

CHOOSING THE RIGHT TECHNOLOGY FOR A DIGITAL AUTOMATION ARCHITECTURE

Rich Timoney, President & CEO
Fieldbus Foundation

Many automation end users face the critical task of selecting a digital communications technology for their process control system. This choice can hinge on a number of cost and performance considerations, so it's important to understand the differences between the leading solutions before making a major investment.

Today, end users want to remove the constraints of closed, proprietary control systems and free their plant's profit potential. They're seeking an open automation infrastructure that integrates installed assets and co-exists with legacy systems—all while protecting valuable investments.

In a recent market study, the ARC Advisory Group reported that the global market for fieldbus control equipment in the process industries had reached USD \$831.7 million. The study projected current growth trends will expand this market to over USD \$2,279 million by 2011, with one technology—FOUNDATION™ fieldbus—increasing its leadership with a strong double-digit growth rate.

The following white paper examines the reasons for FOUNDATION fieldbus' success and its growing adoption among process end users.

BACKGROUND

Fieldbus technology is now replacing the traditional 4-20 mA platform as the basis for a modern plant automation architecture (See Fig. 1). A bidirectional, fully digital communication protocol that exists at the field level of a process plant, fieldbus supports increased intelligence in field devices and enables tighter control of the process.



Fig. 1. Fieldbus technology is now replacing the traditional 4-20 mA platform as the basis for modern plant automation architecture

Fieldbus technology makes it possible to “mine” important information from the plant floor. Delivering information to the right person, at the right time, empowers operators, technicians and process engineers—making plant operation easier, faster and better. Fieldbus also unifies today’s smart instrumentation and analytical highway to provide all-digital access to operational parameters and data at the point of measurement.

As fieldbus migrates into a continually wider range of automation technologies, the true value of fieldbus solutions is being revealed in the form of higher-level business benefits.

EXAMINING THE LEADING SOLUTIONS

In the past decade, two technologies have established themselves as the leading field-level digital communication standards used in the process industries. FOUNDATION fieldbus, introduced in 1994, was designed to be compatible with the SP-50 standards project of the ISA. The other major fieldbus standard is Profibus-PA. Profibus, which originated from academic and research institutions in Germany in the 1980s, developed the Profibus-PA protocol in 1996.

Profibus is a family of protocols originally designed to provide communications from real-world sensors and actuators to area controllers. These protocols are maintained by the Profibus Trade Organization (PTO) as an open standard.

Profibus was initially designed as a remote I/O subsystem to provide a communications hierarchy for a PLC system, primarily in discrete manufacturing and building automation. Profibus has evolved to be used in the process industries for peripheral processes such as packaging lines and control of prime movers such as motor and pumps in a motor control center.

Extensions to the original Profibus architecture were implemented to extend the market of Profibus to process automation and other areas. Profibus now consists of three separate protocols grouped under the common umbrella name of Profibus. These protocols are Profibus-FMS, Profibus-DP and Profibus-PA. In addition, there are a number of totally proprietary protocols that are called Profibus.

FOUNDATION fieldbus, supported by the world’s leading manufacturers of Distributed Control Systems (DCSs) and field instrumentation, is a systemic technology comprised of a bi-directional communications protocol used for: communications among field devices and to the control system; a Function Block structure for true distributed control; Device Description (DD) technology for parameterization and integration of data; a network hierarchy for subsystem integration; and a well-defined system management structure for reliability and determinism of functional execution.

FOUNDATION H1 is intended primarily for process control, field-level interface and device integration (See Fig. 2). Running at 31.25 kbit/s, the technology interconnects devices such as transmitters and actuators on a field network.

The FOUNDATION High Speed Ethernet (HSE) implementation is intended for use as a control backbone. Running at 100 Mbit/s, HSE is designed for device, subsystem and enterprise integration. It supports the entire range of fieldbus capabilities, including standard function blocks and Device Descriptions (DDs), as well as application-specific Flexible Function Blocks (FFBs) for advanced process and discrete/hybrid/batch applications.



Fig. 2. FOUNDATION H1 is intended primarily for process control, field-level interface and device integration.

In its February 2007 report, *Fieldbus Solutions for the Process Industries Worldwide Outlook*, the ARC Advisory Group (Dedham, MA) found FOUNDATION fieldbus accounted for the greatest amount of 2006 fieldbus revenues, with slightly more than 68 percent market share. The study projected FOUNDATION fieldbus adoption would continue to grow at a CAGR of 24.8 percent. ARC determined that revenues of Profibus-PA accounted for nearly 32 percent of the total process market in 2006, but would experience below average growth in the years ahead.

MOVING BEYOND THE BUS

In a study entitled, *FOUNDATION Technology Provides Automation Infrastructure for Operational Excellence*, ARC examined the unique features and capabilities of the Fieldbus Foundation's technology. ARC termed the FOUNDATION solution "more than just a digital replacement for 4-20mA technology."

According to the ARC report, FOUNDATION technology is a unified infrastructure managing data, communication, plant assets, and plant events while providing highly distributed control functionality and interoperability between devices and subsystems. This infrastructure is supplier neutral, standards-based, and provides end users with a common framework to

implement and manage strategies for operational excellence and continuous improvement in process manufacturing.

The replacement of 4-20 mA technology with a digital network was a big factor in the development of FOUNDATION technology, but was only part of the equation. The real differentiator between FOUNDATION fieldbus and its counterparts in process automation, including Profibus-PA, is the incorporation of a function block structure and supporting functions providing a complete infrastructure for process automation.

FOUNDATION technology includes not only control function blocks, but also has mechanisms for time management, global data access, an open and standards-based control network backbone in the form of HSE, and many other aspects making it a true automation infrastructure. At the same time, FOUNDATION technology is open and based on international standards, allowing any automation supplier to incorporate the technology into their framework for automation while still allowing room for competitive advantage.

FOUNDATION technology is essentially a standards-based template for high availability process automation that can serve as a common infrastructure for any process automation system from basic regulatory control to safety applications.

IMPORTANT FACTORS TO CONSIDER

When it comes to choosing a digital automation solution, technological differences ultimately translate into differences in the benefits provided in terms of performance, ease of support, predictive maintenance, ability to stave off obsolescence, and ease of integration.

With these factors in mind, end users should consider the following key issues when evaluating the Profibus and FOUNDATION fieldbus solutions:

Design Intent

Profibus was originally designed as a remote I/O bus for factory automation (discrete on/off signals). Profibus-PA is an additional layered protocol intended to address process automation applications.

FOUNDATION fieldbus was designed from the ground up for process automation. It focuses on leveraging the vast increase of data embedded within intelligent devices, such as transmitters and final control elements. FOUNDATION fieldbus has ease of use and functionality features that make it much better suited for process automation applications.

Number of Protocols

Profibus is not a single protocol—it is a family of protocols. Many claims are made about the large installed base of Profibus, but this includes all types of Profibus.

The largest percentage of applications is Profibus-DP, and a very small percentage of the total is Profibus-PA.

FOUNDATION fieldbus is a single protocol. All articles published regarding FOUNDATION fieldbus test sites and commercial installations refer to a single, comprehensive, standard protocol.

Online Functionality

In the past, new devices could not be added to a Profibus-DP or Profibus-PA segment without shutting down the process and reconfiguring the segment. Considerable resources were invested to add this functionality to the existing protocol. Some on-line additions are now possible, but only if placeholders are pre-configured into the control strategy.

An objective comparison reveals the layered Profibus solution falls well short of control systems, such as FOUNDATION fieldbus, that were designed from the start to accommodate on-line add functionality. With this approach, new devices can be added to a running fieldbus segment. Control systems can also automatically sense the addition of new devices, making the procedure seamless and easy.

Commissioning

Profibus-PA does not have system management, and as such, is not a "plug-and-play" solution. Profibus devices must be added to the network one at a time. Some devices require addresses to be set by DIP switches.

FOUNDATION fieldbus H1 system management provides auto-detection and addressing that eliminates the need for DIP switches or manual offline addressing. This saves time and money during commissioning.

Device Addressing

Profibus addressing requires manual hardware and configuration settings. Errors can stop the segment from working. In comparison, some process control systems are designed to allow FOUNDATION fieldbus to assign addresses automatically. This eliminates human error and reduces configuration time.

Gateways

Profibus-PA requires a gateway to Profibus-DP before it can be brought into a control system. This increases cost, reduces performance, and adds failure points to the solution. It also increases engineering time, drawing complexity, and configuration effort.

Profibus functionality changes depending on the type of gateway used between the Profibus-PA bus and the Profibus-DP bus. Users can have higher speed at higher

cost and lower functionality, or lower cost and higher functionality but at low speed. If the wrong gateway is selected up front, the cost to change includes not only new gateways, but major rewiring costs.

With FOUNDATION technology, no gateways are required. Fieldbus information is delivered directly to the process control system via the H1 or HSE modules. Performance is consistent and predictable.

Message Structure

Profibus requires many more messages to control a loop than FOUNDATION fieldbus. This is because Profibus uses a master/slave communication technology. Master/slave technology is only appropriate for high-speed discrete buses carrying a small amount of information per device. Profibus-PA uses this technology because it was designed as an add-on to Profibus-DP.

FOUNDATION fieldbus H1 uses publisher/subscriber communication technology for real-time communication (See Fig. 3). It allows a maximum of 32 devices per segment, although 16 devices and four complete control loops is a more common practice to ensure sufficient speed when fast control loops are required.



Fig. 3. FOUNDATION fieldbus H1 uses publisher/subscriber communication technology for real-time communication.

FOUNDATION fieldbus also supports client-server communication for non-real-time data, as well as report distribution for alarms and events.

Communications Timing

Profibus runs without timed execution ("free-running") because it was designed initially for discrete control, which does not typically require timed execution. There is no separation between real-time and non-real-time communication. When accessing non-real-time data such

as diagnostics, the cycle time changes depending on communication load. This is not acceptable for PID control, because the constant "dt" in the PID equation no longer is constant. Moreover, the sampling in devices and control execution are not synchronized—also adding jitter. This is the main reason why many users do not consider Profibus-PA acceptable for process control.

FOUNDATION fieldbus, on the other hand, incorporates an accurately timed execution schedule (precisely periodic "isochronous") essential for PID and other control functions, and eliminates the jitter found in the Profibus communication architecture. Furthermore, the execution of function blocks is synchronized with the communication, minimizing jitter.

FOUNDATION fieldbus uses publisher-subscriber communication for real-time data, enabling one device to send data to several different devices in a single communication—reducing overhead. The improvement in response time again translates into better performing process loops.

Unlike FOUNDATION fieldbus, Profibus-PA does not support scheduling and has no common sense of time among devices. Since its communication is not precisely controlled by a schedule, the loop cycle is longer and not precisely periodic.

Thanks to FOUNDATION H1 fieldbus scheduling, handheld tools can be added to an active bus without affecting process applications automatically receiving the highest priority on the network.

FOUNDATION H1 technology has a DCS background, while Profibus-PA has a PLC background (See Fig. 4). As a result, the FOUNDATION solution delivers higher performance and better quality of control than Profibus-PA. This reduces variability and improves plant profits.

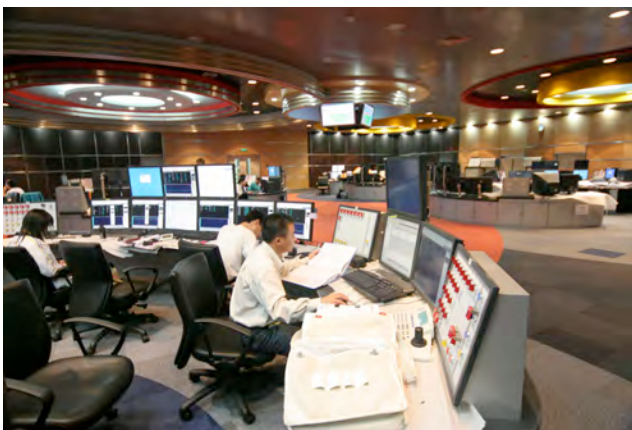


Fig. 4. FOUNDATION H1 technology has a DCS background, while Profibus-PA has a PLC background

Control In The Field

Profibus-PA does not support control in field devices. It only supports control in the master (host). Because intelligent field devices have microprocessors with high levels of computing power, it is cost effective to run control loops in the field devices, rather than in the host. This allows control loops to run independently in the event communication to the host is lost.

With FOUNDATION fieldbus, such functionality is made possible by a set of function blocks for process control, such as PID, which can be executed in the valve positioner. Plus, FOUNDATION technology has the ability to communicate peer-to-peer (for example, sending PV from a transmitter directly to the valve positioner).

Installation Savings

Profibus claims greater savings than FOUNDATION fieldbus based on the combined savings of Profibus-PA for continuous control, and Profibus-DP for discrete functions.

Nevertheless, FOUNDATION fieldbus offers greater ease of integration with other buses and clearly represents the better solution. FOUNDATION fieldbus has numerous advantages over Profibus-PA, and Profibus-DP can be used in either solution. Additionally, AS-I bus and DeviceNet are offered on most FOUNDATION fieldbus solutions.

Function Blocks

The Profibus Trade Organization claims Profibus technology supports a wide variety of function blocks, including those for control. In reality, Profibus-PA currently has only input and output blocks. Any other block claims are for planned or potential future deliverables.

FOUNDATION fieldbus supports a wide variety of function blocks, delivering to the user a high level of flexibility in designing process automation schemes.

Alarms And Events

Profibus-PA does not support spontaneous communication of alarms or events from a field device (slave) to the control system (master). In comparison, FOUNDATION fieldbus H1 supports reporting of time-stamped alarms and events detected in field device. This includes diagnostic faults as well as process alarms.

Clock Synchronization

Unlike FOUNDATION fieldbus H1, Profibus-PA devices do not have a common sense of time. This capability allows alarms and events to be time-stamped at the source for

more accurate Sequence of Event recording and quicker reporting of problems. Common sense of time also allows for coordination of input-control-output in the right order, at the right time, on a precisely periodic basis for optimum control.

Fault Detection

Profibus-PA requires device management software to poll each device for its status in a round-robin fashion. With FOUNDATION fieldbus H1 technology, faults can be communicated to the device management software instantly, and are time stamped in the device itself.

Firmware Download

Profibus-PA devices do not support firmware download. In a Profibus system, there is no separation between real-time and non-real-time data so download of large firmware image files would interfere with control.

FOUNDATION fieldbus H1 bus scheduling separates real-time communication from non-real-time communication in separate time-slots or "channels." It allows easy firmware download over the bus, as well as bumpless switchover without disturbing other communication or the process. H1 devices can be easily upgraded to benefit from the latest features—helping stave-off technology obsolescence.

Field Support

Unlike Profibus-PA, FOUNDATION fieldbus H1 supports portable bus testers for troubleshooting in the field. It also supports handheld communicators for diagnostics and calibration in the field.

VALUE PROPOSITION FOR END USERS

End users are increasingly specifying automation products and services not based upon the level of technology they provide, but on the business value proposition. The three primary value propositions of FOUNDATION technology include process integrity, business intelligence, and open and scalable integration of information across process manufacturing plants (See Fig. 5).



Fig. 5. The three primary value propositions of FOUNDATION technology include process integrity, business intelligence, and open and scalable integration.

FOUNDATION technology provides a path to greater process integrity through its capabilities for field level control, enhanced diagnostics for process safety systems, providing a common architecture for both process and safety systems, and providing more accurate measurements. Enhanced business intelligence is provided by the unification of FOUNDATION technology with the OPC UA standard and through the open data access that fieldbus can provide to any plant application. Open scalable integration is possible with FOUNDATION technology through its ability to interface with OPC UA and provide a unified data model with the incorporation of Enhanced Electronic Device Description technology.

In addition, FOUNDATION is the only technology incorporating key aspects of the "Collaborative Process Automation System" vision, including common data, common time, common presentation, high availability, and network management.

CONCLUSION

In the end, the goal of selecting a digital fieldbus should be to deliver business benefits to the customer. Whether the user is seeking faster commissioning, better diagnostics, better performance, or increased system integrity, FOUNDATION fieldbus is an excellent choice to achieve these objectives.