100GE 40km SMF PMD

SOA-Receiver Performance

IEEE 802.3ba Task Force

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Yuri Vandyshev

Tedros Tsegaye

Chris Cole

yuri.vandyshev@finisar.com

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Outline

- 100GE 40km SMF PMD power budget and receiver specifications
- SOA-receiver Sensitivity model
- SOA Optical Crosstalk experiments
- Chromatic Dispersion Penalty model and experiments
- Polarization Mode Dispersion Penalty experiments
- Conclusions

100GE 40km SMF PMD baseline

100GE 40km SMF PMD Baseline (cole_02_0508)

Key specifications reviewed in this presentation:

Receiver Sensitivity: -22.4dBm OMA

-24dBm Pave (Tx ER=8.0dB min)

Allocation for penalties: 3.2dB

1.5dB CD Penalty, 1.7dB PMD and Other Penalties

SOA-Receiver Model

1. Parameters used in SOA-receiver model

SOA (*similar SOA used in experiments*)

External Gain: 20dB

NF: 7dB

DEMUX

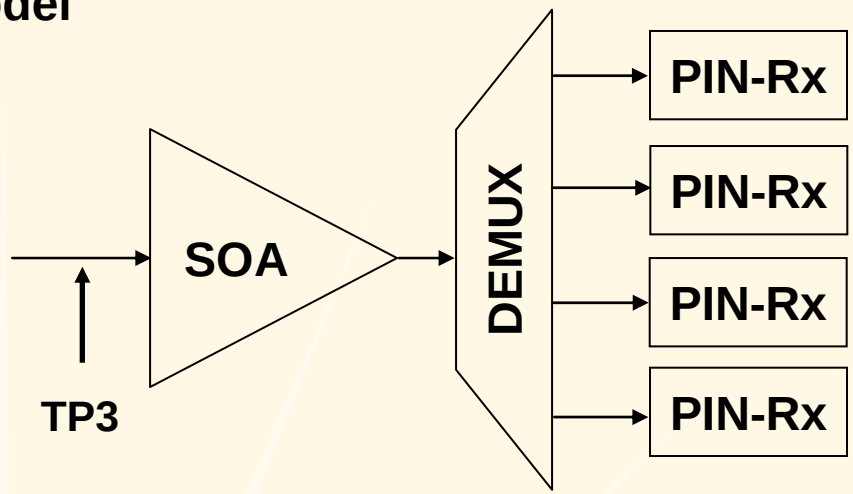
insertion loss: 2.5dB, passband: 2.3nm

PIN-Rx

R ~ 0.8A/W, S21 BW ~ 21GHz

TIA input-referred noise current density ~ 15pA/sqrt(Hz)

⇒ 2.1uA rms noise current ⇒ sensitivity estimate -15.8dBm (Pave, ER~8dB)



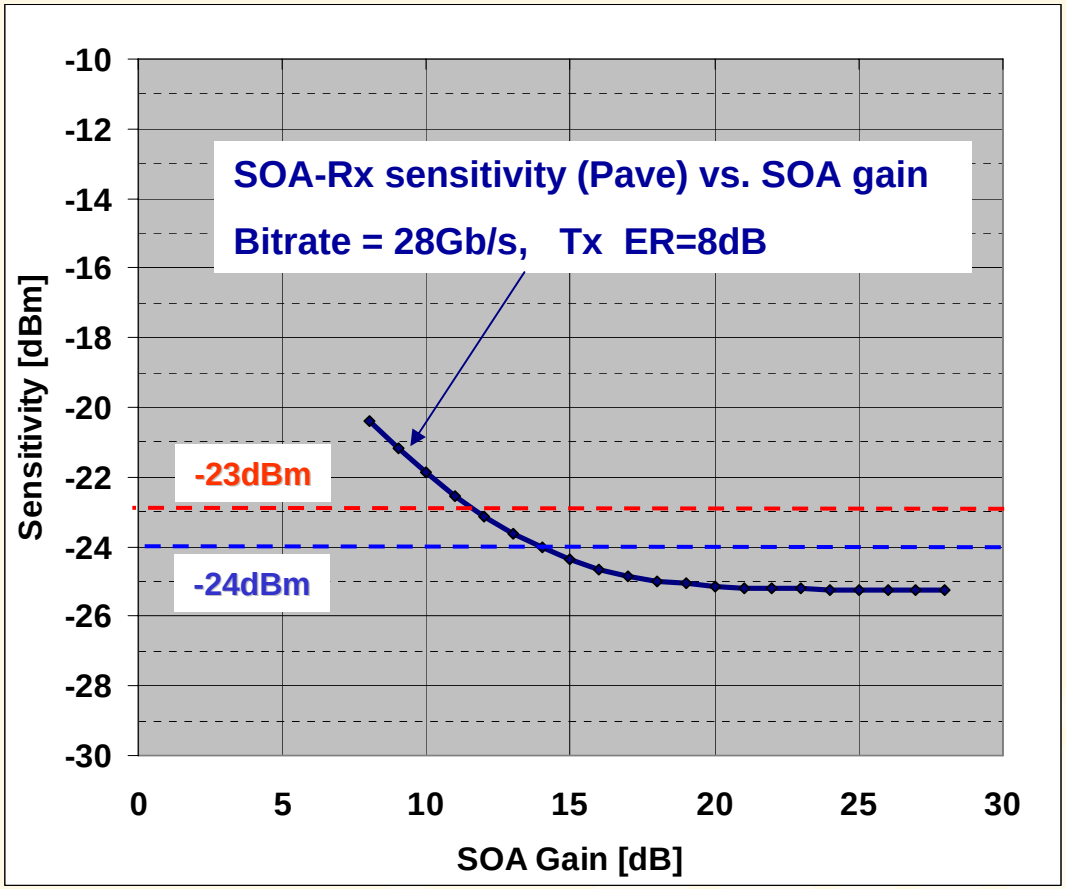
2. SOA-receiver model for sensitivity calculation

calculate signal and noise terms (incl. SOA ASE noise)

⇒ calculate input optical power required for BER=10^{-12}

The model was verified in 10Gb/s and 40Gb/s experiments.

SOA-Receiver Sensitivity: modeling results



Model predicts that

SOA-receiver can meet

sensitivity requirement

-24dBm (Pave)

-22.4dBm (OMA)

Note: -23dBm (Pave), -21.4dBm (OMA) sensitivity target can be met with additional margin

SOA-Receiver impairments: optical crosstalk

SOA gain saturation at high input power can lead to

- waveform distortion (1-channel)
- cross-gain modulation – XGM – (multi-channel WDM environment).

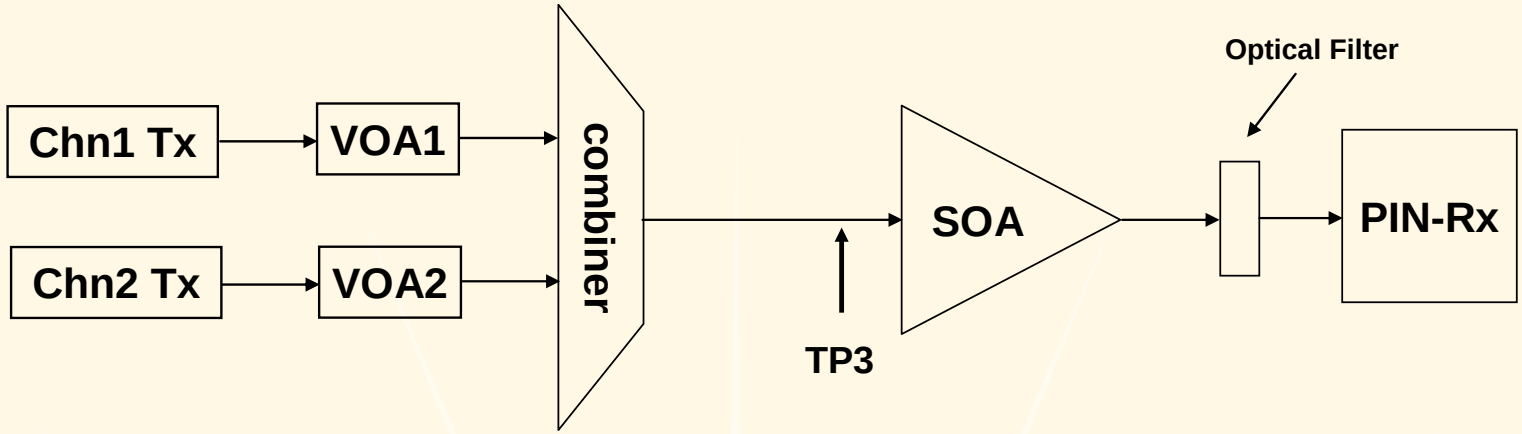
Objective

experimentally evaluate the effect of optical crosstalk on SOA-Receiver sensitivity

Finisar feasibility experiments

- conducted in 1550nm spectral band at 40Gb/s and 10Gb/s
- used commercially available SOA

SOA-Receiver: optical crosstalk experiments



2 channels: Chn1 = SIGNAL, Chn2 =AGGRESSOR

independent PRBS31 streams into Chn1 and Chn2

Tx ER ~ 10dB (Chn1 and Chn2)

channel spacing: 10nm/1250GHz (40Gb/s), 6.4nm/800GHz (10Gb/s)

SOA gain ~ 20dB

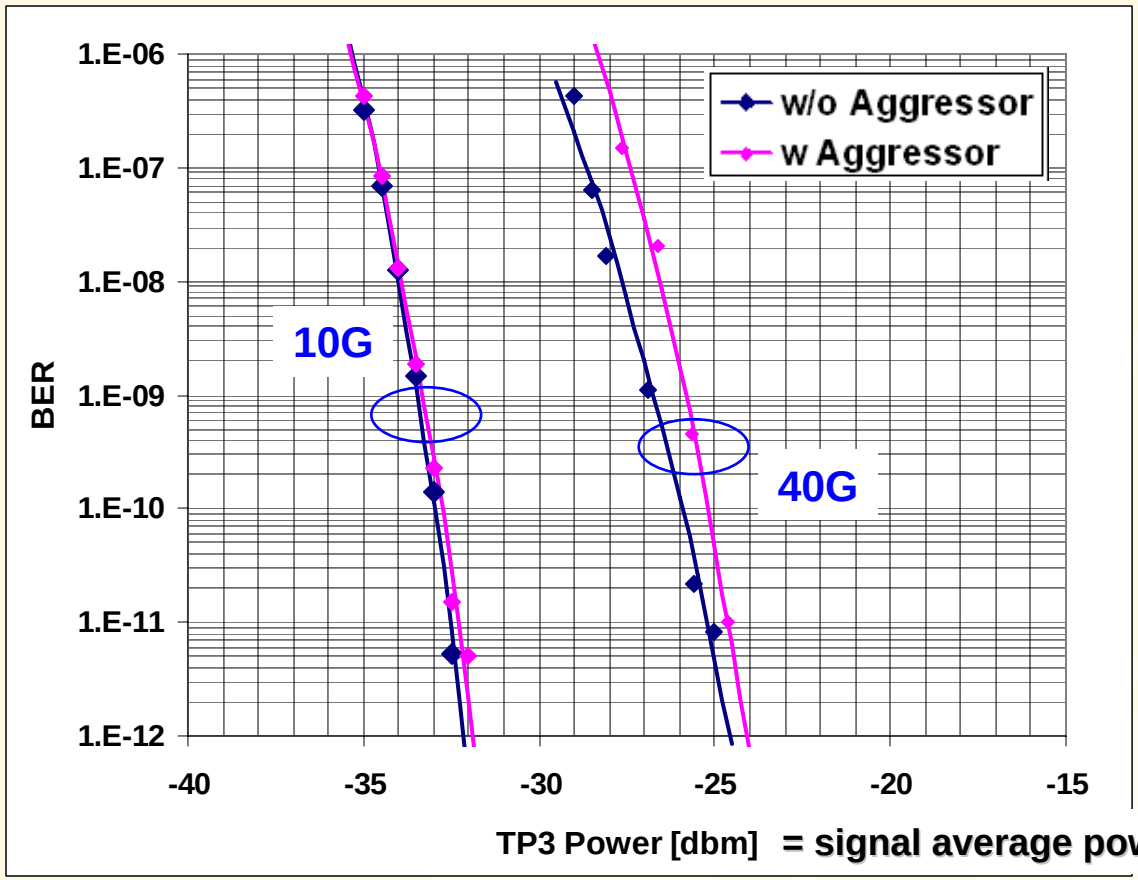
TP3: test point for sensitivity measurement

Tested at aggressor channel power up to Psig + 8dB

(3channels, 3dB channel power window)

SOA-Receiver: optical crosstalk experimental results

SOA-receiver sensitivity measurements with and without aggressor



P(aggressor)=P(signal)+8dB

XTALK penalty at sensitivity

< 0.5dB (40G)

< 0.2dB (10G)

SOA-Receiver: optical crosstalk experimental results

Optical Crosstalk at Sensitivity

40G and 10G experiments indicate small sensitivity penalty due to crosstalk:

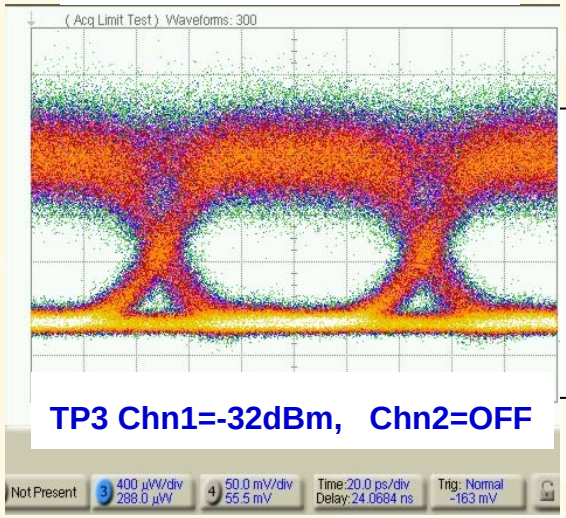
<0.5dB worst case

Explanation

SOA input power (Sig and Agg) at sensitivity is significantly below saturation

⇒ eye closure due to gain saturation and XGM is small/negligible

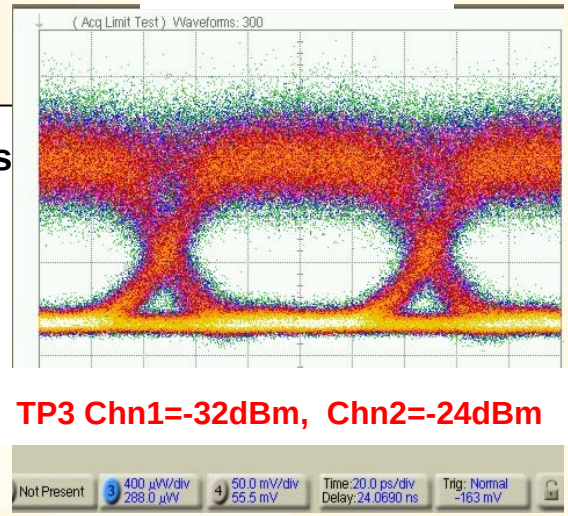
without aggressor



TP3 Chn1=-32dBm, Chn2=OFF

Optical Eye-diagrams at ~sensitivity PIN-PD input 10Gb/s

with aggressor



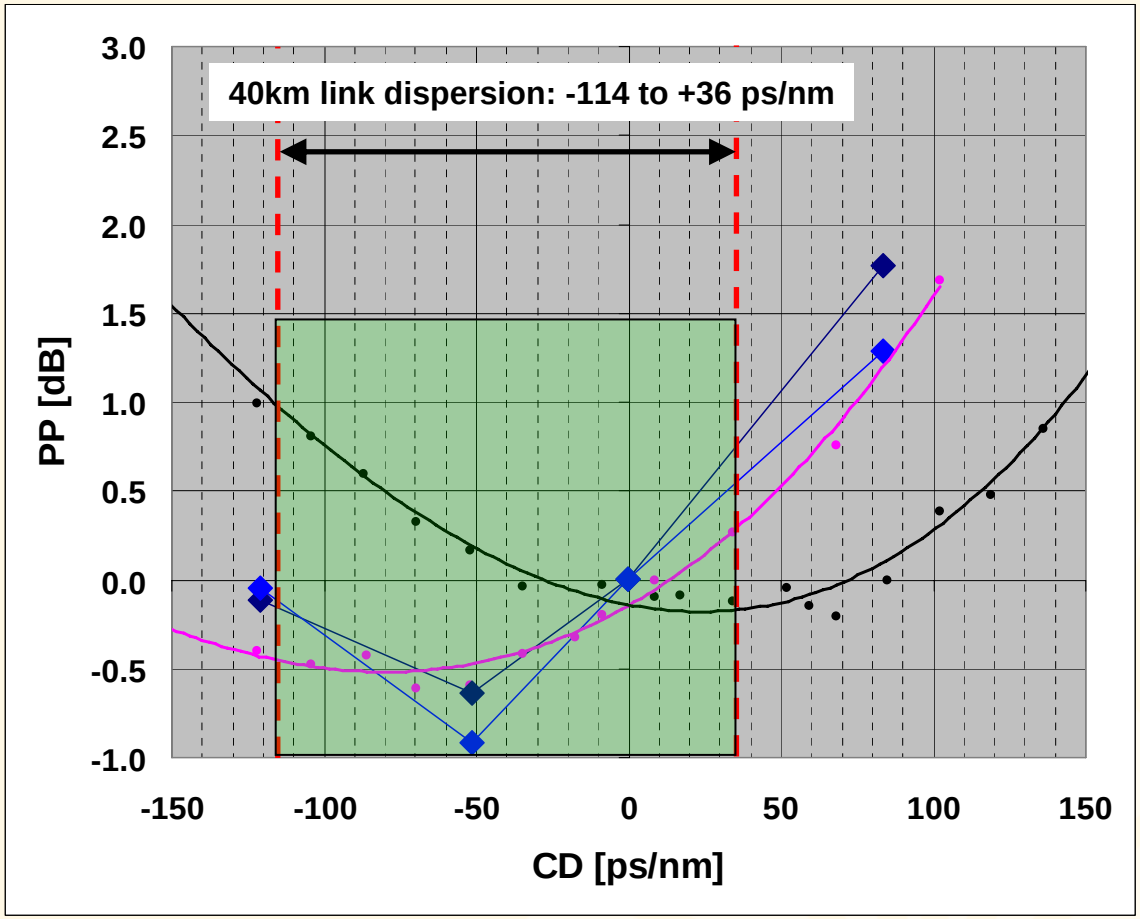
TP3 Chn1=-32dBm, Chn2=-24dBm

100GE 40km path penalties: Chromatic Dispersion

- **Power Penalty due to Chromatic Dispersion (EML transmitter)**
  estimated via 40Gb/s experiments and 28Gb/s computer modeling
- **Experiments – 40Gb/s**
  EML transmitter, 1554nm, ER~10dB
  Path Dispersion adjusted using SMF+DCF combination
  SOA-PIN-Rx (SOA Gain~20dB)
    Extrapolate B=40Gb/s results to B=28Gb/s using "B^2-scaling"
      CD in 100GE 40km link (LAN-WDM baseline grid 1295 -1305nm)
        40km: from -114ps/nm to +36ps/nm
        which corresponds to -55.9ps/nm to 17.6ps/nm at 40Gb/s
- **Modeling - 28Gb/s**
  Optsim fiber link simulator
    EML transmitter
    SOA-PIN-Rx (SOA Gain~20dB)

100GE 40km path penalties: Chromatic Dispersion

Power Penalty vs. Chromatic Dispersion, 28Gb/s, SOA-Rx



EXP Tx1 and Tx2:

40Gb/s test data with

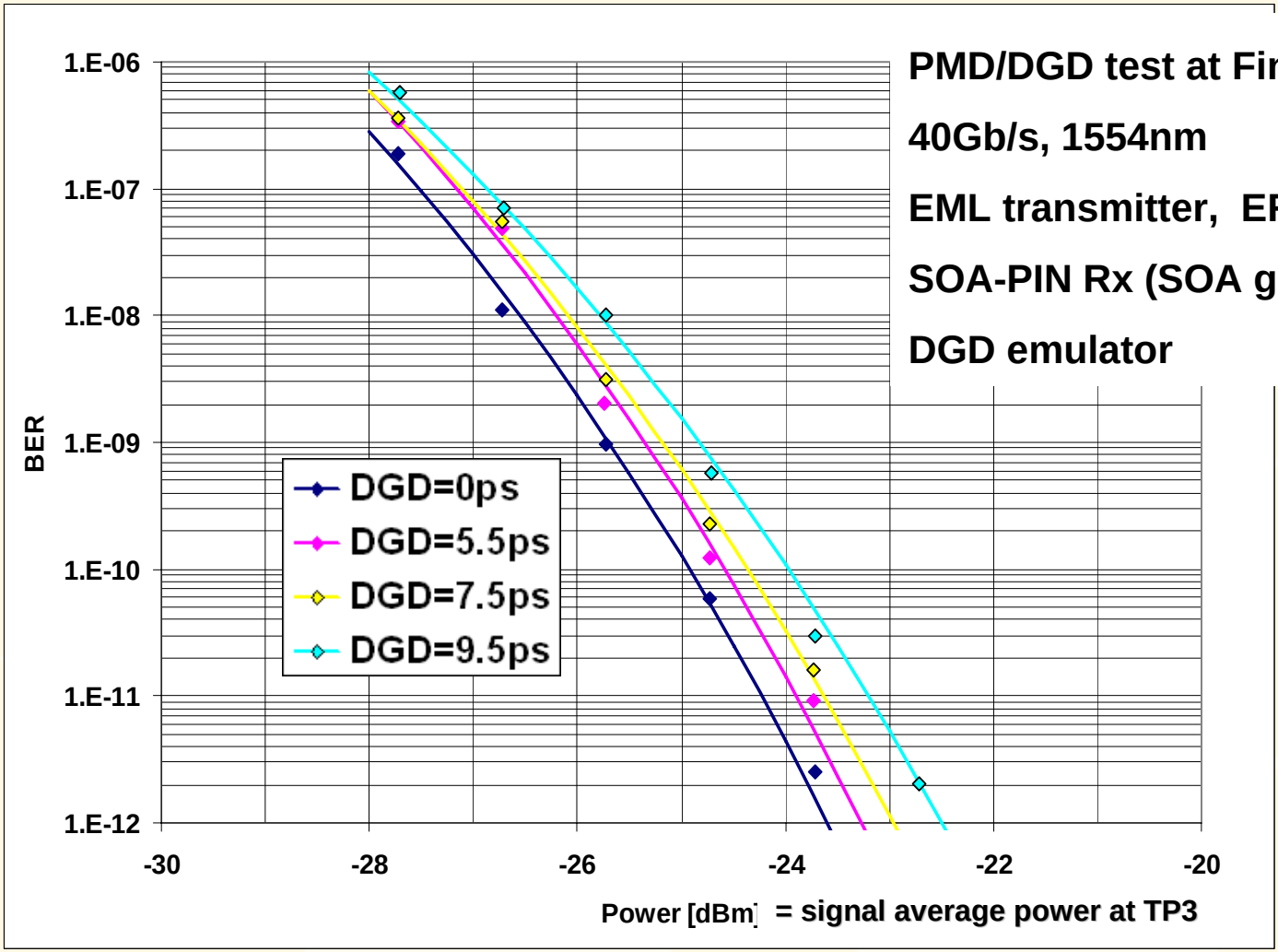
dispersion scaled for 28Gb/s

100GE 40km path penalties: Chromatic Dispersion

- Experimental results using commercial 40Gb/s EML transmitters support proposed 1.5dB CD penalty allocation.
- Modeling results using 28Gb/s EML transmitters support proposed 1.5dB CD penalty allocation.

100GE 40km path penalties: PMD

Sensitivity Measurements for DGD = 0 to 9.5ps



PMD/DGD test at Finisar

40Gb/s, 1554nm

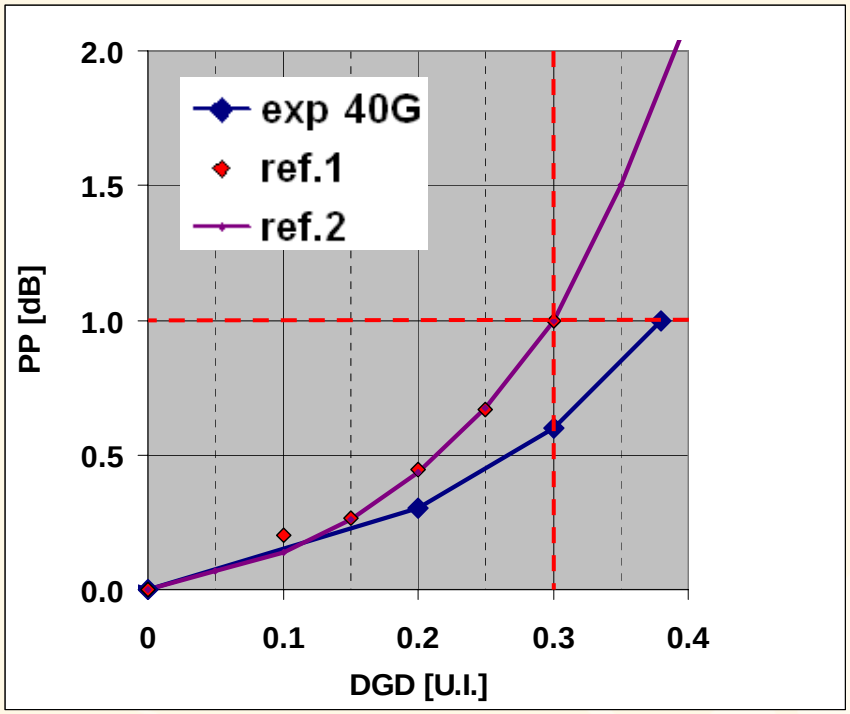
EML transmitter, ER~10dB

SOA-PIN Rx (SOA gain ~ 20dB)

DGD emulator

100GE 40km path penalties: PMD

Power Penalty vs. DGD



Ref.1: ITU-T Rec. G.691, Figure I.3
(receiver with signal-dependent noise)

Ref.2: "Polarization Mode Dispersion in 100GbE links" P. Anslow, anslow_01_0308
(10G measured values)

PMD/DGD experimental results (40G)

<u>Measured DGD penalty values</u>
<u>do not exceed values predicted in Refs.1,2</u>

1 U.I. = 1/25.78125G
PMD penalty allocation = 1.0dB
max DGD = 0.3 U.I. = 11.64ps
$\Rightarrow$ max PMD = 3.1ps
(used safety factor of 3.75
for 2.6 sec/year outage)
$\Rightarrow$ 240km on 0.2ps/$\sqrt{}$km fiber
40km objective met for G.652.B&D fiber

$\Rightarrow$ 38km on 0.5ps/$\sqrt{}$km fiber
30km objective met for G.652.A&C fiber
40km requires an engineered link

Conclusions

- Experiments and modeling demonstrate technical feasibility of the 100GE 40km SMF PMD adopted baseline as per cole_02_0508
  - receiver sensitivity -22.4dBm (OMA), -24dBm (Pave)
  - CD penalty $\leq$ 1.5dB
  - PMD and other penalty allocations $\leq$ 1.7dB

- Recommendation for additional margin
  - Change receiver sensitivity to -21.4dBm (OMA), -23dBm (Pave) for additional 1 dB of margin
  - Change PMD and other penalty allocations to 2.0dB for additional 0.3 dB of margin
  - Proposed in cole_02_0708

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