ML4035 User Operation Manual
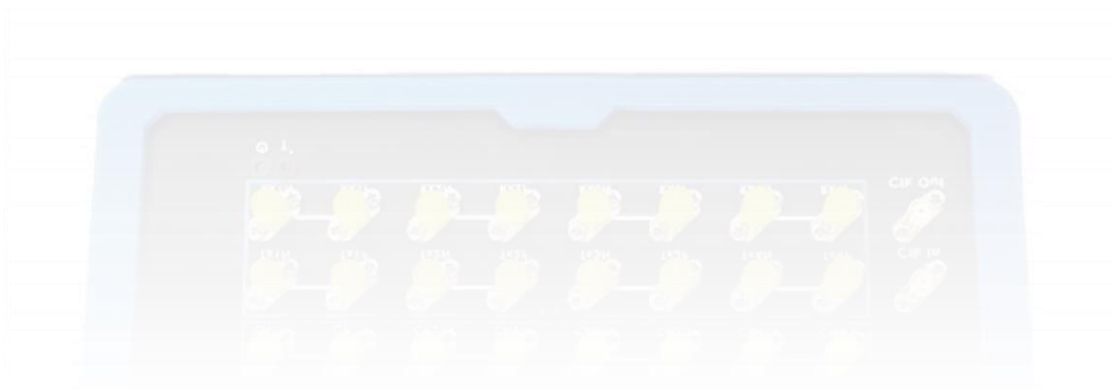
www.multilaneinc.com

User Manual Revision 0.1
Windows GUI Version v.2.1.0.0
API Version 1.0
Firmware Version 1.8

Innovation for the next generation

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General Safety Precautions

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of the system. Read the General Safety Summary in other system manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Only use the power cord specified for this product and certified for the country of use.

Observe All Terminal Ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not apply a potential to any terminal, including the common terminal that exceeds the maximum rating of that terminal.

Do Not Operate Without Covers.

Do not operate this product with covers or panels removed.

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Do Not Operate with Suspected Failures.

If you suspect there is damage to this product, have it inspected by qualified service personnel.

Do Not Operate in Wet/Damp Conditions.
Do Not Operate in an Explosive Atmosphere.
Keep Product Surfaces Clean and Dry.

⚠ **CAUTION:** *Caution statements identify conditions or practices that could result in damage to this product or other property.*

⚠ **CAUTION: Provide adequate cooling.** *Provide adequate cooling to the board to avoid damaging any part of it specifically for the ATE version of the board. Refer to the power section to know the power dissipation values*

Preface

This is the user operation manual for the **ML4035**. It covers the following information:

- Describes the capabilities of the instrument: How to install it and its software.
- Explains how to operate the instrument as a time domain reflectometer, time domain transmitter and sampling scope to measure: Impedance Profile, Insertion Loss, Return Loss, Near-End Crosstalk, Far-End Crosstalk, Integrated Crosstalk Noise.
- Lists the instrument's specifications

Contact MultiLane SAL

MultiLaneSAL *is an engineering services company and an OEM supplier of specialty test and communication equipment for the semiconductor and optical transport industries. Multilane delivers ultra-compact test instruments of the highest value and performance for high speed communication and signal integrity applications. The Company has a large engineering team and a fully equipped lab with state-of-the-art equipment, having recently moved to a 6000sq foot facility in* **Houmal Technology Park (HTP).**

Multilane SAL *customers can leverage great flexibility and capability in product customization thanks to our team's in-depth expertise in high speed I/O, Signal Integrity, and access to advanced development and test tools. MultiLane has the resources and know-how to meet customers' product development and design requirements. Our R&D has a proven track record in delivering leading edge products and development tool kits to the Automated Test market while applying the production processes to deliver high quality products on schedule and within budget.*

Multilane Sa*l's team is composed of experienced and disciplined engineers offering products and turnkey solutions of modules and systems for high speed IO, Signal Integrity, SOC development and optical communication from verbal requirements (Architecture, PRD, HW/FW/SW design implementation and characterization).*

Address	**MultiLane SAL**
	Houmal Technology Park
	Askarieh Main Road
	Houmal
Website	www.multilaneinc.com
Sales support	sales@multilaneinc.com
Support	support@multilaneinc.com

If any further help is needed, please contact MultiLane SAL, by sending general enquiries to info@multilaneinc.com.

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Product Description:

Overview

In today's extremely competitive and fast-pace industry, time is the most expensive form of currency. Every second saved is a step ahead of the competition.
This is what Multilane is all about; with our high performance, automated and throughput optimized solutions, Multilane completely redefines the status quo of large-scale production testing.

The state-of-the-art solutions we provide are fully automated and engineered for the sole purpose of providing our customers with accurate and reliable measurements while also saving them valuable time.

Multilane's ML4035 is the newest kid on the block, joining our large and diverse collection of successful products.
The newcomer is a 3-in-1 400G BERT, 50 GHz electrical scope, and TDR instrument, allowing 400G BER tests, NRZ & PAM4 eye diagram measurements, as well as medium impedance characterization and S-parameter evaluation.
With a total of 24 ports, the ML4035 allows simultaneous testing on 4-channels.
Its diverse applications go from characterization and production testing of DACs and TIAs to compliance testing of transceivers and optical modules as well as switch tuning, cable matching, medium fault detection and various other industry essential applications.

Model and Package Content

This manual covers the instrument ML4035.

Hardware Package

The ML4035 is a benchtop instrument including 4 differential PPG ports, 4 differential E-DSO/TDR ports, and 4 differential ED ports.
It also includes a reference clock input port as well as an external reference clock output port.

Software Package

The ML4035 package includes the driver as well as multiple SW for different applications (free of charge).

- **ML-TDA GUI:** Default GUI which allows full user control over the ML4035 and manual measurements.
- **ML-TDA-DAC:** Multilane's automated DAC testing solution which takes full advantage of the ML4035's high-speed 16-port simultanous measurement technique to automate S-parameter testing on DAC. With a click of a button, the ML-TDA-DAC's automated SW automatically evaluates a 400G cable's impedance profile and performs tests including insertion loss, return loss, Far & Near-End Crosstalk, Integrated Crosstalk Noise, COM and Effective Return Loss, then generates a report with Pass/Fail criteria.

API Library and Documentation

The API library can be provided upon request, along with a detailed documentation.

User Guide and Documentation

This SW user guide is accompanied by the following smaller application-specific documents:

- MDS
- Generic Presentation
- TIA/Driver Test Presentation
- How TDR Works

Key Features

- High Resolution TDR/TDT measurements
- Determination of the magnitude and polarity of any back reflected signal
- Quadruple differential 56GBd NRZ/PAM4 Pulse Pattern Generator
- Quadruple differential Error Detector
- Quadruple differential TDR & 35GHz Digital Sampling Oscilloscope
- Low power dissipation
- Sample aperture jitter below 60 fs
- Return Loss
- Insertion Loss
- Near-End Crosstalk
- Far-End Crosstalk
- Integrated Crosstalk Noise
- Channel Operating Margin
- High Fidelity Signal Capture
- Low intrinsic jitter
- User friendly GUI, high throughput APIs and libraries.
- Supports external API calls from other software such as LabView
- Repeatable performance and traceable to standards
- Single ended and differential electrical inputs for each of the four channels
- Ability to analyze and load captured data into the simulator
- Capability to save statistical measurement and data files for multiple DSOs
- Application-specific automated software for production testing

Target Applications

- Time Domain Reflectometry
- Cable Matching
- Locating the position of discontinuities
- Impedance Profile Measurement
- Propagation/Time delay
- Copper board-trace, connector, and cable evaluation
- Communication Systems/Backplane Test
- Direct Attach Copper Cable Testing
- TIA/Driver Testing
- Switch Tuning
- Electro-optical Transceiver Testing
- Multi-port system testing or Line Cards
- In-Situ testing of high port count systems
- Telecom Equipment Test for Installation and Maintenance.
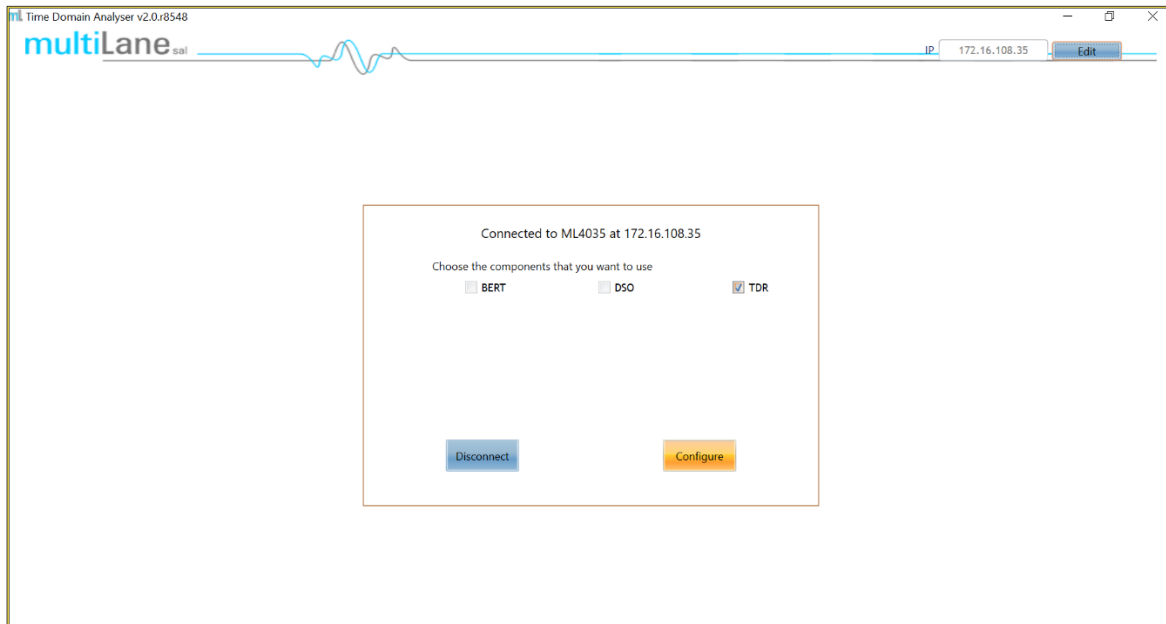
Product Software

Figure 1: ML4035 GUI Main Page

The instrument includes the following software & driver:
- **ML4035 TDA SW**
- **ML4035 ETH Configuration Software.**
- **MultiLane ML4035 USB driver.**

Instrument GUI runs on Windows XP (32/64 bit), Windows 7,8 and 10.

NOTE. These applications require the Microsoft .NET Framework 3.5.
If the Microsoft.NET Framework 3.5 is needed, it can be downloaded through this link:
http://download.microsoft.com/download/2/0/e/20e90413-712f-438c-988e-fdaa79a8ac3d/dotnetfx35.exe.

For more products updates, check the following webpage: www.multilaneinc.com/products.html

Minimum PC Requirements

The Windows PC properties for the **ML4035** software should meet the following specifications:
- Windows XP SP3 or greater
- Minimum 1 GB RAM
- 1 Ethernet card to establish connection with the device
- USB Connector
- Pentium 4 processor 2.0 GHz or greater
- .NET Framework 3.5 sp1

Hardware Overview

With a total of 24 ports, the ML4035 allows 400G BER tests, NRZ & PAM4 eye diagram measurements, as well as medium impedance characterization and S-parameter evaluation on 4-channels simultaneously.

Figure 2: ML4035 Front View

	Port Name	Description
1	Clk In/Out	The trigger input for the sampling scope (DSO). It is used in DSO mode only.
2	CH1 - CH4	TDR/DSO ports. Each channel can be either configured as TX or RX.
3	TX1 – TX4	PPG ports. Each channel can transmit a 53GBd NRZ/PAM4 signal.
4	RX1 – RX4	Error Detector ports. Used to measure BER.
5	LAN	RJ-45 port for data transfer and communication with the GUI

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How to connect this instrument

This section covers the connection options of the instrument, addressing the following topic:

- ▪ **ML4035** Fast Ethernet / USB Connections method.

NOTE. *This release supports Ethernet connection for the software applications (note that the IP[1] should be in the same range of the network).*

Connecting Through an Ethernet cable

To establish an Ethernet connection between the **ML4035** panel and the PC, connect an Ethernet **straight** cable between the panel and the Router or Switch, and connect your PC to the router via cable or wireless. The device can be pinged to verify that a connection has been established.
Make sure to have the instrument's correct IP address.

Figure 3: ML4035 connected to PC via Ethernet

Figure 4: ML4035 connected to PC Wirelessly

Connecting Through USB cables

Connect a USB Mini-B type cable between the instrument and the PC. This connection method is only used to upgrade the firmware.

Figure 5: ML4035 with USB connection

Installation

This section covers installation of the instrument, addressing the following topics:

- System Start-up
- How to connect to the instrument via Ethernet

System Start-up

To use the **ML4035** GUI under Windows XP, Windows 7,8, and 10, it is important that the correct start-up sequence is followed:

- Make sure you have Microsoft *.NET Framework 3.5* installed.
- If not installed, refer to the Note in the Product Software section.
- Install the **ML4035** software.
- After installation, run the software.
- On the main window's top right corner, a textbox labeled "IP" is available for the user to input the instrument's IP address. Doing that, followed by pressing the "Connect" button next to it will allow establishing the connection to the ML4035.

Connect to the Instrument via Ethernet:

- Connect an ethernet cable between the PC and the ML4035's RJ45 connectors to be able to control it.
- In order to connect via Ethernet, the IP address of the board is required.
  To learn more options on how to connect the Ethernet cable go to the section Connect through an Ethernet Cable.
  Note that no drivers are required; the board's IP address should simply be typed in the text box next to the **IP** label then the **connect** button should be pressed as shown in Figure 6.
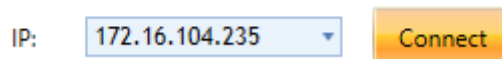

Figure 6: Connect Via Ethernet

- To make sure that you are connected, you can also ping your device through Windows' command prompt.
- To change the IP address of the board, you need to install the USB driver (refer to the section that addresses USB Driver Installation).
- Install the Ethernet configuration software that allows you to read and/or write the **IP** address, **Mask** and **Gateway** of the instrument.
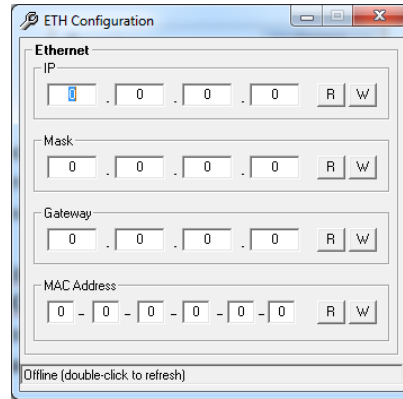
Figure 7: Ethernet Configuration

The instrument is now powered up and connected through Ethernet. In the next section, the measurements that can be performed by the ML4035 along with the needed calibrations will be addressed.

Standard Software (For characterization and R&D)

Connection & Mode Selection

In order to include all the ML4035's diverse functionalities in a single software, the GUI's home page displays all three options at startup for the user to select.

After connecting to the instrument by typing its IP in the appropriate text box, select the desired mode of operation and press "Configure".
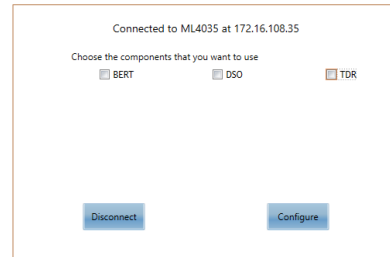
Figure 8: Mode Selection

TDR & S-Parameter Measurements

When selected, the rightmost checkbox starts the instrument and software in TDR/TDT mode. This mode allows the user to perform time and frequency domain measurements such as TDR, Sdd21, Sdd11, NEXT, FEXT, ICN, COM, etc.

This mode can be used for many applications, including impedance profile evaluation, loss characterization, locating faults & discontinuities, phase matching, and more.

The ML4035's ports are differential AC-coupled. However, single-ended measurements can be performed using the negative port of each pair, after terminating the positive one with a 50Ω load.

This section will list and explain how to perform all measurements that fall under this umbrella.

Time-Domain Reflectometry

TDR can be used for many applications, such as to characterize the impedance of DUTs, backplanes, and other physical media, locating faults, discontinuities or breaks along a cable, cable matching, and more.

The ML4035's uppermost ports act as both receivers and transmitters. This allows them to transmit a fast 12ps rise time pulse and receive its reflections then display it with respect to time.

Calibration (alignment)

Amplitude calibration is performed at the factory prior to the shipment of any instrument. No further amplitude related calibration is required by the user.

Step alignment is also performed at the factory but can be modified by the user depending on their application. This calibration consists of setting the graphical starting point of the TDR pulse's rising edge. This process is done as follows:

- Select the channel(s) on which the calibration will be performed.
- Connect the ML4035's TDR ports to the DUT using 2.92mm K/SMA cables.
- Click on "Calibration" followed by "Run" to start the calibration process.
- Disconnect the DUT from its connection point with the ML4035 (desired pulse starting point) as instructed by the calibration wizard and press "Next Setup".
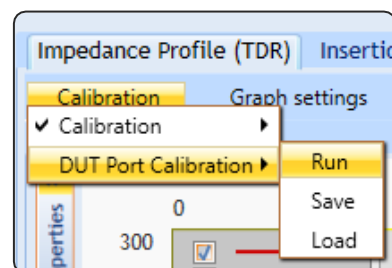- Reconnect the DUT and press "Confirm".

Figure 9: Calibration

TDR Measurement

- After completing the optional calibration process, keep the cables connected to one end of the DUT, and terminate the other end with a 50Ω load.
- Measurements can either be differential or single ended. For single ended measurement, "Single_Ended" mode should be selected in the "Advanced Options" tab and only one port is used for each channel while the second is terminated with a 50Ω load.
- Select the channel(s) on which the impedance profile measurement will be performed.
- Click "Confirm" to measure the impedance profile.
- Press ▶ to measure continuously or ▶▶ for a single capture.
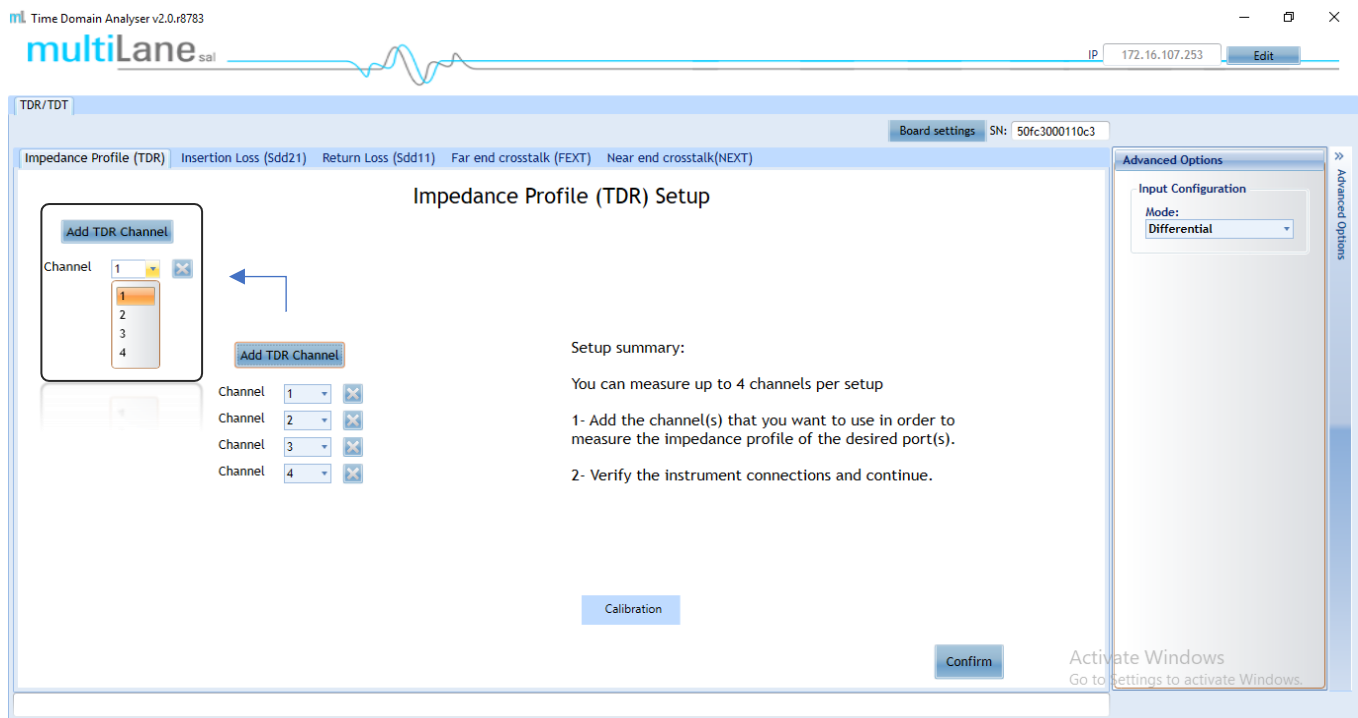

Figure 10: Add TDR Channels

Phase Matching

One of the most popular applications made possible by TDR is cable matching.

To match cables using the ML4035 and its software, first start by connecting up to four cables to the negative port the four available differential channels and terminate the positive ports with 50Ω.

After capturing the TDR profile, locate the edge of the cables and zoom into that area, placing markers at the same horizontal level along the rising edge (Figure 11).

At the bottom of the screen, the time difference between both markers is displayed.
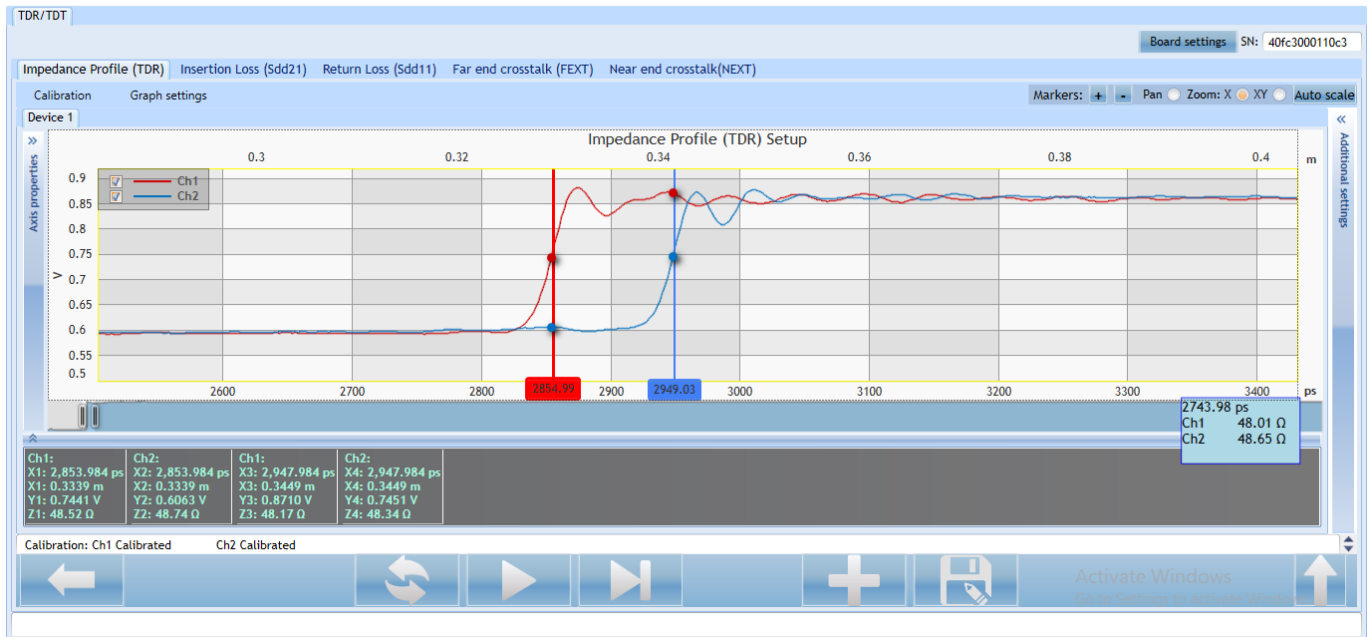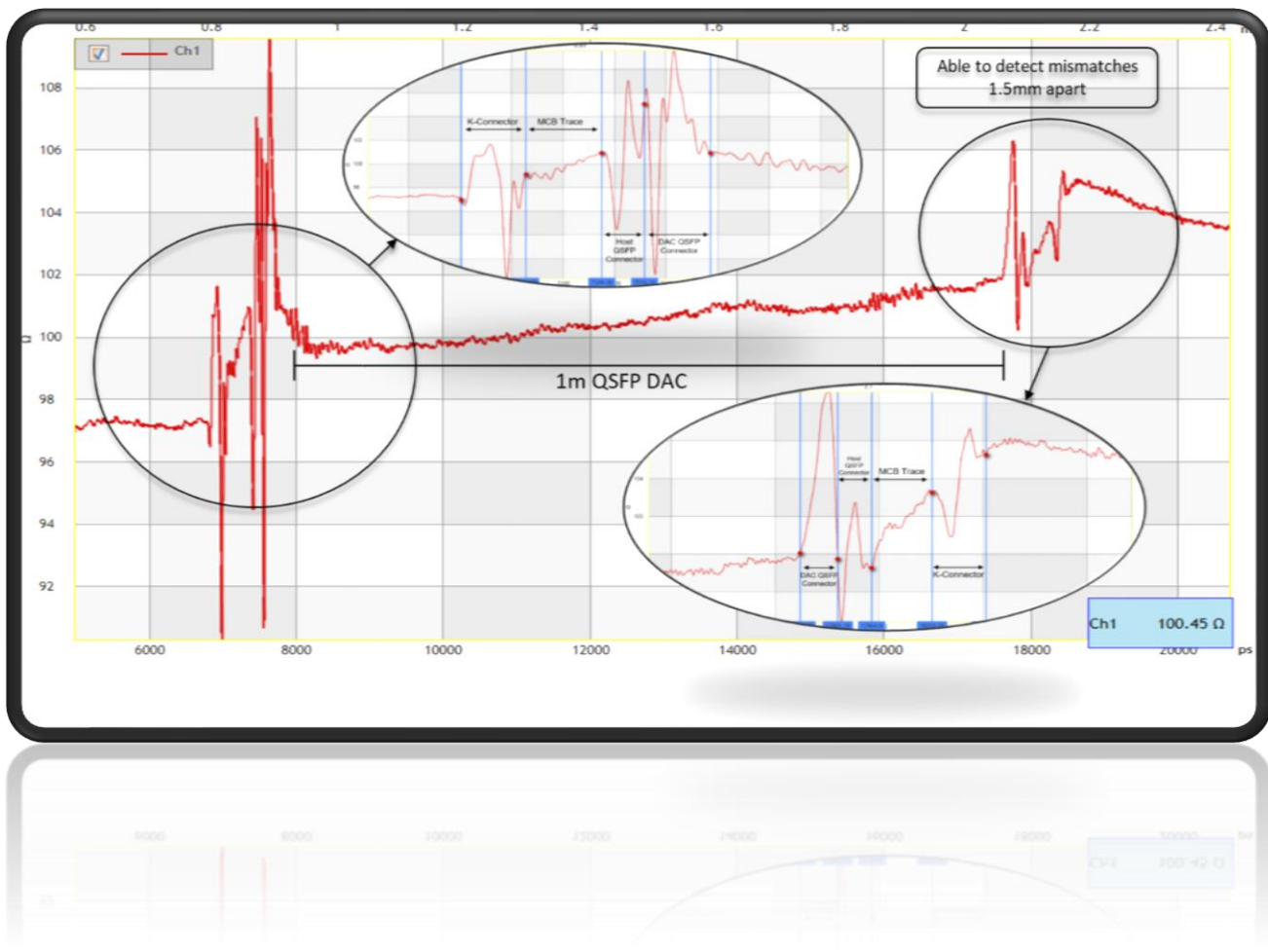
Figure 11: Cable Matching


Figure 12: TDR Measurement

Locating Faults & Discontinuities

Another popular application for TDR is locating faults and discontinuities in a physical medium.

As the velocity of propagation of electromagnetic waves in vacuum is known, additional information related to the characteristics of the physical medium such as the copper cable's velocity of propagation (VoP) allows the speed of propagation to be estimated and the distance between two points can therefore be calculated.

Placing two markers at different points on the graph will allow the user to see both the temporal and spatial difference between the two points.

The velocity of propagation can be set in the "Advanced Settings" tab.

Figure 13: Velocity of Propagation
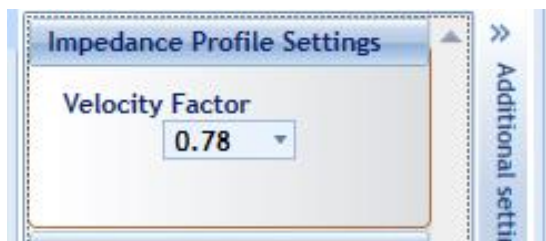
Insertion Loss

In addition to time-domain reflectometry, the ML4035 provides frequency domain S-parameter measurement capability. As opposed to a traditional frequency-domain network analyzer that would use a frequency sweep for these measurements, Multilane's time-domain equivalent solution takes advantage of its 4-port high-speed pulse pattern generator and electrical scope to provide fast, accurate, and repeatable insertion loss measurements up to 32GHz by transmitting a PRBS pattern and transforming it into frequency domain.

Advanced Settings

Before performing the calibration and measurements, advanced settings can be modified by the user to fit their preference.

- Changing the pattern length changes the number of points that will be displayed on the graph.
- As higher rate PRBS yields more energy, increasing the rate will increase the accuracy at high frequencies. 53.125 gives accurate S21 measurements up to 32GHz.
- Main Tap, Pre Emphasis & Post Emphasis are used to tune the transmitted signal. Optimizing these settings will be explained in section x.
- The number of averages can be increased by the user, leading to more accurate measurements.
- Smoothing can be added by the user, and the smoothing window can be varied as well.
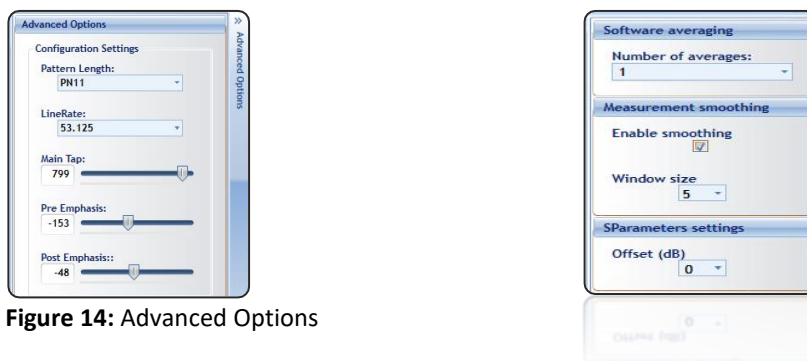- An offset value can be set by the user to compensate for a flat-response attenuation source.

Figure 14: Advanced Options

Calibration

As a time-domain measurement technique is used to evaluate the insertion loss, the calibration that needs to be performed consists of connecting the reference setup (setup including all components except the DUT) and setting its insertion loss to zero.

- Select the channel(s) on which the calibration will be performed.
- Click on "Calibration" followed by "Run" to start the calibration process.
- Connect the ML4035's selected PPG channels (labeled "TX") to the reference circuit's inputs and the DSO channels (labeled "CH") to their respective outputs and press "Confirm".
  For instance, the simplest example would be connecting cables coming out of the TX channels to cables going into the DSO channels using 2.92mm F-F K/SMA connectors. After this calibration, anything that replaces the F-F connector between the cables is considered the DUT.
- The reference plot will be displayed for the user to validate. Closing the window will prompt for the user's confirmation. Press "Yes" to accept the calibration or "No" to run again.
- The calibration can be saved for later use by pressing "Save" in the calibration wizard.
- Press "Done" to exit the calibration wizard.

Figure 17 shows an example of the expected output after calibration.
Previous calibration files can also be loaded by choosing "Load" instead of "Run".
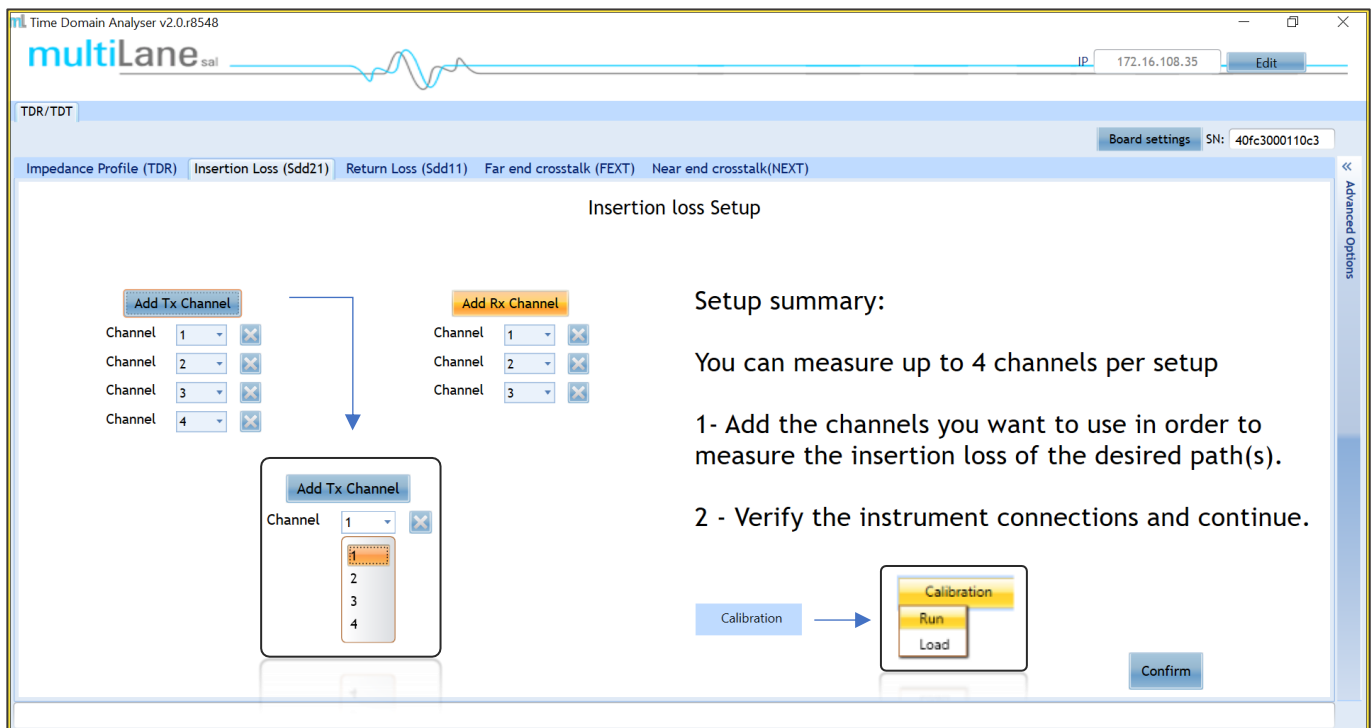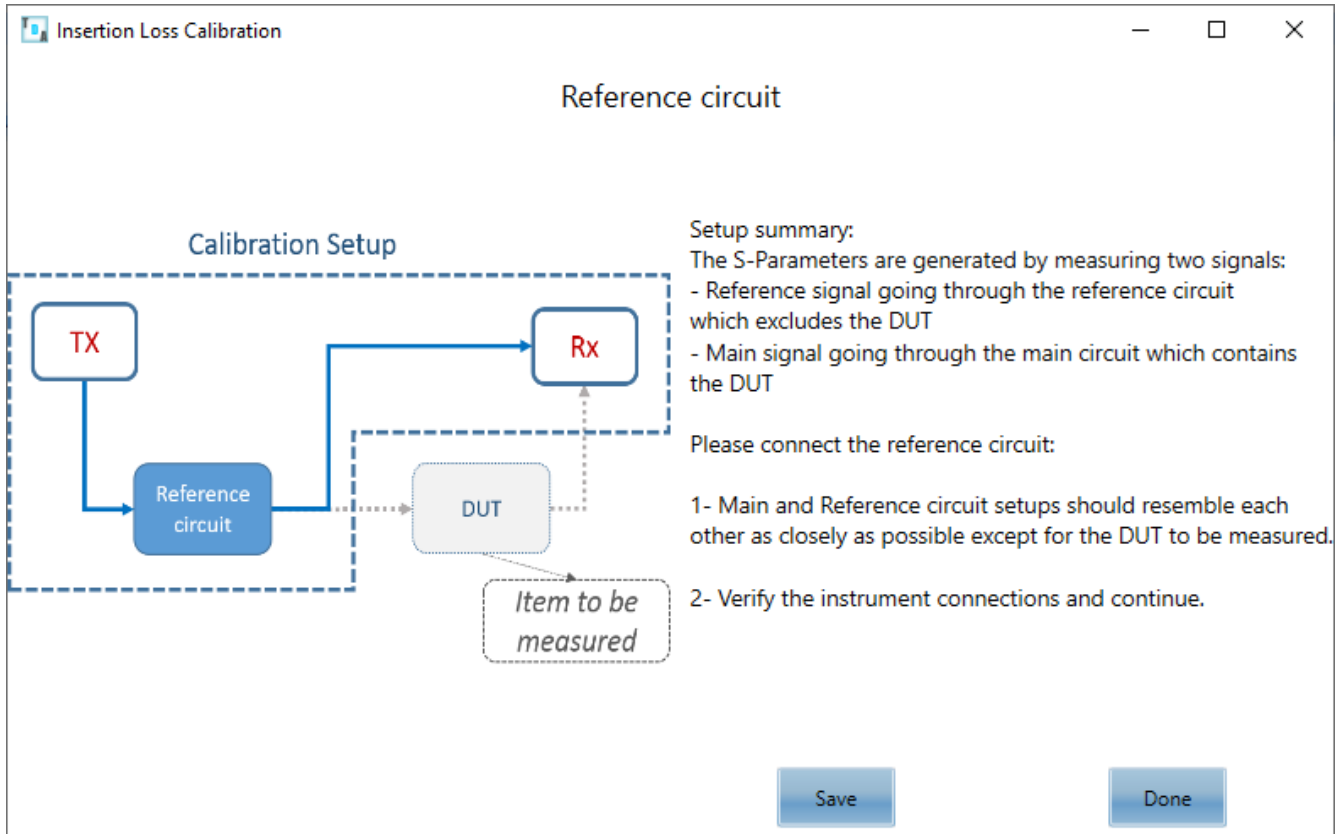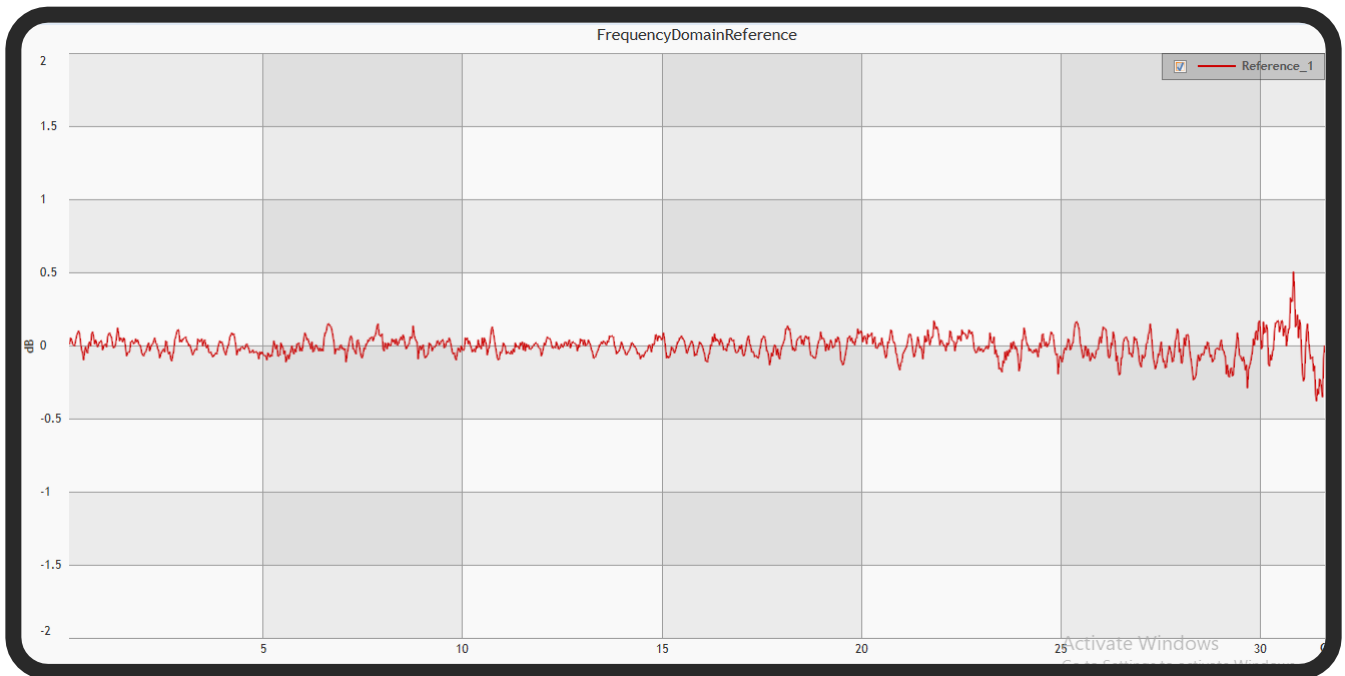

Figure 15: Adding TX/RX Channels & Calibration

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Figure 16: S21 Calibration Wizard

Figure 17: S21 Calibration Plot

Insertion Loss Measurement

- After completing the calibration, disconnect the reference circuit and connect the ML4035's transmitting channel to the DUT's input.
- Connect the DUT's output to the ML4035's receiving channel.
- Measurements can either be differential or single ended. For single ended measurement, only the negative port is used for each channel and the second is terminated with a 50Ω load.
- Select the channel(s) on which the insertion loss measurement will be performed.
- Click "Confirm" to measure the DUT's insertion loss.
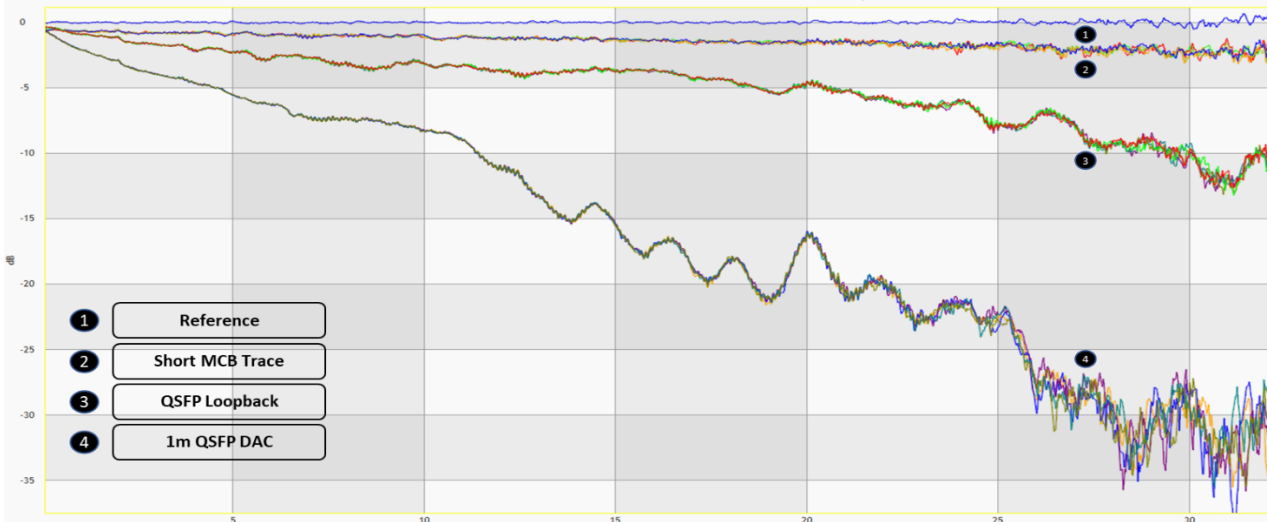- Press ▶ to measure continuously or ▶| for a single capture.

Figure 18: S21 Measurement

Measurements and masks can be loaded in the software by pressing "Measurement" on the bottom right side of the page.
The available measurements for insertion loss are insertion loss deviation limits, insertion loss fitted, and loss at Nyquist, for which the mask type is available for different standards that the user can choose from.
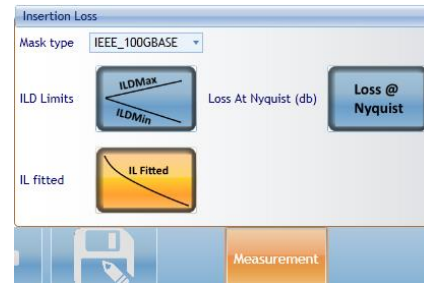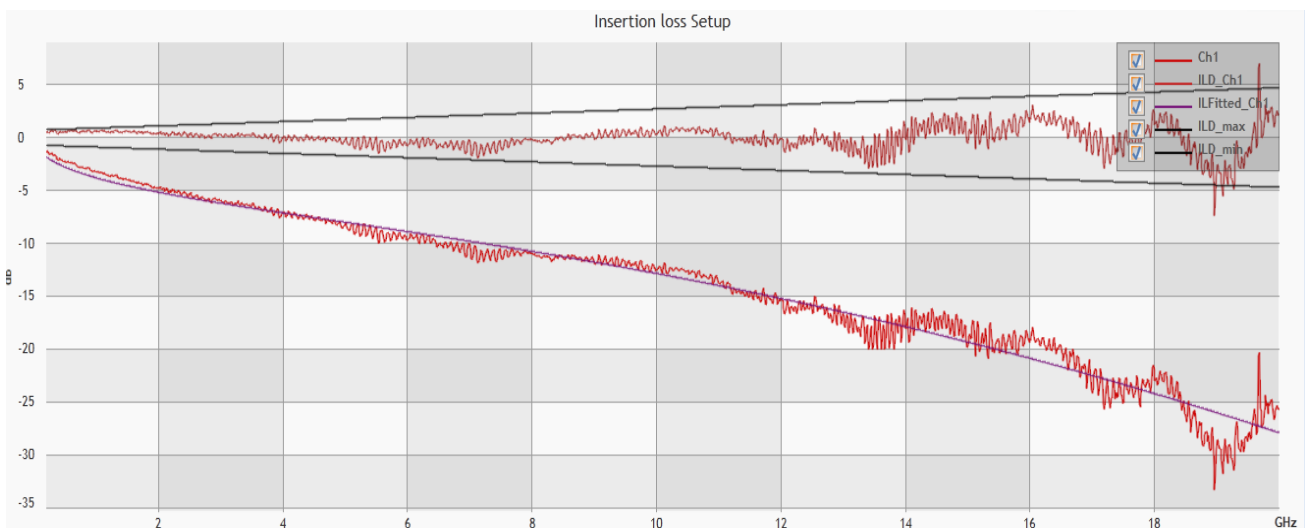

Figure 19: IL Measurements


Figure 20: ILD & IL Fitted

De-Embedding

Unwanted components can be de-embedded easily using the ML4035's software.

After having measured the insertion loss, press "S parameters settings" followed by "De-Embed", then load the S2P/S4P files to be removed and press "Continue".

The software also enables the user to modify S2P/S4P files to downscale the loss profile into half. This can be done by choosing "2x to 1x conversion" under "S parameters settings".

Figure 21: De-Embedding
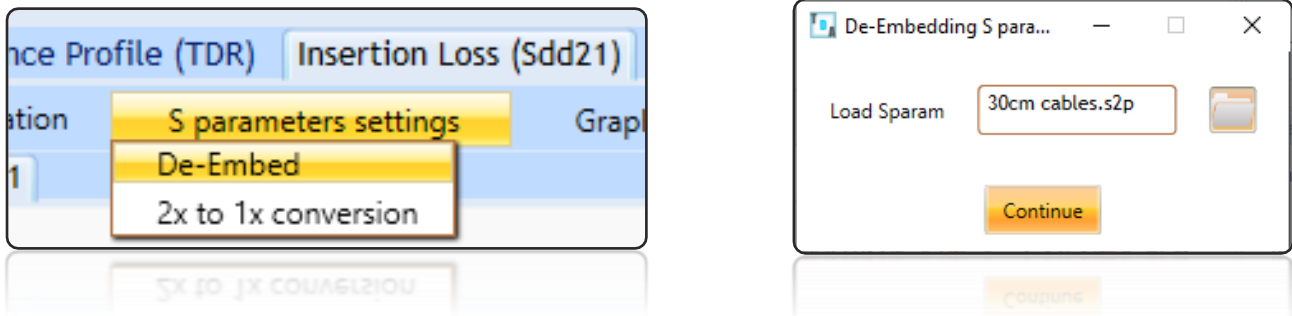
Return Loss

The ML4035's TDR/DSO ports can also be used to measure insertion loss. Similarly to insertion loss, the ML4035 performs a TDR measurement in time domain and then converts it to the frequency domain, resulting in return loss measurements.

Advanced Settings

Before performing the calibration and measurements, advanced settings can be modified by the user to fit their preference.

As with insertion loss measurements, additional settings for return loss also include averaging, smoothing, and offset addition for loss compensation.

An additional exclusive configuration for this measurement is the calibration method. Both SOLT and gating methods are supported by the ML4035. Checking/unchecking "Gating" allows the user to select which calibration method he needs.

Figure 22: S11 Advanced Options
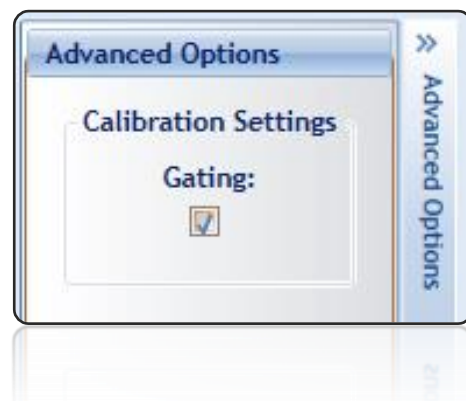
Calibration

The software offers two calibration methods for the user to choose from. The calibration method is selected depending on the application.

SOLT

The Short-Open-Load-Thru (SOLT) method can be used when the DUT's output is not connected to any additional unwanted system components and can be terminated with a 50Ω load.

To choose this calibration method, uncheck "Gating" in the advanced options.

- Select the channel(s) on which the calibration will be performed.
- Click on "Calibration" followed by "Run" to start the calibration process.
- As instructed by the calibration wizard, successively terminate the cables coming out of the ML4035's TDR/DSO channels with 2.92mm open, 50Ω, then short connectors, pressing "Next setup" between each step.
- The calibration can be saved for later use by pressing "Save" in the calibration wizard.
- Press "Done" to exit the calibration wizard.

Previous calibration files can also be loaded by choosing "Load" instead of "Run".
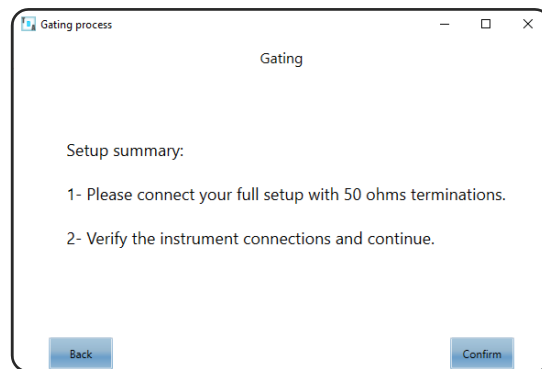
Figure 23: SOLT Calibration
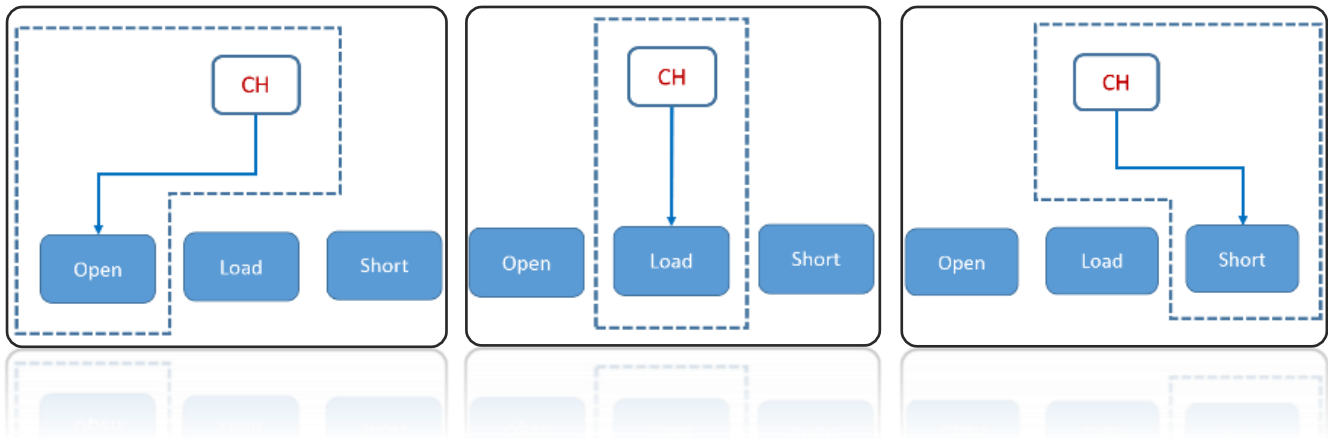
Gating

Gating is the default calibration method, and the one that should be used when the DUT is followed by unwanted system components such as MCB traces, connectors, etc.

As time-domain technology is used to measure the return loss, the calibration wizard uses TDR to allow the user to locate the DUT's boundaries, set markers and apply gating.

- Select the channel(s) on which the calibration will be performed.
- Click on "Calibration" followed by "Run Gating" to start the calibration process.
- As instructed by the calibration wizard, start by disconnecting the DUT and press "Next Setup".
- Next, connect the DUT from the near-end and leave it disconnected from the far-end.
- The last step is to connect the DUT from the far-end or terminate it with 50Ω and press "Confirm".

Figure 24: Calibration Wizard (Gating)

- Apply markers at the points of difference between the main setup's impedance profile and the other two and press "Apply Gating".
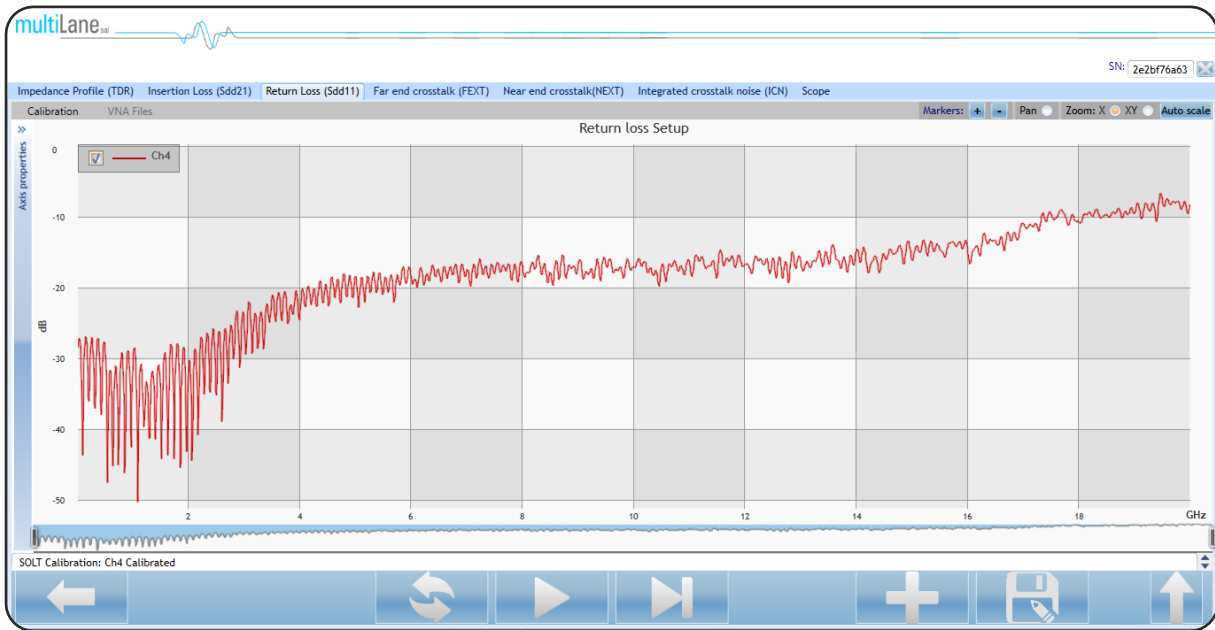- Close the page to exit the calibration wizard.

Figure 25: Applying Markers
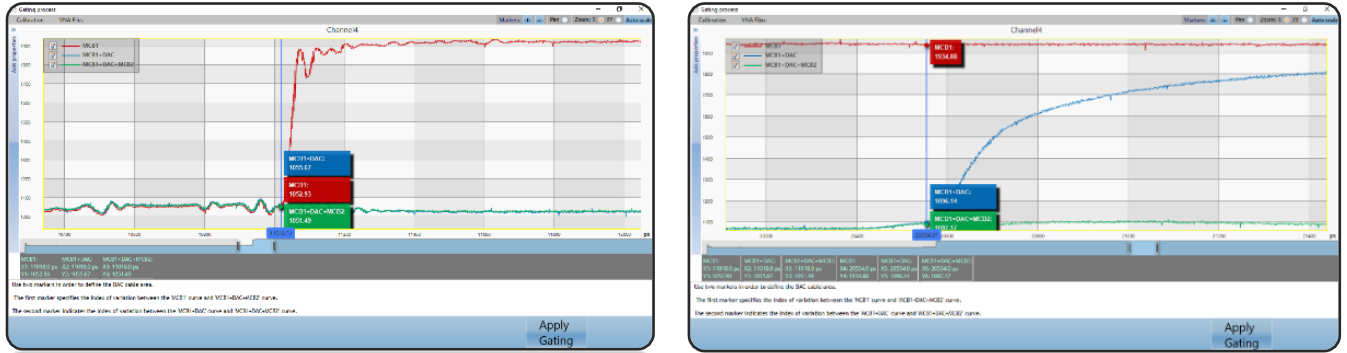
Return Loss Measurement

- In the case of SOLT calibration, connect the cables to the DUT after completing the calibration process
- In the case of gating, no change in connections is needed.
- Press ▶ to measure continuously or ▶▶ for a single capture.

Figure 26: Return Loss Measurement

Measurements and masks can be loaded in the software by pressing "Measurement" on the bottom right side of the page.

The available measurements for return loss are loss at Nyquist and the return loss mask, for which the mask type is available for different standards that the user can choose from.

Figure 27: S11 Measurements

Figure 28: Return Loss Mask