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White Paper

Evolving from Safety Relays to Safety PLCs

Abstract

As machine tools and process operations become more complex, the shortcomings of traditional safety relays become more obvious. This white paper compares safety-control-system solutions and highlights the benefits of safety PLCs.

Which safety solution offers the most cost-effective, flexible, and compliant fit for my application?

Consider the LED light bulb. Technology advancements have greatly improved light quality, extended life, and reduced the price of these high-efficiency bulbs. Still, the fact that they cost more than twice as much as traditional incandescent bulbs has deterred most people from making the transition. That's unfortunate, because average annual energy savings in a typical home amount to approximately \$100,

providing one-year ROI. More importantly, there is a tenfold savings over their typical 10-year life.

The situation is similar with safety-control systems. Manufacturers hesitate to incorporate what they believe to be the more expensive technology represented in safety PLCs, despite guaranteed and measurable lifecycle savings. Beyond the cost savings, this technology also dramatically speeds troubleshooting, resulting in reduced downtime.

As safety-control systems become more common in machine/ industrial environments and as the automation tasks get more complicated, more solutions are becoming available. Choosing the right one is crucial. This white paper provides insights into the safety-control systems available today which support design engineers in simplifying their device selection and ensuring compliant, cost-effective, efficient safety solutions.

Traditional safety-control solutions

Safety Relays

These devices have been used to control plants and machinery since the early days of industrial control technology, and continue to be widely used today. In the event of a hazardous situation, the actuator is simply isolated from the energy supply. Simplicity is their strongpoint.

Long-time car mechanics fondly speak of the days when engines were so simple that much routine maintenance could be performed with only a simple set of tools. Plant maintenance team members also appreciate the straightforward simplicity of safety relays and contactors.

Not surprisingly, simplicity is also their primary shortcoming. To return to the car analogy, those earlier engines truly were easier to work on, but they required far more work to keep them running well. They also lacked many performance and reliability benefits that are now standard in every new car or truck. In the same way, relays don't always have the flexibility to meet all requirements of the modern factory.

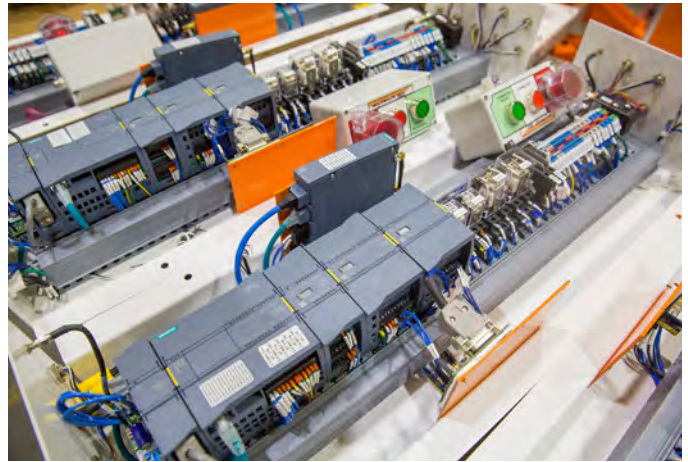
The nature of how safety-relay-based systems are wired means modifications to the system are challenging, requiring significant engineering and wiring time.

There are far more motors, switches, and other control devices that must be accommodated. Each device may require a safety relay that must be individually hardwired, creating serious troubleshooting issues as technicians attempt to identify and repair faults or issues armed only with their multimeters.

One more similarity with older cars is there were a number of mechanical parts – spark plugs, rotors, belts, and others – that were the victim of routine wear and required maintenance at relatively short intervals. Safety relays, also suffer from mechanical wear, requiring frequent maintenance and increased downtime due to faults.

The nature of how safety-relay-based systems are wired means modifications to the system are challenging, requiring significant engineering and wiring time. An electrical enclosure that began as a well-organized cabinet of controls and cabling will often, within a few years, become a confusing tangle of crisscrossed, point-to-point patterns of jumpers and rewires. Future changes become increasingly difficult and problems increasingly more challenging to resolve.

It's also important to note these types of protection systems can simply be bypassed in the event of a malfunction, disabling the protective function.



Safety relays (Single function)

Single-function safety relays ensure proper working of the safety function, keeping both people and equipment well protected. They interface between the control and the actuating device. For instance, an e-stop button (the control device) is detected, evaluated and, through the safety-relay contacts, opens a relay coil (actuating device).

When you look only at the cost of safety relays, they can be a low-cost solution in limited applications, typically controlling three or fewer safety functions/devices. They are simple to operate and have a clear, predefined structure with fixed functionality. Safety relays can achieve up to PL e as per ISO 13849-1 or SIL 3 as per IEC 61508.

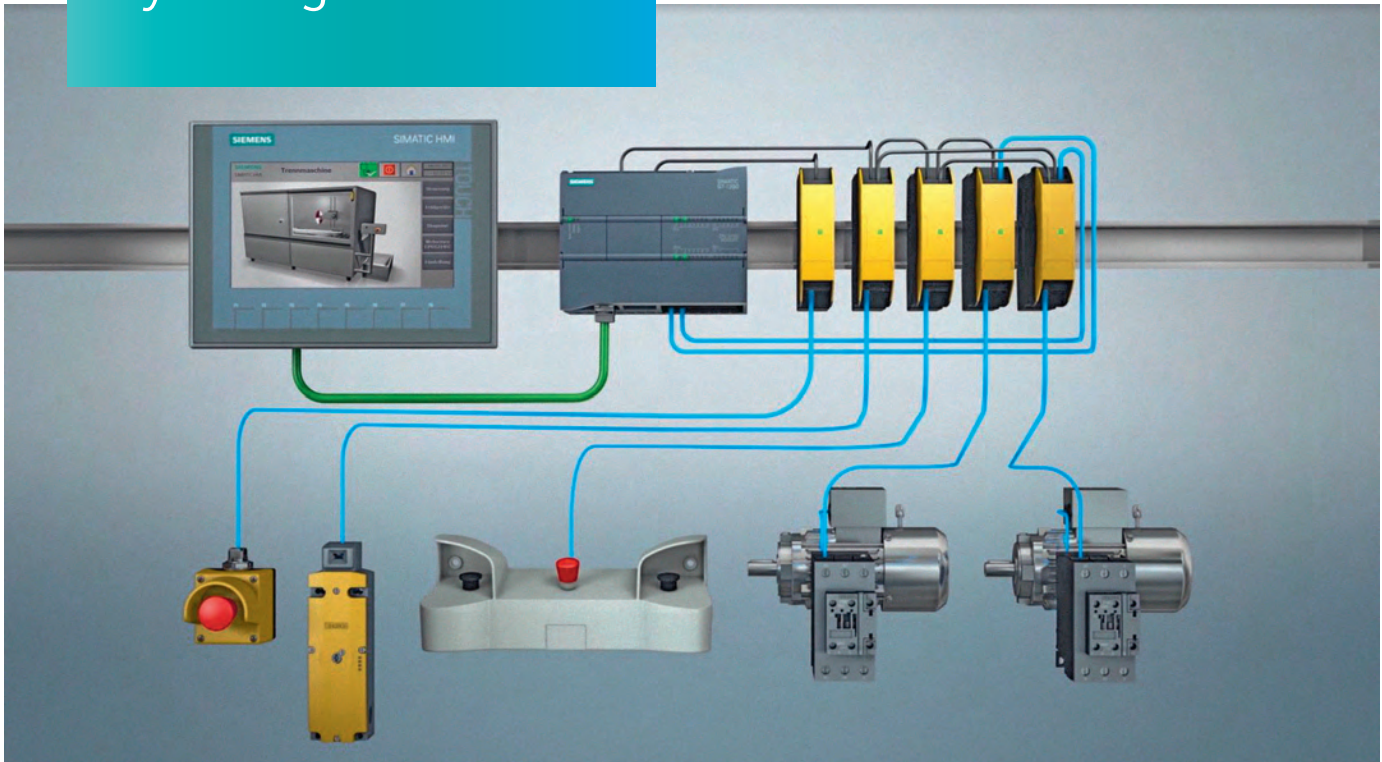
Typical applications for safety relays include:

- Stopping movement in a controlled and safe manner
- Monitoring the position of movable guards
- Interrupting a closing movement during access
- Providing an emergency off/stop

However, as the safety systems become more complex, the shortcomings a safety-relay solution add up, including:

- Complex wiring, with direct hardware connections between each device
- Difficult, and therefore time consuming, troubleshooting – because faults must be manually traced through sometimes complex-wiring layouts
- A logistical nightmare with significant engineering for system modifications or upgrades
- Tedious functionality changes because of each relay's defined purpose or function
- Inability to operate in mixed modes (safety and standard)
- Exponential growth of required number of safety relays if zone control, muting, or additional safety functionality is required.

The logic is done by wiring



Despite their limitations, safety relays are widely used, are commonly built into new equipment, and could be the right choice in simple applications. This would be based on the risk assessment for the machine or application. The relays are typically connected to a standard PLC to control the safety application. It's worth noting that the need for a safety relay is eliminated entirely when safety PLCs, discussed later in this paper, are used instead of safety relays.

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Safety relays (multi-function)

This solution represents a configurable device with a few more inputs and outputs. As a rule of thumb, a programmable safety relay can control between two or three safety functions, representing an incremental flexibility improvement over a single-function safety relay. Additionally, they have a smaller footprint that enables more-compact control panels or cabinets and will reduce and simplify wiring. That simplicity, though, is dependent on the safety functionality required. If zoning or muting is required, based on the application risk assessment, the simplicity benefit greatly diminishes.

Multi-function safety relays are available in several styles and configurations, including but not limited to dual-channel monitoring with or without time delay, two-hand control, light-curtain monitoring, speed monitoring, motor-standstill monitoring, and relay extension to increase the number of output contacts.

Such relays offer many input and output (I/O) configurations. A simple base unit can handle a variety of inputs, and expandable input and output modules can be added as needed. Some multi-function safety relays can be programmed, providing some flexibility. Most, however, require no software for configuration or operation. That makes typical setup and maintenance very straightforward and simple but offers no flexibility.

Multi-function safety relays are often a choice when single-function relays can't meet the safety functionality required for the application, as per the risk assessment. Other situations include systems with more-complex requirements than single-function relays can handle but that are too limited for applications such as machine tools or robots with many I/O points or a high number of safety-related tasks.

Multi-function safety relays are a good choice for common applications with up to three safety functions such as emergency stop, safety door, or light-curtain monitoring using just one device.

However, multi-function safety relays still share some of its most significant shortcomings with the single-function safety relay. That includes:

- Cost and complexity of hard-wiring control devices
- Time-consuming processes to troubleshoot faults
- Difficulty in expanding or modifying the control system
- Limited safety logic due to predefined safety-relay functionality could disrupt an entire production line

Today's safety PLCs

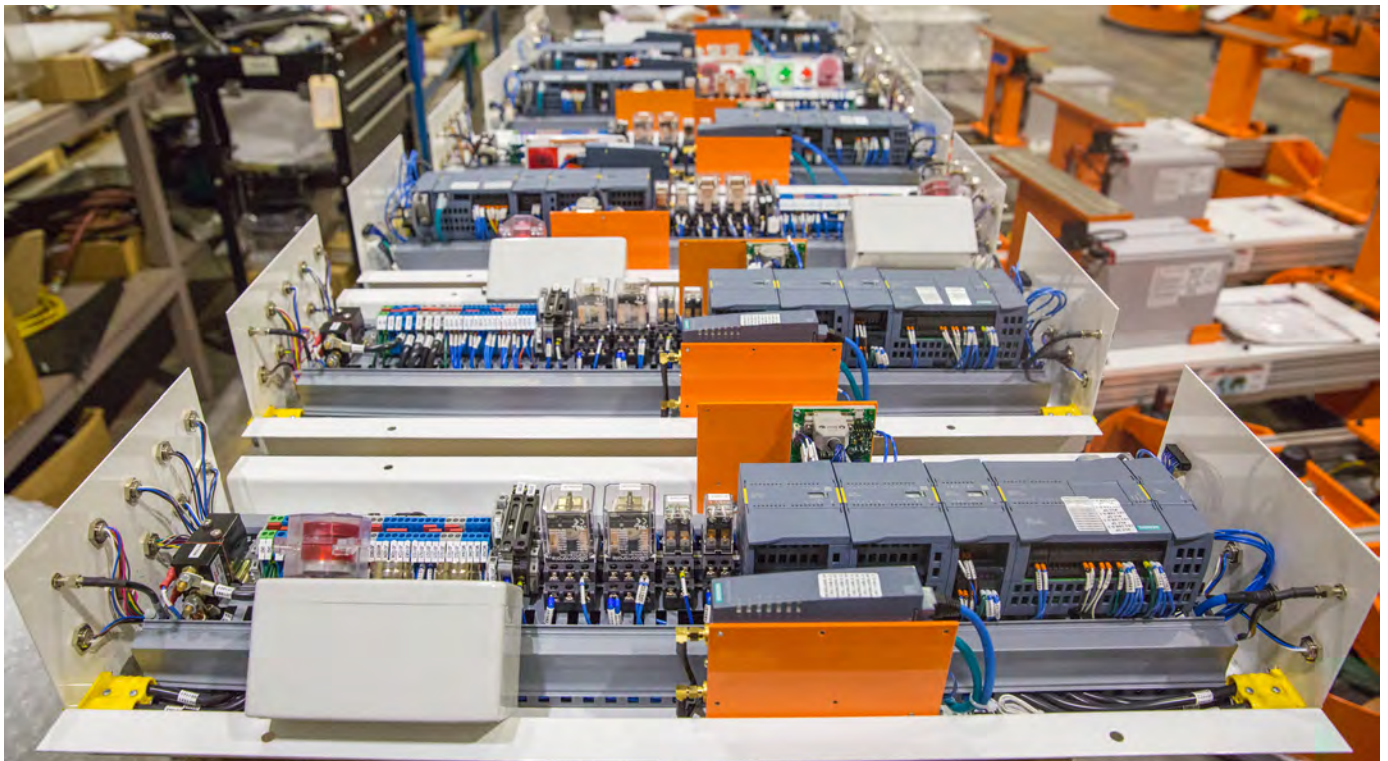
As machine tools, automation systems, and process facilities have grown increasingly complex, so have the demands on safety-control systems. Compared to the past, there is often a need today to monitor a much larger number of I/O points, including those performing safety-related functions.

The safety PLC, sometimes also called a safety controller or fail-safe PLC, is the most capable and cost-efficient device in many of these applications, particularly today's more complex control and safety systems. These PLCs meet the required safety standards, able to achieve up to PL e as per ISO 13849-1 or SIL 3 as per IEC 61508.

Safety PLCs are available that offer a distinct advantage in comparison to safety relays; they provide both standard and safety functionality in a single controller. The fact that both standard and safety-related programs can be executed via a single controller simplifies the system, decreases design time, and considerably reduces the panel size.

- Changes can be easily done via programming
- TÜV-certified, safety-function libraries are available, significantly reducing the design time and increasing flexibility
- PLCs meet the required safety standards, able to achieve up to PL e as per ISO 13849-1 or SIL 3 as per IEC 61508

Using safe ladder logic as one means of safety programming, safety-functionality changes can be easily done via programming rather than device replacement and related rewiring. Modifying an application is as easy as entering the safety password for access to the safety program, updating the program, and then loading the updated program into the safety controller. OEMs can create custom safety libraries for safety functionalities that are commonly used in their solutions. These programs can be password-protected to prevent users from circumventing safety functionality. That ensures the integrity of the safety systems and the personal safety of the operators. TÜV-certified, safety-function libraries are available, significantly reducing the design time and increasing flexibility.



Safety PLCs from some suppliers, including Siemens, also provide scalability, due to the ability to easily add PLCs to a system when upgrading to a larger-capacity device. The existing program is easily transferable to the new safety PLC(s) where it can be modified as necessary for the expanded application.

The embedded diagnostics provide instant identification of faults in the safety and standard circuits. Technicians can rely on the indicator lights or information provided via the HMI or web server to immediately be directed to the location of the fault, enabling fast repair and rapid return to production.

Make an informed decision regarding the right safety solution

The cost and productivity advantage in many, and probably most, applications of safety PLCs over older technology is clear and measurable. OEMs and panel builders should consider a number of factors when exploring the potential benefits in their applications.

One of the first things to consider is the number of I/O points required. In applications with more than three safety functions, the safety PLC is almost always the right choice. This number might be smaller or larger depending on the application but remains a good rule of thumb. The simple economy of a single, multi-function device rather than a device for each I/O makes the PLC a clear choice in these applications.

While less quantifiable, there are several other device traits supporting a transition to safety PLCs.



Guideline 1: Design freedom

Panel builders and OEMs facing pressures to bring products to market more quickly, or to deliver products to customers within a tight time frame, can benefit from shortened system-design times. Product engineers are less constrained by selection of parameters because of the flexibility of the safety PLC. This technology offers numerous possibilities to meet safety-functionality requirements across a multitude of applications. Rather than sizing components based on specific parameters, they can specify that a safety PLC be able to operate within a wide range of application parameters.

End-users also benefit greatly from this advantage of flexibility when modifying or expanding their existing system, or when combining multiple machines.

When designing your safety system you should consider:

- Number of safety functions
- System-design time
- Potential for system modification/expansion
- Downtime tolerance
- Overall cost: initial and ongoing

Guideline 2: Downtime tolerance

Operators of some production or process operations can tolerate downtime better than others. Taking a machine off line for several hours to troubleshoot or modify the control system in these applications doesn't present a critical issue.

In most cases, though, downtime must be avoided at all costs. In these situations, the built-in, advanced diagnostics provided by safety PLCs can be incredibly valuable. Maintenance personnel and operators are instantly guided to the exact location of the fault, enabling rapid restoration and return to productive operations. And the programmability enables much shorter downtimes for system maintenance or modification.

Guideline 3: System modification/expansion

Some safety-control systems are relatively static. Once designed and installed, it's highly unlikely they will be touched aside from routine maintenance. Other systems, though, are likely to be modified or expanded to incorporate process changes or increased production demands. In these more-dynamic applications, the ability to modify functionality solely via reprogramming the device software makes the case for safety PLCs very strong.



Fori Automation Inc., a specialist in automatic conveying and handling systems, relied on this flexibility while modernizing the assembly line of a large U.S. automobile plant with rail guided carts (RGCs). Each individual RGC has a safety bumper, an emergency stop switch, and optional safety scanners.

“While each safety switching device has a specific function, the parameters can change frequently,” says Dean Colwell, controls engineering manager for assembly and welding systems at Fori Automation. “That’s something that wouldn’t be feasible with conventional hard-wired safety systems. And the installation process is also much more economical, as it reduces the time and labor required by 25 percent.”

The system is protected against unauthorized modifications to the code or process values both in the PLC and in TIA portal.

Cost considerations

When comparing technologies, cost is always a consideration. The ability of a safety PLC to perform the task of multiple, single-function safety relays creates a straightforward cost-benefit analysis. In a basic application incorporating two to three safety relays with the standard PLC, the cost of the safety PLC can be initially about 30 percent less. Additional savings are realized over time because of the increased flexibility and simplicity of the safety PLC. As the number of I/Os increase, both the initial and on-going savings multiply.

BWI Group, a global supplier to automotive, motorcycle, and specialty-vehicle industries, is pleased with the cost savings on their safety PLC deployment. According to BWI Group

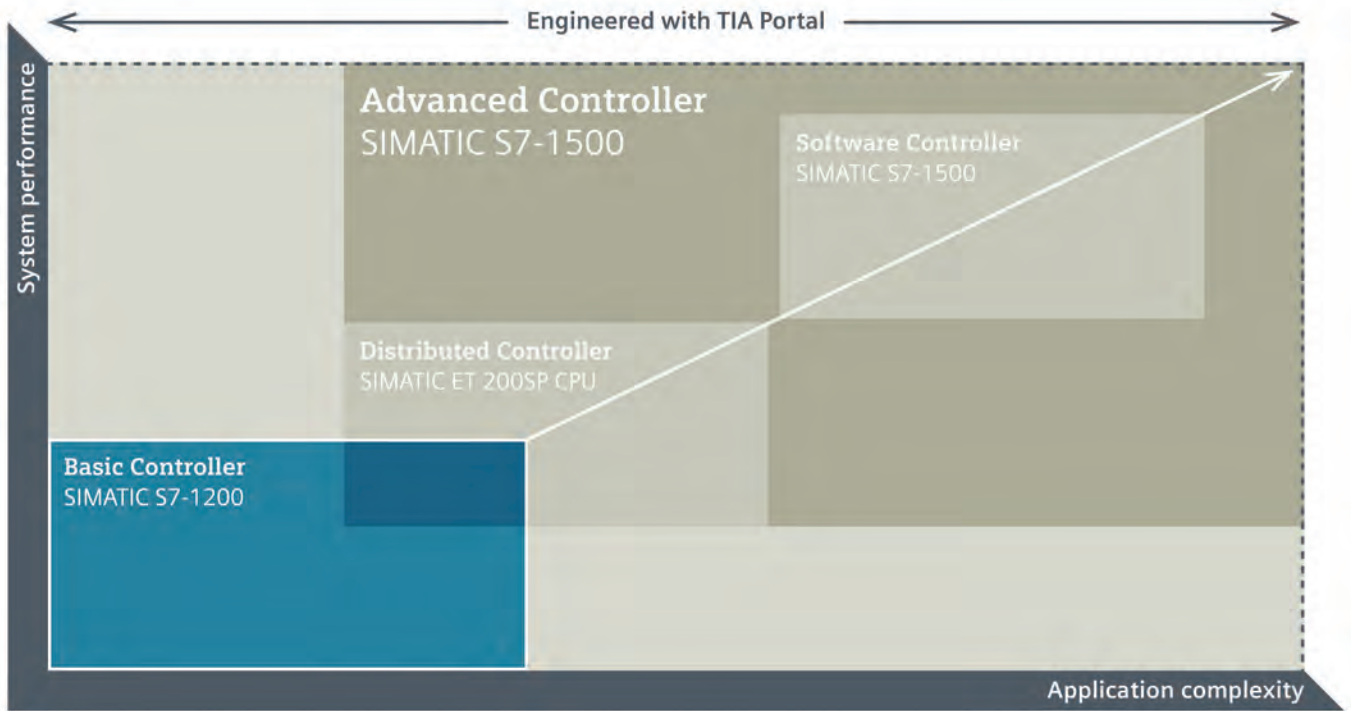
controls engineering supervisor Bill Taylor, “the hardware, including basic and advanced safety controllers, was as much as 40 percent less expensive than our other supplier, and software was less than half the cost.”

The case for safety PLCs

Many OEMs, panel builders, and end users continue to appropriately use older safety-relay technology because it provides all the needed functions in a simple, affordable, and proven device. It’s likely that many more safety-relay users, however, continue to use this technology simply because they are comfortable with it or are unaware of the reliability and cost benefits of safety PLCs.

In applications where more than three safety functions are required, the safety PLC almost always represents a smarter choice. The ability to rely on a single controller that combines control and safety functions, can be part of a standard or fail-safe network. Safety PLCs can replace multiple separate relays performing various functions, which reduces component costs. Built-in diagnostic tools reduce the time required to troubleshoot, repair, modify, or upgrade safety PLC-based systems, providing additional ongoing savings and benefits. And safety PLCs can enable wireless-device communications.

OEMs and panel builders interested in providing their customers with more-flexible, lower-cost products would benefit by including safety PLCs in their automation solutions.



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