

INDUSTRIAL NETWORKS: WIRED & WIRELESS

Know your options for deploying what's best for your application



AutomationWorld

FIELDBUS AND ETHERNET IN BATCH APPLICATIONS

DAVID GREENFIELD / Media and Events Director *Automation World*

In most process industry facilities, the predominant means of communication between field devices and control systems was, for many years, a 4-20 mA analog connection. Though this connection method is highly dependable and still in use, the amount of wiring required is substantial, as each device on the network must have its own separate connection to the controller.

As digital technologies emerged on the industrial scene, the capability of fieldbus protocols became a more attractive alternative to analog 4-20 mA communication because of the reduced wiring requirements of fieldbus networks. Less wiring is required with fieldbus because a fieldbus segment can carry both DC power and digital communication signals to numerous separate devices over one fieldbus cable.

The predominant fieldbus protocols in the process industries are: Foundation Fieldbus, HART, and Profibus.

As Ethernet more clearly becomes the network of choice, not just for the front office, but in production areas as well, the move toward Ethernet-based communications in the process industries is gathering a great deal of attention. Evidence of this can be seen in the increase of end devices for process industry applications that now come standard with an Ethernet port. Most fieldbus protocols now offer Ethernet-based versions of their protocol, thereby enabling ease of network management and connection to enterprise systems.

With all the networking options now facing the process industries, following are a few of the core facts you should be aware of when it comes to assessing your fieldbus and Ethernet options.

The **HART** (Highway Addressable Remote Transducer) protocol is considered by many to be the global standard

in the process industries for sending and receiving digital information across analog wires between smart devices and control or monitoring systems. HART is a bi-directional communication protocol that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety or other system using any control platform.

Originally intended as a replacement for the 4-20 mA standard, **Foundation Fieldbus** can be found in many heavy process applications such as refining, petrochemicals, and power generation. Today the protocol is increasingly used across batch processing industries, such as food and beverage and pharmaceuticals, due to its ability to store data related to the process and to the device for long periods of time, thereby supporting validation purposes and improved traceability.

Two forms of Foundation Fieldbus are available, each uses different physical media and communication speeds:

- H1 works at 31.25 kbit/s and generally connects to field devices. It provides communication and power over standard twisted-pair wiring. Conforming with IEC 61158-2 (as does Profibus, detailed below), power can be delivered over the bus to field instruments, while limiting current flows so that explosive conditions are not created.
- HSE (High-speed Ethernet) works at 100 Mbit/s and generally connects input/output subsystems, host systems, linking devices, gateways, and field devices using standard Ethernet cabling. It doesn't currently provide power over the cable, although work is under way to include this feature.

Another significant process industry fieldbus protocol is **Profibus PA** (process automation), which also operates at 31.25 kbits/s. This protocol is a standard for fieldbus communication in automation technology, first promoted by the German department of education and research (BMBF) and then adopted for use by Siemens. The protocol is commonly found in petrochemical, food/beverage, water and waste treatment plants.

Profinet is the open Industrial Ethernet standard from the Profibus/Profinet International group. Profinet uses TCP/IP and IT standards and operates at Ethernet speeds.

Batch process companies using a fieldbus protocol typically cite its use based on easier regulatory compliance because it is a digital network. As a result, documentation is more precise (e.g., it is time stamped). Foundation Fieldbus, for example, has an integral mechanism to measure data quality, communicating to users whether the data received from devices is good, bad, or of uncertain quality. **AW**

UNDERSTANDING THE DIFFERENCES AMONG INDUSTRIAL ETHERNET PROTOCOLS

DAVID GREENFIELD / Media and Events Director *Automation World*

The rapid adoption of Ethernet on the plant floor over the past decade underscores the need for more production information for better decision-making and the need to simplify networks for easier access and maintenance. But just as there have been “wars” between the varying fieldbus protocols over the years, a similar posturing over the capabilities of the different protocols persists in the Ethernet arena.

To help you make sense of the main differences between six of the major industrial Ethernet protocols, we turn a spotlight on CC-Link IE, EtherCAT, Ethernet/IP, Ethernet Powerlink, Profinet, and Sercos III.

CC-LINK IE

- CC-Link IE is gigabit speed industrial Ethernet.
- It is an inherently deterministic network that uses token passing as the mechanism to guarantee deterministic performance.
- No Ethernet switches are required in the basic topology.
- The protocol is based on ISO model IEEE.802.3 Ethernet at the physical layer.
- CC-Link IE protocol fits at the transport network layer. It is not a TCP/IP or UDP-based network. This is one of the reasons that it’s a separate protocol in order to guarantee deterministic operation out of the box.
- Frame format of the data is the Ethernet frame. Within the Ethernet frame is a CC-Link IE frame with header and data information.



- CC-Link EE works with Mitsubishi Electric’s MES Interface IT hardware appliance to move shop floor data to enterprise level and avoid the need for gateway PCs.

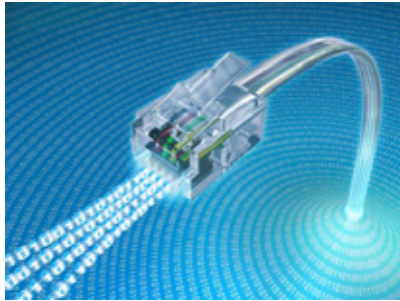
ETHERCAT

- The master does not require a special card to run EtherCAT, and each slave device or node on the network has an ASIC or FPGA chip inside that implements the entire protocol. The slave doesn’t need a micro-controller or random access memory, which means frames can be read and written as data goes through the network at a line speed of 100 Mb/s with no switches built in.
- EtherCAT’s fieldbus memory management unit uses logical addressing so that each slave device knows where to find its data in the frame, regardless of its physical location. One read-write cycle is capable of talking to all the devices without a great deal of CPU overhead on the controller side.
- EtherCAT supports multiple scan rates and multiple acyclic data exchange rates on the same network for use in multiple industrial automation processes including motion, I/O, condition monitoring, and data acquisition.
- There is no separate backplane and, therefore, no conversion needed from EtherCAT to another protocol to the I/O level. This is due to use of LVDS (low voltage differential signal) — a third physical layer in addition to CAT 5 and fiber used to pass the EtherCAT packets directly through all the I/O terminals so that each I/O terminal can be its own independent node on the network.
- EtherCAT can synchronize down to the nanosecond

level on a standard PC with no special fieldbus cards for timing.

ETHERNET/IP

- EtherNet/IP is a control network designed to address enterprise communication rather than focusing on segments across a machine or line.



This enterprise design reportedly allows for easy integration with other devices, as well as network traffic from other protocols and Web servers.

- Safety aspects are addressed through CIP (common industrial protocol) Safety, which allows safety devices to coexist with standard control devices on the same CIP network, with or without a safety PLC. In this environment, safety sensors can operate alongside variable speed drives, safety controllers with standard PLCs and proximity switches. Regardless of the combination of devices used, the integrity of the safety control loop cannot be affected by any of the standard control devices.
- CIP Motion addresses synchronization in motion. CIP Motion, as part of EtherNet/IP, combines the requirements of deterministic, real-time, closed loop motion control with standard, unmodified Ethernet, and complies with Ethernet standards, including IEEE 802.3 and TCP/IP. EtherNet/IP with CIP Motion technology enables multi-axis, distributed motion control through application profiles designed to allow position, speed and torque loops to be set within a drive.

ETHERNET POWERLINK

- Ethernet Powerlink is a broadcast-based system,

meaning that the network doesn't have to transmit the packet through every single station. When the system transmits back, every node transmits the packet back as a broadcast. This makes it possible to multiplex nodes, which means the node doesn't have to transmit its information back on every single scan, allowing for network optimization and high-speed synchronization.

- By using a slot protocol, where each node has a certain slot time on the network and passes data back to the master in a slot manner, this illuminates any collisions on the system. This gives Ethernet Powerlink fast and predictable cycle times and also allows for the removal and reconnection of nodes to the network without interrupting the cycle.

- Redundancy is built in for ease of network recovery whether using a ring, star or daisy chain topology. If any part of network is disconnected, the system will self recover and report back that the network has gone down.

- Ethernet Powerlink can be implemented via free download from Sourceforge.net. It's based on C, so it's transportable to controllers or PCs using a standard Ethernet port. With that in place, any system can be connected to a Powerlink network and control Powerlink nodes.

- The synchronization is around 100 nanoseconds with a guarantee of minimal jitter.

PROFINET

- Profinet uses standard, unmodified Ethernet media, but does not use TCP/IP to transmit real-time information. When real-time data is being sent, those two layers are skipped. Diagnostic information, however, is accessed over TCP/IP.

- Bumpless redundancy — meaning that each node sends its message out in both directions around the

ring (when using a ring topology) to ensure at least one message will always get through.

- In depth diagnostics are available from the I/O rack level down to a module in that rack.
- Profinet supports real time I/O for motion control as well as machine-to-machine, controller-to-controller or peer-to-peer types of communication.
- Profinet allows for integration of other buses (including Foundation Fieldbus, Interbus, ASI, HART, DeviceNet, and others) via proxies, allowing for maintenance of legacy nodes.
- ProfiEnergy is a vendor- and device-neutral data interface based on Profinet that permits a coordinated, centralized shutdown of devices during idle times. This means that individual components or entire subsections of a plant can be switched off automatically when not in use without the aid of external hardware.
- Since there is no explosion-proof industrial Ethernet, Profinet leverages Profibus PA (the process automation version of Profibus), which can be installed in such an atmosphere and then brought in through a proxy to Profinet.

SERCOS III

- The collective telegram approach underlying Sercos III means that each device places its input data on common answer telegrams. During the remaining time in the cycle, which for a typical application can be 80 percent or more of the available bandwidth, any standard Ethernet protocol can be transmitted over the network.
 - Bumpless, single fault redundancy means that Sercos III nodes are specified to detect broken links in less than 25 microseconds and immediately re-route telegrams back in a double line configuration.
 - No telegram data is destroyed in a communication cycle over Sercos, thereby allowing direct cross communication of data between slaves without the CPU burden or time delay that a re-transmission of data by a master would impose.
 - Sercos III can be integrated with EtherNet/IP, allowing integrators to mix Sercos III, EtherNet/IP and TCP/IP components within a single machine on a single cable. **AW**
- Sercos III uses a tightly controlled time synchronization signal emitted from a master control in the system once for every update cycle, providing nanosecond determinism across the network. The time base is a phase-lock loop for deterministic control, allowing for the synchronization of serially connected servo drives, CNCs, and motion controls.
 - Each message sent from the control contains a master sync telegram for hard real-time function. This also places fewer burdens on the host processors, freeing them up for tasks such as running control algorithms and machine programs.

WIRELESS TRENDS

DAVID GREENFIELD / Media and Events Director *Automation World*

The history of wireless networking in industry has largely been that of cable replacement. It was simply a tool to deliver communications in places where you simply couldn't run cable for a variety of reasons. Maybe it was too expensive. Or maybe the cable would be running in a hazardous zone. Through these types of applications, wireless secured a foothold in the process industries over the past two decades.

Now we are beginning to see a shift in the types of wireless technologies used, as well as different types of applications. This shift is coming from a user-needs perspective, rather than from pure technological capabilities.

According to the most recent survey from WINA (Wireless Industrial Networking Alliance), the biggest use of wireless technology today is for **asset management** and **condition monitoring**. Through the use of wireless sensors that can be positioned nearly anywhere on a piece of equipment, maintenance personnel can get a steady stream of data from that equipment about the state of its condition.

The other use of wireless technology, coming in a close second, is **incremental process measurements** — the classic measurements of

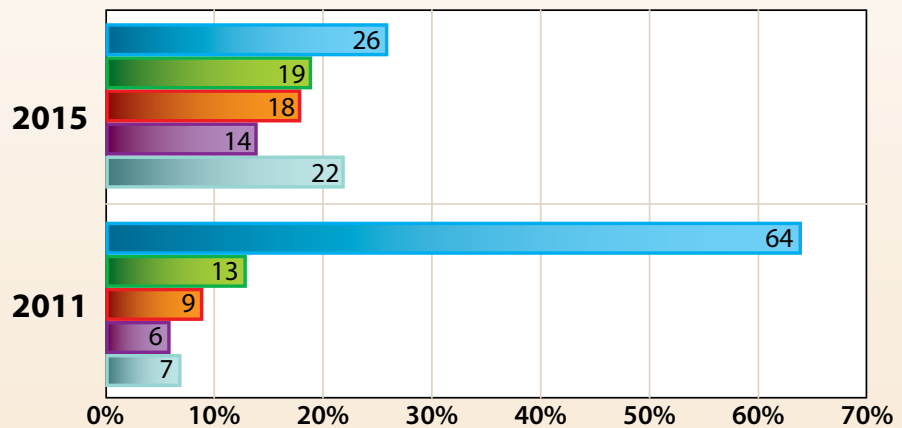
level, temperature, pressure, and flow. It's not difficult to think of many different places in, say, a refinery or water treatment facility, where it makes sense to get incremental temperature readings from segments of the process where you have not been able to collect that data before. Of course, this wouldn't make sense if you had to dig a 1,000-yard trench and stop part of the plant for a couple of weeks while you did that. But if you could easily put a wireless sensor in that part of the plant and do that very cost effectively, that's effective incremental process measurement. Such small steps can certainly help you improve your efficiency and, when examined from the aspect of a large process, like a refinery, there are huge overall efficiency numbers involved in the end result.

Wireless sensors are, perhaps, the biggest area

Rapid Pace of Wireless Adoption

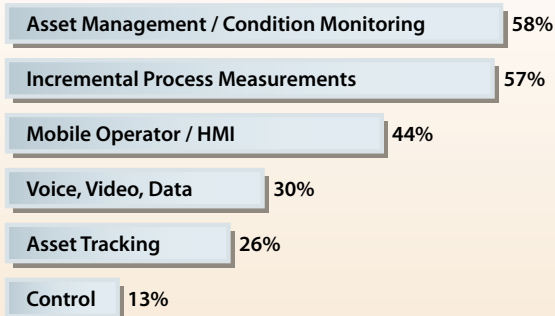
Currently (2011) and in the future (2015) what percent of your field devices do/will communicate using wireless technology?

<5% **10%** **15%** **20%** **>30%**



Source: WINA

Top Industry Applications For Wireless



Source: WINA Annual Survey of End Users - December 2011

for **substantial capital expenditure savings** in the process industries, especially when you think about the potential benefit of establishing pervasive sensor networks. When you literally start to put hundreds and thousands of devices out in the facility or a refinery, that's when you begin to see real cap-ex savings versus hard wiring. And this has already been documented. For example, using temperature sensors positioned directly on the roller can produce a small percentage of improvement in the surface finish of sheet steel by precisely achieving the proper manifold temperature; this small improvement in quality translates into millions of dollars in savings over the course of the process run.

The third most prevalent trend for wireless technology is supporting **mobile operators**. And it's easy to see why: Removing the step of having to connect via an Ethernet jack as measurements are taken at each stop is a big improvement in process.

Following mobile in the fourth and fifth spots are **voice/video data communications** and **asset tracking**. These types of wireless applications have been around for years and continue to be deployed due to their successful track record, so it's not surprising to see them among the top trends.

What is surprising is the application that came in at number six in the 2012 WINA survey — **control**. This is surprising because wireless control had never even ranked in the survey prior to this year. Now, however, 13 percent of survey respondents considered control to be their "top application" of wireless. In industries like mining, wireless pump control has been around for years, because there is no other way to really do it. But this result indicates that people across industry are beginning to experiment with closed-loop control using wireless. **AW**

WIRELESS SENSOR APPLICATIONS

DAVID GREENFIELD / Media and Events Director *Automation World*

If you're working in a facility without a great deal—or any—wireless sensors in place, you may be suspicious about the viability of wireless sensor networks. To help illustrate how ubiquitous wireless sensors have become across industry, following are a few examples of wireless sensor deployments that have become so common that they could be considered textbook application examples.

- **Wireless limit switch networks are commonly used to prevent the overflow of liquid storage tanks.** Their operation is simple: As the tank fills up, the fluid level forces a change in the position of the limit switch. The wireless limit switch then sends a signal to the pump controller to start pumping out the tank to lower the level. When the fluid level drops to a safe level, the switch then sends a signal to the controller to turn off the pump.

- **The safety and security of oil pipelines is largely handled by wireless sensor networks,** according to

Steve Totoda, vice president and general manager of the wireless business unit at Cooper Industries and chairman of the Wireless Industrial Networking Alliance (WINA). “We’re doing a lot of work in Mexico now to monitor and maintain oil pipelines,” he says. “In these applications, there is a hierarchy of networking tools with sensor networks being used with instrumentation on the pipeline itself to capture data and transmit it back to the control system via high-speed backhaul. This combination of technologies—wired, wireless

and cellular—has really brought wireless to the forefront because you’re mixing multiple technologies to monitor pipelines in 20-30 kilometer segments. As you do this with several segments, you’re effectively able to monitor hundreds of kilometers of pipelines.

- **A major pharmaceutical manufacturer recently decided to instrument all of its R&D equipment,** such as incubators and cryofreezers, and connect them to the company’s control systems for 24/7/365 monitoring. Because much of this equipment has casters, it was difficult to wire them, as they need to be moved around. This project is still ongoing, but there are currently nearly 2,000 pieces of equipment equipped with wireless sensors on the company’s R&D campus, which covers an area of about 1.5km. **AW**



WIRELESS PROTOCOLS FOR THE PROCESS INDUSTRIES

RENEE ROBBINS BASSETT / Managing Editor *Automation World*

Two similar wireless protocols—WirelessHART, promulgated by the HART Communication Foundation (www.hartcomm.org) and ISA 100.11a, promulgated by the International Society of Automation (www.isa.org)—are competing for dominance as the enabler of smart instrumentation in Europe and North America. Complicating the issue for end users is the fact that these two standards don't work together. In addition, a third standard, WIA-PA, exists in China and further complicates the task for those with Asian operations.



Most process facilities use a mix of wired networks along with their diverse array of instrumentation, but the inability to integrate the two main wireless standards makes that difficult in the wireless realm. Unlike with wired instrumentation, if you want to mix brands of wireless field devices to get an optimum mix of measurements, you can't. You have to have two separate host systems to talk to two different types of field devices. And they have to come from different vendors.

In many ways, WirelessHART and ISA 100.11a are alike. They are designed to serve the same market in the same way. At an application level, they perform the same function and have the same benefits. Both ISA 100.11a and WirelessHART implement IEEE 802.15.4 radio hardware. Both protocols use DDL and Device Description files. Both can eliminate a lot of PLC I/O hardware, wiring and associated schematics.

The principal difference between the two protocols is in the specification of the protocols' application layer. WirelessHART, for example, specifies HART as the application layer while ISA100.11a leaves

that layer undefined. This means that data in the application layer of ISA100.11a can be transferred using Foundation Fieldbus, Profibus, Modbus, HART or other protocols. While this makes ISA100.11a highly flexible, the customer must decide which protocol to use. WirelessHART's decision to specify only HART in the application layer was done to deliver simplicity via use of a single data communication specification through the network, meaning that data communication on the network is well-defined and understood.

Considering the potential for integrated use of the two wireless protocols, the obstacles preventing a convergence seem to be more commercial than technical. Though the two protocols are similar, investments have been made, vendors and early adopters are lined up on either side, and product certification processes have been established. The two protocols have been developed into products for sale. Marketing programs designed to win over additional customers and vendor partners are in high gear. Both sides believe their approach is "right" and others should come over to their way of thinking. **AW**