

# FOUNDATION Fieldbus: Back To Basics With *Virtual*/Marshalling™

## Revisiting the key advantages of software-based distributed I/O connectivity

With increasing implementation of digital control technologies across the process industries, as well as the growth of industrial wireless and network protocols, the success of the Fieldbus Foundation's open automation infrastructure is sometimes taken for granted.

The global marketplace is still experiencing double-digit growth in the sales of products and services related to FOUNDATION fieldbus. The technology remains a preferred choice for both new construction and plant retrofit projects.

Perhaps now is a good time to revisit the key performance advantages that have made FOUNDATION technology the leader in digital process fieldbus communications.

FOUNDATION fieldbus is a real-time digital communication network designed specifically for process control applications. It replaces analog 4-20 mA and on/off signals for connecting instruments like transmitters, analyzers, control valve positioners, and on/off valves to distributed control systems (DCS), programmable logic controllers (PLC), remote terminal units (RTU), and other automation systems.

As demonstrated at plants around the world,

the benefits of completely digital automation without the limitations of 4-20 mA and on/off signals are enormous. FOUNDATION technology takes automation to the next level by making control loops entirely digital from end-to-end — from transmitter to positioner — without intermediate analog signals, and by communicating multiple signals from multiple devices on the same pairs of wires. It also enables new, more powerful devices, including intelligent two-wire on/off devices with predictive diagnostics.

FOUNDATION fieldbus H1 technology provides an all-digital solution from the sensor to actuator, completely eliminating the need for analog 4-20 mA signals and significantly reducing the overall amount of equipment needed. It also takes the place of proprietary protocols previously used with electric actuators/motor-operated valves (MOV), gas chromatographs, and tank gauging systems. Communication is time-synchronized and scheduled to ensure deterministic closed-loop digital control. Multiple devices, each with multiple I/O signals, share the same bus.

FOUNDATION fieldbus supports long cable lengths to junction boxes far into the field, as well as long

spurs for devices. Fieldbus-based control systems employ two-wire twisted pair cable and provide intrinsically safe or non-incendive device power suitable for all hazardous areas. Unrestricted access to field device intelligence enables centralized configuration/setup and diagnostics for all field instruments, including discrete sensors and actuators. This solution also supports temporary masters such as handheld field communicators, laptops/tablets, and documenting calibrators.

Unlike other digital architectures, FOUNDATION fieldbus was designed from the ground up to enable control-in-the-field (CIF) strategies across the plant.

FOUNDATION fieldbus started with a few simple ideas:

- Reduce cabling
- Simplify marshalling
- Enable real-time digital closed-loop control
- Ensure multi-vendor interoperability
- Expand device intelligence
- Allow diagnostics-based maintenance
- Liberate plants from proprietary protocols

### Reduced Hardware Requirements: Lower overall capital expenses

Today, some automation projects are adopting various alternatives to traditional I/O and marshalling technology. But why make physical marshalling smarter or better when you can eliminate it entirely? Many of the functions provided by hardware in a conventional control system are no longer required by a FOUNDATION fieldbus system, or are handled through software instead.

FOUNDATION technology was developed to provide a solution for *Virtual*/Marshalling™ — software-based distributed I/O connectivity — in which devices provide multiple signals over the same two terminals. Instead of relying on custom hardware configurations to accomplish the functions of traditional marshalling, FOUNDATION fieldbus accomplishes these tasks through a software-based structure. All signal linking (block to block) is done in software without hardwiring. This approach allows late addition of feedback and auxiliary measurement and control signals without the need for additional wiring, as well as change of



devices without switching I/O cards. Burnt shunt resistors are also eliminated. More devices can be added without laying more cable.

FOUNDATION fieldbus is particularly well-suited for expansions at existing sites, which are running out of tray capacity.

#### **Smaller System Footprint: Easier design and implementation**

Rather than use individual wires for each device signal, FOUNDATION fieldbus connects multiple devices in parallel on the same pair of wires recognized by address. A single pair provides both power and communication, and can be intrinsically safe or non-incendive if required. Long distance is also possible. Field junction box hardware is rugged and encapsulated for harsh outdoor field conditions, some even passive and optionally zone 1 certified.

FOUNDATION technology reduces the need for cable, cable trays, I/O cards, and associated labor for installation, as well as the effort of cutting, stripping, crimping, labeling and connecting at every intermediate point. For example, a bus with 10 instruments — and an average of three signals per device — can take the place of 30 pairs of wires and I/O channels. The resulting cost is even lower than remote I/O and local mounting.

In addition, FOUNDATION fieldbus simplifies the integration of devices with multiple signals for operation and feedback. This includes electric actuators/MOVs and discrete devices such as intelligent two-wire intrinsically safe on/off valve actuators. In the past, these devices required one pair of wires and one I/O channel for each signal, meaning as many as 3, 6, 12 or more pairs per device. In comparison, FOUNDATION fieldbus enables a single pair of wires to support multiple devices, resulting in drastic wiring reduction. The reduced number of I/O cards for auxiliary signals also translates into fewer I/O cabinets, a smaller footprint, and reduced weight.

Since all device signals can now be employed at lower cost, plants can fully utilize device capabilities without being limited to a subset of signals and functionality. Continuous feedback and bumpless transfer (a feature in virtually all PID controllers preventing a sudden jump in output when the controller's mode is switched from manual to auto) on hand operation also becomes available for all valves.

Thanks to FOUNDATION technology, transmitters, control valves, and two-wire on/off valves are able to share the same bus. As a result, there is no need to select I/O card or barrier types, since all devices use the same single type of interface card and barrier, and have the same entity parameters — simplifying selection. At design time, it is not necessary to know the exact type and quantity of signal for each device to determine I/O requirements.

#### **Reduced Device Count: Lower wiring and installation costs**

FOUNDATION fieldbus instruments are not limited to transmitting single values in real time. Instead, the

technology supports multi-point devices such as multi-channel temperature transmitters with eight sensor inputs, which are ideal for temperature profiling applications, as well as multi-point indicators. For dual sensor temperature transmitters, both channels can be used for control loops.

The fieldbus solution allows eight-channel temperature transmitters to take the place of many hardwired transmitters, thus reducing the overall device count as well as associated wiring and I/O card points. These and other innovations offering installation cost benefits are not possible with hardwired signals.

#### **Open Network Standard: Fewer protocols and greater interoperability**

Proprietary protocols were eliminated years ago for simple transmitters and valve positioners. Now, FOUNDATION fieldbus can also eliminate these protocols for electric actuators/MOVs, gas chromatographs and tank gauging systems.

These fieldbus devices integrate with intelligent device management software for setup/configuration and diagnostics just like transmitters and valve positioners, enabling predictive maintenance and doing away with special software. Devices also share the same bus infrastructure, eliminating the need for separate networks, gateways, and drivers.

As an open network standard, FOUNDATION fieldbus eliminates single vendor dependency, which limits the ability to interchange or replace existing instruments with third-party devices. This means different brand equipment can share the same network or serve as second-source replacement devices.

#### **Faster Commissioning: Reduced labor and associated errors**

With FOUNDATION fieldbus, time-consuming manual commissioning tasks and their associated errors are no longer a concern. The same is true of 4-20 mA ranging and signal distortion; traditional five-point loop tests are replaced by a simple plausibility check. Technicians can automatically confirm the correct device type (model and manufacturer) has been installed. This applies to not only transmitters and positioners, but also discrete devices such as intelligent two-wire on/off valves and electric actuators.

#### **High Signal Integrity: Better resolution and increased accuracy**

FOUNDATION fieldbus' pure digital signals eliminate the digital-to-analog (D/A) and analog-to-digital (A/D) conversion required in devices and systems utilizing 4-20 mA technology. Fewer conversions lead to higher resolution and accuracy. Errors due to current calibration differences between transmitter output and DCS input are also eliminated. This is particularly important in flow and level applications such as tank gauging, where small percentages correspond to significant revenue.

Using fieldbus, measurement values transmitted digitally cannot be distorted and integrity errors are

immediately detected. This compares with “on-scale” errors associated with 4-20 mA signals, which are often due to undetected ground loop or current restriction issues. Unlike discrete signals where open or short circuits may not be recognized, bus communication errors are easily identified.

#### **Greater Signal Fidelity: Increased awareness of abnormal situations**

FOUNDATION fieldbus devices are designed to transmit measurements as a real number in engineering units (not scaled by range), which are received — unaltered — by a control system at the other end.

Transmitter configuration download from the DCS is done as part of the device replacement process, thus ensuring the units, range, and other settings are correct. This approach eliminates the process variable value skew that sometimes results from mismatched 4-20 mA range settings between transmitters and the control system. Operators gain confidence that the reading, controls, and alarms in the system are correct.

With fieldbus, measurement values are also transmitted over the full sensor limit with greater precision and are not limited to a narrow 4-20 mA portion. As such, they do not saturate at the normal control range, but go beyond, providing valuable information during abnormal conditions.

#### **Tighter Control: Faster response and less variability**

Transmitters, controllers, and valve positioners are digital — so it only makes sense to have pure digital signals between them. A digital bus running 25 times faster than earlier hybrids of analog and digital allows a closed loop that is digital and time-synchronized from end to end, from sensor to valve. Fieldbus communication is deterministic and real-time, offering control response times faster than 150 ms in some cases.

Elimination of analog input (AI) and analog output (AO) cards and their associated scan delays and jitter also improves control response time, particularly compared to remote I/O with additional network and link delays. Reductions in process variability allow set points to be moved closer to the optimal point of operation, with less “comfort margin.” Improvements for each transmitter and valve, loop, and process unit contribute to better plant performance.

#### **Real-time Signal Status: Fewer trips and increased availability**

FOUNDATION fieldbus delivers real-time signal validity indicating if the value is good for control, uncertain, or bad (fault). The status is then propagated as part of the same data structure as the value, eliminating the need for separate data mapping. This enables process problems to be distinguished from device problems, thereby minimizing nuisance trips of the control loop on sensor failure and increasing availability. The valve status includes limit conditions for override windup protection, fault state, bumpless transfer and more — further improving control.



## Major Automation Companies Remain Committed to Fieldbus



Emerson Process Management has released version 5.3.0 of its Segment Design Tool. This tool is designed to verify the physical and electrical parameters of a FOUNDATION fieldbus segment, operating under an H1 card on a DeltaV™ controller. This release has added support for the Windows® 7 operating system, support for both simplex and redundant H1 cards of S series with integrated power supply, and numerous field devices from a variety of manufacturers.



FOUNDATION fieldbus equipment provides valuable information from the field that helps to improve both operation and maintenance. The challenge in fieldbus projects lies mainly in the complexity and risks in terms of device integration, network installation in the field and troubleshooting expertise. To address these issues, Endress+Hauser offers a complete set of services to design, engineer, install, commission and maintain a fieldbus network, taking responsibility and guaranteeing the overall performance of the solution. The company is a competent and reliable partner for any fieldbus project.



The latest product release for the PlantPAx system from Rockwell Automation provides a robust, user-friendly FOUNDATION fieldbus solution helping to lower overall cost of ownership. The linking devices support 16 different H1 topologies, including multiple fault tolerant options with ring dual H1 media and redundant linking devices. A built-in power conditioner reduces the need for additional specialized hardware. Access to device-specific features, such as partial valve stroking and diagnostics for empty pipe detection, are also available in the PlantPAx HMI.



Since the establishment of the Fieldbus Foundation in 1994, Softing has played a leading part in the FOUNDATION fieldbus specification work. The company was first to implement the FOUNDATION H1 protocol and developed the PC interface used for the H1 protocol verification in 1995. Today, Softing is a leading supplier of protocol stacks and embedded communication modules for FOUNDATION fieldbus devices and host systems worldwide.



FOUNDATION fieldbus is a communication network with the highest potential for improving plant productivity. Yokogawa has been developing multivariable devices so that users can enjoy the merits of fully digital communication. The company's multivariable pressure transmitter, EJX910/930, is capable of measuring differential pressure, static pressure and temperature, and outputs mass flow rate by calculating these variables — eliminating extra pressure transmitters and temperature sensors. Its vortex flowmeter, digitalYEWFL0, also outputs mass flow rate using a built-in temperature sensor and accepts inputs from other pressure transmitters through FOUNDATION fieldbus without the need for additional wiring.

The FOUNDATION solution employs NAMUR NE107-compliant device alarm rationalization to notify the right person without alarm flooding.

### More Powerful Devices: New and robust instrument functionality

The electronics in FOUNDATION fieldbus two-wire devices are not restricted to operation on 4-20 mA. The result: bus-powered instruments are able to consume more power, enabling new and more powerful functionality.

Examples of such devices include two-wire radar level transmitters with frequency modulated continuous wave modulation, two-wire eight-channel process temperature transmitters, two-wire tank gauging multi-spot temperature transmitters with water bottom level measurement, two-wire intelligent on/off valves, and two-wire field indicators.

Powerful function blocks in fieldbus instruments provide computation and arithmetic whenever there is a need to calculate or compensate a value in the device so that it may be shown on a local display.

### Enhanced Diagnostics: Improved operations and maintenance programs

The digital nature of FOUNDATION fieldbus supports centralized device configuration/setup, diagnostics, and viewing of internal variables. The technology also allows two-wire devices to drive more powerful electronics and firmware, ensuring more sophisticated self-diagnostics. This includes statistical process monitoring (SPM) for multiple variables across the bus and continuous valve performance diagnostics not found in 4-20 mA devices.

Faster communication also means diagnostics and configuration/setup pages load faster.

Predictive diagnostics with fieldbus is available from two-wire intrinsically safe intel-

ligent on/off valves and other discrete devices not digitally integrated in the past. In addition, the technology employs NAMUR NE107-compliant device alarm rationalization to notify the right person without alarm flooding.

### Simple Online Upgrades: Easier access to new technology

FOUNDATION fieldbus instruments not only communicate faster than older hybrid analog/digital devices, but they also have the speed necessary to allow firmware download from the system. Devices with dual memory banks switch bumplessly to new firmware.

Modern fieldbus devices are easily upgraded to take advantage of features and other improvements in new versions. These upgrades can be performed without going into the field to replace the entire circuit board or connect a laptop.

### Greater Ease of Use: Proven solutions for projects of all sizes

FOUNDATION technology is continuously improving based on feedback from our strong end user advisory council. The FOUNDATION specification now includes NAMUR NE107-compliant role-based and prioritized device diagnostic alarms; backwards compatibility and easy device replacement; and graphically enhanced, device-level electronic device description language (EDDL) user interface and wizards. Constantly improved device interoperability testing kits (ITK) and host profile registration processes ensure that new devices and systems meet our specifications.

