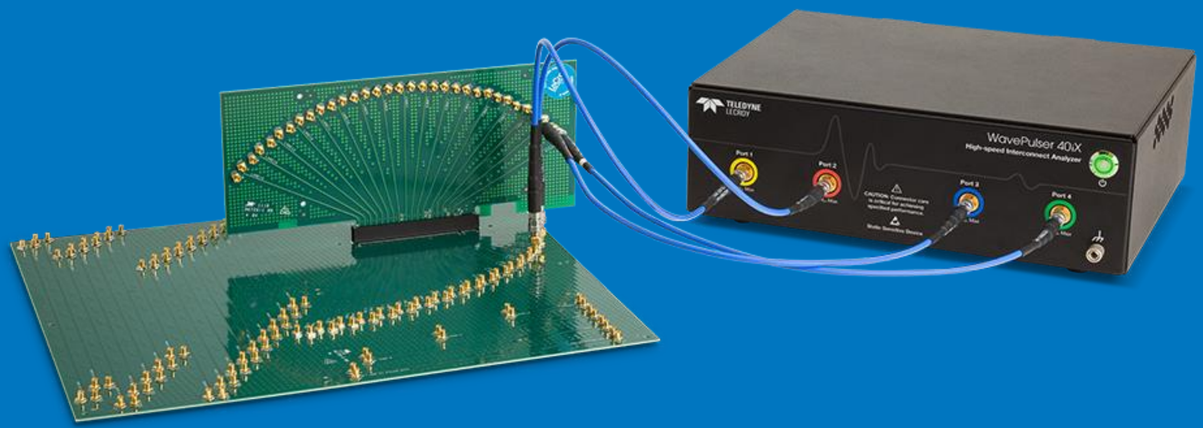
# De-embedding methods for WavePulser 40iX

**High Speed Interconnect Analyzer**

**April-2020**

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Unmatched Characterization Insight

# WavePulser 40iX: Testing in frequency and time domain

Time Domain

**TDR**

Frequency Domain

**VNA**


**Deep Toolbox**

(S-parameter de-embedding, Time Gating, Emulation equalized eye-diagram and jitter analysis )

The combination of S-parameters (frequency domain) and Impedance Profile (time domain) in a single acquisition with a deep toolbox for simulation, emulation, de-embedding and time-gating provides:

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# WavePulser 40iX in a nutshell

Testing in frequency and time in a single acquisition

DC to 40 GHz
Mixed-mode

S-parameters

Frequency Domain

Spatial Resolution < 1 mm
Differential and Common mode

Step and Impulse response
(rise time < 8.5 ps)
Impedance Profile

Time Domain

De-Embedding
Time Gating

Equalized eye-diagram
Jitter Analysis

Deep Toolbox

**WavePulser 40iX**
High Speed Interconnect Analyzer

**Unmatched Characterization Insight**

# WavePulser 40iX three methods of de-embedding

- When measuring S-parameters the DUT is rarely connected directly to the measurement instrument.
- Generally extra circuitry exists between the DUT and the instrument. Examples are cables, adapters and test fixtures.

- De-embedding is the act of removing the extra circuitry surrounding the DUT that is only present for the purpose of making the measurement.

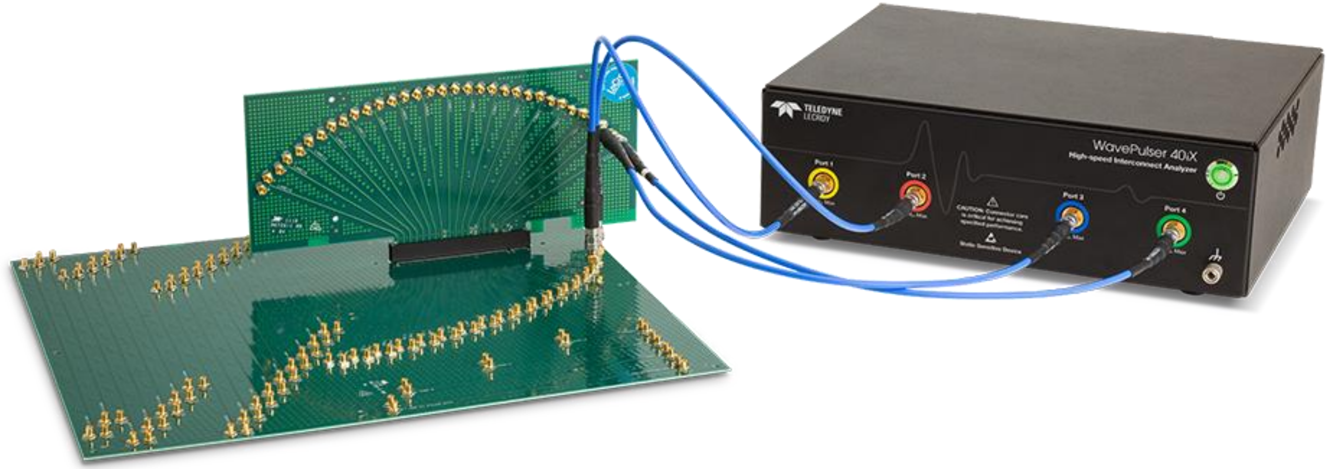
WavePulser 40iX has three methods of de-embedding:

1- Calibration methods

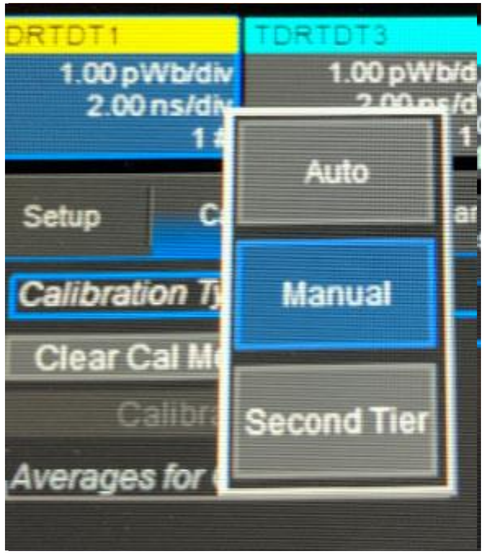
2- Time-domain methods

3- Traditional frequency-domain methods

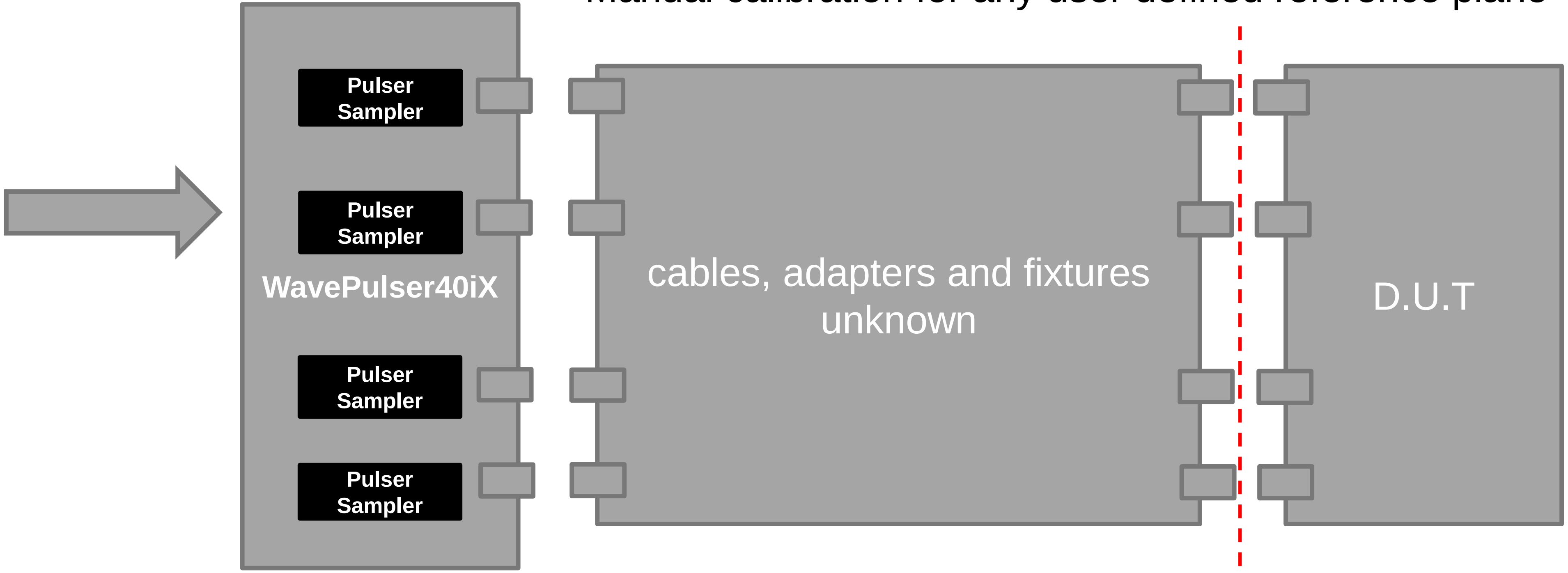
High-speed Interconnect Analyzer: the ideal single tool for high-speed hardware designers and test engineers



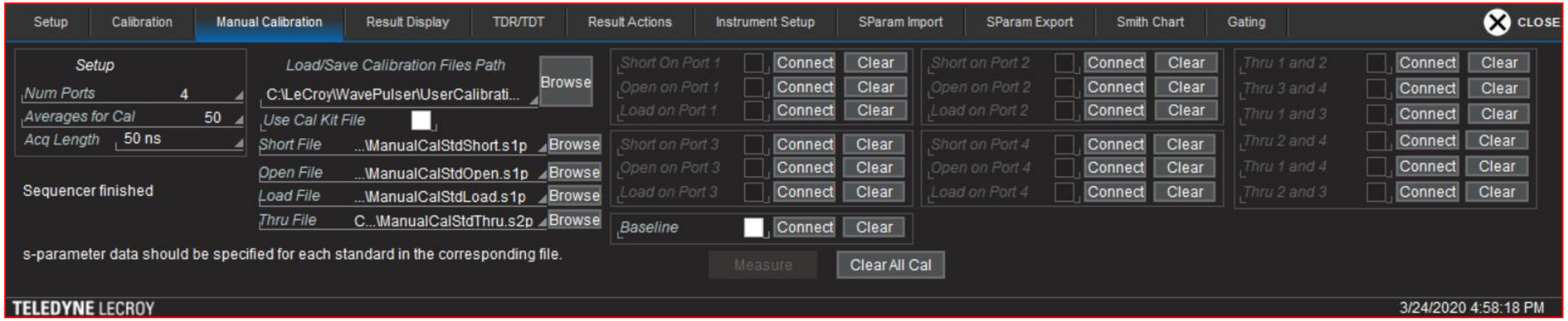
# De-embedding using manual calibration




Manual calibration for any user defined reference plane

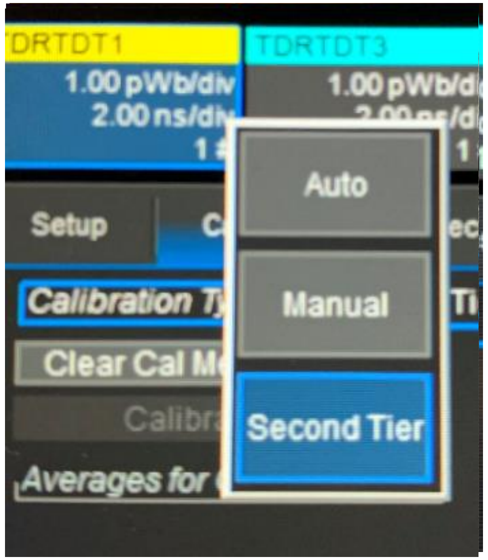



Manual calibration:
measurement reference plane

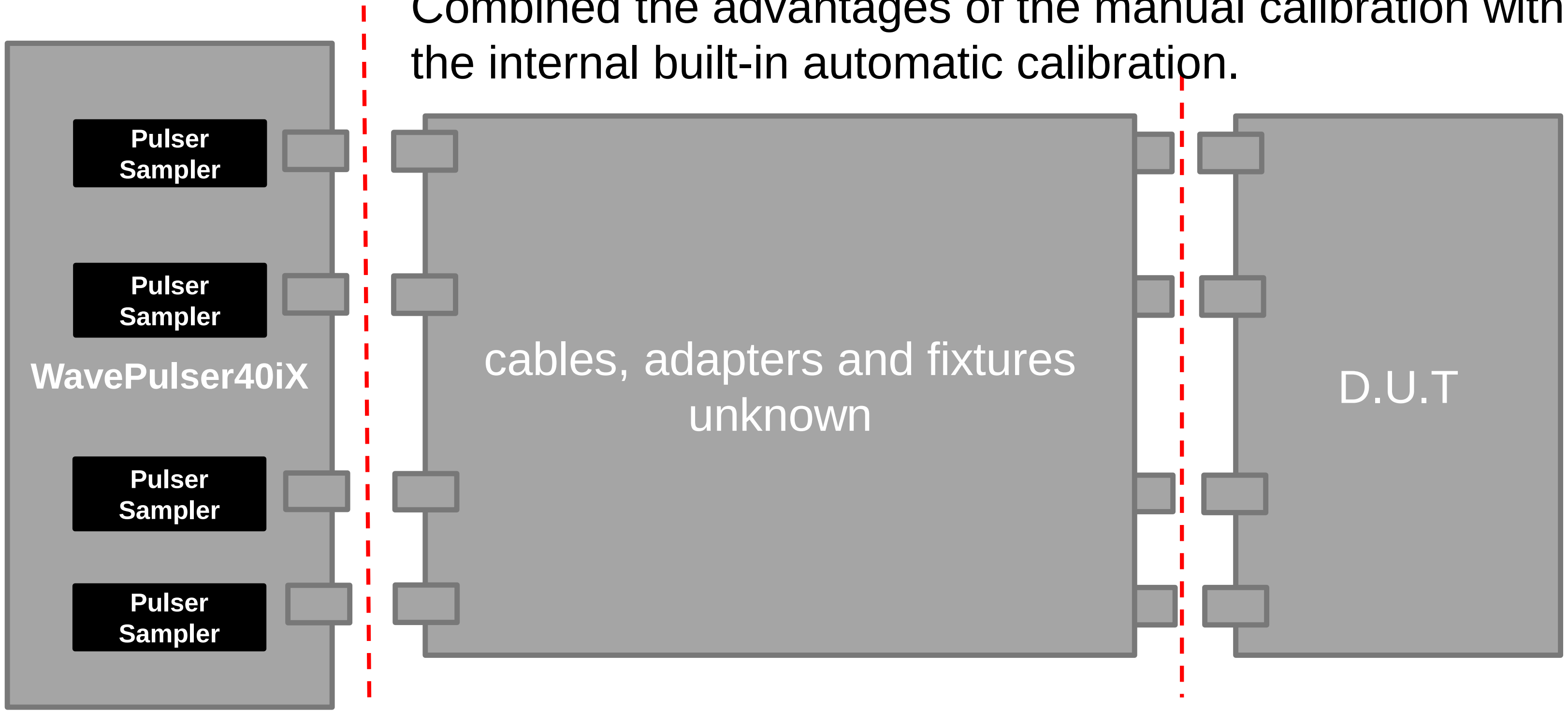



short-open-load-thru
(SOLT)
calibration kit
or
known standards structures
on the fixture itself

# De-embedding using second-tier calibration




Combined the advantages of the manual calibration with the internal built-in automatic calibration.

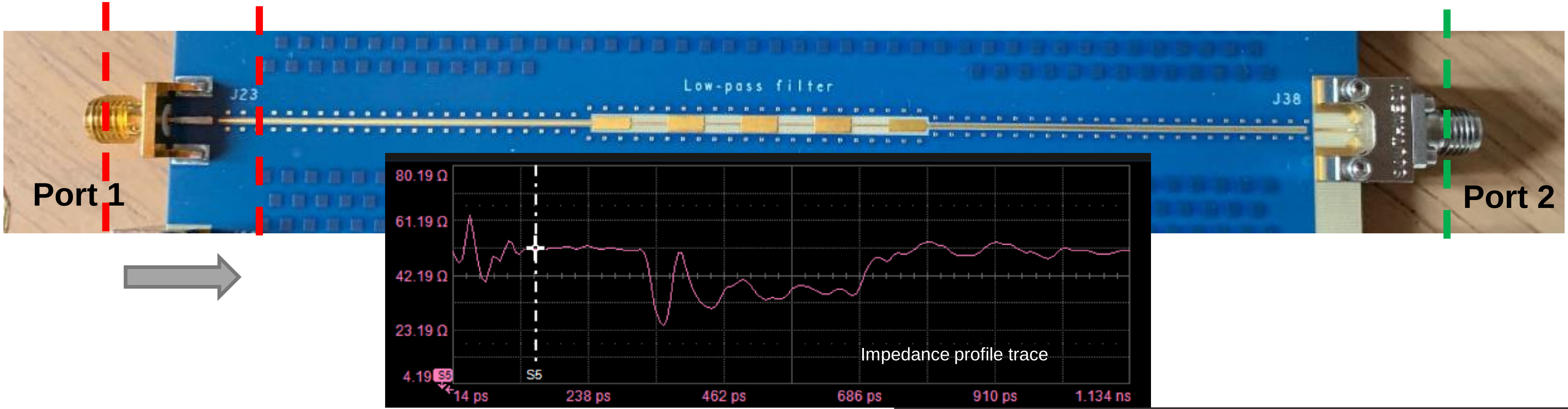



1- the internal auto calibration takes care of drift and changes in pulse/sampler performance.

2- the manual calibration is performing the de-embedding operation.

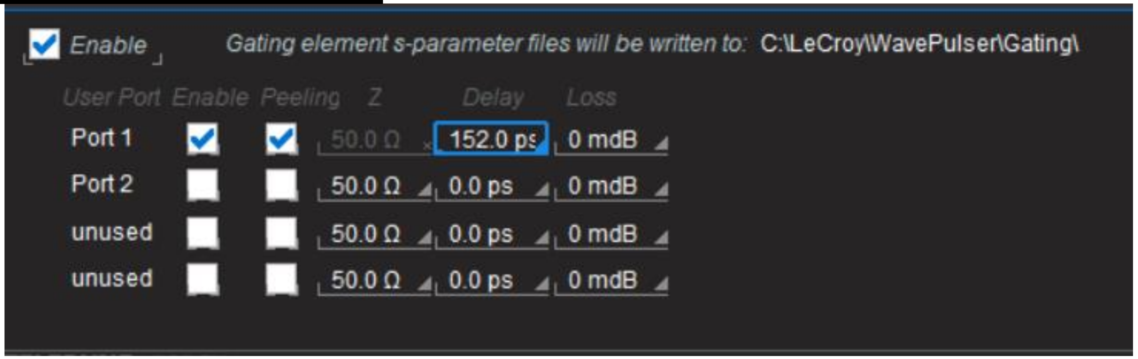
to know more go to:
https://teledynelecroy.com/doc/second-tier-calibration

# De-embedding using time domain methods




Using the information from the impedance profile trace, time-domain de-embedding methods include:

- time-gating also called port-extension
- peeling algorithms using small sections with the measured impedance for the development of a de-embedding model

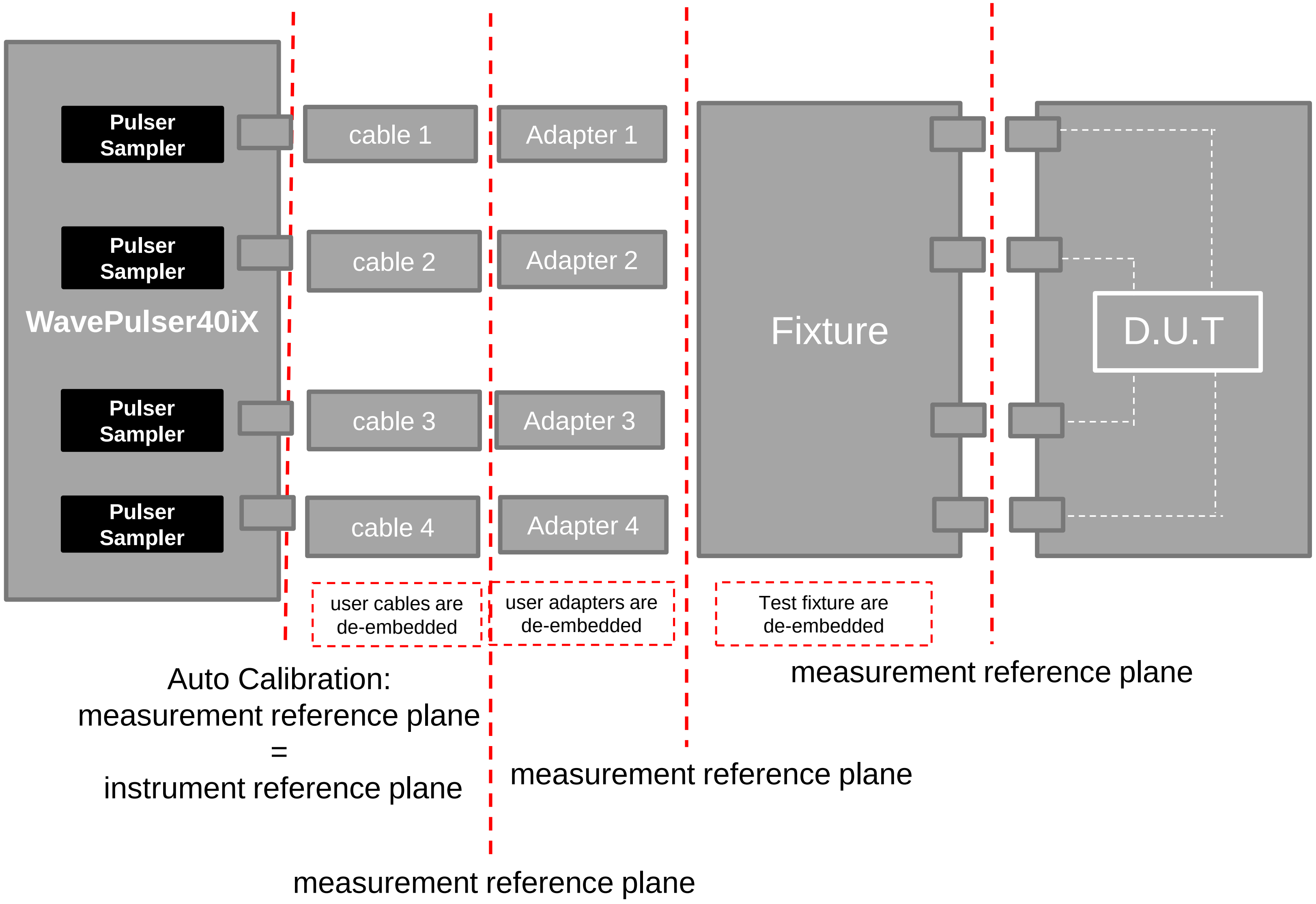



to know more go to:
https://teledynelecroy.com/doc/time-domain-techniques

# De-embedding using traditional frequency-domain methods

- Traditional frequency-domain method for de-embedding is the act of removing the s-parameters for known extra circuitry that is only present for the purpose of making the measurement.

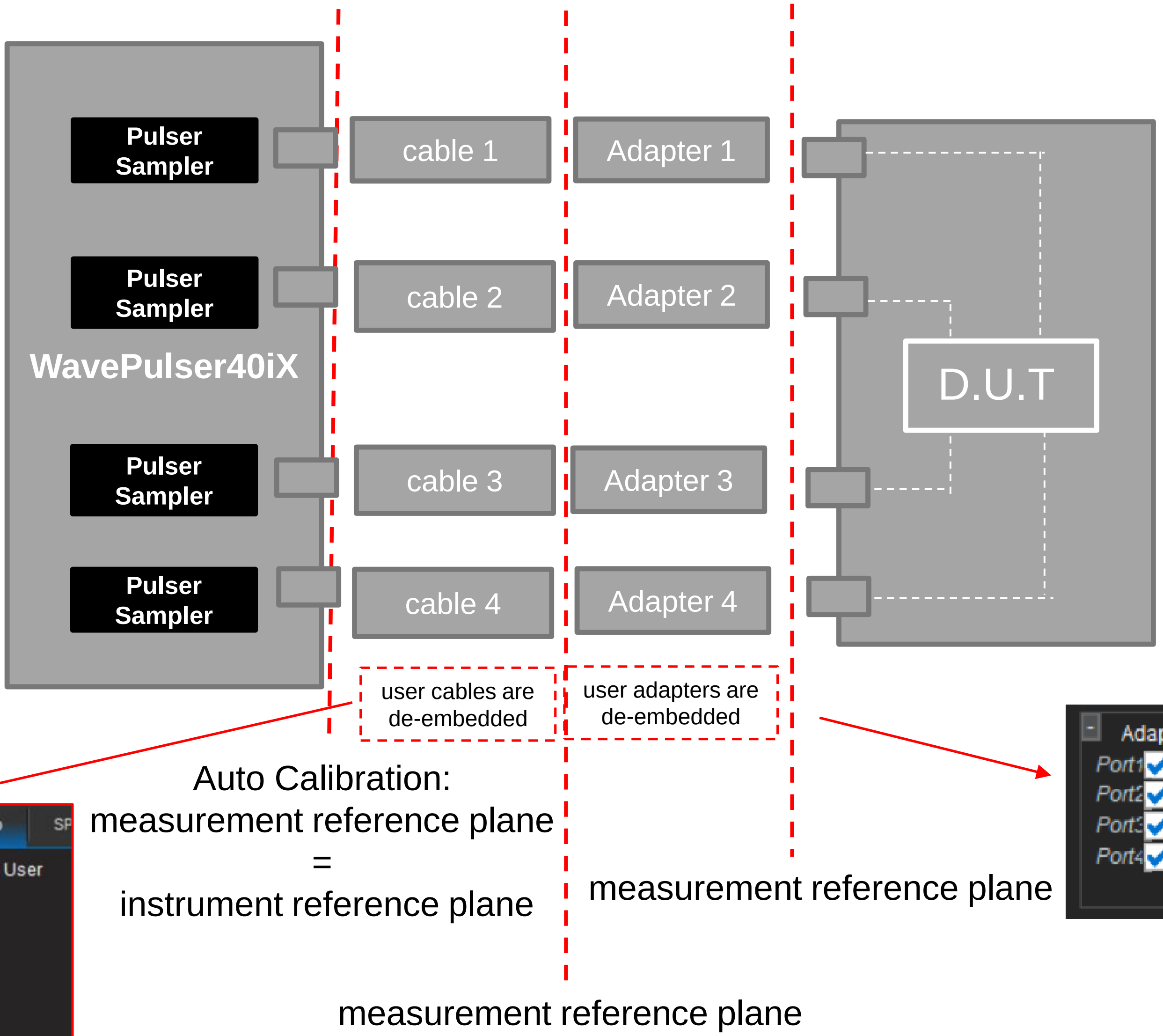
- WavePulser 40iX frequency-domain methods for de-embedding includes:
  - cable de-embedding
  - adapter de-embedding
  - fixture de-embedding

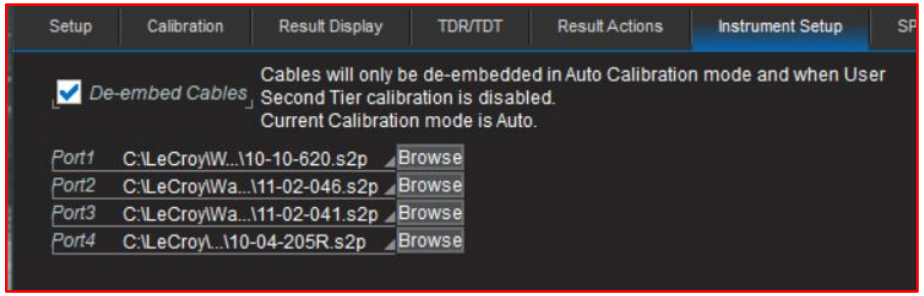


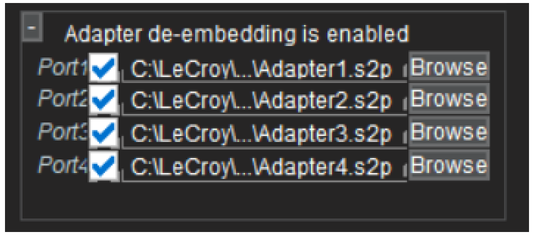
# Cables and adapters de-embedding

- ❑ Traditional frequency-domain method for de-embedding is the act of removing the s-parameters for known extra circuitry that are only present for the purpose of making the measurement.

- ❑ Cable and adapter de-embedding solve the de-embedding requirement when the problem is posed as two-port devices between the instrument ports and the DUT ports

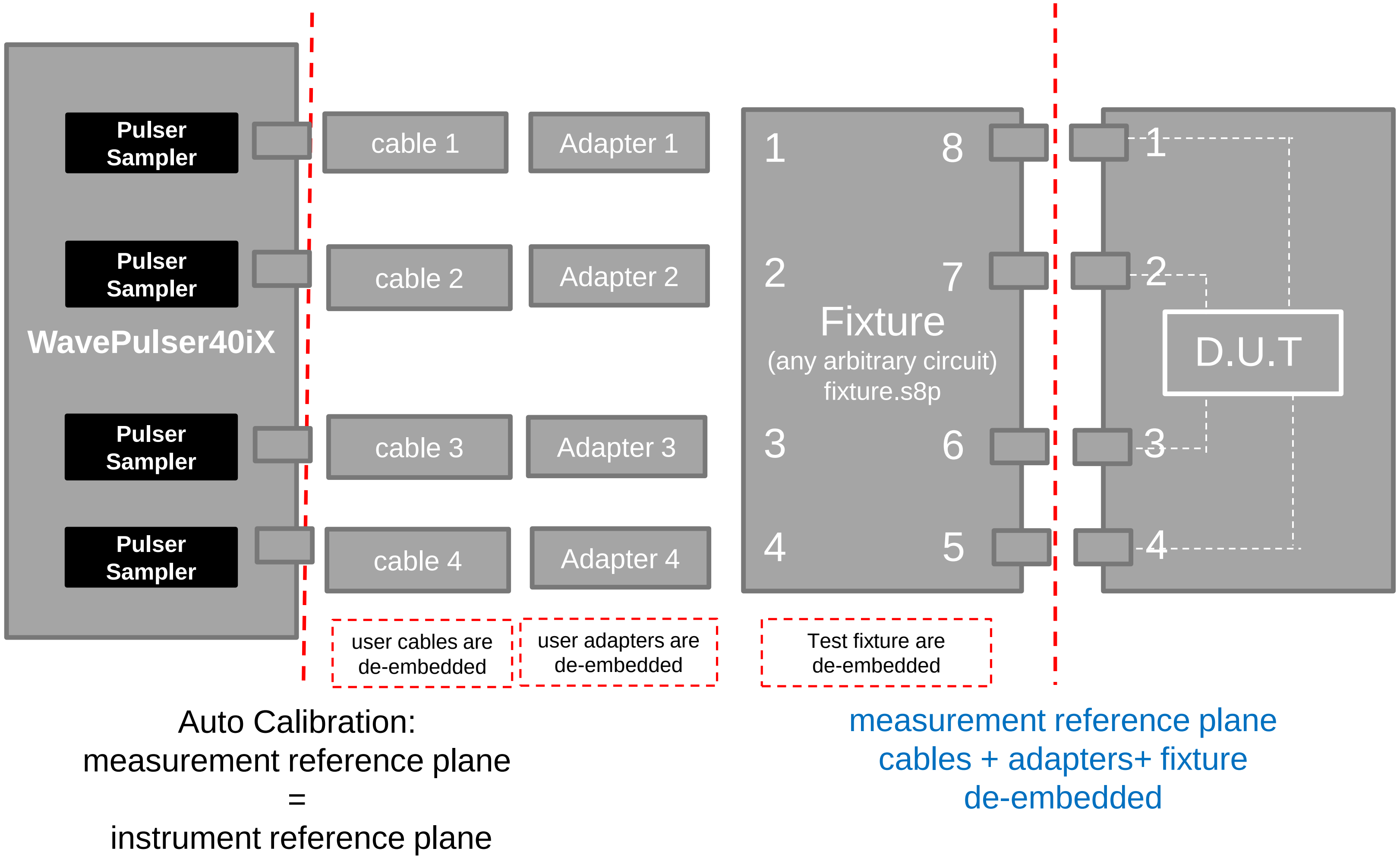


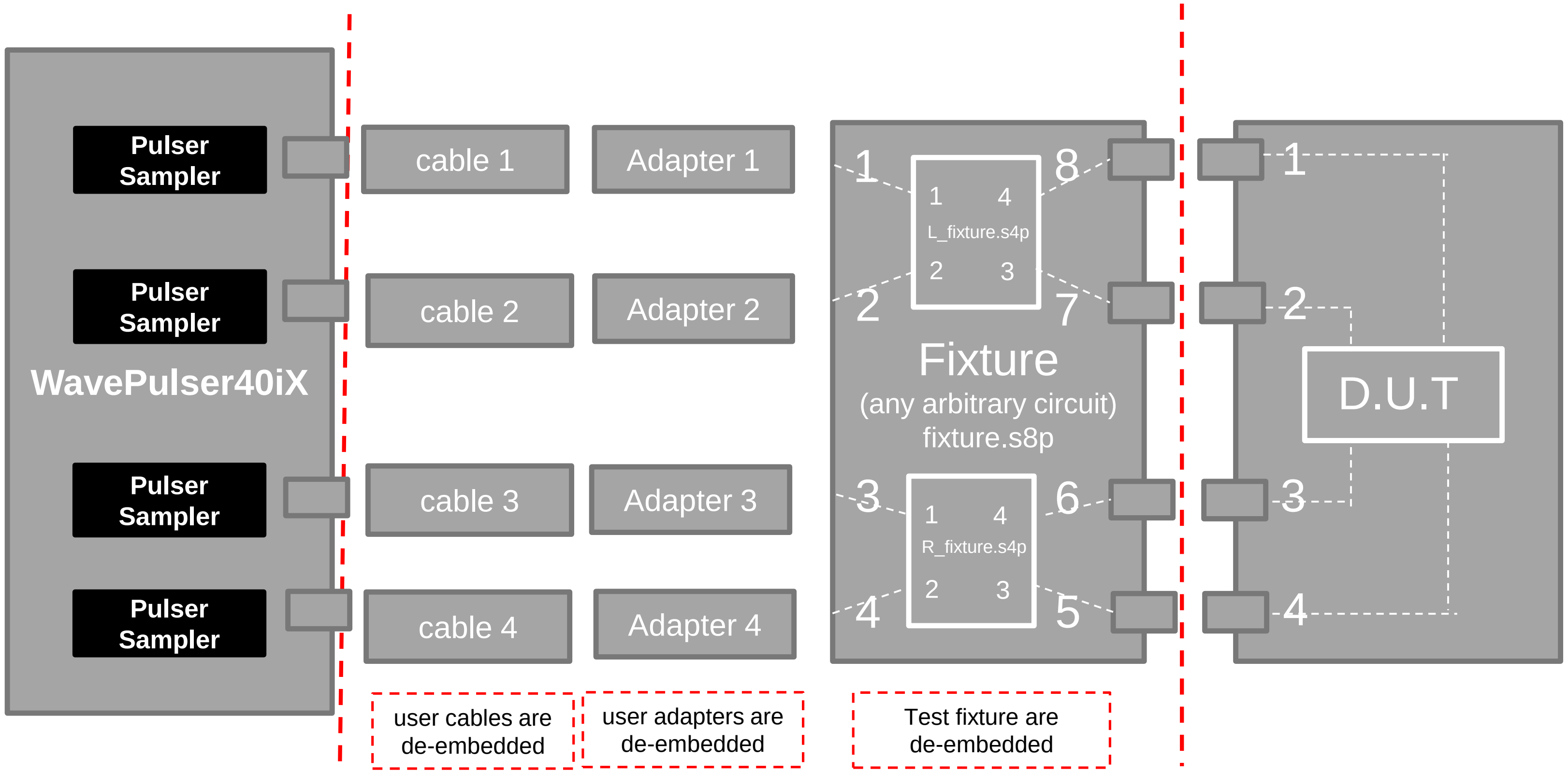
# Fixture de-embedding

- Traditional frequency-domain method for de-embedding is the act of removing the s-parameters for known extra circuitry that is only present for the purpose of making the measurement.
- Fixture de-embedding is capable of solving any traditional frequency-domain de-embedding requirement.
  - It assumes one large fixture between all ports of the measurement instrument and all ports of the DUT
  - Port number assumption is fixed as shown on this slide



# Fixture de-embedding: 4-port DUT with two 4-port fixtures on each end

- Fixture de-embedding is capable of solving any traditional frequency-domain de-embedding requirement.
- Common example of a 4-port DUT whereby two 4-port fixtures are used at each end:
  - L_fixture.s4p
  - R_fixture.s4p
- Open-source software called *SignalIntegrity* offered by Teledyne LeCroy uses Left and Right 4-port fixtures to create the file fixture.s8p
- Signal Integrity application allows you to specify the number of points and end frequency that should be used for the de-embedding




Auto Calibration:
measurement reference plane
=
instrument reference plane

measurement reference plane
cables + adapters + fixture
de-embedded

Open-source Signal Integrity software:
https://github.com/TeledyneLeCroy/SignalIntegrity/wiki

# De-embedding methods for WavePulser 40iX

WavePulser 40iX contains multiple de-embedding methods including:

- ❑ Calibration methods
- ❑ Time-domains methods
- ❑ Traditional frequency-domain methods

Traditional frequency-domain methods for de-embedding includes:

- ❑ cable de-embedding
- ❑ adapter de-embedding
- ❑ fixture de-embedding

Fixture de-embedding can be used to solve any frequency-domain de-embedding problem creating fixture s-parameters, which can be performed using open source SignalIntegrity software

To know more go to:
[https://teledynelecroy.com/doc/de-embedding-methods](https://teledynelecroy.com/doc/de-embedding-methods)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De-embedding with the WavePulser 40iX — TECHNICAL BRIEF

*Peter J. Pupalaikis*
*April 2, 2020*

**Summary**

The WavePulser 40iX offers many de-embedding methods. This technical brief explores these methods and helps the reader understand what he or she needs to provide to the instrument to obtain the best results.

**Introduction**

In signal integrity, when measuring the s-parameters of a device under test (DUT), it is a rare circumstance when the DUT has the same connectors as the measurement instrument. The connector type for the WavePulser 40iX high-speed interconnect analyzer is a 2.92 mm female coaxial connection at the end of the user-supplied cables, and while these connectors are quite popular in the microwave community, most devices that are tested for signal integrity would not have this connector type. For this reason, generally extra circuitry exists in between the WavePulser and the DUT which, at a minimum, provides the change from the standard microwave connectors to other types. If this extra circuitry were completely transparent, meaning it does not affect the measurement, then it could be ignored. Most often, this is not the case, and it is desirable to remove this extra circuitry from the measurement. This is where de-embedding comes in. Simply stated, de-embedding is the act of removing extra circuitry surrounding the DUT that is often present for the sole purpose of making the measurement.

**De-embedding Types Supported**

The WavePulser 40iX supports many different de-embedding methods. These methods fall into three broad categories:

- Calibration methods
- Time-domain methods
- Traditional frequency-domain methods

Calibration methods are methods by which various known standards are attached to a fixture and raw measurements are made. These measurements are called raw because they are measurements of the standards through the fixture. By comparing the measurements made in this way to the definitions of the standards, error terms can be generated which are used to calculate DUT measurements, thus de-embedding the fixture. Another calibration method is to take raw measurements of known standards through a section of trace to define the standard at the end of the trace. Usually, the trace is on the fixture itself, and each trace to the standard is carefully constructed to be as identical as possible to each other and to the actual connection to the DUT. Performing a calibration with the standard defined in this manner enables the de-embedding of the trace during the measurement of the DUT.

All the calibration methods can be applied directly or as a *second-tier calibration*. This is the subject of another technical brief. [1]

Time-domain methods include time-gating, also called port extension, and *peeling* methods using the information provided by the impedance trace. Armed with some knowledge or assumptions about the loss of a small

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