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A Customized Low-Cost Approach for S-Parameter Validation of ATE Test Fixtures

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ATE

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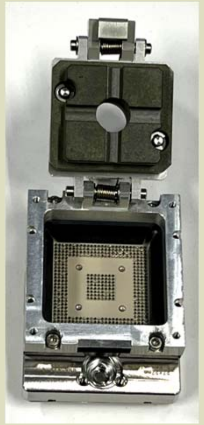
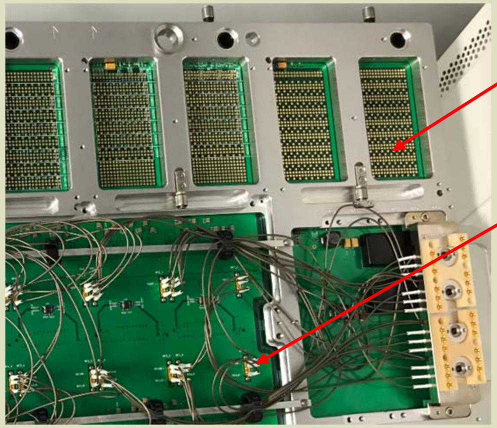
DUT Socket



- How can I quickly and easily measure the DUT test fixture (TDR/S-Parameters)?
- How can I make sure the measurements mimic the ATE to test fixture interface performance?
- How to handle the DUT BGA/socket measurement challenge?

The ATE Side Probing Challenge

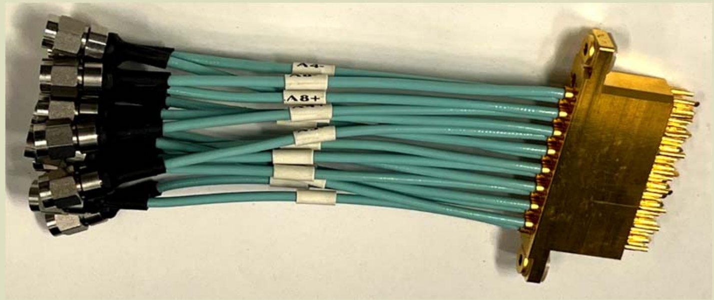
ATE Test Fixture (ATE Side)



Spring pin vias
(Digital signals)

Coaxial Connectors
(RF signals)

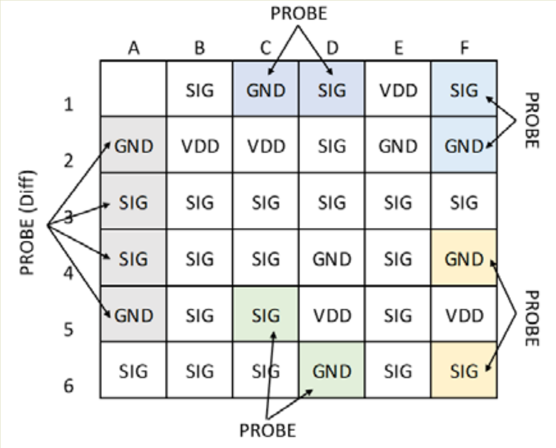
Spring Pin Cable Assembly

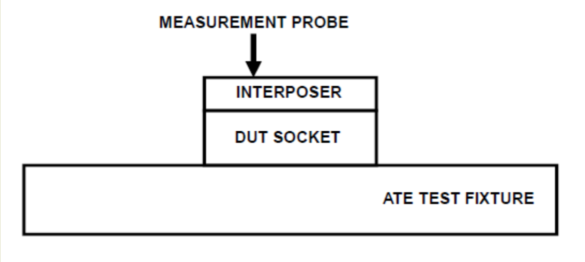


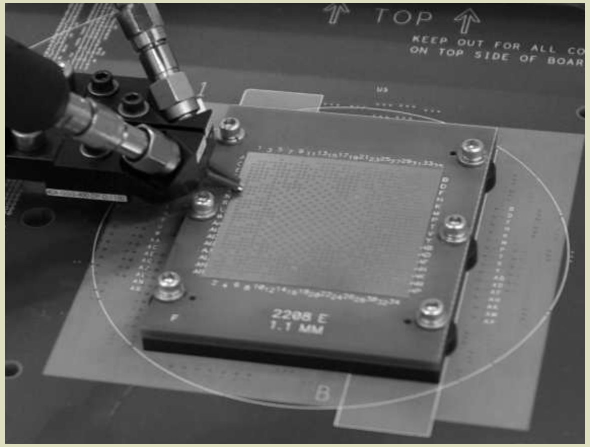
Spring Pin Adapter

- Usually on the ATE side there are only two types of interconnect:
  - Coaxial Connectors
    - Can be easily probed using the appropriate cable assembly
  - Spring Pin Vias
    - More complicated to probe. A spring pin cable assembly with a coaxial connector or a probe/adapter can be used.

The DUT Side Probing Challenge

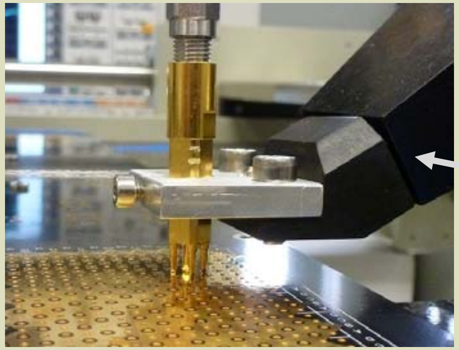






- The BGA ballout of the device (pitch/pin out) presents the first challenge to probe at the socket.
- The second challenge is if one wants to include the socket on the measurement it is necessary to compress the spring pins/elastomer/etc… in the socket. This is far from trivial but possible with a properly designed interposer.

Traditional Approach: Commercial Probe Station

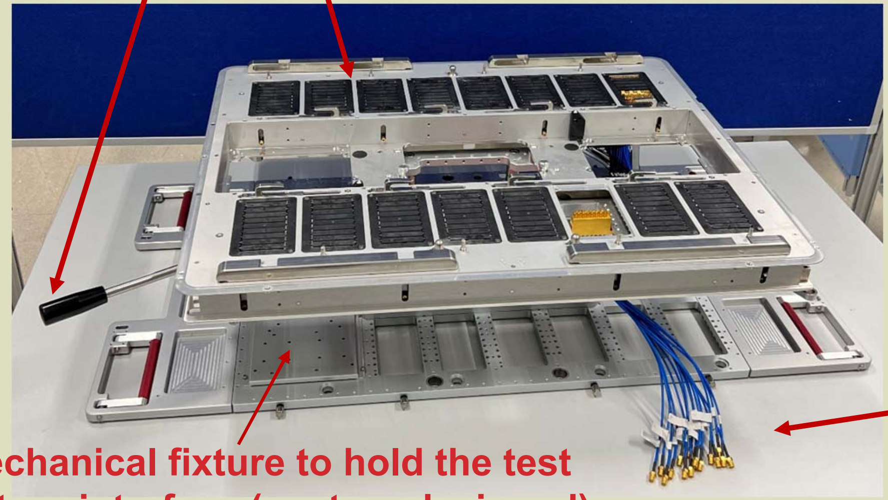


- Very generic, ATE platform independent.
- Requires large probe station size (expensive !!).
- Requires some expertise for usage.

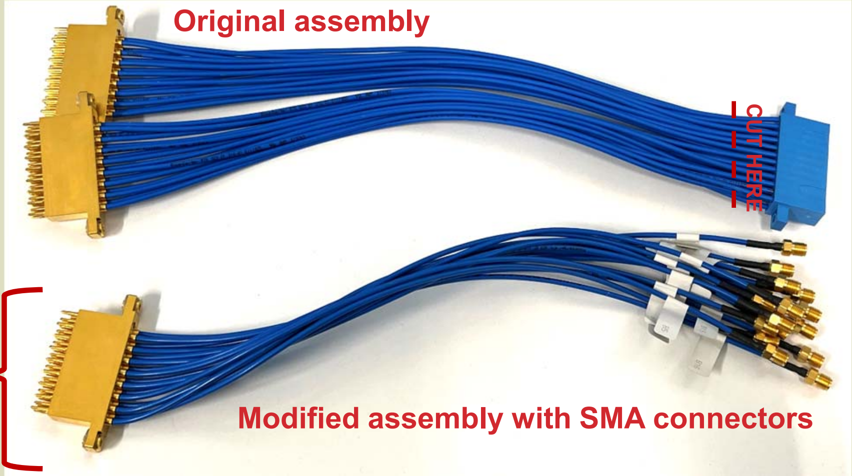
ATE Test fixture Interface (key mechanical components only)

The MacGyver Approach

Manual docking



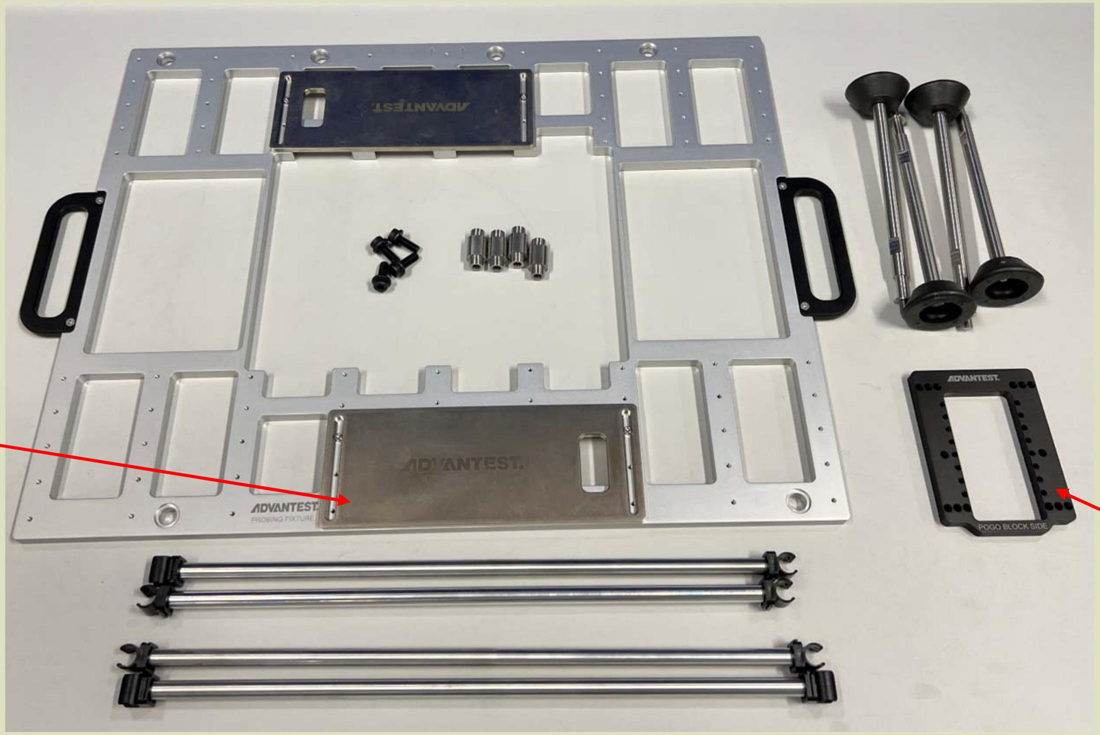
Mechanical fixture to hold the test fixture interface (custom designed)



- Get the ATE test fixture mechanical interface, assemble/modify so it can be used manually.
- Get a spring pin ATE cable assembly, cut-it and attach coaxial connectors.
- This approach requires good connections with ATE manufacturer.

Advantest Approach for the V93000 ATE Test Fixtures

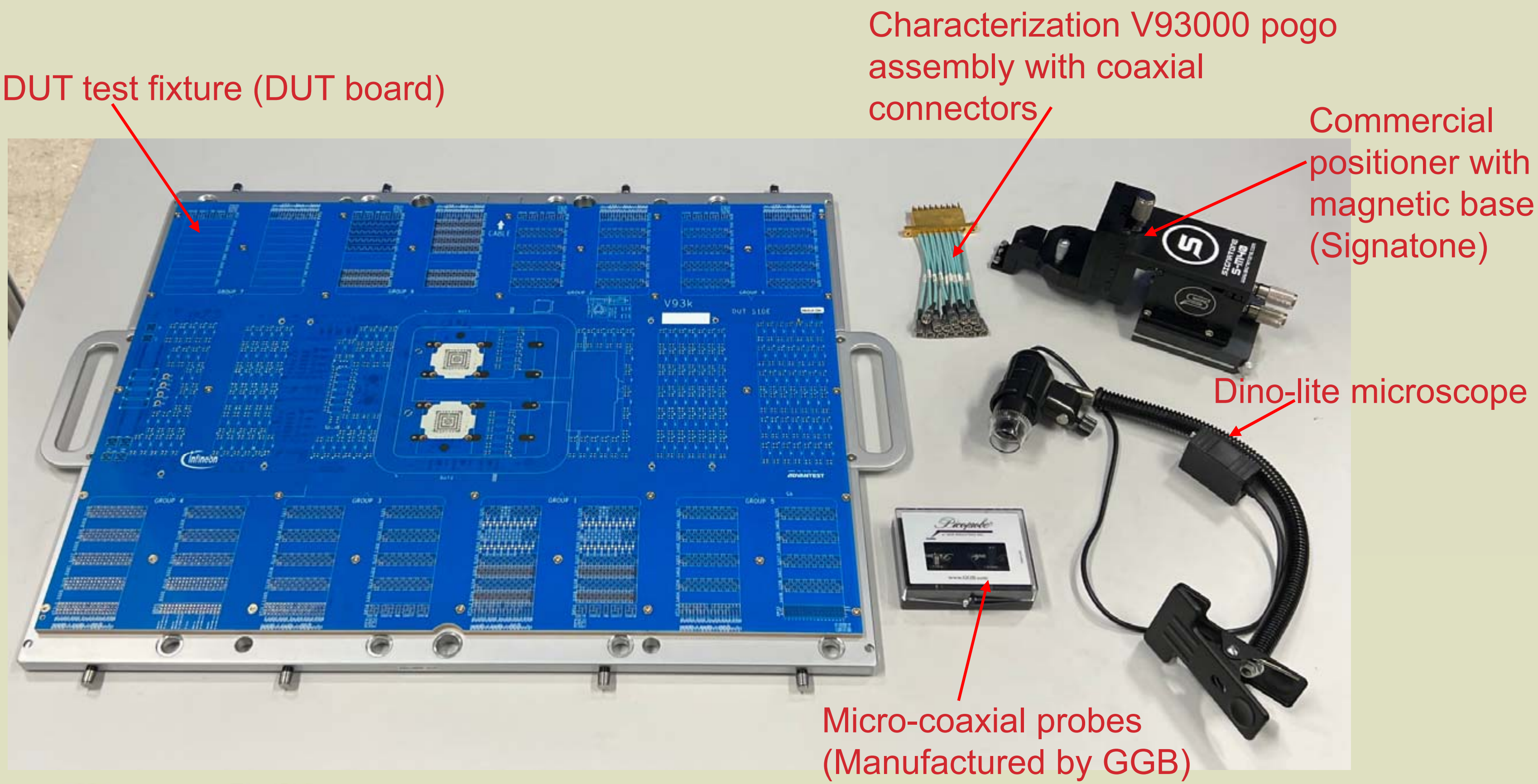
Custom Probing Kit Parts for V93000 DUT Test Fixture (DUT Boards)



Steel plate for magnetic positioner

Bracket to attach the characterization pogo assembly to the DUT Test Fixture

Advantest Approach for the V93000 ATE Test Fixtures



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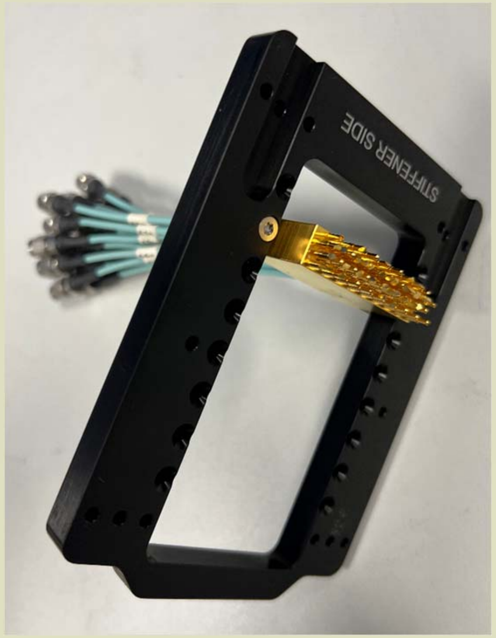
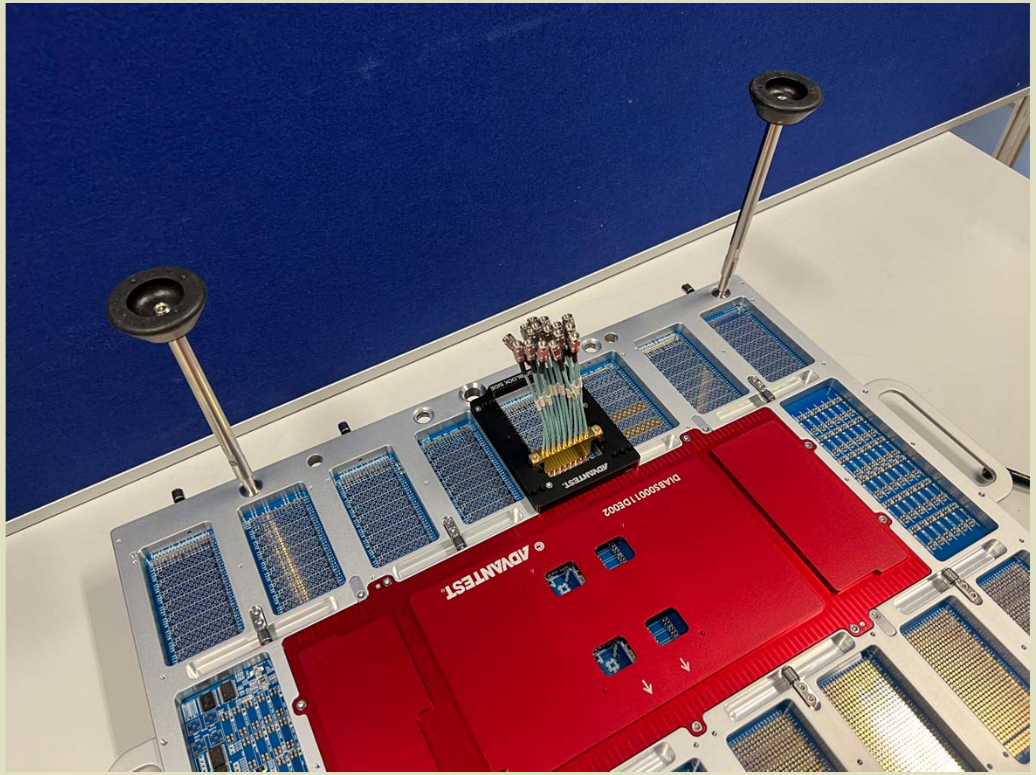
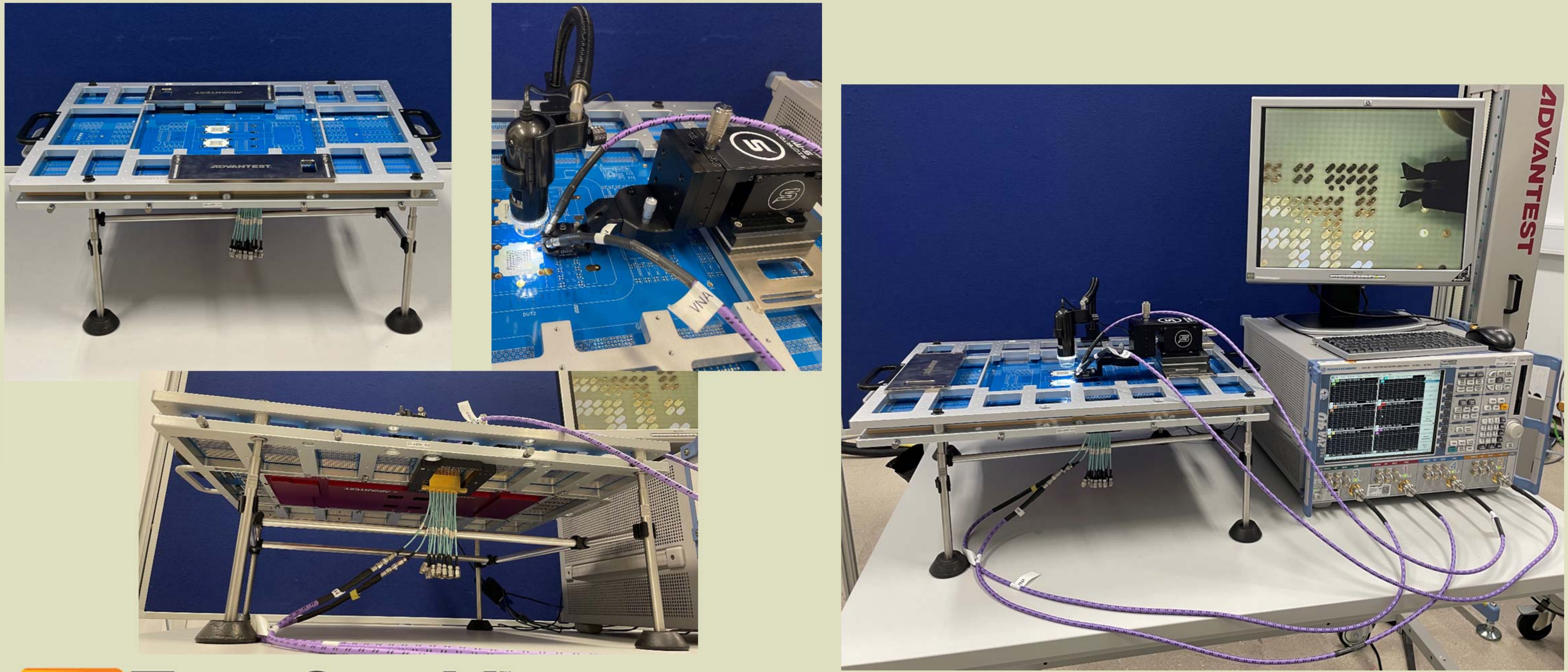
Advantest Approach for the V93000 ATE Test Fixtures

Assembling the V93000 characterization spring assembly in the right location to probe the spring pin signal vias



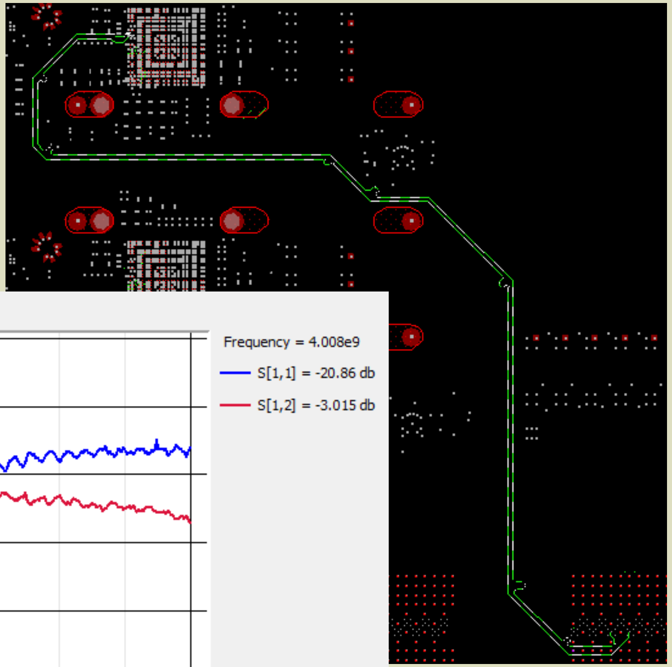


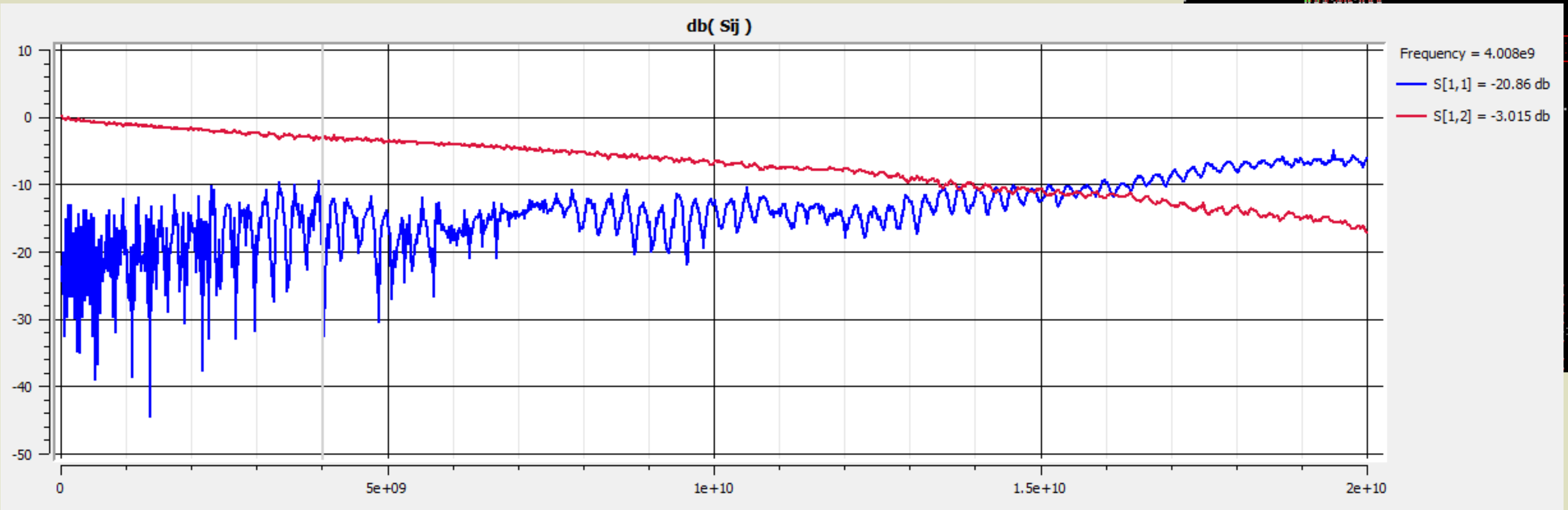
Advantest Approach for the V93000 ATE Test Fixtures



Measurement Example

- Trace length ~ 11.2 inch / 285 mm.
- Trace width 14 mil.
- Dielectric: RO4350B.

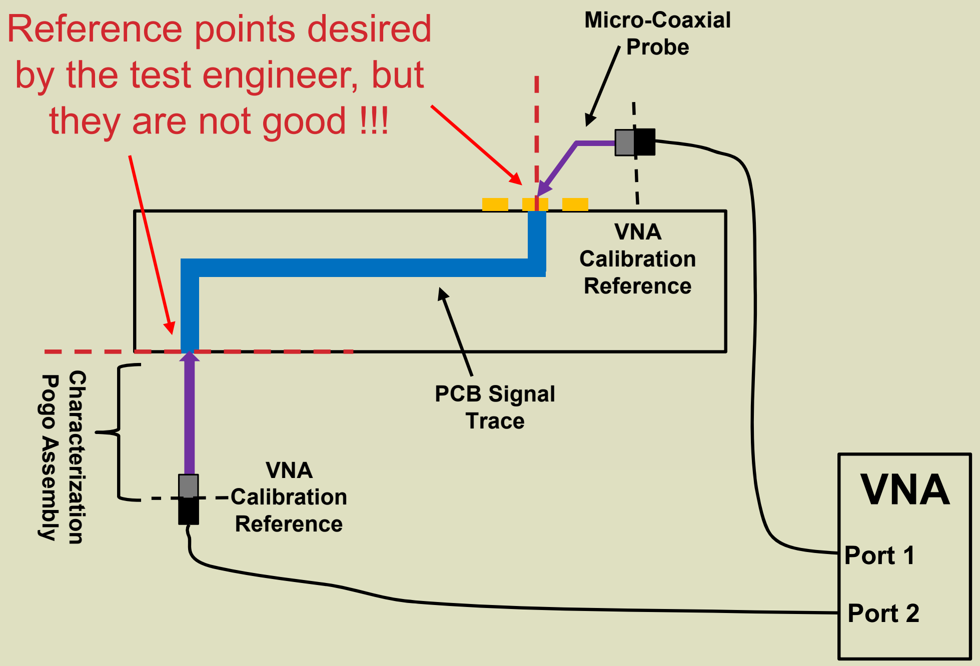




The De-Embedding Challenge

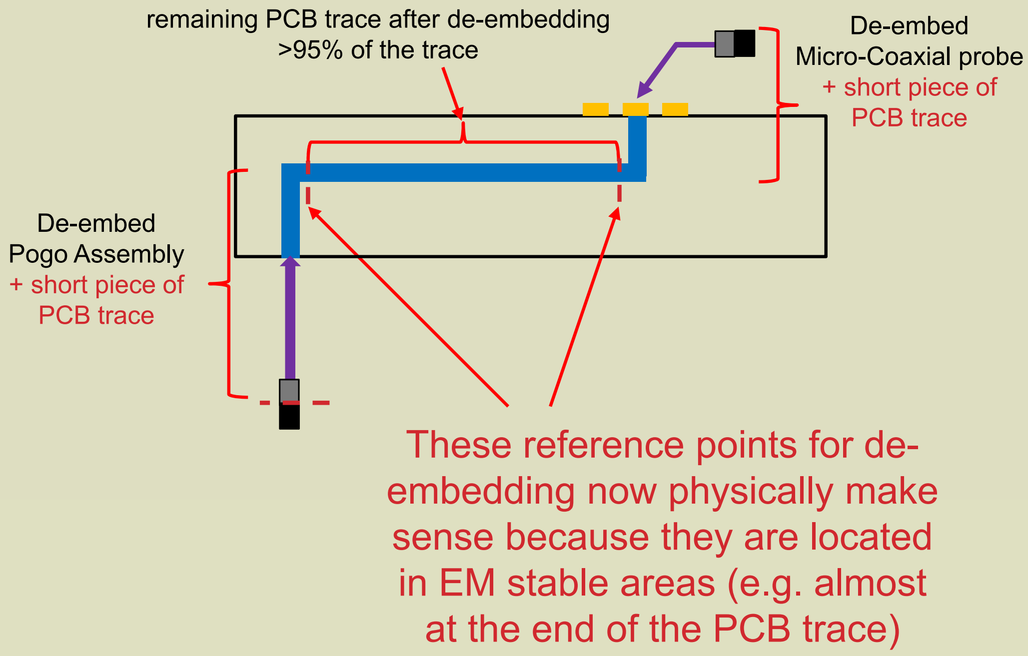
IEEE 370: „de-embedding is the process of removing fixture effects from the measured S-parameters"

- ATE Test Fixture de-embedding is not trivial.
- For proper de-embedding the measurement reference location is critical.
- The de-embedding reference point needs to be a location with stable EM fields (PCB signal trace, coaxial cable, coaxial connector).
- Remember the de-embedding SW will always de-embed whatever data you provide. It does not mean the de-embedding is physically correct.



De-Embedding Options

- There are several de-embedding techniques available.
- For ATE PCB test fixtures we suggest:
  - 2X-Thru: Requires a de-embedding test structure. Supported by the 370-2020 IEEE standard
  - 1X-Reflect: Requires a short or/and open. Not supported by the 370-2020 IEEE standard.



2x-Thru Based Test-Fixture De-Embedding Example

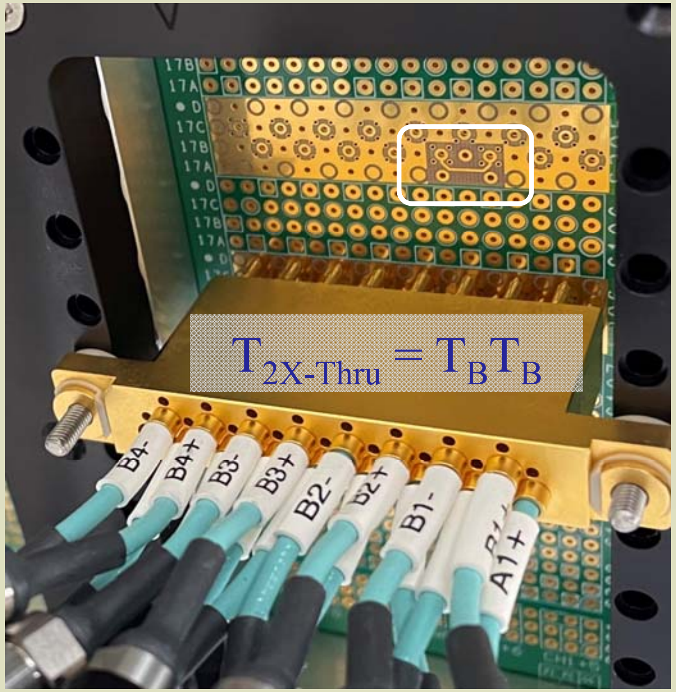
2X-Thru structure, DUT side

$$T_{2X\text{-}Thru} = T_A T_A$$

$$T_{Fullpath} = T_A T_{DUT} T_B$$

$$\boxed{T_{DUT} = T_A^{-1}\, T_{Fullpath}\, T_B^{-1}}$$

2X-Thru structure, ATE side



$$T_{2X\text{-}Thru} = T_B T_B$$

The IEEE 370-2020 Standard

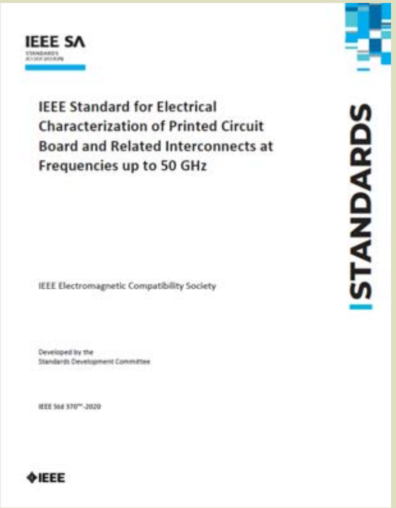


Table 3—Fixture electrical requirement summary for single-ended interconnects

Metric	Structure	Equation	Class A limit	Class B limit	Class C limit
Insertion loss (FER1)	2X-Thru	$20 \times \log_{10} \lvert S_{21} \rvert$	−10 dB	−15 dB	−15 dB
Return loss (FER2)	2X-Thru	$20 \times \log_{10} \lvert S_{11} \rvert$	−20 dB	−10 dB	−6 dB
Difference between insertion and return loss (FER3)	2X-Thru	$20 \times \log_{10} \lvert S_{21} \rvert$ $-20 \times \log_{10} \lvert S_{11} \rvert$	5 dB	0 dB	0 dB
Fixture crosstalk (FER4)	Dogleg structure; see 4.2.5	$20 \times \log_{10} \lvert S_{xy} \rvert$, where y is the aggressor port number, and x is the victim port number. In the case in which two dogleg structures (A and B) are needed, the equation becomes $20 \times \log_{10} \frac{\lvert S_{xy} \rvert_A + \lvert S_{xy} \rvert_B}{2}$.	FIX-FIX crosstalk shall be 6 dB lower than measured FIX-DUT–FIX crosstalk.		
Fixture impedance variation[a] (FER5)	All	Difference in impedance between the 2X-Thru and FIX-DUT-FIX curves in the Fixture region; see Figure 11.	±2.5%	±5%	±10%
Line to line skew (FER7)	All DUT traces	N/A	$1/(10 \times f_{max})$ ps[b]	$1/(10 \times f_{max})$ ps	$1/(10 \times f_{max})$ ps
Minimum length of 2X-Thru (FER8)	2X-Thru	N/A	Three wavelengths at highest measured frequency	Three wavelengths at highest measured frequency	Three wavelengths at highest measured frequency

[a] Apply this equation to the example Gaussian step response defined by Annex S.
[b] f_{max} is the maximum frequency of interest.

- Because of the critical importance of the test fixture in measuring the DUT performance, IEEE has a new standard for this topic: IEEE 370-2020
- The standard applies also to ATE DUT PCB test fixtures
- The more the ATE industry adapts the standard or parts of it, the more confidence we can have on the test fixtures and corresponding de-embedding data.

Conclusions

- Measuring the ATE PCB test fixture is a critical step that can save the test engineer a lot of time later during the application initial turn-on.
- This is especially critical for applications where the test fixture S-parameters are required for de-embedding the test fixture.
- Different probing approaches are possible to address this challenge.
- But because of the specific mechanical design associated to an ATE platform, using a customized probing setup provides the best cost/capability trade-off.

References

Books

- Jose Moreira and Hubert Werkmann, "Automated Testing of High-Speed Interfaces", 2nd Edition, Artech House 2016.
- Luc Martens, "High-Frequency Characterization of Electronic Packaging", Kluwer Academic Publishers 1998.
- Scott A. Wartenberg, "RF Measurements of Die and Packages", Artech House 2002.

Papers on Socket Probing

- Heidi Barnes et al. "Performance at the DUT: Techniques for Evaluating the Performance of an ATE System at the Device Under Test Socket", DesignCon 2008
- Heidi Barnes et al.," Advances in ATE Fixture Performance and Socket Characterization for Multi-Gigabit Applications", DesignCon 2012.
- Jose Moreira, „Design of a High Bandwidth Interposer for Performance Evaluation of ATE Test Fixtures at the DUT Socket", ATS 2012.

Papers on De-Embedding

- Jose Moreira et al.,"DUT ATE Test Fixture S-Parameters Estimation using 1x-Reflect Methodology", BITS China 2017.
- Heidi Barnes et al.,"Verifying the Accuracy of 2x-Thru De-Embedding for Unsymmetrical Test Fixtures", EPEPS 2017.
- Heidi Barnes et al., "S-Parameter Measurement and Fixture De-Embedding Variation Across Multiple Teams, Equipment and De-Embedding Tools", DesignCon 2019.
- Xiaoning Ye et al.,"Introduction to the IEEE P370 Standard and its Applications for High-Speed Interconnect Characterization", DesignCon 2020.

Acknowledgments

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