

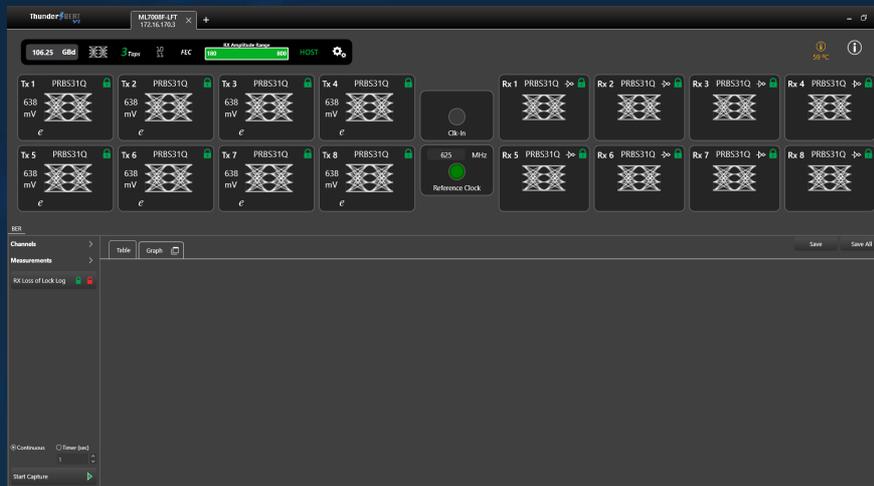


Thunder  **BERT**
V2

User Guide | ML BERT Series

Installation | Connection | Calibration | Measurements

Rev 1.0.1



ML7008F-LFT

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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.

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Do Not Operate with Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

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Revision Control

Revision Number	Description	Release Date
1.0.0	Initial Release	12/12/2025
1.0.1	Second Release	12/02/2026

List of Acronyms

Acronym	Definition
BW	Bandwidth
BER	Bit Error Rate
BERT	Bit Error Rate Tester
CER	Codeword Error Rate
Conf	Configuration
DTx	High Drive Tx Amplitude
DUT	Device Under Test
ER	Extended Reach
FEC	Forward Error Correction
FW	Firmware
GBd	Gigabaud
Gbps	Gigabits per Second
GUI	Graphical User Interface
HSIO	High-Speed Serial Input/Output
HW	Hardware
ISI	Inter-symbol Interference
NRZ	Non-Return to Zero
PAM4	Pulse Amplitude Modulation (4-level)
SER	Symbol Error Rate
SI	Signal Integrity
SNR	Signal-to-Noise Ratio
Sim	Simulation
SW	Software

Introduction

AI clusters drive the development of a rapidly innovating, high-sensitivity, and power-hungry networking landscape. High-speed testing must, therefore, enable and accelerate development cycles with accurate, real-world emulating solutions that account for the stringent requirements of the AI era.

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. Bit Error Rate Testers (BERT) are a core competency at MultiLane and a vital tool industry-wide to measure the actual Bit Error Rate (BER) of device channels – a key metric in determining performance. Our new line-up of ThunderBERT2 enabled BERTs covers virtually any desired line rate up to 1.6T, with an extensive array of diagnostic and tuning capabilities.

This upgraded implementation of our BERT user guide provides a fully revised and unified manual for the flagship ML7008F-LFT BERT, which supports over 40 dB of Rx equalization, real-hardware FEC, and a 16 Tx option (8 Tx and 8 DTx) and 8 Rx for high and low voltage applications.

GUI Introduction

To install and start using the ThunderBERT2 interface for the first time, follow this step-by-step installation guide (with pictures) below:

1. **Run** the ThunderBERT2 setup file.
2. **Install** ThunderBERT2.
3. **Connect** the ML BERT to the local network.
4. **Launch** the GUI.
5. **Start** the measurements.

Installation

After downloading the ThunderBERT2 setup file, select run and follow this easy step-by-step installation procedure:

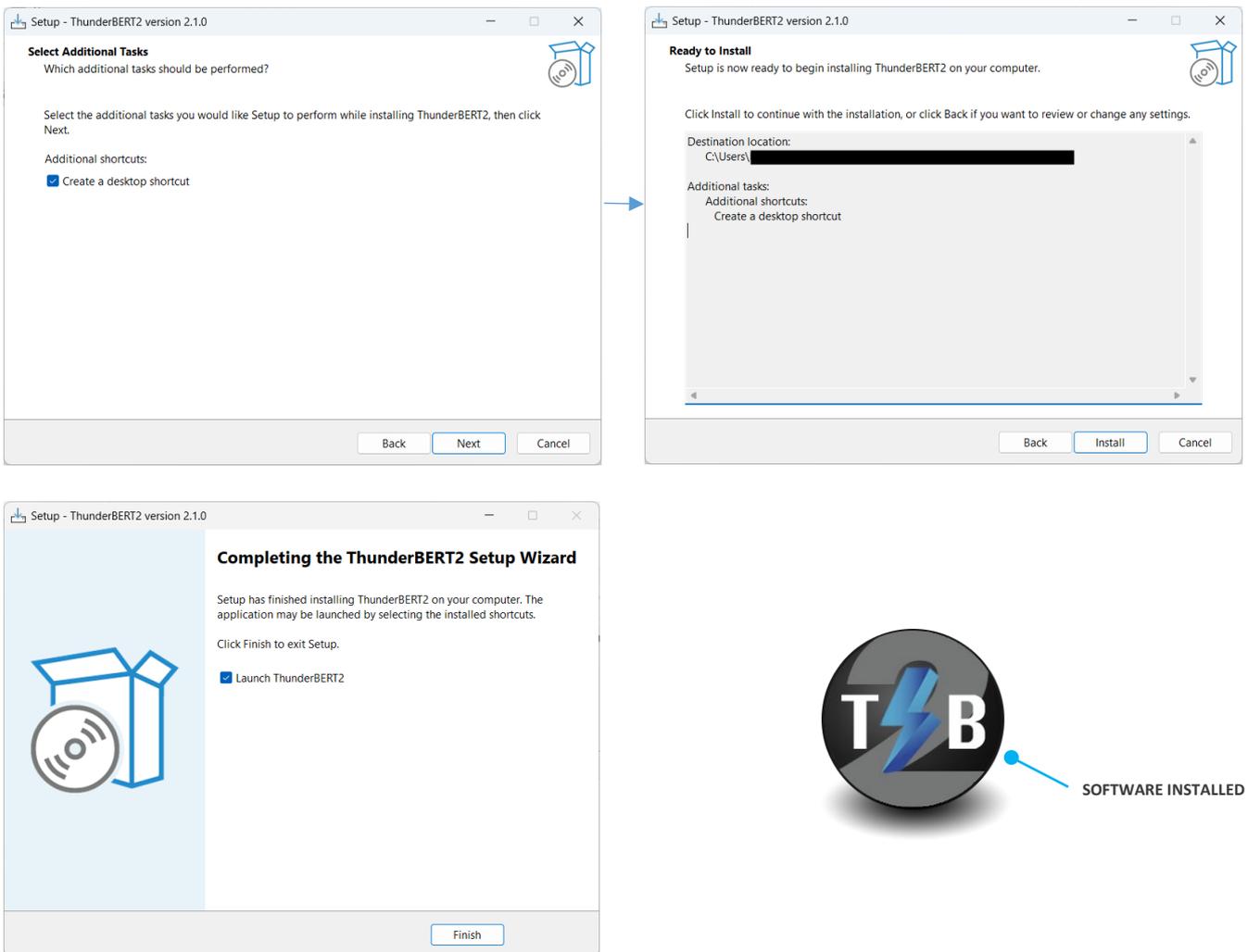


Figure 1: Setup Installation Procedure

ThunderBERT2 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 ThunderBERT2 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** ThunderBERT2 software.
- **Connect** using the IP address of the target instrument (Figure 2). The IP address is printed on the back side of the BERT.

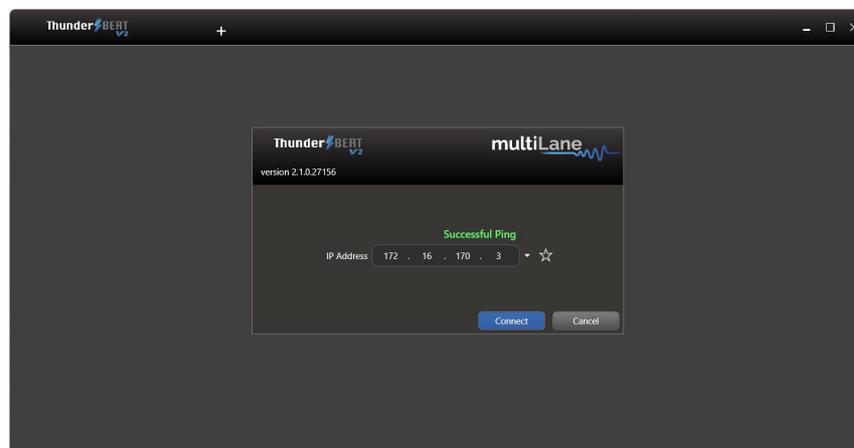


Figure 2: Connection Box

NOTES

- The previously connected IP addresses will appear in the drop-down list next to the type box.
- The connection status will be displayed above the type box; “Unsuccessful Ping” in red while no connection is established and “Successful Ping” in green when instrument is ready to connect (Figure 2).
- IP addresses can be added to Favorites by clicking on the star next to the arrow. These IP addresses will appear in the drop-down list next to the type box in the Favorites section (Figure 3).

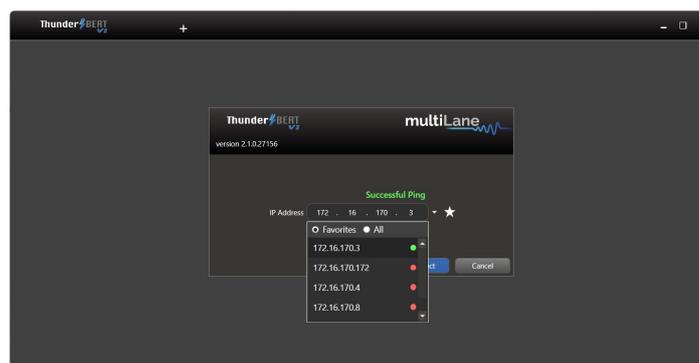


Figure 3: IP addresses Favorites List

*To add the device to the network, consult [Appendix I](#) 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 ThunderBERT2 GUI will appear and you can commence testing.

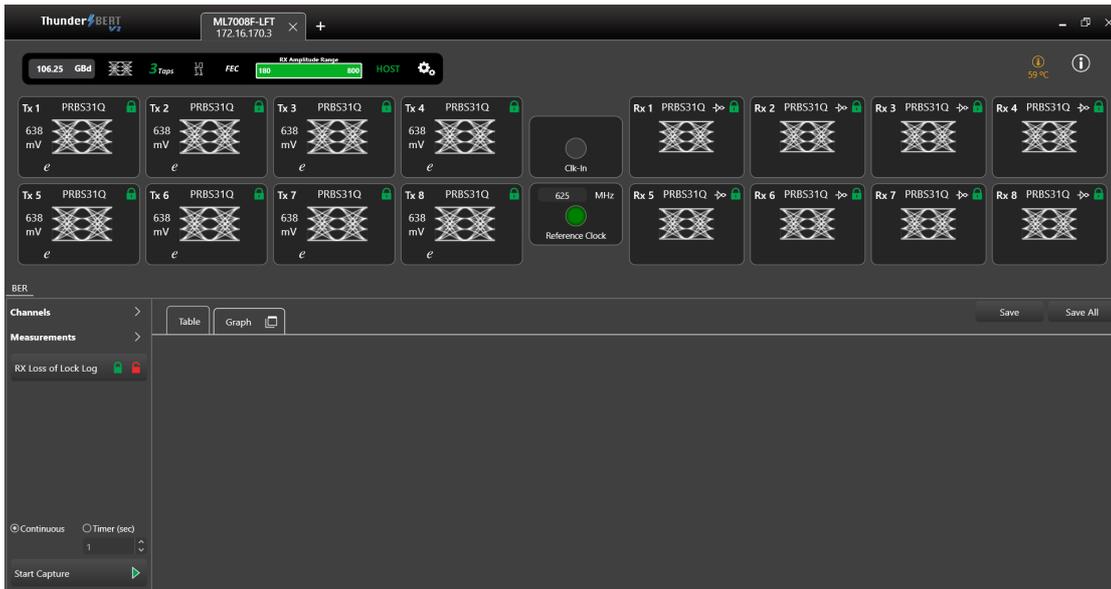
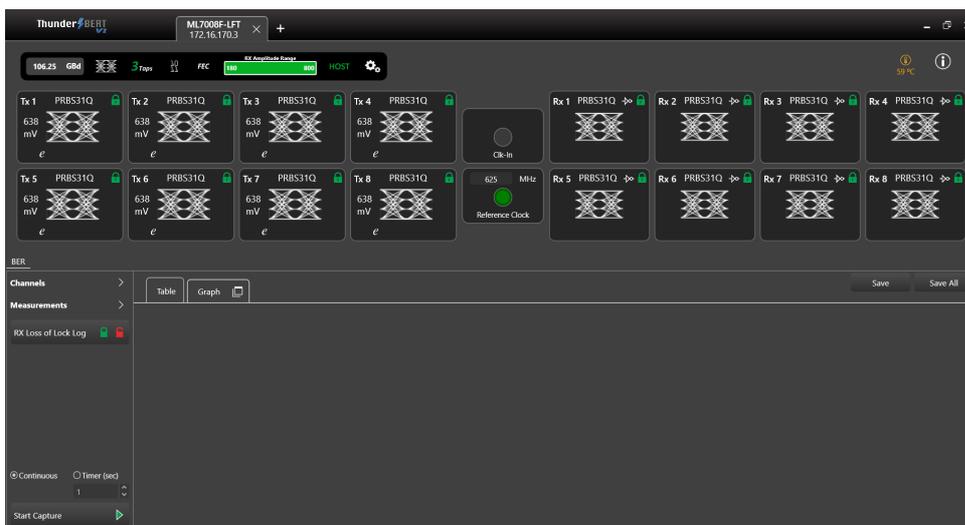


Figure 4: General GUI Display (ML7008F- LFT)

GUI Overview

ThunderBERT2 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.



**Upper Section:
BERT Configs**

**Lower Section:
Display
Measurements**

Figure 5: Segmented GUI Display (ML7008 F- LFT)

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.

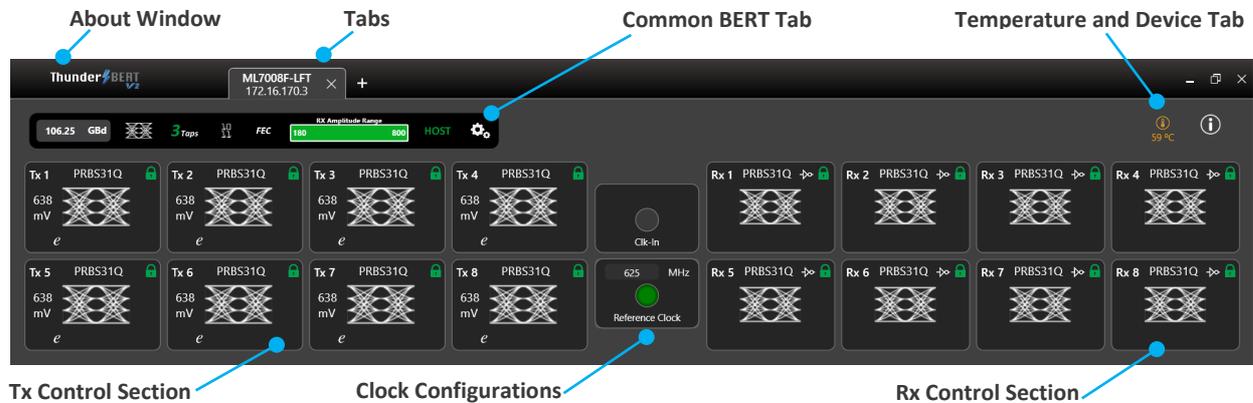


Figure 6: BERT Control Tab

- **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
- **Tabs** contain:
 - Title Tab with the Instrument IP address and a close GUI button
 - A plus sign next to the Title Tab to add a new Instrument having a different IP address
- **Common BERT Settings Tab** contains:
 - Baud rate configuration
 - Signal modulation selection (NRZ/PAM4)
 - FFE tap selection (3- or 6-tap modes)
 - Gray coding and FEC enable
 - RX Amplitude/Sensitivity Range
 - Operation Mode
 - Load and Save configuration options
- **Temperature and Device Tab** contains:
 - Temperature display
 - Info about the device
- **TX Control Section Tab** contains:
 - Pattern and Amplitude control
 - Error insertion in optimal or advanced mode
 - Pre-Coder enable box
- **Clock Configuration Tabs** contain reference clock-out.
- **RX Control Section Tab** contains:
 - RX invert, RX pattern selection
 - Pre-Coder and Extended Reach enable box

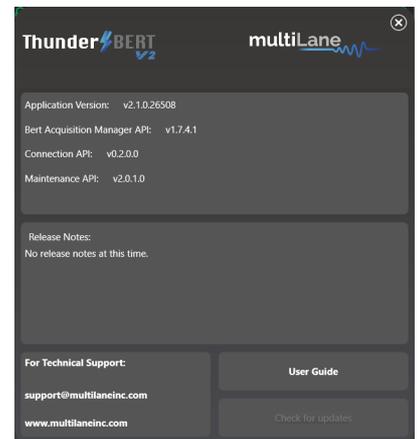


Figure 7: About Window

GUI Navigation

Instrument Control

Tabs

- Displays instrument IP address. (Figure 8).
- Close button: disconnect from the BERT and close GUI instance (Figure 9).
- Add device button: connect to a new device with a different IP address (Figure 10).



Figure 8: Title Tab

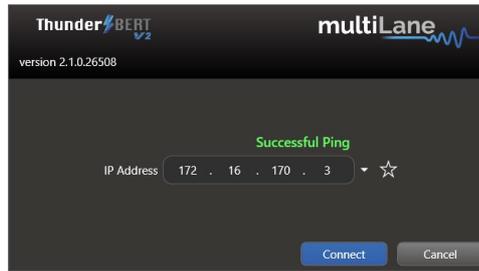


Figure 9: Disconnect Window



Figure 10: Connect to Another Device

BERT Settings Tab

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

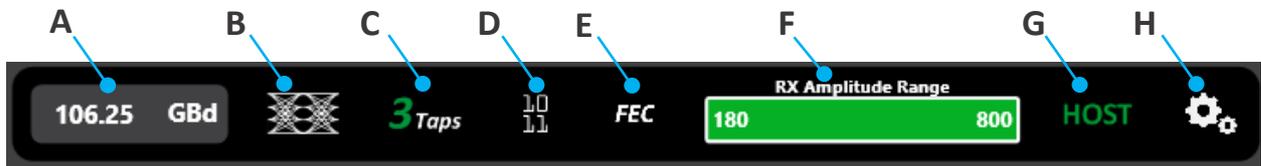


Figure 11: BERT Settings Tab

A: Baud rate Selection – **B:** Modulation Selection – **C:** FFE Tap Selection – **D:** Gray Coding – **E:** FEC – **F:** Rx Amplitude Range – **G:** Operation Mode – **H:** Additional Options

The common **BERT Settings Tab** reflects enabled features; whenever a feature is enabled (gray coding, 3/6-tap and FEC) the corresponding button turns green as shown in Figure 12.



Figure 12: Display of Enabled Features

NOTE

Pre-Coder should be either enabled or disabled on both Tx and Rx channels in order to have Rx Lock.

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

- **Specify the Baud rate.**
- **Specify the signal modulation type:** NRZ/PAM4 (if available/supported).
- **Select the 3 or 6 taps FIR filter mode.**
- **Enable/Disable the Gray Coding option.**
- **Enable/Disable the FEC feature (not available on DTx).**
- **Check the Rx amplitude range** supported by the error detector.
- **Operation Mode:** Tx/DTx.
- **Load/Save** the configurations through the gearbox button.

- A
- B
- C
- D
- E
- F
- G
- H

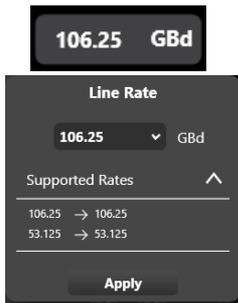


Figure 13: Set Baud Rate

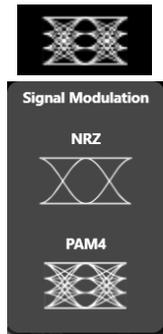


Figure 14: Signal Modulation Selection

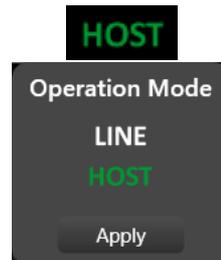


Figure 15: Operation Mode

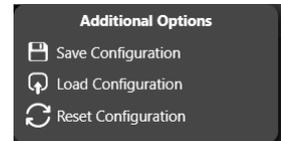


Figure 16: Additional Options

NOTES

- The 'Apply' button should be pressed after any rate change (Figure 13).
- The 'Plus' button next to the Title Window allows you to open a new tab, connect to another device with a different IP address and run tests on both devices simultaneously.
- Operation Mode allows you to switch between Tx and DTx (Figure 15).
- Additional Options let you save, load, or reset test configurations including bit rate, pattern, signal modulation, number of taps and their values, inversion, etc., for all channels (Figure 16).

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 17).

- **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 18).
- **Specify the TX signal pattern.** The supported TX patterns are all available in the dropdown list, depending on the BERT model in use.
- **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.

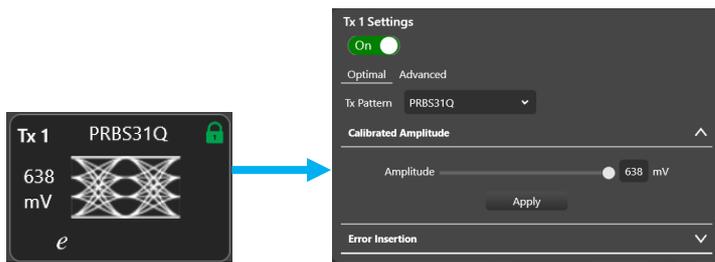


Figure 17: TX Control Tab and Applied Settings in Optimal Mode

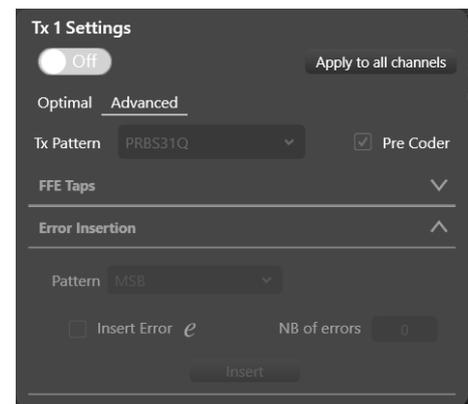


Figure 18: TX OFF - Channel Control Locked

NOTE

Calibration is supported on low and high rates and on both eye modes (NRZ and PAM4).

- **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).
- **Select pattern to MSB or LSB.**
- **Specify the number of errors.**
- **Click** on the Insert button to apply changes.



Figure 19: Error Insertion Tab

TX Control in Advanced Mode

While operating in Advanced Mode, 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:
 - 3 FFE taps (in 3-tap mode) and FIR filter 6 taps (in 6-tap mode). Supported tap values range between -168 and 168.

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.**
- **Enable Pre-Coder** (optional).
- **Customize the FFE taps.**
- **Apply the changes** by clicking on the “Apply” button.

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

- **Error Insertion.** You can insert errors on-demand.

When inserting errors:

- **Enable Error Insertion mode.** 
- **Select the pattern.** Either on MSB or LSB.
- **Set the Number of errors:** The sequence of words to skip without error insertion.
- **Click on insert.**

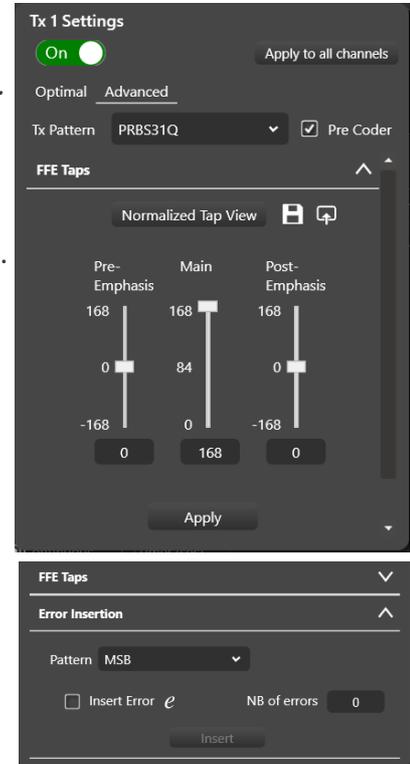


Figure 20: TX Advanced Mode Control

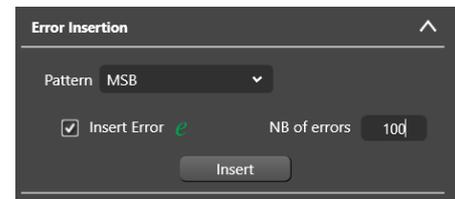


Figure 21: Error Insertion Tab

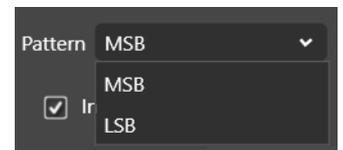


Figure 22: Error Patterns

NOTE

Optimal configurations and calibration are only available in 3-tap mode.

DTX Control

TX Control in Advanced Mode

While operating in Advanced Mode, 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:
 - 3 FFE taps (in 3-tap mode) and 6 taps (in 6-tap mode). Supported tap values range between -60 and 60, and between -168 and 168 if you enable high voltage feature.

To start optimizing the TX setting, follow these steps:

- **Enable the TX settings control** of the channel.
- **Select a TX pattern.**
- **Enable High Voltage** (if needed).
- **Customize the FFE taps.**
- **Apply the changes** by clicking on the “Apply” button.

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

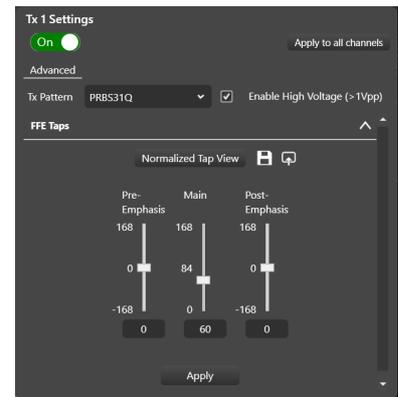


Figure 23: DTX Advanced Mode Control

NOTE

The ML7008F-LFT is characterized by its high amplitude on DTx: the amplitude can go up to 2.4Vpp. Should the amplitude exceed the 1V threshold, a warning message will be displayed, advising you to enable the High Voltage feature (Figure 24). 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.

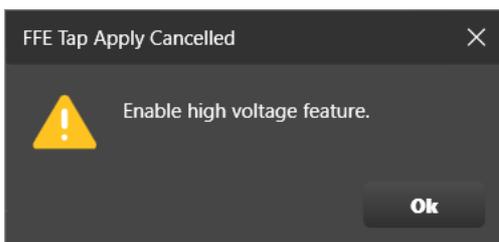


Figure 24: Error Message: Need to Enable High Voltage Feature

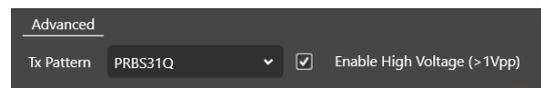


Figure 25: Enable High Voltage Feature Check Box



Figure 26: Apply to All

Apply to all channels option

This option is used for the TX and RX settings. 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.

NOTE

Pre-coder should be turned off during eye measurements.

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. You will be able to select/configure the following settings:

- **RX Pattern** (supported RX patterns depend on the BERT in use).
- **RX Invert:** Inverts the RX polarity. The button becomes green indicating that RX polarity is inverted.
- **Monitor Flags:**
 - **RX Pattern Lock:** The button is usually red but turns green when the pattern is locked and identified successfully.
 - **CDR Lock:** The button is usually red but turns green when the receiver has successfully recovered a clock from the incoming signal.
 - **Loss of Signal (LOS):** The button is usually red when signal is detected and turns green when the signal is lost.
- **Pre-Coder and Extended Reach enable**
 - **Extended Reach** means operating a communication link over a longer distance than the standard reach, while keeping the BER within an acceptable limit. Extended Reach is usually enabled for links with total insertion loss higher than 30dB.
 - **Pre-Coder** minimizes the BER in communication systems by shaping signals at the transmitter to counteract channel distortion, noise and interference.

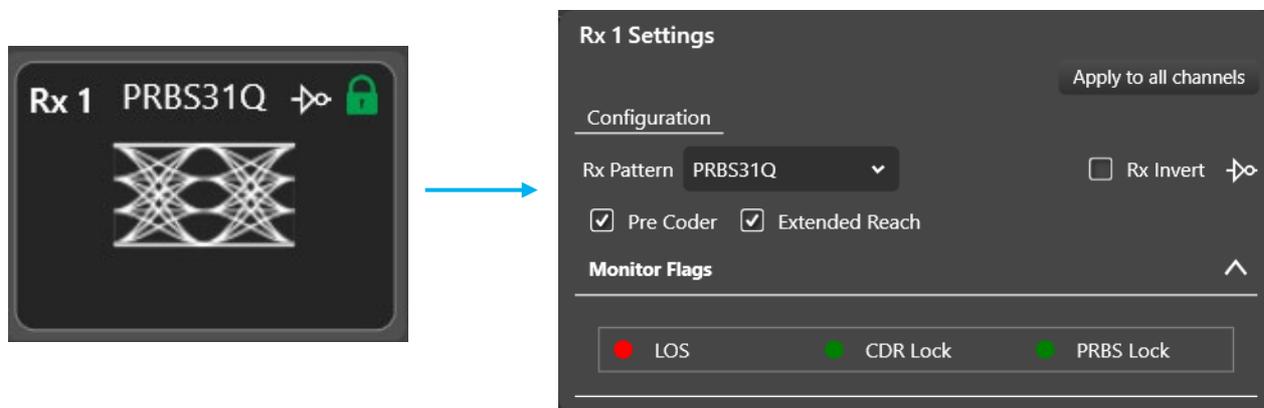


Figure 27: Rx Control and Applied Settings

Clock Configuration

- **Reference Clock**



Figure 28: Reference Clock

Supported Measurements

Measurement Controls

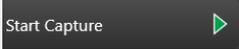
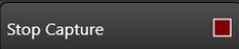
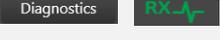
Control	Definition
	Start BER, FEC, and SER Measurements
	Stop BER, FEC, and SER Measurements
	Save BER, FEC, and SER Measurements
	Save All BER, FEC, and SER Measurements
	Save and Load FFE taps, Save and Load BERT Settings
	Set FFE Taps
	Insert Errors
	Apply Unified Settings on all Channels (Supported on Both Tx and Rx Sides)
	Apply Bit Rate, Clock Rates, FEC, and 3- and 6-Tap Mode
	Graph Reset Zoom
	Tx ON/OFF, Rx ON/OFF
	BER/ FEC Measurement Timer
	Additional Options
	Temperature Display
	Device Info
	Add a New Tab
	Open Graph in Window
	Rx Diagnostics: SNR Control

Table 1: Measurement Controls and Icons

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. You have the choice to measure/visualize different options such as:

- *Single and Multichannel BER.*
- *Total and Instant BER.*
- *Continuous BER Test.*
- *Time-defined BER Test.*

Supported measurements are grouped in the following table:

Instant Measurements	Accumulated Measurements
Instant BER	Total Real Time BER
Instant Error Count	Total Error Count
Bit Count MSB/LSB	Total Bit Count

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.

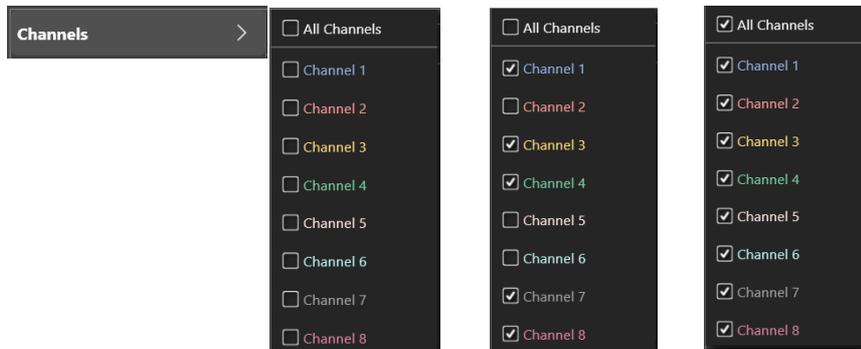


Figure 29: Channels Selection

Instant and accumulated measurements can be displayed simultaneously in the table and on the graph.

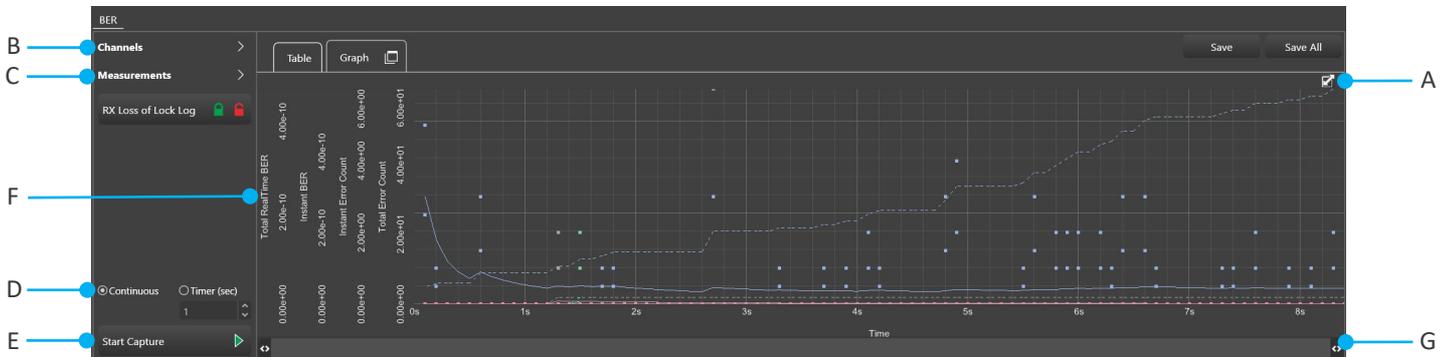


Figure 30: Graph Measurements

A: Graph Reset Zoom – **B:** Channel Selection – **C:** Graph Display Measurements Selection (axes) – **D:** Timer/Continuous Mode – **E:** Stop/Start BER – **F:** Measurements – **G:** Slider

! X-axis Selection: To enable measurements, select a value for both the X and Y axis. Only one option for the X axis selection is supported, 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 PAM4 BER graph combinations is shown below depending on the measurement type:

- PAM 4 Measurements

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

Table 3: PAM4 BER Graph Combinations

- NRZ Measurements

	X axis	Y axis
Time		Total Real Time BER
		Instant BER
		Instant Error Count
		Total 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/save all button.

BER graphs and table measurements are displayed below.

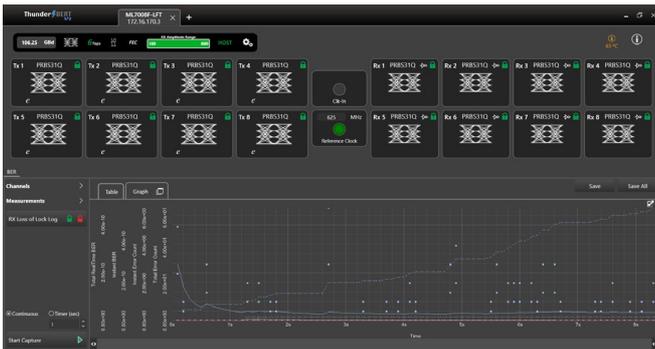


Figure 31: Graph Measurements Display

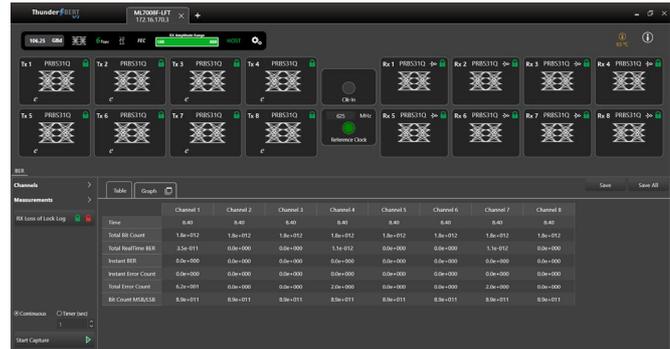


Figure 32: Table Measurements Display

You can switch between graph view and window view, without interrupting the test. In window view, the table measurements are selected alongside the graph. You can close the window to return to its default Tab view in the GUI. The graph supports zooming in and out for a closer look, and you can click 'Reset Zoom' in the top-right corner to return to the default view. Hover over the data points and lines to see measurement results at specific times.

Platform Specific Measurements

MultiLane offers real hardware FEC-supporting devices. Available FEC measurements depend on the HW revisions and the type of BERT in use. In this section, the supported specific measurements will be detailed.

Activating a Purchased Real Hardware FEC License

To Enable FEC licensing, you can request FEC License by placing a Purchase Order to operation@multilaneinc.com by sending a screenshot of your BERT info tab.

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

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

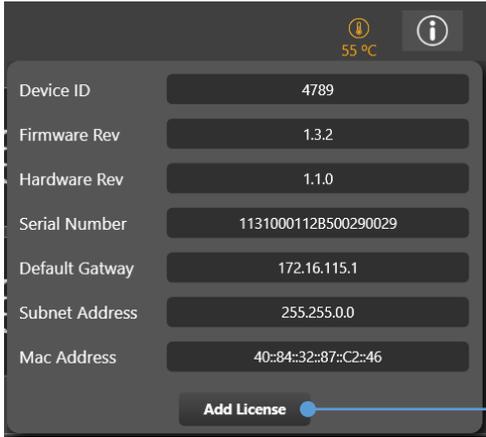


Figure 33: Add License Available in Info Tab

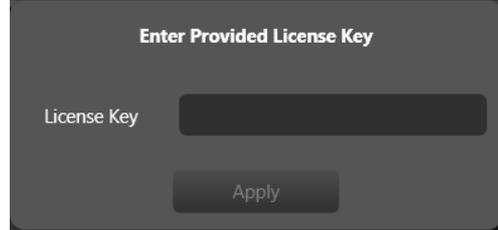


Figure 34: Pop-up Window to Add License

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

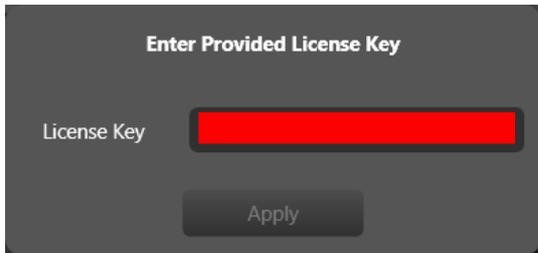


Figure 35: License Key Added

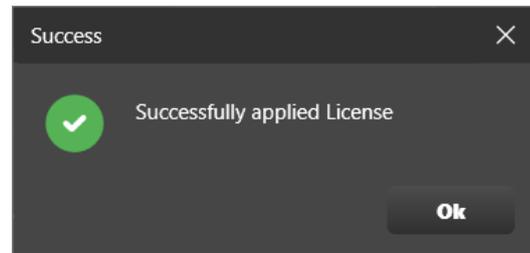


Figure 36: FEC Features Enabled

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



You will be notified if a wrong LK is entered. The GUI will disconnect directly if a wrong LK is entered four times consecutively.

Real Hardware FEC Measurements

After entering an applicable FEC license code into ThunderBERT2, 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.

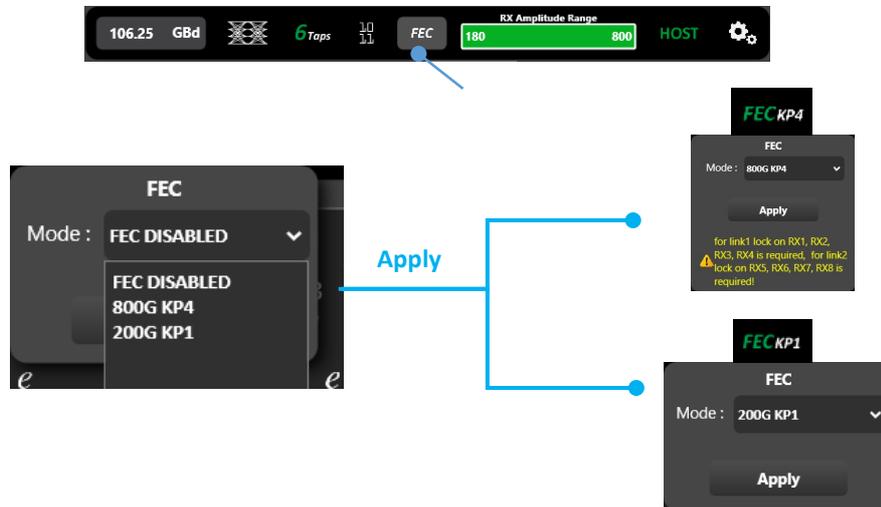


Figure 37: Enabling FEC

- FEC KP4 is implemented with 2 links:
 - Link1 requires lock on Rx1, Rx2, Rx3, Rx4.
 - Link2 requires lock on Rx5, Rx6, Rx7, Rx8.
- FEC KP1 is implemented with 8 links:
 - Each link corresponds to a single channel, and a lock on each individual channel is required to achieve lock on its respective link.

NOTE

FEC is only applicable in PAM4 on host side.

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

Instant and Accumulated Measurement	Measurement Description
Time	Time is the definition of the total codeword over the rate (rate unit is codeword per second).
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 correctable 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 correctable magnitude of symbol errors.
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.
Projected Post-FEC BER	Is based on extrapolation, an estimation of what the BER will be after the FEC is applied, based on the results before FEC

Table 5: Instant and Accumulated Real Hardware FEC Measurements

! To enable measurements, select a value for both the X and Y axes*. Only one option for the X axis selection is supported, 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/save all' buttons. Some FEC and SER screenshots are shown below:



Figure 38: SER Table

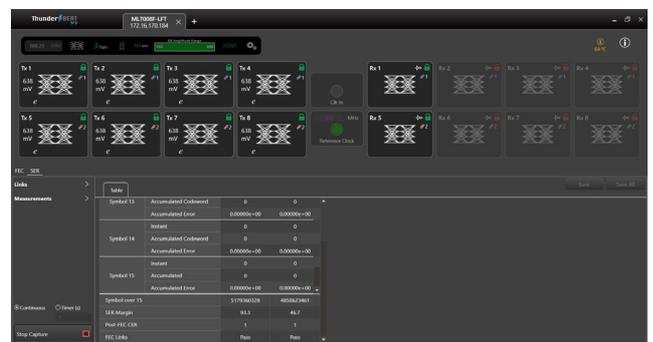


Figure 39: SER Table

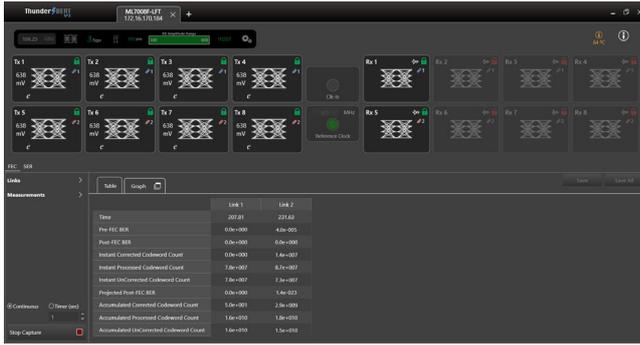


Figure 40: FEC Table

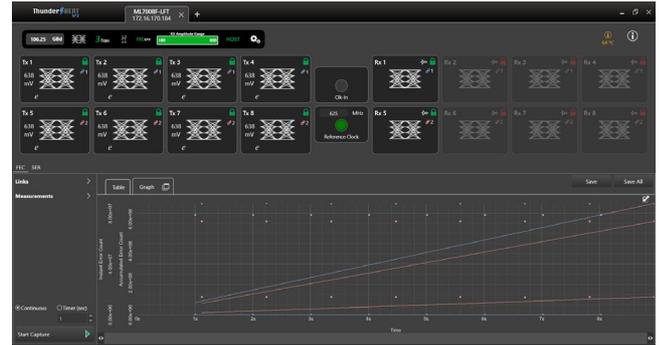


Figure 41: FEC Graph

*To view the axes combination measurements, refer to table 6.

There are three measurement blocks for SER:

1. Instant Codeword Symbol: the symbol error rate distribution for the link under test in a specific 500ms window for the ML7008F-LFT.
2. Accumulated Codeword Symbol: the sum of total symbol error rate distribution for the link under test, accumulating from $t = 0$.
3. Accumulated Error Count: the ratio of the total number of symbol errors to the total number of processed codewords.

The measurements will display:

- a. Symbols ranging from 0 to 15.
- b. Symbols greater than 7 or 15; depending on the mode. In KP4 we have 15 symbols.
- c. SER over symbols count.
- d. The SER margin (metric indicating available margin before codewords become uncorrectable).
- e. The post-FEC CER.
- f. The FEC links.

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

X axis	Y axis
Time	Instant Error Count
	Accumulated Error Count

Table 6: Display of Additional FEC Combinations

BERT Characteristics

The MultiLane BERT family is diverse enough to cover a wide array of baud rates and specific applications. The key distinguishing characteristics of all ThunderBERT2-compatible platforms can be found below. Detailed product specifications are available in the BERT section of the website [Here](#).

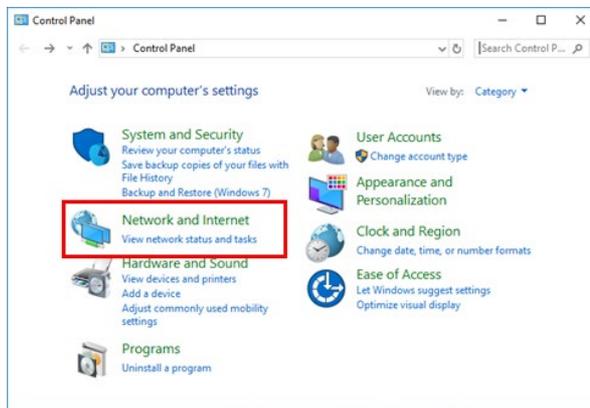
Instrument PN	Channels	Max Baud Rate (GBd)	Max Amplitude (mVpp diff.)	Modulation	Platform-Specific Features
ML7008F-LFT	8 Rx 16 Rx	106.25	800mVpp Tx 2.4Vpp DTx	PAM4/NRZ	<ul style="list-style-type: none"> Supported rates: 106.25GBd, 106.25Gbps and 53.125GBd Real Hardware FEC KP4/KP1 Extended Reach/Precoder

Table 7: ThunderBERT2 Lineup Hardware Characteristics

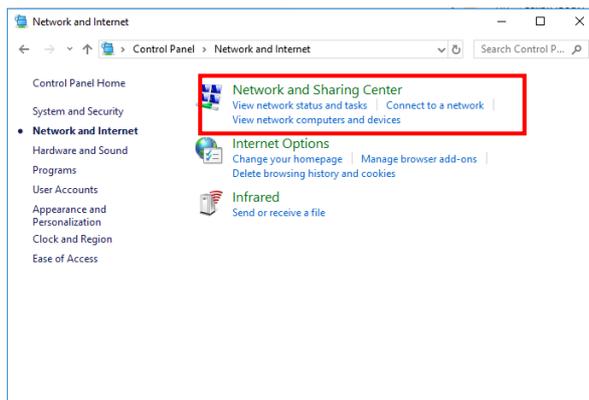
Appendix 1 – Adding a BERT to the Network

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

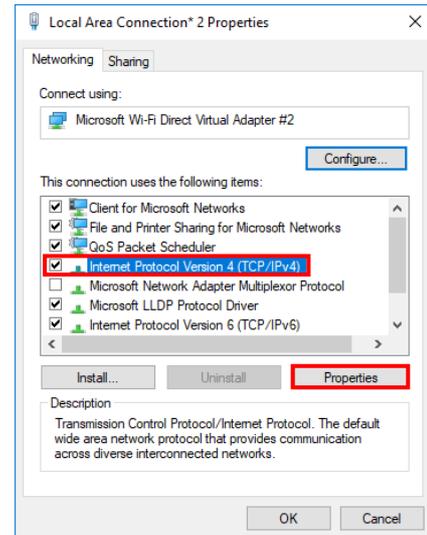
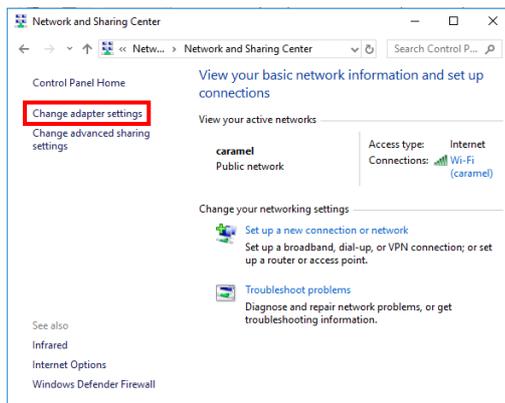
- **Create a local network connection** between the laptop and the BERT using Internet Protocol Version 4 (TCP/IPv4).
 - **Open Control Panel** and **choose Network and Internet**.
 - **Open Network and Sharing Center**.



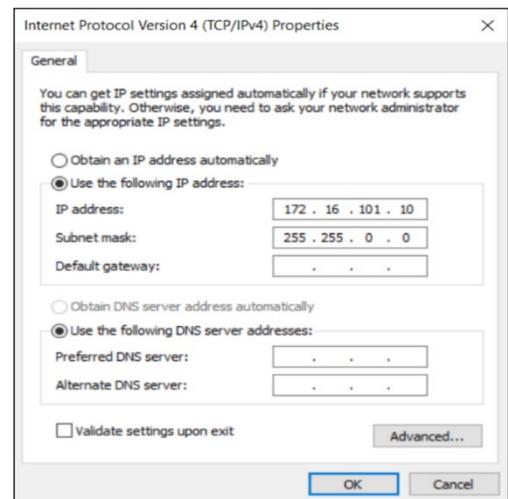
- **Click on Change Adapter Settings**, then **choose Local Area Connection**.



- 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.



NOTE

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 2 – 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.

Please refer to the [Lane Control](#) User Guide [Here](#)