AFL HYPERSCALE®

Understanding 10G to 400G Ethernet Speeds, Transceivers, and Selecting the Correct Fiber Optic Connectivity for Your Data Center

Abhishek Vernekar CDCDP, Application Engineering

1. Introduction

The data center industry today continues to witness a rapidly increasing need for higher bandwidth due to new applications such as machine-to-machine learning, virtual reality, 5G, and online gaming. These new applications are accelerating the transition to new types of fiber connectivity protocols and media.

In a data center, many types of applications co-exist at varying speeds, making it essential to understand various Ethernet standards and transceivers types, as well as identifying the correct fiber optic infrastructure needed.

This whitepaper will examine 10/25/40/100/400GbE in detail and provide a clear guide to choosing the right fiber optic infrastructure.

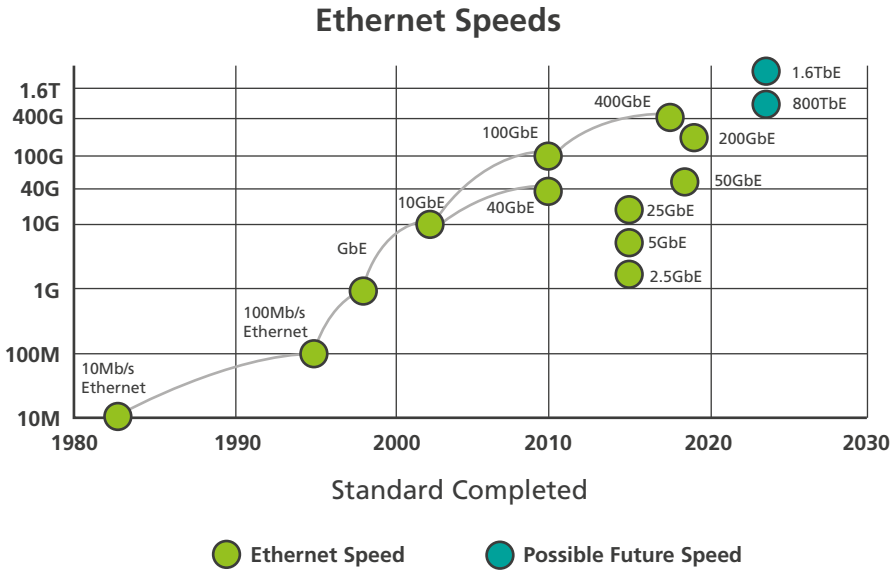


Figure 1.1: Ethernet roadmap
Source: Ethernet Alliance

2. Ethernet Standards and Transceiver Types

When selecting the most appropriate transceiver, it is important to be aware of the various classifications based on speed, transceiver form factor, fiber type, interface connector type, and link reach.

SFP+, SFP28, QSFP+, QSFP28, QSFP-DD are the most commonly used interfaces in the industry for short-range applications (up to 500m). Wherever high speed and long-range are considerations, CFP, CXP, CPAK, etc. interfaces are preferred.

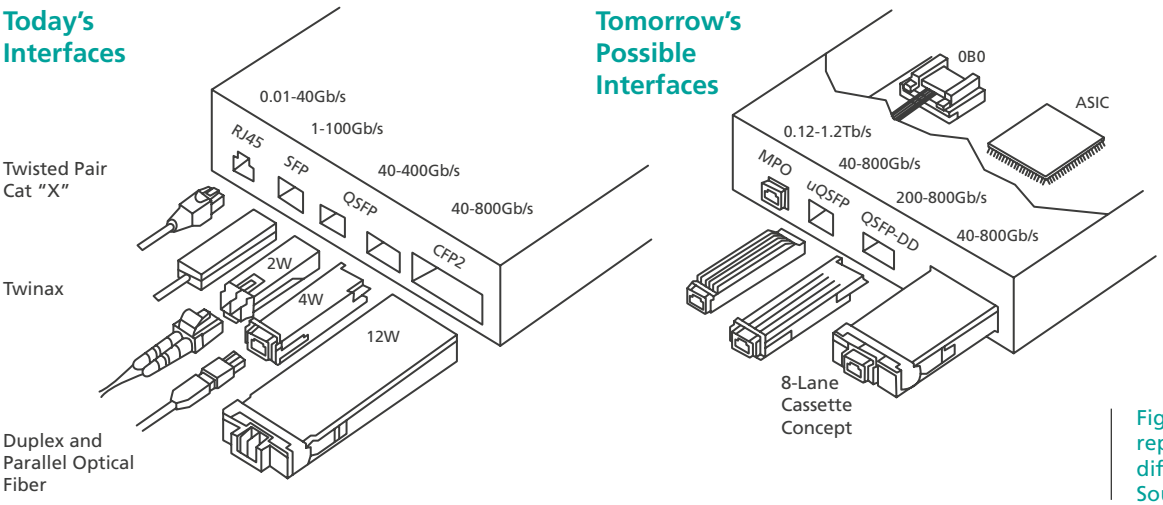


Figure 2.1: Pictorial representation of different transceiver types
Source: Ethernet Alliance

Table 2.1: Classification of Ethernet standards and transceiver types

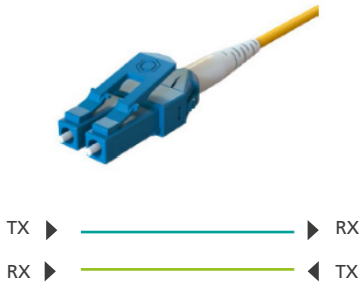
Speed	Ethernet Nomenclature	Ethernet Standard IEEE	Medium	Transceiver Form Factor	Connector Interface	Link Reach
10GbE (10Gb/s)	10GBASE-SR	802.3ae-2002 (CL49/52)	Multimode Fiber (@850nm)	SFP+ XENPAK X2 XPAK XFP	LC Duplex SC Duplex	OM1 – 33m OM2 – 82m OM3 – 300m OM4 – 400m
	10GBASE-LR		Single-mode Fiber (@1310nm)	SFP+ XENPAK X2 XPAK XFP	LC Duplex SC Duplex	OS2 – 10km
	10GBASE-ER		Single-mode Fiber (@1550nm)	SFP+ XENPAK X2 XFP	LC Duplex SC Duplex	OS2 – 40km
25GbE (25Gb/s)	25GBASE-SR	802.3by-2016 (CL112)	Multi-mode Fiber (@850nm)	SFP28	LC Duplex	OM3 – 70m OM4 – 100m
	25GBASE-LR	802.3cc-2017 (CL114)	Single-mode Fiber (@1310nm)			OS2 – 10km
	25GBASE-ER	802.3cc-2017 (CL114)	Single-mode Fiber (@1550nm)			OS2 – 40km
40GbE (40Gb/s)	40GBASE-SR4	802.3ba-2010 (CL82/86)	Multimode Fiber (@850nm)	CFP QSFP+	MPO	OM3 – 100m OM4 – 150m
	40GBASE-LR4	802.3ba-2010 (CL82/87)	Single-mode Fiber (WDM)	CFP QSFP+	LC Duplex	OS2 – 10km
	40GBASE-ER4	802.3bm-2015 (CL82/87)	Single-mode Fiber (WDM)	QSFP+	LC Duplex	OS2 – 40km
100GbE (100Gb/s)	100GBASE-SR10	802.3ba-2010 (CL82/86)	Multimode Fiber (@850nm)	CXP CFP CFP2 CFP4 CPAK	MPO (2x12)	OM3 – 100m OM4 – 150m
	100GBASE-PSM4	proprietary (non-IEEE) (Jan 2014)	Single-mode Fiber (@1310nm)	QSFP28 CFP4	MPO 12	OS2-500m
	100GBASE-CWDM4	proprietary (non-IEEE) (Mar 2014)	Single-mode Fiber (WDM)	QSFP28 CFP2 CFP4	LC Duplex	OS2-2km
	100GBASE -SR2-BiDi (Bi-directional)	proprietary (non-IEEE)	Multimode Fiber (@850nm @900nm) (WDM)	QSFP28	LC Duplex	OM3 – 70m OM4 – 100m
	100G-SWDM4	proprietary (non-IEEE) (Jun 2016)	Wide Band Multimode Fiber (SWDM)	SFP	LC Duplex	OM5 – 150m
	100GBASE-LR4	802.3ba-2010 (CL88)	Single-mode Fiber (WDM)	QSFP28 CFP CFP2 CFP4 CPAK	LC Duplex SC Duplex	OS2 – 10km
	100GBASE-SR4	802.3bm-2015 (CL95)	Multimode Fiber (@850nm)	QSFP28 CFP2 CFP4 CPAK	MPO 12	OM3 – 70m OM4 – 100m
	100GBASE-ER4	802.3ba-2010 (CL88)	Single-mode Fiber (WDM)	QSFP28 CFP CFP2	LC Duplex SC Duplex	OS2 – 40km
400GbE (400Gb/s)	400GBASE-SR8	802.3cm	Multimode Fiber (@850nm)	OSFP QSFP-DD	MPO (16) MPO (2x12)	OM3 – 70m OM4 – 100m OM5 - 100m
	400GBASE-DR4	802.3bs	Single-mode Fiber (WDM)	CFP8 OSFP QSFP-DD	MPO 12 SN Connector	OS2 – 500m
	400GBASE-FR4	802.3cu	Single-mode Fiber (WDM)	CFP8 OSFP QSFP-DD	LC Duplex	OS2 – 2km
	400GBASE-2FR4 (2 x 200G-FR4)	802.3bs	Single-mode Fiber (WDM)	QSFP-DD OSFP	CS Connector	OS2 – 2km

Popularly used transceivers

Data transmission is achieved with these transceivers by sending light signals through the optical fiber cable, for lower speeds i.e. up to 10G and some short-range 40G and 100G applications, a single wavelength is used and light signals are transmitted in single or multiple fiber paths.

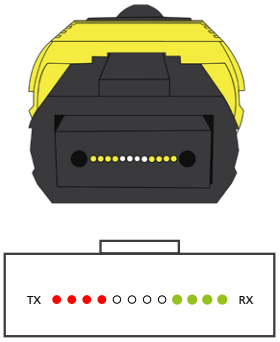
The below illustration (Figure 2.2) outlines the various Short Range (SR) Ethernet standards and how transmission and reception are achieved via optical fibers in different interface connectors called lane allocation.

LC Duplex
(2 fibers used)



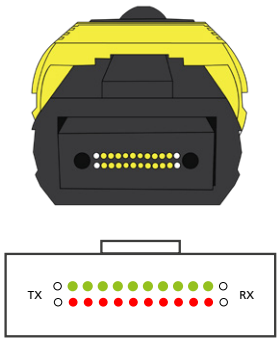
10GBASE-SR (MMF 400m)
25GBASE-SR (MMF 100m)
10GBASE-LR (SMF 10km)
10GBASE-ER (SMF 40km)

BASE-8
12F MPO - 8 fibers used



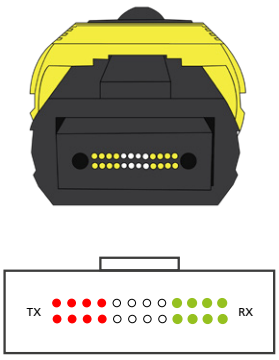
40GBASE-SR4 (MMF 150m)
100GBASE-SR4 (MMF 100m)
100GBASE-PSM4 (SMF 500m)

BASE-24
24F MPO (2x12) - 20 fibers used



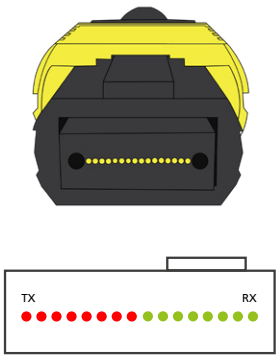
100GBASE-SR10 (MMF 150m)

(2x12) 24F MPO
16 fibers used



400GBASE-SR8 (MMF 100m)
available with QSFP-DD & OSFP

16F MPO



400GBASE-SR8 (MMF 100m)
available with QSFP-DD & OSFP

Note: MPO connector has an off-set notch

Figure 2.2: Lane allocation of fiber optic connectors for short-range transmission

For most of the Long Range (LR) transmission, Wavelength Division Multiplexing (WDM) is used with single-mode fiber (SMF) to transmit multiple wavelengths of light signals resulting in higher data rate speeds with ranges up to 40km.

However, there are some proprietary Short Range (SR) standards that use WDM to achieve very high data rate speeds for both SMF and MMF (multimode fiber) for hyperscale data center applications.

Due to reach requirements and dependency over proprietary products, most hyperscale data centers use SMF to provide the necessary reach and bandwidth for applications, so much so that it is being promoted by businesses as the only viable future solution.

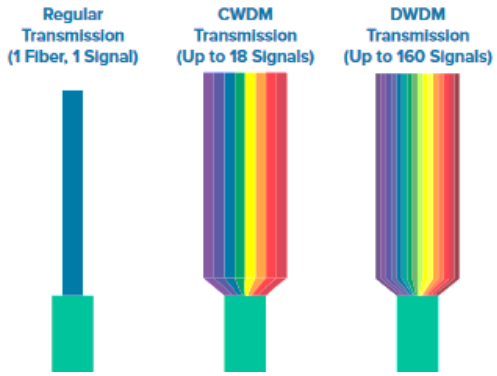
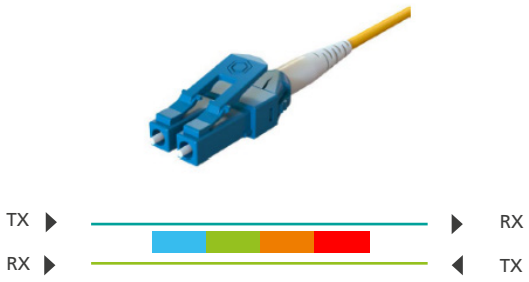


Figure 2.3: Single-lane transmission vs WDM
Source: PROlabs

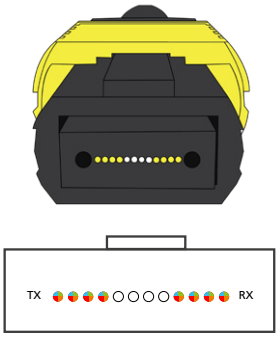
The below illustration (Figure 2.4) outlines the various Ethernet standards and how transmission and reception are achieved via optical fibers in different interface connectors with WDM.

LC Duplex
(2 fibers used)



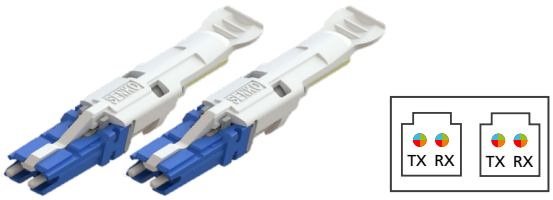
25GBASE-LR (SMF 10km)
25GBASE-ER (SMF 40km)
40GBASE-LR4 (SMF 10km)
40GBASE-ER4 (SMF 40km)
100GBASE-SR2-BiDi (MMF 100m)
100G-SWDM4 (MMF 150m)
100GBASE-LR4 (SMF 10km)
100GBASE-ER4 (SMF 40km)
400GBASE-FR4 (OS2 – 2km)

BASE-8
12F MPO - 8 fibers used



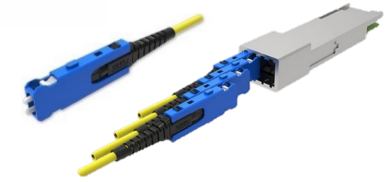
400GBASE-DR4 (OS2 – 500m)

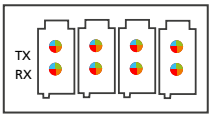
CS® Connector
(4 Fibers used)



Source: SENKO Advanced Components, Inc
400GBASE-2FR4 (OS2 – 2km)

SN® Connector
(Nano Connector, 8 Fibers used)





4x SN connectors in one transceiver (8 fibers used)

400GBASE-DR4 (OS2 – 500m)
Source: SENKO Advanced Components, Inc

Figure 2.4: WDM Ethernet standards and mode of transmission in connectors and optical fiber

The deployment of 400G in the hyperscale market will be supported mostly by QSFP-DD (Quad Small Form-Factor Pluggable – Double Density) transceivers. The interface of a QSFP-DD connector also has 8 electrical lanes running at 50Gb/s each for a total bandwidth of 400Gb/s. The QSFP-DD form factor is similar to the QSFP form factor, except a second row of electrical contacts has been added to double the number of high-speed electrical lanes from 4 to 8.

The IEEE standard has defined a number of different 400G specifications for different industry applications, as listed in Table 2.1. The letters are reach specifications and the number refers to the number of optical channels:

1. SR8: "SR" refers to 100m reach using multimode fiber and "8" indicates there are 8 optical channels. Each of the 8 optical channels from an SR8 cassette is carried on separate fibers, resulting in a total of 16 fibers (8 Tx and 8 Rx). Each optical channel operates at 50Gb/s. The SR8 cassette uses an MPO-16 connector to connect to 8 fiber pairs or an MPO-24 connector as shown in Figure 2.2

2. DR4: "DR" refers to 500m reach using SMF and "4" indicates there are 4 optical channels. Each of the 4 optical channels from a DR4 cassette is carried on separate fibers, resulting in a total of 8 fibers (4 Tx and 4 Rx). Each optical channel operates at 100Gb/s. The DR4 cassette uses an MPO-12 connector to connect to 4 fiber pairs.

3. FR4: "FR" refers to 2km reach using SMF and "4" indicates there are 4 optical channels. Unlike the DR4 and SR8, all 4 optical channels from an FR4 are multiplexed onto one fiber, resulting in a total of 2 fibers from the cassette (1 Tx and 1 Rx). Each optical channel operates at 100Gb/s. The FR4 cassette uses a duplex LC connector to connect to a single fiber pair.

4. 2FR4: The "2FR4" refers to 2 x 200G-FR4 links and has a reach of 2km using SMF. Each of the 200G FR4 links has 4 optical channels, multiplexed onto one fiber pair (1 Tx and 1 Rx per 200G link). A 400G-2FR4 cassette has 2 of these links, resulting in a total of two pairs of SMF (or 4 fibers total) and a total of 8 optical channels. Each optical channel operates at 50Gb/s. The 2FR4 cassette uses a dual CS connector to connect to 2 fiber pairs.

Today, hyperscale data centers use SMF with different connectivity to achieve up to 400G data rates. Some data centers use BASE-16 parallel optics (using 8 lanes of fiber to transmit and 8 lanes of fiber to receive with a 16f or 24f MPO connector) with QSFP-DR4 transceivers that use PAM4 modulation to achieve 400G transmissions. The data signal is modulated via PAM4 to 50G per fiber optic lane (cable). The use of 8 lanes translates to 400G data rates. Likewise, some hyperscale data centers use SMF with BASE-8 parallel optics, with QSFP-DR4 transceivers that use PAM4 modulation and advanced lasers to achieve 100G per lane and 400G per transceiver.

There have also been some developments with the new SN connector, a duplex optical fiber connector designed for 400G data center optimization. The SN has two LC-style 1.25-mm O.D. Zirconia ferrules in a single housing, pitched 3.1 mm apart versus 6.25 mm in an LC duplex. The SN connector allows users to have four connectors (eight fibers) in the QSFP-DD-based transceiver utilizing 400GBASE-DR4 standard.

For longer-distance 400G applications within hyperscale data centers, customers are deploying 400G-FR4, which allows for a reach of up to 2 km. The 400G-FR4 specification will utilize WDM and PAM4 modulation – transmitting 400G over a single lane of fiber, enabling the deployment of LC connectivity.

Table 2.1 summarizes the key parameters for the different 400G transceivers. Note that in all the 400G transceivers, the electrical connector interface is always 8 x 50Gb/s PAM-4 (for a total of 400Gb/s). The optical signals, however, could be 8 x 50Gb/s PAM-4, or 4 x 100Gb/s PAM-4, depending on the type of cassette. For cassette that have 4 x 100Gb/s PAM-4 optical lanes, a gearbox chip inside the cassette converts the 8 x 50Gb/s PAM-4 electrical signals (from the board) to 4 x 100Gb/s PAM-4 signals required to modulate the optical signals.

3. Fiber-Optic Cabling Systems and Configurations for Various Transceiver Types

3.1 LC duplex-based transceivers

As per Table 2.1, we can see that an LC duplex interface is used in applications from 10GbE to 400GbE in the form of various transceivers types. For simplicity, an SFP+ transceiver is shown in the images for illustration.

3.1a Direct Patching

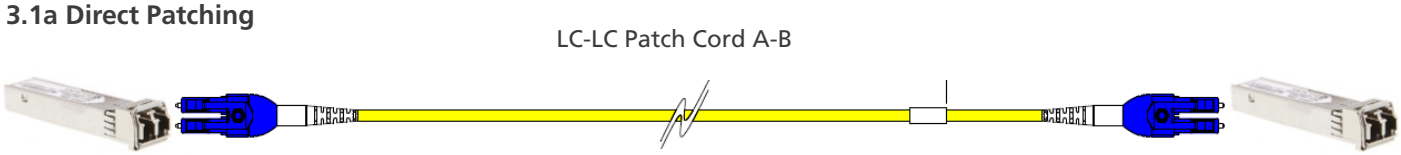


Table 3.1: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet

3.1b Configuration 1 – Use of MPO Cassettes & Pre-Terminated MPO Trunks

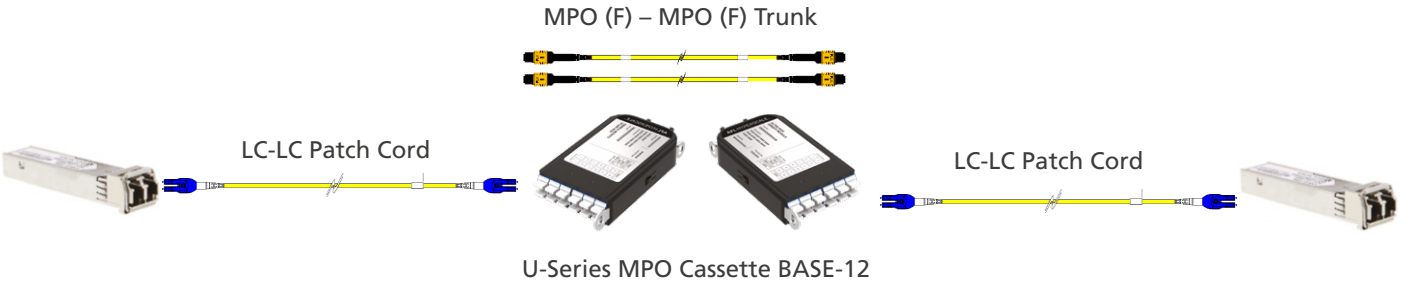


Figure 3.1b consolidation of various ports in a housing

This type of setup is used extensively in hyperscale and enterprise data centers, utilizing MPO cabling. Available in both multimode and single-mode

Table 3.1b Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
U-Series MPO Cassette BASE-12	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet
MPO MicroCable Trunk Assembly	Datasheet

3.1c Configuration 2 – Use of Pre-Terminated LC-LC Trunks & LC Adapter Plates

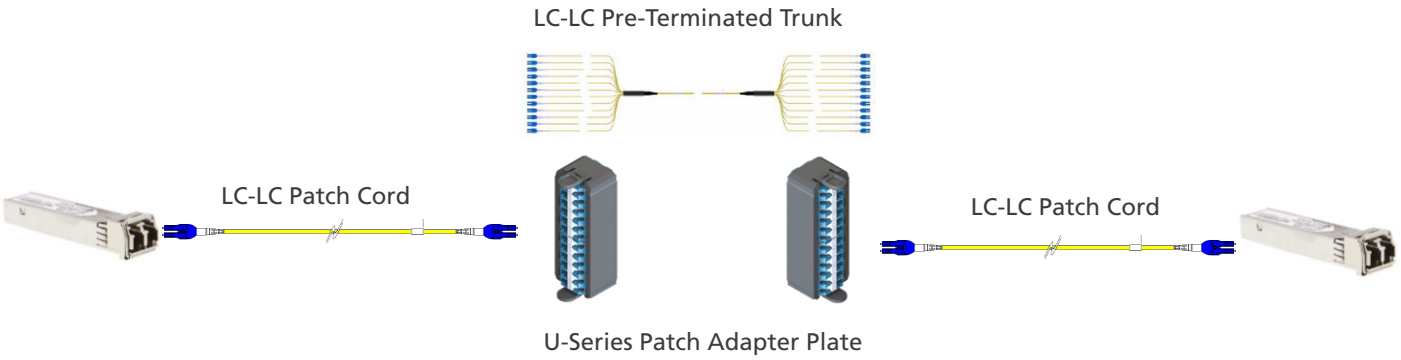


Figure 3.1ca

This type of setup is used extensively to reduce loss caused by multiple connection points in an MPO-based link.

It is also a cost-effective solution with improved performance used by a lot of colocation sites between a Meet-Me-Room (MMR) and the data hall. Typical fiber counts per cable can range from 12 fibers to 144 fibers.

AFL Hyperscale has the capability and product range to support up to 864 fibers in a single pre-terminated cable. The tails can be customized to suit specific site requirements.

Figure 3.1cb: Pre-terminated cable installed in a U-Series 2RU Housing

Table 3.1c: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
U-Series Patch Adapter Plate	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet
Pre-Terminated Assemblies	Datasheet

3.1d Configuration 3 – Use of Pre-Terminated Cassettes

Figure 3.1da

With the combined advantages of configuration 1 and 2, U-Series pre-terminated cassettes provide easy, plug-and-play installation, reduced link loss, and easy cable management. With several custom product configurations, these casssettes are suitable for both greenfield projects as well as brownfield projects.

Pre-Terminated Cassette | Pre-Terminated Cassette to LC Breakout | Pre-terminated Cassette to MPO | Pre-Terminated Cassette to open end

Figure 3.1db U-Series pre-terminated cassette in various configurations

Table 3.1d: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
U-Series Pre-Terminated Cassette	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.2 MPO BASE-8 transceivers

Beyond 10GbE and 25GbE application, 2 lanes of optical fiber are not enough to support higher speeds without WDM. A parallel transmission interface with an MPO connector can be a very cost-effective way to increase transceiver data rate speeds.

As shown in Figure 2.2, there are 12 fiber positions in an MPO connector, of which only 8 are used - 4 to transmit and 4 to receive - facilitating BASE-8 transmission. Below are some of the configurations in which BASE-8 fiber optic cabling can be achieved.

3.2a Direct patching

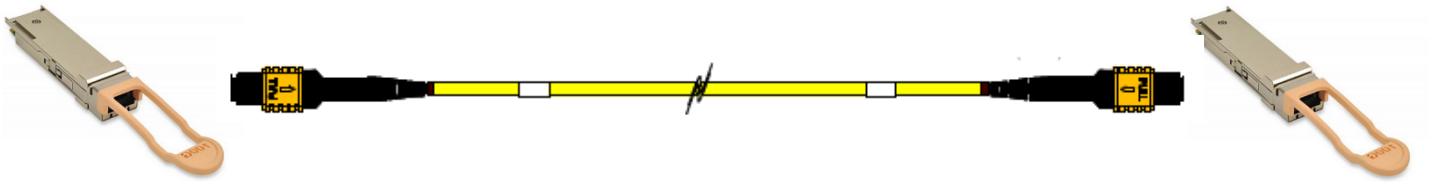


Figure 3.2aa

MPO-based cable assemblies are classified dependent on polarity and gender. MPO BASE-8 transceivers are always pinned meaning the patching cables are female and polarity should always be type B.

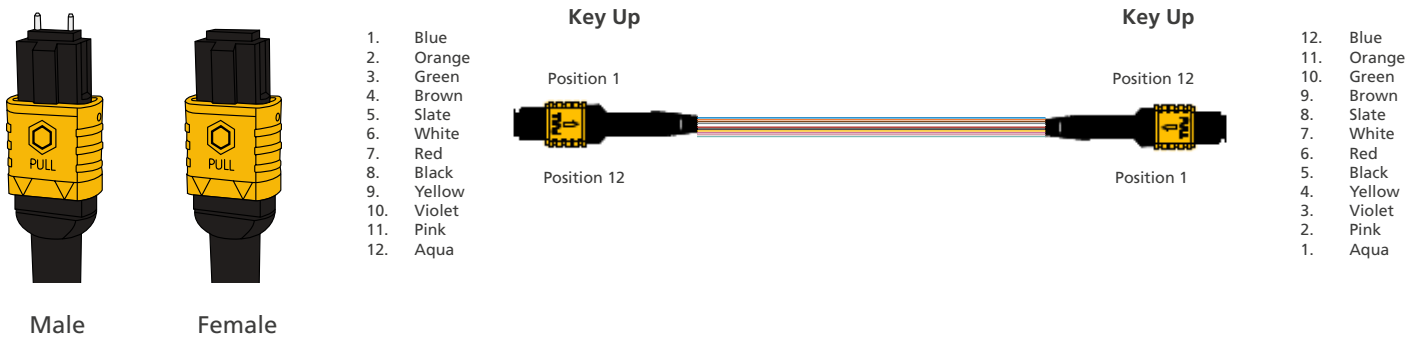


Figure 3.2ab
Source: http://www.fiber-optic-tutorial.com

Table 3.2a: Product selection guide

AFL Hyperscale Product Name	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet

3.2b Configuration 1 – MPO BASE-8 to MPO BASE-8 with Trunk Cabling

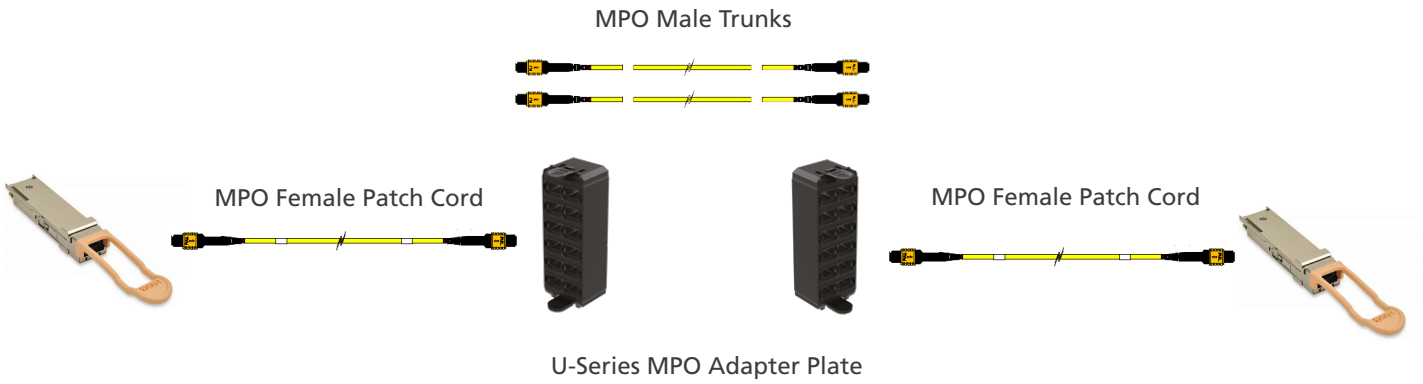


Figure 3.2b

Table 3.2b: Product selection guide

AFL Hyperscale Product Name	Datasheet
MPO MicroCable Patch Assembly (Single Jacket 3mm OD)	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet
U-Series MPO Adapter Plate	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.2c Configuration 2 – U-Series MPO Cassette BASE-8 16f

Fig. 3.2c

Conversion cassettes like these are used to transition from 40GbE to 10GbE or 100GbE to 25GbE applications. With this product, 2 x QSFP ports can be split into 8 x SFP ports with a full-front interface. All optical ports are positioned on the front of U-Series cassettes providing convenient front access.

Table 3.2c: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
MPO MicroCable Patch Assembly (Single Jacket 3mm OD)	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet
U-Series MPO Cassette BASE-8 16f	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.2d Configuration 3 – U-Series MPO Cassette BASE-8 24f

Fig. 3.2d

Table 3.2c: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
MPO MicroCable Patch Assembly (Single Jacket 3mm OD)	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet
U-Series MPO Cassette BASE-8 24f	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.2e Configuration 4 – 3:2 (MPO) Transition Assembly

Fig. 3.2e

Transition assemblies allow for fibers in the existing installed trunks to be fully utilized for 40G or 100G parallel optics transmission (3 x QSFP pairs can be connected using 24-fiber MPO trunks).

Transition assemblies are offered in pre-set configurations allowing for the utilization of legacy Polarity A, B, or C Backbone MPO trunks in 40G or 100G networks, facilitating easy polarity management.

Table 3.2e: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
40G QSFP+ 3:2 (MPO) Transition Assembly	Datasheet
U-Series MPO Cassette BASE-12	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.2f Configuration 5 – MPO to LC Assembly BASE-8

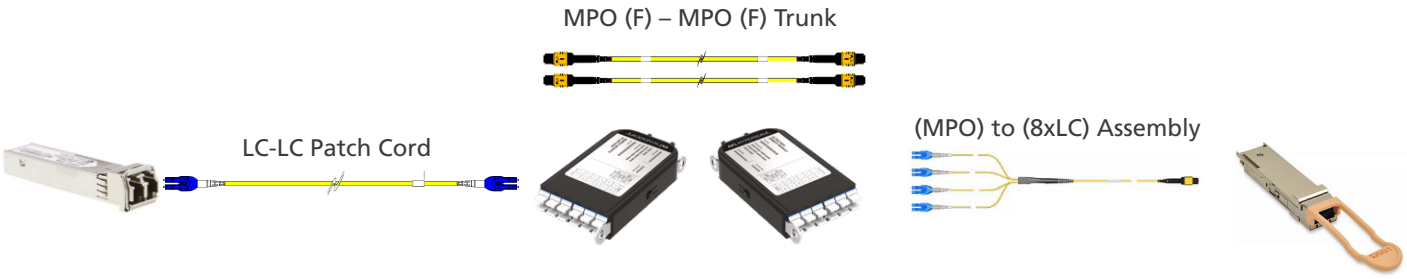


Figure 3.2f

Transition MPO to LC breakout cable assemblies are used to convert from parallel to duplex transmission, allowing 1x40G to 4x10G or 1x100G to 4x25G conversion - a typical scenario is shown in Figure3.2f.

Table 3.2f: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
MPO to LC Assembly BASE-8	Datasheet
MPO MicroCable Patch Assembly (Single Jacket 3mm OD)	Datasheet
U-Series MPO Cassette BASE-12	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.3 MPO BASE-24 transceivers

3.3a Direct Patching

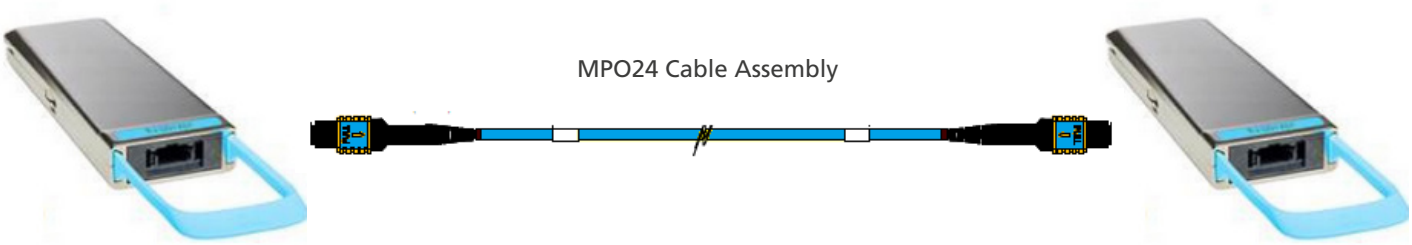


Figure 3.3a

Table 3.3a: Product selection guide

AFL Hyperscale Product Name	Datasheet
CXP/CFP 100G MPO Cable Assembly	Datasheet

3.3a Configuration 1 – 100G to 10G

Figure 3.3a

Table 3.3a: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
CXP/CFP 100G MPO Cable Assembly	Datasheet
U-Series MPO Cassette BASE-8 24f	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.3a Configuration 2 – 100G to 40G/10G

Figure 3.3a

This conversion cassette is used to transition from a BASE-24 to a BASE-8 MPO system. The above illustrates a typical scenario of 100G to 40G and an MPO-LC breakout assembly (Figure 3.2f) is used to further convert 40G to 10G.

Table 3.3a

AFL Hyperscale Product Name	Datasheet
CXP/CFP 100G MPO Cable Assembly	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet
MPO to LC Assembly BASE-8	Datasheet
U-Series MPO Cassette BASE-8 24f	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.4 400GbE transceivers

For 400G hyperscale data center deployment, SMF is used exclusively due to the length requirements and a mixture of MPO (either BASE-8 or BASE-16 deployment) and LC/SN connector-based connectivity will be used to with 400G transceivers. Below are some illustrations of:

(i) OSFP/QSFP-DD to OSFP/QSFP-DD 400G-DR4 to 400G-DR4 BASE-8 MPO connectivity

3.4a Direct patching

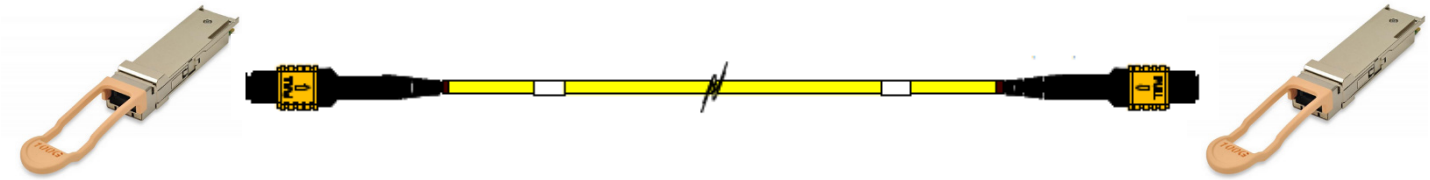


Figure 3.4a

Table 3.4a: Product selection guide

AFL Hyperscale Product Name	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet

3.4b Configuration 1 – MPO BASE-8 to MPO BASE-8 with Trunk Cabling

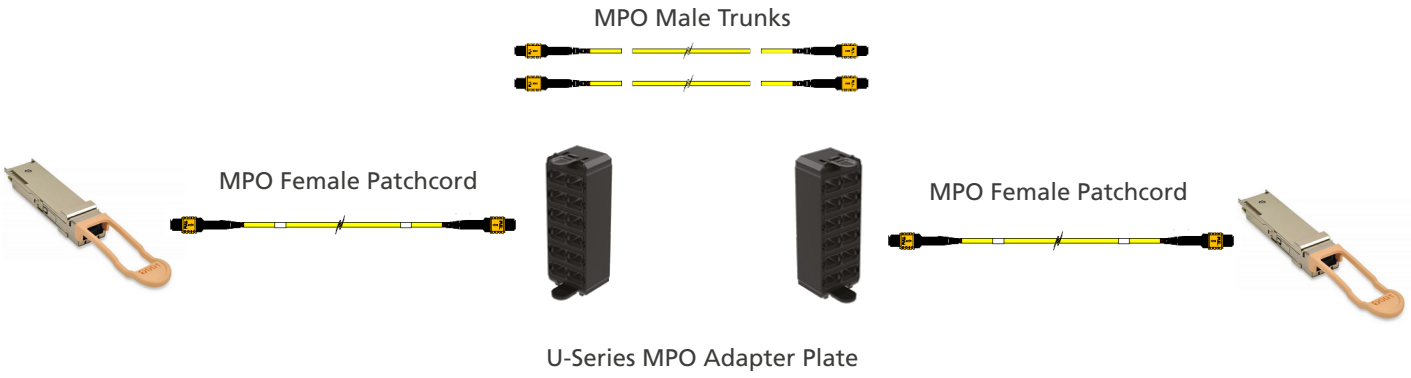


Figure 3.4b

Table 3.4b: Product selection guide

AFL Hyperscale Product Name	Datasheet
MPO MicroCable Patch Assembly (Single Jacket 3mm OD)	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet
U-Series MPO Adapter Plate	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

(ii) OSFP/QSFP-DD to QSFP 400G-DR4 to 4 x 100G-DR BASE-8 MPO connectivity

3.4c Configuration 2 – U-Series MPO Cassette BASE-8 16f

Figure 3.4c

Table 3.4c: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
MPO MicroCable Trunk Assembly	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet
U-Series MPO Cassette BASE-8 16f	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

3.4d Configuration 3 – U-Series MPO Cassette BASE-8 24f

Figure 3.4d

Table 3.4d: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
MPO MicroCable Patch Assembly (Single Jacket 3mm OD)	Datasheet
MPO MicroCable Trunk Assembly BASE-8	Datasheet
U-Series MPO Cassette BASE-8 24f	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

(iii) OSFP/QSFP-DD to OSFP/QSFP-DD 400G-FR8 to 400G-FR8 LC duplex connectivity

3.4e Direct patching

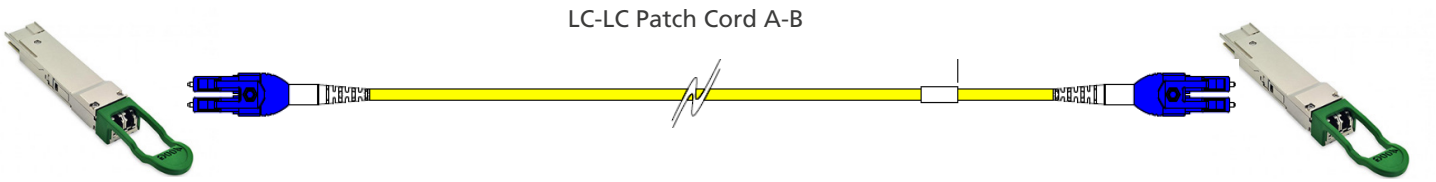


Figure 3.4e: Direct patching

Table 3.4: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet

3.4f Configuration 1 – Use of MPO Cassettes & Pre-Terminated MPO Trunks

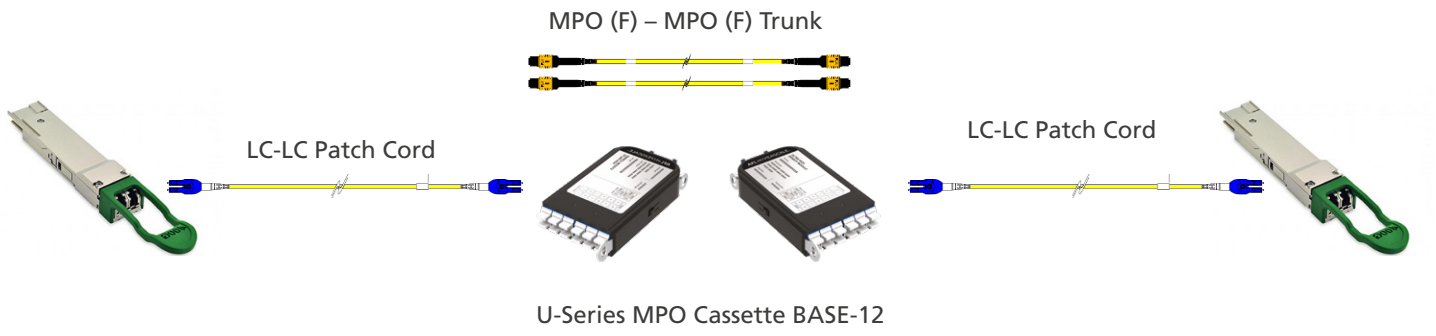


Figure 3.4e: Direct patching

This type of setup is used extensively in hyperscale and enterprise data centers, utilizing MPO cabling. Available in both multimode and single-mode.

Table 3.4f: Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
U-Series MPO Cassette BASE-12	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet
MPO MicroCable Patch Assembly (Single Jacket 3mm OD)	Datasheet

3.4g Configuration 2 – Use of Pre-Terminated LC-LC Trunks & LC Adapter Plates

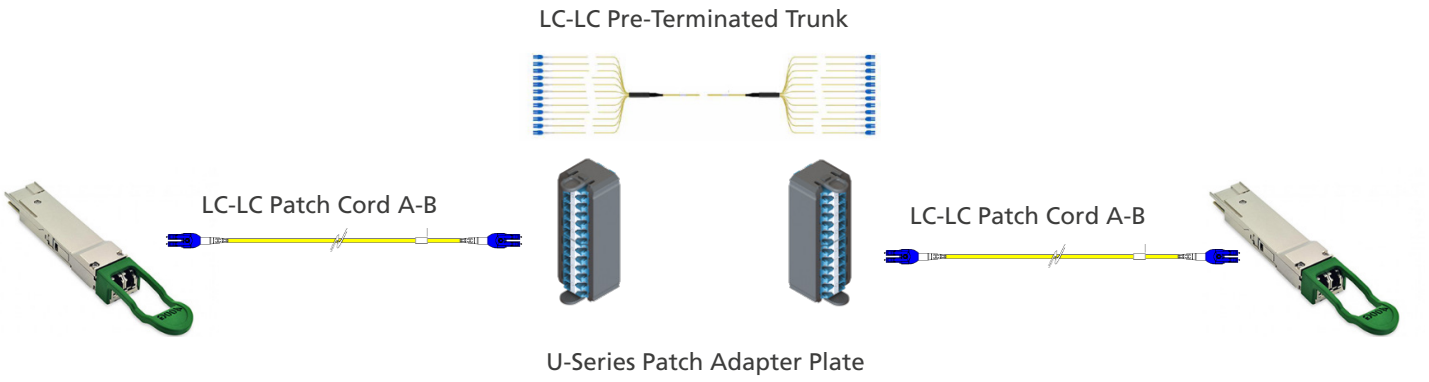


Figure 3.4ha

Table 3.4g Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
U-Series Patch Adapter Plate	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet
Pre-Terminated Assemblies	Datasheet

3.4h Configuration 3 – Use of Pre-Terminated Cassettes

Figure 3.4ha

Table 3.4h Product selection guide

AFL Hyperscale Product Name	Datasheet
Premium LC Duplex Polarity Reversible Uniboot Patch Cord	Datasheet
U-Series Pre-Terminated Cassette	Datasheet
U-Series 2RU Housing	Datasheet
U-Series 1RU Housing	Datasheet

(iv) OSFP/QSFP-DD to OSFP/QSFP-DD 400G-DR4 to 400G-DR4

SN connector-based connectivity

The most commonly used connector types in the industry today are LC and MPO. The introduction of a new connector type, namely the SN connector, is set to have a profound impact on 400G.

The SN interface has already been adopted in transceiver specifications of QSFP-DD and OSFP. These transceivers are the new specifications for the next generation of pluggable transceivers for 200Gbps, 400Gbps, and 800Gbps data center interconnects (DCI).

The SN connector is a new, duplex optical fiber connector that uses LC-style 1.25mm O.D. Zirconia ferrules, designed for the next generation Hyperscale, Edge, Enterprise, or Colocation data centers. The SN connector provides superior optical performance while reducing the typical number of connection points in the optical path.

The SN connector was designed to provide individual and independent duplex fiber breakout at a quad-style transceiver (QSFP, QSFP-DD & OSFP) that is more efficient, reliable, and scalable than the MPO connector. The SFP-DD has also adopted the SN as their independent duo-style interface, mainly for wireless front-haul applications.

Beyond transceiver interfaces, SN increases and improves the fiber density and capacity for the existing fiber optic cassettes and patch panels. Compared to the LC connector, SN provides 3 times higher density. This will further support the implementation of more fibers without adding new rack units.

Below are some examples of how the new SN connector can be utilized in 400G hyperscale networks.

3.4i Direct Patching SN – SN

Figure 3.4i

3.4j Direct Patching SN – SN

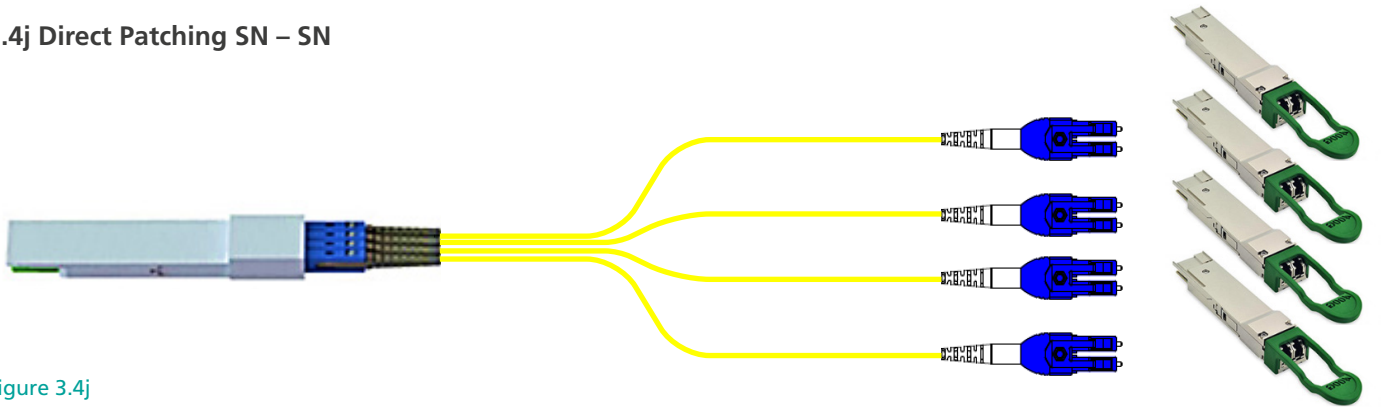


Figure 3.4j

3.4h Direct Patching SN – MPO

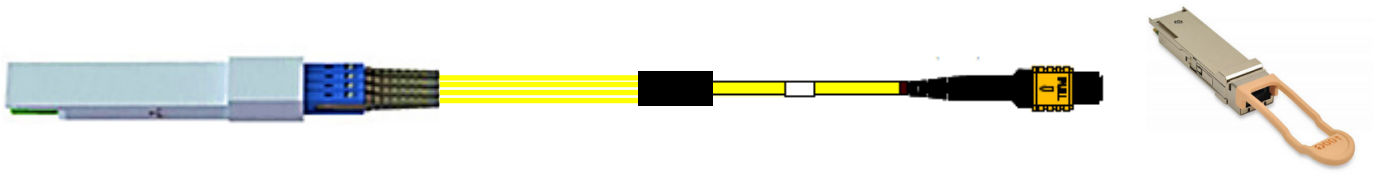


Figure 3.4h

Table 3.4h Product selection guide

AFL Hyperscale Product Name	Datasheet
AFL Hyperscale SN - SN Patch Cord	Contact AFL Hyperscale Sales for more details
AFL Hyperscale SN - LC Patch Cord	
AFL Hyperscale SN – MPO Breakout Assembly	

The uptake of 400G is a key step along the way to the 800G and 1.6T Ethernet future. The right topology today can support the growing data demands of tomorrow.

4. References:

Ethernet Alliance https://ethernetalliance.org/
IEEE 802.3 ETHERNET WORKING GROUP http://www.ieee802.org/3/
AFL Hyperscale https://www.aflhyperscale.com/
Arista Networks https://www.arista.com/en/
Fujikura Global https://www.fujikura.com/
Senko Advanced Components https://www.senko.com/
USConec https://www.usconec.com/
Prolabs https://www.prolabs.com/
EPS Global https://www.epsglobal.com/

AFL HYPERSCALE®

Data Center Cabling and Connectivity Experts

AFL Hyperscale is the first cabling and connectivity solution provider focused on the ever-evolving needs of data centers.

Hyperscale, colocation, and enterprise data centers are united in their pursuit to connect the unconnected, yet their infrastructure, performance, and operational challenges are totally unique.

We work collaboratively with our customers to create connectivity solutions tailored to their current needs and to the requirements of future networks. We then use our responsive, global operational capabilities and distribution network for fast delivery.

This approach has transformed how many data centers grow worldwide and is built on 70 years' combined experience in the design and manufacture of high-performance optical fiber networks, a global presence, and the backing and innovation sharing of our parent and grandparent companies, AFL and Fujikura, the pioneer in optical technology. AFL Hyperscale is your dependable partner to build a more connected world.

AFL Hyperscale - The World, Connected.

www.aflhyperscale.com