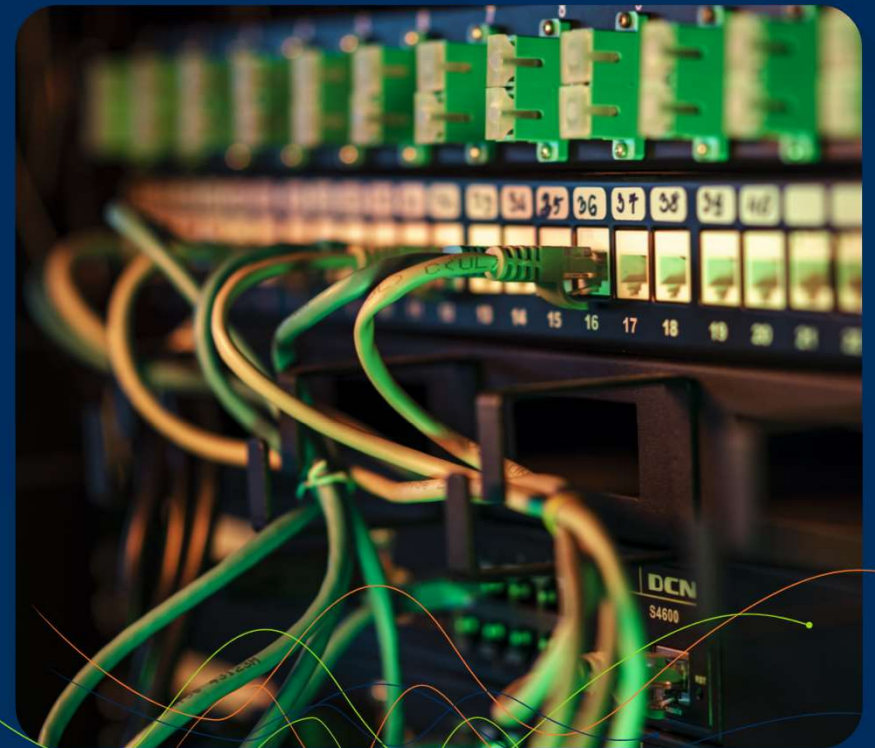


100G / 400G / 800G

**Optical Transceivers
and modulation technologies**

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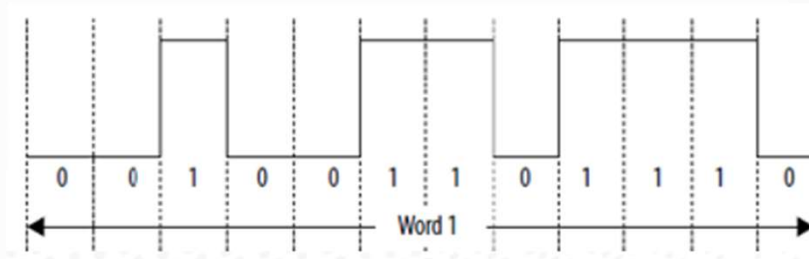
Modulations

Behind optical transceivers

1. PAM2 / NRZ
2. PAM4
3. Coherent

Modulation

PAM2 / NRZ



2 levels of amplitude

1 bit per pulse

PAM2 / NRZ

Distances



PAM2 / NRZ

Best Sellers

100G point to point over fiber pair – 4x25G

- QSFP28 CWDM4 – 2 km
- QSFP28 LR4 - 10 km
- QSFP28 eLR4 - 20 km
- QSFP28 ER4 - 40km
- QSFP28 ZR4 - 80km

PAM2 / NRZ

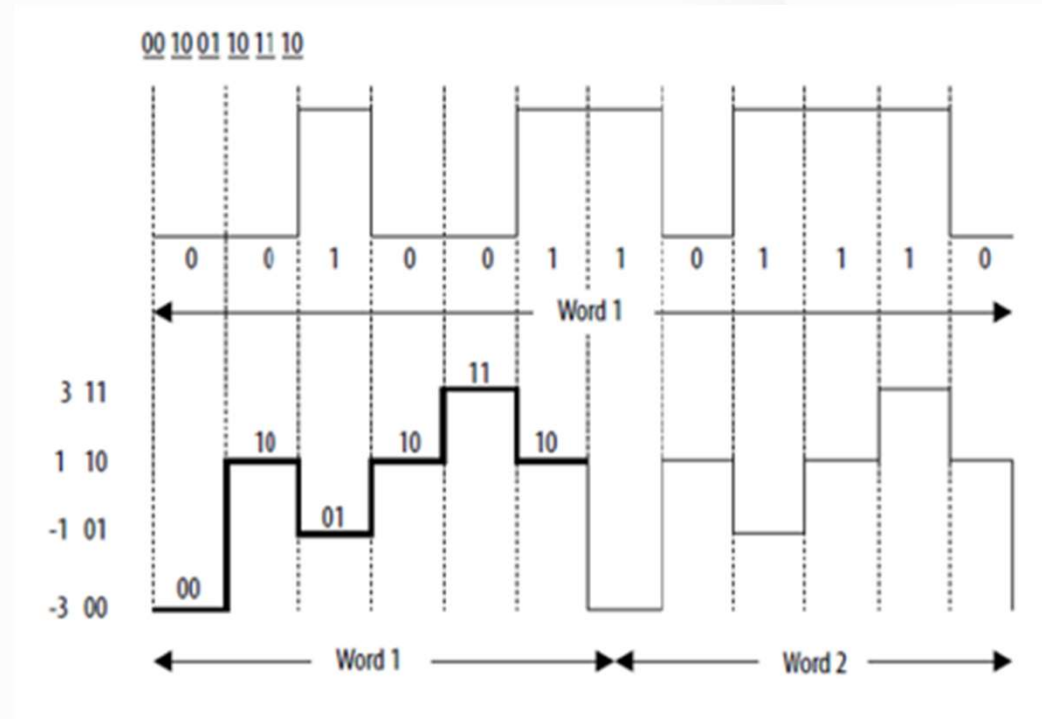
Key parameters

100G point to point over fiber pair – 4x25G

- *CWDM wavelengths for CWDM4 and LAN-WDM all others*
- *LR4, eLR4, ER4, ZR4 – interoperability*
- *ER4, ZR4 – minimum link length 20km (7dB attenuator)*
- *Possible options for LR4, ER4, ZR4:*
 - *Single Rate – support only Ethernet*
 - *Dual Rate – support Ethernet + OTN*

Modulation

PAM4



4 levels of amplitude

2 bit per pulse

2x higher throughput than NRZ

PAM4

Best Sellers

100G point to point over fiber pair – 1x100G

- QSFP28 FR1 – 2 km
- QSFP28 LR1 - 10 km
- QSFP28 ER1 – 40km

All transceivers use 1310 nm

PAM4

Key Parameters

100G point to point over fiber pair – 1x100G

- *All transceivers use 1310 nm*
- *Not compatible with 4x25G, for example LR4 and LR1*
- *Compatible with 400G with 4 lasers – to connect up to 4x 100G transceivers to single 400G transceiver*



PAM4

Best Sellers

100G point to point over single fiber – 1x100G

- QSFP28 BiDi 20 km
- QSFP28 BiDi 40 km

20km use 1270 & 1310

40km use 1290 & 1310

PAM4

Best Sellers

100G point to point over WDM – 1x100G

- QSFP28 O-BAND 25km
- QSFP28 DWDM 80km

Fixed wavelength

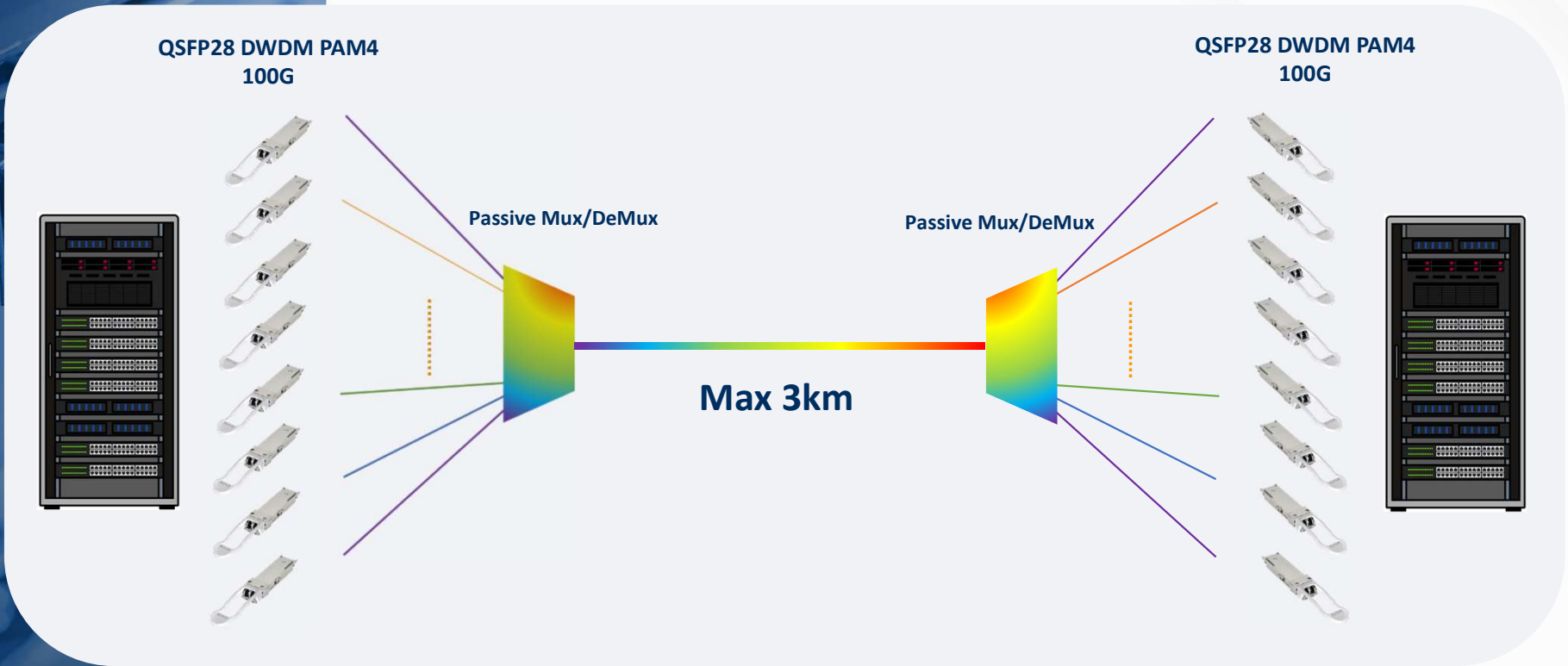
Wideband receivers

Suitable for both single fiber and dual fiber WDM systems

PAM4

Application

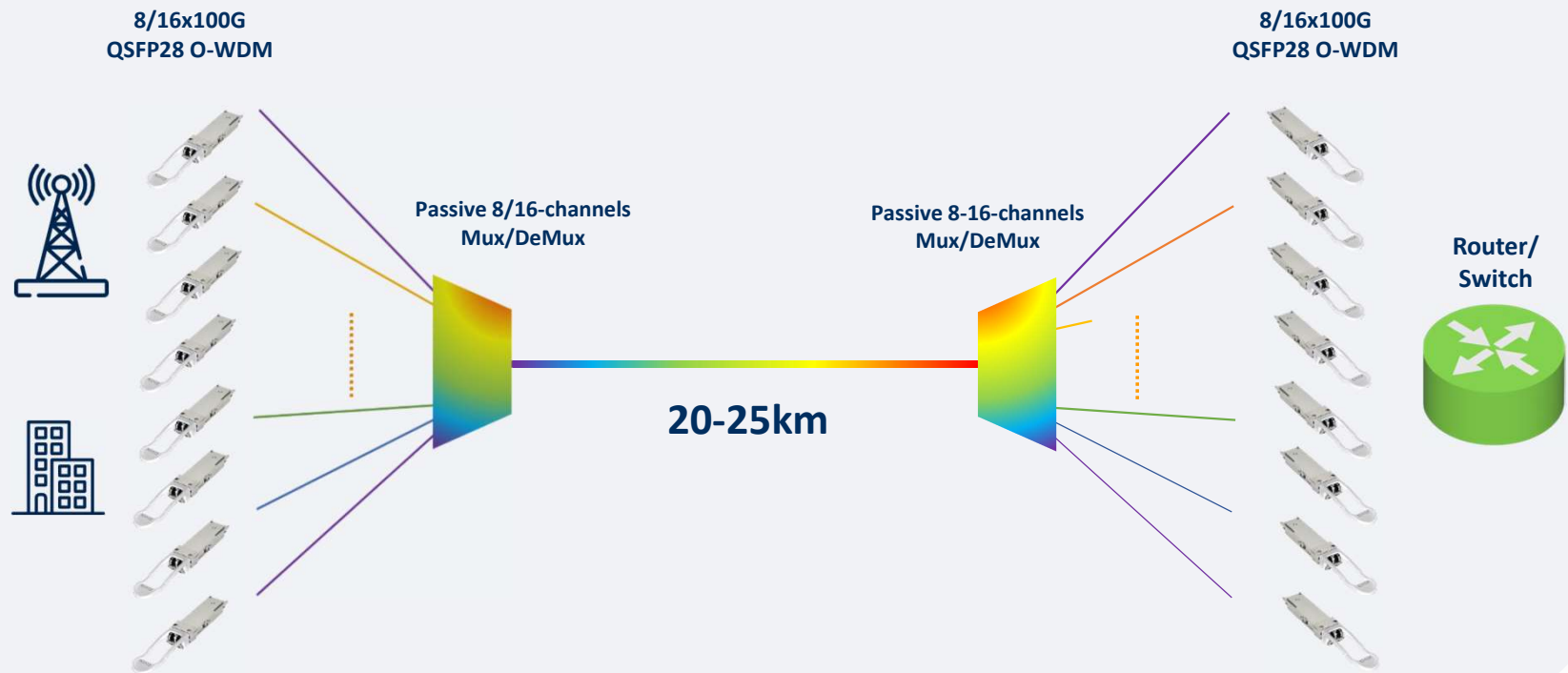
QSFP28 100G DWDM Single Lambda



PAM4

Application

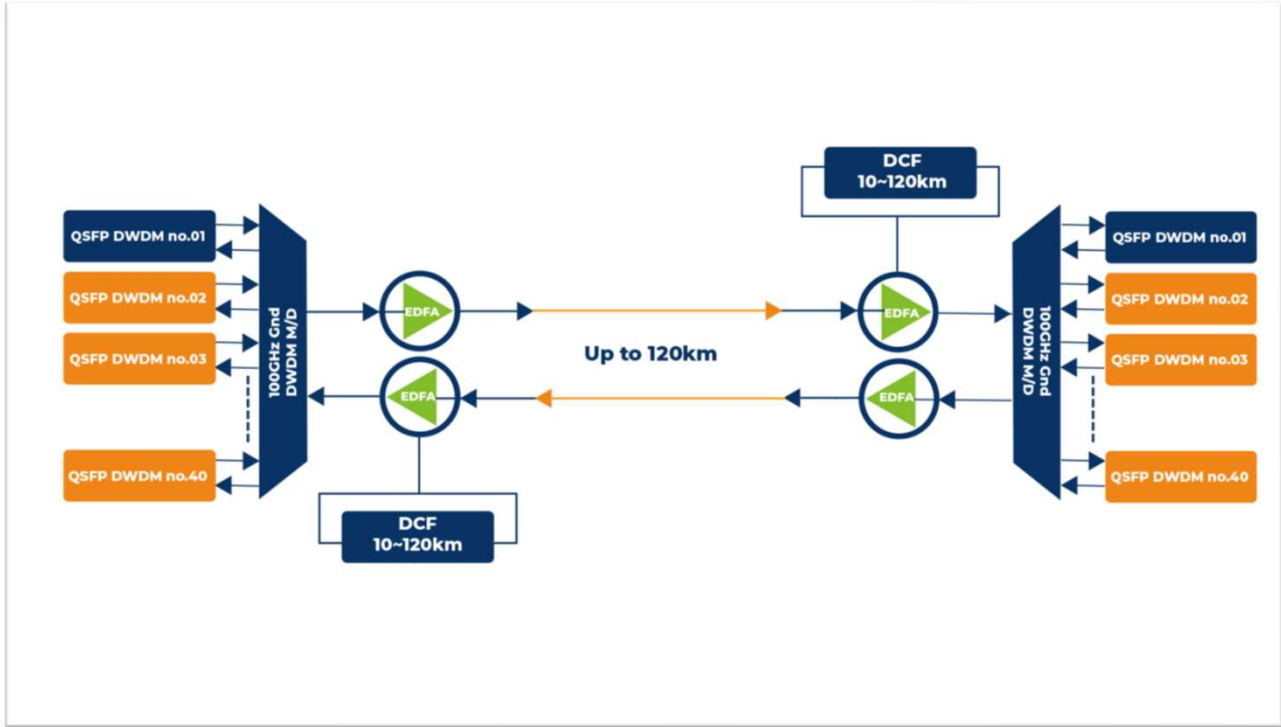
QSFP28 100G O-Band Single Lambda



PAM4

Application

QSFP28 100G DWDM Single Lambda



PAM4

400G Best Sellers

400G point to point over fiber pair

- QSFP-DD FR4/LR4 – 2km / 10 km LC connector
4x100G CWDM4
(1270, 1290, 1310, 1330nm)
- QSFP-DD LR8/ER8 – 10 km / 40 km LC connector
8x50G LAN-WDM
(1273.5, 1277.9, 1282.3, 1286.7, 1295.6, 1300.1, 1304.6, 1309.1nm)

Interoperability between FR4 & LR4

Interoperability between LR8 & ER8

PAM4

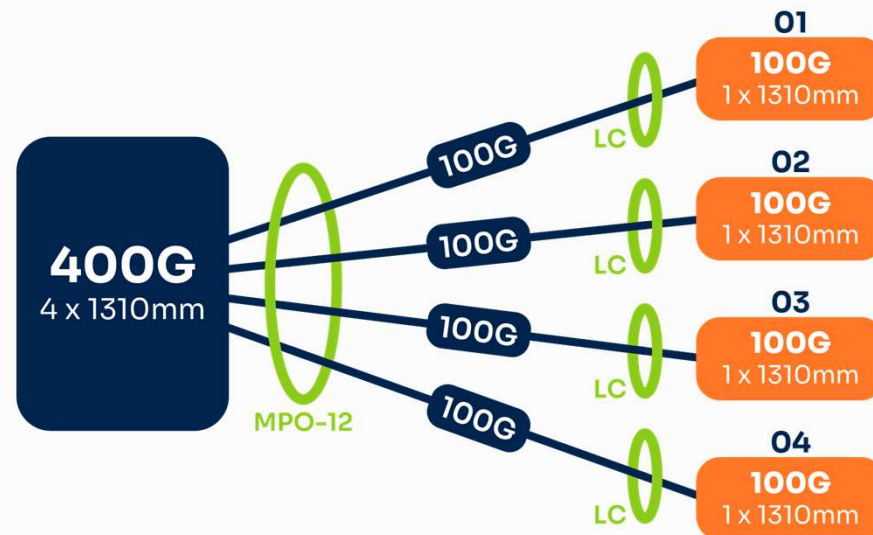
400G Best Sellers

400G to 4x100G point to multipoint

QSFP-DD 4xFR1/4xLR1 – 2km/10 km

MPO12 connector to easy breakout

All use 1310nm



PAM4

400G applications

400G over single fiber



PAM4

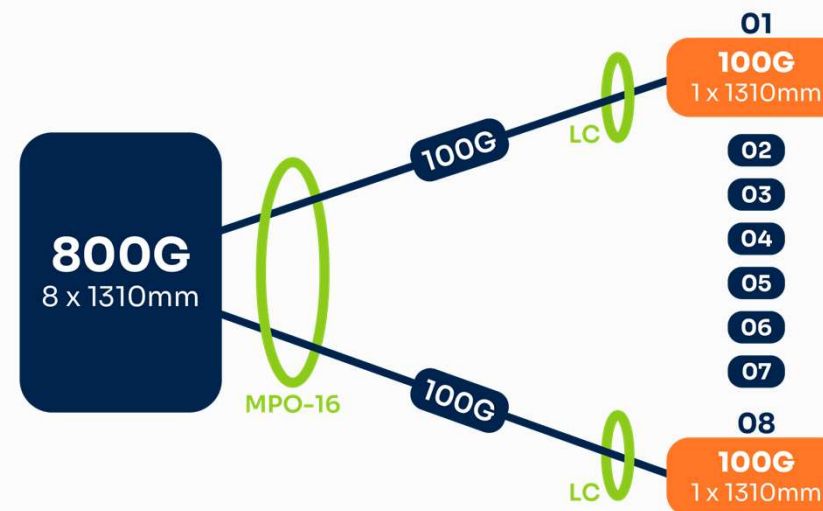
800G Best Seller

800G to 8x100G point to multipoint

QSFP-DD800 XDR8/PLR8 - 2km/10 km

MPO16 connector to easy breakout

All use 1310nm



PAM4

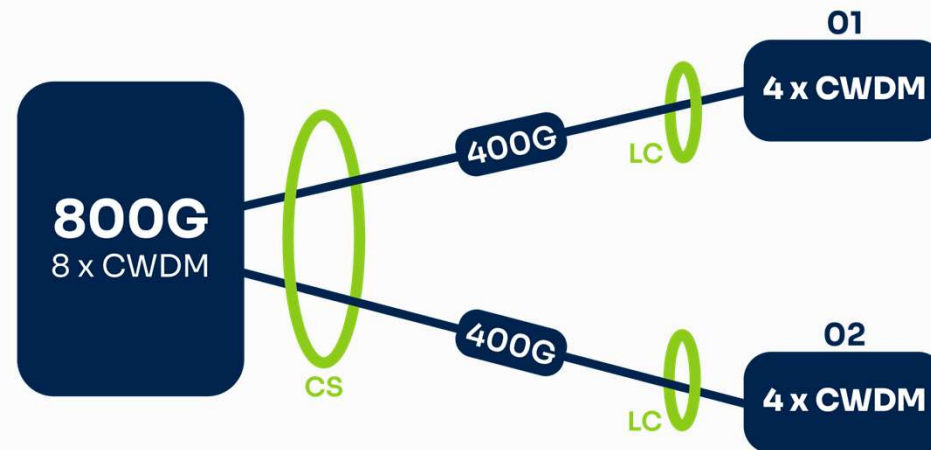
800G Best Sellers

800G to 2x400G point to multipoint

QSFP-DD800 2xFR4/2xLR4 - 2km/10 km

Dual CS connector to easy breakout

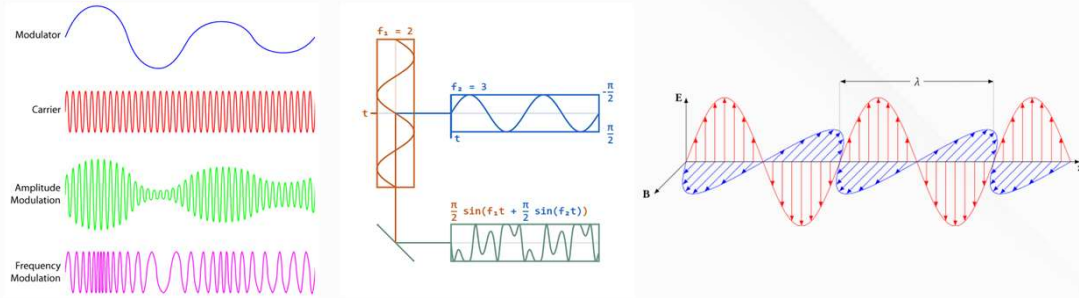
All use 1270/1290/1310/1330 nm



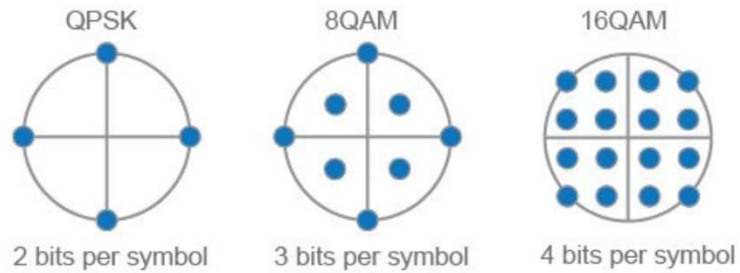
Modulation

COHERENT

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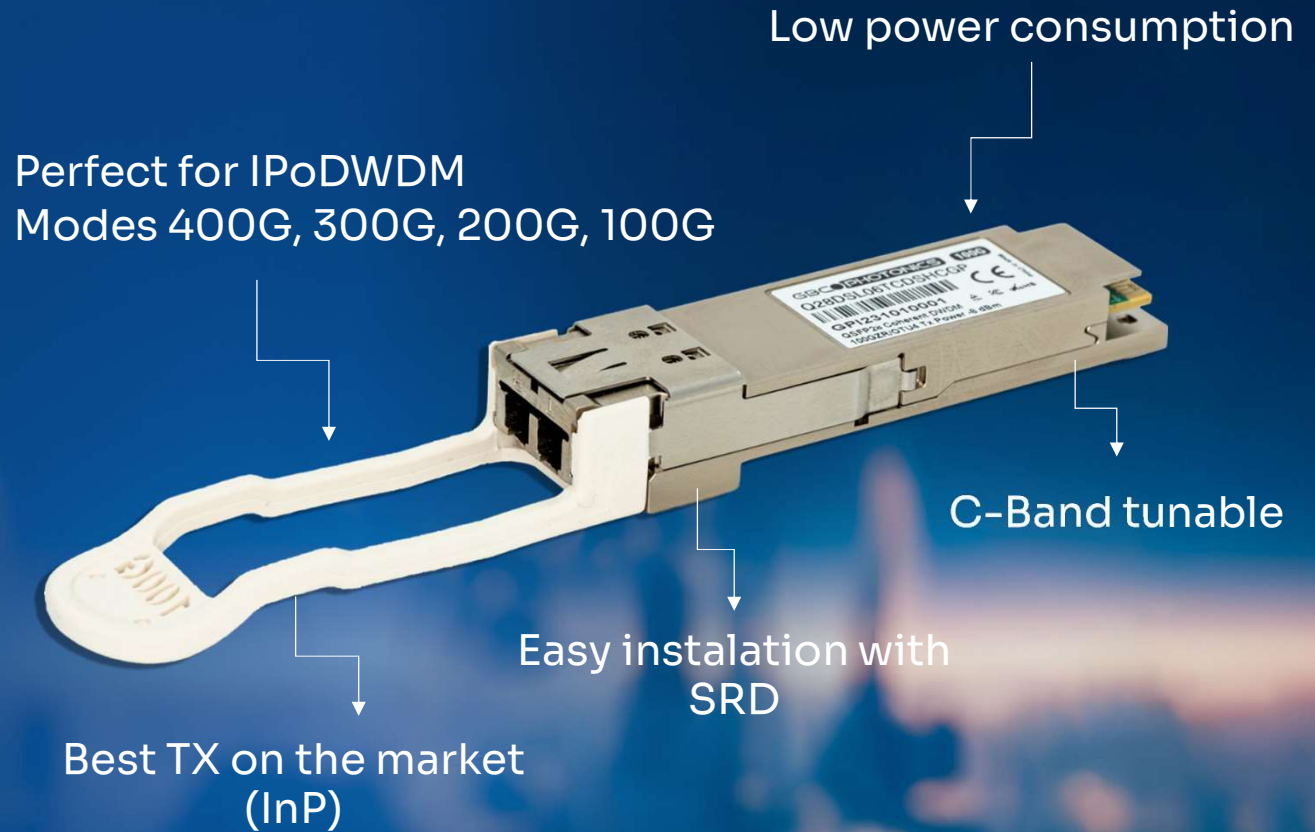


High-Order Modulation - Constellation Diagrams



Transmit bit rate = [symbol rate] x [bits per symbol] x [polarization (x2)]

Coherent transceiver QSFP-DD 400 ZR+ 0dBm.



OpenZR+

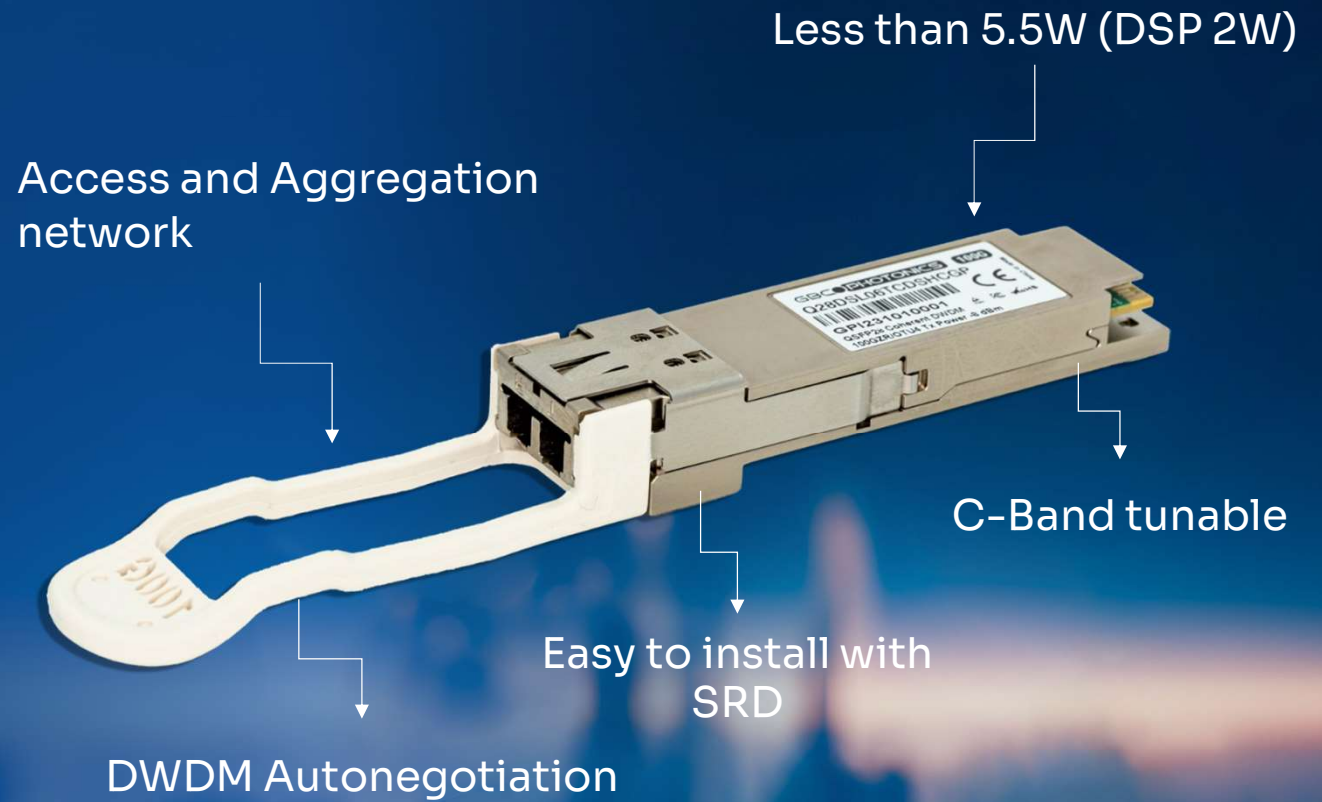
MULTI-SOURCE AGREEMENT



- High output power 0dBm i Tx OSNR 45dB
- OpenROADM, CMIS 5.1 / C-CMIS 1.2 Compliant
- Tunable in C-band, Flex-Grid support
- 400GE or n*100GE host side, multi-rate 400G/300G/200G/100G lane side
- Interoperability with OpenZR+ MSA modules
- Range > 600km at 400G, longer distances with lower transmission speeds
- Power cons. < 22.5W, typically 20.5W at 400G, 15.5W at 100G
- Disp. Compensation 12 000ps/nm (400G) to 40 000ps/nm (100G)
- Min. required OSNR 22dB (400G) to 11.5dB (100G)
- Min. channel grid for 400G – 75GHz or 100GHz (50GHz not enough!)

- High output power 0dBm (power budget 22dB)
- CMIS 5.1 / C-CMIS 1.2 Compliant
- Tunable in C-band
- 400GE or n*100GE host side, 400G lane side
- Interoperability with OIF 400ZR modules
- Range 80km with dark fiber, 120km with DWDM
- Power cons. < 18.5W, typically 16.5W
- Disp. compensation 2 400ps/nm
- Min. required OSNR 24dB

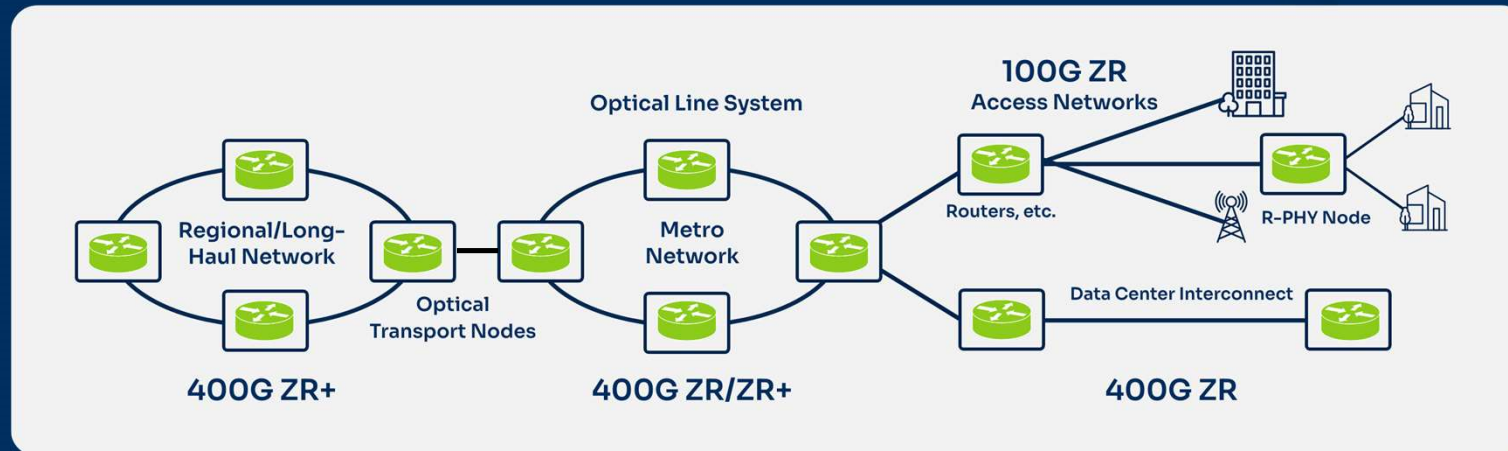
Coherent transceiver QSFP28 100G ZR.



Application – 100G



Coherent transceiver application



Compatibility list:

1. Nokia (7750 SR, OS 22.10.R5, 23.3.R2)
2. Juniper (PTX 10008, OS 23.1R1.8)
3. Cisco (8201, OS 7.9.1)
4. UfiSpace (IP Infusion 6.4.2, DriveNets 18.0.0)
5. Edgecore (IP Infusion 6.4.2, DriveNets 18.0.0)

Thank you for your attention.



Marcin Bała
CEO
Salumanus



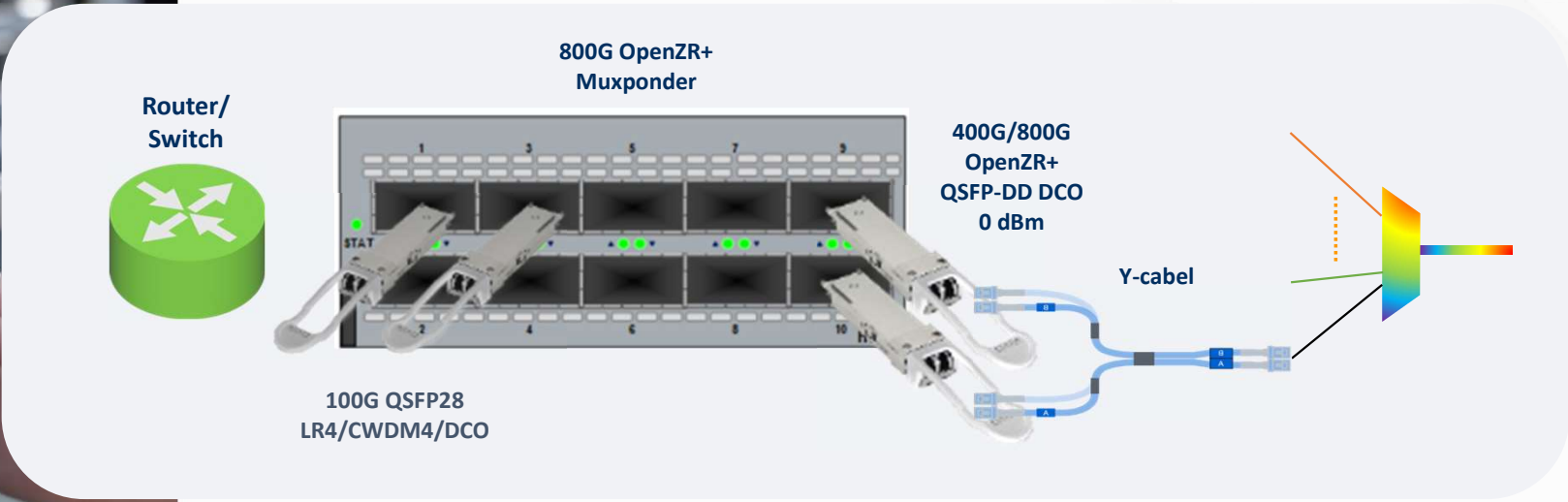
Andrzej Wojnar
Solutions Architect
Salumanus

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Application SUPER Channel

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QSFP-DD 400G OpenZR+

- 400Gbps, 16QAM, O-FEC – OSNR 23dB, range up to 600km – throughput 800Gbps
- 300Gbps, 8QAM, O-FEC – OSNR 20dB, range up to 1000km – throughput 600Gbps
- 200Gbps, QPSK, O-FEC – OSNR 15dB, range up to 2000km – throughput 400Gbps
- 100Gbps, QPSK, O-FEC – OSNR 12dB, range up to 4000km – throughput 200Gbps

Project co-financed by EU funds

The research work was carried out as part of the project RPMP.01.02.01-12-0614/18 pn. „Opracowanie modułów optycznych o wysokiej przepustowości (100Gbps - 400Gbps) wraz z programatorem, przeznaczonych dla operatorów telekomunikacyjnych i data center oraz w celu rozwoju własnych produktów i rozwiązań”, co-financed by the European Union under the Regional Operational Fund of the Małopolska Voivodeship for 2014-2020.



Rzeczpospolita
Polska



MAŁOPOLSKA

Unia Europejska
Europejski Fundusz
Rozwoju Regionalnego





Dziękuję za uwagę

Andrzej Wojnar

Business advantages

Optic	Reach	Cost (CAPEX)	Power	Space
	km	per 400GE port		
Transponder@800G	150/60	87	140 W	0,17 RU
Transponder@600G	1000/700	100	168 W	0,20 RU
Transponder@400G	2000	121	188 W	0,23 RU
OpenZR+@400G	1040/480	59	58 W	0,11 RU
OpenZR+@300G	2300/1600	92	78 W	0,16 RU
400ZR DCI	120/80	47	58 W	0,11 RU

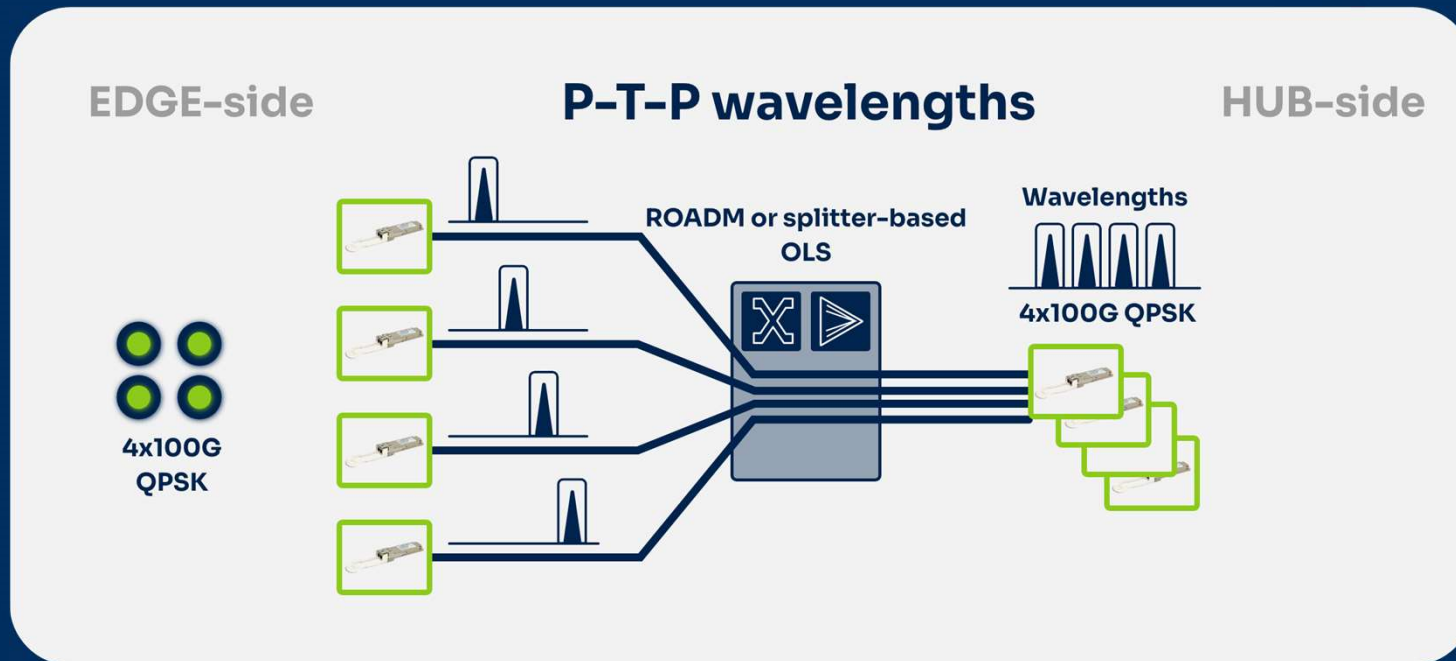
Usage scenarios – coherent QSFP28 100G

P-T-P dark fiber



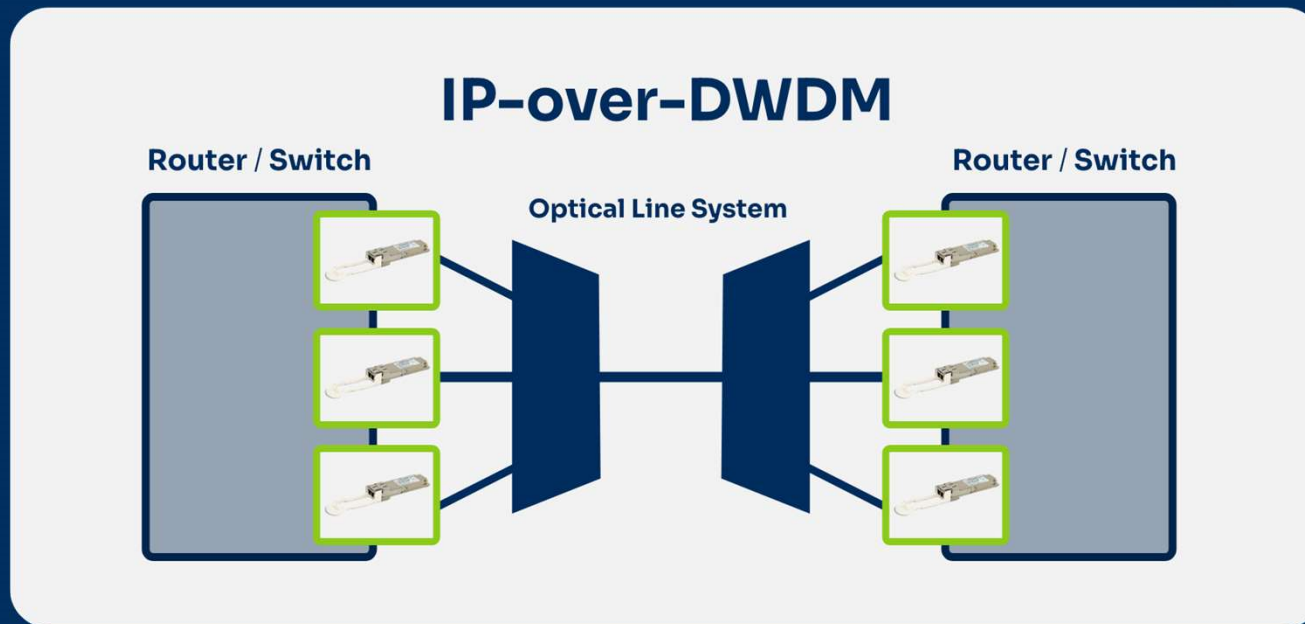
- 80 km or 120 km range (-8dBm or 0dBm)
- Wavelength selected by SRD or the host
- Optional enhanced mode 300 km (0.2-0.3 W higher power consumption)

Usage scenarios – coherent QSFP28 100G



- Tunable selective receiver
- No mux/demux needed

Usage scenarios – coherent QSFP28 100G



- CMIS or SFF-8636 versions
- Tuned from host or SRD
- In amplified links the range limited only with ONSR (min 16.5 dB)

Challenges



Distance
**1000km and
longer links**



Automation
**Across IP and
Optical Layers**



Management
**Cross domain
management**