

2XThru De-embedding Methods with WavePulser 40iX

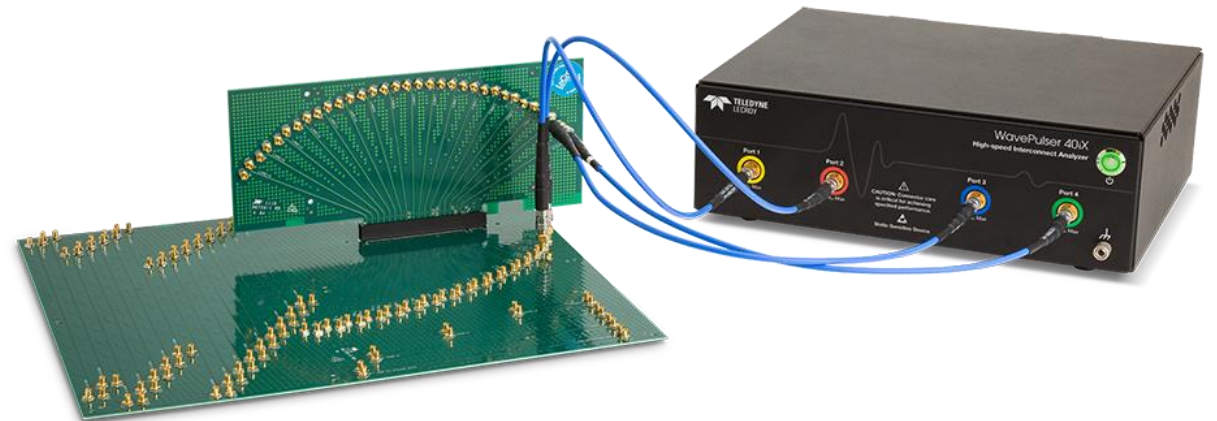
High Speed Interconnect Analyzer

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WavePulser 40iX: Calibrated TDR-Based Network Analyzer

- **High-Quality S-parameters**
(High-speed Serial Data Analysis)
 - Auto-calibrated
 - Advanced de-embedding
 - Full Serial Data Analysis tools
- **Time Domain Reflectometry**
(Cable Assembly TDR analysis)
 - Calibrated measurement of impedance
 - Sub-millimeter impedance profiling
 - Instant detection of signal path imperfections

WavePulser: Complete characterization for high-speed interconnects and cable assemblies—DC to 40 GHz coverage with unmatched sub-millimeter spatial resolution

WavePulser 40iX: Feature Highlights

S-parameters

- DC to 40 GHz
- Single-ended and mixed-mode
- Automatic calibration

De-embedding

- Traditional, Frequency domain
- Time Gating and peeling
- 2XThru and 1XReflect

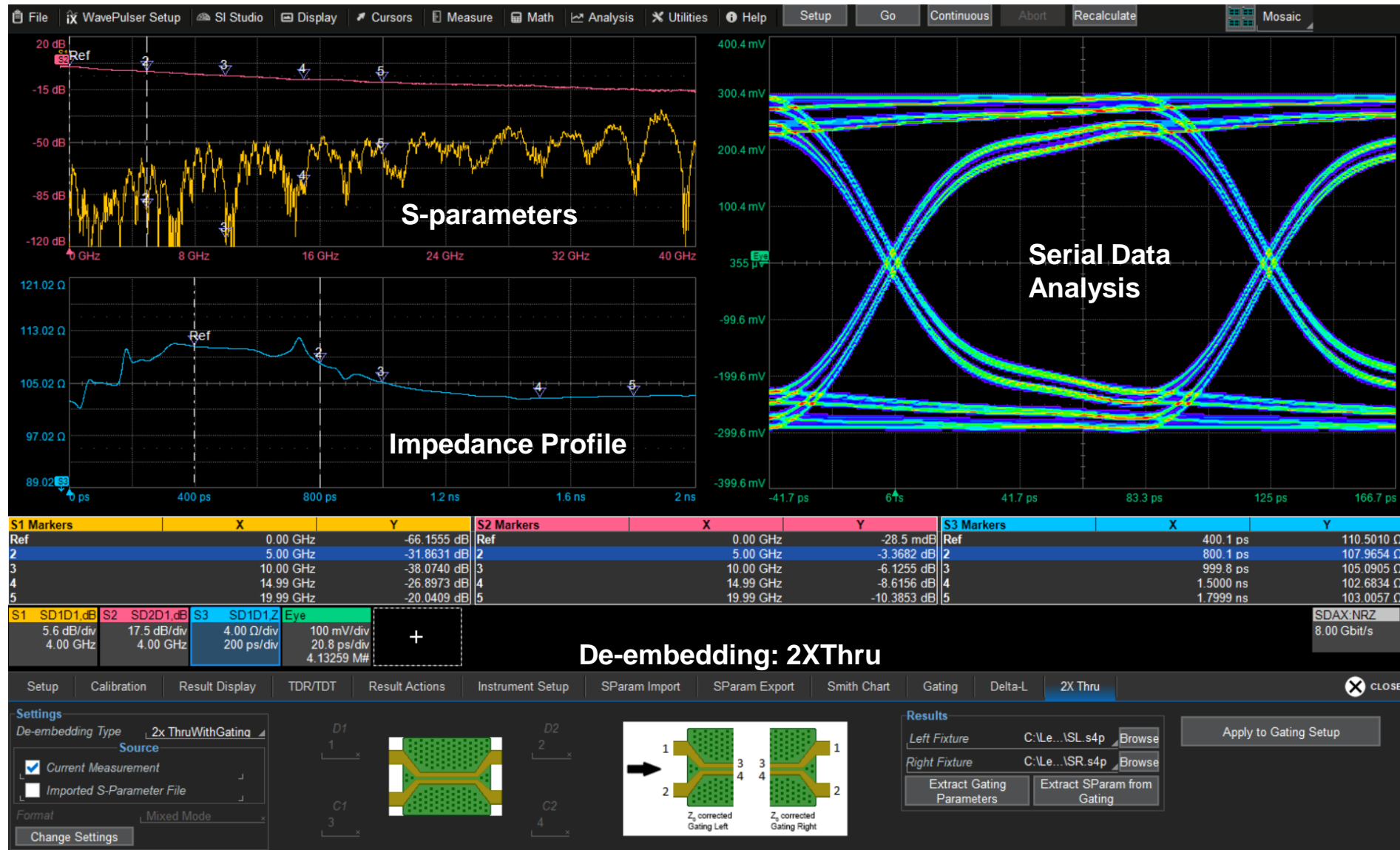
Impedance Profile

- 8.5 ps rise-time
- Single-ended, differential & common mode
- Spatial resolution <1mm (stripline)

Serial Data System Analysis

- Emulation & Equalization
- Eye Diagram
- Jitter analysis

Overview of WavePulser 40iX capabilities



Mastering Advanced De-Embedding with WavePulser 40iX

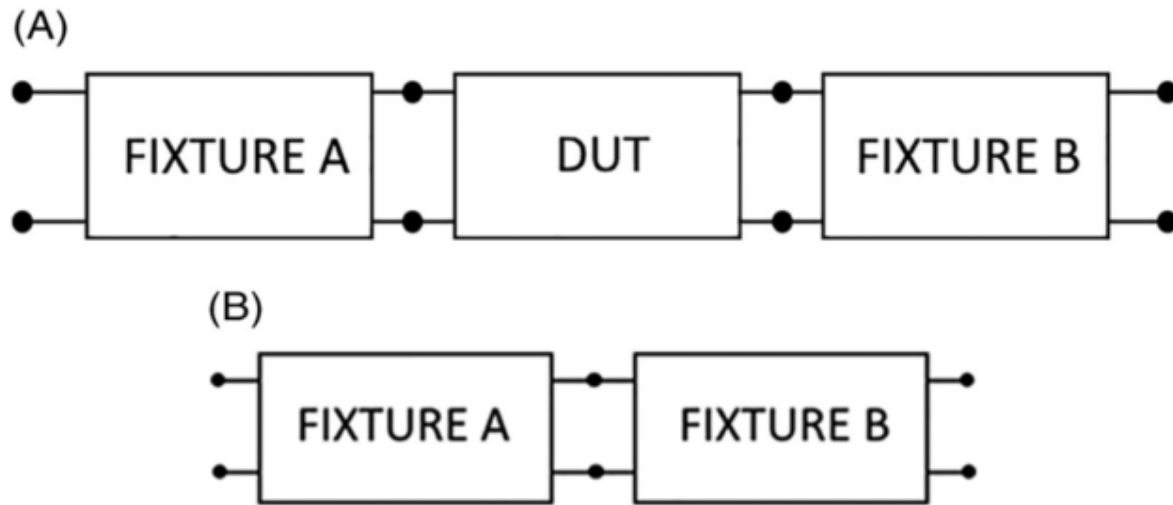
In S-parameter measurements, the Device Under Test (DUT) is typically not connected directly to the instrument. Instead, fixtures, cables, or probes are used—introducing additional elements that must be carefully characterized and de-embedded to ensure accurate results.

De-embedding is the process of mathematically removing the influence of test fixtures, cables, and connectors surrounding the Device Under Test (DUT), isolating its true electrical behavior.

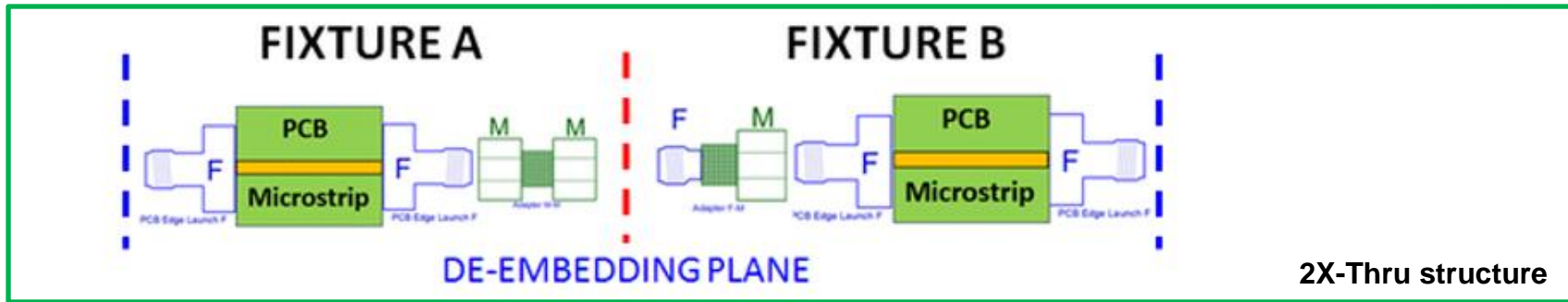
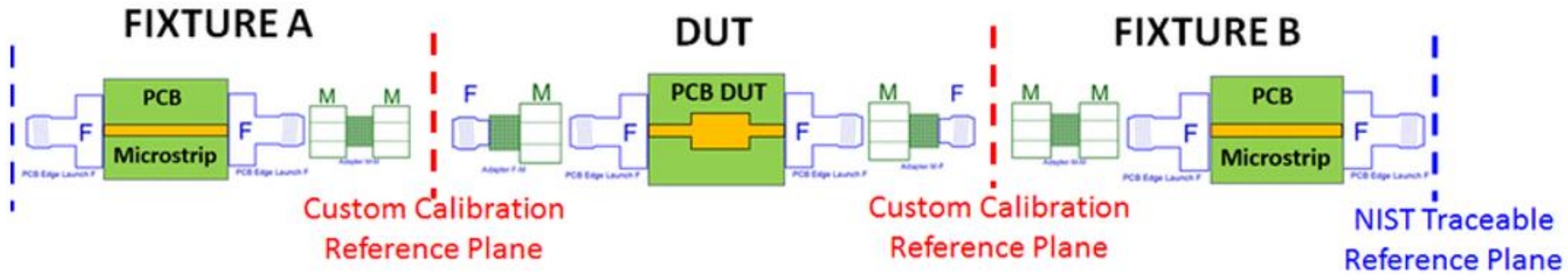
WavePulser 40iX offers multiple de-embedding methods:

- **Calibration** (Automatic and Manual)
- **Time-domain** (Gating and Peeling)
- **Traditional frequency-domain** (S-parameter based)
- **2XThru** (including 1XShort/Open and 2XThru Impedance Corrected)

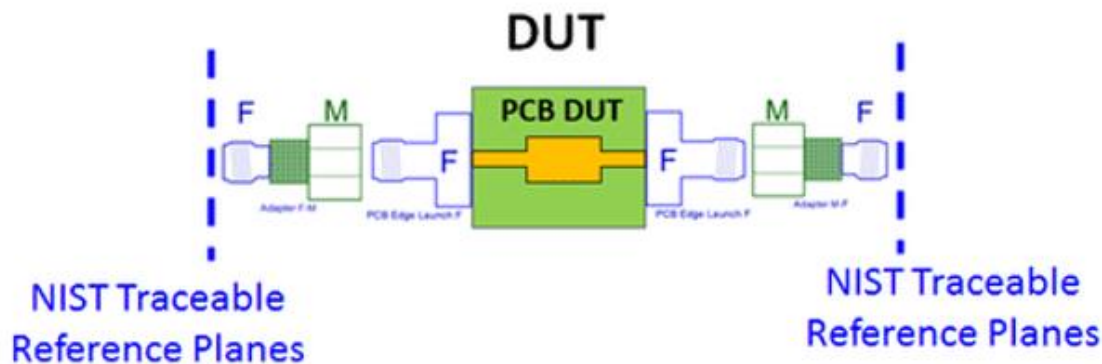
2XThru: Advanced De-Embedding Methods



- Configuration (A) represents a measurement setup that includes the Device Under Test (DUT) connected through custom fixtures. This is how DUT measurements are typically made.
- Configuration (B), the 2XThru structure, depicts the back-to-back fixture configuration used to characterize fixture behavior independently of the DUT.



2X-Thru structure



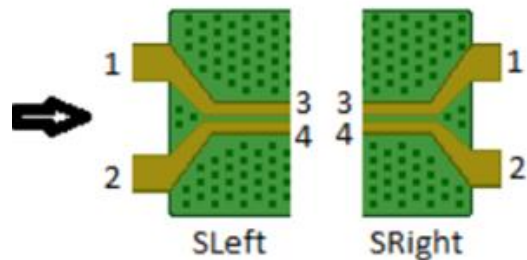
2X-Thru: A de-embedding structure composed of directly connected replicas of left fixture and right fixture for a given device under test (DUT).

2X-Thru de-embedding: A de-embedding method that utilizes the 2X-Thru structure to remove the fixture effects when measuring a device under test (DUT).

Types of 2XThru De-embedding

2XThru (Traditional)

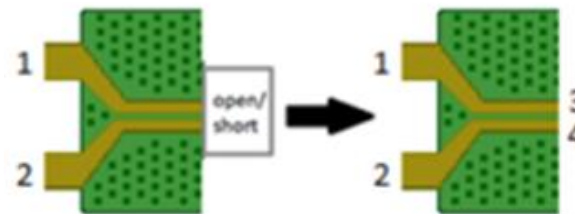
2X Thru (traditional) outputs the structure measurement divided into two, equal halves



1X Short/Open

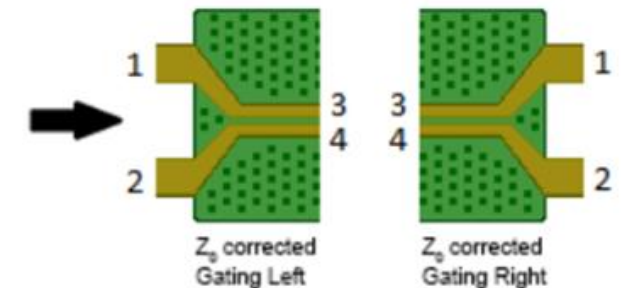
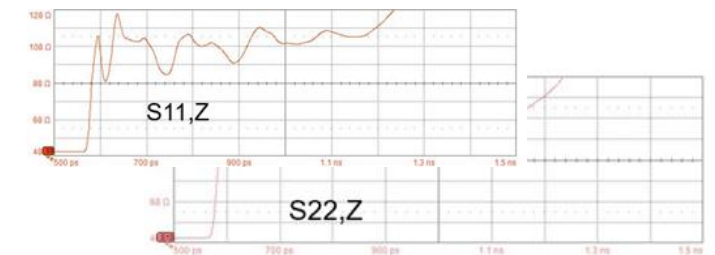


1x Short/Open enables you to de-embed structures on one side of a thru path that cannot be reciprocated in the physical setup and so are terminated using either an open or a short. The software calculates the effect of the full fixture and de-embeds that from the device measurement.



2X Thru with Gating (Impedance Corrected)

2X Thru with Gating provides a structure measurement that includes gating parameters, helping remove impedance mismatches from physical changes. After extraction, the software shows these parameters in the Gating dialog for adjustment. Once the DUT is measured with 2X Thru de-embedded, you can refine gating until the phase response is flat — indicating an ideal thru. These tuned parameters can be saved to S-parameter files for use in other de-embedding applications



2XThru (Traditional) on measured or imported S-Parameter data

This method relies on several key assumptions:

- **Structural Consistency**

The 2X Thru configuration must reflect the same signal path characteristics as the actual test setup, excluding the DUT.

- **Reciprocity:**

Each fixture half is assumed to be reciprocal, exhibiting identical loss characteristics and physical length. In other words, S_{21} equals S_{12} for each fixture, and both halves are considered equivalent. It is assumed that the left half of the 2X Thru structure has the same characteristics as the signal path leading up to the DUT, and the right half of the 2X Thru structure has the same characteristics as the path from the DUT to the connectors.

- **No Mode Conversion:**

For differential traces, it is assumed that the fixtures do not introduce mode conversion between differential and common modes.

2X Thru (traditional) outputs the structure measurement divided into two, equal halves

User Interface for 2XThru (Traditional) for Single-Ended and Measured S-Parameters data

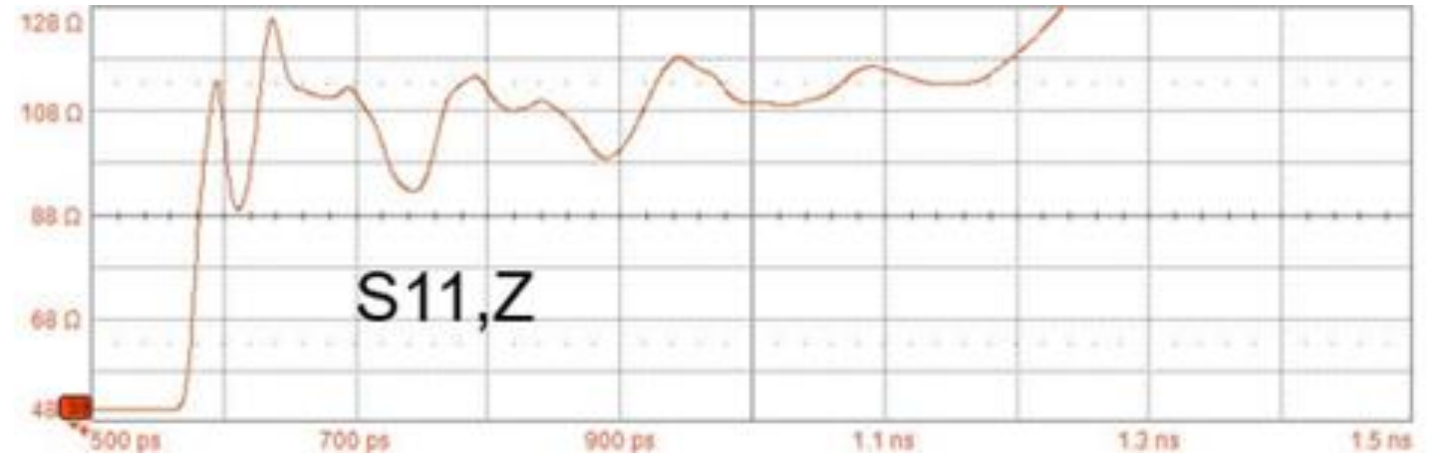


User Interface for 2XThru (Traditional) for Differential and Imported S-Parameters data



1xReflect (1xShort/Open)

- WavePulser is a TDR-based network analyzer that delivers exceptional fidelity in measuring characteristic impedance, paired with ultra-high spatial resolution. These capabilities make the 2XThru method, leveraging the impedance profile, remarkably accurate and reliable
- High-Quality S-parameter extraction
- Short/Open terminated D.U.T.



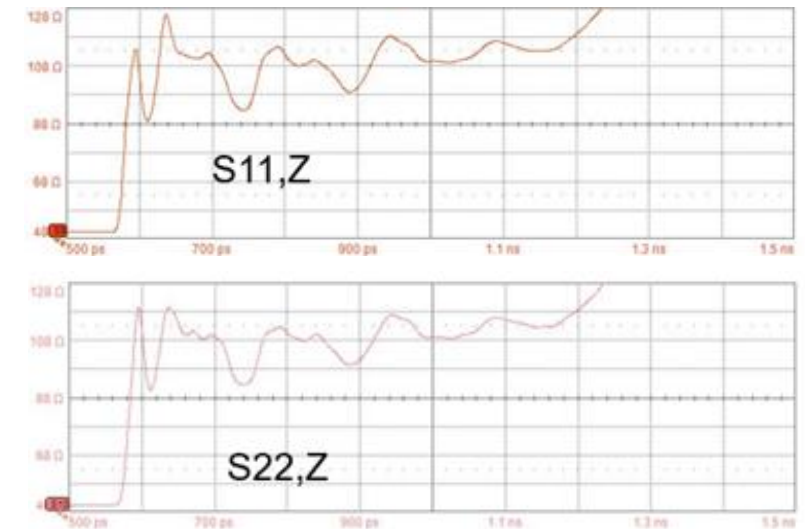
User Interface for 1xReflect (1xShort/Open) for Differential and Measured S-Parameters data

The screenshot shows the software's user interface for the 1xReflect (1xShort/Open) method. It is divided into several sections:

- Settings:** Includes a dropdown for 'De-embedding Type' set to '1x Short/Open', a 'Source' section with 'Current Measurement' checked and 'Imported S-Parameter File' unchecked, and a 'Format' dropdown set to 'Mixed Mode'. A 'Change Settings' button is located at the bottom.
- Measurement Points:** Two points are defined: 'D1' at position 1 and 'C1' at position 2.
- Diagram:** A schematic diagram shows a differential signal path through a device under test (D.U.T.). The input ports are labeled 1 and 2, and the output ports are labeled 3 and 4. A box labeled 'open/short' indicates the termination condition.
- Results:** Shows the fixture file path 'C:\LeCroy...\Strace.s4p' with a 'Browse' button. Below this are two buttons: 'Extract Gating Parameters' and 'Extract SParam from Gating'.

2XThru with Gating (Impedance Corrected)

- WavePulser is a TDR-based network analyzer that delivers exceptional fidelity in measuring characteristic impedance, paired with ultra-high spatial resolution. These capabilities make the 2XThru method, leveraging the impedance profile, remarkably accurate and reliable
- High-Quality S-parameter extraction
- Refines gating to achieve a flat phase response (ideal Thru)



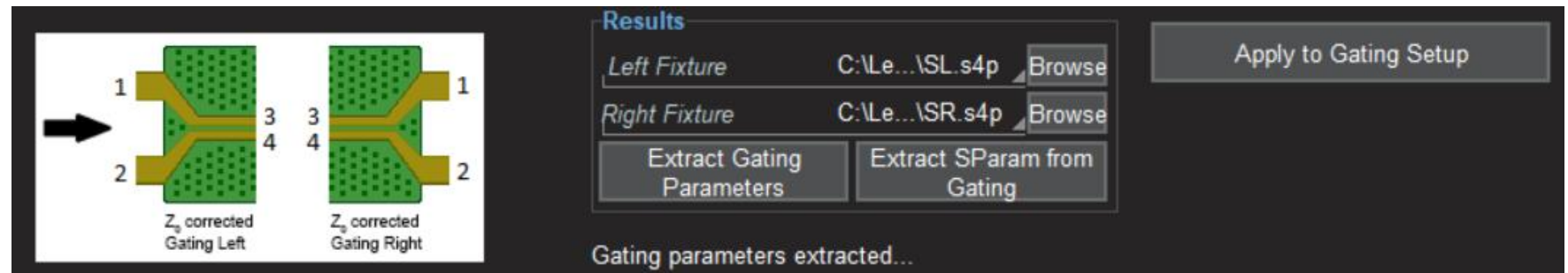
User Interface for 2xThru with Gating (Impedance Corrected) for Differential and Measured S-Parameters data

The screenshot shows the WavePulser software interface. On the left, the 'Settings' panel is visible, with 'De-embedding Type' set to '2x ThruWithGating'. Below this, there are checkboxes for 'Current Measurement' (checked) and 'Imported S-Parameter File' (unchecked). The 'Format' is set to 'Mixed Mode'. In the center, a schematic diagram shows a thru fixture with four ports labeled D1 (1), D2 (3), C1 (2), and C2 (4). An arrow points to a detailed view of the fixture, showing 'Z₀ corrected Gating Left' and 'Z₀ corrected Gating Right'. On the right, the 'Results' panel shows 'Left Fixture' and 'Right Fixture' paths, both pointing to 'C:\Le...\SL.s4p' and 'C:\Le...\SR.s4p' respectively. Below the paths are buttons for 'Extract Gating Parameters' and 'Extract SParam from Gating'.

2XThru with Gating (Impedance Corrected)

- Connect the WavePulser to each end of the 2X Thru structure to be measured and acquire ("Go") so that there is a valid measurement in memory.
- Click [Extract Gating Parameters](#). The software will calculate the measured impedance profile gating parameters and generate corresponding S-parameter files. These will be saved as single-mode left and right S-parameter files in the selected directory.
- Click [Apply to Gating Setup](#). The calculated gating parameters will appear on the Gating dialog for review and tuning. On the Gating dialog, modify values until you have a flat phase response for S21 representing an ideal thru.
- Optionally, after tuning gating parameters on the Gating dialog, click [Extract SParam from Gating](#) to save the modified gating parameter values to the 2X Thru S-parameter files for use in other de-embedding software such as Virtual Probe.

User Interface for 2xThru with Gating (Impedance Corrected) for Differential and Measured S-Parameters data



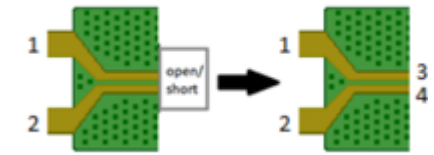
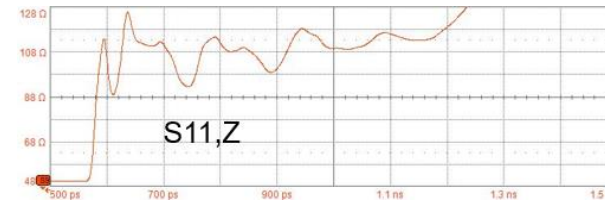
2XTHRU: Precision-Driven Advanced De-Embedding Methods

- WAVEPULSER-SI-STUDIO-2XTHRU (optional)
- Features three advanced algorithms:
 - 1X-Short/Open
 - 2X-Thru
 - 2X-Thru With Gating (Impedance Corrected)
- Fully compliant with IEEE Std 370™ (Electrical Characterization of Printed Circuit Board and Related Interconnects)
- WavePulser's TDR delivers precise impedance profiling for superior 2XThru accuracy.

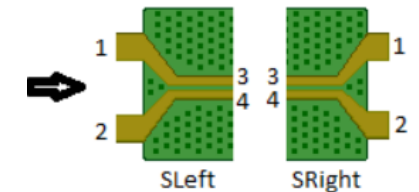
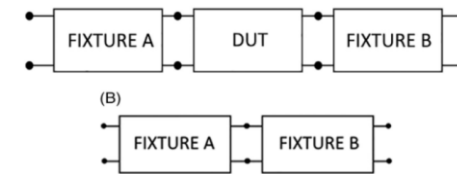
to know more go to:

<https://teledynelecroy.com/doc/2xthru-deembedding>

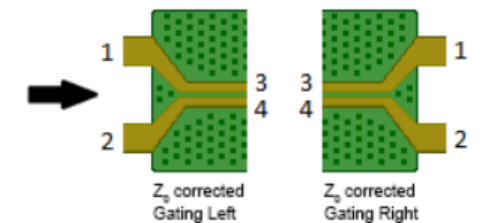
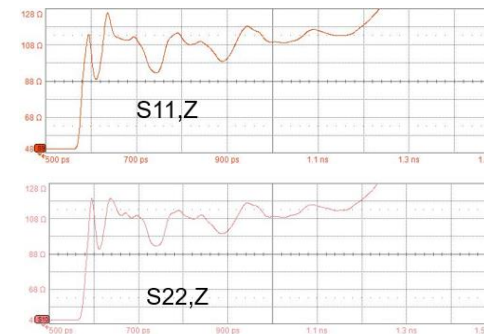
1X-Reflect (Short/Open)



2X-Thru



2X-Thru With Gating (Impedance Corrected)



WavePulser 40iX: 2XThru de-embedding methods

WavePulser 40iX contains multiple de-embedding methods including:

- Calibration methods
- Time-domains methods
- Traditional frequency-domain methods
- 2XThru methods

Time-domain methods for de-embedding includes:

- Gating and Peeling

Traditional frequency-domain methods for de-embedding includes:

- Cable and adapter de-embedding
- fixture de-embedding

2XThru methods for de-embedding includes:

- 2XThru
- 1XShort/Open
- 2XThru With Gating (Impedance Corrected)

To know more go to:

<https://teledynelecroy.com/doc/2XThru-deembedding>



Mastering WavePulser 40iX 2X Thru De-embedding

APPLICATION NOTE

Kaviyesh Doshi

October 27, 2025

Summary

This application note outlines the process for using the WavePulser 2X Thru feature to extract high-quality 2-port and 4-port S-parameters for de-embedding electrical interconnects. It explains the assumptions made by the underlying algorithms, as well as how to connect to the WavePulser and define the inputs for 2X Thru measurements, the expected outputs, and how those outputs are used in the de-embedding process.

Introduction

The fixture de-embedding controls in the WavePulser 40iX are designed to remove fixture effects from the signal path using customer-supplied S-parameter files, which can be measured and stored directly on the instrument.

In certain cases, it may not be feasible to measure the S-parameters of the Device Under Test (DUT) directly—typically due to connector incompatibility between the DUT and the WavePulser interface. In such cases, 2X Thru structures may be used.

For example, when testing a USB cable, direct connection to the WavePulser is not possible. Two custom fixtures are required:

- The first fixture uses a K-type connector on one end and a PCB trace terminating in a male USB connector.
- The second fixture includes a female USB connector with a PCB trace ending in a K-type connector.

These fixtures allow the USB cable to be connected at both ends, while the K-type connectors interface with the WavePulser. When the two fixtures are connected back-to-back—K-type to K-type and USB to USB—this configuration is referred to as a 2X Thru structure or fixture.

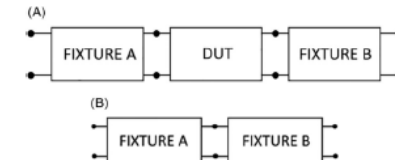


Figure 1: Typical measurement setup vs. 2X Thru structure

In Figure 1 above:

- Configuration (A) represents a measurement setup that includes the Device Under Test (DUT) connected through custom fixtures. This is how DUT measurements are typically made.
- Configuration (B), the 2X Thru structure, depicts the back-to-back fixture configuration used to characterize fixture behavior independently of the DUT.