

Single Fiber Pluggable Transceivers

Fiber Optimization with Fiber Driver®

Introduction

Fiber optic networking has traditionally required two strands of fiber to accomplish full duplex communications. To achieve full duplex transmission (meaning that transmitting and receiving signals can occur simultaneously) one strand is reserved for transmitting, the other for receiving.

Single strand fiber solutions are the simplest way to fiber optimization, immediately doubling the capacity of the installed fiber plant. Instead of using two dedicated strands, one for receiving and the other for transmitting, each strand carries a bi-directional signal. The fiber plant capacity doubles, which in turn can double the per fiber return on investment (ROI) with no need for more physical fiber. These solutions have been incorporated for many years in the Fiber Driver®, MRV's Optical Multi-Service product line. Recent technological advancements at MRV have yielded many new variations of these solutions, doubling the efficiency of fiber even down to Ethernet in the First Mile.

The benefits and overall savings on a single strand (simplex) versus dual strand (duplex) fiber implementation can be considerable. Considerations include not only the cost of fiber optic cabling itself, but also the labor and material involved in terminating the endpoints, simplex versus duplex patch cords, cross-connect rack space, reduced points of failure, and other direct and indirect costs. This technology can also defer the need to install new fiber to support unexpected growth requirements.

Operational and Capital Expenditure Savings

Single fiber solutions, like any other fiber optimization methods, affect both the capital expenses (CAPEX) and the operational expenses (OPEX). For fiber users like carriers and enterprises that lease dark fiber from their provider (carrier's carrier) rather than owning the fiber plant, the OPEX savings is extremely significant. These carriers' challenge is to maximize revenues while reducing their largest expenditure: the cost of fiber based transport. Maximizing fiber usage by using single fiber circuits reduces the OPEX by 50 % for each protocol-independent circuit, and allows the carrier to deliver more revenue-generating content to their subscribers.

For dark fiber owners such as the carrier's provider, the single fiber approach is one of the best ways to reduce the operational costs (OPEX). The first and most important cost saving measure is to avoid installing additional fiber strands to accommodate growth without imposing limitations due to engineering capabilities.



Fiber Run — Engineering Costs

The design and engineering of a fiber run is a complex process. It may require crossing roads or freeways, which requires approvals, thorough design, and inflexible work scheduling. The deployment cost might include trenching or other expenses. In many cases the price of labor, services, permits, and licensing required to install new cabling can far exceed the cost of the media and supporting electronics.

Fiber Termination and Accessories

New fiber runs require terminating and connecting any fiber strand. This process requires qualified labor that will polish, connectorize, and test every fiber strand. Reducing the number of terminated fiber strands by half results in a significant cost reduction.

In general, outdoor fiber runs terminate into indoor patch panel distribution centers. From these distribution centers, the fibers are routed to their usage end points inside the enterprise or carrier center by means of patch cords. Reducing the number of fiber strands by half means fewer patch cords and patch panel ports, which significantly reduces CAPEX.

Network Reliability and Maintenance Cost

Reliability and availability are key in any communications system. Use of single fiber pluggable-based transceivers in an existing dual fiber link opens the possibility of creating redundant link solutions (e.g. EM316DMR3G-3R or Fiber Driver Ethernet Demarcation modules) without altering the fiber infrastructure. Implementation of redundant links highly improves network reliability and availability.

As with any assembly, the mean time between failures (MTBF) is proportional to the number of assembly components. A larger number of fiber strands increases the chance of fiber failure. Common reasons for failures include broken fibers, incorrect splicing, and mishandling of the connectors resulting in dirty fiber infrastructure. As the number of fiber strands grows, so does the maintenance cost. Downtime can be reduced through the simplicity of single fiber technology. Mean time to repair (MTTR) is also significantly reduced.

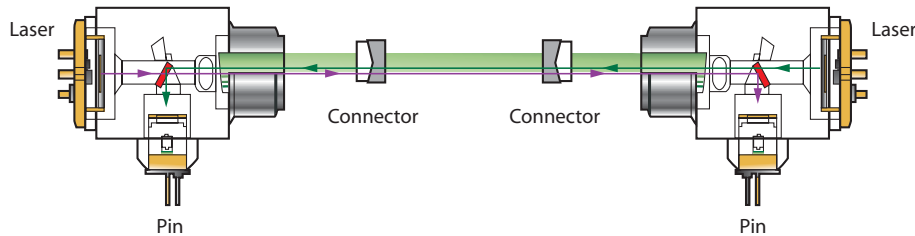


Figure 1: Single fiber, Two Wavelength Integrated Transceiver

Single Fiber Technologies

Early single fiber solutions were based on single wavelength directional coupler technologies. With these solutions, the same wavelength (1310 nm for up to 50 km or 1550 nm for longer distances) travels in each direction (transmit & receive). At the edges, the two signals are coupled into a single fiber strand with a directional coupler (splitter-combiner). This coupler identifies the direction of the two signals (ingress or egress) and separates or combines them. This solution is normally very reliable and cost effective, as long as special installation and connector type (APC -angle polished connector) requirements are observed. Otherwise, this solution is prone to reflections when traversing patch panels and in the cases of fiber cuts or dirty connectors.

In recent years, a new single strand fiber technology has emerged based on two wavelengths traveling in opposite directions. External WDM couplers (multiplexers) combine or separate the two wavelengths at the edges. As technology progressed, the external passive WDM coupler became integrated into a standard interface fixed optical transceiver.

Ethernet in the First Mile (EFM) activity at the IEEE (part of the 802.3AH) working group further encouraged the use of single fiber solutions. The 802.3AH standardized two Physical Medium Dependence (PMD) definitions, one for Fast Ethernet (125 Mbps) and the other for Gigabit Ethernet (1.25 Gbps). 802.3AH (PMD section) mainly defined the wavelengths used and the reservation of the 1550 nm wavelength for CATV downstream distribution (Gigabit Ethernet PMD). The new standards address point-to-point fiber with Ethernet at speeds of 100 Mbps and 1 Gbps and spanning lengths of at least 10 kilometers over

single-mode fiber, allowing for a broad range of applications. Within a subscriber access technology, EFM PMD standards also define extended temperature and reach capabilities for both Fast Ethernet and Gigabit Ethernet.

Initial thoughts indicated the prevalence of Fast Ethernet Service deployments over fiber in small to medium enterprise access. Gigabit Ethernet was intended for medium to large corporations that require significant bandwidth, but also as an aggregation point for multi-dwelling units that house offices and enterprises. As technology progresses and the need for bandwidth increases deployments of Gigabit Ethernet circuits, the need for 10 Gbps single strand circuits slowly begins to emerge.

100Base-BX10

The 100Base-BX10 specification provides single-mode, single fiber support at a signaling speed of 125 Mbps for a span of 10 km or greater, depending on fiber type. The optical output is -14 dBm with a sensitivity of -29.2 dBm. The two wavelength ranges employed are:

- Downlink at 1480 to 1580 nm
- Uplink at 1260 to 1360 nm

The downlink PMD is called 100Base-BX10-D and is typically located in the central office or similar POP presence. The uplink 100Base-BX10-U PMD is located at subscriber premises. While defined specifically for Fast Ethernet, the 100Base-BX10 PMD easily supports other protocols within the Fast Ethernet bandwidth range including SONET/ SDH at 155 Mbps and ESCON at 200 Mbps.

	100 Mbps - SMF	1000 Mbps - SMF
Dual Fiber	100Base-LX10, 10 km	100Base-LX, 5 km 1000Base-LX10, 10 km Extended Temperature
Single Fiber	100Base-BX10-D, 10 km 100Base-BX10-U, 10 km	1000Base-BX10-D, 10 km 1000Base-BX10-U, 10 km

Table 1: IEEE 802.3AH Fiber Optic PMD Standards

White Paper

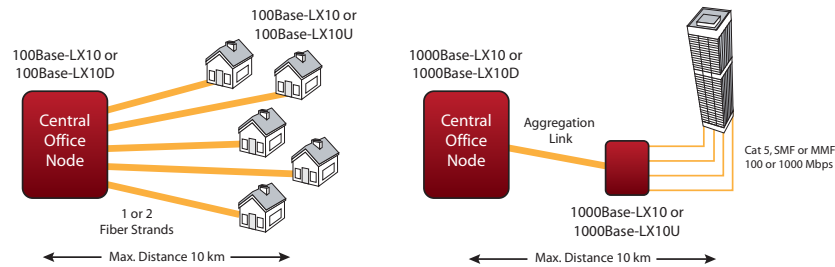


Figure 2: Fast and Gigabit Ethernet Over Fiber Services

1000Base-BX10

The 1000Base-BX_0 specification provides single-mode, single fiber support at a signaling speed of 1250 Mbps for a span of 10 km or greater depending on fiber type. The optical output is -9 dBm with a sensitivity of -20 dBm. The two wavelength ranges employed are:

- Downlink at 1480 to 1500 nm
- Uplink at 1260 to 1360 nm

The downlink is located in the central office or similar POP location, with the uplink located at subscriber premises. Note that the 1550nm window is reserved for CATV downstream distribution over the same fiber optic strand. Defined specifically for Gigabit Ethernet, the 1000Base-BX10 PMD easily supports other protocols within the Gigabit Ethernet bandwidth range including Fibre Channel FC-100 (1.0625 Gbps) and HD-SDI (1.485 or 1.4835 Gbps).

MRV Single Fiber SFP (Small Form Pluggable)

The growing demand of single fiber solutions driven by the Ethernet in the First Mile (EFM) combined with MRV's strategic Pure Pluggable™ marketing direction has led to the development of a wide range of single fiber pluggable SFP transceivers.

MRV's single fiber bi-directional SFPs expand on the 802.3ah PMD, to cover a wider range of protocols with an extended span of up to 95 km. With its unique single fiber bi-directional SFP offering, MRV expands its Pure Pluggable™ flexible solutions into the area of fiber optimization while maintaining the same advantage.

- Small form factor - for high density solutions
- Hot-pluggable optical transceivers
 - Limit repair to the transceiver – does not impact the remainder of the network
 - Low MTTR (short repair cycle)
- Flexibility
 - Customized solutions for protocol and distance
 - Advanced fiber optimization plan — WDM

- Inventory Control – maintain the same host modules with SFP options available
- Advanced optical performance monitoring with Digital Diagnostics (SFF-8472)

MRV single fiber bi-directional SFPs are divided into three bandwidth categories as described below.

Fast Ethernet Bandwidth Range (100-200 Mbps)

The SFPs in this category are an extension of the 100Base-BX10 standard. They cover protocols within the range of 100-200 Mbps including Fast Ethernet, FDDI (125 Mbps), SONET/SDH (155 Mbps), and ESCON (200 Mbps). Their PMD allows for a span from 25 km to 90 km. All the SFPs in this category incorporate advanced Digital Diagnostics support according to SFF-8472, table 2, p4.

Gigabit Ethernet Bandwidth Range (1-1.5 Gbps)

The SFPs in this category are an extension of the 1000BX-10 standard. They cover protocols within the range of 1 Gbps -1.5 Gbps including Gigabit Ethernet (1.25 Gbps), Fibre Channel FC-100 (1.0625 Gbps) and HD-SDI (1.485 Gbps/1.4835 Gbps). Their PMD allows for a span from 20 km to 95 km. All the SFPs in this category incorporate advanced Digital Diagnostics support according to SFF-8472, table 3, page 4.

Multirate Bandwidth Range (622 Mbps-2.5 Gbps)

The SFPs in this category are unique to MRV. They cover protocols within the range of 622 Mbps to 2.5 Gbps including SONET/SDH OC-12/STM-4 (622 Mbps), OC-48/STM-16 (2.5 Gbps), Gigabit Ethernet (1.25 Gbps), Fibre Channel FC-100 (1.0625 Gbps), FC-200 (2.125 Gbps), HD-SDI (1.485 Gbps/1.4835 Gbps), and other protocols in this range. Their PMD allows for a span from 10 km to 80 km. All the SFPs in this category incorporate advanced Digital Diagnostics support according to SFF-8472, table 4, page 4.



Table 2: Fast Ethernet Bandwidth Range (100 - 200 Mbps)

Part Number	Data Rate (Mbps)	Wavelength (nm)		Output Power (dBm)		RX Sensitivity (dBm)	Link Budget (dBm)	Est. Distance Range (km) ¹	Operating Temp. Range (°C)
		Tx	Rx	Min	Max	Min	Min		
SFP-FD-BX35	100 - 200	1310	1550	-14	-8	-28	14	0 - 28	-5 to 70
SFP-FD-BX53	100 - 200	1550	1310	-14	-8	-28	14	0 - 28	-5 to 70
SFP-FD-BD35	100 - 200	1310	1550	-5	0	-28	23	16 - 46	-5 to 70
SFP-FD-BD53	100 - 200	1550	1310	-5	0	-28	23	16 - 46	-5 to 70
SFP-FD-BZ45	100 - 200	1490	1570	-5	0	-28	23	32 - 92	-5 to 70
SFP-FD-BZ54	100 - 200	1570	1490	-5	0	-28	23	32 - 92	-5 to 70

Table 3: Gigabit Ethernet Bandwidth Range (1 - 1.5 Gbps)

Part Number	Data Rate (Mbps)	Wavelength (nm)		Output Power (dBm)		RX Sensitivity (dBm)	Link Budget (dBm)	Est. Distance Range (km) ¹	Operating Temp. Range (°C)
		Tx	Rx	Min	Max	Min	Min		
SFP-GD-BX34	1.0 - 1.5	1310	1490	-9	-3	-20	11	0 - 20	-5 to 70
SFP-GD-BX43	1.0 - 1.5	1490	1310	-9	-3	-20	11	0 - 20	-5 to 70
SFP-GD-BD35	1.0 - 1.5	1310	1550	-5	0	-24	19	10 - 40	-5 to 70
SFP-GD-BD53	1.0 - 1.5	1550	1310	-5	0	-24	19	10 - 40	-5 to 70
SFP-GD-BZ45	1.0 - 1.5	1490	1570	0	5	-24	24	32 - 96	-5 to 70
SFP-GD-BZ54	1.0 - 1.5	1570	1490	0	5	-24	24	32 - 96	-5 to 70
SFP-GD-EBZ45	1.0 - 1.5	1510	1590	2	3	-33	24	32 - 120	-5 to 70
SFP-GD-EBZ54	1.0 - 1.5	1590	1510	2	2	-33	24	32 - 120	-5 to 70

Table 4: Dual Rate Bandwidth Range (OC-3 / OC-12)

Part Number	Data Rate (Mbps)	Wavelength (nm)		Output Power (dBm)		RX Sensitivity (dBm)	Link Budget (dBm)	Est. Distance Range (km) ¹	Operating Temp. Range (°C)
		Tx	Rx	Min	Max	Min	Min		
SFP-DR-35IR1	155 - 622	1310	1550	-15	-8	-28	12	0 - 24	-5 to 70
SFP-DR-53IR1	155 - 622	1550	1310	-15	-8	-28	12	0 - 24	-5 to 70
SFP-DR-35IR2	155 - 622	1310	1550	-3	2	-28	24	20 - 48	-5 to 70
SFP-DR-53IR2	155 - 622	1550	1310	-3	2	-28	24	20 - 48	-5 to 70
SFP-DR-45LR2	155 - 622	1490	1570	-3	2	-28	24	40 - 96	-5 to 70
SFP-DR-54LR2	155 - 622	1570	1490	-3	2	-28	24	40 - 96	-5 to 70

Table 4: Multirate Bandwidth Range (OC-3 / OC-12)

Part Number	Data Rate (Mbps)	Wavelength (nm)		Output Power (dBm)		RX Sensitivity (dBm)	Link Budget (dBm)	Est. Distance Range (km) ¹	Operating Temp. Range (°C)
		Tx	Rx	Min	Max	Min	Min		
SFP-MR-35IR1	100 - 2700	1310	1550	-5	0	-18	12	0 - 24	-5 to 70
SFP-MR-53IR1	100 - 2700	1550	1310	-5	0	-18	12	0 - 24	-5 to 70
SFP-MR-45IR2	100 - 2700	1490	1570	-2	3	-18	15	12 - 60	-5 to 70
SFP-MR-54IR2	100 - 2700	1570	1490	-2	3	-18	5	12 - 60	-5 to 70
SFP-MR-45LR2	100 - 2700	1570	1490	-2	3	-28	25	52 - 120	-5 to 70
SFP-MR-54LR2	100 - 2700	1490	1570	-2	3	-28	25	52 - 120	-5 to 70

¹ Estimated cable length based on typical optical fiber loss

Fiber Driver and Bi-Directional SFPs

Fiber Driver Optical Multi-Service

MRV's Fiber Driver product line is an innovative optical multi-service platform that revolutionizes the industry's image of optical transport.

- Fiber Grooming
 - Multiple protocol media conversion
 - Distance extensions
 - Signal repeaters
- Intelligent Service Demarcation
- Advanced CWDM and DWDM solutions
- Digital Video Distribution

Fiber Driver offers multirate and multi-function converters and transponders based exclusively on small form-factor pluggable transceivers (SFP or XFP). These new solutions provide a chameleon-like ability to adapt to multiple layers of the optical transport domain and to transform the Fiber Driver into a real optical multi-service platform.

The Fiber Driver Pure Pluggable™ solutions cover the full range of the optical hierarchy including media conversion, fiber grooming, service demarcation, and WDM. Single fiber bi-directional SFPs are a natural fit for the Fiber Driver multirate and multi-function converters, together creating optimized fiber solutions that meet the demands of today's fiber services for carriers and enterprises.

Ethernet Services Over Point-to-Point Single Strand Fiber

Once confined to the LAN or campus environment, Ethernet has been readily adopted into today's growing optical infrastructure. It now spans the core of the Metropolitan Area Networks (MAN) to last mile access networks. Simplicity, low cost, scalability, and wide availability of interoperable equipment made Ethernet the ubiquitous choice for establishing end-to-end broadband optical connectivity. Real world installations have shown that Optical Ethernet (OE) networks are very cost-effective to deploy and maintain. The IEEE 802.3ah standard (the same one that defined single fiber Fast and Gigabit Ethernet PMDs) provided OE with operations, administration, and maintenance (OAM) capabilities including mechanisms for link performance monitoring, remote fault indication, and remote loopback.

The Fiber Driver-based Optical Ethernet Services Demarcation (OESD) solution from MRV is IEEE 802.3ah compliant. It offers the service provider the capability of extending the metro network Ethernet port over a fully managed Fast or Gigabit Ethernet first mile demarcation link.

The EM316EFRMAHSH and EM316GRMAHSH OESD modules use SFPs, so they can take full advantage of MRV's extensive line of Fast and Gigabit Ethernet single fiber bi-directional SFPs. Deployments of OE services in metropolitan areas face serious challenges when the existing available fiber optic plant is exhausted. MRV's Fiber Driver single fiber OESD allow carriers to double their fiber optic capacity and the number of subscribers served over the same optical plant. The optimized use of the existing optical infrastructure greatly saves both CAPEX and OPEX while significantly increasing the revenues.

Protocol Transparent Link Extension over Point-to-Point Single Strand Fiber

In a recent case, a cellular phone mobility operator created the need for aggregated signal (SONET OC-3), backhauling over fiber to the carrier's central office (CO) or Point-of-Presence (POP).

The mobile carrier's greatest challenge is to balance flat or declining revenue per user, increasing content delivery, and reducing its largest expenditure; the backhaul. These secondary carriers generally do not own dark fiber and must lease it even from a competitor, which is the largest operating expense (OPEX).

Maximizing fiber usage with single fiber circuits reduces the backhaul OPEX by 50% for each circuit, provides increased bandwidth and protocol independence to the base station, and enables the carrier to deliver more revenue generating content to their subscribers.

The Fiber Driver EM316-2SFP protocol transparent converter combined with Fast Ethernet/OC-3 single fiber bi-directional SFPs provides a flexible, inventory conscientious solution that meets the challenge of mobile carriers today.

SAN Services over Point-to-Point Single Strand Fiber

Reliable, safe, and efficient data storage represents the lifeblood of many enterprises, government agencies, and educational organizations. Data must be safeguarded against loss due to a wide range of natural and human events. Data loss can disrupt daily operations and it may generate significant financial losses. In more extreme examples, personal safety can be at stake if a physician cannot access patient data in a timely manner. More and more organizations recognize the value of business continuity and disaster recovery strategies. Storage extensions over a fiber optic infrastructure enable remote-site mirroring and replication, backup, and restoration. This approach of providing fast and reliable access to remote storage systems lowers the risk associated with lost access to data and applications, especially in enterprise environments.

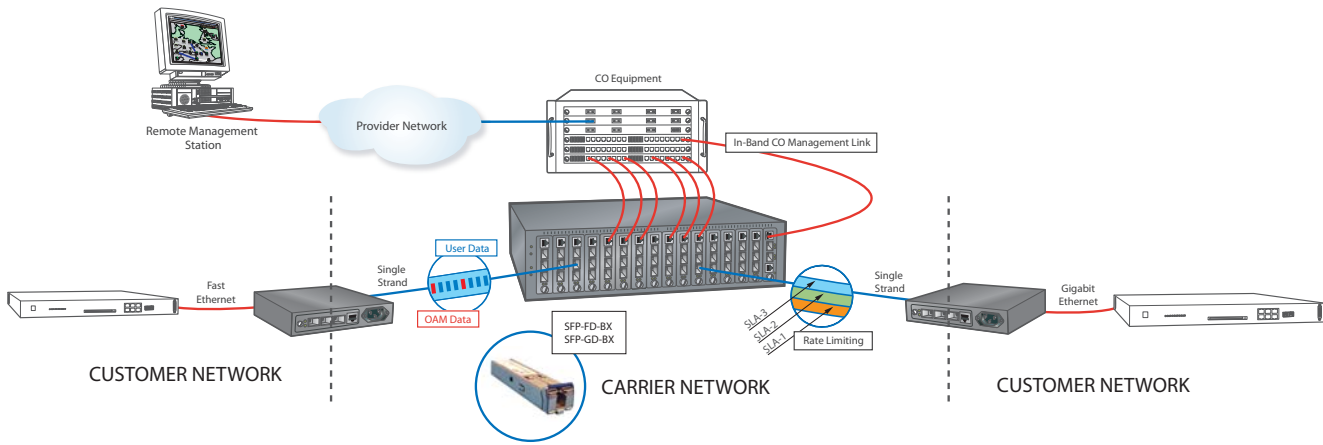


Figure 3: Fast and Gigabit Optical Ethernet Services with Fiber Driver

Service providers offer Fibre Channel (FC-100, FC-200, and FC-400) storage extension services over dark fiber optic links. Similar to Optical Ethernet services or SONET signal backhauling, these services are offered over leased or carrier owned fibers.

Fiber Driver offers a wide range of SFP-based solutions that support Fibre Channel and can take advantage of MRV's extensive single fiber bi-directional SFPs. For short haul links under 10 km, the EM316-2SFP module (see Table 1) combined with SFP-MR-35/53-IR SFPs can carry Fibre Channel 1 and 2 Gbps full-duplex signals over a single strand of fiber. For long haul applications (From 10 to 80 km), the EM316DMR3G-3R module combined with SFP-MR-45/54-IR SFPs offers Fibre Channel 1 and 2 Gbps full-duplex transport over a single fiber strand. The EM316DMR3G-3R module offers the flexibility of high density (dual converter mode) or network line redundancy (redundant mode) for further service optimization and enhancement.

MRV's Fiber Driver single fiber optical storage extensions dramatically reduce the OPEX and CAPEX, which allows the service provider to deliver more revenue services to their subscribers.

Fiber Optimization — Next Steps

Single fiber pluggable transceivers integrate into Wave Division Multiplexing (WDM) technology to cover multiple channels and wavelengths for the next natural step toward further fiber optimization. This step is an easy path to follow with MRV Fiber Driver Optical Multi-Service solutions.

The same pluggable-enabled converter, transponder, or Ethernet demarcation can be used for wavelength-specific CWDM or DWDM connections, depending on the optical transceivers employed. A simple exchange of the SFP transforms a copper-to-fiber media converter to a WDM transponder tuned to a specific CWDM or DWDM ITU-grid wavelength. Pluggable-enabled converters and transponders cover a wide range of protocols. They can be multirate multi-function (100 Mbps to 3.2 Gbps) or protocol-specific using protocols like Fast Ethernet (EM316SW-XY), Fibre Channel (EM316FC-400), or any 10 Gb protocol (EM316-2XFP). Other solutions employ advanced time division multiplexing (TDM) to combine two or more channels of different protocols like Fast and Gigabit Ethernet (LAN), Fibre Channel (SAN), DS3/E3, and T1/E1 (WAN) to further optimize the fiber or wavelength transport.

To complete the picture, the Fiber Driver family integrates a wide set of CWDM and DWDM accessories including passive WDM multiplexers, OADM components (modules or cables), single wavelength or full C-band amplifiers, and dispersion compensation solutions (EM316DCMxxx).

Fiber Driver is the platform of choice for ultimate fiber optimization and it is the path to significant CAPEX and OPEX reduction in optical transport. Fiber Driver continues a long tradition of leading edge technology. Introduced over eight years ago, it has continually demonstrated its agility and the ability to deliver on "future-proof" claims throughout its entire history.

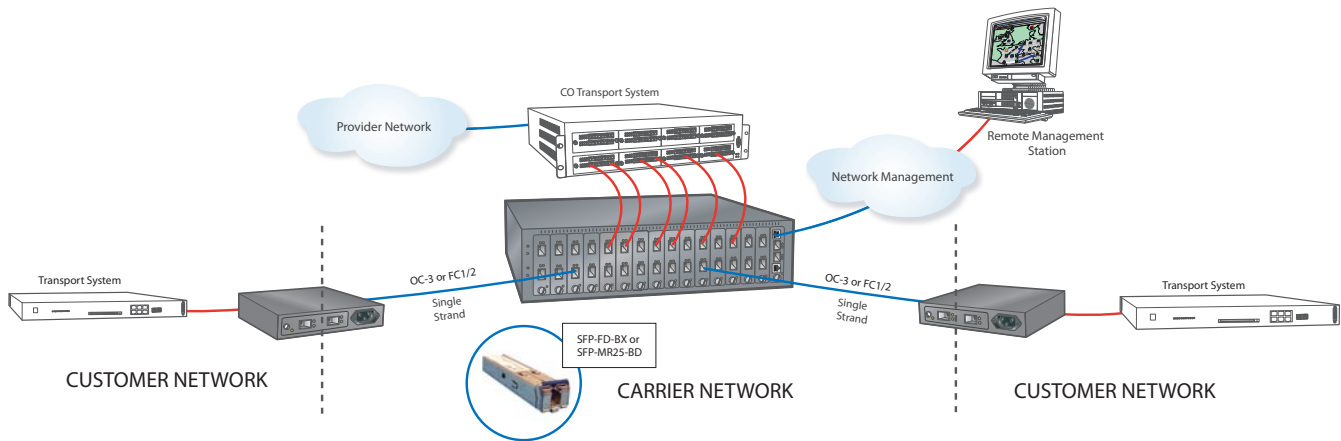


Figure 4: Transparent Link Extension (SONET OC-3/Fibre Channel 1/2 Gbps, etc.)

Fiber Driver Modules

Table 5: Fiber Driver modules mentioned in this paper

OMSP Network Management	
EM316LNxNM-OT	Fiber Driver OMSP Linux-based network management card
Multirate Modules	
EM316-2SFP	Protocol transparent dual SFP-based converter/transponder
EM316DMR3G-3R	Multirate multi-function media converter/transponder, with quad CDR for speeds of 42 Mbps to 3.2 Gbps
Protocol Specific Modules	
EM316-2XFP	10 Gbps protocol transparent dual XFP-based converter/transponder
EM316SW-XY	Fast Ethernet multi-function media converter/transponder, dual 10/100Base-TX RJ-45 and dual 100Base-FX SFP-based fiber ports
EM316-FC400	Fibre Channel (FC-100/FC-200/FC-400) dual SFP-based converter/transponder
Service Demarcation	
Ethernet Demarcation	
EM316EFRMAHSH	User port auto-sensing between 10/100Base-TX copper and 100-FX SFP-based fiber port to redundant SFP-based fiber trunk with 802.3ah extended remote management
EM316GRMAHSH	User port auto-sensing between 10/100/1000Base-T copper and 1000-X SFP-based fiber port to redundant SFP-based fiber trunk with 802.3ah extended remote management
Ethernet and T1/E1 Demarcation	
EM316EFT1RM	T1 (RJ-48) & Ethernet/Fast Ethernet (RJ-45) to SFP-based fiber trunk with remote management
EM316EFE1RM	E1 (BNC) & Ethernet/Fast Ethernet (RJ-45) to SFP-based fiber trunk with remote management
EM316EFE1RJRM	E1 (RJ-48) & Ethernet/Fast Ethernet (RJ-45) to SFP-based fiber trunk with remote management
Sub-Wavelength Aggregation	
EM316GEMX2R	SFP-based TDM multiplexer capable of multiplexing two (2) Gigabit Ethernet data channels onto one trunk with redundant link
EM316MRMX2R	SFP-based TDM multiplexer capable of multiplexing two (2) Gigabit Ethernet or two (2) Fibre Channel (1 Gbps) data channels onto one trunk with redundant link

Fiber Driver Modules

Table 6: Fiber Driver single passive solutions

Single Wavelength Single Fiber Solutions (Splitter Combiner)	
Splitter Combiner Cables	
PASCLCAS/3S	Fiber optic cable, splitter/combiner with cable assembly, LC-SC/APC, 1310 nm, SM
PASCLCAS/5S	Fiber optic cable, splitter/combiner with cable assembly, LC-SC/APC, 1550 nm, SM
PASCSCAS/3S	Fiber optic cable, splitter/combiner with cable assembly, SC-SC/APC, 1310 nm, SM
PASCSCAS/5S	Fiber optic cable, splitter/combiner with cable assembly, SC-SC/APC, 1550 nm, SM
Splitter Combiner Modules	
EM316SC/3M	Splitter/combiner, combines TX and RX outputs onto a single fiber strand, SC/SC-APC, 1310 nm, MM, 62.5 micron
EM316SC/3S	Splitter/combiner, combines TX and RX outputs onto a single fiber strand, SC/SC-APC, 1310 nm, SM, 9 micron
EM316SC/5S	Splitter/combiner, combines TX and RX outputs onto a single fiber strand, SC/SC-APC, 1550 nm, SM, 9 micron
EM316SC/MS	Splitter/combiner, combines TX and RX outputs onto a single fiber strand, DSC/DSC-APC, 1270-1610 nm, SM, 9 micron
Dual Wavelength Single Fiber Solutions	
Dual Wavelength Cables	
PASCSC/3155	Cable, protocol independent single fiber TX:1310 nm, RX: 1550 nm with SC connectors in AB box
PAWSC/5559	Cable, protocol independent single fiber TX:1550 nm, RX: 1590 nm with SC connectors in AB box
PAWLSC/5559	Cable, protocol independent single fiber TX: 1550 nm, RX: 1590 nm with SC common port, LC add/drop & express ports in AB box
PAWLSC/xxyy	Cable, protocol independent single fiber TX:xx RX: yy nm with SC common port, LC add/drop & express ports in AB box
Dual Wavelength Modules	
EM316WP/53S	Protocol independent dual wavelength passive WDM, SM, 1310/1550 nm with SC connectors
EM316WP/5155	Protocol independent single fiber passive WDM, SM, TX: 1510 nm, RX:1550 nm with SC connectors
EM316PLC/5559	Protocol independent single fiber passive WDM, SM, TX: 1550 nm, RX:1590 nm with LC/SC connectors
EM316PSC/5559	Protocol independent single fiber passive WDM, SM, TX: 1550 nm, RX:1590 nm with SC connectors
EM316WP2/53S	Protocol independent dual wavelength single fiber passive WDM, SM, TX: 1550 nm, RX:1310 with SC connectors
EM316WP2/5155	Protocol independent dual wavelength single fiber passive WDM, SM, TX: 1510 nm, RX:1550 with SC connectors
EM316WP2/5961	Protocol independent dual wavelength single fiber passive WDM, SM, TX: 1590 nm, RX:1610 with SC connectors

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