

Update on Baseline Proposal: 400GBASE-ZR operation on 75GHz grid

Presenter: Mike A. Sluyski

May 7, 2020

sluyski_3cw_02_200507



Co-contributors and Supporters

Co-Contributors

- Mike Sluyski - Acacia
- Tom Williams – Acacia
- Eric Maniloff - Ciena
- Mark Nowell – Cisco
- Gary Nicholl – Cisco
- Ray Nering – Cisco
- Hiedeki Isono – Fujitsu
- Ide Satoshi – Fujitsu
- Yamazaki Too – Fujitsu
- Josef Berger – Inphi
- Tomas Maj – Inphi
- Ilya Lubomirsky – Inphi
- Bo Zhang – Inphi
- Jeffery Maki - Juniper
- Liang Du – Google
- Tad Hoffmeister – Google
- Ashaan Yousaf – Google
- Mattia Cantono – Google
- Brad Booth - Microsoft
- Rich Baca – Microsoft
- Mark Filer – Microsoft
- Karthik Balasubramanian - Microsoft
- Yawei Yin – Microsoft
- Atul Srivastava - NEL
- Winston Way – NeoPhotonics

Supporters

- Marek Hajduczenia – Charter
- Matt Schmitt - Cablelabs
- John De'Andrea – II-VI
- Ed Ulrichs - Intel
- Rang-Chen (Ryan) Yu – Sifotonics
- Frank Chang – Source Photonics
- Kenneth Jackson – Sumitomo

400GBASE-ZR optical specification table update

- Compare proposed baseline table entries with http://www.ieee802.org/3/ct/public/19_07/stassar_3ct_02_0719.pdf
 - Focus on parameters, not values (pgs. 4-8)
 - Identify parameters that are consider as non-controversial for baseline approval (pgs. 9-13)
- Propose for Adoption, Parameter/Values. (pgs. 15-18)
- Work list, including potential parameter additions – for further study (pg. 19)

Parameter Tables

- The baseline proposal in sluyski_3cw_01a_200423 included parameters derived from the adopted parameter list (derived from stassar_3ct_02_0719).
- Additional parameters were included in the baseline proposal that were felt were needed in addition to the previously adopted parameter list but were not clearly called out.
- For clarity, in following pages the parameter lists are compared, and differences called out and highlighted along these lines:
 - **Red** = additional compared to adopted parameter list
 - **Blue** = terminology or definition difference compared to adopted parameter list
 - **Turquoise** = missing in original baseline proposal compared to adopted parameter list

Table parameter compare: This baseline vs. adopted parameters

Transmitter Characteristics

sluyski_3cw_01a_200423.pdf

Description	Unit
Signaling rate (range)	GBd
Modulation format	-
Minimum Channel Spacing	GHz
Average channel output power (min)	dBm
Average channel output power (max)	dBm
Nominal center frequency	THz
Spectral excursion (max) @ -3dB ^a	GHz
Spectral excursion (max) @ -10dB ^b	GHz
Spectra Excursion (min) ^c	GHz
Side-mode suppression ratio (SMSR), (min)	dB
Laser linewidth (max)	KHz
Offset between the carrier and the nominal center frequency (max)	GHz

a). Maximum acceptable difference between the nominal central frequency of the channel and the -3 dB points of the transmitter spectrum furthest from the nominal central frequency measured at TP2.

b). Maximum acceptable difference between the nominal central frequency of the channel and the -10 dB points of the transmitter spectrum furthest from the nominal central frequency measured at TP2.

c). Minimum acceptable difference between the transmitter f_0 and the -TBD dB point of the transmitter spectrum measured at TP2.

Adopted per stassar_3ct_02_0719

Parameter Name	Units
Signaling rate (range)	GBd
Modulation format	—
Minimum channel spacing	GHz
Average channel output power (max)	dBm
Average channel output power (min)	dBm
Nominal center frequency	THz
Spectral excursion (max)	GHz
Side-mode suppression ratio (SMSR), (min)	dB
Laser linewidth (max)	kHz
Offset between the carrier and the nominal center frequency (max)	GHz

Red = additional compared to adopted parameter list

Blue = terminology or definition difference compared to adopted parameter list

Turquoise = missing in original baseline proposal compared to adopted parameter list

Table parameter compare: This baseline proposal vs adopted parameters

Transmitter Characteristics (cont.)

sluyski_3cw_01a_200423.pdf

Description	Unit
Power difference between X-Y polarizations (max)	dB
Skew between the X-Y polarizations (max)	ps
Error Vector Magnitude (max)	%
I-Q offset (max)	dB
Transmitter Inband OSNR (193.6) (min) (193.7)	dB
Average launch power of OFF transmitter (max)	dBm
Optical return loss tolerance (max) ^a	dB
Transmitter reflectance (max) ^b	dB
Laser relative intensity noise (avg) ^c	dB/Hz
Laser relative intensity noise (max) ^d	dB/Hz

a). Maximum light power (relative in decibel w.r.t. Tx output) reflected back to transmitter while still meeting performance requirements.

b). 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.

c). Average over $0.2\text{GHz} < f < 10\text{GHz}$.

d). Peak over $0.2\text{GHz} < f < 10\text{GHz}$.

Adopted per stassar_3ct_02_0719

Power difference between polarizations (max)	dB
Skew between the two polarizations (max)	ps

Parameter Name	Units
Error vector magnitude (max)	%
I-Q offset (max)	dB
Transmitter OSNR(193.6) (min)	dB
Average launch power of OFF transmitter (max)	dBm
Transmitter reflectance (max)	dB

Red = additional compared to adopted parameter list

Blue = terminology or definition difference compared to adopted parameter list

Turquoise = missing in original baseline proposal compared to adopted parameter list

Table parameter compare: This baseline vs. adopted parameters

Black Link characteristics

sluyski_3cw_01a_200423.pdf

Description	Unit
Channel spacing (min)	GHz
Ripple (max) ^d	dB
Optical path penalty OSNR (max) ^e	dB
Residual Chromatic dispersion (max)	ps/nm
Residual Chromatic dispersion (min)	ps/nm
Optical return loss at TP2 (min)	dB
Differential Group Delay (DGD) (max)	ps
Discrete reflectance between TP2 and TP3 (max)	dB
Polarization Mode Dispersion (avg) ^a	ps
Polarization Dependent Loss (max) ^b	dB
Polarization rotation speed (max)	krad/s
Inter-channel crosstalk at TP3 (max)	dB
Interferometric crosstalk at TP3 (max)	dB

a). 10 ps of average PMD corresponds to max 33 ps of instantaneous DGD and max 500 ps² of SOPMD.

b). Does not include transmitter polarization imbalance.

c). Effective optical channel bandwidth (FWHM) due to DWDM optical filtering.

d). Peak-to-peak difference in insertion loss from TP2 o TP3.

e) Path penalty is the combined penalty caused by chromatic dispersion, polarization mode dispersion, in-band ripple, inter-channel crosstalk, and interferometric crosstalk.

¹See definition: Maximum optical path penalty includes TBD dB due to inter-channel xtalk.

Adopted per stassar_3ct_02_0719

Parameter Name	Units
Maximum ripple	dB
Maximum optical path OSNR penalty	dB
Maximum chromatic dispersion	ps/nm
Minimum chromatic dispersion	ps/nm
Fiber dispersion slope (min) (S ₀)	ps/nm ² .km
Minimum optical return loss at TP2	dB
Maximum differential group delay, DGD_max	ps
Maximum polarization dependent loss	dB
Maximum polarization rotation speed	krad/s
Maximum inter-channel crosstalk at TP3	dB
Maximum interferometric crosstalk at TP3	dB

Red = additional compared to adopted parameter list

Blue = terminology or definition difference compared to adopted parameter list

Turquoise = missing in original baseline proposal compared to adopted parameter list

Table parameter compare: This baseline vs. adopted parameters

Receiver characteristics

sluyski_3cw_01a_200423.pdf

Adopted per stassar_3ct_02_0719

Description	Unit
Signaling rate (range)	GBd
Modulation format	-
Nominal center frequency	THz
Damage threshold	dBm
Average Input Power (max)	dBm
Average Input Power (min) [amplified]	dBm
Average Input Power (min) [unamplified]	dBm
Receiver OSNR (193.6) (min) ^a [amplified]	dB (0.1 nm)
Receiver OSNR (193.6) (min) [unamplified]	dB (0.1 nm)
OSNR Tolerance (193.6) (min) ^b	dB (0.1 nm)
Optical Return Loss (min) / Maximum reflectance of receiver	dB

Parameter Name	Units
Signaling rate (range)	GBd
Modulation format	—
Nominal center frequency	THz
Damage threshold	dBm
Maximum average input power	dBm
Minimum average input power [amplified]	dBm
Minimum average input power [unamplified]	dBm
Minimum OSNR(193.6) [amplified]	dB (0.1 nm)
Minimum OSNR(193.6) [unamplified]	dB (0.1 nm)
Receiver OSNR tolerance(193.6)	dB (0.1 nm)
Maximum reflectance of receiver	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 in the presence of .

b). Minimum value of OSNR (referred to 0.1 nm noise bandwidth @ 193.6 THz) is equal to the minimum Receiver OSNR plus the maximum optical path penalty OSNR.

Red = additional compared to adopted parameter list

Blue = terminology or definition difference compared to adopted parameter list

Turquoise = missing in original baseline proposal compared to adopted parameter list

Proposed Parameter/Values

- Consolidated tables of parameters and values which are assumed non-controversial and therefore candidates for adoption.

Proposed Transmitter optical specifications

Description	Value	Unit
Signaling rate (range)	59.84375 +/- 20ppm	GBd
Modulation format	DP-16QAM	-
Minimum Channel Spacing	75	GHz
Average channel output power (min)	-10	dBm
Average channel output power (max)	-6	dBm
Nominal center frequency	The frequency in Table 1xx-y corresponding to the variable Tx_optical_frequency_index	THz
Laser linewidth (max)	500	KHz
Offset between the carrier and the nominal center frequency (max)	1.8	GHz

Proposed transmitter optical specifications (cont.)

Description	Value	Unit
Power difference between X-Y polarizations (max)	1.5	dB
Skew between the X-Y polarizations (max)	5	ps
DC I-Q offset (mean), [per polarization]	-26	dB
Transmitter Inband OSNR (193.6) (min)	34	dB
Average launch power of OFF transmitter (max)	-20	dBm
Optical return loss tolerance (max) ^a	-24	dB
Transmitter reflectance (max) ^b	-20	dB

a). Maximum light power (relative in decibel w.r.t. Tx output) reflected back to transmitter while still meeting performance requirements.

b). 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.

Proposed 400GBASE-ZR black link parameters

Description	Value	Unit
Channel spacing (min)	75	GHz
Chromatic dispersion (max)	2000	ps/nm
Chromatic dispersion (min)	-200	ps/nm
Optical return loss at TP2 (min)	24	dB
Differential Group Delay (DGD) (max)	28	ps
Discrete reflectance between TP2 and TP3 (max)	-27	dB
Polarization Dependent Loss (max) ^b	2.0	dB
Polarization rotation speed (max)	50	krad/s

a). 10 ps of average PMD corresponds to max 33 ps of instantaneous DGD and max 500 ps² of SOPMD.

b). Does not include transmitter polarization imbalance.

Proposed Rx optical specs

Description	Value	Unit
Signaling rate (range)	59.84375 +/- 20ppm	GBd
Modulation format	DP-16QAM	-
Nominal center frequency	The frequency in Table 1xx-y corresponding to the variable Tx_optical_frequency_index	THz
Average Input Power (max)	0	dBm
Average Input Power (min)	-12	dBm
Receiver OSNR (193.6) (min) ^a	26	dB (0.1 nm)
Optical Return Loss (min) / Reflectance at Receiver input (max)	20	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 in the presence of .

Consolidated Items for further study (deferred)

Description	Value	Unit
Transmitter Parameters		
Spectral excursion (max)	TBD	GHz
Spectra Excursion (min)	TBD	GHz
Side-mode suppression ratio (SMSR), (min)	TBD	dBm
Error Vector Magnitude (max)	TBD	%
Laser relative intensity noise (avg)	TBD	dB/Hz
Laser relative intensity noise (max)	TBD	dB/Hz
Black Link Parameters		
Ripple (max)	TBD	dB
Optical path penalty OSNR (max)	TBD ¹	dB
Inter-channel crosstalk at TP3 (max)	TBD	dB
Interferometric crosstalk at TP3 (max)	TBD	dB

Description	Value	Unit
Receiver Parameters		
Damage threshold	TBD	dBm
Receiver OSNR (193.6) min [unamplified]	TBD	dB (0.1 nm)

Other potential parameters:

- Instantaneous I/Q offset (Dither) ?
- TX Clock Phase Noise?
- Output power with TX disabled?
- Transmitter back reflectance tolerance?
- PMD Tolerance?
- Tolerance to change in SOP?