Proposal for Extended-Reach MMF Link Characteristics

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Motives

- Compare required transmit characteristics for 100m links on OM3 fiber and for 250m links on OM4 fiber at 10Gb/s/ch
- Based on the differences in characteristics, estimate the cost differences
- Propose a MMF reach of 250m on improved-modal-bandwidth (e.g. OM4) fiber

3_1_16a spreadsheet values

- Dispersion: Disp. So=0.10275, sp. min. Uo = 1316nm
- Always have (straight from 3_1_16a):
  - Wavelength Uc = 840nm
  - RIN (OMA) = -128dB/Hz and -130dB/Hz (3_1_16a uses -130dB/Hz)
  - MPN k (OMA) = 0.3; ModalNoisePen = 0.3dB
  - Baseline wander SD = 0.025 fraction of ½ eye
  - Rec_BW = 8,250MHz; Test Rx BW = 7500MHz
  - Nominal Rx Sensitivity (OMA) = 11.1dBm
  - Power Budget P = 8.3dB
  - Connections C = 1.5dB
  - Effective Modal Bandwidth Eff. BWm 2000 (4400)MHz-km OM3(OM4)
  - DCD_DJ = 20.535ps; Det. Jitter = 29.751ps
- Variable: (RMS Spectral Width) Uw = 0.65nm or 0.45nm
- Variable: (Rise/fall) Ts(20-80)
- Arbitrary: Pisi ≤ 3.0dB

Red indicates parameters changed from 802.3ba Jewell_01_0308

Assigning jitter values to 3_1_16a

Start with 8GFC jitter

- **Take 8.5G Fibre-Channel's 3_1_16a jitter values**
  - **DCD_DJ = 28.235ps**
  - **Det. Jitter = 37.9ps**

TP1 DJ, UI	0.170
TP1 TJ, UI	0.310
TP4 DJ UI	0.420
TP4 TJ, UI	0.710

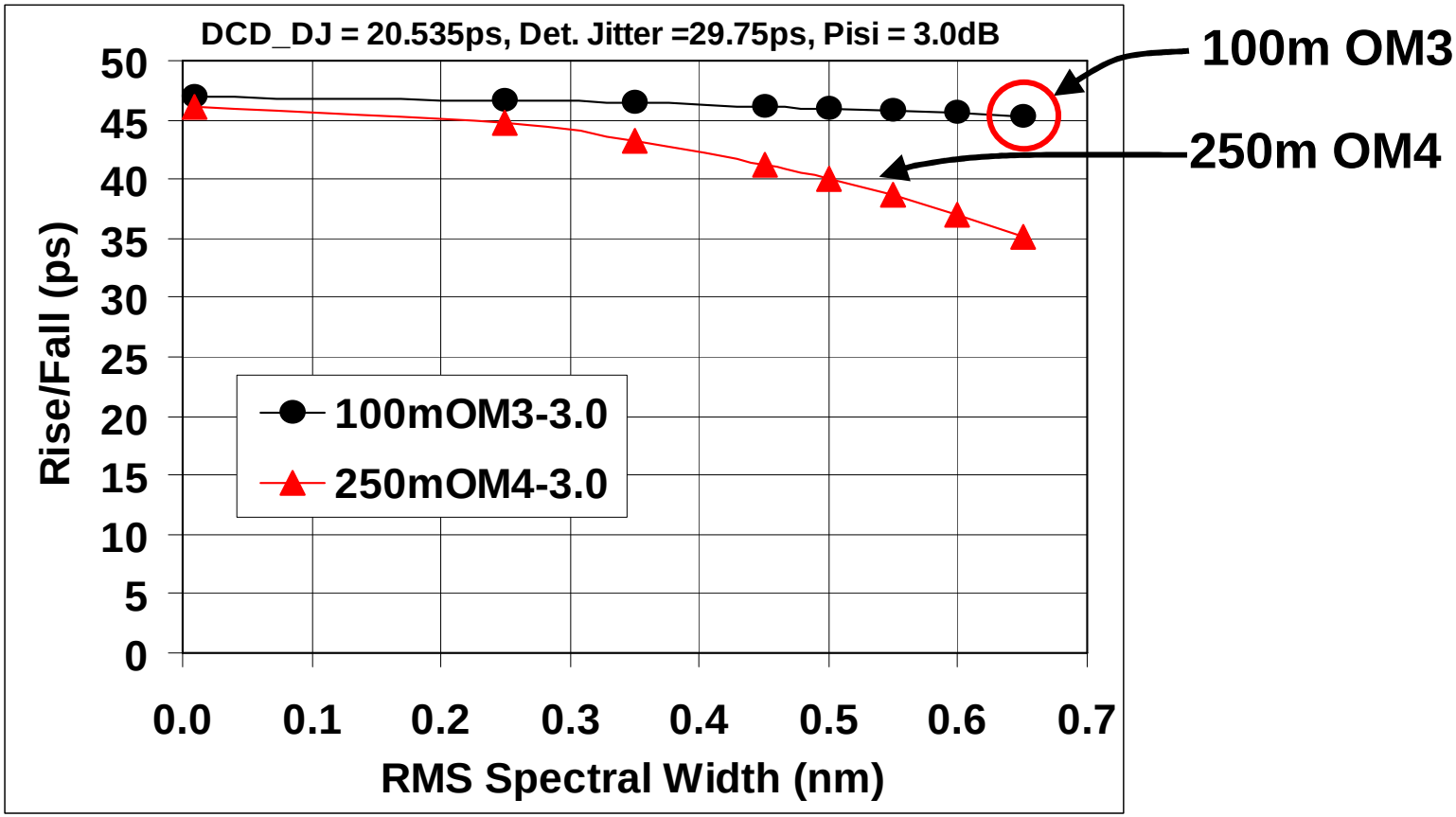
- **1) Scale the F-C jitter by (8.5/10.3125)**
  - **DCD_DJ = 28.235 x (8.5/10.3125) = 23.272ps**
  - **Det. Jitter = 37.9 x (8.5/10.3125) = 31.239ps**
- **2) Scale using jitter budget values from Petrilla**

	8GFC	40/100G Targets
TP1 DJ, UI	0.170	0.150
TP4 DJ, UI	0.420	0.400

  - **DCD_DJ = 28.235 x (8.5/10.3125) x (0.150/0.170) = 20.535ps**
  - **Det. Jitter = 37.9 x (8.5/10.3125) x (0.400/0.420) = 29.751ps**

Reach extension via Tx characteristics

- Vary spectral width and rise/fall time to get Pisi=3.0 (keep Margin >0)
- Nearly all points have RIN OMA = -128dB/Hz; 250m reach w/ 0.60nm and 0.65nm have RIN OMA = -130dB/Hz



Extended-reach Tx characteristics comparison

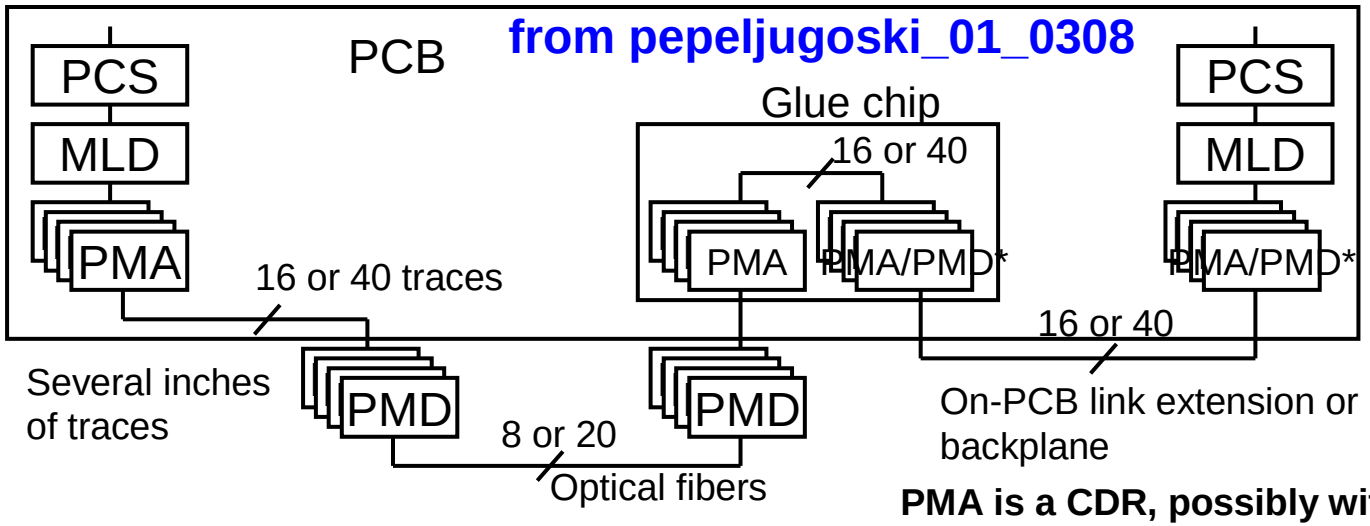
RMS spectral width →	0.35	0.45	0.50	0.55	0.60	0.65	nm
100m OM3 - rise/fall	45.3	45.3	45.3	45.3	45.3	45.3	ps
150/250m OM3/4 - rise/fall	43.2	41.2	40.0	38.6	37.0*	35.2*	ps
Difference	2.1	4.1	5.3	6.7	8.3*	10.1*	ps

* RIN OMA for these conditions are -130dB/Hz; all others are -128dB/Hz

- **The links which reach 250m on OM4, also reach 150m on OM3**
- **The extended reach may be achieved by:**
  - **reducing the rise/fall time by 4.1ps, and**
  - **reducing spectral width from 0.65nm to 0.45nm**
- **Tradeoff between spectral width and rise/fall time allows spectral widths up to 0.65nm**
- **Extended reach via tightened Tx spec is feasible**

Estimated cost increase at the module level: 20%

Reach extension via “glue chip”

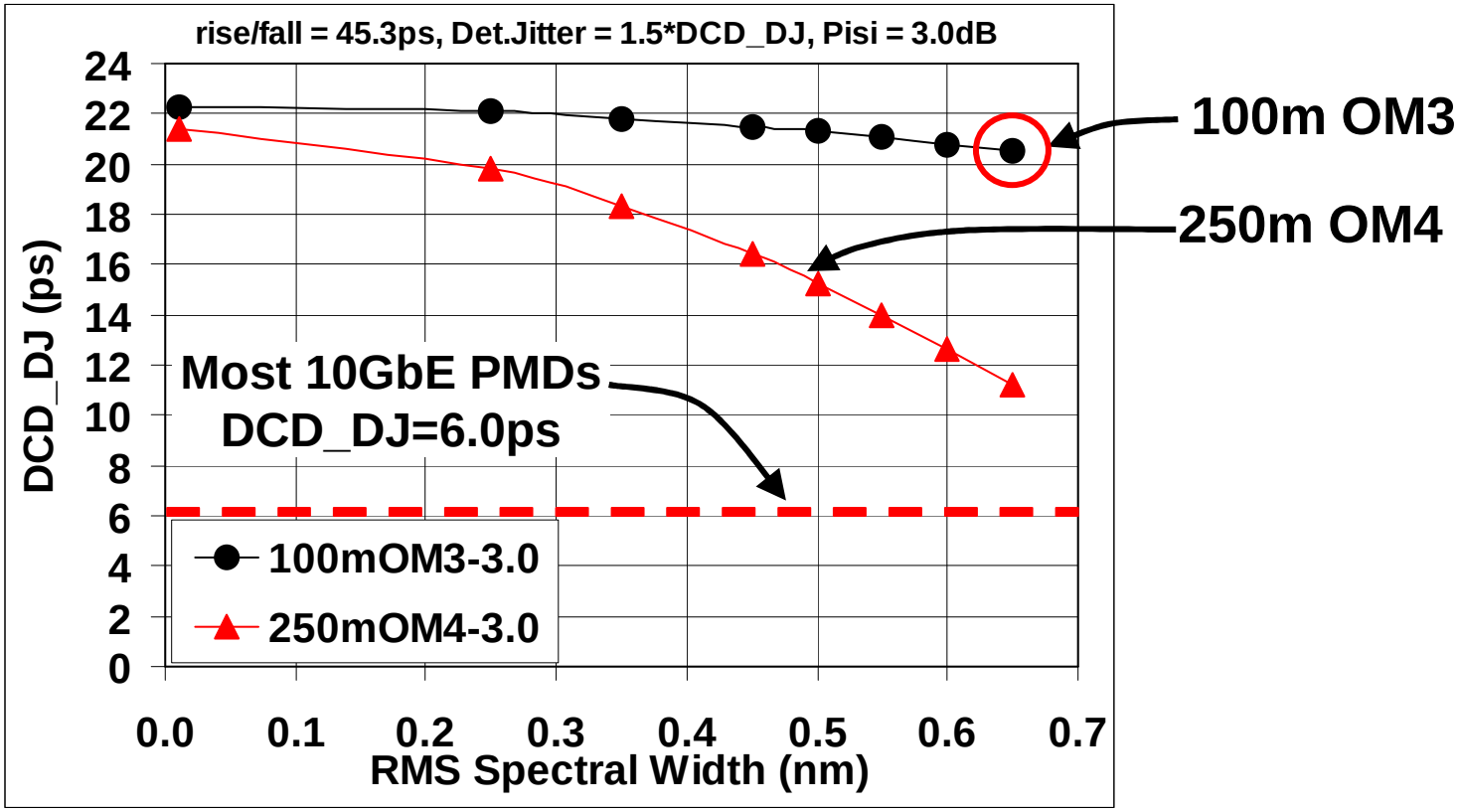


PMA is a CDR, possibly with simple EDC
***10GBASE_KR PMA/PMD is different**

- **CDR on the host PCB reduces jitter, allowing increased reach with the same Tx/Rx characteristics**
- **EDC reduces the effects of modal-bandwidth/distance degradation, as well as limited rise/fall time and reduces effects of noise, due to a more-open eye**
- **FEC allows operation at higher BER**

Reach extension via CDR

- Keep 100m-on-OM3 characteristics; rise/fall=45.3ps
- Vary spectral width and DCD_DJ to get Pisi=3.0 (keep Margin >0)
- All points have RIN OMA = -128dB/Hz



Transmit characteristics (each lane)

Description	100(40)GBASE-SR10(4)	Unit
Signaling speed (nominal)	10.3125	GBd
Signaling speed variation from nominal (max)	±100	ppm
Center wavelength (range)	840 - 860	nm
RMS spectral width (max)	0.65	nm
Average launch power (max) *(1)*	1	dBm
Launch power *(1), (2)* (min) in OMA	-3	dBm
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	3	dB
$RIN_{12}OMA$ *(1), (2) , (5)* (max)	(-128) – (-132)	dB/Hz
Optical return loss tolerance (max)	12	dB
Encircled flux *(1)*	>86% @ 19µm, <30% @ 4.5 µm	
Transmitter eye mask definition *(5)*	TBD	
Aggregate Tx Penalty *(3), (5)* (max)	TBD	dB
TP1 jitter allocation *(4), (5)*	0.3	UI

(1) Subject to further study
(2) To be made informative if aggregate Tx penalty includes the effect
(3) Aggregate Tx penalty may be TDP, TWDP, and may combine other Tx parameters
(4) For further study, intermediate between 10G SFP+ and 8GFC
(5) May be modified by the presence of CDR, FEC, or EDC on the host board

Receive characteristics (each lane)

Description	100(40)GBASE-SR10(4)	Unit
Signaling speed (nominal)	10.3125	GBd
Signaling speed variation from nominal (max)	±100	ppm
Center wavelength (range)	840 - 860	nm
Average receiver power (1) (max)	1	dBm
Average receive power (2), (3) (min)	-7.9	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity in OMA (5) (max)	TBD	dBm
- Vertical eye closure penalty (5) (target)	TBD	dB
- Stressed eye jitter (5) (target)	TBD	UI pk-pk
TP4 jitter allocation (4), (5)	0.7	UI

(1) The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having a power level equal to the Average Receive Power (max) plus at least 1dB.

(2) Informative

(3) For further study; depends on connector loss

(4) For further study; intermediate between 10G SFP+ and 8GFC

(5) May be modified by the presence of CDR, FEC, or EDC on the host board

Link power budget

Parameter	OM3	OM4 (1)	Unit
Modal bandwidth as measured at 850nm (2)	2000	4700	MHz-km
Power budget (3)	8.3	8.3	dB
Operating distance	150	250	m
Channel insertion loss (4)	2.1	2.4	dB

(1) At this time the modal bandwidth OM4 is not standardized.
(2) Depends on launch conditions; simulations used a derated value of 4400 MHz-km at 840nm.
(3) For further study
(4) Connector loss under study

Summary

- Modest tightening of Tx specs over “nominal” (100m over OM3) specs result in reaches of 250m on OM4 (4400 MHz-km) and >150m over OM3 fibers for 100(40)GBASE-SR10(4)
- Modules achieving extended reach via tightened Tx specs occupy no added space, consume no added power, and are interoperable with “nominally spec’d” modules
- Modules achieving extended reach via tightened Tx specs have an estimated cost premium of 20%
- Addition of CDR, EDC or FEC on the host board offers an alternative approach to achieve similar extended reach with the “nominal” (100m) Tx and Rx characteristics, or yet further reaches in combination with the tightened Tx specs.