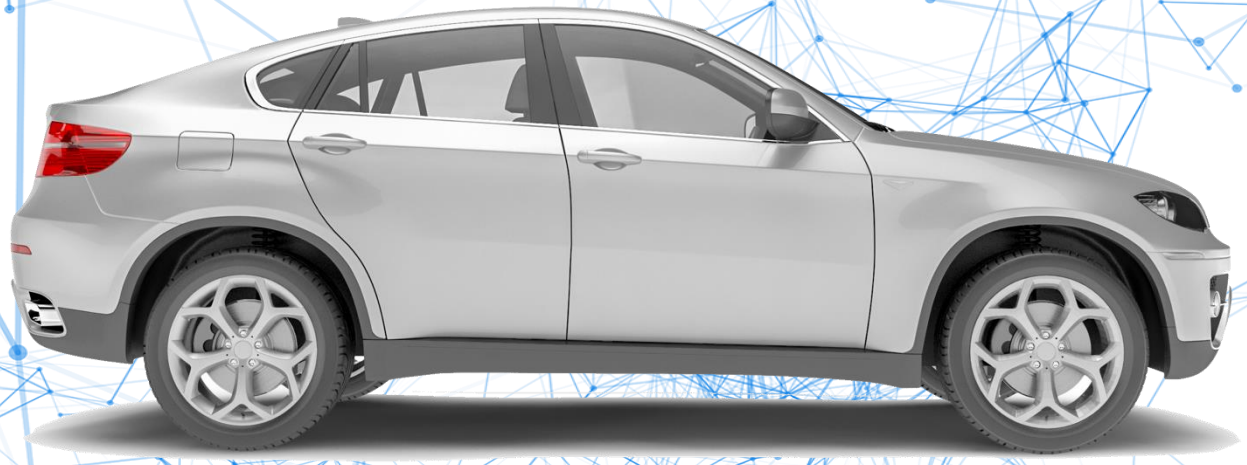


Additional Limits on Echo

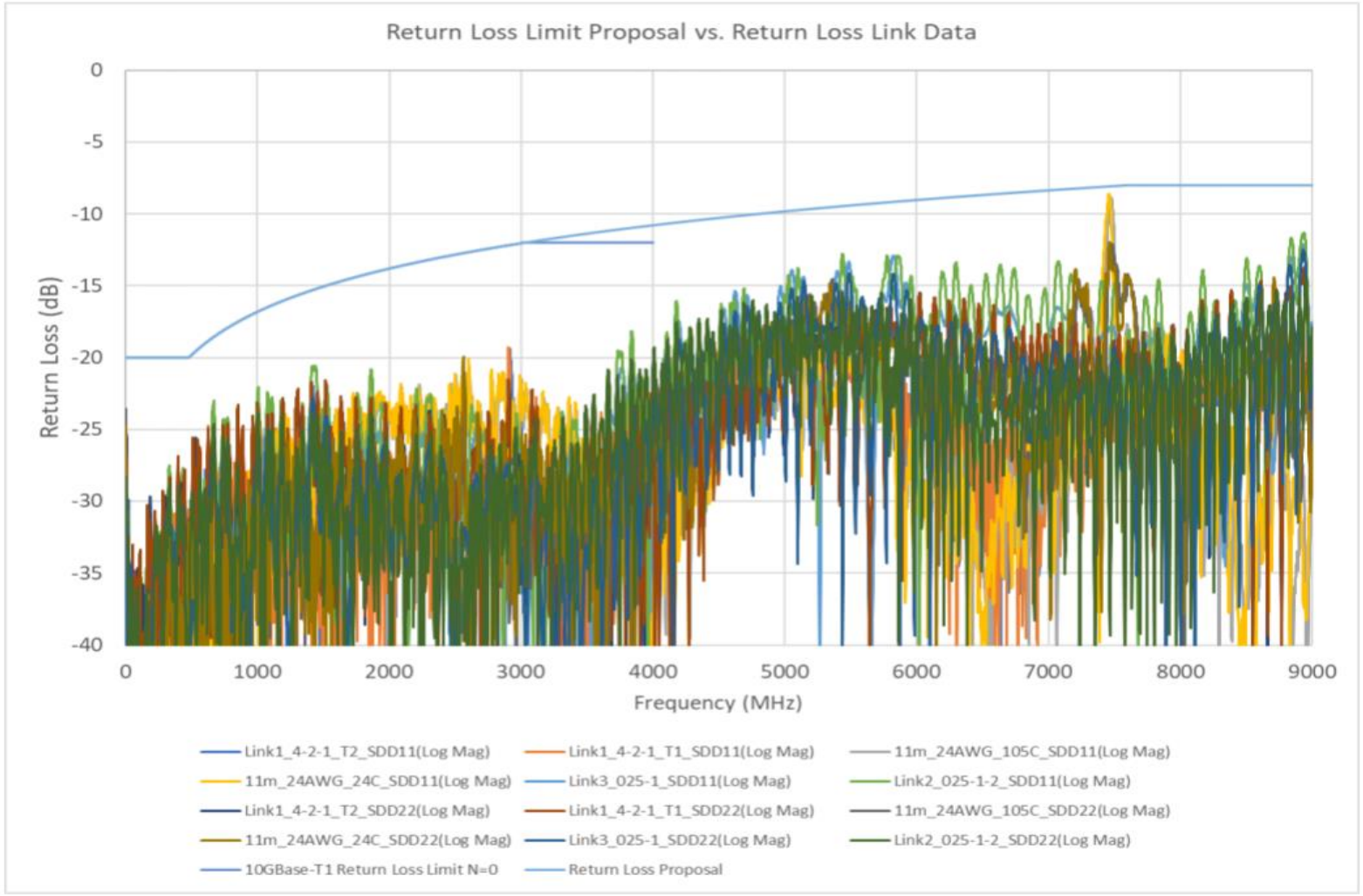
Hossein Sedarat

July 2021

Overview

- The current limit line for return loss is specified as the upper bound of echo response in frequency domain
- Other limits on echo can help simplify the implementation of the PHY significantly (sedarat_3cy_1120)
- This presentation explores possibilities for 2 of such limits using publicly available channel measurements
  - Limit on total power of echo
  - Limit on micro-reflections

Adopted Limit Line for Return Loss



CuestaDiBiasoMüller_3cy_01_06_22_21

Other Limits on Echo to Consider

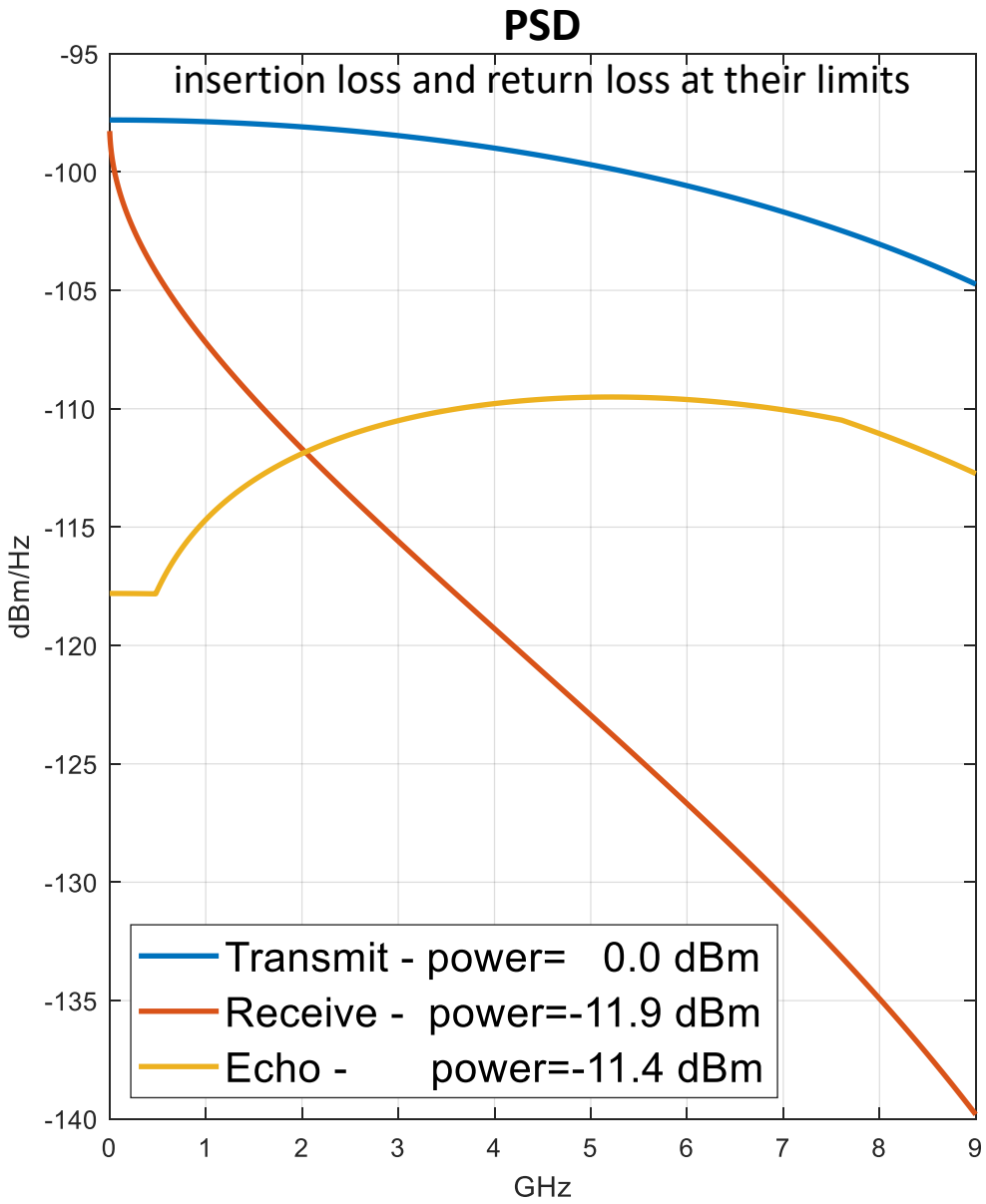
Having a clear bound on the following echo characteristics may reduce the complexity of the PHY

- Focus of this presentation:
  - **Overall power of echo**
  - **Cumulative power of micro-reflections**

- Other parameters that are not considered in this presentation
  - Time-span of echo response (propagation delay)
  - Number, magnitude and time-span of major reflections
  - Dynamic changes in echo response (temperature, vibration, etc.)
  - Cable deformities (bend ratio, compression points, etc.)

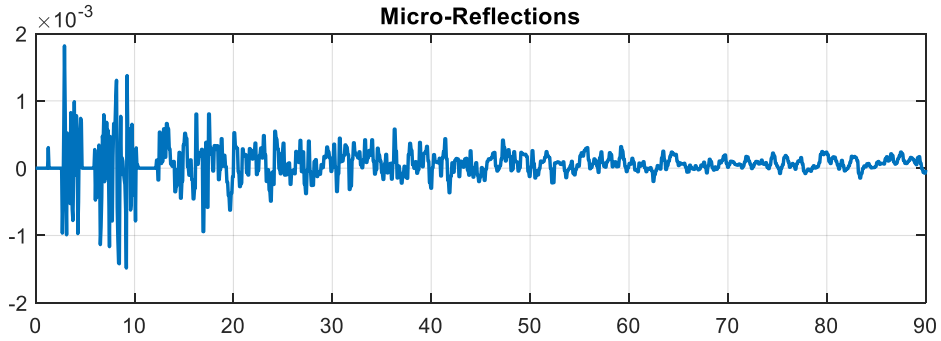
Echo Power

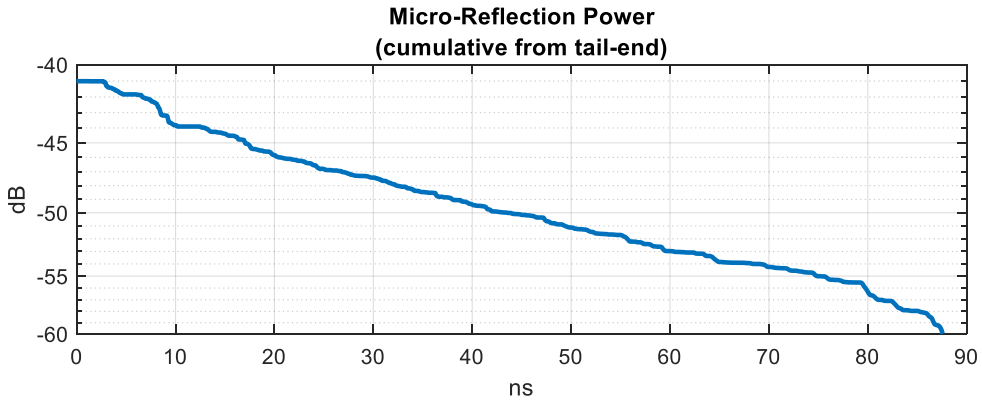
- With insertion loss and return loss at their limits, the power of echo signal is slightly higher than the power of received signal from link-partner
- This demands ~3 dB wider dynamic range for analog front-end resulting in considerably higher power consumption
- It is expected that the total power of echo to be lower with typical cables and connectors
- An explicit limit on total power simplifies the design of PHY



Micro-Reflections

- Echo response consists of a few major reflection points (from connectors) and back-ground micro-reflections (due to inhomogeneity of the cable)
- Significant computational power of PHY is dedicated to cancel micro-reflections
- A limit on the power of micro-reflections can help reduce the complexity of the PHY





Available Link Measurements

The analysis presented here is based on the publicly available measurements posted on 802.3cy webpage

- Very limited set of posted measurements
- Some violating adopted limit lines
- Some incomplete data with no phase information
- Some with anomalies: suck-outs, atypical fluctuations, etc.

Title	Presenters(s)	Affiliation(s)
14 October ad hoc teleconference		
Cable Insertion Loss Measurements Touchstone files (.zip file)	Rich Boyer	Aptiv
28 October ad hoc teleconference		
10 m STP cable Touchstone files (.zip file)	Thomas Mueller	Rosenberger
8 December ad hoc teleconference		
Cable Measurements Touchstone files (.zip file)	Rich Boyer	Aptiv
26 January interim teleconference		
Link Segment Measurements 19 January Touchstone files (.zip file)	Eric DiBiaso, Bert Bergner, Emilio Cuesta	TE Connectivity
27 April ad hoc teleconference		
Additional data for koeppendoerfer_3cy_01_10_28_20 (.zip file)	Erwin Koeppendoerfer	Leoni
1 June ad hoc teleconference		
Touchstone files 24AWG 24C (.zip file) Touchstone files 24AWG 105C (.zip file)	Eric DiBiaso, Bert Bergner, Emilio Cuesta	TE Connectivity
AWG24_simResults_11m pertaining to koeppendoerfer_3cy_01_06_01_21.csv	Erwin Koeppendoerfer	Leoni

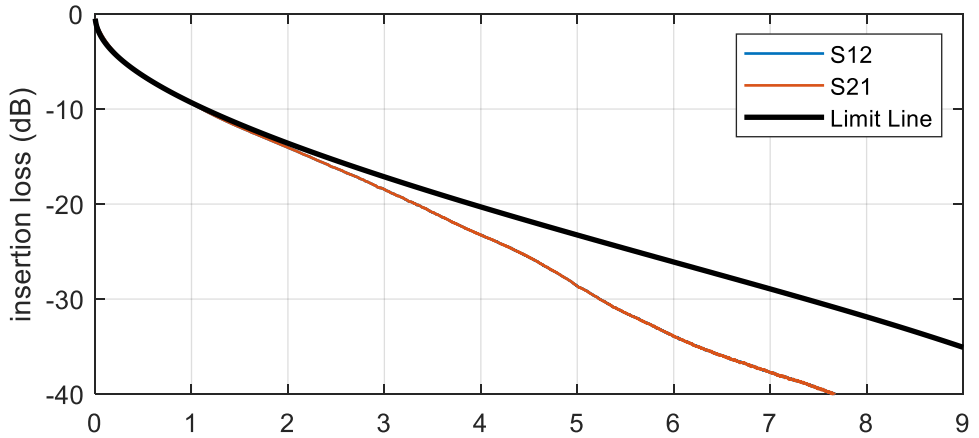
Echo Power:

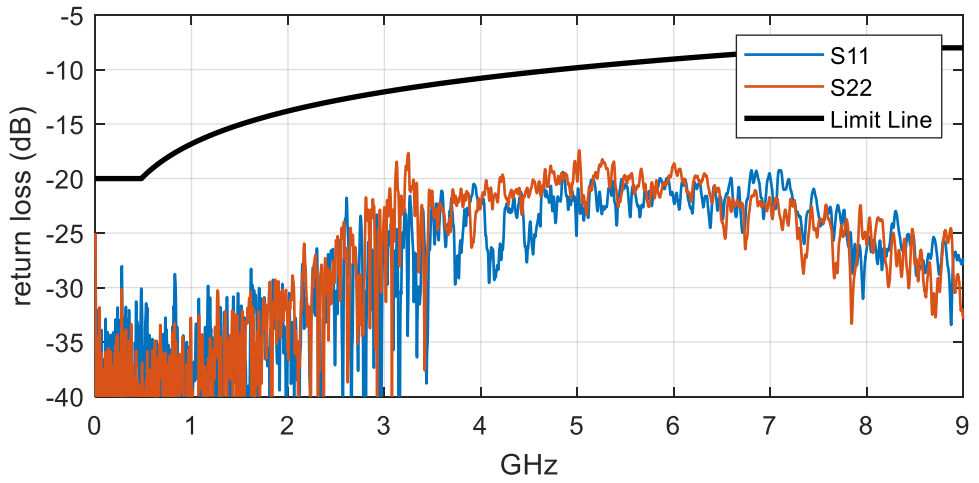
Measurement Shared on 2020-10-28

- The length and the type of cable is unclear
  - Based on propagation delay, the length is estimated to be around 11 m
- Insertion loss violates the limit line
- Return loss shows good margin to limit

	Min Rx Power Gain (dB)	Max Echo Power Gain (dB)	SER[1] (dB)
20201028	**-12.1**	**-24.2**	**12.1**
Limit Line	**-11.9**	**-11.4**	**-0.5**

1) SER = signal to echo power ratio





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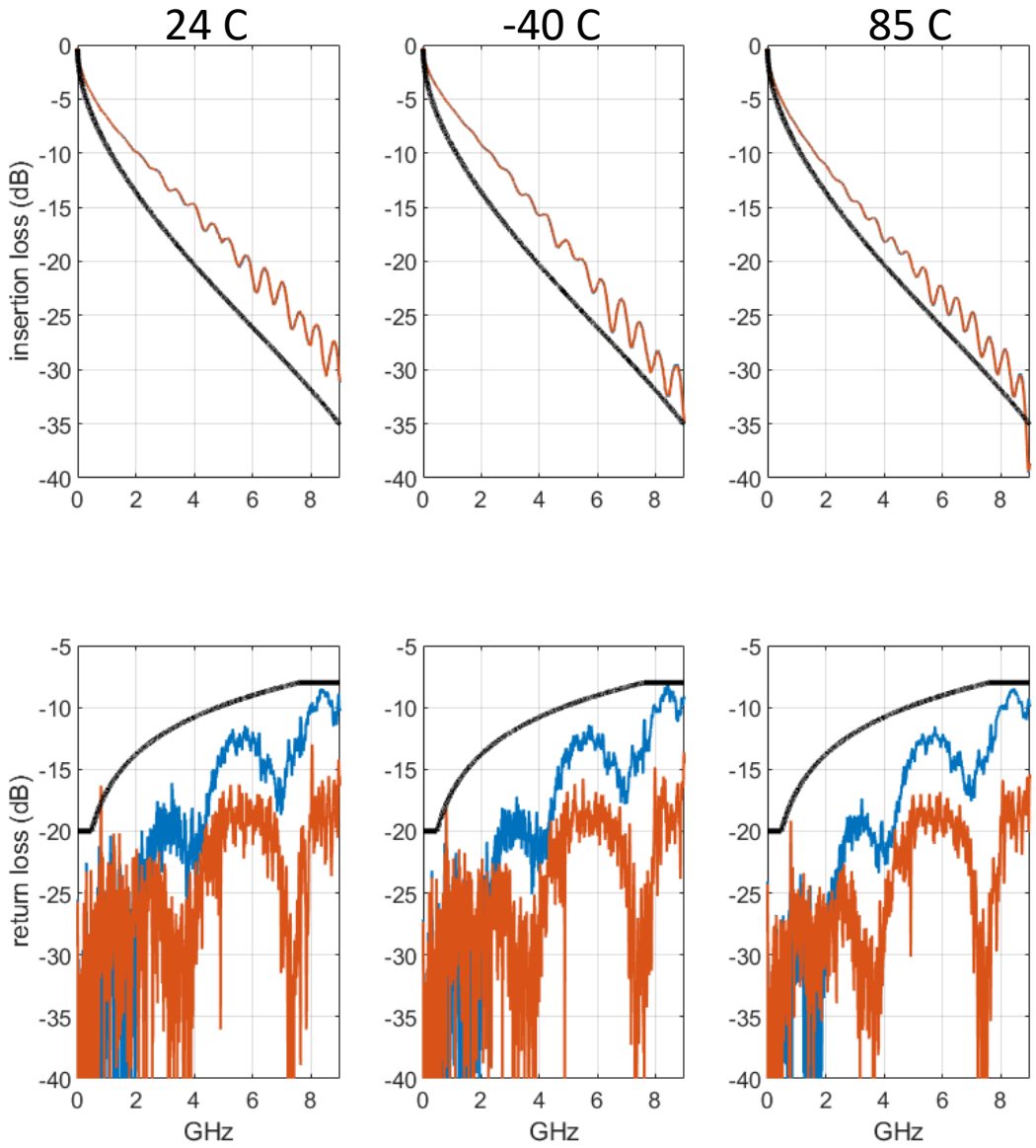
Echo Power:

Measurement Shared on 2020-12-08

- 7 m STP at different temperature
- Insertion loss exhibits fluctuations and barely meets the limit at hot
- Return loss shows minimal margin to the limit line

	Temp (C)	Min Rx Power Gain (dB)	Max Echo Power Gain (dB)	SER (dB)
20201208	+23	**-9.7**	**-16.7**	**7.0**
	-40	**-9.2**	**-16.7**	**7.5**
	+85	**-10.5**	**-16.7**	**6.2**
Limit Line		**-11.9**	**-11.4**	**-0.5**

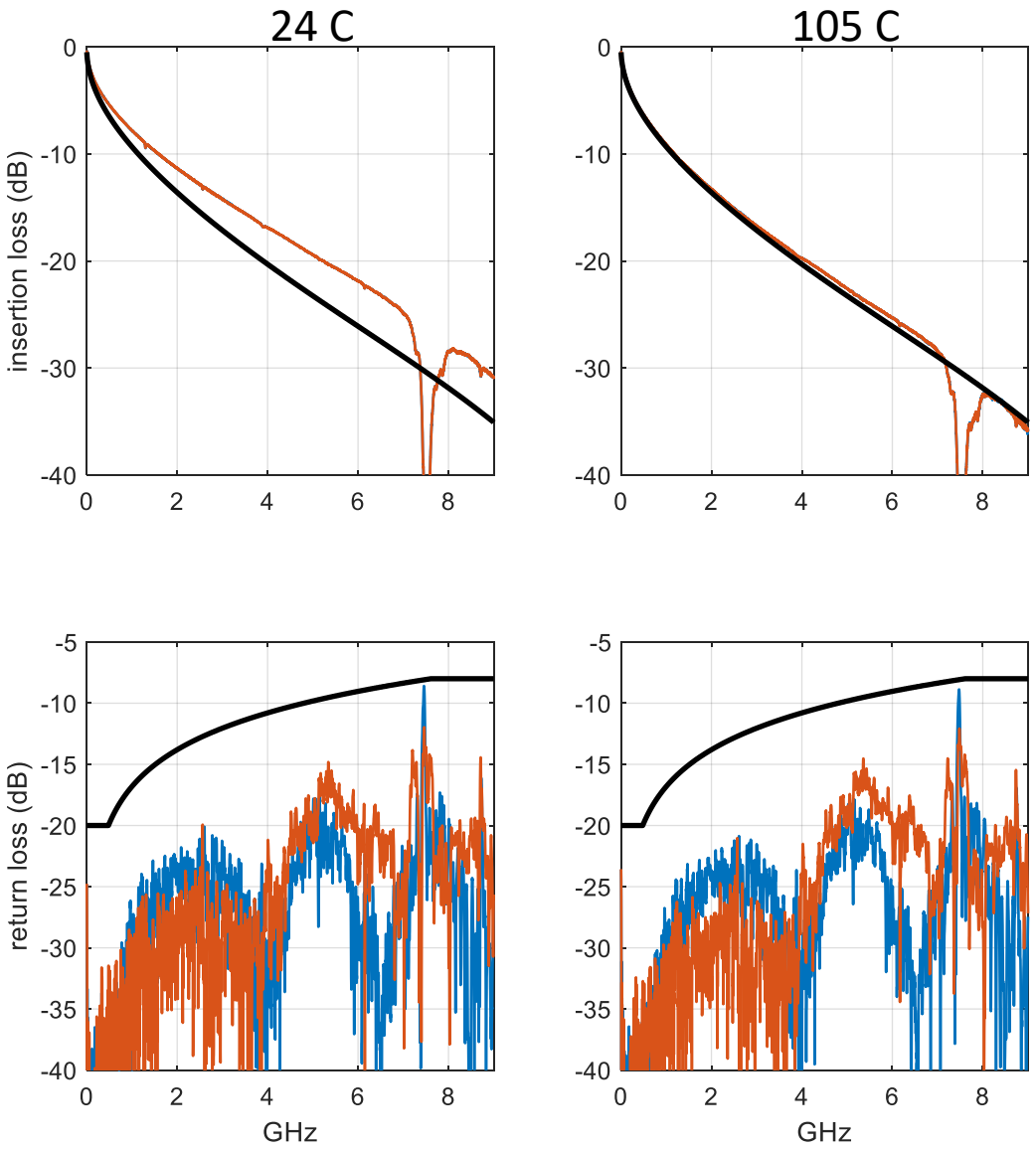


Echo Power:

Measurement Shared on 2021-06-01

- 11 m, 24 AWG solid conductor
- Insertion loss exhibits suck-outs just above Nyquist
- Return loss shows reasonable margin to the limit line at low freq

	Temp (C)	Min Rx Power Gain (dB)	Max Echo Power Gain (dB)	SER (dB)
20210601	+24	**-10.6**	**-23.4**	**12.8**
	+105	**-11.7**	**-23.3**	**11.6**
Limit Line		**-11.9**	**-11.4**	**-0.5**



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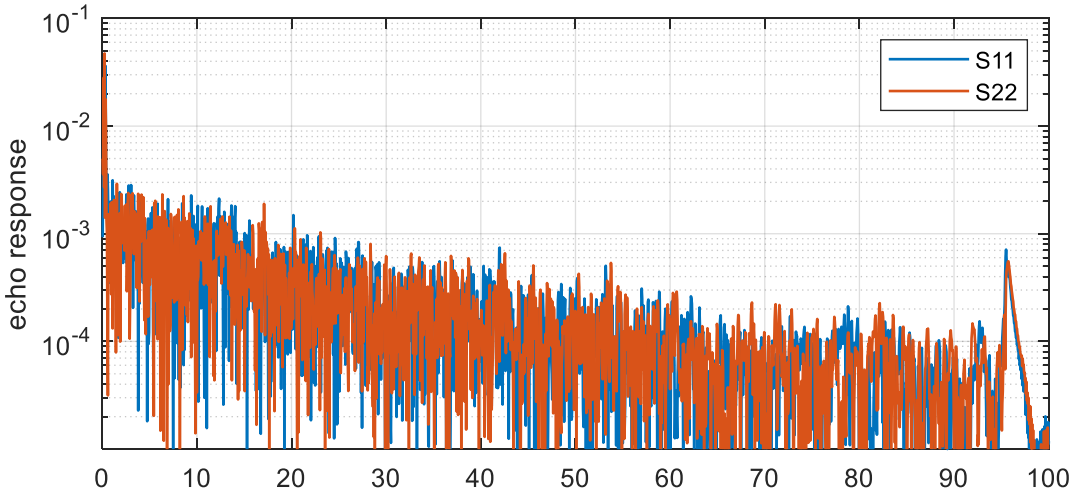
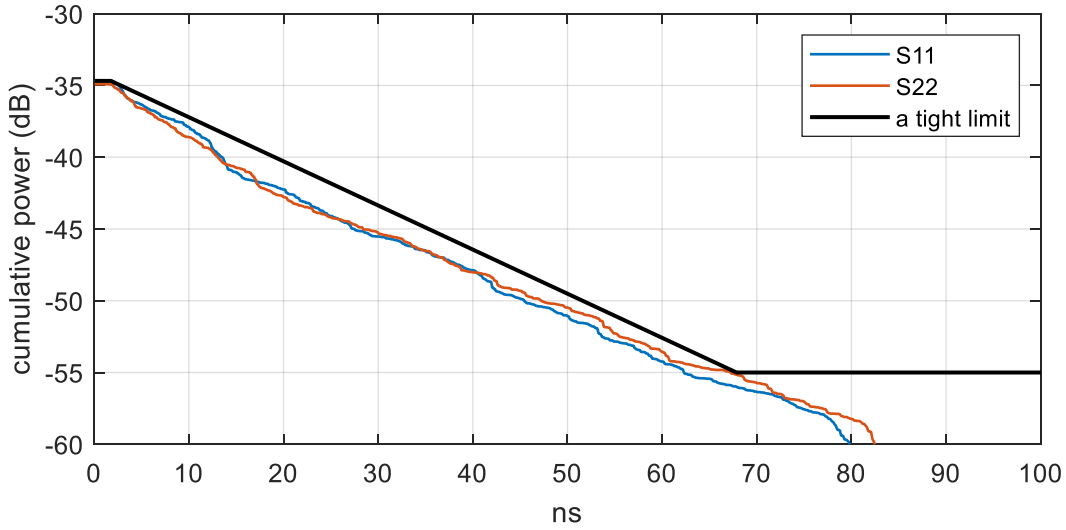
Micro-Reflections:
Measurement Shared on 2020-10-28

- A simple line may be considered as a good limit for the cumulative power of micro-reflections
  - Clipped to a maximum defined by the limit of the total power
  - Clipped to a minimum below which is inconsequential for PHY design

Max MR Power Gain (dB)	MR Offset (dB)	MR Slope (dB/ns)
-34.7	-34.1	-0.31

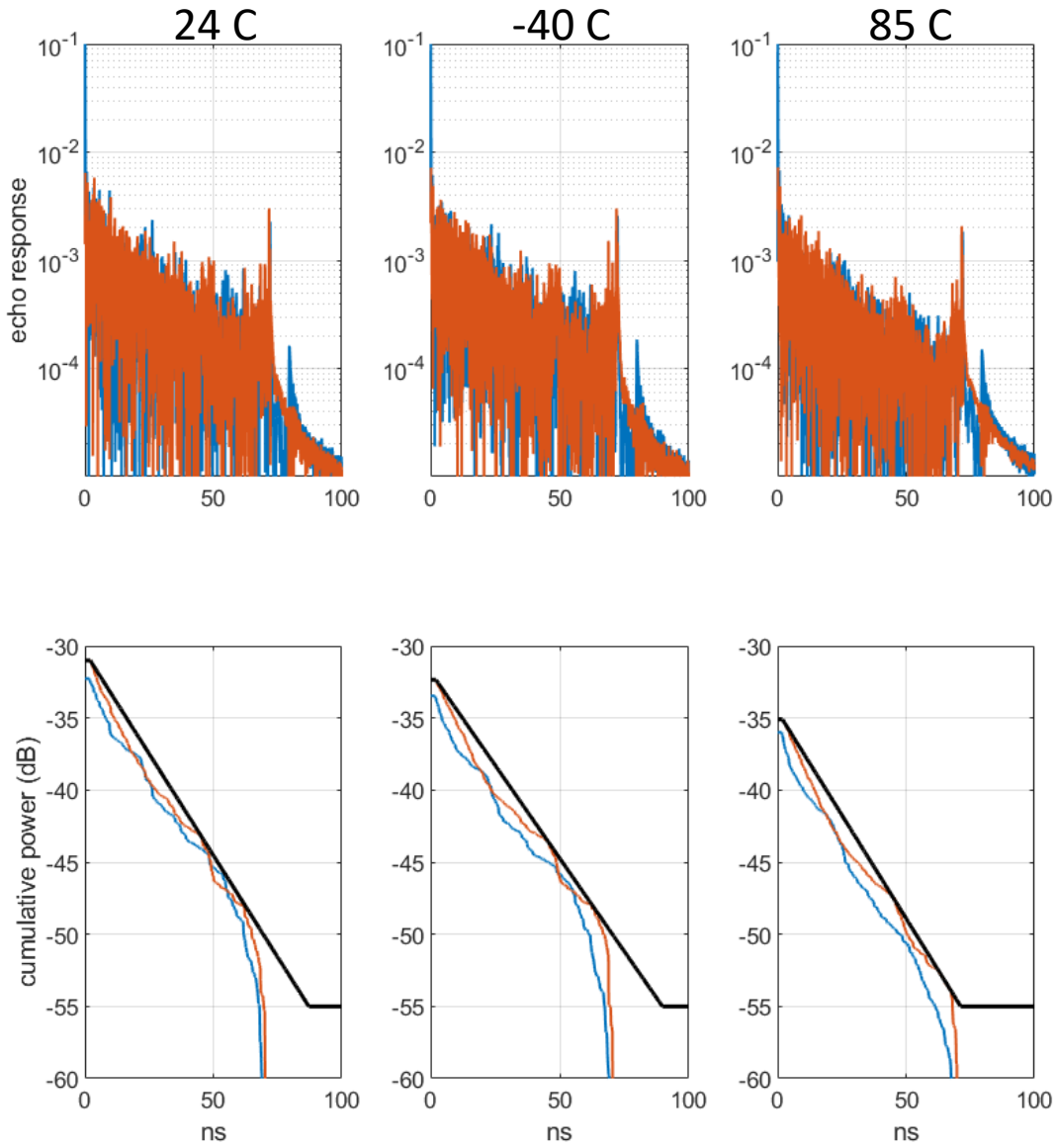




Micro-Reflections:

Measurement Shared on 2020-12-08

Temp (C)	Max MR Power Gain (dB)	MR Offset (dB)	MR Slope (dB/ns)
+24	**-31.0**	**-30.4**	**-0.28**
-40	**-32.4**	**-31.8**	**-0.26**
+85	**-35.1**	**-34.6**	**-0.29**



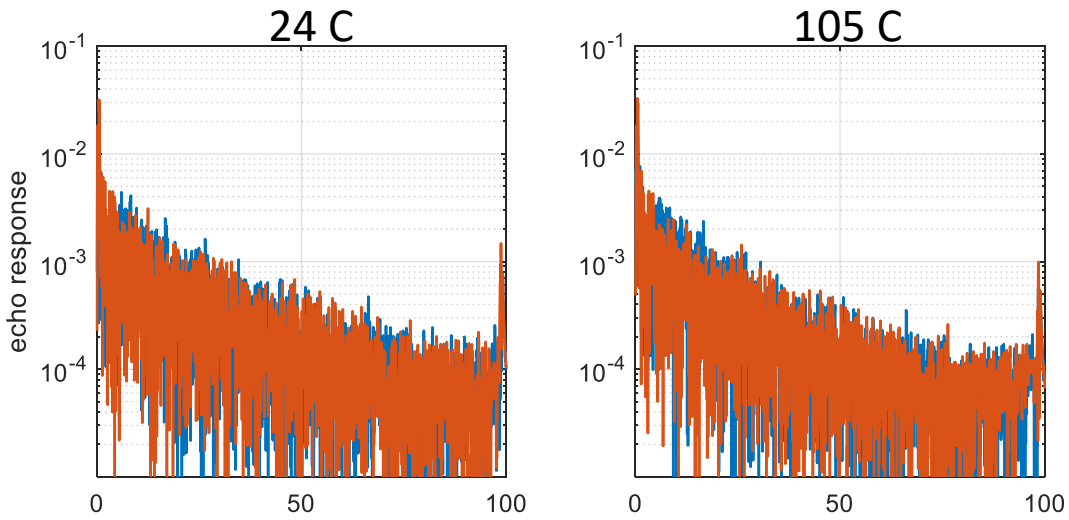
Observations:

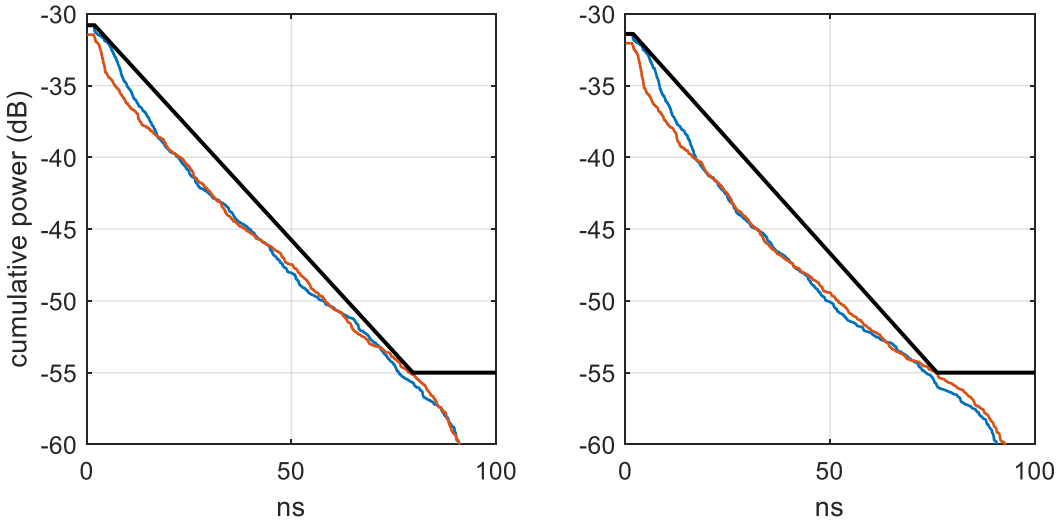
- Considerable variation of power of micro-reflections over temperature
- Room temp show highest power

Micro-Reflections:

Measurement Shared on 2021-06-01

Temp (C)	Max MR Power Gain (dB)	MR Offset (dB)	MR Slope (dB/ns)
+24	**-30.8**	**-30.2**	**-0.31**
+105	**-31.4**	**-30.8**	**-0.32**





Observations:

- Micro-reflection power is slightly stronger at hot
- A single linear limit fit well both hot and room temperature

Summary of all Measurements

	Temp (C)	Rx Power Gain (dB)	Echo Power Gain (dB)	SER[1] (dB)	MR Power Gain (dB)	SMR[2] (dB)	MR Offset (dB)	MR Slope (dB/ns)
20201028		**-12.1**	**-24.2**	**12.1**	**-34.7**	**22.6**	**-34.1**	**-0.31**
20201208	+23	**-9.7**	**-16.7**	**7.0**	**-31.0**	**21.3**	**-30.4**	**-0.28**
	-40	**-9.2**	**-16.7**	**7.5**	**-32.4**	**23.2**	**-31.8**	**-0.26**
	+85	**-10.5**	**-16.7**	**6.2**	**-35.1**	**24.6**	**-34.6**	**-0.29**
20210601	+24	**-10.6**	**-23.4**	**12.8**	**-30.8**	**20.2**	**-30.2**	**-0.31**
	+105	**-11.7**	**-23.3**	**11.6**	**-31.4**	**21.6**	**-30.8**	**-0.32**
Limit Line		**-11.9**	**-11.4**	**-0.5**				

1) SER = signal to echo power ratio
2) SMR = signal to micro-reflection power ratio

- The total power of echo is at least 6 dB lower than what adopted limit lines predict
- The slope of cumulative micro-reflection power is roughly 0.3 dB/ns

Summary

- Additional bounds on echo, beyond the adopted limit line, can help reduce the complexity of the PHY
  - Total echo power
  - Micro-reflections
- From shared and publicly available measurements:
  - The limit on the total power of echo may be reduced by more than 6 dB
  - The slope for micro-reflection power is in the order of 0.3 dB/ns

- **Additional measurements is needed to better study these limits**

THANK YOU

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