Fiber Technology Leadership *BEYOND THE GLASS™*

40/100GbE Fiber Optic Solutions: Just the Facts

To support the changing and fast-growing bandwidth demands of Data Centers (DCs), the IEEE recently ratified standards for supporting 40 Gigabit and 100 Gigabit Ethernet, known as IEEE 802.3ba.

PANDUIT actively participated in the development of this standard by leading the effort to include OM4 fiber optic cabling as physical layer option.

This ***Just the Facts*** document is a quick-reference guide to increase your familiarity with the critical issues and the industry terms used in the migration to 40 and 100 GbE systems.

Existing Fiber Infrastructure

FACT: Both 40 & 100 Gbs Ethernet can be deployed using the same cabling systems in use today. Multimode will employ parallel optics using MPO interconnects and require additional cable infrastructure depending on the system deployed while single mode fiber will employ serial transmission and use LC or SC connectors.

The approach used for the higher speed data rates is based on advanced transceiver technologies engineered to take advantage of the full bandwidth of laser optimized fibers. This allows DCs to leverage their existing investment in higher-grade fiber media. Both single mode fiber (SMF) and multimode fiber (OM3, OM4) were approved in the standard.

Bandwidth

FACT: Specifying the highest bandwidth OM3/OM4 fiber is not sufficient to ensure optimum system performance. In addition to fiber cables from suppliers that have the latest technology in DMD measurement and who specify DMD/EMB performance in excess of standard specifications low-loss connectivity must also be used to ensure the best system performance.

Per the standard, the bandwidth of the fiber is ensured by meeting the Effective Modal Bandwidth (EMB) specification; however, other factors, such as, calculated EMB (EMBc) and Differential Mode Delay (DMD) can impact a fiber optic cables performance. *PANDUIT* Laboratories channel certification testing methodologies are a true measure of network performance since additional factors are taken into account that can impact performance, for example, induced cable stress. These parameters are independent of fiber's intrinsic bandwidth.

40/100 GbE Fiber Optic Trends

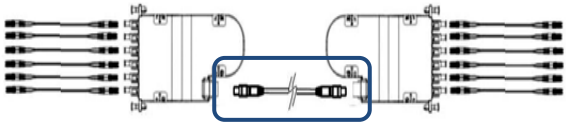
Data Rate	40 Gb/s	100Gb/s
Application	• Access layer apps (e.g., blade servers, virtualization) • High-performance computing (HPC) clusters • SAN Inter Chassis Links	• Core switching and routing • Data center aggregation • Internet service provider peering points • High-demand apps (e.g. streaming video)
Min. Reach 100m 10km 40km	 MMF SMF Not supported	 MMF SMF SMF
Media Type	**Serial or Parallel**	**Parallel Optics**
MMF	Duplex or 12-fiber ribbon cables	12 / 24-fiber ribbon cables (20 fibers per channel)
SMF	**Wave Division Multiplexing (WDM)** 4x10G / 4x25G duplex cables	

Implementing Parallel Optics

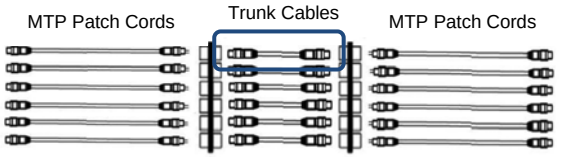
FACT: 10G (serial) MTP systems in use today will require that the cable plant move to be scaled-up in order to migrate to parallel optics based systems.

For example, a one-to-one transceiver swap from six serial 10 Gb/s links to six parallel 40 Gb/s links would involve the addition of five new 12-fiber ribbon cables along the permanent link and twelve MTP equipment cords. Customers may choose to build incrementally.

10G to 40G Example:



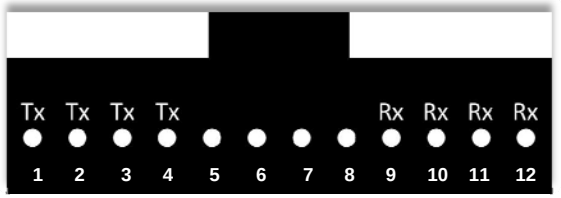
10Gb/s Ethernet 2-Cassette Channel



40Gb/s Ethernet Migration
(Original Trunk Cable is saved)

Converting those same six 10Gb/s serial links to six 100Gb/s parallel links could require as many as 24 new MTP equipment cords and 11 new MTP trunk cables depending on how the 100Gb/s link is implemented.

40GBASE-SR4 (40GbE) Optical Lane Assignments



40G is implemented using eight of the twelve fibers in an MPO connector. Four of these eight fibers are used to transmit while the other four are receive. Each Tx/Rx pair is operating at 10G.

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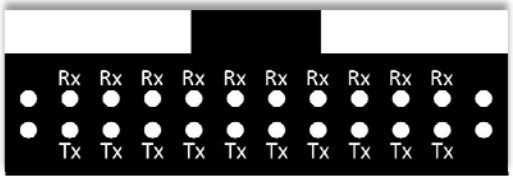
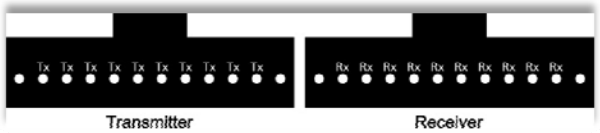
40/100GbE Fiber Optic Solutions: Just the Facts

100GBASE-SR10 (100G) Optical Lane Assignments

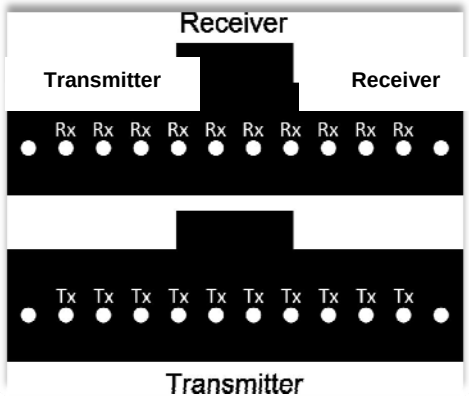


Option A: 24-Fiber MPO Connector (Preferred)

Alternative Option B
Side by side,
transmitter on left



Option B: Side-by-Side



Option C: Stacked (Rx on Top)

100G parallel optics can be implemented using one of the three systems above. The preferred method is to have 10 transmit and 10 receive lanes (each operating at 10G) in a 24-fiber MPO connector. This is the most compact method but can present challenges in maintaining alignment and mating pressure across all 24 fiber positions. Panduit has developed this connector and has successfully demonstrated prototypes at a recent industry "plug fest" for 100G systems. Options B & C separate transmit and receive functions in their own 12-fiber MPO connector which are available today.

Polarity & Gender

FACT: Polarity and gender are critically important features to consider when migrating from 10G to either 40G or 100G. Panduit produced standards-based polarity connectivity solutions is always the safest route for a customer to take.

The objective of polarity is simple: to provide connections between a transmitter and its receiver across the entire fiber optic system in a consistent, standards-based manner. Methods for ensuring polarity of array-based systems are defined in the TIA/EIA-568-C.3 standard. This standard defines an array connector system for conversion of standard polarity Methods 'A' and 'B' to parallel optic systems.

During migration, all backbone ribbon cabling is retained, and cassettes and patch cords at either end of the channel are swapped out for multi-fiber MPO patch cords that plug directly into the transceivers.

Proprietary methods not based on TIA/EIA guidelines will neither assure future interoperability, nor guarantee availability of future product inventory. The most widely available polarity method from component vendors is Method 'A' which Panduit supports.

Performance Issues at 40 & 100 Gbps

FACT: Connector choice and fiber termination has the largest impact on overall system performance.

Several new parameters were defined by the IEEE:

Channel Insertion Loss (CIL)
CIL is the sum of all the signal losses that are incurred as the signal moves along a fiber cable. This includes both the fiber media and the connectors. CIL budgets for 40G and 100GbE are very strict compared to the lower-speed Ethernet variants.

Any connector placed in the fiber path can consume over 50% of the total insertion loss budget. Strategies to minimize total CIL include:

- *Using the lowest-loss connectors available*
- *Using high-quality, factory-terminated patch cords and cable assemblies*

PANDUIT was the first to offer low-loss MPO connector systems and employs Best-In-Class connector polishing techniques to achieve full fiber contact and consistently high return loss. *PANDUIT* also performs full physical layer testing, such as, Bit Error Rate (BER) and EMB testing on all fiber optic systems

Skew

FACT: Skew has been shown to not be a factor in 40G & 100G Ethernet communications.

Skew is defined as the difference between arrival times of simultaneously launched signals across parallel cable lanes. This is a measure of the difference in the delay through different fibers and is dependent on the physical and optical length of the fiber.

Corning published articles regarding skew in 40 & 100G systems prior to the IEEE working group defining the skew specification. This generated concern in the industry at the time. However, Panduit has calculated and demonstrated that the physical length difference between the channels within a link would need to exceed 15 meters in order to fail the skew specification contained in IEEE 802.3ba.

Using OM3 vs. OM4 Fiber

The fact is, the benefits of OM4 fiber are higher network reliability and increased design flexibility allowing links with a reach of 150 meters.

The original draft of the IEEE 802.3ba standard only specified OM3 fiber and a maximum reach of 100 meters. *PANDUIT* determined that OM4 fiber would substantially extend the reach of next generation networking within the data center and worked with the members of the committee to win approval for including OM4 fiber in the final document. OM4 fiber is able to achieve this greater reach because of its greater EMB over OM3 fiber

OM4 optical fiber enables 40/100G Ethernet to reach an additional 60% of the links in the core-to-distribution and in the access-to-distribution channels when compared to OM3. This should lead to faster market acceptance of 40G/100G Ethernet and OM4 fiber.

40/100 GbE: PANDUIT Will Get You There…

The throughput and reliability of a 40/100 Gigabit Ethernet installation is directly related to the performance of the optical fiber, the choice of connectivity, and proper installation. *PANDUIT*'s superior cable and connectivity designs, low mated-pair skew and consistent control of the optical fiber's properties provides superior levels of performance and operation. This attention to detail puts *PANDUIT* in a better position to maintain signal integrity and ensure the robustness of the network.