Rosenberger

Roadmap to 400 Gigabit Ethernet over Multimode Fiber

WHITEPAPER

The unprecedented exponential growth of information technology (IT) data is not a new finding. What is new is that there is now an end in view.

This White Paper shall not deduce the cause of this “data-tsunami”. But it will explain how enormous amounts of data is transmitted via Ethernet using multi-mode fiber (MMF) between the processing IT hardware within data centers. Configurations of the transceivers and the matching Rosenberger interconnect solutions are outlined.

To transmit this rapidly increasing data volume, it is necessary to get faster versions of Ethernet in ever shorter time interval. For this the Ethernet Alliance www.ethernetalliance.org is publishing his

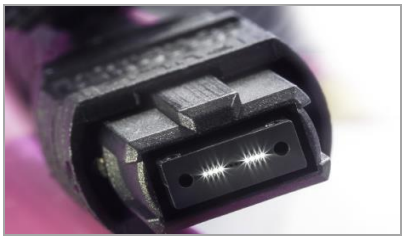
„Roadmap to the Terabit Mountains“.

Image: www.ethernetalliance.org

From 1995 until 2010 the evolution of Ethernet over MMF was relatively slow and simple. Ethernet speed increased linearly – roughly an order of magnitude every few years: 10 Mbit/s to Fast-Ethernet 100 Mbit/s to 1G to 10G. Lastly around 2010 the first 100G Ethernet version 100GBASE-SR10 appeared.

QSFP transceiver with MPO connector interface

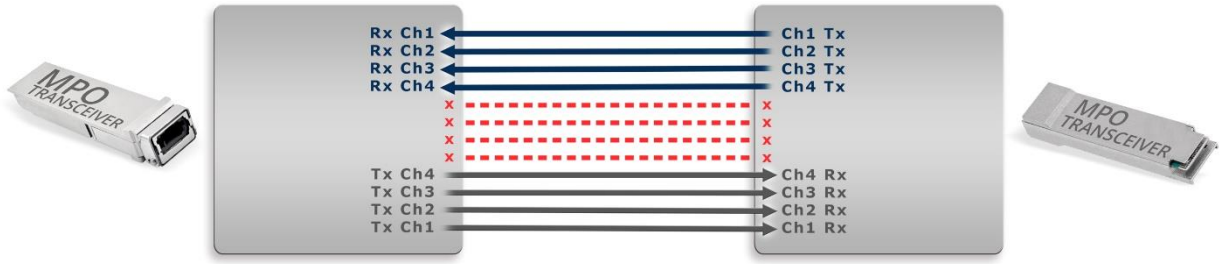
Increasing the transmission speed of Ethernet multi-mode transceivers below 1G was realized by using correspondingly faster LEDs and high-speed 1G VCSEL light sources. These enabled the required amount of data to be transmitted serially over two MMF (one per direction) with fiber optic (FO) duplex connectors



MPO with SR4 polarity

With the introduction of 40GBASE-SR4 and 100GBASE-SR10 it became necessary to split the data into four or ten data streams each running 10G. Multi-mode light sources faster than 10G were not serial ready, hence the need for multiple streams. These streams are transmitted in parallel over the corresponding number of MMF. (One fiber per stream per direction. 40G requires eight fibers and 100G requires 20 fibers for bidirectional links.) This started the era of Ethernet passive parallel optics over MMF.

40BASE-SR4 however did not fit well with the “regular” order of magnitude speed increments of Ethernet. The reason for this non-conforming configuration was simple: the required Short Reach 4 channel (SR4) transceivers in the QSFP form factor were highly cost-efficient and readily available. They were originally developed to provide a multi-mode parallel optics version of the InfiniBand 4x electrical interface in the early 2000s. These transceivers use the multifiber push on (MPO) connector interface with a special fiber assignment for the needed eight MMF. Today this assignment is often called the “SR4 polarity”.



SR4 functional diagram

The first transceivers for 100GBASE-SR10 introduced the C form factor pluggable (CFP) module. This required a new version of a MPO connector interface using twenty MMF with ten fibers in two rows “stacked” upon each other.
(2x10 configuration).

The MPO standard as a transceiver connector interface started with 40GBASE-SR4 and 100GBASE-SR10. With its use many years later by the cabling industry for passive infrastructure cabling, it has become the de-facto standard.

The original MTP® brand of FO connectors was developed in the early 1990s by US Conec Ltd. In the following, IBM introduced the MTP to the market with Rosenberger’s intensive support. In 2000, the core functionality of the MTP was standardized as the MPO in IEC 61754-7.

US Conec has continued to improve the quality and performance of the MTP® while keeping it fully compliant to the MPO standard. Thus we recommend using the original MTP connector wherever you need MPO.

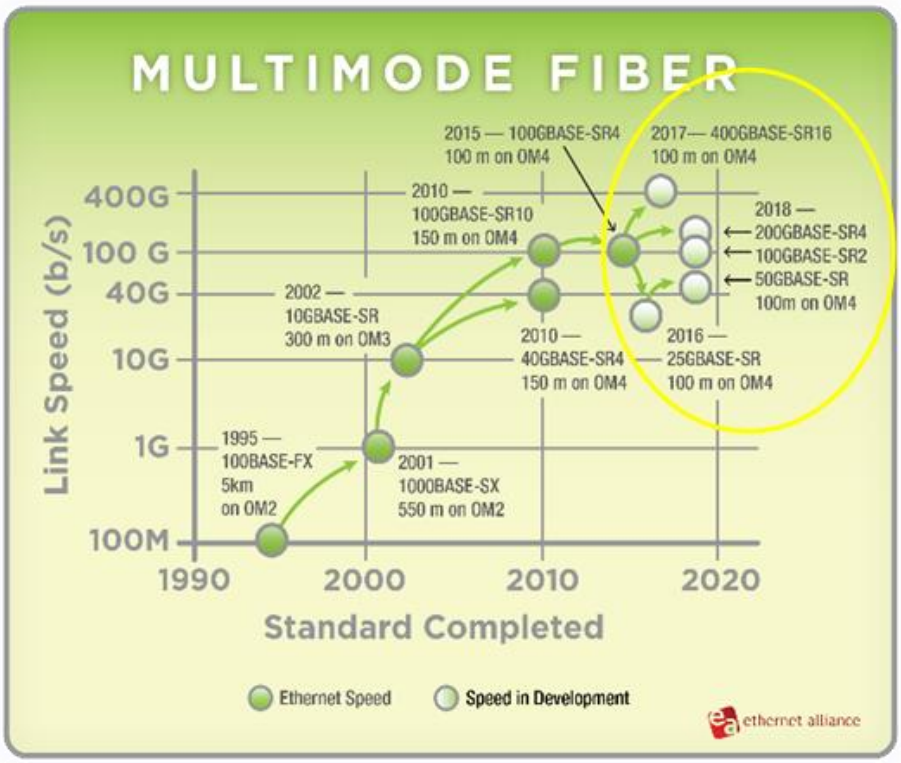


Image: www.ethernetalliance.org

These new standardization projects all have a common objective of reaching a minimum transmission length of 100 meter over MMF. The definition of MMF is graded index 50 µm diameter core / 125 µm diameter cladding (50/125 µm) OM4 fiber (ISO 11801 standard). Shorter reach lengths over OM3 are specified as well for carefully checking on a case-by-case basis is required to determine if existing OM3 cabling can be used.

Market studies are presenting figures projecting the future dominance of 100G transceivers in data centers. These forecasts along with expressed customer interest is driving the continued development of additional new 100G Ethernet versions. Beginning with the first 100GBASE-SR10 in 2010, followed by 100GBASE-SR4 in 2015 and other standards up to and including the forthcoming 100GBASE-SR2 expected in 2018, all use passive parallel optics based upon the MPO connector.

As illustrated below, the MPO is the standard connector interface of MMF transceivers since 40GBASE-SR4 and will continue for the future coming MMF Ethernet versions with higher data rates.

However, there will be different types of MPOs with special polarities of the varying numbers of fibers to support the diverse requirements.

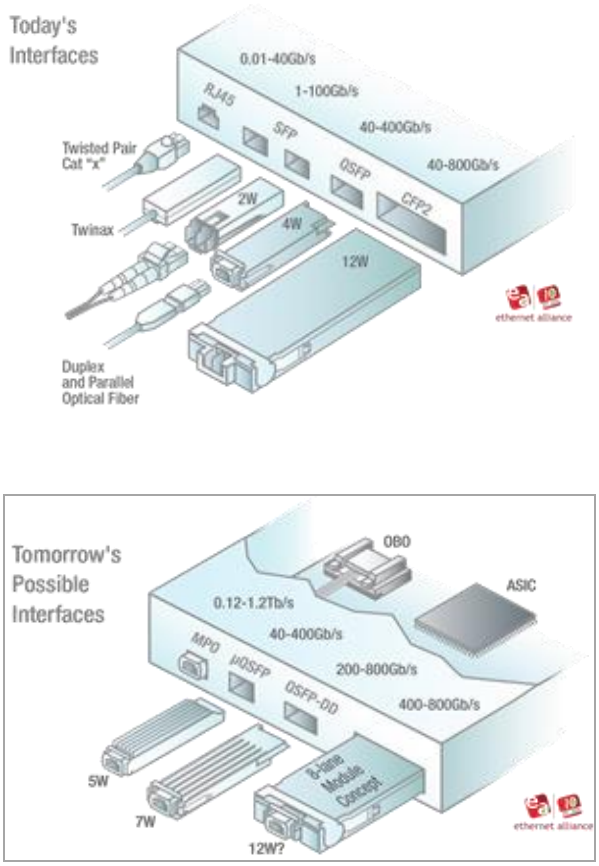


Image: www.ethernetalliance.org

IEEE 802.3 Ethernet Standards in development:

25GBASE-SR:

- Through the development of 100GBASE-SR4 in 2015, it became necessary to develop the intermediate speed 25GBASE-SR standardized as IEEE 802.3by in 2016.
- Established to aggregate four 25G server ports at one 100G switch port.
- Transceiver uses the well-known SFP+ form factor with LC-Duplex connector interface, but with 25G speed.

50GBASE-SR:

- To scale to 200GBASE-SR4, a Task Force in IEEE 802.3cd is currently studying the development of an intermediate 50GBASE-SR standard.
- Designed to aggregate four 50G server ports at one 200G switch port.
- Planned to be brought to market in 2018.
- Presumably, the transceiver will be SFP+ form factor with LC-Duplex connector interface, but in this case with 50G speed.

100GBASE-SR2:

- IEEE 802.3cd Task Force is also currently studying 100GBASE-SR2.
- The intention of this standardization project is to aggregate two 50G server ports at one 100G switch port.
- This Ethernet version is planned to be ready together with the 50GBASE-SR in 2018.
- It is very likely that the transceiver will be the QSFP form factor with MPO connector interface. Presumably it will have a polarity similar to SR4 but using only the outer two fibers on each side of a 12 fiber MPO.

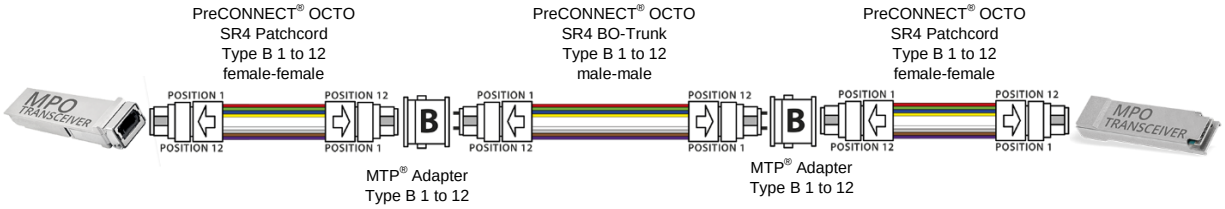
200GBASE-SR4:

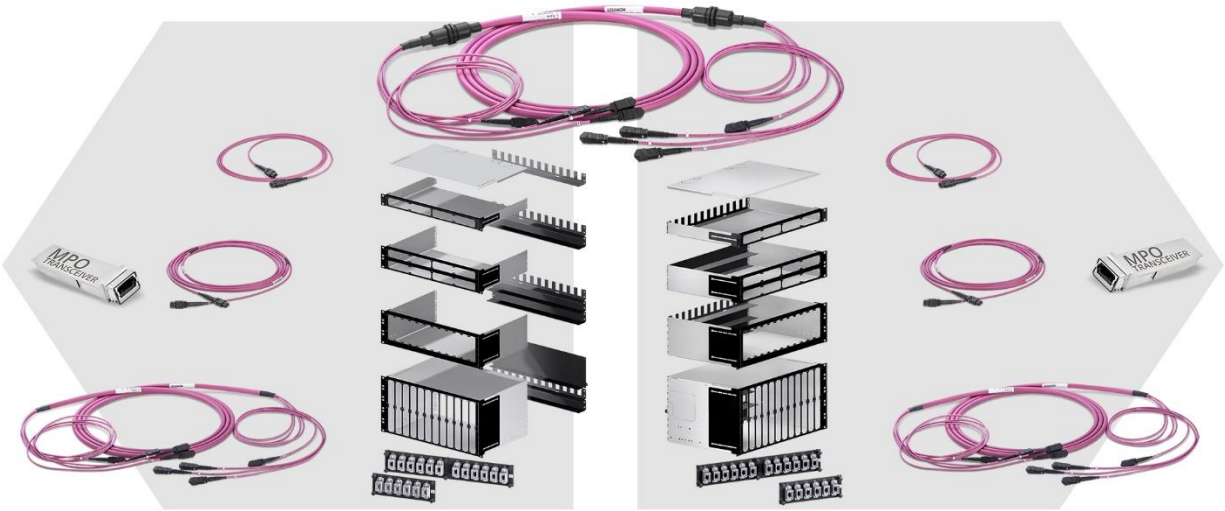
- The third Ethernet speed currently being studied by the IEEE 802.3cd Task Force is the 200GBASE-SR4.
- Planned to be brought to market together with 50GBASE-SR and 100GBASE-SR2 in 2018.
- The configuration will likely follow the previous series of Ethernet SR4 devices: QSFP transceivers with 4 x 50G MPO connector interface and the existing SR4 polarity.

PreCONNECT® OCTO cabling system:

Driven by the widespread adoption of 40GBASE-SR4 starting in 2010, followed by the strong growth of 100GBASE-SR4 beginning in 2015, and with the planned deployment of 200GBASE-SR4 in 2018, SR4 is a core technology for Ethernet over MMF.

As the European MTP® pioneer, we have developed innovative solutions optimized for SR4 Ethernet interconnect based upon the MPO standard. In 2014, we introduced our PreCONNECT® OCTO MTP® (MPO) cabling system.





PreCONNECT® OCTO is perfectly designed to maximize the performance of Ethernet over MMF solutions. We fully support the existing and developing Ethernet standards described here and future standards too!

And we support vendor and multi-source agreement (MSA) specific solutions. For example the 4 x 16G and 4 x 32G Fiber Channel transceivers in the QSFP form factor with MPO connector interface as for example already deployed by Brocade.

PreCONNECT® OCTO features:

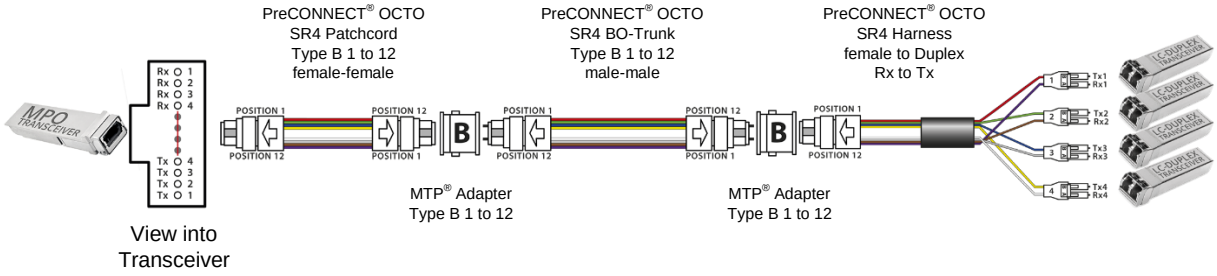
- Cost optimized SR4 8-fiber design per MTP® channel
- Simple and efficient concept, focusing on only the essential elements
- Attenuation and cost optimized system design - no MTP® module cassettes required
- Backwards compatibility to duplex technology using simple MTP harnesses

More frequently than the direct interconnect of two SR4 MPO transceivers is the need to link one SR4 port of a switch to four SFP+ LC-Duplex server ports.

This can be realized in a simple and cost efficient means using our PreCONNECT® OCTO harness solution which breaks out a MTP® connector to four LC-Duplex connectors.

The structure shown below is applicable to:

- 40GBASE-SR4 to four 10GBASE-SR
- 100GBASE-SR4 to four 25GBASE-SR
- 200GBASE-SR4 to four 50GBASE-SR
- 4x16GFC to four 16GFC
- 4x32GFC to four 32GFC



100GBASE-SR2 is realized by using a harness to connect the transceiver directly to the PreCONNECT® OCTO Trunk cables in a highly efficient and simple manner.

This permits two 100GBASE-SR2 channels to be transmitted over one PreCONNECT® OCTO MTP channel.

PreCONNECT® OCTO is the optimal cabling system for 40/100/200GBASE-SR4 and perfectly suited for 100GBASE-SR2 too!

SR4 Harness female to Duplex

400GBASE-SR16:

Is currently under standardization as IEEE 802.3bs with a planned market introduction in 2017. This passive parallelization configuration is pushing optical interconnect technology to the limits. Based upon the currently available fast VCSEL light sources only achieving data rates of 25G, sixteen channels must transmit in parallel to create a 400G data stream.

This requires thirty-two MMF configured in a MPO connector with two rows of sixteen fibers for bi-directional transmission.

Draft Amendment to IEEE Std 802.3-2015
IEEE P802.3bs 400 Gb/s Ethernet Task Force

IEEE *Draft* P802.3bs/D1.4
24th May 2016

123.11.3.1 Optical lane assignments

The 16 transmit and 16 receive optical lanes of 400GBASE-SR16 shall occupy the positions depicted in Figure 123–4 when looking into the MDI receptacle with the connector keyway feature on top. The interface contains 32 active lanes. The transmit optical lanes occupy the upper 16 positions. The receive optical lanes occupy the lower 16 positions. .

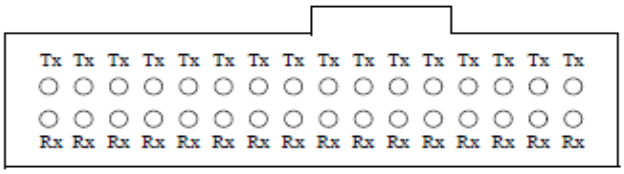


Figure 123–4—400GBASE-SR16 optical lane assignments

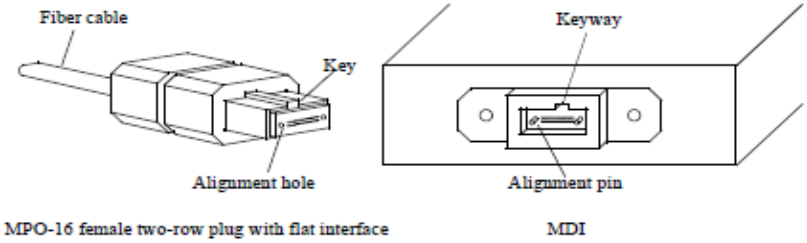


Figure 123–5—MPO-16 female two-row plug with flat interface, and an MDI

The first 400GBASE-SR16 transceiver of the CDFP Multi Source Agreement (MSA), using a 2 x 16 fiber MPO connector interface, has already been demonstrated at the OFC and ECOC shows in 2014.

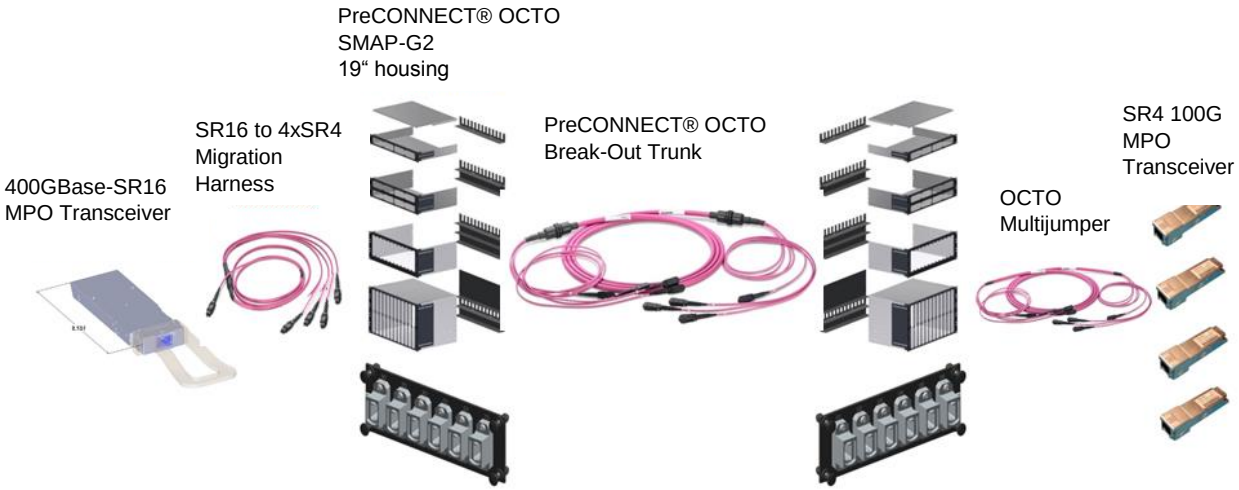
The newer CFP8 transceiver of the CFP MSA appears to have greater potential in the 400GBASE-SR16 market than the CDFP. The CFP8 transceiver will have the same 2 x 16 fiber MPO connector interface as the 400GBASE-SR16 (IEEE 802.3bs) specification. Cable assemblies to support both MSAs using MTP® connectors with 2 x16 fibers are available today from Rosenberger.

CFP8 transceiver with MPO connector interface

Migration to 400GBASE-SR16 over PreCONNECT® OCTO:

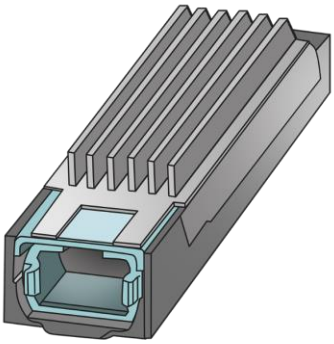
A possible scenario that will be seen as 400GBASE-SR16 is deployed: a switch is configured with 400GBASE-SR16 ports while the (new or existing) infrastructure and servers have 100GBASE-SR4 ports. In this case, the 400GBASE-SR16 switch port can be attached with a 4xSR4 Migration-Harness to transmit it over four MTP® channels of the PreCONNECT® OCTO cabling system.

More proof of the excellent scalability and future usability of the PreCONNECT® OCTO cabling systems!



µQSFP Transceiver:

The µQSFP transceiver is being presented as a potential future interface by the Ethernet Alliance. (Shown in the right-hand figure of page 4.) This is a very challenging technical concept for a 100GBASE-SR4 transceiver with MPO connector interface having the outer dimensions of the SFP+ form factor.



µQSFP transceiver with MPO connector interface

With the µQSFP form factor it becomes possible to keep the usual density of 48 ports in a 1U tall switch. This gives a mathematical performance of 48 x 100G = 4.8 Terabit/s for such a 1U switch which is needed to solve the ever-increasing need for data bandwidth.

Rosenberger is up to the challenge! In addition to supporting the cabling needs of this new transceiver, we are a member of the µQSFP MSA and have under development a µQSFP transceiver.

QSFP-DD Transceiver:

QSFP-DD is a MSA to support 200/400/800G transceivers. The QSFP-DD is a QSFP form factor transceiver but with double the number of electrical lanes. It provides eight electrical interface lanes instead of four (as found in the QSF) to double the bandwidth in the same size.

Hence “DD” for double density.

There are two variants under development:

- 200G as 8 x 25G with non-return to zero (NRZ) coding
- 400G as 8 x 50G with quad phase amplitude modulation (PAM4) coding

Additionally there is a 2x1 stacked transceiver ‘cage’ under development. This will permit two QSFP-DD transceivers to be tightly stacked above each other to increase faceplate density.

This arrangement will permit the bandwidth performance of switches (per given rack height) to be increased to previously unknown levels.

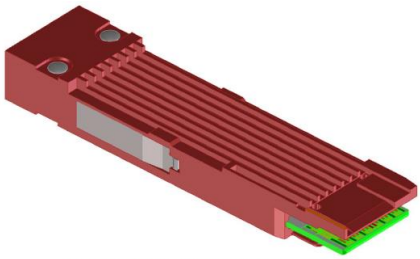


Figure 6c — QSFP-DD slotted top pluggable module rendering

200G 8x25G NRZ
400G 8x50G PAM4

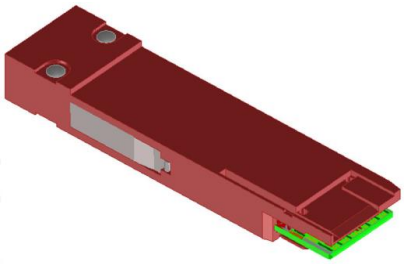


Figure 6d — QSFP-DD flat top pluggable module rendering

400G 2x200G NRZ
800G 2x400G PAM4

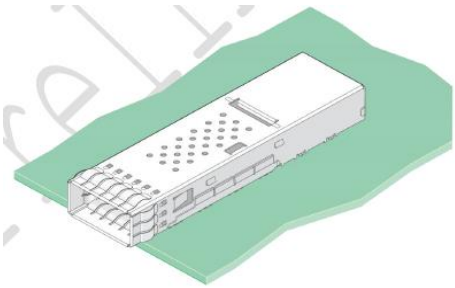


Figure 6b — QSFP-DD press fit cage for surface mount (SMT) connector

As with the QSFP, the connector interface of the QSFP-DD is also MPO. In this particular case it has sixteen fibers with special polarity for bi-directional eight channel transmission.

According to the current revision 1.0 of the QSFP-DD specification it is a MPO with two rows of eight fibers each.

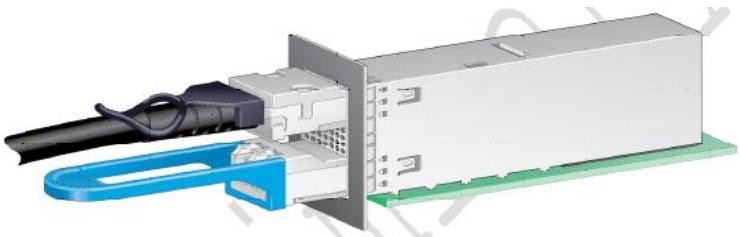


Figure 6a: QSFP-DD 2x1 stacked cage pluggable and direct attach module rendering

QSFP-DD transceivers can be attached to the PreCONNECT® OCTO cabling system in a simple and cost efficient manner by using a migration harnesses especially designed for this application.

The 200G or 400G of QSFP-DD can be transmitted over two PreCONNECT® OCTO MTP® channels. Additional proof of the outstanding scalability and future usability of this cabling system!

OSFP Transceiver:

OSFP transceiver with MPO connector interface

Octal Small Form Factor Pluggable (OSFP) is the newest MSA for 400G transceivers.

Original text:

The OSFP is a new pluggable form factor with eight high speed electrical lanes that will initially support 400 Gbps (8x50G). It is slightly wider and deeper than the QSFP but it still supports 32 OSFP ports per 1U front panel, enabling 12.8 Tbps per 1U.

We are a member of the OSFP MSA. Currently there is no publically available specification. The connector interface will also be MPO, either with two rows of eight fibers like the QSFP-DD or one row with sixteen fibers. Rosenberger is ready to support each configuration, even MTP® connectors with 16 fibers in one row are now available.

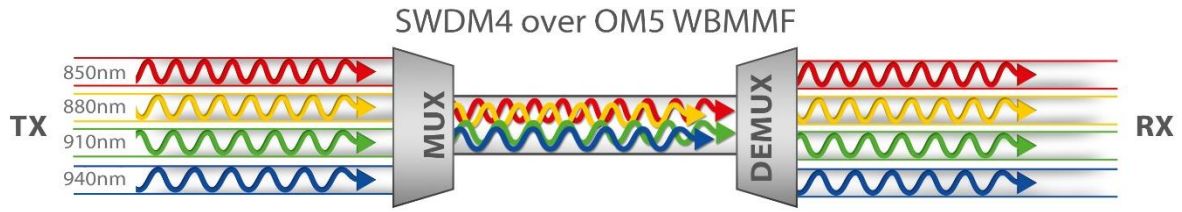
The octal configuration of this transceiver fits perfectly with our PreCONNECT® OCTO cabling system!

SWDM4:

SWDM4 is a new technology under development to support 100G over MMF. Currently there are only proprietary solutions without a MSA but this may change as commercialization continues.

SWDM4 uses a complex shortwave wavelength division multiplex (SWDM) technology. Light at four different wavelengths (850, 880, 910 and 940 nm) are transmitted in a multi-mode fashion over one fiber. This permits one fiber to support 100G - thus two fibers are needed for bi-directional transmission.

The goal for SWDM4 is to transmit 100G over a minimum distance of 300 meters using a new special multi-mode fiber.



Current OM3 and OM4 fibers are not suitable to transmit SWDM4 100G over the desired distance. Today OM4 typically only supports 100-meter links using a single wavelength.

To support 300 meters links, Wideband Multi-mode Fiber (WBMMF) was recently standardized as “OM5”. The OM5 WBMMF is a graded index 50/125 µm fiber especially developed for multi-mode wavelength division multiplex.

SWDM4, like it`s single-mode relative CWDM4, is only suitable for 100G to 100G direct interconnects. There is no ability to aggregate multiple 25G ports passively into a single 100G stream using harness cables or other optical connectors as can be done with SR4 and PSM4.

Time will tell how much market share SWDM4 can win in competition to the 100G single-mode application PSM4. PSM4 transmits 100G cost efficiently over a minimum of 500 meters using eight parallel single-mode fibers (SMF). This is the same manner as PSM4’s multi-mode relative SR4.

QSFP Transceiver 100G SWDM4
with LC-Duplex connector interface
Finisar

List of references:

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www.ieee802.org/3/
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www.psm4.org
www.cwdm4-msa.org
http://osfpmsa.org/

About Rosenberger OSI:

Since 1991, Rosenberger Optical Solutions & Infrastructure (Rosenberger OSI) has been an expert in innovative fiber optic cabling infrastructure and service solutions for Datacom, Telecom and Industrial.

The products and services can be found wherever largest amounts of data have to be transferred quickly and securely. In addition to the development and production of a broad portfolio of fiber optic and copper cabling systems, Rosenberger OSI also offers a variety of services such as planning, installation and maintenance of cabling infrastructure. Rosenberger OSI employs about 600 people in Europe and has been a part of the globally operating Rosenberger Group since 1998, a worldwide leading provider of high-frequency-, high-voltage-, and fiber-optic-connection solutions headquartered in Germany.

For further information, please visit: www.rosenberger.com/osi

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