Logical Sensors

A *sensor* element measures a process variable: flow rate, temperature, pressure, level, pH, density, composition, etc. Much of the time, the measurement is inferred from a second variable: flow and level are often computed from pressure measurements, composition from temperature measurements. A *transducer* is a device that receives a signal and retransmits it in a different form. For example, we've discussed I/P transducers that convert a current signal to pneumatic form. Most industrial sensors act to detect process variables in the form of a position or voltage change, and hence most sensors also function as transducers. For example, a thermocouple represents a temperature change as a voltage change, while a displacer represents a level change as a change in position of a rotating element. If the sensor element does not produce a signal suitable for transmission through the plant, an additional transducer element is needed. This combined sensor/transducer device is typically called a *transmitter*, at least in industrial settings. Laboratory equipment manufacturers are likely to refer to the combined device as a transducer.

Logical Sensors

Sensors allow process controllers such as a PLC to detect the state of a process. Logical sensors can only detect a state that is either true or false. Examples of physical phenomena that are typically detected are listed below.

- Inductive proximity - is a metal object nearby?
- Capacitive proximity - is a dielectric object nearby?
- Optical presence - is an object breaking a light beam or reflecting light?
- Mechanical contact - is an object touching a switch?

Recently, the cost of sensors has dropped and they have become commodity items, typically between $50 and $100. They are available in many forms from multiple vendors such as:

- Allen-Bradley,
- Rockwell Automation
- Asea Brown Boveri (ABB)
- Siemens
- Omron,
- Hyde Park and
- Turck, etc.

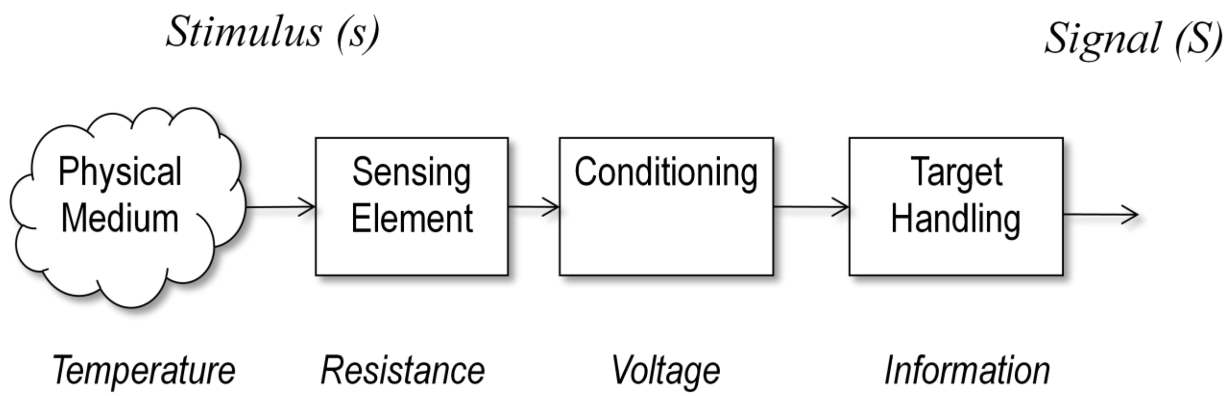
Sensor Type	Method of operation	COTS sensors of this type	Approx. cost ($)
Bump/Proximity	Contact	Momentary/toggle switch	1
Gyro (angular rate)	Inertial	Piezo RC gyro	80
Accelerometers	Inertial	Analog devices MEMES accel.	10
Compass	Magnetic	Precision Navigation Vector 2X	40
Encoder	Optical	US Digital Encoder	35
Laser Ranger	Time of flight	Leica and Sick	1-3k
Ultrasonic Ranger	TOF	Polaroid 6500 / Devantech	70 / 35
IR Ranger	PSD	Sharp GP2D12	12
Camera	CCD array + image processing	CMU Cam	125

In applications sensors are interchangeable between Process Controllers vendors, but each sensor will have specific interface requirements. This chapter will begin by examining the various electrical wiring techniques for sensors, and conclude with an examination of many popular sensor types.

Sensor Wiring

When a sensor detects a logical change it must signal that change to the PLC or any other controller. This is typically done by switching a voltage or current on or off. In some cases the output of the sensor is used to switch a load directly, completely eliminating the PLC. Typical outputs from sensors (and inputs to PLCs) are listed below in relative popularity.

- Sinking/Sourcing - Switches current on or off.
- Plain Switches - Switches voltage on or off.
- Solid State Relays - Switches AC outputs.
- TTL (Transistor Transistor Logic) - Uses 0V and 5V to indicate logic levels.



Switches

The simplest examples of sensor outputs are switches and relays. A simple example is shown in “An Example of Switched Sensors”.

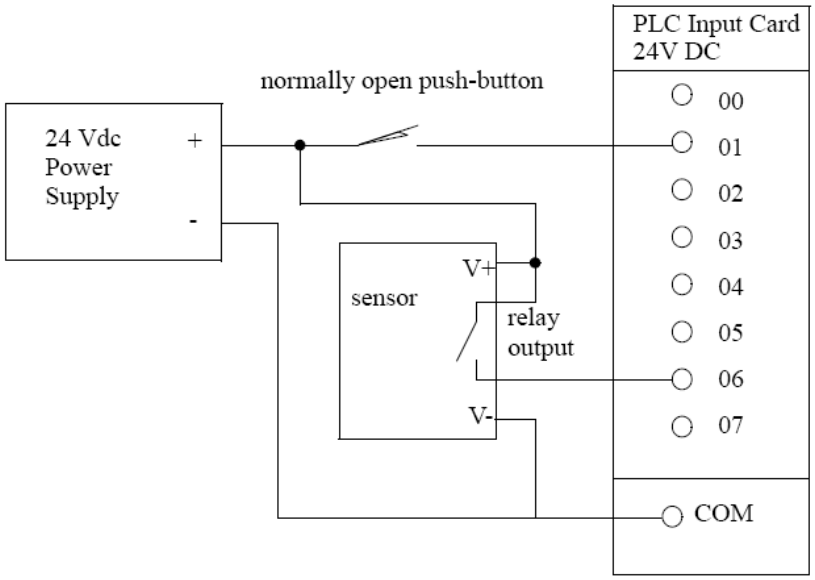


Figure 10.40 An Example of Switched Sensors

In the figure a NO contact switch is connected to input *01*. A sensor with a relay output is also shown. The sensor must be powered separately, therefore the *V+* and *V-* terminals are connected to the power supply. The output of the sensor will become active when a phenomenon has been detected. This means the internal switch (probably a relay) will be closed allowing current to flow and the positive voltage will be applied to input *06*.

Transistor Transistor Logic (TTL)

Transistor-Transistor Logic (TTL) is based on two voltage levels, 0V for false and 5V for true. The voltages can actually be slightly larger than 0V, or lower than 5V and still be detected correctly. This method is very susceptible to electrical noise on the factory floor, and should only be used when necessary. TTL outputs are common on electronic devices and computers, and will be necessary sometimes. When connecting to other devices simple circuits can be used to improve the signal, such as the Schmitt trigger in “A Schmitt Trigger”.

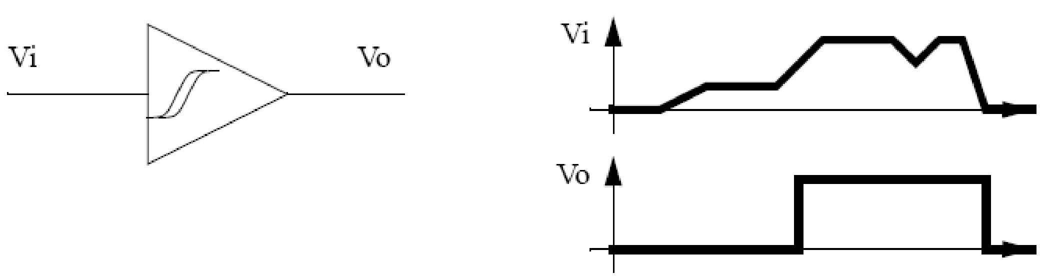
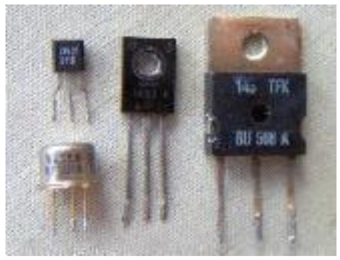
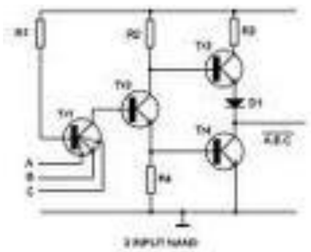


Figure 10.41 A Schmitt Trigger

A Schmitt trigger will receive an input voltage between 0-5V and convert it to 0V or 5V. If the voltage is in an ambiguous range, about 1.5-3.5V it will be ignored. If a sensor has a TTL output the PLC must use a TTL input card to read the values. If the TTL sensor is being used for other applications it should be noted that the maximum current output is normally about 20mA.

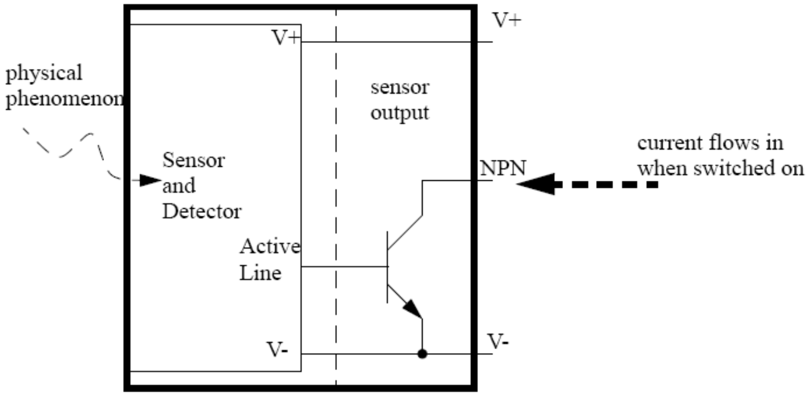




Sinking/Sourcing

Sinking sensors allow current to flow into the sensor to the voltage common, while sourcing sensors allow current to flow out of the sensor from a positive source. For both of these methods the emphasis is on current flow, not voltage. By using current flow, instead of voltage, many of the electrical noise problems are reduced.

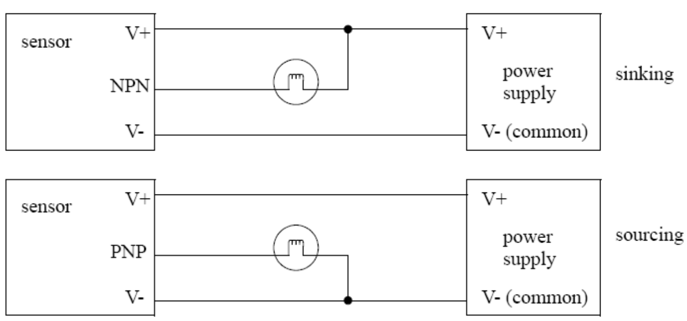
When discussing sourcing and sinking we are referring to the *output* of the sensor that is acting like a switch. In fact the output of the sensor is normally a transistor that will act like a switch (with some voltage loss). A PNP transistor is used for the sourcing output, and an NPN transistor is used for the sinking input. When discussing these sensors the term sourcing is often interchanged with PNP, and sinking with NPN. A simplified example of a sinking output sensor is shown in “A Simplified NPN/Sinking Sensor” on page 305. The sensor will have some part that deals with detection, this is on the left. The sensor needs a voltage supply to operate, so a voltage supply is needed for the sensor. If the sensor has detected some phenomenon then it will trigger the active line. The active line is directly connected to an NPN transistor. (Note: for an NPN transistor the arrow always points away from the center.) If the voltage to the transistor on the *active line* is 0V, then the transistor will not allow current to flow into the sensor. If the voltage on the active line becomes larger (say 12V) then the transistor will switch on and allow current to flow into the sensor to the common.



Aside: The sensor responds to a physical phenomenon. If the sensor is inactive (nothing detected) then the active line is low and the transistor is off, this is like an open switch. That means the NPN output will have no current in/out. When the sensor is active, it will make the active line high. This will turn on the transistor, and effectively close the switch. This will allow current to flow into the sensor to ground (hence sinking). The voltage on the NPN output will be pulled down to V-. Note: the voltage will always be 1-2V higher because of the transistor. When the sensor is off, the NPN output will float, and any digital circuitry needs to contain a pull-up resistor.

Figure 10.42 A Simplified NPN/Sinking Sensor

Most NPN/PNP sensors are capable of handling currents up to a few amps, and they can be used to switch loads directly. (Note: always check the documentation for rated voltages and currents.) An example using sourcing and sinking sensors to control lights is shown in “Direct Control Using NPN/PNP Sensors”. Note: This example could be for a motion detector that turns on lights in dark hallways.



Note: remember to check the current and voltage ratings for the sensors.

Note: When marking power terminals, there will sometimes be two sets of markings. The more standard is V+ and COM, but sometimes you will see devices and power supplies without a COM (common), in this case assume the V- is the common.

Figure 10.44 Direct Control Using NPN/PNP Sensors

In the sinking system in “Direct Control Using NPN/PNP Sensors” , the light has V+ applied to one side. The other side is connected to the NPN *output* of the sensor. When the sensor turns on the current will be able to flow through the light, into the output to V- common. (Note: Yes, the current will be allowed to flow into the output for an NPN sensor.) In the sourcing arrangement the light will turn on when the output becomes active, allowing current to flow from the V+, thought the sensor, the light and to V- (the common).

Presence Detection

There are two basic ways to detect object presence; contact and proximity. Contact implies that there is mechanical contact and a resulting force between the sensor and the object. Proximity indicates that the object is near, but contact is not required. The following sections examine different types of sensors for detecting object presence. These sensors account for a majority of the sensors used in applications.

Contact Switches

Contact switches are available as normally open and normally closed. Their housings are reinforced so that they can take repeated mechanical forces. These often have rollers and wear pads for the point of contact. Lightweight contact switches can be purchased for less than a dollar, but heavy duty contact switches will have much higher costs. Examples of applications include motion limit switches and part present detectors.

IEC Limit Switches

ABM series heavy-duty IEC limit switches

- Featuring a diecast aluminum body for heavy-duty industrial applications
- Single and multiple conduit openings to save wiring time and money when interconnecting several limit switches
- Conduit openings in 1/2" NPT or PG13.5
- Splined actuator shaft allows very fine adjustment of switch to fit all applications
- Choose from eight different actuators including roller levers and plungers


A

B

C

D

E

F

G

H

I

J

ABM Series

Part Number	Price	Actuator Type	No. of Conduit Holes	Conduit Threads	Max. Actuation Speed (m/s)	Min. Actuation Force (N) /Torque (Nm)	Min. Positive Opening Force (N) /Torque (Nm)	Dimensions: Body / Head	Photo
ABM1E11Z11	<--->	Stainless steel plunger	One	PG13.5	0.5	30(N)	45(N)	Figures 1, 5	A
ABM2E11Z11	<--->		One	1/2" NPT	0.5	30(N)	45(N)	Figures 1, 5	A
ABM5E11Z11	<--->		Three	PG13.5	0.5	30(N)	45(N)	Figures 2, 5	B
ABM6E11Z11	<--->		Three	NPT	0.5	30(N)	45(N)	Figures 2, 5	B
ABM1E13Z11	<--->	Stainless steel plunger with roller	One	PG13.5	0.5	22(N)	40(N)	Figures 1, 6	C
ABM2E13Z11	<--->		One	1/2" NPT	0.5	22(N)	40(N)	Figures 1, 6	C
ABM5E13Z11	<--->		Three	PG13.5	0.5	22(N)	40(N)	Figures 2, 6	D
ABM6E13Z11	<--->		Three	1/2" NPT	0.5	22(N)	40(N)	Figures 2, 6	D
ABM1E32Z11	<--->	One-way lever with stainless steel roller	One	PG13.5	1.5	12(N)	40(N)	Figures 1, 7	E
ABM2E32Z11	<--->		One	1/2" NPT	1.5	12(N)	40(N)	Figures 1, 7	E
ABM5E32Z11	<--->		Three	PG13.5	1.5	12(N)	40(N)	Figures 2, 7	F
ABM6E32Z11	<--->		Three	1/2" NPT	1.5	12(N)	40(N)	Figures 2, 7	F
ABM1E42Z11	<--->	Rotary lever with stain. steel roller (See accessories for opt. roller and actuator levers)	One	PG13.5	1.5	0.15(Nm)	0.30(Nm)	Figures 1, 8	G
ABM2E42Z11	<--->		One	1/2" NPT	1.5	0.15(Nm)	0.30(Nm)	Figures 1, 8	G
ABM5E42Z11	<--->		Three	PG13.5	1.5	0.15(Nm)	0.30(Nm)	Figures 2, 8	H
ABM6E42Z11	<--->		Three	1/2" NPT	1.5	0.15(Nm)	0.30(Nm)	Figures 2, 8	H
ABM1E52Z11	<--->	Adj. rotary lever w/ stainless steel roller (See accessaries for opt. roller and actuator levers)	One	PG13.5	1.5	0.15(Nm)	0.30(Nm)	Figures 1, 9	I
ABM2E52Z11	<--->		One	1/2" NPT	1.5	0.15(Nm)	0.30(Nm)	Figures 1, 9	I
ABM5E52Z11	<--->		Three	PG13.5	1.5	0.15(Nm)	0.30(Nm)	Figures 2, 9	J
ABM6E52Z11	<--->		Three	NPT	1.5	0.15(Nm)	0.30(Nm)	Figures 2, 9	J
ABM1E71Z11	<--->	Adjustable rotary lever w/ stainless steel rod	One	PG13.5	1.5	0.15(Nm)	0.30(Nm)	Figures 1, 10	K
ABM2E71Z11	<--->		One	1/2" NPT	1.5	0.15(Nm)	0.30(Nm)	Figures 1, 10	K
ABM5E71Z11	<--->		Three	PG13.5	1.5	0.15(Nm)	0.30(Nm)	Figures 2, 10	L
ABM6E71Z11	<--->		Three	1/2" NPT	1.5	0.15(Nm)	0.30(Nm)	Figures 2, 10	L
ABM1E92Z11	<--->	Wobble lever w/ polyamide tip stainless steel spring	One	PG13.5	1.0	0.18(Nm)	-	Figures 1, 11	M
ABM2E92Z11	<--->		One	1/2" NPT	1.0	0.18(Nm)	-	Figures 1, 11	M
ABM5E92Z11	<--->		Three	PG13.5	1.0	0.18(Nm)	-	Figures 2, 11	N
ABM6E92Z11	<--->		Three	1/2" NPT	1.0	0.18(Nm)	-	Figures 2, 11	N
ABM1E93Z11	<--->	Wobble lever w/stainless steel spring	One	PG13.5	1.0	0.18(Nm)	-	Figures 1, 12	O
ABM2E93Z11	<--->		One	1/2" NPT	1.0	0.18(Nm)	-	Figures 1, 12	O
ABM5E93Z11	<--->		Three	PG13.5	1.0	0.18(Nm)	-	Figures 2, 12	P
ABM6E93Z11	<--->		Three	1/2" NPT	1.0	0.18(Nm)	-	Figures 2, 12	P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ABM Series

AAP Series

Series	ABM Series	ABP Series	AAP Series
Prices start at	<--->	<--->	<--->
Description	Heavy duty IEC	Double-insulated, non-metallic IEC	Double-insulated, non-metallic mini-DIN IEC
Material of Construction	Aluminum	PBT (plastic)	PBT (plastic)
Degree of Protection (IEC529)	IEC IP66	IEC IP65	IEC IP65
Maximum Switching Frequency	Contact blocks: all two cycles per second	Contact blocks: all two cycles per second	Contact blocks: all two cycles per second
Mechanical Service Life	25 million cycles	25 million cycles	25 million cycles
Contact Configuration	One snap-action set of N.O. / N.C. contacts. (Optional contact blocks with other configurations are available)	One snap-action set of N.O. / N.C. contacts. (Optional contact blocks with other configurations are available)	One snap-action set of N.O. / N.C. contacts. (Optional contact blocks with other configurations are available)
Conduit Opening	One and three cable holes, PG 13.5 or 1/2 NPT	One cable hole, PG 13.5 or 1/2 NPT	One cable hole, PG 11 or 1/2 NPT
Connection	2x2.5mm^2 (AWG14) to 2x0.5mm^2 (AWG 18)	2x2.5mm^2 (AWG14) to 2x0.5mm^2 (AWG 18)	2x2.5mm^2 (AWG14) to 2x0.5mm^2 (AWG 18)
Agency Approvals	CE markings for applicable CE Directives (CEE 73/23, CEE 93/68, EN60947.1, EN60947.5.1), UL certified (UL508), File E191072	CE markings for applicable CE Directives (CEE 73/23, CEE 93/68, EN60947.1, EN60947.5.1), UL certified (UL508), File E191072	CE markings for applicable CE Directives (CEE 73/23, CEE 93/68, EN60947.1, EN60947.5.1), UL certified (UL508), File E191072

Reed Switches

Reed switches are very similar to relays, except a permanent magnet is used instead of a wire coil. When the magnet is far away the switch is open, but when the magnet is brought near the switch is closed as shown in “Reed Switch”. These are very inexpensive and can be purchased for a few dollars. They are commonly used for safety screens and doors because they are harder to *trick* than other sensors.

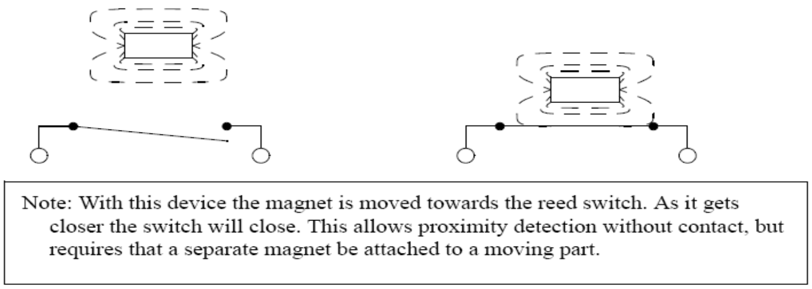


Figure 10.49 Reed Switch

Optical (Photoelectric) Sensors

Light sensors have been used for almost a century - originally photocells were used for applications such as reading audio tracks on motion pictures. But modern optical sensors are much more sophisticated. Optical sensors require both a light source (emitter) and detector. Emitters will produce light beams in the visible and invisible spectrums using LEDs and laser diodes. Detectors are typically built with photodiodes or phototransistors. The emitter and detector are positioned so that an object will block or reflect a beam when present. A basic optical sensor is shown in “A Basic Optical Sensor”.

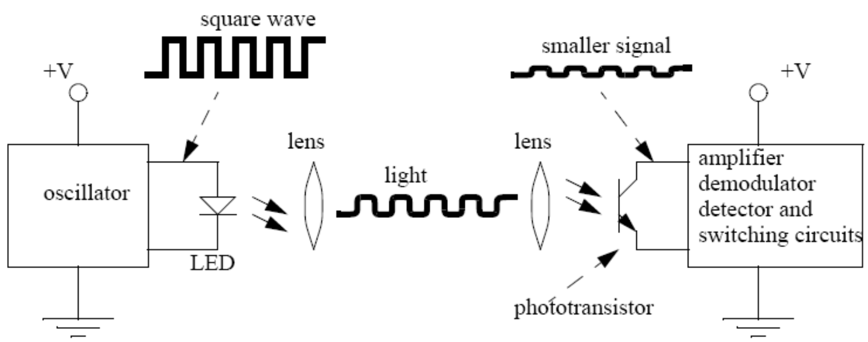


Figure 10.50 A Basic Optical Sensor

In the figure the light beam is generated on the left, focused through a lens. At the detector side the beam is focused on the detector with a second lens. If the beam is broken the detector will indicate an object is present. The oscillating light wave is used so that the sensor can filter out normal light in the room. The light from the emitter is turned on and off at a set frequency. When the detector receives the light it checks to make sure that it is at the same frequency. If light is being received at the right frequency then the beam is not broken. The frequency of oscillation is in the KHz range, and too fast to be noticed. A side effect of the frequency method is that the sensors can be used with lower power at longer distances.

Table 1
Photoelectric Sensing Modes Advantages and Cautions

Sensing Mode	Applications	Advantages	Cautions
Transmitted Beam	General purpose sensing Parts counting	• High margin for contaminated environments • Longest sensing distances • Not affected by second surface reflections • Probably most reliable when you have highly reflective objects	• More expensive because of separate light source and receiver required, more costly wiring • Alignment important • Avoid detecting objects of clear material
Retroreflective	General purpose sensing	• Moderate sensing distances • Less expensive than transmitted beam because simpler wiring • Ease of alignment	• Shorter sensing distance than transmitted beam • Less margin than transmitted beam • May detect reflections from shiny objects (use polarized instead)
Polarized Retroreflective	General purpose sensing of shiny objects	• Ignores first surface reflections • Uses visible red beam for ease of alignment	• Shorter sensing distance than standard retroreflective • May see second surface reflections
Standard Diffuse	Applications where both sides of the object cannot be accessed	• Access to both sides of the object not required • No reflector needed • Ease of alignment	• Can be difficult to apply if the background behind the object is sufficiently reflective and close to the object
Sharp Cutoff Diffuse	Short-range detection of objects with the need to ignore backgrounds that are close to the object.	• Access to both sides of the object not required • Provides some protection against sensing of close backgrounds • Detects objects regardless of color within specified distance	• Only useful for very short distance sensing • Not used with backgrounds close to object
Background Suppression Diffuse	General purpose sensing Areas where you need to ignore backgrounds that are close to the object	• Access to both sides of the target not required • Ignores backgrounds beyond rated sensing distance regardless of reflectivity • Detect objects regardless of color at specified distance	• More expensive than other types of diffuse sensors • Limited maximum sensing distance
Fixed Focus Diffuse	Detection of small targets Detects objects at a specific distance from sensor Detection of color marks	• Accurate detection of small objects in a specific location	• Very short distance sensing • Not suitable for general purpose sensing • Object must be accurately positioned
Wide Angle Diffuse	Detection of objects not accurately positioned Detection of very fine threads over a broad area	• Good at ignoring background reflections • Detecting objects that are not accurately positioned • No reflector needed	• Short distance sensing
Fiber Optics	Allows photoelectric sensing in areas where a sensor cannot be mounted because of size or envir-onment considerations	• Glass fiber optic cables available for high ambient temperature applications • Shock and vibration resistant • Plastic fiber optic cables can be used in areas where continuous movement is required • Insert in limited space • Noise immunity • Corrosive areas placement	• More expensive than lensed sensors • Short distance sensing

PHOTOSWITCH® Photoelectric Sensors

Quick Selection Guide

Specifications	 **42EF** RightSight™	 **42KL** MiniSight™	 **44R** AccuSight™	 **42CA** 18 mm Cylindrical
Features	• Patented housing design with 1200 psi washdown rating • Universal 18 mm and thru-hole mounting options • 360° visible status indicators • DC only and universal supply models • Variety of sensing modes • Variety of output types	• Industry standard housing design with 1200 psi washdown rating • Universal 18 mm and thru-hole mounting options • 360° visible status indicators • 2- and 3-wire models • Variety of sensing modes • 2 m cable and micro QD connections	• Patented status indicators • Low profile housing design • Universal 18 mm and thru-hole mounting options • 360° visible status indicators • Low voltage DC operation • Variety of sensing modes • 2 m cable and micro QD connections	• Industry standard 18 mm housing design • Patented ASIC design offers linear sensitivity adjustment, stability indication, and excellent noise immunity • Stability Indication for ease of alignment and forewarning against detection of background • Complementary light/dark outputs
Applications	• Medium range, general purpose sensing • Washdown applications	• Medium range, general purpose sensing • Washdown applications	• Medium range, general purpose sensing • Conveyors	• Medium range, general purpose sensing • Embedded mounting
Sensing Modes and Max. Range	• Polarized retroreflective 3 m (10 ft) • Retroreflective 4.5 m (14.7 ft) • Diffuse 500 mm (20 in.) • Background suppression 50 mm (2 in.), 100 mm (4 in.) • Transmitted beam 20 m (60 ft), 4 m (13 ft), 8 m (26 ft) • Large aperture fiber optic • Sharp cutoff diffuse 130 mm (5 in.)	• Retroreflective 5 m (16.4 ft) or 2.5 m (8.2 ft) • Polarized retroreflective 2 m (6.6 ft) or 1 m (3.3 ft) • Diffuse 380 mm (15 in.) or 190 mm (7.5 in.) • Wide angle diffuse 180 mm (7 in.) or 90 mm (3.5 in.) • Fixed focus diffuse 43 mm (1.7 in.) or 16 mm (0.63 in.) • Transmitted beam 30 m (98 ft) or 10 m (33 ft) • Large aperture fiber optic • Small aperture fiber optic	• Polarized retroreflective 3 m (10 ft) • Diffuse 300 mm (12 in.) • Wide angle diffuse 200 mm (7.8 in.)	• Retroreflective 4.8 m (15.7 ft) and 7 m (23 ft) • Polarized retroreflective 3.8 m (12.5 ft) • Diffuse 100, 400 and 1000 mm (3.94, 15.75, and 39.37 in.) • Transmitted Beam 16 m (52.5 ft)
Operating Voltage	• 10.8…30V DC • 21.6…264V AC/DC	• 10.8…30V DC • 21.6…250V AC/DC	• 10…30V DC	• 10…30V DC
Output Type	• NPN or PNP 100 mA • Dual NPN/PNP 100 mA • MOSFET 100 mA	• Dual NPN/PNP 100 mA • 2-wire AC 100 mA	• NPN or PNP 100 mA • NPN and PNP 100 mA	• NPN or PNP 100 mA
Response Time	• 1…16 ms	• DC = 1 ms • DC high speed=300 µs • AC = 8.3 ms	• 10 ms	• 1 ms • 0.5 ms (background suppression)
Connections	• 300V PVC cable 2 m • Micro and pico QD	• 300V PVC cable 2 m • Micro and pico QD	• 300V PVC cable 2 m • Micro QD (6 in.) pigtail	• 2 m cable • Micro QD
Enclosure	• Mindel, Acrylic • NEMA 4X, 6P; IP67, IP69K • 1200 psi washdown	• Noryl®, Acrylic • NEMA 4X, 6P; IP67 • 1200 psi washdown	• Valox® • NEMA 12; IP51	• PBT • IP67
Additional Info	• See page 1-31	• See page 1-40	• See page 1-48	• See page 1-52

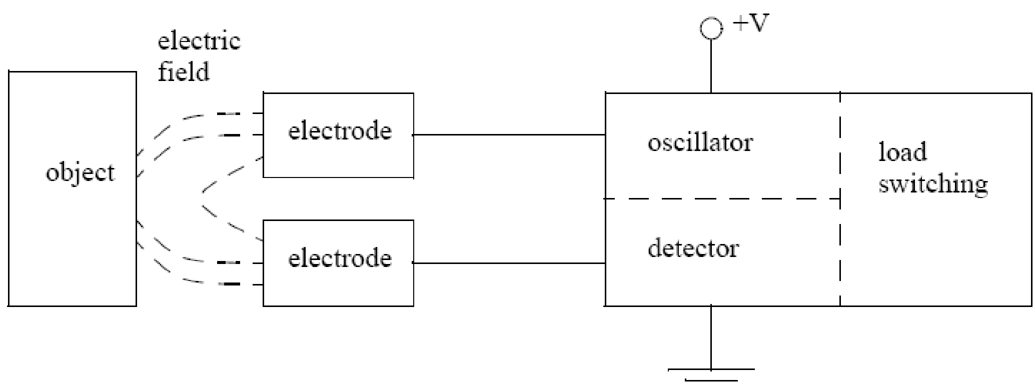
Capacitive Sensors

Capacitive sensors are able to detect most materials at distances up to a few centimeters. Recall the basic relationship for capacitance.

$$C = \frac{Ak}{d}$$

where,
C = capacitance (Farads)
k = dielectric constant
A = area of plates
d = distance between plates (electrodes)

In the sensor the area of the plates and distance between them is fixed. But, the dielectric constant of the space around them will vary as different materials are brought near the sensor. An illustration of a capacitive sensor is shown in “A Capacitive Sensor”. An oscillating field is used to determine the capacitance of the plates. When this changes beyond a selected sensitivity the sensor output is activated.



NOTE: For this sensor the proximity of any material near the electrodes will increase the capacitance. This will vary the magnitude of the oscillating signal and the detector will decide when this is great enough to determine proximity.

Figure 10.62 A Capacitive Sensor

These sensors work well for insulators (such as plastics) that tend to have high dielectric coefficients, thus increasing the capacitance. But, they also work well for metals because the conductive materials in the target appear as larger electrodes, thus increasing the capacitance as shown in “Dielectrics and Metals Increase the Capacitance”. In total the capacitance changes are normally in the order of pF.

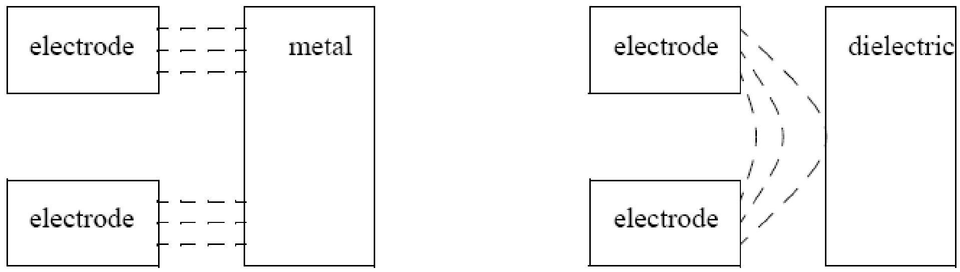
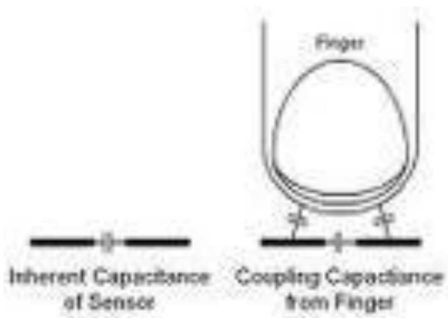
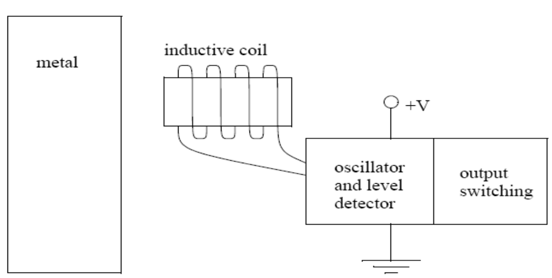


Figure 10.63 Dielectrics and Metals Increase the Capacitance



Inductive Sensors

Inductive sensors use currents induced by magnetic fields to detect nearby metal objects. The inductive sensor uses a coil (an inductor) to generate a high frequency magnetic field as shown in “Inductive Proximity Sensor”. If there is a metal object near the changing magnetic field, current will flow in the object. This resulting current flow sets up a new magnetic field that opposes the original magnetic field. The net effect is that it changes the inductance of the coil in the inductive sensor. By measuring the inductance the sensor can determine when a metal have been brought nearby. These sensors will detect any metals, when detecting multiple types of metal multiple sensors are often used.

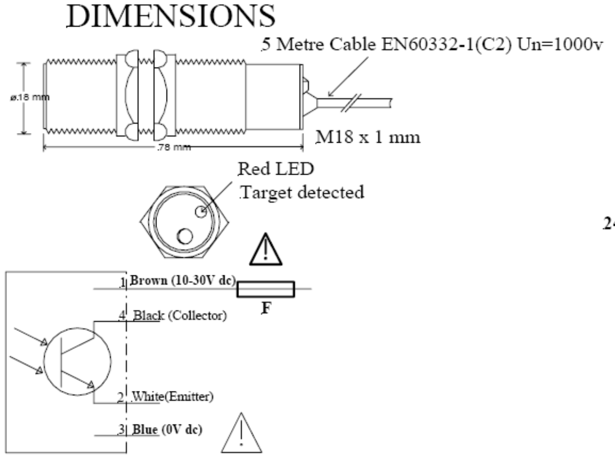


Note: these work by setting up a high frequency field. If a target nears the field will induce eddy currents. These currents consume power because of resistance, so energy is in the field is lost, and the signal amplitude decreases. The detector examines filed magnitude to determine when it has decreased enough to switch.

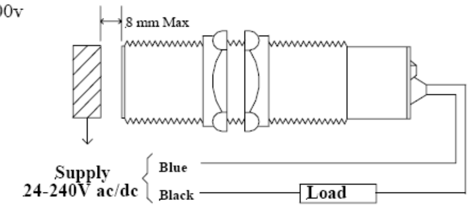
Figure 10.66 Inductive Proximity Sensor

SPECIFICATION			
Type	**P1001V10A**	**P1002V10A**	**P1001V34A**
Supply	24-240V **ac/dc**		10-30V **dc**
Output	NC	NO	NC/NO Selected by polarity
Cable	5 m x 2 wires		5 m x 4 wires
Max. Frequency	100Hz DC. 25 HZ AC		200HZ
Sensitivity	Detection range up to 8mm		
Volt drop	8V max		
Temperature	-15°C to + 50°C		
Min.current	1mA		1mA
Protection	IP 65		
Switching capacity	200mA		100mA 30V dc
Enclosure	Moulded polycarbonate-ISO M18 X 1 mm		
Approvals	EX II 2G 1D EE x m IIB T4 T100°C		
LED	Red:Target detected		

DIMENSIONS

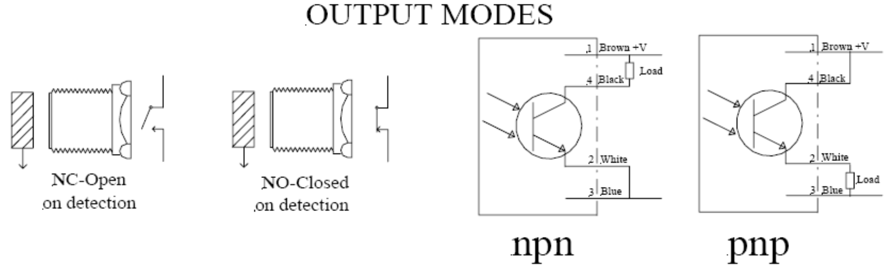


CONNECTIONS



NOTE: F = 1500A Capable fuse (500mA max.rating) 1fuse per unit MUST be used only to gas hasardous area.

OUTPUT MODES



P1001V10A **P1002V10A** **P1001V34A**

Ultrasonic Sensors

An ultrasonic sensor emits a sound above the normal hearing threshold of 16 KHz. The time that is required for the sound to travel to the target and reflect back is proportional to the distance to the target. The two common types of sensors are;

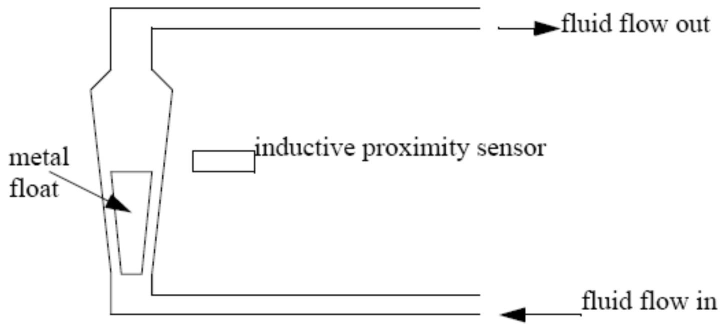
- Electrostatic - uses capacitive effects. It has longer ranges and wider bandwidth, but is more sensitive to factors such as humidity.
- Piezoelectric - based on charge displacement during strain in crystal lattices. These are rugged and inexpensive. These sensors can be very effective for applications such as fluid levels in tanks and crude distance measurement.

Hall Effect Sensors

Hall Effect switches are basically transistors that can be switched by magnetic fields. Their applications are very similar to reed switches, but because they are solid state they tend to be more rugged and resist vibration. Automated machines often use these to do initial calibration and detect end stops.

Fluid Flow Sensors

We can also build more complex sensors out of simpler sensors. The example in “Flow Rate Detection with an Inductive Proximity Switch”, which shows a metal float in a tapered channel. As the fluid flow rate increases the pressure forces the float upwards. The tapered shape of the float ensures an equilibrium position proportional to flowrate. An inductive proximity sensor can be positioned so that it will detect when the float has reached a certain height, and the system has reached a given flowrate.



As the fluid flow increases the float is forced higher. A proximity sensor can be used to detect when the float reaches a certain height.

Figure 10.68 Flow Rate Detection With an Inductive Proximity Switch

Measurement and control of small liquid flows is a delicate matter. Most conventional methods make use of moving parts in the flow as described above. This disturbs the continuity of small flow ranges. The flow meter series LIQUI-FLOW®, (see the picture below), measures and controls flows from 1000 g/h down to 0.25 g/h full scale stabile and continuous. The instruments, based on a thermal measuring principle, are rather new. Many applications of the instruments can be found in R&D laboratories in the chemical and pharmaceutical field, as well as chemical pilot plants and in research projects of fuel cells and catalysers for combustion plants.

The Bronkhorst High-Tech LIQUI-FLOW® controller.

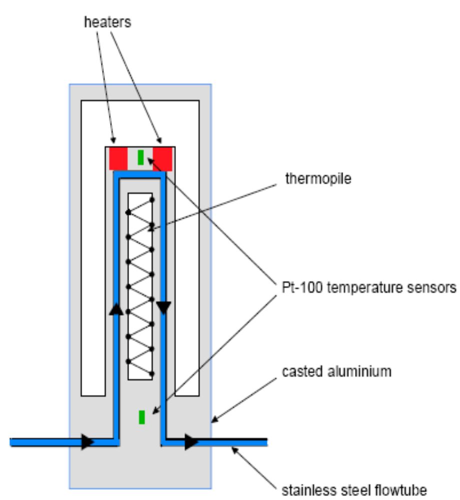


Figure 2: A schematic cross-section of the LIQUI-FLOW®

Thermal Flow Metering: Theory

The measuring principle of a thermal mass flow meter is explained in Figure 1 below. The flow is lead through a tube, sketched at the top of the picture. On this tube, three sensor elements are placed. A heater in the middle, and temperature sensors upstream Tup, and downstream Tdown, of the heater. In the lower part of this figure, the temperature profile along the sensor tube is sketched. When there is no flow through the pipe, this temperature profile is symmetric around the heater. When fluid is flowing through the pipe from left to right, the temperature profile will shift to the right**.** The shift in temperature profile represents a temperature difference DT, between Tup and Tdown. The shift of the temperature profile and the temperature difference DT, is a result of the heat transport of the flowing fluid. Heat transport is proportional with mass flow and heat capacity. So this thermal flow sensor measures the mass flow of the fluid. The temperature difference is transformed into an electrical output signal.

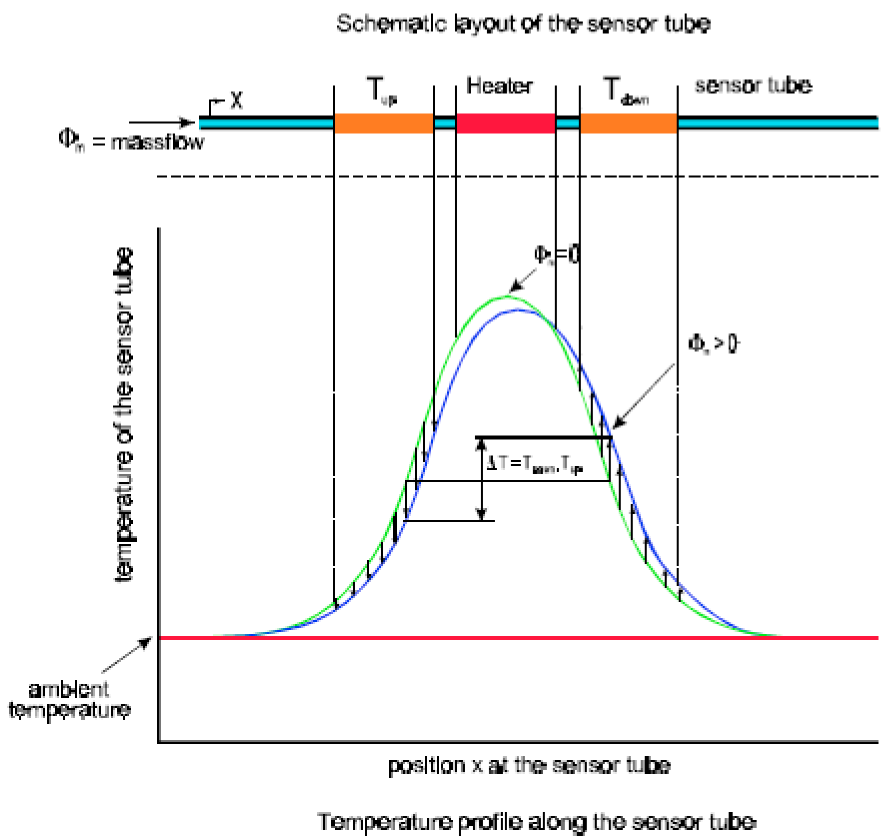


Figure 1: A tube-based thermal mass flow sensor.

The measuring principle described in the paragraph above, can be applied to gases as well as liquids.

SUMMARY

- Sourcing sensors allow current to flow out from the V+ supply
- Sinking sensors allow current to flow in to the V- supply
- Photo-optical sensors can use reflected beams (retroreflective), an emitter and detector (opposed mode) and reflected light (diffuse) to detect a part
- Capacitive sensors can detect metals and other materials
- Inductive sensors can detect metals
- Hall effect and reed switches can detect magnets
- Ultrasonic sensors use sound waves to detect parts up to meters away.