Propagation Delay Skew in Multimode Cabling

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Purpose and Approach

- Estimate the worst-case magnitude of propagation delay skew due to transmission over parallel OM3 and OM4 fibers
  - to provide guidance for de-skewing buffer depth and
  - circuits that must handle dynamic skew variation

- Use kolesar_02_0508 (MM skew model spreadsheet)
  - adjusted for 25.78125 Gbaud operation
  - adjusted for 10 m length increments
  - See kolesar_01_0508 for supporting material on model

Multimode Skew Model Spreadsheet

OM3 cable skew model — Paul Kolesar, Pete Anslow — 15-May-08 rev 1_0

OM3 multimode fiber cable skew factors	parameter 1	parameter 2	parameter 3	normalized skew (ps/m)
numerical aperture (NA) difference	NA, max (unitless) **0.215**	NA, min (unitless) **0.185**	cladding IoR, nom (unitless) **1.457**	13.6
strand length difference	differential length factor **0.0050**	propagation delay (ps/m) **5000**	n.a.	25.0
cabling stress difference	stress, max (kpsi) **50**	stress, min (kpsi) **0**	stress-refraction coef ($kpsi^{-1}$) **2.61E-05**	4.4
DMD difference for OM3 at 850 nm (inner mask)	DMD, max (ps/m) **0.33**	DMD, min (ps/m) **0**	n.a.	0.3
relative group delay for worst-case wavelength range	wavelength, max (nm) **860**	wavelength, min (nm) **840**	n.a.	2.1
total worst-case skew at 850 nm				45.4
total maximum dynamic skew				6.8

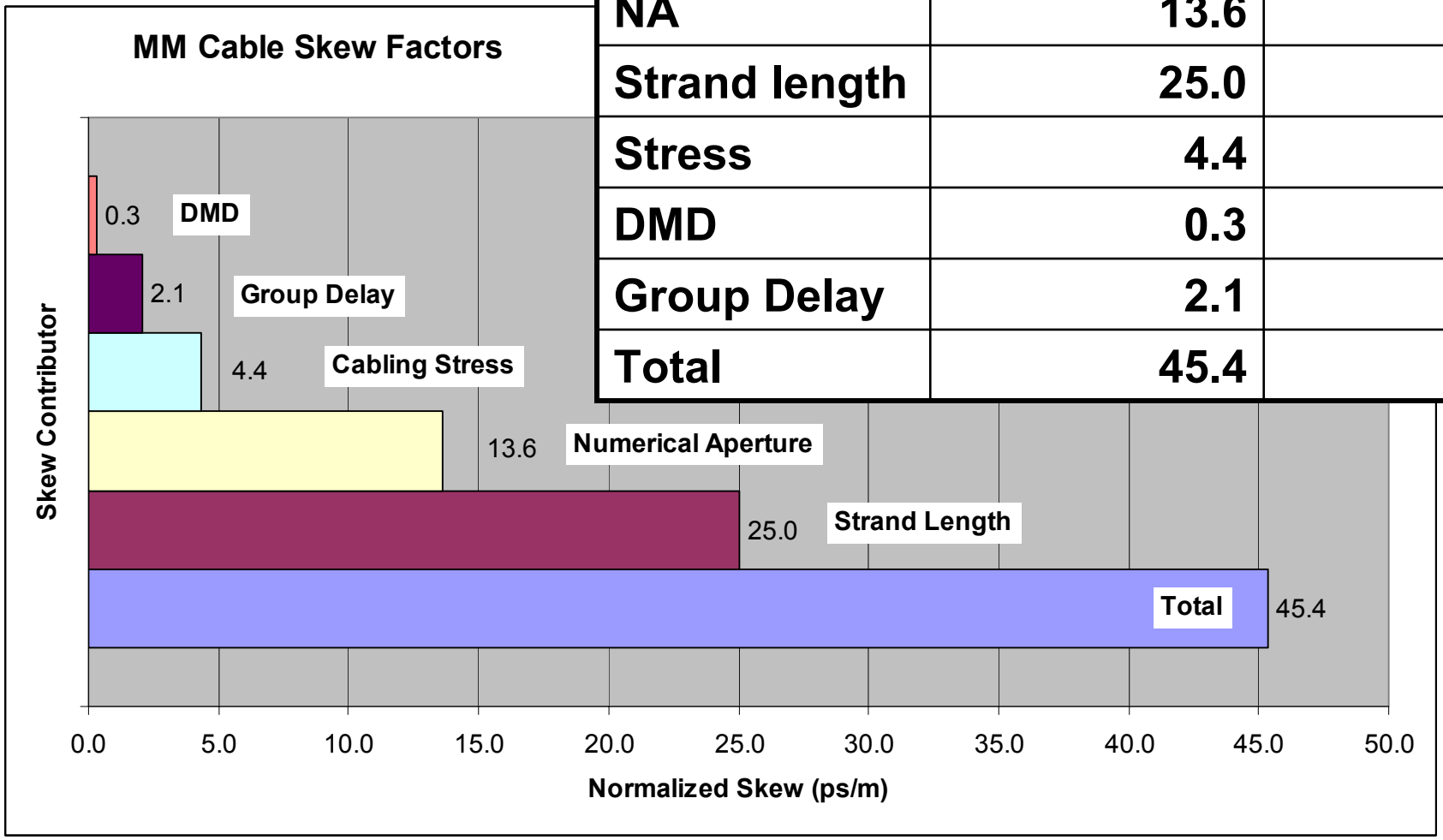
Other inputs		
speed of light in vacuum	**299,792,458**	m/sec
zero dispersion wavelength for max skew @ 850 nm	**1318**	nm
zero dispersion slope at zdw, max	**0.102**	ps/nm^2-km
baud rate	**25.78125**	Gbaud
initial link length	**0**	m
link length increment	**10**	m

Adjusted values relative to kolesar_02_0508

link length (m)	worst-case skew (ps)	worst-case skew (UI)	dynamic skew (ps)	dynamic skew (UI)
0	0	0.0	0	0.0
10	454	11.7	68	1.7
20	907	23.4	135	3.5
30	1361	35.1	203	5.2
40	1815	46.8	270	7.0
50	2268	58.5	338	8.7
60	2722	70.2	405	10.5
70	3176	81.9	473	12.2
80	3629	93.6	541	13.9
90	4083	105.3	608	15.7
100	4537	117.0	676	17.4
110	4990	128.7	743	19.2
120	5444	140.4	811	20.9
130	5898	152.0	879	22.6
140	6351	163.7	946	24.4
150	6805	175.4	1014	26.1

Skew Contributor Magnitude Snapshot

Contributor	Worst-Case Magnitude (ps/m)	Max Dynamic Magnitude (ps/m)
NA	13.6	0
Strand length	25.0	0
Stress	4.4	4.4
DMD	0.3	0.3
Group Delay	2.1	2.1
Total	45.4	6.8



Baseline Skew Values

- Current baseline (draft 1.0) skew values are copied from clause 86

Table 95–12—Fiber optic cabling (channel) characteristics for 100GBASE-SR4

Description	OM3	OM4	Unit
Operating distance (max)	70	100	m
Cabling Skew (max)	79		ns
Cabling Skew Variation[a] (max)	2.5		ns
Channel insertion loss[b] (max)	1.8	1.9	dB
Channel insertion loss (min)	0		dB

[a] An additional 300 ps of Skew Variation could be caused by wavelength changes, which are attributable to the transmitter not the channel.

[b] These channel insertion loss values include cable loss plus 1.5 dB allocated for connection and splice loss, over the wavelength range 840 nm to 860 nm.

- All three skew values will be examined in detail on the next slide

Addressing Skew Specs for SR4

- Cabling Skew
  - 4.54 ns is needed per model
  - 79 ns allocated is 17.4 times larger than necessary
    ► No problem; no change
- Wavelength shift allocation
  - Note “a” value of 300 ps is inappropriate for 100 m channel: †
    2 * 100 m * 2.1 ps/m = 420 ps
    ► Note “a” should be increased to 0.4 ns
    - For consistency with table units and rounded presentation, express value in ns
- Cabling Skew Variation
  (i.e. dynamic skew w/o wavelength shift component, a.k.a. group delay)
  - 0.94 ns is needed: 2 * 100 m * (0.3 ps/m for DMD + 4.4 ps/m for stress) = 940 ps
  - 2.8 ns is available (including Tx wavelength shift) per d1.0 clause 95.3.2
  - Subtracting 0.4 ns for wavelength shift leaves 2.4 ns, 2.5 times larger than necessary. Channel properties easily fit within budget, but
    ► value should be decreased from 2.5 to 2.4 ns

- Propose to change:
  - Note “a” from 300 ps to 0.4 ns
  - Cabling Skew Variation from 2.5 ns to 2.4 ns

† Clause 86 allocation for wavelength shift is too low by a factor of 2

Q & A