800GBASE-LR1 Optical Specifications

Supporting contribution for D1.1 comments 353 & 354

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Comments

Cl **185** *SC* **185.6.1** *P* **508** *L* **6** # 353

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Comment Type **T** *Comment Status* **D** *Tx optical parameter*

Table 185-4 Parameter Updates:

Updates required with vaules for:

- Average Power
- X/Y Skew
- TQM
- Laser Frequency Specifications

SuggestedRemedy

Supporting presentation with values will be contributed

Proposed Response *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.
Pending CRG review of presentation and discussion.

Cl **185** *SC* **185.6.2** *P* **509** *L* **6** # 354

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Comment Type **T** *Comment Status* **D** *Rx optical parameter*

Table 185-5 Parameter Updates required:

Power Levels
Frequency Range
SOP rate of change

SuggestedRemedy

Supporting presentation with values will be contributed

Proposed Response *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.
Pending CRG review of presentation and discussion.

Optical specs for the 800GBASE-LR1 Tx and Rx are required

Intent is to reach agreement on approach for Tx, Rx specs will follow

Background on IMDD Transmit Quality Metric (TQM) usage

IMDD clauses use a per-lane TECQ & TDECQ, based on measurements of each lane's performance

- An example from 802.3cu is shown

Each physical lane's OMA (min) depends on its TDECQ

For TDECQ < 1.4dB, OMA (min) is fixed

Table 151–7—400GBASE-FR4 and 400GBASE-LR4-6 transmit characteristics

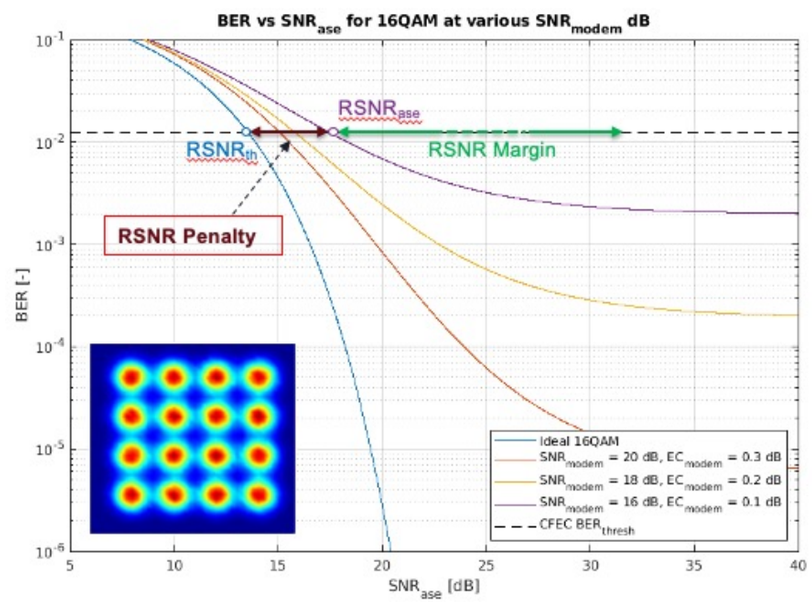
Description	400GBASE-FR4	400GBASE-LR4-6	Unit
Signaling rate, each lane (range)	53.125 ± 100 ppm		GBd
Modulation format	PAM4		—
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5		nm
Side-mode suppression ratio (SMSR), (min)	30		dB
Total average launch power (max)	10.4	11.1	dBm
Average launch power, each lane (max)	4.4	5.1	dBm
Average launch power, each lane[a] (min)	–3.2	–2.7	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	3.7	4.4	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (min) for TDECQ <1.4 dB for 1.4 dB ≤ TDECQ ≤ 3.4 dB	 –0.2 –1.6 + TDECQ	 0.3 –1.1 + TDECQ	 dBm dBm
Difference in launch power between any two lanes (OMA_{outer}) (max)	3.9	4	dB
Transmitter and dispersion eye closure for PAM4 (TDECQ), each lane (max)	3.4	3.4	dB

Coherent TQM Approach

Extended Transmitter Constellation Closure (ETCC) has been proposed as a TQM

- ETCC measures Tx quality by ΔRSNR: The Tx-induced penalty in required SNR
- As presented in (maniloff_3dj_02_2405.pdf) ETCC specifies the SNR penalty between a theoretical (perfect) signal and a practical signal.
- Since ETCC specifies an SNR penalty, Tx power can be used to compensate for larger ETCC values
- Based on experience with coherent optics:
  - A Minimum ISNR for a modem of 15 dB is assumed
  - A Maximum Eye closure of 0.4 dB is assumed
- These values define both Tx and Rx
- Allocations to Tx of 1/3 to 1/2 of the total are assumed

Note: ETCC is based on the correctable BER. As such it should be referenced to the BER being used, in this case ETCC(1.1E-2)



Tx Power relationship to ETCC

Spec for a ‘good’ transmitter:

- overall implementation noise of 16.5dB with 1/3 allocated to Tx
- 0.1 dB Eye Closure
- → 1.0 dB ETCC (RSNR Penalty) from the Transmitter

Potential Spec for a worst-case transmitter

- overall implementation noise of 15 dB with 1/2 allocated to Tx
- 0.2dB Tx Eye Closure
- → 2.5 dB ETCC (RSNR Penalty)

Note: In discussions there was concern that a larger value for ETCC should be allowed, based on analysis of data from interop events. ETCC(1.1E-2)$_{max}$ = 3.4dB is recommended.

Tx Power$_{min}$ = -11.2 dBm for ETCC < 1.0 dB
Tx Power$_{min}$ = -12.2 + ETCC dBm ETCC ≥ 1.0 dB

ETCC$_{max}$ = 3.4 dB

Laser Accuracy

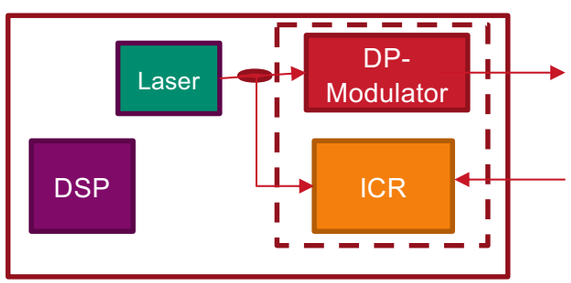
Laser Accuracy is intended to allow acquisition for worst case offset between the Rx signal and LO Laser

- Unlocked lasers with a larger frequency range than can be compensated digitally are supported, as discussed in maniloff_3dj_01_2405.pdf

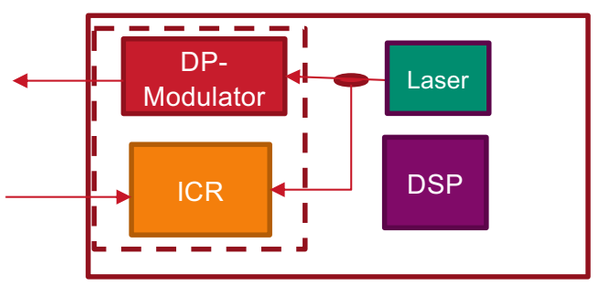
A larger allowed inaccuracy reduces calibration requirements

- Rx needs to be able to measure the sign of any frequency error to allow tuning

A value of ± 20 GHz for the laser accuracy is measurable to allow acquisition, while relaxing laser frequency spec



shared laser



Tx laser Slew Rates

Out of service slew rate target to meet ≤ 2 second acquisition

- Based on a worst case 40GHz offset → 20GHz/s minimum slew rate for acquisition

In service slew rate

- When the Rx frequency exceeds the dead-zone of ±400MHz, a 1 THz/s rate allows fast tracking

The dead zone ensures a laser offset of ≤ 900MHz

SOP Tracking rate

Previous standards have specified a 50kRad/s SOP tracking rate

- Published data on DWDM links shows a wide range of SOP evolution rates, up to multiple Mrad/s

Limited data exists for SOP evolution for shorter/non CD compensated links

Measurements on a 40km and 7 km link reported maximum rates of 32kRad/s:

- Misha Boroditsky et al, “Polarization Dynamics in Installed Fiberoptic Systems”, 2005 IEEE LEOS Annual Meeting Conference Proceedings

Based on this, maintaining a 50kRad/s rate is recommended

Tx Specifications

New items highlighted

Items highlighted in green are proposed to include in 1.2

Note: ETCC refers to ETCC(1.1E-2)

Description	Value	Unit
Signalling rate	123.7±50 ppm	Gbaud
Modulation Format	DP-16QAM	
Average Launch Power (Max)	-6	dBm
Average Launch Power (Min) for ETCC ≤ 1.0 dB for 1.0 > ETCC ≤ 3.4 dB	 -11.2 -12.2+ETCC	dBm
Carrier Frequency (range)	228.5 ± 20 GHz	THz
Optical Frequency Accuracy	±20	GHz
Laser Linewidth	1	MHz
Power difference between X and Y polarizations (max)	1.5	dB
Skew between X and Y polarizations (max)	5	ps
ETCC (Max)	3.4	dB
Instantaneous I-Q offset per polarization (max)	-20	dB
Mean I-Q offset per polarization (max)	-26	dB
I-Q amplitude imbalance (mean)	1	dB
I-Q phase error magnitude (max)	5	deg
I-Q quadrature skew (max)	0.75	ps
Transmitter In Band OSNR	36	dB/12.5 GHz
Average launch power of OFF transmitter (max)	-20	dBm
Transmitter reflectance (max)	-20	dB
RIN average (max)	-145	dB/Hz
RIN peak (max)	-140	dB/Hz
Tx laser frequency slew rate: pre acquisition (max)	20	GHz/s
Tx laser frequency slew rate: post acquisition (max)	1	THz/s
Laser relative frequency tracking accuracy	± 0.9	GHz
Tx clock phase noise (PN): Maximum PN mask Frequency (Hz): 1E4 4E5 1E6 ≥ 1E7	 -100 -132 -136 -146	dBc/Hz
Tx clock phase noise (PN); Maximum total integrated random jitter	0.015	UI_rms
Tx clock phase noise (PN); Maximum total periodic jitter	0.03	UI_pp

Rx Specifications

Description	Value	Unit
Signalling rate	123.7±50 ppm	GBd
Modulation Format	DP-16QAM	
Optical Frequency	228.5 ± 20GHz	THz
Damage Threshold	-4	dBm
Average Receive Power (Max)	-6	dBm
Average Receive Power (Min) For ETCC(1.1E-2)< 1.0 dB For 1.0 ≤ ETCC(1.1E-2) ≤ 3.4 dB	 -17.5 -18.5+ETCC	dBm
Receiver reflectance (max)	20	dB
Frequency offset between received carrier and local oscillator (max)	40	GHz
Polarization dependent loss (max)	TBD	dB
State of polarization (max)	50	kRad/s

Link Parameters

Description	Value	Unit
Power Budget	6.8	dB
Operating distance	10	km
Channel Insertion Loss	6.3	dB
Maximum discrete reflectance	-27	dB
Allocation for Penalties	0.5	dB
Additional insertion loss allowed	0	dB

Parameters from 802.3dj D1.1 are unchanged

Summary

Proposed values for optical parameters for 800GBASE-LR1 are shown

Tx Power is coupled to the ETCC TQM

- A similar approach can be adopted for 800GBASE-ER1

Laser frequency accuracy specifications and slew rates are presented

SOP evolution is maintained at 50krad/s

Proposed values for clock phase noise are presented

Thanks!