The fieldbus comes of age

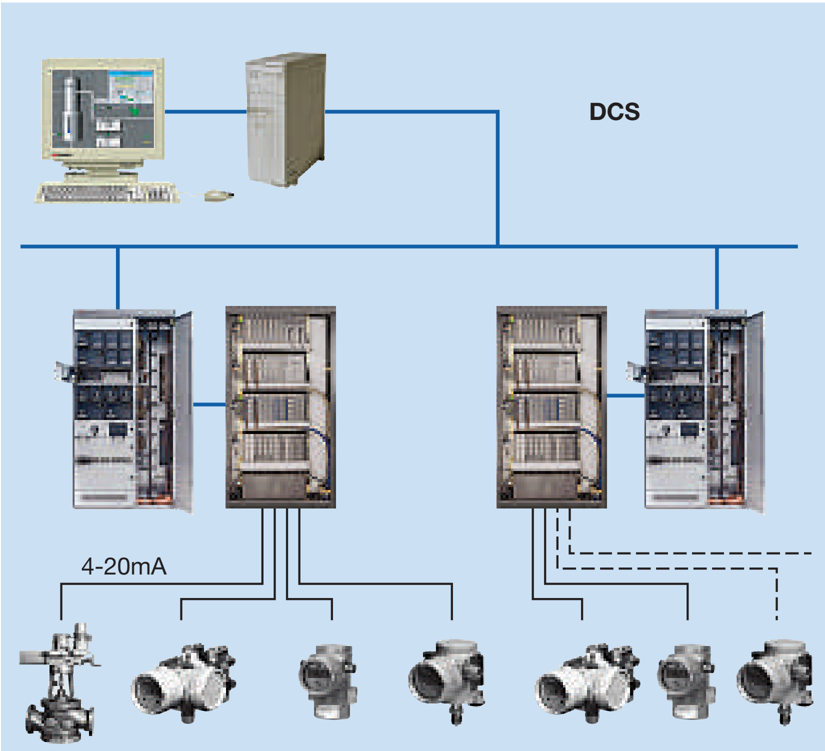
More options with ABB's Industrial^{IT} fieldbus solution

Flavio Tolfo

Fieldbuses employ digital technology, and as such they have vast potential for improving communication between industrial control systems and field instruments. Like most new technologies, however, their full acceptance was initially delayed by the usual period of 'wait and see'. This has long since passed and the fieldbus is now widely used in process automation, where it is set to become a standard feature of future systems.

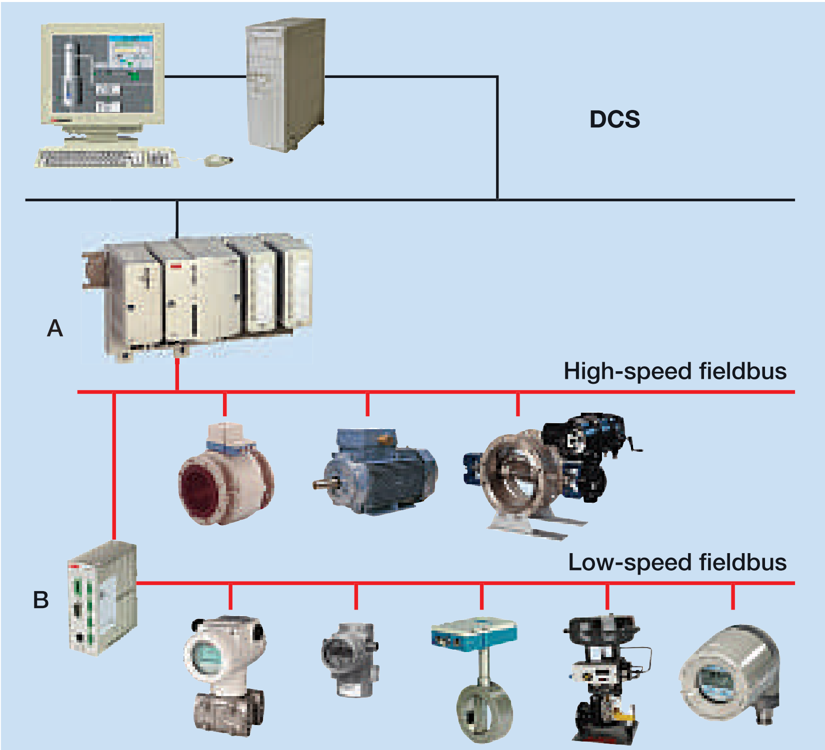
ABB embraced fieldbus technology from the beginning and has made it an integral part of its Industrial^{IT} architecture. A complete fieldbus automation solution is now available that fully exploits the benefits of synergy between the fieldbus and other key Industrial IT features. This solution includes innovative products that offer customers complete freedom when choosing communication protocols, plus standardized engineering, high system availability and asset optimization. What is more, it can be installed without risk in hazardous areas.

Historically, communication between field devices and a control system has been over *analog*, 4–20 mA current loop interfaces. This widely used technology works well and allows accurate transmission of process variable measurements as well as effective closed-loop control 1.



1 Typical traditional automation architecture

Field devices connect to the marshaling racks and safety barriers over 4–20 mA current loop interfaces. Controllers then transfer inputs/outputs to the Distributed Control System (DCS).



2 Fieldbus architecture

The controller (A) interfaces between the DCS and the fieldbus. The fieldbus servicing the high-power devices (PLC, drives, analyzers, MCC, safety, condition monitoring) is connected to the fieldbus handling the devices with lower power requirements (instruments, valves) via a linking device (B).

Fieldbus technology, however, is *digital*. This brings remarkable simplification to system architectures, with a corresponding saving in field cabling, equipment room layout, marshaling racks and safety barriers. Further, when digital field instruments are used, significantly more data becomes available; 'smart' transmitters, with powerful microprocessors and memory chips, manage valuable device configuration and status information. Significant gains come from making the data available to the automation system for remote engineering and maintenance.

With the widespread introduction of digital technology into almost every aspect of society, the era of the fieldbus was always mooted to be just around the corner. However, interoperable and widely available products remained elusive and many early pilot projects ran into unexpected difficulties. So, while some pioneers resorted to proprietary solutions, most viewed fieldbus technology as interesting but premature.

That situation has now completely changed, as is demonstrated by increasing use of the fieldbus in process automation.

The next quantum leap in process automation

'Fieldbus' is actually a generic term and several different versions are available. Technically, it is a digital, bi-directional, multidrop communication system for instruments and other plant automation equipment. Or, put more simply, a single-cable network that can replace conventional means (eg, a 4–20 mA current loop) of transporting data between field devices and a control system **2**.

Devices which can be connected to fieldbuses include flow, pressure, temperature and level instruments, analyzers, switchgear, programmable logic controllers, process controllers, remote I/O stations, drives, motors and human-to-machine interfaces. Different areas of industry have fieldbuses that suit their own specific requirements.

It is no exaggeration to say that fieldbus technology represents a quantum leap for process automation. Several benefits stand out:

Simplified architecture

Traditional 4–20 mA devices require at least two wires each. Data wires are often bundled into multicore cables and led to the equipment room marshaling racks, where I/O signals are individually connected to the control system and safety barriers are applied. This is a complex – and costly – architecture.

By comparison, fieldbus architectures consist of field instruments connected to local, low-speed segments linked together by a high-speed communication backbone. Fieldbus communication is bi-directional over a single cable, and a high-speed Ethernet-based broadband network can easily accommodate hundreds of devices at fast scan rates. The simpler wiring, and consequent saving in material and installation costs, is obvious, at least in theory.

Actual results are, though, somewhat less spectacular. The number of low-speed segments is dictated by the number of field devices that each segment can support. Practical limitations in power consumption and scan cycle rates restrict this number to six to eight devices per segment. (ABB has an innovative solution for this, more of which later).

So, in practice, the number of low-speed segments needed could be high, with each one requiring a linking device, power supply, connectors, terminators, etc. The saving in material procurement and wiring activities may therefore be less than expected and will vary with the system topology.

Simplified installation in hazardous areas

Many industrial processes take place, of necessity, in a hazardous environment (eg, where a risk of explosion exists), so that strict installation standards have to be observed. Different technologies are used for different applications, the most common for measurement and control being Intrinsic Safety Ex-I (IS).

With traditional technology, each signal sent to the hazardous area requires an IS barrier to filter out dangerous current and voltage peaks. IS barriers are usually located on the I/O marshaling racks in the equipment room. The additional equipment footprint required can be expensive.

Fieldbus I/O connections are made in software, which eliminates marshaling panels altogether. Additionally, only one IS barrier is required per low-speed segment, so the number of IS barriers is greatly reduced. A smaller footprint and less material translate into a significant saving, and this is confirmed by experience [1].

Remote engineering

The greatest benefit of fieldbuses lies in the additional data communication they make possible.

With traditional technology, the device engineering and configuration data reside in two separate locations: in the system engineering tool and in the device itself. Any changes that are required must be made in both databases – an error-prone manual operation.

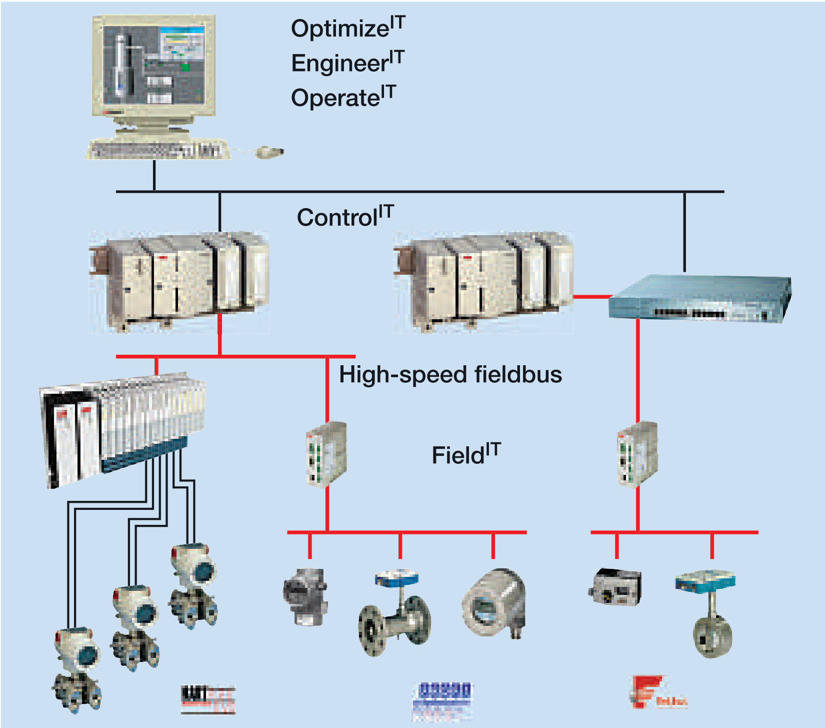
A digital regime has the advantage that the entire automation system, network and field instruments included, can be configured off-line in the systems engineering tool. The greater information content, however, leads to greater complexity in the fieldbus communication structure. Many more parameters and variables need to be specified and the allocation of devices to a particular low-speed segment must take into account new constraints, such as communication, power consumption and scan cycle times; overall, the engineering effort is displaced but may not be significantly reduced. However, with increasing deployment of the technology, the engineering staff's increased familiarity with it and the development of more efficient tools, it is reasonable to expect that the fieldbus engineering effort will significantly decrease in the future.

Reduced commissioning effort

The advantage of using fieldbuses is especially noticeable during commissioning. Instead of the two men (one in the control room and one in the field) often needed to configure a loop in traditional systems, one engineer can single-handedly commission each loop. The saving in time and cost is dramatic, 10–15% having been achieved in one application [2].

Single-loop integrity

In the early days of process automation, one field device was connected to one controller and many such independent loops operated in parallel. A major ad-



3 ABB's Industrial^IT fieldbus solution lets end users select automation solutions without regard to the communication protocol, simplifies engineering, secures communication and supports installation, operation and repair.

vantage of this architecture was that a failure in one loop did not degrade others ('single-loop integrity').

Distributed control systems later concentrated the I/Os and control functions into ever more powerful controllers and I/O modules. But this came at the expense of single-loop integrity; failure of one component could now impact several loops and have a catastrophic effect on operations, so expensive redundancy schemes had to be incorporated into the architecture.

The fieldbus restores single-loop integrity. The Foundation fieldbus protocol, for example, enables control functions to be distributed among the field devices. Peer-to-peer communication between the devices ensures autonomy of this function from the rest of the architecture. Now, a control loop can be assigned to one low-speed segment, ensuring that it will keep running even if there is a failure somewhere in the rest of the network.

Additionally, the fieldbus checks the status of the network elements. Failure of a component is immediately detected and reported. Field devices can be substituted on-line, without having to cut off the power or interrupt normal network operation.

The High-Speed Ethernet components used in the fieldbus are mass-produced and typically redundant and rugged; this drives down the cost of, and need for, redundant architectures.

CAPEX saving

The quantifiable Capital Expenditures (CAPEX) benefits described above are routinely used to justify fieldbus investments in automation projects. A saving of 25% is typically quoted [3].

Actual results are less dramatic. As

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Pedro Sanchez, maintenance manager at Pemex' Minatitlan refinery, Mexico.

previously explained, the predicted saving is diminished by the limitations in low-speed segment capacity, added engineering complexity and extra demands made on the hardware. Reported experience [2] gives an overall CAPEX saving of 10 to 15% which, although not revolutionary, is still significant.

OPEX – where the real benefits are

The *real* payoff comes from the operational benefits that the fieldbus delivers.

'Smart' devices contain valuable status and performance information that cannot be accessed via an analog link. When a fieldbus is used, however, these variables can be retrieved and a whole new world of possibilities opens up for predictive maintenance, advanced diagnostics and asset optimization.

The following two examples serve to illustrate this.

Device failure identification

In an analog architecture, device failure manifests itself as a 'limit violation' alarm somewhere in the process. Locating the faulty device can then be a lengthy process, perhaps necessitating process disruption.

Fieldbus status signals, on the other hand, allow operators to immediately identify the malfunctioning device, obtain an indication of the cause and significantly accelerate repair operations with on-line substitution.

Pedro Sanchez, maintenance manager at Pemex' Minatitlan refinery in Mexico, says: "We used to get 1300 equipment maintenance requests a year, but we expect the fieldbus technology we installed during a recent modernization project to reduce this number by at least 50–60%" [4]

4 ABB's FieldBusPlug – bringing simplicity to fieldbus applications

Predictive maintenance

Regular maintenance, usually during plant shutdown periods, is the best way to prevent potentially catastrophic valve failure. It involves manually opening and inspecting valves, many of which are in perfect working order. This is the price of safe operation.

When a fieldbus is installed, however, maintenance engineers have access to internal valve parameters, such as stem total travel length, number of strokes, total operating time, etc. These parameters are indicative of valve performance and they can reveal degradation. Maintenance need now only be carried out when required.

This all adds up to less plant disruption and shorter downtime. Besides the lower maintenance costs, there are big gains in plant availability, higher production and higher productivity – as Shell Oil found out on revamping a fluid catalytic cracker [5]. The company anticipates a 1% improvement in operating performance and process unit utilization – a significant saving in this business.

ABB's fieldbus solution has significant differentiating features

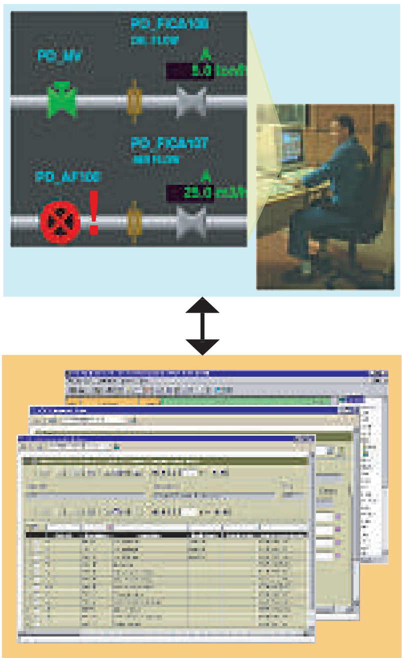
ABB saw the potential of the fieldbus for process automation early on and soon began to participate in various fieldbus organizations, making significant contributions to the technology specifications (High Speed Ethernet and Profibus) as well as playing a prominent role in the pilot tests.

ABB has made fieldbus technology a requirement for its control products and offers a complete fieldbus solution that fully leverages the innovative aspects of Industrial IT, such as Object Aspects. Indeed, fieldbus has been made an integral part of the ABB Industrial IT architecture 3.

The ABB fieldbus solution has several key differentiating features, including the following.

Freedom of choice

There is no shortage of variety in the fieldbus world. Process plant automation architectures often consist of equipment 'islands', each with its own digital communication protocol; fast logic programmable controllers and manufacturing operations often use PROFIBUS DP; process analyzers use Modbus; FOUN-



CMMS

5 The activated maintenance trigger indicates a fault or maintenance request to plant personnel and generates an automatic fault report as the first stage of a work order.

DATION fieldbus and PROFIBUS PA are used for process control; low-voltage drives and switchgear use LON; and so on.

ABB's Control^{IT} AC800 controllers accept simultaneous inputs from all these different protocols. The unique ABB FieldBusPlug 4 allows a product to be simply and quickly connected to any bus [6]. Selection of automation solutions is no longer subject to protocol constraints; they are all accepted in the Industrial IT architecture. The end-user is free to choose the technology that best fits his requirements, regardless of the communication protocol.

Standardized engineering using Aspect Objects

In a typical process industries automation project, it is not unusual to find field devices from as many as five or even ten different suppliers – each with a proprietary engineering tool. These have to be all mastered by the configuration engineer, a tedious, cumbersome and expensive process.

Here again, ABB leads the market with an innovative solution: the Field Device Tool (FDT). The FDT is a software application, based on Microsoft technology, that resides in the system engineering tool and provides a standardized engineering interface. Each device comes with a software 'driver' (Device Type Manager, DTM) that will be accepted by all FDT compliant engineering tools. The device is then configured (eg, setting of the transmitter parameters) via a standard interface, irrespective of the device engineering environment. This makes engineering as simple as loading the printer driver on a PC.

ABB further exploits this feature by making the DTM an Aspect of the device. ABB's Industrial IT architecture then lets users access the device configuration anywhere in the system – a single mouse click is all that is needed.

Secure communication

ABB also has some unique products that ensure continued communication should a network component fail:

The *Redundancy Link Module* (RLM01) duplicates the communication path over two redundant high-speed PROFIBUS DP segments, thereby ensuring continued communication in the case of failure in one line.

The *Linking Device* LD 800 connects the high- and low-speed segments. It offers I/O interface redundancy, whereby failure of one linking module is automatically backed up and access to the low-speed segments continues uninterrupted.

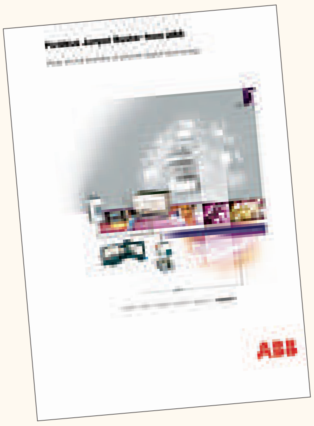
Increased capacity in hazardous areas

One of the unique devices offered by ABB is the *Multibarrier* MB204, a low-speed multiport junction box that provides spurs to four devices. It increases the capacity of a low-speed segment by up to a factor of four, while preventing short circuits in a single spur from affecting the rest of the segment.

Asset optimization

The *maintenance trigger* is a system-resident software that collects selected status

A Foundation in Fieldbus



If you mix up HIST and host, can't tell a chicken foot from a backbone or wonder what Kermit has to do with fieldbus technology, then the ABB Fieldbus Jargon Buster is the publication for you. It contains a clear explanation of dozens of fieldbus technical terms and can be found by following the fieldbus glossary link at *www.abb.com/fieldbus*.

inputs from equipment and processes them in a predefined maintenance logic. All inputs are accessible, irrespective of their communication protocol. Upon reaching one of the predefined maintenance conditions (for instance, a maximum number of strokes in a control valve), the trigger is activated 5 before the valve performance degrades. A fault report is presented at the operator station and the operator can send a maintenance work order request to the Computer Managed Maintenance System (CMMS). Root cause analysis is greatly facilitated by a detailed *audit trail* giving the complete device event history while repair, installation and operation are supported by extensive electronic documentation. All these features are Industrial IT Object Aspects, accessible by mouse click.

Further, a CMMS resident Maintenance Order Manager helps track the Work Order through scheduling, resource allocation, execution and closure. Spare parts inventory management and automatic web-based parts purchasing can also be incorporated, depending on the sophistication of the CMMS package. Provisions are also made for interfacing to established CMMS packages, such as PSDI Maximo, IFS and SAP.

Advanced asset optimization packages for valves, motors and heat-exchangers will be available soon.

Fieldbus and the future

Fieldbus technology, then, has become mainstream and enjoys full acceptance. ABB has fully embraced this technology, embedding it in the ABB Industrial IT architecture and making it a prime feature of its control products. Fieldbus technology will continue to evolve and ABB will continue to exploit the synergy between it and Industrial IT to bring exciting products that make life easier for everyone.

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