Defining 10GBASE-S over OM4 media

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Presentation Scope

Background

- A new class of multimode fiber, OM4, has been standardized
  - TIA (Telecommunications Industry Association) defines OM4 in TIA-492AAAD
  - IEC (International Electrotechnical Comission) define A1a.3 (OM4) in IEC 60793-2-10 ed.4
- OM4 is specified to have higher modal bandwidth at 850 nm than currently specified fiber types in IEEE Std. 802.3 clause 52
- IEEE does not have a specified reach for OM4 for 10GBASE-S in clause 52*
  - OM4 is specified for 40GBASE-SR4 & 100GBASE-SR10 in clause 86
- Longer reach than the OM3 specified 300 m is feasible over OM4 using standard 10GBASE-S transmitters & receivers

Proposal

- Specify reach for 10GBASE-S over OM4 by updating fiber characteristics
- Keep 10GBASE-S transmitter & receiver specifications UNCHANGED

*Note: OM4 fiber meets (exceeds!) IEEE specified requirements for OM3, so in the strictest sense the OM4 reach as of now is equal to the OM3 specified reach

Proposal

- Add OM4 category to clause 52 consistent with the fiber characteristics in clause 86
- Propose reach of **400 m** over OM4
- Propose modified table values consistent with IEEE 802.3 clause 52 & clause 86 methodology

Justification for Reach in Proposal

- Based on simple modifications to the IEEE 10GE spreadsheet (10GEPBud3_1_16a.xls; Tab = “850S2000”)
  a) Modal Bandwidth: 2000 -> 4400 MHz*km
  b) Target Reach[Note]: 0.3 -> 0.4 km
  c) Disp. Min Uo: 1316 nm
  d) Disp. So: 0.10275 ps/nm2*km
    - Worst case (highest dispersion at 840 nm) occurs at 1316nm, 0.10275ps/nm^2*km
    - In 802.3ae, 1320nm & 0.11 ps/nm^2*km were used. OM4 exceeds the clause 52 fiber specifications
- Resulting Calculated Margin: **1.1** dB

Example Calculations

BW (MHz*km)	**Wavelength**	**Uw** (nm)	**TX_{OMA}** (dBm)	**Margin @ 400m** (dB)
4400	840	0.45	-2.8	1.1
		0.35	-3.5	1.6
		0.25	-3.9	1.8

Note: L_inc & L_start were also changed in order to allow for 400m reach to be “centered” on spreadsheet

Example: 10GE spreadsheet (Uw = 0.45 nm)

Spreadsheet by Del Hanson, David Cunningham, Piers Dawe, David Dolfi Agilent Technologies									Rev. 3.2/3		This file	10GEPBud3_1_16a.xls			of	17-Oct-01	
Basics Input=	Bold		Ts(20-80)	35	ps	Case: 850nm serial	newMMF		Attenuation=	3.5	dB/km	Model/format rev	3.1.16a		of	31-Oct-01	
Q=	7.04		Ts(10-90)	53	ps	*Target* Target reach	0.40	km	*Fiber* at	850	nm	NomSens OMA	-11.10	dBm	Margin	1.07	dB at
Base Rate=	10313	MBd	RIN(OMA)	-130	dB/Hz	*and* L_start=	0.2	km	C_att=	1.00		*Receive* Refl Rx	-12	dB	*Answer!*	0.4	km
Transmitter			RIN at MinER	-139.6	dB/Hz	*graph* L_inc=	0.02	km	Attenuation=	3.62	dB/km	Rec_BW=	8,250	MHz	est Rx BW	7500	MHz
Wavelength Uc	840	nm	RIN_Coef=	0.70		Power Budget P=	8.30	dB	at	840	nm	c_rx	329	ns.MHz			
Uw (see notes)	0.45	nm	Det.Jitter	6.0	ps inc. DCD	Connections C	1.5	dB	Disp. min. Uo=	1316	nm	T_rx(10-90)	39.9	ps	Test Source ER=		
Tx pwr OMA=	-2.80	dBm	DCD_DJ=	6	ps TP3	Pwr.Bud.-Conn.Loss	6.8	dB	Disp. So=	0.1028	ps/nm^2*km	TP4 Eye	19	ps	*Test Tx*	6.5	dB
Min. Ext Ratio=	3.00	dB	Effect. DJ=	0.00	(UI) ex DCD	C1=	480	ns.MHz	Disp. D1=	-108.41	ps/(nm.km)	Opening		(=Tx ey	TestERpei	1.98	dBo
'Worst"ave.TxPwr	-1.03	dBm	MPN k(OMA)	0.3		Reflection Noise factor	0	no units				RMS Baseline wander SD	0.025	fraction of 1/2 eye			
Ext. ratio penalty	4.78	dBo	Tx eye height	70.7%		Effective Rate	10993	MBd	(not in use)	10					V.E.C.P.	2.57	dBo
Tx mask X1=	0.3	UI	Refl Tx	-12	dB	Tb_eff=	91	ps	BWm=	4400	MHz*km	P_BLW(no ISI)	0.07	dB			Stressed
X2=	0.4	UI	ModalNoisePen	0.3	dB	Effective Rec Eye	0.21	UI	Eff. BWm=	#######	MHz*km	P_BLW	0.07	dB			Rx sens
Y1=	0.25		Tx mask top	0.2	UI												

L (km)	Patt (dB)	Ch IL (dB)	D1.L ps/nm	D2.L ps/nm	BWcd (MHz)	effBWm (MHz)	Te (ps)	Tc (ps)	Pisi central J=0, dB	P Eye corners (dB)	P_DJ central (dB)	P_DJ corners (dB)	Preflection central (dB)	Beta	SDmpn	Pmpn (dB)	Prin (dB)	Pcross central (dB)	Ptotal central (dB)	<Ptotal corners (dB)	LP Pen central (dB)	Margin (dB)	OMA central (dBm)
0.002	0.01	1.51	-0.22	0.00	2E+06	#######	53	66	0.75	0.22	0.00	0.00		-3E-03	0.00	0.00		0.05	1.11	1.33	1.1	5.7	-5.7
0.20	**0.72**	**2.22**	**-21.7**	**0.01**	**19,166**	**22,000**	**63**	**74**	**1.15**	**0.24**	**0.00**	**0.00**	**0**	**-0.34**	**0.02**	**0.06**	**0.12**	**0.11**	**2.5**	**2.7**	**1.7**	**4.3**	**-6.6**
0.22	0.80	2.30	-23.9	0.01	17,423	20,000	64	76	1.24	0.24	0.00	0.00	0	-0.37	0.03	0.08	0.12	0.12	2.7	2.9	1.9	4.1	-6.7
0.24	0.87	2.37	-26.0	0.01	15,971	18,333	66	77	1.34	0.24	0.00	0.00	0	-0.40	0.03	0.11	0.12	0.14	2.9	3.1	2.0	3.9	-6.8
0.26	0.94	2.44	-28.2	0.01	14,743	16,923	68	79	1.44	0.24	0.00	0.00	0	-0.44	0.04	0.15	0.12	0.16	3.1	3.4	2.2	3.7	-7.0
0.28	1.01	2.51	-30.4	0.01	13,690	15,714	71	81	1.56	0.24	0.00	0.00	0	-0.47	0.04	0.20	0.12	0.19	3.4	3.6	2.4	3.4	-7.1
0.30	**1.09**	**2.59**	**-32.5**	**0.01**	**12,777**	**14,667**	**73**	**83**	**1.68**	**0.24**	**0.00**	**0.00**	**0**	**-0.51**	**0.05**	**0.26**	**0.13**	**0.23**	**3.7**	**3.9**	**2.6**	**3.1**	**-7.3**
0.32	1.16	2.66	-34.7	0.01	11,979	13,750	75	85	1.81	0.25	0.00	0.00	0	-0.54	0.05	0.33	0.13	0.28	4.0	4.3	2.8	2.8	-7.4
0.34	1.23	2.73	-36.9	0.01	11,274	12,941	78	87	1.95	0.25	0.00	0.00	0	-0.57	0.06	0.42	0.13	0.33	4.4	4.6	3.1	2.4	-7.6
0.36	1.30	2.80	-39.0	0.01	10,648	12,222	80	89	2.11	0.25	0.00	0.00	0	-0.61	0.07	0.51	0.14	0.41	4.8	5.0	3.5	2.0	-7.8
0.38	1.38	2.88	-41.2	0.01	10,087	11,579	82	92	2.27	0.25	0.00	0.00	0	-0.64	0.07	0.63	0.14	0.50	5.2	5.5	3.8	1.6	-8.1
0.40	**1.45**	**2.95**	**-43.4**	**0.01**	**9,583**	**11,000**	**85**	**94**	**2.44**	**0.25**	**0.00**	**0.00**	**0**	**-0.67**	**0.08**	**0.76**	**0.15**	**0.63**	**5.7**	**6.0**	**4.3**	**1.1**	**-8.3**
0.42	1.52	3.02	-45.5	0.01	9,126	10,476	88	96	2.62	0.25	0.00	0.00	0	-0.71	0.08	0.92	0.16	0.81	6.3	6.6	4.8	0.5	-8.7
0.44	1.59	3.09	-47.7	0.01	8,712	10,000	90	99	2.80	0.25	0.00	0.00	0	-0.74	0.09	1.10	0.16	1.07	7.0	7.3	5.4	-0.2	-9.1
0.46	1.67	3.17	-49.9	0.01	8,333	9,565	93	101	3.00	0.25	0.00	0.00	0	-0.77	0.10	1.31	0.17	1.46	7.9	8.2	6.2	-1.1	-9.6
0.48	1.74	3.24	-52.0	0.02	7,986	9,167	96	104	3.21	0.25	0.00	0.00	0	-0.81	0.10	1.56	0.19	2.14	9.1	9.4	7.4	-2.3	-10.2
0.50	**1.81**	**3.31**	**-54.2**	**0.02**	**7,666**	**8,800**	**99**	**106**	**3.43**	**0.26**	**0.00**	**0.00**	**0**	**-0.84**	**0.11**	**1.86**	**0.20**	**3.73**	**11.3**	**11.6**	**9.5**	**-4.5**	**-11.4**

- Value of 4400 MHz*km is used for the calculation
- Value of 4700 MHz*km at nominal wavelength to be specified in IEEE tables consistent with IEEE 802.3 style

Example: 10GE spreadsheet (Uw = 0.35 nm)

Spreadsheet by Del Hanson, David Cunningham, Piers Dawe, David Dolfi Agilent Technologies									Rev.	3.2/3	This file		10GEPBud3_1_16a.xls				of	17-Oct-01	
Basics	Input=	**Bold**	Ts(20-80)	35	ps	Case: 850nm serial	newMMF		Attenuation=	3.5	dB/km		Model/format rev	3.1.16a			of	31-Oct-01	
	Q=	7.04	Ts(10-90)	53	ps	*Target* Target reach	0.40	km	*Fiber* at	850	nm		NomSens OMA	-11.10	dBm		Margin	1.58	dB at
	Base Rate=	10313	MBd RIN(OMA)	-130	dB/Hz	*and* L_start=	0.2	km	C_att=	1.00			*Receive* Refl Rx	-12	dB		*Answer!*	0.4 km	
Transmitter			RIN at MinER	-139.6	dB/Hz	*graph* L_inc=	0.02	km	Attenuation=	3.62	dB/km		Rec_BW=	8,250	MHz		est Rx BW	7500	MHz
Wavelength Uc	840	nm	RIN_Coef=	0.70		Power Budget P=	7.60	dB	at	840	nm		c_rx	329	ns.MHz				
Uw (see notes)	0.35	nm	Det.Jitter	6.0	ps inc. DCD	Connections C	1.5	dB	Disp. min. Uo=	1316	nm		T_rx(10-90)	39.9	ps		Test Source ER=		
Tx pwr OMA=	-3.50	dBm	DCD_DJ=	6	ps TP3	Pwr.Bud.-Conn.Loss	6.1	dB	Disp. So=	0.1028	ps/nm^2*km		TP4 Eye	19	ps		*Test Tx*	6.5	dB
Min. Ext Ratio=	3.00	dB	Effect. DJ=	0.00	(UI) ex DCD	C1=	480	ns.MHz	Disp. D1=	-108.41	ps/(nm.km)		Opening		(=Tx ey		TestERper	1.98	dBo
Worst"ave.TxPwr	-1.73	dBm	MPN k(OMA)	0.3		Reflection Noise factor	0	no units					RMS Baseline wander SD	0.025	fraction of 1/2 eye				
Ext. ratio penalty	4.78	dBo	Tx eye height	70.7%		Effective Rate	10993	MBd	(not in use)	10							V.E.C.P.	2.18	dBo
Tx mask X1=	0.3	UI	Refl Tx	-12	dB	Tb_eff=	91	ps	BWm=	4400	MHz*km		P_BLW(no ISI)	0.07	dB			Stressed	
X2=	0.4	UI	ModalNoisePen	0.3	dB	Effective Rec Eye	0.21	UI	Eff. BWm=	#######	MHz*km		P_BLW	0.07	dB			Rx sens	
Y1=	0.25		Tx mask top	0.2	UI														

L (km)	Patt (dB)	Ch IL (dB)	D1.L ps/nm	D2.L ps/nm	BWcd (MHz)	effBWm (MHz)	Te (ps)	Tc (ps)	Pisi central J=0, dB	P Eye corners (dB)	P_DJ central (dB)	P_DJ corners (dB)	Preflection central (dB)	Beta	SDmpn	Pmpn (dB)	Prin (dB)	Pcross central (dB)	Ptotal central (dB)	<Ptotal corners (dB)	LP Pen central (dB)	Margin (dB)	OMA central (dBm)
0.002	0.01	1.51	-0.22	0.00	2E+06	######	53	66	0.75	0.22	0.00	0.00		-3E-03	0.00	0.00		0.05	1.11	1.33	1.1	5.0	-6.9
0.20	**0.72**	**2.22**	**-21.7**	**0.01**	**24,641**	**22,000**	**61**	**73**	**1.06**	**0.23**	**0.00**	**0.00**	**0**	**-0.26**	**0.01**	**0.02**	**0.12**	**0.09**	**2.3**	**2.6**	**1.6**	**3.8**	**-7.8**
0.22	0.80	2.30	-23.9	0.01	22,401	20,000	62	74	1.13	0.24	0.00	0.00	0	-0.29	0.02	0.03	0.12	0.10	2.5	2.7	1.7	3.6	-7.9
0.24	0.87	2.37	-26.0	0.01	20,535	18,333	64	75	1.20	0.24	0.00	0.00	0	-0.31	0.02	0.04	0.12	0.11	2.6	2.9	1.8	3.5	-8.0
0.26	0.94	2.44	-28.2	0.01	18,955	16,923	65	77	1.28	0.24	0.00	0.00	0	-0.34	0.02	0.06	0.12	0.12	2.8	3.1	1.9	3.3	-8.1
0.28	1.01	2.51	-30.4	0.01	17,601	15,714	67	78	1.37	0.24	0.00	0.00	0	-0.37	0.03	0.08	0.12	0.13	3.0	3.3	2.0	3.1	-8.2
0.30	**1.09**	**2.59**	**-32.5**	**0.01**	**16,428**	**14,667**	**69**	**80**	**1.46**	**0.24**	**0.00**	**0.00**	**0**	**-0.39**	**0.03**	**0.10**	**0.12**	**0.15**	**3.2**	**3.5**	**2.1**	**2.9**	**-8.3**
0.32	1.16	2.66	-34.7	0.01	15,401	13,750	71	81	1.57	0.24	0.00	0.00	0	-0.42	0.03	0.13	0.12	0.17	3.4	3.7	2.3	2.7	-8.4
0.34	1.23	2.73	-36.9	0.01	14,495	12,941	73	83	1.68	0.24	0.00	0.00	0	-0.45	0.04	0.16	0.13	0.19	3.7	3.9	2.5	2.4	-8.5
0.36	1.30	2.80	-39.0	0.01	13,690	12,222	75	85	1.79	0.25	0.00	0.00	0	-0.47	0.04	0.20	0.13	0.22	3.9	4.2	2.6	2.2	-8.6
0.38	1.38	2.88	-41.2	0.01	12,969	11,579	77	87	1.92	0.25	0.00	0.00	0	-0.50	0.05	0.25	0.13	0.25	4.2	4.5	2.8	1.9	-8.8
0.40	**1.45**	**2.95**	**-43.4**	**0.01**	**12,321**	**11,000**	**79**	**89**	**2.05**	**0.25**	**0.00**	**0.00**	**0**	**-0.52**	**0.05**	**0.30**	**0.13**	**0.29**	**4.5**	**4.8**	**3.1**	**1.6**	**-8.9**
0.42	1.52	3.02	-45.5	0.01	11,734	10,476	81	90	2.18	0.25	0.00	0.00	0	-0.55	0.06	0.36	0.14	0.34	4.8	5.1	3.3	1.3	-9.1
0.44	1.59	3.09	-47.7	0.01	11,201	10,000	83	92	2.33	0.25	0.00	0.00	0	-0.58	0.06	0.43	0.14	0.40	5.2	5.4	3.6	0.9	-9.2
0.46	1.67	3.17	-49.9	0.01	10,714	9,565	86	95	2.48	0.25	0.00	0.00	0	-0.60	0.06	0.50	0.15	0.48	5.6	5.8	3.9	0.5	-9.4
0.48	1.74	3.24	-52.0	0.01	10,267	9,167	88	97	2.64	0.25	0.00	0.00	0	-0.63	0.07	0.59	0.16	0.57	6.0	6.2	4.3	0.1	-9.6
0.50	**1.81**	**3.31**	**-54.2**	**0.01**	**9,857**	**8,800**	**90**	**99**	**2.81**	**0.25**	**0.00**	**0.00**	**0**	**-0.65**	**0.07**	**0.69**	**0.16**	**0.69**	**6.5**	**6.7**	**4.6**	**-0.4**	**-9.9**

- Value of 4400 MHz*km is used for the calculation
- Value of 4700 MHz*km at nominal wavelength to be specified in IEEE tables consistent with IEEE 802.3 style

Example: 10GE spreadsheet (Uw = 0.25 nm)

Spreadsheet by Del Hanson, David Cunningham, Piers Dawe, David Dolfi Agilent Technologies			Rev. 3.2/3 This file	10GEPBud3_1_16a.xls	of 17-Oct-01
Basics Input= **Bold**	Ts(20-80) 35 ps	Case: 850nm serial newMMF	Attenuation= 3.5 dB/km	Model/format rev 3.1.16a	of 31-Oct-01
Q= 7.04	Ts(10-90) 53 ps	*Target* Target reach 0.40 km	*Fiber* at 850 nm	NomSens OMA -11.10 dBm	Margin 1.81 dB at
Base Rate= 10313 MBd	RIN(OMA) -130 dB/Hz	*and* L_start= 0.2 km	C_att= 1.00	*Receive* Refl Rx -12 dB	*Answer!* 0.4 km
Transmitter	RIN at MinER -139.6 dB/Hz	*graph* L_inc= 0.02 km	Attenuation= 3.62 dB/km	Rec_BW= 8,250 MHz	est Rx BW 7500 MHz
Wavelength Uc 840 nm	RIN_Coef= 0.70	Power Budget P= 7.20 dB	at 840 nm	c_rx 329 ns.MHz	
Uw (see notes) 0.25 nm	Det.Jitter 6.0 ps inc. DCD	Connections C 1.5 dB	Disp. min. Uo= 1316 nm	T_rx(10-90) 39.9 ps	Test Source ER=
Tx pwr OMA= -3.90 dBm	DCD_DJ= 6 ps TP3	Pwr.Bud.-Conn.Loss 5.7 dB	Disp. So= 0.1028 ps/nm^2*km	TP4 Eye 19 ps	*Test Tx* 6.5 dB
Min. Ext Ratio= 3.00 dB	Effect. DJ= 0.00 (UI) ex DCD	C1= 480 ns.MHz	Disp. D1= -108.41 ps/(nm.km)	Opening (=Tx ey	TestERper 1.98 dBo
Worst"ave.TxPwr -2.13 dBm	MPN k(OMA) 0.3	Reflection Noise factor 0 no units		RMS Baseline wander SD 0.025 fraction	of 1/2 eye
Ext. ratio penalty 4.78 dBo	Tx eye height 70.7%	Effective Rate 10993 MBd	(not in use) 10		V.E.C.P. 1.89 dBo
Tx mask X1= 0.3 UI	Refl Tx -12 dB	Tb_eff= 91 ps	BWm= 4400 MHz*km	P_BLW(no ISI) 0.07 dB	Stressed
X2= 0.4 UI	ModalNoisePen 0.3 dB	Effective Rec Eye 0.21 UI	Eff. BWm= ####### MHz*km	P_BLW 0.07 dB	Rx sens
Y1= 0.25	Tx mask top 0.2 UI				

L (km)	Patt (dB)	Ch IL (dB)	D1.L ps/nm	D2.L ps/nm	BWcd (MHz)	effBWm (MHz)	Te (ps)	Tc (ps)	Pisi central J=0, dB	P Eye corners (dB)	P_DJ central (dB)	P_DJ corners (dB)	Preflection central (dB)	Beta	SDmpn	Pmpn (dB)	Prin (dB)	Pcross central (dB)	Ptotal central (dB)	<Ptotal corners (dB)	LP Pen central (dB)	Margin (dB)	OMA central (dBm)
0.002	0.01	1.51	-0.22	0.00	3E+06	######	53	66	0.75	0.22	0.00	0.00		-2E-03	0.00	0.00		0.05	1.11	1.33	1.1	4.6	-7.5
0.20	**0.72**	**2.22**	**-21.7**	**0.00**	**34,498**	**22,000**	**59**	**71**	**0.99**	**0.23**	**0.00**	**0.00**	**0**	**-0.19**	**0.01**	**0.01**	**0.12**	**0.08**	**2.2**	**2.5**	**1.5**	**3.5**	**-8.4**
0.22	0.80	2.30	-23.9	0.00	31,362	20,000	60	72	1.04	0.23	0.00	0.00	0	-0.21	0.01	0.01	0.12	0.09	2.4	2.6	1.6	3.3	-8.5
0.24	0.87	2.37	-26.0	0.00	28,748	18,333	62	73	1.10	0.24	0.00	0.00	0	-0.22	0.01	0.01	0.12	0.09	2.5	2.7	1.6	3.2	-8.6
0.26	0.94	2.44	-28.2	0.00	26,537	16,923	63	74	1.16	0.24	0.00	0.00	0	-0.24	0.01	0.02	0.12	0.10	2.6	2.9	1.7	3.1	-8.6
0.28	1.01	2.51	-30.4	0.01	24,641	15,714	64	76	1.23	0.24	0.00	0.00	0	-0.26	0.01	0.02	0.12	0.10	2.8	3.0	1.8	2.9	-8.7
0.30	**1.09**	**2.59**	**-32.5**	**0.01**	**22,999**	**14,667**	**66**	**77**	**1.30**	**0.24**	**0.00**	**0.00**	**0**	**-0.28**	**0.02**	**0.03**	**0.12**	**0.11**	**3.0**	**3.2**	**1.9**	**2.7**	**-8.8**
0.32	1.16	2.66	-34.7	0.01	21,561	13,750	67	78	1.38	0.24	0.00	0.00	0	-0.30	0.02	0.04	0.12	0.12	3.1	3.4	2.0	2.6	-8.9
0.34	1.23	2.73	-36.9	0.01	20,293	12,941	69	80	1.47	0.24	0.00	0.00	0	-0.32	0.02	0.05	0.12	0.13	3.3	3.5	2.1	2.4	-9.0
0.36	1.30	2.80	-39.0	0.01	19,166	12,222	71	81	1.56	0.24	0.00	0.00	0	-0.34	0.02	0.06	0.12	0.14	3.5	3.7	2.2	2.2	-9.1
0.38	1.38	2.88	-41.2	0.01	18,157	11,579	72	83	1.65	0.24	0.00	0.00	0	-0.36	0.03	0.07	0.13	0.16	3.7	3.9	2.3	2.0	-9.2
0.40	**1.45**	**2.95**	**-43.4**	**0.01**	**17,249**	**11,000**	**74**	**84**	**1.76**	**0.24**	**0.00**	**0.00**	**0**	**-0.37**	**0.03**	**0.08**	**0.13**	**0.17**	**3.9**	**4.1**	**2.4**	**1.8**	**-9.3**
0.42	1.52	3.02	-45.5	0.01	16,428	10,476	76	86	1.86	0.25	0.00	0.00	0	-0.39	0.03	0.10	0.13	0.19	4.1	4.4	2.6	1.6	-9.4
0.44	1.59	3.09	-47.7	0.01	15,681	10,000	78	87	1.97	0.25	0.00	0.00	0	-0.41	0.03	0.12	0.13	0.21	4.3	4.6	2.7	1.4	-9.5
0.46	1.67	3.17	-49.9	0.01	14,999	9,565	80	89	2.09	0.25	0.00	0.00	0	-0.43	0.04	0.14	0.14	0.23	4.6	4.8	2.9	1.1	-9.6
0.48	1.74	3.24	-52.0	0.01	14,374	9,167	82	91	2.22	0.25	0.00	0.00	0	-0.45	0.04	0.17	0.14	0.26	4.8	5.1	3.1	0.9	-9.7
0.50	**1.81**	**3.31**	**-54.2**	**0.01**	**13,799**	**8,800**	**84**	**93**	**2.35**	**0.25**	**0.00**	**0.00**	**0**	**-0.47**	**0.04**	**0.20**	**0.14**	**0.29**	**5.1**	**5.3**	**3.3**	**0.6**	**-9.8**

- Value of 4400 MHz*km is used for the calculation
- Value of 4700 MHz*km at nominal wavelength to be specified in IEEE tables consistent with IEEE 802.3 style

DETAIL ON PROPOSED CHANGES

Solution: Proposed Changes (1)

- Add Row to Table 52-6

Table 52–6—10GBASE-S operating range for each optical fiber type

Fiber type	Minimum modal bandwidth @ 850 nm (MHz•km)	Operating range (m)
62.5 µm MMF	160	2 to 26
	200	2 to 33
50 µm MMF	400	2 to 66
	500	2 to 82
	2000	2 to 300
	4700	**2 to 400**

Solution: Proposed Changes (2)

- Add Column to Table 52-10

Table 52–10—10GBASE-S link power budgets[a,b]

Parameter	62.5 µm MMF		50 µm MMF				Unit
Modal bandwidth as measured at 850 nm	160	200	400	500	2000	4700	MHz•km
Power budget	7.3	7.3	7.3	7.3	7.3	7.3	dB
Operating distance	26	33	66	82	300	400	m
Channel insertion loss[c, d]	1.6	1.6	1.7	1.8	2.6	2.9	dB
Allocation for penalties	4.7	4.8	5.1	5.0	4.7	4.4	dB
Additional insertion loss allowed[e]	1.0	0.8	0.5	0.5	0.0	0.0	dB

[a]Budget numbers are rounded to nearest 0.1 dB.
[b]Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.
[c]Operating distances used to calculate the channel insertion loss are the maximum values specified in Table 52–6.
[d]The specifications for a wavelength of 840 nm and a spectral width of 0.29 nm in Table 52–8 is used to calculate channel insertion loss, allocation for penalties, and additional insertion loss allowed.
[e]This portion of the link budget is permitted to be used to overcome insertion loss higher than the "Channel insertion loss" value and in some cases may be less than the value shown.

Solution: Proposed Changes (3)

- Add Column to Table 52-24

Table 52–24—Fiber optic cabling (channel)

Description	62.5 µm MMF		50 µm MMF				Type B1.1, B1.3 SMF			Unit
Nominal wavelength	850[a]						1310[b]	1550		nm
Modal bandwidth (min)	160	200	400	500	2000	4700	N/A	N/A		MHz•km
Operating distance (max)	26 m	33 m	66 m	82 m	300 m	400 m	10 km	30 km	40 km	
Channel insertion loss (max) [c,d,e]	2.6	2.5	2.2	2.3	2.6	2.9	6.0	11.0[f]		dB
Channel insertion loss (min)	0	0	0	0	0	0	0	5		dB
Dispersion (max)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	546	728	ps/nm
DGD_max[g]	N/A	N/A	N/A	N/A	N/A	N/A	10	19		ps
Optical return loss	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21		dB

[a]Channel insertion loss at 850 nm includes cable, connectors, and splices.
[b]Channel insertion loss at 1310 nm includes cable, connectors, and splices.
[c]These channel insertion loss numbers are based on the nominal wavelength.
[d]Operating distances used to calculate channel insertion loss are those listed in this table.
[e]Maximum attenuation given in Table 52–25.
[f]Channel insertion loss at 1550 nm includes cable, connectors and splices.
[g]Differential Group Delay (DGD) is the time difference between the fractions of a pulse that are transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system must tolerate.

Solution: Proposed Changes (4)

- Add footnote & column in Table 52-25

Table 52–25—Optical fiber and cable characteristics

Description	62.5 µm MMF	50 µm MMF		Type B1.1, B1.3 SMF		Unit
Nominal fiber specification wavelength	**850**	**850**		**1310**	**1550**	**nm**
Fiber cable attenuation (max)	3.5	3.5		0.4[a] or 0.5[b]	see footnote[c]	dB/km
Modal Bandwidth (min)	160[d] or 200[d]	400[d] or 500[d] or 2000[e]	4700[f]	N/A		MHz km
Zero dispersion wavelength (λ_0)	$1320 \le \lambda_0 \le 1365$	$1295 \le \lambda_0 \le 1320$	$1295 \le \lambda_0 \le 1340$[f]	$1300 \le \lambda_0 \le 1324$		nm
Dispersion slope (max) (S_0)	0.11 for $1320 \le \lambda_0 \le 1348$ and $0.001(1458-\lambda_0)$ for $1348 \le \lambda_0 \le 1365$	0.11 for $1300 \le \lambda_0 \le 1320$ and $0.001(\lambda_0-1190)$ for $1295 \le \lambda_0 \le 1300$	0.105 for $1295 \le \lambda_0 \le 1310$ and $0.000375(1590 - \lambda_0)$ for $1310 \le \lambda_0 \le 1340$[f]	0.093		ps / nm^2 km

[a]For the single-mode case, the 0.4 dB/km attenuation for optical fiber cables is defined in ITU-T G.652.
[b]For the single-mode case, the 0.5 dB/km attenuation is provided for Outside Plant cable as defined in ANSI/TIA/EIA 568B.3-2000. Using 0.5 dB/km may not support operation at 10 km.
[c]Attenuation for 1550 nm links is based on the fiber channel and is specified in 52.14.3.
[d]Overfilled launch bandwidth per IEC 60793-1-41 or ANSI/TIA/EIA 455-204-2000.
[e]Effective modal bandwidth for fiber meeting TIA/EIA-492AAAC-2002 when used with sources meeting the wavelength (range) and encircled flux specifications of Table 52–7.

[f] Effective modal bandwidth, zero dispersion wavelength and dispersion slope for OM4 fibers are specified in TIA-492AAAD and IEC 60793-2-10 ed.4

BACKUP

Calculated Margins of 10GBASE-S on OM3

Using new dispersion values for OM3 fiber

- IEEE 10GE spreadsheet (10GEPBud3_1_16a.xls; Tab = “850S2000”)
  a) Modal Bandwidth: 2000 MHz*km
  b) Target Reach: 0.3 km OM3
  c) Disp. Min Uo: 1316 nm
  d) Disp. So: 0.10275 ps/nm^2*km
  e) RIN: -130 dB/Hz
  f) Risetime: Ts(20-80): 35 ps
- Calculated Margin for OM3: ≥ 0.8 dB

BW (MHz*km)	**Wavelength**	**Uw** (nm)	**TX_{OMA}** (dBm)	**OM3 Margin @ 300m** (dB)
2000	840	0.45	-2.8	**1.11**
		0.35	-3.5	**0.96**
		0.25	-3.9	**0.88**

Exploring Margins on OM3 & OM4

Setting TX parameters to values that yield ~***ZERO*** margin for OM3

- IEEE 10GE spreadsheet (10GEPBud3_1_16a.xls; Tab = "850S2000")
  a) Modal Bandwidth: 2000 OM3; 4400 MHz*km OM4
  b) Target Reach: 0.3 OM3; 0.4 km OM4
  c) Disp. Min Uo: 1316 nm
  d) Disp. So: 0.10275 ps/nm2*km
  e) RIN: -130 **-> -128** dB/Hz
  f) Risetime: Ts(20-80): 35 **-> 43** ps
- As expected, OM4 is much more sensitive to Transmitter Spectral Width

BW (MHz*km)	**Wavelength**	**Uw** (nm)	**TX_{OMA}** (dBm)	**OM3 Margin @ 300m** (dB)	**OM4 Margin @ 400m** (dB)
OM3 = 2000 OM4 = 4400	840	0.45	-2.8	**-0.11**	**-0.09**
		0.35	-3.5	**-0.11**	**0.67**
		0.25	-3.9	**-0.12**	**0.99**