40GbE Discussion: SMF Technical Feasibility

WE *light* IT UP

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Objectives for IEEE 802.3ba: New 40GbE Items

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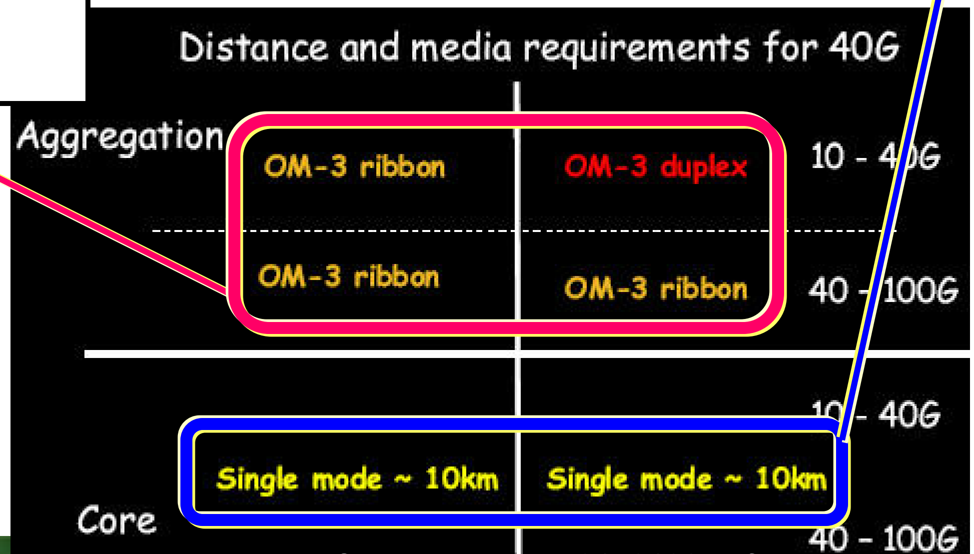
PMD Support	40Gbit/s	100Gbit/s
Backplane (At least 1m)	√	
Copper Cable (At least 10m)	√	√
MMF (At least 100m OM3)	√	√
SMF (At least 10km)		√
SMF (At least 40km)		√

Two Basic Approaches
- Sped up "LX4"
- Serial (single λ)

Two Media ?
- **Ribbon**
- **Duplex Fiber**



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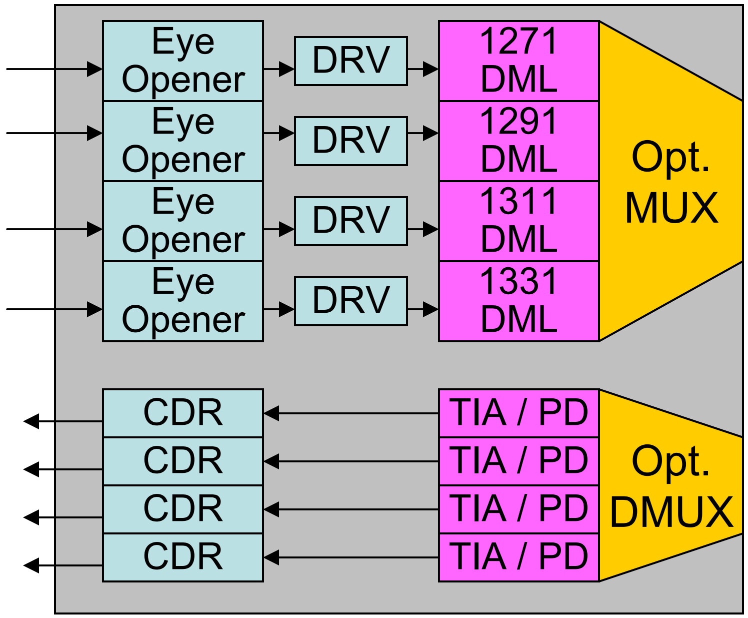
40GbE SMF: “Sped up LX4”



Almost same TX characteristics as 10GBASE-LR

Basics Input=	**Bold**		Ts(20-80)	35	ps
Q=	**7.04**		Ts(10-90)	53	ps
Base Rate=	**10312.5**	MBd	RIN(OMA)	-130	dB/Hz
Transmitter			RIN at MinER	-137.3	dB/Hz
Wavelength Uc	1264.5	nm	RIN_Coef=	**0.70**	
Uw (see notes)	0.20	nm	Det.Jitter	6.0	ps inc.
Tx pwr OMA=	-3.2	dBm	DCD_DJ=	4.2	ps TP3
Min. Ext Ratio=	4.00	dB	Effect. DJ=	0.02	(UI) ex
"Worst"ave.TxPwr	-2.55	dBm	MPN k(OMA)	0	
Ext. ratio penalty	3.66	dBo	Tx eye height	71.3%	
Tx mask X1=	0.3	UI	Refl Tx	-12	dB
X2=	0.4	UI	ModalNoisePen	0	dB
Y1=	0.25		Tx mask top	0.2	UI

Propose **CWDM** λ rather than LX4 λ

Propose using same Rise time as 10GBASE-SR (slightly tougher than LR)

- All block diagram components exist
  - Laser λ’s need to be qualified = simple
  - Lasers & PDs need to be slightly higher spec than 10GBASE-LR (see next slide)
- To meet cost targets integration needed
  - Could combine above “blue” items to single IC
  - Could compact Opt. Mux/DMux & Optics

40GbE SMF: “Sped up LX4” (2)

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Case:1300nm CWDM	SMF		Attenuation=	0.4	dB/km
Target Target reach	10.00	km	*Fiber* at	1310	nm
and L_start=	7.5	km	C_att=	0.27	
graph L_inc=	0.25	km	Attenuation=	0.42	dB/km
Power Budget P=	9.39	dB	at	1264.5	nm
DCD Connections C	2	dB	Disp. min. Uo=	1324	nm
Pwr.Bud.-Conn.Loss	7.39	dB	Disp. So=	0.093	ps/nm'
DCD C1=	480	ns.MHz	Disp. D1=	-5.94	ps/(nm
Reflection Noise factor	0.6	no units			RMS Ba
Effective Rate	10779	MBd	PolMD DGDmax	10	ps at ta
Tb_eff=	93	ps	BWm=	1E+06	MHz*kr
Effective Rec Eye	0.21	UI	Eff. BWm=	3.3E+05	MHz*k

Same as 10GBASE-LR

Same sensitivity as 10GBASE-LR

NomSens OMA	-12.59	dBm	Margin	1.49	dB at
Receiver Refl Rx	-12	dB	*Answer!*		10 km
Rec_BW=	7,725	MHz	est Rx BW	7,500	MHz
c_rx	329	ns.MHz			
T_rx(10-90)	42.6	ps	Test Source ER=		
'2*km TP4 Eye	19	ps	*Test Tx*	6	dB
.km) Opening		(=Tx ey	TestERpen	2.23	dBo
seline wander SD	0.025	fraction of 1/2 eye			
rget 10km			V.E.C.P.	1.21	dBo

More Margin: 1.35dB more !

- Extra margin due to faster rise time, and favorable CWDM grid
  - 10GBASE-LR had 0.15dB margin vs. 1.5dB margin for “sped up” LX4
- However, the LD and PD performance has to be improved versus 10GBASE-LR
  - Loss of optical MUX/DMUX (~5dB) is buried behind TP2 and TP3
- Must balance additional 3.5 dB (5dB loss – 1.5dB margin) between PD & LD

40GbE SMF: Serial

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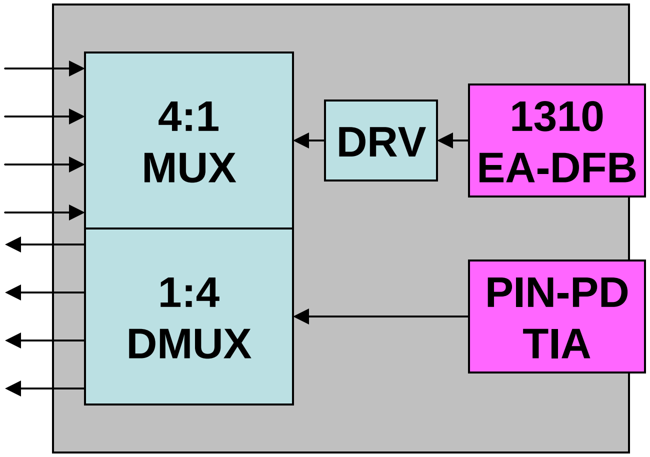

Wavelength	1300 to 1324	nm
SMSR	35	dB
TX OMA	+2.5	dBm
TX Avg.	+0.73	dBm
ER	8.5	dB
RIN	-132	dB/Hz
RX OMA	-6.5	dBm

10km is *challenging* but achievable

0.48dB margin at 10km

Basics Input=	**Bold**		Ts(20-80)	**10**	ps
Q=	**7.04**		Ts(10-90)	15	ps
Base Rate=	**41250**	MBd	RIN(OMA)	**-132**	dB/Hz
Transmitter			RIN at MinER	-134.5	dB/Hz
Wavelength Uc	**1300**	nm	RIN_Coef=	**0.70**	
Uw (see notes)	**0.10**	nm	Det.Jitter	**1.0**	ps inc.
Tx pwr OMA=	**2.50**	dBm	DCD_DJ=	**1**	ps TP3
Min. Ext Ratio=	8.50	dB	Effect. DJ=	0.00	(UI) ex
"Worst"ave.TxPwr	**0.73**	dBm	MPN k(OMA)	**0**	
Ext. ratio penalty	1.24	dBo	Tx eye height	62.7%	
Tx mask X1=	**0.3**	UI	Refl Tx	**-12**	dB
X2=	**0.4**	UI	ModalNoisePen	**0**	dB
Y1=	**0.25**		Tx mask top	0.2	UI

PolMD DGDmax = 7.3ps per ITU recommendation for 0.3UI for DGD

40GbE SMF: Serial (2)

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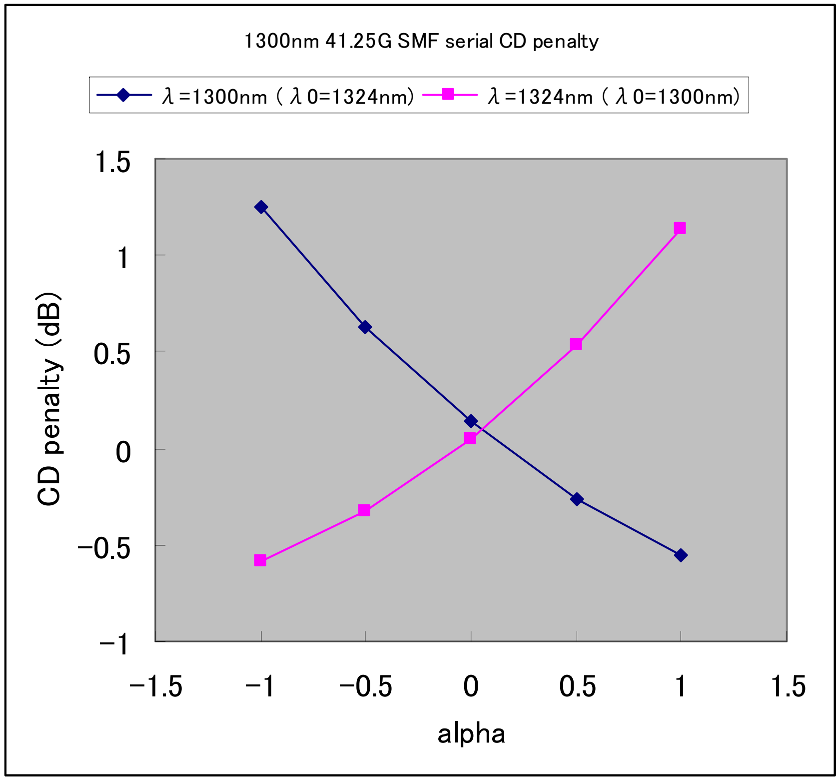


Bit rate: 41.25Gbps
Tr/Tf(20-80%): 10ps
Alpha: -1~1(const.)

λ = 1300nm (λ0=1324nm)

λ = 1324nm (λ0=1300nm)

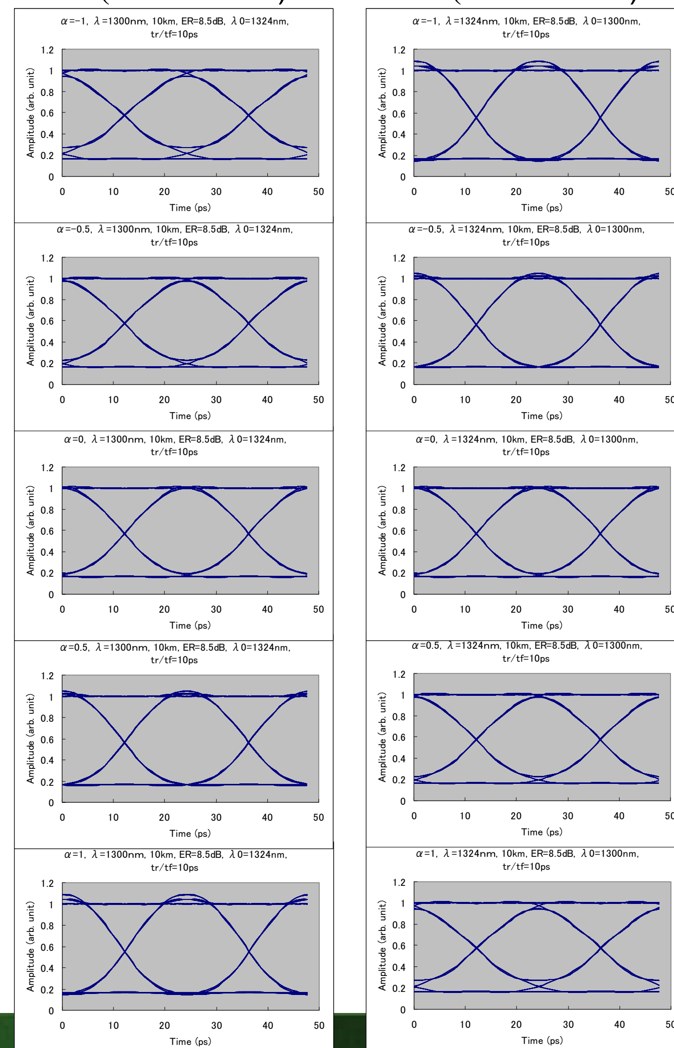
α = -1

α = -0.5

α = 0

α = 0.5

α = 1



40GbE SMF: Approach Comparison

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	"Sped Up LX4"	Serial
Laser	**10G uncooled exists** need other lambdas	**not yet** similar to 25G laser for 100G easier than 40G 1550nm used today
Driver IC	**exists** integrated CMOS needed for low cost	**exists** lower cost packaging needed
Photodiode	**exists** better performance required	**exists** easier than 40G 1550nm used today
TIA	**exists** better isolation required for integrated version	**exists** easier than 40G 1550nm used today
Optical MUX / DMUX	**Modify LX4 type** repackage for form factor?	**N/A**
Electrical Interface	**exists** integrated CMOS needed for low cost	**SiGe exists** 40Gbit/s CMOS needed for small size & low cost

- Serial should be the lowest cost in the mid to long term
- Faster LX4 approach is lowest cost in 2009ish timeframe
  - Likely always higher cost than 4 10GBASE-LR SFP+
  - To quote Chris Cole – single laser chip & photodiode have always proven to be lower cost
- QSFP size more feasible for serial, but still challenging

BACKUP: Other Spreadsheet Inputs for 40G Serial

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PolMD DGDmax = 7.3ps per ITU recommendation for 0.3UI for DGD

Case: 1310nm serial	**SMF**		Attenuation=	0.4	dB/km
Target Target reach	**10.00**	km	*Fiber* at	1310	nm
and L_start=	**7.5**	km	C_att=	0.27	
graph L_inc=	**0.25**	km	Attenuation=	0.40	dB/km
Power Budget P=	9.00	dB	at	1300	nm
DCD Connections C	**2**	dB	Disp. min. Uo=	**1324**	nm
; Pwr.Bud.-Conn.Loss	7	dB	Disp. So=	**0.093**	ps/nm^
: DCD C1=	**480**	ns.MHz	Disp. D1=	-2.29	ps/(nm
Reflection Noise factor	**0.6**	no units			RMS Ba
Effective Rate	43025	MBd	PolMD DGDmax	**7.3**	ps at ta
Tb_eff=	23	ps	BWm=	**1E+06**	MHz*kr
Effective Rec Eye	0.21	UI	Eff. BWm=	4.6E+05	MHz*k

NomSens OMA	**-6.50**	dBm	Margin	0.48 dB at	
Receiver Refl Rx	**-26**	dB	*Answer!*	10 km	
Rec_BW=	**30,900**	MHz	est Rx BW	**30000**	MHz
c_rx	**329**	ns.MHz			
T_rx(10-90)	10.6	ps	Test Source ER=		
\2*km TP4 Eye	5	ps	*Test Tx*	**6**	dB
.km) Opening		(=Tx ey	TestERpen	2.23	dBo
seline wander SD	**0.025**	fraction of 1/2 eye			
rget 10km			V.E.C.P.	1.95	dBo
n P_BLW(no ISI)	0.07	dB		Stressed	
m P_BLW	0.07	dB		Rx sens	

- Using spreadsheet “10GEPBud3_1_16a.xls” as the basis
- The spreadsheet model is not complete but it does offer some rough estimate
  - Spreadsheet lacks robust treatment of dispersion
  - Opnext ran simulation of CD Penalty to partially address this (slide 6)
  - PMD needs to be studied further