multiLane

ThunderBERT V2

User Guide | ML BERT Series

Installation | Connection | Calibration| Measurements

Rev 1.0.5



ML7008F-LFT

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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.

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.

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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
1.0.2	Third Release	24/04/2026
1.0.3	Fourth Release	14/05/2026
1.0.4	Fifth Release	22/07/2026
1.0.5	Sixth Release	06/10/2026

List of Acronyms

Acronym	Definition
BER	Bit Error Rate
BERT	Bit Error Rate Tester
BLER	Block Error Ratio
BW	Bandwidth
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
HM	Histogram
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
Sim	Simulation
SNR	Signal-to-Noise Ratio
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 Test Products (MLTP) provides 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 MLTP and a vital tool industry-wide to measure the 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:

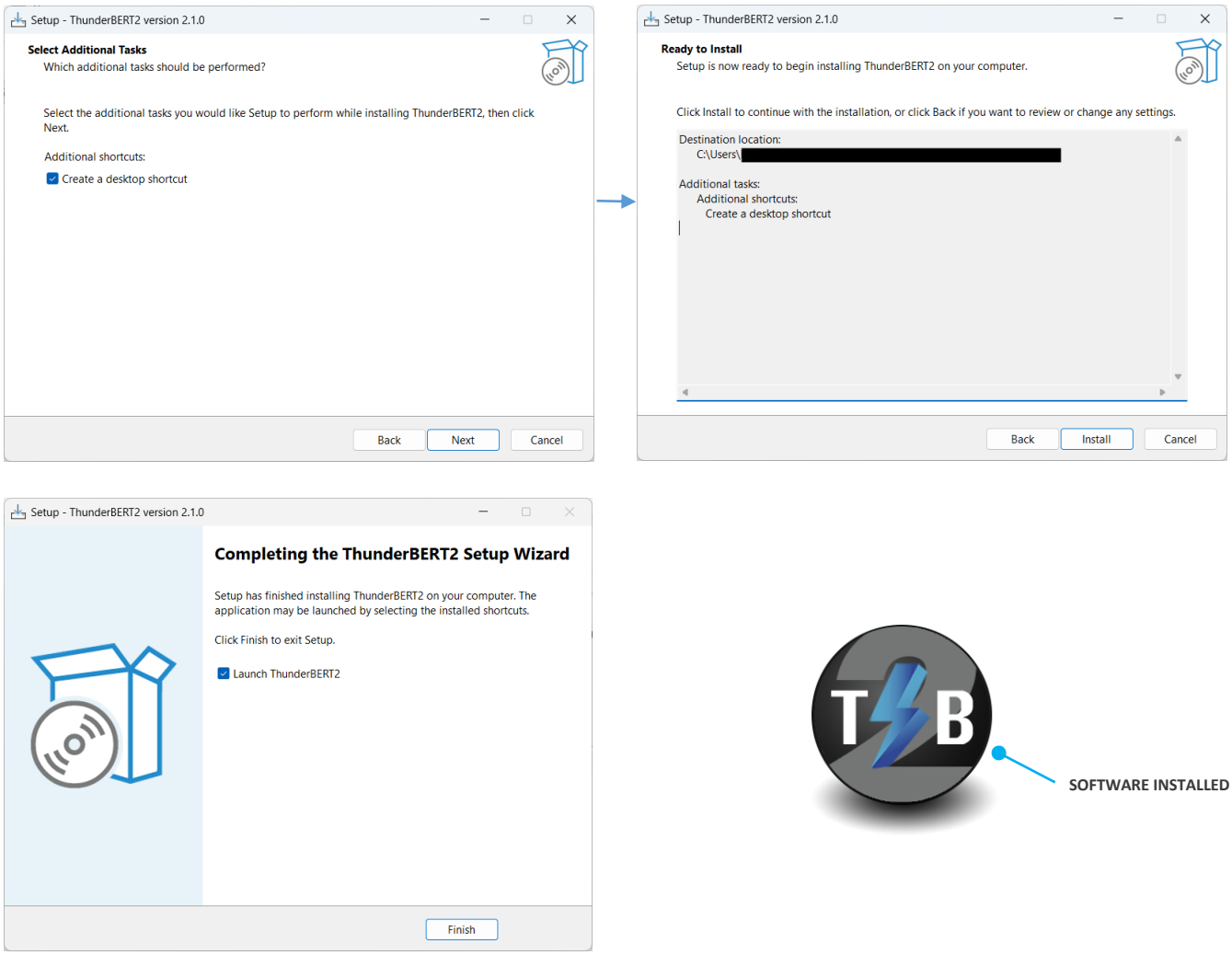


Figure 1: Setup Installation Procedure

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.

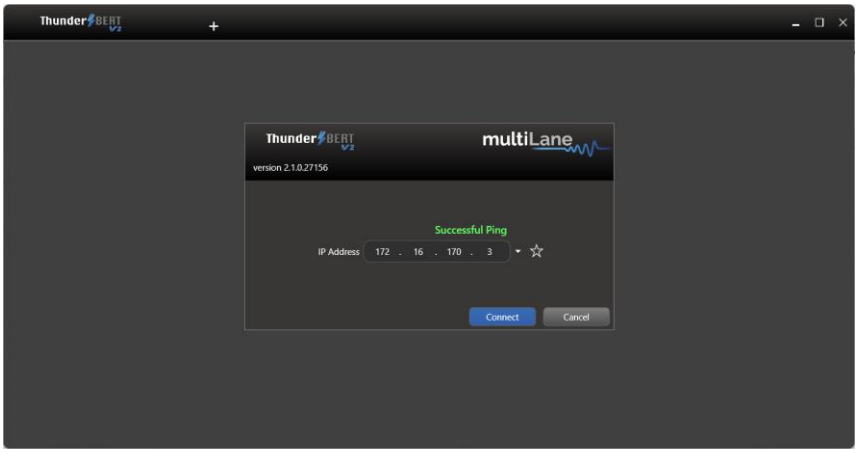


Figure 2: Connection Box

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 remove an IP address from the dropdown list, hover over it with the mouse and click the bin icon that appears.

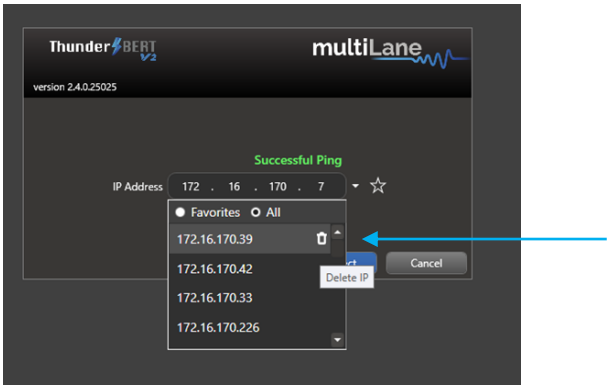


Figure 4: Remove IP Address

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

To rename an IP address, hover over the IP address and click Edit (pencil) icon. Enter the desired name and save changes.



Figure 5: Rename IP Address

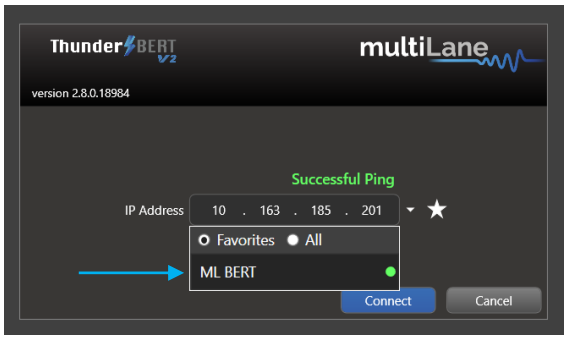


Figure 6: IP Address Renamed to "ML BERT"

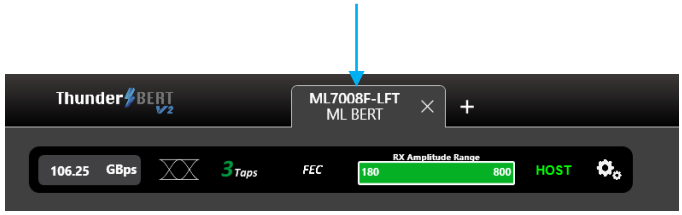


Figure 7: GUI Display

NOTES

- IP address can only be renamed if they are included in the Favorites list.
- Renaming an IP address is for display purposes only and does not modify the actual IP address configured on the BERT.
- Each IP address name must be unique. The same name cannot be assigned sto multiple IP addresses.

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 testing can commence.



Figure 8: 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 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 9: 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.

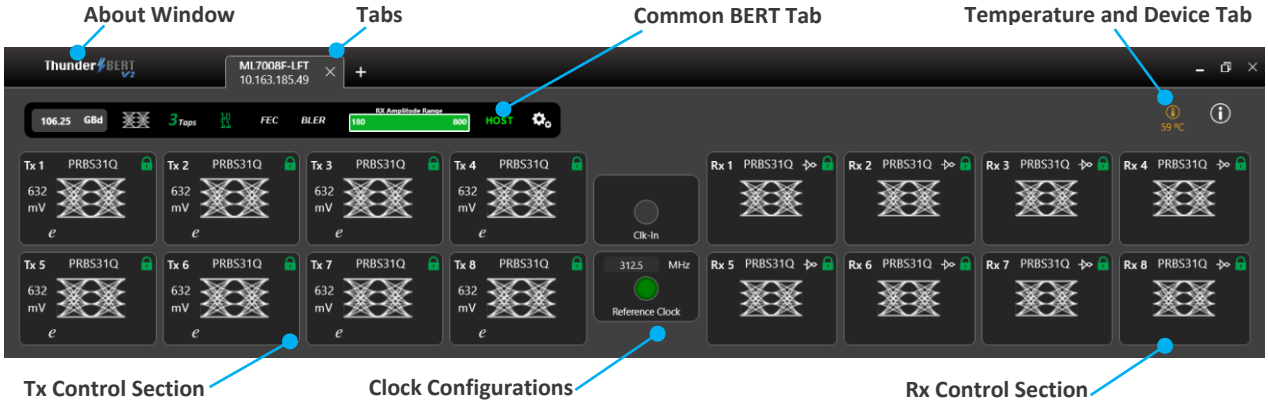


Figure 10: BERT Control Tab

- ***About Window*** (Figure 11) provides 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, 10-tap and 14-tap modes only available in Line side)
  - Gray coding, FEC and BLER enable
  - RX Amplitude/Sensitivity Range
  - Operation Mode
  - Save/Load or Reset 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
  - Link Training

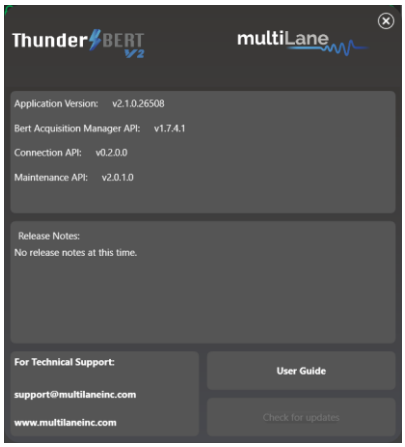


Figure 11: About Window

- ***Clock Configuration Tabs*** contain reference clock-out, high-frequency clock-out and external clock
- ***RX Control Section Tab*** contains:
  - RX invert, RX pattern selection
  - Pre-Coder and Extended Reach enable box

GUI Navigation

Instrument Control

Tabs

- Displays instrument IP address. (Figure 12).
- Close button: disconnect from the BERT and close GUI instance (Figure 13).
- Add device button: connect to a new device with a different IP address (Figure 14).

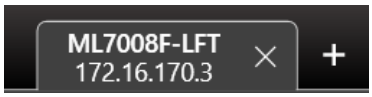


Figure 12: Title Tab

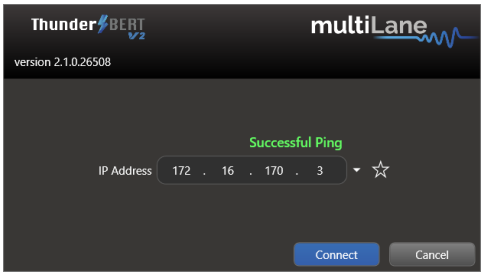


Figure 13: Disconnect Window

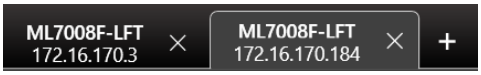


Figure 14: Connect to Another Device

BERT Settings Tab

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

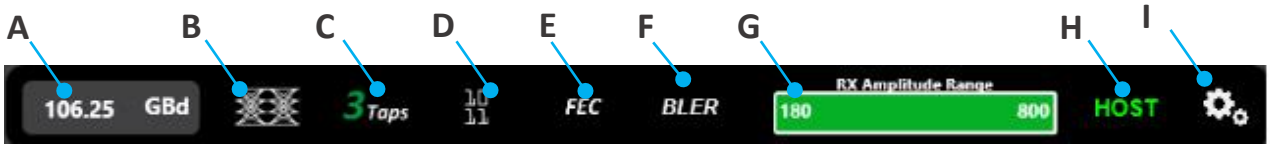


Figure 15: BERT Settings Tab

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

The common ***BERT Settings Tab*** reflects enabled features; whenever a feature is enabled (gray coding, 3/6/10/14-tap and FEC) the corresponding button turns green as shown in Figure 15.



Figure 16: Display of Enabled Features

NOTES

- Pre-Coder should be either enabled or disabled on both Tx and Rx channels in order to have Rx Lock.
- Gray Coding is only supported in PAM4 modulation.
- The NRZ supported rate is 106.25Gbps and is only supported in Line side for 3-tap mode.

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

- ***Specify the Baud rate.*** A
- ***Specify the signal modulation type***: NRZ/PAM4 (if available/supported). B
- ***Select the 3- 6- or 10- 14-taps FIR filter mode.*** C
- ***Enable/Disable the Gray Coding option.*** D
- ***Enable/Disable the FEC feature (not available on DTx).*** E
- ***Enable/Disable the BLER feature.*** F
- ***Check the Rx amplitude range*** supported by the error detector. G
- ***Operation Mode:*** Tx/DTx. H
- ***Load/Save or Reset*** the configurations through the gearbox button. I

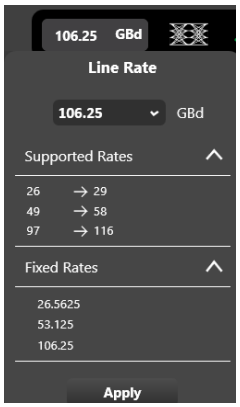


Figure 17: Set Baud Rate



Figure 18: Signal Modulation Selection

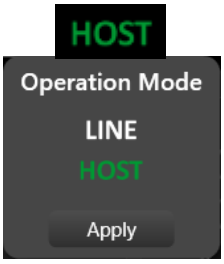


Figure 19: Operation Mode

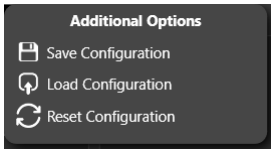


Figure 20: Additional Options

NOTES

- The 'Apply' button should be pressed after any rate change (Figure 17).
- The 'Plus' button next to the Title Window allows new tabs to be opened, connection to another device with a different IP address and tests to be run on both devices simultaneously.
- Operation Mode allows switching between Tx and DTx (Figure 19).
- Additional Options include save, load, or reset test configurations including bit rate, pattern, signal modulation, number of taps and their values, inversion, etc., for all channels (Figure 20).

Reset Configuration

By clicking the Reset Configuration button, all BERT configurations are reset to their default settings:

- Line Rate: 106.25Gbaud.
- Signal Modulation: PAM4.
- FFE Taps: 3-tap mode.
- Gray Coding, FEC and BLER disabled.
- Operation Mode: Host.
- Pattern: PRBS31Q.
- Pre Coder and Extended Reach disabled.
- FFE Taps:
  - 0 168 0 in PAM4.
  - 0 127 0 in NRZ.
  - 0 50 0 in Line for both PAM4 and NRZ.
- Link Training disactivated.
- Error Insertion disabled.
- External Clock disabled.
- Clock-out Mode: reference clock.
- Rx Invert disabled.
- High Voltage disabled.

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 21).

- **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 22).*
- **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.*

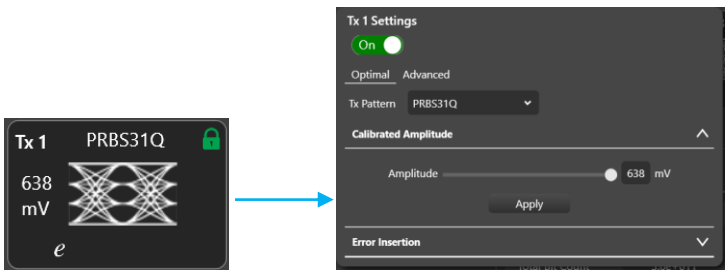


Figure 21: TX Control Tab and Applied Settings in Optimal Mode

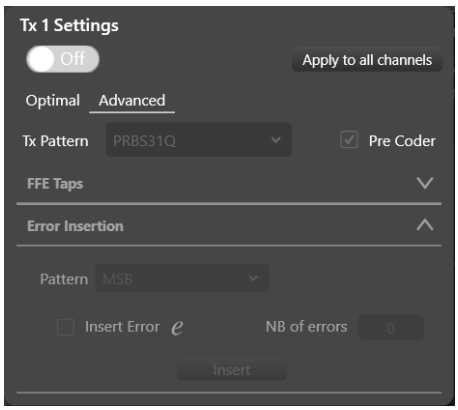


Figure 22: TX OFF - Channel Control Locked

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 23).*

To insert Errors:

- ***Enable Error Insertion mode*** *(the green color indicates that error insertion feature is enabled).*
- ***Pattern set to LSB.***
- ***Specify the number of errors.***
- ***Click*** on the Insert button to apply changes.



Figure 23: Error Insertion Tab

TX Control in Advanced Mode

While operating in Advanced Mode, the following TX settings and parameters can be specified:

- ***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 to 168 in PAM4, and -127 to 127 in NRZ.*

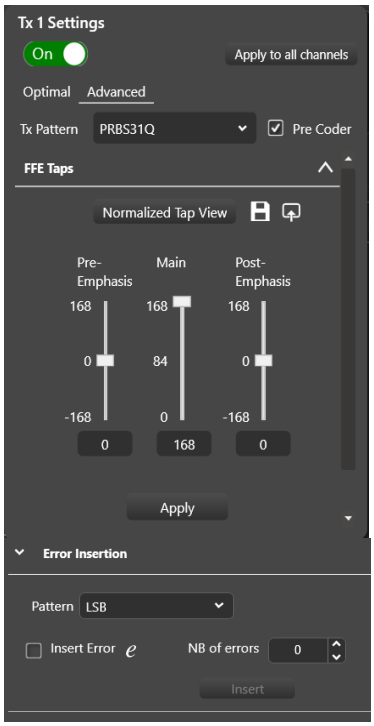


Figure 24: TX Advanced Mode Control

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.**
- ***Enable Pre-Coder*** (optional).
- ***Customize* the FFE taps.** FFE taps and Eye Levels can be controlled in this tab
- ***Apply* the changes** by clicking on the "Apply" button.

To load/save FFE Taps file and use a previous FFE configuration or save it for later use, click on the buttons in the corner.

- **Error Insertion.** *Errors can be inserted on-demand.*

When inserting errors:

- ***Enable Error Insertion mode.***
- ***Pattern set to LSB.***
- ***Set the Number of errors:*** *The sequence of words to skip without error insertion.*
- ***Click on insert.***



Figure 25: Error Insertion Tab

NOTES

- Optimal configurations and calibration are only available in 3-tap mode on the Host side in PAM4.
- The sum of the absolute value of the taps should be equal to 168 in PAM4 and 127 in NRZ.
- The value of the Main Tap should be greater than the values of pre and post Taps.

DTX Control

TX Control in Advanced Mode

While operating in Advanced Mode, the following TX settings and parameters can be specified:

- ***TX Pattern:*** *Supported TX patterns are all available in the dropdown list,*
  - *Depending on the BERT model in use.*
- ***Inner and Outer Eye:*** *Controls only available in PAM4 mode on The Line side (4 eye levels, each level range from -16 to +16)*
- ***FFE Taps:*** *Tap control offers the following on TX:*
  - *3 FFE taps (in 3-tap mode), 6 taps (in 6-tap mode), 10 taps (in 10-tap mode) and 14 taps (in 14 tap-mode). Supported tap values range between -60 to 60, and between -168 to 168 for PAM4, and -127 to 127 in NRZ if the high voltage feature is enabled.*

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.

To load/save FFE Taps file and use a previous FFE configuration or save it for later use, click on the buttons in the corner. 

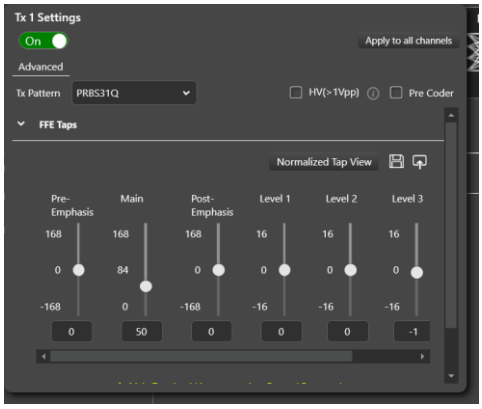


Figure 26: DTX Advanced Mode Control

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 the High Voltage feature to be enabled (Figure 27). 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.

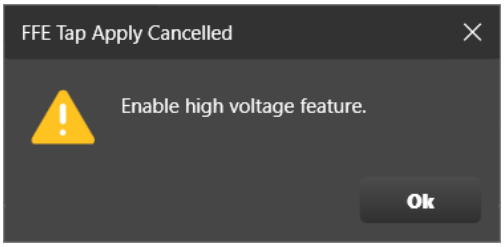


Figure 27: Error Message: Need to Enable High Voltage Feature

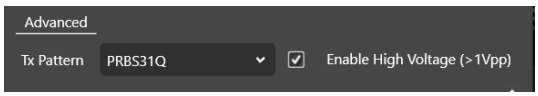


Figure 28: Enable High Voltage Feature Check



Figure 29: 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. The following settings can be selected/configured:

- ***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 red by default but turns green when the pattern is locked and identified successfully.*
  - ***CDR Lock:*** *The button is red by default but turns green when the receiver has successfully recovered a clock from the incoming signal.*
  - ***Loss of Signal (LOS):*** *The button is 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.*

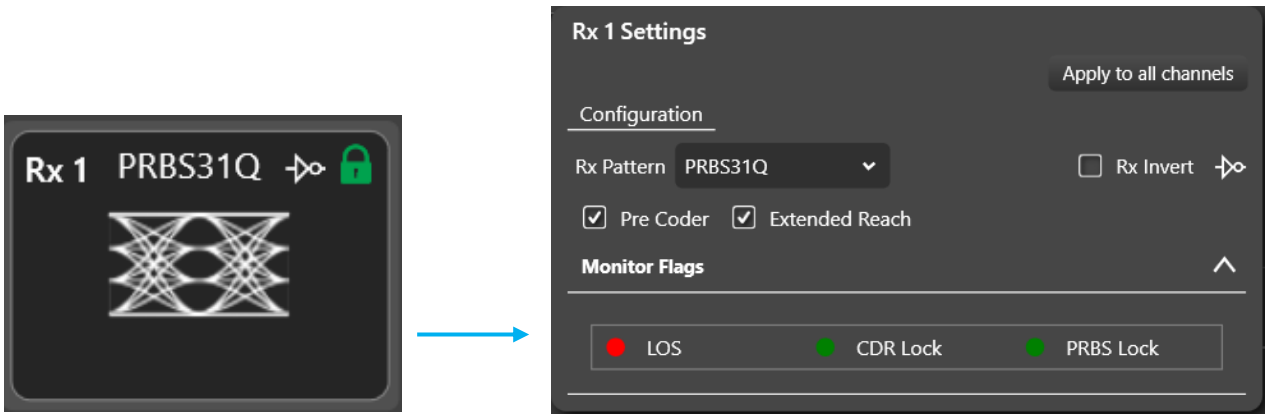


Figure 30: Rx Control and Applied Settings

Clock Configuration

Reference Clock



Figure 31: Reference Clock

High Frequency Clock

Higher clock frequencies can be configured by selecting the "High Frequency Clock" option from the dropdown menu and choosing a multiplier. Supported multipliers range from 1 to 14.

To configure the High Frequency Clock, follow these steps:

- ***Click on** the Clock Configuration Tab**.***
- ***Select "HighFreq Clock"** from the dropdown menu.*
- ***Choose multiplier** by typing it or increase and decrease using the up and down arrows.*
- ***Click "Apply".** The clock configuration display will update to "HighFreq Clock" and the clock value will change according to the selected multiplier.*

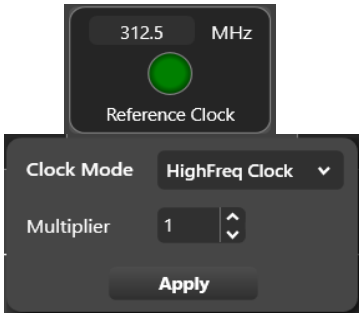


Figure 32: HighFreq Clock

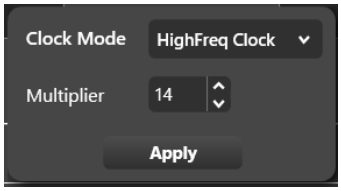


Figure 33: Apply



Figure 34: Display

External Clock

The reference clock can be sourced from an external input by selecting the "External clock" option, right above the reference/high frequency clock. When enabled, the device uses the external clock signal as timing reference.

To configure the External Clock, follow these steps:

- **Click on** "Clk-In" tab.
- **Enable "External"** ("Clk-In" tab will switch to green)
- **Enter the required frequency** in "Input Frequency" tab.
- **Click "Apply".**

NOTE

Ensure that the input frequency configured in the “Input Frequency” field matches the external clock frequency. The external clock accepts only reference clock frequencies (from all supported rates) and does not support high frequency clock inputs.



Figure 35: External Clock

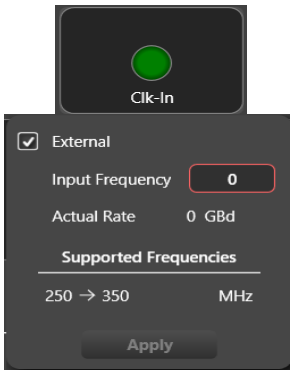


Figure 36: Enable

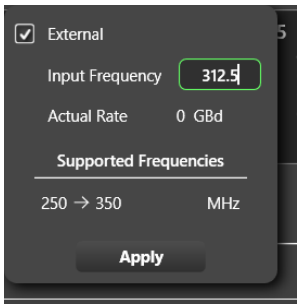


Figure 37: Apply Input Frequency

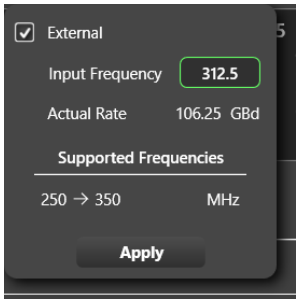


Figure 38: Actual Rate Display

Supported Measurements

Measurement Controls

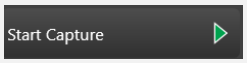
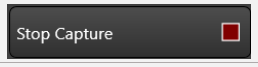
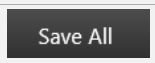
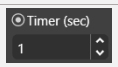
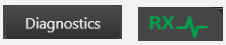
Control	Definition
	Start BER, FEC, and SER Measurements
	Stop BER, FEC, and SER Measurements
	Save BER, FEC, and SER Measurements
	Save All BER, FEC, and SER Measurements
	Save and Load FFE taps, Save and Load BERT Settings
	Set FFE Taps
	Insert Errors
	Apply Unified Settings on all Channels (Supported on Both Tx and Rx Sides)
	Apply Bit Rate, Clock Rates, FEC, and 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

BER measurements are executed according to the selected channels. While the test is running, the X and Y axis can be changed according to the supported graph combinations. Different options can be measured/visualized, including:

- *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
Instant Error Count LSB	
Instant Error Count MSB	
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.

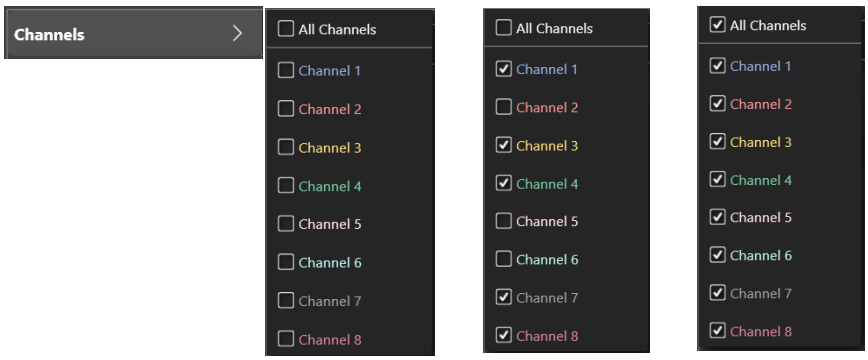


Figure 39: Channels Selection

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

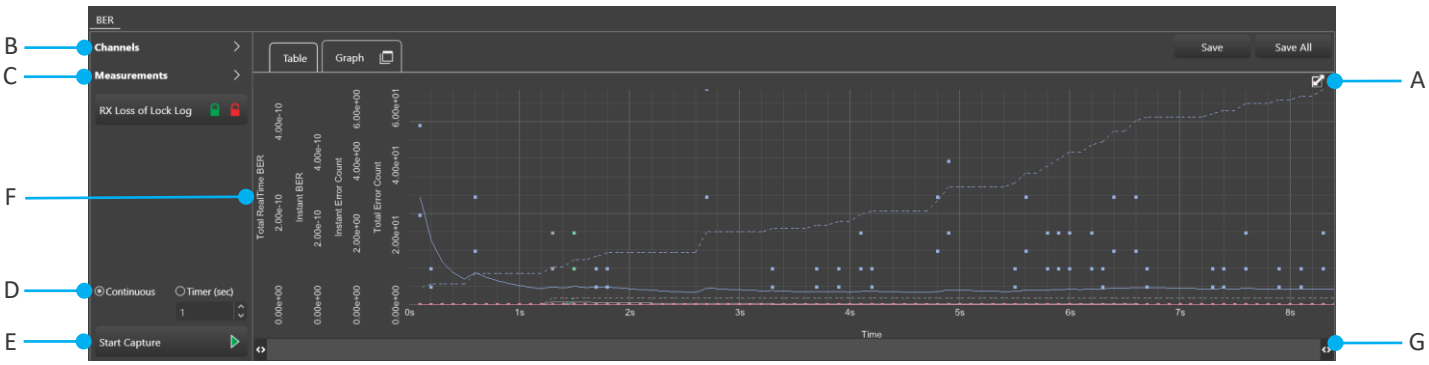


Figure 40: Graph Measurements

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).

Access the instant and accumulated measurements data using the BER measurements table. Switching from graph to table measurements can be done with no test interruptions. Save the table of result to desktop using the save/save all button.

BER graphs and table measurements are displayed below.



Figure 41: Graph Measurements Display



Figure 42: Table Measurements Display

Switching between graph view and window view can be done without interrupting the test. In window view, the table measurements are selected alongside the graph. Close the window to return to its default Tab view in the GUI. The graph supports zooming in and out for a closer look; click on '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, a FEC License can be requested 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 the LK should be copied and applied.

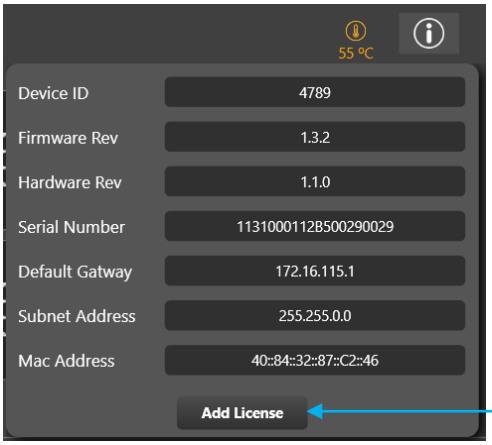


Figure 43: Add License Available in Info Tab

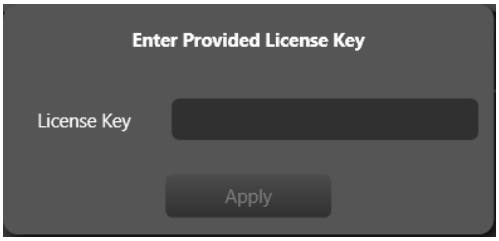


Figure 44: Pop-up Window to Add License

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

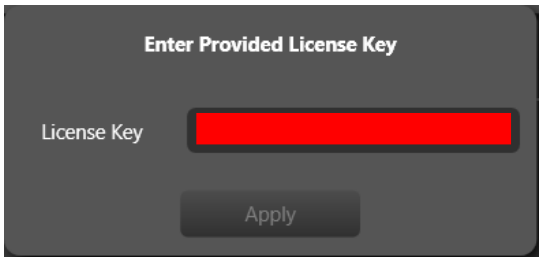


Figure 45: License Key Added

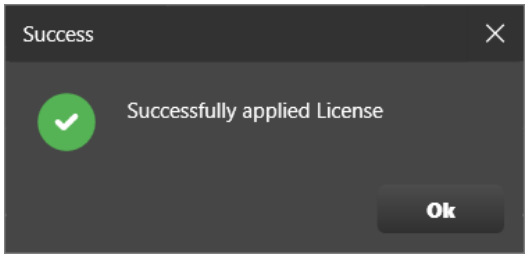


Figure 46: FEC Features Enabled

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

⚠ 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.

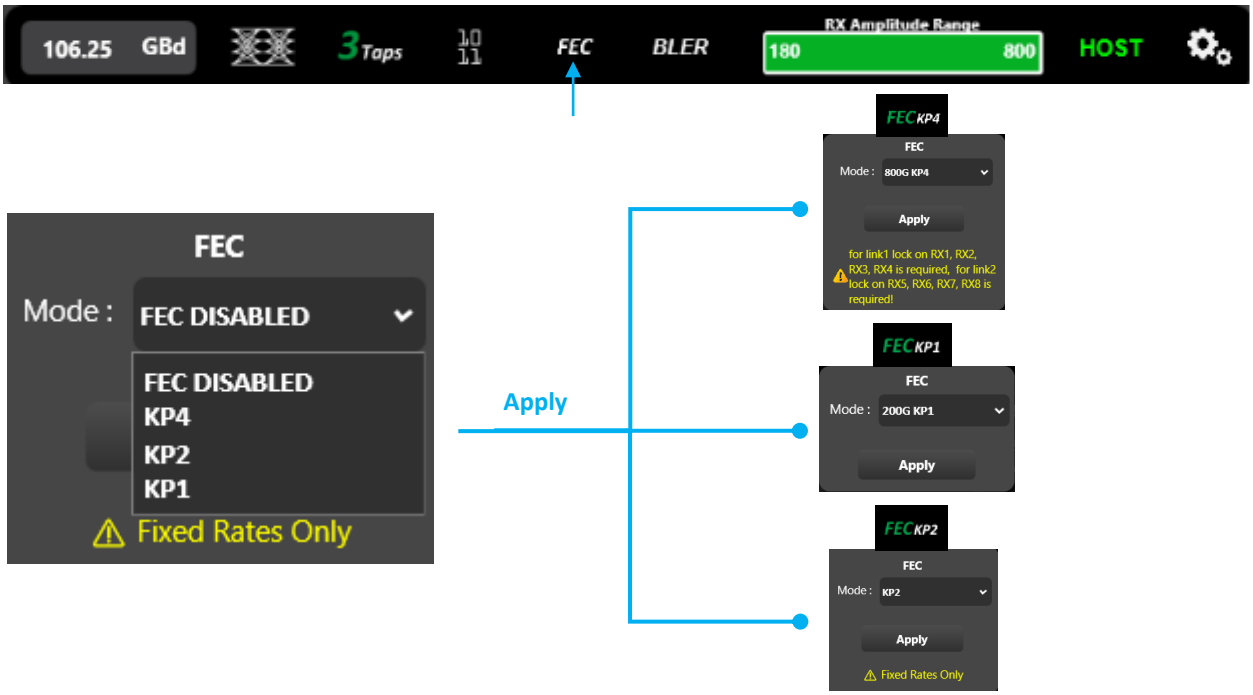


Figure 47: Enabling FEC

- FEC KP4 is implemented with 2 links:
  - Link1 requires lock on Rx1, Rx2, Rx3, Rx4.
  - Link2 requires lock on Rx5, Rx6, Rx7, Rx8.

- FEC KP2 is implemented with 4 links:
  - Link1 requires lock on Rx1, Rx2.
  - Link2 requires lock on Rx3, Rx4.
  - Link3 requires lock on Rx5, Rx6.
  - Link4 requires lock on 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.

NOTES

- FEC is only applicable:
  - In PAM4.
  - On Host side.
  - On fixed rates (106.25GBaud and 53.125GBaud).
- FEC does not support Error Insertion.
- Precoder and Extended Reach are available in FEC mode.

When FEC is enabled, the X and Y axes can be changed 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 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.
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.

Choose between visualizing instant and accumulated measurements, and measurements table under the FEC and SER tabs. Save the table of result to desktop using the ‘save/save all’ buttons. FEC and SER screenshots are shown below:

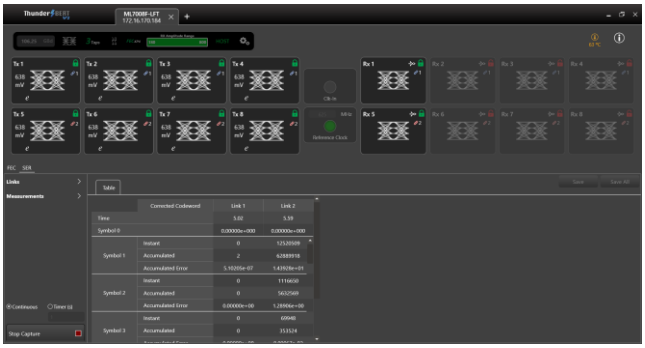


Figure 48: SER Table

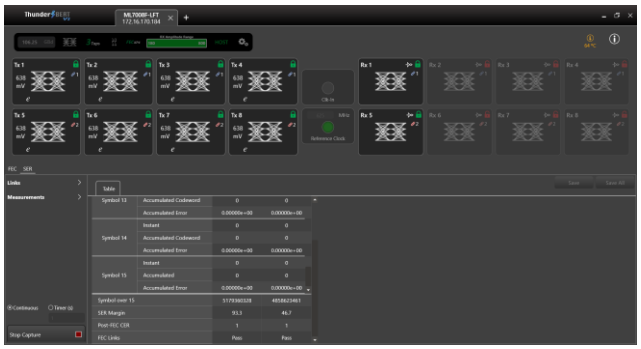


Figure 49: SER Table

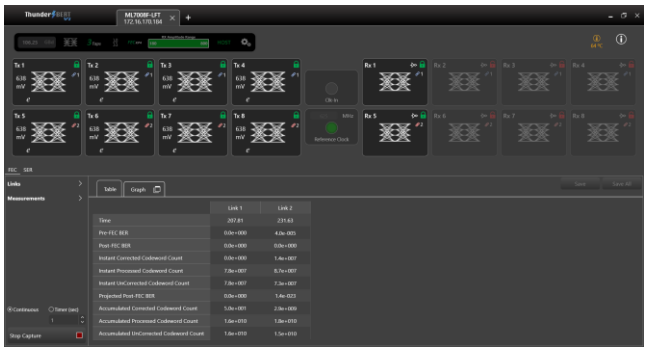


Figure 50: FEC Table

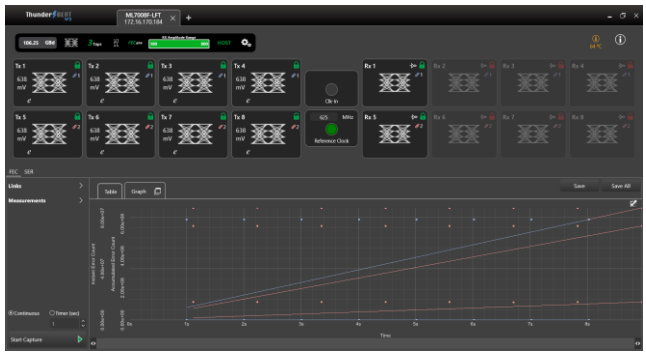


Figure 51: FEC Graph

*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

New Features

Link Training

Link Training is a new GUI feature. When activated, it performs link training in accordance with IEEE specifications and returns taps for each channel independently.

To activate Link Training, follow these steps:

- **Click "Activate".**
- Taps are returned and **"Success"** message is displayed in green.
- **Click "Apply"** to apply the taps to the Tx channel.
- Link Training taps are written to the FFE Taps.

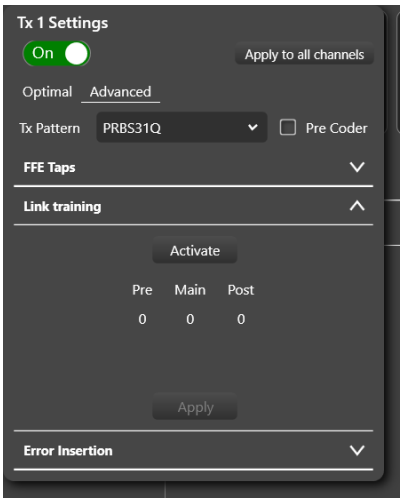


Figure 52: Select

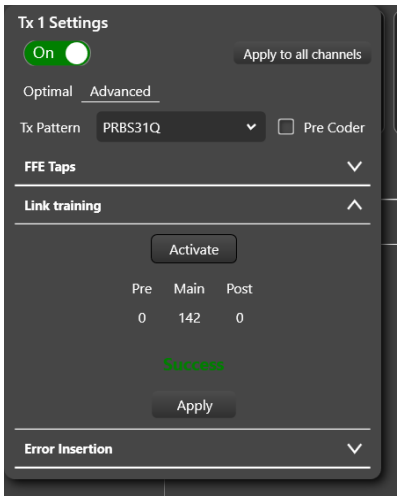


Figure 53: Activation

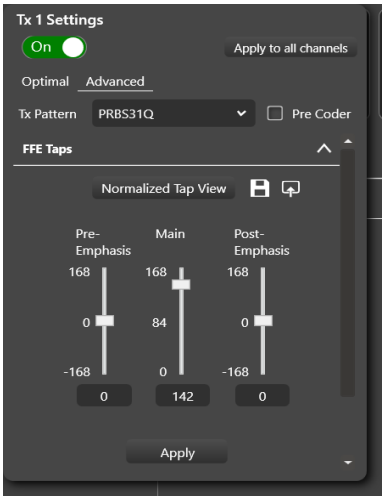


Figure 54: Apply

NOTES

- Link Training is only supported on the Host side.
- Link training is only supported with aligned Tx/Rx channel mapping.

IEEE specification for Link Training:

- Implements LINK_TRAINING_TYPE_802_3CD for 200G PAM4.
- Link Training follows the IEEE 802.3cd standards.

BLER —Block Error Ratio

BLER is a new GUI feature that measures the Block Error Rate (BLER) for each channel independently and provides derived results based on the received data. BLER is a metric used to measure the ratio of erroneous blocks to the total number of transmitted blocks.

Activating a Purchased BLER License

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

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

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

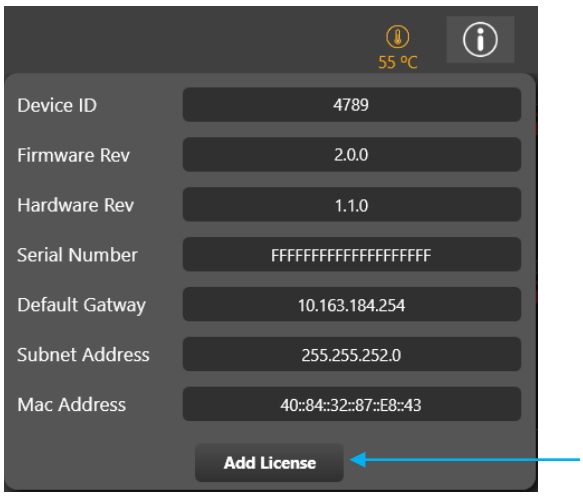


Figure 55: Add License Available in Info Tab

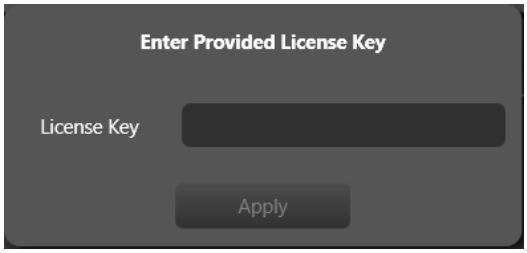


Figure 56: Pop-up Window to Add License

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

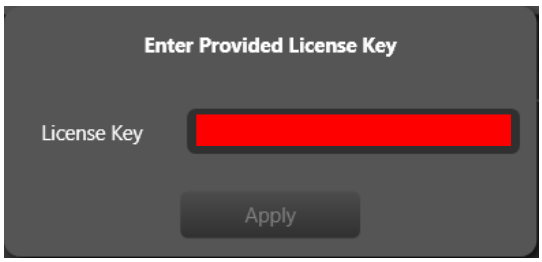


Figure 57: License Key Added

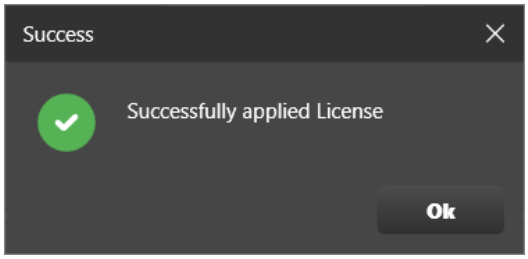


Figure 58: BLER Feature Enabled

After the LK has been applied, the BERT ***should be disconnected*** and ***power cycled***. Full hardware BLER features will then be accessible and ready to use.

⚠ The GUI will disconnect directly if a wrong LK is entered four times consecutively.

BLER Measurements

After entering an applicable BLER license code into ThunderBERT2, enable the BLER measurements and then press apply. Once enabled, the BLER button will become green.

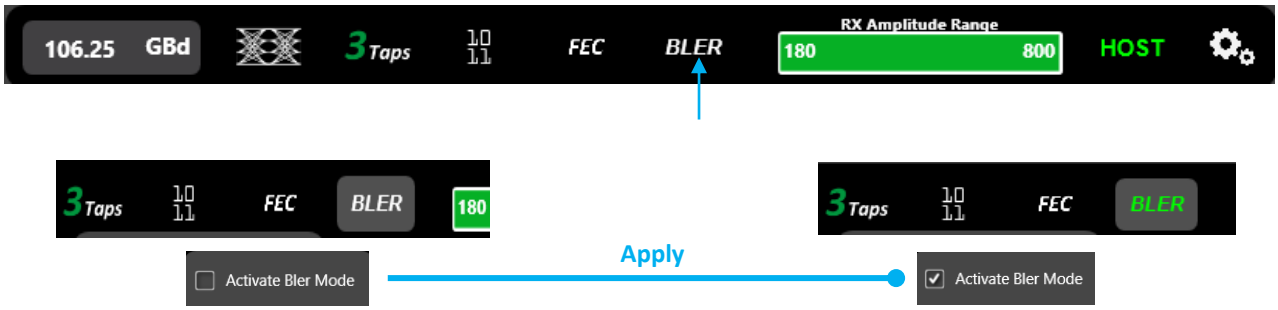


Figure 59: Activating BLER

NOTE

BLER is only applicable in PAM4, on both the Host and Line side.

BLER is defined as the ratio of codewords with 16 or more symbol errors to the total number of transmitted codewords. To efficiently estimate long-term BLER, statistical projection (HM) is used. This method analyzes the distribution of symbol errors per codeword to predict the rate of uncorrectable errors, significantly reducing test time. Modern test equipment provides real-time, per-channel BLER results through intuitive GUI features.

When BLER is enabled, set a capture time in the Timer type box then start the capture. You can see the results of the measurements. Timer values allowed range between 1 and 55 seconds.

BLER Measurements	Measurement Description
Time	Timer in seconds (maximum time capture is 55 seconds)
BLER	Block Error Ratio
Raw BER	Raw Bit Error Rate
Projected BER	Projected BER
Number Of FEC Frames	Number of symbol errors ranging from 0 to 15
HM Projected BER	Histogram Projected BER

Table 7: Instant and Accumulated Real Hardware FEC Measurements

Save the table of result to desktop using the 'save/save all' buttons. BLER screenshots are shown below:



Figure 60: BLER Table



Figure 61: Number of FEC Frames Table

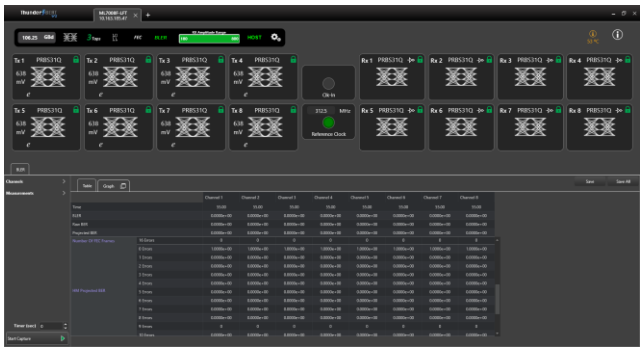


Figure 62: HM Projected BER

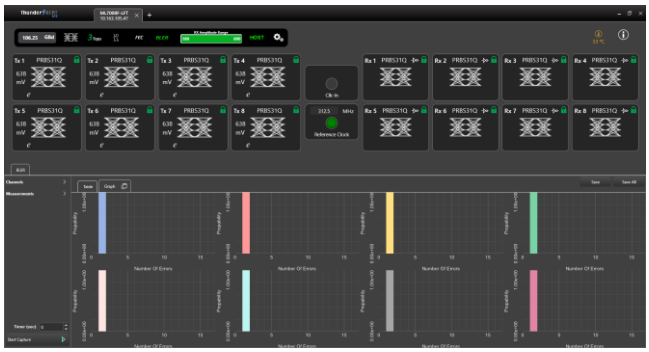


Figure 63: Probability Graph

In the following table, the BLER graph combinations are shown.

X axis	Y axis
Number Of Errors	Probability (HM Projected BER)

Table 8: Display of BLER Graph Combinations

NOTES

- BLER is reported as a probability and is calculated independently on all 8 processing lanes.
- BLER measurements are performed on the receiver's side.
- The maximum BLER capture is 55 seconds.

BERT Characteristics

MultiLane BERTs 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.

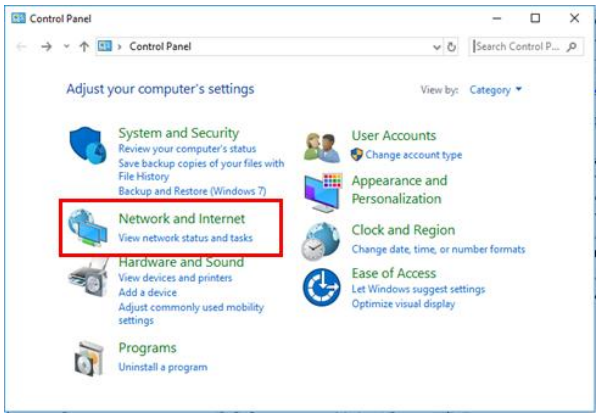
Instrument PN	Channels	Max Baud Rate (GBd)	Max Amplitude (mVpp diff.)	Modulation	Platform-Specific Features
ML7008F-LFT	8 Rx 16 Rx	106.25	800mVpp Tx 2.4Vpp DTx	PAM4/NRZ	• Supported rates: 26 GBaud -> 29 GBaud, 49 GBaud -> 58 GBaud, 97 GBaud -> 116 GBaud • Fixed rate: 106.25 GBaud, 53.125 GBaud, 26.5625 GBaud, 106.25Gbps • Real Hardware FEC KP4/KP1 • Extended Reach/Precoder • Link Training • External Clock • High Frequency Clock

Table 9: ThunderBERT2 Lineup Hardware Characteristics

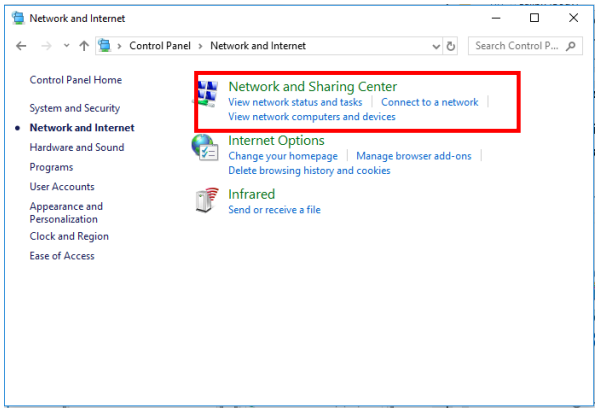
Appendix 1 – Adding a BERT to the Network

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

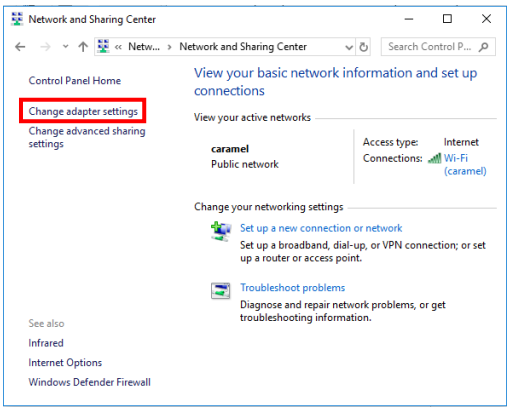
- ***Create a local network connection*** between the laptop and the BERT using Internet Protocol Version 4 (TCP/IPv4).
  - ***Open*** *Control Panel* and ***choose*** *Network and Internet*.
  - ***Open*** *Network and Sharing Center.*

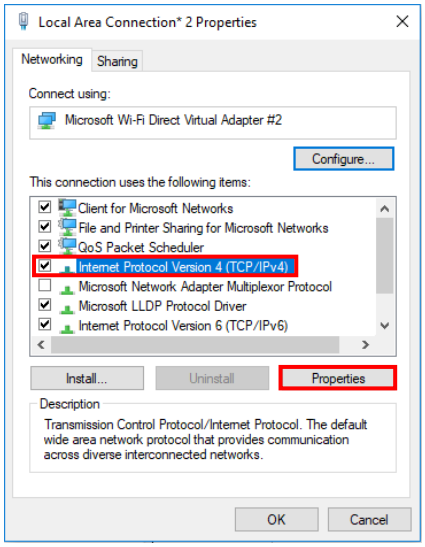


- ***Click on*** *Change Adapter Settings*, then ***choose*** *Local Area Connection*.

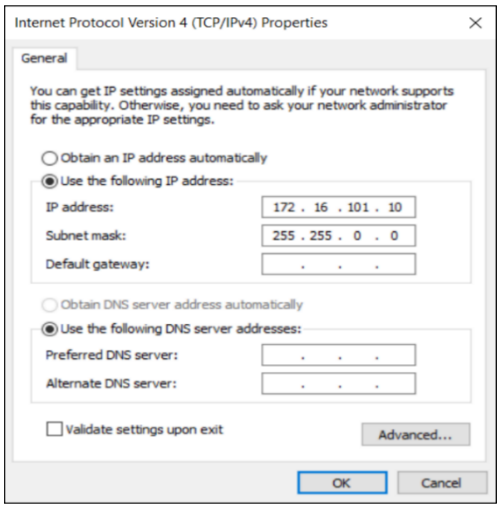


- In the Networking Tab, ***click on*** *Internet Protocol Version 4 (TCP/IPv4)* then *Properties.*





- ***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. An available IP on the network should be provided. If the IP is the same as another device on the network, the device can still be pinged but will not be usable.

Please refer to the Lane Control User Guide Here