

DYMEC
BiDirectional Fiber

Single Fiber Pluggable Transceivers
Fiber Plant Optimization

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.

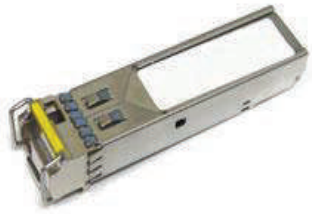
Single strand fiber solutions are the simplest way to fiber optimization, immediately doubling the capacity of the installed fiber plant. Instead of using two dedicated strands, one for receiving and the other for transmitting, each strand carries a bi-directional signal. The fiber plant capacity doubles, 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 KUSA's Industrial, Ethernet Optical-Service product line. Recent S F P technological advancements at KUSA have yielded 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 Expence 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 expences. 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 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.

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DYMEC - Single Fiber Pluggable Outside Plant (OSP)

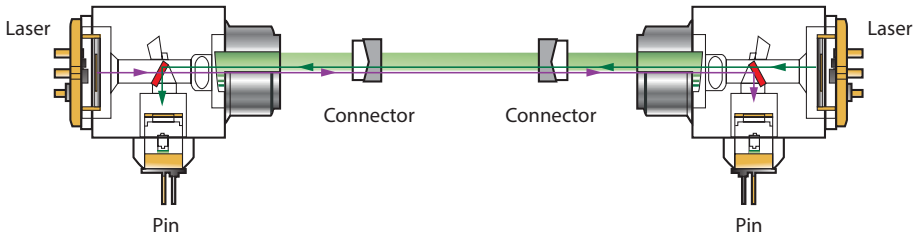


Figure 1: *Single fiber, Two Wavelength Integrated Transceiver*

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.

Table 1: *IEEE 802.3AH Fiber Optic PMD Standards*

	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

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DYMEC -Single Fiber Pluggable SFP



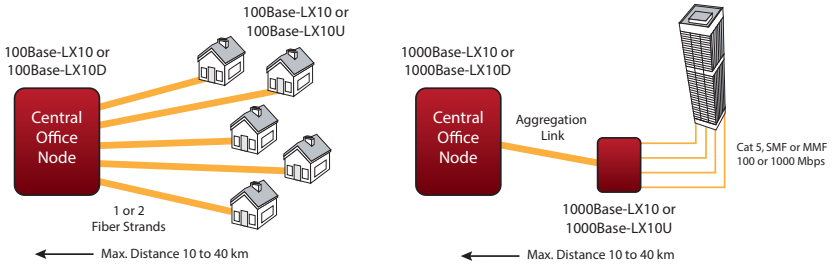


Figure 2: *Fast and Gigabit Ethernet Over Fiber Services*

1000Base-BX10

The1000Base-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).

Single Fiber SFP (Small Form Pluggable)

Single Fiber bi-directional SFPs are 802.3ah PMD compliant, 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, KUSA expands its Pure Pluggable flexible solutions into the area of fiber optimization while maintaining the same advantage.

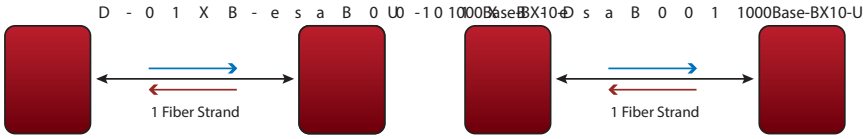
- Small form factor - for high density solutions
- Hot-pluggable optical transceivers
  - Limit repair to the transceiver – does not impact the remainder of the network
  - Low MTTR (short repair cycle)
- Flexibility
  - Customized solutions for protocol and distance
  - Advanced fiber optimization plan — WDM
- Inventory Control – maintain the same host modules with SFP options available
- Advanced optical performance monitoring with Digital Diagnostics

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.

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.



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