

# Safety at Work: Next Generation

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**Abstract:** The popularity of AS-Interface Safe continues to grow across a wide range of industries. This paper provides a brief introduction to AS-Interface followed by an explanation of AS-Interface Safe. The latest enhancements and developments are then discussed together with an examination of the benefits and short discussion of its growth.

## *Introduction*

AS-Interface sits at the lowest level in the hierarchy of fieldbuses (industrial networking protocols providing two way communications for field devices). It provides a simple, low cost method for controlling actuators and monitoring sensors in a wide variety of industrial applications and environments. Yet is easily integrated with higher-level fieldbuses such as DeviceNet, Profibus, CC Link and Industrial Ethernet using gateways that allow the AS-Interface network to be seen as a node on the higher-level network.

It works by transmitting both power and data over a single two-core cable that connects to each of the AS-Interface devices, so forming a network. This drastically reduces the amount of wiring compared to non-networked hard-wired solutions: speeding up installation, commissioning and faultfinding. A complete AS-Interface circuit, therefore, comprises:

- An AS-Interface power supply (nominally 30V at up to 8A)
- An AS-Interface master that is usually part of an industrial PC or PLC and performs the required command, control and monitoring functions. The master reads, writes and alters values within each (separately addressed) slave by sending and receiving messages called telegrams.
- A number of AS-Interface slaves each having a unique address on the AS-Interface network. Within each slave is a cost-effective AS-Interface ASIC that requires no processor but contains an EEPROM in which parameters and addresses are stored. The slaves themselves may actually be actuators or sensors (or both) with the AS-Interface built in. Alternatively, generic slaves can be used which are then connected to traditional actuators or sensors. Slaves can be digital, analogue, full duplex serial or even safety devices.

The cabling requirements are also straightforward. Almost any 1.5mm<sup>2</sup> stranded low-cost two-core unshielded cable can be used. However, the preferred cable is AS-Interface's profiled self-sealing cable: the iconic yellow cable. Many slaves are designed to be used specifically with this to make the

connection process simple. The cable is profiled so that it is very difficult to connect it the wrong way round. Also, an insulation displacement technique, known as a vampire connection because two prongs penetrate the cable, makes the connection process very quick. This yellow cable has an added advantage that if a slave has to be moved then the cable itself is self-sealing back to IP65 protection. This coupled with the fact that field slaves themselves are usually physically and electrically robust (typically IP67) makes the whole network ideal for many industrial environments.

Layout of the network has only one restriction: no closed loops. Thus, very flexible layouts are possible from a basic linear network to complicated tree structures. Both the master and the power supply can be positioned anywhere and there is no need for screening or line terminations. Indeed a key part of the original design of AS-Interface was to make creating networks easy while still retaining a very high noise immunity (even over brushes or slip rings).

AS-Interface itself is an open standard guaranteeing that devices from different vendors will all work together. Also, existing devices are assured to work with any new version of AS-interface thus eliminating obsolescence.

Some of the key benefits of using AS-Interface, therefore, are:

- Simplicity and ease of wiring drastically reducing development and installation time, maintenance and costs
- Very flexible to change and expand
- Ease of off-site (or off-plant) testing
- Monitoring and diagnostics
- Vendor independence
- Gateways allowing AS-Interface to communicate directly with other fieldbuses
- And, as we shall see, integrated functional safety.

Altogether this has made the technology extremely popular worldwide. There are well over 14 million AS-Interface field devices installed globally, a worldwide market of over 300 million Euros spent each year. The market is growing at an average rate of 25% annually, actively supported by 280 companies producing over 1100 certified AS-Interface products.

### ***AS-Interface Safe***

If we now add an AS-Interface Safety Monitor, then we can implement functional safety solutions using safety slaves entirely within AS-Interface and with safety levels up to SIL (Safety Integrity Level) 3 according to IEC 61508 as well as CAT (Category) 4 according to EN954-1. Importantly this safety system works on the same AS-Interface network and at the same time as the non-safety AS-Interface. In particular, all the standard AS-Interface diagnostics continue to be available for all devices including the safety slaves.

The Safety Monitor is programmed independently. In operation, it passively listens to what is happening on the network until a critical safety event occurs. One way of looking at this is to say that the Master, PLC or PC continue to control the application during normal operation until a critical safety event occurs at which time the Safety Monitor takes control to put the system into a safe state. Importantly, therefore, the safety related procedures happen at the lowest level (the AS-Interface level). A critical safety event may be, for example, activation of an emergency stop, opening a protective gate, accessing a Safety at Work sensor, a peripheral voltage drop, a reoccurring communication error or an outright failure of a slave.

This safety technology is called 'AS-Interface Safe' or 'Safety at Work' and has become so popular that many companies are now implementing their functional safety systems using AS-Interface Safe as a stand-alone safety system in its own right. With more than 50,000 Safety at Work systems installed and over 300,000 safety slaves in use worldwide, we are currently seeing a 60% annual growth in safety slave devices.

So how is this level of safety achieved? The AS-Interface Safe slaves still use the standard AS-Interface communication telegrams. However, each safe slave has a set of four-bit codes that it cycles round, providing these as the values every time the master requests its input. The master simply sees these as the normal input coming from a slave and attributes no special meaning to them. In contrast, the Safety Monitor listens to the telegrams on the bus and constantly checks the cyclic code that it expects from each safety slave. If any inconsistency is observed, the Safety Monitor is triggered and acts accordingly.

Specifically, each safety slave has a set of eight four-bit codes stored in a table within it and cycles through these as the master requests its input. The Safety Monitor has a special teach function where it reads and stores these code tables from each safety slave at system commissioning time. Then, during normal operation, the Safety Monitor compares the transmitted code with the expected code. Should the two codes not match, or if a stop code (0000) is transmitted, the Safety Monitor is triggered into action.

This mechanism gives secure protection against interrupted communication, corrupted telegrams, disruption of the safety slave devices and missed or delayed slave responses. Furthermore, the safety is active so it is not possible for a technician to wire out the safety slave.

Because the Safety Monitor is independently programmed and merely listens to the communication during normal operation, it is perfectly possible to put a number of Safety Monitors on the same AS-Interface network (all listening to different or the same safety slaves). Indeed, almost from Safety at Work's inception, there has been dual channel Safety Monitors (two Safety Monitors in the same package which connect to the same AS-Interface network) which can be programmed to work either independently or with one Safety Monitor's output dependent on the output of the other Safety Monitor. This enables a

wide variety of safety scenarios to be implemented including: area zoning and grouping, restart inhibits, safety key transfer systems, motion monitoring and muting systems.

Safety slaves are available, as with non-safety slaves, in both an integrated form and a non-integrated form. In the non-integrated form, traditional safety devices are connected to a special general purpose AS-Interface slave. However, all common safety devices are available in integrated form including emergency stops, protective door switches, light curtains, pressure mats and laser scanners.

## ***Second Generation Safety***

A new version of AS-Interface and the release of a second generation of Safety Monitors simplifies even further the implementation of safety systems on large complex installations while retaining, as always, full backwards compatibility with existing systems and products.

Safe outputs are now in the specification (previously only safe inputs were possible, for example, an emergency stop or a machine guard) so that safety output slaves are now available.

The new versions of the Safety Monitor offer up to sixteen independent release circuits. Of these sixteen release circuits, four of these can be switched in less than 40ms (as originally) by using the outputs local to the monitor: two of these are implemented as relays and two are implemented as fast electronic outputs. Thus it is easy, for example, to implement a staggered shutdown whereby each release circuit is triggered after a predefined time once the Safety Monitor has been triggered.

In fact, there are sixteen independent safe output groups, since, as with any safe output, several safe outputs can be controlled by the same address, so that the actual number of safe outputs is not an issue.

In addition, the new Safety Monitors can monitor and control safety across a number of independent AS-Interface networks.

If we have two Safety at Work networks, each with their own master (or one dual-network master) then each network can simply be connected into the Safety Monitor. Both networks are treated equally but are galvanically separated. The Safety Monitor listens to both networks, using two independent receivers, but processes the information jointly and so creates a higher-level structure for all safety functions concerning the release or deactivation of individual components or release circuits. Safety Monitor diagnostics can be read by one of the masters on the individual networks.

Alternatively, we can implement the safety functions on up to 31 Safety at Work networks by connecting an individual Safety Monitor to each of the

Safety at Work networks and then connecting all of the Safety Monitors together on their own (coupling) network. That is, by constructing a network of networks. Each of the connected Safety Monitors is configured as a safe input slave on the coupling network and transmits a global variable to the coupling network describing, for example, the release status of their local Safety at Work network.

All other Safety Monitors are monitoring this data exchange in the coupling network. Therefore, each monitor in the coupling network is a sender and receiver at the same time. Processing of all of this data occurs concurrently; so all global variables are available for use by each Safety Monitor. In particular, each release circuit on each Safety at Work network can directly influence every other Safety at Work network.

In fact, up to 31 global variables are allowed on any coupling circuit, so if less than 31 Safety at Work networks are in use then the 31 global variables can be shared amongst them. Furthermore, additional safe inputs, for example, emergency stops can be connected directly onto the coupling network and then directly affect each of the Safety at Work networks. In this case, it is not necessary to read their data through one of the Safety Monitors.

Programming the Safety Monitors has also been simplified even further with a new drag and drop graphical interface that clearly shows the functioning of the device.

### ***Expert Alliance***

As AS-Interface and Safety at Work become ever more prevalent in a wide range of industries, a vendor-independent centre of excellence was required in the UK that provides help and support to prospective and current users of the technology. The AS-Interface Expert Alliance was formed to satisfy such a need. Its aim is to promote the technology and assist people in using it and getting the best out of it.

### ***Conclusion***

AS-Interface, and especially Safety at Work, continues to grow very rapidly. Developments with AS-Interface ensure that it keeps pace with users requirements and safety legislation. The Safety at Work technology is such that many companies are using it to implement their functional safety systems in isolation, even when there is no other AS-Interface technology present.