

Low Loss MPO: Vital for 40/100G Ethernet Migration

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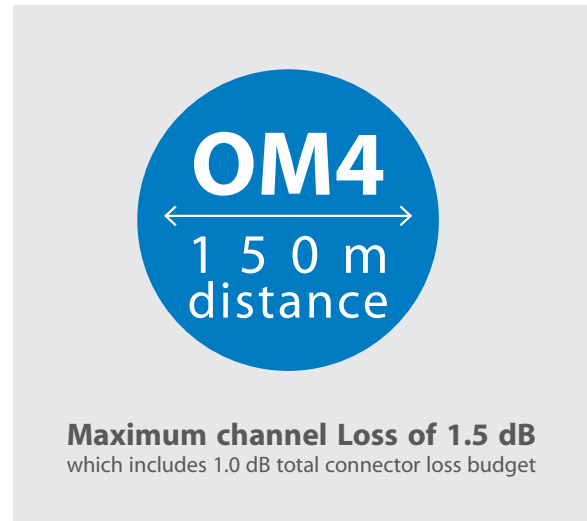
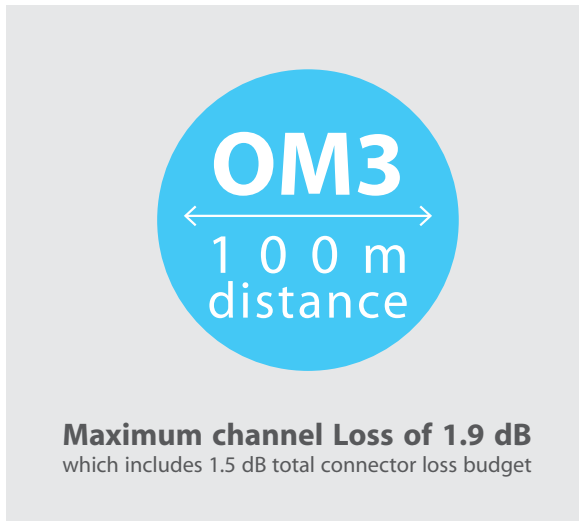
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IEEE 802.3ba: 40GbE and 100GbE Over Multimode fiber

The minimum performance that is needed to support 40GbE and 100GbE over multimode fiber is:



| 850nm Ethernet transmission distance (in meters) | | | | |
|--|------|-----|-----|------|
| | 1G | 10G | 40G | 100G |
| OM3 | 1000 | 300 | 100 | 100 |
| OM4 | 1000 | 550 | 150 | 150 |

The OM stands for Optical Multimode. The main difference between OM3 and OM4 is the fiber bandwidth, where OM3 has a 2,500MHz bandwidth while OM4 has a 4,700MHz bandwidth. The OM3 fiber is currently still the fiber of choice due to its lower cost. In addition 90% of all data centers have designed the cable runs to be under 100 meters. However, with a rapidly increasing bandwidth consumption, the data center capacity will also need to increase, thus pushing the distance between the transmission and receiver equipment further apart.

Multimode fiber uses parallel-optics transmission instead of serial transmission due to the 850nm vertical-cavity surface-emitting laser (VCSEL) modulation limits at the time of guidance was developed. Parallel-optics transmission, compared to traditional serial transmission, uses a parallel optical interface where data is simultaneously transmitted and received over multiple fibers. 40GbE and 100GbE over multimode fiber uses parallel optics at 10Gbps per lane. One lane uses 1 fiber for each direction of transmission. Thus 40GbE requires 8 fibers and 100GbE requires 20 fibers.

High Density and Low Loss Connectivity

In order to manage an array of multi fiber connection, the MPO connector provides a high density connectivity solution. The MPO connector enables 12 or 24 fibers to be terminated within a single connector with the same footprint of an LC duplex connector. The dimensional specification of the flat interface MPO connector is outlined in the IEC 61754-7 specification.

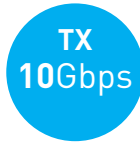
40GbE uses a 12 fiber MPO connector interface where all 12 fibers are aligned in a single row. Four fibers on one side are used for Transmit while another four on the other end of the row are used for Receive.

In total eight fibers are used in the connector while the middle four positions are not used.

It is recommended for the 100GbE to use a 24 fiber MPO connector interface where there are two rows of 12 fibers. The middle 10 positions of the top row are used for Receive while the middle 10 positions of the bottom row are used for Transmit. Alternatively, 2x 12 fiber MPO connector interface can be used where one connector is used for Receive while the other for Transmit.

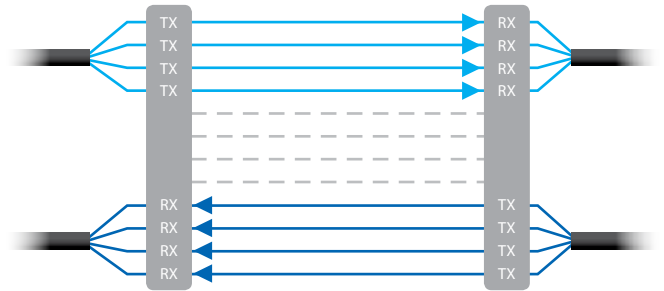
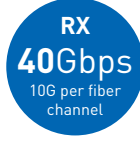
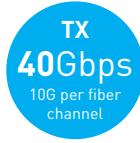
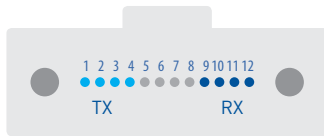
10GBASE-SR

LC Connector



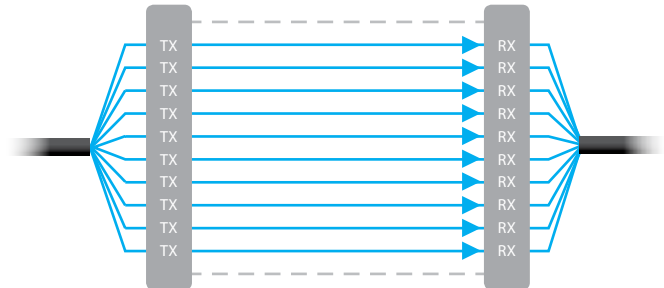
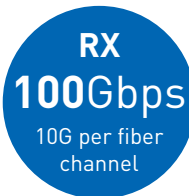
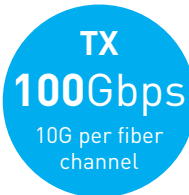
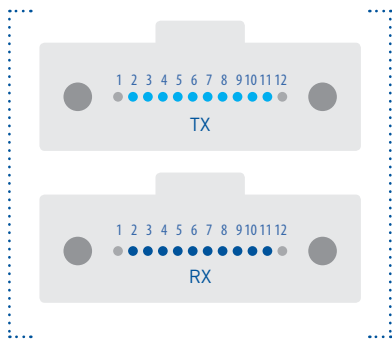
40GBASE-SR

MPO
12 fibers

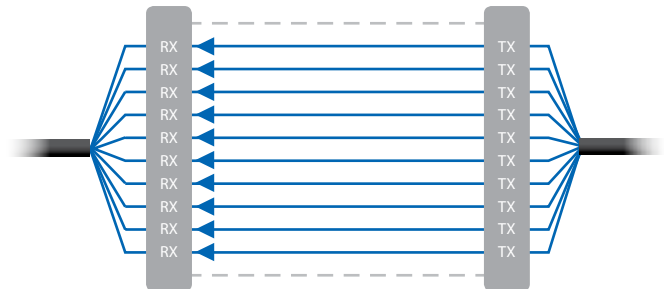
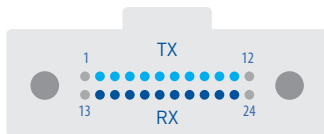


100GBASE-SR

2x MPO
12 fibers



or 1x MPO
24 fibers



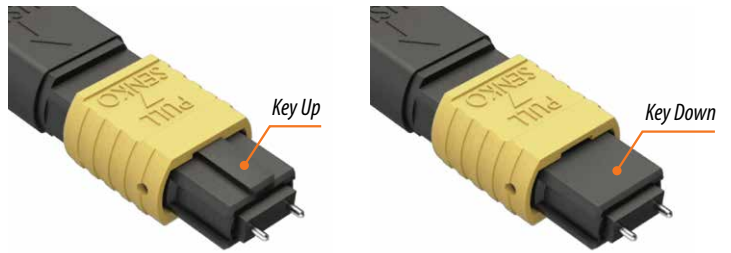


MPO Connector Polarity

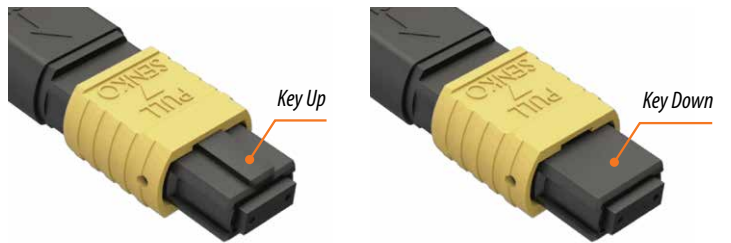
Unlike traditional 10GbE transmission which utilizes a 2-fiber configuration, the 40GbE and 100GbE are implemented over multi fiber array MPO connectors. It is critical that proper connector orientations are established. The TIA 568 standard provides three methods for configuring systems to ensure that proper connections are made.

These three methods differ in the cable orientation, connector orientation and the fiber assignment. Each MPO connector has a key on one side of the connector body. The “Key Up” position refers to the orientation where the key is located at the top position of the connector. When looking at the end face of the connector, position 1 is on the far left while position 12 is on the far right. For a 24 fiber MPO connector, the same orientation applies with the top row being positions 1 to 12 and the bottom row being positions 13 to 24. Depending on the adopted connectivity orientation, the MPO adapter needs to be suitable for its application which is either “Key Up to Key Down” or “Key Up to Key Up”. In addition, MPO connectors are differentiated to a Male and Female connector. A Male MPO connector has two alignment pins while a Female MPO connector has two alignment holes where the pins are to be inserted when a termination is performed. An MPO connection can only be performed between a Male and Female connector to ensure proper alignment which is required to maintain a low loss connection.

♂ MPO Male Connector



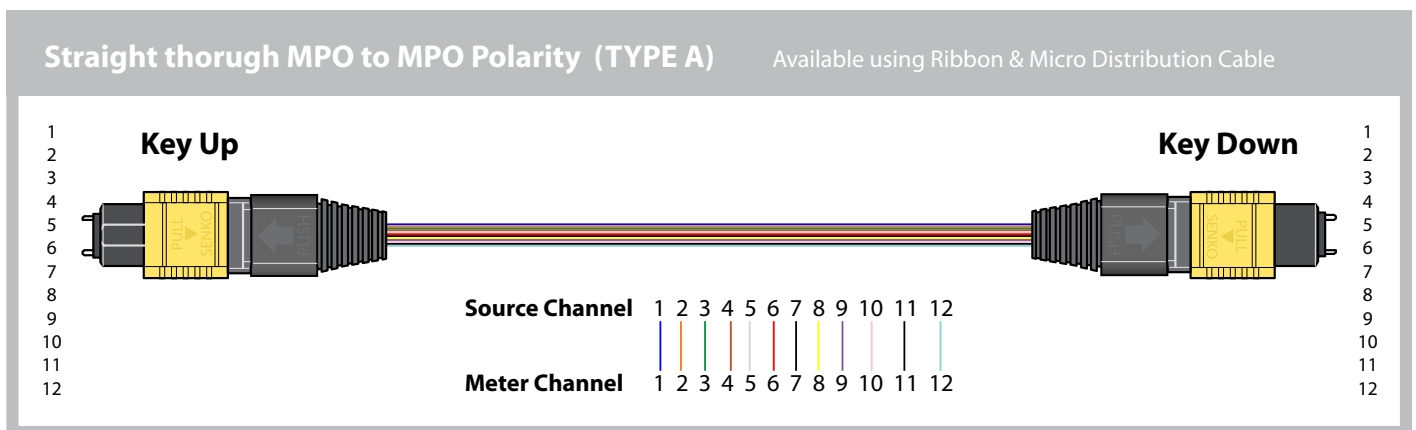
♀ MPO Female Connector



Method A: Patch Cord Polarity Flip

The Patch Cord Polarity Flip, also known as the Transmit-Receive Flip, has fiber 1 in position 1 in the MPO connector at both ends of the patch cord and is maintained throughout the network. This is achieved by a 180 degree twist in the fiber orientation within the patch cord. Although the MPO connector orientation is maintained throughout the network, two different types of duplex patch cords need to be installed, which are a straight patch and a cross patch, at the Transceiver and Receiver end.

This method is the simplest design to install and maintain as the orientation of the connector remains consistent. Although two types of duplex patch cords are required, this can be easily maintained by allocating one type of duplex patch cord to a fixed terminal to avoid a wrong installation.

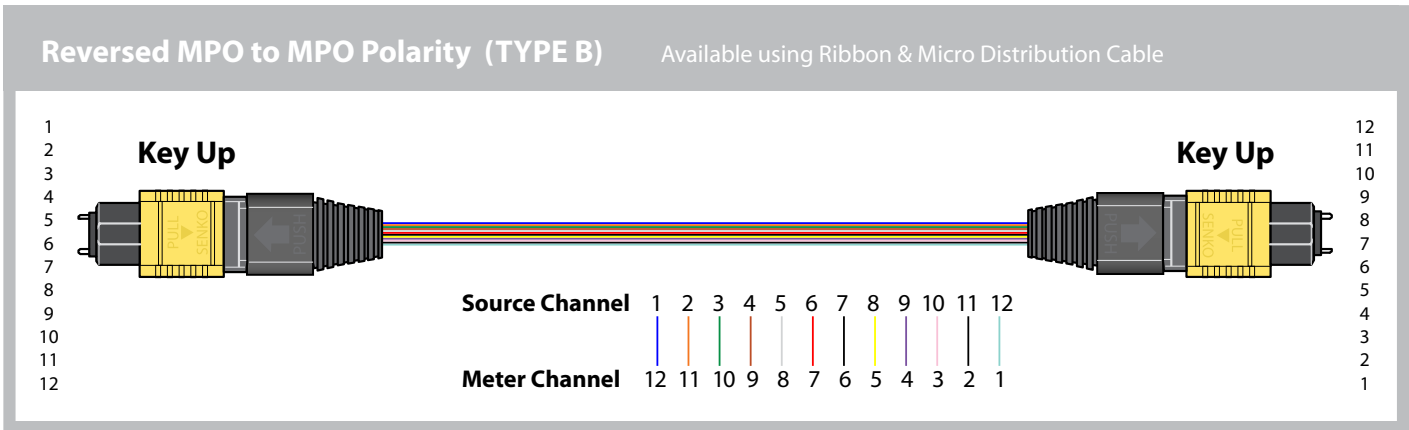




Method B: Adapter Polarity Flip

As stated in the name Adapter Polarity Flip, the polarity at one end of the connector is flipped. At one end of the connector fiber 1 is located at position 12 while fiber 12 is located at position 1. At the Transceiver and Receiver end only a straight duplex patch cord is required at both positions.

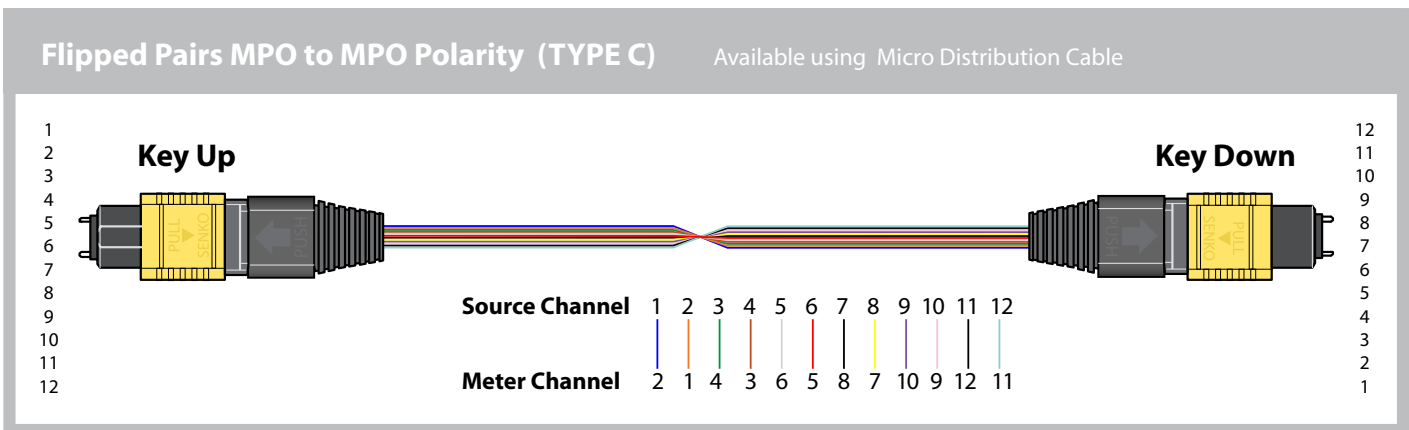
This method requires the installation of the patch cord to be exactly in accordance to the required orientation. The connector orientation at the Transceiver and Receiver end are the same. In addition, although the connector orientation at both ends of the patch cord is different, the physical appearance of the connector is the same. The installer must have deep knowledge of the equipment and their positions to perform a correct connection.



Method C: Pair Polarity Flip

This method is the most complicated method. At one of the patch cord, two adjacent fibers are flipped in the MPO connector. Fiber 1 in position 2 while fiber 2 in position 1. This repeats throughout the whole connector. At the Transceiver and Receiver end only a straight duplex patch cord is required at both positions.

This method is not suitable for a 100GbE transmission where Position 1 and Position 12 are not allocated. Since Positions 1 and 2 are paired as well as Positions 11 and 12, these four ports will not be usable. This reduces the usable positions to 8 which is insufficient for a 100GbE transmission.

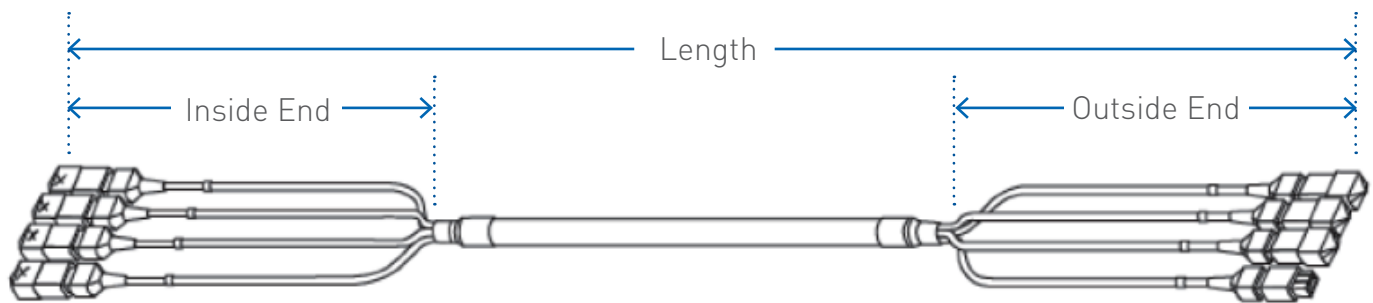




Cabling for 40GbE and 100GbE – Migration Path

Migration from 10GbE that usually uses a duplex SC or LC connector to 40GbE or 100GbE will require a high number of fiber; which then requires a higher density termination method such as the use of MPO connectors.

The use of MPO pre-terminated optical fiber cabling can facilitate this migration path. This can be a single 12 fiber patch cord or a high fiber count MPO trunk cables with fan-out ends.



MPO Trunk Cables - 24, 28, 72, 96 and 144 fibers

The termination modules of a 10GbE network are usually modules of 12 LC duplex adapters for a standard module or 18 LC duplex adapters for a high density module. Within the same footprint, these modules can be replaced by with an MPO module with 12 MPO adapters for a standard module or 18 MPO adapters for a high density module.

In addition, this migration can be perform in stages by having both LC duplex and MPO modules within the same adapter frame. An example of the modules are as shown below.



4 Modules of 12 LC Duplex Adapters



4 High Density Modules of 18 MPO Adapters

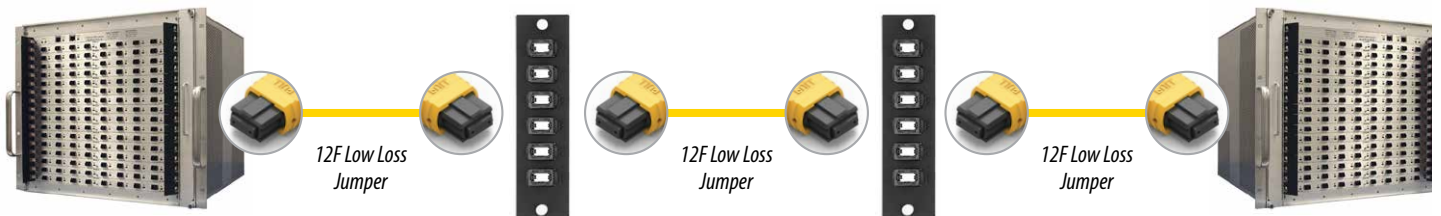


Cabling for 40GbE and 100GbE – Migration Path

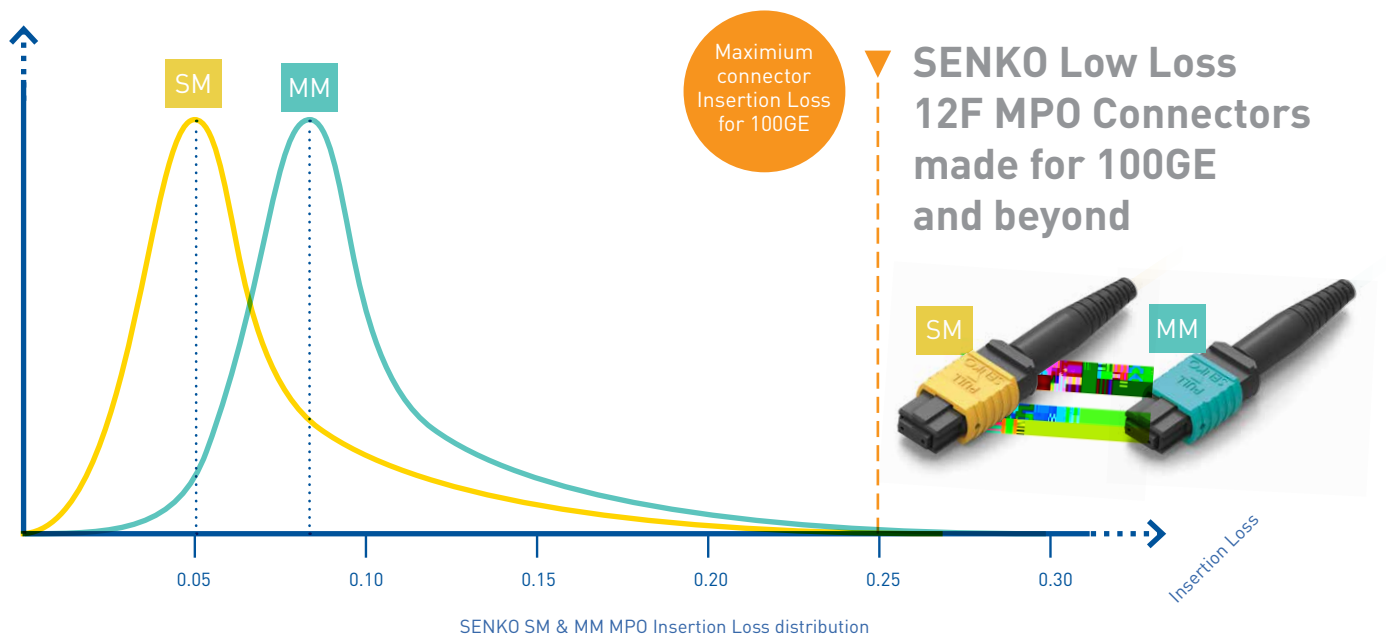
All components that are designed to migrate from 10GbE to 40GbE are the same components that are used for 100GbE. The Only difference is that a 100GbE connection is the requirement to use two MPO connectors per 100GbE link or the use of a 24 fiber MPO connector.

A key factor in defining the MPO connector for 40/100GE is most definitely its insertion loss. The connector Insertion Loss performance is critical to the network flexibility. As stated earlier the maximum Insertion Loss of a 40GbE and 100GbE link over a 100 meter OM3 channel is 1.9dB or 1.5dB over a 150 meter OM4 channel. The standard multimode optical fiber loss is 3dB/km.

In a worst case scenario, the Multimode fiber Insertion Loss over 150m OM4 fiber is 0.45dB, which allows a maximum connector insertion loss of 1.05dB. This optical budget allows two connectors with a maximum Insertion Loss of 0.5dB or up to three connectors with a maximum Insertion Loss of 0.35dB. Nevertheless, realistically a common data center cabling approach will require 4 connections (please refer to diagram below) whereby pushing the requirement for MPO connectors to have a maximum Insertion loss of 0.25dB.



The IEEE 802.3ba standard requires the use of low loss MPO connectors (IL_{max} < 0.25dB) when using OM4 multimode fiber for longer channel lengths. The capability of having an additional connector enables a cross-connect flexibility point in the network.





Summary

With the rapid increase in bandwidth consumption, the migration from 10GbE to 40GbE or 100GbE is inevitable. The economics of cost per port per 10Gbps is much more favorable for a 40GBASE-SR4 and 100GBASE-SR10 network. To meet such bandwidth requirements, the use of Low Loss MPO based connectivity using OM3 and OM4 fiber is required to maintain a high density structured cabling in a seamless migration path in the data center. With the increased port value, the network must be designed to support a high performance and managed structured cabling. This requires the proper cabling length measurement, the use of low loss connectors, a standard connector polarity and the possible deployment of a cross connect panel.

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Biography



Bernard HL Lee is currently the Regional Technology Director at SENKO Advanced Components. He started his career in optical communications when he was appointed as a Senior Research Office for the European Union IST project known as DAVID in 2000. In 2003, he joined Telekom Malaysia R&D where he has held various technical and management positions there including the Head of Photonic Network Research and also Head of Innovation and Communications. Bernard then joined the parent company, Telekom Malaysia (TM) in 2010 as the Assistant General Manager of the Group Business Strategy Division where he oversees the company's business direction. Bernard is also a member of the International Electrotechnical Commission (IEC), the Institute of Engineering and Technology (IET) and is also the Director of the Board of the Fiber-To-The-Home Council APAC

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