One vs. Two Link Length PMDs for 100 Gb/s per Lane

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IEEE P802.3db 100 Gb/s, 200 Gb/s, and 400 Gb/s Short Reach Fiber Task Force
Ad Hoc Teleconference

Task Force Objectives and Straw Poll

- Adopted Task Force Objectives:

Define a physical layer specification that supports 100 Gb/s operation over 1 pair of MMF with lengths up to at least 50 m.

Define a physical layer specification that supports 200 Gb/s operation over 2 pairs of MMF with lengths up to at least 50 m.

Define a physical layer specification that supports 400 Gb/s operation over 4 pairs of MMF with lengths up to at least 50 m.

- Straw poll (7/14/2020) indicated interest in two link lengths, one optimized for cost/power [for example 20-30m], and one optimized for longer reach [for example 80 – 100m].

  - I currently believe the IEEE P802.3db TF should:

  A. make no change to the current 50m objectives,
  B. modify the current 50m objective to longer reach [for example 80-100m], or
  C. have two objectives including one optimized for cost/power [for example 20-30m] and one optimized for longer reach [for example 80-100m]

  - A: 17 B: 3 C: 31

Motivation & Outline

Motivation

- Possible reach targets for 100G wavelengths over MMF
  1. 100m over OM4 is a long-standing reach for IEEE 802.3 MMF PMDs
  2. 50m reach was cited in the CFI as the shortest acceptable reach objective for switch-to-switch connections
  3. 20-30m was cited in the CFI as the needed reach for emerging fiber-to-the-server applications.

- The current 50m objective would satisfy reach targets #2 and #3 above, over OM4 and OM3 MMF, respectively.

- At the first TF meeting, technical feasibility of 100m over OM4 was presented, offering the possibility of also satisfying reach target #1 above.

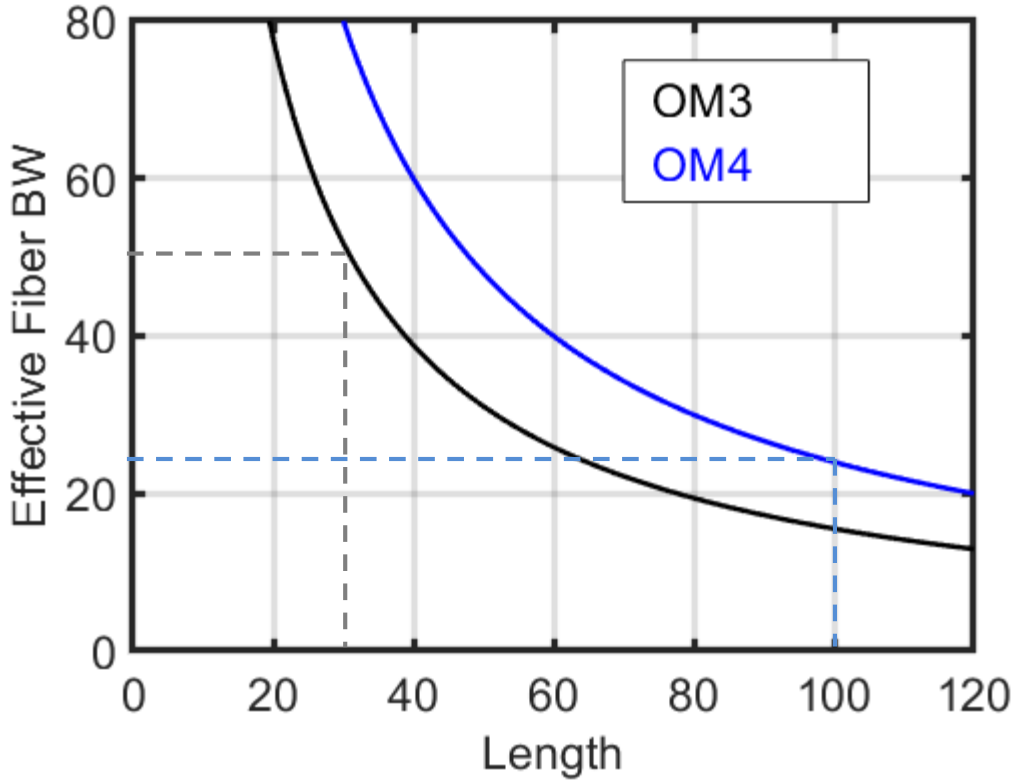
Outline

- Define and identify differences between PMDs for two link lengths.

- Are the differences significant?

Link to CFI - http://www.ieee802.org/3/cfi/1119_1/CFI_01_1119.pdf

Effective Fiber BW



Effective fiber bandwidth calculated by adding modal and chromatic dispersion bandwidth in quadrature[1,2,3] at wavelength of 863 nm and RMS spectral width of 0.6 nm.

30m OM3	52 GHz
100m OM4	24 GHz

1. Expressions for modal bandwidth from kolesar_3cm_01_1118.pdf.
2. Chromatic dispersion parameters U0 = 1316 nm and S0 = 0.10275 ps/(nm^2·km) for OM3 and OM4, abbott_3db_adhoc_01_080620.pdf.
3. Reference king_3cm_adhoc_01_062818.pdf.

Two Link Length PMDs

Parameter	PMD1	PMD2	Units	Notes
MMF	OM3	OM4	—	1
Link length	30	100	m	2
Fiber attenuation	0.1	0.3	dB	
Reference equalizer BT filter Uw = 0.6 nm Uw = 0.5 nm	 21.9 22.2	 14.7 15.7	 GHz GHz	3

⇦ For testing transmitter compliance

Notes

1. Equivalent OM3 and OM4 lengths can be defined for the two links. Lower cost OM3 chosen for the short link, and higher modal bandwidth OM4 for long reach.

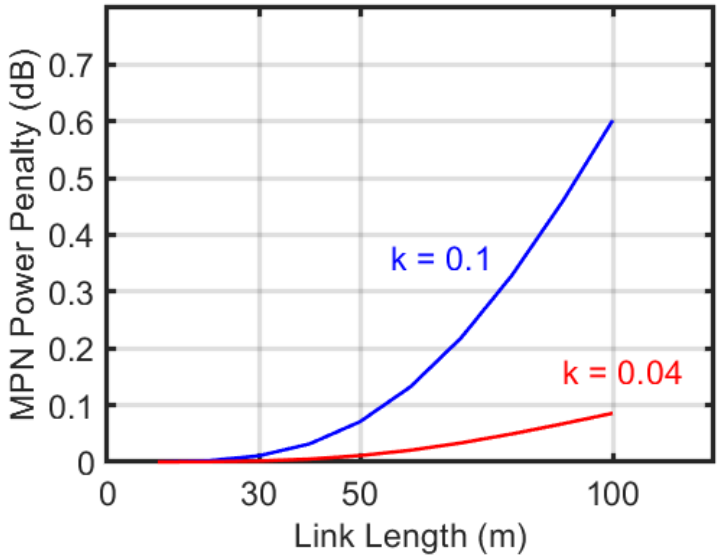
2. The 100m length maintains the reach of MMF links. Technical feasibility of a 100m OM4 link presented in ingham_3db_adhoc_01a_062520.pdf.

3. Calculated at 863 nm and RMS spectral width Uw with fiber chromatic dispersion parameters U0 = 1316 nm and S0 = 0.10275 ps/(nm^2·km). Reference equalizer BT filter bandwidth is a best fit to the combined fiber modal and chromatic dispersion modeled as a Gaussian LPF, and receiver modeled as a 4th order Bessel-Thompson filter with BW of 26.5625 GHz.

Other Potential Differences

- Number of taps on the reference equalizer.
  1. PMD1 (30m) could be supported with 5 taps but with less TDECQ margin
  2. PMD2 (100m) may require 9+ taps.[1]

- Past MMF link Standards (802.3cd, cm) have allocated 0.1 dB for MPN and modal noise penalty. Keeping MPN penalty low requires a smaller k factor for the longer reach (100m). Lower RIN for the 100 Gb/s VCSEL should also decrease k factor.



MPN power penalty calculated according to the Ogawa-Agrawal model[1] with

Q	3.41
B	53.125 GBd
Uw	0.6 nm
D	-106.5 ps/(nm·km)

1. G.P. Agrawal et al., IEEE JLT 6, 620 (1988).

1. Reference ingham_3db_adhoc_01a_062520.pdf.

PMD1 vs. AOC

Can 30m links (PMD1) be served effectively by active optical cable (AOC)?

- AOC has a persistent cost advantage over pluggable transceiver module
  - With fewer connectors, AOC has lower link penalty and thereby more margin for the VCSEL.
  - Lack of TP2 and TP3 compliance requirements provides greater yields.

- There is a need for transceivers for short links, e.g., use of pre-installed cabling.[1]

1. Jim Young in CFI_01_1119.pdf, and young_100GSR_adhoc_01_042320.pdf.

Are the Differences Between the Two PMDs Significant?

1. A consideration of the relative cost Δ between 30m and 100m link.

Item	Difference	Observation
VCSEL (and 9+ tap reference equalizer)	VCSEL yield is higher for OM3 30m today compared to OM4 100m links.	• History suggests difference gets smaller with time.
Reference equalizer	5 taps for the OM3 30m link vs. 9+ taps for the OM4 100m link. 5 tap FFE may enable use of analog equalizer for the 30m link.	• Using fewer taps on Rx equalizer increases TDECQ penalty, and therefore raises the performance pressure on the VCSEL. • Defining different reference equalizers may create an interoperability issue.

2. Will the difference be significant when the 802.3db Standard is released?

   - Historical 802.3bm

     100GBASE-SR4 began with two MMF objectives of 20m and 100m link lengths (Task Force, Nov 2012), and eventually defined only the 100m link (Task Force, Nov 2013).

Summary

Reviewed the differences in specifications for two links, OM3 30m and OM4 100m.

OM3 30m specification

There is an overlap with AOCs for this market segment. Is there a clear need for a transceiver?

Cost Δ from 100m depends on the trajectory of VCSEL development over the next two years.

OM4 100m specification

The 100m distance maintains the reach of MMF links.

Appendix

Historical – 802.3bm

802.3bm 100GBASE-SR4 initially adopted link length objectives (20 and 100m) but eventually the 20m objective was dropped.

Task Force Objectives defined in Nov 2012

- ✧ Define a 100 Gb/s PHY for operation up to at least 100 m of MMF
- ✧ Define a 100 Gb/s PHY for operation up to at least 20 m of MMF

Apr 2013 king_01a_0413_mmf.pdf (Jonathan King, Ryan Latchman)

- By about the same time 802.3bm is technically stable (H2 2014) there will be no significant power, cost or size advantage to be gained from an un-retimed short reach PMD.

Task Force Objectives defined in Nov 2013

- ✧ Define a 100 Gb/s PHY for operation up to at least 100 m of MMF