multiLane

ML4035 | User Guide

Installation | Connection | Calibration| Measurement

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General Safety Summary

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

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 statements identify conditions or practices that could result in damage to this product or other property.

Electro static sensitive device. Operate in ESD supervised and controlled areas.

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Revision Control

Revision number	Description	Release Date
2.0	API Version v6.1.2	14/7/2022
4.3.1	SW rev. 4.1.8.1	5/10/2022

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Product Software

The instrument includes the following software:

- ML4035 Cerberus SW
- ML1105
- ML4035 Maintenance GUI

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

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List of Acronyms

Acronym	Definition
BW	Bandwidth
BERT	Bit Error Rate Tester
Conf	Configuration
DUT	Device Under Test
FEC	Forward Error Correction
FW	Firmware
GBd	Giga Baud
Gbps	Gigabits per second
GUI	Graphical User Interface
HW	Hardware
ISI	Inter-symbol Interference
JTOL	Jitter Tolerance
KGU	Known Good Unit
NRZ	Non-Return to Zero
PAM4	Pulse Amplitude Modulation (4-level)
SI	Signal Integrity
SNR	Signal-to-Noise Ratio
Sim	Simulation
SW	Software

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Introduction

The rapid growth of cloud computing economies demands the need for stable and high-speed data center interconnect solutions. With the widespread adoption of 400G – and move towards 800G and beyond – errors have become an integral part of any HSIO system. Success now lies not only in identifying where errors occur, but also in determining which errors are critical to correct.

A key player in the test and measurement industry, MultiLane provides an essential high-value instrumentation that ensures vendors can keep up with demand and bring their designs to market.

The ML4035 is a 3-in-1 400G BERT, 35GHz electrical scope and time domain reflectometer. It enables 400G BER measurements, NRZ and PAM4 eye diagram characterization as well as TDR and S-parameters evaluation.

Our ML1105 Automated DAC Testing Software, resides on the 16-port simultaneous measurements of the ML4035 to evaluate 10G-800G cables' impedance profile and perform tests including insertion loss, return loss, Far & Near-End Crosstalk, Integrated Crosstalk Noise, COM,then generates a report with Pass/Fail criteria.

In this revised version of the ML4035 – ML1105 user guide, MultiLane provides a full detailed and revised user guide to operate the ML4035 from the connection to the calibration and measurements.

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ML4035: TDR|BERT|DSO

	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	35GHz DSO & TDR ports.
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

The ML4035 is a 3-in-1 400G BERT, 35GHz electrical digital sampling oscilloscope (DSO), and Time Domain Reflectometer (TDR). On its faceplate, the user can detect three main rows of connectors (4-channel differential each).

When operating in DSO mode, the first row of connectors acts as a DSO input. Whereas when the TDR mode is chosen, the first row is a TDR input/output for TDR capture. The BERT section of the faceplate is a combination of 4-channel Pulse Pattern Generator (PPG) on the TX-side and 4-channel Error Detector (ED) on the RX-side.

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For signal synchronization the Clock input and output are at the disposal of the users for accurate and high-precision measurements.

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
- 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
- Passive and active copper cable testing
- High density connector testing
- Cable Matching
- Locating the position of discontinuities
- Impedance Profile Measurement
- Propagation/Time delay

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- Copper board-trace, connector, and cable evaluation
- Communication Systems/Backplane Test
- 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.

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Installation

After downloading the ML4035 setup file, select run and follow this easy step-by-step setup installation procedure:

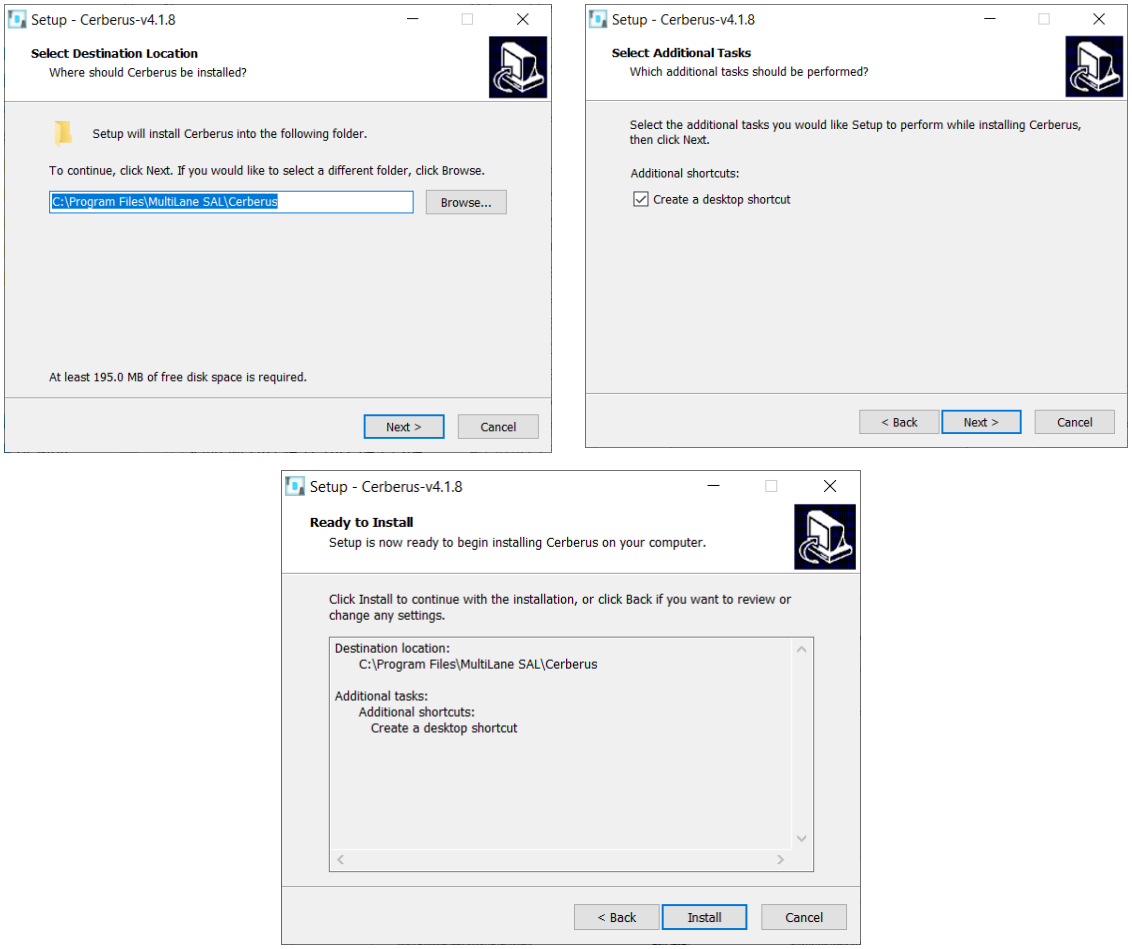

Figure 1: Setup installation procedure

ML4035 is now installed, a shortcut icon is located on the Desktop and ready to be used.

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Connecting to the Instrument

To connect to the instrument, follow this sequence of steps:

- ***Install*** the ML4035 software.
- ***Connect*** the power cable to the power jack of the ML4035 and plug it into an AC outlet.
  The power cable is already included in the package accessories.
- ***Power Up*** the ML4035.
- ***Connect*** the device to the network* using a RJ45/LAN cable.
  LAN connection can be validated with a ping to the static instrument IP.
- ***Run*** ML4035 software.
- ***Connect*** using the IP address of the target instrument(s) (Figure 2). The IP address is printed on the back side of the instrument.

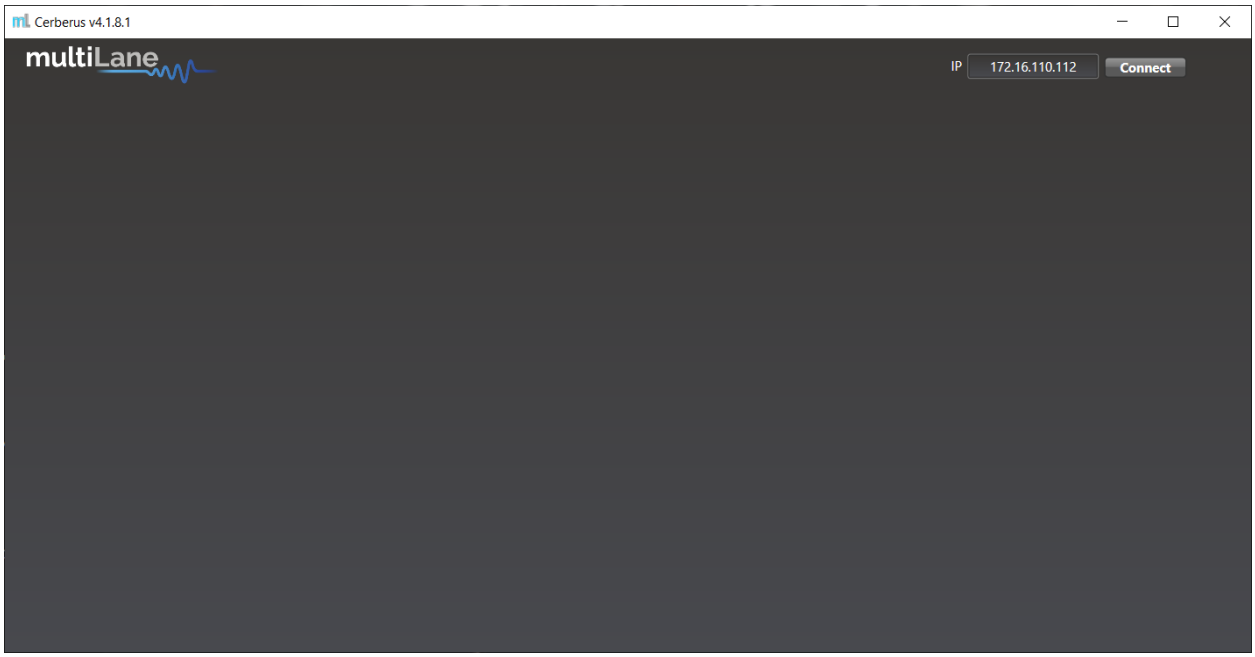

Figure 2: Connection box

NOTES:

- In the case of a connection failure, a pop-up message will appear indicating a connection error (Figure 3).

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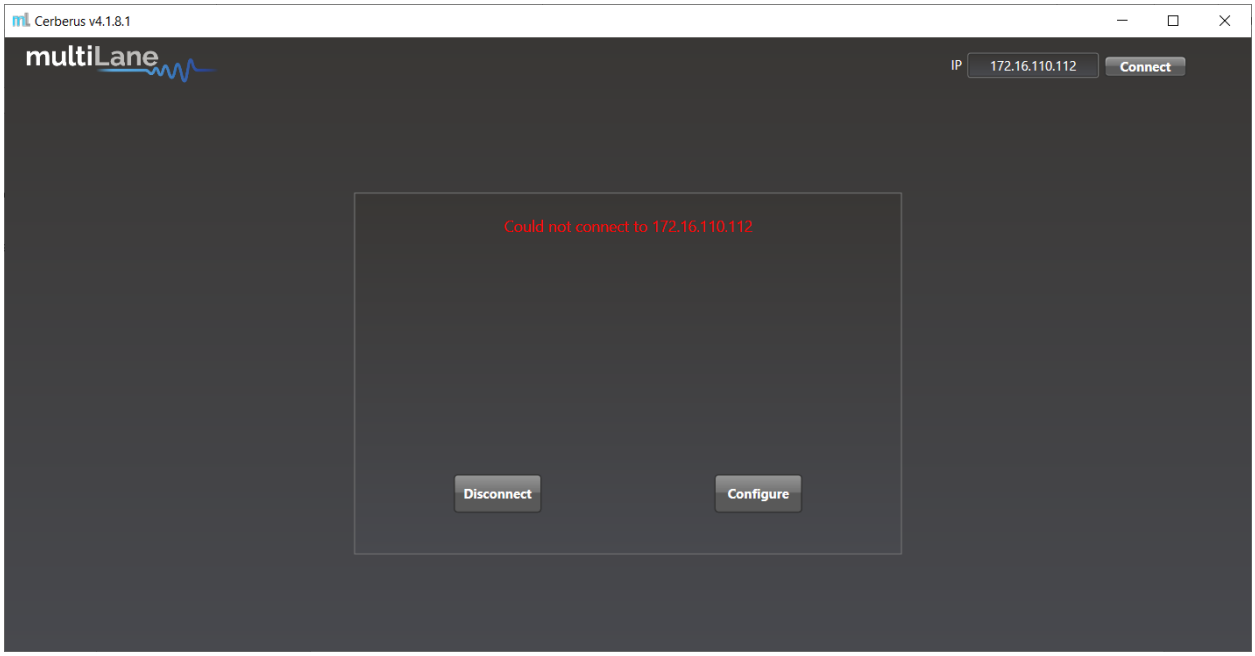

Figure 3: Connection failure notification

*To add the device to the network, consult Appendix I at the end of this manual

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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".

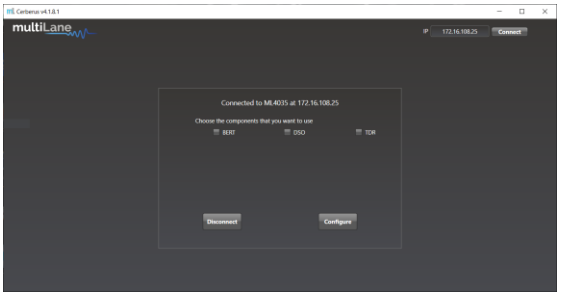

Figure 4 mode selection

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 one of the ports of each pair, after terminating the second one with a 50Ω load.

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

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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 step and receive its reflections then display it with respect to time.

Impedance Profile "Align" step

"Align" is used when the DUT is followed by unwanted system components such as MCB traces, connectors, etc. This step is to allow the user set the starting point on the graph .

- ***Select*** the channel(s) on which the Alignment will be performed.
- ***Connect*** the ML4035's TDR ports to components that are not to be shown on the graph.
- ***Click*** on "Align" followed by "Done.
- ***Reconnect*** the full setup.

TDR Measurement

- 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.

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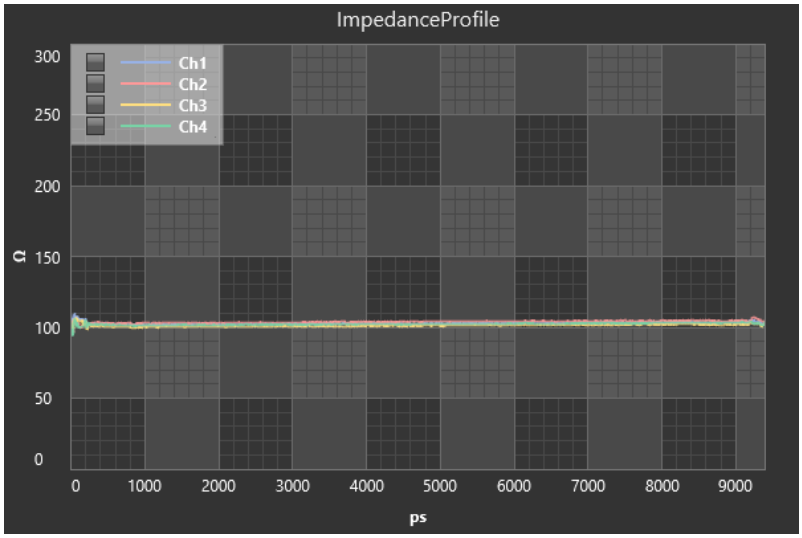

Figure 5 Impedance profile Graph

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 one of the ports of the four available differential channels and terminate the other one 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 6).

At the bottom of the screen, the time difference between both markers is displayed.

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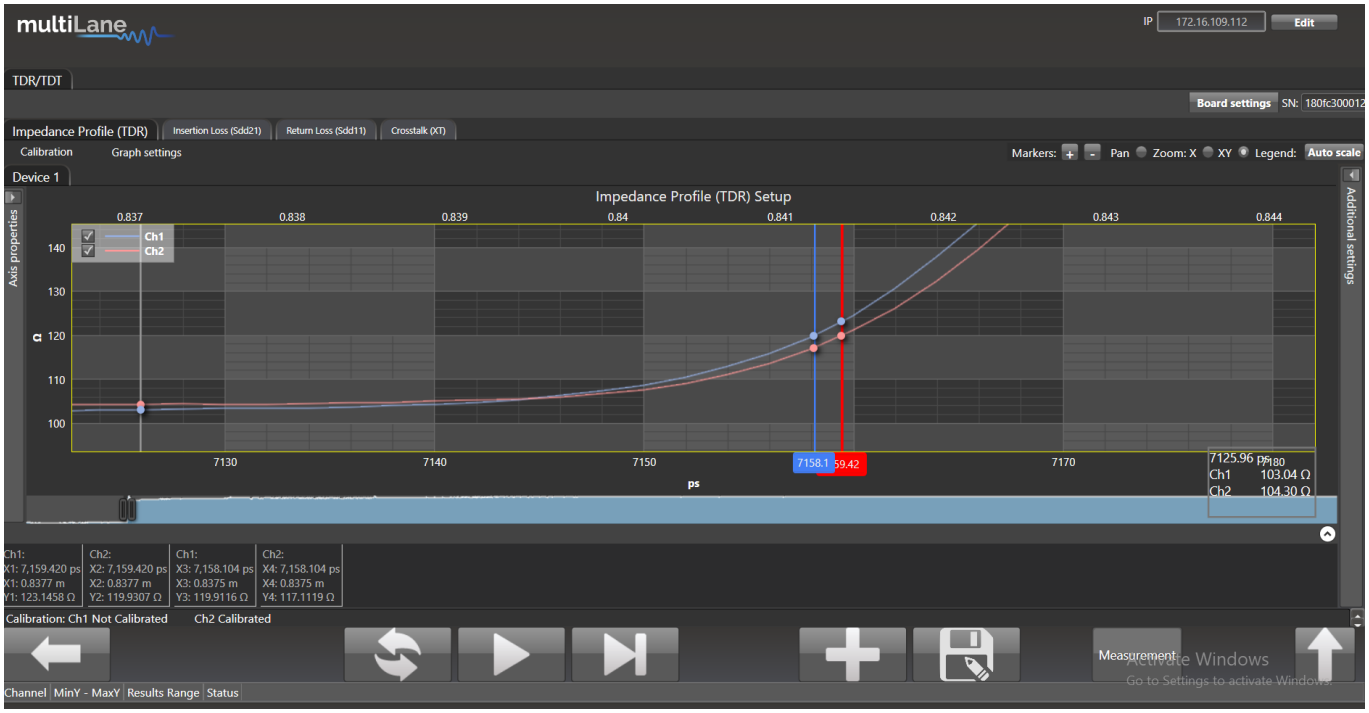

Figure 6 Cables matching

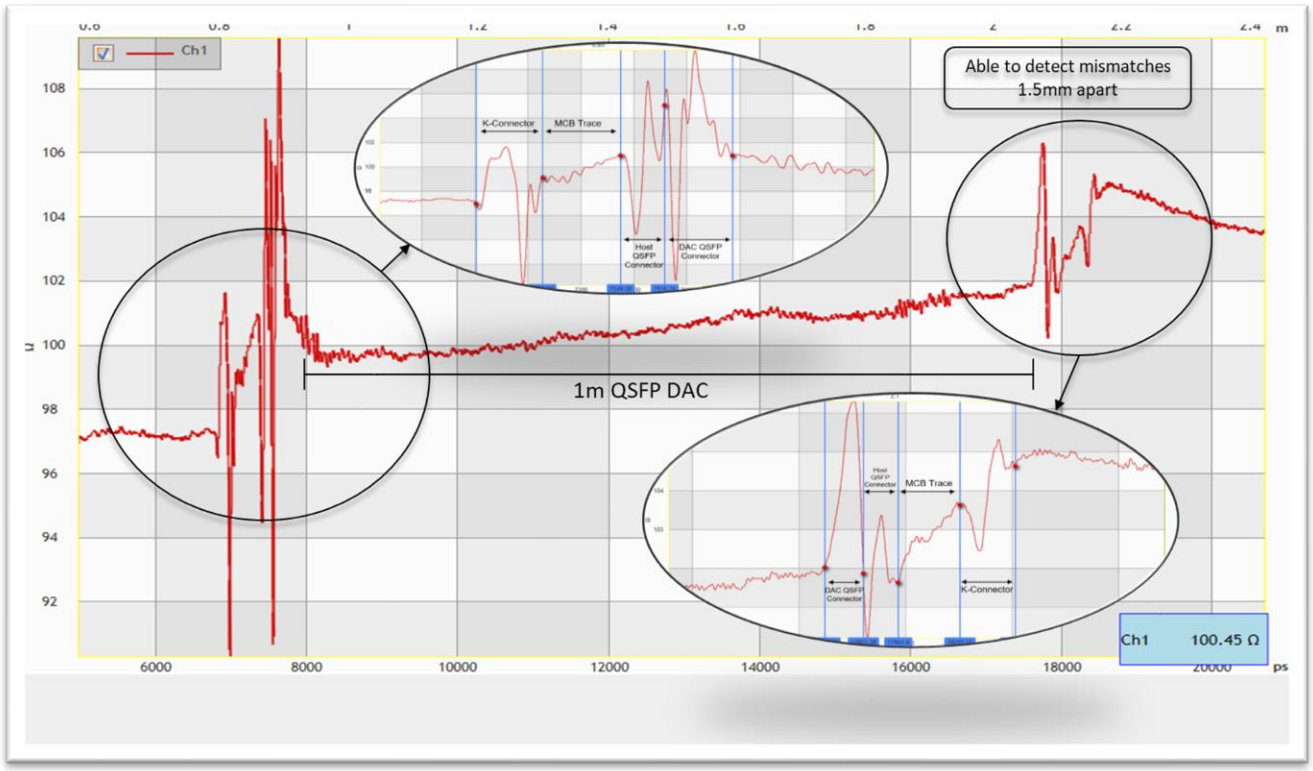

Figure 7 TDR measurement

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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.

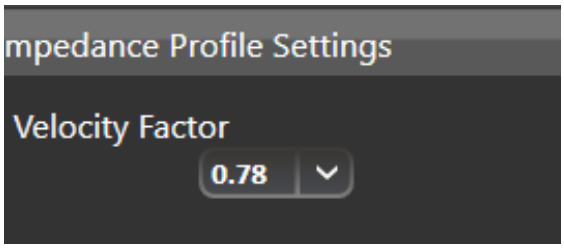
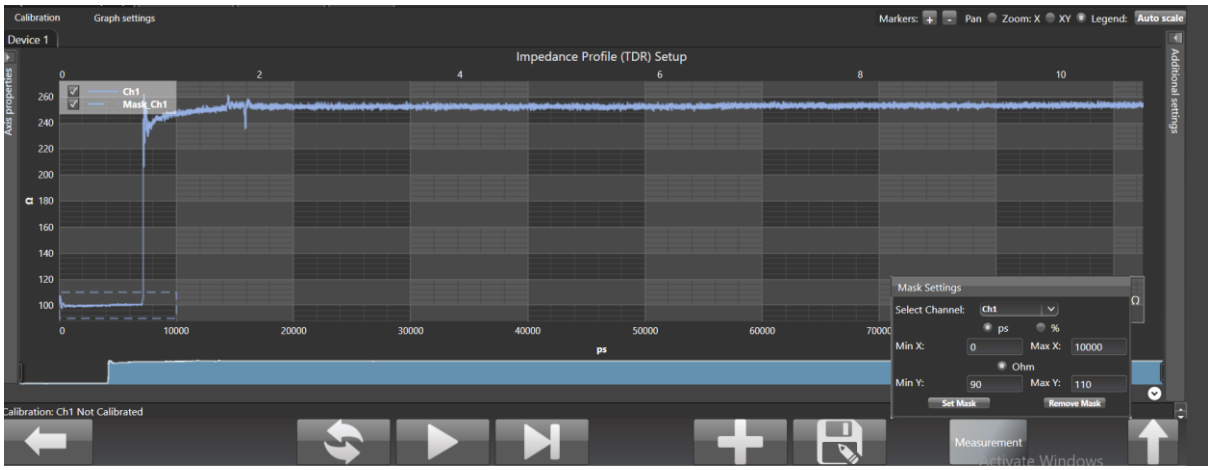


Figure 8 Velocity of propagation

User defined mask



The user can define in the measurement section a custom mask by setting the minimum and maximum time, as well as impedance.

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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.

Insertion Loss 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 normalizing its insertion loss at zero.

When the user runs the insertion loss calibration, a wizard explains each step and shows a diagram explaining the reference circuit connection:

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. ***Previous calibration files can also be loaded by choosing "Load" instead of "Run".***
- ***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".

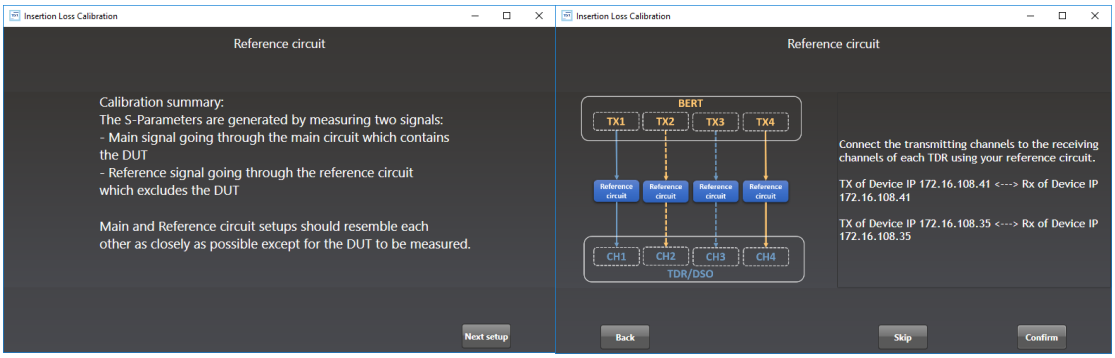

Figure 9 Reference circuit setup

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The simplest example, for a reference circuit would be connecting cables coming out of the TX channels to cables going into the DSO channels using 2.92mm Female-to-Female K/SMA connectors.

After this calibration, anything that replaces the Female-to-Female connector between the cables is considered the DUT.

The reference insertion loss is shown at the end for the customer to review the calibration process.

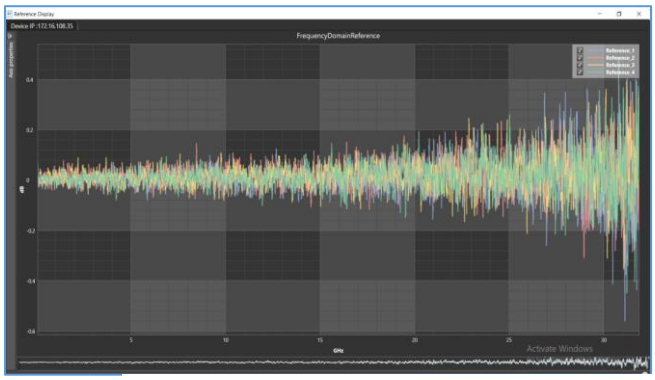

Figure 10 Reference circuit Normalization

Note that the reference circuit has around 0 dB loss.

- ***Close*** the page to exit the calibration wizard.

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.
- In the BERT Amplitude control window, Main Tap, Pre Emphasis & Post Emphasis are used to tune the transmitted signal. It is recommended to keep default settings.
- The number of averages can be increased by the user, leading to more accurate measurements. It is recommended to set the number to 10.
- Calibration type can be selected.
- Smoothing can be added by the user, and the smoothing window can be varied as well. It is recommended to set the number to 5
- An offset value and S21 starting point can be set by the user to compensate for a flat-response attenuation source, after confirming, in the main window.

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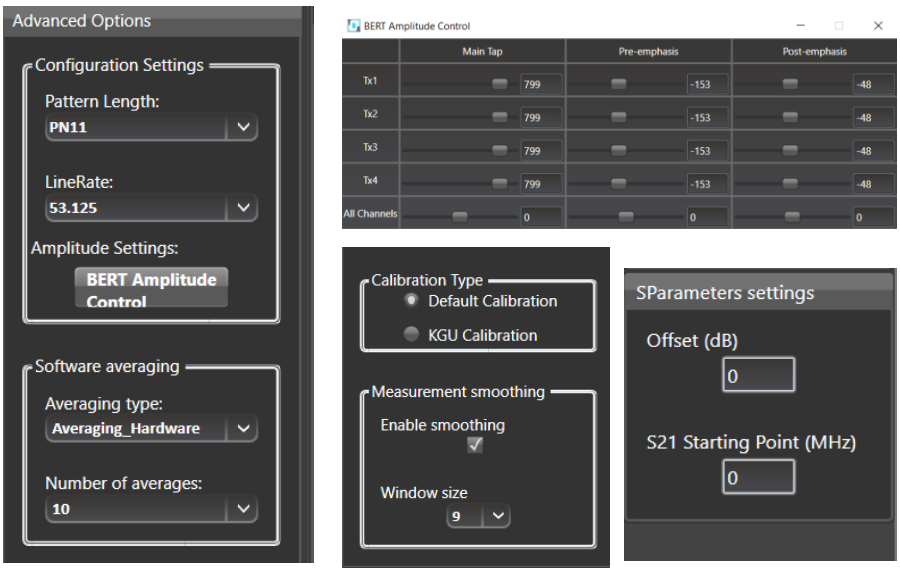

Figure 11: Advanced Options

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, one 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.

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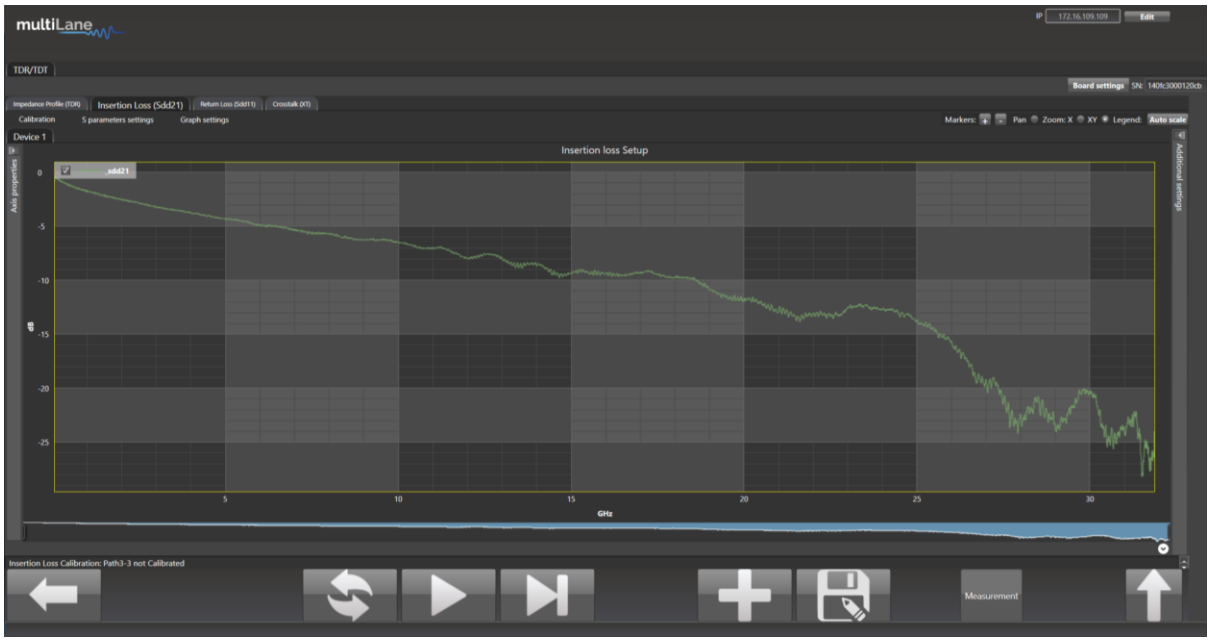

Figure 12 S21 Measurement

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.

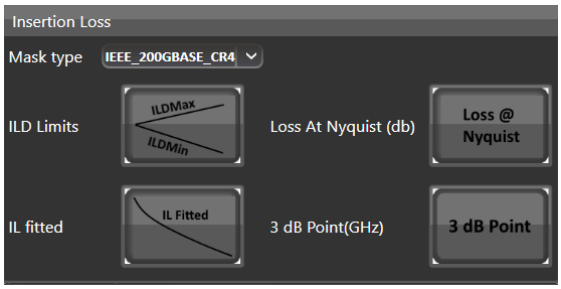

Figure 13 IL Mask

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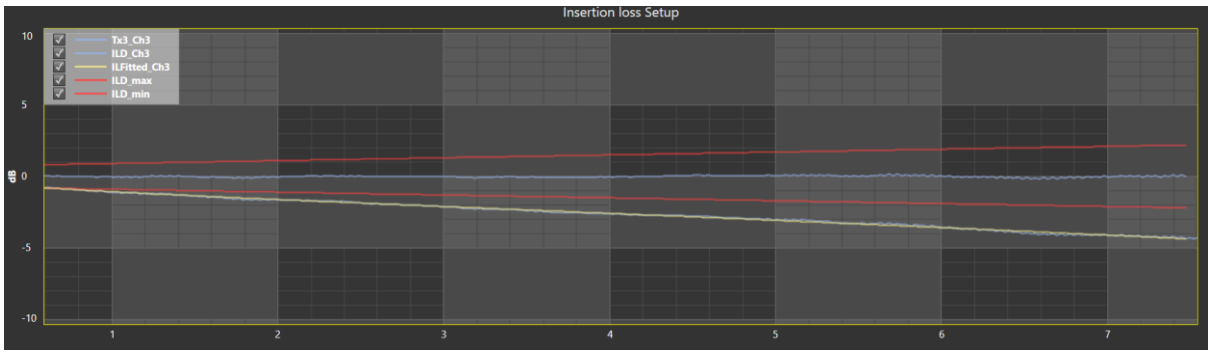

Figure 14: ILD & IL Fitted

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 and reduce the loss by half. This can be done by choosing "2x to 1x conversion" under "S parameters settings".

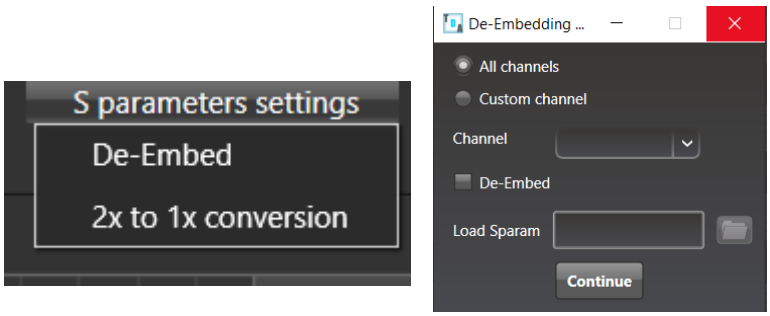

Figure 15 De-embedding

Return Loss

The ML4035's TDR/DSO ports can also be used to measure return 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.

Gating

Gating is the default calibration method for return loss measurements and the one that should be used when the DUT is followed by unwanted system components such as MCB

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traces, connectors, etc. The calibration wizard uses TDR to allow the user to locate the DUT's boundaries, set markers and apply gating. 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 coax cables.
- ***Click*** on "Calibration" followed by "Run" to start the calibration process.

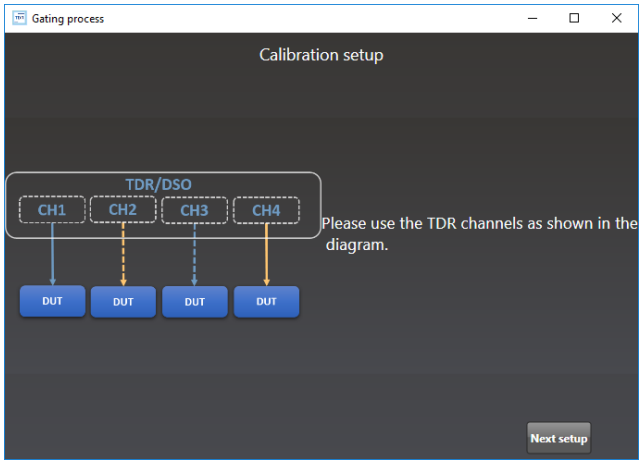

Figure 16 Calibration Wizard

- ***Disconnect*** the DUT and press "Next Setup".
- ***Connect*** the DUT from the near-end[1] and leave it disconnected from the far-end[2].

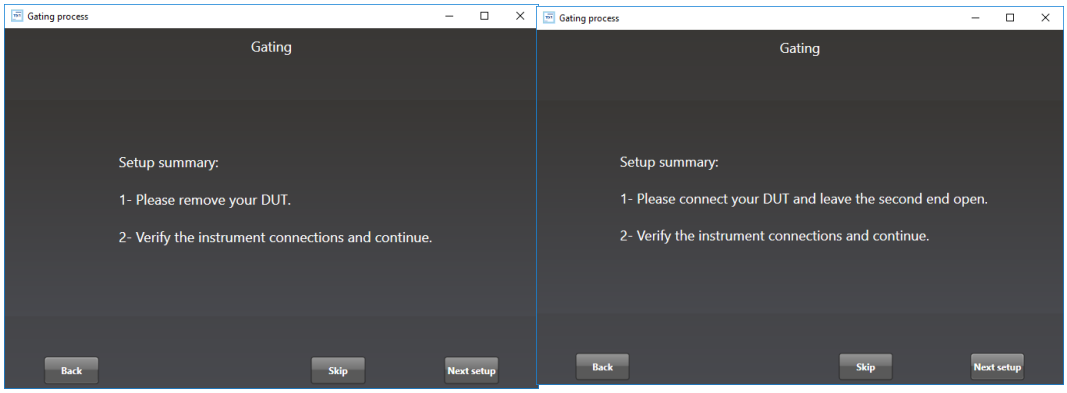

Figure 17 Gating setup

- ***Connect*** the DUT from the far-end and press "Confirm".
- ***The software automatically detects*** the rising edges and sets the markers. However, the user can manually change the markers' positions if needed. The first marker specifies the

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index of variation between the MCB1 curve and MCB1+DAC+MCB2 curve. The second marker specifies the index of variation between MCB1+DAC curve and MCB1+DAC+MCB2 curve.

Figure 18 Markers

- ***Apply Gating*** for effects to be saved.
- ***Close*** the page to exit the calibration wizard.

---

[1]***Near-end***: On the MCB connected to the TDR/Scope ports of the ML4035 (upper row).

[2]***Far-end***: On the MCB connected to the PPG ports of the ML4035 (middle row).

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Return Loss Measurement

Press ▶ to measure continuously or ⏭ for a single capture.

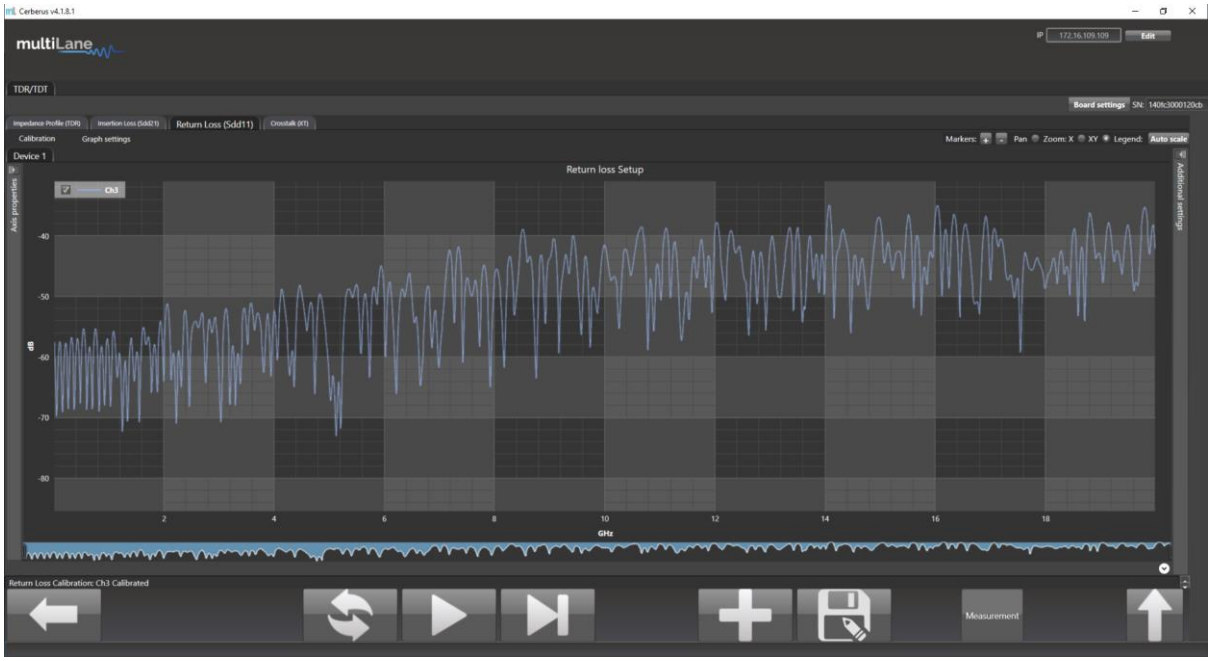

Figure 19 Return Loss Measurement

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.

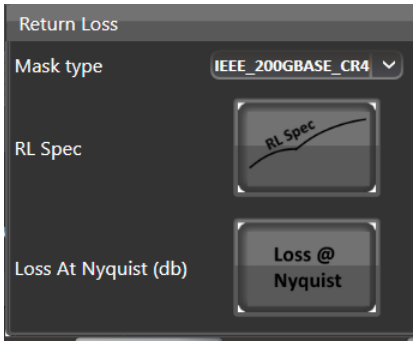

Figure 20: S11 Measurements

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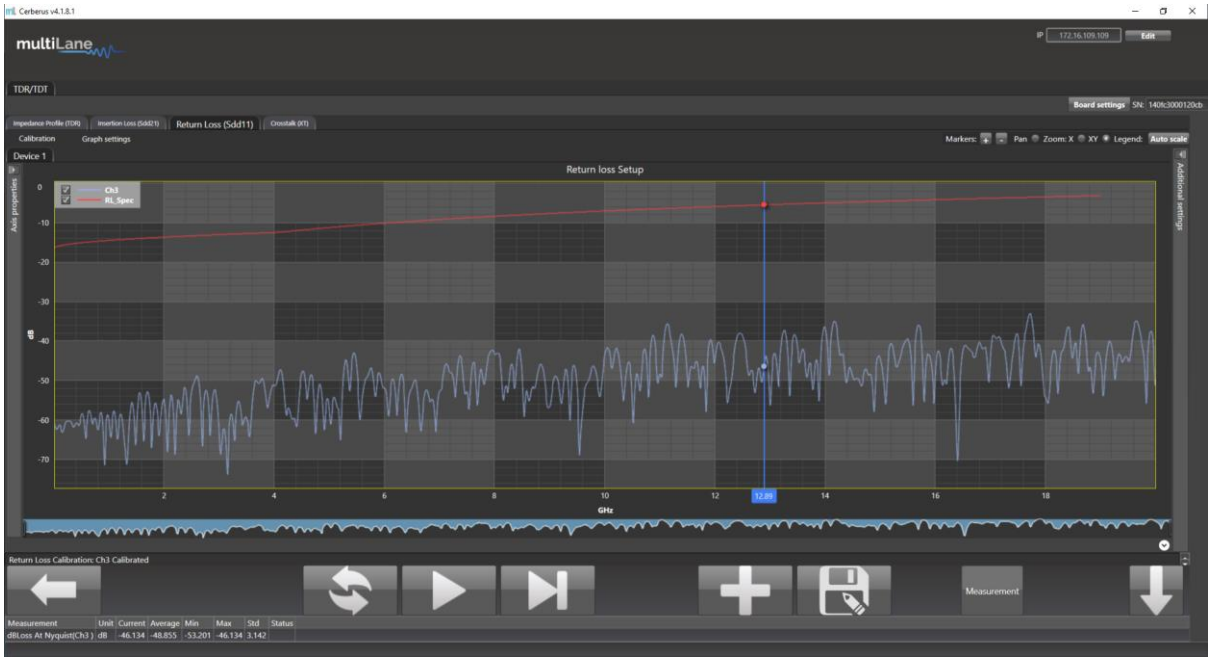

Figure 21: Return Loss Mask

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DSO Configuration Pane

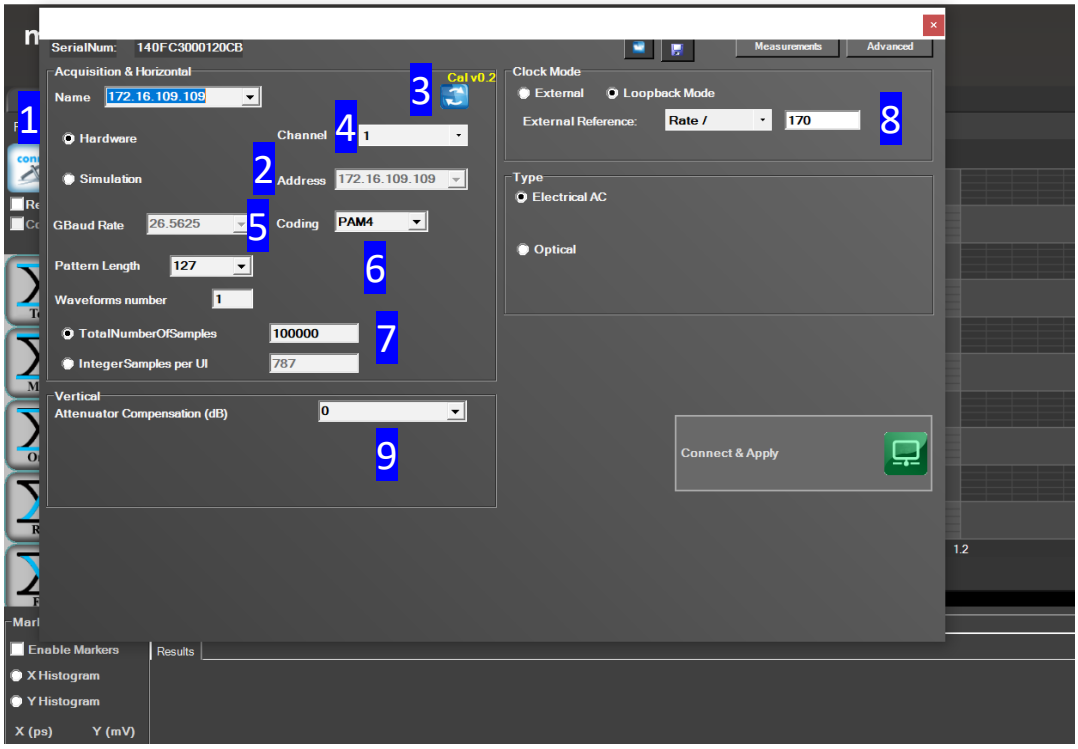

Figure 22: DSO configuration pane

Table 1: DSO configuration window

Item	Description
1	Connect button, opens the DSO config pane
2	Instrument IP address field
3	Click this to check the connection, and to load the latest valid settings for the hardware
4	Select the channel that you are using
5	Specify the bitrate of the signal to measure
6	This field has 2 values: NRZ and PAM4. It toggles the PAM measurements on or off
7	Total number of samples for the entire capture. This is limited by the instrument's memory depth. More samples give a higher definition of the signal but takes longer to capture and process
8	You need to specify as accurately as possible the input clock frequency of the DSO trigger in MHz
9	Compensate the attenuation introduced when an external attenuator is used

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DSO Configuration

The general DSO configuration pane settings are explained in Figure 22 and Table 1.

More settings are available under “Measurement Settings” as shown in Figure 23.

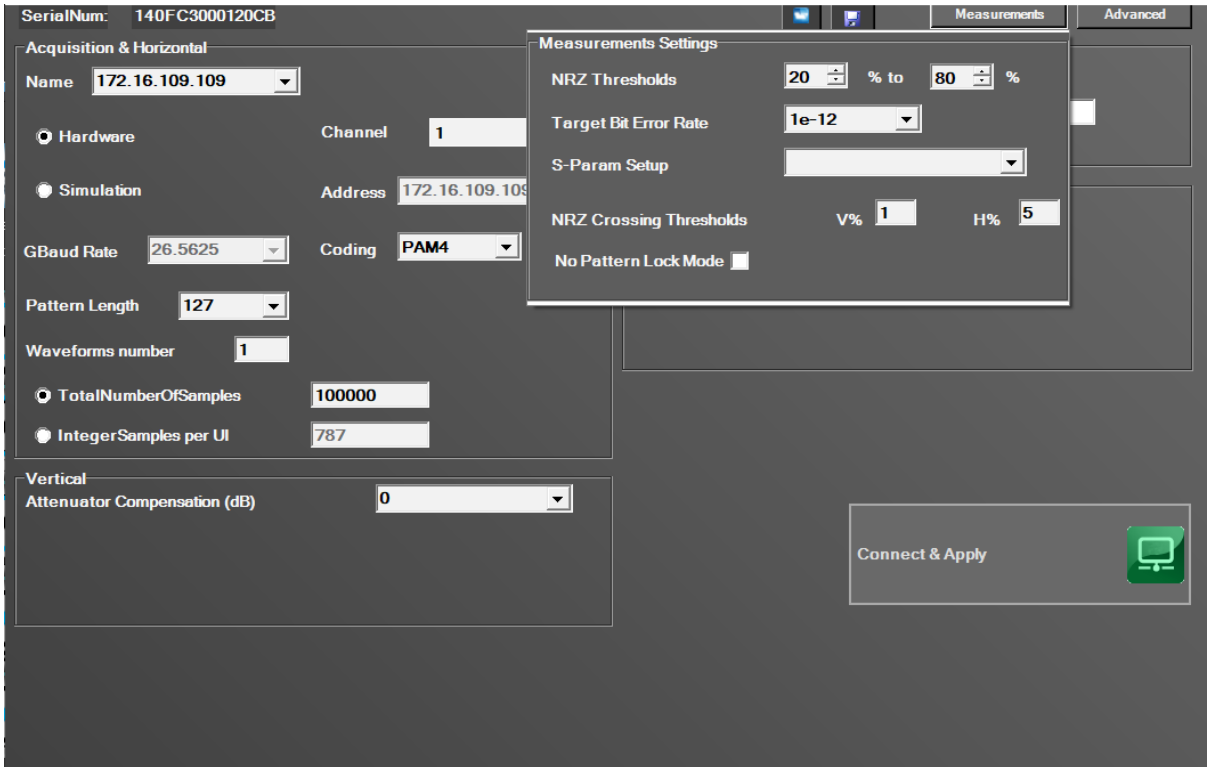

Figure 23: Measurement Settings Pane

Item	Description
NRZ thresholds	Are relevant for transition time measurements. Typical values are 10%/90% or 20%/80%
Target BER	Relevant for eye height and eye width measurements
S-parameter setup	For loading an S-param setup file
No Pattern Lock Mode	Will still show you raw data or noise even in absence of pattern lock

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Modes of Operation

The DSO offers different options to display the captured data as follows:

- ***Eye mode***: this is the typical eye diagram display of a sampling oscilloscope. All captured bits/symbols are stacked on top of each other. Eye mode works regardless of pattern lock
- ***Pattern mode***: this mode works only if you are locked to a pattern. It shows the train of bits. An example is shown in Figure 28.

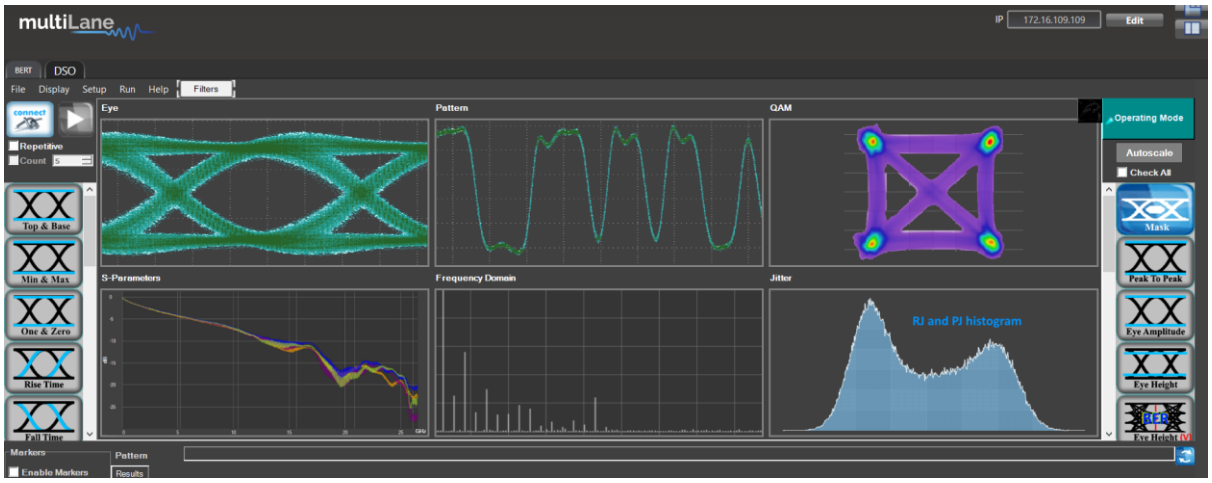

Figure 24: Modes of Operation

- ***QAM mode***: only relevant for hardware with coherent capture capability and where channels are grouped in pairs of I and Q. This mode is not available on the ML4035.

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- ***S-Parameters mode***: using this mode, you can accurately measure the insertion loss S21 or Sdd21 of a channel between source and DSO

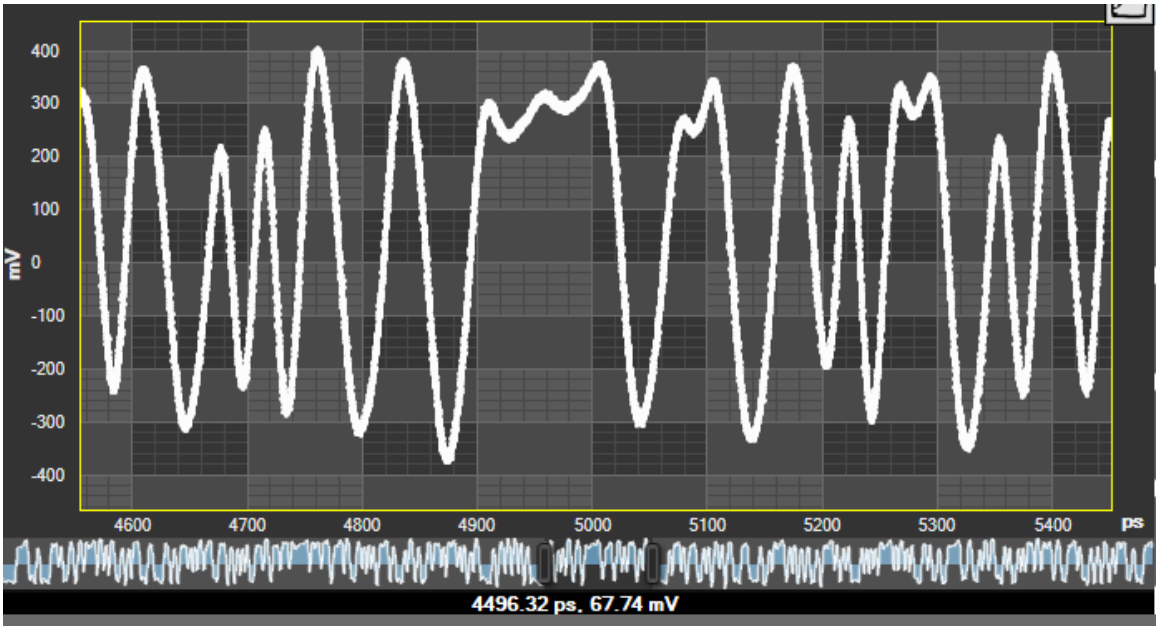

Figure 25: Pattern capture mode

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The DSO Software comes loaded with useful filters that offer a variety of features from cleaning the signal, to de-embedding, or discovering the optimal taps for improving an NRZ or PAM4 signal. Filtering GUI can be used to adaptively detect the minimum number of FFE or DFE taps required for reaching a specific target Eye Height or SNR.

Bessel Thomson

Procedure

- Click on **"Filters"**.
- Choose **"Bessel Thomson"**.
- Set the filter order.
- Set the percentage of BW.
- Save.

Effects

- Reduces high frequency noise.
- Acts like a low pass filter.

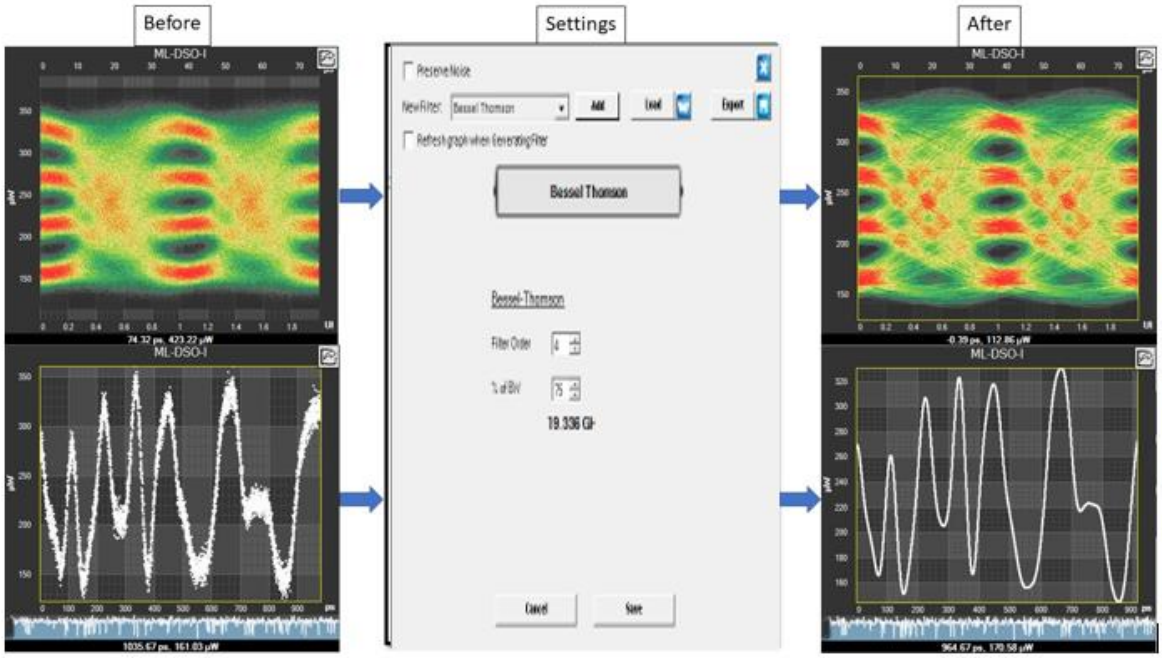

Figure 26: Bessel Thomson Filter

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CTLE

Procedure

- Click on **“Filters”**.
- Choose **“CTLE”**.
- Set the gain.
- Save.

Effect

- Boosts high frequency content.

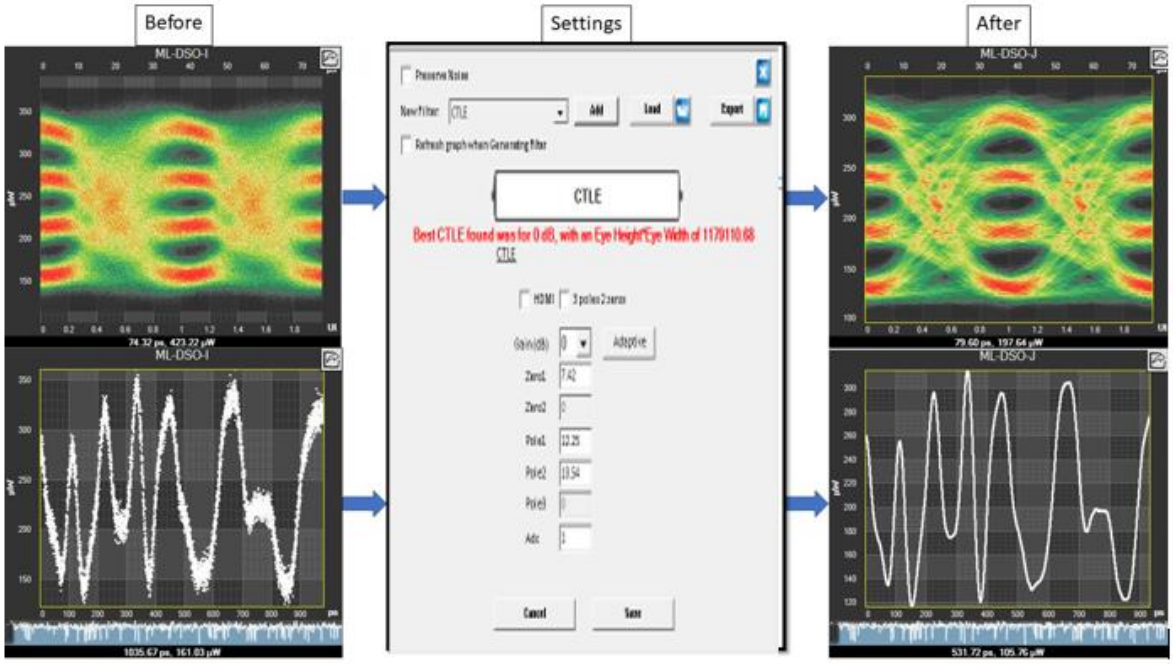

Figure 27: CTLE Filter

De-Embedding Filter

Procedure

- Click on **“Filters”**.
- Choose **“De-Embedding”**.
- Click on de-embed or embed.
- Load an S-Parameters file.
- Save.

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Effect

- Removes cable losses.

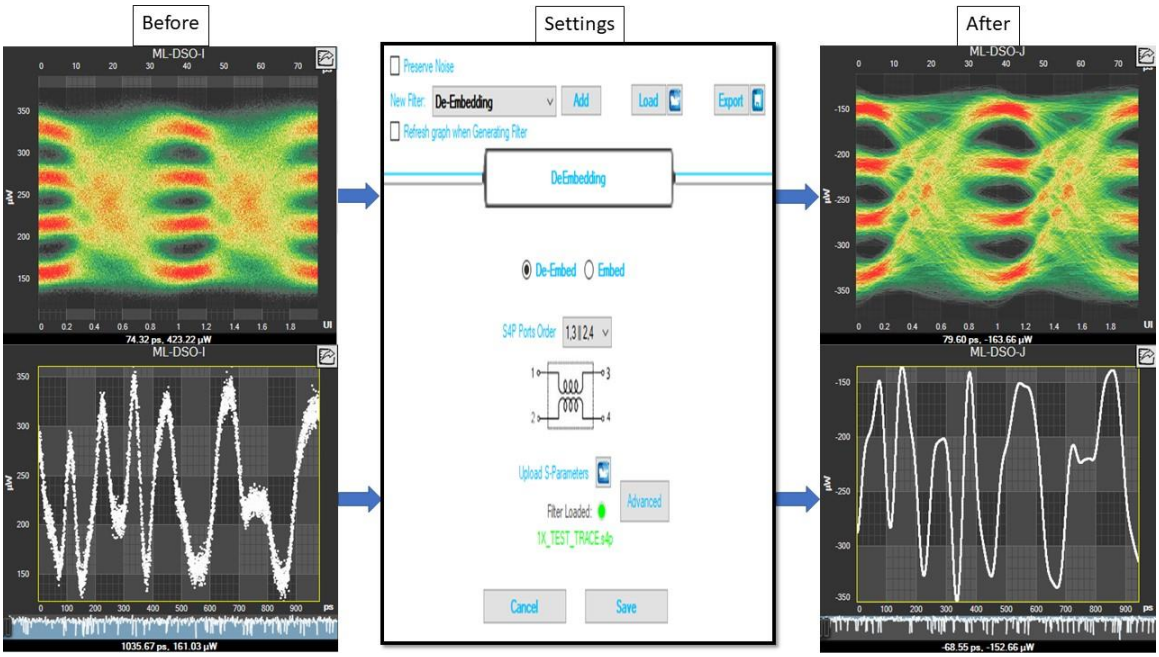

Figure 28: De-Embedding Filter

DFE Filter

Procedure

- Click on **"Filters"**.

- Choose **"DFE"**.
- Set the clock delay.
- Set the number of taps.
- Generate.
- Save.

Effect

- Decision feedback equalizer for fading channel equalization.

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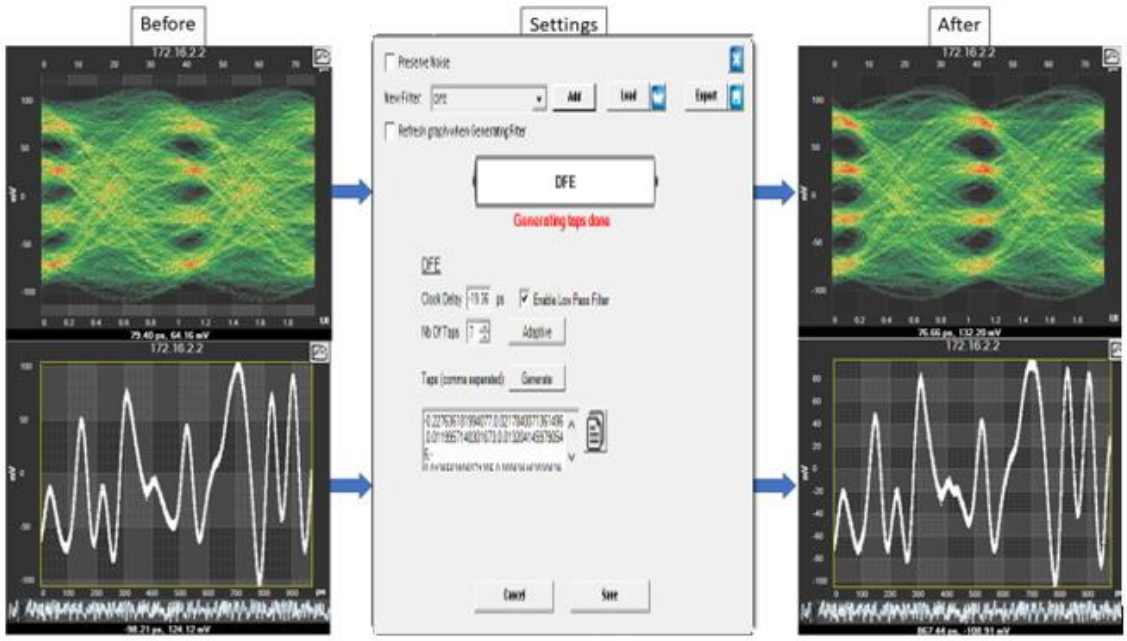

Figure 29: DFE Filter

FFE Filter

Procedure

- Click on **“Filters”**.

- Choose **“FFE”**.
- Set the tap delay.
- Set the number of taps.
- Generate.
- Normalize.
- Save.

Effect

- Feedforward equalizer.

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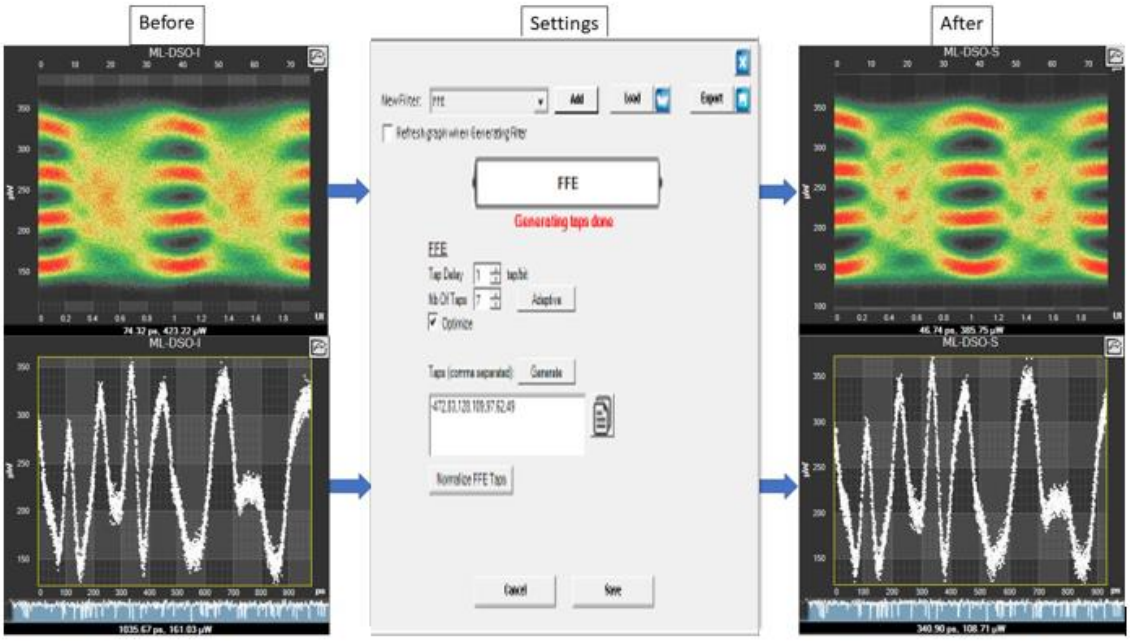

Figure 30: FFE Filter

Moving Average Filter

Procedure

- Click on **“Filters”**.
- Choose **“Moving Average”**.
- Set the smoothing window.
- Save.

Effect

- Averaging / Smoothing.

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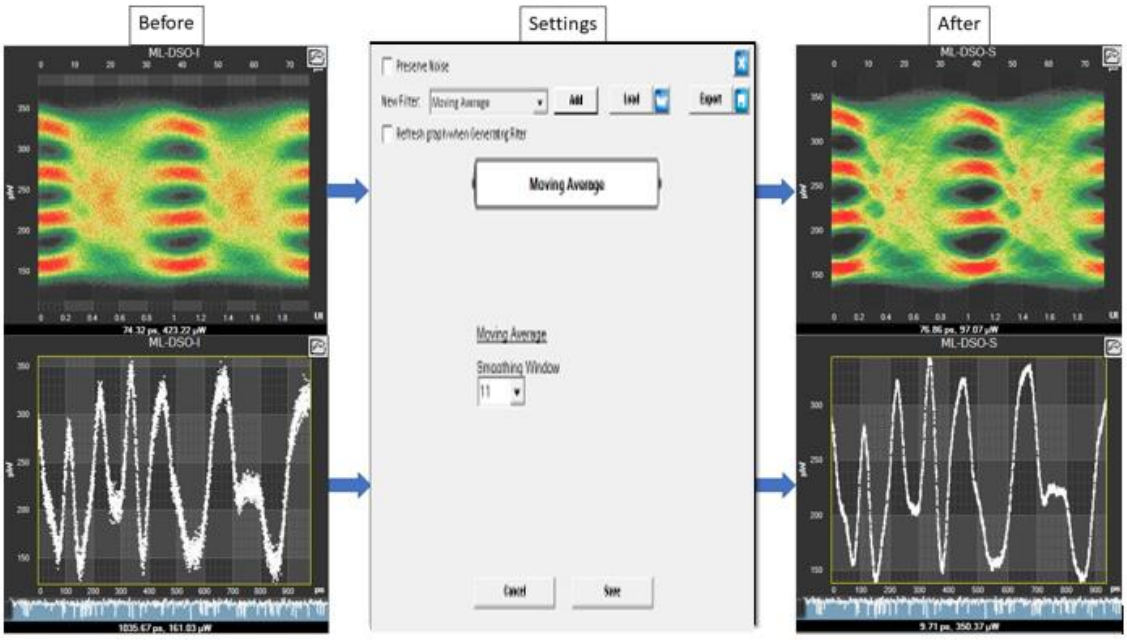
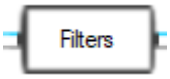


Figure 31: Moving Average Filter

Normalizing Filter

Procedure



- Click on **"Filters"**.
- Choose **"Normalizing Filter"**.
- Generate filter.
- Save.

Effect

- Normalizes the channel.

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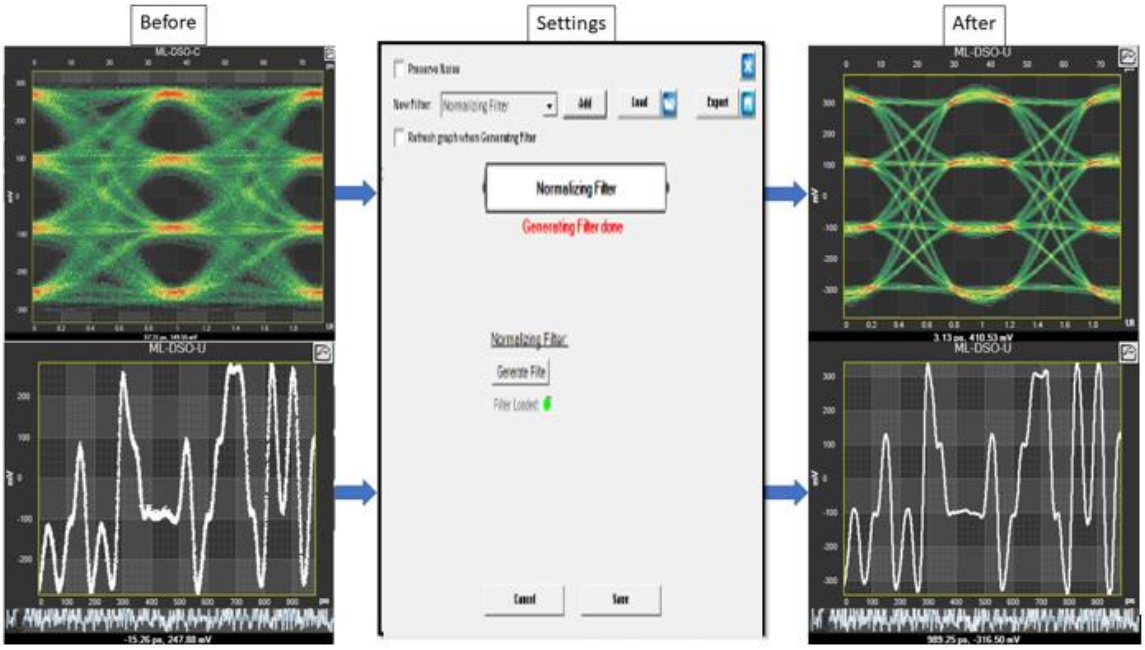

Figure 32: Normalizing Filter

Multiple Filters

Procedure

- Click on **"Filters"**.
- Choose first filter (ex: FFE).
- Save.
- Choose second filter (ex: Bessel Thomson).
- Save.

Effect

- Add the effects of multiple filters at once.

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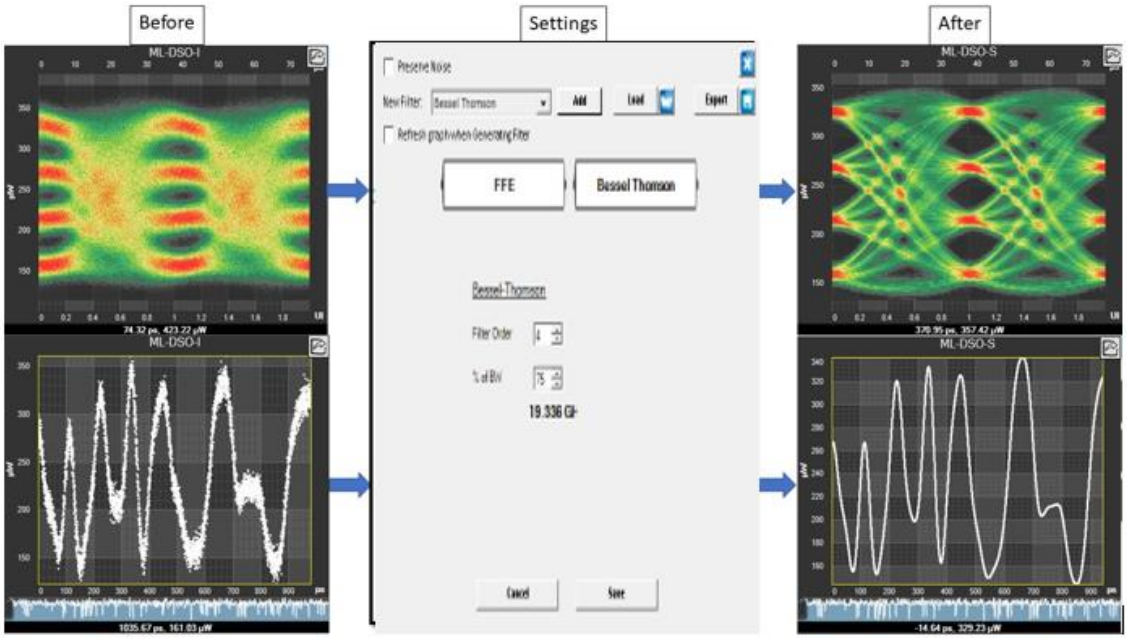

Figure 33: Multiple Filters

Filter + Preserve Noise

Procedure

- Click on **"Filters"**.
- Choose a filter in which preserving noise is applicable (ex: Bessel Thomson).
- Check the **"Preserve Noise"** box.
- Add the preserving noise percentage.
- Save.

Effect

- Preserves noise.

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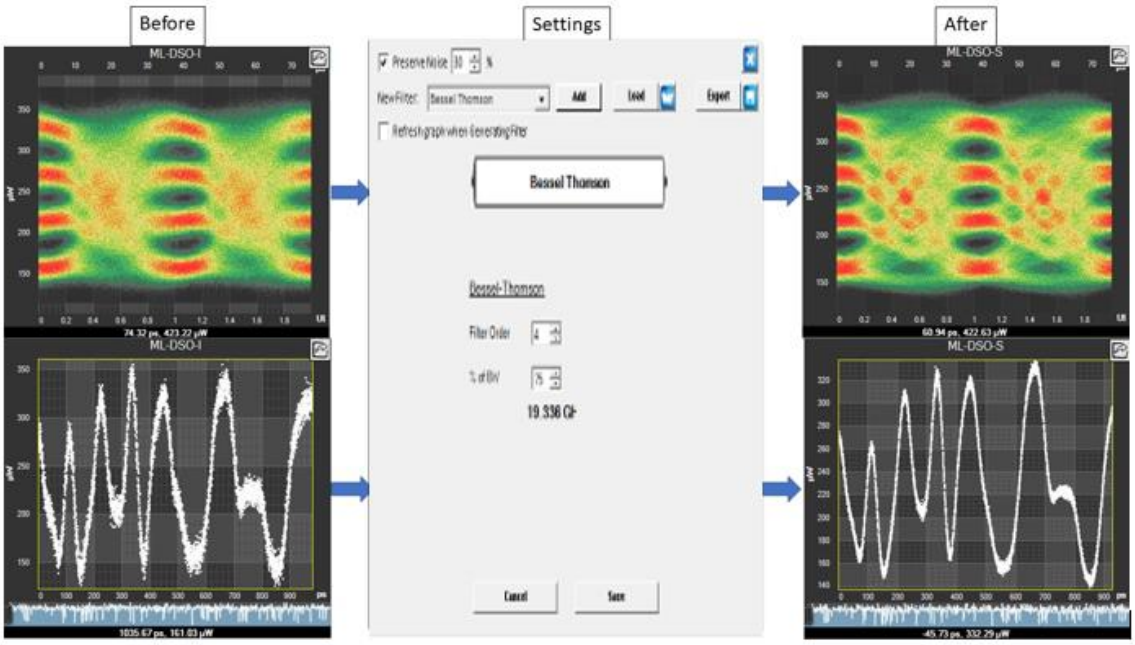

Figure 34: Filter + Preserve Noise

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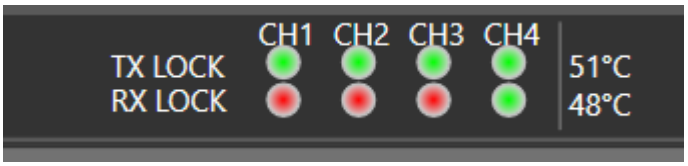
GUI Overview

Figure 35: ML4035 BERT GUI

In your instrument's GUI, there are several control fields that are each explained below.

PLL Lock and Temperature Status Field



Keep an eye on the LEDs and temperature readings in this field. TX Lock means that the PLL of the PPG is locked. RX lock goes green only if a signal of correct polarity and PRBS length is detected on the error-detector.

If the temperature reaches 65C, the electronics will power-off automatically.

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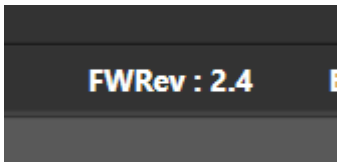
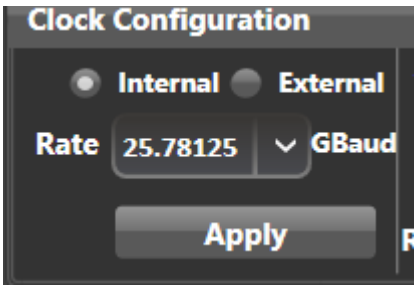
Reading the installed Firmware Revision

The installed firmware version is displayed in the upper right corner of the GUI.



Line Rate Configuration (Applies to all channels at once)



This is where you set the bitrate for all 4 channels. You can also select the clock input. The clock is internal by default. You should only change to external clock feed in when you need to synchronize two or more ML4035s to each other in a slave-master fashion; In that case you connect the clocks in daisy chain. After changing from internal to external clock and vice versa, “Apply” must be clicked for changes to take effect (this takes a few seconds).

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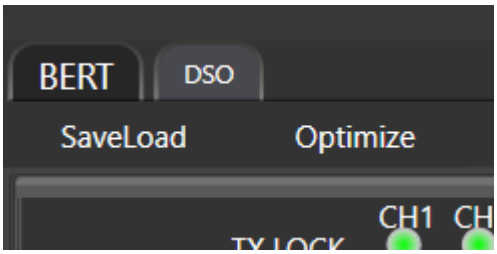
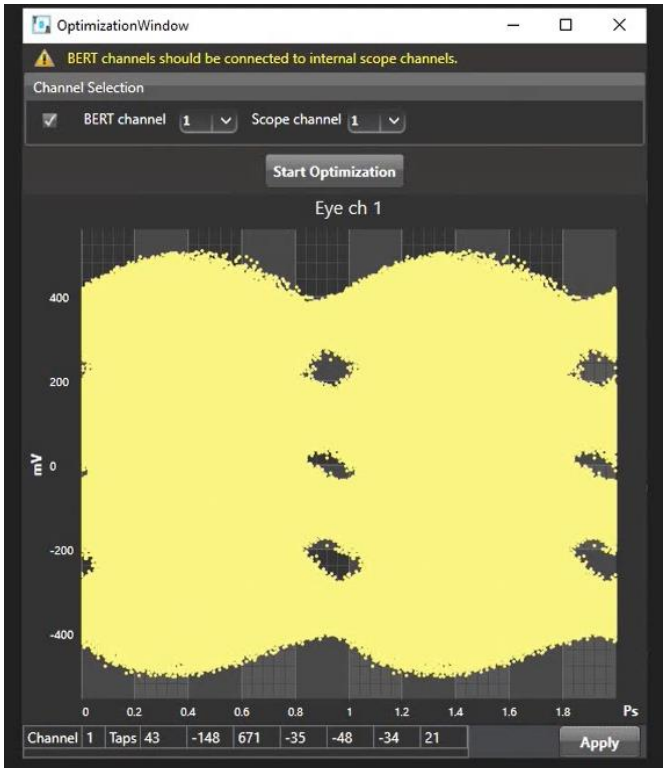
Tx Optimization

It is possible to optimize the Tx signal automatically using the “optimize” button.



To Automatically generate FFE taps and optimize the Tx signal, connect the DSO channels in the DSO Window then click on optimize in the BERT window. If 7 taps are enabled, the software automatically generates 7 taps FFE, else 3 taps FFE are generated. Note that the user can select which BERT and DSO channels are connected to the DUT, making different Tx and CH combinations possible.



After clicking on **Apply,** the software loads the taps in the Amplitude section.

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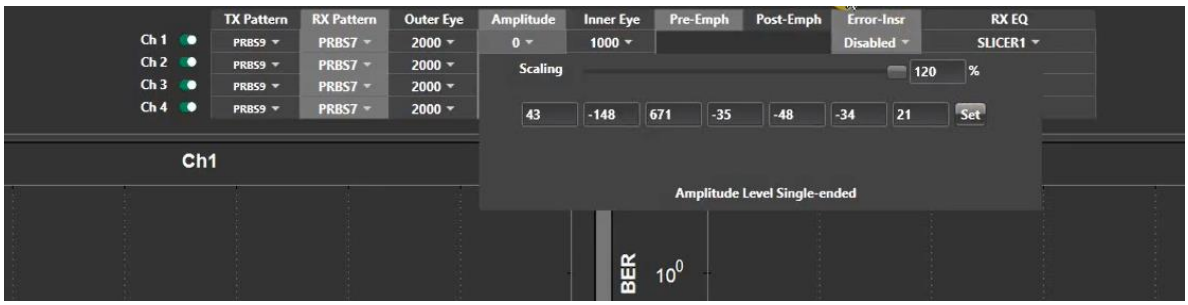
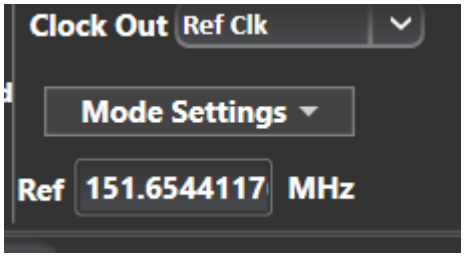
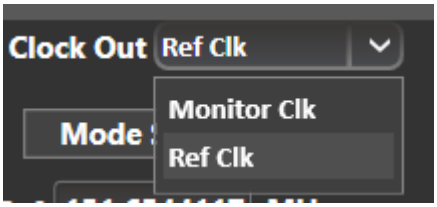


Mode & Clock Out Settings (Apply to all channels at once)





The “Ref” denotes the frequency of the clock output. This is a function of the bitrate and will vary according to your clock-out settings under the “Mode” menu. Knowing the clock frequency being output by the BERT is helpful when you are trying to trigger an oscilloscope. Some oscilloscopes require a clock frequency above 2 GHz. To get this output from the ML4035,, Monitor Clk should be selected from the Clock Out drop down list. Choose the denominator so that the result is within the scope range.

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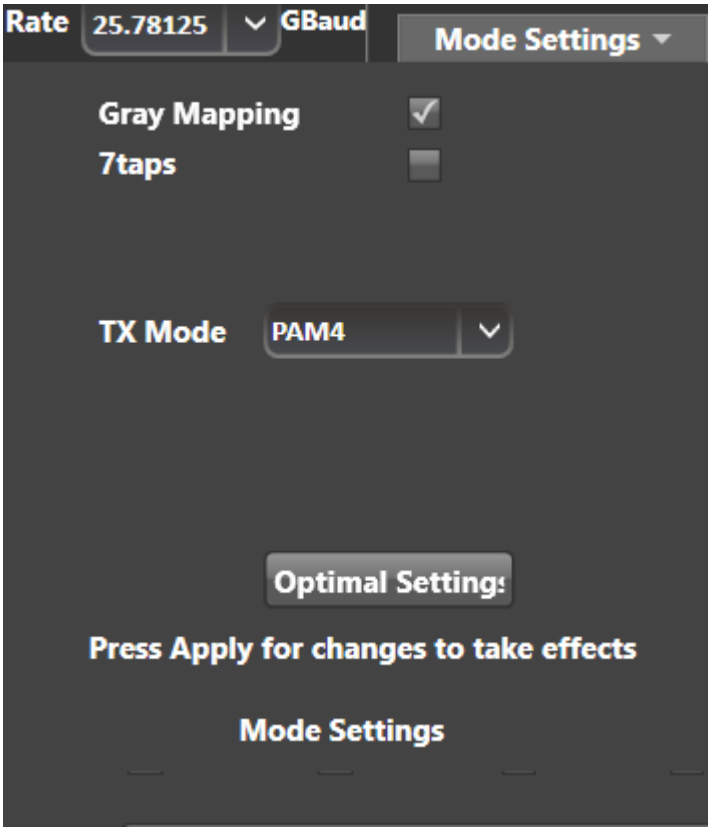

To switch between NRZ and PAM-4 coding, select it from the Mode Settings drop down list, then click Apply.

The option Gray Mapping is only available in PAM4 mode.

Gray Mapping enables use of PRBSxxQ defined in IEEE802.3bs. When Gray mapping is enabled, the PRBS13 and PRBS31 under the pattern select menu turn into PRBS13Q and PRBS31Q respectively. Gray mapping basically re-arranges the symbol mapping to the following:

00 → 0

01 → 1

11 → 2

10 → 3

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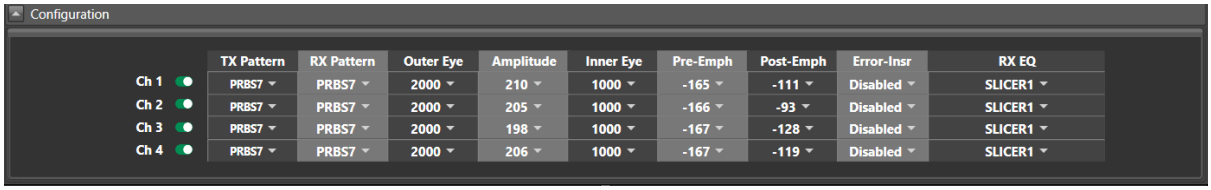
Transmitter and receiver settings



You can adjust these settings on a per channel basis. These are:

PRBS

The ML4035 can output a wide range of pre-defined patterns. The user can select standard pattern, jitter test or custom pattern.

Note: error detection only works on the standard PRBS patterns existing in the RX pattern drop down list.

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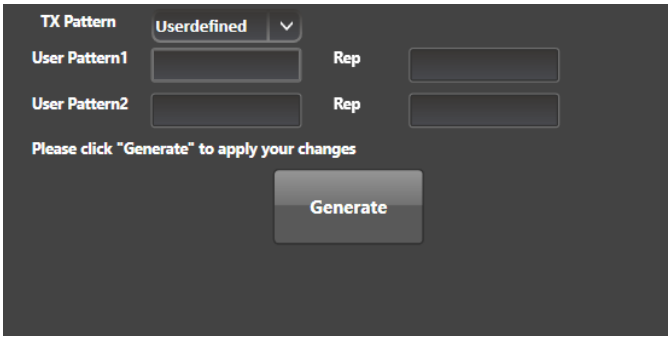
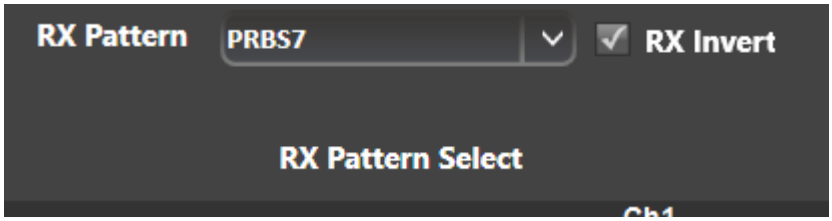
User-defined Pattern



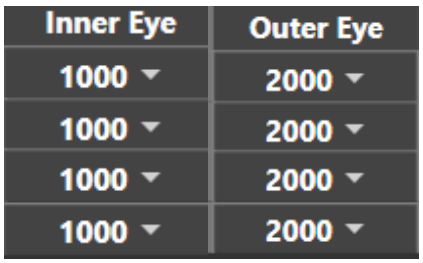
The custom pattern is made up of 2 fields with 16 hexadecimal characters each. Both must be filled with 32 Hex characters.

In PAM4 Gray-coding, there are 4 levels: 0,1,2 and 3. Each of these levels corresponds to a binary sequence respectively 00,01,11,10. If the user wants to transmit a user defined pattern with Gray mapping enabled, first, the pattern should be converted from Gray Mapping to binary, then to HEX.

For example: 0123 in Gray Code is 00 01 11 10 in Binary. Converting 00011110 to Hex gives 1E.



Select the RX pattern from the dropdown menu. In order to lock to the signal, TX & RX patterns must be the same length & polarity. If not connected correctly, polarity can be inverted by checking "RX Invert"



Inner and Outer eye level controls trim the high and low values of the middle PAM eye.

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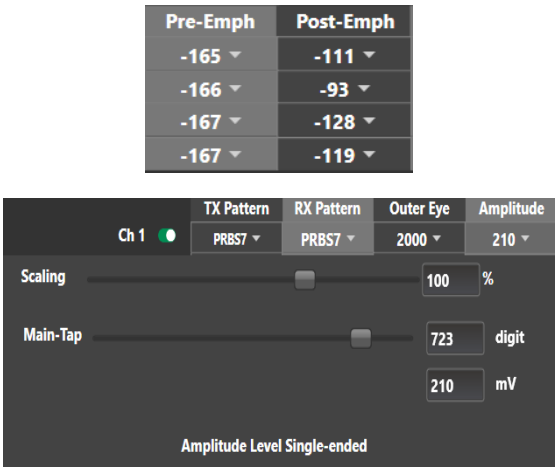
Possible control values range from 500 to 1500 for the inner eye control and from 1500 to 2000 for the outer eye. Optimal values are typically in the middle of the range. Example of tweaking the Outer eye settings is shown below

Amplitude Settings



By default, three taps are shown and can be edited. The pre and post emphasis taps are displayed in the configuration window. The main tap is under Amplitude.

Think of the amplitude as a digital equalizer with main tap, pre-cursor (pre-emphasis) and post-cursor (post-emphasis). In the regular case, pre- and post-cursors are set to zero; the amplitude is controlled using the main tap. This is also the case during factory calibration. The main, pre- and post-taps use digital values ranging between -1000 and +1000. Increasing and decreasing the pre and post cursors will also affect the amplitude; therefore, you should enable constant Vpeak if you wish to maintain the swing level while changing pre- or post-emphasis. Alternatively, please ensure that the sum of pre-, post and main cursors is equal to 1000 to have optimal performance. If the sum of taps exceeds 1000, linearity of the TX signal cannot be maintained.

Note that the amplitude reading in mV will only be accurate if the pre- and post-cursors are zero. Do not confuse the amplitude in mV with the digital value of the Main Tap slider labeled “digit”. The “digit” changes between -1000 and +1000 while the amplitude in mV can only be positive

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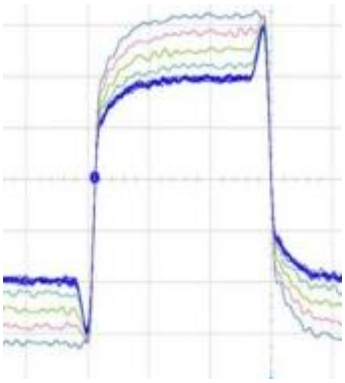
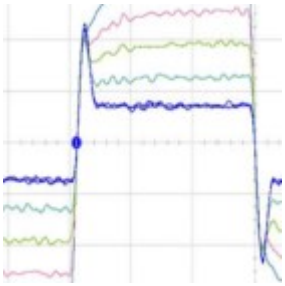
Scaling

changes the scale of the entire signal in steps of 10% while maintaining the pulse shape.

Pre-cursor effect on a pulse:



Post-cursor effect on a pulse:



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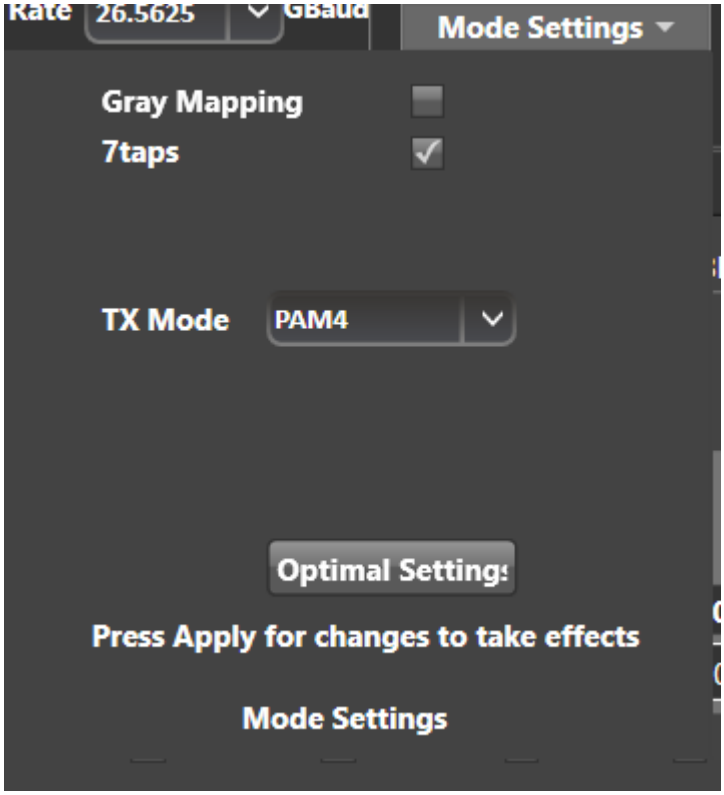
7 Taps Settings



The user can also edit a 7 taps coefficients instead of just 3 taps by clicking on mode settings and then checking the box of 7taps ☑.

After applying the settings, a new section with 7 taps will appear.

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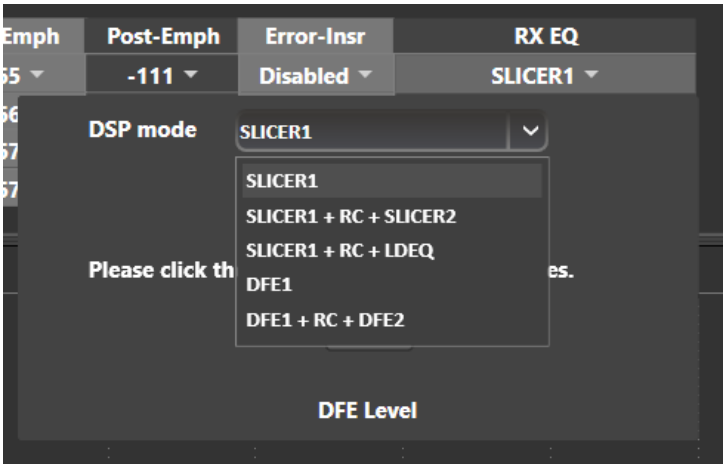
RX Equalization



Note: anytime you select an equalizer, the BERT automatically goes into a soft-reset before coming up again with the new re-calculated equalizer optimal settings for the channel at hand. This process takes about 3 seconds and is very useful to force the BERT to re-evaluate its receiver equalization settings and re-adjust its gain and taps.

SLC1 and SLC2 are slicer blocks that compare the FFE output to their decision thresholds. These thresholds are adaptive. SLC1 is the default equalizer.

LDEQ is a Level Dependent Equalizer, used to equalize the 2 inner-levels of the PAM4 eye. Optional

RC is a Reflection Canceller to compensate for group delay distortion.

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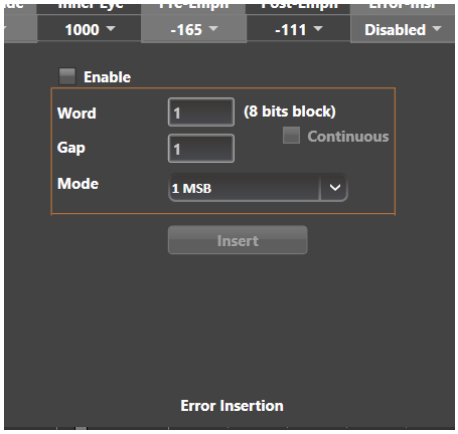
Error Insertion



Error insertion is carried out on a block-by-block basis. Each block is 64 bits, divided into 32 MSBs and 32 LSBs.

Example Inner and Outer setting Effect

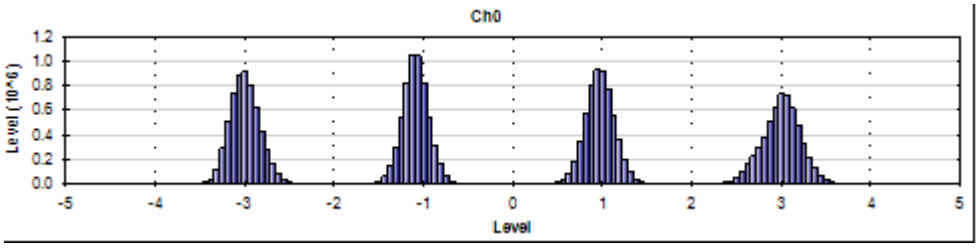


Figure 36: Default Inner and Outer settings of 1000 and 2000

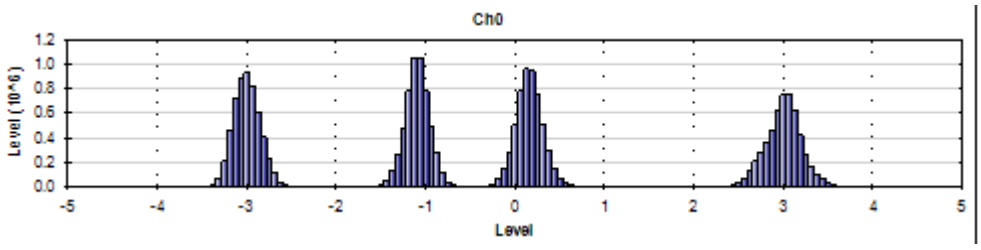


Figure 37: Outer Eye is set 1600; Inner eye kept at 1000

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Bit Error Ratio Reading

To be able to start BER measurements, the instrument ports should be in loopback mode, which means TX port should be connected to the RX port and the PPG and ED patterns should match. One does not necessarily need to supply a PRBS from the same physical instrument – the source can be a different instrument and the error-detector of the ML4035 can derive its own clock from the received data (no need for a separate clock link). However, if Gray coding is used in the source, one should tell the receiver to expect Gray coding as well. If there is a match in pattern, polarity and coding but still no lock, there could be an MSB/LSB swap on one side.

BER Control

Real time BER

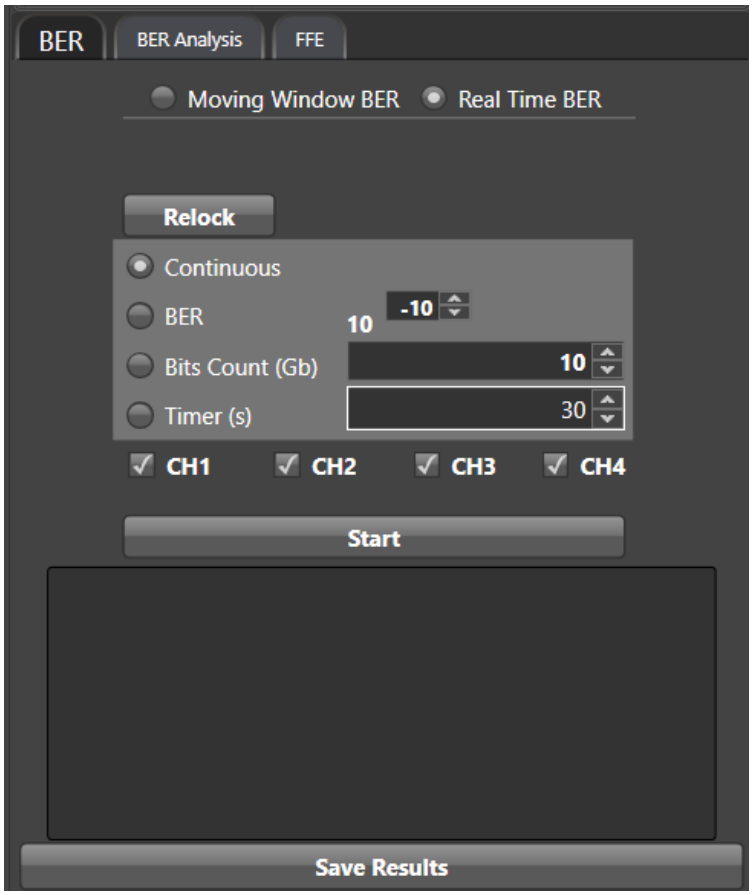

Figure 38: BER Control panel

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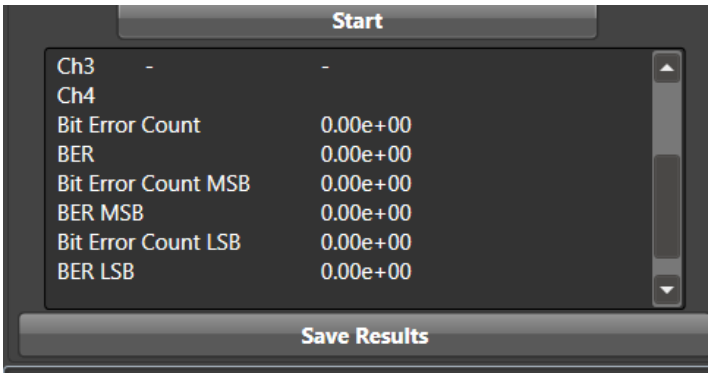
A BER measurement can run in continuous mode and will not stop until the user intervenes and clicks the stop button. BER can also be set to run until a target value is reached or until a certain number of bits has been transmitted (units of 10 gigabits). The Timer lets the user set a time for the BER to stop.

Moving Window BER

Moving window BER measures the BER at each 500 ms time interval instead of continuously averaging it.

BER Table of Results

The summary of BER measurements is shown in the following pane:



BER Graph

Plots BER values collected on the graph

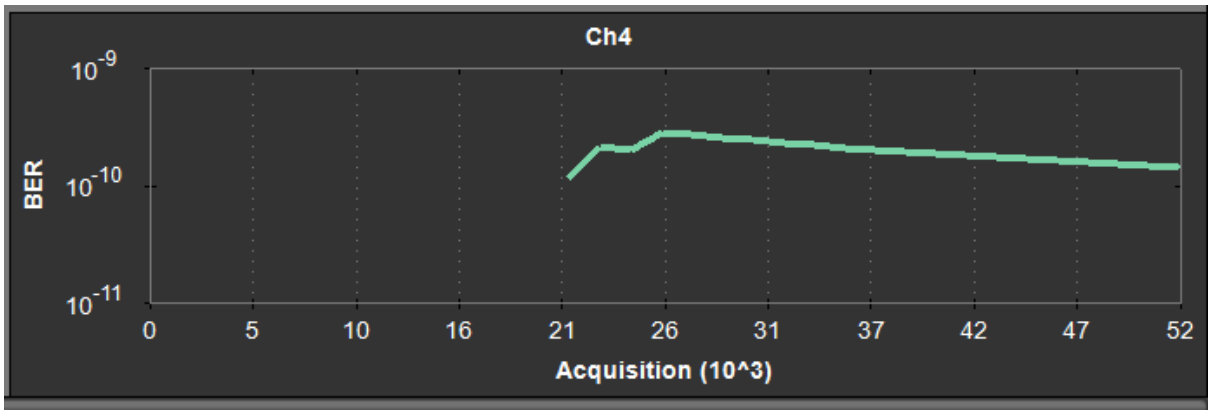


Figure 39: BER Graphs

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Signal to Noise Ratio Analysis

SNR is a quantitative way to measure the strength of the received signal in dB.

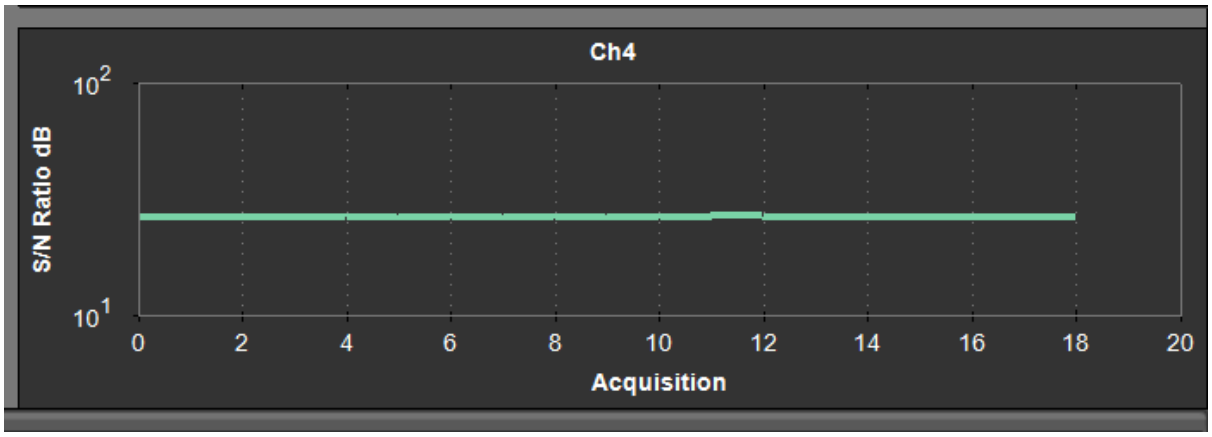

Figure 40: SNR ratio for PAM signal

Log file System

In the ML4035 BERT there is a log file system, where every exception handled or unhandled by the GUI will be saved. After the first run, the GUI creates a file in the main directory/exception log, and saves all the existing exceptions. The logs file can be requested by Multilane team for debugging purposes.

Note: the exception file will be deleted automatically after every 1 week of work.

Saving and Loading Settings

The instrument always saves the last used settings in non-volatile memory. These settings are automatically restored the next time you connect to the BERT. In addition, you can create and save your own set of setup files and can revert to them when needed. Look for the Save/Load menu in the menu bar of the GUI.

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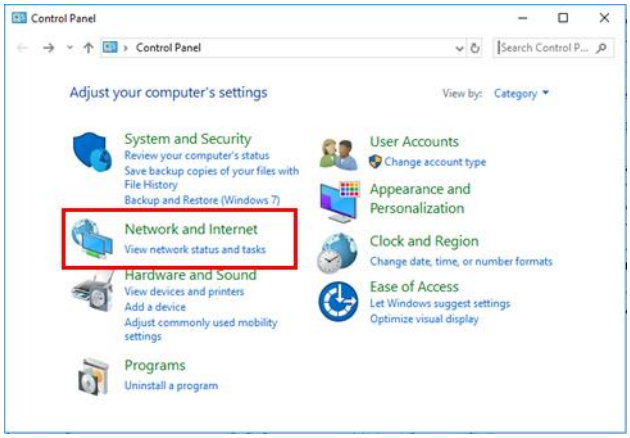
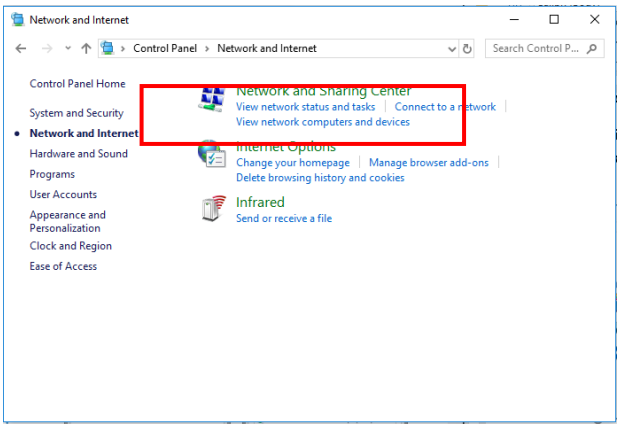
Appendix 1 – Adding the ML4035 to the Network

To create a local network connection, please follow these steps:

- ***Create a local network connection*** between the laptop and the ML4035 using Internet Protocol Version 4 (TCP/IPv4).
  - ***Open*** *"Control Panel"* and ***choose*** "*Network and Internet*".
  - ***Open*** *"Network and Sharing Center".*



- ***Click on*** *"Change Adapter Settings"*, then ***choose*** *"Local Area Connection"*.



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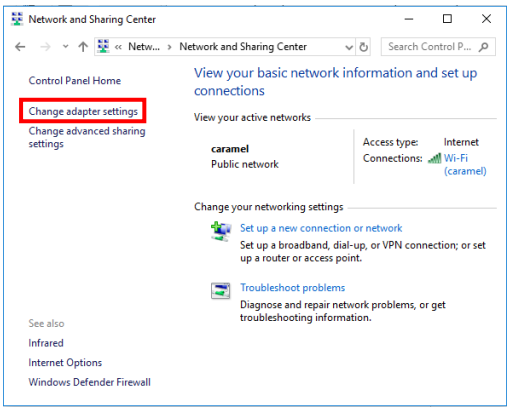
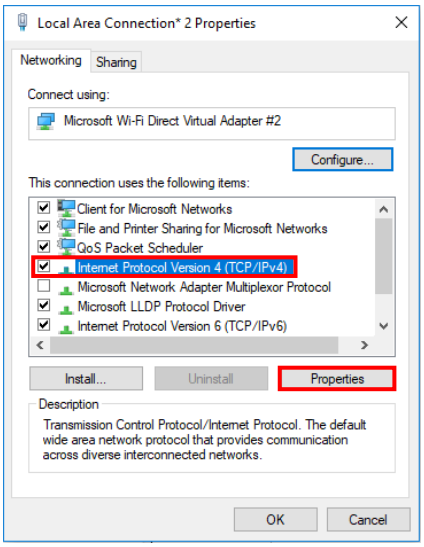
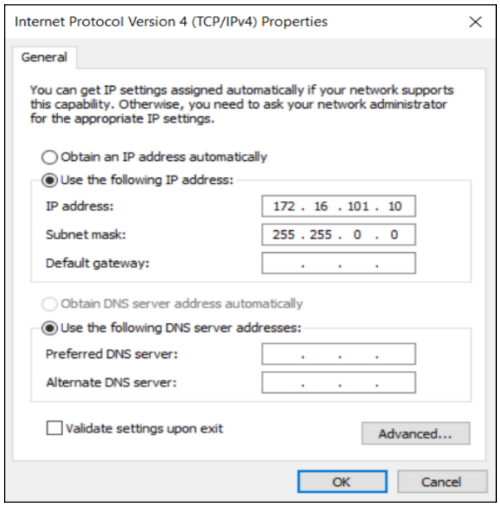
- In the Networking Tab, ***click on*** *"Internet Protocol Version 4 (TCP/IPv4)"* then *"Properties"*.





- ***Add a similar IP Address*** that shares a subnet with the instrument IP in the Advanced tab.
  This will be used to ping the instrument once the IP Address is changed to match that of the network.
- ***Connect the laptop*** directly to the ML4035 using an Ethernet cable.
- ***Copy the IP Address*** found on the back of the unit.
- ***Ping the device*** to make sure that the connection is successful.
- Now a new local network has been successfully defined.



NOTE: steps are illustrated using Windows 10. Kindly note that previous versions of Windows have a similar procedure with slight differences in tabs or folders' names.

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Appendix 2 – Changing the IP Address to Suit a Corporate Network

Multilane does not recommend changing the IP address of the instrument. However, this appendix will detail the steps for each operation.

Before starting the IP address change operation, kindly contact IT department/support. User should be provided an available IP on the network. If the IP is the same as another device on the network, the user can ping the device but will not be able to use it.

IP Address Changing on ML4035

In order to change the IP address of the ML4035 LaneControl is used.

North America

48521 Warm Springs Blvd. Suite 310

Fremont, CA 94539

Worldwide

Houmal Technology Park

Askarieh Main Road

Asia

14F-5/ Rm.5, 14F., No 295

Sec.2, Guangfu Rd. East Dist.,

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