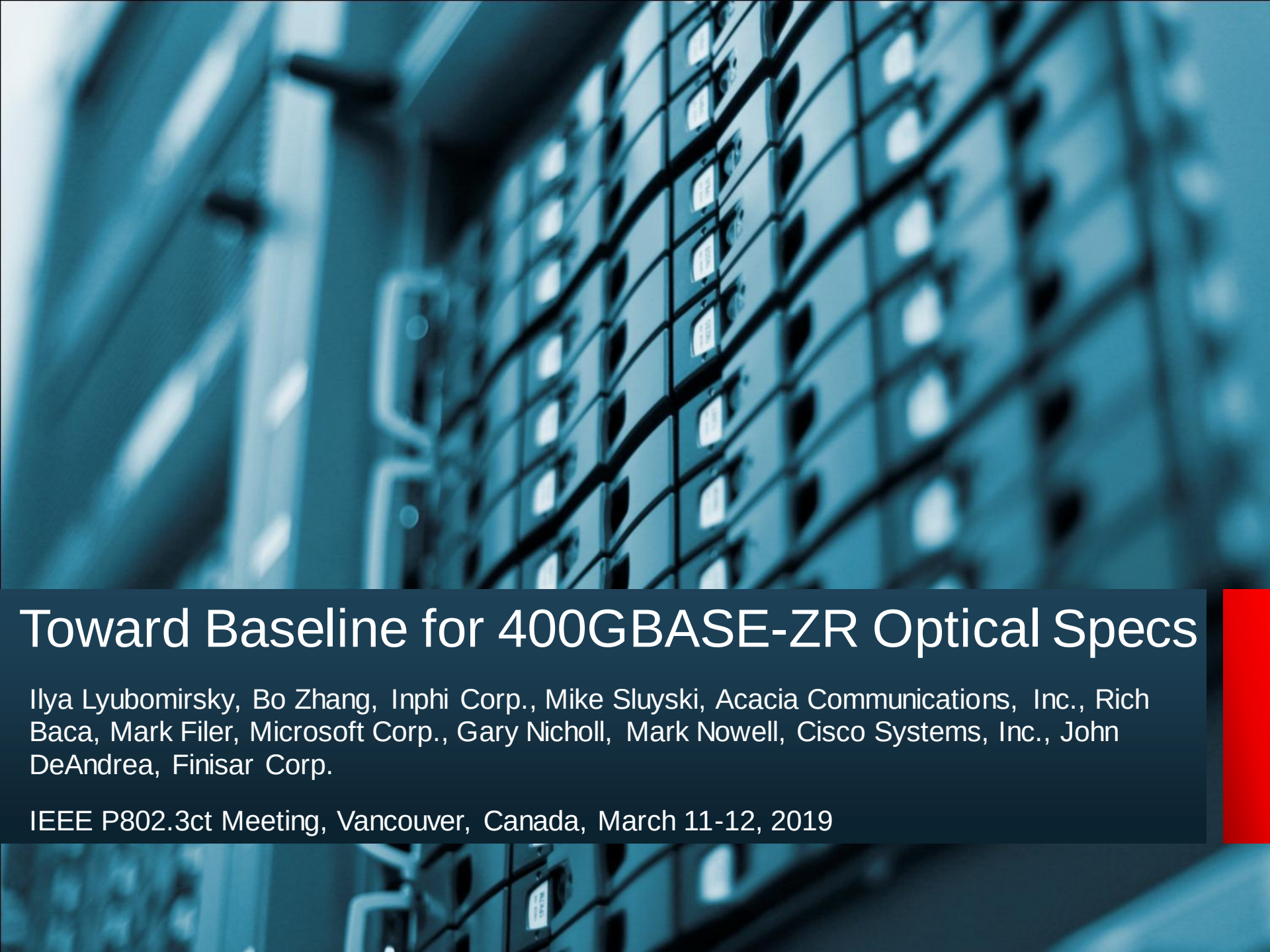

Toward Baseline for 400GBASE-ZR Optical Specs

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IEEE P802.3ct Meeting, Vancouver, Canada, March 11-12, 2019

Supporters

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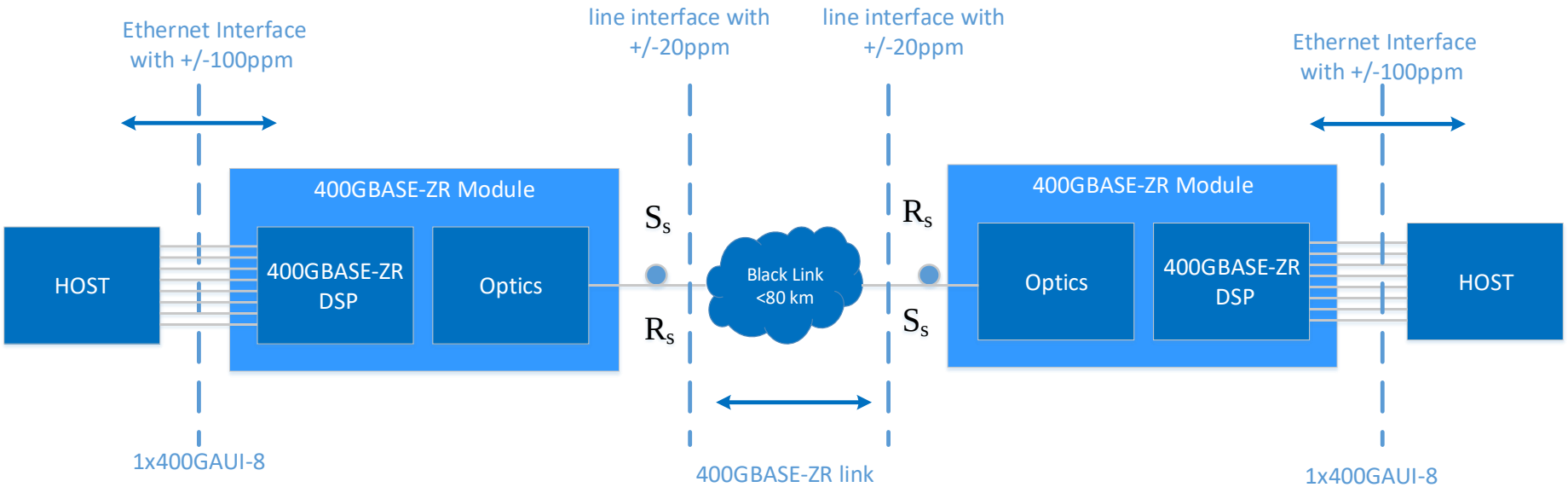
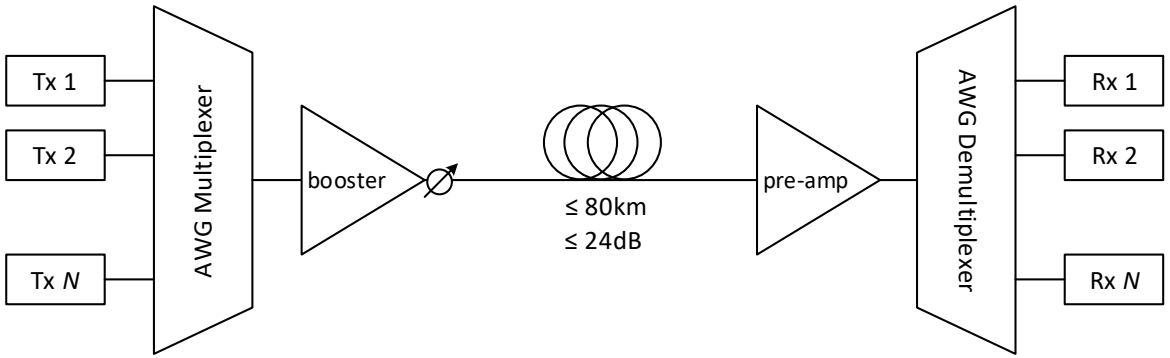
Introduction

- This contribution proposes to leverage OIF 400ZR optical specs as a starting point for 400GBASE-ZR
- Proposed specs include some modifications from OIF 400ZR based on discussions during Feb. 21 ad-hoc call
- Microsoft DCI DWDM link data is provided as a reference

Black Link Methodology



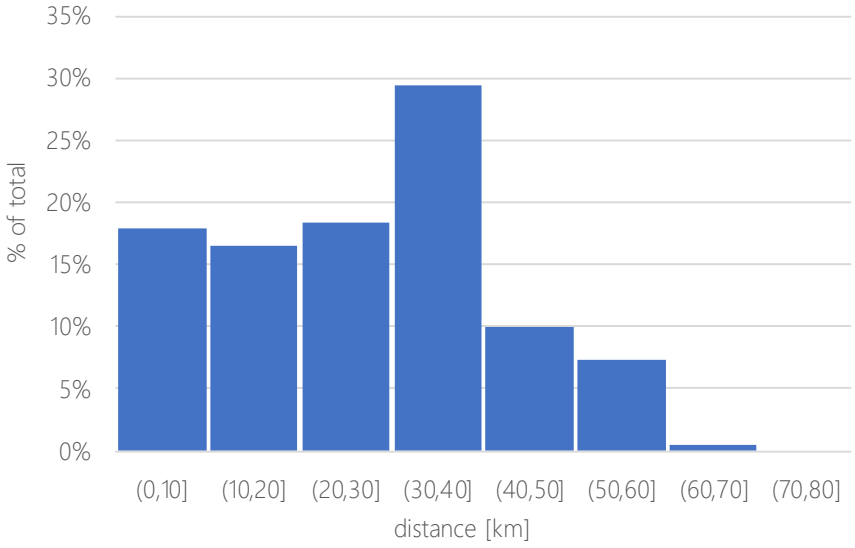
Microsoft Reference Link

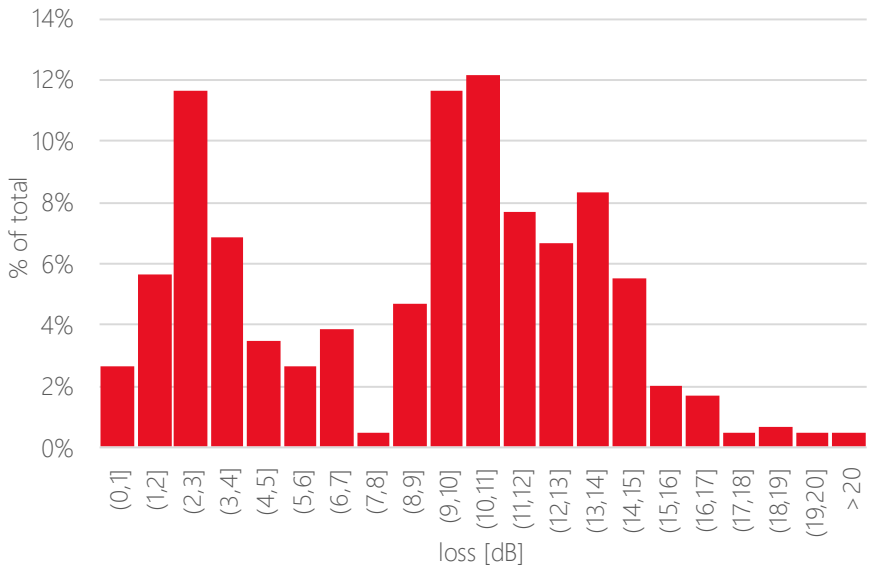


Ref link assumptions

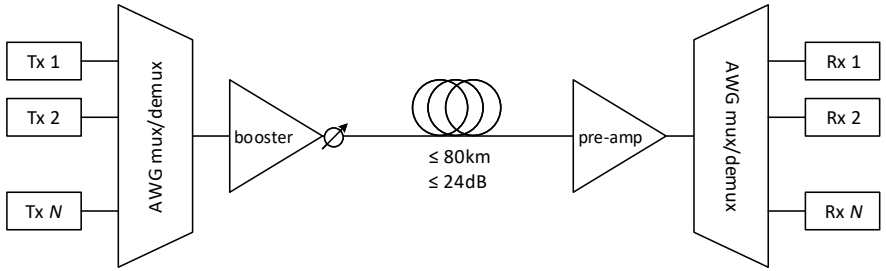
- distance 0-80 km
- high-power booster w/VOA at output
- high-gain pre-amp
- 100 or 75 GHz AWGs
- Optical Channel Monitor (OCM) at ingress / egress

Microsoft DCI fiber plant distance and loss distributions as of 03/2018

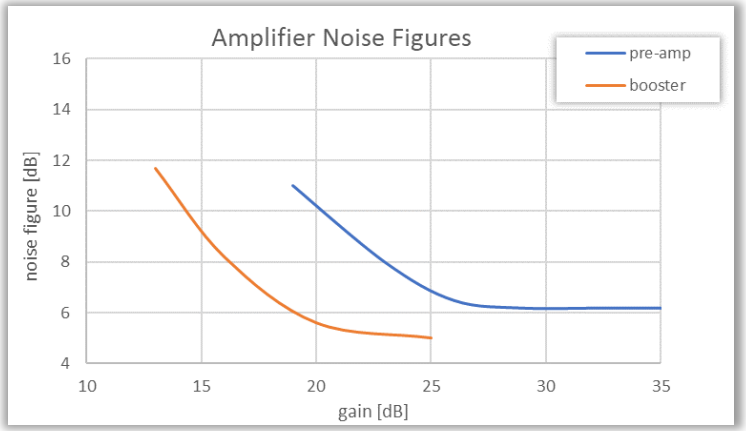




Line system/component assumptions



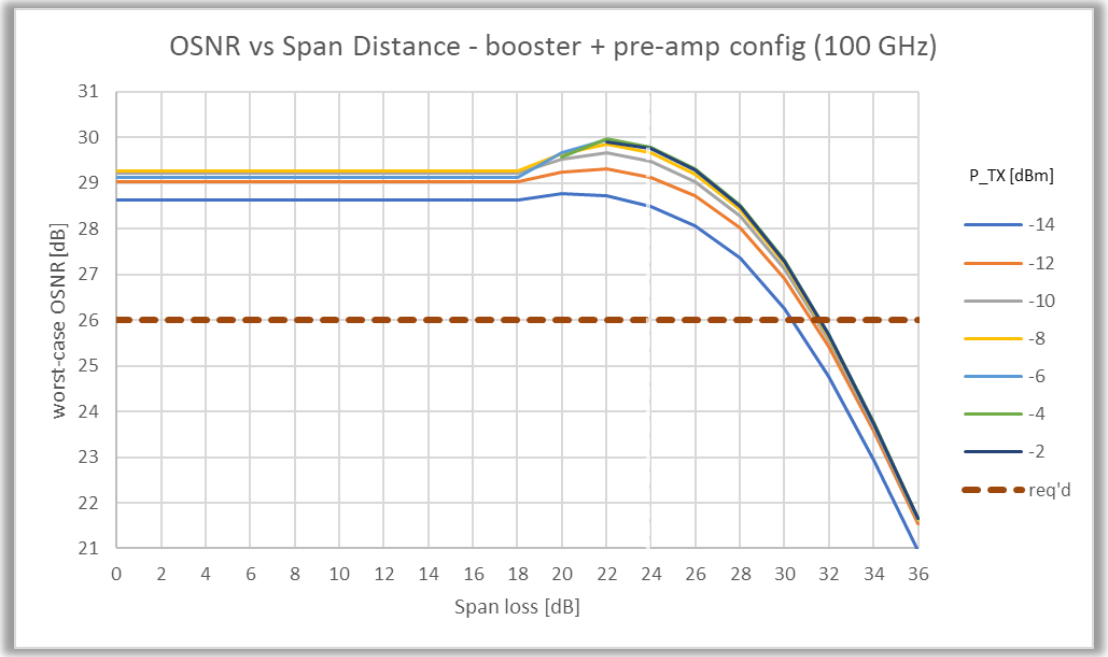
Element	Specification	Value	Unit
Booster amp	gain	11.5 - 25	dB
	max power	24.5	dBm
	output VOA range	0-18	dB
	gain flatness	1.0	dB
Pre-amp	gain	19 - 35	dB
	max power	21	dBm
	gain flatness	1.0	dB
Mux/demux	AWG mux/demux loss	4.0	dB
	spectral uniformity	0.5	dB
400G 64 Gbaud 16QAM module	Tx power (swept for study)	-14 to -2	dBm
	Tx uniformity (incl. cabling loss)	0.5	dB
	Rx req'd OSNR*	26	dB
	Rx req'd Power*	-12	dBm



- Sample specifications

Result: 48 ch @ 100 GHz spacing

- Assumptions:
  - 48 channels / 100 GHz spacing ext. C-band
  - G.652 with up to +7.5 dBm/ch
  - booster and pre-amp present for all cases
- Tx power: range [-14,-2] dBm
- Rx power: ≥ -12 dBm
- Span loss: range [0,36] dB



Microsoft Reference link Summary

- Assuming line system specs from earlier slide with:
  - 400G Tx: -10 to -6 dBm
  - 400G Rx: ≥-12 dBm
  - 400G Required OSNR: 26 dB

# carriers	max P_{fib}†	EOL OSNR margin*	EOL max loss†
48 (100 GHz)	+7.5 dBm	3.2 dB	31 dB
64 (75 GHz)	+6.4 dBm	2.0 dB	30 dB

** 24 dB max span loss;*
† G.652 fiber (non-G652 reduces max loss by 3-4 dB)

Black Link Channel Characteristics

Description	Value	Unit
Channel Spacing	100	GHz
Residual Chromatic dispersion (min)	0	ps/nm
Residual Chromatic dispersion (max)	2000	ps/nm
Polarization Mode Dispersion (ave)[a]	10	ps
Polarization dependent loss (max)[b]	2	dB
Polarization rotational speed (max)	50	krad/s
Optical Channel 1 dB Bandwidth (min)[c]	TBD	GHz
Optical Channel 20 dB Bandwidth (min)[c]	TBD	GHz
Optical Channel IL Ripple (max)[d]	TBD	dB

a). 10 ps of average PMD corresponds to max 33 ps of instantaneous DGD and max 500 ps^2 of SOPMD.
b). Does not include transmitter polarization imbalance.
c). Effective optical channel bandwidth due to DWDM optical filtering.
d). In-band IL ripple due to DWDM optical filtering.

Tx Optical Specs I

Description	Value	Unit
Signaling rate, (range) per polarization	59.84375 +/-100ppm	GBd
Modulation Format	DP-16QAM	
Start Channel Frequency	191.3	THz
Stop Channel frequency	196.1	THz
Laser frequency accuracy	± 1.8	GHz
Laser line-width (max)[a]	500	kHz
Laser relative intensity noise (ave)[b]	-145	dB/Hz
Laser relative intensity noise (peak)[c]	-140	dB/Hz
Optical Output Power (max)	-6	dBm
Optical Output Power (min)	-10	dBm
Transmitter reflectance (min)[d]	-20	dB
Transmitter back reflection tolerance (min)[e]	-24	dB
Spectral Excursion (max)[f]	TBD	GHz

a). Full Width Half Maximum (FWHM) high frequency component of the Tx laser phase noise (100MHz and above).
b). Average over 0.2GHz $< f <$ 10GHz.
c). Peak over 0.2GHz $< f <$ 10GHz.
d). Optical power ratio of the reflected light of Tx output port back to fiber network vs. the external incident light into the Tx output port.
e). Maximum light power (relative in decibel w.r.t. Tx output) reflected back to transmitter while still meeting performance requirements.
f). Defined in G.698.2 for DP-QPSK; may need refinement for 16QAM.

Tx Optical Specs II

Description	Value	Unit
Transmitter polarization power imbalance	1.5	dB
In-band OSNR (min) per 0.1 nm[a]	37	dB
Out-of-band OSNR (min) per 0.1 nm[b]	23	dB
Total output power with transmitter disabled (min)	-20	dBm
Total output power during channel change (min)	-20	dBm
X-Y polarization skew	5	ps
I-Q DC offset[c]	-26	dB
Error Vector Magnitude (max)[d]	TBD	%

a). Signal power over noise power in-band, measured with 12.5 GHz noise bandwidth.
b). Signal power over peak noise power in the whole frequency range, measured with 12.5 GHz noise bandwidth.
c). Ratio of unmodulated power to total signal power.
d). Defined in G.698.2 for DP-QPSK; measurement data provided in anslow_3cn_01_181025 for DP-16QAM.

Rx Optical Specs

Description	Value	Unit
Input Power Range (min)	-12	dBm
Input Power Range (max)	0	dBm
Frequency Offset Tolerance (min)[a]	± 1.8	GHz
OSNR Tolerance (min)[b]	26	dB
CD Tolerance (min) [c]	2000	ps/nm
DGD (max)[d]	33	ps
SOPMD (max)[d]	500	ps^2
Peak PDL Tolerance (min)[e]	3.5	dB
Change in SOP Tolerance (min)[f]	50	rad/ms
Optical Power Transient Tolerance (min)[g]	± 2	dB
Optical Return Loss (min)	20	dB
DWDM Transmission Penalty (max)[h]	0.5	dB

a). Rx must tolerate this amount of Tx frequency offset from the nominal ITU frequency grid based on 100 GHz channel spacing.
b). Minimum value of OSNR (referred to 0.1 nm noise bandwidth @ 193.6 THz) that can be tolerated while maintaining the maximum BER below the CFEC threshold. Must be met for a back-to-back measurement configuration at all input powers defined above.
c). Tolerance to chromatic dispersion with <0.5 dB OSNR penalty
d). Tolerance to max DGD and max SOPMD [according to 10ps mean PMD] with < 0.5 dB OSNR penalty and change in SOP < 1 rad/ms.
e). Peak PDL includes both transmitter polarization imbalance and link PDL. Tolerance to peak PDL with < 1.3 dB OSNR penalty. Tested with noise injected before PDL emulator and PSP < 1 rad/ms.
f). Tolerance to change in SOP with < 0.5 dB OSNR penalty.
g). Tolerance to change in input power with < 0.5 dB OSNR penalty.
h). OSNR penalty due to DWDM optical filtering effects [bandwidth and IL ripple], DWDM nonlinear transmission effects, and link reflections. Verified by design.

Next Steps

- Work toward reaching consensus on a 400GBASE-ZR optical specs baseline proposal