Simulated Cable Transfer Functions

Contribution to 802.3dm Task Force

March 10, 2025

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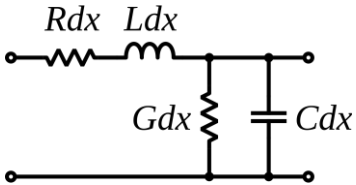
Introduction

- It is important for the 802.3dm Task Force to have access to cable measurements to use in the technical evaluation of different ideas
- So far, no measured cable S-parameters have been shared with the Task Force
- This presentation offers the next best thing, which are simulated coax cable responses, based on realistic cable and connector models
- The simulated cable responses are provided in two formats:
  - Touchstone S2P files
  - simDM simulation input files

Cable and Connector Modeling

Channel Model From Transmission-Line Theory



$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$$

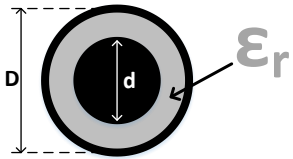
Transmission-Line Theory is used to generate parameterized channel models from channel measurements

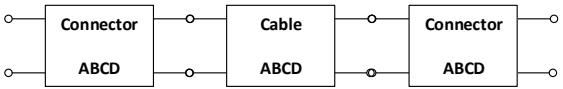
The Primary Coefficients are calculated from the cable properties

We generate two-port model for cable segments based on Primary Coefficients

More complex models are generated by concatenating multiple two-port

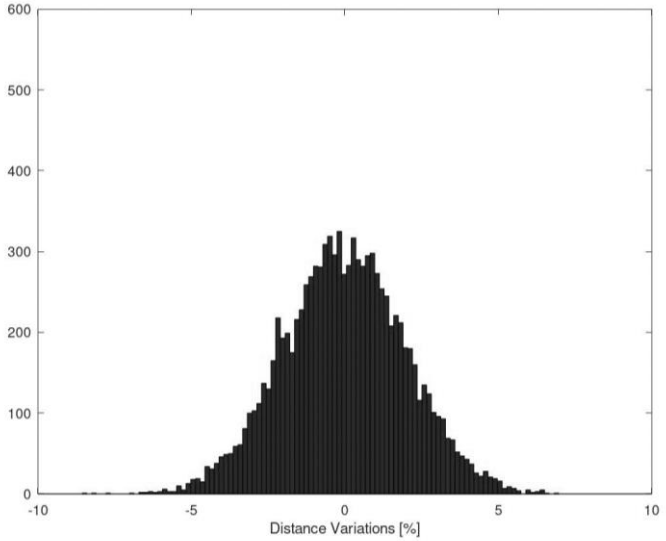
ABCD matrices are used to calculate the composite channel characteristics

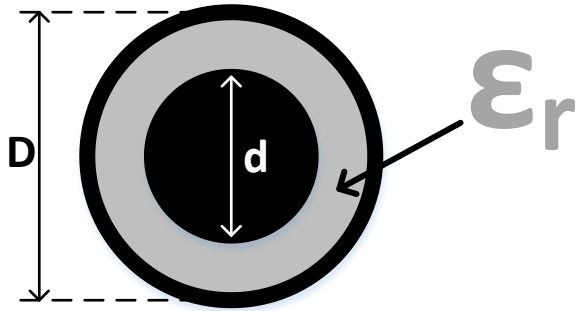




Simulating Micro-Reflections

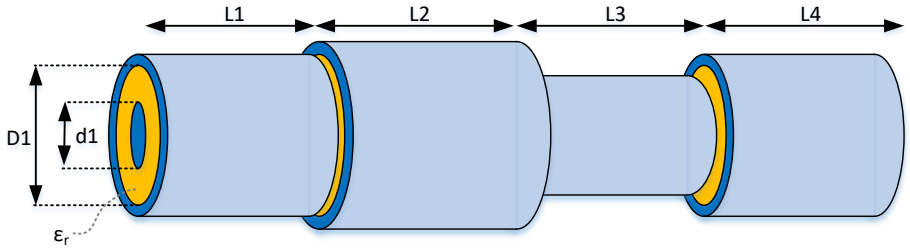
- To simulate micro-reflections in the cable models, the coax radius and dielectric constant is varied slightly for every 1mm length segment of the cable
- To limit the change between adjacent 1mm segments, the random variation in the diameter is filtered with first order recursive filter, resulting in very small impedance mismatch between segments
- More variation in coax radius means stronger micro-reflections
- Note that the modeling of the characteristic impedance for the whole cable is done separately (through manipulation of ABCD matrices)

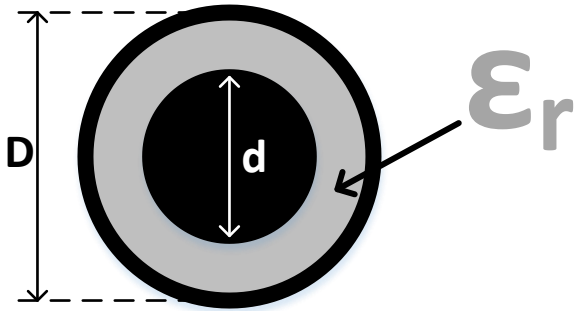




Simulating Connectors

- The connector is simulated as series of coaxial segments, where each segment has different radius (and may have different dielectric constant)
- The number of connector segments and the radius is matched to actual connector measurements





Need for Channel Measurements

- Channel simulations are good for evaluations of different scenarios
- However, simulations are inherently limited by the accuracy of the assumptions used in the models
- The 802.3dm Task Force needs access to real cable measurements to accurately evaluate what to expect for real cables*

* Many participants in the Task Force, including me, have access to measurements of real cables, but these can not be shared publicly without permission

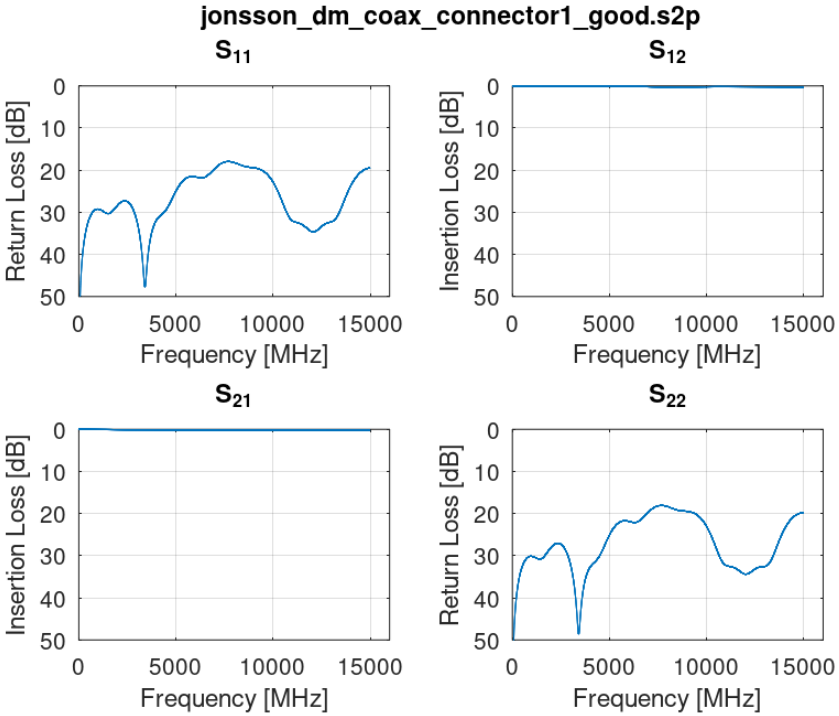
Connector Transfer Functions

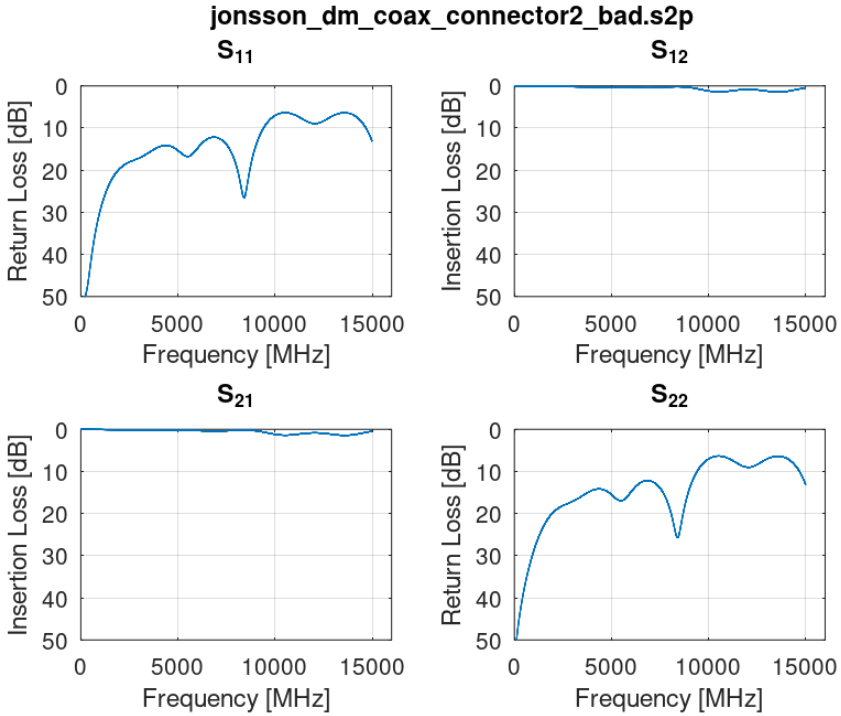
Connector Models

There are four different connector models shared in Touchstone S2P file formats:

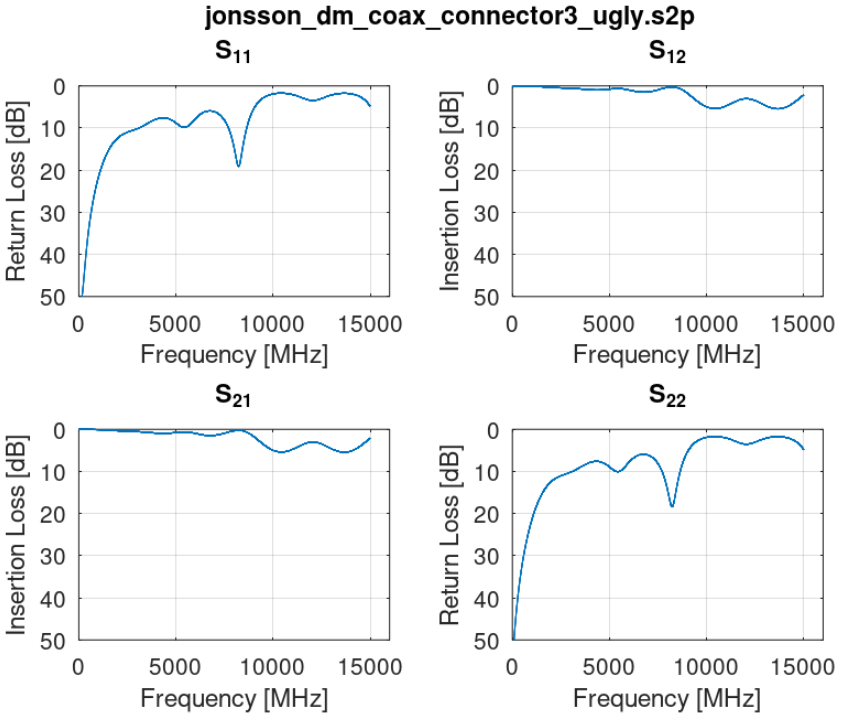
- Good Connector – which is based on real connector measurements that are well below the limits of USCAR49
- Bad Connector – which is based of a very typical connector, but the model is adjusted such that the connector return loss almost violates USCAR49
- Ugly Connector – which is based of a very typical connector, but the model is adjusted such that the connector return loss clearly violates USCAR49
- Typical Connector – which is based on real connector measurements that are below the limits of USCAR49, but have more echo than the good connector

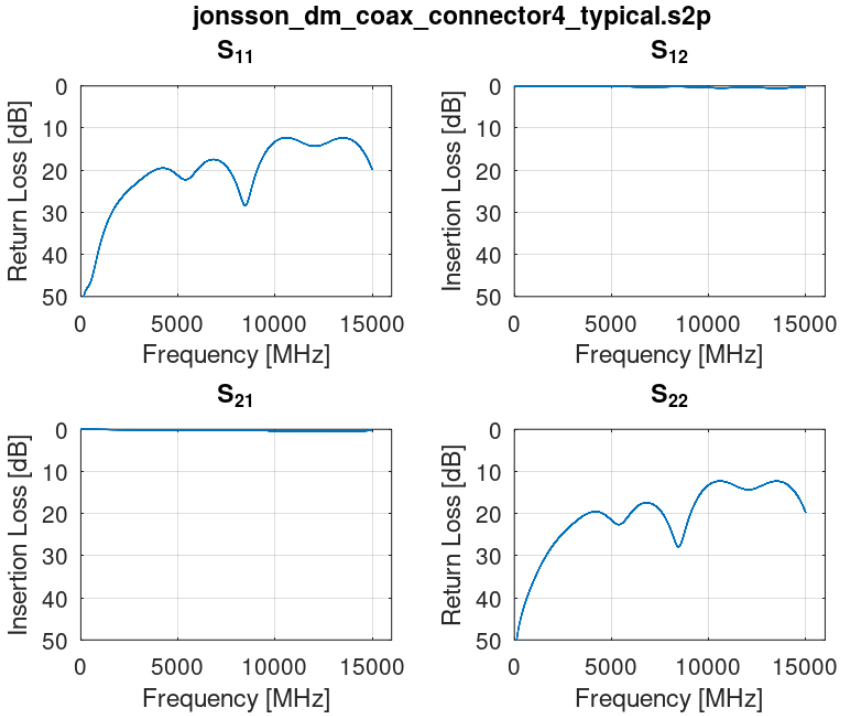
Connector Models





Connector Models





Cable Transfer Functions

Cable Models

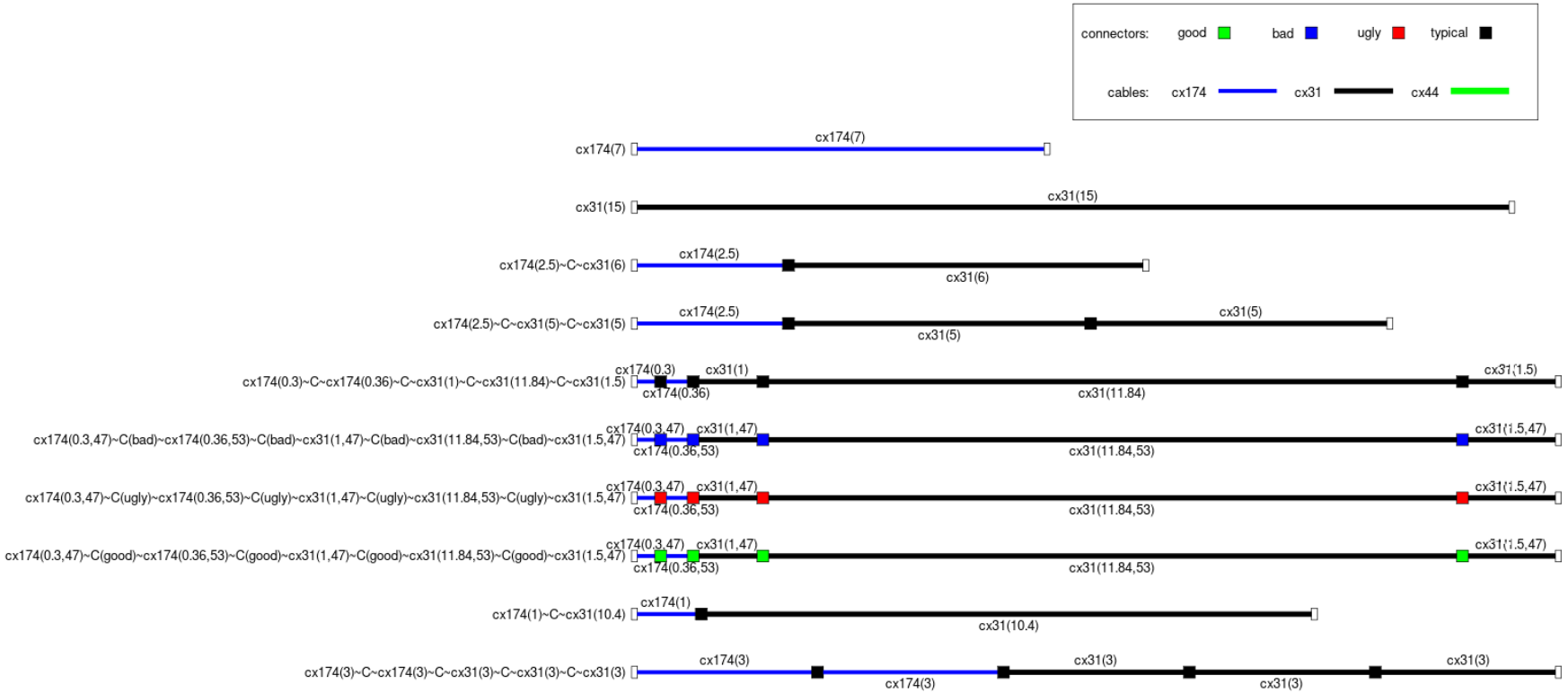
Ten different cable transfer functions are shared in Touchstone S2P and simDM input file formats

- Two different straight cables with no inline connectors
- Two different cables inspired by 802.3cy presentation from several attendees affiliated with automobile makers
- Four different variants of one of the cables used to derive the new ASA 2.1 return loss limit
- Two cables topologies shared by cabling experts in 802.3dm

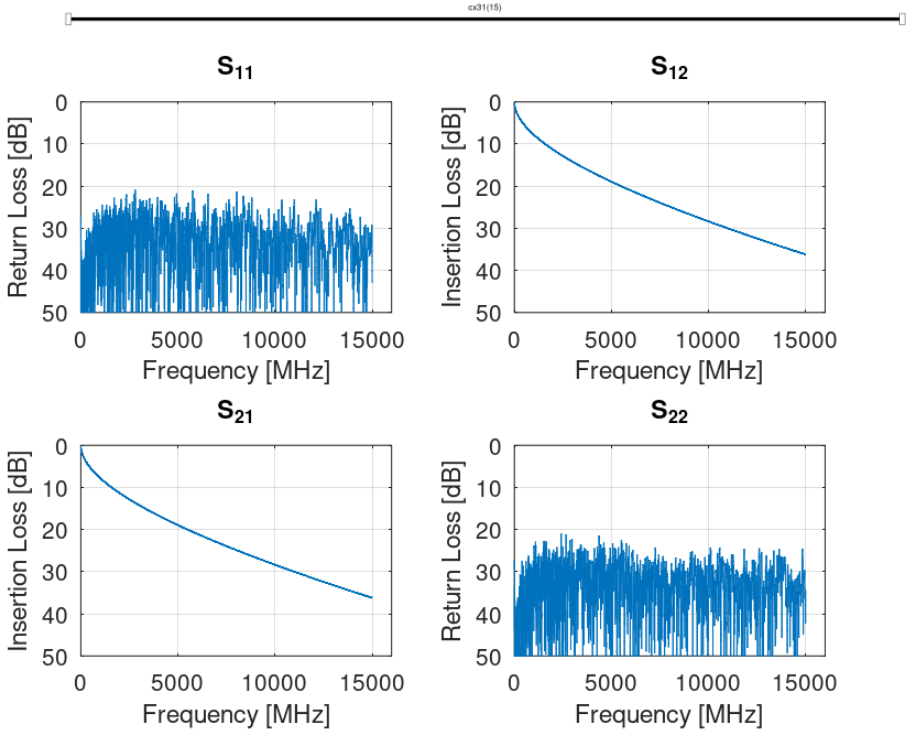
The file names are based on the cable topology, with a series of cable segments and connectors between them. The file names use the following nomenclature:

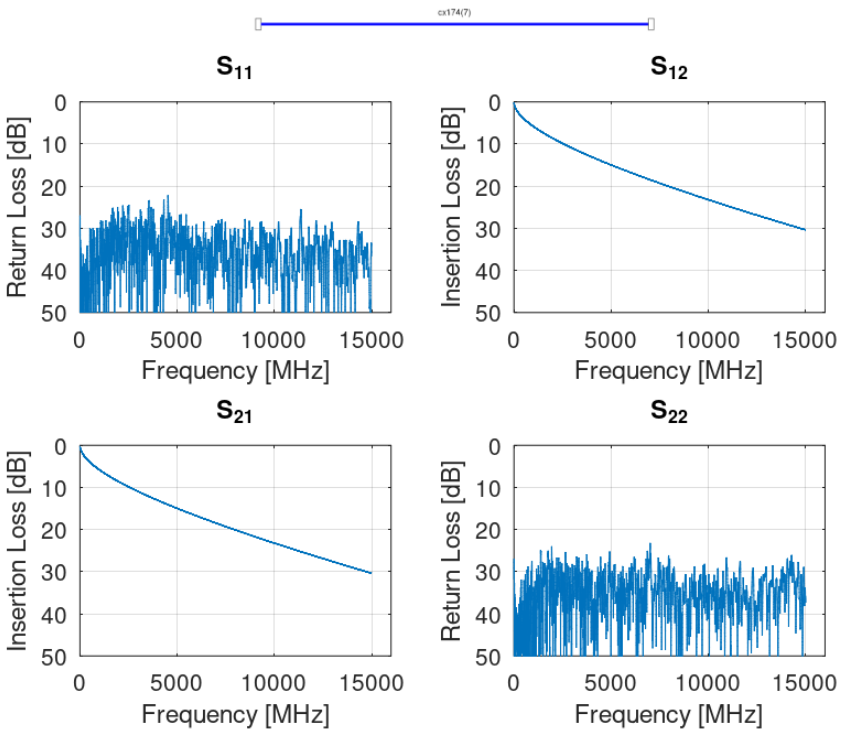
- Cx31(11.84,53) referees to 11.84m segment of CX31 cable with 53Ohm characteristic impedance. The second argument is optional, and the impedance is 50Ohm by default
- C(bad) refers to “bad” connector. The argument is optional and typical connector is used by default

Cable Topology

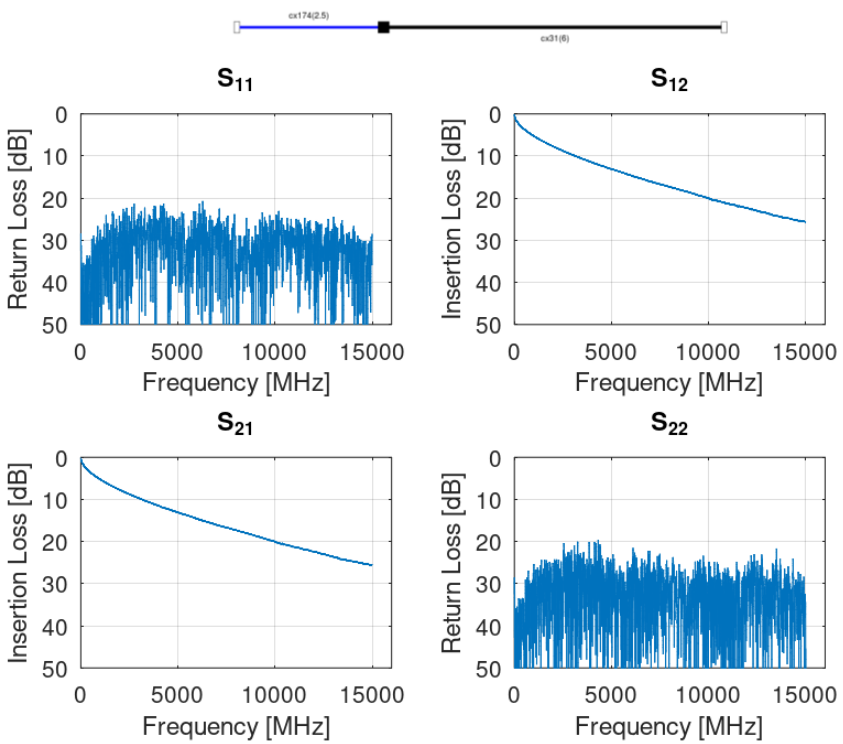


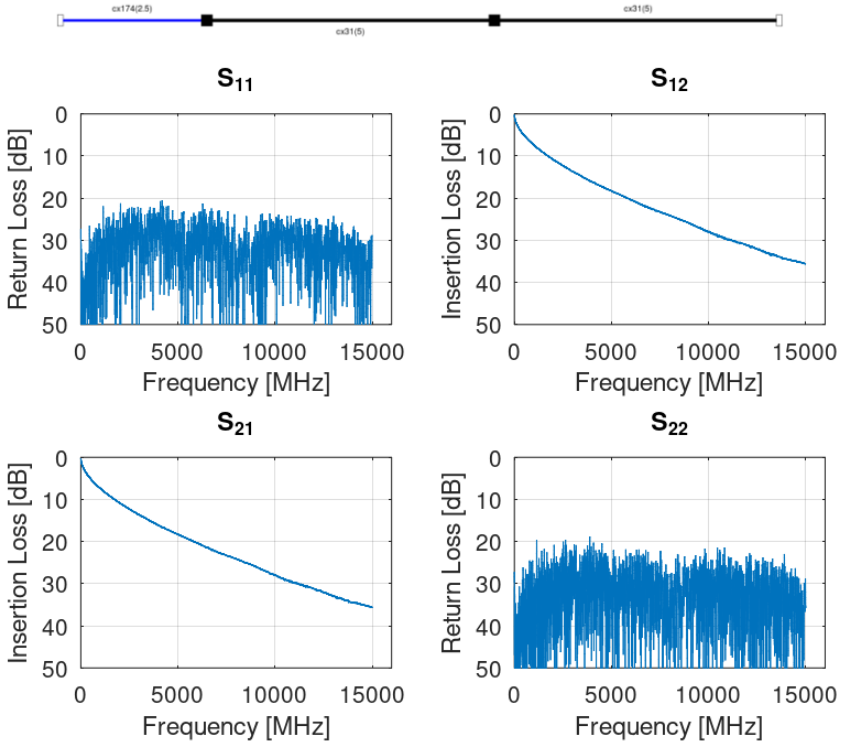
Straight Cables (No Inline Connectors)





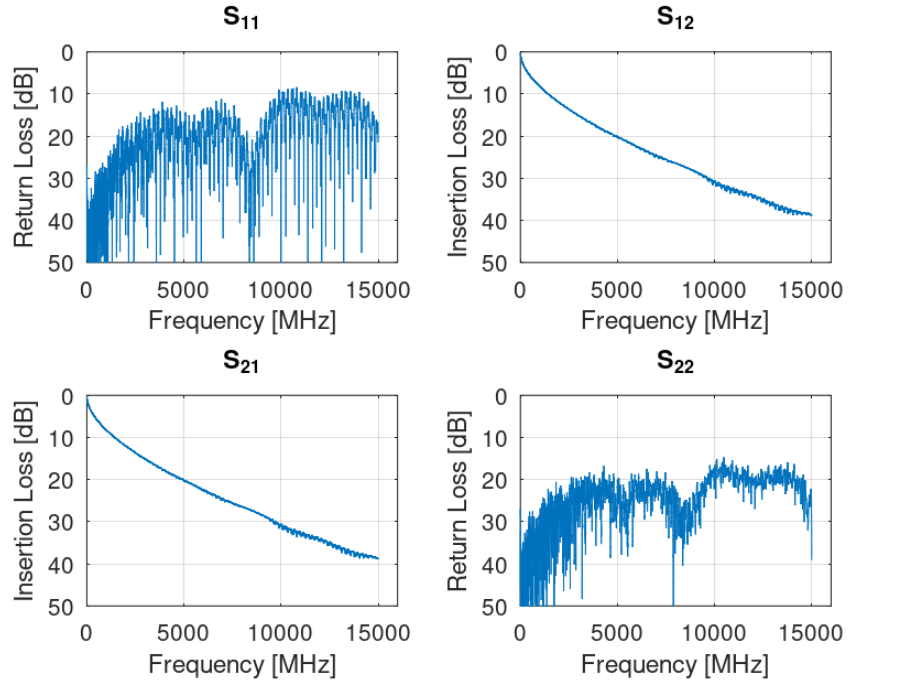
Automaker Inspired Cables

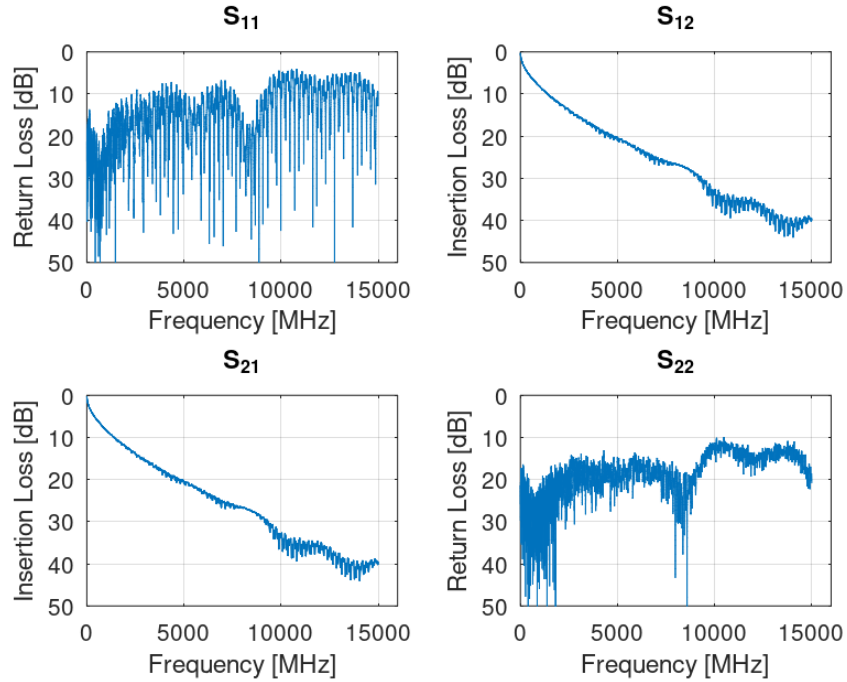




See slide 4 of https://www.ieee802.org/3/B10GAUTO/public/may19/wienckowski_3+10G_01a_0519.pdf

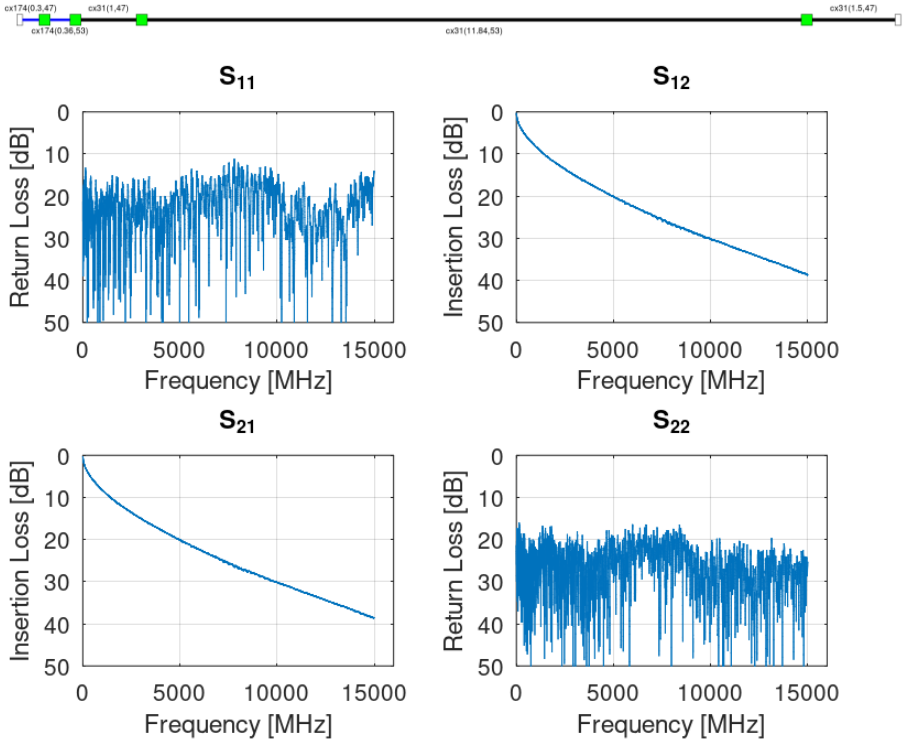
ASA Like Cables (Typical vs Worst-Case)

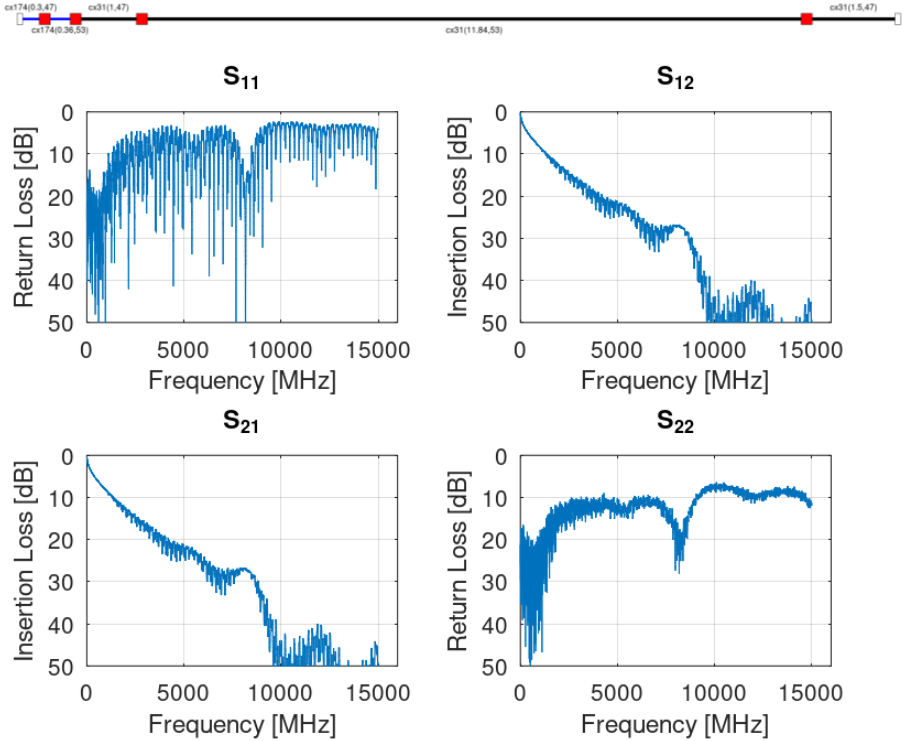




See slide 11 of https://www.ieee802.org/3/dm/public/0724/Zerna_802.3dm_01b_240717_IL_RL_Limits.pdf

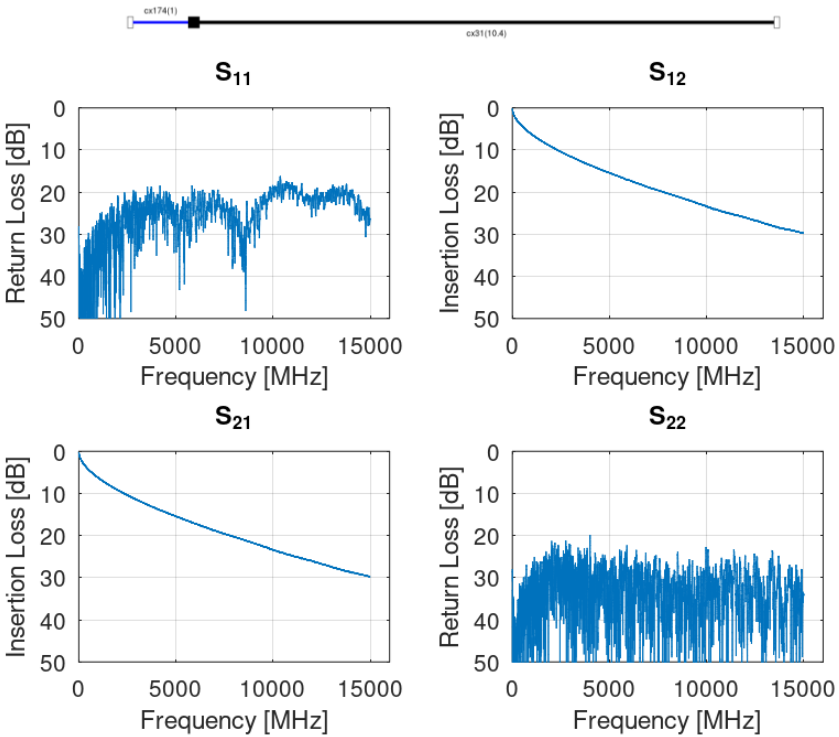
ASA Like Cables (Good vs Ugly Connectors)

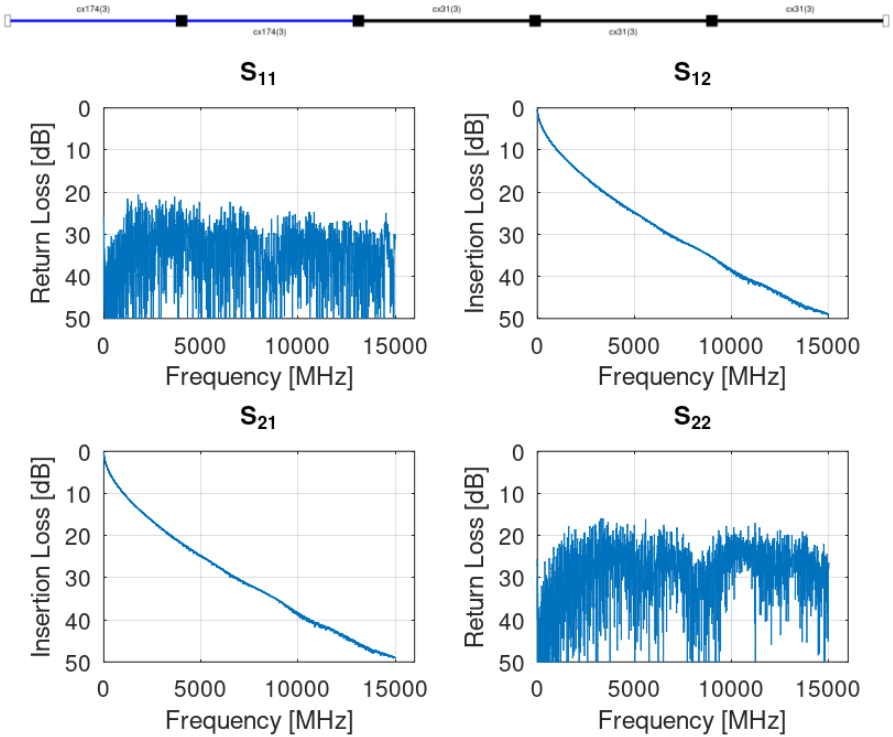




See slide 11 of https://www.ieee802.org/3/dm/public/0724/Zerna_802.3dm_01b_240717_IL_RL_Limits.pdf

Other Cables





See slide 3 of https://www.ieee802.org/3/dm/public/0924/bergner_3dm_01a_18_09_24.pdf
See slide 4 of https://www.ieee802.org/3/dm/public/0125/boyer_sharma-3dm_02_RevA_01-22-25.pdf

Summary

- In the absence of actual cable measurements, this presentation provides simulated cable transfer functions
- The simulations are based on realistic modeling of cable physical characteristics and include micro reflections
- The simulations use simulated connector models, that approximate actual connectors
- The simulated cable transfer functions are provided in Touchstone S2P formatted files and in files suitable for use with the simDM simulator

Real cable measurements are needed

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