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Juniper 1.6T Optical Transceivers and Cables Guide

Published
2026-07-13

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Juniper 1.6T Optical Transceivers and Cables Guide
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About This Guide

Use this guide to learn about the Juniper Networks® 1.6T optical transceivers and cables, their specifications, and how to install, remove, and maintain these transceivers.

Documentation Conventions

For information about the notice icons and text and syntax conventions used in the documentation, see Documentation Conventions.

1

CHAPTER

1.6T Optical Transceivers Overview

IN THIS CHAPTER

- Know Your 1.6T Transceiver | **2**

Know Your 1.6T Transceiver

IN THIS SECTION

- Modulation Method | 3
- Optical Technology | 3
- Key Characteristics | 4
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1.6 Terabit (1.6T) transceivers are optical modules capable of handling data rates of 1.6 Tbps or 1.6T Ethernet. 1.6T transceivers offer double the capacity of their latest predecessor (800G transceivers). These transceivers are ideal for:

- Any host platform with 1.6T-capable ports
- Networks with 1.6 terabits data transmission
- Telecommunication networks that require high-speed data transmission with minimal loss

A 1.6T transceiver uses multiple lanes of optical signals and advanced modulation techniques to achieve higher capacities. 1.6T transceivers employ multiplexing using multiple fibers, along with a combination of fiber and wavelength multiplexing to transmit an optical signal. All 1.6T client optics use 8 lanes of 200G with pulse amplitude modulation 4-level (PAM4) modulation.

1.6T transceivers support multiple transmission rates and breakout modes to ensure compatibility with various network transport requirements. This flexibility allows a single physical transceiver to be logically divided into multiple lower-speed Ethernet ports, adapting to different deployment scenarios. Juniper 1.6T transceivers support the following breakout options:

- 1x1.6T
- 2x800G
- 4x400G
- 8x200G

Juniper 1.6T transceivers use the OSFP1600 form factor, which is further categorized as OSFP (with an integrated heat sink) and OSFP-RHS (with a riding heat sink). Juniper does not currently support the QSFP-DD1600 form factor.

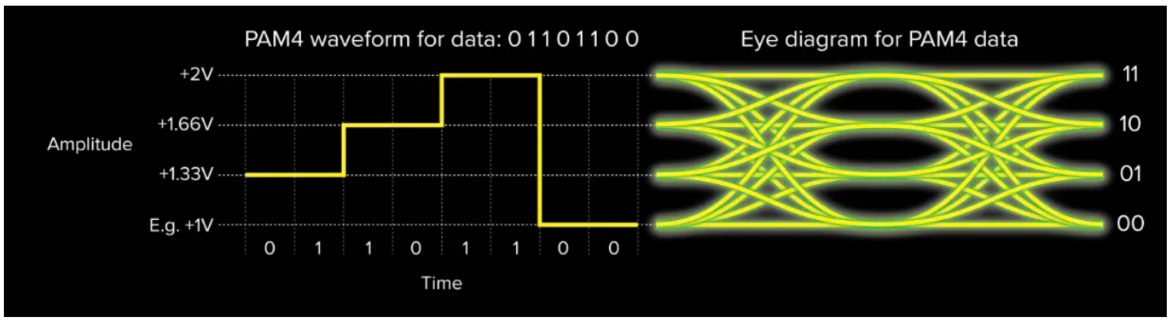
See the Hardware Compatibility Tool for the list of transceivers, their specifications, and the list of devices supported by the transceivers.

Modulation Method

Pulse amplitude modulation 4-level (PAM4) is a modulation method that combines two bits into a single symbol with four amplitude levels, doubling the amount of data transmitted over a network. It enables efficient short distance data transmission, but it demands more signal processing and error correction.

PAM4 has a higher signal to noise ratio (SNR) and is susceptible to internal interference of optical signals over long distances. It is necessary to configure forward error correction (FEC) to handle the signal integrity. You must configure FEC at both the transmitter and receiver ends of a 1.6T communication link. The FEC algorithm encodes data before transmission and decodes and corrects the errors in data upon reception.

Figure 1: PAM4 Modulation



Optical Technology

1.6T optics and transceivers use the following technologies:

Digital Signal Processing

Advanced digital signal processing (DSP) techniques enhance signal integrity and extend the reach of 1.6T transceivers over optical fiber.

Clock Data Recovery

Clock data recovery (CDR) extracts timing information from a data signal and ensures accurate data retrieval and transmission in an optical network.

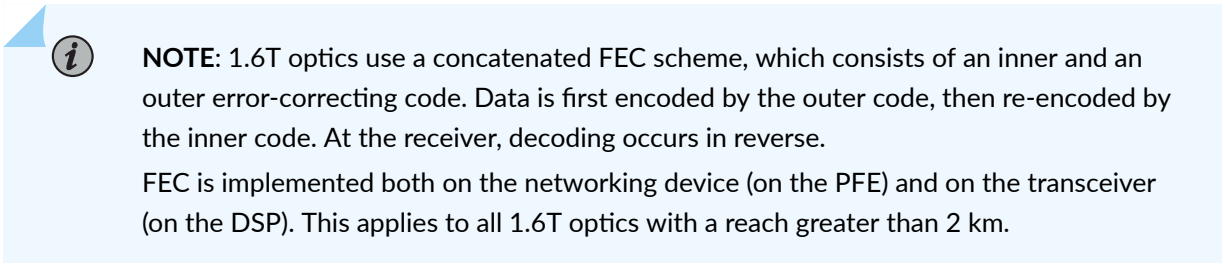
Forward Error Correction

1.6T optical transceivers handle high transmission speeds. They are susceptible to errors caused by noise, signal distortions, and nonlinear effects. Forward Error Correction (FEC) is a method of error control in which the transmitter adds redundant data or parity bits to the original data stream. This redundancy allows the receiver to detect and correct errors without requiring retransmission.

FECs are implemented through algorithms, which are specific mathematical techniques or coding schemes. FEC algorithms detect and correct errors in transmitted data without requiring retransmission. The error correction capability of FEC depends on the specific algorithm used and the amount of redundancy added.

The FEC process involves two steps:

- Encoding (at the Tx or transmitter)—The FEC algorithm processes the original data and adds redundant bits or parity bits based on a specific mathematical rule. The encoded data is then transmitted over the communication channel.
- Decoding (at the Rx or Receiver)—The receiver uses the FEC algorithm to analyze the received data, including the redundant bits. If errors are detected, the algorithm attempts to correct them based on the redundancy.



NOTE: 1.6T optics use a concatenated FEC scheme, which consists of an inner and an outer error-correcting code. Data is first encoded by the outer code, then re-encoded by the inner code. At the receiver, decoding occurs in reverse.

FEC is implemented both on the networking device (on the PFE) and on the transceiver (on the DSP). This applies to all 1.6T optics with a reach greater than 2 km.

Key Characteristics

The following are the key characteristics of a 1.6T transceiver:

- Form factor—Juniper supports the OSFP form factor for 1.6T transceivers. OSFP transceiver modules are designed to accommodate the higher power and thermal requirements, handle higher power dissipation, and provide better cooling solutions.
- Fiber type and reach—The fiber type specifies the type of optical fiber (singlemode or multimode) compatible with 1.6T transceivers. The reach provides the maximum supported distance or range for

an optical transceiver. It helps you to select the appropriate optical transceiver for different applications, such as inter-data center, intra-data center and so on.

- Lane distribution—Juniper's 1.6T optics use eight parallel lanes, either with multiple fiber pairs or wavelength multiplexing. 1.6T optics have parallel fibers that are used over shorter distances. Wavelength multiplexing using duplex single-mode fiber is used for longer distance optical communication.

Juniper Optical Product Numbers

Juniper's optical components such as transceivers, cables, and connectors follow a naming convention. Each element in the product name corresponds to a specification. It helps you to better understand and select the appropriate optical component. For example:

- ORHS-2x800G-FR4-P
  - ORHS—Short for OSFP with riding heat sink. It identifies the form-factor of the transceiver.
  - 2x800G—It indicates that the transceiver supports break-out into two independent 800G Ethernet interfaces for data transmission.
  - FR4—Stands for 800GBase-FR4. It is a specific standard and indicates that each 800G channel uses four parallel lanes of 200 Gbps to deliver 800 Gbps.
  - P—It indicates that the optical connector has a dual configuration (Dual MPO-12/APC or Dual Duplex LC). Without '-P', it indicates a single connector (MPO-16/APC or CS).
- Other transceivers include ORHS-1600G-DR8-2 and ORHS-1600G-DR8-2-P.

1.6T (X8) Transceiver Architecture

The 8x200 gigabit architecture for a 1.6T transceiver uses eight lanes of 200 Gbps each. The following are the different components of a 1.6T transceiver architecture:

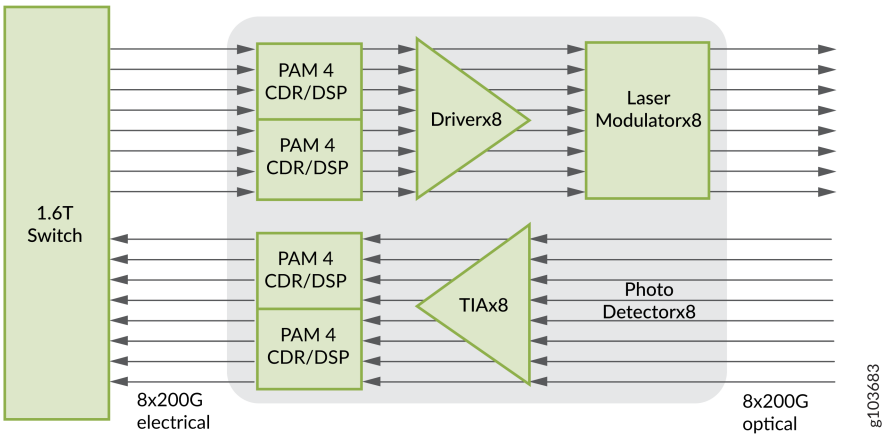
- Host platforms—Juniper devices that support 1.6T architecture.
- 8x200G electrical—The electrical interface between the switch and the transceiver components. It can transmit data over eight separate 200 Gbps electrical lanes.
- PAM4 clock data recovery (CDR)/digital signal processor (DSP)—A PAM4 CDR/DSP supports 200 Gbps electrical lanes. PAM4 effectively doubles the amount of data that you can transmit. The CDR is responsible for re-timing incoming data to reduce jitter. The DSP handles functions like equalization, error correction, and other signal processing tasks.
- Driver x8—Drivers are electronic components that amplify the electrical signal. The x8 transceiver architecture has eight drivers. Each driver corresponds to a 200 Gbps electrical lanes.

- Modulator x8—Eight modulators correspond to 200 Gbps electrical lanes (x8). 1.6T optics uses the following types of modulators:
  - Vertical cavity surface emitting Lasers (VCSEL)—VCSEL is used for multimode optics such as SR8/VR8.
  - Directly modulated lasers (DMLs)—DMLs are used for single-mode optics such as DR8. DMLs use distributed feedback (DFB) structures that incorporate a diffraction grating for stable direct modulation. Their modulation speed and transmission distance depend on the spectral line-width. A narrower line-width allows higher speeds and longer distances. In DMLs, data is modulated by adjusting the injection current on the laser diode, resulting in a compact design suitable for low-power applications.
  - Electro-absorption Modulated Laser (EMLs)—An EML integrates a laser diode with an electro-absorption modulator on a single chip. The laser operates continuously and the modulator turns the signal on and off.

  Unlike DMLs, EMLs maintain constant laser properties during modulation, offering advantages in higher speed and longer distance transmissions due to lower chromatic dispersion. High speed optics such as 1.6T and 800G, with a reach of 10km or greater, generally use EMLs. In many cases, optics with a reach of 2 km or greater may also use EMLs.
- 8x200G optical module—Optical interfaces that carry data in the form of light pulses. Each fiber in this model carries 200 Gbps of data.
- Transimpedance amplifiers (TIA) x8—A TIA converts and amplifies the electrical current from the photodiode into an electrical voltage level. It can operate with very low signal levels that are typical for optical communication.
- Photo-detector x8—It works in tandem with the TIA to convert the optical information back into electrical form.

An 8x200G architecture employs eight lanes to achieve a total data transmission rate of 1.6 Tbps. Each lane handles 200 Gbps.

Figure 2: 1.6T (X8) Transceiver Architecture



2

CHAPTER

1.6T Optical Transceivers Specifications

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- Juniper 1.6T Transceivers | **14**
- Connector Types | **14**
- Cable Types and Length | **16**
- Breakout Capability | **19**

Form Factors

IN THIS SECTION

- Octal Small Form Factor Pluggable (OSFP1600) | 9

Form factor refers to the physical dimensions and shape of a transceiver. Form factor includes aspects like the size, shape, connector type, and other physical characteristics. It determines how the transceiver fits into networking equipment like switches, routers, or servers.

Juniper supports the OSFP1600 form factor for 1.6T transceivers.

Octal Small Form Factor Pluggable (OSFP1600)

OSFP is designed for high-speed applications, including Juniper's 1.6T transceivers. It focuses on efficiently managing heat dissipation. It is compatible with some of the other form factors such as OSFP800. Based on the design, an OSFP transceiver module can be of two types:

- OSFP transceiver module with integrated heat sink (OSFP)—The classic configuration for an OSFP transceiver.
- OSFP transceiver module with riding heat sink (OSFP-RHS or ORHS)—The OSFP-RHS is a 9.5 mm tall pluggable module that is used in place of the integrated heat sink.

OSFP and OSFP-RHS are two different form factors. You cannot have a common host for these optical transceivers. The following are the features of OSFP-RHS:

- 1.6 T capacity using 200G lanes
- Optimization for cold-plate, liquid-cooled system
- Input voltage of 3.3 V

Table 1: Feature Comparison of OSFP and OSFP-RHS

Transceiver Feature	OSFP	OSFP-RHS
Transceiver module (height)	13 mm height for OSFP within the cage	9.5 mm height without heat sink
Cage	Port height/positive stop/bezel cutout is different from OSFP-RHS	The OSFP-RHS cannot be installed in an OSFP cage, as it is mechanically distinct and incompatible with the standard OSFP design.
Durability	Identical	Identical
Thermal requirement	• Standard: 0 through 70° C • High power modules: 75° C to 80° C	• Standard: 0 through 70° C • High power modules: 75° C to 80° C
Power requirement	16 W to 43 W	16 W to 43 W
Electrical and management interface	OIF CEI and OIF CMIS	OIF CEI and OIF CMIS

NOTE: If the feature is not explicitly specified for OSFP-RHS, the same specifications of OSFP are applicable.

Color Codes

Transceiver modules adhere to a color code by application of color to its pull-tab or other appropriate method.

Table 2: OSFP Color Codes

Product Type	Color	Pantone Code
OSFP copper cables	Black	Not applicable
OSFP AOC cables	Gray	422U
OSFP 850 nm solutions	Beige	475U
OSFP 1310 nm solutions for up to 500 m	Yellow	107U
OSFP 1310 nm solutions for up to 2 km	Green	354C
OSFP 1310 nm solutions for up to 10 km	Blue	300U
OSFP 1310 nm solutions for up to 40 km	Red	1797U
OSFP 1550 nm solutions for up to 80 km	White	Not applicable

Insertion, Extraction, and Retention Forces

The following are details about the insertion, extraction, and retention forces acting on an OSFP transceiver module:

Table 3: Insertion, Extraction, and Retention Forces for an OSFP Transceiver Module

Action	Minimum (N)	Maximum (N)	Notes
OSFP transceiver module insertion	Not applicable	40 (55)	Transceiver module to be inserted into connector and cage with latch mechanism engaged (55 N if the cage has riding heat sink)
OSFP transceiver module extraction	Not applicable	30 (45)	Transceiver module to be removed from connector and cage with latching mechanism disengaged (45 N if the cage has riding heat sink)
OSFP transceiver module retention	125	Not applicable	If the module has a pull tab, the pull tab should be able to withstand up to 90 N of the pulling under maximum operating temperature of the module.

Table 4: OSFP Transceiver Module Thermal Requirements

Parameter	Value
Life expectancy	10 years
Maximum temperature rise (when all signal and power contacts are simultaneously energized)	Vendor specific

Table 5: LED Signaling for an OSFP Transceiver Module

LED Status	Indication
On for 0.22 seconds (Channel 1)	Green—Indicates channel 1 is operational. Yellow—Indicates channel 1 is non-operational or disabled.
Off for 0.22 seconds (Channel 1)	Pause until LED indicates status of next channel.
On for 0.22 seconds (Channel 2)	Green—Indicates channel 2 is operational. Yellow—Indicates channel 2 is non-operational or disabled.
Off for 0.22 seconds (Channel 2)	Pause until LED indicates status of next channel.
...	The ellipsis pattern repeats to the final (nth) port.
Off for 1.76 seconds	Long pause for clear separation before pattern repeats from the beginning.

Power Requirements

Transceiver modules have varying power consumption levels and thermal output. It depends on the overall platforms design, airflow, size, height, and quality of the heat sinks on top of the ports.

OSFP and OSFP-RHS—The 1.6T optics clients that use the OSFP and OSFP-RHS form factor consume 16 W to 28 W approximately.

Juniper 1.6T Transceivers

IN THIS SECTION

- Platform Support for 1.6T Transceivers | 14

Juniper's 1.6T transceivers cater to data center and AI-ML cluster applications for routing and switching solutions. To support the multi-vendor network environment, Juniper 1.6T transceivers adhere to key industry standards.

Juniper's 1.6T transceivers use the OSFP1600 form factor (referred to as OSFP). For a list of all 1.6T optics and their supported platforms, see Hardware Compatibility Tool.

Platform Support for 1.6T Transceivers

For information about the Juniper platforms that 1.6T transceivers support, see the Supported Platforms tab for 1.6T transceivers in Hardware Compatibility Tool.

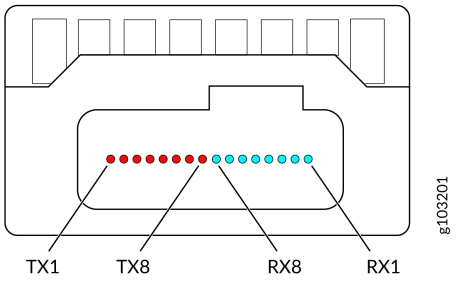
Connector Types

Optical connectors ensure efficient and reliable connections between fiber optic cables. Connectors are designed to minimize insertion loss and back reflection, ensuring high-quality signal transmission.

1.6T transceivers support the following connector types:

- MPO-16/APC—A multi-fiber push-on 16 (MPO-16) connector has 16 optical fibers in a single connector. With angled physical contact (APC), the connector minimizes back reflection and ensure better signal integrity. MPO connectors offer high-density connections and support multiple fibers in a single connector. MPO connectors are often used in data centers.

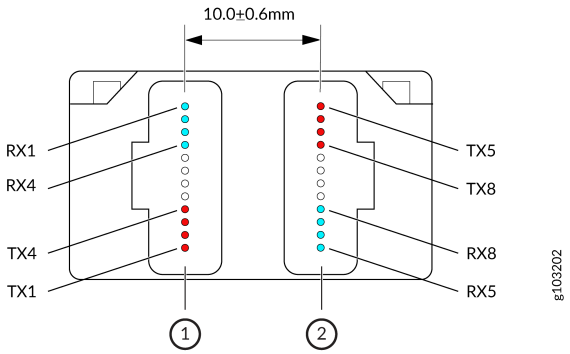
Figure 3: MPO-16 Connector



The connector has 16 fiber channels arranged in a single row. Tx (transmit) is handled by eight channels (denoted in red). The Tx channels are denoted as Tx1, Tx2, Tx3, Tx4, Tx5, Tx6, Tx7, and Tx8 from left to right. Rx (receive) is handled by the other eight channels (denoted in blue). The Rx channels are denoted as Rx1, Rx2, Rx3, Rx4, Rx5, Rx6, Rx7, and Rx8 from right to left.

- Dual MPO-12/APC—It has two separate MPO-12 connectors, each having 12 optical fibers. That is, a Dual MPO-12/APC connector can connect 24 optical fibers at once. Like, an MPO-12, the Dual MPO-12 also provides an angled physical contact.

Figure 4: Dual MPO-12 Connector



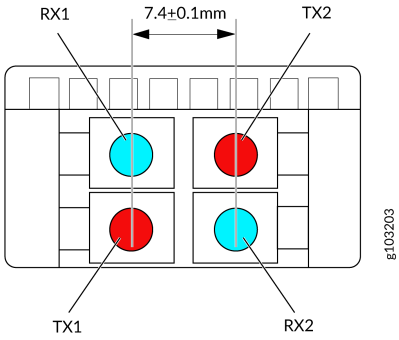
1– Connector 1	2– Connector 2

Tx channels are denoted in red. Rx channels are denoted in blue.

- Dual Duplex LC/UPC—It is a type of lucent connector or local connector (LC). LCs have a small form factor. With a dual duplex construction, the dual duplex LC/UPC connector includes two LC connectors in a single housing. Each of these connectors contain two fibers in each LC connector, one for transmission and the other for reception. With ultra physical contact (UPC), the connector

has a zero-degree angle or flat surface. Though this reduces the amount of back reflection, it is not as efficient as an APC.

Figure 5: Dual Duplex LC Connector



Tx channels are denoted in red. Rx channels are denoted in blue.

Cable Types and Length

IN THIS SECTION

- Direct Attach Copper Cables (DAC) | **17**
- Active Electrical Cable (AEC) | **17**
- Architecture of AEC and DAC Cables | **18**
- Cable Length or Range | **19**

Cables are the physical medium that transmit optical and electrical signals. Juniper offers a broad variety of high-performance and cost-effective cables. These optical and electrical cables are available in various dimensions, distance ranges, and speeds. Cables offer a wide selection of breakout configurations that enable you to operate at lower transmission speeds. It helps to effectively interconnect devices and increase port density. For more information, see Optical and Electrical Cables.

The two broad types of cables are:

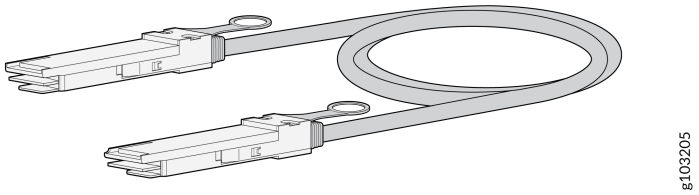
- Direct attach copper cables (DAC)

- Active electrical cables (AEC)

Direct Attach Copper Cables (DAC)

Made of Twinax copper, the primary type of DAC cable is known as Twinax Cable. It is ideal for ultra short-range connections. DAC supports high-speed connections between servers, switches, and storage devices. DAC cables are lower cost and more durable than optical fibers. Also, it is less susceptible to dust and environmental disturbances.

Figure 6: 1.6T DAC Cable



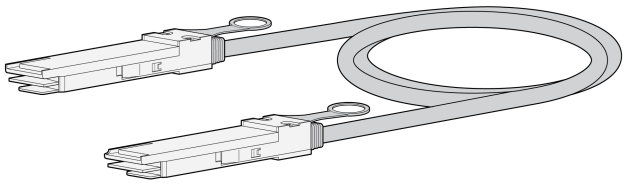
DAC cables can be of two types:

- Passive DAC cables—Passive DAC cables transmit signals without the use of electrical components to boost or regenerate the signal. The network equipment's host handles signal amplification and conditioning. Typically, passive DAC cables are limited to a maximum length of seven meters, as their performance diminishes over longer distances.
- Active DAC cables—Active DAC cables, in contrast, include an additional driving chip that conditions the signal, enhancing transmission quality over longer distances. These cables share the same setup as passive DAC cables but provide signal boosting through built-in electronics. Active DAC cables can typically extend up to 10 meters or more, offering a longer reach in compare with passive DAC cables. By offering both passive and active options, DAC cables provide flexible solutions for various network environments, balancing signal integrity with distance requirements.

Active Electrical Cable (AEC)

AEC cables are similar to DAC cables as they both are copper cables. AEC cables have integrated retimers, equalizers, and amplifiers at both ends to improve signal transmission over longer distances. AEC cables employ continuous signal regeneration to compensate for attenuation and distortion. AEC cables also provide Forward Error Correction (FEC) and Clock Data Recovery (CDR) capabilities.

Figure 7: 1.6T AEC Cable

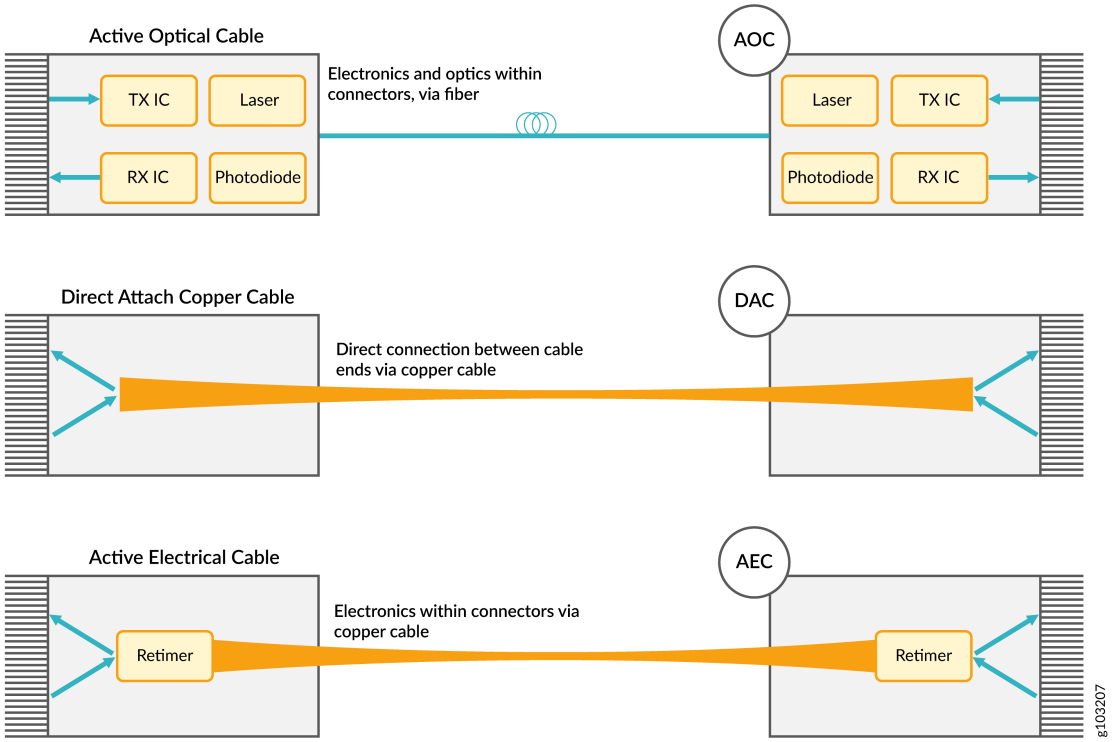


Architecture of AEC and DAC Cables

AEC and DAC each use distinct architectures, resulting in different operational characteristics. DAC cables, both active and passive, use copper wires to transmit electrical signals. Passive DAC cables directly transmit signals without any conditioning. Active DAC cables incorporate a driving chip within the transceivers to enhance and condition the signals.

AEC cables also use copper wires along with integrated signal processors, such as equalizers and retimers, at both ends. This architecture enables AEC cables to maintain high signal integrity over longer distances.

Figure 8: Architecture of AOC, DAC, and AEC Cables



Cable Length or Range

Juniper 1.6T transceivers support varying cable lengths to meet specific needs. For more information about the specific distance range of individual transceivers, see Hardware Compatibility Tool.

Breakout Capability

IN THIS SECTION

- Serializer/Deserializer (SerDes) | **20**
- Breakout Cables | **21**

Breakout capability or port channelization is the ability to split a high-capacity optical link into multiple lower-capacity links. To achieve the split, use breakout cables with suitable connectors. The breakout

cables split the single high-speed ports into multiple lower-speed connections. For more information, see Port Speed Channelization.

You can configure channelization speeds at the level of an individual port, a block of ports, or a quad of ports. A block of ports is a group of ports that share hardware resources within a Juniper switch or router. Hence, the configuration of breakout mostly impacts the entire set of ports in the block. For a block of port that supports breakout capability, you use the SerDes (Serializer and Deserializer) technology.

You can configure port speeds at the chassis level or the interface level. The chassis-level configuration can be as follows:

- Channelize individual port—Configure an individual port to operate at a specific channel speed. Specify a port number and channel speed.
- Channelize block of ports—Channelize a block of ports. Specify a port range and channel speed.
- Configure speed per quad—Configure port speeds only per quad (group of 4 ports) and not individually. Specify the speed for the first port of the quad ports. All ports operate at a single speed within the quad.

For information about interface-level configuration, see Configure Speed at Interfaces Level.

Breakout capability is crucial for optimizing the use of available bandwidth and physical infrastructure in various networking scenarios. For a 1.6T transceiver, breakout capability allows a single high-speed 1.6 Tbps port to be split into multiple lower-speed ports. Juniper supports the following breakout speed or mode options for its 1.6 Tbps ports:

- 1x1.6T
- 2x800G

Breakout capability enables a network architect to configure a single port to support standardized 800 Gbps or 1.6 Tbps data, depending on the network requirement. For more information about the breakout configuration that you can use in your Juniper device, use Port Checker.

Serializer/Deserializer (SerDes)

A SerDes consists of an integrated circuit (IC or chip) transceiver. An IC can hold multiple SerDes. Each SerDes within an IC can have multiple lanes. Each of these lanes in a SerDes can handle input and output traffic. The two functional units or blocks within a SerDes are:

- Parallel in serial out (PISO) or the Serializer—Converts parallel data into serial data. The transmitter section of the transceiver functions as a parallel-to-serial converter that converts parallel data to serial data.

- Serial in parallel out (SIPO) or the Deserializer—Converts serial data into parallel data. The receiver section of the transceiver serves as a serial-to-parallel converter that converts the serial data back to parallel data.

SerDes devices support multiple operational modes between two points:

- Full-duplex operations—Allows data conversion to occur in both directions simultaneously.
- Simplex operations—Allows data conversion to occur only in one direction.
- Half-duplex—Allows data conversion to occur in both directions, but not simultaneously.

SerDes reduces the number of data paths and connecting pins or wires needed to transmit data. It counters the common issues associated with parallel power transmission such as increased power consumption, electromagnetic interference, and clock timing errors. Using SerDes, you can efficiently transmit the data signals from a port through its multiple breakout channels into the optical network and vice versa.

Breakout Cables

Breakout cables have a single transceiver at an end and multiple transceivers at the other end. You can use the breakout cables to channelize a port and increase the number of interfaces. To channelize the network ports on your Juniper device, connect the breakout cables and configure the recommended CLI commands. For more information, see Port Settings.

The inclusion of APC connectors help to minimize reflection loss and ensure high precision. To connect two transceivers of the same type, you can use the a variety of cables with the suitable connector. Breakout cables are use-specific. Depending on port channelization and the type of connectors, some of the breakout cables are:

- 12-Fiber Ribbon Patch Cables with MPO-12/APC Connectors.
- 12-Fiber Ribbon Breakout Cables with MPO-12/APC-to-LC Duplex Connectors.
- 12-Ribbon Patch and Breakout Cables Available from Juniper Networks.
- Patch cables with LC duplex connectors.

Table 6: 12-Ribbon Patch and Breakout Cables

Juniper Model Number	Cable Type	Connector Type	Fiber Type	Cable Length
MTP-4LC-S10M	12-ribbon breakout cable	MTP to 4xLC pairs	SMF	10 m

Table 6: 12-Ribbon Patch and Breakout Cables *(Continued)*

Juniper Model Number	Cable Type	Connector Type	Fiber Type	Cable Length
MTP-4LC-S1M	12-ribbon breakout cable	MTP to 4xLC pairs	SMF	1 m
MTP-4LC-S3M	12-ribbon breakout cable	MTP to 4xLC pairs	SMF	3 m
MTP-4LC-S5M	12-ribbon breakout cable	MTP to 4xLC pairs	SMF	5 m
MTP12-FF-S10M	12-ribbon patch cable	MTP 12 fiber	SMF	10 m
MTP12-FF-S1M	12-ribbon patch cable	MTP 12 fiber	SMF	1 m
MTP12-FF-S3M	12-ribbon patch cable	MTP 12 fiber	SMF	3 m
MTP12-FF-S5M	12-ribbon patch cable	MTP 12 fiber	SMF	5 m

NOTE: The terms MPO and multifiber termination push-on (MTP) describe the same connector type.

CHAPTER 3

Install or Remove 1.6T Optical Transceivers and Fiber-Optic Cables

IN THIS CHAPTER

- Install an OSFP Transceiver | **24**
- Remove an OSFP Transceiver | **26**
- Maintain Fiber-Optic Cables | **28**

Install an OSFP Transceiver

SUMMARY

Use the information in this topic to install OSFP optical transceivers and fiber-optic cables. Juniper Networks transceivers are hot-removable and hot-insertable field-replaceable units (FRUs). You can remove and replace them without powering off your device or disrupting device functions. To understand how to install or remove a transceiver and fiber-optic cables of your device, read the following sections.

Before you install a transceiver in a device, ensure that you have taken the necessary precautions for safe handling of lasers (see Laser and LED Safety Guidelines and Warnings).

NOTE: We recommend that you use only optical transceivers and optical connectors purchased from Juniper Networks with your Juniper Networks device.

CAUTION: The Juniper Networks Technical Assistance Center (JTAC) provides complete support for Juniper-supplied optical modules and cables. However, JTAC does not provide support for third-party optical modules and cables that are not qualified or supplied by Juniper Networks. If you face a problem running a Juniper device that uses third-party optical modules or cables, JTAC may help you diagnose host-related issues if the observed issue is not, in the opinion of JTAC, related to the use of the third-party optical modules or cables. Your JTAC engineer will likely request that you check the third-party optical module or cable and, if required, replace it with an equivalent Juniper-qualified component.

Use of third-party optical modules with high-power consumption (for example, coherent ZR or ZR+) can potentially cause thermal damage to or reduce the lifespan of the host equipment. Any damage to the host equipment due to the use of third-party optical modules or cables is the users' responsibility. Juniper Networks will accept no liability for any damage caused due to such use.

To install an OSFP transceiver:

1. Wrap and fasten one end of the ESD wrist strap around your bare wrist, and connect the other end of the strap to a site ESD point or to an ESD point on the device.
2. Remove the transceiver from its bag.

CAUTION: To avoid electrostatic discharge (ESD) damage to the transceiver, do not touch the connector pins at the end of the transceiver.

3. Check to see whether the transceiver is covered with a rubber safety cap. If it is not, cover the transceiver with a rubber safety cap.

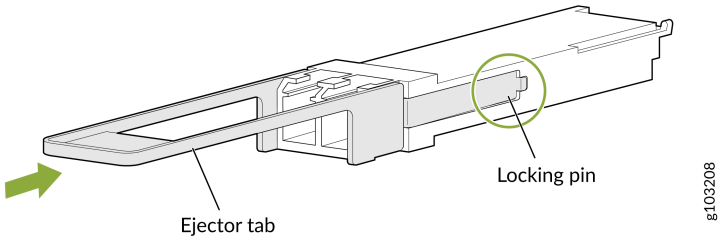
LASER WARNING: Do not leave a fiber-optic transceiver uncovered except when inserting or removing a cable. The rubber safety cap keeps the port clean and prevents accidental exposure to laser light.

4. If the port in which you want to install the transceiver is covered with a dust cover, remove the dust cover and save it in case you need to cover the port later. If you are hot-swapping a transceiver, wait for at least 10 seconds after removing the transceiver from the port before installing a new transceiver.

NOTE: Make sure to use a dust cap to cover ports that are unused.

5. Orient the transceiver over the port so that the transceiver connector faces the appropriate direction. Figure 9 on page 25 shows how to install an OSFP transceiver.

Figure 9: Install an OSFP Transceiver



6. Slide the transceiver into the slot until the locking pins lock in place.
7. Remove the rubber safety cap from the transceiver when you are ready to connect the cable to the transceiver.

LASER WARNING: Do not look directly into a fiber-optic transceiver or into the ends of fiber-optic cables. Fiber-optic transceivers and fiber-optic cables connected to transceivers emit laser light that can damage your eyes.

NOTE: After you insert a transceiver or after you change the media-type configuration, wait for 6 seconds for the interface to display operational commands.

Remove an OSFP Transceiver

SUMMARY

Use the information in this topic to remove OSFP optical transceivers and fiber-optic cables. Juniper Networks transceivers are hot-removable and hot-insertable field-replaceable units (FRUs). You can remove and replace them without powering off your device or disrupting device functions. To understand how to install or remove a transceiver and fiber-optic cables of your device, read the following sections.

Before you remove a transceiver from a device, take the necessary precautions for safe handling of lasers (see Laser and LED Safety Guidelines and Warnings).

CAUTION: The Juniper Networks Technical Assistance Center (JTAC) provides complete support for Juniper-supplied optical modules and cables. However, JTAC does not provide support for third-party optical modules and cables that are not qualified or supplied by Juniper Networks. If you face a problem running a Juniper device that uses third-party optical modules or cables, JTAC may help you diagnose host-related issues if the observed issue is not, in the opinion of JTAC, related to the use of the third-party optical modules or cables. Your JTAC engineer will likely request that you check the third-party optical module or cable and, if required, replace it with an equivalent Juniper-qualified component.

Use of third-party optical modules with high-power consumption (for example, coherent ZR or ZR+) can potentially cause thermal damage to or reduce the lifespan of the host equipment. Any damage to the host equipment due to the use of third-party optical modules or cables is the users' responsibility. Juniper Networks will accept no liability for any damage caused due to such use.

Ensure that you have the following parts and tools available:

- An antistatic bag or an antistatic mat

- Rubber safety caps to cover the transceiver and fiber-optic cable connector
- A dust cover to cover the port or a replacement transceiver

To remove an OSFP transceiver:

1. Place the antistatic bag or antistatic mat on a flat, stable surface.
2. Wrap and fasten one end of the ESD wrist strap around your bare wrist, and connect the other end of the strap to a site ESD point or to the ESD point on the device.
3. Label the cable connected to the transceiver so that you can reconnect it correctly.
4. Remove the cable connected to the transceiver (see "Disconnect a Fiber-Optic Cable" on page 29). Cover the transceiver and the end of the fiber-optic cable connector with a rubber safety cap immediately after disconnecting the fiber-optic cable.

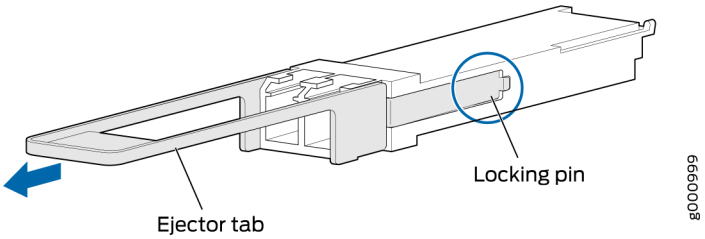
   LASER WARNING: Do not look directly into a fiber-optic transceiver or into the ends of fiber-optic cables. Fiber-optic transceivers and fiber-optic cables connected to transceivers emit laser light that can damage your eyes.

   LASER WARNING: Do not leave a fiber-optic transceiver uncovered except when inserting or removing a cable. The rubber safety cap keeps the port clean and protects your eyes from accidental exposure to laser light.

   CAUTION: Do not bend fiber-optic cables beyond their minimum bend radius. An arc smaller than a few inches in diameter can damage the cables and cause problems that are difficult to diagnose.

5. Pull the transceiver's ejector tab straight back. The locking pins on the transceiver release automatically. shows how to remove an OSFP transceiver.
6. Gently slide the transceiver straight out of the port and place the transceiver on the antistatic mat or in the electrostatic bag.

Figure 10: Remove a OSFP Transceiver



CAUTION: To avoid ESD damage to the transceiver, do not touch the connector pins at the end of the transceiver.

NOTE: After you remove a transceiver or after you change the media-type configuration, wait for 6 seconds for the interface to display operational commands.

7. Insert a dust cover in the empty port.

Maintain Fiber-Optic Cables

IN THIS SECTION

- Connect a Fiber-Optic Patch Cable | 28
- Disconnect a Fiber-Optic Patch Cable | 29
- How to Handle Fiber-Optic Patch Cables | 30

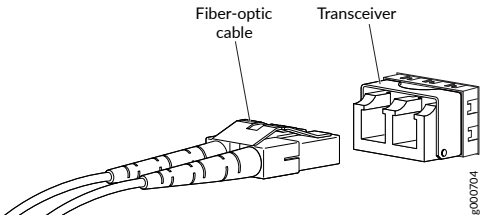
Connect a Fiber-Optic Patch Cable

Before you connect a fiber-optic patch cable to an optical transceiver installed in a device, take the necessary precautions for safe handling of lasers (see Laser and LED Safety Guidelines and Warnings).

To connect a fiber-optic patch cable to an optical transceiver installed in a device:

> **LASER WARNING**: Do not look directly into a fiber-optic transceiver or into the ends of fiber-optic patch cables. Fiber-optic transceivers and fiber-optic patch cables connected to transceivers emit laser light that can damage your eyes.

1. If the fiber-optic patch cable connector is covered with a rubber safety cap, remove the cap. Save the cap.
2. Remove the rubber safety cap from the optical transceiver. Save the cap.
3. Insert the cable connector into the optical transceiver.



4. Secure the cables so that they do not support their own weight. Place excess cable out of the way in a neatly coiled loop. Placing fasteners on a loop helps cables maintain their shape.

> **CAUTION**: Do not bend fiber-optic patch cables beyond their minimum bend radius. An arc smaller than a few inches in diameter can damage the cables and cause problems that are difficult to diagnose.
>
> Do not let fiber-optic patch cables hang free from the connector. Do not allow fastened loops of cables to dangle, which stresses the cables at the fastening point.

Disconnect a Fiber-Optic Patch Cable

Before you disconnect a fiber-optic patch cable from an optical transceiver, ensure that you have taken the necessary precautions for safe handling of lasers. See Laser and LED Safety Guidelines and Warnings.

Ensure that you have the following parts and tools available:

- A rubber safety cap to cover the transceiver
- A rubber safety cap to cover the fiber-optic patch cable connector

Juniper Networks devices have optical transceivers to which you can connect fiber-optic patch cables.

To disconnect a fiber-optic patch cable from an optical transceiver installed in the device:

1. Disable the port in which the transceiver is installed by issuing the following command:

```
[edit interfaces]
user@device# set interface-name disable
```



LASER WARNING: Do not look directly into a fiber-optic transceiver or into the ends of fiber-optic patch cables. Fiber-optic transceivers and fiber-optic patch cables connected to transceivers emit laser light that can damage your eyes.

2. Carefully unplug the fiber-optic patch cable connector from the transceiver.
3. Cover the transceiver with a rubber safety cap.



LASER WARNING: Do not leave a fiber-optic transceiver uncovered except when inserting or removing a cable. The rubber safety cap keeps the port clean and protects your eyes from accidental exposure to laser light.

4. Cover the fiber-optic patch cable connector with the rubber safety cap.

How to Handle Fiber-Optic Patch Cables

Fiber-optic patch cables connect to optical transceivers that are installed in Juniper Networks devices.

Follow these guidelines when handling fiber-optic patch cables:

- When you unplug a fiber-optic patch cable from a transceiver, place rubber safety caps over the transceiver and on the end of the cable.
- Anchor fiber-optic patch cables to prevent stress on the connectors. When attaching a fiber-optic patch cable to a transceiver, secure the fiber-optic patch cable so that it does not support its own weight as it hangs to the floor. Never let a fiber-optic patch cable hang free from the connector.
- Avoid bending the fiber-optic patch cables beyond their minimum bend radius. Bending fiber-optic patch cables into arcs smaller than a few inches in diameter can damage the cables and cause problems that are difficult to diagnose.
- Frequent plugging and unplugging of fiber-optic patch cables in and out of optical instruments can damage the instruments, which are expensive to repair. To prevent damage from overuse, attach a short fiber extension to the optical equipment. The short fiber extension absorbs wear and tear due

to frequent plugging and unplugging. It is easier and more cost-efficient to replace the short fiber extension than to replace the instruments.

- Keep fiber-optic patch cable connections clean. Microdeposits of oil and dust in the canal of the transceiver or cable connector can cause loss of light, reduction in signal power, and possibly intermittent problems with the optical connection.
    - To clean the transceiver canal, use an appropriate fiber-cleaning device such as RIFOCS Fiber Optic Adaptor Cleaning Wands (part number 946). Follow the instructions in the cleaning kit you use.
    - After cleaning the transceiver, make sure that the connector tip of the fiber-optic patch cable is clean. Use only an approved alcohol-free fiber-optic cable cleaning kit such as the Opptex Cletop-S® Fiber Cleaner. Follow the instructions in the cleaning kit you use.

CHAPTER 4

1.6T Optical Transceivers FAQs

IN THIS CHAPTER

- Frequently Asked Questions | 33

Frequently Asked Questions

IN THIS SECTION

- Why should I use 1.6T optics? | **33**
- Which 1.6T optics does Juniper offer? | **34**
- Which 1.6T optics are supported on my device? | **34**
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- What is the lane distribution on 1.6T optics? | **35**
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- What are the components of an 1.6T optic architecture? | **35**
- What are breakout capability and breakout cables? | **36**
- How is breakout/channelization supported on my device? | **36**
- What are single-mode and multi-mode fibers? | **36**
- What are the different types of cables used in 1.6T optics? | **37**
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- What is the difference between OSFP and OSFP-RHS optics? | **37**
- Can I plug OSFP modules into QSFP-DD ports or vice versa? | **37**
- Can I plug 800G modules into 1.6T ports? | **37**
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- Can there be an OSFP connector on one end of an 1.6T link and a QSFP-DD connector on the other? | **37**

Why should I use 1.6T optics?

- Increased capacity—1.6T optics offer twice the capacity of 800G optics, allowing for faster data transmission.

- Higher port density—One 1.6T optic can replace two 800G optics, providing a higher port density and easier aggregation of 800G optics.
- Compatibility and scalability—1.6T optics are compatible with both upcoming network devices and can support constantly evolving deployment scenarios. Their backward compatibility with older device allows for a phased transition.
- Data center scenario—The high transmission speeds and network capabilities make 1.6T optics ideal for large-scale data centers.

Which 1.6T optics does Juniper offer?

See Hardware Compatibility Tool for a list of all the 1.6T optics offered by Juniper, along with their detailed specifications.

Which 1.6T optics are supported on my device?

See Hardware Compatibility Tool for a list of the supported optics for your device.

Can I use a third-party optic with my device?

We recommend that you use only optical transceivers and optical connectors purchased from Juniper Networks with your Juniper Networks device.



CAUTION: The Juniper Networks Technical Assistance Center (JTAC) provides complete support for Juniper-supplied optical modules and cables. However, JTAC does not provide support for third-party optical modules and cables that are not qualified or supplied by Juniper Networks. If you face a problem running a Juniper device that uses third-party optical modules or cables, JTAC may help you diagnose host-related issues if the observed issue is not, in the opinion of JTAC, related to the use of the third-party optical modules or cables. Your JTAC engineer will likely request that you check the third-party optical module or cable and, if required, replace it with an equivalent Juniper-qualified component.

Use of third-party optical modules with high-power consumption (for example, coherent ZR or ZR+) can potentially cause thermal damage to or reduce the lifespan of the host equipment. Any damage to the host equipment due to the use of third-party optical modules or cables is the users' responsibility. Juniper Networks will accept no liability for any damage caused due to such use.

What are the form factors supported on 1.6T optics?

Juniper supports OSFP1600 transceivers, in both Integrated Heat Sink (OSFP) and Riding Heat Sink (OSFP-RHS) variants.

Juniper does not currently support the QSFP-DD1600 form factor.

What are the speeds supported on an 1.6T optic?

1.6T optics can support a range of speeds, depending upon their type. They can support:

- A single port of 1.6 Tbps
- Two ports of 800 Gbps

What does the name of the optic mean?

Optics follow a naming convention where the product name contains the form factor, data rates, and lane distribution of the optic. See "Juniper Optical Product Numbers" on page 5 for a detailed example.

What is the lane distribution on 1.6T optics?

1.6T optics use 8 parallel lanes, each of which support 200 Gbps. Multiplexing occurs over multiple fiber pairs, or using a combination of fiber and wavelength multiplexing.

What are the modulation techniques supported on 1.6T optics?

1.6T optics use Pulse Amplitude Modulation 4-level (PAM4). PAM4 combines two bits into a single symbol with four amplitude levels, enabling you to transmit twice as much data. It has a high signal-to-noise ratio which requires shorter transmission distances. It requires Forward Error Correction (FEC) to handle the loss of signal integrity. You must configure FEC at both ends of the 1.6T link.

What is Clock Data Recovery (CDR)?

Clock Data Recovery is the process of extracting timing information from a data signal. The receiver uses the embedded timing information to re-time the signal and ensure accurate data retrieval and transmission. CDR helps to reduce jitter and improve signal integrity and reach.

What are the components of an 1.6T optic architecture?

1.6T (x8) optics are composed of the following:

- 1.6T Host Platform

- 8x200G Electrical Interface
- PAM4 Digital Signal Processor/Clock Data Recovery (DSP/CDR)
- Drivers (8)
- Modulators (8)
- 8x200G Optical Interfaces
- Transimpedance Amplifiers (TIA) (8)
- Photo-Detectors (8)

See "1.6T (X8) Transceiver Architecture" on page 5 for a detailed explanation of each component.

What are breakout capability and breakout cables?

Breakout capability is the ability to split a high-speed optical link into multiple smaller, lower-speed links. This is also called channelization. Breakout capability is crucial for optimizing the use of available bandwidth and physical infrastructure in various networking scenarios.

You can configure port speeds at the chassis level or the interface level. You can channelize an individual port, a block of ports, or a quad of ports.

Breakout cables have a single transceiver at one end and multiple transceivers at the other end. You can use breakout cables to physically split a single high-speed port to multiple lower-speed ports.

For more details, see "Breakout Capability" on page 19.

How is breakout/channelization supported on my device?

See Port Checker for details on channelization support for your device.

What are single-mode and multi-mode fibers?

Single-mode fibers (SMF) are designed to trasmit only one mode of an optical signal at a time. They have a core diameter of 9 microns. They have low attenuation and can support higher data rates and longer transmission distances.

Multi-mode fibers (MMF) can transmit multiple optical signals at the same time. They have a core diameter between 50 to 62.5 microns. They are easier to handle and manufacture as compared to SMF. They have higher attenuation and are used to transmit data over shorter distances.

What are the different types of cables used in 1.6T optics?

1.6T optics use direct attach cables (DAC) and active optical cables (AOC). See "Cable Types and Length" on page 16 for details.

For a list of AOC and DAC cables supported by Juniper, see Hardware Compatibility Tool.

What are the different types of connectors used in 1.6T optics?

1.6T optical cables use MPO-12/APC, dual MPO-12/APC, and dual duplex LC/UPC connectors. See "Connector Types" on page 14 for more details.

What is the power requirement for 1.6T optics?

OSFP and ORHS optics require 16 W to 28 W of power.

What is the difference between OSFP and OSFP-RHS optics?

OSFP-RHS is an OSFP module with a riding heat sink (RHS) instead of an integrated heat sink.

Can I plug OSFP modules into QSFP-DD ports or vice versa?

No. OSFP and QSFP-DD refer to optics with different form factors. An OSFP port supports only OSFP optics and a QSFP-DD port supports only QSFP-DD optics.

Can I plug 800G modules into 1.6T ports?

Yes, if the physical form factors are compatible.

Can I plug 1.6T modules into 800G ports?

We do not recommend plugging an 1.6T module into a 800G port. 800G optical ports cannot support the 200G per lane speeds that 1.6T ports can support.

Can there be an OSFP connector on one end of an 1.6T link and a QSFP-DD connector on the other?

Yes. OSFP and QSFP-DD connectors can interoperate with each other on the same link, provided the Ethernet media type is the same.