

Feasibility of 40/100G Heterogeneous System based on Channel Data

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Outline

Generalized methodology for feasibility analysis of heterogeneous (electro-optical) links is proposed in this contribution. The main benefit of the approach is its ability of comparative analysis between different PMD proposals using a unified methodology based on objective technical and economical metrics.

Example analysis is made on the “CDR-less Module” introduced at the last HSSG meeting for 100m-MMF [1].

The analysis is based on measured channel and IC package data [2] over various PCB trace lengths and SFP+ module electrical interface [3].

Same methodology would be equally applicable to the 100G PMDs analysis as well: copper and optical.

[1] http://www.ieee802.org/3/hssg/public/nov07/ghiasi_01_1107.pdf

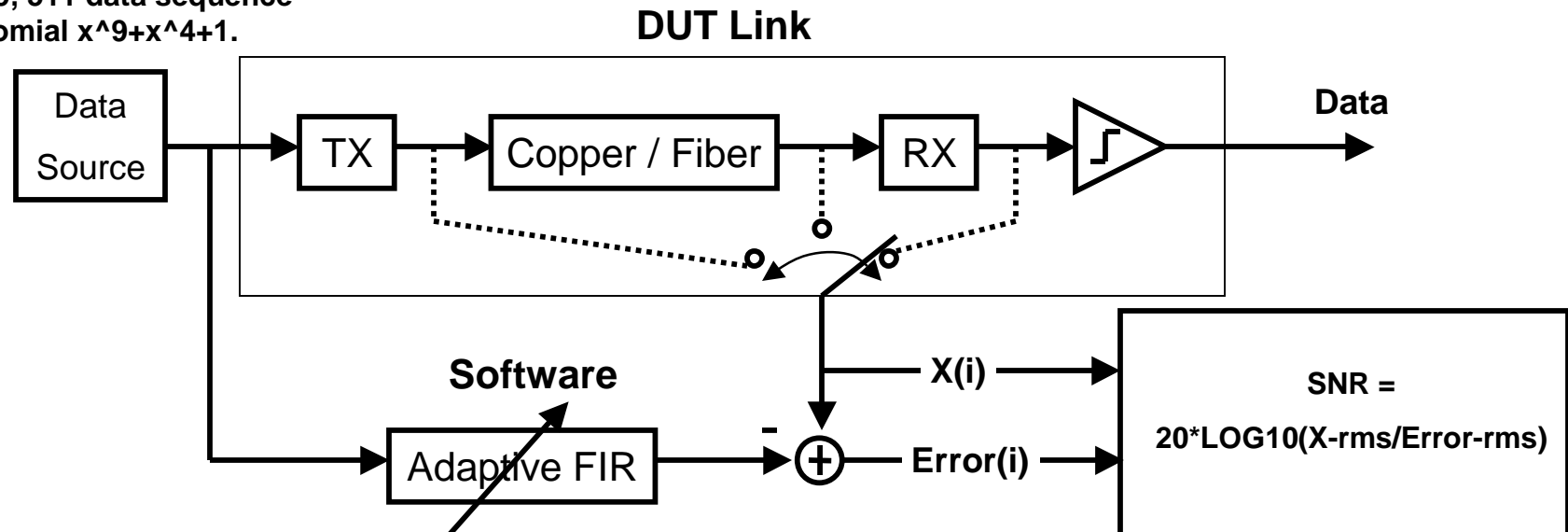
[2] <http://grouper.ieee.org/groups/802/3/ba/public/channel.htm> High-speed package data

[3] <http://grouper.ieee.org/groups/802/3/ba/public/channel.htm> SFP+Channel Model



System ID Basics

PRBS9, 511 data sequence
polynomial x^9+x^4+1 .



“Noise Margin” Definition

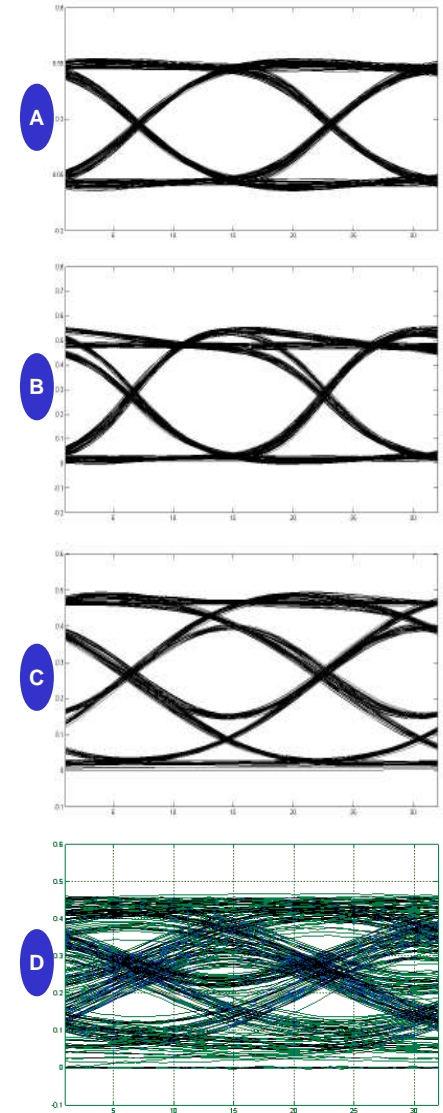
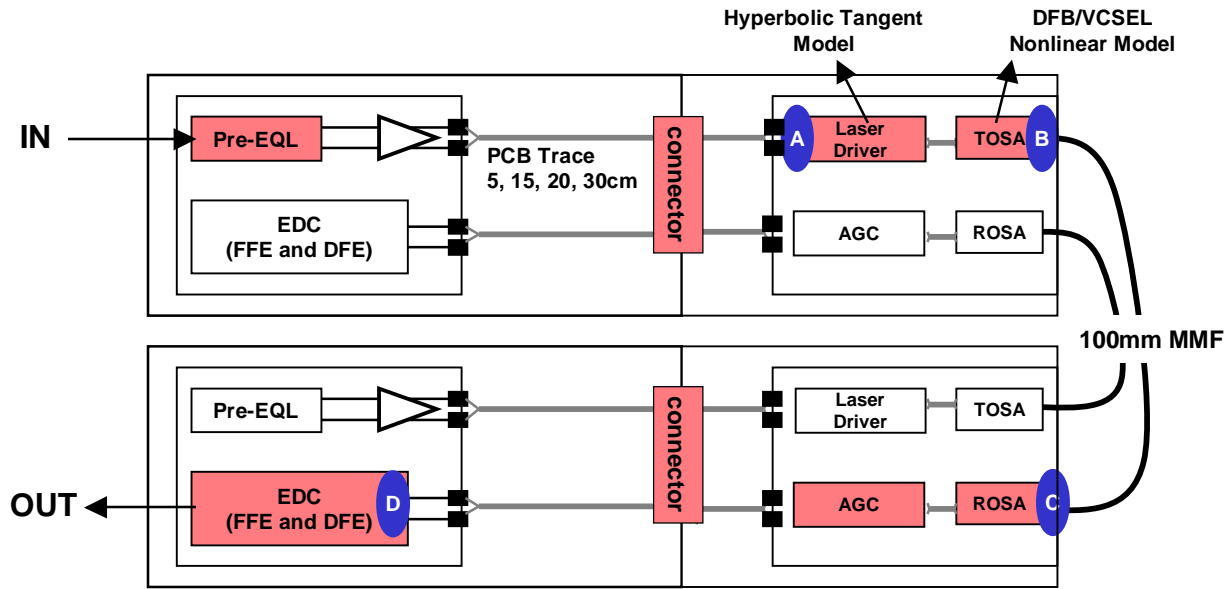
$$\text{Noise Margin} = [\text{Achievable SNR}] - \text{SNR}_{\text{required}}$$

$\text{SNR}_{\text{required}}$ is 17dB for 2PAM-NRZ, BER = 10^{-12}

Std needs to define Noise Margin (~6dB) as a recommendation for a robust operation.

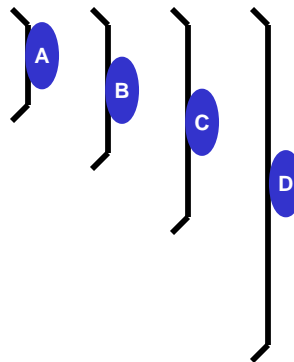


Heterogeneous Link, NRZ-10Gbaud

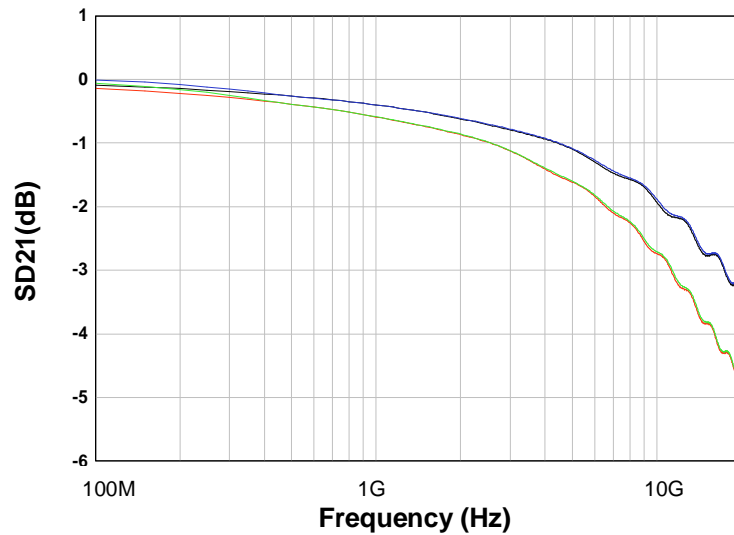


System Components

- Package [2]
- PCB and SFP+ Module [3]
- Laser Driver + Tosa
- 100m MMF
- Rosa + AGC
- PCB and SFP+ Module
- Host EDC

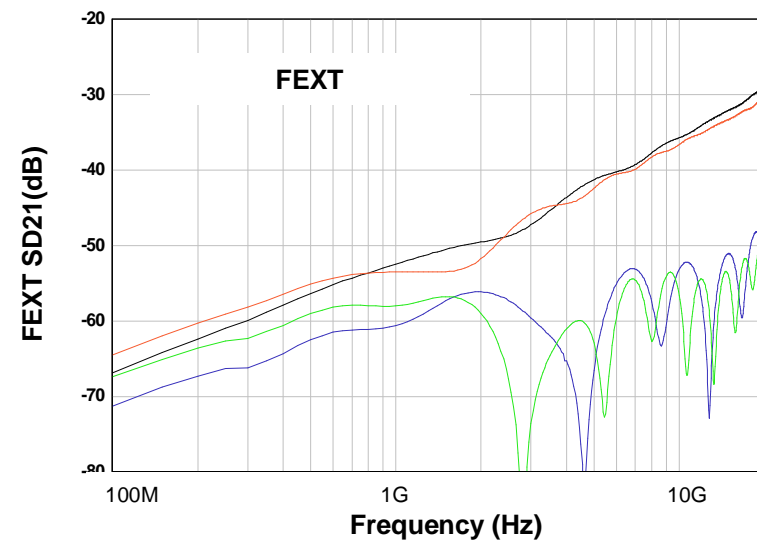
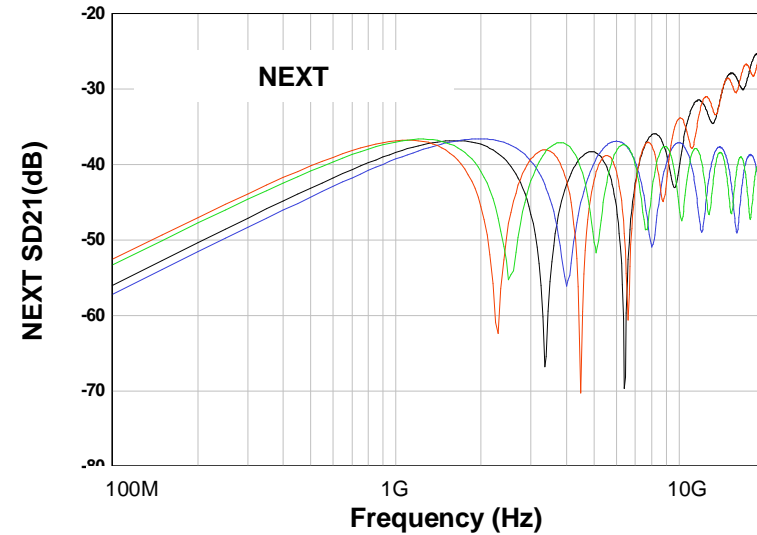


Package Frequency Response

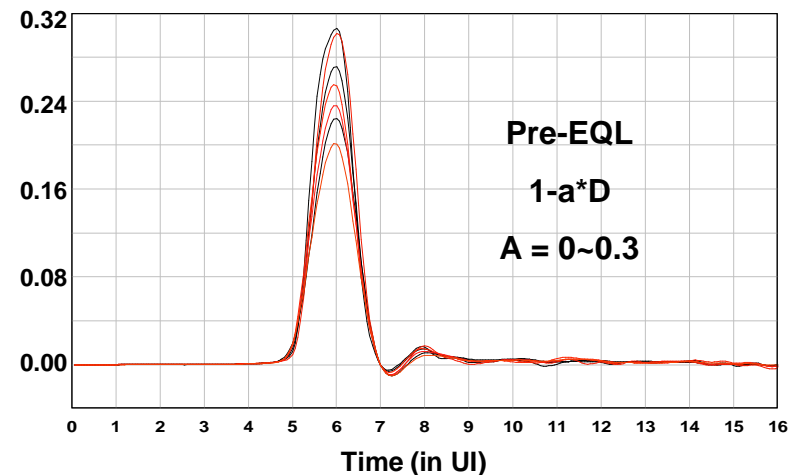
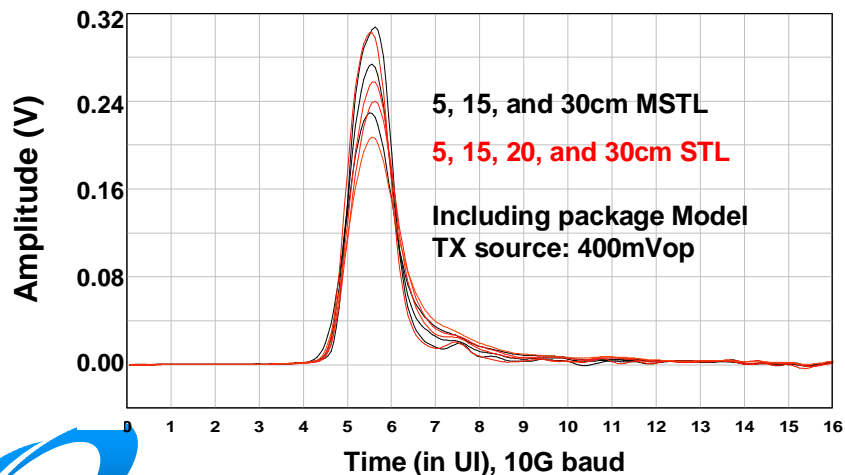
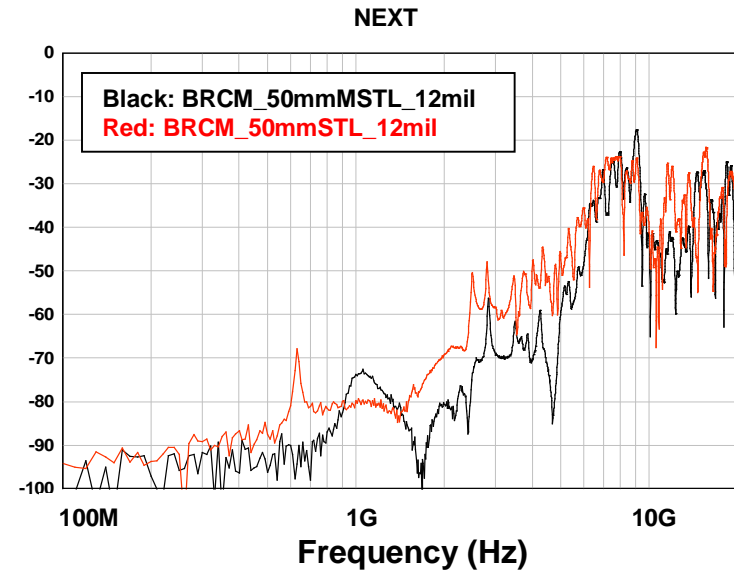
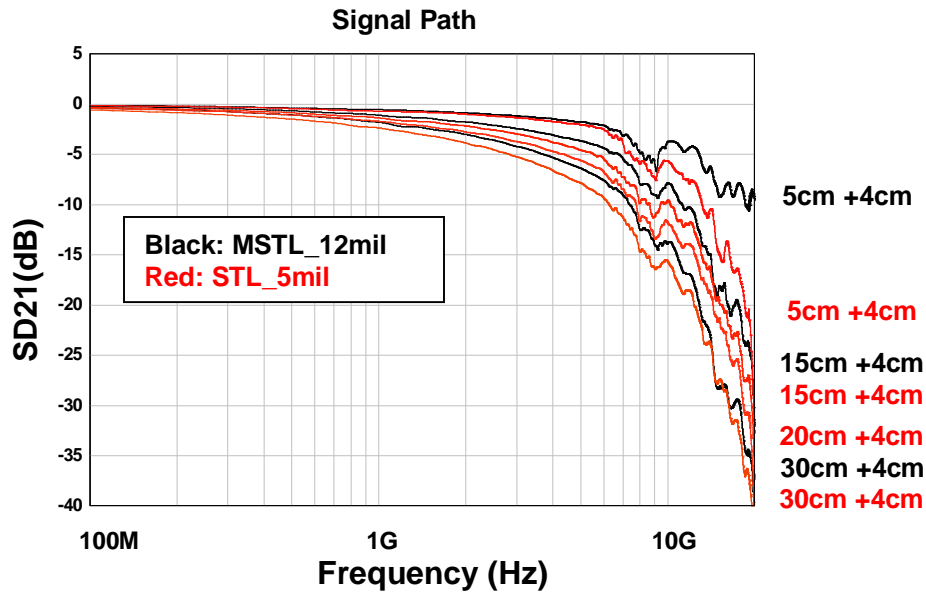


Black: 35mm-21mm High BGA
Blue: 35mm-21mm Low BGA
Red: 55mm-33mm High BGA
Green: 55mm-33mm Low BGA

35mm-21mm High BGA is used for the analysis.



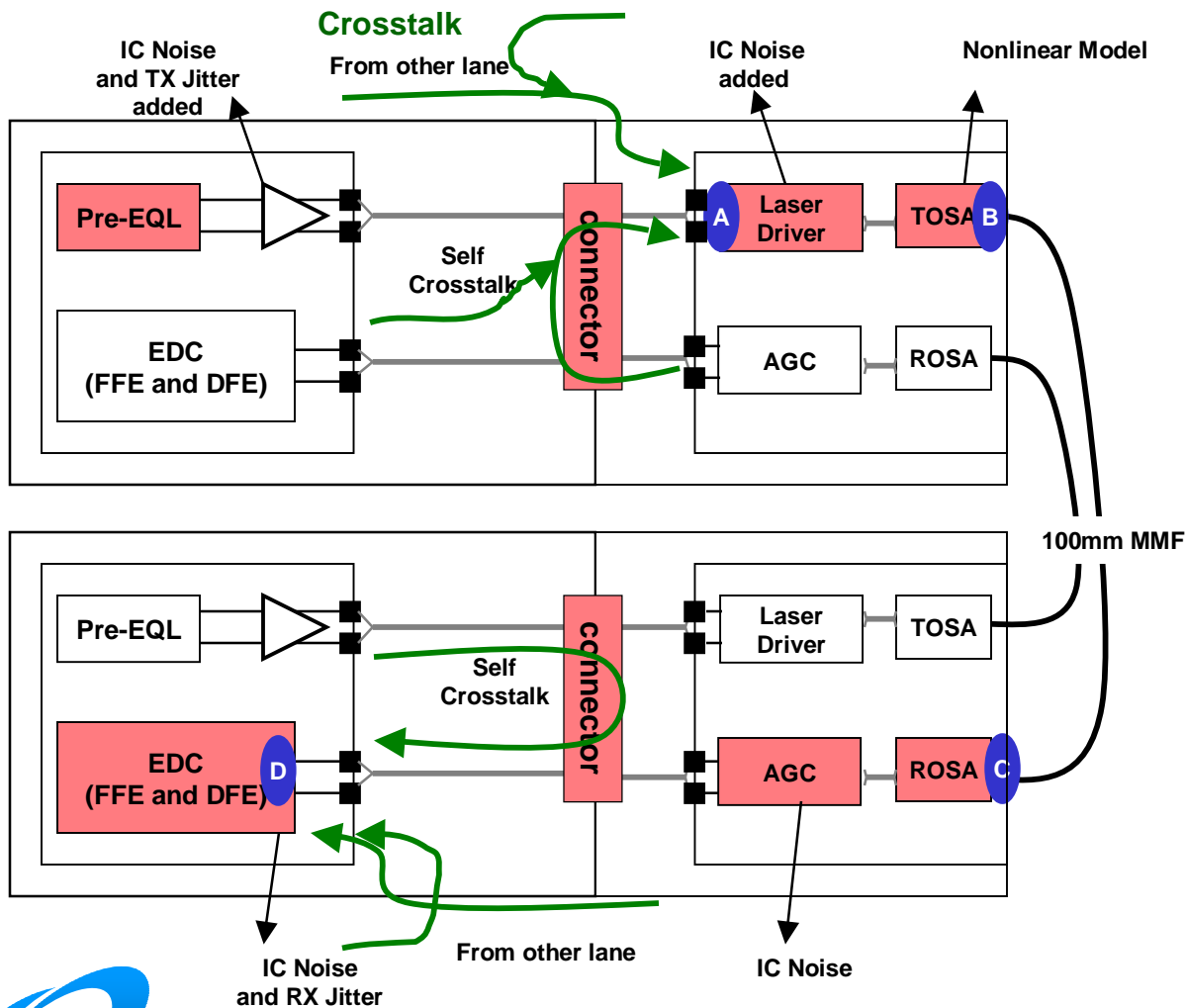
PCB, Module Response



Single Pulse Response (no TX pre-EQL)
Including package model

With one tap TX pre-EQL used in the
system (Prop. delay aligned)

Key Link Impairments



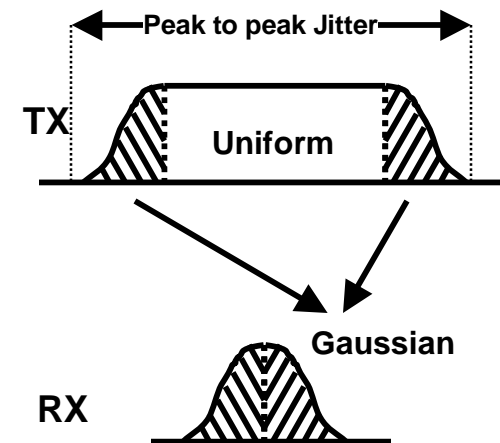
Impairments

Crosstalk at IC-Package and Module

IC electronics noise

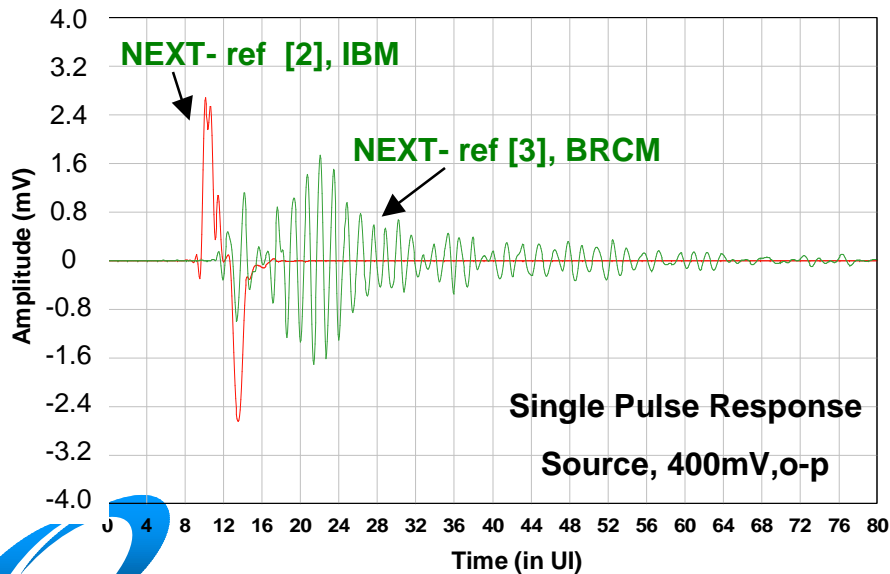
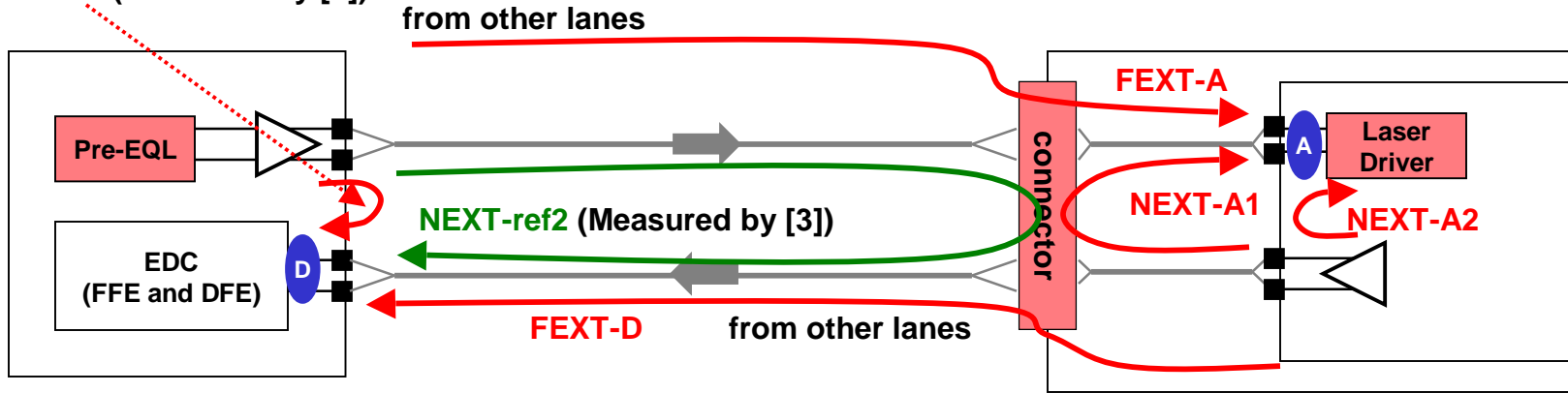
Tosa Linearity and Rosa Noise

TX & RX Jitter



Crosstalk NEXT/FEXT Scenario

NEXT-ref1 (Measured by [2])



Node A

FEXT-A and NEXT-A1,A2 should be considered.

FEXT-A and NEXT-A1 are bigger than NEXT-ref2 by ~2dB for FEXT-A and ~4dB for NEXT-A1

NEXT-A2 is in package and/or IC internal. No data available at this time. Use NEXT-ref1

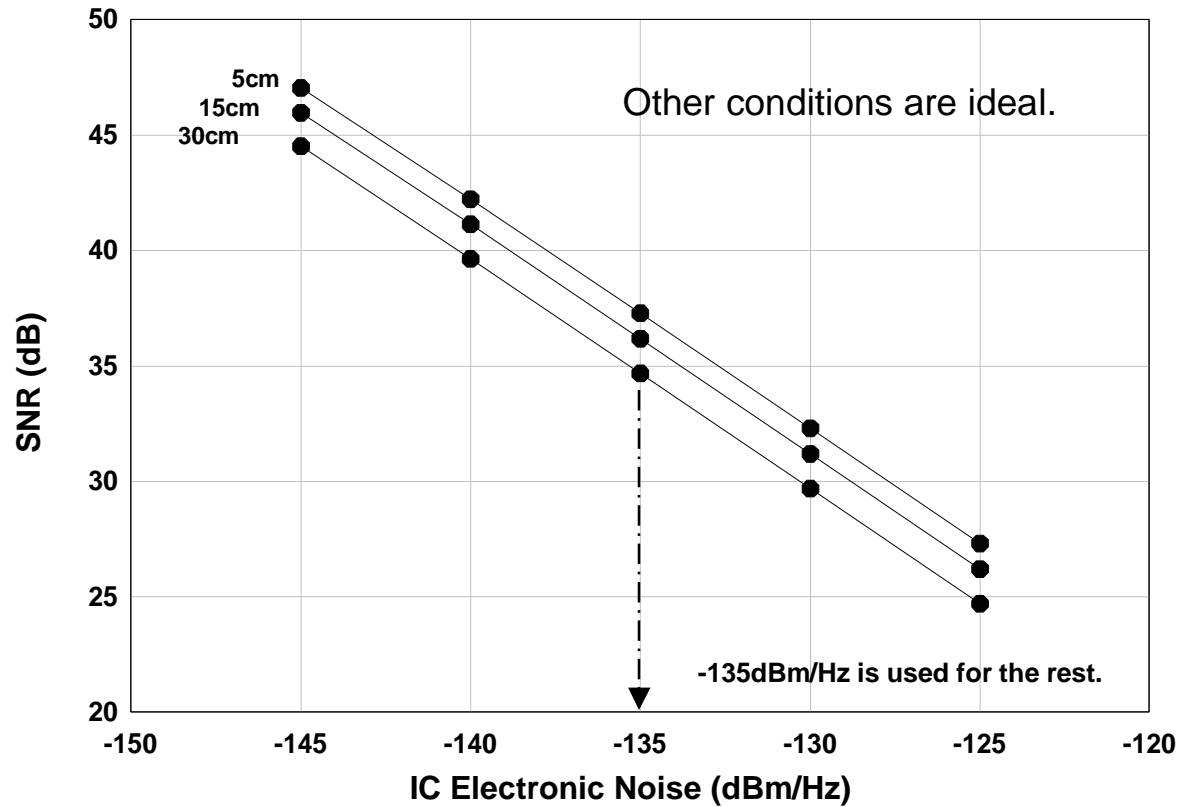
Node D

FEXT-D, NEXT-ref, and NEXT-ref1 should be considered.

FEXT-D is bigger than NEXT-ref2 by ~2dB

More than two disturbers depending lane assembly for both nodes.

Results-1: SNR at A Sensitivities to IC noise



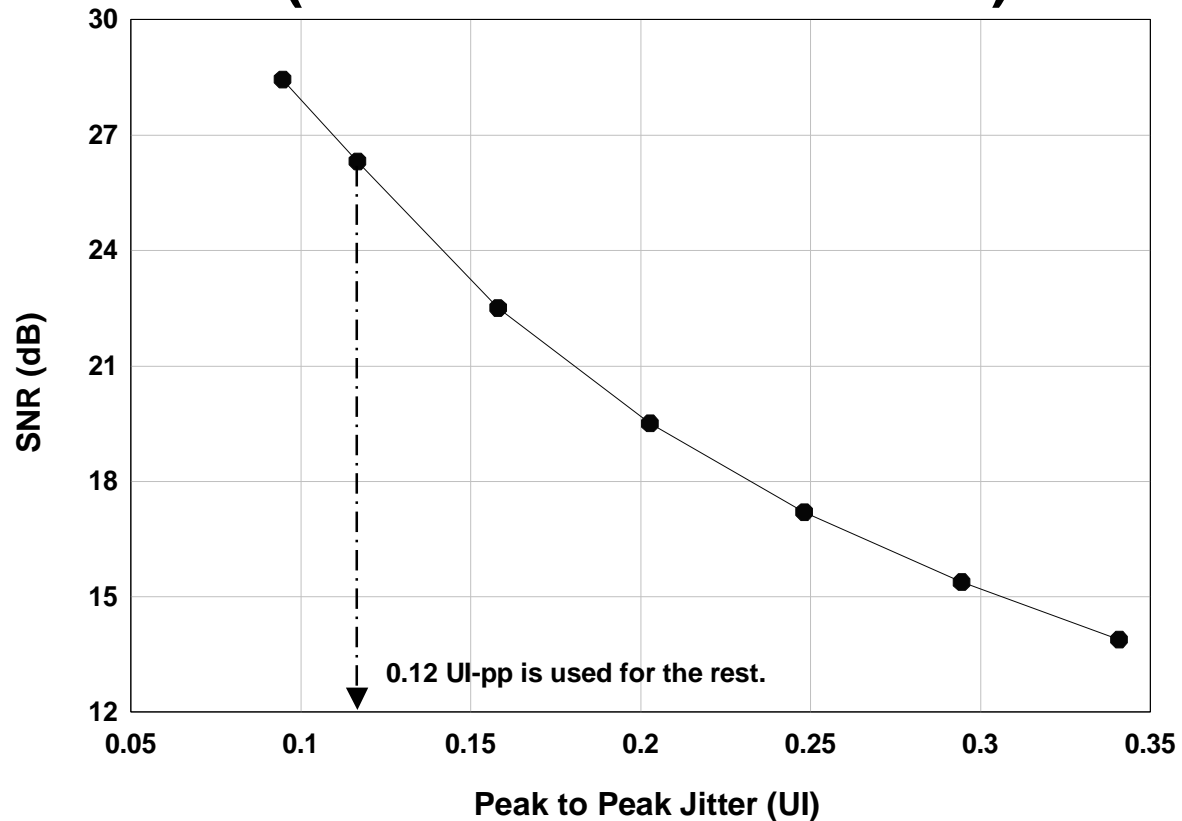
-140dBm/Hz is equivalent to $32\text{nV}/\sqrt{\text{Hz}}$ into 100ohm



Results-2: SNR at A

Sensitivities to Host TX-Jitter

(IC noise = -135dBm/Hz)

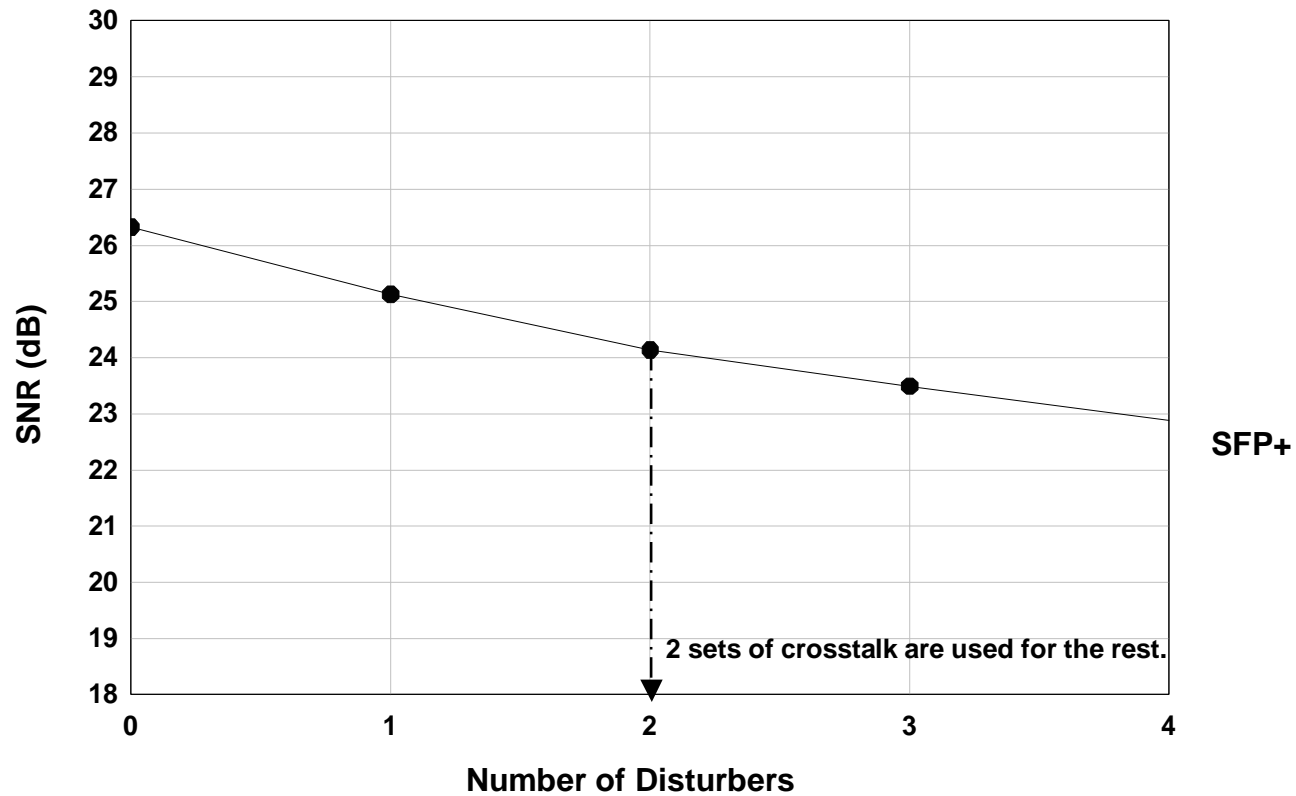


Amplitude of the uniformly distributed jitter is varied and added to the fixed random jitter(0.015UI-rms). Peak jitter is defined as the addition of uniform and random jitters.



Results-3: SNR at A Sensitivities to Crosstalk

(IC noise = -135dBm/Hz, Host TX-jitter=0.12UIpp)



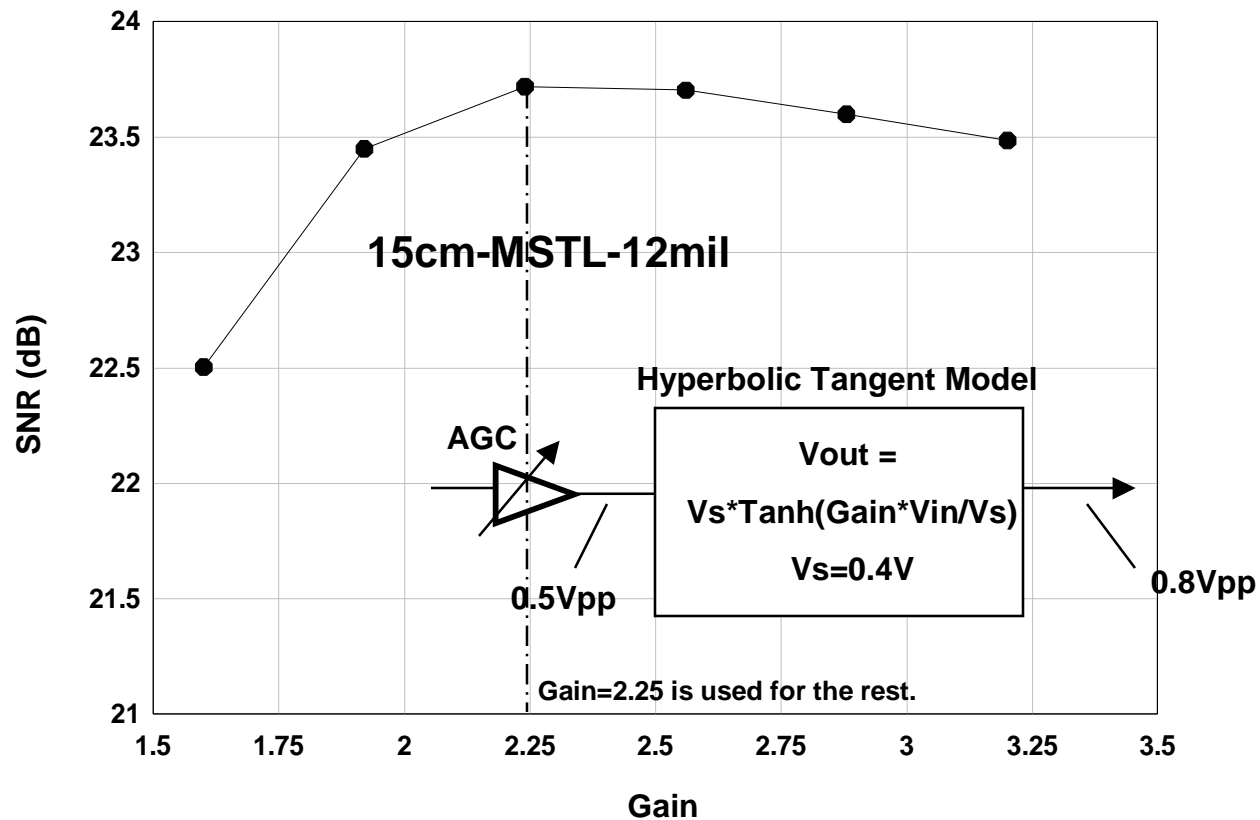
15cm-MSTL-12mil



Results-4: SNR at C

Sensitivities to Limit Amp Gain

(IC noise = -135dBm/Hz, Host TX-jitter=0.12U_{lpp}, 2 crosstalk)



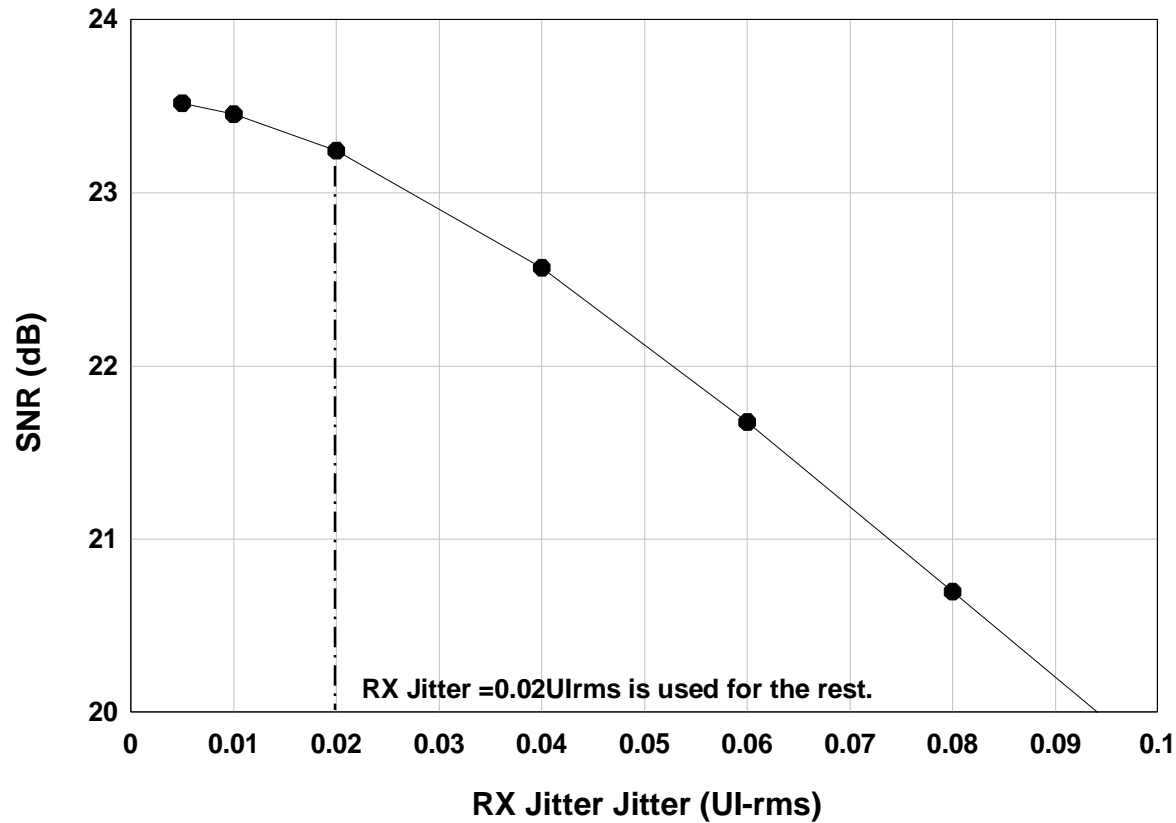
15cm-MSTL-12mil



Results-5: SNR at D

Sensitivities to RX Jitter

(IC noise = -135dBm/Hz, Host TX-jitter=0.12UIpp, 2 crosstalk)

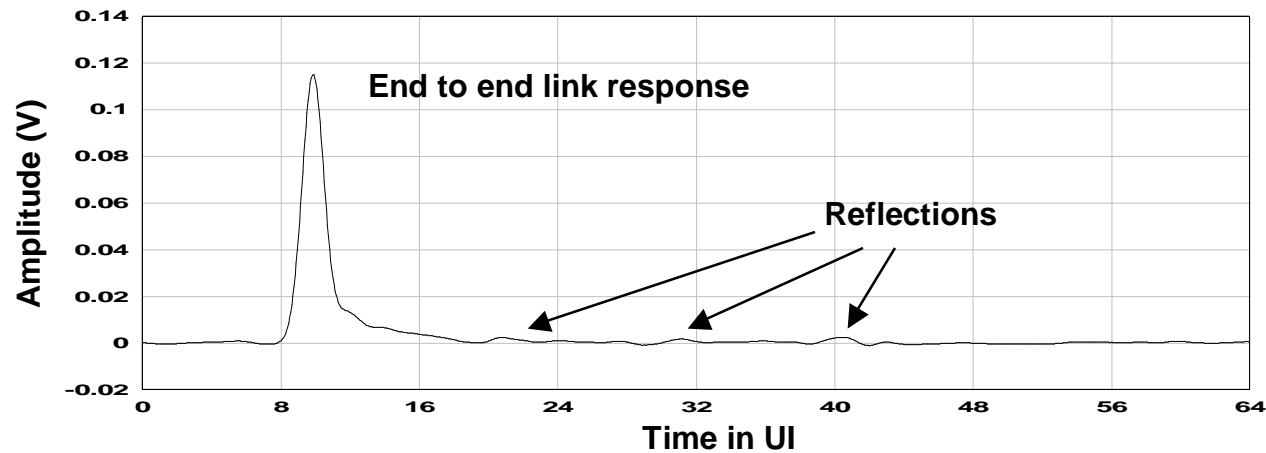
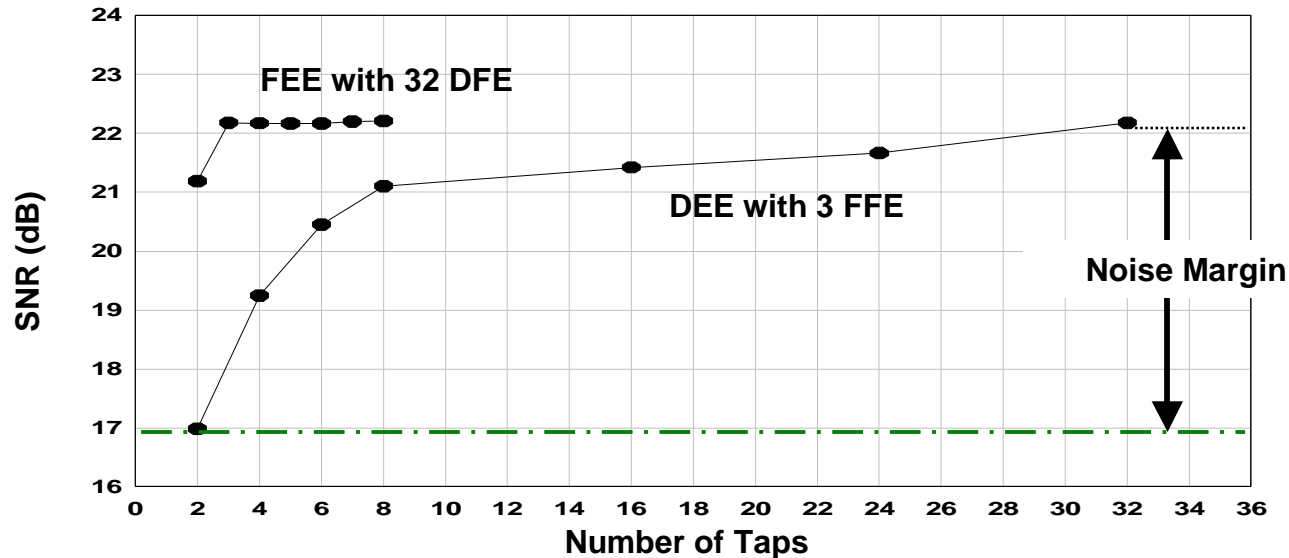


RX jitter spectral is limited to 20MHz.



Results-6: Final SNR

Sensitivities to Number of Taps of FFE and DFE
(IC noise = -135dBm/Hz, Host TX-jitter=0.12UIpp, 2 crosstalk)



Final Result, Noise Margin

Conditions

1. IC noise **-135dBm/Hz**
2. TX Jitter **0.12ppUI (uniform + gaussian)**
3. Crosstalk **SFP+ Module equivalent (2 sets of crosstalk)**
4. RX jitter **0.02UI-rms (gaussian)**
5. 100m MMF
6. EDC/EQL **3tap FFE + 32 tap DFE**

Host PCB trace	MSTL, 12mils width			STL, 5mils width			
	5cm	15cm	30cm	5cm	15cm	20cm	30cm
Margin dB	6.1 dB	5.3	3.9	5.7	5.0	4.5	3.4



Summary

- **Generalized methodology for the feasibility analysis was described using the example of 100m MMF PMD.**
- **SNR analysis of the heterogeneous link (electrical and optical mixed) was based on measured package, PCB, and module.**
- **Link SNR and Margin was estimated with key link impairments: IC noise, jitter, Crosstalk, and optical component non-linearity.**
- **The main benefit of the approach is its ability of comparative analysis between different PMD proposals using a unified methodology based on objective technical and economical metrics.**
- **Analysis shows 3~6dB margin with sufficient number of FFE and DFE taps at the host EDC for the end-to-end link.**
- **The method is applicable not only to 100m MMF but also to other PMDs such as 10m copper, 10/40km SMF.**

