Towards a Transmit Quality Metric for 800GBASE-LR1

Kishore Kota – Marvell

P802.3dj Interim Meeting, St. Petersburg, USA, January 2024

Supporters

- Xiang Liu – Huawei
- Tao Gui - Huawei

Introduction

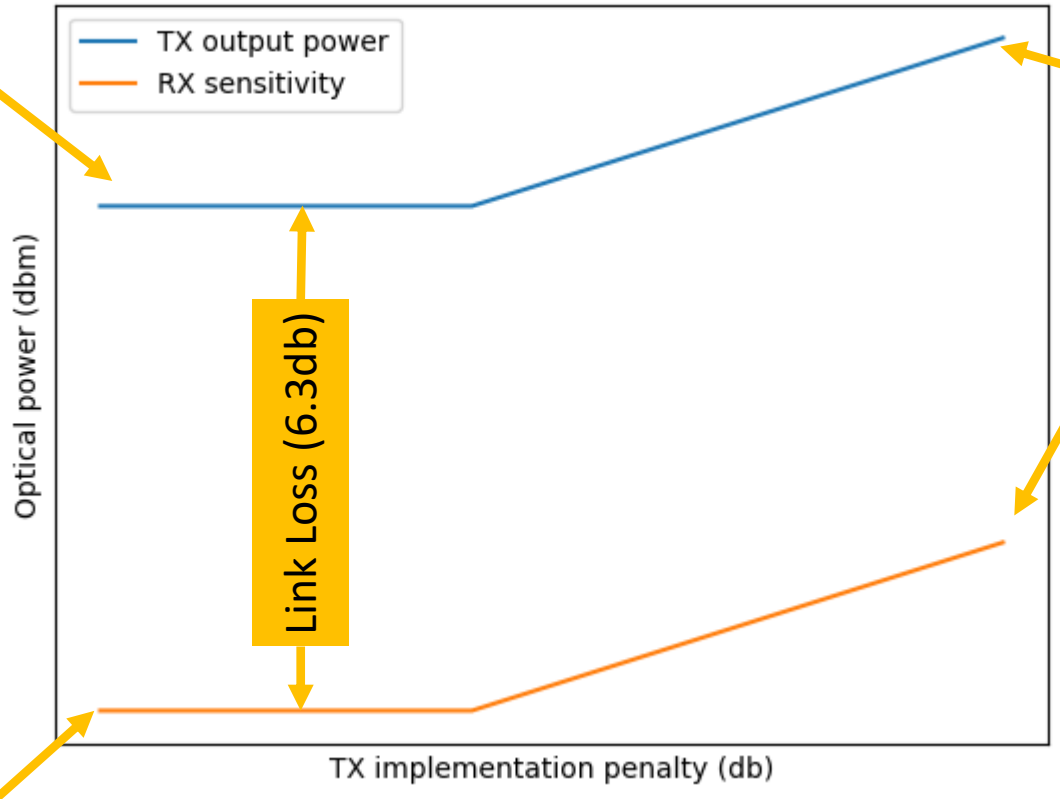
- kota_3dj_01a_2311 proposed the use of a transmit quality metric to specify TX output power and RX sensitivity specifications for 800GBASE-LR1
  - Same concept as TDECQ in IMDD specifications

- 800GBASE-LR1 can benefit from such a specification methodology by allowing more options for implementors to lower complexity of coherent module designs

- This presentation explores some options for a TQM definition

TQM based Specification Methodology

Min TX output power of a perfect transmitter



Min TX output power of an imperfect transmitter

Stressed RX sensitivity

Min RX sensitivity with ideal TX

Updates the traditional specification methodology used in prior coherent standards intended for DWDM applications

Better suited for point-to-point non-DWDM applications because a higher transmit power directly translates into link margin

What is a Transmit Quality Metric?

- Transmit quality metric estimates the BER penalty of the transmitter under test relative to an ideal transmitter measured at a reference receiver

- TQM will not predict the exact behavior of an arbitrary (unknown) receiver implementation!
  - A real receiver could see less penalty because an implementation may choose to use a receiver design which exceeds the capability of a reference receiver. For e.g. the real receiver might use a longer filter or a different sampling rate to improve performance relative to the reference receiver
  - Similarly, a real receiver could perform worse if aspects of the reference receiver aren't implemented. For e.g., TDECQ reference receiver has perfect knowledge and can adjust sampling phase to minimize TDECQ. A real receiver may not be able to match that.

Extension of TDECQ to coherent (1/2)

PAM4 TDECQ	Coherent TQM
Each lane tested individually	All lanes simultaneously
SSPRQ Test pattern on lane under test to stress the timing recovery	Same pattern might be useable for coherent
Worst case optical return loss with splitter, variable reflector	May not be necessary for coherent
Worst RIN by adjusting polarization of reflection	May not be necessary for coherent
4^{th} order Bessel-Thompson filter at half symbol rate	Same filter should be ok
Channel with worst-case CD and return loss, minimum IL and minimum DGD	Carry over the same concept without CD because it is a linear impairment for coherent. Use fixed polarization but adjust for worst case
Scope noise is measured without signal but using same settings to use in the calculation	Use same concept for coherent

Extension of TDECQ to coherent (2/2)

IMDD TDECQ	Coherent TQM
Noise is added as part of calculation to determine largest amount of noise for desired BER target	Use same concept of adding noise to calculated level of noise required to reach desired BER target
BER of receiver is estimated indirectly by calculating noise sigma from histograms of the measured eye	Propose to measure BER directly by comparing bits to ideal bits. Since coherent BER threshold is 1e-2 instead of 2.4e-4, this does not require long captures
Reference receiver consists of fixed-length (5-taps) symbol-rate equalizer, CDR with specified bandwidth (4MHz) .	Reference receiver will consist of fixed-length symbol-rate (?) equalizer, carrier recovery and timing recovery
CDR with specified bandwidth in hardware or software	CDR with specified bandwidth in software. Capture length needs to be long enough to be consistent with the chosen clock recovery bandwidth
Sampling phase is optimized to minimize TDECQ	Sampling phases of each channel will need to be individually optimized (in software)
PAM levels adapted to optimize TDECQ calculation	Needs more discussion
Ideal signal with measured OMAouter is used as the reference	Ideal signal with measured signal power can be used as the reference

The Way forward

- EVM is used in 802.3cw as an overall transmit quality metric with individual parameters

- TCC was recently introduced as an extension of TDECQ to coherent
  - Q. Fan, X. Liu, and T. Gui, “B400G transmitter quality metric based on transmitter constellation closure (TCC)”, ITU-T contribution SG15-C0799, ITU-T Plenary Meeting, 20 Nov. –1 Dec., 2023.

- Recently the OIF ZR+ interop data was processed using TCC
  - Q. Fan, X. Liu, and T. Gui, “Comparison between EVM and TCC for evaluating 400ZR+ Transmitter Quality and rOSNR”, oif2024.062

Summary

- Proposing a specification methodology similar to PAM4 through the use of a transmit Q-metric (TXQ)
- TCC calculated as a BER penalty (in dB) would be a good candidate for this approach and will be explored further
- The OIF ZR+ data captures are a good source to validate the procedure

Thank you!