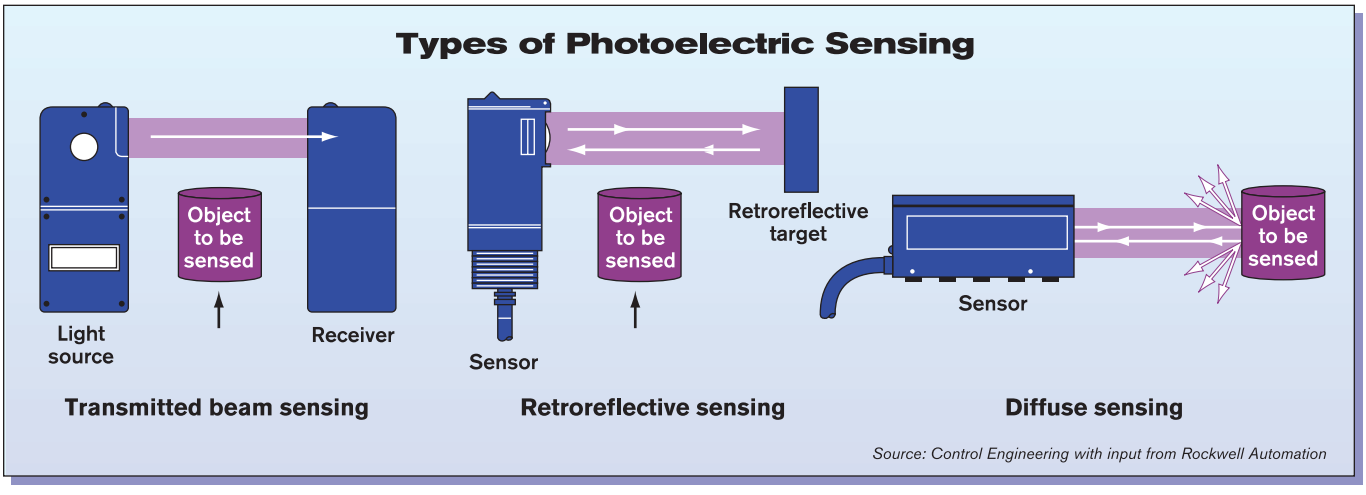
CONTROL ENGINEERING®

Non-contact Sensors

Advance for Discrete Manufacturing

Proximity and photoelectric sensing products and technologies gain intelligence, downsize packaging, and incorporate lower cost memory, enabling more versatile applications.



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KEY WORDS

- **Machine control and discrete sensors**
- **Embedded control**
- **Limit switches**
- **Photoelectric sensors**
- **Proximity sensors and switches**

There really *is* a lot to talk about in the area of discrete sensors. Some may wonder what can be done to proximity or photoelectric switches. Surely there can be no more advances with limit switches. Well, that attitude is just plain wrong. Microcontroller circuits are now small enough to fit within a cylindrical proximity sensor. Add networking connections to the mix, and the potential for more power and flexibility is here.

Originally, limit switches (the term "switch" can be interchanged with sensor) were discrete in nature, turning a contact on or off or changing state in a semiconductor contact. Proximity and photoelectric sensors are noncontact, that is, they are designed to detect an object within their field of view without contacting it. Limit switches, on the other hand, must make contact with the object to be sensed. This typically is accomplished with one of a variety of lever arms or roller plungers.

Proximity switches come in three basic flavors—inductive, capacitive, and ultrasonic. Inductive "proxes" sense metallic objects and are the most common in manufacturing. Capacitive and ultrasonic sensors can detect either metallic or nonmetallic objects.

An inductive sensor operates by generating an electromagnetic field that generally begins with a larger diameter than the switch and decreases over distance. It then detects eddy current losses due to the proximity of the target. When a metallic object enters the field, the eddy current is driven toward zero changing the output state.

There are three basic types of photoelectric sensors. Transmitted beam, or through-beam, requires a sender and a receiver. Retroreflective senses light returning from a reflector. Both types switch an output when the beam is broken. Diffuse sensors sense light returning from the object to be detected and switch the output when it senses light.

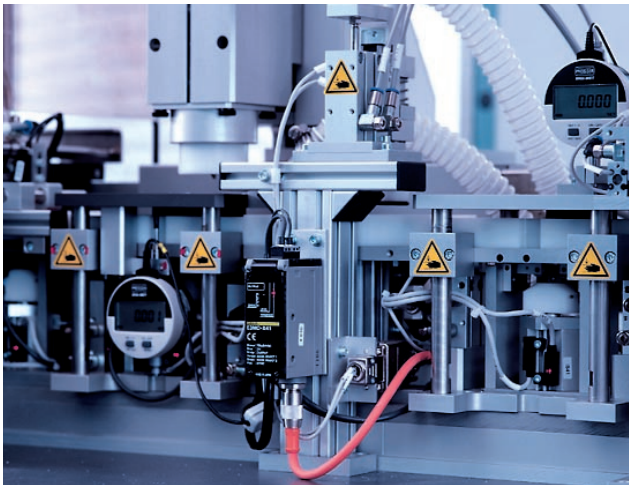
The wide sensing field diameter can mean problems when installing in a metal plate, such as a die. "Shielded" proxes solve this problem. Shielding focuses the field more directly outward so that surrounding metal is not sensed. However, shielding results in loss of sensing distance.

Most product information offers a specified sensing distance, a 1 mm thick square piece of mild steel. If the object is non-ferrous, for instance brass or aluminum, then the rated sensing distance will be reduced.

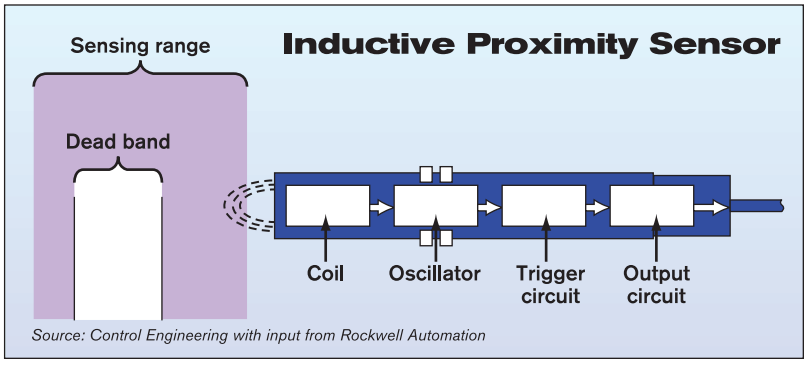
Proximity intelligence

The situation up until now has been that the field either exists or it is collapsed (as when a metallic

object enters). With added intelligence in the switch's circuitry, varying strengths of the field can be sensed and calculated. Manipulating this information means that perhaps an analog output signal can be produced. Another use would be to teach the sensor to sense at only certain points—the ability to program in a deadband. The Cutler-Hammer (Milwaukee, Wis.) switch introduced in *Control Engineering* March 2002 has this capability, as well as the Rockwell Automation (Milwaukee, Wis.) DeviceNet prox. Schneider Electric (Palatine, Ill.), as detailed in the sidebar, has introduced an entire family of "programmable" proximity sensors, certainly a major advance in a venerable input device.



Flexible fiber-optic cabling from a DIN-rail mounted amplifier allows technicians to detect an object deep in a machine while allowing access to the sensor as shown in this application photo from Omron.



Source: Control Engineering with input from Rockwell Automation

An inductive proximity sensor contains a coil to generate an electromagnetic field, an oscillator circuit to excite the coil, a trigger circuit, and an output circuit. The latest sensors can be programmed to sense an object at defined places within the field rather than just anywhere within the field.

Cutler-Hammer's proximity switch can even be "programmed" with a laptop computer. Look for PDA connections to sensors in the near future.

Perhaps the greatest value of a proximity switch is its ability to withstand harsh environments. Most can be applied in cutting areas, with fluid washing around, or other such intense areas. Special models have Teflon coating so that foreign materials like weld slag won't adhere to the face. Ones designed for weld-field immunity also have hardy electronics inside to minimize distortion due to the high electromagnetic field (emf) generated by a welding arc.

What's the most essential advice to give to the electrician installing these devices? Remind installers that these are *non-contact* devices. Even though sensing distance is quite small, sometimes on the order of 8 mm (about 0.3 in.), proxes are not meant to absorb the forces seen by pallet stops. Using a cylindrical prox as a stepladder is also not unusual, so be careful about placement.

Capacitive proximity sensor advantages include a longer sensing distance and ability to detect nonmetallic objects. Circuits inside the switch detect a capacitive field formed by plates within the sensing head and the object to be sensed. These characteristics, plus the ability for an analog output, make it ideal for many liquid level applications. The ultrasonic prox, typically the longest-range sensor, operates by sending and receiving an ultrasonic sound wave.

Red beam for sensing

Photoelectric sensors emit a light beam and detect its return, or lack of return. Most common are visible red and infrared. Visible red light can help during setup, but most sensors today have a signal LED for strength of signal, providing assistance.

There are three basic types of photoelectric sensors, based on the way they emit and receive light: through-beam, retroreflective, and diffuse.

The most reliable is through-beam, which uses separate transmitter and receiver devices. This method generates the greatest light power in the receiver, yielding the most consistent and stable signal. A common use of through-beam photoelectrics is with modern automatic garage door openers. A set is placed about six inches above the floor to assure that there is nothing in the way, say a small child, of the descending door. In manufacturing, this style is best for similar detection of objects across a large opening like a door or gate, or when the environment is dirty and maximum power is necessary.

Drawbacks of through-beam devices are the cost of having two components and difficult setup relative to other styles. The receiver can be placed in the same device as the transmitter and the separate device can be replaced with a reflector. Light emits from the sensor, reflects from the reflector, and is received by a different lens and circuit in the sensor. This style is called retroreflective. It reduces cost because it has only one component, and it is easier to set up because there is only one device to adjust.

Like through-beam sensors, retroreflective sensors detect when the beam is broken. If the object to be detected is shiny, the beam may still be returned foiling the detector. A light-polarizing reflector and lens filter solves that problem. Environment can pose another challenge. Perhaps maintenance painted the adjacent walls white in a facility upgrade, and the sensor became slightly misadjusted. It may still receive light off the wall instead of the reflector and give inappropriate readings.

Diffuse photoelectrics operate in a similar way to proximity sensors. In this case, the sensor uses the object as the reflector. This is good for close range detection or where it is difficult to impossible to place a reflector. A diffuse sensor mounted under a roller conveyor can detect packages while remaining out of harm's way.

Intelligence enhances sensors

Many forms of photos

Photoelectrics have many form factors from big and bulky to cylindrical to smaller than a dime and not much thicker. One style growing in popularity is a DIN-rail mountable amplifier with flexible fiber-optic cables capable of threading through a machine to bring just the right focus on an object.

Intelligence has been added over the past few years, which permits a technician to teach a diffuse sensor to detect to a certain point. For example, several years ago this author used an intelligent photoelectric sensor to detect the presence of a key in a crankshaft. Many companies have added teach functions, but take note of the next level achieved by Schneider Electric in its new line of products detailed in the sidebar.

Another good use of intelligence is for diagnostics. Imagine how useful messages like "Hey, I'm not working" or "Clean my lenses" would be. These, and more, are now possible with embedded intelligence and networking capability. Once again, state-of-the-art has moved beyond simply "discrete" sensors.

Combining on-board diagnostic capability with

EXCLUSIVE

Schneider Electric unveils new Global Detection sensor line

Companies that grow by buying other companies often talk of "synergies" to be obtained by combining expertise and markets of the various components. In the case of Schneider Electric's sensor business, corporate buzzwords have become a reality. For over three years, a worldwide team of sensor experts from the former Square D and Telemechanique met to design a family of sensors to solve many problems found in the field.

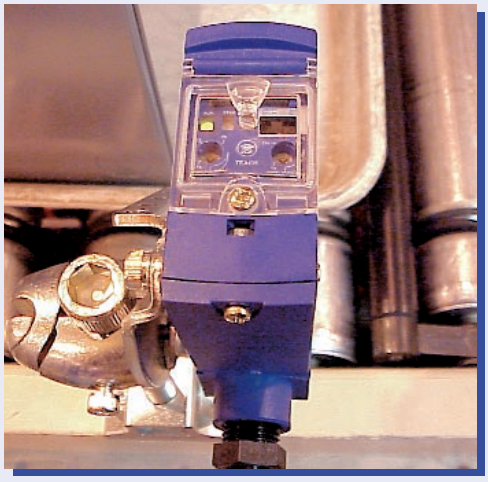
Mark Duncan, sensor product manager, explains that the group asked both customers and prospective customers, as well as used focus groups, to find out what engineers and technicians really wanted in sensor products. For proximity sensors, problems identified were mechanical and electrical setup. They wanted it done faster and easier. For photoelectrics, selecting the proper type was the biggest problem, followed by installation time. Users wanted componentized limit switches to minimize inventory.

The result was a concept called OSI (offering simplicity through intelligence). The family is called Global Detection.

The prime objective of the design team was to make selection, installation, set-up, and maintenance as easy as possible. The second objective was availability, meaning that the greatest number of solutions could be quickly identified, with a minimal number of product part numbers. A third objective was adaptability-products that could to meet all the environmental constraints for a wide variety of installations.

Programmable sensors

The Square D/Telemecanique XS Rectangular proximity sensor line has been designed to eliminate problems like sensitivity to metal environments, setup, and mounting.



This "teachable" photoelectric sensor, one of a new family of sensors from Schneider Electric, can be through-beam, retroreflective, or diffuse depending on its setup at installation.

When the user presses a button, the product runs in "teach" mode to set the maximum sensing distance. The "flat pack" style sensor is programmable to detect when just a portion of the face senses the target, or just where on the face the target is. The target can be moving in either axial or radial orientation, and the sensor will detect it.

By applying OSI concept to photoelectric sensors, Schneider Electric developed multi-mode photoelectric sensors capable of operating accurately in diffuse environments and with background suppression. Each sensor can function in five sensing modes and has two output states (NO or NC). This flexibility can reduce the typical number of product part numbers required by a factor of 10.

The built-in intelligence allows the sensor to run a teach mode set-up for quick installation, with the option of a second precise teach setting for very accurate and reliable detection.

Accurate setting of the sensing range is achieved without use of any particular accessories. If the object to be detected is moved closer within the detection zone, pressing a button takes this modification into account. Also, if the object is translucent, whatever the detection method, it is simply placed in position, the adjustment button is pressed and the sensor adjusts accordingly. Mounting brackets are standard across the product line. Options include a 3D indexing system for set-up adjustment in any direction and protective covers.

The OSI concept principle has even been adapted to limit switches. There is such diversity of operating heads, bodies, and contact blocks from most manufacturers of limit switches that often it's difficult to find exactly the right components for the configuration required for a particular application. The XC family of limit switches from Schneider Electric completely modularizes bodies, contact blocks, operating heads, and cable entries.

More than 40 metal, interchangable operating heads can be combined with five body styles and six conduit entries, all of which conform to standards and local customs worldwide.

These limit switches feature snap-action contact blocks (three or four contacts) with direct opening operation. Product cabling has been simplified, reducing electrical connection time up to 40%. Operating heads and levers with 3D orientation also make installation simpler and enable mounting these limit switches in any position for accurate cam actuation.

This family of sensors, recognizable in dark blue appearance, appears to raise the bar for the state-of-the-art.

computer programs to capture data, users can view histograms, copy and paste configurations, and even access firmware upgrades over the web.

Rockwell Automation has just unveiled a further extension of sensor application technology. Its 22DJ controller module is a preconfigured, DIP-switch programmable controller sitting on a sensor network designed for special purpose installations like material handling conveyor lines. This system architecture replaces a larger PLC, which may be overkill for certain applications, with a small, easy-to-set-up controller.

Application ideas

Another application idea comes from Banner Engineering (Minneapolis, Minn.), which has a 16-beam linear light array of plastic fiber pairs. In an application where ball bearings fall through the light screen, the desired outputs are to count the number and to detect oversize parts. Counting is as easy as setting one output to switch states on each beam breaking and sending the result to a counter. The product can be programmed to detect the number of beams broken. For instance, if the ball bearings are big enough for just two light beams and an object breaks three or more, then another output could be switched to stop the machine and call an operator.

Sensing tool position in machining centers is often accomplished with proximity switches. An application from "ifm efector" (Exton, Pa.) concerns finding the position of a steel tool machining an aluminum transmission case. The environment contains aggressive cutting fluids and flying aluminum chips. Picking a sensor for this application requires first finding a "ferrous only" product that will ignore aluminum chips. Next, the housing must be IP68 rated for zero leakage. Finally, a stainless steel face provides mechanical protection from flying chips, as well as chemical protection from the fluids.

As these examples show, discrete sensors have an important role to play in various types of applications. Embedded intelligence enables control engineers to exploit sensors to a greater degree, sometimes even reducing or replacing high-cost controllers in simple applications. There is a sensor type for almost every application and an intelligence range for almost every control architecture.

Background information was provided by the companies listed below. Search for more companies, with links to web sites in many cases online, in the *Control Engineering* Buyer's Guide or *Control Engineering* Online Buyer's Guide under these categories:

- Limit switches
- Photoelectric sensors
- Proximity sensors and switches
- Sensors, fiber-optic
- Ultrasonic detectors □

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