
802.3dg Link Segment Considerations

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Purpose

- Component and link segment measurements contributed in 802.3cg for consideration:
 - https://grouper.ieee.org/groups///802/3/10SPE/public/Nov2016/diminico_01b_1116.pdf
 - https://www.ieee802.org/3/cg/public/Mar2017/diminico_01_0317.pdf
- In support of Peter Jones presentation "Characterizing installed cabling structures for target applications".
>>https://www.ieee802.org/3/dg/public/May_2022/jones_3_spep2p_2a_110222.pdf.

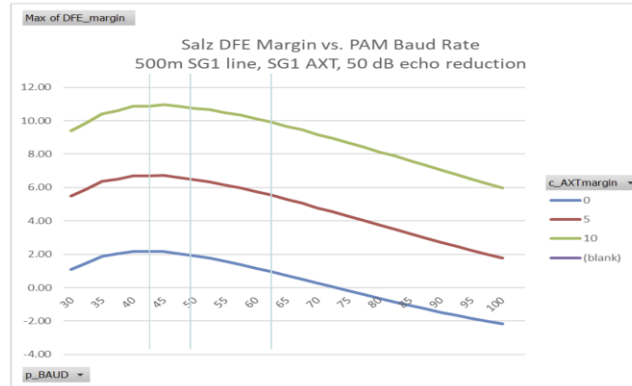
Contributors

- Paul Wachtel, Bob Voss –Panduit
- Steffen Graber, Pepperl+Fuchs

Link Segment Frequency Range

Optimal PHY bandwidth ~ 20 to 30 MHz

- PAM4 to PAM 5
 - PAM 3 pinched off by ANEXT
- Between 5 dB and 10 dB improvement on alien crosstalk + coding gain needed



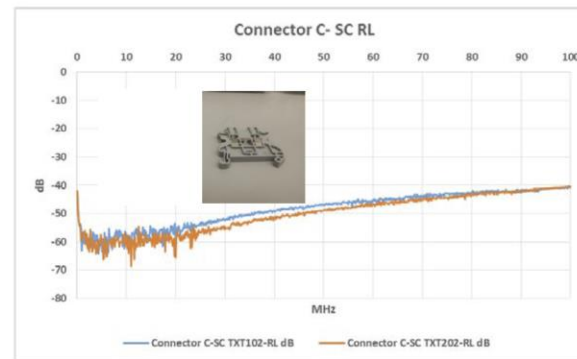
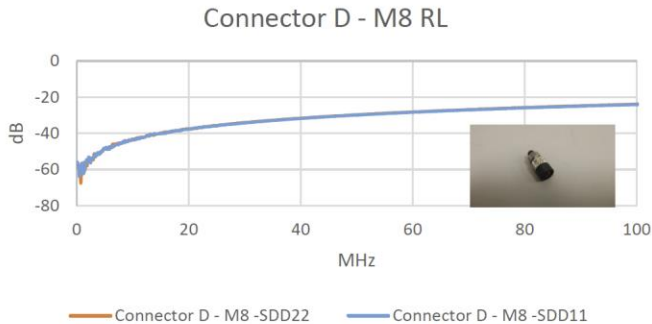
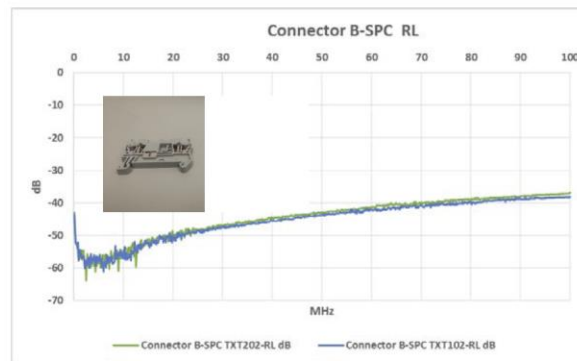
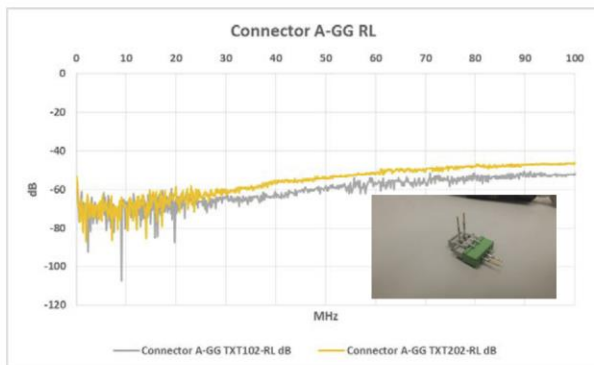
Conclusions

- Insertion loss & Alien Crosstalk functions will determine baseline PHY specifications
 - Proposals from [graber_3dg_01_08302022.pdf](https://www.ieee802.org/3/dg/public/May_2022/zimmerman_3dg_01_11_02_2022.pdf) are a good start
 - Need to get consensus on ANEXT/AFEXT models
 - Determines whether FEC is needed for crosstalk noise
 - Validating measurements will important
- Regardless, optimal Nyquist bandwidths are between 20 and 30 MHz used
 - 'Rule of thumb' would then specify out to at least 40 MHz (25% beyond Nyquist)
- Optimal noise performance is in favor of PAM 4
 - In low noise, PAM 3 could be used, and long reach/high freq noise, PAM 5

https://www.ieee802.org/3/dg/public/May_2022/zimmerman_3dg_01_11_02_2022.pdf

802.3cg Component Measurements (100 MHz)

Connector Return Loss Measurements



Background:

http://www.ieee802.org/3/10SPE/public/Sept2016_Interim/diminico_01_0916.pdf

http://www.ieee802.org/3/10SPE/public/Nov2016/diminico_01b_1116.pdf

IL < 0.02 dB

100 KHz ≤ f ≤ 20 MHz

11

10 Mb/s Single Twisted Pair Ethernet Task Force

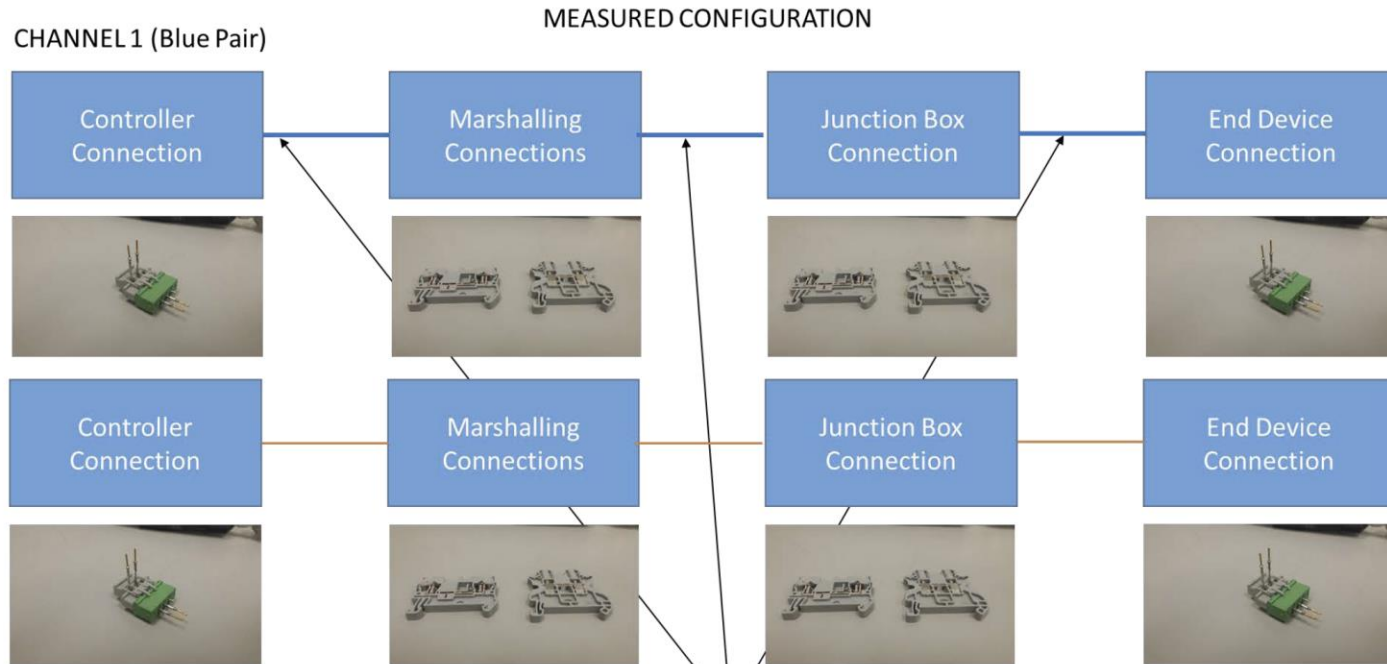
https://www.ieee802.org/3/cg/public/Mar2017/diminico_01_0317.pdf

100 Mb/s Long-Reach Single Pair Ethernet Task Force

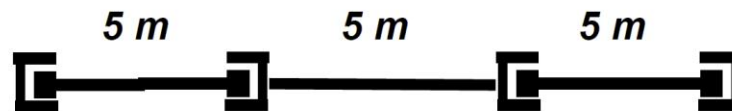
802.3cg Link Measurements - 100 MHz

Link Segment Measurements

https://www.ieee802.org/3/cg/public/Mar2017/diminico_01_0317.pdf



5 meter lengths of 23+ AWG twisted pair harvested from Category 8 cable, 3 places

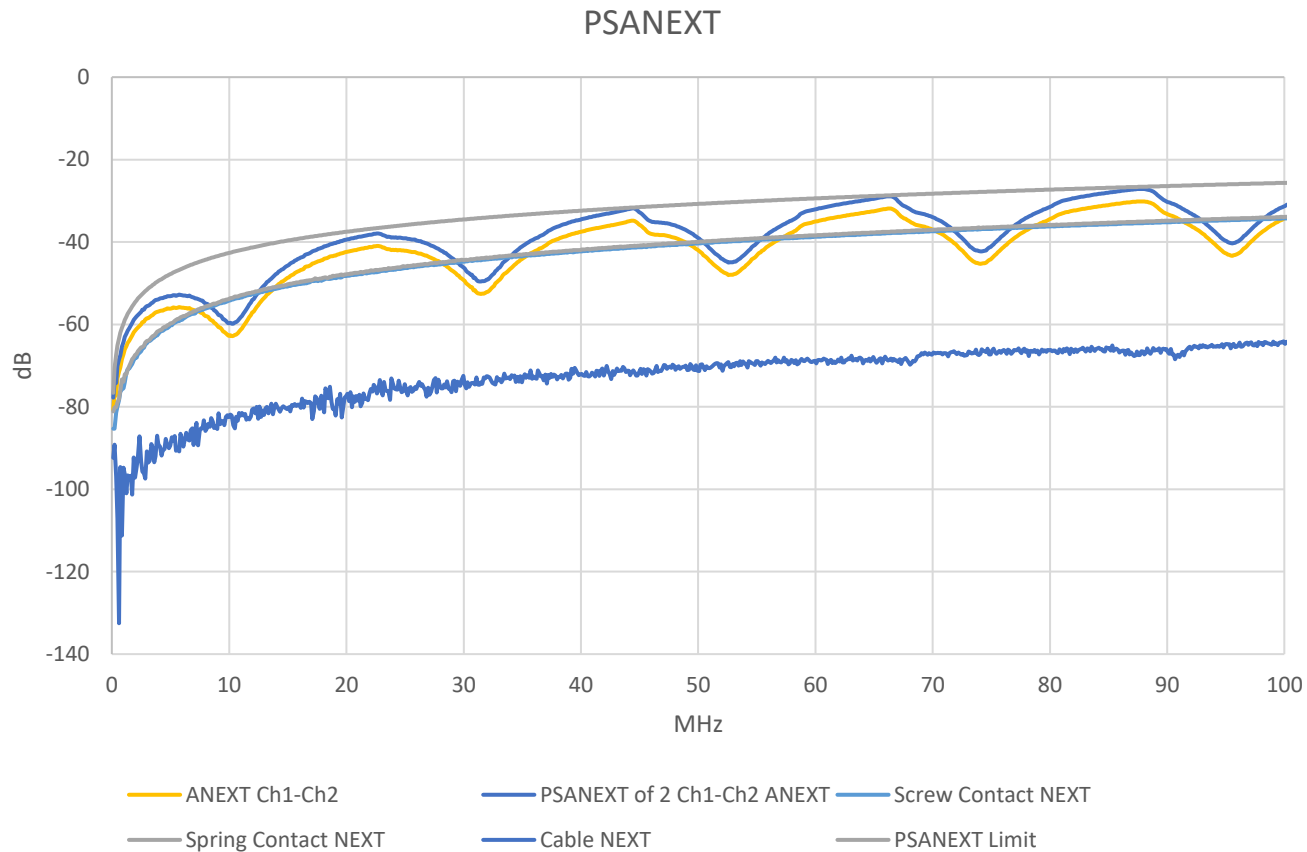


10 Mb/s Single Twisted Pair Ethernet Task Force

13

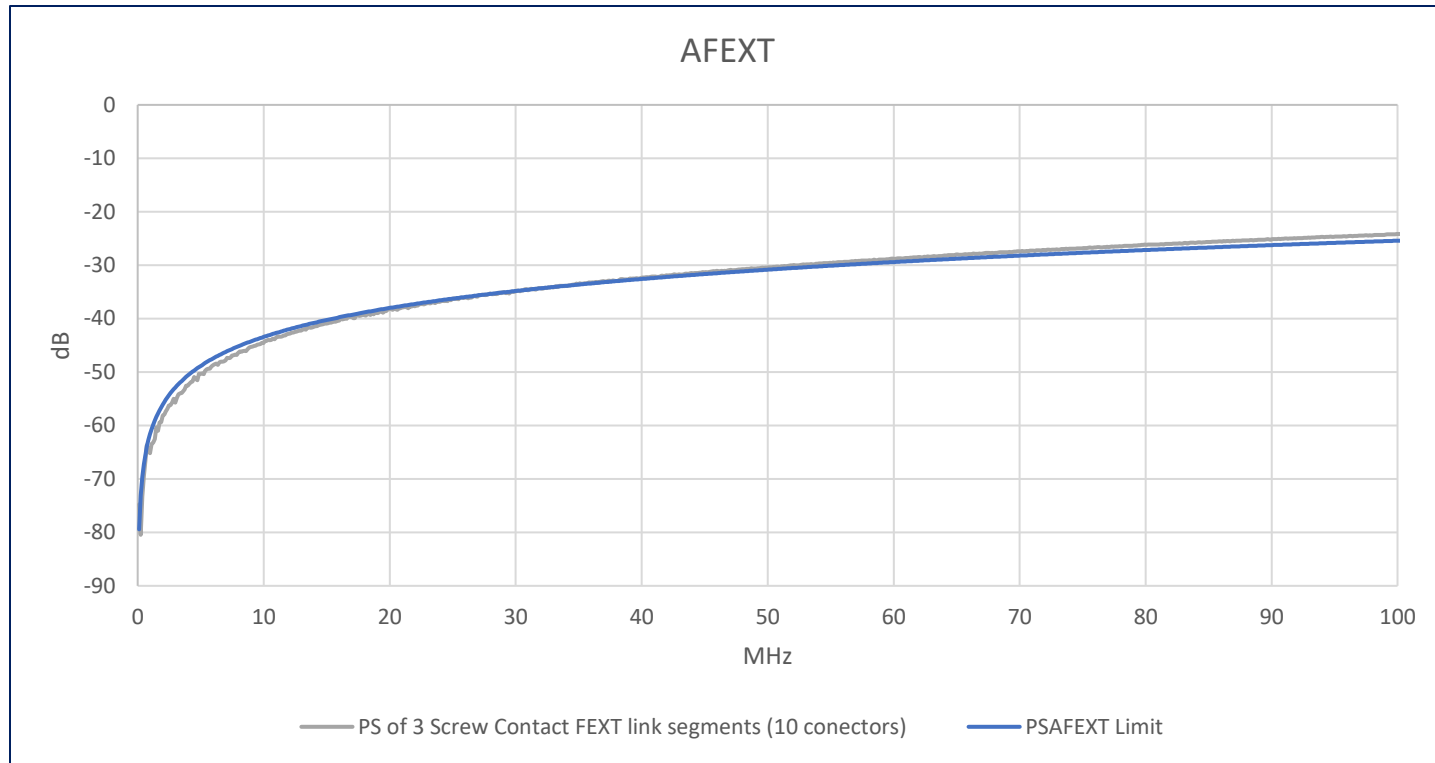
100 Mb/s Long-Reach Single Pair Ethernet Task Force

Link Segment Alien Crosstalk (ANEXT) - 100 MHz



http://www.ieee802.org/3/cg/public/Jan2017/diminico_01a_0117.pdf slide 28

Link Segment Alien Crosstalk (AFEXT) - 100 MHz

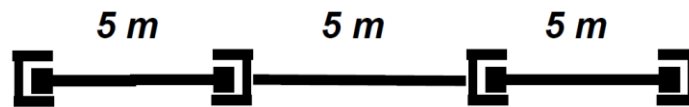
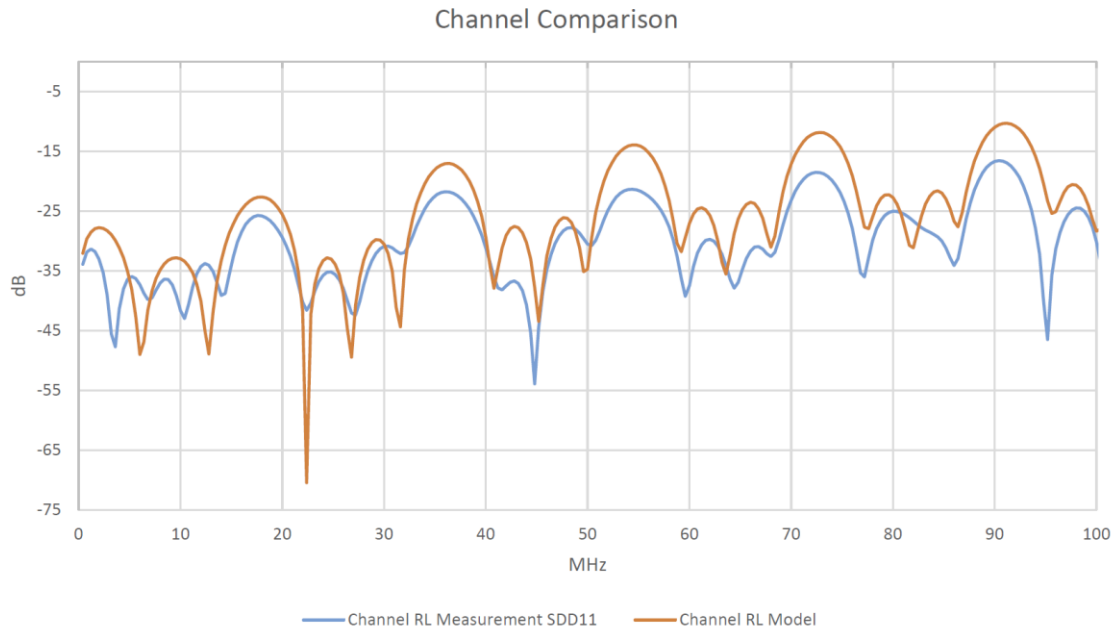


http://www.ieee802.org/3/cg/public/Jan2017/diminico_01a_0117.pdf slide 29

802.3cg Link Measurement Model - 100 MHz

Link Segment RL Model

- Cascade ABCD matrices of connectors and cables

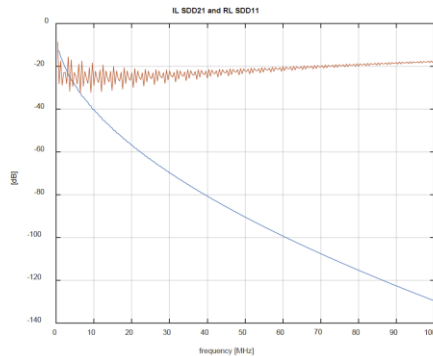
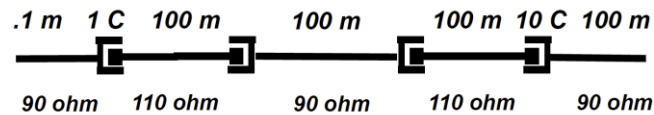


https://www.ieee802.org/3/cg/public/Mar2017/diminico_01_0317.pdf

802.3cg Link Model - 100 MHz

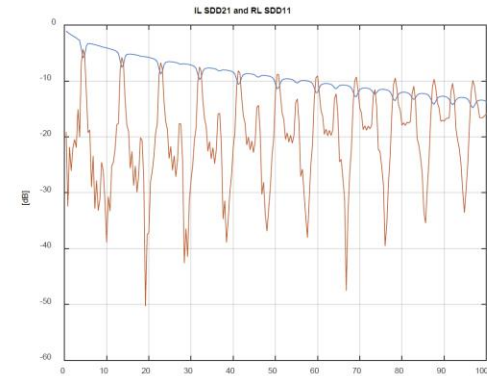
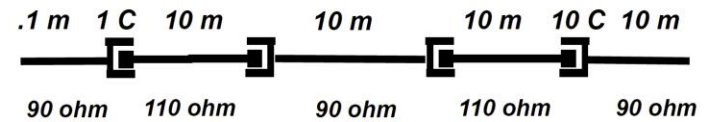
Link Segment RL Model

- 10 connectors separated by 100 meters
- Cables +/- 10%



Link Segment RL Model

- 10 connectors separated by 10 meters
- Cables +/- 10%



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Insertion Loss Considerations

- **Greater than 10 Mb/s long-reach SPE objective - Speed-Specific Objective (100 Mb/s)**

- **Define performance characteristics of a link segment with a single balanced pair of conductors supporting up to 5 inline connectors for up to at least 500m reach, and a PHY supporting point-to-point full duplex operation over the link segment.**

- **146.7.1.1.1 Insertion loss - assumes 1000 m, 18 AWG - 10 connectors $0.02\sqrt{f}$ (MHz)**

$$\text{Insertion loss}(f) \leq 10 \left(1.23 \times \sqrt{f} + 0.01 \times f + \frac{0.2}{\sqrt{f}} \right) + 10 \times 0.02 \times \sqrt{f} \quad (\text{dB})$$

where

f is the frequency in MHz; $0.1 \leq f \leq 20$

- **Proposed insertion loss - assumes 400 m, 18 AWG - 5 connectors $0.02\sqrt{f}$ (MHz)**

- **$IL(f) = 4 \times (1.23 \times \sqrt{f} + 0.01 \times f + (0.2 / \sqrt{f})) + 5 \times 0.02 \times \sqrt{f}$**

- **Remove implied cable length:**

- **$IL(f) = 4.92 \times \sqrt{f} + 0.04 \times f + 0.8 / \sqrt{f} + 5 \times 0.02 \times \sqrt{f}$**

Insertion Loss Considerations

100BASE-T1L Long Reach Link Segment Insertion Loss

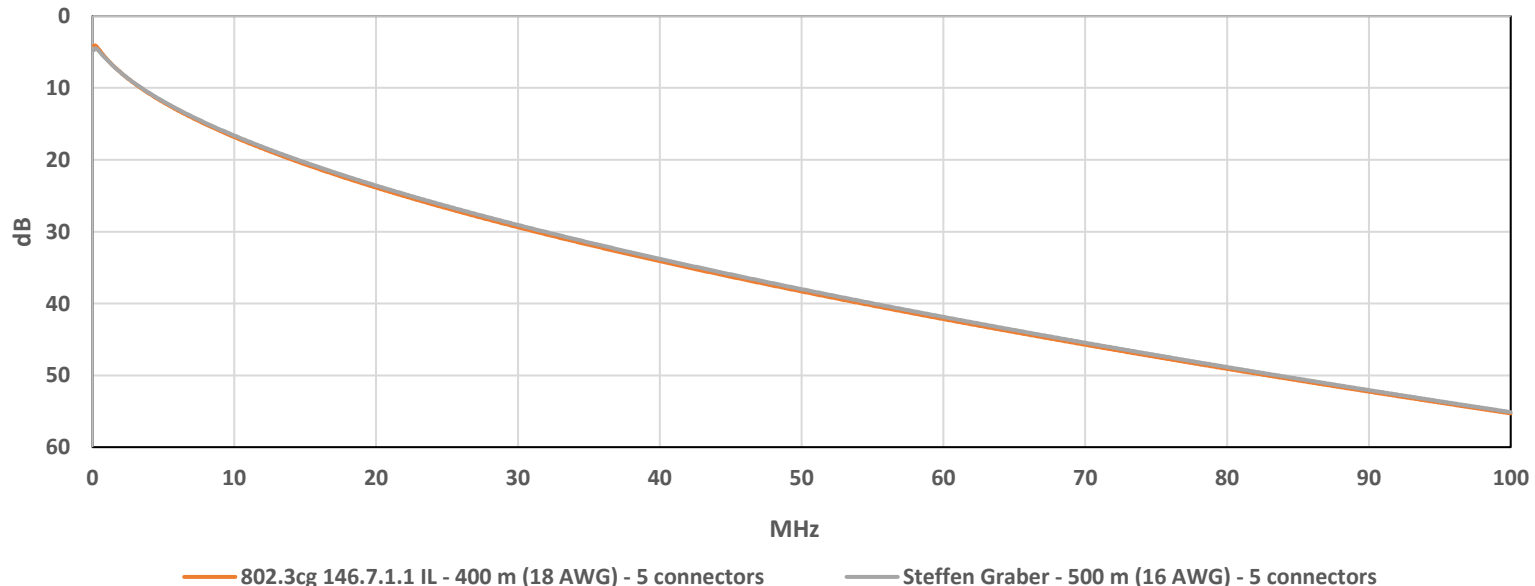
- Proposed insertion loss limit curve for the link segment (500 m AWG16 cable, 5 inline connectors/terminals):

$$IL[dB] = 5 \cdot \left(0.98 \cdot \sqrt{f} + 0.01 \cdot f + \frac{0.2}{\sqrt{f}} \right) + 5 \cdot 0.02 \cdot \sqrt{f}, 0.1 \text{ MHz} \leq f \leq 100 \text{ MHz}, \text{ with } f \text{ in MHz}$$

Source: https://www.ieee802.org/3/dg/public/May_2022/graber_3dg_01_08302022.pdf

- Proposed $IL(f) = 4.92 \cdot \text{SQRT}(f(\text{MHz})) + 0.04 \cdot f(\text{MHz}) + 0.8 / \text{SQRT}(f(\text{MHz})) + 5 \cdot 0.02 \cdot \text{SQRT}(f(\text{MHz}))$

IL Comparison



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