10km SMF 40GbE PMD Analysis

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Agenda

1. Introduction
2. Comparing 4 x 10G with 1 x 40G
3. Analyzing 1 x 40G Link Budget
4. Analyzing 4 x 10G Link Budget
5. Proposal

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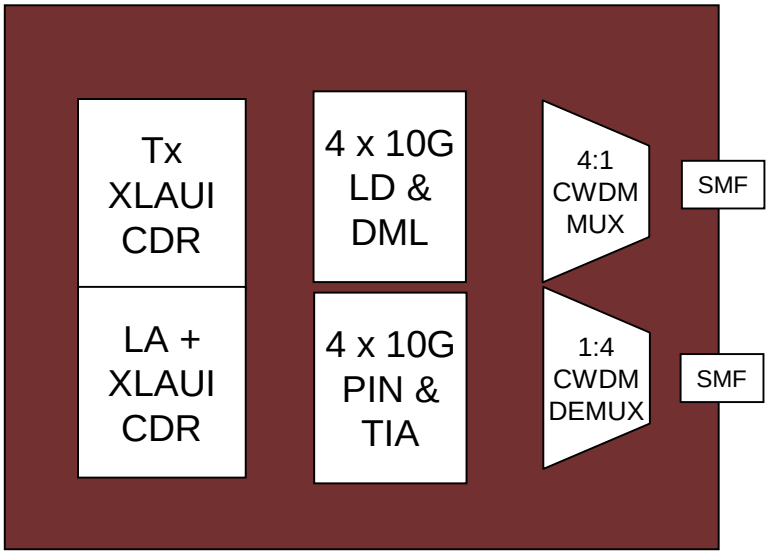
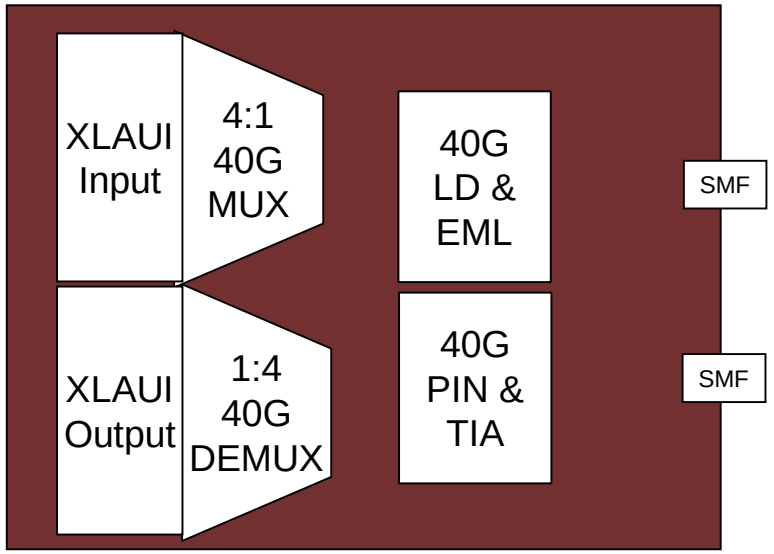
Introduction

- There are two physical layer proposals on how to communicate 10km 40GbE
  - 4 x 10G leveraging CWDM multiplexing
  - 1 x 40G leveraging 40G Serializer / De-serializer
- 4 x 10G Characteristics:
  - Electrical I/O: 4 x 10G
  - Optical I/O: 4 x 10G (4 wavelengths)
  - 1UI = 97ps
- 1 x 40G Characteristics:
  - Electrical I/O: 4 x 10G
  - Optical I/O: 1 x 40G
  - 1UI = 24ps

4 x 10G CWDM



1 x 40G



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Comparing XLAUI CDRs with 40G SERDES

- Jewell_02_0508 with modifications in red

40GbE CWDM vs. Serial Power Comparison

40G 10km CWDM	Y2008 Power (W)	Y2011 Power (W)	40G 10km Serial	Y2008 Power (W)	Y2011 Power (W)
DML TOSA/Mux	0	0	EML TOSA/TEC	1.5	1.0
4X DML Driver	3.0	2.0	EML Driver	0.8	0.6
2 x XLAUI CDR	<2.0	<1.0	40G SERDES	>7	? **
4X PIN/TIA ROSA	1.0	0.7	PIN/TIA	0.4	0.3
Total Power	<6.0	<3.7	-	>9.7	?
Ratio to CWDM	1	1	-	1.6	?

* SiGe

**CMOS.

40G SERDES Power:
SFI-5 40G SERDES – SFI-5 interface power consumption + XLAUI interface power consumption

Analyzing 40GbE Serial Link Budget

- Jewell_02_0508 with modifications in brown

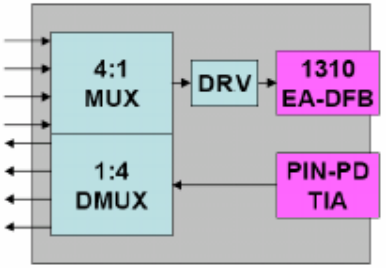
40GbE serial link budget is feasible

Link Power Budget and Penalties

Description	1	2
Operating Distance (m)	10000	10000
Fiber Modal BW (MHz-km)	1000000	1000000
Wavelength Range (nm)	1300-1324	300-1324
Link Power Budget (dB)	8.70	8.70
Channel Insertion Loss (dB)	6.24	6.15
Link Power Penalties (dB)	2.19	2.18
Ptotal central (dB)	6.43	6.33
Unallocated Margin (dB)	0.26	0.37
Pisi (dB)	1.43	1.41

Link Budget 8.7dB

Worst-case margin 0.26dB



Transmit Characteristics

Description		
Signal Speed (Gbaud)	41.2500	41.2500
Wavelength (nm)	1300	1324
Trise / Tfall (20%-80%) (ps)	10.0	10.0
Max RMS Spectral Width (nm)	0.10	0.10
Max Avg Launch Power (dBm)	4.0	4.0
Min Avg Launch Power (dBm)	0.71	0.71
Min Optical Mod. Amp. (mW)	1.736	1.736
OMA ((dBm)	2.40	2.40
Min Extinction Ratio (dB)	8.2	8.2
Max RIN (dB/Hz)	-132	-132
Min Disp Wavelength (nm)	1324	1300

Lower ER can be used w/ higher Avg Pwr

Basics	Input=	Bold	Ts(20-80)	10 ps
	Q=	7.04	Ts(10-90)	15 ps
	Base Rate=	41250 MBd		
Transmitter			RIN at MinER	-134.6 dB/Hz
	Wavelength Uc	1300 nm		
	Uw (see notes)	0.10 nm	Det.Jitter	1.0 ps inc. I
	Tx pwr OMA=	2.395 dBm	DCD_DJ=	1 ps TP3
	Min. Ext Ratio=	8.20 dB		
	"Worst"ave.TxPwr	0.71 dBm	MPN k(OMA)	0
	Ext. ratio penalty	1.32 dBo	Tx eye height	62.7%
			Refl Tx	-12 dB
			ModalNoisePen	0 dB

Receive Characteristics

Description		
Signal Speed (Gbaud)	41.2500	41.2500
Wavelength Range (nm)	1300-1324	300-1324
Rx Bandwidth (MHz)	30,000	30,000
Receive Sensitivity (dBm)	-4.9752	-4.9752
Min Optical Mod. Amp. (mW)	0.2344	0.2344
Min Optical Mod. Amp. (dBm)	-6.30	-6.30

Rx sensitivity (OMA) -6.3dB → PIN

IEEE 802.3ba Task Force - May 13-15, 2008 - Munich, Germany

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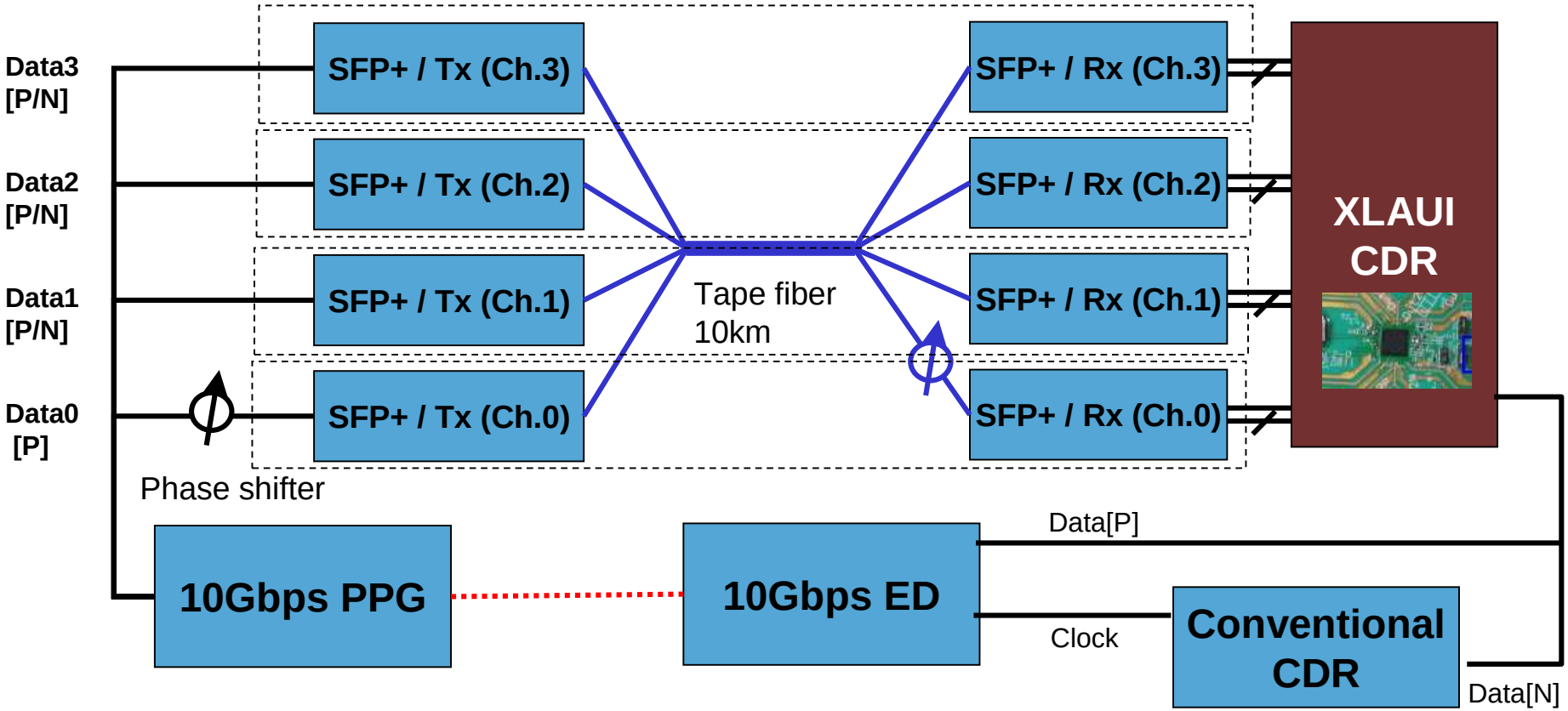
Comparing 40GbE Serial with SONET OC-768

	40GbE Serial Link Budget Feasibility	SONET OC-768
Jitter Generation / Output Jitter	1ps Deterministic Jitter (41mUI)	3.5ps measured in the 16MHz – 320MHz band (140mUI)
Rise / Fall Time (20%, 80%)	10ps	10ps

40GbE Serial Link Budget Feasibility does not represent an opportunity to relax 40G specifications

4 x 10G Link Budget Experimental Setup



- ✓ Output power from the SFP+ Tx is -3.32, -3.88, -3.61, -3.67dBm
- ✓ To generate clock output, conventional CDR was used.

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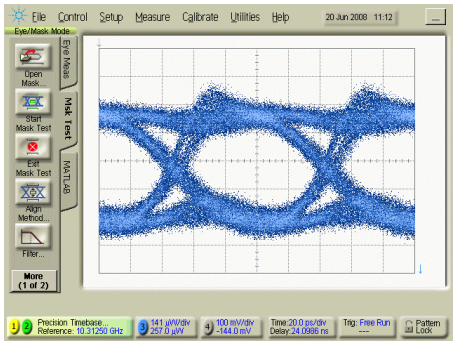
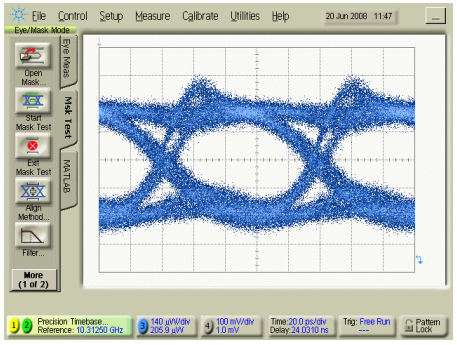
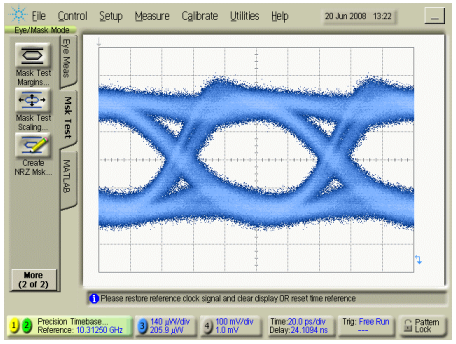
Optical Output Wave Form



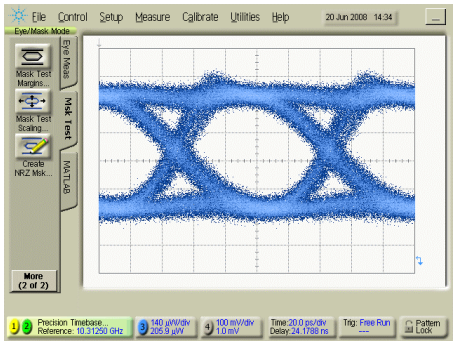
Ch.0



Ch.1



Ch.2



Ch.3

- ✓ 4.5dB Extinction Ratio
- ✓ 1.31um band wavelength. (1315.62nm, 1316.02nm, 1314.84nm, 1314.98nm)

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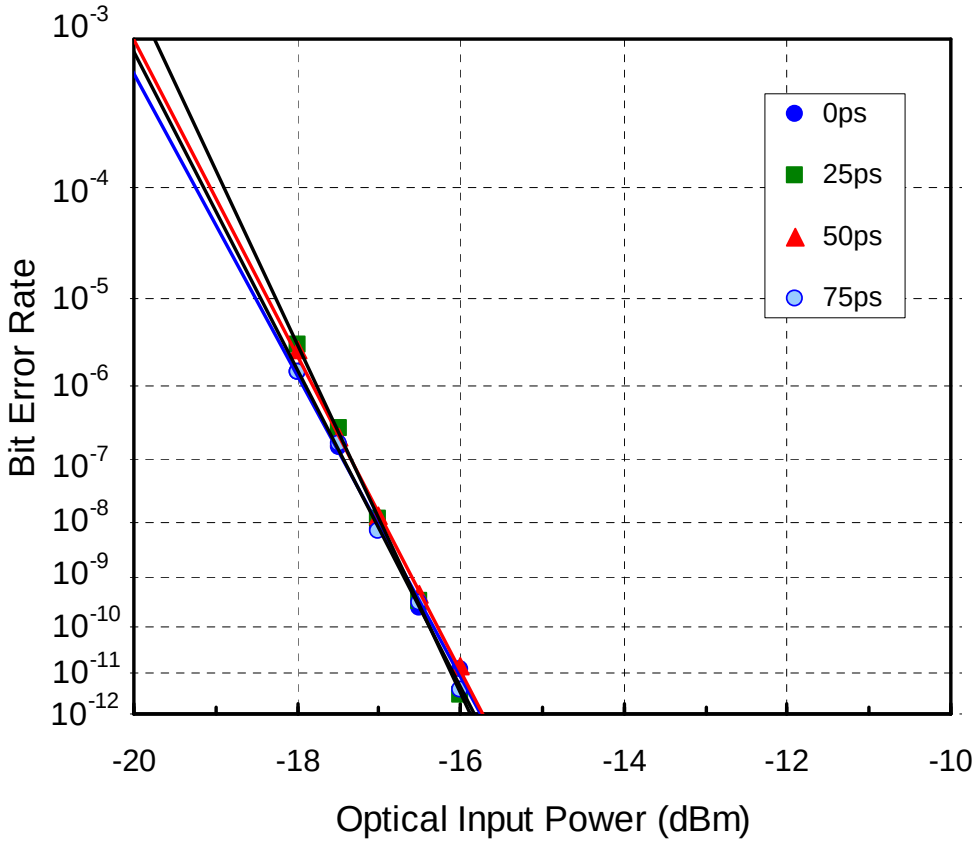
Experimental Results (BER after 10km fiber)

All four channels were operated.



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Recommendation:

- 4 x 10G is the appropriate choice for 802.3ba
  - 10G technology is already well proven
  - Lower cost option for years to come since 10G technology can (has) been amortized across 10GbE
  - Lower power for years to come

4 x 10G CWDM