Baseline Proposal for 100G Backplane Specification Using PAM2

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Introduction

- Dudek_01a_0312 made a proposal for a PAM2 (NRZ) specification for use on copper backplanes for 100G based on Dudek_01a_0112 with updates including more channel specifications and changes based on the assumption of a 0% over- clocking FEC.
- Moore_01_0312 also made a proposal for this specification and specifications for the copper cable and PAM4.
- This presentation takes the PAM2 backplane proposals and puts them into a consensus presentation. It also incorporates some changes suggested during discussions on the proposals.

Introduction (cont)

- All test methodologies refer to 802.3ba unless stated otherwise.
- This specification is based on a channel loss budget of 30 dB at a signaling rate of 25.78125 GBd to meet a BER of 1e-12
- FEC (Mandatory or optional TBD) is incorporated to achieve higher losses of 35 dB (or reduce the BER to 1e-15or lower at somewhat less loss). The Rx will have to meet an uncorrected BER of approx 2e-5 with this 35dB channel with a worst case Tx.
- This proposal is not intended to compete with the test methodology ad-hoc being chaired by Charles Moore. The intent is to update this with the results from that group, when they have been agreed.

Tx proposal

- A 3 tap FIR filter is proposed. (Similar to 10GBASE-KR, CEI-25G-LR of OIF, and FC-PI-5 of FC)
  - OIF has determined that additional tap was not helpful for their 25.5dB channel
  - Need to evaluate if an additional pre-cursor tap is worthwhile for this higher loss channel
- Tx training using the same algorithm as 10GBASE-KR is proposed.
- This presentation uses the linear pulse fit methodology of 802.3ba subclause 85.8.3.3 to enable transmitter testing with a test board with some loss.
- Suggest that it may be better to provide min/max tap weights (as is done in CEI-25G-LR) rather than the precursor and postcursor fullscale range values. Left for future work.

Tx specification at TP0 normative for backplane (KR4), informative for copper CR4

Parameter	IEEE subcla	Value	Units
Nominal Signaling rate		25.78125	GBd
Differential peak to peak output voltage (max)	72.7.1.4	1200	mV
Differential peak to peak output voltage (max) with Tx di	72.6.5	30	mV
Common-mode voltage limits (max)	72.7.1.4	TBD	V
Common-mode voltage limits (min)	72.7.1.4	0	V
Differential output return loss (min)	72.7.1.5	TBD	
Common-mode output return loss (min)	72.7.1.6	TBD	
Common-mode AC output voltage (max, RMS)		12	mV
Transition time (20-80%) (min) de-emphasis off	72.7.1.7	8	ps
Steady state output (Vf) (max) de-emphasis off	85.8.3.3	0.6	V
Steady state output (Vf) (min) de-emphasis off	85.8.3.3	0.4	V
Linear fit pulse (min) de-emphasis off	85.8.3.3	0.8*Vf	V

Tx specification at TP0 normative for backplane (KR4), informative for copper CR4(cont)

Parameter	IEEE subclause reference	Value	Units	Comment
Transmitted waveform				
max normalized error (linear fit) "e"	85.8.3.3	0.037		same as 802.3ba
normalized coefficient step size (min)	85.8.3.3.2	0.0083		same as 802.3ba
normalized coefficient step size (max)	85.8.3.3.2	0.05		same as 802.3ba
minimum precursor fullscale range	85.8.3.3.3	1.54		same as 802.3ba
minimum postcursor fullscale range	85.8.3.3.3	4		same as 802.3ba
Far-end transmit output noise (max)				
Low insertion loss channel	85.8.3.2	2	mV	same as 802.3ba
High insertion loss channel.	85.8.3.2	1	mV	same as 802.3ba
Max output jitter (peak-to-peak)				
Random jitter	72.7.1.9	0.15	UI	same as 802.3ba and OIF
Duty Cycle Distortion	72.7.1.8	0.035	UI	same as 802.3ba and OIF
Total jitter excluding data dependent jitter.	83.5.10	0.28	UI	same as 802.3ba and OIF

Tx specification at TP0 normative for backplane (KR4), informative for copper CR4(cont)

Linear fit pulse and equalizing filter parameters

Parameter	Value (UI)
Linear fit pulse length T_N_p	8
Linear fit pulse delay T_D_p	2
Equalizer length T_N_w	8
Equalizer delay T_D_w	2

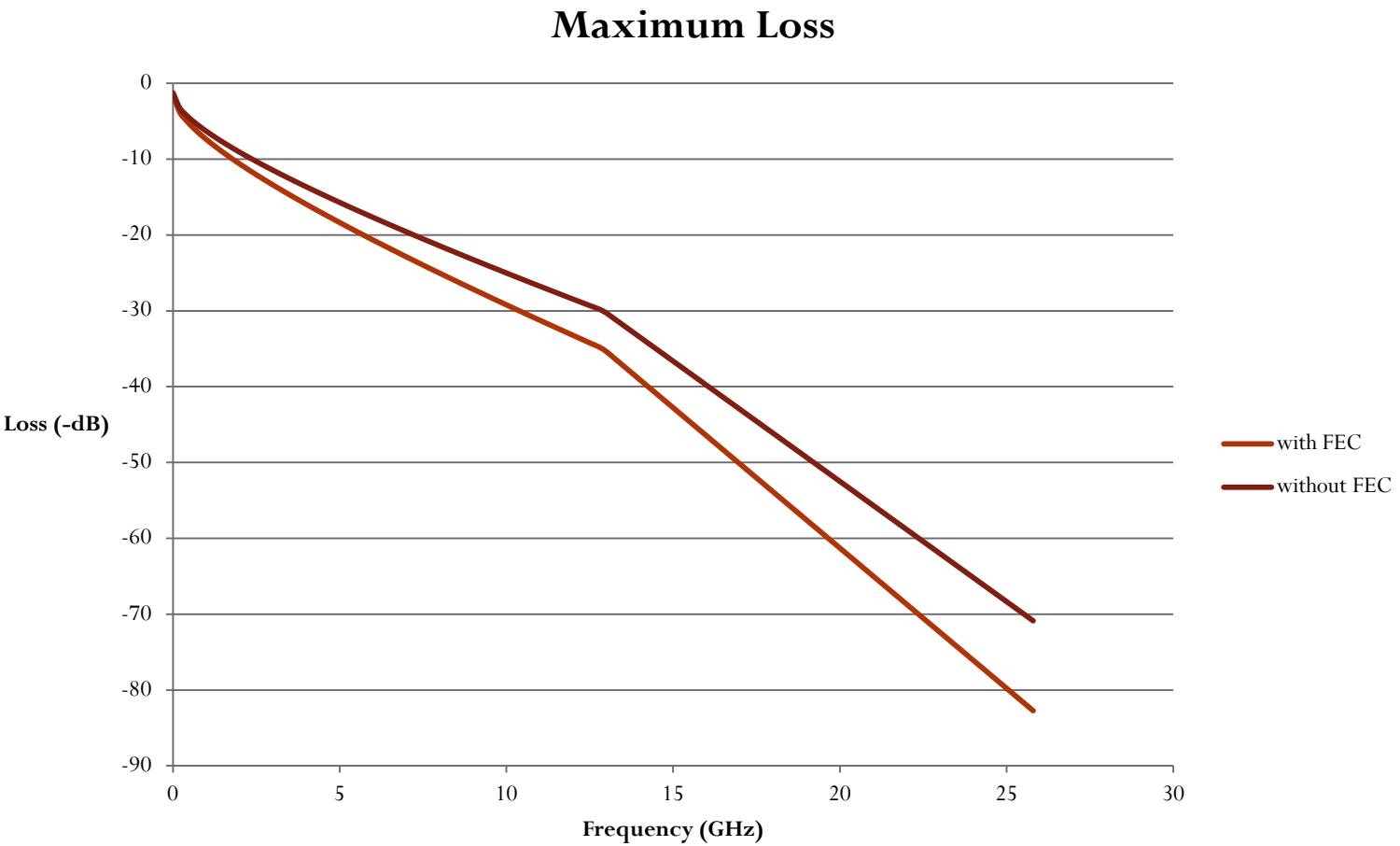
Backplane Channel Specification

- The Channel specification is either informative or normative (TBD) and similar to 10GBASE-KR and CEI-25G-LR
- IL_{max} ($f_b/2$) is targeted at 30 dB w/o FEC and 35 dB with FEC
- Fmin = 50 MHz,
- Proposed values for the parameters (scaled from OIF) are
  - Fmin<f<fb/2
    - With FEC ILmax = 1.5 +4.60*sqrt(f)+1.318*f
    - Without FEC ILmax= 1.27+3.94*sqrt(f)+1.130*f

      (f in GHz)
  - Fb/2<=f<fb
    - With FEC ILmax = -12.71+3.70*f
    - Without FEC ILmax= -10.90+3.17*f

      (f in GHz)

Backplane Channel Max loss Specification



Backplane Channel Specification (continued)

- The measured insertion loss is fitted to the insertion loss equation using the OIF test methodology described in OIF document http://www.oiforum.com/public/documents/OIF_CEI_03.0.pdf section 12.2. The fitted insertion loss equation is listed below. Note that this test methodology fits the curve up to the signaling rate with the pass/fail limits for ILD and ILDrms to 0.75 signaling rate.

$$IL_{fitted}(f) = a_0 + a_1\sqrt{\frac{f}{f_b}} + a_2\frac{f}{f_b} + a_4\left(\frac{f}{f_b}\right)^2 \quad (dB)$$

Backplane Channel Specification (cont)

- Propose to limit the values of the "a" coefficients to restrict the amount of square root and square terms which are more difficult to equalize.
- ILD: Propose to specify an ILD envelope.
- ILDrms: Propose to specify ILDrms (the rms deviation of ILD) as defined in OIF. This would potentially be included in a trade-off with crosstalk and noise and channel loss. It may also be replaced by a different measure of integrated ILD based on work from the test methodology group).
- Crosstalk and noise: Propose to have a Max ICN allowance which is a function of loss at Nyquist. Loss to extend to 30dB for without FEC and 35dB with FEC for low ICN (and low ILDrms)

Backplane Channel Specification (cont)

- The differential return loss, differential to common mode return loss, and common mode return loss would also be specified, as well as the differential to common mode through response.

Rx specification at TP5 normative for backplane (KR4), informative for copper CR4

- The Rx is specified to meet the required BER when specific stressed input signals (including jitter, noise and insertion loss versus frequency) are applied (interference tolerance test)
- These input signals are generated by passing a degraded signal from a pattern generator through a maximum loss channel and a lower loss channel with more noise degradation. Also additional low noise and higher noise channels with higher loss channels with the use of FEC
- Differential return loss, common mode return loss, and differential to common mode conversion would also be specified.

Interference tolerance test Rx specification normative for backplane (KR4), at TP5

Parameter	Test 1 values	Test 2 values	Test 3 values	Test 4 values	Units
Type of test	short	long	Long Noisy	Very long	
Bit error ratio before FEC max (BER < 10^{-12} after FEC)	10^{-12}	10^{-12}	$2x10^{-5}$	$2x10^{-5}$	
Channel Loss at 12.89 GHz Real part of a0 min Real part of a1 min Real part of a2 min Real part of a4 min	TBD TBD TBD TBD TBD	TBD TBD TBD TBD TBD	TBD TBD TBD TBD TBD	TBD TBD TBD TBD TBD	dB $Hz^{-1/2}$ Hz^{-1} Hz^{-2}
Channel Noise minus Tx-Rx re-reflection noise	0.0	0.0	0.0	0.0	mV
Applied SJ (min peak-to-peak) at > 100 MHz	TBD	TBD	TBD	TBD	UI
Applied RJ (peak-to-peak at BER=10^{-12})	TBD	TBD	TBD	TBD	UI
Applied DCD (peak-to-peak)	TBD	TBD	TBD	TBD	UI
Broad band Noise (RMS)	TBD TBD	TBD TBD	TBD TBD	TBD TBD	mV

For all test channels: maximum a0=0.1, maximum for a1, a2, a4 is 0

Conclusions

- A specification is proposed for a PAM2 backplane system achieving 30 dB loss at Nyquist without FEC and 35dB loss at Nyquist with FEC.
- Proposal is to adopt this as the baseline proposal for meeting an 802.3bj objective of 35 dB loss at 12.89 GHz.