BROCADE
A Broadcom Company

High-Density Cabling

Design Guide

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Chapter 1: Preface

As the number of devices connected to Fibre Channel fabrics grows, the demand for options to enable simplified connectivity grows as well. Alternatives to widely used LC connectors are being offered to address this demand, including quad-port QSFPs and dual-port SFP-DD (double-density) transceivers, and are increasingly being deployed to enable denser consolidation of optics and cabling. QSFP optics are used on multiple products, including the FC32-64 high-density port blade for the Brocade® X6 Directors and X7 Directors, the UltraScale inter-chassis link connections on the Brocade X6 and X7 Director families, and the Q-Flex ports on the Brocade G620 and G630 Switches. The QSFP form factor has been widely deployed across the networking industry for both Ethernet (40GbE, 100GbE, and 200GbE speeds) and Fibre Channel connectivity, making cabling options readily available. 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 as well. SFP-DD optic support high-speed 64G FC connectivity through a two-lane electrical host interface with two SN cable connections per optic. This document provides customers deploying QSFP-equipped and SFP-DD-equipped products with general guidelines for proper optical fiber cable management.

1.1 Purpose of This Document

Using QSFP and SFP-DD optics to connect to device ports may not be familiar to all Fibre Channel users. This document provides customers who deploy QSFP and SFP-DD 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 X6 Directors and X7 Directors equipped with FC32-64 or FC64-64 blades and other QSFP or SFP-DD 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 QSFP and SFP-DD connectivity in a storage fabric. While not intended as a definitive cable design document, it does introduce concepts and guidelines to help you 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 QSFP and SFP-DD optics
- Structured high-density cable management solutions based on MPO/MTP connectors and patch panels
- Best-practice guidelines and recommendations for optical fiber cabling
- Descriptions of cabling required for various configurations
- Part numbers for some of the 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
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	Lucent Coupler connector found on single-channel SFP, SFP+, or XFP transceivers.
MPO/MTP	MPO is an industry term for multifiber push-on connector; 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 but 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.
Patch cable	Cables consisting of single or multiple fibers used for connectivity between switches or devices.
Patch panel	A device with ports or jacks used as an interface for connecting and routing optical signals across a network.
RU	Rack unit (4.4 centimeters/1.75 inches).
SFP-DD transceiver	Small form-factor pluggable – A double-density interface that supports the use of a single SFP+ transceiver or two-lane SFP-DD optical transceivers.
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. SN is a registered trademark of Senko Advanced Components.
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.

1.5 Related Documents

- Brocade Transceiver Support Matrix
- Brocade FC32-64 Port Blade Product Brief
- Brocade X7 Director Product Brief
- Brocade X7-8 Director Hardware Installation Guide
- Brocade X7-4 Director Hardware Installation Guide
- Brocade X6-8 Director Hardware Installation Guide
- Brocade X6-4 Director Hardware Installation Guide
- Brocade G730 Switch Hardware Installation Guide
- Brocade G720 Switch Hardware Installation Guide
- Brocade G630 Switch Hardware Installation Guide
- Brocade G620 Switch Hardware Installation Guide

Chapter 2: Introduction

As data centers scale to handle higher amounts of stored data distributed across a growing numbers 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, 4-channel QSFP (quad small form-factor pluggable) optic on the Brocade FC32-64 blade, Brocade X6, and Brocade X7 Director ICLs, and Q-Flex ports on the Brocade G620 and 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 SFP-DD (small form-factor pluggable double-density) 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. Both QSFPs and SFP-DDs retain the performance and functionality of the standard SFP+ transceivers.

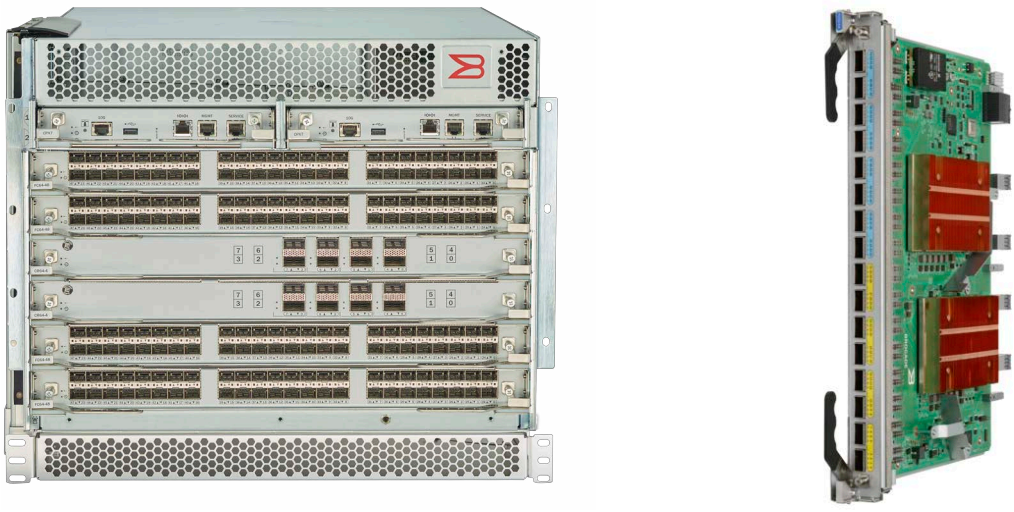
Brocade products offer QSFP optics with MPO connectors on several models. For more information, see the following sections.

2.1 Brocade Gen 6 and Gen 7 Directors

Brocade X6 Directors and X7 Directors with the Brocade FC32-64 Port Blade

The Brocade FC32-64 high-density 64-port Fibre Channel blade for the Brocade X6 and X7 Director families combines industry-leading port density, scalability, reliability, and energy efficiency to maximize the benefits of SAN and server consolidation. The FC32-64 enables mid to large enterprise customers to deploy high-density modular chassis-based solutions that minimize the physical footprint without compromising performance. High-density Fibre Channel port blades increase chassis density by 33 percent over a chassis populated with 48-port blades, enabling the Brocade X6-8 and X7-8 to scale up to 512 ports and the Brocade X6-4 and X7-4 to scale up to 256 ports.

Figure 1: Brocade X7-4 with Four FC32-48 FC Port Blades and Two CR Blades with Eight ICL Ports Each-With a standalone Brocade FC32-64 Blade on the Right



Brocade X7 Directors with the 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 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 percent over a chassis populated with 48-port blades, enabling the Brocade X7-8 to scale up to 512 ports and the Brocade X7-4 to scale up to 256 ports with full 64G performance.

Figure 2: Brocade X7-4 Populated with Four Brocade FC64-64 FC Port Blades and a standalone Brocade FC64-64 Blade on the Right

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

Figure 3: Brocade FC64-64 Port Blade Port Numbering

Inter-Switch Cabling of High-Port-Count Fiber Equipment

UltraScale inter-chassis links provide optical connectivity for up to 12 Brocade director chassis to a common core-edge or up to nine directors in an active-active mesh chassis topology across distances up to 2 km. These high-density topologies use QSFP optics from dedicated ports on the core routing blades, which consolidate inter-switch cabling by 75 percent and free up to 25 percent 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 RU in a modular chassis.

2.2 Brocade Gen 6 Switches

Brocade G620 Switch

The Brocade G620 is a 64-port, high-density Fibre Channel switch to support rapid growth, demanding workloads, and data center consolidation in small- to large-scale enterprise infrastructures. This high-density design enables organizations to connect more devices across the data center with a smaller footprint, reducing costs and management complexity. To enable maximum flexibility and scalability, the Brocade G620 is configurable from 24 to 64 ports with 48 SFP+ and four Q-Flex ports. Organizations can scale from 24 to 64 ports with a combination of 12-port SFP+ Ports on Demand (PoD) licenses and a 16-port Q-Flex PoD. Each of the four Q-Flex ports is capable of supporting 4×32G or 128G speeds for device port or ISL port connectivity. As an ISL connection, the Q-Flex ports can be broken out into individual 32G connections or can be connected to a Brocade FC32-64 blade in a core director using a 32G QSFP optic in the Q-Flex port.

Figure 4: Brocade G620 Switch with 4 x Q-Flex MPO Connectors

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 Q-Flex ports. Organizations can scale from 48 to 128 ports with a combination of 24-port SFP+ Ports on Demand (PoD) licenses and a 32-port Q-Flex PoD. Each of the eight Q-Flex ports is capable of supporting 4×32G or 128G speeds for device port or ISL port connectivity. As an ISL connection, the Q-Flex ports can be broken out into individual 32G connections or can be connected to a Brocade FC32-64 blade in a core director using a 32G QSFP optic in the Q-Flex port.

Figure 5: Brocade G630 Switch with 8 x Q-Flex MPO Connectors

Q-Flex Ports

Brocade Gen 6 G620 and G630 Switches have Q-Flex ports that are available for flexible inter-switch link (ISL) and device connectivity with 32G speeds. These ports are designed to support single QSFP optical transceiver connections or to fan out to four standard SFP+ connections, enabling administrators to simplify cabling infrastructure. The Ports on Demand (PoD) feature of the Brocade G620 and G630 gives organizations the flexibility to mix and add Q-Flex ports at any time.

Figure 6: Quad SFP (QSFP) Optical Transceiver with a Pull-Tab

2.3 Brocade Gen 7 Switches

Brocade G720 Switch

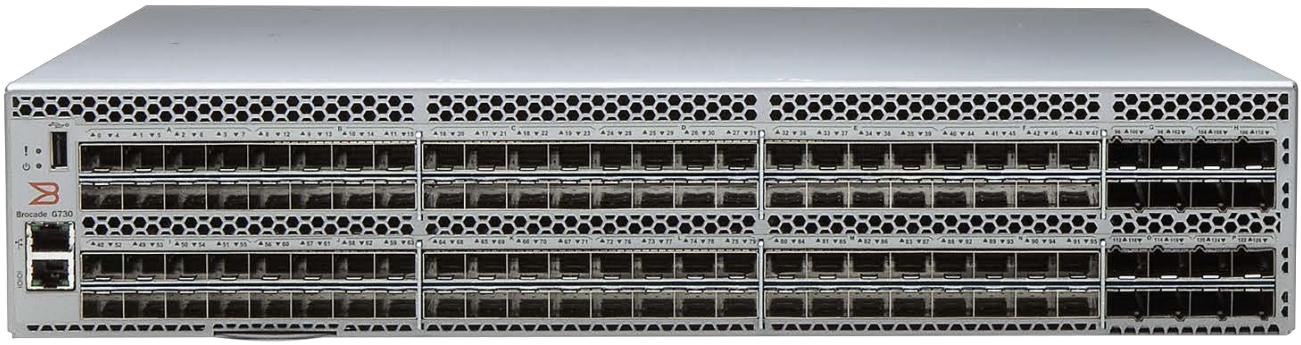
The Brocade G720 Switch is built for maximum flexibility, scalability, and ease of use, providing comprehensive telemetry with built-in analytics to optimize storage network performance and eliminate disruptions. The Brocade G720 scales from 24 to 64 ports with 48 SFP+ and 8 SFP-DD ports, which support up to 16 channels at full 64G Fibre Channel 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 64G Fibre Channel performance.

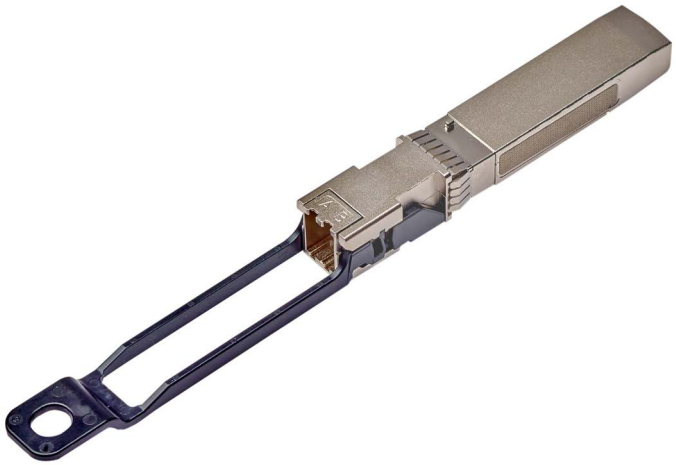
Figure 8: Brocade G730 Switch with 16 x SFP-DD Connectors



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

Gen 7 FC64-64 blades for Brocade X7 Directors and Brocade G720 and G730 Switches support a double-density 64G optical transceiver (SFP-DD), which allows them to scale to achieve industry-leading port density. SFP-DD port interfaces support the use of 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 SFP+ or SFP-DD transceivers, 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 for some patch cable options from leading cabling vendors.

Figure 9: SFP-DD with a Pull-Tab



2.4 Differences between Standard SFP+, QSFP, and SFP-DD Optics

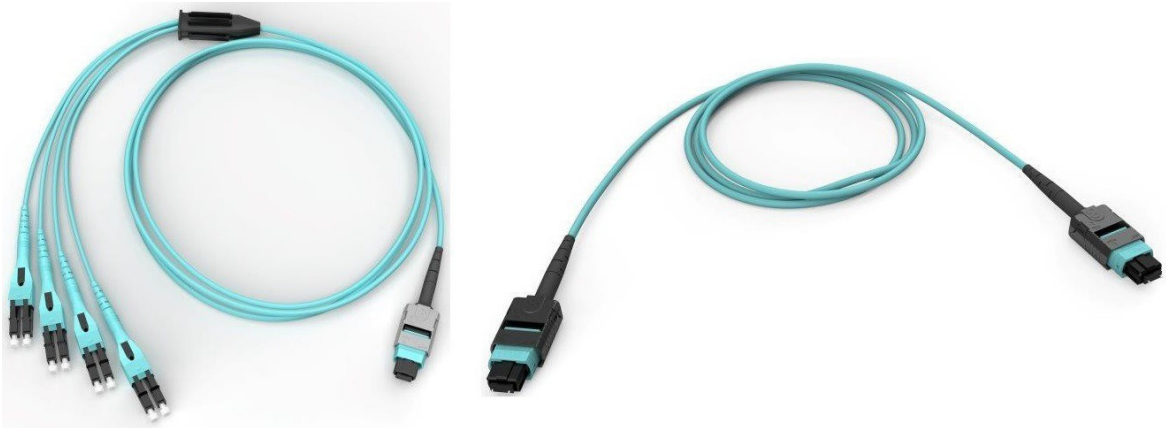
The following table provides an overview of the differences between standard SFP+, QSFP, and SFP-DD optics. QSFPs leverage the same technology as standard SFPs but combine four channels into one optic to better support high-density SAN solutions, while SFP-DDs combine two independent channels into one port interface.

Specification	SFP+	QSFP	SFP-DD
Speed Grades	2G, 4G, 8G 4G, 8G, and 16G 8G, 16G, and 32G 16G, 32G, and 64G	4G, 8G, and 16G 16G and 32G	16G, 32G, and 64G
Operating Distance	Same	Same	Same
Availability of SWL Transceivers	Yes	Yes	Yes
Availability of LWL Transceivers	Yes	Yes, up to 2 km	No
Regulatory Compliance	Same	Same	Same
Dimensions: Fiber Pitch	6.25 mm	0.25 mm	3.8 mm
Dimensions: Width	13.55 mm	18.35 mm	8.6 mm
Dimensions: Depth	56.40 mm	Excluding pull-tab: 68.00 mm Including pull-tab: 132.00 mm	Excluding pull-tab: 54.25 mm Including pull-tab: 117.84 mm
Patch Cord Compatibility	LC-LC patch cord	MPO/MTP–MPO/MTP or MPO/MTP–LC breakout patch cords for 100m optics. LC-LC patch cords are required for 32G and Gen 7 ICL 2-km LWL optics.	SN-LC, SN-SN or 4x SN (breakout)-QSFP patch cord up to 100m
Optics Supplier	Broadcom	Broadcom	Broadcom

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 (Figure 10) provide the same flexibility in connectivity as standard LC cables:

- MPO-4xLC breakout cable assembly: Provides the FC32-64 port blade or G620/G630 Q-Flex ports with the ability to connect to port blades, switches, hosts, or storage devices utilizing LC connectors or patch panels.
- MPO-MPO cable assembly: Allows one FC32-64 port blade to connect to an MPO/MTP patch panel or another FC32-64 port blade as an ISL, as well as connecting ICL ports between Brocade DCX® 8510, X6, or X7 Directors.

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



SN-terminated cables can be used to connect to Brocade SFP-DD optics used on the Brocade G720 and G730 Switches 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 four channels into one transceiver and MTP-connect fiber cable like a QSFP, Therefore, cable management guidance will be the same as LC-terminated cables.

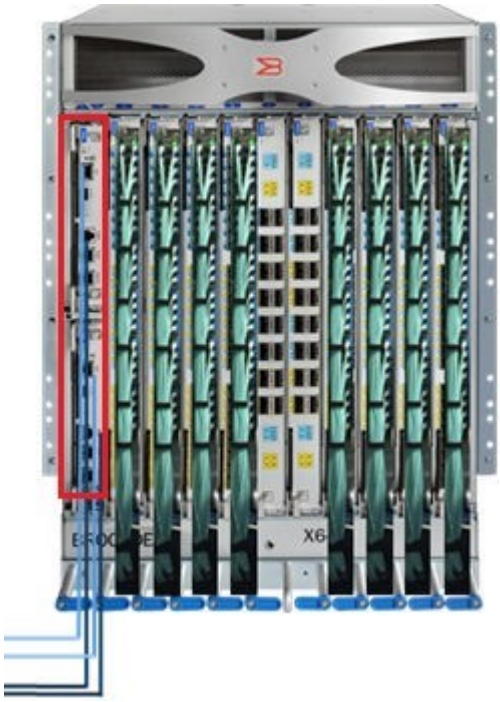
- SN-LC cable assembly used for connections between servers, storage devices, or LC patch panels and SN-connector-equipped SAN ports
- SN-SN cable assembly for ISL connections between SN connector-equipped SAN ports
- 4x SN-QSFP breakout cable assembly is used for connections from SN connector-equipped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

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

Chapter 3: Planning

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 can be managed in a variety of ways, such as by routing cables below the chassis, to either side of the chassis, 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 X6 and X7 power supplies to eliminate cable interference when servicing the power supplies and cords. Additionally, note the location of the Brocade X6-8 and X7-8 half-height control processor blades on the far left side of the chassis to ensure unblocked access to management ports.

Figure 12: Brocade X6-8 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 built-in flexibility will permit devices to be located anywhere within the data center.

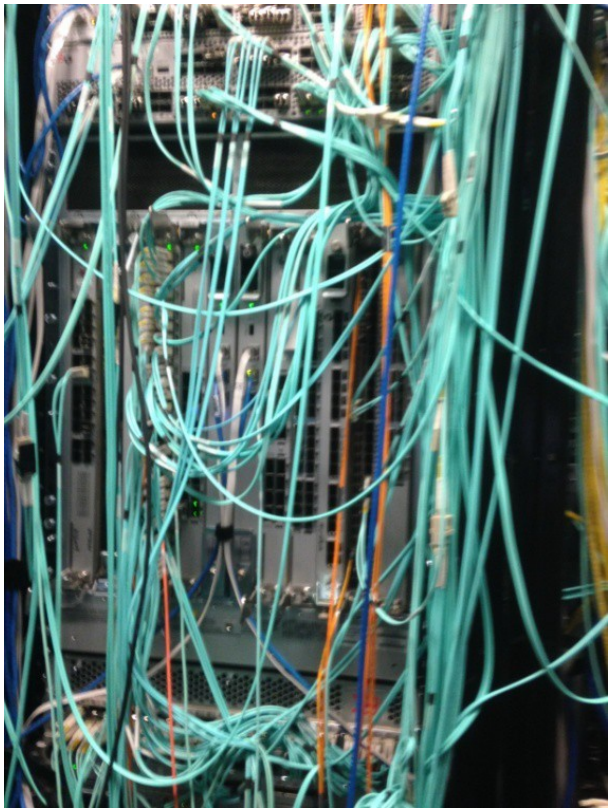
3.1 Challenges with Unstructured High-Density Solutions

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 13: Cable Clutter



3.2 Using a Structured Approach

Cable management solutions designed specifically for Brocade SAN infrastructures with the Brocade X6 or X7 Director with QSFP-based FC32-64 port blades or Brocade G620 and G630 switches 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.

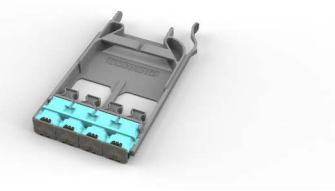
3.2.1 High-Port-Count Fiber Equipment for QSFP Connectivity

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.

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 MTP 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.

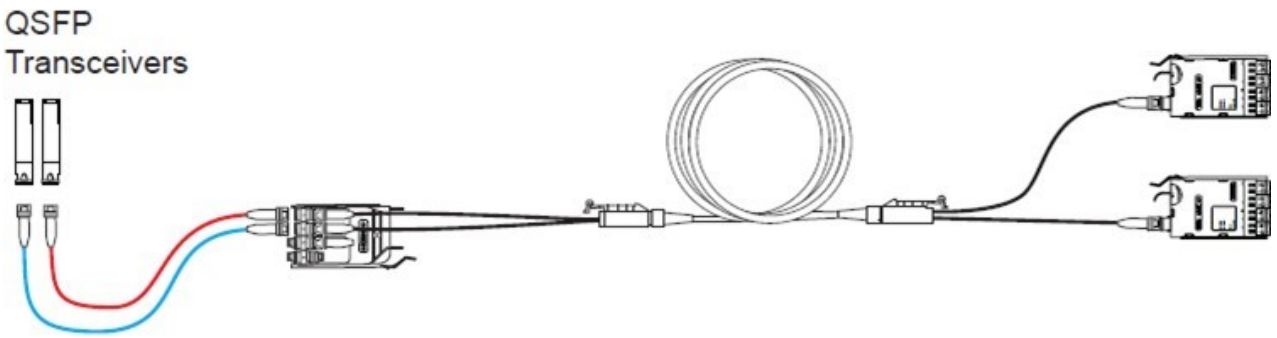
Typical components used in optical cabling infrastructure are shown in the following table.

MTP Trunk Assembly		MTP-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 MTP connectors at a specified length and have a pulling grip for easy installation and removal.
Connector Housing		Connector housings are physically mounted in a19-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.
MTP-LC Module		MTP-to-LC modules are installed into the connector housings. They break out the MTP connection from the trunk cables into LC connectivity. Thus, the trunk cables plug into the rear MTP of the module, and LC jumpers plug into the front of the module.

MTP Adapter Panel		MTP adapter panels (sometimes called bulkheads) are installed into the housings. They offer a connection point between the MTP trunks and the MTP jumpers or breakout harnesses. Thus, the trunk cables will plug into the rear of the panel, and the MTP jumpers or harnesses will plug into the front of the panel.
MTP-LC Harness (breakout cable)		MTP-LC harness assemblies are used for breaking out the MTP connector into multiple LC connections.
MTP or LC Jumpers	 	LC and MTP jumpers serve to create the connection between device ports and the structured cabling.

When cabling high-density, high-port-count MTP equipment, such as the Brocade X6 and X7 with FC32-64 blades, 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 MTP/MPO-based structured cabling for breakout into LCs in another connector housing at the other end of the cabling link (see Figure 14).

Figure 14: Structured Cabling Example for MTP Connectivity to LC Breakout in Central Patching Area



Once fully cabled, the housings in this central patching area functions as if it 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, thus 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*
- 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 Standard

- 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 11801:2009, *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 http://global.ihs.com/.

3.4 Establishing 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 communications 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)
- 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)

(Building and room may be excluded if there is only one instance of this entity in the environment.)

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 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 multimode fiber with 12 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, OM4+, or OM5 multimode fiber. OM4, OM4+, and OM5 will generally allow for the longest link distances up to 100m and are strongly recommended.

4.2 QSFP-to-4-SFP+ (4x LC) Optical Breakout Cables

Breakout cables can also be used with newer SWL (100m) QSFP transceivers that support breakout (XBR-000275/475) 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, OM4+, or OM5 multimode fiber, with OM4, OM4+, and OM5 recommended for the longest link distances at full line-rate speed.

4.3 QSFP-to-2-SFP-DD (4x SN) 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, OM4+, or OM5 multimode fiber. This cable configuration may not be widely available, so we recommend that you check with your preferred vendor for guidance.

Broadcom also offers 2-km Gen 7 QSFP optics for Brocade X7 ICL connectivity. These extended distance QSFP transceivers use a passive CWDM (coarse wave division multiplexing) 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, a high-quality SMF LC-LC cable at the required length up to 2 km from your preferred optical cabling vendor is recommended.

The following table summarizes the supported Brocade QSFP 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-MPO	MMF
XBR-000476	Gen 7 QSFP	2 km	ICL	Gen 7 ICL	LC-LC	SMF
XBR-000475	32G QSFP	100m	Device/ISL/ICL	32G FC	MPO-MPO or MPO-4x LC	MMF
XBR-000285[a]	32G QSFP	2 km	ISL/ICL	32G FC	LC-LC	SMF

a. Supported but no longer offered for sale.

Chapter 5: Cable Management Setup and Configuration

A cable management solution using an MPO/MTP patch panel allows for easy management of high-density cabling, even for a Brocade X6 and X7 Director with up to eight FC32-64 port blades. The traditional method of cabling blades with SFP ports uses MTP-LC modules to break out the MTP trunk assemblies into LC ports for jumper connectivity into the SAN director. Or, for improved cabling, MTP-LC harnesses are used to transition the MTP connector to LC leads that connect into the SAN director ports. Larger installations with multiple units may require multiple patch panels to accommodate the transition from the MTP connectivity to the traditional LC connectivity, which can use up to an additional 10 RU of valuable rack space. With the use of QSFP transceivers on the Brocade FC32-64 blades, cabling density can be further optimized through the use of MTP patch cords from the structured cabling directly into the SAN director ports, with breakouts to LCs at the other end of the cabling link. 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 for the FC32-64. Please consult with your preferred cabling provider to learn about solutions available from alternative vendors.

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

5.1 CABLExpress

CABLExpress' Port Replication Rack Mount Modules provide a patch panel with a direct one-to-one relationship between the ports on a Brocade G620 or G720 Switch and the patch panel. This correlation reduces the chance for patching errors since the ports are numbered and oriented exactly the same, facilitating the cabling moves, adds, and changes (MACs). This type of patch panel solution increases the benefits and scalability of the Brocade G720 or G620 64-port design, while also offering the benefits of structured cabling. These replication patch panels come prewired to convert the Brocade G620 Q-Flex MPO or Brocade G720 SFP-DD ports into duplex LC ports, avoiding the need for conversion harnesses.

Figure 15: CABLExpress Port Replication Modules

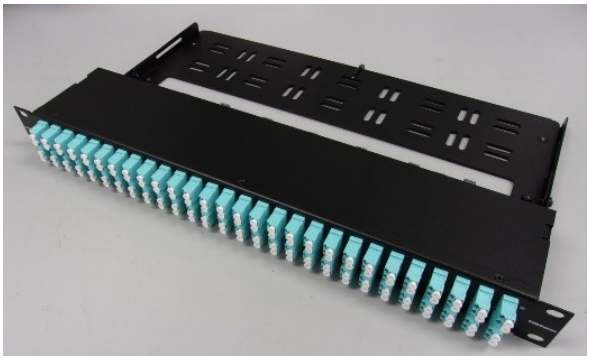


Figure 16: SN Duplex to LC Duplex Structured Cabling Interconnect

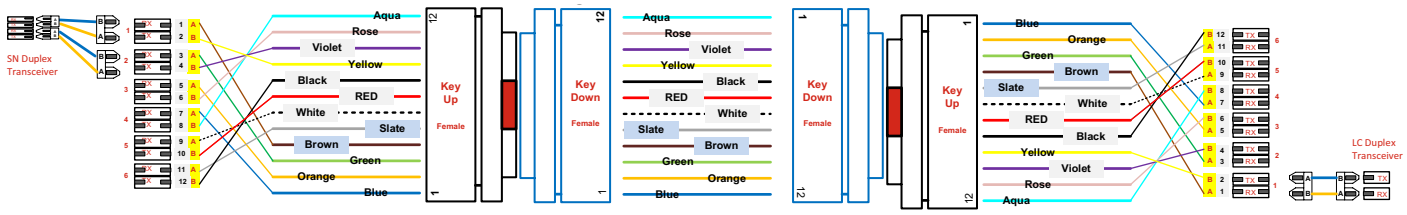
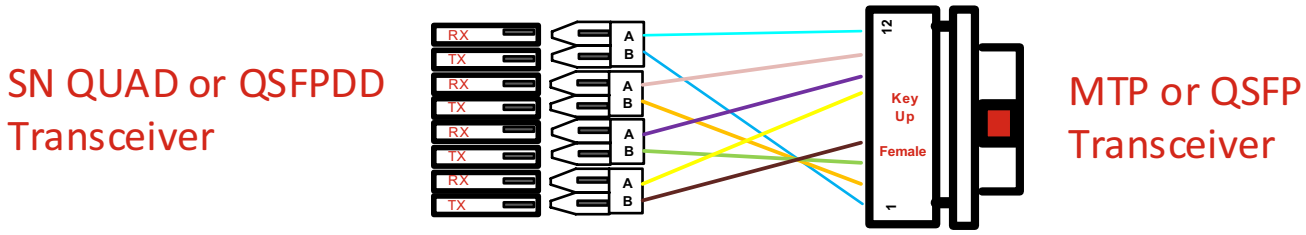


Figure 17: SN Duplex to MTP Harness



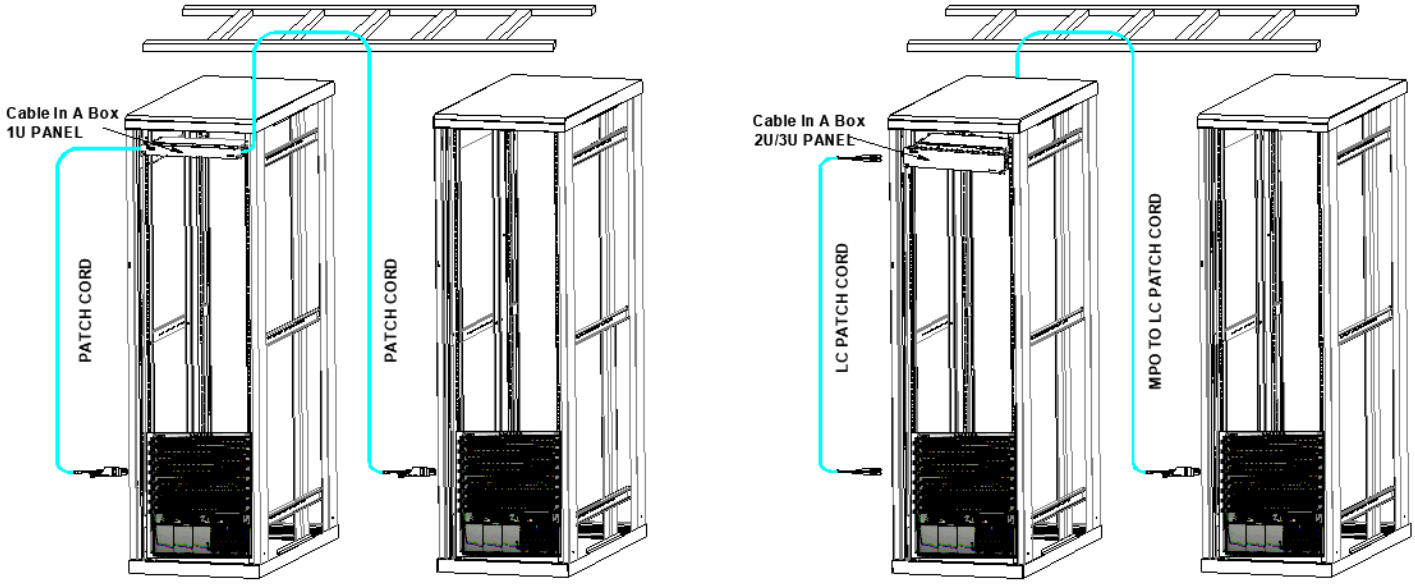
5.2 Cabling123 (Wave2Wave)

Cabling123 (Wave2Wave) also offers smart panel and next generation connector-SN for the modern generation data center.

Figure 18: Smart Panel-EVO Series

Cabling123 (Wave2Wave) also provides a turn-key structured cabling solution for the Brocade FC32-64 port blades. The turn-key solution is designed with kits to each row, packaging to each rack, and labeling to each connection end-to-end.

Figure 19: Smart Panel Scenarios



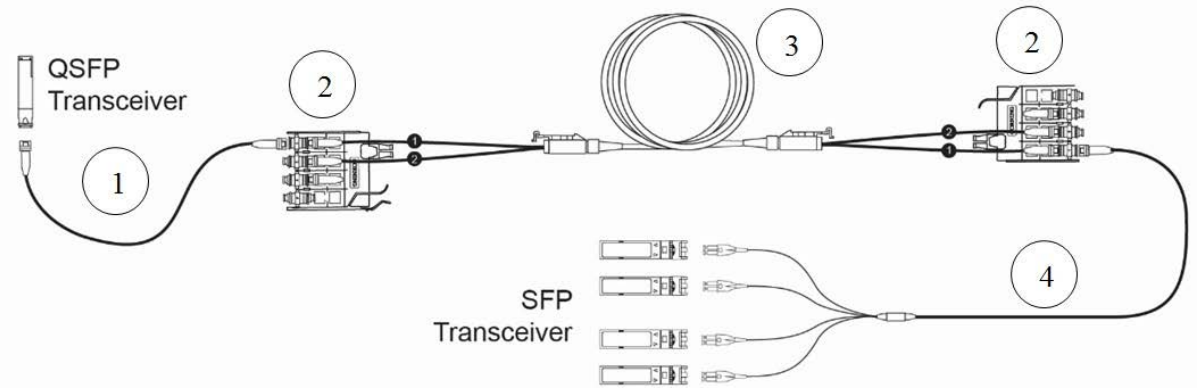
5.3 Corning

Corning provides a structured cabling solution for the Brocade X6 and X7 FC32-64 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's EDGE8 solutions with MTP-based connectivity. MTP jumpers are installed from each of the QSFP ports on the FC32-64 blade to MTP adapter panels in an EDGE8 patch panel. Using high-density EDGE8 housings and 4-port MTP adapter panels, a full Brocade X6-8 or X7-8 Director can be supported with one 2U EDGE8 housing, and a full Brocade X6-4 or X7-4 can be supported with one 1U EDGE8 housing.

5.3.1 Point-to-Point Structured Cabling Options

As shown in Figure 20, from the housing at the director cabinet, MTP-terminated trunk assemblies are installed to the end equipment cabinets and landed in MTP adapter panels in an EDGE8 housing or bracket at the end equipment (server) as well. From each MTP port in the housing, an 8-fiber MTP-to-LC harness assembly is installed and the 4xLC Uniboot legs of the assembly are installed to the SFP ports at the host or storage equipment. This design would be utilized when the four SFP ports are located on the same device in nearby proximity for clean cable management and when these ports are operating on the same fabric through a single QSFP port at the director.

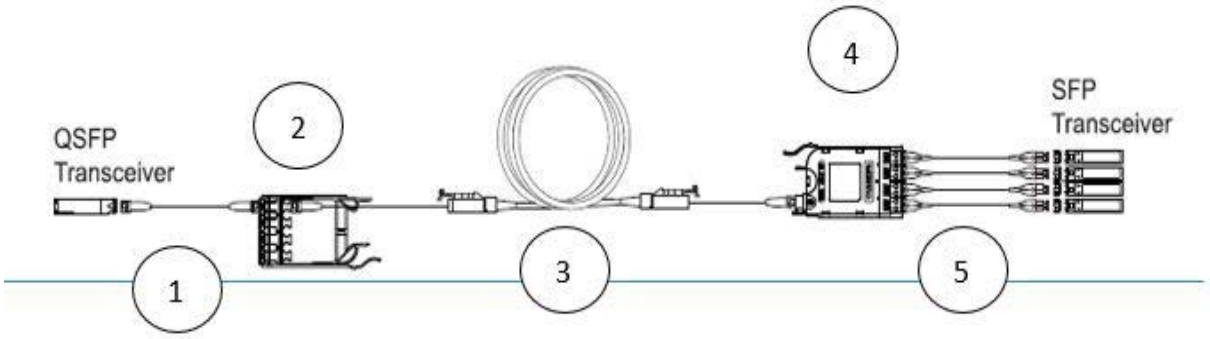
Figure 20: Connectivity Line Diagram for Point-to-Point Structured Cabling with 8-Fiber Harness



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 FC32-64 blade 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.

For servers, or other end equipment, where the 4xLC ports are not located in close proximity on a single device or are being split between multiple devices, a more manageable approach is to land the MTP-terminated trunk assemblies into MTP-to-LC modules, where individual LC jumpers can be used for each of the 4xLC ports, as shown in Figure 21.

Figure 21: Connectivity Line Diagram for Point-to-Point Structured Cabling with Module Breakouts



5.3.2 Cross-Connect Structured Cabling Options

Utilizing a cross-connect design enables port replication of the SAN director ports, which in turn provides for 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. By moving the patching function to this central patching area, risk of damage to director ports is eliminated as day-to-day MACs occur only at this passive patching field and not directly at the QSFP 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 the 48-port FC32-48 blade, 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 FC32-64 blade, 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 http://csmedia.corning.com/CableSystems//Resource_Documents/application_engineering_notes_rl/AEN152.pdf.

5.4 Data Center Systems

The 64-Channel FC32-64 Mimic Adapter Panel available through Data Center Systems (DCS) 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:

- Implementing the structured connectivity solution shown in Figure 22 provides the least amount of mated pair insertion loss.
- Two 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 23) at the central patching location.
- One DCS 64-Channel FC32-64 Mimic Adapter Panel (Figure 23).

To further enhance management, DCS offers Mimic Adapter Panels and Cassettes with color schemes to distinguish between A and B fabrics as well as backup.

Figure 22: Data Center Systems Centralized Structured Connectivity Solution with Core-Edge Topology

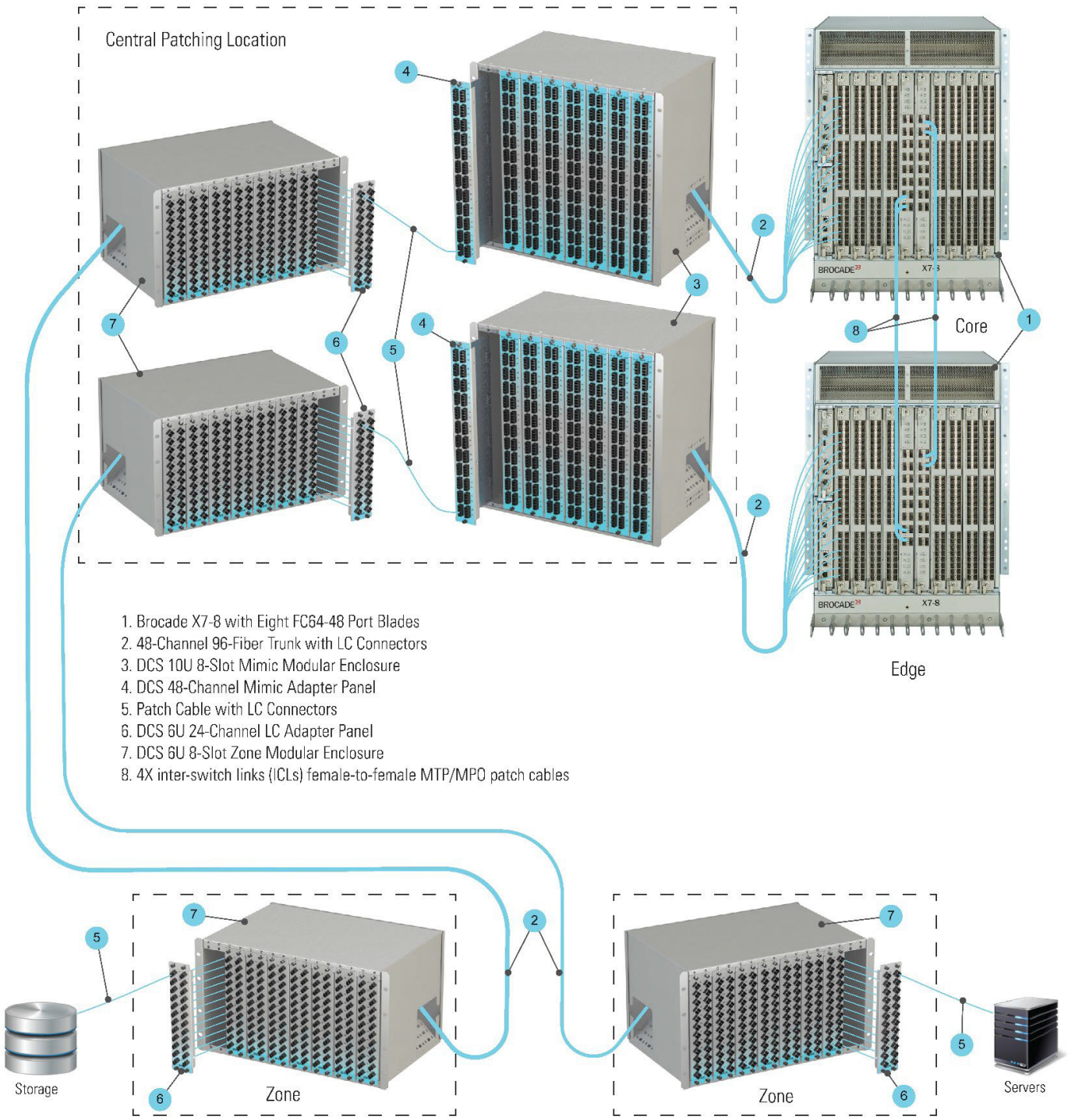
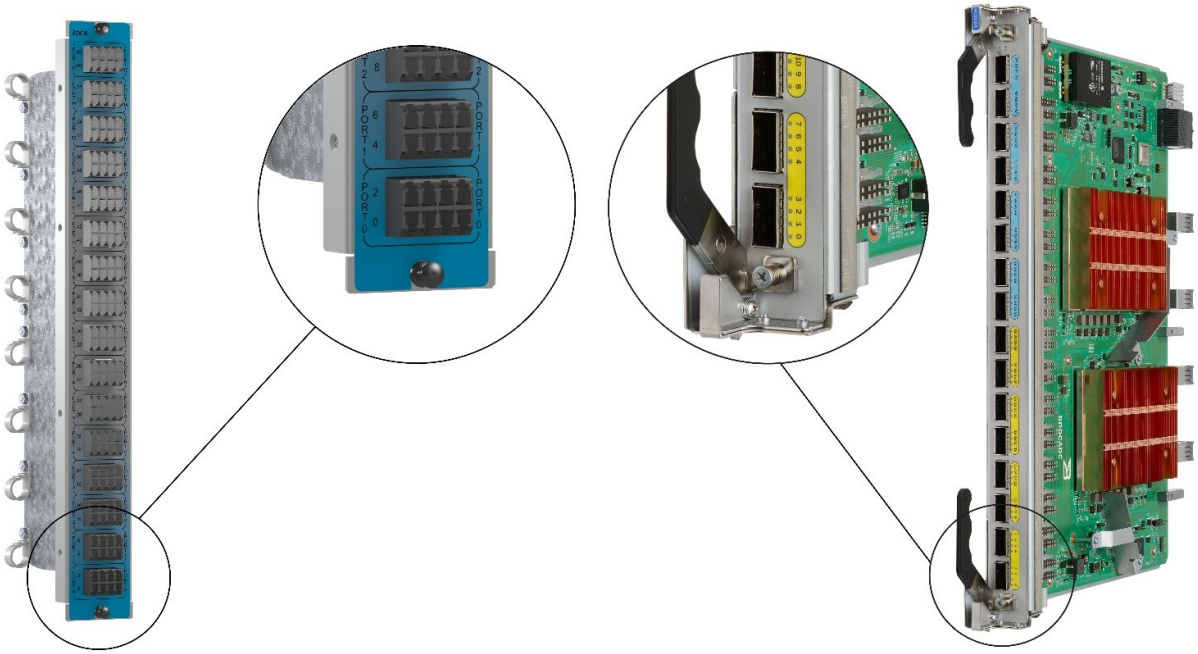


Figure 23: Data Center Systems 64-Channel FC32-64 Mimic Panel for the Brocade X6 Director and X7 Director

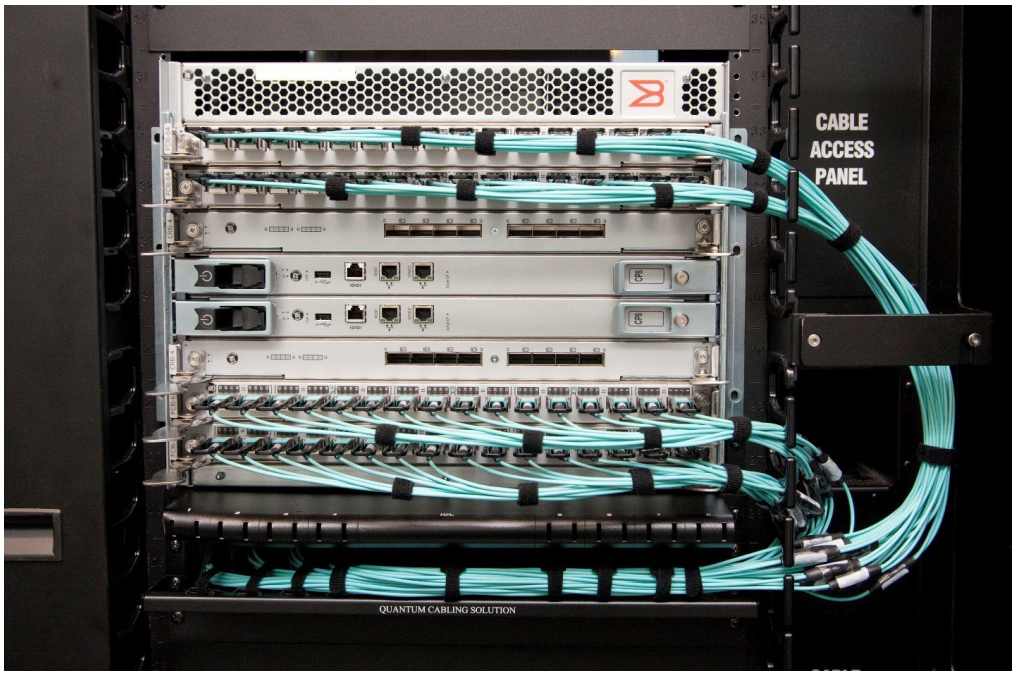


Chapter 6: Brocade X6 and X7 Cabling Installation

1. For a Brocade X6-8 and X7-8 chassis with vertically mounted blades, start cabling from the bottom QSFP port group (such as ports 0 to 3), working up the blade to the top QSFP port (60 to 63). 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 X6-4 and X7-4 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 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 will minimize the confusion as to which director ports are allocated to which MPO/MTP patch panel ports. Allocate 30 centimeters (12 inches) 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 X6-8 and X7-8 (8-slot) chassis and then to the left/right and 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 a 4-slot director chassis, cables can be routed to the right of the chassis (Figure 24).

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

Figure 24: 256-Port Wrapped/Bundled and Completed Cabling Solution



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

Figure 25: Device-to-Patch-Panel Trunk Cabling

Chapter 7: Servicing High-Density QSFP Solutions

When servicing during an anomaly because of cable density, identifying and servicing individual fiber cables at the port level can be a challenge. The QSFP transceivers used in the Brocade FC32-64 port blade are fitted with a pull-tab to aid in installation and removal. The following steps will ease the servicing process.

7.1 Connecting a Cable to an Empty QSFP

1. Remove the QSFP optic from the port. Hold the QSFP pull-tab firmly and gently pull the QSFP away from the connected port.
2. Verify that the chosen optical cable supports QSFPs.
3. Connect the cable to the QSFP.
4. Insert the QSFP into the port. Hold the pull-tab on the QSFP firmly, insert the QSFP into the port, and slide it back into the port until the transceiver locks into place with a click.

7.2 Removing a Cable from a Populated QSFP

1. Remove the QSFP 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 QSFP pull-tab firmly, and gently pull the QSFP away from the connected port.
2. Disconnect the cable from the QSFP.

Chapter 8: Servicing SFP-DD Solutions

SFP-DD optics use connectors referred to as VSFF, very small form factor. As the name implies, the duel 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 servicing process. Additional training materials on SFP-DD optic handling can be found on the Broadcom learning portal here. Customer access to the learning portal is required. Follow the steps in this video to create an account.

8.1 Connecting a Cable to an Empty SFP-DD

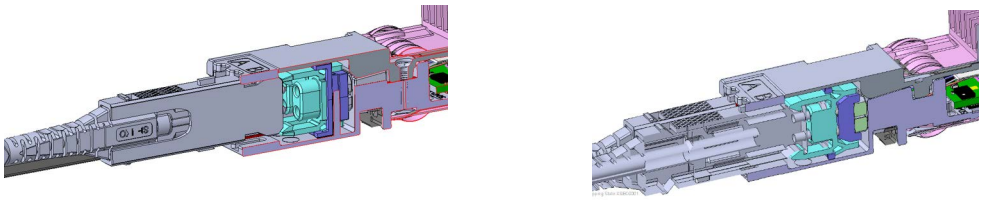
1. Remove the SFP-DD optic from the port. Use the SFP-DD pull-tab to grasp the optic firmly and gently pull the SFP-DD optic away from the connected cage. The best practice is to leave the dust caps inserted into the SFP-DD until you are ready to insert the fiber cable into the optic.
2. Verify that 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 26: Brocade SFP-DD Optic without Cables or Dust Covers versus Brocade SFP-DD Optic with 2x SN Cable Connectors

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 27: Brocade Optic Fully Inserted Into the SFP-DD Cage with 2x SN Cable Connectors Attached

Optic Engagement to First Click / Optic Engagement to Second Click



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 Removing a Fiber Cable from a Populated SFP-DD

1. Identify the correct cable to be removed. Loosen any cable wraps used for holding 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 separated. 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 cabling components in locations that block access to other equipment (power strip or fans) inside and outside the racks.
- Keep all cable runs under 90 percent 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.
- Cabling 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.
- Locate the main cabling distribution area nearer the center of the data center to minimize cable distances.
- Do not route cables such that they block equipment cooling fans and restrict airflow.
- Use thin and high-density cables wherever possible, allowing more cable runs in tight spaces. Ensure that quality cabling that meets standards specifications is used.
- Dedicate outlets for terminating horizontal cables; that is, 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 the 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-based 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/physical cabling diagrams.

9.3 Summary

Although cabling represents less than ten percent 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 the 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, comply with TIA or ISO cabling standards. Build in additional capacity, as it is much easier to install now than later. Use higher bandwidth grades of cabling to postpone having to re-cable 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 each 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 solution design guide will help provide you with 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 log book located near the rack.

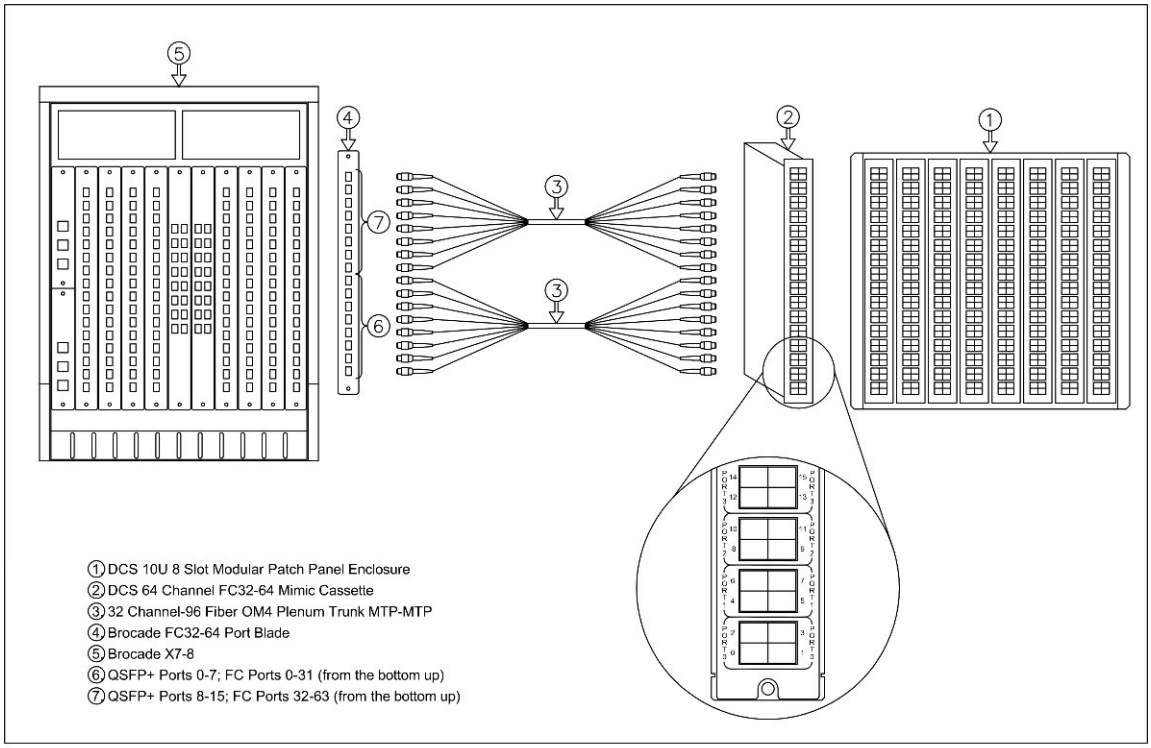
Director Slot/Port #			MPO/MTP Shelf		Description
Slot	Port	32G Link	Plate	Port	
Slot 1	0	0	Slot 1	1	
		1			
		2			
		3			
	1	4			
		5			
		6			
		7			
	2	8		2	
		9			
		10			
		11			
	3	12			
		13			
		14			
		15			
	4	16		3	
		17			
		18			
		19			
	5	20			
		21			
		22			
		23			
	6	24		4	
		25			
		26			
		27			
	7	28			
		29			
		30			
		31			

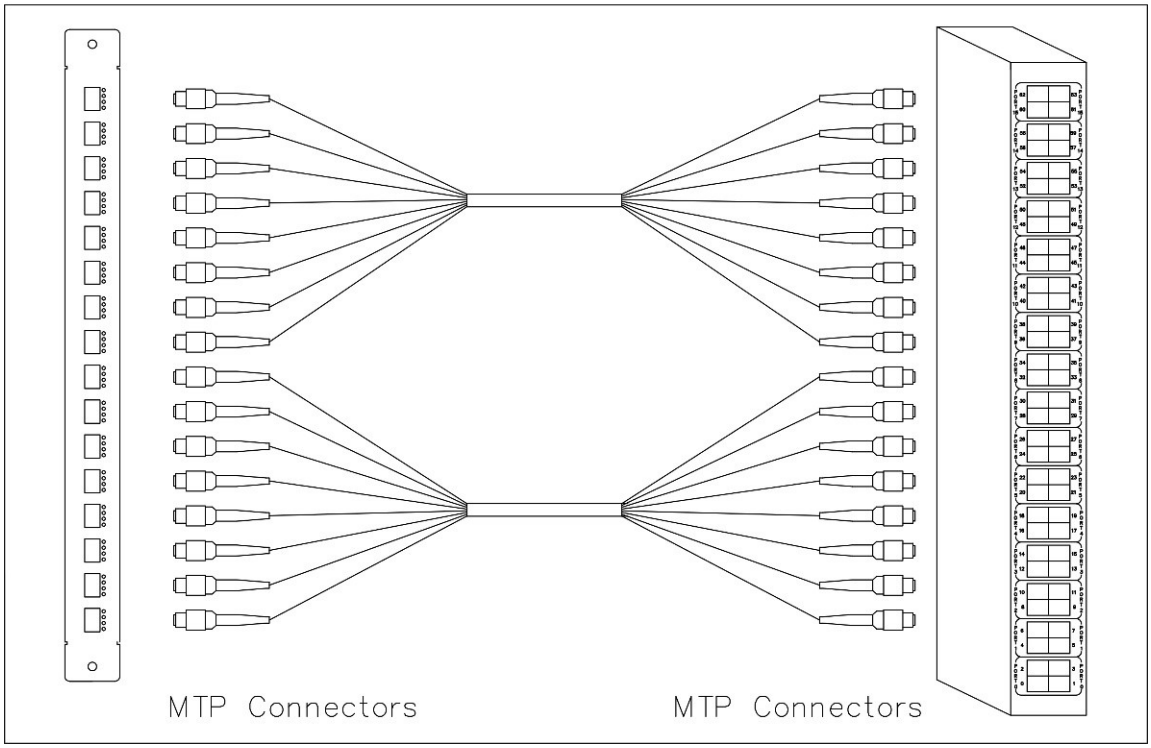
Director Slot/Port #			MPO/MTP Shelf		Description
Slot	Port	32G Link	Plate	Port	
Slot 2	0	0	Slot 2	1	
		1			
		2			
		3			
	1	4			
		5			
		6			
		7			
	2	8		2	
		9			
		10			
		11			
	3	12			
		13			
		14			
		15			
	4	16		3	
		17			
		18			
		19			
	5	20			
		21			
		22			
		23			
	6	24		4	
		25			
		26			
		27			
	7	28			
		29			
		30			
		31			

Director Slot/Port #			MPO/MTP Shelf		Description
Slot	Port	32G 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			

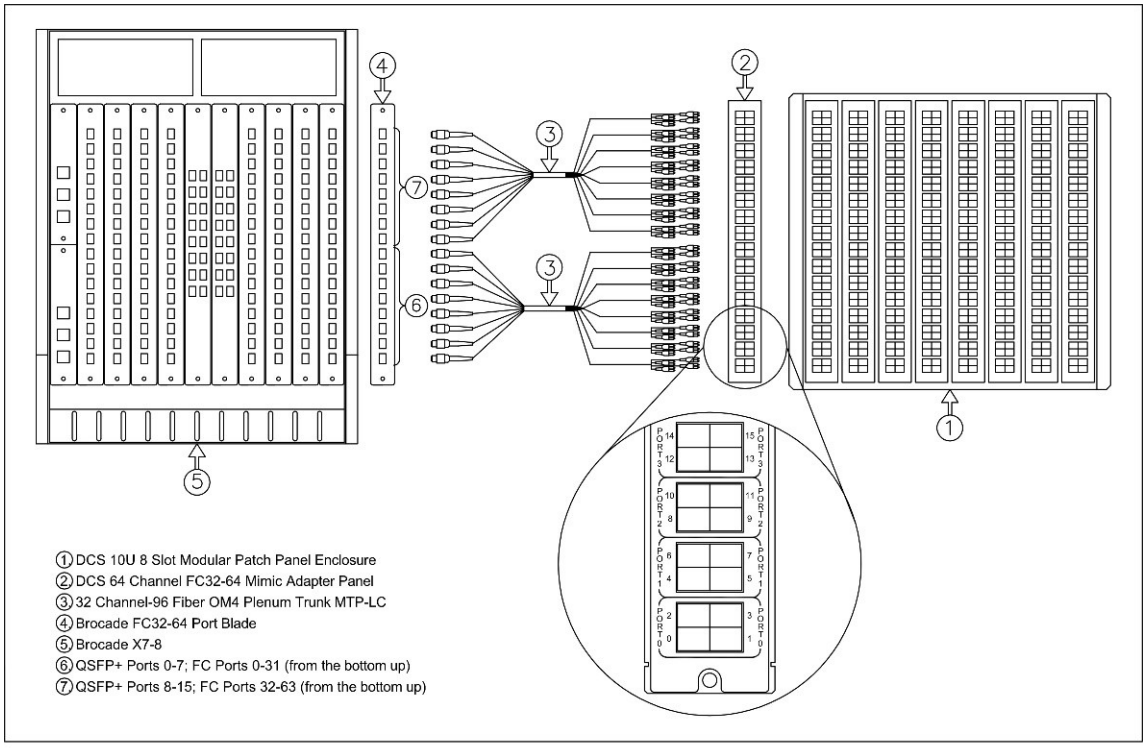
Director Slot/Port #			MPO/MTP Shelf		Description
Slot	Port	32G Link	Plate	Port	
Slot 2	8	32	Slot 2	5	
		33			
		34			
		35			
	9	36			
		37			
		38			
		39			
	10	40		6	
		41			
		42			
		43			
	11	44			
		45			
		46			
		47			
	12	48		7	
		49			
		50			
		51			
	13	52			
		53			
		54			
		55			
	14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

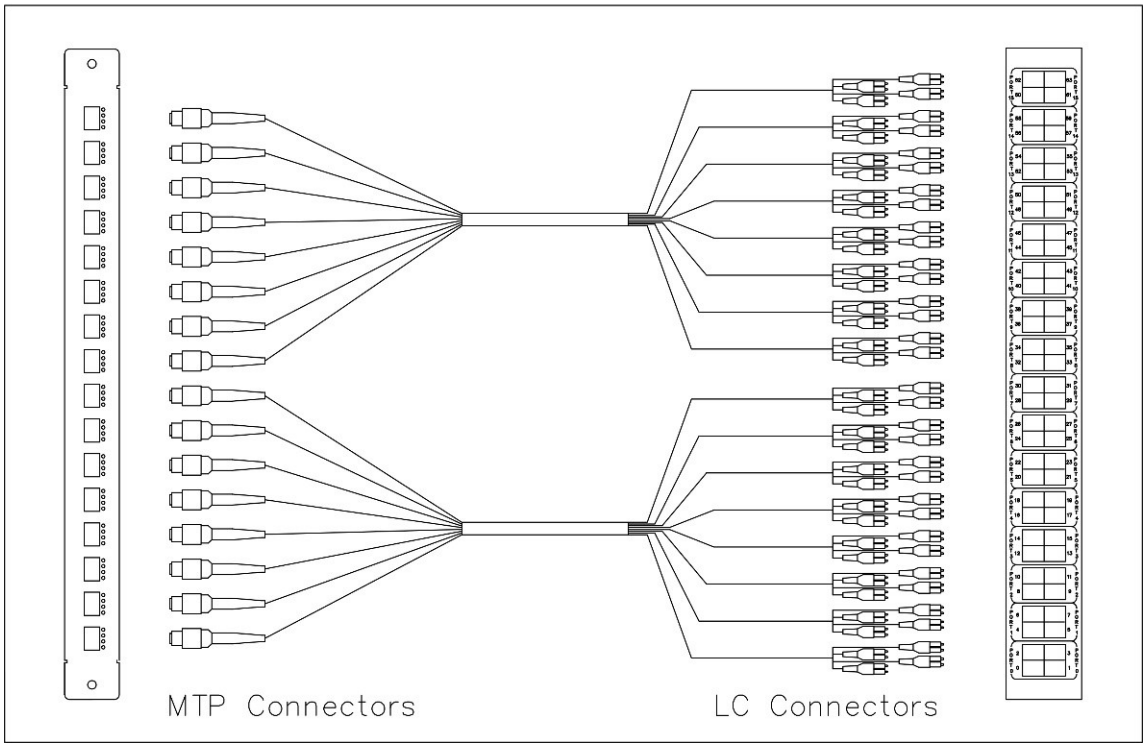
Appendix B: DCS MTP-to-MTP-Port Mapping





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





Appendix D: Equipment List

D.1 Patch Cables for QSFP Connections

The QSFP patch cables listed below are for use in the Brocade FC32-64 port blade. These cables are used to connect end devices to patch panel ports and to connect ports between two local patch panels. The cable part numbers are provided as a reference only and have not been tested or qualified by Broadcom.

Type	Description	Length	Device (QSFP) to Device (QSFP) (MTP Nonpinned/Nonpinned)	
			CABLExpress P/N	Corning P/N (Type B Polarity)
QSFP-QSFP	OM4 - QSFP (MTP) to QSFP (MTP) optical cable	1m	CBX-STC012BPF-MXXN-MXXN-001M	JE6E608QE8-NB001M
QSFP-QSFP	OM4 - QSFP (MTP) to QSFP (MTP) optical cable	3m	CBX-STC012BPF-MXXN-MXXN-003M	JE6E608QE8-NB003M
QSFP-QSFP	OM4 - QSFP (MTP) to QSFP (MTP) optical cable	20m	CBX-STC012BPF-MXXN-MXXN-020M	JE6E608QE8-NB020M
QSFP-4xSFP	OM4 - QSFP (MTP) to 4 SFP+ (LC) optical cable	1m	CBX-STH008BPQ-MXXN-UC4N-001M	HE67908QPH-JB001M
QSFP-4xSFP	OM4 - QSFP (MTP) to 4 SFP+ (LC) optical cable	3m	CBX-STH008BPQ-MXXN-UC4N-003M	HE67908QPH-JB003M
QSFP-4xSFP	OM4 - QSFP (MTP) to 4 SFP+ (LC) optical cable	20m	CBX-STH008BPQ-MXXN-UC4N-020M	HE67908QPH-JB020M

Type	Description	Length	Device (QSFP) to Device (QSFP) (MTP Nonpinned/Nonpinned)	
			Molex P/N	Wave2Wave P/N
QSFP-QSFP	OM4 - QSFP (MTP) to QSFP (MTP) optical cable	1m	106283-7001	50-8120P-1M
QSFP-QSFP	OM4 - QSFP (MTP) to QSFP (MTP) optical cable	3m	106283-7003	50-8120P-3M
QSFP-QSFP	OM4 - QSFP (MTP) to QSFP (MTP) optical cable	20m	106283-7020	50-8120P-20M
QSFP-4xSFP	OM4 - QSFP (MTP) to 4 SFP+ (LC) optical cable	1m	106283-5401	51-8080P-1M
QSFP-4xSFP	OM4 - QSFP (MTP) to 4 SFP+ (LC) optical cable	3m	106283-5403	51-8080P-3M
QSFP-4xSFP	OM4 - QSFP (MTP) to 4 SFP+ (LC) optical cable	20m	106283-5407	51-8080P-20M

NOTE:

- Additional pinning/polarity configurations are available. For design assistance, contact the manufacturer.
- Verify the appropriate cable number and description with the cable manufacturer before placing an order.

D.2 Patch Cables for SFP-DD Connections

Type	Description	Length	CABLExpress	Cabling123 P/N
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	1m	CXJ04-U2-SN-D2-001P	12U-8020m-MG1M
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	3m	CXJ04-U2-SN-D2-003P	12U-8020m-MG3M
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	20m	CXJ04-U2-SN-D2-020P	12U-8020m-MG20M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	1m	CXJ04-SN-SN-D2-001P	11U-8020m-MG1M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	3m	CXJ04-SN-SN-D2-003P	11U-8020m-MG3M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	20m	CXJ04-SN-SN-D2-020P	11U-8020m-MG20M
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	1m	—	15U-8080P-MG1M
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	3m	—	15U-8080P-MG3M
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	20m	—	15U-8080P-MG20M

Type	Description	Length	Conexus P/N	Corning P/N[a]
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	1m	BCM-002M420P-LSU-EV001M	NM7902QD116001M
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	3m	BCM-002M420P-LSU-EV003M	NM7902QD116003M
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	20m	BCM-002M420P-LSU-EV020M	NM7902QD116020M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	1m	BCM-002M420P-SSU-EV001M	NMNM02QD116001M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	3m	BCM-002M420P-SSU-EV003M	NMNM02QD116003M
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	20m	BCM-002M420P-SSU-EV020M	NMNM02QD116020M
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	1m	BCM-008M420P-LSU-EV001M	—
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	3m	BCM-008M420P-LSU-EV003M	—
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	20m	BCM-008M420P-LSU-EV020M	—

a. Part number for Riser Rated 1.6-mm jacket. Check with the vendor for general-purpose or plenum-rated cabling options.

Type	Description	Length	Data Center Systems P/N	OptiClarity P/N
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	1m	820OM4-0259-001M	OCI-B-MM-SNLC-1M-OM4
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	3m	820OM4-0259-003M	OCI-B-MM-SNLC-3M-OM4
SFP-DD to SFP+	OM4 - SFP-DD (SN) to SFP+/Patch Panel (LC) optical cable	20m	820OM4-0259-020M	OCI-B-MM-SNLC-20M-OM4
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	1m	820OM4-5959-001M	OCI-B-MM-SNSN-1M-OM4
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	3m	820OM4-5959-003M	OCI-B-MM-SNSN-3M-OM4
SFP-DD to SFP-DD	OM4 - SFP-DD (SN) to SFP-DD (SN) optical cable	20m	820OM4-5959-020M	OCI-B-MM-SNSN-20M-OM4
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	1m	913OM4-3659-001M	OCI-B-MM-4SN12FMPO-1M-OM4
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	3m	913OM4-3659-003M	OCI-B-MM-4SN12FMPO-3M-OM4
SFP-DD to QSFP	OM4 - SFP-DD (SN) to QSFP/Patch Panel (MTP) optical trunk cable	20m	913OM4-3659-020M	OCI-B-MM-4SN12FMPO-20M-OM4

D.3 Patch Panels

Vendor	Type	Rack Unit	Number of Ports	Part Number
Cabling123 (Wave2Wave)	MTP-MTP Conversion Patch Panel	1U	5 slots	69EVO-1U00-5v2
	MPO-MPO Conversion Patch Panel	2U	14 slots (front and rear wire managers, blank coupler plates and mounting rails)	69EVO-2U00-14V2

Vendor	Type	Rack Unit	Number of Ports	Part Number
CommScope	MPO-MPO	1U	Up to 3 x 24 MPO panel adapters	760136473

Vendor	Corning	
Bill of Materials for Figure 20		
Item Number	**Part Number**	**Description**
1	JE6E608QE8-NBxxxF	EDGE8 (OM4), MTP (nonpinned) to MTP (nonpinned) Jumper, TIA-568 Type-B.
2	EDGE8-CP32-V3	EDGE8 32-Fiber MTP Adapter (4 port). 50-µm multimode (OM4/OM3); mounts in EDGE8 Housings (example: EDGE8-02U).
3	GE5E508QPNDDUxxxF	EDGE8 Solution Trunk Cable, 50-µm multimode (OM4), MTP Connector (pinned) to MTP Connector (pinned), 8 Fibers, with 33/33 inch legs, pulling grip one side, xxx ft. **NOTE:** Trunks are available in fiber counts from 8 to 288 fibers.
4	HE67908QPH-KBxxxF	EDGE8, 8-fiber Harness, 50-µm multimode (OM4), MTP (nonpinned) to LC Uniboot, xxx ft., 24-in. LC legs. TIA-568 Type-B.

Vendor	Corning	
Bill of Materials for Figure 21		
Item Number	**Part Number**	**Description**
1	JE6E608QE8-NAxxxF	EDGE8, 8-Fiber MTP Jumper, (OM4), MTP (nonpinned) to MTP (nonpinned), TIA-568 Type-A polarity, xxx ft.
2	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.
3	GE5E508QPNDDUxxxF	EDGE8 Solutions Trunk Cable, 50-µm multimode (OM4), MTP Connector (pinned) to MTP Connector (pinned), 8 Fibers, 33/33 inch legs, pulling grip one side, xxx ft. **NOTE:** Trunks are available in fiber counts from 8 to 288 fibers.
4	ECM-UM08-05-E6Q-ULL	EDGE8 Solutions Ultra Low Loss (OM4) Module, 8 F, LC Duplex to MTP (nonpinned).
5	797902QD120xxxF	EDGE Jumper, 2 F, LC Uniboot to LC Uniboot, Riser, 50-µm multimode (OM4), xxx ft.

Vendor	Type	Rack Unit	Number of Ports	Part Number
Data Center Systems	Enclosure: 10U x 8 Slot x 11.5" D ECO X7-8 Modular Enclosure 3-6, 9-12 Overlay	10U	Up to 512	7510-0101-029
	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	7110-0118-000
	Modular Cassette: 10U-8 64-Channel Black LC-Quad OM4 ECO Modular Cassette FC32-64 QSFP 0-15/FC 00-63	10U	64	7310 0105-000

D.4 Custom Director Trunks

Vendor	Type	Rack Unit	Number of Ports	Part Number
Data Center Systems	Trunk: 64-Fiber X7-8 FC32-64 0-31 OM4 Plenum Trunk LC-MTPf xxx Feet	N/A	32 ports	TB1964F5-3236-XXXF
	Trunk: 64-Fiber X7-8 FC32-64 32-63 OM4 Plenum Trunk LC-MTPf xxx Feet	N/A	32 ports	TB2064F5-3236-XXXF

D.5 Velcro Cable Wraps

Use Velcro-based 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.6 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: QSFP Supported Connection Distances

Optic Type	Connection Type	Speed	Multimode Max Distance		Single-Mode Max Distance	Comments
			OM3	OM4/4+/5		
Gen 7 SWL ICL QSFP	QSFP<>QSFP	Gen 7 ICL	70m	100m	—	0-dB connector loss assumes point-to-point connection without patch panel.
Gen 7 LWL ICL QSFP	QSFP<>QSFP	Gen 7 ICL	—	—	2 km	0-dB connector loss assumes point-to-point connection without patch panel.
32G SWL QSFP	QSFP<>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[a]	QSFP<>QSFP	32G	—	—	2 km	0-dB connector loss assumes point-to-point connection without patch panel.
16G SWL QSFP	QSFP<>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<> 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<>QSFP	16G	—	—	2 km	0-dB connector loss assumes point-to-point connection without patch panel.

a. Supported but no longer offered for sale.

Appendix F: Cable Management and Patch Panel Vendors

CABLExpress

Phone: +1-800-913-9465

E-mail: info@cablexpress.com

www.cablexpress.com

Cabling123, Inc. (Wave2Wave Solution)

Phone: +1-408-586-8800

E-mail: sales@cabling123.com

www.cabling123.com

CommScope

E-mail: mailto://support@systimax.com

http://www.commscope.com/Product-Catalog/#market-enterprise

Conexus

Phone: +1-513-779-5448

E-mail: mailto:sales@conexus-technologies.com

www.conexus-technologies.com

Corning

Phone: +1-800-743-2671

www.corning.com/opcomm

Data Center Systems

Phone: +1-972-620-4997

E-mail: mailto://info@datacentersystems.com

http://datacentersystems.com

Molex

Phone: +1-800-833-3557

E-mail: mailto://onlinesales@arrow.com

E-mail for quotes outside the U.S.: mailto://iccsales@arrow.com

www.arrow.com (Contact your local branch if you are already an Arrow customer.)

OptiClarity

Phone: 1-510-456-6754

E-mail: mailto://areynoso@opticlarity.com

www.opticlarity.com

TE Connectivity

Phone: 1-800-342-5267

E-mail: mailto://entwest@te.com

http://www.te.com/

Wave2Wave Solution Corporation

Phone: 1-877-223-2296

E-mail: mailto://sales@Wave-2-Wave.com

www.wave-2-wave.com

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-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.