Configuring 400G Digital Coherent Optics

Feature Name	Release Information	Description
Support for DP04QSDD-HE0 Optical Module	Release 7.9.1	This release introduces support for the Cisco 400G QSFP-DD High-Power (Bright) Optical Module, Ethernet Variant. The Cisco 400G QSFP-DD High-Power (Bright) Optical module is an enhanced version of the currently available QSFP-DD ZR+ Optical Module, leveraging the same operational modes but providing as a major enhancement the increase of the Tx Optical Power up to +1dBm. DP04QSDD-HE0 optical module is supported in the following hardware: • A9K-20HG-FLEX-SE/TR/FC • A9K-8HG-FLEX-SE/TR/FC
Support for 3x100G Muxponder Mode on A99-10X400GE-X-SE/A99-10X400GE-X-TR Line Cards	Release 7.9.1	QDD-400G-ZRP-S optical module operating in A99-10X400GE-X-SE/A99-10X400GE-X-TR line cards now supports 3x100G muxponder mode.
oFEC Traffic Configuration for QDD-400G-ZRP-S	Release 7.9.1	QDD-400G-ZRP-S optical module can now support the following oFEC traffic configurations: • 400G-TXP-1x1 DAC-16 QAM • 3x100G-MXP-1x1 DAC-8 QAM This increases the interoperability of the QDD-400G-ZRP-S optical module across network components supporting these formats.

Feature Name	Release Information	Description
Support for 8 and 16 Quadrature Amplitude Modulation (QAM) Formats on QDD-400G-ZRP-S Optical Modules	Release 7.8.1	QDD-400G-ZRP-S optical module operating in 200G interfaces now supports the 8 QAM and 16 QAM modulation formats. This increases the interoperability of the optical module across network components supporting these formats.

Cisco offers a range of the new 400G Digital Coherent QSFP-DD optical modules. The two optical modules that are available are:

- QDD-400G-ZR-S
- QDD-400G-ZRP-S
- DP04QSDD-HE0

For more information about the optic module portfolio, see the Cisco 400G Digital Coherent Optics QSFP-DD Optical Modules Data Sheet.

This chapter describes the 400G Digital Coherent QSFP-DD optical modules and their supported configurations.

The following table shows the line cards, ports, and modes that support these two optical modules.

Table 1: Supported Line Cards, Ports, and Modes

Components	Default Port Speed	Supported Front Panel Ports	1x400G Transponder Mode	4x100G Muxponder Mode	3x100G Muxponder Mode	2x100G Muxponder Mode	1x100G Transponder Mode
[illegible]	1x100G	0, 7, 8, 12, 19	Yes	Yes	Yes	Yes	Yes
[illegible]	1x100G	0, 7	Yes	Yes	Yes	Yes	Yes
[illegible]	1x400G	3, 5, 6, 7, 9	Yes	Yes	Yes	Yes	Yes
A9903-20HG-PEC	1x100G	0, 4, 8, 12, 16	Yes	Yes	Yes	Yes	Yes
ASR-9902	1x100G	11, 37	No	No	No	No	Yes

The 400G Digital Coherent QSFP-DD optical modules enable wavelength-division multiplexing (WDM) functionality in the router. These optical modules are DWDM C-band (196.1 THz to 191.3 THz) tunable optical modules. They can be used in both transponder and muxponder modes.

Cisco IOS XR software creates optics and coherent DSP controllers to configure and monitor the performance of the 400G Digital Coherent QSFP-DD optical modules. Optics controllers are used to configure and monitor optical parameters, such as frequency, chromatic dispersion, transmitted output power, and so on. Coherent DSP controllers are used to monitor network performance parameters like pre- and post-forward error correction (FEC) bit-error rate (pre-FEC BER, post-FEC BER), error corrected bits (EC-BITS), and so on. Forward error correction (FEC) is configured using optical controllers and monitored using coherent DSP controllers.

The 400G Digital Coherent QSFP-DD optical modules support traffic1 configuration and firmware download. The Cisco IOS XR software collects performance monitoring data and alarms.

Due to more power consumption by the 400G Digital Coherent QSFP-DD optical modules, the Cisco IOS XR software operates the fans at an higher speed to cool these optical modules.

Configuring frequency, chromatic dispersion, optical transmit power, digital to analog conversion (DAC) sampling rate, and FEC parameters impacts traffic. Also, configuring modulation is supported. Modulation is dependent on the mode of operation. See Table 3: QDD-400G-ZR-S Transponder and Muxponder Configuration Values, on page 4 and #unique_473 unique_473_Connect_42_table_u5x_f13_ppb, on page 5.

The 400G Digital Coherent QSFP-DD optical module configuration is divided into the following categories:

- Traffic configuration – Comprises configuring DAC rate, breakout, and FEC parameters. Applicable for optics controllers:
  - Configuring DAC Rate, on page 6
  - Configuring Breakout, on page 8
  - Configuring FEC, on page 11
- Optical configuration – Comprises configuring frequency, chromatic dispersion, and optical transmit power. Applicable for optics controllers:
  - Configuring Frequency, on page 12
  - Configuring Chromatic Dispersion, on page 14
  - Configuring Optical Transmit Power, on page 16
- Performance monitoring (PM) – Enables or disables performance monitoring in optical modules. You can also configure PM parameters that comprise signal power, chromatic dispersion, optical signal-to-noise ratio (OSNR), and differential group delay (DGD). Applicable for optics controllers and coherent DSP controllers:
  - Configuring Performance Monitoring, on page 18
  - Configuring PM Parameters, on page 18
- Loopback configuration – Configures loopback. Applicable for coherent DSP controller:
  - Configuring Loopback, on page 21
- Alarms threshold configuration – Configures thresholds for monitoring alarms that include optical signal-to-noise ratio (OSNR), differential group delay (DGD), chromatic dispersion (cd high and low), and so on. Applicable for optics controllers:
  - Configuring Alarms Threshold, on page 22

The following table contains the possible traffic configuration values for the 400G Digital Coherent QSFP-DD optical modules, in the transponder and muxponder mode:

QDD-400G-ZR-S and QDD-400G-ZRP-S FPD Upgrade

Table 2: Feature History Table

Feature Name	Release Information	Feature Description
FPD Upgrades Enabled for QDD-400G-ZR-S and QDD-400G-ZRP-S Optical Modules	Release 7.3.2	This feature allows you to perform Field Programmable Device (FPD) upgrades on the QDD-400G-ZR-S and QDD-400G-ZRP-S optical modules to ensure they have the latest fixes and features. For more information about the optic module portfolio, see the Cisco 400G Digital Coherent Optics QSFP-DD Optical Modules Data Sheet.

Although an FPD upgrade is not mandatory in this release, we recommend upgrading the FPD to the latest version in the subsequent releases to ensure that all the latest fixes and features are enabled on the optical modules. Auto and parallel FPD upgrades are not supported. Only a manual FPD upgrade (one optical module at a time) using the **upgrade hw-module location** *node-id* **fpd** *fpd-name* command is supported.

The *fpd-name* can be obtained from the FPD description column of the **show fpd package** or the **show hw-module fpd** command. The *fpd-name* in the FPD description column displays QDD_*instance_port-number*. For example, depending on the instance and the port number, the FPD names for the QDD-400G-ZR-S and QDD-400G-ZRP-S modules will be QDD_0_3, QDD_0_0, and so on.

Note Only in case of Cisco ASR 9903 routers, the *fpd-name* in the FPD description column displays QDD_*bay_port-number*. The *bay* value for Cisco 9903 routers is always 1. Therefore, depending on the port number, the FPD names for the QDD-400G-ZR-S and QDD-400G-ZRP-S modules will be QDD_1_3, QDD_1_4, and so on.

See the "**Upgrading Field-Programmable Devices**" chapter in the *System Management Configuration Guide for Cisco ASR 9000 Series Routers* for details on the procedure to upgrade the FPD.

QDD-400G-ZR-S Transponder and Muxponder Configuration Values

The following table contains the possible Transponder and Muxponder configuration values for the QDD-400G-ZR-S optical module:

Table 3: QDD-400G-ZR-S Transponder and Muxponder Configuration Values

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 client, 400G speed	1 trunk, 400G	16 QAM	cFEC	1x1
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G	16 QAM	cFEC	1x1

QDD-400G-ZRP-S Transponder and Muxponder Configuration Values

The following table contains the possible Transponder and Muxponder configuration values for the QDD-400G-ZRP-S optical module:

Table 4: QDD-400G-ZRP-S Transponder and Muxponder Configuration Values

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.25
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	QPSK	oFEC	1x1.50
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	8 QAM	oFEC	1x1.25
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	16 QAM	oFEC	1x1.25
1x100G-MXP	1 client, 100G speed	1 trunk, 100G speed	QPSK	oFEC	1x1.50

DP04QSDD-HE0 Transponder and Muxponder Configuration Values

The following table contains the possible Transponder and Muxponder configuration values for the DP04QSDD-HE0 optical module:

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1.5

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.5
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1.5
4x100G-MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.5
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.25
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.5
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	QPSK	oFEC	1x1.5
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	8 QAM	oFEC	1x1.25
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	16 QAM	oFEC	1x1.25
1x100G-MXP	1 client, 100G speed	1 trunk, 100G speed	QPSK	oFEC	1x1.5

- Configuring DAC Rate, on page 6
- Configuring Breakout, on page 8
- Configuring FEC, on page 11
- Configuring Frequency, on page 12
- Configuring Chromatic Dispersion, on page 14
- Configuring Optical Transmit Power, on page 16
- Configuring Performance Monitoring, on page 18
- Configuring PM Parameters, on page 18
- Configuring Loopback, on page 21
- Configuring Alarms Threshold, on page 22

Configuring DAC Rate

You can set the DAC (digital to analog conversion) sampling rate on optics controllers. You can modify the DAC sampling rate only on the QDD-400G-ZRP-S optical module.

Note QDD-400G-ZR-S supports 1x1 dac-rate in cFEC mode. QDD-400G-ZRP-S supports 1x1 dac-rate in cFEC mode and 1x1.25 dac-rate in oFEC mode.

DAC Rate Configuration Example

The following example shows how to set the DAC rate on the optics controller:

```
Router#config
Router(config)#controller optics 0/19/0/3
Router(config-Optics)#dac-rate 1x1.25
```

Verification

This example shows the running configuration:

```
Router#show run controller optics 0/19/0/3
Thu May 13 12:52:35.020 UTC
controller Optics0/19/0/3
 DAC-Rate 1x1.25
!
!
```

Verification

This example shows how to verify the configured DAC rate for the optics controller:

```
Router#show controller optics 0/19/0/3
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 LED State: Green
 FEC State: FEC OFEC
 Optics Status
         Optics Type:  400G QSFP-DD ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm

         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Laser Bias Current = 70.9 mA
         Actual TX Power = -7.06 dBm
         RX Power = -7.88 dBm
         RX Signal Power = -7.88 dBm
         Frequency Offset = -220 MHz
         Laser Temperature = 53.79 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25

         Performance Monitoring: Enable
         THRESHOLD VALUES
         ----------------
         Parameter                High Alarm  Low Alarm  High Warning  Low Warning
         -----------------------  ----------  ---------  ------------  -----------
         Rx Power Threshold(dBm)         1.9      -28.2           0.0        -25.0
         Tx Power Threshold(dBm)         0.0      -18.0          -2.0        -16.0
         LBC Threshold(mA)              0.00       0.00          0.00         0.00
         Temp. Threshold(celsius)      80.00      -5.00         75.00        15.00
         Voltage Threshold(volt)        3.46       3.13          3.43         3.16

         LBC High Threshold = 98 %
```

```
        Configured Tx Power = -7.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 180.00 ps
        Baud Rate =  30.0692729950 GBd
        Modulation Type: QPSK
        Chromatic Dispersion -2 ps/nm
        Configured CD-MIN -4000 ps/nm  CD-MAX 4000 ps/nm
        Second Order Polarization Mode Dispersion = 109.00 ps^2
        Optical Signal to Noise Ratio = 32.30 dB
        Polarization Dependent Loss = 0.05 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps

        Temperature = 48.00 Celsius
        Voltage = 3.30 V

Transceiver Vendor Details

        Form Factor             : QSFP-DD
        Optics type             : QSFP-DD 400G-ZRP-S
        Name                    : CISCO-ACACIA
        OUI Number              : 7c.b2.5c
        Part Number             : DP04QSDD-E30-19E
        Rev Number              : 01
        Serial Number           : ACA2503003X
        PID                     : QDD-400G-ZRP-S
        VID                     : ES03
        Firmware Version        : 61.20 (Build : 13)
        Date Code(yy/mm/dd)     : 21/01/22
```

Configuring Breakout

Feature Name	Release Information	Description
Support for 2x100G, 3x100G and 4x100G Breakout Configurations	Release 7.8.1	This release introduces 2x100G, 3x100G and 4x100G breakout configurations on the following line cards: • A9903-20HG-PEC (2x100G, 3x100G, and 4x100G) • A99-10X400GE-X-SE/TR (3x100G) • A9K-20HG-FLEX-SE/TR (2x100G, 3x100G, and 4x100G) • A9K-8HG-FLEX-SE/TR (2x100G, 3x100G, and 4x100G)

Using the **hw-module location** *node-id* port *port-number* **breakout** *muxponder-mode* command, you can configure breakout on the ports.

For configuring breakout on Cisco ASR 9903 router, use the following command:

hw-module location *node-id* **bay** *bay-number* **port** *port-number* **breakout** *muxponder-mode*

The value for *bay-number* is always 1.

For the supported line cards, ports, and modes, see Table 1: Supported Line Cards, Ports, and Modes, on page 2.

Configuring Breakout on the Line card with Default 100G Port Speed

The ports with default 100G speed can be configured to operate at 400G port speed using the following command:

This example shows how to configure 1x400G transponder mode on a port with default 100G port speed:

- **hw-module location 0/0/CPU0 port 0 breakout 1xFourHundredGigE**

To remove the breakout configuration and revert to the default 100G port speed, use the **no** form of the command.

For example:

- **no hw-module location 0/0/CPU0 port 0 breakout 1xFourHundredGigE**

Note In the A9903-20HG-PEC card, to configure 1x400G transponder mode, use the **hw-module location 0/0/CPU0 bay 1 port 0 breakout 1xFourHundredGigE** command. To remove the breakout configuration and revert to the default 100G port speed, use the **no** for the command - **no hw-module location 0/0/CPU0 bay 1 port 0 breakout 1xFourHundredGigE**.

To configure 4x100G or 2x100G muxponder mode, use the 4x100G or 2x100G breakout on the supported port(s).

For example:

- **hw-module location 0/0/CPU0 port 0 breakout 4xHundredGigE**
- **hw-module location 0/0/CPU0 port 7 breakout 2xHundredGigE**
- **hw-module location 0/0/CPU0 port 7 breakout 3xHundredGigE**

To remove the breakout configuration and revert to the default 100G port speed, use the **no** form of the command.

For example:

- **no hw-module location 0/0/CPU0 port 0 breakout 4xHundredGigE**
- **no hw-module location 0/0/CPU0 port 7 breakout 2xHundredGigE**
- **no hw-module location 0/0/CPU0 port 7 breakout 3xHundredGigE**

Configuring Breakout on the Line card with Default 400G Port Speed

The ports with default 400G speed can be configured to operate at 100G port speed using the following command:

This example shows how to configure 1x100G transponder mode on a port with default 400G port speed:

For example:

- **hw-module location 0/0/CPU0 port 0 breakout 1xHundredGigE**

To remove the breakout configuration and revert to the default 400G port speed, use the **no** form of the command.

For example:

- **no hw-module location 0/0/CPU0 port 0 breakout 1xHundredGigE**

To configure 4x100G or 2x100G or 3x100G muxponder mode, use the 4x100G or 2x100G or 3x100G breakout on the supported port(s).

For example:

- **hw-module location 0/0/CPU0 port 0 breakout 4xHundredGigE**
- **hw-module location 0/0/CPU0 port 7 breakout 2xHundredGigE**
- **hw-module location 0/0/CPU0 port 7 breakout 3xHundredGigE**

To remove the breakout configuration and revert to the default 400G port speed, use the **no** form of the command.

For example:

- **no hw-module location 0/0/CPU0 port 0 breakout 4xHundredGigE**
- **no hw-module location 0/0/CPU0 port 7 breakout 2xHundredGigE**
- **no hw-module location 0/0/CPU0 port 7 breakout 3xHundredGigE**

Muxponder Mode Configuration Example

The following example shows how to configure muxponder mode on the optics controller:

```
Router#config
Router(config)#hw-module location 0/0/CPU0 port 3 breakout 4xHundredGigE
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Note In the above example, the Cisco IOS XR software creates four Ethernet clients with 100GE speed, which can be verified using the **show ipv4 interface brief location | include** *R/S/I/P* command.

Running Configuration

This example shows the running configuration for the optics controller:

```
Router#show running-config | inc break
Building configuration...
hw-module location 0/1/CPU0 port 1 breakout 1xHundredGigE
hw-module location 0/1/CPU0 port 3 breakout 4xHundredGigE
hw-module location 0/1/CPU0 port 8 breakout 1xHundredGigE
 !
```

Verification

This example shows how to verify the muxponder mode configuration:

```
Router#show ipv4 interface brief location 0/1/CPU0 | inc 0/1/0/3
HundredGigE0/1/0/3/0 unassigned Shutdown Down default
HundredGigE0/1/0/3/1 unassigned Shutdown Down default
```

```
HundredGigE0/1/0/3/2 unassigned Shutdown Down default
HundredGigE0/1/0/3/3 unassigned Shutdown Down default
```

Configuring FEC

You can configure forward error correction (FEC) only on optics controllers. You can modify FEC only on the QDD-400G-ZRP-S optical module. FEC is a feature that is used for controlling errors during data transmission. This feature works by adding data redundancy to the transmitted message using an algorithm. This redundancy allows the receiver to detect and correct a limited number of errors occurring anywhere in the message, instead of having to ask the transmitter to resend the message.

Note QDD-400G-ZR-S supports cFEC (concatenated forward error correction) and QDD-400G-ZRP-S supports cFEC and oFEC (open forward error correction).

FEC Configuration Example

The following sample shows how to configure FEC on the optics controller:

```
Router#configure
Router(config)#controller optics 0/19/0/5
Router(config-Optics)#fec CFEC
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration:

```
Router#show run controllers optics 0/19/0/5
controller 0/19/0/5
 fec CFEC
!
```

Verification

This example shows how to verify the FEC configuration for the optics controller:

```
Router#show controller coherentdsp 0/19/0/5

Port                                          : CoherentDSP 0/19/0/5
Controller State                              : Up
Inherited Secondary State                     : Normal
Configured Secondary State                    : Normal
Derived State                                 : In Service
Loopback mode                                 : None
BER Thresholds                                : SF = 1.0E-5  SD = 1.0E-7
Performance Monitoring                        : Enable
Bandwidth                                     : 400.0Gb/s

Alarm Information:
LOS = 0 LOF = 0 LOM = 0
OOF = 0 OOM = 0 AIS = 0
IAE = 0 BIAE = 0        SF_BER = 0
SD_BER = 0      BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0     FLEXO_GIDM = 0
FLEXO-MM = 0    FLEXO-LOM = 0   FLEXO-RDI = 0
FLEXO-LOF = 1
```

```
Detected Alarms                                  : None

Bit Error Rate Information
PREFEC  BER                                      : 4.5E-04
POSTFEC BER                                      : 0.0E+00
Q-Factor                                         : 10.40 dB
Q-Margin                                         : 3.20dB
OTU TTI Received

FEC mode                                         : C_FEC
```

Configuring Frequency

You can configure frequency on optics controllers. You can select any C band frequency between the range 196.1 to 191.3 THz, in both ITU and NON-ITU channels.

Note The 100MHz-grid keyword accepts only frequency values as user input. The 50GHz-grid keyword accepts frequency, ITU-channel, or wavelength values as user input. The Cisco IOS XR software then caculates the frequency for a given wavelength or ITU-channel.

Frequency Configuration Example

The following example shows how to configure frequency on the optics controller:

```
Router#config
Router(config)#controller optics 0/1/0/9
Router(config-Optics)#dwdm-carrier 100MHz-grid frequency 1921500
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration:

```
Router#show run controller optics 0/1/0/9
controller Optics0/1/0/9
 dwdm-carrier 100MHz-grid frequency 1921500
 cd-low-threshold -5000
 cd-high-threshold -5000
!
```

Verification

This example shows how to verify the frequency configuration:

```
Router#show controllers optics 0/1/0/9
Controller State: Up
Transport Admin State: In Service
Laser State: On
LED State: Green
FEC State: FEC OFEC
Optics Status

    Optics Type: 400G QSFP-DD ZRP
    DWDM carrier Info: C BAND, MSA ITU Channel=80, Frequency=192.15THz,
    Wavelength=1560.200nm

    Alarm Status:
```

```
     -------------
     Detected Alarms: None
     LOS/LOL/Fault Status:

     Laser Bias Current = 52.5 mA
     Actual TX Power = -11.03 dBm
     RX Power = -12.15 dBm
     RX Signal Power = -12.15 dBm
     Frequency Offset = -140 MHz
     Laser Temperature = 52.45 Celsius
     Laser Age = 0 %
     DAC Rate = 1x1.25
     Performance Monitoring: Enable

     THRESHOLD VALUES
     ----------------
          Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
          ------------------------  ----------  ---------  ------------  -----------
          Rx Power Threshold(dBm)          1.9      -23.0           0.0        -20.0
          Tx Power Threshold(dBm)          0.0      -18.0          -2.0        -16.0
          LBC Threshold(mA)               0.00       0.00          0.00         0.00
          Temp. Threshold(celsius)       80.00      -5.00         75.00        15.00
          Voltage Threshold(volt)         3.46       3.13          3.43         3.16

     LBC High Threshold = 98 %
     Configured Tx Power = -7.00 dBm
     Configured CD High Threshold = 5000 ps/nm
     Configured CD lower Threshold = -5000 ps/nm
     Configured OSNR lower Threshold = 9.00 dB
     Configured DGD Higher Threshold = 180.00 ps
     Baud Rate = 60.1385459900 GBd
     Modulation Type: 16QAM
     Chromatic Dispersion 0 ps/nm
     Configured CD-MIN -26000 ps/nm CD-MAX 26000 ps/nm
     Second Order Polarization Mode Dispersion = 36.00 ps^2
     Optical Signal to Noise Ratio = 35.80 dB
     Polarization Dependent Loss = 0.08 dB
     Polarization Change Rate = 0.00 rad/s
     Differential Group Delay = 1.00 ps

     Temperature = 54.00 Celsius
     Voltage = 3.29 V

Transceiver Vendor Details

     Form Factor : QSFP-DD
     Optics type : QSFP-DD 400G-ZRP-S
     Name : CISCO-ACACIA
     OUI Number : 7c.b2.5c
     Part Number : DP04QSDD-E30-19D
     Rev Number : B0
     Serial Number : ACA2440001M
     PID : QDD-400G-ZRP-S
     VID : VES1
     Firmware Version : 61.20 (Build : 13)
     Date Code(yy/mm/dd) : 20/10/02
```

Configuring Chromatic Dispersion

You can configure chromatic dispersion on optics controllers. When you configure the maximum and minimum values for chromatic dispersion for any data rate, ensure that the minimum difference between the configured values is equal to or greater than 1000 ps/nm.

The following table lists the default CD search range:

Table 5: Default CD Search Range

Muxponder Rate	FEC Value	Default CD Search Range (Min-Max)
400	OFEC	-26000 to +26000
400	CFEC	-2400 to +2400
300	OFEC	-50000 to +50000
200	OFEC	-50000 to +50000
100	OFEC	-80000 to +80000

Chromatic Dispersion Configuration Example

This example shows how to configure chromatic dispersion on the optics controller:

```
Router#configure
Router(config)#controller optics 0/19/0/5
Router(config-Optics)#cd-max 2500
Router(config-Optics)#cd-min -2500
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the optics controller:

```
Router#show run controller optics 0/19/0/5
controller Optics0/19/0/5
 cd-min -2500
 cd-max 2500
 !
```

Verification

This example shows how to verify the configured chromatic dispersion values for the optics controller:

```
Router#show controller optics 0/19/0/5
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 LED State: Red
 FEC State: FEC CFEC
 Optics Status

         Optics Type:  400G QSFP-DD ZR
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm
```

```
        Alarm Status:
        -------------
        Detected Alarms: None
        LOS/LOL/Fault Status:
        Laser Bias Current = 52.5 mA
        Actual TX Power = 2.02 dBm
        RX Power = 0.91 dBm
        RX Signal Power = -7.44 dBm
        Frequency Offset = -65 MHz
        Laser Temperature = 54.54 Celsius
        Laser Age = 0 %
        DAC Rate = 1x1
        Performance Monitoring: Enable

        THRESHOLD VALUES
        ----------------
        Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
        ------------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)          1.9      -23.0           0.0        -20.0
        Tx Power Threshold(dBm)          0.0      -18.0          -2.0        -16.0
        LBC Threshold(mA)               0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)       80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)         3.46       3.13          3.43         3.16

        LBC High Threshold = 98 %
        Configured Tx Power = -7.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 180.00 ps
        Baud Rate =  59.8437500000 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 1 ps/nm
        Configured CD-MIN -2500 ps/nm  CD-MAX 2500 ps/nm
        Second Order Polarization Mode Dispersion = 39.00 ps^2
        Optical Signal to Noise Ratio = 36.40 dB
        Polarization Dependent Loss = 0.07 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 5.00 ps

        Temperature = 51.94 Celsius
        Voltage = 3.31 V

Transceiver Vendor Details

        Form Factor             : QSFP-DD
        Optics type             : QSFP-DD 400G-ZR-S
        Name                    : CISCO-ACACIA
        OUI Number              : 7c.b2.5c
        Part Number             : DP04QSDD-E20-190
        Rev Number              : A
        Serial Number           : ACA25220027
        PID                     : QDD-400G-ZR-S
        VID                     : V01
        Firmware Version        : 61.20 (Build : 13)
        Date Code(yy/mm/dd)     : 21/06/01
```

Configuring Optical Transmit Power

You can set the transmit power of the optical signal.

Each QDD-400G-ZR-S and QDD-400G-ZRP-S optical module has its own optical transmit (TX) power range. User can change the optical transmit (TX) power value based on the module capability. For "Transmitter specifications", see the *Cisco 400G Digital Coherent Optics QSFP-DD Optical Modules Data Sheet*.

Table 6: Optical Transmit Power Values

Optical Module	Trunk Speed	Optical Transmit Power (Tx) Shaping	Interval	Supported Range of Optical Transmit Power (Tx) Values (in units of 0.1dBm)[1]		
				Minimum Value	Maximum Typical Value	Maximum Worst CaseValue
QDD-400G-ZR-S	400G	No	1	-150	-100	-100
QDD-400G-ZRP-S	400G	Yes	1	-150	-110	-130
				-150	-104	-119
				-150	-90	-105
				-150	-59	-75
DP04QSDD-HE0	400G	Yes	1	-150	15	25
	300G					
	200G					
	100G					

1. The default optical transmit power (Tx) value is -10 dBm, however with TX shaping enabled the maximum power in 1x400G, 4x100G, 3x100G, and 2x100G modes may be less than -10 dBm.

Transmitting Power Configuration Example

The following example shows how to configure the optical transmit (TX) power on the optics controller:

```
Router#config
Router(config)#controller optics 0/19/0/3
Router(config-Optics)#transmit-power -70
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the optics controller:

```
Router#show run controller optics 0/19/0/3
Thu May 13 12:52:35.020 UTC
controller Optics0/19/0/3
 cd-min -4000
 cd-max 4000
```

```
 transmit-power -70
!
```

Verification

This example shows how to verify the configured optical transmit power for the optics controller:

```
Router#show controller optics 0/19/0/3
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 LED State: Green
 FEC State: FEC OFEC
 Optics Status

         Optics Type:  400G QSFP-DD ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm

         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Laser Bias Current = 70.9 mA
         Actual TX Power = -7.06 dBm
         RX Power = -7.88 dBm
         RX Signal Power = -7.88 dBm
         Frequency Offset = -220 MHz
         Laser Temperature = 53.79 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25
         Performance Monitoring: Enable

         THRESHOLD VALUES
         ----------------

         Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
         ------------------------  ----------  ---------  ------------  -----------
         Rx Power Threshold(dBm)          1.9      -28.2           0.0        -25.0
         Tx Power Threshold(dBm)          0.0      -18.0          -2.0        -16.0
         LBC Threshold(mA)               0.00       0.00          0.00         0.00
         Temp. Threshold(celsius)       80.00      -5.00         75.00        15.00
         Voltage Threshold(volt)         3.46       3.13          3.43         3.16

         LBC High Threshold = 98 %
      Configured Tx Power = -7.00 dBm
         Configured CD High Threshold = 80000 ps/nm
         Configured CD lower Threshold = -80000 ps/nm
         Configured OSNR lower Threshold = 9.00 dB
         Configured DGD Higher Threshold = 180.00 ps
         Baud Rate =  30.0692729950 GBd
         Modulation Type: QPSK
         Chromatic Dispersion -2 ps/nm
         Configured CD-MIN -4000 ps/nm  CD-MAX 4000 ps/nm
         Second Order Polarization Mode Dispersion = 109.00 ps^2
         Optical Signal to Noise Ratio = 32.30 dB
         Polarization Dependent Loss = 0.05 dB
         Polarization Change Rate = 0.00 rad/s
         Differential Group Delay = 0.00 ps
         Temperature = 48.00 Celsius
         Voltage = 3.30 V

 Transceiver Vendor Details

         Form Factor            : QSFP-DD
```

```
Optics type             : QSFP-DD 400G-ZRP-S
Name                    : CISCO-ACACIA
OUI Number              : 7c.b2.5c
Part Number             : DP04QSDD-E30-19E
Rev Number              : 01
Serial Number           : ACA2503003X
PID                     : QDD-400G-ZRP-S
VID                     : ES03
Firmware Version        : 61.20 (Build : 13)
Date Code(yy/mm/dd)     : 21/01/22
```

Configuring Performance Monitoring

Performance monitoring (PM) parameters are used by service providers to gather, store, set thresholds for, and report performance data for early detection of problems. The user can retrieve both current and historical PM counters for the various controllers in 30-second, 15-minute, and 24-hour intervals.

Performance monitoring can be configured on optics controllers and coherent DSP controllers.

To stop performance monitoring on optics or coherent DSP controllers, use the **perf-mon disable** keyword.

Configuring PM Parameters

The performance monitorning (PM) threshold and the threshold crossing alert (TCA) reporting status can be configured for optics controllers and coherent DSP controllers:

Table 7: PM Thresholds and TCA Report Status for Optics Controllers

PM Parameters	Description
CD	Sets the CD (chromatic dispersion) threshold or TCA reporting status.
DGD	Sets the DGD (differential group delay) threshold or TCA reporting status.
LBC	Sets the LBC (laser bias current) threshold or TCA reporting status in mA.
FREQ-OFF	Sets the FREQ-OFF (low signal frequency offset) threshold or TCA reporting status in Mhz.
OPR	Sets the OPR (optical power RX) threshold or TCA reporting status in uW or dbm.
OPT	Sets the OPT (optical power TX) threshold or TCA reporting status in uW or dbm.
OSNR	Sets the OSNR (optical signal-to-noise ratio) threshold or TCA reporting status.
PCR	Sets the PCR (polarization change rate) threshold or TCA reporting status.

PM Parameters	Description
PDL	Sets the PDL (polarization dependent loss) threshold or TCA reporting status.
RX-SIG	Sets the RX-SIG (receiving signal power) threshold or TCA reporting status in uW or dbm.
SNR	Sets the SNR (signal-to-noise ratio) threshold or TCA reporting status.
SOPMD	Sets the SOPMD (second order polarization mode dispersion) threshold or TCA reporting status.

Table 8: PM Thresholds TCA Report Status for Coherent DSP Controllers

PM Parameters	Description
Q	Sets the Q threshold or TCA reporting status.
Q-margin	Sets the Q margin threshold or TCA reporting status.
EC-BITS	Sets the EC-BITS (error corrected bits) threshold or TCA reporting status.
PostFEC BER	Sets the post-FEC BER threshold or TCA reporting status.
PreFEC BER	Sets the pre-FEC BER threshold or TCA reporting status.
UC-WORDS	Sets the UC-WORDS (uncorrected words) threshold or TCA reporting status.

Performance Monitoring Configuration Example

This example shows how to enable performance monitoring and set PM thresholds on the optics controller:

```
Router#config
Router(config)#controller optics 0/2/0/16
Router(config-Optics)#perf-mon enable
Router(config-Optics)#pm 30-sec optics threshold cd max 100
Router(config-Optics)#pm 30-sec optics threshold cd min -100
Router(config-Optics)#commit
```

Running Configuration

This example shows the running configuration on optics controllers:

```
Router#show run controller optics 0/2/0/16
Thu May 13 20:18:55.957 UTC
controller Optics0/2/0/16
pm 30-sec optics threshold cd max 100
pm 30-sec optics threshold cd min -100
 perf-mon enable
!
```

Verification

This example shows how to verify the PM parameters on optics controllers. Verify the configuration changes in the Configured Threshold fields:

```
Router#show controller optics 0/2/0/16 pm current 30-sec optics 1
  Thu May 27 17:58:49.889 UTC
Optics in the current interval [17:58:30 - 17:58:49 Thu May 27 2021]
Optics current bucket type : Valid
            MIN       AVG       MAX      Operational      Configured      TCA   Operational
      Configured     TCA
                                          Threshold(min)   Threshold(min) (min) Threshold(max)
   Threshold(max) (max)
LBC[mA ]       : 0.0       0.0       0.0      0.0               NA              NO   100.0
           NA              NO
OPT[dBm]     : -9.98     -9.98     -9.98    -15.09            NA              NO   0.00
           NA              NO
OPR[dBm]     : -40.00    -40.00    -40.00   -30.00            NA              NO   8.00
           NA              NO
CD[ps/nm]    : 0         0         0        -80000          -100          NO   100
    100          NO
DGD[ps ]     : 0.00      0.00      0.00     0.00              NA              NO   80.00
           NA              NO
SOPMD[ps^2]  : 0.00      0.00      0.00     0.00              NA              NO   2000.00
           NA              NO
OSNR[dB]     : 0.00      0.00      0.00     0.00              NA              NO   40.00
           NA              NO
PDL[dB]      : 0.00      0.00      0.00     0.00              NA              NO   7.00
           NA              NO
PCR[rad/s]   : 0.00      0.00      0.00     0.00             NA              NO   2500000.00
       NA              NO
RX_SIG[dBm]  : -40.00    -40.00    -40.00   -30.00            NA              NO   1.00
           NA              NO
FREQ_OFF[Mhz]: 0         0         0        -3600             NA              NO   3600
           NA              NO
SNR[dB]      : 0.00      0.00      0.00     7.00              NA              NO   100.00
           NA              NO

Last clearing of "show controllers OPTICS" counters never
!
```

Performance Monitoring Configuration Example

This example shows how to enable performance monitoring and set PM thresholds and TCA reporting status on the coherent DSP controller:

```
Router#config
Router(config)#controller CoherentDSP0/2/0/16
Router(config-CoDSP)#perf-mon enable
Router(config-CoDSP)#pm 30-sec fec report Q max-tca enable
Router(config-CoDSP)#pm 30-sec fec report Q-margin max-tca enable
Router(config-CoDSP)#pm 30-sec fec report Q min-tca enable
Router(config-CoDSP)#pm 30-sec fec report Q-margin min-tca enable
Router(config-CoDSP)#pm 30-sec fec threshold Q max 1200
Router(config-CoDSP)#pm 30-sec fec threshold Q-margin max 500
Router(config-CoDSP)#pm 30-sec fec threshold Q min 900
Router(config-CoDSP)#pm 30-sec fec threshold Q-margin min 280
Router(config-CoDSP)#commit
```

Running Configuration

This example shows the running configuration on coherent DSP controllers:

```
Router#show run controller coherentdsp 0/2/0/16
Thu May 13 19:56:09.136 UTC
controller CoherentDSP0/2/0/16
 pm 30-sec fec report Q max-tca enable
```

```
 pm 30-sec fec report Q-margin max-tca enable
 pm 30-sec fec report Q min-tca enable
 pm 30-sec fec report Q-margin min-tca enable
 pm 30-sec fec threshold Q max 1200
 pm 30-sec fec threshold Q-margin max 500
 pm 30-sec fec threshold Q min 900
 pm 30-sec fec threshold Q-margin min 280
 perf-mon enable
 !
```

Verification

This example shows how to verify the PM parameters on coherent DSP controllers. Verify the configuration changes in the highlighted fields:

```
Router#show controllers coherentdsp 0/2/0/16 pm current 30-sec fec
Thu May 27 23:04:54.167 UTC
g709 FEC in the current interval [23:04:30 - 23:04:54 Thu May 27 2021]
FEC current bucket type : Valid
    EC-BITS   : 0                       Threshold : 111484000000          TCA(enable)  :
YES
    UC-WORDS  : 0                       Threshold : 5                     TCA(enable)  :
YES
                                      MIN       AVG        MAX      Threshold      TCA
 Threshold     TCA
                                                                        (min)     (enable)
   (max)     (enable)
PreFEC BER                    :     0E-15     0E-15     0E-15      0E-15        NO
0E-15        NO
PostFEC BER                   :     0E-15     0E-15     0E-15      0E-15        NO
0E-15        NO
Q[dB]                         :      0.00      0.00      0.00      9.00  YES 120.00  YES
Q_Margin[dB]                  :      0.00      0.00      0.00      2.80  YES  5.00   YES
 !
```

Configuring Loopback

You can configure internal or line loopback on coherent DSP controllers. Loopback can be performed only in the maintenance mode.

Loopback Configuration Example

This example shows how to enable internal loopback configuration on coherent DSP controllers:

```
Router#config
Router(config)#controller coherentDSP 0/0/0/4
Router(config-CoDSP)#secondary-admin-state maintenance
Router(config-CoDSP)#loopback internal
Router(config-CoDSP)#commit
```

Running Configuration

This example shows the running configuration on coherent DSP controllers:

```
Router#show run controller coherentdsp 0/0/0/4
controller CoherentDSP0/0/0/4
 secondary-admin-state maintenance
 loopback internal
!
```

Verification

This example shows how to verify the loopback configuration on coherent DSP controllers:

```
Router#show controller coherentdsp 0/0/0/4
Thu May 27 17:28:51.960 UTC
Port                                        : CoherentDSP 0/0/0/4
Controller State                            : Down
Inherited Secondary State                   : Normal
Configured Secondary State                  : Maintenance
Derived State                               : Maintenance
Loopback mode                               : Internal
BER Thresholds                              : SF = 1.0E-5  SD = 1.0E-7
Performance Monitoring                      : Enable
Bandwidth                                   : 400.0Gb/s
Alarm Information:
LOS = 6 LOF = 0 LOM = 0
OOF = 0 OOM = 0 AIS = 0
IAE = 0 BIAE = 0        SF_BER = 0
SD_BER = 0      BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0     FLEXO_GIDM = 0
FLEXO-MM = 0    FLEXO-LOM = 0   FLEXO-RDI = 0
FLEXO-LOF = 5
Detected Alarms                             : LOS
Bit Error Rate Information
PREFEC  BER                                 : 5.0E-01
POSTFEC BER                                 : 0.0E+00
Q-Factor                                    : 0.00 dB
Q-Margin                                    : -7.20dB
OTU TTI Received
FEC mode                                    : C_FEC
```

Configuring Alarms Threshold

The alarms threshold can be configured for monitoring alarms on optics controllers:

Table 9: Alarms Threshold Parameters for Optics Controllers

Alarm Threshold Parameters	Description
CD	Sets the CD (chromatic dispersion) alarm threshold (cd-low-threshold and cd-high-threshold).
DGD	Sets the DGD (differential group delay) alarm threshold.
LBC	Sets the LBC (laser bias current) threshold in mA.
OSNR	Sets the OSNR (optical signal-to-noise ratio) alarm threshold.

Alarm Threshold Configuration Example

This example shows how to configure alarm threshold on the optics controller:

```
Router#config
Router(config)#controller optics 0/2/0/16
Router(config-Optics)#cd-low-threshold -5000
Router(config-Optics)#cd-high-threshold 5000
Router(config-Optics)#commit
```

Running Configuration

This example shows the running configuration on the optics controller:

```
Router#show run controller optics 0/2/0/16
controller Optics0/2/0/16
 cd-low-threshold 5000
 cd-high-threshold 5000
!
```

Verification

This example shows how to verify the alarm threshold on optics controllers:

```
Router#show controller optics 0/2/0/16
Fri May 28 01:04:33.604 UTC
 Controller State: Up
 Transport Admin State: In Service
 Laser State: Off
 LED State: Off
 FEC State: FEC OFEC
 Optics Status
         Optics Type:  400G QSFP-DD ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm
         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Alarm Statistics:
         -------------
         HIGH-RX-PWR = 0            LOW-RX-PWR = 0
         HIGH-TX-PWR = 0            LOW-TX-PWR = 0
         HIGH-LBC = 0               HIGH-DGD = 0
         OOR-CD = 0                 OSNR = 0
         WVL-OOL = 0                MEA  = 0
         IMPROPER-REM = 0
         TX-POWER-PROV-MISMATCH = 0
         Laser Bias Current = 0.0 mA
         Actual TX Power = -40.00 dBm
         RX Power = -40.00 dBm
         RX Signal Power = -40.00 dBm
         Frequency Offset = 0 MHz
         Laser Temperature = 0.00 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25
         Performance Monitoring: Enable
         THRESHOLD VALUES
         ----------------
         Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
         ------------------------  ----------  ---------  ------------  -----------
         Rx Power Threshold(dBm)         13.0      -24.0          10.0        -22.0
         Tx Power Threshold(dBm)          0.0      -16.0          -2.0        -14.0
         LBC Threshold(mA)               0.00       0.00          0.00         0.00
         Temp. Threshold(celsius)       80.00      -5.00         75.00         0.00
         Voltage Threshold(volt)         3.46       3.13          3.43         3.16
         LBC High Threshold = 98 %
         Configured Tx Power = -10.00 dBm
         Configured CD High Threshold = -5000 ps/nm
         Configured CD lower Threshold = -5000 ps/nm
         Configured OSNR lower Threshold = 9.00 dB
         Configured DGD Higher Threshold = 80.00 ps
         Baud Rate =  60.1385459900 GBd
         Modulation Type: 16QAM
         Chromatic Dispersion 0 ps/nm
```

```
        Configured CD-MIN -26000 ps/nm  CD-MAX 26000 ps/nm
        Second Order Polarization Mode Dispersion = 0.00 ps^2
        Optical Signal to Noise Ratio = 0.00 dB
        Polarization Dependent Loss = 0.00 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps
        Temperature = 21.00 Celsius
        Voltage = 3.42 V
 Transceiver Vendor Details

        Form Factor            : QSFP-DD
        Optics type            : QSFP-DD 400G-ZRP-S
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E30-19E
        Rev Number             : 01
        Serial Number          : ACA2503003X
        PID                    : QDD-400G-ZRP-S
        VID                    : ES03
        Firmware Version       : 61.20 (Build : 13)
        Date Code(yy/mm/dd)    : 21/01/22
!
```