Specifications for a linear system with 10G per lane to achieve over 250m on OM3

July 15 2008

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Comparison with Fibre Channel 8GFC

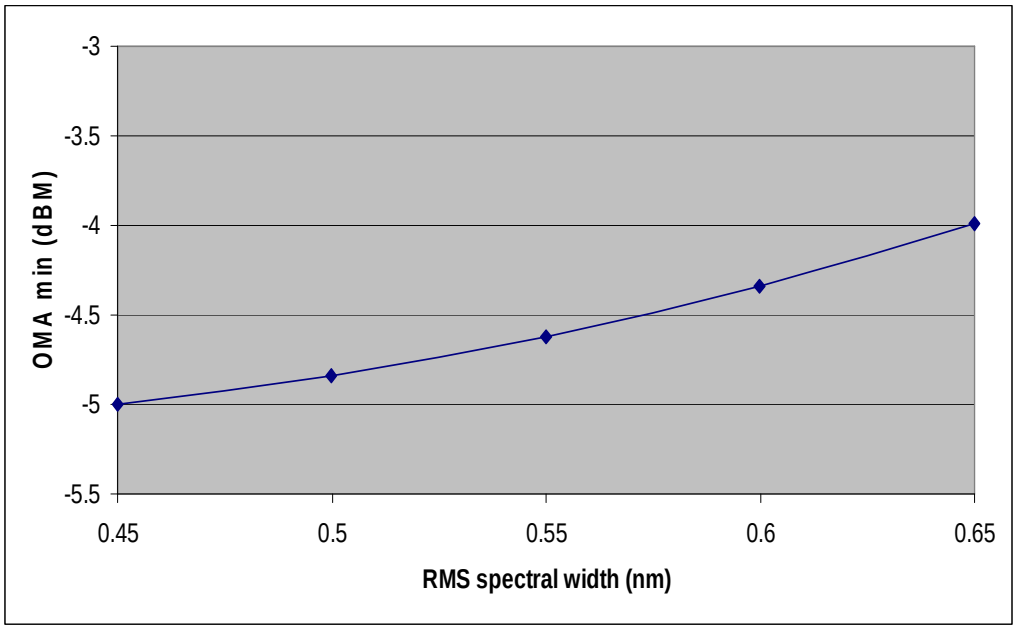
- **8GFC runs at 8.5Gb/s and includes a specification for a linear system operating over 300m of OM3 fiber with only a 1,2 equalizer (One main tap and two decision feedback taps.)**
- **Direct scaling of this system would achieve 247m at the 10.3125Gb/s lane rate for 40/100G.**
  - **Propose using the same per lane specifications for 40G and 100G.**

Tx specifications based on FC scaled system.

Description	Units	Value	Notes
Signalling speed (nominal)	GBaud	10.3125	
Center Wavelength (range)	nm	840-860	
RMS spectral width	nm	0.65	
Average Launch power (max)	dBm	0	
Launch Power (min) in OMA	dBm	-5	1
$RIN_{12}OMA$ (max)	dB/Hz	-128	
Transmitter Waveform Distortion penalty (TWDP) (max)	dB	4.2	2
Extinction ratio (min)	dB	3	
Uncorrelated jitter (UJ) rms (max)	UI	0.03	

Notes on Transmitter specs

- **1 The minimum OMA is increased for spectral widths above 0.45nm. See the figure below.**



- **2 TWDP is measured with a simulated channel with a transversal filter with two equal amplitude taps spaced at 46ps and with a 1,2 equalizer.**

Rx specifications based on FC scaled system.

Description	Units	Value	Notes
Signalling speed (nominal)	GBaud	10.3125	
Center Wavelength (range)	nm	840-860	
Average Receive power (max)	dBm	0	
Peak Receive power (max)	dBm	2	
Receiver reflectance (max)	dB	-12	
Stressed Receiver sensitivity in OMA (Max)	dBm	-6.7	1

Note 1 Condition for stressed receiver sensitivity are
Relative noise 0.054
WDPo 4.2dB
Exact pulse shape is TBD.

Use of OM4.

- **The additional reach achieved with OM4 is determined by the maximum spectral width allowed as this system is limited by mode partition noise caused by chromatic dispersion.**
- **With the specifications listed (including the spectral width trade off allowing 0.65nm max spectral width) a distance in the range 300 to 320m can be supported on OM4.**

Equalizer discussion

- **Expectation is that a more powerful equalizer (KR which is equivalent to approx 2,5) will be used for the copper solutions. This more powerful equalizer could be used to do any of the following or a combination thereof.**
  - **Somewhat increase the distance. 300m on OM3 is feasible (see later slides). (keep the same TWDP spec value but use a more stringent channel and the more powerful equalizer)**
  - **Keeping the TWDP spec number the same but using the more powerful equalizer in the code relaxes the difficulty of meeting the TWDP spec.**
  - **Leave the specs the same and let the more complex equalizer make it very easy to meet the receiver stressed sensitivity spec.**
  - **Use the additional margin to offset the crosstalk penalty for link robustness with a combination of effective Tx and Rx spec relaxation.**

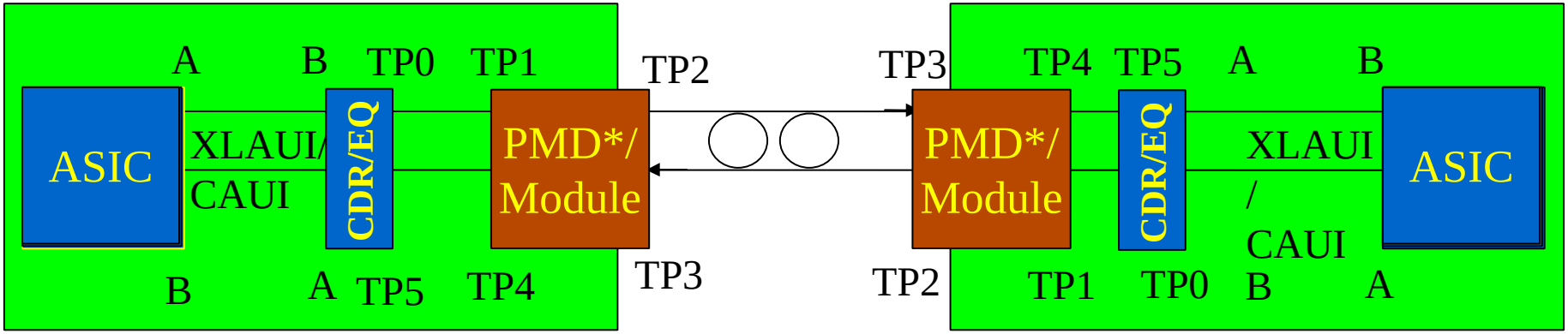
Extending the OM3 Reach to 300 m with KR Equalizer

Introduction

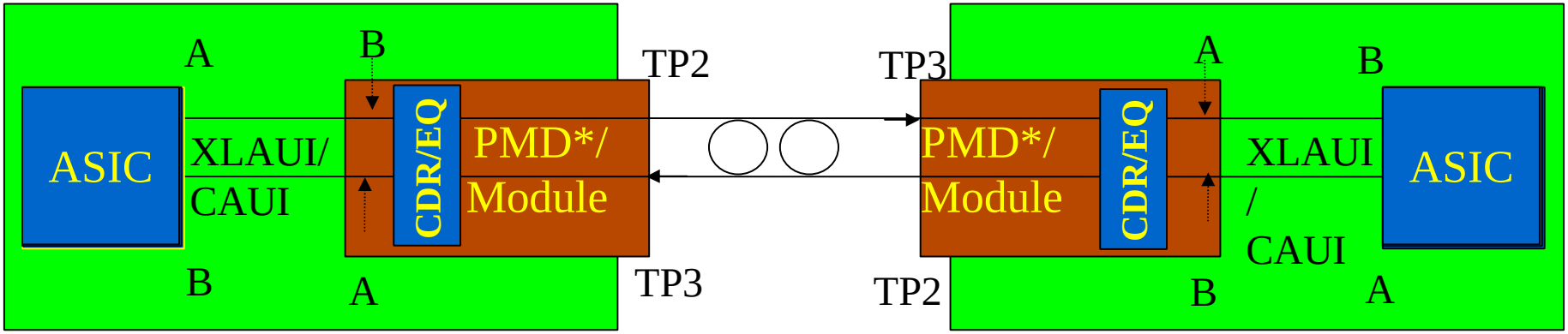
- **diminico_01_0508 proposed to use “a.ka. KR” for 10 m copper cable.**
- **ghiasi_01_0108 investigated use of 6-T/2FFE+2T DFE**
- **This section investigates use of KR like EQ to extend the fibre reach on OM3 fiber to 300 m.**
- **All host system will have an EQ either for the PCB traces or copper cable, KR EQ is a simple upgrade.**

40/100 GbE Applications

- **In the QSFP applications KR EQ will either be part of the CDR or part of the ASIC to drive 10 m Cu.**

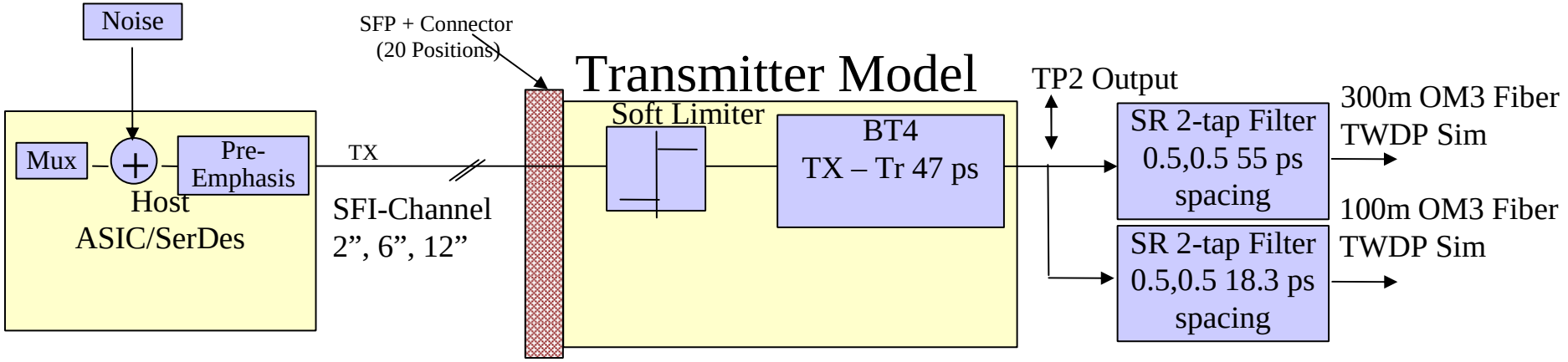


- **In the CFP applications the KR EQ will be part of the CDR**



SFI TP2 Simulation Set-up for TWDP

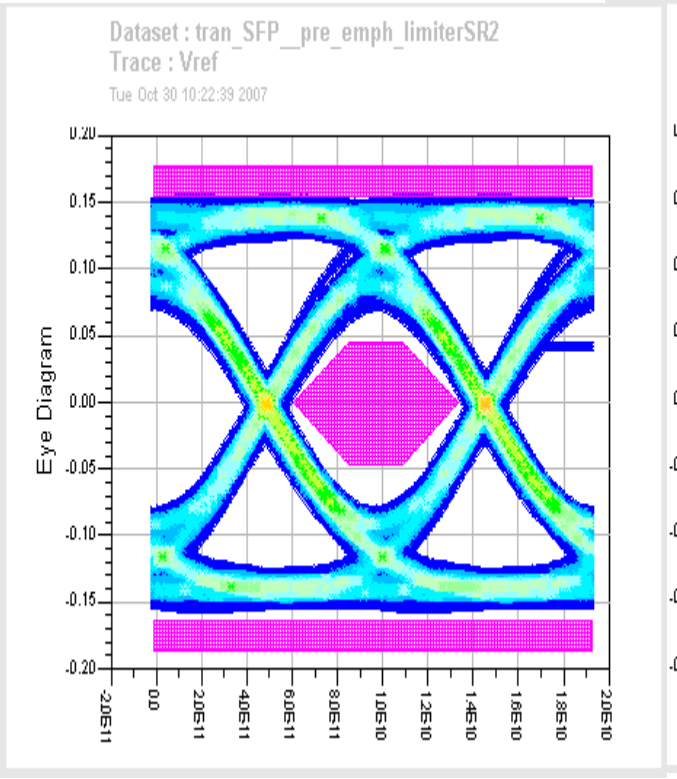
- **RIN penalty is not included**
- **Noise source at the SerDes was adjusted for UJ of ~0.023 UI (RMS) at TP1.**
- **BT4 filter in the module was adjusted for Trise/fall of 47 ps 20-80% with 2" trace. Due to soft limiting the rise/fall times are larger with longer traces.**



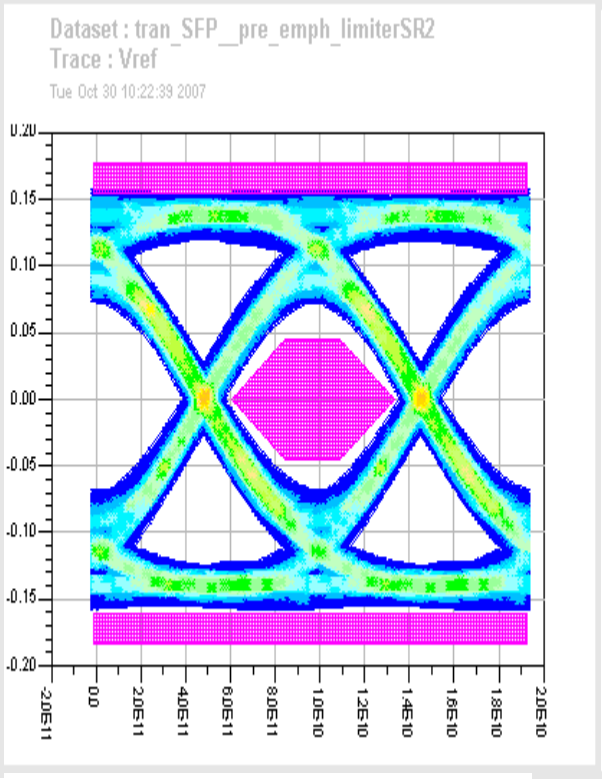
SFI Output at TP1 with Optimum Pre-emphasis

- **Pre-emphasis single T-Spaced post cursor**
- **PCB and IC variations will somewhat degrade the eye mask from this performance**

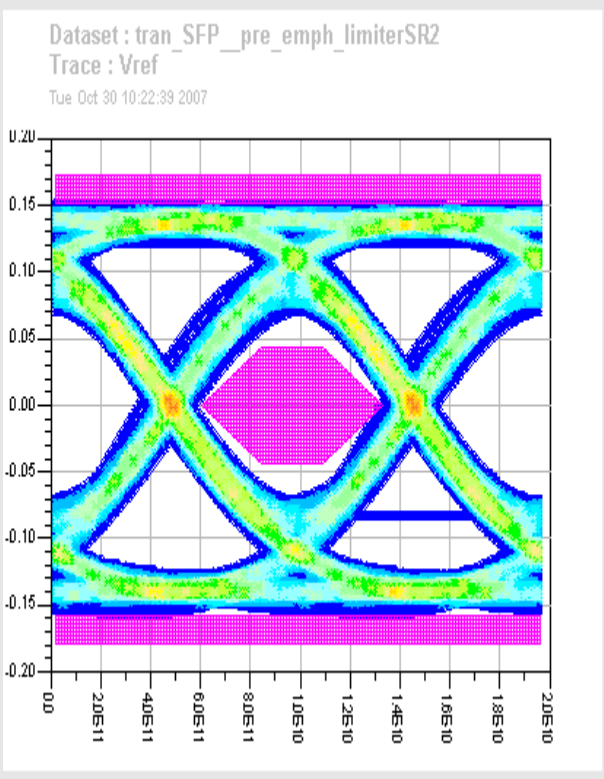
2” Fr4-13



6” Fr4-13



12” Fr4-13



Transmitter Characteristics

- **The SerDes pre-emphasis was used to create different optical transmitter.**
  - **Used 6” FR4**
  - **When pre-emphasis=0, the TX is similar to jewel_01_0508 but with rise of 66 ps instead of 45 ps.**
  - **When pre-emphasis=0.3, the TX is similar to petrilla_02_0508 but with rise time of 60 ps instead of 35 ps.**
  - **Faster rise time will reduce the penalty.**

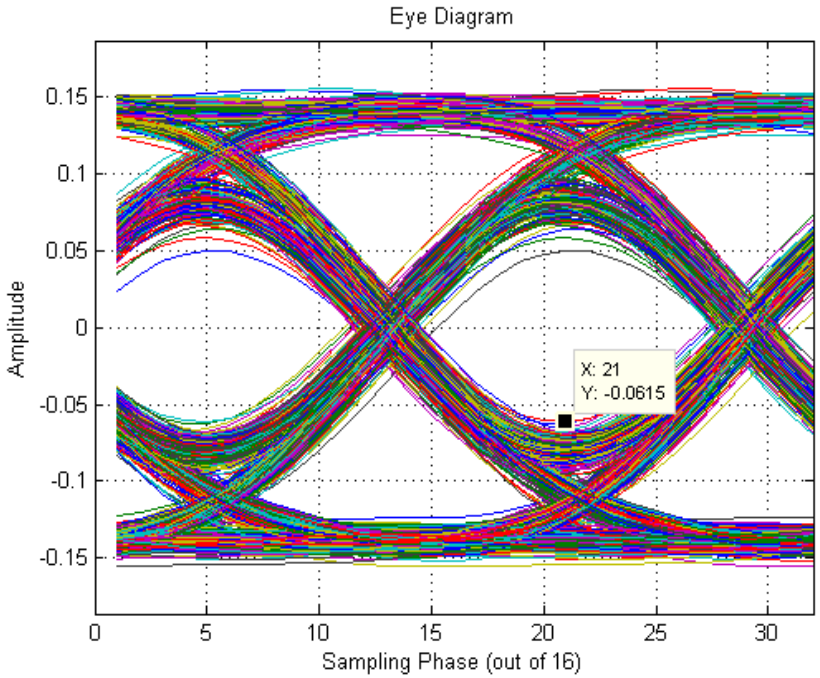
Pre-Emphasis	TP2 Trise (ps)	TP1 DDJ (UI)	TP1 DDPWS (UI) *	TP2 DDJ (UI)	TP2 DDPWS (UI)	TP2 Eye Height %	TWDP B-B (dB) (Ideal Channel)
0.000	66.000	0.120	0.095	0.26	0.24	39	3.7
0.080	60.000	0.061	0.032	0.18	0.14	48	2.88
0.120	60.000	0.060	0.030	0.21	0.11	52	2.94
0.016	60.000	0.079	0.029	0.19	0.12	50	2.82
0.300	60.000			0.27	0.09	51	2.83

* DDPWS is Data Dependent Pulse Width Shrinkage and is modeled in the IEEE spreadsheet by DCD cell

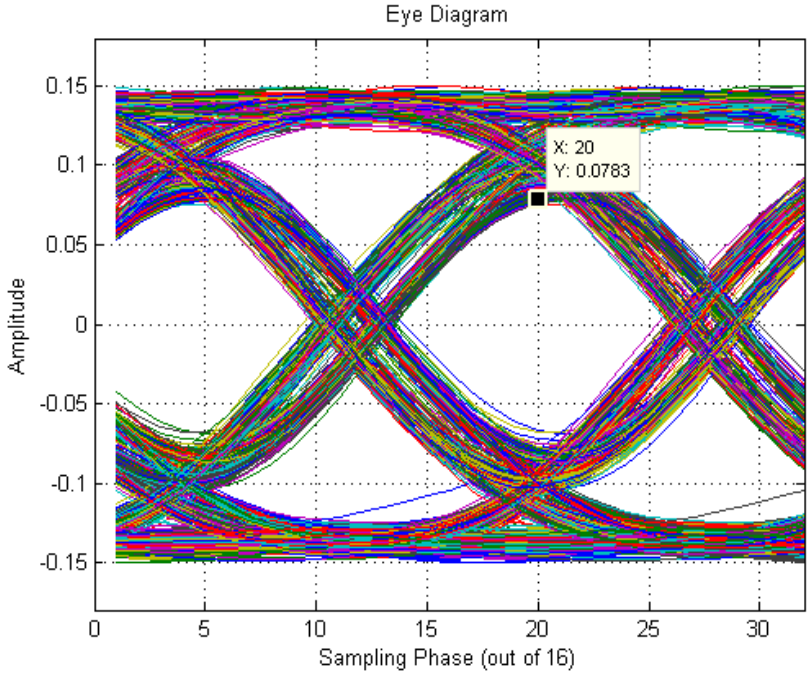
Transmitter TP2 Eye Diagram

- **The two extreme transmitter cases:**
  - **Slow with significant amount of DDPWS**
  - **Faster with dual Dirac jitter but low DDPWS**

Pre-emphasis 0.00

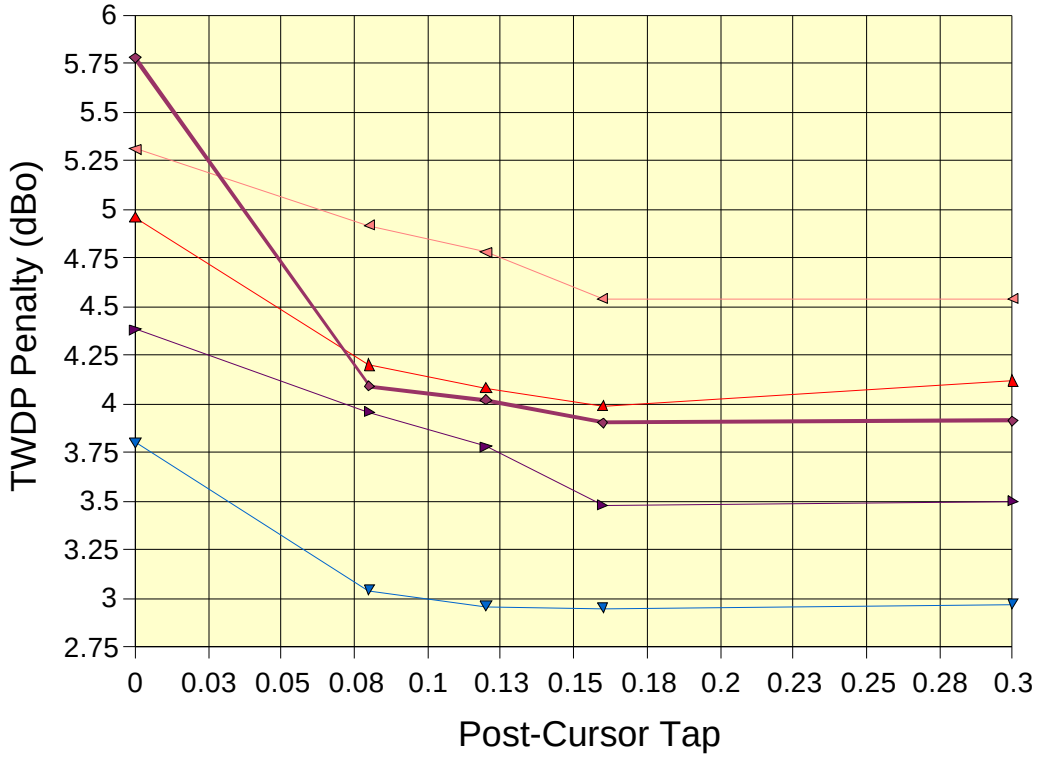


Pre-emphasis 0.30



TWDP as Function of Transmitter Setting for KR Equalizer

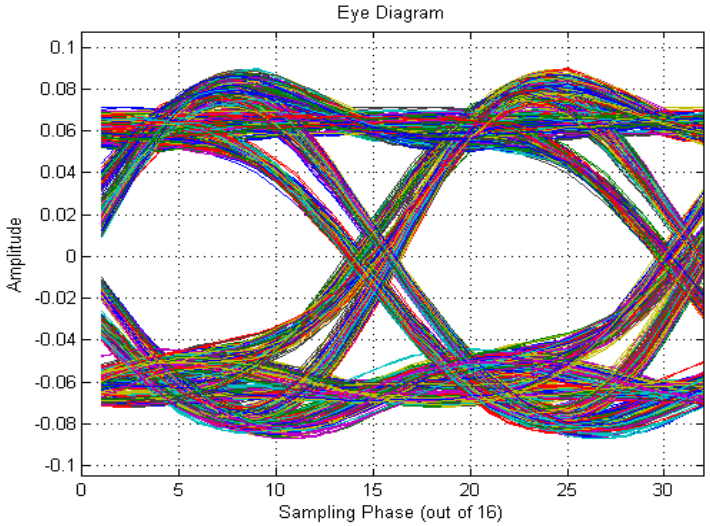
- **Pre-emphasis was used to change transmitter DDJ and DDPWS.**
- **Common implementation of KR equalizer has peaking followed by ~ 5 tap DFE, here approximated by 2 T/2 FFE + 5T DFE**
- **A 300m OM3 linear link with KR EQ has either similar or lower penalty than a 100 m limiting link or 10 m Cu cable.**



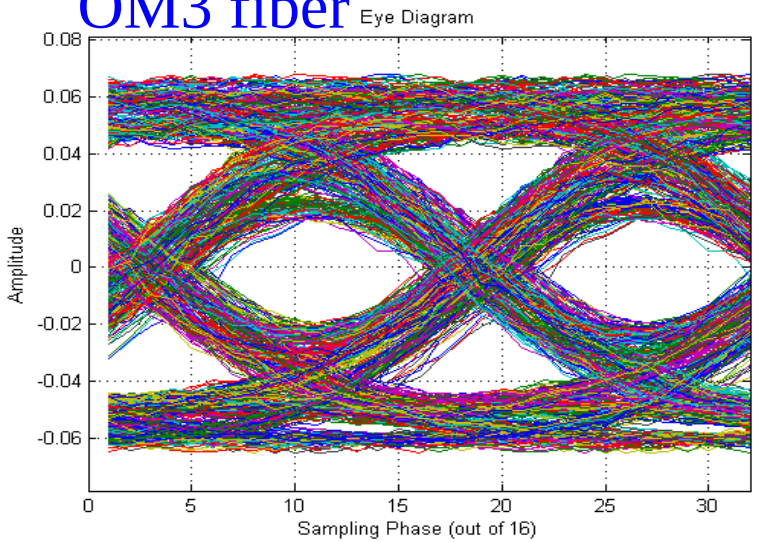
10 m Cu TWDP Penalty
(Uses short test board and SFF8431 Rev 3.0 Channel)
Post=0.2: 2F-5D=6.22 dBo 1F-5D=6.8 dBo
Post=0.375: 2F-5D=4.83 dBo 1F-5D=5.78 dBo

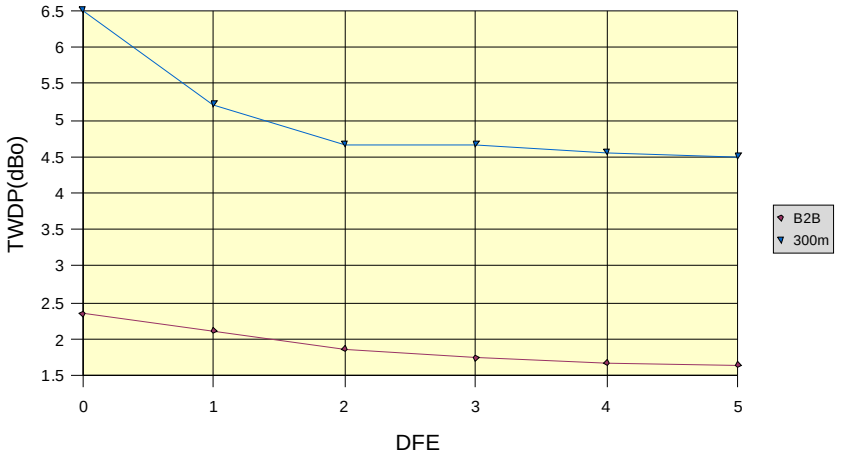
Link Performance with Commercial 10G SFP+ SR Module

TP2 Eye with 6” Fr4-13 with optimum pre-emphasis DDJ=0.19 UI DDPWS=0.05 UI



TP3 Eye with 300 m of low BW OM3 fiber





As demonstrated here with 10G laser just 2 tap DFE is sufficient to extend the fiber reach to 300 m!

Conclusion

- **The benefits of a linear receiver with very simple EDC on the host are**
  - **250m reach on OM3 is achievable with a very simple 1,2 equalizer (with 300m on OM4)**
  - **No tightening of TP1 specifications which could impact cost**
  - **Relaxation in TP2 specifications is possible (but will reduce distance achieved if only one end uses linear)**
  - **No additional chip**
  - **No latency impact**
  - **No auto-negotiation required**
- **The additional benefits using a KR EQ are**
  - **Commonality with copper interface**
  - **Extend the reach to 300 m on OM3.**
  - **If the spectral width is reduced below 0.65nm then significantly longer reaches could be achieved on OM4.**

Back-up (alternative equalizers)

TWDP as Function of Transmitter Setting for non-KR Equalizer

- Pre-emphasis was used to change transmitter DDJ and DCD.
  - 6” STL has TWDP of 5.8 dBo for 100m with 1FFE-0DFE but only 3.4 dBo with just 6T/2FFE+2TDFE!
  - Linear can do 300 m with about 1 dB less penalty than limiting can do 100 m!