FIBERROAD

TECH NOTE

Ethernet OAM

Operations
Administration
Maintenance

About The Tech Note

Introduction

This document includes an introduction to the Ethernet OAM Features and Fiberroad products family. To give you a quick overview of the Fiberroad products.

Conventions

This document contains notices, figures, screen captures, and specificnventions.

Figures and Screen Captures

This document provides figures and screen captures as an example. These examples contain sample data. This data may vary from the actual data on an installed system.

Units of Measurement
Units of measurement in this publication conform to SI standards and practices.

Jan 01, 2022

1. Overview of Ethernet OAM

OAM is a set of functions that provides a system or network fault indication, performance monitoring, security management, diagnostic functions, configuration and user provisioning. The purpose of these management tools or capabilities is to enable the monitoring and quick restoration of the network in case of failure. Given that a network is typically comprised of equipment owned by different operators and built by many different manufacturers, OAM has to be standardized to ensure consistency and interoperability, OAM entities are network-aware in that they use information from and provide information to other network entities. They cooperate to provide the consistency and conformity that are critical to an entity's OAM functions.

OAM mechanisms for server-layer services such as synchronous digital hierarchy (SDH) and for client-layer services-layer OAM and has been developed to support the following functions:

- Monitors Ethernet link connectivity.
- Pinpoints faults on Ethernet networks.
- Evaluate network usage and performance.

These functions help carriers provide service based on service level agreement (SLA). Ethernet operation, administration and maintenance (OAM) are used for Ethernet networks.

Ethernet OAM provides the following functions:

- Fault management
- Ethernet management
- Ethernet OAM sends detection packets on-demand or periodically to monitor network connectivity.
- Ethernet OAM uses methods similar to Packet Internet Groper(PING) and traceroute used on IP networks to locate and diagnose faults on Ethernet networks.
- Ethernet OAM is used together with a protection switching protocol to trigger a device or link switchover if a connectivity fault is detected. Switchovers help networks achieve carrier-class reliability, by ensuring that network interruptions are less than or equal to 50 milliseconds.
- Performance management

Ethernet OAM measures network transmission parameters including packet loss ratio, delay, and jitter and collects traffic statistics including the numbers of send and received bytes and the number of frame errors. Performance management is implemented on the access device. Carriers use this function to monitor network operation and dynamically adjust parameters in real-time based on statistical data. The process reduces maintenance costs.

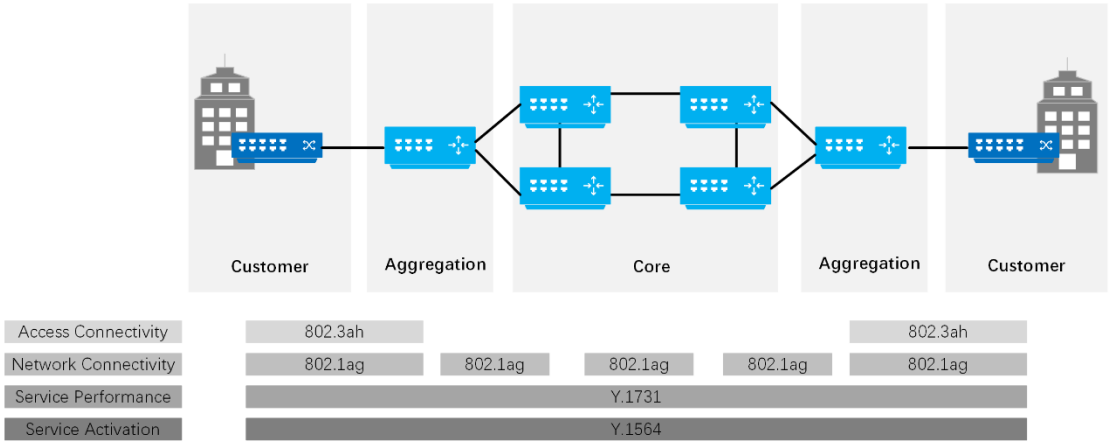
Table 1 shows the hierarchical Ethernet OAM networks structure.

Layer	Description	Feature	Usage Scenario
Link-level Ethernet OAM	Monitors physical ethernet links directly connecting	EFM supports link continuity check, fault detection,	EFM is used on links between customer

	carrier networks to user networks. For example, the Institute of Electrical and Electronics Engineers(IEEE) 892.3ah, also known as Ethernet in the First Mile(EFM), supports Ethernet OAM for the last-miles links and also monitors direct physical Ethernet links.	fault advertisement, and loopback for P2P Ethernet link maintenance. Unlike CFM which is used for a specific type of service, EFM is used on links transmitting various services.	edges(CEs) and user-end provide edges(UPEs) on a metropolitan area network(MAN). It helps maintain the reliability and stability of connections between a user network and a provider network. EFM monitors and detects faults in P2P Ethernet physical links or simulated links.
Network-level Ethernet OAM	Checks network connectivity, pinpoints connectivity faults, and monitors E2E network performance at the access and aggregation layers., For example, IEEE802.1ag(CFM) and Y.1731.	IEEE 802.1ag, also known as connectivity fault management (CFM), defines OAM functions, such as continuity check, loopback, and linktrace, for Ethernet bearer networks. CFM applies to large-scale E2E Ethernet networks.	CFM is used at the access and aggregation layers of the MAN. For example, CFM monitors the link between a user-end provider edge (UPE) and a PE. It monitors network-wide connectivity and detects connectivity faults. CFM is used together with protection switchover mechanisms to maintain network reliability.
		Y.1731 is an OAM protocol defined by the Telecommunication Standardization Sector of ITU-T. It covers items	Y.1731 is a CFM enhancement that applies to access and aggregation network. Y.1731 supports performance

		defined in IEEE 802.1ag and provides additional OAM messages for fault management and performance monitoring. Fault management includes alarm indication signal (AIS), remote defect indication (RDI), locked signal (LCK), test signal, maintenance communication channel (MCC), experimental(EXP) OAM. Performance monitoring includes frame loss measurement (LM) and delays measurement(DM).	monitoring functions, such as LM and DM, in addition to fault management that CFM supports.

Figure 1 Typical MAN Networking



The importance of Ethernet OAM

Traditional TDM services typically were physical 'hard wired' from point to point or from a service provider CO to the access CPE/CLE. While this posed limitations on flexibility and scalability it did provide accurate visibility to troubleshoot network issues by performing simple loopback tests, for example, to validate if the physical circuit was intact. Ethernet over copper solutions as offered by Fiberroad, benefit

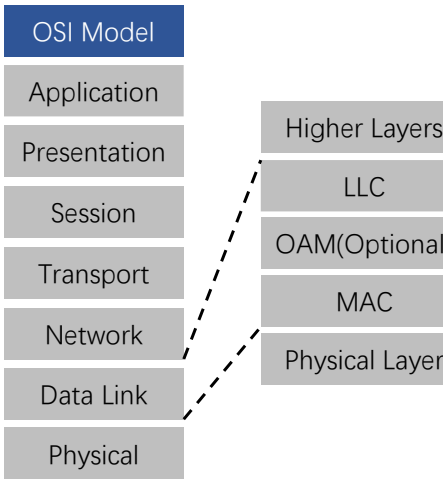
from maintaining physical (Layer 1) traceability, but introduces a virtual connectivity layer with Ethernet virtual circuits (EVCs) at Layer 2, as all Ethernet services do. EVCs can traverse multiple physical paths and often share the same physical path with many other EVCs. This in itself makes it difficult to determine where exactly the source of a problem on an Ethernet circuit is unless it can be correlated to a physical level fault, which may not always occur, particular for performance-related issues. This challenge is overcome by the aforementioned Ethernet OAM functions and standards which provide activation, monitoring and test tools for L2 Ethernet service, enabling network operators to actively and proactively manage and maintain their Ethernet service for high availability while minimizing their ongoing OPEX.

2. Link-level Ethernet OAM

802.3ah Clause 57 EFM-OAM) defines the Operations, Administration, and Maintenance (OAM) sublayer, which provides mechanisms useful for monitoring link operation such as remote fault indication and remote loopback control. In general, OAM provides network operators the ability to monitor the health of the network and quickly determine the location of failing links or fault conditions. **EFM-OAM** described in this clause provides data link layer mechanisms that complement applications that may reside in higher layers.

OAM information is conveyed in slow protocol frames called OAM protocol data units (OAMPDUs). OAMPDUs contain the appropriate control and status information used to monitor, test and troubleshoot OAM-enabled links. OAMPDUs traverse a single link, being passed between peer OAM entities, and therefore, are not forwarded by MAC clients (like bridges or switches).

- ❖ Provides mechanisms useful for "monitoring link operation", such as:
- ● Link Monitoring
- ● Remote Failure Indication
- ● Remote Loopback Control
- ❖ Defines an optional OAM sublayer
- ❖ Intended for single point-to-point IEEE 802.3 links
- ❖ Uses "Slow Protocol"1 frames called OAMPDUs which are never forwarded by MAC clients
- ❖ Standardized: IEEE 802.3ah, clause 57 (now in IEEE 802.3-2005)



2.1 IEEE 802.3ah Key Features

❖ **OAM Discovery and Link Monitoring**

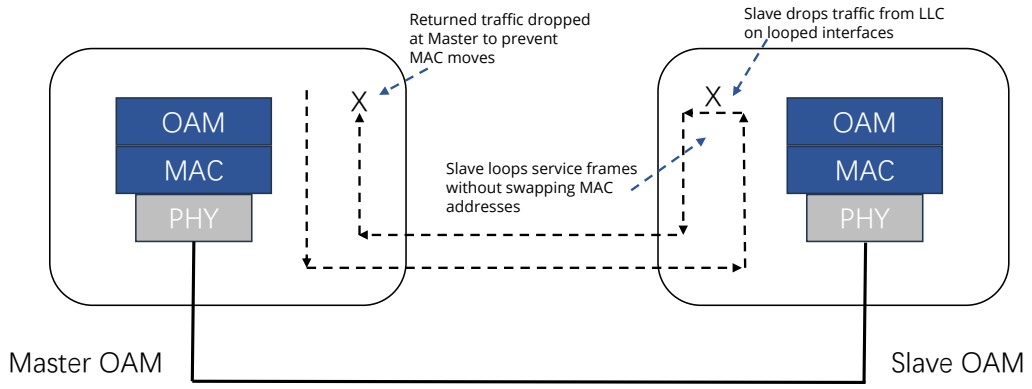
The discovery process is triggered automatically when OAM is enabled on the interface. The discovery process permits Ethernet interfaces to discover and monitor the peer on the link if it also supports the IEEE 802.3ah standard. You can specify the discovery mode used for IEEE 802.3ah OAM support. In active mode, the interface discovers and monitors the peer on the link if the peer also supports IEEE 802.3ah OAM functionality. In passive mode, the peer initiates the discovery process. After the discovery process has been initiated, both sides participate in the discovery. The switch performs link monitoring by sending periodic OAM protocol data units (PDUs) to advertise OAM mode, configuration, and capabilities.

❖ **Remote Fault Detection**

Remote fault detection uses flags and events. Flags are used to convey the following: Link Fault means a loss of signal, Dying Gasp means an unrecoverable condition such as a power failure, and Critical Event means an unspecified vendor-specific critical event. You can specify the periodic OAM PDU sending interval for fault detection. The switch uses the Event Notification OAM PDU to notify the remote OAM device when a problem is detected.

❖ **Remote Loopback Mode**

Remote loopback mode ensures link quality between the switch and a remote peer during installation or troubleshooting. In this mode, when the interface receives a frame that is not an OAM PDU or a pause frame, it sends it back on the same interface on which it was received. The link appears to be in the active state.



Advanced OAM Features

With the industry's most comprehensive offering of full features products, Fiberroad's media converter stand out as "the choice" among industry IT professionals.

Generally, media converters are low-level OSI model devices with no IP or MAC addresses and therefore are transparent to the network. This "transparency" makes them very inexpensive and easy to use, but also can make troubleshooting the network very difficult. In an effort to overcome this difficulty and to make a media converters "visible" to network managers, Fiberroad has designed full featured products to include the most advanced features on the market such as:

- Auto-Negotiation
- Auto MDI/MDIX
- Far-End-Fault
- Link Fault Pass Through
- Transparent Link Fault Pass Through
- Pause
- Remote Management
- Automatic Laser Shutdown
- Automatic Link Restoration
- Port Speed Setting
- Loopback
- Bandwidth Allocation
- Field Upgradeable Firmware
- Source Address Change
- Dying Gasp
- Jumbo Frame
- Cut Through Mode and Store-and-Forward Mode
- Power over Ethernet
- Pseudo Random Binary Sequence (PRBS)

Classes of OAM

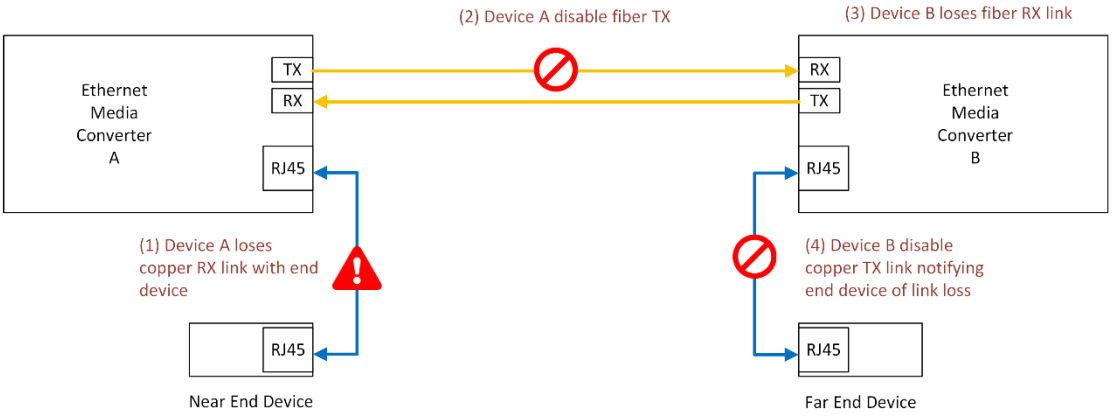
OAM Capabilities	FR-2000 Series	FR-POE332	FR-6101/4I	FR-6000 Series
Basic				
Auto-Negotiation	✓	✓	✓	✓
Auto MDI/MDIX	✓	✓	✓	✓
Link Fault Pass Through	✓	✓	✓	✓
Far End Fault	✓	✓	✓	✓
Automatic Link Restoration	✓	✓	✓	✓
Automatic Laser Shutdown	✓	✓	✓	✓
Port Speed Setting	✓	✓	✓	✓
Loopback	✓	✓	✓	✓
Advance Features				
Dying Gasp			✓	✓
ROMON Counters			✓	✓
Bandwidth Allocation			✓	✓
Field Upgradeable Firmware			✓	✓
PRBS				✓
Power Over Ethernet		✓	✓	✓
802.1q VLANs			✓	✓
Q-in-Q VLANs			✓	✓
IP addressable			✓	✓
SNMPv1/v2/v3			✓	✓
IEEE 802.3ah Link OAM				
Discovery			✓	✓
Dying Gasp			✓	✓
Link Fault			✓	✓
Transparent Link Fault Pass Through			✓	✓
Critical Events			✓	✓
Remote/Local Lookback			✓	✓
Fault Isolation			✓	✓

Advance Product Features

Link Fault Pass Through

Link Fault Pass Through is a troubleshooting feature that prevents devices from isolating link failures and it allows end devices to be notified in the event of a loss of link. Link Pass Through provides the device with ability to monitor both the fiber and the copper RX ports for a loss of signal. If a loss of RX signal occurs on one media port, the device will automatically disable the TX signal on the other port. By shutting down the fiber TX port, the link failure is “pass through” to remote and local devices(See diagram below)

- ❖ End device automatically notified of link loss.
- ❖ Prevents loss of valuable data unknowingly transmitted over an invalid link.

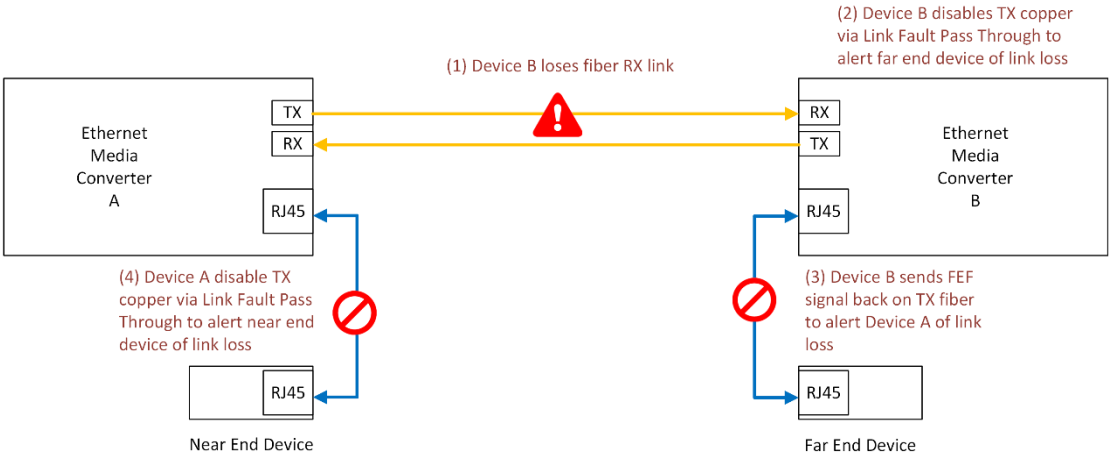


Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	DIP Switch	NMC or DIP Switch

Far-End-Fault

Far-end-Fault(FEF) is a troubleshooting feature that is generally used in conjunction with Link Fault Pass Through to notify both end devices of a loss of link by monitoring the fiber receive(RX) signal. In the event of a loss of the fiber RX signal on the far end, the converter will automatically generate a Far-End-Fault signal and send it on its TX fiber port to notify the near end converter of a fiber link loss. Link Fault Pass Through will then disable the copper links on both ends; alerting both end devices of network trouble(see diagram below).

- ❖ Both end devices are automatically notified of link loss
- ❖ Prevents loss of valuable data unknowingly transmitted over invalid link
- ❖ Allows for quick diagnosis and resolution of network problems

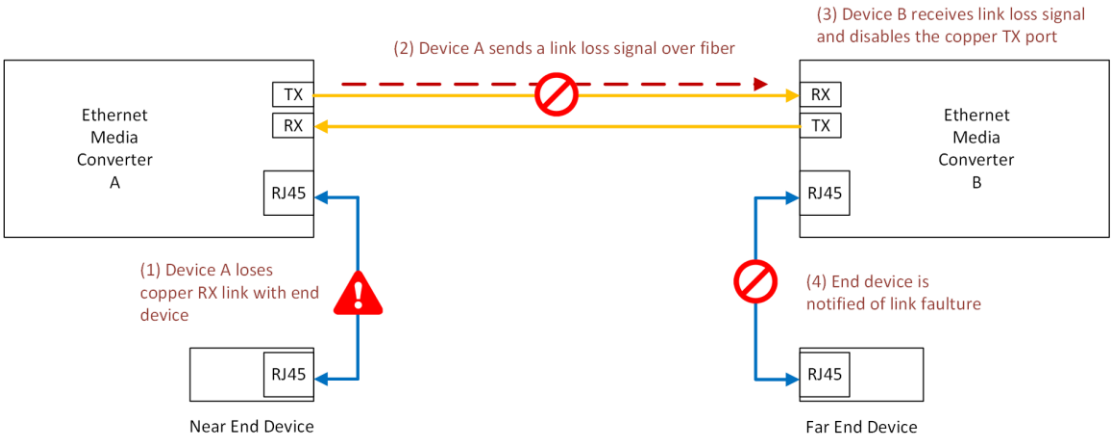


Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	DIP Switch	NMC or DIP Switch

Transparent Link Fault Pass Through

Transparent Link Fault Pass Through will notify an end device of a link failure just like Link Fault Pass Through, however it uses a different method for "Passing Through" this information. Transparent Link Fault Pass Through sends a link loss signal over the fiber, instructing the remote device to shut down the copper port thus notifying the end device, while maintaining the fiber link between the two devices(see diagram below).

- ❖ End device automatically notified of link loss
- ❖ Fiber link remains up as it carries a loss signal

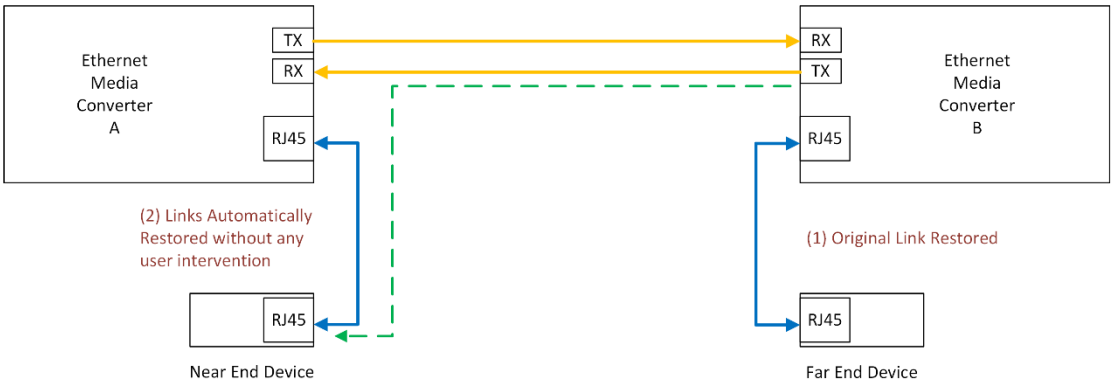


Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	N/A	NMC and DIP Switch

Automatic Link Restoration

After a link failure condition has been corrected, Fiberroad devices will automatically re-establish the link in all network conditions.

- No need to reset devices: Fiberroad devices will automatically re-establish the link when connected to switches if link was lost. With other manufacturers' device the user must reset the converter to re-establish the link.
- Auto-Negotiation Enabled: Automatic Link Restoration allows the users to continue using Auto-Negotiation with Link Loss Notification features. With other manufacturers' devices the user must disable Auto-Negotiation and hard set the link.
- Link Fault Pass Through Activated in both directions: Automatic Link Restoration on Fiberroad products allows users to continue using Link Loss Notification feature activated in both directions.



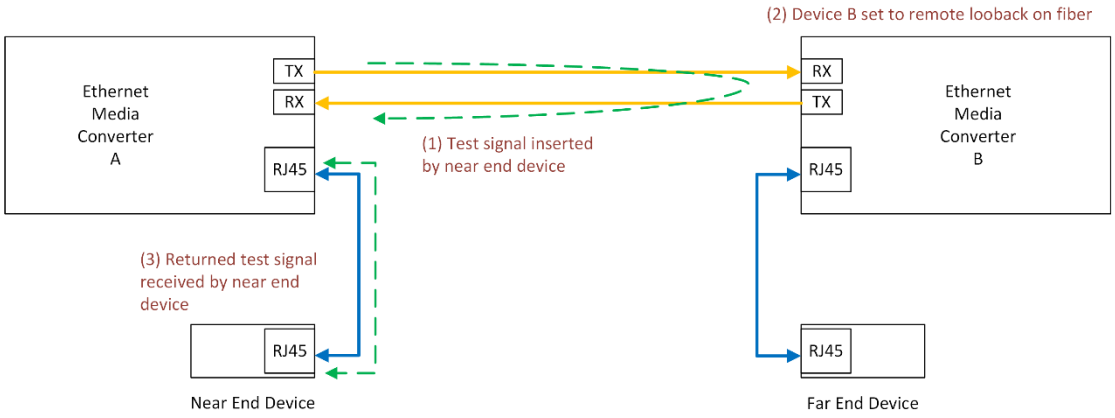
Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	DIP Switch	NMC or DIP Switch

Loopback

Select Fiberroad products are equipped with Loopback. This features puts a converter in a special mode that enables the device to loop back the signal from the RX port to TX port on either media for testing and testing and troubleshooting purposes. Test signals from a tester can then be inserted into the link and looped back as received by a device to test a particular segment of the link(i.e copper or fiber). Loopback can be either local or remote depending on the location of the

device in the link.

- ❖ Allows network diagnostics from local or remote location
- ❖ Quickly pinpoints problem areas of end to end link by testing a particular segment. Some devices have separate copper and fiber loopback functions that can be enabled separately, while others will loopback both copper and fiber at the same time when enabled.

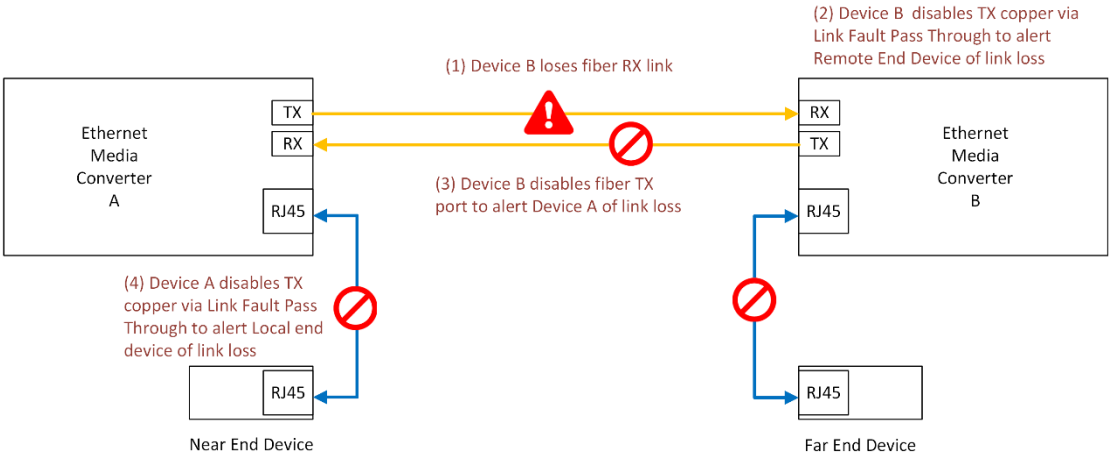


Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	 DIP Switch	  NMC or DIP Switch

Remote Fault Detect

Remote Fault Detect(RFD) is a trouble shooting feature found on Gigabit Ethernet copper-to-fiber devices. By enabling Remote Fault Detect on the remotely located device, the status of fiber link will be monitored and any link failures will be reported back to the local device. Should the remote device lose its fiber RX signal, Remote Fault Detect will force the device to shut down its fiber TX port. If Link Fault Pass Through is enable on both ends, then the copper ports will also be shut down to notify both end devices of the link future.

- ❖ Enable Remote Fault Detect on the remote device
- ❖ Local end-device will be notified of remote fiber RX loss

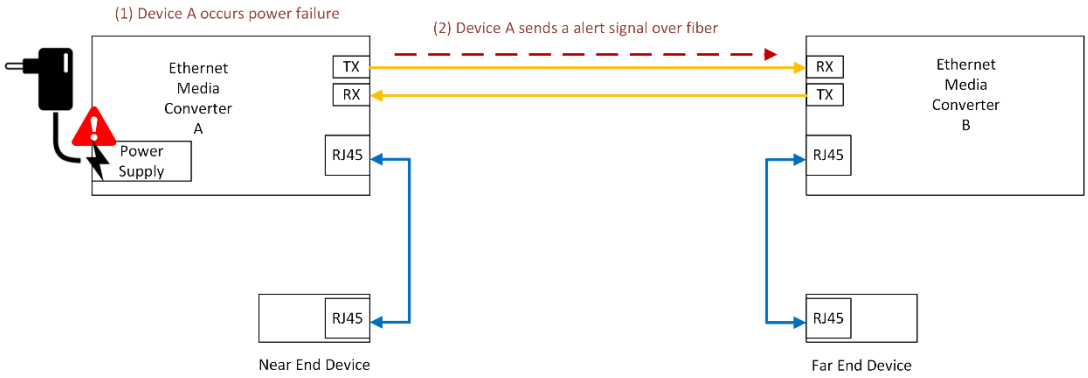


Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	N/A	NMC and DIP Switch

Dying Gasp

Select Fiberroad products are equipped with Dying Gasp, This feature enables the device to store a small amount of power to enable it send out a trap to alert the management unit in the event of a power failure.

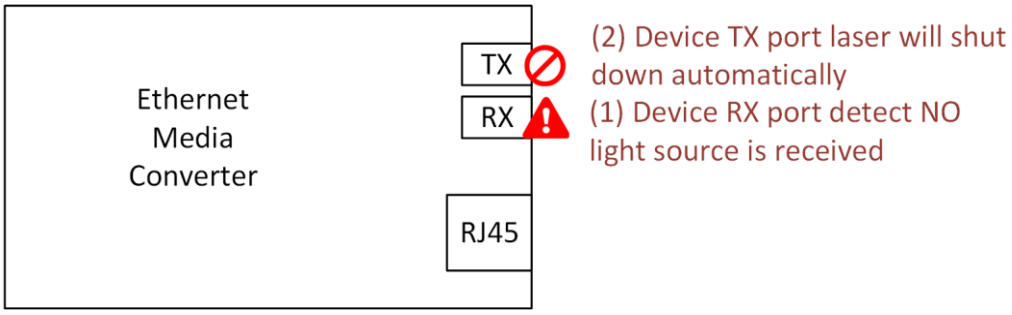
- ❖ Notification of an impending power loss before it happens
- ❖ Allows for quicker resolution of power loss



Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	N/A	NMC and DIP Switch

Automatic Laser Shutdown

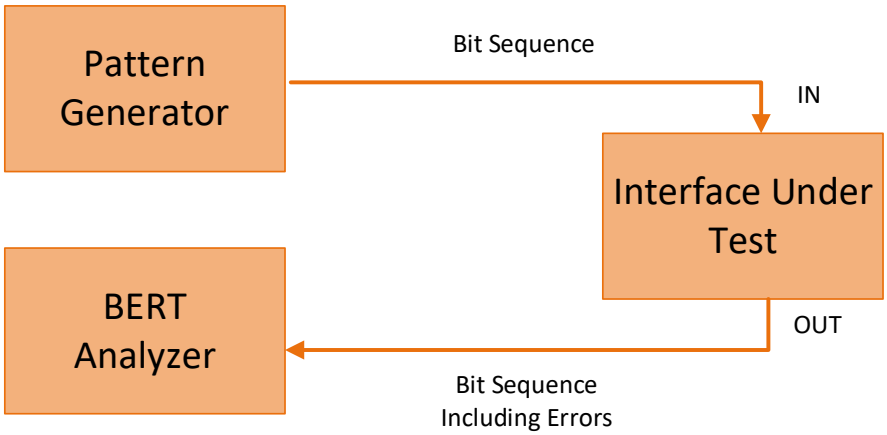
To avoid operator injury or transmission of unreliable data, or to provide quick path switchover, the Fiberroad Ethernet Media Converter Series supports mechanisms to automatically shut down optical lasers.



Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	DIP Switch	NMC or DIP Switch

Pseudo Random Binary Sequence (PRBS)

A PRBS sequence is a series of digital 1's and 0's that is statistically random within the sequence length. This type of sequence shows no correlation between adjacent bits and as such can be considered a "worst case" stress test signal for testing serial digital interface. If the interface can handle a "noisy" random sequence of bits without generating bit-errors, then we can be confident that it will be able to handle "clean" non-random sequences.



Although a PRBS sequence demonstrates random behaviour, it's in fact generated deterministically and the bit sequence will always be the same when repeated. As an example, a PRBS7 sequence has a word length of 7-bits and will generate a sequence length of 2^7-1(127) bits, which is repeated indefinitely by the pattern generator. In general, any PRBSk sequence will have a word length of k bits and a sequence length 2^k-1 bits. It's this combination of both deterministic generation and random bit

pattern that make these sequences ideal for testing interfaces. As the BERT analyser knows what PRBS bits were generated, it's relatively straight forward to conduct a bit-error count on the interface's output bit stream.

Auto-Negotiation(802.3u)

Auto-Negotiation allows devices to perform automatic configuration to achieve the best possible mode of operation over fiber. Devices with this feature will broadcast their speed and duplex capabilities to other devices and negotiate the best mode of operation between the two devices.

- ❖ No user intervention is required to determine the best mode of operation
- ❖ Optimal link established automatically
- ❖ Quick and easy installation

While the inclusion of these features is beneficial, the ability to disable it is equally beneficial. In the event of a non-negotiation end device trying to connect to a negotiating device, the mode of operation will drop to the least common denominator between the two devices(i.e 100Mbps, half-duplex). Disabling this feature gives the user the ability to force the connection to the best mode of operation when trying to link with a non-negotiation device. Most Fiberroad converters with Auto-Negotiation will allow you to disable this feature.

Auto-MDI/MDIX

Automatically detects and configure the twisted pair port on the converter to the correct MDI or MDI-X configuration.

- ❖ Eliminates an entire category of troubleshooting
- ❖ No need to identify cable type—straight-through or crossover
- ❖ No user intervention is required to determine correct button/switch settings

Pause(IEEE 802.3X)

PAUSE signaling is an IEEE feature that temporarily suspends data transmission between two devices in the event that one of the device becomes overwhelmed. In the event that a device needs some time to clear network congestion, it will send out a PAUSE signal to the other end device, which will then wait a pre-determined amount of time before re-transmitting the data. Fiberroad devices will pass PAUSE signaling unhindered; ensuring that the message is delivered to the end device.

- ❖ PAUSE enabled devices allowed to work properly
- ❖ Prevents loss of valuable data transmission
- ❖ Reduces bottlenecks and allows for efficient use of network devices
- ❖ PAUSE signaling is not standardized over fiber media. Fiberroad device will communicate this signaling over fiber between the units to pass this signaling on to the other end device.

Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	N/A	 NMC

Remote Management

All managed-based converters from Fiberroad can be manage via WEB/SNMP/CLI. Select stand-alone products can also be managed through WEB/SNMP/CLI. Some remotely managed devices are IP addressable, while others must be used in conjunction with a managed chassis bases device. While chassis-based products are generally placed in the telecommunications room, stand-alone device are generally placed in remote locations away from network administrators. Remote in-band management over fiber allows administrators access to the remote device to check the status and enable/disable features or the device itself.

- ❖ Visibility of remote converters for network administrators.
- ❖ Allow for centralized management of devices.

Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	N/A	 NMC

Bandwidth Allocation

Bandwidth allocation is an important feature found on select devices allows network administrators to set the bandwidth of the device ports for both ingress and egress bandwidth allocation. The bandwidth can be allocated in a variety of rates up to the full bandwidth capability of the devices.

- ❖ Effectively manage bandwidth usage in the network to support critical processes or activities
- ❖ Provide only the contracted amount of bandwidth to paying customers
- ❖ Provide only the bandwidth necessary to end-users

Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	N/A	 NMC

Field Upgradeable Firmware

New product features are continuously being added to Fiberroad products. These improvements are also available for many products already installed in the field. Management module and many devices can be updated remotely via firmware upgraded. The field-upgradeable feature eliminates the need to ship the products back to the manufacturer. The firmware upgrades can be performed by a user either locally via a console port or remotely via TFTP. The upgrades do not require reconfiguration of the WEB/SNMP/CLI management or converter feature setting.

Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	N/A	 NMC

Jumbo Frame

Enabling jumbo frames can improve network performance by making data transmission more efficient. The CPUs on Media Converter/Switch can only process one frame at a time. By putting a larger payload into each frame, the CPUs have fewer framers to process. In return, this can reduce the amount of heat the network devices generate. The Fiberroad Media Converter supports this feature, particularly meeting the needs of high-resolution video surveillance in present applications.

Store-and-Forward and Cut-Through Mode

Store-and-Forward Mode: The converter will wait until the entire frame has arrived prior to forwarding it . The method stores the entire frame in memory.

Cut-Through Mode: The converter will begin forwarding the frames as soon as the destination address is identified. The difference between this and store-and forward is that store-and forward receives the whole frame before forwarding. Cut-through may impact network performance by forwarding corrupted or truncated frames. But if enable Cut-Through Mode, it can improve network performance by making data transmission more efficient. The Fiberroad Media Converter supports this feature, particularly meeting the needs of high-resolution video surveillance in present applications.

Supported models	FR-2000 Series, FR-POE332	FR-6101/4I, FR-6000 series
Configuration Methods	 DIP Switch	  NMC or DIP Switch

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