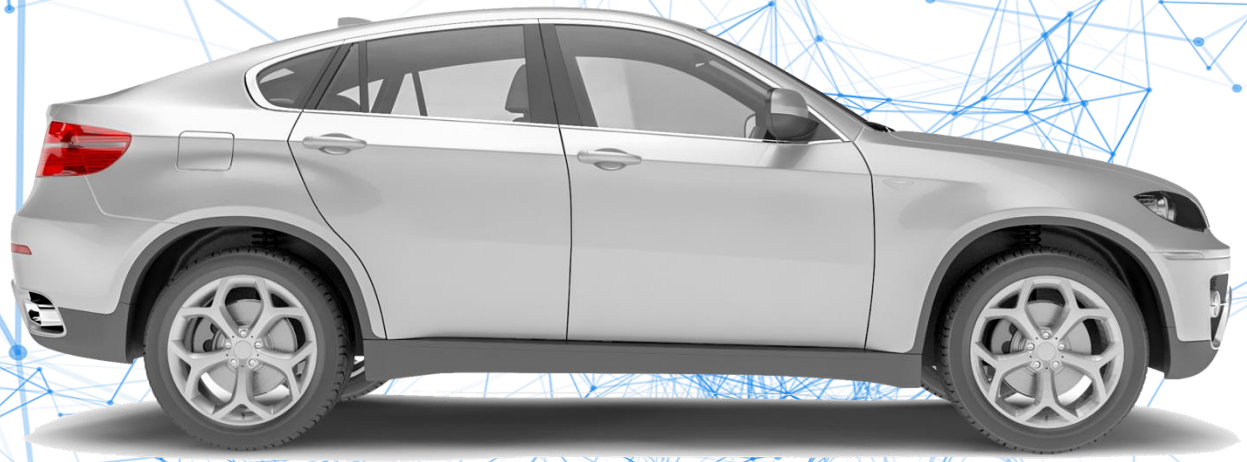

Insertion Loss and PHY Complexity

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Overview

- The recent measurements for insertion loss and the suggested limit line indicate more than 37 dB of loss at 7 GHz
  - Extension of 802.3ch limit line to higher frequency: Kadry_3cy_02_0820
  - Measurements:
    - DiBiaso_Bergner_Cuesta_3cy_adhoc_01_091620
    - Patel_3cy_01a_0920
- The complexity of the PHY is strongly coupled with the insertion loss of the channel
- This presentation compares the order of the complexity of the PHY for a few options for insertion loss

Agenda

- Basic PHY requirements for a target insertion loss
- Broad discussion on PHY complexity
- Fundamental limits
- Suggestions for an upper bound for insertion loss

Basic PHY Requirements

- Starting from 802.3ch as a point of reference:
  - PAM4
  - FEC redundancy and other overheads similar to 802.3ch
  - BER = 10^{-12}

- Basic PHY requirements:

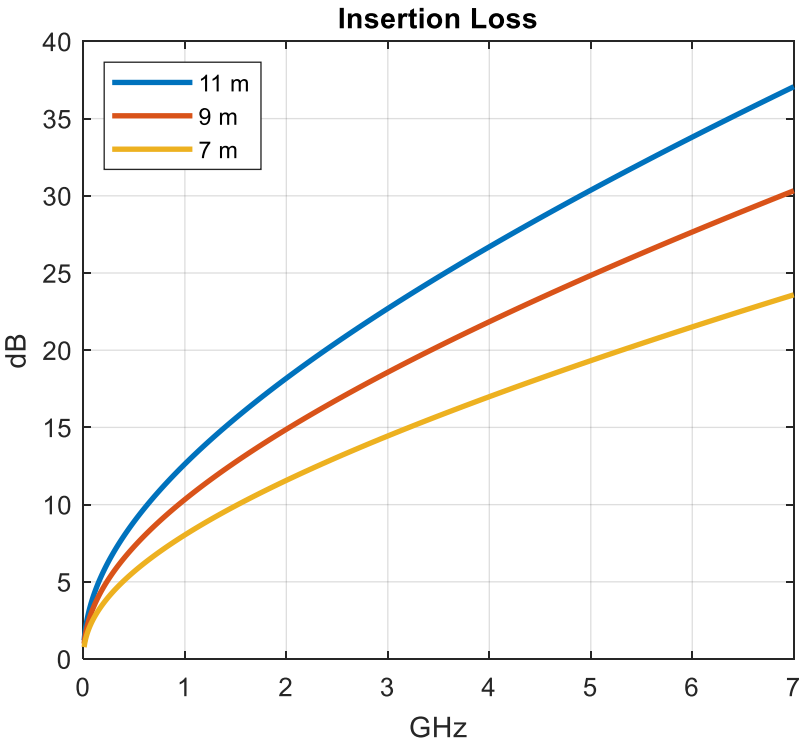
  ➔ Baud rate = 14.1 GHz

  ➔ SNR @Slicer: 24 dB

SNR and Noise Floor

- Assumptions:
  - 0.5 v peak transmit signal
  - Insertion loss according to 802.3ch
  - Insertion loss with linear scaling for cable length

Bit Rate (Gbps)	Cable Length (m)	IL @ Nyquist (dB)	SNR Input (dB)*	Noise Floor (dBm/Hz)*
25	11	37.2	**33.9**	**-145.9**
	9	30.4	**31.2**	**-141.7**
	7	23.7	**28.9**	**-137.4**
10	15	29.9	31.0	-137.8



* The numbers on SNR and Noise Floor are the theoretical limits representing the overall budget for tolerated noise including external crosstalk, thermal noise and all other sources of nonlinearity and noise within the PHY

PHY Complexity

- Designing a PHY that runs at around 14 GHz and supports 50 to 60 dB of dynamic range within a reasonable power budget is exceedingly hard!
- Designing a PHY with an operating point close to the fundamental limits is prohibitively hard!
- We should not specify a system with an operating point that is close to the following fundamental limits:
  - Alien crosstalk
  - Thermal noise

Fundamental Limits

- Thermal noise:
  - **-166** dBm/Hz (100 ohm, 400°K)
- Alien crosstalk:
  - Scales with transmit power
  - Scales inversely with bandwidth
  - Depends on shielding attenuation and coupling attenuation and CMRR
  - -152 dBm/Hz in 10GT1
  - Speculated to be higher than **-156 dBm/Hz** for 25GT1

Bit Rate (Gbps)	Cable Length (m)	Noise Floor (dBm/Hz)
25	11	**-145.9**
	9	**-141.7**
	7	**-137.4**
10	15	-137.8

Summary and Conclusion

Bit Rate (Gbps)	Cable Length (m)	IL @ Nyquist (dB)	Noise Floor (dBm/Hz)*	PHY Complexity
25	11	37.2	-145.9	Prohibitively Hard
	9	30.4	-141.7	Exceedingly Hard
	7	23.7	-137.4	Very Hard
10	15	29.9	-137.8	Hard

- Suggested limit on insertion loss: **24 dB @ Nyquist**
- This limit on insertion loss includes the loss of cable as well as connectors and boards

THANK YOU

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