E-training

"Welcome to the K Controls e-training course designed to deliver useful "Pneumatic Valve Actuation" application information in small instalments."

To unsubscribe or to register a colleague to receive these documents
Click here

The selection of inductive proximity switches for valve monitoring applications

Mechanical switches rely on some mechanical movement taking place. Micro switches and reed switches are sometimes avoided in automated systems because wherever parts touch there can be wear and the potential for eventual failure. For this reason solid state proximity switches with no internal moving parts are becoming increasingly popular. The most common types of sensors in this category are the inductive proximity sensor, the capacitive proximity sensor, the Hall Effect sensor, the sonar proximity sensor and the optical proximity sensor. All of these sensors are actually transducers, but they can include control circuitry that allows them to be used as switches. The circuitry changes an internal electronic switch when the transducer output reaches a certain value.

Capacitive sensors are triggered by changes in the capacitance caused by proximity to virtually any material in solid, powder or liquid state. However this versatility can lead to inadvertent switching. They can also susceptible to dirt and humidity. Hall Effect sensors are triggered by a magnet influencing the Hall Effect element. They tend to use a lot of power and when used in a two wire system they have a prohibitively high leakage current (leakage "off state" current is explained below). Sonar proximity sensors generally operate over distances between 6 cms and 10 metres. They transmit ultrasonic pulses that, when reflected by objects or surfaces produce an echo that can be received by the sensor; the distance is then calculated and converted into an output signal. Optical proximity sensors generally cost more than inductive proximity sensors, and about the same as capacitive sensors. They are also known as photoelectric, fibre optic, diffuse, thru-beam type or retro reflective type sensors. A complete optical proximity sensor includes a light source, and a sensor that detects the light. They are widely used in factory automation applications (e.g. automotive, food and drink) where they are used during material handling, assembly or packaging processes. They are used to help position, classify or count a variety of objects regardless of their composition. The type commonly used for valve position monitoring is the inductive proximity sensor or switch.

Inductive proximity switches

Proximity switches sense the presence of metallic (non-austenitic) substances within the sensing range and have the ability either to change the value of current flowing through them (two wire I.S), or switch power, (three wire DC or two wire AC/DC switches). Proximity switches have become a popular alternative to mechanical or reed switches in recent years for two prime reasons:

1. There are no moving parts which can either wear or corrode.
2. When used in conjunction with computer based interface systems there is no possibility of 'contact bounce' which can lead to false indication of plant status. This is particularly critical in "ladder logic " systems where incorrect indication can initiate the next process sequence.

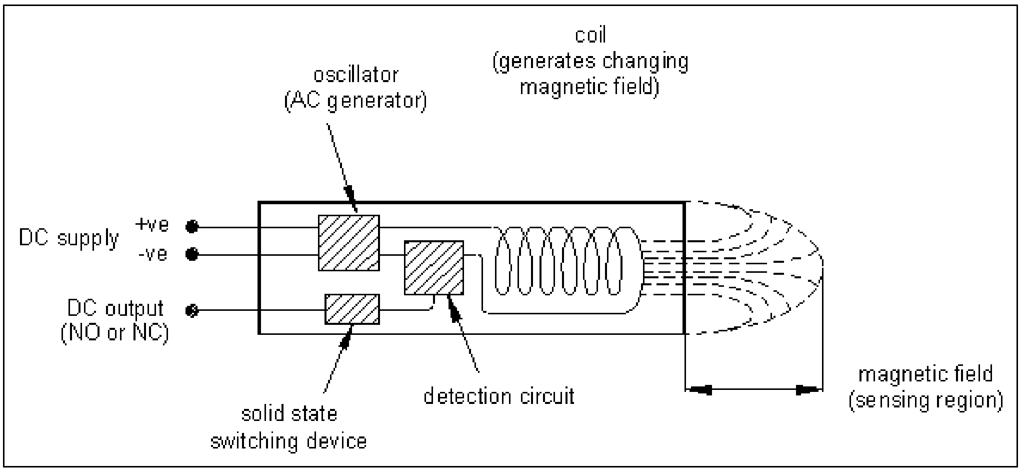
E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

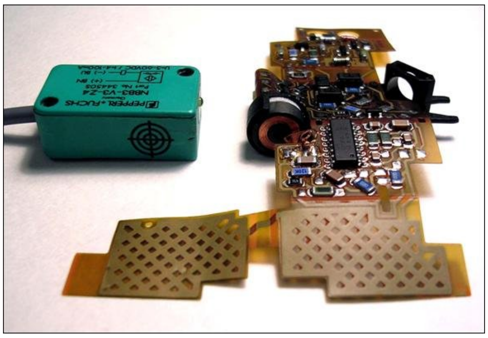
K Controls can also supply your positioner requirements

How do they work?



The inductive proximity sensor is small and robust. It detects the presence of an electrically conductive material (metal target). The switch consists of four main components: Coil, oscillator, detection circuit and solid state switching device (transistor in DC switches, thyristor in AC switches). The supply AC or DC is used to generate AC in an internal coil, which in turn causes an alternating magnetic field. The physical size of this alternating field determines the range of the device. If no conductive materials are near the face of the sensor, the only impedance to the internal AC is due to the inductance of the coil. If, however, a conductive material enters the changing magnetic field, eddy currents are induced (hence the term "inductive") in the conductive material (metal target), and there is a resultant increase in the impedance to the AC in the proximity sensor. A current sensor (detection circuit), also built into the proximity sensor, detects when there is a drop in the internal AC current due to increased impedance. The current sensor controls a solid state switch providing the output. After the metal target leaves the sensing range, the oscillator resumes normal functioning, and the switch returns to its normal state (either normally open or normally closed).

The left hand side of photograph below shows a two wire rectangular "V3" format proximity switch. The internals are shown on the right hand side. The coil is clearly visible. The surface mount components on the flexible backing make up the oscillator, detection and switching circuits.



E-training

K Controls designs and manufactures valve monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

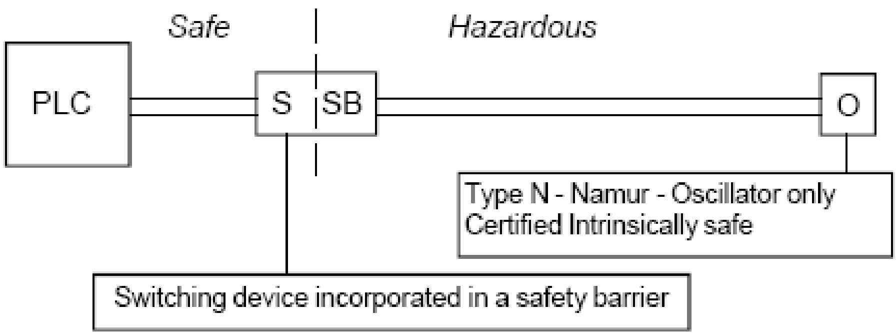
K Controls can also supply your positioner requirements

Proximity switch targets in switchboxes

Metal targets built into plastic switch cams in switchboxes can either be of the “single point” or “full quadrant” type. A “single point” target is required to monitor an intermediate position but at the extremes of travel any significant valve over travel could lead to the signal being lost. A “full quadrant” target can allow conversion from a “normally open” to a “normally closed” function and it can be adjusted to allow for over travel. Another useful benefit is that it can be set such that the switch senses the target at one end position and also throughout intermediate travel. The switch would then only cease to sense the target when the other end position is reached. Detecting both switches during intermediate travel confirms that the end positions have not been reached and importantly, that both switches are still functioning correctly.

Intrinsically safe (NAMUR) proximity sensors

As electronic components can store or induce energy the component count is kept to a minimum in intrinsically safe proximity sensors. The low power consumption characteristics of 2 wire I.S sensors make them ideally suited for use in hazardous areas when I.S approved. Intrinsically safe options will not provide a switched output without the use of an additional device containing its own switching device, (e.g. certain versions of safety barrier). These sensors are simple two wire direct current units which contain an oscillator but no detection circuit or switching device. As the sensing face is covered, the current flowing through the device changes from nominally 1mA to 3mA. Connected to an appropriate safety barrier in the non-hazardous area, a change in current is detected and then switched to provide a usable value of voltage and current to the user. Note that we refer to an intrinsically safe version as a “proximity sensor” and an AC or DC version for safe area use as a “proximity switch”. The ambient operating temperature of these units when fitted in switchboxes is typically -20 to +40 degrees C.



E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

NAMUR was founded at Leverkusen, Germany, on 3 November 1949 as the body to represent the interests of the users of measurement and control technology in the chemical industry. At the second meeting in December 1949, the founding members of the working group settled on the name: "Standardisation association for measurement and control in the chemical industries — this leads to the acronym NAMUR "Normen Arbeitsgen Mess Und Regeltechnik" in German. NAMUR is an association of users of process control technology; manufacturers of process control technology, hardware and software are not eligible as members. The work of the NAMUR working group resulted in the NAMUR standard (DIN 19234, IEC 60947-5-6) for intrinsically safe proximity sensors and the associated safety barriers.

Failsafe Intrinsically safe (NAMUR) proximity sensors

I.S. proximity sensors are available that provide a failsafe function. Should there be a fault in the sensor, failsafe barrier or interconnecting cable the signal will always revert to a pre-defined state. As they use very high quality components in their construction the sensors can be used down to -40C or -50C (varies with type) in both failsafe and standard applications.

Intrinsically safe (NAMUR) proximity sensors that permit 2:1 wiring

Intrinsically safe proximity sensors are now available fitted with an internal diode. This gives rise to integral LED indication and also permits 2:1 wiring to compatible safety barriers or field bus valve couplers. This can reduce wiring by 50%. LED indication means that the end user can see whether or not the sensor has been activated by the target. This is especially helpful during commissioning and fault finding as frequent trips back to the panel can be avoided.

E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

Typical Interfacing devices are galvanically isolated safety barriers and fieldbus valve coupler units. The benefits of this approach are particularly significant when using fieldbus valve couplers as the number of inputs per coupler can typically be increased to 8 thereby saving the number of couplers needed per installation. Up to four 007 switchboxes or four 007C switch solenoid control centres* can therefore be connected to each fieldbus valve coupler. (*When fitted with special low powered pilot solenoid valves.)

Proximity switches with a safety integrity level (e.g. SIL 2)

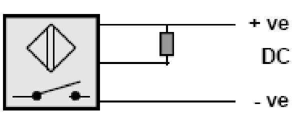
K Controls can supply proximity sensors that conform to IEC 61508 SIL 2 in an ATEX certified switchbox.

Three wire DC proximity switches

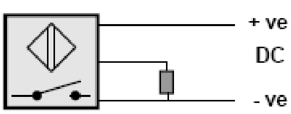
Three wire DC or 2 wire AC/DC switches switch higher levels of voltage and current. Three wire DC switches have a switching device (transistor) in addition to an oscillator. When used in DC circuits three-wire sensors typically have a power wire, a return wire and a signal wire. The power and return wires supply power to the circuit and when metal is present in the target region the circuit will connect the signal wire to the load if operating “normally open” . If operating normally closed the signal will be disconnected from the load.

They can switch either positive (PNP positive negative positive), current sourcing, or negative (NPN negative, positive, negative), current sinking, loads. LED indication of switch status is usually provided. Normally used with 24V dc circuits these switches give a very robust signal in the range 10 to 30V dc. Non I.S proximity switches can only be used in hazardous areas if they are fitted in Exd enclosures.

Sinking circuits (NPN) have the load connected between the power and signal wires and when energized the switch "sinks" the power from the load to the return (the signal will go voltage negative when the sensor has to signal an ON state). A sourcing circuit (PNP) has the load attached between the signal and return wires and when energized will "source" power to the load (the signal goes voltage positive when the sensor needs to signal an ON state). The requirement for NPN (current sinking) or PNP (current sourcing) DC proximity switches is defined by the electrical construction of the associated control equipment, (typically a P.L.C.). The customer will usually be able to specify the function required. PNP is sometimes regarded as safer in the UK due to the fact that any earth faults could make NPN sensors give a false switching signal.



NPN



PNP

E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

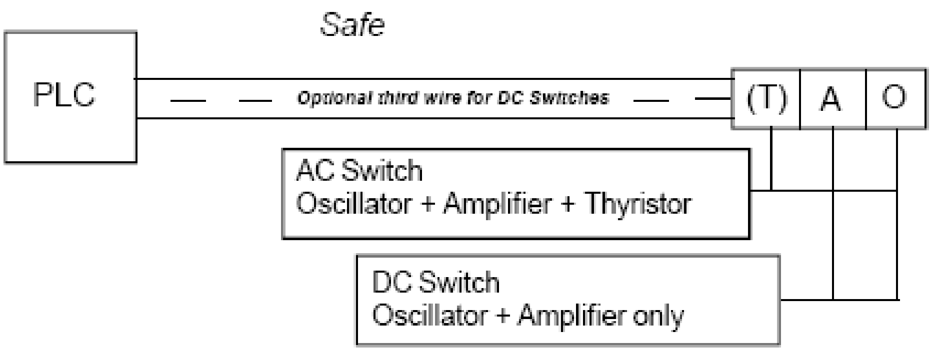
Two wire DC proximity switches

The signal wire and power wires are combined in a two wire switch. In the "off" state, sufficient current must flow through the circuit to keep the sensor active. This off state current is called the "leakage current". When the switch is operated it will conduct the load circuit current. It is very important to ensure that the leakage (off-state) current is compatible with the switching thresholds of the PLC. See "application issues" below.

Two wire DC proximity switches are reverse polarity protected. They can be wired positive or negative to the same connection so there is no chance of error. Two wire proximity switches may be used in most applications as a direct replacement for three wire proximity switches with no changes other than optionally using two core cable instead of three core. Where three core cable is already in place the third wire is simply not connected to the sensor. (In the K Controls range of products we have left the third terminal unconnected to terminate existing wires as necessary). Most mechanical switches are installed using only two wires (single pole single throw SPST). 2 wire proximity switches can therefore usually be substituted for mechanical switches without incurring rewiring costs.

Two wire AC proximity switches

AC proximity switches contain an oscillator and switching device (thyristor). They have normally open contacts. Normally used with 110V ac circuits these switches give a very robust signal in the range 20 to 250V ac. They are not frequently used in valve position monitoring applications.



E-training

Application issues

Load current – a minimum level of load current is important for proper operation with interface devices. Since most sensors drive low load current PLCs, it is important to ensure load current compatibility. Two-wire DC and AC switches are designed to need a minimum load current in order to operate, if the current falls below the minimum, the sensor will not turn on.

Leakage (off-state) current is important in ensuring that the interface can distinguish between the ON and OFF states of AC or DC two-wire proximity switches. If the proximity switches leakage current is greater than the interface's ON threshold, the interface will not be able to detect whether the switch is on or off. To select the correct load when proximity switches are wired in parallel, be sure to take into account the sum of the leakage currents. The off-state current of three wire proximity switches is usually lower than that of the equivalent two wire device. For example in a computer input circuit the parameters may be as follows: Off threshold less than 0.9 mA and on threshold greater then 1.8 mA. If the leakage current is less than 0.9 mA the computer will go to the off state. If the leakage current exceeds 1.9 mA it will remain on. Between those two states the outcome is uncertain so good design practice is to ensure the leakage current of the proximity switch will be well below 0.9 mA.

Voltage drop when calculating the cumulative voltage drop of a circuit, especially one containing two-wire proximity switches it is important to include the voltage drop across the load when it is energised. Otherwise there is a risk of accumulating too great a voltage drop around the circuit and the proximity switch will not operate.

Short-circuit protection is a feature that prevents damage to the proximity switch output during a short-circuit condition.

Overload protection is a feature that prevents damage to the proximity switch when the load current is too high.

Reverse polarity protection is a feature that prevents damage to the proximity switch when the polarity of the power leads is reversed (negative power lead connected to switch positive and vice versa).

False pulse protection is a feature which makes it impossible for a false signal to be transmitted to the load upon proximity switch power-up.

Transient noise protection ensures proper operation when fast transients such as those created by fast switching motors or drives are induced in the wiring.

E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

If you have any questions or comments, would like a colleague to receive this information or you would like the latest list of training documents, please use the contact details below:

K Controls Ltd
2 Crown Way
Crown Business Centre
Horton Road
West Drayton UB7 8HZ
United Kingdom

Phone:
+44 (0)1895 449601

Fax:
+44 (0)207 990 8111

E-mail:
sales@k-controls.co.uk

Web:
www.k-controls.co.uk

Blog:
www.k-controls.info

Visit us:
View a map

High and low temperature versions

Inductive proximity sensors generally are self-contained devices that include their silicon amplifiers and detection circuitry inside the sensor-head housing. Self-contained proximity sensors are practical for most applications until environmental conditions begin to exceed the standard operating parameters for a silicon-based circuit. Normally, silicon-based circuitry operates between −25C and 80C.

Extreme temperatures will reduce operating life of a proximity switch, causing premature failure. Hot temperatures will make it more sensitive, while cold temperatures will lower its resistance to shock. Versions for use at -50C and +200C are available but the sensor head contains the inductive coil and little else. The amplifier and detection circuitry and switching device are located safely away in a remote, environmentally controlled area.

Similar documents covering mechanical and reed switches are available on request.