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Revision History

Version	Date	Comments
1.0	02/10/2024	Initial Publication

Document Overview

In this blog we will focus on the ongoing monitoring of digital coherent optics (DCO) once they are deployed in the network. More information on the installation and provisioning of DCO optics can be found in the above locations. We will look at the types of Performance Measurement data important to be monitored and how to monitoring the PM data through several interfaces including the router CLI interface, using streaming telemetry, and using Cisco's Crosswork family of network automation products.

Routed Optical Networking

Routed Optical Networking introduced by Cisco in 2020 introduced a fundamental shift in how IP+Optical networks are built. Collapsing previously disparate network layers and services into a single unified domain, Routed Optical Networking simplifies operations and lowers overall network TCO. More information on Routed Optical Networking can be found at the following locations:

- <https://www.cisco.com/c/en/us/solutions/service-provider/routed-optical-networking.html>
- <https://xrdocs.io/latest-routed-optical-networking-hld>

Pluggable Digital Coherent Optics Overview

One of the foundations of Routed Optical Networking is the use of small form factor pluggable digital coherent optics. These optics can be used in a wide variety of network applications, reducing CapEx/OpEx cost and reducing complexity vs. using traditional external transponder equipment.

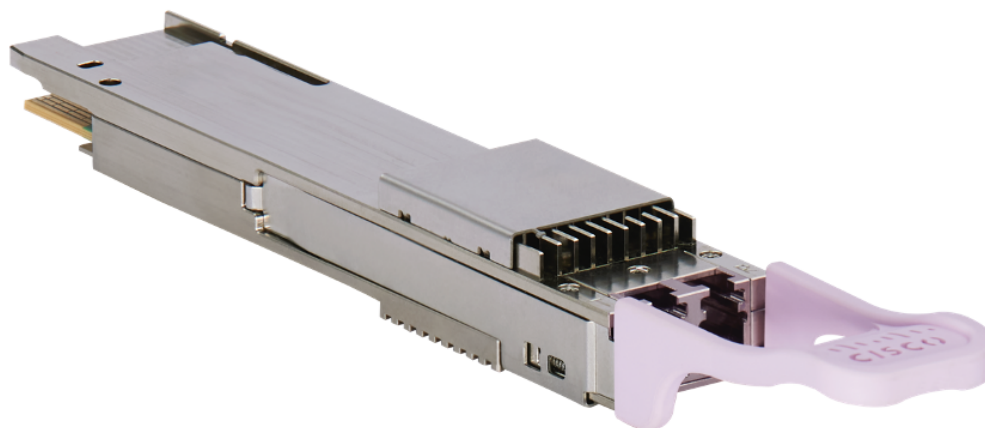
OIF 400ZR and OpenZR+ Standards using QSFP-DD Transceivers

The networking industry saw a point to improve network efficiency by shifting coherent DWDM functions to router pluggables. Technology advancements have shrunk the DCO components into the standard QSFP-DD form factor, meaning no specialized hardware and the ability to use the highest capacity routers available today. ZR/OpenZR+ QSFP-DD optics can be used in the same ports as the highest speed 400G non-DCO transceivers.

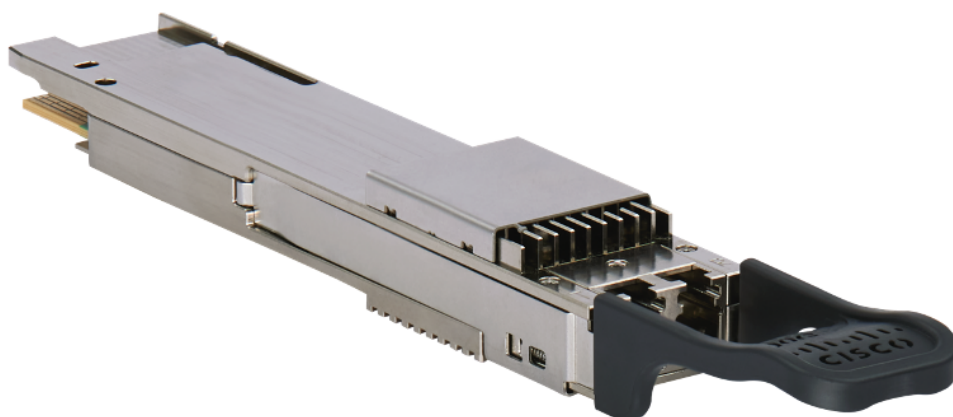
Cisco High-Power OpenZR+ "Bright" Transceiver (DP04QSDD-HE0)



Cisco OpenZR+ Transceiver (QDD-400G-ZRP-S)



Cisco OIF 400ZR Transceiver (QDD-400G-ZR-S)



Two industry optical standards have emerged to cover a variety of use cases. The OIF created the 400ZR specification, <https://www.oiforum.com/technical-work/hot-topics/400zr-2> as a 400G interoperable standard for metro reach coherent optics. The industry saw the benefit of the approach, but wanted to cover longer distances and have flexibility in wavelength rates, so the OpenZR+ MSA was created,

<https://www.openzrplus.org>. The following table outlines the specs of each standard. ZR400 and OpenZR+ transceivers are tunable across the ITU C-Band, 196.1 To 191.3 THz.



Reach	< 120km	> 120km
Client	400GbE Only	100-400GbE
Application	Campus, Metro, Edge DCI	DCI, Metro, Regional, Long Haul
FEC	C-FEC	<u>oFEC</u>
Max. Power Consumption	15W	~20W
Multi-vendor Interop	Yes	Yes
Standards	OIF	<u>OpenZR+</u> MSA

The following part numbers are used for Cisco's ZR400 and OpenZR+ MSA transceivers

Standard	Part
400ZR	QDD-400G-ZR-S
OpenZR+	QDD-400G-ZRP-S
OpenZR+ High-Power (Bright)	DP04QSDD-HE0

The Cisco datasheet for these transceivers can be found at

<https://www.cisco.com/c/en/us/products/collateral/interfaces-modules/transceiver-modules/datasheet-c78-744377.html> and <https://www.cisco.com/c/en/us/products/collateral/interfaces-modules/transceiver-modules/400g-qsfp-dd-high-power-optical-module-ds.html>

Cisco Hardware Support for 400G ZR/ZR+ DCO Transceivers

Cisco supports the OpenZR+ and OIF ZR transceivers across all IOS-XR product lines with 400G QSFP-DD ports, including the ASR 9000, NCS 540, NCS 5500, NCS 5700, and Cisco 8000. Please see the Routed Optical Networking Design or the individual product pages below for more information on each platform.

Cisco 8000

<https://www.cisco.com/c/en/us/products/collateral/routers/8000-series-routers/datasheet-c78-742571.html>

NCS 500

<https://www.cisco.com/c/en/us/products/collateral/routers/network-convergence-system-500-series-routers/ncs-540-large-density-router-ds.html>

Cisco ASR 9000

https://www.cisco.com/c/en/us/products/collateral/routers/asr-9000-series-aggregation-services-routers/data_sheet_c78-501767.html

NCS 5500 and NCS 5700

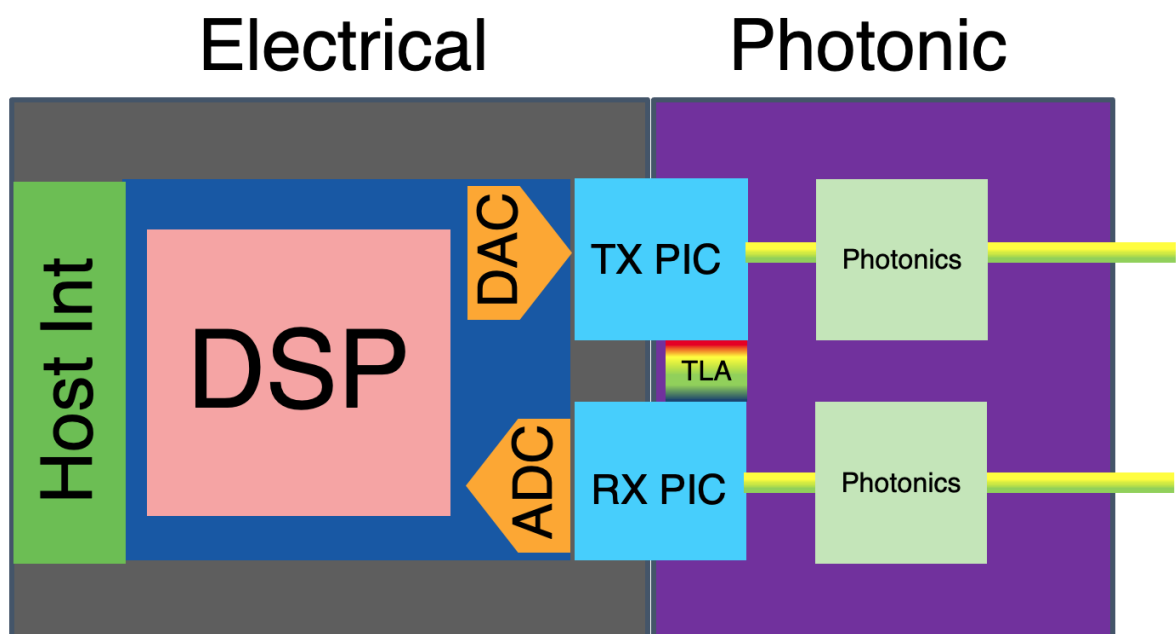
<https://www.cisco.com/c/en/us/products/collateral/routers/network-convergence-system-5500-series/datasheet-c78-736270.html>

<https://www.cisco.com/c/en/us/products/collateral/routers/network-convergence-system-5500-series/datasheet-c78-744698.html>

Pluggable Digital Coherent Optics Detail

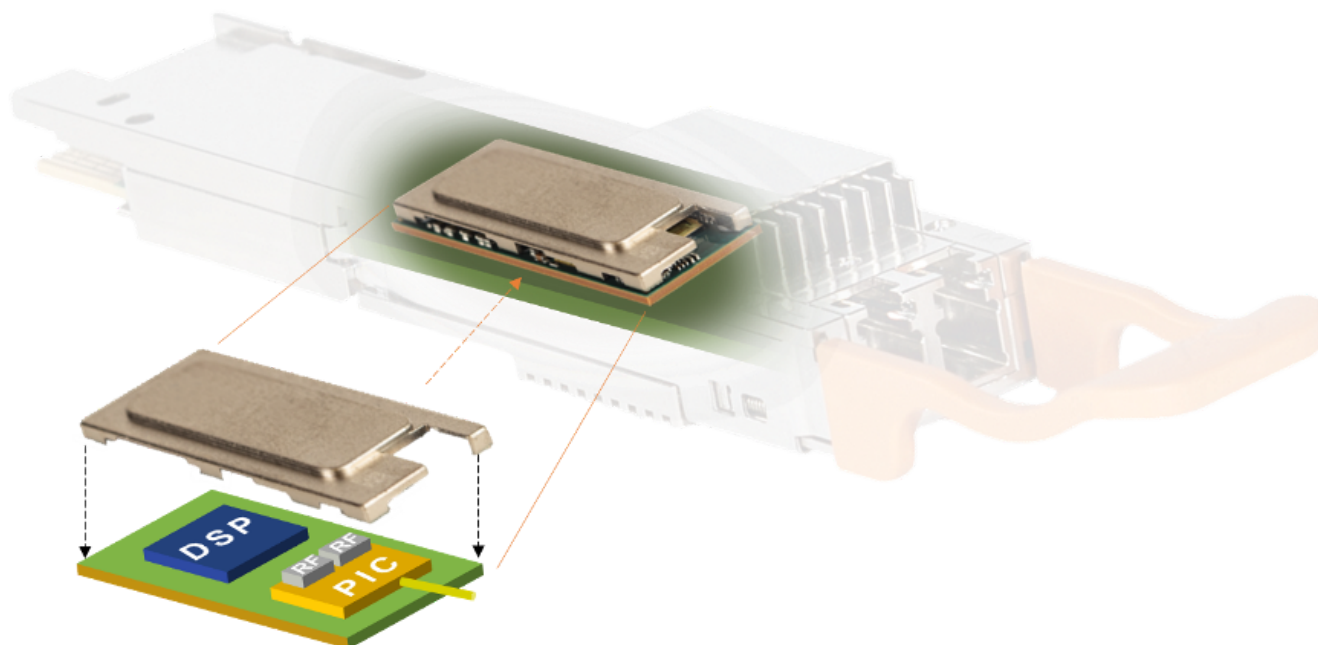
Digital Coherent Optics are complex technology. In this blog we will not go into low level detail of the inner workings of the optics, but look at some of the basic components to help understand where specific performance measurement data is derived from and how best to monitor the optics.

Component Diagram



Component Packaging

On modern DCO like Cisco's ZR/ZR+ multiple elements are co-packaged leading to simpler design and greater power efficiency.



Coherent DSP

At the heart of "Digital" coherent optics is a Digital Signal Processor (DSP). The definition of a DSP is in the name, the DSP analyzes an incoming signal, typically performs some type of manipulation, and then passes that signal onto another element. DSPs can be very simple, such as one re-sampling digital audio signals, or complex DSPs can perform many functions. The input interface into the DSP and the output interface may or may not be the same format, requiring the DSP to perform the conversion. Signal conversion is just one of many jobs performed by the DSP in a DCO. It is a bit of a stretch to only call the processing component inside the DCO a "DSP" due to the number of functions it performs.

We will consider the Analog to Digital Conversion (ADC) and Digital to Analog Conversion (DAC) components part of the "DSP" since they are typically packaged with the actual signal processor and associated digital components. The ADC/DAC is responsible for converting electrical analog to digital, not converting electrical analog to an optical signal.

Photonic (Optical) Components

While the DSP takes on many functions performed by photonic components in the past, we still need photonic components to send/receive light across fiber. The optical components within the DCO are similar to those found in non-DCO applications. Common components are the TLA (Tunable Laser Assembly) generating the signal along with TOFs (Tunable Optical Filter) and other pure photonic components such as splitters, combiners, and waveguides. In higher power optics, an integrated EDFA is used to amplify the signal before it leaves the DCO.

Photonic Integrated Circuit (PIC)

At some point in the signal path a translation between the electrical signal to the optical signal must take place. This is done through the use of modulators and receivers built using Photonic Integrated Circuits in

modern DCO. These are commonly referred to as opto-electric modules because they span both signal domains. The electrical signal generated by the DSP and then the DAC is used to modulate the transmit optical laser to match the data being sent.

Receivers are likewise responsible for processing the optical signal into electrical domain signals which after some pre-processing can be processed by the DSP.

IOS-XR DCO Conventions

As we have seen the DCO has both Digital and Optical components, IOS-XR represents the optics in a similar manner as a way to better manage each layer, including the PM data we gather and analyze.

Optics Controller

The optics controller on a IOS-XR router represents the physical pluggable faceplate port on the router. Whether the pluggable is DCO or not, there will be an optics controller. The optics controller is used to manage and monitor the physical layer characteristics of an optic. A plug and play gray pluggable optic doesn't require any physical layer configuration since it's built into the standard and can only be configured one way. However, there are a number of optical properties which can still be monitored on the optics, such as per-lane receive power.

In the case of the DCO, the optics controller is where we configure physical layer properties such as the frequency and output power. It's also where we monitor physical layer alarms and PM data.

CoherentDSP Controller

The CoherentDSP controller matches the naming conventions of the optics controller. It represents the digital layer of the DCO and is responsible for alarms and PM data associated with the digital signal.

DCO Performance Measurement Data

Overview

In this section we will introduce the performance measurement data available with an explanation of what each component is, why it's important, and what is considered an ideal range of values.

TL;DR What PM values to monitor and what to look for?

The rest of the document goes into detail about the PM data available and how to monitor them. These however are the key values which should be monitored.

- Total Optical Receive Power (RX Power)
- Optical Signal Receive Power (RX Signal Power)
- Q-Factor
- Q-Margin

RX power, Q-Factor, and Q-Margin will have some absolute value once the circuit is operational. Each of these values have known minimums based on the DCO specifications, but will be different for every operational circuit. It's important to monitor the values for changes.

Note changes may occur due to other network changes such as adding more channels on the same fiber span.

Optical Layer PM Data

Optical Power - Transmit

Transmit power, or TX power represents the strength of the optical signal leaving the DCO. It can be adjusted by user configuration. In most cases leaving the TX power to the default value is advised. On the QDD-400G-ZR-S and QDD-400G-ZRP-S the default power for 400G mode is -10dBm. On the DP04QSDD-HE0 the default power for 400G mode is 0dBm. Changes in the TX power can help identify hardware issues. The TX power will fluctuate slightly but changes of more than .2 dBm may indicate an issue.

Optical Power (Total) - Receive

Receive power, or RX power represents the strength of the optical signal entering the DCO from the line side. There is a direct correlation between the RX power and the quality of the signal. The DCO has a defined receiver sensitivity range. If the RX power drops below the minimum RX sensitivity value, it may not be able to process the incoming signal. It is difficult to give a specific acceptable range for RX power since other impairments such as noise may also degrade the signal even at acceptable RX power levels. However, in practice the signal should always be above -20 dBm. The total optical power is measured at the ingress point into the optic.

****Note in IOS-XR the minimum reported power is -40dBm indicating there is no signal present.**

Optical Power (Signal) - Receive

Receive signal power represents the signal strength of the coherent channel the DCO is tuned to receive. It's important to represent both the total power and the signal power since total power indicates there is some optical signal being received from the far end, and the RX signal power indicates the correct wavelength is being received. If the total RX power is in the normal range and the RX signal power is very low it indicates a frequency configuration issue.

****Note in IOS-XR the minimum reported power is -40dBm indicating there is no signal present.**

Optical Signal to Noise Ratio

OSNR is one of the key PM values in monitoring an optical signal. Background noise is inherent in almost all analog signals. It can also be introduced into the signal by different photonic elements. Amplifiers can introduce and increase noise. As the primary signal is amplified so is the noise inherent in analog signals. Measuring the true optical signal to noise ratio requires test measurement equipment which cannot be packaged in the size of a DCO. The DCO estimates the OSNR based on DSP compensation and are not precise in all conditions.

Chromatic Dispersion

Chromatic Dispersion is a linear optical impairment which degrades the overall signal and must be corrected by the DCO. Different wavelengths travel at different speeds, this can commonly be seen using a prism. 400G signals use 75GHz of spectrum which covers a wide band of frequencies so they do not all travel together. As the signal travels along the fiber the signal spreads out meaning the receive end must compensate for the delay between the beginning and end of the signal. The spread of the signal is measured in picoseconds/nanometer or ps/nm.

In IOS-XR the user can configure the "sweep" range used to compensate for the chromatic dispersion using the cd-min and cd-max threshold values.

The user can also monitor the current estimated Chromatic Dispersion values. These values are derived from calculations done by the DSP during its CD compensation.

Polarization Mode Dispersion

PMD is another type of signal dispersion or spread. PMD is unique to coherent signals and measures the spread in time between the X and Y polarized signals comprising the coherent signal. We don't measure PMD directly but several of the following PM values are used to measure the effect of PMD. PMD is typically introduced via imperfections in the fiber or mechanical manipulation of the fiber such as bending.

Differential Group Delay

DGD is the measure of PMD and is used to express the difference in arrival time of the two orthogonal signals. DGD can also be known as First Order PMD or FOPMD. DGD is measured in picoseconds. Perfect fiber has no PMD/DGD but fiber used in the field is not perfect. Modern SM fiber can introduce .5-1ps of DGD over 100km, it is directly related to fiber length. Optical components can also introduce DGD. DGD is wavelength dependent so may be different for different wavelengths, it can also be introduced by temperature fluctuations in the fiber.

Polarization Dependent Loss

Signal polarization can also have another effect in introducing signal loss as the signal propagates through the fiber. The value is dependent on fiber length and is compensated for by the coherent DSP. The value should remain low in most instances and is measured in dB. Keep in mind this is dB and not the dBm that optical power is expressed in.

Second-Order Polarization Mode Dispersion

SOPMD is a measure of the PMD rates of change related to signal frequency. The name is due to SOPMD being the second order differential with respect to PMD. The DGD value does not remain static so the DSP must compensate not only for the DGD value but the rates of change in DGD. This value is measured in picoseconds squared or ps².

Polarization Change Rate

As the polarized signals travel through the fiber, the fiber can cause changes in the polarization state or SOP (State of Polarization). The coherent DSP must compensate for these changes to properly decode the signal. The PCR is measured in radians/second or rad/s since the state change is rotational. On shorter fiber spans this value should be 0 but longer spans or poor fiber may introduce higher values.

General guidelines for acceptable values

The following represents the range of values for each optical PM metric and what is considered a "good" value. The "range" represents the range of reporting on Cisco ZR/ZR+ DCO.

Metric	Units	Range	Healthy range	Comment
Optical Power - Receive	dBm or mW	-33 to +15	-14 to +8	High alarm is set to +10, low to -24
Optical Signal Power - Receive	dBm or mW	-33 to +15	-14 to +8	High alarm is set to +10, low to -24
Optical Signal Power - Transmit	dBm or mW	-15 to +5	-12 to +2	Healthy depends on DCO model and mode
OSNR	dB	16.5 to 28.5	need comment	Healthy range changes dependent on mode
CD	ps/nm	-100 to 100	need comment	
DGD	ps	-10 to 10		need comment
PCR	rad/s	0-50	need comment	
PDL	dB			

Digital Layer PM Data

We've covered optical impairments in the analog optical domain. Ultimately any type of signal degradation can lead to errors at the digital layer.

Pre-FEC Bit Error Rate

High speed coherent optics expect transmission errors at the bit level due to optical signal impairments. Forward error correction uses an algorithm to send extra data with the signal so it can be used to "correct" the original signal when information is lost or incorrect. Modern algorithms are used to minimize the amount of extra data which needs to be sent.

The Pre-FEC BER is expressed in a ratio of bit errors per samples bits, and at the rates being used for ZR/ZR+ optics is very small. It's expressed in scientific notation such as 3.7E-04, which is .00037. It's difficult to monitor this as an absolute value, but can be monitored for change over time to help identify issues with the fiber. Q-Margin explained below is an easier value to monitor.

Post-FEC BER and Uncorrectable Words

Post-FEC BER measures the amount of bits which are unable to be corrected, and ultimately lead to UCs or uncorrectable words/bytes.

Any value other than 0 means there is a critical issue with the signal, and in most cases due to the sharp FEC cliff it's unlikely the interface will be up if you are receiving bit errors.

Quality Factor (Q-Factor)

The Q-Factor is a DSP calculated value closely related to the Pre-FEC BER and OSNR. The Q-Factor provides a minimum SNR value required to meet a certain BER requirement. Based on the properties of the DCO optics we know at a certain BER we require a specific SNR, if the BER is very high then we need a higher SNR. The Q-Factor expressed this relationship via a single value. On the DCO the value is based on measured BER over a specific time period.

Quality Margin (Q-Margin)

The Q-Margin is a calculated value used to convey the health of the overall signal after being processed. It indicates how much signal margin exists and if degradation occurs how much it can degrade before the signal is lost. A Q-Margin less than 1 is considered unhealthy. The Q-Margin is useful during both circuit turn-up as well as checking the ongoing health of the circuit.

General guidelines for acceptable values

The following table highlights some general acceptable values and how the OSNR, Pre-FEC BER, and Q-margin relate to each other.

Q-margin	Pre-FEC BER	OSNR margin	Optical channel health
< 0.5dB	> 1.5E-2	< 1dB	Unhealthy
0.5dB to 1dB	1.5E-2 to 1.0E-2	1dB to 2.2dB	Acceptable
1.0dB to 1.5dB	1.0E-2 to 7.0E-3	2.2dB to 3.4dB	Healthy
> 1.5dB	<7.0E-3	> 3.4dB	Very Healthy

Environmental PM

Temperature

Modern DCO have multiple temperature sensors. The "temperature" reading reported by the operating system may be the case temperature or the DSP temperature. The laser component typically has its own temperature sensor and is reported as the laser temperature.

Voltage

The voltage supplied to the DCO is specified by various standards such as the QSFP-DD MSA specifications. The voltage should be approximately 3.3v but can vary. Larger fluctuations in the voltage indicate a hardware problem.

Laser Bias Current (LBC)

The LBC is a measure of the bias current applied to the transmit laser used to maintain stable optical transmit power. This value may change due to fluctuations in voltage and temperature. The value can be

measured either as an absolute value in milliamps or a percentage of the operating threshold of the laser.

IOS-XR DCO Monitoring

The PM values we've introduced will be used in monitoring the health of our DCO circuit. We'll focus on IOS-XR as the network operating system, but similar methods are usually available with other network operating systems.

"Current" Performance Data

When the user issues show commands such as "show controller optics" and "show controller coherentdsp" what is shown for PM data is the last read or "current" value or the metric. Certain data is collected at different intervals but in general all data shown has an update interval below 30s. The following tables list the instant PM data available via different methods.

CLI "show controller optics" Optical layer PM data

As you can see below the PM data we discussed in the overview section is shown when issuing the command. The "RX Power" is the total optical receive power, the "RX Signal Power" is the power of the specific coherent channel the DCO is tuned to receive.

```
Laser Bias Current = 273.1 mA
Actual TX Power = -9.95 dBm
Actual TX Power(mW) = 0.10 mW
RX Power = -2.92 dBm
RX Power(mW) = 0.51 mW
RX Signal Power = -3.15 dBm
Frequency Offset = -1 MHz
Laser Temperature = 51.48 Celsius
Laser Age = 0 %
LBC High Threshold = 98 %
Chromatic Dispersion 2 ps/nm
Second Order Polarization Mode Dispersion = 46.00 ps^2
Optical Signal to Noise Ratio = 35.60 dB
SNR = 18.80 dB
Polarization Dependent Loss = 0.60 dB
Polarization Change Rate = 0.00 rad/s
Differential Group Delay = 1.00 ps
Temperature = 52.00 Celsius
Voltage = 3.29 V
```

CLI "show controller coherentdsp" Digital layer PM data

As you can see below the PM data we discussed in the overview section is shown when issuing the command.

```

PREFEC BER          : 3.1E-04
POSTFEC BER         : 0.0E+00
Q-Factor            : 10.60 dB
Q-Margin            : 4.10 dB

```

YANG data models for "current" PM data retrieval

The following YANG model paths can be used to retrieve all of the data shown in the CLI commands. Interfaces such as NETCONF, gNMI/GRPC, or native Cisco MDT can be used to retrieve the data on demand, on change, or via periodic subscription.

YANG data model for "current" Optical PM data

```

Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/optics-
port/optics-info

```

YANG data model for "current" Digital PM data

```

Cisco-IOS-XR-controller-otu-oper:otu/controllers/controller/info

```

SNMP MIBs for "current" PM data retrieval

In IOS-XR the optics and coherentdsp controllers are modeled as interfaces. The SNMP OIDs used for DCO monitoring will reference the interface ifIndex for the respective controller.

SNMP MIB for "current" Optical PM data

The following Cisco native SNMP MIB can be used to retrieve the current PM data.

```

CISCO-OPTICAL-MIB (OID 1.3.6.1.4.1.9.9.828)

IF-MIB::ifDescr.27 = STRING: Optics0/0/0/24
CISCO-OPTICAL-MIB::coiOpticalControllerFrequency.27 = Gauge32: 1940000 100
MHz

```

SNMP MIB for "current" Digital PM data

The following Cisco native SNMP MIB can be used to retrieve the current PM data.

```

CISCO-OTN-IF-MIB (OID 1.3.6.1.4.1.9.9.639)

```

```
IF-MIB::ifDescr.65 = STRING: CoherentDSP0/0/0/24
CISCO-OTN-IF-MIB::coiIfControllerPreFECBERMantissa.65 = INTEGER: 140
CISCO-OTN-IF-MIB::coiIfControllerPreFECBERExponent.65 = INTEGER: -5
```

Previous values equal PreFEC BER of 1.4e-05

Events and Alarms

There are many alarms associated with the state of the optics. This is not meant to be an exhaustive list of alarms, just highlight some of the more commonly seen alarms during specific events.

Platform alarms generated by DCO events are reported via the system log and output to remote monitoring tools as syslog messages and SNMP traps if enabled. These alarms will show up when executing a "show alarms" command on the CLI and retrieving alarms via YANG models such as openconfig-alarms and Cisco-IOS-XR-alarmmgr-server-oper.

Optics Controller Alarm Thresholds

The following PM threshold values are defined for the optics controller. See the table below on user-configurable values. When a threshold is crossed the system will generate an alarm of different severity based on Low vs. High crossing.

It is recommended to leave the values at their defaults unless the user has characterized the optical network closely to determine proper values.

Parameter	High Alarm	Low Alarm	High Warning	Low Warning
Rx Power Threshold(dBm)	13.0	-24.0	10.0	-21.0
Rx Power Threshold(mW)	19.9	0.0	10.0	0.0
Tx Power Threshold(dBm)	4.0	-18.0	2.0	-16.0
Tx Power Threshold(mW)	2.5	0.0	1.5	0.0
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 CD High Threshold = 160000 ps/nm				
Configured CD lower Threshold = -160000 ps/nm				
Configured OSNR lower Threshold = 9.00 dB				
Configured DGD Higher Threshold = 80.00 ps				

Parameter	Explanation	User-Configurable
Rx Power Threshold(dBm)	Receive power in dBm	No
Rx Power Threshold(mW)	Receive power in mW	No
Tx Power Threshold(dBm)	Transmit power in dBm	No
Tx Power Threshold(mW)	Transmit power in mW	No

Parameter	Explanation	User-Configurable
LBC High Threshold	Laser bias % of max	Yes, lbc-high-threshold command
Temp threshold	Case temperature of transceiver	No
CD High Threshold	Chromatic dispersion high	Yes, cd-high-threshold command
CD Low threshold	Chromatic dispersion low	Yes, cd-low-threshold command
OSNR Low threshold	Optical signal to noise ratio	Yes, osnr-low-threshold
DGD Low threshold	Differential group delay low value	Yes, dgd-low-threshold command

Counted Optical Alarms

Based on either an event or built-in PM threshold, specific alarms increment over time. These are seen with the "show controller optics" CLI command or appropriate YANG model.

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 = 18
WVL-OOL = 0              MEA = 0
IMPROPER-REM = 0
TX-POWER-PROV-MISMATCH = 0

```

Alarm	Expansion	Comment
HIGH-RX-PWR	RX power too high	
HIGH-TX-PWR	TX power too high	
LOW-RX-PWR	RX power too low	
LOW-TX-PWR	TX power too low	
HIGH-LBC	Laser bias current too high	
HIGH-DGD	Diffeential group delay too high	
OOR-CD	Chromatic dispersion out of range	
OSNR	Optical signal to noise ratio too low	
WVL-OOL		

Alarm	Expansion	Comment
MEA	Mismatch equipment alarm	Optic speed not supported by port
IMPROPER-REM	Improper removal	Not applicable to IOS-XR routers
TX-POWER-PROV-MISMATCH	Difference in configured and actual value too large	

Counted Digital Alarms

Based on either an event or built-in PM threshold, specific alarms increment over time. These are seen with the "show controller coherentdsp" CLI command or appropriate YANG model.

```
Alarm Information:
LOS = 40          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 = 35
Detected Alarms           : LOS
```

Alarm	Expansion	Comment
LOS	Loss of signal	In IOS-XR <24.1.1 this is based on the RX power being below the sensitivity threshold, but possible for signal to still be up
LOF	Loss of frame	Not used for ZR/ZR+
LOM	Loss of multi-frame	Not used for ZR/ZR+
OOF	Out of frame	Not used for ZR/ZR+
OOM	Out of multi-frame	Not used for ZR/ZR+
IAE	Incoming alignment error	Not used for ZR/ZR+
BIAE	Backward incoming alignment error	Not used for ZR/ZR+
SF_BER	Signal fault due to high Bit-Error rate	Not used for ZR/ZR+
SD_BER	Signal degrade due to high Bit-Error rate	Not used for ZR/ZR+

Alarm	Expansion	Comment
BDI	Backward defect indication	Not used for ZR/ZR+
TIM	Trace identifier mismatch, OTN TTI mismatch	Not used for ZR/ZR+
FECMISMATCH	FEC Mismatch between endpoints	Not used for ZR/ZR+
FEC-UNC	Uncorrectable words	
FLEXO-GIDM	FlexO framing group ID mismatch	Not used for ZR/ZR+
FLEXO-MM	FlexO multi-frame mismatch	Not used for ZR/ZR+
FLEXO-LOM	FlexO framing loss of multi-frame	Common alarm
FLEXO-RDI	FlexO remote defect indicator	Not used for ZR/ZR+
FLEXO-LOF	FlexO loss of frame	Common alarm

Common Optical Alarms

```
%PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :OPTICS RX LOS LANE-0 :DECLARE :0/RP0/CPU0: Optics0/0/0/10
%PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :OPTICS RX LOL LANE-0 :DECLARE :0/RP0/CPU0: Optics0/0/0/10
%PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :OPTICS MEDIA RX CHROMATIC DISPERSION LOSS OF LOCK :DECLARE :0/RP0/CPU0: Optics0/0/0/10
%PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :OPTICS MEDIA RX LOSS OF FRAME :DECLARE :0/RP0/CPU0: Optics0/0/0/10
%PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR :OSNR :DECLARE :Optics0/0/0/20
```

Common Digital Alarms

```
%PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :OPTICS MEDIA FEC DEGRADED :DECLARE :0/RP0/CPU0: Optics0/0/0/10
%PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :OPTICS MEDIA FEC EXCESS DEGRADED :DECLARE :0/RP0/CPU0: Optics0/0/0/10
%PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :FLEXO-LOF :DECLARE :CoherentDSP0/0/0/10:
```

Common Alarms on Fiber Cut

The active alarms on the device can be shown using the "show alarms brief system active"

```

-----
-----
Active Alarms (Brief) for 0/RP0
-----
-----
Location          Severity      Group          Set Time
Description
-----
-----
0/RP0/CPU0        Major        Software        11/30/2023 12:11:06 PST
Optics0/0/0/0 - hw_optics: RX LOS LANE-0 ALARM
0/RP0/CPU0        Major        Software        11/30/2023 12:11:06 PST
Optics0/0/0/0 - hw_optics: RX POWER LANE-0 LOW ALARM
-----
-----
Conditions (Brief) for 0/RP0
-----
-----
Location          Severity      Group          Set Time
Description
-----
-----
0/0               Critical      OTN            11/30/2023 12:11:06 PST
CoherentDSP0/0/0/0 - Incoming Payload Signal Absent

```

IOS-XR Performance Measurement Engine and Threshold Crossing Alerts

Another class of flexible monitoring and alerting is available to the user using IOS-XR's Performance Measurement Engine feature.

Performance Measurement Engine Overview

Select metric data in IOS-XR is collected and stored at regular intervals for consumption by the user or management systems. The data by default is collected across three different time periods or "bins/buckets": 10s, 30s, 15m, and 24h. Within each period the min, max, and avg values during the period are stored. This can take some of the burden off the management system as it no longer needs to calculate these values.

The actual collection interval is dependent on the specific metric. As an example even though the storage bucket is 30 seconds, some data is collected at a faster cadence such as every 5 seconds. The "flex-bin" option uses a period of 10s and is not user configurable. The flex-bin period can be used to mimic the behavior of current/instantaneous PM.

Performance Measurement History

Data collected using the PM Engine is stored on the router for a number of time periods. The following table lists how many historical periods are stored for each time period.

Note the data will NOT be retained across a router reload

Period	History buckets	Max history
flex-bin (10s)	1	NA
30s	30	15m
15m	32	8h
24h	7	7d

Optics Controller PM Engine metrics

The following table lists all of the available optics controller PM metrics

Metric	Units	Definition
LBC	mA	Laser bias current
OPT	dBm in .01 increment	Optical power transmit
OPR	dBm in .01 increment	Optical power receive
CD	ps/nm	Chromatic dispersion
DGD	ps	Differential group delay
OSNR	dB	Optical signal to noise ratio
SOPMD	ps ²	Second order polarization mode dispersion
PDL	dB	Polarization dependent loss
PCR	rad/s	Polarization change rate
RX_SIG	dBm in .01 increments	Coherent signal power
FREQ_OFF	Mhz	Frequency offset, difference between expected and actual receive frequency
SNR	dB	Signal to noise ratio (not OSNR)

Coherent DSP Controller PM Engine metrics

Metric	Units	Definition
--------	-------	------------

Metric	Units	Definition
EC-BITS	NA	Number of error corrected bits in interval
UC-WORDS	NA	Uncorrectable words in interval
PreFEC BER	Rate	Pre-FEC bit error rate
PostFEC BER	Rate	Post-FEC bit error rate
Q	dB	Quality factor
Q_Margin	Quality margin	
Host-Intf-0-FEC-BER	Host side FEC it error rate	
Host-Intf-0-FEC-FERC	Host side FEC received corrected	

Note the last two metrics are associated with the electrical connection to the Ethernet PHY/NPU

Displaying and retrieving PM Engine Data

The data being collected by the PM Engine can be displayed using CLI commands or retrieved using the following YANG models and paths.

The CLI command to output the optics controller PM Engine data is the following:

```
show controllers optics 0/0/0/10 pm <current,history> <flex-bin,30-sec,15-min,24-hour> optics 1
```

Note the last "1" is the lane, which will always be 1 for DCO.

This results in the following output:

```
RP/0/RP0/CPU0:ron-poc-8201-1#show controllers optics 0/0/0/10 pm current
30-sec optics 1
Mon Feb 19 09:53:38.238 PST
```

Optics in the current interval [09:53:30 - 09:53:38 Mon Feb 19 2024]

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] : 273 273 273 0 NA
NO 524 NA NO OPT[dBm] : -9.98 -9.98 -9.98 -15.09 NA NO 5.00 NA YES OPR[dBm] : -2.92 -2.92 -2.91
5.00 5.00 YES 8.00 10.00 YES CD[ps/nm] : 2 2 3 -160000 NA YES 160000 NA YES DGD[ps] : 1.00 1.00 1.00
0.00 NA NO 80.00 NA NO SOPMD[ps^2] : 41.00 44.89 48.00 0.00 NA NO 2000.00 NA NO OSNR[dB] :
35.10 35.38 35.60 0.00 NA YES 40.00 NA YES PDL[dB] : 0.60 0.66 0.70 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] : -3.15 -3.15 -3.14 -10.00 -10.00
YES 1.00 5.00 YES FREQ_OFF[Mhz]: -14 -13 -12 -3600 NA NO 3600 NA NO SNR[dB] : 18.90 18.90 18.90
7.00 NA NO 100.00 NA NO

The CLI command to output the coherent DSP controller PM Engine data is the following:

```
show controllers coherentDSP 0/0/0/10 pm <current,history> <flex-bin,30-sec,15-min,24-hour> fec
```

This results in the following output:

```
RP/0/RP0/CPU0:ron-poc-8201-1#show controllers coherentDSP 0/0/0/10 pm
current 30-sec fec
Mon Feb 19 09:58:33.576 PST
```

g709 FEC in the current interval [09:58:30 - 09:58:33 Mon Feb 19 2024]

FEC current bucket type : Valid EC-BITS : 729415917 Threshold : 111484000000 TCA(enable) : YES UC-WORDS : 0 Threshold : 5 TCA(enable) : YES

TCA	Threshold	TCA	MIN	AVG	MAX	Threshold
(enable)	(max)	(enable)				(min)

PreFEC BER : 3.2E-04 3.2E-04 3.2E-04 0E-15 NO 0E-15 NO PostFEC BER : 0E-15 0E-15 0E-15 0E-15 NO
 0E-15 NO Q[dB] : 10.60 10.60 10.70 0.00 NO 0.00 NO Q_Margin[dB] : 4.10 4.10 4.10 5.00 YES 0.00 NO
 Host-Intf-0-FEC-BER : 0E-15 0E-15 0E-15 0E-15 NO 0E-15 NO Host-Intf-0-FEC-FERC : 0E-15 0E-15 0E-15
 0E-15 NO 0E-15 NO

YANG data models for XR PM Engine data retrieval

The following YANG model paths can be used to retrieve all of the data shown in the CLI commands. Interfaces such as NETCONF, gNMI/GRPC, or native Cisco MDT can be used to retrieve the data on demand, on change, or via periodic subscription.

Note the sensor path being used is dependent on whether retrieving current or historical data and the time period/bucket being used for retrieval. In the example given below the parent path is shown and then the path for retrieving the current dataset for the 30 second time period. "second30" can be replaced with minute15, hour24, or flex-bin.

YANG data model for current or historical PM Engine Optical PM data

```
Cisco-IOS-XR-pmengine-oper:performance-management/optics
Cisco-IOS-XR-pmengine-oper:performance-management-
history/global/periodic/optics-history/optics-port-histories
Cisco-IOS-XR-pmengine-oper:performance-management/optics/optics-
```

```
ports/optics-port/optics-current/optics-second30/optics-second30-
optics/optics-second30-optic
```

YANG data model for current or historical PM Engine Digital PM data

```
Cisco-IOS-XR-pmengine-oper:performance-management/otu
Cisco-IOS-XR-pmengine-oper:performance-management-
history/global/periodic/otu-history
Cisco-IOS-XR-pmengine-oper:performance-management/otu/otu-ports/otu-
port/otu-current/otu-second30/otu-second30fec/otu-second30fec
```

The data can also be retrieved using the following native YANG models and paths:

Optical PM Engine data native model path

```
Cisco-IOS-XR-pmengine-oper:performance-management/optics
```

Digital PM Engine data native model path

```
Cisco-IOS-XR-pmengine-oper:performance-management/otu/otu-ports/otu-port
```

The PM Engine data can also be retrieved via the following SNMP MIB

PM Threshold Crossing Alert Overview

User defined TCAs can be set for the metrics the PM infrastructure collects. The TCAs can be set for the min and max values collected. TCAs can be individually set for each time interval. TCA also includes the ability to report when a min or max TCA has been crossed. TCAs are not stored as system alarms, they are recorded in the main system log and also reported as syslog/SNMP traps if the system is configured to report those.

Keep in mind that a TCA alert will be generated every time interval the alert is configured for. If TCA reporting is enabled for a min RX power in the 30s bucket, an alert will be generated every 30s the RX power is below the min threshold.

Performance measurement configuration

Performance measurement for all available metrics is enabled by default on DCO for both the optics controller and coherentdsp controller. See the tables below for a list of all PM metrics collected for each.

Threshold crossing alert configuration

Most metrics collected by the PM infrastructure have pre-defined TCA min/max values, but those can be changed by the user to match their specific deployment.

TCA reporting is not enabled by default on the optics and coherentdsp controller except for the following exception: The coherentDSP controller has two TCAs set by the system, "EC-BITS" and "UC-WORDS." The

EC-BITS is a measurement of error corrected bits over the time interval and UC-WORDS is a measure of the uncorrectable words post-FEC. These are absolute values and not time-series metrics. The EC-BITS is set by the system based on the current rate of the DCO and should not be changed.

Reporting must be enabled for both min and max values for the metric and for specific time intervals.

Optical Controller TCA alert configuration example

This example shows configuring the TCAs via XR CLI, however the TCAs could also be configured using the appropriate YANG models.

The following configuration does the following:

- Enables TCA reporting for crossing the min threshold for opr,cd,osnr,rx-sig-pow
- Enables TCA reporting for crossing the max threshold for opt, opr, cd, osnr,rx-sig-pow
- Changes default optical power receive min threshold to 1 dBm (100*.01)
- Changes default optical power receive max threshold to 10 dBm (1000*.01)

```
controller Optics0/0/0/10
pm 30-sec optics report opr min-tca
pm 30-sec optics report cd min-tca
pm 30-sec optics report osnr min-tca
pm 30-sec optics report rx-sig-pow min-tca
pm 30-sec optics report opt max-tca
pm 30-sec optics report opr max-tca
pm 30-sec optics report cd max-tca
pm 30-sec optics report osnr max-tca
pm 30-sec optics report rx-sig-pow max-tca
pm 30-sec optics threshold opr-dbm min 100
pm 30-sec optics threshold opr-dbm max 1000
```

You can see below TCAs are now enabled for the appropriate parameters.

```
RP/0/RP0/CPU0:ron-poc-8201-1#show controllers optics 0/0/0/10 pm current
30-sec optics 1
Thu Feb 22 06:15:22.811 PST
```

Optics in the current interval [06:15:00 - 06:15:22 Thu Feb 22 2024]

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] : 273 273 273 0 NA
NO 524 NA NO OPT[dBm] : -10.01 -10.00 -9.96 -15.09 NA NO 5.00 NA YES OPR[dBm] : -2.96 -2.93 -2.91
5.00 5.00 YES 8.00 10.00 YES CD[ps/nm] : 2 3 4 -160000 NA YES 160000 NA YES DGD[ps] : 1.00 1.00 1.00
0.00 NA NO 80.00 NA NO SOPMD[ps^2] : 43.00 51.22 59.00 0.00 NA NO 2000.00 NA NO OSNR[dB] :
35.20 35.40 35.60 0.00 NA YES 40.00 NA YES PDL[dB] : 0.60 0.62 0.70 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] : -3.14 -3.14 -3.13 -10.00 -10.00

YES 1.00 5.00 YES FREQ_OFF[Mhz]: -12 -5 -2 -3600 NA NO 3600 NA NO SNR[dB] : 18.80 18.83 18.90 7.00
NA NO 100.00 NA NO

CoherentDSP (Digital) Controller TCA alert configuration example

This example shows configuring the TCAs via XR CLI, however the TCAs could also be configured using the appropriate YANG models.

The following configuration does the following:

- Enables TCA reporting for crossing the min threshold for Q-margin
- Changes default Q-margin min threshold to 5

```
controller CoherentDSP0/0/0/10
pm 30-sec fec report Q-margin min-tca enable
pm 30-sec fec threshold Q-margin min 500
```

You can see below TCA is now enabled for the min threshold for the 30-second bucket.

```
RP/0/RP0/CPU0:ron-poc-8201-1#show controllers coherentDSP 0/0/0/10 pm
current 30-sec fec
Thu Feb 22 06:03:27.771 PST
```

g709 FEC in the current interval [06:03:00 - 06:03:27 Thu Feb 22 2024]

FEC current bucket type : Valid EC-BITS : 4326181146 Threshold : 111484000000 TCA(enable) : YES UC-WORDS : 0 Threshold : 5 TCA(enable) : YES

TCA	Threshold	TCA	MIN	AVG	MAX	Threshold
(enable)	(max)	(enable)				(min)

PreFEC BER : 2.9E-04 3.1E-04 3.2E-04 0E-15 NO 0E-15 NO PostFEC BER : 0E-15 0E-15 0E-15 0E-15 NO
0E-15 NO Q[dB] : 10.60 10.63 10.70 0.00 NO 0.00 NO Q_Margin[dB] : 4.10 4.10 4.10 5.00 YES 0.00 NO
Host-Intf-0-FEC-BER : 0E-15 8.3E-14 2.3E-10 0E-15 NO 0E-15 NO Host-Intf-0-FEC-FERC : 0E-15 0E-15
0E-15 0E-15 NO 0E-15 NO

TCA alert message example

The following will be shown in the system logs when a TCA is crossed. This example is when the Q-Margin has dropped below the min value of 5.0. All PM TCA alarms will use the L1-PMENGINE-4-TCA nomenclature when being logged.

```
RP/0/RP0/CPU0:2024 Feb  5 08:07:30.185 PST: optics_driver[192]: %L1-
PMENGINE-4-TCA : Port CoherentDSP0/0/0/10 reports FEC Q-MARGIN-MIN(NE) PM
TCA with current value 4.10, threshold 5.00 in current 30-sec interval
window
```

Monitoring DCO using Cisco Network Automation

Crosswork Hierarchical Controller

Crosswork Hierarchical Controller or HCO has capabilities for monitoring Routed Optical Networking PM for both the IP and Optical Line System layers in the same tool together. HCO's Link Assurance application presents and end to end multi-layer view of circuits using DCO endpoints and overlays relevant PM data on the view.

Link Assurance with PM Data

Link Assurance

Inspect Links

Settings

Select Links For In-Depth Analysis

Define Valid Links For Inspection By:

☐ Specific link(s) / underlay link(s)
 ☒ Tags
 ☐ Device(s) in 1 of the endpoints
 ☐ Device(s) in both endpoints

Add Tag

Links UnderlayType is "RON "

Name

Type

Status

10 ITEMS

100.21.22.0 to 100.21.22.1	L3 Logical	UP
102.20.20.20 to 102.20.20.21	L3 Logical	DOWN
21.1.9.0 to 21.1.9.1	L3 Logical	UP
100.20.21.20 to 100.20.21.21	L3 Logical	UP
100.20.26.18 to 100.20.26.19	L3 Logical	UP
100.21.40.0 to 100.21.40.1	L3 Logical	UP
80.80.80.1 to 80.80.80.0	L3 Logical	UP

100.20.26.18 to 100.20.26.19 L3 Logical Link

LOG

PHY

ETH

ZRC

ZRM

OCH

NMC

MC

MC

OMS

OTS

Summary

Performance

Events

Name	Layer	Admin Status	Operational Status	Endpoint A	Endpoint Z
CoherentDSP0/0/0/18...	ZR Media	UP	UP	ron-8201-1	ron-ncs57b1-1

Port A Pre-FEC BER	Port Z Pre-FEC BER	Port A Post-FEC BER	Port Z Post-FEC BER	Port A Q Factor [db]	Port Z Q Factor [db]
Min: 4.8000e-03	Min: 1.7000e-03	Min: 0.0000e+00	Min: 0.0000e+00	Min: 8.20	Min:
Average: 4.9000e-03	Average: 1.8000e-03	Average: 0.0000e+00	Average: 0.0000e+00	Average: 8.20	Average:
Max: 5.0000e-03	Max: 1.9000e-03	Max: 0.0000e+00	Max: 0.0000e+00	Max: 8.20	Max:

HCO's Performance application allows the user to explore the PM data at a device and interface level in a tabular format. The user can query based on a device or set of devices. The DCO data is

Crosswork Network Controller Device Level Monitoring

The Health Insights application within CNC can be used to monitor any available telemetry sensor paths including the Optical and Digital PMs we've discussed. Health Insights can also be configured to alert based on different criteria such as deviations in measured valued or absolute value changes. The Health Insights documentation located here can be used as a reference:

https://www.cisco.com/c/en/us/td/docs/cloud-systems-management/crosswork-cahi/6-0/User-Guide/cisco-crosswork-CLNA-6-0-user-guide/m_healthinsights600.html

Key Performance Indicators and KPI Profiles

A KPI in Health Insights is used to monitor a specific telemetry sensor PM attribute. In YANG these refer to the YANG operational mode leaf values.

A set of KPIs are grouped together as part of a KPI Profile. This allows the user to have a set of KPIs applied to a set of devices without having to manage per-device individual KPIs. When a KPI is added or removed from an active profile, telemetry collection will start for the devices using the KPI profile.

Health insights includes a built-in set of pre-defined KPIs under the "Layer1-Optics" category. These sensor paths can be used to monitor both DCO and gray optics.

L1 Optics Available PM Metrics

KPI Name	Category	Description	Linked Alert Severity
<input type="checkbox"/> Layer 1 optical alarms	Layer1-Optics	Monitors per-port optical alarms	
<input type="checkbox"/> Layer 1 optical errors	Layer1-Optics	Monitors per-port Layer 1 errors; generates al...	
<input type="checkbox"/> Layer 1 optical FEC errors	Layer1-Optics	Monitors per-port optical FEC errors; generat...	
<input type="checkbox"/> Layer 1 optical power	Layer1-Optics	Monitors per-port optical power; generates al...	
<input type="checkbox"/> Layer 1 optical temperature	Layer1-Optics	Monitors per-port optical temperature; gener...	
<input type="checkbox"/> Layer 1 optical voltage	Layer1-Optics	Monitors per-port optical voltage; generates ...	

L1 Optics KPI Profile

Name	Devices Enabled	Description
<input checked="" type="radio"/> L1_OPTICS	1	
<input type="radio"/> RON_METRICS	10	

L1_OPTICS

Description : -
Destination : Not Found ⓘ Server Type : - Topic : -

KPI On Profile

Layer 1 optical alarms

Alerts ☒ ON
Cadence(sec) 300
Alert Frequency 1
Alert Type No Operati..
Monitored Interfaces N/A

Edit Details

Layer 1 optical FEC errors

Alerts ☒ ON
Cadence(sec) 60
Alert Frequency 1
Alert Type Two Level..
Monitored Interfaces All

Edit Details

Layer 1 optical power

Alerts ☒ ON
Cadence(sec) 60
Alert Frequency 1
Alert Type alarm_stat..
Monitored Interfaces N/A

Edit Details

Layer 1 optical temperature

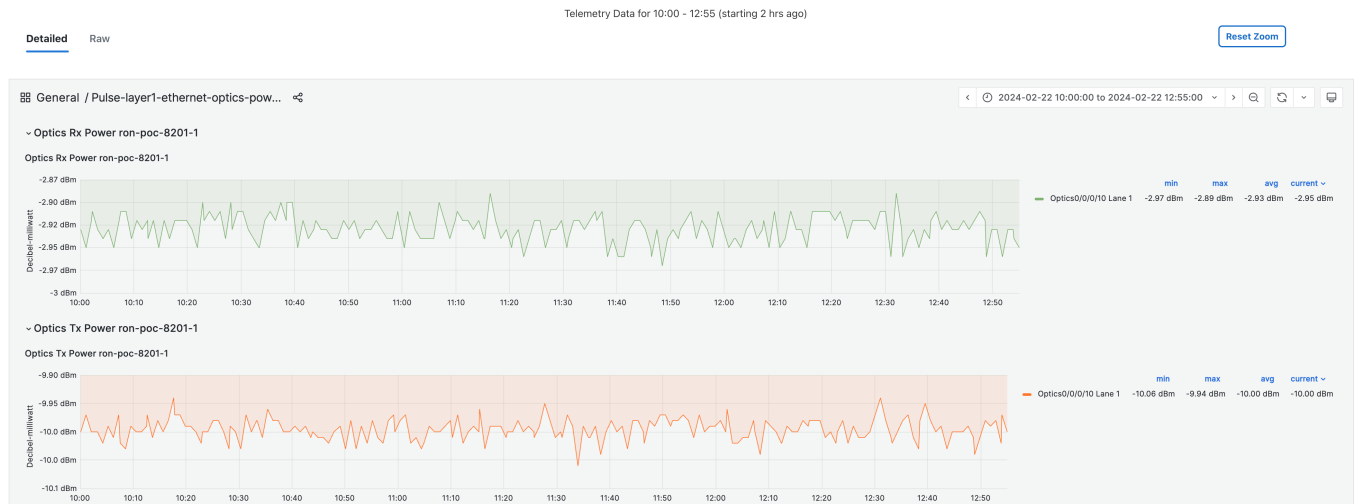
Alerts ☒ ON
Cadence(sec) 60
Alert Frequency 1
Alert Type alarm_stat..
Monitored Interfaces N/A

Edit Details

Alert All ☒ + Alert Group

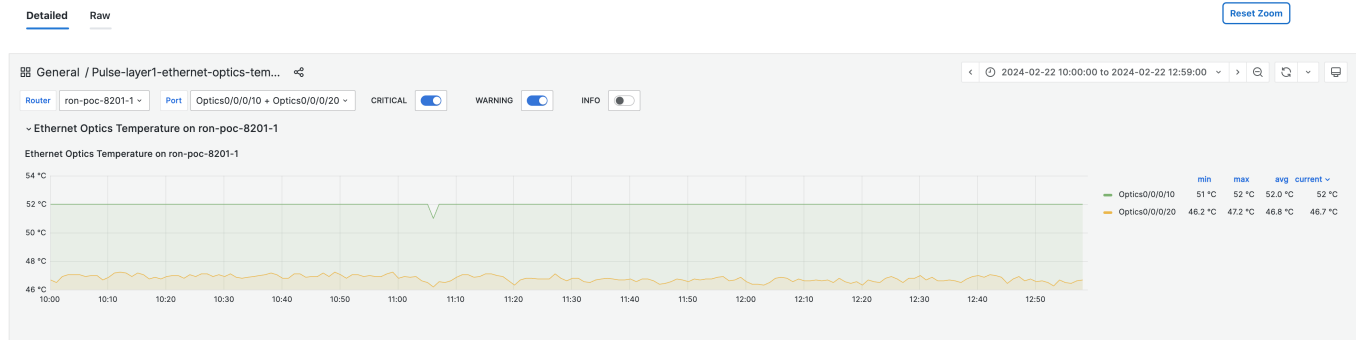
L1 optics power data

Layer 1 optical power - Last 72 Hrs



L1 optics temperature data

Layer 1 optical temperature - Last 72 Hrs



Custom KPIs and KPI Profiles

Health Insights allows the user to customize the KPIs being used and group them into KPI Profiles specific to the application.

Here we see a KPI Profile being used to monitor RX/TX Power and Q-Margin which can then be applied to devices with DCO.

KPI Profiles

Dashboard Topology Network Automation Performance Alerts Services & Traffic Engineering Device Management Alerts Administration

Total 2

RON_METRICS

Description : - Destination : Not Found Server Type : - Topic : -

#KPIs on Profile 2 Enabled Devices 10

Alert All ☒ [+ Alert Group](#)

KPI On Profile

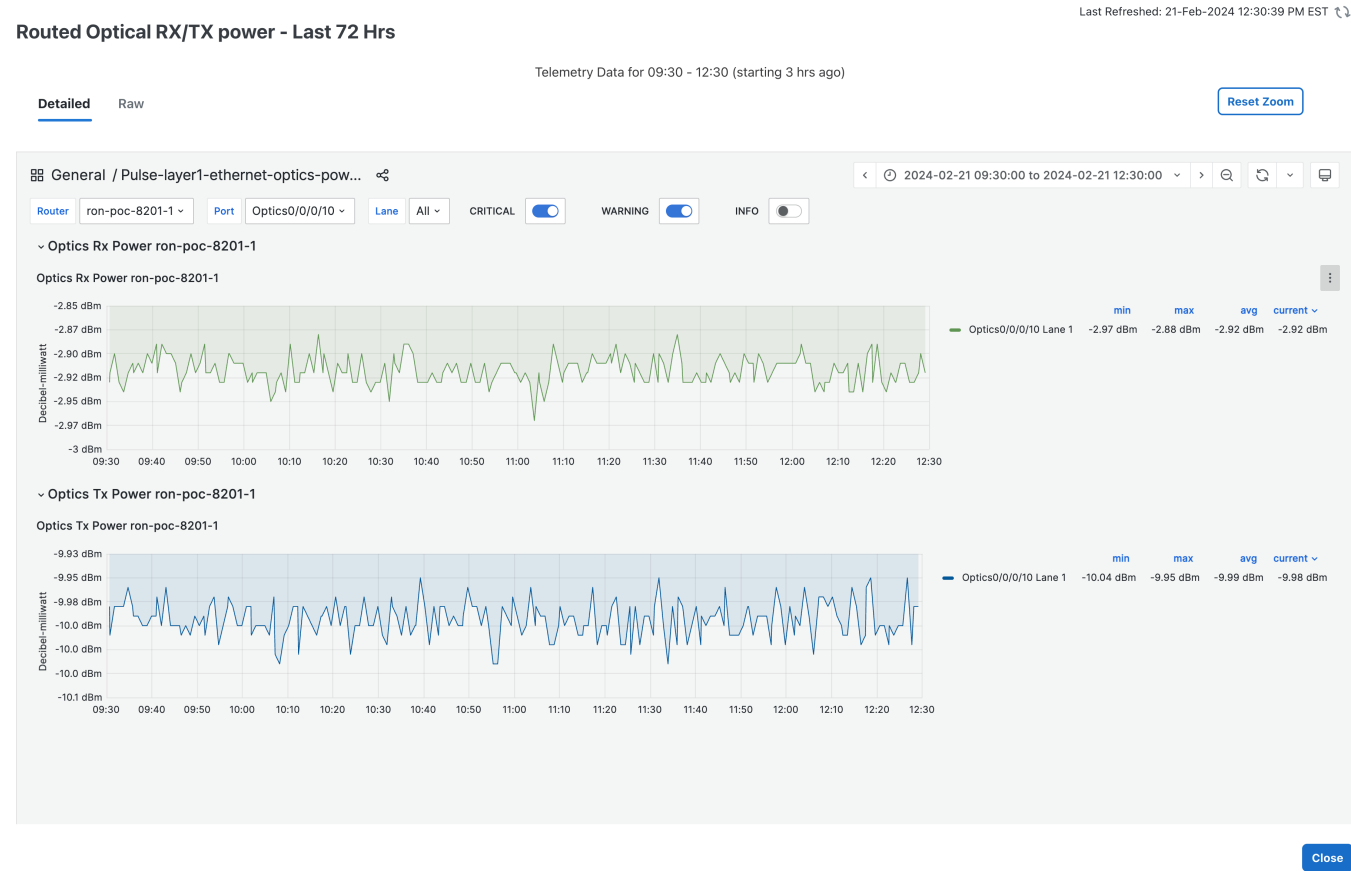
Routed Optical RX/TX power

Alerts ☒ ON Cadence(sec) 60 Alert Frequency 1 Alert Type alarm_stat.. Monitored Interfaces N/A [Edit Details](#)

Routed Optical Q-Factor

Alerts ☒ ON Cadence(sec) 60 Alert Frequency 1 Alert Type alarm_stat.. Monitored Interfaces N/A [Edit Details](#)

KPI graph being used specifically for DCO monitoring. Any sensor path leaf returning data as numeric data can be graphed. If the data is non-numeric it cannot be graphed but can be shown in a tabular format.



The following shows alerts triggered by our custom KPIs. A critical alarm is raised when the Q-Factor of the DCO drops below .5 for a specific amount of time, and clears when the Q-Factor returns to a nominal value.

Alert Dashboard
ron optics afactor

Enabled Devices
Summary - past 1h

Status	Device Name	Severity Dis...	Actions	Severity	Device	Message
	poc					
Summary						
✓	ron-poc-57b1-1		↗	ℹ	ron-poc-8201-1	INFO: CoherentDSP0/0/0/10 Optics QFactor: 10.60 has been normal for 300.00 seconds. Threshold: 2.00.
✓	ron-poc-8201-1		↗	ℹ	ron-poc-8201-2	INFO: CoherentDSP0/0/0/10 Optics QFactor: 10.50 has been normal for 300.00 seconds. Threshold: 2.00.
✓	ron-poc-8201-2		↗	✖	ron-poc-8201-1	CRITICAL: CoherentDSP0/0/0/10 Optics QFactor: 0.00 has been at a CRITICAL level for 119.98 seconds! Th
				✖	ron-poc-8201-2	CRITICAL: CoherentDSP0/0/0/10 Optics QFactor: 0.00 has been at a CRITICAL level for 60.00 seconds! Thr

Additional Resources

Routed Optical Networking Design Guide

<https://xrdocs.io/design/blogs/latest-routed-optical-networking-hld>

Routed Optical Networking Landing Page

<https://www.cisco.com/site/us/en/solutions/routed-optical-networking/index.html>

Crosswork Network Automation Home

<https://www.cisco.com/c/en/us/products/collateral/cloud-systems-management/crosswork-hierarchical-controller/solution-overview-c22-744695.html>

Crosswork Network Controller

<https://www.cisco.com/c/en/us/products/cloud-systems-management/crosswork-network-controller/index.html>

Crosswork Hierarchical Controller

<https://www.cisco.com/c/en/us/products/cloud-systems-management/crosswork-hierarchical-controller/index.html>