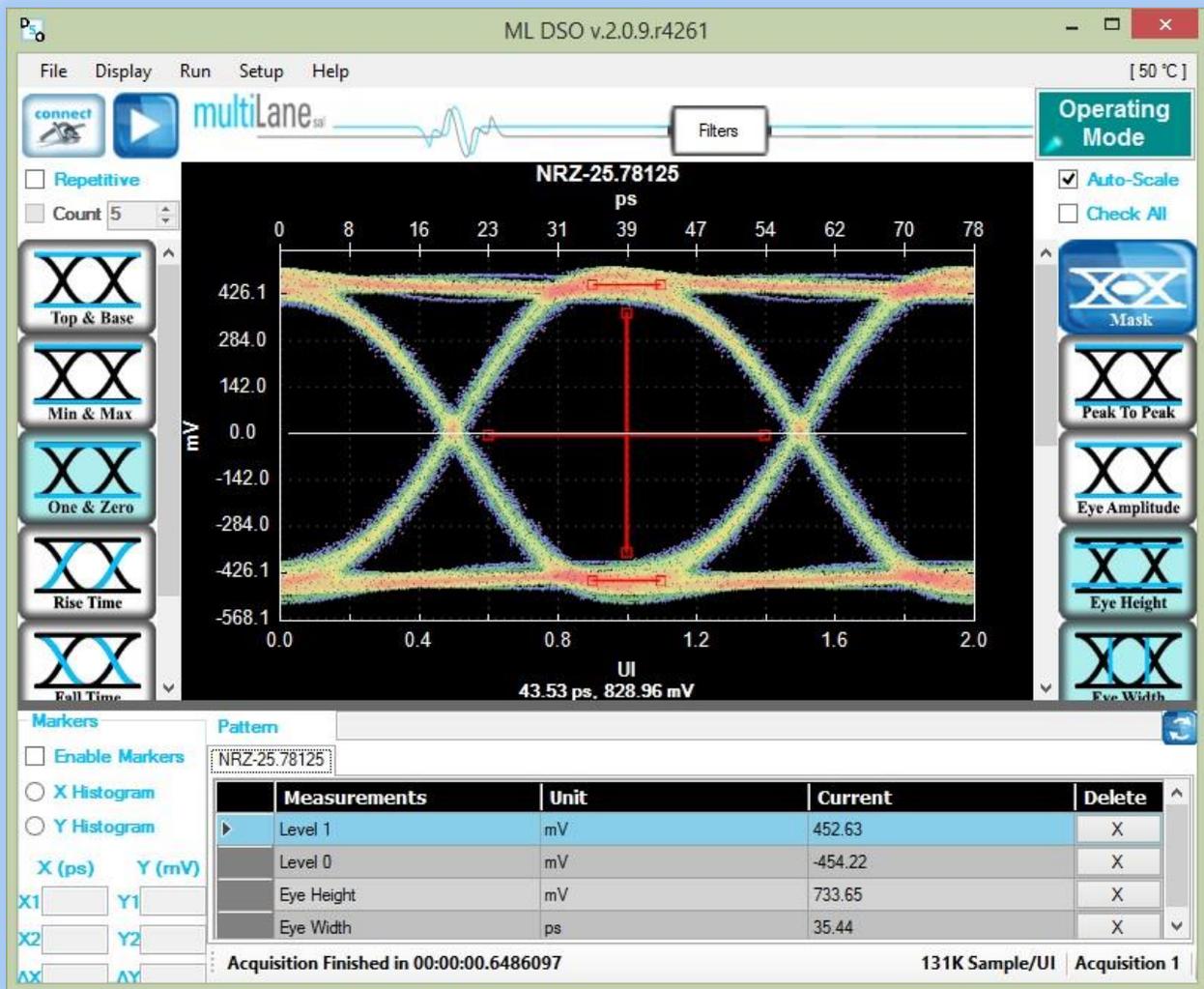


ML-DSO User Manual

www.multilaneinc.com



User Manual Rev 2.0.9
Firmware Rev 3.2
GUI Rev 2.0.9

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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 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.*



Symbols on the Product

The following symbols appear on the product:

CLK: SMA Clock input

INN: SMA Negative Data Input

INP: SMA Positive Data Input

Preface

This is the user manual for the **ML-DSO**. It covers the following information:

- Describes the capabilities of the instrument: how to install it and its software
- Explains how to operate the instrument for: Pattern generation, Error Detection; how to control the clocking system, inputs/outputs and all the available measurements
- Lists the specifications

Power Requirements

| <i>Parameter</i> | <i>Symbol</i> | <i>Condition s</i> | <i>Min</i> | <i>Typ</i> | <i>Max</i> | <i>Units</i> |
|---|---------------|------------------------|------------|------------|------------|--------------|
| External + 5V supply | | External | | 1.5 | | A |
| The Typical power dissipation for the ML-DSO is 7.5W; the module can be powered externally from an external source 5V/1.5 A. through a power jack. | | | | | | |

Ordering Information

| Order Information | |
|--|--|
| Order No. | Description |
| ML4006 | Single Channel DSO |
| ML4005 | Single Channel DSO with optical receiver |
| ML4025 | 4-Channel DSO |
| <ul style="list-style-type: none"> • Standard Warranty - 1 Year | |
| <i>For more information on this or other products, contact Multilane sales team by email at sales@multilaneinc.com</i> | |

For more information on this or other products contact MultiLane sales team by email at sales@multilaneinc.com.

Glossary of Terms/ Acronyms

BW: Bandwidth

NRZ: Non Return to Zero

DUT: Device under test

SONET: Synchronous Optical Networking

SOC: System On a Chip

PCIe: Peripheral Component Interconnect Express

SATA: Serial Advanced Technology Attachment

PAM4: Pulse Amplitude Modulation

Optical Reference Receiver: 12G Wideband Optical Reference Receiver, MultiLane's product

Sim: Simulation

Conf: Configuration

PRD: Product Requirements Documentation

HW: Hardware

FW: Firmware

SW: Software

RF: Radio Frequency

Gbps: Gigabits per second

P.C. Mode: Pattern Capture Mode

GUI: Graphic User Interface

THD: Total Harmonic Distortions

MultiLane SAL Contact Information

MultiLane SAL 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 6,000sq 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 customer's 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 SAL'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 Lebanon |
| Web site | 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.

Product Description

- *Installation* shows you how to configure and install the instrument, as well as how to install the system software included with the product.
- *Incoming Inspection* provides a procedure for verifying basic operation and functionality
- *Accessories and Options* lists the instrument options available and the standard and optional accessories for this product.

Overview

The **ML-DSO** Digital Sampling Oscilloscope (DSO) is a fully integrated, ultra compact (**Smartphone size**), USB/ Ethernet controlled instrument that automatically performs accurate Eye-diagram and Pattern Capture analysis to characterize the quality of transmitters and receivers, interconnecting with a 32GHz input BW. It is operational under Windows and Linux.

The **ML-DSO** implements a statistical under-sampling technique with comprehensive software libraries for eye measurement, jitter analysis and processing of NRZ data enabling:

- Eye measurements, with 4 classes of operation:
 - Oscilloscope Measurements
 - NRZ Measurements
 - PAM4 Measurements
 - Multiple measurements
 - Mask Test
- Advanced Pattern acquisition with Pre-emphasis measurements.
- Jitter Components Decomposition
- Filtering
- S-Parameter Generation & De-Embedding
- Frequency Domain Plot and Total Harmonic Distortions

Key Features

- Low cost instrument grade sampling scope optimized for high speed data analysis.
- External reference clock input
- Single ended and differential electrical input
- Eye, jitter, rise/fall, histogram, mask measurement, pattern capture, S21 Capture & Frequency Domain, all in a single instrument.
- Multiple modules can be controlled via Fast Ethernet 100Base-T
- The DSO tool can operate in a data acquisition only mode where the data is saved on multiple acquisitions for post processing.
- Supports high density parallel application with unlimited concurrent testing.
- Ultra compact form-factor replaces conventional rack test solutions and solves impractical physical requirements of testing large lane counts. Can fit in the Verigy 93K.
- User friendly GUI that enables: zooming, markers, X and Y histograms, overlays, pre-emphasis and multiple measurements, statistics.
- Load and analyze data that was previously captured in simulation mode
- Capability to save statistical measurement, data files and configurations
- Color graded display for visualizing jitter and noise distributions
- Standard stress masks selection for LRM pre-cursor, LRM post-cursor, LRM symmetric, and LRM Clean Eye.
- Mask user defined, Auto Detect Mask
- Percentage of failing points
- Save data and Mask
- Load Mask

Scope Measurement Suite

- Mask Margin, Alternate Mask Margin rules available.
- The mask margin (positive or negative) can be extracted for a defined number of points that fail, thus allowing for DUT quality assessment, control and binning.
- The number of failed points for a region can be returned as well as the actual points that failed.
- Eye opening, Eye height and width, Eye Amplitude, Top, Base, Hi, Lo, Peak to Peak, Max, Min.
- Rise/ Fall Time, Single Edge measurement in pattern capture.
- Total Edge Jitter.
- Statistics histograms and Histogram measurements.
- Crossing point, crossing percentage.
- Advanced Pattern Measurements:
 - Eye measurements on specific bits of the pattern.
 - Single Edge measurement in pattern capture.
 - Pre-emphasis (Positive and Negative, Height and Width).
- Jitter Analysis
 - Deterministic jitter.
 - Random jitter.
- S-Parameters & Harmonic Distortions
- Filters: Adaptive CTLE, FFE, and DFE. Bessel Thomson, Moving Average, De-Embedding...

Target Applications

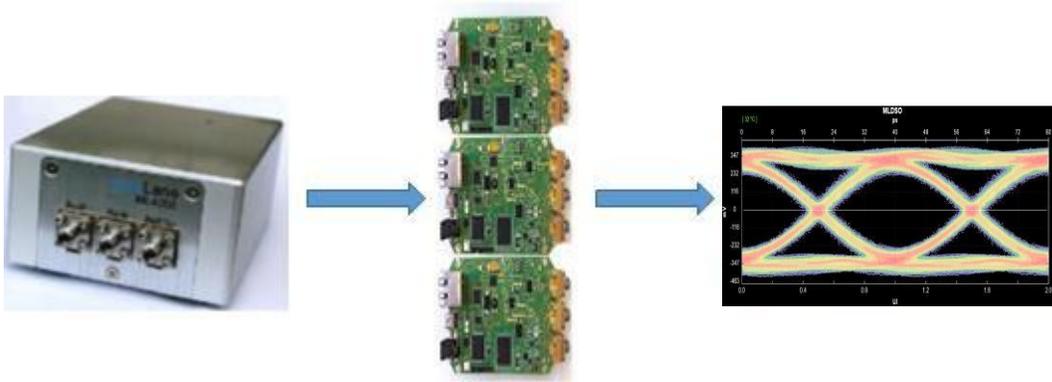


Figure 1: DSO Application

- Interconnect testing (SFP, SFP28, CFP, CFP2, CFP4, QSFP, QSFP28, ...)
- Backplane testing
- Interference and crosstalk testing
- Receiver sensitivity testing
- Receiver jitter tolerance testing equalizer characterization
- Electro-optical module testing
- Electrical stressed eye testing for 100 Gbps Ethernet, MLD/CAUI application, OIF CEI-28G-VSR, CPPI-4, CAUI-4, 32G Fiber Channel chip to module
- High Speed SerDes Testing & Characterization.
- Handheld 10G test equipment for field Installation and maintenance.
- Multi-port system testing or Line Cards.
- In-Situ testing of high port count systems.
- Can be mounted in Automatic Test Equipment or in socketed load board
- Telecoms equipment test for installation and maintenance.
- Fiber channel, Ethernet, PON, parallel optics, etc.*
- High port count burn-in test
- Research and development applications.

Product Software



Figure 2: DSO GUI

The instrument comes with the following software:

- **ML-DSO** Digital Sampling Oscilloscope GUI (Windows)
- DSO Ethernet Configuration: Use the USB Interface to change device IP
- **ML-DSO** Digital Sampling Oscilloscope API that runs on Windows & Linux

For software updates, check the downloads section in the multilane webpage:

www.multilaneinc.com

Minimum PC Requirements

The Windows PC properties for the Multilane Software must meet the following specifications:

- Windows XP SP3 or greater
- Minimum 2 GB RAM
- 1 Ethernet card to establish connection with the device
- USB Connector
- Pentium 4 processor 2.0 GHz or greater
- .NET Framework 4.0

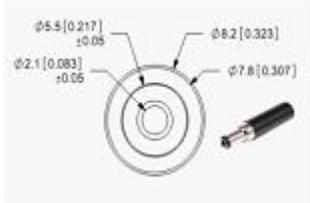
NOTE: *It is recommended to connect the ML-DSO via Ethernet to one PC only to prevent conflict from multiple user commands.*

Installation

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

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

System Start-up



To use the **ML-DSO** under Windows XP, Windows 7 and Vista, it is important that the correct start-up sequence is followed:

- Make sure you have the Microsoft *.NET Framework 4.0*
- Install the GUI Software **ML-DSO**
- Connect the power cable to the power jack and field it with a +5V/ 1.5A.
- The mate of the power connector should have the dimensions as the figure above, or this part number PP3-002A.
- Note that it is already included in the package accessories.
- The communication through USB to the instrument is required to configure its own IP only.
- Install the USB driver to the PC (Check Appendix)
- Change the IP of the DSO to fit in the network range by and using the software **DSO Conf** (Check Appendix)
- The communication through Ethernet port is required for data acquisition.
- Connect the PC to the DSO through an Ethernet cable; no driver is required
- Now the **ML-DSO** is powered up, having the right IP, the Ethernet cable interconnects the instrument and the PC, the Windows GUI is installed;
- To open the GUI, double click on the software icon located on the Desktop window.
- In order to characterize the signals fielding the instrument, check the Data and Connection Configuration.

NOTE. This release supports Ethernet connection for the software applications, and the USB interconnection is used only to configure the device IP Address (note that the IP should be in the same range of the network).

Digital Sampling Oscilloscope

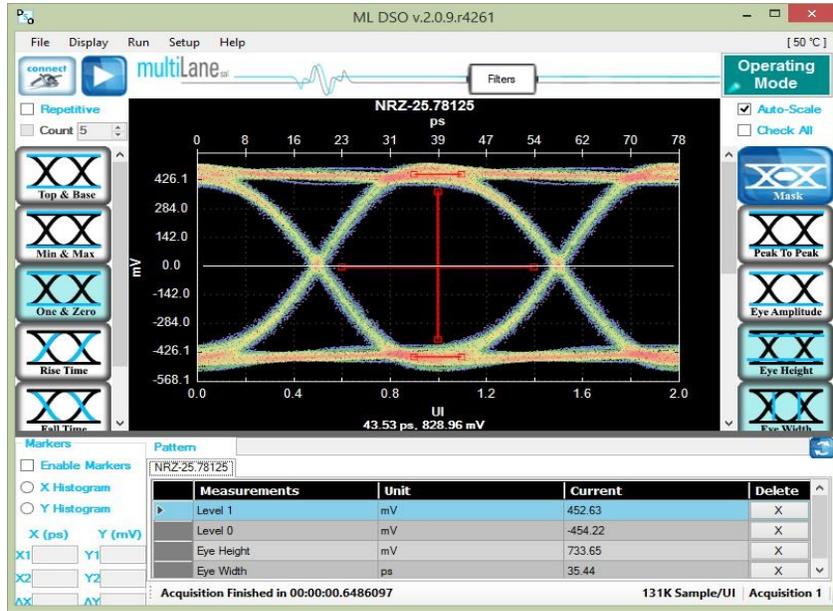
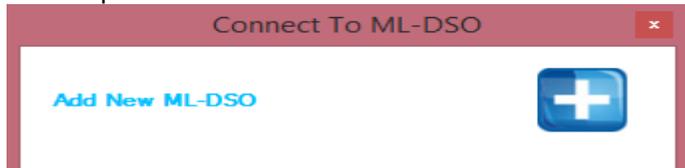


Figure 3: GUI

- Click the connect button  at the top right of your screen.
- The “Connect to ML-DSO” window will pop up.
- Click on the add button  to add the virtual ML-DSO.
- The “ML-DSO configuration” window opens



- If both software the ML-DSO and simulator are being worked with on the same computer, choose the “Simulation” mode.
- If one of the software is being run on a different PC, choose “Hardware” instead of “Simulation” and enter the “IP” of the PC where the simulator is running.
- Click on the refresh button , in order to retrieve the simulator configuration, or configure the ML-DSO by filling the “ML-DSO configuration” window respecting the information provided by the simulator. For more information on how to fill the “ML-DSO configuration” window refer to the following section.

Note that any data file that has already been saved using the ML-DSO software can be loaded.

DSO Configuration

Connection Configuration

- Change the configuration as needed:
 - The default display name of DSO can be edited as preferred.
 - The IP of the DSO connected by writing it next to “IP” label
 - Name the DSO by writing next to the “Name” label.
 - Click on the hardware radio button to use the instrument, type in IP and Channel

Data Configuration

The DSO has 3 SMA inputs (two for the differential data (RF Input +, RF Input –) and one for the Clock input)

External Clock Operation

Clock Input in normal mode ranges between 5 and 525 MHz (710 MHz for certain models)

- Choose the Normal Operation radio button to use the onboard timing generator.
- Enter a line rate less than 15Gbps into Line Rate (Gbps) or choose a Gbps value, example: 10.709, 10.625, 10.3125, 9.95328, 8.5, 6.25, 4.25 and 3.125.
- Specify the number of packets; it can be 4, 8, 16, 32, 64, 128, 256 or 512.
Each packet consists of 512 sample points per UI, which are duplicated when drawing the Eye. Eg: 256 packets means 131072 points per pattern, and 262144 points per Eye (131072 for each of the 2 UIs displayed in Eye mode)

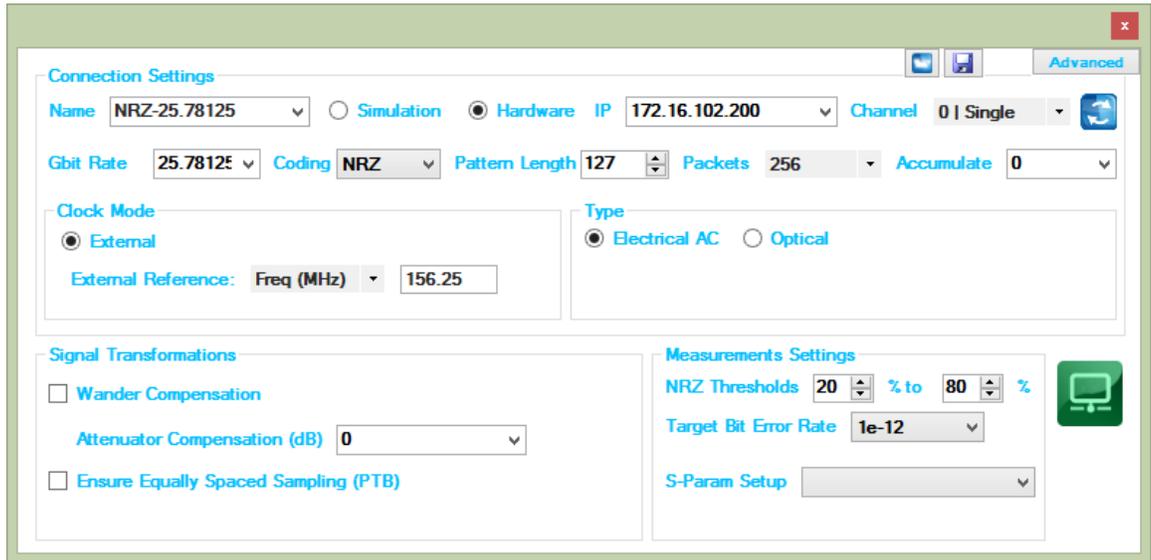


Figure 4. DSO Configuration

- Enter the percentage level of rising and falling time next to the “NRZ Thresholds”.
- Enter the External Reference Clock frequency in MHz or as a factor of the bit rate

External Reference Rate / 64

External Reference Freq (MHz) 156.25

- Its value can vary from 50MHz to (525/710) MHz, with an amplitude range from 0.05 to 1.5 Vpp:
- Typically this will be rate / 16, 64, or 80, but can be any other rate.
- Enter the “Pattern Length” of the data feeding the ML-DSO to capture the full pattern. Incorrect pattern length would still be able to display the eye mode, however full pattern capture is required for certain features of the software such as Jitter decomposition, PTB and filters.

e.g: Pattern Length = 127 for PRBS-7, The Pattern length of PN(n) is $(2^n) - 1$.

- To get wander correction, check its box; then choose between the 3 frequencies, 1024 or 2048 or 4096 Hz
- In order to retrieve the last configuration, enter the specified IP and then press the refresh button. 
- In order to scale the measured results, to remove the effect of an attenuator connected at the receiving end of the scope, enter the Attenuation value in dB. In optical mode, the value is doubled when the attenuator is at 3dB. In electrical mode, at 6dB.
- To capture more points for finer measurements, accumulate the number of points from all the acquisitions by entering the total number of points to persist in the accumulate field. This will set the number of points filling the entire eye diagram, for both UI's; half this number of points will be displayed in the pattern diagram. Accumulation works in infinite persistence mode, and unless the points are cleared or the connection is reset, all acquisitions will take part in the accumulated result with equal amounts of points randomly selected from each acquisition.

Wander Compensation

The Time Base “**Wander Compensation**” check box enables or disables the Time Base Wander Correction for a measurement. Small variations in the **DSO** internal reference time base appear as low-frequency jitter (wander) in the acquired signal.

For mask tests and edge jitter measurements, the **DSO** analyzes the acquired samples and removes the effect of the temporal drift (wander). Wander correction improves the accuracy of **DSO** measurements but may increase the time to acquire data. For applications where measurement speed is important, disabling wander correction is suggested. Reducing the number of blocks to less than 128 significantly reduces the effect of wander and increases the throughputs.



Figure 5: Wander Compensation

DSO Menu

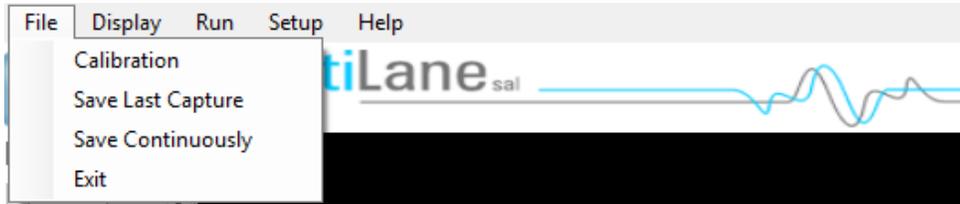


Figure 6: DSO menu bar

File menu

- **Save:** after clicking on this icon, a “Save” window appears enabling to save Configurations, data and measurements files for each acquisition.

In the case of being connected to multiple **DSOs**, there are check boxes next to each **DSO**, check the one related to the needed **DSO** and save preferences. Each checked **DSO** has a separate folder. If the 3 options Conf, Data and Measurements are checked; in this folder 3 kinds of files will be found.

Conf: check it to save the configuration file.

Data: check it to save the Data file.

Measurements: check it to save the statistical measurements files.

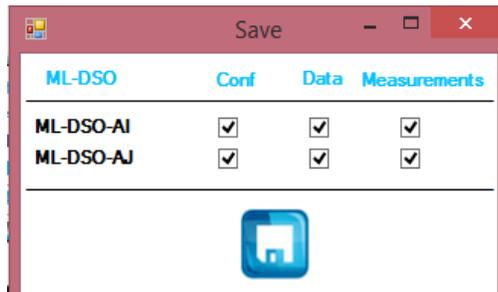


Figure 7: Save window

The version for this software can be found after selecting the “About Us” under “help” menu option. Then, the following information will be displayed:

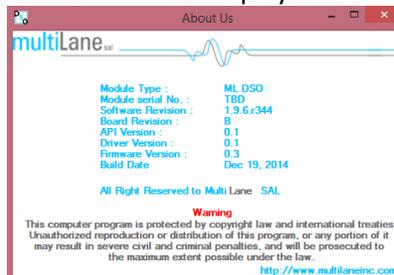


Figure 8: About us

Zooming can be done by clicking on the graph and dragging, which would draw a dotted window. When the mouse is release, the graph will zoom to display only the content within the drawn box. This method of zooming may alter aspect ratio of the graph is the drawn box is of disproportional dimensions.

Zooming also can be done using the mouse wheel when the Ctrl button is held. This method will maintain the original aspect ratio of the graph.

In order to go back to the initial view, right click on the graph, and choose “**Undo All Zoom/ Plan**”

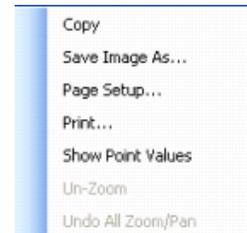
Panning

The position of the graph in the display window can be panned by dragging the graph with the mouse while the Ctrl key is held.

Copy, Save, Undo Zoom and print a graph

Right clicking the graph exposes these features:

- Copy:** to copy the present graph as an image into clipboard.
- Save Image As:** to save the present graph in the desired location.
- Page Setup:** View page information for printing.
- Print:** to print the graph.
- Show point values:** to display the coordinates of points when hovering over them in the graph.
- Un-Zoom:** to undo the last zooming performed
- Undo All Zoom/ Plan:** to undo all zooming



Operating Modes

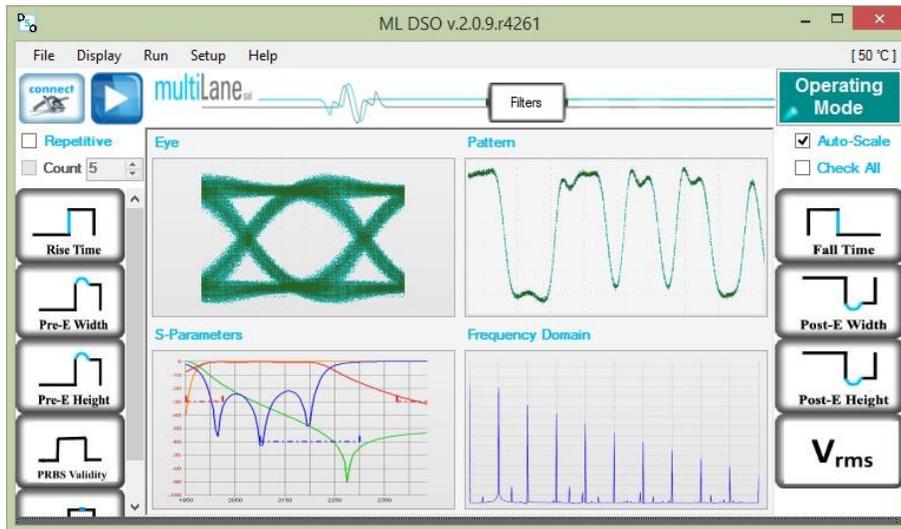


Figure 9: Operating Modes

Clicking Operating Modes on upper right corner allows switching between:

- Eye Measurements Mode
 - Oscilloscope Measurements
 - Multiple measurements
 - NRZ Measurements
 - PAM4 Measurements
 - Mask Test
- Pattern Capture Mode including Jitter components decomposition
- S-Parameters Mode
- Frequency Domain Mode

Eye Measurements Mode

Irrespective of hardware or the simulation mode, it will be possible to draw the eye and attain its measurements after filling the configuration window and connecting to the instrument. In the Eye Mode, in order to draw the eye diagram, click on the “**Start data acquisition**” button

Check the “**Check All**” button to view all the eye measurements down the screen for one time, or select only the needed measurement by pressing on the specified button. Use the second option to reduce the measurements operation time.

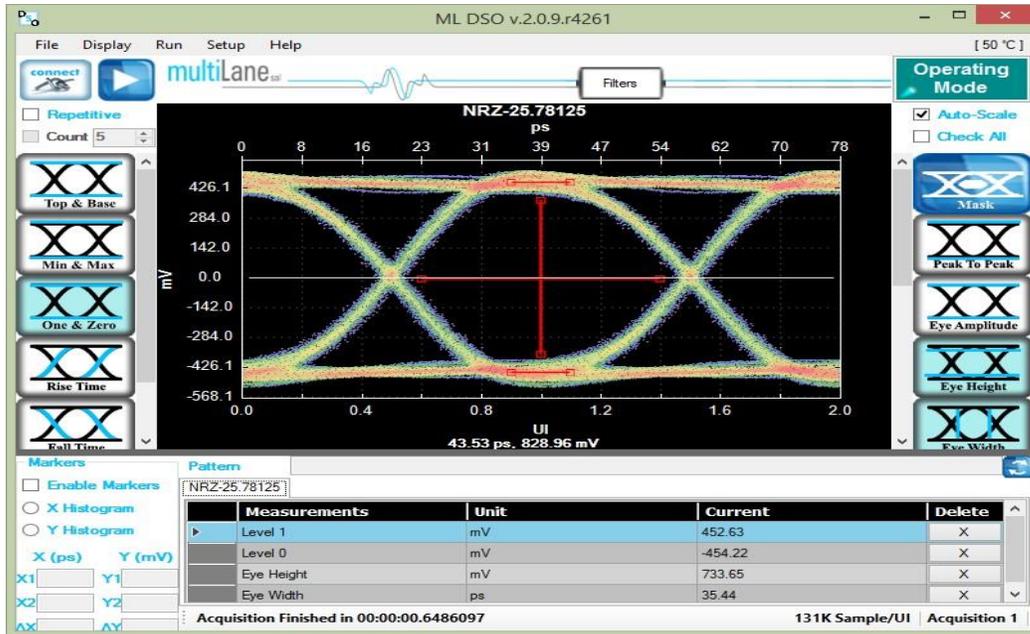


Figure 10: Measurements Mode

If a large number of acquisitions need to be done, click on the “**Repetitive**” check box, then press the “**Start data acquisition**” button . Check the “**Count**” Text box and specify the number of acquisition if you want acquisition to stop automatically after a certain number of measurements.

By default, the measurements are displayed continuously. However, the eye diagram is frozen since the first acquisition;

By default the Eye Mode is chosen; if you are located in the Pattern Capture Mode, to move to the Eye Mode click on the button “**Switch to Eye Mode**”

During the acquisition phase the “**Start data acquisition**” button turns to be red and becomes a stop acquisition functionality. Clicking on the red stop button will stop after completing the acquisition currently in progress, and will display the eye and its statistical measurements.

In order to restart the acquisitions, click again on the “**Start data acquisition**” button; a new set of acquisition starts. Accumulated data continues across several runs if not cleared.

In order to save data, statistical measurements and to save configuration files check the SavedData folder under the deployment directory. A folder is created for each ML-DSO and inside of this folder you can find 3 different files one for the statistical measurements, one for the configuration, and a data file.

Status Bar

Number of Samples

The status bar displays the number of kilo samples drawn in the Eye mode.

1k Samples is equivalent to 1000 samples point in the Eye Graph, including accumulated point when applicable.

Operation Status

| Operation Status | Status description |
|------------------|--------------------|
|------------------|--------------------|

| | |
|---|---|
| Gathering Data | Acquiring data (reading from hardware) |
| Saving Data | Saving data in the data file |
| Error connecting to DSO | When the connection between SW and HW cannot be established |
| Error applying Wander Compensation on DSO | Wander cannot be applied because an eye cannot be detected at the first place |
| Saving Results | Saving acquired data points and statistical measurements into their file. |
| Displaying results | Showing the statistical measurements and refreshing the graph |
| Acquisition Finished | Acquiring data and sampling is finished |

Table 1: Operation Status

How to add multiple ML-DSO Channels/Disconnect/Reconfigure

To add a new **ML-DSO channel**, press the **“Add New ML-DSO Channel”** button in the **“Connect to ML-DSO”** configuration window. Fill it and press connect.

To disconnect from a specified **ML-DSO**, simply click on the **“Close”** button next to its name in the **“Connect to ML-DSO”** form.

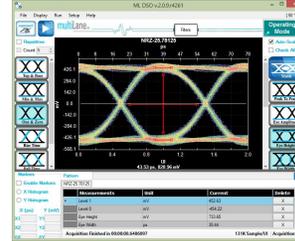
To reconfigure the data, click the **“Edit ML-DSO configuration”** icon, and then fill the configuration window as preferred.

To add multiple **ML-DSOs**, repeat the first step.



Oscilloscope Measurements

Drawing the eye, the user can perform eye measurements by simply clicking the corresponding buttons: Top, Base, Min, Max, Fall time, Rise time, Peak to Peak, Eye Amplitude, Eye Height, Eye Width, Jitter, and the crossing percentage. The “Check All” text box can be selected to see all the measurements in one shot.



When multiple DSOs are connected, and after drawing all the eyes or patterns, the measurements are displayed for all DSOs down the screen in the tables.

Markers

This feature by default is Off; in order to use it, switch it to On by choosing the “On” radio button, under the “Markers” group box.

Pair of movable markers in both X-axis and Y-axis is displayed. The horizontal and vertical markers help bound the measurement region by giving the difference between the 2 horizontal and vertical markers.

The results are displayed in the top of the graph. Pico second or UI is the unit of the X axis; mV is the unit of the Y axis.

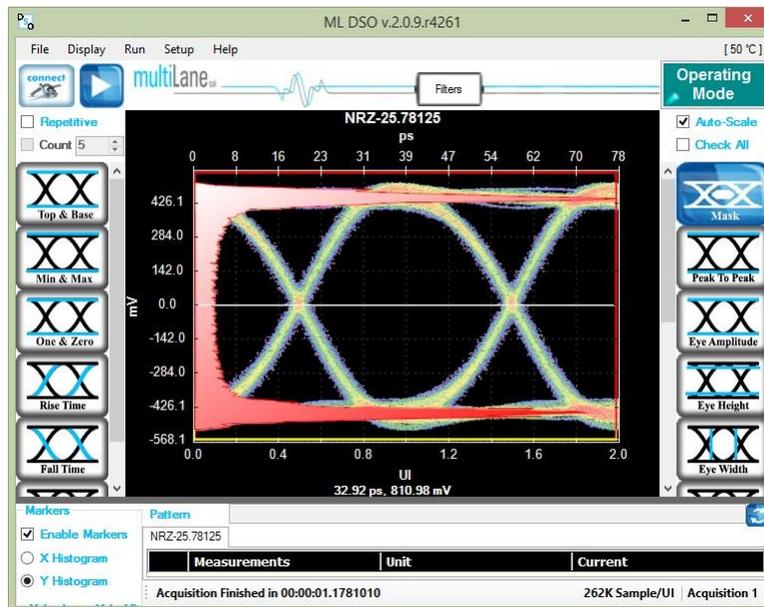
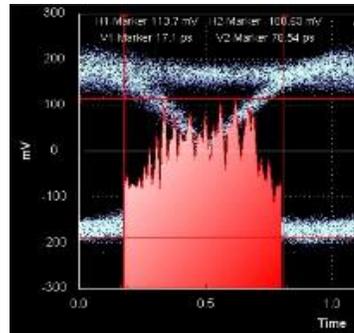
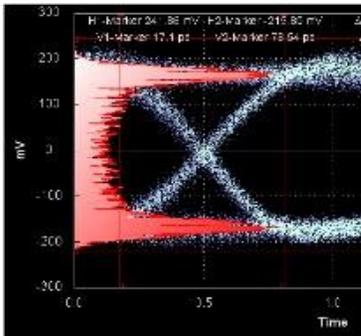


Figure 11: DSO Markers

- First select the marker to be moved; it should be highlighted in yellow.
- Drag the markers to the required location.
- The marker values displayed in the textboxes bottom left can be used to manually specify the marker positions.
- Markers help verify horizontal and vertical measurements, such as jitter, eye width, eye height, and mask margins. They can be dragged manually to view the delta or difference between 2 markers.

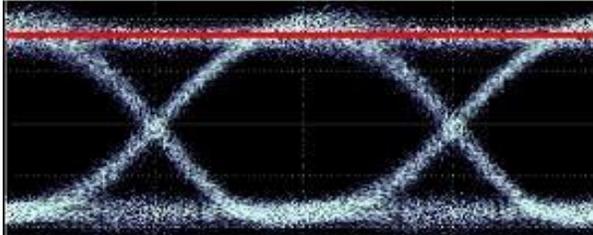
Histograms

The X and Y histograms shows the Density Distribution of the samples along the x and y axis.



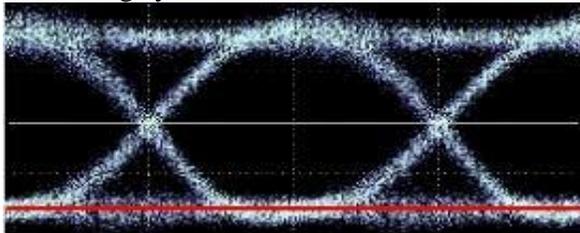
Top

The average y-value of the high-to-high transitions.



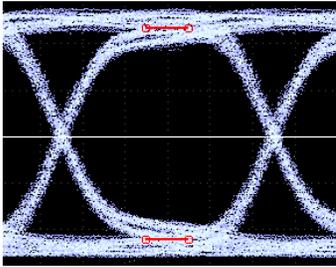
Base

The average y-value of the low-to-low transitions.



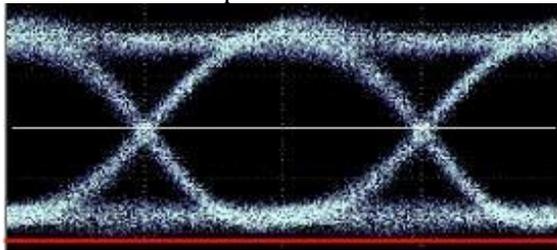
One and Zero level

The average y-value at 20% around center of the eye



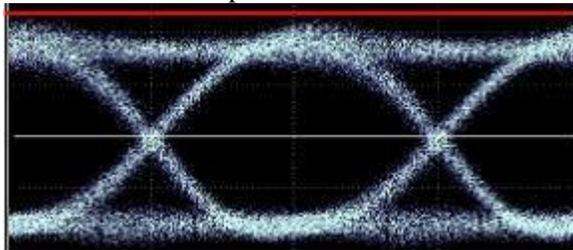
Min

The minimum sample value.



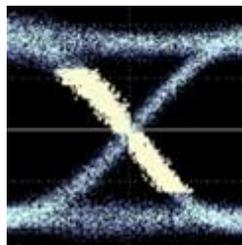
Max

The maximum sample value.



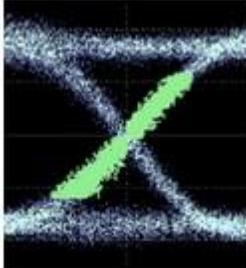
Fall Time

The mean transition time of the data on the downward slope of an eye diagram between 2 defined thresholds e.g. 80% and 20%. Note that the percentage level of the rise and falling time can be changed by modifying the NRZ thresholds in the data configuration window.



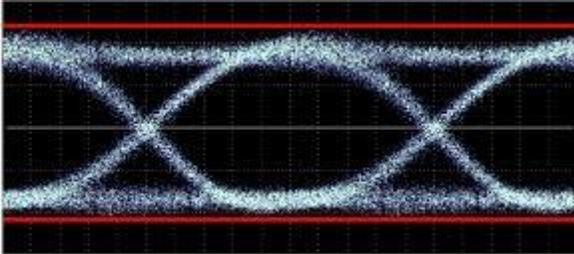
Rise Time

The mean transition time of the data on the upward slope of an eye diagram between 2 defined thresholds e.g. 20% and 80%.



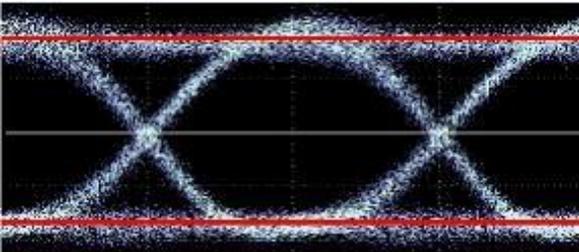
Peak to Peak

The difference between the max and the min eye sample values, here Max is the value of the sample point with the highest amplitude and Min is the value of the sample point with the lowest amplitude.



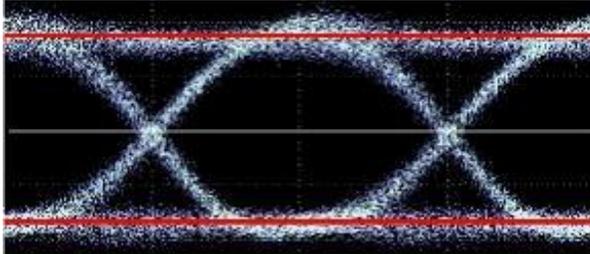
Eye Amplitude

The difference between One level and Zero level of an eye.



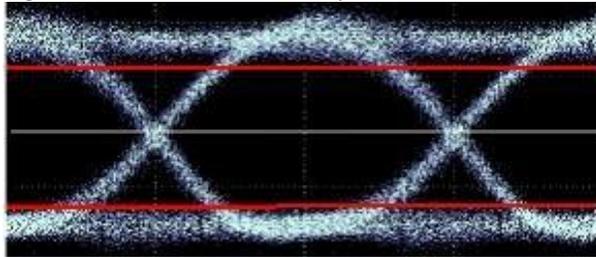
Voltage Amplitude

The difference between top and base of an eye.



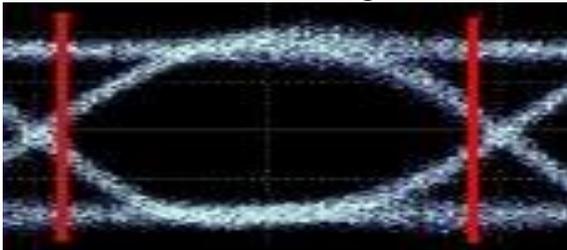
Eye Height

The vertical opening of the eye. Eye Height is the vertical opening of the eye measured as the difference between the -3 sigma value of the high samples within the NRZ window and the +3 sigma values of the low samples within the NRZ window.



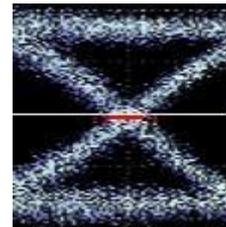
Eye Width

The time between the latest possible occurrences of one eye Crossing to the earliest possible occurrence of the next crossing



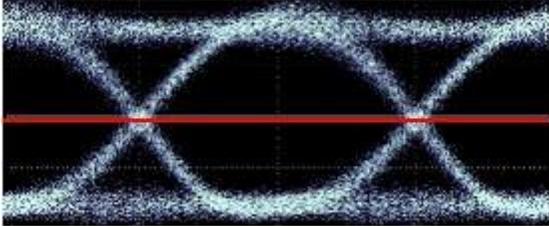
Total Peak-to-peak Jitter

Jitter is defined as a measure of the short-term variations of the significant instances of a digital signal from its ideal position on the time axis. In other words, ideally, an edge should always land at the same position on the time axis. In the real world, the edge is sometimes a little early, sometimes a little late. This is jitter. In this revision the Jitter value is Peak to Peak.



Crossing percentage

The amplitude of the crossing level relative to the low and high levels.
 (The value of the crossing percentage is displayed in the bottom of the screen.)

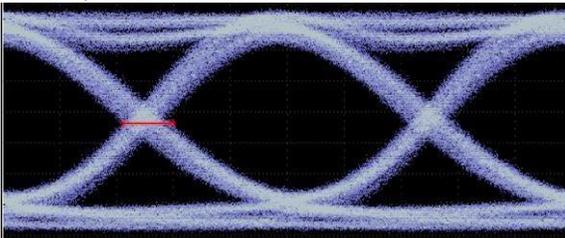


SNR

The signal to noise is a ratio of the signal difference between one level and zero level relative to the noise present at both levels.

Jitter

The jitter measurement allow to calculate the total jitter, the jitter peak to peak and the jitter rms in ps.



VEC

VEC = Vertical Eye Closure in dB.

Calculated in NRZ as: $20 \times \text{Log} [\text{Eye Amplitude} / \text{Eye Height}]$

Calculated in PAM 4 as: $20 \times \text{Log} [\text{Max}(\text{AVupp}/\text{Vupp} , \text{AVmid}/\text{Vmid} , \text{AVlow}/\text{Vlow})]$

Note: AV is the eye amplitude and V is the eye height in PAM4 mode

Multiple measurements

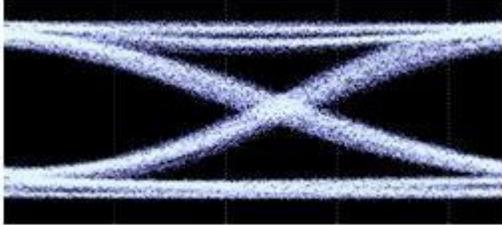
The multiple measurements gives the user the ability to view the different measurements: Top, Base, Min, Max, Fall/ Rise time, Peak to Peak, Eye Amplitude, Eye Height, Eye Width, Jitter, and the crossing percentage for a number of measurements specified in the repetitive box or for an undetermined number. Use the **Check All** text box to display all the measurements

Statistics

To enable repetitive data acquisition, and statistics measurements, the repetitive mode needs to be checked or the numbers of acquisition in the counter box needs to be increased, then the statistical measurements are shown and the following is displayed: Current value, Average, Minimum, Maximum and the standard deviation of each measurement.

DJ & RJ

The DJ value is displayed in ps, and the RJ value in fs

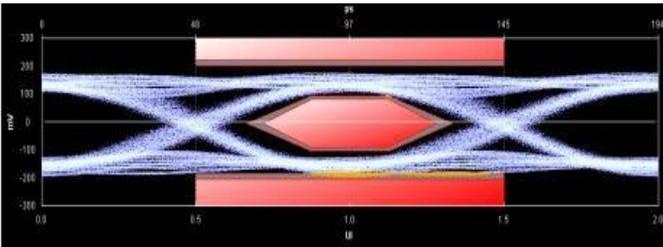


Mask Margin

The “Switch to Mask Mode” button, located between the Eye and Pattern buttons, is used to find the maximum mask margin that results in no more than a specified number of failing points. The figure below shows an example where the user wants to determine the maximum mask margin available for the highest number of failing points, but no more than 25.

The answer in this example is +13% for 8 points. Setting the margin below this level would result in less failing points in total. Setting the margin above this level would result in fewer failing points.

The number of failing points is displayed down the screen in the status bar.



The DSO has these standard masks: 100Gbase-SR, LR, STM-1, STM-4, STM-16, Gb Ethernet, Fiber Channel (1x), Fiber Channel (2x, 4x), Fiber Channel (8x), Fiber Channel (10x), 10 Gb Ethernet, and user defined masks. New masks are continuously added. Recent additions are QDR & FDR.

Mask Settings

Mask: 10 GB Ethernet

Mask Margin (%): 0

Find Max Margin

Failing Points: 0

Mask Uses X1, X4

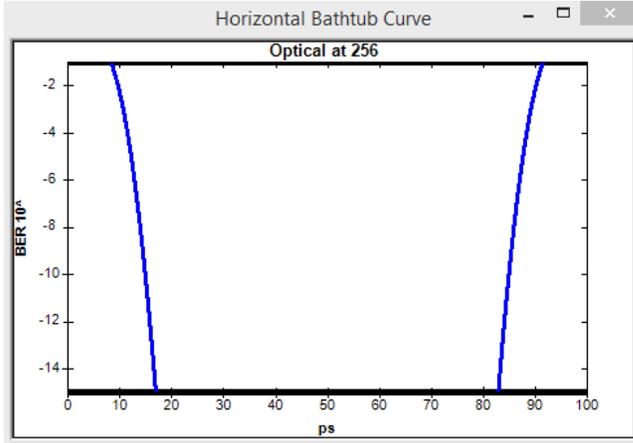
Mask uses X5, X6, Y5, Y6

Mask uses Y3, Y4

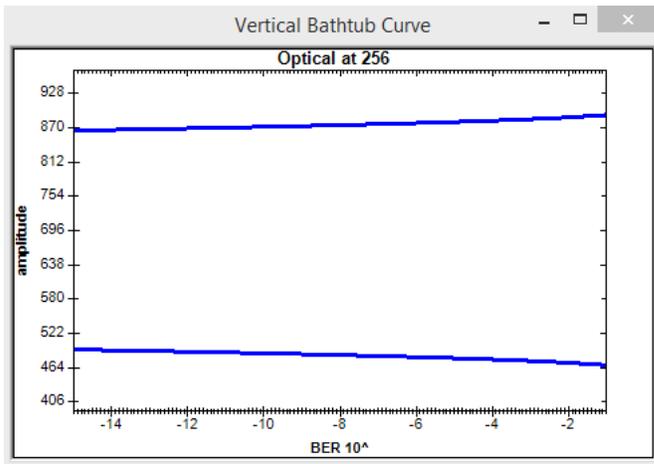
| | |
|----------|----------|
| x1: 0.25 | x4: 0.75 |
| x2: 0.45 | x3: 0.55 |
| x5: 0.4 | x6: 0.6 |
| y1: 0.25 | y2: 0.75 |
| y3: -0.4 | y4: 1.4 |
| y5: 0.28 | y6: 0.72 |

y0: 0.5

Horizontal Bathtub



Vertical Bathtub



Pattern Capture Mode

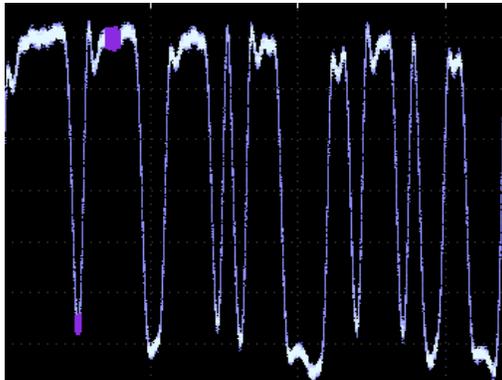
The Pattern Capture mode enables the bit sequence captured by the DSO to be seen. In order to see the behavior of a specified sequence of bits, zoom in and out by scrolling the mouse wheel, or using the cursor to specify the region to be zoomed in upon. Pattern rise/fall times pre-emphasis, post-emphasis, PRBS validity and VMA (voltage modulation amplitude) can be measured in this mode. Note Pattern Capture mode needs to be able to show the full pattern for certain features of the software to work, such as:



Figure 12: Pattern Mode

VMA

The voltage modulation amplitude of a pattern displayed in mV



Voltage RMS

The voltage RMS measurement can be conducted without Pattern or Eye Lock, and can be used to determine noise floor, which can then be entered in the Configuration/Advanced Menu for De-Embedding the setup's intrinsic noise

PAM4

Pulse-amplitude modulation (PAM4), is a form of signal modulation where the message information is encoded as one of 4 amplitude levels. Unlike NRZ which varies between 2 amplitude levels indicating zero and one, PAM 4 varies between 4 amplitude levels indicating with one symbol a value in the range zero to three. This leads to double the bit rate for the same baud rate as NRZ.

To use the PAM4 you have to choose the PAM 4 mode.

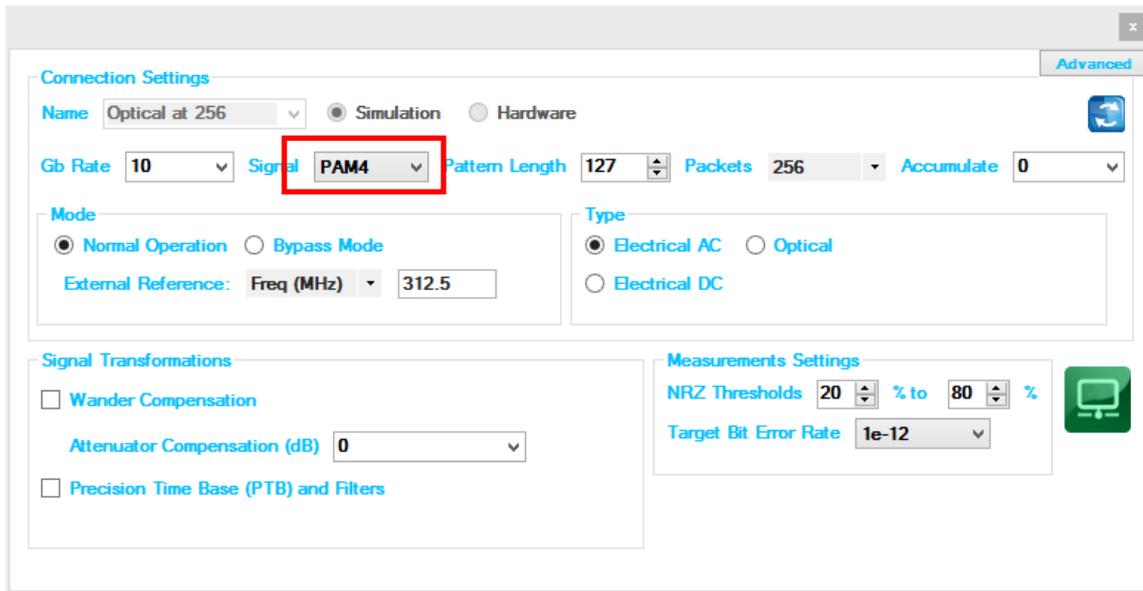


Figure 13: Enabling PAM4

Three eyes will be displayed on 4 levels as shown below

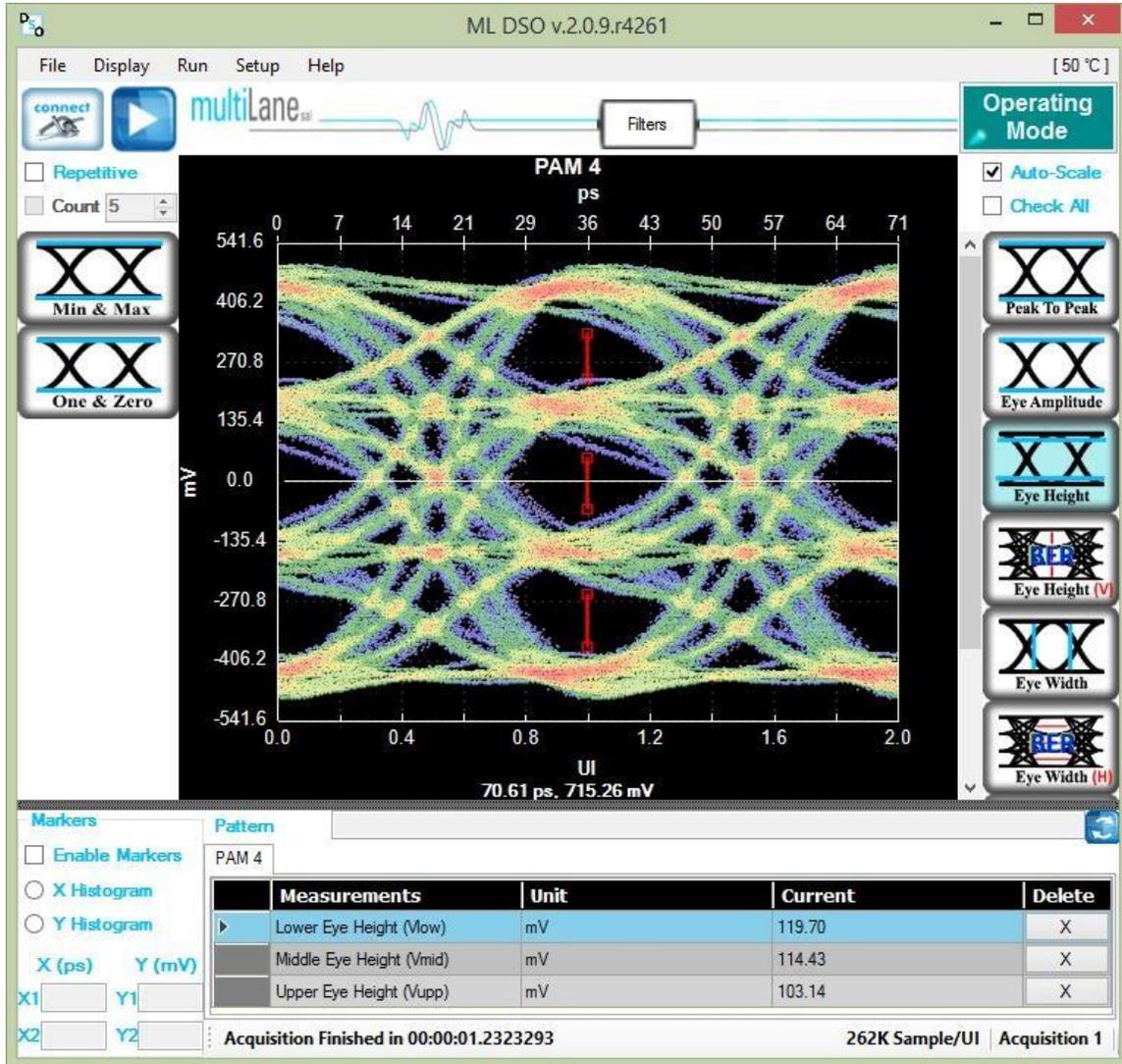


Figure 14: PAM4 Display

Some of the measurements (Min, Max, One, Zero, Peak to Peak, Eye Amplitude, Eye Height, Eye width, Eye Height BER, Eye Width BER and VEC) are applied on the PAM 4 mode

Filters

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

Click on Filters Button after seeing the signal to start changing it:

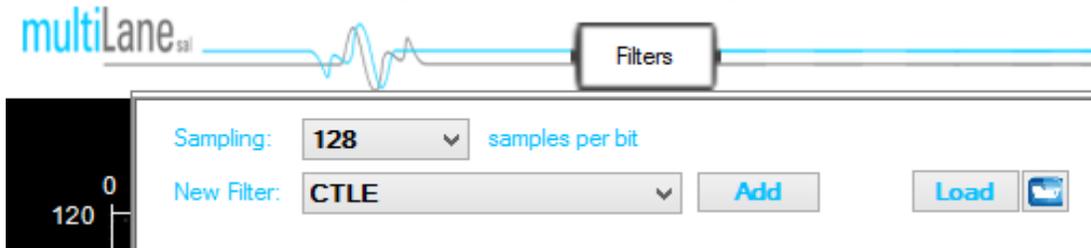


Figure 17: PAM4 pattern mode

Current List of Filters Supported:

- 1- Moving average filter for smoothing and can specify window size.
- 2- 4th Order Bessel Thomson filter at Frequency equal to 0.75 of the bit rate (Order and Cutoff Configurable)
- 3- CTLE filter, and can automatically or manually select the filter parameters. Adaptive CTLE can determine the CTLE for best Eye Height
- 4- S2P/S4P De-Embedding filter simulating the inverse of a channel or DUT, where the channel's S2P or S4P file is loaded. Can also emulate a Channel's Insertion Loss.
- 5- DFE : decision feedback equalizer (nonlinear adaptive equalizer), it is based on the principle that once you have determined the value of the current transmitted symbol, you can exactly remove the ISI contribution of that symbol to future received symbols. The optimal DFE Parameters can be determined by the software, and it can also adaptively detect minimum taps required for a target Eye Height or SNR
- 6- FFE: feed forward equalizer (linear equalizer) each value of the output sequence is a weighted sum of the most recent input values. The optimal DFE Parameters can be determined by the software, and it can also adaptively detect minimum taps required for a target Eye Height or SNR

The configuration parameters are:

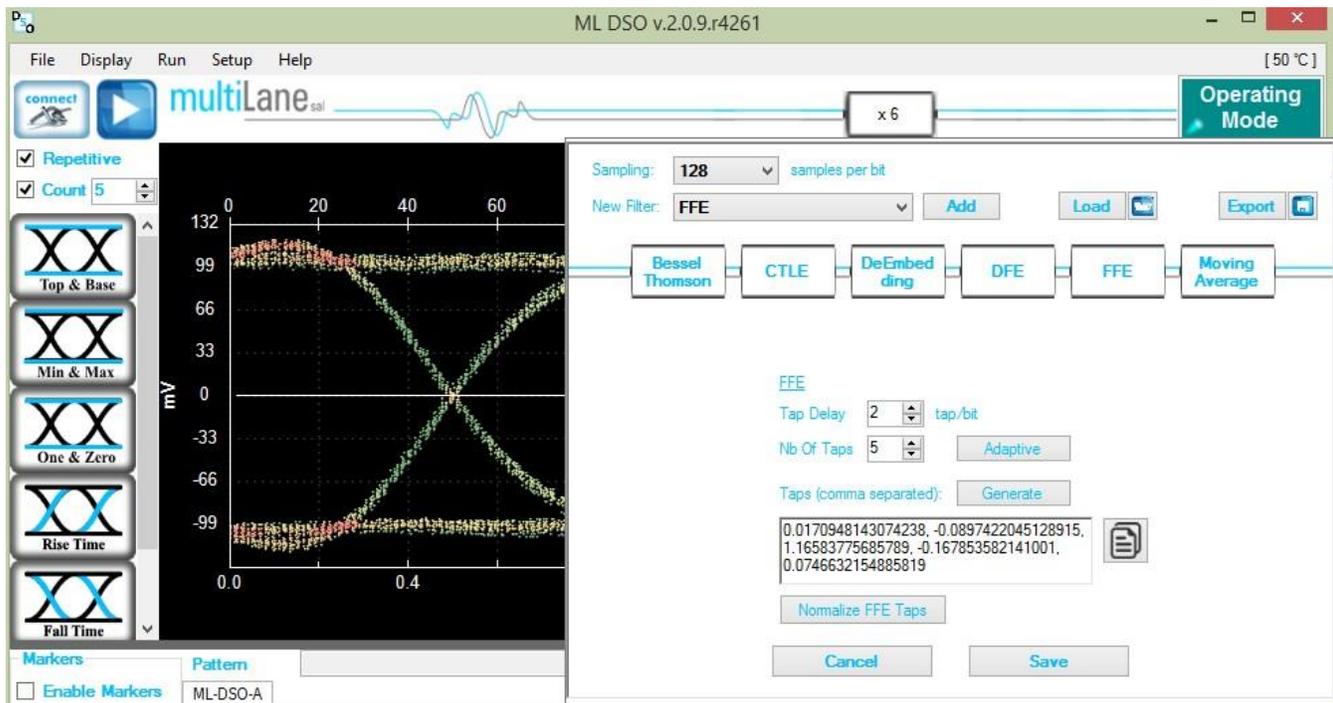
For FFE:

- 1- The Tap Delay, expressed as an integer fraction of the Bit Period.
- 2- The number of taps
- 3- Tap coefficients: here you enter the different tap coefficients separated by commas, from tap 0 to tap N
- 4- Normalize: This would normalize the filter taps ensuring unity gain. Note that if taps were generated automatically, they would be already normalize (their sum = 1)

36 / 49 For DFE:

- 1- The number of taps.

- In DFE tap delay is always fixed to 1 tap per bit
- 2- Tap coefficients: here you enter the different tap coefficients separated by commas, from tap 0 to tap N
- 3- A delay value in Pico Seconds, which should be ranging from negative bit period / 2, $-T_b / 2$ to $+T_b / 2$. This delay defines a shift from the center of the bit UI, at which the DFE slicer decision should be made



S Parameter Mode

The Multilane DSO is now capable of measuring the insertion loss S-Parameter. Depending on how you connect the DSO, you should be able to measure either of S21 dd, S12 dd, S21, S12, S43, S34...

The only difference between all the above is:

- 1- Whether you're connected single ended or differential
- 2- The direction in which you've connected the DUT for which you are measuring S-Parameters
- 3- The ports which you've used when connecting the DUT in case of a Single Ended connection

The approach used consists of these steps:

- 1- Define your Circuits:
 - a. Main Circuit: Contains the DUT whose S-Parameters is to be measured
 - b. Reference Circuit:
 - i. Excludes the DUT whose S-Parameters need to be measured
 - ii. Is as identical as possible to the Main Circuit, except for the DUT
 - iii. May require an additional component, such as a through, to be placed in the location of the DUT in order to close the circuit
- 2- Setup your PPG:
 - a. PRBS 7 or 9, 9 is recommended
 - b. Maximum Bit-Rate supported (For Maximum Frequency Range in your result)
 - c. Cleanest Eye Possible. This sometimes translates to Maximum Amplitude in order to maximize Signal-To-Noise Ratio. However be careful not to exceed the maximum amplitude supported by your MultiLane DSO without using attenuators

Kindly note PPG settings and amplitudes should not be altered after this point

- 3- Capture your Reference Signal: When having the cleanest PPG settings as above, and your Reference Circuit connected, run the DSO S-Parameter Setup Wizard to capture reference data for you
- 4- Without altering any of the PPG settings, connect your Main Circuit, basically just connect the DUT where needed to switch from 'Reference Circuit' to 'Main Circuit', and run in S-Parameter mode, you should now be able to see the S21 Insertion Loss Magnitude drawn on the screen.

For a constant PPG Source Signal, S21 Is calculated using the equation:
 Frequency Response of DUT = FFT (Main Circuit Signal) / FFT (Reference Circuit Signal)

- 5- The insertion loss can be saved in external .S21 and .DsoCirc files. These files contain both magnitude and phase information; however phase information is not accurate in

38 / 49 the sense that there will always be a linear shift in phase. These files with their

magnitude and phase information can later be used in the DSO Software for de-embedding or emulating the DUT

Components in Use

- 1- Two Pairs of Cable
- 2- Two Module Compliance Boards that support the DAC connector. We will need the S-Parameters of these MCBs. Often S-Parameter information is supplied by their vendor
- 3- One DAC Cable
- 4- Two through connectors that can connect the cable pairs together. These connectors will be considered to have negligible insertion loss
- 5- A MultiLane DSO
- 6- Any PPG, in this example the MultiLane BERT was used

First, Connect Your Reference Circuit Hardware

Begin with connecting the circuit you will use as reference circuit as follows:
 Connect PPG differentially to Cable Pair 1, to Throughs, to Cable Pair 2, then to the DSO
 PPG → Cables 1 → Through → Cables 2 → DSO

Step 2, Configure your PPG for Cleanest Signal

- 1- Setup your PPG:
 - a. PRBS 7 or 9, PRBS 9 is recommended
 - b. Maximum Bit-Rate supported (For Maximum Frequency Range in your result)
 - c. Cleanest Eye Possible. This sometimes translates to Maximum Amplitude in order to maximize Signal-To-Noise Ratio. However be careful not to exceed the maximum amplitude supported by your MultiLane DSO without using attenuators
- 2- Observe the signal on the DSO after Going through the ‘Reference Circuit’. Tune the PPG settings, sometimes you need to alter emphasis settings, sometimes amplitudes, sometimes bit rates. Do your best to achieve the cleanest eye possible, for the highest rate possible. Note that you will get S-Parameter Data up to 80% of this rate used
- 3- Once you have clean settings, note them down. Kindly note PPG settings should not be altered after this point

Step 3, Go Through the S-Parameter Wizard on the DSO

Connect to the DSO

This DSO should currently be reading the signal going through the reference circuit
Recommended settings include 512 for Packets and PTB

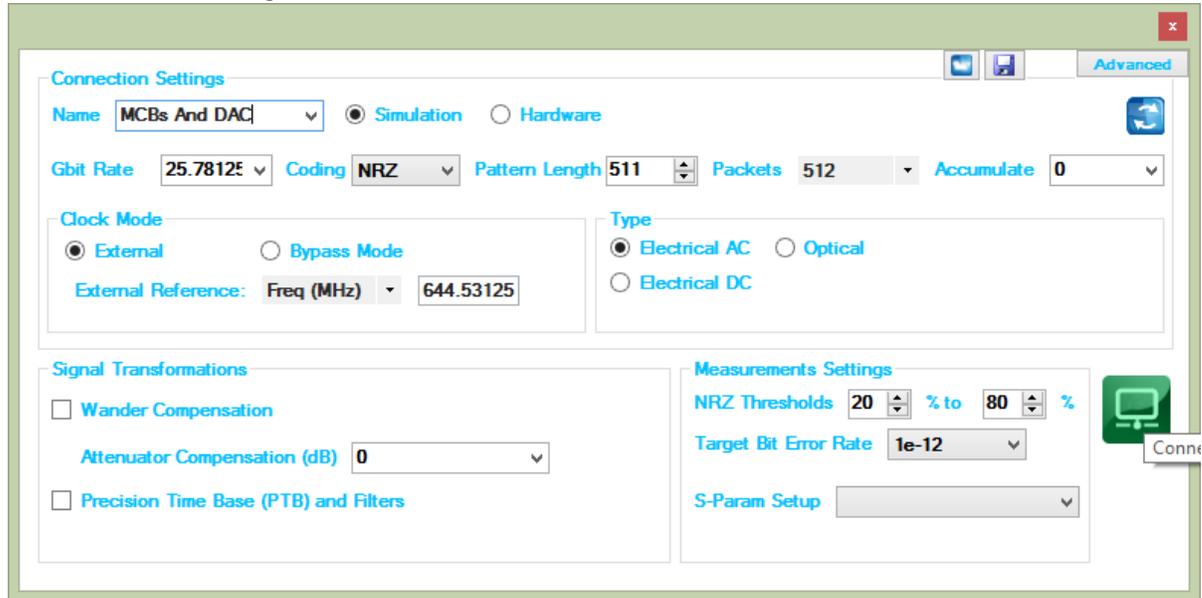


Figure 18: S-Param Configuration

Go to S-Parameter Setup



Figure 19: S-Param setup

Select the DSO Connected

After Selecting the DSO click 'New Setup'

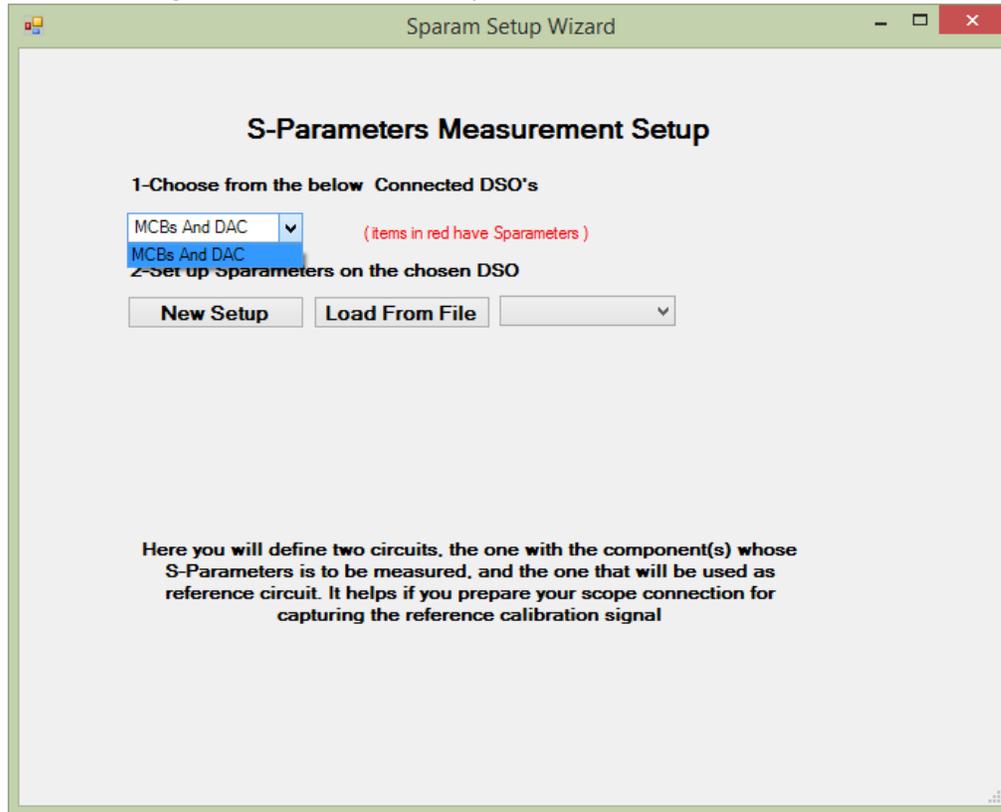


Figure 20: Setup

Create Your Main Circuit

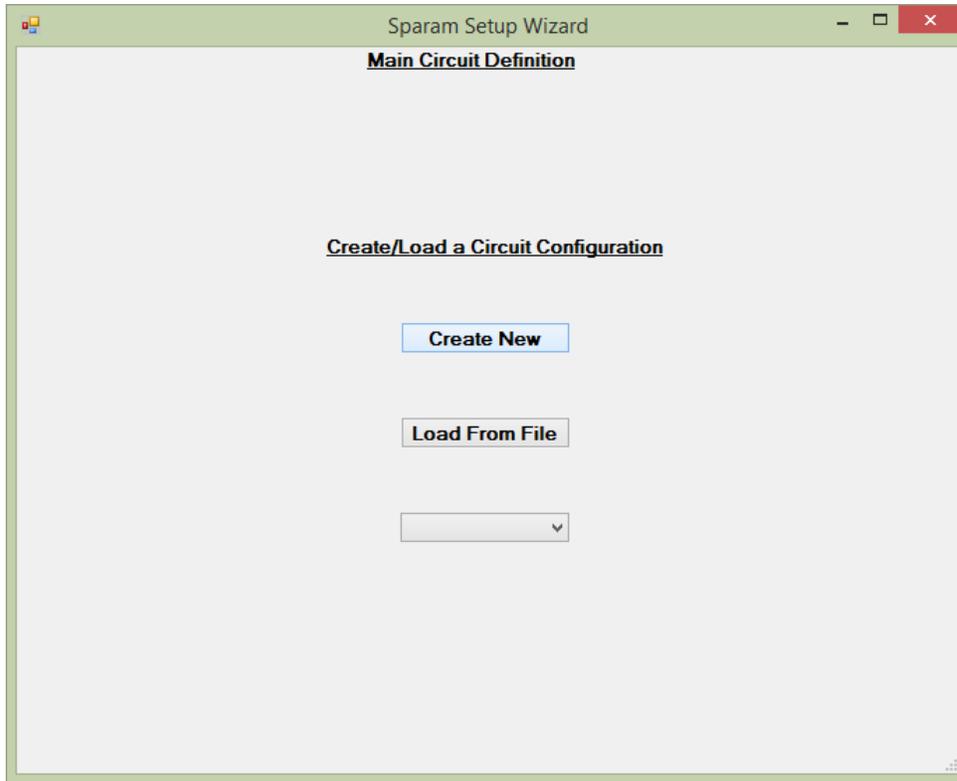


Figure 21: Main Circuit

Add the Main Circuit Components

Load the S-Parameters of the MCBs. These will be used to calculate the S-Parameters of the DAC

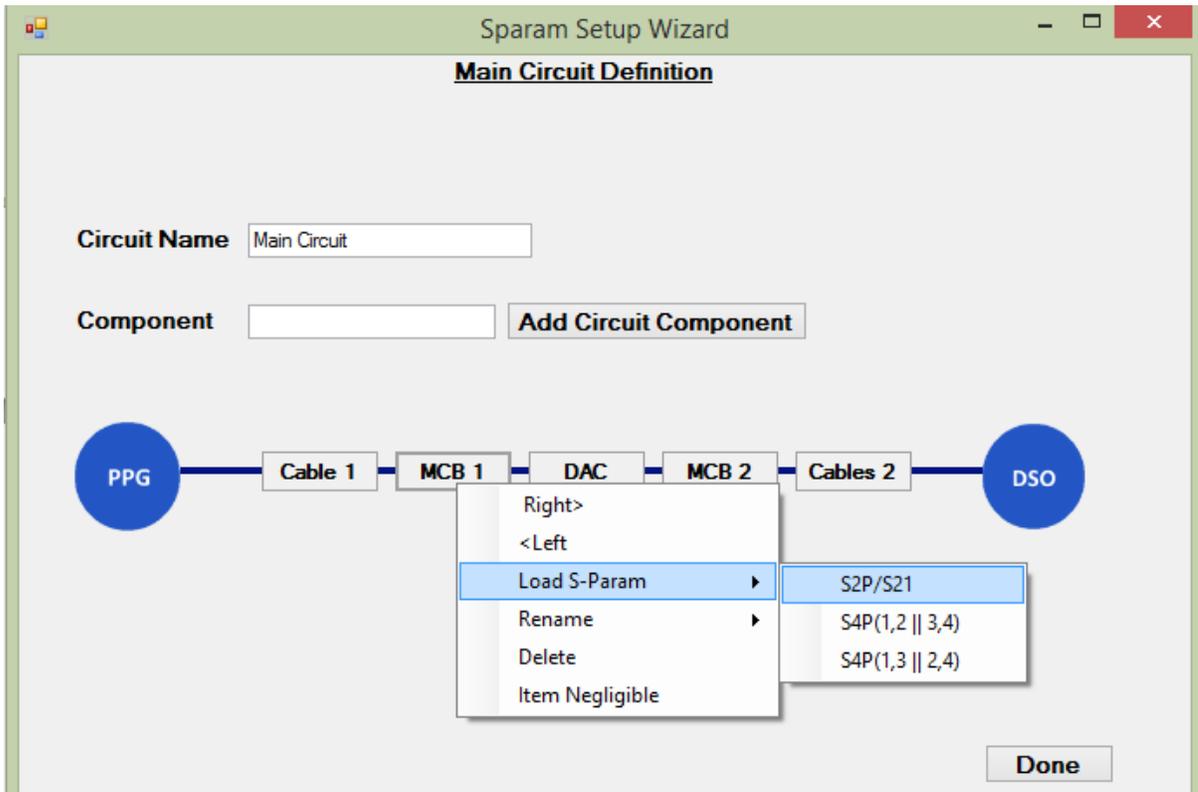
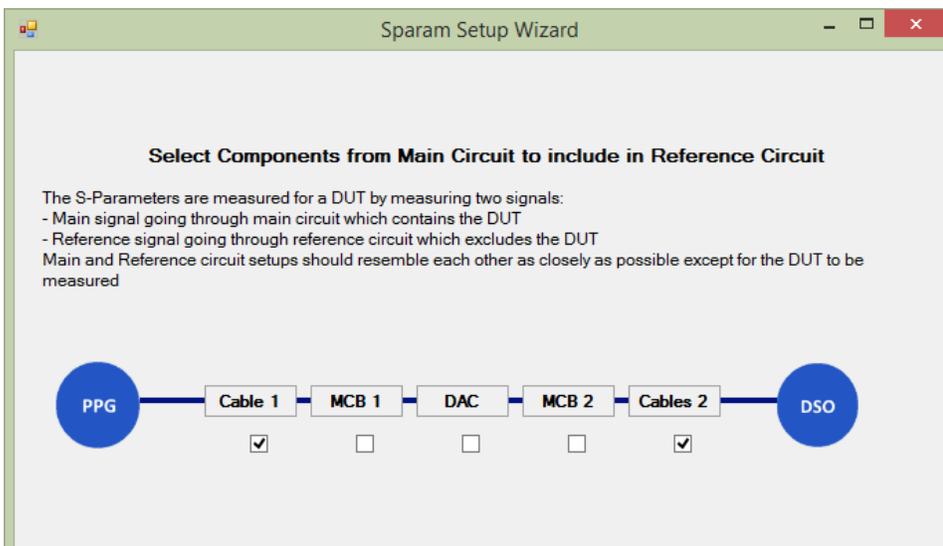


Figure 22: Main circuit component

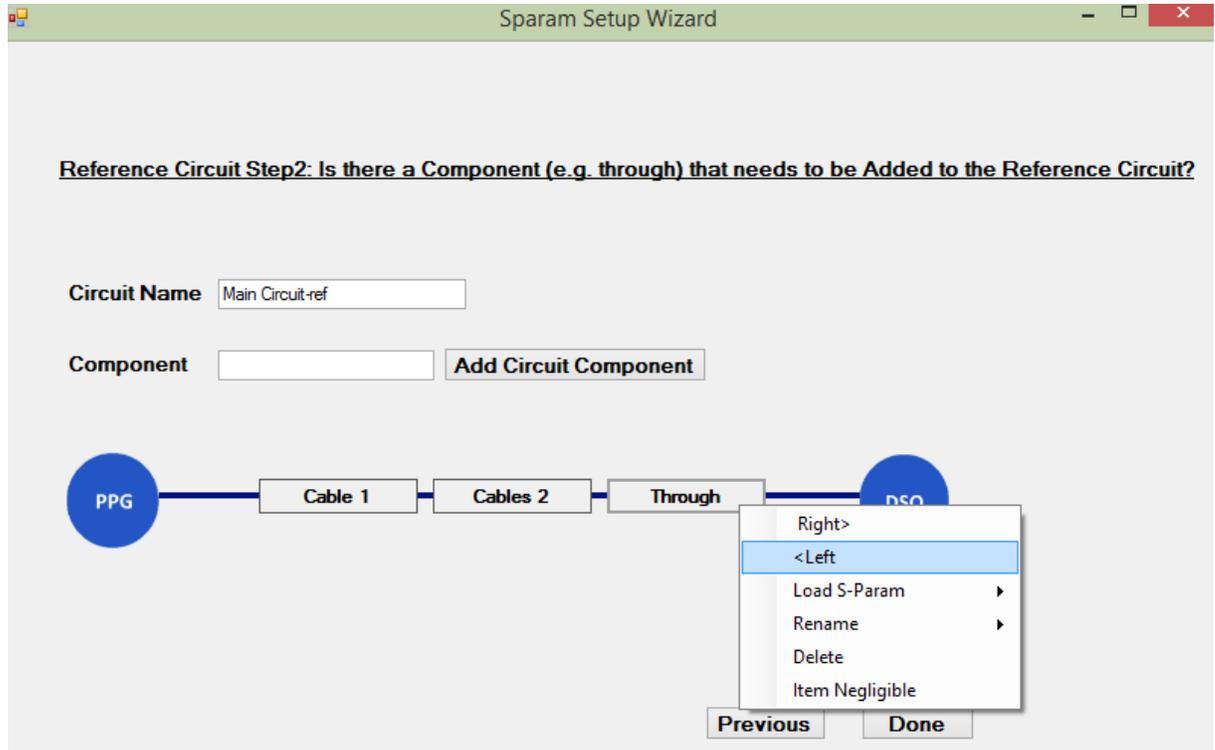
Proceed by clicking 'Done'

Select Components from Main Circuit Present in Reference Circuit

Select Cables 1 and 2 and click Next



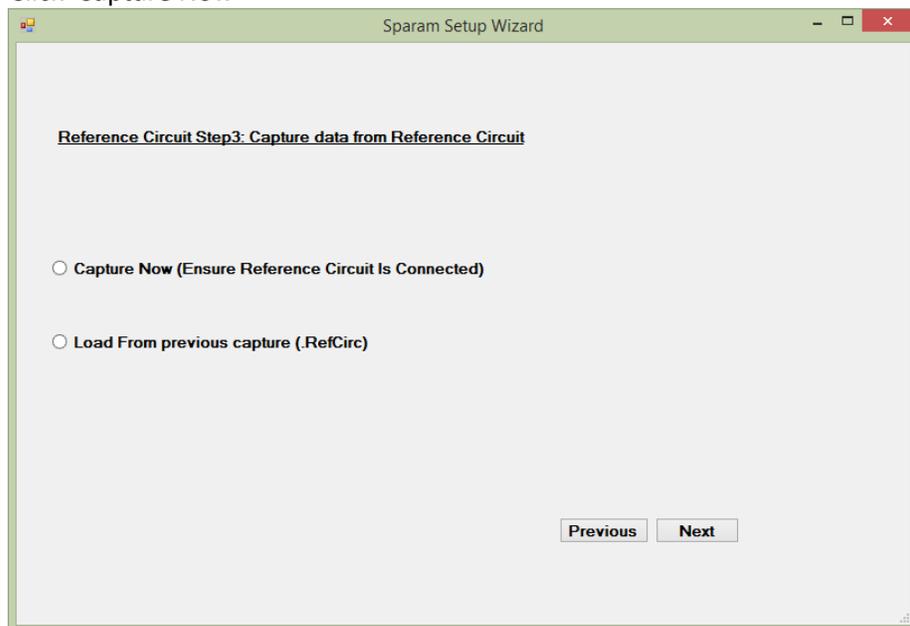
Add Through Connector in Reference Circuit Definition



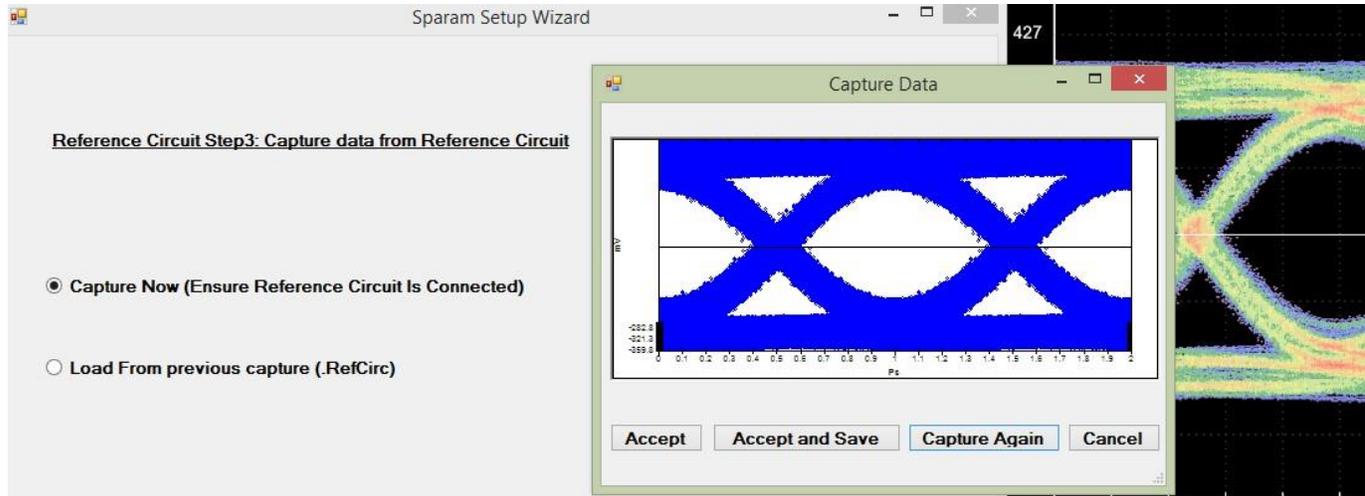
When done, click next,

Capture Your Reference Data

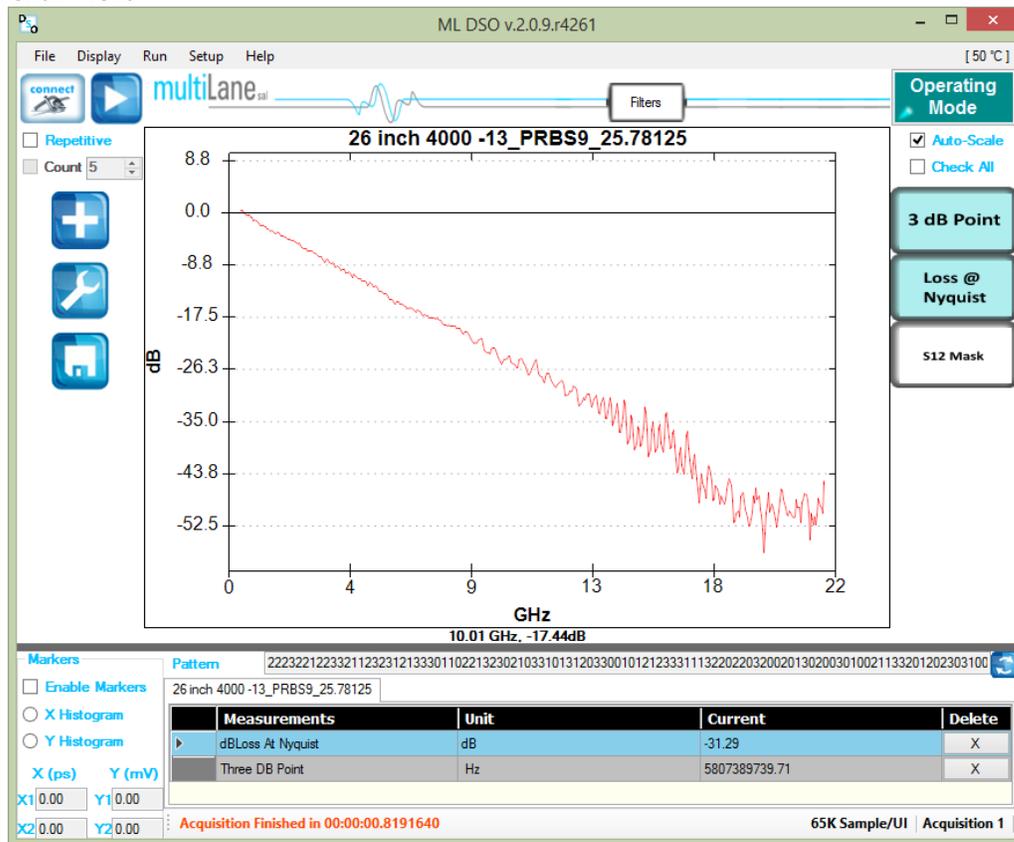
Click 'Capture Now'



You are presented with the captured eye,
 You may accept it or capture again
 Alternatively, you may 'Accept and Save' the reference eye data. This will save the captured reference data for future use, allowing you to use 'Load from .RefCirc' in the future when visiting this page, hence you avoid reconnecting the Reference Circuit

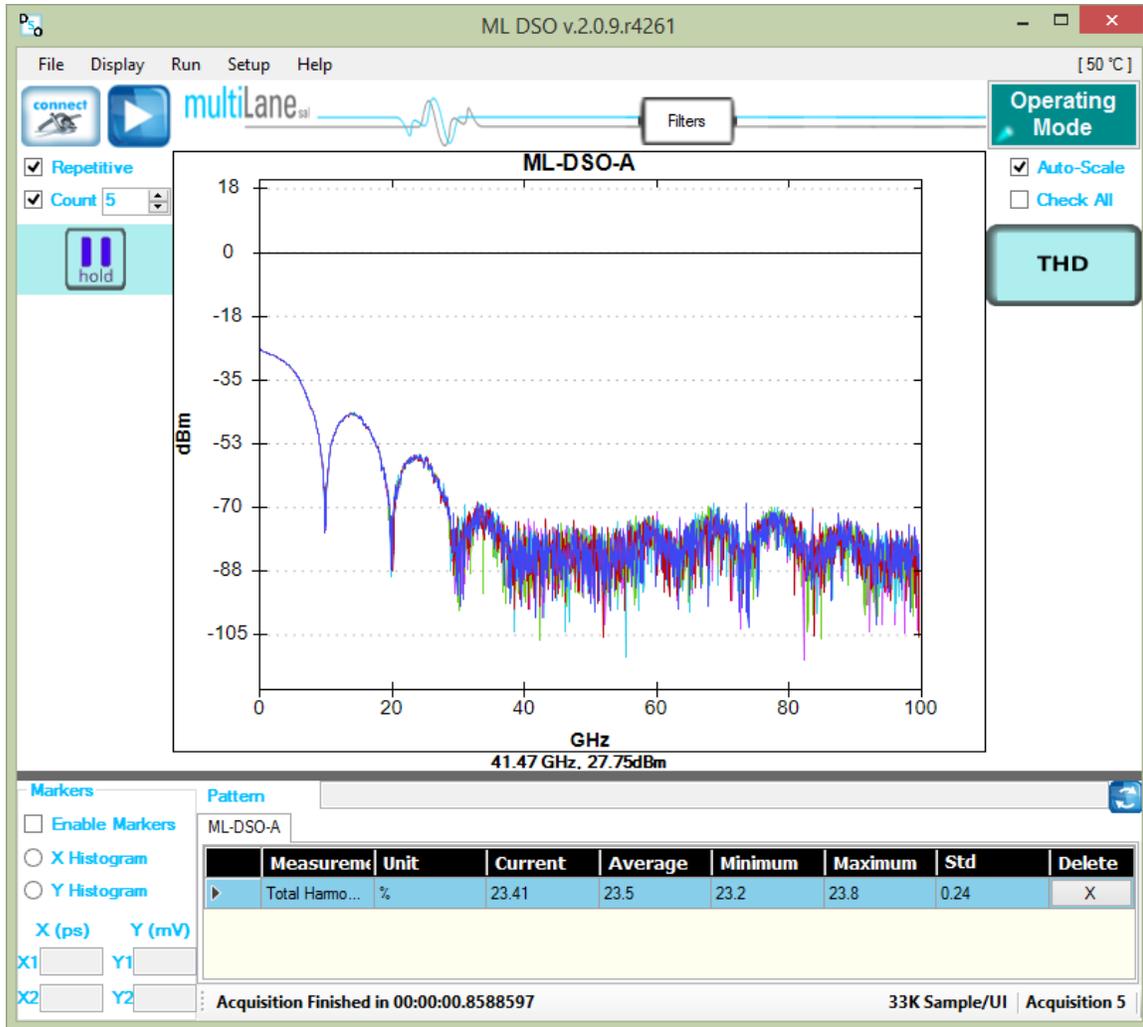


Click 'Next'



Frequency Domain Mode

Switching to frequency domain mode, the frequency domain can be plotted and the total harmonic distortions calculated



Appendix: USB Driver Installation

USB software drivers' names:

- **ML-DSO USB driver.**

The following instructions are applicable for a manual USB driver installation using Windows XP, Windows 7 and 8. If you're on windows 8, you first should disable driver signing.

- Power up the instrument.
- Plug the USB cable into the PC and connect it to the ML-DSO
- Ignore the messages *new hardware found* or *driver software not successfully installed* by pressing **cancel** or **close**.
- Go to the device manager via a right click on **My Computer**:
 - Click on **Manage**.
 - Click on **Device Manager**.
- Right click on the top level tab (Here multilane-PC) and select **"Scan for hardware changes"**.



Figure 23: Scan for Hardware

- A message appears stating: **"Scanning Plug and Play compliant hardware"**.



Figure 29: Scanning for plug and play compliant hardware

In the **Other Devices** tab, the **ML-DSO USB Device** description appears.

- In the **Other Devices** tab, right-click on the **ML-DSO USB Device** and select **"Update Driver Software"**...
- A dialog box appears asking for the method to search for the driver software. Select **"Browse my computer for driver software"**.
- A dialog box appears asking for the Driver software path. Enter the path and click **"Next"**.
- A security dialog box appears, select **"Install this driver software anyway"**.
- The PC commences Driver software installation.
 - A Windows message appears (after some time) saying that you have successfully updated your driver software.

- Press close.

- In the Device Manager, a new tab appears named **MultiLane SAL Devices**. Expanding it reveals “**MultiLane SAL ML-DSO USB Device**”.
- You are now connected via USB and you can control the instrument

Appendix: How to connect this instrument

The **ML-DSO** has 2 connection ports: USB (For Configuring Ethernet IP) and Fast Ethernet.

Connection through a USB cable

The USB interconnection is only used to configure the IP address of the device but not to perform measurements in real application mode.

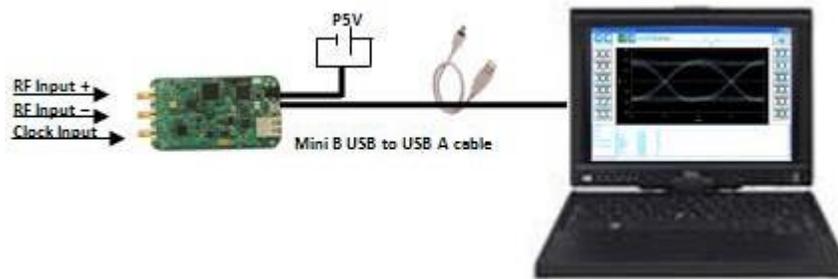


Figure 24: Connection via USB

Connection through an Ethernet cable

Connect an Ethernet crossover cable between the **ML-DSO** and the PC or instead an Ethernet straight cable between the **ML-DSO** and the Router or Switch. The device can be pinged to verify that a connection has been established

Appendix: Ethernet Configuration

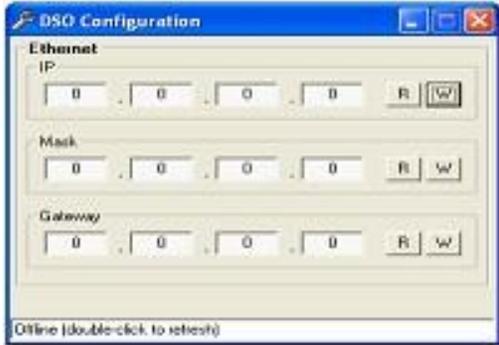


Figure 25: Ethernet Configuration

After connecting the ML-DSO to the PC through the USB cable, run the “**DSO Conf**” software. Read the current IP address by pressing the “**R**” button. Note that the device has a default IP address: 172.16.115.155; it can be changed to fit the network.

Press “**W**” to save it. Also, the Mask and the gateway configurations can be changed in order to fit the network.

Double click inside the white Box in order re-establish the connection.

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Fremont, CA 94539
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