Analysis of a coherent solution for the 800Gb/s single SMF 10 km objective

Eric Maniloff, James Harley, Kevin Farley, Doug Mcghan, Ian Betty
Ciena

IEEE P802.3df

July Plenary, Montreal, 2022

Supporters

- Cedric Lam, Google
- Shuang Yin, Google
- Xiang Zhou, Google
- Paul Brooks, Viavi
- Kishore Kota, Marvell
- Lenin Patra, Marvell

Overview

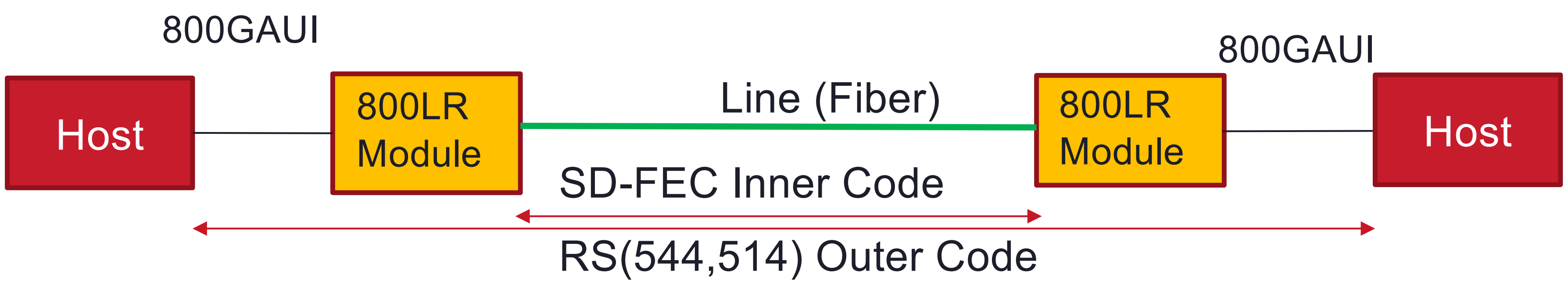
802.3df includes the following 800Gb/s objectives that are suitable for a coherent optical solution

- over a single SMF in each direction with lengths up to at least 10 km
- over a single SMF in each direction with lengths up to at least 40 km

Both coherent and 4 wavelength 200G/lane solutions have been proposed to meet the 10km SMF objective

This contribution provides analysis of a coherent solution tailored to meet the 10km SMF application

Concatenated FEC overview



An allocation of BER ≤ 1E-5 is assumed for the electrical links

Termination of the RS544 FEC is available as an alternative (ie FEC segmentation), if future electrical specifications are unable to meet the BER target

Tx Overview

Operation at 1310 nm

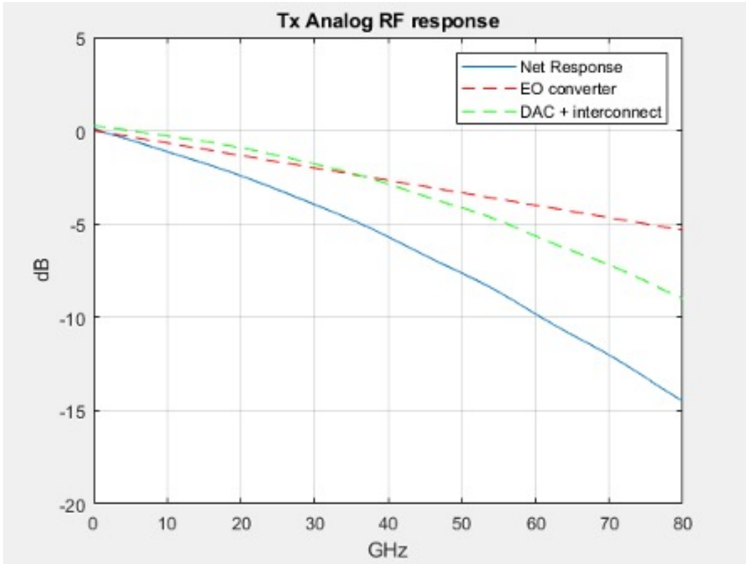
Tx Specs:

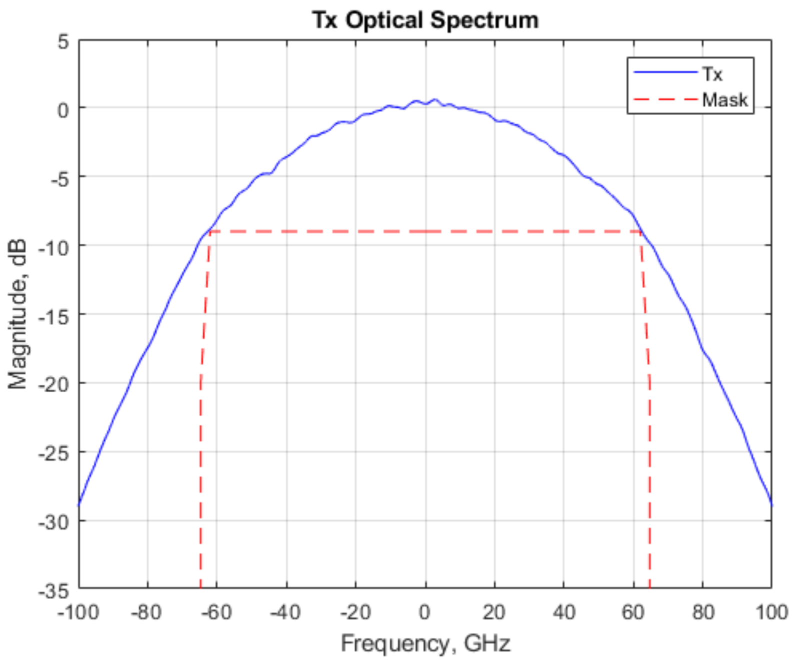
- Laser power: 16 dBm (EOL)
- Tx/Rx Split: 3 dB (50/50)
- Max Tx path modulated insertion loss (EOL): 23 dB
- Tx output power: ≥ -10 dBm

Modulation:

- Dual polarization 16QAM
- Baud = 123.7 Gbaud

Tx net frequency response loss of 10dB at Fbaud/2.





Rx BER Analysis

Noise sources for EO/DAC/ADC/DSP included in analysis

- Based on projections for this application

Additional noise source included for interop

- Interop NSR is included based on a 1dB penalty consistent with the 400GBASE-ZR application
- Treating as a noise term provides a baud-independent derating for interop

Overall modem-noise is consistent with implementation penalties used to derive the OSNR requirements in 400GBASE-ZR / 802.3cw

10km Power budget

Loss Budget assumes 0.43dB/km +2dB for patch panels

- → 6.3dB Loss budget is required for this application

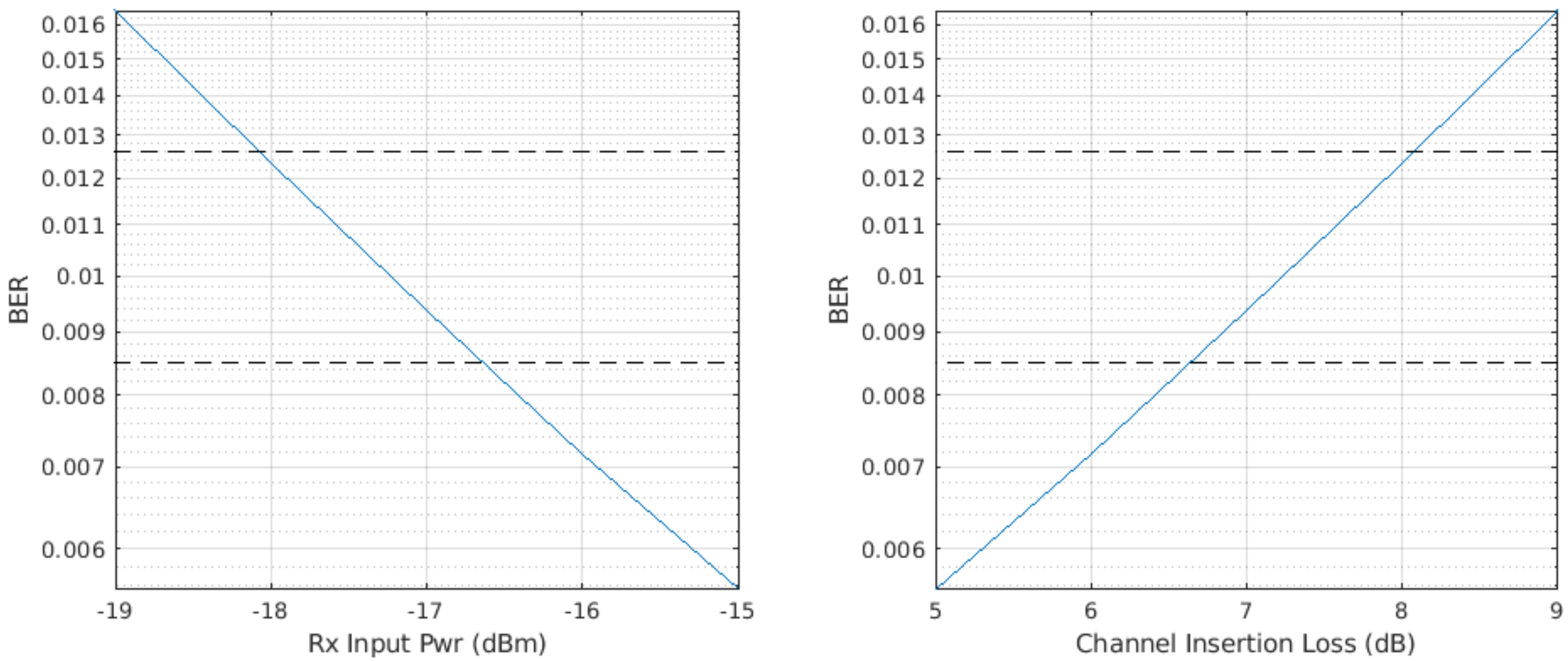
FEC for this analysis is based on a concatenated RS544 end-to-end FEC concatenated with a BCH SD FEC covering the optical link

- Post FEC BER target of 1E-13

FEC thresholds of 8.5E-3 and 1.26E-2 are used to determine Rx sensitivity values

- 1.26E-2 is based on a concatenated FEC with a BCH(126,110) inner code
- 8.5E-3 is based on a concatenated FEC with a BCH(176,160) inner code

Rx Performance



Horizontal dashed lines correspond to the two FEC thresholds

The higher coding-gain FEC provides a 1.4 dB sensitivity improvement
Note: the higher baud does come with a theoretical ~0.2dB noise penalty

Proposed 800 LR FEC and DSP Frame

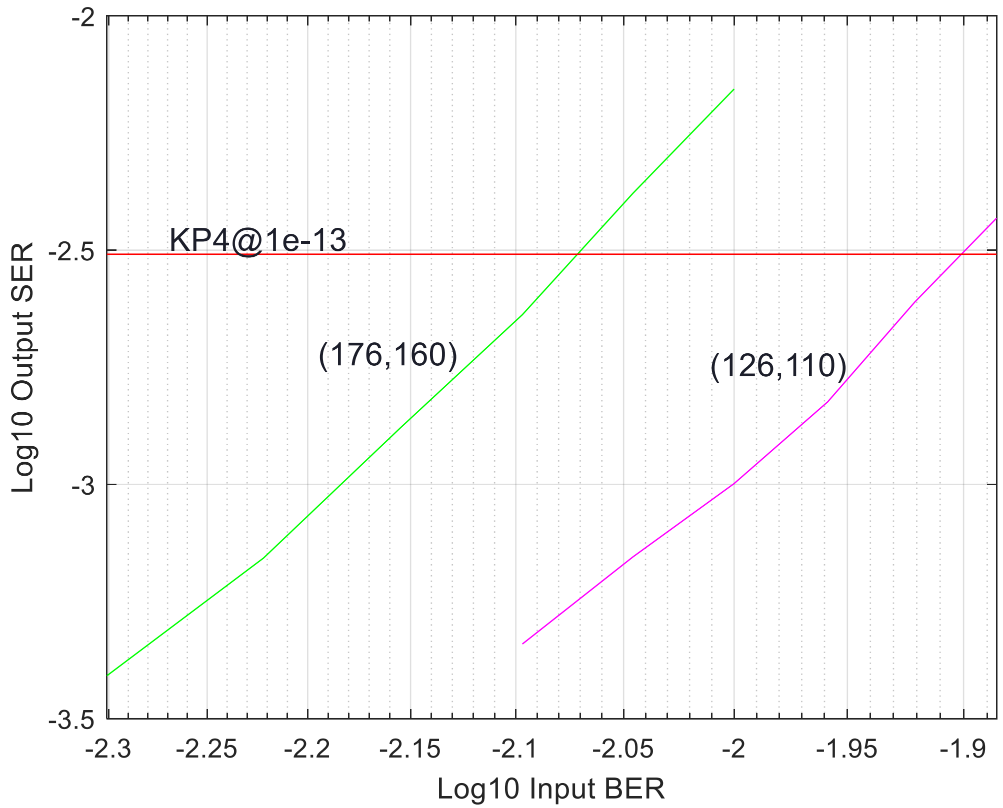
Concatenated RS(544,514)+BCH(126,110) with full 11- way 10-bit Symbol interleaving for no correlation of BCH decoder errors for each RS(544,514) codeword

1/64th Pilot DSP frame with no Training Symbols to eliminate gearbox and enable coherent phase detection with no cycle slips

Low latency encoder architecture with no gearbox and no PCS lane de-skew

An alternative is RS(544,514)+BCH(176,160) with 800G ZR DSP frame

Performance Comparison with Same Decoder



	KP4+BCH(126,110)	KP4+BCH(176,160)
Optical BER for KP4@1e-13	1.26e-2	8.5e-3

2e-5 BER budgeted for two Electrical interfaces

Public domain 1 soft iteration Chase 2 decoder with 64 test vector decoder

Comparison Table for 800LR

	BCH(176,160)	BCH(126,110)	Comments
FEC Latency	100ns	75ns	Interleaver + decoder (20ns)
DSP Frame	~20ns	0	11 baud TS require clock domain transfer
Lane de-skew	~14ns	0	Processing latency for de-skew
Total Latency	134 ns	75ns	
Modem Power delta	0	250mW	
Baud	119 GBaud	123.7 GBaud	
Link loss at KP4 output at 1e-13	6.7 dB	8.1dB	BCH(126,110) will have an additional ~0.2dB penalty from baud increase, not included in this analysis

Summary

A coherent solution for the 800G 10km single SMF application is analyzed based on:

- Concatenated FEC
- Realistic noise sources
- O-band fiber losses

This solution meets the 10km application, with ~1.8dB of margin

Note: A similar approach including amplification in the module can be defined to meet the 40km application

- Additional analysis on specifics is needed define details

Thanks!