

AS-Interface in a Real-Time Environment

AS-Interface, the Actuator-Sensor-Interface, is the simplest automation networking solution. It has already proved to be the new industrial standard for networking on the lowest field level i.e. in the range of mostly binary sensors and actuators and other simple elements. The general benefits for the user are obvious: low-cost, easy handling, flexible structures etc. But what does this mean for networking with PLCs and PCs in a real-time environment?

In this paper we discuss three aspects that are of particular importance in real-time applications: connectivity, cycle time and availability.

- optimised system for binary sensors and actuators and for simple analogue elements
- master-slave principle with cyclic polling
- tree structure of the network
- data and energy on one unshielded 2-wire cable
- flat cable for contacting by piercing technology
- modules as remote I/Os for conventional sensors and actuators
- integrated slaves with own AS-Interface capabilities
- no communication SW in the slaves, only firmware in the self-configuring master
- user benefits: low costs, simple installation, easy handling, flexible networks, high reliability in an industrial environment, open and internationally accepted system with many manufacturers and products

CONNECTIVITY

AS-Interface has two distinct ways to be connected to the first control level. The first and most important way is a direct connection (fig. 2, left). In that case, the system's master is part of a PLC or PC, running at its own cycle time. As AS-Interface is an open system, any PLC or PC manufacturer can build a master for his own sys-

tem. There exist masters available to a lot of systems already, with several more in development.

The second way is to connect AS-Interface via a coupler to a higher fieldbus and to use it as a sub-system (fig. 2, right). In that case, all data from the AS-Interface network is handled in one node of the fieldbus and it is connected to the above lying host together with other components of the higher fieldbus. The application program has to handle all data as usual for the particular fieldbus. For real-time applications, an analysis of the cycle time and the availability of the combination of the two systems have to be done.

AS-Interface is definitely open to such solutions and offers couplers to most known higher fieldbuses like Profibus, Interbus, FIP, DeviceNet, CAN etc., others (e.g. LON, Fieldbus Foundation) being in preparation.

Together with its tree structure AS-Interface thus offers the most flexible networking solution to any application in automation.

CYCLE TIME

AS-Interface is a single-master system with cyclic polling. Thus any slave is addressed in a definite time. For a complete net with 31 slaves the cycle time is 5 ms. It may be shorter with fewer slaves. (With very few slaves the cycle time can be shortened to less than 500 µs.) Analogue data with more than 4 bit needs several cycles depending on its length, but without affecting the basic cycle time for binary sensors and

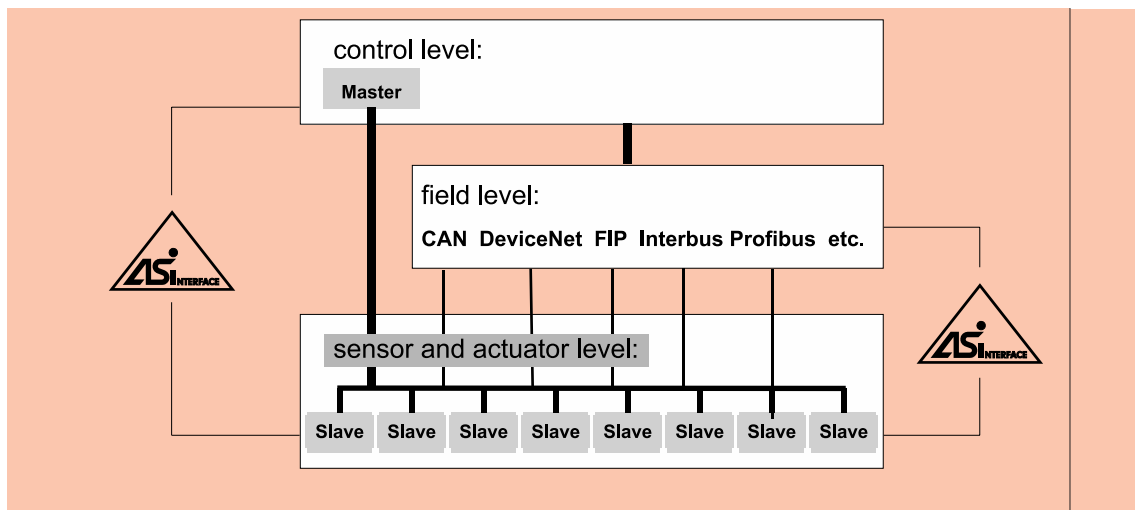


Figure 1. Two ways to the control: AS-Interface direct (left) or via a fieldbus (right)

actuators.

The cycle time includes all steps from and to the interface to the host system and even includes one repetition (see below). The data exchange with the host happens from here via process I/O images at the end of each cycle stored in e.g. a dual ported memory at the interface. Therefore no other steps have to be taken into account for a direct connection to the control device.

Nevertheless, this is asynchronous coupling and in real-time applications the cycle times of both the network and the controller may present a restriction, but for many systems and applications this is short enough.

AVAILABILITY

Availability in this context means that a system will deliver reliable data and diagnostic values continuously and in time under all specified conditions, especially under severe electro-magnetic noise. The answers to three questions are of special importance for real-time applications:

- Can electro-magnetic noise or other faults disturb the reliability of data?
- How much time is necessary for the correction of a faulty transmission?
- How often does such a fault happen and can this affect the whole system?

Answers:

1 Several of the benefits of AS-Interface result from the use of unshielded two-wire cable for data and energy. Such a cable has up to now been thought impossible for data transmission in an industrial environment and as a consequence several measures had to be taken to make the transmission of data reliable:

- The system is floating; each slave has to be built very symmetrically. Thus common mode rejection is very high.
- Next, in all slaves and in the master each detected data telegram is checked for possible transmission errors by means of six indepen-

dent features. It has been shown that AS-Interface is capable to detect all single and double faults in any transmission with a certainty of 100 % and all threefold and fourfold faults with a certainty of 99.999 %. That is a very high degree of reliability, especially if remembering that a telegram is not longer than 14 bit. (From a theoretical point of view people often use the "hamming distance" to describe these facts. For principle reasons it is not possible to state a HD-value as it is commonly defined, but we want to stress that this value does only focus on the detectable number of faults in a reconstructed telegram. It does not consider either the length of a telegram (correlated with the chance for multiple faults) or the reaction of the system to a fault. Thus it is not sufficient to describe the stability and availability of a system.)

- In addition, the bus-structure allows for "intelligent" features of a slave, e.g. a self-test or the detection of some faults of the element itself, like over-temperature, missing an additional power supply etc. These cases may be signalled immediately by an additional status bit (D1 or D2 in fig. 3). Of course this is a feature which is - like diagnostics of the network - common to all bus-systems. But as the AS-Interface IC can be built economically not only into remote I/O-points (we call them modules) but into very small sensors and actuators too, the diagnostic capabilities of the system may be used up to the ends of a network's branches. Possible faults can be signalled and handled immediately - an important advantage in real-time systems.
- 2 In case of a transmission fault, in AS-Interface only one pair of telegrams (master to slave and

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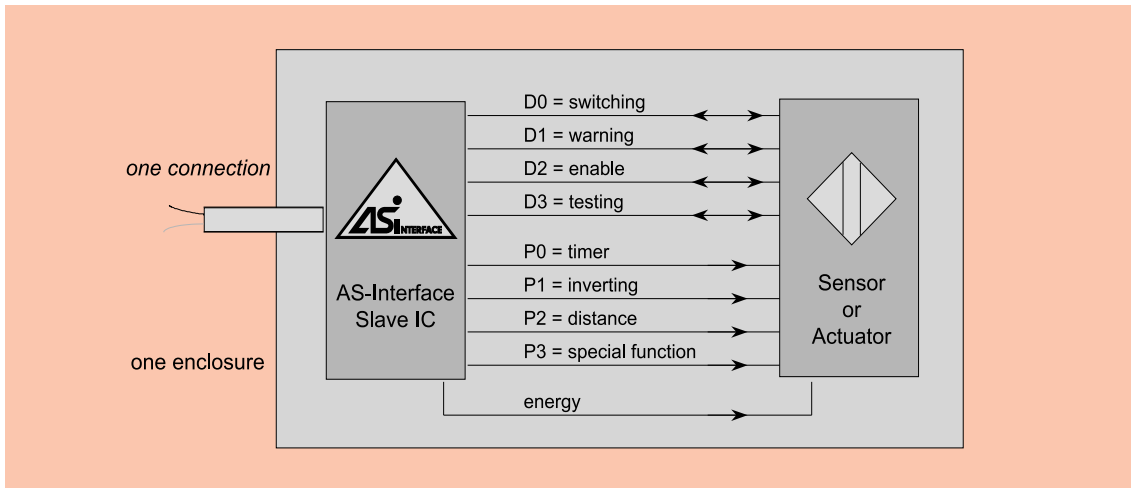


Figure 2. One part of availability is the reliability in difficult situations, like electro-magnetic noise or a sudden fault in a slave. AS-Interface offers an economical solution for these cases too. The figure shows one possibility to design an intelligent" slave.

slave to master) have to be repeated. This may happen at the end of each cycle if necessary and takes 150 μs only, the time for one repetition being included in the stated cycle time.

If there is again a fault during this repetition and during the following two cycles, a "configuration error" occurs and is transmitted to the host to decide about the necessary reaction. This includes the case of a missing slave. Thus an AS-Interface network is monitored completely up to the individual slaves.

- 3 Even an "absolutely safe" system - in the sense of detecting all possible faults - would not be reliable if it blocks itself by a huge amount of repetitions or even by a black-out after an anomalous high noise pulse. The specification of AS-Interface puts two conditions to the system, which is part of the certification tests, too:

- Under the condition of severe electro-magnetic noise (level 3 according to IEC 1000) a system may have one repetition per cycle at maximum, which in practice does not disturb the performance and keeps the function within its limits (stated cycle time!).
- At even higher noise levels (2 kV in burst test) the system may stop working momentarily, but has to recover immediately after the noise has gone. All components have to resist including the stored data; "lost" slaves (no answers during three cycles) have to be accepted automatically again.

These conditions are tested during the certification test with the result that most components have much less repetitions than allowed. (About 50 % of the tested components have no repetition at all in 10 million telegrams under 1 kV and sometimes even under 2 kV.) Thus also the availability of AS-Interface is very high in such situations.

The discussion of these 3 properties of AS-Interface - connectivity, cycle time and availability - shows that the system is well suited to meet the demand of most real-time applications, if the cycle time is within the limits of

the particular case. In real applications AS-Interface has proven already how reliable and insensitive against noise it is. It has been used successfully in welding machines, near frequency converters, and for transmission in sliding ring systems (including the transmission of energy!). The simplest automation networking solution is a high-tech solution in many aspects, including difficult situations like real-time applications.

Dr. Otto W. Madelung is the operations manager of AS-International Association e.V., the central user organisation of AS-Interface. Together with six international daughter associations in the most important industry countries it has about 100 member companies. The association offers an Internet page (<http://www.as-interface.com>) and a fax-on-demand service (+49-2174-74758001) for detailed information.