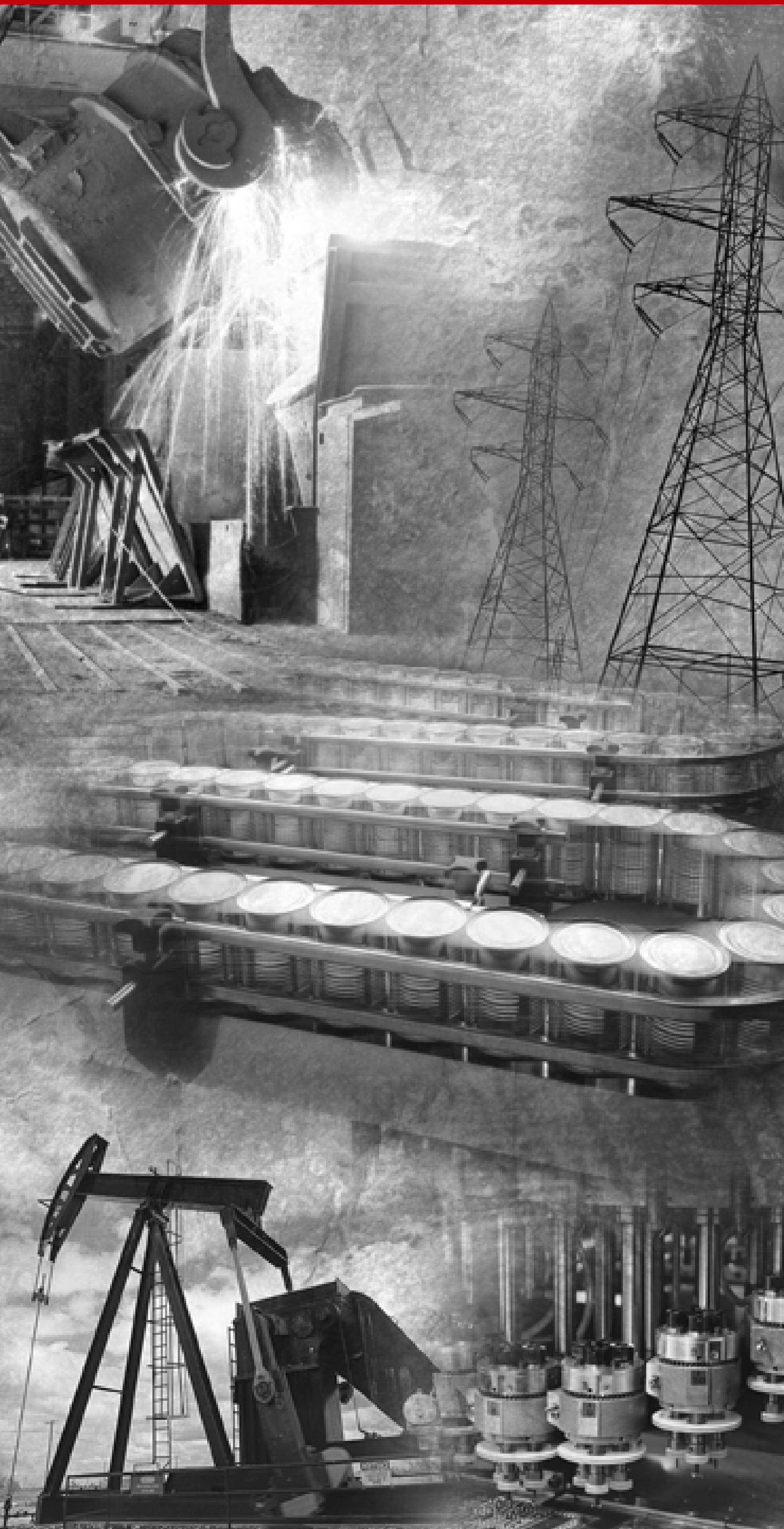


Allen-Bradley

ControlNet Fiber Media Planning and Installation Guide

1786 Series

User Manual

Rockwell Automation

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, *Safety Guidelines for the Application, Installation and Maintenance of Solid-State Control* (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

Throughout this manual we use notes to make you aware of safety considerations:

ATTENTION Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attention statements help you to:

- identify a hazard
- avoid a hazard
- recognize the consequences

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

European Communities (EC) Directive Compliance

If this product has the CE mark it is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

EMC Directive

This product is tested to meet the Council Directive 89/336/EC Electromagnetic Compatibility (EMC) by applying the following standards, in whole or in part, documented in a technical construction file:

- EN 50081-2 EMC — Generic Emission Standard, Part 2 — Industrial Environment
- EN 50082-2 EMC — Generic Immunity Standard, Part 2 — Industrial Environment

This product is intended for use in an industrial environment.

Low Voltage Directive

This product is tested to meet Council Directive 73/23/EEC Low Voltage, by applying the safety requirements of EN 61131-2 Programmable Controllers, Part 2 - Equipment Requirements and Tests. For specific information required by EN 61131-2, see the appropriate sections in this publication, as well as the Allen-Bradley publication Industrial Automation Wiring and Grounding Guidelines For Noise Immunity, publication 1770-4.1.

This equipment is classified as open equipment and must be mounted in an enclosure during operation to provide safety protection.

About This Manual

This guide is not intended to be used as step-by-step instructions for cable installation. Actual procedures may vary depending on cable style and installation environment. We recommend that you consult cable designers for precise handling and installation details regarding your specific application(s). Please refer to the Glossary in the rear of the book for clarification of terms associated with fiber technologies.

The following table will help you find specific information in this manual.

Topic:	Chapter:
Quick Start to the ControlNet Fiber Media system	1
Complete overview of the ControlNet Fiber Media system	2
Plan your ControlNet Fiber Media system	3
Review general guidelines for fiber cable installation	4
Install a ControlNet Fiber Media system	5
Terminate your fiber cable	6
Verify your ControlNet Fiber Media system	7

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

Related Publications

The following table contains numbers and names of publications related to this topic.

Catalog Number:	Publication Name:	Publication Number:
1770	Industrial Automation Wiring and Grounding Guidelines Application Data	1770-4.1
1786	ControlNet Cable Planning and Installation Guide	1786-6.2.1
1786	ControlNet Cable System Planning and Installation Guide	1786-6.2.1-RN
1786-RPA	ControlNet Modular Repeater Adapter Installation Instructions	1786-5.13
1786-RPFS	ControlNet Modular Repeater Short-distance Fiber Module Installation Instructions	1786-5.12
1786-RPFM	ControlNet Modular Repeater Medium-distance Fiber Module Installation Instructions	1786-5.11
1786-RPFRL/RPFRXL	ControlNet Modular Repeater Long and Extra Long-distance Fiber Ring Module Installation Instructions	1786-IN003A-EN-P
1786-RPCD	ControlNet Modular Repeater Dual Copper Module	1786-IN001A-US-P
Various	ControlNet Media Component List	AG-2.2
1797	ControlNet Ex System Planning and Installation Guide	1797-6.2.1

Common Techniques

The following conventions are used throughout this manual:

- bulleted lists provide information, not procedural steps
- numbered lists provide sequential step

TIP

This symbol identifies helpful tips.

Rockwell Automation Support

Rockwell Automation offers support services worldwide, with over 75 sales/support offices, 512 authorized distributors, and 260 authorized systems integrators located throughout the United States alone, plus Rockwell Automation representatives in every major country in the world.

Local Product Support

Contact your local Rockwell Automation representative for:

- sales and order support
- product technical training
- warranty support
- support service agreements

Technical Product Assistance

If you need to contact Rockwell Automation for technical assistance, first call your local Rockwell Automation representative, then:

- Network Pre-sales Hotline, 440.646.3638 (3NET)
- Fax Back system, 440.646.5436 (requires a touch-tone telephone)
- Post-sales Technical Support, 440.646.5800
- Web Links http://www.ab.com — as a registered member, open to http://www.ab.com/mem/technotes/techmain.html

Your Questions or Comments about This Manual

If you find a problem or have a comment about this manual, please notify us of it on the enclosed Publication Problem Report (at the back of this manual).

If you have any suggestions about how we can make this manual more useful to you, please contact us at the following address:

Rockwell Automation, Allen-Bradley Company, Inc.
Control and Information Group
Technical Communication
1 Allen-Bradley Drive
Mayfield Heights, OH 44124-6118

Plan a ControlNet Fiber Media System

Chapter 3

Chapter 4
Guidelines for Fiber Optic Installation

Chapter 5
Install a ControlNet Fiber Media System

Terminate Your Network

Chapter 6

Verify Your Network

Chapter 7

Glossary

Index

The ControlNet Fiber Media System Quick Start

What This Chapter Contains

Read this chapter for a quick start to the ControlNet fiber media system. You will notice that some of the information in this chapter repeats in subsequent chapters. Chapter 1 is simply a quick overview to the process you need to follow when you apply fiber media.

The following table describes what this chapter contains and where to find specific information.

Fiber Media Quick Start

Fiber media offers the following features:

- electrical isolation
- immunity to interference
- longer distances
- decreased size and weight
- entry into hazardous areas

The following steps outline what you need to do to apply the ControlNet fiber media system.

1. **Analyze** your network application.

ATTENTION

If you are going to use fiber media in an intrinsically safe area, consult with your local safety coordinator. For hazardous locations, refer to publication CNET-IN003A-US-P, The ControlNet EX Media Planning and Installation Manual because you need specific products designed for intrinsically safe locations.

2. **Identify** the fiber media components that your network application requires.
3. **Plan** the installation of the fiber media components.
4. **Install** the fiber media system.
5. **Provide** the NUT, SMAX, UMAX, and worst case network delay data for RSNetworx.
6. **Terminate** your fiber cable.
7. **Power** your network.
8. **Test** your fiber media segments.
9. **Verify** your network.

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. The table below describes the features and benefits of a fiber optic media system.

ATTENTION

If you are going to use fiber in an intrinsically safe area, consult with your local safety coordinator.

Table 1.A The Features and Benefits of Fiber Media

Features:	Benefits:
Electrical Isolation	Fiber media is isolated from any potential electrical sources that cause disruptions on copper media.
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, etc.) where copper could suffer disruptions.
Longer Distances	A fiber media has less loss than copper. The less loss in fiber media means fewer repeaters than traditional media; making fiber more effective for applications requiring long distance media connections. Fiber's signal capacity is ideal for a deterministic control network.
Decreased Size and Weight	Fiber media can carry more information than copper or coax, and is smaller than traditional media.
Entry into Hazardous Areas	Fiber media may provide a way to carry information into hazardous areas reducing the risk of injury.

For information on purchasing these components see the Allen-Bradley ControlNet Cable System Component List, publication AG-2.2.

1. Analyze your network.

Take the time to analyze your current or new network application. Use a project plan to design your network. If you are 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.

Understand the ControlNet Fiber Media System

The ControlNet fiber media system gives you the flexibility to design a communication network for your particular application. To take full advantage of this flexibility, you should spend sufficient time to plan the installation of your network **before** you assemble any of the hardware. Fiber media applications mainly provide the ability to extend or isolate a segment of a network.

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. The features and benefits of a fiber media system range from EMI immunity to decreased size and weight when compared to coax media. See Chapter 2 for a full explanation of the features and benefits of a fiber media system. Use the following figure and term definitions to understand the ControlNet fiber media system.

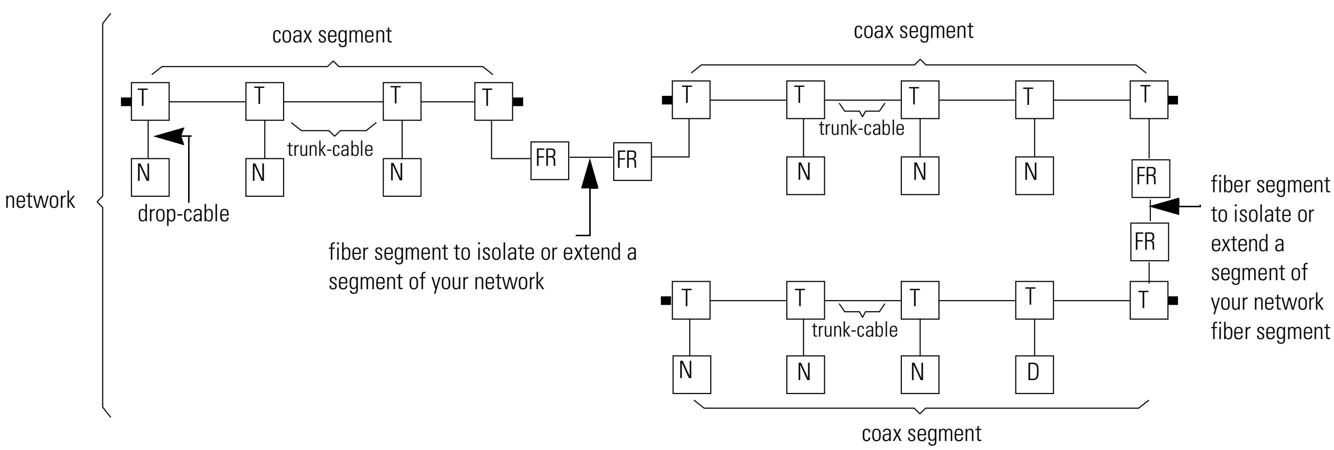


Table 1.B Network Terms

Term:	Means:
coax repeater **CR**	• a two-port active physical layer component that reconstructs and retransmits all traffic it hears on one coax segment to another coax segment
coax segment	• trunk-cable sections connected via taps with terminators at each end and with no repeaters
fiber section	• a length of fiber optic cable connecting two fiber repeater modules
fiber repeater **FR**	• consists of a fiber repeater module and a fiber adapter components that reconstruct and retransmit all traffic it hears on one fiber or coax segment side to another coax or fiber segment side
node **N**	• any physical device connecting to the ControlNet fiber or ControlNet media system which requires a network address in order to function on the network — a link may contain a maximum of 99 nodes this address must be in the range of **1 - 99** and be unique to that link
link	• a collection of nodes with unique addresses in the range of 1-99
network	• a collection of connected nodes • the connection paths between any pair of devices may include repeaters and bridges
tap **T**	• the connection between any device and the ControlNet media system
tap terminator **D**	• dummy load that terminates a tap drop-cable that has yet to be connected to a node
terminator ■	• a 75Ω resistor mounted in a BNC plug
trunk-cable section	• a length of a cable between any two taps
●●●	• network continues (other nodes not shown)

Determine Your Topology

The main purpose of fiber media is either to extend a segment or to isolate a segment of your network. You can use the fiber repeater system, whether it be fiber or a hybrid of fiber and copper to isolate suspect segments of your network to avoid failures to your entire network. Troubleshooting becomes easier when you apply isolated segment topologies, especially to problem prone areas such as a segment that has high flexing.

For example, a major car manufacturer used fiber media to isolate segments of their network that contained a turntable with a slip ring. Since the hardware went through the repeater, a failure of the turntable would not take down the entire network.

The first step to using fiber media is to analyze your application and determine the topology of your current or new network application. Then you need to decide which topology you need to use.

The following figures illustrate the variety of topologies possible when you apply the ControlNet Fiber Media System. See Chapter 2 and 3 for additional illustrations and detailed information, including “incorrect” examples of fiber topologies.

Figure 1.1 Star Topology

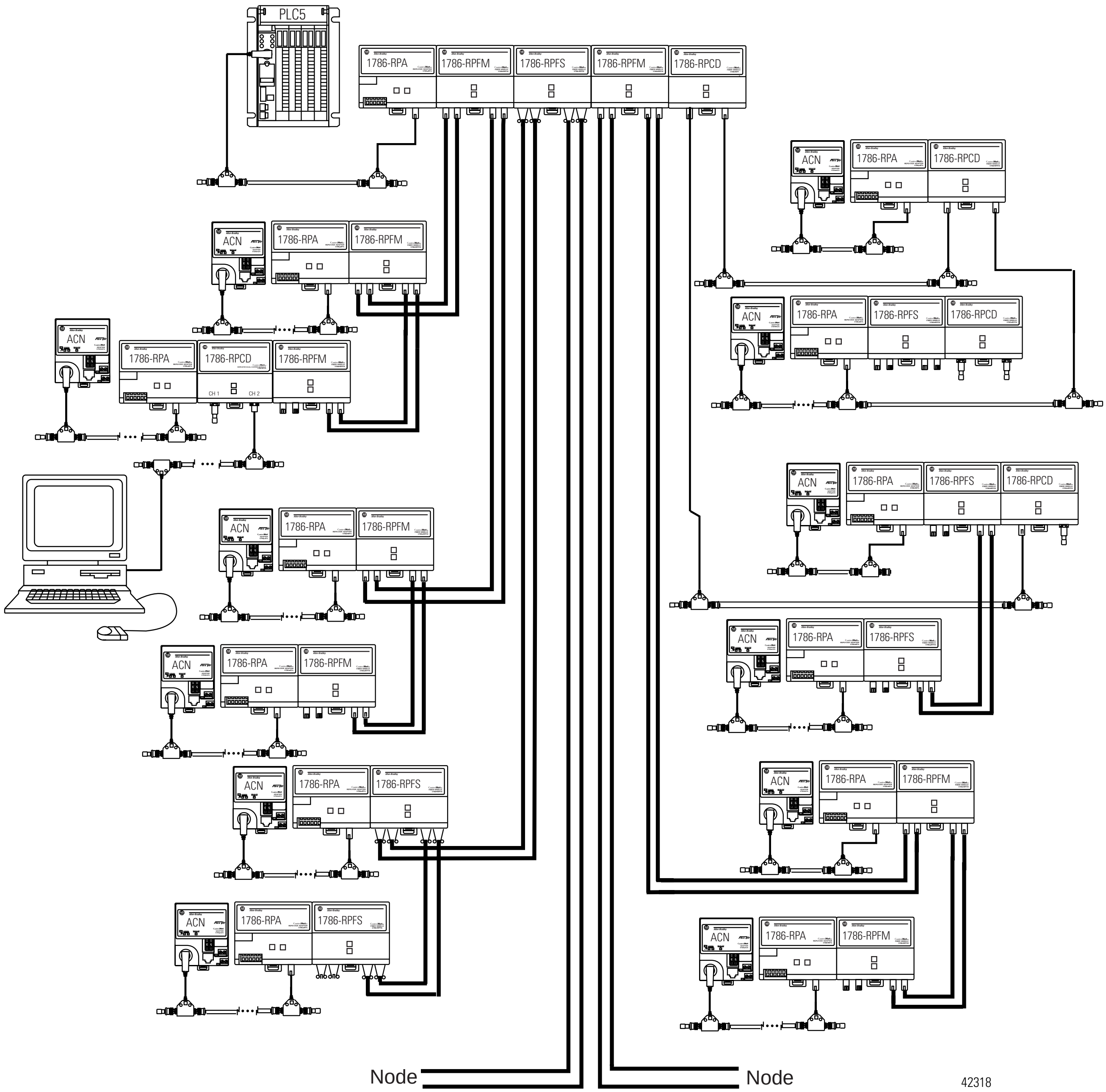


Figure 1.2 Ring Topology

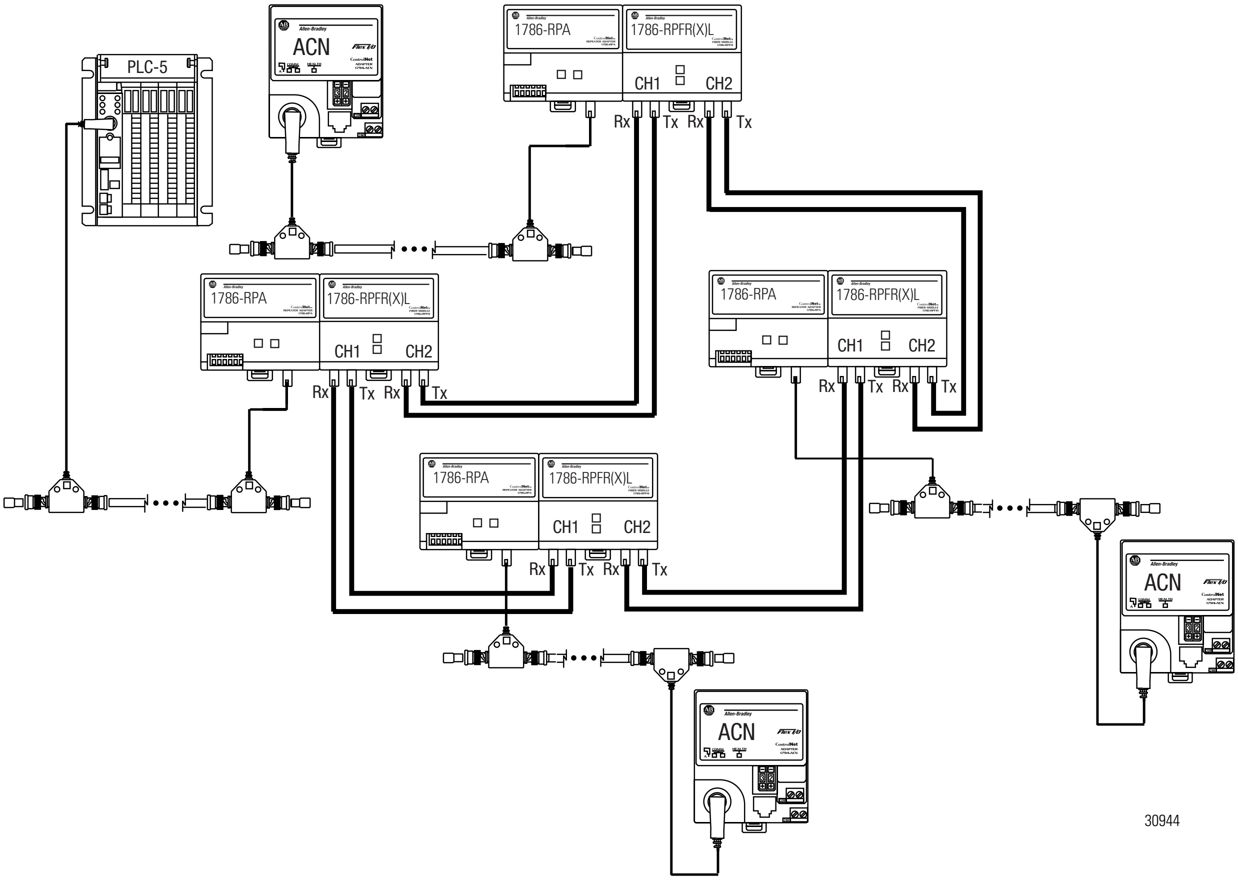
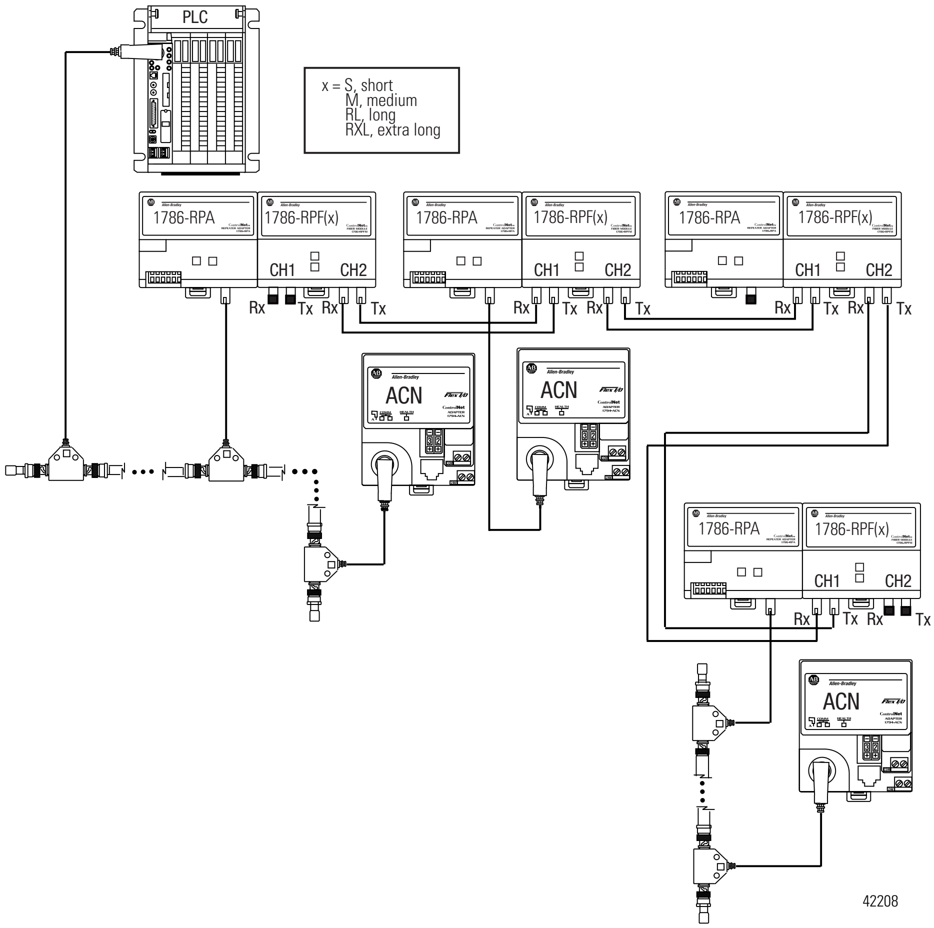


Figure 1.3 Point-to-point Topology



2. Identify the ControlNet fiber media components.

The ControlNet fiber media system is comprised of these components:

- fiber cable
- nodes
- connectors
- repeater adapters
- fiber repeater modules
- power supply for repeater

For information on purchasing these components see the Allen-Bradley ControlNet Cable System Component List, publication AG-2.2.

3. Plan the installation of the fiber media components.

Use your project plan and create checklists to help you determine the components needed for your application.

- Determine how many nodes (taps) will be in the fiber segment
- Determine the length of the fiber segments
- Decide the type of fiber cable and connections to use
- Determine how many fiber connectors you will need
- Calculate the maximum allowable segment length
- Determine if you will need additional repeaters and coax segments

4. Install the fiber media system.

Fiber Connectors

Fiber cable connectors connect fiber cable to the fiber repeater module. Currently, all the fiber repeaters accept single-mode fiber connections. The short distance (1786-RPFS) repeater uses the V-pin "plug-n-play type connector. The medium and long distance modules over 300m use an "ST" type connector. Your upper level distances can increase by using high quality cable and connectors.

The specifications needed to determine the type of connectors you need for your system (based on distance and attenuation levels) and how to connect and terminate the fiber cable is in this manual.

Module type:	Distance:	Connector:
1786-RPFS	0-300m	V-pin
1786-RPFM	0-3km	ST
1786-RPFRL	0-10km	ST
1786-RPFRXL	0-20km	ST

Although, sophisticated tools are required to terminate medium distance cable as well as a delicate touch, the termination kit we recommend (the Siecor® Termination Kit) is easy to master. In Chapter 6, we provide an overview of how to terminate the longer distance cable with one of these kits. Siecor provides an excellent instruction manual with the kit and fiber optics training is available.

IMPORTANT Be certain that you follow the manufacturers termination kit instructions.

The Siecor® Termination Kit has shown through our testing to produce repeatable high quality connections. The kits offers high quality tools and effective instructions on how to terminate the fiber cable. Although fiber media is more delicate than coax, we have found that once you terminate a few fiber connections, it is as easy or easier than coax media.

Depending on your resources and individual network requirements, you may find it necessary to consult with a fiber media specialist for network design application, to determine what type of connectors necessary for your system and the physical installation. It is a good idea to have a third party specialist review the network and certify the installation.

IMPORTANT The multi-mode MT-RJ connectors will be used on future Rockwell Automation products.

Fiber Repeater Hubs

ControlNet uses a modular fiber repeater system. The repeater adapter (1786-RPA) connects to the coax media and repeats signals from the coax media to the fiber repeater modules and is referred to as the adapter in this publication. The fiber repeater modules (1786-RPFS, RPFM, RPFRL, RPFRXL) sends the signal through the fiber cable to the next fiber repeater on the network and is referred to as the module here. The combination of the adapter and the module is referred to as the fiber repeater.

IMPORTANT The fiber repeater adapter (1786-RPA) is referred to as the adapter throughout this document. The fiber repeater module (1786-RPFS, RPFM, RPFRL, RPFRXL) is referred to as the modules in this document.

Fiber Repeaters

The fiber repeater consists of a fiber repeater adapter (1786-RPA) and 1 to 4 fiber repeater modules (1786-RPFS, RPFM, RPFRL, RPFRXL). Extend the total length of your segment with a fiber repeater. You can create a star configuration, (multiple directions from one point.) The number of fiber repeaters and cable length total limit depends on your network topology. You can also use fiber repeaters to cross into hazardous areas.

ATTENTION You must use products specifically designed for hazardous areas. You can use fiber repeaters that are design for hazardous areas as a link from your non-hazardous area to your hazardous area. Hazardous areas require the use of specifically designed products.

If you are going to use fiber in an intrinsically safe area, consult with your local safety coordinator. For hazardous locations, consult publication CNET-IN003A-US-P, The ControlNet EX Media Planning and Installation Manual because you need specific products designed for intrinsically safe locations.

The total number of repeaters (1786-RPFS, RPFM, RPFRL, RPFRXL and coax 1786-RPCD) in series (path) length total is limited to 5 repeaters and 6 segments.

Figure 1.4 Basic fiber ring topology

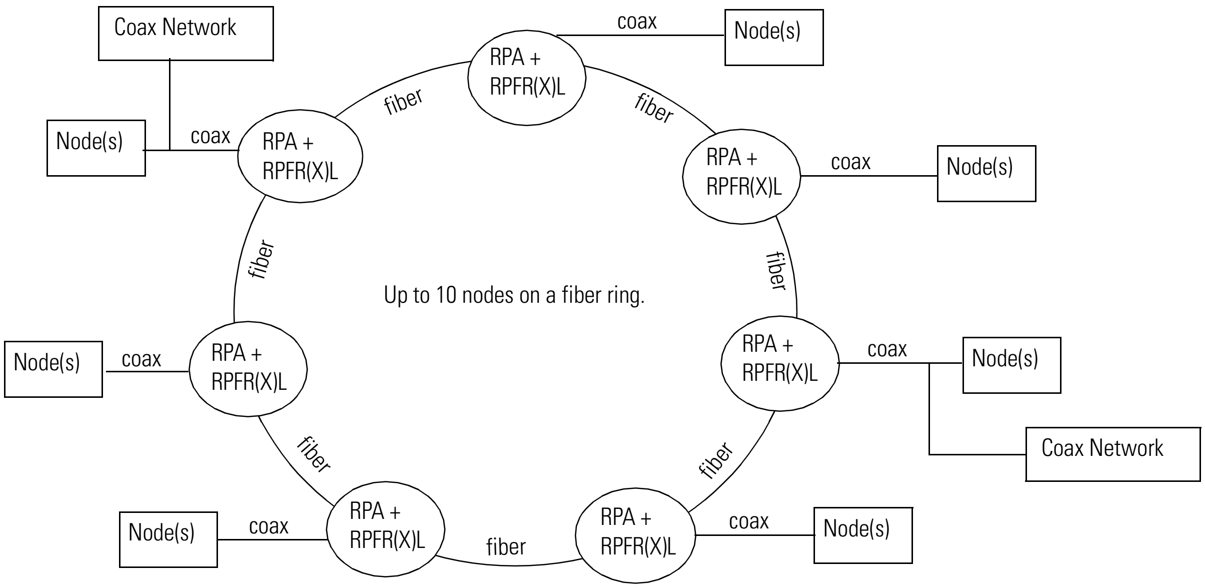
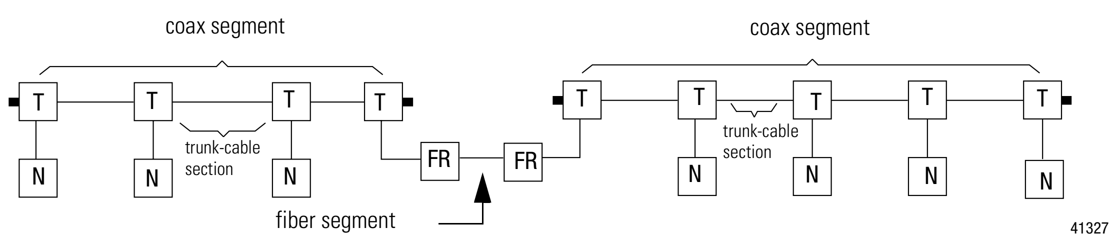


Figure 1.5 Create a new segment with a fiber repeater.



When you insert a fiber repeater into your media system, you create a new segment. The same restrictions on the number of taps and cable length apply to this new segment.

5. Provide the data for RSNetworx.

You can use RSNetWorx for ControlNet to determine whether or not your system meets the network parameter requirements. Based on your system planned requirements (NUT, SMAX, UMAX, and worst case network delay), RSNetWorx will calculate your planned network parameters. Once the parameters are calculated, the software will tell you whether or not if your configured network is acceptable as you have planned. If you network is not valid, you must adjust your planned requirements.

6. Terminate your fiber cable.

Terminating is the process of adding a fiber connector to a fiber cable. Fiber cable must have a connector on the end. If a cable and connector are not going to be used, a dust cap should be placed on the unconnected terminated fiber cable end.

Rockwell offers the short distance (<0-300m) fiber cable preterminated as a kit. The medium, long and extra long distance (> 300 m) cable is the media that needs to be terminated in the field. See page 2-6 for a list of cable sizes, connector types, and catalog numbers. For a complete list of ControlNet media, see publication AG-2.2

MT-RJ is the latest connector technology that allows for more compact connector grouping that is possible with the current ST style connector. The ST- connector can be used with multi-mode cable and is compatible with the Rockwell medium distance fiber module, fiber ring module, and repeater products.

The Corning Cable Systems kit has shown to produce reliable and consistent high quality fiber connections/termination. You can also use this kit with the MT-RJ connectors that we will use in our next generation products such as the daughter cards and Rockwell Automation Ethernet/IP products.

IMPORTANT For best results, use a high quality microscope design for use with fiber optics.

ATTENTION

NEVER LOOK DIRECTLY INTO THE FIBER CABLE. YOUR EYES WILL BE DAMAGED.

The Unicam Kit will install the MT-RJ connectors as well as the ST connectors. This process is similar for the other Corning Cable Systems connectors designed for use with the Unicam kit. You can obtain information about ordering the various kits from your Distributor.

Terminate your cable

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. Follow the assembly procedures for your termination kit.
4. Attach the end cap to the unused connector or attach the connector to a repeater module.

7. Power your network.

The power for your fiber modules comes from the repeater adapters.

1. Connect to the ControlNet network by attaching the fiber modules to the DIN rail. Refer to the instructions provided with the fiber modules for installation instructions.
2. Connect the fiber modules to a repeater adapter.
3. Connect the repeater adapter to a 24V dc power supply. Refer to the instructions provided with the repeater adapter for wiring instructions.

IMPORTANT Be certain that all repeater modules are attached and secured prior to applying power to the adapter. Failure to do so may cause damage to the adapter and modules.

Be certain to properly ground the DIN rails. Refer to the instructions provided with the DIN rails.

8. Test your fiber media connections and segments.

There are currently no products available on the market that test the connector on the short distance fiber cable but there are many products available to test the connectors on the medium and long distance cable.

9. Verify your network.

You can use RSNetWorx for ControlNet to verify whether or not your system meets the network parameter requirements.

1. Go online and browse your network.
2. Look for invalid node addresses.
3. Look for segments that violate distance constraints.
4. Run logic that tests a single segment.
5. Run logic that tests multiple segments.
6. Run logic that tests complete network.

What is next?

Now that you have a general understanding of the ControlNet fiber media system, go to Chapter 2 for a detailed overview of the fiber media system or go to Chapter 3 and plan your network.

Overview of the ControlNet Fiber Media System

What This Chapter Contains

Read this chapter to familiarize yourself with the ControlNet fiber media system. The following table describes what this chapter contains and where to find specific information.

Understand the ControlNet Fiber Media System

The ControlNet fiber media system gives you the flexibility to design a communication network for your particular application. To take full advantage of this flexibility, you should spend sufficient time to plan the installation of your network **before** you assemble any of the hardware. Fiber media applications mainly provide the ability to extend or isolate a segment of a network.

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. The features and benefits of a fiber media system range from EMI immunity to decreased size and weight when compared to coax media. See Chapter 2 for a full explanation of the features and benefits of a fiber media system. Use the following figure and term definitions to understand the ControlNet fiber media system.

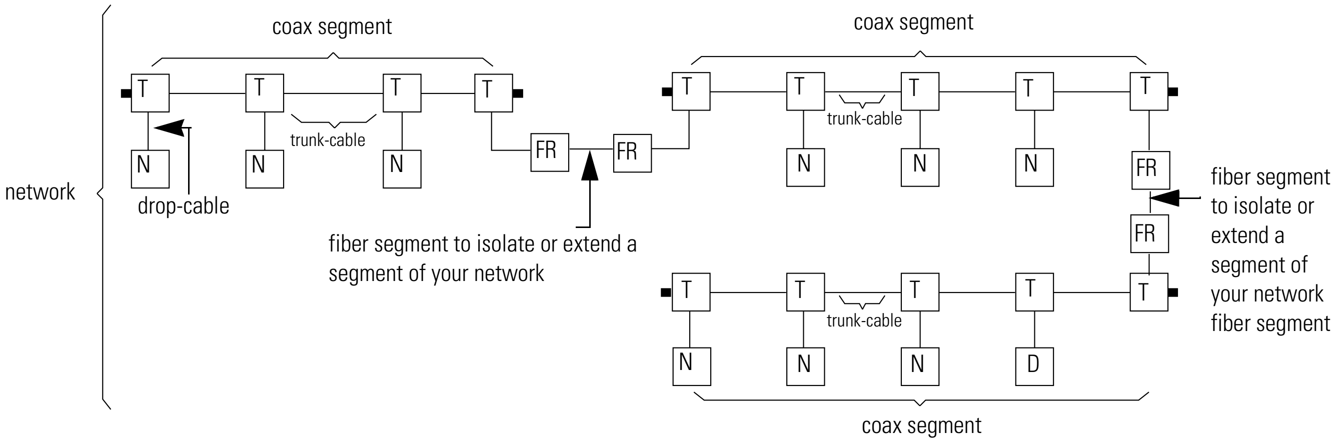
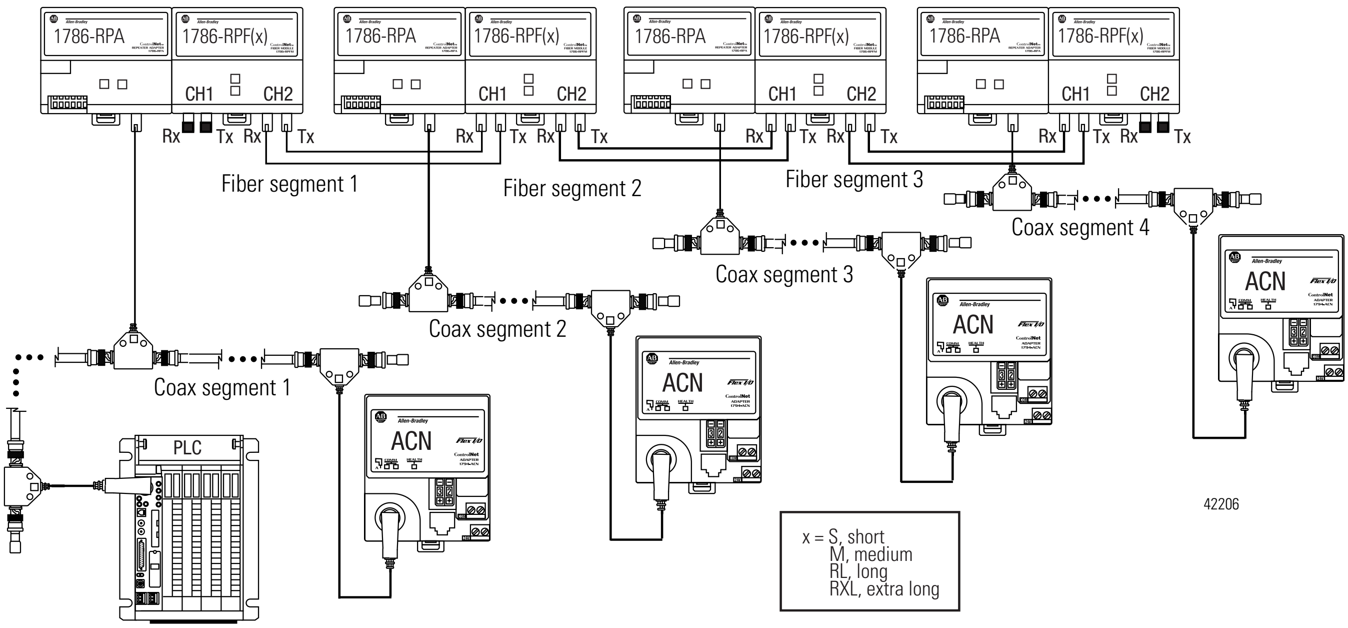


Table 2.A Network Terms

Term:	Means:
coax repeater CR	• a two-port active physical layer component that reconstructs and retransmits all traffic it hears on one coax segment to another coax segment
coax segment	• trunk-cable sections connected via taps with terminators at each end and with no repeaters
fiber section	• a length of fiber optic cable connecting two fiber repeater modules
fiber repeater FR	• consists of a fiber repeater module and a fiber adapter components that reconstruct and retransmit all traffic it hears on one fiber or coax segment side to another coax or fiber segment side
node N	• any physical device connecting to the ControlNet fiber or ControlNet media system which requires a network address in order to function on the network — a link may contain a maximum of 99 nodes • this address must be in the range of **1 - 99** and be unique to that link
link	• a collection of nodes with unique addresses in the range of 1-99
network	• a collection of connected nodes • the connection paths between any pair of devices may include repeaters and bridges
tap T	• the connection between any device and the ControlNet media system
tap terminator D	• dummy load that terminates a tap drop-cable that has yet to be connected to a node
terminator ■	• a 75Ω resistor mounted in a BNC plug
trunk-cable section	• a length of a cable between any two taps

Figure 2.1 Example topology: Point-to-point



ControlNet Fiber Media Components

The ControlNet fiber media system is comprised of these components:

- fiber cable
- nodes
- connectors
- repeater adapters
- fiber repeater modules
- power supply for repeater

The following table lists the available cable, connectors, and repeaters for the ControlNet Fiber Media system. You can also refer to publication AG-2.2, ControlNet Media Component List, for more information on other ControlNet products and suppliers.

Table 2.B Fiber Media Products

Product:	Catalog Number:	Description:
Repeaters		
repeater adapter	1786-RPA	adapter portion of the repeater
short-distance fiber module	1786-RPFS	fiber module used with the adapter for distances ≤ 300m
medium-distance fiber module	1786-RPFM	fiber module used with the adapter for distances ≤ 3km(2)
long-distance fiber module	1786-RPFRL	fiber module used with the adapter for distances ≤ 10km
extra long-distance fiber module	1786-RPFRXL	fiber module used with the adapter for distances ≤ 20km
Intrinsically safe repeater adapter	1797-RPA(1)	adapter for use in areas where there is a risk of explosion or an explosive atmosphere
Intrinsically safe medium-distance module	1797-RPFM(2)	module for use in areas where there is a risk of explosion or an explosive atmosphere
Fiber cables for 1786-RPFS		
10 m cable assembly for 1786-RPFS	1786-FS10	10 m pre-terminated 200y HCs cable segment for use with the RPFS module
20 m cable assembly for 1786-RPFS	1786-FS20	20 m pre-terminated 200y HCs cable segment for use with the RPFS module
60 m cable assembly for 1786-RPFS	1786-FS60	60 m pre-terminated 200y HCs cable segment for use with the RPFS module
100 m cable assembly for 1786-RPFS	1786-FS100	100 m pre-terminated 200y HCs cable segment for use with the RPFS module
200 m cable assembly for 1786-RPFS	1786-FS200	200 m pre-terminated 200y HCs cable segment for use with the RPFS module
300 m cable assembly for 1786-RPFS	1786-FS300	300 m pre-terminated 200y HCs cable segment for use with the RPFS module
Fiber connectors		
connector kit for 1786-RPFS fiber cable	1786-FSKIT	includes 10 blue V-pins™, 10 black V-pins™ and 10 clamshells
Short distance tools		
termination kit	1403-NTOL	Short distance fiber connector kit
stripping tool	1403-N13	replacement tool
bullet splice kit	1403-N11	slice tool
simplex pull bullet	1403-N12	adapter

(1) For more information on the planning and installation of intrinsically safe fiber repeaters, reference publication 1797-6.2.1, ControlNet EX Media Planning and Installation Manual

(2) Maximum fiber distance is dependent on the signal attenuation of the fiber segment and the quality of the fiber cable and connectors.

Determine Topology

The main purpose of fiber media is either to extend a segment or to isolate a segment of your network. The first step to using fiber media is to analyze your application and determine the typology of your current or new network application. Then you need to decide which topology you need to use.

The following figures illustrate the variety of topologies available when you apply the ControlNet Fiber Media System. See Chapter 3 for larger illustrations and detailed information.

Figure 2.2 Star Topology

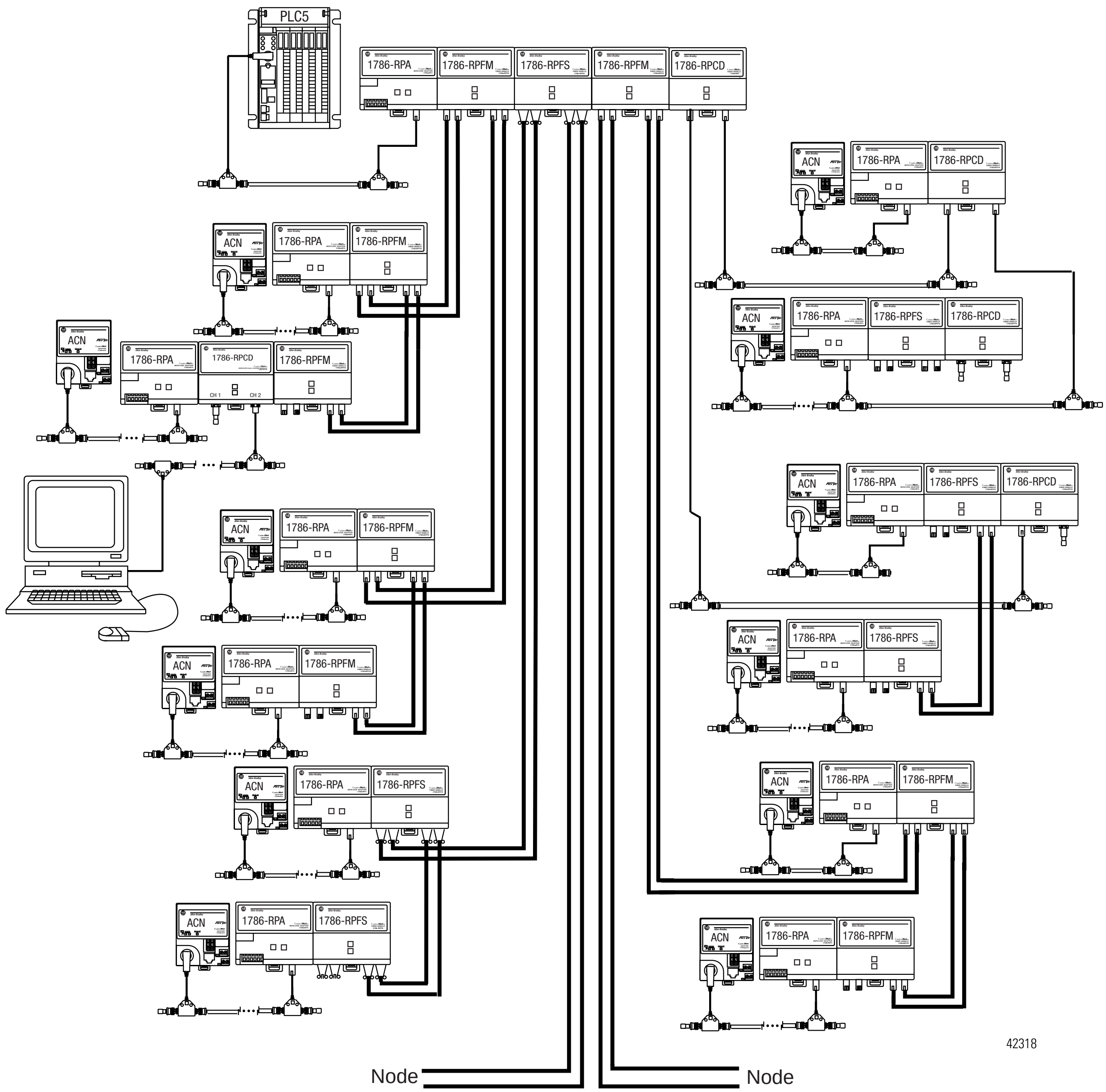
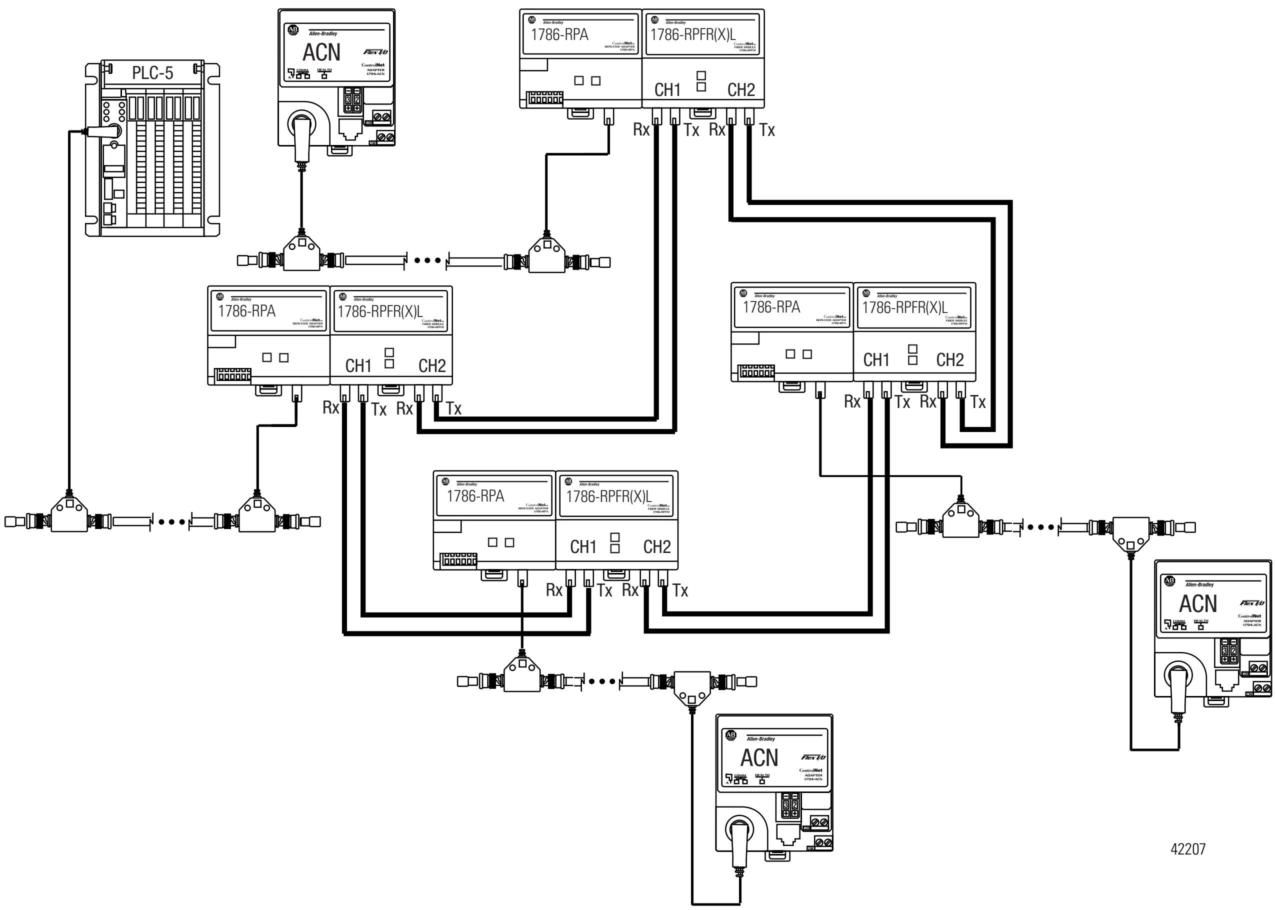


Figure 2.3 Ring Topology

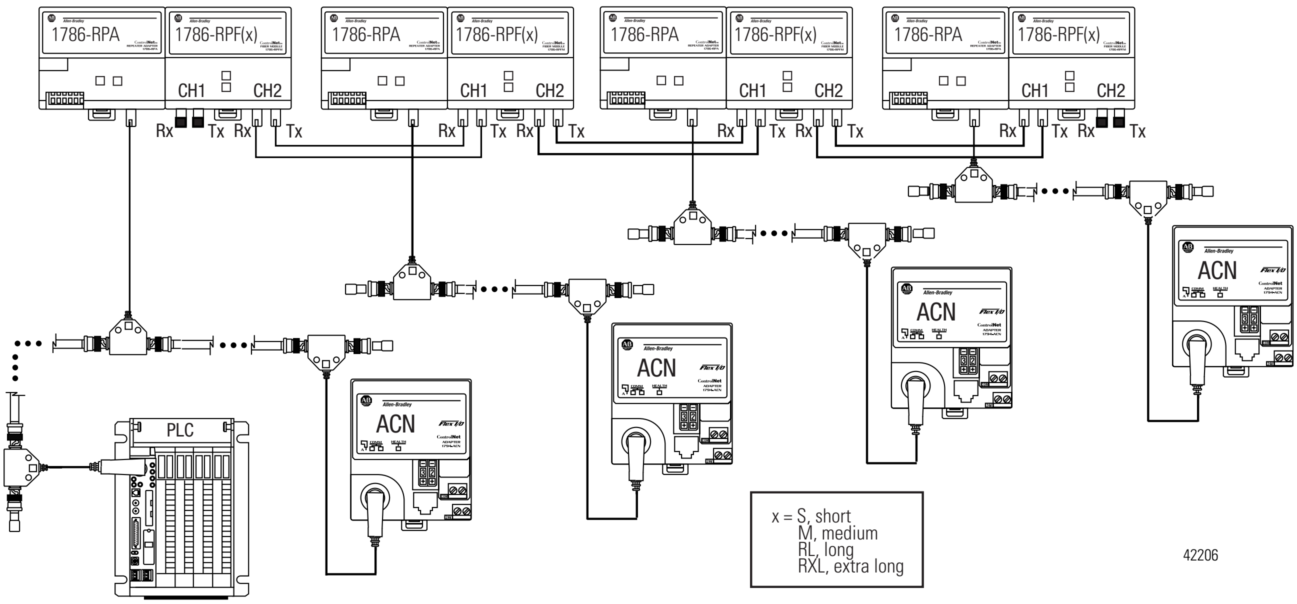
You can use a ring topology when you need an “optical link” between terminal units or bus segments. The implementation is a redundant link with the 1786-RPFRL/XL repeaters and ensures a high degree of reliability. The failure of an optical cable between any two 1786-RPFRL/XL repeaters does not affect the availability of the network. The repeaters detect the failure of an optical link. The port LED of the faulty link is deactivated and the failure is indicated by red illumination. We recommend that you install the duplex optical cables of the two optical channels along different routes.



Point-to-point Topology

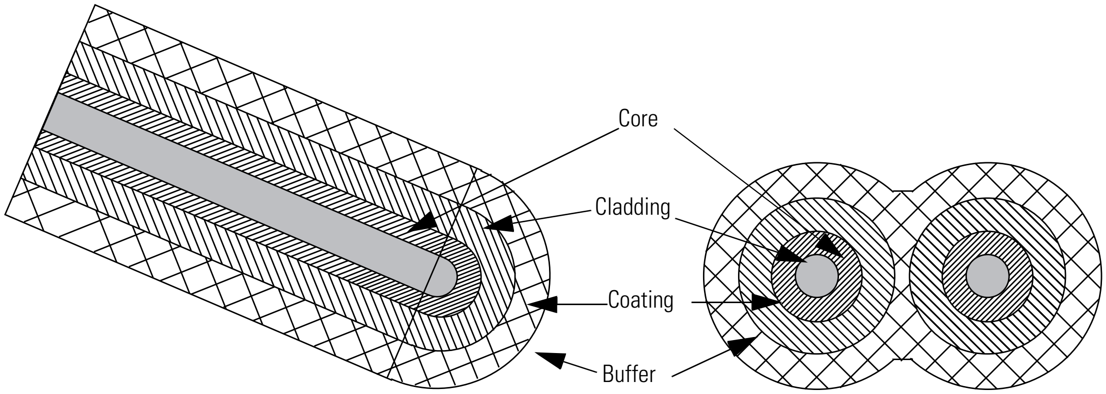
Point-to-point is also called a bus. A point-to-point is simply one fiber module transmitting to another like module. For example, you can not transmit from a medium distance module to a short distance.

Figure 2.4 Point-to-point Topology



Fiber Optic Cable

Fiber optic cables consist of three major parts, the buffer and coating, cladding, and the core. Refer to the figure below for a look inside the cable.



Fiber Cable 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 which carries information in the form of light pulses.

Fiber Connectors

Fiber cable connectors connect fiber cable to the fiber repeater module. The medium distance fiber repeaters use an “ST” type connector and the short distance fiber repeaters use a V-pin type connector. The short distance fiber connectors come factory terminated and it is as simple as plugging the connection into the repeater. The termination process for medium distance connectors has become as easy as coax. With the use of a precision termination kit and some practice, you can make the fiber connections as easy as coax. See Chapter 6 for more information.

Fiber Repeater Hubs

ControlNet uses a modular fiber repeater system. The repeater adapter (1786-RPA) connects to the coax media and repeats signals from the coax media to the fiber repeater modules and is referred to as the adapter in this publication. The fiber repeater module (1786-RPFS, RPFM, RPFRL, RPFRXL) sends the signal through the fiber cable to the next fiber repeater on the network and is referred to as the module here. The combination of the adapter and the module is referred to as the fiber repeater.

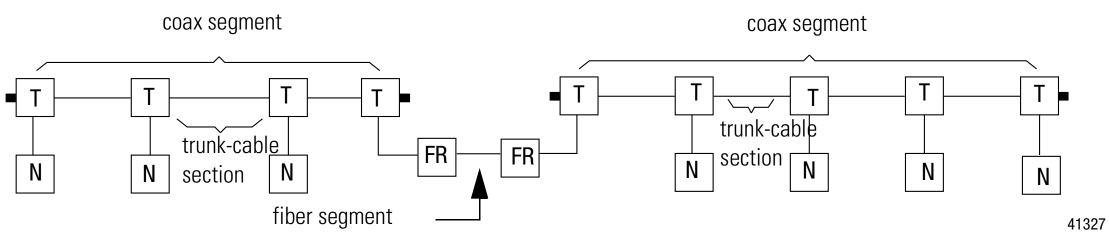
IMPORTANT The fiber repeater adapter (1786-RPA) is referred to as the adapter throughout this document. The fiber repeater module (1786-RPFS, RPFM, RPFRL, RPFRXL) is referred to as the modules in this document.

Fiber Repeaters

The fiber repeater consists of a fiber repeater adapter (1786-RPA) and 1 to 4 fiber repeater modules (1786-RPFS, RPFM, RPFRL, RPFRXL). Use a fiber repeater as a link from your non-hazardous area to your hazardous area. Hazardous areas require the use of specifically designed products. Refer to the 1797 catalog series.

A fiber repeater is used to extend the total length of your segment, or create a star configuration (go off in multiple directions from one point) The number of fiber repeater and cable length total is limited depending on your network topology. You may also use fiber repeaters to cross into hazardous areas. See CNET-IN003A-US-P for more information on hazardous area applications.

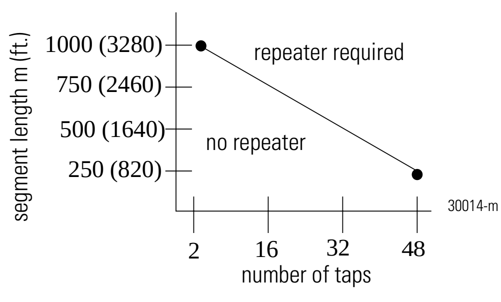
The total number of repeaters (fiber and coax) length total is limited to 5 repeaters and 6 segments. See CNET-IN002A-US-P, ControlNet Coax Media Planning and Installation Manual for more information on network distance limitations.



When you insert a fiber repeater into your media system, you create a new segment. The same restrictions on the number of taps and cable length apply to this new segment.

Figure 2.5 Repeater Requirements

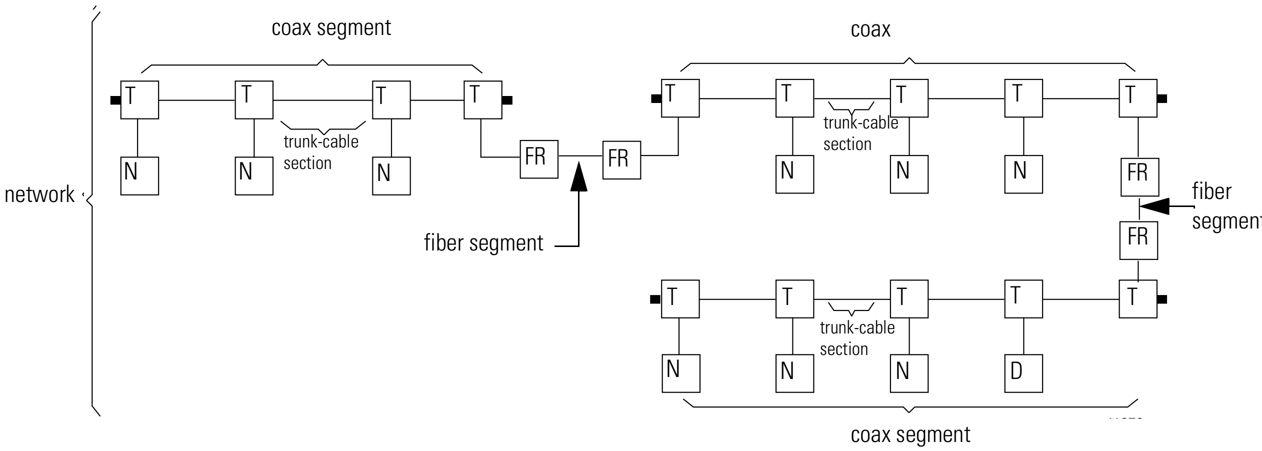
maximum allowable segment length =
1000m (3280ft) - 16.3m (53.4ft) X [number of taps - 2]



Basic Network Example

A network is the collection of segments with nodes connected together by fiber repeaters

Figure 2.6 ControlNet Topology example



Configure Your Link With Repeaters

When you configure your link using repeaters, you can install them in one of three ways:

You can install repeaters in:	See:
series	page 2-11
parallel	page 2-12
a combination of series and parallel	page 2-13

IMPORTANT A repeater can be connected to a segment at any tap location.

ATTENTION

The maximum system size is based on the distance between any two nodes. The total amount of cable used in the network is only limited by the distance between the furthest two nodes.

Install Repeaters in Series

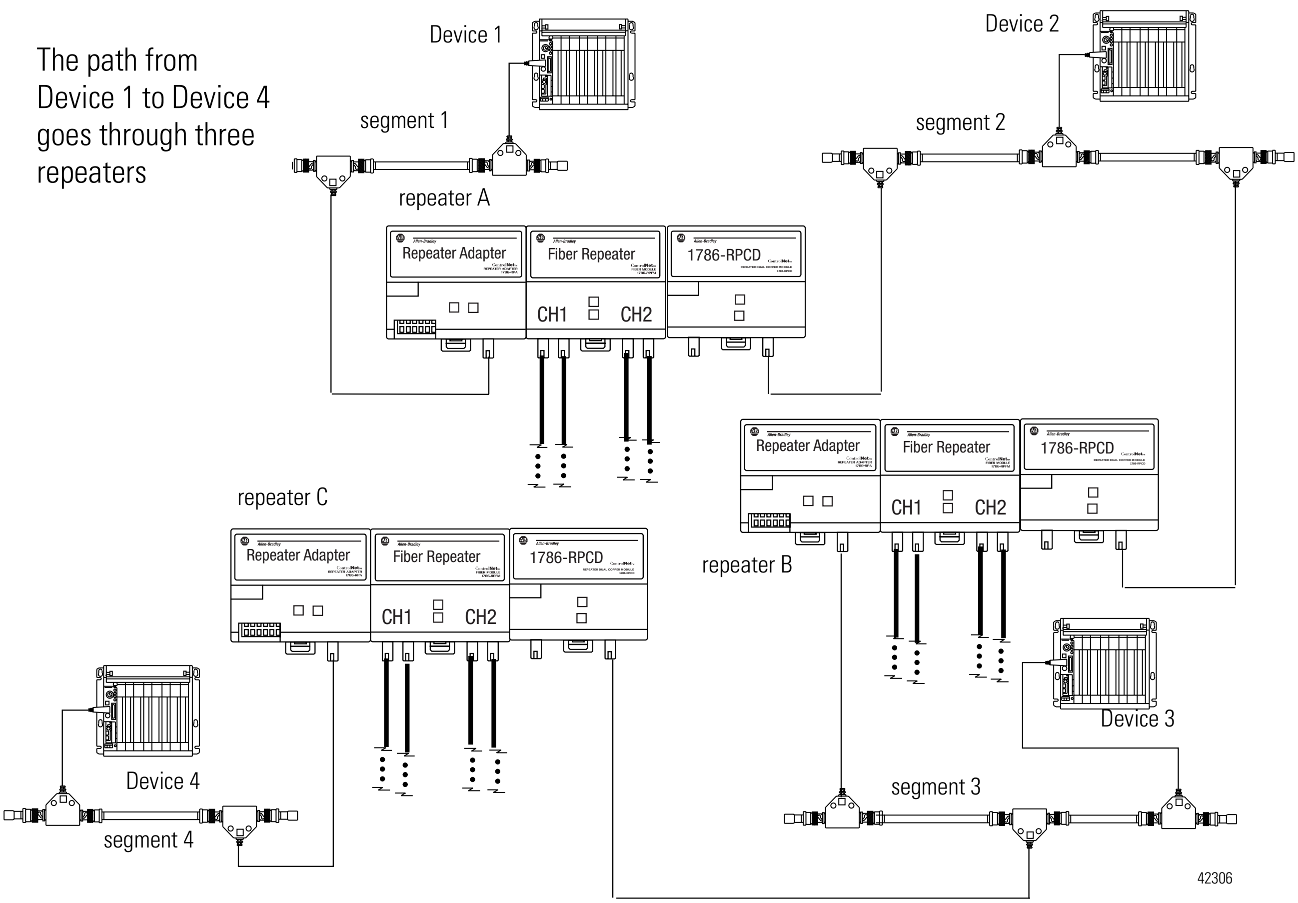
When you install repeaters in series, use your ControlNet Network management Software (RSNetWorx) to verify that the system is an allowable configuration. The system size is based on the maximum number of repeaters in a series and length of the media used between any two nodes

Example: Combination Point-to-point and Star topology

- segments 1 and 4 each have 2 taps and each = 1000 m (3280 ft.)
- segments 2 and 3 each have 3 taps and each = 983.7 m (3226.6 ft.)
- the total length of this link = 3967.4 m (13,013.2 ft.)
- there are three repeaters in series (A, B, C)

Figure 2.7 Repeaters in Series

The path from Device 1 to Device 4 goes through three repeaters



Install the Repeaters in Parallel

When you install repeaters in parallel, **you can install a maximum of 48 repeaters** (the maximum number of taps per 250m segment) on any one segment.

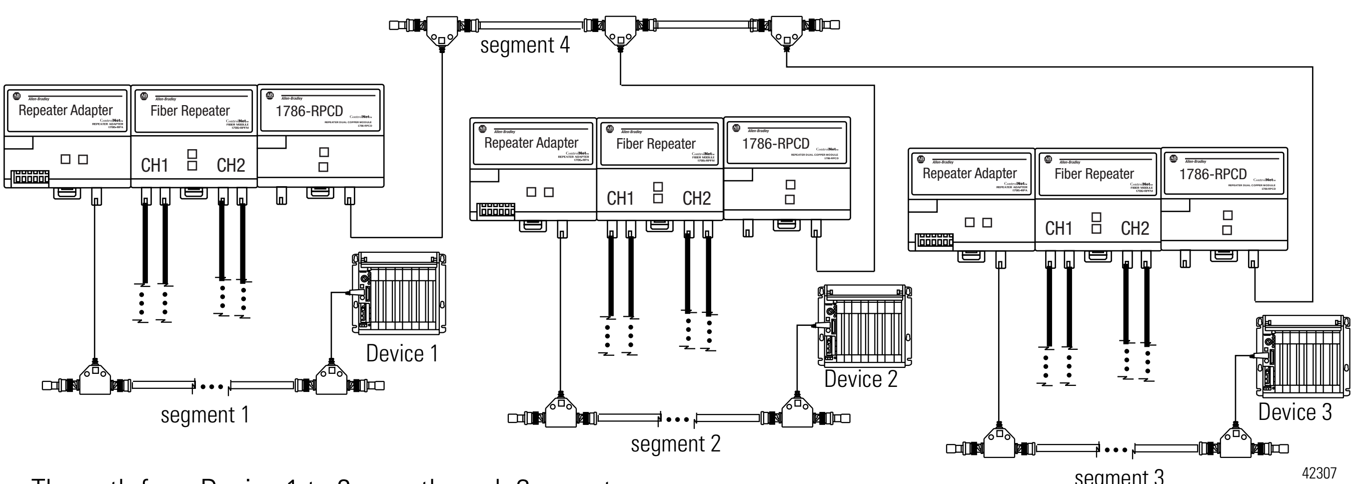
If your link is configured using repeaters in parallel, you count one of the repeater taps for one segment and the other repeater tap for the parallel segment that the repeater is connecting to the backbone network.

In the example below, Segment 1 counts only one repeater tap (as well as the taps for the nodes). The other repeater tap is counted toward the limitations of Segment 4.

Example:

- segment 4 is 983.7 m (3226.6ft)
- segments 1, 2, and 3 (if they have an equal number of nodes) can each have up to 33 nodes on them (a link can have 99 connections, not including repeaters)
- segments 1, 2, and 3 with 33 nodes on them, can not exceed 478.4 m (145.8 ft.**)**

Figure 2.8 Repeaters in Parallel



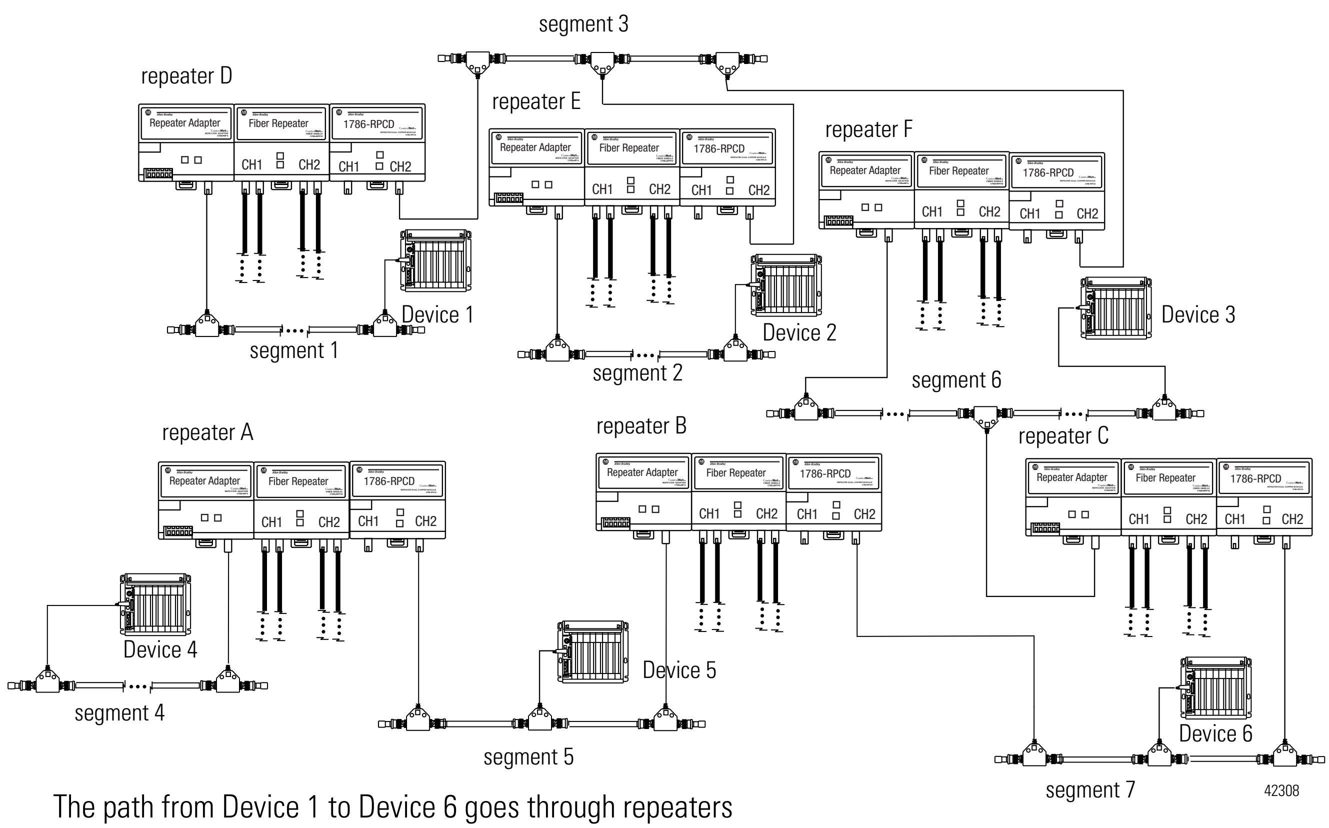
The path from Device 1 to 3 goes through 2 repeaters
The path from Device 2 to 3 goes through 2 repeaters

Install the Repeaters in a Combination of Series and Parallel

You can install repeaters in a combination of series and parallel connections following the guidelines listed in Chapter 3. When you create mixed topologies (series and parallel), you must verify the maximum number of repeaters and media by using your ControlNet Network Management Software (RSNetWorx).

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

Figure 2.9 Repeaters in Series and Parallel



What is next?

After you review and have a general understanding of the ControlNet fiber media system, go to Chapter 3 and begin to plan and design a ControlNet fiber media system for your specific network requirements.

Plan a ControlNet Fiber Media System

What This Chapter Contains

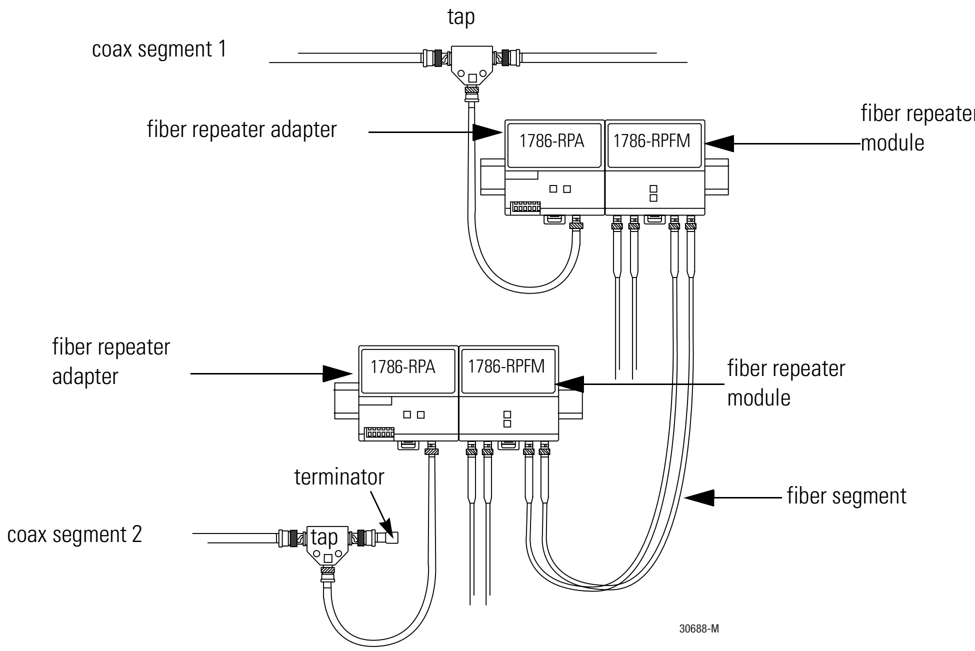
Read this chapter to begin to plan your ControlNet fiber media system application. The following table describes what this chapter contains and where to find specific information.

Develop a Plan

Fiber optic links can be included in a ControlNet™ system to increase network length and to obtain galvanic isolation in a highly noisy environment. Its use is strongly recommended to avoid lightning problems when you place interconnecting equipment in different buildings.

Point-to-point and star configurations can be created by use of standard fiber cable. The fiber repeater adapter must be connected to a coax trunk-cable by means of the standard tap. Up to four fiber modules with two fiber ports each can be directly plugged to a Repeater Adapter. Each port needs two fiber connections, one for receive and another for transmitting signals. The basic configuration connects two coax segments point-to-point by means of two fiber repeater adapters and two fiber modules as illustrated below.

Figure 3.1 Basic Fiber Media Topology



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

Select a Topology

The topologies that you can select are:

- Point-to-point or bus
- Star
- Redundant
- Ring

Determine the Constraints of Your Topology

Listed below are instances that determine the constraints of your topology.

Table 3.A Topology Constraints

Constraint:	Example:
Only one path is allowed between nodes	Only one path between Device 1 to Device 3 as in Figure 2.7 on 2-11.
Maximum of 99 nodes are allowed on the network	N/A
Maximum of 5 repeaters in series	The path between Device 1 to Device 5 as in Figure 2.9 on 2-13.
Constraint of each coax segment (Taps & Trunk-Cable Sections)	See figure on page 2-3
Power Loss Budget of each fiber segment	See Page 3-10
Maximum propagation delay through the network	See Page 3-19
Network parameter requirements	Use RSNetworx to verify your network topology

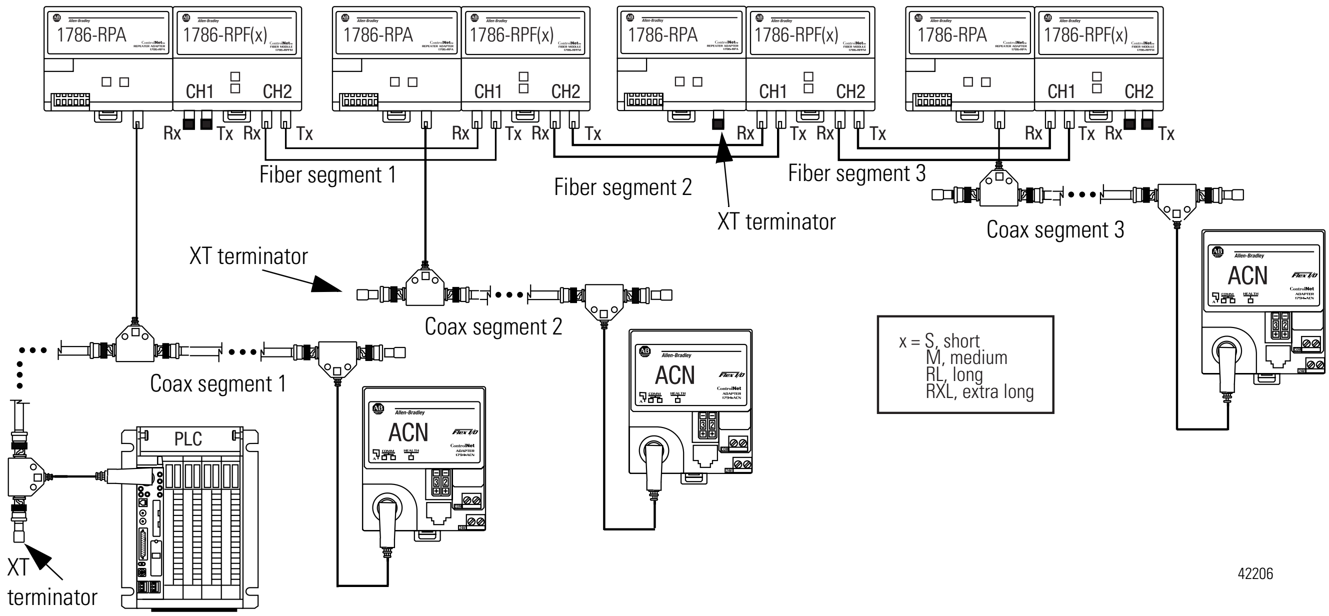
Calculate Your Network

Refer to the following examples when designing your ControlNet system.

Point-to-point Topology

The following network example illustrates a point-to-point topology.

Figure 3.2 Point-to-point Topology

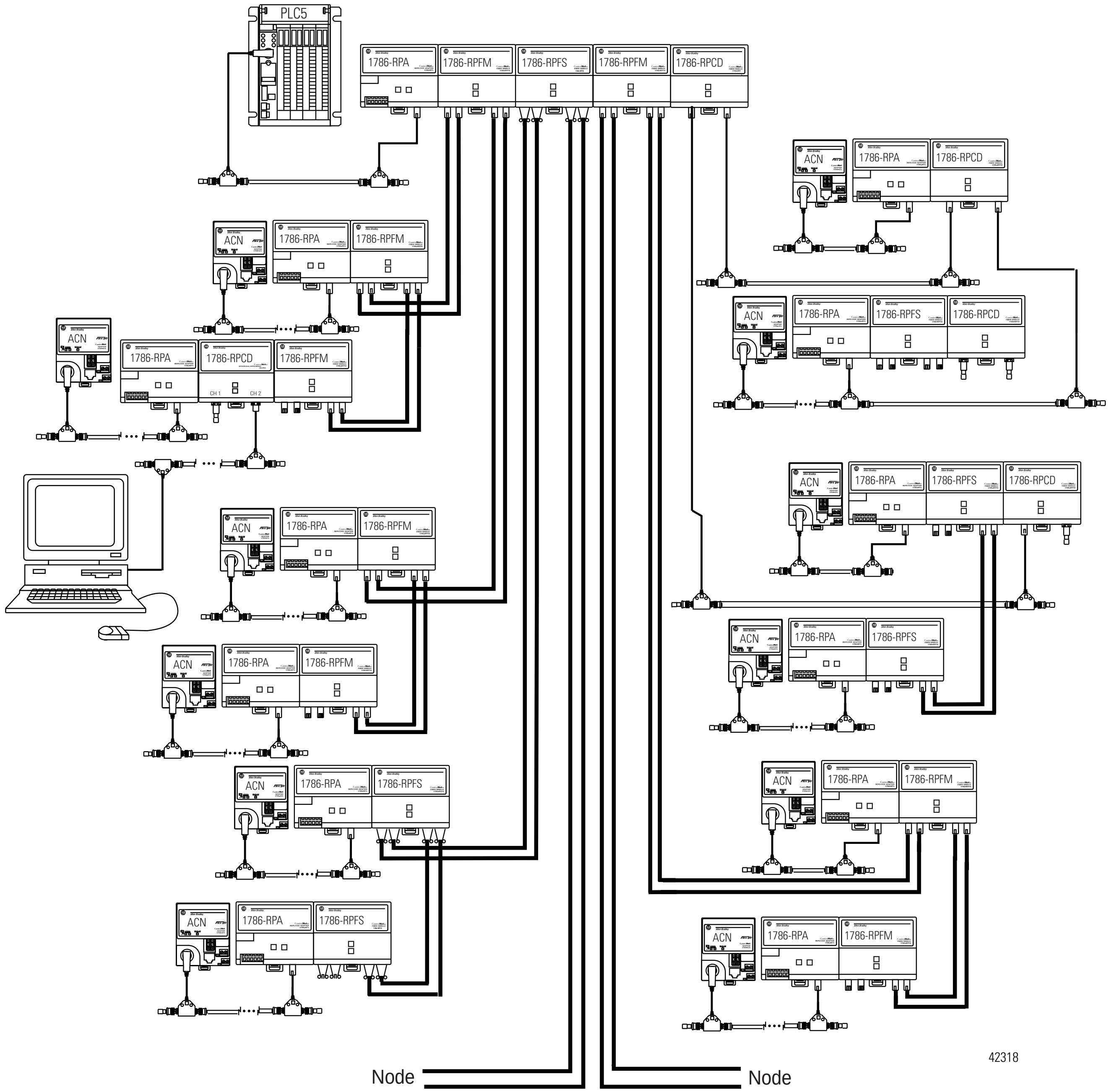


IMPORTANT It is not necessary to install nodes on coax segments. If you are only using the repeaters to extend then install a 75-Ω terminator (1786-XT) on the BNC coax connector on the fiber repeater adapter (1786-RPA). This should be done to all repeaters that are not connected to coax segments.

Star Topology

All segments of the fiber network start from a central location. The star topology usually requires an active hub or passive optical coupler.

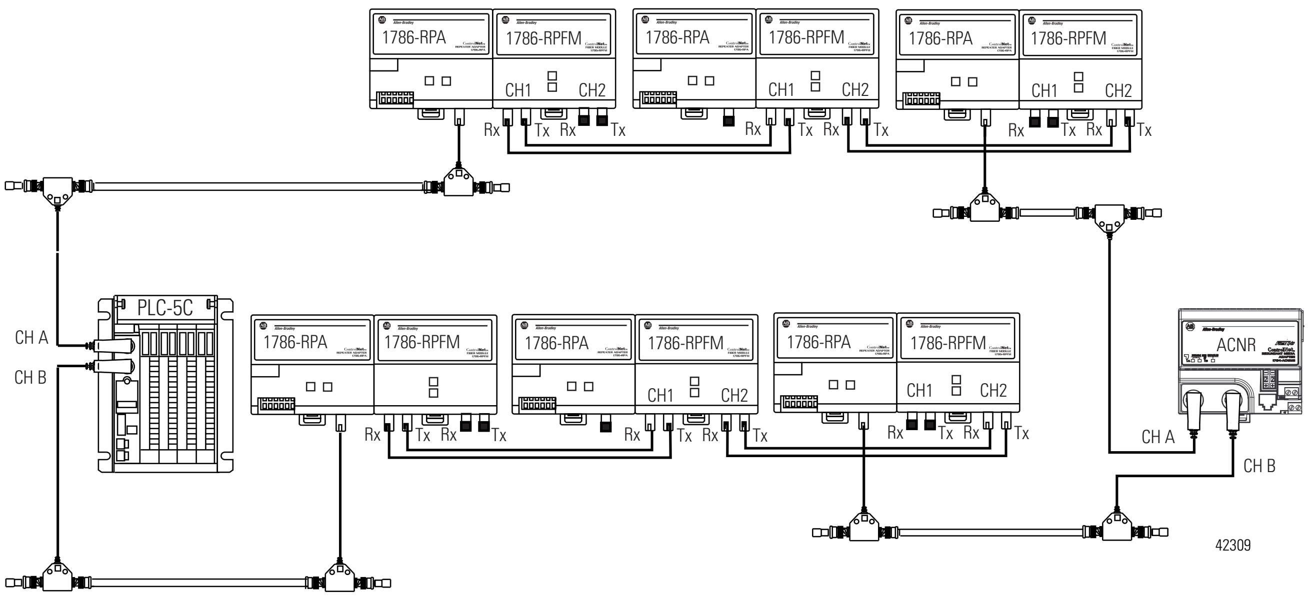
Figure 3.3 Star Topology



Redundant Topology

Use a redundant topology when you need system backup. A constraint of the redundant topology is that the fiber length on A and B must be within 650m.

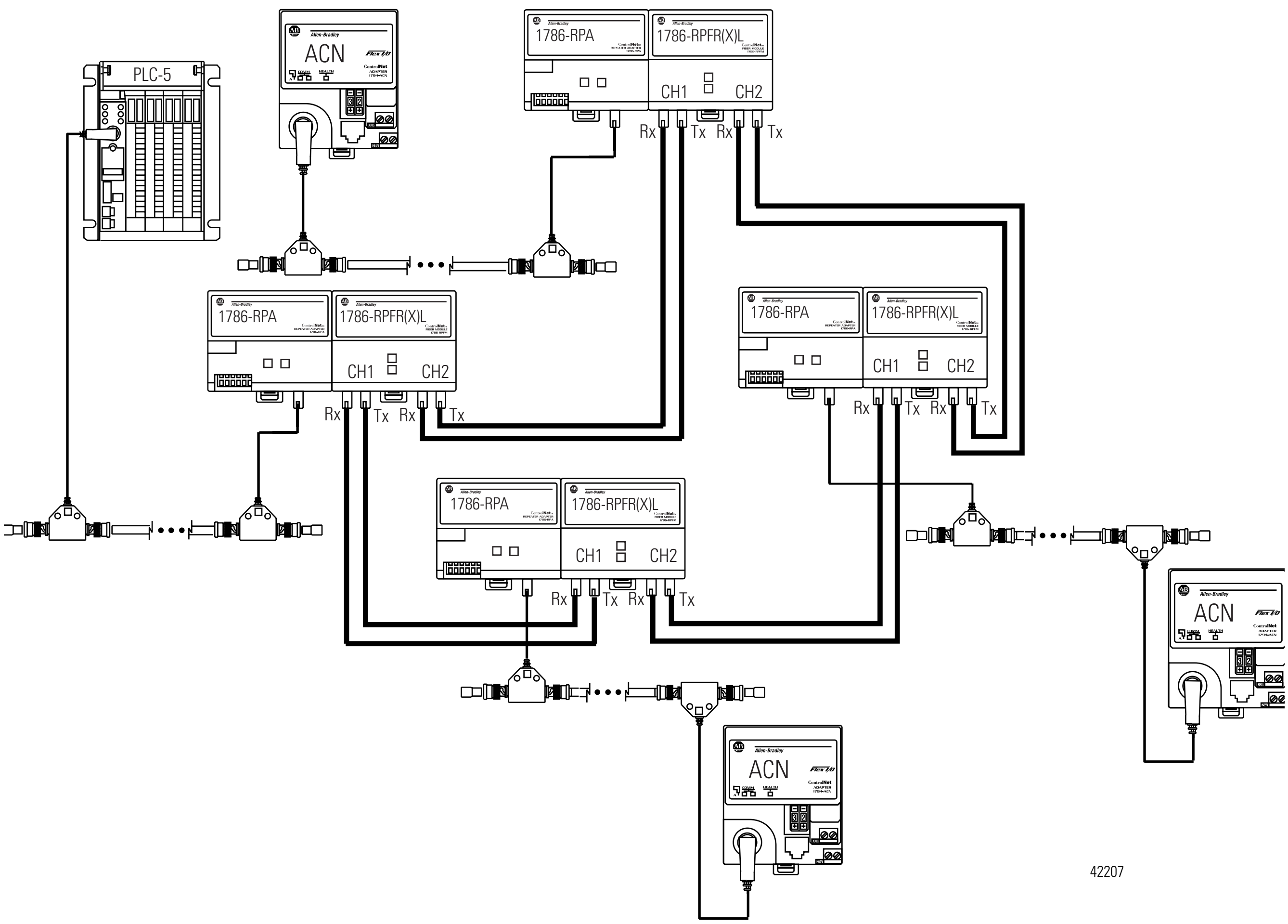
Figure 3.4 Redundant Topology



Ring Topology

In the ring topology, the nodes are daisy chained together. A fiber ring provides inherent redundancy. If the ring is broken, communications will travel in the opposite direction on the ring.

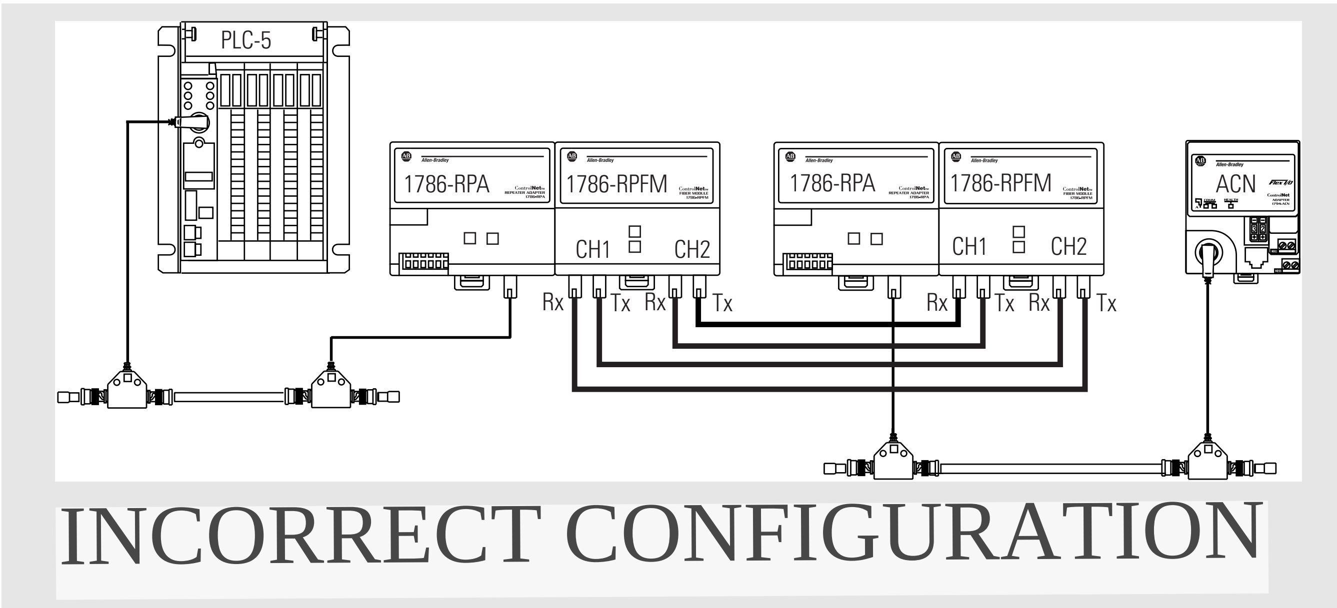
Figure 3.5 Ring Topology



Incorrect Topology Configurations

Shown below in Figure 3.6 is an example of an **incorrect** network configuration using the 1786-RPA and 1786-RPFM. Figure 3.6 illustrates both channels of a 1786-RPFM module used for redundancy purposes which violates the rule that states that no more than one path exists between two nodes.

Figure 3.6 INCORRECT MULTI-PATH



Invalid topology because there are 2 fiber paths connecting the same coax segments.

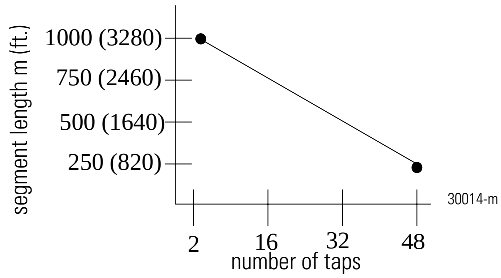
Constraints of the Coax Segment

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 1,000m (3,280ft) with two taps connected. Each additional tap decreases the maximum length of the segment by 16.3m (53ft). The maximum number of taps allowed on a segment is 48 with a maximum length of 250m (820ft).

Figure 3.7 Maximum Segment Length

maximum allowable segment length =
1000m (3280ft) - 16.3m (53.4ft) X [number of taps - 2]



Coax Segment Constraint Example

If your segment requires 10 taps, the maximum segment length is:

1000m (3280ft) - 16.3m (53.4ft) x [10 - 2]
1000m (3280ft) - 130.4m (427.7ft)) = **869.6m (2852.3ft)**

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 (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 1786-6.2.1, Planning and Installation Manual for a ControlNet coax cable system.

Constraints of the Fiber Segment

Every network that uses fiber repeaters must maintain a minimum signal attenuation 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 repeater module 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

The most common question we hear is "Can I use a particular cable with a particular module?" There are two types of cable, single and multi-mode. If your distance requirements is less than 300m, we offer short distance cable that comes pre-terminated for use with our 1786-RPFS repeater. You simply "plug and play" the connector into the module. If your distance requirements are greater than 300m you must use a medium or long distance module and terminate the cables in the field.

Estimate Cable Lengths

For short distance modules the segments are limited to a maximum of 300m. If your distance requirements are greater than 300m, you need to use a medium or long distance module.

The maximum length of a fiber cable section for the 1786-RPFM is dependent on the quality of the fiber, number of splices, and the number of connectors. The total attenuation for a medium distance cable section **must** be less than **13.3dB**.

Typically cable attenuation for a wavelength of 1300nm is less than 1.5dB/km and connection losses are 1dB per connection.

IMPORTANT Avoid jointing your cable. 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 Allen-Bradley fiber system has different constraints, therefore determining maximum fiber optic cable lengths differs for each system. Allen-Bradley offers two different systems that are targeted to solve different applications.

1786-RPFS

The 1786-RPFS (0-300m) system specializes in solving short-distance applications. This system requires the use of pre-terminated cable assemblies. The total attenuation for a cable section **must** be less than **6.9dB**. Refer to publication AG-2.2, ControlNet Media Component List, for a complete list of cable assemblies.

200 Micron HSC Cable

Use this type of cable with the 1786-RPFS module for short distance applications. When you use plug-n-play systems, you are required to use pre-terminated cable assemblies. The 200 hcs cable is also a step index multimode type of fiber cable.

TIP

Refer to publication AG-2.2, ControlNet Media Component List, for a complete list of cable assemblies.

1786-RPFM

The 1786-RPFM (0-3km)is designed to solve medium distance applications that require 3000m (9843ft) between two ControlNet products. The medium distance module provides ground isolation between nodes and is not disrupted by the noise that affects traditional copper media. The termination of the medium distance cable must be done in the field.

IMPORTANT

If you have not been properly trained, we recommend that the longer distance systems be specified, installed, verified, and certified by a fiber optic specialist.

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 **13.3dB**.

62.5/125 Micron Cable

The 62.5/125 micron cable is graded index multimode fiber. Use the cable with the 1786-RPFM, RPFRL, and RPFRXL modules. You can apply it to medium distance applications that require greater distances than what coax cable can provide.

The medium and long distance modules provide ground isolation between nodes and is not disrupted by the noise that affects traditional copper media.

IMPORTANT This system requires the use of a termination kit. In order to master the steps to terminate the medium and long distance fiber cable, training and practice are mandatory. As with any network system, we recommend a specialist to verify and certify your network before going online.

1786-RPFRL (Fiber Ring or Point to Point)

The 1786-RPFRL (0-10km) is designed to solve long distance applications that require 10000m (32,810 ft.) between two ControlNet products. The long distance module also provides ground isolation between nodes and is not disrupted by the noise that affects traditional copper media. The termination of the long distance cable must be done in the field.

1786-RPFRXL (Fiber Ring or Point to Point)

The 1786-RPFRL (0-20km) is designed to solve extra long distance applications that require 20000m (65,620 ft.) between two ControlNet products. The extra long distance module also provides ground isolation between nodes and is not disrupted by the noise that affects traditional copper media. The termination of the extra long distance cable must be done in the field.

Determine Attenuation Levels

You must calculate what your power budget for you fiber cable. The short distance fiber cable is pre-terminated, therefore the attenuation levels are preset at a maximum of 13.3db. 3dB for the two connectors and 10dB for 1km of fiber cable.

Once you start modifying the lengths of the cable, installling bulkhead or fusion splices, installing longer distances, exposing the cable to temperature ranges, 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 you attenuation levels.

Attenuation Levels for a Short Distance Fiber Segment

The power budget for the short distance fiber repeater module is **4.2** db. Therefore 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 to 60 degrees C). The power budget of the repeater module can be increased to 6.9 db when the fiber repeater module's operating temperature does not exceed 25 degrees C. You can also affect the power budget by the quality of the connectors and fiber cable. If you use a high quality connector and fiber cable you will be able to stretch your power budgets. The 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 preterminated with connectors with the proper length of cable to be used under the maximum attenuation levels. But if you start modifying the cables with splices then you have to be able to calculate the attenuation levels.

Shown below is an example of determining the maximum fiber distance between two repeater modules at a maximum operating temperature of 25 degrees C and 60 degrees C. These are measured path losses, not theoretical. If you calculate an out of system budget, you will need to add a repeater.

Step 1: Total your Loss Budget

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

Step 2: Subtract Loss for connectors

Select Connectors, each connector for the short is 1.5db, you need to account for two connectors per fiber cable segment.

Loss x 2

Step 3: Subtract Loss for cable lengths

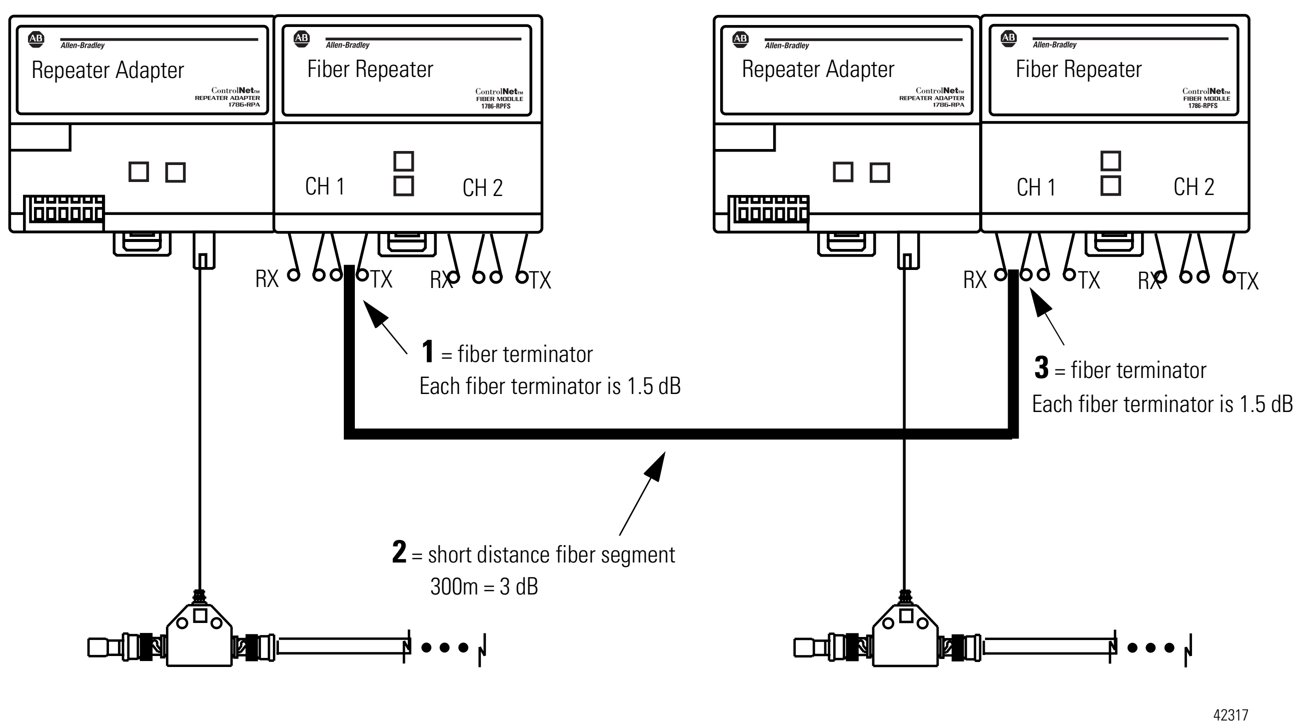
Select Fiber cable and identify

Loss x (Loss/km)

Step 4: Compare Losses

Compare losses in Steps 2 & 3 with Total Loss Budget in Step 1

- If Steps 2 & 3 are equal to or less than Step 1, then you are within your loss budget.
- If Steps 2 & 3 are greater than Step 1, then you will need to reconfigure topology, shorten cable lengths, or reduce the number of connectors and calculate the loss budget again.



1 + 2 + 3 = Total Attenuation
1.5 + 3 + 1.5 = 6 dB

maximum cable Length (km) =

$$\frac{\text{Power Budget - Total attenuation of connectors, splices, bulkhead, and etc.}}{\text{Fiber cable attenuation in db/km}}$$

For another topology that uses the following:

- Two short distance fiber repeater modules with a 4.2 db power budget at 60 degrees C and 6.9 db at 25 degrees C each.
- 2 cable connections on each fiber segment having an attenuation of 1.5 db each.
- Fiber cable having an attenuation of 10.0 db/km @ 650 nm.

IMPORTANT Due to possible fiber connector degradation, it is recommended that an allowance of 0.5 db to 1.0 db per short distance fiber cable segment be added to the total attenuation. Therefore in the above example, the maximum cable length would be 20 to 70 meters @ 60 degrees C and 290 to 340 meters @ 25 degrees C.

There is no minimum length of cable for the short or medium distance fiber repeater module.

Total Attenuation =

Total attenuation from connectors, splices, bulkhead, etc. = 2 x 1.5 db = 3.0 db

Maximum Cable Length (km) =

$$\frac{\text{(Power Budget)} - \text{(Total attenuation of connectors, splices, bulkhead, and etc.)}}{\text{Fiber cable attenuation in db/km}}$$

Max cable length @ 60 degrees C (km) **=** (4.2 db – 3.0 db) / 10.0 db/km **=** 120 meters

Max cable length @ 25 degrees C (km) **=** (6.9 db – 3.0 db) / 10.0 db/km **=** 390 meters

Attenuation Levels for a Medium Distance Fiber Segment

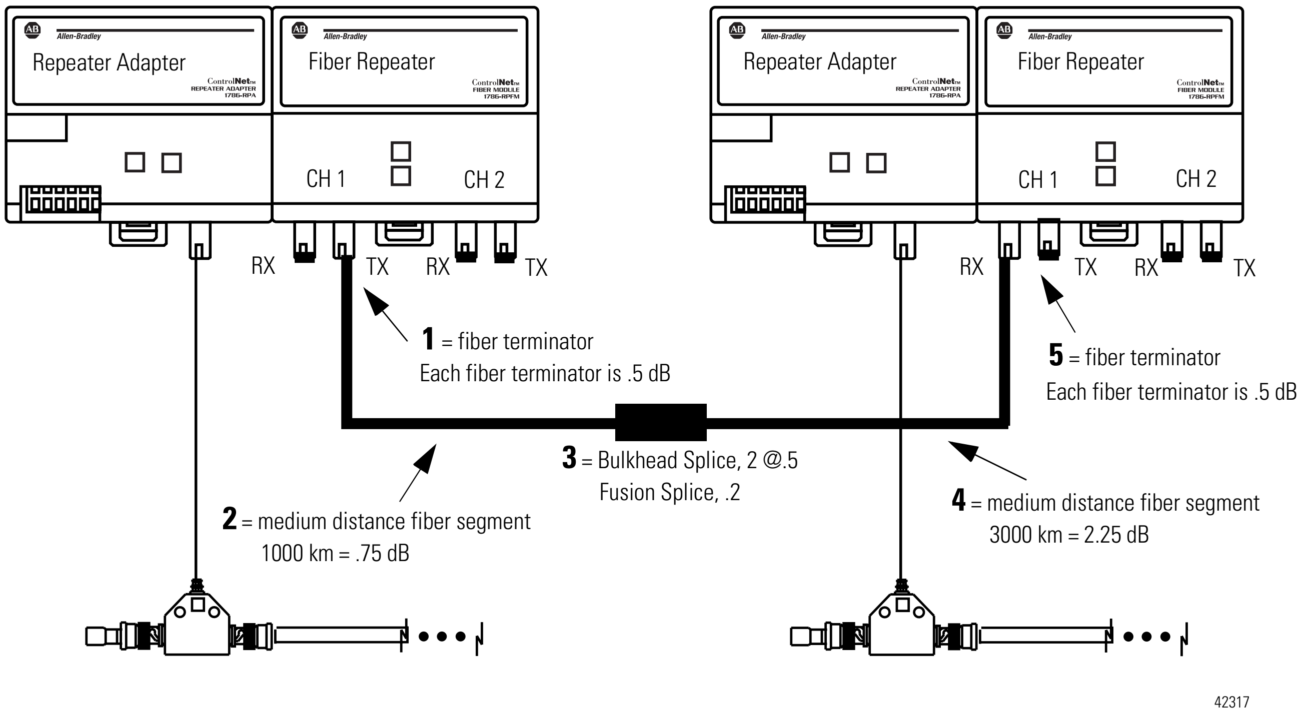
The power loss budget for the medium distance fiber repeater module (1786-RPFM) is 13.3 db. Therefore the maximum amount of attenuation between the two fiber repeater modules shall not exceed 13.3 db. This power loss budget includes the entire bulkhead/fusion splice. This power loss budget is valid throughout the operating temperature range (0 to 60 degrees C) of the 1786-RPFM.

Shown below is an example of determining the maximum fiber distance between two repeater modules:

The system uses the following:

- Two medium distance fiber repeater modules with a 13.3 db power loss budget.
- Two fiber connectors on each fiber segment, each having an attenuation of 0.5 db each.
- Fiber cable having an attenuation of 1.0 db/km @1300 nm

IMPORTANT	Be certain that you refer to the specifications that accompany the fiber cable that you purchase.



1 + 2 + 3 + 4 + 5 = Total Attenuation

.5 + .75 + .5 + 2.25 + .5 = 4.5 dB

Total Attenuation = Total segment attenuation from connectors, splices, etc. = 2 x 0.5 db = 1.0 db

Maximum Cable Length (km) =

$$\frac{\text{(Power Budget - Total attenuation of connectors, splices, bulkhead, and etc.)}}{\text{Fiber cable attenuation in db/km}}$$

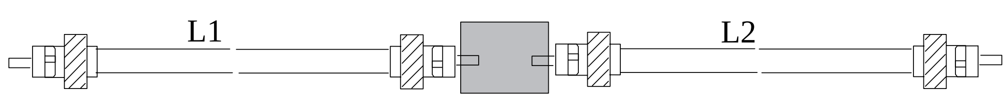
Maximum cable length (km) = (13.3 db – 1.0 db) / 1.0 db/km = 13.3 km

2x fiber connections + Fiber Length * Fiber Attenuation @ 1300nm

2 * Fiber Connections + Fiber Length * Fiber Attenuation @ 1300nm < 13.3db

2 *.5db + 3 km + 2 * .5dB * 1.5db/km = 5.5db < 13.3db

$$\frac{\text{4 * connectors + Bulkhead}}{\text{Fusion splice + L1(km) * Attenuation(km) + L2(km)}}$$



.5 1km = 1dB .5 .5 2km = 2dB .5 =5dB <13.3dB

IMPORTANT

Due to possible fiber connector degradation, it is recommended that an allowance of 1.0 db per medium distance fiber cable segment be added to the total attenuation. Therefore in the above example, the maximum cable length would be 12.3 km.

There is no minimum length of cable for the short or medium distance fiber repeater module.

IMPORTANT

As of this printing date the attenuation calculations for the 1786-RPFRL/RPFRXL are being developed. They will be provided in the next revision of this manual and will accompany the modules.

Determine Propagation Delay

ControlNet has a specification called Maximum Propagation Delay. This specification is 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/or the number of repeaters the signal has to travel.

The delay of a network would include the delays through coax and fiber media, coax repeaters and including the delays through fiber 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 121µs** (slot time).
The total network allowable delay, each way is **121µs**.

Listed below are delay values for the current ControlNet media items:

Table 3.B Delay values for ControlNet media

ControlNet Media Items:	Delay values:
1786-RPT, RPTD	815 ns
1786-RPCD	100 ns
1786-RPA	901 ns
1786-RPFS	94 ns
1786-RPFRL	TBD
1786-RPFRXL	TBD
1786-RPFM	153 ns
62.5 micron fiber	5.01 ns/meter
200 micron fiber	5.01 ns/meter
coax cable	4.17 ns/meter

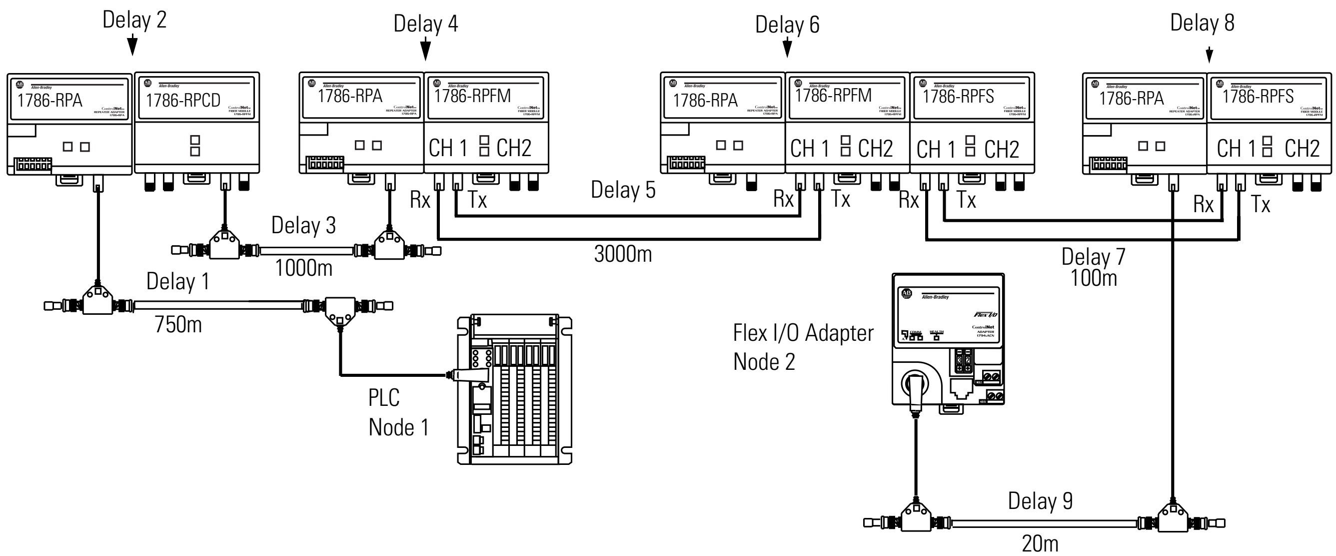
Maximum Propagation Delay Through a Network

The example below has the following maximum delay path from node 1 to node 2, end to end. See Figure 3.8 on page 3-21.

Delay Path 1	From PLC to Flex I/O Adapter
Delay Path 2	1786 RPCD
Delay Path 3	1000 meters of coax cable
Delay Path 4	Fiber repeater; 1786 RPA and 1786 RPFS
Delay Path 5	3000 meters of 62.5 micron fiber cable
Delay Path 6	Fiber repeater, 1786 RPA, RPFS
Delay Path 7	100 meters of 200 micron fiber cable
Delay Path 8	Fiber repeater, 1786 RPA and 1786 RPFS
Delay Path 9	20 meters of coax cable

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

Figure 3.8 Calculate and Total the Delays



Delay 1	750 meters x 4.17 ns/meter	= **3.1μs**
Delay 2	Fiber repeater, 901ns + 100ns	= **1.0μs**
Delay 3	1000 meters x 4.17 ns/meter	= **4.2μs**
Delay 4	Fiber repeater; 901ns + 153ns	= **1.1μs**
Delay 5	3000 meters x 5.01 ns/meter	= **15.03μs**
Delay 6	Fiber repeater, 901ns + 153ns + 100ns	= **1.2μs**
Delay 7	100 meters x 5.01 ns/meter	= **0.5μs**
Delay 8	Fiber repeater, 901ns + 100ns	= **1.0μs**
Delay 9	20 meters x 5.01 ns/meter	= **0.1μs**
	Total DELAY	= **27.1μs**

Maximum Propagation Delay Through a Redundant Network

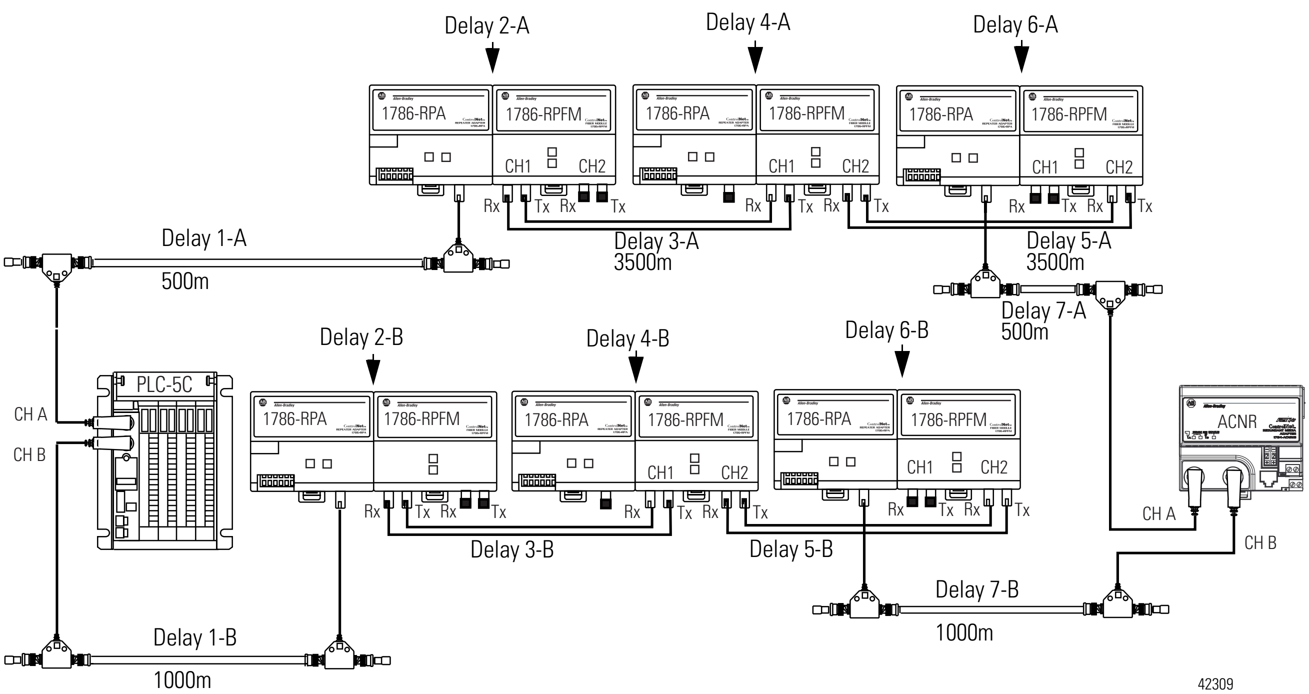
For redundant networks, not only do you have to calculate the worst case path delay between two nodes, but also you have to calculate the worst case delay skew between channels A and channel B of the network.

IMPORTANT	**The worst case skew between redundant paths shall be less than or equal to 6.4 µs**.

The example below depicts a redundant network with the following:

- Two nodes separated by three fiber repeaters in series on both A and B Channels.
- Channel A uses 3500 meter segments on the fiber segments versus 3000 meter segments on Channel B.

Figure 3.9 Maximum Propagation Delay Through a Redundant Network



Calculate and Total Delays for Channel A

Delay 1	500 meters x 4.17 ns/meter	=	**2.1 µs**
Delay 2	Fiber repeater, 901ns + 153ns	=	**1.1 µs**
Delay 3	3500 meters x 5.01 ns/meter	=	**17.5 µs**
Delay 4	Fiber repeater; 901ns + 153ns	=	**1.1 µs**
Delay 5	3500 meters x 5.01 ns/meter	=	**17.5 µs**
Delay 6	Fiber repeater, 901ns + 153ns	=	**1.1 µs**
Delay 7	500 meters x 4.17 ns/meter	=	**2.1 µs**
TOTAL DELAY FOR CHANNEL A		**=**	**44.6 µs**

Calculate and Total the Delays for Channel B

Delay 1	1000 meters x 4.17 ns/meter	=	**4.2µs**
Delay 2	Fiber repeater, 901ns + 153ns	=	**1.1µs**
Delay 3	3000 meters x 5.01 ns/meter	=	**15.0µs**
Delay 4	Fiber repeater; 901ns + 153ns	=	**1.1µs**
Delay 5	3000 meters x 5.01 ns/meter	=	**15.0µs**
Delay 6	Fiber repeater, 901ns + 153ns	=	**1.1µs**
Delay 7	1000 meters x 4.17 ns/meter	=	**4.2µs**
TOTAL DELAY FOR CHANNEL B		**=**	**42µs**

Skew between channels =
(Delay through A) – (delay through B) = 44.6µs – 42µs = 2.6µs

If your calculations show that you are out of system budget, you need to add a repeater. You will be able to stretch your system budget by using high quality fiber media, connectors and cable.

Network Parameter Requirements

You can use RSNetWorx for ControlNet or other network configuration software to determine whether or not your system meets the network parameter requirements. Based on your planned system requirements such as, NUT, SMAX, UMAX, and worst case network delay, RSNetWorx will calculate your planned network parameters.

Once you have entered these values into RSNetWorx and the parameters are calculated, the software will tell you whether or not if your configured network is acceptable as you have planned. If you network is not valid, you must adjust your planned requirements.

Refer to publication 9399-CNETGR, Getting Results with RSNetWorx for ControlNet for information on how RSNetWorks can help you verify your network.

What is next?

After you have sufficiently planned the installation of your fiber media you are ready to physically install the components. Chapter 4 provides you with general guidelines for handling fiber media. Chapter 5 instructs you on how to install, wire modules and estimate cable lengths.

Chapter 4

Guidelines for Fiber Optic Installation

What This Chapter Contains

The following table describes what this chapter contains and where to find specific information.

Warnings

ATTENTION

Never look into a laser's output or the end of a cable with an active transmitter connected.

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.

Never use a microscope to view an active cable system. The concentration of light from the microscope could cause permanent damage to your eye!

General Rules and Safety

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

Hire Fiber Optic Specialists for Installation and Certification

Many of our customers are qualified to plan and install their own fiber systems. Rockwell Automation sells the necessary media to implement an application but we do not offer installation services. If your company does not have qualified staff to install fiber media you will need to contract a specialist. Fiber media installation is required to be certified so it is important to select a fiber optic installation specialist to assess what type of cable you need and to perform the installation for you. Trained specialists have the -expertise to select the correct type of fiber cable for your environmental and intrinsically safe area needs.

The specialist you choose should install your cable and terminate it following the supplier’s installation instructions. Installation should include complete documentation of cable routing and where every cable strand is connected.

If you are going to use the 1786-RPFS, we offer pre-terminated kits that allow you to easily install fiber media. If you are going to use the 1786-RPFM, RPFRL, or the RPFXL, it is mandatory that a trained specialist install and certify your application.

Install Local Equipment

It is not necessary to have your fiber specialist connect your local equipment. Someone with media installation experience can connect local equipment using pre-terminated interconnect cables purchased in their required lengths.

Guidelines for Handling Fiber Optic Cable

We encourage you to observe all of the guidelines listed below to be successful when you handle fiber optic cables. These guidelines are designed to protect the safety of everyone who handles, uses or works near fiber optic systems. Also the guidelines help establish an environment that will allow you to get the greatest 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 4.A 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.
Contamination	• 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.
Protective caps	• Always attach protective caps onto fiber cable connectors and fiber ports when they are disconnected.
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 4.A Guidelines for Handling Fiber optic Cable

Guideline	Description
Proper disposal	• Always dispose of fiber waste. 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 less than the maximum allowable. This will crack the glass and result in optic loss. • The cable should never be pulled at a force greater than the maximum allowable pulling tension. Excessive loads from bending or pulling may cause fiber damage. 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 • The cable should not be pulled around any bends smaller than 20 times the cable diameter when under load and 10 times the cable diameter at no load. • 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.

ATTENTION

Never look into a laser's output or the end of a cable with an active transmitter connected.

Never use a microscope to view an active cable system. The concentration of light from the microscope could cause permanent damage to your eye!

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 mounted. 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 manufacturers specifications for the fiber cable for additional information.

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.

It is necessary to 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 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, small fiber optic cables should never be subjected to foot traffic or potentially crushing forces.

The following is a procedure for conduit or duct installation.

1. Attach the towline to the cable using direct or indirect attachment as described in previous section.

2. Establish two way communications 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 on 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 3 feet (1 meter) of cable behind it.

9. Terminate the cable.

10. Measure and record optical cable loss using either an OTDR (Optical Time Domain Reflectometer) or an optical test.

11. Seal the ends of the cable with endcaps until they are connected.

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 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 in 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 using methods similar to those for electrical cables.

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

IMPORTANT Use 3/8" strands of cable to support aerially placed cable to limit the problems caused by differences in expansion and contraction of the support and strand cable.

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 damage.

3. Determine which 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 50 feet (15 meters) 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 using a guy clamp on the strands behind the first roller.
   - place the cable 2 feet (0.6 meters) past the pole if the cable should start at a dead end pole
   - place the first cable block within 1 foot (0.3 meters) if the pull starts midstrand between poles

IMPORTANT Use manila rope (1/4" minimum), 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 1 foot (0.3 meters) 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 using direct or indirect attachment as your application dictates.(See 4-5)

10. Establish communications between the cable payoff station, intermediate hand assist stations, and the pulling station.

11. Pull the cable slowly 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 guideblocks after the pull is completed and the pulling end is anchored. Use the payoff break to maintain the proper tension.

13. Measure and record optical cable loss 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 towards 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 connected.

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 36 and 48 inches (1 to 1.2 meters) 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 the following steps as a guide for installing your fiber optic cable 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 36 inch (1 meter) 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, etc.) 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, etc.

   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 optical cable loss using either an OTDR (Optical Time Domain Reflectometer) or an optical test.

12. Seal the ends of the cable with endcaps until they are connected.

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.

Plans for Vertical Cable Installation

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 3 feet (1 meter) and as long as 50 to 100 feet (15-30 meters) 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 1 foot (0.3 meters) in diameter at the top, bottom, and every 500 feet (150 meters).

   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 2 inches (5 cm).

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

5. Measure and record optical cable loss using either an OTDR (Optical Time Domain Reflectometer) or an optical test.

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

What is next?

When you are confident that you can follow the fiber installation guidelines and have been trained to terminate fiber cable go to Chapter 5 to begin to install your fiber segments.

Install a ControlNet Fiber Media System

What This Chapter Contains

This chapter provides you with generic steps to connect short and medium distance fiber cable. The following table describes what this chapter contains and where to find specific information.

Use pre-terminated short distance fiber cable

We offer simplex or zipcord cable. You can use (multi-mode) fiber cable with our modules but at this time we do not sell this cable. You need to check with your distributor to get the information and equipment needed. For information regarding other fiber products not covered in this manual, consult your local fiber media distributor.

ControlNet Fiber Repeater Hubs

ControlNet uses a modular fiber repeater system. The repeater adapter (1786-RPA) connects to the coax media and repeats signals from the coax media to the fiber repeater module and is referred to as the adapter in this publication. The fiber repeater module (1786-RPFS or 1786-RPFM and RPFR(X)L) sends the signal through the fiber cable to the next fiber repeater on the network and is referred to as the module here. The combination of the adapter and the module is referred to as the fiber repeater hub.

IMPORTANT The fiber repeater adapter (1786-RPA) is referred to as the adapter throughout this document. The fiber repeater module (1786-RPFS, -RPFM, -RPFR(X)L) is referred to as the module in this document.

Up to 4 repeater modules can be mounted on the DIN rail and plugged together with one repeater adapter. Short-distance modules (1786-RPFS), medium-distance modules (1786-RPFM), and fiber ring modules 1786-RPFR(X)L may be mixed and matched in any combination to a single RPA.

Installation Guidelines for Fiber Units

Follow these guidelines when you plan and install your fiber units:

- 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 exposure to water or direct sunlight
- mount the units in a NEMA type enclosure
- allow a minimum of 5 cm space from surrounding equipment for proper ventilation
- vertical mounting of the modules is OK, but to maintain proper ventilation, do not mount the modules upside down

Refer to the following publications for repeater and module installation instructions:

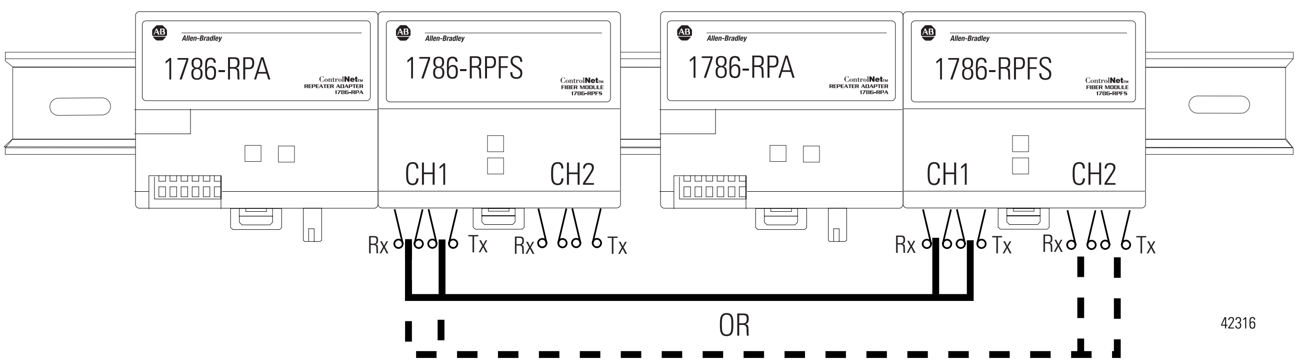
Table 5.A Reference Publications

Publication	Publication Number
ControlNet Modular Repeater Adapter Installation Instructions (1786-RPA)	1786-5.13
ControlNet Modular Repeater Short-distance Fiber Module Installation Instructions (1786-RPFS)	1786-5.12
ControlNet Modular Repeater Medium-distance Fiber Module Installation Instructions (1786-RPFM)	1786-5.13
ControlNet Modular Repeater Long and Extra Long-distance Fiber Ring Module Installation Instructions (1786-RPFL/RPFXL)	1786-IN003A-EN-P

Wire the Fiber Module for Zipcord Operation

A zipcord is a pre-manufactured 650mm 200/230 micron cable with a versalink V-pin connection at the ends. The zipcord is a duplex cable. A duplex cable is manufactured with the fiber reversed on opposite ends. This automatically connects “Transmit” from one unit to “Receive” of the other.

Figure 5.1 Zipcord Connection Example.



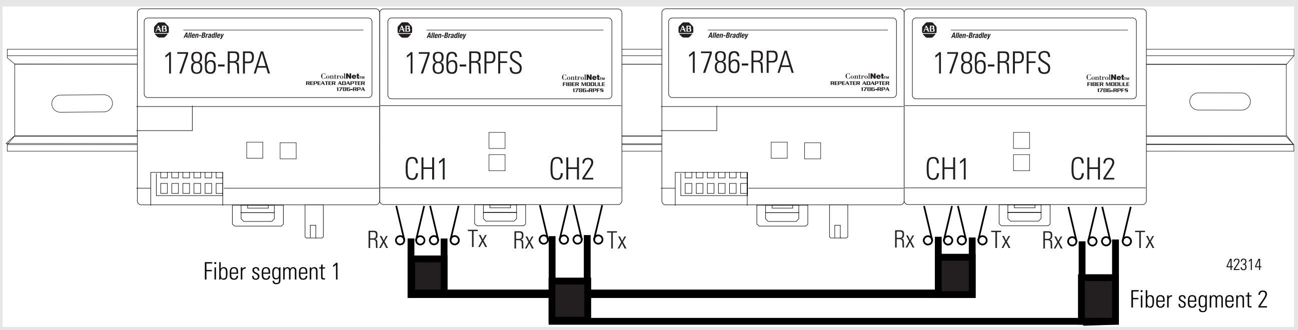
The 1786-RPFM is not a redundant module, therefore never connect more than one duplex fiber or two simplex fibers between the same modular repeaters, even if they are from different modules on the same hub. See Figure 5.2 on page 5-4 for an incorrect example of a redundant topology.

ATTENTION

Do not look directly into the fiber ports. Light levels may cause damage to eyesight.

IMPORTANT Never make a fiber or copper connection between modules that are connected to the same adapter.

Figure 5.2 Incorrect Configuration Example

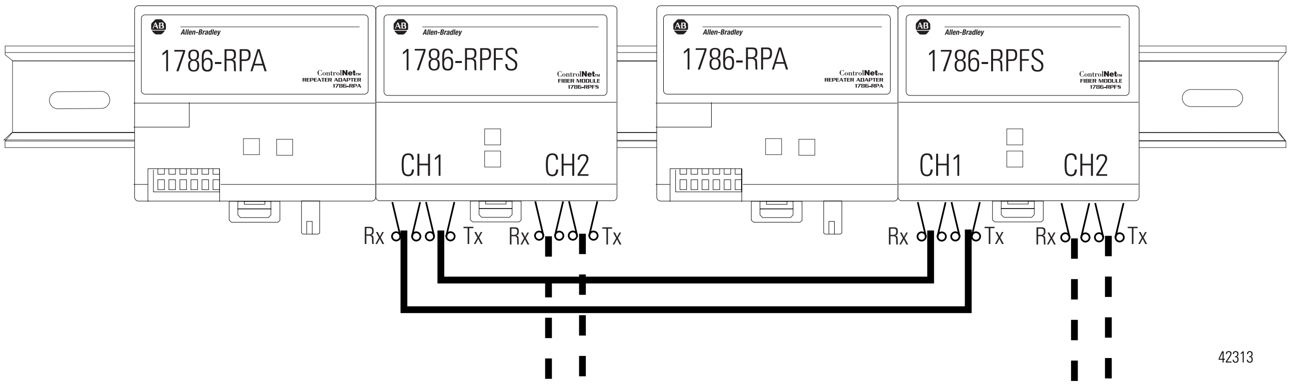


INCORRECT CONFIGURATION

Channel 1 to Channel 1	**OK**
Channel 1 to Channel 2	**OK**
Channel 2 to Channel 2	**NOT OK**

IMPORTANT Never connect the fiber cable between channel 1 or channel 2 on the same repeater module, even between channels from different modules on the same repeater. Refer to the figure below.

Figure 5.3 Correct Connection Example



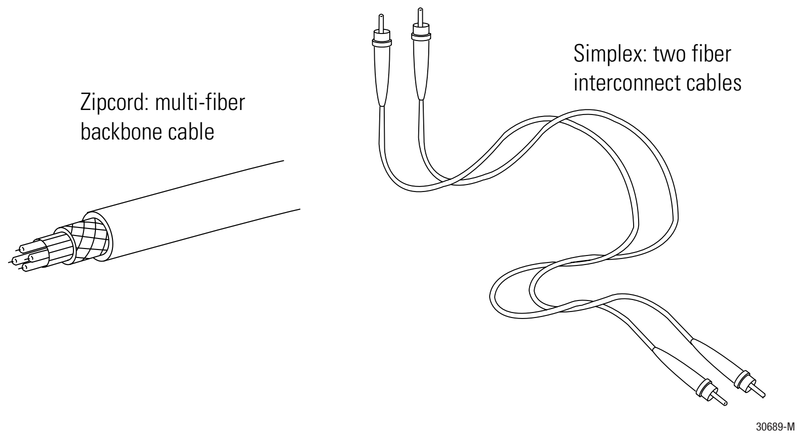
Correct Configuration

IMPORTANT Be certain that the fiber connected to Rx (receive) on one 1786-RPFM is connected to Tx (transmit) on the other 1786-RPFM. You can use channel 1 or channel 2 on either card.

Identify Cable and Connector Types

The short-distance fiber module (1786-RPFS) is designed for use with a 200 micron (step index multi-mode) **H**ard **C**lad **S**ilica fiber type with a wavelength of 650nm and versalink connection system. The medium-distance fiber module (1786-RPFM) is designed for use with 62.5/125μm multi-mode optic fiber and plastic or ceramic ST type connectors. The wavelength used is 1300 nm.

Multi-fiber cables for backbone use are available with a wide range of fiber counts; between 2 and 216 fibers. The following figure shows an example of a multi-fiber backbone cable and two fiber interconnect cable.



We recommend that you use the Corning Cable Systems Termination Kit with the unicam ST connectors. The Corning Cable Systems Termination Kit has proven to be a simple and reliable method to terminate fiber cable. See Chapter 6, Terminate Your Network for details. The type of fiber cable you choose to use depends on the network environment. Consult your installation professional to determine the best type of cable to use for your environmental conditions.

Estimate Cable Lengths

The maximum length of a fiber cable section for the 1786-RPFM 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 13.3dB.

Typically cable attenuation for a wavelength of 1300nm is less than 1.5dB/km.

IMPORTANT Avoid jointing your cable as much as necessary. 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 Allen-Bradley fiber system has different constraints, therefore determining maximum fiber optic cable lengths differs for each system. Allen-Bradley offers two different systems that are targeted to solve different applications.

1786-RPFS

The 1786-RPFS system specializes in solving short-distance applications, we guarantee a distance of 0-300m. This system requires the use of pre-terminated cable assemblies, such as the Versalink V-System. Refer to publication AG-2.2, ControlNet Media Component List, for a complete list of cable assemblies.

1786-RPFM

The 1786-RPFM is designed to solve medium distance applications that require 3km (9843ft) between two ControlNet products. We guarantee up to 3km, but you can achieve greater distances by increasing the quality of the fiber cable and termination connector media. The medium distance module provides ground isolation between nodes and is not disrupted by the noise that affects traditional copper media.

200 Micron HSC Cable

Use this cable with the 1786-RPFS module and specializes in solving short distance applications. When using plug-n-play systems it requires the use of pre-terminated cable assemblies. Refer to publication AG-2.2, ControlNet Media Component List, for a complete list of cable assemblies.

62.5 Micron Cable

Use this cable with the 1786-RPFM and 1786-RPFR(X)L modules and solves medium to long distance applications that require greater distances than what coax cable can provide. The medium and long distance modules provide ground isolation between nodes and is not disrupted by the noise that affects traditional copper media.

Specifications for Fiber Optic Cable

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

The table below provides specifications for fiber optic cable:

1786-RPFS Fiber Optic Cable

Item	Description
Fiber Type	200/ 230 micron HCS (hard- clad silica)
Fiber Termination Type	Versalink V– System
Fiber Operating Wavelength	650 nm (red)
Optical Power Budget	4.2 dB

1786-RPFM Fiber Optic Cable

Item	Description
Fiber Type	62.5/125 micron
Fiber Termination Type	ST® (Plastic or ceramic)
Fiber Operating Wavelength	1300 nm
Optical Power Budget	13.3[1]

① This includes all loss associated with the fiber link, including: splices, fiber attenuation, bulkhead connectors, and the 1786– RPFM ST terminations.

What is next?

Now that you have:

- identified what modules you are going to use
- decided where you will install the modules in your network topology
- determined what quality of cable and connectors you will be using
- calculated the attenuation levels for the distances and numbers of connections you are going to use

you can now physically terminate the cable. Go to Chapter 6.

You may find that you will use the information in Chapters 3, 5, and 6 in different sequences than what is in this manual. For example, you may have to go back to Chapter 3 and recalculate if you change the quality of the fiber cable.

Terminate Your Network

What This Chapter Contains

Refer to the following table to find information on how to terminate the fiber cable.

This chapter provides you with generic steps to terminate medium distance fiber cable. Rockwell Automation offers pre-terminated kits for the short distance module. You simply “plug-n-play” the connections. The medium distance cable must be terminated in the field. We provide an overview as well as recommendation on how to terminate the cable.

Refer to publication, AG 2.2 ControlNet Media Component Listing for ordering information.

What is termination?

Termination is simply, the process of attaching a connector to the ends of your fiber cable. Unlike the ControlNet coax media where you are required to use a 75 ohm terminator on an unused tap, the MT-RJ connector has a dust cap that you place in the end of the connector.

When you are ready to use the MT-RJ connector you simply remove the end cap and attach the cable.

Rockwell offers the short distance (<300 m) fiber cable preterminated as a kit for use with the 1786-RPFS fiber module.. You terminate the medium and long distance (> 300 m) cable in the field.

Termination kits

MT-RJ is the latest connector technology that allows for more compact connector grouping that is possible with the current ST style connector.

This section describes in general, how to assemble the Corning Cable Systems® Unicam® ST- compatible connectors. The ST- connector is a single-mode connector and is compatible with the Rockwell medium distance fiber module and repeater products. The Corning Cable Systems kit has shown to produce reliable and consistent high quality fiber connections/termination. This kit can also be used with the MT-RJ connectors that will be used in our next generation products such as the daughter cards.

The Unicam Kit will install the MT-RJ connectors as well as the ST connectors. This process is similar for the other Corning Cable Systems connectors designed for use with the Unicam kit.

There are currently no products available on the market that test the connector on the short distance fiber cable but there are many products available to test the connectors on the medium distance cable.

Terminate Your Cable

This section does not contain illustrations. It is simply meant to provide an overview on how to assemble the fiber connectors. The fiber termination process can be uncomplicated and reliable using the Corning Cable Systems kit. Training, patience and practice will enable you to terminate fiber cable as simply and quickly as coax. Terminating coax can actually be more difficult and frustrating than fiber.

The following sections are excerpts from the Corning Cable Systems kit instructions and provide the generic steps to terminate your fiber media by installing an MT-RJ or ST connector.

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 preforming the connections.
4. Follow the assembly and safety procedures for your termination kit.
5. Attach the end cap to the connector to your module.

Assembly Instructions for Corning Cable Systems ® UniCam ® Connectors

When you purchase the Corning Cable Systems kit you will be provided with excellect detailed instructions with illustrations and a video tape demonstration. The following information is a snapshot from the information provided with the Corning Cable Systems manual, modified by Rockwell Automation.

The Corning Cable Systems UniCam connectors are field-installable connectors that do not require epoxy or polishing. The units incorporate a fiber stub that is bonded into a ferrule and polished in the factory, not in the field. The field fiber is cleaved and inserted into the connector so that it touches the cleaved end of the fiber stub. When the cam is rotated, both fiber ends are precisely aligned inside the connector and help in place.

After strain relieving the fiber to the connector, it is ready to be mated to another connector inside an adapter.

Please be certain to read through the entire procedure in the Corning Cable Systems manual or other kit manufacturer before starting to assemble a connector.

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.

ATTENTION

Isopropyl Alcohol is Flammable. Flashpoint = 54o F. Can cause irritation to your eyes on contact. Wear safety glasses. In case of eye contact, flush eyes with water for at least 15 minutes. Inhaling fumes may cause mild narcosis. In case of ingestion, consult a physician. Use with adequate ventilation.

ATTENTION

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.

ATTENTION

Fiber optic cable is sensitive to excessive pulling, bending and crushing forces. Consult the cable specification sheet for the cable you are installing. Do not bend cable more sharply than the minimum recommended bend radius. Do not apply more pulling force to the cable than specified. If you crush the cable or allow it to kink the cable may be damaged and that can alter the transmission characteristics of the cable.

ATTENTION

Laser light can damage your eyes. Laser light is invisible. Viewing 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. Never look into the end of a fiber when may have a laser coupled to it, Should accidental eye exposure to laser light be suspected, get an eye examination immediately.

IMPORTANT

Please read though this entire section and the manual that is provided with the termination kit before you attempt to assemble a connector.

Components

The UniCam ST-compatible connector package contains these parts:

- Dust cap
- Ferrule
- Bayonet
- Cam
- Lead-in tube
- Rear cap
- Crimp ring
- Strain-relief boots.

Connector Preparation

The UniCam installation tool:

- positions the fiber into the connector
- rotates the cam that aligns the fibers
- and crimps the buffered fiber in place

The tool makes it easy and accurate to assemble connectors. A separate crimp tool is required to secure the aramid yarn when present in the cable.

IMPORTANT The following steps are provided as an overview to the process. Be certain to refer to the illustrated instructions that Corning Cable Systems provides with your kit.

1. Flip the crimp handle open and rotate the wrench so that the handle is up.

2. Remove the connector components from the bag. Remove and discard the cap from the rear of the connector.

   Do not remove the front dust cap until the connector is completely assembled and you are ready to install it into an adapter sleeve.

3. Examine the connector to be certain that it is in the open position.

   The ST-compatible connector is in the open position when the key on the cam is positioned 90o from the rounded side of the dust cap with the label "UP". The connectors will not fit into the installation tool with the wrench handle up unless the cam is in its open position.

4. Pull back the slider and insert the connector, "UP" label up, into the tool as far as it will go.

   The lead-in tube should rest on the crimp platform when the connector is fully seated.
   The front of the connector should rest in the slider.

IMPORTANT A gentle push should be adequate to insert the connector. If you attempt to force the connector into the tool, you can damage the tool.

If the connector does not slide into the tool when gently pushed, be certain that the connector is in the open position, the wrench handle is up, and you are inserting the connector with its proper side up.

Fiber Preparation

1. Slide the boot (small end first) down the fiber until it is out of the way.
2. Measure and mark 40mm (1.5in) from the end of the buffered fiber.
3. Strip off the 40mm section of the outer jacket with the 16 AWG opening of the buffer stripping tool.
4. Use the scissors to trim the aramid yarn flush to the end of the outer jacket.
5. Measure and mark 11 mm (0.43 in) from the end of the outer jacket.
6. Strip off the 11 mm section of the outer jacket. You should have 11 m of aramid yard showing.
7. Fold the aramid yarn back over the cable jacket and slide the crimp ring about 5 mm (0.2 in) down the yarn to hold it out of the way.
8. Measure and mark the 900 um buffer coating 10 mm (o.43 in) from the end of the cable jacket.

   Place an additional mark on the buffer at the edge of the jacket. This mark is a visual aid to indicate when the field fiber contacts the fiber stub.
9. Remove approximately 41 mm (1.6 in) of coating to the first mark with the 203 um No-Nik tool.
10. Clean the bare fiber with two passes of an alcohol wipe. Do not touch the bare fiber after cleaning it. Do not remove the 10 mm mark.

Connector Installation

1. Press down on the handle to open the cleaver's fiber clamp.

2. With your other hand, place the fiber in the cleaver's fiber guide so that the end of the fiber is under the fiber clamp and the end of the fiber coating lines up with the 8.5 mm length marking.

IMPORTANT DO NOT FLEX THE FIBER GUIDE AT THIS TIME.

It is critical that the cleaver blade lightly touch the fiber and then be released before the bending motion of the guide is used to break the fiber. Bending the guide while the blade is in contact with the fiber will result in poor cleaves.

3. Gently release the handle to lower the clamp into the bare fibers.

4. Press down the cleaver arm until it just touches the fiber and guide. This will apply enough pressure to properly score the fiber.

5. Gently release the cleaver arm.

6. Flex the fiber guide to break the fiber. The fiber is now ready for insertion.

7. Press down on the cleaver's handle to once again lift the fiber clamp. Remove the end piece of the fiber with tweezers and place it on a loop of tape for proper disposal.

8. Carefully insert the cleaved fiber into the lead-in tube of the connector in the installation tool until you feel it firmly stop against the connector's fiber stub.
   - Guide the fiber straight. Do not bend or angle it.
   - If you feel resistance at the entry funnel, pull the fiber back out a short distance and re-insert it.

IMPORTANT If you strip and cleave the fiber to the correct length, the end of the cable jacket or the buffer mark should stop within 2 mm (0.08 in) of the lead-in tube.

If this mark is not visible, the fibers may have been broken. Remove the connector, re-strip and relceave the fiber, and begin with a ne connector.

9. Rotate the wrench past 90^{o} to cam the connector. (an audible click from the tool is normal) The wrench must stay down - do not rotate it back upright.

10. The fiber is now held inside the connector by the splice. You no longer need to hold it in place, but be careful not to pull on the fiber.

11. Carefully flip the crimp handle 180^{o} until it contacts the crimp tube. Push down firmly to crimp. The tool cannot over-crimp the connector.

12. Flip the crimp handle back. You should see a flat impression in the crimp tube, indicating a proper crimp.

13. Leave the wrench handle down. Remove the connector be lifting it and its cable straight up and out of the tool. Do not pull the cable away from the crimped tube. Handle connector only.

14. Slide the boot up the back of the connector until it reaches the cam.

    A small bead of Loctite 411 adhesive my be applied around the cable at the rear of the connector, just past the metal crimp tube, before putting the boot on. This will assist in holding the cable jacket in place. Slide the boot into place quickly. Do not hesitate or the adhesive will cure before the boot is fully seated.

The connector is now ready to use. Leave the front dust cap on until you are ready to insert the UniCam connector into an adapter sleeve.

What is next?

After you assemble your connectors onto your fiber cable and made the connections to your modules, you are ready to go to Chapter 7 and verify your network.

Verify Your Network

What This Chapter Contains

Refer to the following table to find information on how to verify your network before you go online.

Verify Your Network

You can use RSNetWorx for ControlNet or other network configuration software to determine whether or not your system meets the network parameter requirements. Based on your planned system requirements such as, NUT, SMAX, UMAX, and worst case network delay, RSNetWorx will calculate your planned network parameters.

Once you have entered these values into RSNetWorx and the parameters are calculated, the software will tell you whether or not if your configured network is acceptable as you have planned. If you network is not valid, you must adjust your planned requirements.

Refer to publication 9399-CNETGR, Getting Results with RSNetWorx for ControlNet for information on how RSNetWorks can help you verify your network.

Power Loss Measurement

After you install medium or long distance fiber cable, check your sections using an optical power meter to verify that your attenuation is less than 13.3dB. The power source you choose to test with must match the power source rating of the cable you are testing.

The power loss measurement should match the tables in the previous chapters, if you do not follow the power loss recommendations in the previous chapters then 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 loss budgets are at the source wavelengths.

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 viability of your section.

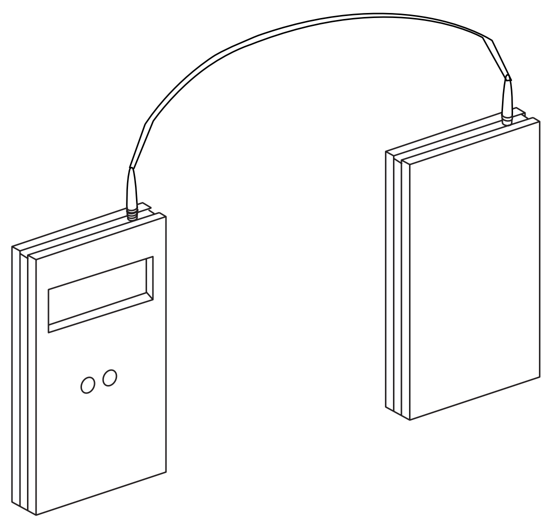


Table 7.A Fiber Module Distance and Ratings

Fiber Module:	Distance:	Rating:
short, 1786-RPFS	640nm	200/230 μ
medium, 1786-RPFM	1300nm	62.5/125 μ
long, 1786-RPFRL	1300nm	62.5/125 μ
extra long, 1786-RPFRXL	1300nm	9 μ

Incorrect Loss Measurement Example

If it is a medium distance system that you are testing and if you test it at 640nm lightsource, you will get incorrect loss measurement, it will not have any bearing. You must to test the fiber at 1300nm because that is where the cable is rated.

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

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

- 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 using an *optical time domain reflectometer* (OTDR). The OTDR emits light into a strand of fiber optic cable and displays the reflected light.

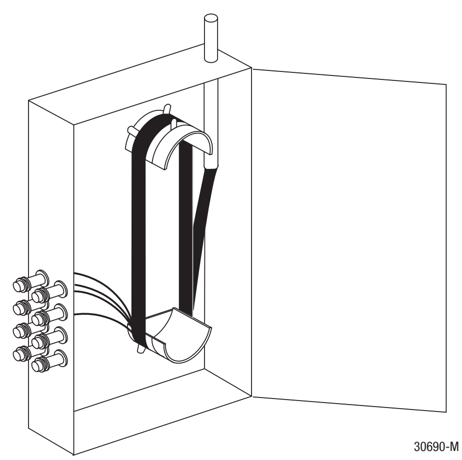
IMPORTANT Disconnect the fiber modules from the fiber cables before performing an OTDR test.

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 diskette.

The following figure shows an example of a connector panel with incoming multi-fiber backbone cable and connectors for interconnect cables.



There are many choices of fiber optic cables designed for use in different environments. Consult your applications designer or an installation professional to determine the best type of cable to use for your environmental conditions.

Troubleshoot the Fiber Module

The fiber repeater has one LED for the coax connection and one for the accumulative indications of fiber channels.

Table 7.B LED Indications on the 1786-RPA

If both are:	This indicates:
off	• Unit not powered. Check power line for correct voltage.
red	• Faults caused by a jabber condition are automatically cleared when the condition is removed. • Repeater fault. Replace the repeater or troubleshoot the network
If either is flashing:	**This indicates:**
green/off	Experiencing temporary network errors. Situation normally corrects itself. If it persists, troubleshoot nodes and cable system. Make sure: • all connector pins are properly sealed • all taps are connected properly • all coax terminators are 75Ω and installed at both ends of all coax segments • coax cable has not been inadvertently grounded
red/off	• Experiencing a high level of network errors. Possibly a broken cable, tap or missing segment terminator. • The indicators will flash red/off on a system that has no network activity. Red/off is normal for a system that has no ControlNet nodes installed or enabled.

The status indicators are individually related to channel 1 or 2.

Table 7.C LED Indications on 1786-RPFS or 1786-RPFM(1).

Status:	Indicates:
LED is off	• Unit is not powered from the repeater adapter • Module is not properly seated to 1786-RPA • Faulty module, order a replacement • Transmit and receive are backwards
LED is flashing green/off	• No data activity on associated channel
LED is solid green	• Proper fiber connection between module pair
LED is flashing green/off	• No data activity on associated channel

(1) As of this print date, the LED Indications for the 1786-RPFRL and 1786-RPFPXL are not available.

APD (Avalanche Photo Diodes)

converts light to current in fiber receivers

Attenuation

light loss of the fiber cable specified in dB/km

Bandwidth

pulse broadening caused by multimode 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

the maximum amount the cable can be bent and still function up to specification.

Buffer

the 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/1mw)

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 producing low energy wavelengths onto fiber media

Local Area Network

family of computer networks, industrial control networks, and office networks used in short-distance multi-user environments

Loss

see *Attenuation*

Multimode

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. $NA = \sin\alpha = \sqrt{(n1^2 - n2^2)}$ where n1= core refractive index and n2=cladding refractive index.

Network Update Time (NUT)

the 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 current

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 rates than glass

Receiver

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

Refractive Index

the 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 power

Return Loss

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

Scheduled Maximum Node Address (S_{max})

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 performance

Single Mode

single wavelength-mode in conjunction with fibers and single wavelength fibers in conjunction with lasers

Speed of Light

the phase velocity of an optical wave

Splice

connection in the fiber designed to increase the distance 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 (U_{max})

The highest unscheduled node address on the ControlNet network.

Numerics

A

B

C

D

E

F

G

H

I

L

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