Propagation Delay and Return Loss: Data-Driven Considerations for 802.3dm

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Introduction

This is a continuation of July – Madrid Plenary comparison done by TJ Houck and Jay Cordaro focusing on Propagation Delay and Return Loss for 802.3dm.

Objective #1: Focus on Data driven results for Propagation Delay and Return Loss

Objective #2: Compare current 802.3dm RL proposals with production SerDes RL limits

Objective #3: Propose Link Delay and Return Loss suggestions for text

Previous Comparison Presentations:

July Plenary: https://www.ieee802.org/3/dm/public/0725/Houck_Cordaro_3dm_01b_07292025.pdf

May Interim: IEEE 802.3dm PHY evolution Comparative Analysis for GMSLE, ACT, and TDD approaches

March Interim – Jay Cordaro - GMSLE FDD PHY Simulation Results and PHY Complexity

Longer Cable Length Summary

- Insertion Loss must drive link length requirement **NOT** delay.
  - This will limit markets size in automotive, trucking, bussing, aero, industrial, robotics, agricultural, biomedical, etc.

- This is an issue on 802.3ch which prevents customers from achieving longer cable length and will become problematic for the standard if they want cable lengths further than 15 meters.

802.3ch Link Delay = 94ns

149.7.1.6 Maximum link delay

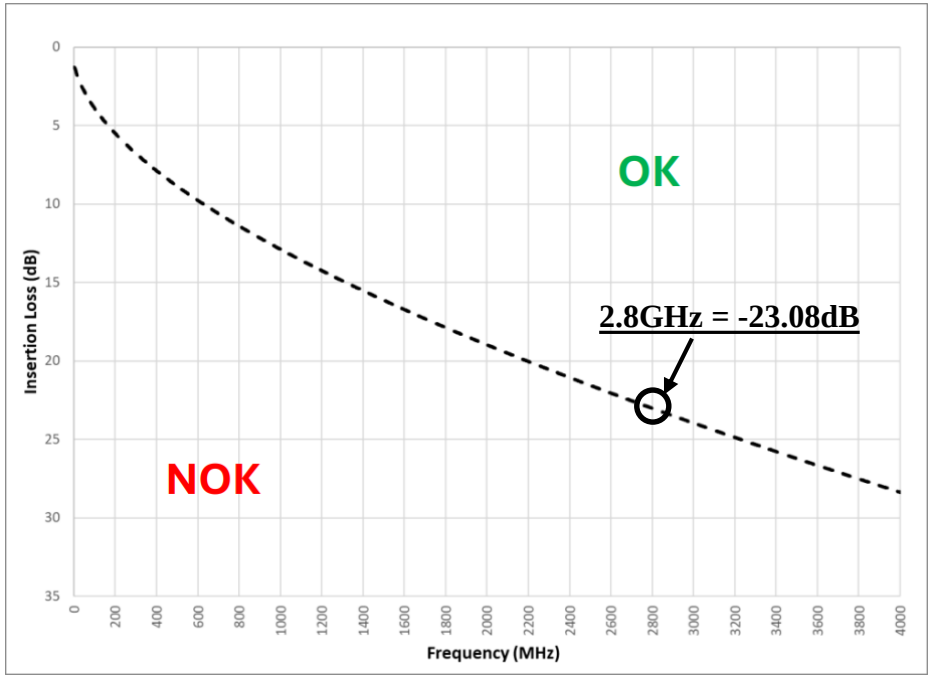
The propagation delay of a link segment shall not exceed 94 ns at all frequencies between 2 MHz and F_{max} MHz.

Current TDD proposal does not even exceed 802.3ch = 84ns

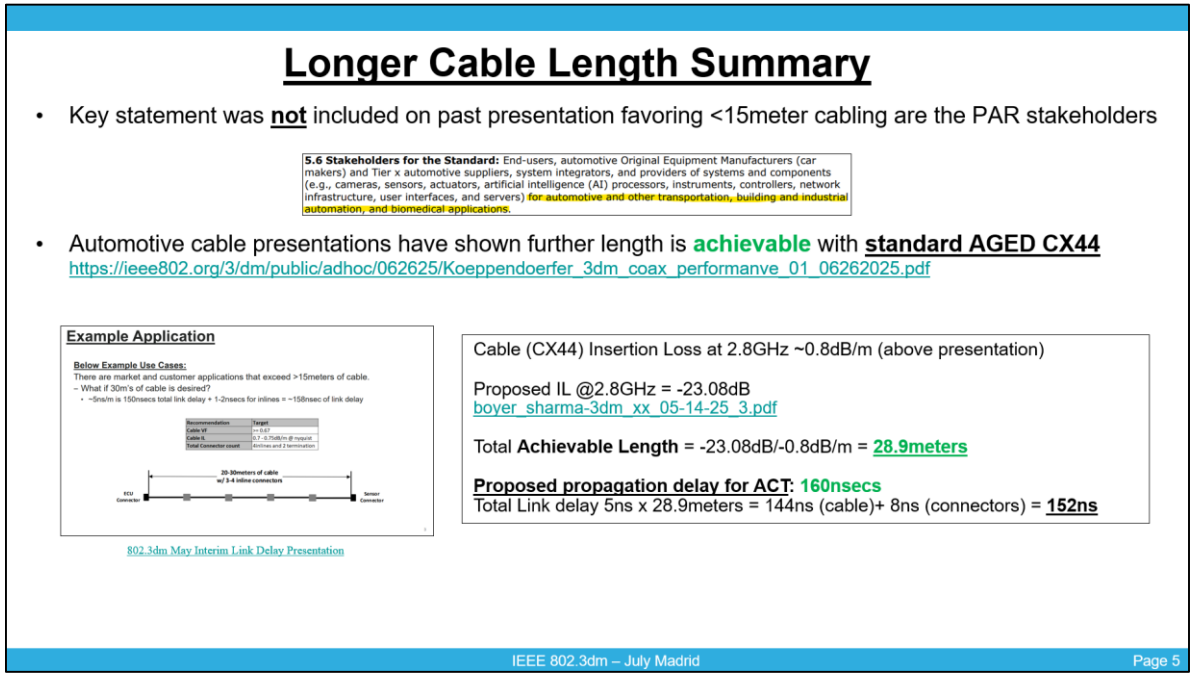
recommend the value of no more than 84ns for coaxial cable, which already a compromise in that it adds >7ns of margin to the calculated value for 15m

Longer Cable Length Summary

Proposed Insertion Loss



Previous Madrid Presentation



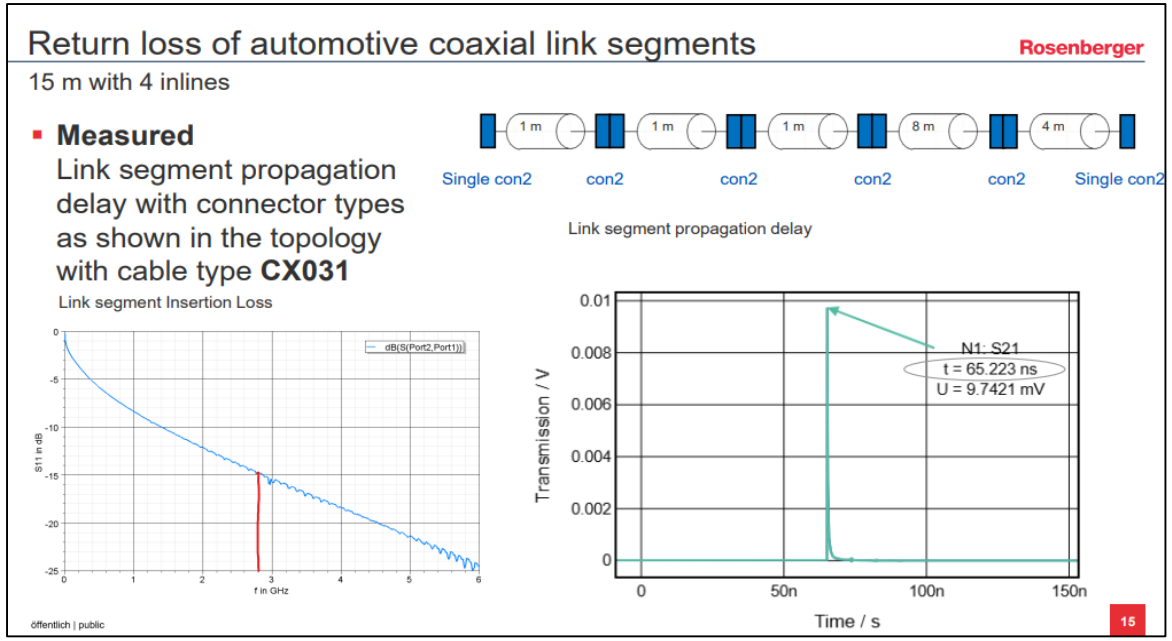
Cable (CX44) Insertion Loss at 2.8GHz ~0.8dB/m

Proposed IL @2.8GHz = -23.08dB
boyer_sharma-3dm_xx_05-14-25_3.pdf

Total **Achievable Length** = -23.08dB/-0.8dB/m = **28.9meters**

Proposed propagation delay for ACT: **160nsecs**
Total Link delay 5ns x 28.9meters = 144ns (cable)+ 8ns (connectors) = **152ns**

Longer Cable Length Summary



mueller_3dm_01a_08_21_25.pdf

Insertion Loss at 2.8GHz = -15dB (above presentation)

Proposed IL @2.8GHz = -23.08dB – (-15dB) = -8.08dB

Additional Length = -8.08dB/-0.8dB/m = **10.1meters**

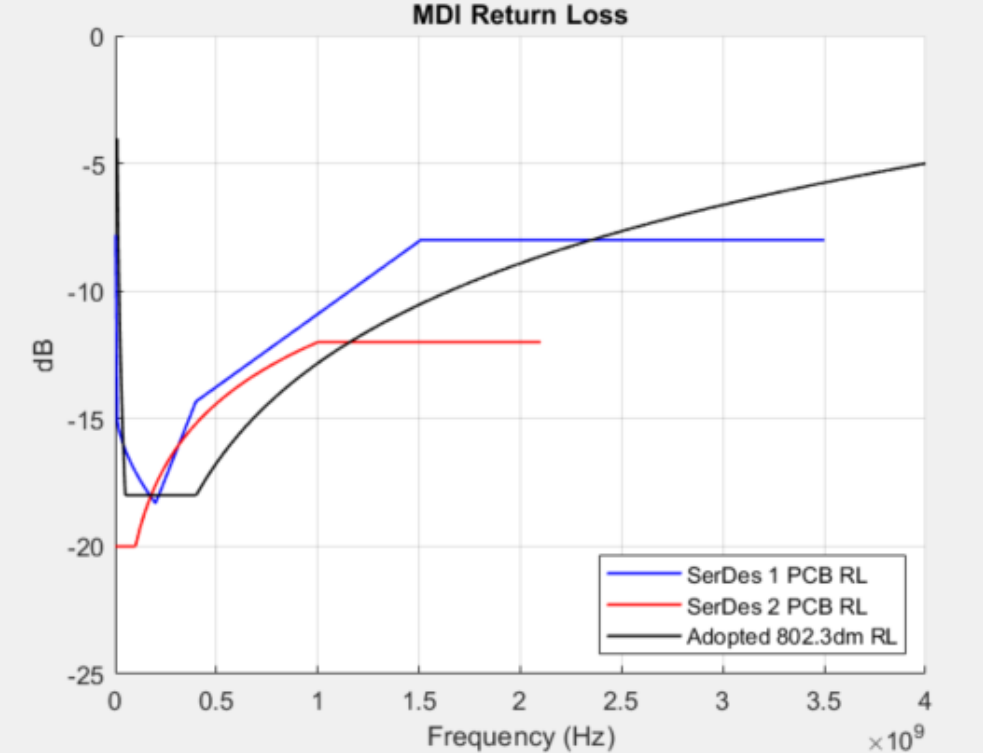
Propagation Delay Estimates: 65.223ns/15m = 4.35ns/m x 25.1m = **109ns**

Return Loss Considerations in 802.3dm

- Link Segment Return Loss (RL) has been a popular topic in 802.3dm, often explored via simulation with many contributions, although **no consensus**
- MDI Return Loss has been less frequently addressed but has important considerations which impact RL:
  - Power Over Coax (PoC)
  - Sensor PCB design (for example, right angle coax MDI connectors instead of edge launch)
- Investigating MDI and Link Segment for 802.3dm versus production automotive SerDes solutions in mass production provides a perspective on 802.3dm proposals
  - How do they compare to production SerDes solutions?
  - Do differences from production SerDes make sense?

MDI - Return Loss Comparison

- Production SerDes Return Loss specifications [1] are compared with adopted 802.3dm MDI RL [2,3]
  - **1-40MHz**: 802.3dm is more relaxed below 40MHz, and not defined below 10MHz. This will allow for smaller POC than production SerDes
  - **200-1000MHz:** 802.3dm requires better RL –> PCB layout will be more critical than production SerDes

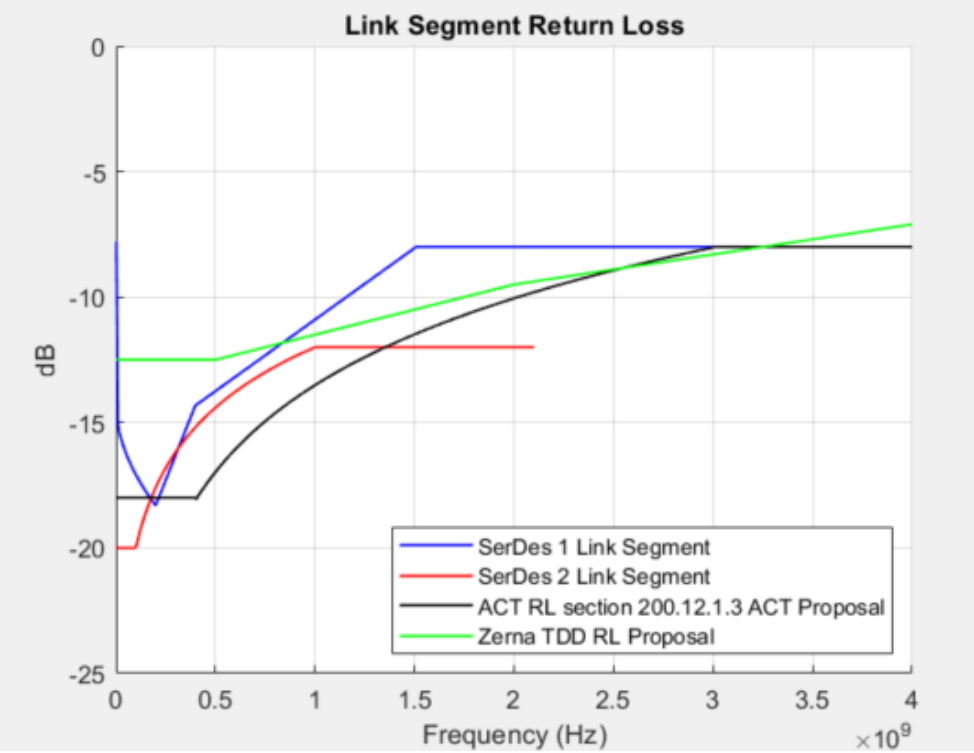


Linear Scale

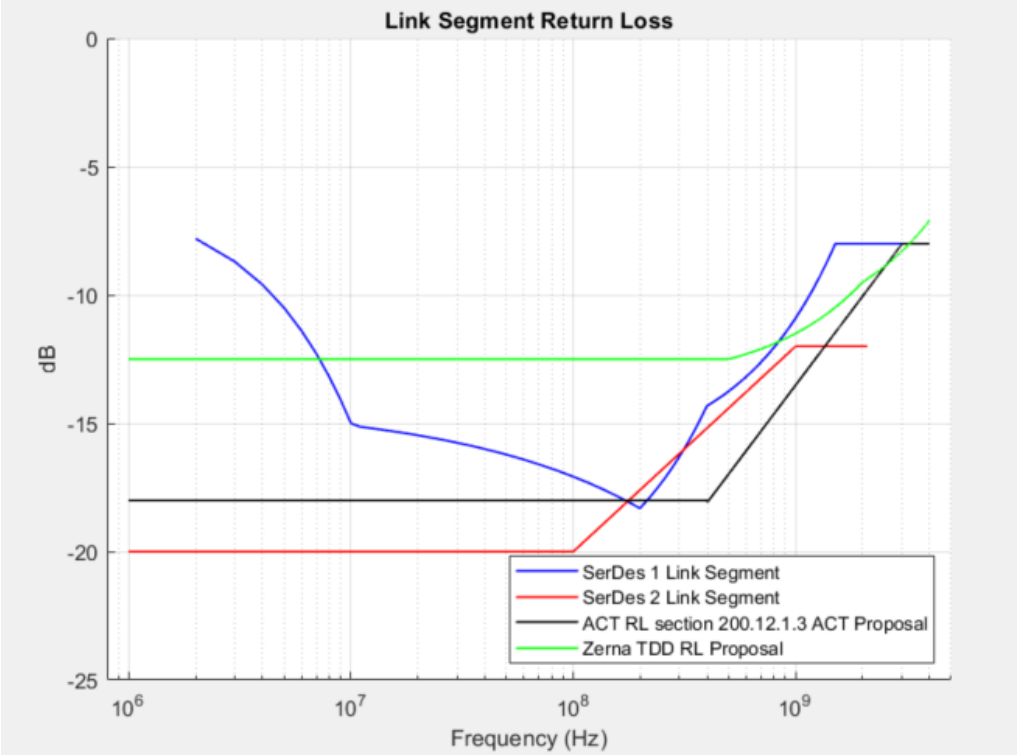
Log Scale

Link Segment - Return Loss Comparison

- Two production SerDes Link Segment RL limits are plotted against ACT Draft Text proposal and Zerna TDD proposal [4]
  - 10-800MHz: Zerna TDD proposal allows worse RL than production SerDes
  - For the production SerDes, the link segment and MDI equivalent specs are the same
  - Typical link segments have margin to production SerDes limits except in the 2000-3000MHz range



Linear Scale



Log Scale

Discussion of MDI and Link Segment RL

- Proposed 802.3dm TDD and ACT MDI and Link Segment Return Loss was compared with production automotive SerDes solutions
- MDI low frequency RL seems appropriate for 802.3dm PoC corner frequency objective
- **MDI mid range frequency RL** may warrant more consideration in light of production SerDes limits derived from module manufacturing considerations
- From 10MHz-300MHz, TDD Link Segment RL limit **allows far worse RL** than production SerDes which have not seen issues with link segments in this frequency range
- From 2000MHz-3000MHz, production SerDes has seen link segments approaching the “SerDes 1” link segment limit – **the Task Force may wish to consider this and the tradeoff with insertion loss in this frequency range**

Summary

1. Cables with Propagation Delay of 4-5ns/meter create an Link Delay **>100nsec**

2. Link Delay specification needs to meet **MAX** proposed Insertion loss for the cable

3. Proposed Link Delay of **160nsecs**
   - If installed length and ns/m (velocity factor) increases while keeping the same IL mask, the link delay should scale accordingly (ns/m x length + connector), which may require >160ns

4. Mid range MDI return loss justifies more investigation

5. TDD and ACT proposal for 2000-3000MHz link segments **may need adjustment**

References

[1] Analog Devices Inc., *GMSL2 Channel Specification User Guide Rev 1* GMSL2 Channel Specification User Guide

[2] ”Proposed text for MDI Return Loss” R. Jonsson, A. Chini Proposed text for MDI Return Loss

[3] “Error in MDI RL formula” R. Jonsson Error in MDI RL formula

[4] “Cable Channel IL and RL limits” Cable Channel IL and RL limits

THANK YOU

Questions?