Experimental Investigation on Dispersion Tolerance of 8x53.2Gbps NRZ for 400GbE 2km and 10km PMD

Yangjing Wen, Fei Zhu, and Yusheng Bai
Huawei Technologies, US R&D Center

Alan McCurdy, Benyuan Zhu, and Robert Lingle, Jr.
OFS

Mizuki Shirao, and Keisuke Kojima
Mitsubishi Electric

IEEE802.3bs 400GbE Task Force
Berlin Plenary Meeting
March, 2015

HUAWEI

Contents

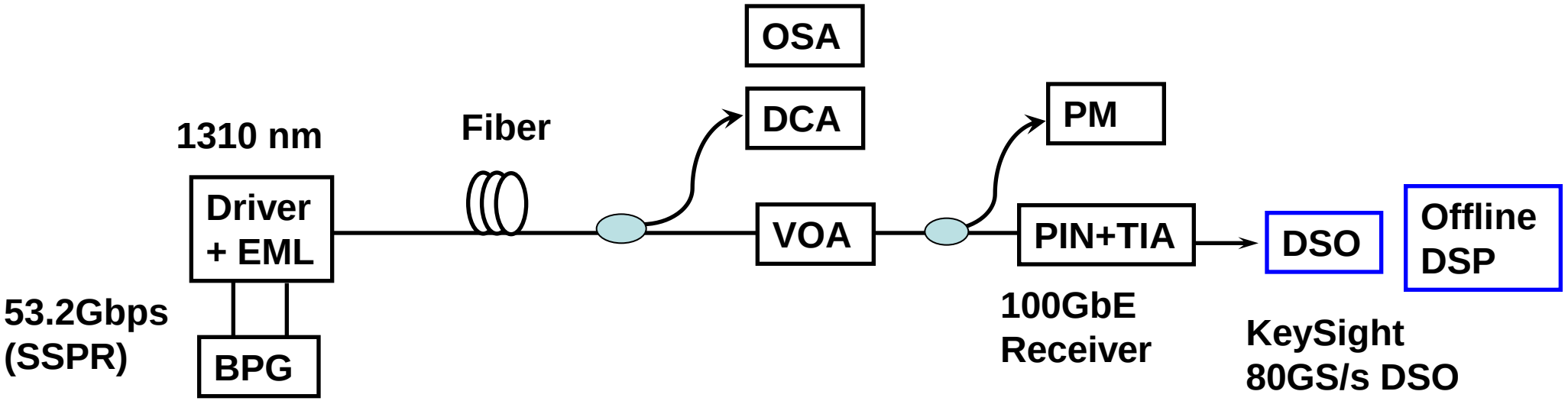
Introduction

- 50Gb/s NRZ considered a promising candidate for 400GbE PMD due to its simplicity, high sensitivity, and high tolerance to MPI:

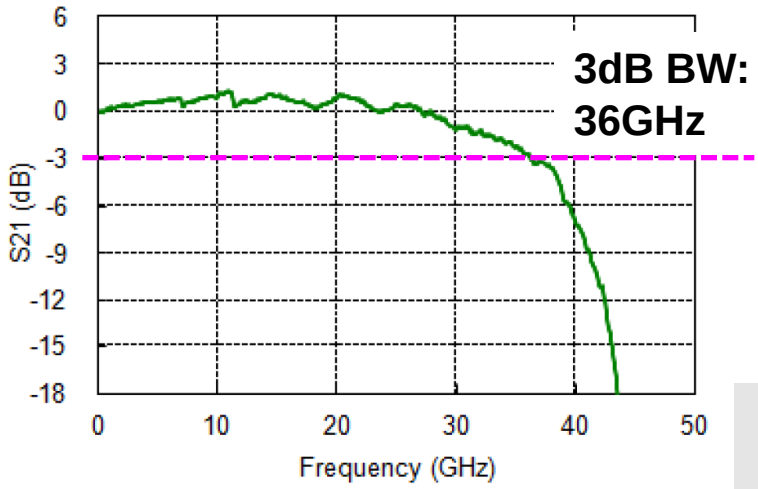
  cole_01_0914_smf.pdf; qian_3bs_01_0714.pdf; wen_3bs_01_0914.pdf; kojima_3bs_01a_0115.pdf; stassar_01_1014_smf.pdf

- Chromatic dispersion has been a concern and listed as the big ticket item at January Interim Meeting for 8x50Gbps NRZ PMD.
- Stassar addressed the dispersion requirement for various PMDs at the Feb Ad Hoc Meeting (*stassar_01_0215_smf.pdf*).
- Shirao presented the worst dispersion penalty for 50Gbps NRZ (*kojima_01_0215_smf.pdf* **)**.
- In this contribution, we evaluate dispersion tolerance for 50Gbps NRZ to cover worst dispersion scenarios and address the sensitivity and link budget issue.

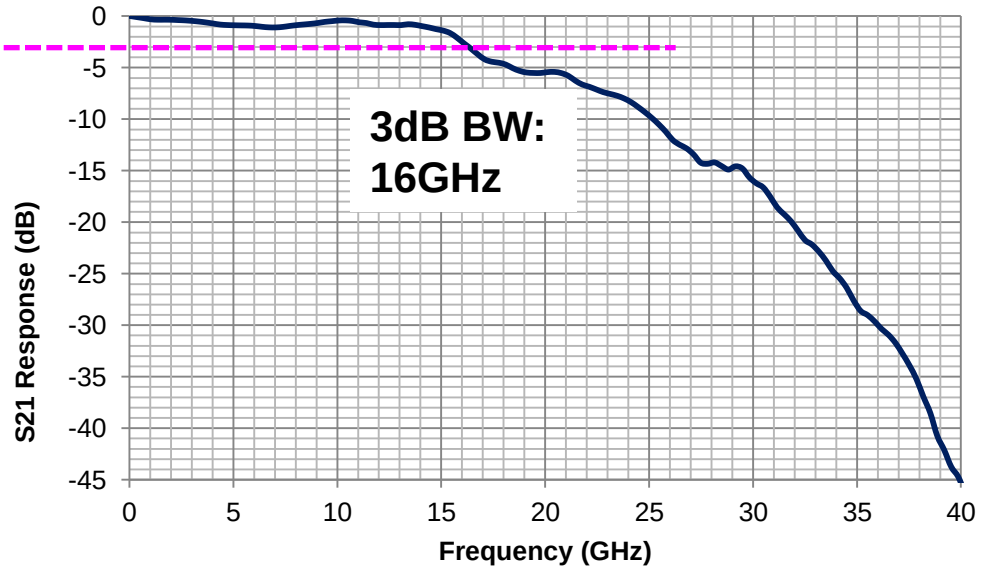
Experimental Setup



S21 of Driver + EML (Mitsubishi FU-697SEA-T3M2)

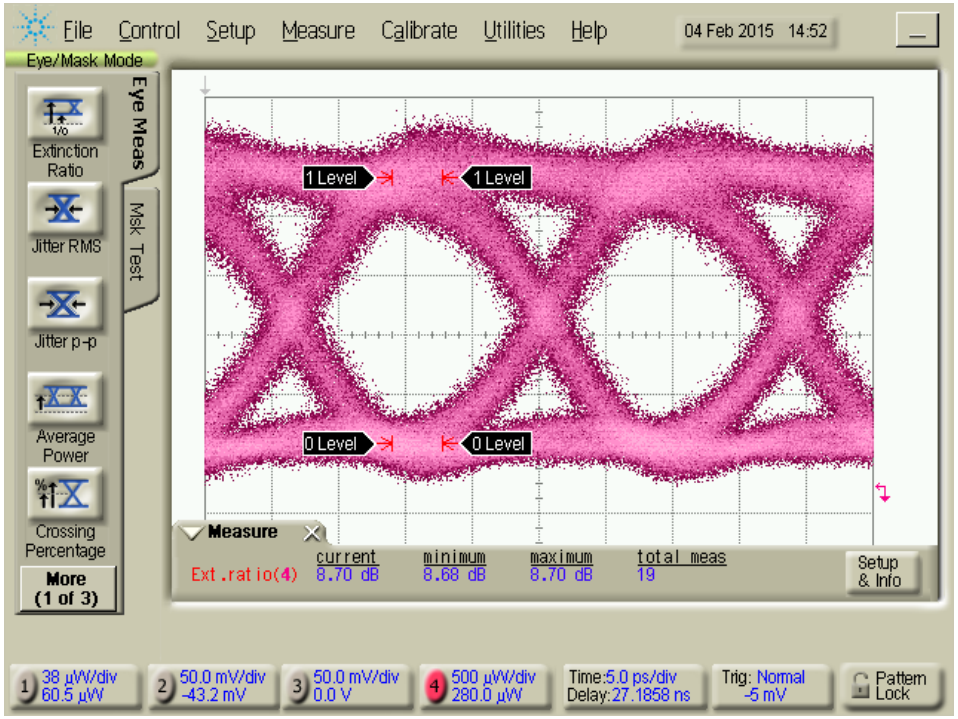


Receiver S21 Response

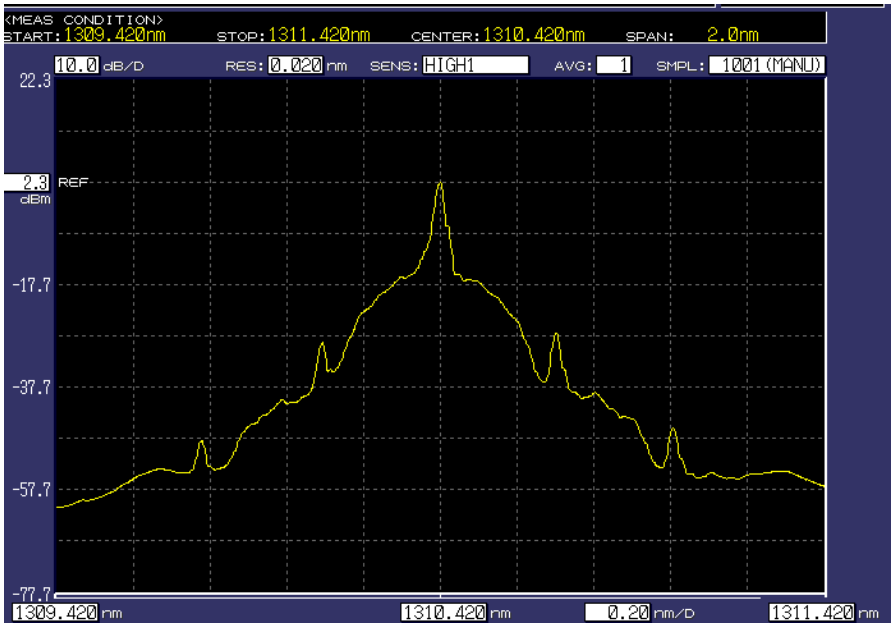


Eye Diagram & Optical Spectrum

53.2Gbps Eye Diagram



Optical Spectrum

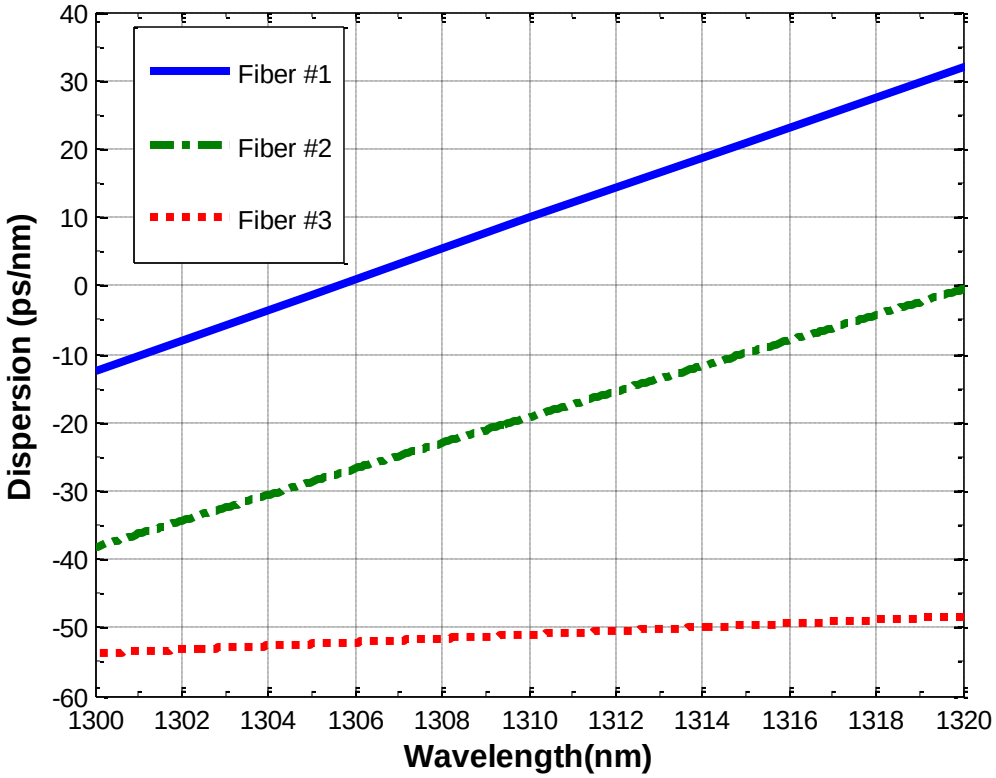


Measured with an Agilent 40G optical module (86116C Opt. 025)

- **ER =8.7dB**
- **Laser wavelength: 1310.4nm**

- **Operation conditions of EML:**
  - **Laser bias current = 80mA**
  - **Operating temperature: 40 deg C**

Dispersion vs Wavelength of Used Fibers

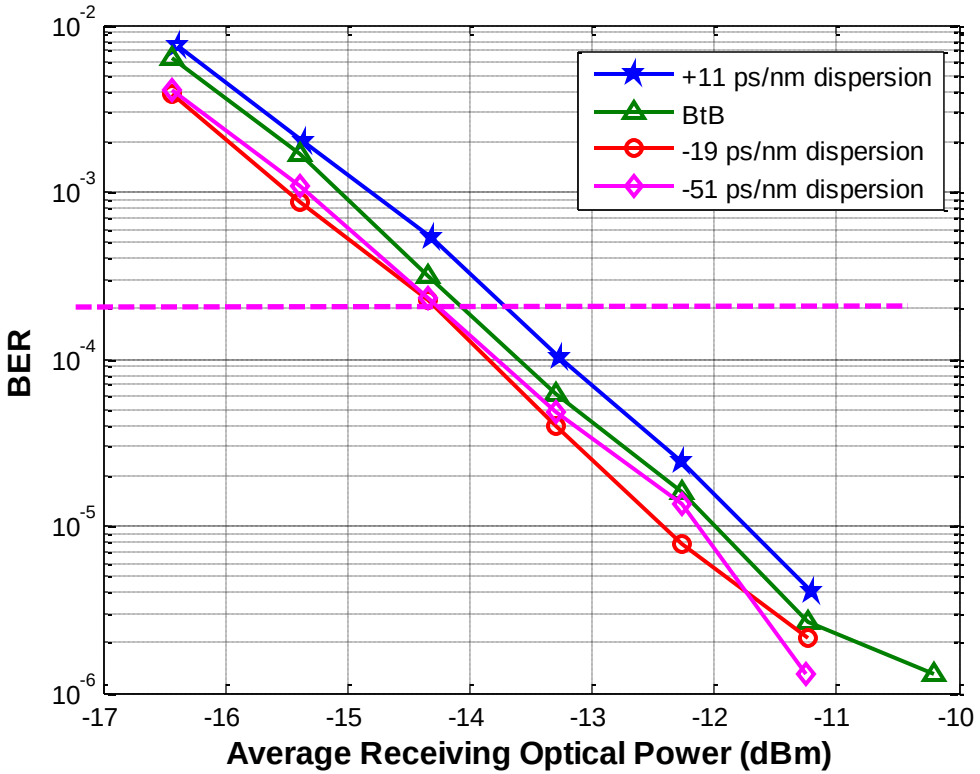


Three spools of fiber used for evaluating dispersion tolerance

- **Fiber #1:**
  - **25.3km SMF, λ_0= 1305.4nm**
  - **+11ps/nm dispersion at 1310.4nm**
- **Fiber #2:**
  - **22.2km SMF, λ_0= 1320 nm**
  - **-19ps/nm dispersion at 1310.4nm**
- **Fiber #3:**
  - **20km-LEAF DCM**
  - **- 51ps/nm dispersion at 1310.4nm**

Choosing these fibers with various dispersion with respect to 1310.4nm is to cover the worst cases of CD for the entire 8 wavelengths of 8x53.2Gbps

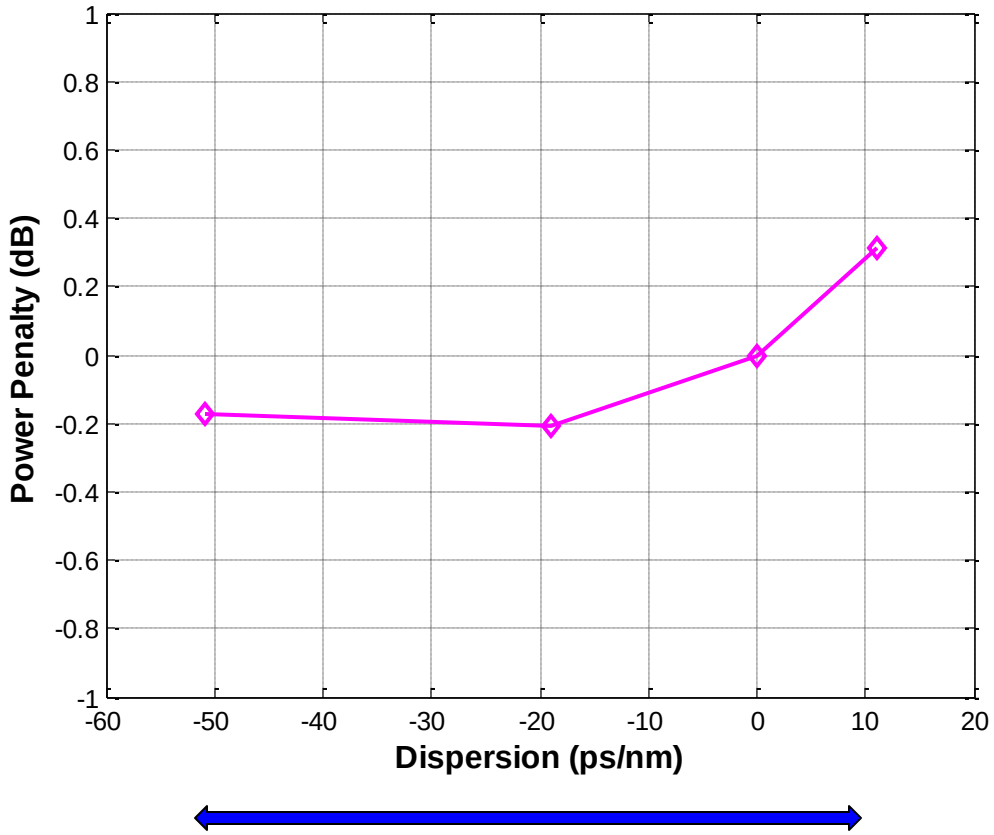
BER vs Average Receiving Optical Power



- **EML Sample #1 used**
- **ER ~ 9.1dB**
- **5 tap FFE in Rx**

- **Negative penalty observed for negative dispersion, positive penalty observed for positive dispersion**
- **BtB receiver sensitivity is around -14.1dBm at BER@2e-4**

Power Penalty vs Dispersion



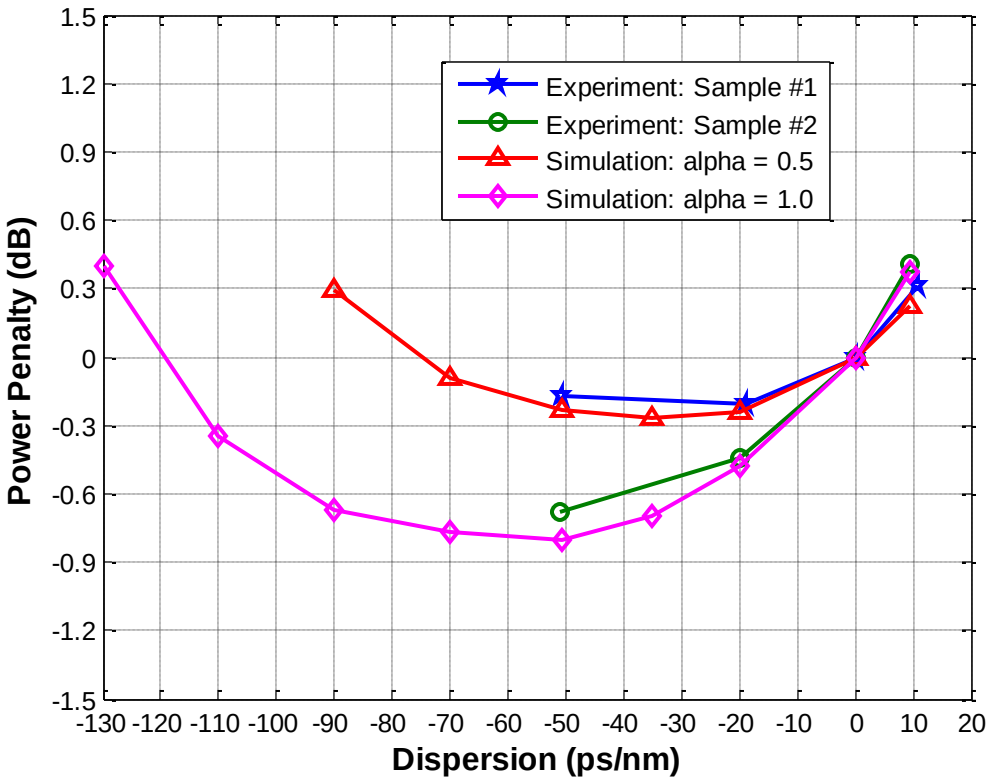
Dispersion range

- **EML Sample #1 used**
- **Power penalty defined at BER@2e-4**
- **The measured power penalty induced by chromatic dispersion is well below 1dB**

Comparison with Experiment – Simulation Conditions

Parameters	**Values**
Format	NRZ
Baud Rate	53.2 Gbaud/s
Pattern	SSPR
Modulator	intensity modulation with chirp
Tx BW	35GHz with
Tx S21 shape	4^{th} order Bessel filter
Extinction ratio	6 dB
RIN	-140 dB/Hz
Rx BW	16GHz
Rx S21 shape	4^{th} order Bessel filter
Rx Responsivity	0.6 A/W
Rx input noise density	15 pA/sqrt(Hz)
Equalizer in Rx	5 tap FFE

Comparison with Simulation - Results



Dispersion range

- **Sample #2 has a laser wavelength of 1309.7nm**
- **Sample #2 close to simulation of alpha= +1.0**
- **Sample #1 close to simulation of alpha= +0.5**
- **For both evaluated EML samples, dispersion penalty at maximum positive dispersion is well below 1 dB**

Link Budget in OMA

Applications	Duplex 2km	Duplex 10km
Number of wavelength	8	
Baud rate	53.2 GBaud/s	53.2 GBaud/s
Operating BER	2e-4	2e-4
ER	≥6dB	
Transmitter output OMA	1.0dBm	3.0dBm
Mux IL	3dB	3dB
Fiber/connector loss (1)	5dB	6.4dB
MPI penalty (2)	0.2dB	0.2dB
Dispersion penalty	0.5dB	1.5dB
DeMux IL	3dB	3dB
Post-DeMux Rx input OMA	-10.7dBm	-11.1dBm
Rx sensitivity (OMA)(3)	-12.3dBm	-12.3dBm
Margin	1.6 dB	1.2dB

Any Tx and Rx induced penalty has already been included in the BtB receiver sensitivity test

(1) kolesar_3bs_01_0514.pdf;

(2) wen_3bs_01_0914.pdf, at 30dB MPI

(3) The receiver sensitivity was measured in average power and has been converted to OMA

Summary

- Experimentally investigated chromatic dispersion tolerance of 8x53.2G NRZ for 400GbE 2km and 10km PMD.
- The observed power penalty induced by chromatic dispersion is well below 1dB, which is consistent with that in (*kojima_01_0215_smf.pdf*).
- Demonstrated sufficient link budget for both 2km and 10km (with 1.2dB extra margin) 400GbE applications.