

Enhanced Spreadsheet Model for 10Gb/s MMF Links

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Why this presentation?

- Not to ask to change current Ethernet and FC spreadsheet models
- Not to offer new model (for now)
- Show what feature enhancements are possible
 - True signal propagation, eye diagrams
 - Possibility to include equalizer structures
 - Incorporation of models of arbitrary complexity
- Demonstrate user interface simplification

Modeling approach in the Ethernet spreadsheet model

- Assumes Gaussian signal shapes and transfer functions, uses approximate formulas
- Propagation effects can not be added in a simple manner
 - DMD effects and launch effects (pulse splitting etc.)
 - Group delay distortions
 - Chirp
 - Reflections
- Uses power model assumptions exclusively – not accurate for predicting 1300nm and 1550nm SMF link performance
- Uses effective baud rate instead of base rate to take into account deterministic jitter effects
 - Noise calculations affected (mode partition noise, RIN), chromatic dispersion effects affected
 - Jitter calculation affected
- Formula assumptions inaccurate for some noise models
 - Mode partition noise – continuum of modes is not valid assumption
- Low frequency cut-off added as a noise penalty, may be inaccurate

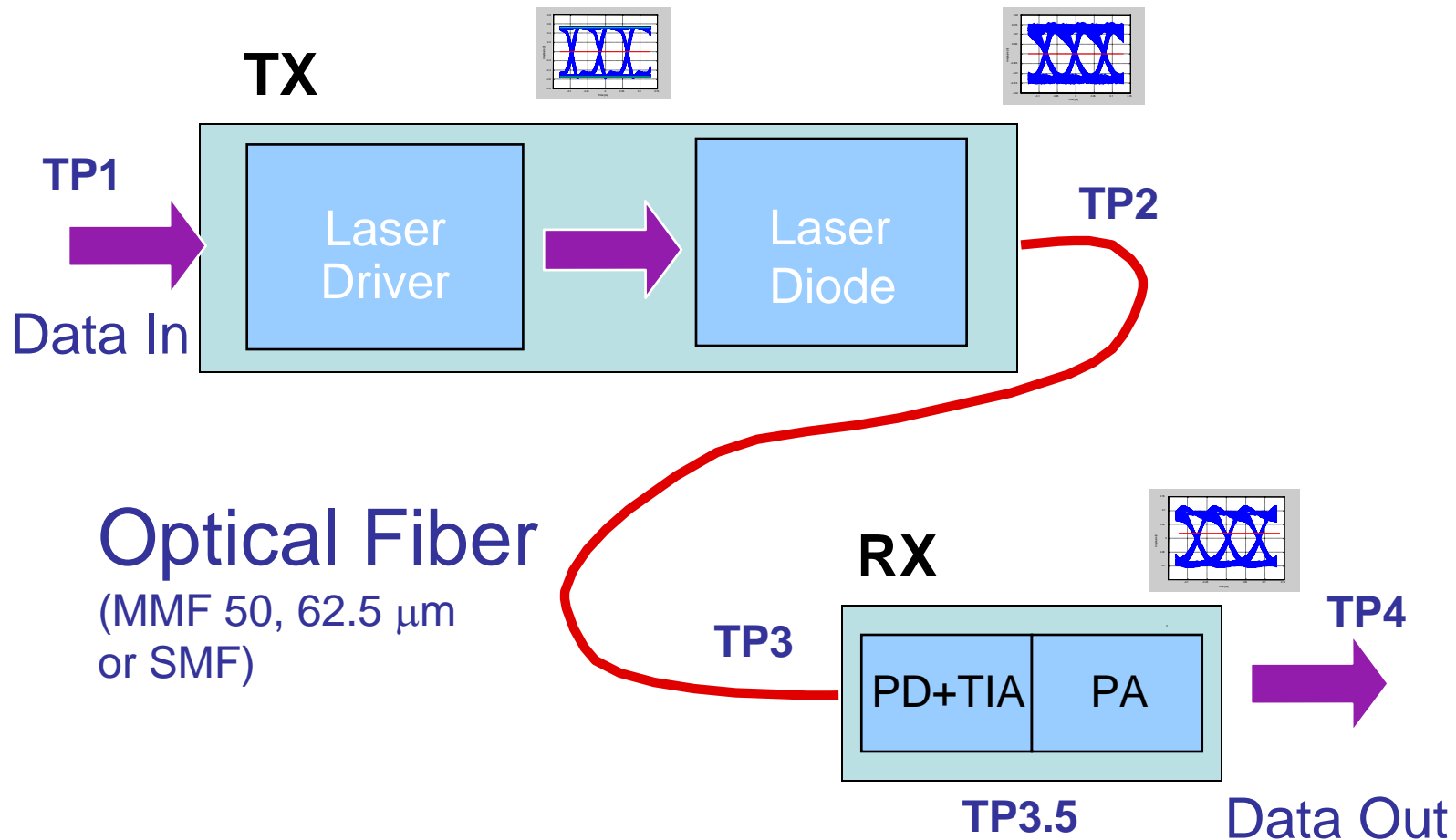
Why do we still use it?

- ✓ It is cost effective (free)
- ✓ Instant results – push of a button
- ✓ Runs on Excel – virtually on any PC
- ✗ Overestimates some and underestimates other penalties, overall accurate

Why do we need changes to the model?

- **Optimal trade-offs between link components may be affected, leading to higher total link costs**
- **Equalized links can't be easily simulated**

Typical Link Diagram



Excel Add-in

- Based on IBM Multimode Fiber Model presented at the January Interim in Vancouver, BC
- ✓ Models developed in Matlab were translated to C++, compiled and Excel add-in created
 - Retains advantages of full blown simulator
- ✓ Similar interface to existing Ethernet spreadsheet model
 - Fewer cells
 - Demo version does not have all bells and whistles
 - ✗ Takes ~10 sec to compute link budget for 10 lengths (CPU speed dependent)
- ✓ Creates eye diagrams
- ✗ User can't make changes to the compiled models
 - How much do we care about this?

Excel Add-in Interface

Microsoft Excel - ExcelPort4 with MPD.xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

Q10

System Parameters				Transmitter Parameters				Fiber Parameters				Receiver Parameters				Testing		For VQTO Model	
Base Rate	10312.5 MBd	λ_0	850.00 nm	N.L.	Type	1 (1-MMF, 2-SMF)	Sensitivity/OMA	-11.1 dBm	BW	7500 MHz	MPD	0.0428	-0.2442	7					
Q-factor	7.04	σ_1	0.30 nm	N.L.	Core Size	50 μ m	PN bandwidth	8250 MHz	ER	6 dB	Delays	0.0824	0.0221	5					
Initial Length	0.2 km	OMA _{ext}	-3.80 dBm	N.L.	Att. at 850nm	3.5 dB/km	Filter Order	1 dB				0.0431	0.0441	5.00E-11					
Length Increment	0.025 km	P_{max}	-2.03 dBm	N.L.	Att. at 1310nm	0.4 dB/km	LowFreqCutoff	30 kHz				0.0587	0.0882						
Number of Incr.	11	$T_s(20-80)$	35.00 ps	N.L.	Zero disp. λ	1320 nm	RefI2	-12 dB				0.0343	0.0926						
Pattern Type	1 (1-RAND, 2-K285)	Filter order	1	N.L.	C_{att}	1						0.0521	0.097						
Pattern Length	400 bits	Bandwidth	6.59E+03 MHz	N.L.	S_v	0.11 ps/(nm ² km)						0.0361	0.1014						
Samples/bit	32	RI/N	-128 dB/Hz	N.L.	Effective BW	2000 MHz ² /km						0.0389	0.1058						
Show Eye Diagram	1 (1-Yes, 0-No)	RI/coef	0.7 (not used)	N.L.	OFL	1500 MHz ² /km						0.0388	0.1102						
Edge reference	1 (1 for MEAN)	DCD	0.5	N.L.	Flat/DMDmask	0.33 psm						0.0296	0.1146						
Modal Noise Pen	0.3 dB	DJ	0.07 μ i.	N.L.	PMD DGD max	0.3						0.037	0.119						
		PreFill	-12 dB	N.L.	FiberModel	0 (1 for LP)						0.0255	0.1234						
		MPN k	0.4	N.L.	Connections	2 dB						0.0318	0.1278						
			2	N.L.								0.0242	0.1322						
			Spectrum	N.L.								0.0258	0.1366						
			1 (1-GAU, 2-LOR)	N.L.								0.0232	0.1409						
			Nmodes	N.L.								0.0201	0.1561						
			1 <4	N.L.								0.0185	0.1712						
			Type	N.L.															
			VCSEL (or FP, DFB)	N.L.															
			Mode sep	N.L.															
			0.7 nm	N.L.															

Noise Penalties														
L	Patt	Ch. IL	Pisi TP35	DJ TP35	Pisi TP3	DJ TP3.5	Pmpn	Prin	Other pe	Pmn	Total LP Pen	Ptotal	Margin	SRS
0.20	0.70	2.70	153	152E-12	103	2.27E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.23	0.79	2.79	185	3.03E-12	111	152E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.25	0.88	2.88	177	3.79E-12	120	3.03E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.28	0.96	2.96	189	4.55E-12	129	3.03E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.30	1.05	3.05	200	4.55E-12	138	4.55E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.33	1.14	3.14	211	6.06E-12	146	4.55E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.35	1.23	3.23	224	6.82E-12	157	5.30E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.38	1.31	3.31	238	6.82E-12	168	5.30E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.40	1.40	3.40	252	6.82E-12	180	5.30E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.43	1.49	3.49	267	7.58E-12	193	6.06E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91
0.45	1.58	3.58	282	8.33E-12	208	6.06E-12	0.00	0.00	0.00	0.00	1.04	1.04	2.66	-6.91

Figure No. 1

Using MMF Model

Amplitude

Time [Bit Intervals]

Distance [km]

Delays

Conclusion

- Signal propagation based models are more flexible, potentially more accurate
- Use of Excel Add-ins Enables:
 - Retain familiar user interface suitable for most users
 - May offer better trade-offs
 - May simplify the spreadsheet (eliminate unnecessary cells), artificial accounting for jitter
 - Possible to add arbitrarily complex device models
 - Possible to include various equalizer structures
- How do we proceed from here?