Refined Method for Restricting Micro-Reflections

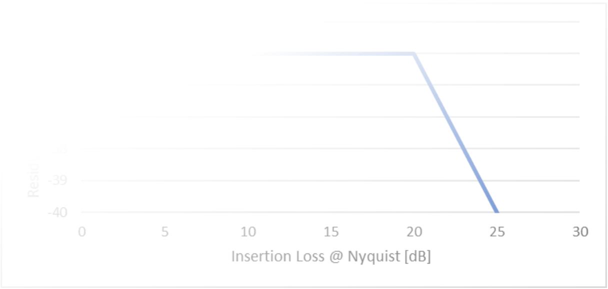
Contribution to IEEE 802.3cy

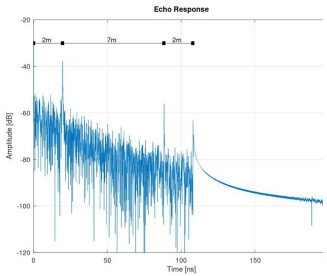
Ragnar Jonsson
Marvell

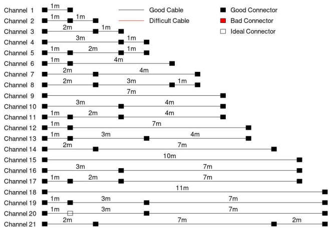
December 8, 2020

Introduction

- We present refinements to limits on micro-reflections that we had proposed earlier
- We use simulations to evaluate the suggested refinements
- The new limits on micro-reflections strike a balance between PHY Complexity and Cable Complexity

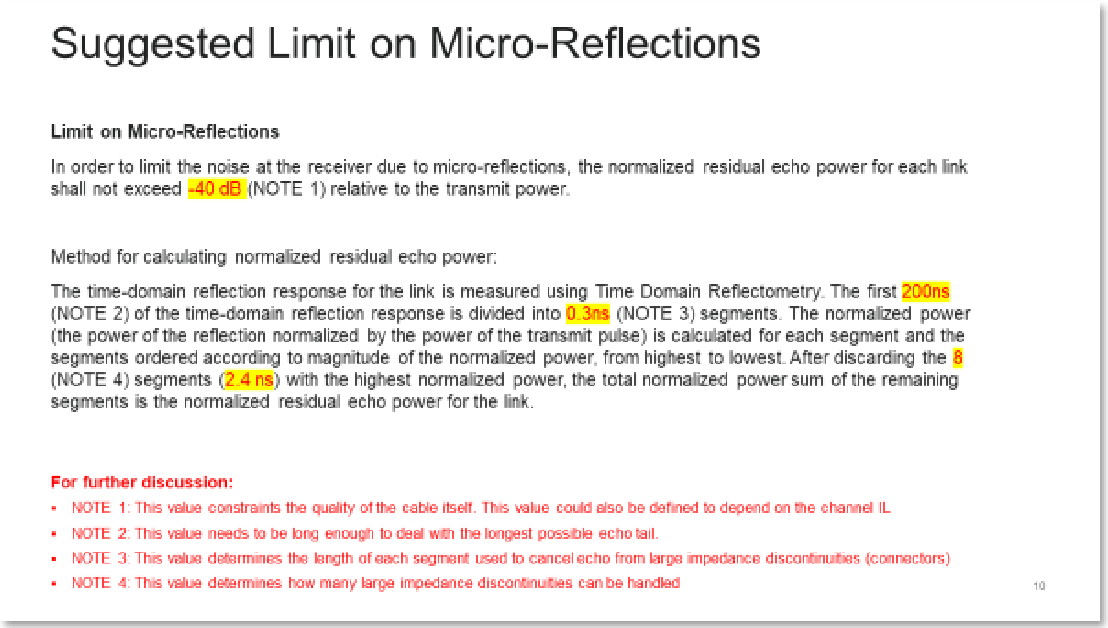






Background

- This presentation provides an updated version of the limit on micro-reflections suggested in [jonsson_3cy_01a_10_14_20] (see picture to the right)
- Instead of having a single threshold value -40dB, the threshold value depends on the Insertion Loss of the cable at Nyquist frequency (see next slide)



Refined Suggested Limit on Micro-Reflections

Limit on Micro-Reflections

In order to limit the noise at the receiver due to micro-reflections, the Residual Return Loss for each link shall not exceed the value determined by Equation (1) (NOTE 1) relative to the transmit power.

$$ResidualEchoLimit(IL@Nyquist) = MIN(-35, -IL@Nyquist - 15) \qquad (1)$$

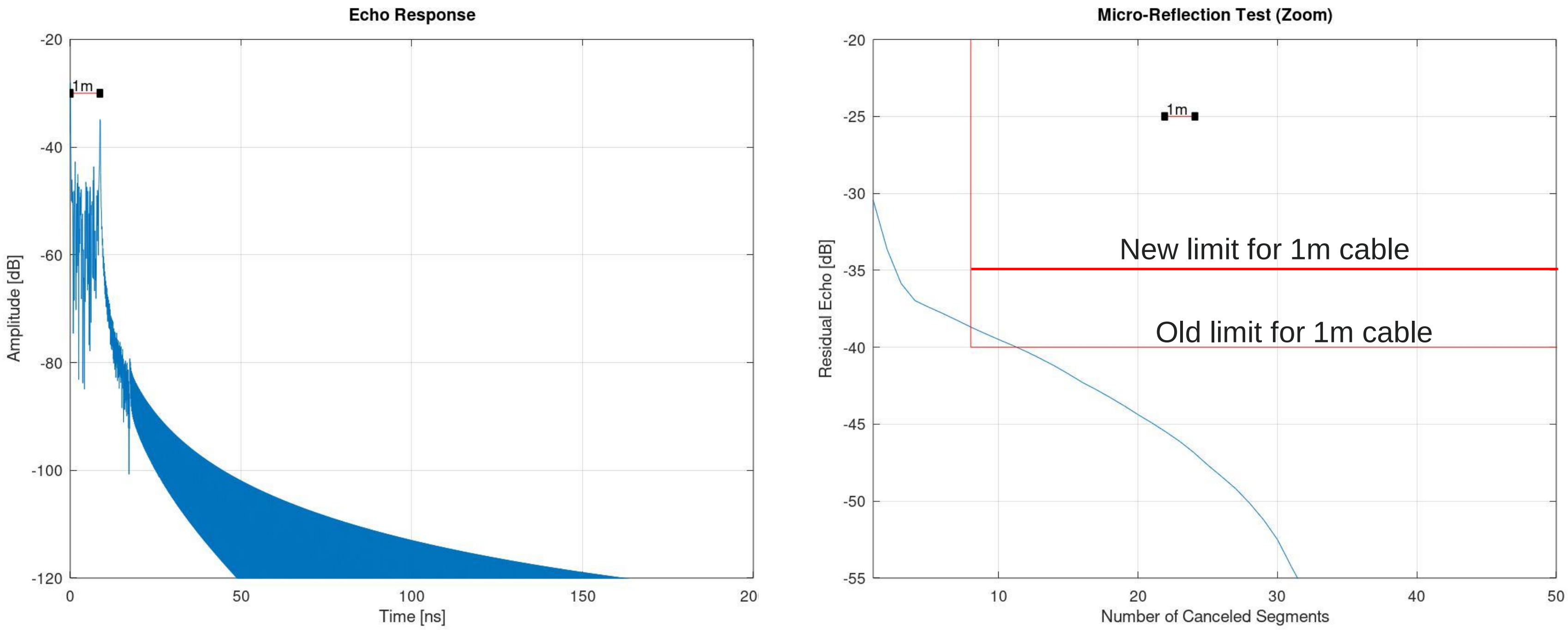
Method for calculating Residual Return Loss:

The time-domain reflection response for the link is measured using Time Domain Reflectometry. The first 200ns (NOTE 2) of the time-domain reflection response is divided into 0.3ns (NOTE 3) segments. The reflected power (the power of the reflection normalized by the power of the transmit pulse) is calculated for each 0.3ns segment. After discarding the 8 (NOTE 4) segments (2.4 ns) with the highest reflected power, the total reflected power of the remaining segments is the Residual Return Loss for the link.

For further discussion:

- NOTE 1: This value constraints the quality of the cable itself and exact values in Equation (1) need further evaluation
- NOTE 2: This value needs to be long enough to deal with the longest possible echo tail.
- NOTE 3: This value determines the length of each segment used to cancel echo from large impedance discontinuities (connectors)
- NOTE 4: This value determines how many large impedance discontinuities can be handled

Key Change In Refined Micro-Reflection Limit



Evaluating the Micro-Reflection Limit

- We use the Chanel Capacity Calculator presented in jonsson_3cy_01a_12_01_20 to evaluate the suggested limit for the Residual Return Loss for different cable lengths
- The micro-reflection level is set according to Equation (1)
- We calculate SNR Margin using model of SDP cables presented in mueller_3cy_01_12_01_20
- The calculations do not account for the Insertion Loss of the PCB

	Upstream	Downstream
Requrements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	11	11
Wire u-reflections [dB]:	-41.6408137	-41.6408137
Number of Connectors:	4	4
Modulation		
PAM Levels:	4	4
FEC Block Size (n):	360	360
FEC Data Size (k):	326	326
RS-FEC Correction Efficiency:	100%	100%
Bits per FEC Symbol:	10	10
TDD Time Duty-Cycle:	100%	100%
Framing Overhead:	1.875%	1.875%
Transmit Signal		
PSD-mask:	PSD_brick	PSD_brick
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-140
EC cancelation [dB]:	5	5
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	3	3
Simulation Parameters		
Cable Model:	mueller*sdp	
Connector Echo Model:	hard	
Temperature [°C]:	20	
Max Simulation Frequency:	9.00E+09	

Calculated Values		
	Upstream	Downstream
Theoretical Slicer SNR [dB]:	23.67	23.67
Estimated Slicer SNR [dB]:	20.67	20.67
Required Slicer SNR [dB]:	17.78	17.78
SNR Margin [dB]:	2.88	2.88
Nyquist Frequency [GHz]:	7.03	7.03
Insertion Loss @ Nyquist [dB]:	26.64	26.64

Micro-Reflections according to limit in Equation (1)

Assume 3dB Implementation Loss

Use SDP cable model

Margin must be positive

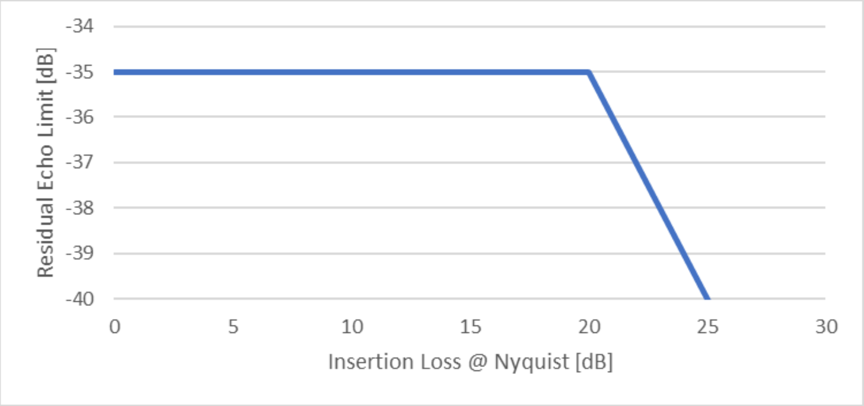
IL used in Equation (1)

Residual Echo Limit

Requrements						
Data Rate [Gbps]:	25	25	25	25	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12	1.00E-12	1.00E-12	1.00E-12	1.00E-12
Cable Length [m]:	1	3	5	7	9	11
Wire u-reflections [dB]:	-35.00	-35.00	-35.00	-35.00	-36.80	-41.64
Number of Connectors:	4	4	4	4	4	4

Calculated Values						
Theoretical Slicer SNR [dB]:	36.12	33.09	30.07	27.04	24.98	23.67
Estimated Slicer SNR [dB]:	33.12	30.09	27.07	24.04	21.98	20.67
Required Slicer SNR [dB]:	17.78	17.78	17.78	17.78	17.78	17.78
SNR Margin [dB]:	15.33	12.31	9.28	6.26	4.20	2.88
Nyquist Frequency [GHz]:	7.03	7.03	7.03	7.03	7.03	7.03
Insertion Loss @ Nyquist [dB]:	2.42	7.27	12.11	16.95	21.80	26.64

- The residual echo limit should be chosen such that it is the right tradeoff between cable and PHY complexity
- The limit plotted to the right is the limit given in Equation (1)
- The channel capacity calculator shows that this limit has positive SNR margin for all the simulated cases



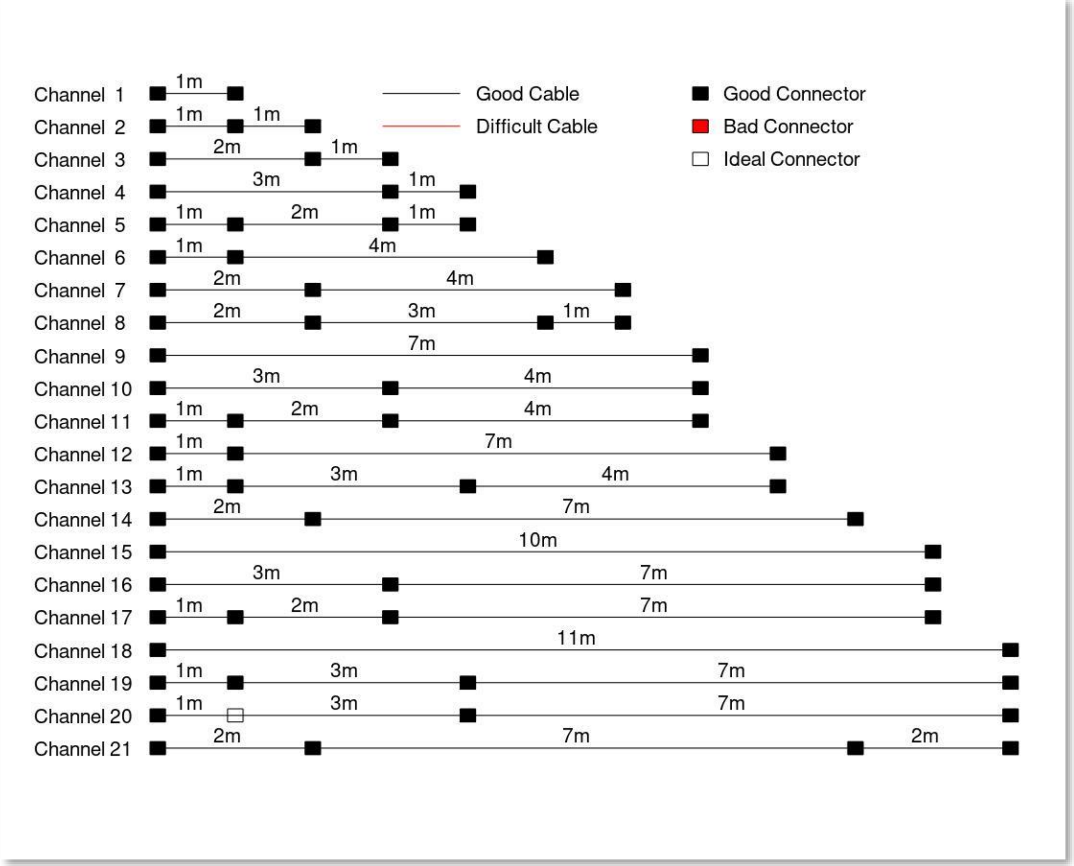
The exact limit levels need more discussion

Simulation Results

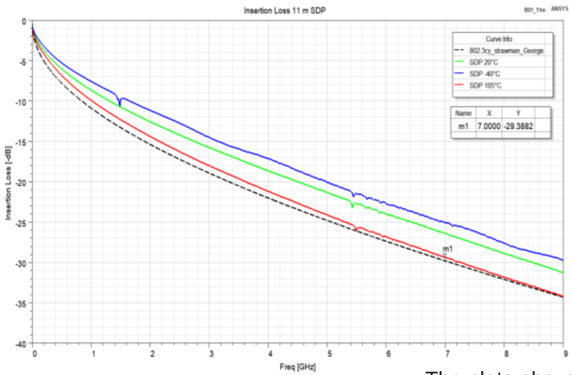
Evaluating micro-reflection limits for different cables

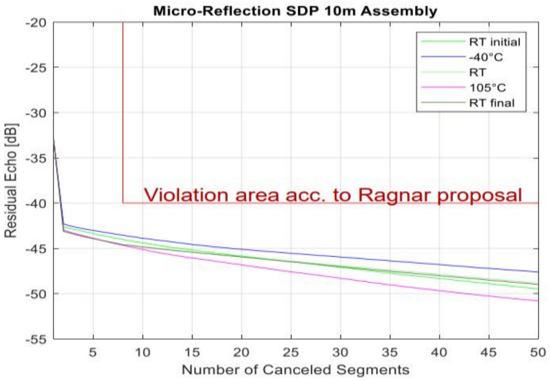
Simulating Many Cables

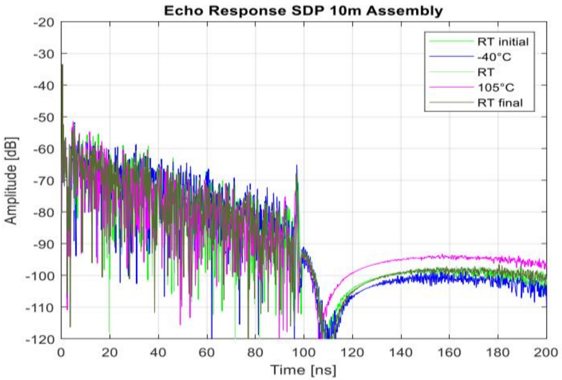
- We use the cable topologies shown to the right to evaluate the suggested micro-reflection limits
- These cable topologies are based on the table in [mueller_3cy_01a_10_21_20]() with minor updates
- We simulated Insertion Loss and Echo for bot SDP and STP cables presented in [mueller_3cy_01_12_01_20]()
- The simulations were done using the methodology described in [jonsson_3cy_01a_0720]()



Validating SDP Cable Model

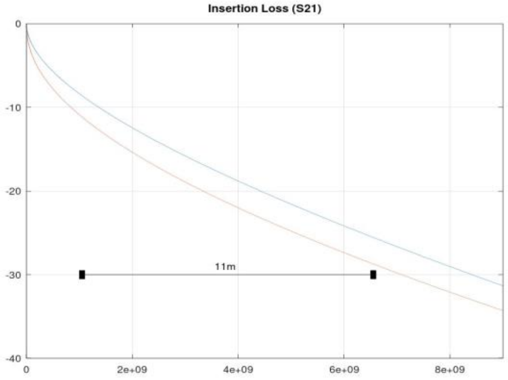


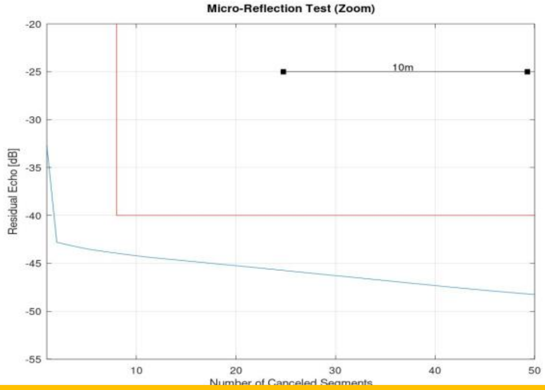


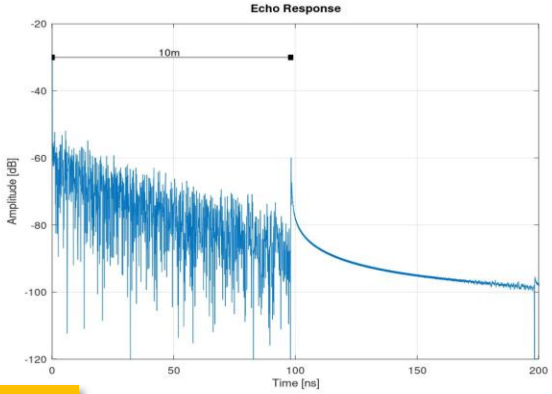


The plots above are from: https://www.ieee802.org/3/cy/public/adhoc/mueller_3cy_01_12_01_20.pdf

The plots below are from the SDP models used in this presentation

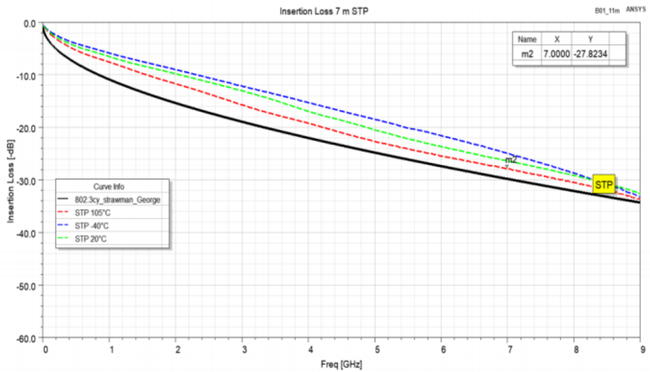


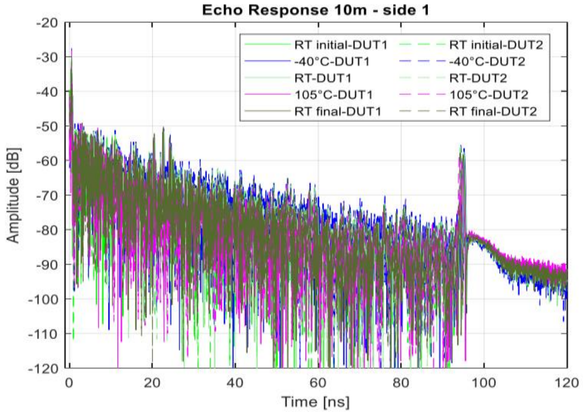




We have a good match for both Insertion Loss and Echo

Validating STP Cable Model

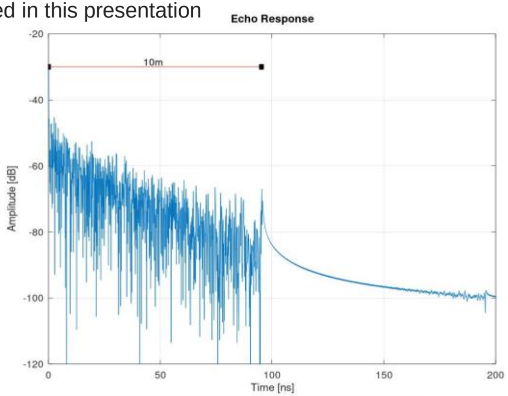




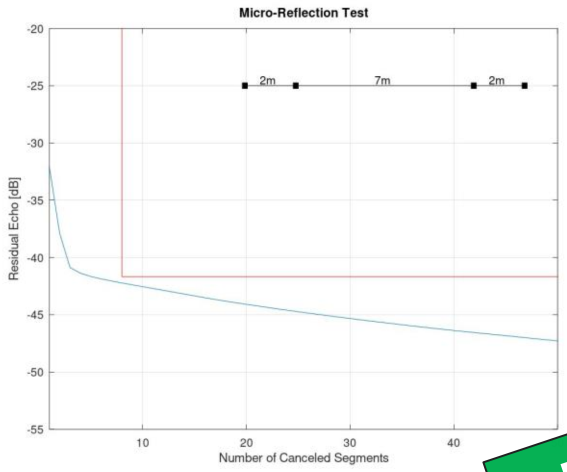
The plots above are from: https://www.ieee802.org/3/cy/public/adhoc/mueller_3cy_01_12_01_20.pdf

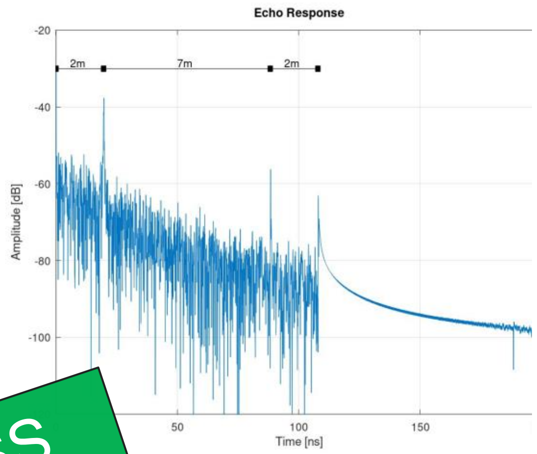
---

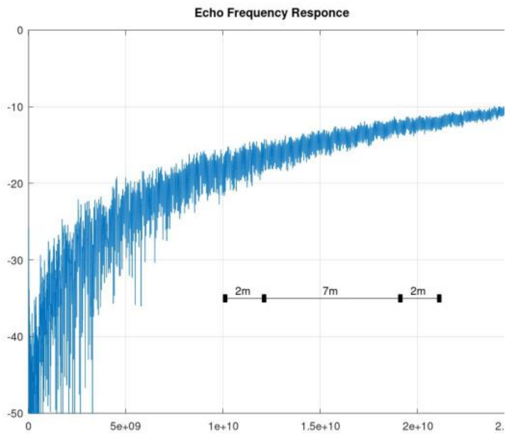
The plots below are from the SDP models used in this presentation



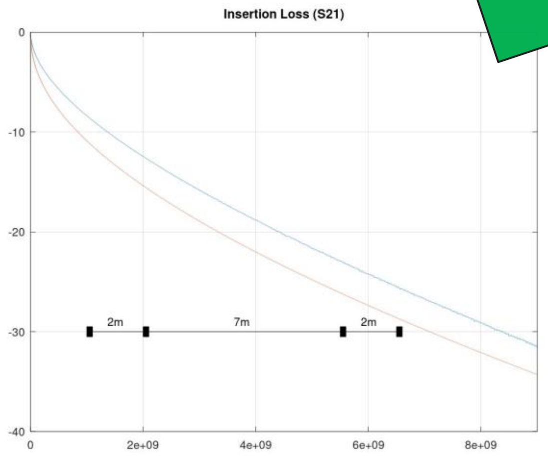
We have a reasonably good match for both Insertion Loss and Echo



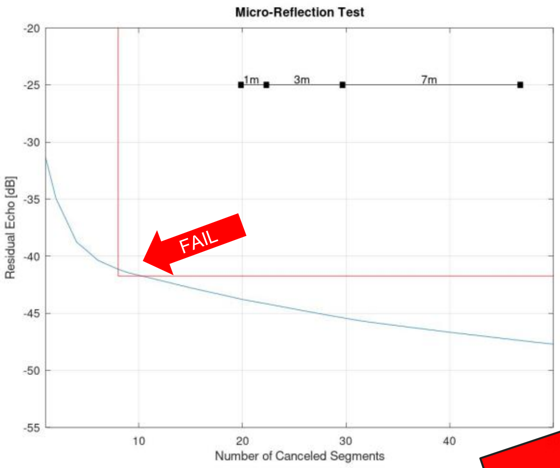


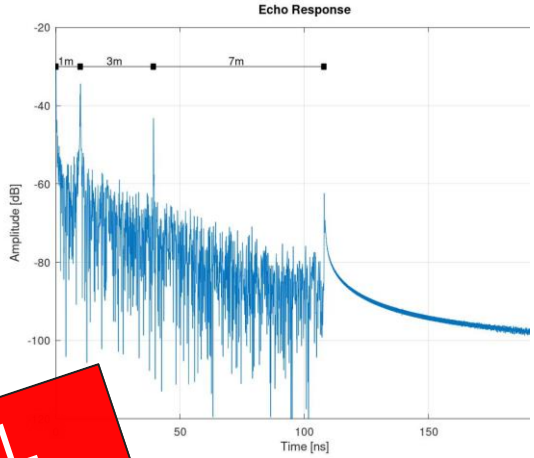


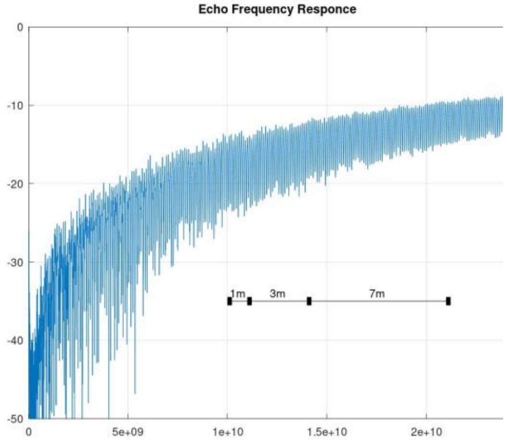
PASS



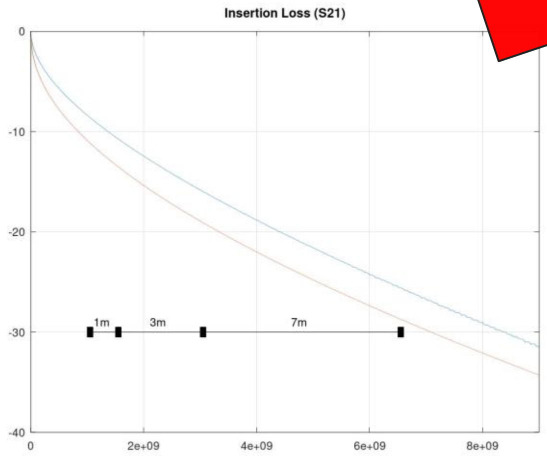
SDP Cable 21 - 11m



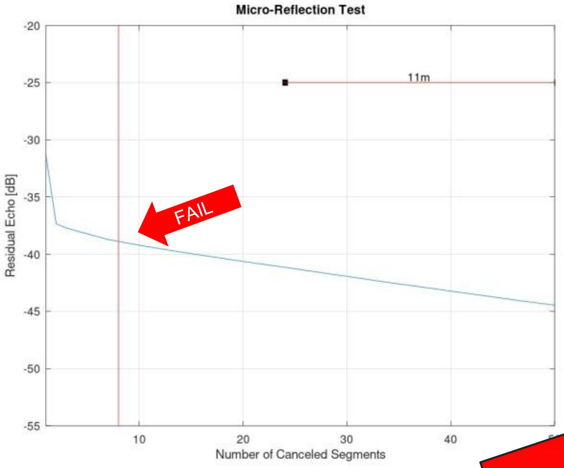


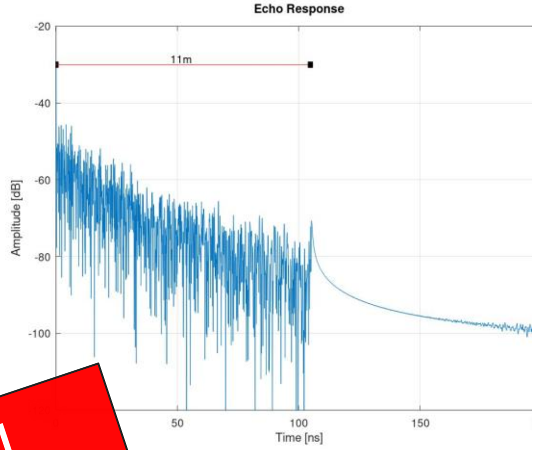


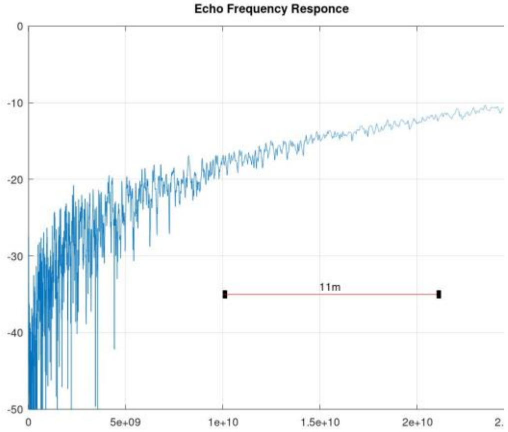
FAIL



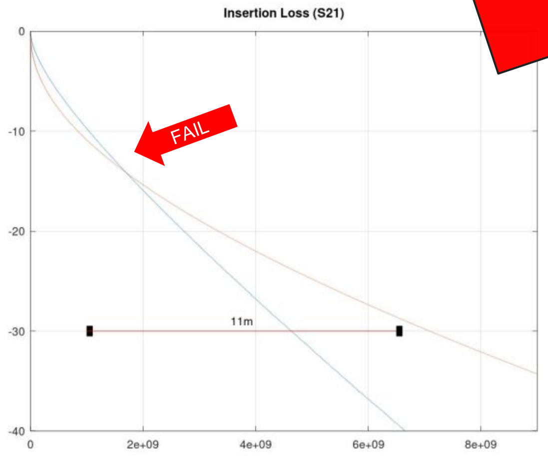
SDP Cable 19 - 11m



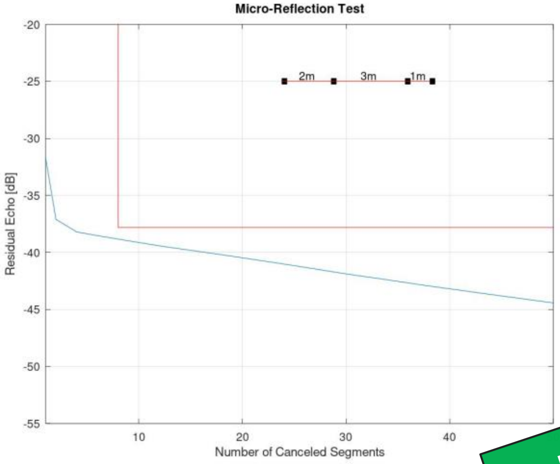


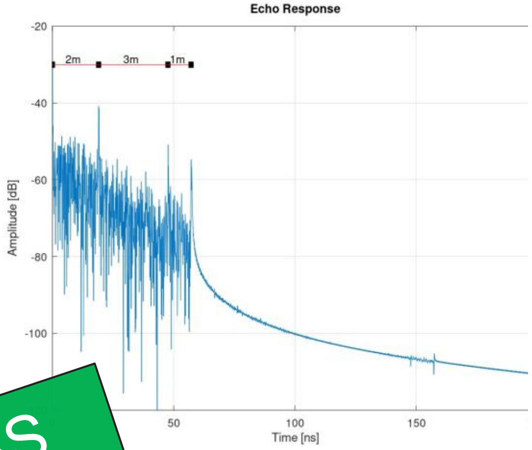


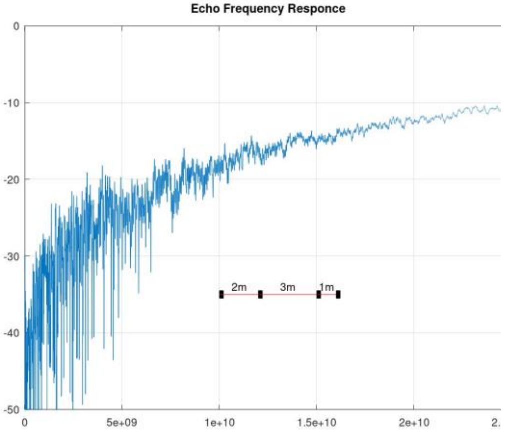
FAIL



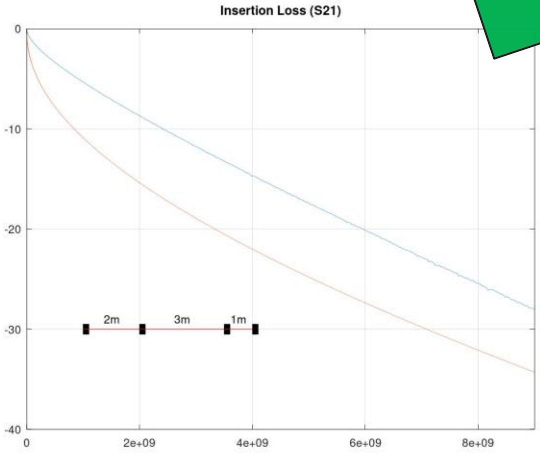
STP Cabe 18 - 11m







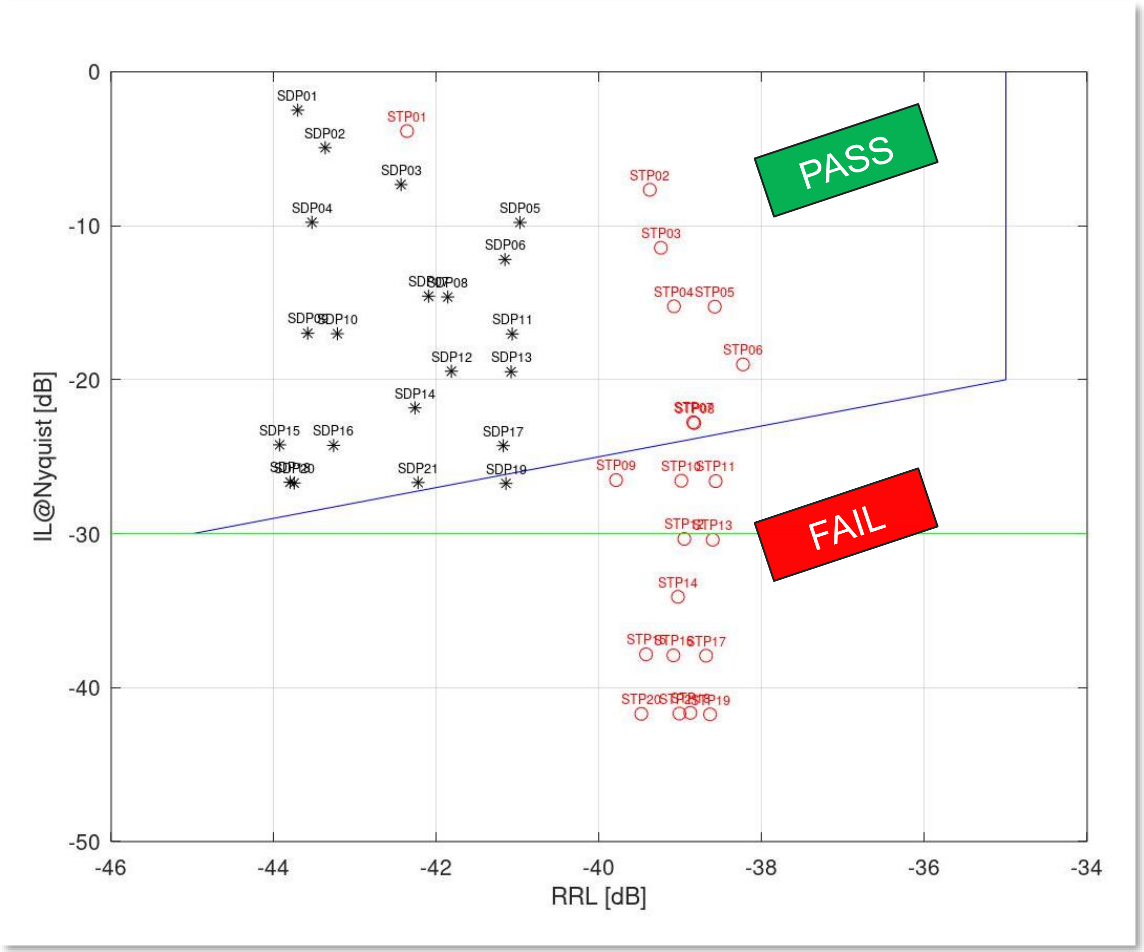
PASS



STP Cable 8 - 6m

Cable Classification

- The plot to the right shows scatter plot of IL at Nyquist vs Residual Return Loss for the SDP and STP cables in our simulation
- The cables must be above the green line to satisfy the strawman IL limit line
- The cables must be above and to the left of the blue line to satisfy the micro-reflection limits presented in this presentation
- Only one SDP cable violates these criteria



The 11m Objective

- The 802.3cy objectives ask for
  - Supporting up to 11m on at least one type of cable
  - Supporting up to 2 inline connectors
- In our simulations
  - SDP Cable 19 does not meet the requirements
  - none of the 11m STP cables meets the requirements
- Is it sufficient to demonstrate one example of 11m cable with two connectors?
  - Simulations for SDP Cables 20 and 21 do meet the requirement

Excerpts from Approved Objectives P802.3cy:

Support a **BER better than or equal to 10^{-12}** at the MAC/PLS service interface (or the frame loss ratio equivalent)

Support operation in automotive environments (e.g., EMC, temperature)

Define the performance characteristics of an automotive link segment and an electrical PHY to support 25 Gb/s (50Gb/s, 100Gb/s) point-to-point operation over this link segment **supporting up to 2 inline connectors for at least 11 m on at least one type of automotive cabling**

Support optional Clause 104 power over data lines on appropriate media

Conclusion

The updated micro-reflection mask accounts for increased SNR margin on short cables

The updated micro-reflection mask strikes a balance between cable and PHY complexity

Initial values for the mask are reasonable, but need more validation with real cables

MARVELL™

Essential technology, done right™