# Bus Technology - Digital Automation in Processing Plants

*The digital revolution has gripped the globe with vines that have delivered a quantum of possibilities, which just two decades ago would have been deemed impossible to implement within the workings of a process manufacturing plant. Today, new refineries are built and existing plants upgraded on a bus technology platform. This article explores considerations to be made in the application of bus technology for optimal digital plant architecture.*

Digital communications technology, streamlines the wiring in a plant by allowing the installation of multiple devices and multiple signals on the same set of wires which allows a faster transfer within the same physical confinements. Conduit, cable trays, terminations, IO cards, barriers, and control footprints are reduced using the fieldbus approach. Wiring reductions in these areas facilitate overall ease in engineering drawings, the related documentation and allow faster loop checks and commissioning due to the digital architecture which automates these tasks. Overall, use of digital technology can reduce automation project costs by as much as 30%. As typical plant operations generally continue for 15 years or more, a critical advantage which fieldbus provides is- the digital platform, which is extremely adaptable to technology and hardware upgrades and changes for an extended period of time.

Digital communication improves end-to-end accuracy and signal integrity, gives access to a wider sensor range, avoids range mismatches, provides remote access to more information from the device such as validity, failure alerts, and detailed diagnostics for faster troubleshooting. The technology also features an online bumpless device firmware upgrade, thus ensuring a seamless transition when the occasional firmware upgrade is required. These features simplify work processes and keep devices in better condition reducing the risk of downtimes. They help the digital architecture deliver a 2 percent operational improvement stemming from better product quality and higher throughput while reducing process variability and lowering maintenance cost by enabling a more accurate, predictive maintenance schedule.

Figure 1 handheld communicator based on EDDL enables field work

## Bus Technology in Process Automation

Process control, factory automation, and robotics etc. pose different control challenges and therefore require different bus technologies. Out of some twenty four bus technology options, process automation primarily uses three protocols: HART, FOUNDATION fieldbus, and PROFIBUS-DP. These protocols are extensively supported in all modern plant control

systems with HART and FOUNDATION fieldbus also incorporating support for handheld communicators used in remote locations.

## Foundation fieldbus H1

Refineries and petrochemical plants have in their inventory hundreds perhaps even thousands of devices. Wiring is significantly reduced by connecting six to eight devices or more per cable to maximize their operational capacity.

THE FOUNDATION fieldbus H1 protocol is ultimate the preferred bus for instrumentation in the petrochemical and refining industries as well as many others because it uniquely satisfies control requirements. For example, regulatory process control such as PID and totalized flow measurements require an input/output sampling to be precisely periodic and synchronized with communications and control. This is necessary to avoid aliasing, prolonged response time, and instability due to jitter. Likewise, there must be channel separation of non-real-time communications to prevent interfering with real-time communication. Other bus requirements met by H1 include the ability to work over long distances from control room to field, long spurs for topology flexibility, Electronic Device Description Language (EDDL) support for easy setup and diagnostics, automatic addressing for plug-and-play commissioning, bus power, and intrinsic safety to permit live work in hazardous areas.

Unique to the FOUNDATION fieldbus H1 is the IEC 61804-2 function block language for building control strategies. The H1 execution of function blocks is synchronized to the execution of the communication functions, minimizing dead-time and results in better control. The control can also be done from field devices thus reducing the network communications load. Fast new digital field devices execute control loops as fast as 250 ms, meeting requirements of even the most demanding process technologies resulting in resounding approval from process licensors.

| Name | FOUNDATION fieldbus H1 |
|---|---|
| Distance | 1.9 km, 9.5 km with repeater |
| Devices per segment | 32 (theoretical), 8-16 (typical) |
| Bus power | Yes |
| Intrinsically safe | Yes |
| Speed | 31.25 kbit/s |
| Spur length | max 120 m |
| Devices per bus | 240 (theoretical), 8-16 (typical) |
| Communication relationships | Scheduled publisher/subscriber peer-to-peer, master/slave, alert distribution |
| Data | Cyclic IO and acyclic device data |
| EDDL support | Yes |
| Automatic addressing | Yes |
| Others | Data organized by blocks and parameters |
| Device types | Temperature, pressure, level, flow, density, and concentration transmitters<br>Conductivity, pH/ORP, resistively, dissolved oxygen, and oxygen analyzers<br>Machinery health monitors<br>Control valve positioners, electric actuators, discrete switches, and on/off valves<br>Signal converters |

## HART

HART combines digital communications with 4-20 mA technology on the same pair of wires to connect single devices and it can also be used as a pure digital multi-drop bus.

The range of supported device types is nearly the same as for FOUNDATION fieldbus. Additionally, HART is used for transmitters and valve positioners in Safety Instrumented Systems..

| Name | HART |
|---|---|
| Distance | 3 km |
| Devices per segment | 15 (possible), 1 (usually) |
| Bus power | Yes |
| Intrinsically safe | Yes |
| Speed | 1.2 kbit/s |
| Spur length | N/A |
| Devices per bus | 15 (possible), 1 (usually) |
| Communication relationships | Master/slave polling |
| Data | Usually only acyclic data |
| EDDL support | Yes |
| Automatic addressing | No |
| Others | Based on commands |
| Device types | Temperature, pressure, level, flow, density, and concentration transmitters<br>Conductivity, pH/ORP, resistively, dissolved oxygen, and oxygen analyzers<br>Control valve positioners |

**Figure 2 Smart safety logic solver communicates HART**

## PROFIBUS-DP

PROFIBUS-DP is available in a few different configurations and uses the RS485 media. Note, that discrete proximity switches, solenoids, and other simple on/off devices do not connect using PROFIBUS. However, remote I/O subsystems on PROFIBUS connect discrete signals through conventional wires.

| Name | PROFIBUS-DP |
|---|---|
| Distance | 1.2 km at 93.75 bit/s or below, 100 m at 3 Mbit/s or above |
| Devices per segment | 32 |
| Bus power | No |
| Intrinsically safe | No |
| Speed | 9.6/19.2/45.45/93.75/187.5/500 kbit/s or 1.5/3/6/12 Mbit/s |
| Spur length | Spurs max 6.6 m for 1.5 Mbit/s and below |
| Devices per bus | 126 (theoretical) |
| Communication relationships | master/slave polling without scheduled synchronization |
| Data | Cyclic IO and acyclic device data |
| EDDL support | Yes |
| Automatic addressing | No |
| Others | Data organized by slots and index |
| Device types | Remote I/O, weighing scales, motor drives, motor starters, circuit breakers, electric actuators, and solenoid valve manifolds |

## Proprietary Protocols

Although HART has displaced proprietary smart protocols in most refineries and petrochemical plants using 4-20 mA, some plants are still trapped with instrumentation using proprietary protocols. Plants that purchased a DCS some years ago which used input cards with a proprietary protocol, plants are now faced with continuing to buy transmitters from the same DCS vendor so as to maintain interoperability. Without alternate sources, maintenance departments pay higher prices for spares and replacements. With PROFIBUS-DP this issue is avoided by using open standard communications for new systems. Existing plants are increasingly moving to the standards-based approaches by installing device management systems based on standard protocol multiplexers or wireless gateways in parallel with the DCS, bypassing the proprietary protocol in the DCS input cards. The multiplexer "peels off" HART communications to access the all-important diagnostics from intelligent digital instrumentation.

## The Bus Technology Promise

Whilst cabling cost reduction is the primary capital saving with fieldbus, the maintenance savings arising from the device management software are highly valuable too. The software enables process instrument identification, information access, remote diagnostics and performance analysis Furthermore, operational statistics, audit trail, calibration trim and log, document access, device event capture and monitoring as well as maintenance log and service notes fall within the arsenal of this software.

To ensure that the device management software is used to its fullest capacity, it must be tightly integrated with the operator workstation software. The operator can then simply click on a suspect device or a device alarm to open up the device page and check the operational health of the device. What is equally important is that the device management software must be incorporated into the daily operations of the work processes.

IEC 61804-3 standard EDDL technology is of importance too as it is a key component of open standard protocols. EDDL is an integral part of the HART, FOUNDATION fieldbus, and PROFIBUS protocols as it allows the plant's range of field devices to flawlessly operate from the same software. Each version of a device is provided with an EDDL file which communicates to the software how to access information in the device and display it in a user-friendly format. A key aspect is that the EDDL file is in a compressed text and not in programming language, making possible the integration of new devices into the control system without requiring

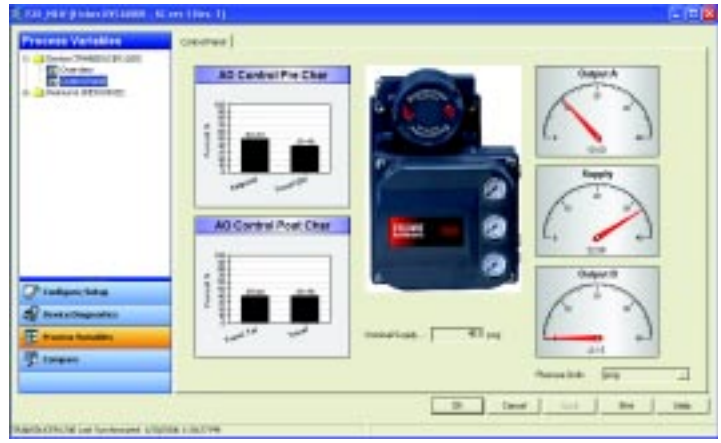

**Figure 3 Device management software based on EDDL gives access to information to enable maintenance savings**

Figure 4 Digital automation system architecture

Table 1 Device category and protocol availability

| | ASI | HART | DP | FF |
|---|---|---|---|---|
| Control transmitters | | X | | X |
| Control valve | | X | | X |
| Motor drive | | | X | |
| Safety transmitters | | X | | |
| Safety valve | | X | | |
| On/off switch | X | | | |
| On/off valve | X | | | X |
| On/off solenoid | X | | | |
| Electric actuator | | | X | X |

ways. Further, the engineering workstation software must support configuration of the various fieldbuses, rather than requiring a more complex back-and-forth solution using stand alone softwares.

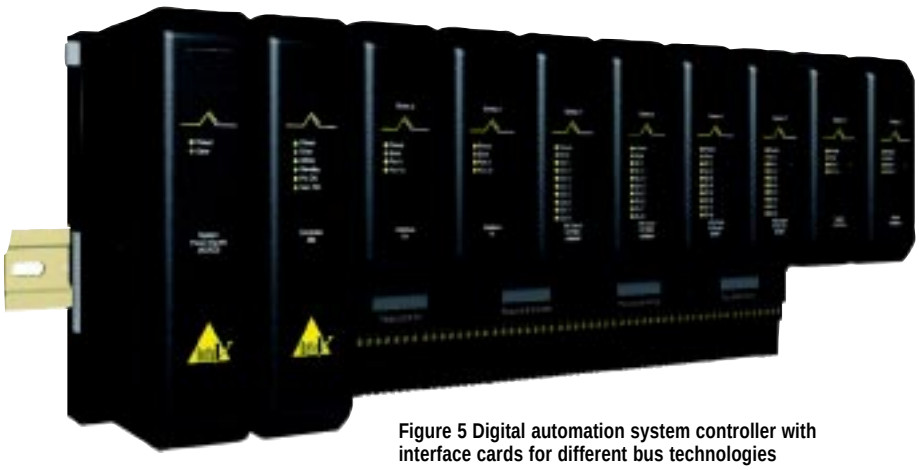

Figure 5 Digital automation system controller with interface cards for different bus technologies

Using the best modern technologies and employing the best practices, plants with fully integrated digital plant architecture will progress through project phases with remarkable speed and efficiency, the follow-on operations will sustain better and add to improvements. Open standard FOUNDATION fieldbus and complementary bus technologies are a vital enabler of these advantages for process manufacturers.

installation of new software that could put system stability at risk.

## Digital Plant Architecture

Delivering on all of the advantages of open standard communications, digital plant architecture uses the power of intelligence in field instrumentation and equipment to improve plant performance by delivering accurate, actionable information to operations and maintenance personnel in time to allow improvements in process and plant efficiency.

Since various devices use different protocols to deliver their unique functionality (Table 1) plants have a mix of bus technologies that must be integrated effectively to create the optimum digital architecture. Control systems must have functionality to integrate all protocols rather than requiring a more complex and less functional solution using gate-

## References

1. Jonas Berge, "Fieldbuses for Process Control: Engineering, Operation, and Maintenance", ISA, 2002, ISBN 1-55617-760-7



*This publication thanks Mr. Jonas Berge, who is a manager at Emerson Process Management in Singapore. Educated in Sweden, he has more than twenty years of experience in development and application in the field of instrumentation and controls. He is one of the architects of FOUNDATION fieldbus. Mr. Berge is a senior member of ISA and President of the Fieldbus Foundation Marketing Society in Singapore. Mr. Berge is the author of the books " Fieldbuses for process control: Engineering, Operation, and Maintenance" and "Software for Automation: Architecture, Integration, and Security". Mr. Berge received the 1999 ISA award for excellence in documentation.*