Reference test fixture S-parameters

(in support of comment R2-100 against D3.2)

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Supporters

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Abstract

- This presentation suggests two minor changes in Annex 179B:
  - Addition of informative notes in 179B.2.1 and 179B.3.1, pointing to S-parameter files that will be available for download (companion contribution).
  - Correction of a stale value in 179B.1 (9.75 dB should be 8.75 dB to match the normative eqations).
- The changes are not expected to be contentious or cause future comments.

Background

- Annex 179B specified the reference IL magnitude for HCB (Equation 179B-1) and MCB (Equation 179B-2), but phase or impedance profile are not provided.
- Measurements are done using physical test fixtures…
  - 179B.3.1 states that "Differences between the insertion loss of an actual test fixture and the reference insertion loss, including those arising from other MDI connectors, **shall be accounted for** in the measurements".
  - 179B.2.1 states similarly that "The effects of differences between the insertion loss of an actual test fixture and the reference insertion loss **are to be accounted for** in the measurements".
- This accounting can be done by de-embedding techniques as suggested by Heck et al. in heck_3dj_01_2607.
  - However, these techniques require S-parameters for the reference test fixtures, which are not defined in the standard.
  - The presentation included a procedure for calculating S-parameters from the reference IL, but results were not provided.

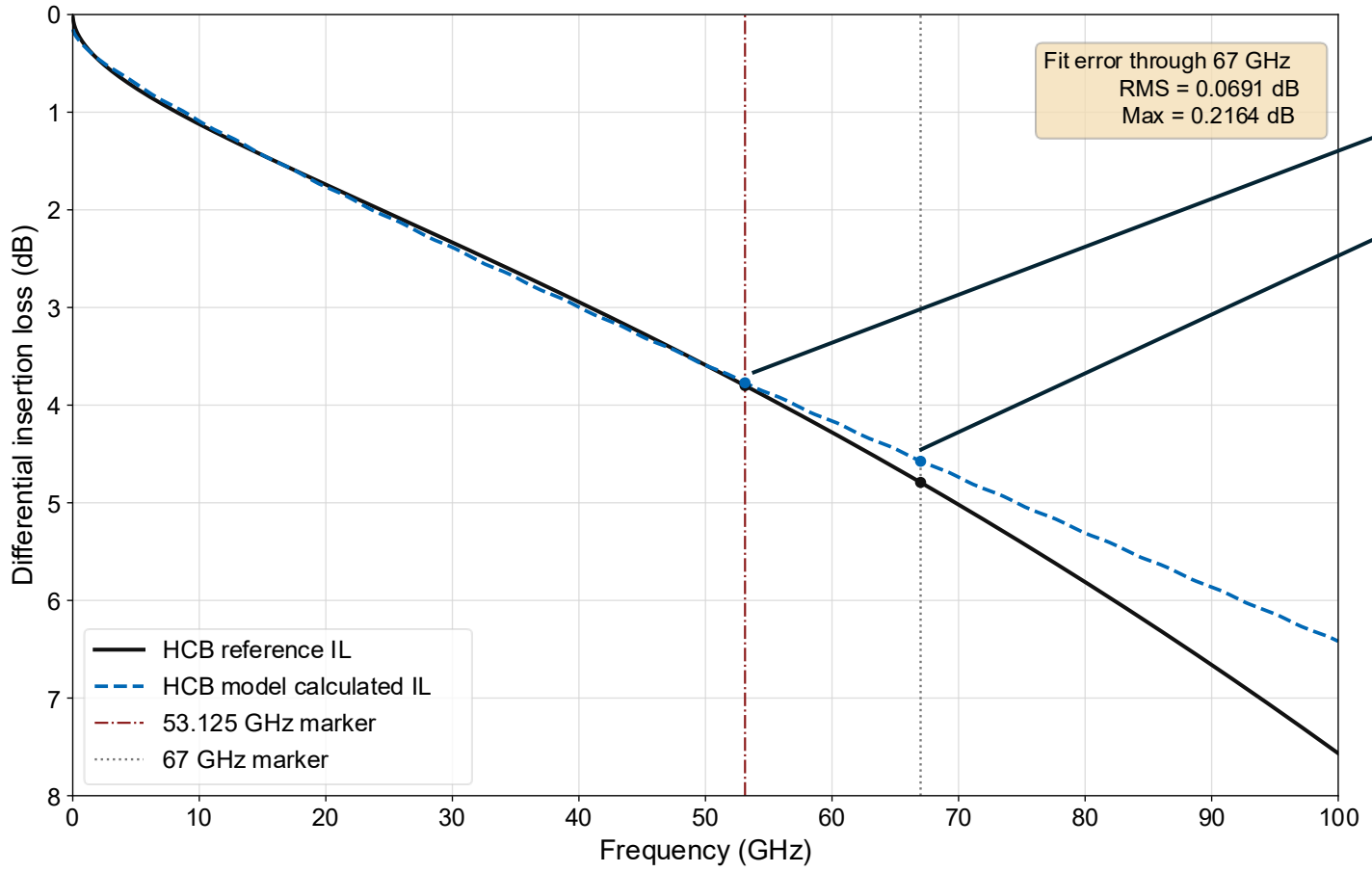
Goals of this contribution

- Provide S-parameters that closely match the reference IL for HCB and MCB over the specified frequency range.
- The S-parameters are generated from models comprising cascaded 2-port elements of the type used frequently in 802.3 specifications (93A.1.2.2 and 93A.1.2.3). Frequency-sampled Touchstone (s4p) files are provided alongside this presentation.
- Having these s4p files will enable users of the standard to implement the requirement to “account for the differences” using de-embedding techniques, to effectively “calibrate out” the specific test fixture and replace it with the reference.
  - The specific method of performing de-embedding depends on test equipment and is the subject of considerable research.
  - It is <u>not</u> proposed to include de-embedding guidance in the standard.

Notes on the provided models

- The lengths of the transmission line elements were chosen based on estimates of physical dimensions of MCBs and HCBs.
- Other parameters were selected based on per-unit-length loss and propagation delay assumptions, and by numerical optimization of the fit.
  - The models do not attempt to match specific test fixtures (especially since the IL of contributed test fixtures deviates from the reference)
  - The reference IL magnitude equations do not uniquely determine the underlying model, phase response, and impedance profile.
- The models have differential insertion loss closely matching the reference equations up to 67 GHz. They also create a specific return loss (not specified). Mode conversion and crosstalk are not modeled. They are passive, reciprocal and causal.
- The sum of the insertion losses at 53.125 GHz is 8.75 dB, as expected.
  - The cascaded MTF model has an IL of 8.64 dB – not equal but close enough.
  - Note that 179B.1 erroneously states “The reference insertion loss of the mated test fixtures is 9.75 dB at 53.125 GHz using Equation (179B–5)”. This is not mentioned in comment R2-100, but is worth fixing.

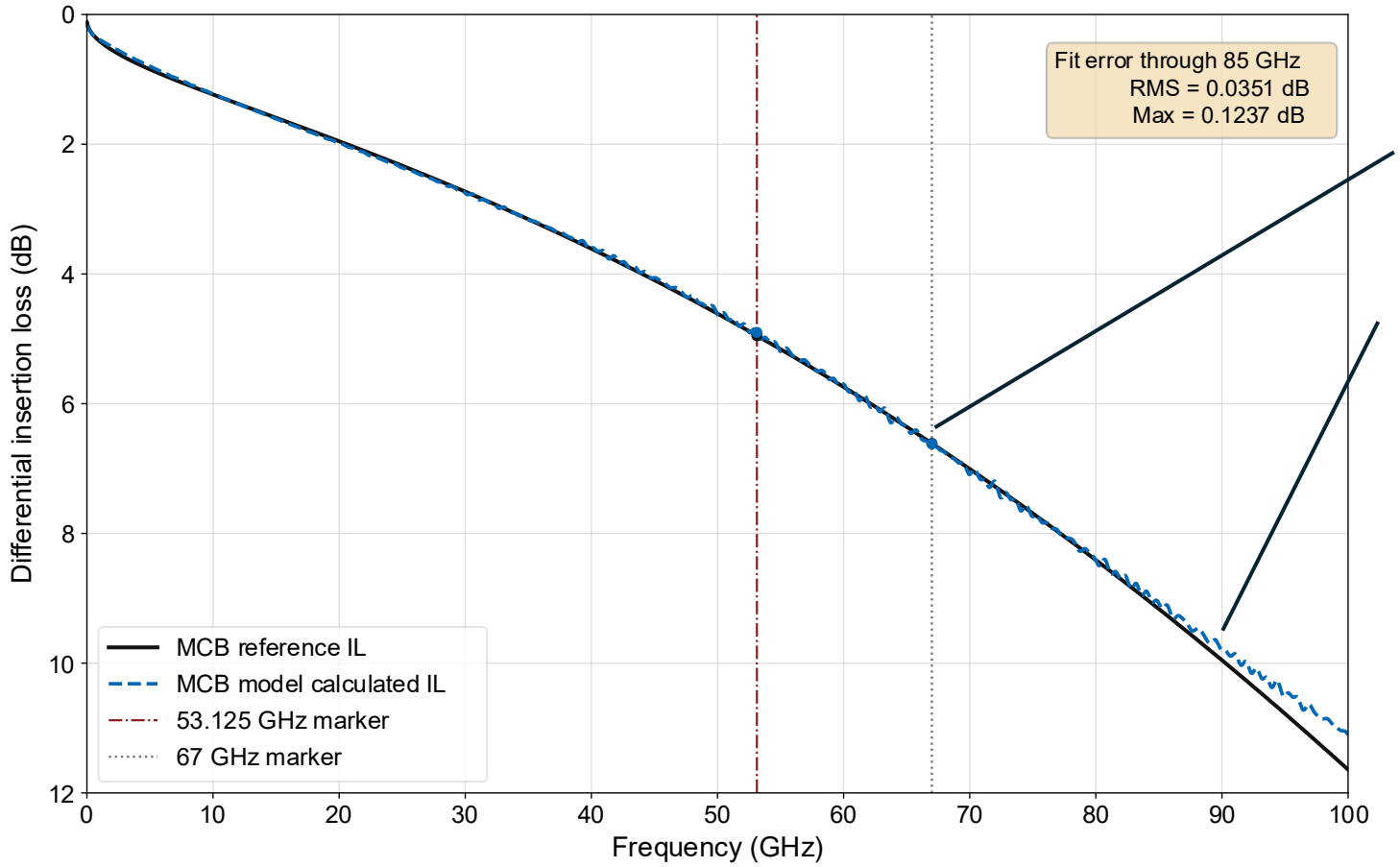
HCB model fit to reference



Excellent fit at Nyquist frequency

Very good fit up to 67 GHz, the upper limit for MTF specifications

MCB model fit to reference



Excellent fit at Nyquist frequency and up to 67 GHz

Very good fit up to ~90 GHz

HCB model parameters

	TL1	TL2	TL3	Units
Element type	TL	TL	TL	
Length (zp)	24	100	121	**mm**
Impedance (Zc)	97.8	92.2	92.5	**Ohm**
gamma0	2.56e-5	4.63e-5	8.56e-5	**1/mm**
a1	2.77e-5	5.02e-5	9.29e-5	**$ns^{1/2}/mm$**
a2	9.08e-6	1.64e-5	3.04e-5	**ns/mm**
tau	4.83e-3	4.83e-3	4.83e-3	**ns/mm**

Coax reference plane

Mating interface

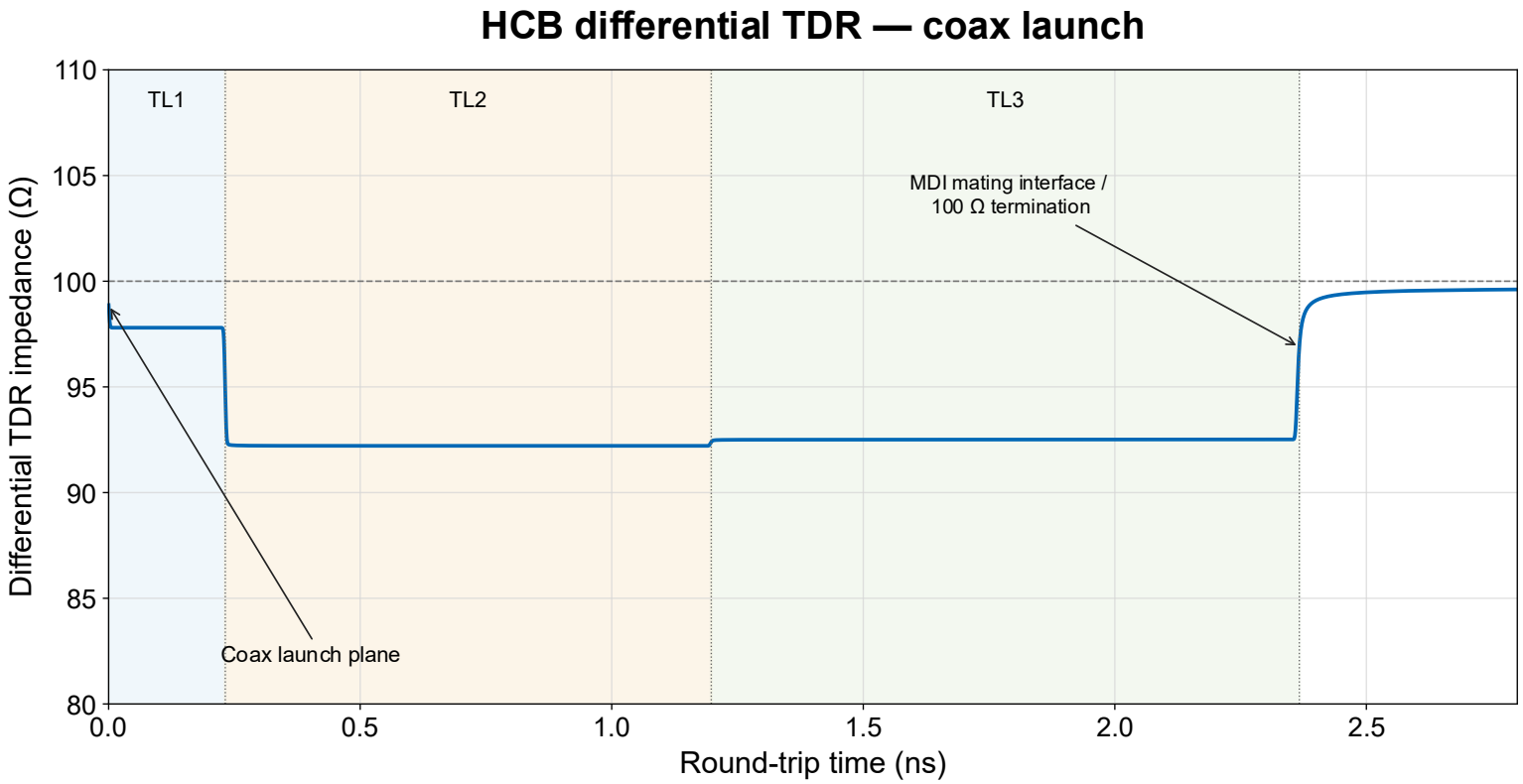
MCB model parameters

	TL1	TL2	C1	TL3	TL4	TL5	Units
Element type	TL	TL	Cap	TL	TL	TL	
Length (zp)	10	120		0.5	69.5	13	**mm**
Impedance (Zc)	94.8	96.9		145	89.8	91	**Ohm**
gamma0	8.24e-5	8.24e-5		8.24e-5	8.24e-5	8.24e-5	**1/mm**
a1	8.94e-5	8.94e-5		8.94e-5	8.94e-5	8.94e-5	**$ns^{1/2}/mm$**
a2	2.93e-5	2.93e-5		2.93e-5	2.93e-5	2.93e-5	**ns/mm**
tau	4.83e-3	4.83e-3		4.83e-3	4.83e-3	4.83e-3	**ns/mm**
C			4.78e-5				**nF**

Coax reference plane

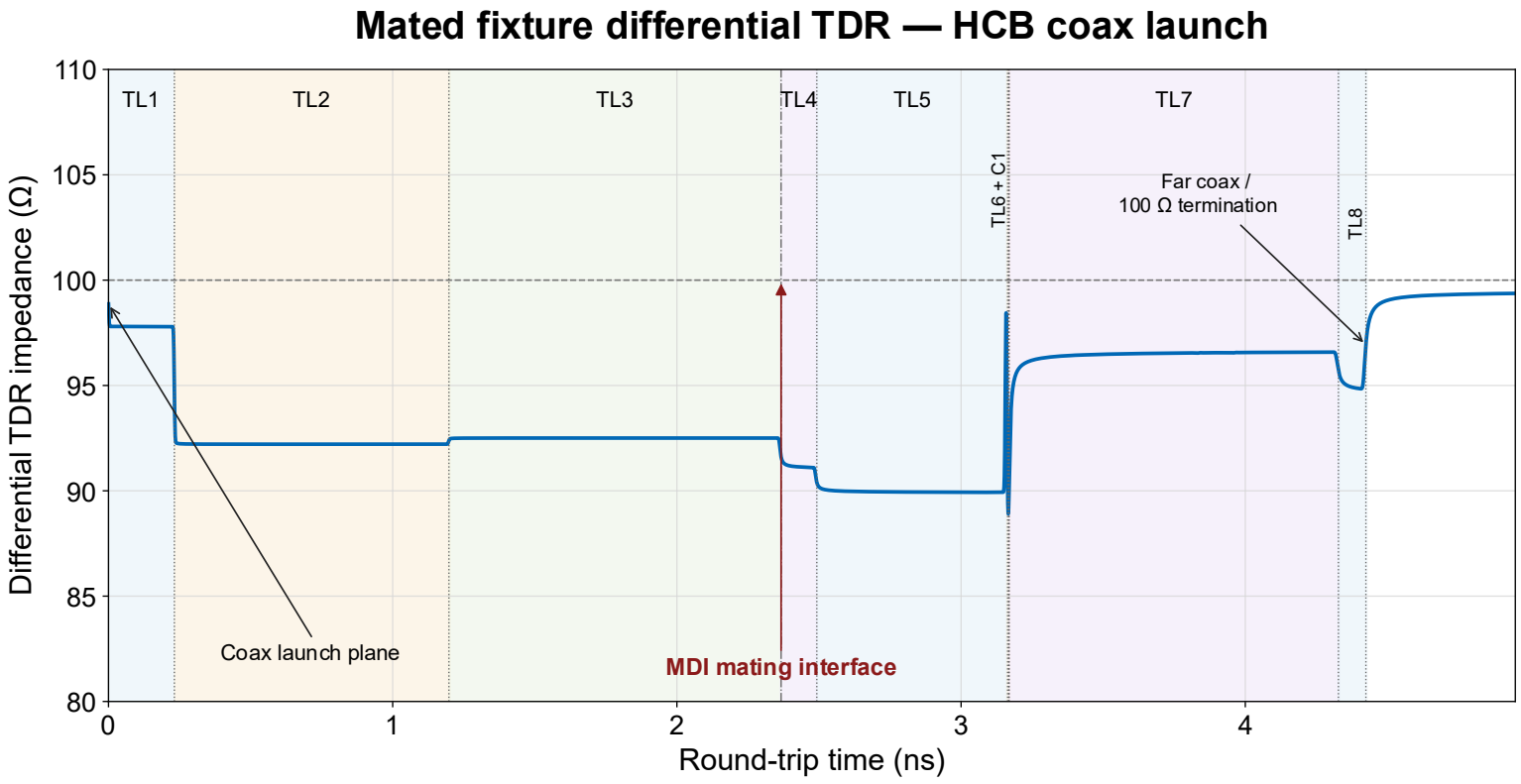
Mating interface

HCB TDR



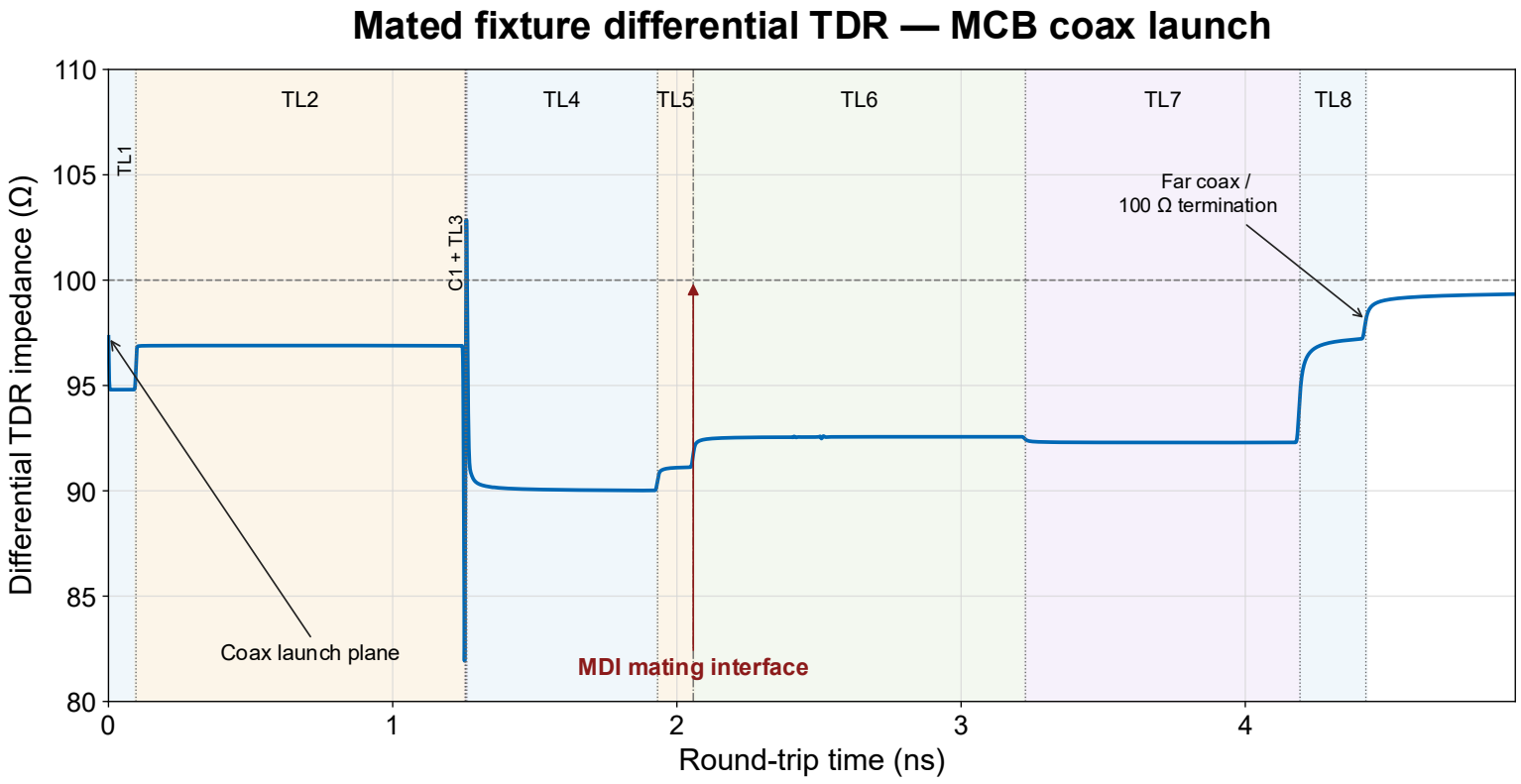
TDRs were calculated from the analytic model up to 300 GHz to minimize Gibbs ringing with a 5 ps rise time.

MTF TDR from HCB side



Launch/termination: 100 Ω differential • Gaussian 10–90% rise time: 5 ps

MTF TDR from MCB side



Launch/termination: 100 Ω differential • Gaussian 10–90% rise time: 5 ps

Provided Touchstone files

- Files in the zip archive:
  Annex_179B_reference_HCB_20260825.s4p and
  Annex_179B_reference_MCB_20260825.s4p
- Port order in both files: (1,3) are coax connectors, (2,4) are the mating interface
- Linear-step frequency scale from 0.01 to 100.00 GHz.
- Reference impedance is 46.25 Ohm single-ended (92.5 Ohm differential).
- File header sections include the model parameters.

Proposed D3.3 changes

- In 179B.1, change 9.75 dB to 8.75 dB.
- In each of 179B.2.1 and 179B.3.1 add the following informative NOTE:

  "A Touchstone file containing S-parameters that approximate the reference insertion loss is available at https://standards.ieee.org/downloads/802.3".

(with editorial license)

That’s all!

Questions?