

100GBASE-FR2, -LR2 Baseline Proposal

802.3cd 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet
Task Force

IEEE 802 Plenary Session

San Diego, CA

26-28 July 2016

Chris Cole

Contributors & Supporters

Contributors & Supporters:

- Jonathan King, Finisar
- Peter Stassar, Huawei

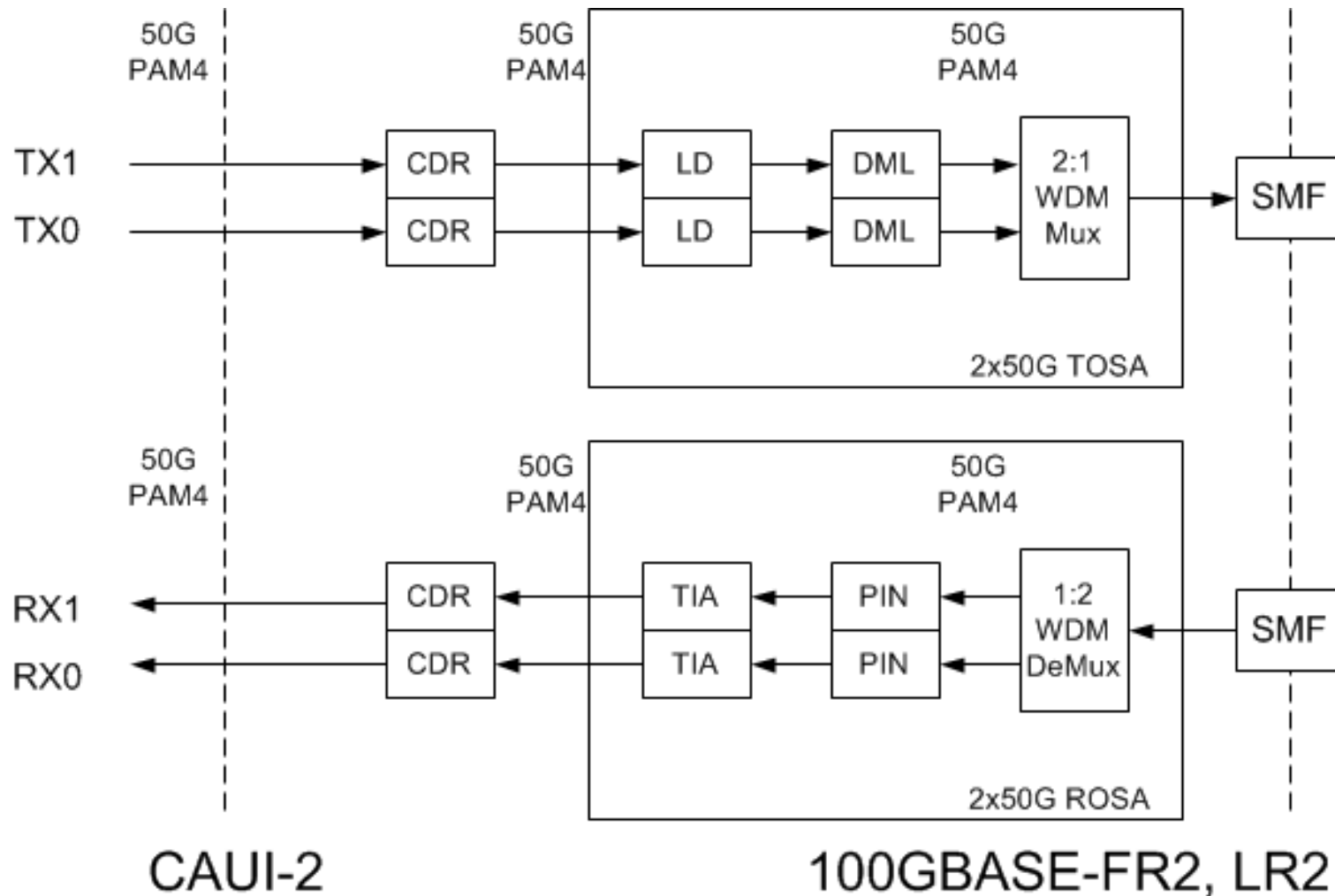
Supporters:

- Pete Anslow, Ciena
- Sudeep Bhoja, InPhi
- Ali Ghiasi, Ghiasi Quantum, Huawei
- Scott Kipp, Brocade
- Vasu Parthasarathy, Broadcom
- Siddharth Sheth, InPhi
- Rob Stone, Broadcom
- Kohichi Tamura, Oclaro
- Steve Trowbridge, Nokia
- Helen Xu, Huawei

Background

- 50G PAM4 WDM technology was identified as the next technology step for SMF PMDs and 8x50G PAM4 WDM was proposed for 400 Gb/s Ethernet in X. Song, et. al, ["Considerations on Options for 400GE Optical Interfaces,"](#) 400 Gb/s Ethernet SG, May 2013.
- 2x50G PAM4 WDM (100G) per fiber was identified as an alternative for 400G PSM4 PMD in C. Cole, ["400Gb/s 500m PMD Alternatives,"](#) 400Gb/s Ethernet TF, May 2014.
- Rationale and specs for 2x50G PAM4 CWDM2 100 Gb/s 2km & 10km SMF PMDs were presented in: C. Cole, ["100 Gb/s SMF PMD Specifications and Objectives Proposal,"](#) 50, Next Gen 100 & 200 Gb/s Ethernet SG, Jan. 2016
- 4x50G PAM4 WDM 200 Gb/s 2km & 10km SMF PMDs were presented in: C. Cole, ["200GBASE-FR4 & -LR4 Baseline Proposal,"](#) 400Gb/s Ethernet TF, May 2016

100BASE-FR2, -LR2 Example Block Diagram



Transmit Characteristics

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Reach	2	10	km
Signaling Rate, each lane	26.5625	26.5625	GBd
Operating BER	2.4E-04	2.4E-04	
Average power, each lane (max)	4.7	5.3	dBm
OMA _{outer} , each lane (max)	4.5	5.1	dBm
OMA _{outer} , each lane (min)	-1.2	-0.4	dBm
Diff. in launch power between any two lanes (OMA _{outer}) (max)	4	4	dB
Launch Power in OMA _{outer} minus TDECQ, each lane (min)	-2.2	-1.4	dBm
TDECQ, each lane (max)	2.4	2.5	dB
Extinction ratio (ER) (min)	4.5	4.5	dB
RIN OMA (max)	-136	-136	dB/Hz

Receive Characteristics

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Signaling Rate, each lane	26.5625	26.5625	GBd
Operating BER	2.4E-04	2.4E-04	
Receiver reflectance (max)	-26	-26	dB
Receiver Sensitivity ($\text{OMA}_{\text{outer}}$), each lane (max)	-6.5	-8.2	dBm
Difference in receive power between any two lanes ($\text{OMA}_{\text{outer}}$) (max)	4.1	4.6	dB
Stressed receiver sensitivity ($\text{OMA}_{\text{outer}}$), each lane (max)	follow 200G FR4	follow 200G LR4	dBm
Conditions of stressed receiver sensitivity test	follow 200G FR4	follow 200G LR4	

Illustrative Link Power Budgets

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Power Budget (for maximum TDECQ)	6.7	9.3	dB
Operating Distance	2	10	km
Channel Insertion Loss	4	6.3	dB
Maximum Discrete Reflectance	-35	-35	dB
Allocation for Penalties (for maximum TDECQ)	2.7	3	dB
Modulation Penalty	4.8	4.8	dB
MPI Penalty	0.3	0.5	dB

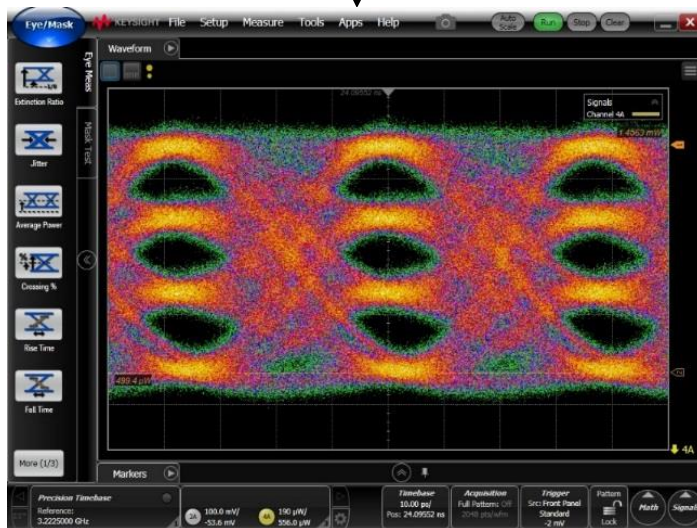
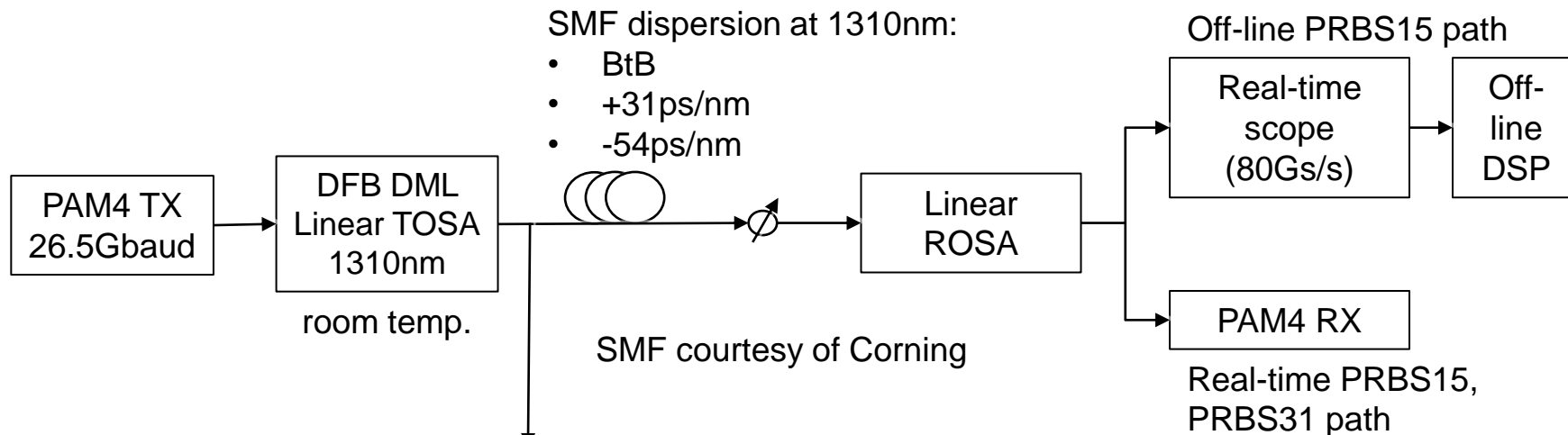
WDM Lane Assignments

100GBASE WDM Lane	Center Wavelength nm	Wavelength Range nm
L0	1271	1264.5 to 1277.5
L1	1311	1304.5 to 1317.5

Optical Margin

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Receiver Sensitivity ($\text{OMA}_{\text{outer}}$), each lane, pre-DeMux (max)	-6.5	-8.2	dBm
DeMux Loss	1	1	dB
Cross-talk penalty	0.2	0.2	dB
Modulation Penalty	4.8	4.8	dB
Receiver Sensitivity ($\text{OMA}_{\text{inner}}$), each lane, post-DeMux (max)	-12.5	-14.2	dBm
Receiver Sensitivity ($\text{OMA}_{\text{inner}}$) single lane (typical measured)	-17	-17	dBm
Optical Margin	4.5	2.8	dB

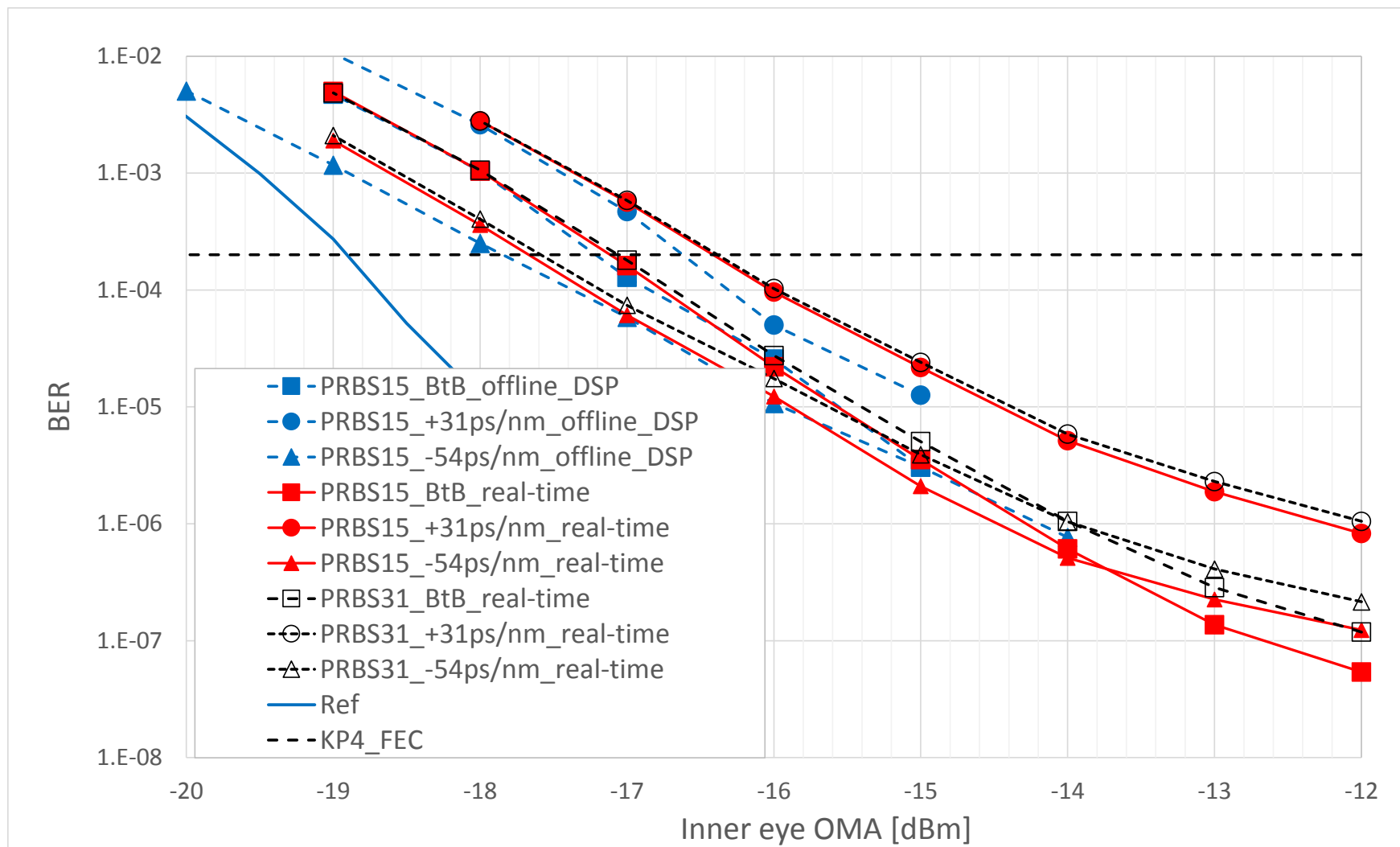
Supporting Data Measurement Set-up



Data presented at the May 2016 IEEE 802.3 Interim Meeting in Whistler, Canada:

http://www.ieee802.org/3/bs/public/16_05/cole_3bs_01a_0516.pdf

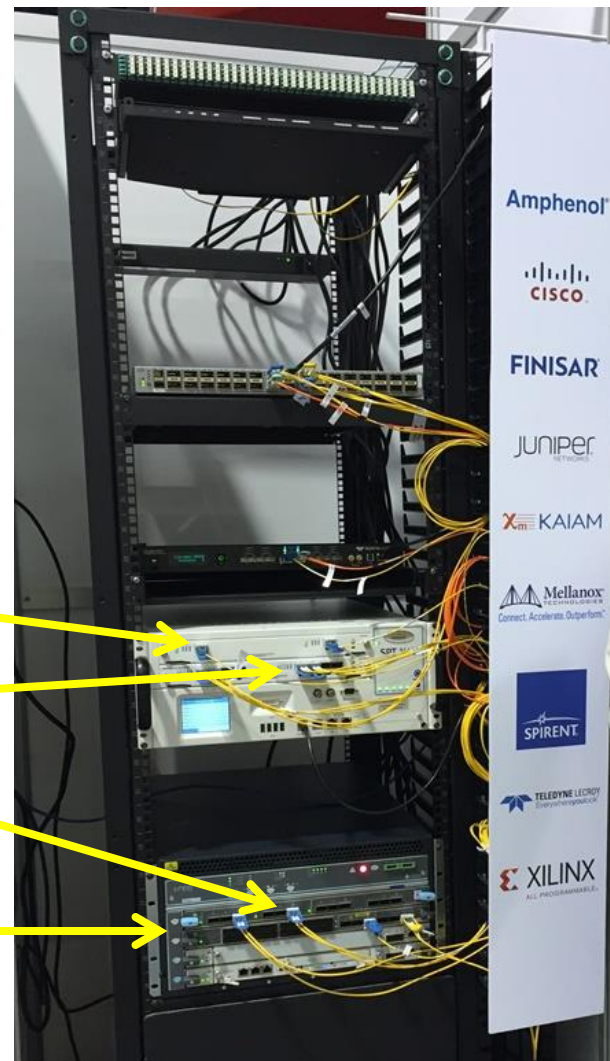
Off-line & Real-time DSP Supporting Data



Supporting Data Demonstration Set-up

OFC 2016 Ethernet Alliance Booth

- March 21 – 24, 2016
- 100Gb/s Ethernet live-traffic demo
- Standard QSFP28 KR4 FEC ports
- Error-free operation each of 4 days
- Spirent Tester
- QSFP28 modules with 4:2 Mux and “LR2” TOSA & ROSA (2x 50G PAM4 CWDM2)
- Juniper Switch



100GBASE-FR2, -LR2 Baseline Proposal

Thank you