



T e c h n o l o g y t o t h e C o r e

Link Budget Analysis for CX4 **Ze'ev Roth, Dimitry Taich**

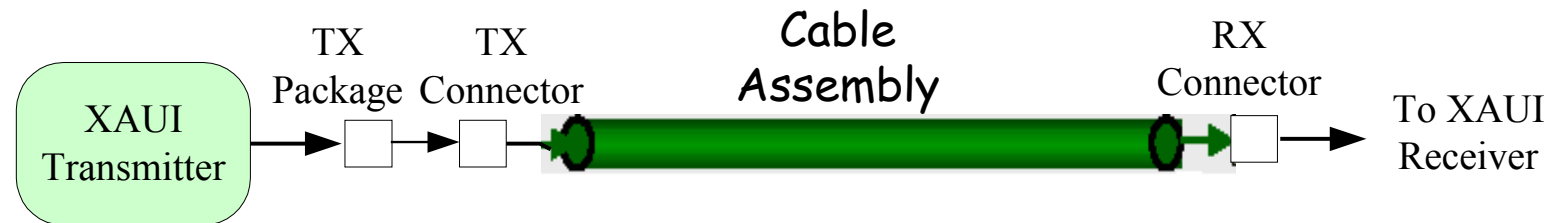
Overview

- Link budget calculation
- Two proposals for Technical Spec
- Simulation results for “Worst Case Compliant Channel”
- Delay
- Summary and Conclusions

Link Budget

- Objective is to get insight for eye opening at receiver by considering 3 data streams:
 - Low frequency 11111 00000 11111 ...
 - Mid frequency 11 00 11 00 ...
 - High frequency 101010 ...
- Neglecting jitter, return loss and cross-talk

System Description



Link Budget Elements

- Assumption: Assembly loss comprised of:
 - Cable having 1.04dB/meter loss
 - Connectors having 2dB insertion loss
- Therefore in calculating the loss for 10 meters assembly
 - Only cable related loss is factored

Case A:15m Worst Case Cable Assembly

CX4 Link Budget									
Symbol rate	3.13E+09	Hz							
pi	3.141592654								
Preemphasis	0.5	67%	using CX4 definition for pre-emphasis						
Cable length	15	Meters	Assume Chris's Model						
Connector Loss	-0.25	dB	Very optimistic						
Loss[dB]				Eye opening at receiver input					
Point in Path	Flow	Fmid	Fhigh	Launch voltage	Flow	Fmid	Fhigh		
	3.125E+08	7.813E+08	1.563E+09	1200	241	278	96		
Tx package	0	-0.13	-2	1000	201	232	80		
Preemphasis	-7.08	-2.55	0	800	161	185	64		
Tx connector	-0.25	-0.25	-0.25						
Cable Assembly	-6.37	-9.52	-19.42						
Rx connector	-0.25	-0.25	-0.25						
Equalizer	0	0	0						
Total Insertion Loss [dB]	-13.9	-12.7	-21.9						
voltage ratio	4.98	4.32	12.47						

Case B: 15m, 3dB Improved Assembly

CX4 Link Budget								
Symbol rate	3.13E+09	Hz						
pi	3.141592654							
Preemphasis	0.45	62%	using CX4 definition for pre-emphasis					
Cable length	15	Meters						
Connector Loss	-1	dB						
Cable improvement	3	dB	Improved worst case cable assembly (15m: 16.4dB loss @ 1.56GHz)					
Loss[dB]				eye opening at receiver input				
Point in Path	Flow	Fmid	Fhigh	Launch voltage	Flow	Fmid	Fhigh	
	3.125E+08	7.813E+08	1.563E+09	1200	203	205	114	
Tx package	0	-0.13	-2	1000	169	171	95	
Preemphasis	-6.47	-2.43	0	800	135	137	76	
Tx connector	-1	-1	-1					
Cable Assembly	-7.0	-10.8	-16.4					
Rx connector	-1	-1	-1					
Equalizer	0	0	0					
Total Insertion Loss [dB]	-15.4	-15.3	-20.4					
voltage ratio	5.90	5.85	10.50					

Case C: 15m, 6dB Improved Assembly

CX4 Link Budget							
Symbol rate	3.13E+09	Hz					
pi	3.141592654						
Preemphasis	0.45	62%	using CX4 definition for pre-emphasis				
Cable length	15	Meters					
Connector Loss	-1	dB					
Cable improvement	6	dB	Improved worst case cable assembly (15m: 13.4dB loss @ 1.56GHz)				
Loss[dB]				eye opening at receiver input			
Point in Path	Flow	Fmid	Fhigh	Launch voltage	Flow	Fmid	Fhigh
	3.125E+08	7.813E+08	1.563E+09	1200	218	244	162
Tx package	0	-0.13	-2	1000	181	203	135
Preemphasis	-6.47	-2.43	0	800	145	163	108
Tx connector	-1	-1	-1				
Cable Assembly	-6.4	-9.3	-13.4				
Rx connector	-1	-1	-1				
Equalizer	0	0	0				
Total Insertion Loss [dB]	-14.8	-13.8	-17.4				
voltage ratio	5.51	4.92	7.43				

Case D: 10m Worst Case Cable Assembly

CX4 Link Budget								
Symbol rate	3.13E+09	Hz						
pi	3.141592654							
Preemphasis	0.36	53%	using CX4 definition for pre-emphasis					
Cable length	10	Meters						
Connector Loss	-1	dB						
Loss[dB]				Eye opening at receiver input				
Point in Path	Flow	Fmid	Fhigh	Launch voltage	Flow	Fmid	Fhigh	
	3.125E+08	7.813E+08	1.563E+09	1200	249	245	146	
Tx package	0	-0.13	-2	1000	208	204	122	
Preemphasis	-5.29	-2.14	0	800	166	163	98	
Tx connector	-1	-1	-1					
Cable Assembly	-6.37	-9.52	-14.28					
Rx connector	-1	-1	-1					
Equalizer	0	0	0					
Total Insertion Loss [dB]	-13.7	-13.8	-18.3					
voltage ratio	4.82	4.89	8.20					

Case E: 10m 3dB Improved Assembly

CX4 Link Budget								
Symbol rate	3.13E+09	Hz						
pi	3.141592654							
Preemphasis	0.3	46%	using CX4 definition for pre-emphasis					
Cable length	10	Meters						
Connector Loss	-1	dB						
Cable improvement	3	dB	Improved worst case cable assembly (15m: 16.4dB loss @ 1.56GHz)					
Loss[dB]				eye opening at receiver input				
Point in Path	Flow	Fmid	Fhigh	Launch voltage	Flow	Fmid	Fhigh	
	3.125E+08	7.813E+08	1.563E+09	1200	287	283	184	
Tx package	0	-0.13	-2	1000	239	236	153	
Preemphasis	-4.46	-1.9	0	800	191	189	123	
Tx connector	-1	-1	-1					
Cable Assembly	-6.0	-8.5	-12.3					
Rx connector	-1	-1	-1					
Equalizer	0	0	0					
Total Insertion Loss [dB]	-12.4	-12.6	-16.3					
voltage ratio	4.18	4.24	6.52					

Observation 1

- Using worst case cable
 - for 15m the eye opening at receiver is too small
 - Need margin to account for jitter, reflections and cross-talk
 - for 10m the eye opening at receiver is ok
 - Assuming 100mv p2p requirement at receiver
- Using only pre-emphasis one can not overcome a 15m worst case cable assembly
 - Either:
 - Make do with 10m
 - Improve cable spec
 - Require both pre-emphasis and equalizer

Proposal for CX4 - A

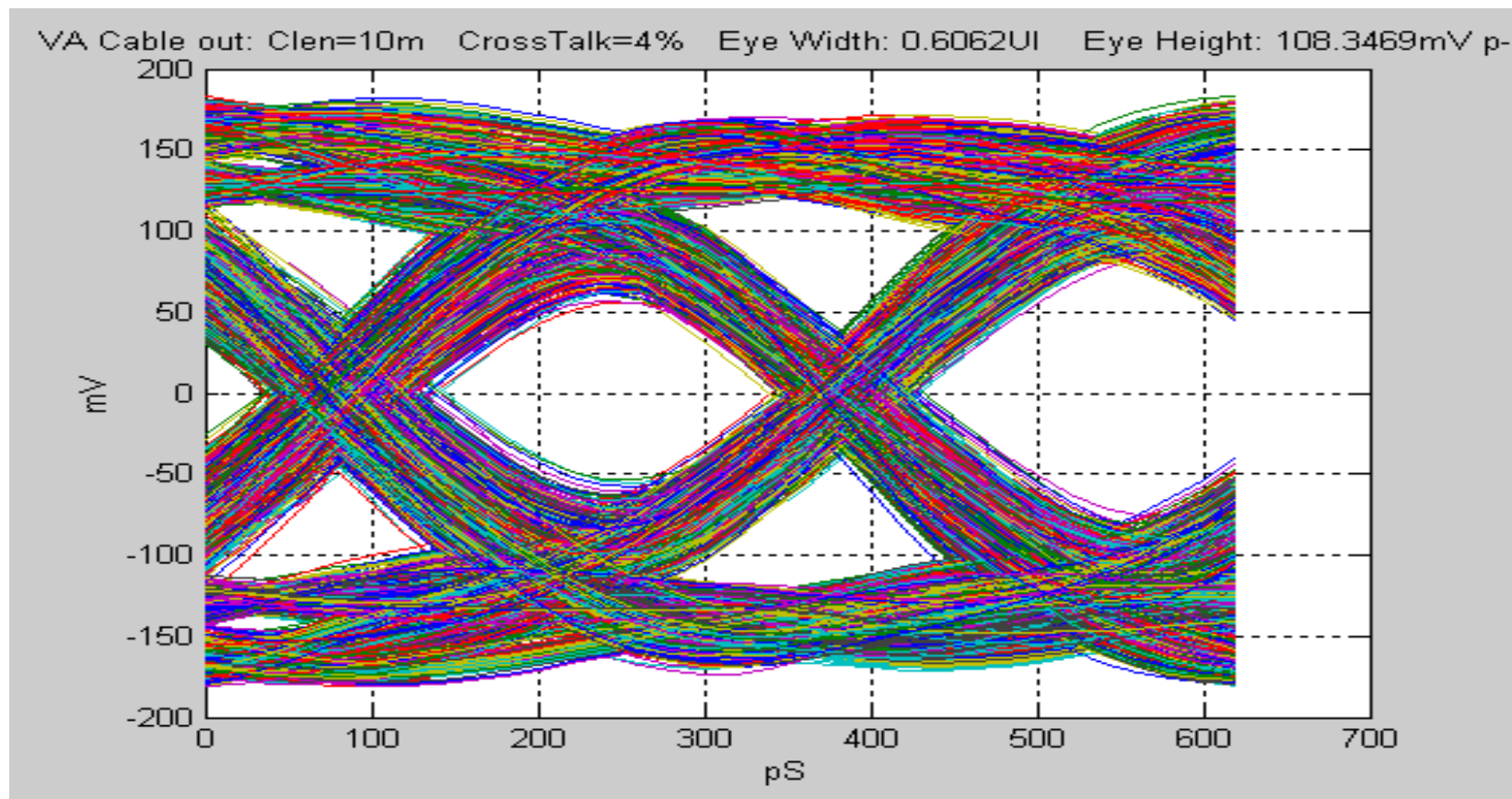
- Assuming little or no cable improvement
 - Compatible channel is 10m cable assembly
 - Pre-emphasis only for 10m
 - Equalizer required (on top of pre-emphasis) for 15m
 - Requirements at BOTH Tx AND Rx
 - Rx eye opening @10m 100mv p2p
 - Rx jitter @10m as XAUI
 - BER at Rx $< 1e-12$
 - For any cable length $\geq 10m$

Proposal for CX4 - B

- Assuming cable improvement
 - 13.4dB @ 1.56GHz for 15m cable
- Specification
 - 15m cable assembly
 - Pre-emphasis only (equalizer at receiver not required)
 - Requirements at BOTH Tx AND Rx
 - Rx eye opening 100mv p2p (at 15m)
 - Rx jitter as XAUI (at 15m)
 - BER at Rx < 1e-12

Simulation Results 10m Worst Case Assembly

4% Cross-Talk, 2dB Connector loss
 $V_{\text{peak}}=0.5\text{V peak}$ Pre_Emphasis = 36%



Delay Requirement

- CX4 is mainly intended for chassis to chassis interconnections (see Bruce's "Market Potential" presentation in Hawaii) - in these application there is no need to restrict the latency to 512BT as specified in the XAUI specification. Increasing that number – or even leaving it unspecified - will allow in future advanced DSP technique (like FEC) sufficiently increases operation distance and/or improve BER.

Summary and Next Steps

- Link budget at 1.56GHz is a good estimator for eye-opening
 - Need margin (10%-20%) to account for jitter + cross-talk effects
- Worst case channel currently defined (-19.4dB loss @1.56GHz) can not be solved by pre-emphasis alone
- It seem that “worst case channel” should be improved,
 - both cable and connectors
- Recommend to define “compatible channel” as 10m assembly
 - 15m used through combination of pre-emphasis and equalization