Inductive proximity sensor

Inductive Proximity Switches operate by using an L/C resonant oscillator which generates, with the aid of a coil located in the open pot core, a high frequency alternating electromagnetic field. This field emerges from the active face of the switch.

When an electrically conductive material (for example a steel plate)moves into the electromagnetic field, an induced eddy current occurs.This eddy current extracts energy form the L/C resonant circuit in the switch, and produces a reduction in the oscillation amplitude. This reduction in the amolitude is converted by the associated electronic circuitry into a clear electronic signal, and changes the state of the switch.

When the electrically conductive material is removed from the alternating field the oscillation amplitude increases which, by way of the electronic circuitry, will restore the switch to the original unswitched state.

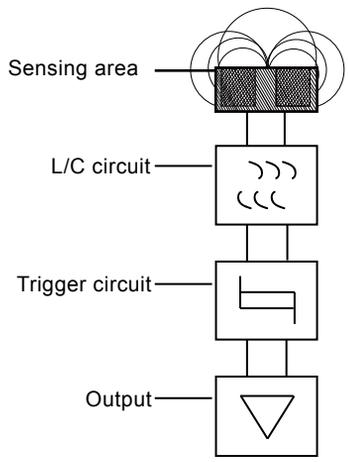


Fig.1
Block Diagram - Inductive Switch

Normal operating distance

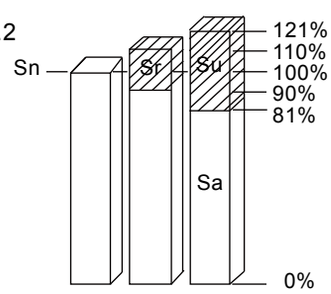
The normal operating distance is defined as the distance between the detector and the target when the change(switching) in the logic state of the proximity switch occurs. This distance and the tests associated in obtaining this distance are outline in CENELEC EN 50010 Standards. From this standard the target for establishing Normal Operating Distance is an iron (Fe 360) square 1 mm thick, and for cylindrical switches, the size is as showen in Table 1. The normal sensing distance Sn and Sr, Su, Sa information see Fig.2 .

Table 1

Diameter (mm)	Nominal distance SN (mm)	Fe 360 actuator (mm)
8	1	8X8x1
8	2	8X8x1
12	2	12X12x1
12	4	12X12x1
18	5	18X18x1
18	8	24X24x1
30	10	30X30x1
30	15	45X45x1

Table 1: Actuator dimensions as function of the diameter and of the operating distance

Fig.2



Sn = nominal sensing distance
Sr = effective operating distance
0.9 Sn <= Sr <= 1.1 Sn
Su = useful sensing distance
0.9 Sr <= Su <= 1.1 Sr
Sa = operating zone
0 < Sa <= 0.9 x 0.9 x Sn

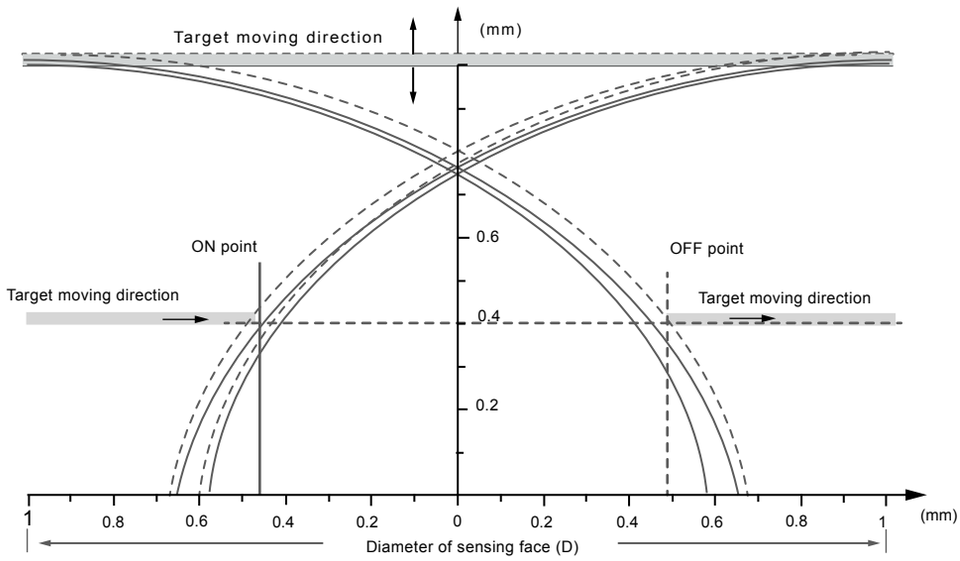
Correction Factor

When using inductive proximity switches with non-ferrous metals it is nescessary to apply a correction factor to the operating distance (sensing range), see Table 2.

Correction Factor:	
Non-ferrous metal	Factor
Fe 360	1
Aluminum	0.35-0.45
Brass	0.35-0.5
Copper	0.25-0.45
Stainless Steel	0.6-1.0
Cast Iron	0.93-1.05
Nickel	0.65-0.75

(Table 2)

Sensor response curve (Fig.3)



(Fig. 3)

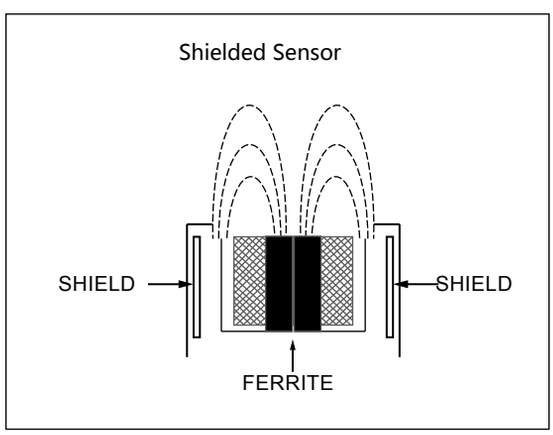
Repeatability

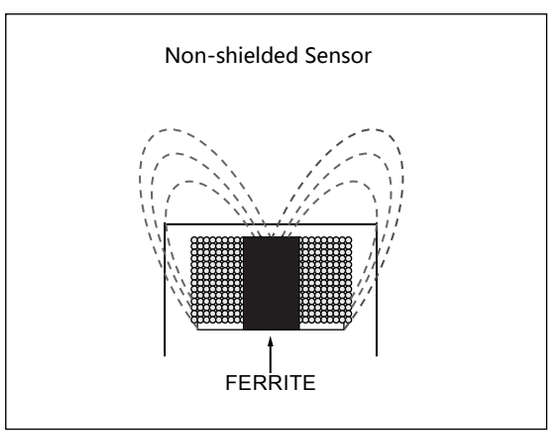
Variation in sensing distance for successive operations under specified conditions (specified sensing range,temperature at 23±5℃, humidity ≤90% specified operating voltage, circyle is 8 hours).

Shielded & Non-shielded

Shielded construction includes a metal band which surrounds the ferrite core and coil arrangement. This helps to direct the electro-magnetic field to the front of the sensor.

Non-shielded sensors do not have this metal band, therefore they can be side sensitive.

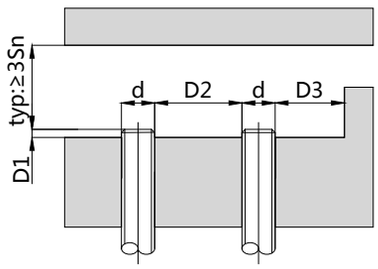




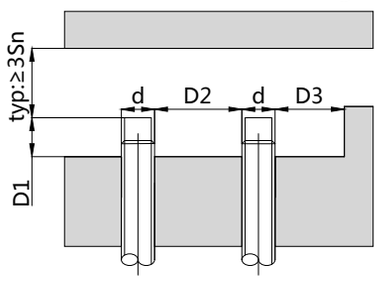
Product is installed in metal material

Standard distance	flush mounting	D1≥0		
		D2≥d		
		D3≥d		
	non-flush mounting	D1	ϕ6.5≥6mm	M8≥6mm
			M12≥9mm	M18≥16mm
			M30≥22mm	
		D2≥2d		
		D3≥d		
	opposite mounting	D4≥3d		
Medium distance	flush mounting	D1	M8≥0mm	M12≥1mm
			M18≥2.5mm	M30≥3.5mm
		D2≥d		
		D3≥d		
	non-flush mounting	D1	ϕ6.5≥8mm	M8≥8mm
			M12≥12mm	M18≥25mm
			M30≥40mm	
		D2≥2d		
		D3≥d		
	opposite mounting	D4≥4d		
Over a long distance	flush mounting	D1	ϕ6.5≥2mm	
			M8≥2mm	M12≥2.5mm
			M18≥4mm	M30≥8mm
		D2≥3d		
		D3≥d		
	non-flush mounting	D1	ϕ6.5≥8mm	M8≥8mm
			M12≥12mm	M18≥25mm
			M30≥40mm	
		D2≥3d		
		D3≥d		
	opposite mounting	D4≥5d		

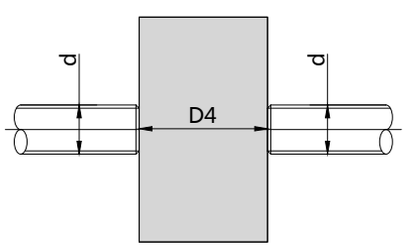
(Flush/Quasi-flush mounting)



(Non-flush mounting)



Opposite Mounting



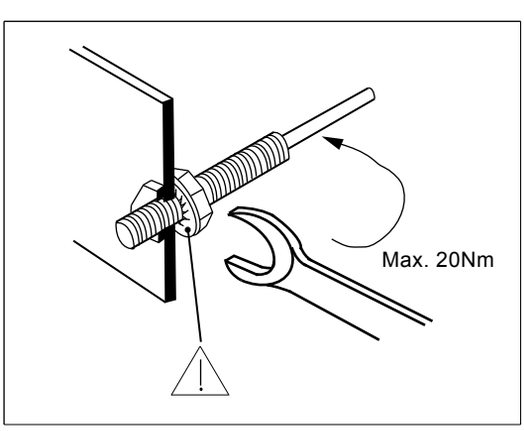
Maximum torque for proximity sensor threads in Nm:

For metal housing :

M5	1.5Nm	(Stainless steel)
M8	10Nm	(Stainless steel)
M12	10Nm	(Brass)
	30Nm	(Stainless steel)
M18	20Nm	(Brass)
M30	40Nm	(Metal)

For plastic housing :

M12	1Nm	(POM)
M18	1.5Nm	(POM)
M30	1.5Nm	(POM)



These values are based on using the nuts supplied with the sensors.

Hysteresis

Hystersis is the travel of the target between the "switch-on" point and the "switch-off" point. This distance is required to allow the switch to properly detect the target, and reduces the possibillity of false trips. See the Fig.4and Fig.5.

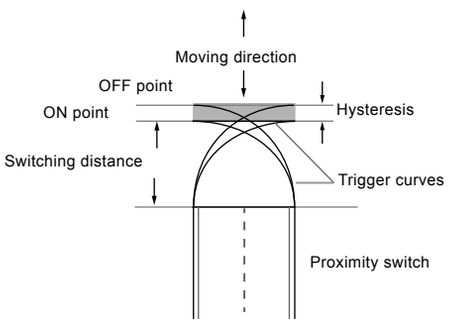


Fig.4

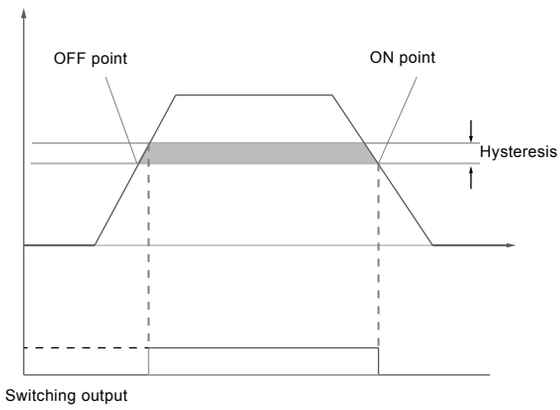
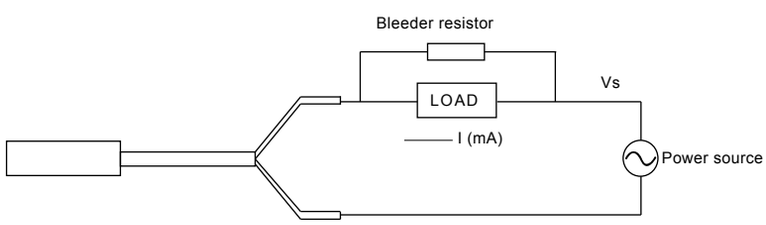


Fig.5

Leakage current

A leakage current flows through the proximity switches even when the output is turned off. Because of this the voltage remaining in the load may result in accidental operation or chattering, depending upon the load. If this occurs, connect a bleeder resister parallel to the load in order to decrease the residual voltage across the load.See Fig.6.



$R \leq \frac{Vs - 3.6}{5(mA) - 1\ (mA)}$ (kΩ) DC 2-WIRE type

$R \leq \frac{Vs}{5(mA) - 1\ (mA)}$ (kΩ) AC 2-WIRE type

$P > \frac{Vs^2}{R} \times 0.001(w)$

Fig.6

Load impedance

Instead of a maximum output current, a minimum load impedance may be specified.

A minimum load of 120 Ohms e.g. Translates into a maximum output current of 100mA at 12V or 200mA at 24V.On the other hand, if the maximum output current is 200mA, the lowest acceptable load impedance at 24V is120 Ohms.

Short circuit protection

Pulsing short circuit protection.In case of overload or short circuit,the output transistor is rapidly switched on and off.This tests whether the short has been removed or not.

See Fig.7.

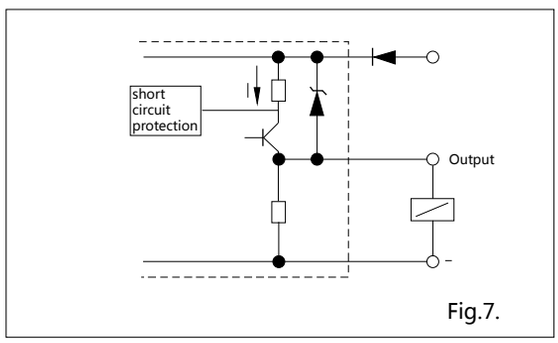


Fig.7.

Switching frequency,maximum

This frequency indicates the maximum number of pulses per second, this for an on/off ratio of 1:2 and at one half the nominal switching distance sn.

See Fig.8.

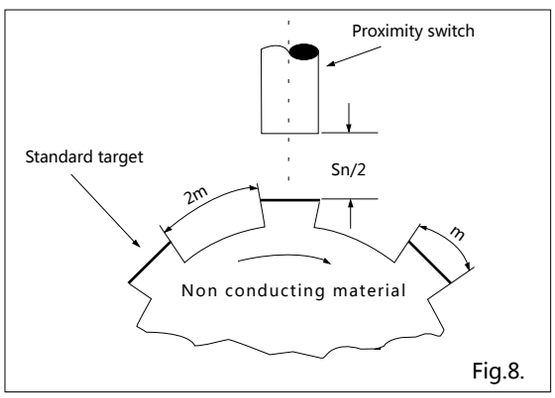


Fig.8.

Temperature drift of Sn

The switching distance is specified for an ambient temperature of 20 ℃。The following diagram gives the switching distance as a function of ambient temperature.

See Fig.9.

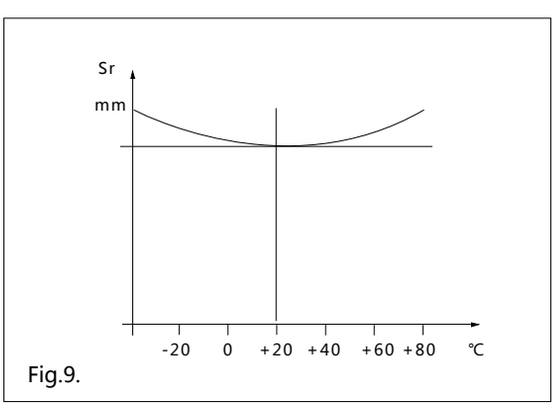
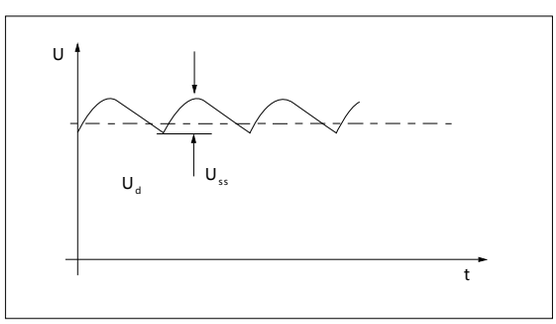


Fig.9.

Ripple content,maximum



$W = \frac{U_{ss}}{U_d} X100(\%)$

Too much ripple content causes an undefined switching behaviour. Remedy:increase the smoothing capacitor or use a stabilized power supply.

Protection class

The international electrotechnical commission(IEC)has defined a classification system for specifying the enclosures of electrical equipment on the basis of the degree of protection(IP)provided by the enclosure.The standard includes two characteristic numerals which follow the letters IP,and are defined as follows.

1st Characteristic Numeral

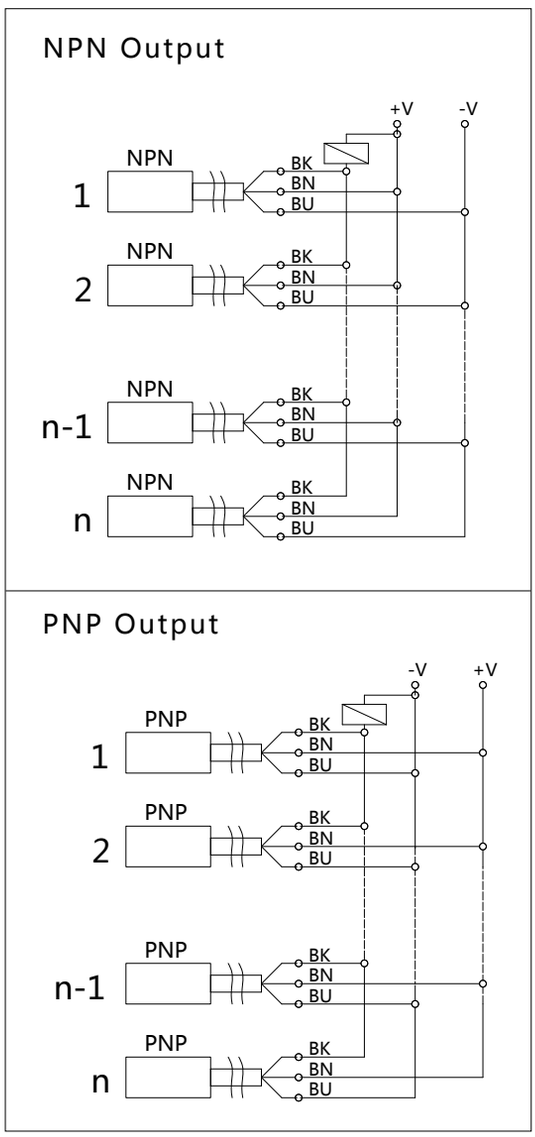
1 protection against solid objects greater than 50 mm
2 protection against solid objects greater than 12 mm
3 protection against solid objects greater than 2.5 mm
4 protection against solid objects greater than 1 mm
5 dust protected
6 dust tight

2nd Characteristic Numeral

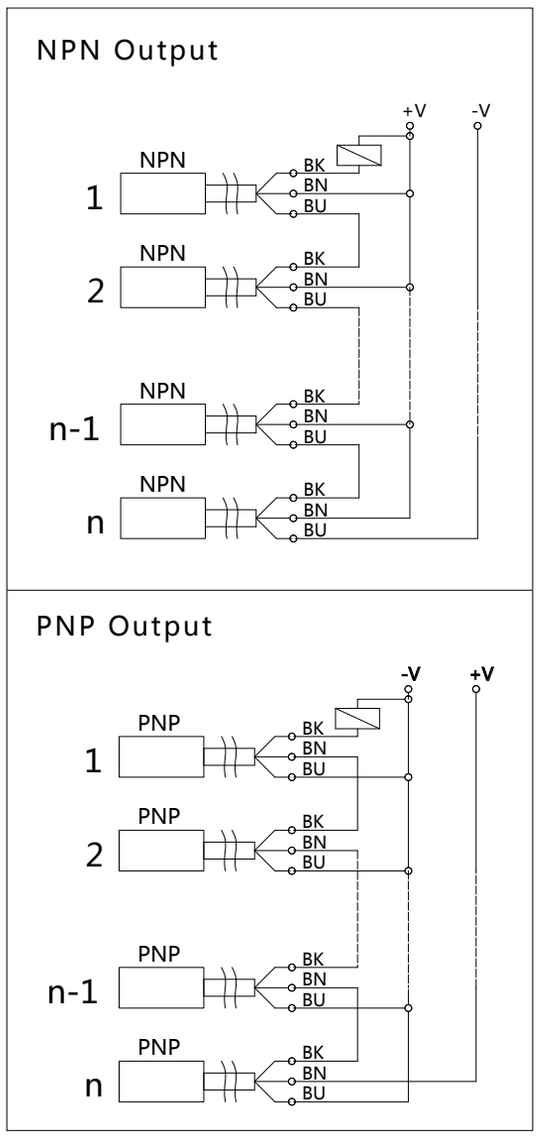
1 protection against dripping water
2 protection against dripping water when tilted up to 15°
3 protection against spraying water
4 protection against splashing water
5 protection against water jets
6 protection against heavy seas
7 protection against the effects of immersion
8 protection against submersion

Example:IP67 is defined as a dust tight enclosure and protected against the effects of immersion.

Parallel connection



Series connection



Logic functions with DC proximity sensors:

Self-contained proximity sensors can be wired in series or paralled to perform such logic functions as AND,OR, NAND,NOR.The wiring diagrams show the connection of four sensors with NPN and PNP outputs.Take into account the accumulating voltage drop per sensor added in the series-string.

Parallel-connection:

N.O.sensors:OR Function(any one sensor or all made:load"on")
N.C.sensors:NAND Function((all sensors open:load"off")

Series-connection:

N.O.sensors:AND Function(all sensors made: Load"on")
N.C. sensors:NOR Function(any one sensor open:load"off")

DC NPN output type

DC NPN output proximity switches consist of the following circuit(Fig.10.)In N.O.operation,with no sensing,the transistor is in the OFF mode.When sensing,the load current passes through the transistor.In N.C. operation,the function is opposite.In N.O. operation,as the load current passes 200mA(capacitive version over 300mA),the load short circuit protection is activated.

Remarks:Voltage drop<1V,it is tested in the max.load current, 200mA,Capacitive proximity switch is tested in 300mA.

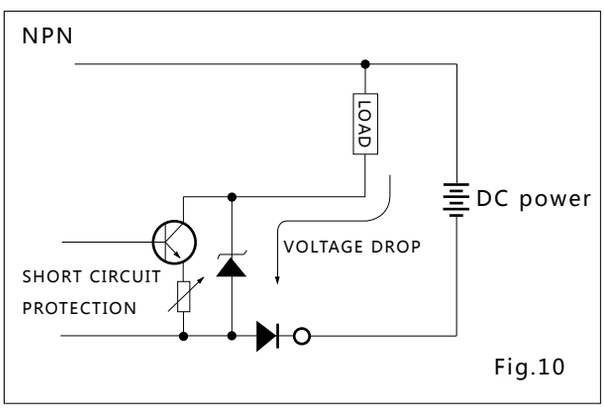


Fig.10

DC PNP output type

DC PNP output type proximity switches are designed with the following output circuit(Fig.11)In N.O.operation without sensing status,the transistor is in the OFF mode,with sensing status the transistor is in the ON mode,as the load current passes through the transistor;in the N.C.mode,the operation is opposite in the N.O.operation.AS the load current passes 200mA(capacitive proximity switch over 300mA),the load short circuit protection circuit is activated.

Remark:Voltage drop<1V is tested at the max. load current,200mA. Capacitive Proximity switches are tested at 300mA.

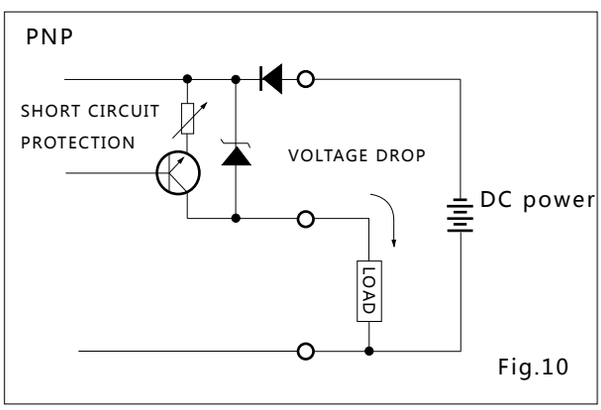


Fig.10

DC 2 wire proximity switch

The devices operate exactly like mechanical switches,with the connected load being switched in series.They can be used into PLC inputs like relays.Notice should be taken on the influence of minimum load current,leakage current and voltage drop.See following Fig.12.In the “off” condition,only the leakage current (the no load current)flows through the externalload.In the “on” conditionthe amplifiers’ output transistor conducts.

Between the connections of the proximity switch there is now a voltage drop created by the internal Z-diode(<6V)and this should be allowed for within the supply voltage.The voltage applied to the external load is lower than the supply voltage by an amount equal to the voltage drop.The output amplifier is short circuit proof and voerload protected.

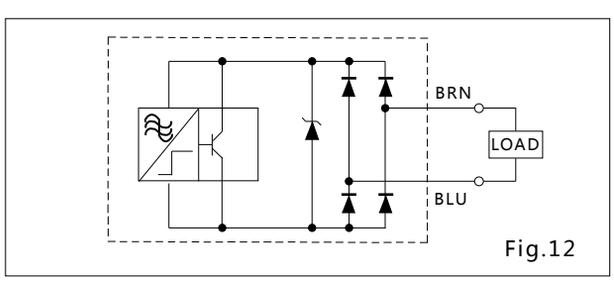


Fig.12

DC 4 wire proximity switch

N.O.,N.C.changeover 4 wire devices are shown in the following Fig.13.When the proximity switch is in the sensing mode transistor 1 is in the OFF mode;transistor 2 is in ON mode.

The max.load current is 200mA with short circuit protection. Output terminal N.O. and N.C. may be connected to the load at the same time.

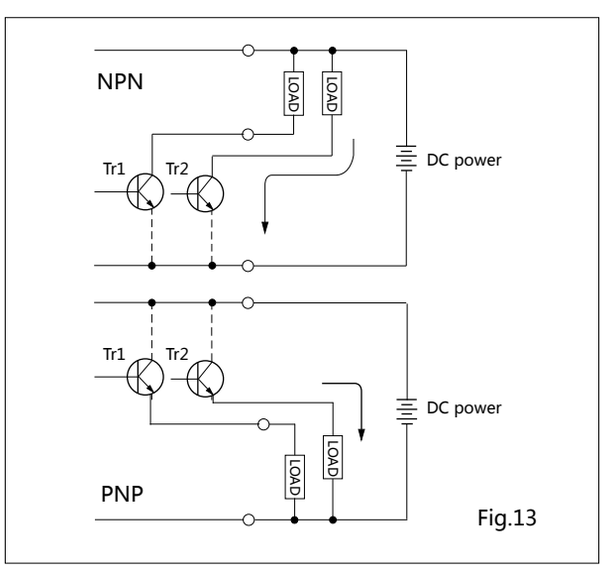


Fig.13

AC 2 wire proximity switch

AC output two wire proximity switches have output circuits with SCR.In the N.O. operation and non-sensing mode, the SCR appears OFF,in the sensed mode the SCR is ON.Load current passes through the SCR and to form feed circuit With extend load.In N.C. operation, the operation is opposite the N.O. operation. SCR in OFF mode, (it needs by the operation internal circuit for proximity switch).The small current passing through the load is called leakage current. When the SCR is in ON mode internal circuit of proximity switch operates).This small voltage is called dropping voltage.The max. load current is 500mA.Leakage voltage is below 5V(load current is over 20mA)leakage current is below 2.5mA.See Fig.14.

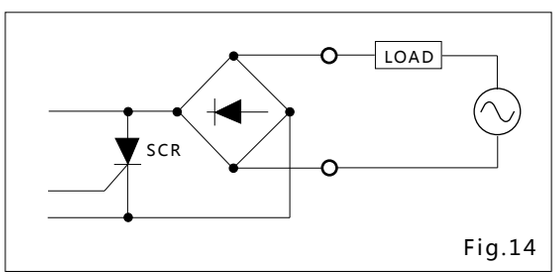


Fig.14

AC/DC outputs

These proximity switches are used as pilot devices for AC-operated loads such as relays,contactors,solenoids,etc.The solid state output permits the use of the proximity switches directly on the line in series with an appropriate load.They,therefore,replace mechanical limit switches without alteration of circuitry,where operating speed or environmental conditions require the application of solid state proximity switches.See following Fig.15.

These proximity switches are typically available in a voltage range of 20-250V AC or DC.All models are available with either N.O./N.C., or with programmable outputs(from N.O. to N.C.).

Proximity switches with AC/DC outputs are not recommended for use with 24V DC programmable controller inputs.

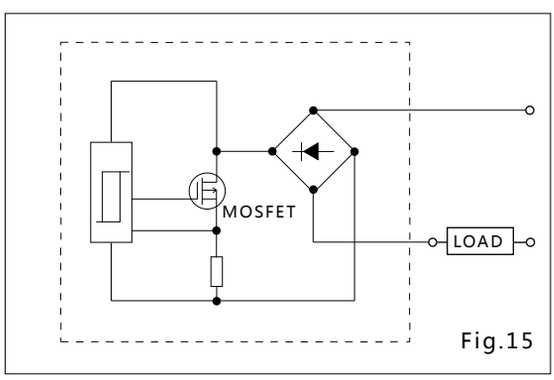


Fig.15

NAMUR-Sensors to DIN 19234

NAMUR-Sensors are polarized 2-wire-sensors which change their internal resistance depending on the distance to the target.They are designed for use with external amplifiers,which convert the current changes into a digital signal.Please see Fig.16.

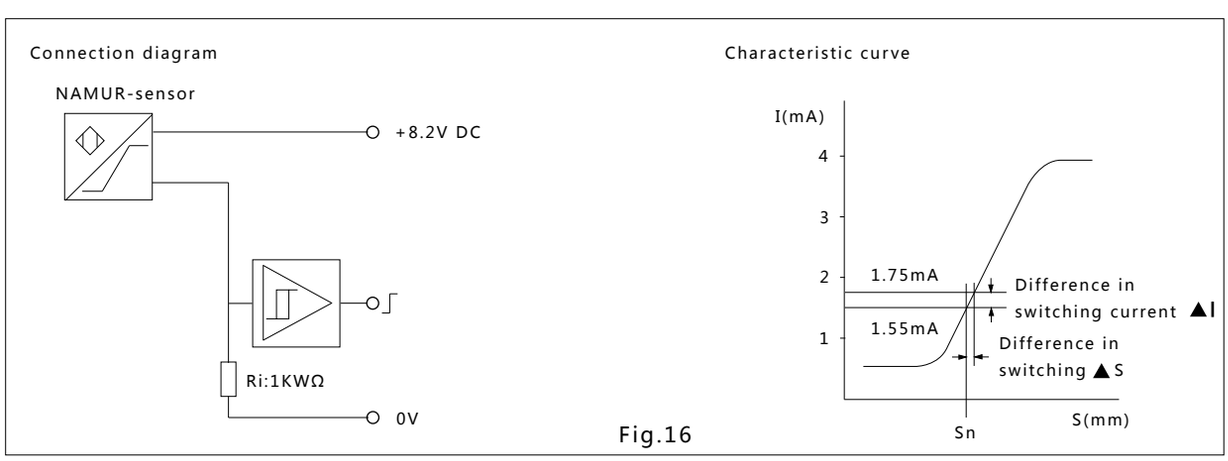


Fig.16

Connection diagram

NAMUR-sensors operate with a supply voltage from 5 to 25V DC.It is possible to work directly into logic circuits such as CMOS etc.

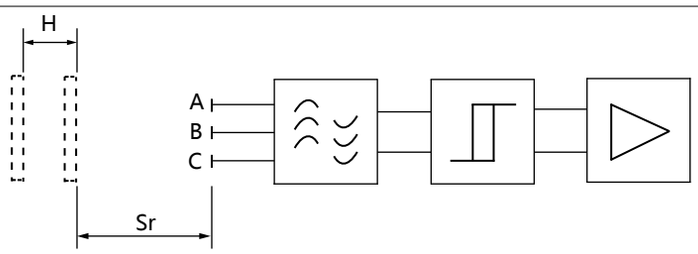
Note:different operating values(V,Ri)will counteract a change of the switching distance.Within the admissible voltage range it is necessary to adopt the resistance Ri,as well as the current in the switching point I(Sn). The following table shows typical values.

Capacitive proximity sensor

Capacitive proximity sensors consist of an RC-oscillator with a special multi-part sensing electrode.The electrode and the oscillator circuit have a tube connected with earth potential for lateral shielding. This enables flush mounting of the sensor in metal, since the electrial field is only present in front of the sensing electrode. This field is the active zone of the sensor. See Fig.17.

When the conductive material is removed from the active zone,the oscillator is undamped and the oscillation amplitude decreases. The amplifier of the oscillator voltage and the sensitivity of the sensor can be altered ty the built-in potentiometer.

The middle electrode together with the built-in re-coupling gives very effective compensation under conditions of humidity, dust or icing. Special circuitry automatically compensates for these influences. The preset sensing distance remains nearly constant. The electrode design, along with the compensating circuitry of capacitive sensors, is a unique design, and provides performance advantages far superior to other capacitive sensors.



A indicates sensor electrode
B and C indicates compensation electrodes

Fig. 17

Applications

The capacitive sensors may be used to limit the level in tanks and containers. The contents may be fluids, pulverized or granulated materials such as PVC powder,dyes,flour,sugar,powdered milk etc. Further applications are as end and limit switches for checking and regulating machinery setting,(even if the materials are non-metallic as in conveyor belt positioning and material stacking); checking drive belts and paper reels for sag and tear.Additionally they may be used as detectors for counting metal and non-metal components. Areas of application for capacitive sensors.

Shielded configuration

Sensors with a straight-line electrical field.These units scan solids(e.g.wafers,components,PCB’ s,hybrids, cartons,paper piles, bottles, plastic blocks and stacks of paper at a distance, or liquids through a separating wall (glass or plastic up to a max of 4 mm thick).

Non-shielded configuration

Sensors with a spherical electrical field. These units are designed to touch the product, bulk goods or liquids (e.g.granulate,sugar, flour, corn, sand, or oil and water) with their active surface.

Sensing distance

The data was obtained using a 1 mm thick square steel plate (st37) as an actuator, with a side length equal to 3×Sn. The steel plate was grounded. Ambient temperature was 25℃.The largest possible sensing distance is defined as the nominal sensing distance with a tolerance ±10% Sn.
The sensing distance depends upon shape, size and nature of the object concerned. If the plate is made from a different material or has a smaller diameter, the sensing distance will be reduced.

Material correction factor

If the material of the object in question is not metal or water,the sensing distance is reduced.
The reduction factors for the different materials are shown as the table below.

Actuating Material	Sensing-distance Compared to a surface of water			
	20mm	10mm	15mm	10mm
Hand	20	10	15	10
Square steel plate(100X100X1)	20	10	15	10
Round steel plate(30ΦX1)	11	6	4	2
Stone(marble)	18	8.5	8	5
Wood	13	5	5	3
Glass	12	4	6	2.5
Carbon	19	9	12	9
PVC-BLOCK(30x30x5)	8	4	1.5	-
Lupulin granulate 1800H	8	3	2.5	Head approx.2mm immersed
Polystyrene 454H	9.5	3	4	1
Hostalen GC 8960H	8.2	1.5	2	Head approx.1mm immersed
Vestyron 719-50	7.9	1.2	2	Head approx.3mm immersed
Hostyren	8.2	3	3	Head approx.1mm immersed
BM scrap material(Z)	6.7	1.4	1	Head surrounded
Hostalen GC coarse powder	8	2	1.5	Head approx.3mm immersed
Lupulin fine granulate	7.7	1.5	1	Head approx.3mm immersed
HostaformC	9.8	3.5	4	1
Hostyren(polystyrene)	7.4	2	2.5	Head approx.2mm immersed
Hostalit S	7.5	2	1.5	Head surrounded
Hostalen PP	5	1.5	1.5	Head surrounded
Hostalit E	7.2	1	1	Head approx.4mm immersed
Styropor unfoamed	8.1	3	3	0.5
Styropor Φ 1.5	-	-	-	-
Antimony-trioxide	6.2	0.9	2.5	Direct contact
Oil	9	3	5	3
Maximum sensing-distance Critical point	55		110	

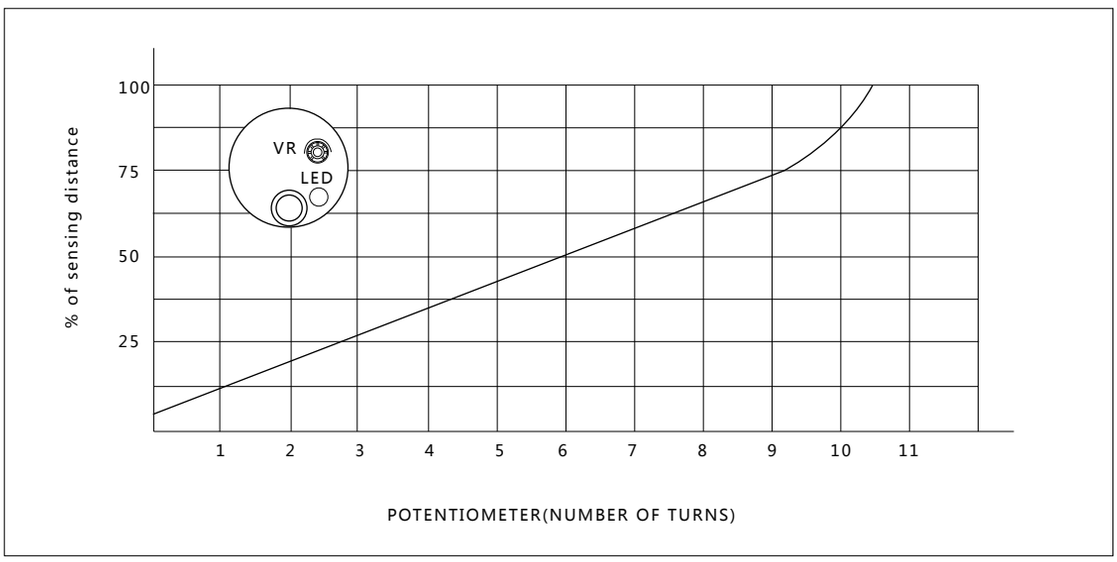
Conditions:

Tu=25℃ ; V_A=24V DC

In each case,the measurements were made from a level surface.

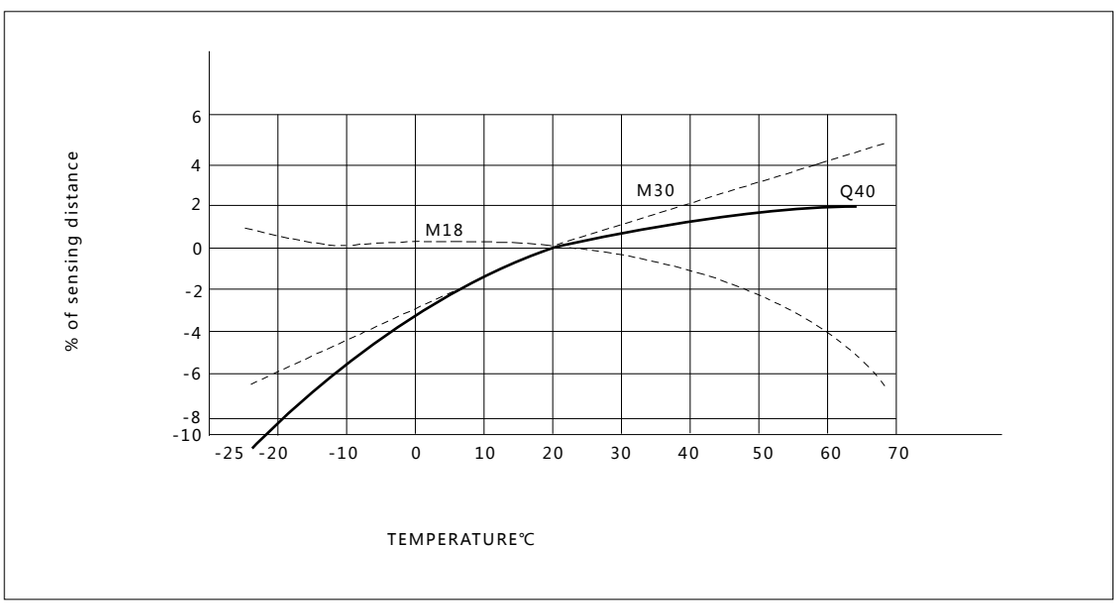
Sensitivity adjustment

Capacitive proximity sensors have a fourteen turn potentiometer.The potentiometer must be adjusted to suit most applications.Turn clockwise to increase sensitivity.From the original setting of 0.7-0.8xSn(Sn=nominal range),the nominal sensing range is reached after 2-3 clockwise turns. This, however,leads to nonlinearity of the curve and oversensitivity,which may lock on the sensor.If this occurs,decrease sensitivity by turning the potentiometer 2-3 turns counterclockwise.



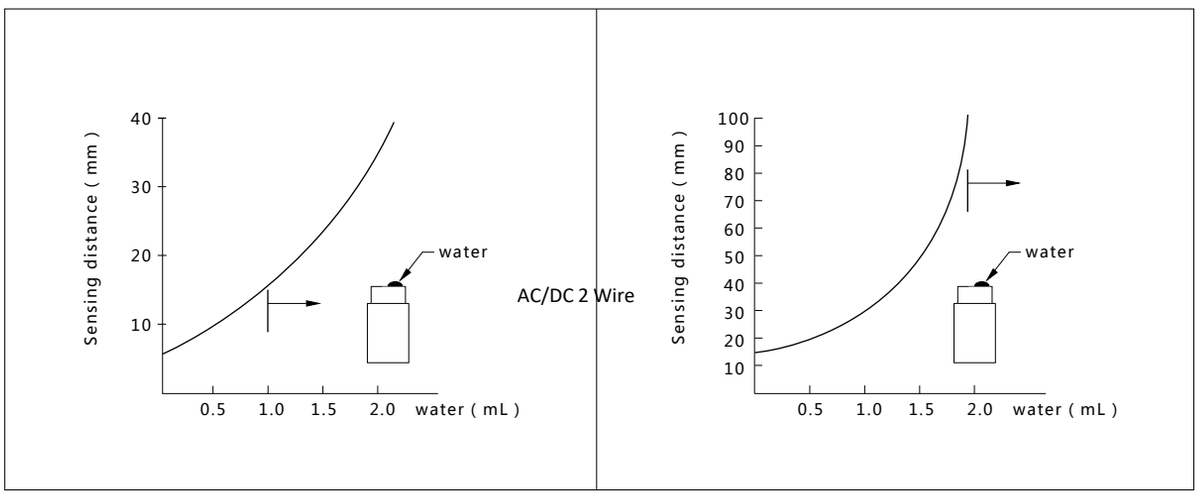
Temperature

Capacitive proximity switches will function within a temperature range of -25℃ to +70℃.The switching distance deviation is 20% provided that the switching distance is not greater than the nominal switching distance(taking into consideration the reduction factors of the material).



Influence to sensing face covered with drops of water

The following figures show the changes to operating distance caused by drops of water on the sensing face of capacitive proximity switches.If the water drops are 0.2 mL(about 2-3 drops),the operating distance will be increased about 20%,as the attached water drops on the sensing face cover the surface and is flowing operating distance is increased over 300%.,



Caution

If ice,frost,moisture,oil or dust is on the active surface,it will cause faultly operation.

The detecting of liquid or powder on non-metallic tanks,if the liquids or powders are attached to tank wall like as Fig.19,it will cause faulty operation.

The application of a DC capacitive proximity switch,connectted to a heavy load current (current over 200 mA),(electric motor,electrical-magnetic contact)the output transistor will break down.It should be connected through a relay.

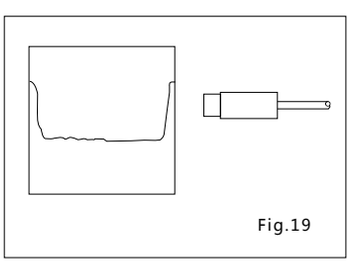


Fig.19