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Values for Micro-Reflection Limit

Contribution to IEEE 802.3cy

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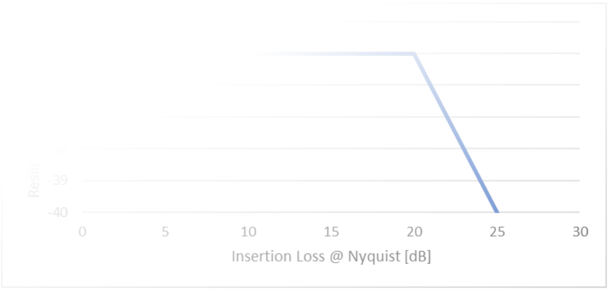
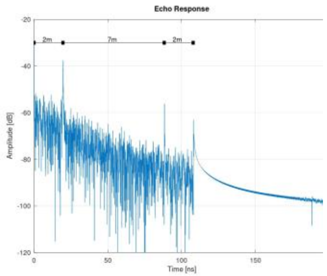
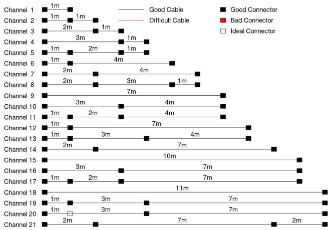
March 16, 2021

Introduction

- We proposed text for the micro-reflection limits in [jonsson_3cy_01_03_16_21]
- In this contribution we will suggest possible values for the micro-reflection limits
- We use simulations to evaluate the suggested refinements
- The suggested limits on micro-reflections strike a balance between PHY Complexity and Cable Complexity







Suggested Values for Limit Parameters

Paramete r	Parameter Value	Parameter Description
Δf_{max}	**2.5MHz**	The maximum allowed frequency spacing for the frequency domain transfer function measurements – **NOTE 1**
T	**$0.5/f_{Nyquist}$**	Time domain sampling interval – **NOTE 2**
$f_{Nyquist}$	**TBD**	Nyquist frequency of the transmit signal (half the baud rate) – **NOTE 3**
N	**4096**	Number of sampling points to use for the time domain representation of the echo impulse response – **NOTE 4**
N_{seg}	**4**	Number of samples in each segment – **NOTE 5**
$N_{discard}$	**12**	Number of largest segments to discard – **NOTE 6**
f_c	**4GHz**	Reference frequency to use in calculation of the REM limit – **NOTE 7**
REMmax	**-30dB**	Lower limit on the REM limit – **NOTE 8**
REMoffset	**18dB**	Offset of REM limit relative to IL at frequency f_c – **NOTE 9**

- NOTE 1 – This value needs to be chosen small enough to avoid time domain aliasing when transforming from frequency domain to time domain.
- NOTE 2 – The calculated Residual Echo Metric changes with different *T* values, so it is important to select this value carefully and make it consistent when evaluating the micro-reflections .
- NOTE 3 – For the PAM4 strawman proposal this value is 7.0312GHz.
- NOTE 4 – This value needs to be large enough, to account for twice the maximum length of the echo. Assuming maximum echo length to be about 150ns, the number needs to correspond to about 300ns.
- NOTE 5 – This value should be chosen such that one or two segments will cover the duration of most micro-reflections. The value of 4 corresponds to about 3cm of the cable length.
- NOTE 6 – The number of segments to discard should be sufficient to drop all segments with significant echo from connectors.
- NOTE 7 – This value should be chosen such that the IL at that frequency is the best indicator of the final SNR variations due to the cable. For 25G PAM4 systems this is about 4GHz.
- NOTE 8 – This value should be chosen such that the residual echo is never too high. There is considerable freedom in the choose of this number.
- NOTE 9 – This number is critical in determining the achievable SNR on a given cable with given PHY implementation complexity.

Evaluating the Micro-Reflection Limit

- We use the Channel Capacity Calculator presented in jonsson_3cy_01_01_12_21 to evaluate the suggested limit for the Residual Echo Metric for different cable lengths
- The micro-reflection level is set according to Step 4 of proposed text
- We calculate SNR Margin using model based on SDP cables presented in mueller_3cy_01_12_01_20
- The calculations show two PHY design tradeoffs to achieve the required margin:
  - improving EC performance or
  - lower AFE-noise

	Upstream	Downstream
Requirements		
Data Rate [Gbps]:	25	25
Target RS-FEC output BER:	1.00E-12	1.00E-12
Cable Length [m]:	11.000	11.000
Wire u-reflections limit:	-37	-37
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_ZOH	PSD_ZOH
Transmit Power [dBm]:	0	0
Design Tradeoff		
Impulse Error Rate:	1.00E-04	1.00E-04
AFE-noise [dBm/Hz]:	-140	-143
EC cancelation [dB]:	9	6
EC Connector cancelation [%]:	100%	100%
Implementation Loss [dB]:	5	5
Simulation Parameters		
Cable Model:	mueller_3cy_01_12_01_20_sdp	
PCB model:	pcb_kadry_3cy_02_0820	
PCB trace length [m]:	0.0762	
Connector Echo Model:	Hard	
Temperature [°C]:	20	
Max Simulation Frequency:	9.00E+09	

Micro-Reflections according to limit in Equation (1)

Assume 5dB Implementation Loss

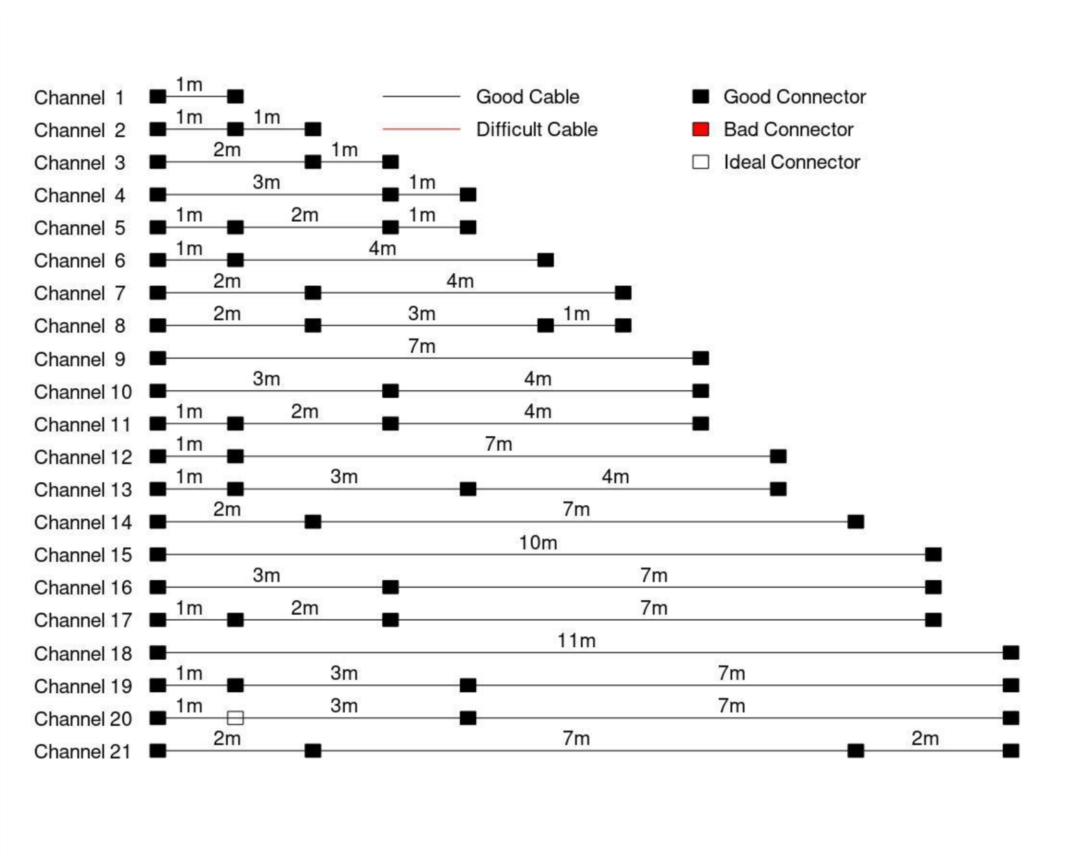
Use SDP cable model

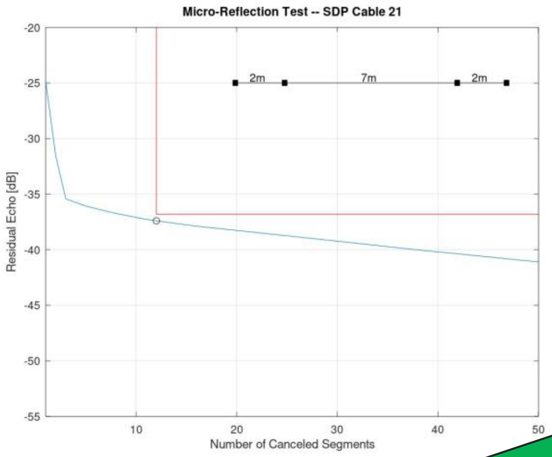
Calculated Values		
	Upstream	Downstream
Theoretical Slicer SNR [dB]:	22.14	22.66
Estimated Slicer SNR [dB]:	17.14	17.66
Required Slicer SNR [dB]:	17.20	17.20
SNR Margin [dB]:	-0.06	0.46
Wire u-reflections [dB]:	-37.00	-37.00
Nyquist Frequency [GHz]:	7.03	7.03
Channel Insertion Loss @ Nyquist [dB]:	28.99	28.99
Cable Insertion Loss @ Nyquist [dB]:	26.64	26.64

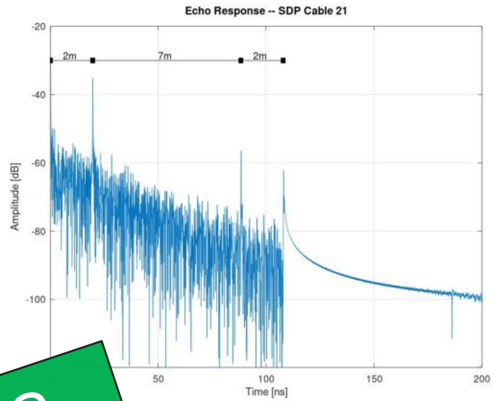
Margin should be positive

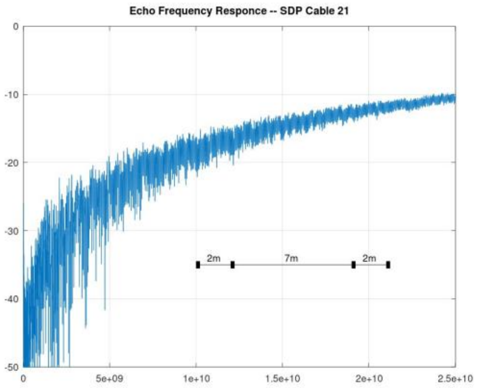
Simulating Different Cables

- 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
- This is the same cable simulation as used in jonsson_3cy_01_12_08_20









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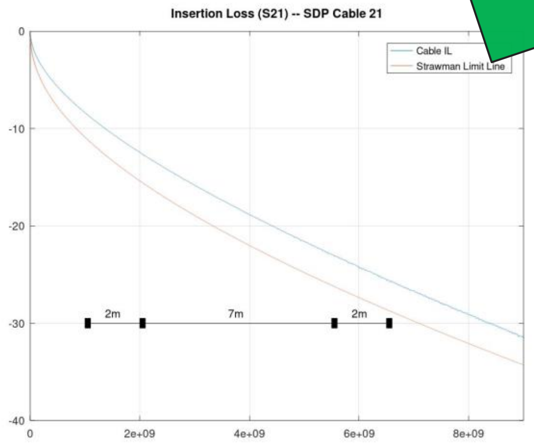
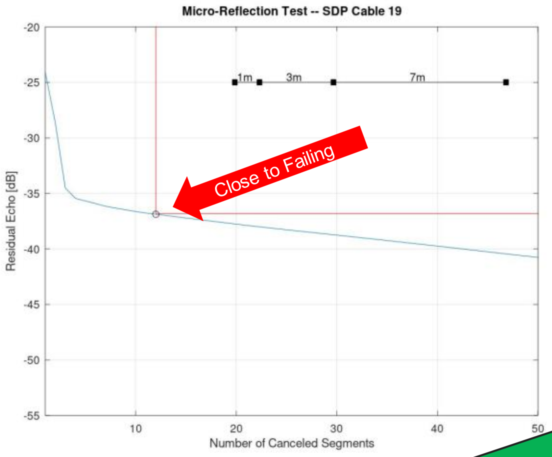
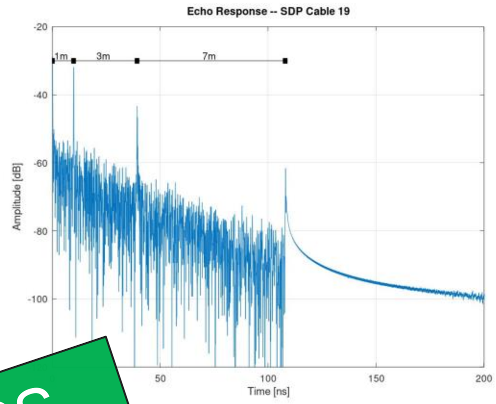
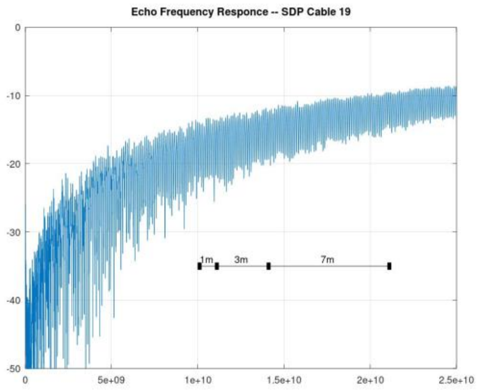


SDP Cable 21 - 11m







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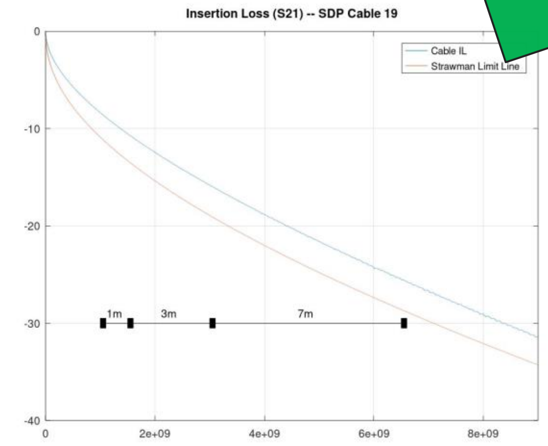
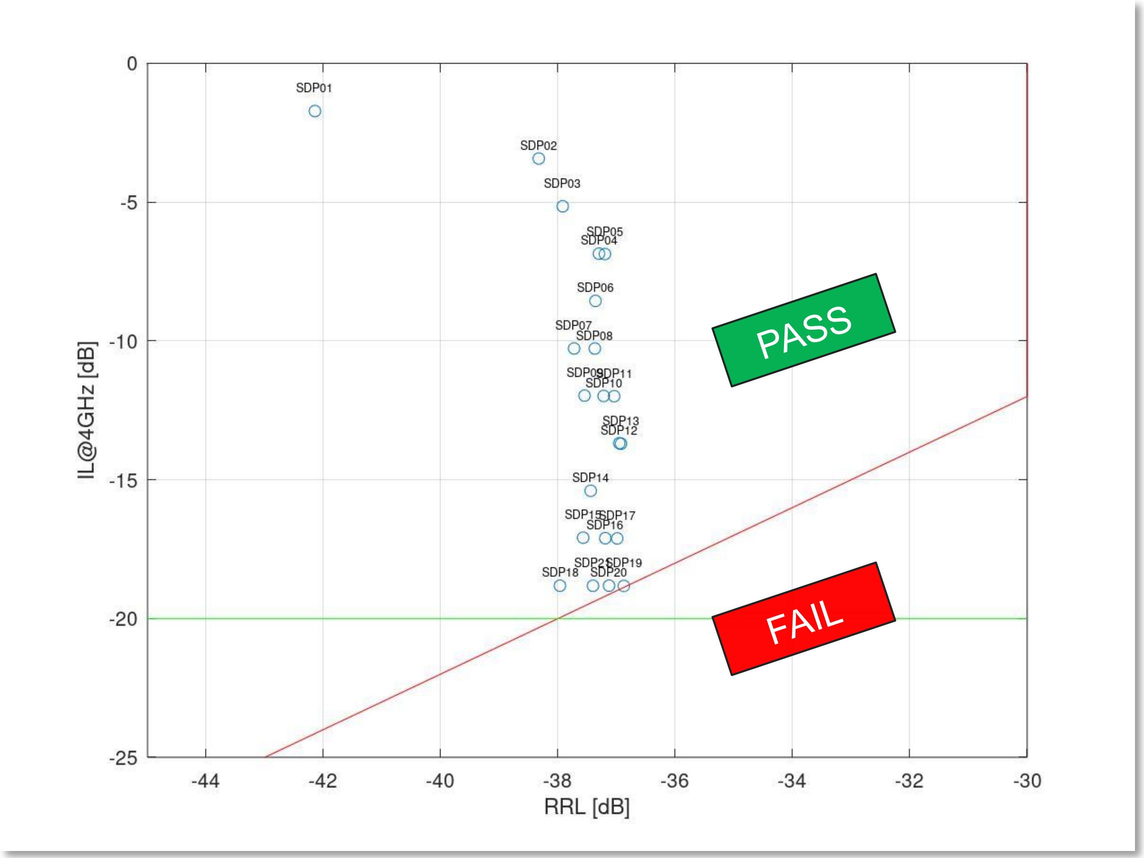


SDP Cable 19 - 11m

Cable Classification

- The plot to the right shows scatter plot of IL at 4GHz vs Residual Return Loss for the SDP and STP cables in our simulation
- The cables should be above the green line to get sufficient slicer SNR
- The cables must be above and to the left of the red line to satisfy the micro-reflection limits presented in this presentation
- One SDP cable is close to violating these criteria



Conclusion

Specific values for the micro-reflection limit calculations are suggested

The suggested micro-reflection limit strikes a balance between cable and PHY complexity

The suggested values are reasonable, but need more validation with real cables

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