ML4079EN ThunderBERT User Guide

multiLane

ML BERT Series: ML4079EN

Installation | Connection | Calibration| Measurement

User Manual Revision, March 2024.

ThunderBERT

Innovation for the next generation

Notices

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

Contents

List of Acronyms

Acronym	Definition
BW	Bandwidth
BERT	Bit Error Rate Tester
Conf	Configuration
DUT	Device Under Test
FEC	Forward Error Correction
FW	Firmware
GBd	Gigabaud
Gbps	Gigabits per Second
GUI	Graphical User Interface
HW	Hardware
ISI	Inter-symbol Interference
JTOL	Jitter Tolerance
NRZ	Non-Return to Zero
PAM4	Pulse Amplitude Modulation (4-level)
SI	Signal Integrity
SNR	Signal-to-Noise Ratio
Sim	Simulation
SW	Software
SJ	Sinusoidal Jitter
RJ	Random Jitter
BUJ	Bounded Uncorrelated Jitter
JTOL	Jitter Tolerance
ITOL	Interference Tolerance

Introduction

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

A key player in the test and measurement industry, MultiLane provides an essential high-value instrumentation that ensures vendors can keep up with demand and bring their designs to market. Our ThunderBERT line-up of BERTs, which covers virtually any desired line rate up to 800Gbps, offers an extensive array of diagnostic and tuning capabilities.

By generating specific signals to determine the actual bit error rate (BER) of the target channel, BERTs are mandatory instruments for communication testing. The brand new ThunderBERT GUI provides you with an intuitive and comprehensive tool to validate your designs.

In this upgraded implementation of our BERT user guide, MultiLane provides a fully revised and unified manual for the ML BERT series compatible with the ThunderBERT GUI.

GUI Introduction

To install and start using the ThunderBERT interface for the first time, follow this step-by-step installation guide (with pictures) below:

1. **Run** the ThunderBERT setup file.
2. **Install** ThunderBERT.
3. **Connect** the ML BERT to the local network.
4. **Launch** the GUI.
5. **Start** the measurements.

Installation

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

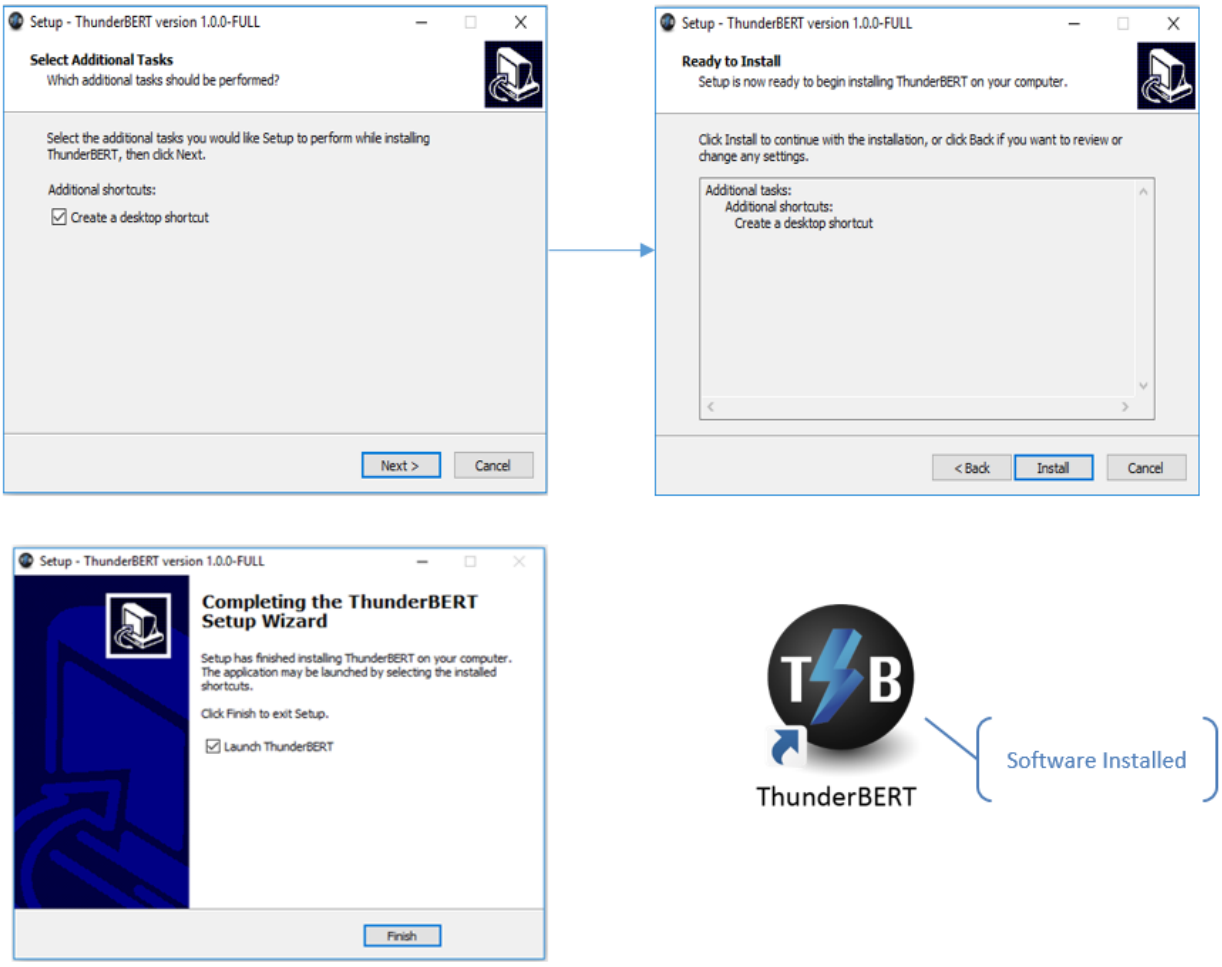


Figure 1: Setup Installation Procedure

ThunderBERT should now be ready to run, with a shortcut button on the Desktop.

Connecting to the Instrument

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

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

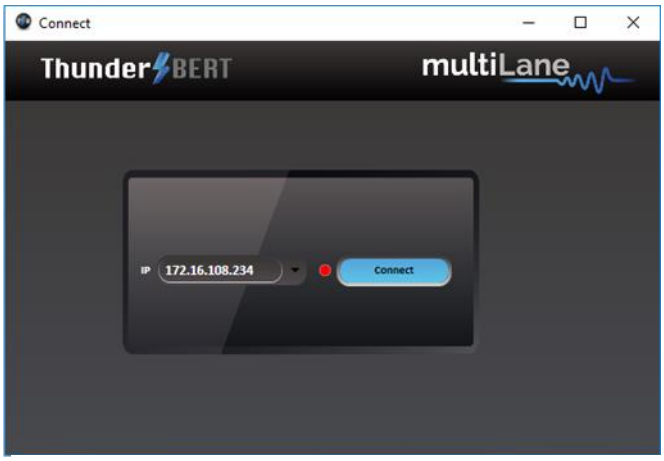


Figure 2: Connection Box

NOTES:

- The previously connected IP addresses will appear in the drop-down list next to the type of box.
- The red-light indicator (R) will remain red while no connection is established (Figure 2).
- In the case of a connection failure, a pop-up message will appear indicating a connection error (Figure 3).

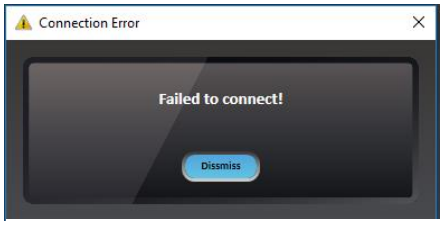


Figure 3: Connection Box

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

Launching the GUI

After establishing connection to the BERT, the GUI is initialized immediately, and all the BERT features are ready for use.

The general display of the ThunderBERT GUI will appear and you can commence testing.

Figure 4: General GUI Display (ML4079EN)

GUI Overview

ThunderBERT provides end users with the ability to navigate and configure instruments from the ML BERT product family. The provision of a responsive and intuitive GUI enables you to perform different kinds of tests and measurements as well as control every aspect of the BERT platform.

Figure 5: Segmented GUI Display (ML4079EN)

BERT Configurations

This section is used to parameterize BERT measurements and to control the TX/RX configurators of each channel in addition to clock rate and other common BERT settings.

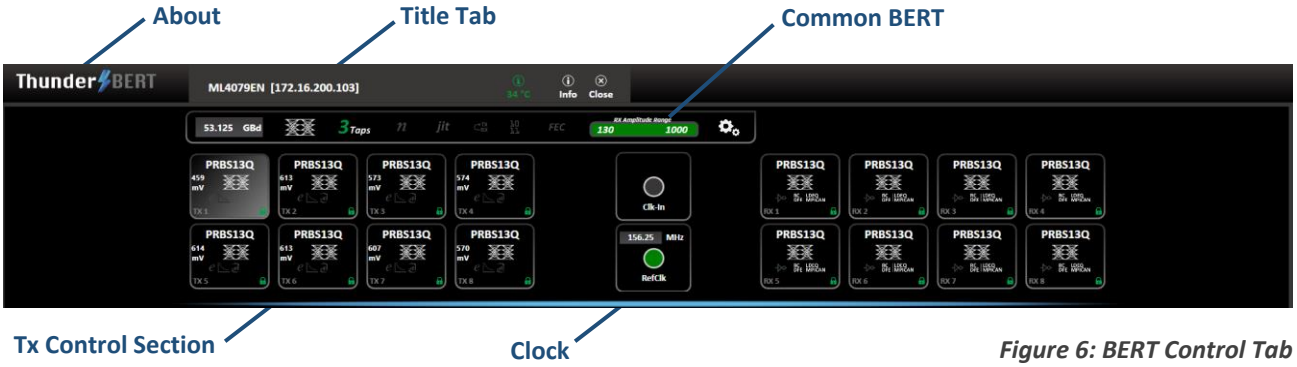


Figure 6: BERT Control Tab

- **About Window** (Figure 7) will give you access to the necessary information about the product including:
  - SW and API versions and Release Note
  - A link to this User Guide
  - Logs and configuration Files
- **Title Tab** contains:
  - Instrument ID, Instrument IP address, and Temperature display
  - "Info" tab
  - "Close" button
- **Common BERT Settings Tab** contains:
  - Baud rate configuration
  - Signal modulation selection (NRZ/PAM4)
  - FFE tap selection (3- or 7-tap modes)
  - Noise Injection Enable Button
  - Jitter Injection Enable Button and Control
  - Shallow Loopback Enable Button
  - Grey Coding Enable Button
  - Real Hardware FEC Enable Button
  - RX Amplitude/Sensitivity Range
  - Load + Save Configurations Options
- **TX Control Section Tab** contains:
  - Pattern and Amplitude control
  - Error insertion in optimal or advanced mode
  - Noise Control for Each Channel
- **Clock Configuration Tabs** contain:
  - Reference Clock Out
  - High Frequency Clean Clock
  - Clock-In
- **RX-side Control Section Tab** contains:
  - RX invert, RX pattern selection and RX diagnostics
  - Equalization block

Figure 7: About Window

Instrument Control

Title Tab

Figure 8: Title Tab

- Displays general information of the BERT (BERT PN, instrument IP, instrument temperature).
- The device tab where all board details are displayed (Figure 9).
- Close button: disconnect from the BERT and close GUI instance (Figure 10).

Figure 9: Device Tab

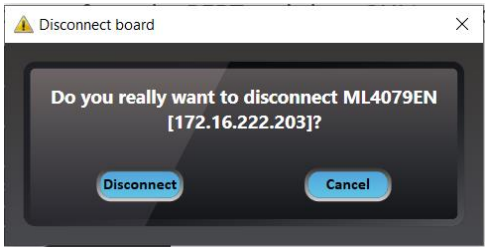


Figure 10: Disconnect Popup Window

BERT Settings Tab

The ***BERT Settings Tab*** shows all primary BERT configurations which you can set.

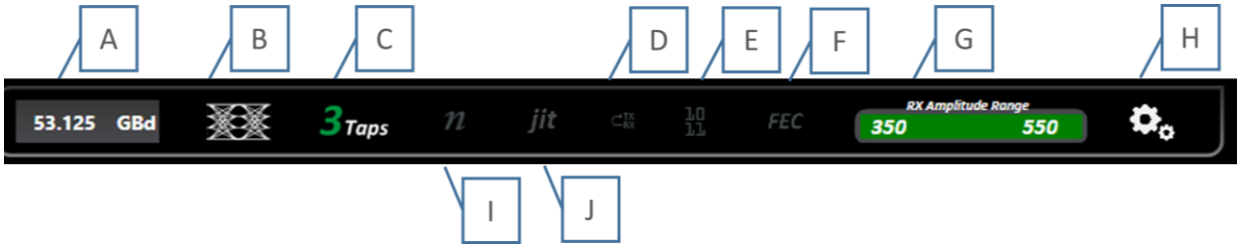


Figure 11: BERT Settings Tab

A: Baud rate Selection – **B:** Modulation Selection – **C:** FFE Taps Selection– **D:** Noise Injection Enable – **E:** Jitter Injection Enable and Control - **F:** Shallow Loopback Enable – **G:** Gray Coding Enable – **H:** Real Hardware FEC – **I:** RX Amplitude Range– **J:** Additional Options

The common ***BERT Settings Tab*** reflects enabled features; whenever a feature is enabled (gray coding, 3/7-tap, Jitter, Noise, Shallow Loopback and FEC) the corresponding button turns green as shown in Figure 11.

From this tab, select/configure to control the following features:

- **Specify the Baud rate** (Figure 13)
- **Specify the signal modulation type**: NRZ/PAM4 (if available/supported) (Figure 14)
- **Select the 3 or 7 taps FIR filter mode**
- **Enable/Disable the Noise Injection**
- **Enable/Disable and Control the Jitter Injection**
- **Enable/Disable the Shallow Loopback feature**
- **Enable/Disable the gray code option**
- **Enable/Disable the FEC feature**
- **Check the Rx amplitude range** supported by the error detector
- **Load/Save** the configurations through the gearbox button (Figure 15)

A
B
C
D
E
F
G
H
I
J

Figure 12: Display of Enabled Features

Figure 13: Set Baud Rate

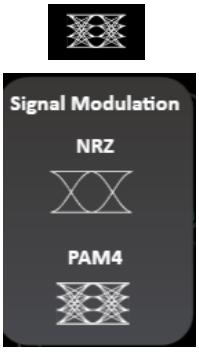


Figure 14: Signal Modulation Selection

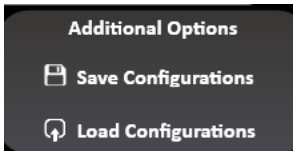


Figure 15: Additional Options

- The 'Apply' button should be pressed after any rate change; the new line rate is set within one second (Figure 13).
- Switching between NRZ and PAM4: Modulation Type available based on the selected baud rate (Figure 14).
- Additional Options let you save and load test configurations including bit rate, pattern, signal modulation, number of taps and their values, inversion, etc., for all channels (Figure 15).

Tx Control

TX Control in optimal Mode

TX channel settings can be controlled individually. A display window reflecting all the enabled features and the applied TX settings per channel is displayed after clicking on each TX channel tab (Figure 16)

- **Enable/Disable TX control for each channel (TX ON/OFF).** Once turned off, the control of TX settings is disabled: channel control is locked from any selections, and TX output is turned off (Figure 17).
- **Specify the TX signal pattern.** The supported TX patterns are all available in the dropdown list, for the ML4079EN the Supported PRBS Pattern are (PRBS7-9-9/4-11-13-13Q-15-15Q-16-23-31-31Q-58), in addition to SSPRQ, JP083B, LIN, CJT. As for square wave the supported dividers are: rate/(4, 8, 16, 32, 128, 256, 512 and 1024)
- **Specify the TX amplitude.** In optimal mode, the slider shows the calibrated differential peak to peak amplitude range, each displayed value is the combination of the optimal FFE taps. Pre-Emphasis, Main, and Post-Emphasis taps are calculated during calibration. The ML4079EN is characterized by its high amplitude swing: at low rates the amplitude swing can go up to 1.8Vpp as for the high rates it is up to 1.2Vpp. Should the amplitude exceed the 1V threshold, a warning message will be displayed, advising you to enable the High Voltage feature (Figure 18). This warning message is specifically designed to appear to help prevent potential damage to the receiver side (RX), ensuring the integrity and longevity of the system components.

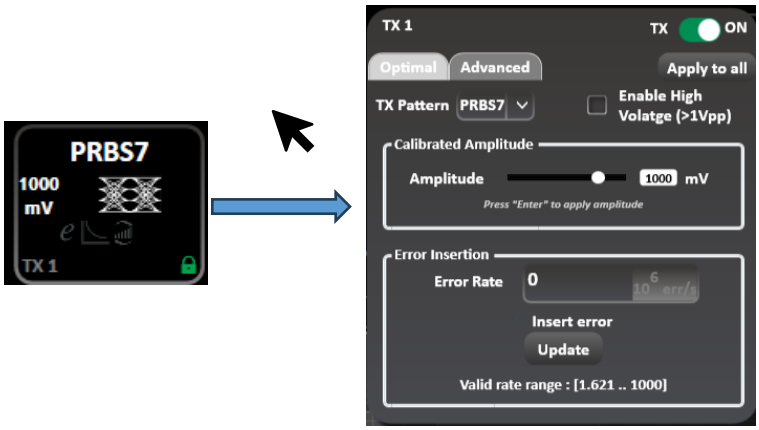


Figure 16: Tx Control Tab and Applied Settings in Optimal Mode

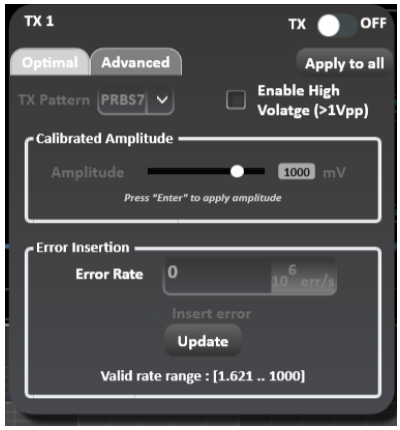


Figure 17: Tx-Off-Channel Control Locked

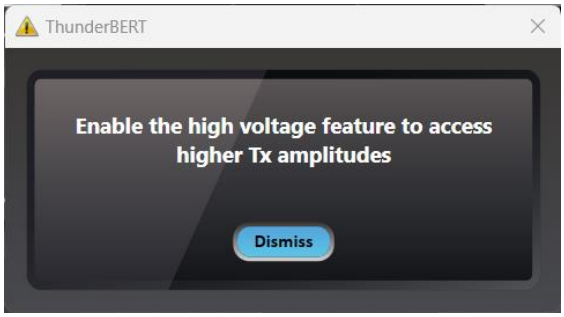


Figure 18: High Amplitude Warning

NOTES: Calibration is supported on low and high rates and on both eye modes (NRZ and PAM4). The optimal FFE taps are currently calculated at scaling 80%.

- **Specify Error insertion rate.** The actual rate of errors per second depends on architecture capabilities (Figure 19).

To insert Errors:

- **Enable Error Insertion mode** $e \rightarrow e$ (the green color indicates that error insertion feature is enabled).
- **Specify the Error Insertion Rate.**
- **Click** on the Update button to apply changes.

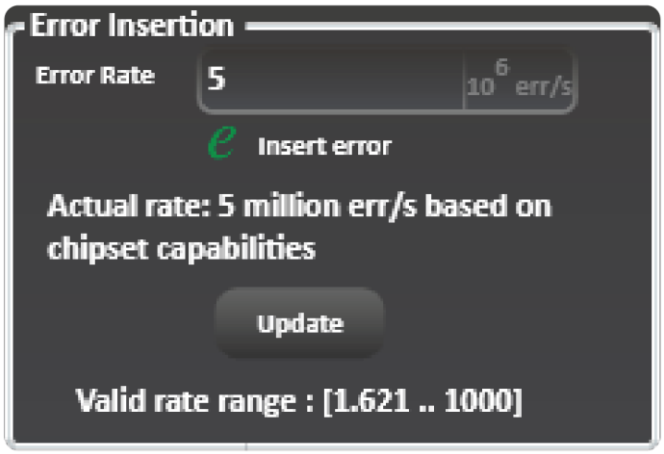


Figure 19: Error Insertion in Optimal Mode

Tx Control in Advanced Mode

While operating in Advanced Mode, you can fine-tune the transmitter signal with high granularity. You will be able to specify the following TX settings and parameters:

- **TX Pattern:** Supported TX patterns are all available in the dropdown list, depending on the BERT model in use.
- **FFE Taps:** Tap control offers the following on TX:
  - Scaling between 60% and 120%
  - 3 FFE taps (in 3-tap mode) and FIR filter 7 taps (in 7-tap mode). Supported tap values range between -1000 and 1000.
  - Inner and Outer Eye: Controls only available in PAM4 mode (Inner eye value is between 500 and 1500, while Outer eye is in between 1500 and 2500).

Figure 20: Tx Advanced Mode Control

To start optimizing the TX setting, follow these steps:

- **Enable the TX settings control** of the channel (TX button ON/OFF).
- **Select a TX pattern.**
- **Customize the FFE taps**. Scaling, FFE taps, and Inner and Outer Eye can be controlled in this tab. If the amplitude is higher than 1V a warning message will be shown to avoid any damage on the Rx Side (Figure 21). This warning message is specifically designed to appear to help prevent potential damage to the receiver side (RX).
- **Apply the changes** by clicking on the "Set" button.

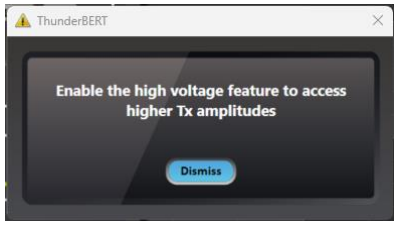


Figure 21: High Amplitude Warning

You can load/save FFE Taps file to load and use a previous FFE configuration or save it for later use by clicking on the  buttons in the corner.

Note that if a channel is not in use, it is imperative that it be turned off. As an alternative to turning off unused channels, these channels can be looped back to the receiver side (RX). This is particularly useful for preventing reflections that could potentially harm the transmitter (TX).

NOTES: Optimal configurations and calibration are only available in 3-tap mode. The Channel Emulation feature is only supported in 7-tap mode.

- **Channel emulation.** To emulate channel loss, start by clicking the emulation button. When enabled, the emulation button will turn to green.
  You can insert the magnitude of the loss at the Nyquist frequency (half of the configured baud rate) in decibels. In addition, an S-parameter file can be selected, loaded, and used to calculate the taps creating the entered loss value.

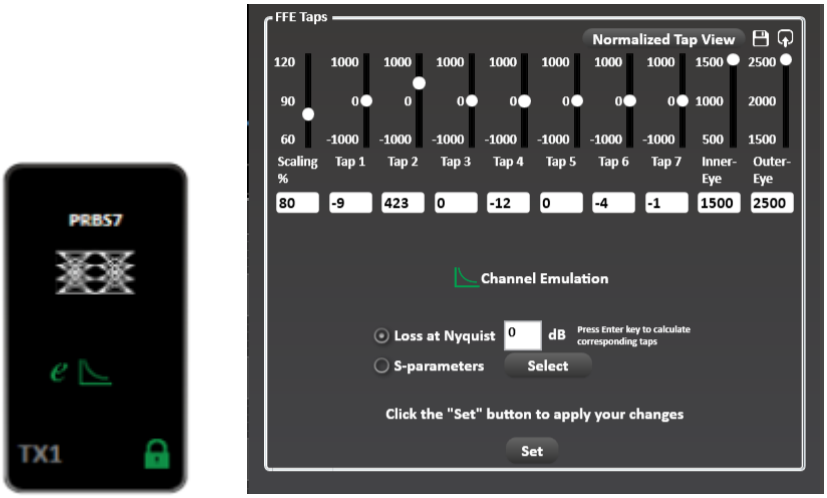


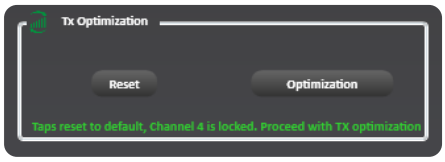
Figure 22: Channel Emulation Enabled + 7-Tap Filter with Channel Emulation Enabled

Tx Auto-Optimization Mode

Operate in 7-tap mode to enable TX auto-optimization mode. After enabling 7-tap mode, you can now apply the auto-optimization settings where the ThunderBERT GUI will calculate the optimized FFE taps for the current setup.

To **apply** the TX Optimization settings:

- **Enable TX Optimization** by clicking on the button right next to the Tab. When enabled, the button turns green.
- **Click on the Optimization** button to calculate the optimal FFE Taps for the testing setup.

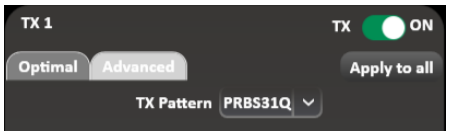


You can reset the **FFE Taps values** anytime by clicking on the **Reset button**.

To perform the Optimization process on the current setting, a lock must be detected on the channel in question.

Apply To all Channels Option

This option is used for the TX and RX settings, and transceiver control if available. When selected, it applies the configuration of the current channel to all BERT channels. For example, pressing “Apply to all” on the TX window will apply all TX configurations displayed in this window to every other channel.



Rx Control

RX settings can also be controlled on a per-channel basis. A window reflecting all the enabled features and applied receiver settings per channel is displayed after clicking on each RX channel tab.
To note that the ML4079EN Rx maximum Range is 800mVpp, so when in direct loopback mode make sure the Tx Amplitude swing doesn’t go above this level.
Using the Rx Control, you will be able to select/configure the following settings:

- **RX Pattern** (PRBS,9, 11, 13Q, 15Q, 16, 23 and 31Q).
- **RX Invert:** Inverts the RX polarity. The button becomes green indicating that RX polarity is inverted.
- **Equalization type:** Includes DFE, RC, LDEQ, and MPICAN (supported EQ types appear in this block according to the BERT type).
  - **DFE** (Decision Feedback Equalizer) is used for strenuous links.
  - **RC** (Reflection Canceller) extends the FFE and smooths out the tail in the pulse response. It is used for links with strong reflections or that have too high energy in the pulse response tail.
  - **MPICAN** (Multipath Interference Canceller).
- **RX Diagnostics** RX: This Window monitors FFE Taps, SNR and Histogram graphs over time.
- **RX Pattern Lock:** The button is usually red but turns green when the pattern is locked and identified successfully.

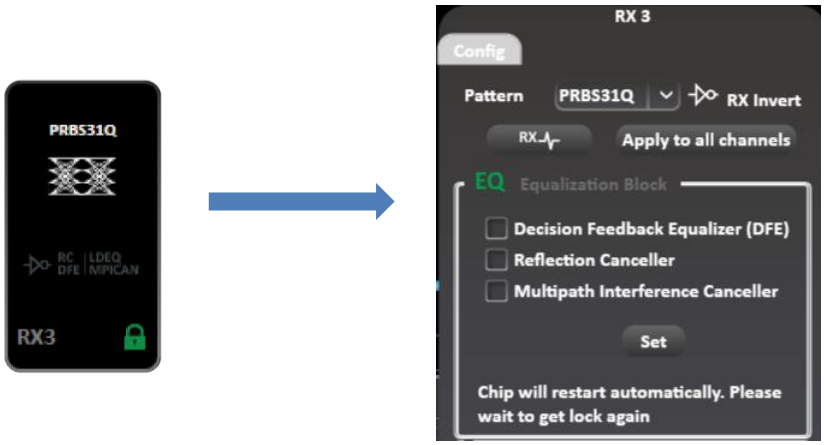


Figure 23: Rx Channel Display & Control Tab

The RX channel tab employs green shading to highlight the enabled RX features (RX polarity inversion, RC, DFE, MPICAN).

Figure 24: Rx Side with Different EQ Types Enabled

Rx Diagnostics

To access the RX diagnostics graph section, select the RX button found in the RX configuration window of each channel

After pressing the button, RX diagnostics button is shaded in green, and a graph section will appear as shown in Figure 24.

The Rx diagnostics features 3 measurement tabs:

- **FFE Taps:** Displays the Feed Forward Equalizer tap values.
- **SNR:** Measures Signal to Noise Ratio in decibels (dB).
- **Histogram:** Measures density distribution of the samples.

Screenshots of the available RX diagnostics measurements graphs are shown in Figures 25-27.

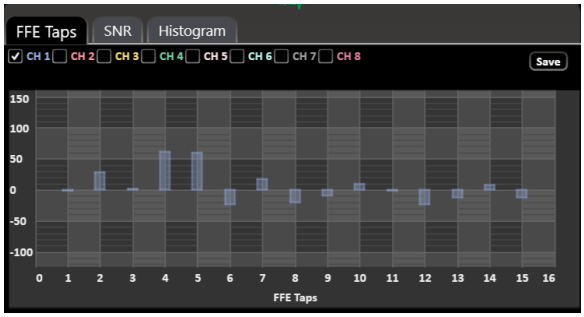


Figure 25: Rx Diagnostics FFE Taps

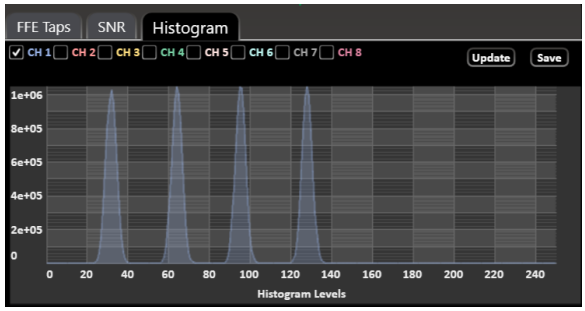


Figure 26: Rx Diagnostics Histogram

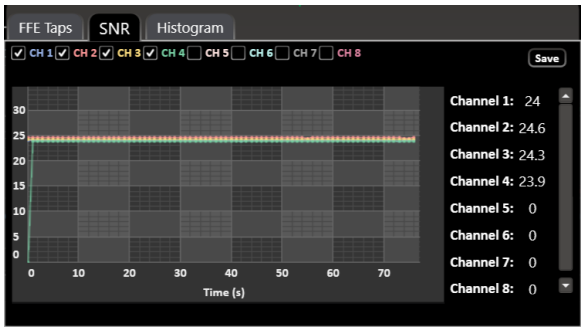


Figure 27: Rx Diagnostics SNR Measurements

NOTES:

- You can save the graphs with the save button in the upper righthand corner of the window.
- You also have the option to view all the channels at once for selected measurements

Clock Configuration

With ThunderBERT, you can choose between different clock configuration options:

- **Internal Clock Mode or CleanClk:** Choose between reference clock or high frequency clean clock. In the high frequency clean clock mode, the multipliers range from 2 to 30.

- **External Clock Rate or Clk-In:** When the Clk-In mode is enabled, you cannot use the BERT as a reference clock generator (Clk-Out). The permissible analog clock input range for the ML BERT platforms varies between 136.36 and 178.78 MHz with an optimal value of 156.25 MHz. Optimal frequency will be visible within the Clk-In menu of ThunderBERT.

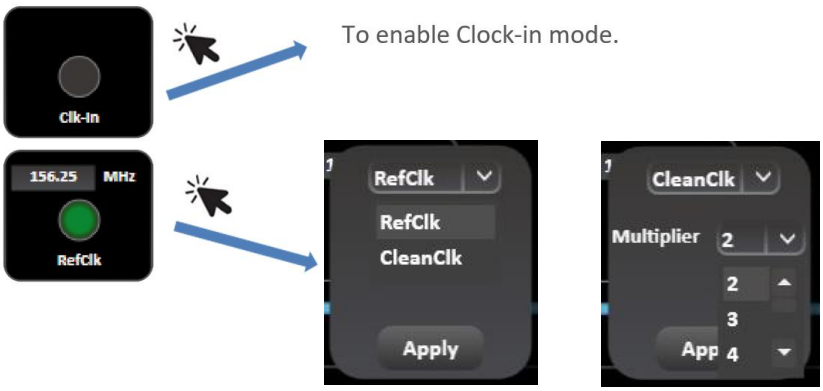


Figure 28: Clock Options

Supported Measurements

The ThunderBERT platform provides comprehensive control of all supported measurements including BER, FEC, SER and Rx Diagnostics

Measurement Controls

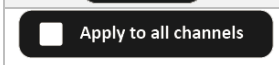
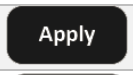
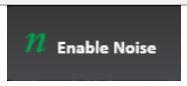
Control	Definition
	Start and Stop BER, FEC, and SER measurements
	RX diagnostics: RX FFE taps, SNR, and Histogram Control
	Capture histogram and update error insertion rate
	Save RX FFE taps, SNR values, histogram captures
	Save and Load FFE taps, Save and Load BERT settings
	Set FFE taps
	Insert Errors
	Apply unified settings on all channels (supported on both TX and RX sides)
	Apply bit rate, clock rates, FEC, and 3- and 7-tap mode
	Graph Autoscale
	TX ON/OFF AND Enable/ Disable History navigation measurements to be listed in details tab
	Enable Noise
	Enable Jitter
	BER/ FEC Measurement Timer
	Additional Options

Table 1: Measurement Controls

Generic Measurements

You can execute BER measurements according to the channels you select. While the test is running, you can change the X and Y axis according to the supported graph combinations.
During a direct loopback test, to avoid any damage on the Rx side always make sure to adjust the Tx amplitude swing to a maximum of 800mV
You have the choice to measure/visualize different options such as:

- Single and Multichannel BER
- Accumulated and Instant BER
- Continuous BER Test
- Time-defined BER Test

Supported measurements are grouped in the following table:

Instant Measurements	Accumulated Measurements
Instant BER	Real Time BER
Instant Error Count	Accumulate Error Count
Instant BER MSB	Real Time BER MSB
Instant BER LSB	Real Time LSB
Instant Error Count MSB	Accumulated Count MSB
Instant Error Count LSB	Accumulated Error Count LSB

Table 2: Supported BER Measurements

To start visualizing the selected BER results/measured data, select the channel(s) on which the measurement(s) are to be displayed and press the Start button to run the measurement.
There is also an option to select/deselect all channels.

Figure 29: Clock Options

Instant and accumulated measurements can be displayed simultaneously in the details panel and on the graph. In addition, you can navigate through the measurement behavior at any past time in the test using ***History Navigation*** in the details panel at 100 ms intervals.

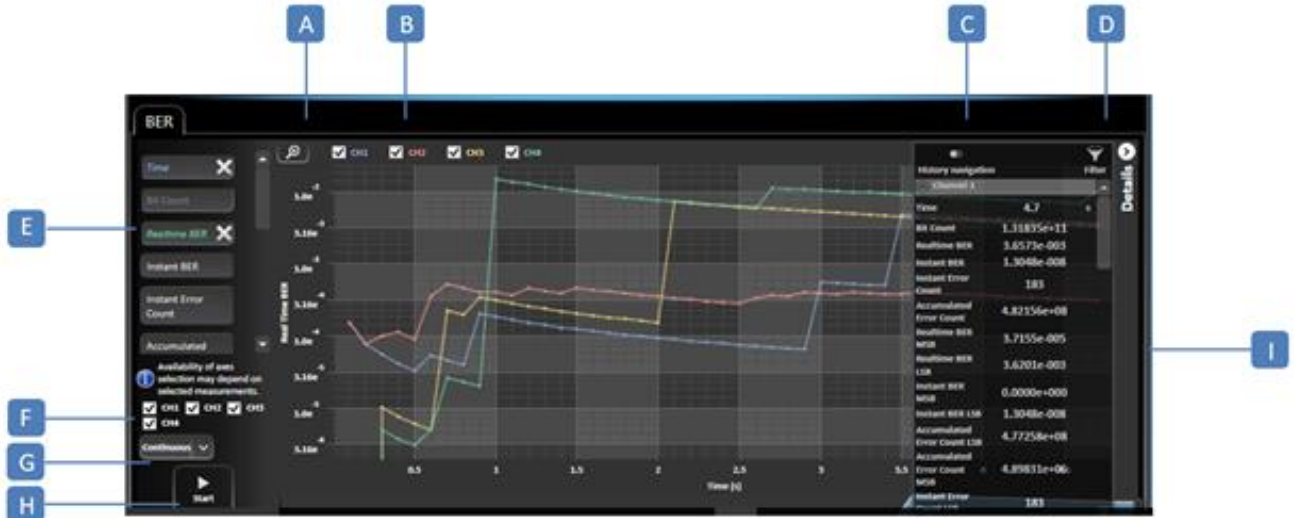


Figure 30: Measurement Display

A: Graph Autoscale – **B:** Channel Selection – **C:** History Navigation – **D:** Measurement Filtering – **E:** Graph Display Measurements Selection (axes) – **F:** Channel Selection – **G:** Timer/Continuous Mode – **H:** Stop/Start BER – **I:** Details panel

X-axis selection: To enable measurements, select a value for both the X and Y axis. Different options for the X axis selection are supported, but only one can be selected per measurement, while more than one Y axis can be selected and displayed simultaneously. The scale of each Y axis selected will be displayed on the left of the graph.

A display of supported NRZ/PAM4 BER graph combinations is shown below depending on the measurement type:

- PAM4 Measurements:

X axis	Y axis
Time	Real Time BER
	Instant BER
	Instant Error Count
	Accumulated Error Count
	Real Time BER MSB
	Real Time BER LSB
	Instant BER MSB
	Instant BER LSB
	Accumulated Error Count MSB
	Accumulated Error Count LSB
	Instant Error Count MSB
	Instant Error Count LSB

X axis	Y axis
Bit Count	Real Time BER
	Instant BER
	Instant Error Count
	Accumulated Error Count
	Real Time BER MSB
	Real Time BER LSB
	Instant BER MSB
	Instant BER LSB
	Accumulated Error Count MSB
	Accumulated Error Count LSB
	Instant Error Count MSB
	Instant Error Count LSB

X axis	Y axis
Accumulated Error Count	Instant BER
	Instant Error Count
	Instant BER MSB
	Instant BER LSB
	Accumulated Error Count MSB
	Accumulated Error Count LSB
	Instant Error Count MSB
	Instant Error Count LSB

X axis	Y axis
Accumulated Error Count MSB	Instant BER MSB
	Instant Error Count MSB

X axis	Y axis
Accumulated Error Count LSB	Instant BER LSB
	Instant Error Count LSB

Table 3: PAM4 Graph Combinations

- NRZ Measurements

X axis	Y axis
Time	Real Time BER
	Instant BER
	Instant Error Count
	Accumulated Error Count

X axis	Y axis
Bit Count	Real Time BER
	Instant BER
	Instant Error Count
	Accumulated Error Count

X axis	Y axis
Accumulated Error Count MSB	Instant BER MSB
	Instant Error Count MSB

X axis	Y axis
Accumulated Error Count	Instant BER
	Instant Error Count

Table 4: NRZ BER Graph Combinations

After selecting the desired graph configuration, data will be plotted instantly (make sure to choose the desired channel and click on the Start button).

You can access the instant and accumulated measurements data using the BER measurements table. You can switch from graph to table measurements with no test interruptions. You can save the table of result onto your desktop using the save button.

BER graphs and table measurements are displayed below in Figure 31.

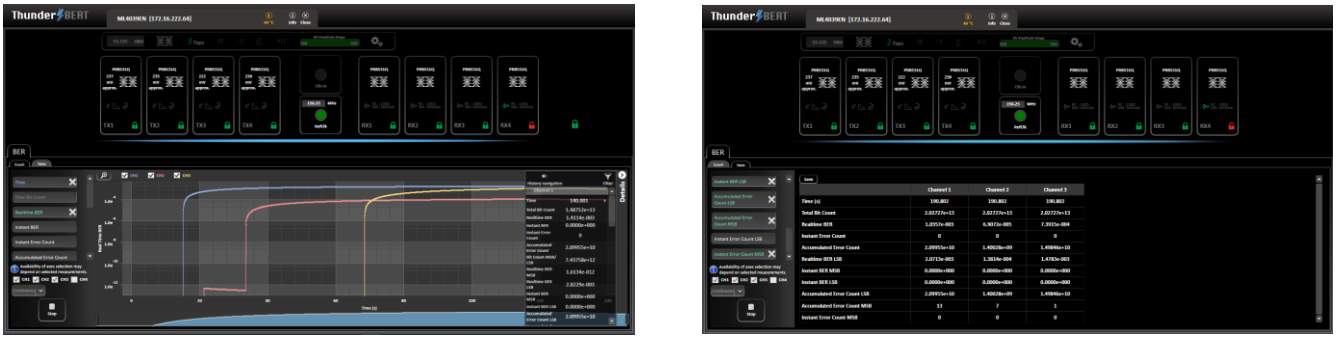


Figure 31: Error Tracking Vs Time and BER Table Measurements

Platform Specific Measurements

MultiLane offers the new ML4079EN with Real Hardware FEC and stress testing features such as Jitter injection in both FM and PM Mode, Single Frequency, and IEEE JTOL in addition to random, burst noise injection and automated ITOL Testing

Activating a purchased Real Hardware FEC License or a Jitter/JTOL License:

To Enable FEC or Jitter licensing, you can request a License by placing a Purchase Order to operation@MultiLaneinc.com by sending a screenshot of your BERT info tab.
The 2 licenses are seperate so you can order them both or only one of them

After purchasing a license, you will be eligible for a license key (LK). This LK is needed to unlock all the features.

After clicking on "Add License" available in Info tab, a pop-up window will appear, where your LK should be copied and applied.

Figure 32: Add License Available in Info tab

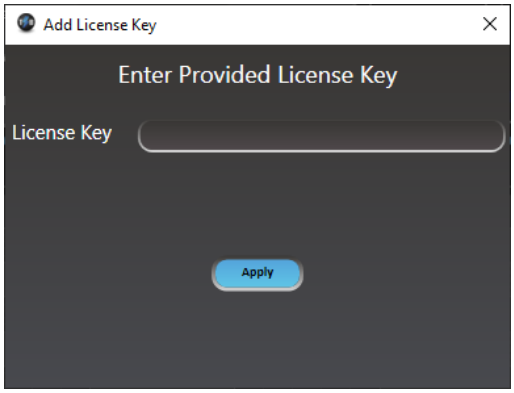


Figure 33: Pop-up window to Add License

If the LK is valid, another pop-up window will appear, informing you that the LK has been applied.

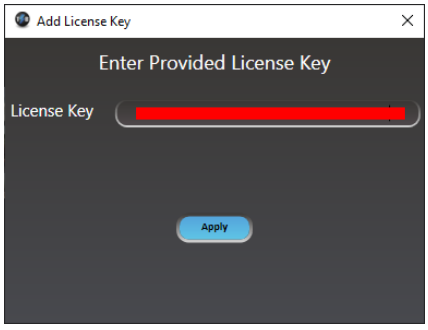


Figure 34: License Key Added

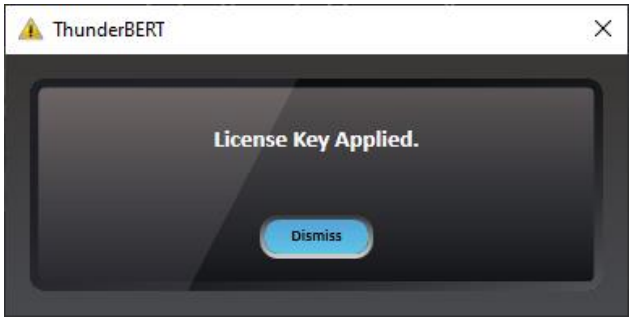


Figure 35: FEC Features Enabled

After you have applied your LK, the BERT ***should be disconnected,*** and ***power cycled***. Full features will then be accessible and ready to use.

You will be notified if a wrong LK is entered (figure 36). The GUI will disconnect directly if a wrong LK is entered four times consecutively (figure 37)

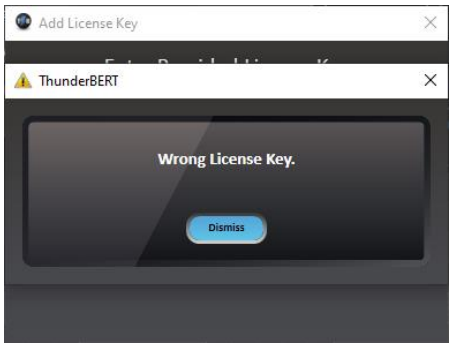


Figure 36: Wrong License Key

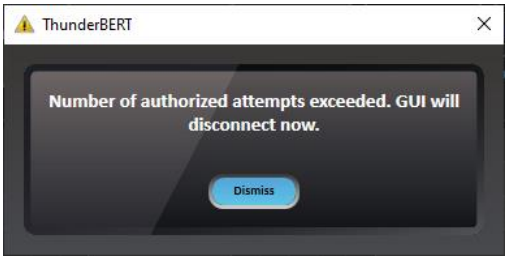


Figure 37: Number of Authorized Attempts Exceeded

Jitter Injection

The ML4079EN includes 2 types of jitter injection. The first one is manual jitter injection in both FM and PM modes. The other one is the JTOL option including both IEEE JTOL and Single Frequency JTOL

All jitter options are enabled after installing the license

A. Manual Jitter Injection:

The ML4079EN supports 2 types of jitter injection: Frequency Modulation in both Sinusoidal and random jitter and Phase Modulation including Sinusoidal, random and Bounded Uncorrelated Jitter

1) Frequency Modulation:

For the frequency Modulation **FM** Jitter injection, you can choose between Sinusoidal Jitter **(SJ)** or Random Jitter (**RJ**) or both.

To enable Jitter injection: click on the Jitter on the **BERT Settings Tab**,

- SJ Enable:

  Click on the **FM Icon**. When enabled, this icon will turn green

  To enable **FM SJ**, click on the **SJ Checkbox**, select the Frequency, and use the slider to adjust the jitter amplitude and click on **Set**

  In FM SJ Mode, the factory calibration includes 10 frequencies in KHz: 40, 100, 400, 1000, 1330, 2500, 7000, 10000 and 12000. The factory calibrated frequencies were chosen to cover the IEEE 802.3 ck requirements and the jitter injection capabilities are above 3x the requirements.

  The user can do his own calibration, save/load it but shall use the factory calibrated ones for the automated JTOL Test.

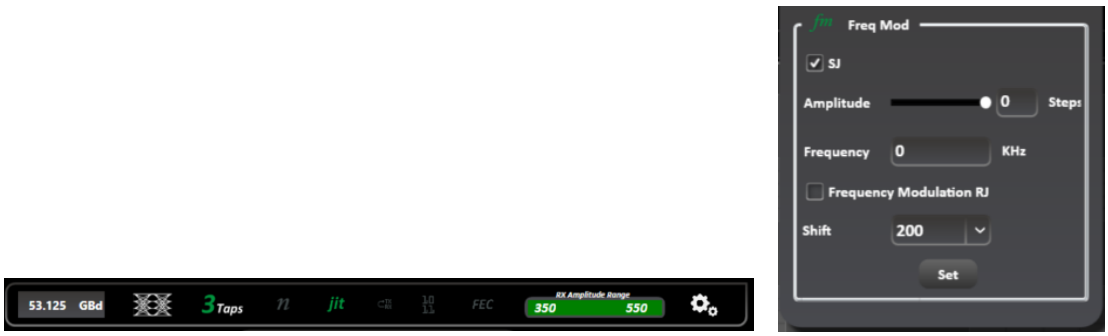


Figure 38: FM SJ Enabled

- RJ Enable:

  Click on **FM Icon**. When enabled, this icon will turn green

  To Enable **FM RJ**, Click on **RJ Checkbox**, use the slider to adjust the jitter amplitude and click on **Set**: the amplitude slider varies between 0 and 4095 in digital value

  You can change the Shift value to adjust the skew, the recommended shift value is 485

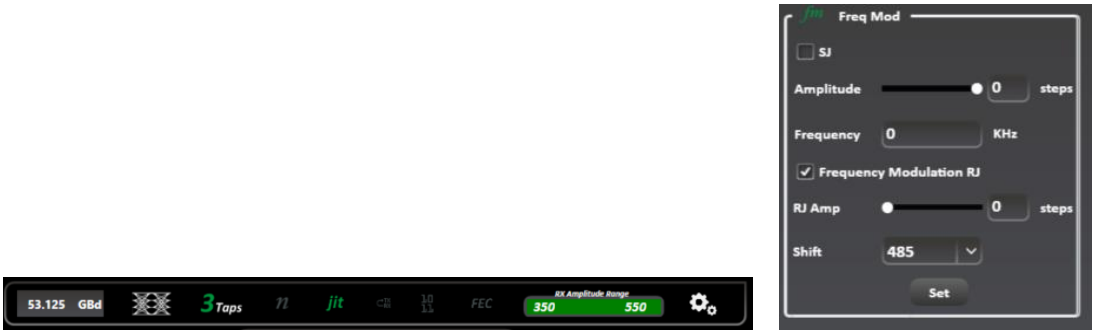


Figure 39: FM RJ Enabled

2) Phase Modulation:

For the Phase Modulation PM Jitter injection, you can choose between Sinusoidal Jitter (SJ), Random Jitter (RJ), Bounded Uncorrelated Jitter (BUJ) or all of them.

- SJ Enable:

  Click on the **PM Icon**. When enabled, this icon will turn green

  To enable **PM SJ**, click on the **SJ Checkbox**, select the Frequency, use the slider to adjust the jitter amplitude, Adjust the **PM Shift** slider to the middle and click on **Set**

  A recommended **PM Shift** value is around 1700.

  In PM SJ Mode, the factory calibration includes 10 frequencies in KHz: 40, 100, 400, 1000, 1330, 2500, 7000, 10000 and 12000. The factory calibrated frequencies were chosen to cover the IEEE 802.3 ck requirements and the jitter injection capabilities are above 3x the requirements.

  The user can do his own calibration, save/load it but shall use the factory calibrated ones for the automated JTOL Test.

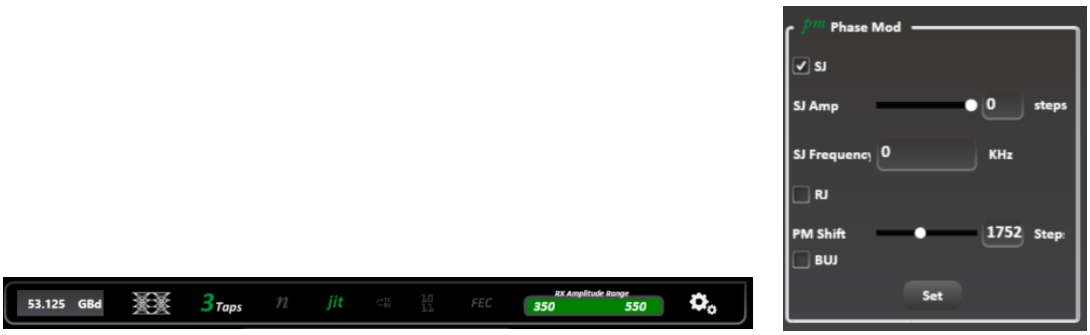


Figure 40: PM SJ Enabled

- RJ Enable:
  Click on **PM Icon**. When enabled, this icon will turn green
  To Enable **PM RJ**, Click on **RJ Checkbox**, use the slider to adjust the jitter amplitude and click on **Set,** Adjust the **PM Shift** slider to the middle and click on **Set**
  A recommended **PM Shift** value is around 1700. The amplitude slider varies between 0 and 4095 in digital value

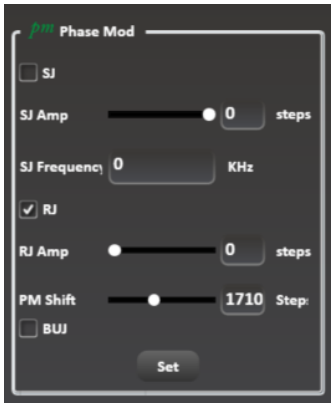


Figure 41: PM RJ Enabled

- BUJ Enable:
  Click on **PM Icon**. When enabled, this icon will turn green
  To Enable **PM BUJ**, click on **BUJ Checkbox**, use the slider to adjust the jitter amplitude and click on **Set,** Adjust the **PM Shift** slider to the middle and click on **Set**
  A recommended **PM Shift** value is around 1700. The amplitude slider varies between 0 and 4095 in digital value

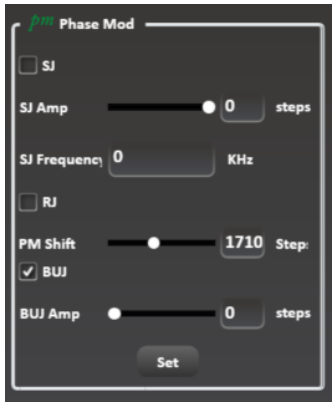


Figure 42: PM BUJ Enabled

B. JTOL:

In addition to the manual jitter injection, the ML4079EN Offers an automated Jitter Tolerance Test. With this feature, the user can test it's DUT based on IEEE 802.3 Specifications using the IEEE JTOL. In addition, the user can use the single frequency JTOL to test his DUT at one frequency and between 2 amplitude values

Also, the JTOL options, includes Margin calculations and a save as CSV File option

1) IEEE JTOL:

Click on the **JTOL Tap**, Select **IEEE**, Chose the **IEEE section** you want to test against based on the line rate you're using: CAUI4, 400GAUI-8 or 800GAUI-8. If the line rate and the chosen section are not compatible a warning message in yellow will be shown.

Select the **Target BER** based on which you will get the pass/fail verdict and the **BER Test Time.** To start your test, click on **Start**

This test is to be done on one channel at a time

This feature will test your DUT at 10 frequencies and at 4 testing points for each frequency.

The frequencies are: 40, 100, 400, 1000, 1330, 2500, 7000, 10000 and 12000KHz.

As for the testing points: at each frequency there is a maximum injection point always higher than 3x the IEEE Requirements: so, the test points are: Maximum Value (MV), 75% of MV, 50% of MV and 25%

You can monitor the results using the graph or in table mode:

- Graph Mode:

  In the X axis, you can find the frequencies (KHz) from 0 to 12000Khz and in the Y axis you have the jitter injection in UI

  The passing point will be colored in green while the failed ones will be colored in Red. The last passing point at each frequency will be joined together to form the Margin Graph

- Table Mode:

  at each test point, a table showing the Time (s), the test point jitter Amplitude (UI) and frequency (Khz), the BER result, the JTOL Result: Pass/Fail based on the target BER Selected by the user before starting the test and the JTOL Margin(%)

  $$\text{JTOL Margin (\%)} = \frac{\text{Jitter Injection Value} - \text{IEEE Mask}}{\text{Jitter Injection Value}} * 100$$

To save the results, click on **Save** and **Save All**. The results will be saved as a CSV File

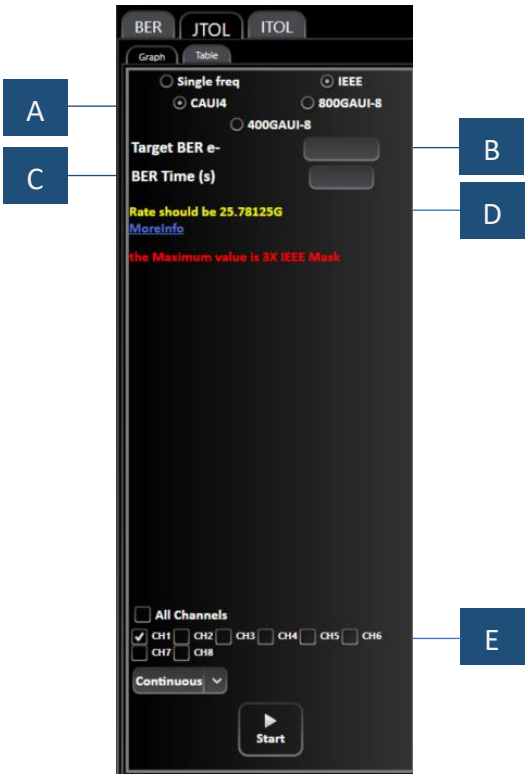


Figure 43: IEEE JTOL Options

A: IEEE Specification depending on selected line rate – B: User's Target BER based on which the pass/fail verdict will be done – C: BER Time: in seconds – D: Warning message if the IEEE Spec chosen and the line rate don't match – E: Channel Selected for the test

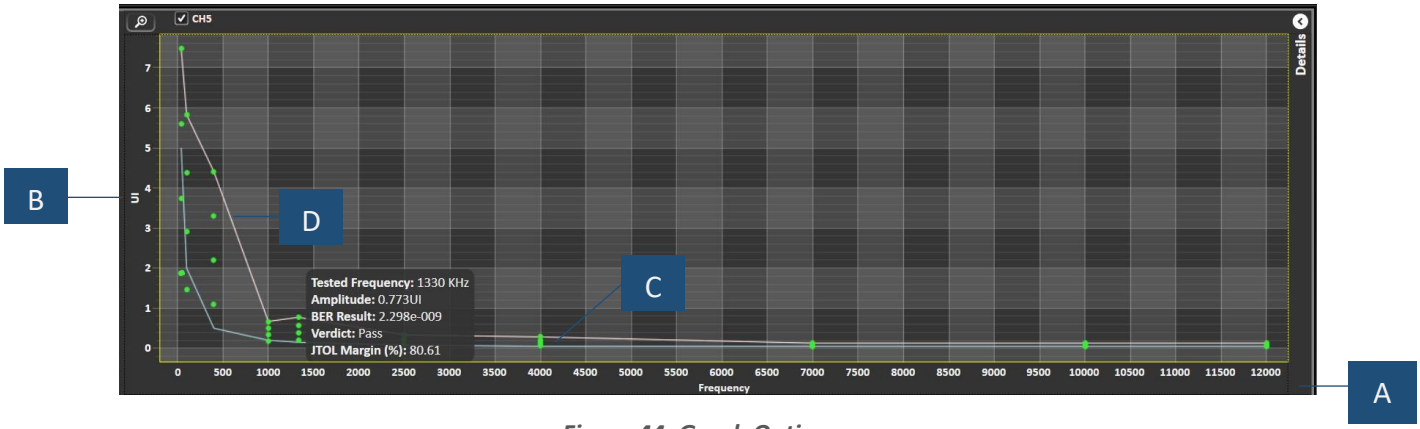


Figure 44: Graph Option

A: X axis: Frequencies (KHz) – B: Y Axis: Jitter Injection Values (UI) – C: IEEE Mask – D: Margin Graph Hovering over any point will show test information: tested frequency, amplitude, BER result, JTOL margin, and verdict.

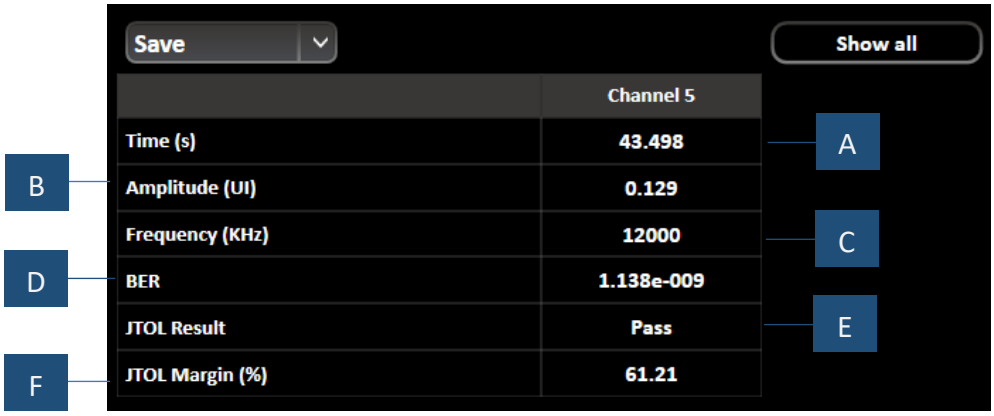
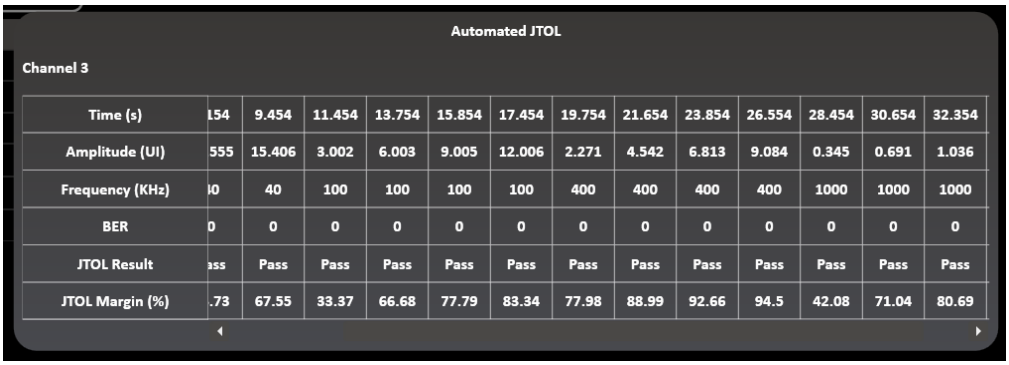


Figure 45: Table Option

A: Test Time (s) – B: Jitter Injection Amplitude (UI) – C: Test Frequency (KHz) – D: BER result – E: JTOL Result: Pass/Fail after comparing the BER Result to Target BER – F: JTOL Margin

Clicking Show All will show all the tested frequencies with time, amplitude, BER, JTOL result and margin:



Time (s)	154	9.454	11.454	13.754	15.854	17.454	19.754	21.654	23.854	26.554	28.454	30.654	32.354
Amplitude (UI)	555	15.406	3.002	6.003	9.005	12.006	2.271	4.542	6.813	9.084	0.345	0.691	1.036
Frequency (KHz)	40	40	100	100	100	100	400	400	400	400	1000	1000	1000
BER	0	0	0	0	0	0	0	0	0	0	0	0	0
JTOL Result	ass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
JTOL Margin (%)	.73	67.55	33.37	66.68	77.79	83.34	77.98	88.99	92.66	94.5	42.08	71.04	80.69

Figure 46: Automated JTOL Table

2) Single Frequency JTOL:
   Click on the **JTOL Tap**, Select **Single Frequency**, Chose the **SJ Frequency** you want to test on, Select your **Start** and **Finish** Point as Jitter Injection Amplitude in steps 0 being the minimum and 4095 the maximum, select the number of points you need to test by specifying the step then select the **Target BER** based on which you will get the pass/fail verdict and the **BER Test Time.** To start your test, click on **Start**
   This test is to be done on one channel at a time
   You can monitor the results using the graph or in table mode:
   - Graph Mode:
     In the X axis, you can find the frequencies (KHz) from 0 to 12000Khz and in the Y axis you have the jitter injection in UI. The graph will show you at the selected frequencies the different testing points
     The passing point will be colored in green while the failed ones will be colored in Red. The last passing point at each frequency will be joined together to form the Margin Graph

- Table Mode:
  at each test point, a table showing the Time (s), the test points jitter Amplitude (UI) and selected frequency (Khz), the BER result, the JTOL Result: Pass/Fail based on the target BER Selected by the user before starting the test and the JTOL Margin (%)
  JTOL Margin (%) = $\frac{\text{Jitter Injection Value} - \text{IEEE Mask}}{\text{Jitter Injection Value}} * 100$
  To save the results, click on **Save** and **Save All**. The results will be saved as a CSV File

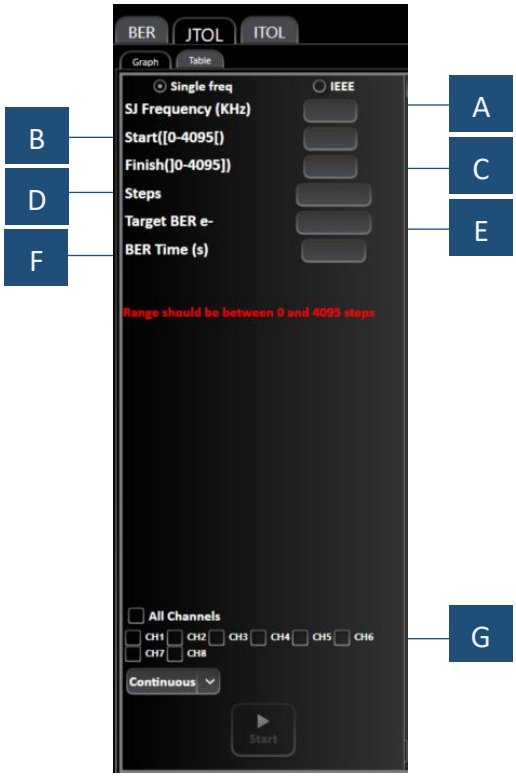


Figure 47: Single Frequency JTOL

A: Selected SJ Frequency – B: Starting Test Point - C: Final Test Point – D: to help identify the number of test points – E: Target BER to determine the Pass/Fail Points – F: BER Test Duration G: Selected Channel for this test

C) SJ Calibration:

Sinusoidal Jitter (SJ) is calibrated in both modes FM and PM

The factory calibration is done at 10 frequencies as per IEEE 802.3 Requirements: 40, 100, 400, 1000, 1330, 2500, 7000, 10000 and 12000KHz

In addition to the factory calibration, the ML4079EN enables the user to do his own calibration

To note that, when in IEEE JTOL Mode the factory calibration shall be used

a) Calibration Setup:
   1) Connect one of your ML4079EN Tx to any digital sampling scope where you can measure the pattern width when jitter is injected
   2) In between the ML4079EN and the scope, you can add your DUT or any additional fixtures
   3) You can calibrate 10 frequencies
   4) Start collecting the Raw Data:
      a. Start moving the slider of the ML4079EN and Note on an Excel Table the equivalent measured Value on your scope: you can use this EXCEL SHEET
      b. Take as many points as you can to get a more accurate calibration
      c. Copy/Paste this file to a wordpad .txt file
   5) Load this table to Matlab to get the 3rd order Equation from the fitting Graph:
      a. Load the Excel file on Matlab (Line 6)
      b. Change the x and y dimensions depending on the number of points used in Excel (Line 7 and 8)
      c. Click on Run
      d. Adjust the points to avoid saturation at both ends of the graph
      e. Click on Run again
      f. On Matlab Workspace, click on a and save the 4 values you got on Excel: the values you get are the equation coefficients: a, b, c, and d respectively
      g. On Matlab Workspace, click on data, and get the min and max values in ps, copy/paste the values to Excel
      h. Repeat the same procedure to all 10 frequencies you need to save in FM Mode at the 2 line rates (53.125Gbd and 26.5625Gbd), then repeat the procedure to PM Mode
      i. After getting all the necessary coefficients (a, b, c and d) and min and max at all 10 frequencies, open the Calibration GUI, Click on SJ Calibration
      j. On the Freq tap, insert all the frequencies you want to calibrate, a, b, c and d, min and max, click on save frequencies, save all and save to file to access them later on
      k. To calibrate PM, click on the PM Checkbox at the top left of the page and repeat the same procedure
      l. To read an already saved file: click on read from file, save frequencies, and save all

b) Calibration Example: FM Mode 100KHz:

1) Raw Data Collection, copy the excel values to a wordpad file .txt

Raw Data	
BERT Slider (Steps)	Equivalent from DSO (ps)
500	32.8
550	35
575	37
600	38.2
625	39.8
650	41.4
675	43.2
700	44.8
725	46.4
750	47.8
775	51
800	52.4
825	54.2
850	56
875	57.4
900	60
925	62.2
950	64.2
975	66.8
1000	68.8
1025	72
1050	74.8
1075	77.4
1100	80.2
1125	84
1150	87.4
1175	90
1200	93.4
1225	97
1250	100.2
1275	104
1300	107.8
1325	111.4
1350	115.6
1375	120.4
1400	124.8
1425	129.2
1450	134.4
1475	140.4
1500	145.4
1525	152
1550	156.8
1575	163.8
1600	170.4
1625	176.8
1650	183.6
1675	188.8
1700	197
1725	202.5
1750	210.5
1775	214.5
1780	216
1790	220
1800	223
1810	226

1) Go to Matlab: load the txt file, change the x,y dimensions and click on Run:

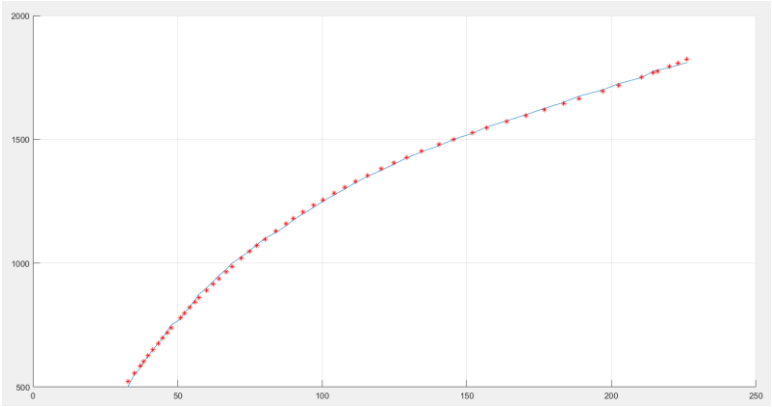
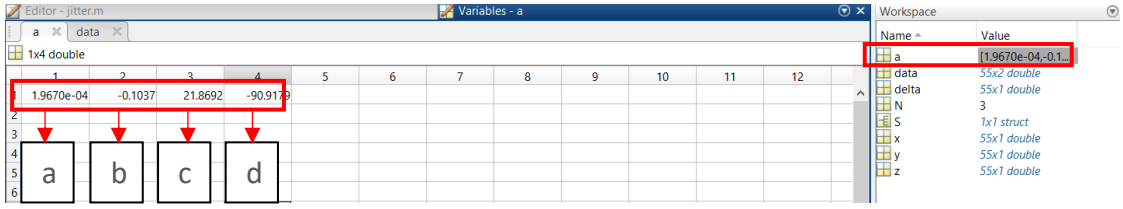


Figure 48: Raw Data and Data after Fitting

2) Verify that the fitting data is accurate and remove all saturated points
3) Go to Matlab workspace, “a” and copy the values



4) Go to Matlab workspace, “data”, copy the min and max values in ps: the values shall be integer

a data

55x2 double

	1	2
1	500	32.8000
2	550	35
3	575	37
4	600	38.2000
5	625	39.8000
6	650	41.4000
7	675	43.2000
8	700	44.8000
9	725	46.4000
10	750	47.8000
11	775	51
12	800	52.4000
13	825	54.2000
14	850	56
15	875	57.4000
16	900	60
17	925	62.2000
18	950	64.2000
19	975	66.8000
20	1000	68.8000
21	1025	72

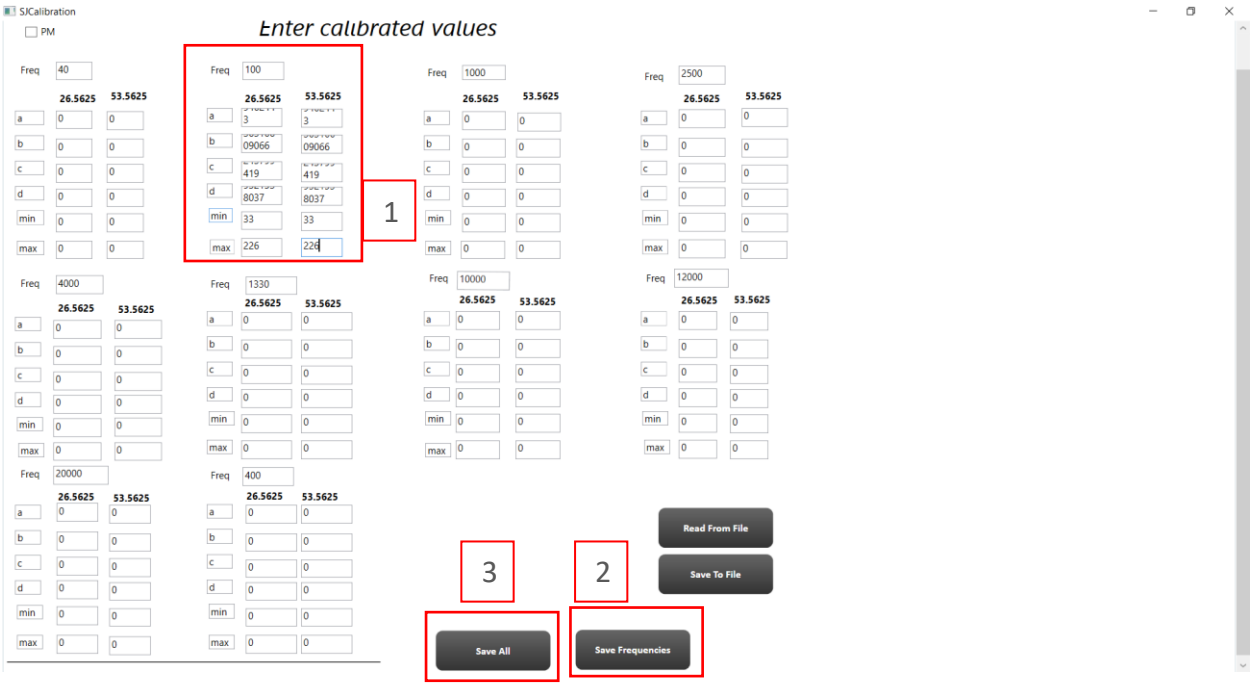
Editor - jitter.m

a data

55x2 double

	1	2
37	1425	129.2000
38	1450	134.4000
39	1475	140.4000
40	1500	145.4000
41	1525	152
42	1550	156.8000
43	1575	163.8000
44	1600	170.4000
45	1625	176.8000
46	1650	183.6000
47	1675	188.8000
48	1700	197
49	1725	202.5000
50	1750	210.5000
51	1775	214.5000
52	1780	216
53	1790	220
54	1800	223
55	1810	226

5) After Finalizing the other Frequencies, a,b,c and d, min and max are copied to the Jitter Calibration GUI, click on save frequencies, save all and save to file if you want to save the calibration values to be read later on



Noise Injection:

With the new ML4079EN, the user can now inject Random or Burst Noise and benefit from the automated interference tolerance test (ITOL). In addition, to emulating real life crosstalk scenarios the ML4079EN supports shallow loopback testing

Random Noise Scenarios can be configured on each 2 channels independently

1) Random Noise:
   To enable Random Noise, click on the Noise Icon located at the top configuration bar, the click on **Enable Noise**
   You can control each 2 adjacent channels independently, to enable Noise on a specific pair of channels: go to the Tx Advanced Mode control and click on **Noise Injection** and then on Noise TX Pattern select **Random Noise**
   Move the **Noise level Slider** to control the Noise Level and press on **Enter** to apply the settings. Random noise is calibrated with a value in $\mathrm{mV_{Rms}}$
   Random noise featured in the ML4079EN is following the IEEE 802.3ck Requirements, so the Crest Factor is higher than 5 and the spectral shape is flat.
   The maximum noise injection is up to 15mV_rms noise injection.

Figure 49: Random Noise Injection Tap

2) Burst Noise:
   To enable Burst Noise, click on the Noise Icon located at the top configuration bar, the click on **Enable Noise**
   You can control each 2 adjacent channels independently, to enable Noise on a specific pair of channels: go to the Tx Advanced Mode control and click on **Noise Injection** and then on Noise TX Pattern select **Burst Noise**
   Configure the **Burst Rate**, move the **Noise level Slider** to control the Noise Level and press on **Enter** to apply the settings.

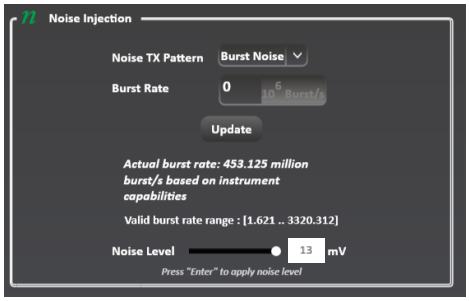


Figure 50: Burst Noise Injection Tap

3) Automated Interference Tolerance (ITOL):

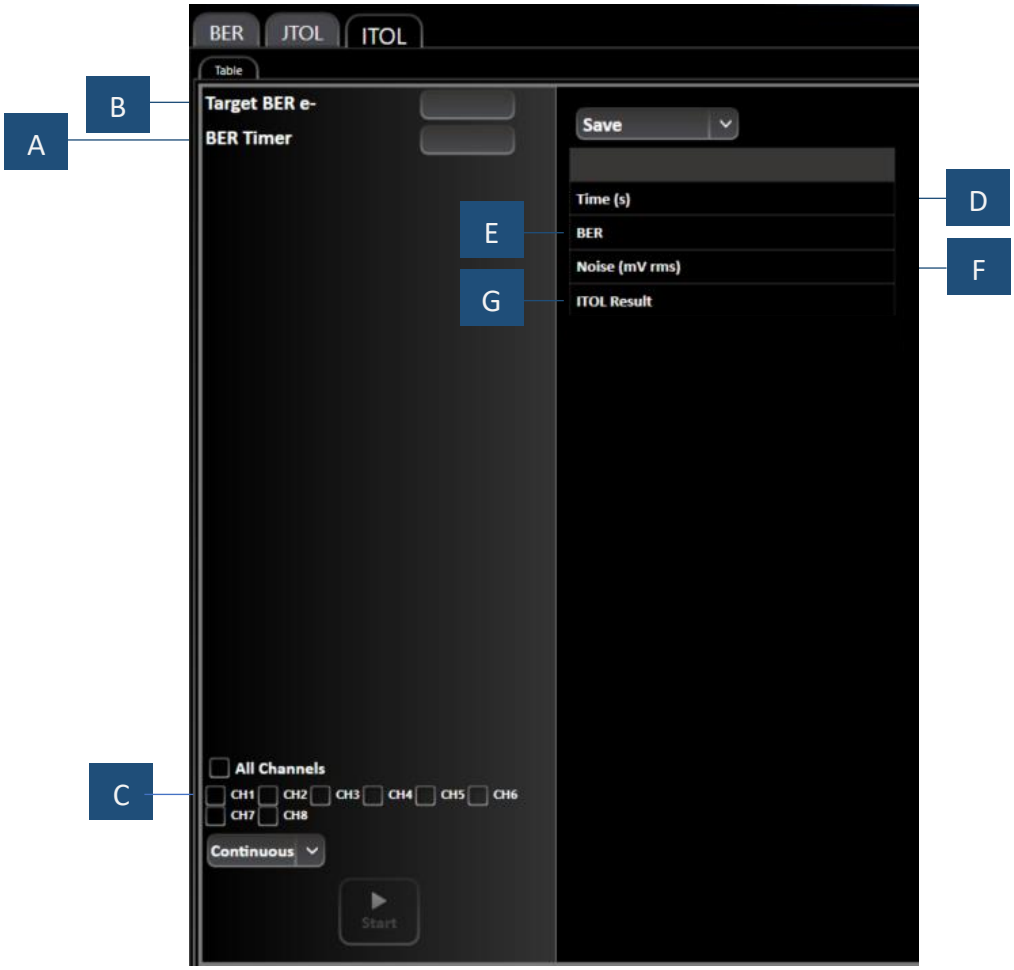


Figure 51: ITOL Tab

A: Target BER Based on which the Pass/Fail Verdict will be issued – B: BER Test Time at each point – C: Test is done on each 2 consecutive channels – D: test time – E: BER Value – F: injected Random Noise in (mVrms) – G: ITOL Verdict Pass/Fail based on selected target BER

4) Shallow Loopback:

The shallow loopback function works with a variety of traffic types including unframed PRBS, framed ethernet and FEC traffic. The following figure depicts a ML4039EN accepting traffic from an external 400G switch, looping the traffic back internally and re-transmitting it back to the RX side of the host.

To activate the Shallow Loopback feature, Enable the function via the **Shallow Loopback button** in the top of the configuration bar, connect an external source to the RX port(s) of the BERT.

External traffic must be within the following range: 23-29 or 46-56 GBd

Inject noise into the external traffic via the Noise Injection menu on each channel. **Apply** intended noise injection on the looped-back external signal. **Access** looped-back traffic via the TX ports.

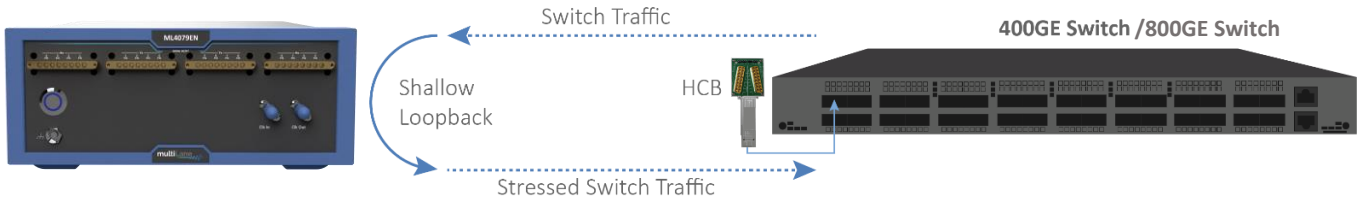


Figure 52: Shallow Loopback Setup using ML4079EN and 400GE/800GE Switch

Real Hardware FEC Measurements.

After entering an applicable FEC license code into ThunderBERT, enable the FEC measurements from the drop-down list and then press apply. Once enabled, the FEC button will become green and display the FEC type selected.

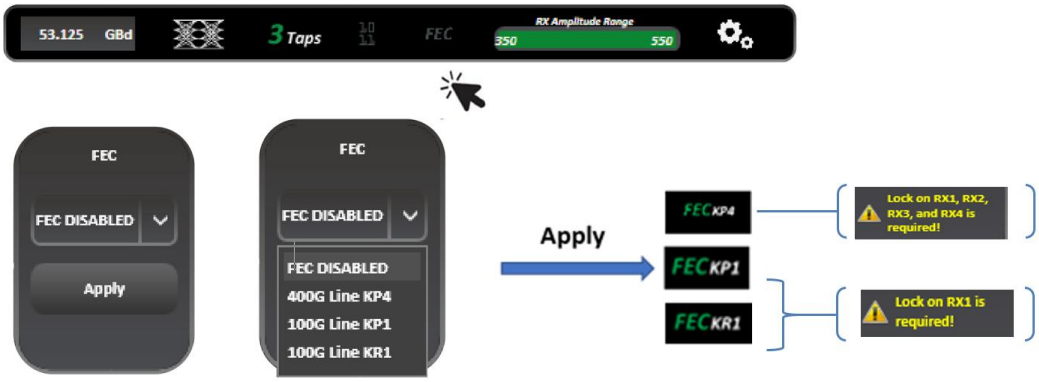


Figure 53: Enabling FEC

When FEC is enabled, you can change the X and Y axes to the supported graph combinations where instant and accumulated bit counts are supported and can see the results of the measurements in the details section. SER measurements are also supported in FEC mode; corrected codewords with symbol error distribution are displayed.

Instant and Accumulated Measurement	Measurement Description
Corrected Bit Count	Sum of corrected “0” and “1” bits after decoding.
Corrected Zero Count	Number of “0” bits that were corrected to be “1” bits after decoding.
Corrected One Count	Number of “1” bits that were corrected to be “0” bits after decoding.
Processed Codeword Count	Total number of codewords, correctable and uncorrectable processed by the decoder.
Corrected Codeword Count	Number of codewords (FEC blocks) that were corrected by the decoder, which means the number of codewords that were determined to have a correctible magnitude of symbol errors.
Uncorrected Codeword Count	Total number of codewords that were deemed uncorrectable by the decoder, which means number of codewords that were determined to have more than the correctible magnitude of symbol errors.
Uncorrected Codeword Rate	Number of uncorrected codewords compared to the number of processed codewords.
FEC Symbol Error Rate	Number of symbol errors divided by the total number of processed symbols.
FEC Symbol Error Count	Total number of symbol errors processed by the decoder.
Pre-FEC BER	Raw and unframed ratio of incorrect bits (Bit Errors/Total Bits) on a channel-by-channel basis.
Post-FEC BER	Total number of bit errors remaining after real FEC decoding divided by the total number of received bits.

Table 5: Instant and Accumulated Real Hardware FEC Measurements

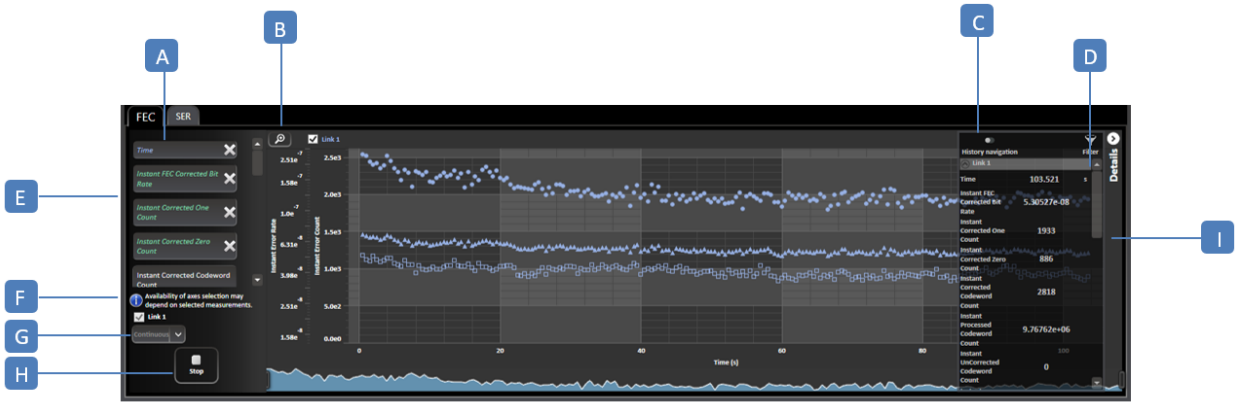


Figure 54: Measurement Display

A: FEC/SER graphs – **B:** Graph Auto Scale – **C:** History Navigation – **D:** Measurement Filtering
E: Graph Display Measurements Selection – **F:** Link Selection – **G:** Timer/Continuous Mode
H: Stop/Start FEC/SER – **I:** Details panel

To enable measurements, select a value for both the X and Y axes*. Different options for the X axis selection are supported, but only one can be selected per measurement, while more than one Y axis can be selected and displayed simultaneously. The scale of each Y axis selected will be displayed on the left of the graph.

You can choose between visualizing instant and accumulated measurements, and measurements table under the FEC and SER tabs. You can save the table of result on your desktop using the save button. Some FEC and SER screenshots are shown below:

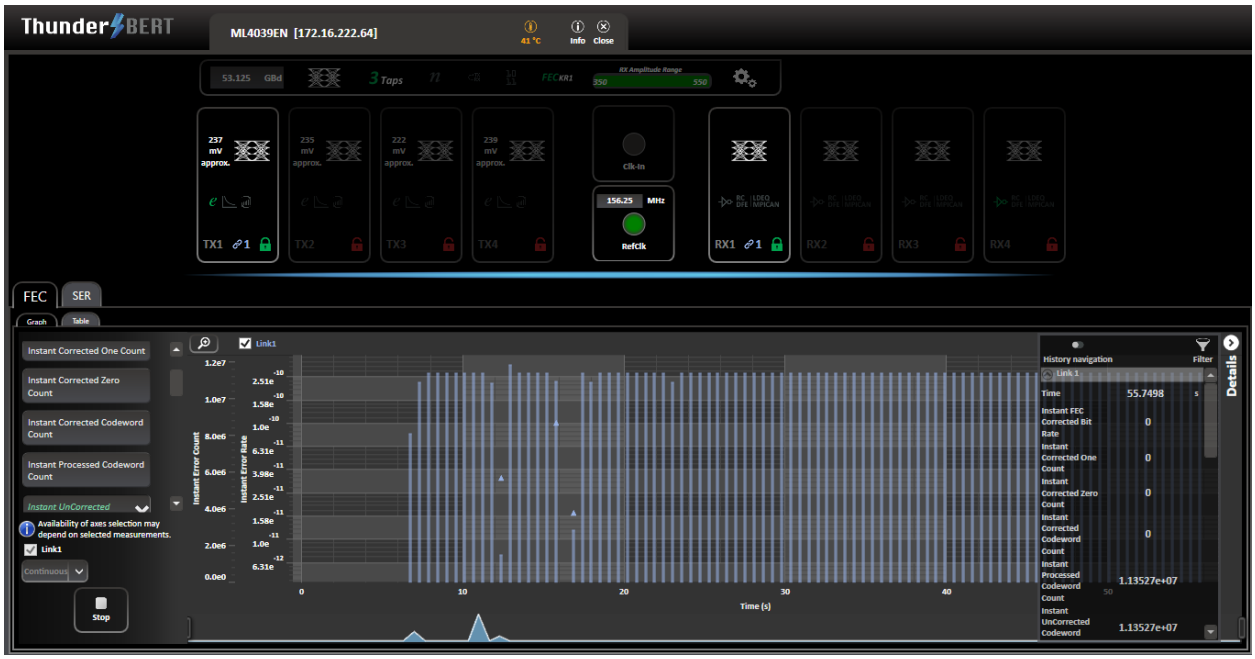


Figure 55: FEC Graph with Details Panel

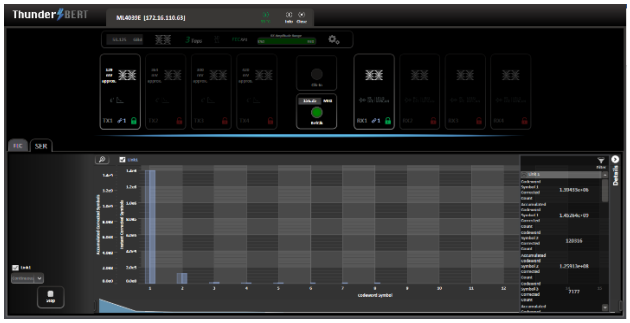


Figure 56: SER Graph

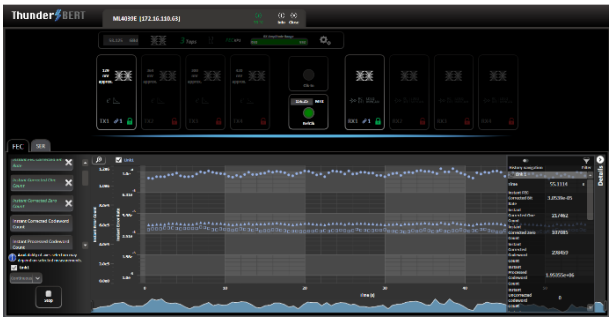


Figure 57: Instant FEC Measurements Graph

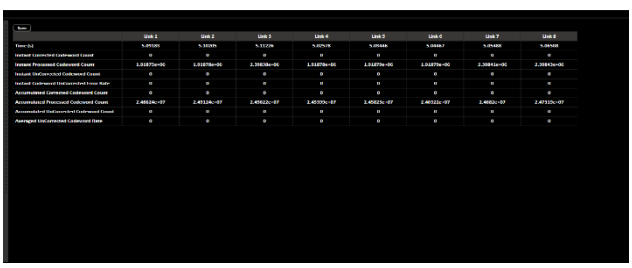


Figure 58: FEC Table

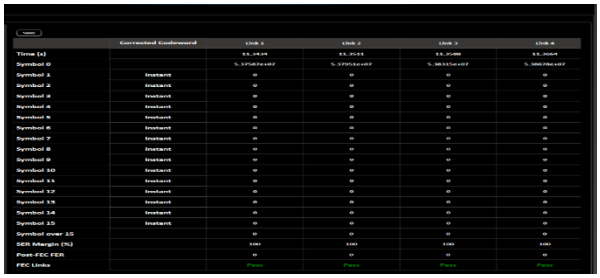


Figure 59: SER Table

There are three measurement blocks for SER:

1. Instant Codeword Symbol: the symbol error rate distribution for the link under test in a specific 100 ms window. Refreshes 10 times per second.
2. Accumulated Codeword Symbol: the sum of total symbol error rate distribution for the link under test, accumulating from t =0.
3. Accumulated Percentage Distribution: the percentage distribution of total symbol error rate for the link under test, accumulating from t=0.
4. The measurements will display:
    a. Symbols ranging from 0 to 7 or from 0 to 15 (depending on the mode).
    b. Symbols greater than 7 or 15 (depending on the mode).
    c. The SER margin (metric indicating available margin before codewords become uncorrectable).
    d. The post-FEC FER (Frame Error Rate).
    e. The FEC link.

In the following tables, the supported Real Hardware FEC graph combinations are shown.

X axis	Y axis
Time	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Processed Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Ones Count
	Accumulated Corrected Zeros Count
	Accumulated Corrected Codeword Count
	Accumulated Processed Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated Corrected Bit Count
	Accumulated FEC Symbol Error Count
	Accumulated FEC Corrected Bit Rate
	Averaged Uncorrected Codeword Rate
	Averaged FEC Symbol Error Rate

X axis	Y axis
Accumulated Processed Codeword Count	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Processed Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Ones Count
	Accumulated Corrected Zeros Count
	Accumulated Corrected Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated Corrected Bit Count
	Accumulated FEC Symbol Error Count
	Averaged FEC Corrected Bit Rate
	Average Uncorrected Codeword Rate
	Averaged FEC Symbol Error Rate

X axis	Y axis
Accumulated Corrected Zeros Count	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Ones Count
	Accumulated Corrected Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated Corrected Bit Count
	Accumulated FEC Symbol Error Count

X axis	Y axis
Accumulated Corrected Ones Count	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Zeros Count
	Accumulated Corrected Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated Corrected Bit Count
	Accumulated FEC Symbol Error Count

X axis	Y axis
Accumulated Corrected Codeword Count	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Ones Count
	Accumulated Corrected Zeros Count
	Accumulated Corrected Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated Corrected Bit Count
	Accumulated FEC Symbol Error Count

X axis	Y axis
Accumulated Uncorrected Codeword Count	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Ones Count
	Accumulated Corrected Zeros Count
	Accumulated Corrected Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated Corrected Bit Count
	Accumulated FEC Symbol Error Count

X axis	Y axis
Accumulated FEC Symbol Error Count	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Processed Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Ones Count
	Accumulated Corrected Zeros Count
	Accumulated Corrected Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated Corrected Bit Count

X axis	Y axis
Accumulated Corrected Bit Count	Instant FEC corrected Bit Rate
	Instant Corrected One Count
	Instant Corrected Zero Count
	Instant Corrected Codeword Count
	Instant Processed Codeword Count
	Instant Uncorrected Codeword Count
	Instant Uncorrected Codeword Error Rate
	Instant Corrected Bit Count
	Instant Frame Error Rate
	Instant FEC Symbol Error Count
	Instant FEC Symbol Error Rate
	Accumulated Corrected Ones Count
	Accumulated Corrected Zeros Count
	Accumulated Corrected Codeword Count
	Accumulated Uncorrected Codeword Count
	Accumulated FEC Symbol Error Count

Table 6: Display of Additional FEC Combinations

In KP1 mode, the user has the capability to conduct FEC measurements on each channel sequentially. This feature allows the user to select between two sets of transmitters and receivers for FEC measurements: Tx1 - Tx4 and Rx1 - Rx4 and Tx5 - Tx8 and Rx5 - Rx8

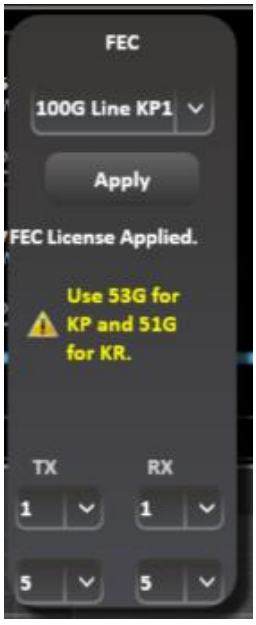


Figure 60: KP1 FEC

Appendix 1- Using ML Instrument Manager to enable DHCP

MultiLane created a new platform “ML Instrument Manager”, to help the user to change the Instrument’s IP address and to enable the use of DHCP.

To access all the ML4079ENs available, the user has 2 options, to connect the instrument to his PC via USB or Via Ethernet

A) ML Instrument Manager Installation:
   After downloading the GUI:
   1) An installation wizard will appear:
   2) Choose the destination folder to install the GUI
   3) Select all the additional shortcuts: “Create a Desktop Shortcut” and “Install ML Instruments Driver”
   4) Click on Install

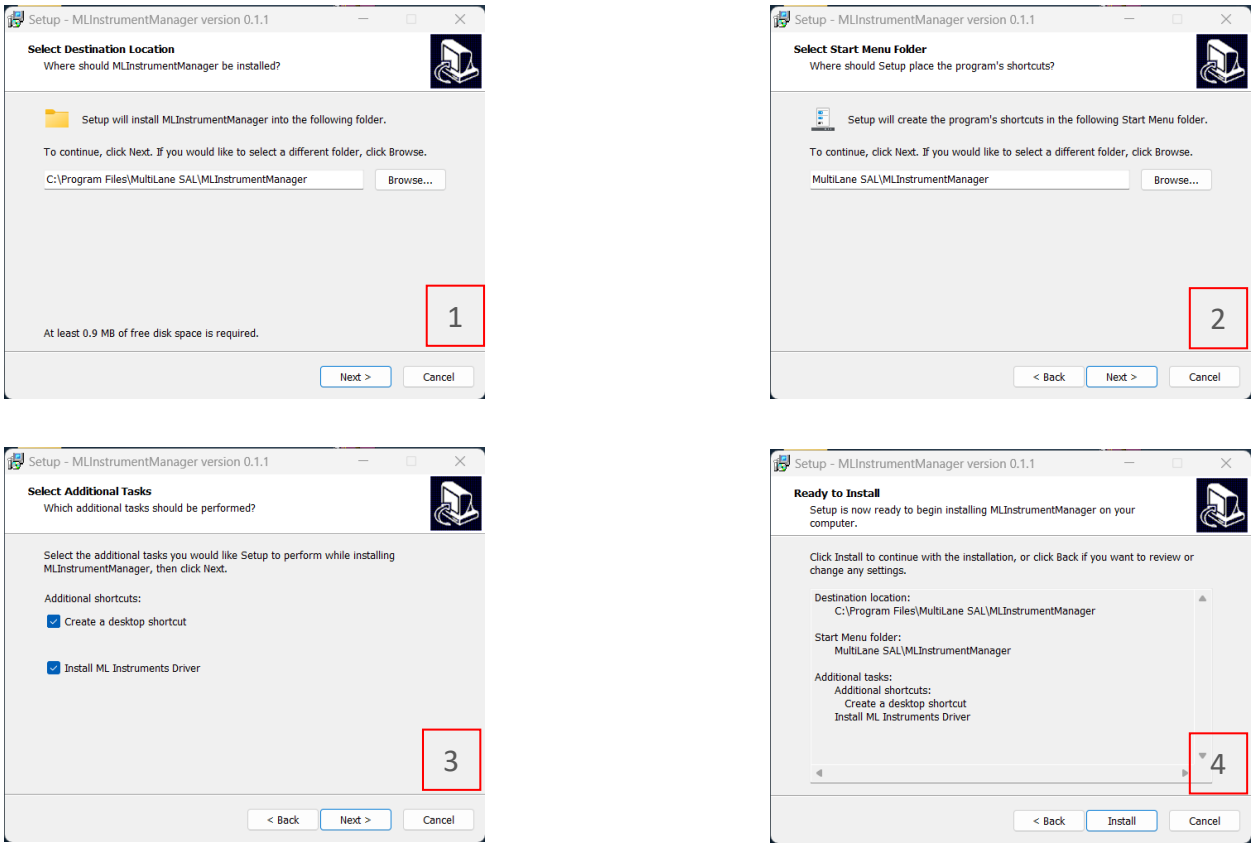


Figure 61: ML Instrument Manager Installation Wizard

After completing these steps, a device driver installation wizard will appear:

1) Click on Next
2) After verifying that the drivers were successfully installed, click on Finish
3) Click on the “Launch MLInstrumentManager” checkbox and press on Finish

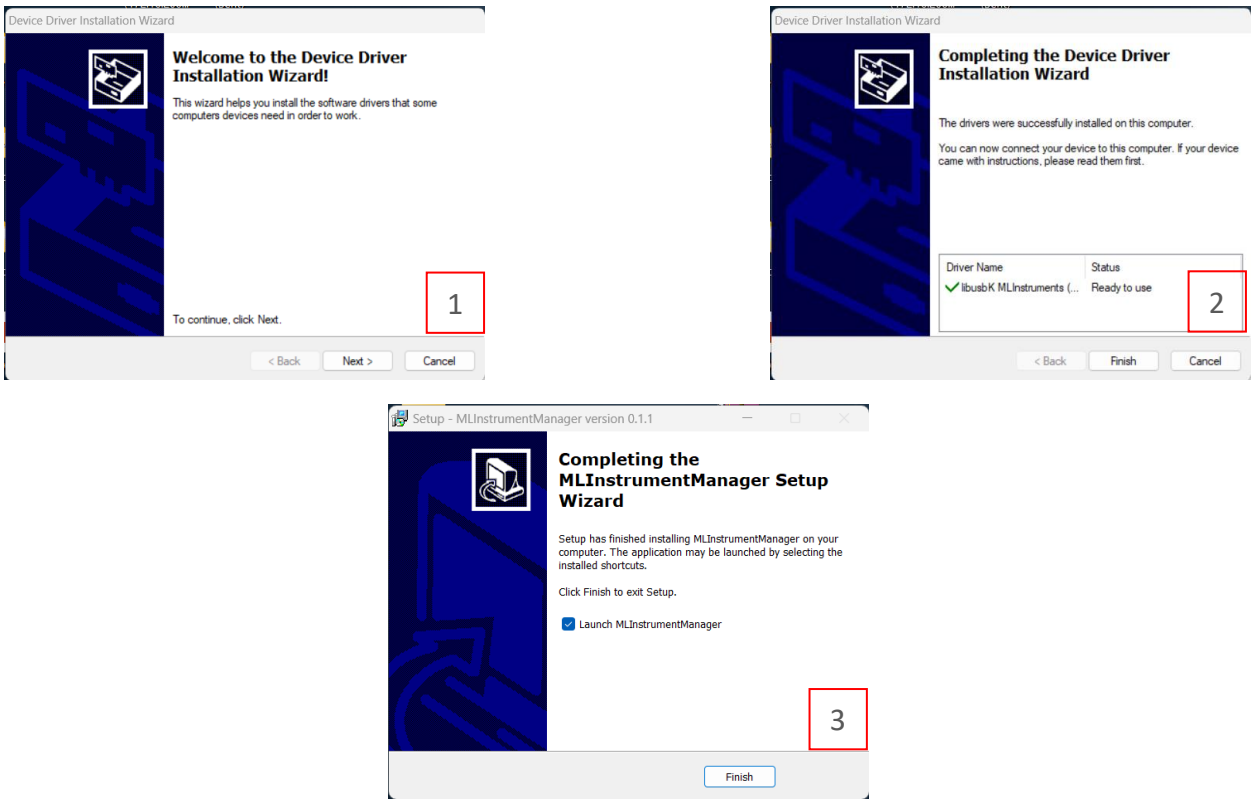
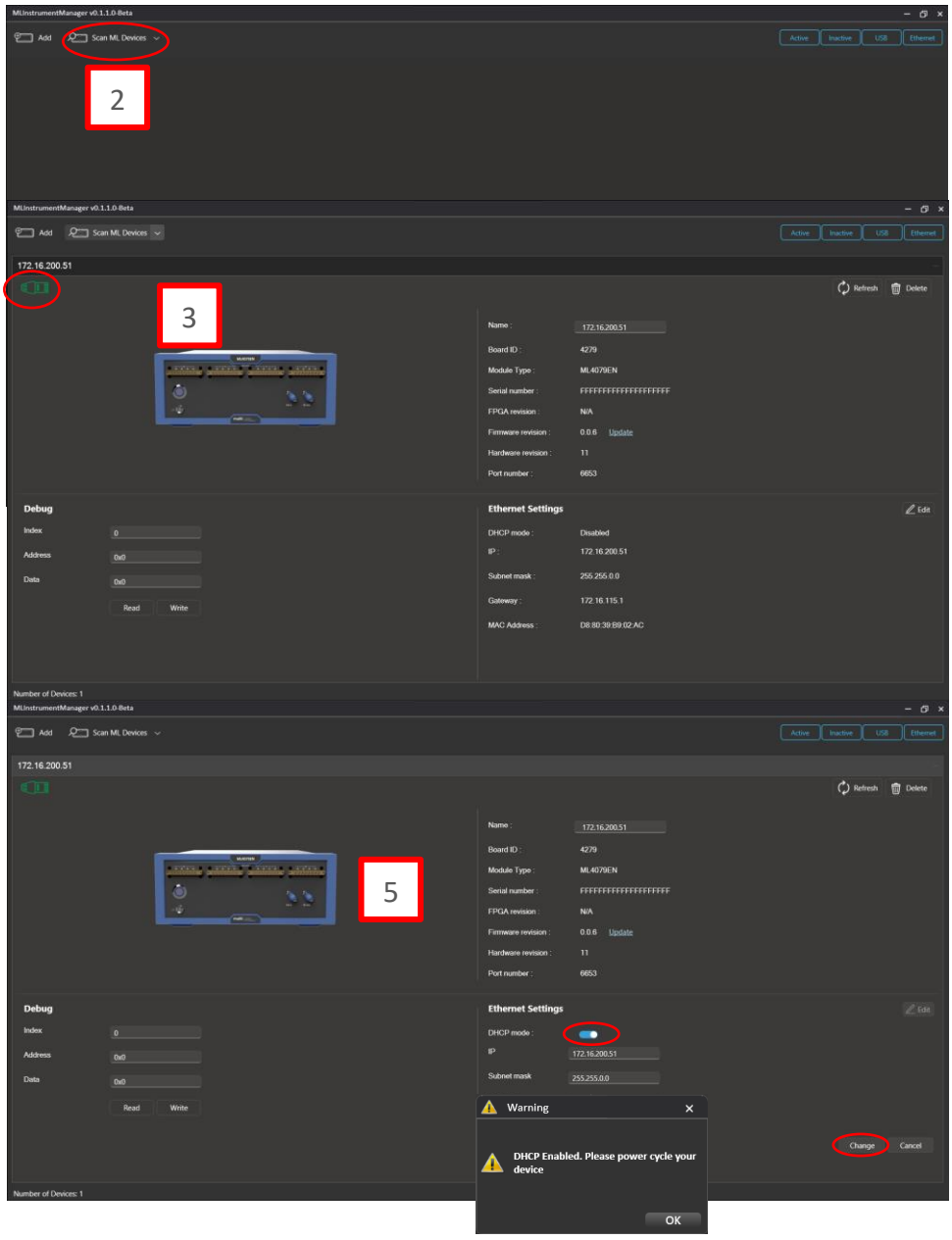
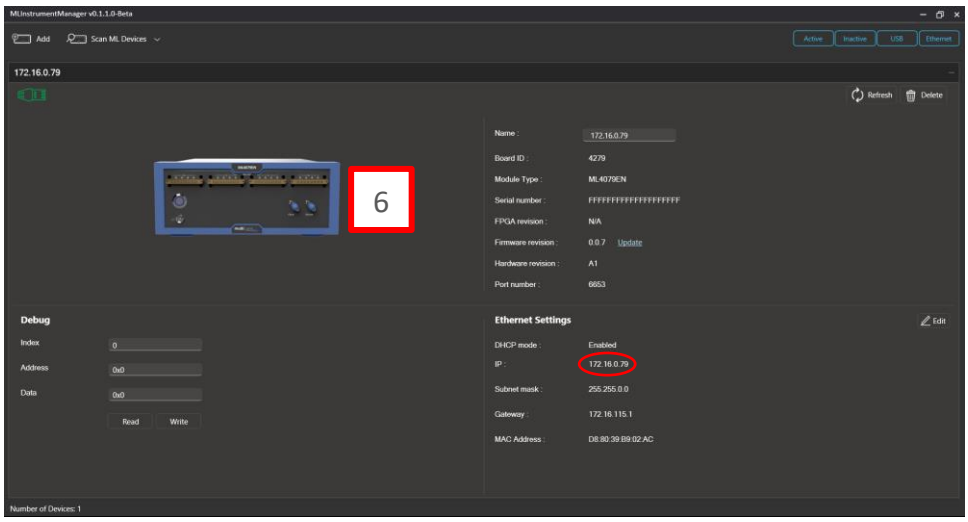


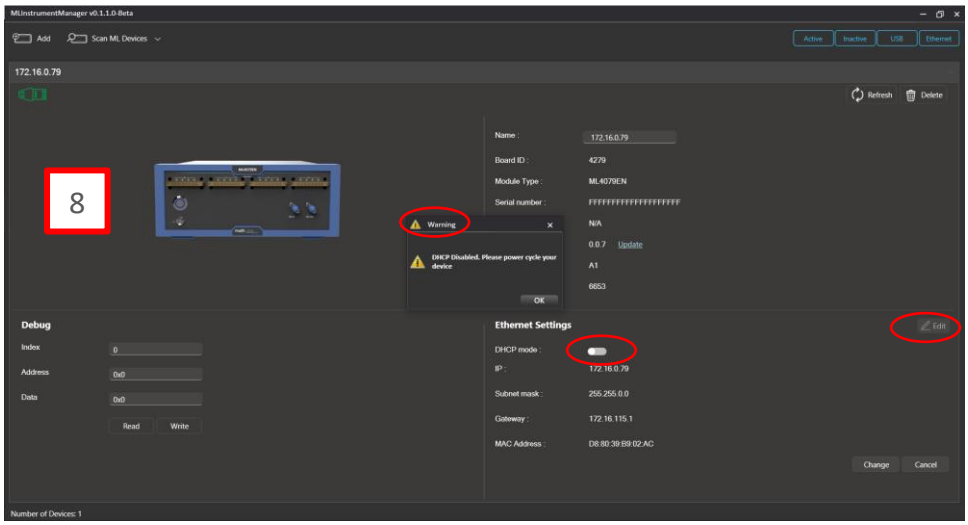
Figure 62: ML Instrument Manager Device Driver Installation Wizard

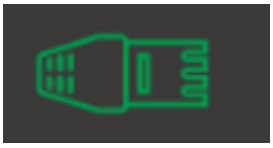
B) ML InstrumentManager Usage : Ethernet Connection

1) Make sure the PC is connected via Ethernet/USB
2) Click on Scan ML Devices at the TOP of the GUI
3) The instrument you are using will be shown with all its information, in addition to the Ethernet or USB Icon depending in the used mode:
4) To change the IP, Check the Ethernet Settings and click on Edit
5) To enable DHCP, turn the DHCP Mode Tuggle On, then click on Change and power cycle your instrument
6) A new IP address will be shown
7) Open the ThunderBERT GUI and connect to you instrument Via the new IP
8) To disable DHCP, Click on Edit next to Ethernet Settings, turn the DHCP Mode Tuggle off, click on change and power cycle your device.
9) Connect to the ThunderBERT GUI using the default IP

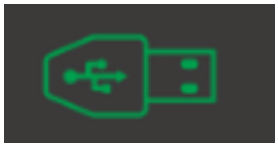








Ethernet Icon

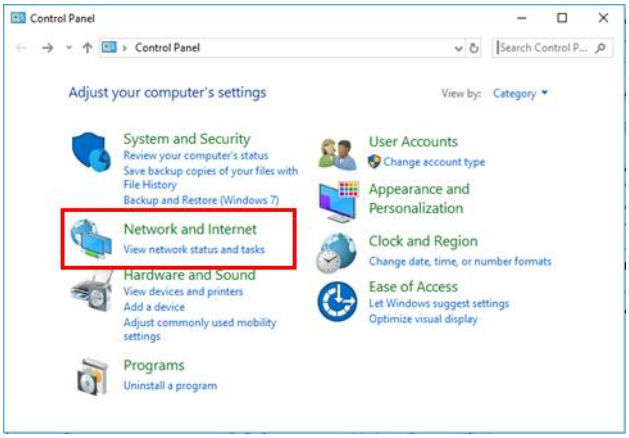


USB Icon

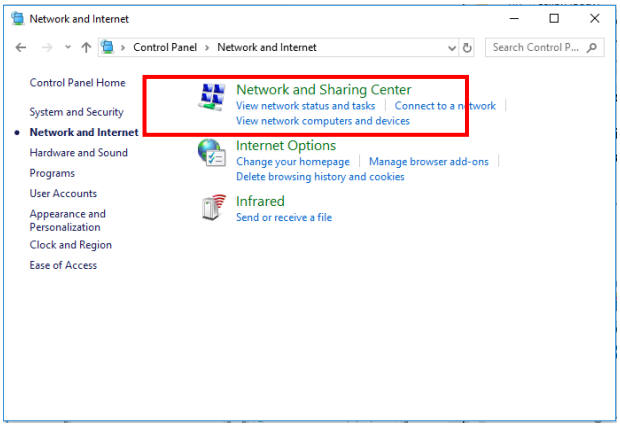
Appendix 2 – Adding a BERT to the Network

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

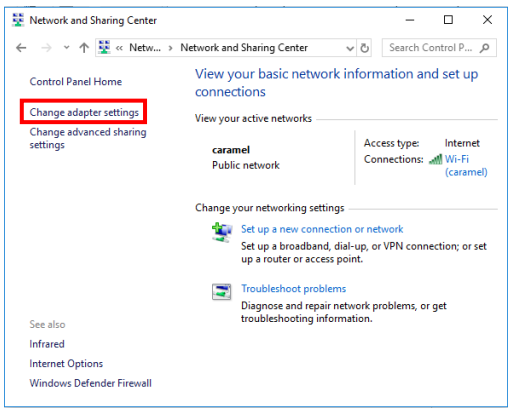
- **Create a local network connection** between the laptop and the BERT using Internet Protocol Version 4 (TCP/IPv4).
  - **Open** Control Panel and **choose** Network and Internet.
  - **Open** Network and Sharing Center.

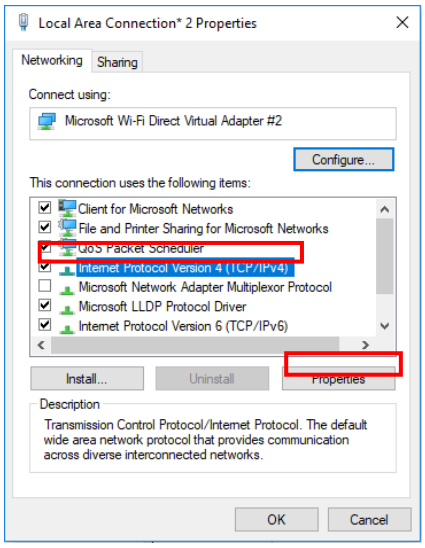


- **Click on** Change Adapter Settings, then **choose** Local Area Connection.

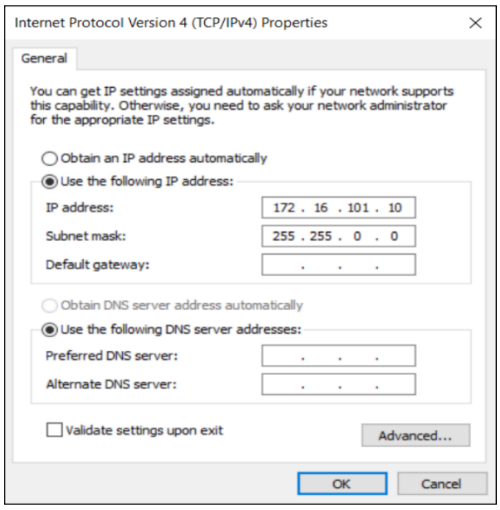


- In the Networking Tab, **click on** Internet Protocol Version 4 (TCP/IPv4) then Properties.





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



NOTES: These steps are illustrated using Windows 10. Note that previous versions of Windows have a similar procedure with slight differences in tabs or folder names.

Appendix 3 – Changing the IP Address to Suit a Corporate Network

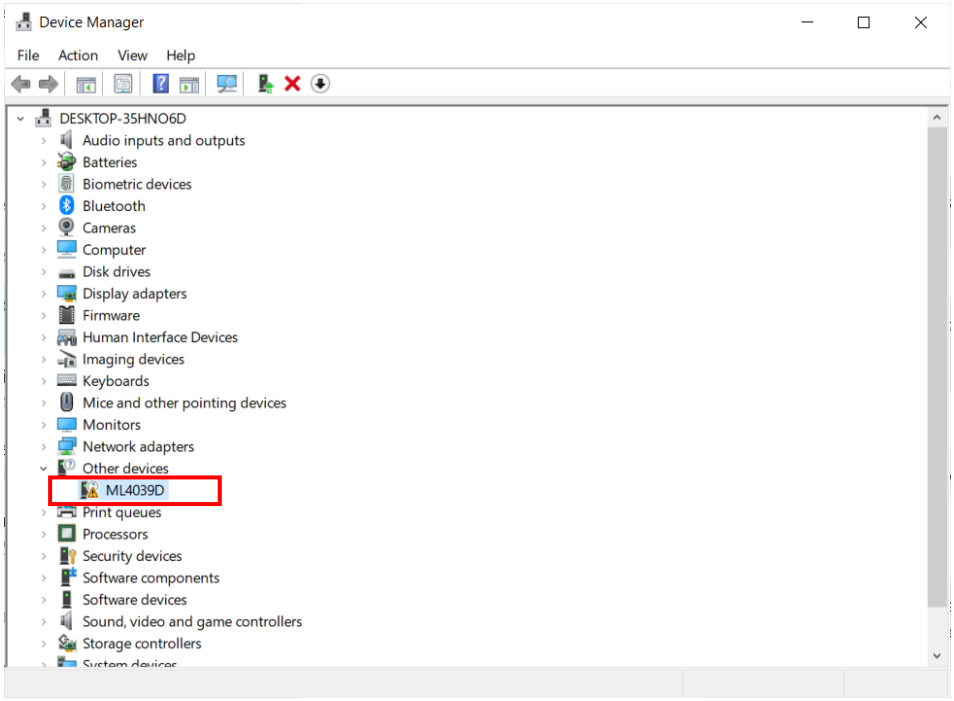
MultiLane does not recommend changing the IP address of the BERT instrument. However, this appendix will detail the steps for each operation.

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

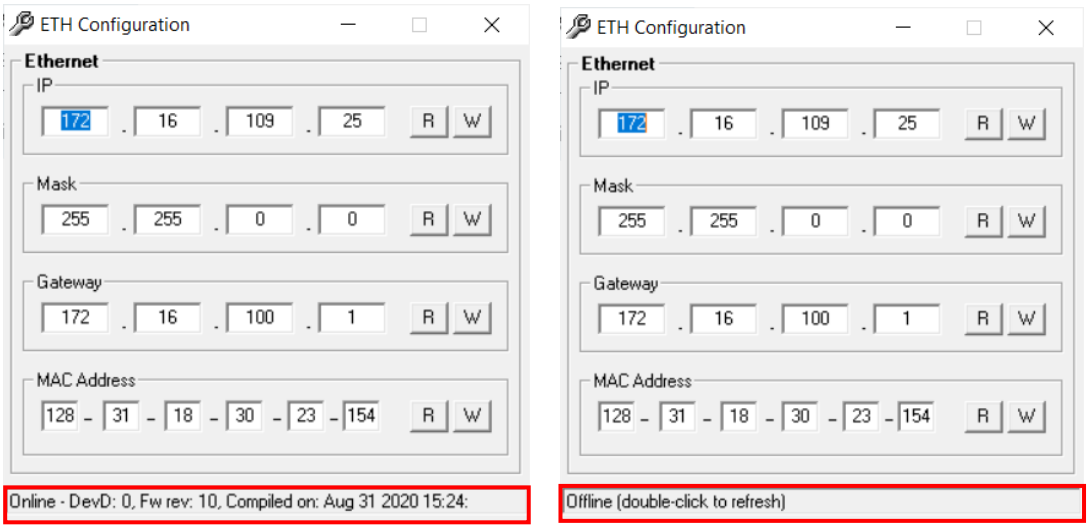
The process can be completed using two different methods: USB Driver Ethernet Configuration or using the *MLIPChanger* tool with Ethernet cable connection.

Changing the IP Address of the Instrument Using USB Driver Ethernet Configuration

- **Download** the USB driver and the Ethernet tool of the instrument from https://www.multilaneinc.com/products/ml4079en/
- **Connect** the instrument to the PC using USB cable.
- **Navigate** to device manager. The device will appear as shown in the following figure.



- **Right click** on the device and **select** update driver.
- **Select** "Browse my computer for driver software" and **select** the previously downloaded USB driver file.
- **Open** the Ethernet software downloaded previously (view the following figures).
- **Change** the IP, Mask or Gateway by writing the desired address and **click** on **W** (to write them).
- **Power cycle the device.**
- **Click** on **R**, to read the values and make sure they have changed.

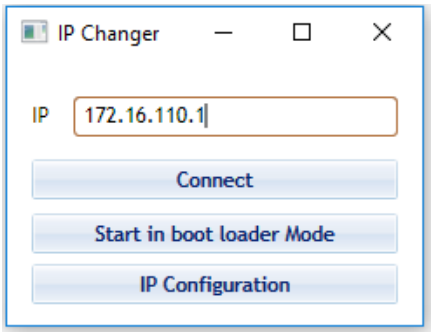


Ethernet Configuration Windows, when the Device is Connected and Powered On (Online, Left Figure) and Disconnected (Offline, Right Figure).

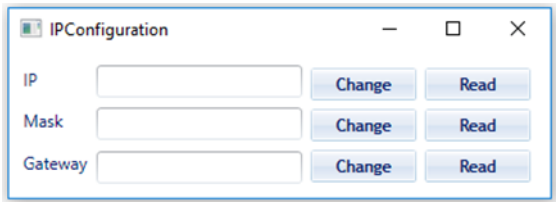
Changing the IP Address Using ML IPChanger

Before changing the IP address using the ML IPChanger tool, make sure there is a local network between the unit and the PC using one single Ethernet cable with RJ45 connector at each end.

Make sure that the **unit is powered on** and **has established a ping between the current factory IP and your PC** by creating a **Local Network Connection**.



- **Open** MLIPChanger tool.
- **Enter the IP Address** in the highlighted field and click on **Connect**
- Once connected, **click on IP Configuration.**
- **Click on read** to display the current IP Address of the BERT.
- **Enter the desired IP Address and click on Change.**
- **Reboot** the device.
- If the ping is successful, you can now connect to the instruments using the latest IP Address.
- If the ping is not successful, check the local network settings and make sure that they are in line with the instrument's latest IP address you entered.



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