100 Gbps Copper Cable Channels

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Integrated Products Division

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Presentation Objectives

- Evaluate ability to manufacture 100Gbps copper cable assemblies against proposed baseline limits
- Does a low loss high ILD channel, or a channel with a deep narrow suckout still support the Task Group objectives
- Provide worst case "passing" copper cable for analysis
- Provide worst case "passing" copper cable assembly measurements and channels for analysis
- Have an understanding of "Are the limits on the right track?"
- Do proposed limits produce channels that support Task Force objectives?

> - Support a BER of better than or equal to 10^{-12} at the MAC/PLS service interface

> - Define a 4-lane 100 Gb/s PHY for operation over links consistent with copper twin-axial cables with lengths up to at least 5m.

Contributors

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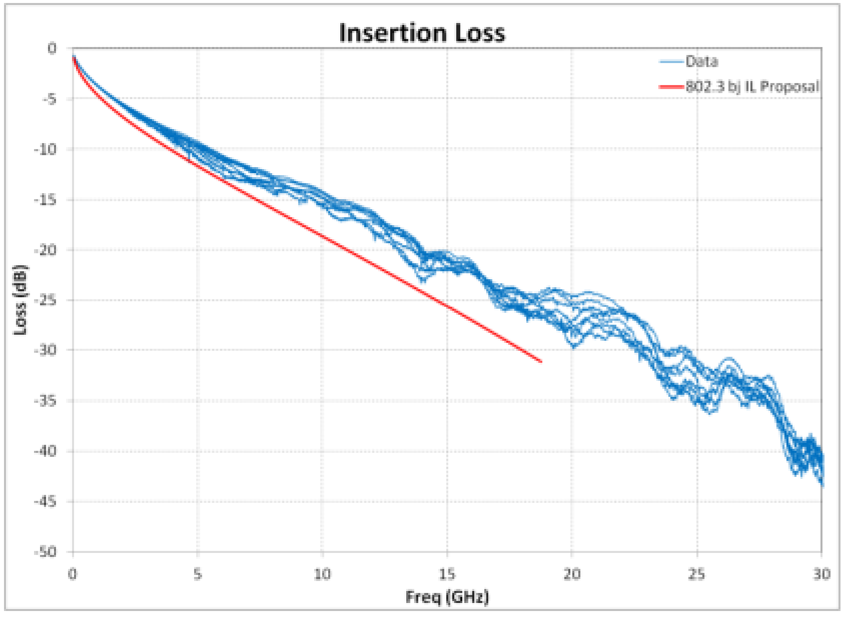
5m 24AWG Measured Data Test Setup

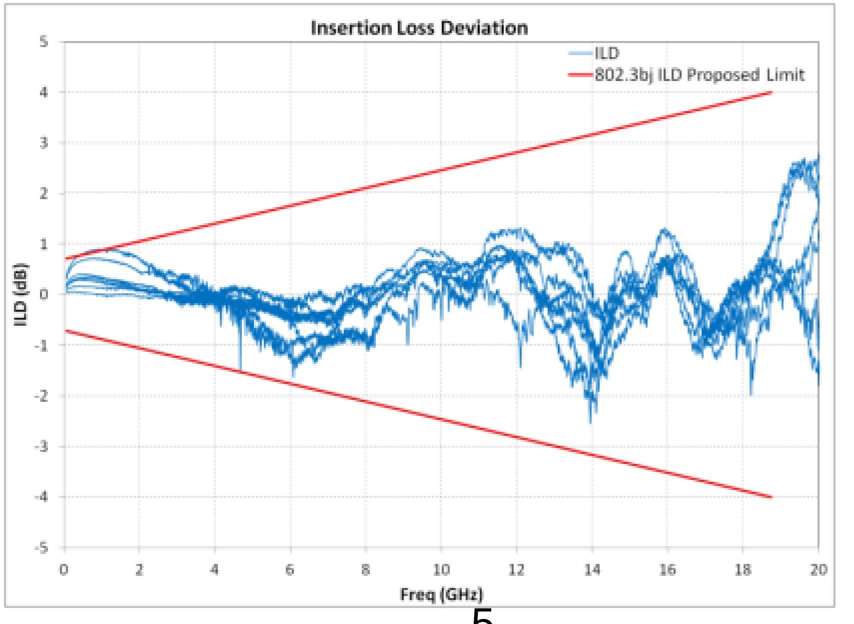
- **Measured 50MHz-40GHz**
- **10MHz step,1kHz IF Bandwidth**
- **Molex zQSFP+ test board (x2)**
  - Nelco 4000-13SI
  - 37.25mm trace
  - Board loss @12.89 GHz – 1.03 dB (x2) – diminico_01_0312.pdf suggests test fixture loss of 1.25dB, a difference of 0.22dB per end
- **Includes paddle card and cable termination losses (x2)**
- **Includes SMT connector loss (x2)**
- **ILD calculations per 802.3ba extended to 18.75GHz**
- **IL/ILD/RL limits as proposed in diminico_01_0312.pdf**

IL – Cable A –18.56 dB loss @12.89



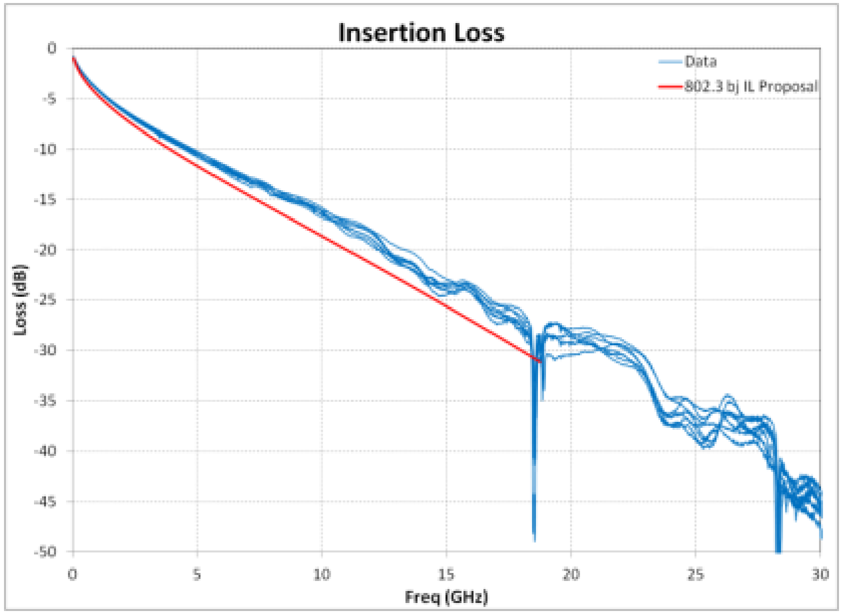
- Cable A meets proposed cable assembly IL limit

Limits per Diminico_01_0312.pdf



- Cable A nearly meets proposed cable assembly ILD limit
- Is the curve fit correct at the lower frequencies?
- High ILD through the measured bandwidth.
- ILD 0.89dB to -0.702dB at 12.89GHz

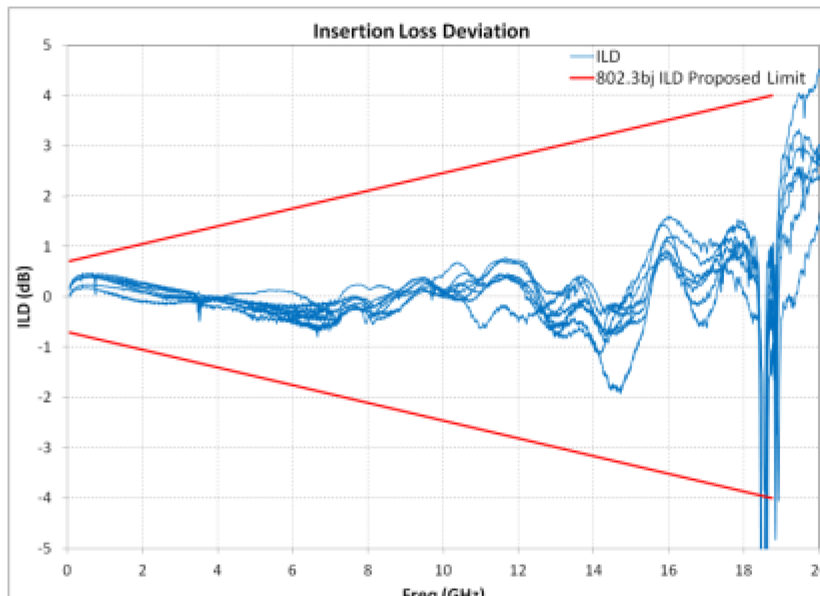
IL – Cable B –20.68 dB loss @12.89



- Cable A nearly meets proposed cable assembly ILD limit
- ILD 0.1dB to -0.651dB at 12.89GHz

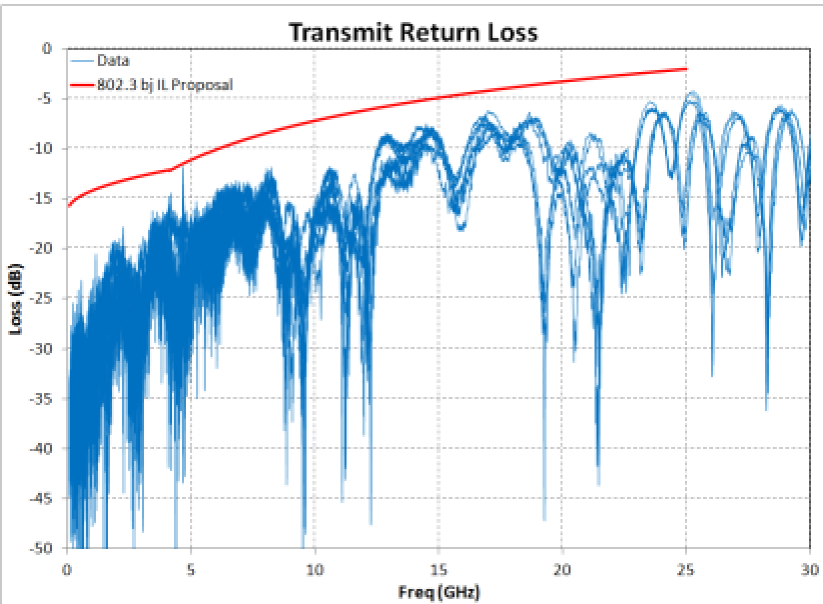
- Cable B misses proposed cable assembly IL limit at end of proposed frequency range.
- Deep narrow suckout

Limits per Diminico_01_0312.pdf

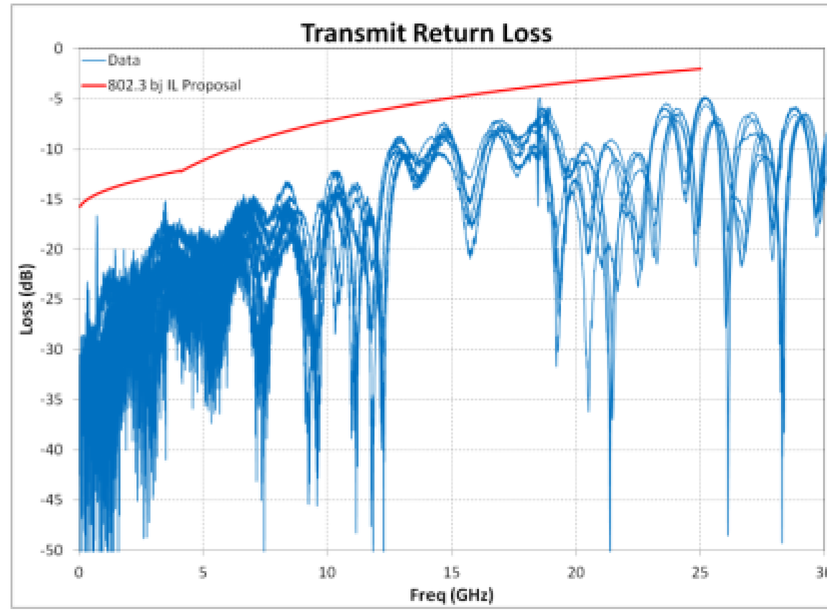


Return Loss – SDD11

Cable A



Cable B



- Both cables assemblies meet the proposed return loss limit

Limits per Diminico_01_0312.pdf

ICN

- **Assume MDFEXT and MDNEXT are calculated per 802.3ba with extended measurement range to 20GHz**

$$MDNEXT\_loss(f) = -10\log_{10}\left(\sum_{i=0}^{i=3\text{ or }9} 10^{-NLi(f)/10}\right)\text{(dB)} \quad (85\text{–}26)$$

$$MDFEXT\_loss(f) = -10\log_{10}\left(\sum_{i=0}^{i=2\text{ or }8} 10^{-NLi(f)/10}\right)\text{(dB)} \quad (85\text{–}27)$$

- **ICN Parameters**

Parameter	Value	Units	Explanation
Ant	1200	mV	Near End Disturber Diff. Output Amplitude
fb	25.78125	GBd	Symbol Rate (Given)
fn	Calculate	GHz	This is the frequency step
fnt	24.64	hertz	Constant of Proportionality (0.2365) = Tnt*Fnt, Tnt = 9.6ps
fr	20	GHz	3dB Reference Receiver Bandwidth
Aft	1200	mV	Far End Disturber Diff. Output Amplitude
fft	24.64	hertz	Constant of Proportionality (0.2365) = Tnt*Fnt, Tnt = 9.6ps

ICN Cont.

- **Extend ICN cable limits to 22.64 dB**

Cable A

P1 RX1		P2 RX1	
IL @ 5.15625GHz	ICN	IL @ 5.15625GHz	ICN
19.21452	3.008266378	19.42877	2.91379
P1 RX2		P2 RX2	
IL @ 5.15625GHz	ICN	IL @ 5.15625GHz	ICN
17.93161	3.344124887	17.7239	3.06897
P1 RX3		P2 RX3	
IL @ 5.15625GHz	ICN	IL @ 5.15625GHz	ICN
18.21257	2.663265064	18.03871	2.41855
P1 RX4		P2 RX4	
IL @ 5.15625GHz	ICN	IL @ 5.15625GHz	ICN
19.72026	2.965518333	18.17616	2.83286

Cable B

P1 RX1		P2 RX1	
IL @ 12.89GHz	ICN	IL @ 12.89GHz	ICN
21.28884	1.966020262	20.83558	2.302287
P1 RX2		P2 RX2	
IL @ 12.89GHz	ICN	IL @ 12.89GHz	ICN
19.50886	2.09344203	20.5627	1.968806
P1 RX3		P2 RX3	
IL @ 12.89GHz	ICN	IL @ 12.89GHz	ICN
20.84237	2.139436402	20.81699	2.191258
P1 RX4		P2 RX4	
IL @ 12.89GHz	ICN	IL @ 12.89GHz	ICN
20.57817	2.319157151	21.0176	2.313332

- Cable A has max ICN of 3.34mV
- Cable B has max ICN of 2.32 mV
- ICN values are expected to be higher is shorter cables
- Future work should include analysis of low loss higher ICN channels

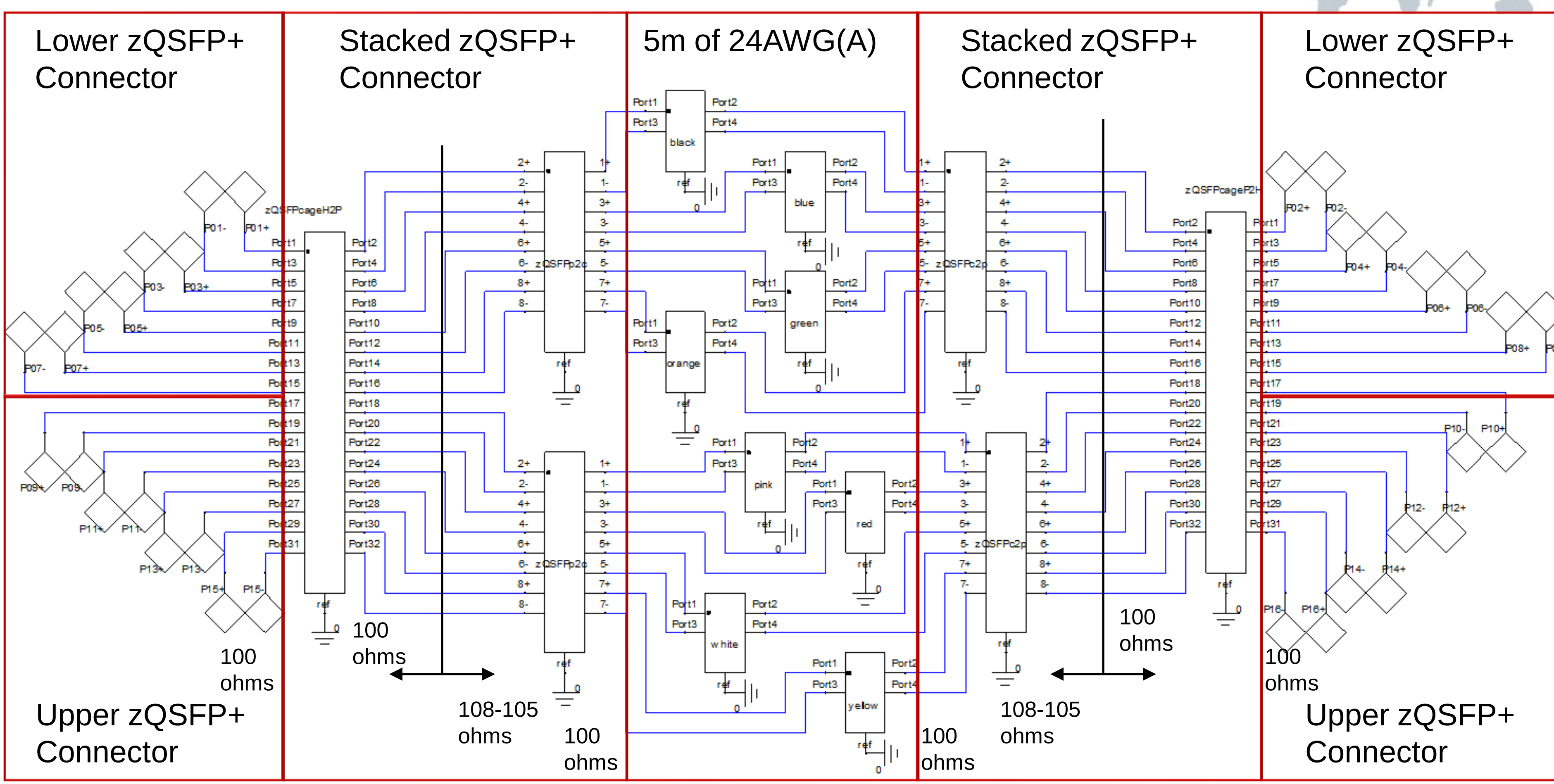
Measured Cable Assembly Summary

- Cable A is low loss but high ILD
- Cable B has higher loss with large narrow suckout at upper frequencies
- Would either or both of these cable assemblies meet the BER objective?
- Proposed limits appear to be a good starting point, but work needs to be done to validate values properly constrain channels

Full Cable Assembly Model

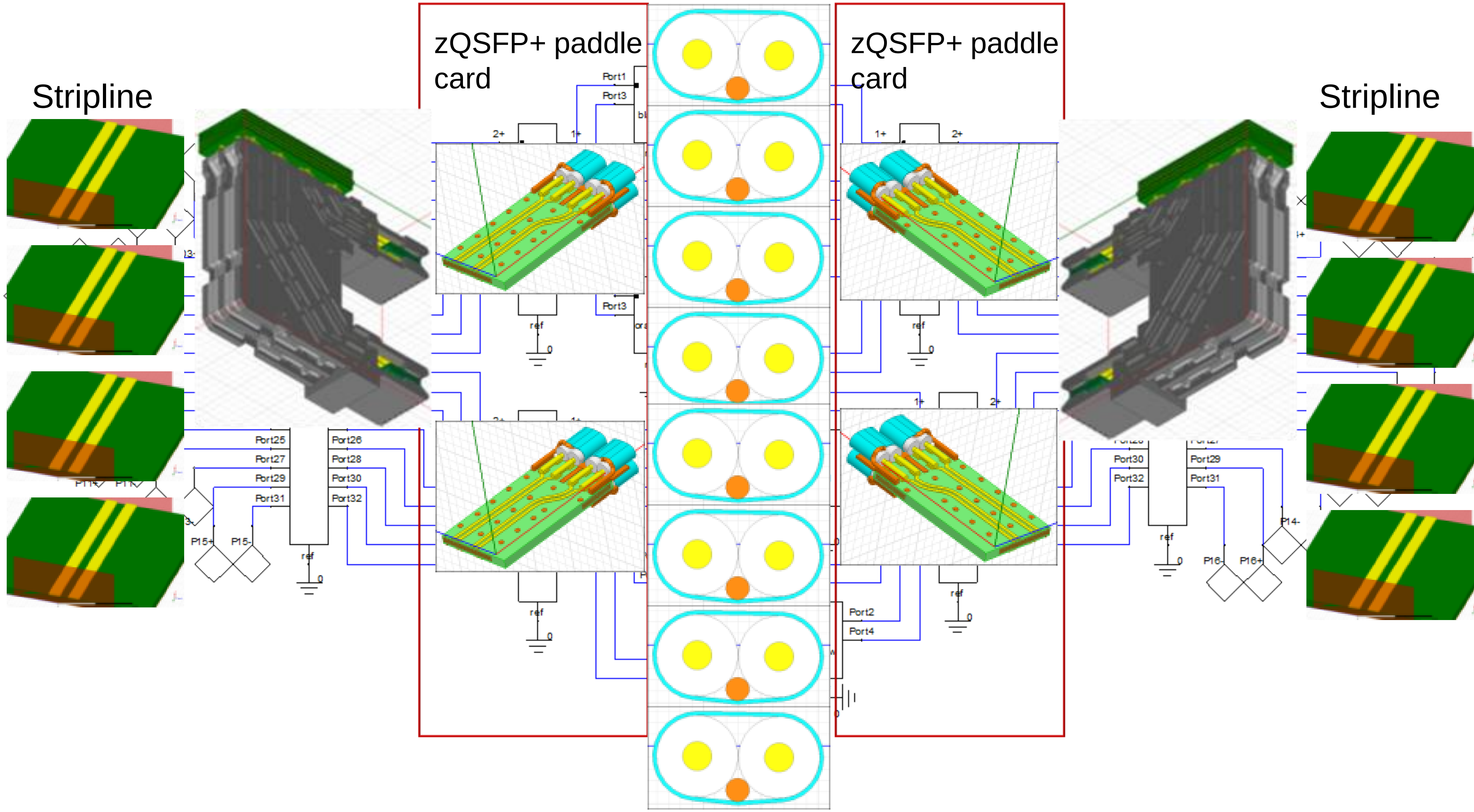
- 7.5" PCB trace. Measured trace includes SMA connections. Length chosen ONLY to meet loss objective.
- Stacked zQSFP+ connector 4 top ports, 4 bottom ports
- Paddle card and cable termination
- 5m measured raw cable. Cable A raw cable and Cable B raw cable were selected
- 4 channels representing standard and worst case performance

Schematic of Link

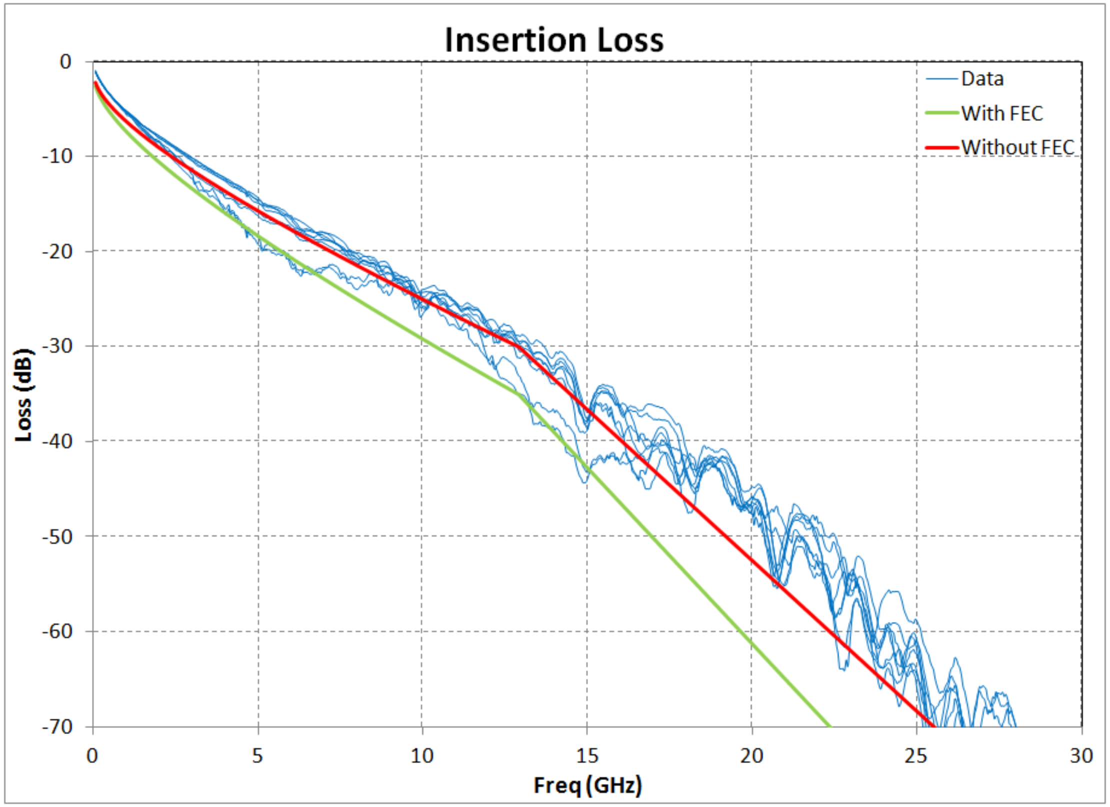


Note: PCB Trace with 2 SMA's on both ends not shown for simplification

Visually



Results of Full Link – Cable A



- 2 channels of Cable A miss all proposed limits
- 6 channels meet the proposed “With FEC” channel limits

* Does a low loss channel with higher ILD meet objectives?

Limits per Dudek_01_0312.pdf

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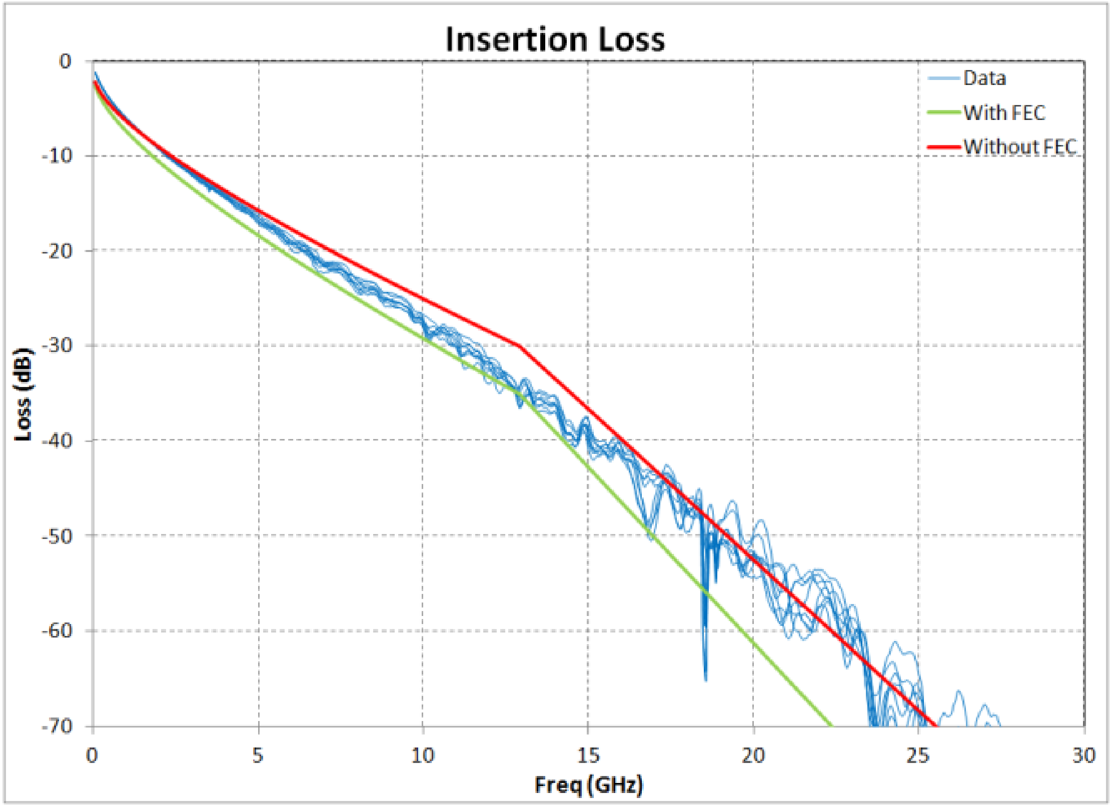
Results of Full Link – Cable B



- All channels of Cable B miss all proposed limits
- Several channels very close to compliance below 18GHz

* Is 26GHz measurement bandwidth necessary?

Limits per Dudek_01_0312.pdf

Contribution Summary

	Average Loss @12.89GHz	Proposed values in diminico_01_0312.pdf	Max Loss @12.89GHz (Outlier)
Cable Only A (5m 24AWG)	16.08 dB	17dB	18.62 dB
Cable Only B (5m 24AWG)	20.37 dB	17dB	20.78 dB
Paddle Card Interface	0.367 dB x2	0.5dB x 2	N/A
Mated Connector [Top]	0.950 dB x2	1.07dB x 2	0.987 dB
Mated Connector [Bottom]	0.800 dB x2	1.07dB x 2	0.836 dB
Host Loss (SMA+7.5"PCB+SMA)	5.83 dB x2	6.36dB x 2	N/A
Total Cable A	30.37 dB	35dB	30.91 dB
Total Cable B	34.66 dB	35dB	33.07 dB
Actual (Meas/Modeled) [from Full Link Simulation – Cable A]	**29 dB**	35dB	**34.9 dB**
Actual (Meas/Modeled) [from Full Link Simulation – Cable B]	**34.4 dB**	35dB	**36.4 dB**

The Host loss listed is a host loss approximation using calibration traces on a test fixture made of Nelco 4000-13SI and routed as a straight uncoupled stripline

Conclusion

- Measured data supports the baseline IL/RL cable assembly limits proposed in Diminico_01_0312.pdf
- Further work needs to be done to validate method and limits of ILD
- Modeled/Measured data supports the baseline IL channel limits proposed in Dudek_01_0313.pdf
- Further work needs to be done to validate necessary measurement bandwidth
- Further testing/Models should be used to evaluate limits of ICN and bandwidth.
- Future work should include dibit gain analysis, ILDrms and other analysis of channel constraint proposals
- Changes tightening the IL limits will put pressure on raw cable producers making economic feasibility more difficult to achieve