Single Mode Fibre Skew Variation and Link Models

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Skew Variation Introduction

During the discussion following the presentation of anslow_01_0907.pdf in Seoul, it was suggested that it might be useful to include the calculation of skew variation in a revised version of the fibre characteristics spreadsheet:

http://www.ieee802.org/3/hssg/public/tools/Fibre_characteristics_V_2_0.xls

This was done and the resulting spreadsheet sent to the HSSG exploder on 18 September msg00869.

Changes to the skew spreadsheet

The changes with respect to version 2.0 are:

- Where choices are made between fixed alternatives this is done via an in-cell dropdown.
- The worksheet is locked except for the input cells. Use Tools, Protection, Unprotect sheet to unlock (no password needed)
- The equations for dispersion, relative delay and loss have been made into user defined functions to make future modification of the worksheet easier.
- The curves of loss, dispersion and delay have been moved on to a separate sheet (Functions)
- The revision history has been captured on a separate sheet (Rev)
- This version only covers 4 channels of WDM. If other numbers of WDM channels emerge as we go forward, additional sheets can easily be added to cover them.

Single Mode Fibre Properties

Since there has only been two comments on this revised spreadsheet:

- The macros must be enabled for the functions to work, this should be mentioned in the notes.
- "bits" is ambiguous. In 802.3 "bit time" is a bit at the MAC. I expect here you mean a symbol period on the line. Better to call it UI

I have created Version 3.0 Draft 2 of the spreadsheet with these modifications as anslow_03_1107.xls.

Proposal: Add the spreadsheet contained in anslow_03_1107 to the HSSG Tools web page as Fibre characteristics V 3.0.

Link Models

Link model introduction

Previous Ethernet Task Forces have used Link Model spreadsheets to aid in developing the specification and to compare options see dawe_01_1106.pdf.

- Not a tool for developing product
- For verifying that the numbers in a technical proposal actually do add up and would deliver the performance claimed
- Can be used for refining spec numbers: "getting the last dB right"

Existing Link Models:

- Last version accepted by P802.3ae (10GbE) was 3.1.16a (aligned to D3.2/3).
- Last version accepted by P802.3ah (EFM) was EFM0_0_2.7 (aligned to D2.1)

- Most recent version accepted by P802.3av (10GEPON) link model V2.0

As for previous projects, it is likely that some form of link model will be required to support the development of specifications for 40 and 100 GbE, particularly if one of the chosen PMDs is 4 x 25 Gbit/s WDM

10G EPON link model (recent un-approved version)

	A	B	C	D	E	F
1	Parameter name	Value	Unit	Description	Value min	Value max
2						
3	Transmitter parameters					
4	ITU_ERnom	6.00	dB	Extinction Ratio used to convert average power values to OMA values	0.00	9.00
5	ITU_Tx_Ave_Min	2.00	dBm	Average output power in ITU format (min)	-99.00	99.00
6	ITU_Tx_Ave_Max	7.00	dBm	Average output power in ITU format (max)	-99.00	99.00
7	IEEE_Tx_OMA_Min	2.78	dBm	Average output power in IEEE OMA format (min)		
8	Tx_Wavelength_Min	1260.00	nm	Transmitter wavelength (min)	1200.00	1600.00
9	Tx_Wavelength_Max	1280.00	nm	Transmitter wavelength (max)	1200.00	1600.00
10	Tx_Wavelength_Uc	1270.00	nm	Transmitter wavelength (central wavelength)	1260.00	1280.00
11	Tx_Chirp_Parameter_Max	-2.00	-	Chirp parameter for transmitter signal (max) [C] (Normal DML's are negative)		
12	Tx_Data_Rate	10312.50	MBd	Effective data rate in Mbaud	9500	11500
13						
14	Link parameters					
15	Fibre_Attenuation_Curve	G652AB	-	Fibre attenuation curve type (lambda^-4,G652AB,G652CD models)		
16	Fibre_Attenuation_Curve_Type	min	-	Maximum / minimum value curve (not available for lambda^-4 model)		
17	Fibre_Attenuation_Base_Value	0.35	dB/km	Base fibre attenuation (for lambda^-4 model)	0	1
18	Fibre_Attenuation_Base_Wavelength	1270.00	nm	Base wavelength for fibre attenuation estimation		
19	Fibre_Attenuation_Value	0.40	dB/km	Fibre attenuation at base wavelength		
20	Channel_Length_Max	10	km	Maximum distance between an ONU and the OLT	0.5	20
21	Fibre_Loss	4.00	dB	Fibre (no connectors) CHIL @ Tx_Uc		
22	PSC_Split_count	16.00	-	Number of splitter ports (powers of 2 only)	2	64
23	PSC_Loss_Curve	max	-	Type of PSC loss curve (minimum, average and maximum types)		
24	PSC_Loss	14.93	dB	PSC induced CHIL		
25	SRS_Loss	1.00	dB	SRS induced nonlinear penalty (from other services)		10
26	Excess_Loss	0.07	dB	Connectors, splices and any other excess loss		
27	ITU_Optical_Path_Penalty	3.00	dB	Optical path penalty in accordance with ITU definition	0	5
28	Channel_Loss_Min	8.00	dB	Channel Insertion Loss (CHIL) (min) - user input	0	20.00
29	Channel_Loss_Max	20.00	dB	Channel Insertion Loss (CHIL) (max)		29
30	Dispersion_Uo_Min	1300.00	nm			
31	Dispersion_Uo_Max	1324.00	nm			
32	Dispersion_So	0.09	ps/nm^2·km			
33	Dispersion_D_Max	-1.90	ps/(nm·km)			
34	Dispersion_D_Min	-6.42	ps/(nm·km)			
35	Dispersion_Penalty	-0.41	dB	Dispersion penalty calculated following 3av_0705_saeki_1.pdf		
36	TDP	1.00	dB	Transmitter Disperson Penalty	0	10
37						
38	Receiver parameters					
39	ITU_Rx_Sensitivity_Ave	-21.00	dBm	Average power receiver sensitivity @ BER 1e-3		
40	ITU_Rx_Sensitivity_Ave_OMA	-20.22	dBm	OMA receiver sensitivity (dBm) @ BER 1e-3		
41	ITU_Rx_Sensitivity_Ave_OMA	20.45	uW	OMA receiver sensitivity (uW) @ BER 1e-3		
42	IEEE_Rx_Stressed_Sensitivity_Ave	-18.00	dBm	Average stressed receiver sensitivity in IEEE formalism @ BER 1e-3		
43	IEEE_Rx_Stressed_Sensitivity_OMA	-17.22	dBm	OMA stressed receiver sensitivity in IEEE formalism (dBm) @ BER 1e-3		
44	IEEE_Rx_Stressed_Sensitivity_OMA	36.43	uW	OMA stressed receiver sensitivity in IEEE formalism (uW) @ BER 1e-3		
45	IEEE_Rx_Sen_OMA	-18.22	dBm	OMA ideal receiver sensitivity in IEEE formalism (dBm)		
46	IEEE_Rx_Sen_OMA	30.05	uW	OMA ideal receiver sensitivity in IEEE formalism (uW)		
47	Rx_Overload	-1.00	dBm	This is what the overload needs to be...		
48						
49	Check Conditions					
50	Dispersion_Penalty <= ITU_Optical_Path_Penalty			PASSED		

This is an updated version of P802.3av (10GEPON) link model (V2.1) msg00774

10G EPON model

Features of the 10G EPON spreadsheet so far include:

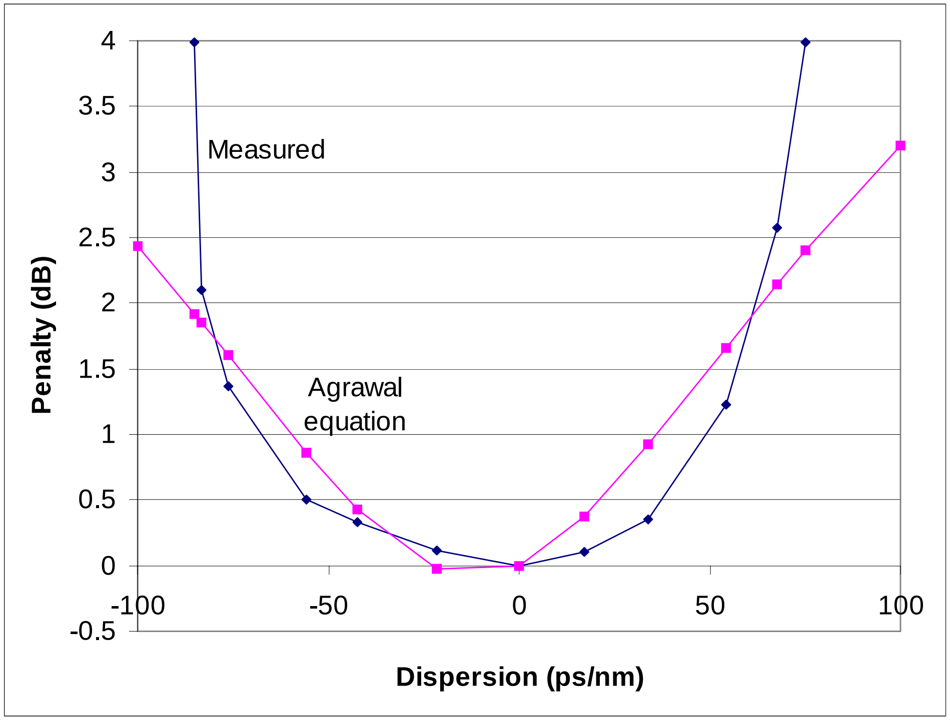
- Much simpler tool – only calculates losses and dispersion penalty
- Many effects (e.g. RIN, reflection noise) not included
- Loss of G.652.A&B and G.652.C&D included. (Same as in HSSG Fibre characteristics V 2.0)
- Splitter loss included (dependent on split ratio)
- Dispersion penalty calculated from equation from G. P. Agrawal, Fiber-Optic Communication Systems, Third edition. See 3av_0705_saeki_1.pdf

$$\mathrm{Pen} = 5\log_{10}\left(\left(1+8C\beta_2 B^2 L\right)^2 + \left(8\beta_2 B^2 L\right)^2\right) \qquad \beta_2 = -\frac{\lambda^2}{2c\pi} D$$

B = Bit rate, L = Fibre length, D = Dispersion per unit length,
λ = wavelength, C = Chirp parameter ≈ - α

10G EPON dispersion penalty equation

Comparing measured penalty vs. dispersion at 40 Gbit/s with the penalty predicted by the Agrawal equation with the best fit chirp parameter does not give very accurate results, but chirp is taken in to account (important for direct mod lasers).

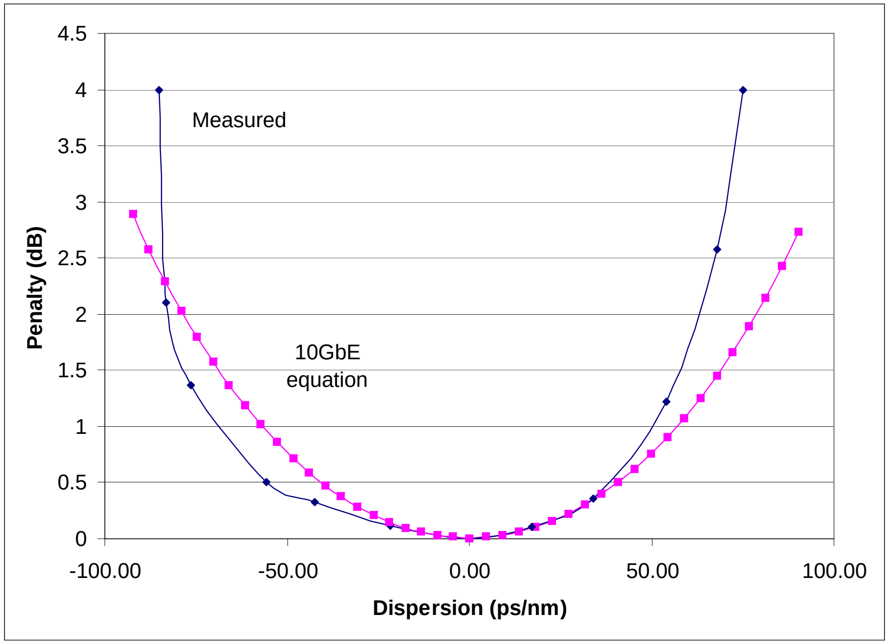


Measured values courtesy of Finisar

10G Ethernet dispersion penalty equation

Comparing measured penalty vs. dispersion at 40 Gbit/s with the penalty predicted by the 10Gb Ethernet spreadsheet with the best fit spectral width parameter gives a more realistic curve but does not take chirp in to account.

Measurements of penalty vs dispersion at 25.8 Gbit/s for the appropriate technology transmitters are required before we can assess the accuracy of any model.



Measured values courtesy of Finisar

40GbE and 100GbE requirements

Possible optical interfaces:

40 Gb Ethernet

- 100 m on Multimode – 4 x 10G?

100 Gb Ethernet

- 100 m on Multimode – 10 x 10G?
- 10 km Singlemode – 4 x 25G via WDM?
- 40 km Singlemode – 4 x 25G via WDM?

If this is what the Task Force chooses, then what link models will be needed?

- For 10G on multimode fibre propose use of existing link models
- For WDM (especially if it is at 25G) may need a revised or new model
    - The current spreadsheet format is getting cluttered and contains features that would not be required - may be unwieldy to modify this for multi-channel operation

Considerations for a WDM model at 25G

Effects that may need to be included:

- Multiplexer loss
- Demultiplexer loss
- Realistic fibre loss
- Dispersion penalty
- Inter-channel crosstalk
- Characteristics of amplifier in receiver for 40 km link?
- Others?

Before starting to generate such link model enhancements, we need to see measurement results:

- Penalty vs dispersion at 25.8 Gbit/s
- SOA distortion and crosstalk penalties
- Etc.

Thanks!

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