TX Optical Return Loss Tolerance and RX Reflectance Considerations (In support of comment #I-34)

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Supporters

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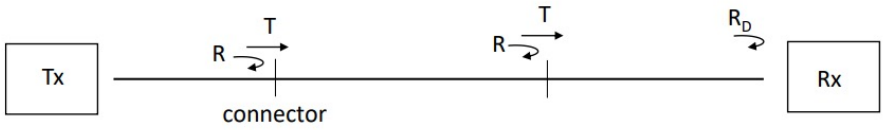
Problem Statement

- TX ORL (Optical Return Loss) tolerance is specified as 12dB in D3.0 - leveraged from previous generation specs. No data/information has been presented to demonstrate that the transmitter can indeed tolerate 12dB ORL at 53GBd.
- By adopting the same level of RX reflectance and TX ORL tolerance as 50G, the current spec put 100G operation burden solely on TX even though it is likely more cost effective to address the issue at RX.
  - RX reflectance: well-established and cost-effective techniques such as anti-reflective coating to improve the performance.
  - TX ORL tolerance: relative difficult and expensive to achieve robust performance (e.g. isolators, introducing attenuation)
- Comment #I-34 proposes to re-evaluate the margin allocation between TX and RX.

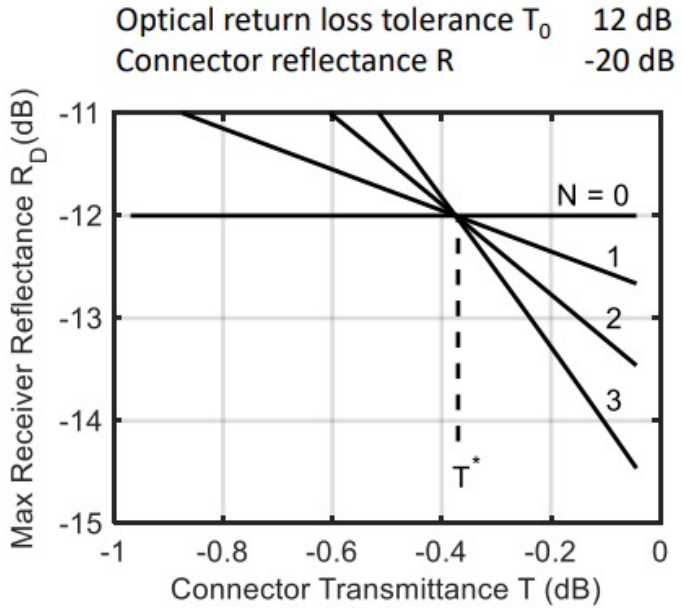
Existing Return Loss Model

- Return Loss (in support of comment 36) from Ramana Murty provided the model and the background how 12dB limit was determined.



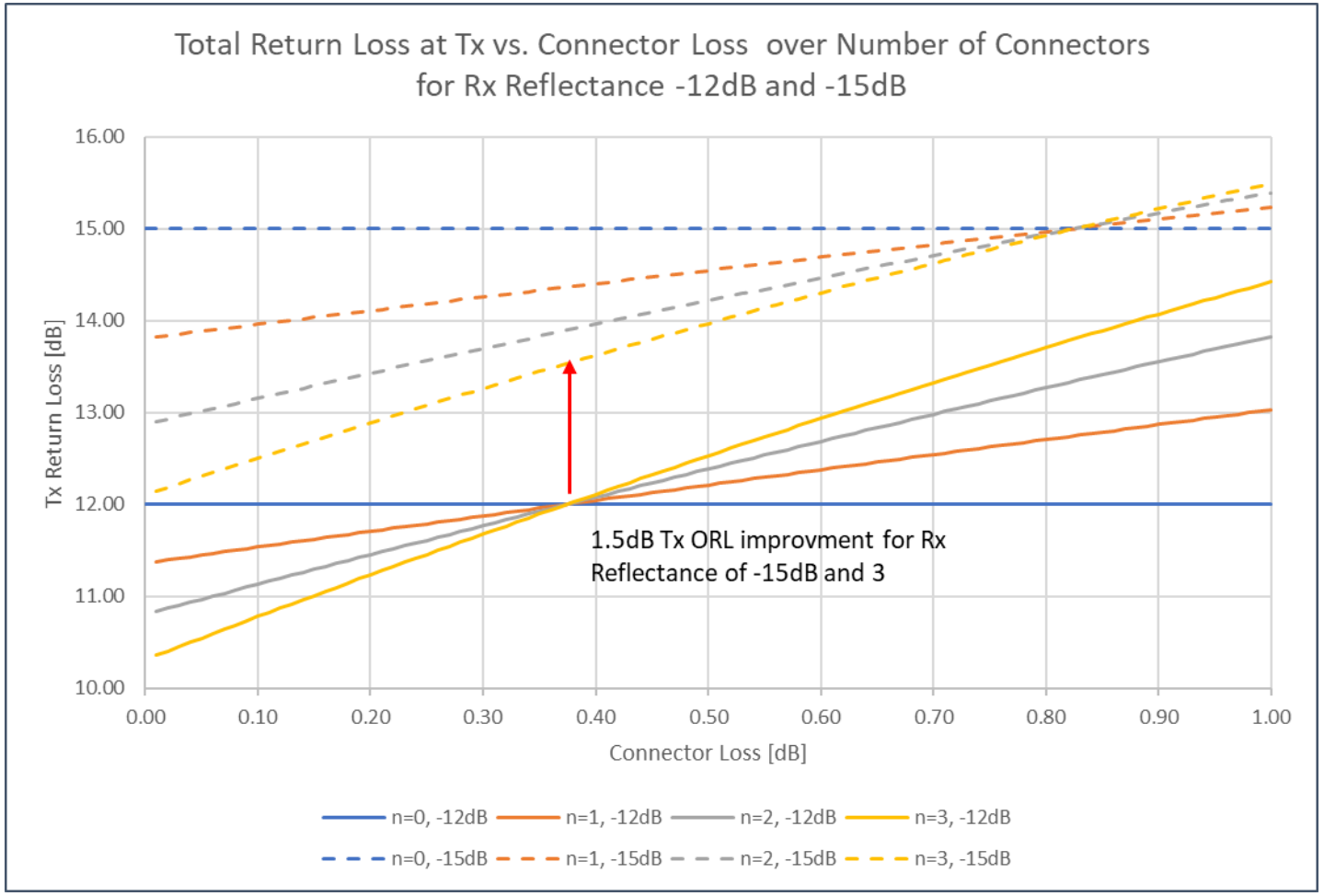
Optical return loss tolerance	T_0
Receiver reflectance	R_D
Connector reflectance (into waveguide)	R
Connector transmittance (into waveguide)	T
Number of connectors	N

Simplifications:
1. Incoherent addition of reflected intensity
2. No fiber attenuation
3. Multiple reflections from a connector are ignored



Conclusion: if the connector transmittance is at -0.37dB (a reasonable assumption), at 12dB ORL level, the ORL seen by TX doesn't depend on the number of connectors.

Shift Margin Allocation from RX to TX



- Same model used
- 1.5dB TX ORL improvement by reducing RX reflectance from -12dB to -15dB with 3 connectors considered.

Multiple Connectors' Impact to ORL at TX

- The number of connectors allowed? – Current text

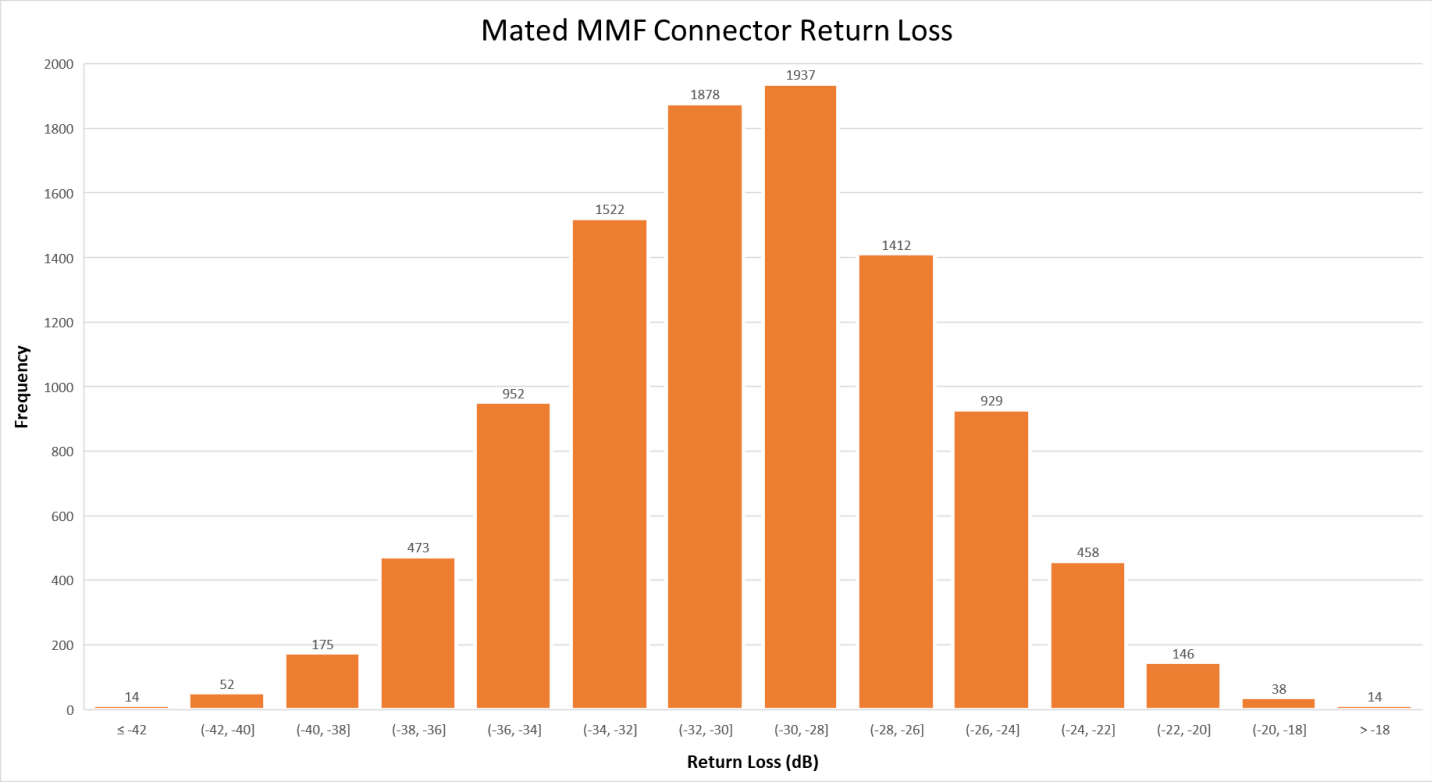
167.10.2.2.1 Connection insertion loss

The maximum link distance is based on an allocation of 1.5 dB total connection and splice loss. For example, this allocation supports three connections with an average insertion loss per connection of 0.5 dB. Connections with lower loss characteristics may be used provided the requirements of Table 167–14 are met. However, the loss of a single connection shall not exceed 0.75 dB.

- "Statistical MMF Connector Insertion Loss" by Doug Colemen (Corning, T11-2015-265v0.pdf (incits.org))demonstrated that connector loss distribution of **4 mated pairs** is less than 1.5dB for 99% installation.
  - Insertion loss assumption $50\% \leq 0.2dB; 35\% \leq 0.3dB; 12\% \leq 0.4dB;\ 5\% \leq 0.5dB;$
- Multiple connectors' impact to ORL can be modeled following similar approach. 4 mated pairs are used in the following study as constrained by 1.5dB attenuation limit.

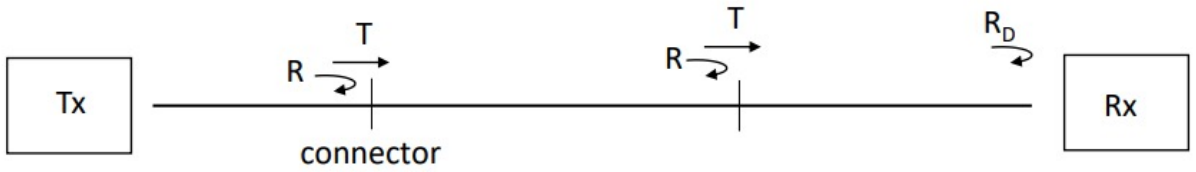
Mated MMF Connector Reflectance Distribution

Assumption: Mean: -30dB; Sigma: 4dB



Reflectance (dB)	Frequency	Cumulative %
-40	66	0.66%
-38	175	2.41%
-36	473	7.14%
-34	952	16.66%
-32	1522	31.88%
-30	1878	50.66%
-28	1937	70.03%
-26	1412	84.15%
-24	929	93.44%
-22	458	98.02%
-20	**146**	**99.48%**
-18	38	99.86%
<-18	14	100.00%

Modified Return Loss Model



Optical return loss tolerance
Receiver reflectance
Connector reflectance (into waveguide)
Connector transmittance (into waveguide)
Number of connectors

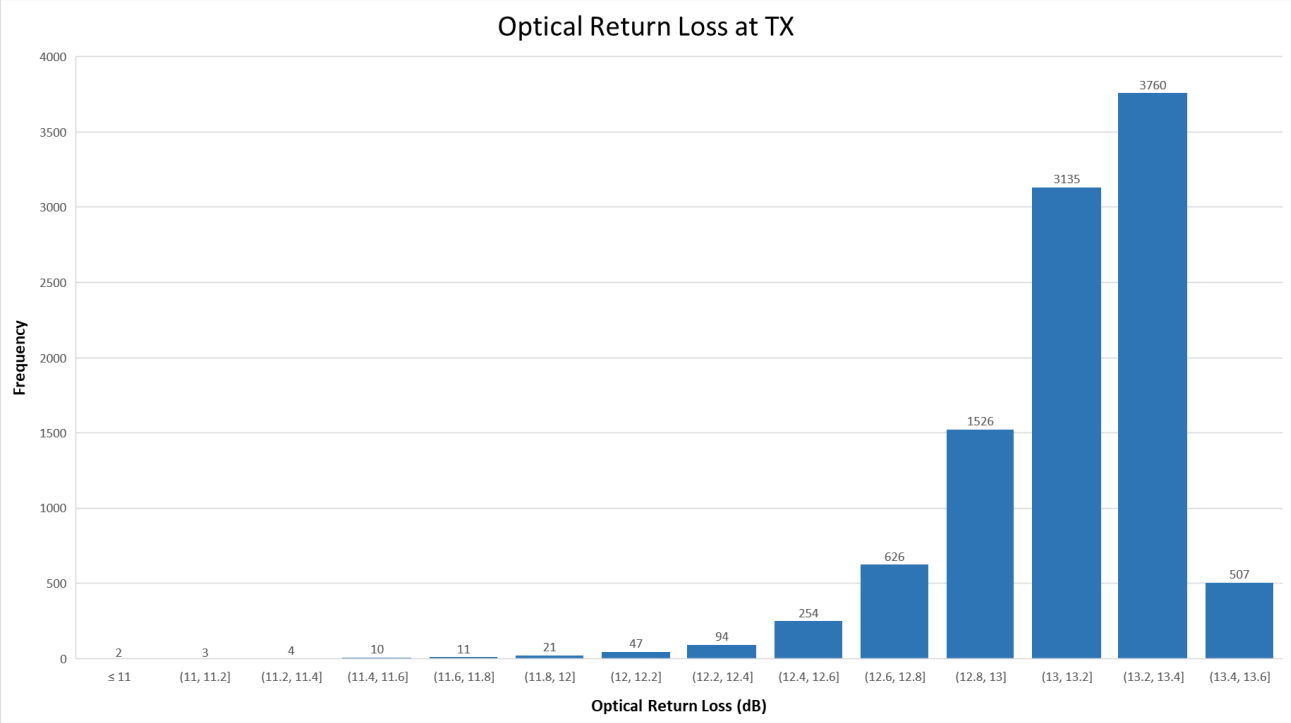
T_0
R_D → Two cases: R_D = -12dB / -15dB
R → R1/R2/R3/R4: Randomly generated, 10000 data points
T → T1/T2/T3/T4: -0.2dB assumed at each connector
N → N = 4

Simplifications:
1. Incoherent addition of reflected intensity
2. No fiber attenuation
3. Multiple reflections from a connector are ignored

ORL at TX with RX Reflectance @ -12dB

Assumptions:

- Number of connectors: 4
- Transmittance per connector: -0.2dB

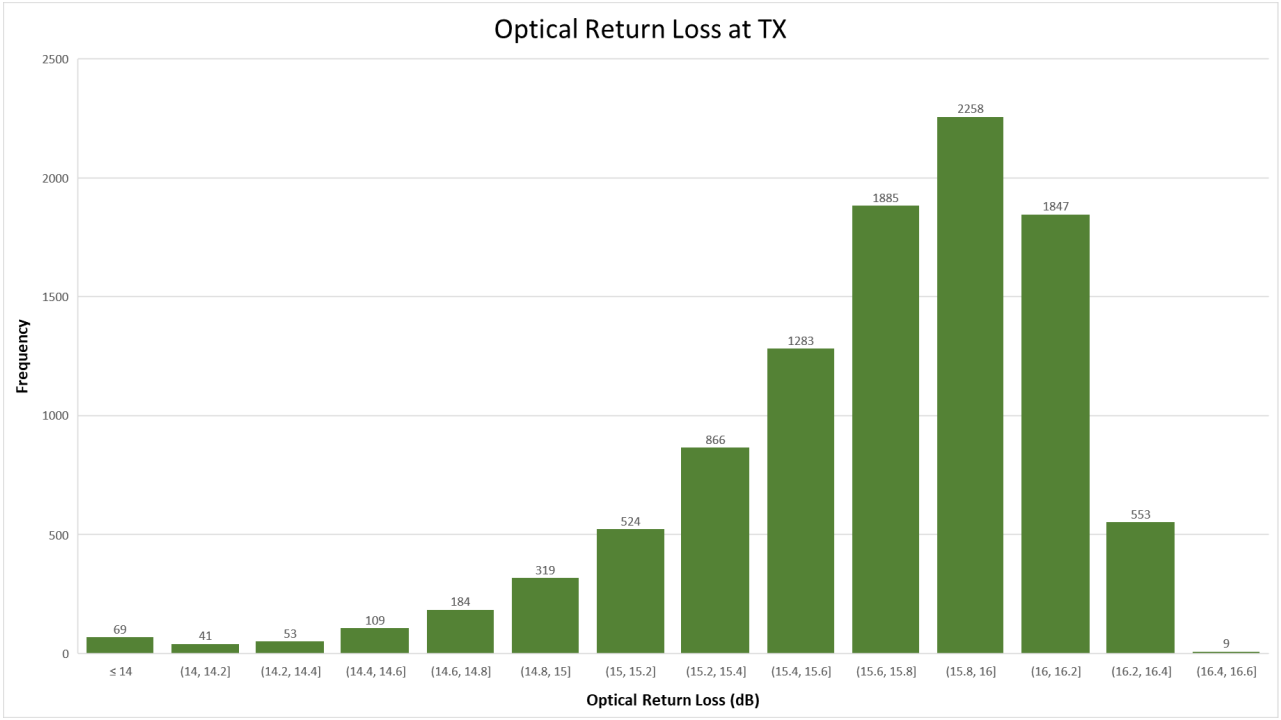


ORL @ TX (dB)	Frequency	Cumulative %
14	0	0.00%
13.8	0	0.00%
13.6	507	5.07%
13.4	3760	42.67%
13.2	3135	74.02%
13	1526	89.28%
12.8	626	95.54%
12.6	254	98.08%
12.4	94	99.02%
12.2	**47**	**99.49%**
12	21	99.70%
11.8	11	99.81%
11.6	10	99.91%
11.4	4	99.95%
11.2	3	99.98%
11	2	100.00%
	0	100.00%

ORL at TX with RX Reflectance @ -15dB

Assumptions:

- Number of connectors: 4
- Transmittance per connector: -0.2dB



ORL @ TX (dB)	Frequency	Cumulative %
16.6	9	0.09%
16.4	553	5.62%
16.2	1847	24.09%
16	2258	46.67%
15.8	1885	65.52%
15.6	1283	78.35%
15.4	866	87.01%
15.2	524	92.25%
15	319	95.44%
14.8	184	97.28%
14.6	109	98.37%
14.4	53	98.90%
14.2	**41**	**99.31%**
14	69	100.00%
	0	100.00%

Summary and Proposal

- Summary
  - The current RX reflectance requirement was leveraged from previous generation product/spec and based on glass-air interface assumption. -15dB reflectance can be achieved with minimum cost increase.
  - RX reflectance reduction can enable ORL tolerance margin for TX based on the existing model.
- Comment #I-34 proposes to
  - Change “Receiver Reflectance (max)” from -12dB to -15dB
  - Change transmitter “Optical Return Loss Tolerance (max)” to ~~-15dB~~ -> -14dB
  - Change transmitter spec “RIN$_{12}$OMA” to “RIN$_{\sout{15}14}$OMA”