On Insertion and Return Loss

Contribution to 802.3dm Task Force

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Introduction

- The 802.3dm development should define link segment Insertion Loss (IL) limits consistent with the objectives
- The 802.3dm development should define link segment Return Loss (RL) limits that allow media to be competitive with existing and planned practices
- Specific IL and RL limits are suggested for 802.3dm

Insertion Loss Limits

Approved Objective
Define performance characteristics of link segments suitable for use with automotive balanced-pair cabling and automotive unbalanced coaxial cabling supporting use of up to 4 inline connectors and up to at least 15m reach on at least one type of automotive cabling.

- The wording of the objective above allows an interpretation that it is sufficient to reach 15m on some types of cables, and the reach for other cables could be shorter

Link Segment Insertion Loss Limit for 802.3dm

The proposed Insertion Loss Limit is

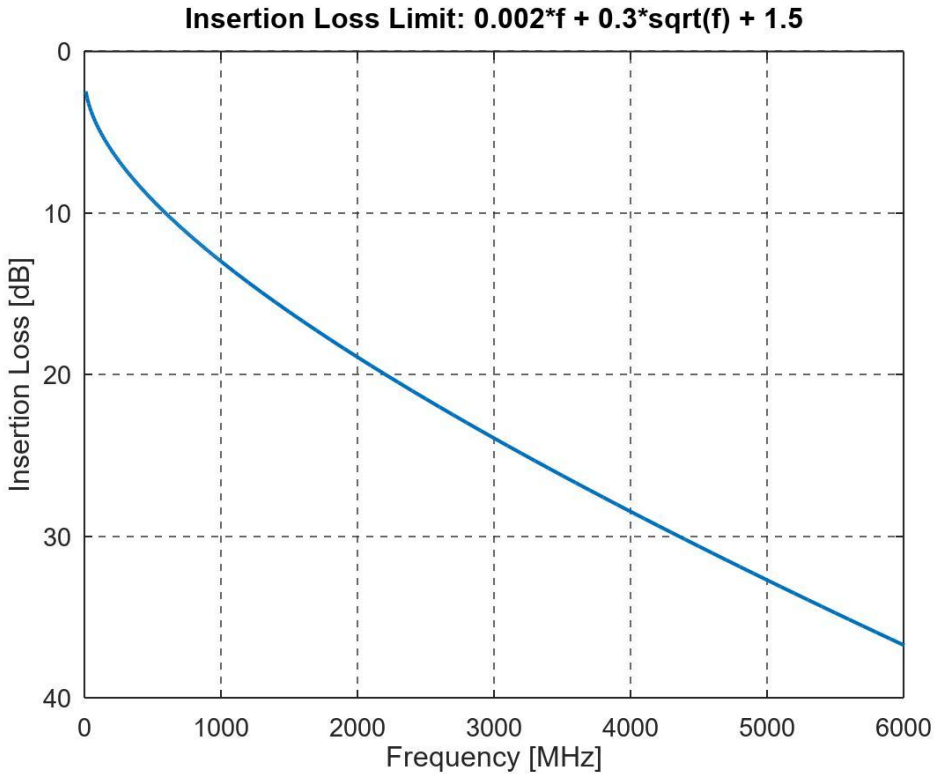
IL(f) < 0.002*f + 0.3*sqrt(f) + 1.5

where f is in MHz and the limit is defined in the frequency range

10MHz < f < F_max

This limit should apply to both coax cables and balanced pairs*

NOTE: F_{max} is expected to be few GHz



* It may be appropriate to multiply the limit by 1.1 for balanced pairs

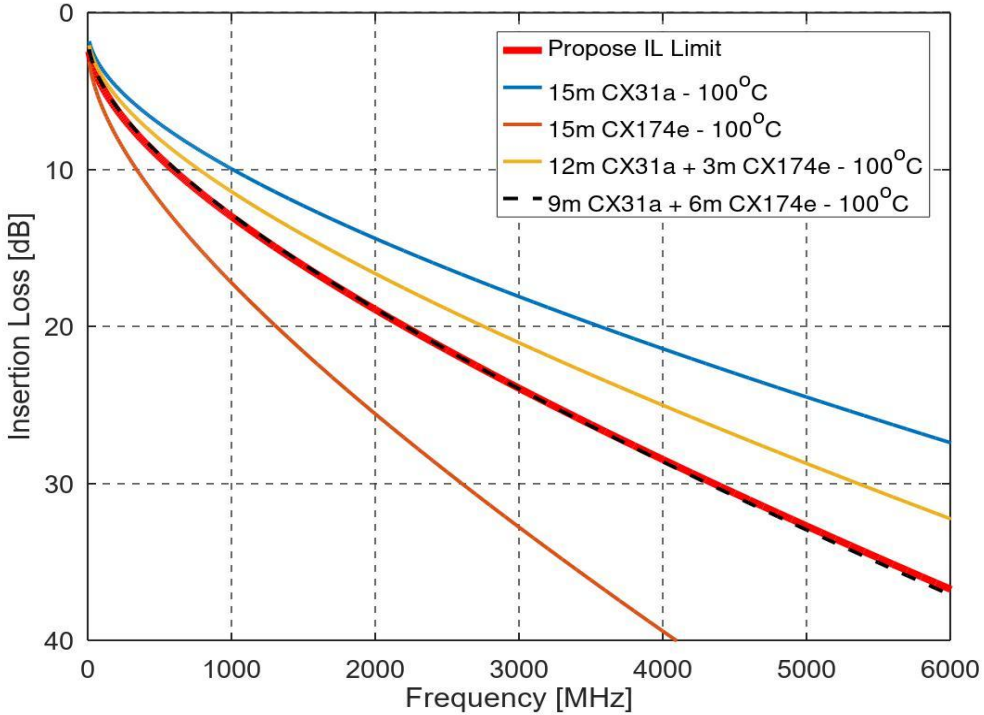
IL Limit vs Coax Cable Models

Presentation 03May24_802.3dm_Cliber proposes to use combination of CX31a and CX174d grade cables

The plot on the right compares the proposed limit with different length combinations of coax cables

The 3m CX174d/e plus 12m CX31a combination easily passes the proposed IL limit

The 6m CX174d/e plus 9m CX31a combination is almost exactly at the proposed IL limit



IL Limit vs Balanced Differential Pair Simple Models

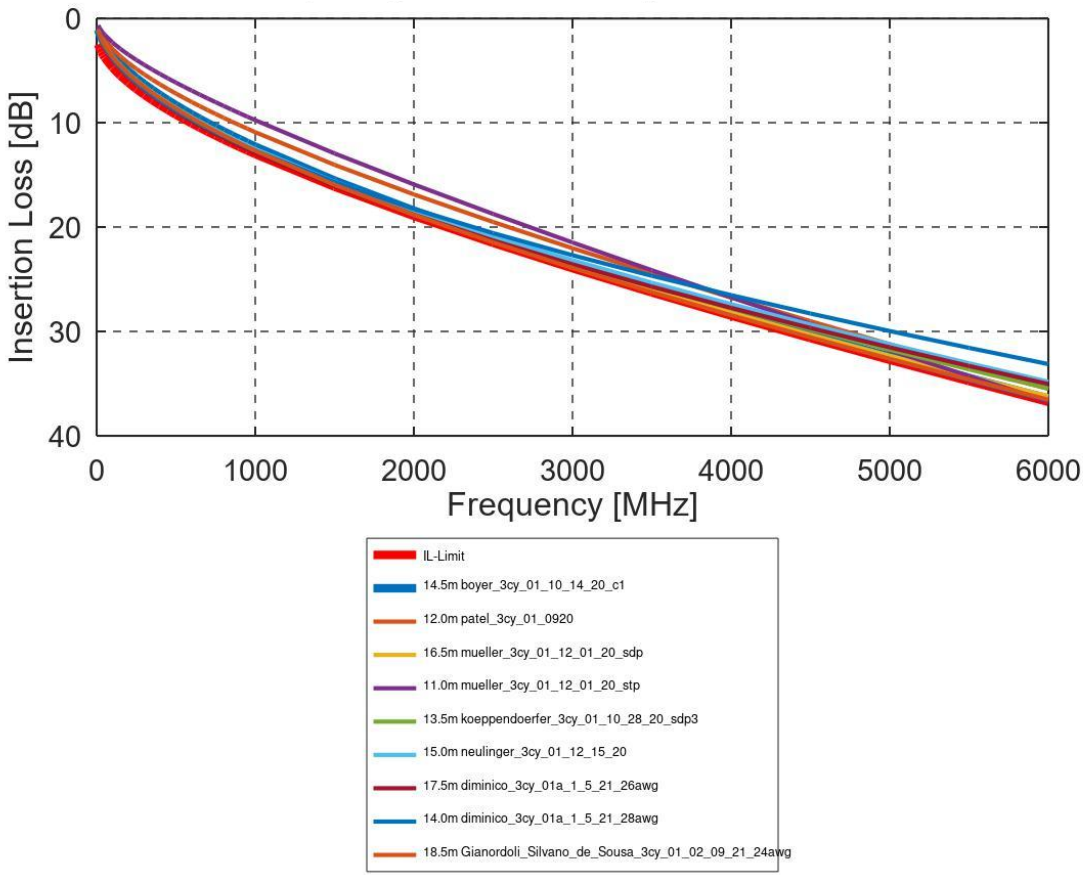
The parametric models used are based on the approximation

*IL(f) = b*f + c*sqrt(f)*

where *b* and *c* are estimated using best fit to the cable measurements (see backup slides for details)

The plot on the right shows how the different cable models compare to the proposed IL limit

The maximum cable lengths range from 11m to 18.5m (see legend)

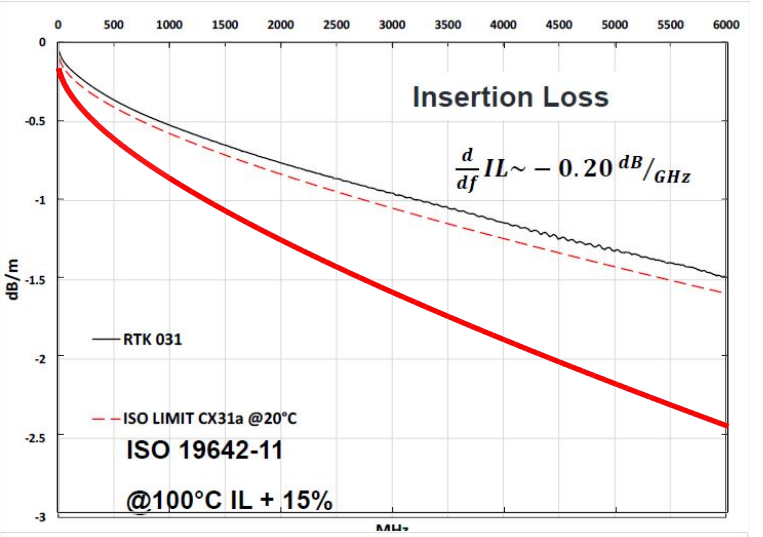


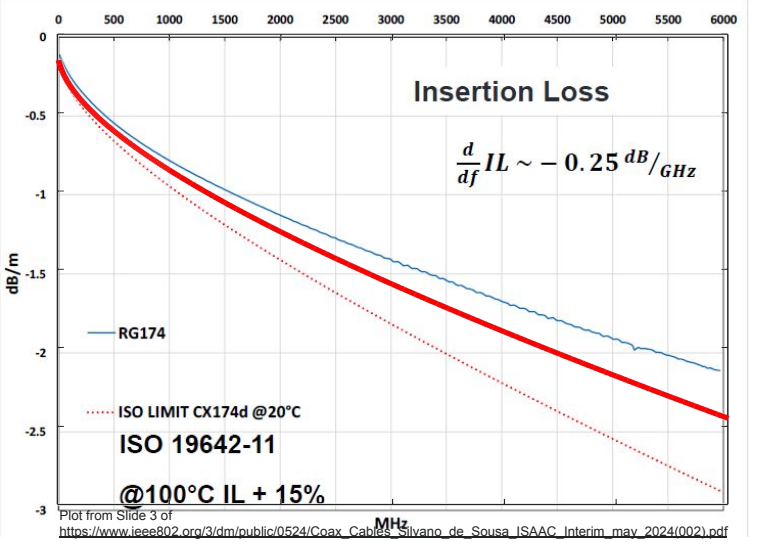
Insertion Loss Limit vs Coax Cable 1

Presentation Coax_Cables_Silvano_de_Sousa_ISAAC_Interim_may_2024(002).pdf provides Insertion Loss measurements for Coax Cables

The plots on the right is taken from Slide 3 of the presentation, with proposed Insertion Loss Limit overlayed in red (normalized to 1m, by dividing by 15)

The top plot passes, but the bottom plot fails by narrow margin





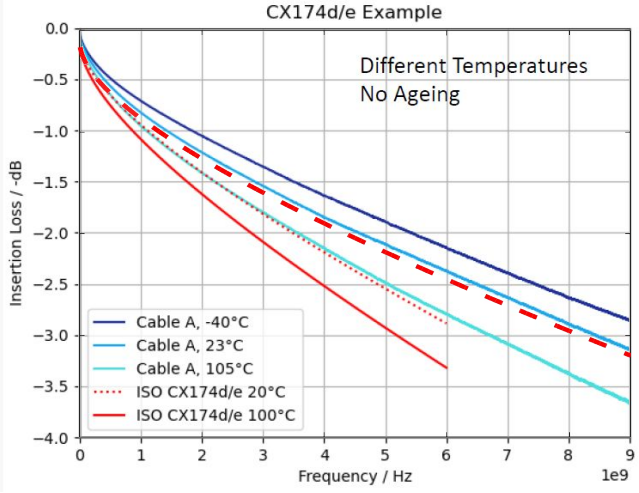
Plot from Slide 3 of https://www.ieee802.org/3/dm/public/0524/Coax_Cables_Silvano_de_Sousa_ISAAC_Interim_may_2024(002).pdf

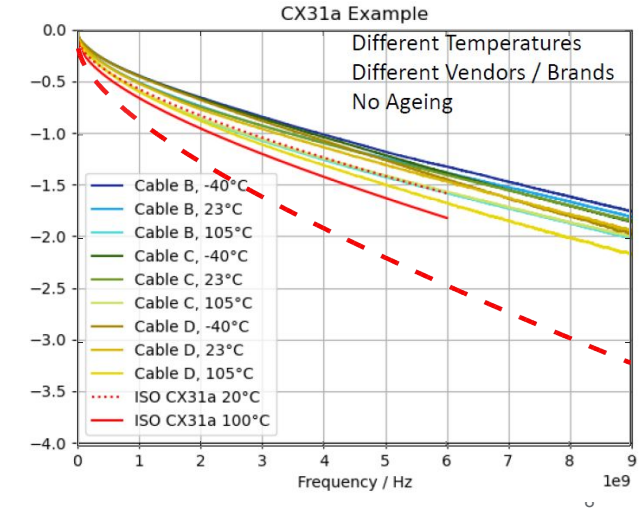
Insertion Loss Limit vs Coax Cable 2

Presentation [03May24_802.3dm_Cliber.pdf]() provides Insertion Loss measurements for Coax Cables

The plots on the right is taken from Slide 7 of the presentation, with proposed Insertion Loss Limit overlayed as broken red line (normalized to 1m, by dividing by 15)

The top plots fail (except for -40C), but the bottom plot pass





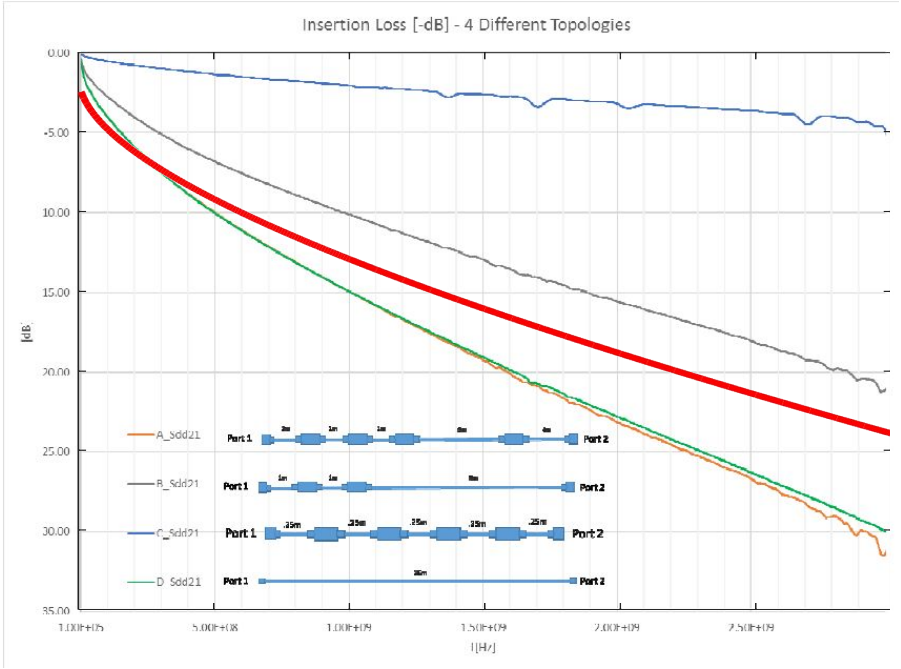
Plot from Slide 7 of https://www.ieee802.org/3/dm/public/0524/03May24_802.3dm_Cliber.pdf

Insertion Loss Limit vs Balanced Differential Pair 1

Presentation DiBiaso_3ch_01a_0917.pdf provides Insertion Loss measurements for Balanced Differential Pair

The plot on the right is taken from Slide 5 of the presentation, with proposed Insertion Loss Limit overlayed as red line

The 15m cables (A and D) fail the limit, but the 10m (B) and 1.25m (C) pass the limit



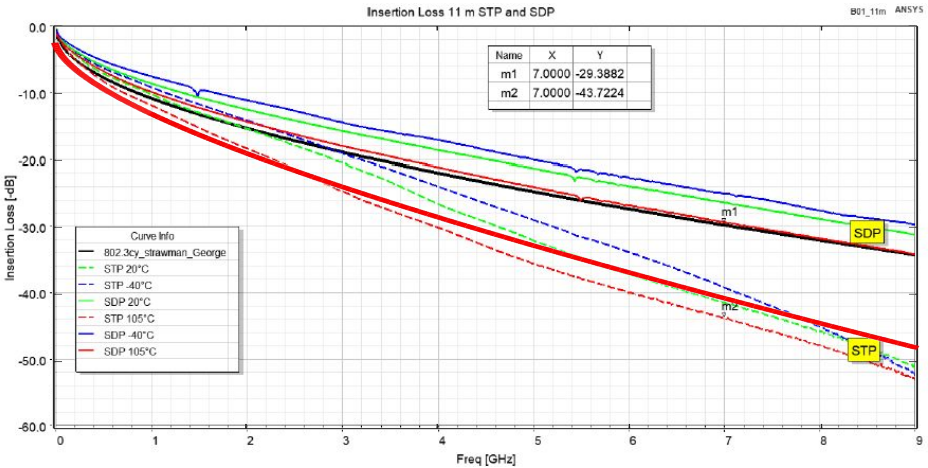
Plot from Slide 5 of https://www.ieee802.org/3/ch/public/sep17/DiBiaso_3ch_01a_0917.pdf

Insertion Loss Limit vs Balanced Differential Pair 2

Presentation [mueller_3cy_01_12_01_20.pdf]() provides Insertion Loss measurements for Balanced Differential Pair

The plot on the right is taken from Slide 9 of the presentation, with proposed Insertion Loss Limit overlayed as red line

The 11m SDP link passes with good margin, but the 11m STP fails at high temperature and at high frequency



Plot from Slide 9 of https://www.ieee802.org/3/cy/public/adhoc/mueller_3cy_01_12_01_20.pdf

Link Segment Return Loss Limit for 802.3dm

The proposed Return Loss Limit is

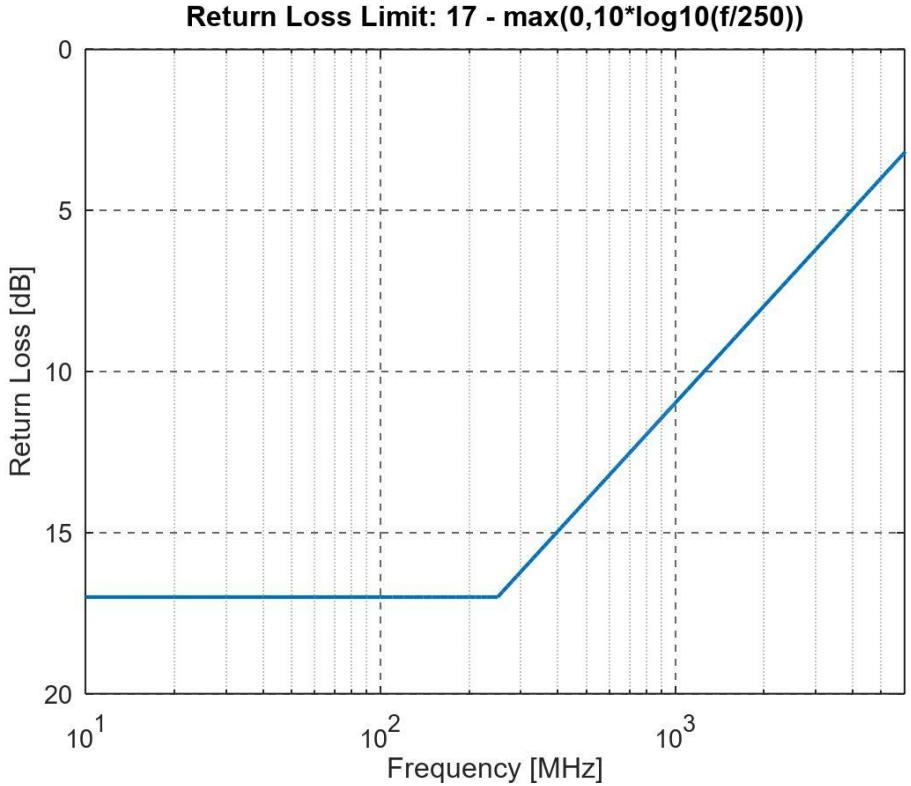
$$RL(f) > \begin{cases} 17 & f \leq 250 \\ 17 - 10\log_{10}\left(\frac{f}{250}\right) & f > 250 \end{cases}$$

where f is in MHz and the limit is defined in the frequency range

10MHz < f < F_{max}

This limit should apply to both coax cables and balanced pairs

NOTE: F_{max} is expected to be few GHz

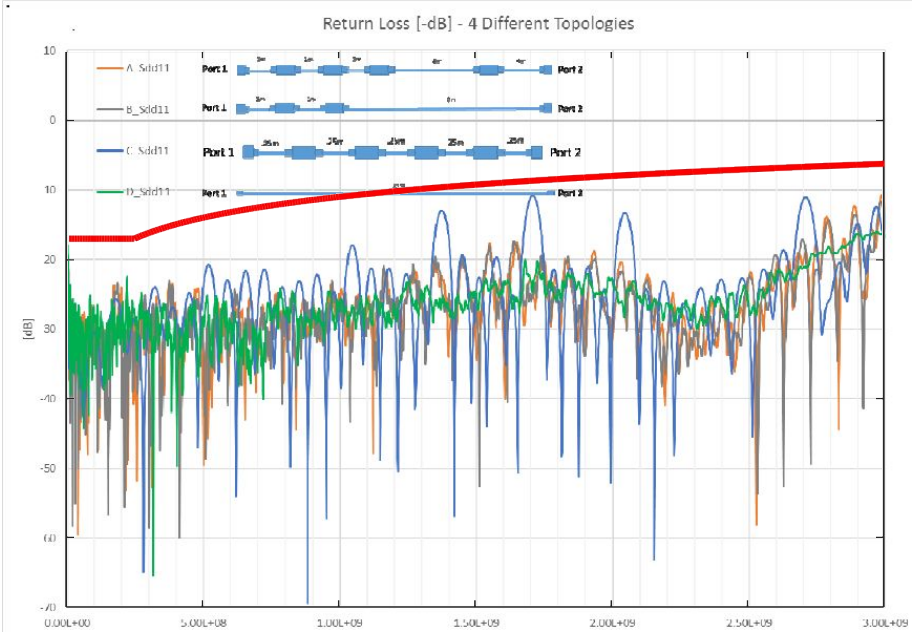


Return Loss Limit vs Balanced Differential Pair

Presentation DiBiaso_3ch_01a_0917.pdf provides Return Loss measurements for Balanced Differential Pair

The plot on the right is taken from Slide 7 of the presentation, with proposed Return Loss Limit overlayed as red line

The all the cables pass the limit



Plot from Slide 5 of https://www.ieee802.org/3/ch/public/sep17/DiBiaso_3ch_01a_0917.pdf

Summary

- Specific Insertion Loss and Return Loss limits are proposed
- These limits are chosen with the camera application in mind, while not being too restrictive on system designers

Feedback on the proposed IL and RL limits would be greatly appreciated

Backup Material

Simplified Cable Models

The simplified models are based on the commonly used insertion loss function

IL(f) = a + b*f + c*sqrt(f) + d./sqrt(f)

where IL is the insertion loss in dB/m, f is the frequency in MHz and the model coefficients are given in the table on the right

The STP/SDP coefficients were obtained by curve fitting to the plots from the 802.3cy presentations (only using b and c for the fitting)

The parameters for CX31a and CX174e were obtained by using curve fitting to available plots (note that these are not the official parameters from 19642-11).

Model	*a*	b	c	d
CX31a	0.06	7.40E-05	0.014	0
CX174e	0.11	0.0002	0.02	0
boyer_3cy_01_10_14_20_c1	0	0.000124	0.022867	0
patel_3cy_01_0920	0	0.000207	0.022167	0
mueller_3cy_01_12_01_20_stp	0	0.000329	0.017601	0
diminico_3cy_01a_1_5_21_26awg	0	5.57E-05	0.021532	0
diminico_3cy_01a_1_5_21_28awg	0	4.21E-05	0.027283	0
koeppendoerfer_3cy_01_10_28_20_sdp3	0	9.93E-05	0.026227	0
neulinger_3cy_01_12_15_20	0	7.78E-05	0.023934	0
mueller_3cy_01_12_01_20_sdp	0	9.22E-05	0.021182	0
Gianordoli_Silvano_de_Sousa_3cy_01_02_09_21_24awg	0	8.38E-05	0.019005	0

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