

# Preventing Fieldbus Physical Layer Problems

## 1 Introduction

Foundation Fieldbus is highly reliable when correctly installed and maintained. The key is in knowing what must be done to start with and to maintain a reliable fieldbus network.

The purpose of this application note is to:

- ◆ Briefly describe the physical layer
- ◆ Identify common fieldbus physical layer problems
- ◆ Discuss the causes of the problems
- ◆ Present methods for preventing fieldbus physical layer problems

For a basic introduction to Foundation Fieldbus, see the Fieldbus Wiring Guide, available for viewing or download at [www.relcominc.com](http://www.relcominc.com).

For help with diagnosing problems with a Foundation Fieldbus network, see the Fieldbus Physical Layer Troubleshooting Guide, also available at [www.relcominc.com](http://www.relcominc.com).

## 2 The Physical Layer

The physical layer is what connects all the devices on a fieldbus segment together. It provides DC power to the devices and allows them to communicate with each other. The physical layer consists of four parts: cable, wiring blocks, terminators, and a power supply. Figure 1 shows a typical fieldbus segment including all parts of the physical layer.

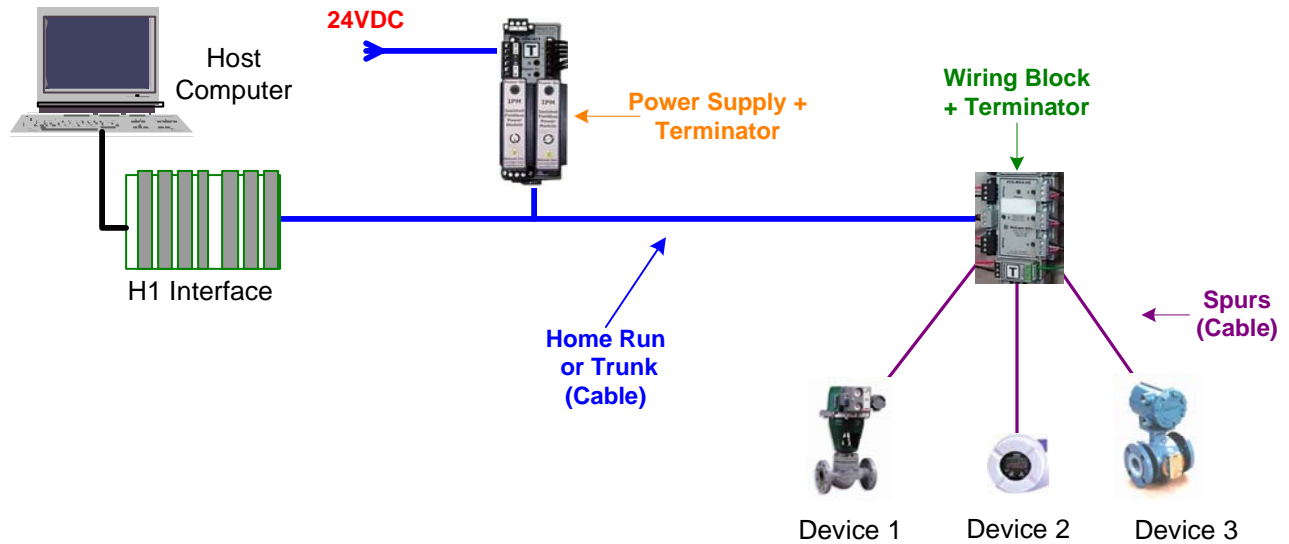


Figure 1

The cable is typically Type A 18 AWG twisted shielded pair.

Wiring blocks come in many forms, but all of them allow connection of one or more devices to the fieldbus cable. Many include short circuit protection that prevents the entire fieldbus segment from failing in the event of a short in one device or in a spur cable.

Two terminators are installed at the furthest ends of the trunk cable to provide the proper impedance for fieldbus signaling.

The fieldbus power supply provides DC power to the fieldbus and incorporates a power conditioner that prevents the fieldbus digital signal from being absorbed by the DC power supply. It is common for one terminator to be built-in to the fieldbus power supply.

### **3 Common Physical Layer Problems**

Relcom and MTL have visited and helped to troubleshoot fieldbus physical layer problems for many years. Some problems clearly stand out as common. The most common problems include:

- Missing or extra terminators
- Improper grounding of the cable shield
- Water/condensation in cables, junction boxes, devices, splices, etc.
- Un-isolated fieldbus segments
- Connectors not securely plugged in
- Loose wires
- Damaged cable or wires
- Stray wire strands at wire terminations
- Screw terminals and hold-down screws inadequately tightened down

### **4 Causes of Physical Layer Problems**

After analyzing the list of common fieldbus physical layer problems, it is easy to blame installers and Mother Nature. However, the root causes are deeper than that.

- Inadequate training
- Inadequate supervision
- Inadequate tools
- Inadequate monitoring

### **5 Preventing Physical Layer Problems**

These problems can be drastically reduced. The steps to minimize these problems seem expensive at first glance. However, troubleshooting just one physical layer problem can take days or weeks resulting in large amounts of overtime, plant down time, ruined product, and lost sales. Fieldbus installations that are correct from the start save money. Monitoring the health of the fieldbus segments and proper maintenance techniques save even more.

## **5.1 Training**

Training is not just critical, it is essential. Proper training prior to installation is the foundation for a fieldbus that is trouble-free for years.

Start with the engineers designing the fieldbus. Train the fieldbus segment designers on proper segment architecture and design, including how many terminators are installed on each segment, where the terminators are installed, how long the fieldbus segment and spurs can be, the need for isolated fieldbus power supplies, and proper shield grounding.

Installers and supervisors must know how to use the tools necessary for installation, where to route cables, how to mount wiring blocks, how to properly terminate cables at the power supply, wiring blocks, and devices.

Supervisors must be instructed on how to inspect the cabling and connections. They must know how to identify common physical layer problems.

## **5.2 Supervision**

Supervision starts in the design stage. Conduct a review of the fieldbus network design by knowledgeable people. These people may be co-workers or an outside contractor.

Before segment installation starts, supervisors must ensure that people working on the project are properly trained and have the right tools to do the job.

People that supervise fieldbus installations must either inspect the installation themselves or ensure that a thorough inspection is made by a knowledgeable person. The inspector must be properly trained as mentioned above and walk the cable runs to check for problems. They must pull on wires and cables to verify they are tight, look for damaged cabling and connectors, confirm the shield is properly grounded, and verify LEDs are appropriately lit on the wiring blocks and fieldbus power supply.

Following installation, supervisors should establish a program to monitor the fieldbus segments and make sure the monitoring is carried out.

### 5.3 Monitoring

One of the strengths of Foundation Fieldbus is the diagnostic capability available to help identify and diagnose problems. In many cases, identifying early symptoms can prevent plant down time. That is why regular monitoring is part of the routine at plants that want to maximize profitability.

Some fieldbus power supplies, such as the F800 series of power supplies from MTL/Relcom, provide plug-in fieldbus physical layer diagnostic modules. The F809F diagnostic module plugs into the power supply carrier and constantly monitors the segments connected to the power supply. Alarms can be setup to activate when the module discovers a measurement that is out of the desired range. The F809F measurements can be reviewed to identify the cause of the alarm so that it can be corrected.

Another approach is to use portable diagnostic equipment, such as the FBT-6 Fieldbus Monitor, to measure critical network parameters. A set of data is collected when the segment is operating correctly as a baseline report. The report is transferred to a PC for storage or printing. The FBT-6 can be used every 6 months or so to generate another report to compare with the baseline report and look for changes that indicate trouble. If a problem is suspected, the FBT-6 can be used as a troubleshooting tool to help isolate and eliminate the cause of the problem.

### 5.4 Tools

When installers and maintenance personnel do not have the proper tools to do a job, they often come up with creative ways to get it done. However, make-shift tools and methods often result in problems later.

Many tools are available to help determine the health of a fieldbus and ensure proper installation. Here is a list of the more important ones.

#### 5.4.1 Digital Multimeter (DMM)

A good DMM can take resistance, voltage, and current measurements. Measurements of bus voltage and shield resistance to ground (continuity) can be taken any time. Resistance between wires and shield can only be measured when the network is without power, such as when the segment is initially setup or down for maintenance.



#### 5.4.2 Wire Stripper

Good wire strippers help avoid cutting strands in wire for a stronger, more reliable connection. They also help avoid excessive wire stripping by cutting to a fixed length. This reduces the possibility of shorts and wire corrosion.





### 5.4.3 Ferrules and Crimper

Ferrules are metal sheaths with a plastic protector that are squeezed onto stripped wires with a crimper tool. Ferrules form a reliable electrical connection. They also protect wires by reducing breakage due to vibration, bending and stress and prevent stray wire strands that cause cable shorts.



### 5.4.4 Torque Screwdriver

To make sure screw terminals are adequately tightened, use a torque screwdriver. The amount of force that should be applied to the screw terminals surprises most people. Without a torque screw driver, screw terminals are often under- or over-torqued. Relcom products use screw terminals that should be tightened to 5 inch-pounds (in-lbs) of torque. The Wiha TorqueFix 28503 screwdriver and replaceable 28537 3.0mm slotted blade is an example. Torque screwdrivers are expensive (~\$85) but much cheaper than plant down-time.



### 5.4.5 FBT-3 Fieldbus Monitor

The FBT-3 is a hand-held electronic device specifically made to help determine the health of fieldbus segments and troubleshoot segments with problems. The bus powered FBT-3 passively listens to the device communications when connected to the fieldbus. It measures bus voltage, noise, and indicates the lowest device signal level detected as well as the signal level of the Link Active Scheduler (LAS). It also indicates when devices are added or removed from a network, indicates the number of devices on the segment, and more.

### 5.4.6 FBT-6 Fieldbus Monitor

The FBT-6 is the follow-on to the FBT-3. It is hand-held, measures bus voltage, noise, the number of devices on the segment, and indicates when devices are added or removed from a network like the FBT-3. The noise measurement is split into 3 bands: the fieldbus frequency band, below it and above it. In addition, it counts retransmissions to devices, checks for the presence of shield shorts to the (+) or (-) fieldbus wire, specifies the address and signal level of each device, and identifies which device is the Link Active Scheduler (LAS). The data collected from a segment can be saved in memory and then downloaded to a PC via a USB port.

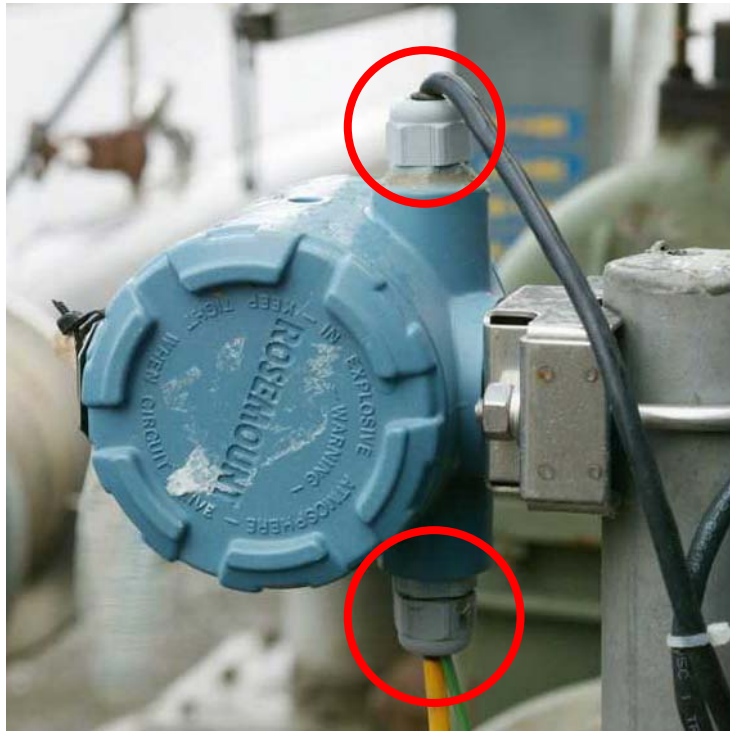


### 5.4.7 FBT-5 Fieldbus Wiring Validator

Fieldbus wiring can be tested using the FBT-5 Wiring Validator. It puts a DC voltage and Fieldbus signals on the wire pair. A Fieldbus Monitor, FBT-6 or FBT-3, is used to test the voltage, signal levels and noise on the wiring. These tests can be performed on existing instrumentation wiring, newly installed fieldbus cable or a fieldbus wiring system with wiring blocks and terminators already installed. The FBT-5 is not for use on operating segments and cannot power a segment with Fieldbus devices.

## 6 Examples

This section provides pictures of common fieldbus problems encountered in the field.



This picture illustrates 3 problems.

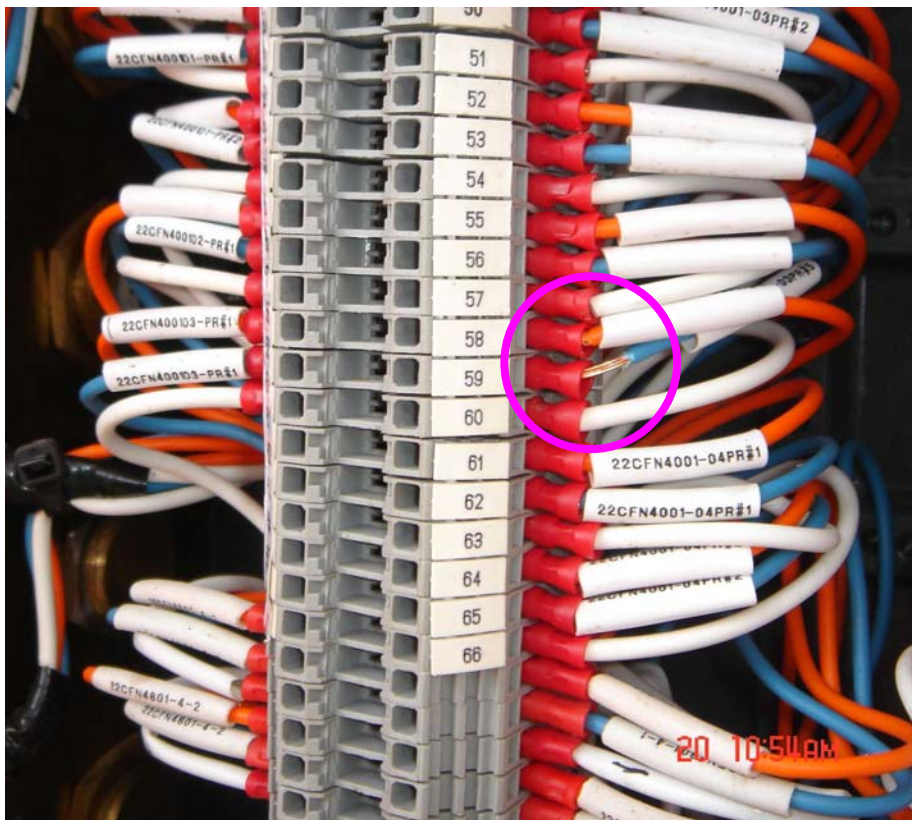
1. The cable exiting the gland at the top of the device is exceeding its bend radius.
2. The cable exiting the gland at the top of the device is pointed straight up toward the sky. Eventually, water will get in.
3. The cable gland at the bottom of the device has a cable and a ground wire exiting it. Cable glands will not form a proper seal with more than one cable going through them.



The cable jacket has been stripped and the individual wires put through the cable gland. Water is likely to enter both the cable and the device.



Water ingress into a fieldbus device has corroded the wires and contacts, likely causing the wiring to short out or the device to fail.



This is a very nice looking wiring strip installation. Cables are labeled and color-coded. The terminals are numbered. However, the wires were not properly crimped into the ferrules and they easily pulled out.

## 7 Avoiding Physical Layer Problems

Prevention is the key to a reliable fieldbus network: proper training, tools, and supervision during installation and maintenance. Use quality cable and certified products from reputable companies. Save a set of data as a baseline when the fieldbus is operating properly. Perform regular segment checks, comparing current data with baseline data to look for significant changes. When problems are encountered take a new set of data and compare it to the baseline.

## 8 Glossary

Drop	A cable between the trunk cable and a fieldbus device. Also called a “Spur”
Fieldbus Power Supply	The device providing isolated and conditioned power to a fieldbus segment.
Home Run	The main cable between the control room and a junction box in the field. Also called “Trunk”.
Link Active Scheduler (LAS)	A device that tells other devices on the network when they are allowed to transmit.
Power Conditioner	The filter between a power supply and fieldbus wiring.
Segment	A fieldbus network that is separately powered and has its own terminators.
Spur	A cable between the trunk cable and a fieldbus device. Also called a “Drop”
Terminator	A device on a segment that shapes the transmitted signals and prevents signal distortion.
Trunk	The main cable between the control room and a junction box in the field. Also called “Home Run”.
Wiring Block	A device attached to the trunk cable to provide connections for multiple devices. Wiring blocks often provide short-circuit protection for each device also.