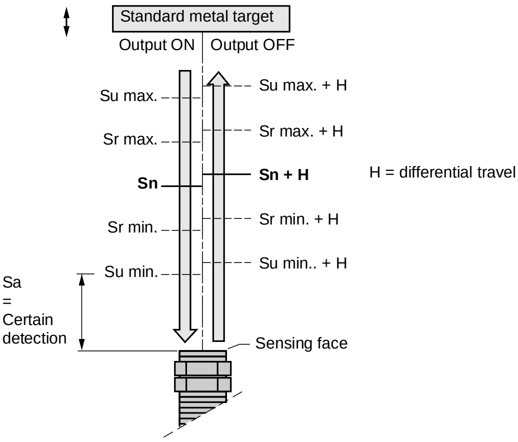
Tightening torque for cylindrical type sensors

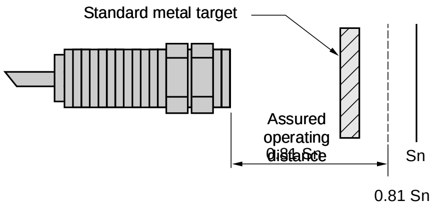


	Maximum tightening torque for the various sensor case materials			
	Brass	Brass	Stainless steel	Plastic
Diameter of sensor in mm	Short case model	Form A model	Form A model	All models
	XS5 ●●B1	XS6 ●●B1 XS6 ●●B2 XS5 AV●	XS1 ●● XS2 ●●	XS4 P●●
Ø 5	1.6 N.m	1.6 N.m	2 N.m	–
Ø 8	5 N.m	5 N.m	9 N.m	1 N.m
Ø 12	6 N.m	15 N.m	30 N.m	2 N.m
Ø 18	15 N.m	35 N.m	50 N.m	5 N.m
Ø 30	40 N.m	50 N.m	100 N.m	20 N.m

Inductive proximity sensors

Sensing distance





Definitions

To allow customers to make reliable comparisons and selections, the IEC 60947-5-2 standard 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).

- **Real sensing distance (Sr)**

The real sensing distance is measured at the rated voltage (Un) and at the rated ambient temperature (Tn).
It must be between 90 % and 110 % of the real sensing distance (Sn): $0.9\ Sn \leq Sr \leq 1.1\ Sn$.

- **Usable sensing distance (Su)**

The usable sensing distance is measured at the limits of the permissible variations in the ambient temperature (Ta) and the supply voltage (Ub). It must be between 90 % and 110 % of the real sensing distance: $0.9\ Sr \leq Su \leq 1.1\ Sr$.

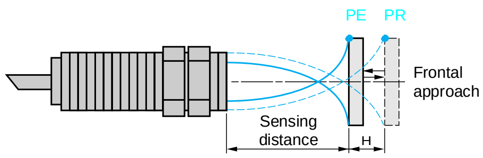
- **Assured operating distance (Sa)**.

This is the operating zone of the sensor. The assured operating distance is between 0% and 81% of the nominal sensing distance (Sn): $0 \leq Sa \leq 0.9 \times 0.9 \times Sn$

Standard metal target

The IEC 60947-5-2 standard 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 active surface of the sensing face, or 3 times the nominal sensing distance (Sn).

Terminology



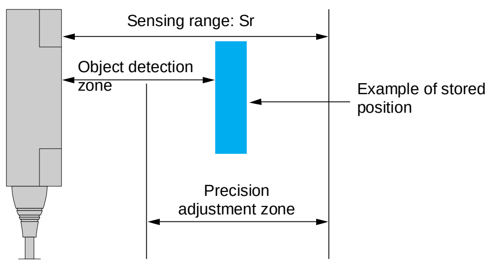
PE = pick-up point
PR = drop-out point

Differential travel

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

Repeat accuracy

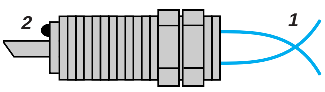
The repeat accuracy (R) is the repeatability of the usable sensing distance between successive operations. Readings are taken over a period of time whilst the sensor is subjected to voltage and temperature variations: 8 hours, 10 to 30 °C, Un ± 5 %.
It is expressed as a percentage of Sr.



Detection zone and precision adjustment zone

- Through sensitivity adjustment in teach mode, **Osi**concept proximity sensors allow the position of an object to be detected when it approaches from the front or the side.

The teach mode can be used when the object is located in the zone known as the “precision adjustment zone”. When the object approaches from the front, the object’s detection zone ranges from the stored distance to zero.



1 ***Detection threshold curves***
2 ***"Object detected" LED***

Operating zone

- The operating zone relates to the area in front of the sensing face in which the detection of a metal object is certain.

The values stated in the characteristics relating to the various types of sensor are for steel objects of a size equal to the sensing face of the sensor.
For objects of a different nature (smaller than the sensing face of the sensor, other metals, etc.), it is necessary to apply a correction coefficient.

Inductive proximity sensors

Correction coefficients to apply to the assured sensing distance

Sensor operating distance

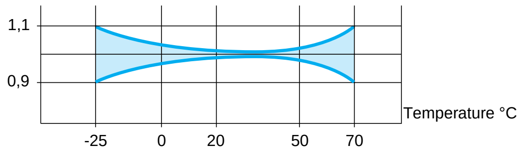
In practice, most target objects are generally made of steel and are of a size equal to, or greater, than the sensing face of the proximity sensor.

For the calculation of the assured operating distance for different operating conditions, one must take into account the correction coefficients which influence it.

The curves indicated are purely representative of typical curves. They are only given as a guide to the approximate usable sensing distance of a proximity sensor for a given application.

Influence of ambient temperature

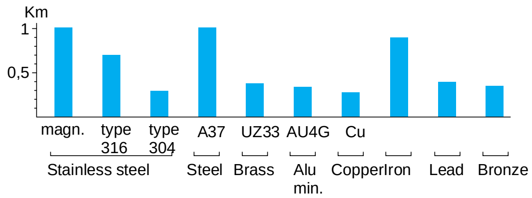
Apply a correction coefficient Kθ determined from the curve shown opposite.



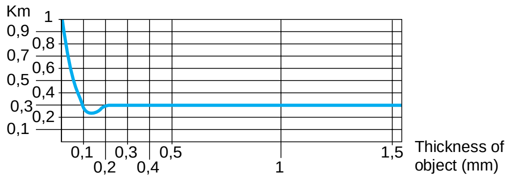
Influence of the object material to be detected

Apply a correction coefficient Km, determined from the diagram shown opposite.

The fixed sensing distance models for ferrous/non ferrous (Fe/NFe) materials enable the detection of different objects at a fixed distance, irrespective of the type of material.



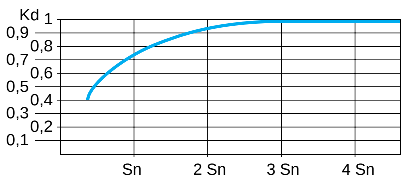
Special case of a very thin object made of a non ferrous metal.



Typical curve for a copper object used with a Ø 18 mm cylindrical sensor

Size of the object to be detected

Apply a correction coefficient Kd, determined from the curve shown opposite.
When calculating the sensing distance for the selection of a sensor, make the assumption that Kd = 1.



Typical curve for a steel object used with a Ø 18 mm cylindrical sensor

Variation of supply voltage

In all cases, apply the correction coefficient Kt = 0.9.

Calculation examples

Correction of the sensing distance of a sensor

Sensor with a nominal sensing distance Sn = 15 mm.
Ambient temperature variation 0 to + 20°C.
Object material and size: steel, 30 x 30 x 1 mm thick.
The assured sensing distance **Sa** can be determined using the formula:
Sa = Sn x Kq x Km x Kd x Kt = 15 x 0.98 x 1 x 0.95 x 0.9
i.e. Sa = 12.5 mm.

Selecting a sensor for a given application

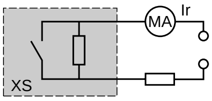
Application characteristics:
- object material and size: iron (Km = 0.9), 30 x 30 mm,
- temperature: 0 to 20 °C (Kθ = 0.98),
- object detection distance: 3 mm ± 1.5 mm, i.e. Sa max. = 4.5 mm,
- assume Kd = 1.

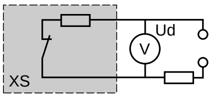
A sensor must be selected for which $\mathbf{Sn} \geqslant \dfrac{\mathbf{Sa}}{\mathbf{Kq \times Km \times Kd \times Kt}} = \dfrac{\mathbf{4.5}}{\mathbf{0.98 \times 0.9 \times 1 \times 0.9}}$,

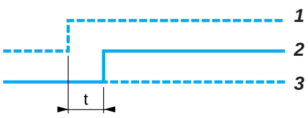
i.e. **Sn ⩾ 5.7 mm**

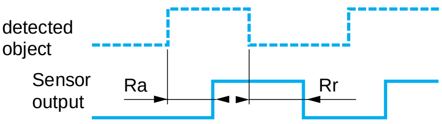
Inductive proximity sensors

Specific aspects of electronic sensors









Terminology

■ Residual current (Ir)
□ The residual current (Ir) corresponds to the current flowing through the sensor when in the "open" state.
□ Characteristic of 2-wire type proximity sensors.

■ Voltage drop (Ud)
□ The voltage drop (Ud) corresponds to the voltage drop at the sensor's terminals when in the "closed" state (value measured at nominal current rating of sensor).

■ First-up delay
□ The first-up delay corresponds to the time (t) between the connection of the power supply to the proximity sensor and its fully operational state.
1 Supply voltage U on
2 Sensor operational at state 1
3 Sensor at state 0

■ Delays
□ Response time (Ra): the time delay between the object to be detected entering the proximity sensor's operating zone and the subsequent change of output state. This parameter limits the speed and size of the object.
□ Recovery time (Rr): the time delay between an object to be detected leaving the sensor's operating zone and the subsequent change of output state. This parameter limits the interval between successive objects.

Supply

Sensors for a.c. circuits (∿ and ≂ models)

Check that the voltage limits of the sensor are compatible with the nominal voltage of the a.c. supply used.

Sensors for d.c. circuits

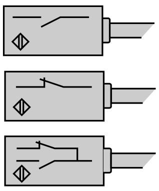
■ **d.c. source**: check that the voltage limits of the sensor and the acceptable level of ripple, are compatible with the supply used.

■ **a.c. source** (comprising transformer, rectifier, smoothing capacitor): the supply voltage must be within the operating limits specified for the sensor.

Where the voltage is derived from a single-phase a.c. supply, the voltage must be rectified and smoothed to ensure that:
- the peak voltage of the d.c. supply is lower than the maximum voltage rating of the sensor.
Peak voltage = nominal voltage x $\sqrt{2}$
- the minimum voltage of the supply is greater than the minimum voltage rating of the sensor, given that:
$\Delta V = (I \times t) / C$
ΔV = max. ripple: 10% (V),
I = anticipated load current (mA),
t = period of 1 cycle (10 ms full-wave rectified for a 50 Hz supply frequency),
C = capacitance (µF).
As a general rule, use a transformer with a lower secondary voltage (Ue) than the required d.c. voltage (U).

Example:
∿ 18 V to obtain ⎓ 24 V,
∿ 36 V to obtain ⎓ 48 V.

Outputs



Output signal (contact logic)

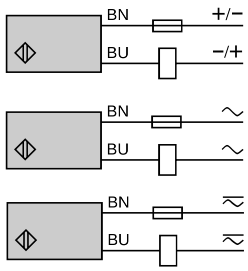
■ N/O
Corresponds to a sensor whose output changes to the closed state when an object is present in the operating zone.

■ N/C
Corresponds to a sensor whose output changes to the open state when an object is present in the operating zone.

■ N/O + N/C complementary outputs
Corresponds to a sensor with a normally closed output and a normally open output.

Inductive proximity sensors

Outputs (cont'd)



2-wire type ⎓, non polarised NO or NC output

■ **Specific aspects**

These sensors are wired in series with the load to be switched.
As a consequence, they are subject to:

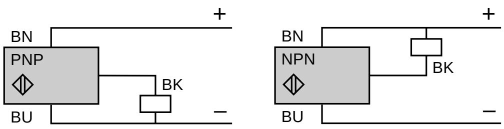
□ a residential current in the open state (current flowing through the sensor in the “open” state),
□ a voltage drop in the closed state (voltage drop across the sensor’s terminals in the “closed” state).

■ **Advantages:**

□ Only 2 leads to be wired: these sensors can be wired in series in the same way as mechanical limit switches,
□ They can be connected to either positive (PNP) or negative (NPN) logic PLC inputs,
□ No risk of incorrect connections.

■ **Operating precautions**

□ Check the possible effects of residual current and voltage drop on the actuator or input connected,
□ For sensors that do not have overload and short-circuit protection (a.c. or a.c./d.c. symbol), it is essential to connect a 0.4 A quick-blow fuse in series with the load.



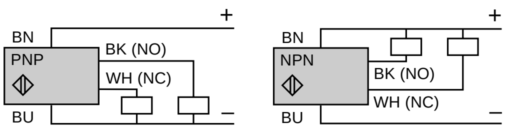
3-wire type ⎓, NO or NC output; PNP or NPN

■ **Specific aspects**

□ These sensors comprise 2 wires for the d.c. supply and a third wire for the output signal,
□ PNP type: switching the positive side to the load,
□ NPN type: switching the negative side to the load.

■ **Advantages:**

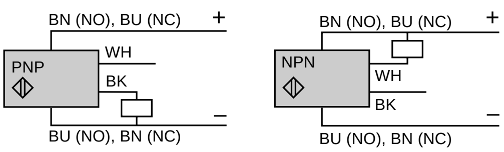
□ Protected against reverse supply polarity,
□ Overload and short-circuit protection,
□ No residual current, low voltage drop.



4-wire type, complementary outputs ⎓, NO and NC outputs, PNP or NPN,

■ **Advantages:**

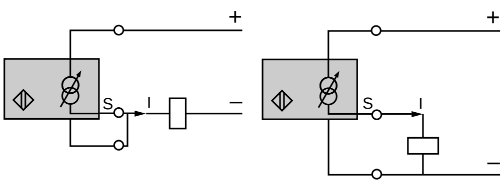
□ Protected against reverse supply polarity (+/-),
□ Overload and short-circuit protection.



4-wire type, multifunction, programmable ⎓, NO or NC output, PNP or NPN,

■ **Advantages:**

□ Protected against reverse supply polarity (+/-),
□ Overload and short-circuit protection.



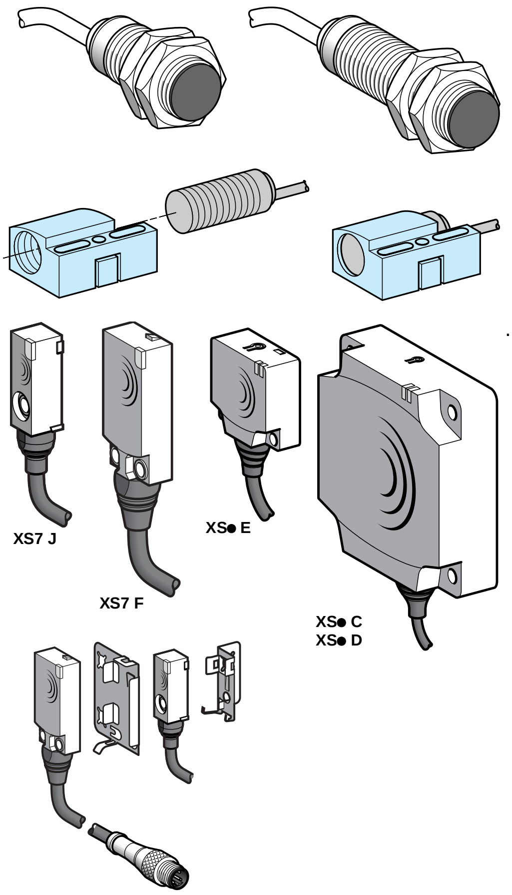
2-wire connection   *3-wire connection*

Specific output signals, analogue type

■ These sensors convert the approach of a metal object towards the sensing face into an output current variation which is proportional to the distance between the object and the sensing face.
■ Two models available:
- output 0...10 V (0...10 mA) for 3-wire connection,
- output 4-20 mA for 2-wire connection.

Inductive proximity sensors

Features of the various models



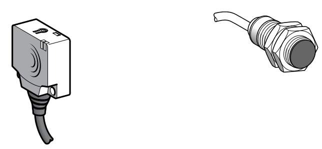
Types of case

■ **Cylindrical case**
□ Fast installation and setting-up,
□ Pre-cabled and connector versions,
□ Small size facilitates mounting in locations with restricted access.
□ **Interchangeability**, provided by indexed **fixing bracket**: when assembled, becomes similar to a block type sensor.

■ **Flat case**
□ Reduced size (sensor volume divided by 8).
□ Fast installation by mounting on clip-on brackets.
□ Precision detection through **Osi**concept teach mode.

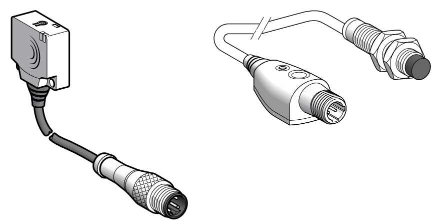
Electrical connection

1



2

3



Connection methods

1 Pre-cabled: factory fitted moulded cable, good protection against splashing liquids (IP 68). Example: machine tool.
2 Connector: easy installation and maintenance (IP 67).
3 Remote connector: easy installation and maintenance (IP 68 at sensor level and IP 67 at remote connector level).

Wiring advice

■ **Length of cable**
□ No limitation up to 200 m or up to a line capacitance of < 100 nF (characteristics of sensor remain unaffected),
□ In this case, it is important to take into account the voltage drop on the line.

■ **Separation of control and power circuit wiring**
□ The sensors are immune to electrical interference encountered in normal industrial conditions,
□ Where extreme conditions of electrical "noise" could occur (large motors, spot welders, etc.), it is advisable to protect against transients in the normal way:
- suppress interference at source,
- separate power and control wiring from each other,
- smooth the supply,
- limit the length of the cable.

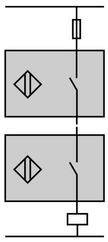
■ **Connect the sensor with the supply off.**

Inductive proximity sensors

Setting-up

Connection in series

2-wire type proximity sensors



- ■ The following points should be taken into account:
- □ Series wiring is only possible using sensors with wide voltage limits.

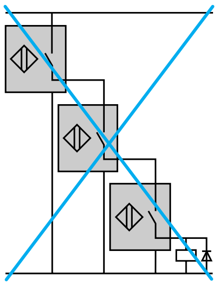
Based on the assumption that each sensor has the same residual current value, each sensor, in the open state, will share the supply voltage, i.e.

$$U\ sensor = \frac{U\ supply}{n\ sensors}.$$

U sensor and U supply must remain within the sensor's voltage limits.

- □ If only one sensor in the circuit is in the open state, it will be supplied at a voltage almost equal to the supply voltage.
- □ When in the closed state, a small voltage drop is present across each sensor. The resultant loss of voltage at the load will be the sum of the individual voltage drops and therefore, the load voltage should be selected accordingly.

3-wire type proximity sensors



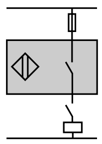
This connection method is not recommended.

- ■ Correct operation of the sensors cannot be assured and, if this method is used, tests must be made before installation.

The following points should be taken into account:

- □ Sensor 1 carries the load current in addition to the no-load current consumption values of the other sensors connected in series. For certain models, this connection method is not possible unless a current limiting resistor is used.
- □ When in the closed state, a small voltage drop is present across each sensor. The load should thus be selected accordingly.
- □ As sensor 1 closes, sensor 2 does not operate until a certain time "t" has elapsed (corresponding to the first-up delay) and likewise for the following sensors in the sequence.
- □ The use "flywheel" diodes is recommended when an inductive load is being switched.

Sensors and devices in series with an external mechanical contact

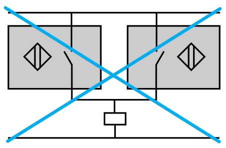


2 and 3-wire type sensors

- ■ The following points should be taken into account:
- □ When the mechanical contact is open, the sensor is not supplied.
- □ When the contact closes, the sensor does not operate until a certain time "t" has elapsed (corresponding to the first-up delay).

Connection in parallel

2-wire type proximity sensors



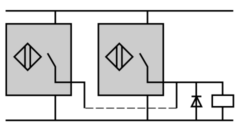
This connection method is not recommended.

- ■ Should one of the sensors be in the closed state, the sensor in parallel will be "shorted-out" and no longer supplied.

As the first sensor passes into the open state, the second sensor will become energised and will be subject to its first-up delay.

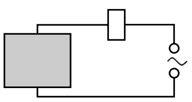
- ■ This configuration is only permissible where the sensors will be working alternately.
- ■ This method of connection can lead to irreversible damage of the units.

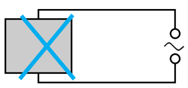
3-wire type proximity sensors



- ■ No specific restrictions. The use of “flywheel” diodes is recommended when an inductive load (relay) is being switched.

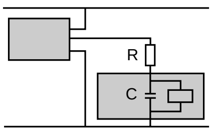
a.c. supply





- ■ **2-wire type sensors cannot be connected directly to an a.c. supply.**
- □ This would result in immediate destruction of the proximity sensor and considerable danger to the user.
- □ An appropriate load (refer to the instruction sheet supplied with the sensor) must always be connected in series with the proximity sensor.

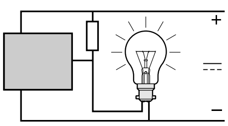
Capacitive load (C > 0.1 µF)

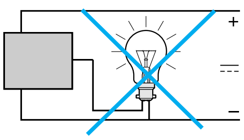


- ■ At switch-on, it is necessary to limit (by resistor) the charging current of the capacitive load C.
- □ The voltage drop in the sensor can also be taken into account by subtracting it from the supply voltage for calculation of R.

$$R = \frac{U\ (supply)}{I\ max.\ (sensor)}$$

Load comprising an incandescent lamp





- ■ If the load comprises an incandescent lamp, the cold state resistance can be 10 times lower than the hot state resistance. This can cause very high current levels on switching. Fit a pre-heat resistance in parallel with the proximity sensor.

$$R = \frac{U^2}{P} \times 10$$, U = supply voltage and P = lamp power

Inductive proximity sensors

Fast troubleshooting guide

Problem	Possible causes	Remedy
The sensor's output will not change state when a metal object enters the detection zone	On an **Osi**concept sensor: setting-up or programming error.	■ After a RESET, follow the environment teach mode procedure. See the sensor instruction sheet.
	Output stage faulty or complete failure of the sensor or the short-circuit protection has tripped	■ Check that the proximity sensor is compatible with the supply being used. ■ Check the load current characteristics: □ if load current I ≥ maximum switching capacity, an auxiliary relay, of the CAD N type for example, should be interposed between the sensor and the load, □ if I ≤ maximum switching capacity, check for wiring faults (short-circuit). ■ In all cases, a 0.4 A "quick-blow" fuse should be fitted in series with the sensor.
	Wiring error	■ Verify that the wiring conforms to the wiring shown on the sensor label or instruction sheet.
	Supply fault	■ Check that the sensor is compatible with the supply (∼ or ⎓). ■ Check that the supply voltage is within the voltage limits of the sensor. Remember that with a rectified, smoothed supply, U peak = U nominal x $\sqrt{2}$ with a ripple voltage ≤ 10%.
False or erratic operation, with or without the presence of a metal object in the detection zone	On an **Osi**concept sensor: setting-up or programming error.	■ After a RESET, follow the environment teach mode procedure. See the sensor instruction sheet.
	Influence of background or metal environment	■ Refer to the instruction sheet supplied with the sensor. For sensors with adjustable sensitivity, reduce the sensing distance.
	Operating distance poorly defined for the object to be detected	■ Apply the correction coefficients. ■ Realign the system or run the teach mode again.
	Influence of transient interference on the supply lines	■ Ensure that any d.c. supplies, when derived from rectified a.c., are correctly smoothed (C > 400 µF). ■ Separate a.c. power cables from d.c. low-level cables (24 V low level). ■ Where very long distances are involved, use suitable cable: screened and twisted pairs of the correct cross-sectional area.
	Equipment liable to emit electromagnetic interference	■ Position the sensors as far away as possible from any sources of interference.
	Response time of the sensor too slow for the particular object being detected	■ Check the suitability of the sensor for the position or size of the object to be detected. ■ If necessary, select a photo-electric sensor with a higher switching frequency.
	Influence of high temperature	■ Eliminate sources of radiated heat, or protect the sensor casing with a heat shield. ■ Realign, having adjusted the temperature around the fixing support.
No detection following a period of service	Vibration, shock	■ Realign the system. ■ Replace the support or protect the sensor.