



Inductive Sensors

- Overview types**4
- Principle of operation – Inductive**8
 - Sensing range in practice8
- Tips, tricks and background information**10
 - General10
 - Sensor cross talk10
 - Parallel and series connection of proximity switches10
 - Series connection of mechanical and electronic switches11
 - What happens when using smaller or larger targets?11
 - What happens when operating outside the permitted temperature range?12
 - Reduction effect of installing a flush sensor as non-flush12
 - Connecting to cable boxes and the error with the wire color12
 - Weld Field Immunity (WFI)13
 - Increased switching frequency13
 - Sensors for explosive areas14
 - What is ATEX?14
 - Zone division15
 - Equipment groups and categories16
 - Equipment protection level17
 - Context zones, equipment categories and equipment protection level17
 - Ignition protection18
 - The function of Namur sensors18
 - Design of intrinsically safe circuits20
 - Stainless steel all-metal sensor-INOX20
 - Patented sensing technology20
 - INOX sensors sensing range as a function of the material thickness21
 - INOX series reduction factors21
 - Explanation IP68 at INOX series21
 - IMF sensors for the food industry22
 - IMA sensors with analog output22
 - Response curve23
 - Resolution23
 - Output voltage23
 - Output current23
 - Bandwidth23

IEC/EN 60947-5-7	23	Shock resistance	33
Temperature de-rating	23	Vibration resistance	33
Repeat accuracy	24	Enclosure rating	34
Repeat accuracy (TA = constant)	24	Protection class	34
Glossary / Basic Concepts	25	Voltage drop	34
Wire colors and pin assignments	25	Power consumption	34
Resolution	25	Temperature drift	34
Active sensing face	25	Temperature de-rating	34
Inductive proximity sensor response curve	25	Ambient temperature	34
Tightening torque	26	Reverse polarity protection	34
Output functions	26	Supply voltage Vs	34
Output voltage	27	Repeat accuracy	34
Output current	27	Approvals and Certificates	35
ATEX	27		
Rated operating distance Sn	27		
Bandwidth	27		
Time delay before availability	27		
Output current Ia	27		
Wire-break protection	27		
Installation	28		
Power-up pulse suppression	29		
LED adjustment aid	29		
EMC	29		
Electrical wiring	29		
Short-circuit protection	30		
Intermittent current Ik	30		
No-load supply current	30		
Minimum load current	30		
Hysteresis	30		
Standard target	31		
Reduction factor	31		
Repeat accuracy	31		
Residual current: IR	31		
Residual ripple	32		
Sensing range Sn	32		
Switching output	33		
Switching frequency	33		






Overview types

Rectangular housings

	Dimensions (mm)	Sn flush	Sn non-flush	Electrical wiring					Connection			
				DC 2-wire	DC 3-wire	DC 4-wire	AC 2-wire	AC/DC 2-wire	Cable	M8 plug	M12 plug	Terminal space
	IQ04	4.7x8x16	1.5 mm	-								
	IQ05	5x5x25	0.8 mm	-								
	IQ06	6x10x27	3 mm	-								
	IQ08	8x8x40	2 mm	4 mm								
	IQ10	10.3x16x28	3 mm	6 mm								
	IQ12	12x26x40	4 mm	8 mm								







additional types on request

Rectangular housings






	Dimensions (mm)	Sn flush	Sn non-flush	Electrical wiring					Connection			
				DC 2-wire	DC 3-wire	DC 4-wire	AC 2-wire	AC/DC 2-wire	Cable	M8 plug	M12 plug	Terminal space
 IQ20	20x8x32	7 mm	-		•	•				•	•	
 IQ25	25x10x50	5 mm	-		•	•			•			
 IQ40 Short	40x40x 62	20 mm	40 mm		•	•					•	
 IQ40 Long	40x40x121	15 mm 20 mm	20 mm 30 mm	•	•	•		•				•
 IQ80	80x40x112	50 mm	60 mm		•	•		•			•	•

additional types on request

Cylindrical shapes

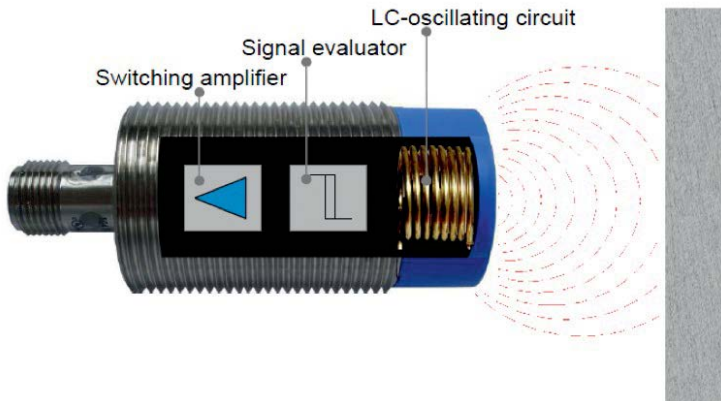
	Dimensions (mm)	Sn flush	Sn non-flush	Electrical wiring					Connection			
				DC 2-wire	DC 3-wire	DC 4-wire	AC 2-wire	AC/DC 2-wire	Namur	Cable	M8 plug	M12 plug
 IH03	ø 3 mm	0.6 mm	-		•					•		
 IM04	M4	0.6 mm	-		•					•		
 IH04	ø 4 mm	0.8 mm	-		•					•	•	
 IM05	M5	0.8 mm	4 mm		•					•	•	
 IH06	ø 6.5 mm	1.5 mm	2.5 mm		•					•	•	
		2 mm	4 mm		•					•	•	
 IM08	M8	1 mm							•	•		
		1.5 mm	2.5 mm		•					•	•	•
		2 mm	4 mm		•					•	•	•
		3 mm	6 mm		•					•	•	

Cylindrical shapes

	Dimensions (mm)	Sn flush	Sn non-flush	Electrical wiring					Connection			
				DC 2-wire	DC 3-wire	DC 4-wire	AC 2-wire	AC/DC 2-wire	Namur	Cable	M8 plug	M12 plug
	M12	2 mm	4 mm	•	•	•	•		•	•		•
		4 mm	8 mm		•	•				•		•
		6 mm			•					•		•
	M18	5 mm	8 mm	•	•	•		•	•	•		•
		8 mm	12 mm		•	•				•		•
		12 mm	20 mm		•							•
		10 mm	20 mm		•			•	•	•		•
	M30	10 mm	15 mm	•	•					•		•
		15 mm	20 mm		•					•		•
		22 mm	40 mm		•					•		•
		20 mm	40 mm		•							•
	ø 20 mm		10 mm					•		•		
	ø 34 mm		30 mm					•		•		

Principle of operation – Inductive

An inductive proximity sensor consists of a LC circuit – an electrical circuit comprising a coil (L) and a capacitor (C) –, a signal evaluator and a switching amplifier. The two output states of an inductive proximity sensor are referred to as activated or deactivated.



The coil of the resonant circuit generates a high frequency electromagnetic alternating field. This field is emitted from the active surface of the sensor. The size of the field is defined by the size of the ferrite core and the coil. If an activated material approaches the active surface, non-ferrous metal eddy currents are generated. In ferromagnetic metals, there are additional core losses. These losses deprive the resonant circuit of energy and dampen the oscillation. The signal evaluator detects this change and translates this into a switching signal.

Sensing range in practice

To compare individual sensors, the data sheet always gives the theoretical value of the sensing range S_n (for explanation see basic terms "sensing range S_n "). In practice, however, there are several factors that can reduce the effective usable sensing range:

- Size and material of the object to be detected (if not standard size and not ST37)
- Component tolerances (component manufacturing tolerances such as resistors, manufacturing tolerances, etc.)
- Ambient conditions (temperature change, voltage fluctuations, EMC interference, etc.)

- Other properties in the vicinity which are not part of the detection (parts of machines, etc.)

Standard size of the object to be detected:

Square metal target made of ST37 with a thickness of 1 mm. The side length is equal to the diameter of the active area or $3 \times S_n$, whichever is the greater value.

Example IQ12-06NPS-KW1

Active area diameter: 12 mm

$3 \times S_n \times 3 \times 6 \text{ mm} = 18 \text{ mm}$

The metal target thus has a side length of 18 mm.

A higher metal target does not increase the sensing range, but a smaller object greatly reduces the sensing range. The same applies to the thickness of the metal target – objects thicker than 1 mm do not affect the sensing range, but thinner objects do.

! See also the section "**Tips and Tricks**", page 11, "What happens when using smaller or larger targets?"

Material of the object to be detected:

The sensing range is always from a target made of ST37.

For targets made of metal, which are **not made of ST37**, the **sensing range decreases** depending on the material used.

This is described by the reduction factor.

The reduction factor varies from sensor to sensor.

It is generally listed in the relevant data sheet.

Examples of reduction factors:

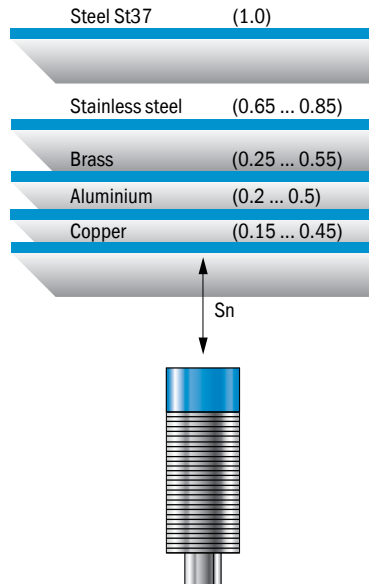
Material	Reduction factor
Steel (St37)	1
Stainless	0.65 ... 0.9
Brass	0.25 ... 0.6
Aluminum	0.20 ... 0.5
Copper	0.20 ... 0.4

Example calculation:

$S_n = 8$ mm aluminum target,
reduction factor of 0.2

$8 \text{ mm} \times 0,2 = 1.6 \text{ mm}$

The effective sensing range is reduced to 1.6 mm.



Sensing range example:

According to the standard for proximity switches EN 60947-5-2, the individual sensors should have a manufacturing tolerance of 90 % ... 110 % of the sensing range.

! see also Explanation **"Sensing range = >effective operating range Sr"**,
■ page 32

Example:

S_n according to data sheet: 40 mm

$0.9 \times S_n$ or $1.1 \times S_n$

Example permitted manufacturing tolerance 36 mm ... 44 mm.

Influence of ambient conditions:

The sensor may/can show a further +/- 10 % difference in the temperature sensing range, the full voltage range, etc. Thus the S_n may fluctuate in the range of 81 % ... 121 %.

! see also glossary term **"sensing range"**
sub-point **"Usable operating distance"**
■ **Su**", page 32

Example:

Example of permissible manufacturing tolerance:
36.0 mm ... 44.0 mm sensing range

Incl. permissible influence of environmental conditions: 32.4 mm ... 48.4 mm sensing range

Summary:

The data sheet specification sensing range S_n of a proximity switch of 1:1 cannot be used in practice. All influential factors in the design of a sensor must always be taken into account. (similar to black/white shift with optical sensors). To ensure safe switching under all permissible operating conditions, you must be always in the range 0 ... 81 % of the data sheet sensing range

Prerequisite: a standard switch target made from ST37. For other materials and sizes, it is recommended to move closer to the sensor to improve detection.

**Usable operating distance =
0.81 x data sheet specification S_n**

Tips, tricks and background information

General

Sensor cross talk

Sensors require a certain distance so as not to influence each other (see installation conditions for each sensor). The further the internal oscillator frequencies of two sensors are apart, the less they influence one another.

If the sensors have to be aligned more closely than the data sheet specification, they can be fitted with a second oscillation frequency.

Tip:

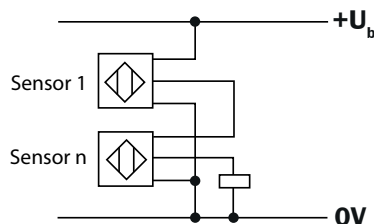
Identical switches from different vendors usually have a different oscillator frequency. If one takes a sensor from SICK and a competitor's sensor, these can be strung together more closely than installing two sensors from the same manufacturer.

Parallel and series connection of proximity switches

Series connection of 3-wire sensors:

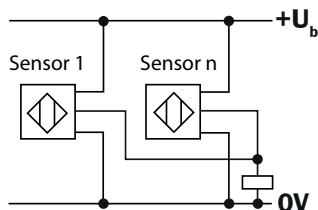
In the series connection, the voltage drops add up, and therefore so does the time delay before the availability of individual proximity switches.

It is therefore important to ensure that the voltage applied to the sensors does not fall below the permissible operating voltage.



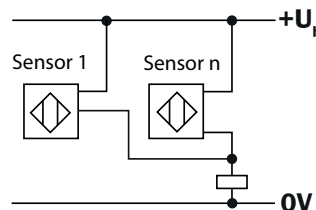
Parallel connection of 3-wire sensors:

The LEDs of all proximity switches illuminate – even if only one is activated. Therefore, blocking diodes are recommended at the OSSD.



Parallel connection of 2-wire sensors:

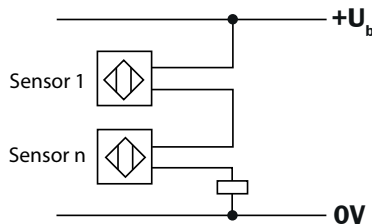
In the parallel connection all the off-state currents of each proximity sensor adds up. It is therefore important to ensure that this does not prevent a shutdown of the load as the sum of the off-state currents may become identical to the output current.



Series connection of 2-wire sensors:

In the series connection, the voltage drops of the individual proximity switches add up. Thus, the useful voltage is reduced at the load. But this must not fall below the minimum operating voltage at the load. It is also important to ensure that the voltage applied to the sensors does not fall below the permissible supply voltage.

Sensors with Namur technology cannot be connected in series!



Series connection of mechanical and electronic switches

The time delay before availability of the proximity switch generally always leads to an increase in response time.

What happens when using smaller or larger targets?

The smaller the target is, compared to the standard target, the smaller the real sensing range. But increasing the target beyond the standard target does **not** increase the effective operating distance!

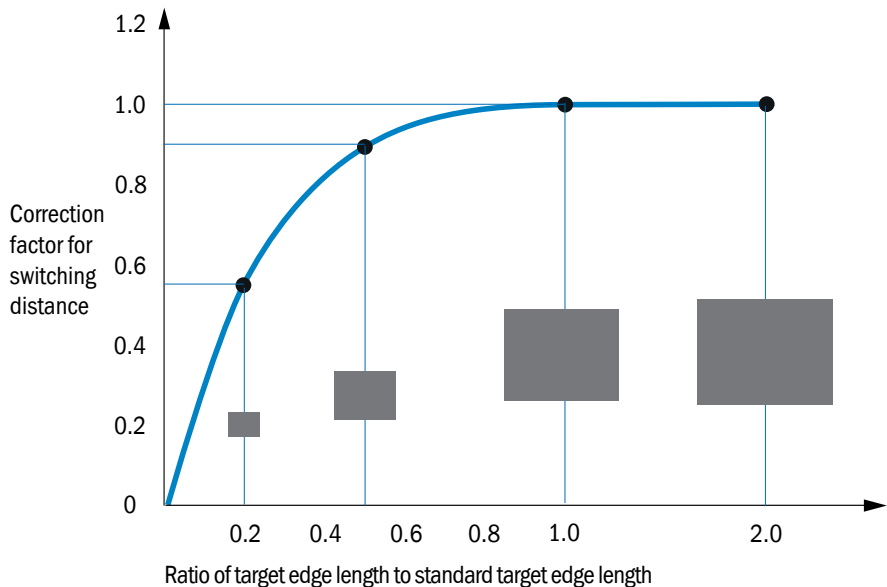


Figure 1: Ratio of switching flags to sensing range

What happens when operating outside the permitted temperature range?

There can be no general rule derived about the behavior of the sensor when used outside the permitted temperature range. The behavior depends on the design, the layout of the circuit, the properties of the components and so forth. Mostly, however, this increases the sensing range. This allows objects such as shields and other machine parts, for example, to be detected, which are located outside of the working distance.

The hysteresis (see Glossary term) increases so that the sensor is switched on, but only turns off if the target is moved a long distance from the sensor. In the worst case scenario, the sensing range can move infinitely and therefore the sensor would be permanently "on". By operating outside the specified ambient operating temperature range, the sensor will not definitely be destroyed. **It only shifts the switching point.** Often it works perfectly again when the ambient temperature drops to within the specified operating range.

Reduction effect of installing a flush sensor as non-flush

A flush sensor can be flush mounted into metal. If a flush sensor is installed non-flush (e.g. only screwed into a thin metal sheet) it lacks pre-activation. This can result in a reduction of the sensing range. One way to counteract this behavior is by using a copper shield around the ferrite core. This causes the sensor to be artificially pre-activated and thus minimizes the reduction effect. The greater the sensing range and the core size, the greater the influence of the installation based reduction effects. This is also the reason why triplex sensors are only available as quasi-flush versions with a metal free zone.

One could trim a triplex sensor for a flush installation in metal, but reduction effect when installing it non-flush would be so strong. The sensing range would go down to around 20 % of the nominal sensing range due to the lack of pre-activation.

Connecting to cable boxes and the error with the wire color

In an identical 3-wire output function of a sensor, the color coding of the wires can be different for the user for NC versions, depending on whether the cable is connected directly to the sensor or whether it uses a connector version in combination with a cable box.

	Connection	Wire color
Cable directly to sensor	+ : Q : - :	brown Black blue
4-pin cable connector	+ : Q : - :	brown White blue

Weld Field Immunity (WFI)

Welding systems generate high electrical currents and electromagnetic fields and also physical damage to the sensors. Sensors must be protected mechanically and electrically. A distinction is made between mechanical and electrical resistance weld immunity.

Mechanical protection:

This includes mechanical protection against splashes of slag, which are produced during the welding process. This can destroy the sensor by burning through the sensor cap or lead to a permanent activation by attaching to the active surface. These problems can be avoided by using a special coating (e.g., Teflon coating, etc.).

Electric protection:

This includes protection against magnetic fields which arise from the high welding currents (usually between 8 ... 30 kA). These can saturate the ferrite core and thus interfere with the sensor or induce direct voltages which influence the electronics. Weld immunity sensors are characterized by specific suppressors that minimize the effects of such induced voltages. Furthermore, either special ferrite cores, which are saturated at higher field strengths or print coils (printed circuit boards on which coil turns are affixed) are used without ferrites.

Increased switching frequency

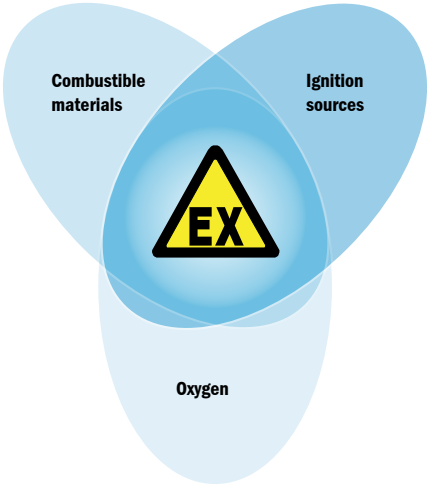
The switching frequency is always measured at a distance of $\frac{1}{2}$ Sn. If a higher switching frequency is needed, it can help to move the sensor a further away. (e.g., rotate one revolution backwards.) If the distance to the target increases, the switching frequency also increases, since the oscillator is not activated as strongly and needs less time to swing up.

Sensors for explosive areas

Sensors are used in explosive areas, such as refineries, mills, farms, chemical processing plants, oil platforms, paint, etc. Sensors must meet certain requirements and standards in order to be used in explosive areas. Depending on the requirement, a thorough check must be undertaken by an authorized institution in order to obtain the necessary authorization for the particular sensor and the specific area.

Why special sensors?

The sensors must be specially constructed to prevent causing an explosion in a hazardous area. Explosions occur when combustible materials, ignition sources and oxygen come together in a particular concentration.



What is ATEX?

ATEX (from the French: Atmosphère Explosive) is a synonym for the ATEX guidelines of the European Union. The directive currently includes two guidelines relating to explosion protection, namely **ATEX Directive 94/9/EC** and **ATEX Workplace Directive 1999/92/EC**.

The Product Directive 94/9/EC lays down the rules for the marketing of products which are used in hazardous areas. Those affected include manufacturers, importers, etc. of devices such as Namur sensors, etc.

The ATEX Directive 1999/92/EC lays down basic safety requirements, which the operator/employer has to implement and is used for improving the health and safety of workers who are working in explosion areas.

Target Group	Directive
Manufacturer	94/9/EG
Operator	1999/92/EG

The EN60079 series of standards is designed to help manufacturers because it determines overall demands for the design, testing and marking of electrical devices and Ex components, which are intended for use in explosion areas.

Zone division

Explosive areas must be divided by the operator of a facility into standard zones – based on the IEC/EN 60079 10 Parts 1 and 2

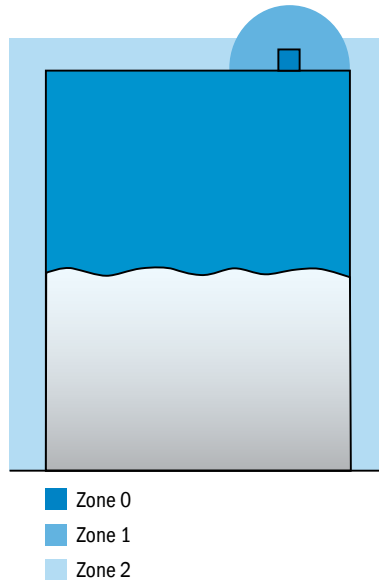
One basically differentiates between zones for

- gas explosive areas (G)
- dust explosive areas. (D)

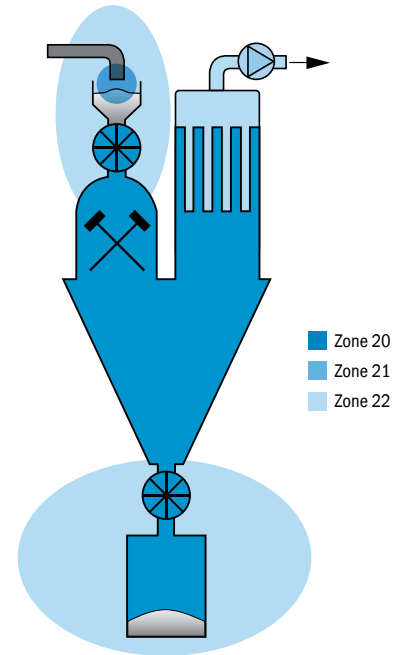
Furthermore, a distinction is made in a particular sub-category between the frequency of the occurrence of an explosive atmosphere.

Zone for gas (G)	Period of the danger	Zone for dust (D)
Zone 0	constantly, long	Zone 20
Zone 1	occasionally	Zone 21
Zone 2	not normally, only briefly	Zone 22

Example of zoning for flammable liquids in a tank¹



Example of zoning for combustible dust in a mill²



¹ Source: Guidance on the application of Directive 1999/92/EC.

² Source: Guidance on the application of Directive 1999/92/EC.

Equipment groups and categories

Each device which a manufacturer brings to the market must undergo a conformity assessment and the device has to be assigned to a corresponding device group and category beforehand.

Divided into groups of devices:

Equipment Group I: "Underground" black damp leading mines

Group II: "Above ground" for other explosive areas

Note: SICK only provides devices for **device group II**.

Divided into groups of devices:

Within a device group, a category represents the classification in terms of the required level of safety.

Category M1:

For rare disruptions, safety is ensured by two safety precautions and even if two errors occur independently.

Category M2:

Safety is ensured for typical errors in normal operation under difficult conditions.

Category 1:

For rare faults safety is ensured by two independent safety precautions or is safe even when two errors occur independently

Category 2:

Safety is ensured by a safety measure for a typical error during normal operations.

Category 3:

In normal operation, safety is ensured.

Equipment group	Group I		Group II		
	M1	M2	1	2	3
Category					

For category 1 and 2 devices, an EC-type examination certificate must be undertaken as part of a conformity assessment by a notified body such as PTB, TÜV Nord, etc.



Example of EC type examination certificate from the PTB body.

Category 3 equipment can either undergo a conformity evaluation by the manufacturer itself (i.e., internally) or by a notified body (e.g., TÜV Nord). They are subject to their own production checks.

Conclusion: As category 1 and 2 devices must be assessed externally, this takes a long time and is very expensive. Even the creation of variants (such as a 5 m cable instead of 2 m cable) must be documented at the notified body.

Equipment protection level

In EN 60079-0, the term equipment protection level (EPL) has been introduced, which shows the level of device protection. The equipment protection level is comparable to the equipment category of ATEX Directive 94/9/EC. Therefore, it is also possible to categorize equipment to the zones simply by using the labeling that corresponds to the ignition protection type.

Context zones, equipment categories and equipment protection level

The user can now select the appropriate sensor for the requirements of its zone based on Directive 1999/92/EC. Sensors in each zone may be used in the following categories:

EN 60079-0		Directive 94/9/EC		EN 60079-10-X
Equipment protection level (EPL)	Group	Device group	Device category	Zone
MA	I	I	M1	NA
Mb			M2	
Ga	II	II	1G	0
Gb			2G	1
Gc			3G	2
Da	III		1D	20
Db			2D	21
DC			3D	22

Example:
Sensors with 1G approval may be used in Zone 0 in the gas ex-area.

EC-type examination certificate:	PTB 03 ATEX 2037
EC-area category:	1G, 2G
Device designation:	II 1 G Ex ia IIC T6 Ta: -20 °C ... +55°C, II 2 G Ex ia IIC T6 Ta: -20 °C ... +70 °C
Usable thread length:	29 mm
Power consumption, metallised:	≤ 1 mA
Power consumption, unmetallised:	≥ 2,2 mA

Figure 3: Excerpt from data sheet | Hard copy from the online data sheet

Ignition protection

There are several ways one can avoid an electrical device becoming a source of ignition of an explosive mixture. The technical measure, i.e., the ignition protection type used by the manufacturer for particular equipment, depends essentially on the type and function of the device and the environment. From a health and safety perspective, all standardized ignition protection types are to be considered in equal measure.

Examples of types of ignition protection:

Ignition protection	Protection principle	Used in	Category	Zone
"nA" - non- sparking equipment	prevent sparks	Gas explosive areas	1G	2
"ia" - intrinsic Safety	Limit the ignition energy (Intrinsic Safety)	Gas explosive areas	1G, 2G, 3G	0, 1, 2
"d" - pressure enclosure	Preventing the spread of an explosion	Gas explosive areas	2G, 3G	1, 2
"ta" - protection provided by housings	Exclusion of explosive atmosphere	Dust explosive areas	1D, 2D, 3D	20, 21, 22
"ma" - encapsulation	Exclusion of explosive atmosphere	Dust explosive areas	1D, 2D, 3D	20, 21, 22

The function of Namur sensors

Namur sensors are special 2-wire sensors without an output stage. These are usually evaluated by external switching amplifiers and are classified in this combination by their ignition protection type as "intrinsically safe Ia". The switching amplifier transforms current changes into a binary output signal. The power output characteristics and their interaction with the inputs of an amplifier circuit is specified in the standard 60947-5-6.

The sensor states "closed" (damped) and "open" (undamped) are generally associated with different currents:

Damped: 0.4 ... 1.2 mA

(typically 1.2 mA)

Undamped: ≥ 2.1 mA

(at least 400 Ω internal sensor impedance)

There is a distinction between two forms:

Namur sensors with **constant current path** provide an almost proportional output signal to the target distance and are therefore often used as simple analog sensors. The characteristic curve is **independent** of the movement direction of the target.

The switching points set by the external switching amplifier must lie in the range from 1.2 mA to 2.1 mA. They should have a switching current distance (hysteresis) of 0.2 mA. (Typical values are 1.6 mA and 1.8 mA).

Sensors with **non constant current path** have a different characteristic curve depending on the movement direction of the target. The characteristic curve changes volatile between the "locking" and "conducting" output current.

The sensors are generally utilized with a Namur switching amplifier, which supplies the sensors with a voltage of typically 8.2 V and has an internal resistance of 1 KOhm. Because of this combination, the operating values are kept so low that the installation of the proximity switch

is possible in explosive areas – in the "intrinsic safety" ignition protection type. Permanent open-circuit and short circuit monitoring is possible by using the switch amplifier.

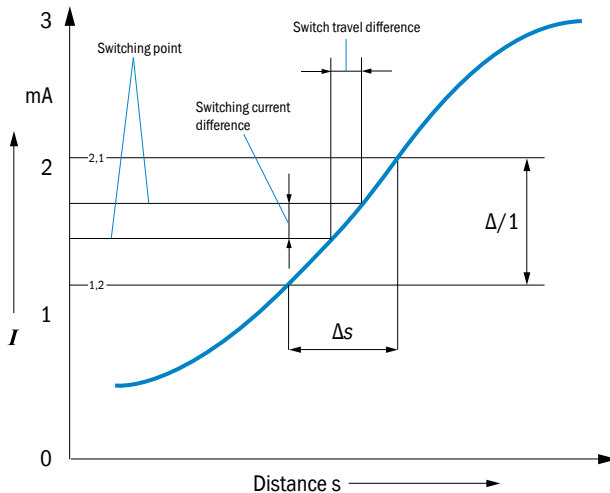


Figure 1: Example of a constant characteristic of a proximity sensor

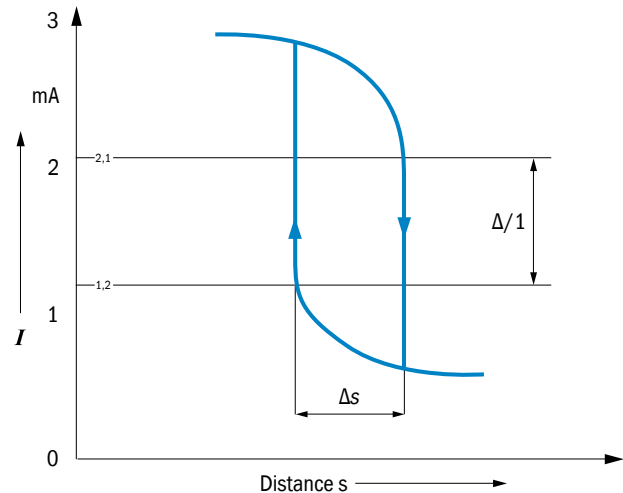


Figure 2: Example of a non constant characteristic of a proximity sensor

Namur sensors from SICK:

Inductive Namur Sensors from SICK can be used outside the explosive area in a voltage range of 7.5 ... 25 V DC and have an "NC" behavior. The current value in the deactivated state increases proportionally to the voltage while the current value is constant in the activated state.

Design of intrinsically safe circuits

The total intrinsically safe circuit, in which the Namur sensors are located, must be protected against the penetration of energy from other sources.

All inductances and capacities are to be taken into consideration so you will always find information on our data sheets about the max. internal capacitance C_i and the max. internal inductance L_i .

In practice, pay particular attention to the capacity, since this can significantly restrict the length of the cables and lines which can be used between the sensor and switching amplifier.

Other important information in the data sheet are max. input voltage U_i , the max. input power P_i and the max. input current I_i , which are needed for further scaling of the intrinsically safe circuit.

Stainless steel all-metal sensor-INOX

Stainless steel sensors are characterized by an all metal housing. Unlike conventional sensors, the active area is not plastic, but metal, which increases the sensor robustness. INOX sensors are always used for applications requiring high durability and resistance, such as in the food industry, machine tools, etc.

Patented sensing technology

INOX sensors from SICK function according to the patented principle (Patent Contrinex company).

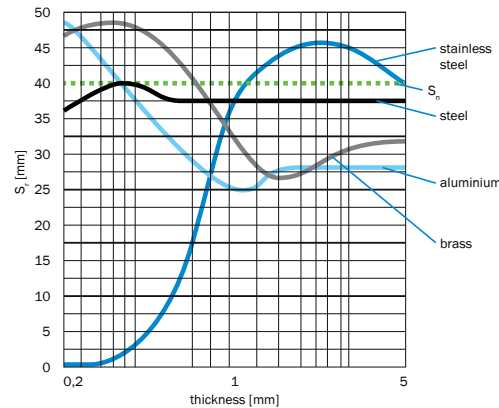
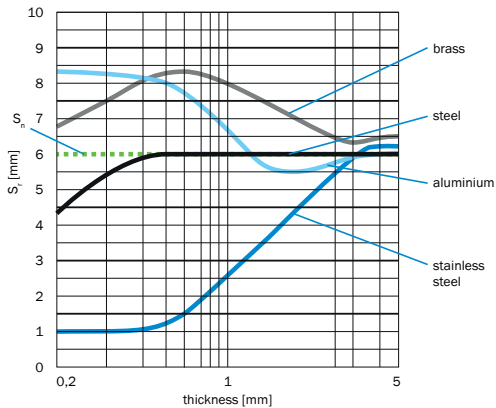
The patented principle works like an ordinary transistor. Behind the active area is a simple coil. This is used as the primary winding during the transmit power impulses. The current pulse builds up a magnetic field before the coil and induces a voltage in the detected object, which allows a current to flow. After the abrupt shutdown of the transmitting current pulse, the object becomes the primary winding. The decaying current now induces a voltage on the sensor side – now the secondary winding. This is evaluated by the sensor. The cycle time lies between 0.1 to 0.2 msec. The penetration depth of the magnetic field increases greatly in conductive materials due to this relatively low frequency range.

This allows production of the active surface made of metal.

For non-magnetic materials, e.g., such as stainless steel, – a penetration depth of 1 to 2 mm can be achieved. It also shows very good results on non-ferrous metals. The correction factors depend on such factors as the thickness of the material and are nearly at 1.

INOX sensors sensing range as a function of the material thickness

Because of patented technology, INOX sensors require a stainless steel targets to have thickness of at least 2 mm. For other materials, e.g., brass, a thickness of 1 mm is sufficient. For example, the behavior of the flush M12 sensor and the non-flush sensor M30 is listed below.



INOX series reduction factors

	FE360 steel	Copper	Aluminum	Brass	Steel (1 mm thick)	Steel (2 mm thick)
M12 flush	1.0	0.85	1.0	1.3	0.5	0.9
M12 non-flush	1.0	0.8	1.0	1.4	0.0	0.7
M18 flush	1.0	0.8	1.0	1.2	0.5	0.9
M18 non-flush	1.0	0.9	1.0	1.35	0.3	0.6
M30 flush	1.0	0.9	1.0	1.3	0.35	0.7
M30 non-flush	1.0	0.9	1.0	1.2	0.0	0.25

Explanation IP68 at INOX series

Test conditions: 30 days in 5 m water depth

IMF sensors for the food industry

The IMF sensor family from Sick has been designed to meet the special requirements of the food industry and can be operated in a wider temperature range of $-40 \dots +85^{\circ}\text{C}$. (For a short time of 15 min they can even be exposed to $+85 \dots 100^{\circ}\text{C}$ during the cleaning cycle without being destroyed. During this time they should not be operated).

The sensors qualify for the food industry based on their IP rating of IP69k, their high grade stainless steel housing, the usage of FDA conform materials, and their ECOLAB and Johnson Diversey certifications.

FDA:

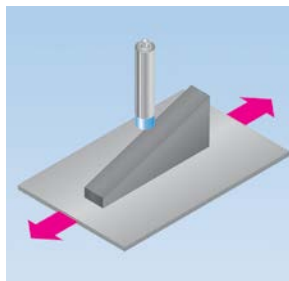
FDA is an US regulation authority that approves and certifies products and materials used in the food and pharmaceutical industries. All sensor parts which can come in contact with food must meet the FDA requirements.



IMA sensors with analog output

The inductive analog sensors IMA provide a current- or voltage output proportional to the target distance and can be connected to a PLC's analog card. Targets at the same distance but of different size, shape or material also provide a different output signal. Therefore analog sensors can be used e.g. for distance measurements, positioning tasks, angle detection, detection of material thickness, or to distinguish between different shapes or materials.

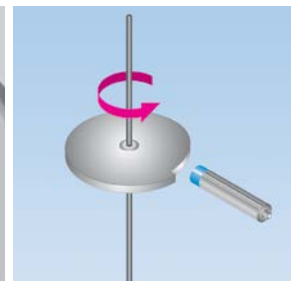
The main difference of the IMA sensors compared to most competitor products is the triple sensing range and the fact that they have no "bind zone".



Linear position detection with an inclined plane

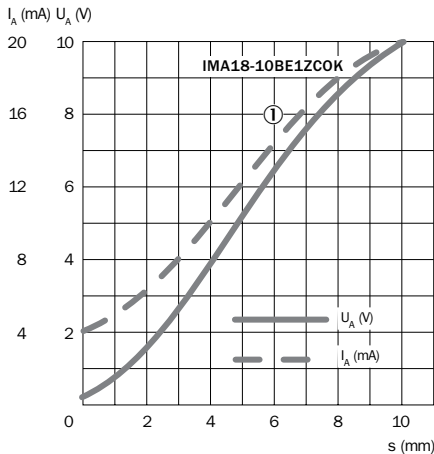


Clearance and run-out control directly to a shaft



Angle detection using a hub in angular form

Response curve



SICK's IMA sensor family provides a non-linear response, which can be seen from the S-shaped curve.

Resolution

The resolution describes the smallest possible change that can be detected by the sensor.

Output voltage

The voltage which is present at the output and varies depending on the distance (between target and sensor). (for example, in the range 0 ... 10 V).

Output current

The current which is present at the output and varies depending on the distance (between target and sensor). (for example, in the range 4 ... 20 mA).

Bandwidth

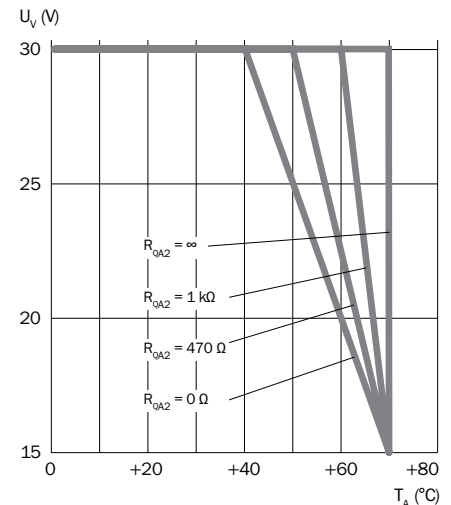
The bandwidth describes the highest frequency for periodic sensor operation, where the output signal decreases by not more than 3 dB. Bandwidth is always measured at $\frac{1}{2}$ Sn.

IEC/EN 60947-5-7

Standard for low-voltage switchgear – Part 5-7: Control units and switching elements – Requirements for proximity sensors with analog output

Temperature de-rating

The temperature de-rating is the restriction of the ambient temperature when using the current output. It is determined by the current flow across the load resistor and the resulting self-heating of the sensor.



Repeat accuracy

Repeat accuracy is the difference between any two measurements. This difference – measured at the distance below, at the top and in the middle distance range – may not exceed 5 %.

The repeat accuracy is measured over a period of eight hours at an ambient temperature of 23 ± 5 °C, a relative humidity up to 90 % and a fixed supply voltage of 24 V. (Note: A distinction is made between the repeat accuracy of analog sensors and the repeat accuracy of traditional proximity sensors with switching output. See Glossary: repeat accuracy)

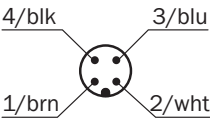
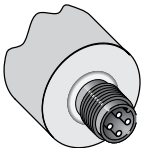
Repeat accuracy (TA = constant)

The repeat accuracy $T_a = \text{constant}$ is a short-term repeat accuracy measured over a period of a few minutes at a constant temperature. The idea behind this specification is that, as is often the case, the reality differs from the norm. In many applications, the sensor is used for the reference measurement. This is commonly based on a period of just a few minutes. This information is often more important for end customers than the repeat accuracy specified in the standard.

Glossary / Basic Concepts

Wire colors and pin assignments

Final stage type	Function	Wire	Wire color	Port numbers
2-wire devices AC and DC polarity-free	N/O		Each color ¹⁾ except yellow, green or green/yellow	3
	N/C			4
	NO / NC programmable			1 2
2-wire devices Observe DC polarity	N/O	+ -	brown blue	1 4
	N/C	+ -	brown blue	1 2
3-wire devices Observe DC polarity	N/O	+ - output	brown blue black	1 3 4
	N/C	+ - output	brown blue black	1 3 2
3-wire devices Observe AC and AC/DC polarity-free	N/O	L output	brown blue black	1 3 4
	N/C	L output	brown blue black	1 3 2
4-wire devices Observe DC polarity		+ - NO output NC output	brown blue black white	1 3 4 2



- 1) It is recommended that both the wires have the same color.
- 2) The port numbers (except Proximity sensor for AC and proximity switch with 3-pin 8 mm connectors) and the pin numbers of the device plug must be equal.

Resolution

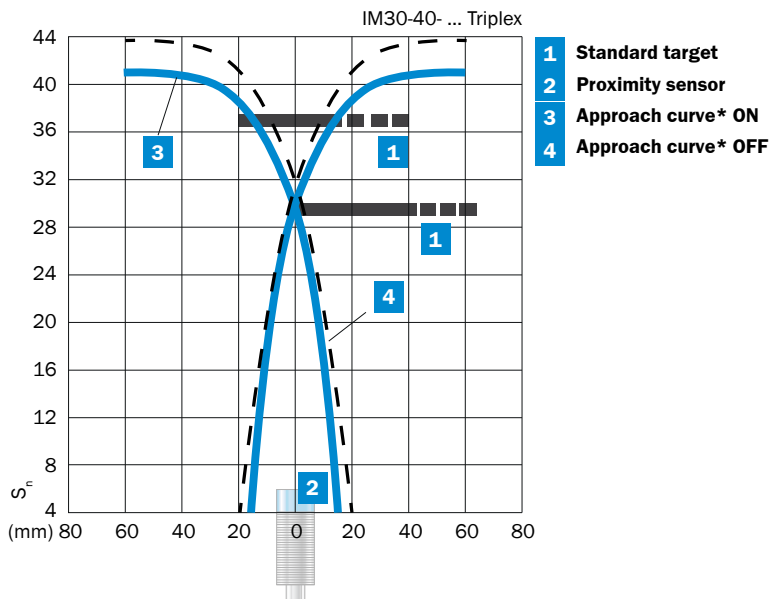
For explanation, see the **"IMA sensors with analog output"**, page 22

Active sensing face

The active sensing face of an inductive proximity sensor is the area where the magnetic field is generated and where the sensor responds to an approaching target. The sensing range is measured from the center of the active sensing face.

Inductive proximity sensor response curve

The stated sensing ranges are determined at the **axial** (frontal) approach direction at the sensor reference axis. A **Radial** (lateral) approach results in a reduction of the sensing range. The edge of the target represents only a small surface. This results in less eddy current losses. The sensor only responds if the switching target enters near the side of the active area. The complete surface of the switching target is exposed during an axial approach. Therefore the maximum sensing range is achieved with the axial approach.



Tightening torque

For cylindrical shapes with thread, the maximum permitted tightening torque to avoid over-stretching of the sensor housing. Depending on design, the following typical values apply:

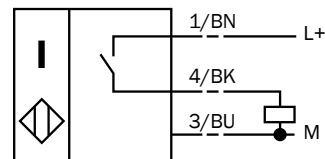
Design	Torque	Design	Torque
IM04	0.8 Nm	Inox IM12	20 Nm
IM05	1.5 Nm	Inox IM18	50 Nm
IME08	5 Nm	Inox IM30	150 Nm
IME12	12 Nm	Triplex IM08	4 Nm
IME18	40 Nm	Triplex IM12	10 Nm ¹⁾
IME30	100 Nm	Triplex IM18	25 Nm
		Triplex IM30	70 Nm

1) 6 Nm for the first 10 mm

Output functions

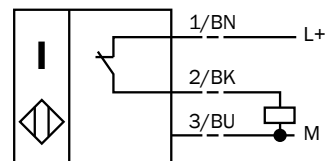
Normally open

A proximity sensor with normally open output function is blocked (high impedance) as long as no target is detected. Once a target is detected the output is activated (low impedance)



Normally closed

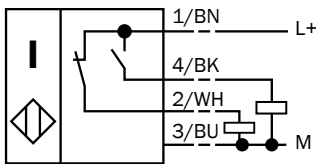
A proximity sensor with normally closed output function is activated (low impedance) as long as no target is detected. Once a target is detected the output blocked (high impedance).



Complementary output

A proximity sensor with complementary output has a normally open as well as a normally closed output function available. When the target is detected by the sensor Pin 2 is blocked (high impedance) and Pin 4 is activated (low impedance).

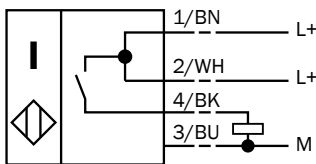
Once the target is removed, Pin 2 is activated (low impedance) and Pin 4 is blocked (high impedance).



Programmable

A proximity sensor with programmable function can, depending on the type, provide NO or NC function and can sometimes even implement PNP or NPN outputs. The type of programming is dependent on the particular type of sensor and can be found in the manual.

Example:



Output voltage

For explanation, see the *"IMA sensors with analog output"*, page 22

Output current

For explanation, see the *"IMA sensors with analog output"*, page 22

ATEX

ATEX (Explosive Atmosphere) refers to the Directive of the European Union regarding explosion protection.

See also *"Sensors for explosive areas"*, on page 14

Rated operating distance S_n

With this device parameter, manufacturing variations and changes are not taken into account by external influences such as temperature and voltage.

Bandwidth

For explanation, see the *"IMA sensors with analog output"*, page 22

Time delay before availability

The time delay before availability is the time it takes for the proximity sensor to be ready according to the operating voltage.

Example IME: 100 ms

Output current I_a

Output current is defined as the maximum load current for continuous operation (also called the rated current according to EN 60947-5-2)

Wire-break protection

Due to the wire break protection the output stays blocked when a power supply cable breaks. Faulty switching can be avoided.

Installation

Flush

Flush inductive sensors can be mounted with the sensing face flush in metal. These sensors can also be installed non-flush.

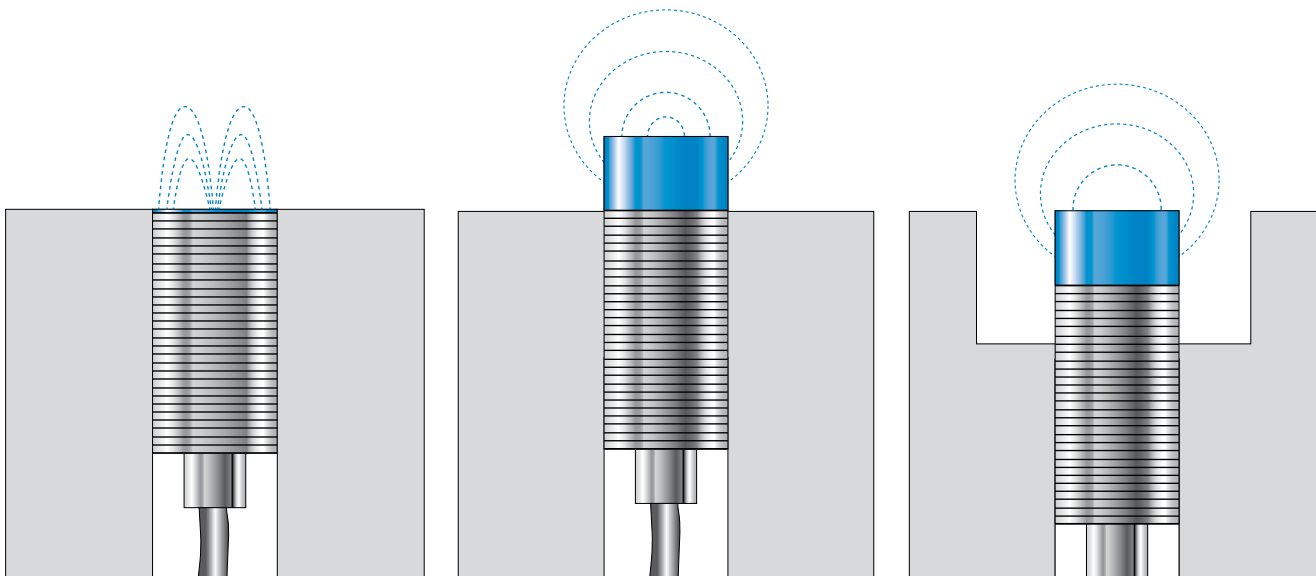
! see also *"Reduction effect of installing a flush sensor as non-flush"*, page 12

Non-flush

A non-flush proximity sensor requires a free space around the sensing face, in which there should be no metal. The size of the space is type specific. The sensing range is greater than with flush versions.

Quasi-flush

A quasi-flush proximity sensor requires a small space around the sensing face, in which there should be no metal. The size of the space is type specific. Although these sensors look identical to flush sensors, they may not be completely incorporated into the metal, or the mounting nut may not be mounted in the metal free area!

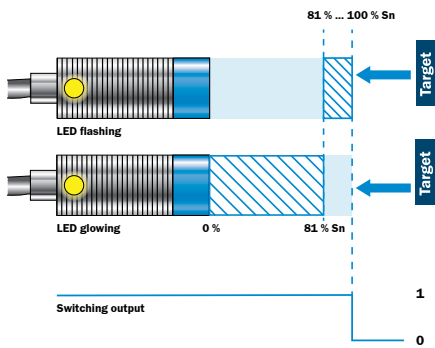


Power-up pulse suppression

The power-up pulse suppression is used to suppress false pulses at the output, the time between the application of the operating voltage and the oscillation of the oscillator.

LED adjustment aid

The optical adjustment aid enables the user to quickly mount the sensor in a correct way. The LED indicator flashes in the range 81 – 100 % of the nominal sensing range and in continuous display overflow when it reaches the secure sensing range (81 %).



EMC

According to EC Directive 2004/108/EC on electromagnetic compatibility, systems and components must satisfy certain properties in order to function smoothly in an electromagnetic environment. These properties are specified in more detail in EN 60947-5 -2 (low-voltage switchgear – Part 5-2: control units and switching elements – proximity switches) :

Electrical wiring

Number of wires	Model name	Example of connection diagram:	
2-wire	DC AC/DC AC	2-wire, NO 	
	NAMUR	2-wire, NO 	
3-wire	DC	3-wire PNP, NO 	3-wire, NPN, NC
4-wire	DC	4-wire, PNP NO + NC 	4-wire, NPN NO + NC

Type of test	Severity
EN 61000-4-2 ESD Immunity to electrostatic discharge	4 kV contact discharge 8 kV air discharge
EN 61000-4-3 RF field Immunity to radiated electromagnetic fields	3 V/m (80 ... 2000 MHz)
En 61000-4-4 Burst Immunity to electrical fast transient disturbances	2 kV
EN 61000-4-5 Surge Surge immunity	1 kV
61000-4-6 RF power Immunity to conducted electromagnetic fields	3 V (0.15 – 80 MHz)
Field-related interference emission to EN 55011	30 ... 230 MHz 40 dBuV/m quasi-peak 230 ... 1000 MHz 47 dBuV/m quasi-peak

Short-circuit protection

Short-circuit protection protects against overload and a direct short circuit. After exceeding the trigger threshold, the output is disabled. Then it is periodically (pulsed) queried whether the short circuit persists. After eliminating the short-circuit, the output is switched on again.

Intermittent current I_k

Intermittent current is the maximum short term load the output can tolerate without destroying the sensor.

No-load supply current

See glossary term "**Power consumption**", page 34

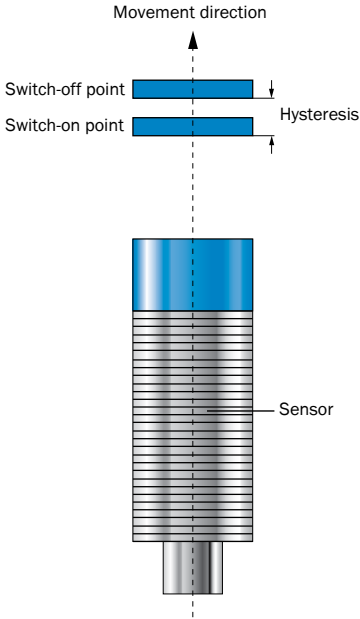
Minimum load current

Describes the smallest current which is required for self-supply of 2-wire sensors to function in the switched-on state. (referred to as a "Minimum operating current" according to the standard). The minimum load current must be supplied by the PLC.

Hysteresis

Hysteresis is defined as the difference between the activation and deactivation point of the sensor based on target's axial approach to the active sensing face; it is used to create chatter bounce free signals.

The hysteresis is defined as a percentage of the effective operating distance S_r . It is measured at the rated voltage and an ambient temperature of $23 \pm 5 \text{ }^\circ\text{C}$ and must be less than 20 % of the effective operating distance S_r . (A typical value for the hysteresis is 10 %)



Standard target

The standard target is a square metal target made from ST37 mild steel to determine the rated sensing range S_n . The standard target has a thickness of 1 mm and the surface length is either the diameter of the sensing face or $3 \times S_n$ – the larger of the two values is to be taken.

Examples

Rectangular sensor Q12-06NPS KW1

Active area diameter: 12 mm

S_n : 6 mm

$3 \times S_n$: $3 \times 6 \text{ mm} = 18 \text{ mm}$

The standard target has a surface length of 18 mm.

Cylindrical sensor IME12-02BPSZCOK

Active area diameter: 12 mm

S_n : 2 mm

$3 \times S_n$: $3 \times 2 \text{ mm} = 6 \text{ mm}$

The standard target has a surface length of 12 mm.

Cylindrical sensor IME12-08NPSZCOK

Active area diameter: 12 mm

S_n : 8 mm

$3 \times S_n$: $3 \times 8 \text{ mm} = 24 \text{ mm}$

The standard target has a surface length of 24 mm.

rectangular sensor cylindrical sensor



D = diameter of the active area

Reduction factor

When using metal targets which are not made of ST37, the sensing range decreases depending on the material used. This behavior is described by the reduction factor.

Since the reduction factor is among other things coil-dependent, it varies from sensor type to sensor type and must be specified in the data sheet.

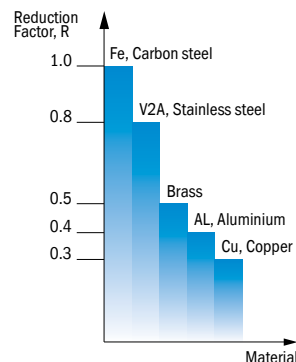
Typical examples of reduction factors:

Material	Reduction factor
Steel (ST37)	1
Stainless	0.65 ... 0.9
Brass	0.25 ... 0.6
Aluminum	0.20 ... 0.5
Copper	0.20 ... 0.4

Sample calculation reduction factor:

$S_n = 8 \text{ mm}$ aluminum target,
reduction factor of 0.5

$8 \text{ mm} \times 0.5 = 4 \text{ mm}$



Repeat accuracy

See glossary term "**Repeat accuracy**", page 34

Residual current: IR

Describes the current flowing in the blocked state in the load circuit of the proximity switch (also called off-state current according to EN60947-5-2).

For 2-wire sensors:

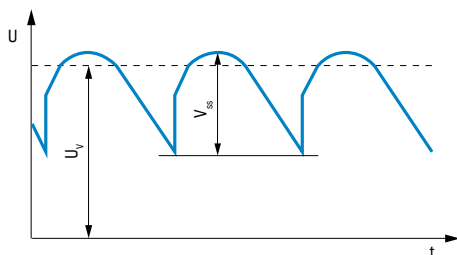
Current flowing in the blocked state

For 3 and 4-wire sensors:

Current that flows in the blocked state between the output Q and 0 V (PNP output) or output Q and the supply voltage (NPN output).

Residual ripple

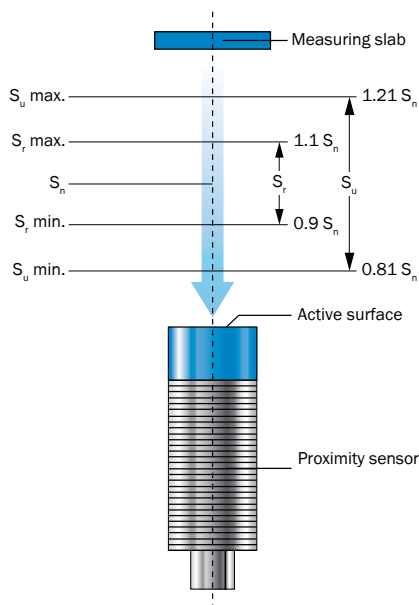
Residual ripple is defined as the superimposed AC component (maximum allowable peak, expressed as a % of U_v) of the DC operating voltage (typically 10 %).



Sensing range S_n

Nominal Sensing Range S_n

The sensing range S_n (also called "rated operating distance" according to EN60947-5-2) is the distance at which an axially to the active sensing face approaching norm target triggers the output. Production tolerances and changes due to external influences (such as temperature, changes of the supply voltage) are not considered.



Effective operating distance S_r :

The sensing range of an individual proximity switch measured at a fixed temperature of $23 \pm 5^\circ\text{C}$, fixed voltage and fixed installation conditions. (Example distribution/manufacturing tolerance)

Effective operating distance S_r :
 $0.9 s_n \leq s_r \leq 1.1 s_n$

Usable operating distance S_u :

The sensing range of an individual proximity switch, measured in the ambient temperature T_a (e.g. $-25 \dots 70^\circ\text{C}$) at a fixed voltage and installation conditions. (Effect of temperature on the sensing range)

Usable assured operating distance S_u :
 $0.9 s_r \leq s_u \leq 1.1 s_r$

Operating sensing range S_a :

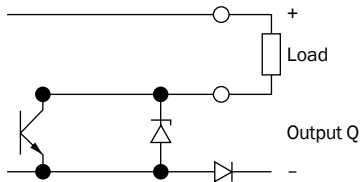
The distance at which a response of the proximity switch is ensured under the specified temperature, installation and voltage conditions. It is between 0 % and 81 % of the rated operating distance S_n .

Switching output

A switching output is the performance via which the output state of the sensor is digitally outputted.

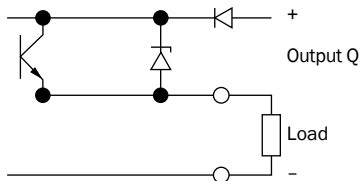
NPN output

The negative potential is here connected to the load. This output is also referred to as **negative switching** or **current-sinking**.



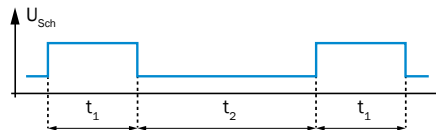
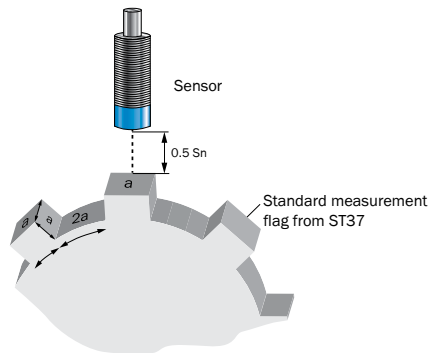
PNP output

The positive potential here is connected to the load. This output is also known as **current sourcing** or **positive switching**.



Switching frequency

The switching frequency is defined as the maximum number of switching from the activated state to the deactivated state in hertz (also called frequency of operating cycles according to EN60947-5-2). It is measured using a standard $\frac{1}{2}$ Sn and a switching flag. The rated value shall be satisfied if either the on-time (t_1) or off-time (t_2) is less than 50 microseconds.



Shock resistance

According to IEC 60068-2-27 6 shocks (six separate tests) are fitted in each direction along three mutually perpendicular axes:

Pulse shape:	half sine
Acceleration:	≤ 30 g
Pulse duration:	11 ms

Vibration resistance

According to IEC 60068-2-6 The test shall be conducted in three mutually perpendicular axes under the following conditions:

Frequency range:	10 to 55 Hz
Amplitude:	1 mm
Oscillation period:	5 min

Duration of the durability at resonance frequency or at 55 Hz: 30 min on each axis

Enclosure rating

The IP enclosure rating indicates the extent of a device's protection against contact with impurities, such as dirt or water. The code starts with the letters IP and is followed by the first digit, which is an ascending indicator of the degree of protection against contact and impurities, while the second digit is an indicator of protection against ingress of water.

IP65: Complete protection against dust and protection against water jets

IP67: Complete protection against dust and protection against water in 1 m of water for a period of 30 minutes at a constant room temperature

IP68: Any definable

IP69K: Protection against high pressure cleaning according to EN 60529. Jet duration 30 s depending on jet angle 0 ... 90° in 30° steps at a water pressure of 80 ... 100 bar and a water temperature of 80 +/- 5 °C.

Protection class

Electrical equipment is classified in relation to existing safety measures for prevention of electric shocks. Protection classes are defined in DIN EN 61140. There are four classes "Basic insulation" (Class 0) to "Safety extra-low voltage" (Class 1), double insulation (Class 2), safety transformer" (Class 3).



Class 1



Class 2



Class 3

Voltage drop

Voltage drop is defined as the voltage loss that occurs with maximum output current I_a across the switching stage of the proximity switch. This behavior is particularly to be observed in the series connection.

Power consumption

Power consumption refers to the current consumption of 3 and 4-wire sensors without a load being connected. (also referred to as "no-load-supply current" according to EN60947-5-2)

Temperature drift

Temperature drift is the shifting of the switching point caused by a change in ambient temperature.

Temperature de-rating

See *IMA Sensors with analog output*, Term "**Temperature de-rating**", page 23

Ambient temperature

The ambient temperature describes the range within which the proximity sensor works properly.

Reverse polarity protection

Reverse polarity protection is protection built into a proximity sensor against damage caused by mixing supply voltage connections

Supply voltage V_s

Supply voltage describes the range within which the proximity switch is working properly (also referred to as "operating voltage U_b " according to EN60947-5-2).

Repeat accuracy

The repeat accuracy describes the percentage deviation of the switching point. It is measured over a period of eight hours at an ambient temperature of 23 ± 5 °C, relative humidity up to 90 % and a fixed supply voltage of 24 VDC for DC devices or 230 VAC for AC devices.

The difference between any two measurements shall not exceed 10 % of the real sensing range (sr).

This definition applies only for sensors with switching output stage. For the definition of the repeatability of analog sensors, see "IMA sensors with analog output"

Approvals and Certificates

UL

The UL (Underwriters Laboratories Inc.), headquartered in Northbrook, Illinois, USA, is an American company, which undertakes product safety testing and issues appropriate certificates. Founded as a public service company for fire insurance companies, today UL also focuses on fire protection. The certificates issued by UL include UL Listing and UL Recognized Component as well as a number of other certificates for particular product groups.

Although there is no statutory requirement to certify products in accordance with UL, it has become a standard in many industries. Therefore, almost all industry segments require machine components including sensors to have cULus for their industry.



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