High-Density Cabling

Design Guide

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Chapter 1: Preface

As Fibre Channel network data rates continue to increase, the need for options to support faster and simpler connectivity is growing as well. Alternatives to the widely used LC connectors, including dual-port double-density (SFP-DD), quad-port small form-factor pluggable (QSFP), and eight-port octal small form-factor pluggable (OSFP) transceivers, are increasingly being deployed to enable a denser consolidation of optics and cabling. The SFP-DD optics used on the FC64-64 high-density port blade for the Brocade® X7 Directors, and Brocade G720 and G730 Switches are increasingly becoming a common option to increase connectivity from a limited space. Brocade SFP-DD optics support high-speed 64GFC connectivity through a two-lane electrical host interface with two SN cable connections per optic. QSFP optics are used on Brocade X7 Director UltraScale inter-chassis link (ICL) connections, and Q-Flex ports on the Brocade G630 Switch as well as legacy products going back several generations, with many readily available cabling options. OSFPs are used for even higher port density to meet the needs of large-scale data center operators are using for Brocade X8 Director ICL connectivity.

1.1 Purpose of This Document

Using SFP-DD, QSFP, and OSFP optics to connect to device ports may not be familiar to all Fibre Channel users. This document provides customers who deploy SFP-DD-equipped, QSFP-equipped, and OSFP-equipped devices with general guidelines for optical fiber cable procurement and cable management.

1.2 Audience

This guide is for technical IT architects and storage area network (SAN) administrators who are responsible for SAN design or infrastructure management based on the Brocade X7 and X8 Directors equipped with FC64-64 blades, UltraScale ICLs, and other SFP-DD-connected, QSFP-connected, or OSFP-connected products.

1.3 Objectives

This document provides best practices in cable deployment and management to avoid many unforeseen challenges that SAN designers face when implementing cabling solutions to support SFP-DD, QSFP, and OSFP connectivity in a storage fabric. While not intended as a definitive cable design document, it does introduce concepts and guidelines to help avoid potential issues that can result from poor cable implementation practices, and it provides a reference for procurement of compatible cabling options for those connectors.

This guide covers the following topics:

- An overview of the Brocade products that use SFP-DD, QSFP, and OSFP optics
- Structured high-density cable management solutions based on available connectors and patch panels
- Best-practice guidelines and recommendations for optical fiber cabling
- Descriptions of cabling required for various configurations
- Part numbers for some available optical cables and patch panels, and vendor contact information

1.4 Terminology

The following table contains some commonly used terms that you will find throughout this guide.

Term	Description
APC connector	Angled physical contact fiber connector constructed with an angle (typically 8°) applied to the end faces to minimize back reflection.
Breakout cable	Also called a fan-out cable, a multifiber cable enveloped in a common jacket, allowing individual fibers to split out from a single common connector to multiple connectors.
LC connector	Lucent Connector found on single-channel SFP, SFP+, or XFP transceivers.
LCx2 connector	Dual duplex LC receptacle optical connector used for 2-km ICL connections from a Gen 8 chassis.
MPO/MTP	MPO is an industry term for multifiber push-on connectors including the MPO-12 and MPO-16 used on Brocade products. MPO/MTP connectors are used with multilane transceiver types including QSFPs and OSFPs. MTP is a trademarked name of an MPO connector with design enhancements to improve mechanical and optical performance. An MTP is a fiber connector that complies with the MPO standard and is often used synonymously with MPO, but not all MPO connectors are MTP. **NOTE:** The terms MPO and MTP may be used in this document in combination or interchangeably to represent what are understood to be compatible designs.
Optical cable harness	An assembly of bundled optical fibers that transmit signals bound together by a durable material or weave.
OSFP transceiver	Octal small form-factor pluggable (OSFP) eight-lane transceivers used for high-performance computing applications with high-density connectivity requirements, connecting via an MPO/MTP or LC connector.
Patch cable	Cables consisting of single or multiple fibers for connectivity between switches or devices.
Patch panel	A device with ports or jacks used as an interface to connect and route optical signals across a network.
QSFP transceiver	Quad small form-factor pluggable (QSFP) four-lane transceivers used for high-performance computing applications connecting via an MPO/MTP or LC connector.
SFP-DD port	A double-density interface that supports the use of two-lane SFP-DD optical transceivers or a single SFP+ transceiver.
SN connector	A very small form-factor (VSFF) optical fiber connector used on SFP-DD optics that enables two independent channel connections from a single transceiver port.
Structured cable management	A series of cabling interfaces and trunks that provide connections from hardware ports to patch panels connected through a trunk in the main distribution area (MDA). Structured cabling provides a standardized, organized way of cabling systems.
U	Rack unit; 1U = 4.4 cm/1.75 in.
UPC connector	Ultra physical contact (UPC) fiber connectors are designed to have essentially flat end faces with a slight curvature that improves core alignment.

1.5 Related Documents

- Brocade Transceiver Support Matrix
- Brocade X8 Director Product Brief
- Brocade X8-8 Director Hardware Installation Guide
- Brocade X8-4 Director Hardware Installation Guide
- Brocade X7 Director Product Brief
- Brocade X7-8 Director Hardware Installation Guide
- Brocade X7-4 Director Hardware Installation Guide
- Brocade G730 Switch Hardware Installation Guide
- Brocade G720 Switch Hardware Installation Guide
- Brocade G630 Switch Hardware Installation Guide

Chapter 2: Introduction

As data centers scale to handle higher amounts of stored data distributed across a growing number of devices, the use of high-port-count switching products featuring smaller form-factor connectors has grown as well. To enable high-density port configurations as well as improved serviceability and simplicity of use, Brocade products use a space-efficient, four-channel quad small form-factor pluggable (QSFP) optic on Brocade X7 Director ICL ports, and Q-Flex ports on the Brocade G630 Switches. On the Brocade Gen 7 FC64-64 blade and the Brocade Gen 7 G720 and G730 Switches, SFP-DD ports support either small form-factor pluggable double-density (SFP-DD) optics with dual SN connectors or single-channel SFP+ optics from the same port. The SN is a push-pull style connector that offers twice the port density of an LC connector with the same quality and mechanical performance. The X8 ICL blades connect to other chassis using an eight-lane OSFP connector for even higher port density per cable. SFP-DDs, QSFPs, and OSFPs all retain the performance and functionality of the standard SFP+ transceivers.

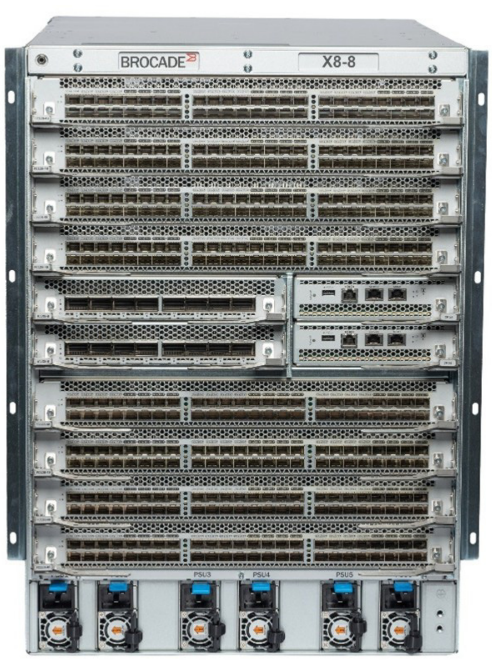
Brocade products offer SFP-DD, QSFP, and OSFP optics on several models. For more information, see the following sections.

2.1 Brocade Gen 8 Directors

Brocade X8 Directors with Gen 8 UltraScale Inter-Chassis Links

The Brocade X8 Director features Gen 8-speed ICL connectivity that connects up to 12 Brocade director chassis in a common core edge, or up to nine directors in an active-active mesh chassis topology across distances up to 2 km while running at twice the speed of Gen 7 ICLs. Cabling infrastructure is minimized with the use of octal SFPs on the ICL port blades that connect eight links via an MPO-16 connector and multimode fiber (MMF) up to 100m or a 2xLC connector and single-mode fiber (SMF) up to 2 km. The eight-lane OSFP transceivers reduce cabling requirements from the ICL ports by 88% compared to single-lane SFPs.

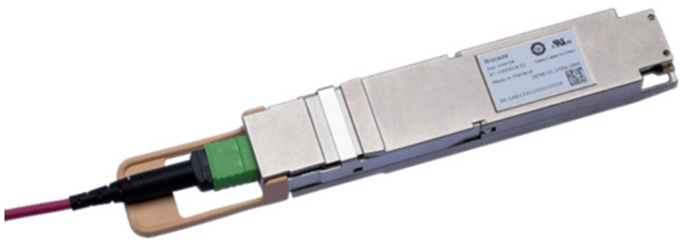
Figure 1: Brocade X8-8 Populated with ICL Blades (Left) and a Brocade ICLX8-8 Blade (Right)



Octal Small Form-Factor Pluggable (OSFP) Transceivers

Gen 8 ICLX8 blades support eight-lane OSFP transceivers for industry-leading port density for ICL connectivity within a SAN fabric. Brocade OSFP port interfaces use transceivers with MPO-16 connectors, providing eight bidirectional links of Gen 8 ICL connectivity between X8 chassis or Gen 7 ICL-speed connectivity to an X7 ICL connector. The OSFP connector can also be plugged into QSFP or OSFP-connect patch panels or cable management systems. See Appendix D, Equipment List for patch cable options from leading cabling vendors.

Figure 2: Brocade Gen 8 OSFP 100m Optical Transceiver with Connected MPO-16 Fiber Cable

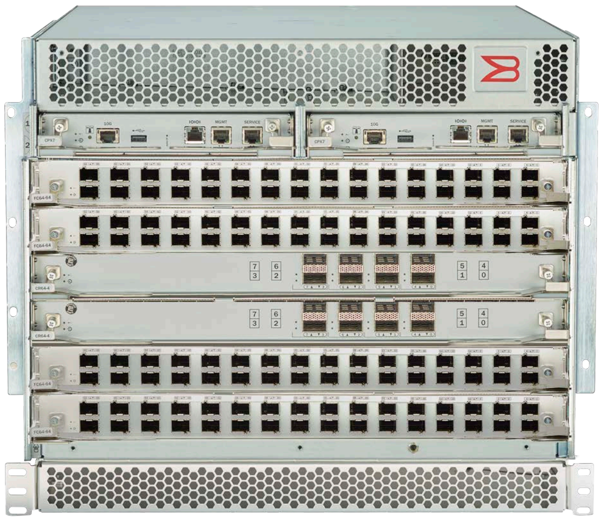


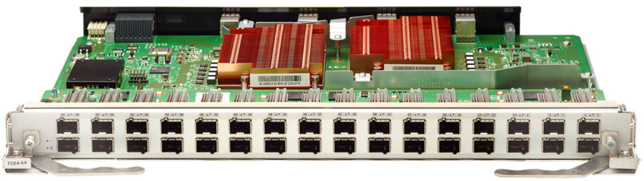
2.2 Brocade Gen 7 Directors

Brocade X7 Directors with Gen 7 UltraScale Inter-Chassis Links and Brocade FC64-64 Port Blade

The Brocade FC64-64 high-density 64-port Fibre Channel blade for the Brocade X7 Director provides industry-leading port density in a Brocade X7 chassis with full support for the Gen 7 feature set. The FC64-64 enables users to maximize the port count of the X7 chassis along with the ability to monitor both FC and NVMe traffic and automate actions to quickly resolve issues in the fabric when they occur. The FC64-64 blade increases Fibre Channel port count by 33% over a chassis populated with 48-port blades, enabling the Brocade X7-8 to scale up to 512 device ports and the Brocade X7-4 to scale up to 256 device ports with full 64G performance.

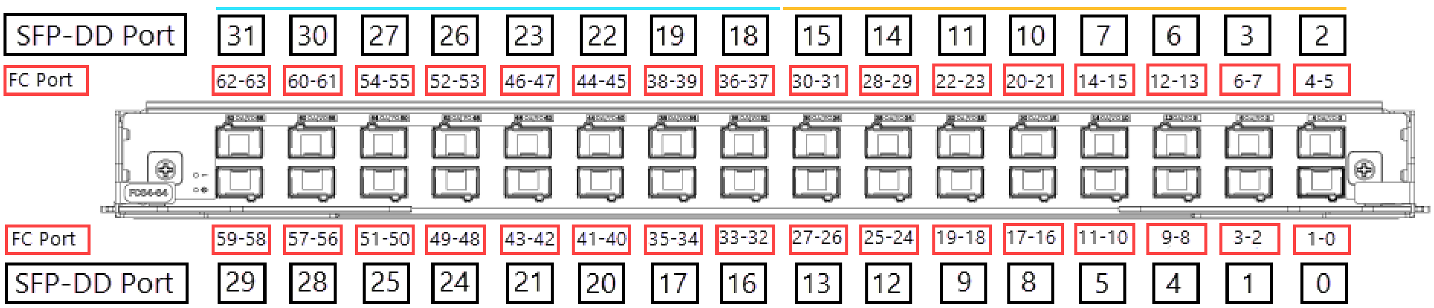
Figure 3: Brocade X7-4 Populated with Four Brocade FC64-64 FC Port Blades (Left) and a Brocade FC64-64 Blade (Right)





The FC64-64 SFP-DD ports provide two ports for device or ISL connectivity with SN connectors, and port speed is configurable independently for each port. Four SN connectors can combine into a single QSFP breakout cable for connection to a QSFP patch panel or switch port, or individual fiber cables can terminate with an LC connector to connect to an LC patch panel or ports. The Brocade FC64-64 blade port numbering is shown in the following figure.

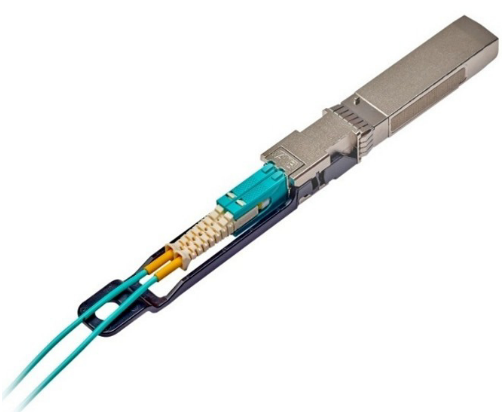
Figure 4: Brocade FC64-64 Port Blade Port Numbering



Double-Density 64G Optical Transceiver (SFP-DD)

The Gen 7 FC64-64 blades SFP-DD support double-density 64G optical transceivers (SFP-DD), which allows them to scale to achieve industry-leading port density. Brocade SFP-DD port interfaces use transceivers with SN connectors, one of a new generation of very small form-factor (VSFF) optical fiber connectors that have been optimized for space efficiency, reliability, and scalability. Each SFP-DD port can accommodate either an SFP+ or SFP-DD transceiver, providing the flexibility to use either transceiver in those ports as needed. The other end of the cable is most often an LC connector that can be plugged into LC-connect devices, standard LC patch panels, or cable management systems. Whether using SFP+ or SFP-DD transceivers, cable management practices are no different from other standard single-cabling systems. See Appendix D, Equipment List for patch cable options from leading cabling vendors.

Figure 5: Brocade 64G-SFP-DD Optical Transceiver with Connected Fibers



Gen 7 UltraScale ICL Cabling of High-Port-Count SAN Fabrics

UltraScale ICLs provide optical connectivity for up to 12 Brocade director chassis in a common core-edge or up to nine directors in an active-active mesh chassis topology across distances up to 2 km. Gen 7 topologies use QSFP optics from dedicated ports on the core routing blades, which consolidate inter-switch cabling by 75% and free up to 25% of chassis ports to use as server and storage device connections. This topology provides the equivalent of up to 640 line-speed connections in a 14U chassis, the highest density available per rack unit (U) in a modular chassis. Core routing blades with ICL connectors occupy the middle two slots of the X7-4 chassis shown in Figure 3.

Figure 6: Quad SFP (QSFP) Optical Transceiver with an MPO-12 Connector

2.3 Brocade Gen 7 Switches

Brocade G720 Switch

The Brocade G720 Switch is built for maximum flexibility, scalability, and ease of use, providing comprehensive telemetry with built-in analytics to optimize storage network performance and eliminate disruptions. The Brocade G720 scales from 24 to 64 ports with 48 SFP+ and 8 SFP-DD ports, which support up to 16 channels at full 64GFC speed. Each SFP-DD port can accommodate either a single-channel SFP+ optic or a dual-channel SFP-DD transceiver, providing the flexibility to use either transceiver in those ports when needed. SFP-DD ports can be used to form dense, high-performance device connectivity or ISLs between Brocade switches and directors.

Figure 7: Brocade G720 Switch with 8 x SFP-DD Transceiver Ports

Brocade G730 Switch

The Brocade G730 Switch provides high-density port count and Gen 7 connectivity to enable dense rackmount environments to connect more devices and build larger fabrics. 128 ports in a 2U design allow organizations to create high-scale fabrics in less space. Its 16 SFP-DD ports support up to 32 channels with line-rate 64GFC performance.

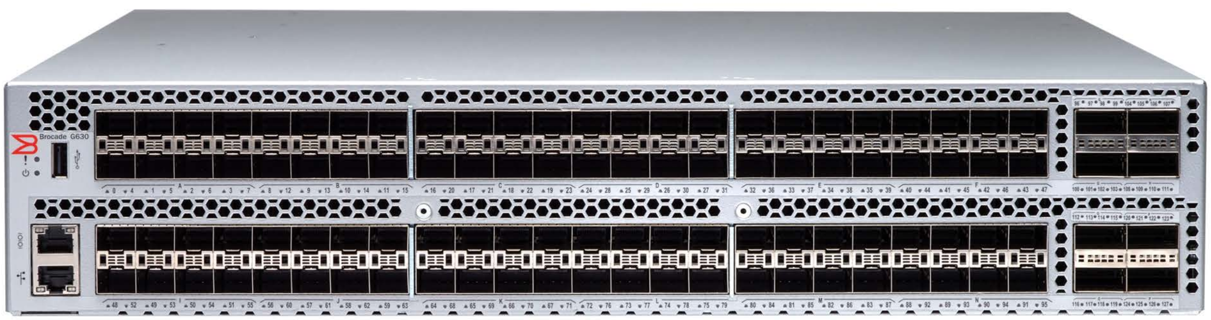
Figure 8: Brocade G730 Switch with 16 x SFP-DD Connectors

2.4 Brocade Gen 6 Switch

Brocade G630 Switch

The Brocade G630 is a 128-port, enterprise Fibre Channel switch to support the growing requirements of large and dynamic environments. The Brocade G630 is configurable from 48 to 128 ports with 96 SFP+ and 8 QSFP-based Q-Flex ports. The G630 scales from 48 to 128 ports with a combination of 24-port SFP+ Ports-on-Demand (PoD) licenses and a 32-port Q-Flex PoD license. Each of the eight Q-Flex ports is capable of supporting 4×32G or 128G speeds for device port or ISL port connectivity. Q-Flex ports are designed to support connections to another single QSFP optical transceiver or to fan out to four standard LC connectors, enabling administrators to customize their cabling infrastructure as they wish. The PoD feature of the Brocade G630 gives organizations the flexibility to quickly scale port count at any time.

Figure 9: Brocade G630 Switch with 8 x Q-Flex MPO Connectors



2.5 Differences between SFP+, SFP-DD, QSFP, and OSFP Optics

The following table provides an overview of the differences between standard SFP+, SFP-DD, QSFP, and OSFP ports used on current Brocade platforms.

Specification	SFP+	SFP-DD	QSFP	OSFP
Speed Grades[a]	16GFC: 4G/8G/16G 32GFC: 8G/16G/32G 64GFC: 16G/32G/64G 128GFC: 32G/64G/128G	64G: 16G/32G/64GFC	16G: 4G/8G/16GFC 32G: 8G/16G/32GFC GEN 7 ICL: 50Gb	GEN 8 ICL: 50Gb/100Gb
Operating Distance	100m/10 km/25 km	100m	100m/2 km	100m/2 km
Availability of SWL Transceivers	Yes	Yes	Yes	Yes
Availability of LWL Transceivers	Yes	No	Yes, up to 2 km	Yes, up to 2 km
Availability of ELWL Transceivers	Yes	No	No	No
Regulatory Compliance	Same	Same	Same	Same
Dimensions: Width	13.55 mm	13.55 mm	18.35 mm	22.58 mm
Dimensions: Depth	56.40 mm	Without pull-tab: 79.09 mm With pull-tab: 146.44 mm	Without pull-tab: 71.0 mm With pull-tab: 122.3 mm	Without pull-tab: 114.0 mm With pull-tab: 149.7 mm
Patch Cord Compatibility	LC to LC patch cord	SN to SN, SN to LC, or 4x SN (breakout) to MPO-12 patch cords up to 100m	MPO-12 to MPO-12 or MPO-12 to 4xLC breakout patch cords for 100m optics. LC to LC SMF patch cords are required for Gen 7 and Gen 8 ICL 2-km LWL optics.	MPO-16 to MPO-16 or MPO-16 to 2x MPO-12 breakout patch cords for 100m optics.
Optics Supplier	Broadcom	Broadcom	Broadcom	Broadcom

a. Referenced speeds may vary by individual optic. Please reference the *Brocade Transceiver Support Matrix* for detailed specifications.

Brocade products require the use of OM-3, OM-4, OM-4+, or OM5 fiber cables with QSFP or SFP-DD optics to attain FC standards for connectivity distance. See Appendix D, Equipment List, for cable manufacturer and part number details. The following MPO-terminated cables provide the same flexibility in connectivity as standard LC cables:

- MPO-12 to MPO-12 cable assembly: Allows a G630 to connect to an MPO/MTP-12 patch panel or a G630 or G620 Switch as an ISL, as well as connecting ICL ports between Brocade X6 and X7 Directors.
- MPO-12 to 4xLC breakout cable assembly: Provides G630 Q-Flex ports with the ability to connect to port blades, switches, hosts, or storage devices utilizing LC connectors or patch panels.
- MPO-16 to MPO-16 cable assembly: Allows Gen 8 OSFPs to connect ICL ports between Brocade X8 Directors up to 100m.
- MPO-16 to 2xMPO-12 cable assembly: Allows one X8 ICL blade to connect to an MPO/MTP patch panel or connect ICL ports up to 100m between Brocade X8 and X7 Directors. *Cables listed in the* Appendix D.3, Patch Cables for OSFP Connections *table with the OSFP to 2x QSFP type have been validated for use in this configuration.*

Figure 10: MPO/MTP-12 to LC Breakout Cable (Left) and MPO/MTP-16 to 2xMPO/MTP-12 Breakout Cable (Right)

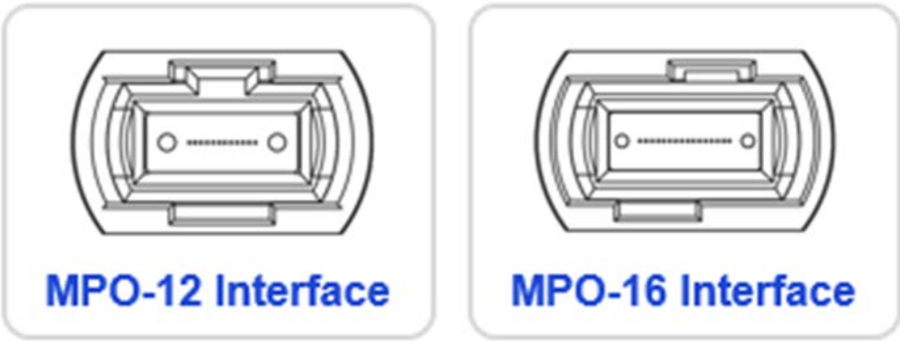
SN-terminated cables can be used to connect to Brocade SFP-DD optics used on the Brocade G720 and G730 Switches and the FC64-64 port blade, and follow the same cabling distance specifications as standard LC-terminated MMF (OM3 or OM4/OM5) cables. Single SFP-DD optics provide two separate duplex connections per transceiver, one per channel, rather than combining multiple channels into one transceiver and MPO-connect fiber cable like a QSFP or OSFP. Therefore, cable management guidance will be the same as LC-terminated cables.

- SN to LC cable assembly used for connections between servers, storage devices, or LC patch panels and SN-connector-equipped SAN ports
- SN to SN cable assembly for ISL connections between SN connector-equipped SAN ports
- 4x SN to QSFP breakout cable assembly is used for connections from SN-connected ports to QSFP patch panels

Figure 11: SN Connector (Left) and SN to SN (Middle) and SN to LC (Right) Patch Cables

Figure 12: MPO-16 Connector (Left), MPO-16 to MPO-16 (Middle) and MPO-16 to 2x MPO-12 Breakout (Right) Patch Cables

Figure 13: MPO-12 and MPO-16 Connector Interfaces

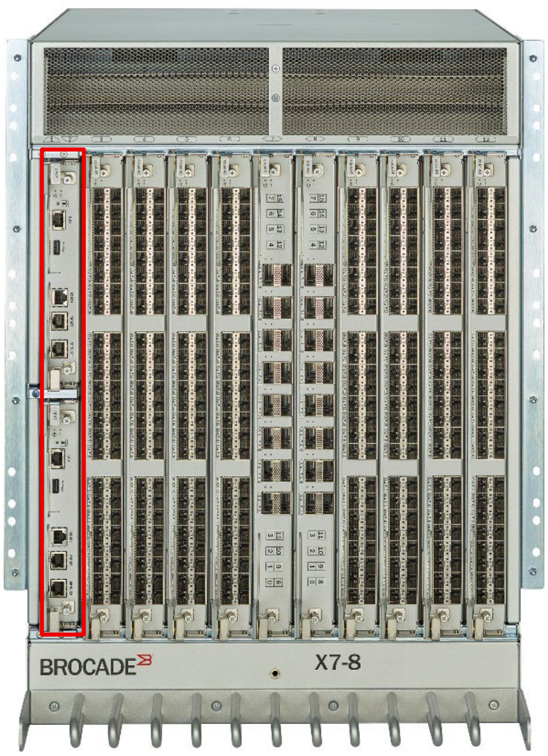


Chapter 3: Plan for Cable Management Deployment

As port density per director and per rack increases, having an appropriate cable management plan is key during servicing or scaling of a fabric and eases troubleshooting. The cable management plan should include current and future SAN design requirements. Cables may need to be managed in a variety of ways. For an X7-8 chassis, the cleanest cable routing is below the chassis, whereas an X7-4 or an X8 chassis requires that the cables be routed to the sides of the chassis. Alternate methods may be through cable channels on the sides of the cabinet or by using patch panels. When planning a cable management solution and the cable routing path, consider the location of the rack's power strip and the Brocade Director's power supplies to eliminate cable interference when servicing the power supplies and cords.

For Brocade X7-8 users, ensure that the location of the half-height control processor blades on the far-left side of the chassis allows for unblocked access to management ports.

Figure 14: Brocade X7-8 Director with Control Processor Blades in Slots 1/2 Position



The cable management plan may involve wiring a new data center or upgrading the cabling in an existing data center.

- If an existing data center is being upgraded, evaluate, capture, and understand the present cabling infrastructure thoroughly.
- Document the current (if any) and projected network topologies using an application such as Microsoft Visio. Focus on the physical aspects, especially equipment interfaces. Document the various cable types and counts present, proposed, and projected; the approximate routed distances to distribution areas and equipment; and the present and anticipated equipment port counts. Additionally, document any areas of concern and any established internal cabling standards.
- Plan to accommodate for current and future growth. Build in flexibility, so that the patching structure will allow a device to connect to any other device in the data center. This flexibility will permit devices to be located anywhere within the data center.

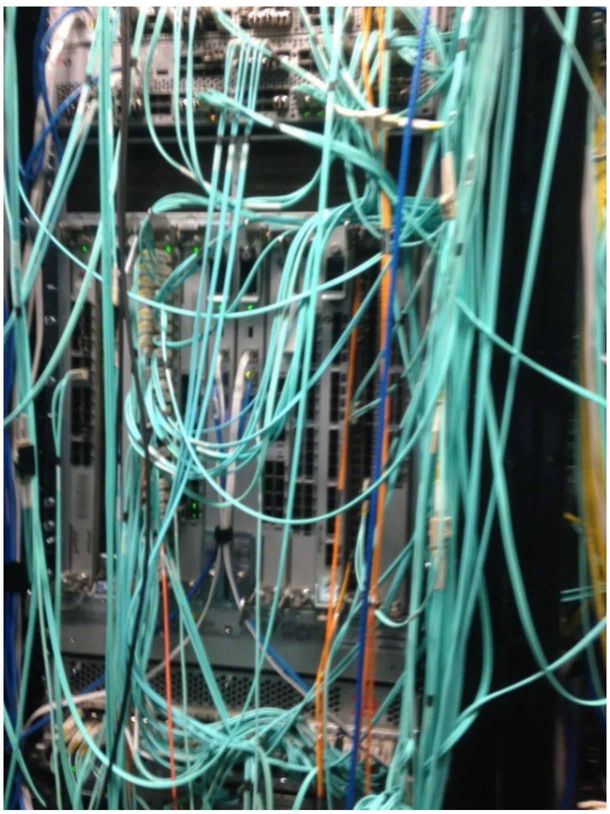
3.1 Challenges with Unstructured High-Density Solutions

All three growth factors (volume, performance, and distance) have placed enormous strain on IT organizations, requiring miles of cable infrastructure to interconnect servers, storage, and Fibre Channel fabrics for fast, reliable data and application delivery. Unfortunately, many organizations still rely on traditional point-to-point cable solutions, reactively deploying cables one at a time to suit immediate needs.

The resulting cable clutter inhibits intelligent, pragmatic growth and contributes to an inefficient growth strategy that will only worsen over time. The tasks of verifying proper connectivity, troubleshooting, and managing device change also become more complex and time consuming and can lead to planned or unplanned downtime of critical business applications.

This inefficient approach also contributes to the overheating of data centers, particularly within raised flooring and around the racks where cable clutter primarily occurs, requiring additional resources to cool the systems.

Figure 15: Cable Clutter



3.2 Use a Structured Approach

Cable management solutions designed specifically for Brocade Switches and Directors enable a reliable, flexible, and highly efficient cable infrastructure throughout the data center. Depending on their specific requirements, organizations can choose from various structured fiber-optic cable management solutions. By moving from traditional low-density, duplex patch-cord cable solutions to high-density, structured cable solutions, organizations can implement the physical layer in a much more manageable and flexible manner while streamlining data center reconfigurations and simplifying management. These cable technologies are also more energy efficient, and they help organizations consolidate their IT infrastructures.

3.2.1 High-Port-Count Fiber Equipment for QSFP or OSFP Connectivity

As networking equipment becomes denser and port counts in the data center increase to the hundreds and thousands, managing cables connected to these devices becomes a difficult challenge. Traditionally, connecting cables directly to individual ports on low port-count equipment was considered manageable. Applying the same principles to high-port-count equipment made the task more tedious, eventually becoming nearly impossible to add or remove cables connected directly to the equipment ports. The guidance below may apply to MPO-12 connectors used with Brocade QSFPs or MPO-16 connectors used with Brocade OSFPs.

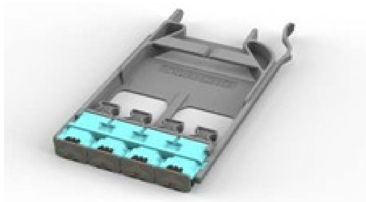
Structured cabling uses optical fiber connector housings that are connected through permanent links of optical cabling, typically configured in a physical star topology from the various areas within the data center (storage, servers, SAN, and network). Using pre-terminated MPO cabling from each of these areas to a central patching area provides an infrastructure where any port from any device can be connected to any other port.

Typical components used in optical cabling infrastructure are shown in the following table.

Table 1: Optical Cabling Infrastructure Components

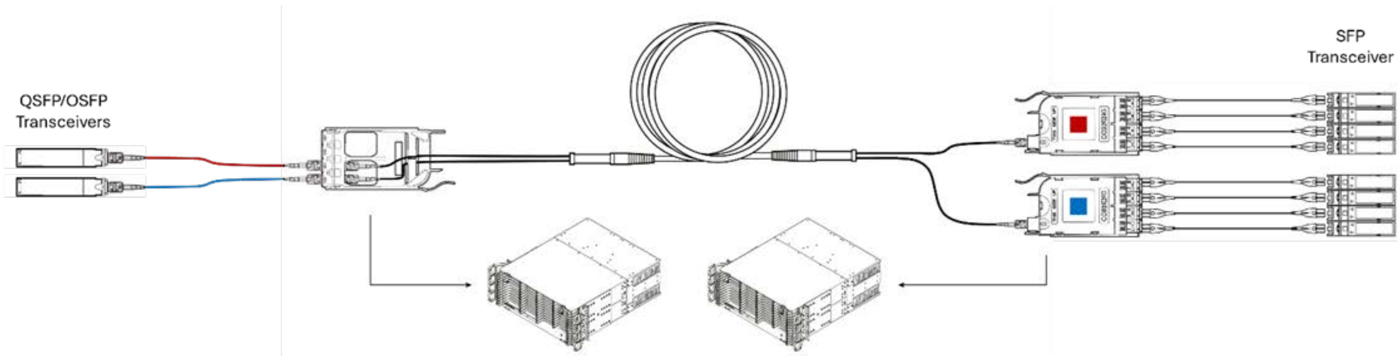
Component	Image	Description
MPO Trunk Assembly		MPO-terminated optical fiber trunk assemblies are typically 8 to 288 fibers and create the permanent fiber links between patch panels in a structured cabling environment. These assemblies are pre- terminated from the manufacturer with MPO connectors at a specified length, and have a pulling grip for easy installation and removal.
Connector Housing		Connector housings are physically mounted in a 19-in. rack or cabinet. They are typically offered in various sizes such as 1U, 2U, or 4U, which refers to the amount of rack space required for mounting.
MPO to LC Module		MPO to LC modules are installed into the connector housings. They break out the MPO connection from the trunk cables into LC connectivity. The trunk cables plug into the rear MPO of the module, and LC jumpers plug into the front of the module.

Table 1: Optical Cabling Infrastructure Components

Component	Image	Description
MPO Adapter Panel		MPO adapter panels (sometimes called bulkheads) are installed into the housings. They offer a connection point between the MPO trunks and the MPO jumpers or breakout harnesses. The trunk cables plug into the rear of the panel, and the MPO jumpers or harnesses plug into the front of the panel.
MPO to LC Harness (breakout cable)		MPO to LC harness assemblies are used to break out the MPO connector into multiple LC connections.
MPO or LC Jumpers	 	LC uniboot and MPO jumpers serve to create the connection between device ports and the structured cabling.
MPO-16 to 2xMPO-12 Harness (breakout cable)		MPO-16 to 2xMPO-12 harness assemblies are used to break out the MPO-16 connector at the OSFP into two 8-fiber MPO-12 connections at the QSFP.

When cabling high-density, high-port-count MPO equipment, such as Brocade Directors and the G630 Switch, the recommendation is to pre-connect the director blades with MTP/MPO jumpers with connectivity to dedicated connector housings. From these housings, the MTP jumpers interconnect to MPO-based structured cabling for breakout into LCs in another connector housing at the other end of the cabling link (see Figure 16).

Figure 16: Structured Cabling Example for MPO Connectivity to LC Breakout in Central Patching Area



Once fully cabled, the housings in this central patching area function as if they were remote ports for the director ports. These dedicated patch panels may be located in the same or adjacent cabinet as the director (typically in small data center footprints) or in a separate central patching area (typically in medium-large data center footprints). Using this strategy drastically reduces equipment cabling clutter and improves cable management.

3.3 Cabling Standards

Industry cabling standards are designed to protect the end user, providing a firm foundation for establishing a coherent infrastructure and guidelines for maintaining high levels of cable performance. Cabling standards define cabling specifications that look out to the next several years, supporting future needs for higher-speed transmissions. Standards enable vendors to use common media, connectors, test methodologies, and topologies, and they allow planners to design a cabling layout in the data center without worrying about compatibility issues.

There are a number of standards organizations and standards. The best-known cabling standards are listed below.

3.3.1 Data Center-Specific Standards

- United States: ANSI/TIA-942, *Telecommunications Infrastructure Standard for Data Centers*
- United States: ANSI/BISCI 002, *Data Center Design and Implementation Best Practices*
- Europe: CENELEC EN 50173-5, *Information Technology—Generic Cabling Systems—Part 5: Data Centres*
- International: ISO/IEC 24764, *Information Technology—Generic Cabling for Data Centres*

3.3.2 General Commercial Building Cabling Standards

- United States: ANSI/TIA-568, *Generic Telecommunications Cabling for Customer Premises*
- Europe: EN 50173-1, *Performance Requirements of Generic Cabling Schemes*
- International: CSA ISO/IEC 118019, *Information Technology: Generic Cabling for Customer Premises*

3.3.3 Cabling Administration Standards

- United States: ANSI/TIA-606, *Administration Standard for the Commercial Telecommunications Infrastructure*

NOTE: Cabling standards are reviewed and changed every five to ten years, which allows them to keep pace with technology advances and future requirements. Standards may be purchased online from IHS at global.ihs.com/.

3.4 Establish a Naming Scheme

Once the logical and physical layouts for the cabling are defined, apply a logical naming scheme that will uniquely and easily identify each cabling component. Effective labeling promotes better communication and eliminates confusion when someone is trying to locate a component. Labeling is a key part of the process and should not be skipped. The following list provides some suggested naming schemes for labeling and documenting cable components (examples appear in parentheses):

- Building (SJ01)
- Room (SJ01-5D11)

  NOTE: Building and room may be excluded if there is only one instance of this entity in the environment.
- Rack or grid cell: Can be a grid allocation within the room (SJ01-5D11-A03)
- Patch panel: Instance in the rack or area (SJ01-5D11-A03-PP02)
- Workstation outlet: Instance in the racks or area (SJ01-5D11-A01-WS02)
- Port: Instance in the patch panel or workstation outlet (SJ01-5D11-A03-PP02_01)
- Cable (each end labeled with the destination port)

Once the naming scheme is approved, start labeling the components. Create a reference document that will become part of the training for new data center administrators.

NOTE: Additional recommendations can be found in the ANSI/TIA-606 standard, *Administration Standard for the Commercial Telecommunications Infrastructure*.

Chapter 4: High-Density Cabling Requirements for QSFP, OSFP, and SFP-DD Optics

4.1 QSFP to QSFP Optical Cables

The connector and cable required for connection between two Brocade SWL (100m) QSFP transceivers is MTP 1×12 with 12 UPC multimode fiber lanes in a row. Only the outer eight lanes of this cable are used (four from each end); the central four lanes are unused. The left-most four lanes are used for transmit; the right-most four lanes are used for receive. When connecting one QSFP to another QSFP, the cable connectors must be female at both ends.

In terms of polarity, the cable connectors need to be key-up/key-up, also known as crossed or type-B. For the actual fiber itself, the customer can choose OM3, OM4, or OM5 multimode fiber. OM4 and OM5 will allow for the longest link distances up to 100m and are strongly recommended.

4.2 QSFP to Four SFP+ (4xLC) Optical Breakout Cables

Breakout cables can also be used with newer SWL (100m) QSFP transceivers that support breakout (XBR-000475) to connect the QSFP to individual SFP+ ports at a device or another switch port, or an LC connector on a patch panel.

The connector on the SWL (100m) QSFP side is still a female MTP 1×12 as described above, with a breakout to 4x individual standard duplex LC connectors. For the actual fiber itself, the customer can choose OM3, OM4, or OM5 multimode fiber, with OM4 or OM5 recommended for the longer link distances at full line-rate speed.

4.3 QSFP to Two SFP-DD (4xSN) Optical Breakout Cables

Breakout cables can also be used with SWL (100m) QSFP transceivers to connect the QSFP to individual SFP-DD ports at another switch port, or an SN connector on a patch panel.

The connector on the SWL (100m) QSFP side is still a female MTP 1×12, with a breakout to 4x individual SN connectors. The fiber used is the same OM3, OM4, or OM5 multimode fiber. This cable configuration may not be widely available, so check with your preferred vendor for guidance.

4.4 OSFP to OSFP Optical Cables

The connector and cable required for connection between two Brocade SWL (100m) OSFP transceivers is MPO/MTP 1×16 APC with 16 multimode fiber lanes in a row. All sixteen lanes of this cable are used (eight from each end) for this application. The left-most eight lanes are used for transmit; the right-most eight lanes are used for receive. When connecting one OSFP to another OSFP, the cable connectors must be female at both ends.

In terms of polarity, the cable connectors need to be key-up/key-up, also known as crossed or type-B. For the actual fiber itself, the customer can choose OM3, OM4, or OM5 multimode fiber. OM4 and OM5 fiber supports the longest link distances up to 100m and are strongly recommended.

4.5 OSFP to 2x QSFP Optical Cables

Connecting 100m ICL ports from an X8 Director to an X7 Director over MMF requires a breakout cable to connect the X8's 8-port OSFPs to the X7's 4-port QSFPs. The connector on the SWL (100m) OSFP side is a female MPO/MTP 1×16 APC, with a breakout to 2x individual female MPO/MTP 1×12 UPC connectors for the QSFPs. The fiber used is the same OM3, OM4, or OM5 multimode fiber.

Figure 17: Gen 7 to Gen 8 ICL Connectivity using MPO-16/APC to 2x MPO-12/UPC Y-cable

To ensure optimal performance, see Appendix D.3, Patch Cables for OSFP Connections for a list of validated cable vendors.

4.6 LC Connectivity for 2-km ICLs

Broadcom also offers 2-km QSFP and 2-km OSFP optics for longer-distance Brocade ICL connectivity on X7 and X8 Directors. These extended-distance transceivers use a passive coarse wavelength-division multiplexing (CWDM) design that combines four channels onto a common 9-µm single-mode fiber (SMF) cable with a standard LC connector on each end. For these applications, high-quality SMF LC to LC cables at the required length (up to 2-km) from your preferred optical cabling vendor are recommended. The 2xLC connector on the X8 2-km ICL blade requires two equal-length LC-terminated cables or an integrated cable with a breakout to two LC connectors.

The following table summarizes the supported Brocade ICL optics along with their cabling characteristics.

Part Number	Optic	Distance	Use Case	Speed	Connector Type	Fiber Type
XBR-000420	Gen 7 QSFP	100m	ICL	Gen 7 ICL	MPO-12	MMF
XBR-000476	Gen 7 QSFP	2 km	ICL	Gen 7 ICL	LC	SMF
XBR-000475	32G QSFP	100m	Device/ISL/ICL	32GFC	MPO-12	MMF
XBR-000285[a]	32G QSFP	2 km	ISL/ICL	32GFC	LC	SMF
XBR-000502	Gen 8 OSFP	100m	ICL	Gen 8 ICL	MPO-16	MMF
XBR-000503	Gen 8 OSFP	2 km	ICL	Gen 8 ICL	2xLC	SMF

a. Supported but no longer offered for sale.

Chapter 5: Cable Management Setup and Configuration

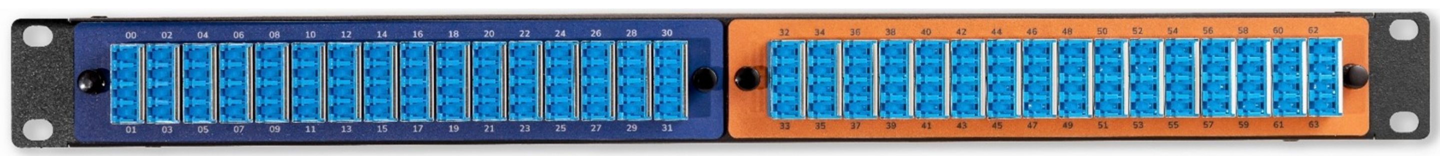
A cable management solution using an LC or MPO patch panel allows for easy connectivity of high-density cabling between Brocade Director ICL ports. Structured cabling solutions are available from multiple leading vendors and allow for higher consolidation of cabling into a compact patch panel. The following are examples of several vendors' solutions for cable management configurations. Consult with your preferred cabling provider to learn about solutions available from alternate vendors.

NOTE: Part numbers for the various design options are shown in Appendix D.

5.1 Cable Vendor

Cable Vendor is a Conexus Technologies brand, providing customized structured cabling solutions including the ULTRALiiT family of patch panels and matching cabling solutions designed to replicate Broadcom® 64-port blades. Users may connect to their structured cabling backbone via these 1U, 64-port LC to LC or MTP to LC patch panels. For dual fabric redundancy, users may want to deploy a simple color-coded blue/orange visual overlay for simple physical differentiation of fabrics. Individual ports are conveniently labeled 00-63 to match the Brocade 64-port blade or switch labeling.

Figure 18: PNL-UL1U-64-BO 64-Port Patch Panel



Where rack space is at a premium, the ULTRALiiT double-density SN panel solutions support 128 ports in a 1U chassis to reduce rack space requirements by 50%.

Figure 19: PNL-UL1U-64-BO 128-Port Patch Panel

5.2 CABLExpress

CABLExpress offers port replication solutions tailored for Brocade Gen 8 Directors, as well as Brocade X7 and legacy X6 Director models. These solutions support a range of Brocade line cards using SFP+, SFP-DD, and QSFP connectors.

The CABLExpress Brocade Port Replication solution is a 10U modular system consisting of adapter panels, cassettes, and a staggered-trunking configuration. Designed specifically for Brocade Directors, the solution aligns port-for-port and blade-for-blade with the Director line card layout to extend and mirror the active director ports to a passive patching environment at the MDA or CPL, providing clear port mapping and structured access for ongoing management.

As a form of structured cabling, CABLExpress Port Replication is recommended in the TIA-942-C Data Center Standard for improving manageability and reducing risk in high-density environments.

Figure 20: CABLExpress Gen 8 Port Replication with a Brocade X8-8 Director Chassis in a 384-Port Configuration

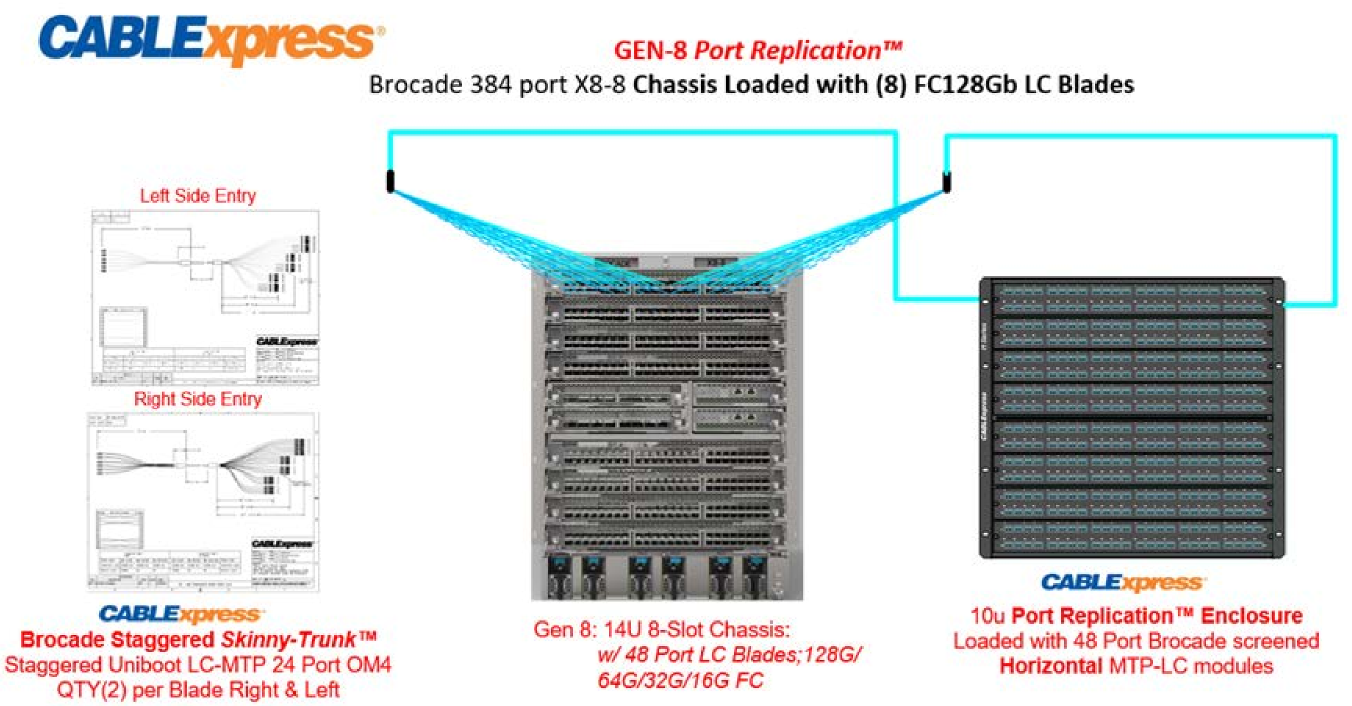


Figure 21: CABLExpress Gen 7 Port Replication with a Brocade X7-8 Director Chassis in a 512-Port Configuration Using FC64-64 Port Blades

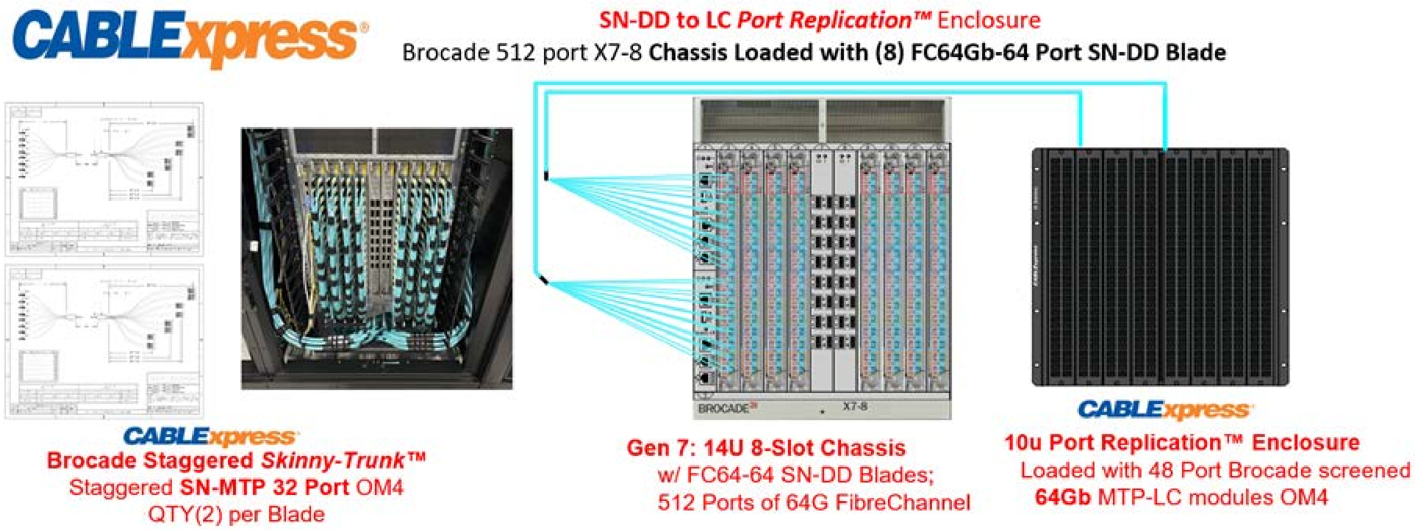
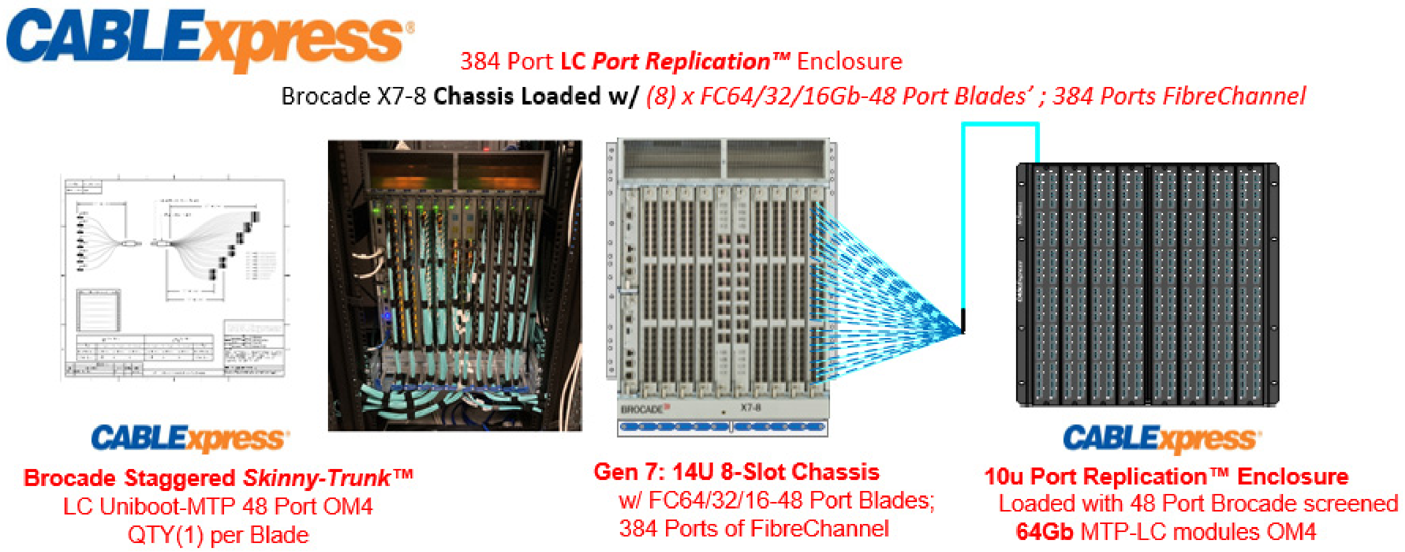


Figure 22: CABLExpress Gen 7 Port Replication with a Brocade X7-8 Director Chassis in a 384-Port Configuration Using FC64-48 Port Blades



CABLExpress Port Replication rack mount modules provide a patch panel with a direct one-to-one relationship between the ports on a Brocade G720 switch and the patch panel. This correlation reduces the chance for patching errors since the ports are numbered and oriented the same, facilitating the cabling moves, adds, and changes (MACs). These replication patch panels are prewired to convert the Brocade G720 SFP-DD ports into duplex LC ports, avoiding the need for conversion harnesses.

Figure 23: CABLExpress 64-Port Replication Modules for Brocade G720 Switch with SFP-DD Ports

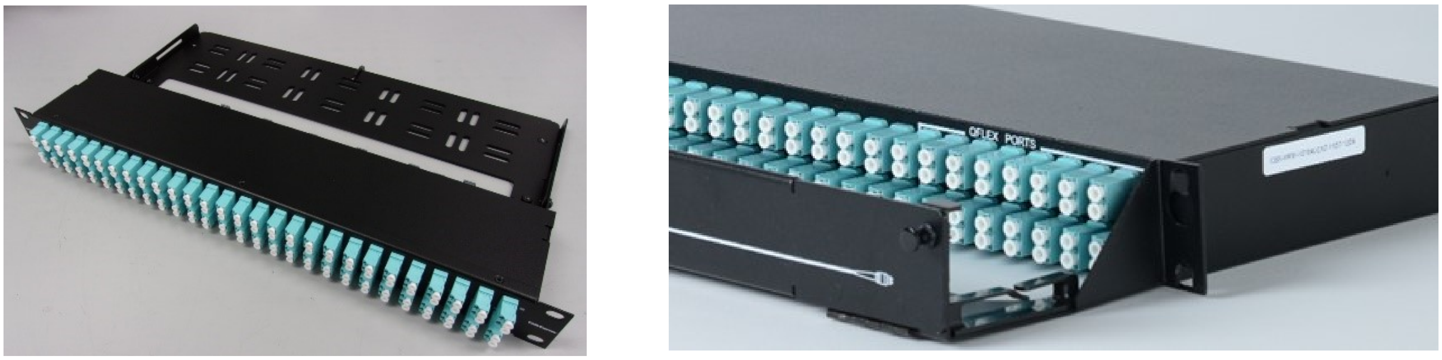


Figure 24: SN Duplex to LC Duplex Structured Cabling Interconnect

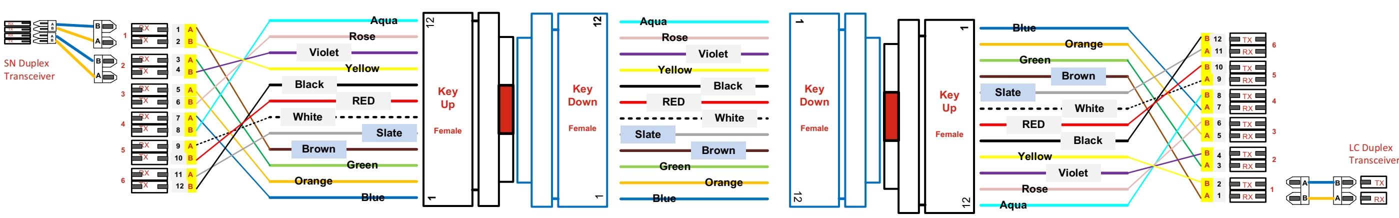
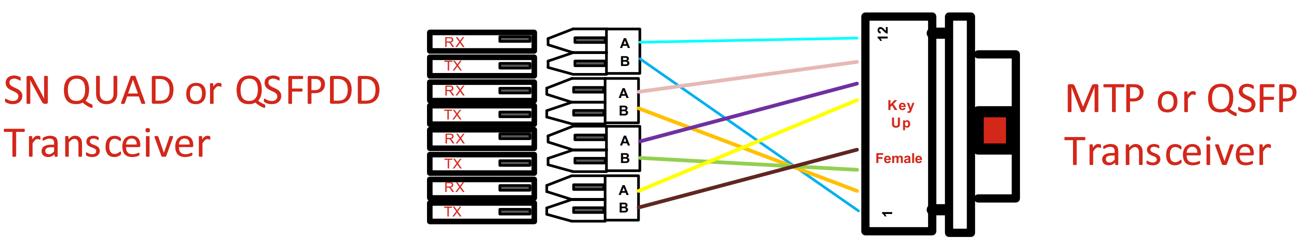


Figure 25: SN Duplex to MTP Harness



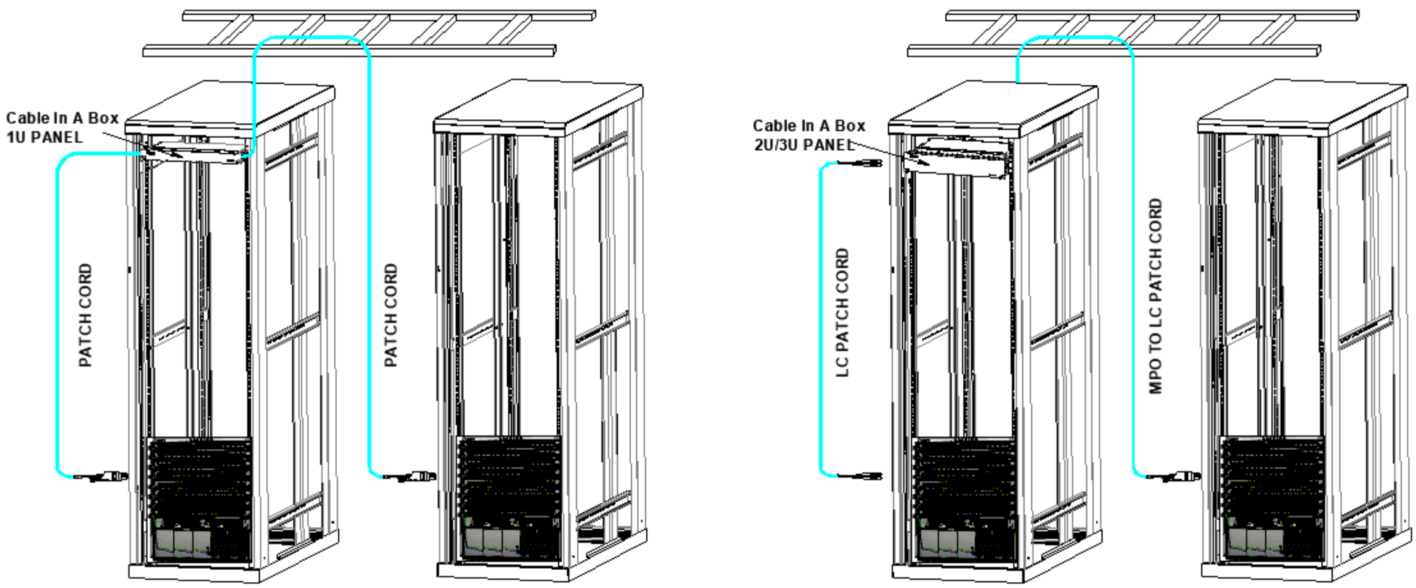
5.3 Wave2Wave

Wave2Wave (formerly Cabling123) offers smart panels and next-generation SN connectors for the modern data center.

Figure 26: Smart Panel-EVO Series

Wave2Wave also provides a turnkey structured cabling solution that can be used with the Brocade G630 Switch and X7 Director ICLs. The turnkey solution is designed with kits for each row, packaging for each rack, and labeling for each connection end-to-end.

Figure 27: Smart Panel Scenarios



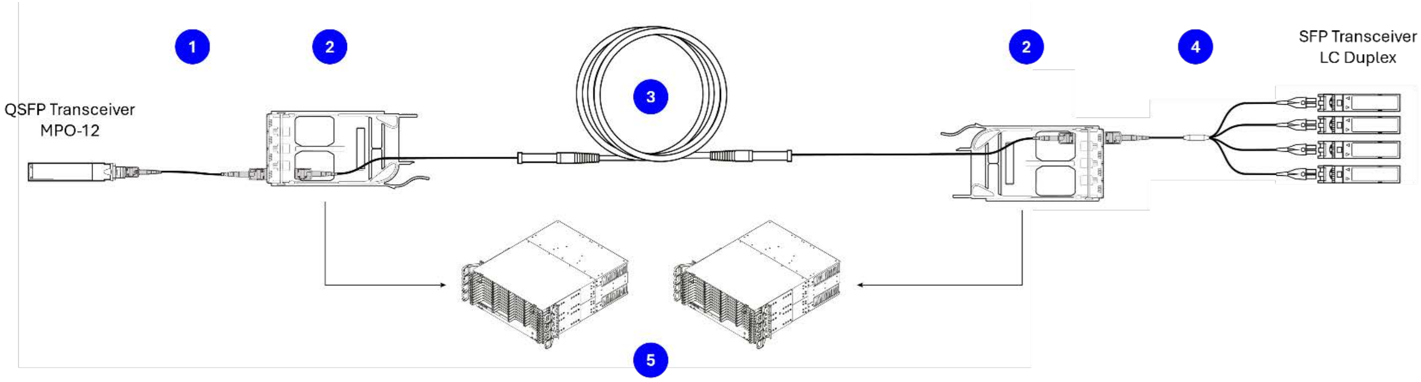
5.4 Corning

Corning provides a structured cabling solution for the Brocade G630 Switch and director port blades that can be deployed in either point-to-point trunk implementations or using a cross-connect for port replication. In both designs, density is maximized using Corning EDGE8 solutions with MTP-based connectivity. MTP jumpers are installed from each of the QSFP ports on a G630 Switch or an X7 ICL blade to MTP adapter panels in an EDGE8 patch panel. Using high-density EDGE8 housings and 4-port MTP adapter panels, a full Brocade 8-slot Director can be supported with one 2U EDGE8 housing, and a full Brocade 4-slot or G630 Switch can be supported with one 1U EDGE8 housing.

5.4.1 Structured Cabling Options

As shown in Figure 28, at the director cabinet, 8-fiber MTP jumpers are first connected to the QSFP ports and then to the MTP-terminated trunk assemblies. These trunk assemblies are routed from the housing in the director cabinet to the end equipment cabinets, where they are terminated in MTP adapter panels housed within an EDGE8 housing or bracket at the end equipment (server). From each MTP port in the housing, an 8-fiber MTP-to-LC harness assembly is connected, with the 4xLC uniboot legs of the harness plugged into the SFP ports on the host or storage equipment. This design is particularly suitable when the four SFP ports are located on the same device in close proximity, allowing for clean and efficient cable management. Furthermore, it is utilized when these ports operate on the same fabric, connected via a single QSFP port on the G630 Switch.

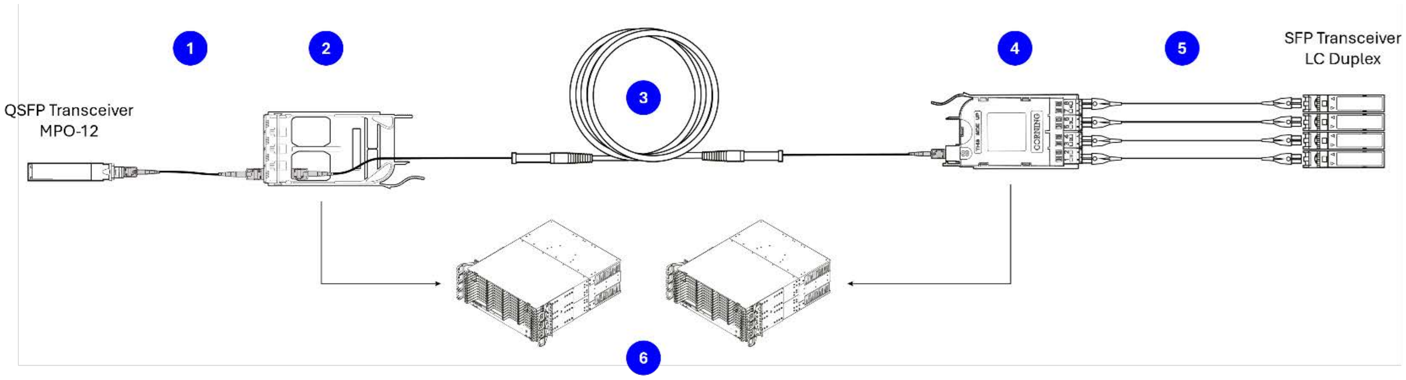
Figure 28: Connectivity Line Diagram for Point-to-Point Structured Cabling with 8-Fiber Harness



As most servers have a single dual-port HBA to support redundancy over separate fabrics, the typical installation requires that the four 32GFC channels transmitting from each QSFP port on the G630 Switch be broken out to different (multiple) servers, rather than all four channels terminating at the same device. The LC harness legs from the design can be ordered with longer LC legs to split them between multiple devices; however this design often results in messy or congested cable and jumper management at the servers.

As an alternative to LC harnesses, for servers or other end equipment where the 4xLC ports are not located in proximity on a single device or are being distributed across multiple devices, a more organized solution is to terminate the MTP-terminated trunk assemblies into MTP-to-LC modules. This allows individual LC jumpers to be used for each of the 4xLC ports, as shown in Figure 29.

Figure 29: Connectivity Line Diagram for Point-to-Point Structured Cabling with Module Breakouts



As illustrated in Figure 30, when using OSFP MPO-16 ports, a 16-fiber Y-harness with MTP-16 APC (non-pinned) connectors on one end and two 8-fiber MTP APC (non-pinned) connectors on the other is used to convert the 16-fiber connectivity into a standard 8-fiber base system, which is compatible with the 8-fiber MTP-terminated trunk assemblies. As in previous examples, adapter panels are used to terminate the 8-fiber MTP connections. An 8-fiber MTP jumper is then used to connect to the QSFP MPO-12 ports on the active equipment.

Figure 30: Connectivity Line Diagram for Structured Cabling Converting MPO-16 OSFP to 2x MPO-12 QSFP

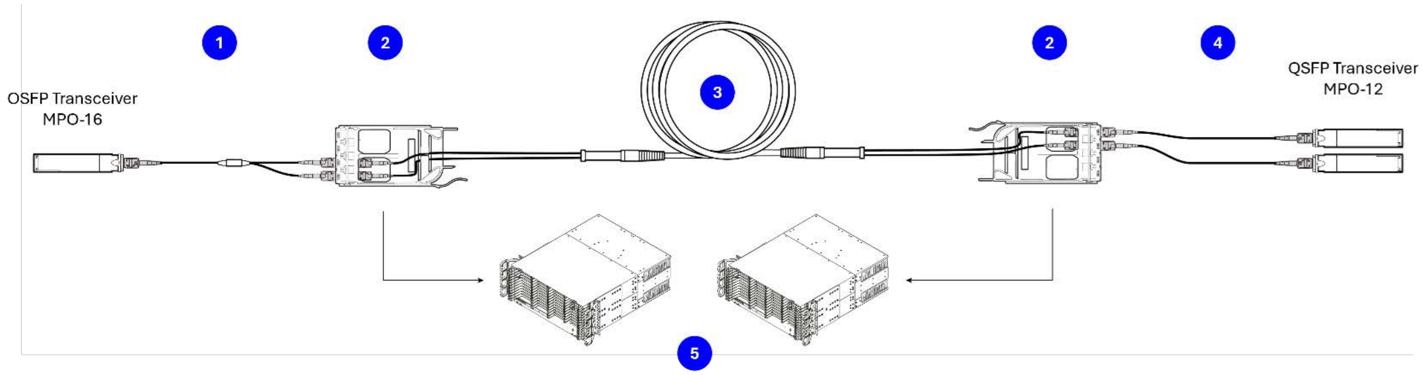
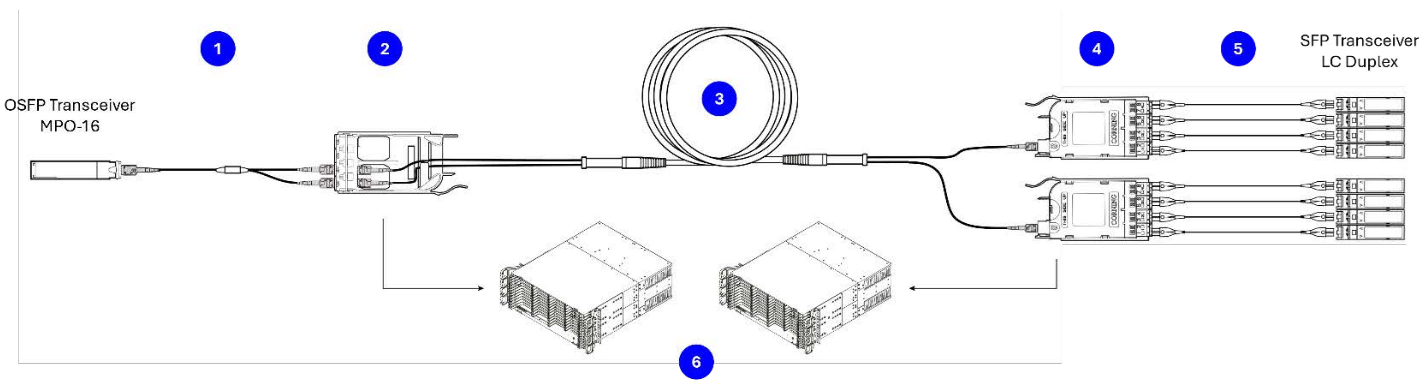


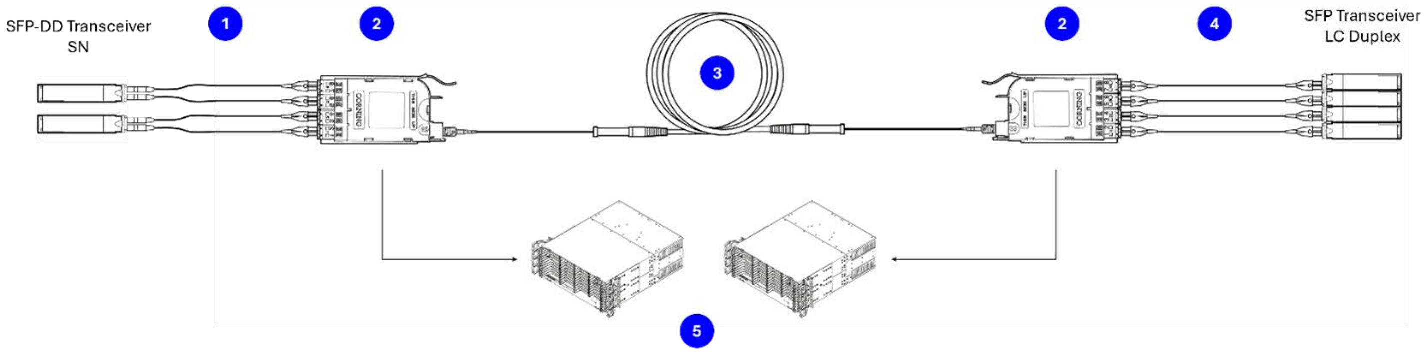
Figure 31 shows an alternative breakout option for scenarios where the link requires conversion from OSFP MPO-16 ports to SFP LC duplex ports. In this case, a 16-fiber Y-harness with MTP-16 APC (non-pinned) connectors on one end and two 8-fiber MTP APC (non-pinned) connectors on the other is used to convert the 16-fiber connectivity into a standard 8-fiber base system, ensuring compatibility with 8-fiber MTP-terminated trunk assemblies. The trunk is then connected to two MTP-to-LC modules, allowing individual LC jumpers to be used for each of the 8xLC duplex ports (SFP) in the active equipment.

Figure 31: Connectivity Line Diagram for Structured Cabling Converting MPO-16 OSFP to LC Duplex SFP



When using an SFP-DD SN transceiver, a duplex SN to LC uniboot jumper can be used to connect to an SFP port. For structured cabling, MTP-to-LC modules and MTP-terminated trunks can be used to connect SFP-DD to SFP ports across the data center, as shown in Figure 32.

Figure 32: Connectivity Line Diagram for Structured Cabling Converting SN SFP-DD into LC Duplex SFP



5.4.2 Cross-Connect Structured Cabling Options

A cross-connect design enables SAN port replication, which in turn provides a flexible patching infrastructure where any SAN director port can be connected easily to any host, storage, or switch port. In this design, the director is pre-cabled with a high-density solution, moving the patching functions to a central patching field, which is typically designed for jumper management. Moving the patching function to this central patching area eliminates the risk of damage to director ports, as day-to-day MACs occur only at this passive patching field and not directly at the transceiver ports.

Deploying MTP trunk assemblies from the director cabinets to the central patching area is typically accomplished with high-fiber-count trunk assemblies (rather than multiple low-fiber-count assemblies), reducing required pathway spaces and reducing installation time for this backbone structured cabling. With 48-port blades, it is common to utilize 96-fiber trunks so that each trunk is allocated to a blade for ease of servicing the director. In the case of the 64-port blades, four 32-fiber trunks can be deployed per blade, or a 96-fiber and a 32-fiber trunk can be utilized per blade to maintain 1:1 assignment.

Design scenarios with the corresponding part numbers can be found at www.corning.com/catalog/coc/documents/application-engineering-notes/AEN152.pdf.

5.5 Hexatronic Data Center

The 64-channel FC32-64 mimic adapter panel available through Hexatronic Data Center (Data Center Systems) is a 10U, modular adapter panel that supports 64 LC connections distributed in 16 groups, each containing four channels. Segments are numbered with an overlay to map precisely with QSFP ports and FC channels on the face of the Brocade FC32-64 blades. Located at the central access point (CAP), utilizing a DCS 10U, 8-slot modular patch panel enclosure populated with eight DCS 64-channel FC32-64 mimic adapter panels, this solution provides a mimic of a fully populated Brocade X6 and X7 Director chassis. Introducing the mimic adapter panel at the CAP improves manageability and mitigates risk associated with all MACs by taking management of up to 512 ports away from the active director. Converting from the 16 QSFP ports on the face of each FC32-64 blade to LC connectors required at the central patching location (CPL) can be accomplished in the following ways:

- Implement the structured connectivity solution shown in Figure 33, which provides the least amount of mated-pair insertion loss.
- Utilize two Hexatronic DCS 32-channel, 96-fiber OM4 plenum trunks terminated with 16 MTP/MPO connectors at the Brocade FC32-64 blade, and 32 LC duplex connectors at the back of the DCS 64-channel FC32-64 mimic adapter panel (Figure 34) at the central patching location.
- Utilize one DCS 64-channel FC32-64 mimic adapter panel (Figure 34).

To further enhance management, Hexatronic offers DCS mimic adapter panels and cassettes with color schemes to distinguish between A fabrics and B fabrics, as well as backup.

Figure 33: Hexatronic Data Center Centralized Structured Connectivity Solution with Core-Edge Topology

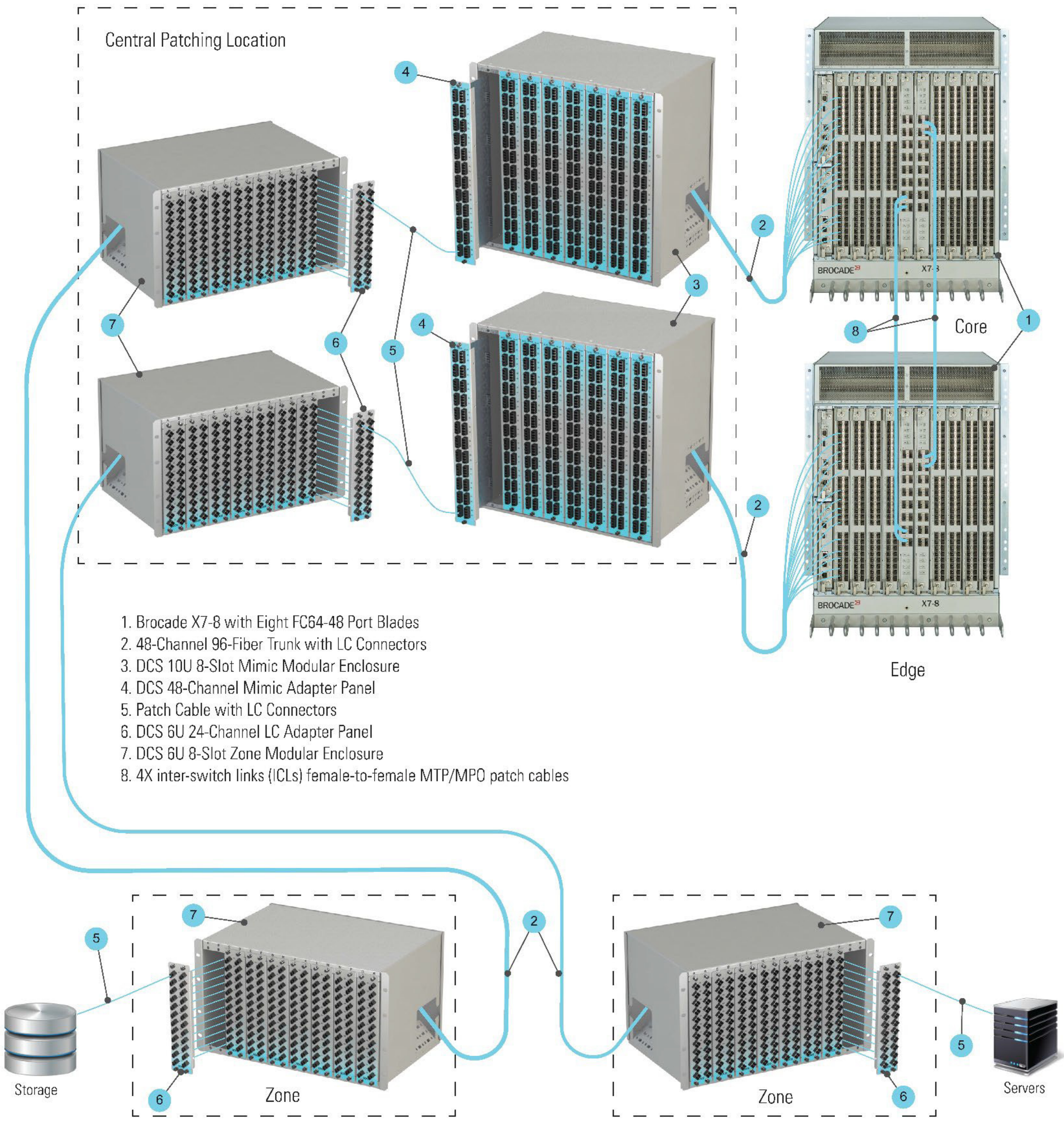
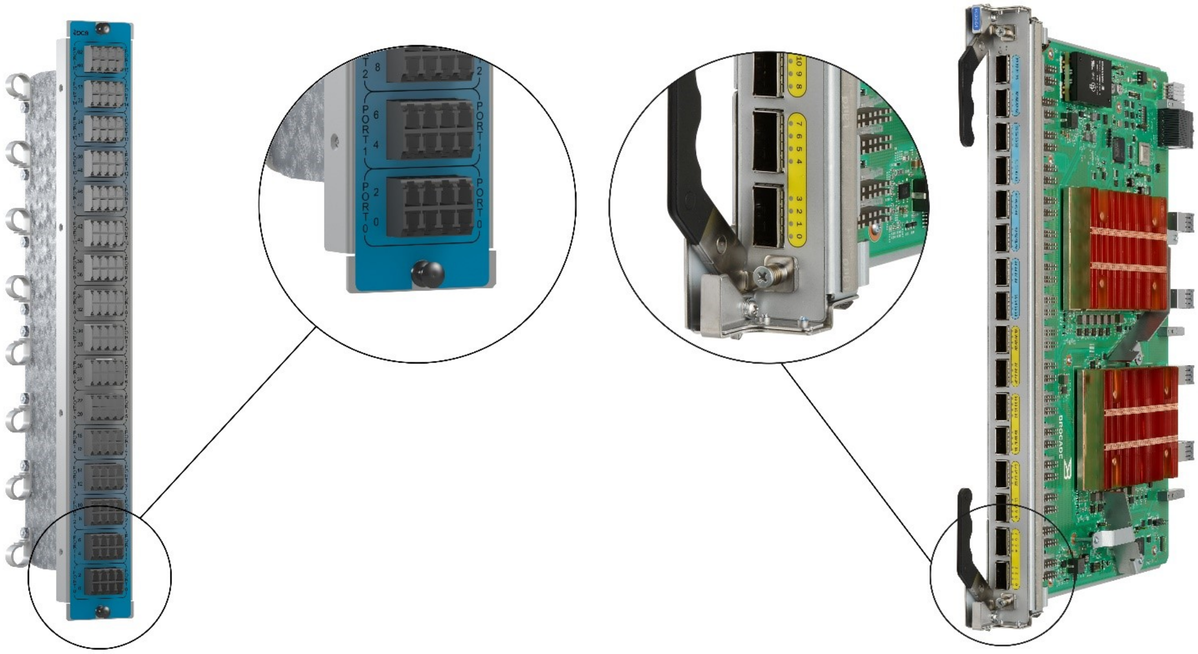


Figure 34: Hexatronic Data Center 64-Channel FC32-64 Mimic Panel for the Brocade X7 Director

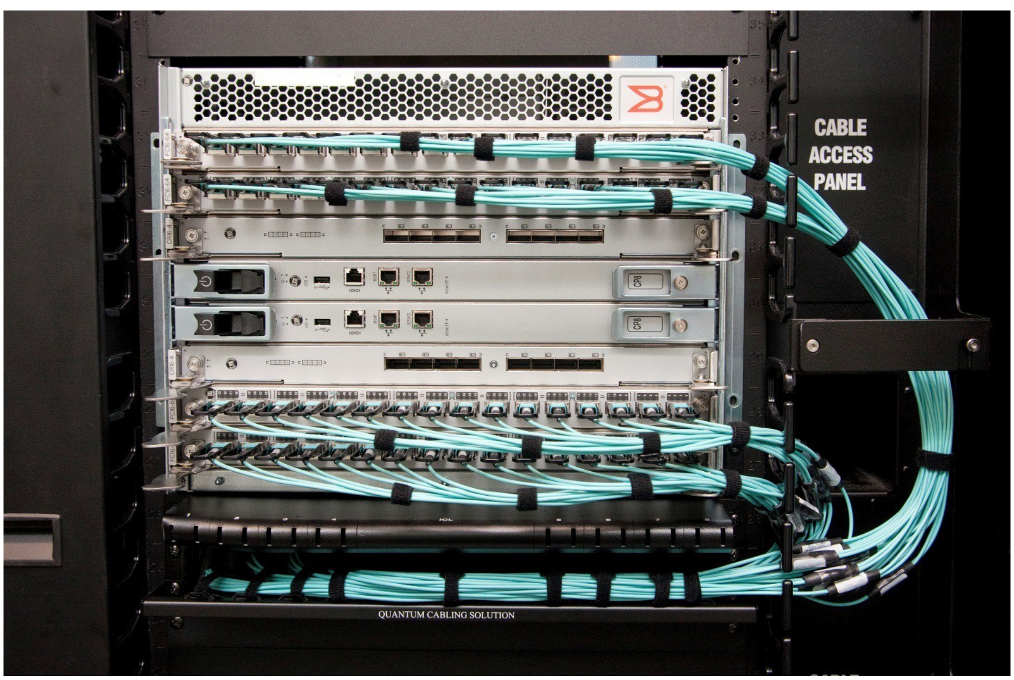


Chapter 6: Brocade X7 and X8 Cabling Installation

1. For a Brocade X7-8 chassis with vertically mounted blades, start cabling from the bottom LC ports (port 0), working up the blade to the top LC port (47). In this way, cables can be installed on top of the waterfall as the cables drop down, rather than trying to work below the cascading cables. Similarly, for a Brocade X7-4 or X8 chassis with horizontally mounted blades, start at the right and work to the left for cabling that will be routed on the right side.
2. Bundle the cables using Velcro cable wraps in groups of eight to match the ASIC or trunk boundaries (0 to 31, 32 to 63). This will facilitate servicing the system through easy identification of the cable path.
3. Work up to the top port.
4. Connect each cable to an LC or MPO/MTP patch panel port using the numbering schema defined in Appendix A.
5. If a different methodology is chosen, it is important to be consistent across all port blades and patch panel ports. This consistency minimizes confusion regarding which director ports are allocated to which MPO/MTP patch panel ports. Allocate 30 cm (12 in.) of slack at the patch panel to enable the patch panel's top and middle shelf to be raised into the up position for servicing.
6. Route the cables down to the bottom of a Brocade X7-8 (8-slot) chassis, and then left or right to the cable management area at the side of the enclosure/rack, and then down. If using a cabling harness, all harnesses and cables are routed straight down and into the patch panel, reducing the cable management required on the sides of the rack. On an X7-4 or X8 Director chassis, cables can be routed to the sides of the chassis (Figure 35).

NOTE: On an X7-8 Director, do not route cables from slot 1 to 4 to the right, as this could cause the fiber cables to be damaged if ICL cables are used in the configuration.

Figure 35: Wrapped/Bundled and Completed Cabling Solution



When connecting cables from outside devices to the back side of the patch panel, the MPO cables can be connected to the back of the patch panel; pay attention to the defined cable number schema (see Appendix B and Appendix C).

Figure 36: Device-to-Patch-Panel Trunk Cabling

Chapter 7: Servicing High-Density Cabling Solutions

Cable density can make identifying and servicing individual fiber cables at the port level a challenge. The QSFP and OSFP transceivers used in the Brocade G630 and Brocade Director ICL ports are fitted with a pull-tab to aid in installation and removal. The following steps will ease the service process.

7.1 Connect a Cable to an Empty QSFP/OSFP

1. Remove the QSFP or OSFP optic from the port:
   a. Hold the pull-tab firmly.
   b. Gently pull the QSFP/OSFP away from the connected port.
2. Verify that the chosen optical cable supports the type of transceiver being used, either QSFP or OSFP.
3. Connect the cable to the transceiver.
4. Insert the transceiver back into the port:
   a. Hold the pull-tab on the QSFP/OSFP firmly.
   b. Insert the transceiver into the port.
   c. Slide it back into the port until it locks into place with a click.

7.2 Remove a Cable from a Populated QSFP/OSFP

1. Remove the QSFP or OSFP from the port.
   a. Make sure that the patch cable is not wrapped around the pull-tab.
   b. Loosen any cable wraps used for holding the cables in place.
   c. Hold the transceiver pull-tab firmly.
   d. Gently pull it away from the connected port.
2. Disconnect the cable from the QSFP/OSFP transceiver.

Chapter 8: Servicing SFP-DD Solutions

SFP-DD optics use connectors referred to as very small form-factor (VSFF). As the name implies, the dual SN connectors used in an SFP-DD optic are designed to be as compact as possible, requiring particular caution when handling to ensure proper seating of optics in the ports and cabling in the optics. The SFP-DDs used in the Brocade G720 and G730 Switches, and Brocade FC64-64 port blade for the Brocade X7 Director are fitted with a stiff pull-tab design required for installation and removal operations. Standard SFP optics are also supported in an SFP-DD cage, with normal SFP handling procedures. The SFP-DD transceivers are designed so that they cannot be inserted into a standard SFP cage.

Following the recommended steps below for SFP-DD handling will help to ease the service process. Additional training materials on SFP-DD optic handling can be found on the Broadcom learning portal. Customer access to the learning portal is required. Follow the steps in this video to create an account.

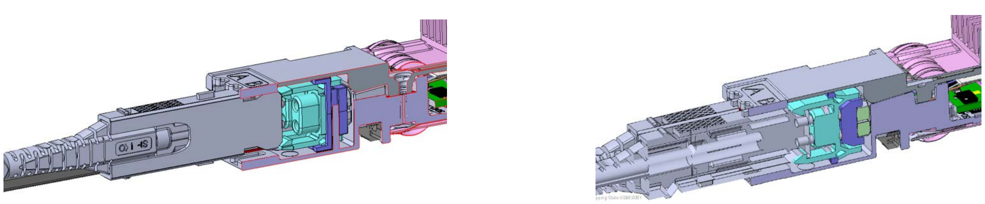
8.1 Connect a Cable to an Empty SFP-DD

1. Remove the SFP-DD optic from the port. Use the SFP-DD pull-tab to grasp the optic firmly, and gently pull the SFP-DD optic away from the connected cage. Leave the dust caps inserted into the SFP-DD until you are ready to insert the fiber cable into the optic.
2. Verify that the chosen optical cables have SN connectors. Locate the wide key and molded grid pattern that identify the top edge of the SN connector. The polarized connector requires that the cable be inserted with the wide key facing up and the narrow key facing down in the optic cable port.

Figure 37: Brocade SFP-DD Optic without Cables or Dust Covers (Left) versus Brocade SFP-DD Optic with 2x SN Cable Connectors (Right)

3. Connect the cable to the SFP-DD by gripping the SN cable connector assembly by the push-pull boot and pushing the assembly forward until you hear two audible click sounds. Repeat to connect the second fiber cable as required. Ensure that the cables are properly mated in the optic by confirming that the wide keys are inserted into the keyways of the optic. A light tug on the cable will ensure that the latching system has secured the SN cable.

Figure 38: Brocade Optic Fully Inserted into the SFP-DD Cage with 2x SN Cable Connectors Attached; Optic Engagement to First Click (Left), and Optic Engagement to Second Click (Right)



4. Insert the SFP-DD into the SFP-DD cage. Hold the pull-tab on the SFP-DD firmly, insert it into the port, and slide it back into the port until the transceiver locks into place with a click sound.

8.2 Remove a Fiber Cable from a Populated SFP-DD

1. Identify the correct cable to be removed. Loosen any cable wraps used to hold the cable in place.
2. Grasp the boot of the desired cable and gently pull the cable from the connected optic until the latch releases and the connector slides out of the transceiver. The SFP-DD optic is locked into the cage and does not come out unless you pull the optic handle.
3. Insert a dust cover into the port with the removed cable.
4. If both cables in the optic should be removed, you can first remove the optic and then disconnect the cables from the SFP-DD by grasping the push-pull boot of the cable and pulling.

Chapter 9: Best Practices for Managing the Cabling

Whether implementing, upgrading, or maintaining cabling in the data center, establish a set of guidelines that are thoroughly understood and supported by the staff. Here are some cable management suggestions.

9.1 During Installation

- Avoid over-bundling the cables or placing multiple bundles on top of each other, which can degrade the performance of the cables underneath.
- Keep fiber and copper runs separate. The weight of the copper cables can crush fiber cables that are placed underneath.
- Consider using cables that are resistant to bend loss.
- Avoid mounting cable components in locations that block access to other equipment (power strip or fans) inside and outside the racks.
- Keep all cable runs under 90% of the maximum distance supported for each media type as specified in the relevant standard. This extra headroom is for the additional patch cables that will be included in the end-to-end connection.
- Install higher-performance cable types (OM4 or OM5) that will meet current and future application requirements.
- Cable installations and components should be compliant with industry standards.
- Do not stress the cable by doing any of the following:
  - Applying additional twists
  - Pulling or stretching beyond its specified pulling-load rating
  - Bending it beyond its specified bend radius, and never beyond 90 degrees
  - Creating tension in suspended runs
  - Stapling or applying pressure with cable ties
- Avoid routing cables through pipes and holes. This may limit additional future cable runs.
- Label cables with their destination at every termination point; this means labeling both ends of the cable.
- Test every cable as it is installed and terminated with Brocade ClearLink™ diagnostics to identify potentially faulty links. It will avoid the challenge of identifying problem cables later.
- Establish the main cabling distribution area near the center of the data center to minimize cable distances.
- Do not route cables in a manner that causes them to block equipment cooling fans and restrict airflow.
- Use thin and high-density cables wherever possible, allowing more cable runs in tight spaces. Use quality cabling that meets standards specifications.
- Dedicate outlets for terminating horizontal cables; allocate a port in the patch panel for each horizontal run.
- Include sufficient vertical and horizontal managers in your design; future changes may involve downtime as cables are removed during the changes.
- Utilize modular cabling systems to map ports from equipment with high-density port counts, as described in Chapter 5, Cable Management Setup and Configuration.

9.2 Daily Practices

- Avoid leaving loose cables on the floor, which creates a major safety hazard. Use horizontal, vertical, or overhead cable managers.
- Avoid exposing cables to direct sunlight and areas of condensation.
- Do not mix different cable types within a bundled group.
- Remove abandoned cables that can restrict air flow and contribute to possible increases in operational temperatures that can affect the longevity of the system.
- Keep some spare patch cables. The types and quantity can be determined from the installation and projected growth. Keep all unused cables bagged and capped when not in use.
- Use horizontal and vertical cable guides to route cables within and between racks. If cable spool devices are used in cable managers to avoid kinks and sharp bends in the cable, use caution not to wrap patch cords around these spools like a hose on a hose reel.
- Document all cabling components and their linkage between components, and make sure that this information is updated on a regular basis. The installation, labeling, and documentation should always match.
- Use the correct length patch cable, leaving some slack at each end for end-device movements.
- Bundle cables together in groups of relevance (for example, ISL cables and uplinks to core devices), as this will ease management and troubleshooting.
- When bundling or securing cables, use Velcro cable wraps every 1 to 2 meters. Avoid using zip ties as they apply pressure on the cables.
- Avoid routing cables over equipment and other patch panel ports. Route below or above and into the horizontal cable manager for every cable.
- Maintain the cabling documentation, labeling, and logical and physical cabling diagrams.

9.3 Summary

Although cabling represents less than 10% of the overall data center network investment, it can be expected to outlive most network components and be the most difficult and potentially costly component to replace. When purchasing a cabling infrastructure, consider not only the initial implementation costs, but also the subsequent costs. Understand the full lifecycle and study industry trends to arrive at the right investment decision for your environment.

Choose the strongest foundation to support present and future network technology needs, and comply with TIA or ISO cabling standards. Build in additional capacity, as installation is much easier now than later. Use higher-bandwidth grades of cabling in order to postpone re-cabling as technologies advance. The cabling itself calls for the right knowledge, the right tools, patience, a structured approach, and most of all, discipline. Without discipline, it is common to see complex cabling *masterpieces* quickly get out of control, leading to increased support costs and increased downtime.

Since every environment is different, there is no single solution that will meet all of your cable management needs. Following the guidelines and best practices highlighted in this design guide will help provide the information required to successfully deploy a cabling infrastructure in your data center.

Appendix A: Cable-to-Port Mapping

For easy identification of devices, print and paste the following table on the rack door or in a logbook located near the rack.

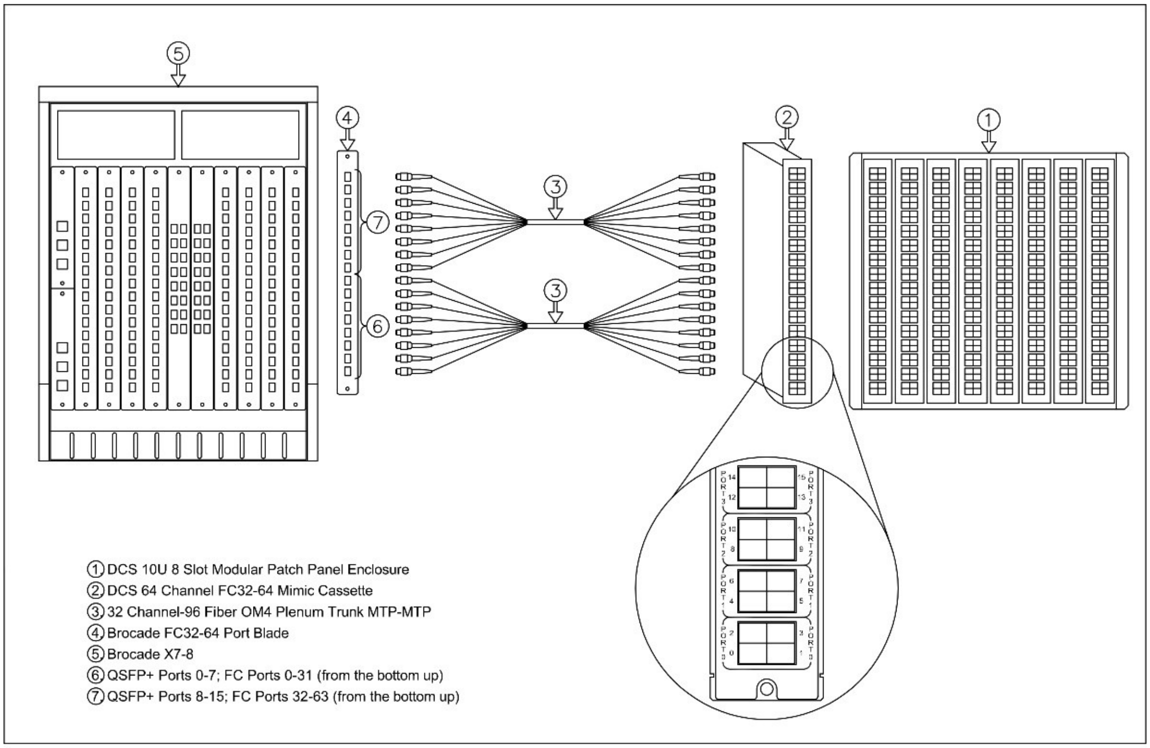
Director Slot/Port Number			MPO/MTP Shelf		
Slot	**Port**	**64G Link**	**Plate**	**Port**	**Description**
Slot 1	0	0	Slot 1	1	
		1			
		2			
		3			
	1	4			
		5			
		6			
		7			
	2	8		2	
		9			
		10			
		11			
	3	12			
		13			
		14			
		15			
	4	16		3	
		17			
		18			
		19			
	5	20			
		21			
		22			
		23			
	6	24		4	
		25			
		26			
		27			
	7	28			
		29			
		30			
		31			

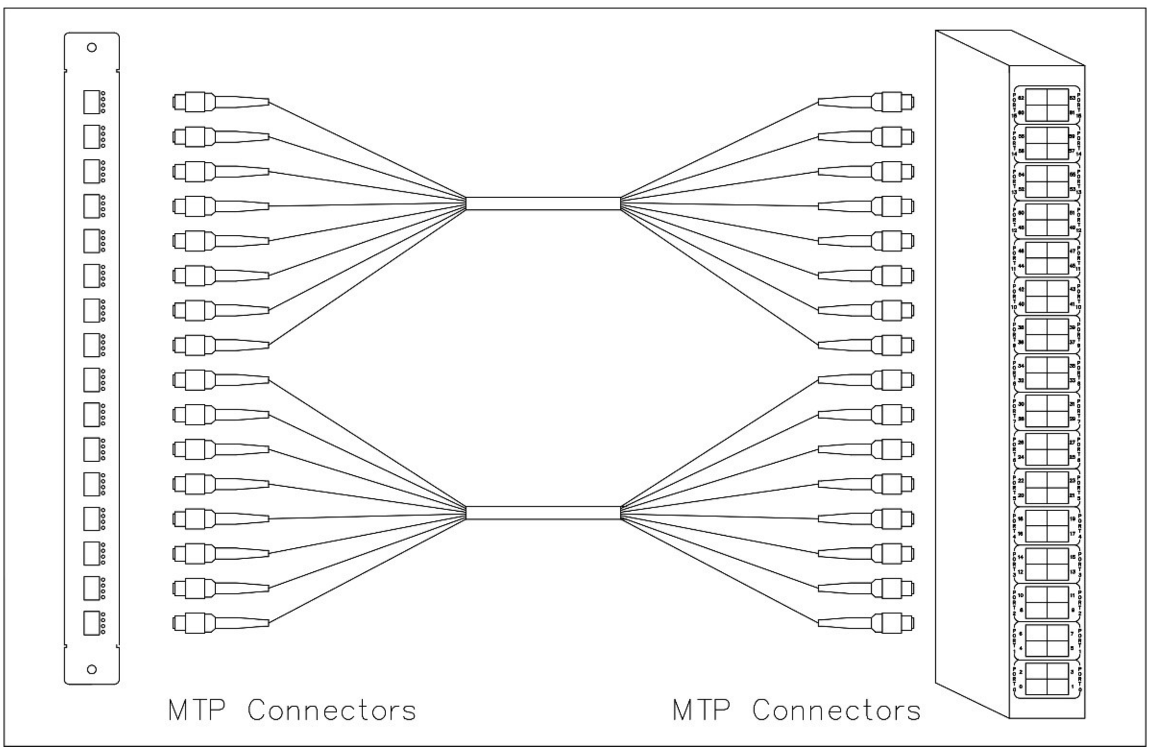
Director Slot/Port Number			MPO/MTP Shelf		
Slot	**Port**	**64G Link**	**Plate**	**Port**	**Description**
Slot 2	0	0	Slot 2	1	
		1			
		2			
		3			
	1	4			
		5			
		6			
		7			
	2	8		2	
		9			
		10			
		11			
	3	12			
		13			
		14			
		15			
	4	16		3	
		17			
		18			
		19			
	5	20			
		21			
		22			
		23			
	6	24		4	
		25			
		26			
		27			
	7	28			
		29			
		30			
		31			

Director Slot/Port #			MPO/MTP Shelf		Description
Slot	Port	64G Link	Plate	Port	
Slot 1	8	32	Slot 1	5	
		33			
		34			
		35			
	9	36			
		37			
		38			
		39			
	10	40		6	
		41			
		42			
		43			
	11	44			
		45			
		46			
		47			
	12	48		7	
		49			
		50			
		51			
	13	52			
		53			
		54			
		55			
	14	56		8	
		57			
		58			
		59			
	15	60			
		61			
		62			
		63			

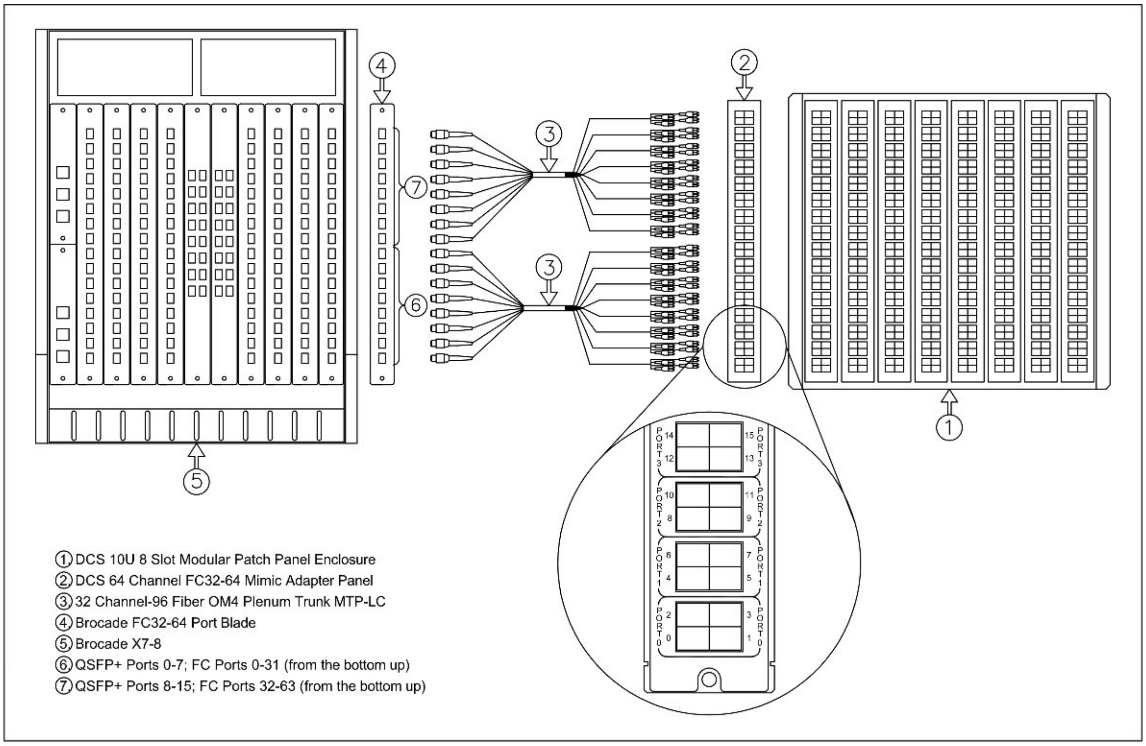
Director Slot/Port #			MPO/MTP Shelf		Description
Slot	Port	64G Link	Plate	Port	
Slot 2	8	32	Slot 2	5	
		33			
		34			
		35			
	9	36			
		37			
		38			
		39			
	10	40		6	
		41			
		42			
		43			
	11	44			
		45			
		46			
		47			
	12	48		7	
		49			
		50			
		51			
	13	52			
		53			
		54			
		55			
	14	56		8	
		57			
		58			
		59			
	15	60			
		61			
		62			
		63			

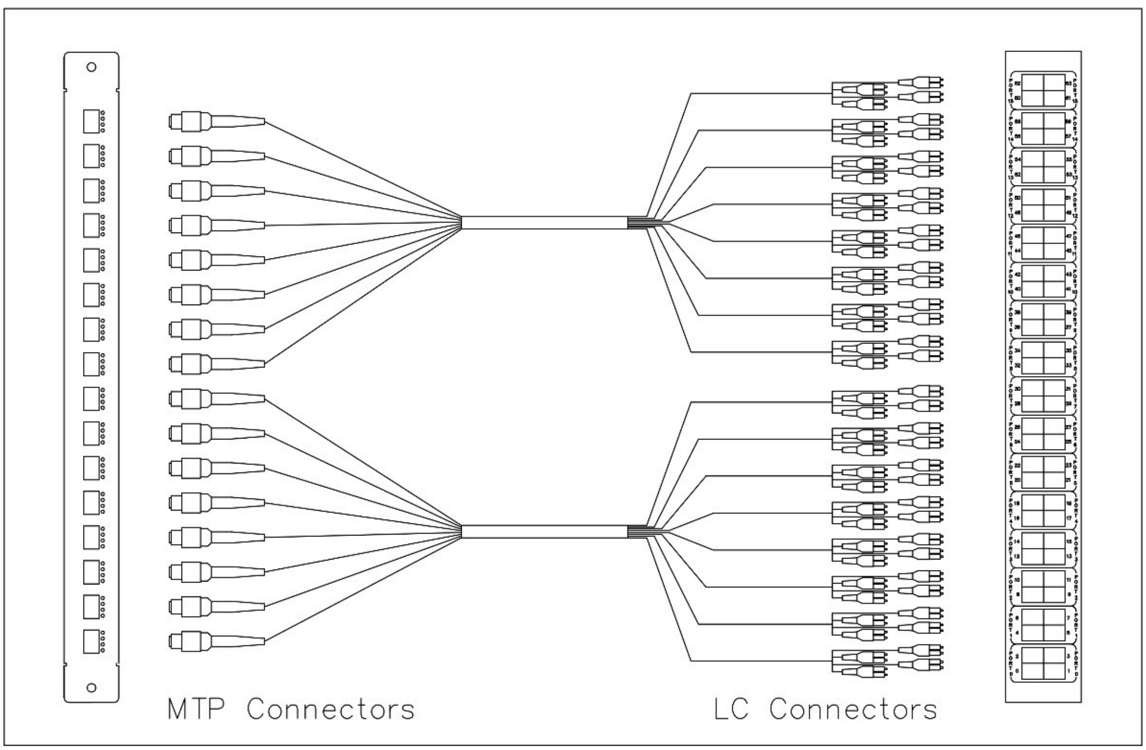
Appendix B: DCS MTP-to-MTP-Port Mapping





Appendix C: DCS MTP-to-LC-Port Mapping





Appendix D: Equipment List

D.1 Patch Cables for QSFP Connections

Use the QSFP patch cables listed below with the Brocade G630 Switch and X7 ICLs to connect ports to local patch panels or end devices. Cable part numbers are provided as a reference only and may not have not been tested or qualified. Verify the appropriate cable number and description with the cable manufacturer before placing an order. Contact the manufacturer for additional pinning/polarity configurations.

			Device (QSFP) to Device (QSFP) (MTP Nonpinned/Nonpinned) Vendor Part Number				
Type	**Description**	**Length**	**Cable Vendor**	**CABLExpress**	**Corning (Type B Polarity)**	**OptiClarity**	**Wave2Wave**
QSFP to QSFP	OM4 - QSFP (MPO-12) to QSFP (MTO-12) optical cable	1m	J12-QSFP-MM001P (aqua) J12-MM001-PEVOM4 (heather violet)	CBX-STC012BPF-MXXN-MXXN-001M	JE6E608QE8-NB001M	MTF-MTF-12FOM4-1M-KUKU	50-8120P-1M
QSFP to QSFP	OM4 - QSFP (MPO-12) to QSFP (MPO-12) optical cable	3m	J12-QSFP-MM003P (aqua) J12-MM003-PEVOM4 (heather violet)	CBX-STC012BPF-MXXN-MXXN-003M	JE6E608QE8-NB003M	MTF-MTF-12FOM4-3M-KUKU	50-8120P-3M
QSFP to QSFP	OM4 - QSFP (MPO-12) to QSFP (MPO-12) optical cable	20m	J12-QSFP-MM020P (aqua) J12-MM020-PEVOM4 (heather violet)	CBX-STC012BPF-MXXN-MXXN-020M	JE6E608QE8-NB020M	MTF-MTF-12FOM4-20M-KUKU	50-8120P-20M
QSFP to 4x SFP	OM4 - QSFP (MPO-12) to 4x SFP+ (LC) optical cable	1m	JH08-X50BM001P (aqua) JH08-X50BM001P-EVOM4 (heather violet)	CBX-STH008BPQ-MXXN-UC4N-001M	HE67908QPH-JB001M	MTF8-4LCU-1M-QSFP	51-8080P-1M
QSFP to 4x SFP	OM4 - QSFP (MPO-12) to 4x SFP+ (LC) optical cable	3m	JH08-X50BM003P (aqua) JH08-X50BM003P-EVOM4 (heather violet)	CBX-STH008BPQ-MXXN-UC4N-003M	HE67908QPH-JB003M	MTF8-4LCU-3M-QSFP	51-8080P-3M
QSFP to 4x SFP	OM4 - QSFP (MPO-12) to 4x SFP+ (LC) optical cable	20m	J08-X50BM020P (aqua) JH08-X50BM020P-EVOM4 (heather violet)	CBX-STH008BPQ-MXXN-UC4N-020M	HE67908QPH-JB020M	MTF8-4LCU-20M-QSFP	51-8080P-20M

D.2 Patch Cables for SFP-DD Connections

Type	Description	Length	Vendor Part Number					
			Cable Vendor	CABLExpress	Corning	Hexatronic Data Center	OptiClarity	Wave2Wave
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/patch panel (LC) optical cable	1m	BCM-002M420P-LSU-EV001M	CXJ04-U2-SN-D2-001P	79NM02QD116 001M	820OM4-0259-001M	OCI-B-MM-SNLC-1M-OM4	12U-8020m-MG1M
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/patch panel (LC) optical cable	3m	BCM-002M420P-LSU-EV003M	CXJ04-U2-SN-D2-003P	79NM02QD116 003M	820OM4-0259-003M	OCI-B-MM-SNLC-3M-OM4	12U-8020m-MG3M
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/patch panel (LC) optical cable	20m	BCM-002M420P-LSU-EV020M	CXJ04-U2-SN-D2-020P	79NM02QD116 020M	820OM4-0259-020M	OCI-B-MM-SNLC-20M-OM4	12U-8020m-MG20M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	1m	BCM-002M420P-SSU-EV001M	CXJ04-SN-SN-D2-001P	NMNM02QD116 001M	820OM4-5959-001M	OCI-B-MM-SNSN-1M-OM4	11U-8020m-MG1M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	3m	BCM-002M420P-SSU-EV003M	CXJ04-SN-SN-D2-003P	NMNM02QD116 003M	820OM4-5959-003M	OCI-B-MM-SNSN-3M-OM4	11U-8020m-MG3M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	20m	BCM-002M420P-SSU-EV020M	CXJ04-SN-SN-D2-020P	NMNM02QD116 020M	820OM4-5959-020M	OCI-B-MM-SNSN-20M-OM4	11U-8020m-MG20M
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/patch panel (MPO-12) optical cable	1m	BCM-008M420P-LSU-EV001M	—	—	913OM4-3659-001M	OCI-B-MM-4SN12FMPO-1M-OM4	15U-8080P-MG1M
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/patch panel (MPO-12) optical cable	3m	BCM-008M420P-LSU-EV003M	—	—	913OM4-3659-003M	OCI-B-MM-4SN12FMPO-3M-OM4	15U-8080P-MG3M
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/patch panel (MPO-12) optical cable	20m	BCM-008M420P-LSU-EV020M	—	—	913OM4-3659-020M	OCI-B-MM-4SN12FMPO-20M-OM4	15U-8080P-MG20M

D.3 Patch Cables for OSFP Connections

Type	Description	Length	Vendor Part Number				
			Cable Vendor	CABLExpress	Corning	OptiClarity	Wave2Wave
OSFP to OSFP	OM4 - OSFP (MPO-16/APC) to OSFP (MPO-16/APC) MMF optical cable	1m	J164M4C-PMPM-001 (aqua) J16M4C-PMPM-EV001 (heather violet)	CBX-STJ016BPF-4XXN-4XXN-001M	JC3C316QPH-NB001M	MTFA-MTFA-16FOM4-1M-KUKU	50G-8162P-MG1M
OSFP to OSFP	OM4 - OSFP (MPO-16/APC) to OSFP (MPO-16/APC) MMF optical cable	3m	J164M4C-PMPM-003 (aqua) J16M4C-PMPM-EV003 (heather violet)	CBX-STJ016BPF-4XXN-4XXN-003M	JC3C316QPH-NB003M	MTFA-MTFA-16FOM4-3M-KUKU	50G-8162P-MG3M
OSFP to OSFP	OM4 - OSFP (MPO-16/APC) to OSFP (MPO-16/APC) MMF optical cable	20m	J164M4C-PMPM-020 (aqua) J16M4C-PMPM-EV020 (heather violet)	CBX-STJ016BPF-4XXN-4XXN-020M	JC3C316QPH-NB020M	MTFA-MTFA-16FOM4-20M-KUKU	50G-8162P-MG20M
OSFP to 8x SFP+	OSFP (MPO-16/APC) to 8x SFP+ (LC) MMF optical trunk cable	1m	—	—	—	—	51G-8164P-MG1M
OSFP to 8x SFP+	OSFP (MPO-16/APC) to 8x SFP+ (LC) MMF optical trunk cable	3m	—	—	—	—	51G-8164P-MG3M
OSFP to 8x SFP+	OSFP (MPO-16/APC) to 8x SFP+ (LC) MMF optical trunk cable	20m	—	—	—	—	51G-8164P-MG20M
OSFP to 2x QSFP	OM4 - OSFP (MPO-16/APC) to 2x QSFP (MPO-12/UPC) MMF optical cable	1m	J16M4C-PMMB-001 (aqua) J16M4C-PMMB-EV001 (heather violet)	CBX-STJ016BPF-4XXN-M02N-001M	HC3E616QPH-LB001M	MTFA-2-MTF-OM4-1M-KUKU	50G-8164P-MG1M-M2
OSFP to 2x QSFP	OM4 - OSFP (MPO-16/APC) to 2x QSFP (MPO-12/UPC) MMF optical cable	3m	J16M4C-PMMB-003 (aqua) J16M4C-PMMB-EV003 (heather violet)	CBX-STJ016BPF-4XXN-M02N-003M	HC3E616QPH-LB003M	MTFA-2-MTF-OM4-3M-KUKU	50G-8164P-MG3M-M2
OSFP to 2x QSFP	OM4 - OSFP (MPO-16/APC) to 2x QSFP (MPO-12/UPC) MMF optical cable	20m	J16M4C-PMMB-020 (aqua) J16M4C-PMMB-EV020 (heather violet)	CBX-STJ016BPF-4XXN-M02N-020M	HC3E616QPH-LB020M	MTFA-2-MTF-OM4-20M-KUKU	50G-8164P-MG20M-M2

D.4 Patch Cables for LCx2 Connections

Type	Description	Length	Vendor Part Number			
			Cable Vendor	Corning[a]	OptiClarity	Wave2Wave
LCx2 to LCx2	2x SFP+ (LC) optical cable to 2x SFP+ (LC) optical cable	1m	JH04-X50BB001P (aqua)	797902QD120001M	SM-DXCLCULCU-1M	31U-8040m-MG1M
LCx2 to LCx2	2x SFP+ (LC) optical cable to 2x SFP+ (LC) optical cable	3m	JH04-X50BB001P-EVOM4 (heather violet)	797902QD120003M	SM-DXCLCULCU-3M	31U-8040m-MG3M
LCx2 to LCx2	2x SFP+ (LC) optical cable to 2x SFP+ (LC) optical cable	20m	JH04-X50BB003P (aqua)	797902QD120020M	SM-DXCLCULCU-20M	31U-8040m-MG20M

a. Two LC Uniboot jumpers are required to connect LCx2 to LCx2.

D.5 Patch Panels

Vendor: Cable Vendor (Conexus Technologies)		
Part Number	**Rack Units/Ports**	**Description**
PNL-UL1U-64LL-B	1U/64 ports	ULTRALiiT patch panel, 64-port duplex LC, blue overlay
PNL-UL1U-64LL-O	1U/64 ports	ULTRALiiT patch panel, 64-port duplex LC, orange overlay
PNL-UL1U-64LL-BO	1U/64 ports	ULTRALiiT patch panel, 64-port duplex LC, dual-fabric blue/orange overlay
PNL-UL1U-128SN-B	1U/128 ports	ULTRALiiT patch panel, 128-port duplex SN, blue overlay
PNL-UL1U-128SN-O	1U/128 ports	ULTRALiiT patch panel, 128-port duplex SN, orange overlay
PNL-UL1U-128SN-BO	1U/128 ports	ULTRALiiT patch panel, 128-port duplex SN, dual-fabric blue/orange overlay

Vendor: CABLExpress	
Part Number	**Description**
Bill of Materials for Figure 20	
CBX-HE-H10U8	H-Series 10U 8-slot horizontal high-density fiber enclosure
CBX-HM-H10848LCAZ-1076A	H-Series 10U 8-slot module 96-fiber (48-port) LC duplex/8 MTP aqua OM4 multimode (Brocade vertical 48 ports numbered 0-47)
CBX-STS048BPX-M00N-V85N-00xx	xxFT skinny-trunk 48-fiber 50/125 multimode aqua OM4 2-mm LC uniboot/MTP female plenum trunk cable, right-side entry
CBX-STS048BPX-M00N-V8AN-00xx	xxFT skinny-trunk 48-fiber 50/125 multimode aqua OM4 2-mm LC uniboot/MTP female plenum trunk cable, left-side entry
Bill of Materials for Figure 21	
CBX-HE-V10U8	H-Series 10U 8-slot vertical high-density fiber enclosure
CBX-HM-V10864LCAZ-1076B	H-Series 10U 8-slot module 128-fiber (64-port) LC duplex/16 MTP male aqua OM4 multimode (Brocade vertical 64 ports numbered 0-63)
CBX-STS064BPX-M00N-D4HN-0030	xxFT 64-fiber 50/125 multimode aqua OM4 MTP female/SN duplex plenum trunk cable, XXXX (top half of blade)
CBX-STS064BPX-M00N-D5HN-0030	xxFT 64-fiber 50/125 multimode aqua OM4 MTP female/SN duplex plenum trunk cable, XXXX (bottom half of blade)
Bill of Materials for Figure 22	
CBX-HE-V10U8	H-Series 10U 8-slot vertical high-density fiber enclosure
CBX-HM-V10832LCAZ-1076B	H-Series 10U 8-slot module 64-fiber (48-port) LC duplex/8 MTP male aqua OM4 multimode (Brocade vertical 48 ports numbered 0-47)
CBX-STS064BPX-M00N-V40N-00xx	xxFT skinny-trunk 64-fiber 50/125 multimode aqua OM4 2-mm LC uniboot/MTP female plenum trunk cable

Vendor: Corning	
Part Number	**Description**
Bill of Materials for Figure 28	
JE6E608QE8-NBxxxF	EDGE8 (OM4), MTP (non-pinned) to MTP (non-pinned) jumper, TIA-568 type-B, xxxF (ft) or xxxM (m)
EDGE8-CP32-V3	EDGE8 32-fiber MTP adapter (4 port). 50-µm multimode (OM4/OM3); mounts in EDGE8 housings (example: EDGE8-02U)
GE5E508QPNDDUxxxF	EDGE8 trunk cable, 50-µm multimode (OM4), MTP connector (pinned) to MTP connector (pinned), 8 fibers, with 33/33-in. legs, pulling grip one side, xxxF (ft) or xxxM (m) NOTE: Trunks are available in fiber counts from 8 to 288 fibers.
HE67908QPH-KBxxxF	EDGE8 8-fiber harness, 50-µm multimode (OM4), MTP (non-pinned) to LC uniboot, xxxF (ft) or xxxM (m), 24-in. LC legs, TIA-568 Type-B
EDGE8-02U	EDGE8 housing with a 2U height supports up to 36 MTP-to-MTP panels or MTP-to-LC modules; MTP density of 1152 fibers (144 8-fiber MTP ports), LC density of 288 fibers (144 2-fiber LC duplex ports) NOTE: Housings are also available in 1U and 4U heights.
Bill of Materials for Figure 29	
JE6E608QE8-NAxxxF	EDGE8 8-fiber MTP jumper, (OM4), MTP (non-pinned) to MTP (non-pinned), TIA-568 type-A polarity, xxxF (ft) or xxxM (m)
EDGE8-CP32-V3	EDGE8 32-fiber MTP adapter panel (4 port), 50-µm multimode (OM4/OM3); mounts in EDGE8 housings (example: EDGE8-02U) NOTE: Panels are available in 4 ports.
GE5E508QPNDDUxxxF	EDGE8 trunk cable, 50-µm multimode (OM4), MTP connector (pinned) to MTP connector (pinned), 8 fibers, 33/33-in. legs, pulling grip one side, xxxF (ft) or xxxM (m) NOTE: Trunks are available in fiber counts from 8 to 288 fibers.
ECM-UM08-05-E6Q-ULL	EDGE8 ultra-low-loss (OM4) module, 8F, LC duplex to MTP (non-pinned).
797902QD120xxxF	EDGE jumper, 2F, LC uniboot to LC uniboot, riser, 50-µm multimode (OM4), xxxF (ft) or xxxM (m)
EDGE8-02U	EDGE8 housing with a 2U height supports up to 36 MTP-to-MTP panels or MTP-to-LC modules; MTP density of 1152 fibers (144 8-fiber MTP ports), LC density of 288 fibers (144 2-fiber LC duplex ports) NOTE: Housings are also available in 1U and 4U heights.
Bill of Materials for Figure 30	
HC3E616QPH-LBxxxF	16F Y-harness, MTP-16 APC (non-pinned) to two 8F MTP PC (non-pinned), 36-in. (910 mm) breakout leg length, Type-B polarity, xxxF (ft) or xxxM (m)
EDGE8-CP32-V3	EDGE8 32-fiber MTP adapter panel (4 port), 50-µm multimode (OM4/OM3); mounts in EDGE8 housings (example: EDGE8-02U) NOTE: Panels are available in 4 ports.
GE5E508QPNDDUxxxF	EDGE8 trunk cable, 50-µm multimode (OM4), MTP connector (pinned) to MTP connector (pinned), 8 fibers, 33/33-in. legs, pulling grip one side, xxxF (ft) or xxxM (m) NOTE: Trunks are available in fiber counts from 8 to 288 fibers.
JE6E608QE8-NBxxxF	EDGE8 MTP PC (non-pinned) to MTP PC (non-pinned) 8F jumper, TIA-568 type-B polarity, xxxF (ft) or xxxM (m)
EDGE8-02U	EDGE8 housing with a 2U height, supports up to 36 MTP-to-MTP panels or MTP-to-LC modules; MTP density of 1152 fibers (144 8-fiber MTP ports), LC density of 288 fibers (144 2-fiber LC duplex ports) NOTE: Housings are also available in 1U and 4U heights.
Bill of Materials for Figure 31	
HC3E616QPH-LBxxxF	16F Y-harness, MTP-16 APC (non-pinned) to two 8F MTP PC (non-pinned), 36-in. (910 mm) breakout leg length, Type-B polarity, xxxF (ft) or xxxM (m)
EDGE8-CP32-V3	EDGE8 32-fiber MTP adapter panel (4 port), 50-µm multimode (OM4/OM3); mounts in EDGE8 housings (example: EDGE8-02U) NOTE: Panels are available in 4 ports.
GE5E508QPNDDUxxxF	EDGE8 trunk cable, 50-µm multimode (OM4), MTP connector (pinned) to MTP connector (pinned), 8 fibers, 33/33-in. legs, pulling grip one side, xxxF (ft) or xxxM (m) NOTE: Trunks are available in fiber counts from 8 to 288 fibers.
ECM-UM08-05-E6Q-ULL	EDGE8 ultra-low-loss (OM4) module, 8 F, LC duplex to MTP (nonpinned)
797902QD120xxxF	EDGE jumper, 2 F, LC uniboot to LC uniboot, riser, 50-µm multimode (OM4), xxxF (ft) or xxxM (m)
EDGE8-02U	EDGE8 housing with a 2U height, supports up to 36 MTP-to-MTP panels or MTP-to-LC modules; MTP density of 1152 fibers (144 8-fiber MTP ports), LC density of 288 fibers (144 2-fiber LC duplex ports) NOTE: Housings are also available in 1U and 4U heights.

Vendor: Corning	
Part Number	**Description**
Bill of Materials for Figure 32	
79NM02QD116001M	EDGE jumper, 2F, SN to LC uniboot, riser, 50-µm multimode (OM4), xxxF (ft) or xxxM (m)
ECM-UM08-05-E6Q-ULL	EDGE8 ultra-low-loss (OM4) module, 8 F, LC duplex to MTP (nonpinned)
GE5E508QPNDDUxxxF	EDGE8 trunk cable, 50-µm multimode (OM4), MTP connector (pinned) to MTP connector (pinned), 8 fibers, 33/33-in. legs, pulling grip one side, xxxF (ft) or xxxM (m) NOTE: Trunks are available in fiber counts from 8 to 288 fibers.
797902QD120xxxF	EDGE jumper, 2F, LC uniboot to LC uniboot, riser, 50-µm multimode (OM4), xxxF (ft) or xxxM (m)
EDGE8-02U	EDGE8 housing with a 2U height, supports up to 36 MTP-to-MTP panels or MTP-to-LC modules; MTP density of 1152 fibers (144 8-fiber MTP ports), LC density of 288 fibers (144 2-fiber LC duplex ports) NOTE: Housings are also available in 1U and 4U heights.

Vendor: Hexatronic Data Center			
Part Number	**Description**	**Rack Unit**	**Number of Ports**
7510-0101-029	Enclosure: 10U x 8 slot x 11.5-in. (d) ECO X7-8 modular enclosure 3-6, 9-12 overlay	10U	Up to 512
7110-0118-000	MTP/MPO-LC panel: 10U-8 64-channel black LC-quad ECO modular adapter panel FC32-64 QSFP 0-15/FC 00-63	10U	64
7310 0105-000	Modular cassette: 10U-8 64-channel black LC-quad OM4 ECO modular cassette FC32-64 QSFP 0-15/FC 00-63	10U	64

Vendor: Wave2Wave			
Part Number	**Type**	**Rack Unit**	**Number of Ports**
69EVO-1U00-5v2	MTP-MTP Conversion Patch Panel	1U	5 slots
69EVO-2U00-14V2	MPO-MPO Conversion Patch Panel	2U	14 slots, front and rear wire managers, blank coupler plates and mounting rails
69EVO51F-8020P-3x12-MG2M	MPO-LC Conversion Cassette	NA	EVO cassettes: OM4 3x 8-fiber MPO/APC (female) to 12xLC/UPC duplex (magenta), 2M, 3/12 (8F MPO/LC)
69EVO51F-8020P-3x12-2M	MPO-LC Conversion Cassette	NA	EVO cassettes: OM4 3x 8-fiber MPO/APC female to 12xLC/UPC duplex (aqua), 2M, 3/12 (8F MPO/LC)
69S6Z31U-8080P-10M	LC-LC Conversion Cable in A Box	1U	1U cable in a box with 6- 4xLC/PC To 4xLC/PC duplex, OM4, 10M, 24x LC duplex
69S2Z50P-8080P-10M-T3	MPO-MPO Conversion Cable in A Box	1U	1U cable in a box with 2- 3x 8F MPO/PC to 8F MPO/PC, OM4, 10M, 6x 8F MPO
69S2Z51PU-8240P-10M	MPO-LC Conversion Cable in A Box	1U	1U cable in a box with 2- 24F MPO/PC to 12xLC/PC duplex, OM4, 10M, 2/24 (24F MPO/LC)
69S2Z51PU-8080P-20M	MPO-LC Conversion Cable in A Box	1U	1U cable in a box with 2- 8F MPO/PC to 4xLC/PC duplex, OM4, 20M, 2/24 (24F MPO/LC)
69S32Z51P-8080P-3M	MPO-LC Conversion Cable in A Box	2U	2U cable in a box with 32x MPO/PC (female) to 4xLC/PC duplex, OM4, 3M OM4, 3M, 32/128 (MPO/LC)
69S24Z51P-8080P-10M	MPO-LC Conversion Cable in A Box	3U	3U cable in a box with 24x MPO/PC (female) to 4xLC/PC duplex, OM4, 10M, 24/96 (MPO/LC)
69S64Z51P-8080P-3M	MPO-LC Conversion Cable in A Box	3U	3U cable in a box with 64x MPO/PC (female) to 4xLC/PC duplex, OM4, 3M, 64/256 (MPO/LC)

D.6 Custom Director Trunks

Vendor: Hexatronic Data Center			
Part Number	**Description**	**Rack Unit**	**Number of Ports**
TB1964F5-3236-XXXF	Trunk: 64-fiber X7-8 FC32-64 0-31 OM4 plenum trunk LC-MTPf xxx (ft)	N/A	32 ports
TB2064F5-3236-XXXF	Trunk: 64-fiber X7-8 FC32-64 32-63 OM4 plenum trunk LC-MTPf xxx (ft)	N/A	32 ports

D.7 Velcro Cable Wraps

Use Velcro tie wraps instead of plastic zip ties or metal tie wraps. Over-tightening plastic zip ties or metal tie wraps can cause sheathing and can overstress the patch cables, causing signal loss and impacting performance. Velcro cable ties come in a roll or in predetermined lengths. Bundle groups of relevant cables with Velcro cable ties as you install the cables, which will help you identify cables later and facilitate better overall cable management.

D.8 Labelers

Labelers are used to print sticky labels for devices and cables. Here are some considerations when you choose a hand-held labeler:

- The labeler should be capable of operating with batteries.
- The labeler can print labels on smooth, textured, flat, and curved surfaces.
- The actual label material should resist solvents, chemicals, and moisture.
- Labels are durable and resist fading.
- Adhesive should be long lasting.

If you choose a labeler with bundled software, install it on a client workstation. You can then customize labels, print labels in batches, and store the formats for future printing.

Appendix E: OSFP/QSFP Supported Connection Distances

Optic Type	Connection Type	Speed	Multimode Max. Distance		Single Mode Max. Distance	Comments
			OM3	OM4/4+/5		
Gen 8 SWL ICL OSFP	OSFP to OSFP	Gen 8 ICL	70m	100m	—	0-dB connector loss assumes point-to-point connection without patch panel.
Gen 8 LWL ICL OSFP	OSFP to 2x QSFP[a]	Gen 7 ICL	—	—	2 km	0-dB connector loss assumes point-to-point connection without patch panel.
Gen 7 SWL ICL QSFP	QSFP to QSFP	Gen 7 ICL	70m	100m	—	0-dB connector loss assumes point-to-point connection without patch panel.
Gen 7 LWL ICL QSFP	QSFP to QSFP	Gen 7 ICL	—	—	2 km	0-dB connector loss assumes point-to-point connection without patch panel.
32G SWL QSFP	QSFP to QSFP or SFP (1-dB connector loss)	32G/16G	70m	100m	—	1 dB represents the maximum likely signal loss from a breakout cable.
32G LWL QSFP[b]	QSFP to QSFP	32G	—	—	2 km	0-dB connector loss assumes point-to-point connection without patch panel.
16G SWL QSFP	QSFP to QSFP	16G/8G/4G	100m	125m	—	0-dB connector loss assumes point-to-point connection without patch panel. Tri-modal support on FC-compliant version only, P/N 57-1000294-02.
16G SWL QSFP	QSFP to QSFP or SFP (1-dB connector loss)	16G/8G/4G	66m	100m	—	1 dB represents the maximum likely signal loss from a breakout cable. Tri-modal support on FC-compliant version only, P/N 57-1000294-02.
16G LWL QSFP	QSFP to QSFP	16G	—	—	2 km	0-dB connector loss assumes point-to-point connection without patch panel.

a. Requires the use of QSFP with the serial number sequence BAB1yywwxxxxxxxs and FOS 10.0 in order to run SFP upgrade on the QSFP.

b. Supported but no longer offered for sale.

Appendix F: Cable Management and Patch Panel Vendors

Vendor	URL	Email	Phone
Cable Vendor *a Conexus Technologies Inc. brand*	www.cablevendor.com	sales@cablevendor.com	1-800-681-1574
CABLExpress	www.cablexpress.com	info@cablexpress.com	1-800-913-9465
Corning	www.corning.com/opcomm	—	1-800-743-2671
Hexatronic Data Center *Data Center Systems*	www.hexatronicdatacenter.com/en/dcs	info@datacentersystems.com	1-972-620-4997
OptiClarity	www.opticlarity.com	areynoso@opticlarity.com	1-510-456-6754
Wave2Wave *formerly Cabling123*	www.wave2wave.io	info@wave2wave.io	1-866-473-2701

Appendix G: Reference Materials

- *High-Density Fiber Adapter Panel Shelf Instructions* (CommScope Part Number: 860499748)
- TIA-568-C.0—*Generic Telecommunications Cabling for Customer Premises*
- TIA-568-C.3—*Optical Fiber Cabling Components Standard*

Revision History

HD-Cabling-DG105; January 9, 2026

Updated to include X8 Director and OSFP optics.

HD-Cabling-DG104; March 11, 2024

Updated FC64-64 port numbering.

HD-Cabling-DG103; September 26, 2023

Updated images to decrease overall file size.

HD-Cabling-DG102; June 17, 2023

Updated to include the Brocade FC64-64 port blade X7-2 hardware references.

HD-Cabling-DG101; July 15, 2022

In Chapter 2, added an image of the Brocade G630 Switch and replaced the drawing of the SFP-DD optical transceiver with a photograph of the transceiver.

HD-Cabling-DG100; June 17, 2022

Updated to include the Brocade FC32-64 port blade, SFP-DD connectivity, and Gen 7 hardware references.

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