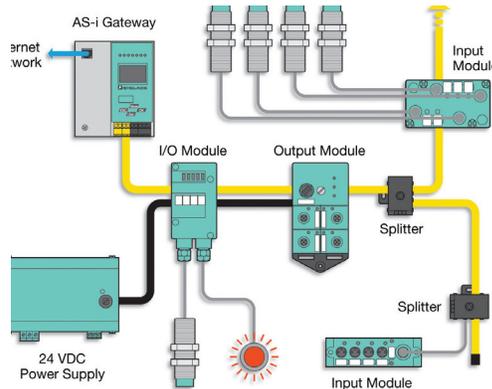


# ETHERNET AND AS-INTERFACE: THE IDEAL PARTNER NETWORKS FOR INDUSTRIAL AUTOMATION

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Networking of industrial systems is a common practice today. Reliable networks allow machine builders and end users to construct powerful manufacturing and logistics systems while limiting the number of cables running between PLCs, drives, HMIs and RFID systems. What is frequently overlooked, however, is the lowest level of automation, where sensors, simple binary actuator and safety inputs like light curtains, door interlocks and e-stops reside. At this level the number of wire leads that must be routed, stripped and terminated is staggering.

Using a suitable low-level network in conjunction with an upper-level networking solution results in higher performance, reliability and lowest possible total cost of ownership. In a sense, the low-level network can be viewed as an intelligent, standardized wiring technology and with over 11 million installed nodes AS-Interface has been the de-facto standard solution for networking simple actuators and sensors for over one decade.



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Ethernet-based, upper-level solutions using the Modbus/TCP, and more recently EtherNet/IP and PROFINET protocol, have received a great deal of attention. While the strength of Ethernet in conjunction with a suitable protocol is undisputed, it is also clear that it cannot satisfy every requirement necessary to be used down to the “sensor level.” But combining Ethernet-based solutions with AS-Interface results in a system with unparalleled performance, simplicity and reliability.

## It takes two to network

Ultimately, networks have one and one task only: the reliable transmission of data between networked devices. Upper level networks designed to transmit larger data packets show the following behavior.

Given random plant noise it is clear that longer messages have a higher likelihood of being corrupted than short messages. Consequently, whenever possible a messaging protocol using many short messages is preferred over a protocol transmitting a few extremely large packets.

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Of course, the error detection and correction procedures built into any industrial network worth considering take over, and retransmissions will finally get a correct message to the target. Unfortunately, these retransmissions reduce the effective data throughput and have a negative impact on the possible performance.

With this in mind, it is clear that the shortness of the AS-Interface message—a message reply from an AS-Interface node is only 7 bits long—results in fewer retransmissions and, thus, increases the net data throughput. On the other hand, once the I/O data is safely collected at the sensor level, combining this data for further transmission via Ethernet makes sense. The reasons are as follows:

- In contrast to Ethernet, AS-Interface was designed to operate in noisy plant environments. The closer the network cable is to drives and other machine components the higher the possible noise level. High noise immunity combined with the noise-resistant, short-message based data transmission makes AS-Interface the ideal network for sensors and actuators.
- Keeping the Ethernet cable away from the high-noise environment results in a reduced number of message repeats. And since AS-Interface is used to consolidate the data from a large number of I/O points, the inherent overhead of Ethernet is becoming less of an issue. Industrial Ethernet protocols possess very strong data verification methods, either based on the TCP part of the protocol or a secondary method used directly on the data. Combining Ethernet with AS-Interface allows users to keep the Ethernet cable away from the truly bad noise sources, thus relying less and less on message repeats.
- AS-Interface is not only a network but also a complete electro-mechanical installation solution. As such, routing cables and connecting I/O devices could not get any simpler. AS-Interface makes extensive use of insulation displacement technology, making expensive and inflexible preconfigured cables a thing of the past. And since I/O nodes are IP67 field mountable, expensive enclosures are not needed.
- Ethernet is a very fast network limited to the star topology. By including a miniature switch in each device it is possible to construct a linear network; adding additional cost to the device. Both star and linear topologies are ideally suited to connect groups of systems or machines to a PLC. The star topology, and to a lesser degree the linear topology, are not an ideal choice for collecting distributed I/O data from sensors placed on a typical automated system. Here, a more flexible solution is needed and available. AS-Interface does not limit how cable can be routed. Branching off is possible at any point and branches themselves can contain more branches that can still hold other branches.
- One of the most vulnerable cable sections in any automated system is the length connecting sensors to the I/O cards and I/O nodes. The reason is that this simple On/Off signal does not have any protection in terms of checksums or parity bits. Consequently, a well-designed machine uses short sensor cables, handing the data off to the network as soon as possible. This calls for a highly distributed approach where typical I/O nodes have only a few inputs. Using I/O nodes with 2 to 4 inputs makes economical sense only if those I/O nodes can be built inexpensively—a requirement that AS-Interface I/O nodes satisfy.

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- All automation systems share one important requirement: I/O data must be deterministic. Determinism means that the worst case response time of a system can be calculated with certainty. AS-Interface is a deterministic system and the I/O update time can be calculated easily.
- Highly engineered solutions must be “future-proof.” By combining AS-Interface at the I/O level with Ethernet at the PLC level, any enhancements to Ethernet can be quickly utilized. Only the Gateway between AS-Interface and Ethernet must be updated; the I/O system remains unchanged.
- The total cost of an installation is always very important. With time-saving installation hardware, reduced wiring/labeling effort, a significant reduction of expensive wire, and power and data over the same cable, installation of an AS-Interface-based I/O solution is extremely cost competitive.

Taking these factors into consideration, it is clear that AS-Interface is the ideal solution to handle field-level I/O. While the basic principles of AS-Interface have not changed since its introduction 15 years ago, significant advancements have steadily been made, including maintaining full backward compatibility to the I/O infrastructure. Another important advancement was the introduction of AS-Interface Safety at Work in 2001. Since then e-stops, light curtains, interlock switches and many other safety devices can be part of the AS-Interface network. The solution has been approved up to category 4 according to EN 954 and SIL3 according to IEC 61508. Combining AS-Interface with Ethernet, the safety information can now be shared across several control levels, allowing Ethernet based control to utilize safety information - just another example why the two networking concepts are ideal automation partners.

## How AS-Interface Connects with Ethernet

Once data has been collected at the I/O level it is safely transmitted via AS-Interface. The device that is responsible for this data exchange is a *Gateway*. Gateways are electronic devices with a dual personality. On one hand they are Masters for the I/O nodes on AS-Interface. This part of the Gateway collects sensor inputs and distributes actuator outputs via the flexible AS-Interface network. On the other hand, the Gateway is a slave (sometimes also called server) on Ethernet. From the point of view of the PLC programmer, the entire AS-Interface network is nothing more than a large set of I/O data transmitted by Ethernet. The AS-Interface details are hidden from the user and advantages such as automatic node replacement are available, even though they are not functions of Ethernet. A similar statement can be made for the availability of safety related data over Ethernet. AS-Interface collects and transmits safety data to the Gateway. At the PLC level this information can be used to perform HMI updates and detailed event based fault analysis. Again a functionality that is not part of Ethernet by itself.



*An AS-Interface gateway enables upper-level networks such as Ethernet to benefit from the strengths of AS-Interface. As far as the upper-level network is concerned, the AS-Interface gateway is a large collection of I/O. Gateways are Masters for I/O nodes on AS-Interface, and slaves (or servers) on Ethernet.*