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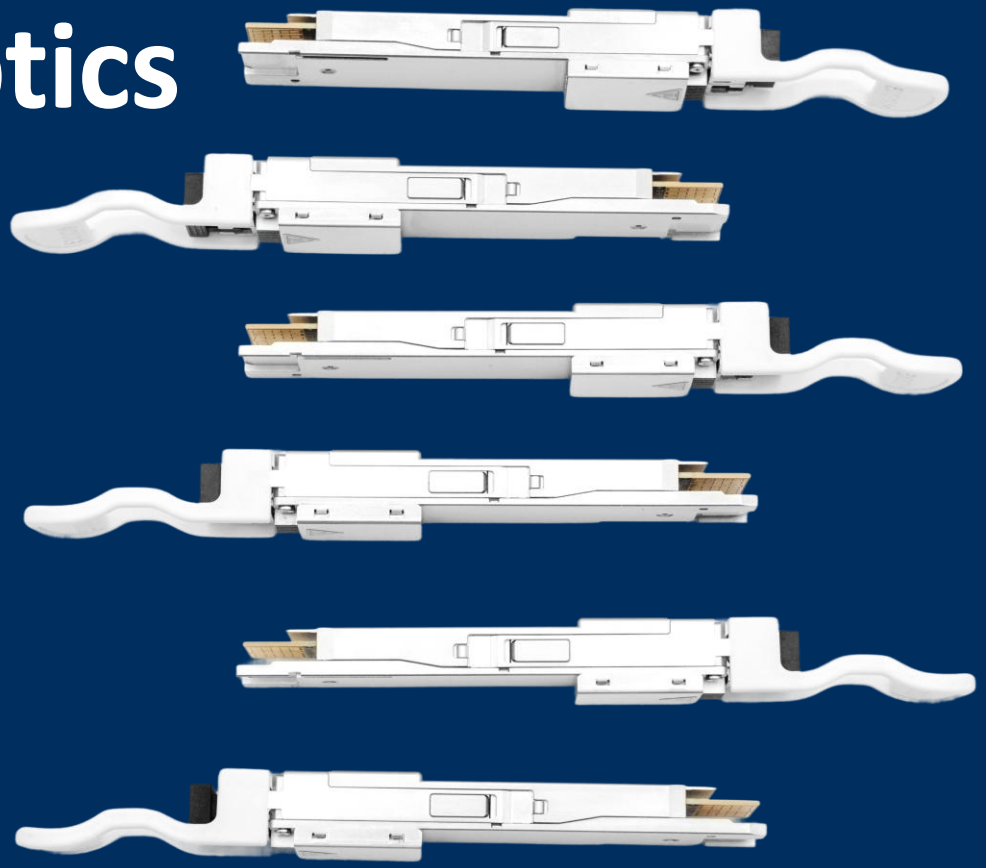
Demystifying Coherent Optics for Network Professionals



Practical Use Cases and configuration tips for 100G, 400G and 800G coherent plugs

Marcin Bała | CTO
Salumanus

What is a Coherent Transceiver?

- **Brief introduction to coherent technology**
  Coherent technology is an advanced method for transmitting data over fiber using amplitude, phase and polarization of light. Coherent plugs combines a tunable laser, coherent receiver, digital signal processor (DSP), and FEC engine in a single compact form factor like QSFP-DD.

- **How it differs from traditional (IMDD) optics?**
  IMDD (Intensity Modulation Direct Detection) uses only the light's amplitude to transmit data, making it simple, cost-effective, and suitable for short distances.

- **What standards are behind coherent transceivers?**
  OIF 400ZR, OIF 800ZR, OpenZR+, OpenROADM, CMIS, C-CMIS

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What types are available on the Market today?

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- **QSFP28 100G** with support for 100GbE or/and OTU4
  - 0dBm output power
  - -8dBm output power
- **QSFP-DD 400G**
  - 400ZR with support for 400GbE & 4x100GbE on host side, TX power -10dBm
  - OpenZR+ with support for 400GbE, Nx200GbE, Nx100GbE, TX power -10dBm/0dBm
  - ZR++ with support for 400GbE, TX power 0dBm
- **QSFP-DD 800G**
  - ZR supporting 800GbE, 2x400GbE, 4x200GbE, 8x100GbE on host side, TX power -8dBm
  - ZR+ supporting 800GbE, 2x400GbE, 4x200GbE, 8x100GbE on host side, TX power -7dBm/0dBm

What shoud I know about host & media side applications?

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Host Side	Datapath					Media Side
Host Interface	Host Map/Demap	MUX/DMUX	Media Framing	FEC Encode/Decode	Modulation	Media Interface
1 x 400GBASE-R	1 x 400ZR.ts		400ZR	OFEC	16QAM	ZR400-OFEC-16QAM
2 x 200GBASE-R	2 x 200ZR.ts					
4 x 100GBASE-R	4 x 100ZR.ts					
1 x 400GBASE-R	1 x 400ZR.ts		400ZR	OFEC	8QAM	ZR400-OFEC-8QAM
2 x 200GBASE-R	2 x 200ZR.ts					
4 x 100GBASE-R	4 x 100ZR.ts					
3 x 100GBASE-R	3 x 100ZR.ts		ZR300	OFEC	8QAM	ZR300-OFEC-8QAM
1 x 200GBASE-R	1 x 200ZR.ts		ZR200	OFEC	QPSK	ZR200-OFEC-QPSK
2 x 100GBASE-R	2 x 100ZR.ts					
1 x 100GBASE-R	1 x 100ZR.ts		ZR100	OFEC	QPSK	ZR100-OFEC-QPSK

Source: https://openzrplus.org/

What shoud I know about host & media side applications?

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		Instances by Operational Mode Data Rate		
Client Type	Chip-to-Module interface	800G	600G	400G
100GBASE-R	100GAUI-1	8x	6x	4x
200GBASE-R	200GAUI-2	4x	3x	2x
400GBASE-R	400GAUI-4	2x	N/A	1x
800GBASE-R	800GAUI-8	1x	N/A	N/A

Description	Modulation	FEC	Symbol Rate (GBd)
OIF 800ZR, DWDM, amplified	16QAM	O-FEC	118,2
OpenZR+ ZR800-OFEC-16QAM	16QAM	O-FEC	118,2
OpenZR+ ZR600-OFEC-8QAM	8QAM	O-FEC	118,2
OpenZR+ ZR400-OFEC-QPSK	QPSK	O-FEC	118,2

Source: https://openzrplus.org/ & https://www.oiforum.com/

What shoud I know about host & media side applications?

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- **Step 1** – link requirements
  Link length? Dark fiber or DWDM? What is your channel spacing? OSNR level? Throughput?

- **Step 2** – select right transceivers
  Example: 200km, DWDM, 50GHZ, 19dB OSNR, 100GbE
  Option 1 -> QSFP28 100ZR
  Option 2 -> QSFP-DD OpenZR+

- **Step 3** – match application to link budget
  Option 1 -> for QSFP28 it could work with 100GbE on 50GHz grid
  Option 2 -> for QSFP-DD OpenZR+ we could select ZR100-OFEC-QPSK, and 1x100GbE on host side*
  * some vendors support 200G, OFEC, 16QAM and 2x100GbE or 1x200GbE on host side

- **Step 4** – configure transceivers
  Detailed guide on next slides ☺

Understanding basic optical parameters

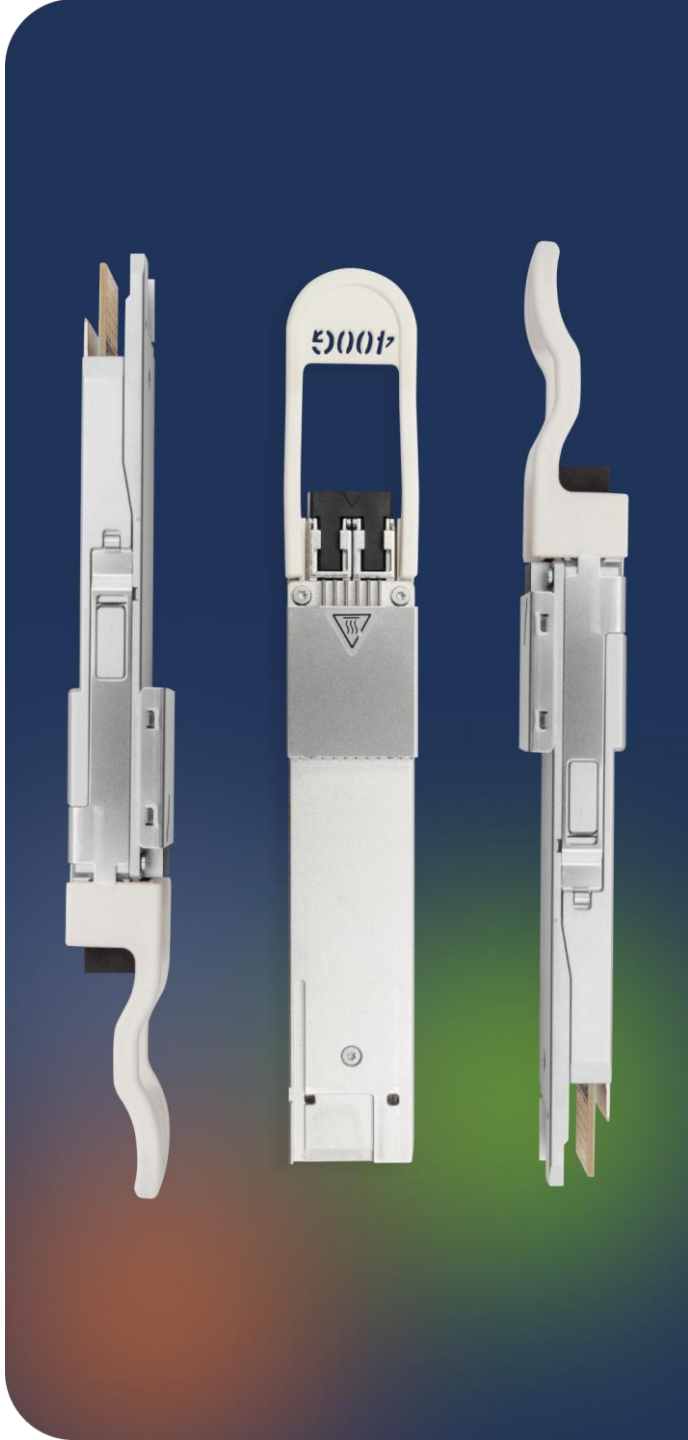
TX Power

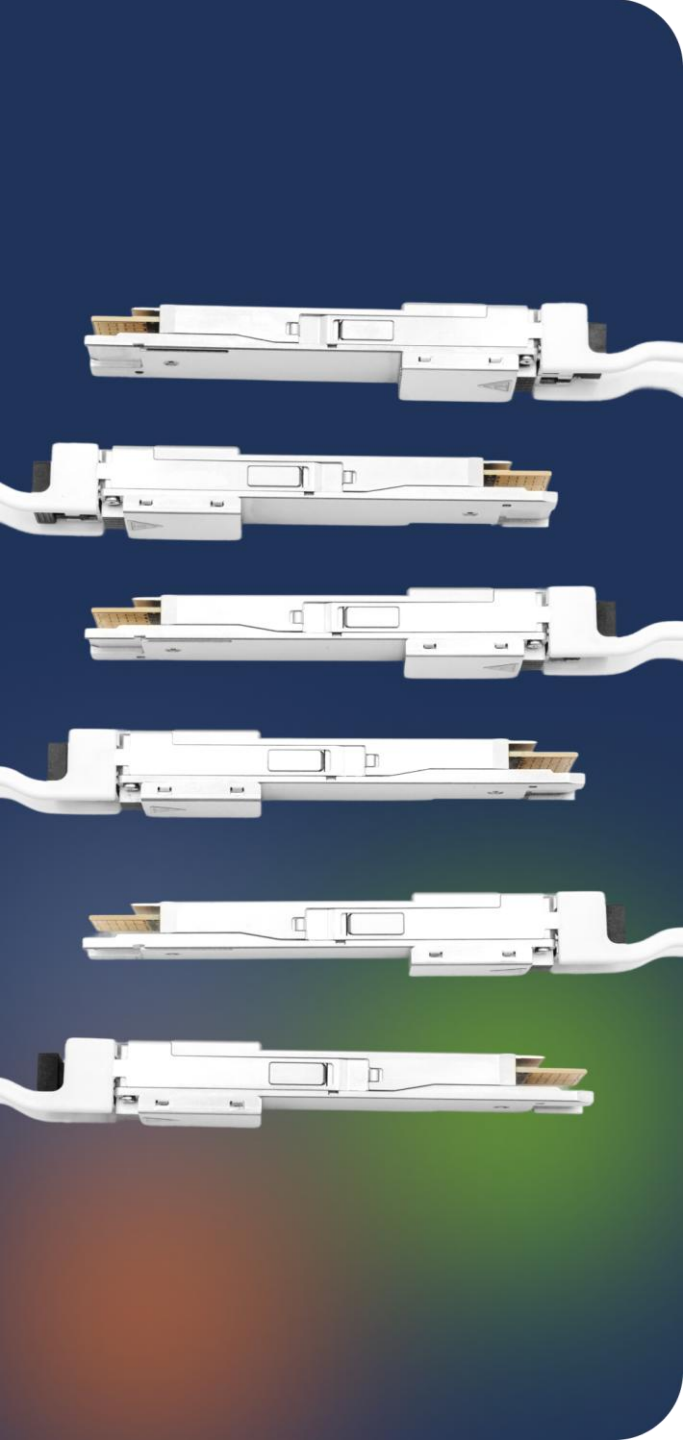
- **What is it?**
  The amount of optical power emitted by the transceiver onto the fiber
- **Why is it important?**
  It determines whether the signal can travel the required distance and remain detectable on the receiver side.
- **Unit:** *dBm (decibel-milliwatts)*
- **Typical range:** *-10 dBm to +1 dBm*
  depending on the module type and mode
- **Note:** *Insufficient TX power may result in poor signal quality*

Understanding basic optical parameters

RX Power

- **What is it?**
  The amount of optical power received by the transceiver
- **Why is it important?**
  It shows if the incoming signal is strong enough for successful decoding
- **Unit:** *dBm*
- **Typical value:** *0 dBm to -30 dBm*
- **Note:** *If RX power is too low → errors or link down*
  If RX power is too high → receiver saturation





Understanding basic optical parameters

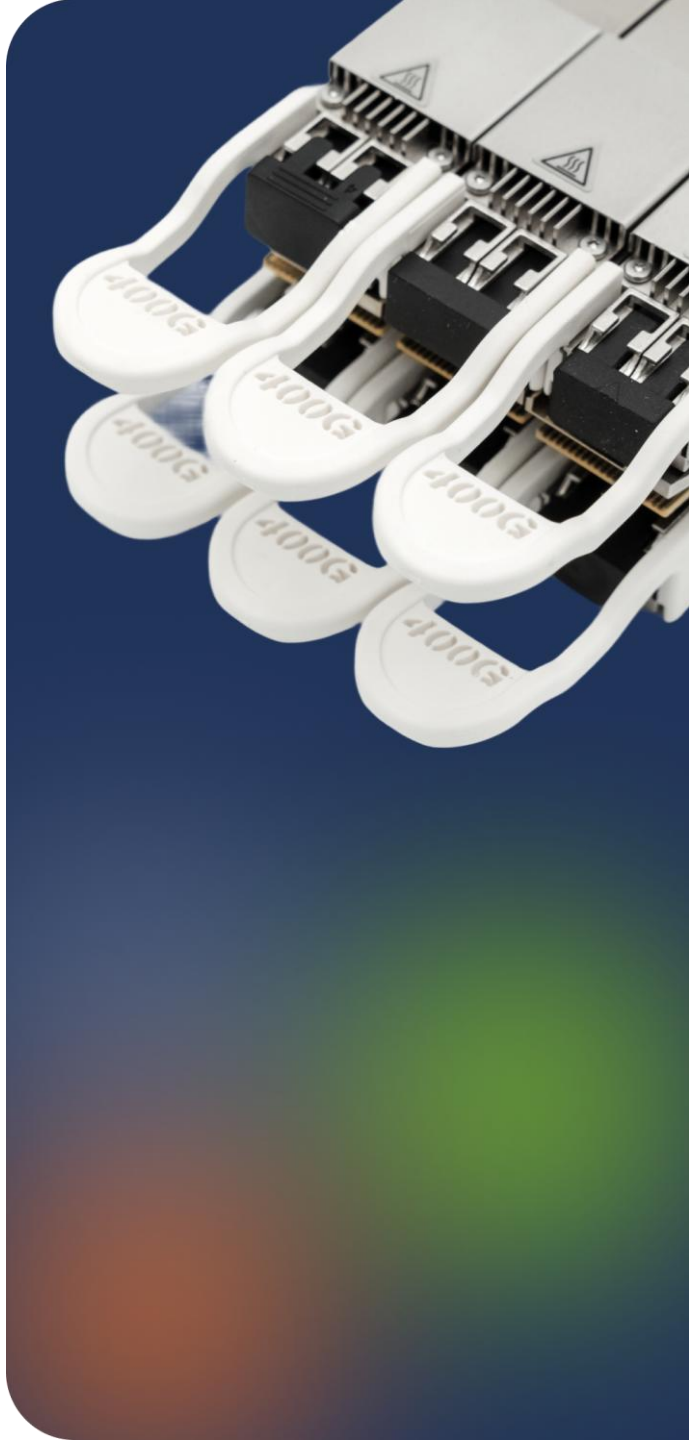
OSNR

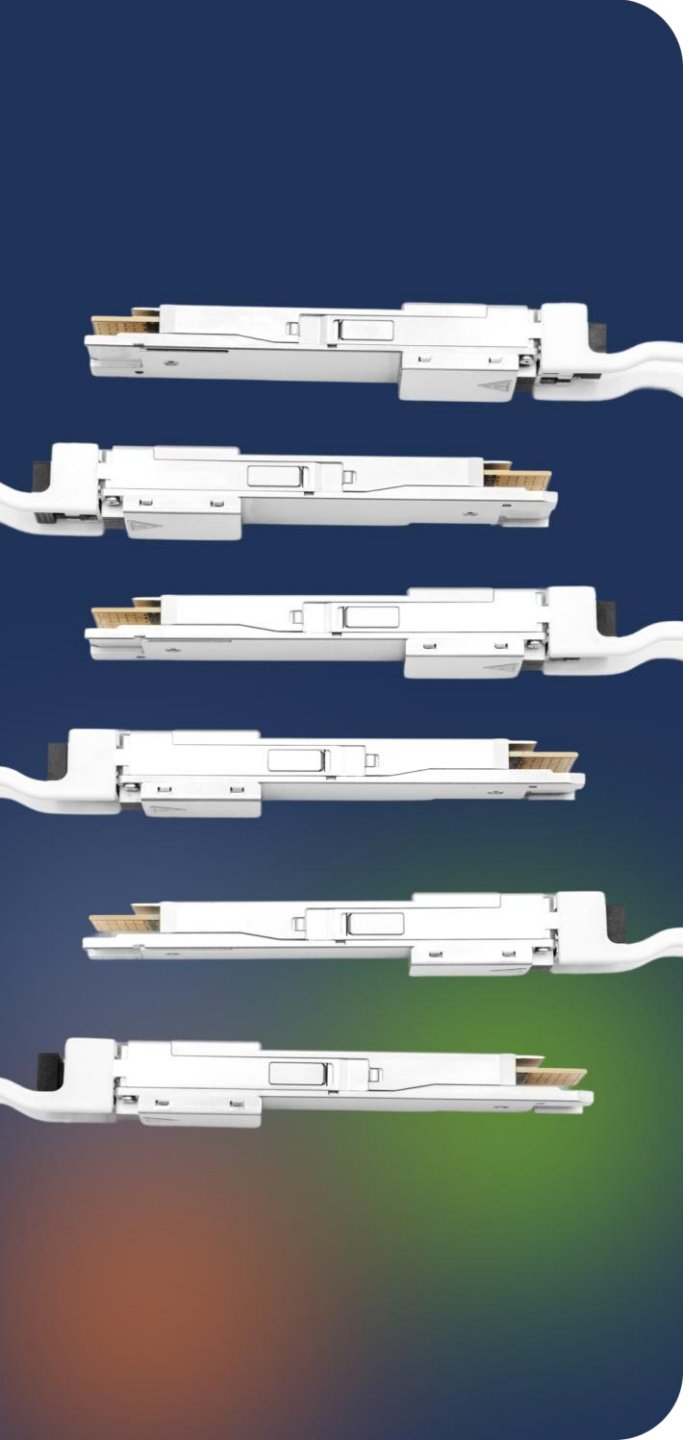
- **What is it?**
  The ratio of the signal power to the noise power in the optical channel
- **Why is it important?**
  OSNR is a critical metric for coherent optics, as it directly impacts the bit error rate (BER)
- **Unit:** *dB*
- **Typical value:** *400G 16QAM: ~24 dB*
  200G QPSK: ~16 dB

Understanding basic optical parameters

Q-factor

- What is it?
  A measure of how distinguishable the optical signal is from noise and distortion.
- Why is it important?
  Higher Q-factor = cleaner signal, lower BER.
- Unit: *dB*
- Interpretation: *> 8 dB = Good*
  6.5–8 dB = Monitor
  < 6.5 dB = Risk of link failure





Understanding basic optical parameters

Q-margin

- **What is it?**
  The difference between measured Q-factor and the minimum required Q.
- **Why is it important?**
  It reflects how much "headroom" you have before errors start appearing.
- **Example:**

  Required Q = 6.5 dB
  Measured Q = 9.0 dB
  → Q-margin = 2.5 dB

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Understanding basic optical parameters

```
root@QFX5220-32CD> show interfaces transport pm optics all et-0/0/14
Physical interface: et-0/0/14, SNMP ifIndex 569
  Current: 2015-01-01,03:15:00 - current
  Suspect Flag: True
  Reason: New Object
```

PM	CURRENT	MIN	MAX	AVG	THRESHOLD (MIN)	THRESHOLD (MAX)	TCA-ENABLED (MIN)	TCA-ENABLED (MAX)	TCA-RAISED (MIN)	TCA-RAISED (MAX)
Module temperature(Celsius)	53	23	63	53	0	73	No	No	No	No
Pre-FEC BER	9.14e-3	0.00e+0	9.45e-3	7.85e-3	0	9.00e-3	NA	No	NA	No
Uncorrected FER	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0	0.00e+0	NA	No	NA	No
SNR(dB)	14.4	0.0	14.6	12.8	15.0	0	No	NA	No	NA
Tx power(dBm)	-0.04	-40.00	0.04	-0.50	-16.00	0.00	No	No	No	No
Rx total power(dBm)	-23.77	-33.98	-23.37	-24.12	-21.00	2.00	No	No	No	No
Rx signal power(dBm)	-24.28	-24.71	55.73	45.69	-13.50	0.00	No	No	No	No
Carrier frequency offset(MHz)	0.0	0.0	0.0	0.0	-3600.0	3600.0	No	No	No	No
Chromatic dispersion(ps/nm)	156.0	0.0	156.0	138.5	0	0	NA	NA	NA	NA
Differential group delay(ps)	1.3	0.0	1.8	1.4	0	0	NA	NA	NA	NA
SOPMD(ps^2)	38.7	0.00	46.4	34.8	0	0	NA	NA	NA	NA
PDL(dB)	0.3	0.0	0.4	0.2	0	0	NA	NA	NA	NA
OSNR(dB)	24.2	0.0	29.7	21.9	0	0	NA	NA	NA	NA

```
  Current Day: 2015-01-01,00:00:00 UTC - current
```

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Setting up the first link

Basic commands:

show interfaces diagnostics optics-applications et-0/0/0

This command provides detailed optical module information, including supported applications

set interface et-0/0/0:0 optics-options application mediaid 70 hostid 17

This command set both line and host side application

set interfaces et-0/0/0:0 optics-options tx-power -10

This command set TX output power

set interfaces et-0/0/0:0 optics-options wavelength 1552.52

This command set wavelength

Additional commands:

set interface et-0/0/0 number-of-sub-ports 4 speed 100g
run show interfaces et-0/0/0
run show interfaces diagnostics optics et-0/0/0
run show interfaces transport pm et-0/0/0

Juniper

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Setting up the first link

Basic commands:

configure port 1/1/1 ethernet mode 400G
configure port 1/1/1 transceiver digital-coherent-optics true

configure port 1/1/1 optics-profile 400ZR
configure port 1/1/1 dwdm coherent compatibility long-haul

This command sets both line and host side application

configure port 1/1/1 dwdm coherent target-power 0

This command sets TX output power

configure port 1/1/1 dwdm frequency 194400000

This command sets wavelength

Additional commands:

configure port 1/1/1 connector breakout c1-400g
show port 1/1/c1 detail
info flat | match [port number]

Nokia

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Setting up the first link

Basic commands:

configure terminal
interface ethernet 1/1

zrp-optics fec oFEC muxponder 1x400 modulation 16QAM dac-rate 1x1
This command sets both line and host side application

configure port 1/1/1 tx-power 0
This command sets TX output power

zrp-optics dwdm-carrier wavelength 1552.52
This command sets wavelength

Additional commands:

interface breakout module 1 port 1 map 100g-4x-pam4
show port 1/1/1 optics detail
show port 1/1/1 statistics
show port 1/1/1 performance

Cisco

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Setting up the first link

Basic commands:

show qsfp-dd [port number] advertisement applications

This command provides detailed optical module information, including supported applications

qsfp-dd [port number]
application 8

This command sets both line and host side application

laser channel 20
laser fine-tune-freq 2.000
laser grid 50
laser output-power -1.00

This command sets TX output power & set wavelength

Additional commands:

show qsfp-dd [port number] eeprom
show interface brief
show running-config interface
show qsfp-dd [port number] state
show qsfp-dd [port number] laser status

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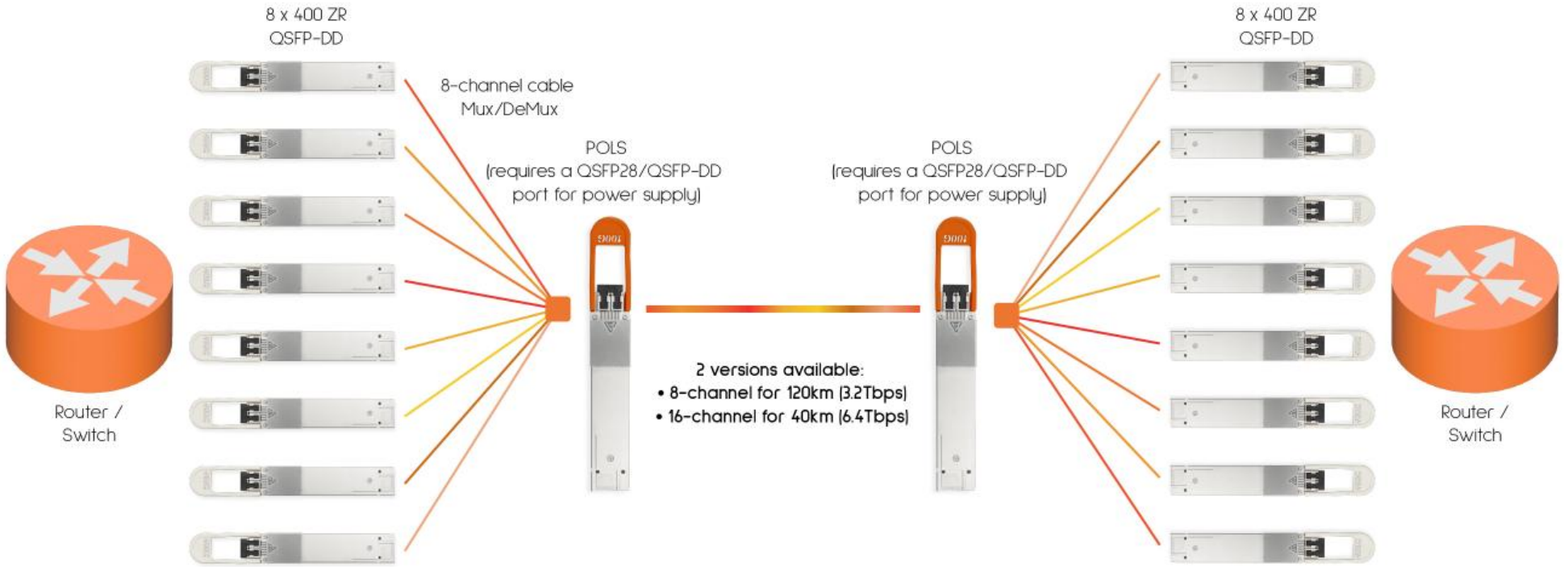
What do I need to know about the optical path?



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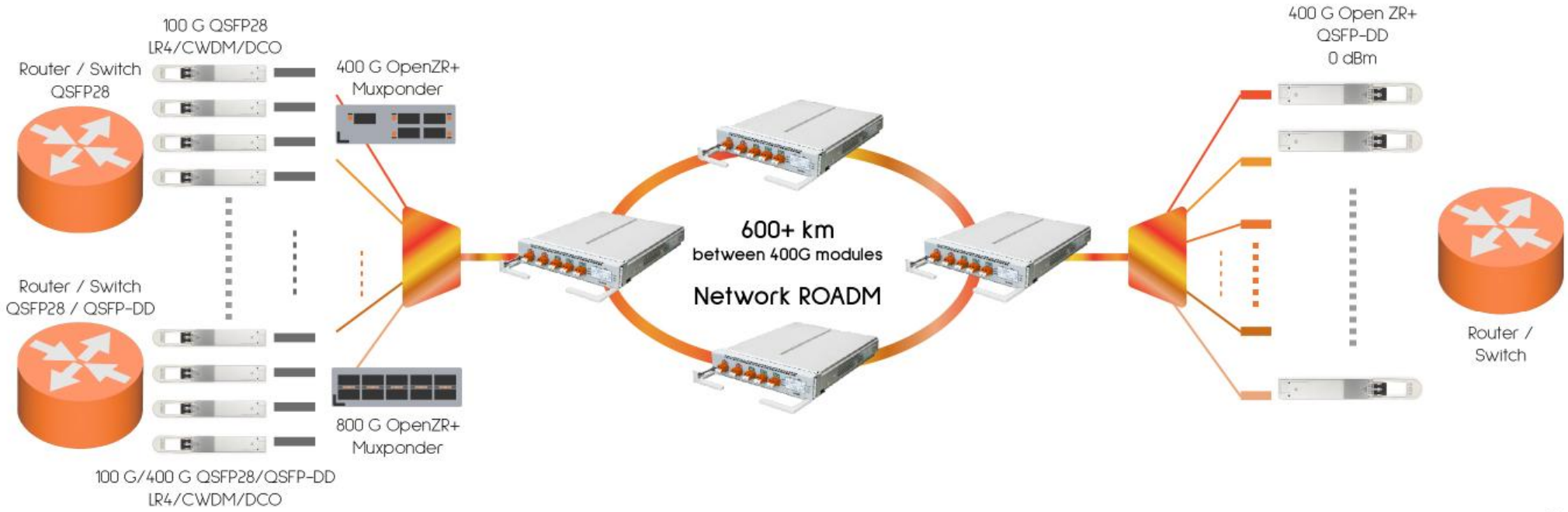
What do I need to know about the optical path?



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What do I need to know about the optical path?

- **Example 1, my path OSNR is 21dB, grid 100GHz**
  - Option 1 – I could still use standard transceivers, but need to set it up to ZR300-oFEC-8QAM and 3x100GbE (switch needs to be set to 3 sub-interfaces)
  - Option 2 – I could use ZR++ transceivers, which support also ZR400-oFEC-8QAM, this will allow me to use 400GbE mode on the host side
- **Example 2, my path OSNR is 18dB, flex-grid**
  - Option 1 – I could still use standard transceivers, but need to set it up to ZR200-oFEC-QPSK and 2x100GbE (switch need to be set to 2 sub-interfaces)
  - Option 2 – I could use 800G transceivers, which support ZR400-oFEC-QPSK, this will allow me to use on host side 400GbE mode (it will require passband 150GHz)

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What do I need to know about the optical path?

- **Step 1** – RX power
  Different operation modes require different RX power levels
- **Step 2** – channel
  Coherent receiver is reading only one wavelength
- **Step 3** – OSRN/Q-factor/Q-margin
  To make link stable, we need to be within range
- **Step 4** – host side application
  Both end host side applications need to be same
- **Step 5** – …
  LINK UP ☺

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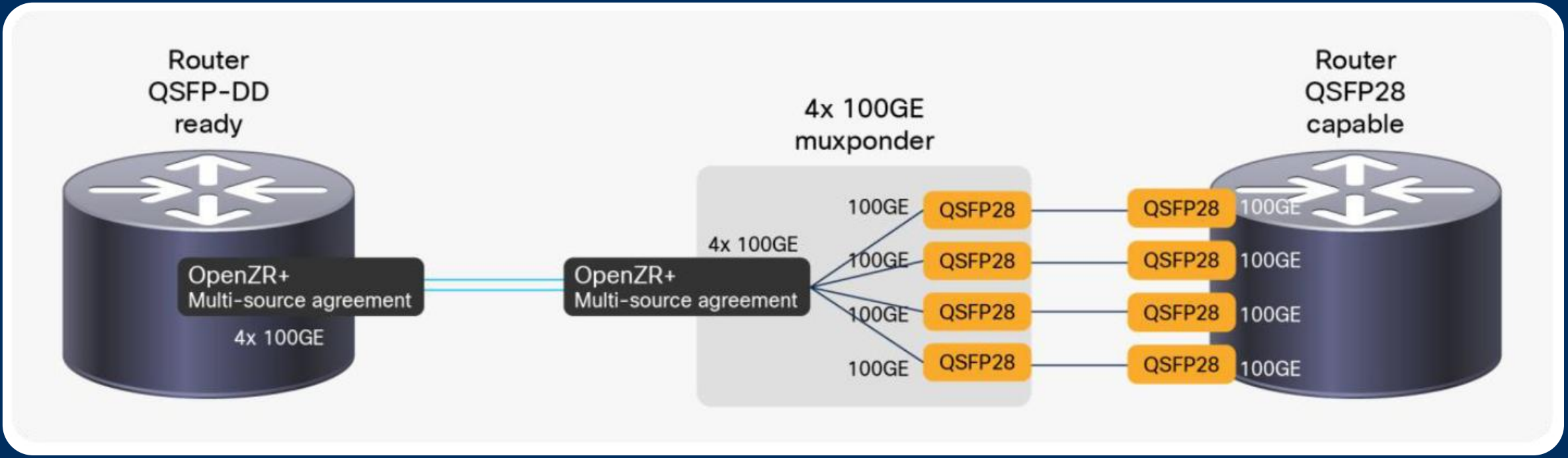
What if…

I need to connect 400G to 100G?



Source: https://openzrplus.org/

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What if...

I need to connect 400G to 100G?

```
port 14 {
        number-of-sub-ports 4;
        speed 100g;
}
et-0/0/14:X {
        optics-options {
                wavelength 1561.42;
                laser-enable;
                application {
                        hostid 13;
                        mediaid 70;
                        }
                high-power-mode;
                }
        }
}
```

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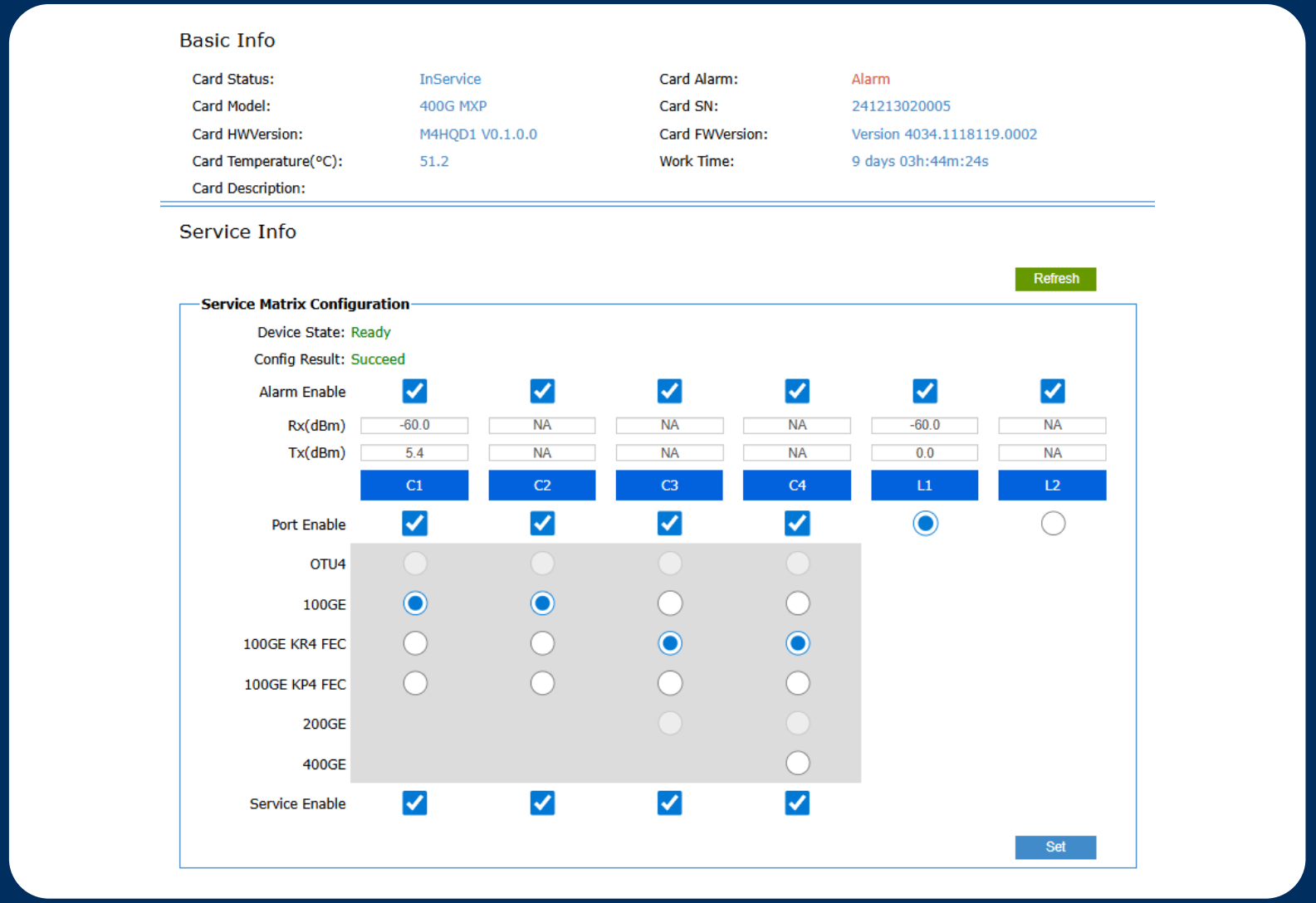
What if...

I need to connect 400G to 100G?



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What if...

I need to connect 400G to 100G?

Line Side 1(QSFP-DD-ZR)

Real Wavelength(nm):	1545.32		
Wavelength:	100GHz(48CH)	1545.32nm(194000.00GHz)	Set
Output Power(-6.0 ~ 1.0dBm):	0.0		Set
Rx Pre-FEC BER:	1.00e+00		
Rx Post-FEC BER:	0.00e+00		
Dispersion(ps/nm):	0		
OSNR Level(dB):	0.0		
QSFP-DD-ZR Module State:	Normal		

Port Description Information

C1:	
C2:	
C3:	
C4:	
L1:	
L2:	

Set

DDM Information

Port	Interface Type	VendorName	PN	SN	Lane	WL(nm)	Rx(dBm)	Tx(dBm)	Bias(mA)	Temp(°C)	Service Rate	Port State	Admin State
C1	QSFP28_LR4	GBC PHOTONICS	Q28DSLOLQE010CGP	GPH241029091	1	1295.56	-60.0	-0.4	44.3	31.1	100GE	Alarm	Up
					2	1300.05	-60.0	-0.5	38.3				
					3	1304.58	-60.0	-0.8	34.8				
					4	1309.14	-60.0	-0.4	35.8				
C2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Absent	NA
C3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Absent	NA
C4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Absent	NA
L1	QSFP_DD_ZR	GBC PHOTONICS	740-0__ZR+	GPI231211020	1	1545.32	-60.0	0.0	20.0	51.6	OTUC4	Normal	Up
L2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Absent	NA

What if…

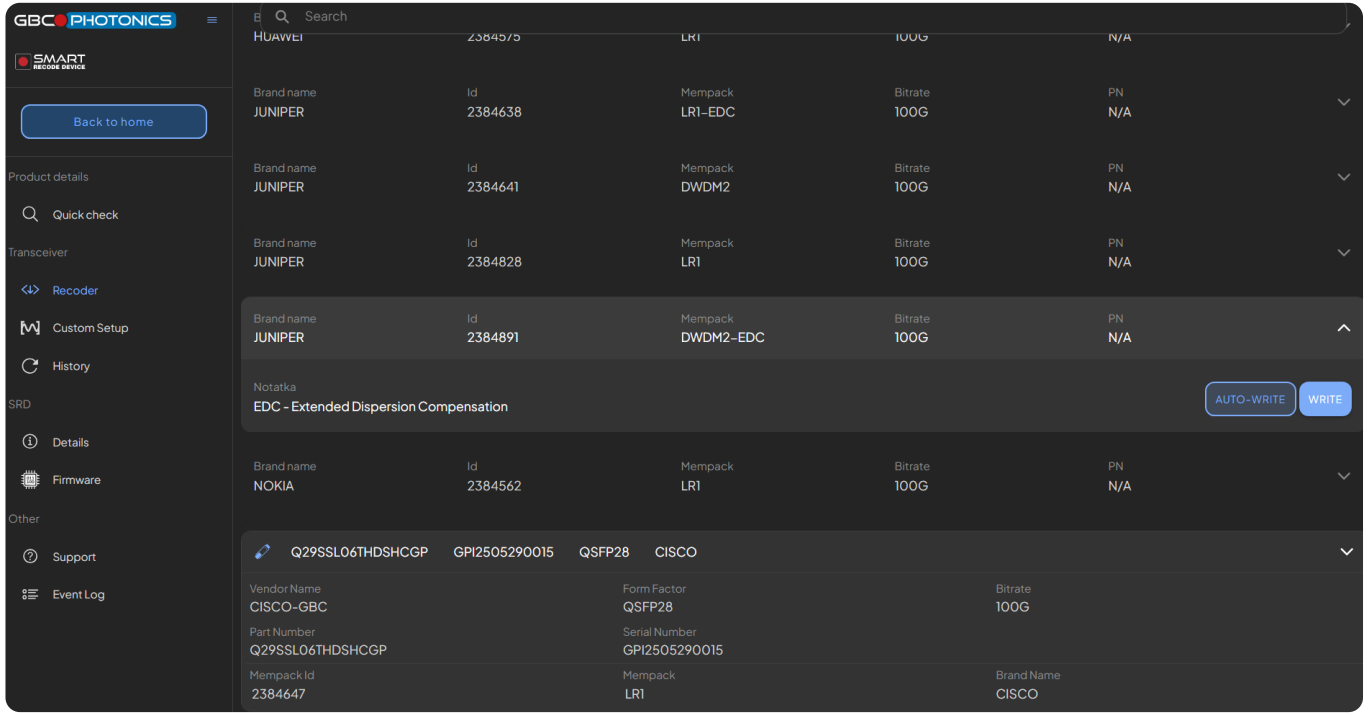
I need to connect 400G to 100G?

- **Why?**
  - Because we could deploy 400G coherent optics today, even if only one side of the link supports 400G transceivers
  - More efficient use of DWDM spectrum – 75GHz instead of 200GHz
  - Future ready design – once both ends are upgraded to support 400G interfaces, you can remove the muxponder and connect same optics directly
- **Cost**
  Less than 2x 100G
- **Flexibility**
  Client side of muxponder could be equipped with different transceivers

What if…

My device doesn’t support CMIS?

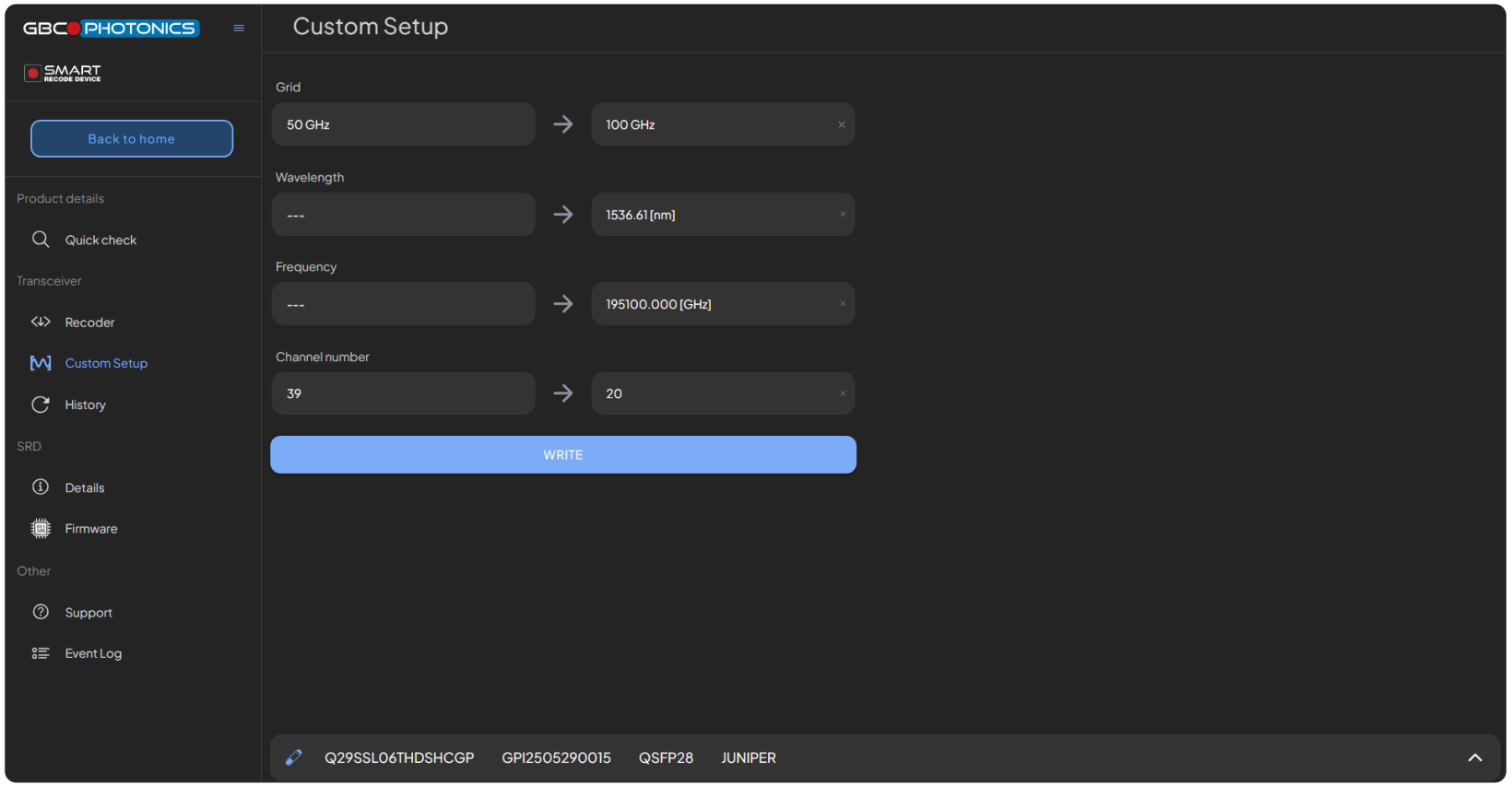
- How I could benefit from 100G Coherent transceivers if my device does not support CMIS?
  - SFF version – Simulating QSFP28 LR4
  - SFF version – Simulating QSFP28 LR1
  - SFF version – Simulating QSFP28 DWDM2



What if…

My device doesn’t support CMIS?

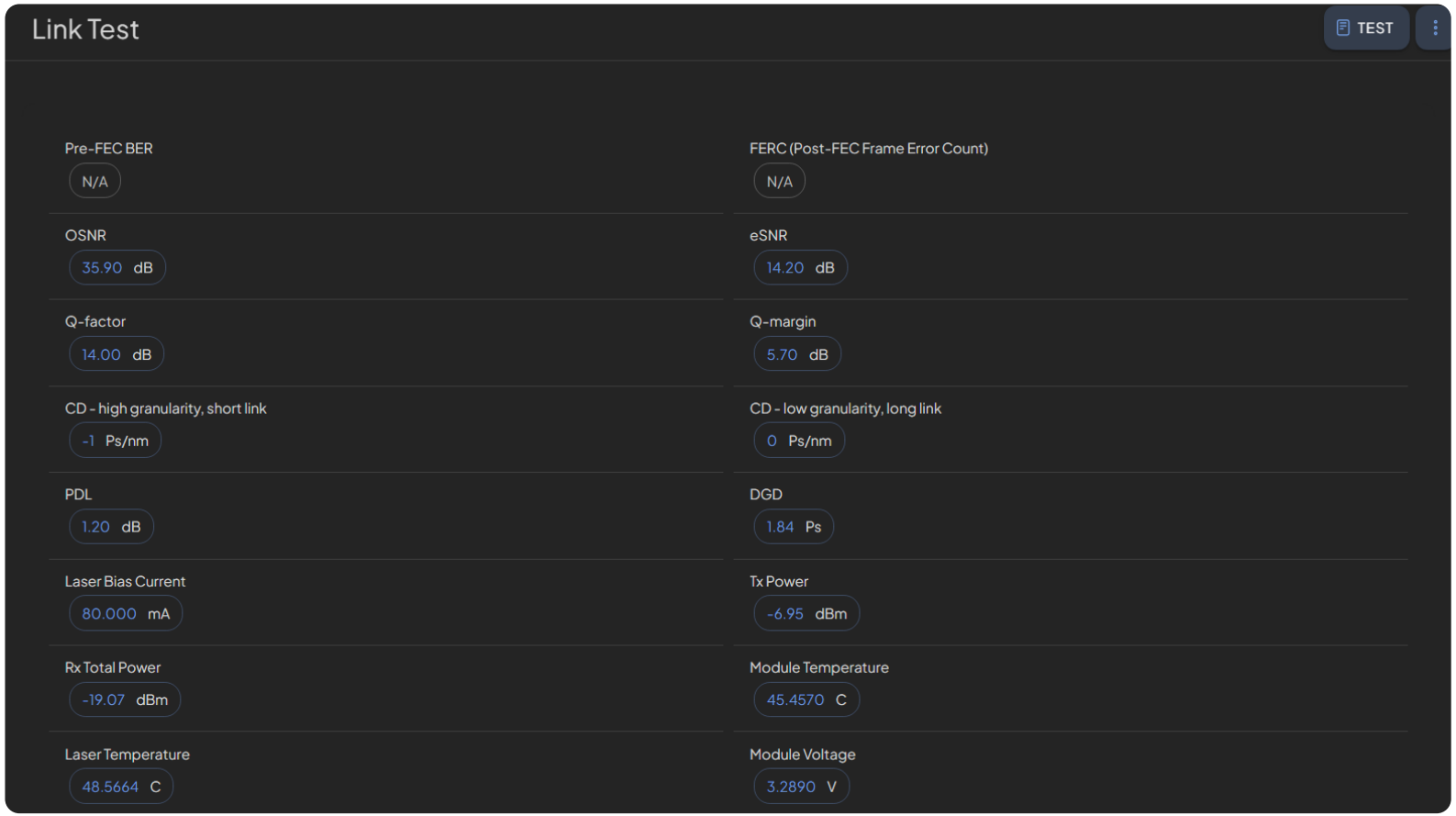
- How to run it on legacy devices? - wavelength tuning



What if…

My device doesn’t support CMIS?

- **How to run it on legacy devices? – link testing**



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Summary

Key Takeaways

- Coherent transceivers simplify High-Speed, Long-Distance Networking
- Proper configuration is critical for success
- Coherent transceivers support flexible internetworking with legacy infrastructure

Common deployment mistakes to avoid

- Mismatch applications, host & media side on both ends
- Mismatch channel number
- Ignoring optical budget & OSNR requirements

Checklist for successful coherent deployment

- ✓ Confirm platform compatibility
- ✓ Select and apply correct application mode
- ✓ Veirify optical path parameters
- ✓ Monitor link health after turn-up

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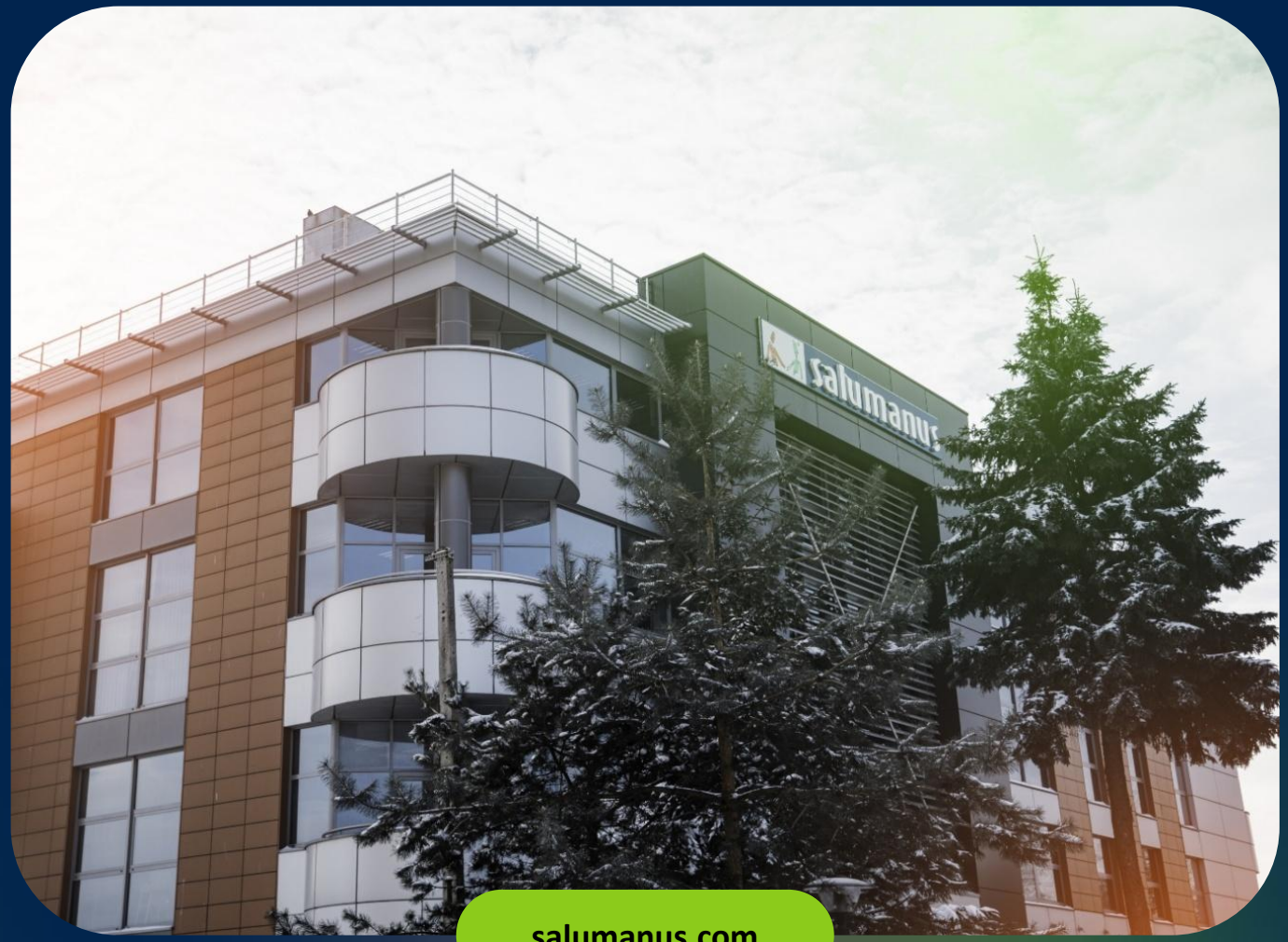
Thank you for your attention

Our name comes from the Latin words "salus" (helpful) and "manus" (hand), **reflecting our mission to support you**

Marcin Bała
CTO Salumanus
@: marcin.bala@salumanus.com



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