

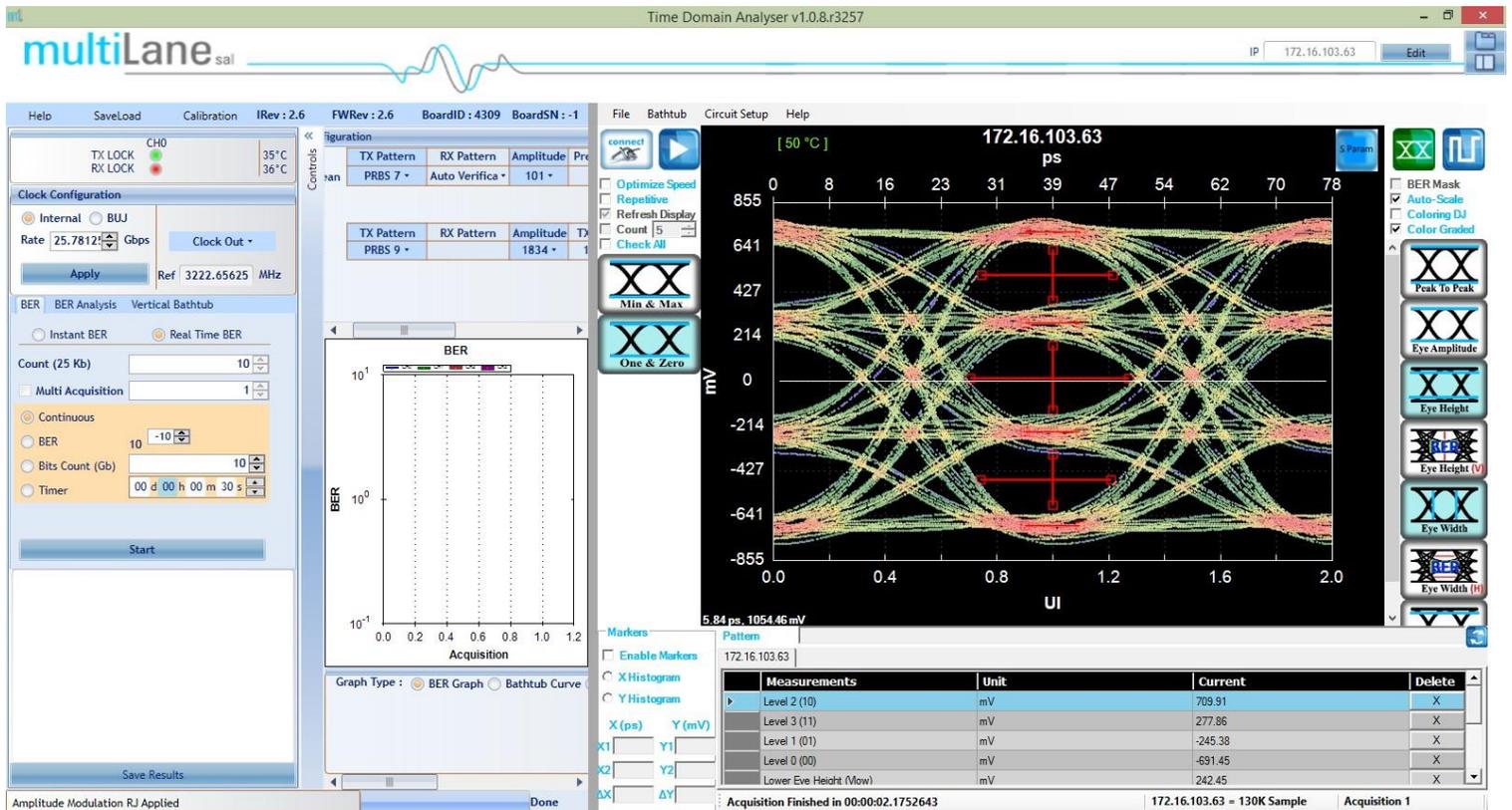


ML4004-PAM Time Domain Analyzer User Manual

www.multilaneinc.com

ML4004-PAM
2x28 GB/sNRZ or 2x56 GB/s PAM4 BERT
with 50 GHz Scope





User Manual Revision 1.3
 Windows GUI Version 1.0.5
 API Version 2.6*
 Firmware Version 2.6*

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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.

These terms may appear in this manual:

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

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

Preface

This is the user manual for the [ML4004-PAM](#). 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

Contact MultiLane SAL

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).

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Product Description

This chapter describes your instrument, operating under Windows.

- *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.

Model and Package Content

- This manual supports the instrument [ML4004-PAM](#)

Hardware Package

[ML4004-PAM](#): Dual Channel 37.2-60 Gbps BERT, trigger output, external reference clock input and DSO.

User Guide Manual

- Manual containing user operation guide, software installation and start up procedure.

Software package and documentations:

- Main [ML4004-PAM](#) GUI.
- USB driver. The Ethernet interface is controlled through APIs that include the Ethernet package.

Overview

The [ML4004-PAM Time Domain Analyzer](#) is a dual Channel BERT and DSO with PAM4 mode. It is low cost, simple to use, fully integrated, ultra compact, and USB/Fast Ethernet controlled. It is an instrument that combines the functions and features of a signal generator, bit error-rate tester, digital sampling oscilloscope, and data analysis system with Pre and Post Emphasis capabilities with lower intrinsic jitter.

Key Features

BERT features:

- NRZ Bit Rates: 10-15¹ and 18.6-30.2 Gb/s
- PAM4 Bit Rates: 37.2-60 Gb/s
- Histogram and SNR measurements
- FEC KR4 and scaled KP4 supported (PAM mode)
- Supports QPRBS13 and user-defined patterns up to 16kSym
- Supports PRBS 7, 9, 11, 15, 23, 31 as well as square 16 and square 32 patterns
- Clock out rate/165
- Intuitive comprehensive GUI
- Supports all basic BERT functions
- 6 dB pre-emphasis
- Adaptive CTLE and DFE on the receiver with AGC
- Mask Margin, Alternate Mask Margin rules available (NRZ mode).
- Inner eye amplitude variation (PAM4 mode)

DSO features:

- Low intrinsic jitter
- Scope BW of 32 or 50 GHz (Option -50)
- External trigger input
- SW filters applicable include PTB, CTLE, FFE, DFE, De-Embedding, Moving Averages and Bessel-Thomson 4th order.
- Single ended and differential electrical input
- Eye, jitter, rise/fall, histogram, mask measurement and pattern capture in a single instrument.
- Eye opening, Eye height and width, Eye Amplitude, Top, Base, Hi, Lo, Peak to Peak, Max, Min.
- 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).
- PAM4 mode enhanced measurements
- Insertion Loss measurements i.e. Sdd21 and Sdd12 with embedding/de-embedding capability.
- An easy to use wizard for Insertion loss measurements
- The DSO tool can operate in a data acquisition only mode where the data is saved on multiple acquisitions for post processing.
- Integrated synthesizer

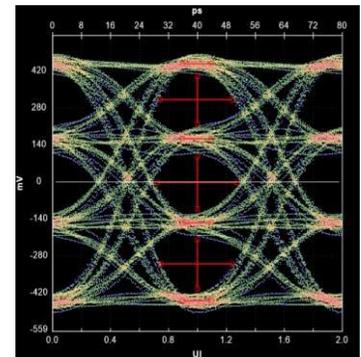


Figure 1: ML4004-PAM Eye diagram

¹Channel 0 only

- 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 persistence display in eye and pattern capture mode
- Standard stress masks selection for LRM pre-cursor, LRM post-cursor, LRM symmetric, and LRM Clean Eye.
- The mask margin (positive or negative) can be extracted for a defined number of points that fail, thus allowing for DUT quality assessment.
- Mask user defined, Auto Detect Mask
- Percentage of failing points
- Save data and Mask
- Load Mask

Package characteristics:

- Low cost, simple to use, dual channel PAM4 and NRZ BERT in case of ML4004-PAM TDA
- Supports high density parallel application with unlimited concurrent testing.
- Windows and Linux API available
- Repeatable traceable measurement
- 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.

Target Applications

- Interconnect testing(SFP, SFP28, CFP, CFP2, CFP4, QSFP, QSFP28, ...)
- Backplane testing
- Wafer level testing where an output clock cannot be extracted from an IC
- 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

The user interface for the ML4004-PAM is an all-new combination of the ML BERT and ML DSO graphical interfaces. Both the DSO and BERT functions are accessible by the same IP address, and can either be arranged to be tabs, or side by side in the same window, as seen below:

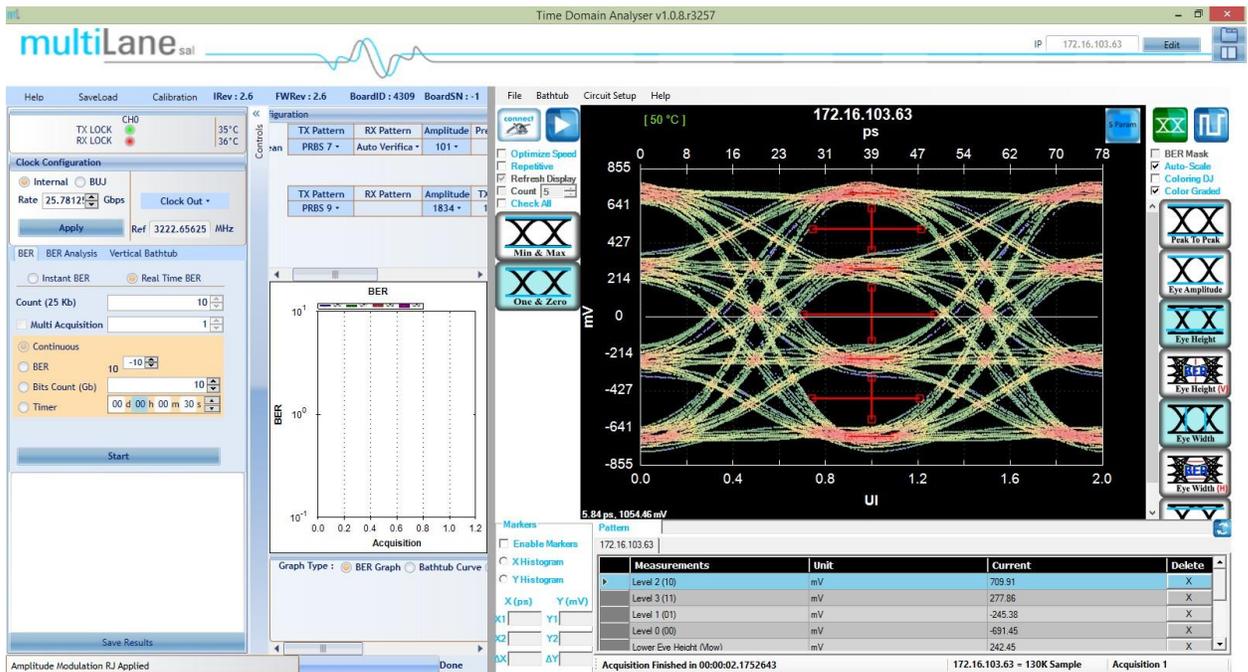


Figure 2: ML4004-PAM TDA GUI

The instrument comes with the following software:

- **ML-TDA GUI** (GUI to Control the Instrument)
 - **MultiLaneML4004-PAM USB driver**
 - **ML4004-PAM ETH Configuration Software** (Utility to configure the static IP Address over USB)
 - **ML-IP changer** (Utility to configure the static IP Address over Ethernet)
- The Multilane Software runs on Windows XP (32/64 bit), Windows 7 and 10.

NOTE. These applications requires the Microsoft .NET Framework 4. If the Microsoft .NET Framework 4 is needed, it can be downloaded through this link:

<https://www.microsoft.com/en-us/download/details.aspx?id=17851>

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

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

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

Instrument Ports

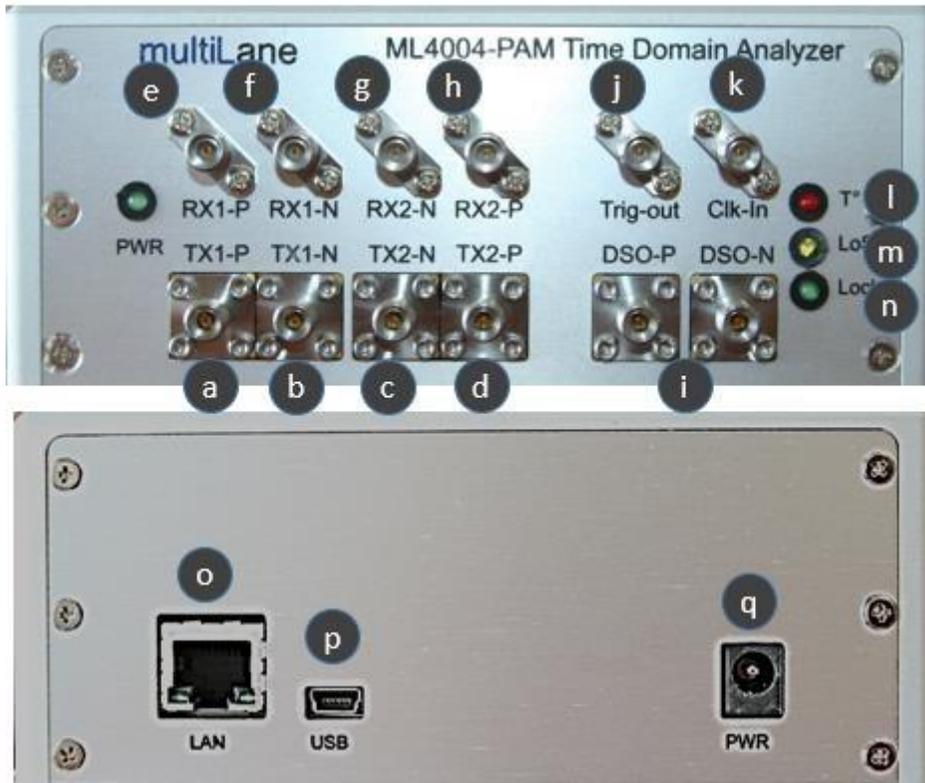


Figure 3: ML4004-PAM Panels

ML4004-PAMPorts

	Port Name	Description
a	Tx1-P	Positive TX1 Channel
b	Tx1-N	Negative TX1 Channel Amplitude range: 125-800mV Differential. Bit rate 37.2-60Gb/s– Electric interface
c	Tx2-N	Negative TX2 Channel Amplitude range: 125-800mV Differential. Bit rate 37.2-60 Gb/s– Electric interface
d	Tx2-P	Positive TX2 Channel
e	Rx1-P	Positive RX1 Channel Amplitude range: 100-800mV. Bit rate 37.2-60Gbps – Electric interface
f	Rx1-N	Negative RX1 Channel
g	Rx2-N	Negative RX2 Channel
h	Rx2-P	Positive RX2 Channel Amplitude range: 100-800mV. Bit rate 37.2-60Gbps – Electric interface
i	DSO input	RX-N and RX-P for DSO
j	Trig-out	Trigger out port
k	Ref-Clk-in	DSO Ref Clock in
l	T	LED, indicates the board is overheating when glowing red
m	Los	LED, indicates loss of signal on Rx when glowing red for the following reasons: <ul style="list-style-type: none"> ▪ Cable not inserted ▪ Signal inverted ▪ PRBS pattern on Rx do not match the TX pattern
n	Lock	LED, indicates Ref CLK-Out is functional when lit green, ML4004-PAM is generating a clock signal.
o	LAN	RJ-45 port
p	USB	Mini-B USB port
q	PWR	Power port

Table 1. Instrument Ports

Installation

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

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

Note: always run the GUI as administrator

System Start-up

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

- Make sure you have Microsoft *.NET Framework 4* installed.

If not installed, refer to the Note in the Software section.

- Install the **ML-TDA GUI**.
- After installation, open it with double click on the software icon on desktop or from your start menu.
- A new window will appear titled **ML-TDA GUI**; this is the main software interface.
- Note: The **ML-TDA GUI** itself only operates over Ethernet. USB is only used to configure the static IP address of the card with the ETH Configuration Utility that requires a USB cable to be connected from the ML4004-PAM to your PC. Using USB cable to configure IP is not mandatory as you can stick to the default IP that came with the device
- Follow the steps below to connect the **ML-TDA GUI** to the ML4004-PAM:
 - Connect your PC to the ML4004-PAM via the RJ45 connector located on the front panel through an Ethernet cable. In order to connect via Ethernet the IP address of the board is required and the IP address of your PC needs to be on the same subnet as the address of the ML4004-PAM. To learn more options on how to connect the Ethernet cable go to the section [Connect through an Ethernet Cable](#).
 - Ping your device to make sure that you are connected.
 - Note that no drivers are required; you only have to know the current board IP address, which you need to enter it in the text box next to the **IP** label shown in the below picture, then click on the **config** button.



Figure 4: Configure IP of device

- Depending on which module you want to use, you need to connect separately on the BERT or DSO side. Once connected, on the BERT side, you'll get a green light and a temperature indicator which confirms a successful connection. On the DSO side, when clicking connect on the configuration settings window, you would get a clear error in case of failure to connect; otherwise, the settings window would close taking you back to the main screen, confirming a successful connection.

- If you need to change the IP address of the board, you need to install the USB drivers (refer to section [USB Driver Installation](#)). Install the ETH Ethernet configuration Utility that allows you to read, write the IP address, Subnet Mask and Gateway of the instrument.

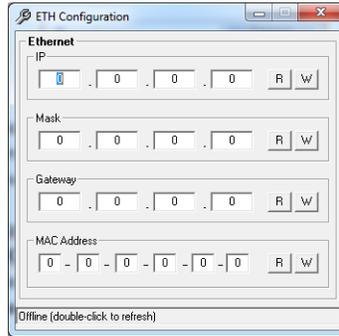


Figure 5: Ethernet Configuration

- If you have failed to connect via Ethernet, and you are not able to ping the instrument, then it could be an Ethernet Configuration error. Connect your PC via USB to the ML4004-PAMBox and use the ETH Utility to change the static board IP address to fit in the network range. Refer to the section "How to connect to this Instrument".

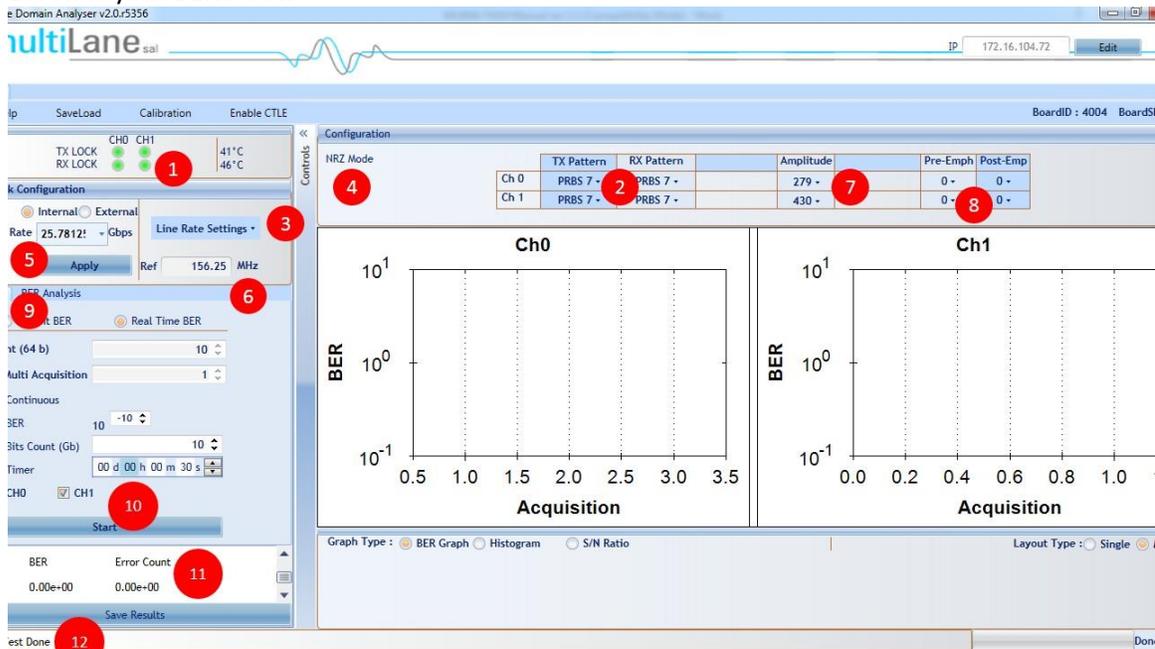
Starting the GUI



When you enter the IP address and connect to the instrument, you are presented with the above menu. Choose if you plan on using the ML4004-PAM as BERT only, Scope only or both.

Operating the ML4004-PAM BERT

Below is your BERT GUI.



- 1- Connect cables of equal length and type between TX and RX. This should give you lock on RX. If not, go to the TX pattern menu and invert the pattern. Also check that the amplitude is not very low for the receiver to lock. It goes without saying that the TX and RX pattern must be the same, e.g both PRBS 9 or both PRBS 31.
 - a. Your BERT can generate custom patterns but it cannot lock or do BER measurements on anything except the standard PRBS patterns
- 2- This is where you select the TX pattern. Both TX and RX patterns must have the same polarity and same type to be able to do BER measurements. You can invert the pattern polarity from either TX or RX.
- 3- Under Line rate settings you can switch PPG mode between PAM4 and NRZ. The currently configured mode is shown in (4). Under line rate settings you can also enable and disable FEC, pre-coding and grey coding. After changing any settings under this menu, please click on apply for changes to take effect.
- 4- Shows the operation mode selected: PAM4 or NRZ
- 5- This is the line rate setting. In PAM mode, only line rates between 21 and 30 GBaud are allowed. In NRZ you also enter line rates between 10 and 15 Gbps on channel 0 only. After changing the line rate always click apply.
- 6- This shows the frequency of the clock output connector. It is usually rate/165.
- 7- This is the amplitude setting. In PAM mode, you have two amplitude settings, one for the coarse amplitude range and the other for the amplitude fine-tuning.
- 8- This is the control for the pre and post-emphasis on the PPG.
- 9- This is the measurement menu where you can either do traditional BER measurements or go into the analysis mode. The analysis mode is a great troubleshooting tool where you can display the signal histogram on the receiver or measure the SNR to determine if you have excess noise affecting lock or resulting in errors.

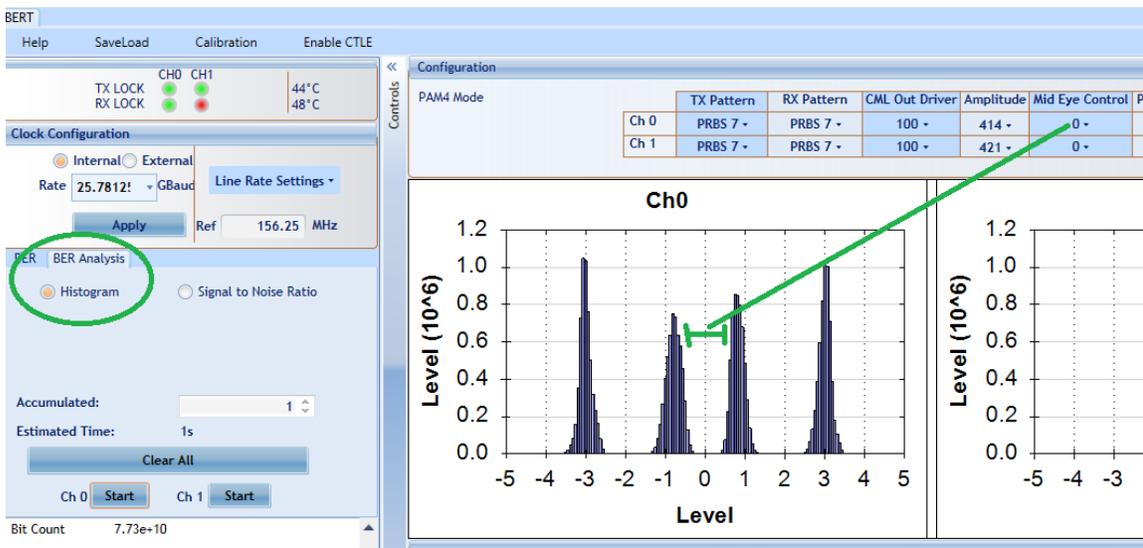
- 10- This is where you select the channels to run measurements on and the start measurement button.
- 11- In this window you see the results for the BER measurement. This includes a timer, the total number of bits transmitted and the BER. It also shows you the cumulative number of errors.
- 12- In this field you see error messages or warnings generated by the TDA.

Note: there is a temperature reading on the GUI, for both TX and RX. This is a safety feature on the instrument. If any of the two temperatures reaches 65°C, the firmware will disable the main circuits of the TDA to prevent damage. Also, the T° LED on the front panel of the instrument will go on.

Achieving a good signal in PAM4 mode

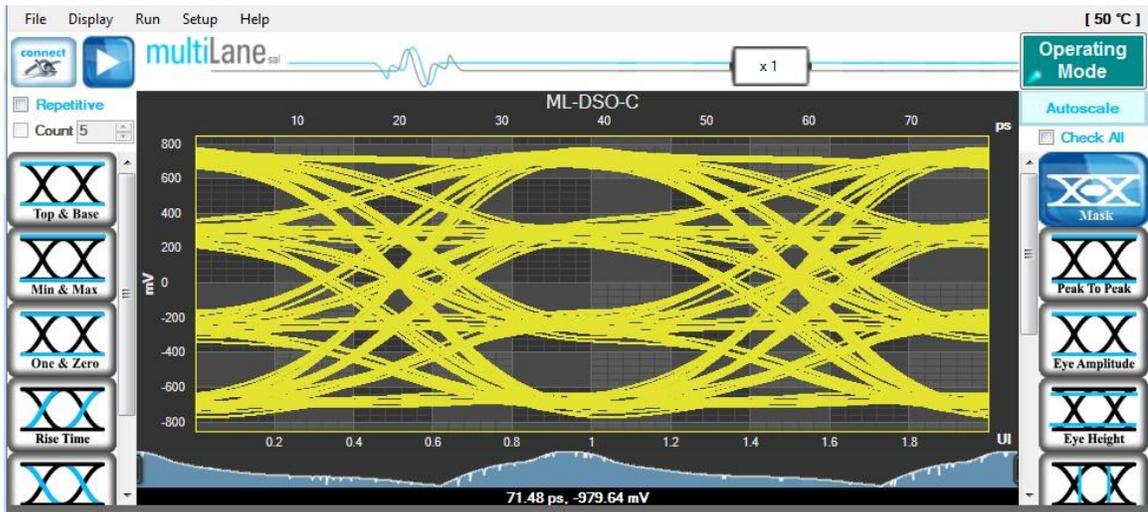
Working with PAM4 signals can be a bit trickier than NRZ. Therefore, the ML4004-PAM gives you several powerful troubleshooting and tuning tools to get the best results possible.

- 1- Use the histogram function under the analysis tab to see what your PAM/NRZ eye looks like.



In the histogram above, you see that the inner eye is smaller than the upper and lower eyes. To change this ratio, go under the Mid eye control tab and change the value then repeat the histogram scan.

- 2- Make sure the signal strength at the receiver is between 250 and 400 mVpp.
- 3- Use the DSO to tune your PAM signal coming out of the PPG.



Setting the TX Line Rate

- First select the internal clock generator, then write the bit rate value next to the **Line Rate** label. The value entered must be in between 37.2-60 Gb/s. The line rate will apply to the TX output channel
- Press **Apply** to save the value. You'll see 'Bitrate Applied' on the status bar confirming the changed values.
- A reference clock output (synchronous to the transmit clock) is provided on SMA "j" (see table 1). This clock will be equal to the line rate divided by 40 for low rates (NRZ mode) between 10 and 15Gbps, and divided by /165 for high rates (NRZ and PAM4 modes) between 18.6 and 30.2 (equal to 37.2 and 60 Gb/s -PAM4 mode-). The frequency of the reference clock output signal is shown in the field next to the **Ref** label in the GUI as can be seen in figure 6.
- Note: CDR RX CLK out is not supported in the single channel BERTs.
- Note: External Reference CLK input is not supported on the Single Channel BERTs.

Pattern Configuration

- In the **PRBS Configuration** group box, select the pattern required; the available patterns are 7, 9, 11, 15, 23, 31, Square_16, Square_32 and user defined in addition to the 80 bits user pattern. The TX Pattern tab is used for Configuring the Transmit Patterns, the RX Pattern tab is used for pattern verification.

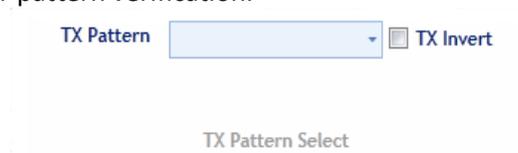


Figure 6: PRBS Channel Configuration

Note: while a user pattern is selectable, the error detector can NOT lock onto user patterns. This can only take place with PRBS patterns.

- To use the **User defined** capability, first select it from the **Pattern** combo box list, then in the text box specified for the **User Defined** write the sequence of bits you want, and then select the **Set** button.
- In case the test engineer wires the positive TX channel to the negative RX Channel by mistake, the software can compensate for this error by clicking on the invert button.
- The specified generator now starts generating a clean signal. If you would like to inject jitter to the signal generated to start shaping the eye diagram, you have to adjust the slide bars existing in the Eye Shaping group box (refer to **Eye Shaping** below).

PRBS Pattern Verification

There are 2 ways to set the Error Detector for the RX Channel of the [ML4004-PAM](#):

- **MANUAL:** pick the same pattern as you selected for the TX channel, the RX Channel LED in the top of the GUI indicates that the channel is locked by turning green. Channel will be locked if the data received at RX matches the selected pattern. If not locked try inverting the TX or RX side using the checkbox.
- **AUTOMATIC:** If the user selects **Automatic Verification**, the software will try to detect the received signal pattern, even if it is inverted; upon success it will show the result and the LED will indicate that the channel is locked.



Figure 7: RX Configuration

Eye Shaping

The [ML-TDAGUI](#) provides 3 sliders to shape the data eye of the TX output: amplitude, Pre-emphasis and Post-emphasis. All slider values and other configurations are saved in the EEPROM:

- **Amplitude:** TX output amplitude is between 0 mV and 500 mVpp.
- **Inner Amplitude:** amplitude for the center inner eye in PAM4 mode.
- **Pre Emphasis:** TX output Pre-emphasis amplitude value can be changed from 0 to 20%.
- **Post Emphasis:** TX output Signal Post-emphasis amplitude value can be changed from 0 to 35%.

Pre and Post Emphasis values can be adjusted in order to attain the clearest eye condition (e.g. 2/4 and 5/10).

Amplitude	Inner Amplitude	Pre-Emph	Post-Emp
233 -	2 -	2 -	3 -
251 -	2 -	2 -	3 -

Figure 8: Eye Shaping Sliders

Running BER Tests

In order to run a BER test, the TX port needs to be connected to the RX port, simply looped back on itself.

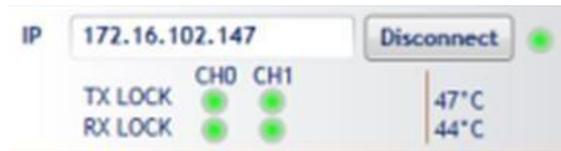


Figure 9: LED Channels

The TX LED indicator lights in the top right hand corner of the GUI (see Figure below) indicate if the TX channel is transmitting data. The RX indicator LEDs are defined as follows:

- If the LED is green that means the RX channel is locked to the incoming data pattern.
- If the LED is red that means that the RX channel is not locked to the incoming data. Please make sure the RX Channel is expecting the correct PRBS pattern that is being transmitted on the TX channel (of Auto Verification is turned off), also make sure the cables are not inverted by selecting the Invert checkbox in the Pattern Generation Tab for the TX Channel.

When the TX and RX LEDs are both Green, you can use the [ML-TDA GUI](#) to run several different BER tests on this channel. Select the BER Tab in the GUI. This will show a menu as displayed in Figure 8. In this menu one can select one of 2 different BER Test modes: Instant BER or Real-time BER. These two modes are described in detail below.

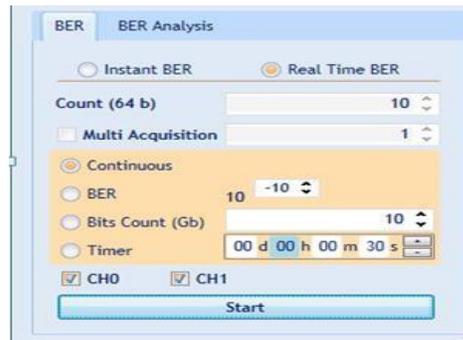


Figure 10: BER

Instant BER

The Instant BER Mode is useful for test cases where a very high error rate is expected (i.e. an error rate above 4×10^{-5}) and an accurate reading is needed. In Instant BER mode the BERT takes a snapshot of 25K bit samples, counts the exact number of errors, and returns the error rate. If the user selects multiple 25Kbit acquisitions, the BERT will continue to take 25KBit samples, return the BER and take the next sample etc. This way, the user is able to read an exact BER with rates as high as 10^{-1} . However, not all errors can be captured as there is a delay in between taking 25KBit snapshots and therefore not all received bits are examined for errors.

The Instant BER test has the following configurations:

Count (25Kbit): Number of 25K Bit snapshots to be collected (Controller Hardware Count).

Multi Acquisition: This allows you to choose the number of acquisitions (Software Count).

Note: A very high sample count of 25Kbit samples will take a short time but could use up 100% of the Micro Controller's Bandwidth possibly preventing the **ML-TDAGUI** from responding to any other configuration changes while the test continues to run. It is best to select a balanced number of 25Kbit Counts and Multiple Acquisitions.

Once you have selected the desired number of 25Kbit counts and Multi Acquisitions, press the start button as shown in figure 8.

Real Time BER

In this mode, the Error Detector is constantly looking for errors, therefore this mode is good for long BER test cases with relatively small amounts of errors (low BER rates). However, in this mode the user is limited to Bit Error Rates below 4×10^{-5} due to error counter limitations of the Error Detector itself. So for Bit Error Rates above 4×10^{-5} , BER test in Real-time BER mode are not 100% accurate like the Instant BER mode because the error counter will overflow before the next scheduled counter read, and therefore some bit errors will pass the Error Detector without being detected.

The Real Time BER test can be run in 4 different modes as described below. It can be run by pressing the start button.

Real Time BER Configurations:

Bit Count: This configuration will run a BER test until the user-set number of bits have been transmitted and received.

Continuous BER: This process begins collecting BER data when the user presses start, and ends when the user presses stop.

BER (Target): The BER test will run till it reaches the BER level selected.

Timer: The BER test will run for the specified amount of time.

BER Graph

The BER Graph Window plots the channel BER Rate in the above mentioned BER Test Modes. An example graph is shown below.

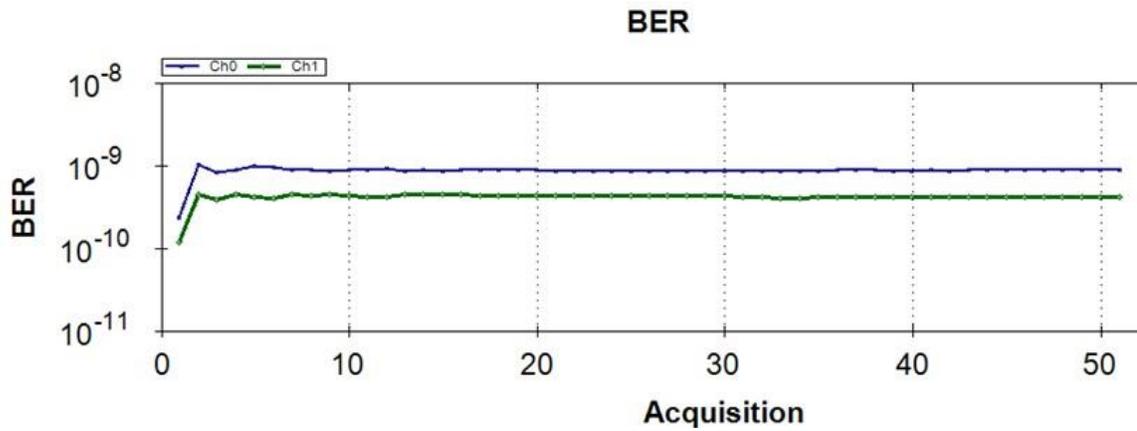


Figure 11: BER Graph

BER Analysis

The **ML-TDAGUI** offers 2 different Bit Error Rate Analysis modes: the Histogram and the Signal to Noise Ratio. Selecting the BER Analysis Tab in the GUI provides the menu as shown below:

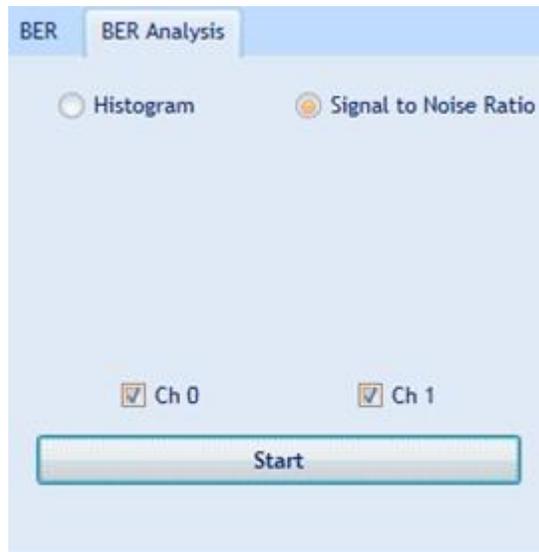


Figure 12: BER Analysis Menu

Digital Sampling Oscilloscope

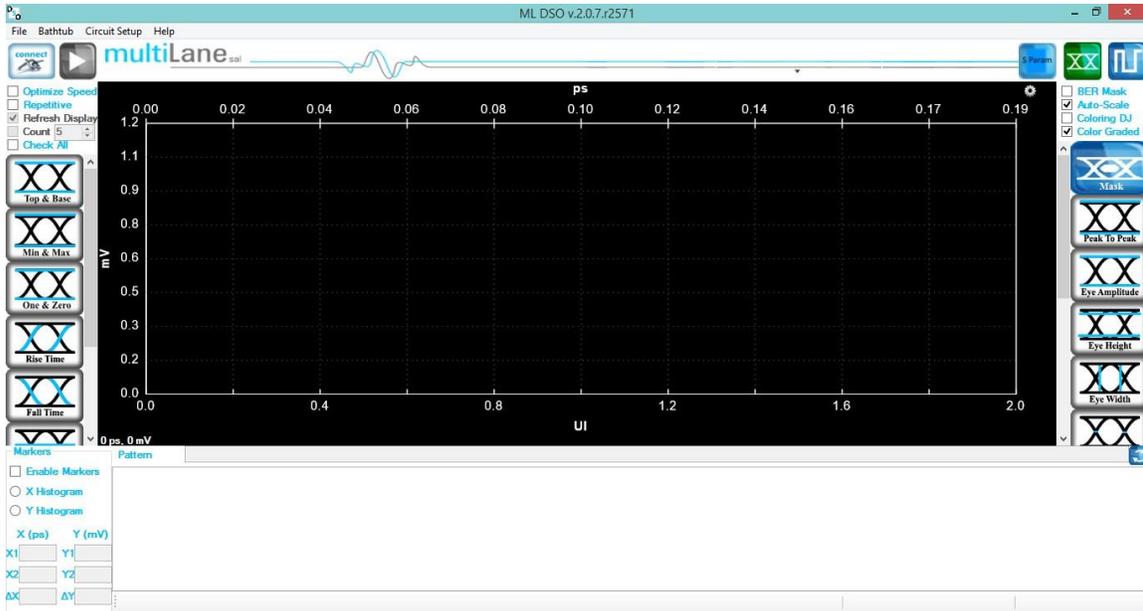


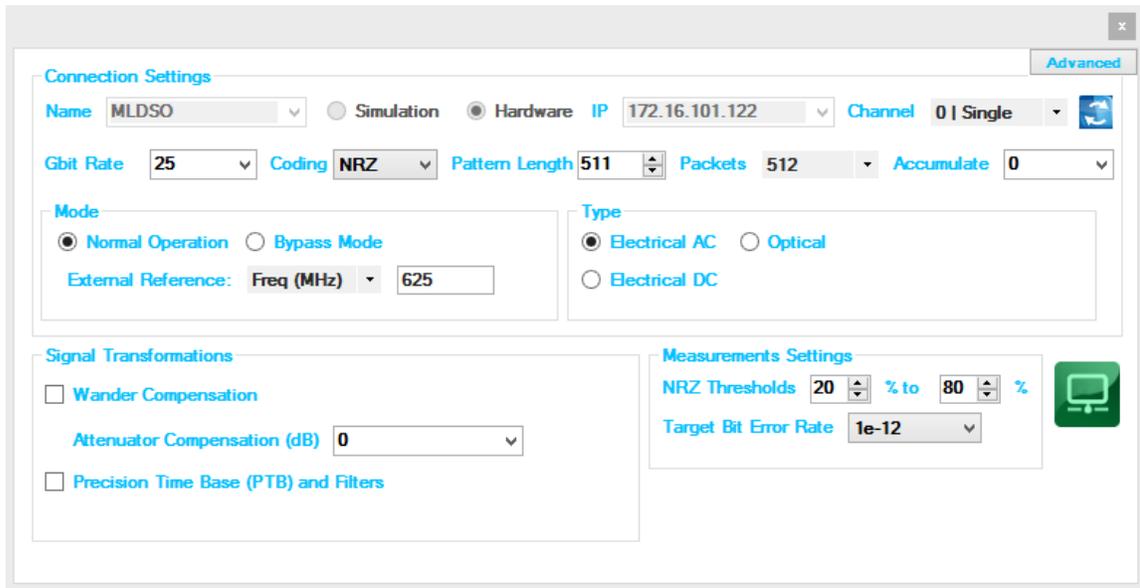
Figure 13: GUI

- 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.

Data Configuration

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

- The ML-DSO can be mounted in different modes:
 - Normal Operation
 - Bypass Mode

Normal Operation

Clock Input in normal mode ranges between 50 and 710 MHz.

- 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.
The number of packets specifies the number of sample blocks that will be used to create the 'Eye diagram'. Each sample block 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)

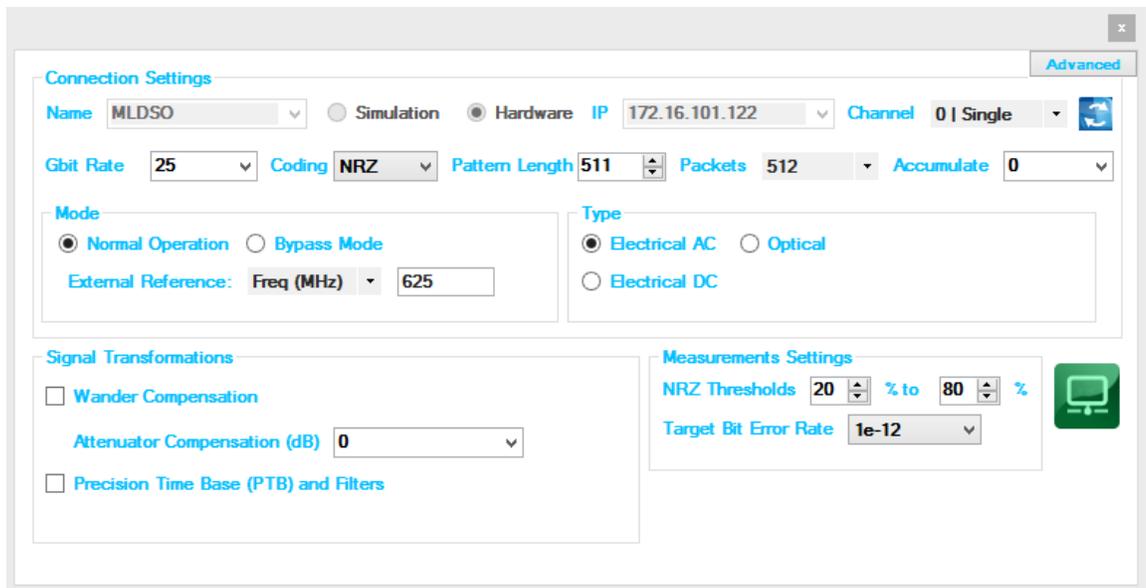


Figure 14. DSO Configuration

- 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 /
 - External Reference Freq (MHz)
- Its value can vary from 50MHz to 710MHz, with an amplitude range from 0.25 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.
- In order to improve graph clarity and minimize/cancel random jitter, enable “Precision Time Base (PTB)”, and enter a value greater than zero. With PTB enabled, you can apply filters such as:
 - Moving average filter for smoothing and can specify window size.
 - 4th Order Bessel Thomson filter at Frequency equal to 0.75 of the bit rate
 - CTLE filter, and can automatically or manually select the filter parameters
 - S2P De-Embedding filter simulating the inverse of a channel or DUT, where the channel's S2P file is loaded
 - 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
 FFE: feed forward equalizer(linear equalizer) each value of the output sequence is a weighted sum of the most recent input values
 The user can use the latest GUI to generate taps automatically for either DFE or FFE, but it can only come up with taps for NRZ PRBS 7 or PRBS 9 signals. The taps can be applied on any type of signal, PAM 4 or NRZ. Therefore if in need of using the software to come up with taps that open the eye, generate the taps for a specific channel using an NRZ PRBS7 or 9 signal, then switch to the desired signal over the same channel using the same taps.

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 normalized (their sum = 1)

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

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.

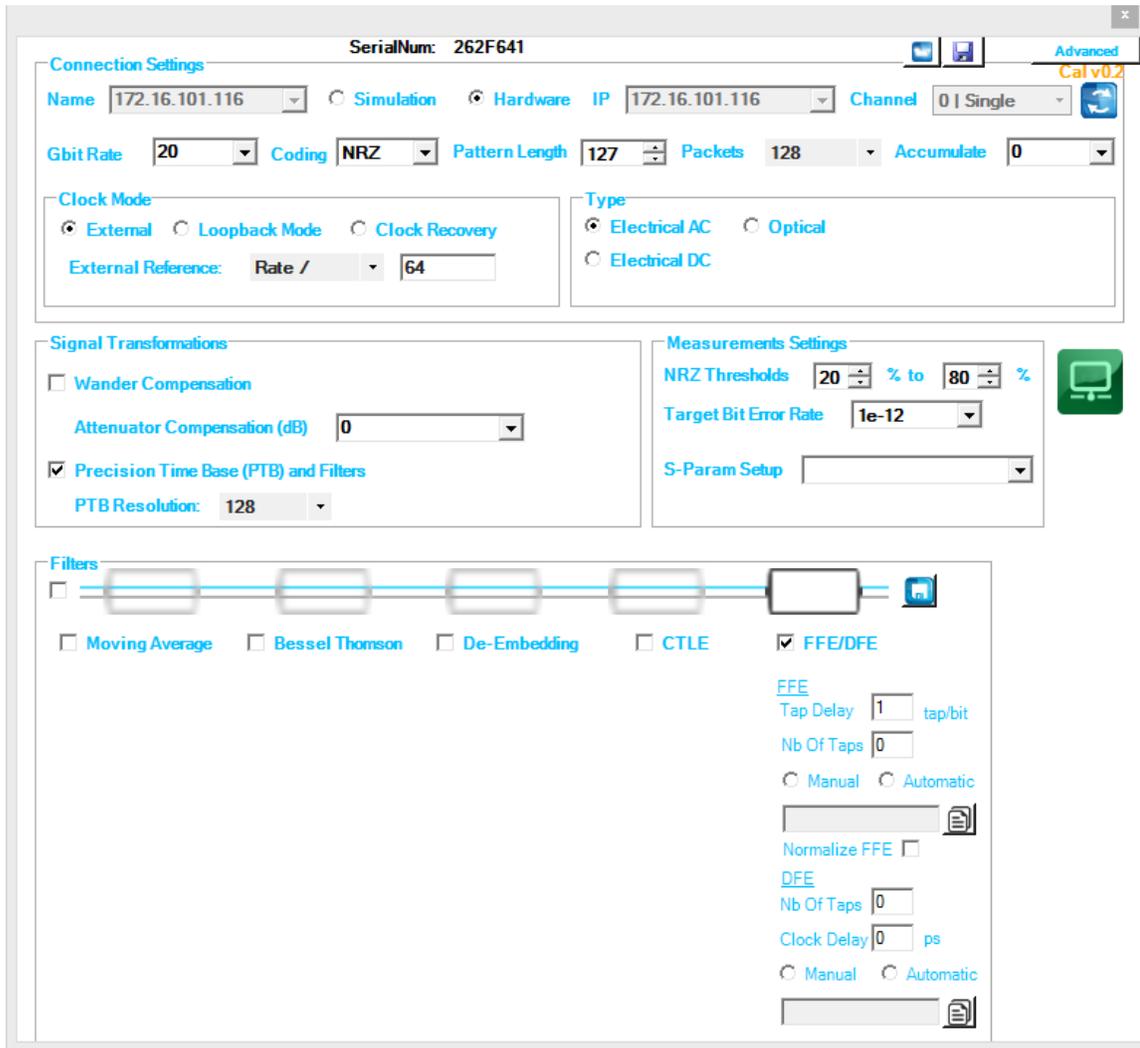


Figure 15: Filters



Figure 16: Wander Compensation

DSO menu bar

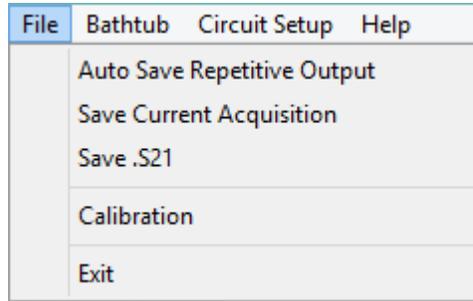


Figure 17: DSO menu bar

The menu bar includes “**File**” and “**Help**” menus. It is visible when you right click on the DSO part of the GUI

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 **DSO**s, 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.

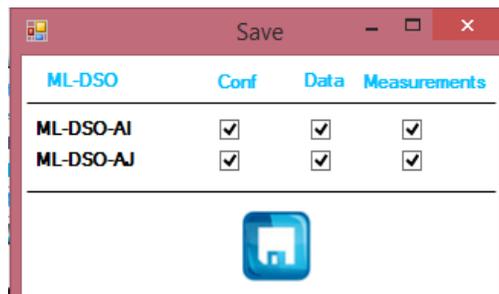


Figure 18: Save window

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

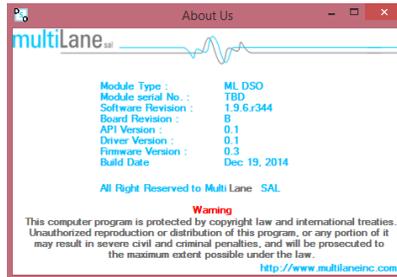


Figure 19: About us

Zoom functions

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”

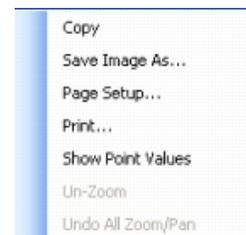
Panning

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



Mode of operation

This section covers the different operation mode of the instrument, addressing the following topics:

- Eye Measurements Mode
 - Oscilloscope Measurements
 - Multiple measurements

- NRZ Measurements
- PAM4 Measurements
- Mask Test
- Color Graded Persistence Mode
- Pattern Capture Mode including Jitter components decomposition

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.

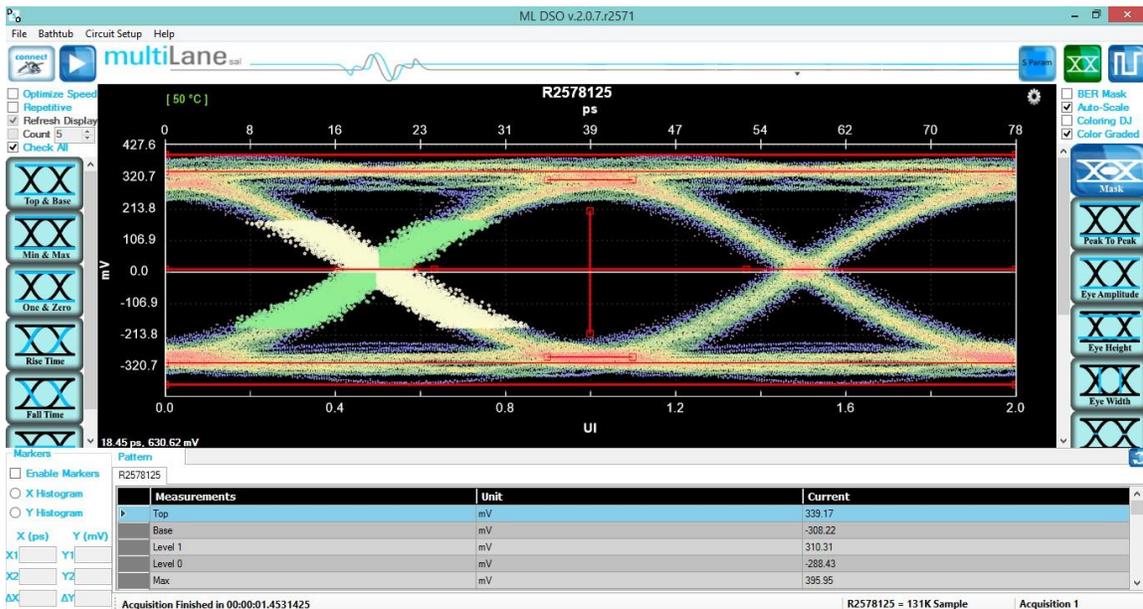


Figure 20: Measurements Mode

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; in order to display the eye for each acquisition check the “**Refresh Display**” text box.

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 Saved Data 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 2: Operation Status

How to add multiple ML-DSOs/Disconnect/Reconfigure

To add a new **ML-DSO**, press the “**Add New ML-DSO**” 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.

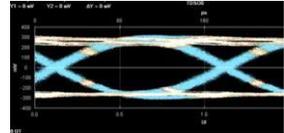
To reconfigure the data, click the “**Edit ML-DSO configuration**” icon, and then fill the configuration window as preferred.

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.

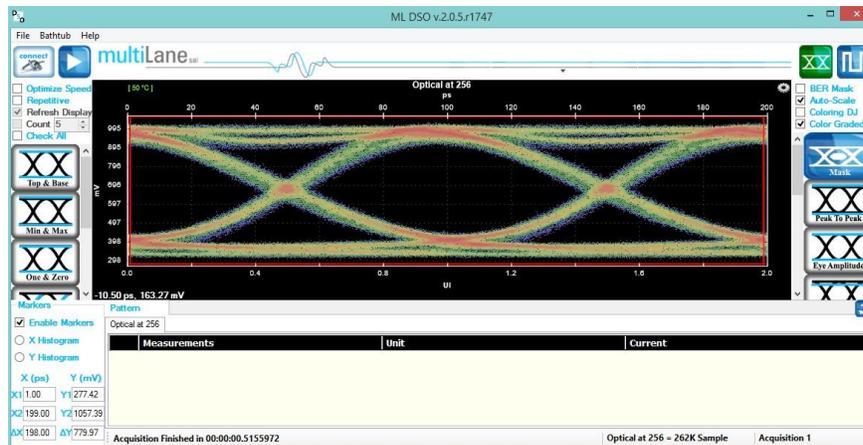
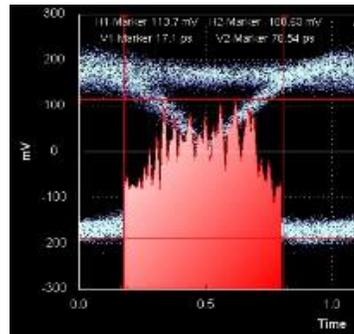
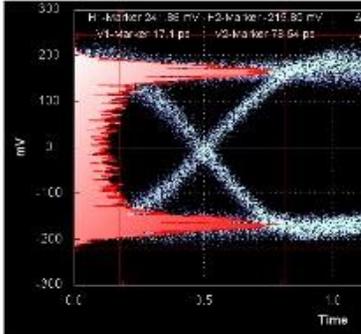


Figure 21: DSO Markers

- 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.

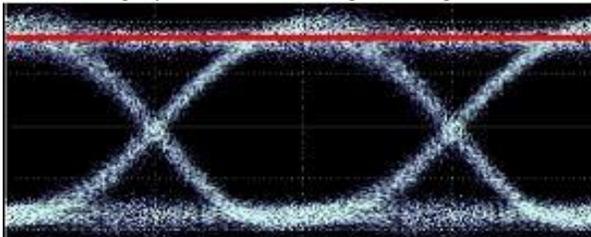
Histograms

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



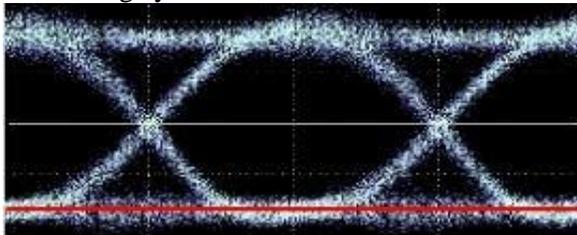
Top

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



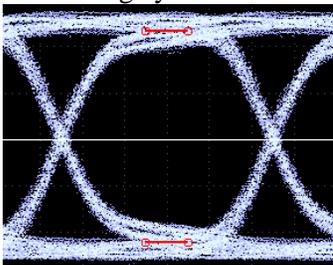
Base

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



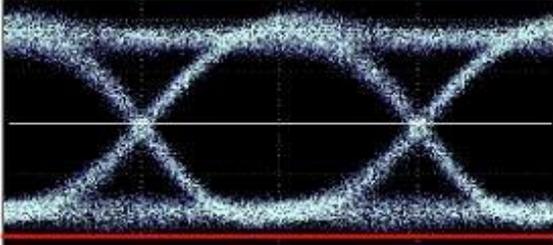
One and Zero level

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



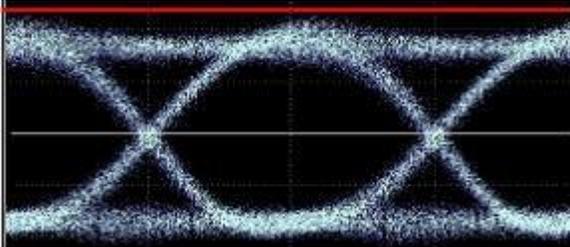
Min

The minimum sample value.



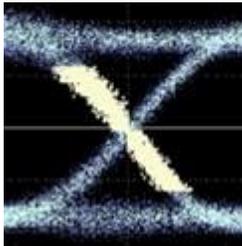
Max

The maximum sample value.



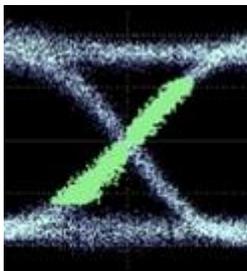
Fall Time

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.



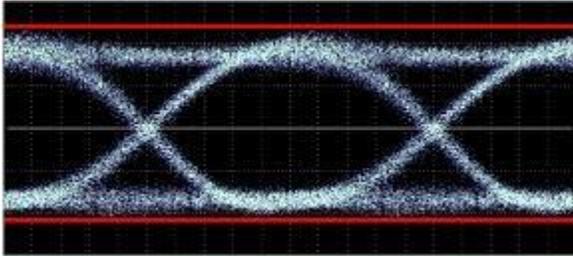
Rise Time

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



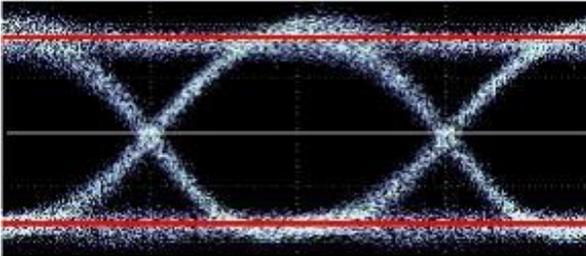
Peak to Peak

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.



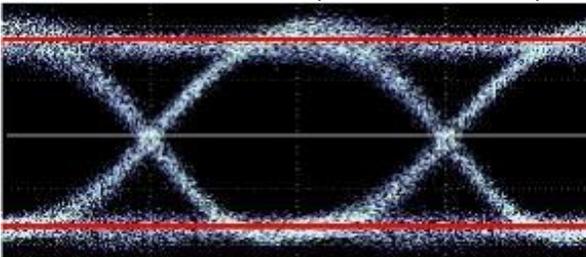
Eye Amplitude

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



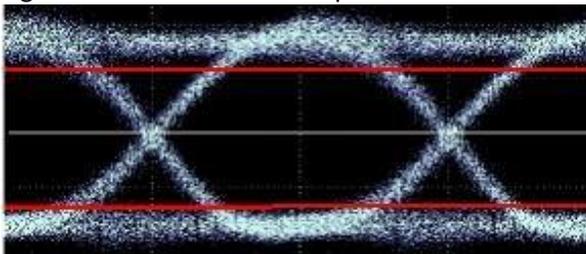
Voltage Amplitude

The difference between top and base of an eye.



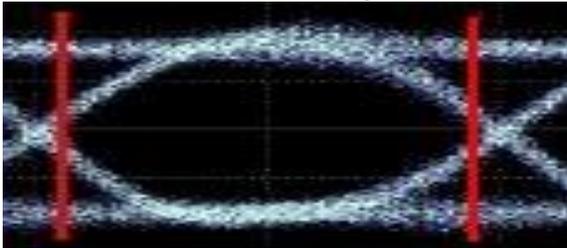
Eye Height

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.



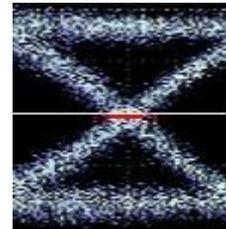
Eye Width

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



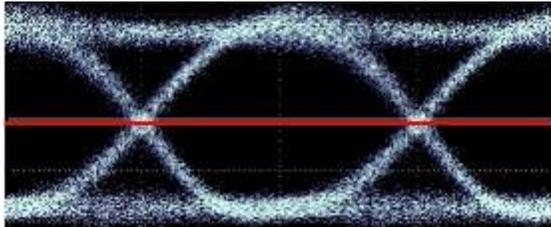
Total Peak-to-peak Jitter

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.)

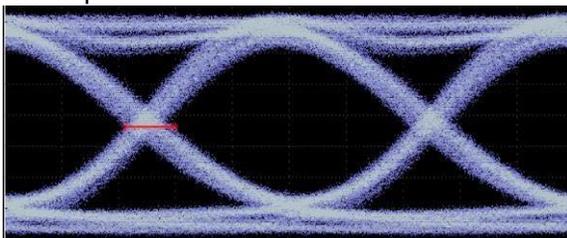


SNR

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

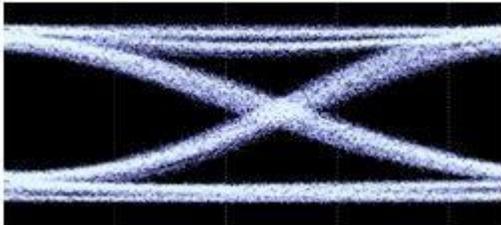
The multiple measurements gives the user the ability to view the different measurements: Top, Base, Min, Max, Fall/ Rise time, Peak to Peak, Eye Amplitude, Eye Height, Eye Width, Jitter, and the crossing percentage for a number of measurements specified in the repetitive box or for an undetermined number.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

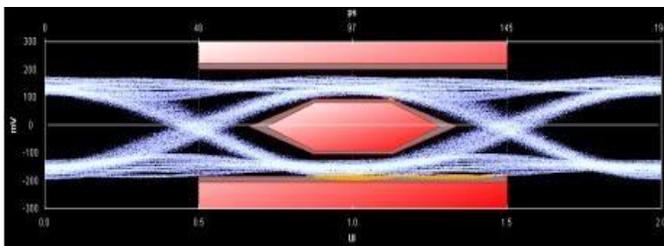


Mask Margin

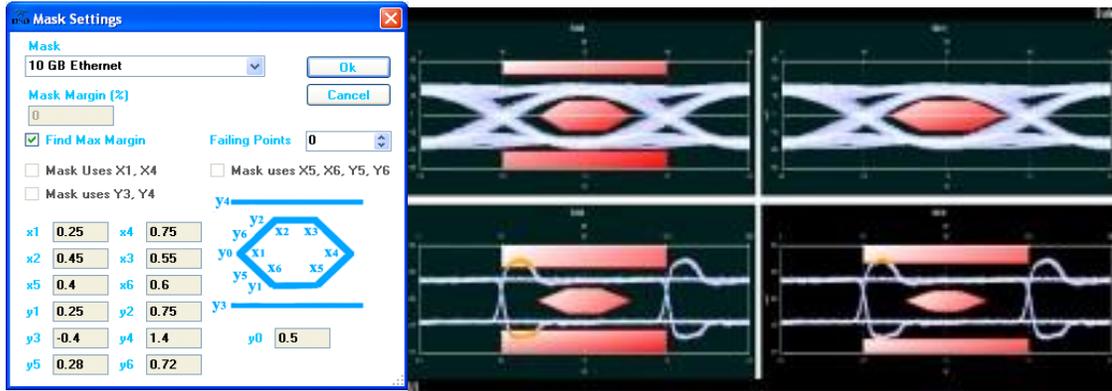
The **“Switch to Mask Mode”** button, located between the Eye and Pattern buttons, is used to find the maximum mask margin that results in no more than a specified number of failing points. The figure below shows an example where the user wants to determine the maximum mask margin available for the highest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

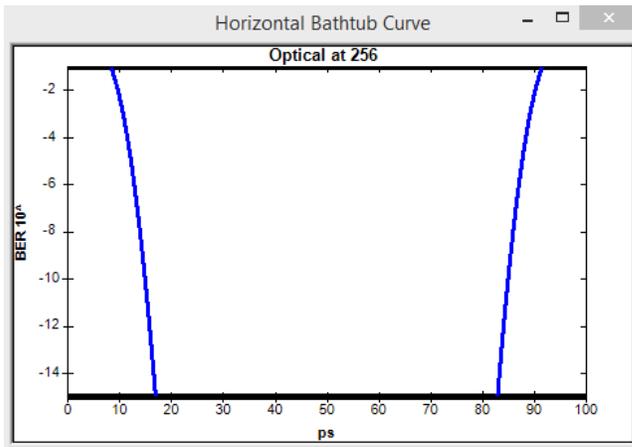
The number of failing points is displayed down the screen in the status bar.



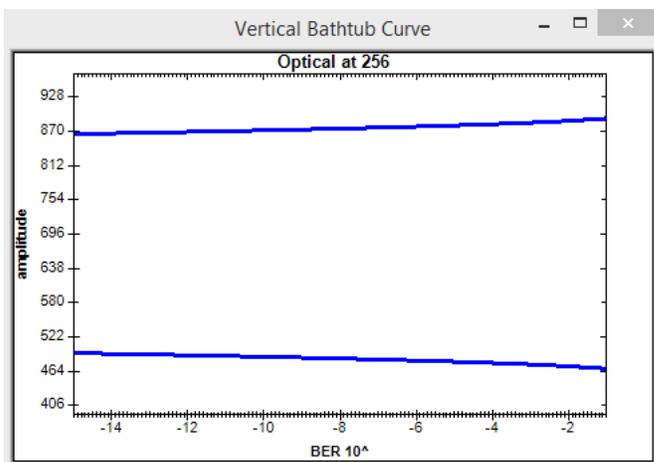
The DSO has these standard masks: 100Gbase-SR, LR, STM-1, STM-4, STM-16, Gb Ethernet, Fiber Channel (1x), Fiber Channel (2x, 4x), Fiber Channel (8x), Fiber Channel (10x), 10 Gb Ethernet, and user defined masks. New masks are continuously added. Recent additions are QDR & FDR.



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:

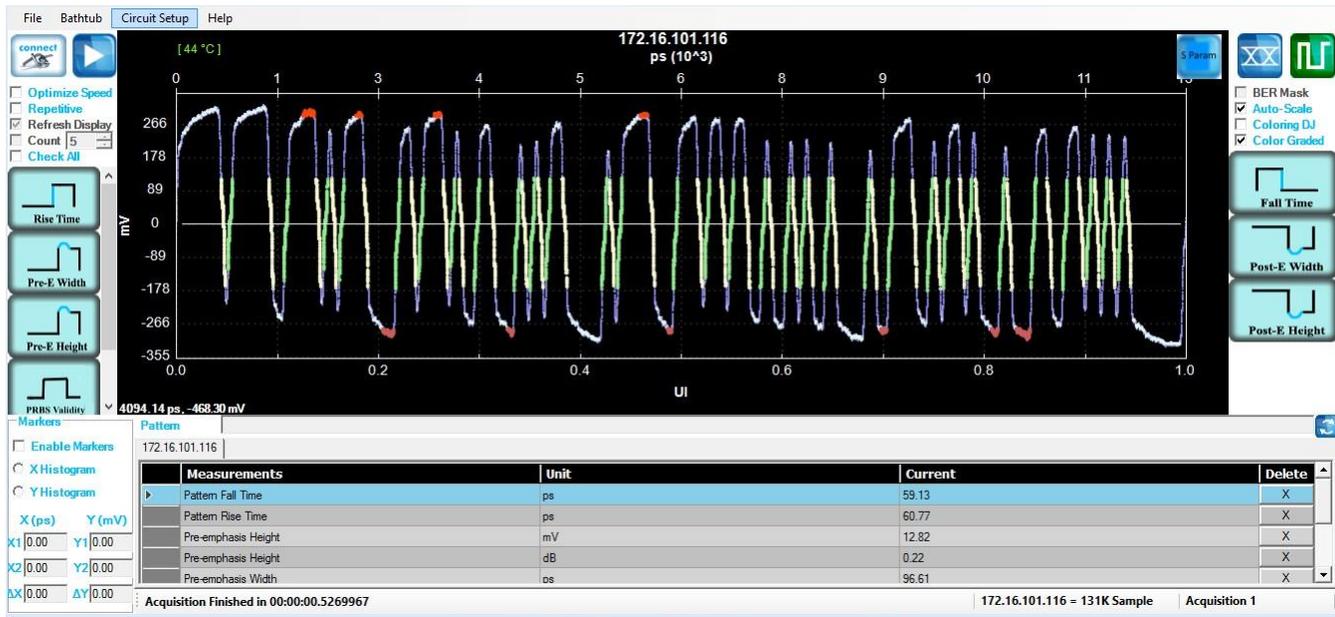
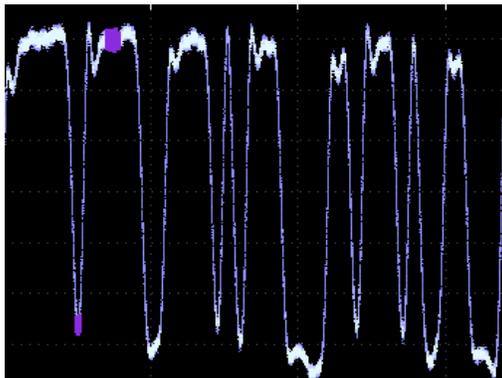


Figure 22: Pattern Mode

VMA

The voltage modulation amplitude of a pattern displayed in mV



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.

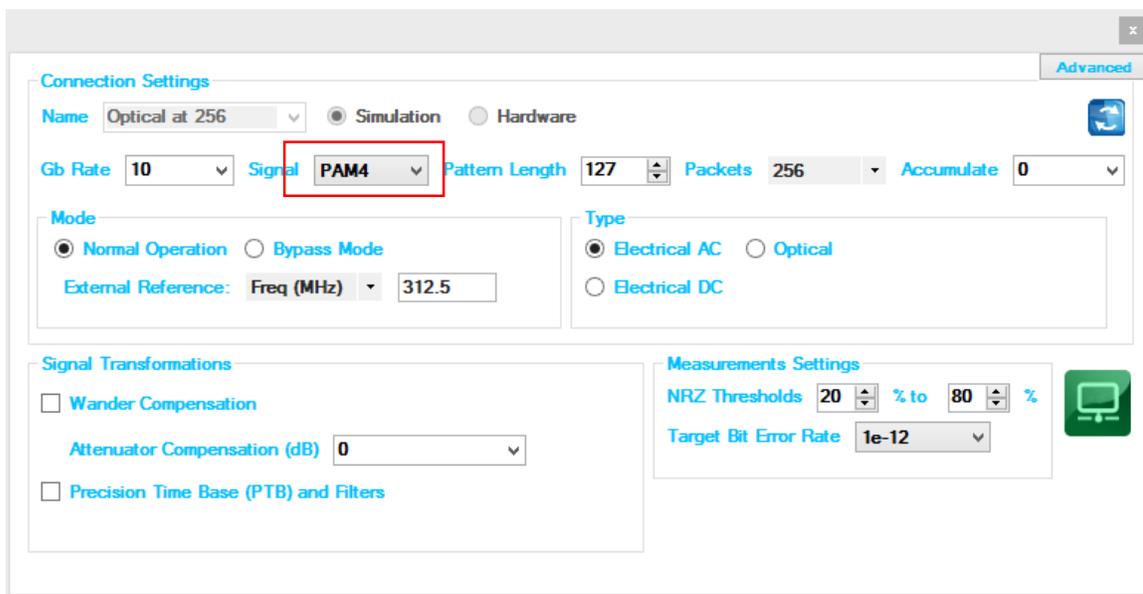


Figure 23: Enabling PAM4

Three eyes will be displayed on 4 levels as shown below

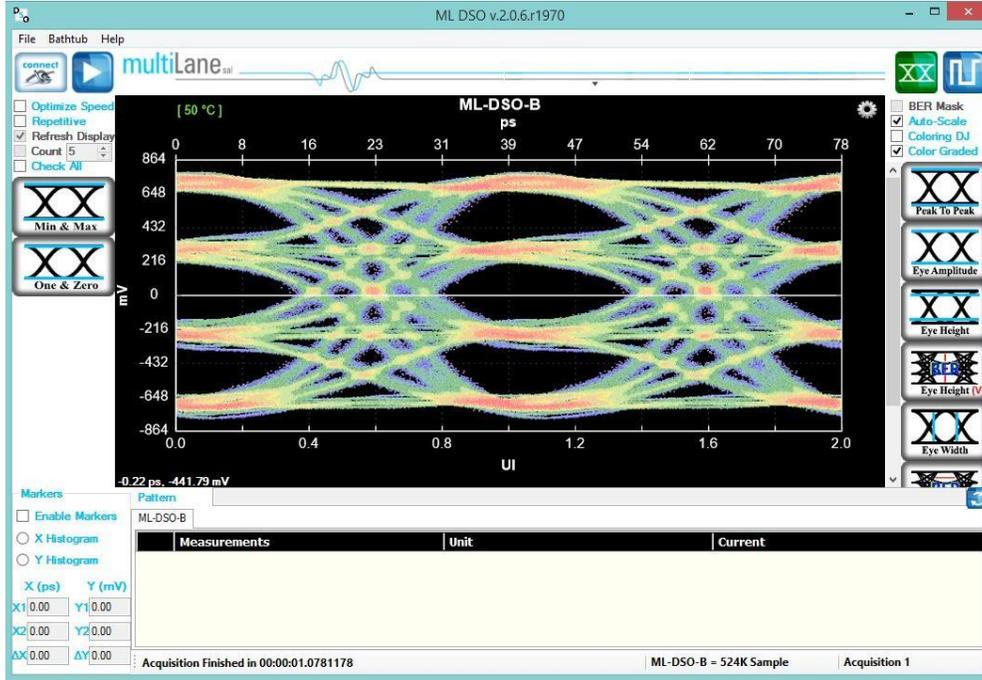


Figure 24: PAM4 Display

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

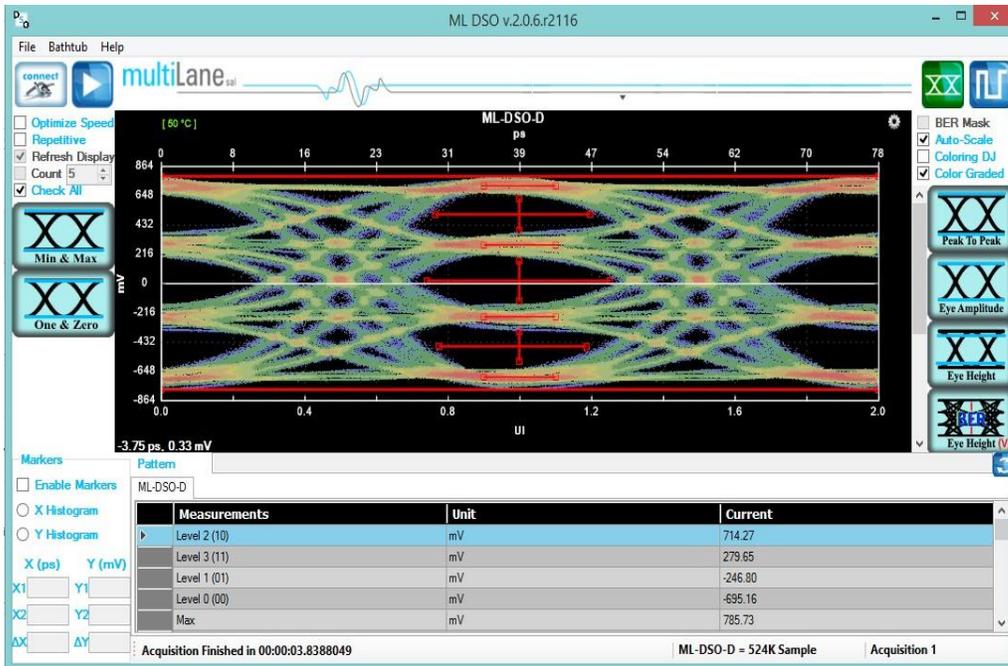


Figure 25: PAM4 Measurements

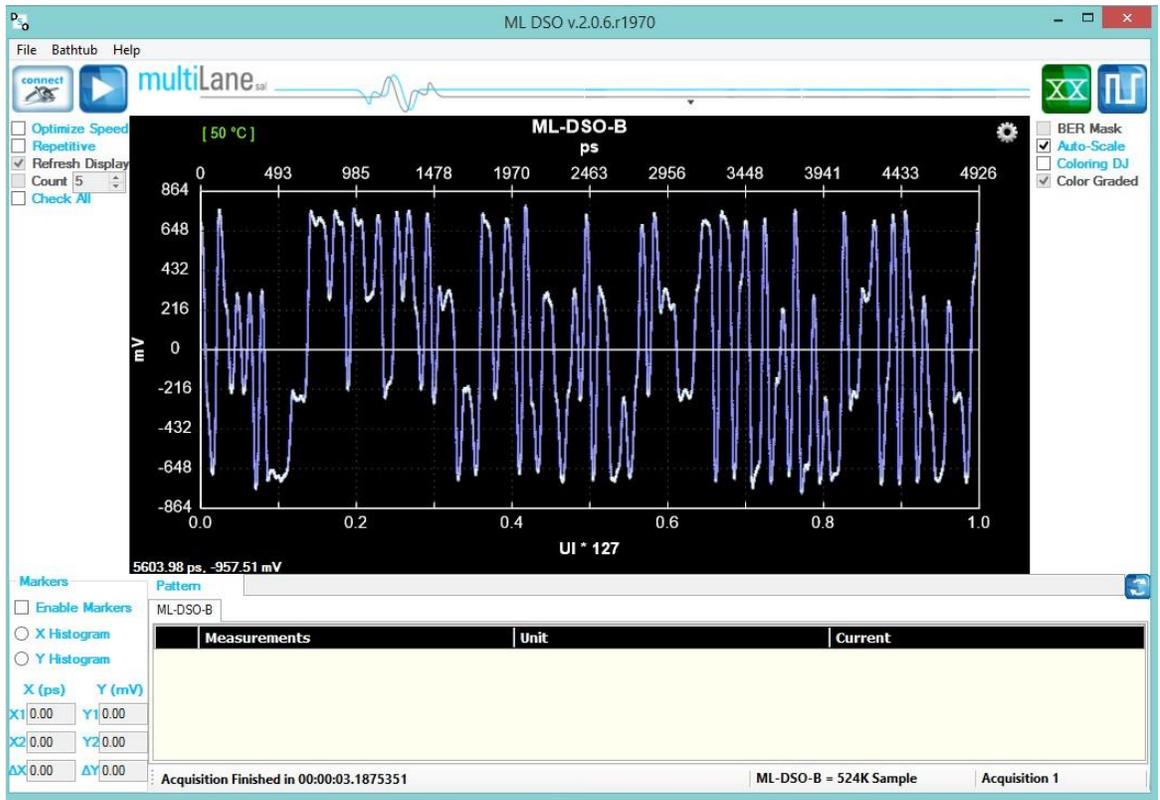


Figure 26: PAM4 pattern mode

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:

$$\text{Frequency Response of DUT} = \text{FFT (Main Circuit Signal)} / \text{FFT (Reference Circuit Signal)}$$

- 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 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

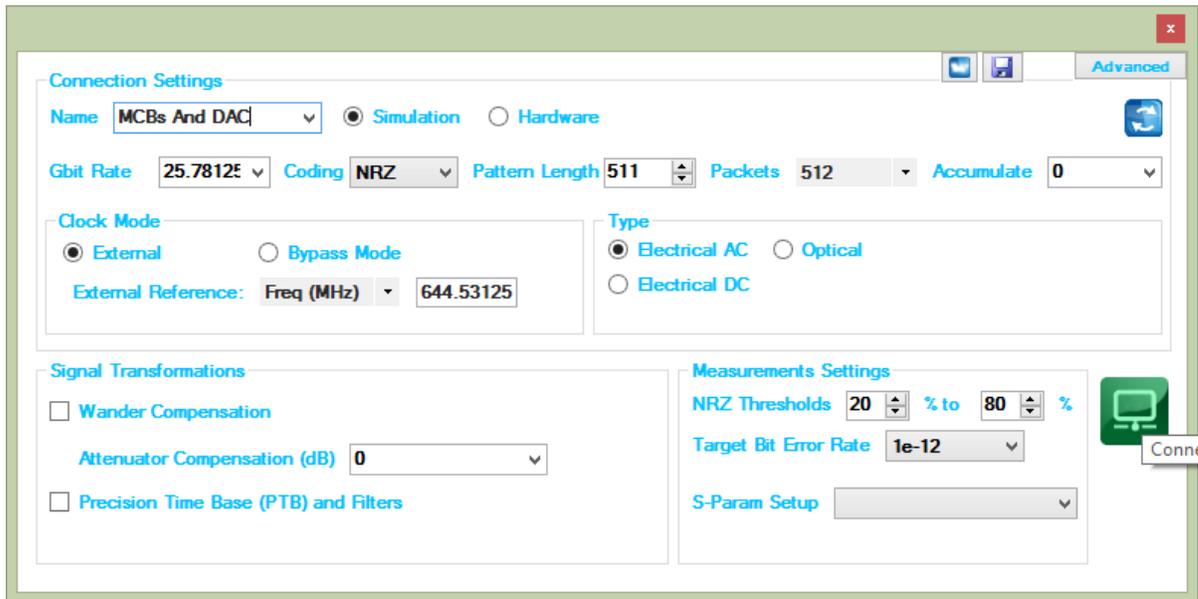


Figure 27: S-Param Configuration

Go to S-Parameter Setup

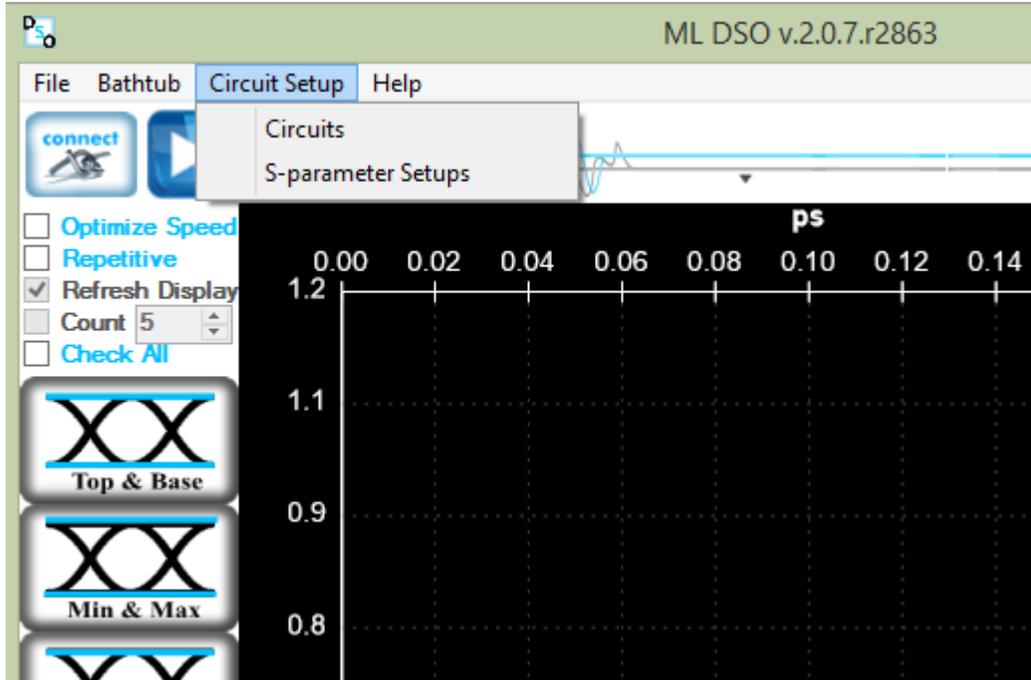


Figure 28: S-Param setup

Select the DSO Connected

After Selecting the DSO click 'New Setup'

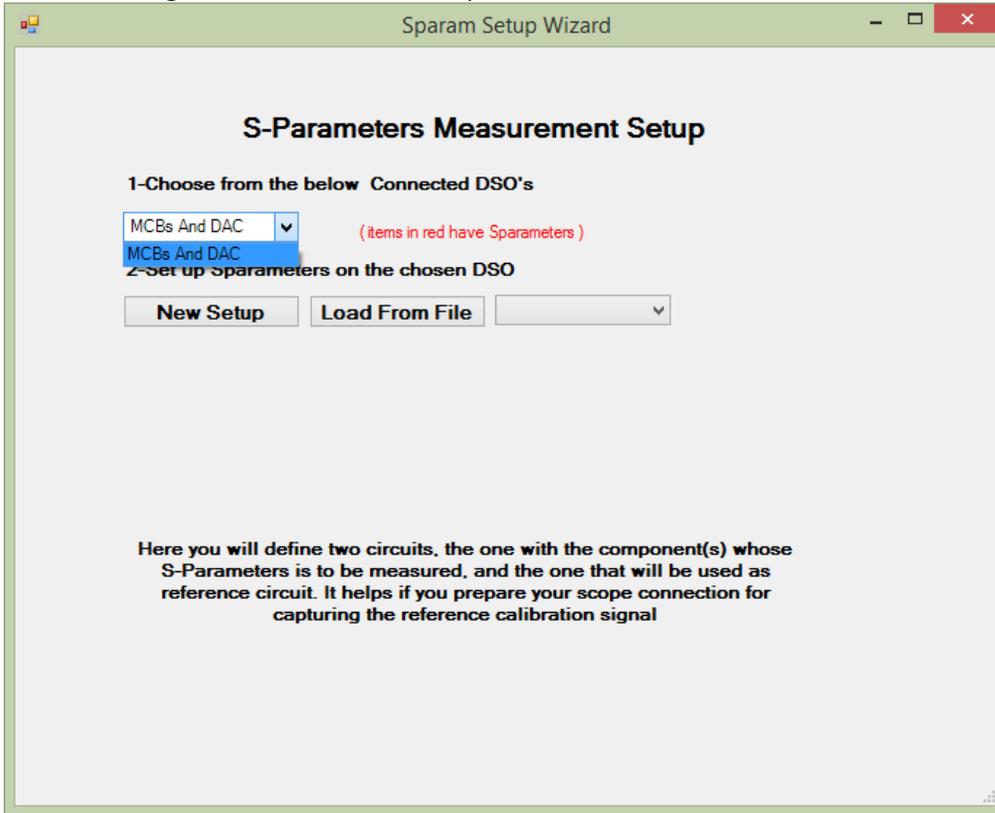


Figure 29: Setup

Create Your Main Circuit

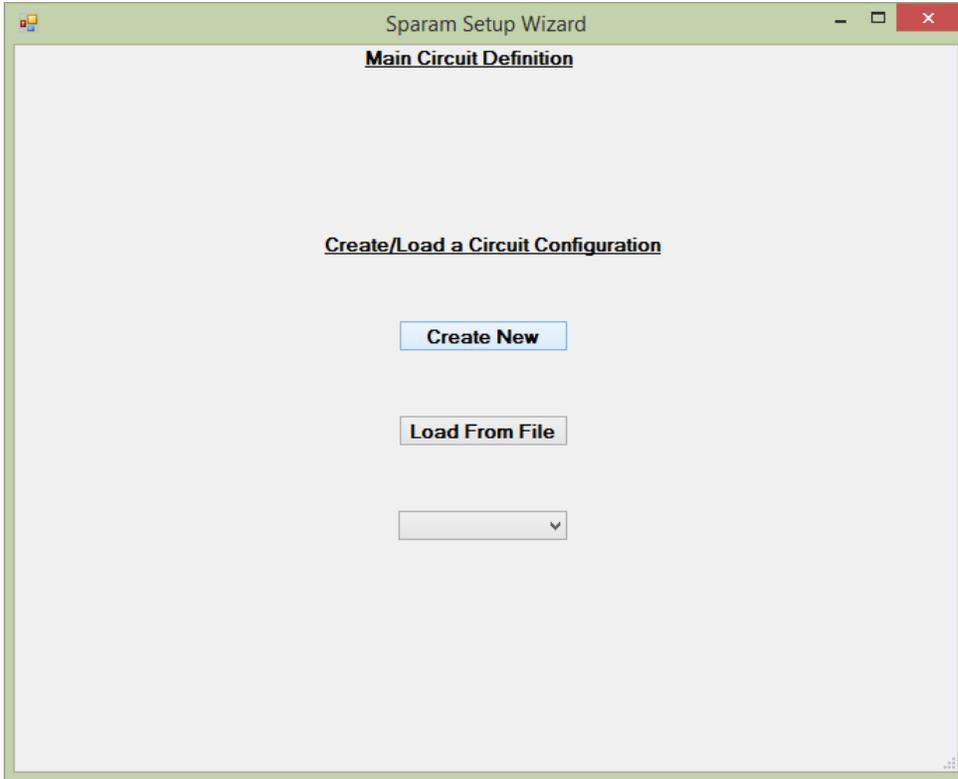


Figure 30: Main Circuit

Add the Main Circuit Components

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

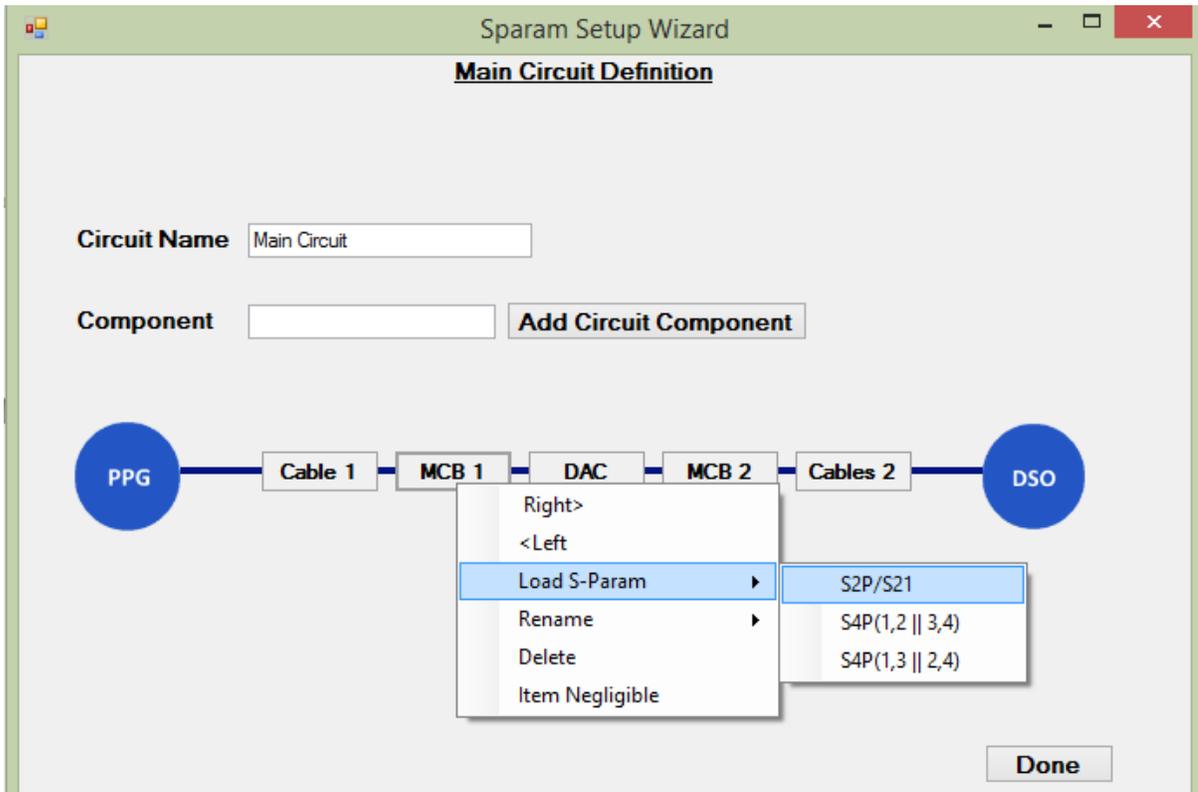
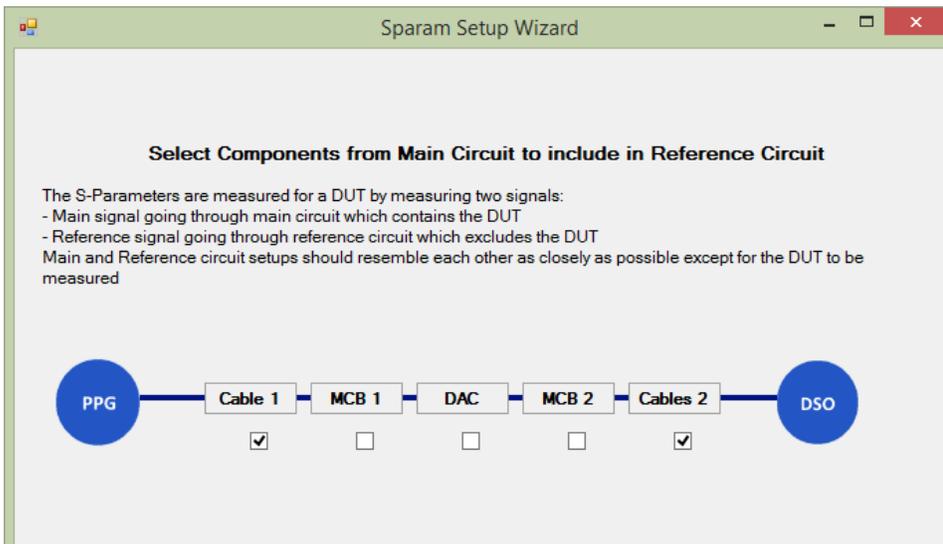


Figure 31: Main circuit component

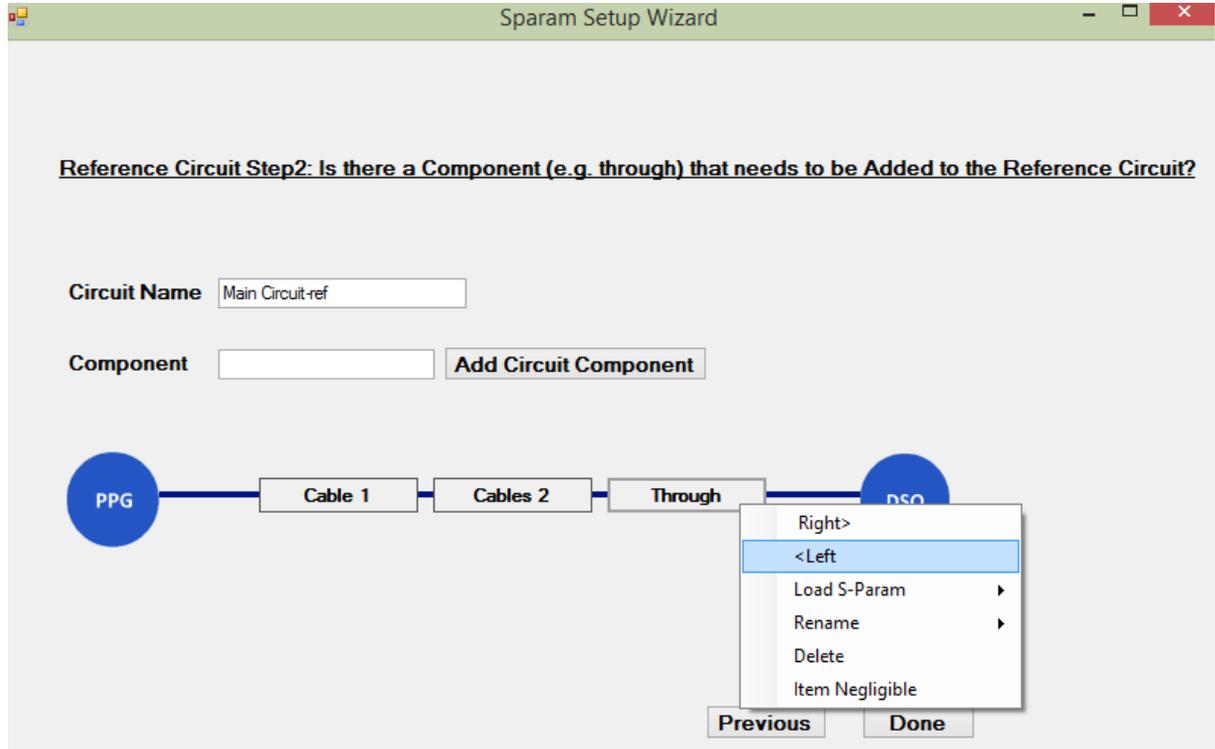
Proceed by clicking 'Done'

Select Components from Main Circuit Present in Reference Circuit

Select Cables 1 and 2 and click Next



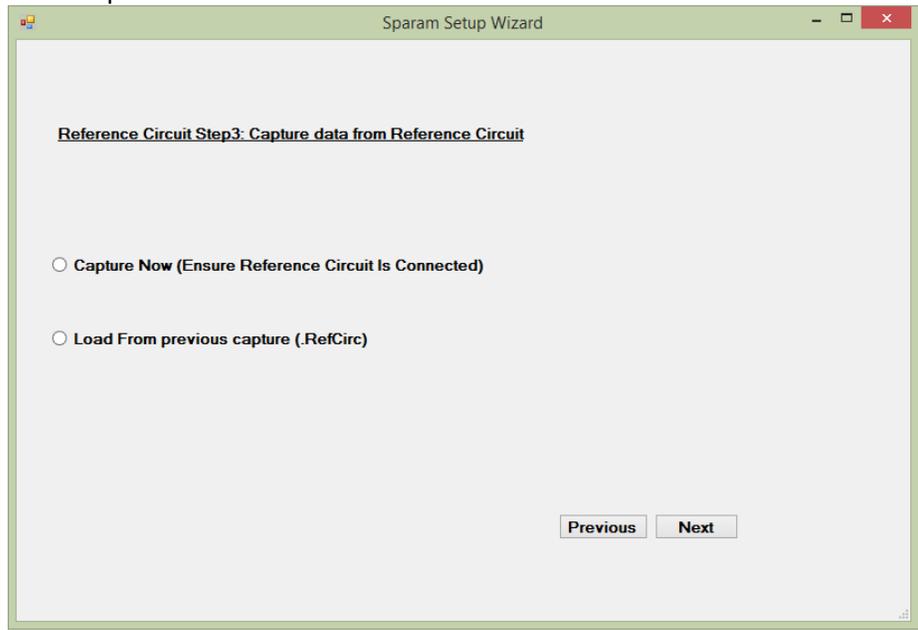
Add Through Connector in Reference Circuit Definition



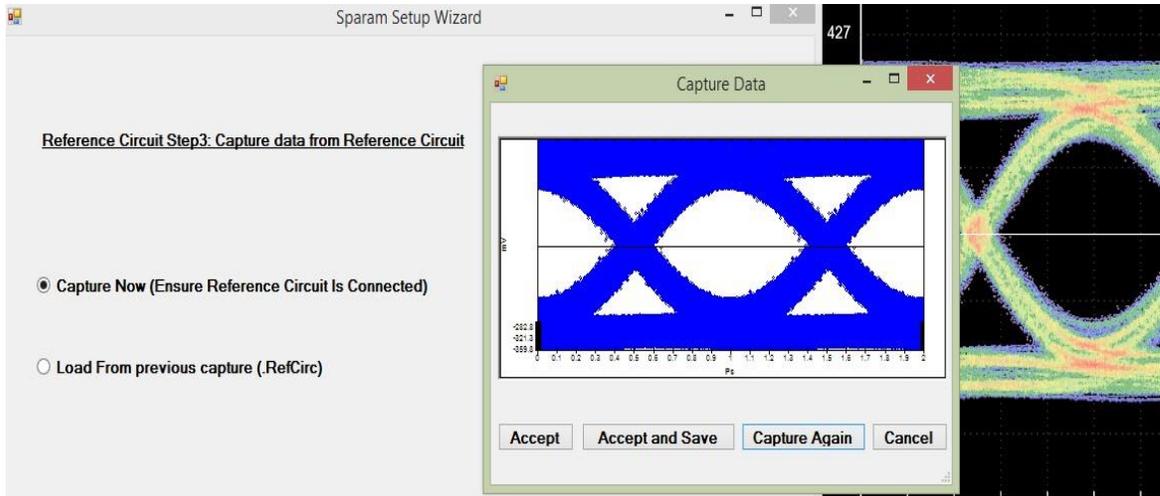
When done, click next,

Capture Your Reference Data

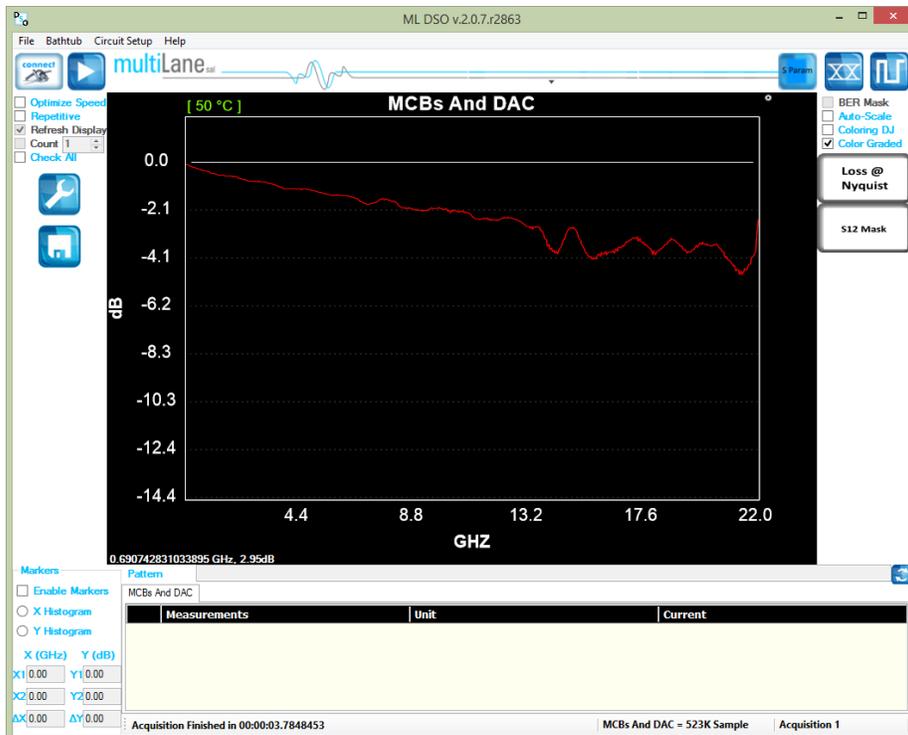
Click 'Capture Now'



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'
 The result is displayed as below. You can also import a s4p/s2p file from a VNA to display it side by side on the same graph.



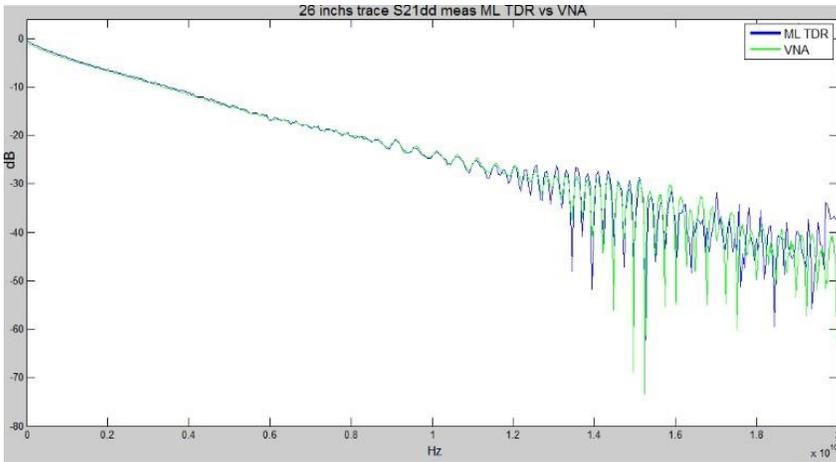


Figure 32: Comparison of performance and accuracy between a 40 GHz VNA and the ML DSO

How to connect to this instrument

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

- [ML4004-PAM](#) BERT Fast Ethernet and USB Connections.

NOTE: The ML BERT GUI can only communicate with the ML4004-PAM over Fast Ethernet. USB is only used to reconfigure the static IP address of the instrument. (note that the IP² should be in the same range of the network).

Connecting through an Ethernet cable

²[http:// en.wikipedia.org/wiki/IP_address](http://en.wikipedia.org/wiki/IP_address)

To establish an Ethernet connection between the **ML4004-PAM**Box and a PC, connect an Ethernet **straight** cable between the ML4004-PAM and the Router or Switch, and make sure you can connect your PC to the router via cable or wireless. Or instead use a **crossover** cable directly between the ML4004-PAM and the PC. The device can be pinged to verify that a connection has been established.

Make sure to have the correct IP address



Figure 33: ML4004-PAM connected with Ethernet crossover cable

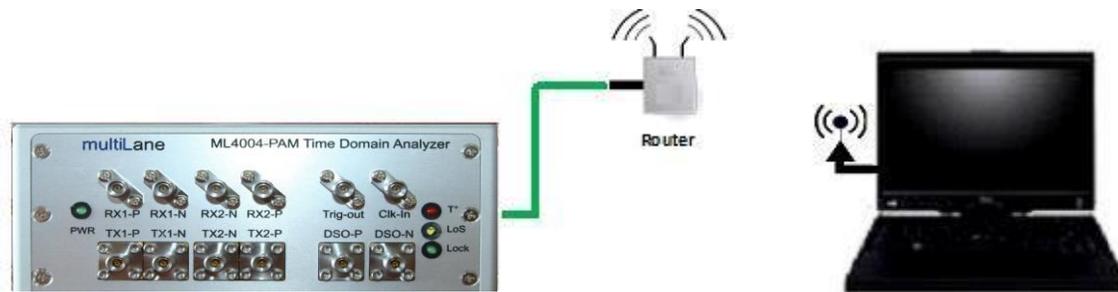


Figure 34: ML4004-PAM connected to PC via Wireless

USB Driver Installation

USB software drivers' names:

- **ML4004-PAM 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 ML4004-PAM
- 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 35: Scan for Hardware

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



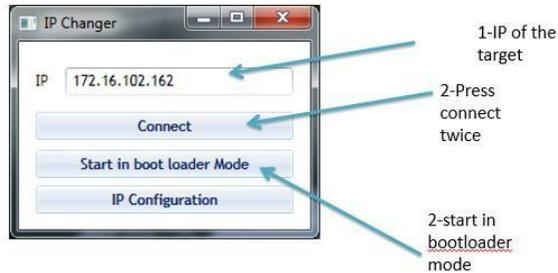
Figure 36: Scanning for plug and play compliant hardware

- In the **Other Devices** tab, the **ML4004-PAMUSB Device** description appears.
- In the **Other Devices** tab, right-click on the **ML4004-PAM 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 SALML4004-PAM USB Device”**.
- You are now connected via USB and you can control the instrument.

Firmware Upgrade

Instructions to upgrade the Firmware

1. In order to invoke the device into boot loader mode, run the ML-IP changer tool



Press connect twice, start in boot loader mode, you will be redirected to the PIC 32 tool.

2. In order to successfully connect the Boot loader to the ML4004-PAM Boot IP address of 192.168.1.11, the user's laptop must have its Ethernet port configured with the same 192.168.1.XX Subnet. This may necessitate disabling the wireless connection via Network sharing settings in the control panel.
3. When connecting to an instrument with outdated/incorrect firmware, the board LEDs 1 and 2 start blinking and Boot loader Software pops up automatically.

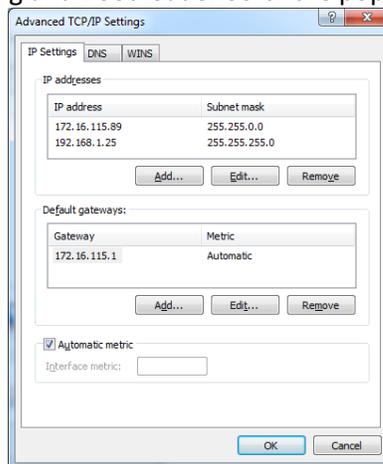
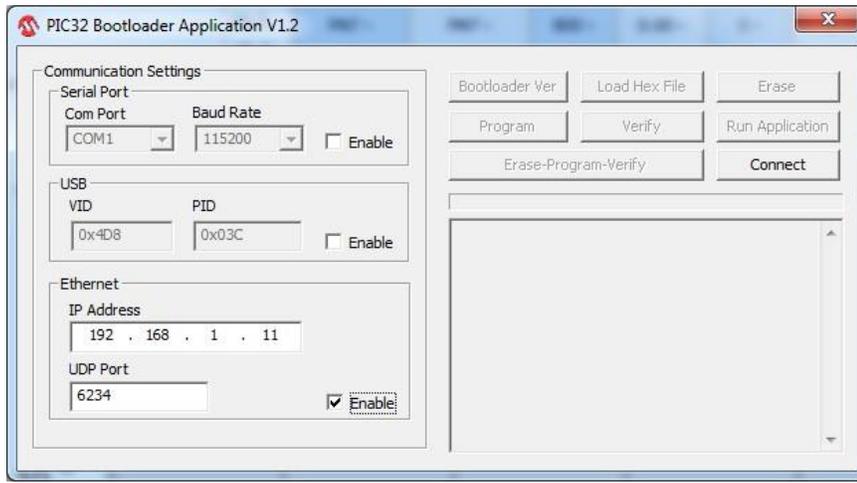


Figure 37: Boot loader Software

4. The IP Address should already be set to 192.168.1.11 and the UDP port should already be set to 6234. Next, click on the "Enable" check box in the Ethernet Tab and then press the "Connect" button.



5. If the connection is successful, the software will display “Device connected”
6. Press “Load Hex File” then load the new ML4004-PAM firmware and press on “Open”. The firmware hex file is located in C:/Program files/Multilane SAL/ML BERT/FWLoad.

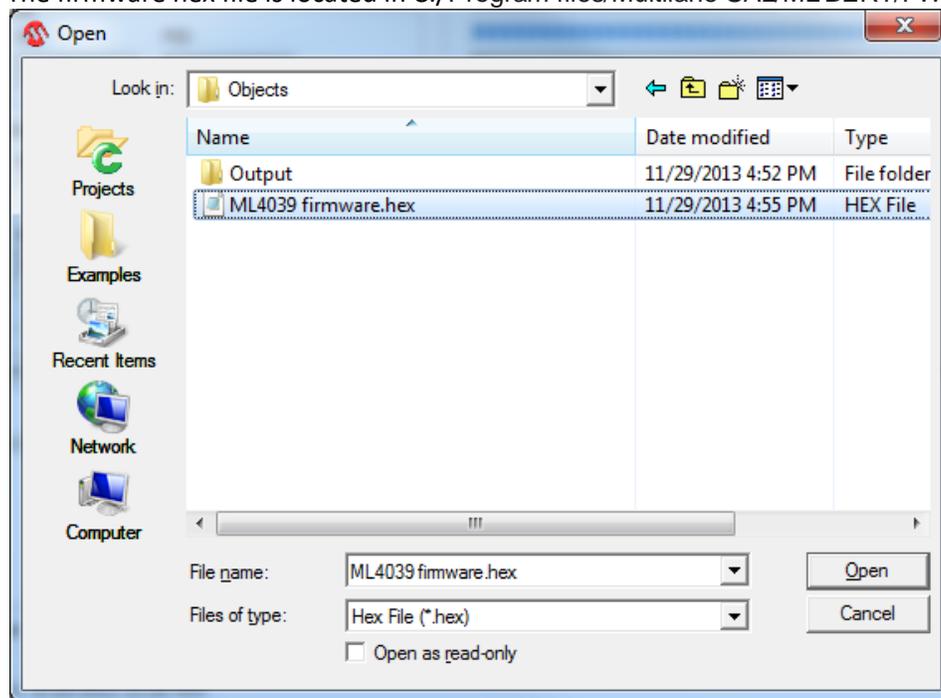


Figure 38: Select Hex File

7. Then press the “Erase-Program-Verify” button. A successful firmware load will show the same results in the Boot loader message window as shown below.

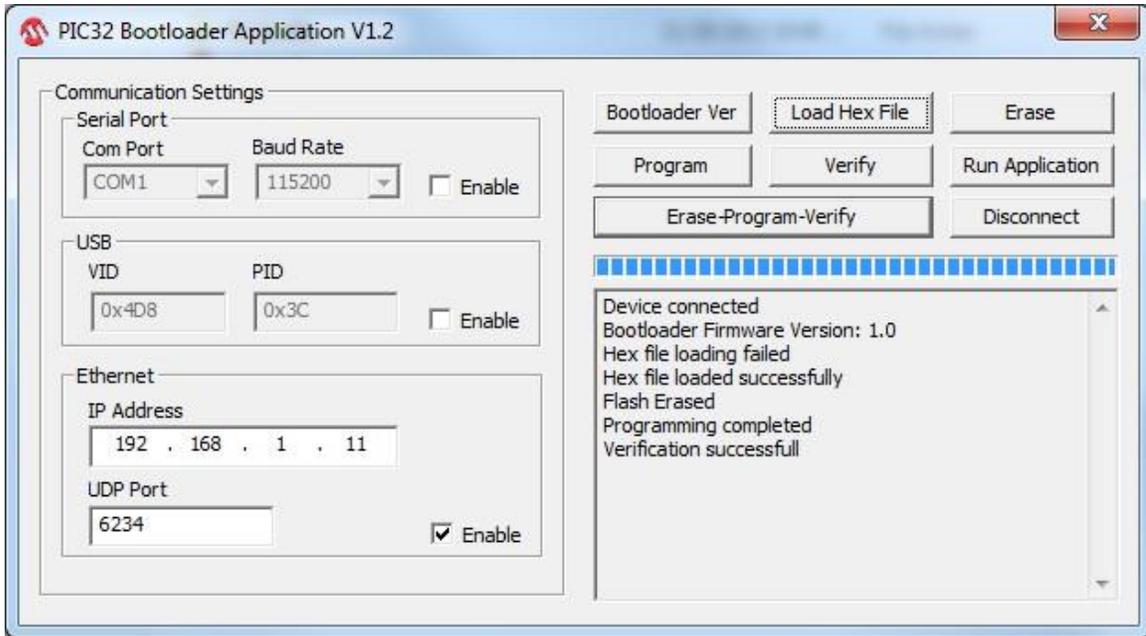
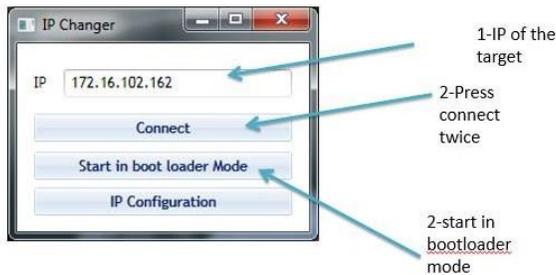


Figure 39: Erase-Program-Verify

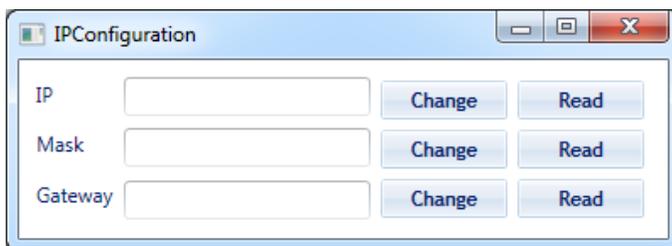
8. Next, power cycle the **ML4004-PAM**.
9. The **ML4004-PAM** is now ready for normal operation.

IP changing

1. In the same ML-IP changer tool, click “IP Configuration”



2. Press Read to read the current IP, Mask and Gateway configuration. To put custom configuration press change.



RELATED PRODUCTS

For a complete transmitter/receiver test solution, MultiLane offers the following products:

- **ML4039**: Four Channel 28G BERT for low cost production testing.
- **ML4039-JIT**: Four Channel BERT with full jitter control for receiver sensitivity and jitter tolerance testing.
- **ML4009-JIT**: Single channel with full jitter control for receiver sensitivity and jitter tolerance testing in a standalone metal box.
- **ML4004**: Single Channel BERT and DSO
- **ML4004-JIT**: Single Channel BERT and DSO with jitter generation

Ordering Information

Order Information	
Order No.	Description
ML4004	Base Model, 800 mV diff. output swing
ML4004-HV	High Voltage option, 3.2V diff. output swing
ML4004-JIT	Jitter Generation output option
ML4004-PAM	
<ul style="list-style-type: none"> • Standard Warranty - 1 Year 	
<p><i>For more information on this or other products, contact Multilane sales team by email at sales@multilaneinc.com</i></p>	

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

Manual Revision History

This section describes the changes that were implemented in this document. The changes are listed by revision, starting with the most current publication.

Revision 1.0: first publication of PAM TDA.

Revision 1.1: DSO modifications.

Revision 1.2: DSO modifications.

Revision 1.3: DSO modifications.

Glossary of Terms/ Acronyms

BW: Bandwidth

TDA: Time Domain Analyzer

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

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

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