Insertion Loss Limit Proposal for 802.3cy

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Eric DiBiaso

Contributors:
Jonathan Silvano de Sousa
Natalie Wienckowski
Thomas Mueller
Stefan Gianordoli
Erwin Koeppendoerfer
Chris Diminico
Bert Bergner
Rich Boyer
Christian Neulinger
Harsh Patel

Links to previous IL proposals & Measurement data

- https://www.ieee802.org/3/cy/public/nov20/zimmerman_3cy_01a_1120.pdf
- https://www.ieee802.org/3/cy/public/adhoc/zimmerman_3cy_01a_01_19_21.pdf
- https://www.ieee802.org/3/cy/public/jan21/diminico_3cy_01_0121.pdf
- https://www.ieee802.org/3/cy/public/adhoc/neulinger_3cy_01_12_15_20.pdf
- https://www.ieee802.org/3/cy/public/jan21/neulinger_3cy_01_01_26_21.pdf
- https://www.ieee802.org/3/cy/public/adhoc/mueller_3cy_01_12_01_20.pdf
- https://www.ieee802.org/3/cy/public/adhoc/mueller_3cy_01a_12_15_20.pdf
- https://www.ieee802.org/3/cy/public/adhoc/boyer_3cy_01_12_08_20.pdf
- https://www.ieee802.org/3/cy/public/adhoc/sedarat_3cy_01_01_05_21.pdf
- https://www.ieee802.org/3/cy/public/adhoc/sedarat_3cy_01_01_12_21.pdf
- https://www.ieee802.org/3/cy/public/adhoc/BergnerCuestaDiBiaso_3cy_01a_01_19_21.pdf
- https://www.ieee802.org/3/cy/public/adhoc/jonsson_3cy_01_01_19_21.pdf
- https://www.ieee802.org/3/cy/public/adhoc/Gianordoli_Silvano_de_Sousa_3cy_01a_02_09_21.pdf
- https://www.ieee802.org/3/cy/public/adhoc/Kadry_3cy_01a_03_01_21.pdf

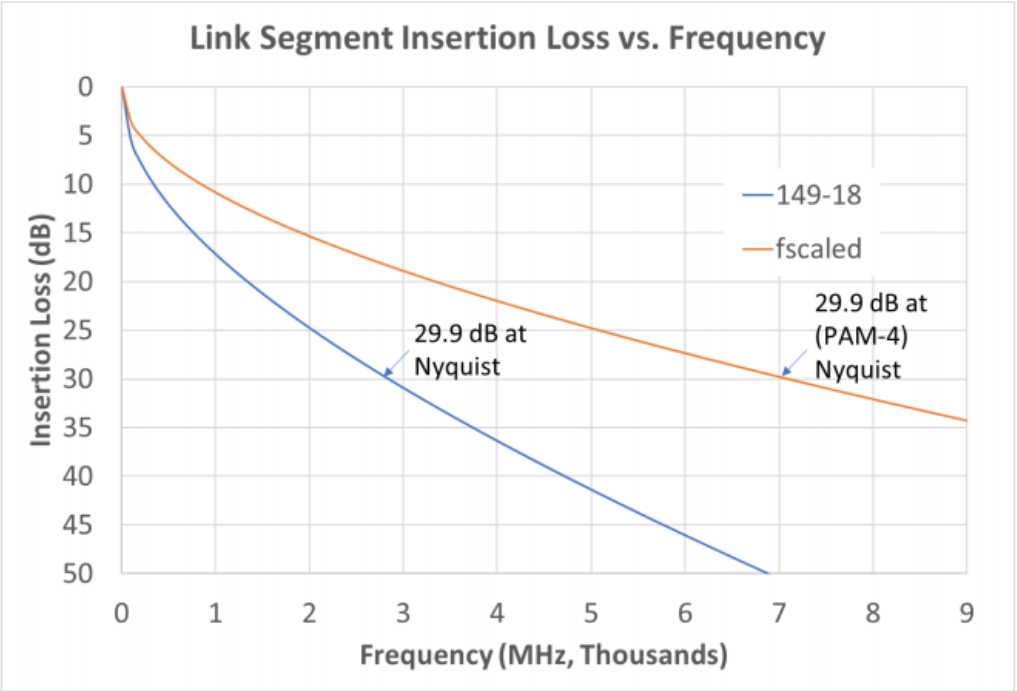
https://www.ieee802.org/3/cy/public/nov20/zimmerman_3cy_01a_1120.pdf

Frequency Scaled link segment IL

$$IL \leq 0.002\left(\frac{f}{2.5}\right) + 0.68\left(\frac{f}{2.5}\right)^{0.45}$$

This is a starting point

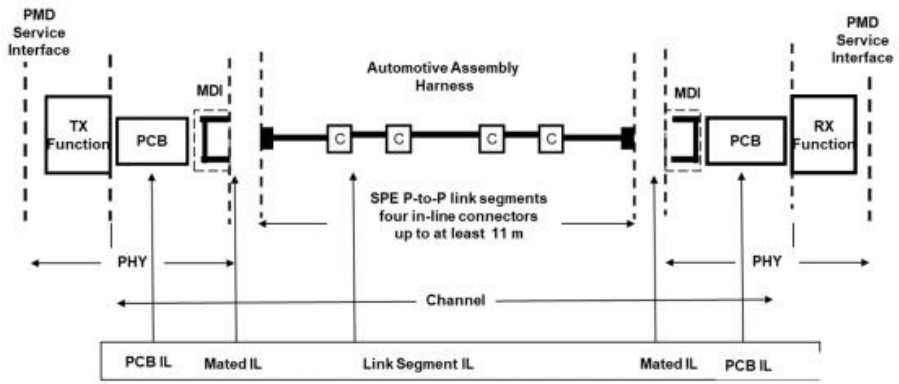
Same IL at Nyquist as .3ch



https://www.ieee802.org/3/cy/public/jan21/diminico_3cy_01_0121.pdf

Tx Function to Rx function channel IL

- **Tx Function to Rx function channel IL proposal**



$$IL_{Channel} \leq 2 \cdot IL_{PCB(76.2mm)} + 2 \cdot IL_{MDI} + IL_{Linksegment} \quad (dB)$$

$$IL_{PCB(76.2mm)} \leq \left(0.0071 \cdot \sqrt{f/2.5 \cdot 10\text{^}3} + 0.0045 \cdot f/2.5 \cdot 10\text{^}3\right) \cdot 76.2 \ (dB)$$

$$IL_{Linksegment} \leq 0.002\left(\frac{f}{2.5}\right) + 0.68\left(\frac{f}{2.5}\right)^{0.45} \ (dB)$$

$$IL_{MDI} \leq 0.1\sqrt{\frac{f}{2.5 \cdot 10\text{^}3}} \quad (dB)$$

https://www.ieee802.org/3/cy/public/adhoc/diminico_3cy_01a_1_5_21.pdf

PHY	MBd	Bandwidth (GHz)	PCBILdb/76.2mm	IL Link Segment	IL MDI	IL Channel Max
25GBASE-T1	14062.25	7031.25	1.8717	29.8688	0.168	33.948

https://www.ieee802.org/3/cy/public/adhoc/sedarat_3cy_01_01_12_21.pdf

Decision to Consider

- PROPOSED:

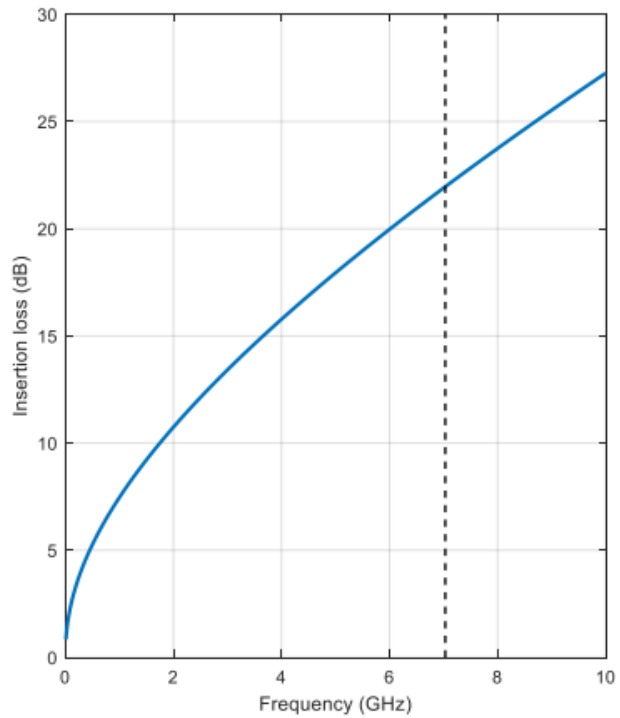
  Move that: 802.3cy consider the following limit-line for insertion loss

$$Insertion\ Loss(f) \leq \frac{6.5}{15}(0.002 \times f + 0.68 \times f^{0.45})$$

Where f is the frequency in MHz,

$1 \leq f \leq F_{max}$, *and* F_{max}=10 GHz

(F_{max} is chosen to be 2.5x the corresponding 802.3ch value)



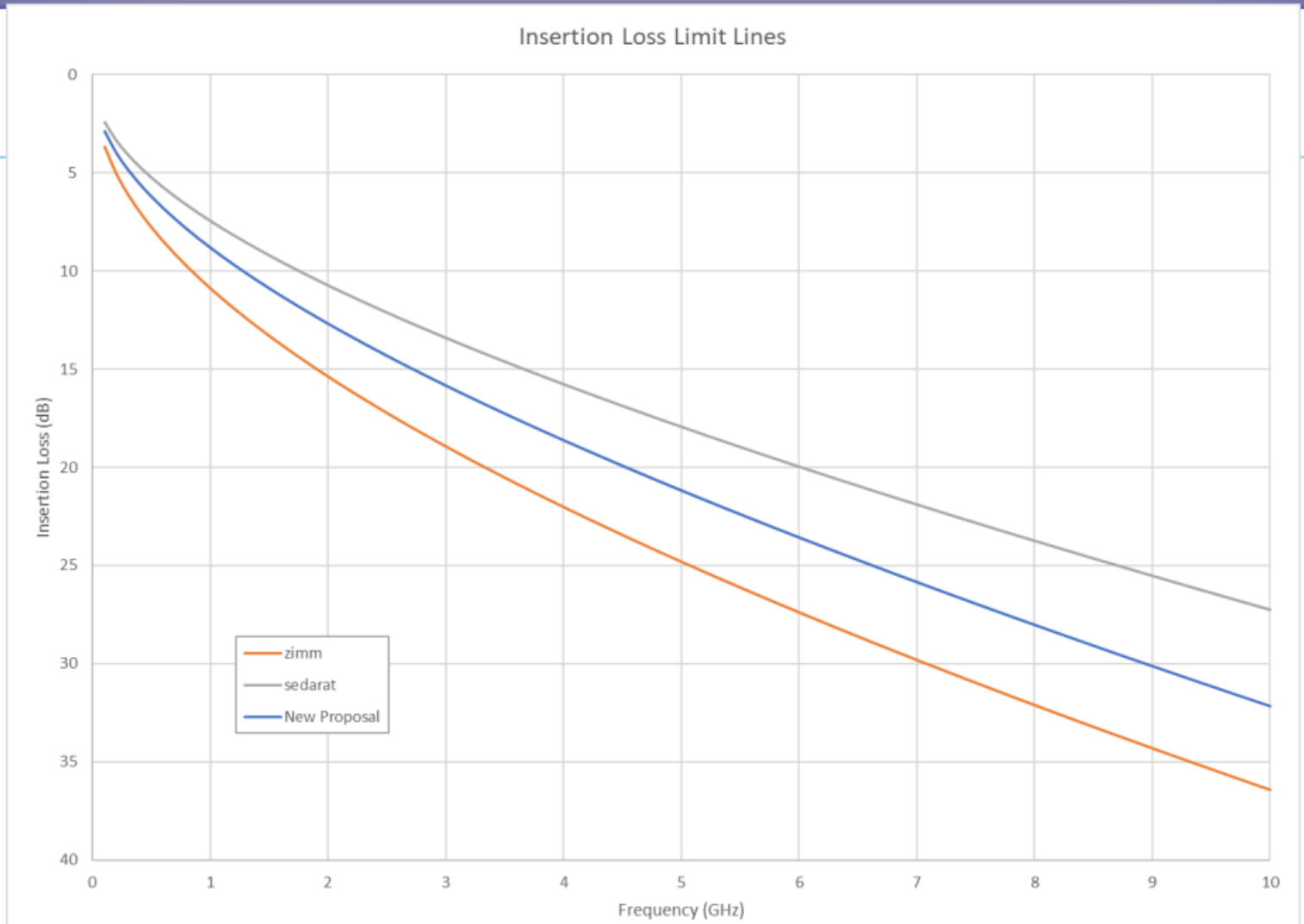
ETHERNOVIA
TRANSFORMING HOW CARS OF THE FUTURE ARE BUILT

https://www.ieee802.org/3/cy/public/adhoc/zimmerman_3cy_01a_01_19_21.pdf

Reconciliation

	dB IL at 7 GHz	Insertion Loss (dB) vs. freq (MHz)
802.3ch	29.80	$\leq 0.002\,f + 0.68\,f^{0.45}$
Nov. Strawman (zimmerman):	29.80	$\leq 0.002\,(f/2.5) + 0.68\,(f/2.5)^{0.45}$
Jan 12 Proposal (sedarat):	21.90	$\leq (6.5/15) \times (0.002\,f + 0.68\,f^{0.45})$
New Strawman proposal	25.85	$\leq 1.180 \times (6.5/15) \times (0.002\,f + 0.68\,f^{0.45}) = 0.00102\,f + 0.348\,f^{0.45}$
Mueller_3cy_01_12_01_20 SDP cable @ 95C	26.7 dB	(relaxation from 105C from wiencowski, based on model in Jonsson spreadsheet)

https://www.ieee802.org/3/cy/public/adhoc/zimmerman_3cy_01a_01_19_21.pdf



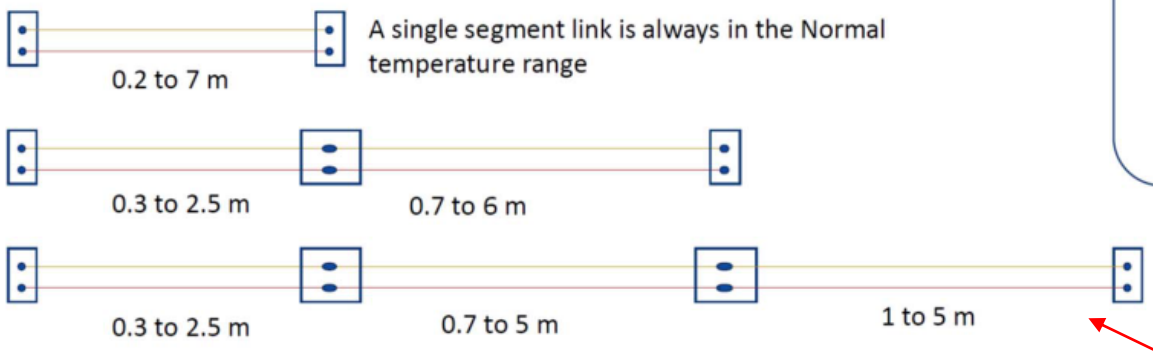
IL Factors to consider

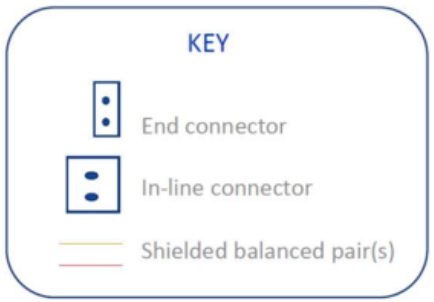
- Only consider the Automotive Harness Link segment
- 11m of cable
  - IL of Inline connectors
- Temperature maximum is 105^0C, but not all 11m (Max. 5m)
  - Remaining cable maximum is 85^0C
  - Additional clarification to follow
- Effect of Long term aging

Cable Topology and Temperature

CABLE TOPOLOGY & TEMPERATURE

- Based on https://www.ieee802.org/3/B10GAUTO/public/may19/wienckowski_3+10G_01a_0519.pdf
- Each segment is part of a different harness and the temperature is usually similar across a segment
- No more than 1 segment is in the "hot" temperature zone
- Only an end segment would be in the "hot" temperature zone
- Normal temperature range: -40 ˚C to + 85 ˚C
- "Hot" temperature range: -40 ˚C to + 105 ˚C (These devices may be underhood or in the roof, but not near the engine.)





Maximum of 5m at 105^0C

Source: wienckowski_3cy_01_01_12_21.pdf

https://www.ieee802.org/3/cy/public/adhoc/mueller_3cy_01_12_01_20.pdf

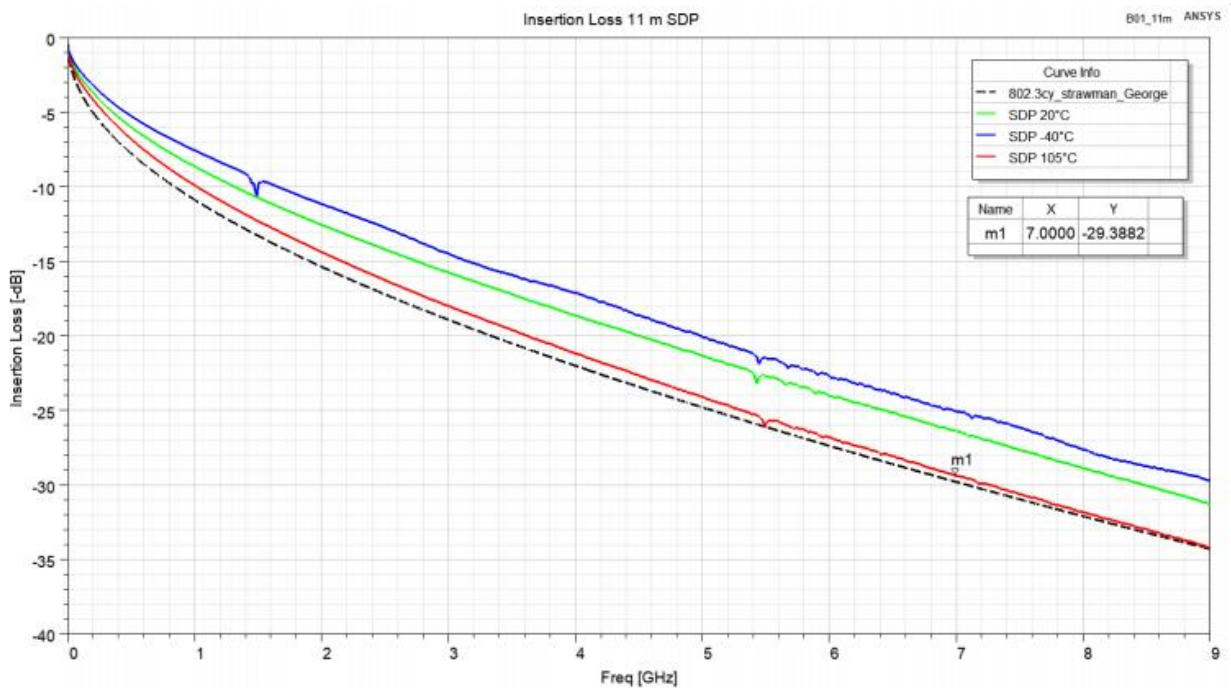
802.3cy cable

Rosenberger

Measurement results IL of SDP

- New SDP cable concept IL measured as ~2.7 dB/m @ 7 GHz at +105°C.
- 11 m cable passes strawman proposal even at +105°C.

IL: -29.4 @ 7GHz
(No Aging)
(No InLine Connectors)



- Further improvements on the residual resonances are expected.

https://www.ieee802.org/3/cy/public/adhoc/BergnerCuestaDiBiaso_3cy_01a_01_19_21.pdf

Insertion Loss – Sample C (fixtures removed)

- 11m as measured
- No inline connectors

IL: -31.4 @ 7GHz
(No Aging)
(No InLine Connectors)

https://www.ieee802.org/3/cy/public/adhoc/diminico_3cy_01a_1_5_21.pdf

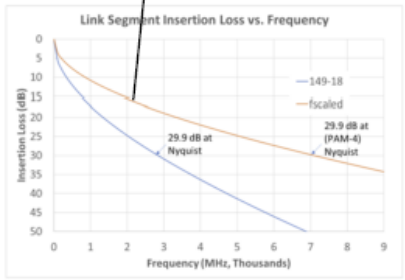
Insertion Loss Consideration

Frequency Scaled link segment IL

$$IL \leq 0.002\left(\frac{f}{2.5}\right) + 0.68\left(\frac{f}{2.5}\right)^{0.45}$$

This is a starting point

Same IL at Nyquist as .3ch

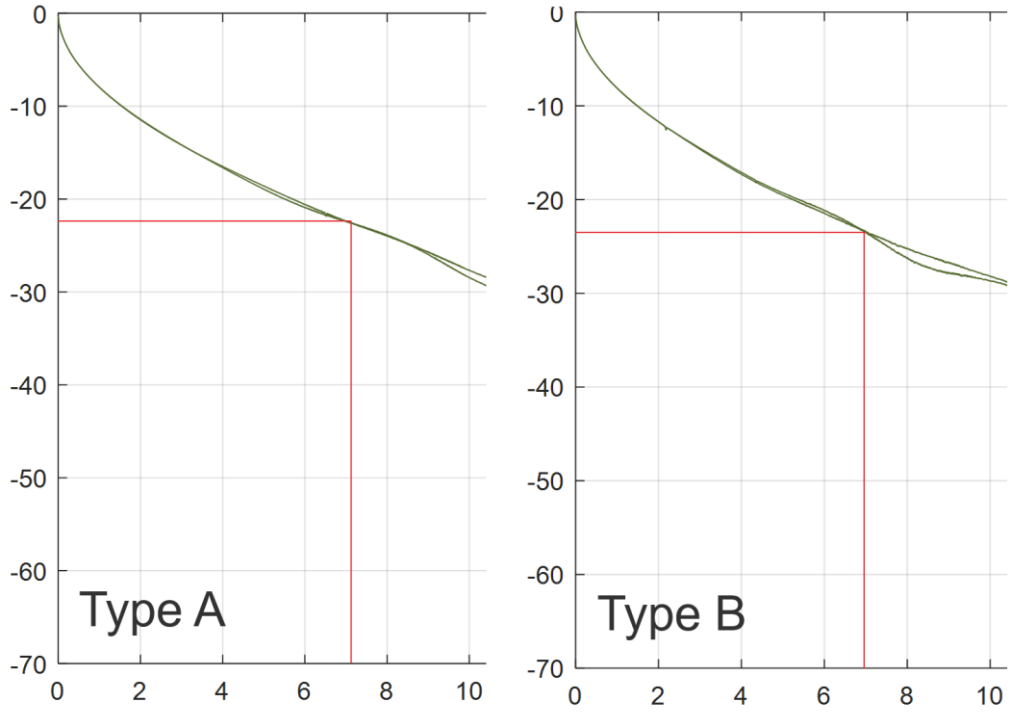


IL: -26dB @ 7GHz
(Room Temperature)
(No Aging)
(No InLine Connectors)
(Not Automotive Cable)

802.3cy link segment insertion loss

Status summary

- Previous cable results in [mueller_3cy_01_12_01_20.pdf]
- Measurement on 10 m cable assemblies 0.14mm² at room temperature.
- All IL values used for calculation are at 7 GHz.
- Cable type A shows 2.3 dB/m.
- Cable type B shows 2.4 dB/m.

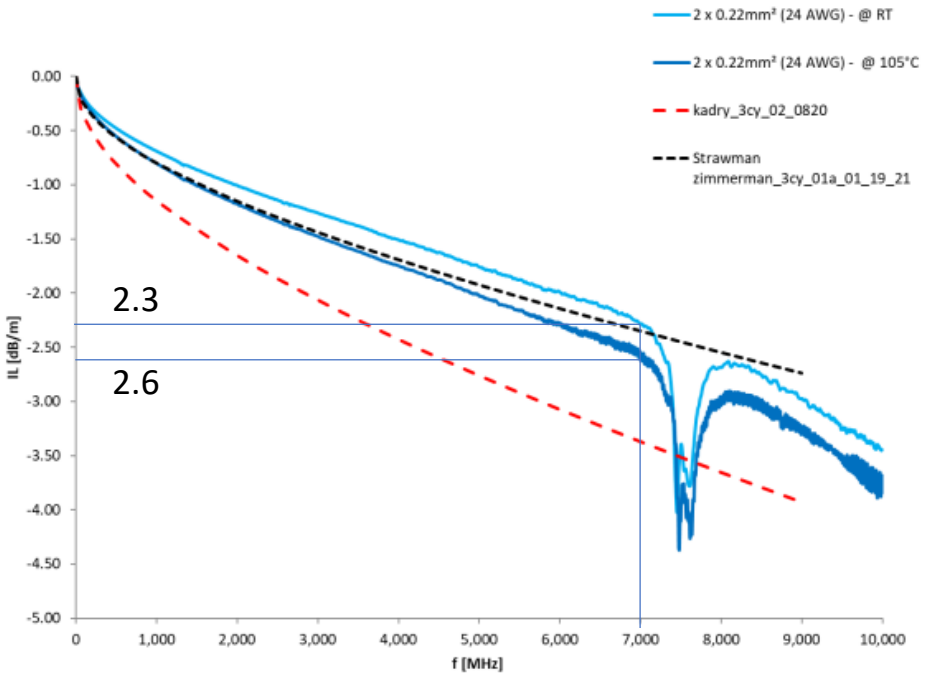


- Considering 2.4 dB/m and 20% margin for temperature, ageing, bending and two inline connectors, link segment IL for 11 m would be **31.7 dB @ 7 GHz**.

802.3cy link segment insertion loss

0.22 mm²

- Results in Gianordoli_Silvano_de_Sousa_3cy%20_01_02_09_21.pdf show 2.3 dB/m @ 7 GHz at room temperature.
- Link segment IL for 11 m would be
  2.3 dB/m * 11 m * 1.2 = **30.4 dB @ 7 GHz**.



Potential for optimization

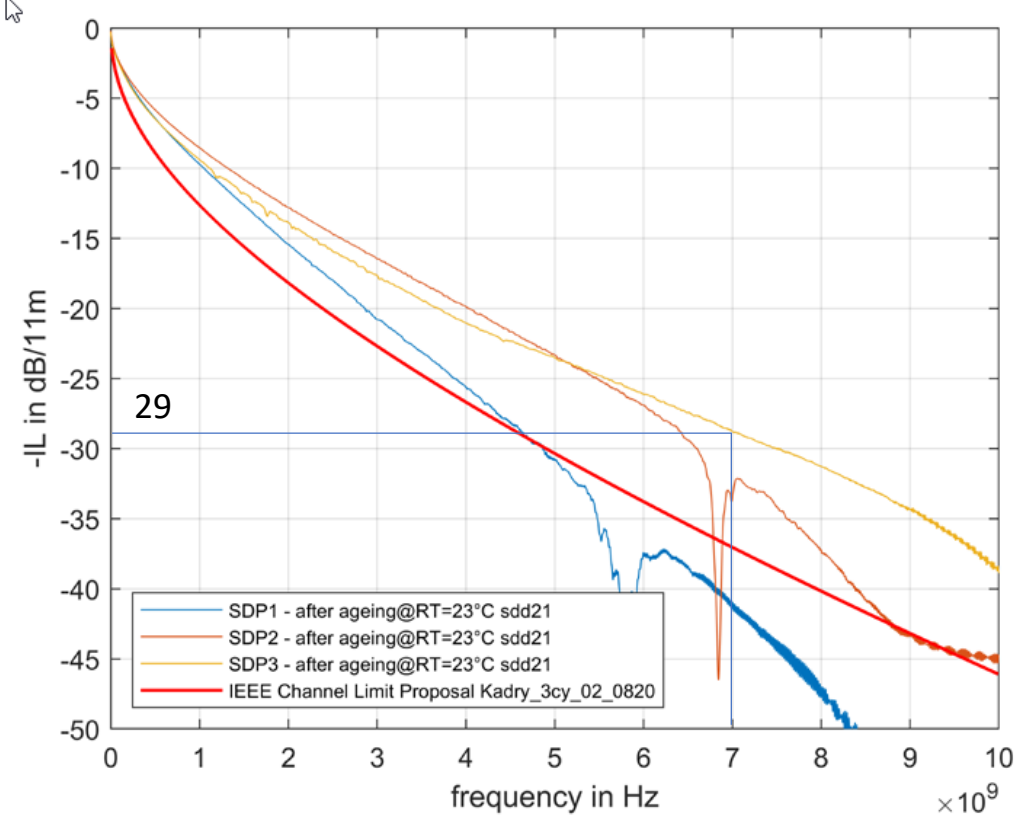
5 m @ 105°C

- 2.3 dB/m * 11 m * 1.15 = **29.1 dB @ 7 GHz** for a 0.22 mm² link segment IL over 11 m including ageing and connectors

802.3cy link segment insertion loss

Status summary

- Presentation by Erwin koeppendoerfer_3cy_01_10_28_20.pdf says
- Common SDP concepts (SDP2 and SDP3) have a IL of 3.0 dB/m @ 7GHz
  (cable only; with temperature and aging)
- Adding 5% margin for two inline connectors, link segment IL for 11 m would be



connectors

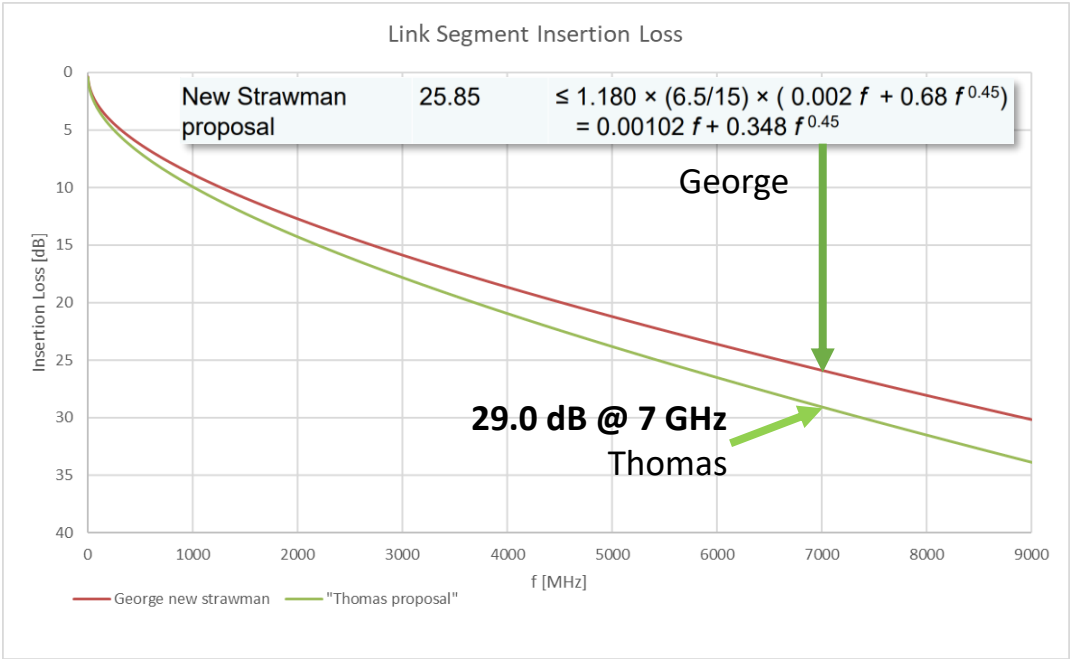
- 3.0 dB/m * 11 m * 1.05 = **34.7 dB @ 7 GHz**.
- Estimation for 0.22 mm² link segment would be
  34.7 dB x 0.87 = 30.2 dB, with only 5 m at 105°C probably 30.2 dB / 1.2 * 1.15 = **28.9 dB**

802.3cy link segment insertion loss

Target estimation and summary

Target estimation

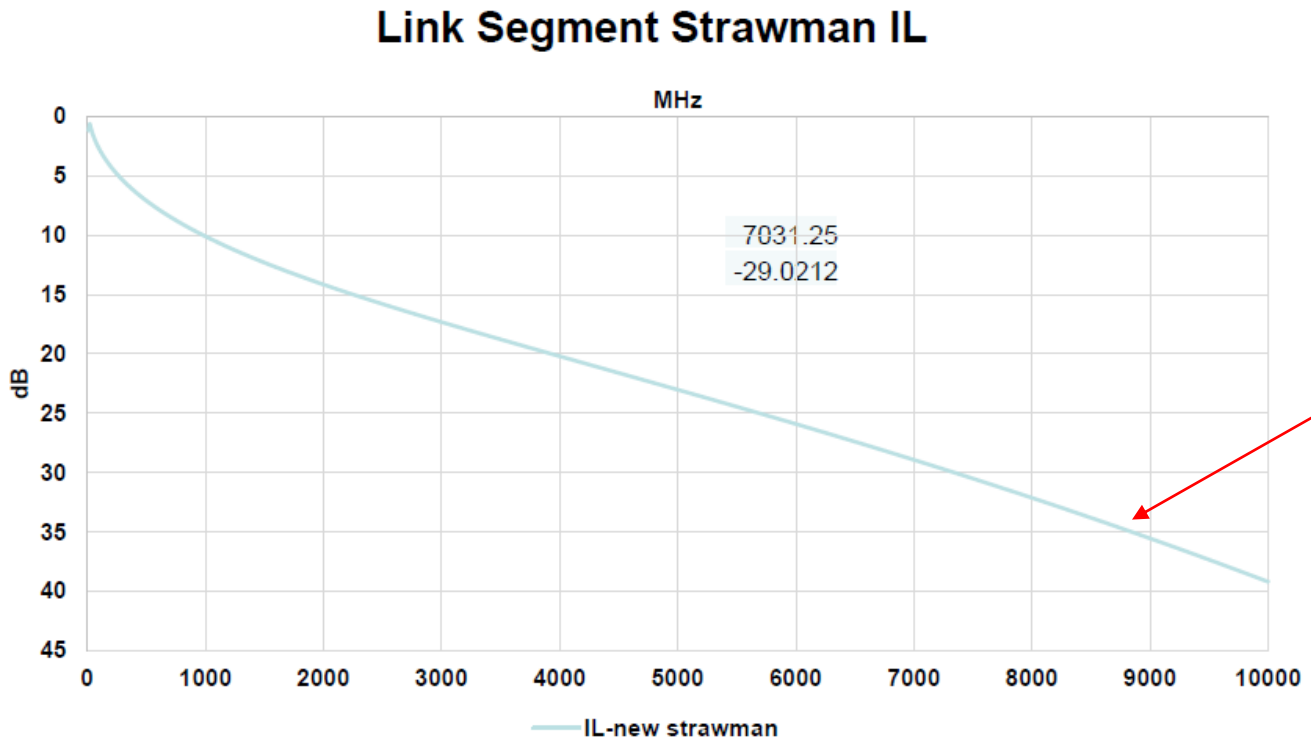
- To reach 24 dB link segment IL, 1.8 dB/m at room temperature would be needed.
- (1.8/2.4) dB/m = 75% -> 25% improvement needed.
- 24 dB link segment IL technically feasible but less economical and probably diminishing market potential.



- Suggest to adopt a modification George's new strawman proposal as:

$$IL \leq \mathbf{1.325} \times \left(\frac{6.5}{15}\right) \times (0.002f + 0.68f^{0.45})dB, \qquad f \text{ in } MHz$$

Link Segment Strawman IL



Additional Relaxation of IL Limit above 7GHz

*Link Segment IL= -1.2+0.41*SQRT(f_{MHz})-0.00185* f_{MHz} +1.79E-07* f_{MHz} ^2*

*Link Segment IL= -1.2+0.41*SQRT(7031.25)-0.00185* 7031.25+1.79E-07* 7031.25 ^2= ~29 dB*

Fmin = 10MHz

Fmax = 9/10GHz

26AWG vs 24AWG

- 26AWG or 0.14mm^2: Limit of 31.7dB @ 7GHz for 11m (2.9dB/m)
- 24AWG or 0.22mm^2: Limit of 29.0dB @ 7GHz for 11m (2.64dB/m)

- Basically 24AWG will allow 1 extra meter of link segment
- If this extra 2.7dB is not enough to allow the PHY to get the necessary 11m, and some other design modification needs to be considered, it may make sense for the PHY to consider the 26AWG limit of 31.7dB.
  - This could eliminate lots of design effort related to 24AWG for minimal applications requiring 1 extra meter of cabling.