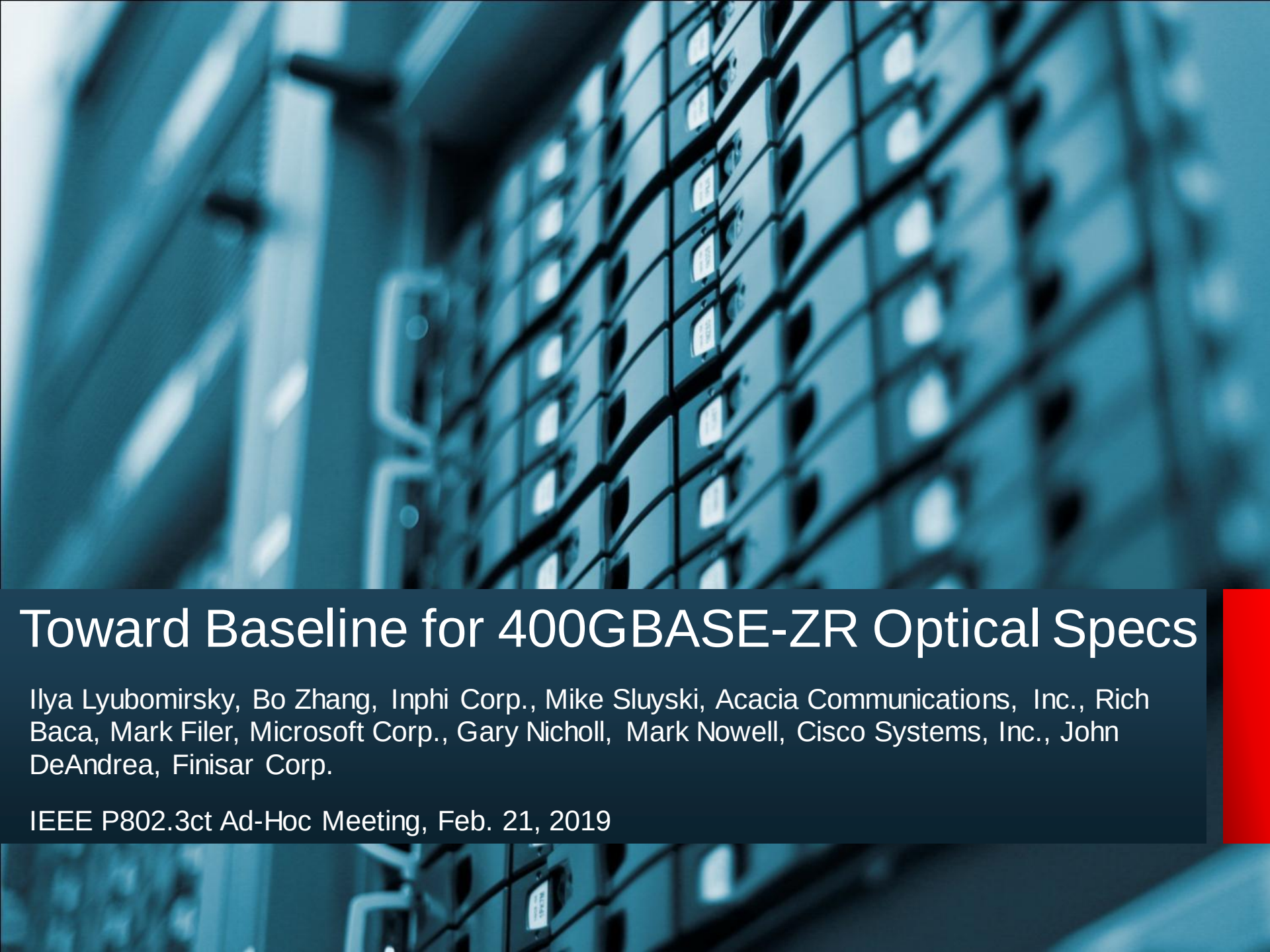

Toward Baseline for 400GBASE-ZR Optical Specs

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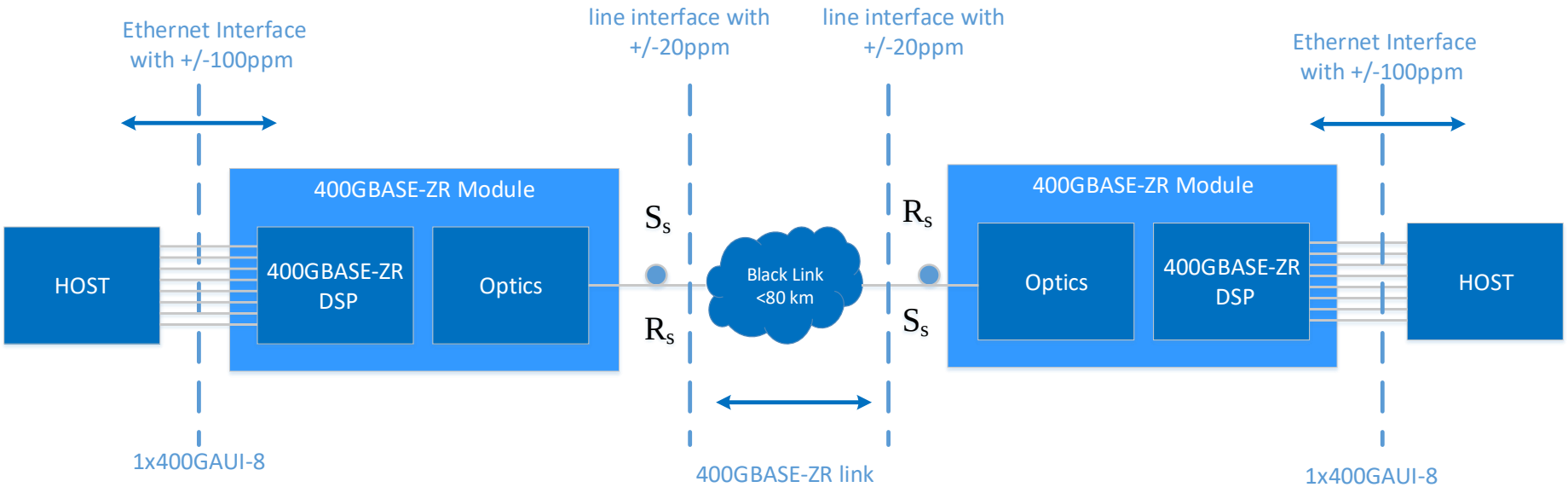
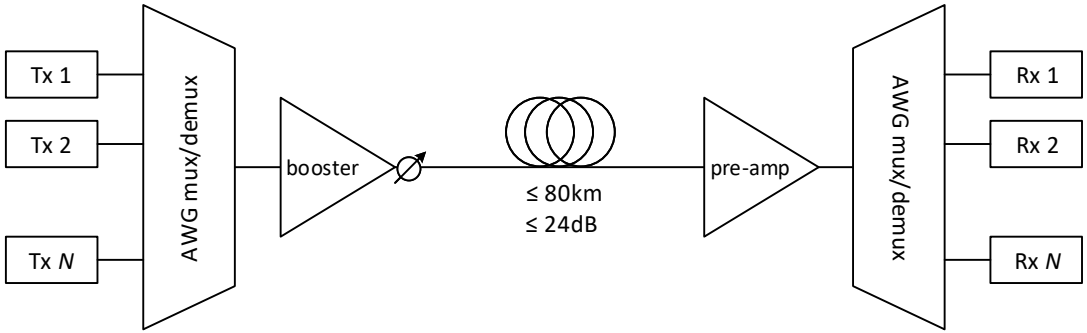
Introduction

- This contribution proposes to leverage OIF 400ZR optical specs. as a starting point for 400GBASE-ZR
- Microsoft DCI DWDM link data is provided as a reference

Black Link Methodology



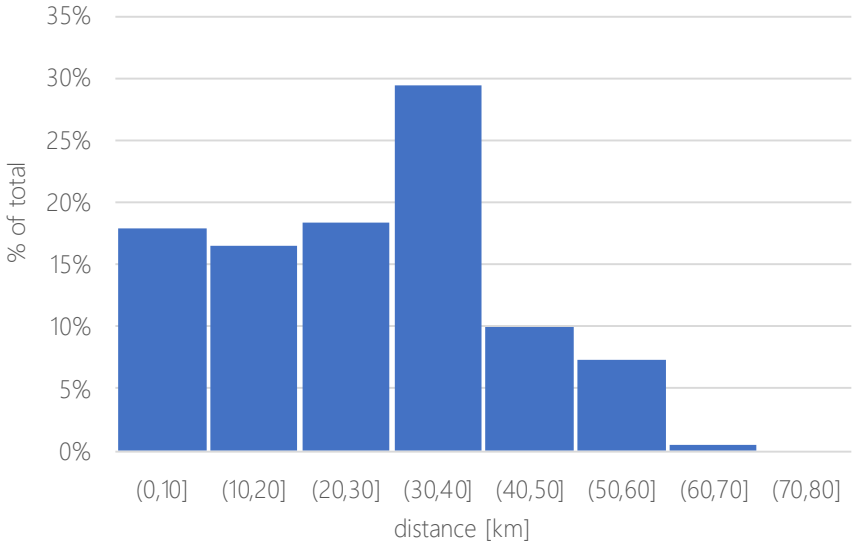
Microsoft Reference Link

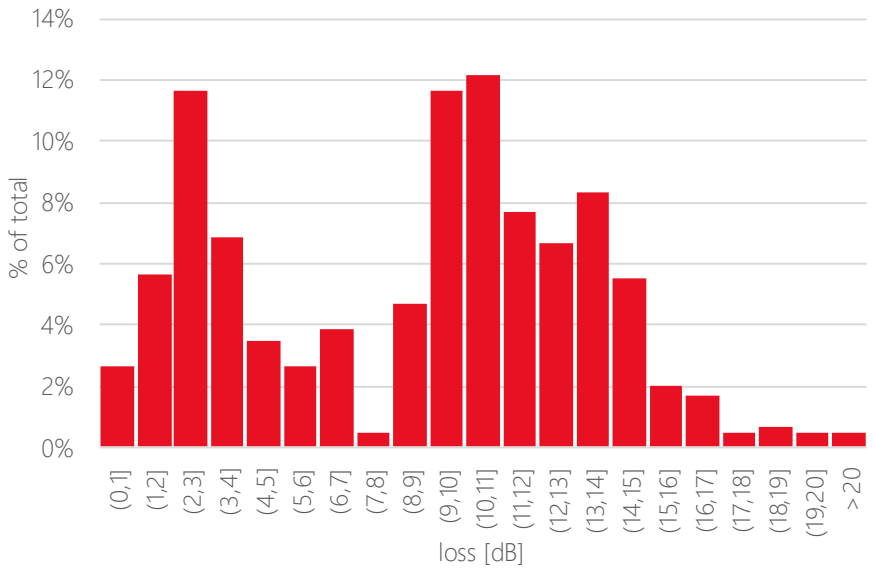


Ref link assumptions

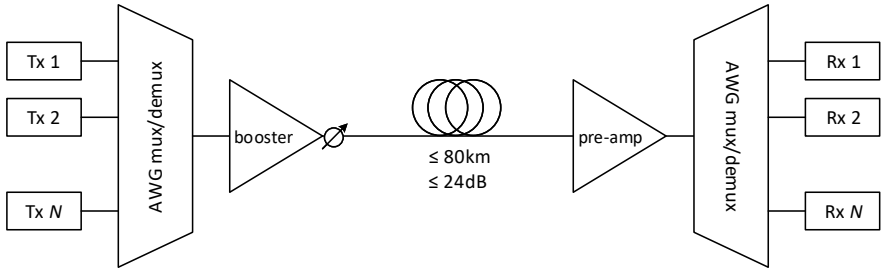
- distance 0-80 km
- high-power booster w/VOA at output
- high-gain pre-amp
- 100 or 75 GHz AWGs
- Optical Channel Monitor (OCM) at ingress / egress

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

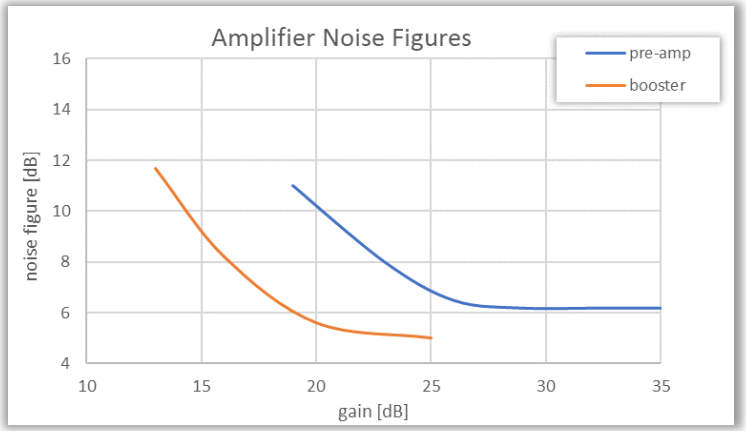




Line system/component assumptions



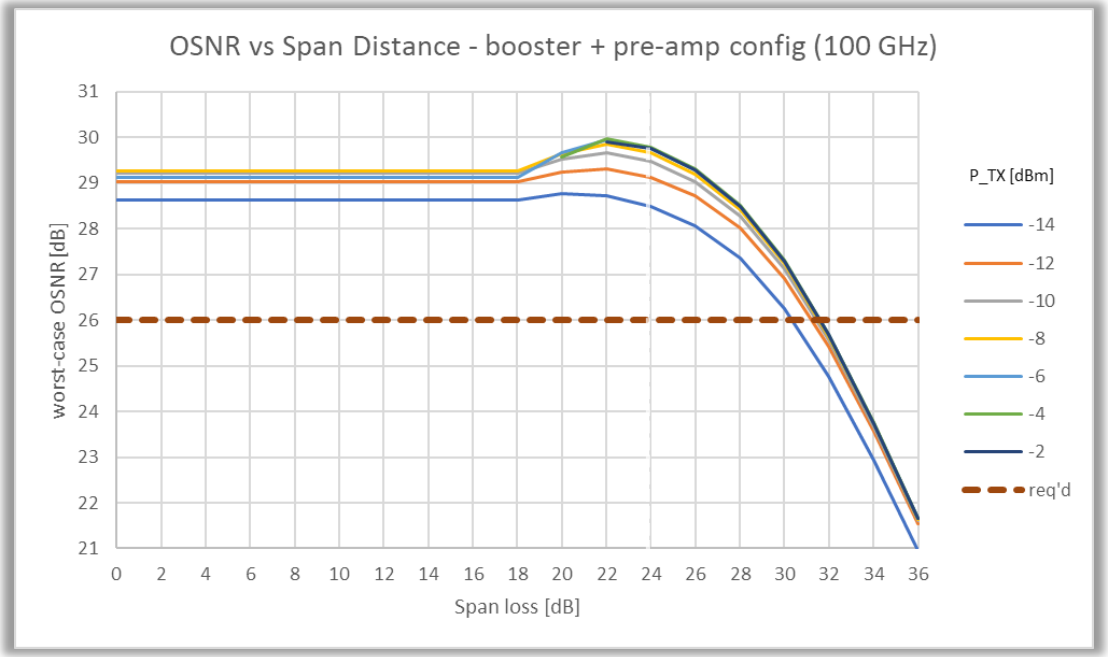
Element	Specification	Value	Unit
Booster amp	gain	11.5 - 25	dB
	max power	24.5	dBm
	output VOA range	0-18	dB
	spectral uniformity	1.0	dB
Pre-amp	gain	19 - 35	dB
	max power	21	dBm
	spectral uniformity	1.0	dB
Mux/demux	AWG mux/demux loss	4.0	dB
	spectral uniformity	0.5	dB
400G 64 Gbaud 16QAM module	Tx 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 (Required)	100	GHz
Channel Spacing (Optional)	75	GHz
Residual Chromatic dispersion (min)	0	ps/nm
Residual Chromatic dispersion (max)	1600	ps/nm
Polarization Mode Dispersion (ave)[a]	10	ps
Polarization dependent loss (max)[b]	2	dB
Polarization rotational speed (max)	50	krad/s
Pre FEC BER (max)[c]	1.25e-2	

a). 10 ps of average PMD corresponds to a maximum 33 ps of DGD when SOPMD = 0 ps^2, and maximum 272 ps^2 SOPMD when DGD = 23.3 ps.
b). Does not include transmitter polarization imbalance.
c). BER at the CFEC threshold.

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

a). FWHM high frequency component of the laser phase noise (100MHz and above). Applies to both Tx laser and receiver LO laser.
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.

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 phase imbalance	±5	degrees
I-Q skew	0.75	ps
I-Q DC offset[c]	-26	dB
I-Q amplitude imbalance	1	dB

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.

Rx Optical Specs

Description	Value	Unit
Input Power Range (min)	-12	dBm
Input Power Range (max)	0	dBm
Frequency Offset Tolerance (min)	± 3.6	THz
OSNR Tolerance (min)[a]	26	dB
CD Tolerance (min)	1600	ps/nm
Average PMD Tolerance (min)[b]	10	ps
Peak PDL Tolerance (min)[c]	3.5	dB
Change in SOP Tolerance (min)[d]	50	rad/ms
Optical Power Transient Tolerance (min)[e]	± 2	dB
Optical return Loss (min)	20	dB
Optical path OSNR penalty (max)[f]	0.5	dB

a). 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.
b). Tolerance to PMD with < 0.5 dB OSNR penalty.
c). 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.
d). Tolerance to change in SOP with < 0.5 dB OSNR penalty.
e). Tolerance to change in input power with < 0.5 dB OSNR penalty.
f). OSNR penalty due to chromatic dispersion and optical reflections in the link.

Next Steps

- Incorporate feedback from .3ct Task Force participants toward reaching a consensus on 400GBASE-ZR optical specs baseline proposal