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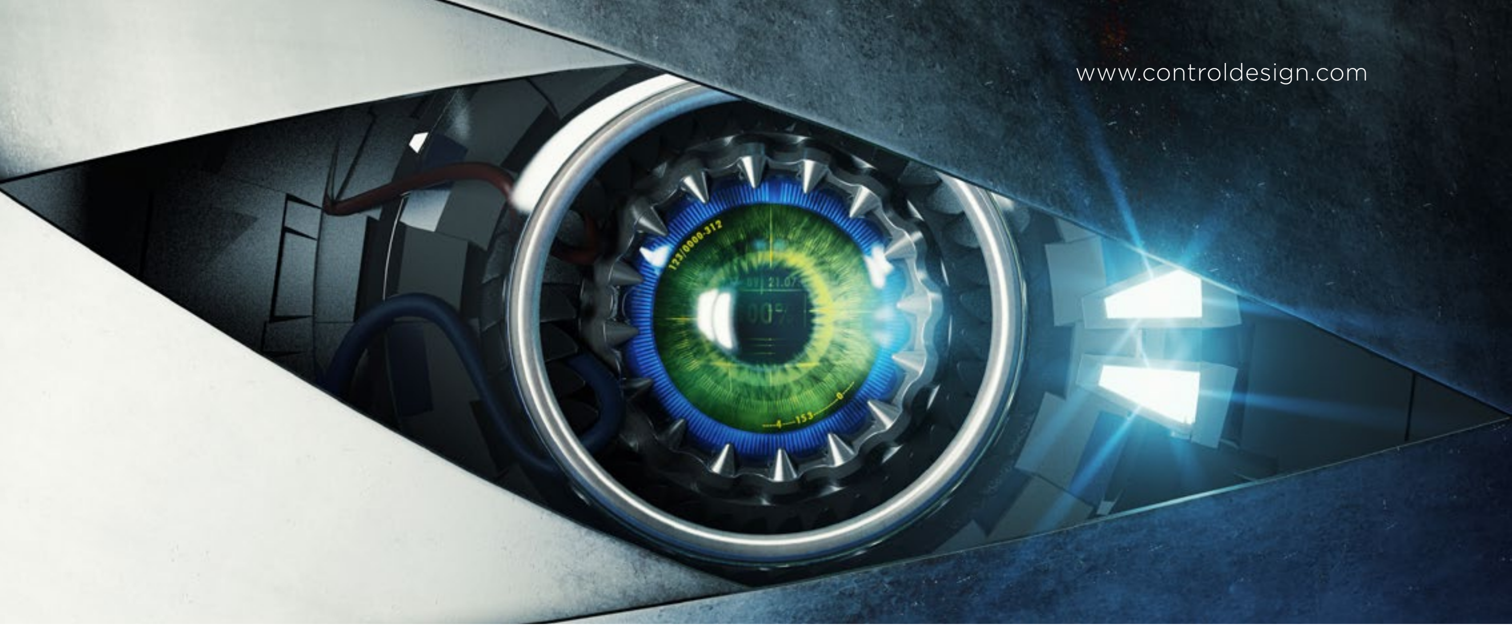

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What is safety in industrial automation?

By Jeremy Pollard, CET

I remember back in the good old days that an e-stop wired into a master control relay (MCR) was the only way to go to take power away from the controlled outputs in an automated process. There were always 200 devices in series—an exaggeration, maybe—so that any one of these device could take the system down.

Have fun troubleshooting that mess.

Anti-tiedown pushbuttons on presses were all the rage until someone decided to see if they could tie wrap one of the buttons in the closed position and see if the press would still work. Imagine their surprise when it did. Pushbuttons were replaced by finger sensing, so that the operator had to use both hands for safety.

Therein lies the rub. The safety is for what or whom—the operator or the press?
Well, it's the operator.

Modern-day safety systems have morphed into something unrecognizable from the early days of simply protecting the operator. Safety devices, controllers and networks are all part of the puzzle that falls under the safety umbrella. This umbrella suggests that there is protection for all things automation, and it can do it with the same flexibility and software that we have come to take for granted in standard control systems.

Today there are different safety integrity levels (SILs). As per “A Guide to the Automation Body of Knowledge” from ISA, a SIL is not directly a measure of process risk, but rather a measure of the safety system performance of a single safety instrumented function (SIF) required to control the individual hazardous event down to an acceptable level.

Imagine an e-stop button that is required to stop a pallet wrapper in its tracks when hit. The reasons for this need can vary and need to be defined by operations. Remember it is an emergency-stop function.

Let’s say it is wrapping tires, and the top course of tires shifts on the first wrap and needs to be repositioned. A normal stop function may be OK for this. However should someone open a gate that has not been identified as part of the safety system performance review, and approaches the wrapper, the wrapper has to stop 100%.

With a normal stop button, the contact block may have fallen off, and pressing the button does nothing. I have seen that happen.

With an e-stop, however, it has to work. Back to the old MCR system, an e-stop button was a mushroom-head button, red in color, with a single NC contact block—no different from a normal stop button, and it can suffer from the same issues.
In today’s 100% world, the e-stop now has two contact blocks and is normally wired into a safety relay or controller. This system detects a contact failure and wiring malfunctions. Also, when this e-stop is hit, it stays locked in, and the user has to twist it to release—all positive actions.

Some safety relays cannot tell you which e-stop has been pressed, but I would submit that a safety relay should only be used in a closed system, such as a small machine skid. For larger processes and processes that are distributed, the risk management system has to adjust.

The safety controller is software-driven and can report to the control system when the e-stop has been pressed. A safety network can be employed to connect multiple safety controllers together to create a homogenized system to protect all aspects of the operation.

Safety-device application determines the level of SIL. Level 1 is the old MCR system where the systems employ standard control elements.

Level 2 is entry level for a true safety system. Redundancy is the word of the day here. You could use a standard e-stop with two contact blocks with two MCR relays, and you would create a better safety system. But you would normally want to use fail-safe devices with a safety-rated relay system.

Imagine an e-stop button that is required to stop a pallet wrapper in its tracks when hit.

Level 3 is fully fault-tolerant. This is the level in which true safety-rated devices, relays and controllers would be used, along with the connectivity component where needed.

One application I was involved in was to detect a person who has entered an area in between moving carts. We used a Pilz eye-in-the-sky device, which detected movement within a configurable area.

There were two issues. The first was personnel safety. The company didn't want to have anyone hurt from being in the wrong place. Secondly, a cart could twist and get trapped causing a pileup, which could harm the overall process.

There were times where an operator had to be in that area to perform his duties, which would shut the process down, which could not be disabled. The need to run the process became more important than the safety aspect, so it came down to training.

Being safe means different things to different people and to different processes. Be sure you have a proper safety design and that it is fail-safe.

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What's your position?

How to measure motion

By Rick Rice, contributing editor

When we set out to design a control system, the algorithm that brings all the elements together depends on knowledge of where the various components are at any given moment. The means by which that data is collected and transmitted are what we all know as sensors. Simple motion only requires simple sensors, while complex motion requires something more sophisticated.

One simple motion, where a device meets with a physical barrier like the end of stroke on a cylinder or rotary actuator, the feedback might be translated into the element of time. With a known volume of air (or hydraulic oil) and known pressure of delivery of the medium, a cylinder will travel a known distance in a specific amount of time. The problem with using time is it's, well, relative. A slight variation in volume or pressure and the device arrives too early or two late. To enhance the indication of simple motion, digital sensors can be used to indicate positions along the path of the motion. Start and end points are the usual points of reference but other sensors can be used along the path to anticipate the arrival at either end of travel or, perhaps, a position in the middle.

Digital feedback is good for relatively slow processes but the desire to move faster renders these simple on or off sensors of limited use. As control processes become more elaborate, other means of feedback must be employed. The more complicated the item being controlled, the more complex the sensing method must be. In a blending operation, for example, opening a rotary valve releases product into a vessel. In order to determine when to close the valve, a means of measurement needs to be employed. A device that measures pressure or flow would be most appropriate for this.

The methods of sensor feedback mentioned thus far work great when the process or motion is relatively slow. Beyond simple motion, however, any control system that involves moving parts must include a more elaborate form of feedback to indicate the physical position of the object in motion rather than the presumed position at a given time.

Motion can be divided into two basic types, linear and rotary. As a matter of fact, in many circumstances a rotary device can be used to induce linear motion through the use of pulleys and belts. The important factor in motion, especially where more than one object is in motion at a time, is to know the precise physical position of each element, relative to the other objects in motion.

Let’s look into the methods of translating linear motion into relational data. The great thing about linear motion is there is a start point and an end point. Since there is a known start point, then any variety of methods can be used to determine the distance between the stationary start point and a point along that linear path. Linear position sensors convert displacement of an object into an output signal.

One simple example of a linear sensor employs a string pot attached between the base of the device and the end of the linear rod. As the device extends, the string extends with it causing a change in the string pot. Another example of this type of technology would be a linear potentiometer. In this situation, the mechanical linear movements are transformed into corresponding electrical variations. Another type of linear sensor measures the distance between a position magnet and head end of a sensing rod. This technology is known as a magnetostrictive linear sensor. In all of these examples, the output can be in the form of analog signals in either voltage or current.

When measuring rotary motion, a different type of sensor is employed. Rotation is measured as equal segments of a circle. A complete circle (one rotation) can be measured in term of degrees, radians, gradians or other equal divisions. The most common measure of a circle learned in school is a degree. There are 360° in a circle. A radian, used in trigonometry is defined as the measure along the circumference of a circle that is equal to the radius of that circle. For that reason, 1 degree equals 57.295°. As one can imagine, when wanting to accurately measure the rotary motion, the use of radians would not make sense. A gradian, on the other hand, is defined as 1/100th of a right angle. A right angle is defined as 90° so 1 gradian is 0.9°. From these examples we can see that measuring in degrees or gradians would provide many more counts for one complete rotation of a shaft.

Early measuring devices would use degrees or radians to convert circular motion into counts relative to the amount of rotation of the driven device. One such early method was to use a disk mounted to a shaft where bumps on the disk would activate a line of switches resulting in a count using binary. Binary, you will remember is a sequence of 1s and 0s (on and off) to represent a count. In such a manner, the turning off or on of switches as the device rotates through 360° would provide a count representing the position of the rotating shaft at any point in the motion. One main disadvantage of this type of technology came with the realization that, at any given time, more than one switch might be changing states at the same time. During these moments, the count would suddenly be unstable. A quick example of this would be a count of 3 (decimal) which is represented at 0111 in binary. To go from 3 to 4, the binary counters (switches) would go from 0111 to 1000. During the exact moment of transition from 3 to 4, the three lower bits would be turning off while the 4 bit would be turning on. The result would be a brief moment where a 0 result would appear between 3 and 4. More likely, since these were mechanica switches being activated but a bump or groove in a disk, other counts as little as 0 and as much as 1111 or 16 decimal could be translated. To solve this issue, a researcher at Bell Labs, Frank Gray, devised a modified binary code, called reflective binary code, where the bumps or gaps in the disk (and associated switch) were rearranged so that only one switch at a time is ever changing state. This development became known as Gray Code and provided a way of accurately representing rotary motion.

Much has changed over the years but these basic principles are very much in play today. The angular relationship between two pulses makes up the encoder that we know today. As technology has improved, the ability to resolve a circle into more and more segments is possible. Where 360 equal segments (counts) might have been possible in the past, multiples of 360° became the norm. 360 pulses per revolution, 720 pulses per revolution 1,640 pulses per revolution … you can see where this goes.

Encoders are divided into two types, incremental and absolute. Incremental encoders begin counting from zero each time they are powered up while absolute encoders retain their count while powered down. For this reason, an incremental encoder must always come back to a reference position when first powered up to provide an accurate representation of rotation made after the “homing” move. Generally, incremental encoders tend to count in pulses per revolution and absolute encoders count in bits. Some high resolution absolute encoders can count over 10,000 bits per revolution.

In recent years, encoder technology has been enhanced by the emergence of communications protocols that have become commonplace in controls designs. Early encoders depended on specialty modules to convert the electrical counts (like Gray Code) into position feedback. Now, with an easy-to-use connection to network protocols like Profibus or Ethernet I/P, encoders are a snap to install and commission. Modern day marvels include numerous value added features like software configuration to change parameters like resolution and direction simply by changing a value in the programming interface. My favorite automation company has added some more features like teachable home positions (resetting the count or setting it to a specific value) and velocity feedback in addition to the traditional position feedback value. With the ever present Internet of Things, the encoder of today can even provide health status of the device.

It's hard to imagine that just a few years ago (or so it seems) the inclusion of an encoder meant adding code to convert a Gray Code device back into a decimal representation of a rotary position. With motion so easy to implement and feedback so accurate, it's not hard to imagine a future where all devices will be electro-motion activated. What's your position?

The eyes have it

Machine vision comes of age

By Jeremy Pollard, CET

My very first interface with machine-vision systems was working with a Canadian company that wanted to use a PLC to automate television CRT tuning using four high-resolution analog cameras. The cameras were on a gantry system that would be placed in front of the CRT, and a pattern generator would provide the signal to display. The PLC was to automate the setting of the RGB guns and convergence to provide for a color-accurate display that was sharp.

It didn’t work for reasons that have slipped past my recall, but it had something to do with the lack of data coming to or from the cameras to allow the PLC to perform its duties. The project was in the 1980s while I was working for Rockwell Automation.

Machine vision has come a long way since then. My last interface was with a Keyence image color camera, which was detecting whether or not a tube had been inserted into a bag for sealing. Detecting the orientation of the tube meant two things. First, was the tube inserted far enough into the bag? And, second, the tube could vary in angle by 45°. The camera had to be very fast in determining the result.

And it was and worked flawlessly. It had to evaluate color, as well. Lots to do, and it did it well. We have come a long way.

In the beginning, machine-vision systems were disguised as barcode readers as such. Reading barcodes and QR codes is child's play today.

Heuft makes bottle inspectors. I saw it in action at a local brewery while it was scanning bottles at 120 bottles per minute for foreign objects that had been left in the bottle after washing. It was fascinating to watch and to understand the technology behind it. It interfaced with a PLC for bottle rejection and control. It simply compared a black-and-white image to a stock pattern, and, if there was a difference, then it rejected the bottle.

What a difference 20 years makes in vision.

Black-and-white vision can do pattern recognition easily enough, and today's cameras can go far beyond that by using color for part sortation and final inspection among other tasks. Some cameras can detect colors in 24-bit resolution, which translates into 16 million different color variations, and that is probably better than any human can detect. The nuances in color are lost with the human eye, but not to technology.

Cognex, a vision vendor, can detect color variations down to the pixel level using its color model tool. Imagine producing cosmetics and scanning for imperfections in the finished product based on color tones. The surface of the product has to be uniform to within specifications, and the vision system can perform this task.

Most machines have network connectivity these days, and IP cameras can play an important role in machine vision. An IP camera can be placed strategically on the machine to allow the operator to see certain operational locations that would be unsafe for them see natively.

Machine vision covers a wide assortment of options from a task perspective. I am sure that if you take a look at a modern day assembly system you could identify where a vision system could be employed.

If you think it, it can be done. A vision system can detect anything with a very high degree of resolution and accuracy. The ability to interface with control systems has been greatly enhanced, as well as the ability to pre-process information and deliver that information directly to HMI/SCADA systems.

The ability to be networked has expanded the application base, as well as the capabilities such as machine learning, operational learning and cloud interfacing. It truly is a different world today.

I learned that the automotive industry uses color-coded glues in manufacturing processes. There is no better way to have quality control of the glue application than to have a vision system monitoring the application from the robot, as well as final inspection once the robot is done. Redundant quality checks are paramount with these subassemblies.

The ability to see using technology has been revolutionary. The incurred costs are miniscule compared to waste and lost production due to a failed process, which can be nipped in the bud using machine vision.

The industry has done a great job in providing the tools to successfully set up their systems and to monitor their operations. The hardest part is product selection for the job at hand. You don't need color for pattern recognition, but for advanced applications you just might. These two parameters can be used in tandem to replicate the human eye. Who could ask for more?

It is a very cost-effective solution to some very complex problems. Keep an eye out for these solutions.