AS-Interface Safety at Work

Networking Safety

Hardwired safety systems are the equivalent of a 30 year time warp—a modern dinosaur that should go extinct today rather than tomorrow. Fortunately, there is an alternative that addresses all the problems safety experts have known about for decades, without having to deal with the complexity and cost of a full-fledged and expensive safety PLC. With the introduction of AS-Interface Safety at Work in 2001, it was finally possible to utilize the many features that make AS-Interface the strong player it is today, and apply them to machine safety up to safety Category 4.

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SENSING YOUR NEEDS

Safety Relays. Auxiliary contacts. Redundant cable runs. These are products and terms familiar to every safety and control engineer. And chances are, those automation professionals are not terribly excited to develop the systems based on these hardwired safety system technologies.

The long list of reasons why plant engineers do not look forward to working on such safety systems includes complex engineering for all but the most trivial cases, poor diagnostics, high setup complexity, time consuming installations, nonexistent flexibility, and only rudimentary troubleshooting ability to name only a few. Some people still think that since it is safety is must be complex, cumbersome, and difficult. Fortunately, nothing could be further from the truth.

Just imagine the following situation. A machining center uses a few illuminated e-stops with redundant safety contacts and auxiliary contacts for "diagnostics." Add a number of door interlock switches and even a couple of safety light curtains. So that it is not too difficult, these safety input devices control only three motors or drives associated with three safety zones. Without going into any detail on the particular logic that needs to be wired up, we just consider a mix of AND and OR logic between the various devices. This arrangement could also be found on a typical conveyor-based manufacturing system where downstream conveyors are not stopped with the activation of an upstream e-stop or light curtain. A zoned approach increases productivity since it does not "penalize" the entire manufacturing line if one section must be temporarily stopped. Assuming this project will keep even an experienced engineer busy for some time is certainly correct. And once the hardwired logic is designed, trained electricians must wire it up, test it, and (we all make mistakes) correct any number of small and large errors.

Realizing that this sounds like the steps necessary when implementing relay logic in the days before PLCs increased the flexibility and reliability of automated machines. Hardwired safety systems are the equivalent of a 30 year time warp—a modern dinosaur that should go extinct today rather than tomorrow.

Fortunately, there is an alternative that addresses all the problems safety experts have known about for decades, without having to deal with the complexity and cost of a full-fledged and expensive safety PLC.

AS-Interface Safety at Work – CAT 4 safety with ease on any PLC

AS-Interface is the world's dominant lower-level, bit-oriented networking technology designed to work with (and enhance), rather than against the many capable byte-level solutions (DeviceNet, PROFIBUS, EtherNet/IP …) that are available today. To underline the viability and popularity of AS-Interface, consider the fact that since its introduction to the market 15 years ago, automation professionals around the globe have installed over 14 million AS-Interface I/O nodes with an annual growth approaching 2 million nodes. With this success in mind, in 1997, several AS-Interface vendors identified safety as the most antiquated segment within automation and initiated the Safety at Work initiative. With the introduction of AS-Interface Safety at Work in 2001, it was finally possible to utilize the many features that make AS-Interface the strong player it is today, and apply them to machine safety up to safety Category 4.

AS-Interface Safety at Work brings many advantages to the plant floor:

1. True wiring reduction compared to hardwired solutions while maintaining (or increasing the safety level to) Category 4 safety
2. Detailed diagnostics down to the contact level without a single inch of additional wire
3. The ability to capture nuisance shutdowns due to faulty safety contacts or wiring connections at the safety device level
4. The power to immediately identify welded safety contacts
5. The possibility to expand a safety system in minutes
6. Enables multiple safety zones, dependent and independent, with no additional wiring
7. Connect illuminated, Category 4 e-stops on just two wires (instead of eight)

Safety on just two wires! How is that possible?

Hardwired safety solutions are based on media redundancy. Redundant sets of contacts are individually wired back via redundant sets of leads to redundant terminals on safety relays. This is necessary because, other than being ON or OFF, the electrical current transmitted over the wires carries no information. At the safety relay, the signals received via these two channels is then compared in the safety relay, resulting in a transition to the SAFE (i.e., OFF) state when necessary.

Networking safety over the two-conductor AS-Interface approaches this information problem in a different way: more elegantly and much smarter. While the safety inputs (e-stops, door interlock switches, light curtains …) are still designed mechanically redundant, they are now connected to a safe coupling circuit that transmits data over the network. Once the information is on the network, it is the transmission protocol that is an integral part of AS-Interface Safety at Work allowing this solution to be used in SIL 3 and CAT 4 applications. Because each contact of the safety input device still has only two different states, the safe protocol needs to transmit only those two states.

The way this is done is as simple as it is ingenious. During manufacturing, each safety device is assigned a unique, never-to-be-repeated, 32-bit safety code number. During operation, this code number is divided into four-bit nibbles, where one nibble is sent over the network each time the safety device is instructed to communicate. Consequently, after eight communication cycles the 32-bit code number has been transmitted. To close the safety loop it takes a SafetyMonitor, a device not that different from a traditional safety relay, connected as a participant on the network and constructed in a safe fashion, with channel redundancy up to the OSSDs. Listening in on all data exchanges over the network, the SafetyMonitor receives the four -bit nibbles from the safety devices.

During system configuration, the SafeyMonitor records and stores the 32-bit code numbers from all safety devices that are part of its user-defined configuration. After that, all it has to do is compare the expected four -bit nibble with the actually received four -bit nibble. As long as there is no discrepancy, the OSSDs remain in RUN mode[1]. As soon as

1 In a sense this is a conversation with predetermined content.

the connected safety contacts are interrupted, indicating the need to safely stop the machine, the safety device transmits a constant stream of zero bits over the network. The SafetyMonitor receives these 0000 packets and the OSSDs open immediately. Because the safety data is dynamic, any abnormality in the data channel results in the opening of the OSSDs thus stopping of the unsafe motion. Understanding these fundamentals, we can now look at AS-Interface Safety at Work advantages in more detail.

The details of AS-Interface Safety as Work

1. True wiring reduction compared to hardwired solutions while maintaining (or increasing the safety level to) Category 4 safety

Most hardwired safety systems are not designed to satisfy Category 4; instead, safety inputs are often daisy chained, introducing multiple possible points of failure, reducing these installations to Category 3 at best. When using AS-Interface Safety at Work, each safety device has its own network address. As a result, the redundant contacts in the safety device are wired individually to the coupling electronics and Category 4 can be reached. All the well-known advantages of AS-Interface are retained, reducing wiring complexity easily by an order of magnitude[2].

2. Detailed diagnostics down to the contact level without a single inch of additional wire

The four-bit nibble contains additional diagnostic information. Since each connected safety device, an e-stop for instance, has two redundant sets of contacts, the designers of AS-Interface safety at Work "assign" two of the four-bit nibble to one contact set and the other two bits to the other contact. The PLC can easily distinguish the following four states (see figure 1).

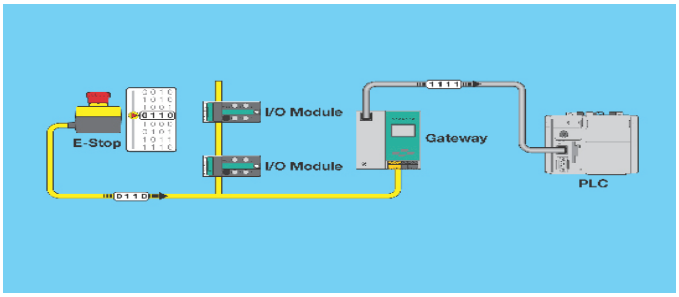

Figure 1 – When instructed to transmit data the safety e-stop will send the next data nibble. The gateway receives this data and passes it on to the PLC for diagnostics. This gateway performs intelligent preprocessing and simplifies the information so that the PLC program can be even simpler.

- 0000 – The safety device is in STOP mode; OSSDs of the SafetyMonitor will be opened.
- 00xx -- One contact is open, one is closed. This can indicate a welded contact or a contact that erroneously does not open up.
- xx00 -- Same as above but for the other contact set of the safety device.
- Dynamic data -- The details of the data are not important to the user but these states indicate that the safety device is in RUN mode.

3. The ability to capture nuisance shutdowns due to faulty safety contacts or wiring connections at the safety device level

Using the contact information just discussed, it is clear how faulty contacts can be found automatically. As the PLC receives the data transmitted via the network, it is easy to write logic that captures states indicating unusual contact asynchronism. It is also possible to write a few rungs of ladder that detect which contact caused the nuisance shutdown. Just imagine the amount of downtime reduction!

4. The power to immediately identify welded safety contacts

Welded contacts are a relatively common issue on magnetic door interlock switches. While the redundant character of the switch still enables safe deactivation of the unsafe motion when a door is opened, restarting of the system is, of course, not possible. Specifically, when using Safety at Work this situation is identified by the PLC observing the following safety code sequence:

a) Before opening the safety gate the safety switch will transmit the aforementioned dynamic safety sequence.

b) When the door is opened, one contact will be open while the other contact will remain closed. This is easily detected by the PLC receiving either 00xx or xx00 data packets[3]. In fact, because AS-Interface Safety at Work receives this data immediately, it is possible to flag the welded contact the second the operator opens the door. Maintenance can be called right away. The ability to identify quickly and automatically a welded contact is a significant diagnostic advancement, allowing fast problem resolution, system restart, and significant productivity gains.

5. The possibility to expand a safety system in minutes

Safety at Work inherits all implementation advantages of AS-Interface. This means that safety devices – a new e-stop button or cable-pull switch for instance – can be added just as fast as any standard I/O node. To make this new e-stop available for safety shutdowns, it only needs to be added to the safety configuration, which is then downloaded to the SafetyMonitor and activated. Typically, these simple changes take only a few minutes, making safety changes possible during lunch breaks or between shifts. This level of flexibility is simply impossible with other, more traditional solutions.

2 For instance, wiring 10 illuminated e-stops with auxiliary contacts results in the 20 terminal connections for the illumination, 20 terminal connections for the aux contacts and 40 terminal connections for the safe contacts. Any additional connections required when daisy-chaining the safety contacts have not been considered. On the other hand, when using Safety at Work, those same 10 illuminated e-stops can be connected to the network without a single terminal connection (M12 and single mounting screw connections to the AS-Interface network are utilized.)

3 Technically this is not exactly correct as a single data packet in the form 00xx and xx00 is always allowed. To further reduce the burden on PLC programmers several, AS-Interface gateways pre-analyze the safety data, making contact level diagnostics even simpler.

6. Enables multiple safety zones, dependent and independent, with no additional wiring

Constructing safety systems where multiple safety devices ensure the shutdown of a hazardous motion, while cumbersome and wiring intensive, has always been structurally simple; at least when the system does not require CAT 4 operation. Daisy chaining the redundant contacts was the most common wiring practice in these cases. Unfortunately, when a particular e-stop has to activate multiple safety relays things get tricky fast. This is unfortunate, because this type of configuration is needed to construct zoned safety, which has the potential of increasing machine uptime and productivity gains. Now it is necessary to run additional wires between multiple safety relays. Consequently, few safety engineers implement such zone-controlled systems; instead, they opt for global shutdowns, being fully aware of the efficiency consequences.

A standard SafetyMonitor with two independent OSSDs is inherently able to perform independent logic operations for each CAT 4 safety channel. Even more complex safety shut-down operations are possible without additional wiring. All it takes is another SafetyMonitor, configured to evaluate the safety code sequences of those safety input devices needed in its safety logic (see figure 2.)

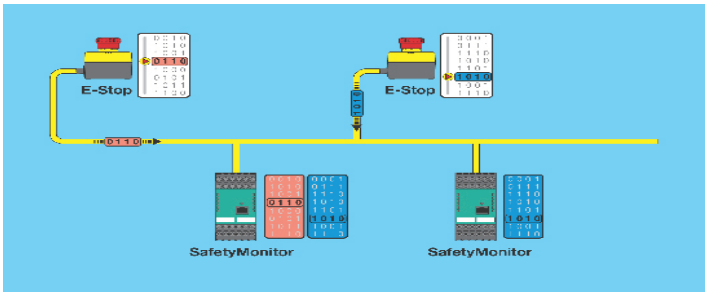

Figure 2 – The data from the two e-stops are processed by the SafetyMonitor on the left; this functionality is equivalent to daisy-chaining contact in a traditional hardwired safety installation. Additionally, the SafetyMonitor on the left also processes the data from the safety e-stop on the right. This shows how simple a two-zone configuration is when using Safety at Work.

7. Connect illuminated, Category 4 e-stops on just two wires (instead of eight)

AS-Interface is a two-wire data and power network. Therefore, safety devices like e-stops not only transmit data over the two leads but also receive the necessary power to operate illumination.

With these significant installation, implementation, and diagnostic advantages, it is easy to understand why AS-Interface Safety at Work is a dominate player in the safety network arena. Its simplicity in terms of installation ease make it far superior to traditional hardwiring while offering a lower cost point. Its diagnostic capabilities are comparable to those of full-fledged safety PLC solutions without the added cost. The question "where does it make financial sense" depends on many installation details. Some users found this technology advantageous with only two safety devices and a small number of standard I/O points. Even if the economics are less favorable, an AS-Interface installation with approximately three safety devices and 20 to 40 standard I/O points will be economically beneficial with lower initial installation cost, faster commissioning and startup time, and increased operational availability. Let your AS-Interface hardware supplier help you evaluate your particular needs. Many have 15 years of experience and can offer valuable tips to get the best possible solution at the most attractive price.

Where is Safety-at-Work going next?

AS-Interface Safety at Work was the first fully-approved dual use (i.e., safety inputs and standard I/O) network available on the market. Since its initial introduction, the vendor community has added products that make Safety at Work even better. Integrated e-stops with illumination or safety door interlock switches that take only minutes to add and configure on the network, are now readily available. The ability to connect a large variety of safety light curtains with electronic outputs and then use them in situations where muting/supervisory overwrite is necessary signifies that the technology has undergone constant improvements.

The next innovative enhancement comes with the introduction of safe outputs and allows the realization of even more powerful, decentralized safe control over the simplest, most flexible and by far most successful low-level industrial I/O network available (see figure 3.)

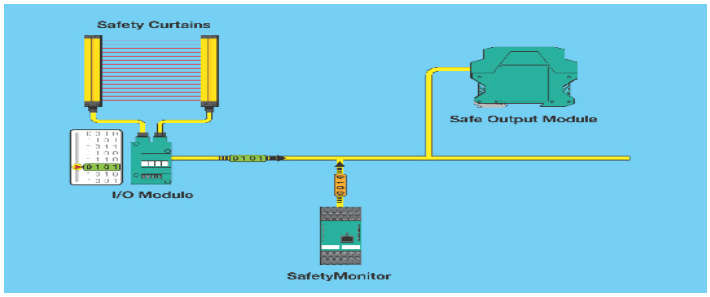

Figure 3 – A safety light curtain is connected to a safety module designed to accept electronic safety inputs. As long as the light curtain is not interrupted the safety module transmits the safety data and the OSSDs on the SafetyMonitor remain closed. This network also contains a safe output module. As long as the OSSDs on the SafetyMonitor are closed it sends safety data which in turn is received by the safety output module. The safe contacts on the safe output module follow the state safe contacts on the SafetyMonitor. This makes installation of motors even simpler as three-phase power does not have to be brought back to safe contacts in the main control cabinet.