Extended-Reach MMF Via TxSpec/OM4

Jack Jewell - JDSU

IEEE 802.3ba Extended-Reach MMF Ad Hoc
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Goals

- Achieve 150m on OM3 and 250m on OM4 with minimal changes to specifications
- Maintain interoperability with "standard-reach" modules for ≤100m reach
  - No changes to Rx characteristics
  - Change only Tx "Aggregate TP2 signal metrics" and/or "RMS spectral width"

3_1_16a values (from jewell_01_0508)

- 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

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

8GFC	
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) = <u>23.272ps</u>
  - Det. Jitter = 37.9 x (8.5/10.3125) = <u>31.239ps</u>
- 2) Scale using jitter budget values from Petrilla

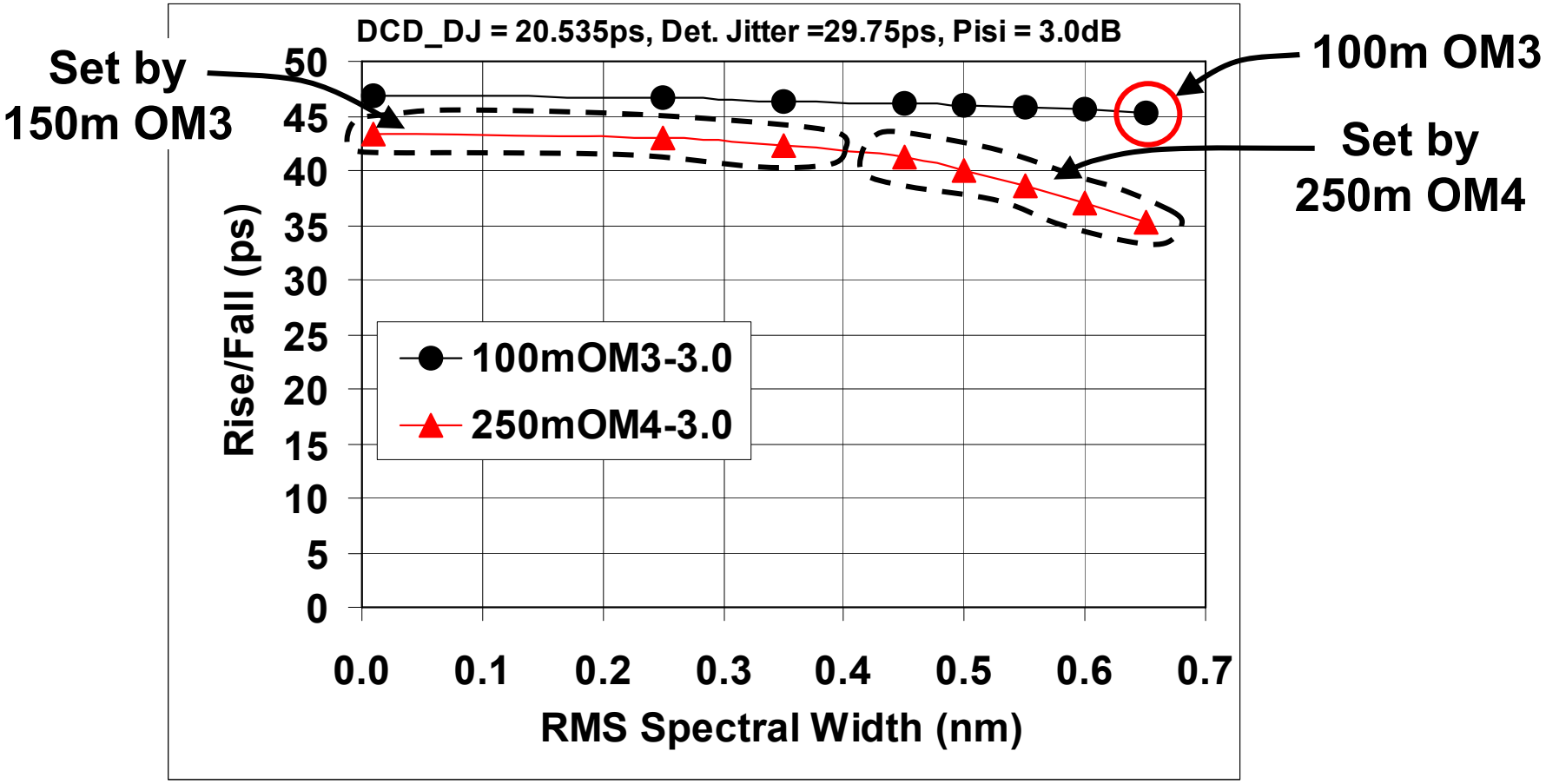
Petrilla_01_0508	
TP1 DJ, UI	0.150
TP1 TJ, UI	0.300
TP4 DJ UI	0.400
TP4 TJ, UI	0.700

	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) = <u>20.535ps</u>
  - Det. Jitter = 37.9 x (8.5/10.3125) x (0.400/0.420) = <u>29.751ps</u>

Extended-reach Tx characteristics

- Vary spectral width and rise/fall time to get Pisi=3.0 (keep Margin >0) for both 250m over OM4 and 150m over OM3; take minimum rise/fall
- 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 →	0.01	0.25	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	45.3	45.3	ps
150/250m OM3/4 - rise/fall	43.4	42.9	42.3	41.2	40.0	38.6	37.0*	35.2*	ps
Difference	1.9	2.4	3.0	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 conditions reach 250m on OM4 and 150m on OM3**
- **The extended reach may be achieved by (for example):**
  - **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**
- **Actual spec will be 'Aggregate TP2 signal metrics," not rise/fall**

Estimated cost increase at the module level: 20%

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 (1) (max)	0.65	nm
Average launch power (max) (2), (3)	1	dBm
Launch power (2), (4), (5) (min) in OMA	-3	dBm
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	3	dB
$RIN_{12}OMA$ (2), (4), (5) (max)	(-128) – (-132)	dB/Hz
Optical return loss tolerance (max)	12	dB
Encircled flux (2)	>86% @ 19μm, <30% @ 4.5 μm	
Transmitter eye mask definition	TBD	
Aggregate TP2 signal metrics (5), (6) (max)	TBD	dB
TP1 jitter allocation (7)	0.3	UI

(1) Tradeoff with aggregate TP2 signal metrics
(2) For further study
(3) See presentation on eye safety petrilla_02_0308
(4) To be made informative if aggregate TP2 signal metrics includes the effect
(5) Value may differ from “standard-reach” value
(6) For further study, e.g. TDP, TWDP
(7) For further study, intermediate between 10G SFP+ and 8GFC

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 power at receiver input (1), (2) (min)	-7.9	dBm
Receiver reflectance (max)	-12	dB
Stressed receiver sensitivity in OMA (max)	TBD	dBm
- Vertical eye closure penalty (target)	TBD	dB
- Stressed eye jitter (target)	TBD	UI pk-pk
TP4 jitter allocation (3)	0.7	UI

(1) For further study
(2) For further study; depends on connector loss
(3) For further study; intermediate between 10G SFP+ and 8GFC

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, 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 “standard-reach” (100m over OM3) specs results 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 “standard-reach” modules
- Modules achieving extended reach via tightened Tx specs have an estimated cost premium of 20%