BROCADE
A Broadcom Company

Scale-Out Architecture with Brocade® UltraScale Inter-Chassis Links

Design Guide

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Chapter 1: UltraScale ICL Overview

Brocade® UltraScale inter-chassis links (ICLs) are dedicated high-performance ports for interconnecting multiple Brocade Directors, enabling industry-leading scalability while preserving ports for server and storage connections. Brocade optical UltraScale ICLs connect the core routing blades between Brocade X8, X7 or X6 Director family chassis to provide a virtual backplane that enables high-port-count fabrics to scale seamlessly. Gen 8 octal small form-factor pluggable (OSFP)-based UltraScale ICL ports combine eight links into one ultra-compact connector, supporting up to 16 UltraScale ICL ports on the Brocade X8-8 and eight UltraScale ICL ports on the Brocade X8-4. Gen 7 quad small form-factor pluggable (QSFP)-based ports combine four links into one port, providing up to 32 UltraScale ICL ports on the Brocade X7-8 and up to 16 UltraScale ICL ports on the Brocade X7-4.

The dense optical form factor of the Brocade OSFP-based and QSFP-based UltraScale ICL technology offers several advantages over connecting multiple director platforms using inter-switch links (ISLs). The combination of multiple cables into a single optical transceiver provides a dramatic reduction in the number of ISL cables required—an up to eight-to-one reduction compared to traditional SFP optic-based ISLs with the same amount of interconnection bandwidth. Because the UltraScale ICL connections reside on dedicated ICL ports instead of consuming traditional ports on the port blades, up to 33% more FC user ports are available for server and storage connectivity. Given that ICL ports switch on core routing (CR) blades rather than across a backplane, frame switching avoids one hop (on each chassis) to egress port blades, resulting in significantly lower latency. ICL-based connectivity also provides flexibility for deploying different network topologies, including a massive 9-chassis full-mesh design with only a single hop between any two points within the fabric and a 12-chassis core-edge design.

Unless otherwise noted, for the remainder of this paper, *8-slot director chassis* will be used to refer to the Brocade X8-8 or X7-8, and *4-slot director chassis* will be used to refer to the Brocade X8-4 or X7-4.

Chapter 2: UltraScale ICL Offerings

For Gen 8 Director chassis, ICL blades that provide ICL port connectivity are physically separate from the CR blades that mount internally in the X8 chassis. Base X8 chassis do not come with ICL blades populated, and ICL are enabled by installing an X8 ICL Kit that include a pair of ICL Blades specific to an X8-8 or X8-4 chassis and enough OSFP optics to half-populate the ports. Gen 8 ICL ports do not require a POD license and can be scaled simply by adding additional Brocade Gen 8 ICL OSFP transceivers to empty ports on the ICL blades.

An ICL ports on demand (POD) license is applicable to the Gen 7 and Gen 6 director families. ICL POD licenses are unique for Gen 7 and Gen 6 product generation families.

2.1 Brocade X8 ICL Kit Offerings

In contrast to earlier generations that offered Ultrascale ICL connectivity from the chassis core blades, Gen 8 directors provide dedicated ICL port blades with switching functionality via back-end connections to the chassis core blades. Gen 8 ICL blades come with all ports activated, with no need to install any licenses to enable any functionality. ICL ports are enabled simply by installing additional OSFP transceivers in pairs to the ICL bades. Base X8 chassis ship without ICL blades which are purchased separately as part of an ICL kit specific to the chassis model.

- **X-8 100m ICL kit (P/N BR-X88ICLKIT-100M-01):** The X8-8 100m ICL kit includes two X8-8 ICL blades with eight OSFP ICL ports each that support connectivity for up to 128 links to an X8 or an X7 chassis and eight Gen 8 100m ICL OSFPs. To use the remaining OSFP ICL ports on both X8-8 ICL blades, two additional X8 ICL upgrade kits are required. Ports may be populated with any combination of 100m SWL and 2-km LWL ICL OSFP optics as required.
- **X8-4 100m ICL kit (P/N BR-X84ICLKIT-100M-01):** The X8-4 100m ICL kit includes two X8-4 ICL blades with four OSFP ICL ports each that support connectivity for up to 64 links to an X8 or an X7 chassis and four Gen 8 100m ICL OSFPs. To use the remaining OSFP ICL ports on both X8-4 ICL blades, one additional ICL upgrade kit is required. Ports may be populated with any combination of 100m SWL and 2-km LWL ICL OSFP optics as required.
- **X8-8 2-km ICL kit (P/N BR-X88ICLKIT-2KM-01):** The X8-8 2-km ICL kit includes two X8-8 ICL blades with eight OSFP ICL ports each that support connectivity for up to 128 links to an X8 or an X7 chassis and eight Gen 8 2-km ICL OSFPs. To use the remaining OSFP ICL ports on both ICL blades, two additional ICL upgrade kits are required for an X8-8 chassis. Ports may be populated with any combination of 100m SWL and 2-km LWL ICL OSFP optics as required.
- **X8-4 2-km ICL kit (P/N BR-X84ICLKIT-2KM-01):** The X8-4 2-km ICL kit includes two X8-4 ICL blades with four OSFP ICL ports each that support connectivity for up to 64 links to an X8 or X7 chassis, and four Gen 8 2-km ICL OSFPs. To use the remaining OSFP ICL ports on both X8-4 ICL blades, one additional ICL upgrade kit is required. Ports may be populated with any combination of 100m SWL and 2-km LWL ICL OSFP optics as required.
- **X8 100m ICL upgrade kit (P/N BR-X8ICLUPG-100M-01):** This kit includes four 100m SWL OSFPs, enabling 32 additional links up to 100m on either an 8-slot or a 4-slot chassis. An 8-slot chassis requires two kits to fully populate the ICL blades, and a 4-slot chassis requires only one. Ports are enabled simply by plugging the optics into the empty OSFP port connectors, with no POD license required. ICL ports support a mix of SWL and LWL OSFPs as required by the user.
- **X8 2-km ICL upgrade kit (P/N BR-X8ICLUPG-2KM-01):** This kit includes four 2-km LWL OSFPs, enabling 32 additional links up to 2-km on either an 8-slot or a 4-slot chassis. An 8-slot chassis requires two kits to fully populate the ICL blades, and a 4-slot chassis requires only one. Ports are enabled simply by plugging the optics into the empty OSFP port connectors, with no POD license required. ICL ports support a mix of SWL and LWL OSFPs as required by the user.

2.2 Brocade X7 ICL POD Licensing and ICL Kit Offerings

For Gen 7 ICLs, X7 ICL ports integrated into the CR blades are enabled via X7 POD licenses supporting both Brocade X7-8 and X7-4 Directors, each of which enables eight UltraScale ICL ports. For an X7-8 Director, a total of four X7 ICL POD licenses are required to fully enable all 32 ICL ports. The first ICL POD license enables QSFP ports 0, 1, 8, and 9 on each core blade, and the second ICL POD license enables ports 2, 3, 10, and 11. The third ICL POD license enables ports 4, 5, 12, and 13, and the fourth ICL POD license enables the remaining ports 6, 7, 14, and 15. An X7-4 Director requires a total of two X7 ICL POD licenses to enable all 16 ICL ports. The first ICL POD license enables QSFP ports 0, 1, 4, and 5 on each core blade, and the second ICL POD license enables the remaining ports 2, 3, 6, and 7. Three ICL kit offerings are currently available for the Brocade X7 Directors:

- **Gen 7 100m ICL kit (P/N BR-X7ICLKIT-100M-01):** This kit includes one Gen 7 ICL POD license and eight 4 × Gen 7 100m ICL SWL QSFPs that support connectivity between two X7 chassis or from an X7 to an X8 chassis at Gen 7 ICL speed. One POD license enables four QSFP ports on each CR blade or eight QSFP ports per chassis. To enable all QSFP ICL ports on both CR blades, four kits (either 100m or 2-km) are required for an 8-slot X7 chassis and two kits are required for a 4-slot X7 chassis.

  NOTE: To connect to an X8 chassis over MMF, the X7 ICLs require the use of QSFPs with the serial number sequence BAB1yywwxxxxxxxs. The X7 must have FOS v10.0.x or later installed, as it is required to update the QSFPs to the latest firmware, and use a 2x QSFP to OSFP breakout cable. Refer to an *X8 Hardware Installation Guide* for complete details.
- **Gen 7 2-km ICL kit (P/N BR-X7ICLKIT-2KM-01):** This kit includes one Gen 7 ICL POD license and eight 4 × Gen 7 2-km ICL SWL QSFPs that support connectivity between two X7 chassis or from an X7 to an X8 chassis at Gen 7 ICL speed. One POD license enables 4 QSFP ports on each CR blade or 8 QSFP ports per chassis. To enable all QSFP ICL ports on both CR blades, four kits (either 100m or 2-km) are required for an 8-slot X7 chassis and two kits are required for a 4-slot X7 chassis. 2-km Gen 7 ICLs cannot be used to connect to an X6 Director unless the X6 has been upgraded to a Gen 7 chassis. Gen 7 2-km ICL optics require FOS v9.1.0 or later.

  NOTE: Gen 7 2-km QSFP optics have a maximum air intake temperature rating of 40°C while operating at sea level only. From sea level up to 1500m elevation, the optics are rated at a maximum of 35°C ambient temperature, and they are rated at maximum 30°C from 1500m to 3000m elevation.
- **Gen 6 100m ICL kit for the X7 chassis (P/N BR-X7GEN6ICLKIT-100M-1):** This kit includes one Gen 7 ICL POD license, and eight 4×32G 100m ICL SWL QSFPs that enable connectivity to an X6 chassis at 32G (manual configuration of the port speed is required on an X6 or X7 chassis). Port enablement via license installation is the same as the Gen 7 100m ICL kits.

NOTE: The POD license is the same in each of the ICL kits listed above. The only difference between the kits is the type of optics that are included as part of the kit. Ports that have been license-enabled can be populated with any of the supported optics. X7 Directors and X6 Directors that have been upgraded to Gen 7 require the use of secure optics. Once an X6 has been upgraded to Gen 7, 32G nonsecure QSFP optics (MPN 57-1000351-01 or 57-1000480-01) are no longer supported for use.

2.3 Brocade X6-8 ICL POD Licensing and ICL Kit Offerings

For Gen 6 Directors, there are different ICL POD licenses for both the Brocade X6-8 and X6-4 Directors. For an X6-8 Director, a total of two X6-8 POD licenses are required to fully enable all 32 ICL ports. A minimum of one ICL POD license is required on an 8-slot chassis. The first ICL POD license on the Brocade X6-8 enables a total of 16 QSFP UltraScale ICL ports per director chassis, enabling 8 ICL ports (0, 1, 2, 3, 8, 9, 10, and 11) on each core blade. A second ICL POD license enables the remaining 16 QSFP UltraScale ICL ports on the chassis, enabling the remaining 8 ICL ports (4, 5, 6, 7, 12, 13, 14, and 15) on each core blade; so all 32 QSFP ports across both core routing blades are enabled. These ICL POD licenses are bundled as part of the ICL kit offerings. Currently available ICL kit offerings for the Brocade X6-8 include the following:

- **Gen 6 100m 8-slot ICL kit (P/N BR-X68ICLKIT-100M-02):** This kit includes one ICL POD license and sixteen 4×32G 100m SWL QSFPs. One POD license enables 8 QSFP ports on each CR blade (16 QSFP ports per chassis). To enable all QSFP ICL ports on both CR blades, two kits are required. This kit bundles 4×32G QSFPs supporting connectivity from X6-8 to X6 ICLs or X6-8 to X7 ICLs at 32G speed. ICL connectivity between Gen 6 and Gen 8 director chassis requires that the Gen 6 Directors be field-upgraded to Gen 7.

2.4 Brocade X6-4 ICL POD Licensing and ICL Kit Offerings

The X6-4 Director requires its own unique license to enable ICL ports. The X6-4 requires a total of two X6-4 POD licenses to enable all 16 ICL ports. A minimum of one ICL POD license is required on a 4-slot chassis. The first ICL POD license on the Brocade X6-4 enables a total of 8 QSFP UltraScale ICL ports per director chassis, enabling 4 ICL ports (0, 1, 4, 5) on each core blade. A second ICL POD license enables the remaining 8 QSFP UltraScale ICL ports, enabling ICL ports 2, 3, 6, and 7 on each core blade. These ICL POD licenses are bundled as part of the ICL kit offerings. Currently available ICL kit offerings for the Brocade X6-4 include the following:

- **Gen 6 100m 4-slot ICL kit (P/N BR-X64ICLKIT-100M-02)**: This kit includes one ICL POD license and eight 4×32G 100m SWL QSFPs. One POD license enables 4 QSFP ports on each CR blade (8 QSFP ports per chassis). To enable all QSFP ICL ports on both CR blades, two kits are required. This kit bundles 4×32G QSFPs supporting 4×32G speeds, supporting connectivity from X6-4 to X6 ICLs or X6-4 to X7 ICLs at 32G speed. ICL connectivity between Gen 6 and Gen 8 director chassis requires that the Gen 6 directors be field upgraded to Gen 7.

NOTE: X6 Directors that have been upgraded to Gen 7 require the use of secure optics. Once an X6 has been upgraded to Gen 7, 32G nonsecure QSFP optics (MPN 57-1000351-01 or 57-1000480-01) are no longer supported for use.

Chapter 3: Supported ICL Topologies

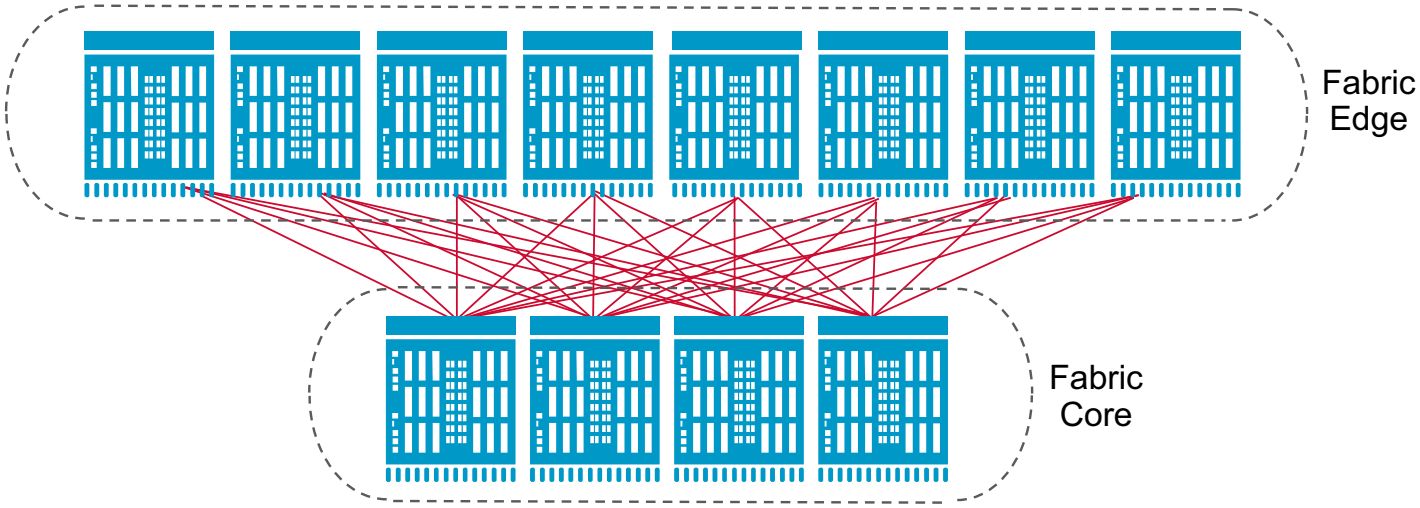
Two network topologies are supported with the Brocade director platforms and optical UltraScale ICLs: core/edge and mesh. Both topologies deliver unprecedented scalability while dramatically reducing ISL cables.

NOTE: Always refer to the *Brocade SAN Scalability Guidelines* for appropriate Brocade Fabric OS® versions for supported UltraScale ICL topology scalability limits.

3.1 Core/Edge Topology

A core/edge topology is an evolution of the well-established and popular star topology often used in data networks. Core/edge designs are the most common storage area network (SAN) architecture for many reasons, including the fact that they are well tested, well balanced, and economical. Figure 1 shows how a customer could deploy four Brocade director chassis at the core and eight more directors at the edge, for a highly scalable, cost-effective topology. In most environments, servers are attached to the edge chassis, with storage being attached to the core. By connecting each edge chassis to each core, all hosts/targets are separated by a maximum of one hop, regardless of where they are attached in the fabric. A variety of different core/edge designs can be implemented, with varying ratios of core versus edge chassis being used to meet the needs of any environment.

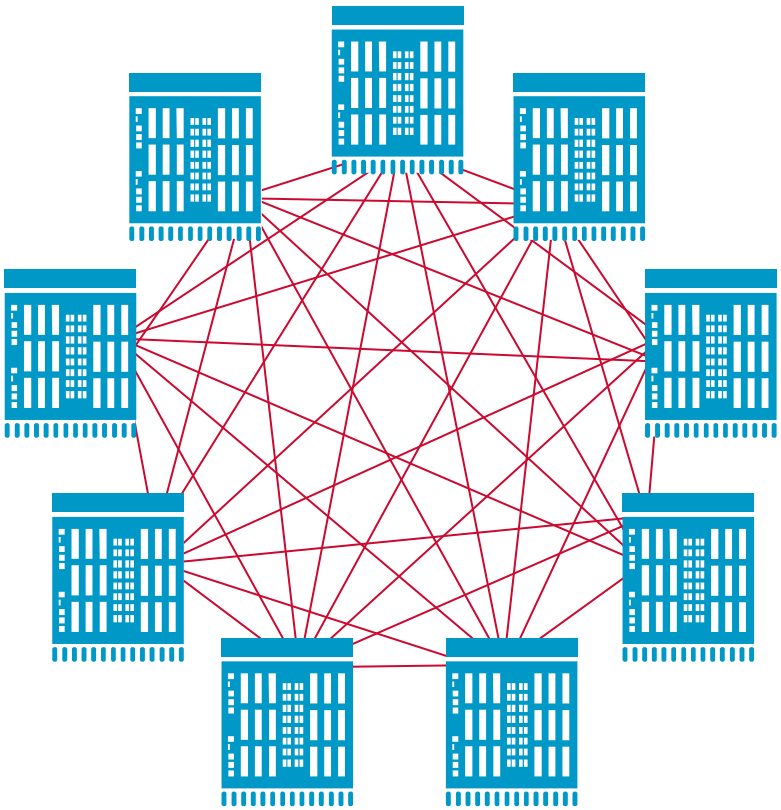
Figure 1: Twelve-Chassis Core/Edge Topology Supported with the Brocade X8, X7 (Shown), and X6



3.2 Mesh Topology

A mesh topology was a common design philosophy when SAN fabrics were first being built, as these fabrics were simple and easy to manage. But as larger fabrics became more common, the cabling infrastructure to support such a topology became impossible to manage. Without direct connections between every pair of chassis, knowing where each storage and server port is located in order to provide ideal fabric routes can quickly become an operational nightmare. Brocade optical UltraScale ICL technology solves this issue by allowing each Brocade director to connect directly to every other director in the fabric to simplify design and operational issues associated with deployment. Figure 2 shows a nine-chassis active-active mesh topology using UltraScale ICLs.

Figure 2: Nine-Chassis Mesh Topology Supported with the Brocade X8, X7 (Shown), X6

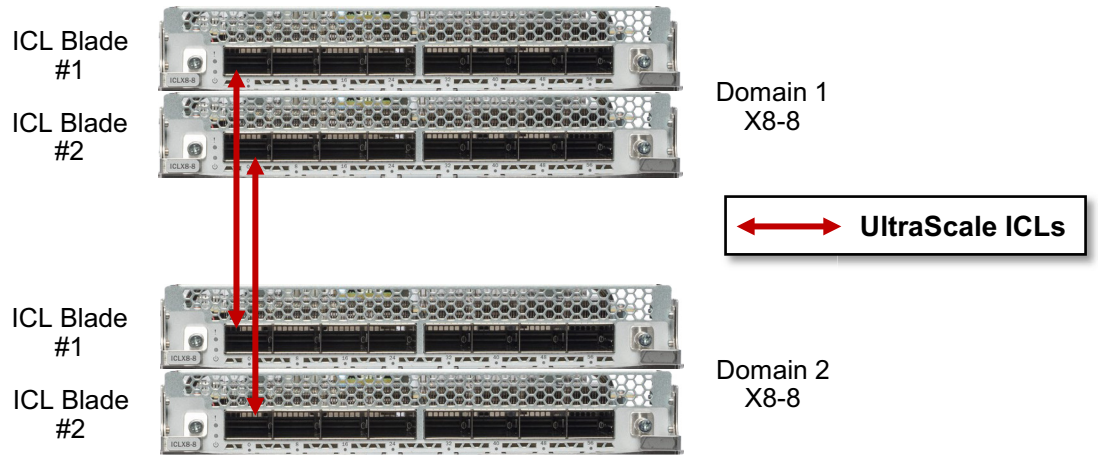


Chapter 4: OSFP-Based Gen 8 UltraScale ICL Connection Requirements

To connect multiple Brocade X8 chassis via UltraScale ICLs, a minimum of two ICL ports (one on each ICL blade) must be connected between each chassis pair. The 16 UltraScale ICL ports available on the 8-slot X8 Director chassis support ICL connectivity with up to eight other X8 or X7 chassis. Figure 3 shows the minimum connectivity between a pair of Brocade X8-8 chassis. If more than two UltraScale ICL connections are required between a pair of director chassis, additional UltraScale ICL connections must be added in pairs (one on each core blade).

NOTE: The physical location of UltraScale ICL connections may differ from what is shown in the figure. There must be at least one connection per ICL blade.

Figure 3: Minimum ICL Connections Needed Between a Pair of X8-8 Chassis



The connections on each ICL blade must reside within the same UltraScale ICL trunk boundary on the ICL blades. UltraScale ICL trunk boundaries are described in detail in Chapter 7. A maximum of eight UltraScale ICL connections or ICL trunk groups between any pair of director chassis is supported.

Combining OSFP-based UltraScale ICLs and traditional ISLs is not supported between a single pair of directors. All inter-chassis connectivity between any pair of director chassis must be done using either ISLs or UltraScale ICLs and at the same speed between any two directors. However, if Brocade Virtual Fabrics is enabled, simultaneous ICLs and ISLs can coexist between a pair of Brocade X8 and X7 chassis as long as ICLs are in a different logical switch than the ISLs.

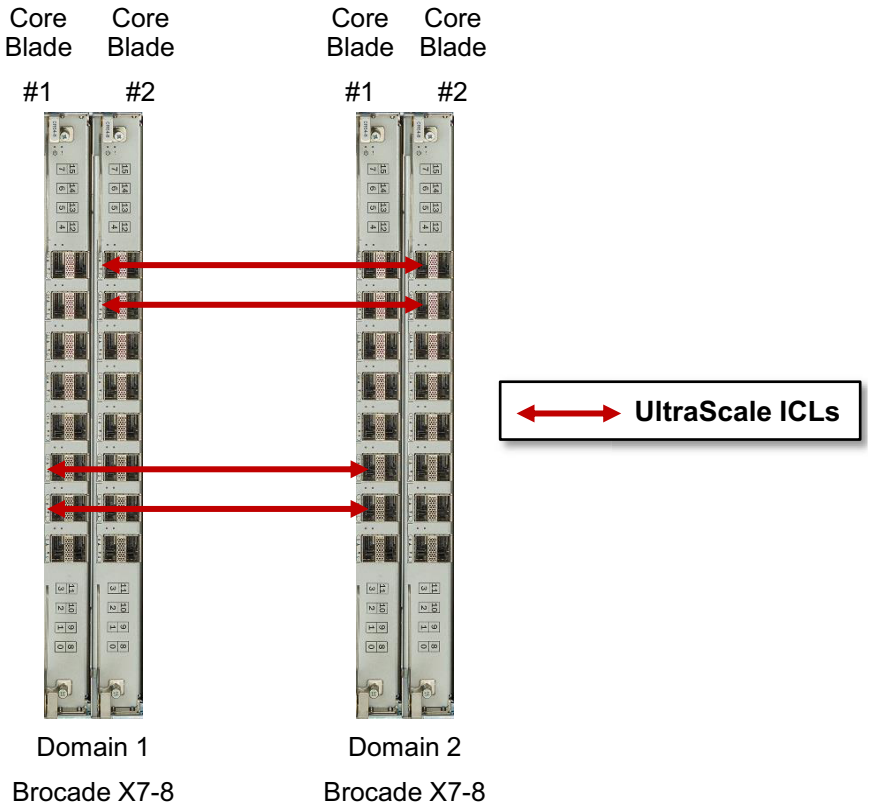
The final layout and design of UltraScale ICL interconnectivity are determined by the customer's unique requirements and needs, which dictate the ideal number and placement of ICL connections between each pair of director chassis in the fabric. Brocade Professional Services can assist in developing large-scale ICL-based designs.

Chapter 5: QSFP-Based Gen 7/Gen 6 UltraScale ICL Connection Requirements

To connect multiple Brocade X7 and X6 chassis via UltraScale ICLs, a minimum of four ICL ports (two on each core blade) must be connected between each chassis pair. The 32 UltraScale ICL ports available on the 8-slot director chassis (with all ICL POD licenses installed) support ICL connectivity with up to eight other chassis. Figure 4 shows the minimum connectivity between a pair of Brocade X7-8 chassis. If more than four UltraScale ICL connections are required between a pair of director chassis, additional UltraScale ICL connections must be added in pairs (one on each core blade).

NOTE: The physical location of UltraScale ICL connections may differ from what is shown in the figure. There must be at least two connections per core blade.

Figure 4: Minimum ICL Connections Needed Between a Pair of Chassis



The dual connections on each core blade must reside within the same UltraScale ICL trunk boundary on the core blades. UltraScale ICL trunk boundaries are described in detail in Chapter 7. A maximum of 16 UltraScale ICL connections or ICL trunk groups between any pair of director chassis is supported.

Combining QSFP-based UltraScale ICLs and traditional ISLs is not supported between a single pair of directors. All inter-chassis connectivity between any pair of director chassis must be done using either ISLs or UltraScale ICLs and at the same speed between any two directors. However, if Brocade Virtual Fabrics is enabled, simultaneous ICLs and ISLs can coexist between a pair of Brocade X8, X7, and X6 chassis as long as ICLs are in a different logical switch than the ISLs.

The final layout and design of UltraScale ICL interconnectivity are determined by the customer's unique requirements and needs, which dictate the ideal number and placement of ICL connections between each pair of director chassis in the fabric. Brocade Professional Services can assist in developing large-scale ICL-based designs.

Chapter 6: OSFP-Based to QSFP-Based Gen 8/Gen 7 UltraScale ICL Connection Requirements

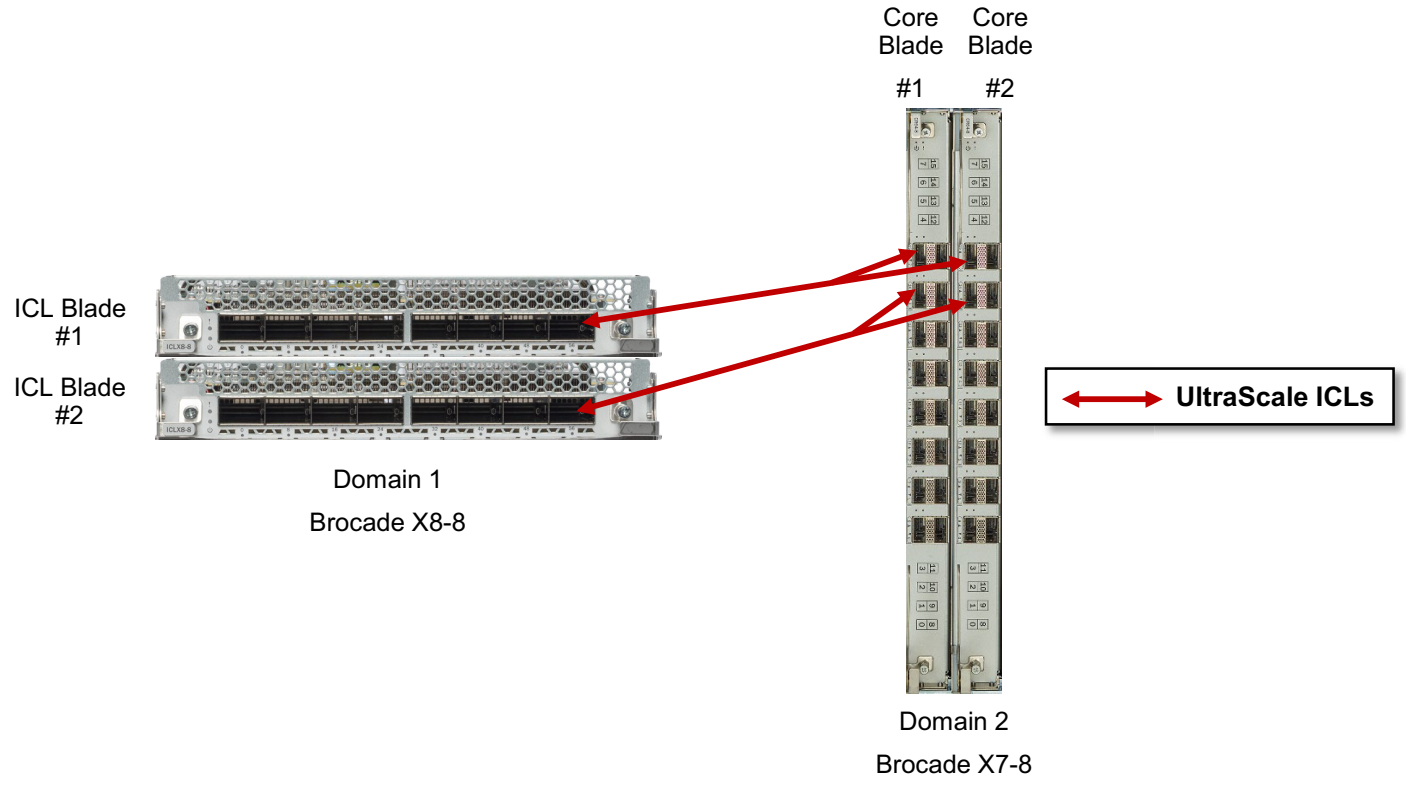
To connect a Brocade X8 with an X7 chassis via UltraScale ICLs, a minimum of one Gen 8 OSFP port on each ICL blade must connect to two Gen 7 QSFP ICL ports on X7 core blades between each chassis pair. The 16 Gen 8 UltraScale ICL ports available on the 8-slot director chassis support ICL connectivity with up to eight other Gen 8 or Gen 7 chassis with all ICL POD licenses installed on the X7s. No POD licenses are required for Gen 8 ICL connectivity. Figure 5 shows the minimum connectivity between a Brocade X8-8 chassis and a Brocade X7-8 chassis.

NOTE: The physical location of UltraScale ICL connections may differ from what is shown in the figure. There must be at least two connections per Gen 7 core blade to a Gen 8 ICL blade.

NOTE: Connectivity from an X8 chassis to an X6 chassis via Ultrascale ICLs is not supported. X8 Directors can only connect via ICL to another X8 chassis or to an X7. Fabric connectivity from an X8 to an X6 requires that the X6 be field-upgraded to a Gen 7 chassis or connected to the X8 Director via ISLs.

NOTE: To connect to an X8 chassis over MMF, the X7 ICLs require the use of QSFPs with the serial number sequence BAB1yywwxxxxxxxs. The X7 must have FOS v10.0.x or later installed, as it is required to update the QSFPs to the latest firmware, and use a 2x QSFP to OSFP breakout cable. Refer to an *X8 Hardware Installation Guide* for complete details.

Figure 5: Minimum ICL Connections Needed Between a Pair of Chassis



The dual connections on the X7 core blade must reside within the same UltraScale ICL trunk boundary on the core blades. UltraScale ICL trunk boundaries are described in detail in Chapter 7. If additional UltraScale ICL connections are required between a pair of director chassis, additional UltraScale ICL connections must be added in pairs, one on each X8 ICL blade to two per X7 Core blade. A maximum of 16 UltraScale ICL connections or ICL trunk groups between any pair of director chassis is supported.

Combining UltraScale ICLs and traditional ISLs is not supported between any single pair of directors. All inter-chassis connectivity between any pair of director chassis must be done using either ISLs or UltraScale ICLs and at the same speed between any two directors. However, if Brocade Virtual Fabrics is enabled, simultaneous ICLs and ISLs can coexist between a pair of Brocade X8, X7 and X6 chassis if ICLs are in a different logical switch than the ISLs.

The final layout and design of UltraScale ICL interconnectivity are determined by the customer's unique requirements and needs, which dictate the ideal number and placement of ICL connections between each pair of director chassis in the fabric. Brocade Professional Services can assist in developing large-scale ICL-based designs.

Chapter 7: UltraScale ICL Trunking and Trunk Groups

Trunking involves taking multiple physical connections between a chassis or switch pair and forming a single virtual connection, aggregating the bandwidth for traffic to traverse. Brocade offers a number of hardware-based trunking solutions, including Brocade ISL trunking for traditional ISLs, trunking for integrated routing (FCR connectivity), trunking for access gateway, and trunking for UltraScale ICLs. This chapter describes the trunking capability used with the UltraScale ICL ports on the Brocade director platforms.

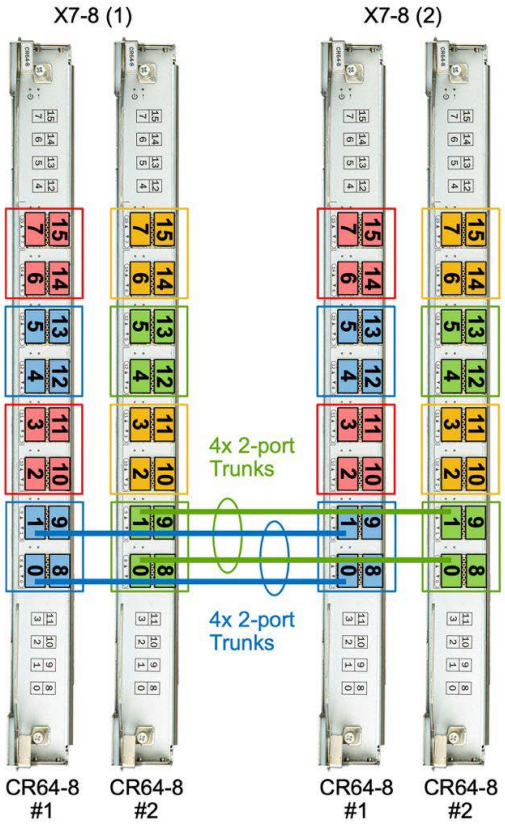
NOTE: Trunking is enabled automatically for UltraScale ICL ports, and it cannot be disabled by the user.

7.1 QSFP-Based ICL Trunking

As previously described, each QSFP-based UltraScale ICL port on an X7 or X6 has four independent links, each of which terminates on one of four Condor switching ASICs on an 8-slot director core blade or on two ASICs on an 4-slot director core blade. Trunk groups can be formed using any of the ports that make up contiguous groups of eight links on each ASIC that define an ICL trunk boundary. A minimum of two QSFP ports within an ICL trunk boundary are required to form a trunk group to a neighboring domain.

Figure 6 shows that each 8-slot director core blade has two ICL trunk boundaries of eight UltraScale ICL ports (indicated by the blue/red and green/yellow boxes) that can participate in common trunk groups together with links from the other ports within the same ICL trunk boundary to form an ICL trunk, assuming that all ports are enabled with POD licenses.

Figure 6: Core Blade ICL Trunk Boundaries on 8-Slot QSFP-Based Director Core Blades

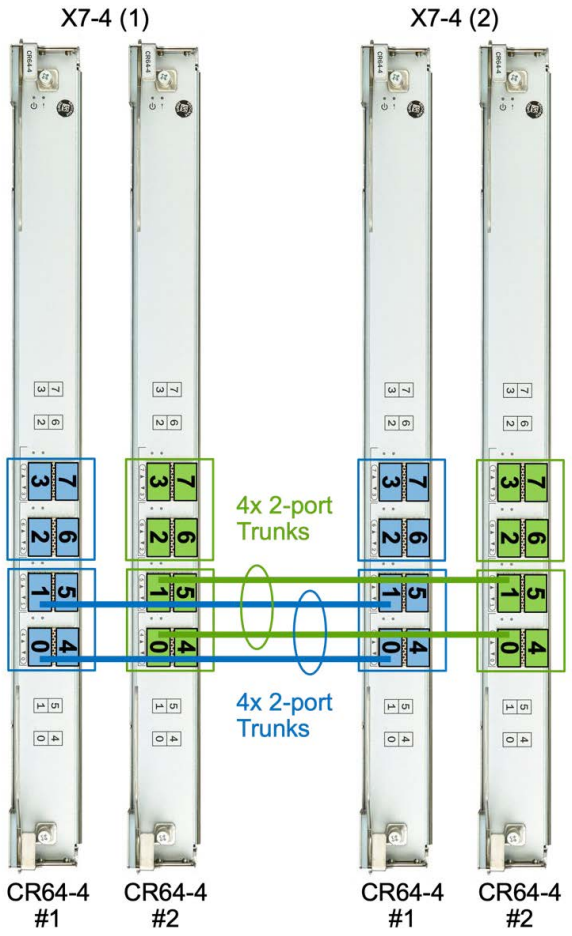


Core Blade 1 (CR 1)	ICL Trunk Boundary 1	ICL Trunk Boundary 2
QSFP Port#	**0,1,8,9,4,5,12,13**	**2,3,10,11,6,7,14,15**

Core Blade 2 (CR 2)	ICL Trunk Boundary 3	ICL Trunk Boundary 4
QSFP Port#	**0,1,8,9,4,5,12,13**	**2,3,10,11,6,7,14,15**

For 4-slot director chassis, each core blade has a single ICL trunk boundary of eight UltraScale ICL ports per core blade, for a total of 16 per chassis. A user can have four 8-port trunks within these ICL trunk boundaries, assuming that all ports are enabled with POD licenses. Figure 7 shows trunk boundaries on a 4-slot director core blade.

Figure 7: Core Blade ICL Trunk Boundary on a 4-Slot QSFP-Based Director Core Blade



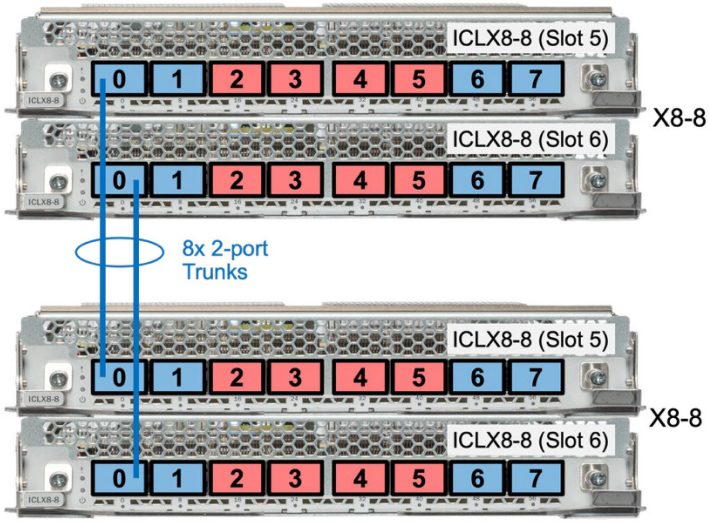
Core Blade 1 (CR 1)	ICL Trunk Boundary 1
QSFP Port#	**0,1,2,3,4,5,6,7**

Core Blade 2 (CR 2)	ICL Trunk Boundary 2
QSFP Port#	**0,1,2,3,4,5,6,7**

7.2 OSFP-based ICL Trunking

While the X8's OSFP-based ICL blades differ in design and connectivity from prior designs that had QSFP connector ports mounted on CR blades, the principles are the same between all generations of products. Each OSFP-based X8 UltraScale ICL port has eight independent links, each of which terminates on one of four Condor 6 switching ASICs on each 8-slot director core blade (eight ASICs in total), or two on each of two ASICs on each 4-slot director core blade (four ASICs in total). Figure 8 shows that each ICL blade in the X8-8 director has two groups of four UltraScale ICL ports (indicated by the blue and red boxes) that can participate in common trunk groups with links from the other ports in the same ICL trunk boundary. A minimum of two OSFP ports within an ICL trunk boundary are required to form a trunk group to a neighboring domain.

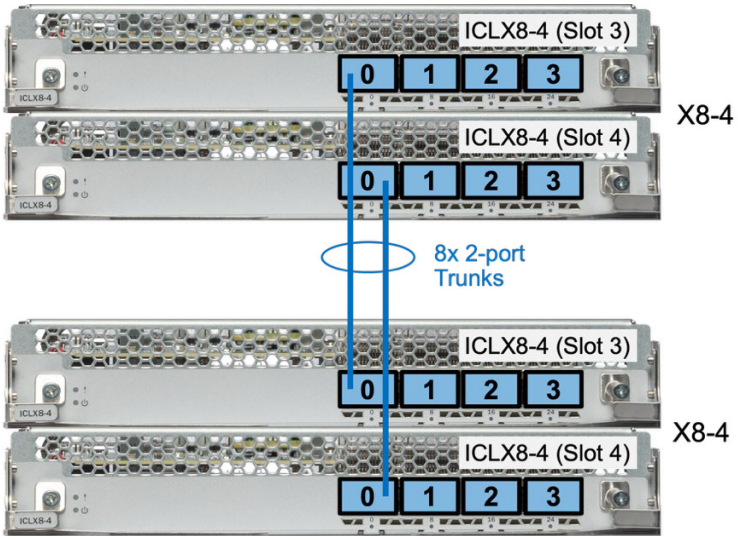
Figure 8: ICL Trunk Boundary on an 8-Slot OSFP-Based Director ICL Blade



Trunk Boundary	1	2
ICLX8-8 (Slot 5)	0, 1, 6, 7	2, 3, 4, 5
ICLX8-8 (Slot 6)	0, 1, 6, 7	2, 3, 4, 5

For 4-slot director chassis, each ICL blade has a single ICL trunk boundary of four UltraScale ICL ports per core blade, for a total of eight per chassis. A user can have four 8-port trunks within these ICL trunk boundaries. Figure 9 shows trunk boundaries on a X8-4 director ICL blade.

Figure 9: ICL Trunk Boundary on a 4-Slot OSFP-Based Director ICL Blade



Trunk Boundary	1
ICLX8-4 (Slot 3)	0, 1, 2, 3
ICLX8-4 (Slot 4)	0, 1, 2, 3

On all OSFP-based and X8-8 Directors, trunks can never be formed by links within the same ICL port, because each of the links within the ICL port terminates on a different ASIC of the 8-slot director core blade and belong to different trunk groups. Thus, each of the links from an individual ICL is always part of independent trunk groups. When connecting N × ICL ports within the same ICL trunk boundary, four QSFP or eight OSFP independent N-port trunks are always formed; the first one containing the first link of each ICL port, the second one containing the second link, and so on.

7.3 Considerations and Best Practices

As a best practice, deploy trunk groups by ensuring that the UltraScale ICL ports intended to form trunks all reside within the groups indicated by the colored boxes in Figure 6.

By following this best practice, trunks can be easily formed using UltraScale ICL ports, whether you are connecting two 8-slot chassis, two 4-slot chassis, or an 8-slot chassis and a 4-slot chassis.

When additional UltraScale ICL connections are added to a chassis, they should be added in pairs by including at least one additional UltraScale ICL on each core blade. Also, trunks on a core blade should always have an equal number of links, and connections should be deployed in an identical fashion on both core blades within a chassis. For example, if you deploy two UltraScale ICLs within a group of four ICL ports in one of the red trunk groups in Figure 6, you can add a single additional ICL to an existing trunk in the same red trunk group, or you can add a pair of ICLs to any of the other trunk groups on the core blade. This ensures that no trunks are formed that have a different total bandwidth from other trunks on the same blade. Deploying a single additional UltraScale ICL to another blue trunk group could result in mismatched trunked port capacity between the pair (4 × 2 port trunks in the red group and 4 × 1 port trunks in the blue group).

The port mapping information shown in Table 1 and Table 2 also indicates the recommended UltraScale ICL trunk groups by showing ports in the same recommended trunk group with the same color.

Chapter 8: Port Numbering Layout on 8-Slot Chassis Core Blades

Table 1 and Table 2 show the layout of ports 0 to 15 on the 8-slot director chassis core blade (Table 1 for both the Brocade X7-8 CR64-8 and X6-8 CR32-8 core blades and Table 2 for the Brocade X8-8 ICL blade). You can also see what the `switchshow` output would be if you issued a `switchshow` command using the Brocade FOS CLI.

The colored groups of external UltraScale ICL ports indicate those ports that belong to the same ICL trunk boundary. For example, for the X7-8 or X6-8, ICL ports 0, 1, 8, 9, 4, 5, 12, and 13 (shown in gray in Table 1) belong to the same ICL trunk boundary, with one link being added to the trunk group from each of the eight external ICL ports. For the 8-slot director chassis, you can create up to 2 ICL trunks of 8 ICL ports each on each of the two core blades represented by either the gray or green port groups highlighted below..

Table 1: Brocade X7-8 CR64-8 Core Blades and X6-8 CR32-8: External UltraScale ICL Port Numbering to switchshow (Internal) Port Numbering

External ICL Port No.	switchshow Port No.	External ICL Port No.	switchshow Port No.
7	28–31	15	60–63
6	24–27	14	56–59
5	20–23	13	52–55
4	16–19	12	48–51
3	12–15	11	44–47
2	8–11	10	40–43
1	4–7	9	36–39
0	0–3	8	32–35

Table 2: Brocade X8-8 ICLX8-8 ICL Blades: External UltraScale ICL Port Numbering to switchshow (Internal) Port Numbering

External ICL Port No.	switchshow Port No.
7	56-63
6	48-55
5	40-47
4	32-39
3	24-31
2	16-23
1	8-15
0	0–7

8.1 POD License-Enabled Ports for QSFP-Based ICLs

The first ICL POD license on the Brocade X7-8 enables a total of 8 QSFP UltraScale ICL ports on the director chassis, enabling 4 ICL ports on each core blade (QSFP ports 0, 1, 8, and 9) that are part of the first 8-port ICL trunk boundary in Table 3. A second ICL POD license enables an additional 8 QSFP UltraScale ICL ports on the director chassis, enabling QSFP ports 2, 3, 10, and 11 on both core blades that are part of the second 8-port ICL trunk boundary in Table 3. A third ICL POD license enables QSFP ports 4, 5, 12, and 13 on both core blades, corresponding to the remaining ports on the first 8-port ICL trunk boundary in Table 3. The fourth ICL POD license enables the last eight QSFP ports 6, 7, 14, and 15 on both core blades.

Table 3: POD License-Enabled Ports on an X7-8

Brocade X7-8	CR1			CR2	
ICL POD License 4 Enables 8 Ports	7	15		7	15
	6	14		6	14
ICL POD License 3 Enables 8 Ports	5	13		5	13
	4	12		4	12
ICL POD License 2 Enables 8 Ports	3	11		3	11
	2	10		2	10
ICL POD License 1 Enables 8 Ports	1	9		1	9
	0	8		0	8

The first ICL POD license on the Brocade X6-8 enables a total of 16 QSFP UltraScale ICL ports on the director chassis, enabling 8 ICL ports on each core blade (QSFP ports 0, 1, 8, 9, 2, 3, 10, and 11) that are lower 4 ports on the two 8-port ICL trunk boundary groups in Table 4. A second ICL POD license enables the remaining 16 QSFP UltraScale ICL ports on the director chassis, enabling QSFP ports 4, 5, 12, 13, 6, 7, 14, and 15 on both core blades that are part of the remaining ports of the two 8-port ICL trunk boundaries in Table 4.

Table 4: POD License-Enabled Ports on an X7-8

Brocade X7-8	CR1			CR2	
ICL POD License 2 Enables 16 Ports	7	15		7	15
	6	14		6	14
	5	13		5	13
	4	12		4	12
ICL POD License 1 Enables 16 Ports	3	11		3	11
	2	10		2	10
	1	9		1	9
	0	8		0	8

8.2 Ports for OSFP-Based X8-8 ICLs

Two ICL blades with eight OSFP ports (64 links) per blade are included in the X8-8 ICL POD kit and require only that OSFP optics be inserted to enable the ports. X8-8 ICL POD kits also include eight OSFP optics, enough to half-populate the ICL ports on each blade. ICL blades can be fully populated by purchasing two additional ICL upgrade kits that include four OSFP optics per kit.

Table 5: ICL Ports on an X8-8

Brocade X8-8 ICL Kits, no POD, all Ports Are Enabled								
ICL 1	0	1	2	3	4	5	6	7
ICL 2	0	1	2	3	4	5	6	7
	ICL Kit				ICL Upgrade Kit 1		ICL Upgrade Kit 2	

Chapter 9: Port Numbering Layout on 4-Slot Chassis Core Blades

Table 6 shows the layout of ports 0 to 7 on the Brocade X7-4 CR64-4 or Brocade X6-4 CR32-4 core blades, where all ports belong to a single ICL trunk boundary. You can also see what the `switchshow` output would be if you issued a `switchshow` command using the Brocade FOS CLI.

Table 6: Brocade X7-4 CR64-4 and X6-4 CR32-4 Core Blades: External UltraScale ICL Port Numbering to switchshow (Internal) Port Numbering

External ICL Port No.	switchshow Port No.	External ICL Port No.	switchshow Port No.
3	12–15	7	28–31
2	8–11	6	24–27
1	4–7	5	20–23
0	0–3	4	16–19

Table 7 shows the layout of ports 0 to 3 on the Brocade X8 ICLx8-4 ICL blade, where all ICL ports belong to a single ICL trunk boundary. You can also see what the `switchshow` output would be if you issued a `switchshow` command using the Brocade FOS CLI.

Table 7: Brocade X8-4 ICLX8-4 ICL Blades: External UltraScale ICL Port Numbering to switchshow (Internal) Port Numbering

External ICL Port No.	switchshow Port No.
3	21–31
2	46–23
1	8–15
0	0–7

9.1 POD License-Enabled Ports for QSFP-Based ICLs

Licensing is the same on the Brocade X7-4 and X6-4 chassis. The first ICL POD license enables ICL ports 0, 1, 4, and 5 on both core blades. Adding a second ICL POD license enables the remaining eight ICL ports, QSFP ports 2, 3, 6, and 7 on both core blades.

Table 8: POD License-Enabled Ports on an X7-4 and X6-4

Brocade X7-4	CR1		CR2	
ICL POD License 2 Enables 8 Ports	3	7	3	7
	2	6	2	6
ICL POD License 1 Enables 8 Ports	1	5	1	5
	0	4	0	4

Brocade X6-4	CR1		CR2	
ICL POD License 2 Enables 8 Ports	3	7	3	7
	2	6	2	6
ICL POD License 1 Enables 8 Ports	1	5	1	5
	0	4	0	4

9.2 Ports for OSFP-Based X8-4 ICLs

Two ICL blades with four OSFP ports (32 links) per blade are included in the X8-4 ICL POD kit and require only that OSFP optics be inserted to enable the ports. X8-4 ICL POD kits also include four OSFP optics, enough to half-populate the ICL ports on each blade. ICL blades can be fully populated by purchasing one additional ICL upgrade kit that includes four OSFP optics per kit.

Table 9: ICL Ports on an X8-4

Brocade X8-4 ICL Kits, no POD, all Ports Are Enabled				
ICL 1	0	1	2	3
ICL 2	0	1	2	3
	ICL Kit		ICL Upgrade Kit 1	

Chapter 10: Connecting QSFP-Based Brocade Directors Using ICLs

To connect multiple Brocade X7 and/or X6 Director family chassis via UltraScale ICLs, a minimum of four ICL ports (two on each core blade) must be connected between each chassis pair. The 32 UltraScale ICL ports available on the 8-slot chassis support ICL connectivity with up to 8 other chassis in a mesh topology (for a total of 9 in a fabric) and 11 other chassis in a core/edge topology (for a total of 12 in a fabric).

Figure 10 shows the minimum connectivity between a pair of X7-8 or X6-8 chassis.

NOTE: The physical location of the UltraScale ICL connections may differ from what is shown in the figure. There must be at least two connections per core blade, and those connections must be from within the same ICL trunk boundary.

Figure 10: X7-8 to X6-8 ICL Connectivity

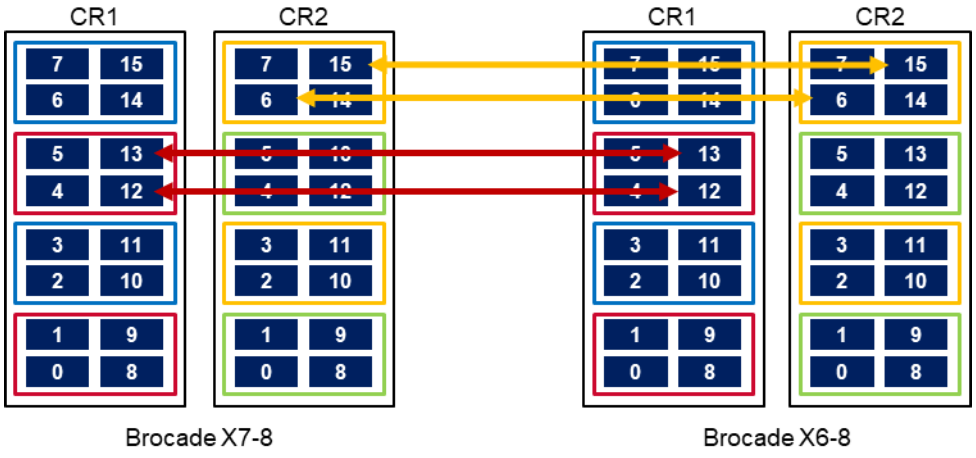
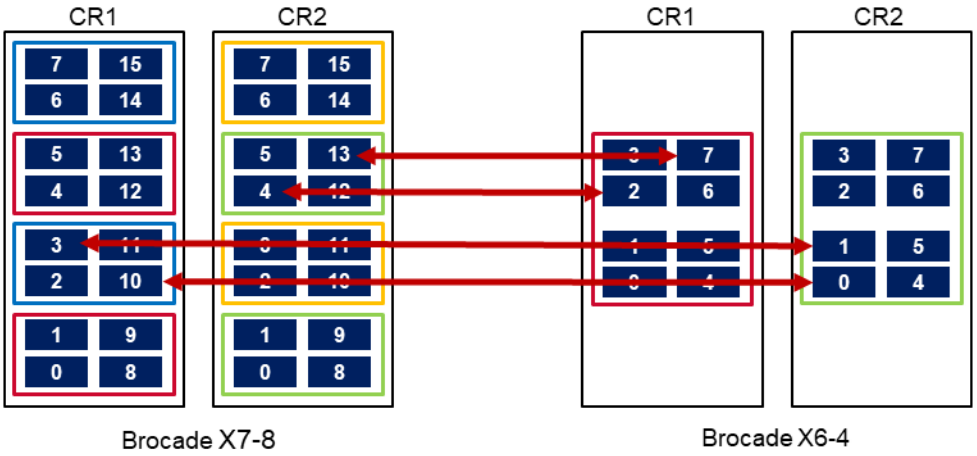


Figure 11 shows the minimum ICL connectivity between an X6-8 chassis and an X6-4 chassis.

Figure 11: X7-8 to X6-4 ICL Connectivity



The dual connections on each core blade must reside within the same UltraScale ICL trunk boundary on the core blades. If more than four UltraScale ICL connections are required between a pair of Brocade director chassis, additional UltraScale ICL connections must be added in pairs, one on each core blade.

NOTE: Optics bundled in the BR-X68ICLKIT-100M-02/BR-X64ICLKIT-100M-02 kits also support interoperability with any of the supported Gen 5 4×16G optics from a BR-X68GEN5ICLKIT-01/BR-X64GEN5ICLKIT-01 that was originally purchased to connect an X6 to a DCX 8510 via ICLs. Connectivity from an X7 or X6 to a DCX 8510 chassis is no longer supported following the Gen 5 end-of-support date.

The preceding figures demonstrate minimum ICL connectivity. The maximum number of trunks between any two directors is 16. The maximum number of physical ICL QSFP connections between two X7-8/X6-8 chassis is 32 which will provide 16 8-port ICL trunks.

Chapter 11: Connecting OSFP-Based Brocade Directors Using ICLs

To connect multiple Brocade X8 Director family chassis via UltraScale ICLs, a minimum of two ICL ports (one on each ICL blade) must be connected between each chassis pair. The 16 UltraScale ICL ports available on the 8-slot chassis support ICL connectivity with up to 8 other chassis in a mesh topology (for a total of 9 in a fabric) and 11 other chassis in a core/edge topology (for a total of 12 in a fabric).

Figure 12 shows the minimum connectivity between a pair of X8-8 chassis.

NOTE: The physical location of the UltraScale ICL connections may differ from what is shown in the figure. There must be at least two connections per core blade, and those connections must be from within the same ICL trunk boundary.

Figure 12: X8-8 to X8-8 ICL Connectivity

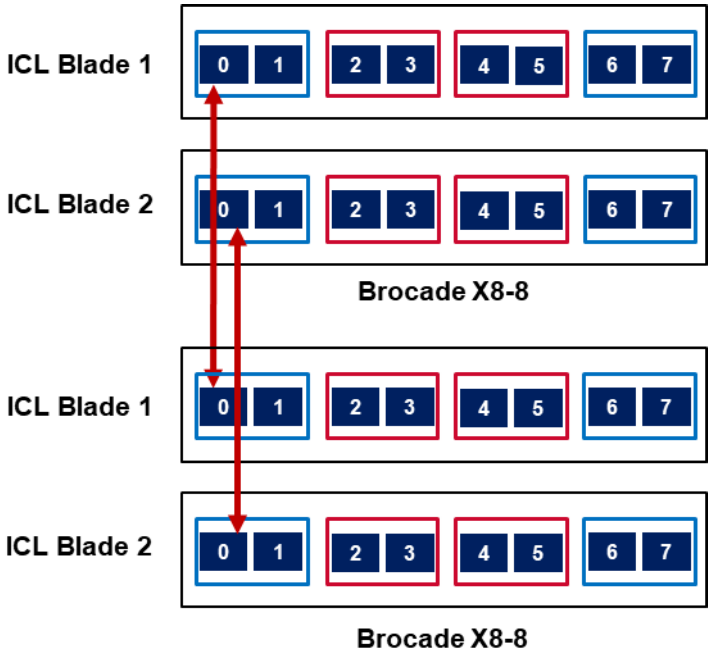
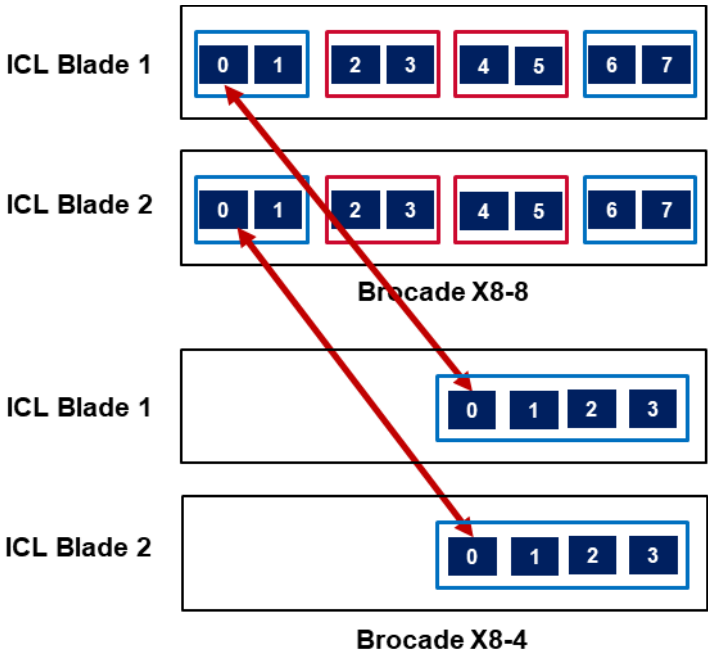


Figure 13 shows the minimum ICL connectivity between an X8-8 chassis and an X8-4 chassis.

NOTE: The physical location of the UltraScale ICL connections may differ from what is shown in the figure. There must be at least two connections and those connections must be from within the same ICL trunk boundary.

Figure 13: X8-8 to X8-4 ICL Connectivity



Chapter 12: UltraScale ICL Diagnostics

Brocade Fabric OS provides ClearLink® diagnostic port (D_Port) support for UltraScale ICLs, helping administrators quickly identify and isolate ICL optics and cable problems. ClearLink diagnostics on UltraScale ICLs measures link latency, link distance, and signal power, and it also performs link traffic tests. First-generation Gen 6 4×32G QSFPs, and Gen 7 QSFPs, and Gen 8 OSFPs skip the electrical loopback and optical loopback tests because they do not support these functions. The second generation of the 4×32G SWL QSFP does support electrical and optical loopback functions; however these functions are not supported in ICL use cases. Use port decommissioning of the ICL ports prior to performing ClearLink diagnostics to ensure a graceful and lossless shut down of the ports prior to taking the ports offline for diagnostics. In addition, configuring the directors with Dynamic D_Port greatly simplifies ClearLink operations; to ensure that ClearLink is not mistakenly invoked on ports with Dynamic D_Port enabled, the ports must be provisioned prior to performing a diagnostics test. Details on ClearLink diagnostics port configuration and usage can be found in the *Brocade Fabric OS Troubleshooting and Diagnostics Reference Manual*.

Chapter 13: UltraScale ICL Routing

For environments enabled with virtual fabrics, FOS provides the ability to configure EX_Ports on the UltraScale ICLs, utilizing the ICL bandwidth to route traffic across different fabrics. This capability allows users to build high-performance inter-fabric links (IFLs) using UltraScale ICLs, while simplifying cabling.

Appendix A: ICL POD Kit Reference Table

The following tables are not official support matrices, but they can be used as a reference. Always check the latest release notes and documentation.

Table 10: X8 ICL Kit and ICL Upgrade Kit Reference Table

Description	SWL/ LWL	Product	Kits per Chassis	OSFP Ports per Chassis	OSFPs per Kit	Connector	Connectivity	Distance
X8-8								
X8-8 100m ICL Kit P/N BR-X88ICLKIT-100M-01 includes 2x X8-8 ICL blades, 8x GEN 8 ICL OSFPs 100m Optics: XBR-000502	SWL	X8-8	1 includes 2x ICL blades	16	8	MPO-16	X8 to X8 (Gen 8 ICL speed) X8 to X7 (Gen 7 ICL speed)	OM3: 70m OM4/5: 100m
X8-8 2-km ICL Kit P/N BR-X88ICLKIT-2KM-01 includes 2x X8-8 ICL blades, 8x GEN 8 ICL OSFPs 2-km Optics: XBR-000503	LWL	X8-8	1 includes 2x ICL blades	16	8	2x LC	X8 to X8 (Gen 8 ICL speed) X8 to X7 (Gen 7 ICL speed)	OS1/OS2: 2 km
X8-4								
X8-4 100m ICL Kit P/N BR-X84ICLKIT-100M-01 includes 2x X8-8 ICL blades, 8x GEN 8 ICL OSFPs 100m Optics: XBR-000502	SWL	X8-4	1 includes 2x ICL blades	8	4	MPO-16	X8 to X8 (Gen 8 ICL speed) X8 to X7 (Gen 7 ICL speed)	OM3: 70m OM4/5: 100m
X8-4 2-km ICL Kit P/N BR-X84ICLKIT-2KM-01 includes 2x X8-4 ICL blades, 8x GEN 8 ICL OSFPs 2-km Optics: XBR-000503	LWL	X8-4	1 includes 2x ICL blades	8	4	2x LC	X8 to X8 (Gen 8 ICL speed) X8 to X7 (Gen 7 ICL speed)	OS1/OS2: 2 km
X8 ICL Upgrade Kit								
X8 100m ICL Upgrade Kit P/N BR-X8ICLUPG-100M-01 includes 4x OSFPs 100m Optics: XBR-000502	SWL	X8-8 or X8-4	1 (X8-4) or 2 (X8-8)	16 or 8	4	MPO-16	X8 to X8 (Gen 8 ICL speed) X8 to X7 (Gen 7 ICL speed)	OM3: 70m OM4/5: 100m
X8-4 2-km ICL Upgrade Kit P/N BR-X8ICLUPG-2KM-01 includes 4x OSFPs 2-km Optics: XBR-000503	LWL	X8-8 or X8-4	1 (X8-4) or 2 (X8-8)	16 or 8	4	2x LC	X8 to X8 (Gen 8 ICL speed) X8 to X7 (Gen 7 ICL speed)	OS1/OS2: 2 km

Table 11: X7 ICL POD Kit Reference Table

Description	SWL/ LWL	Product	Licenses per Chassis	QSFP Ports per Chassis per License	FC Ports per Chassis per License	QSFPs per Kit	Connector	Connectivity	Distance
X7									
Gen 7 100m ICL kit P/N BR-X7ICLKIT-100M-01 X7 ICL POD KIT, enables 8 ICL ports, 8x GEN 7 ICL QSFPs 100m Optics: XBR-000420	SWL	X7-4	1 or 2	8 or 16	32 or 64	8	MTP	X7 to X7	OM3: 70m OM4: 100m
		X7-8	1, 2, 3, or 4	8, 16, 24, or 32	32, 64, 96, or 128				
Gen 7 2-km ICL kit P/N BR-X7ICLKIT-2KM-01 X7 ICL POD KIT, enables 8 ICL ports, 8x GEN 7 ICL QSFPs 2 km Optics: XBR-000476	LWL	X7-4	1 or 2	8 or 16	32 or 64	8	LC	X7 to X7	2 km
		X7-8	1, 2, 3, or 4	8, 16, 24, or 32	32, 64, 96, or 128				
Gen 6 100m ICL kit for the X7 chassis P/N BR-X7GEN6ICLKIT-100M-1 X7 32G ICL POD KIT, enables 8 ICL ports, 8x 32G QSFPs 100m Optics: XBR-000475	SWL	X7-4	1 or 2	8 or 16	32 or 64	8	MTP	X7 to X7 (32Gb/s) X7 to X6 (32Gb/s) X7 to DCX 8510 (16Gb/s)	OM3: 70m OM4: 100m
		X7-8	1, 2, 3, or 4	8, 16, 24, or 32	32, 64, 96, or 128				
Gen 6 2-km ICL kit for the X7 chassis P/N BR-X7GEN6ICLKIT-2KM-01[a] X7 32G ICL POD KIT, enables 8 ICL ports, 8x 32G QSFPs 2 km Optics: XBR-000285	LWL	X7-4	1 or 2	8 or 16	32 or 64	8	LC	X7 to X7 (32Gb/s) X7 to X6 (32Gb/s)	2 km
		X7-8	1, 2, 3, or 4	8, 16, 24, or 32	32, 64, 96, or 128				

a. The Gen 6 2-km ICL POD kit for the X7 is no longer available for purchase.

Table 12: X6 ICL POD Kit Reference Table[a]

Description	SWL/ LWL	Product	Licenses per Chassis	QSFP Ports per Chassis per License	FC Ports per Chassis per License	QSFPs per Kit	Connector	Connectivity	Distance
X6-8									
Gen 6 100m ICL kit P/N BR-X68ICLKIT-100M-02 X6 32G ICL POD KIT, enables 16 ICL ports, 16x 32G QSFPs 100m Optics: XBR-000475, XBR-000275	SWL	X6-8	1 or 2	16 or 32	64 or 128	16	MTP	X6 to X6 (16/32G) X6 to DCX 8510 (16G)	OM3: 70m OM4: 100m
Gen 6 2-km ICL kit P/N BR-X68ICLKIT-2KM-01 X6 32G ICL POD KIT, enables 16 ICL ports, 8x 32G QSFPs 2 km Optics: XBR-000285	LWL	X6-8	1 or 2	16 or 32	64 or 128	8	LC	X6 to X6 (32G)	2 km
Gen 5 2-km ICL kit for the X6-8 chassis P/N BR-X68GEN5ICLKIT-2KM-01 X6 32G ICL POD KIT, enables 16 ICL ports, 8x 16G QSFPs 2 km Optics: XBR-000255	LWL	X6-8	1 or 2	16 or 32	64 or 128	8	MTP 3m pigtail APC	X6 to DCX 8510 (16G)	2 km
X6-4									
Gen 6 100m ICL kit P/N BR-X64ICLKIT-100M-02 X6 32G ICL POD KIT, enables 8 ICL ports, 16x 32G QSFPs 100m Optics: XBR-000475, XBR-000275	SWL	X6-4	1 or 2	8 or 16	32 or 64	8	MTP	X6 to X6 (16/32G) X6 to DCX 8510 (16G)	OM3: 70m OM4: 100m
Gen 6 2-km ICL kit P/N BR-X64ICLKIT-2KM-01 X6 32G ICL POD KIT, enables 8 ICL ports, 8x 32G QSFPs 2 km Optics: XBR-000285	LWL	X6-4	1 or 2	8 or 16	32 or 64	8	LC	X6 to X6 (32G)	2 km
Gen 5 2-km ICL kit for the X6-4 chassis P/N BR-X64GEN5ICLKIT-2KM-01 X6 32G ICL POD KIT, enables 8 ICL ports, 8x 16G QSFPs 2 km Optics: XBR-000255	LWL	X6-4	1 or 2	8 or 16	32 or 64	8	MTP 3m pigtail APC	X6 to DCX 8510 (16G)	2 km

a. Gen 6 ICL POD Kits are EOL and no longer available for purchase. Information is provided for support purposes only.

Revision History

Scale-Out-ICLs-DG107; March 17, 2026

Clarified explanations of Gen 8 ICL Kit offerings within section 2.1.

Scale-Out-ICLs-DG106; February 10, 2026

Added Gen 8 ICL Kit offerings and configuration examples, and deleted the Gen 5 ICL kits from the available offerings.

Scale-Out-ICLs-DG105; September 6, 2022

Deleted the Gen 6 2-km ICL kits from the list of available offerings. Deleted the two-kit minimum requirement for the X7-8.

Scale-Out-ICLs-DG104; February 23, 2022

Added the Gen 7 2-km ICL kit to the X7 ICL POD licensing and ICL kit offerings. Also added Appendix A: ICL POD Kit Reference Table.

Scale-Out-ICLs-DG103; March 29, 2021

Added the 32G 2-km ICL kit to the X7 ICL POD licensing and ICL kit offerings.

Scale-Out-ICLs-DG102; November 6, 2020

Clarified the explanation of ICL trunk groups.

Scale-Out-ICLs-DG101; September 9, 2020

Corrected ICL POD license information.

Scale-Out-ICLs-DG100; September 1, 2020

Initial version to cover new Gen 7 ICL kit offerings. Gen 7 ICLs support 4 × Gen 7 ICL speeds and are interoperable with Gen 5 and Gen 6 ICLs.