C2C return loss

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Some related issues with C2C spec

- List partly from dawe_3bs_03_0717

1. 400GAUI-8 C2C needs a channel RL spec to complement the RL spec it has (Clause 137 has a channel RL spec already)
   - Fixed in D3.3: 120D.4.1 Channel return loss added
2. 400GAUI-8 C2C test fixture RL is not compatible with tightened RL spec
   - Fixed in D3.3: The test fixture return loss may be de-embedded from return loss measurements.
3. 400GAUI-8 C2C RL is too tight at low frequencies
   - The same problem that applied to Tx now applies to Rx

- COM with non-neutral termination impedances is inaccurate
  - Fixed in D3.3: transmission line characteristic impedance Zc changed from 90 Ω to 95 Ω, single-ended termination resistance Rd changed from 55 Ω to 50 Ω

Effect of moving COM to neutral termination

- Previously, COM calculation on channel:

Tx		Channel	Rx	
Term	Pkg	Channel	Pkg	Term
High	Low	under test	Low	High

- Receiver interference tolerance test:

Test Tx		Channel	Rx	
Term	Pkg	Channel	Pkg	Term
Neutral	Neutral	Neutral?	Under test	

- Some receiver return loss was in the RITT channel COM calibration, so it was expected that real receivers should not be much worse than the COM termination

Effect of moving COM to neutral termination

- Now, COM calculation on channel:

Tx		Channel	Rx	
Term	Pkg	Channel	Pkg	Term
Neutral	Neutral	under test	Neutral	Neutral

- Receiver interference tolerance test:

Test Tx		Channel	Rx	
Term	Pkg	Channel	Pkg	Term
Neutral	Neutral	Neutral	Under test	

- Very little receiver return loss is in the RITT channel COM calibration, so it is now the receiver's own responsibility and can be traded off with other receiver attributes
- Now there is no need to try to match modelled COM RL and product RL limit

What do we want the RL specs for now?

1. Contain Tx to channel double reflections
2. Contain channel to neutral Rx double reflections
3. No longer – contain neutral channel to product Rx double reflections
4. Contain Tx to Rx double reflections
   - At all but the lowest frequencies, channel loss makes these insignificant

How are we doing?

1. Contain Tx to channel double reflections
   - New (D3.3) channel RL spec and recently tightened (D3.1) Tx RL spec address this
     - Very tight (12 + 14.25 dB) at low f, looser in few GHz range
2. Contain channel to neutral Rx double reflections
   - New (D3.3) channel RL spec addresses this
3. No longer – contain neutral channel to product Rx double reflections
4. Contain Tx to Rx double reflections
   - Overkill: 14.25 + 14.25 dB near DC, even more attenuated at other frequencies where channel loss is higher

Proposed remedies

1. Tx RL at low frequencies can be relaxed
2. Channel RL at very low frequencies could be tightened
   - Or, we can just accept that it will be OK
3. –
4. Rx RL should be relaxed significantly
   - Use Eq 93-3 that we had before as a backstop – probably overkill but the industry is used to it

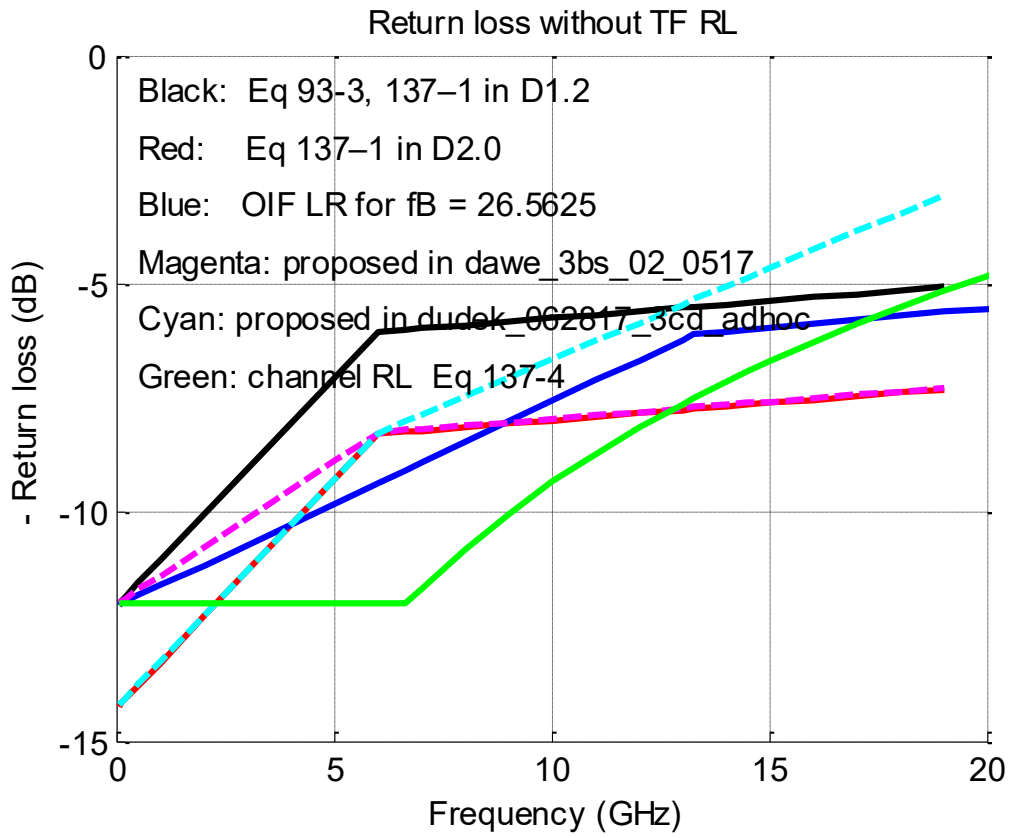
Detail: comment 32

- The low frequency RL at 14.25 dB is insignificant for signal integrity compared with the 8.7 dB at 6 GHz. This RL is much tighter than CEI-56G-MR at low (and high) frequency (although apparently looser between 4 and 9 GHz). Also it is tighter at low frequencies than the new channel return loss limit, which seems wrong.
- Following D3.1 comment 41, D3.2 r02-44
- Particularly now we have a channel return loss limit, we can **change 14.25 - f to 12 -0.625f**
  - [in Eq 120D–2]

Detail: comment 34

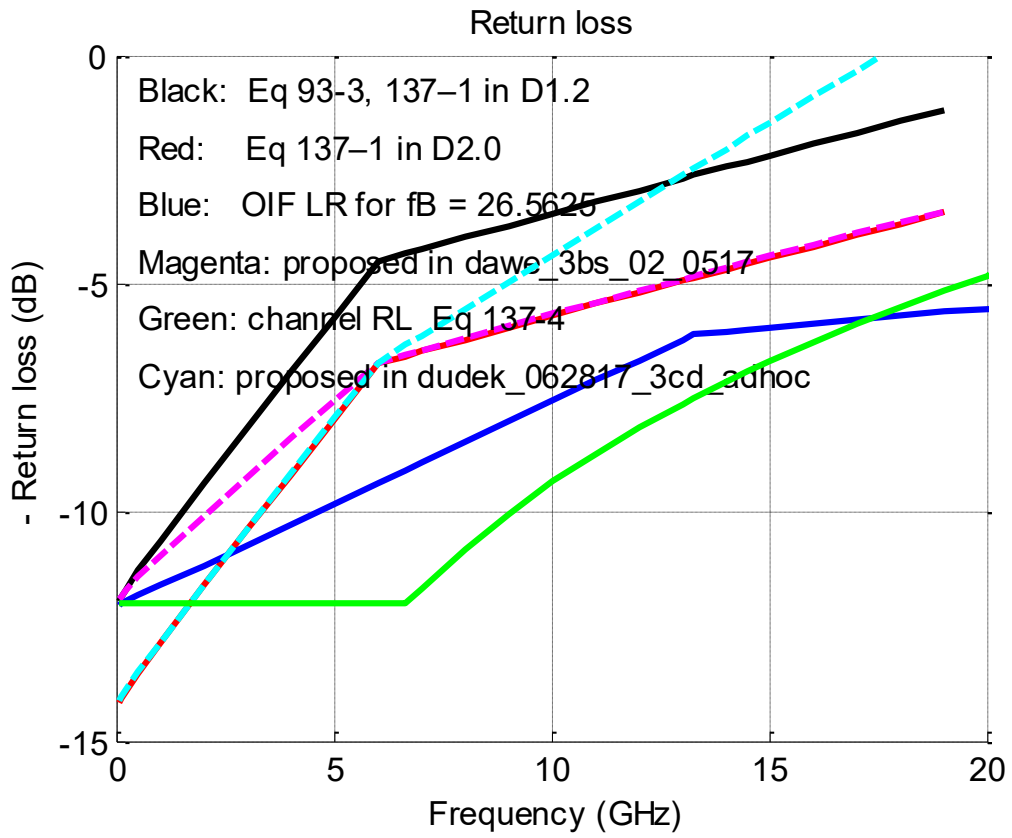
- Changing the return loss spec for the receiver was a mistake, because the effects of receiver reflections to a nominal-impedance channel and transmitter are in the receiver interference tolerance test, and the extra reflections to a channel and transmitter with different impedances are controlled/accounted for by the channel COM, now based on nominal impedances, the new channel return loss spec and the transmitter return loss spec.
- From the simple formula for reflection at an impedance mismatch, one can see that these effects are close to additive, so controlling/accounting for them separately is OK. In other words, the receiver pays for its own reflections in the interference tolerance test, so **we don't have to tell the receiver designer how to do his job** in this regard.
- **In Table 120D–5, revert 120D.3.1.1, Equation (120D-2) to 93.8.1.4, Equation (93-3).**

Showing various return loss limits



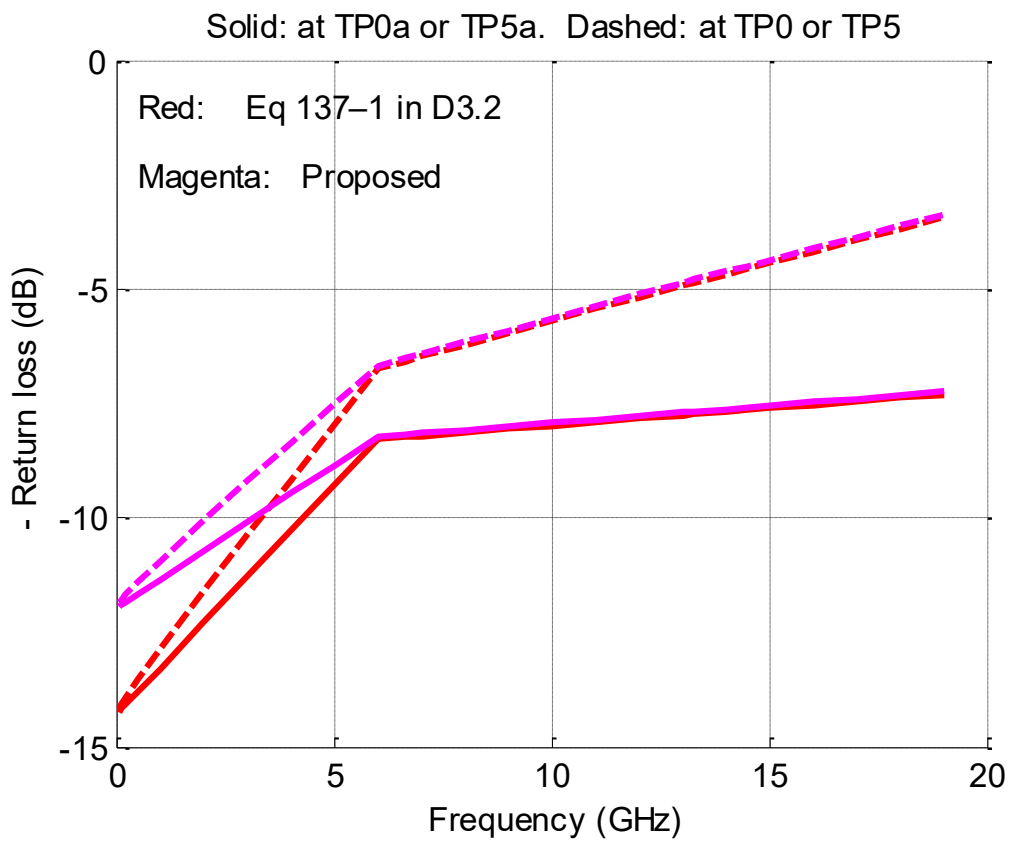
Nominal return losses: channel and OIF at IC, others at test fixture

Adjusting for test fixture IL but not its RL



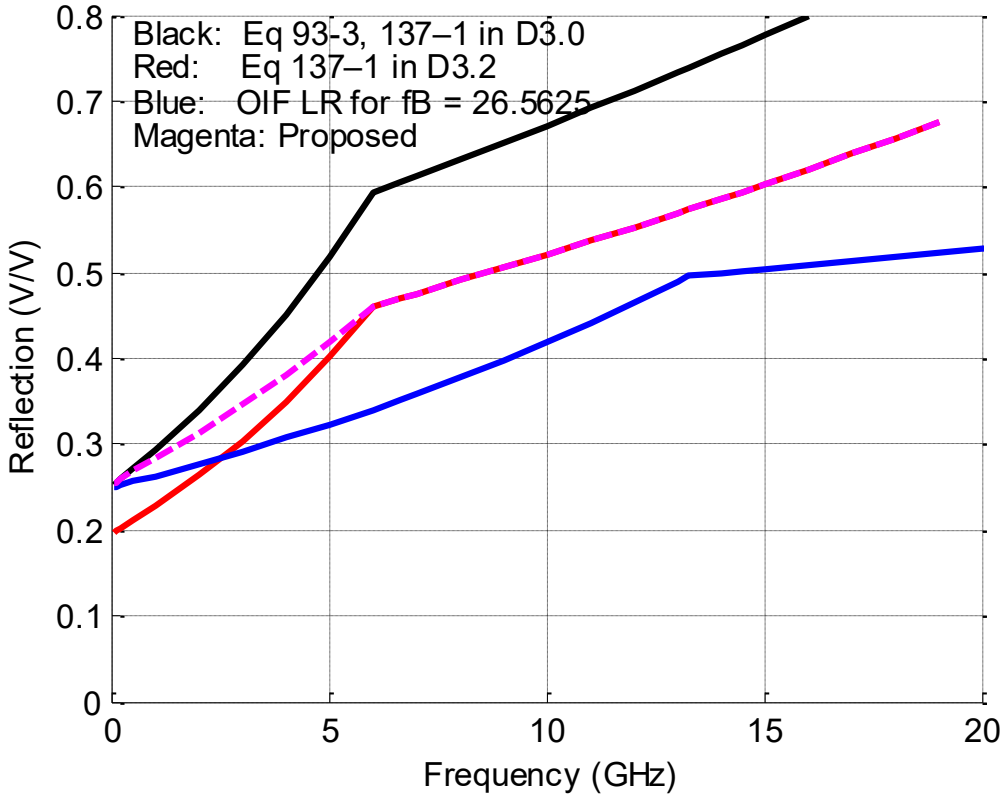
- Compare previous slide
- See next slide for simpler view
- Red and cyan are too tight at low f
- Cyan is too loose at high f
- Black is too loose at mid f
- Green – channel (later slides show more about the channel RL)

Focus on Tx, Rx RL

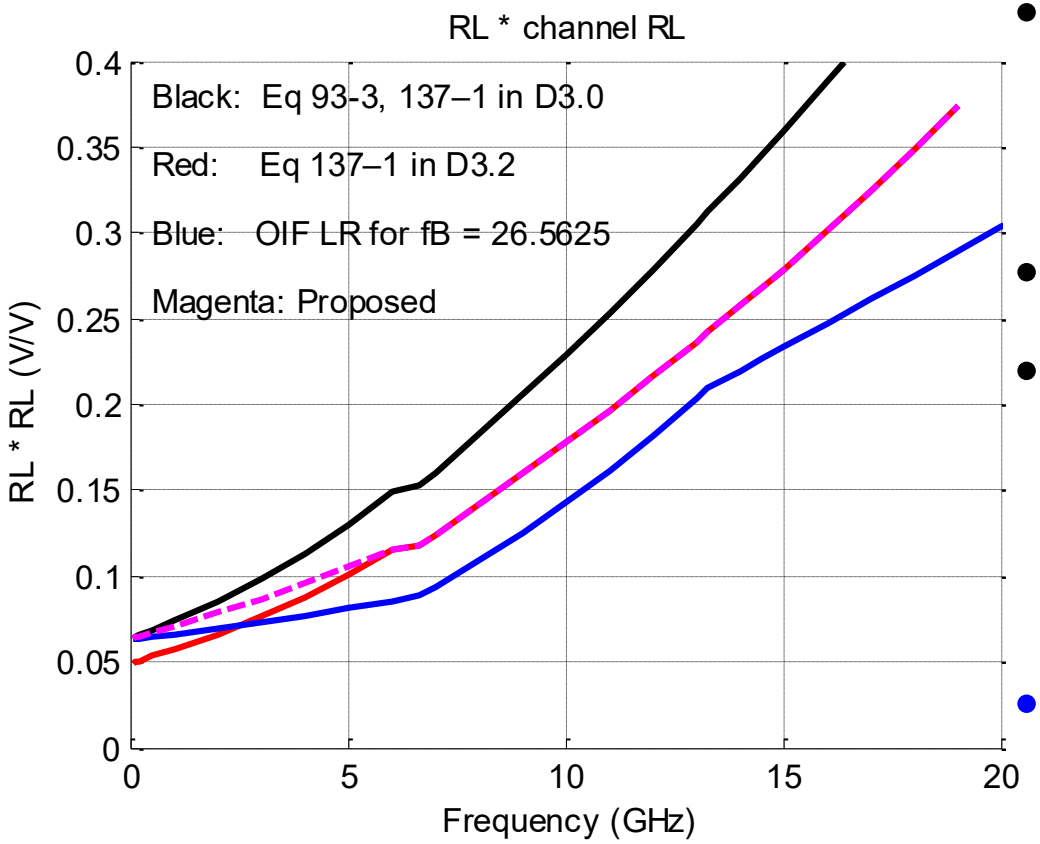


- Red is too tight at low f

Converting to linear scale: RL of Tx or Rx



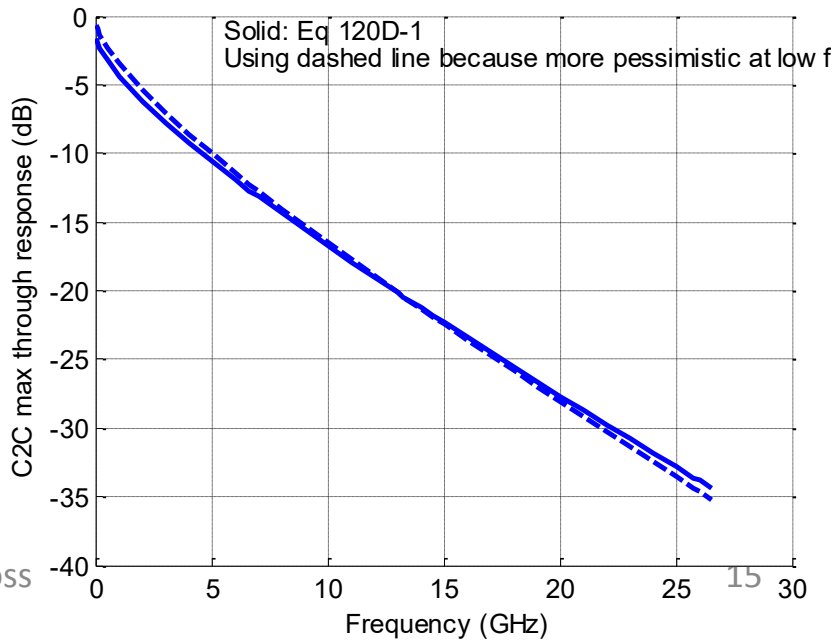
The echo, which is what matters, is caused by two reflections



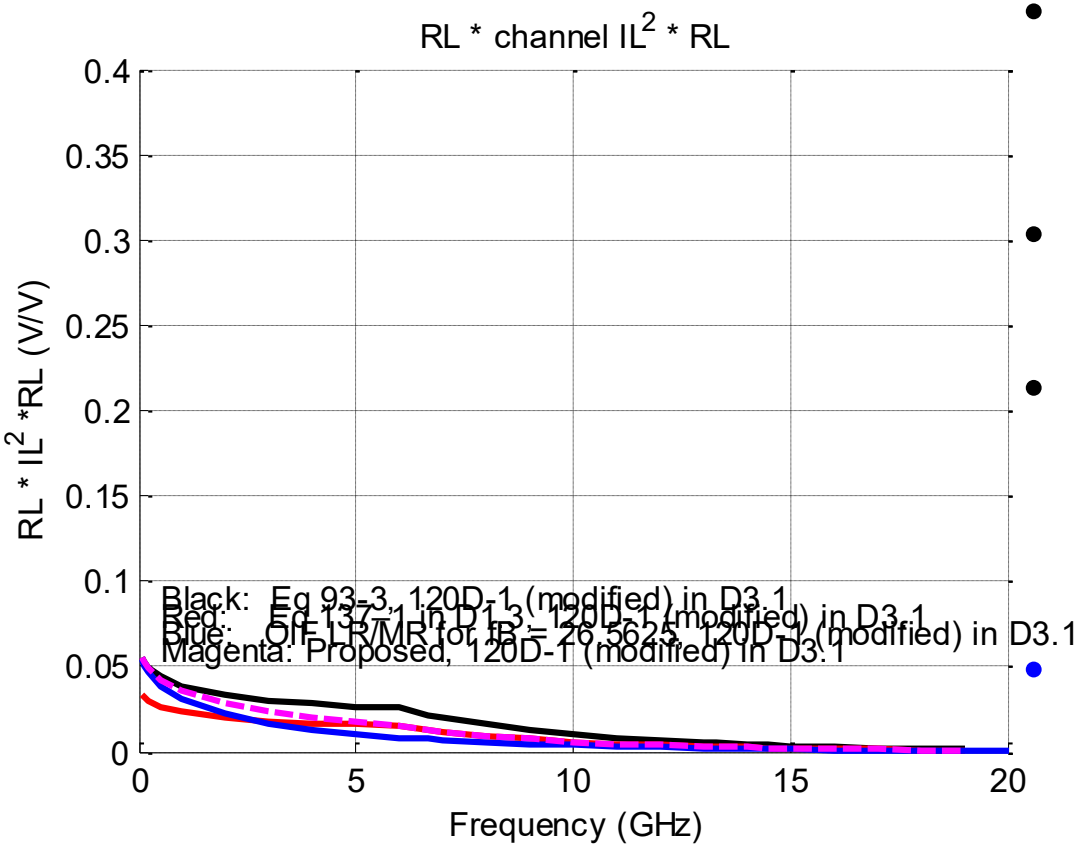
- Multiplying (Tx or Rx) reflection by channel reflection
- Voltage scale is different
- Receiver boosts high frequencies
  - and attenuates beyond Nyquist
- The low frequency content is insignificant

Summary so far

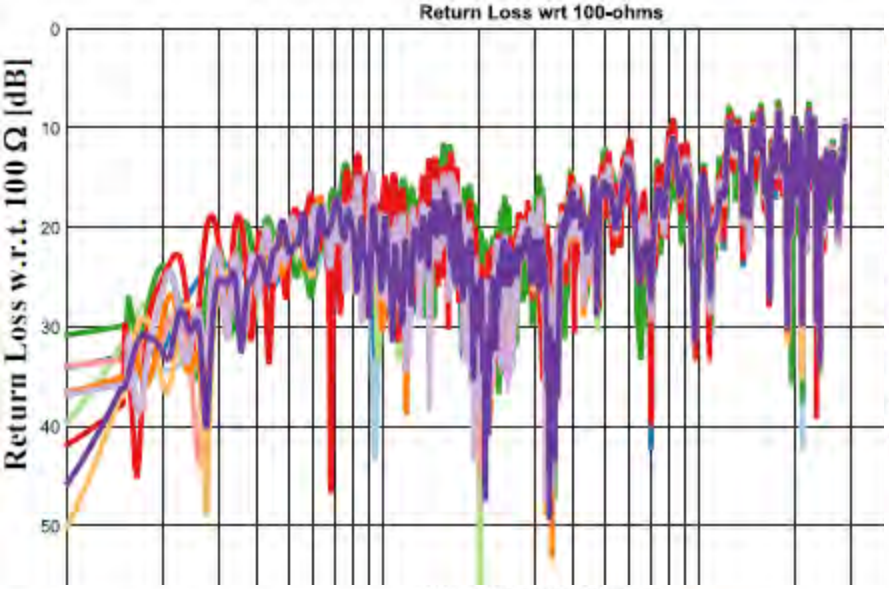
- The low frequency reflections between Tx and channel or Rx and channel are negligible – higher frequency reflections dominate
- Reflections between Rx and nominal channel are in RITT anyway – only some of the Rx-channel reflection needs to be bounded by the RL specs, the other part is in the test
- But, what about end-to-end reflections?

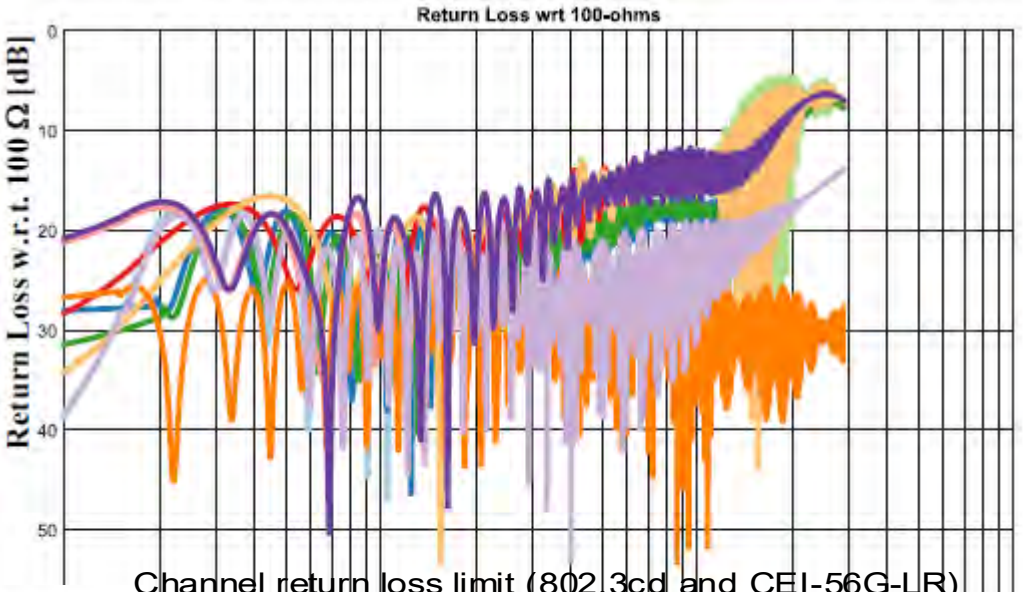


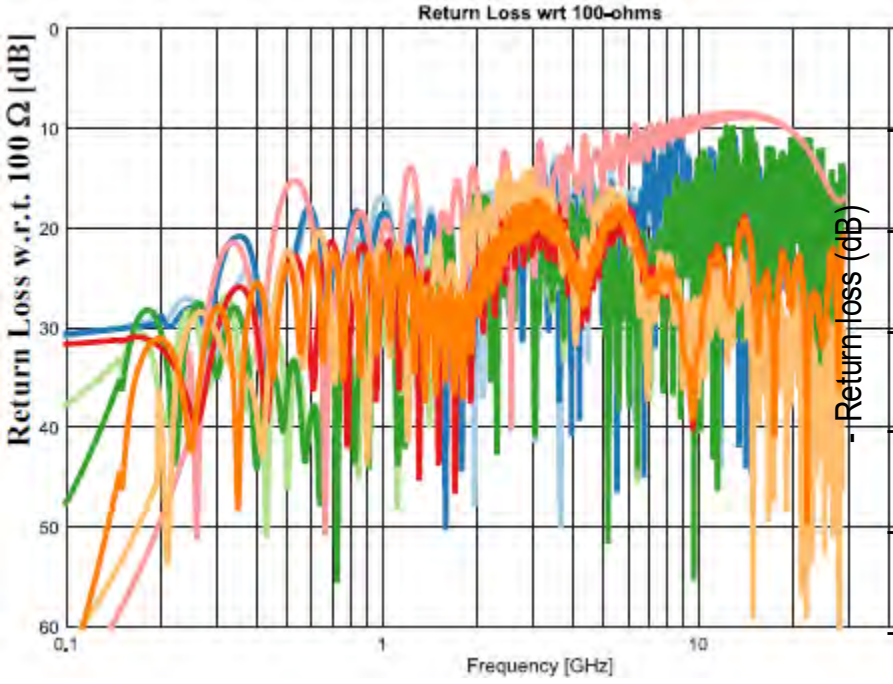
The echo, which is what matters, is caused by two reflections



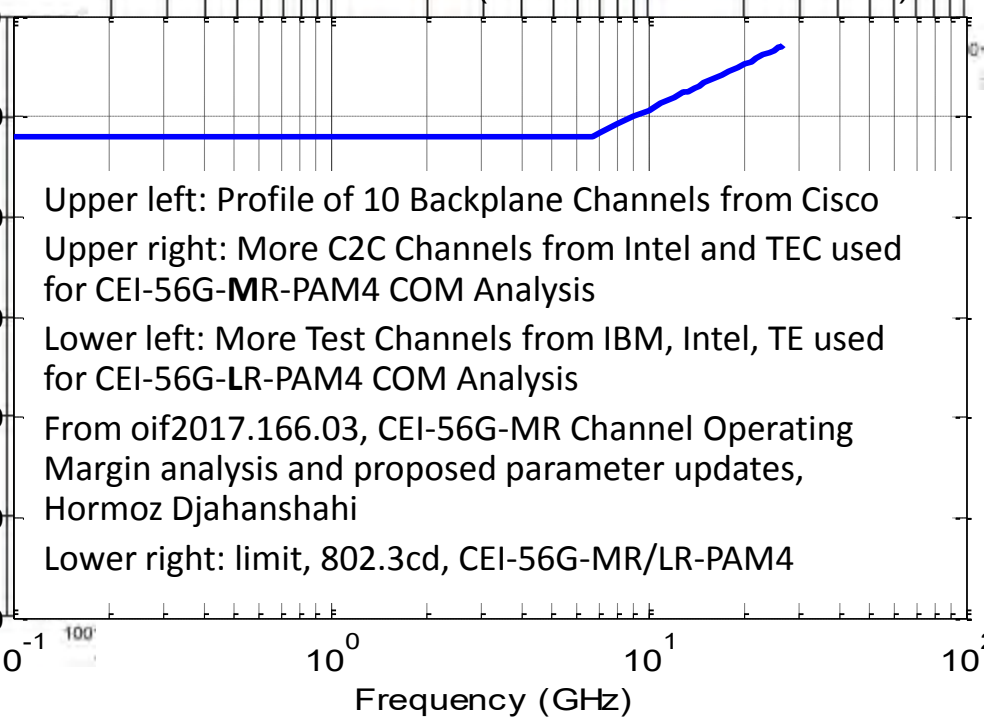
- Multiplying (Tx or Rx) reflection by channel through response squared
- Same voltage scale as two slides before
- Receiver boosts high frequencies
  - and attenuates beyond Nyquist
- For high loss channels, the end-to-end reflections are much smaller than the end-channel reflections







Channel return loss limit (802.3cd and CEI-56G-LR)



Upper left: Profile of 10 Backplane Channels from Cisco

Upper right: More C2C Channels from Intel and TEC used for CEI-56G-**M**R-PAM4 COM Analysis

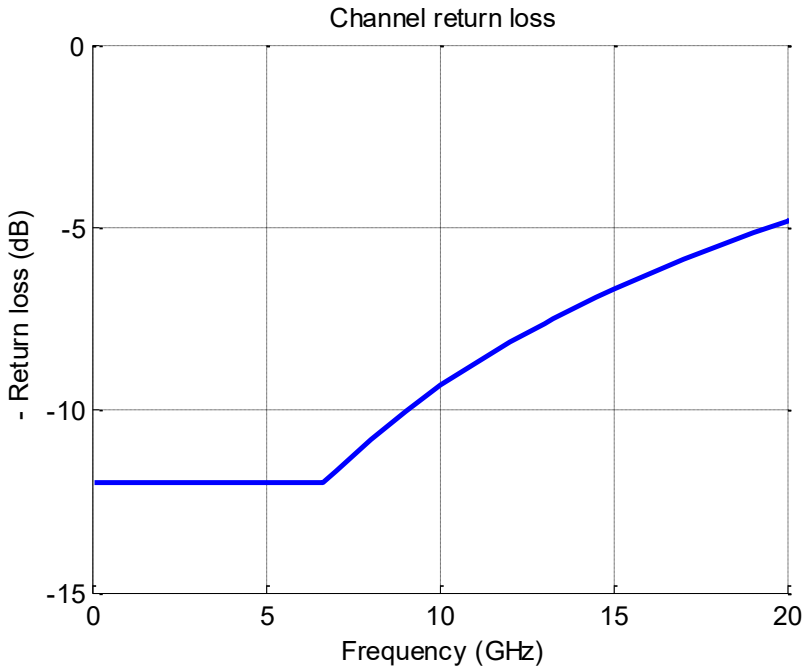
Lower left: More Test Channels from IBM, Intel, TE used for CEI-56G-**L**R-PAM4 COM Analysis

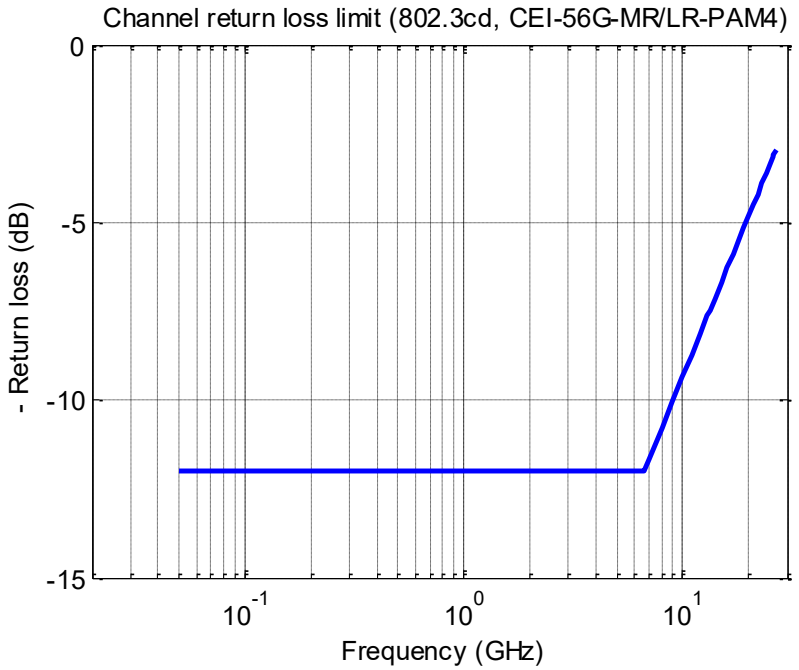
From oif2017.166.03, CEI-56G-MR Channel Operating Margin analysis and proposed parameter updates, Hormoz Djahanshahi

Lower right: limit, 802.3cd, CEI-56G-MR/LR-PAM4

It appears that channel RL will be much better than spec << 1 GHz

Channel return loss





- Channel return loss (at TP0 or TP5) from 802.3bs Eq. 120D-12, 802.3cd Eq. 137-4
- Also OIF CEI-56G-MR-PAM4 Eq 17-3 and LR-PAM4 Eq 21-3