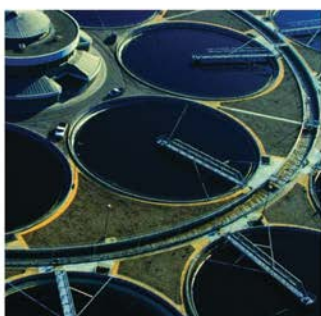


FOUNDATION Fieldbus Design Considerations

Catalog Numbers 1788-EN2FFR, 1788-CN2FFR, 1788-FBIB4R, 1788-FBIB6



Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.



WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.



ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

IMPORT-

Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.



SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.



BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.



ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

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The design of a FOUNDATION Fieldbus network is multifaceted with multiple design options that provide reliable communication to each field device. This document provides design choices and best practices for implementing a FOUNDATION Fieldbus network with the 1788-EN2FFR or 1788-CN2FFR linking devices. This document assumes that you have experience with Foundation Fieldbus networks.

Basic Function Blocks

Function blocks make it possible to build a control loop by using fieldbus devices. Create interoperation between function blocks by linking an output parameter of one function block to an input parameter of another. Function blocks can be linked together within and across field devices.

[Table 1](#) describes the three primary block types.

Table 1 - Block Descriptions

Object	Description
Resource block	<p>The resource block is the base block needed in all transmitters; only one is defined for each fieldbus device. It holds data specific to the device, such as the name, manufacturer, and serial number.</p> <p>A resource block contains an algorithm that is used to control and monitor the overall health and operational status of the device hardware. The algorithm also can generate events. You can change parameters but you cannot modify the block because its data is contained (no links to this block).</p>
Transducer block	<p>Transducer blocks provide the interface between function blocks and the physical sensors and actuators. The transducer block also provides for running calibration and diagnostics for field devices.</p> <p>MODE_BLK and TERMINAL_NUMBER are parameters within the transducer block. Putting the MODE_BLK to AUTO allows the function block to be active upon download.</p> <p>TERMINAL_NUMBER reflects the physical wiring on a transmitter. Some transmitters have multiple inputs or outputs, so the parameter links the function block to the actual physical wires that have been placed on that terminal.</p>
Function block	<p>A function block represents the basic automation functions performed by the function block application. Each function block processes input parameters according to a specified algorithm and an internal set of control parameters. They produce output parameters that are available to use within the same function block application or by other function block applications.</p> <p>Typical function blocks include the following:</p> <ul style="list-style-type: none"> • Analog Input Block (AI) • Analog Output Block (AO) • Digital Input Block (DI) • Digital Output Block (DO)

Visualize Fieldbus Instrument Data

Use the Add-On Instructions with pre-designed, instrument-specific faceplates for a visual representation of field device data.

IMPORT- For specific Add-On Instruction procedures and faceplates, see the Knowledgebase Answer ID 54857 at <http://www.rockwellautomation.custhelp.com>. You must have a Rockwell Automation TechConnectSM contract for Process to access Foundation Fieldbus faceplates.

Additional Resources

These documents contain additional information concerning products from Rockwell Automation.

Resource	Description
EtherNet/IP and ControlNet to FOUNDATION Fieldbus Linking Devices User Manual, publication 1788-UM057	Installation and operation of the 1788-EN2FFR and 1788-CN2FFR linking devices.
Redundant ControlNet to FOUNDATION Fieldbus Linking Device Quick Start, publication 1788-QS007	Installation procedures for the 1788-CN2FFR linking device to communicate over ControlNet media to the FOUNDATION Fieldbus H1 segment.
Redundant EtherNet/IP to FOUNDATION Fieldbus Linking Device Quick Start, publication 1788-QS006	Installation procedures for the 1788-EN2FFR linking device to bridge an EtherNet/IP network to the FOUNDATION Fieldbus H1 network.
PlantPAx Process Automation System Reference Manual, publication PROCES-RM001	Implementation recommendations for PlantPAx TM process automation systems.
ControlNet Modules in Logix5000 Control Systems, publication CNET-UM001	Information on how ControlNet devices communicate on the ControlNet network.
EtherNet/IP Modules in Logix5000 Control Systems, publication ENET-UM001	Information on how EtherNet/IP devices communicate on the EtherNet/IP network.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	General guidelines for installing a Rockwell Automation® industrial system.
Product Certifications website http://www.ab.com	Declarations of conformity, certificates, and other certification details.

You can view or download publications at <http://www.rockwellautomation.com/literature>. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

These FOUNDATION Fieldbus documents contain information that can be helpful as you read this manual:

- System Engineering Guidelines, publication [AG-181](#)
- Wiring and Installation 31.25 kbit/s, Voltage Mode, Wire Medium Application Guide, publication [AG-140](#)

For more information, go to <https://www.fieldcommgroup.org/>

FOUNDATION Fieldbus Linking Devices

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The 1788-EN2FFR and 1788-CN2FFR linking devices differ from standard FOUNDATION Fieldbus devices:

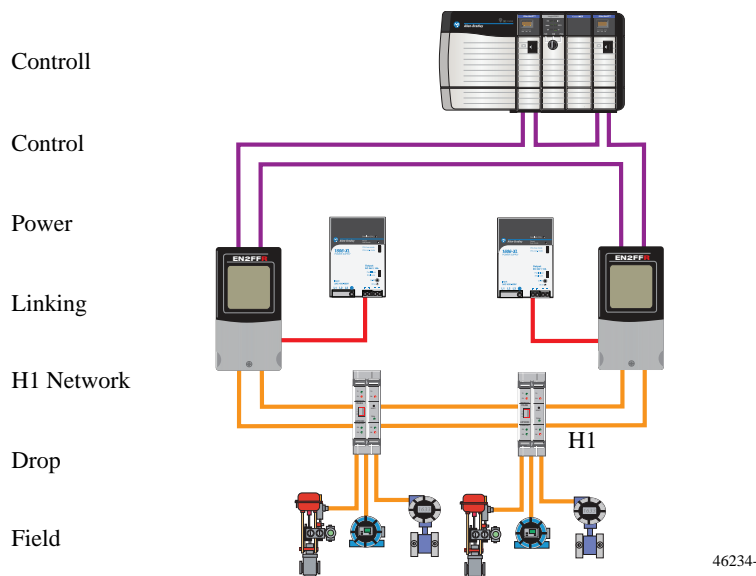
- The linking devices do not include the High-speed Ethernet (HSE) layer, but instead link the FOUNDATION Fieldbus H1 layer directly to the EtherNet/IP or ControlNet network, respectively.
- The power conditioning functionality is built into the linking devices.
- External power for the network is supplied by a standard 24V DC power supply.

The linking devices split the H1 segment connection between two physical ports. Although these two ports form part of the same logical segment, they need to be considered separate when designing the physical network. Each port can supply 500 mA at the supply voltage (24...32V DC) and have individual over current trips and termination.

From the perspective of macrocycle timing and inter-device communication (Control in the Field), the two ports are part of the same segment.

This two-port architecture supports dual H1 media redundancy options, as well as split and ring H1 network topologies.

Figure 1 - Two-port Architecture



The PlantPAx system provides a single plant-wide control and information platform while the FOUNDATION Fieldbus protocol lets H1 process instruments communicate with the controller via EtherNet/IP or ControlNet network linking devices. Illustrations and examples aid system design choices, including high availability offerings by using redundant linking devices and H1 networks.

Control in the Field

Control in the Field (CIF) enables the input, control algorithm, and output to be processed at the instrument level. PID blocks in the field devices replace PID functions in the controller, which enables plant control to continue after a break in communication with the controller. However, with loss of communication with the controller, you also lose visibility into the process and the ability to perform a controlled shut down.

Implementing CIF requires that the input device, PID block, and output device all be on the same H1 segment. The transfer of data between devices increases the macrocycle time so choosing the PID block in the output device (for example the valve positioner) can make the cycle more efficient.

Although the CIF ability to provide distributed control does provide a solution when losing connectivity between the controller and the linking device, it does not overcome breaks in the H1 network or the loss of connectivity between the linking device and the field devices. Employ redundant strategies to mitigate these risks.

Additional attention needs to be given to which PID block is chosen as not all PID blocks are the same. Carefully study the processing capability of the micro-processor in the field device and characteristics of the block described in the devices specification.

CIF provides higher process control performance by providing a faster reaction to disturbances, which is achieved by eliminating the need to transfer data to and from the controller via the linking device.

Macrocycle

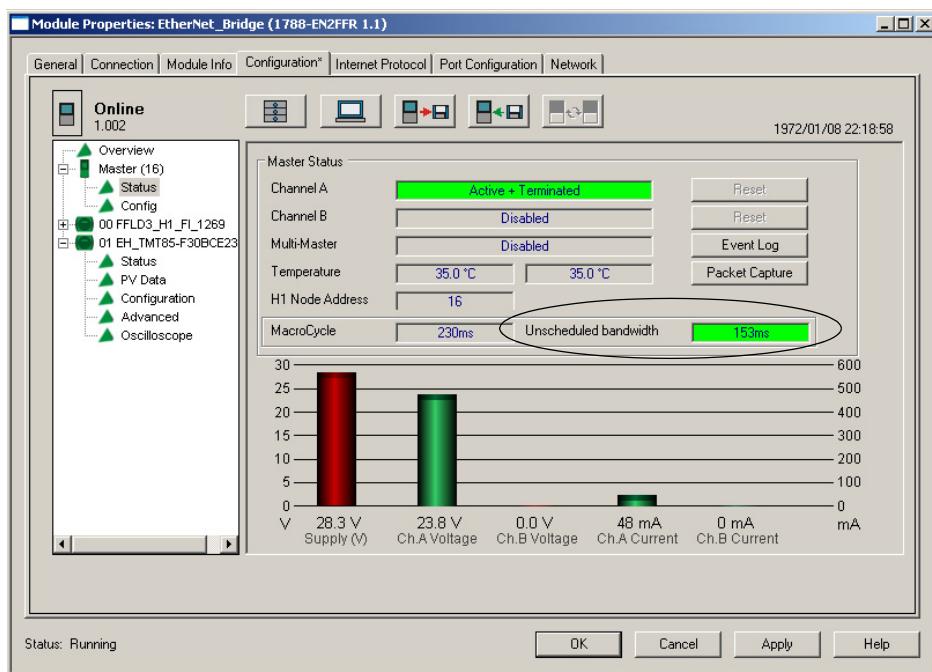
The linking devices act as the link master and controls the link active schedule (LAS). The linking device automatically calculates the schedule after the field devices are configured. The schedule accounts for data subscriber requirements and block execution times.

The macrocycle time is the period after which the schedule repeats itself. This value can be set manually or the least possible period can be calculated automatically.

The following factors increase the macrocycle time:

- Number of field devices on the segment
- Number of process variables from each device
- Number of blocks executed in each device
- Bandwidth allowed for unscheduled communication

Unscheduled bandwidth is any time the bus is **not** transferring scheduled communication. The unscheduled bandwidth for each scan is calculated by the linking device and can be observed in the AOP master status view (as shown in the graphic).



1788-EN2FFR or 1788-CN2FFR Linking Device

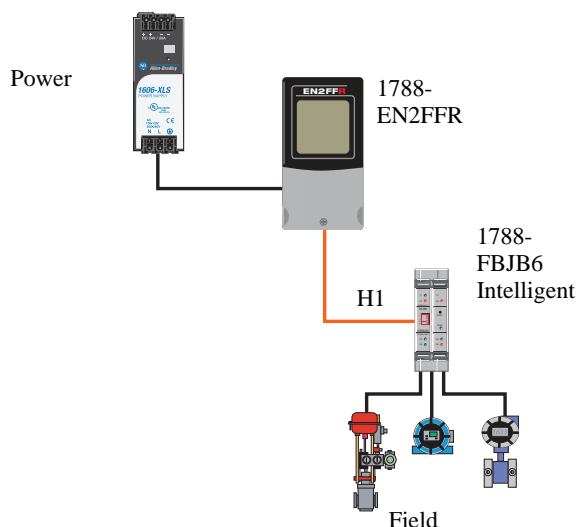
The choice of your Allen-Bradley® linking device depends on your network requirements:

- The 1788-EN2FFR linking device bridges an EtherNet/IP network to a FOUNDATION Fieldbus H1 device network.
- The 1788-CN2FFR linking device for the ControlNet network allows systems with ControlNet media to communicate with FOUNDATION Fieldbus H1 process instrumentation.

Power Supply and Built-in Conditioners

Typical FOUNDATION Fieldbus segments require a FOUNDATION Fieldbus power supply or a standard power supply with a FOUNDATION Fieldbus conditioner.

The Rockwell Automation 1788-EN2FFR and 1788-CN2FFR linking devices have a built-in FOUNDATION Fieldbus power conditioner and use a standard 24...30V DC power supply to power the linking device and the H1 segment.



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Bus-powered devices typically require 10...30 mA of current at 9...32V DC. The current and H1 device signal travel on the same line. If the power is not conditioned, the H1 signal is forced back to the standard power supply and distorts the DC voltage.

Each linking device supports one H1 segment. Each H1 segment can support a maximum of 16 devices, but we suggest 8...12 devices per segment. The reduced number of linking devices provides for spares and a reduced macrocycle time for better data communication.

FOUNDATION Fieldbus Cable

FOUNDATION Fieldbus cables are specified in FOUNDATION Fieldbus FF 844 H1 and are based on EN 50288-7 and IEC 61158-2 specifications.

Attribute	Value
Conductor size	18 AWG (0.8 mm ²)
Impedance	100 Ω \pm 20
Attenuation @ 39kHz, max	3 dB/km
DC resistance	24 Ω /km
Shield coverage, min	90%
Length, max	1900 m (6234 ft)
Operating temperature	-30...90 °C (-22 ...94 °F)

We highly recommend that you use shielded, twisted-pair cable specifically designed for FOUNDATION Fieldbus H1 networks:

- For new installations, especially those with large cable runs and noisy environment, use Type A cable.
- For retrofits and short cable runs, you can use Type B cable.
- Do not use Type C or Type D cable because of their high signal attenuation characteristics.

Multi-pair cables are also available for Type A FF cable with options of 2...24 pairs.

Armored cables options are also available for ATEX and IS applications.

A typical fieldbus device draws about 20 mA of current from the cable. Check the manufacturer specifications for the current draw.

IMPORT- You cannot use pigtails or wire nuts to splice the cable. The bus **must** be continuous; no splices are permitted.

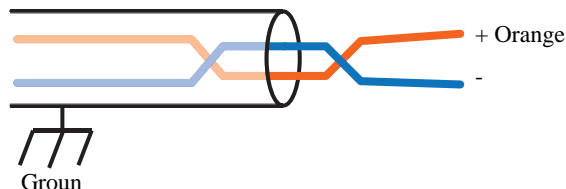
Other considerations when specifying cable include the following:

- Certifications approval
- Chemical protection
- High temperature tolerance
- Flexibility
- Direct burial

The standard color code for wiring uses are the following:

- Orange PVC jacket for general purpose or Class 1, Division 2 applications
- Blue PVC jacket – intrinsically safe applications
- Orange Positive conductor
- Blue Negative conductor

The fieldbus is configured so that one of the wires has a (+) voltage, the other wire has a (-) voltage, and the shield is grounded.



Other cables or existing plant wiring conventions can be different. Regardless of the color convention, keep the sense of fieldbus polarity consistent throughout the plant.⁽¹⁾

Cable Lengths

The Foundation Fieldbus organization recommends that overall cable length be limited to 1900 m (6234 ft) per segment with spur lengths limited to 120 m (390 ft) for 12 or fewer devices.

Note that these limitations are just guidelines and voltage drop calculations must be performed to determine that the minimum voltage (usually around 9V) is supplied to each device.

The maximum spur length of 120 m (390 ft) must also be reduced when adding more than 12 field devices as shown in the table below.

Number of Field Devices	Spur Length, max (m)	Spur Length, max (ft)
1...12	120	390
13...14	90	295
15...16	60	196

Designs usually build in a safety margin of 10% making the minimum voltage 10V. Include two additional field devices in the load and voltage drop calculations to plan for future expansion to the network.

Although the recommended supply voltage for an H1 network is 24V, the linking devices and most field devices can support voltages from 32...9V, which lets you increase the supply voltage to overcome excessive voltage drops.

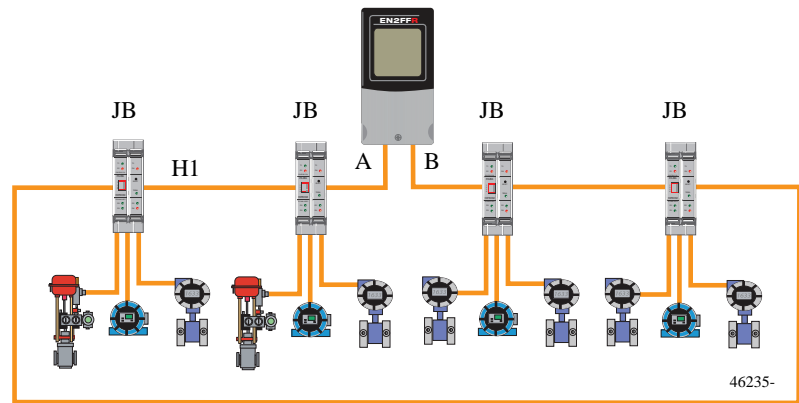
Base calculations for dual-trunk media networks on a single trunk with the same length. The assumption is that one of the conductors is open circuit, thus ensuring that the network is fault tolerant.

Calculations for ring bus networks need to determine the worst-case failure point of the cable, which is normally close to the linking device with the highest loads on the longest section of the cable.

(1) RELCOM Inc., Fieldbus Wiring Design and Installation Guide, page 5. Reprinted by permission.

In this example, the following is true:

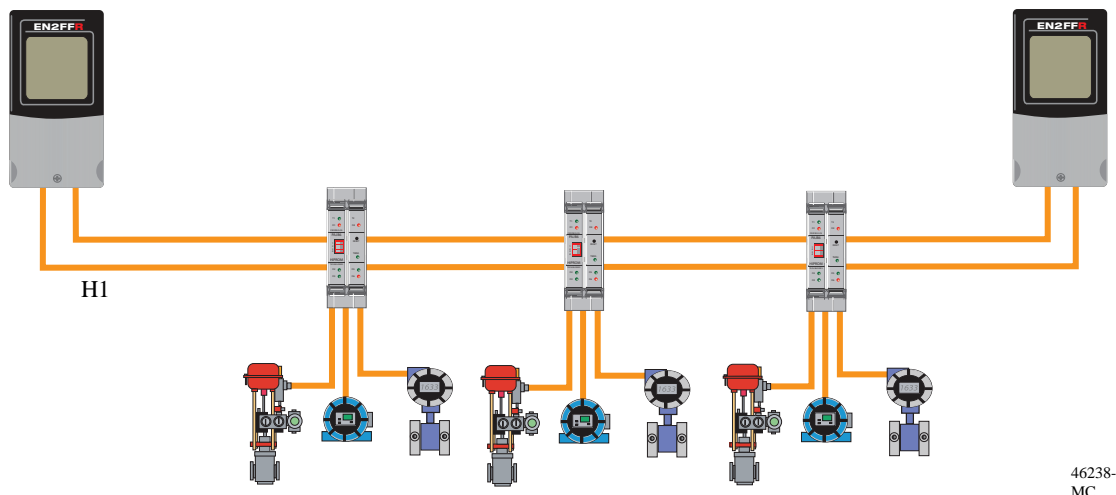
- Ring network with no cable breaks
- Linking device supplies 500 mA on each port



Failure Scenario	Topology
Cable break at port A Linking device supplies 500 mA on port B	
Cable break at port B Linking device supplies 500 mA on part A	

The linking devices have two H1 physical ports, which are part of the same logical segment but can be considered as two separate networks for the physical design. In split-bus architectures, the 1900 m (6234 ft) limitation applies to each port so you can place the linking device in the middle of the network to overcome long cable-run limitations and excessive voltage drops.

When redundant linking devices are used and not placed at the same point in the network, the voltage drop calculations need to be repeated as if each linking device were the only power source.



Cable lengths in hazardous areas do not need to be reduced to meet Entity or Intrinsically Safe specifications when using the high powered trunk concept (HPTC).

Segment Protection

Junction boxes, segment protectors, and fieldbus barriers operate at the physical layer of the network.

The inclusion of junction boxes in non-hazardous environments provides short-circuit protection to each of the drops by limiting the current when a fault occurs. The Allen-Bradley junction boxes 1788-FJB6 and 1788-FJB4R offer six and four drop, respectively. The current limit of each drop is approximately 50 mA so more than one field device can be attached to a drop.



The 1788-FJB4R redundant junction box also provides protection on the trunk. If more than 490 mA is drawn on any trunk line, that trunk trips and remain tripped until the reset button is pressed.

For hazardous environments, use segment protectors and field barriers that limit the power for the particular environment.

Termination

Fieldbus networks require terminators at each end of the network to reduce signal reflections and limit noise interference. Terminators are usually placed at each end of the trunk, however in networks with short trunk lines and long spurs, place terminators at the ends of the longest two spurs.

Place terminators such that removing the field device does not also disconnect the terminator.

Terminators consist of a 100 Ω resistor in series with a 1 μ F capacitor placed between the positive and negative conductors.

Most modern linking device, junction boxes, and segment protectors have built-in termination. Termination in the linking devices can be configured by setting the network topology.

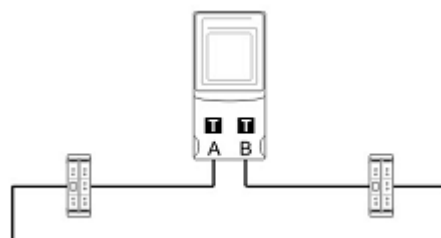
The Allen-Bradley redundant 4-way junction box provides an auto-termination option where the junction box determines if the connecting trunk segment has been broken and automatically provide termination.

Termination in the linking devices is software configurable with the choice of H1 topology.

In split bus topologies, terminators are required at the end of each physical segment.



In ring topologies, termination is supplied by the linking device.



Notes:

Network Architecture

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Network topology refers to the shape and design of a fieldbus application. You must consider the number of devices, their locations, cable length, and power supply considerations.

FOUNDATION Fieldbus Physical Network

There are three supported types of topologies for a fieldbus:

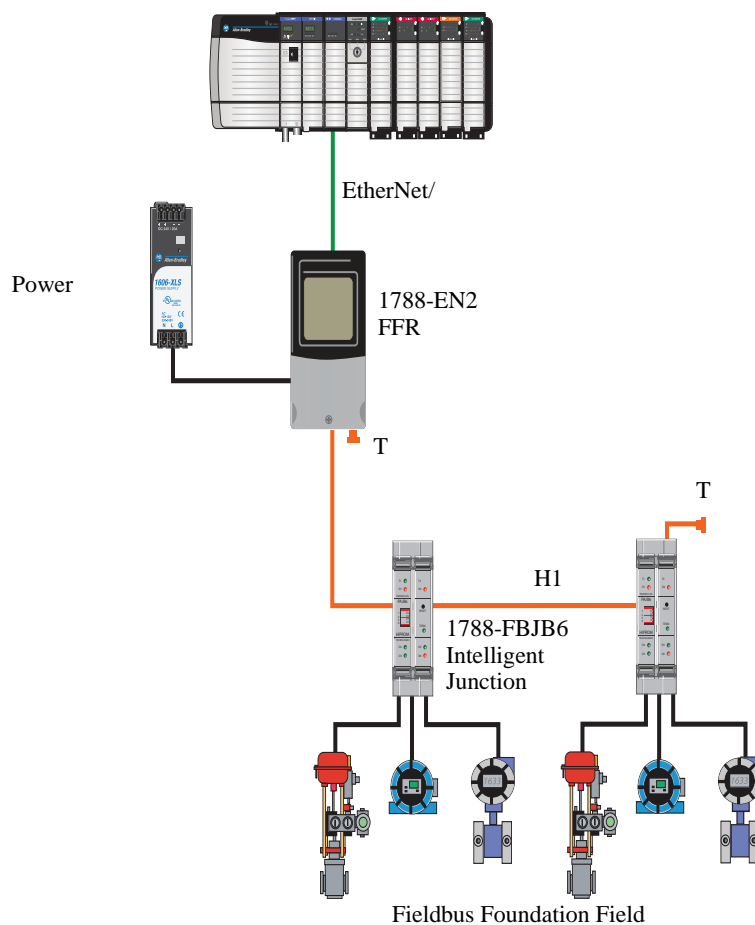
- [Tree Topology](#)
- [Spur Topology](#)
- [Combination Topology](#)

A daisy chain network, which consists of a cable segment that is routed from device to device, is not recommended. If a daisy chain is used, devices cannot be added or removed from the segment during operation without disrupting service to the other devices.

A point-to-point topology also is not suggested because the network consists of only two devices. Therefore, it's not an economical design.

The illustration shows a network configuration for a 1788-EN2FFR linking device supporting an H1 segment.

Figure 1 - 1788-EN2FFR Device on an H1 Fieldbus Network



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There are two terminators and a power conditioner built into the 1788-EN2FFR linking device. We recommend placing the terminators at the farthest ends of the trunk, and, if necessary, the terminator built into the 1788-EN2FFR linking device can be used on the end with the linking device.

IMPORT- There **must** be two terminators per segment; one at each end of the cable. The terminator allows the fieldbus signal to be viewed as a voltage while being offset on the DC segment voltage supply. This prevents distortion of the signal.

Do not use terminators at a field device because the whole segment is affected if the device is removed.

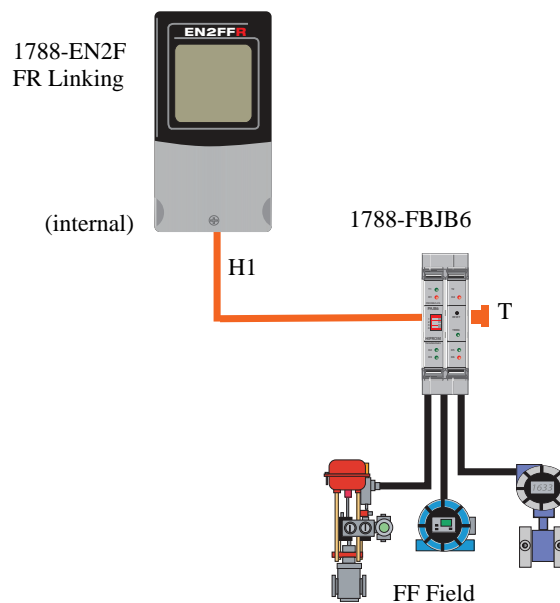
The built-in power conditioner of the 1788-EN2FFR linking device prevents the digital communication signal from back-feeding to the power supply and causing power supply anomalies.

Tree Topology

A tree topology, which is commonly referred to as a chicken foot, consists of a single fieldbus segment connected to a common junction box to form a network. A tree topology is practical if the devices on the same segment are well separated but in the general area of the junction box. It allows maximum flexibility when configuring and assigning devices to networks/segments, and it is the preferred topology for reuse of existing wiring.⁽¹⁾

Figure 2 is an example of a junction box at the end of a trunk. A trunk is the longest cable path between any two devices on the network. Because it is at the end of the trunk, the terminator within the junction box is activated. The spurs that are shown on the bottom of the junction box must be taken into consideration by using the maximum spur length table.

Figure 2 - Tree Topology



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'T' is for terminator. Required power supply is not

Spur Topology

This topology consists of fieldbus devices that are connected to the bus segment through a length of cable called a spur. Spur lengths can vary from 1...120 m (3.28...394 ft).

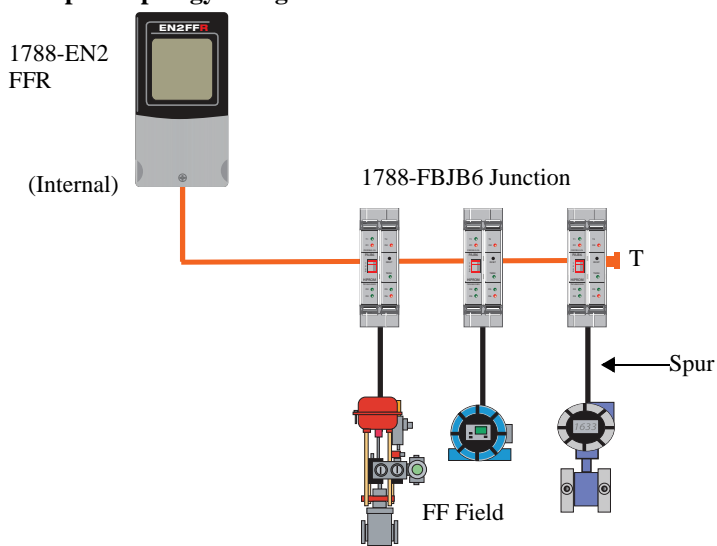
The general rule is that the shorter the spur, the better.

Spur topology is technically acceptable, but not generally a good economic choice when there is a high density of devices. It can be used for new installations that have a low density of devices in an area.

(1) FOUNDATION Fieldbus System Engineering Guidelines (7.1.2).

Figure 3 shows an example of a spur topology. Because it is at the end of the trunk, the junction box on the right has its internal terminator enabled.

Figure 3 - Spur Topology Using Junction Boxes



'T' is for terminator. Required power supply is not

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The total cable length is the sum of trunk and spur lengths. For more information, see the ControlNet Fiber Media Planning and Installation Guide, publication [CNET-IN001](#).

Table 2 - Fieldbus Cable Characteristics

Attribute	Value
Operating temperature	-30...90 °C (-22...194 °F)
Characteristic impedance	20 = 100 ±20 Ω
Attenuation	0 dB/km at 39 kHz, max 3
Resistance	Copper, tin-coated wire at 23.5 Ω/k mA at 20 °C (68 °F) (18 AWG) per conductor
Shielding	Each twisted pair shall be individually shielded. A drain wire shall have resistance less than 52 Ω/km
Wire-to-shield capacitance unbalanced	No more than 4 pF/m with 30 m cable length
Wire twist per meter	10...22 twists per meter

The total length of the trunk and spurs cannot exceed 1900 m (6234 ft) for Type A cable. Connect spurs to current-limiting connections for short-circuit protection.

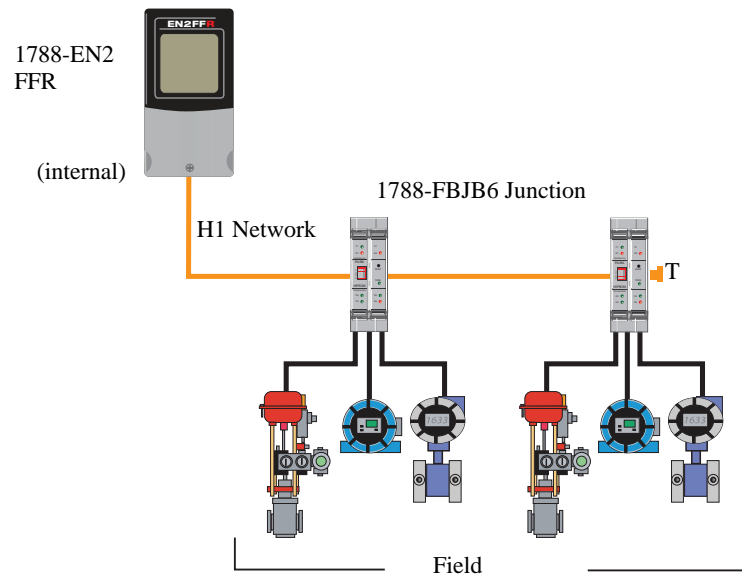
Table 3 - Recommended Spur Lengths

Total Devices	1 Device per Spur	2 Devices per Spur	3 Devices per Spur	4 Devices per Spur
1...12	120 m (394 ft)	90 m (295 ft)	60 m (197 ft)	30 m (98 ft)

Combination Topology

The most likely fieldbus scenario, and economical, is a combination tree and spur topology. You must follow the rules for maximum fieldbus network/segment length, including the length of the spurs in the total calculation.

Figure 4 - Combination Tree and Spur Topology

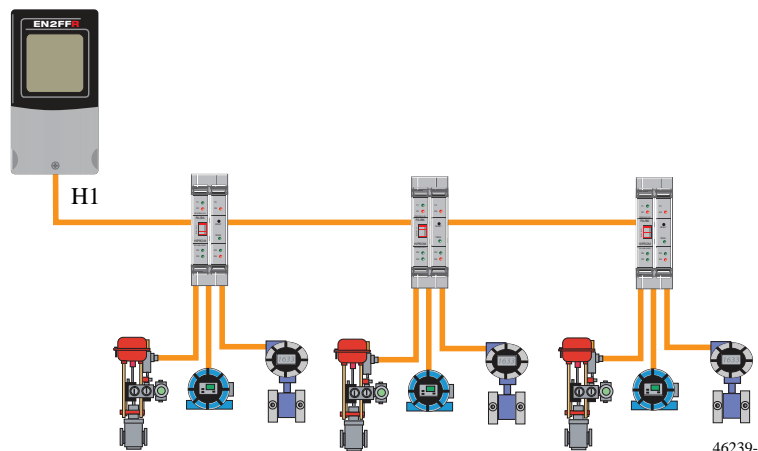


'T' is for terminator. Required power supply is not

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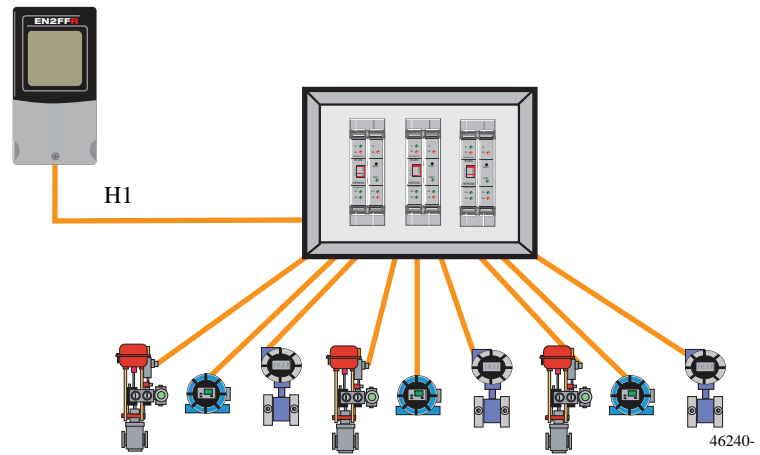
Network Layout

To provide power and data to all the field devices over a single, two-conductor cable, all the devices have to be attached in parallel. A daisy chain connecting the field devices has the inherent risk of disrupting part all or part of the network when you add or remove an instrument. You can overcome this risk with a main trunk that has drops to each field device with short-circuit protection on each drop. This lets you add and remove field devices under power without disrupting the rest of the network. This architecture works well where field devices are distributed over a large area or multiple skids.



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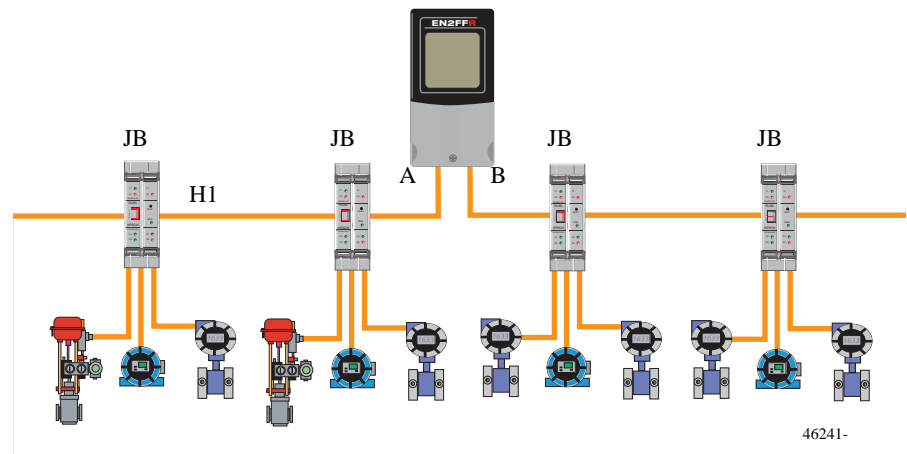
When field devices are clustered in close proximity with a short trunk line and longer spur lines, the network layout resembles more of a star topology. The centralization of the linking device and junction boxes reduces the cost of multiple enclosures.



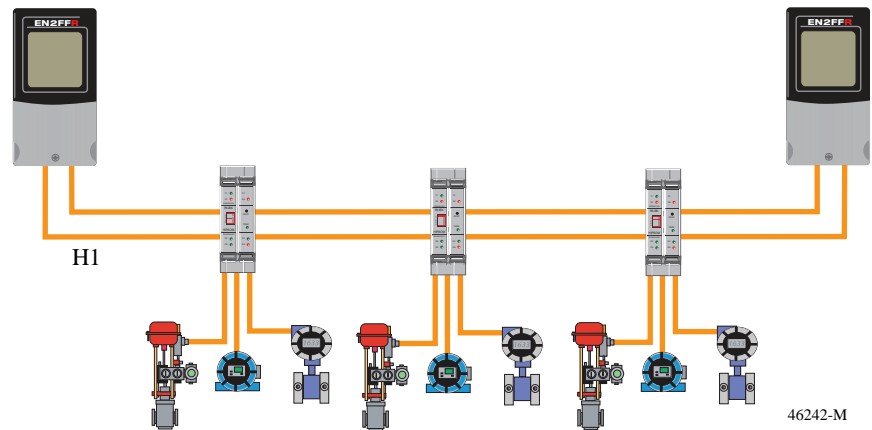
Network layout design needs to consider distribution of the field devices, possible cable routes, placement of the linking devices, voltage drops, potential sources of noise to be avoided, together with fault tolerance and redundancy options.

The linking devices support redundancy, redundant H1 trunk media (dual cable runs), and an H1 ring topology. All dual-bus and ring topologies must use the redundant junction box, catalog number 1788-FBJB4R.

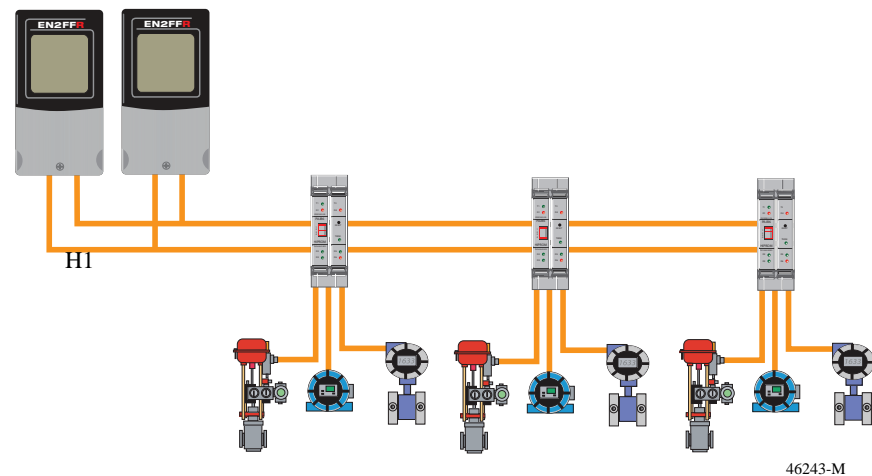
This example shows a ring bus topology that can tolerate a single break in the ring without affecting communication between the field devices and the linking device.



This example shows redundant linking devices with a dual H1 media trunk. This network can tolerate multiple faults in the H1 network, as well as a failure or complete disconnection of one linking devices.



Consider the placement of the linking devices from a voltage supply standpoint, as well as from a fault tolerance standpoint. This example shows linking devices that are positioned together.

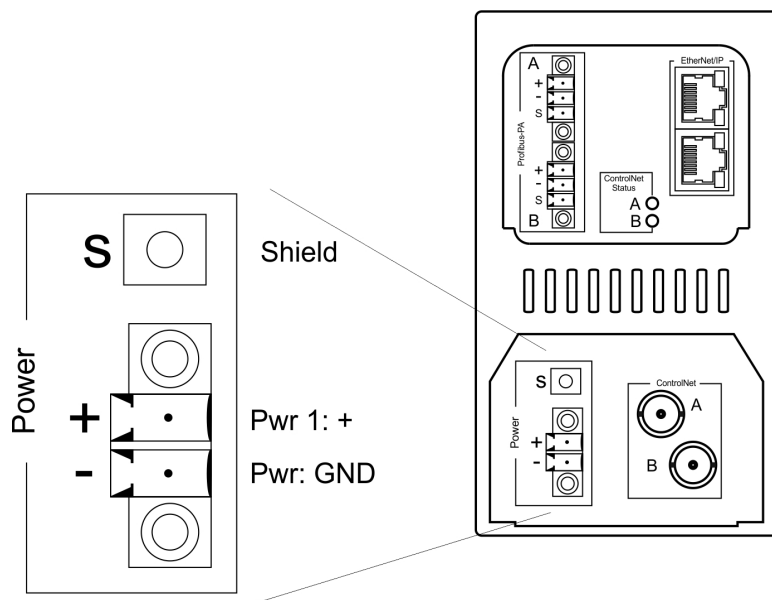


Grounding and Shielding

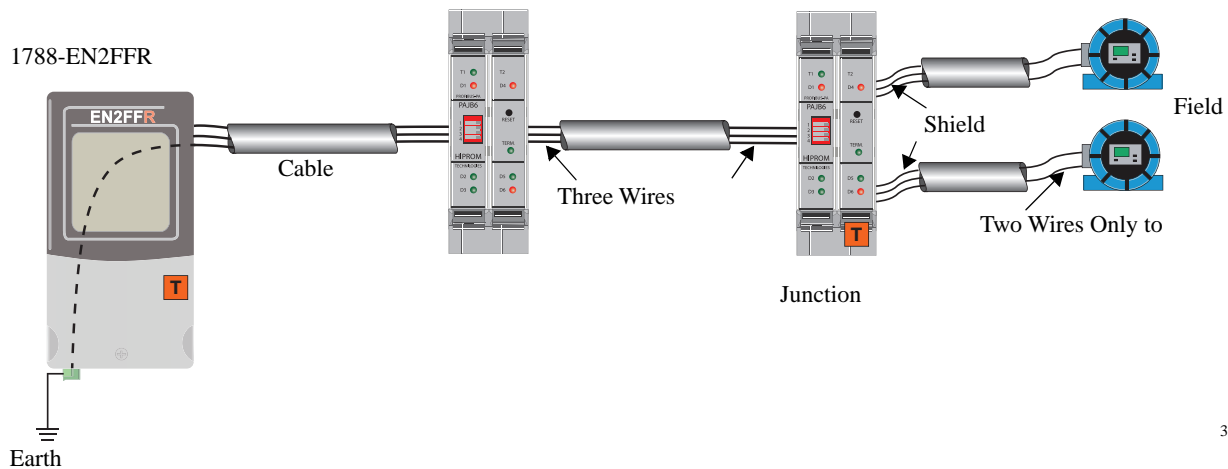
Follow all international, national, and local codes for grounding and bonding equipment. Above all, follow the manufacturer's instructions and recommendations for each device installed in a plant.

IMPORT- Signal wiring of the fieldbus segment cannot be grounded. Grounding out one of the signal wires shuts down an entire fieldbus network.

To prevent ground loops, ground a fieldbus segment at only one point. The linking devices provide a grounding connection labeled Shield next to the power connector on the bottom surface. This connects to the shield connectors on the H1 ports A and B.



Connect the cable shield to the H1 connector. Connect earth ground to the shield screw on the bottom of the linking device.

Figure 5 - Proper Shield and Ground Wiring

Shielding is an important aspect of segment design to prevent noise interruptions on the H1 conductors. A cable signal encountering a discontinuity, such as a wire open or short, produces a reflection. The reflection is a form of noise that distorts the original signal.

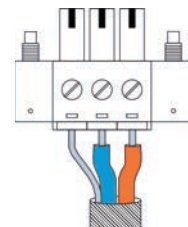
Various shielding options (Class A...D) can be used, depending on local codes, standards and practices. Class A, single-point shielding, is recommended for most regions of the world. The instrument shield is terminated at the host (fieldbus power supply) end of the network and is not connected to ground at any other place.⁽¹⁾

For optimal performance, use shielded fieldbus cables to reduce electromagnetic and electrostatic signal interference. Common multi-conductor (multi-core) 'instrument' cable can be used. It has one or more twisted pairs, an overall metallized shield, and a shield wire.

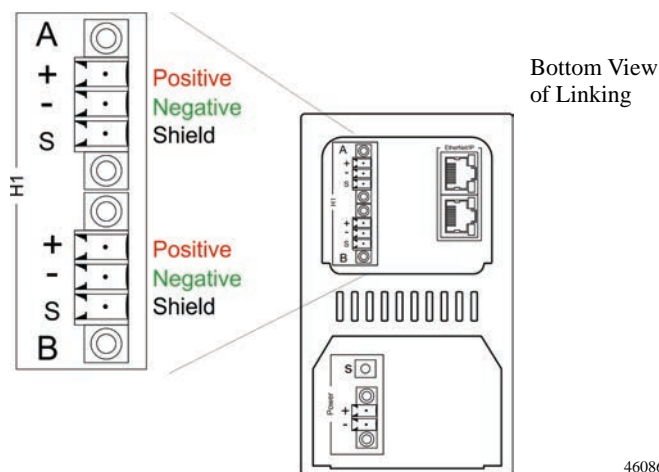
We recommend terminating the instrument shield at the host (power conditioner) end of the network in a marshalling cabinet and not connecting to ground at any other place. If a multiple trunk cable goes to a fieldbus junction box, do not attach the cable shield wires from different networks together. This creates ground loops and noise on the network.

If the linking device is earth/grounded correctly, you can connect the shield to the connectors as shown:

- Orange wire (H1+) to the right pin
- Blue wire (H1-) to the middle pin
- Shield of the cable to the left pin



(1) FOUNDATION Fieldbus System Engineering Guidelines (7.3.4).

Figure 6 - Cable Shield to H1 Connector

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IMPORT- The most common anomalies with fieldbus networks are usually due to noise, which can occur if you have the wrong wiring, improper grounding, or bad connections.

Be careful that you don't inadvertently connect the cable shield to the metallic housing of the field device at the gland. This could cause a ground loop and introduce noise to the network.

Field Device Groupings

The two key parameters for deciding how many field devices to place on a segment, are macrocycle time and power consumption. The more field devices that are added to a segment, the longer the macrocycle needs to be. In addition, the number of Process Variables (PVs) that are read also affects the cycle time.

The linking device can supply 500 mA to the segment for all network topologies, except in split bus topology where it can supply 1000 mA (500 mA per port). You need to tally the current draw from all field devices and junction boxes. Field devices usually draw 20...30 mA each.

Although the linking device can support 16 FOUNDATION Fieldbus devices, the recommended total is 8...12 devices. More devices can be added, but at the expense of a longer macrocycle time.

Physical proximity usually determines which instruments are grouped together on a segment. This reduces cost by limiting cable runs.

If you are using CIF, devices in the same control loop need to be on the same segment with a limit of two loops per segment.

Single segment failure risks can be limited by placing critical measurement from a process on different segments. For example, pressure and temperature measuring devices placed on different segments can provide separate alarms.

Avoiding electrical sources of noise is another consideration. Keep cable runs as far as possible from variable frequency drives, motors, electrical arcs, and transformers.

Signal Considerations

The cable length and voltage load are considerations to prevent a weakened communication signal. The more field devices placed on a segment increases the load. The longer the cable with a larger load increases the voltage drop across the cable, thus affecting the signal.

When a fieldbus network's signal quality is poor, it can cause intermittent loss of communication to devices, unreasonably long downloads, and lost data. The following components are critical to achieving good signal quality:

- Shielded two-wire cable, preferably specifically designed for fieldbus. The type of cable determines overall length of the trunks and drops.
- Terminators reduce noise on segments caused by signal reflections at the end of an open cable. One terminator on each end of the H1 trunk is needed for proper performance.
- Power conditioners, which are built-in for the 1788-EN2FFR and 1788-CN2FFR, are mandatory between a supply and the H1 trunk. The bus can deliver 9...32V DC consistently out of the conditioner when under the appropriate load from the cable resistance and while powering the devices. One power supply, or redundant power supplies designed for fieldbus, can be used.
- In areas vulnerable to lightning, we recommend installing lightning arresters.
- Avoid placing cable near equipment that generates a lot of noise, such as motors or drives, high-voltage cable, and switch-mode power supplies.
- We recommend that you use power supplies with built-in, short-circuit protection.

Cable Attenuation

Signals attenuate, or get smaller, as they travel through cables. Attenuation is measured in decibels (dB) based on the following formula.

$$\text{dB} = 20 \log (V1/V2)$$

Where:

V1 = amplitude of transmitted signal in volts

V2 = amplitude of received signal in volts

Cable has attenuation ratings for a given frequency; the frequency for fieldbus being 39 kHz. The preferred Type A cable for fieldbus has an attenuation of 3 dB/km.

A fieldbus device can transmit a signal as low as 0.75V peak-to-peak (V_{pp}) and detect a signal as small as 0.15 V_{pp}. This means that the cable can attenuate the signal by 14 dB ($20 \log (0.75/.015) = 14 \text{ dB}$).

When using the preferred Type A cable, a fieldbus can run up to 4.6 km (15,091 ft), as determined by this formula.

$$14 \text{ dB} / 3 \text{ dB/km} = 4.6 \text{ km}$$

A shorter cable has proportionately less attenuation. For example, a preferred Type A cable that is 500 m (1640 ft) has an attenuation of 1.5 dB.

Signal Distortion versus Capacitance

Other factors, such as varying characteristic impedance, spur connection reflections, and capacitive unbalance between the wires and shield can distort signals as they travel through the cable. This means that an ideal signal transmission within fieldbus specifications can arrive at the other end of the cable as a distorted signal.

In addition to cable attenuation, calculations for determining maximum fieldbus cable length must also use these guidelines to calculate signal distortion due to spurs:

- Each spur is converted to an equivalent capacitance.
- All spurs are assumed to be at the extreme end of the trunk.
- Signal attenuation is calculated as 0.035 dB/nF.

For example, if the fieldbus topology includes five devices, with each on a 20 m (66 ft) spur, the total cable length is 100 m (328 ft), equivalent capacitance is 3 nF (100 m x 0.03 nF/m), and the spur distortion is 0.105 dB (3 nF x 0.035 dB/nF = 0.105 dB).

Another source of distortion is the fieldbus device's equivalent capacitance. Use the following guidelines to calculate the distortion due to device capacitance:

- Determine each device's input capacitance.
- Assume all devices are at the extreme end of the trunk.
- Use 0.035 dB/nF as the signal attenuation calculation.

For example, if the fieldbus topology includes five devices, each with a 3000 pF input capacitance, the equivalent capacitance is 15 nF (5 x 3000 pF) and the resulting attenuation is 0.525 dB (15 nF x 0.035 dB/nF).

Power Considerations

Fieldbus devices can be either powered from the segment (bus) or locally powered, depending on the design. If at all possible, use field devices that are bus powered.

Bulk power supplies convert local electrical power to direct current. Segment supply voltage ranges from 9...32V DC, according to FOUNDATION Fieldbus specifications. However, for most applications, trunk supply voltage at the power supply is $24 \pm 2V$.⁽¹⁾

Calculate the power supply distribution to determine the number of devices that can be used on a fieldbus segment. Bus powered devices usually require 10...30 mA of current and between 9...32V.

The number of bus powered (two-wire) devices on a segment is limited by these factors:

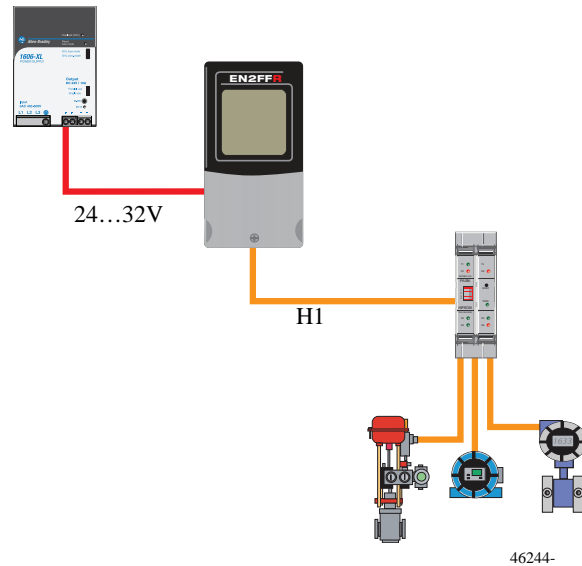
- Output voltage of the fieldbus power supply.
- Current consumption of each device.
- Location of the device on the network/segment.
- Location of the fieldbus power supply.
- Resistance of each section of cable.
- Minimum operating voltage of each device.
- Additional current consumption due to one spur short-circuit fault (10 mA).

The length of a fieldbus wiring system and the number of devices on a segment are limited by the power distribution, attenuation, and signal distortion. Refer to ISA 50.02 for the limitations on cable length.

(1) FOUNDATION Fieldbus System Engineering Guidelines (6.2.1, 6.2.3).

Power Supply Options

The linking devices have built in power conditioners and power is supplied to the H1 network through the linking device. This architecture enables bus voltages and currents to be monitored and also enables the linking device to trip the power if an overload situation is detected.

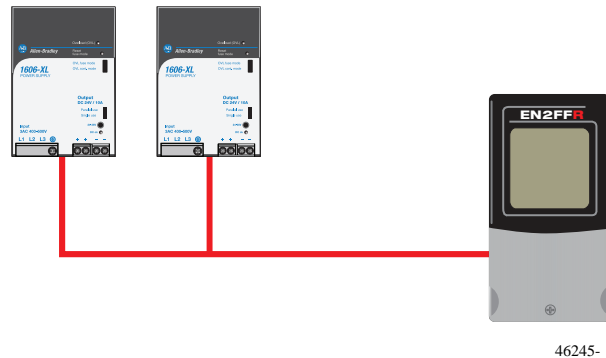


IMPORT- Be certain to remove old FF network power conditioners when retrofitting the Rockwell Automation 1788-EN2FFR and 1788-CN2FFR linking devices.

IMPORT- Most switch-mode power supplies when operated below half of their designed load can introduce excessive noise on their outputs and contaminate the H1 network. It is therefore suggested that the power supplies be sized to operate close to their design load.

You can use redundant power supplies if they have built-in protection diodes to be sure that if one power supply fails, that power supply does not short out the other power supply.

IMPORT- Do not parallel power supplies unless you have confirmed that they have built-in diode protection.



A bulk power supply can be used to power multiple segments. Be careful when sizing the supply to meet the power demand to reduce noise.

IMPORT- Do not share power supplies with non-communication consumers, particularly inductive based loads like solenoid valves.

Signal Wire Polarity

The combination signal/power wires have a plus (+) and minus (-) polarity associated to the power conditioner outputs, which must be wired to the appropriate terminals on the devices. Some devices are polarity insensitive, meaning they still work if you connect the positive wire to the negative terminal, and vice-versa. But, some instruments are polarity sensitive and do not operate if incorrectly wired.

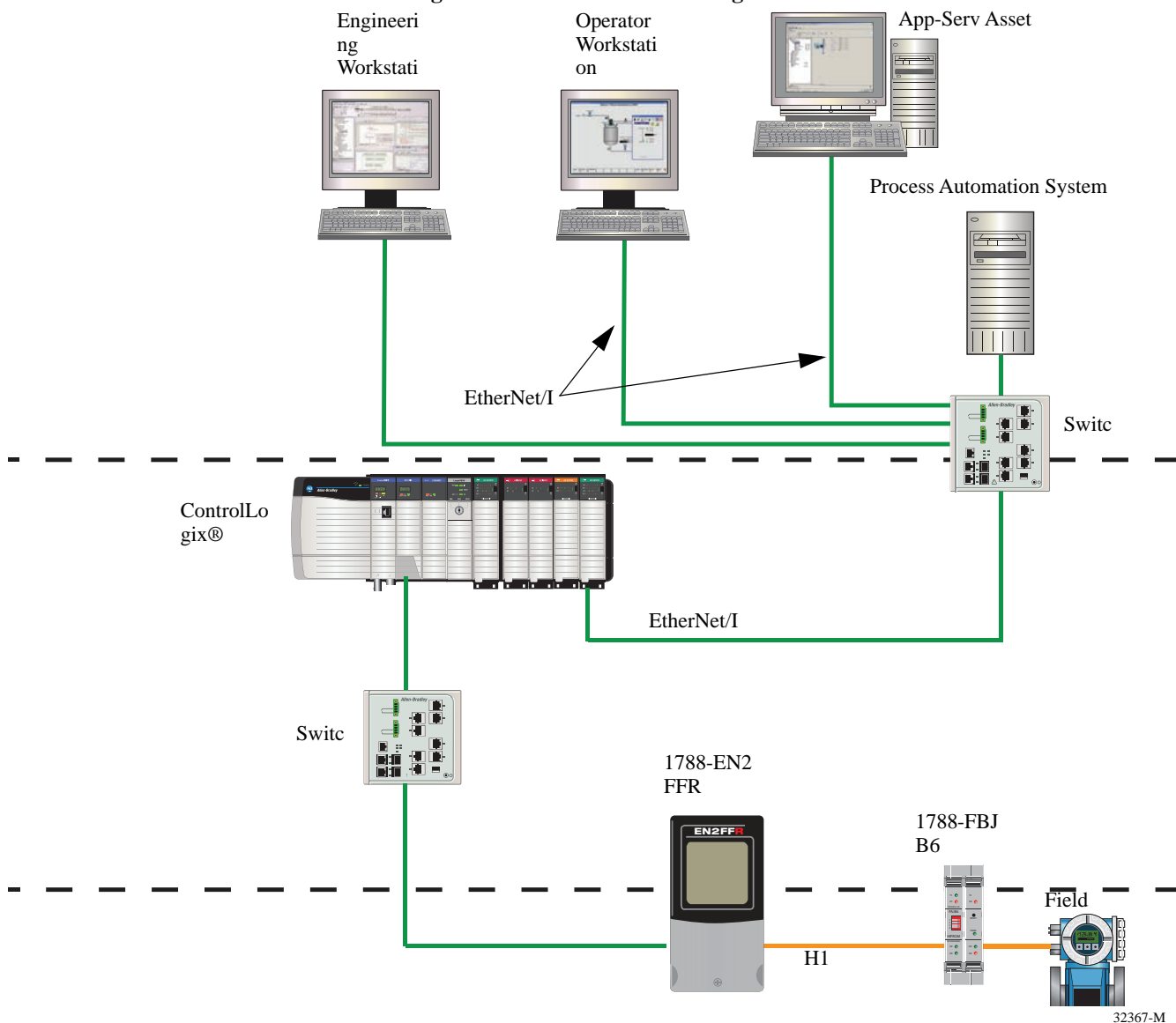
EtherNet/IP Considerations

Real-time data from the field devices is transmitted on the EtherNet/IP network through the Foundation Fieldbus linking device to a controller on the PlantPAx system. The PlantPAx system architecture uses produce and consume technology that lets input information and output status to be shared by all Logix controllers in the system.

To be sure of fluid network transmissions, you must consider the number of connections and managed router switches. Each 1788-EN2FFR linking device requires four Common Industrial Protocol (CIP) network connections, and each connection supports four devices. A network connection must be counted even if there are no field devices connected to a port.

Therefore, the number of connections must be factored into the number of devices that are connected to a single controller. Fortunately, an Add-On Profile with the linking device can assist you with the available number of connections during the initial setup. See [Chapter 3](#) for more information.

Figure 7 - 1788-EN2FFR Linking Device on an EtherNet/IP Network



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Assigning IP Addresses and Subnet Masks

You must assign an IP address and subnet mask by using a BOOTP server for each linking device on the network. The 1788-EN2FFR and 1788-CN2FFR linking devices do not support the Dynamic Host Configuration Protocol (DHCP).

The IP address specifically identifies the device from other devices on the network to receive multicast messages.

An IP address consists of 32 bits, often shown as 4 octets of numbers from 0...255 represented in decimal form instead of binary form.

For example, the IP address 168.212.226.204 in binary form is 10101000.11010100.11100010.11001100.

It's easier to remember decimals as opposed to binary numbers, so we use decimals to represent the IP addresses when describing them. However, the binary number is important because it determines which class of network the IP address belongs to.

An IP address consists of two parts, one identifying the network and one identifying the node, or host. The class of the address determines which part belongs to the network address and which part belongs to the node address. All nodes on a given network share the same network prefix, but must have a unique host number.

The subnet mask defines a segmented group for better control and security. If the host computer and linking device are not on the same subnet, a switch is needed to connect the two.

Using a Managed Switch

A Layer-2 access switch is essential for the security and data dissemination on the EtherNet/IP network. You must enable IP multicasting to distribute I/O control data, which is consistent with the CIP produced/consumed model. Most switches retransmit multicast packets and broadcast packets to all ports.

A Layer-2 managed switch, however, provides Internet Group Multicast Protocol (IGMP) snooping, support for Virtual Local Area Networks (VLAN), and port mirroring.

You must **not** filter IGMP snooping or you risk shutting down the IP multicasting. IGMP snooping enables switches to forward multicast packets only to ports that are part of a particular multicast group.

VLAN segregates network traffic; creating multiple isolated networks so traffic from one network does not burden another network. Port mirroring lets you direct frames being transmitted on one port to another port for analysis by a traffic analyzer.

TIP We recommend removing all filtering on your VLAN.

Refer to these publications for more information:

- EtherNet/IP Modules in Logix5000™ Control Systems, publication [ENET-UM001](#)
- Converged Plantwide Ethernet (CPwE) Design and Implementation Guide, publication [ENET-TD001](#)

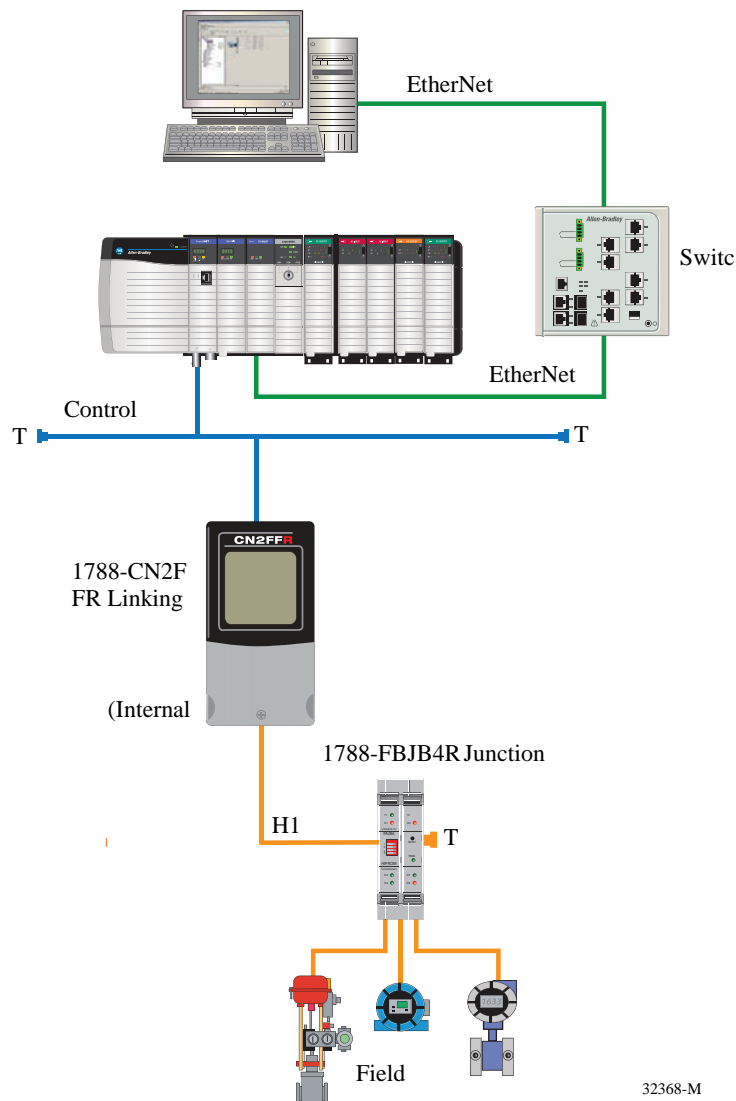
ControlNet Considerations

The number of connections and scheduled or unscheduled bandwidth are considerations when designing a fieldbus system on the ControlNet network. The ControlNet network does not require a router switch because of a non-active physical layer (no power). The ControlNet network uses the Common Industrial Protocol (CIP) to combine the functionality of an I/O network and a peer-to-peer network.

The 1788-CN2FFR linking device requires four CIP connections, and each connection supports four devices. You must consider the number of connections to determine the number of devices connected to a controller.

In addition, the ControlNet network requires each node to have its own address to communicate on this trunk/drop (bus) network. You cannot have more than 48 active devices and taps on a single coax segment. A repeater lets you extend the allowable cable distance for additional nodes (maximum of 99 on a ControlNet network).

Figure 8 - 1788-CN2FFR Linking Device on a ControlNet Network



Scheduling Data Communication

If you plan to do asset management on the ControlNet network, you must allow for some unscheduled bandwidth. If the unscheduled bandwidth is too small, the bandwidth is extremely slow and information packets can be dropped from the network.

We recommend that you set the value of your RPI to half of your macrocycle value. For example, if the macrocycle is 1000 ms then the RPI must be set to 500 ms. Setting the RPI faster (specifying a smaller number) than what your application needs wastes network resources, such as ControlNet scheduled bandwidth, network processing time, and CPU processing time.

The 1788-CN2FFR uses unscheduled messages to communicate to the Add-On Profile (AOP) and Device Type Managers (DTM). If there is minimal unscheduled bandwidth, you cannot configure the linking device or field devices. If you are planning to do a lot of asset management via DTM's, it is recommended that it be done via the 1788-CN2FFR linking device's onboard Ethernet port. This can be done by selecting the 1788-EN2FFR gateway DTM in a FDT frame and connecting to the 1788-CN2FFR linking device.

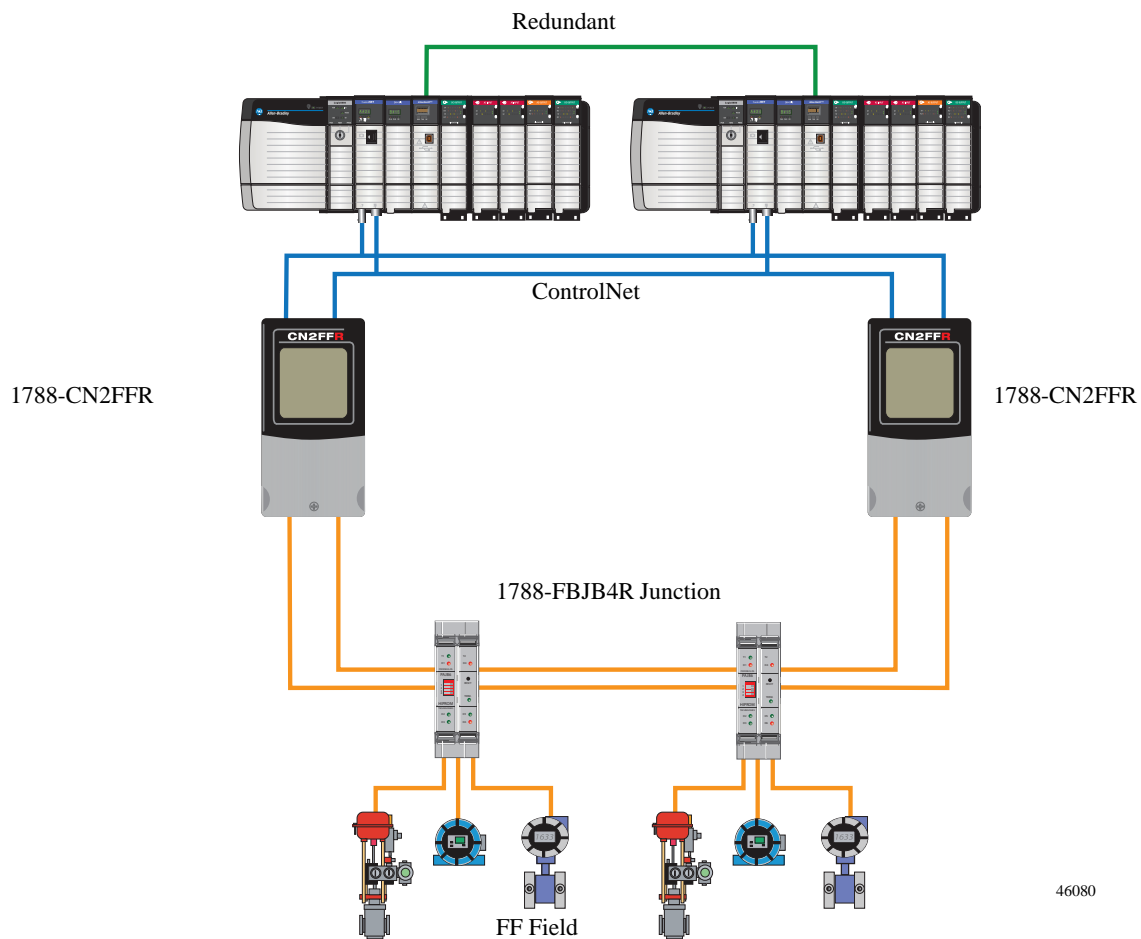
Redundancy Considerations

The 1788-EN2FFR and 1788-CN2FFR linking devices support controller redundancy, which provides for an increased level of protection by switching control to a secondary controller chassis if anything in the primary controller chassis fails:

- Any redundancy at the H1 segment level (redundant linking devices, redundant trunk cabling, and so forth) requires a specific junction box (catalog number 1788-FBJB4R).
- Redundant media provides an alternate connectivity path between the controller and the linking device. Routing cables in different physical paths also reduces the risk of simultaneous damage to both cables.
- Redundant H1 media provides an alternate connectivity path between the linking device and the field devices.
- Redundant linking devices overcomes the failure of one linking device, in which case the second linking device takes over and CIF loops continue uninterrupted.

Redundant Linking devices can also overcome a break in the H1 network. Place devices on both ends of the H1 network so that if one linking device fails, the devices continue uninterrupted, but CIF communication between devices on either side of the break is lost.

In a redundant ControlNet configuration, the primary controller chassis automatically determines what data changes during its scan and sends that data to the secondary controller to keep it ready to immediately take over control without any change in the outputs. One of the basic considerations is the network update time (NUT) that specifies the switchover response time. A typical NUT used with a redundant system ranges from 5...10 ms.

Figure 9 - ControlNet Network Redundancy

The two trunk cables are routed similar in distance and duplicate nodes for proper redundant cable operation.

When configured for redundant cabling on the ControlNet network, all nodes simultaneously transmit and receive on both channel A and channel B. There is no distinction on the network between packets on channel A and channel B. Each node independently decides which channel, A or B, it listens to; this is based on historical counters that are internal to each node.

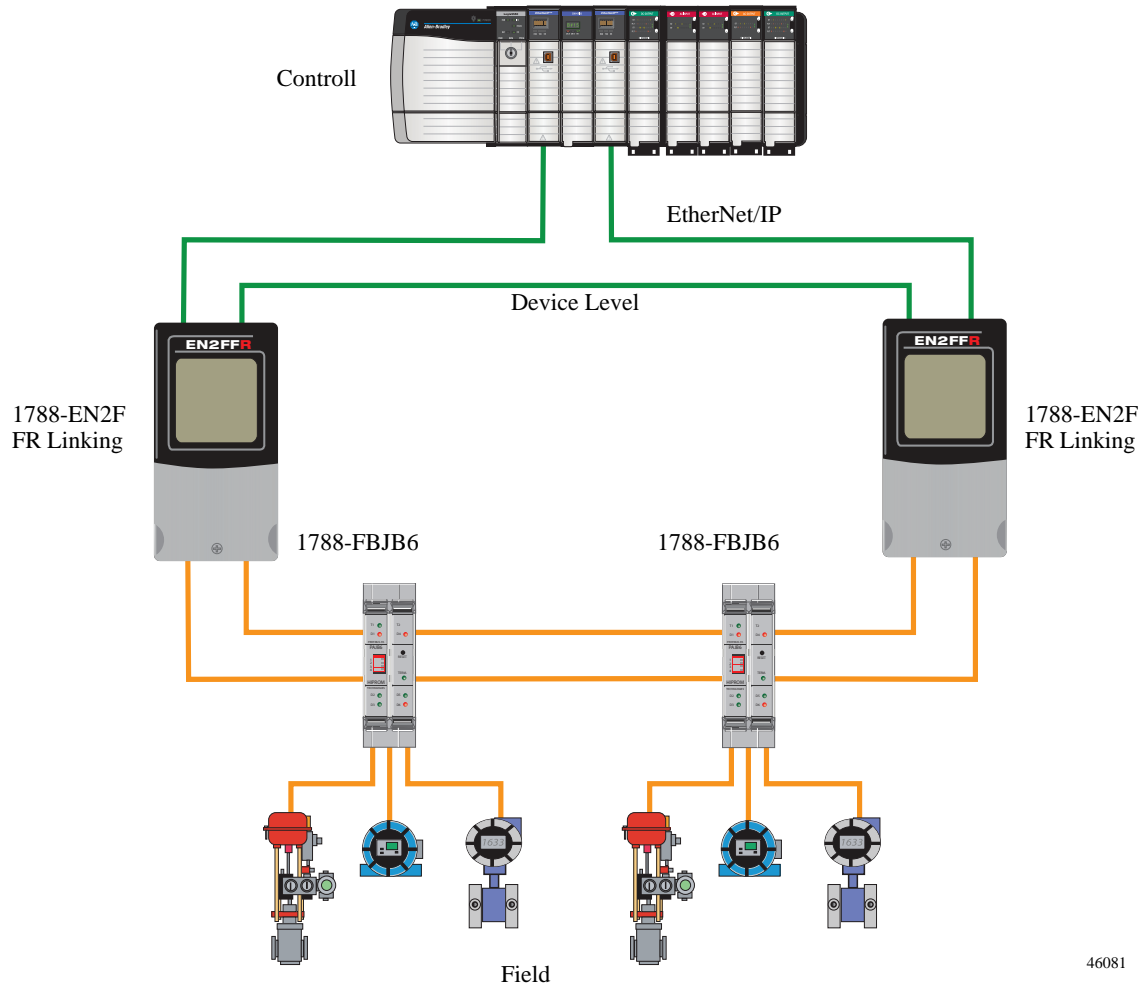
You can have as many as seven ControlNet communication modules in a redundant chassis. Each redundant pair of ControlNet bridge modules must occupy the same slot position in each chassis.

IMPORT- Redundant devices must be on separate linking devices.

You can use a 1756-CN2R module for standalone or redundant control. For standalone control, only one module is required. For redundant control, a pair of 1756-CN2R modules are configured in the same slot position in both chassis.

The 1788-EN2FFR linking device supports device-level ring (DLR) topology for single-fault tolerance ([Figure 10](#)). We suggest that you use IP address swapping between your partnered 1756-EN2T modules on the same subnet for a switchover. The partnered module must use the same values for the IP address, subnet mask, and gateway address.

Figure 10 - EtherNet/IP Network Redundancy



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Intrinsically Safe Installations

Intrinsically safe (IS) installations must follow the same guidelines as imposed by the technology for non-IS installations. The major differences are the power constraints imposed by the need to remain intrinsically safe and the requirement to use suitably certified power supplies, field instruments, and wiring components. IS wiring has a light blue outer jacket.⁽¹⁾

IMPORT- Intrinsic safety (IS) barriers can limit the maximum device numbers on the IS H1 segment to 4...6 devices, depending on the power consumption of the devices installed and the manufacturer's specification for both the barrier and the transmitter.

There are several methods for limiting power for installation in IS classified areas. These methods include the following:⁽²⁾

- High-power trunk, with current limiting device couplers (non-incendive)
- High-power trunk, with isolating device couplers (intrinsically safe)
- FNICO (Fieldbus Non-Incendive COncept) non-incendive bus-limited power
- FISCO (Fieldbus Intrinsically Safe COncept) intrinsically safe bus-limited power
- IS Entity Concept intrinsically safe bus-limited power

(1) FOUNDATION Fieldbus System Engineering Guidelines (7.6.1).

(2) FOUNDATION Fieldbus System Engineering Guidelines (7.6).

Hazardous Area Installations

The linking devices support the high power trunk concept (HPTC) for hazardous area installations. HPTC does not add any additional design limitations to power supplies and cable lengths. Field barriers limit the energy supplied to individual spur connections to be sure that each spur conforms to Entity as well as FISCO / FNICO requirements.

IMPORT- The linking devices do not support connections to Entity or FISCO / FINCO limiting power supplies.

Under the HPTC requirements, spurs connected to field barriers are still limited to 120 m (393.7 ft) in length and restricted to a single field device that must be Entity or FISCO rated.

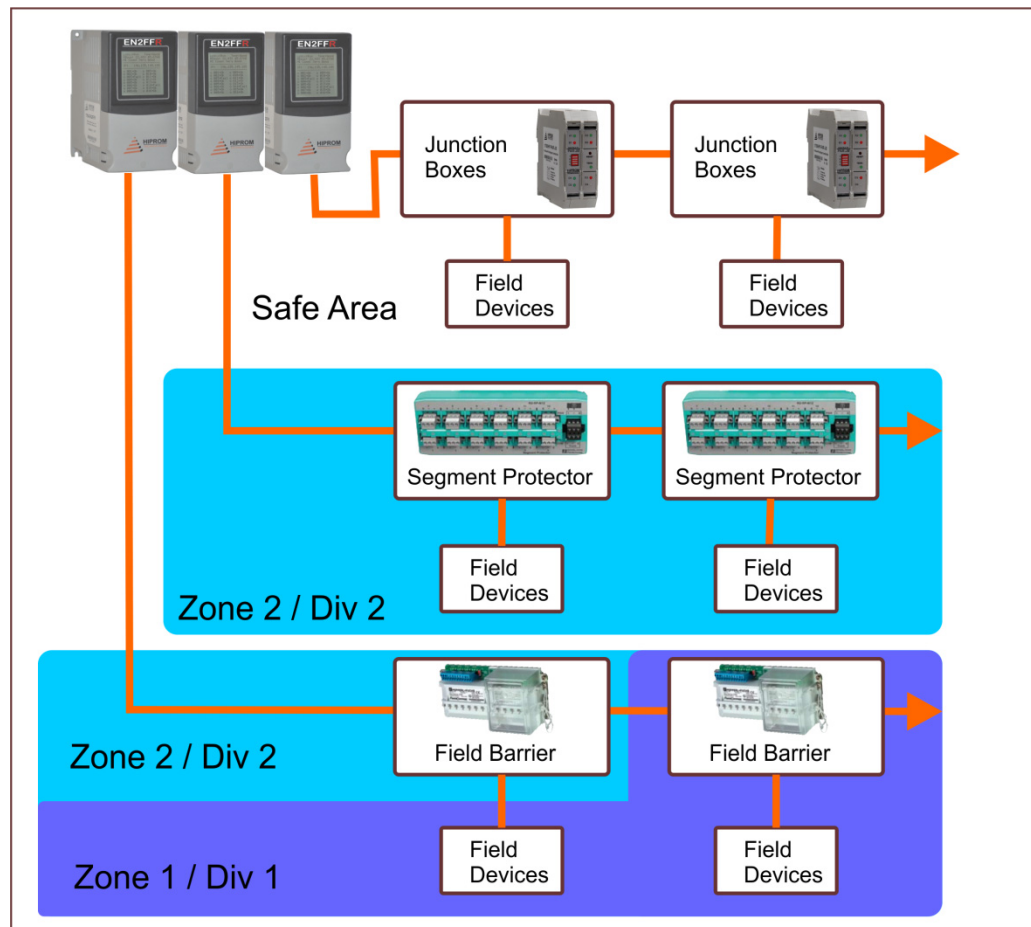
You can use field barriers in place of safe areas or Zone 2/Division 2 areas with spurs running into Zone 1/Division 1 areas. Some barriers also provide galvanic isolation of the spurs from the high power trunk.



For Class 2/ Division 2 areas, use segment protectors on the trunk to provide sufficient energy limitations (non-incendive) and short circuit protection to a single intrinsically safe-rated field device.



Placement of barriers and segment protectors in hazardous areas means that all wiring must meet the area specifications. Maintenance on the high power trunk is not permitted in hazardous areas, but maintenance on the spurs is permitted.



Voltage Drop Calculations

You need to consider the voltage drop between the external power supply and each port on the linking device. The voltage drop ranges from 3.0V @ no load...5.5V @ 500mA. Estimate voltage drop as the following:

$$V = 0.0043 * \text{Current} + 3.46V$$

Table 4 - Voltage Drop between Power Supply and H1 Port

Current	0	50	100	150	200	250	300	350	400	450	500
Voltage	2.94	3.63	3.87	4.10	4.32	4.52	4.72	4.91	5.11	5.28	5.42

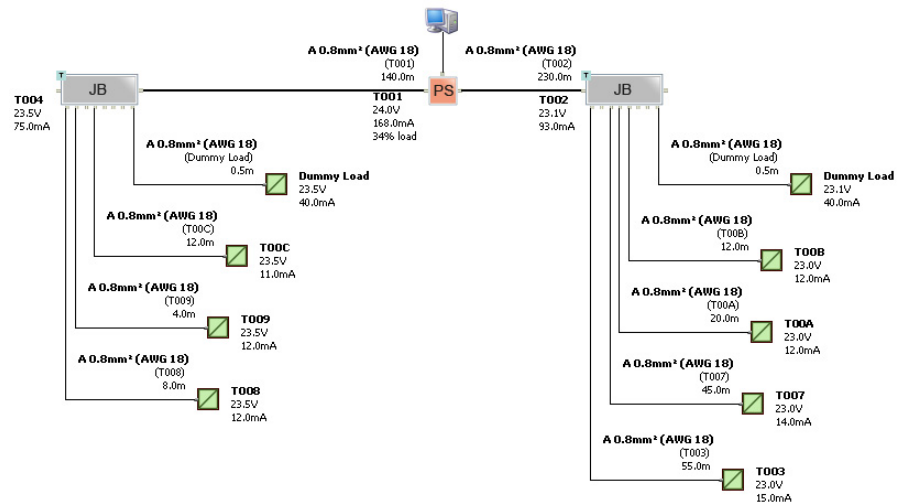
The following tools are available to make sure fieldbus infrastructure is working properly:

- Pepperl+Fuchs offers a free online calculator at <http://www.SegmentChecker.com>
- FOUNDATION Fieldbus offers DesignMATE for segment verification at <http://www.fieldbus.org/DesignTools>

These tools include the following:

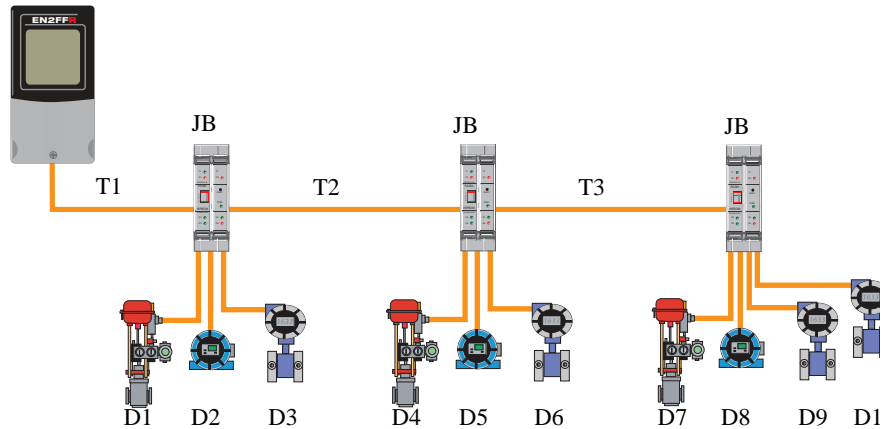
- Provides voltages at each node on the network
- Verifies minimum voltages for field devices
- Monitors cable lengths
- Number and type of installed devices

Although the online calculator is primarily designed for P&F products, model the linking devices by using the General Power Supply with the Integrated Host option. Model junction boxes by using a P&F junction box and adding a dummy instrument with the correct load.



Manual Network Calculations

This example is based on the following network layout where field device D10 is actually a place holder for the future addition of two instruments. Fields with white backgrounds are obtained from the instruments and network design while fields with grey backgrounds are calculated. The segment trunk is divided into three sections T1...T3. H1 cable is Type A with 24 Ω /km or 48 Ω /km loop impedance (accounting for both conductors). You also need to manage the current draw of the junction boxes and their minimum supply voltages.



Field Device	Cable Length (m)	Current Draw (mA)	Voltage, min (V)	Spur Voltage Drop (V)	Device Voltage (V)	Device Voltage (V)
1	100	25	9	0.12	13.24	17.24
2	80	30	9	0.115	13.25	17.25*
3	60	18	9	0.052	13.31	17.31
JB1	—	40	12	—	13.36	17.36
4	29	24	9	0.033	10.62	14.62
5	22	33	9	0.035	10.62	14.62
6	5	27	9	0.006	10.65	14.65
JB2	—	40	12	—	10.65	14.65
7	5	27	9	0.006	8.07	12.07
8	10	30	9	0.014	8.06	12.06
9	60	28	9	0.081	8.00	12.00
10	60	60	12	0.0173	7.90	11.90
JB3	—	40	12	—	8.08	12.08
Trunk	Length (m)	Spur Current (mA)	Trunk Current (mA)	Resistance	Voltage Drop (V)	Voltage Drop (V)
T1	500	113	395	24	9.48	9.48
T2	200	124	282	9.6	2.71	2.71
T3	340	158	158	16.32	2.58	2.58
Port Voltage (V)					22.84	26.84
Total	1471	394	Supply Voltage (V)		28	32

1. Add the trunk and spur lengths (<1900 m) to calculate the total cable length.

Also check spurs (120 m for 12 or fewer devices).

2. Add the current draw from each of the spurs and the totals of the downstream junction boxes to calculate the current in each trunk segment.

This results in 395 mA for segment T1, 282 mA for segment T2, and 158 mA for segment T3.

3. Add the current draw of the linking device (260 mA) to the current draw for segment T1 (395 mA) to calculate the power supply current needed for the network.
4. Multiply the length of each segment by the impedance per km to calculate the impedance of each segment.

Divide by 1000 to get an answer in Ω .

Double the impedance because there are two conductors. This example has Type A cable with a loop impedance of 48 Ω /km.

5. Subtract the voltage drop of the linking device from the supply voltage to calculate the voltage supplied on the linking device H1 port.

In this example, for 395 mA there is a voltage drop of 5.16V. The voltage at port A is the following:

$$28V - 5.16V = 22.84V$$

6. Multiple current by impedance to calculate the voltage drop from the impedance and the total current in each segment.

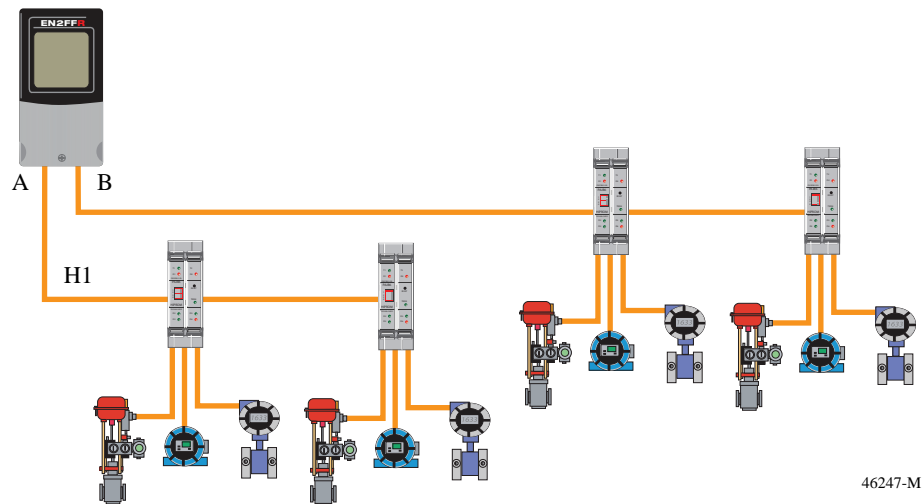
Divide mA by 1000 to convert to amperes.

In this example, the voltage drop across each segment is 9.48V for segment T1, 2.71V for segment T2, and 2.58V for segment T3. This means a total voltage of 8.08V supplying JB3. This shows that if we use a 28V power supply, the supply voltage to JB3 is below the minimum required.

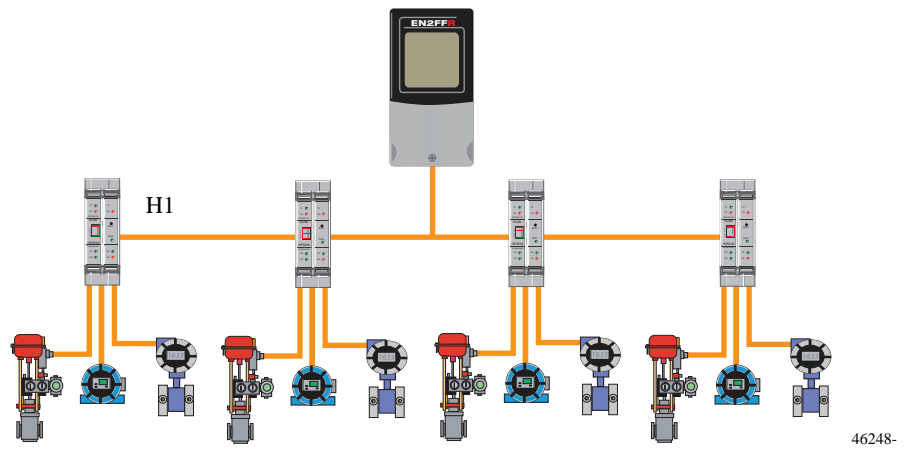
7. Calculate the impedance and voltage drop for each of the spurs.
8. Add the voltage at each field device to calculate the total supply voltage.
9. Compare results with requirements and adjust as necessary.

In this example, increase supply voltage by to 32V to meet the minimum requirements for JB 3 and all of its devices.

Excessive voltage drops can also be overcome by using a split bus topology that shares the load between two ports but increases the amount of cabling required.



Placing the linking device at the center of the H1 network also reduces voltage drops at the ends, but requires longer EtherNet/IP or Control wiring.



Notes:

Startup and Maintenance

Topic	Page
Optional Tools	47
Device Replacement	50
Web Pages	62
Advanced Diagnostics	67

This chapter describes techniques and tools that can be used to set up, maintain, and replace fieldbus devices. Third-party tools that are discussed are suggestions and do not include all the diagnostic equipment that is available to keep your system running optimally.

Optional Tools

The following optional tools are available to capture fieldbus data:

- Relcom's Fieldbus Network Monitor FBT-6
- Pepperl+Fuchs mobile diagnostic module and fieldbus analyzer

Relcom's FBT-6 can be used to examine the operation of a live fieldbus network, without interfering with its operation.⁽¹⁾

The FBT-6 verifies the DC voltage on the network and checks how much noise is on the network. It also can be used to measure peak noise levels, framing errors, the number of transmitters on the wire, and what the signal level of the weakest field transmitter is. In addition, you can see the total number of devices up and running, and what devices are left on the network. The FBT-6 can be purchased from Relcom (<http://www.relcominc.com>).

A protocol analyzer is a tool that lets you test for the content of the message sent, what the messages mean, and in what sequence the fieldbus devices talk to each other. However, a protocol analyzer is an advanced tool with a complex range of functions.

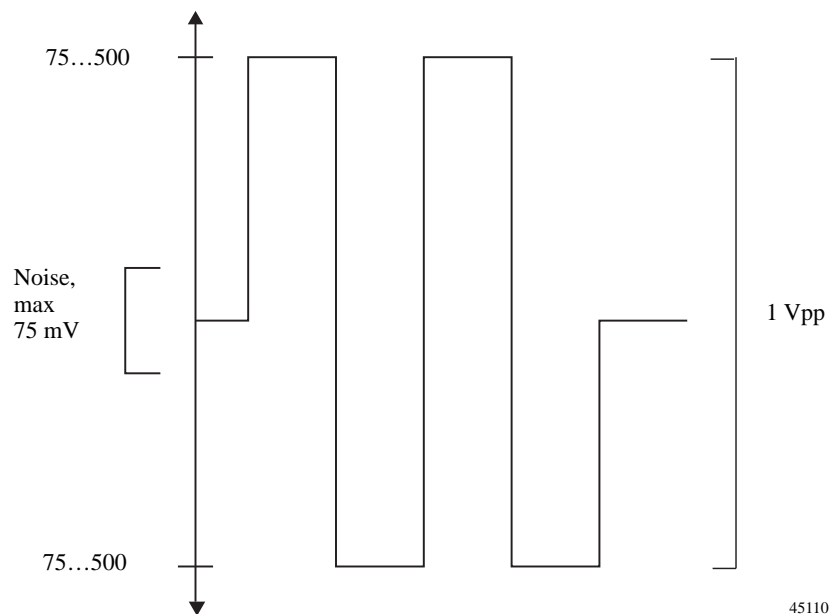
(1) FBT-6 Manual.

Signal Analysis

An oscilloscope feature, which is available via the Add-On Profile, captures and examines waveforms. We recommend the power supply waveform be a $\pm 0.75\text{...}1.00\text{V}$ DC square wave riding on the $9\text{...}32\text{V}$ DC steady power supply with $<0.10\text{V}$ DC ripple. The sharper the rising and falling edges of the waveform, the better the data transfer. The physical media of a system determines what shape the waveform takes.

[Figure 11](#) shows a signal that is a current modulated $\pm 10\text{ mA}$ signal on a 50 test load. This generates a 1.0 Vpp signal. A valid signal can range from 150 mVpp up to 1.0 Vpp and noise must not exceed 75 mVpp .

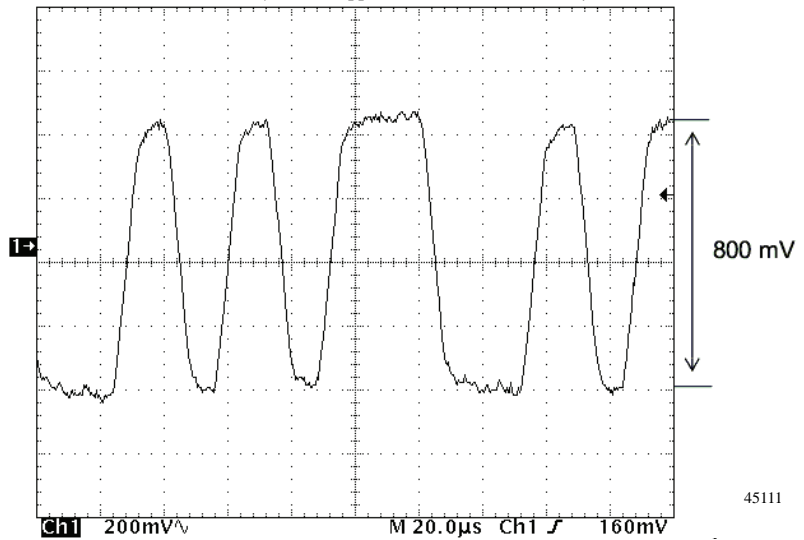
Figure 11 - Ideal Fieldbus Communication Signal



Good Network Scope Display

To analyze a fieldbus network signal, you must know what constitutes a good signal versus a bad one. [Figure 12](#) represents a normal signal consisting of two terminators and 305 m (1000 ft) of cable. Its peak-to-peak voltage is 850 mV, which is close to the ideal value of 1 V_{pp}.

Figure 12 - Good Network Signal⁽¹⁾

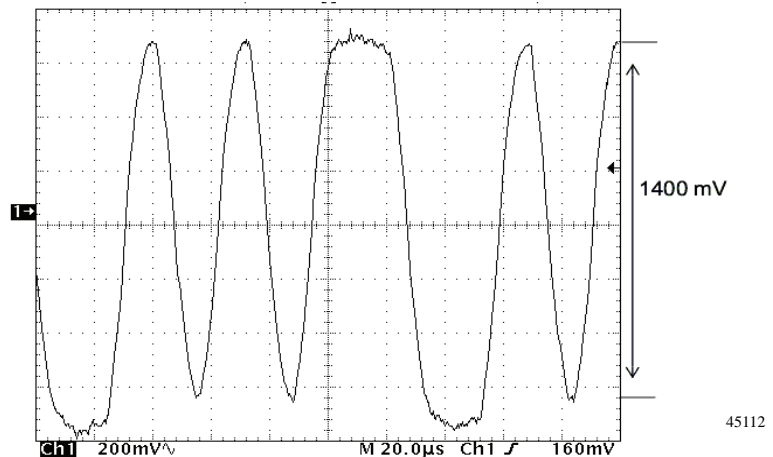


Bad Network Scope Display

Bad network signals can inhibit the performance of your network. A common reason for bad signals is the addition of one or more unnecessary terminators in a network.

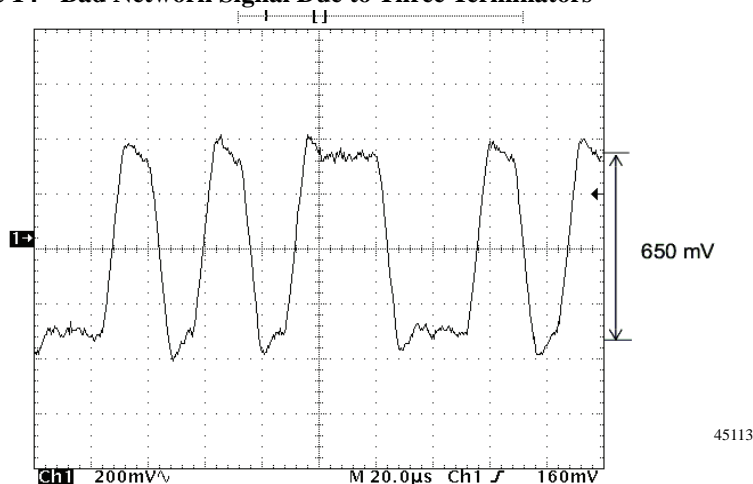
IMPORT- Remember, there can be only **two** terminators per bus segment.

Figure 13 - Bad Network Signal Due to One Terminator⁽²⁾



(1) FOUNDATION Fieldbus System Engineering Guidelines (Appendix 5.1).

(2) FOUNDATION Fieldbus System Engineering Guidelines (Appendix 5.2).

Figure 14 - Bad Network Signal Due to Three Terminators⁽¹⁾

In both examples of a bad signal, the V_{pp} is far from the ideal of 1 V_{pp} that a good signal displays.

Device Recovery

These tools can be used to reset a device:

- Rosemont 375 or 475
- Endress + Hauser Field Expert, handheld model

Device Replacement

When a device is exchanged, you receive a warning message if the parameters list does not match. The parameters in the device running must be related to the common parameters in the function blocks.

Also, because FOUNDATION Fieldbus is a communication protocol with manufacturer specific function blocks, there is no guarantee that one manufacturer's function blocks operate in a similar manner as another's. Therefore, reuse of one manufacturer's function block in another manufacturer's device is to be avoided.

Interoperability versus Interchangeability

If a device is to be replaced with another manufacturer's device, or a device from the same manufacturer but from a different model series, this replacement falls under the category of interoperability.

Interoperability requires a complete recreation of the control strategy function blocks in the failed unit. The existing blocks in the failed unit need to be deleted and then replaced by appropriate function blocks in the existing strategy. The resulting strategy then requires a complete download of the entire network.

(1) FOUNDATION Fieldbus System Engineering Guidelines (Appendix 5.3).

Interchangeability is the ability to replace one failed device with a good device, provided that the devices are from the same manufacturer and class. The replacement device can be downloaded without any need to edit the strategy or download the entire network.

Different Ways for Replacing Field Device

There are three scenarios when doing a device replacement:

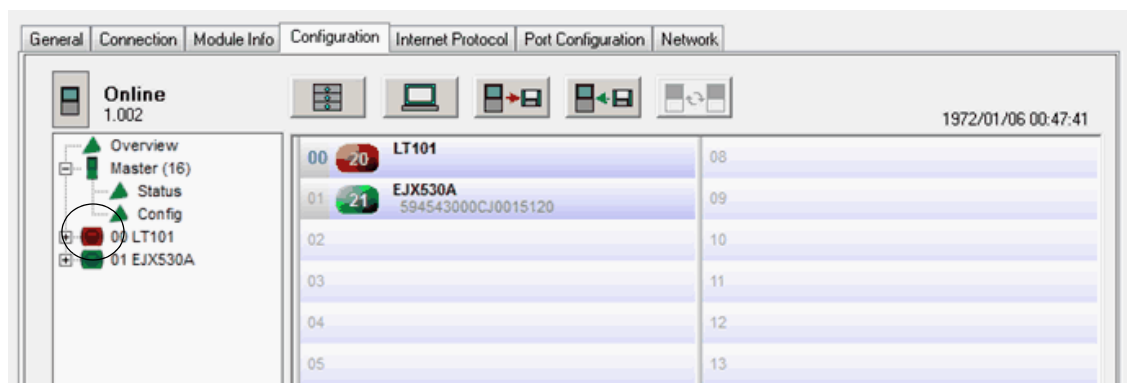
- Scenario 1: Replace field device from same vendor with same DD (Device Description) revision and device revision. See [page 51](#).
- Scenario 2: Replace field device from same vendor with different DD revision and device revision. See [page 57](#).
- Scenario 3: Replace field device from different vendor. See [page 62](#).

Scenario 1: Same Vendor with Same DD Revision and Device Revision

You can manually configure the device or choose to merge the online device with an offline configuration. This is a simple procedure but we suggest you do this task automatically (see [page 56](#)).

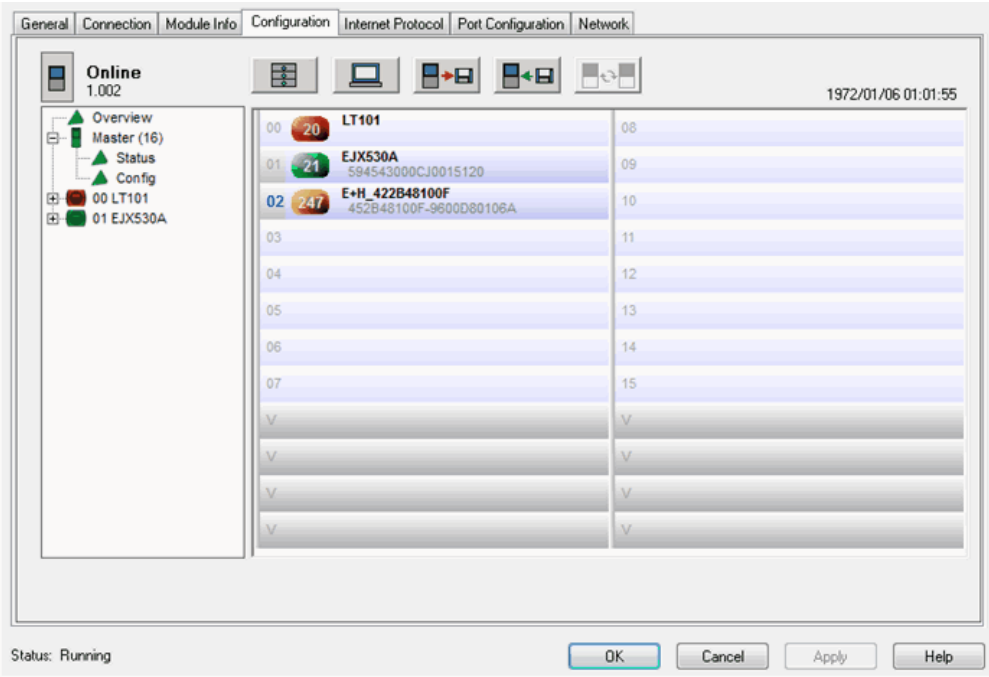
IMPORT- Complete the following procedure on the Configuration tab of the Add-On Profile's Master Configuration dialog box.

On the Configuration tab, if a field device is lost, such as LT101 in the example, the device is red in the AOP overview, and the Live and ConnectionStatus bit is cleared.



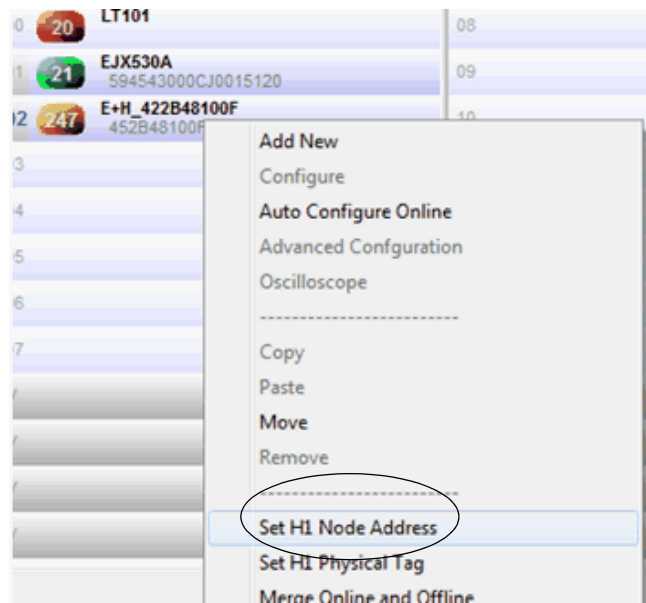
+	FFR:IA.Master.MasterMode	0
-	FFR:IA.Master.RedundantMediaOK	0
+	FFR:IA.Master.ConnectionStatus	2#0000_0000_0000_0000_0000_0000_0000_0000
-	FFR:IA.FieldDevice00	{...}
+	FFR:IA.FieldDevice00.FFNode	20
-	FFR:IA.FieldDevice00.Allocate	1
-	FFR:IA.FieldDevice00.Compel	1
-	FFR:IA.FieldDevice00.Live	0

When you add the new field device, it appears in the Live List as an unconfigured field device.



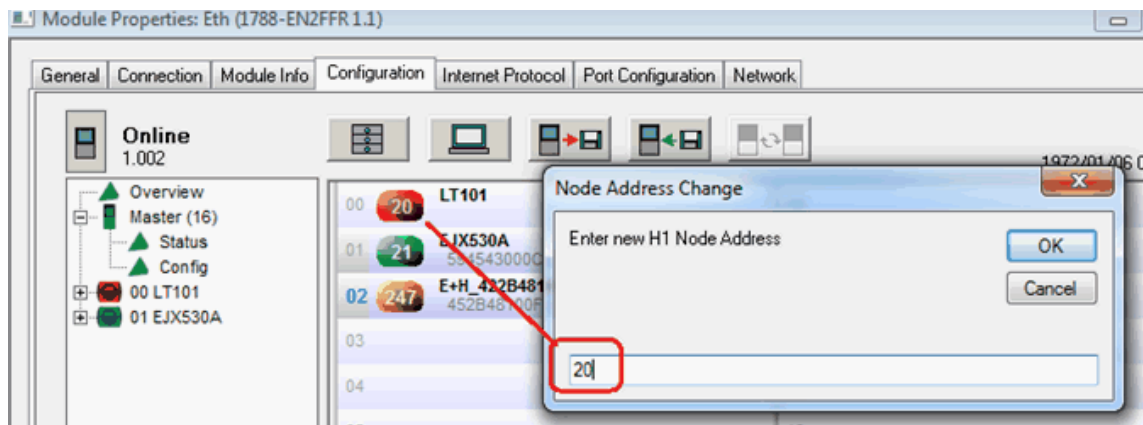
The new field device tag name and node number must be changed to the same as the configured device in the Live List, for example, tag name 'LT101', Node: 20.

1. Right-click the new field device and choose Set H1 Node Address.

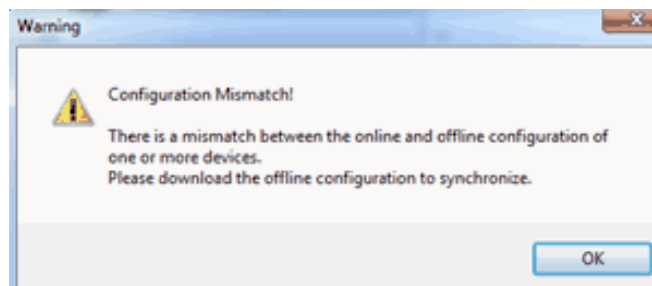


The Node Address Change dialog box appears.

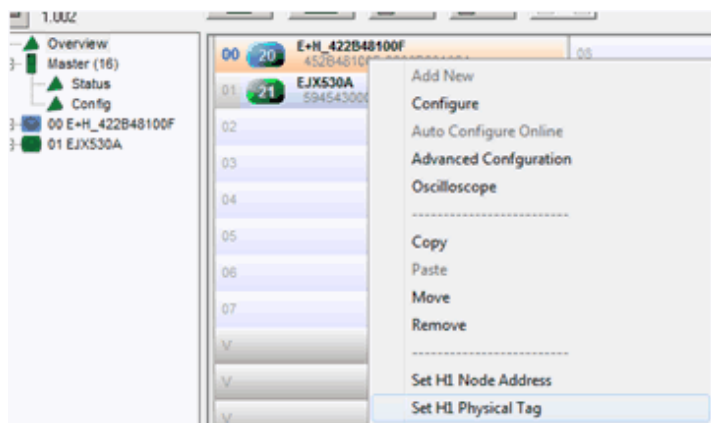
2. Type the same node address as the offline configuration, for example 20.



A warning message appears if there is a mismatch in the configuration. The tag name does not match for the online and offline devices.



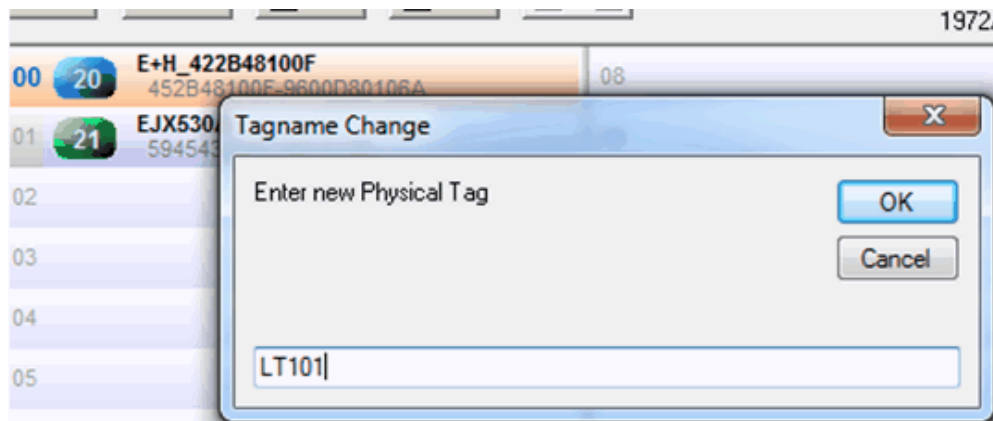
IMPORT- The tag name in the Live List is the name of the online device and not the offline configuration. Right-click the device and choose Configure to view the offline tag name in the function block view.



The background colors in the above example indicate the following:

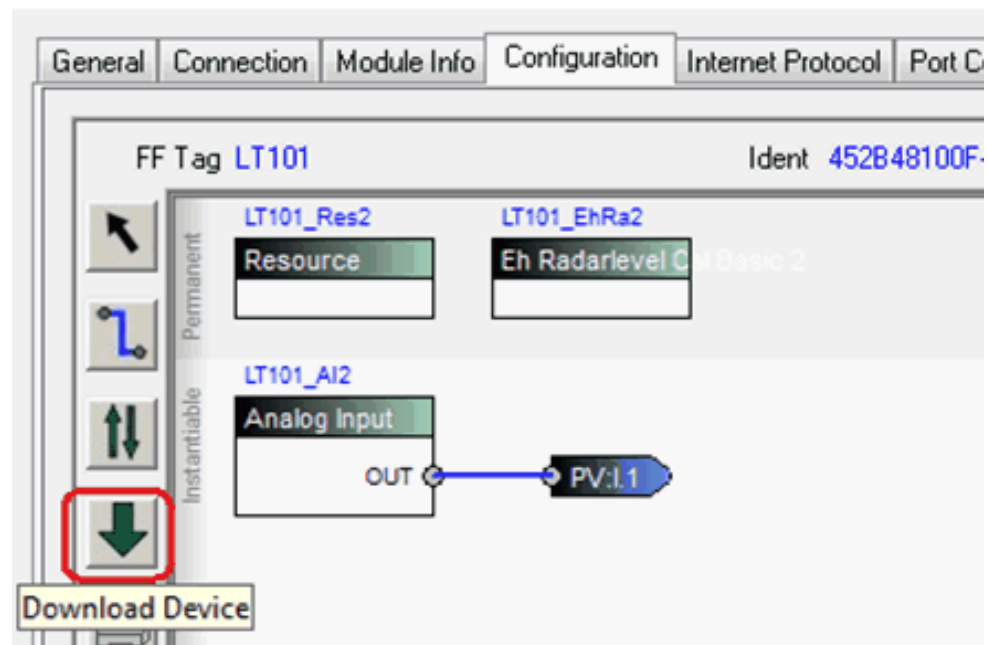
- Light blue icon on the field device means the device has a different Ident.
 - Orange background shows a mismatch in the configuration, either a tag name or node address.
3. To change the tag name, right-click the device and choose H1 Physical Tag.

The Tagname Change dialog box appears.



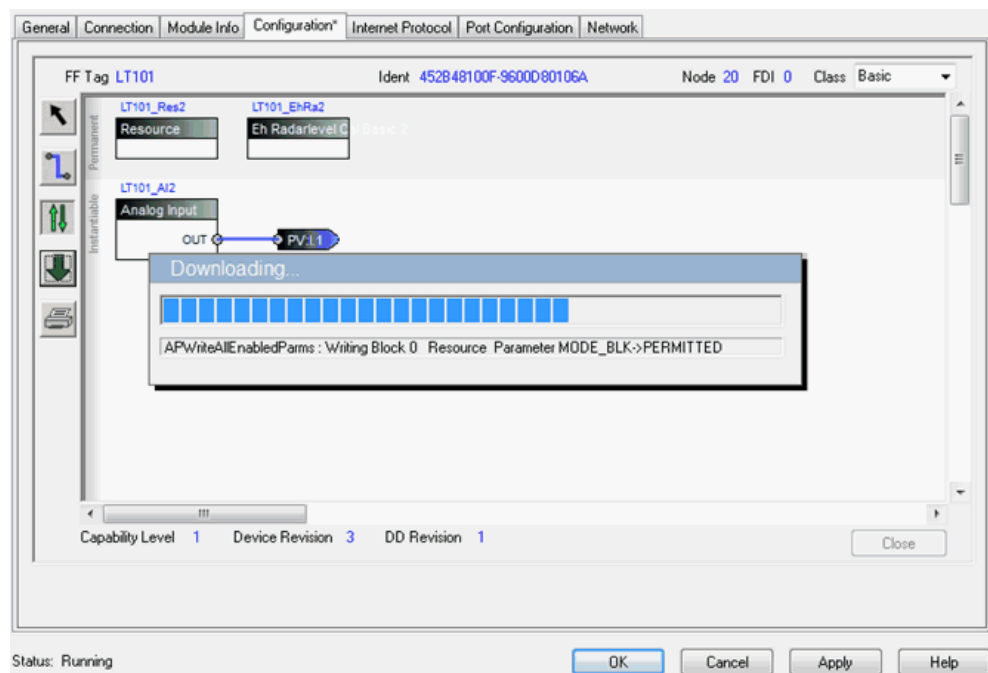
4. Type the tag name of the offline configuration.
5. To download the offline configuration to the new field device, right-click the device and choose Configure.

The function block view appears.



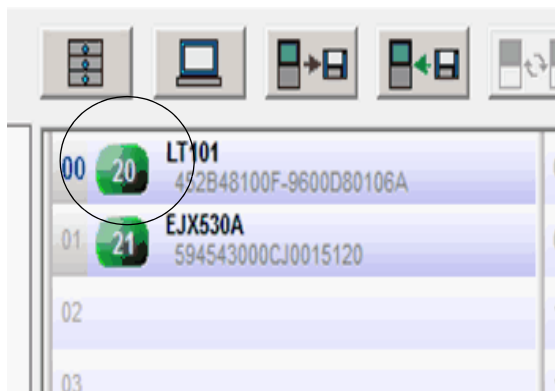
6. Click the Download icon as shown in the example.

The offline configuration download begins to the field device.



7. Click OK to complete the download.

The replacement field device is ready to run.

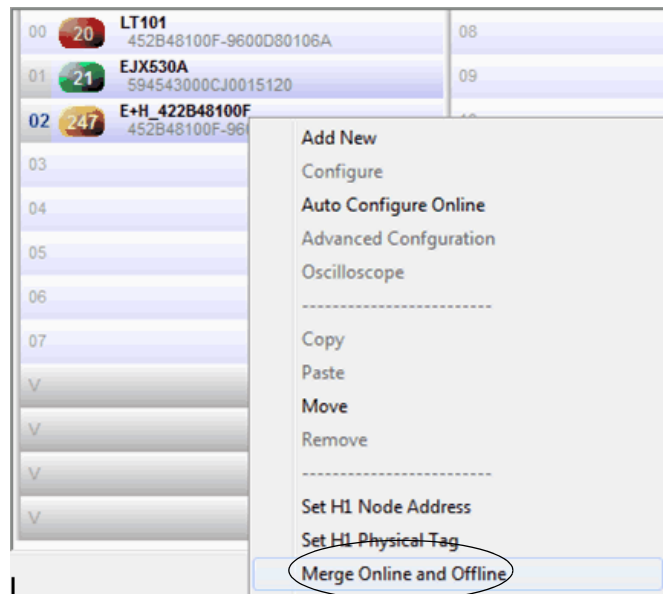


Automatic Replacement Configuration

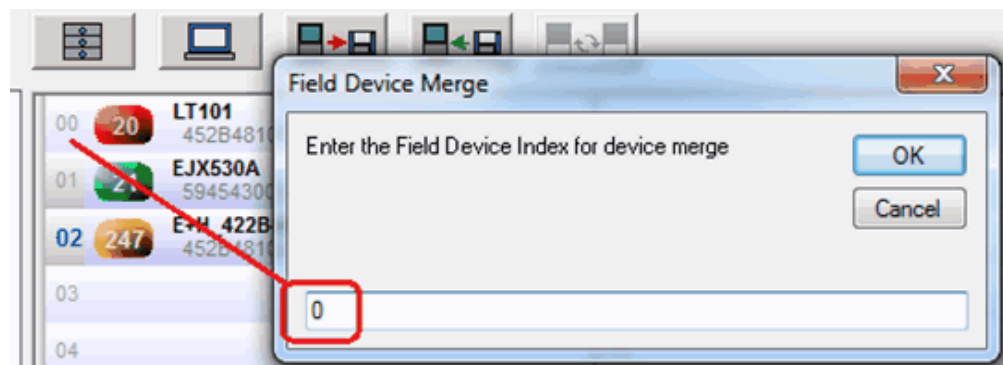
Complete these steps to automatically replace a device from the same vendor with the same DD and device revisions. You also need the same catalog number of the device that is being replaced.

IMPORT- Complete the following procedure on the Configuration tab of the Add-On Profile's Master Configuration dialog box.

1. On the Configuration tab, right-click the new device in the Live List and choose Merge Online and Offline.



The Field Device Merge dialog box appears.

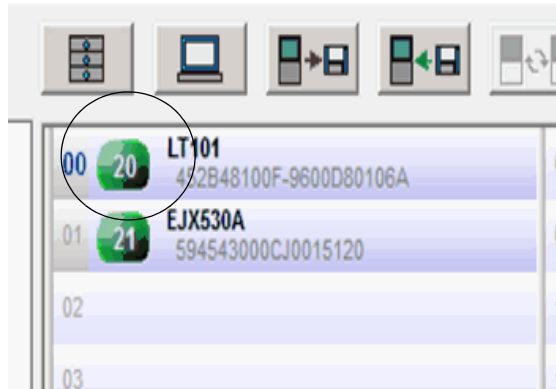


2. Type the Field Device Index (FDI), which is the number 00...15 in the Live List and Logix input and output assemblies.
3. Click OK.

The tag name and node address are automatically downloaded to that of the offline configuration.

4. Click OK to complete the download.

The replacement field device is ready to run.



Scenario 2: Same Vendor with Different DD Revision and Device Revision

Some field devices allow older revisions of the DD files to operate with the newer field devices. You can simply follow the Manual or Automatic procedures in Scenario 1. If you cannot use the older revision of the DD files, you must remove the offline configuration and add the newer DD file and regenerate the offline configuration. You can then follow the Manual or Automatic procedures for device replacement in Scenario 1.

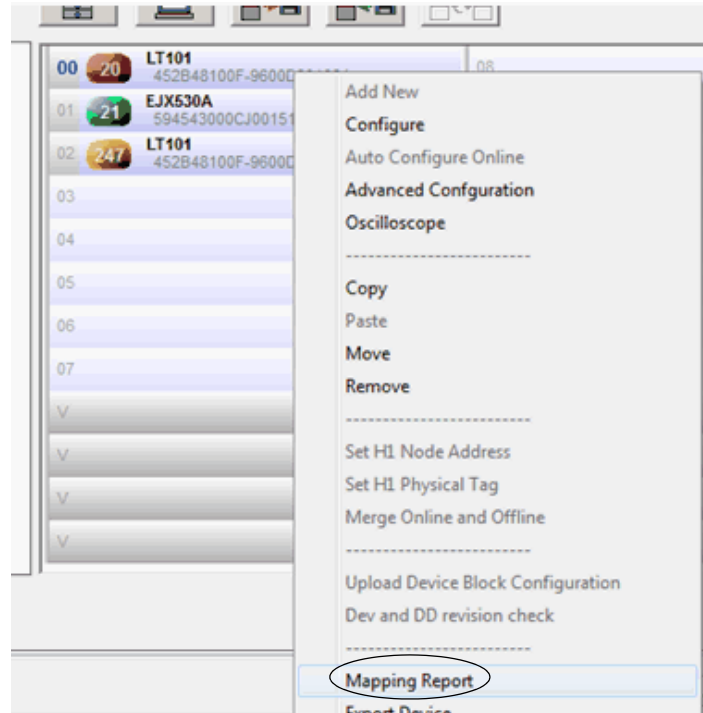
To export and import device configurations can be a time-consuming task. Complete the following actions to help speed up the process.

Generate the Field Device Mapping Report

Prior to removing the current device, you can create a report with a list of changed parameters and values. Reviewing the list of changed parameters and their values helps you determine what needs to change in the new configuration.

IMPORT- Complete the following procedure on the Configuration tab of the Add-On Profile's Master Configuration dialog box.

1. On the Live List, right-click the offline field device and choose Mapping Report.



The Field Device Mapping Report appears.

Field Device Mapping Report

Close Save Print

Source	Blocks	Parameters
Resource - Enabled Block Parameters		
Parameter	Offline Value	Online Value
TAG_DESC	LT101_Res2	
MODE_BLK	-	-
TARGET	Auto	
ACTUAL	Auto	
PERMITTED	Auto + OOS	
NORMAL	Auto	
Eh Radarlevel Cal Basic 2 - Enabled Block Parameters		
Parameter	Offline Value	Online Value
TAG_DESC	LT101_EhRa2	
MODE_BLK	-	-
TARGET	Auto	
ACTUAL	Auto	
PERMITTED	Auto + OOS	
NORMAL	Auto	
Analog Input - Enabled Block Parameters		
Parameter	Offline Value	Online Value
TAG_DESC	LT101_AI2	
MODE_BLK	-	-
TARGET	Auto	
ACTUAL	Auto	
PERMITTED	Auto + OOS	
NORMAL	Auto	
OUT	-	-
STATUS	Bad: NonSpecific: NotLimited	
VALUE	0.0	
CHANNEL	measured Value	
L_TYPE	Direct	

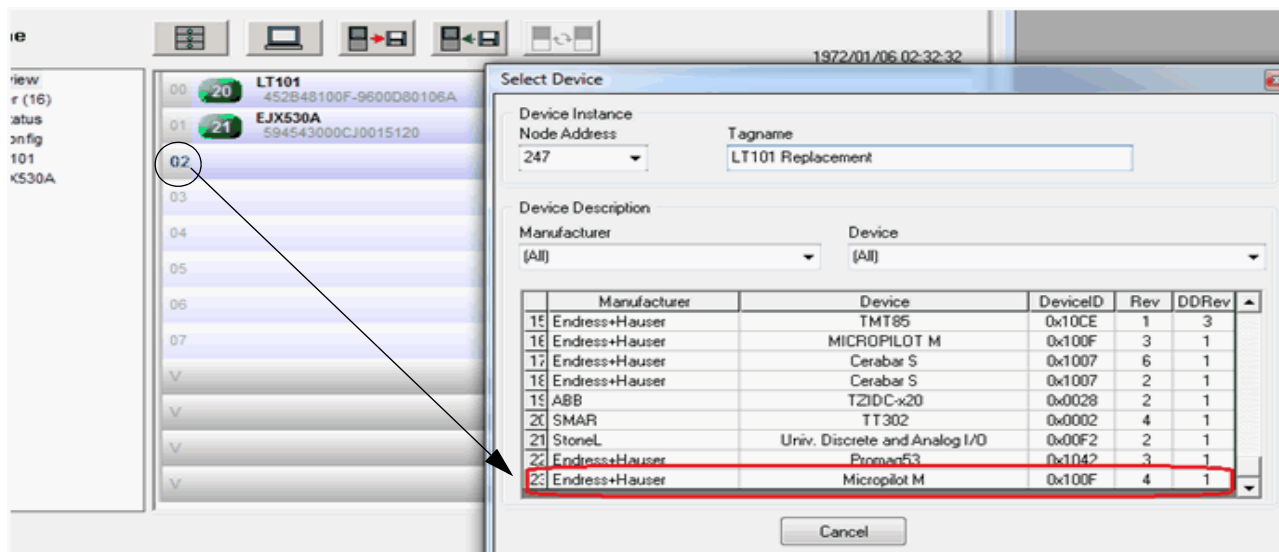
2. Click Print.

Configure the New Device Revision

This example is used to export and import device configurations. We replace an E+H Micropilot, Device Revision 3, DD Revision 1, with an E+H Micropilot, Device Revision 4, DD Revision 1. The tag name and node number must be the same when the new device replaces the old one.

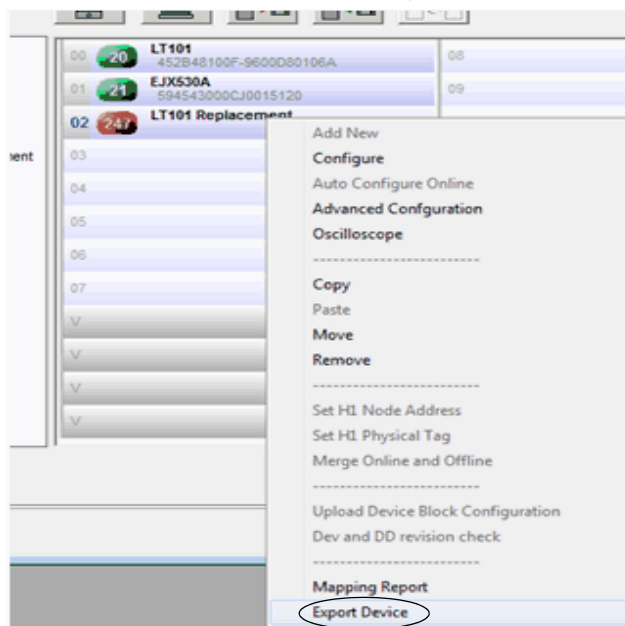
1. Once the device is added to the Live List, right-click the FDI, which is the index number to the left of the device, in the Live List.

The Select Device dialog box appears.

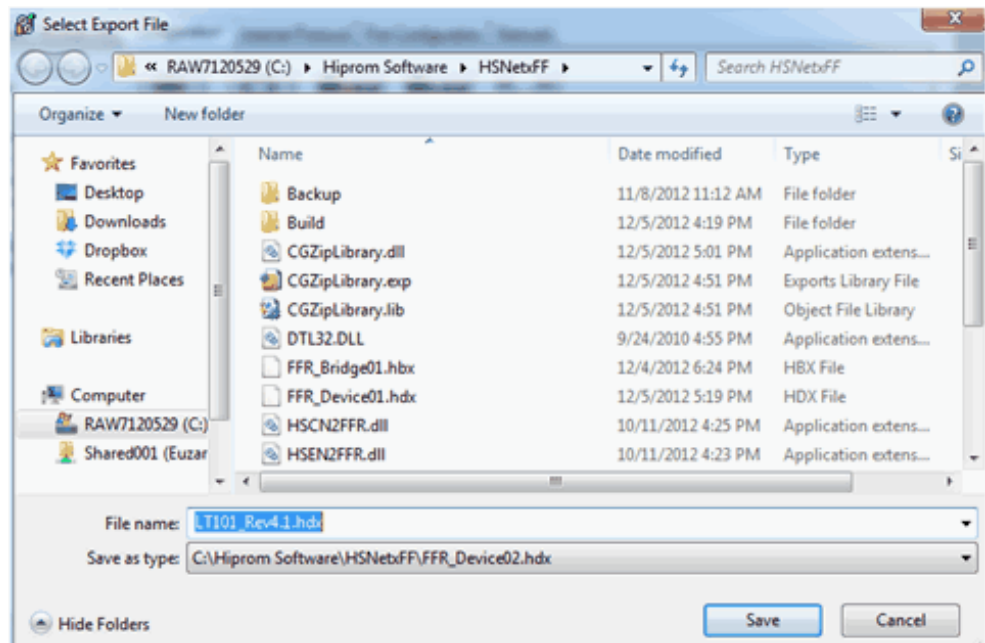


Use the Mapping Report to determine the parameters to change.

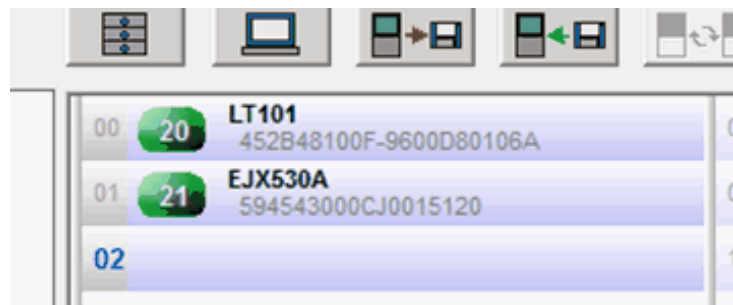
2. Right-click the new offline configuration and choose Export Device to export the field device's offline configuration for later use.



The Select Export File dialog box appears.



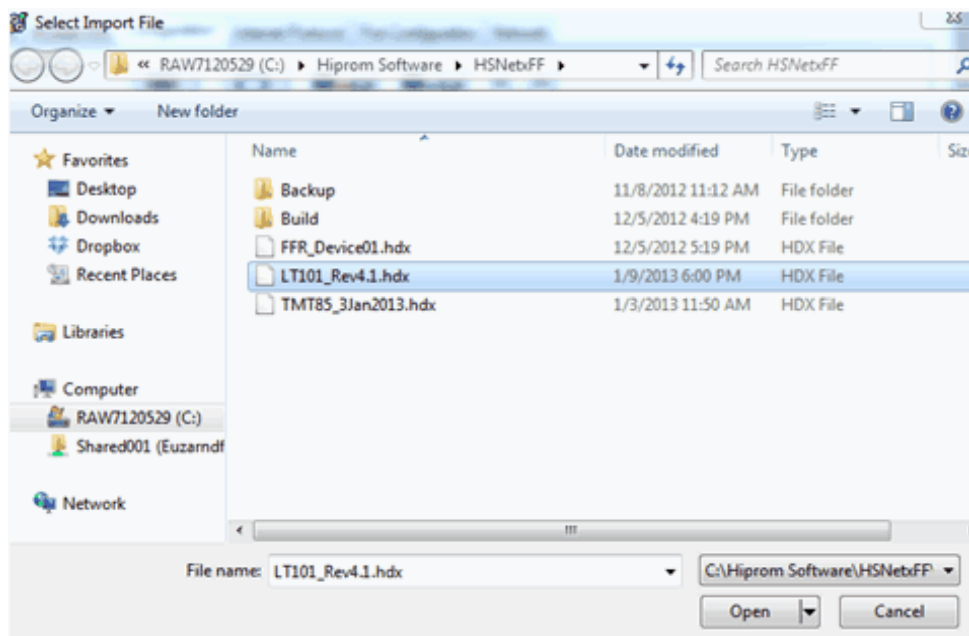
3. Type the export file name and file location.
4. Click Save.
5. Delete the new exported device from the Live List.



When the running device needs replacement, remove the old offline configuration and import the saved configuration for the new device.

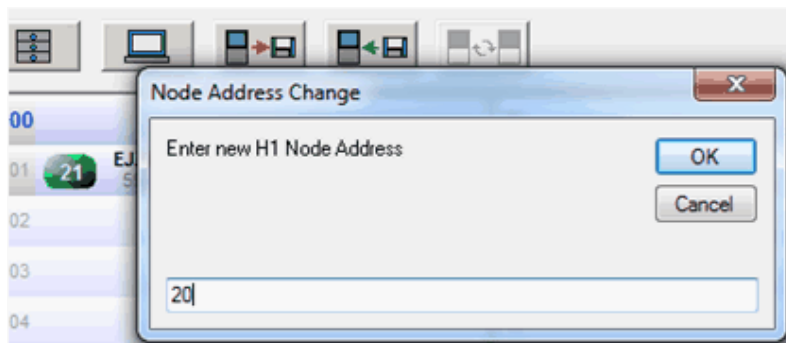
6. In the Live List, right-click the device and choose Remove.
7. In the Live List, right-click the open space and choose Import Device.

The Select Import File dialog box appears.



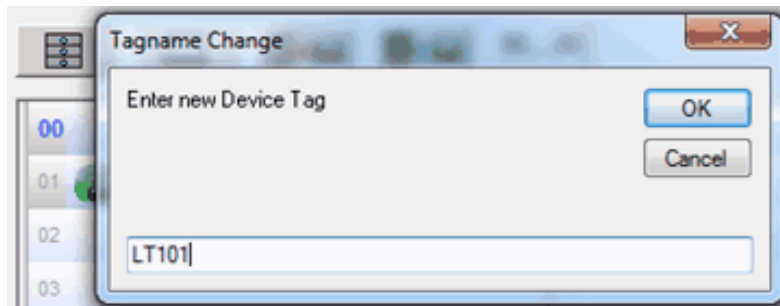
8. Select the device from the list.

The Node Address dialog box appears.



9. Type a node address and click OK.

The Tagname Change dialog box appears.



10. Type a tag name and click OK.
11. Click OK to complete the device load.

Follow the Manual or Automatic procedures in Scenario 1 for device replacement.

Scenario 3: Replace Device from Different Vendor

You must remove the offline configuration, add the newer DD file, and regenerate the offline configuration. Then, follow the Manual or Automatic device replacement procedures in Scenario 1.

We also suggest you use the procedures in Scenario 2 to complete the following tasks:

- [Generate the Field Device Mapping Report on page 57](#)
- [Configure the New Device Revision on page 59](#)

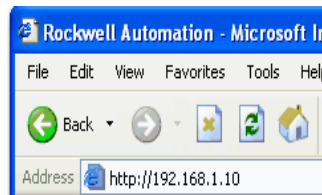
Web Pages

There are web pages available to show you the status of your devices and H1 network. The H1 Live List captures information for the traffic between the linking device and field devices.

You can assign an IP address through the BOOTP server or set a static IP address through switches. The Ethernet port of the linking device accesses module data.

1. In your Web browser, enter the IP address of the linking device and press Enter.

The IP address shown is an example.

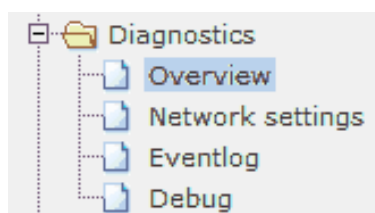
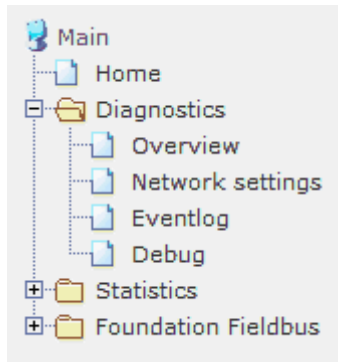


The Home page appears.

1788-EN2FFR

<p>open all close all</p> <ul style="list-style-type: none"> Main <li style="background-color: #e0e0e0;">Home Diagnostics Statistics Foundation Fieldbus 	<div style="background-color: #cc0000; color: white; text-align: center; padding: 2px; font-weight: bold;">HOME</div> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="border-bottom: 1px solid #ccc;">Device Name</td><td style="border-bottom: 1px solid #ccc;">1788-EN2FFR/B</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">Device Description</td><td style="border-bottom: 1px solid #ccc;">Foundation Fieldbus</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">Ethernet MAC Address</td><td style="border-bottom: 1px solid #ccc;">00:60:35:16:A5:F6</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">IP Address</td><td style="border-bottom: 1px solid #ccc;">192.168.1.120</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">Hardware Revision</td><td style="border-bottom: 1px solid #ccc;">Rev 9.4</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">Firmware Revision</td><td style="border-bottom: 1px solid #ccc;">Rev 1.01.13</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">Serial Number</td><td style="border-bottom: 1px solid #ccc;">3516A5F6</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">Status</td><td style="border-bottom: 1px solid #ccc;">Ok</td></tr> <tr><td style="border-bottom: 1px solid #ccc;">Uptime</td><td style="border-bottom: 1px solid #ccc;">0 days 1h 58m 15s</td></tr> </table>	Device Name	1788-EN2FFR/B	Device Description	Foundation Fieldbus	Ethernet MAC Address	00:60:35:16:A5:F6	IP Address	192.168.1.120	Hardware Revision	Rev 9.4	Firmware Revision	Rev 1.01.13	Serial Number	3516A5F6	Status	Ok	Uptime	0 days 1h 58m 15s
Device Name	1788-EN2FFR/B																		
Device Description	Foundation Fieldbus																		
Ethernet MAC Address	00:60:35:16:A5:F6																		
IP Address	192.168.1.120																		
Hardware Revision	Rev 9.4																		
Firmware Revision	Rev 1.01.13																		
Serial Number	3516A5F6																		
Status	Ok																		
Uptime	0 days 1h 58m 15s																		

You navigate the web pages by using the navigation panel on the left side of the Home page.



Diagnostics

The Diagnostic pages include the network and event logs. To access the respective web page, click the page title in the left pane.

Figure 15 - Diagnostics Overview Page

OVERVIEW	
Web Server	
Page Hits	2
TCP Connections	
TCP Client Count	0
Maximum Clients Supported	100
Foundation Fieldbus	
Configured field device count	1
Unconfigured field device count	0
Status	Ok
Overall success rate	100
Field device index 0	Running (producing data)
Field device index 1	N/A
Field device index 2	N/A
Field device index 3	N/A
Field device index 4	N/A
Field device index 5	N/A
Field device index 6	N/A
Field device index 7	N/A
Field device index 8	N/A
Field device index 9	N/A

Figure 16 - Network Settings Page

Network Settings	
Network	
IP Address	192.168.1.120
Subnet Mask	255.255.255.0
Default Gateway	0.0.0.0
BOOTP Active	False
IGMP Active	False
Configuration	
Auto Negotiation Status	True
Speed	100 Mbps
Duplex	Full Duplex
Switches	1 : 2 : 0

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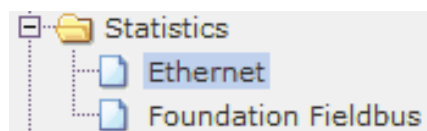
Figure 17 - Event Log Page

EVENT LOG	
Event	Time
Tag : EH_Cerabar S-XXXXXXXXXXXXXXXXXX	0 days 0h 0m 29s
Ident : 452B481007-XXXXXXXXXXXXXXXXXX	0 days 0h 0m 29s
Device Found: 0x1A	0 days 0h 0m 28s
H1 ring recovered	0 days 0h 0m 1s
Reset tripped bus B	0 days 0h 0m 0s
Reset tripped bus A	0 days 0h 0m 0s
Module Powerup	0 days 0h 0m 0s
Update Master config: topology 4	20358 days 22h 44m 41s

Figure 18 - Debug Page

DEBUG	
4	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0

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Statistics

The Statistics pages show data for the port communication traffic and fieldbus. To access the respective web page, click the page title in the left pane.

Figure 19 - Ethernet Stats Page

ETHERNET STATS	
Port 1	
Multicast and Broadcast Frames Received Without Errors	
Unicast Frames Received Without Errors	
Received Byte Count Without Errors	
Large Frames Received	
Alignment Error Frames Received	
Frame Check Sequence Error Frames Received	
Other Error Frames Received	
Multicast and Broadcast Frames Transmitted without Errors	
Unicast Frames Transmitted without Errors	
Transmitted Byte Count Without Errors	
Frames Transmitted After One Collision in Half-Duplex Mode	
Frames Transmitted After More Than One Collision in Half-Duplex Mode	
Frames Dropped After Excessive Collisions in Half-Duplex Mode	
Frames Truncated Without Error During Transmission	
Port 2	
Multicast and Broadcast Frames Received Without Errors	
Unicast Frames Received Without Errors	
Received Byte Count Without Errors	
Large Frames Received	
Alignment Error Frames Received	

Figure 20 - Foundation Fieldbus Statistics Page

FOUNDATION FIELDBUS - Statistics		
General		
Total Packets Sent		481119
Total Packets Received		124763
Total CRC error Packets Received		0
Total No-Replies Count		116279
Pass Token		232068
Return Token		229990
Probe Node		116275
Probe Response		1
Compel Data		8969
Data Transfer 1		3624
Data Transfer 2		0
Data Transfer 3		8969
Data Transfer 4		0
Data Transfer 5		0
Time Distribution		904
Claim LAS		2
Establish Connection		19
Disconnect Connection		0
Copyright © 2011 Hiprom Technologies, Inc. All Rights Reserved.		



Device Statistics

The Device Statistics pages show information on the linking device on the H1 network and the individual field devices connected to the master.

Figure 21 - Linking Device Statistics Page

FOUNDATION FIELDBUS - H1 Master	
General	
Tag	1788-EN2FFR
Ident	1788-EN2FFR_3516-A5F6
Node Address	16
Status	Ok
Logix Owned	False
PA Bus A Enabled	True
PA Bus B Enabled	True
PA Bus A Tripped	False
PA Bus B Tripped	False
PA Bus A Terminated	True
PA Bus B Terminated	True
Multi-master Mode	False
Primary Linking Device	True
MacroCycle	1000ms
Diagnostics	
External Voltage	24.11 V
PA Bus A Voltage	20.56 V
PA Bus B Voltage	20.46 V
PA Bus A Current	67.68 mA
PA Bus B Current	79.20 mA

Figure 22 - Field Device Statistics Page

FOUNDATION FIELDBUS - Field Device	
General	
Tag	EH_Cerabar S-XXXXXXXXXXXXXXXXXX
Ident	452B481007-XXXXXXXXXXXXXXXXXX
Node Address	26
Status	Ok
Allocated	True
Compel	True
Live	True
Input Process Variables	
PV 1	0.2666
PV 2	0.0000
PV 3	0.0000
PV 4	0.0000
PV 5	0.0000
PV 6	0.0000
PV 7	0.0000
PV 8	0.0000
Input Process Variable Status	
PV 1 Status	0x80
PV 2 Status	0x00
PV 3 Status	0x00
PV 4 Status	0x00

Advanced Diagnostics

The Pepperl+Fuchs Advanced Diagnostic Module is a tool that analyzes a fieldbus network. The module lets you troubleshoot for ground faults, faulty or noisy field devices, and other potential anomalies to help prevent network downtime.

The ADM module can check segments during a Factory Acceptance Test (F.A.T.) or during startup.

Other equipment, such as a valve positioner from Westlock Controls, provide precise and repeatable feedback for predictive maintenance.

Diagnostic Blocks

There also are field devices that have diagnostic function blocks that can show the status of the transmitters. Fieldbus standards define the type and format of the diagnostic data, however, how this information is processed by a controller is vendor-specific. Check the manufacturers' support documentation to gauge whether the diagnostic function blocks can be used.

Network Checklist

A segment testing form, per FOUNDATION Fieldbus guidelines, must be completed for checking out and commissioning a segment. The installation of wiring shall be carried out according to the procedure below and requires the completion of the field wiring (trunk and spurs) before the trunk wiring is connected to the FOUNDATION Fieldbus power supply.

These steps must be followed with the testing checklist, which is shown in [Table 5 on page 69](#).

1. Install trunk cables, making sure that cable tags are installed.
2. Check wiring for the proper color code.
3. Tag and terminate the trunk cable in the field junction box.
4. Tag and terminate the trunk (segment) wiring at the fieldbus power supply plug, but **do not plug into the fieldbus power supply at this time**.

The segment is powered up after step 1 in [Table 5 on page 69](#) is complete.

Do not connect the trunk cables to the fieldbus power supplies until all devices on the segment have been properly terminated.

5. Perform the resistance tests for each segment according to step 1 in [Table 5 on page 69](#).

IMPORT- [Table 5 on page 69](#) is applicable to nonisolated couplers. If isolated couplers are being used, a separate procedure is necessary to test the associated FOUNDATION Fieldbus segments. See [step 10](#) below for instruction.

6. Power up the segment by plugging the segment into the fieldbus power supply, see step 2 in [Table 5 on page 69](#).
7. Log the shield to ground bus bar resistance.

Be careful that no signal conductor becomes grounded because the system is now powered.

8. Capture the segment diagnostic files with clip-on segment test tools (for example, a Pepperl+Fuchs tester, FBT-6, and so forth) per step 3 in [Table 5 on page 69](#).
9. Save the diagnostic files and combine them into a master document as a deliverable record.
10. For segments with isolated couplers, repeat [step 6](#) and [step 8](#) for each spur before proceeding with these instructions.
11. Capture segment trace files with clip-on segment test tools (optional per project) per step 4 in [Table 5 on page 69](#).
12. Save the segment trace files and combine them into a master document as a deliverable record.

Table 5 - Fieldbus Segment Commissioning Form⁽¹⁾

Company		
Location		
Unit		
Segment No.		
Date		
Step 1: This testing is performed before the segment is plugged into the power conditioner.		
■ (+) to (-)	Expected > 50 k Ω	Actual =
■ (+) to shield	Expected > 20 M Ω	Actual =
■ (-) to shield	Expected > 20 M Ω	Actual =
■ (+) to ground	Expected > 20 M Ω	Actual =
■ (-) to ground	Expected > 20 M Ω	Actual =
■ shield to ground	Expected > 20 M Ω	Actual =
Step 2: Plug the segment into the power conditioner.		
■ Shield to ground	Expected < 1 Ω	Actual =
Step 3: Clip a FBT-6 or P&F tester onto the segment and capture the segment diagnostics file.		
Segment Diagnostic File		
Date		
Technician		
Step 4: Optionally capture a segment trace file with an oscilloscope.⁽²⁾		
Segment Trace File		
Date		
Technician		

(1) This form is for nonisolated couplers or trunks only on segments with isolated couplers (for spurs on segments with isolated couplers repeat the test for each spur).

(2) Segment trace files are retained for historical reference to aid in troubleshooting. They are not intended for segment acceptance. Segment acceptance is primarily based on conformance to the measurement requirements.

Notes:

Troubleshooting

This chapter offers troubleshooting tips.

The table explains the topics discussed in this chapter.

Topic	Page
Manufacturer's Documentation	71
Signal Anomalies	71
Shielding Options	74

Manufacturer's Documentation

Most manufacturers of fieldbus devices and components offer product-specific support documentation in some form, whether it be online or in print. When experiencing difficulties with these elements, we recommend that you use the specific documentation provided by individual manufacturers.

Signal Anomalies

Poor signal quality can inhibit the optimization of your fieldbus network. [Table 6](#) describes a list of common causes for poor signal quality.

Table 6 - Poor Signal Causes/Results

Cause of Poor Signal	Result
Wrong type of cable	Can attenuate the signal below the low AC cutoff limits. Also, this could lead to cable length being too long.
H1 segment too long	Tends to attenuate the signal below the low AC cutoff limit by inducing inductance. Also, the length, along with the number of devices, can create a power anomaly.
Missing terminators	Causes ringing, which enlarges the signal outside the high AC cutoff limits.
Grounded /shorted signal wires	Causes the signal to be 0V.
Bad terminator or junction block	Can ground/short/load the signal, which causes the signal to be low or 0V.
Improper shielding	Causes shorts with signal wire, which causes the signal to be 0V. Dressing shields with heat-shrink tubing prevents this situation.
Bad device or transmitter	Causes short or load down the H1 segment.
Bad connectors	Can drop transmitters off the H1 network intermittently or permanently.
Too many devices	Drawing too much current reduces the voltage below 9V DC because the power supply or power conditioner cannot supply enough power to the H1. Also results in small power dips from the AC supply. Ideally, keep the system at 11...12V DC at the lowest so that there is some safety margin for the devices in the event of a poor power condition.
Improperly specified power supply	Can shut down devices or damage them. Make sure your power supply provides only 32V DC out of the conditioner output terminals.
Noisy power supply	Causes data loss and reset of devices when the low 9V DC cutoff is reached.

An oscilloscope is used to determine the quality of a signal. We recommend that the scope be differential or battery-operated to avoid grounding one side of the network through the scope probe. Use probes that have at least 1 M Ω input resistance and less than 1000 pf input capacitance.⁽¹⁾

Wiring Guidelines

Review these wiring guidelines to make sure instruments are operating properly and without signal loss:⁽²⁾

- No splices or wire nuts are allowed in instrumentation wiring circuits. Wiring terminations shall be made at terminal strips.
- We recommend that when pre-molded cable is used, protect coupler and fieldbus device ports with temporary plastic plugs to the cable installation to prevent damage due to water, sand, dirt, and so forth.
- Do not install spurs until both the coupler and the field device are installed.
- We recommend the minimum cable bend radius not be exceeded for all installations. Excess wire that occurs with pre-terminated fieldbus cables can be coiled. Tie wraps can be used to secure the excess cable. Be careful not to pinch the wire with the cable tie.
- Install individual cables to the field instruments. Complete wire tagging and wire terminations for these individual cables.
- The use of heat shrinkable tubing instead of tape is the preferred method for isolating the shield wire terminations.

Cable Checkout

The cable must comply with these requirements:

- These ratings apply for UL certification:
 - Instrument Tray cable (ITC)
 - Power Limited Tray Cable (PLTC)
 - Tray Cable (TC)
 - Metal Clad Cable (MC or MC-HL)
- Operating temperature range: -30...90 °C (-22...194 °F), min
- Characteristic impedance of each twisted pair: 100 \pm 20 Ω
Characteristic impedance is determined by any one of the methods described in ASTM D4566-05 or equivalent international standard at 31.25 kHz.
- Signal attenuation of each twisted pair: 3.0 dB/km at 39 kHz, max
- Minimum trunk wire-pair size has a maximum resistance of 23.5 Ω /km at 20 °C (68 °F) (18 AWG) per conductor

(1)Fieldbus Foundation Wiring and Installation Application Guide, publication [AG-140](#).

(2) FOUNDATION Fieldbus System Engineering Guidelines (8.5.1).

- Minimum spur wire-pair size has a maximum resistance of $59.4\ \Omega/\text{km}$ at $20\ ^\circ\text{C}$ ($68\ ^\circ\text{F}$) (22 AWG) per conductor

Network and Segment Checkout

With segment wiring in place and tested for correctness, commissioning of the devices can begin.

The methods for commissioning the field devices can vary with the host system being used. Once connected to the segment with system power available and the LAS running, the device can be ‘assigned’ to its permanent node address.

The device also requires a combination of uploading information, which is unique to the device and to the host system database, and then downloading preconfigured information from the host system database to the device. The methods for data reconciliation vary with the host system being used.

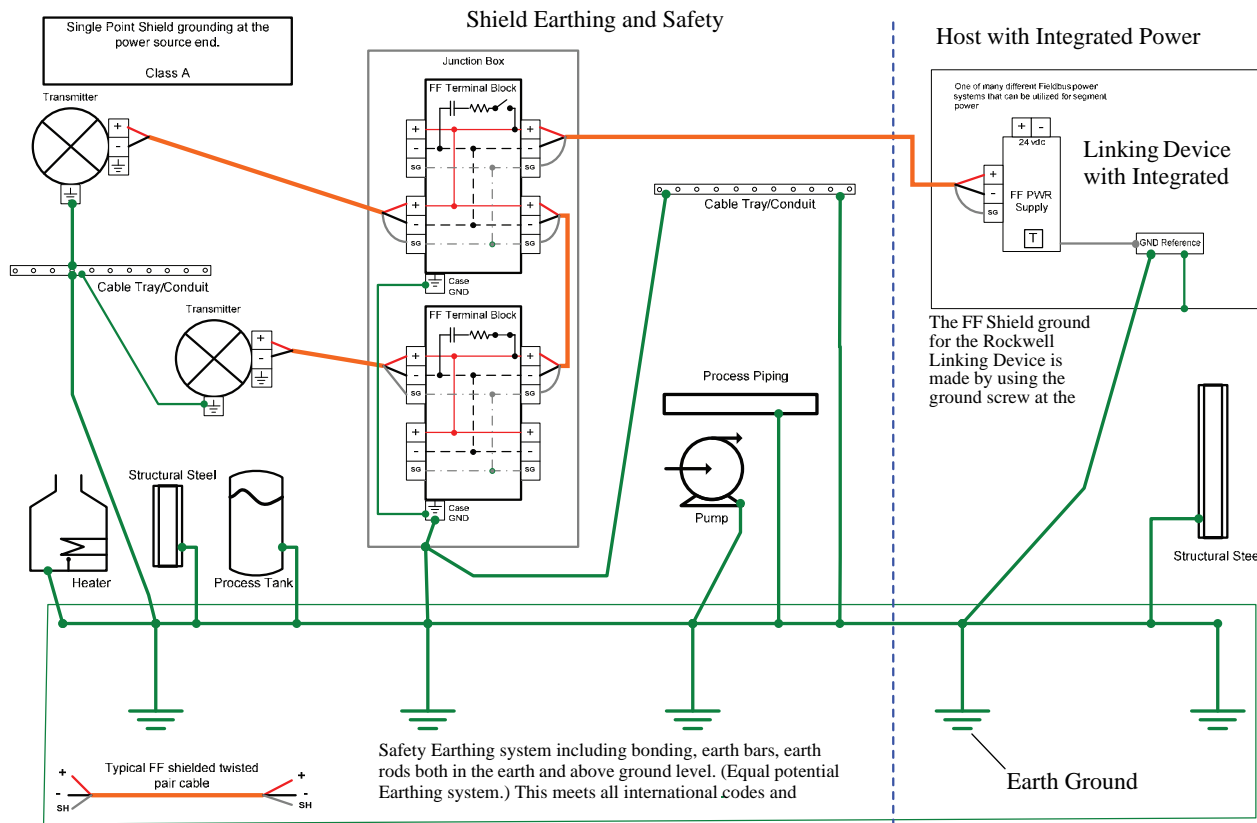
Be careful that data is not overwritten inadvertently. With these procedures completed, the device is ready for ‘loop-checking’.

IMPORT- Segments often contain multiple loops, and because of this, it is advisable to have all field devices either permanently wired or make provisions to be sure that testing in stages does not compromise portions of the segment that have been ‘loop checked’.

Shielding Options

Use shielded fieldbus cable to reduce or eliminate electromagnetic noise. The illustrations in the following pages show the shielding types (Class A...D). Class A (shown in [Figure 23](#)) is recommended in most plants, but check with an electrical engineer for safety considerations. Some regions, such as Europe, prefer using Class B design in areas where equipotential grounding is assured.

Figure 23 - Class A - Single-point Shielding



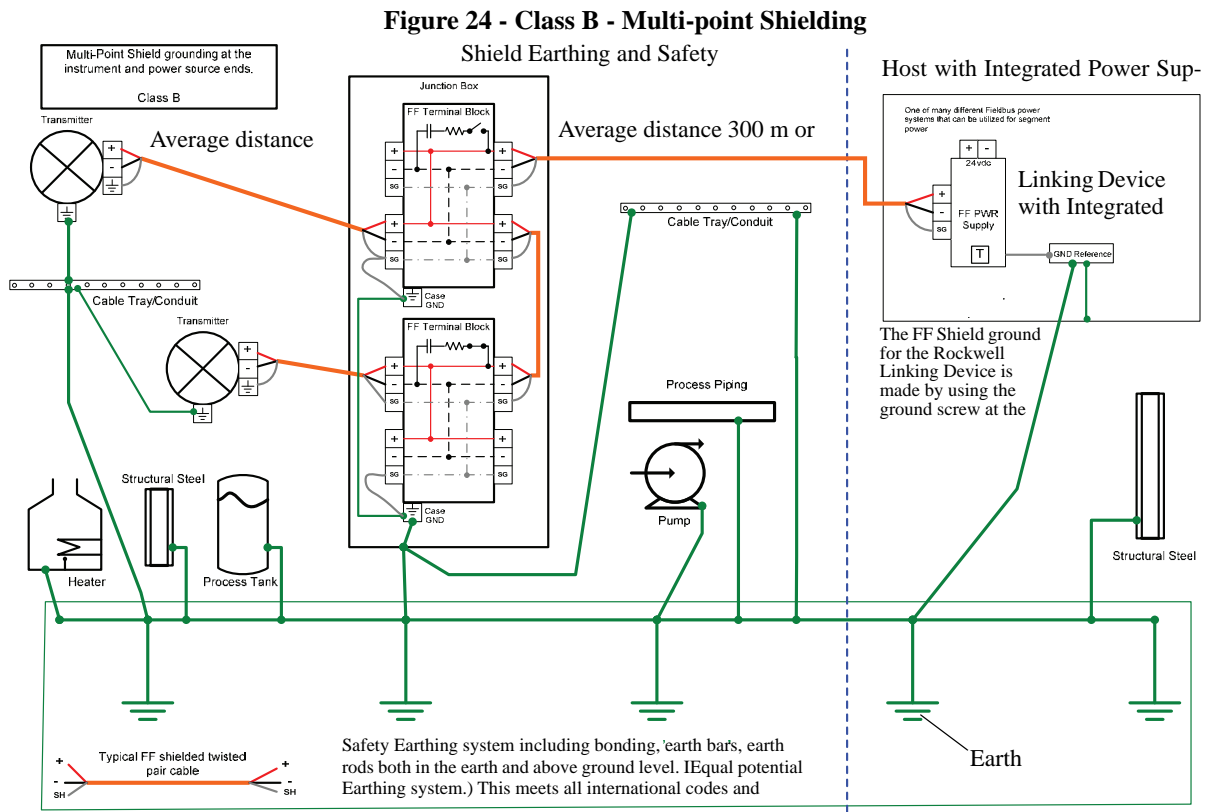
45293

Single-point shielding (Class A) requires that the shield be connected to ground at only one location on a segment. IEC 61158-2⁽¹⁾ recommends single-point shielding installation. The cable shield is usually connected to the common system referencing ground (GND Reference) through the fieldbus power supply.

The advantages to this type of installation include the following:

- Protection against interference frequencies up to a few megahertz.
- Protection against lightning, by separating the cable shield and plant grounding the equalizing currents cannot flow over the cable shield.
- EMC protection by laying the fieldbus cable in a steel pipe (conduit) or armored cable that acts as an additional Faraday shield.

(1) FOUNDATION Fieldbus System Engineering Guidelines (7.3.4).



45301

Multi-point shielding (Class B) provides the greatest degree of protection against electromagnetic interference, similar to conduit or armored cable, in the upper frequency range even for interferences that are above several megahertz.

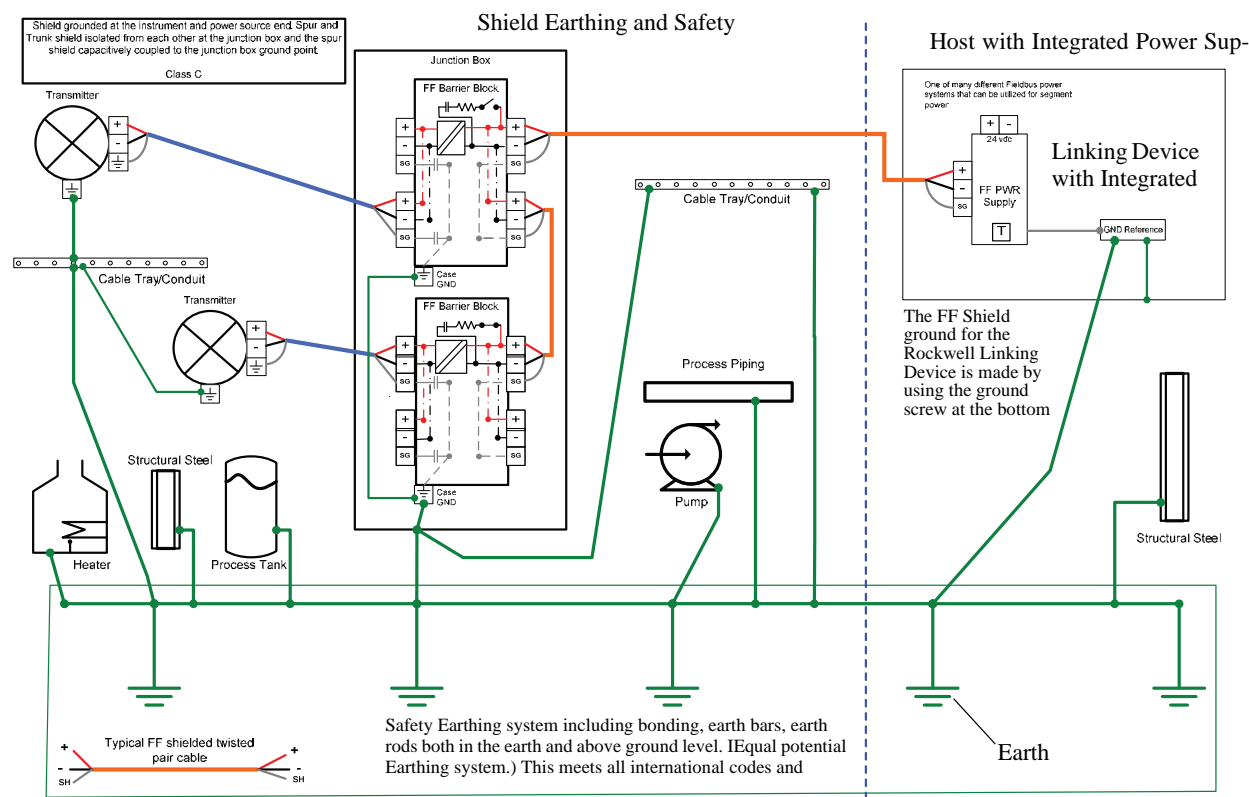
All the instrument and cable shields of the bus cable are grounded locally, which, in turn, has to be grounded in the safe area for installations in hazardous areas. Multi-point grounding provides optimal protection from a single-noise source at any location.

In accordance with IEC 60079-13⁽¹⁾, Class B shielding can be used if the installation provides a high degree of safety with potential matching. Under these conditions, this grounding method meets the requirements of hazardous area installation rules.

The disadvantages for this type of installation include the following:

- The shield becomes a current-carrying conductor and induces noise into the network if there is poor equipotential ground.
- Multi-point grounding provides a direct connection for lightning surges back to the control room through the signal and shield wires and can require special attention.

(1) FOUNDATION Fieldbus System Engineering Guidelines (7.3.4).

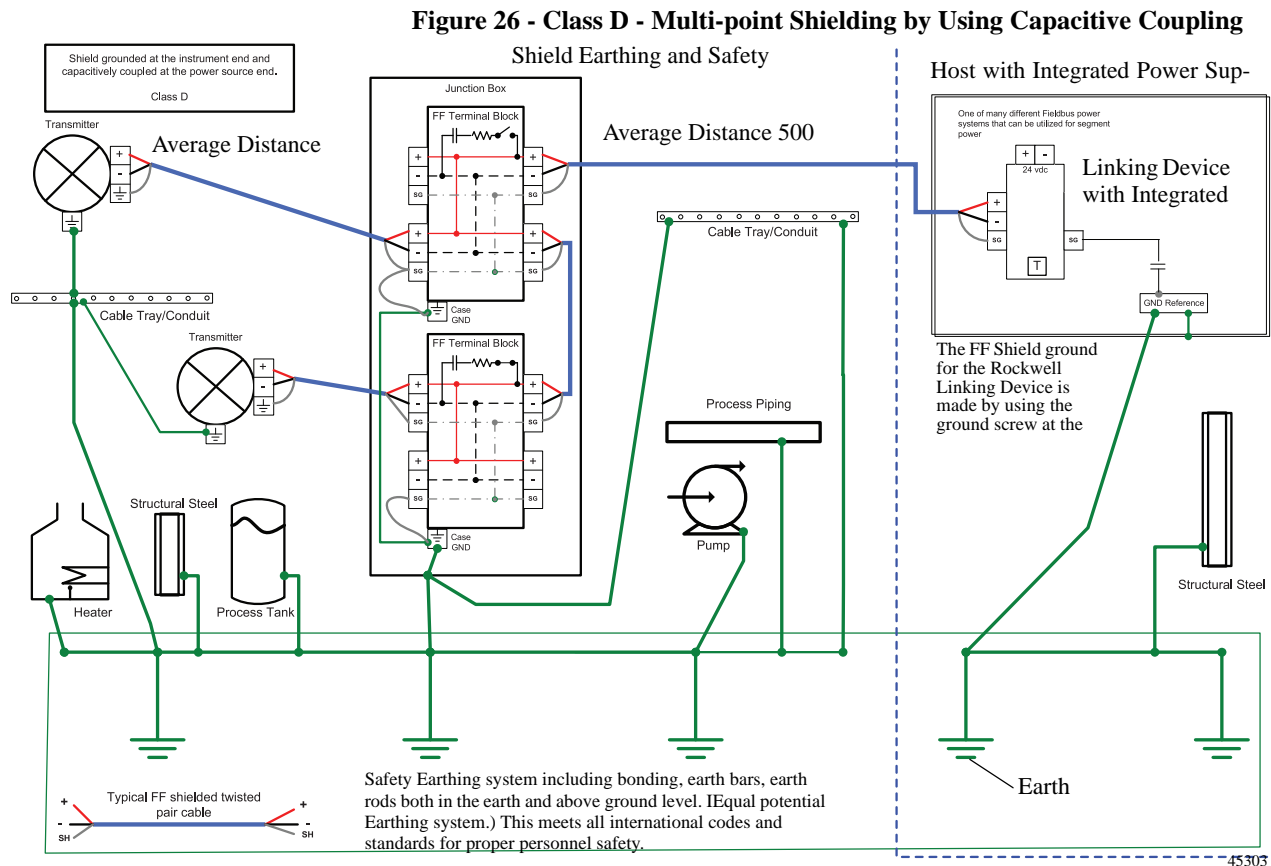
Figure 25 - Class C - Shielding by Using Isolating Device Couplers

45302

Class C shielding is a combination of topologies from Class A (single) and Class B (multi-point), with signal isolation in the field junction box. The mixed topology breaks up paths for ground circulation currents and surges that can exist in the Class B topology.

In this concept, the shield of the trunk segment from the control room to the field junction boxes is connected to ground at a single location, typically at the fieldbus power supply. At the junction box, we recommend that the trunk shield be continuous if multiple isolated device couplers are used; but do not connect the trunk shield to ground at the junction box.

On the field side, the shield is connected both at the instrument and connected at the isolated device coupler. This topology is common in hazardous areas that involve a mixture of increased safety and intrinsic safety and moves the barrier into the junction box to provide a maximum number of devices for the segment. The trunk side maintains all of the benefits associated with Class A, while the field side provides enhanced electromagnetic noise immunity offered by Class B.



Class D shielding is a variation of Class B (multi-point), except that an adequate equipotential ground does not exist throughout the plant site. Similar to Class B, this topology requires the shield to be connected to ground at several points, including the instruments and field junction boxes. However, at the control center area, the shield is connected to ground through a coupling capacitor. The coupling capacitor is used to block DC ground loop currents that can result from a poor equipotential ground.

Similar to Class B, this topology offers better EMC susceptibility at high frequencies and blocks low frequency currents that are carried by the shield in a multi-point shielding method. However, a fault condition, such as a lightning strike, could result in a high voltage being present at the host system side. A Class A, B, or C shield is preferred topology over a Class D shield.

Notes:

The following terms and abbreviations are used throughout this manual. For definitions of terms not listed here, refer to the Allen-Bradley Industrial Automation Glossary, publication [AG-7.1](#).

1788-CN2FFR linking device	Provides a gateway between the ControlNet and Foundation Fieldbus networks.
1788-EN2FFR linking device	Provides a gateway between the EtherNet/IP and a single segment Foundation Fieldbus H1 layer.
acyclic period	Portion of the communication cycle time when information other than publisher/subscriber data is transmitted. This information includes alarms, events, maintenance, and diagnostic information.
AOP	Abbreviation for Add-On Profile; provides an intuitive graphical interface for configuring devices.
application layer	A layer in the communication stack containing the object dictionary.
automation system	A process automation, control, and diagnostic system that is composed of distinct modules. These modules can be physically and functionally distributed over the plant area. The automation system contains all the modules and associated software required to accomplish the regulatory control and monitoring of a process plant. This definition of automation system excludes field instruments, remote terminal units, auxiliary systems and management information systems.
basic device	A device that can communicate on the fieldbus, but cannot become the LAS.
block	See function block .
block tag	A character string name that uniquely identifies a block on a fieldbus network.
BOOTP	A protocol to boot a diskless workstation and receive the boot information from a server.
branch line	A segment of an H1 network. For example, a spur is a branch line connecting to a trunk that is a final circuit.
bridge	An interface in a fieldbus network that interconnects two or more H1 networks.
bus	An H1 fieldbus cable between a Host and field devices connected to multiple segments, sometimes through the use of repeaters.
bus topology	A link topology in which all stations are connected single path or multiple parallel paths for power or data signals to which several devices can be connected at the same time.
capabilities file	This file describes the communication objects in a fieldbus device. A configuration device can use Device Description (DD) Files and Capabilities Files to configure a fieldbus system without having the fieldbus devices online.

- CF** Abbreviation for capabilities files, which describes the communication objects in a fieldbus device. A configuration device can use Device Description (DD) files and capabilities files to configure a fieldbus system without having the fieldbus devices online.
- CFF** Abbreviation for common file format, which is an ASCII text file used by the Host to know the device detailed fieldbus capabilities without requiring the actual device. This file format is used for capabilities and value files.
- channel** A path for a signal.
- CIP** Acronym for Common Industrial Protocol; a communication protocol, or language, between industrial devices. CIP provides seamless communication for devices on DeviceNet, ControlNet, and EtherNet/IP networks.
- communication stack** Layered software supporting communication between devices. A communication stack is device communication software that provides encoding and decoding of user-layer messages, deterministic control of message transmission, and message transfer.
- configurable** Capability to select and connect standard hardware modules to create a system; or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.
- configuration** Physical installation of hardware modules to satisfy system requirements; or the selection of software options to satisfy system requirements.
- connector** Coupling device used to connect the wire medium to a fieldbus device or to another segment of wire.
- contained parameter** An internal parameter that can not be linked to other function blocks or devices.
- control loop** Group of function blocks that execute at a specified rate within a FOUNDATION Fieldbus device or distributed across the fieldbus network.
- control network** Control of plant floor devices, such as I/O chassis, robots, and other intelligent devices.
- ControlNet network** An open control network that uses the producer/consumer model to combine the functionality of an I/O network and peer-to-peer network, while providing high-speed performance for both functions.
- cycle** Scanning of inputs, execution of algorithms and transmission of output values to devices.
- deterministic** Ability to measure the maximum worst-case delay in delivery of a message between any two nodes in a network. Any network protocol that depends on random delays to resolve mastership is nondeterministic.

- device description** Abbreviated as DD, this is a set of files (CFF, SYM, and FFO) that describes the parameter capabilities of a fieldbus device. The file information on these block parameters includes names, data types, and specifications.
- device** The term in this manual refers to the instruments that make up the fieldbus system.
- device coupler** Physical interface between a trunk and spur, and a device.
- device ID** An identifier for a device that the manufacturer assigns. Device IDs must be unique to the device; no two devices can have the same device ID.
- device tag** A character string name that uniquely identifies a device on a fieldbus network.
- DI** Abbreviation for discrete input; the signal is from the field device to the host system.
- discrete control** Control where inputs, algorithms, and outputs are based on logical (yes or no) values. In the case of FOUNDATION fieldbus, discrete includes any integer operation between 0 and 255.
- DLL** Abbreviation for data link layer, which controls transmission of messages onto the fieldbus, and manages access to the fieldbus through the Link Active Scheduler. (See [link active scheduler](#).)
- DO** Abbreviation for discrete output; signal is generated by the host system and transmitted to a field device.
- dual redundancy** See redundancy.
- EDDL** Abbreviation for electronic device description language (see <http://www.eddl.org>).
- Ethernet** Physical and data link layer defined by IEEE 802 standards used by the EtherNet/IP network.
- EtherNet/IP** An open, industrial networking standard that supports both real-time I/O messaging and message exchange.
- FAT** Abbreviation for factory acceptance test, which is the final test at the vendor's facility of the integrated system being purchased.
- FB VFD** Acronym for Function Block Virtual Field Device.
- FFB** Abbreviation for flexible function block, which is similar to a standard function block, except that an application-specific algorithm, created by a programming tool determines the function of the block, the order and definition of the block parameters, and the time required to execute the block.

FISCO	Acronym for Fieldbus Intrinsic Safe COncept. Allows more power to an IS segment for approved FISCO devices, providing for more devices per IS segment.
FMS	Abbreviation for fieldbus messaging specification, which contains definitions of application layer services in FOUNDATION Fieldbus. The FMS specifies services and message formats for accessing function block parameters, as well as object dictionary descriptions for those parameters defined in the virtual field device (see VED).
FNICO	Acronym for Fieldbus Non-Incendive COncept. Allows more power to a fieldbus segment in a Zone 2 area, thus enabling more devices per segment than is possible with a FISCO solution.
fieldbus	A digital, two-way, multi-drop communication link among intelligent measurement and control devices. It serves as a Local Area Network (LAN) for advanced process control, remote input/output, and high-speed factory automation applications.
Fieldbus Foundation	The organization that developed a fieldbus network specifically based upon the work and principles of the ISA/IEC standards committee.
FOUNDATION Fieldbus	The communication network that the Fieldbus Foundation created.
function block	A named block consisting of one or more input, output, and contained parameters. The block performs some control function as its algorithm. Function blocks are the core components with which you control a system. The Fieldbus Foundation defines standard sets of function blocks.
gateway	Translates another protocol to FOUNDATION fieldbus or vice versa, for example HART to FOUNDATION fieldbus or Modbus to FOUNDATION fieldbus.
H1	A fieldbus segment that operates at 31.25 Kbps.
H1 field device	A fieldbus device connected directly to an H1 FOUNDATION fieldbus, such as valves and transmitters.
H1 repeater	An active, bus-powered or non-bus-powered device used to extend the range over which signals can be correctly transmitted and received for a given medium. A maximum of four repeaters and/or active couplers can be used between any two devices on an H1 FOUNDATION fieldbus network. Repeater connect segments together to form larger networks.
HIST	Abbreviation for Host Interoperability Support Test Profiles and Procedures performed by the Fieldbus Foundation to test host conformance to the FOUNDATION fieldbus specifications.

host	Control system that has FOUNDATION fieldbus capabilities to configure and operate FOUNDATION fieldbus segments. There are several classes of Host systems: <ul style="list-style-type: none">• Class 61 - Integrated Host - Primary, or process Host that manages the communication and application configuration of all devices on the network.• Class 62 - Visitor Host - Temporary, on process Host with limited access to device parameterization.• Class 63 - Bench Host - Primary, off process Host for configuration and setup of a non-commissioned device.• Class 64 - Bench host - Primary, off process Host with limited access to device parameterization of an off-line, commissioned device.• Class 71 - Safety Integrated Host - Primary, on-process Host that manages the communication and application configuration of all safety and control and monitoring devices on a network.
IEC	Acronym for International Electrotechnical Commission, which is a technical standards committee that is at the same level as the ISO.
IEEE	Acronym for Institute of Electrical and Electronic Engineers, which specifies a family of standards for data communication over local and metropolitan area networks.
input parameter	A block parameter that receives data from another block.
input/output subsystem interface	A device used to connect other types of communication protocols to fieldbus segments. See also gateway .
ISA	Acronym for International Society of Automation.
instantiable	Ability of function blocks to create multiple tagged function blocks of different types from a library as required by an application. Quantity per device is restricted by device memory and other resources.
interchangeability	The capability to substitute a device from one manufacturer with that of another manufacturer on a fieldbus network without loss of functionality or degree of integration.
interoperability	Capability for a device from one manufacturer to interact with that of another manufacturer on a fieldbus network without loss of functionality.
IS	Abbreviation for intrinsic safety, a protection technique for safe operation of electronic equipment in explosive atmospheres. The concept was developed for safe operation of process control instrumentation in hazardous areas by making sure that the available electrical and thermal energy in the system is always low enough that ignition of the hazardous atmosphere cannot occur.
ITK	Abbreviation for interoperability test kit, which is used by the Fieldbus Foundation to register devices and conform compliance with the relevant FOUNDATION fieldbus standards.

- junction box/quick connection** Junction box connection lets you quickly install multiple field instruments via terminal connectors.
- LAS** See [link active scheduler](#).
- link** A logical link is a connection between function blocks; a physical link is a connection between fieldbus devices.
- linking device** As a bridge, enables peer-to-peer communication between H1 devices without the need for host system intervention. As a gateway, connects the HSE network to other plant control and information networks.
- link active scheduler** Abbreviated as LAS, this scheduler is responsible for coordinating all communication on the fieldbus; maintaining a list of transmission times for all data buffers in all devices that need to be cyclically transmitted. The LAS circulates tokens, distributes time, probes for new devices, and removes non-responsive devices from the link.
- link master** An LM is a device that contains [LAS](#) functionality that can control communication on a FOUNDATION fieldbus H1 fieldbus link. There must be at least one LM on the H1 link; one of those LM devices is chosen as the LAS.
- logical component** Function blocks and algorithms that control a project.
- m** Prefix meaning milli- and has a value of 10^{-3} .
- mac address** Unique hardware address given to each Ethernet interface chip.
- macrocycle** A calculated time for a fieldbus device to send and receive data. The AOP can automatically generate the value, or the value can be manually entered. The LAS is responsible for scheduling of the segment macrocycle.
- methods** An optional, but highly desirable, addition to [device descriptions](#). Methods are used to define and/or automate procedures, such as calibration, for operation of field devices.
- MIB VFD** Acronym for Management Information Base Virtual Field Device.
- mode** Control block operational condition, such as manual, automatic, or cascade.
- network** A network as applied in this document is the termination of one or more fieldbus segments into an interface card of the Host system.
- NMA** Abbreviation for network management agent, which is responsible for managing the communication within a device. The NMA and the network manager (NMgr) communicate through the use of the fieldbus messaging specification ([FMS](#)) and virtual communication relationship ([VCR](#)).
- node** The connection point at which media access is provided.

object dictionary	Contains all function block, resource block, and transducer block parameters that are used in a device. Through these parameters, the blocks can be accessed over the fieldbus network.
OPC	Acronym for OPen Connectivity, formerly Object Linking and Embedding for Process Control. It's a software application that lets a bi-directional data flow between two separate applications. These applications can be running on the same or separate servers.
offline	Perform tasks while the Host system is not communicating with the field devices.
online	Perform tasks, such as configuration, while the Host system is communicating with the field devices.
output parameter	A block parameter that sends data to another block.
physical component	The hardware of the fieldbus project.
physical layer	Physical layer receives messages from the communication stack and converts the messages into physical signals on the fieldbus transmission medium, and vice-versa.
PID	Acronym for Proportional Integral Derivative.
protocol	A set of conventions governing the format and timing of data between communication devices.
PV	Acronym for Process Variable, which is the primary value.
redundancy	The duplication of devices for the purpose of enhancing the reliability or continuity of operations in the event of a failure without loss of a system function.
reflections	The 'bounce back' of signals at the end of the cable.
regulatory control	Functions of process measurement, control algorithm execution, and final control device manipulation that provide closed loop control of a plant process.
repeater	See H1 repeater .
resource block (RES)	This block controls the linking device. It contains data specific to the linking device's hardware. All data is modeled as contained, so there are no links in this block.
ring bus	A network where signals are transmitted from one station and replayed through each subsequent station in the network. Signal can travel in either direction of the ring so it creates network redundancy; if the ring breaks in one place the nodes can still communicate.
s	Abbreviated unit specification for second.

segment	A physical link (cable) between fieldbus devices and a pair of terminators on an H1 channel. Segments can be linked by repeaters to form a longer H1 fieldbus. We recommend that a fully loaded (maximum number of connected devices) 31.25 Kbps voltage-mode fieldbus segment has a total cable length, including spurs, between any two devices of up to 1900 m (6234 ft). There cannot be a non-redundant segment between two redundant systems.
self-diagnostic	Capability of an electronic device to monitor its own status and indicate faults that occur within the device.
setpoint	The desired value in a closed-loop feedback system, as in regulation of temperature or pressure.
signal	The event or electrical quantity that conveys information from one point to another.
SM NM VFD	Acronym for System Management, Network Management Virtual Field Device.
splice	A splice is an H1 spur that measures less than 1 m (3.28 ft) in length.
spur	An H1 branch line connecting to the trunk that is a final circuit. A spur can vary in length from 1...120 m (3.28...394 ft).
standard function block	Standard function blocks are built into fieldbus devices as needed to achieve the desired control functionality. Automation functions provided by standard function blocks include analog input (AI), analog output (AO), and proportional integral derivative (PID) control.
tag ID	Unique alphanumeric code assigned to inputs, outputs, equipment items, and control blocks.
terminator	Impedance-matching module used at or near each end of a transmission line that has the same characteristic impedance of the line. Terminators are used to minimize signal distortion, which can cause data errors. H1 terminators convert the current signal transmitted by one device to a voltage signal that can be received by all devices on the network.
topology	The shape and design of the fieldbus network.
transducer block	The transducer block decouples function blocks from the local input/output (I/O) function required to read sensors and command output hardware. Transducer blocks contain information, such as calibration date and sensor type. There is usually one transducer block for each input or output of a function block.
transmitter	An active fieldbus device that contains circuitry, which applies a digital signal on the bus.
trunk	The main communication highway between devices on an H1 fieldbus network. The trunk acts as a source of main supply to spurs on the network.

- USB** A Universal Serial Bus (USB) establishes communication between device and a host controller.
- user layer** Provides scheduling of function blocks as well as device descriptions that let the host system communicate with devices without the need for custom programming.
- VCR** Acronym for Virtual Communication Relationship. Configured application layer channels that provide for the transfer of data between applications. FOUNDATION Fieldbus describes three types of VCRs: Publisher/Subscriber, Client/Server, and Source/Sink.
- VFD** Abbreviation for virtual field device, which is used to remotely view local device data described in the object dictionary. A typical device has at least two VFDs.

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Rockwell Automation Support

Rockwell Automation provides technical information on the Web to assist you in using its products.

At <http://www.rockwellautomation.com/support> you can find technical and application notes, sample code, and links to software service packs. You can also visit our Support Center at <https://rockwellautomation.custhelp.com/> for software updates, support chats and forums, technical information, FAQs, and to sign up for product notification updates.

In addition, we offer multiple support programs for installation, configuration, and troubleshooting. For more information, contact your local distributor or Rockwell Automation representative, or visit <http://www.rockwellautomation.com/services/online-phone>.

Installation Assistance

If you experience a problem within the first 24 hours of installation, review the information that is contained in this manual. You can contact Customer Support for initial help in getting your product up and running.

United States or Canada	1.440.646.3434
Outside United States or Canada	Use the Worldwide Locator at http://www.rockwellautomation.com/rockwellautomation/support/overview.page , or contact your local Rockwell Automation representative.

New Product Satisfaction Return

Rockwell Automation tests all of its products to help ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning and needs to be returned, follow these procedures.

United States	Contact your distributor. You must provide a Customer Support case number (call the phone number above to obtain one) to your distributor to complete the return process.
Outside United States	Please contact your local Rockwell Automation representative for the return procedure.

Documentation Feedback

Your comments will help us serve your documentation needs better. If you have any suggestions on how to improve this document, complete this form, publication [RA-DU002](#), available at <http://www.rockwellautomation.com/literature/>.

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