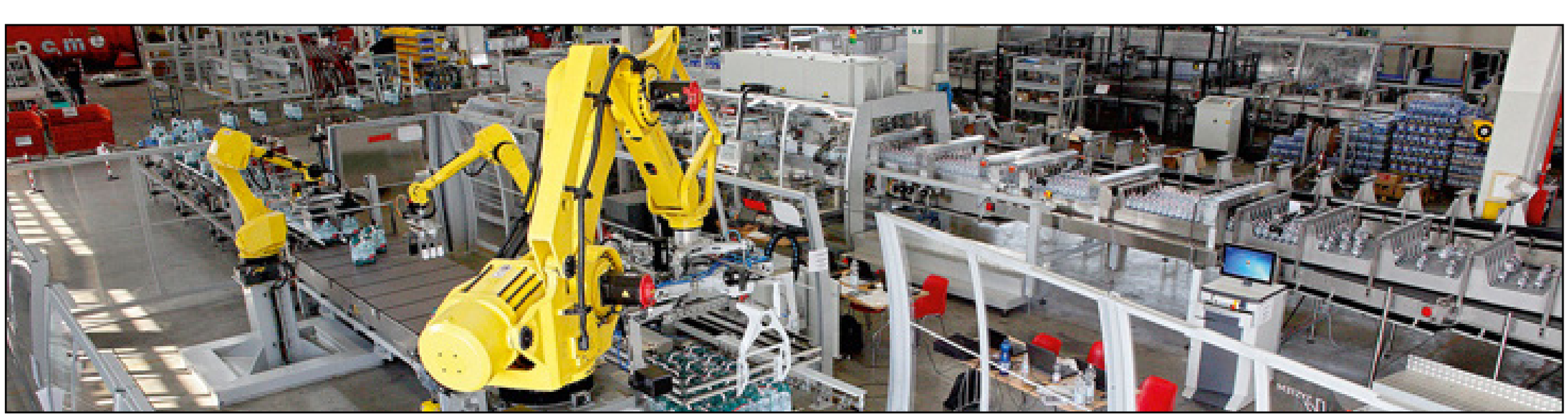
Networked safety: why it will pay you big to start small

The vision of networked safety has largely centered on networking safety of functions across integrated systems, cells and lines.

The reality is that machine builders are typically not responsible for safety beyond their own machines.

For them, even a hardwired safety PLC is often considered cost prohibitive for a feature not required by the customer. So for the majority of stand-alone machines, hardwired safety circuits remain the norm. ■



Discussions of networked safety have centered on lines, not individual machines

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A huge potential to be realized

A huge potential to be realized

Despite attempts to modernize safety circuits, hardwired devices can provide only rudimentary communications.

As long as hardwired safety remains the norm, significant improvements in efficiency, response time, diagnostics and productivity will not be realized.

There remains some resistance to troubleshooting 'invisible' software over a network versus taking out a screwdriver and meter to test copper connections. ■

Networked safety can increase productivity

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To proliferate, networked safety has to pay for itself up front

To proliferate, networked safety has to pay for itself up front

Some progressive European OEMs have implemented networked safety

This, of course, is déjà vu. First came fieldbuses to replace long runs of wire between sensors and controllers. Then came motion buses. Then came a convergence of the separate networks onto industrial Ethernet.

It's inevitable that safety will converge onto that same Ethernet cable as well. This is essential in order to access the same benefits as the other networked control applications. Chief among these are diagnostics, for a preventive rather than corrective approach to safety. Networked safety also supports modular design and simplifies customization, just as networking has for non-safety control devices.

Safe motion, safe robotics and zoned safety are in fact being applied today, but only by a relatively small number of progressive, technology-centric, typically European OEMs.

To make this happen on every machine, networked safety has to be competitive with the installed cost of hardwired safety devices – which is now the case. ■

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Cost breakthrough: safety I/O slices replaces safety circuits

Cost breakthrough: safety I/O slices replace safety circuits

Networked safety I/O slices have lower installed cost than hardwired

The latest development in safety technology is safety I/O slices that do not require use of a dedicated safety PLC. This makes the hardware cost comparable and the installation and testing costs actually lower than hardwired.

As simple as it may sound, this is a major breakthrough. Because until networked safety becomes standard or a no/low cost option on individual machines, networking safety across a production line isn't likely to take hold, either.

When the true cost of engineering, installing and maintaining machine safety systems is analyzed, networked safety also provides lower Total Cost of Ownership – just like the benefits of word processing compared to a manual typewriter. ■

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Installed cost comparisons

Vertical form/fill/seal machine

Installed cost comparisons

Following are cost comparisons for a simple vertical form/fill/seal machine and a slightly more complex case packer. The costs compared include:

- Engineering and installer labor
- Device wiring and electrical cabinet sheet metal work
- Testing, troubleshooting and debug time
- Hardware cost, including wiring, terminations and trays ■

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Cost comparison: vertical bagger

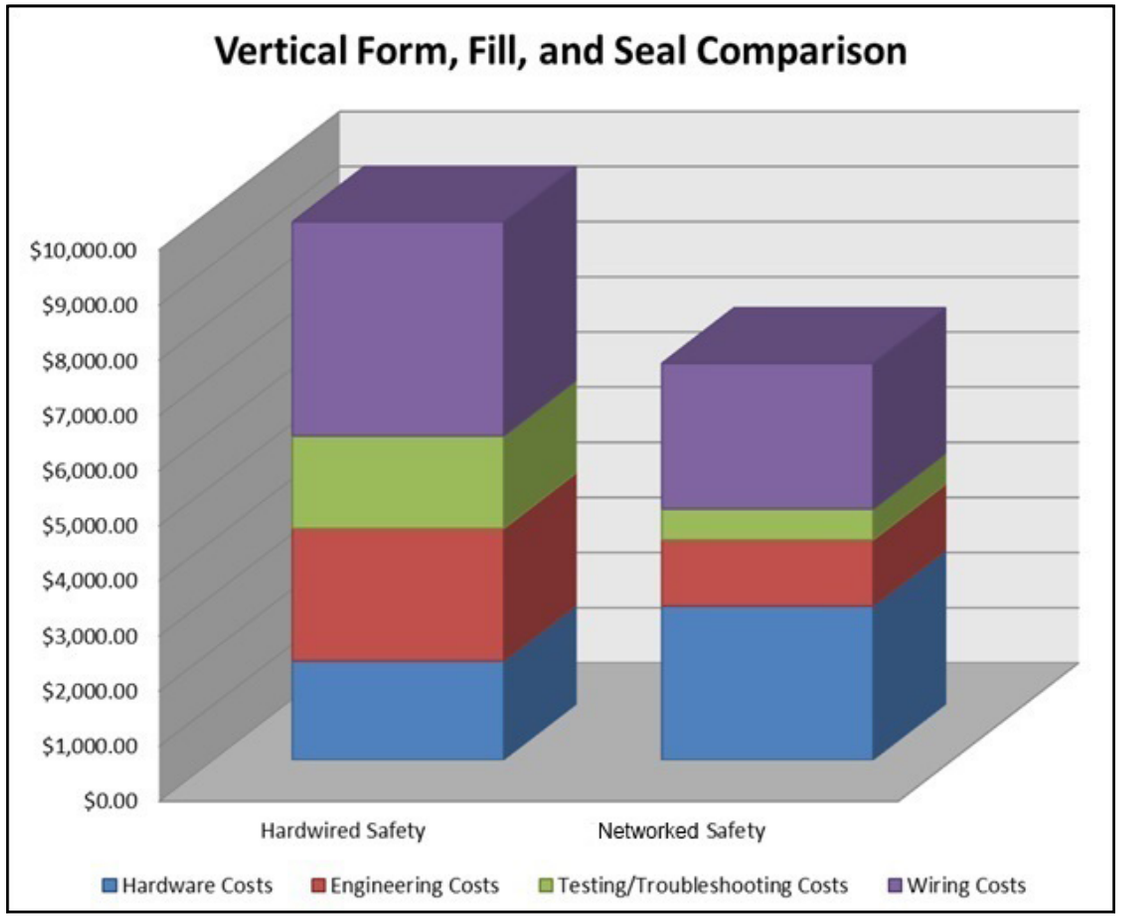
Cost comparison: vertical bagger

Vertical form/fill/seal machines are straightforward machines that compete in a price-sensitive marketplace. So, networked safety would appear to be cost prohibitive.

Yet, the upfront component cost for I/O based networked safety is only slightly higher than traditional hardwired relays.

Once installation and testing costs are factored in, networked safety wins hands-down, even if recurring labor costs and production stoppages are not considered.

For a detailed breakdown of time to complete tasks, hourly rates and material costs, click here. ■



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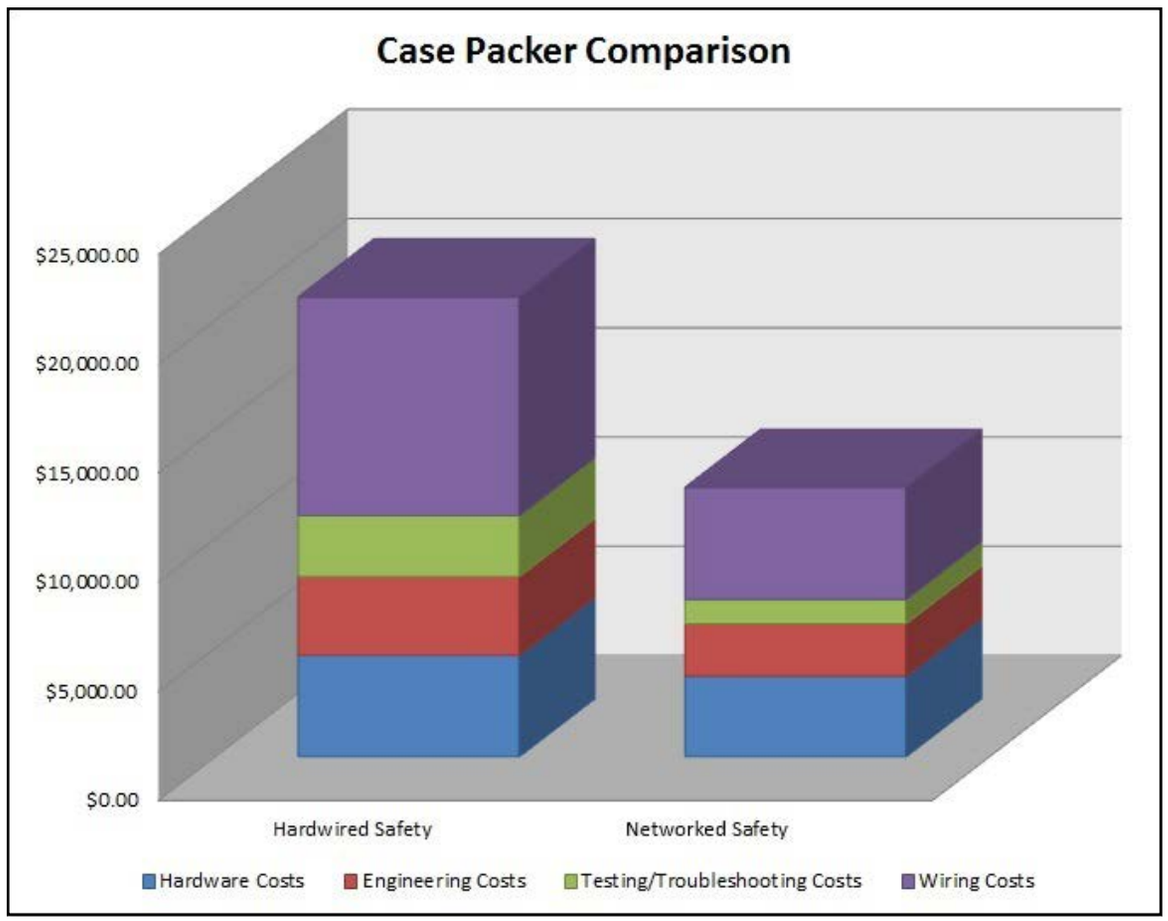
Cost comparison: case packer

Cost comparison: case packer



As machinery increases in size, complexity and functionality, so do the disparities in installed cost between hardwired and networked safety.

On a case packer, for example, the hardware cost itself becomes less for networked safety than hardwired safety. And the wiring, testing, troubleshooting and engineering costs are substantially reduced, even with the addition of some programming time.

For a detailed breakdown of time to complete tasks, hourly rates and material costs, click here. ■

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A closer look: hardwired light curtain

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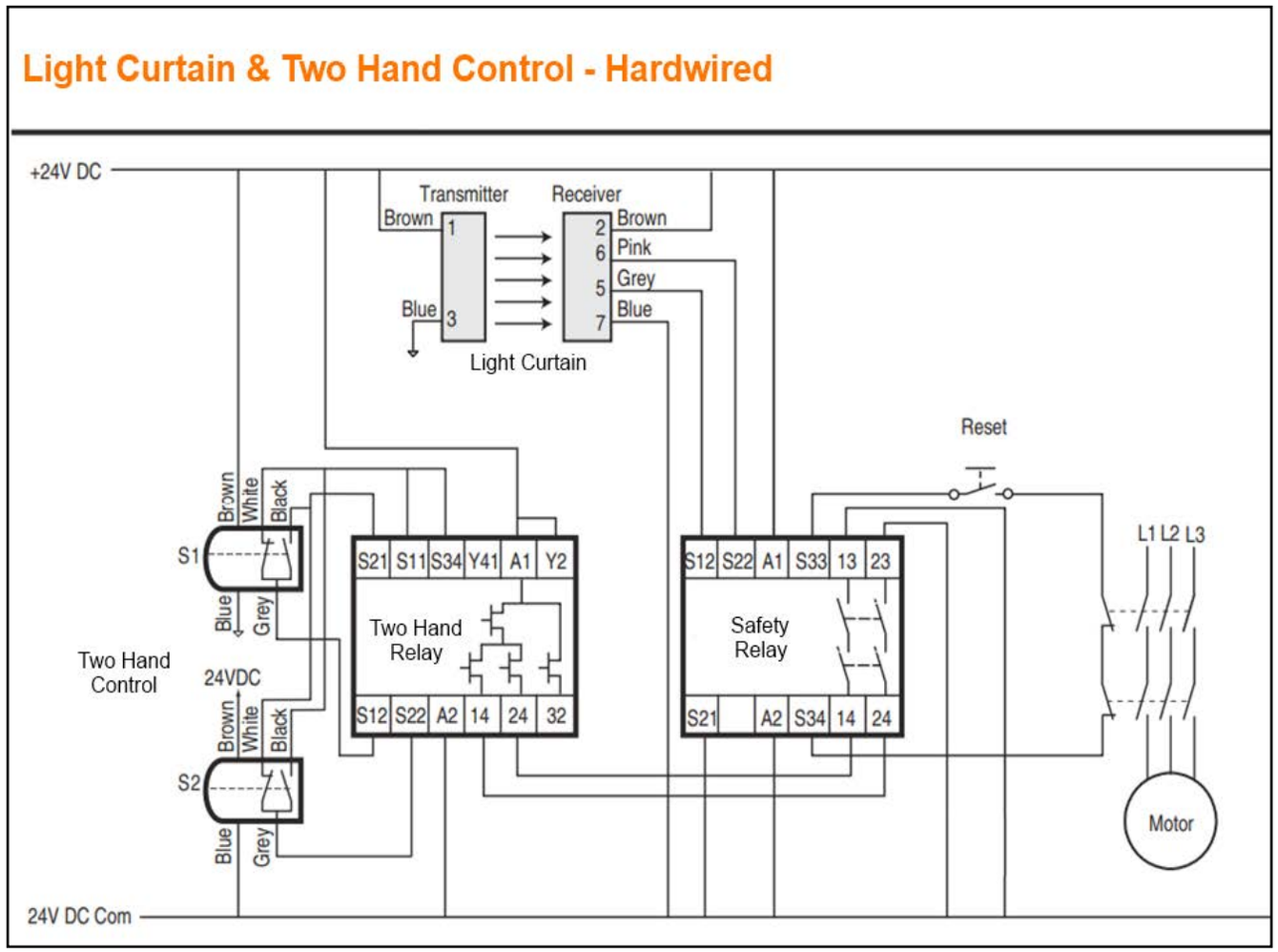
A closer look: hardwired light curtain



Here is a hardwired light curtain with two-hand control.

Two separate safety relays are wired in series to allow the system to shut down the motor when either function is tripped.

Each connection must be thoroughly tested to ensure that the system is wired and operates properly. ■

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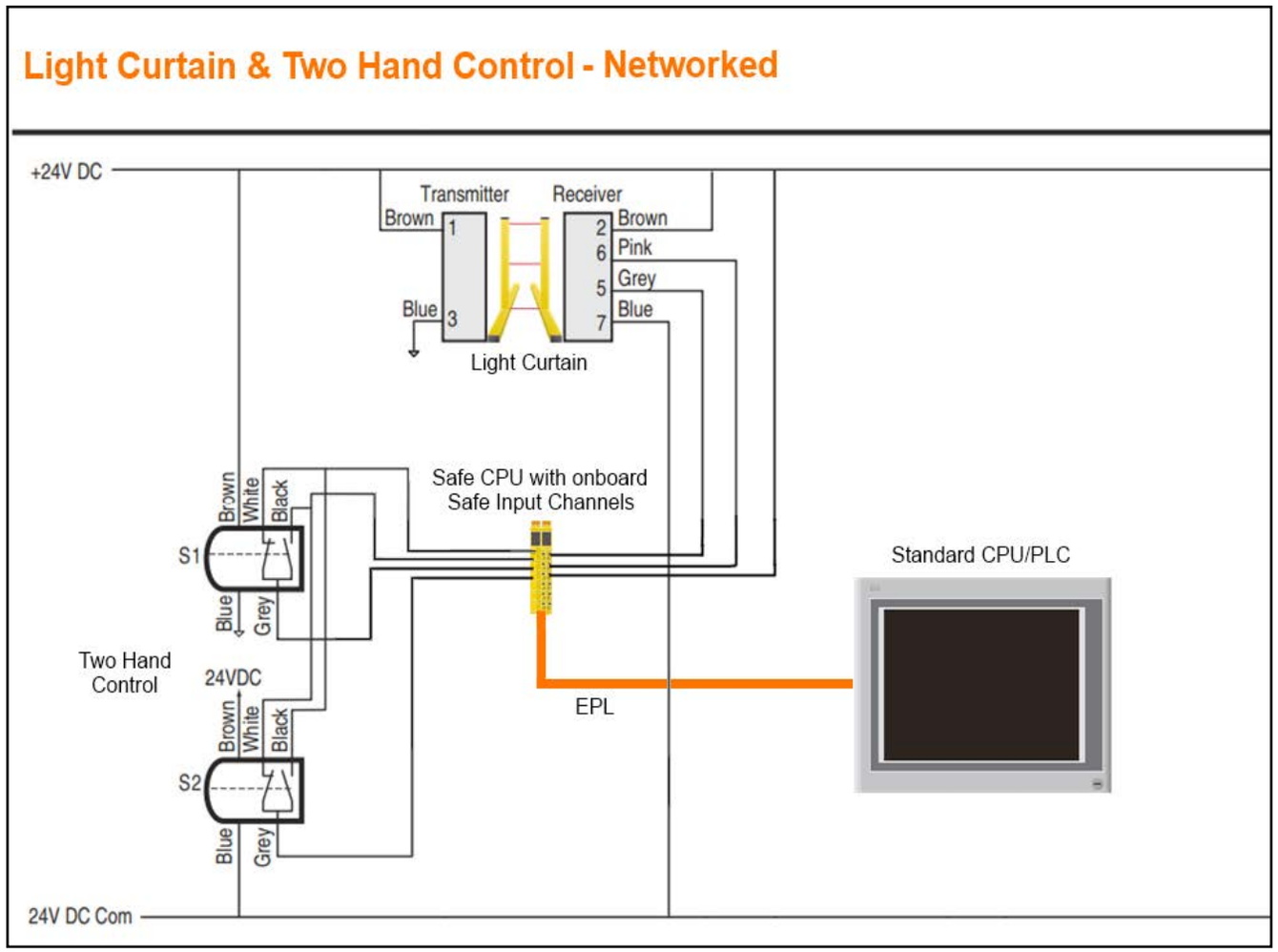
A closer look: networked light curtain

NEXT

A closer look: networked light curtain

In the networked safety implementation, wiring is greatly simplified.

The safety PLC evaluates the functionality and determines the response to a breach of the light curtain through safety rated Function Blocks. It communicates over the machine's industrial Ethernet network to inform the machine's and line's controllers of the change in running status. ■



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A closer look: hardwired door interlock

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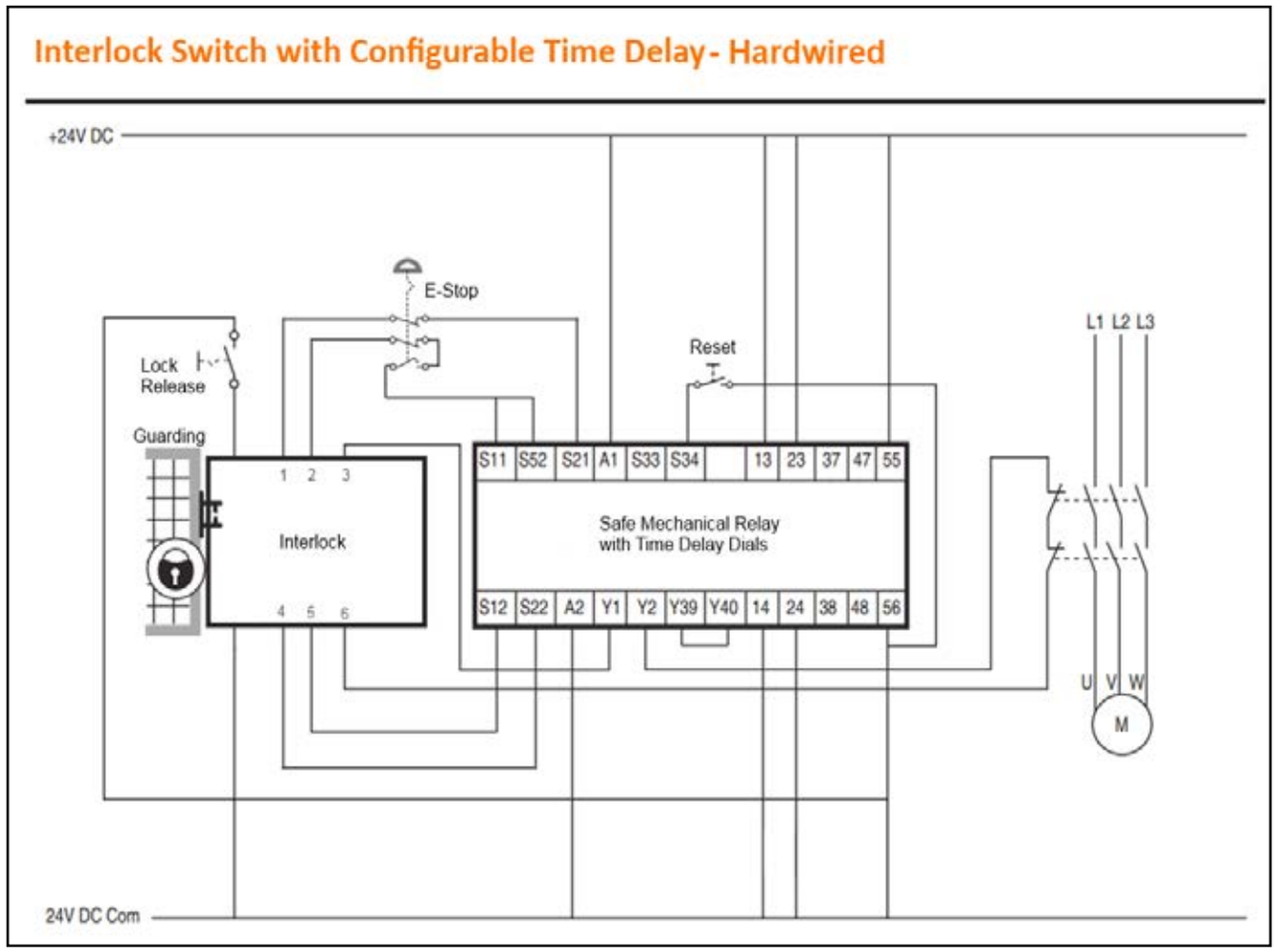
A closer look: hardwired door interlock



Here is a hardwired interlock with a time delayed mechanical relay.

A safe mechanical relay is connected in between the motor and the door interlock. The relay needs to be manually configured using dials to parameterize the delay between removal of power to the motor and the release of the door interlock mechanism. This means that each change requires the shutdown of the electrical cabinet and the machine to change the time delay. The system also lacks feedback so this time delay is required even if the motor is not powered.

Each connection must be thoroughly tested to ensure that the system is wired and operates properly. ■

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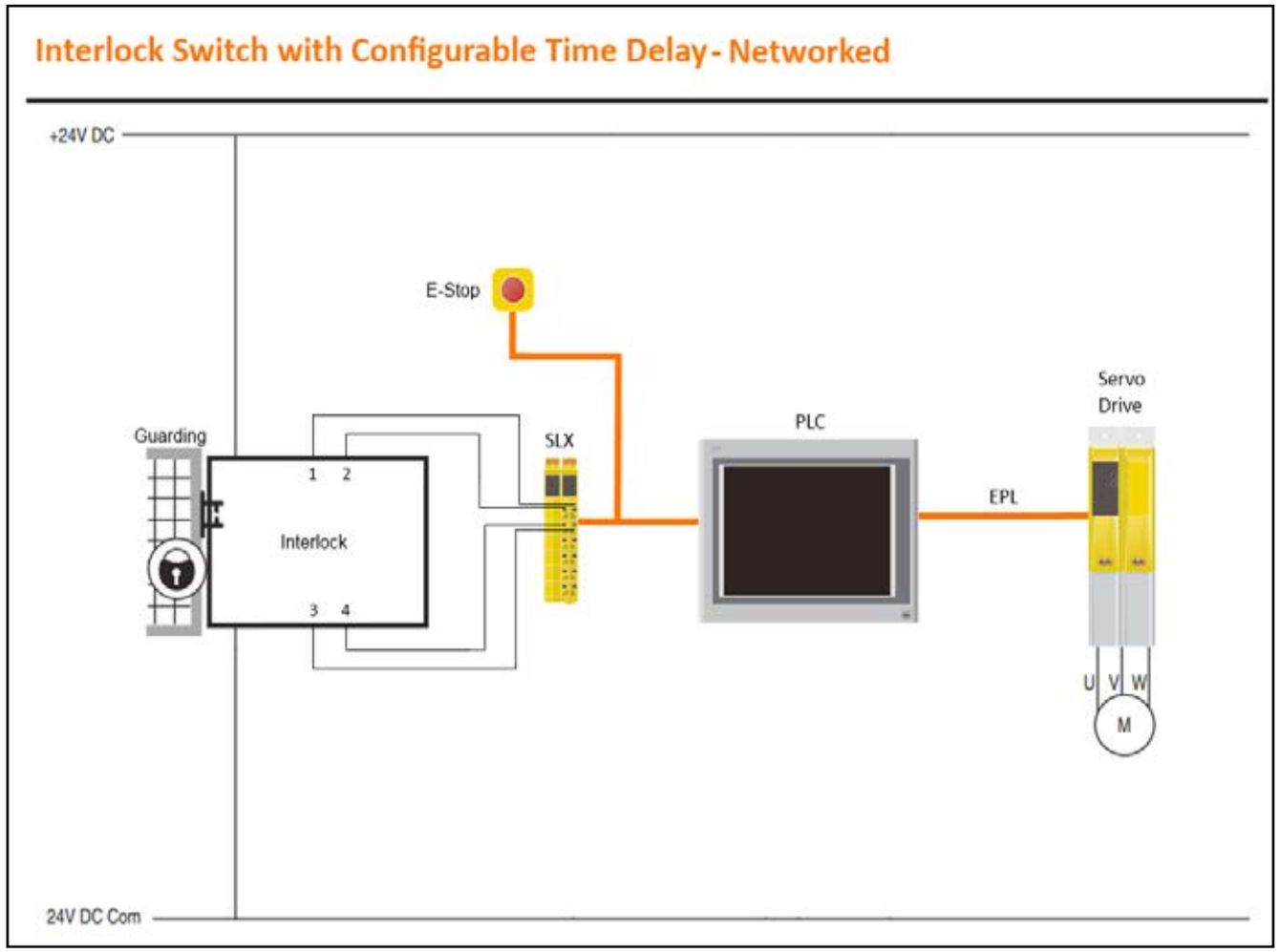
A closer look: networked door interlock

A closer look: networked door interlock

In the networked safety implementation, wiring is greatly simplified.

The safety PLC configures the time delay between cutting the power to the motor and a door entrance request through safety rated Function Blocks. This configurability means the system parameters can be changed over the Ethernet network and does not require a system shutdown. ■



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Productivity improvements

Productivity improvements

Networked safety slows the line instead of stopping it.

Once installed, Overall Equipment Effectiveness (OEE) comparisons show the advantages of networked safety over hardwired safety by reducing and preventing stoppages.

Networked safety provides the ability to create safety zones, reducing speed instead of stopping to clear jams, home and replenish consumables.

A high incidence of even short stoppages will result in lost production, starting current spikes and the inability to maintain the most efficient steady state speed. ■

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Safe motion

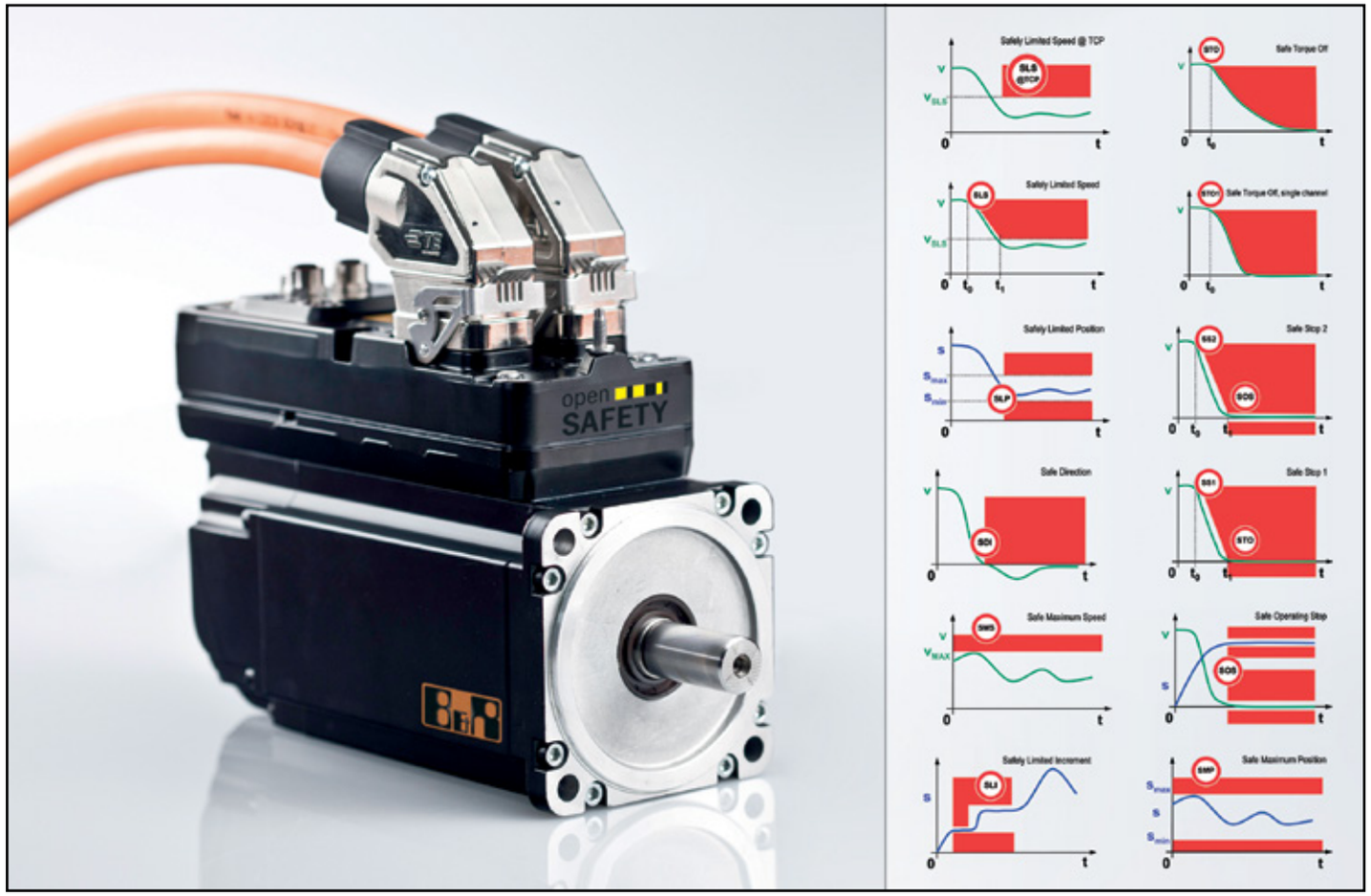
Safe motion

Safe motion provides a new opportunity for increasing productivity by maintaining control over the motor position, speed and torque in a variety of ways. Networked safe motion goes far beyond the Safe Torque Off (STO) that's a common feature of today's servo drives. It allows the machine to continue to run in a safe mode.

Safe motion is easier on drivetrains than shutting all power off. It provides meaningful diagnostics, reduces component and wiring costs, and permits access to the safety zone while still operating the machine. Here are a few examples.

- SOS -- Safe Operating Stop – where position needs to be maintained during a stop, as in web handling.
- SLS -- Safe Limited Speed – allows a human intervention while a machine runs at reduced speed.
- SDI – Safe Direction – eliminates pinch points by only permitting operation in a direction that cannot draw an object or limb between the moving parts.

Safe motion will be the topic of an upcoming white paper. ■



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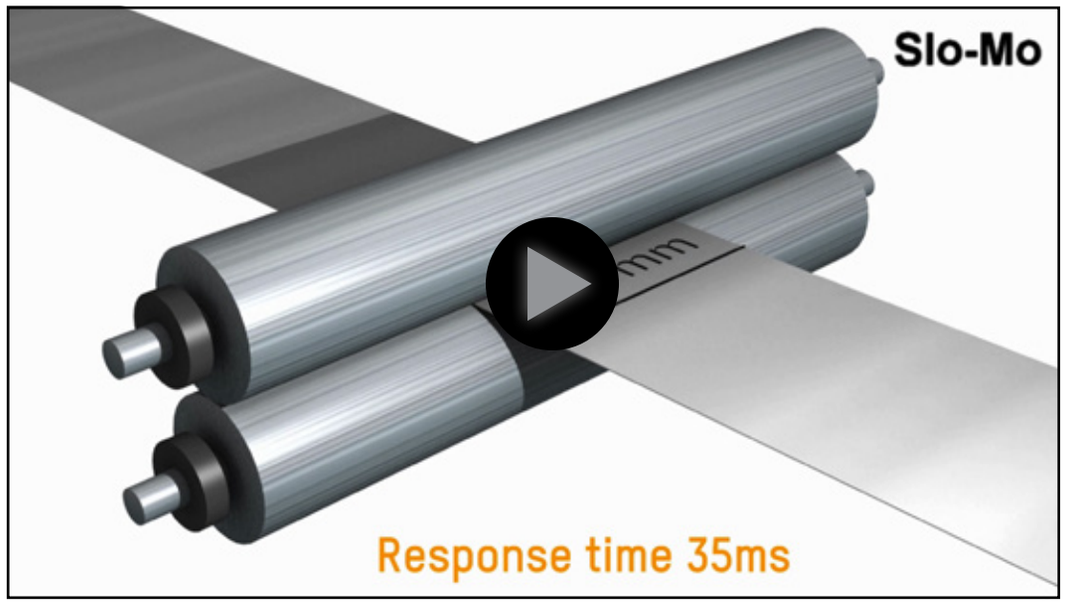
Response time is critical to safe motion

Response time is critical to safe motion



Safety functions like Safe Limited Speed are dependent on system response time.

It should be noted that response time of the safe motion system is directly related to safe speed and torque limitations.

The response rates of available safety networks range from as fast as a few milliseconds up to 80 milliseconds. Response times on the slower end of the spectrum make some safe motion functions, like Safe Limited Speed (SLS), impractical.

Faster response also means the machine footprint can be smaller because it's not necessary to build a buffer zone between the guarding and the machinery. ■

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Scalability

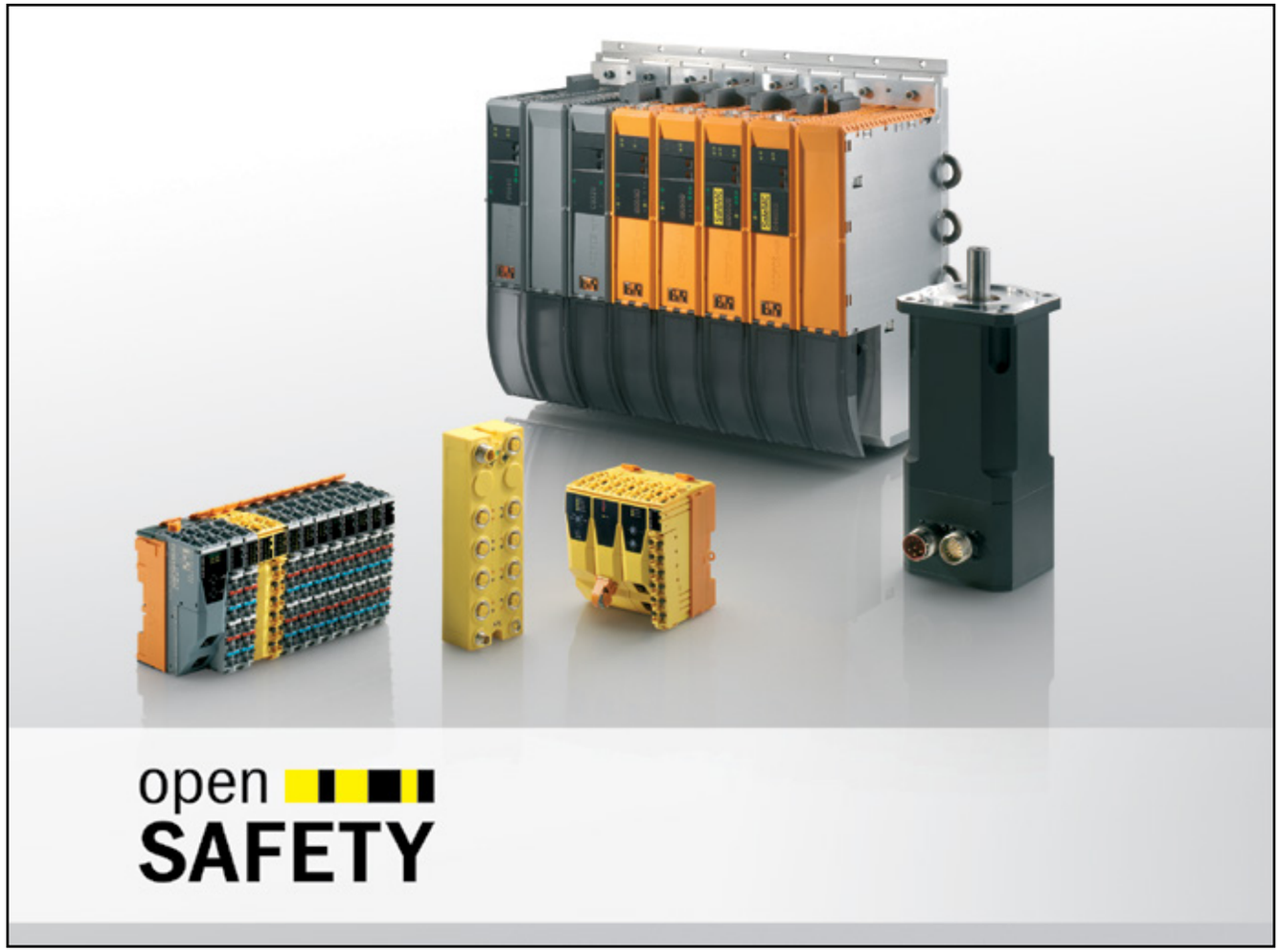
Scalability

Networked safety products should have the flexibility to adapt to any desired SIL (Safety Integrity Level) or PL (Performance Level) rating without having to change hardware.

One reason that safety relays aren't scalable is the physical wear associated with electromechanical switches versus electronic devices, making it more costly to achieve higher mean time to failures (MTTF).

Programmable devices also inherently provide the high levels of diagnostic coverage (DC) needed to achieve the highest safety ratings -- PL d-e, SIL 3 and CAT (Category) 4.

The availability of IP67 rated remote safe I/O blocks further reduces length of wiring runs and cabinet space requirements while supporting modular design. ■



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Compliance to current safety standards

Compliance to current safety standards

Performance Level (PL) in accordance with ISO 13849-1	Probability of a dangerous failure per hour (1/h)	Safety Integrity Level (SIL) in accordance with IEC 62061
a	$\geq 10^{-5}$ to $< 10^{-4}$	-
b	$\geq 3 \times 10^{-6}$ to $< 10^{-5}$	SIL 1
c	$\geq 10^{-6}$ to $< 3 \times < 10^{-6}$	SIL 1
d	$\geq 10^{-7}$ to $< 10^{-6}$	SIL 2
e	$\geq 10^{-8}$ to $< 10^{-7}$	SIL 3

DIN EN ISO 13849-1:2007

EN ISO 13849-1 has replaced EN 954-1 to support the EU Machinery Directive. The new standard accommodates networked safety and programmable safety functionalities that weren't available when the earlier standards were developed.

It is necessary to migrate from the old EN 954 or ANSI B.11 standards. It is considered inadvisable to conform to the new standards for machines going to Europe while applying the old standards in North America. ■

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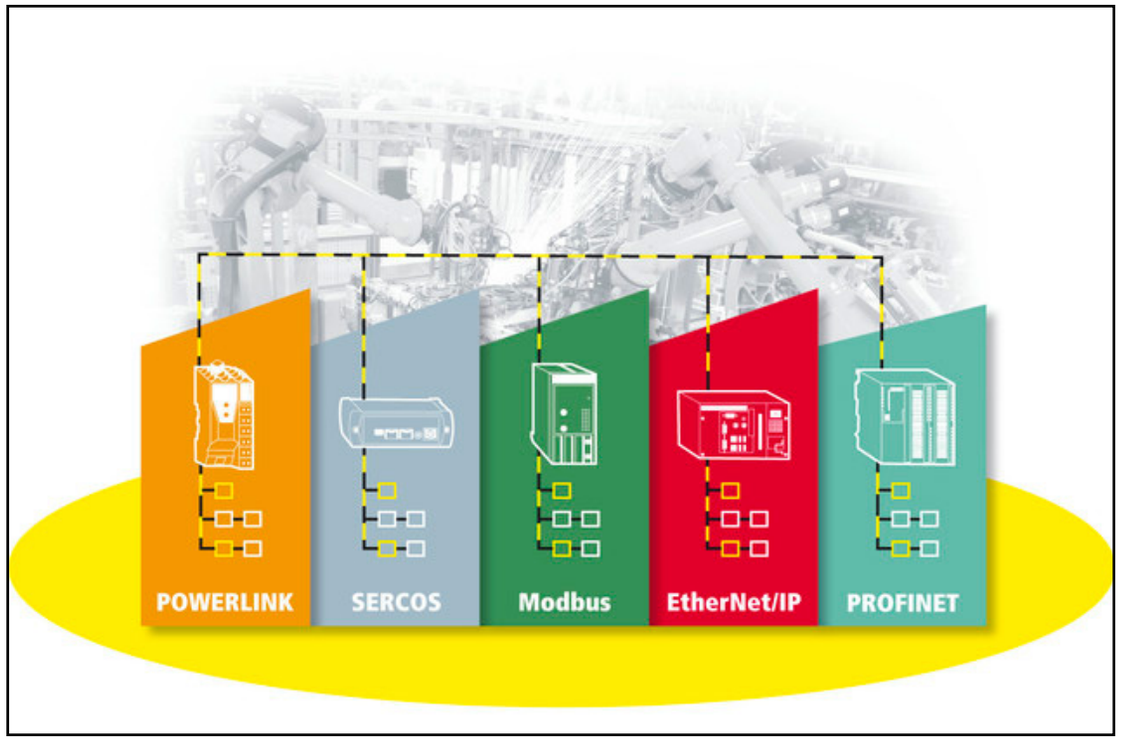
The cost equilizer: an open safety protocol

The cost equalizer: an open safety protocol

The need to support multiple bus providers' dedicated safety protocols increases component and integration costs.

openSAFETY has been demonstrated to run on the application layer of virtually all major industrial networks: EtherNet/IP, Modbus TCP, Profibus, SERCOS III, EtherCAT and the network standard it was originally developed for, POWERLINK.

With openSAFETY, networked safety device have a unified, patent-free, license-free, IEC and TÜV certified, open source protocol with proven performance. ■



open SAFETY

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Machine configuration dashboard and remote diagnostics

Machine configuration dashboard and remote diagnostics

Networked safety enables testing and diagnostics without opening the cabinet.

With arc flash regulations, it's no longer a simple task to open a cabinet with power on, even 24 vdc control power. Instead of opening the electrical cabinet to access and test safety relays, networked safety can be remotely diagnosed.

Some networked safety systems even feature machine configuration dashboards that show each safety function being controlled. This also makes it easier to reconfigure machinery without the need to make programming changes or revalidate.

With conventional safety, it can be difficult to determine when a door lock is slightly out of alignment, or e-stop timing is off. With networked safety, the diagnostics will clearly identify such errors.

Some networked safety systems also allow temperature sensors such as thermocouples to be directly connected to a safe temperature module. ■

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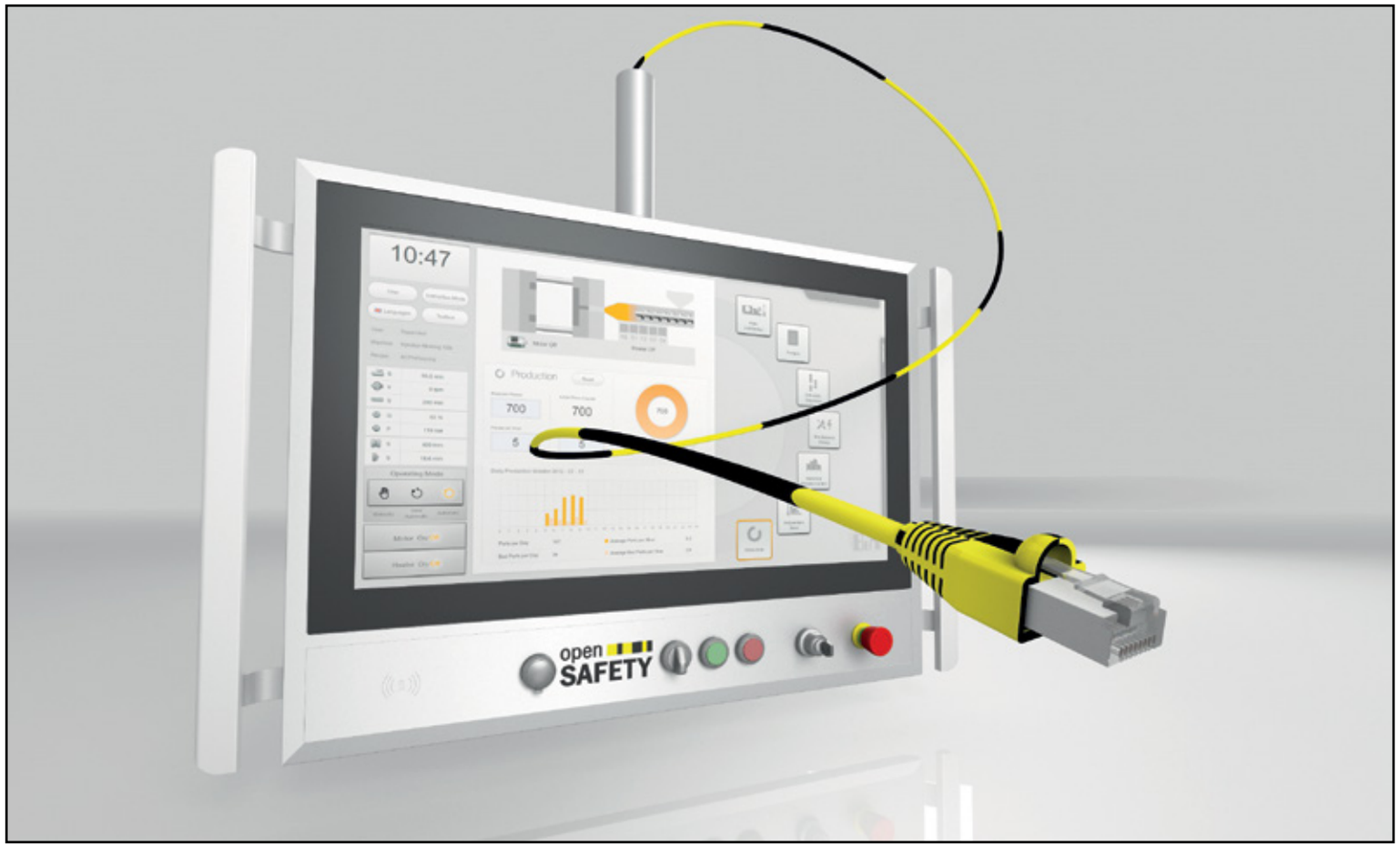
Life cycle costs

Life cycle costs

Networked safety has a life expectancy of 20 years, much longer than electromechanical safety relays that need to be replaced at various intervals. Some users replace safety relays annually as a pre-emptive measure. The switching frequency of the relay impacts its service life, which is not a factor for electronic systems.

Unnecessary wear and tear caused by e-stops is also reduced. Rapid cycling of drives after a full power drop can cause cumulative thermal damage.

Likewise, a $1,000 gearbox may need to be replaced after 500 hard stops. With one e-stop occurrence per 8-hour shift, two shifts per day, a gearbox may only last eight months. ■



Today, even e-stop, operating mode and start buttons can be networked instead of hardwired.

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You have to specify it, or you won't get it

You have to specify it, or you won't get it

Initial meeting of the DDASCA Consortium, which named openSAFETY an official standard in 2011.

Timely adoption of open and networked safety depends heavily on users adding the requirement to their specifications. To learn more, visit the openSAFETY website at www.open-safety.org.

In 2011, the DDASCA Consortium for safety, which notably counts Airbus and the French national railway as members, adopted the openSAFETY protocol, which is certified to IEC 61508 and tested according to the IEC 61784-3 FSCP13 safety bus standard.

Only by specifying open safety based networked safety devices instead of hardwired relays when purchasing machinery, can users drive adoption in a meaningful way.

And, as demonstrated in this document, networked safety need not increase machine cost. ■