Validation of the Reference Impedance in Multiline Calibration With Stepped Impedance Standards

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Multiline Calibration

Assumptions:

- All lines share same cross-section and differ only in length.
- Each line is measured in a repeatable way (consistency).

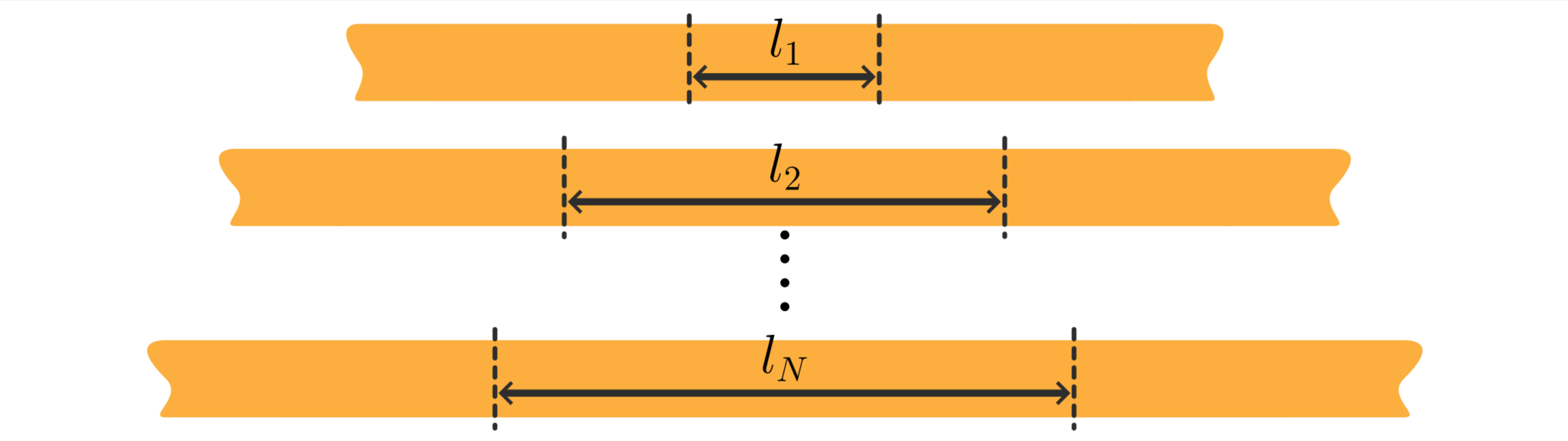

Fig. 1: Illustration of ideal multiline standards.

Reality:

- Cross-section variation due to manufacturing.
- Usage of non-homogeneous materials.
- Other errors, e.g., contact repeatability, noise... etc.

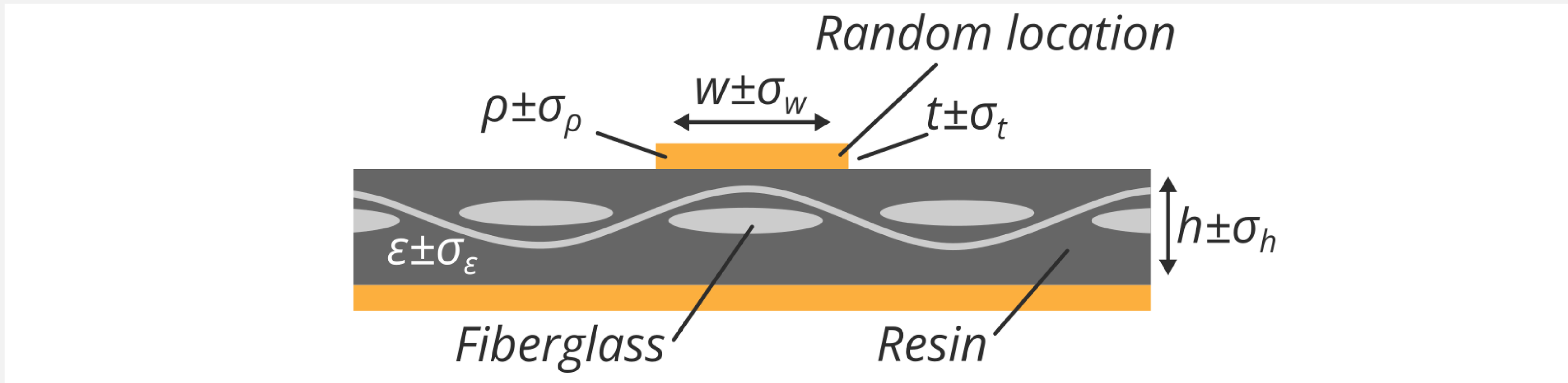

Fig. 2: Illustration of cross-section of a microstrip line on a PCB.

Stepped Impedance Line to Verify the Calibration

- ✓ Simple to make along with the calibration kit.
- × Bandwidth limited.
- × Contain patristics of the abrupt impedance jump.

Fig. 3: Illustration of stepped impedance line (Beatty line).

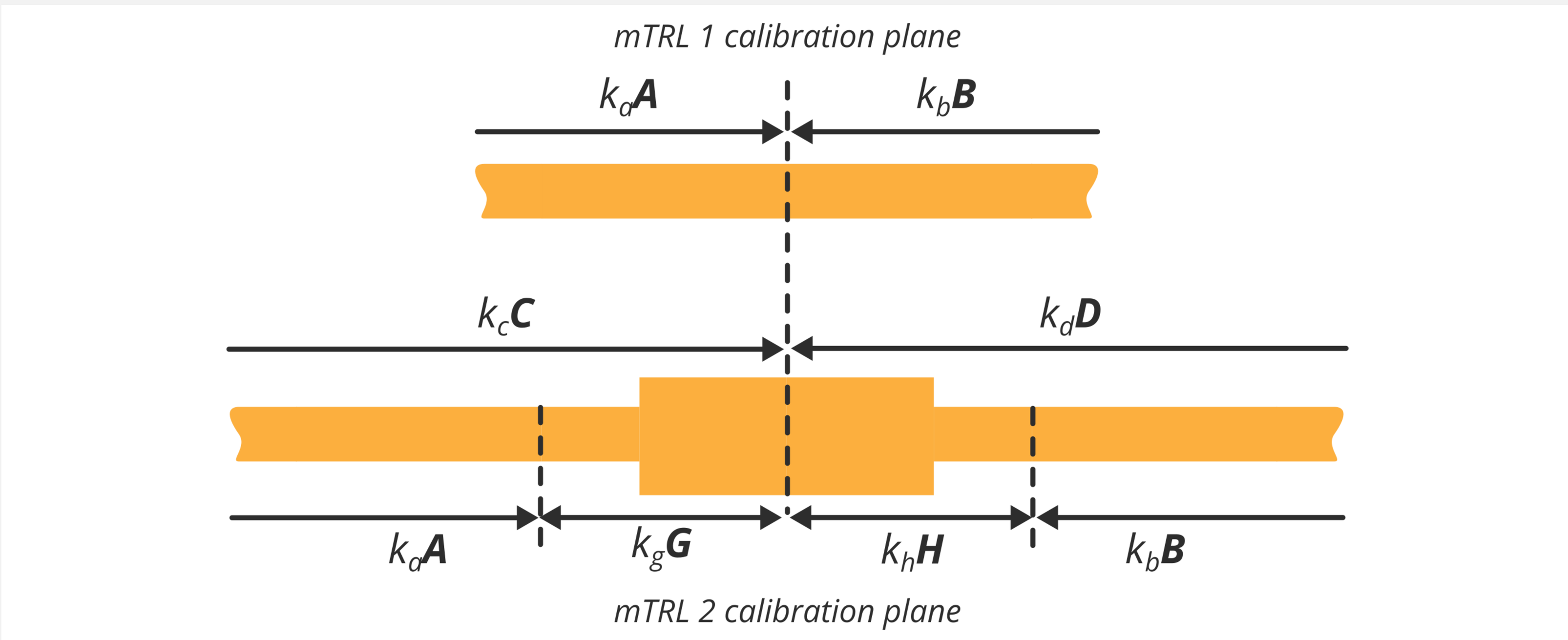

Fig. 4: Illustration of a thru standard using two multiline TRL calibration kits.

Extracting Broadband Impedance Jump Reflection

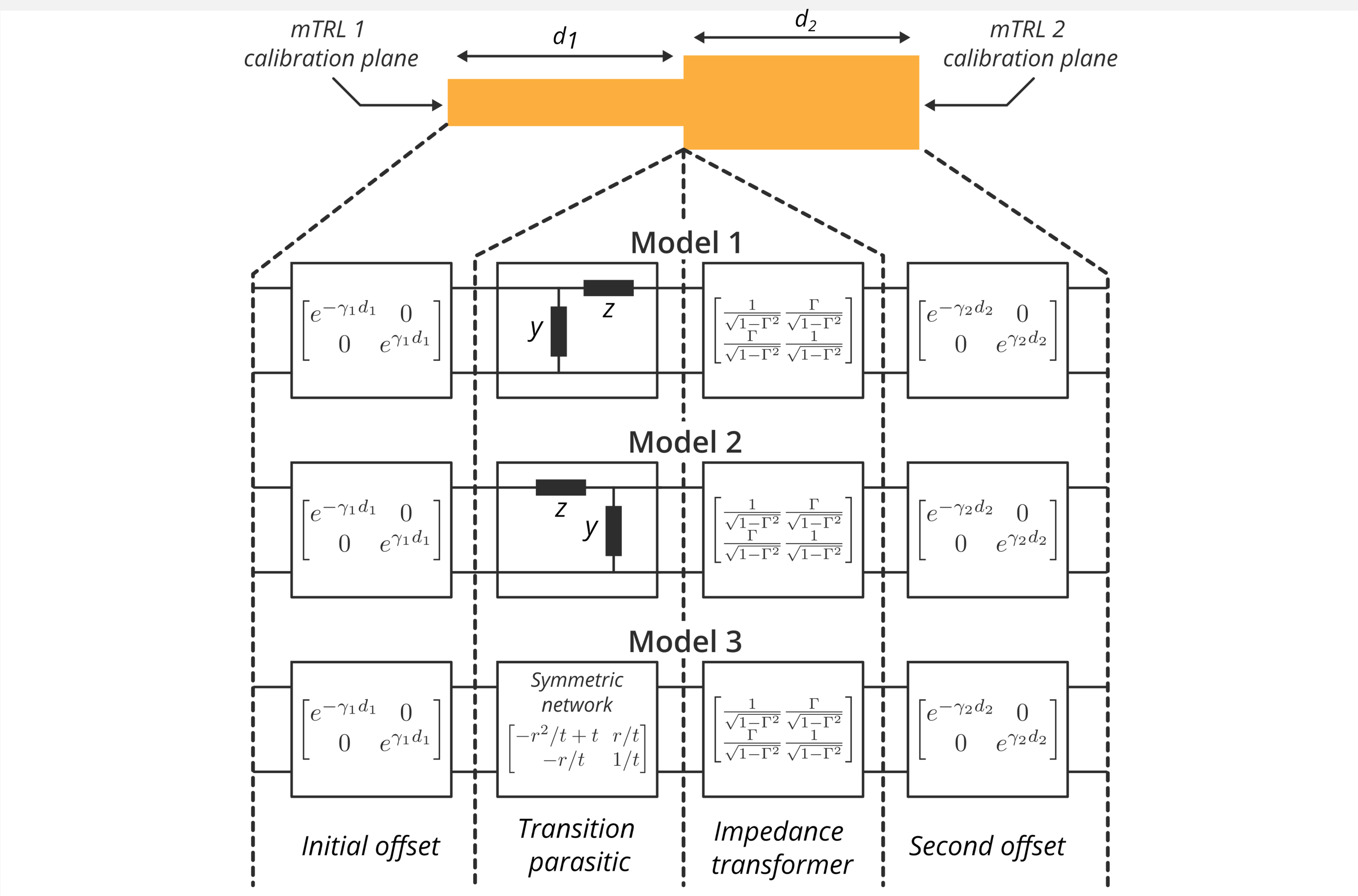

Fig. 5: Proposed models to descripe the impedance transition segment. All matrices are given as T-parameters.

Model 1 and 2

$$\Gamma^{(1,2)} = \pm\frac{(g_{11}\pm_{21}\pm g_{12}+1)^2-4(g_{11}-g_{21}g_{12})}{(g_{11}\pm_{21}\pm g_{12}+1)^2+4(g_{11}-g_{21}g_{12})}$$

Model 3

$$\Gamma^{(3)} = \frac{g_{21}+g_{12}}{g_{11}+1}$$

Extracted T-parameters (without offset parts)

$$\boldsymbol{G} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & 1 \end{bmatrix}$$

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Measurement Setup

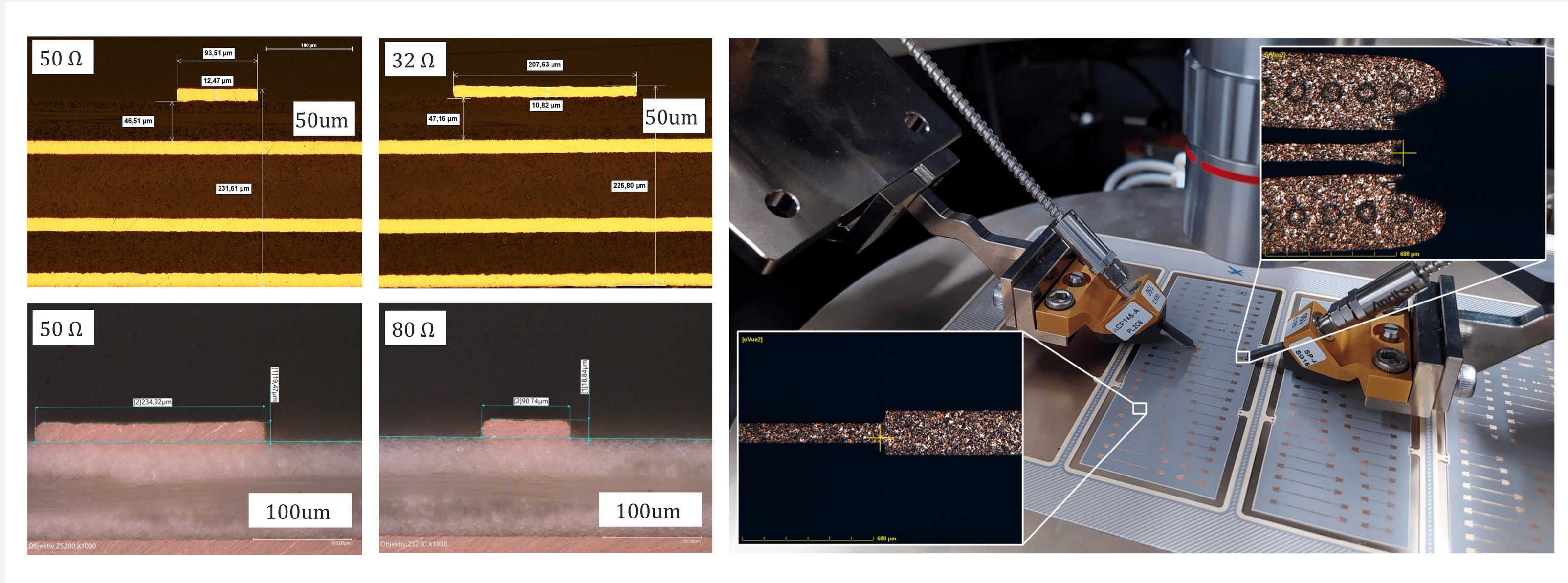

Fig. 6: (left) Cross-section of measured lines. (left-top) Megtron 7 substrate. (left-bottom) Tachyon-100G substrate. (right) measurement setup.

- Two microstrip line variants were tested:
  - 50um Meg7 substrate (50 and 32 Ohms).
  - 100um Tachyon-100G substrate (50 and 80 Ohms).
- On-wafer probe station connected with a VNA up to 150 GHz.

Results

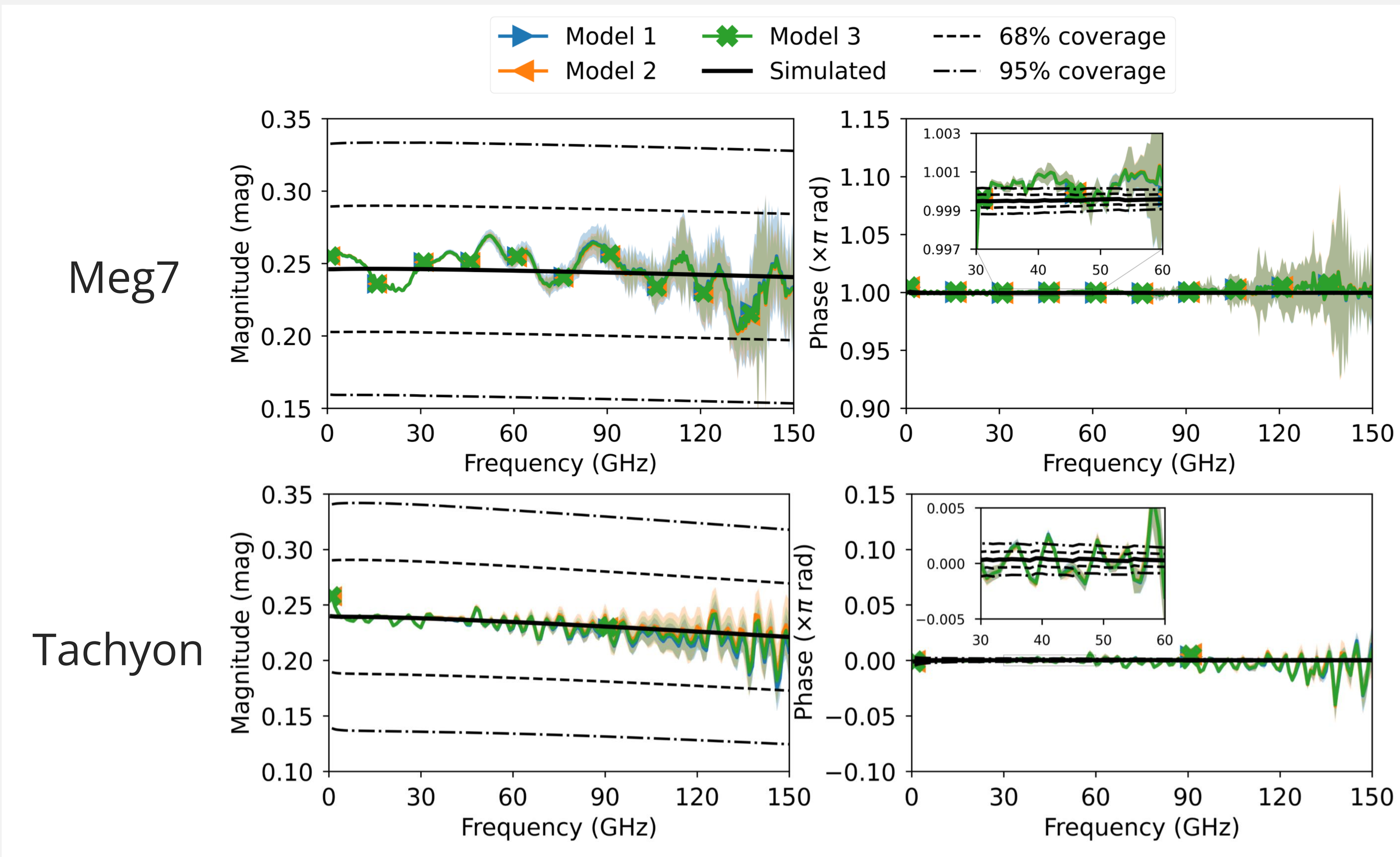

Fig. 7: Measured reflection of the impedance transition.

Normalized impedance $Z' = \frac{Z_{step}}{Z_{ref}} = \frac{1+\Gamma}{1-\Gamma}$

Impedance deviation $\Delta Z = (Z'_{meas} - Z'_{ideal})Z_{ref}$

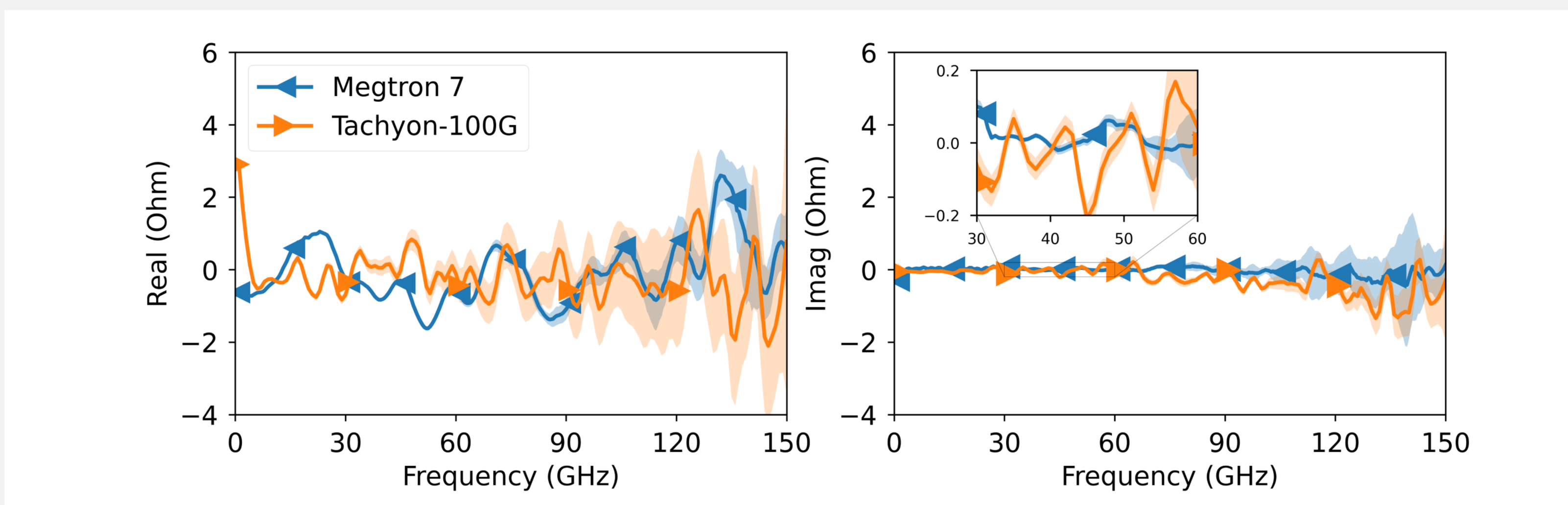

Fig. 8: Estimated characteristic impedance deviation.

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