Fixturing and Fixture Removal for Multiport Devices with Non-Standard RF Interfaces

What We Do

Fully automate for:
- Speed,
- Accuracy,
- Ease of Use

To give confidence in test results

Interface DUT to test instruments

MUX's to turn-key test systems
Automate to Improve Performance

- Improved instrumentation
- Addition of ITA with automated calibration
- Improved fixturing

Test Rack

1/4 size
3 x throughput
Common Tower
Increased product mix

Enabled by:

Test System Modernization

- Common instrumentation rack
- Improved fixturing
- Automated calibration

1/5 size
1/4 the cost
4 x throughput
Add ITA (Instrument Test Adapter) to Clean Up Test Bench

Eliminate:
- Exposed cables
- Connection issues
- Cable movement
- Fixture instability

Enabled by:
- Addition of ITA
- Automated calibration
- Improved fixturing

Summary of Enablers

<table>
<thead>
<tr>
<th>Technology Improvement</th>
<th>Benefit</th>
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<tr>
<td>Improved instrumentation</td>
<td>Industry-leading high performance instrumentation from Agilent has excellent measurement speed, accuracy</td>
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<tr>
<td>Use of ITA (Interface Test Adapter)</td>
<td>Design for multi-functional, multiport devices &amp; design to support multiple fixtures / DUT types increases product mix and reduces changeover time</td>
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<tr>
<td>Improved Fixturing</td>
<td>RF: match, loss, isolation, ability to de-embed, repeatability</td>
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<td>Mechanical: alignment, ease of use, thermal capability</td>
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<td>Provide accurate, repeatable measurements</td>
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<tr>
<td>Automated Calibration</td>
<td>Dramatically reduces calibration time, operator errors while improves accuracy; Eliminates cable movement</td>
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ITA & Fixturing Design

Hardware may consist of two pieces:

1. ITA
   - RF signal conditioning and optimization
   - Incorporates automatic calibration artifacts
   - May support multiple test fixture / DUT types
   - May support multiple instrument / measurement parameters
   - Thermal & other mechanical considerations

2. Test Fixture design requirements
   - Physical interface from (non-standard) DUT interface to (standard) coax interface
   - High performance RF paths able to be characterized
   - DC, control signals integrated
   - Thermal & mechanical considerations

Typical ITA Features

- Supports multiple test fixtures or DUT types
- ATE FCM Calibration artifacts embedded in ITA
- VPC interface to multiple instruments
Standard Rack with Custom ITA

ITA supports automated calibration for:
- S-parameters
- Mixers
- Scalar power
- Noise figure

Example Block Diagram

Multi-port, multi-function DUT's
ITA with Fixture/Device #1

Measurements
- 5 RF ports (2 in 2 out 1 LO)
- S-parameters
- Conversion gain
- Flatness
- Noise figure
- P1dB
- Thermal -35 C to +85 C

- Completely automated calibration
- One ITA for multiple DUT’s
- One calibration works across multiple devices

Same ITA with Fixture/Device #2

Measurements
- 2 RF ports
- Detector Linearity
- VSWR
- Isolation
- Bandwidth
- Switching speed
- Thermal -35 C to +85 C

- Same ITA used for device in previous slide
- Different fixture / DUT
- Different types of measurements
- One calibration
Support for Non-Standard Interfaces

How can we establish an accurate measurement reference plane at a “non-standard” DUT interface?

- Non-standard = no traceable cal kit
  - SMT
  - BGA
  - Push-on connector (SMPM, OSP, GPO, GPPO, etc.)
  - etc.

Calibrating to DUT Reference Plane

1. Characterize fixture (done only once)
2. Automatically calibrate to coaxial port of test fixture
Calibrating to DUT Reference Plane

1. Characterize fixture (done only once)
2. Automatically calibrate to coaxial port of test fixture
3. Move reference plane to DUT using fixture characterization data
4. Measure DUT

Fixture Characterization

Need to Characterize Fixture Halves
Fixture Characterization Approach #1

Cascade Fixture Halves

Fixture Requirements:
• $S_{21A} \approx S_{21B}$

Procedure:
• Measure S-parameters of cascaded fixture halves

Results:
• S-parameters of “A” & “B”

Adapter Characterization Example

Phase matched pair of insertable adapters

3.5 mm 3.5 mm
SMPM(f) SMPM(m)

Use Approach #1 to characterize mating adapters
Fixture Characterization Approach #2

Replace DUT with Unknown Thru

Fixture Requirements:
- S21_A = S21_B

Procedure:
- Measure S-parameters of cascaded Fixture Half “A” + Unknown Thru + Fixture Half “B”
- Measure 1-port S-parameters of A with unknown discontinuity at Reference Plane A
- Measure 1-port S-parameters of B with unknown discontinuity at Reference Plane B

Results:
- S-parameters of “A” “M” & “B”

Another Application Example

Phase matched pair of adapters connected with bullet

Use Approach #2 to characterize non-mating adapters
Using Characterization Data

Practical example of in-fixture adapters (SMA to SMPM)

Small 2.5" SMA to SMPM adapter cable

Desired DUT reference plane (SMPM)

Commonly used calibration reference plane (SMA)

Is Fixture Removal Important?

If you would have measured this device at the SMA interface it would have failed BUT by removing the fixture effects the device is in specification
Extending to Scalar Power & Noise Figure

For measuring:
• Conversion gain
• Power saturation
• IP3
• Spurious output signal levels
• Noise Figure

Having all s-parameters allows:
• Re-Map power readings from sensor to DUT reference plane
• Adjust ENR table to new reference plane
• Correct for mismatch effects for power and noise measurements

Same Automated Approach Applied to RF Probe Measurements

Greatly simplifies RF probe measurements
**Fixture / ITA Design Goals Summary**

**Simplicity**
- Simple, secure insertion of DUT
- Quick connection to instrument rack
- Integrated calibration artifacts – fully automated calibration

**Speed**
- Fast DUT removal and insertion
- Fully automated calibration
- Zero changeover time from calibration to measurement

**Accuracy**
- Accurate calibration at non-standard interface
- Instrument accuracy preserved down to DUT interface

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**System Validation**

Calibrate → Verify → Measure

![Diagram showing the calibration, verification, and measurement process.](image)
**Verify System Specifications**

Verify measurement of standards are within the system specification.

Compare system results to metrology results

Determine system is measuring accurately and within uncertainty specifications

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**System Uncertainty**

Series of measurements used to establish uncertainty and accuracy limits on system

Uncertainty contribution from various sources identified
Calibrate → Validate → Verify

Procedure:
• Calibrate system
• Measure verification artifacts
• Compare measurement results to vendor characterization data
• Does it fall within the published uncertainty?

Verification at Non-Standard Interfaces

Custom standard in the same form factor as DUT

Device Type:
• Offset Shorts
• Standard Mismatch
• Beatty standard
• Other custom standards

Custom verification standard includes characterization data measured in calibration lab

Provide confidence in measured results
Need Help…

… With Improving
Increasing throughput
Improving accuracy
Eliminating operator error
Reducing cost of test
Increasing confidence

Range of potential solutions depends on your needs
Add ITA to existing station
Fixture design
Fixture characterization
Automation of calibration
Custom verification standards
Turnkey system

Solutions tend to be semi-custom
Draw on a common set of tools, techniques
Customized for specific interface, parameters, or other requirements

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