Values for Micro-Reflection Limit

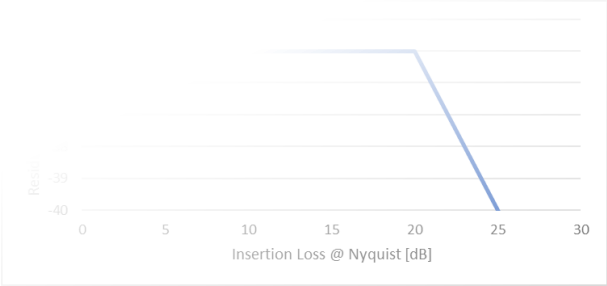
Contribution to IEEE 802.3cy

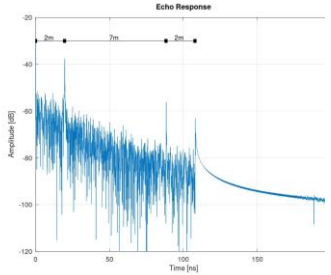
Ragnar Jonsson
Marvell

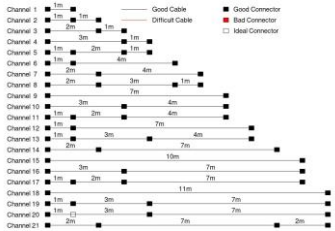
August 10, 2021

Introduction

- In the Telephonic Interim Meeting on March 30, 2021, the micro-reflection limit text from jonsson_3cy_01a_03_30_21 was adopted
- The adopted text did not have specific values for the micro-reflection limits
- This contribution suggests specific limits to use in the text







Values to be determined

- The values in Table 1 need to be determined
- The values in equations 9 and 10 need to be determined
- We suggest values for all, except equitation 10

Micro-Reflection Limit Text

#1 of 6

xxx.1 Echo Tail and Residual Echo Metrics

This subclause defines metrics to limit Noise from echo outside of major discontinuities in a link segment. Such echo that is beyond the required capability of the PHY to cancel the echo is referred to as residual echo. These metrics are determined using the following procedure using the parameters in Table 1:

Table 1

Parameter	Parameter Value	Parameter Description
Δf	TBD	The sample frequency spacing for the frequency domain transfer function measurements
N	TBD	Number of sampling points to use for the time domain representation of the echo impulse response
N_{seg}	TBD	Number of samples in each segment
$N_{discard}$	TBD	Number of largest segments to discard

3

Micro-Reflection Limit Text

#6 of 6

xxx.2 Limit on Residual Echo Metric

The REM value of each end of the link segment, defined by the calculation described in Section xxx.1, shall comply with Equation xxx-9:

(Equation xxx-9)

$$REM(N_{discard}) \leq \min(REMmax, -IL(f_c) - REMoffset) \quad (dB)$$

where f_c is TBD, *REMmax* is TBD and *REMoffset* is TBD.

xxx.3 Limit on Echo Tail Metric

The ETM value of each end of the link segment, defined by the calculation described in Section 1, shall comply with Equation xxx-10:

(Equation xxx-10)

$$ETM(k) \leq \min(ETMmax, -IL(f_c) - ETMoffset(k)) \quad for\ k \in TBD$$

where f_c is TBD, *ETMmax* is TBD and *ETMoffset(k)* is TBD.

8

Proposed Values for Table 1

Parameter	Parameter Value	Parameter Description
Δf	**2.5MHz**	The sample frequency spacing for the frequency domain transfer function measurements
N	**4096**	Number of sampling points to use for the time domain representation of the echo impulse response
N_{seg}	**4**	Number of samples in each segment
$N_{discard}$	**12**	Number of largest segments to discard

- Δf – This value needs to be chosen small enough to avoid time domain aliasing when transforming from frequency domain to time domain
- N – 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
- N_{seg} – 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.
- $N_{discard}$ – The number of segments to discard should be sufficient to drop all segments with significant echo from connectors.

Limit on Residual Echo Metric

(Equation xxx-9)

$$REM(N_{discard}) \leq \min(REMmax, -IL(f_c) - REMoffset) \quad (dB)$$

where f_c is TBD, *REMmax* is TBD and *REMoffset* is TBD.

- f_c is **4GHz**,
- *REMmax* is **-30dB** and
- *REMoffset* is **20dB**

- f_c – 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.
- *REMmax* – This value should be chosen such that the residual echo is never too high. There is considerable freedom in the choose of this number.
- *REMoffset* – This number is critical in determining the achievable SNR on a given cable with given PHY implementation complexity.

Evaluating the Limits

- The suggested limits are chosen such that they strike a balance between cable complexity and PHY complexity
- For our conventional configuration of the SNR calculation the SNR margin are too low at -1.55dB
- By enhancing the AFE the SNR margin become positive at 0.52dB

	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:	jonsson_3cy_01	jonsson_3cy_01
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	-140
Cable Reflection Echo Cancelation [dB]:	6	6
Connector Echo Cancelation [dB]:	50	50
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]:	85	
Max Simulation Frequency:	9.00E+09	

	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:	jonsson_3cy_01	jonsson_3cy_01
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]:	-143	-143
Cable Reflection Echo Cancelation [dB]:	6	6
Connector Echo Cancelation [dB]:	50	50
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]:	85	
Max Simulation Frequency:	9.00E+09	

Calculated Values		
	Upstream	Downstream
Theoretical Slicer SNR [dB]:	20.65	20.65
Estimated Slicer SNR [dB]:	15.65	15.65
Required Slicer SNR [dB]:	17.20	17.20
SNR Margin [dB]:	-1.55	-1.55
Wire u-reflections [dB]:	-40.47	-40.47
Nyquist Frequency [GHz]:	7.03	7.03
Channel Insertion Loss @ Nyquist [dB]:	31.38	31.38
Cable Insertion Loss @ Nyquist [dB]:	29.03	29.03

Calculated Values		
	Upstream	Downstream
Theoretical Slicer SNR [dB]:	22.72	22.72
Estimated Slicer SNR [dB]:	17.72	17.72
Required Slicer SNR [dB]:	17.20	17.20
SNR Margin [dB]:	0.52	0.52
Wire u-reflections [dB]:	-40.47	-40.47
Nyquist Frequency [GHz]:	7.03	7.03
Channel Insertion Loss @ Nyquist [dB]:	31.38	31.38
Cable Insertion Loss @ Nyquist [dB]:	29.03	29.03

Conclusion

The micro-reflection text, adopted on March 30, 2021, had several TBD values

We suggest specific values for some of these TBD values

The suggested values are chosen such that they balance cable complexity and PHY complexity

Essential technology, done right™