Nx10G I/O Specification Proposal

IEEE 802.3 Higher Speed Study Group

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Outline

- Background on considerations for N x 10G electrical interface
- Methodology
- Strawman 100m OM3 link specifications
- Resulting electrical interface / jitter budget specifications
- Questions for further study

Background

- **Presented in aronson_01_0707**
- **Current 10G I/O Electrical Specifications for N x 10G applications**
  - XFI would increase power and cost of N x 10G MMF (and Cu) PMDs
  - SFI would increase power and cost of N x 10G Host
  - Neither XFI nor SFI take advantage of 100m reduced MMF reach
  - Neither XFI nor SFI lead to the lowest overall system cost
- **Proposed N x 10G I/O Electrical Specification**
  - Optimizes power and cost of 40GE and 100GE MMF systems
  - Define a limiting, non-retimed PMD interface derived from SFI specifications
  - Retain return loss specs of SFI
  - Take advantage of reduced loss and jitter penalties of 100m (vs. -SR) MMF
    - Allocate budget to allow high yield, low cost of 100m MMF PMD
    - Allocate remaining budget to electrical link at TP1 and TP4 points
    - Provide jitter margin to overcome additional parallel channel impairments

Considerations for Electrical Interface Details

- **Driven by Minimum Host jitter requirements**
- **In Ghiasi_01_0707, key jitter limits were proposed based on derating the SFI specification with extra penalties for 4x and 10x parallel interfaces:**

Degradation	4x Jitter (UI)	10x (UI)
SFI B	0.1	0.1
SerDes Penalty	0.03	0.05
PCB Routing	0.02	0.03
Total DDJ B	0.15	0.18

Degradation	4x Jitter (UI)	10x (UI)
SFI C'	0.7	0.7
SerDes Penalty	-0.04	-0.07
PCB Routing	-0.02	-0.03
TJ at C'	0.64	0.6

- **Ideally, have a single specification for 4x and 10x, thus:**
  - TP1 (B' in SFP+) of DDJ <= 0.18 UI, TJ <= 0.36 UI [present SFI + 0.08UI]
  - TP4 (C in SFP+) of DDJ <= ? UI, TJ <= 0.60 UI
- **Splitting the 4x and 10x targets appears achievable**

Considerations for 100m OM3 optical interface

- **100m OM3 objective allows major changes relative to 10GBASE-SR**
  - Chromatic dispersion penalties are negligible
    - Dispense with spectral bandwidth triple tradeoff
  - Modal bandwidth penalties small
    - Stressed receiver test, if retained, would be primarily a jitter tolerance test
  - Dispense with Transmitter Dispersion Penalty spec?
- **Examine practicality of Class 1 eye safety**
  - Recent major IEC / CDRH relaxation of Class 1 test
  - Parallel interface extended source considerations
  - Retain a manufacturable transmit power window
    - Difference between chosen eye safety limit/RX overload and Min TX OMA
- **Consider retaining some loss penalty to reduce RX jitter**
  - Loss budget may be adequate to increase min RX OMA (rel to –SR)
  - Retaining 10GBASE-SR unstressed sensitivity (or better) reduces RJ
  - May allow closure of tight host TJ budget per Ghiasi.

Strawman OM3 Transmitter Characteristics

Transmit Characteristics			
Description	**10GBASE-SR**	**Proposed 40/100G**	**Unit**
Signaling Speed	10.3125	10.3125	GBd
Signaling Speed Variation	±100	±100	ppm
Center Wavelength	840 to 860	840 to 860	nm
RMS spectral width	Triple Tradeoff	**0.6**	nm
Average launch power max	Class 1 eye safe	**0 / Class 1 (NOTE 1)**	
Average launch power min	-7.3	**-7.5**	
Launch power min OMA	Triple Tradeoff	**-4.5**	dbm
Average launch power off	-30	-30	dBm
Extinction ratio (min)	3	3	dbm
RIN12OMA	-128	**-130**	dB/Hz
Opt. Return Loss Tolerance (max)	12	12	dB
Encircled flux	footnote f	same as -SR	
Transmitter eye mask	{0.25,0.40, 0.45,0.25, 0.28.0.40}	{0.25,0.40, 0.45,0.25, 0.28.0.40}	
Transmitter and dispersion penalty	3.9	**tbd**	dB
NOTE 1: Evaluate new limits from IEC for Class 1 / Class 1M for 4 and 12 channel Parallel TX			

Strawman OM3 Receiver Characteristics

Receive Characteristics			
Description	**10GBASE-SR**	**Proposed 40/100G**	**Unit**
Signaling Speed	10.3125	10.3125	GBd
Signaling Speed Variation	±100	±100	ppm
Center Wavelength	840 to 860	840 to 860	nm
Average receive power max	-1	**0**	nm
Average receive power min	-9.9	**-9.4**	dBm
Receiver sensitivity (max) in OMA	0.077 (-11.1)	**0.056 (-12.5)**	mW (dBm)
Receiver reflectance (max)	-12	-12	dB
Stressed RX Sensitivity in OMA	0.18 (-7.5)	**0.087 (-10.6)**	mW (dBm)
VECP	3.5	**2.0**	dB
Stressed eye jitter	0.3	**0.3?**	UI pk-pk
RX elec. 3 dB upper cutoff (max)	12.3	12.3	GHz
NOTE: May be worth changing definition of stressed RX test			

- **Other considerations:**
  - May be worth changing definition of stressed RX test
    - Vertical eye closure now small, DJ stress large.
  - Required sensitivity driven by reducing RJ contribution of RX

Link Budget Comparison

Link Budget				
Parameter	**Unit**	**10GBASE-SR**	**Proposed 40/100G**	**Difference**
Operating Distance	m	2 - 300	2 - 100	
Connector Loss	dB	1.50	1.50	0.00
Attenuation	dB	1.09	0.36	**0.73**
Intersymbol Interference	dB	3.02	1.65	**1.37**
RIN, MPN, Modal Noise, Cross	dB	0.90	0.70	0.20
Total Penalties	**dB**	**6.51**	**4.21**	**2.30**
Link Power Budget	dB	7.30	8.00	-0.70
Unallocated link margin	dB	0.79	3.79	-3.00

- **Calculated using 10GbE Spreadsheet (Rev 3.1.16a)**
  - Cell G7: TP2 DJ input = 26.2 ps (0.16UI from host, 0.11 from PMD TX)
  - Cell G8: TP3 DCD / PWS = 17.5 ps (50% of host DJ, 0.10 from PMD TX)
    - Same relative assumptions as 8GFC
  - All other parameters from original spreadsheet or as in strawman specs
  - Link power budget / unallocated power margin driven by RJ considerations only

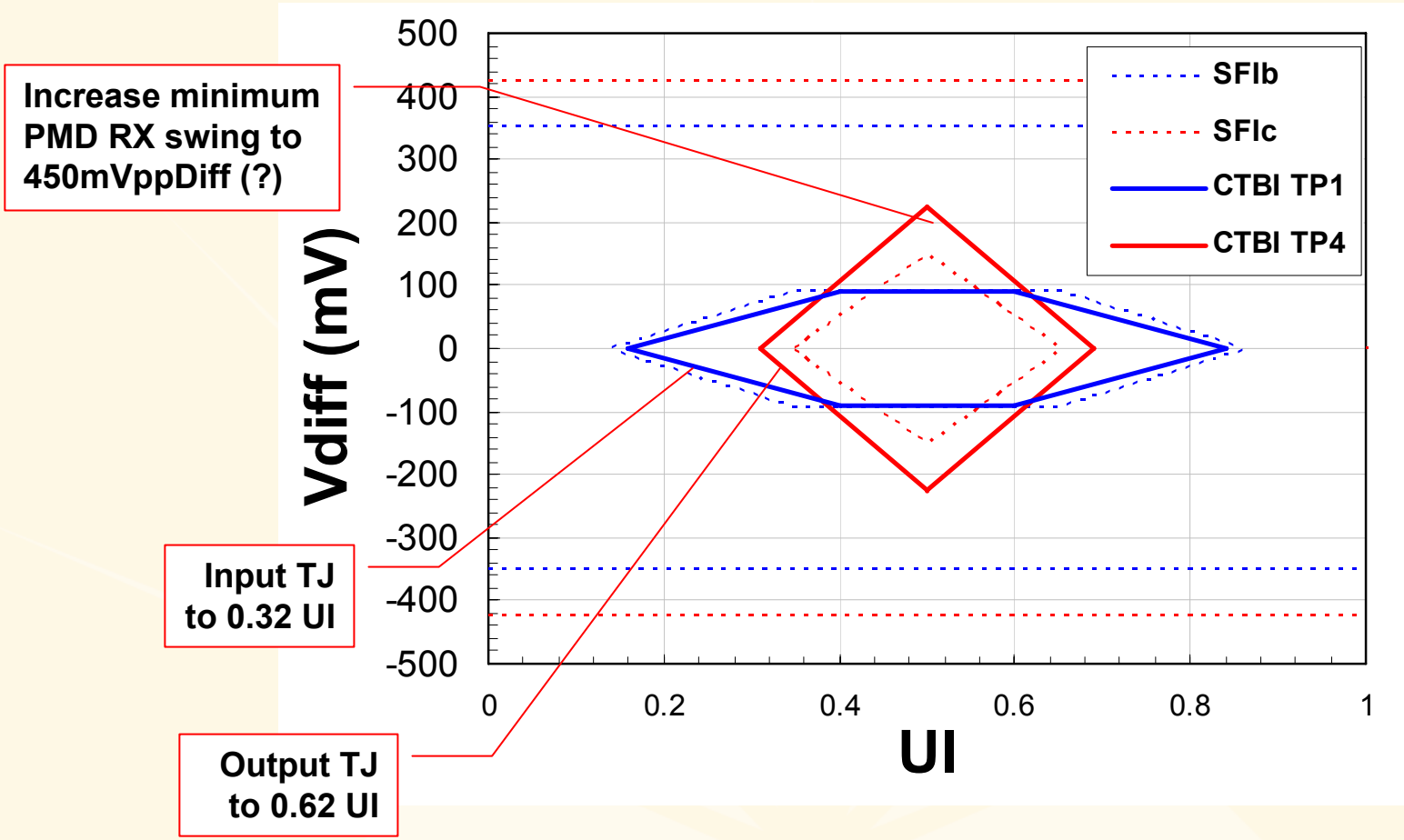
Jitter Budget Analysis

Jitter Assumptions / Calculations					
	Parameter	**Unit**	**SFI**	**Proposed 40/100G**	**Notes**
TP1	DCD / PWS	UI		0.08	1
	DDJ	UI	0.10	**0.16**	2
	TJ	UI	0.28	0.32	3
TP2	DCD / PWS	UI		0.18	4
	DDJ	UI		0.27	5
	TJ	UI		0.47	6
TP3	DCD / PWS	UI		tbd	
	DDJ	UI		tbd	
	TJ	UI		tbd	
TP4	DCD / PWS	UI	N/A	N/A	
	DDJ	UI	0.42	0.35	7
	TJ	UI	0.70	**0.62**	8

Notes	
1	Assumption that half of TP2 DDJ is DCD/PWS from 8 GFC budget
2	Midpoint of Ghiasi 4x and 10x Host requirements
3	Adding 0.157 UI RJ from 1 ps rms crystal jitter, 40 dB S/N
4	Assumption of 0.1 UI worst case PMD transmitter PWS jitter contribution (from 8GFC)
5	Assumption of 0.11 UI worst case PMD transmitter DDJ contribution (from 8GFC)
6	Adding in RIN contribution at TX rise/fall
7	RX DJ contribution <= 0.08 [ISI contribution negligible]
8	Receiver sensitivity -> noise contribution, combined with RX bandwidth r/f for TJ

Strawman electrical interface specifications

- **Return Loss**
  - Same as in SFI (SFF-8431)



Summary

- **Proposed strawman OM3 link characteristics**
- **Increases host jitter margins to allow for multiple channels**
  - TP1 DDJ = 0.16 UI [vs Ghiasi 0.15 @ 4chan, 0.18 @ 10chan]
  - TP4 TJ = 0.62 UI [vs Ghiasi 0.64 @ 4chan, 0.60 @ 10chan]
- **Results support consistent limiting, non-retimed electrical interface**
- **Other tradeoffs may be better**
  - Large power budget, reduced RIN included to reduce RJ from receiver
  - Reduced host RJ generation or improved TJ tolerance would dramatically improve power budget
    - Would allow much less aggressive sensitivity and/or lower min TX OMA
- **Analysis of New Class 1 eye safety limits for arrays needed**

Nx10G I/O Specification Proposal Background Slides

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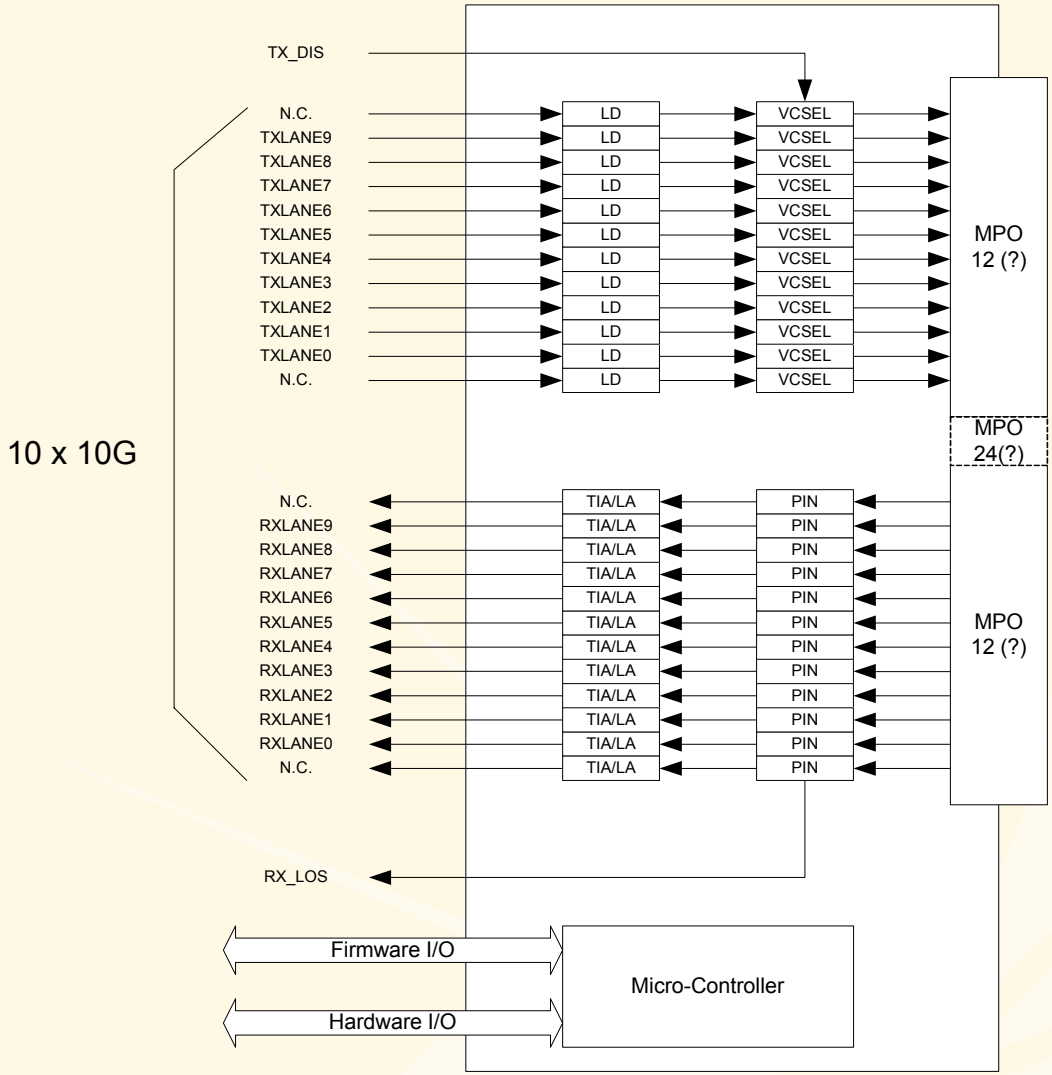
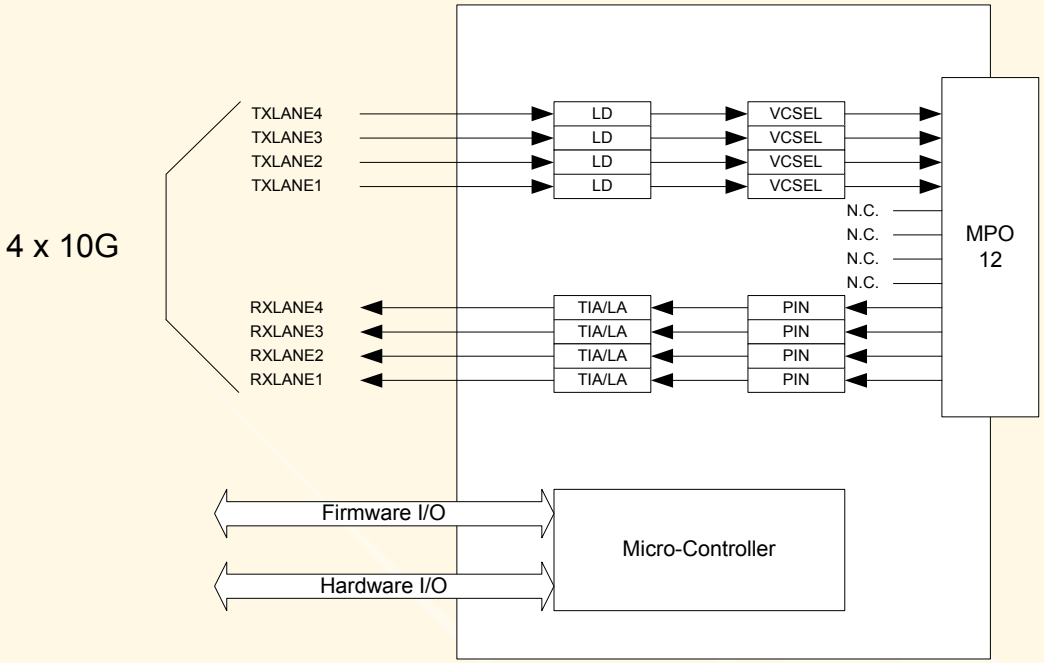
MMF 10x10G 850nm Transceiver Architecture



- Lowest cost, lowest power MMF Transceiver does not retime the interface, (no CDRs.)
- Two 12-fiber MPO cables vs. one 24-fiber MPO cable is an open question.
- Requirement for MMF functionality in the same large form factor as SMF Transceiver is an open question. (A small form factor only for MMF Transceivers is possible.)
- Aligning 100GE MMF parallel PMD solution with 12x10G Infiniband may be beneficial.

MMF 4x10G 850nm Transceiver Architecture



- Lowest cost, lowest power MMF Transceiver does not retime the interface, (no CDRs.)
- QSFP is a candidate 4x10G MMF form factor
- A common 10G electrical I/O and optical specification between 40GE and 100GE is an open question. (Full set of 10x10G interface requirements may differ from full set of 4x10G interface requirements.)
- Aligning 40GE MMF parallel PMD solution with 4x10G Infiniband may be beneficial.

Current 10G I/O Electrical Specification Observations

- **XFI (XFP I/O)**
  - Designed for retimed PMDs (w/ CDR)
  - 30cm Host trace targets (no equalization)
  - 3 dB margin for crosstalk and reflection
  - Easy Host design.
  - Straightforward Module design
- **SFI (SFP+ I/O)**
  - Designed for existing non-retimed PMDs (w/o CDR)
    - 10GBASE-SR (300m OM3)
    - 10GBASE-LRM (220m OM1, OM2)
    - 10GBASE-LR
  - 30cm Host trace targets (w/ equalization)
  - Equalizer must also support the entire 10GBASE-LRM fiber link
  - Difficult Host and Module design
    - Jitter budget tight with open issues
    - Measurements challenging with open issues.