PROXIMITY SWITCHES, GENERAL

Inductive Proximity Switches

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 electro-magnetic field, an induced eddy current occurs. This eddy current extracts energy from the L/C resonant circuit in the switch, and produces a reduction in the oscillation amplitude. This reduction in the amplitude is converted by the associated electronic circuitry into a clear electronic signal, and changes the state of the switch.

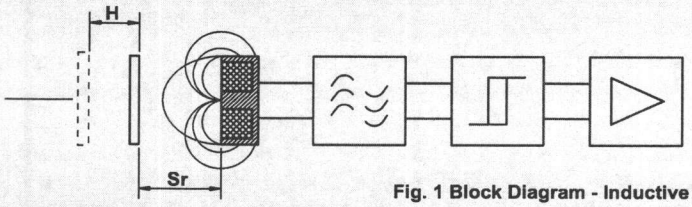


Fig. 1 Block Diagram - Inductive Switch

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.

Normal Operating Distance

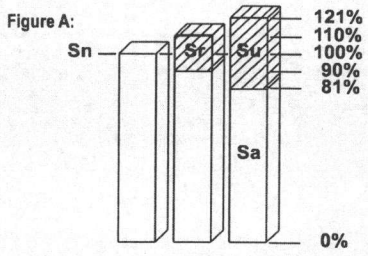
The Normal Operating Distance is defined as the distance between the detector and the target when the change (switching) in the logic state of the proximity switch occurs. This distance and the tests associated in obtaining this distance are outline in CENELEC EN 50010 Standards. From this standard the target for establishing Normal Operating Distance is an iron (Fe 37) 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 Figure A.

Table 1:

Diameter (mm)	Nominal distance SN (mm)	Fe 37 actuator (mm)
8	1	☐ 8x1
8	2	☐ 8x1
12	2	☐ 12x1
12	4	☐ 12x1
18	5	☐ 18x1
18	8	☐ 24x1
30	10	☐ 30x1
30	15	☐ 45x1

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

Figure A:



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

PROXIMITY SWITCHES, GENERAL

Correction Factor

Inductive : When using inductive proximity switches with non-ferrous metals it is nescessary to apply a correction factor to the operating distance (sensing range) as follows:

Brass	**Distance**	**X. 0.50**
Aluminum	**Distance**	**X. 0.45**
Copper	**Distance**	**X. 0.40**
Chrome Nickel Alloy	**Distance**	**X. 0.90**
Stainless steel	**Distance**	**X. 0.85**

Capacitive : Capacitive switches have an adjustable detection range, and are dependent upon the type of material to be sensed. See Figure 4.

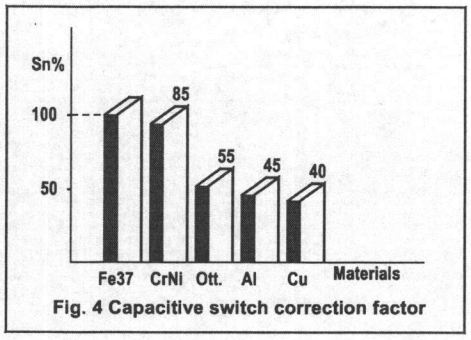
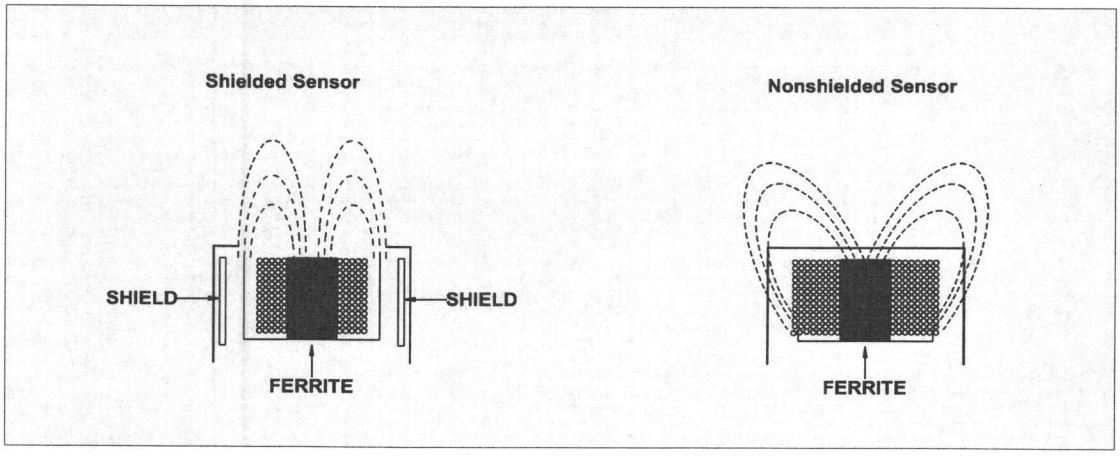


Fig. 4 Capacitive switch correction factor

Shielded & Nonshielded

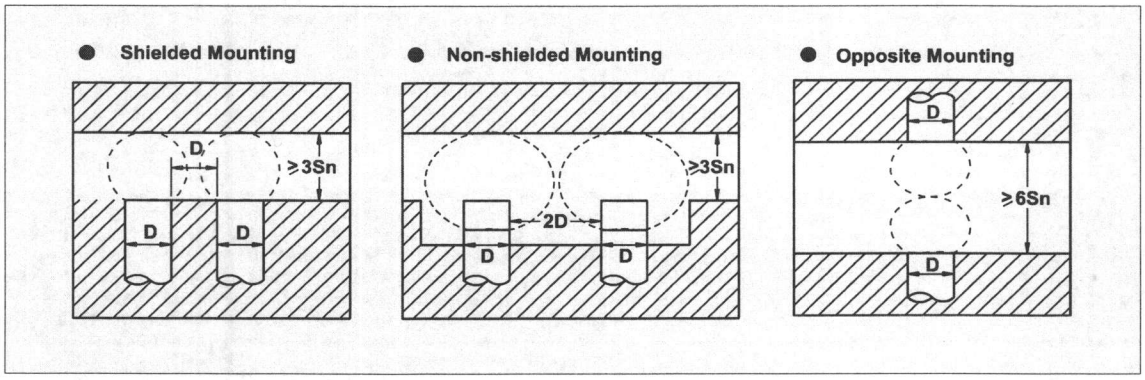
Shielded construction includes a metal band which surrounds the ferrite core and coil arrangement. This helps to direct the electro-magnetic field to the front of the sensor.

Nonshielded sensors do not have this metal band, therefore they can be side sensitive.



PROXIMITY SWITCHES, GENERAL

■ Mounting



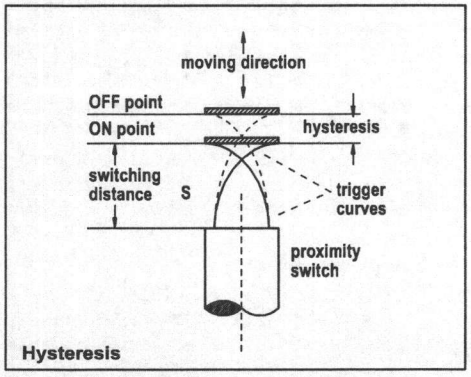
Because of possible interference of the electromagnetic fields generated by the oscillators, minimum spacing is required between adjacent or opposing "active surfaces" of proximity switches.

The "active surface " may be flush with the metal in which the switch is mounted, (see figure "Shielded Mounting".) The "active surface" must have a free zone in which no metal is present, (see figure "Non-shielded Mounting".) When mounting proximity switches in this manner where the "active surfaces" are opposite each other, there must be a minimum distance between them,(see figure "Opposite Mounting".)

It is good engineering practice to mount proximity switches horizontally or with the active surface facing down. Avoid proximity switches that face up wherever possible, especially if metal filings and chips are present.

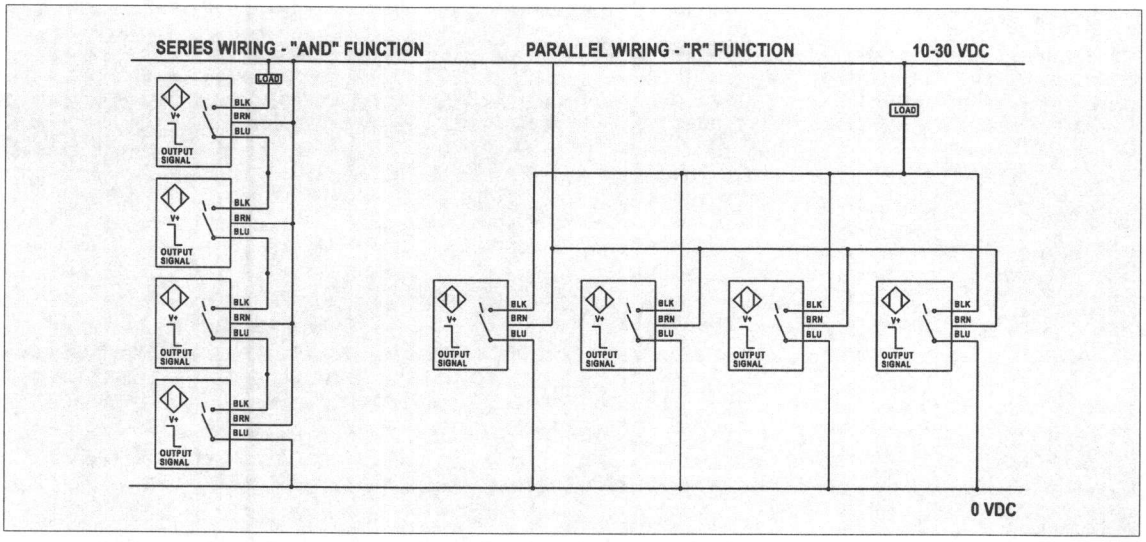
■ Hysteresis

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 following figure.

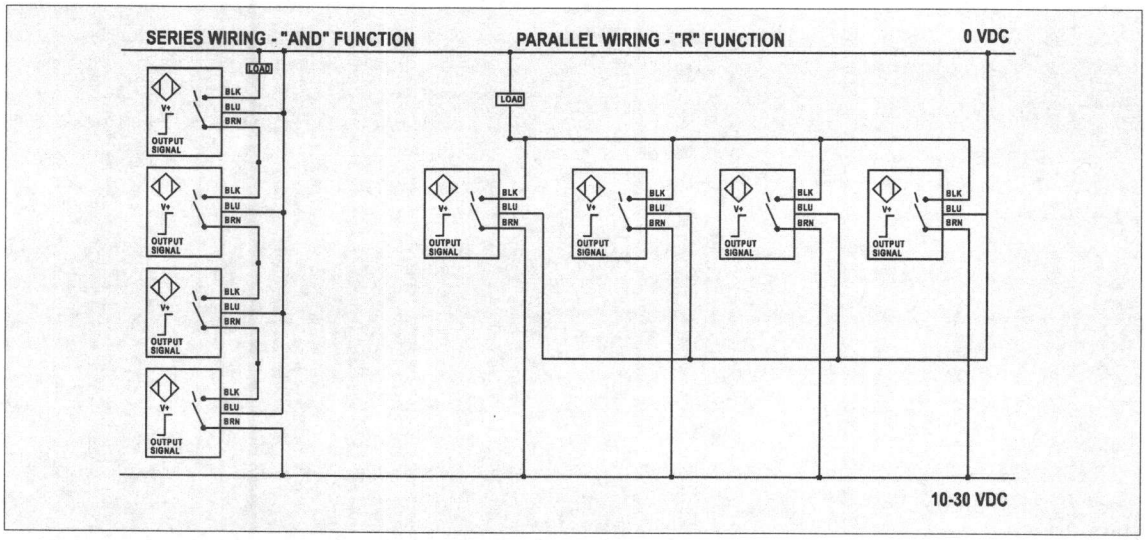


PROXIMITY SWITCHES, GENERAL

NPN Connection



PNP Connection



Logic functions with DC proximity sensors:

Self-contained proximity sensors can be wired in series or parallel 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.

Series-connection:

N.O. sensors: AND Function (all sensors made: Load "on")

N.C. sensors: NOR Function (any one sensor open:load "off")

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")

PROXIMITY SWITCHES, GENERAL

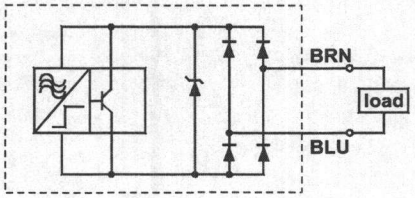
■ DC 2 wire proximity switch

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.

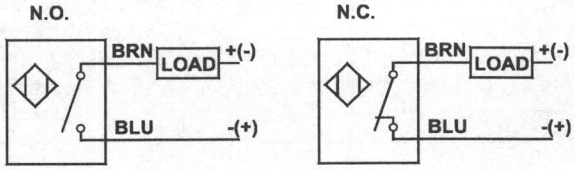
In the "off" condition, only the leakage current(the no load current) flows through the external load. In the "on" condition the amplifiers' output transistor conducts.

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 overload protected.

● Output circuit



● Wiring diagram



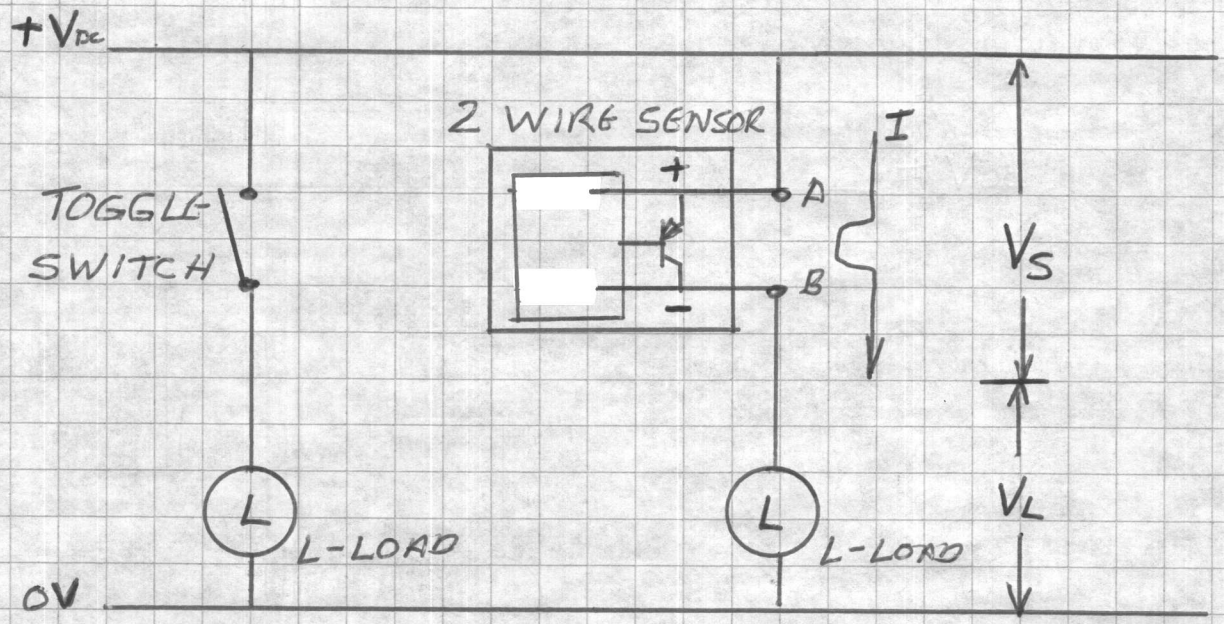
Series and parallel connection of 2 wire DC proximity switches is not permitted.

CONTROLL DIAGRAMS NEXT PAGE

○ Specifications

Item \ Diameter	M8		M12		M18		M30 or Q-type	
	Shielded	Non-shielded	Shielded	Non-shielded	Shielded	Non-shielded	Shielded	Non-shielded
Supply voltage	10-60 V DC							
Ripple Vpp	<10%							
Output	N.O. or N.C.							
Continous load current	3-100 mA							
Leakage current	<1.2 mA		<0.8 mA					
Voltage drop(at Icont.)	<8 V		<6 V					
Reverse polarity protection	Yes							
Short-circuit protection	Yes							
Overload trip point	>120 mA							
Transient protection	2 kV, 1 mS, 1 kohm							
Switching frequency	2KHz	2KHz	1KHz	1KHz	1KHz	500Hz	500Hz	200Hz
Switching hysteresis	15%							
Temperature drift	±10%							
Repeat accuracy	<2%							
Operating temperature	-25°C to +70°C							

2 WIRE DC SENSOR PNP MOOG



TOGGLE - OPEN - NO CURRENT FLOW
- LOAD NOT ACTIVE - (OFF)

- CLOSED - CURRENT FLOW
- LOAD CONNECTED TO +V LINE
- LOAD IS ACTIVE - (ON)

2 WIRE - OPEN - LEAKAGE CURRENT FLOWS TO KEEP ALIVE
- LOAD IS NOT ACTIVE (OFF)
-

IN 24V CIRCUT (APPROX)

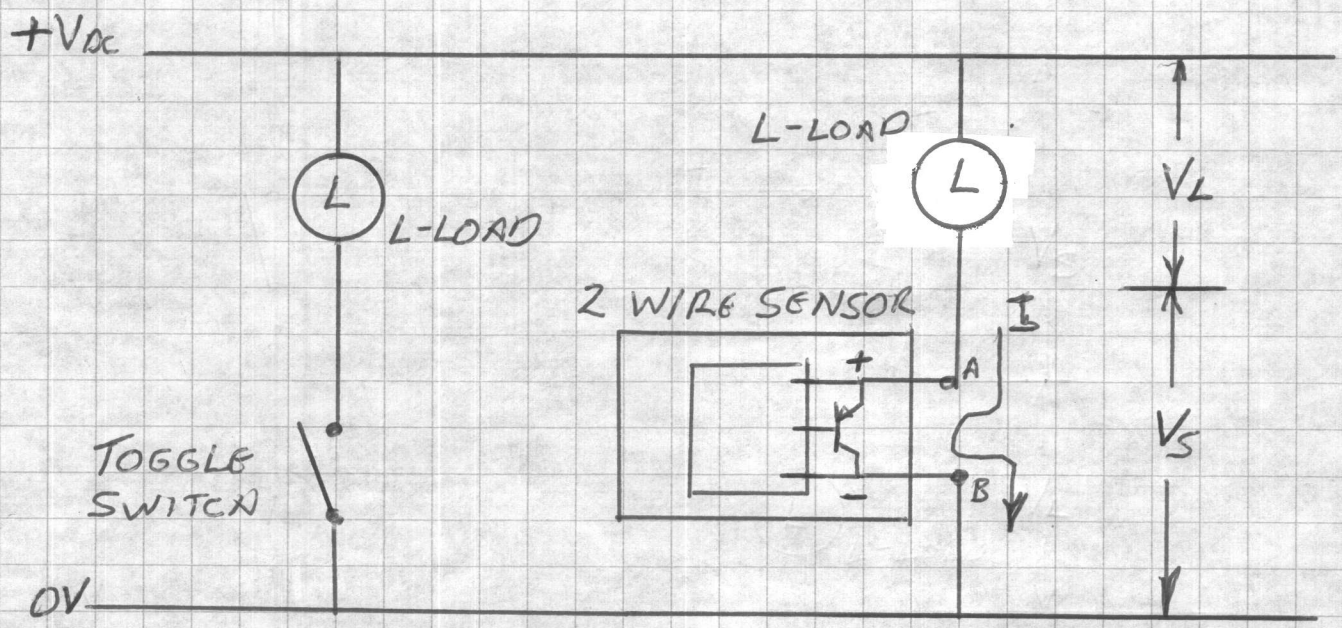
OPEN I_L = 1mA V_L = 6V

CLOSED $I_L = I_L + 1_{mA}$ V_L = 20V

- CLOSED - LEAKAGE AND LOAD CURRENT FLOW
- LOAD IS ACTIVE (ON)
VOLTAGE V_S = 6V, V_L = 18V
- LOAD CONNECTED TO +V (-V_S) OR HIGH

NOTE!
LEAKAGE CURRENT MUST ALWAYS BE LESS THAN CURRENT REQUIRED TO TURN ON THE LOAD!

2 WIRE DC SENSOR — NPN MODE



TOGGLE — OPEN — NO CURRENT FLOW
- LOAD NOT ACTIVE (OFF)

- CLOSED - CURRENT FLOW
- LOAD CONNECTED TO OV LINE
- LOAD IS ACTIVE

2 WIRE - OPEN - LEAKAGE CURRENT FLOWS TO KEEP ALIVE
- LOAD IS NOT ACTIVE (OFF)

CLOSED - LEAKAGE AND LOAD CURRENT FLOW
- LOAD IS ACTIVE (ON)
- LOAD IS EFFECTIVELY CONNECTED TO OV

IN 24V CIRCUIT (APPROX)

OPEN - $I_L = 1mA$ $V_L = 6V$

CLOSED - $I_L = I_L + 1mA$ $V_L = 18V$

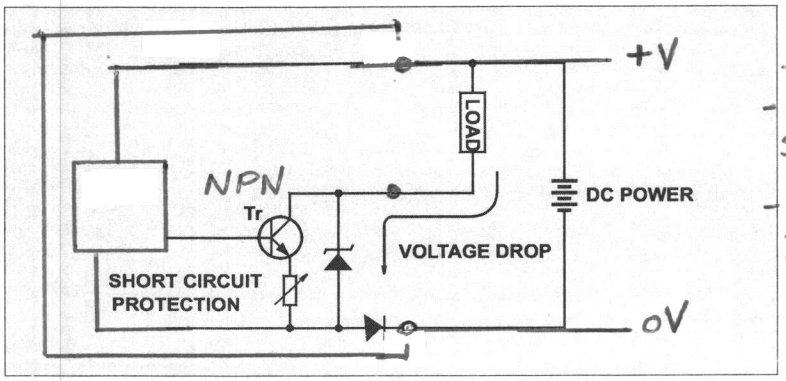
NOTE:
LEAKAGE CURRENT MUST ALWAYS BE LESS THAN CURRENT REQUIRED TO TURN ON THE LOAD!

PROXIMITY SWITCHES, GENERAL

■ DC NPN output type

DC NPN output proximity switches consist of the following circuit. 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.



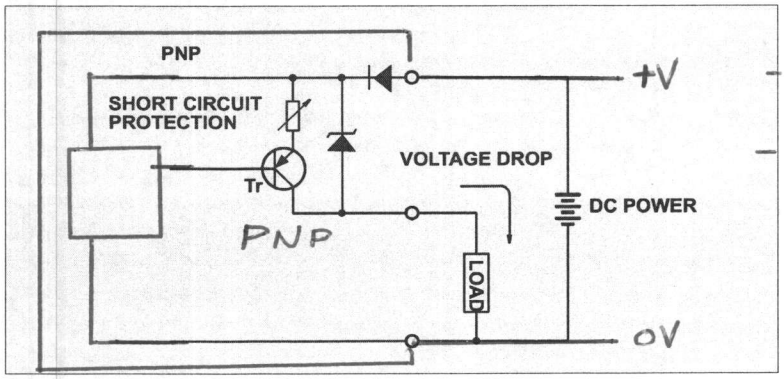
NPN
- NEGATIVE SWITCH
- PULL DOWN

■ DC PNP output type

DC PNP output type proximity switches are designed with the following output circuit.
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.



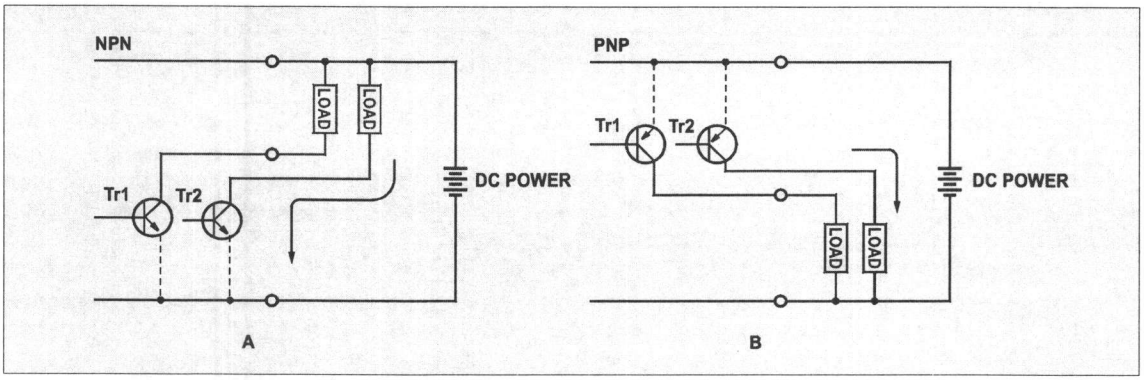
PNP
- POSITIVE SWITCH
- PULL HIGH

PROXIMITY SWITCHES, GENERAL

■DC output type four wire

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

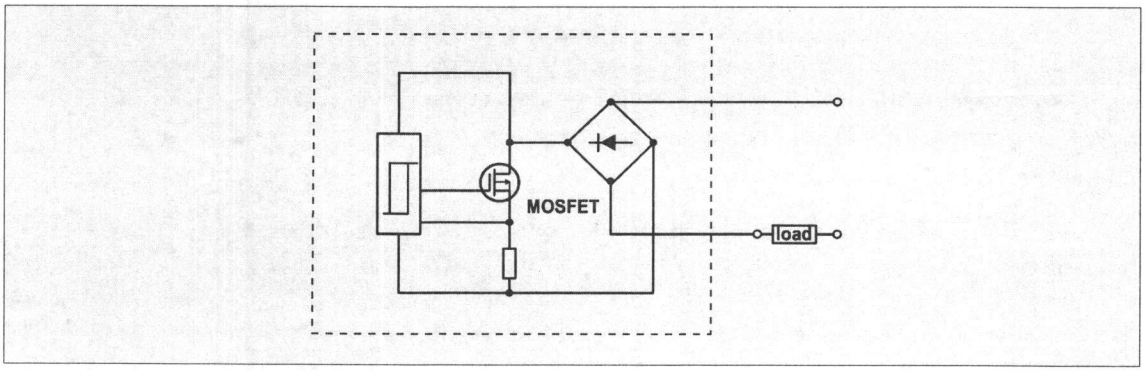
The max. load current is 200mA with short circuit protection. Output terminal N.O. and N.C. may be connected to the load at the same time.



■ 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.

These proximity switches are typically available in a voltage range of 20-250V AC or DC. All models are available with either normally open(N.O.) normally closed(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.

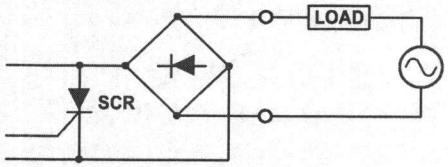


PROXIMITY SWITCHES, GENERAL

■ AC output two wire device

AC ouput 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 500 mA.
Leakage voltage is below 5V(load current is over 20mA) leakage current is below 2.5mA.

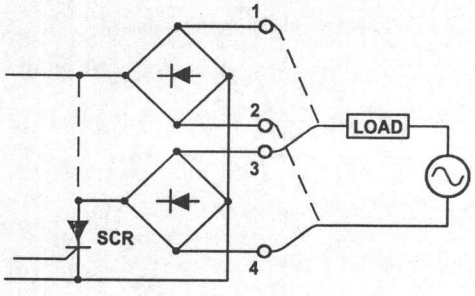


■ AC two wire output, N.O., N.C. changeable

AC two wire output, N.C. / N.O. operation is changeable, per the schematic below.
Feedback circuit as head is connected with terminal 3 and 4, proximity switch is in N.O. mode.
As load is connected with terminal 1 and 2, proximity switch is in N.C. mode. As SCR is in OFF status, the internal circuit of proximity switch the working needs the very small current which is called leakage current.

As SCR is in the status of ON, the internal operation of proximity switch,the very small voltage available is called dropping voltage.

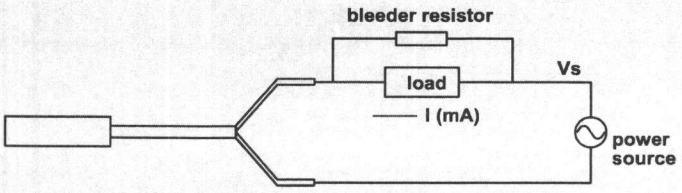
The max. load current is 500 mA.
Dropping voltage below 5V(load current over 20mA), leakage current is below 2.5mA.
N.O.,N.C. operation are not available at the same time.It is only available for N.O. or N.C.



PROXIMITY SWITCHES, GENERAL

■ 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.



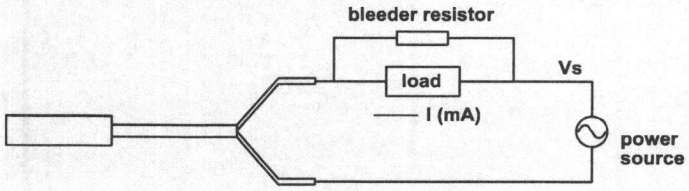
$R \leq \frac{Vs - 3.6}{5(mA) - I(mA)}$ (kΩ) DC 2-WIRE type

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

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

■ Continuous current

If continuous current flowing through the load is less than 10 mA, the proximity switch will malfunction. Connect the bleeder resistor parallel to the load in order to increase the current flowing through the load to more than 10 mA. This allows the SCR in the circuit to operate reliably, and decreases the remaining voltage across the load.



$R \leq \frac{Vs - 3.6}{10(mA) - I(mA)}$ (kΩ) DC 2-WIRE type

$R \leq \frac{Vs}{10(mA) - I(mA)}$ (kΩ) AC 2-WIRE type

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

Example

AC power source	bleeder resistor	
AC 100V	4.7kΩ	more than 5W
AC 200V	8.2kΩ	more than 10W

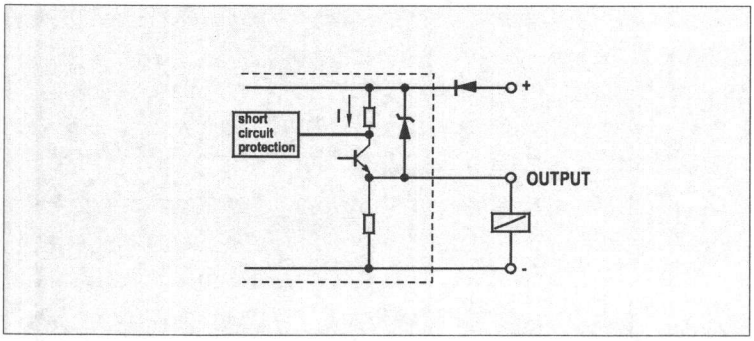
PROXIMITY SWITCHES, GENERAL

■ 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.

  This kind of proximity switch's voltage drop is <1V.



■ Maximum torque for proximity sensor threads in Nm:

Thread	POM	Brass	Stainless steel
M5x0.5	———	———	1.5
M8x1	———	3.5	4.5
M12x1	1	16	25
M18x1	2.3	28	60
M30x1.5	7	150	230
M42x1.5	———	200	———

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