Mated Test Fixture Insertion Loss Comment #149

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Objective

Provide supporting content for D3.1 comment #149 which addresses MTF insertion loss.

1. Show measured and fitted MTF IL and estimate the manufacturability impact of tightening the min/max MTF limits.
2. Address the proposal to provide "more details" on the de-embed/re-embed process.

Cl **179B** *SC* **179B.4.1** *P* **920** *L* **2** # 149

Heck, Howard TE Connectivity

Comment Type **TR** *Comment Status* **X**

MTF insertion loss specification and the method for accounting for differences between the fitted insertion loss of an actual test fixture and the reference insertion loss remains an open from D3.0.

SuggestedRemedy

Change page 920, line 9 to ILdd(f) is the fitted insertion loss in dB at frequency f

Change page 918 line 1 and page 918, line 28 and to
The effects of differences between the fitted insertion loss of an actual test fixture and the reference insertion loss are to be accounted for in the measurements.

Add text describing the de-embed/re-embed method for account for the differences between MTF actual and reference insertion loss that will be provided in a planned supporting presentation to be given at the Plenary.

Proposed Response *Response Status* **O**

Straw Poll #10

For the change to the Mated Test Fixture ILdd specification, I prefer the approach of:

A> no change needed

B> fitted ILdd mask

C> more details on de-embed/re-embed process included in the draft

D> B plus C

(choose one)

Results: A: 10 , B: 8 , C: 8 , D: 27

Slide 14 of https://ieee802.org/3/dj/public/26_03/motions_3dj_2603.pdf

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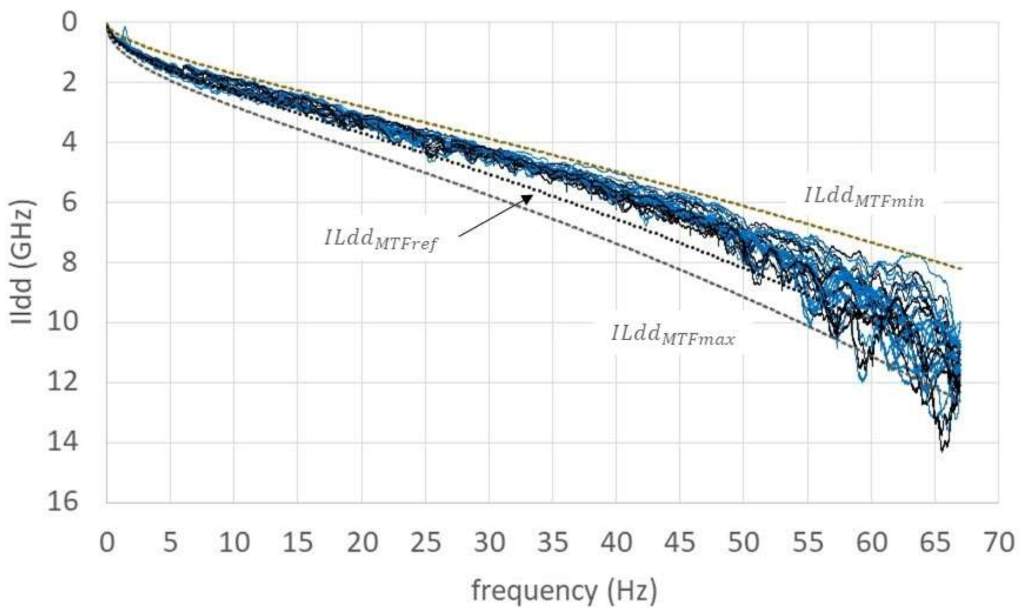
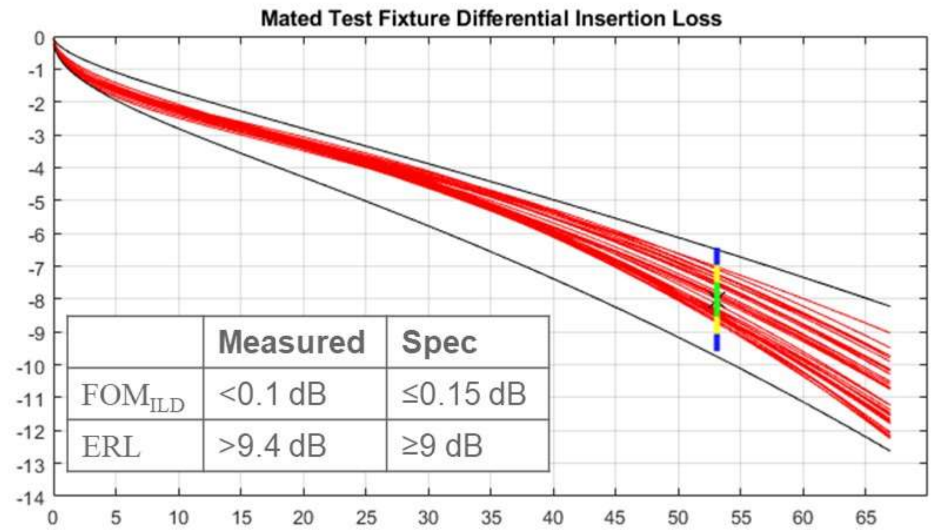
Fitted Insertion Loss





	Measured	Spec
FOM_{ILD}	<0.1 dB	≤0.15 dB
ERL	>9.4 dB	≥9 dB

Data from heck_3dj_01_2605
acknowledgement: Sam Kocsis, Amphenol

- Data for mated test fixtures from two suppliers.
- Fitting IL shows ability to meet the min/max specs. Recommend basing specs on fitted IL.
- Recommendation: No change to the limits.

Proposed De-embed/Re-embed draft wording

- Applies to 179B.2.1 (p. 907, lines 5-7) and 179B.3.1 (p. 907, lines 32-34).
- Specific text to address (applies to both sub-clauses):

  The effects of differences between insertion loss of an actual test fixture and the reference insertion loss are to be accounted for in the measurements.

- Draft wording

  The effects of differences between insertion loss of an actual test fixture and the reference insertion loss are accounted for in the measurements. The recommended method is to de-embed the fixture trace and re-embed the reference insertion loss.

  Multiple methods for de-embedding are available. One documented method is provided by IEEE Std 370™ using the impedance corrected 2x thru de-embedding method. It is acknowledged that other known de-embed methods exist and are allowed.

  Re-embedding of the reference insertion loss is accomplished by cascading the de-embedded S-parameters with the S-parameters for the reference insertion loss using equation (93A-6). The HCB/MCB trace reference insertion loss scattering parameters for the re-embedding are computed using the method described in 178A.3 and the values in Table 179B-x.

Table 179B-x-Mated test fixture reference S-parameter values

Parameter	Symbol	Value	Units
Transmission line parameter τ	τ	5.79×10^{-3}	ns/mm
HCB transmission line length	z_p	76.505	mm
MCB transmission line length	z_p	98.7	mm
Maximum frequency	f_{max}	67	GHz
Frequency step	Δf	0.01	GHz

Or whatever annex/subclause we deem appropriate.

178A.3 Method for calculating HCB and MCB S-parameters

S-parameters for the HCB and MCB reference insertion loss curves are calculated using the procedure in this subclause.

a) Define the sampling points, $f[k]$ over the range from DC to f_{max} with frequency step Δf where

- f_{max} and Δf are taken from Table 179B-X , $k = 0,1, \ldots n_{half}$, and $n_{half} = \frac{4 \cdot f_{max}}{\Delta f}$

b) Compute the sampled reference insertion loss magnitude $IL_{dd}[k]$ in dB using Equation (179B-1) for the HCB or Equation (179B-2) for the MCB and is converted to magnitude as $|S_{21}[k]| = 10^{-IL_{dd}[k]/20}$.

c) Compute the causal (minimum) phase, $\varphi_{min}(k) = -\mathcal{H}(A[k])$ where $A[k] = \ln(|S_{21}[k]|) = -\ln(10)/20 \cdot IL_{dd}[k]$ and $\mathcal{H}$ is the Hilbert transform defined in 178A.3.1.

d) Compute the bulk phase, $\varphi_{bulk}[k] = -2\pi f[k]\tau z_p$ using the values for τ and z_p from the subclause that invokes this procedure.

e) Compute the total phase: $\varphi_{tot}[k] = \varphi_{min}[k] + \varphi_{bulk}[k]$

f) Compute the S-parameters: $S_{21}[k] = |S_{21}[k]| \cdot exp\left[i \cdot \varphi_{tot}[k]\right]$

Notes:

- In step f) $S_{21}(k) = S_{12}(k)$

178A.3.1 Minimum phase computation

The minimum phase for the reference insertion loss S-parameters is computed from the reference insertion loss magnitude for the HCB and MCB using the procedure in this subclause.

1. Define the sampling points & extend the magnitude to include negative frequencies.
   - Extend $A[k]$ to $n = 2n_{half}$ points where $A[n-k] = A[k]$ for $k = 1, \dots n_{half} - 1$
2. Flatten the response at frequencies beyond f_{max}: $A[k] = \begin{cases} A[k] & k < k_{max} \\ A[k_{max}] & k \geq k_{max} \end{cases}$

   where k_{max} is the sample index responding to f_{max}.
3. Compute the inverse DFT: $c[k] = IDFT(A[k])$
4. Perform a causal fold $c_{fold}[n] = w[n]c[n]$ where

$$w[n] = \begin{cases} 1, & n = 0 \\ 2, & 1 \leq n \leq n_{half} - 1 \\ 1, & n = n_{half} \\ 0, & n_{half} + 1 \leq n \leq n - 1 \end{cases}$$

5. Compute the discrete Fourier transform: $z[k] = DFT\left[c_{fold}[k]\right]$
6. The minimum phase is the imaginary portion of $z[k]$: $\varphi_{min}[k] = Im(z[k])$

Summary

Suggested Remedy:

- Change the text on p. 920, line 8 to read “The fitted insertion loss of the mated test fixtures shall meet Equation (179B-3) and Equation (179B-4).
- Keep the existing min/max insertion loss limits in Figure 179B-1.
- Implement text on slides 4-6 for de-embedding MCB/HCB insertion loss and ‘re-embedding’ of the reference insertion loss.

Thank You

De-embedding/Re-embedding

- Goal: Provide guidance while keeping the magnitude of the draft change small.
- Approach:
  - De-embedding
    - Provide optional guidance by referencing the methodology defined in IEEE 370™-2020, IEEE Standard for Electrical Characterization of Printed Circuit Board and Related Interconnects at Frequencies up to 50 GHz, 2021. Given the frequency limit of that existing document, only the general methodology can be cited. Acknowledge and allow other known de-embedding methodologies as options.
  - Re-embedding
    - Generate S-parameters for the reference IL (179B.2.1 & 179B.3.1)
    - Re-embed by cascading the S-parameters for the reference IL by the de-embedded S-parameters.

Slide taken from heck_3dj_01_2605