Installation Instructions

Allen-Bradley

ControlNet Fiber Media Planning and Installation Guide

Catalog Number 1786 Series

Important User Information

Solid-state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation® sales office or online at http://www.rockwellautomation.com/literature/) describes some important differences between solid-state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid-state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

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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.

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

This manual contains new and updated information. Changes throughout this revision are marked by change bars, as shown to the right of this paragraph.

New and Updated Information

This table contains the changes made to this revision.

Topic	Page
Updated the terminology for determining fiber topology	15
Added information for allowable ring configurations	18
Included installation procedures for fiber repeater modules and a repeater adapter	59
Updated status indicator descriptions for fiber repeater modules and a repeater adapter	73

Notes:

Notes:

This guide provides basic information for fiber cable planning and installation. Actual procedures for installing your system may vary depending on cable style and installation environment. We recommend that you consult a network design specialist for the design of your fiber network.

Refer to the Glossary for clarification of terms associated with fiber technologies.

IMPORTANT	To successfully apply the concepts and techniques contained in this manual, you must have a fundamental knowledge of electronics and electrical codes.

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
NetLinx Selection Guide, publication NETS-SG001.	Describes the NetLinx-based networks—DeviceNet, ControlNet, and EtherNet/IP.
ControlNet Media System Components List, publication AG-PA002	Lists category numbers and specifications for the components that comprise the ControlNet media system.
ControlLogix System User Manual, publication 1756-UM001	Describes how to use your ControlLogix operating system.
ControlNet Modular Repeater Adapter Installation Instructions, publication 1786-IN013	Provides instructions for installing a repeater adapter.
ControlNet Modules in Logix5000 Control Systems User Manual, publication CNET-UM001	Describes how your Logix5000 controller communicates with different devices on the ControlNet network.
ControlNet IP67 Tap and Cable Assembly Kit Installation Instructions, publication 1786-IN017	Provides installation instructions for a tap with an IP67 rating.
ControlNet Coax Media Planning and Installation Guide, publication CNET-IN002	Describes the media that comprises a copper cable system.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, http://www.ab.com	Provides 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.

Notes:

Get Started with the ControlNet Network Fiber Media System

This chapter is an overview of the process you need to follow when you apply fiber media. Some of the information in this chapter repeats in subsequent chapters for instructional purposes.

Why Choose a Fiber-optic Media System?

Fiber media holds many advantages over traditional copper media. Since fiber-optic media transmits digitized information via light pulses over glass or plastic fibers, it avoids many of the problems common with copper applications.

In certain applications, the advantages of fiber over coax media outweigh the higher cost of fiber media and components.

ATTENTION: If you are using fiber in an intrinsically safe area, consult with your local safety coordinator.

Table 1 - Fiber Media Advantages

Features	Benefits
Electrical isolation	Fiber media is isolated from any potential electrical sources that cause disruptions on copper media. Fiber media is well-suited for installations between buildings, and provides immunity to lightning strikes.
Immunity to interference	Fiber media is immune to EMI (electromagnetic interference) since it uses light pulses on glass fibers. Fiber media is effective in noisy environments (heavy machinery, multiple cable systems, and so forth) where copper could suffer disruptions. Fiber media is also suited for high-voltage environments.
Longer distances	Fiber media has less transmission loss than copper media. The lower loss in fiber media means fewer repeaters than copper media, making fiber more effective for applications requiring long-distance media connections.
Decreased size and weight	Fiber media is smaller and lighter than coax media for ease of installation.
Entry into hazardous areas	Fiber media is a portal for information into hazardous areas, reducing the risk of injury. For more information on choosing components for use in hazardous areas, refer to the ControlNet EX Media Planning and Installation Guide, publication CNET-IN003.

Analyze Your Network

Take the time to analyze your current or new network application to see where it makes the most sense to use coax or fiber media. If you are creating a new network or adding fiber to an existing network, create a design plan for the fiber segments of your network and identify the purpose for the fiber segments.

By creating a plan and analyzing your design you will be eliminating the potential for misapplication of media. Use the example topologies to determine your network's topology. When you understand your network's topology it will help you determine the media components you need to achieve your application requirements.

Identify Fiber Media Components

The ControlNet network fiber media system is comprised of these components:

- Fiber-optic Cable
- Nodes
- Connectors
- Repeater Modules
- Repeater Adapters

For information on purchasing these components, see the ControlNet Media System Components List, publication AG-PA002.

Fiber-optic Cable

Fiber-optic cables consist of three major components, the buffer and coating, cladding, and the core.

Figure 1 - Fiber-optic Cable Components

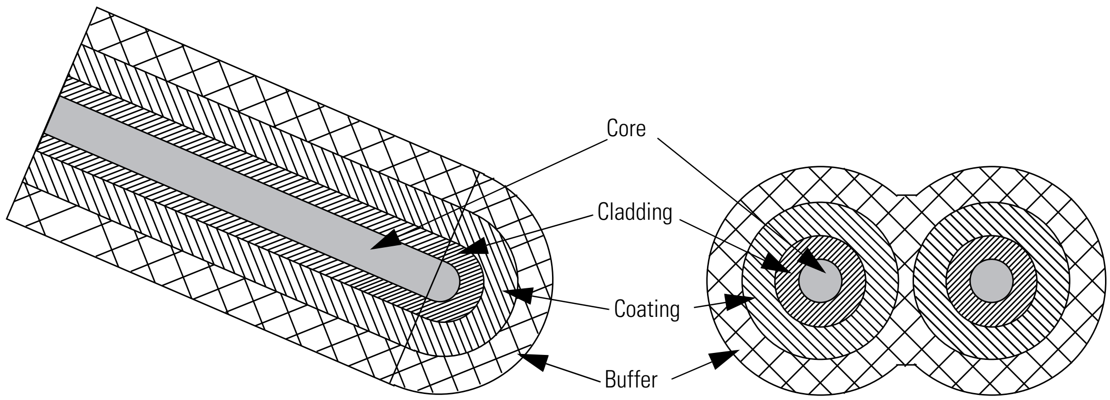


Table 2 - Fiber-optic Cable Description

Parts	Description
Buffer and coating	The buffer and coating are the material that surround the glass fiber. They are responsible for protecting the fiber strands from physical damage.
Cladding	The cladding is a material that provides internal reflection so that the light pulses can travel the length of the fiber without escaping from the fiber.
Core	The core is the cylinder consisting of glass fiber that carries information in the form of light pulses.

Nodes

A network is a collection of segments with nodes connected together by repeaters. A node is any physical device connecting to the ControlNet fiber or ControlNet media system that requires a network address to function on the network.

Connectors

Fiber cable connectors connect fiber cable to the fiber repeater module. The medium, long, and extra-long distance fiber repeater modules use an ST-type connector and the short-distance fiber repeater modules use a V-pin type connector. The short-distance fiber cables come factory terminated in various lengths. You can increase the distance of the network by using low loss cable and connectors.

See page 33 for more information.

Repeater Modules

There are two types of repeater modules: coax repeater (catalog number 1786-RPCD) and fiber repeaters (catalog numbers 1786-RPFS, 1786-RPFM, 1786-RPFRL/B, and 1786-RPFRXL/B). Although you can repeat coax signals on a network by using a 1786-RPCD module, this manual mainly focuses on fiber cabling for the fiber repeater modules.

See the ControlNet Coax Media Planning and Installation Guide, publication CNET-IN002, for more information on ControlNet copper networks.

The fiber repeater modules send an optical signal through the fiber cable to the next fiber repeater module on the network. The combination of the repeater adapter (see below) and a fiber repeater module, such as the 1786-RPFM, is referred to as a fiber repeater.

Repeater Adapters

The ControlNet network uses a modular fiber repeater system. The 1786-RPA/B repeater adapter connects to both coax and fiber media, supplies power to the repeater modules, and repeats signals from the coax media to the fiber repeater modules.

The repeater adapter can supply a maximum of 1.6 A @5V DC of current to power the repeater modules.

To determine how many repeater modules you can use with a single repeater adapter, calculate the current draw of all repeater modules in your system. Do not exceed 1.6 A @ 5V DC per repeater adapter.

Table 3 - Repeater Module Current Draw

Repeater Module	Backplane Current Draw
1786-RPFS	300 mA
1786-RPFM	400 mA
1786-RPFRL/B	570 mA
1786-RPFRXL/B	570 mA
1786-RPCD	400 mA

IMPORTANT The 1786-RPFRL/B and 1786-RPFRXL/B repeater modules require 570 mA each, therefore you can attach **only two of these modules** to a 1786-RPA/B repeater adapter.

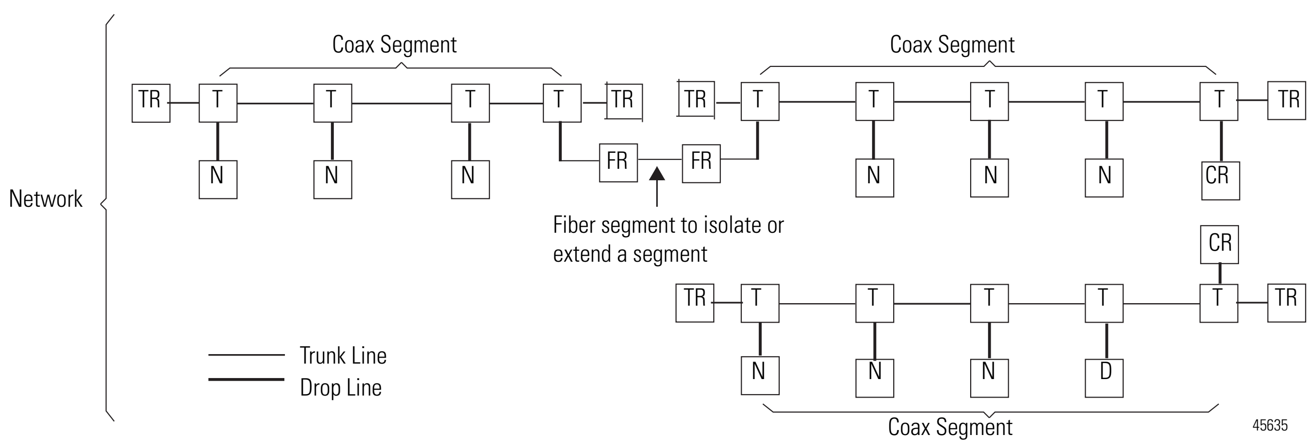
Regardless of repeater module current draw, you are limited to a **maximum of four** repeater modules per repeater adapter.

Determine Network Topology

We suggest that you take sufficient time to plan the installation of your network before assembling any components. The table defines some of the basic ControlNet network terminology used in example topologies.

Item	Term	Description	Item	Term	Description
T	Passive tap with drop cable	The connection between any device and the cable system. The length of the drop cable is 1 m (3.28 ft).	CR	Coax repeater	An active physical layer component that reconstructs and retransmits all traffic it hears on one coax segment to another coax segment.
N	Node or device	Any physical device connecting to the ControlNet network cable system that requires a network address to function on the network.	FR	Fiber repeater	An active physical layer component that reconstructs and retransmits all traffic it hears on one fiber segment to another fiber segment. A coax port on the repeater adapter is available to relay the fiber traffic to the coax segment.
D	Terminator (dummy load)	Terminates a tap drop cable that has yet to be connected to a node to help prevent noise on the line.	TR	Terminating resistor	A 75 Ω resistor mounted in a BNC plug to absorb electrical energy of the signal at the end of the cable to prevent reflections. Each end of a segment must be terminated.

The illustration describes an example trunk line topology.



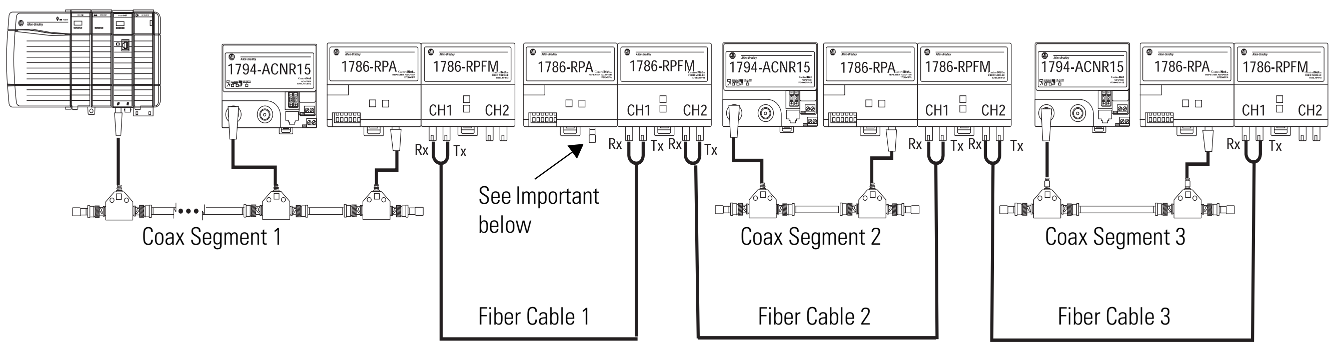
You can configure these topologies on a ControlNet network:

- Point-to-Point Topology
- Star Topology
- Ring Topology

Point-to-Point Topology

Point-to-point is also called a bus or a trunk line topology. A point-to-point topology can be described as one fiber module transmitting to another module. For example, you cannot transmit from a medium-distance module to a short-distance module.

Figure 2 - Example Point-to-Point (Trunk Line) Topology

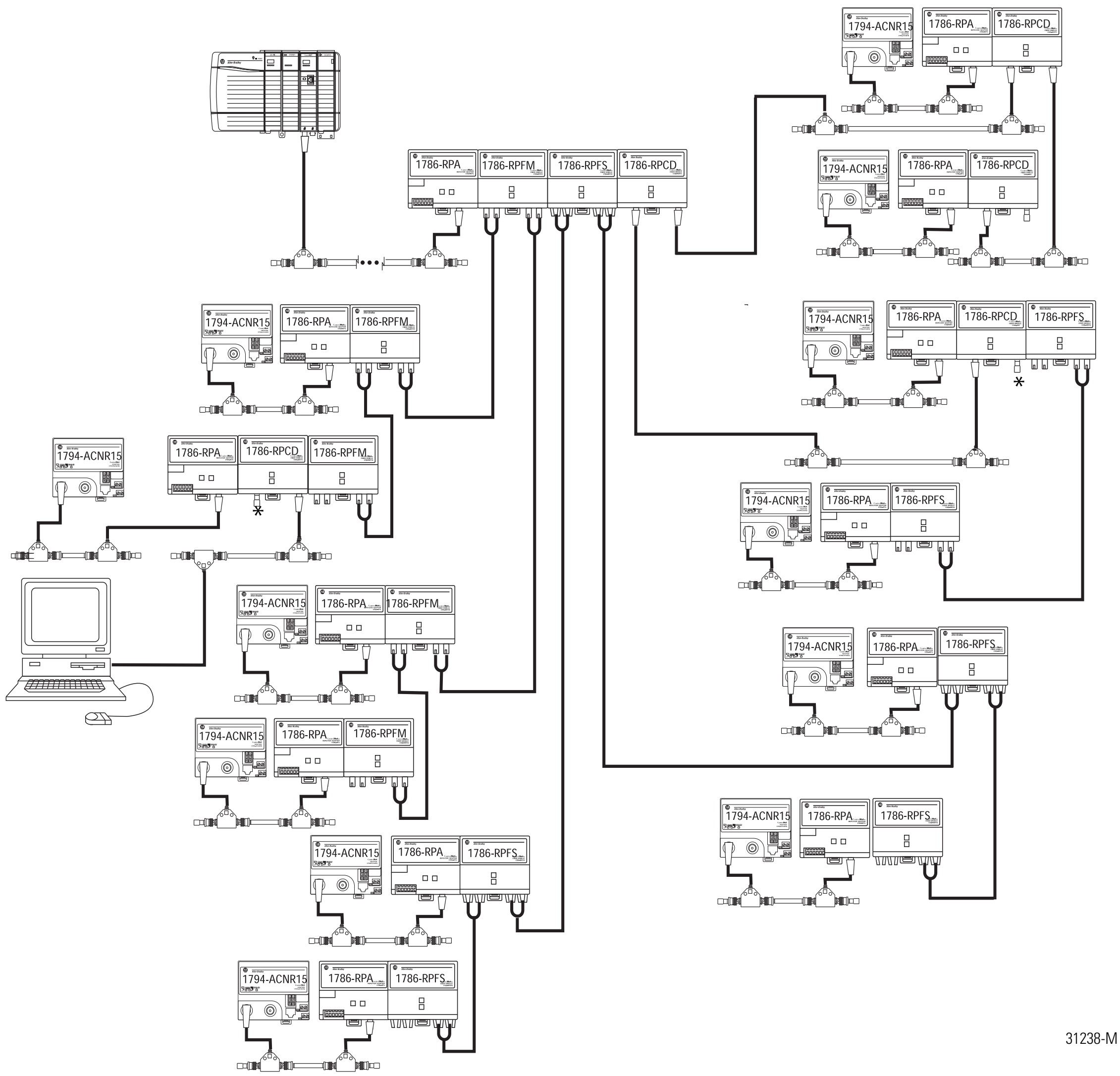


IMPORTANT	It is not necessary to install nodes on coax segments. If you are using only the repeaters to extend the network, install a 75-Ω terminator (catalog number 1786-XT) on the BNC coax connector on the 1786-RPA/B repeater adapter or 1786-RPCD module. This should be done to all repeater modules that are not connected to coax segments.

Star Topology

In a star topology, all segments of the fiber network start from a central location.

Figure 3 - Star Topology



* See Important on page 16

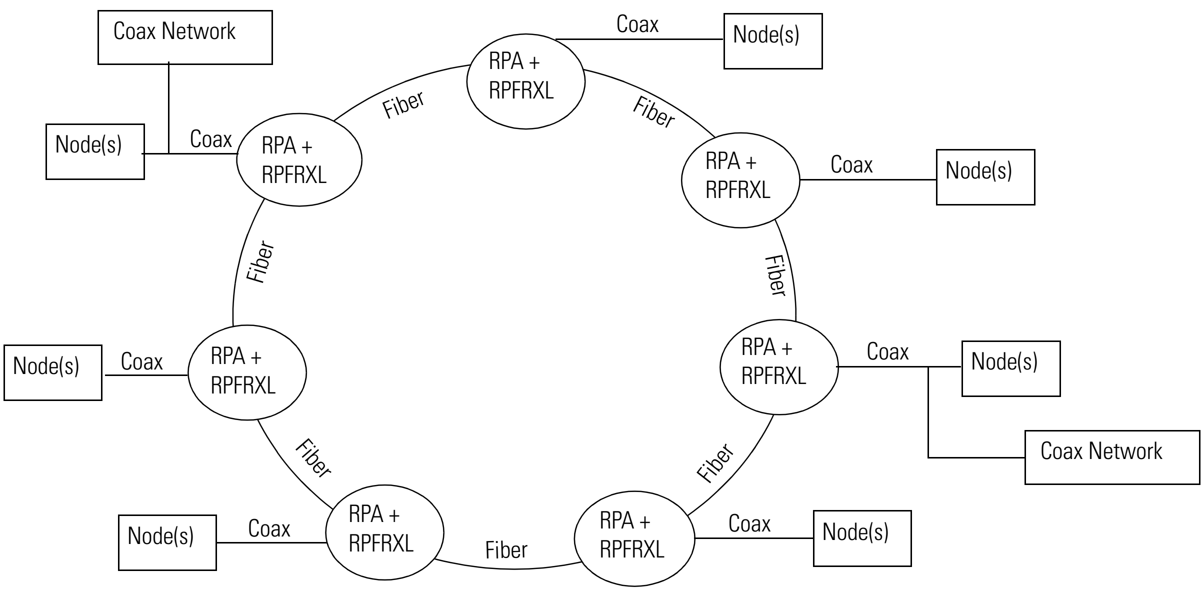
Ring Topology

A ring topology provides redundancy by providing two data paths in a single ring. A ring can sustain two faults before that data connection is lost. You should consider a ring when your devices (Controller and I/O) are single port (A only) and media redundancy is required. Only the 1786-RPFRL and 1786-RPFRXL repeater modules support ring topologies.

In a ring topology on the ControlNet network, you can use:

- Up to 5 repeaters by using one 1786-RPA/A repeater adapter.
- The 1786-RPA/B repeater adapter allows for a maximum of 20 1786-RPFRL (long distance) or 1786-RPFRL/X (extra long-distance) ring repeaters.

Figure 4 - Ring Topology



If a ring is broken, the configuration then becomes a linear bus and the number of repeaters in SERIES depends on where the ring is broken. You will have as many repeaters as in the original ring.

See page 29 to determine different topology constraints.

Plan the Installation of the Fiber Media Components

During the planning phase of your network design, create checklists to help you determine the following components that are needed in an application:

- Number of nodes in your network

  TIP In a network containing a fiber repeater module, such as a 1786-RPFRL/B or 1786-RPFRXL/B module, you cannot have more than 98 node addresses assigned.

- Length of the fiber segments
- Number of fiber connectors and splices in your network
- Calculate the maximum allowable segment length
- Any additional repeaters and coax segments you need

Choose the Fiber Media System Composition

The fiber repeater consists of the following:

- A 1786-RPA repeater adapter
- Up to two 1786-RPFRL/B (long-distance) or 1786-RPFRXL/B (extra-long distance) fiber repeater modules
- Up to four 1786-RPFS (short-distance) or 1786-RPFM (medium-distance) fiber repeater modules

It is allowable to mix these repeater modules on a single repeater adapter.

Refer to Table 3 on page 14 to determine how many repeater modules you can connect to one repeater adapter. The number of repeaters and the total cable length depends on your network topology limits and the repeater modules you select.

You can use fiber repeaters for these tasks:

- Extend the total length of your segment (point-to-point or trunk line topology)
- Create star and ring configurations (multiple directions from one point)
- Cross into hazardous areas

ATTENTION: In hazardous areas, you must use products specifically designed for that purpose. You can use fiber repeaters that are designed for hazardous areas as a link from your non-hazardous area to your hazardous area.

For hazardous locations, consult the ControlNet EX Media Planning and Installation Manual, publication CNET-IN003.

When you configure your network by using fiber repeaters, you can install them in one of the following ways:

Fiber Repeater Installation	Page
Series	21
Parallel	22
Combination of series and parallel	23
Ring (only fiber)	24

ATTENTION: The maximum distance in the network is limited by the distance between the two nodes farthest from one another, and the number of repeaters.

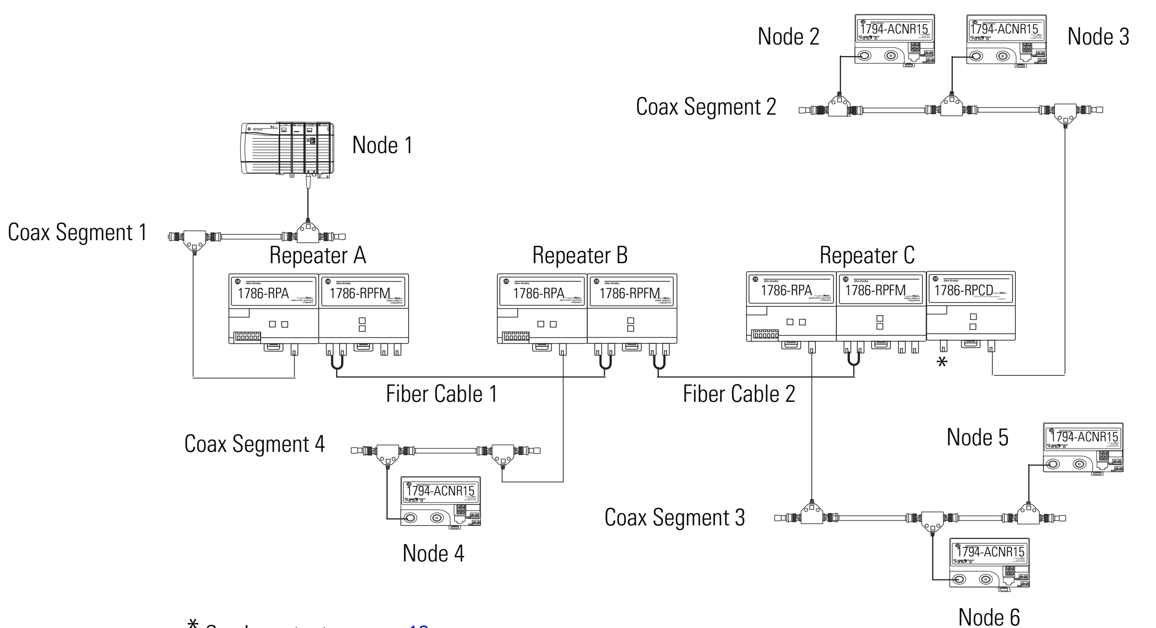
Install Repeaters in a Series

Series is defined as the number of repeater assemblies (repeater adapter plus fiber repeater module) between two devices on a network. When you install fiber repeaters in a series, use the RSNetWorx™ for ControlNet™ software to verify that the system is an allowable configuration. The system size is based on the maximum number of repeaters in a series and maximum length of the media used between any
two nodes.

When you install repeaters in series, you can install a maximum of:

- 5 repeater modules (or 6 segments) with a 1786-RPA/A series A repeater adapter
- 20 repeater modules (or 21 segments) with a 1786-RPA/B series B repeater adapter

Figure 5 - Fiber Repeaters in a Series



* See Important on page 16

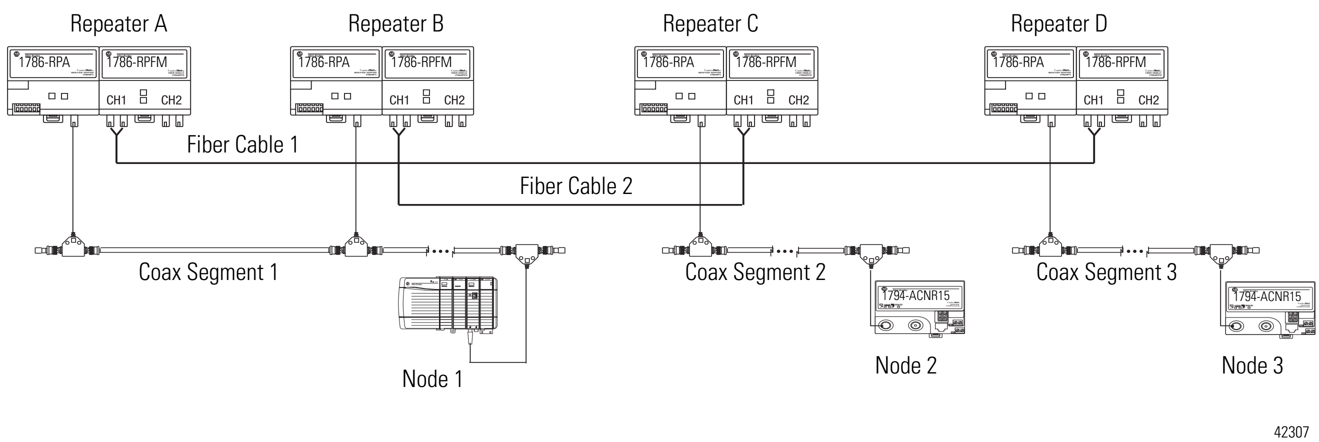
In Figure 5, the maximum number of fiber repeaters is 3, because a message from coax segment 1 to coax segment 2 travels through 3 repeaters in series (A, B, and C).

For any given architecture, the highest number of repeaters that a message might travel through to get from any single node to another determines the number of repeaters in a series.

Install Repeaters in Parallel

When you install repeaters in parallel, you can install a maximum of 48 repeaters (the maximum number of taps per 250 m segment). Figure 6 shows an example of fiber repeaters being used in parallel.

Figure 6 - Fiber Repeaters in Parallel



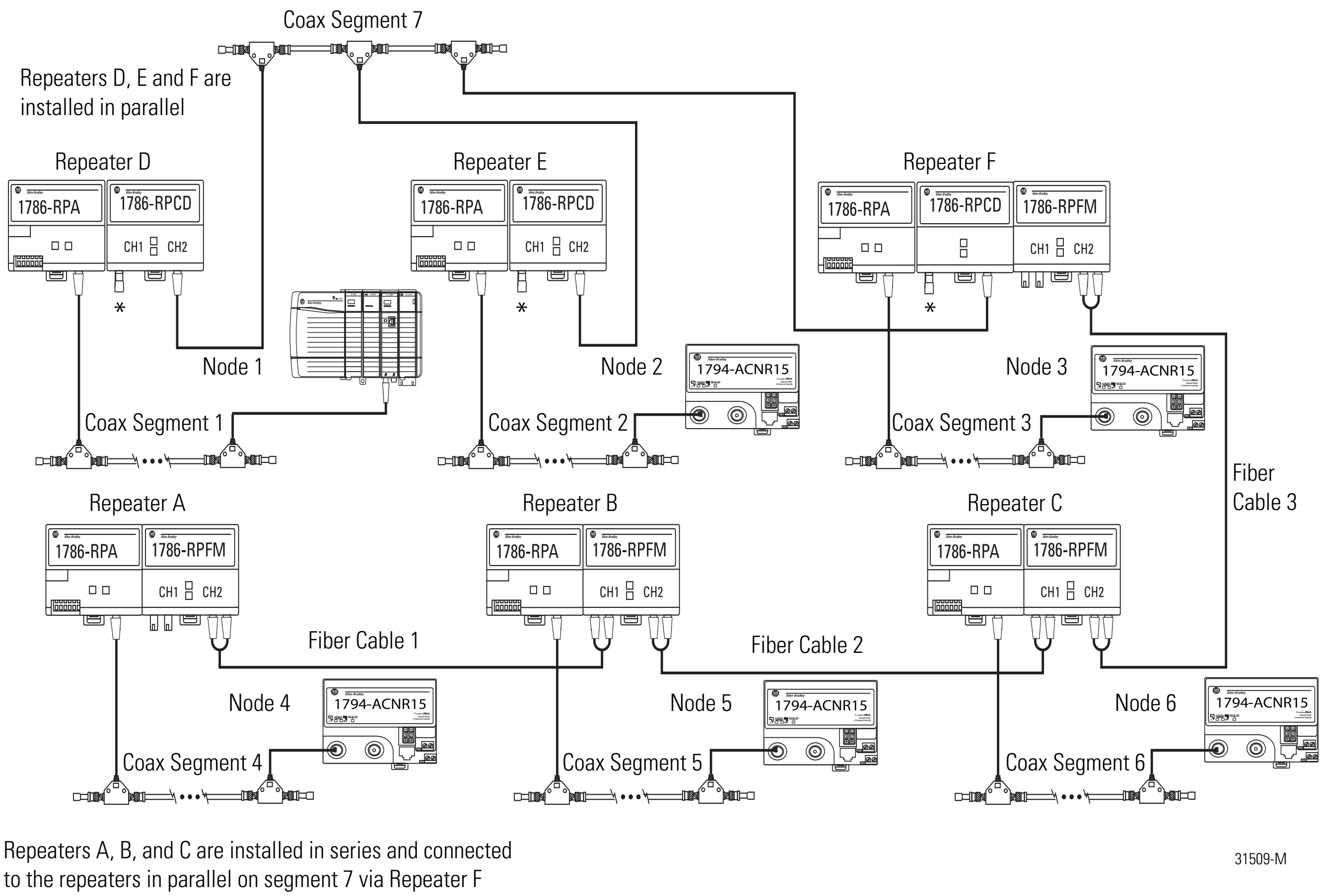
Fiber repeaters A and B are in parallel off of coax segment 1. The network example shows 2 fiber repeaters in series. This is determined by counting the number of fiber repeaters a message must travel through to get from one node to another. For example, if a message travels from node 1 to node 2 (B, C) or from node 1 to node 3 (A,D), it travels through 2 fiber repeaters.

Install Repeaters in a Combination of Series And Parallel

You can install repeaters in a combination of series and parallel connections. For mixed topologies (series and parallel) the maximum number of repeaters in series between any two nodes is 20.

- If you configure your network by using repeaters in combination of series and parallel, you need to count the repeaters in series on the worst-case path between any two nodes.
- There can be only one path between any two nodes on a ControlNet network link. Multiple repeater connections between two segments are not allowed.

Figure 7 - Repeaters in a Combination of Series and Parallel



* See Important on page 16

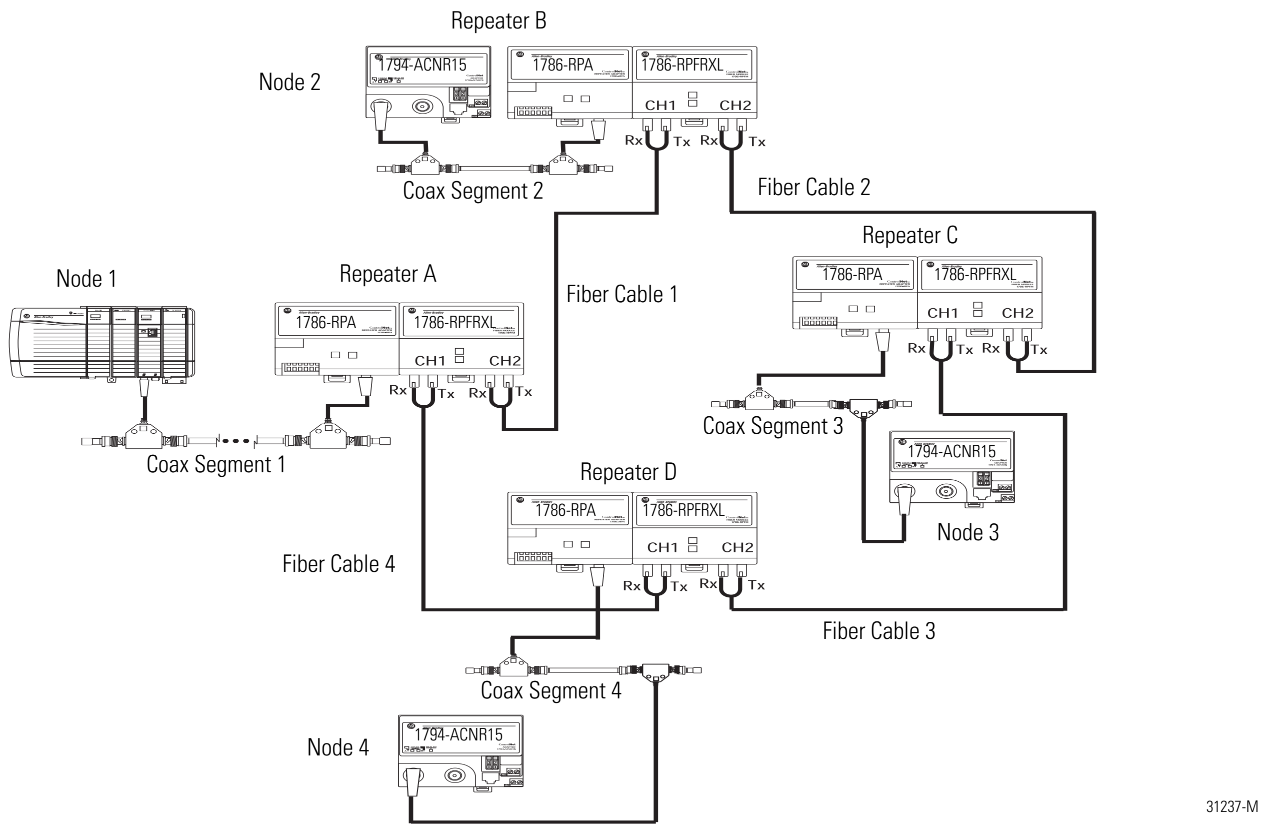
In this network example, the maximum number of repeaters that a message will travel through is 5. The path is as follows: Node 1 to Node 4 travels through repeaters D, F, C, B, A. Repeaters D and E are in parallel, so you must consider the path of Node 2 to Node 4 through repeaters E, F, C, B, A. This secondary path is dependant on the fiber and coax lengths of Segment 1 and Segment 2, including Segment 7.

Install Repeaters in a Ring

Use this configuration to achieve an increased level of protection (in case of cable failure) over a long distance (not available when you use traditional copper media). To achieve this increased level of protection, a fiber ring network transmits messages in the two directions of the ring (clockwise and counter-clockwise).

In Figure 8, the path from node 1 to node 4 in a counter-clockwise direction is through 2 fiber repeaters (A, D). In a clockwise direction, the path from node 1 to node 4 is though 4 fiber repeaters (A, B, C, D). We refer to the longer path as the worst-case delay path.

Figure 8 - Fiber Repeaters in a Ring



The 1786-RPFRXL/B and 1786-RPFRL/B fiber repeaters automatically detect which message arrives first and disregards the other at each fiber repeater location. In the above example, the 1786-RPFRXL fiber repeater for node 4 would automatically detect the packet that arrives on a channel first, and disregard the second packet.

A fiber-optic ring may contain up to 20 1786-RPFRL/B (long distance) or 1786-RPFRXL/B (extra-long distance) fiber repeaters, depending on the application.

IMPORTANT	When used in a ring topology, redundant coaxial cabling (linear bus) or redundant rings are not allowed. Due to timing differences, the 1786-RPFRXL/B and 1786-RPFRL/B fiber modules do not support redundant rings.

Configure the Media in RSNetWorx for ControlNet Software

You can use RSNetWorx for ControlNet software to determine whether or not your system meets the network parameter requirements. Based on your system planned requirements (NUT, SMAX, UMAX, types and length of cable, number and types of repeaters and worst case network delay), RSNetWorx software will verify the network configuration parameters.

If RSNetWorx is unable to schedule the network due to errors, make the necessary changes. Changes might include inserting the correct media lengths and number of repeaters or increasing RPI, so the software can calculate the correct network parameters and download them to the keeper.

Set up the Network SMAX Parameter in RSNetWorx Software

You must properly set up the SMAX parameter in RSNetWorx for ControlNet software when used with the 1786-RPFRL or 1786-RPFRXL repeater module. The SMAX parameter sets the maximum scheduled node address on a ControlNet network. Refer to the documentation supplied with the RSNetWorx for ControlNet software.

You must set the SMAX parameter at least **one** node number higher than the highest-used scheduled node number. For example, on a network with 49 scheduled nodes (with 49 being the highest-used scheduled node number), you must set SMAX to at least 50. In this example, node number 50 is an unused scheduled node number.

IMPORTANT	When setting the SMAX parameter, you must allow one unused scheduled node address. This unused node address must be the highest available scheduled node number. Therefore, the maximum usable node address when using the 1786-RPFRL/B or 1786-RPFRXL/B module is 98.

For more information, see Getting Results with RSNetWorx for ControlNet, publication CNET-GR001.

Terminate Your Fiber Cable

Be sure to use the correct connectors on the end of your fiber cable for the best optical and mechanical connections. For example, ST- and V-pin are the only two connectors that the ControlNet network recognizes.

See Table 8 on page 54 for more information on available connector kits for repeater modules.

You also want to use a dust cap on an unconnected terminated fiber cable end if a connector is not going to be used.

Test Your Fiber Media Connections and Segments

Many field testers are available to test the connectors on cable that is used with the 1786-RPFM, 1786-RPFRL/B and 1786-RPFRXL/B repeater modules. Consult with your fiber network specialist to determine which tester is the best for your media.

Power Your Repeaters

The power for your fiber repeaters comes from the repeater adapters. The repeater adapters must be powered by using a 24V power supply.

See page 68 for the 1786-RPA/B repeater adapter installation instructions and power supply requirements.

Verify Your Network

Verify whether your system meets the network parameter requirements.

1. In RSNetWorx for ControlNet software, go online, browse your network, and look for invalid node addresses.
2. OTDR and fiber field testers will help make sure that no segments violate distance constraints.
3. Make sure your network does not violate general network rules.

   See Chapter 3, starting on page 43, for details.
4. Isolate a single segment of the network and verify its operation.
5. Connect multiple segments of the network , being mindful of bandwidth, insertion loss of the segment, and segment length.
6. Verify that the correct connectors and cable have been installed.

   See page 55 for additional information.

Chapter 2

Topology and Signal Considerations

Develop a Plan

Fiber-optic links in a ControlNet network system can do the following:

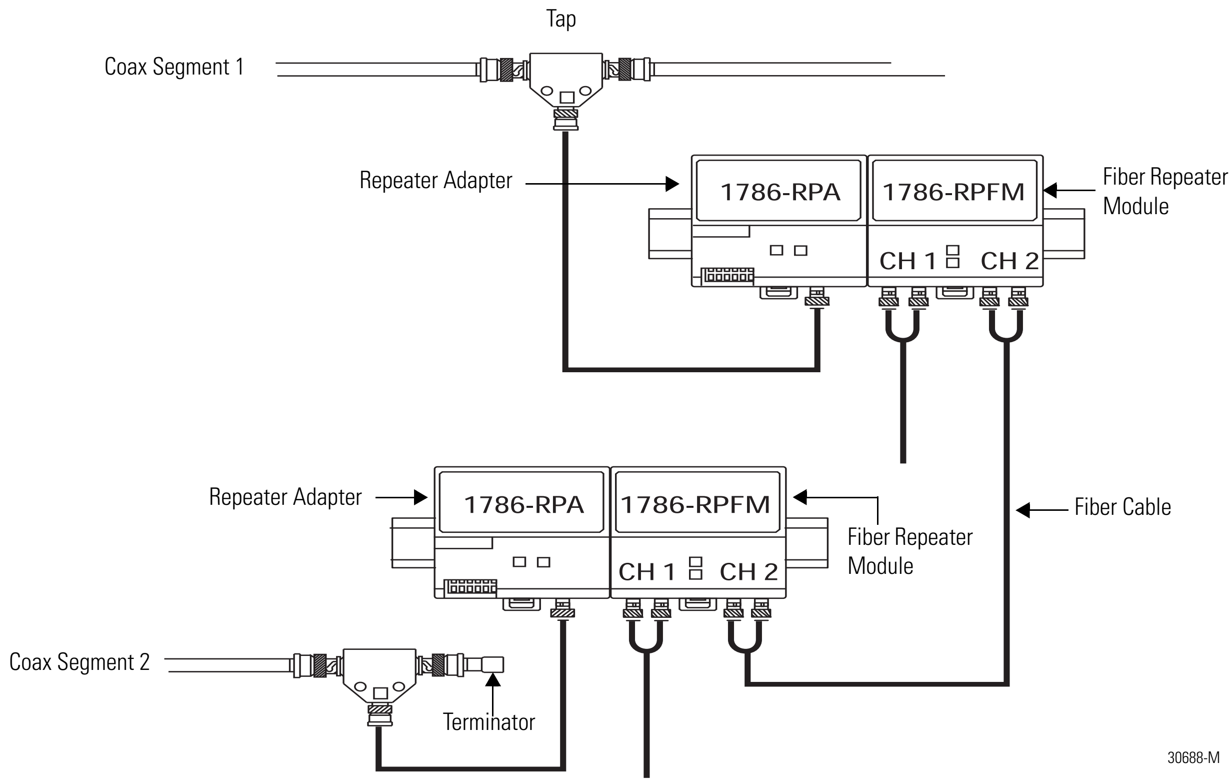
- Increase network length beyond that supported by coax
- Provide immunity to EMI
- Provide better electrical isolation than standard coax cable

Fiber is strongly recommended to avoid lighting problems when connecting equipment in different buildings together.

You can create point-to-point, star, and ring configurations. Up to four fiber modules, with two fiber ports each, can be directly plugged to a repeater adapter. Multiple repeater adapters can be used to increase the number of fiber or coax connections.

Each port needs two fiber connections, one for receiving and another for transmitting signals. The basic configuration connects two coax segments point-to-point by two repeater adapters and two fiber repeater modules, as illustrated in Figure 9.

Figure 9 - Basic Fiber Media Topology



This configuration is equivalent to the use of a coax repeater. Fiber cable can provide communication over longer distances than coax media.

Redundant Media

Use redundant media when you need module and media redundancy. With redundant media, the channel-to-channel skew travel time difference must be less than 1.6 µs.

To keep skew time to a minimum, configure the cable paths on channels A and B in a similar manner as shown in Figure 10 on page 29.

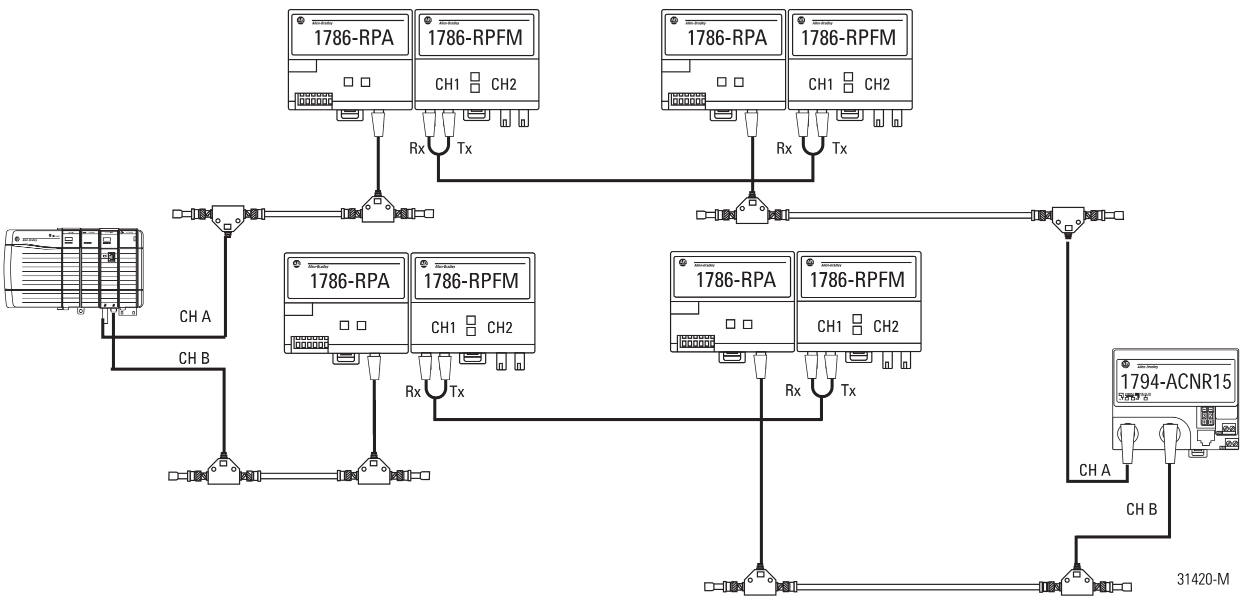
Media redundancy can be achieved via a ring topology or linear bus topology. The 1786-RPFRL/B and 1786-RPFRXL/B fiber repeaters can provide media redundancy in a ring or linear bus topology, but not both. A redundant linear bus topology can be obtained by using the 1786-RPFS, 1786-RPFM, and 1786-RPCD repeater modules. The planning phase should consider the advantages and disadvantages of using a ring or redundant linear bus topology.

TIP If you use a ring topology to provide media redundancy, you can connect to only one channel (A or B) of redundant port modules. ControlNet does not support mixed (linear and ring) redundancy in the same network. When using linear bus redundancy all ControlNet modules must have redundant ports (A and B) and must be connected throughout the network.

For redundancy, you should do the following on each channel:

- Use the same number and types of repeater assemblies (repeater adapters plus repeater modules)
- Use the same type of cable
- Keep cable lengths similar
- If using redundant media in a linear bus topology, ring topologies are not supported.

Figure 10 - Redundant Topology



Topology Considerations

For best results, determine the constraints of your topology. For example, a maximum of 99 nodes are allowed on a network (98 nodes if you are using ring redundancy).

Table 4 - Topology constraints

Constraint	Example
Only one path is allowed between nodes (non-ring repeater modules only)	See Figure 7 on page 23.
In series topology, maximum of 20 repeaters in a series In ring topology, up to 20 1786-RPFRL/B or 1786-RPFRXL/B modules per ring	See Figure 5 on page 21 See Figure 8 on page 24
Constraint of each coax segment (taps and trunk-cable sections)	See Figure 11 on page 30.
Constraint of each fiber segment application	See page 31.
Power loss budget of each fiber segment	See Table 5 on page 33.
Maximum propagation delay through the network	See page 39.

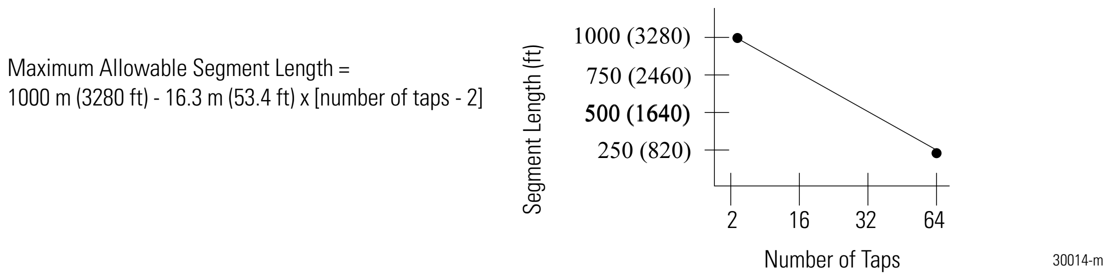
Coax Segment Constraints

The total allowable length of a segment containing standard RG-6 quad shield coaxial cable depends upon the number of taps in your segment. There is no minimum trunk-cable section length requirement.

The maximum allowable total length of a segment is 1,000 m (3280 ft) with two taps connected. Each additional tap decreases the maximum length of the segment by 16.3 m (53 ft).

The maximum number of taps allowed on a segment is 48, with a maximum length of 250 m (820 ft).

Figure 11 - Maximum Segment Length (Using 1786-RG6 Coax Cable)



The data in Figure11 assumes you are using standard low-loss coax. High-flex cable may not support the distance versus the number of taps due to the higher loss factor associated with high-flex designs.

Example Coax Segment Constraint

EXAMPLE	If your segment requires 10 taps, the maximum segment length is: 1000 m (3280 ft) - 16.3 m (53.4 ft) x [10 - 2] 1000 m (3280 ft) - 130.4 m (427.2 ft) = 869.6 m (2852.8 ft) The total trunk-cable length or number of taps can be increased by installing repeaters on the segment. This creates another segment. The amount of high-flex RG-6 cable (catalog number 1786-RG6F) you can use in a system is less than the amount of standard RG-6 cable, so you should keep high-flex cable use to a minimum. Use BNC bullet connectors to isolate areas that require high-flex RG-6 cable from areas that require standard RG-6 cable; this allows the high-flex RG-6 section to be replaced before flexture life is exceeded.

For more information in the installation of a coax segment, see publication CNET-IN002, ControlNet Coax Media Planning and Installation Guide.

Fiber Segment Constraints

Every network that uses fiber repeaters must maintain a minimum signal level for each fiber segment in order to achieve an effective signal strength. Attenuation of a fiber segment is effected by the quality of the termination at each connector, splices, bulkheads, and the fiber cable. At any time, the total amount of attenuation shall not exceed the power budget of the type of repeater module that is being used.

IMPORTANT	The attenuation values for connectors, splices, bulkheads, and cable are available in the manufacturer's specifications for your products.

Select a Module Type Based on Distance Requirements

When choosing a module type to use in a configuration, a commonly asked question is 'Can I use a particular cable with a particular module?' You must select a module (and the corresponding cable type) based on the distance you want to achieve.

There are two types of fiber cable supported: single and multi-mode. These two cable types differ in that single-mode cable allows light to travel in a single path. Multi-mode cable allows light to travel in multiple paths. Single-mode cable is generally used in longer distance applications.

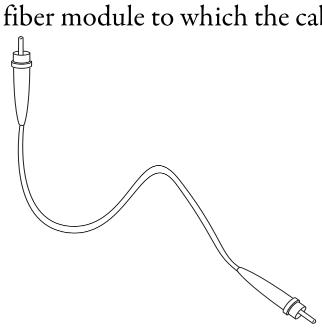
Of these two types of cores, there are three configurations of cable commonly found in manufacturing environments:

- Simplex Cable
- Duplex Cable
- Multi-fiber Backbone Cable

All three cable configurations have either single- or multi-mode cores.

Simplex Cable

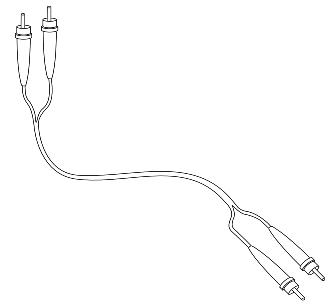
At each end, the cable is terminated with a connector appropriate to the type of fiber module to which the cable is attached.



31506-M

Duplex Cable

A duplex cable is made up of two jacketed fiber cores, with their jackets fused together to form a single cable. A duplex cable is sometimes called a zipcord fiber jumper.

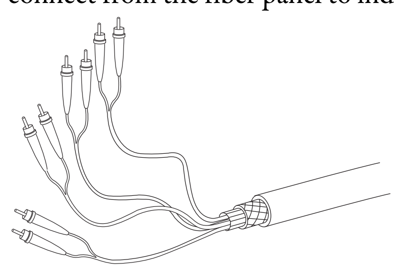


31507-M

Smaller lengths of simplex and duplex interconnect cable are typically directly connected between modules, or to a fiber panel within an enclosure.

Multi-fiber Backbone Cable

Multi-fiber backbone cable is composed of many fiber cores bundled into a jacketed cable. These cables are often run to a fiber panel within an enclosure. Smaller lengths of simplex or duplex interconnect cable are then typically used to connect from the fiber panel to individual modules or networks.



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What is Zipcord?

The term ‘zipcord’ refers to any cable that is a duplex cable whereby the jacket is fused together to form a lamp cord-like cable that can be easily parted. The V-pin connector makes sure the fiber is reversed on opposite ends of the cable so that the Transmit end from one module is automatically connected to the Receive end of the other module.

Multiple lengths of zipcord (catalog number 1786-FSxx) are available for use with the 1786-RPFS module.

See page 65 for connection instructions.

Estimate Cable Lengths

The maximum length of a fiber cable section for the fiber-optic modules is dependent on the quality of the fiber, number of splices, and the number of connectors.

If your distance requirements are less than 300 m, you can use a short-distance (single-mode) cable that comes pre-terminated for use with the 1786-RPFS fiber module. If your distance requirements are greater than 300 m, you must use a 1786-RPFM, 1786-RPFRL/B, or 1786-RPFRXL/B fiber module and terminate the cables in the field, or purchase pre-terminated cables from your supplier.

When estimating maximum cable length, take into account attenuation that occurs along the entire fiber path. Attenuation refers to the loss of light power as it passes through the cabling components.

Table 5 - Fiber Module Distance and Ratings

Module	Typical Repeater Distance[1]	Cable Type	Optical Power Budget	Connector Type
1786-RPFS	0…300 m	200/230 micron, single-mode 650 nm	4.2 dB	V-pin
1786-RPM	0…3 km	62.5/125 µm, multi-mode 1300 nm, graded index	13.3 dB	ST (plastic or ceramic only; do not use metal connectors)
1786-RPFRL/B	0…10 km	62.5/125 µm, multi-mode 1300 nm, graded index	15 dB	
1786-RPFRXL/B	0…20 km	62.5/125 µm, multi-mode[2] 1300 nm, graded index	10.5 dB	
		9/125 µm, single-mode[3] 1300 nm		

(1) Entire network limited to 20 km max, per ControlNet network specifications.

(2) Although you can use multi-mode cable with the 1786-RPFRXL/B module, it is not recommended because achieveable distance is limited to 6.6 km.

(3) Also compatible with 62.5/125 µm, multi-mode cable.

Typically cable attenuation for multi-mode fiber at a wavelength of 1300 nm is less than 1.5 dB/km, and connection losses are 1 dB per connection.

IMPORTANT Avoid lengthening your cable by joining sections with connectors. Connectors can cause considerable attenuation and limit the maximum length of your system. Be sure to check the attenuation of different cable sections after the cable is installed.

Each Rockwell Automation fiber system has different constraints; therefore maximum fiber-optic cable lengths differ for each system. Rockwell Automation offers four different systems that are targeted to solve different applications:

- 1786-RPFS: Short-distance fiber system
- 1786-RPFM: Medium-distance fiber system
- 1786-RPFRL/B: Long-distance fiber system
- 1786-RPFRXL/B: Extra-long distance fiber system.

1786-RPFS Module

The 1786-RPFS (0…300 m) module specializes in solving short-distance applications. This system requires the use of pre-terminated cable assemblies. The total attenuation for a fiber cable section must be less than 4.2 dB.

200/230 Micron HCS (hard-clad silica) Fiber

Use 200 micron HSC cable with the 1786-RPFS module for short-distance applications. The 200 hcs cable is also known as a step index multi-mode type of fiber cable.

1786-RPFM Module

The 1786-RPFM (0…3 km) module is designed to solve medium-distance applications that require less than 3000 m per segment (9843 ft) between two ControlNet fiber repeaters. You must terminate medium-distance cable in the field.

The maximum length of a section is dependent on the quality of the fiber, number of splices, and the number of connectors. The total attenuation for a cable section must be less than 13.3 dB.

62.5/125 Micron multi-mode OM1 Fiber

Use 62.5/125 micron cable with the 1786-RPFM, 1786-RPFRL/B, and 1786-RPFRXL/B module for medium-distance applications. The OM1 cable is a graded index multi-mode type of fiber cable.

1786-RPFRL/B Module

The 1786-RPFRL/B (0…10 km) module is designed to solve long-distance applications that require up to 10,000 m (32,810 ft) between two ControlNet network devices. You must terminate long-distance cable in the field.

The maximum length of a section is dependent on the quality of the fiber, number of splices, and the number of connectors. The total attenuation for a cable section must be less than 15 dB.

62.5/125 Micron multi-mode OM1 Fiber

Use 62.5/125 micron cable with the 1786-RPFM, 1786-RPFRL/B, and 1786-RPFRXL/B modules for long-distance applications. The OM1 cable is a graded index multi-mode type of fiber cable.

1786-RPFRXL/B (Fiber Ring or Point-to-Point) Module

The 1786-RPFRXL (0…20 km) module is designed to solve extra-long distance applications that require up to 20,000 m (65,620 ft) for single-mode fiber between two ControlNet network devices. You must terminate extra long-distance cable in the field.

The maximum length of a section is dependent on the quality of the fiber, number of splices, and the number of connectors. The total attenuation for a cable section must be less than 10.5 dB. This applies to single- or multi-mode fiber.

62.5/125 Micron multi-mode OM1 Fiber

Use 62.5/125 micron cable with the 1786-RPFM, 1786-RPFRL/B, and 1786-RPFRXL/B modules for extra-long distance applications. The OM1 cable is a graded index multi-mode type of fiber cable.

9/125 Micron single-mode OS1 Fiber

Use 9/125 micron with the 1786-RPFRXL/B module to achieve distances of up to 20 km. The OS1 cable is a graded index single-mode type of fiber cable.

Determine Attenuation Levels

You must calculate the power budget for you fiber cable. The short-distance fiber cable is pre-terminated; therefore the maximum attenuation level is 4.2 dB.

Once you start modifying the lengths of the segment, installing bulkhead or fusion splices, installing longer distances, exposing the cable to temperature ranges, or employing different quality cable and connector types, you must determine your attenuation levels. The following examples provide you with a place to start when you begin to determine your attenuation levels.

Attenuation Levels for a Short-distance Fiber Segment

The fiber cabling path loss can be verified by using the appropriate field test equipment. You must test the cable using the same wavelength as the specific fiber module in use.

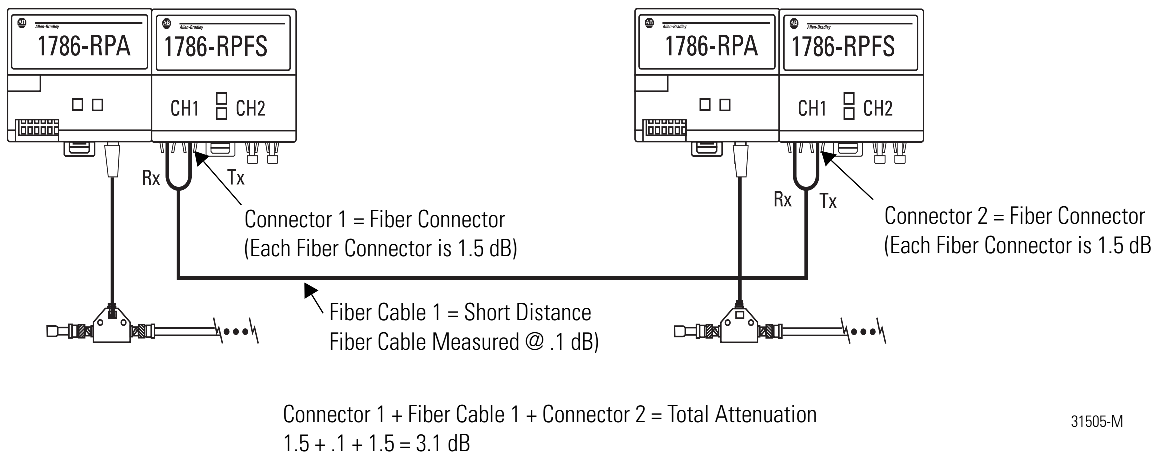
The power budget for the short-distance fiber repeater module is 4.2 dB. This means that the maximum amount of attenuation between the two repeater modules shall not exceed 4.2 dB. This power budget is valid throughout the operating temperature range (0…60 C° (140 °F)).

You can also affect the power budget by the quality of the connectors and fiber cable you choose. If you use a high-quality connector and fiber cable, you will be able to stretch your power budgets. Higher-quality connectors and cable can withstand a broader range of temperatures and distances.

In most situations you will not have to determine the attenuation levels for short-distance fiber cable. The cable comes pre-terminated with connectors with the proper length of cable to be used under the maximum attenuation levels. If you modify the cables with splices then you must calculate the attenuation levels.

Figure 12 is an example of determining the maximum distance between two fiber repeaters. These are measured path losses, not theoretical. If the system attenuation exceeds the power budget, you will need to add additional repeaters.

Figure 12 - Maximum Distance Between Two Repeater Modules



Step 1: Total your loss budget

With the type of fiber module selected, how much total loss (dB) can you have?

4.2 dB on the 1786-RPFS module

Step 2: Subtract loss for connectors

Select connectors. You need to account for at least two connectors per fiber cable segment.

Loss per connector x 2 connectors (1 at each end)

2 (1.5 dB) = 3 dB

Step 3: Subtract loss for cable lengths

Select fiber cable and identify loss = length of cable x (loss due to fiber cable/km)

Measured @ .1 dB

Step 4: Compare losses

Compare the sum of losses in steps 2 and 3, with total power budget in step 1.

4.2 dB - 3 dB - .1 dB = 1.1 dB

If the sum of steps 2 and 3 are equal to or less than step 1 (which applies for our example), then you are within the power budget.

If steps 2 and 3 are greater than step 1, then you will need to reconfigure the topology, shorten cable lengths, or re-calculate the loss budget.

IMPORTANT Due to possible fiber connector degradation, it is recommended that an allowance of 0.5 …1.0 dB per short-distance fiber cable segment be added to the total attenuation. In the above example, the maximum cable length would be 20…70 meters.

There is no minimum length of cable for the short-, medium-, or long-distance fiber repeaters.

Attenuation Levels for Medium-distance Fiber Segments

The power loss budget for the medium-distance fiber repeater (catalog number 1786-RPFM) is 13.3 dB. The maximum amount of attenuation between the two fiber repeaters shall not exceed 13.3 dB. This power loss budget includes the entire bulkhead/fusion splice.

This power loss budget is valid throughout the operating temperature range (0...60° C) of the 1786-RPFM module.

IMPORTANT Due to possible fiber connector degradation, it is recommended that an allowance of 1.0 dB per 62.5/125 multi-mode cable segment be added to the total attenuation.

There is no minimum length of cable for the short-, medium- or long-distance fiber repeaters.

Attenuation Levels for Long-distance Fiber Segments

The power loss budget for the long-distance fiber repeater (catalog number 1786-RPFRL) is 15 dB. The maximum amount of attenuation between the two fiber repeaters shall not exceed 15 dB. This power loss budget includes the entire bulkhead/fusion splice.

Attenuation Levels for an Extra-long Fiber Segment

The power loss budget for the extra-long distance fiber repeater (catalog number 1786-RPFRXL) is 10.5 dB. The maximum amount of attenuation between the two fiber repeaters shall not exceed 10.5 dB. This power loss budget includes the entire bulkhead/fusion splice.

Determine Propagation Delay

The ControlNet network maximum propagation delay specification refers to the worst-case signal delay between any two nodes on a network. You need to figure out the worst-case scenario based on distances and the number of repeaters through which the signal has to travel.

Network delays include the delays through coax and fiber media, coax repeaters, repeater adapters, and fiber modules.

In order for a network to operate, the sum of the network's delays must be equal to or less than the maximum propagation delay of 121 µs. The total network allowable delay each way is 121 µs.

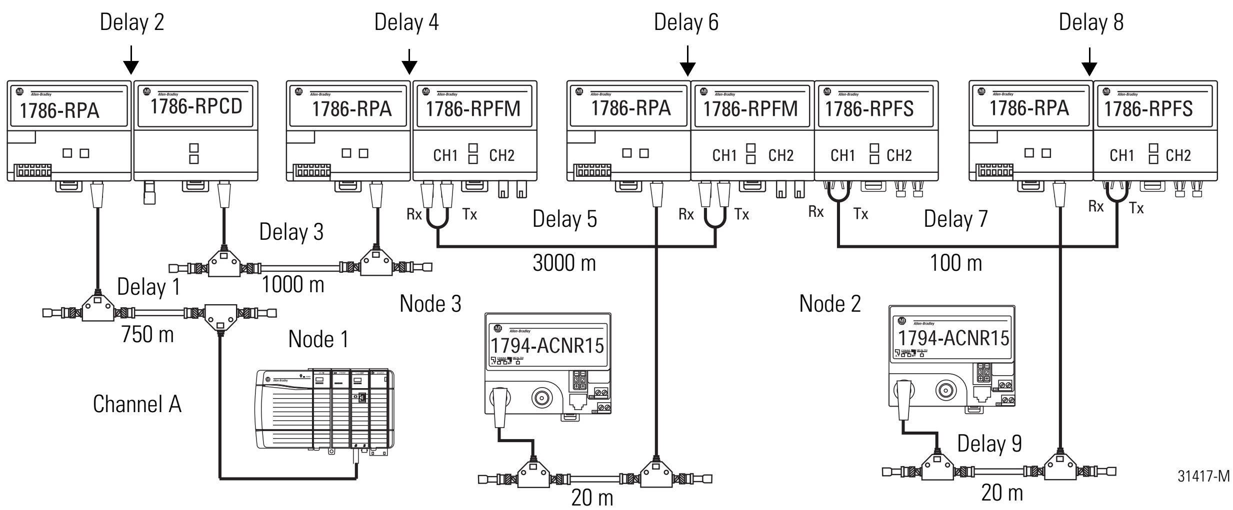
Table 6 - Delay Values for ControlNet Network Media

ControlNet Network Items	Delay Values
1786-RPCD	100 ns
1786-RPA/B	901 ns
1786-RPFS	94 ns
1786-RPFRL/B	420 ns
1786-RPFRXL/B	420 ns
1786-RPFM	153 ns
Coax cable	4.17 ns/meter
62.5/125 micron fiber	5.01 ns/meter
200 micron fiber	
9/125 micron fiber	

Maximum Propagation Delay Through a Network

Figure 13 is an example of a maximum propagation delay through a network.

Figure 13 - . Calculating the Delays



The example has the following maximum delay path from node 1 to node 2, end to end.

IMPORTANT	Cable delays through taps are minimal and can be ignored.

Delay Path 1: From controller to repeater adapter

Delay 1: 750 m coax cable x 4.17 ns/m = 3127 ns

Delay Path 2: 1786-RPCD module

Delay 2: Coax repeater; 901 ns (1786-RPA/B module) + 100 ns (1786-RPCD module) = 1001 ns

Delay Path 3: 1000 m of coax cable

Delay 3: 1000 m coax cable x 4.17 ns/m = 4170 ns

Delay Path 4: Fiber repeater; 1786-RPA/B module and 1786-RPFM module

Delay 4: Fiber repeater; 901 ns (1786-RPA/B module) + 153 ns (1786-RPFM module) = 1054 ns

Delay Path 5: 3000 m of 62.5 micron fiber cable

Delay 5: 3000 m fiber cable x 5.01 ns/m = 15030 ns

Delay Path 6: Fiber modules; 1786-RPFM, 1786-RPA/B, 1786-RPFS modules

Delay 6: 153 ns (1786-RPFM module) + 901ns (1786-RPA/B module) + 94 ns (1786-RPFS module) = 1148 ns

Delay Path 7: 100 m of 200 micron fiber cable

Delay 7: 100 m fiber cable x 5.01 ns/m = 501 ns

Delay Path 8: Fiber modules; 1786-RPFS and 1786-RPA/B modules

Delay 8: 94 ns (1786-RPFS module) + 901 ns (1786-RPA/B module) = 995 ns

Delay Path 9: 20 m of coax cable

Delay 9: 20 m coax cable x 4.17 ns/m = 83 ns

Total delay = 27109 ns (27.1 µs)

This is a valid network because the calculated propagation delay of 27.1 µs is less than the maximum allowable propagation delay of 121 µs.

Maximum Propagation Delay and Skew Through a Redundant Network

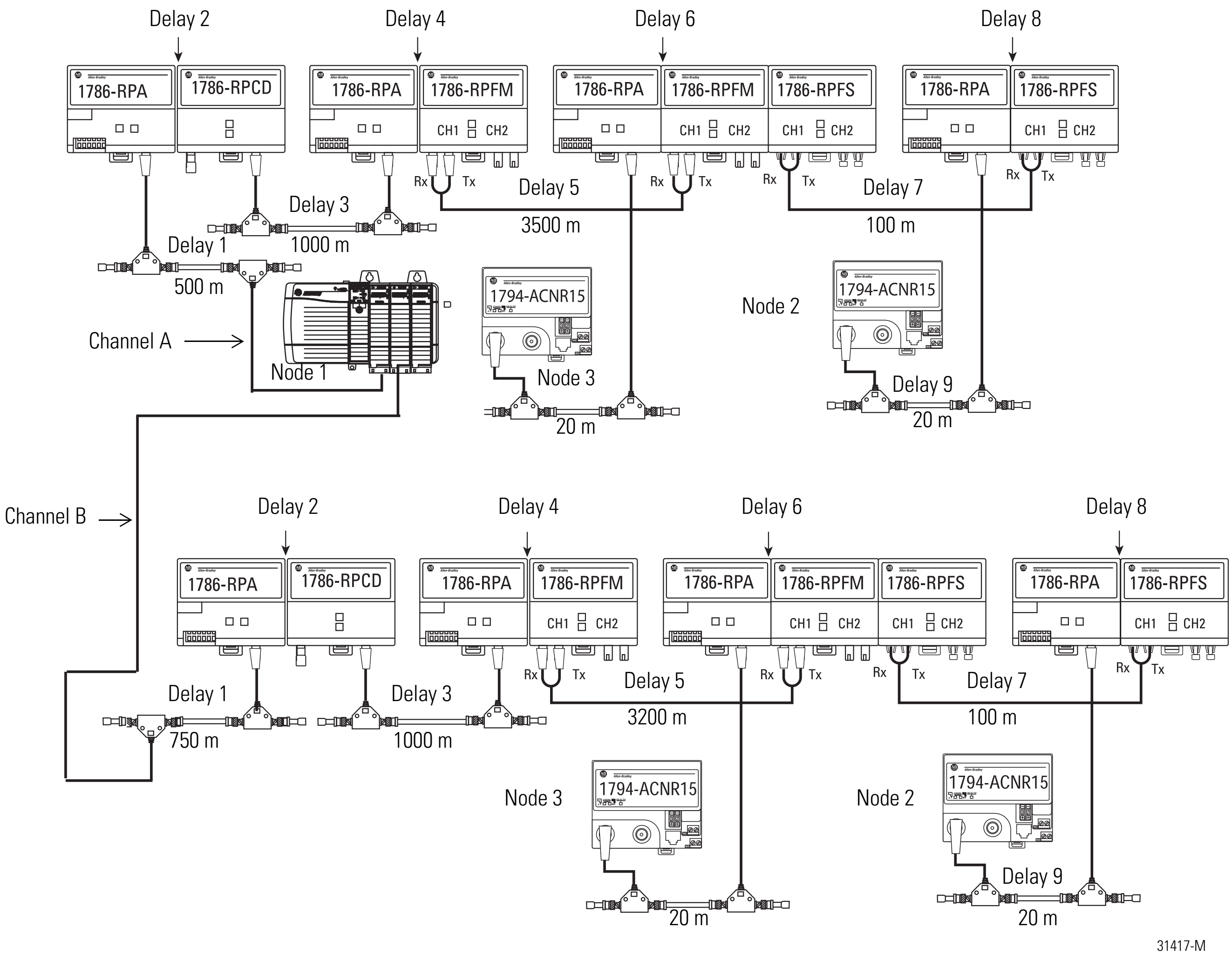
For redundant networks, not only do you have to calculate the worst-case path delay between two nodes, but you also must calculate the worst-case delay skew between channel A and channel B of the network.

IMPORTANT	The worst-case skew between redundant paths shall be less than or equal to 1.6 µs.

The following example (that uses the cable lengths in Figure 14) depicts a redundant network with these conditions:

- Node 1 and Node 2 are separated by four fiber repeaters in series on both A and B channels
- Channel A uses 3600 m fiber segments total versus 3300 m fiber segments total on channel B. Channel A uses 1520 m of coax cable total versus 1770 m of coax cable total on channel B.

Figure 14 - Maximum Propagation Delay Through a Redundant Network



Calculate and Total Delays for Channel A

Delay 1	500 m coax cable x 4.17 ns/m	= **2.085 µs**
Delay 2	Coax repeater; 901 ns + 100 ns	= **1.001 µs**
Delay 3	1000 m coax cable x 4.17 ns/m	= **4.17 µs**
Delay 4	Fiber repeater; 901 ns + 153 ns	= **1.054 µs**
Delay 5	3500 m fiber cable x 5.01 ns/m	= **17.535 µs**
Delay 6	Fiber modules; 153 + 901 ns + 94 ns	= **1.148 µs**
Delay 7	100 m fiber cable x 5.01 ns/m	= **0.501 µs**

Delay 8	Fiber modules; 94 ns + 901 ns	=	**0.995 µs**
Delay 9	20 m coax cable x 4.17 ns/m	=	**0.083 µs**
Total delay for Channel A		=	**28.57 µs**

Calculate and Total the Delays for Channel B

Delay 1	750 m coax cable x 4.17 ns/m	=	**3.127 µs**
Delay 2	Coax repeater; 901 ns + 100 ns	=	**1.001 µs**
Delay 3	1000 m coax cable x 4.17 ns/m	=	**4.17 µs**
Delay 4	Fiber repeater; 901 ns + 153 ns	=	**1.054 µs**
Delay 5	3200 m fiber cable x 5.01 ns/m	=	**16.032 µs**
Delay 6	Fiber modules; 153 + 901 ns + 94 ns	=	**1.148 µs**
Delay 7	100 m fiber cable x 5.01 ns/m	=	**0.501 µs**
Delay 8	Fiber modules; 94 ns + 901 ns	=	**0.995 µs**
Delay 9	20 m coax cable x 4.17 ns/m	=	**0.083 µs**
Total delay for Channel B		=	**28.11 µs**

Skew between channels =
(Delay through A) – (delay through B) = 28.57 µs – 28.11 µs = 0.46 µs

This is a valid network because the calculated skew of 0.46 µs is less than the maximum allowable skew of 1.6 µs.

Chapter 3

Guidelines for Fiber-optic Installation

General Rules and Safety

This section outlines specific rules and guidelines to follow when you install fiber-optic cable systems.

Warnings

ATTENTION: Follow these safety guidelines:

Safety glasses are required to protect your eyes when you handle chemicals and cut fiber. Pieces of glass fiber are very sharp and can easily damage the cornea of your eye.

Cleaved glass fibers are very sharp and can pierce the skin easily. Do not let cut pieces of fiber stick to your clothing or drop in the work area where they can cause injury later. Use tweezers to pick up cut or broken pieces of the glass fibers and place them on a loop of tape kept for that purpose alone. Keep your work area clean.

Laser light can damage your eyes. Laser light is invisible. Looking at it directly does not cause pain. The iris of the eye will not close involuntarily as when you view a bright light. Consequently, serious damage to the retina of the eye is possible. Should accidental eye exposure to laser light be suspected, get immediate medical attention.

Never look into a potentially active fiber with a microscope. Doing so can cause serious eye damage.

Hire Fiber-optic Specialists for Installation and Certification

You may plan and install your fiber network or contract a fiber network engineer. It’s not necessary to have your fiber specialist connect your local equipment. Someone with media installation experience can connect local equipment by using pre-terminated interconnect cables that are purchased in their required lengths. Rockwell Automation offers the short-distance (<300 m) fiber cable pre-terminated as a kit for use with the 1786-RPFS module.

Single- and multi-mode pre-terminated fiber cables for medium, long, and extra-long distances also can be purchased that are made to order or off the shelf from your supplier. However, keep in mind that a fiber media installation must be certified and terminating longer distances in the field can be challenging. Trained specialists can select the correct type of fiber cable for your environmental and intrinsically safe area needs.

We recommend a trained specialist for installation of single- and multi-mode cables for the 1786-RPFM, (medium), 1786-RPFRL (long-distance), and 1786-RPFRXL (extra long-distance) fiber modules.

The specialist you choose should install your cable and terminate it following the supplier's installation instructions. The installation should include verification testing that provides segment length and loss at the appropriate optical wavelength. Verification should also provide pass/fail based on the limits defined in the fiber module users documentation or this manual.

Guidelines for Handling Fiber-optic Cable

These guidelines are designed to protect the safety of personnel who handle fiber-optic cable. The guidelines in Table 7 help establish an environment that allows for the best performance from your fiber-optic system.

ATTENTION: Do not look directly into the fiber ports. Light levels may cause damage to your eyesight. Do not view an active cable end through a fiber microscope.

Table 7 - Guidelines for Handling Fiber-optic Cable

Guideline	Description
Minimum bend radius	• Observe the minimum fiber cable bend radius specified.
Skin contact	• Do not touch the ends of the fiber-optic strands. The fiber can break easily and pierce your skin.
Installation training	• Train personnel on usage of the installation tools to place and terminate fiber cable. This would include training on hand-held tools, tension meters, optical power meters, cleaners, and adhesives.
Installation regulations	• Observe all local regulations for installation, including personal safety equipment and the guidelines for its use.

Table 7 - Guidelines for Handling Fiber-optic Cable

Guideline	Description
Proper disposal	• Always dispose of fiber waste in an approved container. Disposing of fiber waste prevents the contamination of clothes, fingers, or eyes of glass fragments. Do not leave pieces of fiber cable on your work surfaces.
Specifications	• Review cable specifications for distances and required connectors. • Review all cable parameters and specifications before installation. Make sure that you have the proper amount of connectors and installation equipment. Never attempt to use non-compatible connectors and installation tools.
Pulling tensions	• Observe the maximum pulling tensions. Do not pull directly on fiber or force cable into a bend radius smaller than 20 times the cable diameter when under load and 10 times the cable diameter at no load. This will crack the glass and result in optical loss. • Use a running line tension meter to determine the pulling tension applied during cable placement. • Never allow tight loops, knots, kinks, or tight bends in the cable. • Entrance in and out of metal pull boxes must be smooth as not to damage the cable sheath

ATTENTION: Do not leave any fiber pieces on your work surface. The glass is very small and can penetrate your skin easily.

Types of Fiber Media Installations

You can use fiber media in many different application types. When you plan the application of fiber media, keep in mind the following installation types.

Pulled Application Guidelines

Pull fiber-optic cable prior to connector installation since it becomes more difficult to protect fiber from stress after connectors have been installed. Connectors may be pre-installed on one end, leaving the other end for pulling. Take precautions to protect ends from damage if the cable is pre-terminated. Refer to the manufacturer's specifications for the fiber cable for additional information.

You must identify the strength member and the optical fiber location within the cable. Afterwards, a decision should be made to choose a cable pull method—pull or indirect attachment to ensure effective pulling without fiber damage. Never pull the cable by the fiber strand.

Direct Attachment

The cable strength member is attached directly to a pulling eye. Since epoxy glass central strength members are too rigid to tie, they may be secured to the eye by using tight clamping plates or screws.

Indirect Attachment

Indirect attachment uses a pulling grip attached to the cable's outer jacket to distribute the pulling force over the outer portion of the cable. The pulling grip produces the least amount of stress in cables where the strength member lies directly beneath the jacket.

Conduit and Duct Installation

Installation procedures for conduit and duct installation of fiber-optic cables are very similar to those of electrical wires. Avoid yanking, flipping, or wrapping cables causing unnecessary tightening. Fiber cable, electrical wires, or small fiber-optic cables should never be subjected to foot traffic or potentially crushing forces.

Cables should be lubricated prior to pulling to minimize the pulling forces on the cables. Lubricants such as waxes, greases, clay slurries, and water-based gels are compatible with most fiber-optic jacket materials. Check with the fiber manufacture of your cable for the approved lubricants to be used on your cable.

Use this procedure for conduit or duct installation.

1. Attach the towline to the cable by using direct or indirect attachment as described in the previous section.
2. Establish two-way communication between the cable payoff station, intermediate hand assist stations, and the pulling station.
3. Use the following items for duct or cable tray replacements:
   - Adjustable lip clutch winch or equivalent
   - Tension monitoring system with continuous readout
   - Tow line that assures minimum friction
   - Dedicated inner duct, mainly for pulls in underground conduit
   - Cable end caps for use in flooded or unknown conduits and sealing cable ends after placement
4. Position the cable reel and payoff frame for pulling.
   a. Mount the cable reel into the payoff apparatus so that the cable pays out from the top of the reel.
   b. Attach the pulling grip to the cable and position the reel with its flanges perpendicular to the floor or support foundation.
   c. Secure the payoff frame so it cannot move during pulling.

5. Maintain enough slack on the cable as the pull starts to prevent the cable from contacting any equipment in the area.

IMPORTANT	Do not allow slack loops to form on the reel. Slack loops could cause a crossover and damage the cable. Always pull at slow speeds to limit the possibility of crossovers.

   Plan your pull to avoid a pull equaling or exceeding the total bends to 360° per pull. If it is not possible to avoid a pull of 360°, install an intermediate junction box within the 360° pull. Plan on manually handling the cable along the pull route to help limit the bends.

6. Position the winch at the pull station to avoid a steep angle either entering the duct or exiting the cable tray.

IMPORTANT	Do not exceed the maximum pulling tension for your fiber-optic cable.

7. Leave enough extra cable to route to the equipment rack, put connectors on, and allow for future repairs when your pull is complete.
8. Cut off the pulling grip and the first 1 m (3 ft) of cable behind it.
9. Terminate the cable.
10. Measure and record the optical cable attenuation and length by using either an OTDR (optical time domain reflectometer) or an optical test.
11. Seal the ends of the cable with endcaps until they are terminated.

In some applications you may have to start your pull in the middle of a duct or conduit and pull in both directions. In this scenario, pull in the first direction by using the reel and payoff frame. In the other direction, lay out the cable in a figure-8 pattern on the floor. When the second pull begins, hand feed the cable into the duct system.

IMPORTANT	Be certain to clear the floor of dust, debris, and dirt before placing the cable on the floor.

Aerial Installation

Most round, tight buffer, and loose-tube optical cables are compatible with helical lashing, clamping, and tied mounting. These cables can be used in aerial installations by using methods similar to those for electrical cables.

The following procedure describes the stationary method for aerial cable installation.

IMPORTANT	Aerial cable must be properly supported using 'J' hooks or loops of wire of sufficient diameter not to damage the fibers due to loading.

1. Use the following tools for aerial placement:
   - Adjustable lip clutch winch or equivalent
   - Tension monitoring system with continuous readout
   - Tow line that assures minimum friction over cable blocks
   - A payoff apparatus equipped with a breaking system. The breaking system can be used to place **light** tension on the cable during placement.
2. Mount the cable reel into the payoff apparatus so that it pays out from the top.

IMPORTANT	Do not drag fiber-optic cable across or around any obstacles that may cause outer jacket abrasion.

3. Determine the direction to pull your cable.
   - Pull the cable up-grade whenever possible
   - Place the payoff apparatus on an even surface and in-line with the support strand whenever possible
4. Place cable blocks along the support strand at a distance of no greater than 15 m (50 ft) apart. The first cable block should be placed as close to the initial pole as possible.
5. Place additional cable blocks:
   - One on each side of a corner
   - Where distinct vertical clearances are required
6. Guide the cable to a position parallel with the strand as it approaches the payoff by securing the cable guide to a strand by using a guy clamp on the strands behind the first roller.
   - Place the cable 0.6 m (2 ft) past the pole if the cable should start at a dead end pole
   - Place the first cable block within 0.3 m (1 ft) if the pull starts midstrand between poles

IMPORTANT	Use manila rope (1/4-in., min), kevlar rope, capstan winch rope, or coated line winch rope as a cable towline.

7. Place a one-sheave cable block or snatch block within 0.3 m (1 ft) of the pole at the end of the pull. Make sure the winch is positioned to avoid steep angles exiting the block.
8. Thread the towline through the all of the cable blocks and the cable guide to the end of the cable for aerial placement.
9. Attach the towline to the cable by using direct or indirect attachment as your application dictates.
10. Establish communications between the cable payoff station, intermediate hand assist stations, and the pulling station.
11. Pull the cable slowly by using the towline and winch.

IMPORTANT	Do not exceed the maximum pulling tension as specified by the manufacturer of your cable.

12. Reverse the payoff reel by hand to rework any excessive sag between guide blocks after the pull is completed and the pulling end is anchored. Use the payoff break to maintain the proper tension.
13. Measure and record the optical cable attenuation and length by using either an OTDR (optical time domain reflectometer) or an optical test.
14. Tighten the strand suspension clamps at the poles where the cable is to be lashed.
15. Lashing should begin immediately after the cable has been placed.
16. Pull the lasher toward the cable reel.

    Always take up the slack of the unlashed spans by reversing the payoff reel slowly by hand.
17. Remove the cable blocks as the lasher progresses towards the payoff reel.
18. Secure the strand wire to keep it from loosening on the previously lashed span as the lasher is transferred from strand to strand.
19. Proceed with the lasher until each lash is complete.
20. Leave enough extra cable to route to the equipment rack, put connectors on, and allow for future repairs when your pull is complete.
21. Seal the ends of the cable with endcaps until they are terminated.

Direct Burial Installation

Some applications call for a direct burial installation. Direct burial installation requires some special considerations that aren't necessary for other pulled applications. These guidelines are designed to prevent hazards such as freezing water, crushing forces, ground disruption from construction, and rodents.

Use the following guidelines to help you plan your direct burial installation.

- Use cable specifically designed for direct burial.
- Use heavy duty armor cables buried directly into the ground.
- Bury the cable between 1…1.2 m (36…48 in.) deep.
- Use gel filling, metal sheathing, and armoring when possible.
- Use loose-tube cable constructions where uneven pulling forces are a problem.

Open Trench Installation

Use these steps as a guide for installing fiber-optic cable by using an open trench method.

1. Maintain minimum tension on the cable as it rolls over the guide rollers and through the guide shoot.

IMPORTANT	Do not pull the cable in excess of its maximum allowable installation tension as specified in the cable manufacturer's specifications.

2. Consider methods of placement like boring or creating a conduit when your installation intersects with objects like streets, sidewalks, or landscaping.
3. Maintain at least a 1 m (39 in.) separation when your fiber-optic cable is placed in proximity to an existing power cable.
4. Use some form of mechanical protection (steel pipe, cement conduit, and so forth) when adequate earth cover cannot be maintained in your application.

5. Use the following procedure if you must start cable placement in the middle of a selected trenching route.
   a. Pull in the first direction until the end point is reached.
   b. Remove the cable for the opposite direction from the reel by hand and carefully coil it on the ground in a figure-8 pattern.

IMPORTANT	Be certain to place the cable in a manner that will prevent the cable from binding against foliage, rocks, or other impediments.

   c. Hand guide the cable in the second direction as the pull begins.
6. Begin cable placement as soon as possible after trenching.

   You can avoid possible collapse and fill of your trench by filling it as soon as possible. Depending on your application, you may want to use a trencher with a mobile cable trailer and payoff.
7. Be certain that your cable trailer has properly sized rollers and an adjustable breaking system.

IMPORTANT	Do not allow fiber-optic cable to be pinched, braided, or bent back during payoff from the cable trailer. Do not exceed the cable's minimum bend radius and tension. You may even want to guide your cable into the trench by hand.

8. Backfill over the cable as soon as possible after cable placement.

   Consult your local ordinances for guidance on backfilling and trenching procedures.
9. Avoid backfilling with materials like frozen earth, rocks and boulders, construction debris, and so forth.

   These objects could create point discontinuity along the buried cable and harm the cable's performance.
10. Machine tap any areas where trenching could be threatened by erosion or washout.
11. Measure and record the optical cable attenuation and length by using either an OTDR (optical time domain reflectometer) or an optical test.
12. Seal the ends of the cable with endcaps until they are terminated.

Vertical Installation

The requirements of your application may require a vertical installation. You can install fiber-optic cable vertically in trays, shafts, or towers. Dielectric cables are recommended for applications requiring high vertical installations, radio towers for example.

Use the following guidelines when planning a vertical cable installation.

1. Clamp cable to give extra support in preventing ice loading and wind slapping.

   Your specific environment will determine where you should clamp your cable. Clamping intervals can be as short as 1 m (3 ft) and as long as 15…30 m (50…100 ft) in interior locations.

   Cables in vertical cable shafts are generally clamped directly to the walls of the shaft.

   Cables installed in elevator shafts are usually supported by suspension strands and suspended from the top of the shaft. The suspension strand is attached to the wall at frequent intervals and at the bottom of the shaft. Consult your local codes and practices for installation in an elevator shaft.

2. Avoid downward migration of cable in loose-tube constructions by looping the cable approximately 0.3 m (1 ft) in diameter at the top, bottom, and every 150 m (500 ft).

   In loose-tube constructions cable may migrate downward creating crowding at the bottom. The crowding may cause an increase in attenuation, especially in below freezing temperatures.

3. Plan cable runs that keep bends to a minimum.

4. Drill all holes for the entire run larger enough to accommodate steel sleeves when passing cables through walls and floors.

   The inside diameter of steel sleeves should be 4 times the diameter of the cable. The minimum diameter of a steel sleeve is 5 cm (2 in.).

   Steel sleeves are required to run cable through a firewall. Consult your local codes and practices for installations through firewalls.

5. Measure and record the optical cable attenuation and length by using either an OTDR (optical time domain reflectometer) or an optical test.

6. Seal the ends of the cable with endcaps until they are terminated.

Terminate Your Fiber-optic Cable

What Is Termination?

Termination is the process of attaching a connector to the ends of your fiber cable. Use protective caps on the ends of unused connectors.

Follow these additional recommendations to terminate your fiber cable:

- Decide on the type of cable dressing based on the fiber cable construction (for example, loose tube, zipcord, simplex, and so forth)

  See page 31 for more information.
- Decide if a patch panel is to be used
  - A loose tube cable should be terminated into a patch panel
  - Jumpers should be used to connect the segment from the patch panel to the fiber repeater; determine the jumper lengths for the patch panel
- Route fiber cable in the cabinet appropriately
- Provide sufficient cable length for maintenance and determination if it becomes necessary to re-terminate the fiber ends
- ST-type terminations must be plastic or ceramic; no metal

Figure 15 - Patch Panel Example

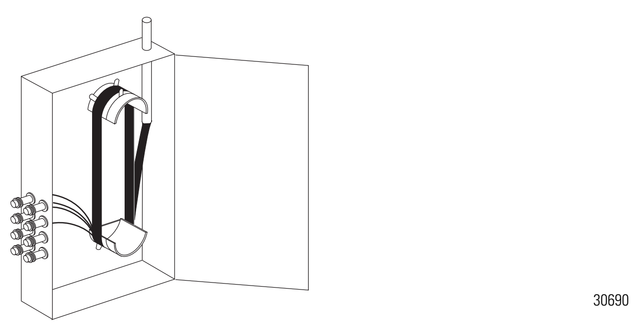


Figure 15 shows a patch panel with incoming multi-fiber backbone cable and connectors for interconnect cables.

Terminate Your Cable

Most connector manufactures offer connector termination systems that are specific to the connector. We recommend that the termination kit be purchased from the same manufacture.

There are two types of connector systems in the market:

- One common type is fast termination where the cable end is prepared and inserted into the back end of the connector. The system then locks the cable and fiber in place. This type uses an index matching gel so no fiber polishing is needed.
- Other connector termination systems require polishing and are more difficult to use.

You must decide which connector system is appropriate for your needs.

Table 8 details the connector types that fiber repeaters use in the ControlNet network.

Table 8 - Termination Kits

Fiber Module	Kit Types
1786-RPFS	V-Pin pre-terminated and commercially available field termination kits are available.
1786-RPFM 1786-RPFRL	ST, and MM connector pre-terminated or commercially available field terminations kits are available.
1786-RPFRXL	ST, SM, and MM connector pre-terminated or commercially available field termination kits are available.

Follow these general instructions when terminating fiber cable.

1. Organize your termination kit materials.
2. Reference your plan to be certain that you have enough supplies to make the fiber connections and to terminate all used fiber cable ends.
3. Follow the assembly and safety procedures for your termination kit.
4. Place a dust cap (supplied in fiber cable kits) on the end of the connector.

ATTENTION: Do not let the ends of a fiber-optic strand come into contact with dust, dirt, or other contaminants. Clean contaminated ends with a soft, clean, lintless cloth and alcohol.

Always attach protective caps onto fiber cable connectors and fiber ports when they are disconnected.

Verify Your Network

Set Network Parameters

You can use RSNetWorx for ControlNet software to determine if network parameters are set up correctly. Based on the system parameters you entered, such as, NUT, SMAX, UMAX, and worst-case network delay, RSNetWorx software calculates scheduled messaging for your network.

If your network is not valid, you must adjust your parameters.

For more information, see Getting Results with RSNetWorx for ControlNet, publication CNET-GR001.

Measure Power Loss

After you install short-, medium- or long-distance fiber cable, check your sections by using an optical power meter to verify that your attenuation is less than or equal to the maximum allowed by the fiber type. The light source you are using must match the wavelength of the fiber module in use.

See Table 9 on page 56 for the wavelengths of each module.

The power loss measurement should match the tables in Chapter 2. If you do not follow the cable insertion loss recommendations in Table 5 on page 33, you can assume that you will have high-loss cable and high-loss connections.

Do not test the cable with the wrong power source because you will get inaccurate readings. The power budgets are at the source wavelengths.

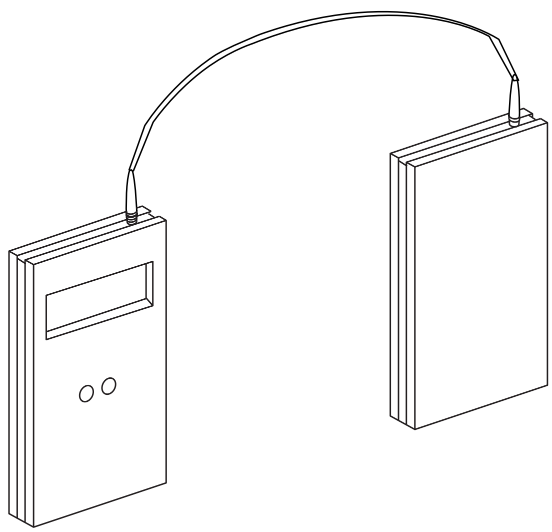
Table 9 - Fiber Operation Wavelengths

Module	Wavelength
1786-RPFS	650 nm
1786-RPFM	1300 nm
1786-RPFRL/B	
1786-RPFRXL/B	

Verify each segment length by using an optical time domain reflectometer (OTDR) field tester or by using the markings on the cable jacket.

See page 57 for more information.

Optical power meters transmit a light source at one end of your cable with an optical power meter at the other end of the cable. You can read the attenuation or power from the power meter to confirm the attenuation of your section.



See Table 5 on page 33 for module distance ratings.

Incorrect Loss Measurement Example

If you are testing a single-mode or multi-mode cable with a 640 nm light source, you will get an incorrect loss measurement. You must test the fiber at 1300 nm to match the cable rating.

Always record and maintain records for attenuation levels for each cable section strand. The attenuation records are valuable tools for troubleshooting and maintaining your network.

Considerable power loss in your cable could be a result of the following conditions:

- Poor splices
- Improper bend radius
- Bending losses
- Broken fibers
- Poor connections
- Contaminated or damaged connectors
- High fiber bend radius
- Poorly polished connector

OTDR Measurement

In addition to power loss measurement, you should examine your total fiber network by using an optical time domain reflectometer (OTDR). The OTDR emits light into a strand of fiber optic cable and displays the reflected light.

IMPORTANT	Disconnect the fiber modules from the fiber cables before performing an OTDR test.

OTDR tests provide the following measurements that will help you troubleshoot and maintain your network.

- Total distance along the cable to a fiber break
- Distance to an event (splice, bend, connector) that attenuates the light
- Distance between two attenuating events
- Light attenuation between two points of the cable
- Total reflected light or light reflected from a single event

Keep records of the traces for each cable strand on either hard copy or computer backup.

Notes:

Install Your Fiber Repeater Modules and Repeater Adapters

Installation Guidelines

Use these guidelines when you install your fiber repeater modules and repeater adapters.

IMPORTANT	Because two paths to the same nodes are not allowed, do not make a fiber or copper connection between modules that are connected to the same repeater adapter.

- Observe the environmental specifications for the fiber units as outlined in each installation instruction.
- Avoid electrostatic and electromagnetic fields at installation sites.
- Avoid corrosive and inflammable gases, dust, conductive particles, oil mist, and organic solutions when choosing an installation site.
- Prevent equipment exposure to water or direct sunlight.
- Mount the units in a NEMA-rated enclosure based on the environmental protection for where the units are being installed.

  Fiber repeater modules are IP20 components. IP means Ingress Protection, a rating based on the IEC 60529 standard to determine the strength of an enclosure for electrical equipment.

- Allow a minimum of 5 cm from surrounding equipment for proper ventilation.
- To maintain proper ventilation, do not mount the repeater modules upside down.

TIP Horizontal mounting is preferred. Vertical mounting is allowed. We recommend that the 1786-RPA/B module be mounted at the top if vertical mounting is chosen.

- Use zinc-plated yellow-chromate-steel DIN rails to prevent corrosion.

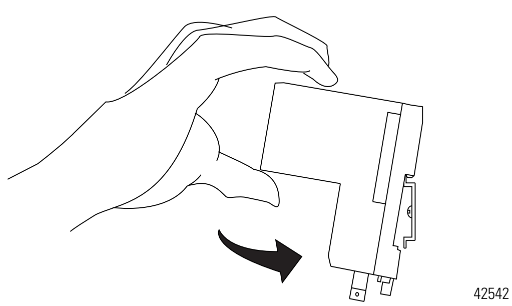
ATTENTION: Never install a 1786-RPCD repeater module to the right of a 1786-RPFRL/B or 1786-RPFRXL/B fiber repeater module on the same DIN rail. The1786-RPCD repeater module will not operate properly. Install the 1786-RPCD repeater module to the left of a 1786-RPFRL/B or 1786-RPFRXL/B fiber repeater module.

Mount the Fiber Module

The following steps are generic for mounting a module. Refer to the documentation with the repeater adapters and modules for specific installation information.

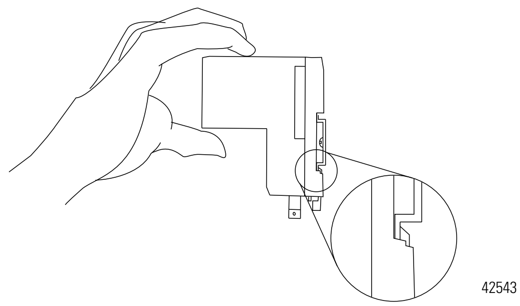
ATTENTION: This product is grounded through the DIN rail to chassis ground. Use a zinc-plated yellow-chromate-steel DIN rail to assure proper grounding. The use of other DIN rail materials (for example, aluminum or plastic) that can corrode, oxidize, or are poor conductors, can result in improper or intermittent grounding. Secure DIN rail to mounting surface approximately every 200 mm (7.8 in.) and use end-anchors appropriately.

1. Position the module at a 30° angle.
2. Hook the lip on the rear of the module onto the top of the DIN rail, and rotate the module onto the rail.



3. Press the module onto the DIN rail until flush.

The locking tab should snap into position and lock the module to the DIN rail.

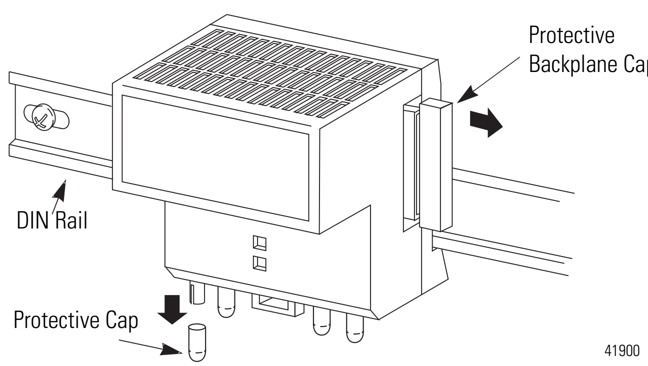


TIP Use a screwdriver to move the locking tab downward, if the module is not secured.

WARNING: Removal and insertion under power (RIUP) is not supported. These modules must be powered down while connecting and disconnecting them from any interconnected modules.

If you insert or remove the module while backplane power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.



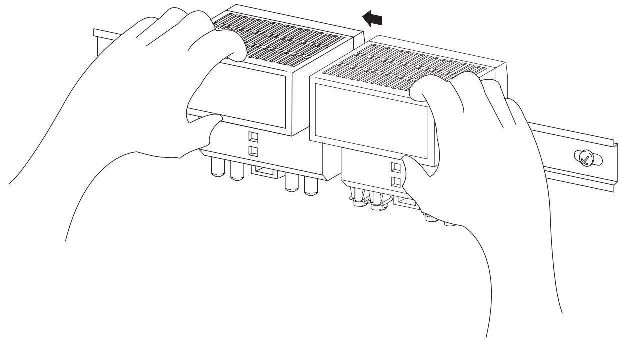
Both sides of the module contain a backplane connector.

4. If necessary, remove the protective caps from the transmit and receive fiber channels.

If	Then
You will use a channel	Remove the protective cap from the channel.
You will not use a channel	Keep the protective cap on to protect the channel from dust.
You place the module in storage	

ATTENTION: Do not discard the end cap. Use this end cap to cover the exposed interconnections on the last module on the DIN rail. Failure to do so could result in equipment damage.

5. If applicable, slide the module to the left to mate with the repeater adapter or another repeater module.



IMPORTANT	Make certain that you secure the repeater adapter and repeater modules with DIN-rail anchors. If you do not, loss of communication or module damage may result.

You can attach a maximum of four modules to the repeater adapter or attach the number of modules whose total power consumption does not exceed 1.6 A @ 5V DC, whichever occurs first.

Install the Ferrites

A ferrite is connected to the relay contact connector on the 1786-RPFRL/B and 1786-RPFRXL/B modules. A relay contact connector helps identify a faulted module in your system.

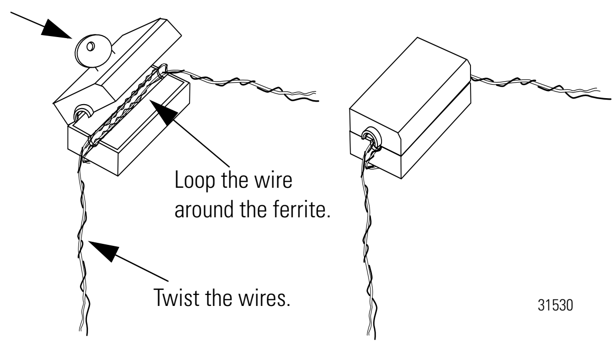
TIP	If you are not planning to use the relay contact connector on the module for system status, you do not need to install the ferrites.

Do these steps to attach the ferrite to the power supply of the 1786-RPA/B repeater adapter module.

1. Obtain 0.25...2.5 mm^2 (22...14 AWG) wire in a length sufficient for your application.

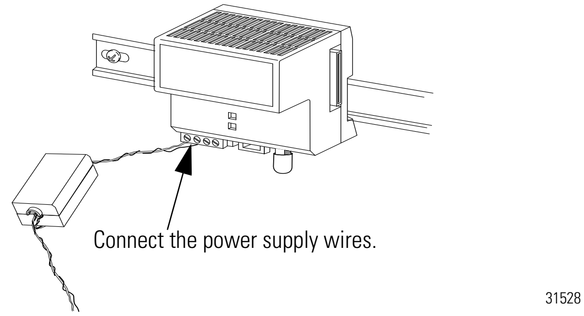
TIP	You may want to choose a smaller wire gauge (for example, 0.25…0.823 mm^2 (22…18 AWG)) with sufficient size and rating to handle amperage requirements of the power supply to aid in installation of the ferrite.

2. Use the key supplied with the ferrite to open it.



3. Twist the wires, but be careful not to damage them.
4. Form a loop with both wires (+ and -) approximately 100 mm (4 in.) away from the power supply connector of the 1786-RPA/B module.
5. Loop the wires through the ferrite.
6. Close the ferrite.

   Be careful not to damage the wires.
7. Strip approximately 6 mm (0.24 in.) of wire from the end that will connect to the power supply connector on the 1786-RPA/B module.
8. Remove the power supply connector from the 1786-RPA/B module.
9. Install the stripped ends of the wires in the power supply connector on the 1786-RPA/B module.



IMPORTANT	Do not use more than one ferrite per 1786-RPA/B module.

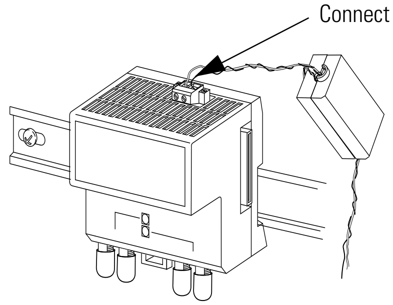
10. Reinsert the power supply connector into the 1786-RPA/B module.

Install the Ferrite at the Relay Contact Connector

1. Use the key to open the remaining ferrite.
2. Form a loop with both wires (+ and -) approximately 100 mm (4.0 in.) away from the relay contact connector of the 1786-RPFRL/B or 1786-RPFRXL/B module.

3. Loop the wires through the ferrite.
4. Close the ferrite.

   Be careful not to damage the wires.
5. Strip approximately 6 mm (0.24 in.) of wire from the end that will connect to the relay contact connector on the 1786-RPFRL/B or 1786-RPFRXL/B module.
6. Remove the relay contact connector from the 1786-RPFRL/B or 1786-RPFRXL/B module.
7. Install the stripped ends of the wires in the relay contact connector on the fiber repeater module as shown below.



8. Reinsert the relay contact connector into the 1786-RPFRL/B or 1786-RPFRXL/B module.
9. Connect the fiber cable as described on page 66.
10. If you plan not to use a channel, attach a small section of fiber cable (or a Simplex fiber loop) between the Receive port (RX) and the Transmit port (TX) of any unused fiber port to create a jumper.

    Although not required for module operation, the jumper turns the status indicators green and prevents the relay contact connector from opening and indicating a failure.

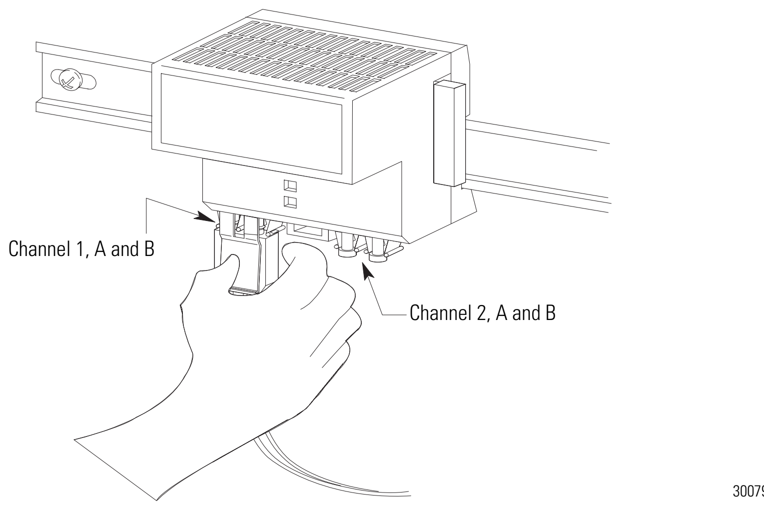
Connect a 1786-RPFS Module

The 1786-RPFS module requires a pre-terminated zipcord wiring kit. The kits are offered in a variety of lengths. Consult with your local distributor for attenuation specifications before you purchase your fiber media components.

The zipcord uses a duplex cable that contains two separate fibers, one for transmit and one for receive. If you are wiring only one channel, you can use either channel 1 or channel 2.

1. Hold down the latch and insert the channel 1 zipcord connector into the A and B connectors until the pins and latch lock into place.

   Make certain you insert the blue pin, receive, of the zipcord connector in A and the black pin, transmit, into B.



2. Hold down the latch and insert the other end of the duplex cable into another module by using either channel 1 or channel 2 of the other module.

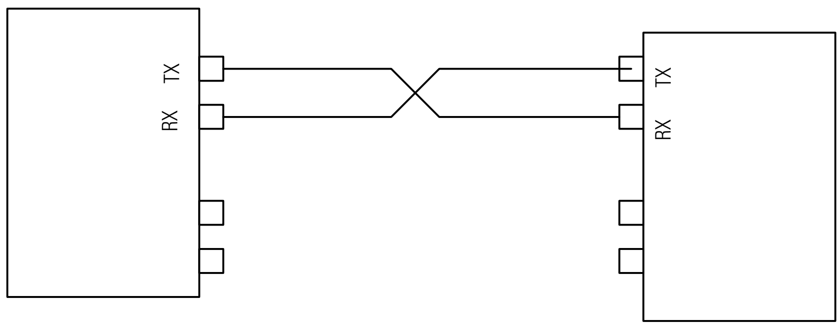
IMPORTANT	The duplex cable is manufactured with the fiber reversed on opposite ends. This automatically connects channel A of one unit to channel B of the other. Do not connect more than one duplex fiber or two simplex fibers between the same modular repeaters, even if they are from different modules on the same repeater. See page 66 for using a tracer on a duplex cable.

Connect Fiber Repeater Modules

This section describes how to connect cables for fiber repeater modules (other than the 1786-RPFS; see page 65). A tracer on a duplex cable helps to identify and follow the cable throughout your system. A tracer is one of the two wires on the duplex cable that is one of the following:

- Printed with the cable legend
- Ribbed

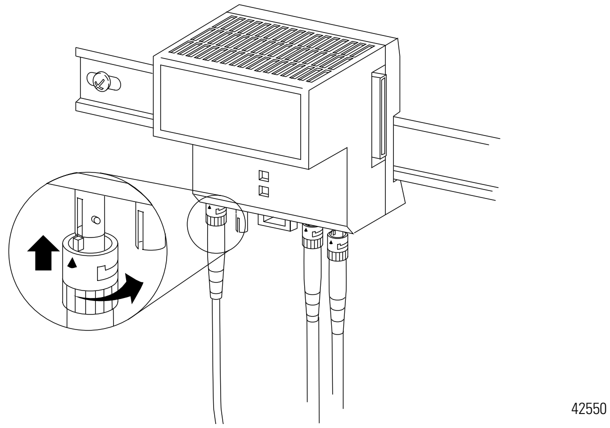
Connect the cable between the fiber modules by making a simple crisscross connection. To do this, you will connect the cables between modules from the receive (RX) end of one channel to the transmit (TX) end of the other module, as shown in the following diagram.



TIP Channels 1 and 2 on the module are identical. Channel 1 of a module can be connected to either channel of another module.

Do these steps to connect the cable.

1. Use the tracers on the cable to identify which cable is connected to the receive (RX) port and which one to the transmit port (TX).
2. Connect the receive port (RX) and transmit port (TX) at the starting module.
3. Do the following to attach the cable connector to the module connector.



a. Align the key of the cable connector with the slot in the module connector, and insert the connector into the RX port.

b. Push and twist the locking cap until the bayonet lug is locked into place.

4. At the second module, connect the cables in reverse.

   For example, tracer to TX port on module 1, non-tracer to RX port on module 1: tracer to RX port on module 2, non-tracer to TX port on module 2.

> **ATTENTION:** Do not look directly into the optical port to avoid damage to your eyes.

Terminate the Cable

Termination is the process of attaching connectors to the ends of fiber cable. Follow these general instructions when terminating fiber cable.

> **ATTENTION:** Safety glasses are required to protect your eyes when you handle chemicals and cut fiber. Pieces of glass fiber are very sharp and can easily damage the cornea of your eye.
>
> Cleaved glass fibers are very sharp and can pierce the skin easily. Do not let cut pieces of fiber stick to your clothing or drop in the work area where they can cause injury later. Use tweezers to pick up cut or broken pieces of the glass fibers and place them on a loop of tape kept for that purpose alone. Keep your work area clean.

IMPORTANT	Be certain to follow the instructions that are provided by your fiber termination kit manufacturer.

1. Organize your termination kit materials.
2. Reference your plan to be certain that you have enough supplies to make the fiber connections and to terminate all used fiber cable ends.
3. Make a schedule for performing the connections.
4. Follow the assembly and safety procedures for your termination kit.
5. Place a dust cap (supplied in fiber cable kits) on the end of the connector.

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

Wire a Repeater Adapter Module

This section describes how to wire a repeater adapter module.

WARNING: An electrical arc can occur under these circumstances:

- When you connect or disconnect the removable terminal block (RTB) with field side power applied
- If you connect or disconnect the communication cable with power applied to this module or any device on the network

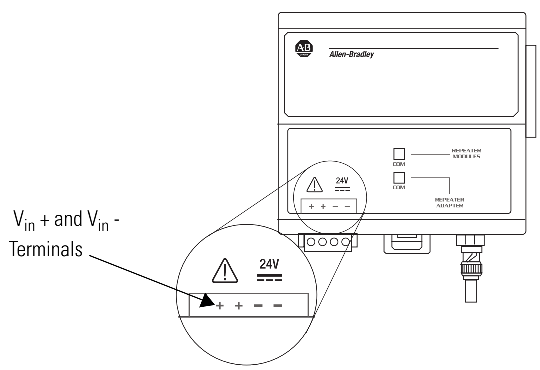
This could cause an explosion in hazardous location installations. Be sure that power is removed or the area is nonhazardous before proceeding.

TIP Make sure you have obtained the following items before you begin to wire the module:

- Two lengths of 0.21…3.3 mm^2 (24…12 AWG) wire
- Wire stripping tool
- Small, flathead screwdriver

Follow these steps to wire the module.

1. Strip about 7 mm (0.28 in.) of insulation from the end of each wire.
2. Attach the V_{in} + wire to one of the V_{in} + terminals on the RTB.



   Tighten the screws to 0.6...0.8 N•m (5...7 lb•in).

3. Attach the V_{in} - wire to one of the V_{in} - terminals on the RTB.

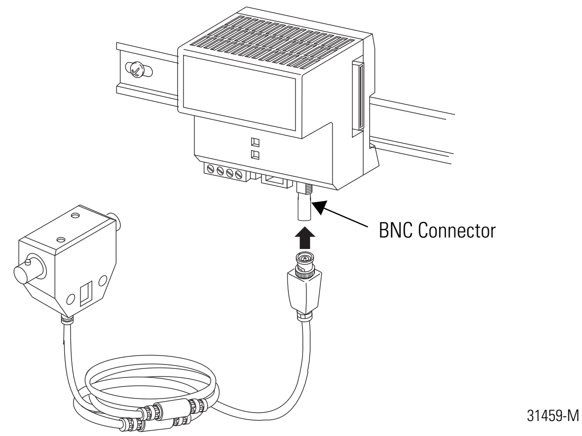
   Tighten the screws to 0.6...0.8 N•m (5...7 lb•in).

   TIP The unused V_{in} + and V_{in} - terminals can be used to supply power to other devices.

4. Install the removable terminal block (RTB) onto the repeater adapter module.

   Tighten the screws to 0.6...0.8 N•m (5...7 lb•in).

5. Connect the repeater adapter module to the ControlNet network by connecting the drop line of the coax tap to the BNC connector.



6. Terminate any unused coax ports by connecting a 75 Ω terminator to the unused BNC connector.

   One 75 Ω terminator is shipped with the repeater adapter module.

Troubleshoot the Module

Use the channel 1 or channel 2 status indicators to check module status and troubleshoot the module.

For status indicator descriptions, see page 73.

Specifications for Fiber-optic Cable

The quality of the fiber cable determines the distance you can achieve. Consult your your local distributor for attenuation specifications prior to purchasing your fiber media components.

1786-RPFS Fiber-optic Cable

Item	Description
Fiber type	200/ 230 micron HCS (hard- clad silica)
Fiber termination type	Versalink V– System
Jacket	PVC
Pull tension, max	110 lb (490 N)
Cyclic flexing	>5000
Bend radius, min	25 mm
Temperature, operating	-20 °C (-4 °F)…80 °C (176 °F)
Temperature, nonoperating	-40 °C (-40 °F)…80 °C (176 °F)
Fiber operating wavelength	650 nm (red)
Optical power budget	4.2 dB(1)

(1) This includes all loss associated with the fiber link, including splices, fiber attenuation, bulkhead connectors, and the ST terminations.

1786-RPFM Fiber-optic Cable

Item	Description
Fiber type	62.5/125 μm micron multi-mode OM-1 fiber
Fiber termination type	ST (plastic or ceramic only; do not use metal connectors)
Fiber operating wavelength	1300 nm
Optical power budget	13.3 dB(1)

(1) This includes all loss associated with the fiber link, including splices, fiber attenuation, bulkhead connectors, and the ST terminations.

1786-RPFRL/B Fiber-optic Cable

Item	Description
Fiber type	62.5/125 μm micron multi-mode
Fiber termination type	ST (plastic or ceramic only; do not use metal connectors)
Fiber operating wavelength	1300 nm
Optical power budget	15 dB(1)

(1) This includes all loss associated with the fiber link, including splices, fiber attenuation, bulkhead connectors, and the ST terminations.

1786-RPFRXL/B Fiber-optic Cable

Item	Description	
Fiber type	62.5/125 μm micron multi-mode	9/125 μm micron single-mode
Fiber termination type	ST (plastic or ceramic only; do not use metal connectors)	
Fiber operating wavelength	1300 nm	
Optical power budget	10.5 dB(1)	

(1) This includes all loss associated with the fiber link, including splices, fiber attenuation, bulkhead connectors, and the ST terminations.

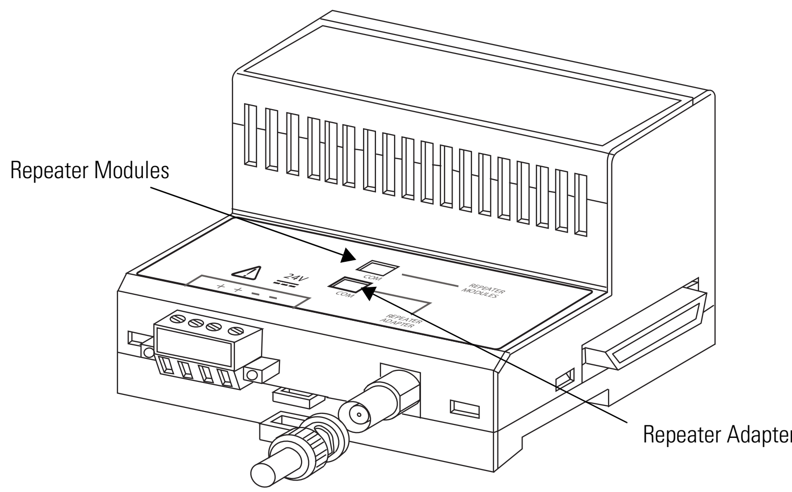
Notes:

Status Indicators

The 1786-RPA/B repeater adapter has a pair of status indicators:

- One status indicator for the condition of the coax connection
- One status indicator for the accumulative indications of fiber channels

The status indicators on the repeater adapter module can be interpreted alone or together.



The following three tables list different combinations of status indicators and their interpretations.

Status Indicators	Page
Power-up and fault conditions	Table 10 on page 74
Repeater adapter module only	Table 11 on page 74
Repeater modules only	Table 12 on page 75

IMPORTANT The following are the only valid indicator combinations. Other combinations are not valid. For example, the combination of the repeater adapter module's solid green status indicator and the repeater module's solid red status indicator is not valid and probably indicates a defective module.

Table 10 - Power-up and Fault Conditions

Indicator	Status	Description
Repeater adapter	Alternating red/green	Repeater adapter module is being powered up or reset. Do nothing. The repeater adapter module is operating properly.
	Solid red	A jabber condition has occurred. Another node or repeater on the network is transmitting constantly. Check the network and components for proper operation.
	Off	Repeater adapter module is not powered up or has failed. Check the power input to the repeater adapter module for correct voltage and polarity.

Table 11 - Repeater Adapter Module Status Indicator

Indicator	Status	Description
Repeater adapter	Solid green	Error-free data is being recovered at the coax port of the repeater adapter module. Do nothing. This is the normal operating mode.
	Flashing green/off	Data with errors is occasionally being recovered at the coax port of the repeater adapter module. This situation normally corrects itself. If the situation persists, check the following: • All BNC connector pins are seated properly. • All taps are Rockwell Automation taps. • All terminators are 75 Ω and are installed at both ends of all segments. • Coax cable has not been grounded.
	Flashing red/off	Either no data is being received at the coax port of the repeater adapter module, or data with a large number of errors is being received at the coax port of the repeater adapter module. Check the following components: • Broken cables • Broken taps • Missing segment terminators

Table 12 - Repeater Modules Status Indicator

Indicator	Status	Description
Repeater module	Solid green	Error-free data is being recovered at all of the attached repeater modules. Do nothing. This is the normal operating mode.
	Flashing green/off	Data with errors is occasionally being recovered at some or all of the repeater modules. This situation normally corrects itself. If the situation persists, check the following: • All BNC connector pins are seated properly. • All taps are Rockwell Automation taps. • All terminators are 75 Ω and are installed at both ends of all segments. • Coax cable has not been grounded. • Fiber-optic connectors are of the correct type and are correctly attached to the fiber-optic cable. • Fiber-optic cable is the correct type.
	Flashing red/off	Either no data is being received at any of the repeater modules, or the received data at some or all of the repeater modules has a high number of errors. Check the following components: • Broken cables • Broken taps • Missing segment terminators

1786-RPFS and 1786-RPFM Status Indicators

Use the channel 1 or 2 status indicators to check module status.

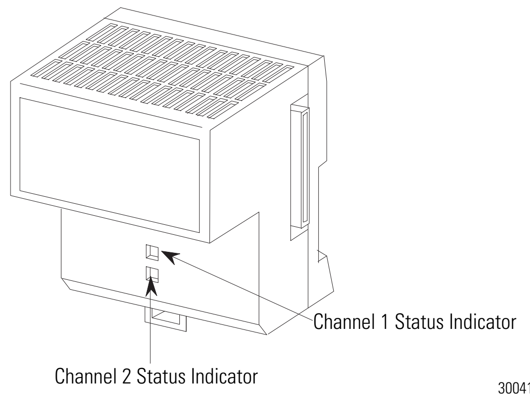


Table 13 - Short- or Medium-distance Fiber Repeater Modules

Indicator	Status	Description
Either channel 1 or channel 2	Off	Repeater not connected to power supply.
	Green	Channel is operating normally.
	Flashing green	No activity on the channel.

1786-RPFRL/B or 1786-RPFRXL/B Status Indicators

Use the channel 1 or 2 status indicators to check module status.

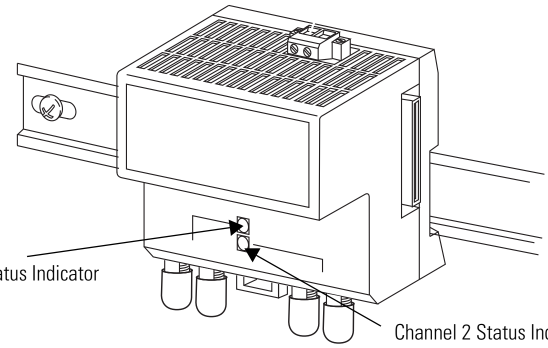


Table 14 - Long- or Extra-long Fiber Repeater Modules

Indicator	Status	Description
Repeater module	Off	Fiber repeater module is not connected to the power supply. Connect the repeater to the power supply.
	Green	The fiber repeater module is operating properly.
	Flashing green/off	No data activity on the network. If the cable is attached, do the following: • Make sure the receive (RX) channel is connected to the transmit (TX) channel on both modules. • Check for broken fiber.
	Flashing red/off	Module is powered, but not ready for operation. This state should also occur during module reset and last for approximately 5 seconds. Do nothing. The fiber repeater module is operating properly.
	Intermittent red	As more data errors are detected, the frequency of the flashing red increases until a solid red is displayed. Check for proper operation.

Table 14 - Long- or Extra-long Fiber Repeater Modules

Indicator	Status	Description
Repeater module	Red	Excessive receive signal distortion. Review these items: • Be certain that you are using the correct fiber type for your module. • Check fiber length and attenuation to make sure that it is within specification. • Replace the downstream 1786-RPFRL module on the channel that has the intermittently flashing red status indicator. • Be certain that your total network length is not out of specification. • Be certain that SMAX is correctly defined in the RSNetWorx for ControlNet software.

1786-RPFRL/B or 1786-RPFRXL/B Relay Contact Connectors

The 1786-RPFRL/B and 1786-RPFRXL/B fiber repeater modules contain a single electromechanical relay for communication and system status. The relay provides an efficient way to locate a faulted module.

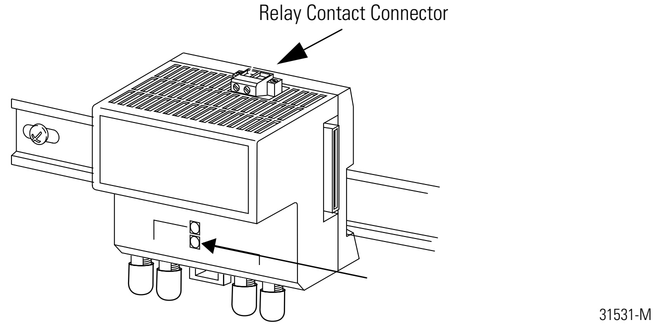


Table 15 - Relay Contact Connector Diagnostics

Indicator	Status	Description
Channel 1 or channel 2	Not solid green	The relay contact is open. No receive data is present at one or both fiber-optic ports for more than 1300 ms (that means if either of the channel status indicators are not solid green, the fault relay opens.) The repeater is not connected to the power supply.
	Off	The relay contact is closed. Neither of the above conditions is met.

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.

APD (avalanche photo diodes) Converts light to current in fiber receivers.

attenuation (loss) Ratio of input optical power to output optical power for a length of fiber optic cable in dB/km.

bandwidth Pulse broadening caused by multi-mode dispersion and chromatic dispersion within the cable.

baseband Information is transmitted through fiber by modulation of the optical power.

BER (bit error rate) Primary method of describing the data error rate. An acceptable error rate is 1×10^{-9} bit errors (or 1 error in 1000 Mbits transmitted).

bend radius Maximum amount the cable can be bent and still function up to specification.

buffer Material surrounding the fiber (core, cladding, coating) that protects the fiber from physical damage. Tight buffers are in direct contact with the fiber. Loose-tube buffers provide a free environment for the fiber to float.

cladding Layer of material surrounding the core of a fiber.

coating Protective plastic material surrounding the cladding.

core Central cylinder of a fiber that is made of plastic or glass.

dB Unit of measure for loss or gain of power described as 10 × log (pout/pin).

dBM Power level referenced to 1 mw described as 10 × log (poptical/1 mw).

ferrite A passive electric component that is used to suppress high frequency noise in electronic circuits.

graded index Fiber system where light travels in wave-like tracks to increase cable bandwidth.

insertion loss Loss in dB caused by the disruption of light when an object is inserted in the light path (a connector, bulkhead, splice, or cable).

laser diode Converts electric energy into light energy to be coupled onto fiber media.

LED (light emitting diode) Converts electric energy into light.

local area network Family of computer networks, industrial control networks, and office networks used in short-distance, multi-user environments.

loss see attenuation (loss)

multi-mode Class of fibers where the light travels in multiple paths down the fiber core.

numerical aperture (NA) In a lens or fiber, the sine of half the maximum angle of acceptance α. NA = sin α = $\sqrt{(n1^2 - n2^2)}$ where n1= core refractive index and n2=cladding refractive index.

network update time (NUT) Time necessary to complete the scheduled bandwidth, unscheduled bandwidth, and network maintenance in the network interval.

OTDR (optical time domain reflectometer) Tool for characterizing fiber attenuation, uniformity, splice loss, breaks, or length.

photo diode see pin diode

pin diode Used as a receiving device in fiber optic systems to detect the presence of light and convert that light energy into electrical energy.

plastic clad silica fiber Step-index fiber made from silica core and a plastic cladding.

plastic fiber fiber consisting only of plastic with usually higher attenuation than glass.

receiver Produces logic levels in a fiber optic system by using photo diodes, resistors, amplifiers, and level shift circuits.

refractive index Ratio of the speed of light in a vacuum to the speed of light in the material.

responsivity Ratio of output current/voltage to the optical input power.

return loss Logarithmic ratio of power into a device to the power reflected back due to mismatches in a system. Return Loss = $10 \times \log (P_{in}/P_{back})$.

scheduled maximum node address (SMAX) Highest scheduled node address on the ControlNet network.

sensitivity Minimum optical power amplitude at the input of a receiver in order to achieve a predefined BER.

single-mode Class of fibers in which light travels in a single path down the fiber core.

speed of light Phase velocity of an optical wave in a vacuum.

splice Connection in the fiber designed to increase the length of the fiber.

step index Fibers with a refractive-index profile form in a rectangle.

tap Couples a fraction of optical power from a fiber to a receiver.

unscheduled maximum node address (UMAX) The highest unscheduled node address on the ControlNet network.

Notes:

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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 manuals, a knowledge base of FAQs, technical and application notes, sample code and links to software service packs, and a MySupport feature that you can customize to make the best use of these tools.

For an additional level of technical phone support for installation, configuration, and troubleshooting, we offer TechConnect support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit http://www.rockwellautomation.com/support/.

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/support/americas/phone_en.html, or contact your local Rockwell Automation representative.

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Publication CNET-IN001C-EN-P - October 2011
Supersedes Publication CNET-IN001B-EN-P - July 2004