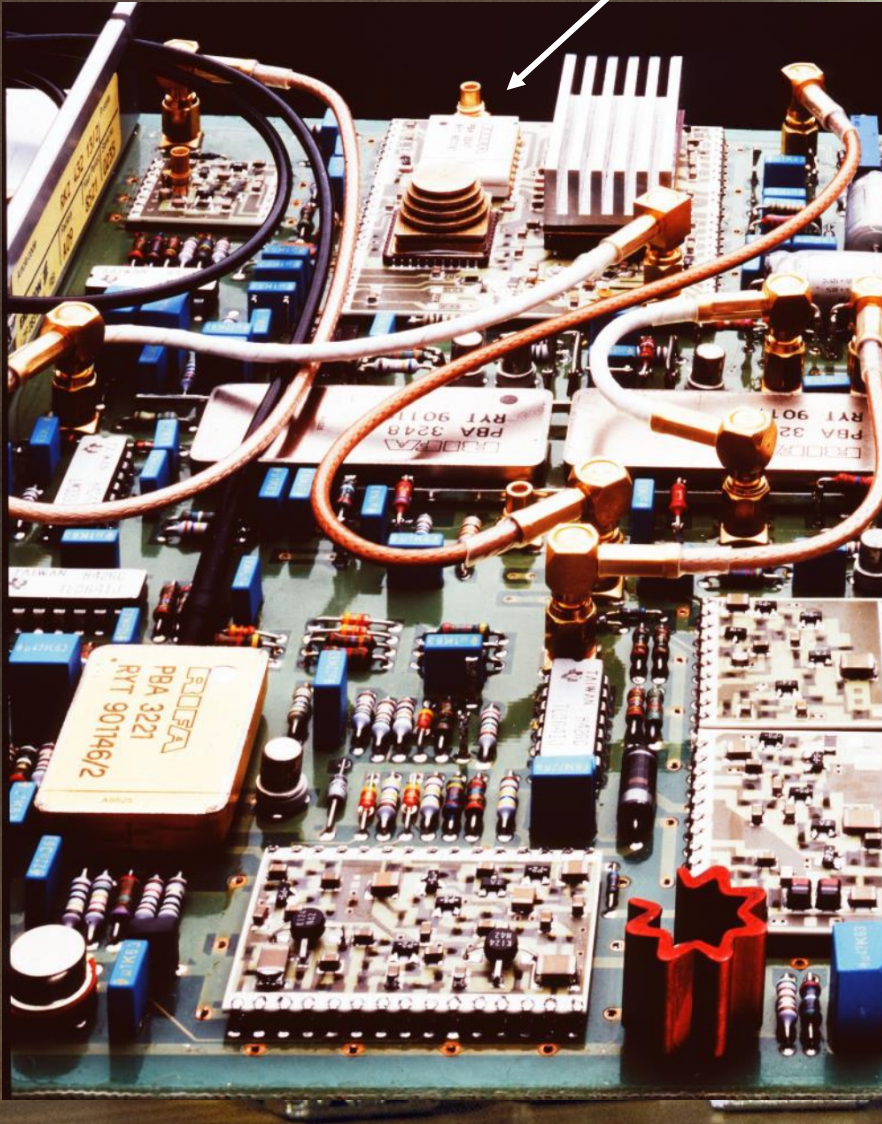This is a 1987 state of the art 600Mbps "transceiver"

Patrik von Matern
PLM Optical Devices
Smartoptics
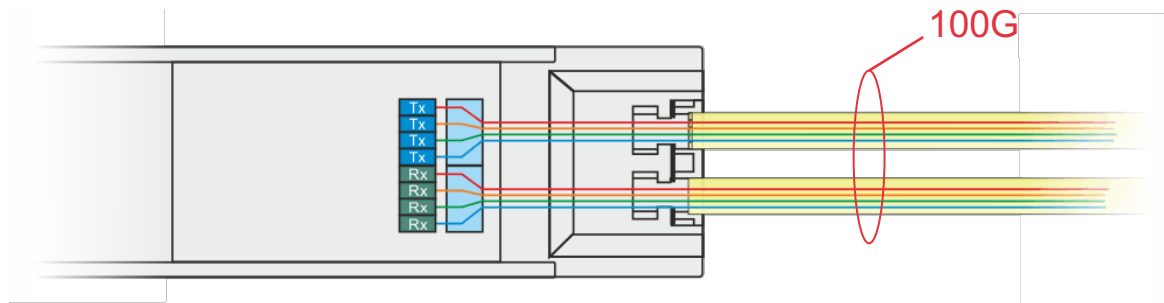
"Transceivers beyond 100G"
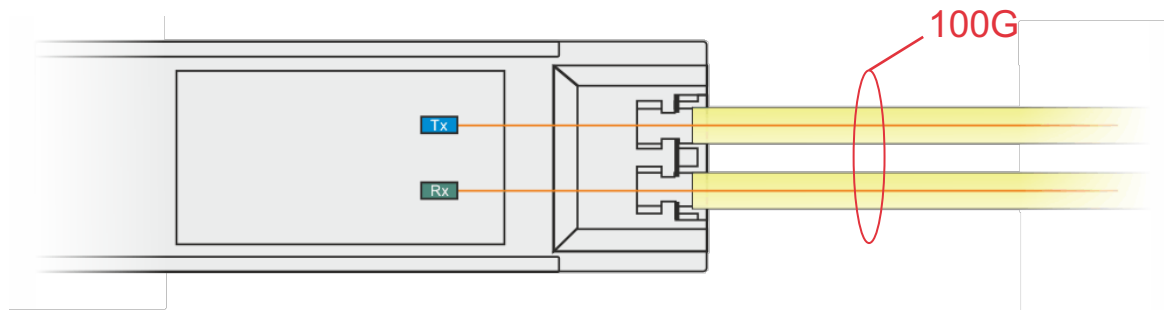
10 min

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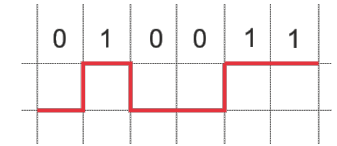
100G standards and MSA's for Grey optics

4 lanes
25Gbps

CWDM
LANWDM

N on
R eturn
Z ero

| 0 | 1 | 0 | 0 | 1 | 1 |

1 lane
50GBaud

CWDM
1311nm

P ulse
A mplitude
M odulation
4 Levels

| 01 | 00 | 10 | 11 |

LR4

ER4

SR4

ZR4

CWDM4

4WDM10

4WDM20

SWDM4

FR

LR

DR

4WDM40

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100G standards and MSA's for Grey optics

100G

1 lane   CWDM
50GBaud   1311nm

Tx
Rx

	01	00	10	11

Pulse
Amplitude
Modulation
4 Levels

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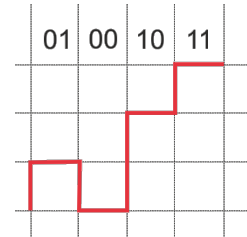
400G standards and MSA's for Grey optics
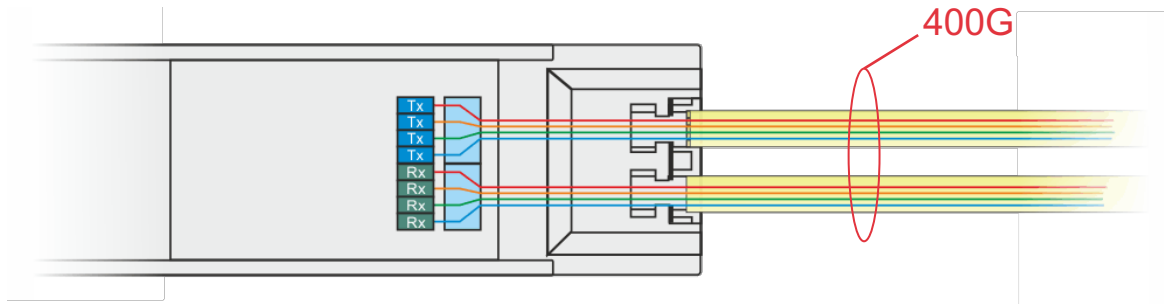
400G

4 lanes
50GBaud

CWDM

	01	00	10	11

P ulse
A mplitude
M odulation
4 Levels
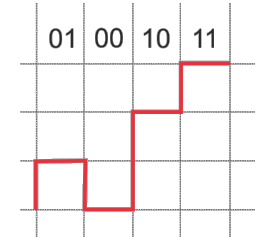
400G transceiver for fiber-pair configurations

PAM4 ASIC
8x 25Gbd ⟷ 4x 50Gbd

4x CWDM EML
4x PIN ARRAY

WDM LC
LC WDM

CWDM filter
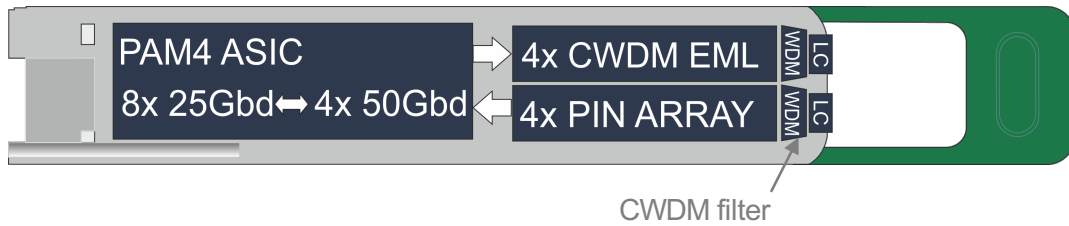
400G-FR4

2km Fiber-pair

400G-LR4

10km Fiber-pair

400G transceiver for ribbon cable

PAM4 ASIC
8x 25Gbd ⟷ 4x 50Gbd

4x 1311nm EML
4x PIN ARRAY

MPO-12

400G-DR4
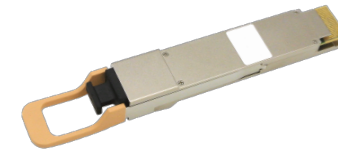
500m Ribbon-fiber

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Step up in form-factor

Things that matter:

Size and Power!

78.3mm

QSFP-DD Type 1

18.35mm

8.5mm

93.3mm

QSFP-DD Type 2

18.35mm

8.5mm
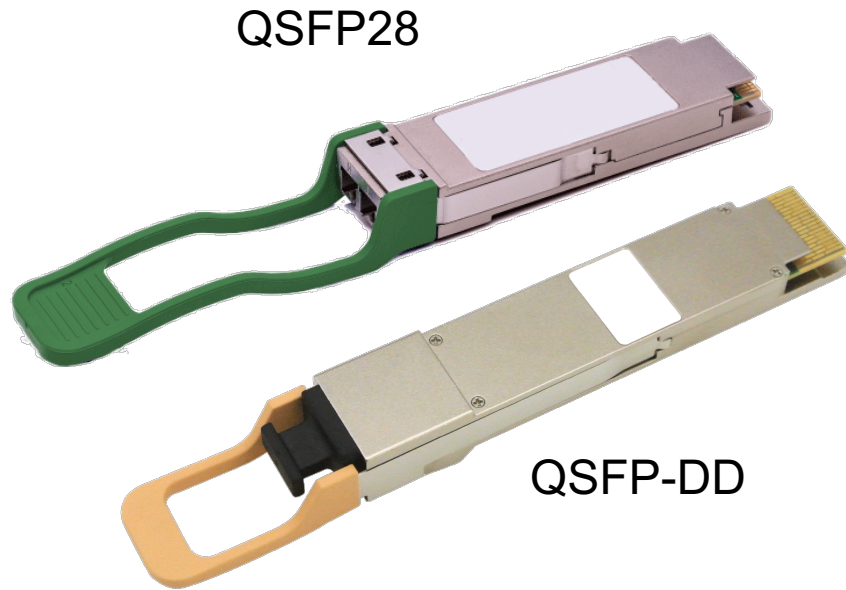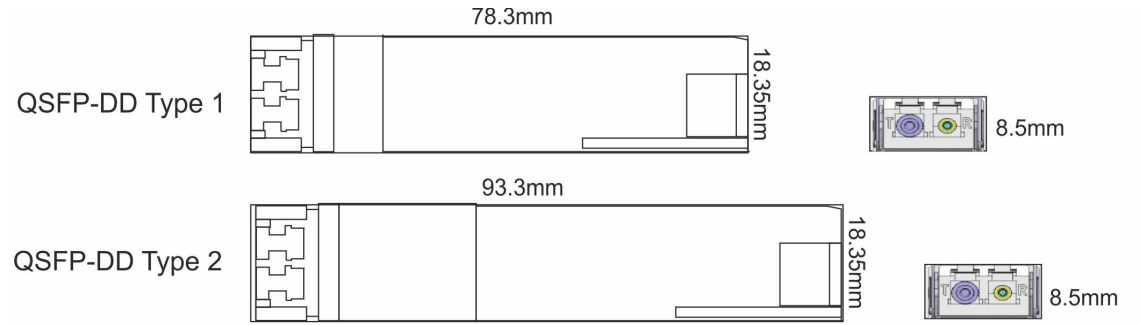
QSFP28

QSFP-DD

QSFP-DD

- is longer than a QSFP28
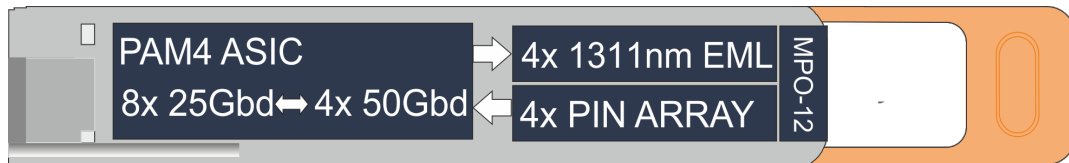
- is backwards compatible with QSFP28

- has a higer power class capability than QSFP28

QSFP28		QSFP-DD	
Power Class	Max	Power Class	Max
1	1.5W	1	1.5W
2	2.0W	2	3.5W
3	2.5W	3	7.0W
4	3.5W	4	8.0W
5	4.0W	5	10.0W
6	4.5W	6	12.0W
7	5.0W	7	14.0W
8	10W	8	>14.0W

A typical 400G grey transceiver consumes ~ 10W

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Coherent 400G

QSFP-DD type 2a

SOSA

400G Coherent DSP

8x 25Gbd ⟷ 2x 60Gbd

FEC Frame DAC

Coherent driver | SiPho modulator

Tunable Laser

4x PIN | SiPho demodulator

LC LC
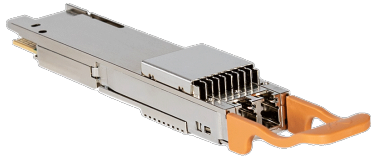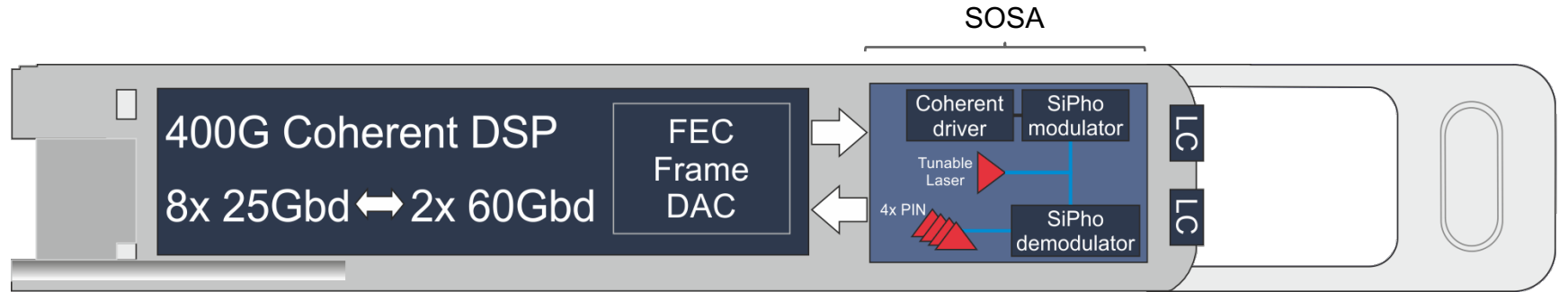
Electrical interface: 8 lanes PAM4 25Gbd / 50Gbps (400GAUI-8) for ZR and also 4x100GAUI-2 for ZR+.

Internal conversion to 1 lane DP-16QAM, ~60Gbd / 400Gbps.

01 00 10 11

P ulse
A mplitude
M odulation
4 Levels

2 bits per symbol

16 Levels
Q uadrature
A mplitude
M odulation

Q

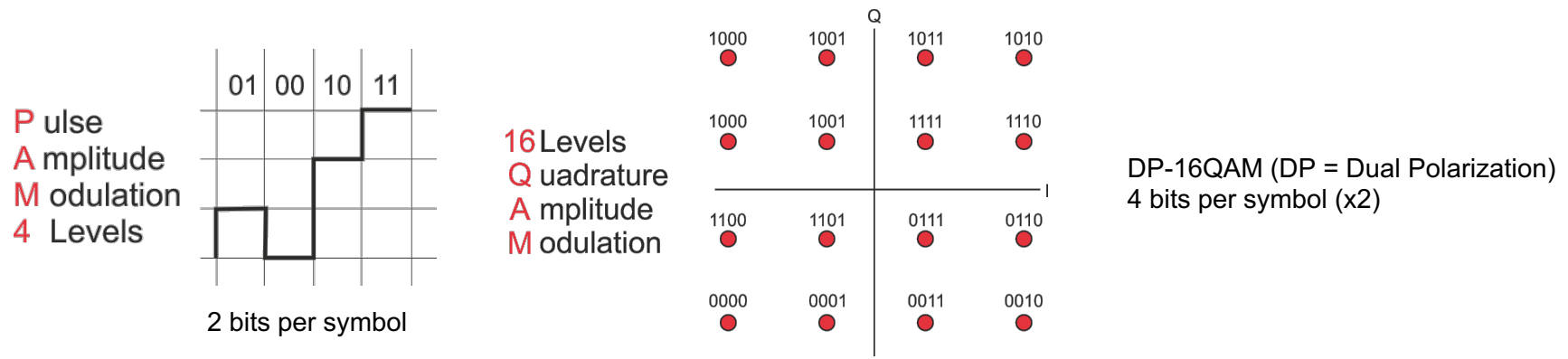| 1000 | 1001 | 1011 | 1010 |
1000	1001	1111	1110
1100	1101	0111	0110
0000	0001	0011	0010

DP-16QAM (DP = Dual Polarization)
4 bits per symbol (x2)

AUI = Attachment Unit Interface
400GAUI-8 where 8 is number of lanes

DSP: Digital Signaling Processor

SOSA: Silicon Optical Sub-Assembly

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400G Industry Standards

There are three principal initiatives to provide standardized 400G solutions.

|	OIF 400ZR	OpenZR+ MULTI-SOURCE AGREEMENT	Open ROADM
Target application	Edge DCI/Campus	Metro/Regional DCI	Metro/Regional DCI
Reach	80 – 120km / 11dB	>120km	>120km
Line capacity	400G	100G/200G/300G/400G	200G/300G/400G
Client formats	400GE	100GE/200GE/400GE	100GE-400GE + OTN
FEC	CFEC	oFEC	oFEC
Line modulation	16QAM	QPSK/8QAM/16QAM	QPSK/8QAM/16QAM
In short:	400G Ethernet Mid span meet	100/400G Ethernet Performance Competition	Ethernet + OTN Performance ROADM network mgmt

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Tx power challenges
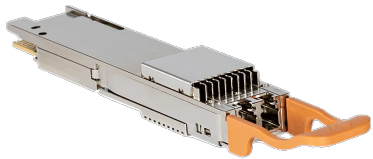
QSFP-DD type 2a

400G ZR is challenging to mix with 10G to 100G channels due to low Tx power (-10dBm) and OSNR performance (26dB).

TECHNICAL DATA

Parameter	Value
Technology	DWDM QSFP-DD type 2
Transmission media	SM (2x LC)
Typical reach	120km
Nominal wavelengths	192.00 - 196.00 THz
Interface standards	400GBASE-ZR
Protocol support	400GbE
	4x 100GbE
Power consumption	< 17 W (Class 8)
Operating temperature	0°C to +70°C
Storage temperature	-40°C to +85°C

[1] Receiver sensitivity at unamplified configurations

[2] Signal power of the channel at the OSNR performance value

[3] Input power needed to achieve post FEC BER

[4] At CFEC threshold

[5] OSNR tolerance penalty over OSNR Tolerance due to reflections and dispersion

[6] Tolerance to PMD with <0.5 dB penalty to OSNR sensitivity.

Safety/regulatory compliance:

TUV/UL/FDA (contact Smartoptics for latest certification information)

RoHS compliance

| Parameter	Value
Transmitter data:	
Output power	Min: -10.0dBm
	Max: -6.0dBm
Transmit wavelengths	192.00 - 196.00 THz
	in 100 (75) GHz steps
	(G.694.1)
Receiver data:	
Minimum input power	-20.0dBm [1]
	-12.0dBm [2]
Input sensitivity	-12.0dBm [3]
Overload (max power)	0 dBm [2]
OSNR tolerance	Max: 26dB/0.1nm [4]
CD tolerance	Min: 2400ps/nm
Optical path OSNR penalty tolerance	Max: 0.5dB [5]
PMD tolerance	Min: 10 ps [6]
DDM	Yes
MSA compliance	QSFP-DD MSA
	CMIS4.0

The Smartoptics DCP-M Flexible Open Line Systems are designed to manage these signals.

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400G and Common Management Interface Specification CMIS
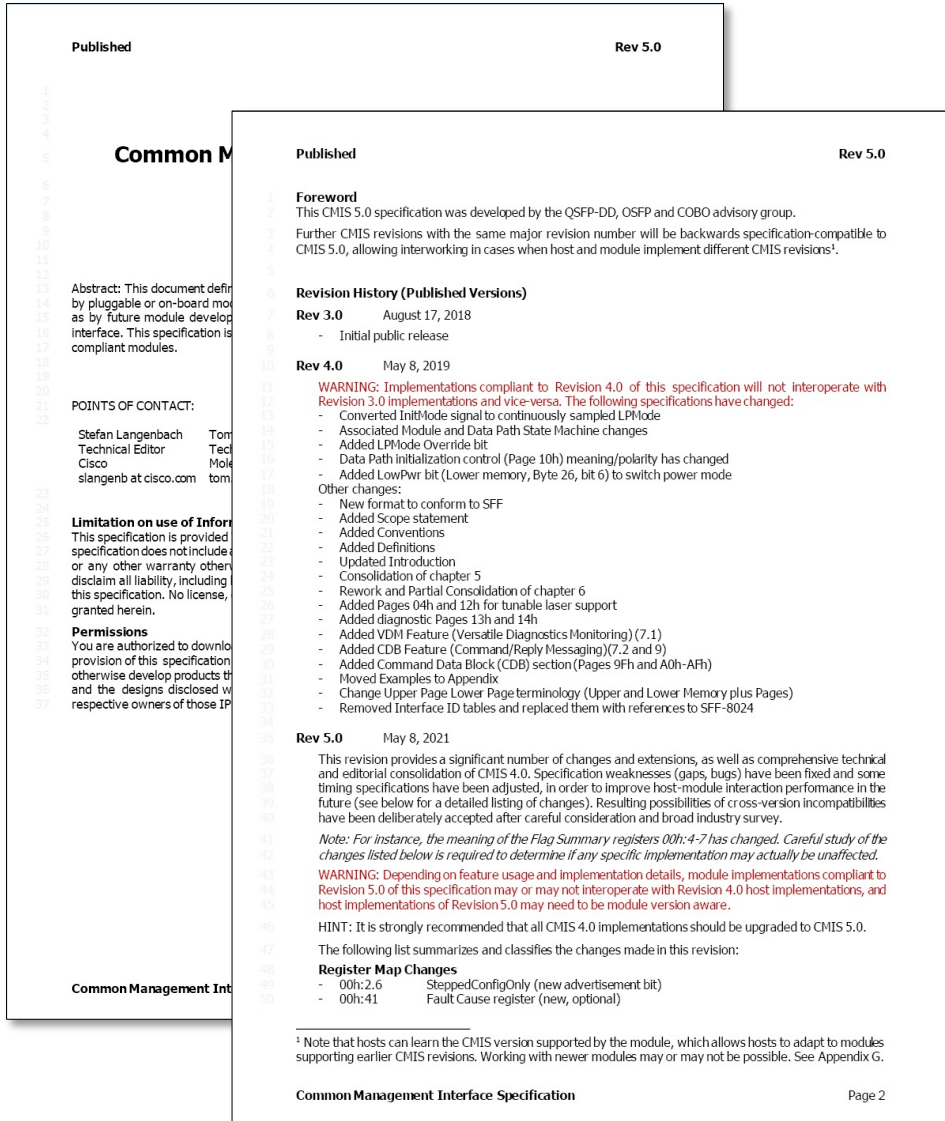
Revision 3.0 was released in Aug 2018. A 3.0.1 update in Jan, 2019.
Revision 4.0 was released in May 2019.
Revision 5.0 was released in May 2021

Different system vendors have implemented different versions!

CMIS3.0 is not compatible with CMIS4.0 or CMIS5.0 and vice verse.

CMIS5.0 contains additions and bug fixes.

Imperative to check what version that the host equipment supports and select a transceiver having the corresponding CMIS version.

Used by both grey and coherent 400G transceivers!
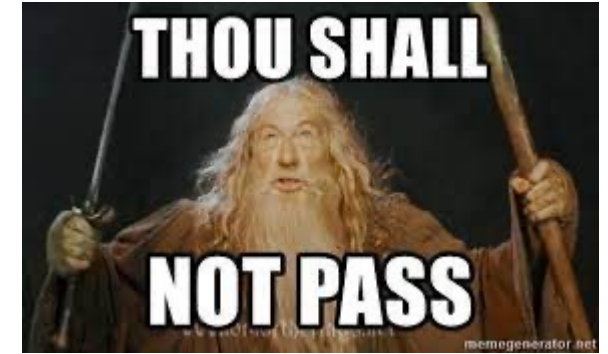
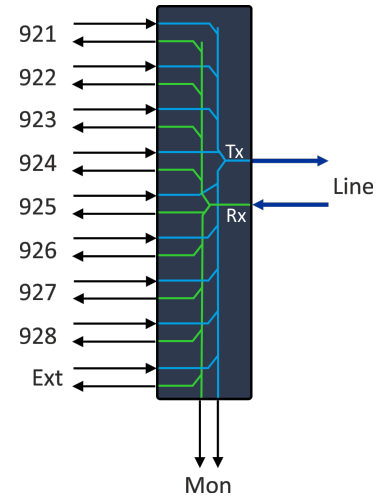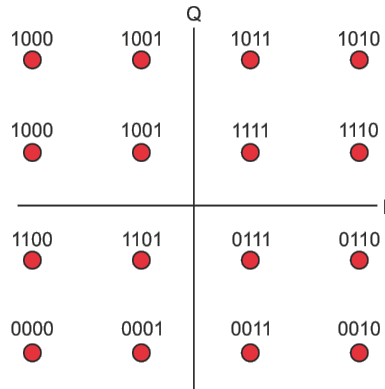smartoptics

Coherent 400G capable filters
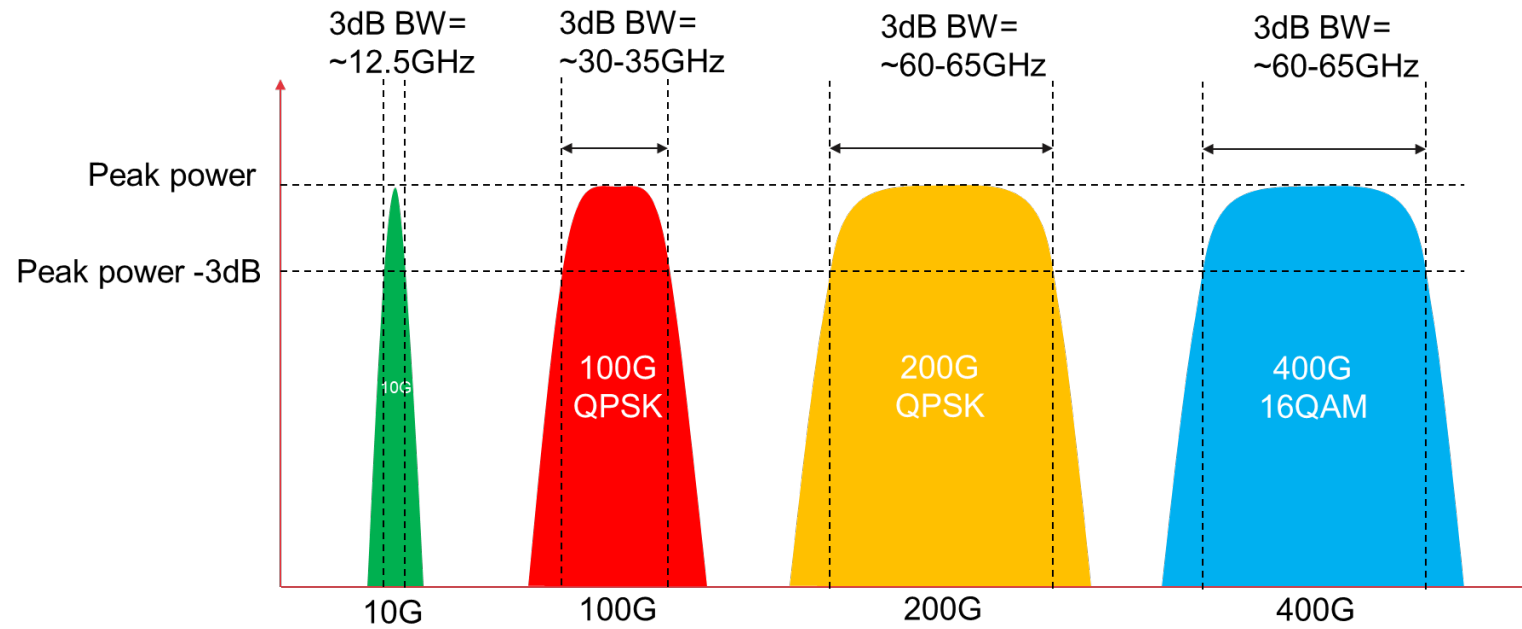
Signal spectrum for different rates and modulation formats.

400G Capable filters

400G 16QAM

1000 1001 1011 1010
1000 1001 1111 1110

16 Levels
Q uadrature
A mplitude
M odulation

1100 1101 0111 0110
0000 0001 0011 0010

921
922
923
924 Tx
925 Line
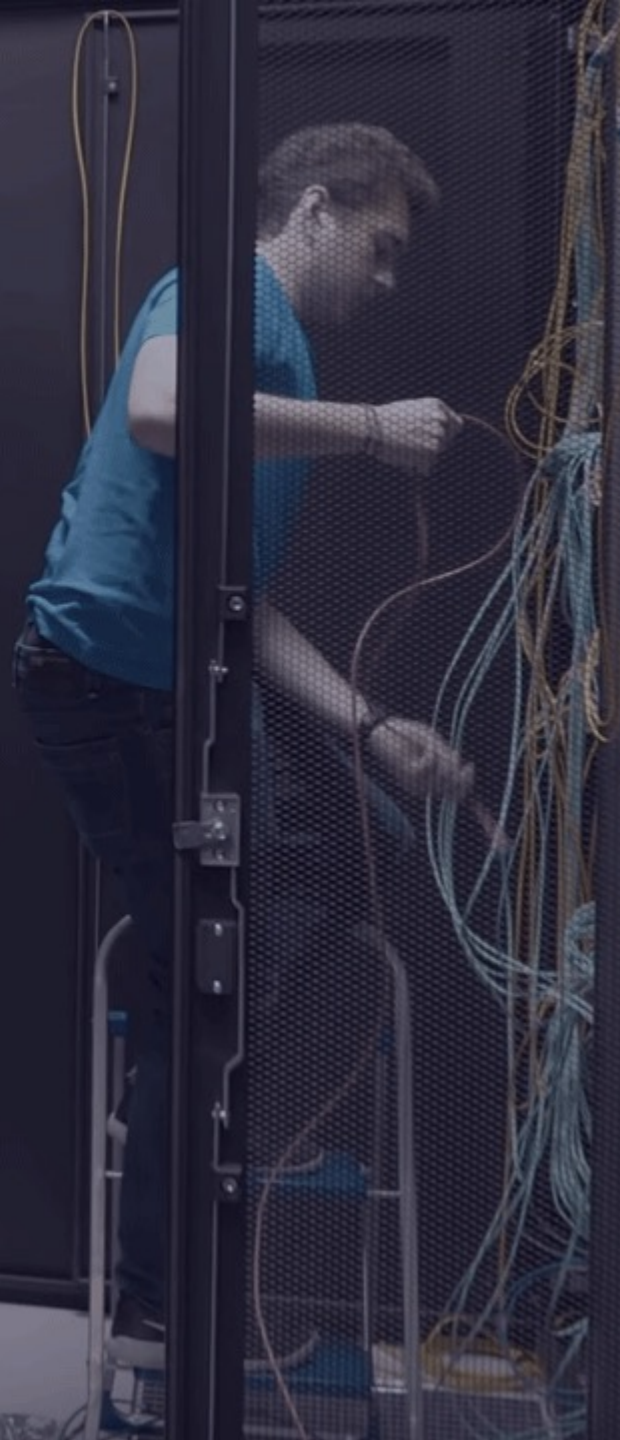Rx
926
927
928
Ext
Mon

THOU SHALL NOT PASS

400G 16QAM can be multiplexed @ 100GHz grid, but requires a wider channel passband than lower rates!
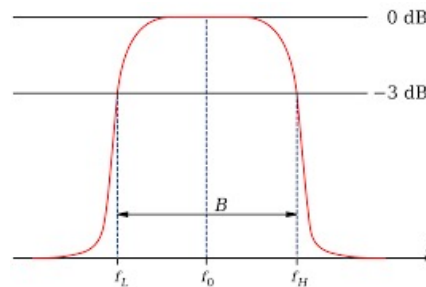
Must be > 75GHz

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11

800G Technology

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800G Grey optics

How is 800G achieved?

By doubling 400G technology!

Challenge!

Double number of optical connections!
Size and power consumption of
electronics and optics.

400G Transceivers

400G-DR4

MPO12

4+100G

4x 100G connections
@ 1310nm

SM Ribbon 8-fiber 500m

800G Transceivers

800G-DR8

MPO16   or   MPO12

8+100G

8x 100G connections
@ 1310nm

SM Ribbon 16-fiber 500m

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800G Grey optics

How is 800G achieved?

By doubling 400G technology!

Challenge!

Double number of optical connections!
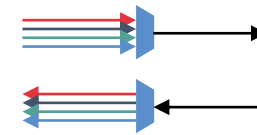Size and power consumption of
electronics and optics.

400G Transceivers

400G-LR4

4+100G

4x 100G connections
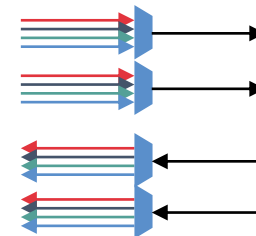@ 1271, 1291, 1311, 1331nm

1x Duplex LC

SM fiber-pair 10km

800G Transceivers

8+100G

800G 2xLR4

2x   4x 100G connections
@ 1271, 1291, 1311, 1331nm

2x Duplex LC

SM 2x fiber-pair 10km

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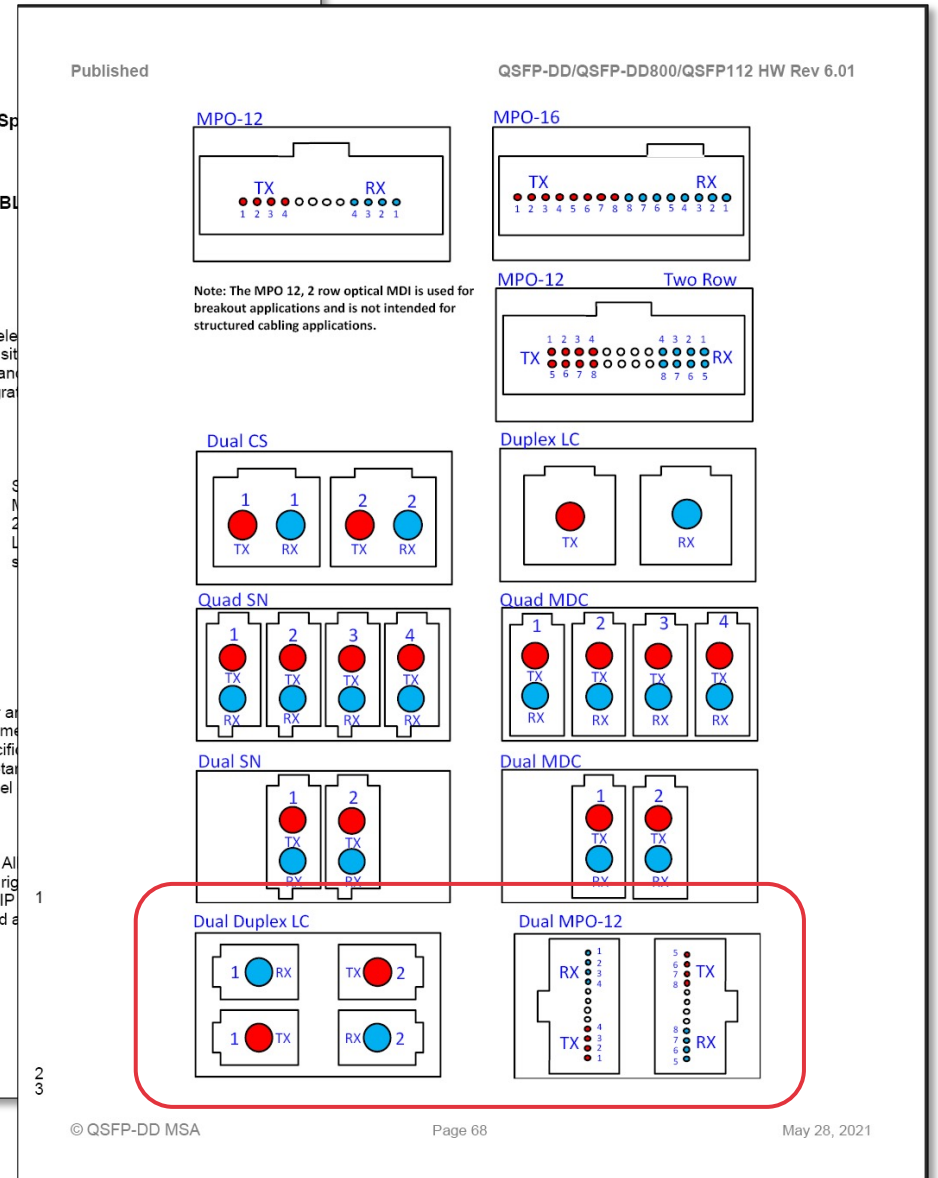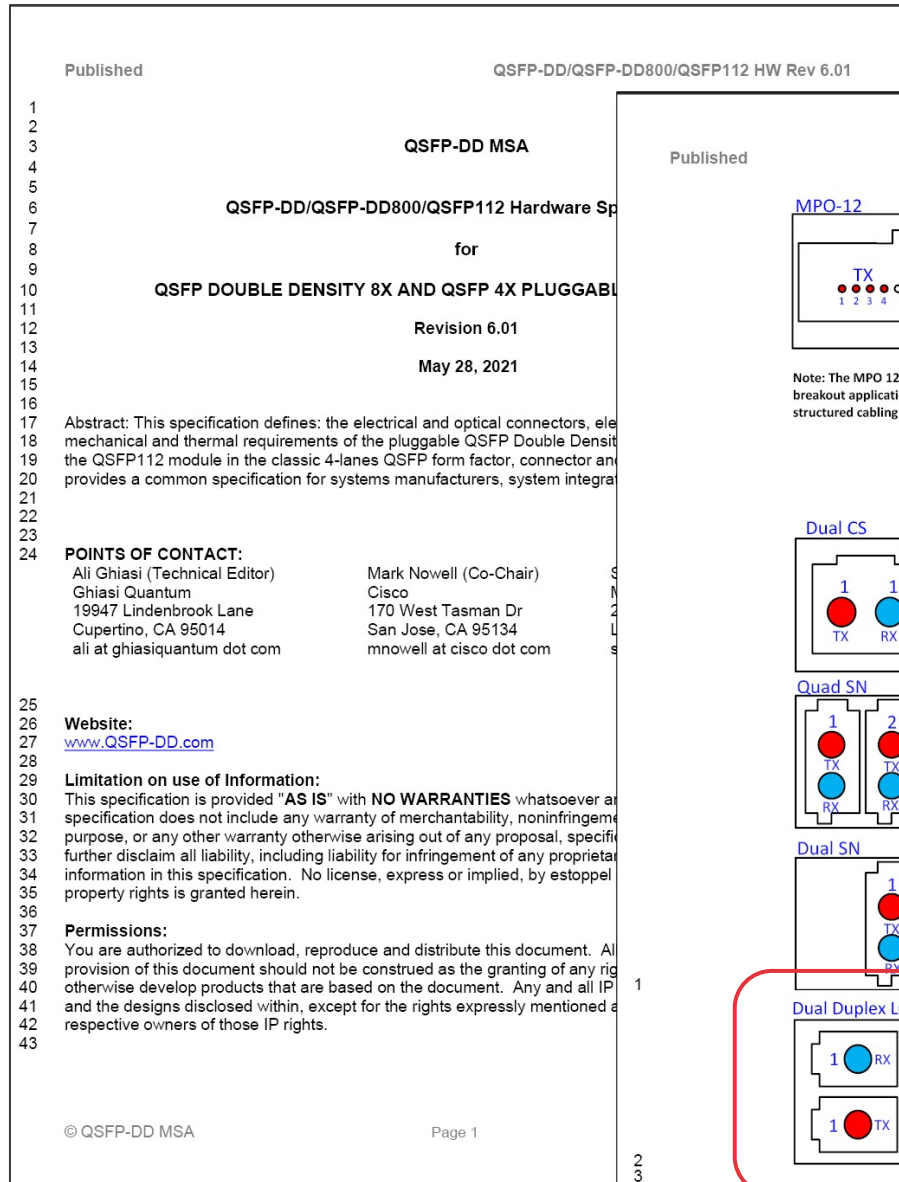# Form-factors for 800G

Form-factor options:
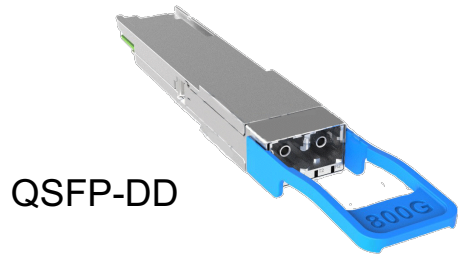
QSFP-DD

New QSFP-DD MSA spec with
multiple connector options!

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Coherent 800G

"interoperable 800G coherent line specifications for campus and DCI applications".

Scope:

- Define single-lambda 800G coherent line interfaces for two applications:
  - Amplified, single span, DWDM links up to 80-120km
  - Unamplified, fixed wavelength links of 2-10km

- Support Ethernet client(s) (minimum 100GE) up to 800G aggregate bandwidth

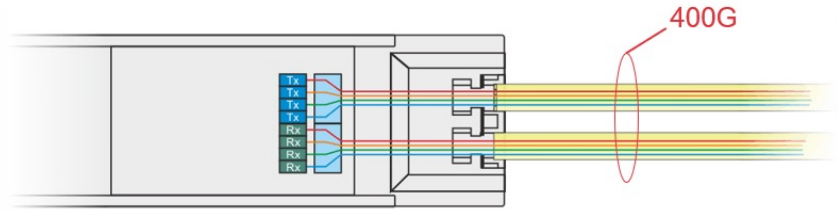First availability in second half of 2023.

Power consumption between 24-27W
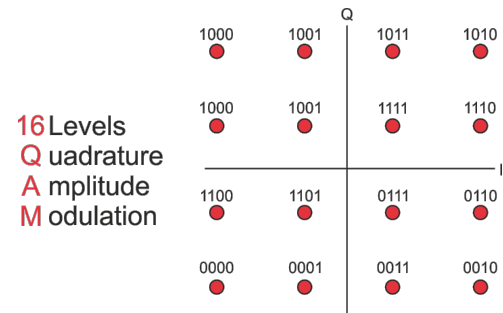
Same modulation format as 400G, but with a higher baud rate.
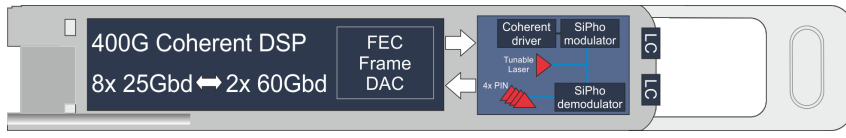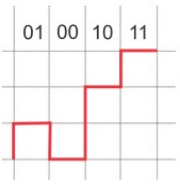
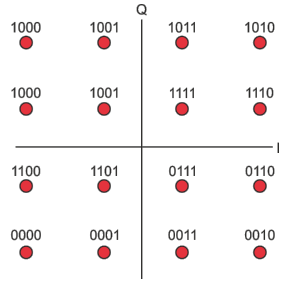Will require even wider channel filter passband than 400G.

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Summary

400G

4 lanes   CWDM
50GBaud

P ulse
A mplitude
M odulation
4 Levels

| 01 | 00 | 10 | 11 |

Common Management Interface Specification (CMIS)

400G Coherent DSP

8x 25Gbd ⟷ 2x 60Gbd

FEC Frame DAC

Coherent driver / SiPho modulator
Tunable Laser
4x PIN / SiPho demodulator

16 Levels
Q uadrature
A mplitude
M odulation

1000	1001	1011	1010
1000	1001	1111	1110
1100	1101	0111	0110
0000	0001	0011	0010

	OIF 400ZR	OpenZR+	OpenROADM
Target application	Edge DCI/Campus	Metro/Regional DCI	Metro/Regional DCI
Reach	80 – 120km / 11dB	>120km	>120km
Line capacity	400G	100G/200G/300G/400G	200G/300G/400G
Client formats	400GE	100GE/200GE/400GE	100GE-400GE + OTN
FEC	CFEC	oFEC	oFEC
Line modulation	16QAM	QPSK/8QAM/16QAM	QPSK/8QAM/16QAM
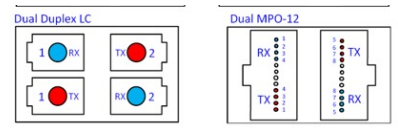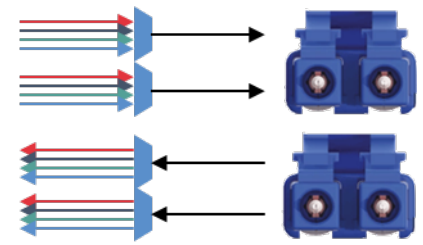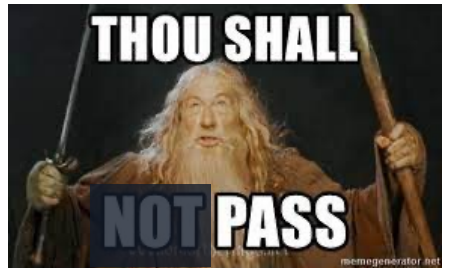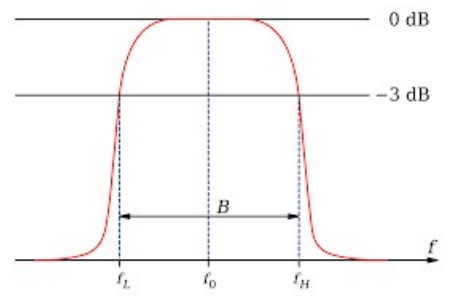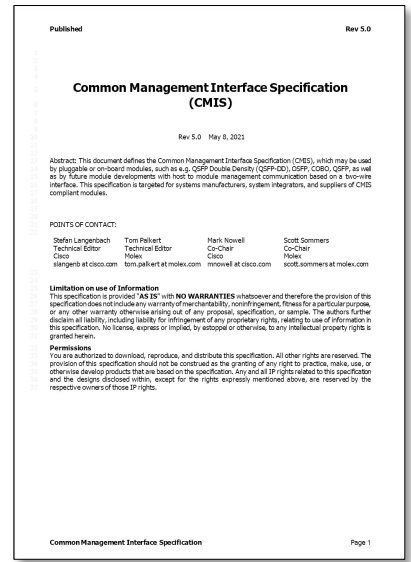
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Thank you!

please visit smartoptics.com

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