10 Steps to Better Foundation Fieldbus Installations

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Lessons learned from fieldbus users can help improve your systems, performance and personnel. Presented in three parts:

Part 1: How Wiring Mistakes Interfere with Communication
Part 2: Configuration and Addressing Makes All the Difference
How Wiring Mistakes Interfere With Communication
Part 1 of 3

Over years of visiting end user sites, talking to system integrators, and internal conversations with others within our own company, tribal knowledge begins to accumulate of what works, what doesn’t and what can be improved. When working in a Foundation fieldbus (FF) context, we find some user companies swear by the technology and won’t consider anything else, while others cannot claim such positive experiences.

When considering what differentiates enthusiastic users from those who gave up, many of the same top 10 points emerge. Some of these points are specific to Foundation fieldbus and others are more universal, so even if you aren’t a Foundation fieldbus user you might find some familiar topics addressed. Here are the Top 10, plus one:

Top Ten Fieldbus Issues Plus One
1. Wiring Practice Pitfalls
2. Terminators
3. Power Supplies
4. Stick with Tested and Registered Products
5. Incorrect DD/CFF Files
6. Using the Link Active Scheduler
7. Device Addressing
8. Choosing Between Publisher-Subscriber and Client-Server Communication
9. Traditional Project Management Techniques May Not Apply
10. Mismatch of Work Processes
11. Misunderstanding the Value Proposition

1. Wiring Practice Pitfalls
Good wiring practices apply to all sorts of field devices, but are particularly important with Foundation fieldbus because the digital communication running through the cables is sensitive to electrical noise. Terminations need to be executed properly and Foundation fieldbus cabling should be installed in appropriate cable trays or conduit just like any other field device wiring, so why is this a potential problem area?

Many companies have encountered issues with simple termination and routing rules. In one instance we found high-voltage cables in the same trays with cables from process sensors and actuators. As a result, individual field devices might fall off a segment for a while and then mysteriously reappear.

Basic troubleshooting may show a correlation between operating a specific piece of equipment, say a pump controlled by a variable frequency drive (VFD), and device segment drop-offs. If the cables to that VFD are too close to the Foundation fieldbus cables, electrical noise generated by the VFD can
disrupt the digital signal. Putting an oscilloscope on the segment can prove the point by showing the offending electrical noise and consequent distorted waveforms.

Other wiring pitfalls relate to device connections. Many field devices are insensitive to polarity, but others are not, and technicians need to pay particular attention.

Here’s a quick quiz: Most Foundation fieldbus cables are brown, blue, and green colored wire coverings. Which wire should be positive? The brown wire or the blue one? How is it connected at the H1 module or power isolator? Trying to figure it out by intuition is a good way to get into trouble. Perhaps you say to yourself: “Brown represents earth or ground and is therefore negative. That means blue is for the sky and positive.”

There is a certain logic to that idea but it’s wrong. With Foundation fieldbus, brown is positive and blue is negative, which provides a guide for hooking up transmitters, positioners and H1 interfaces. However, the key is consistency in which wire is connected to which pole.

Device manufacturers may not help much. Some terminal blocks are more clearly marked than others, and just because polarity is not obvious does not mean the device is not sensitive to polarity.

To complicate matters further, Foundation fieldbus cable has three conductors: blue, brown and a shield, often green or striped green. A given device may also have three terminals. Since a Foundation fieldbus cable provides power to the instrument, the normal assumption is that it must follow the same practice as normal power wiring. Standard 120 Vac power has a hot (usually black or some other color), neutral (white) and ground (green or conduit). Everything needs to be thoroughly grounded.

But Foundation fieldbus is first and foremost a communication medium so a different rule applies: signal wires shall not be grounded. Unfortunately, what sometimes happens is the installer sees three conductors and terminates three conductors. The result is noise on the segment. Hopefully, the installer will know to check the number of Fieldbus terminators (more on that later). If that count is correct, a look at the terminal block will show that the shield is screwed down at the wrong
termination. Shields should only be connected to a single point. Most installers now do this at the H1 host or power isolator interface end only.

2. Terminators
Since Foundation fieldbus is a bus system, terminators are placed at each end of the segment to avoid communication reflections which can add noise to the segment and therefore inhibit communication. Technicians typically expect that two terminators on a segment, one near the H1 card and one on the last device on the segment, solves the problem, but it doesn’t. There can be either too few or too many terminators on the segment, as sometimes one terminator can be too few and three too many.

Here’s what can happen: If the segment length is short, there is probably very little noise on the segment whether it has a terminator or not, and this situation may have existed in the field for years.

But the day comes when you need to add more devices, and you decide to use a short segment because there is plenty of room, which is perfectly sensible. You extend the trunk cable from one junction box/tee to another and increase the overall segment length. Now noise shows up where you didn’t have it before. Why?

The problem has to be solved through consistent use of terminators. The best approach isn’t always intuitive, and vendors may not be able to help as even something as simple as a terminator can vary from company to company.

Manufacturer X uses a jumper, manufacturer Y uses a switch and manufacturer Z has to be mounted in a junction box. Fortunately, this whole issue is becoming less of a problem as Foundation fieldbus ancillary product suppliers have offered more self-terminating junction boxes and power isolators. A wider range of devices is now available that avoids setting jumpers, selecting DIP switches or screwing down connectors in a termination device.

3. Power Supplies
Beware the temptation of using generic, non-Foundation fieldbus rated 24 Vdc bulk power supplies, as Foundation fieldbus devices have stringent power requirements.

The Foundation fieldbus specification allows for 9 to 32 Vdc power. Applying Ohm’s Law, voltage on a segment will dip slightly as each new device is added and consumes current, but that’s just milliamps and doesn’t affect the voltage all that much.
The voltage should still remain comfortably within the requirements, well above 9 V, but there is more to it. There are many factors affecting voltage drop along the segment, so power isolators from many vendors are designed to ensure that power is maintained in the 19 to 28 Vdc range with little variation regardless of the number of devices drawing current.

That opens a new set of questions: What capacity (amperage rating) power supply is needed? Should it be redundant? Should the power isolator be redundant? Must there be one power supply per segment, or is it appropriate to use a single large unit to power multiple segments? Again, there are no simple answers, but here are many guidelines for segment design to deal with voltage and current consumption in order to answer these questions.

Suppliers are helping as many power isolators now provide segment diagnostics that can be sent to the host or asset management systems. Some can even determine where noise is originating down to individual devices, simplifying troubleshooting.

4. Stick with Tested and Registered Products
The Fieldbus Foundation has instituted a series of testing processes and procedures for devices, host systems and ancillary products to ensure interoperability among products from different suppliers. These tests go through regular reviews and revisions to help users ensure products from different suppliers will work with each other and the host. Suppliers also do their own internal testing with different devices and hosts to minimize risk during product development and ensure interoperability.

While this sounds very sensible, it has not always been the case, and problems may surface when using older devices. In the early days of Foundation fieldbus technology, suppliers often found areas where the specifications had to be interpreted, and this caused some interoperability issues. Reviews and revisions over the years have eliminated most of these ambiguities. Foundation fieldbus ancillary products like power isolators, junction boxes, cables and terminators are also tested with the same test criteria and registered at the Foundation.
5. Incorrect DD/CFF Files
Let's say you have a malfunctioning pressure sensor and you decide to replace it with an older unit from your inventory. Unfortunately, you discover that it has an older device description (DD) or Capabilities File, aka Common File Format (CFF) file. (The Device Descriptor (DD) File allows operation of devices from different suppliers on the same fieldbus with single host system. The Common File Format (CFF) is an ASCII file which describes the functions and capabilities of a field device. The CFF file is used in conjunction with the Device Descriptor file to enable a host system to configure the system off-line.) Conversely, you may want to replace an older unit with a newer model with a new DD of CFF file. Either scenario can cause you problems, because if the files are different in the host system and the device, then the device will not commission or communicate.

Fortunately, this legacy problem is being addressed and hopefully disappearing. Suppliers are tackling this issue by reading DD/CFF files from devices connected to the host, and self selecting the correct files for the device during commissioning, allowing for more plug-and-play functionality.

This means that when the device is added to a segment, the host automatically reads and performs some configurations to itself and/or the device to communicate correctly. In some cases, the host can self-generate a CFF by reading it from the device.

DD revision management is another issue addressed by automatically reading DD information from each device and keeping this information current on the host control system or asset management system. This functionality is often supported by the supplier via a software upgrade, but in the meantime it may require manual effort.

6. Using the backup Link Active Scheduler
The backup Link Active Scheduler (LAS) is one of the unique capabilities of Foundation fieldbus, but it isn’t used as widely as one might expect. It manages data traffic control to achieve scheduled communication on the segment, and it can keep the segment working even when the host system has failed.
LAS functionality can reside in any one of the devices on a segment with link master capability. The scheduled communication cycle to run all the function blocks in all the devices on the segment is known as the macrocycle of the segment, which is the base time (0.5, 1 and 2 seconds are used most commonly) for scheduled communication.

As the number of devices and function blocks to be executed on the segment grows, so will the minimum macrocycle time. The time left over after deterministic communication is made available for responding to other types of requests for information from FF devices, such as diagnostic information or other messages.

Generally, the host system H1 module is automatically configured as the primary LAS. There may be a redundant module in the system that serves as the backup LAS, which works well when LAS redundancy on the H1 I/O modules is desirable.

But what is the actual requirement for configuring a backup LAS? If it’s desirable that the segment should keep running despite loss of communication from the host system, then the LAS function needs to be resident in one of the devices on the segment.

In some implementations, host redundancy is all that is necessary, as depending upon the configuration of the power and power isolator, a loss of an H1 I/O card will result in a loss of the host’s view of the process, rendering LAS redundancy via a device irrelevant.

Another requirement is power redundancy for a bulk power supply and power isolators. If power to the entire segment is lost, then the location of the LAS function doesn't matter. However, if the configuration is such that the backup LAS can function without the main power supply because it has its own backup source of power, then that device needs LAS capabilities. Some vendors offer LAS capability within a device for an extra cost, so it’s important to only specify this feature as needed.

Rules for backup LAS in the Foundation fieldbus specification call for the lowest address on the segment to claim LAS first. Upon failure of that device, the next lowest address takes over, and so on. Thus, most implementations make the host redundant H1 module the lowest address on the segment.

But is a third backup configured in a device in addition to the host backup? In practice this is rarely done, either due to an unwillingness to buy such functionality in the device, or by not activating and providing a suitable address when putting the device on the segment. This is often a simple feature to implement and it ensures execution of devices on a segment without the host, and should thus be configured where applicable. Also if control functionality is being run in a host system, then running a backup LAS in field device is useless.

7. Device Addressing

Are all the addresses for devices on a segment in the range that the system is scanning? Some systems scan a finite range in the link-master address range from 20-32 (0x14-0x20), and then at the basic address range 232-248 (0xE8 - 0xF7). This is done to increase performance for sink/source event reporting, and for on-demand communication of parameters to entities such as asset
management systems. Knowing this simple fact can reduce the agony of finding why some devices don’t appear on the live-list, which is the list of devices replying to the host’s request as being on the segment.

Many devices come from the factory with a default address. A technician may install the device on the segment without checking the address, and then have to figure out why it doesn't show up on the live-list.

He or she often assumes the device is inoperative and uses a bench tool, such laptop with Foundation fieldbus interface card or handheld communicator, to scan the segment. Suddenly the supposedly inoperative device shows up because that tool scans the entire range. Hopefully that causes the light bulb to go on, prompting the technician to check the scan range of the host.

8. Choosing Between Publisher-Subscriber and Client-Server Communication
Foundation fieldbus supports publisher-subscriber and client-server communication. Some devices have multiple variables available, and should use publisher-subscriber for the primary variable and client-server for any other information. This is done to reduce scheduled communication time for the segment since the other information may only be needed upon request and not need to be executed every macrocycle.

Host systems should generally be configured to access all the variables required for real-time control and display via publisher-subscriber to guarantee update time. Additional data and diagnostic information can then be accessed via client-server on an as-needed basis.
9. Traditional Project Management Techniques May Not Apply

More often than not, end users, system integrators and engineering contractors want to apply traditional project management techniques to a Foundation fieldbus project, which is not always the best course of action.

Foundation fieldbus is a device network with some general similarities to control or IT networks. A device has a network address and a unique physical address called a device ID. This is similar in concept to a PC which has a TCP/IP address and a MAC address. Multiple devices then communicate on the same pair of wires on the segment, just like multiple PCs on an IT network.

Thus, analysis needs to be done to determine how many devices of each type should go on a particular segment. Many end users have their own guidelines for this analysis.

For example, loops that include a critical function shall have only one valve positioner and shall restrict the number of other devices on that segment in case of a loss of a segment. Category-two segments may allow two valve positions and four to eight devices. Another category description may allow some number of measurement devices and no actuating devices.

This kind of analysis and up-front engineering effort rarely happens in traditional 4-20 mA or HART projects where devices are not shared on the wire in the same manner. But when working with Foundation fieldbus, segment design and topology is a critical path in project management.

Often when going out for bids on a project, there is no functional design specification that covers the design, specification, installation, configuration, commissioning and maintenance for the Foundation fieldbus-based process control system and instrumentation. The vendor has little more than a count of various types of instruments and is left to estimate segment designs. Working in this informational vacuum, the vendor may resort to rules-of-thumb to determine the number of segments needed.
This dictates the number of Foundation fieldbus H1 interface modules, which, in turn, translates into the number of I/O nodes and possibly controllers. When the detailed design for the project is finally performed, the participants may be dismayed to find that many more segments are needed. Discussions follow over change orders to add modules, I/O racks and controllers with associated expenses and finger-pointing.

Other related specification items include wiring schemes, selection of Foundation fieldbus-related ancillary products such as junction boxes, power supplies and terminators, segment design for voltage and current consumption, selection of FF cables, shielding and grounding practices.

Another common complicating factor is not choosing devices early enough in the project. Implementing control strategy depends on having correct function blocks in field devices. These need to be part of the instrument specification sheets so device vendors can provide transmitters with proper functionality.

Once the project is in the works, there can be more stumbling blocks. FAT (factory acceptance test) and SAT (site acceptance test) practices for FF projects are different than traditional device installations. In a Foundation fieldbus project there is limited testing during FAT, but all devices are tested during SAT. Sufficient consideration should be given to define FAT and SAT specifications to reduce risks during start up and commissioning phases.

10. Mismatch of Work Processes
In a Foundation fieldbus environment, work practices have to be different than with traditional analog and HART installations. Foundation fieldbus is a network with its own tools for implementing, diagnosing and operating the system. Companies adopting Foundation fieldbus for the first time routinely underestimate the change in skill set and knowledge required at the technician level for the Foundation fieldbus network. On the other hand, most of the engineering personnel and technicians who have studied the technology and attended FF seminars and vendor presentations get comfortable and gain proficiency quickly.

In the real world, too often technicians have Foundation fieldbus thrust upon them and are left to flounder and learn through trial and error. The result is a haphazard installation that performs poorly. Without adequate training, technicians can become frustrated and even fearful of the technology.

Part of that training is simply getting the right tools. Instead of a multi-meter to troubleshoot conventional instruments, technicians need segment monitors, oscilloscopes or other diagnostic tools to perform similar functions with FF transmitters. Diagnostics and troubleshooting are done through computer terminals with FF-specific software and asset management systems, instead of by clipping lead wires to terminal on field device.

A training program has to match knowledge and responsibility. Engineers that have been only trained to design segments will have a hard time training maintenance technicians to troubleshoot segments. Those tasks require much different skill sets and should be considered separately.
11. Misunderstanding the Value Proposition

This point is a bonus, and while it isn’t a technical issue, it can still cause problems. Your management may simply not understand the value of Foundation fieldbus, which can lead to poor investment decisions.

The right individuals might have been convinced enough to launch a program, but can’t pinpoint where the saving is actually achieved. That isn’t entirely their fault because there have been mixed messages over the years.

In the early days, Foundation fieldbus was touted as a way to reduce design and wiring along with their documentation and associated costs. Those savings were real, but additional training and device costs for Foundation fieldbus transmitters compared to 4-20 mA or HART, and requirements for additional expertise, largely offsets these gains. Dollar for dollar, Foundation fieldbus is a wash if only wiring and design savings are considered.

So what has been the driving force that has kept Foundation fieldbus viable? Many have found the greatest value in the diagnostic communication from the devices to the host. Instead of maintenance activities following a schedule or broad-brush directives like refitting all valves during a turn around, Foundation fieldbus diagnostics can make maintenance predictive by using condition-based diagnostics to help schedule and determine what devices need attention and which are OK. Foundation fieldbus is thus an enabling technology for asset management, adding value at a completely different level.

Companies that deploy sophisticated asset management programs often find the biggest bang-for-the-buck comes from more intelligent scheduling of valve maintenance. An FF valve positioner can gather and report extensive diagnostic information including but not limited to time near close, number of strokes and time open.

Self-diagnostic functions can detect deteriorating conditions and report problems before failure while there is still time to correct the situation. Field devices can issue messages through asset management systems and to the control systems to alert (not alarm) users of impending conditions.

Who then is the main beneficiary of this new condition-based diagnostic approach? With many companies, it’s the maintenance department. But who specified Foundation fieldbus for the unit? In many instances it was the engineering group. So, these two groups must come together to realize and properly account for all Foundation fieldbus benefits.

Maintenance is responsible to some extent for uptime, which should increase with Foundation fieldbus through higher plant availability and reliability, but only if maintenance works with engineering and operations to monitor and determine device and segment health. All these people and departments are interrelated and must work together for the greater good of the plant. Much depends on designing and implementing new work processes to maximize the benefit offered by Foundation fieldbus technology.
Going Forward
Foundation fieldbus technology has come a long way by learning from practical implementations. End user trials and tribulations contributed to overall knowledge, and these users provided input to vendors for improving products. Discoveries that added to users’ procedures and practices were shared in order to gain benefits.

Looking over the list again, one can see many of these issues involve noise on the segment, how that causes communication problems, and how to determine its origin. Other issues involve compatibility between devices and host software. And of course, people and processes always figure into the picture.

What’s on your top-ten list of potential FF issues?