Optical specification alignment of 800GBASE-LR1 & 800GBASE-ER1

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IEEE P802.3dj

May Interim, 2025, New Orleans, USA

Overview

800GBASE-LR1 & ER1 definition methodologies overview

ETCC Updates:

- Analysis Required to arrive at final values

Next steps

- Continuing analysis using realistic Rx assumptions
- Updating ETCC values as needed

800GBASE-LR1 and 800GBASE-ER1 specification methodologies

100GBASE-ZR and OIF 800LR use a fixed minimum Tx power approach

800GBASE-LR1 is being defined to have the Tx power related to the ETCC value

- This is similar to how IMDD couples Tx power to TECQ/TDECQ
- ETCC is defined to represent the SNR penalty of a transmitter’s implementation

800GBASE-ER1 currently uses a fixed minimum Tx power approach

Moving forward, the 800GBASE-LR1 and 800GBASE-ER1 methodologies will be aligned, coupling power to ETCC

Tx Specs

Table 185–5—800GBASE-LR1 transmit characteristics

Description	Value	Unit
Signaling rate (range)	123.6364 ± 50 ppm	GBd
Modulation format	DP-16QAM	—
Average launch power (max)	–6	dBm
Average launch power (min) for ETCC ≤ 1 dB for 1 < ETCC ≤ 3.4 dB	 –11.2 –12.2 + ETCC	dBm
Carrier frequency (range)	228.675 ± 20 GHz	THz
Power difference between X and Y polarizations (max)	1.5	dB
Skew between X and Y polarizations (max)	5	ps
Extended transmit constellation closure (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 OSNR in a 12.5 GHz resolution bandwidth (min)	40	dB
Average launch power of OFF transmitter (max)	–20	dBm
Transmitter reflectance[a] (max)	–20	dB
RIN average (max)	–145	dB/Hz
RIN peak (max)	–140	dB/Hz
Laser linewidth (max)	1	MHz
Tx laser frequency slew rate: pre acquisition (max)	10	GHz/s
Tx laser frequency slew rate: post acquisition (max)	1	GHz/s

Table 187–5—800GBASE-ER1-20 and 800GBASE-ER1 transmit characteristics

Description	800GBASE-ER1-20	800GBASE-ER1	Unit
Signaling rate (range)	118.203351 ± 20 ppm		GBd
Modulation format	DP-16QAM		—
Average launch power (max)	–7	–1	dBm
Average launch power (min)	–11	–5	dBm
Carrier frequency (range)	193.7 ± 1.8 GHz		THz
Power difference between X and Y polarizations (max)	1		dB
Skew between X and Y polarizations (max)	5		ps
ETCC	2.5		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 OSNR in a 12.5 GHz bandwidth (min)	35		dB
Average launch power of OFF transmitter (max)	–20		dBm
Transmitter reflectance[a] (max)	–20		dB
RIN average (max)	–145		dB/Hz
RIN peak (max)	–140		dB/Hz
Laser linewidth (max)	1		MHz

LR1 minimum Average Launch power is coupled to ETCC.

ER1 uses a fixed minimum Tx power approach

Rx Specs

Table 185–6—800GBASE-LR1 receive characteristics

Description	Value	Unit
Signaling rate (range)	123.6364 ± 50 ppm	GBd
Modulation format	DP-16QAM	—
Carrier frequency (range)	228.675 ± 20 GHz	THz
Damage threshold[a]	–2	dBm
Average receive power tolerance (max)	–6	dBm
Average receive power tolerance (min) for ETCC ≤ 1 dB for 1 < ETCC ≤ 3.4 dB	 –17.5 –18.5 + ETCC	dBm
Receiver sensitivity (max)[b] for ETCC ≤ 1 dB for 1 < ETCC ≤ 3.4 dB	 –18 –19 + ETCC	dBm
Receiver reflectance (max)	20	dB
Frequency offset between received carrier and local oscillator (max)	40	GHz
Polarization dependent loss (max)	2	dB
Polarization rotation speed (max)	50	krad/s

[a] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level. The receiver does not have to operate correctly at this input power.
[b] Receiver sensitivity is optional.

Table 187–6—800GBASE-ER1-20 and 800GBASE-ER1 receive characteristics

Description	800GBASE-ER1-20	800GBASE-ER1	Unit
Signaling rate (range)	118.203351 ± 20 ppm		GBd
Modulation format	DP-16QAM		—
Carrier frequency (range)	193.7 ± 1.8 GHz		THz
Damage threshold[a]	2		dBm
Average receive power tolerance (max)	–1		dBm
Average receive power tolerance (min)	–18		dBm
Receiver sensitivity (max)[b]	–18.5	–19	dBm
Receiver reflectance (max)	20		dB
Frequency offset between received carrier and local oscillator (max)	± 1.8		GHz
Polarization dependent loss (max)	1.5		dB
Polarization rotation speed (max)	50		krad/s

[a] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level. The receiver does not have to operate correctly at this input power.
[b] Receiver sensitivity is optional.

By coupling the Tx value to the measured ETCC, a wider range of TX implementations can be supported

Both methodologies are valid approaches, but moving forward should be aligned

ETCC Analysis

$RSNR_{FEC}$ represents the theoretical SNR at which the FEC can meet the BER requirements

- For 800GBASE-LR1 with BCH FEC, this is ~13.9 dB
- For 800GBASE-ER1 with OFEC, this is ~12.7 dB

The overall noise budget needs to be sufficient to accommodate

- Transmitter Implementation Noise (IMN & Eye Closure)
    - This term is measured by ETCC
- Receiver Implementation Noise (IMN & Eye Closure)
- Electrical noise introduced at the receiver

IMN view of optical implementation impairments

As presented in [1] imperfections in an optical implementation can be modeled as Implementation Noise (AWGN) and Eye Closure.

Increasing the Tx power with increasing ETCC will increase the Rx Power, and hence the Rx SNR

- However, it will not impact the increase in RSNR that arises from the higher ETCC or the Rx Implementation noise

Evaluation of the specifics of the impact of ETCC on the SNR budget is important to ensure appropriate values are selected

The overall SNR required at the Rx is defined by the FEC gain, ~13.9 dB for 800GBASE-LR1

[1] https://www.ieee802.org/3/dj/public/24_05/maniloff_3dj_02_2405.pdf

Examples of Noise stackup

		RSNR	NSR	Penalty
RSNR_FEC		13.90	0.04073803	
Tx EC	0.10	14.00		
Tx IMN	21.30	14.89	0.03239761	1.0
Rx EC	0.20	15.09		
Rx IMN	18.00	18.21	0.01509055	4.3

		RSNR	NSR	Penalty
RSNR_FEC		13.90	0.04073803	
Tx EC	0.20	14.10		
Tx IMN	18.00	16.37	0.02305558	2.5
Rx EC	0.20	16.57		
Rx IMN	18.00	22.10	0.00616898	8.2

ETCC

As Tx Impairments increase, the ETCC noise term uses an increasing proportion of the overall noise budget

Allowing higher ETCC puts additional restrictions on Rx design

- Final values need further analysis

Summary

A full analysis of the impact of ETCC on performance is required to finalize values

Allowing higher ETCC can potentially allow simplification of transmitter designs

However, these higher ETCC values:

- Impose more stringent Rx implementation noise requirements
- Reduce the allowable noise contribution from the receiver

A more complete analysis of these tradeoffs is required

Values for LR1 and ER1 will differ, due to their differing FEC gains/noise budgets

Thanks!