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PCI Express® Protocol Analysis
Summit™ T5 Gen5 Analyzer
User Manual



For PCIe Protocol Analysis Software Version 13.34

Generated: June 2, 2026 9:46 AM

Teledyne LeCroy Protocol Solutions Group

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WEEE Program



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Chapter 1

Overview

Designed for developers and validators, the Teledyne LeCroy Summit T5™ Analyzers (Summit T516/T54) are PCI Express 5.0 compliant advanced verification systems supporting 2.5/5.0/8.0/16.0/32.0 GT/s speeds for PCIe, NVMe and CXL protocols.

By leveraging years of experience in protocol analysis tools for emerging markets, the Summit T5 Analyzers blend sophisticated functionality with practical features to speed the development of PCI Express™ IP cores, semiconductors, bridges, switches, add-in boards, and systems.

1.1 PCIe Protocol Analysis™ Analyzer Hardware and Software

Features and Benefits

Summit T5 Analyzers features and benefits:

TABLE 1.1: Summit T5 Analyzer Features and Benefits

Features	Benefits
Powerful and Intuitive CATC Trace™ Analysis Software	Faster interpretation and debug of PCI Express traffic with color-coded, clearly labeled protocol elements in a graphical display.
Extensive Decoding	Complete, accurate and reliable decoding of TLPs (Transaction Layer Packets), DLLPs (Data Link Layer Packets), NVMe 1.4, PQI, AHCI, ATA, SOP and SCSI command transactions and all PCI Express Primitives.
Intelligent Reporting	Quickly identify and track error rates and abnormal link or timing conditions. Display configuration space and protocol specification details.
Sophisticated Viewing	View Packet, Link, Split, NVMe 1.4, PQI, AHCI ATA, SOP and SCSI command transaction levels of the PCI Express protocol. Collapsible/expandable headers with Tool tip explanations make it easy to navigate and interpret packet contents, headers, and commands. View packets, transactions of TLPs and DLLPs in classic CATC Trace™ format or in raw bit stream for deeper analysis.

TABLE 1.1: Summit T5 Analyzer Features and Benefits (Continued)

Features	Benefits
Summit T5 64 GB Recording Capacity, 32 GB in each direction	Capture long recording sessions for analysis and problem solving.
Flexible Host Interface	USB and GIGE.
Downloadable CATC Trace Viewer	Share and annotate CATC Trace recordings within a development team. Freely distributable PCIe Protocol Analysis enables collaborative analysis across sites and time zones.
Summit T5 Bidirectional x1-x16, 2.5 GT/s to 32.0 GT/s recording support	Accurate and non-intrusive collection of PCI Express CATC Trace data.
Field-upgradeable firmware and recording engine	Upgrades available for download direct from the Teledyne LeCroy website.
Flexible probing options	Gen4 Host and Device Probe Cards.
External interface	Enables cross triggering between other test instruments.
Dword to Transaction Level Viewer	View Dwords, Packet, Link, Split, NVMe, PQI, AHCI ATA, SOP and SCSI command transaction levels of the PCI Express protocol.
Support for Gen1/Gen2/Gen3/ Gen4/Gen5 Compliance Patterns	Gen1/Gen2/Gen3/Gen4/Gen5 Compliance Patterns can be decoded as well as filtered out of the traffic stream.

1.2 CATC Trace Software

The Summit T5 analyzers utilize the CATC Trace™ to assist users in analyzing how PCI Express components work together, diagnose problems, and test for interoperability and standards compliance.

The CATC Trace is a powerful and intuitive expert software system embedding detailed knowledge of the protocol hierarchy and intricacies, as defined in the protocol specification. The software allows the user to control the Analyzer and set specific real-time triggering and filtering conditions. The CATC Trace uses a Windows-based graphical display that has been optimized for fast and easy navigation through a captured traffic session. Users are alerted as violations are detected at all levels of the protocol layering and can easily drill down on areas of interest or collapse and hide fields that are not relevant.

1.3 Summit T5 Analyzers

The Teledyne LeCroy Summit T516/T54 are Teledyne LeCroy's high performance PCI Express Analyzers for customers in server, workstation, desktop, graphics, storage and network card markets.

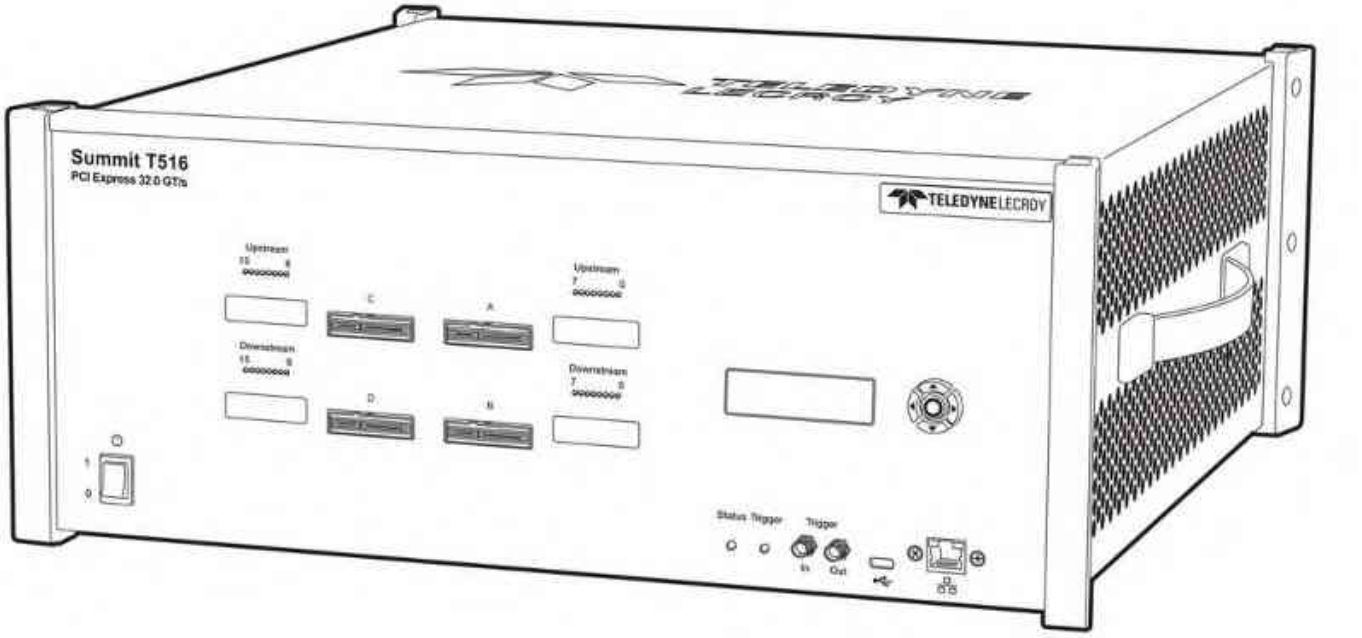


Figure 1.1: Summit T516 Analyzer

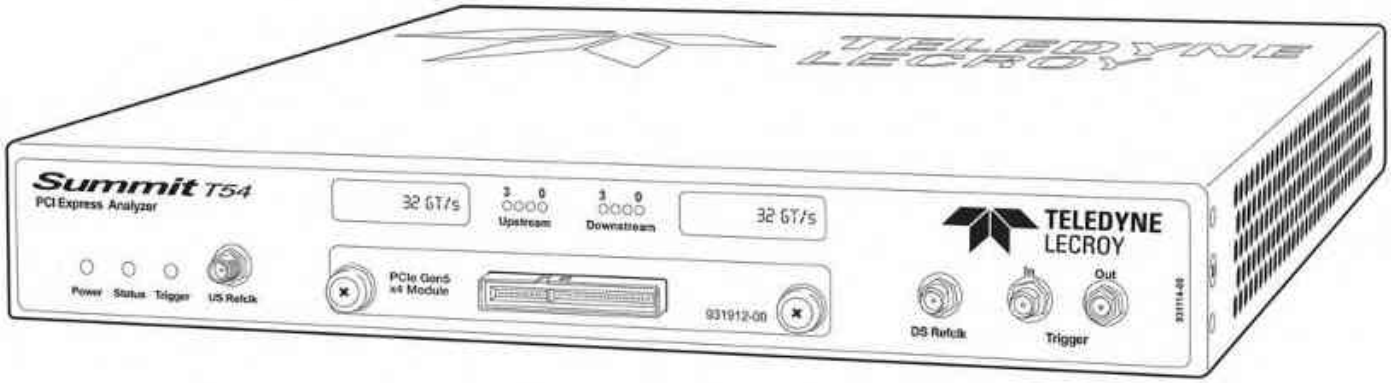


Figure 1.2: Summit T54 Analyzer

With advanced features such as support for PCI Express Spec 5.0, data rates from 2.5 to 32.0 GT/s, lane widths from x1 to x16, and up to 256 GB of memory, the Summit T5 analyzers provide unmatched capability and flexibility for developers and users of advanced PCI Express products. The Summit T5 analyzers are the most advanced and sophisticated PCI Express Analyzers available in the market today.

As with other Teledyne LeCroy PCI Express analyzers, the Summit T5 analyzers leverage the intuitive and powerful CATC Trace analysis software system, embedding a deep understanding of the PCI Express protocol hierarchy and intricacies. The colorful, intuitive and easy-to-use graphical display allows you to quickly capture and validate PCI Express product designs.

In addition to a full suite of advanced hardware and software features, the Summit T5 analyzers have user-convenience and analysis features, such as support for "lane swizzling," which allows a board developer to lay out a mid-bus probe pad with lanes in non-standard order, simplifying the design of the board. Internally, the Summit T5 analyzers map the lanes back into their correct order and accurately displays the embedded bus traffic. An optional BitTracer™ mode allows bytes

to be recorded as they come across the link, allowing debugging of PHY layer problems and combining the features of a logic analyzer format with a protocol analyzer format.

The Summit T5 analyzers support USB and GIGE host interfaces. By connecting over GIGE, engineers can operate the system remotely (for example, install the client software on their desktop systems to control an analyzer operating in a remote lab). Also, multiple engineers working collaboratively can time-share use of a single analyzer, reducing the need for an additional analyzer for each engineer and increasing the cost effectiveness of the product.

1.4 Features

- **Powerful and Intuitive CATC Trace Analysis Software System**: The CATC Trace embeds deep understanding of the PCI Express protocol hierarchy and intricacies. This knowledge is presented in a colorful, intuitive and easy-to-use graphical display, allowing you to quickly capture and validate PCI Express product designs.
- **Protocol Hierarchical Viewing**: Displays Packet, Transaction, Split, NVMe 1.4, PQI, AHCI, ATA, SOP and SCSI command transactions levels of the PCI Express protocol, with increased drill-down detail for PCI Express primitives, errors, payloads or individual packets.
- **Lane-Reversal Compatible**: Triggers, records, and displays PCI Express traffic logically, regardless of the physical configuration of the lanes.
- **Statistical and Error Reporting**: Provides a quick summary of the CATC Trace file to identify and track error rates and abnormal link or timing conditions.
- **BitTracer™ Recording Mode (optional)**: Records the bytes exactly as they come across the link, allowing debugging of PHY layer problems.
- **Auto Speed detection**: Follows link transitions through speed changes.
- **Lane Swizzling Support**: Allows board developers to lay out lanes in a non-standard order, simplifying board design.
- **Field-upgradeable Firmware and Engine**: Positions you to receive the latest PCIe Protocol Analysis enhancements and future additional capabilities. Allows field upgrades of all system types.
- **T5 Analyzers have up to 256-GB Data Buffer**: Capture long time windows for in-depth analysis and identification of erratic problems.
- **GIGE Ethernet Connectivity**: Allows connection to an Ethernet network and sharing of analyzer resources by multiple engineers.
- **USB connectivity**: Allows connection by USB cable.
- **CrossSync™ Application:** The CrossSync™ application allows you to select analyzers for synchronization and manage the recording process.

1.5 Other Documents

For more information, refer to the following documents:

- Teledyne LeCroy Analyzers File-based Decoding Manual
- PCIe Protocol Analysis/Trainer Automation Manual
- PCIe Protocol Analysis VSE Manual
- CrossSync™ Control Panel User Manual
- Scripting and Automation API Reference Manual

Chapter 2

Hardware Description

The PCI Express™ system features Summit Analyzers.

2.1 System Components

Summit T5 Analyzer system:

- ❑ Summit T516™ analyzer box
- ❑ Summit T54™ analyzer box

2.2 Host Machine Requirements

The Summit T5 Analyzers connects to a host machine. Please consult the **readme** file in the installation software (download from http://teledynelecroy.com/sw/pciexpress/) for the latest host machine requirements.

2.3 Summit T516 Front Panel Description

When powered on, the Summit T516 activates the user-accessible controls and LEDs on the front panel. See Figure 2.1 on page 5.

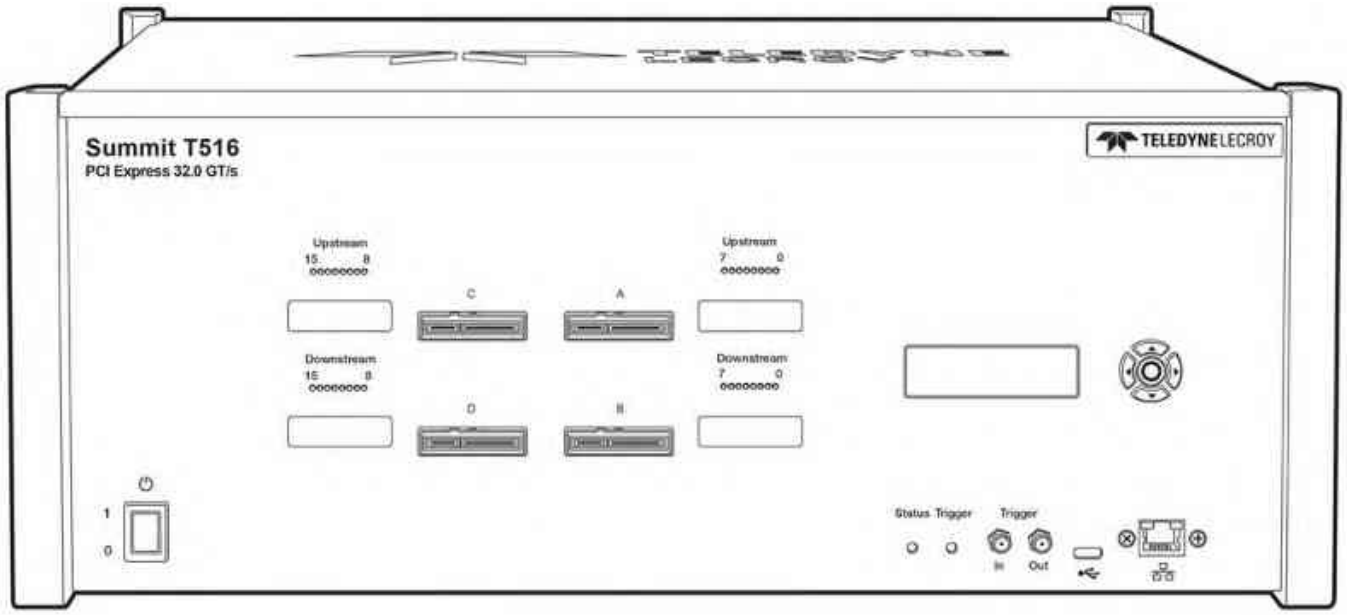


Figure 2.1: Summit T516 Front Panel

The controls and LEDs are:

Power Switch (black): 1 = On and 0 = Off

Status LED: Displays the connection status of the link.

- Red – Error condition. Try using the PCIe Protocol Analysis application to clear the error. Please contact the factory if this does not work.
- Green – Configuring system.
- Blue – Unit ready/connected.

Trigger LED: Lights when Summit T516 triggers on an event.

Speed LED Displays: Indicates current speed the analyzer is using for either the Upstream direction or the Downstream direction.

Upstream [15:0] LEDs: Indicates which Upstream Lanes are currently showing activity. OFF for electrical idle state, orange for activity with errors detected, green for normal operation.

Upstream [15:8] and Upstream [7:0] connectors: Connection to the probe for the capture of upstream directions of the link.

Downstream [15:0] LEDs: Indicates which Downstream Lanes are currently showing activity. OFF for electrical idle state, orange for activity with errors detected, green for normal operation.

Downstream [15:8] and Downstream [7:0] connectors: Connection to the probe for the capture of downstream directions of the link.

Trigger: Provide external trigger capabilities. You can configure Summit T516 to trigger external equipment using Trigger Out. You can use Trigger In to trigger the Analyzer from another device.

- **In** for SMA external trigger input.
  - Trigger Input has a 1.5kohm pullup resistor to 3.3 volts and a 50 ohm RC termination
  - Threshold voltage for Trigger Input is 0.55 volts.
  - Voltages below 0.4 volts will be detected as low, voltages above 0.7 volts will be detected as high.
  - The minimal pulse width is 70 ns for rising pulses and 20 us for falling pulses
  - When Internal Triggering option is selected in the recording options, any edge of this signal will cause the analyzer to trigger.
- **Out** for SMA external trigger output.
  - Output buffer is 3.3 volts. The buffer can drive up to 32 mA of current and meet VOH (2.5 V) and VOL (0.5 V) thresholds.
  - Output buffer can drive a 50 ohm DC load (such as scope input).

USB Type C Host Machine Connector: To connect the Analyzer to the host machine using a USB connection.

Ethernet Port: 1 GIGE Connectivity allows connection to the analyzer through an Ethernet network.

2.4 Summit T516 Rear Panel Description

The rear panel of the T516 has the following connections (see Figure 2.2):

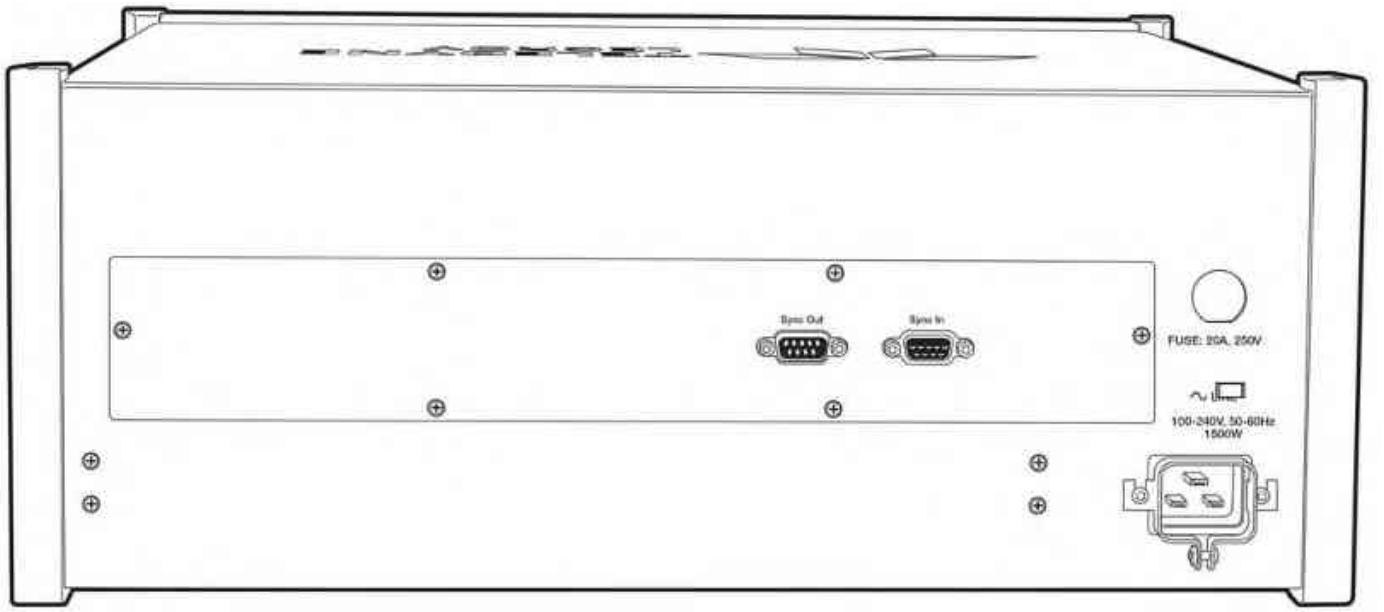


Figure 2.2: Summit T516 Analyzer: Rear Panel

The Connections are:

Wide-range AC Connector Power Socket: Enclosed 20.0 A, 250 V fuse

Sync In: Allows multiple Teledyne LeCroy analyzers to send synchronization and control messages to one another.

Sync Out: Allows multiple Teledyne LeCroy analyzers to send synchronization and control messages to one another.

WARNING: Do not open the enclosure. There are no operator serviceable parts inside. Refer servicing to Teledyne LeCroy.

2.5 Summit T54 Front Panel Description

When powered on, the Summit T54 activates the user-accessible controls and LEDs on the front panel. See Figure 2.3.

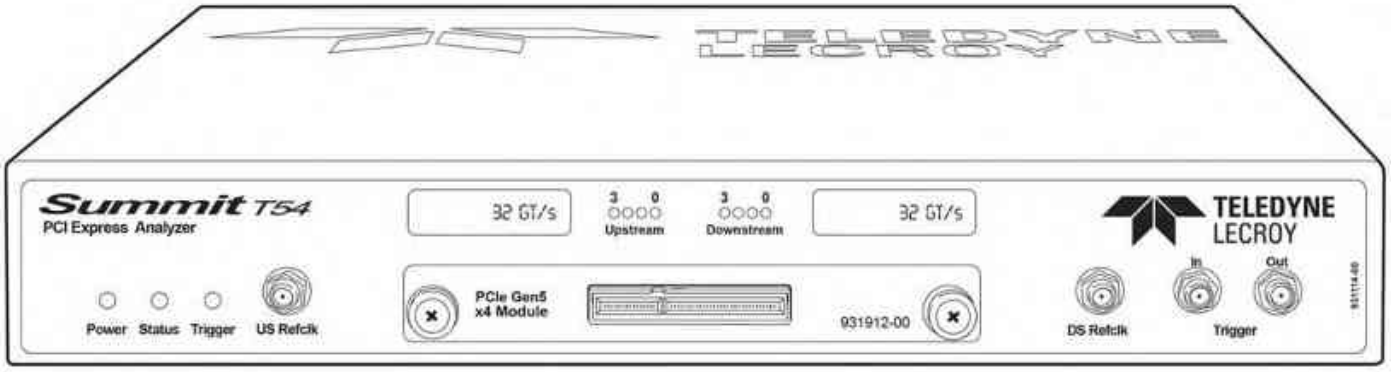


Figure 2.3: Summit T54: Front Panel

WARNING: Do not open the enclosure. There are no operator serviceable parts inside. Refer servicing to Teledyne LeCroy.

The controls and LEDs are:

Power LED: Lights when power is On.

Status LED: Displays the connection status of the link.

- Red – Error condition. Try using the PCIe Protocol Analysis application to clear the error. Please contact the factory if this does not work.
- Green – Configuring system.
- Blue – Unit ready/connected.

Trigger LED: Lights when Summit T54 triggers on an event.

US Refclk (Upstream Reference Clock Input): Provides an optional alternative connection from an external reference clock source to the Summit T54 analyzer Upstream direction.

Note: By default in the application software, the Summit T54 analyzer uses the reference clock from the interposer cable.

Speed LED Display: Indicates current speed the analyzer is using for the Upstream direction.

Upstream [3:0] LEDs: Indicates which Upstream Lanes are currently showing activity. OFF for electrical idle state, orange for activity with errors detected, green for normal operation.

PCIe Gen5.0 or Gen4.0 x4 Module: This module can be upgraded and replaced per installation instructions in “Swapping Front End Modules on the Summit T54” on page 11.

Upstream [3:0] and Downstream [3:0] connector: Connection to the probe for the capture of both upstream and downstream directions of the link.

Downstream [3:0] LEDs: Indicates which Downstream Lanes are currently showing activity. OFF for electrical idle state, orange for activity with errors detected, green for normal operation.

Speed LED Display: Indicates current speed the analyzer is using for the Downstream direction.

DS Refclk (Downstream Reference Clock Input): Provides an optional alternative connection from an external reference clock source to the Summit T54 analyzer Downstream direction. Note: By default in the application software, the Summit T54 analyzer uses the reference clock from the interposer cable.

Trigger: Provide external trigger capabilities. You can configure Summit T54 to trigger external equipment using Trigger Out. You can use Trigger In to trigger the Analyzer from another device.

- **In** for SMA external trigger input.
  - Trigger Input has a 1.5kohm pullup resistor to 3.3 volts and a 50 ohm RC termination
  - Threshold voltage for Trigger Input is 0.55 volts.
  - Voltages below 0.4 volts will be detected as low, voltages above 0.7 volts will be detected as high.
  - The minimal pulse width is 70 ns for rising pulses and 20 us for falling pulses
  - When Internal Triggering option is selected in the recording options, any edge of this signal will cause the analyzer to trigger.
- **Out** for SMA external trigger output.
  - Output buffer is 3.3 volts. The buffer can drive up to 32 mA of current and meet VOH (2.5 V) and VOL (0.5 V) thresholds.
  - Output buffer can drive a 50 ohm DC load (such as scope input).

2.6 Summit T54 Rear Panel Description

The rear panel of the T54 has the following connections (see Figure 2.4):

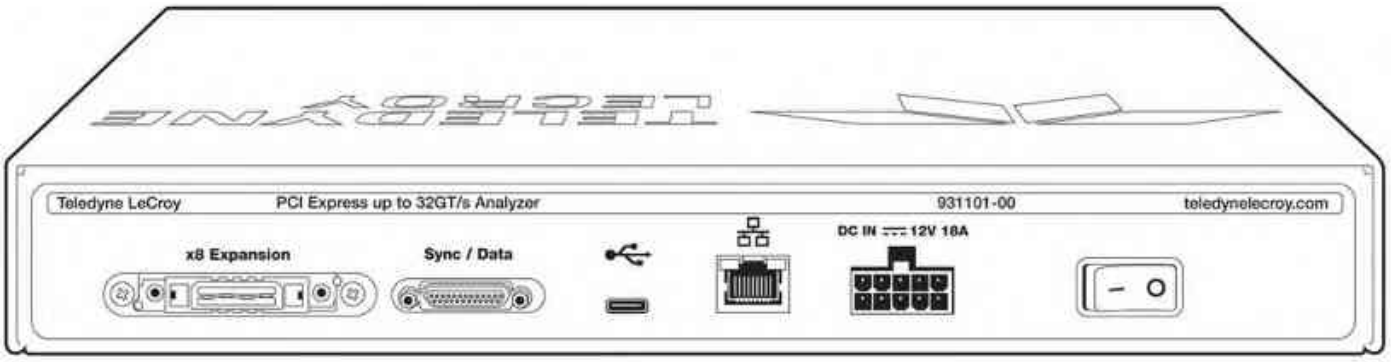


Figure 2.4: Summit T54 Analyzer: Rear Panel

The Connections are:

x8 Expansion: Used to connect two T54 systems using a special cable to record x8 traffic.

Sync/Data: Use a special cable to allow multiple Teledyne LeCroy analyzers to send synchronization and control messages to one another. This connection is also required for x8 Expansion.

USB Type C Host Machine Connector: To connect the Analyzer to the host machine using a USB connection.

Ethernet Port: 1 GIGE Connectivity allows connection to the analyzer through an Ethernet network.

DC IN: 12V, 18A

Power Switch (black): 1 = On and 0 = Off

WARNING: Do not open the enclosure. There are no operator serviceable parts inside. Refer servicing to Teledyne LeCroy.

2.7 Swapping Front End Modules on the Summit T54

By default the Summit T54 will be configured as Gen5 but if the unit has been configured as Gen4 you can upgrade to the faster speed and swap the front end Phy module. To change analysis capabilities is fairly simple:

1. Disconnect the Summit T54 from the power supply.
2. Unscrew the two large thumbscrews on the front panel.
3. Pull out existing module.
4. Carefully insert the new Analysis Module and ensure that it's connector seats with the corresponding socket.
5. Tighten the thumbscrews.
6. Turn on power & wait for the unit to initialize.



Figure 2.5: Unscrew Large Thumbscrews



Figure 2.6: Pull Out PCIe 4.0 Module



Align PCIe 5.0 x4 Module with card guides

Figure 2.7: Align PCIle 5.0 Module



Carefully insert PCIe 5.0 x4 Module and tighten thumbscrews

Figure 2.8: Insert and Secure PCIe 5.0 Module to Summit T54 Analyzer

2.8 Interposers and Probes

The Summit T516/T54 support a full range of Teledyne LeCroy PCIe legacy, Gen4 and Gen5 Interposers and probes, including:

Part Number	Description	Cable/Comments
PE180UIA-X	Gen4 x1 MultiPort Capable Slot Interposer	PE020UCA-X Gen4 x4 Straight Cable
PE181UIA-X	Gen4 x4 MultiPort Capable Slot Interposer	
PE186UIA-X	Gen4 x4 M.2 M-Key Interposer	
PE200UIA-X	Gen4 EDSFF Interposer	
PE163UIA-X	Gen4 x8 OCuLink Cable Interposer	PE021UCA-X Gen4 x8 Y-Cable
PE182UIA-X	Gen4 x8 MultiPort Capable Slot Interposer	
With older generation interposers Gen2 and Gen3 up to x4		PE026UCA-X Gen3/Gen2 Interposer to Gen4 High Speed Connector Adapter Straight Cable
With older generation interposers Gen2 and Gen3 up to x8 and Summit T54 in Expanded Mode		PE016UCA-X Gen3/Gen2 Interposer to Gen4 High Speed Connector Adapter Cable
PE100ACA-X	Gen4 x8 Multi-Lead Cable	SMA connectors Lane 7 to Lane 0 should be used as follows: Lane 3 - Lane 0 connect to PCIe downstream lanes 3-0 Lane 7 - Lane 4 connect to PCIe upstream lanes 3-0 Connect the P SMA to the p end of the PCIe differential pair and the N SMA to the n end of the PCIe differential pair.
PE105ACA-X	Gen4 x8 MidBus Cable	Flying leads for Lane 7 to Lane 0 should be used as follows: Lane 3 - Lane 0 connect to PCIe downstream lanes 3-0 Lane 7 - Lane 4 connect to PCIe upstream lanes 3-0.
PE188UIA-X	Gen4 U.2/U.3 standard 12 Inch Interposer for NVMe x4/x2	Summit T54 Analyzer with Gen4 PHY and U.3 DUT use PE032UCA-X Gen4 x4 U.3 Straight Cable Summit T54 Analyzer with Gen4 PHY and U.2 DUT use PE020UCA-X Gen4 x4 Straight cable Summit T54 Analyzer with Gen5 PHY and U.2 DUT use PE034UCA-X Gen4 to Gen5 x4 Straight Conversion cable
PE202UIA-X	Gen5 x8 MultiPort Capable Slot Interposer	PE027UCA-X Gen5 x4 Straight Cable PE028UCA-X Gen5 x8 Y Cable for Expanded Mode
PE207UIA-X	Gen5 x16 MultiPort Capable Slot Interposer	PE028UCA-X Gen5 x8 Y Cable for Expanded Mode

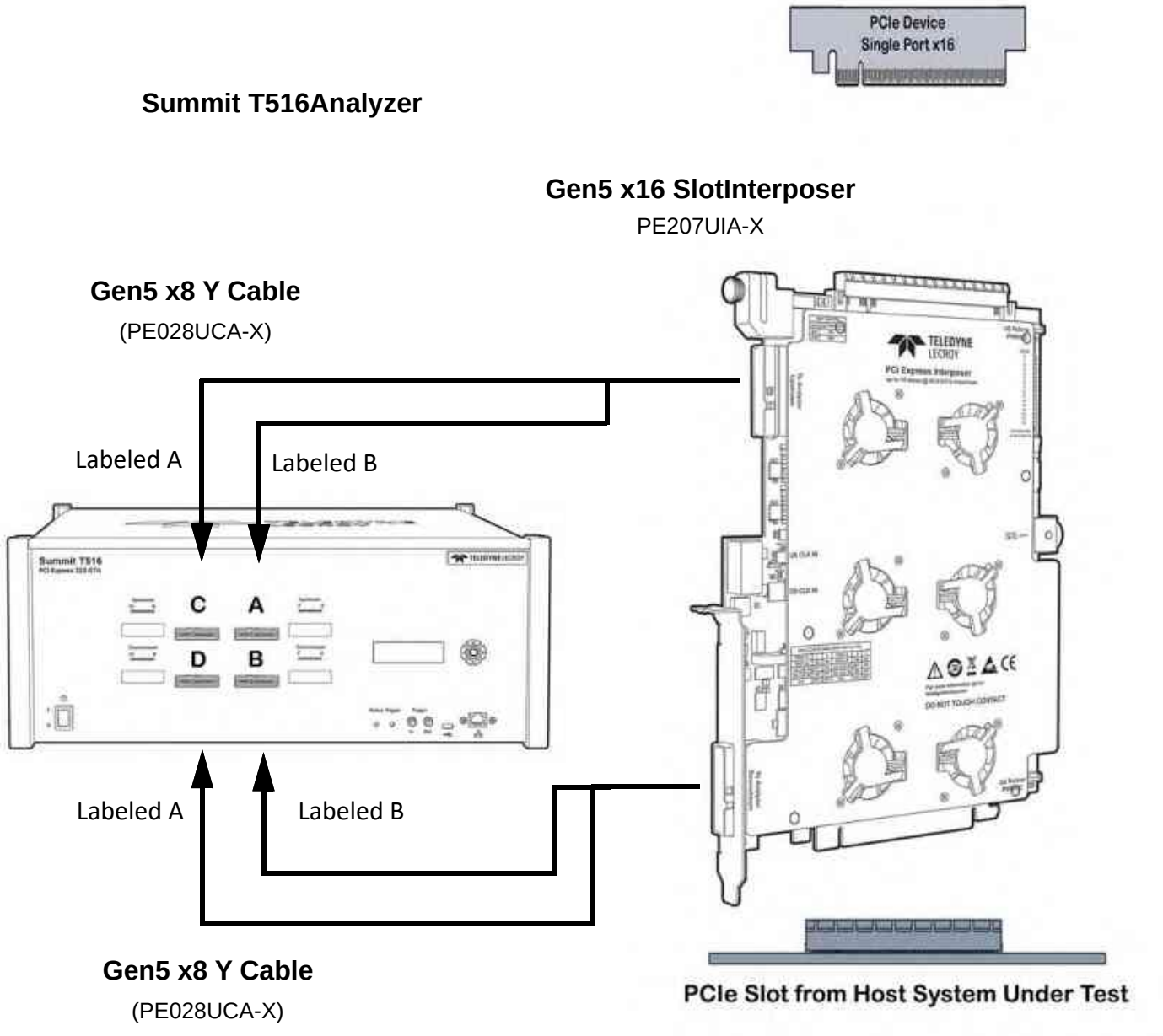
WARNING: Interposer has electrostatic-sensitive components.
Handle only at static-safe work stations.

2.9 Summit T516 Analyzer/Cable/Interposer Connection Diagrams

There are four methods for connecting the Summit T516 Analyzer to Gen5 and Gen4 Interposers:

- When connecting a Summit T516 Analyzer with a Gen5 x16 interposer you must use two Gen5 x8 Y cables. See “Summit T516 using Gen5 x16 Interposer” on page 15.
- When connecting a Summit T516 Analyzer with a Gen5 x8 interposer you must use one Gen5 x8 Y cable. See “Summit T516 using Gen5 x8 Interposer” on page 16.
- When connecting a Summit T516 Analyzer with a Gen4 x16 interposer you must use two Gen4 x8 Y conversion cables. See “Summit T516 using Gen4 x16 Interposer” on page 17.
- When connecting a Summit T516 Analyzer with a Gen4 x8 interposer you must use one Gen4 x8 Y conversion cable. See “Summit T516 using Gen4 x8 Interposer” on page 18.

2.9.1 Summit T516 using Gen5 x16 Interposer

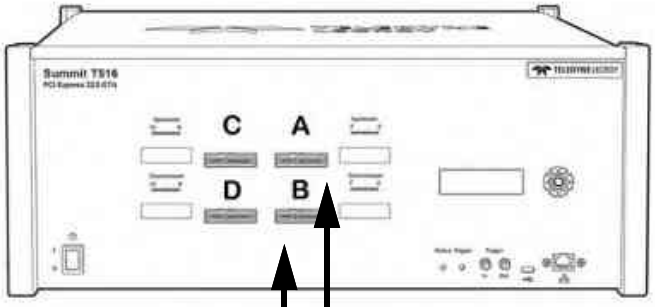


Connection diagram for single port up to x16 using a Gen5 Interposer

Figure 2.9: Summit T516 with Gen5 x16 Interposer

2.9.2 Summit T516 using Gen5 x8 Interposer

Summit T516Analyzer



Labeled B

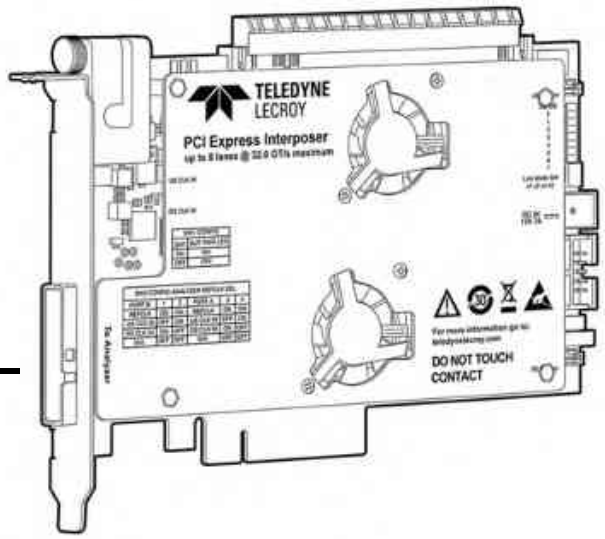
Downstream[7:0]

Labeled A

Upstream[7:0]

PCI Express 5.0 x8 Slot Interposer (MultiPort capable)

(PE202UIA-X)



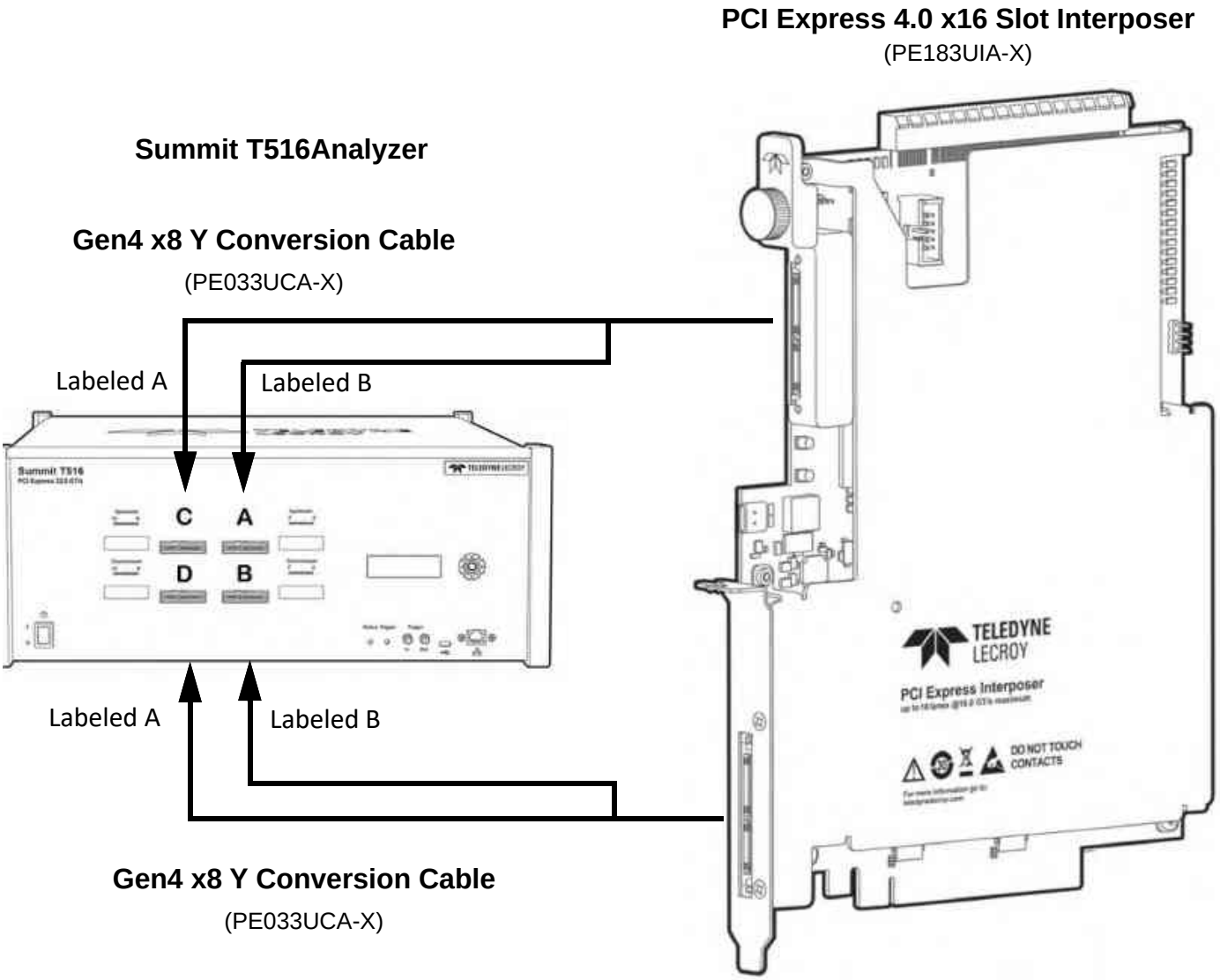
Gen5 x8 Y Cable

(PE028UCA-X)

Connection diagram for single port up to x8 using a Gen5 Interposer

Figure 2.10: Summit T516 with Gen5 x8 Interposer

2.9.3 Summit T516 using Gen4 x16 Interposer

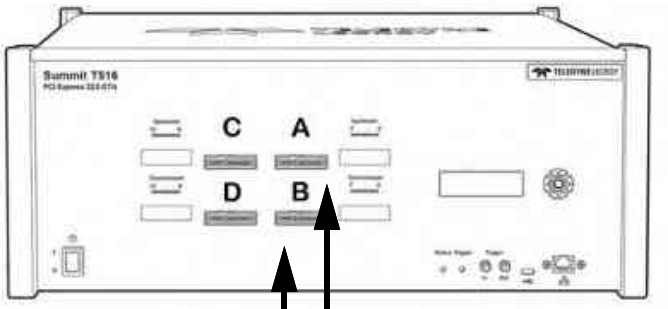


Connection diagram for single port up to x16 using a Gen4 Interposer

Figure 2.11: Summit T516 with Gen4 x16 Interposer

2.9.4 Summit T516 using Gen4 x8 Interposer

Summit T516Analyzer



Labeled B

Downstream[7:0]

Labeled A

Upstream[7:0]

PCI Express 4.0 x8 Slot Interposer

(PE182UIA-X)



Gen4 x8 Y Conversion Cable

(PE033UCA-X)

Connection diagram for single port up to x8 using a Gen4 Interposer

Figure 2.12: Summit T516 with Gen4 x8 Interposer

2.10 Summit T54 Analyzer/Cable/Interposer Connection Diagrams

There are four methods for connecting the Summit T54 with Gen5/Gen4 Phy plug-in modules to Gen5 and Gen4 Interposers:

- When connecting a Summit T54 Analyzer with a Gen5 Phy you must use a Gen5 straight cable when connecting to a Gen5 Interposer
  See “Summit T54 (with Gen5 PHY) Connection to Gen5 Interposer” on page 20.
- When connecting a Summit T54 Analyzer with a Gen5 Phy you must use a Gen5 to Gen4 conversion cable when connecting to a Gen4 Interposer
  “Summit T54 (with Gen5 PHY) Connection to Gen4 Interposer” on page 24.
- When connecting a Summit T54 Analyzer with a Gen4 Phy you must use a Gen4 straight cable when connecting to a Gen4 Interposer
  “Summit T54 (with Gen4 PHY) Connection to Gen4 Interposer” on page 25.
- When connecting a Summit T54 Analyzer with a Gen4 Phy you must use a Gen4 to Gen5 conversion cable when connecting to a Gen5 Interposer
  “Summit T54 (with Gen4 PHY) Connection to Gen5 Interposer” on page 29.

A wide variety of interconnection diagrams are shown in the following sections to configure two Summit T54s in Expanded mode to analyze up to 8 lanes of traffic:

- “Two Summit T54s (with Gen5 PHY) in Expanded Mode Connection to Gen5 Interposer” on page 22.
- “Two Summit T54s (with Gen5 PHY) in Expanded Mode Connection to Gen5 x16 Interposer” on page 23.
- “Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen4 x8 Interposer” on page 27.
- “Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen5 Interposer” on page 30.
- “Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen5 x16 Interposer” on page 31.
- “Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen3 x8 Interposer” on page 35.

There is also a connection diagram for connecting the Summit T54 with Gen4 Phy to a Gen4 U.2/U.3 Interposer using a straight cable. See “Summit T54 (with Gen4 PHY) Connection to Gen4 U.2/U.3 Interposer using Gen4 x4 U.3 Straight Cable” on page 32.

There is also a connection diagram for connecting the Summit T54 with Gen5 Phy to a Gen4 U.2/U.3 Interposer using a straight conversion cable. See “Summit T54 (with Gen5 PHY) Connection to Gen4 U.2/U.3 Interposer using Gen4 to Gen5 x4 Straight Conversion Cable” on page 33.

To connect the Summit T54 with Gen4 Phy to a Gen3 Interposer see “Summit T54 (with Gen4 PHY) Connection to Gen3 Interposer” on page 34.

2.10.1 Summit T54 (with Gen5 PHY) Connection to Gen5 Interposer

Single Port x4 DUT

Summit T54 (with Gen5 PHY) in Standard Mode connected to Gen5 x8 Interposer (PE202UIA-X) with Gen5 x4 Straight Cable (PE027UCA-X). In this mode you can analyze a DUT with a single port x4 bus.

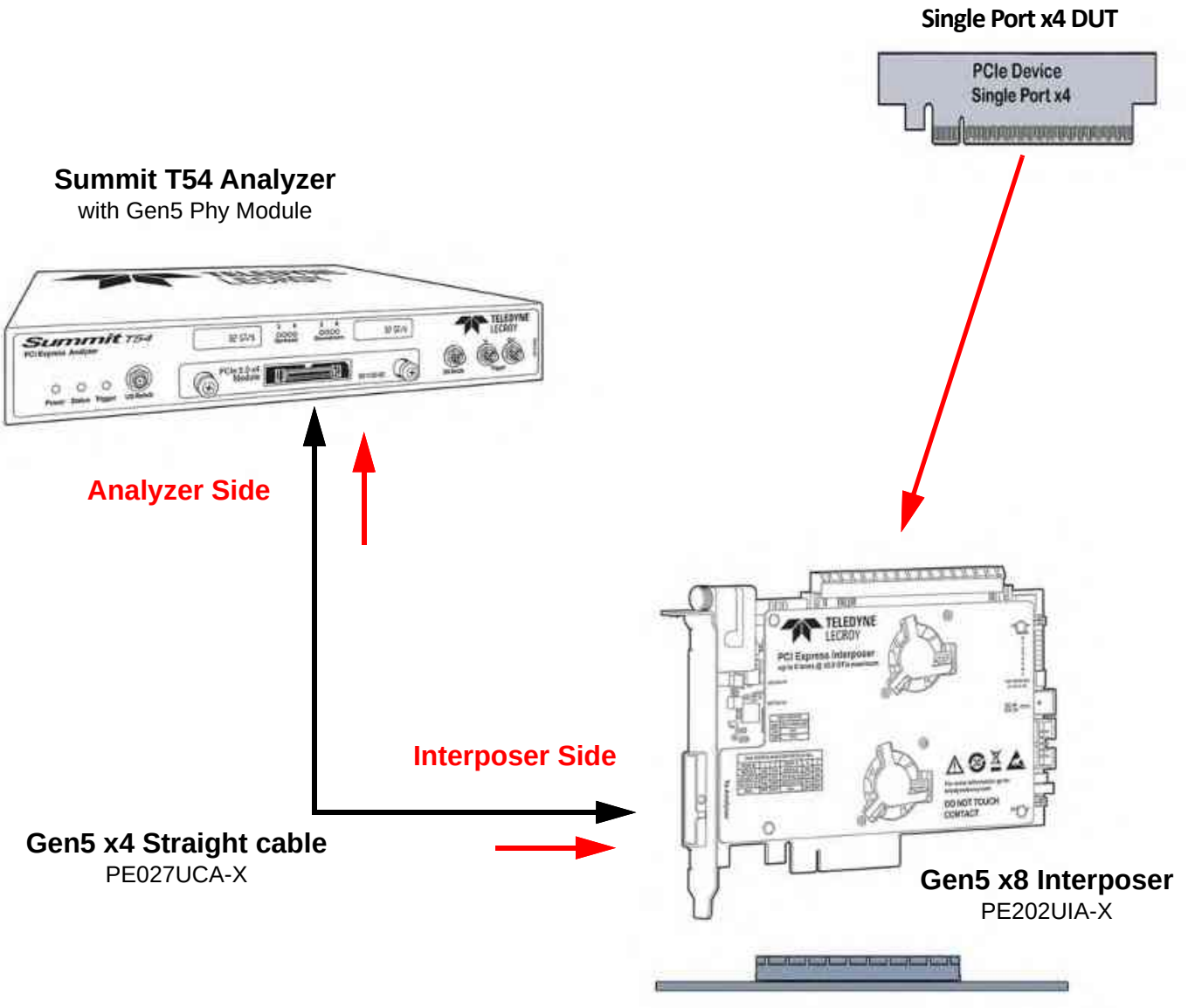


Figure 2.13: Summit T54 Gen5 PHY with Gen5 x8 Interposer (Single Port DUT)

Dual Port x2 DUT

Summit T54 (with Gen5 PHY) in Multiport Mode connected to Gen5 x8 Interposer (PE202UIA-X) with Gen5 x4 Straight Cable (PE027UCA-X). In this mode you can analyze a DUT with a dual port x2 buses.

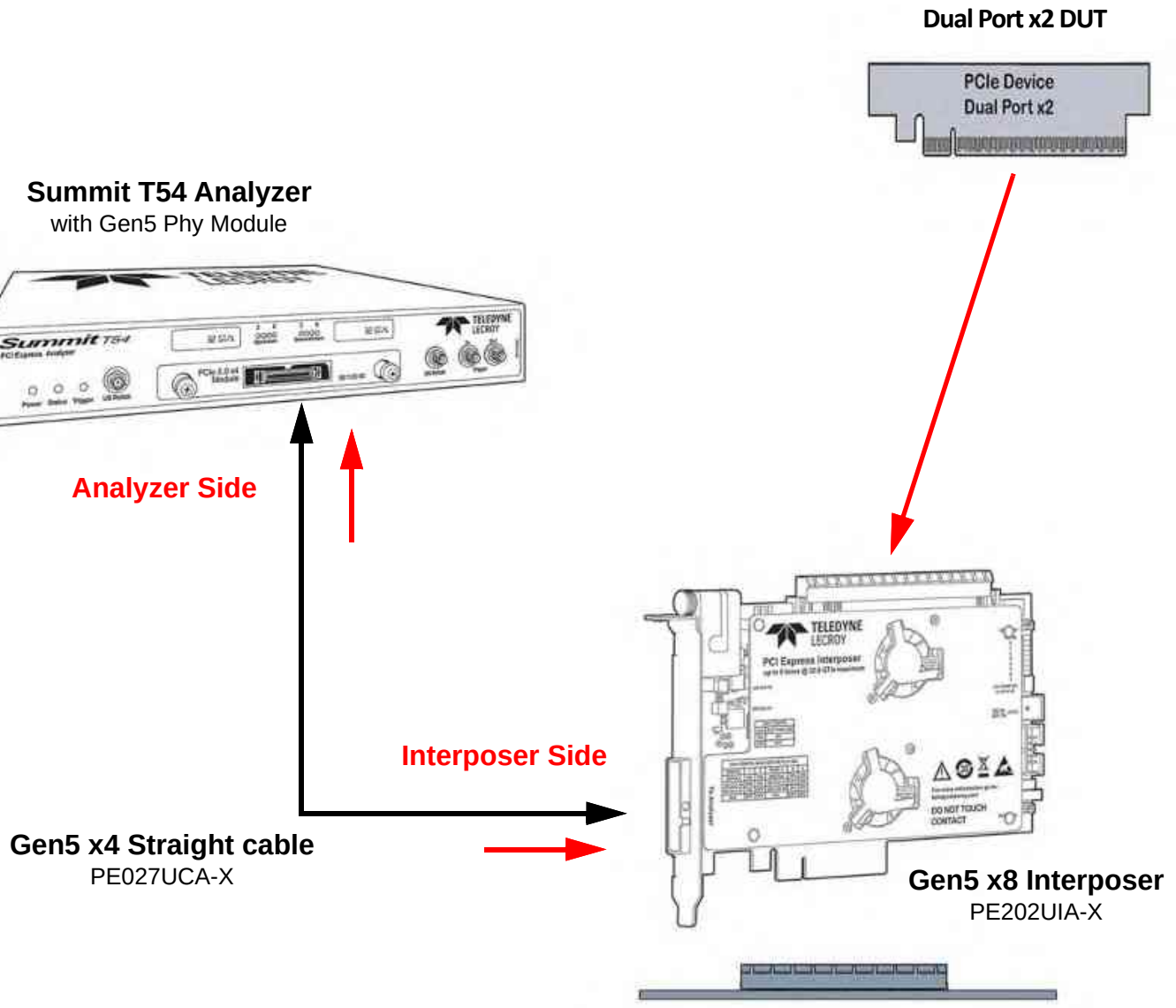


Figure 2.14: Summit T54 Gen5 PHY with Gen5 x8 Interposer (Dual Port DUTs)

2.10.1.1 Two Summit T54s (with Gen5 PHY) in Expanded Mode Connection to Gen5 Interposer

Two Summit T54s (with Gen5 PHYs and in Expanded Mode) connected to Gen5 x8 Interposer (PE202UIA-X) with Gen5 x8 Y Cable (PE028UCA-X). Up to 8 lanes can be analyzed in this configuration (x8 analysis).

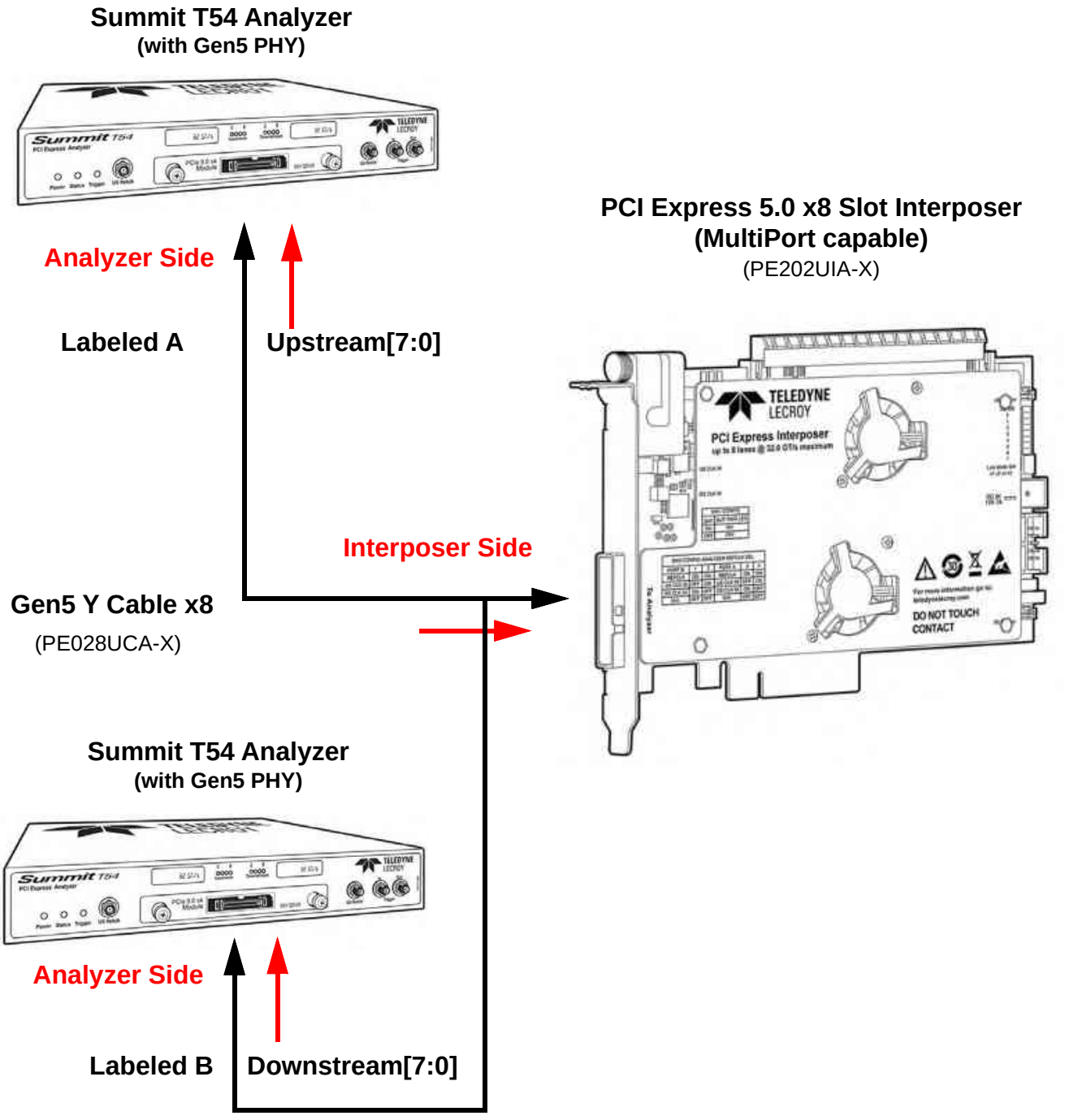


Figure 2.15: Summit T54 with Gen5 PHY connected in Expanded Link Mode

See "Two Summit T54s Configured in Link Width Expansion Mode" on page 739 for more details.

2.10.1.2 Two Summit T54s (with Gen5 PHY) in Expanded Mode Connection to Gen5 x16 Interposer

Two Summit T54s (with Gen5 PHYs and in Expanded Mode) connected to Gen5 x16 Interposer (PE207UIA-X) with two Gen5 x8 Y Cables (PE028UCA-X). Up to 8 lanes can be analyzed in this configuration (x8 analysis).

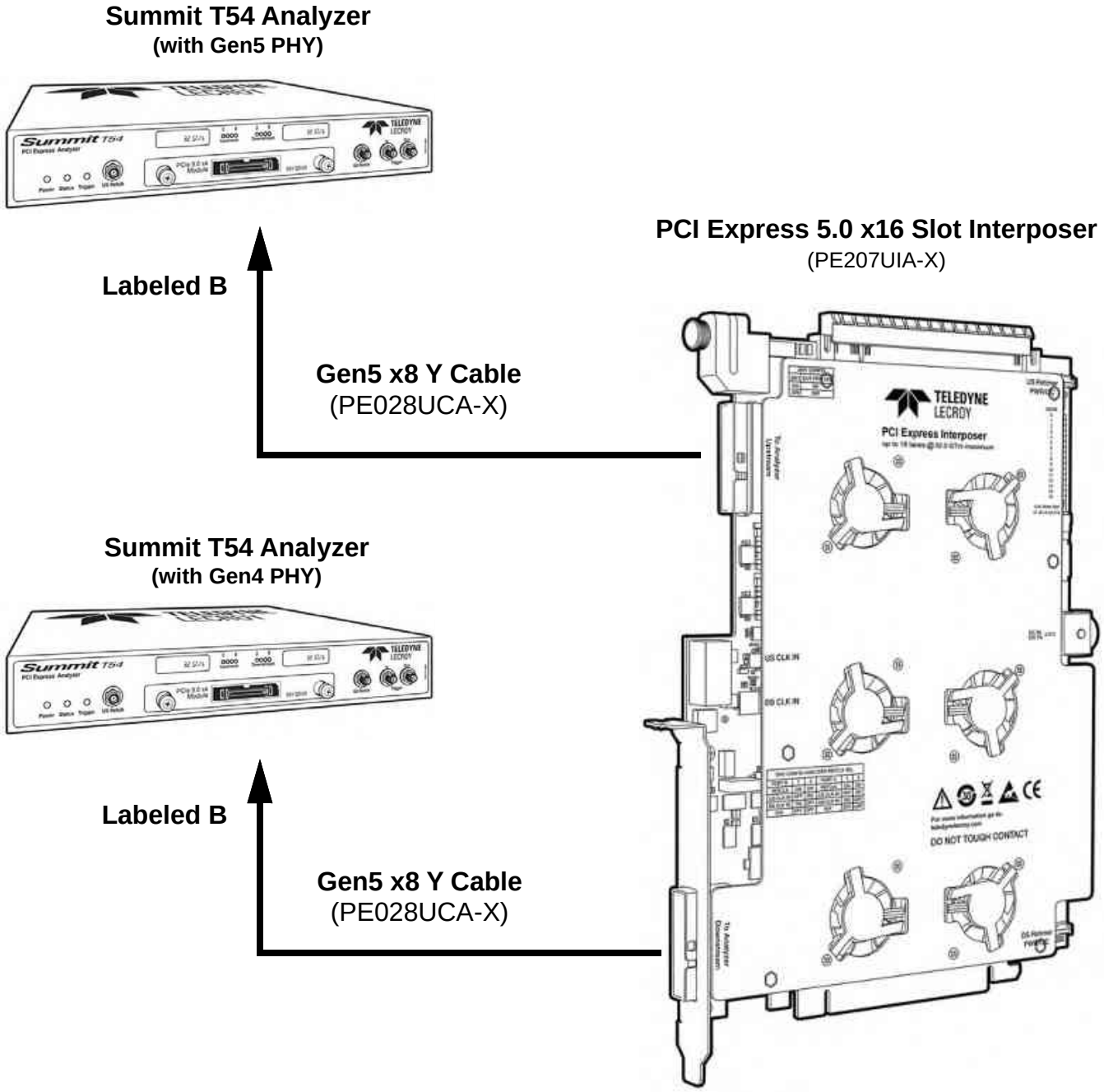


Figure 2.16: Summit T54 with Gen5 PHY connected in Expanded Link Mode

2.10.2 Summit T54 (with Gen5 PHY) Connection to Gen4 Interposer

Summit T54 (with Gen5 PHY) in Standard Mode connected to Gen4 x4 Interposer (PE181UIA-X) with Gen5 to Gen4 x4 Straight Conversion Cable (PE034UCA-X). In this mode you can analyze a DUT with a single port x4 bus.

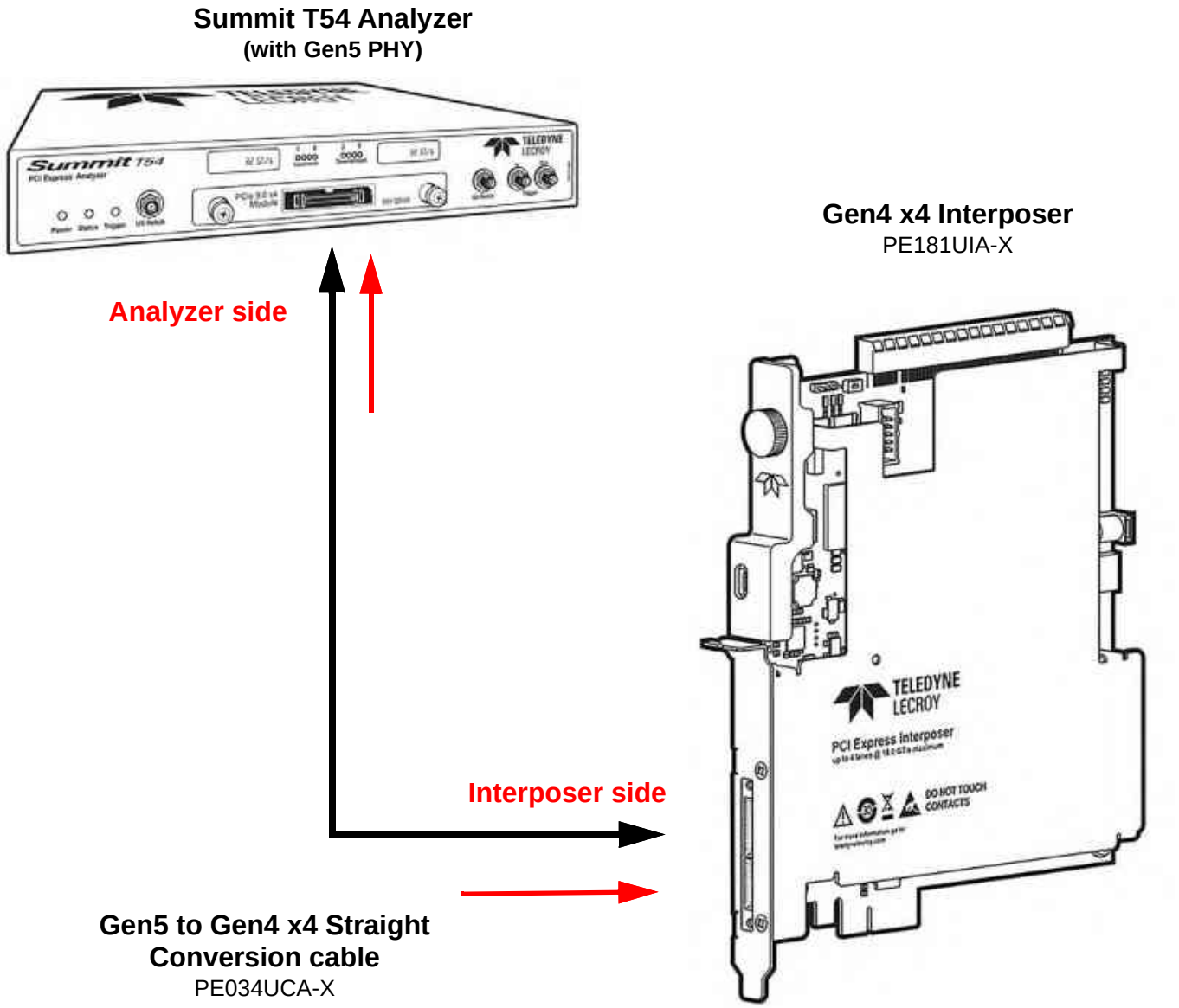


Figure 2.17: Summit T54 with Gen5 PHY connected with Gen5 to Gen4 x4 Straight Conversion Cable to Gen4 x4 Interposer

2.10.3 Summit T54 (with Gen4 PHY) Connection to Gen4 Interposer

Single Port x4 DUT

Summit T54 (with Gen4 PHY) connected to Gen4 x4 Interposer (PE181UIA-X) with a Gen4 x4 Straight Cable (PE020UCA-X). In this mode you can analyze a single port x4 DUT.

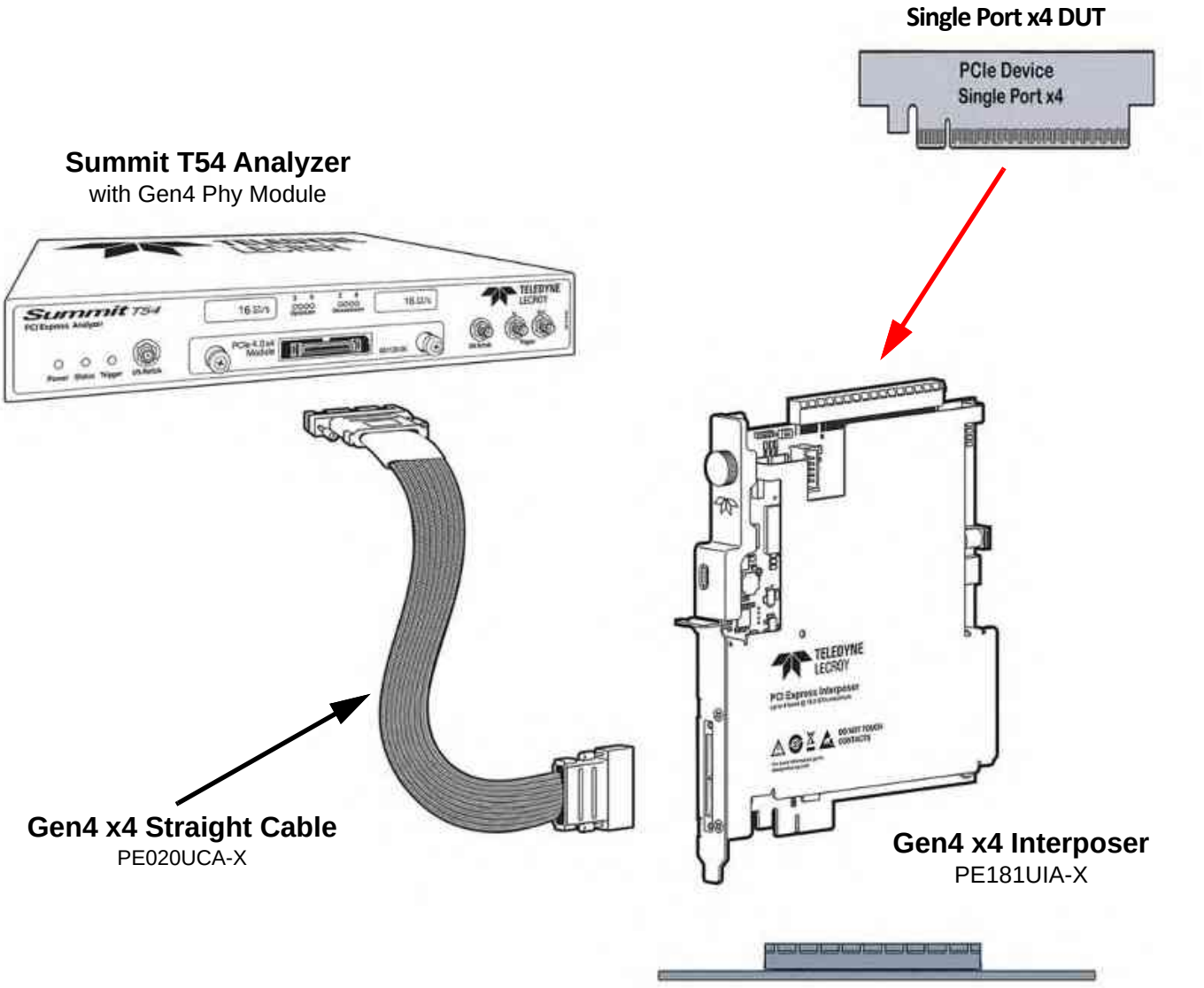


Figure 2.18: Summit T54 Gen4 PHY with Gen4 x4 Interposer (Single Port x4 DUT)

Dual Port x2 DUT

Summit T54 (with Gen4 PHY and in Multiport Mode) connected to Gen4 x4 Interposer (PE181UIA-X) with Gen4 x4 Straight Cable (PE020UCA-X). In this mode you can analyze a dual port x2 DUT.

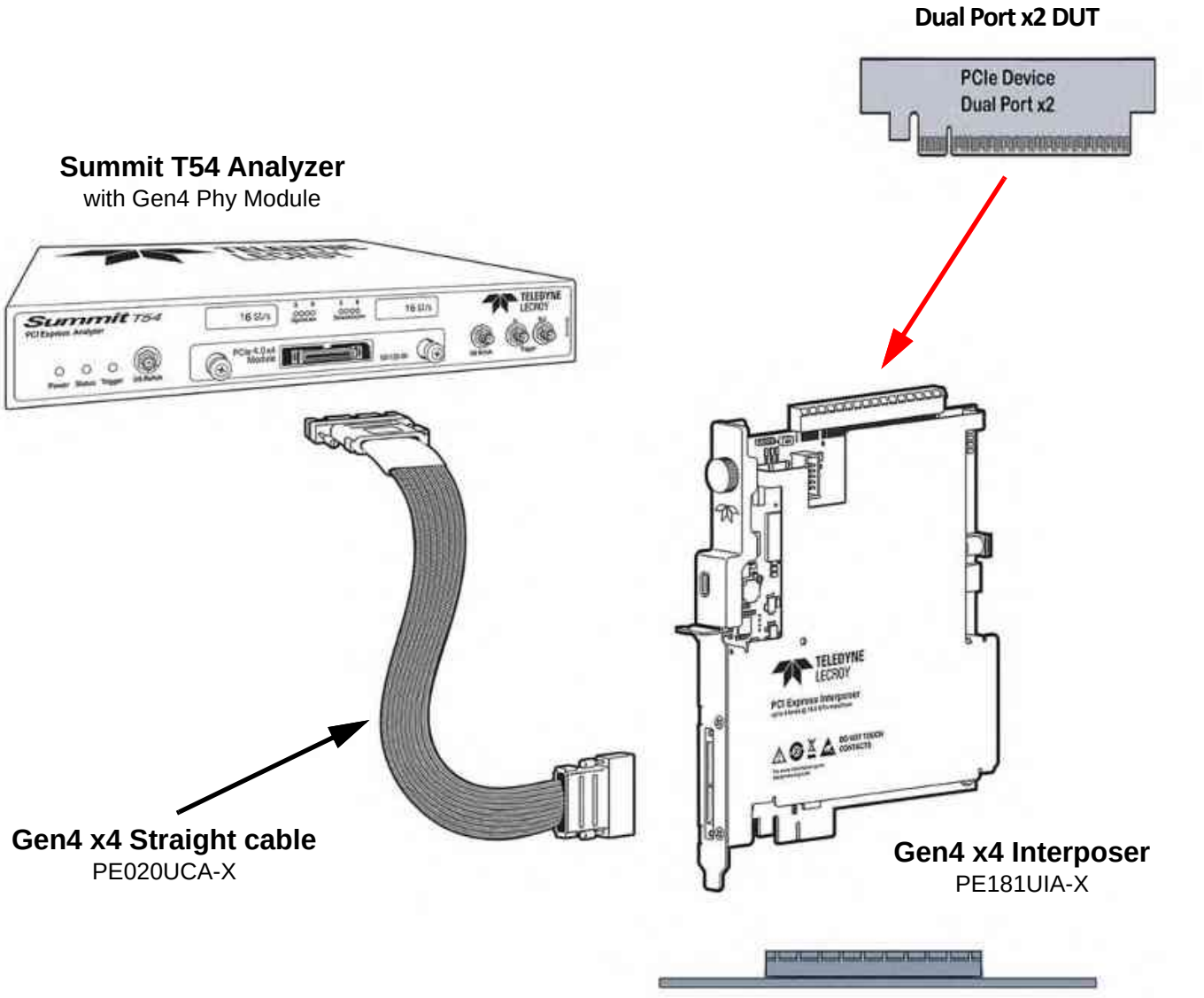


Figure 2.19: Summit T54 Gen4 PHY with Gen4 x4 Interposer (Dual Port x2 DUT)

2.10.3.1 Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen4 x8 Interposer

Two Summit T54s (with Gen4 PHYs and in Expanded Mode) connected to Gen4 x8 Interposer (PE182UIA-X) with Gen4 x8 Y Cable (PE021UCA-X). Up to 8 lanes can be analyzed in this configuration (x8 analysis).

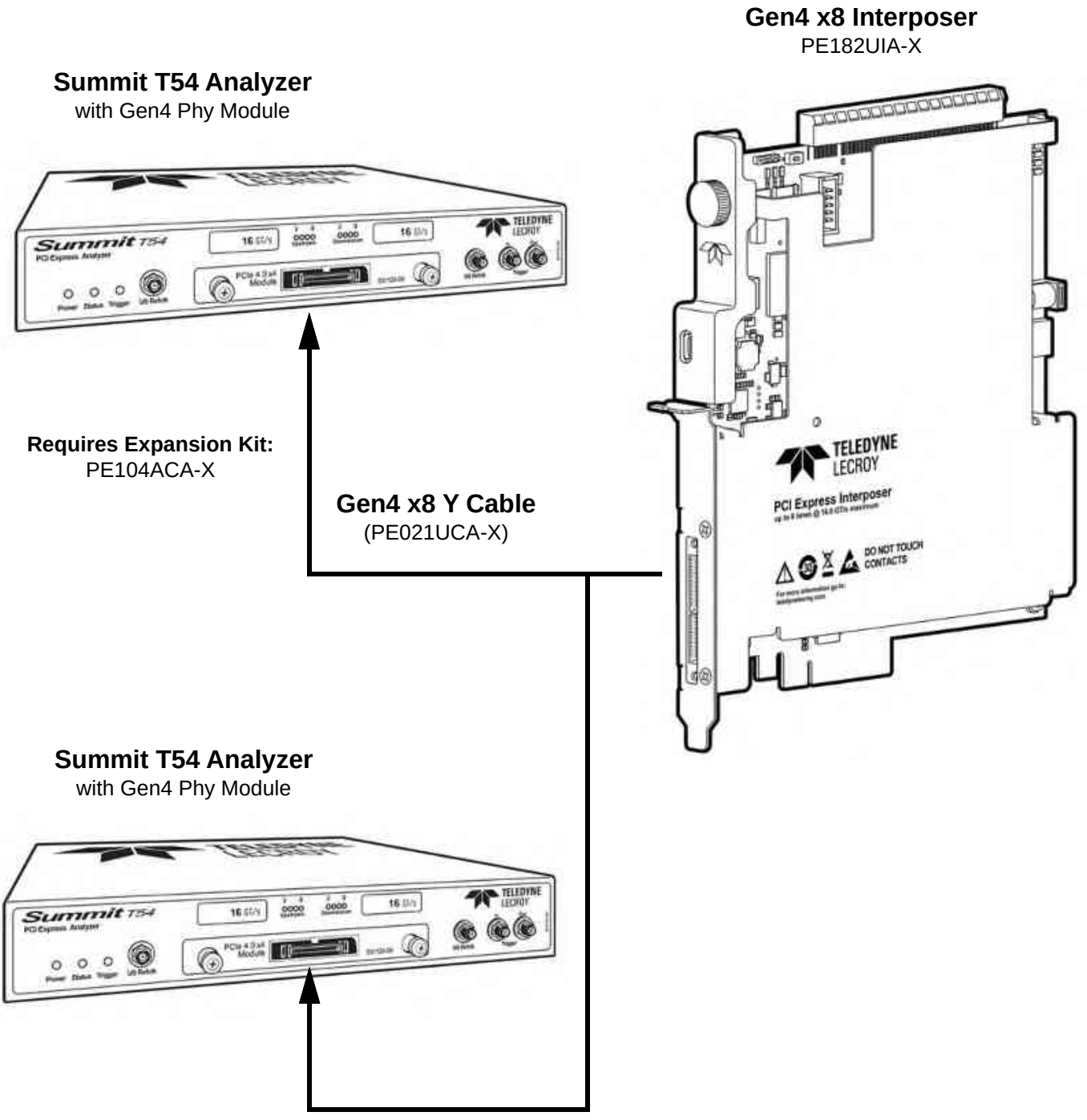


Figure 2.20: Expanded Mode Summit T54s: Gen4 x8 Interposer with iPass Y- Conversion cable

Two Summit T54s (with Gen4 PHYs and in Expanded Mode) connected to Gen4 x8 Cable attached Interposer (PE123UIA-X). Up to 8 lanes can be analyzed in this configuration (x8 analysis).

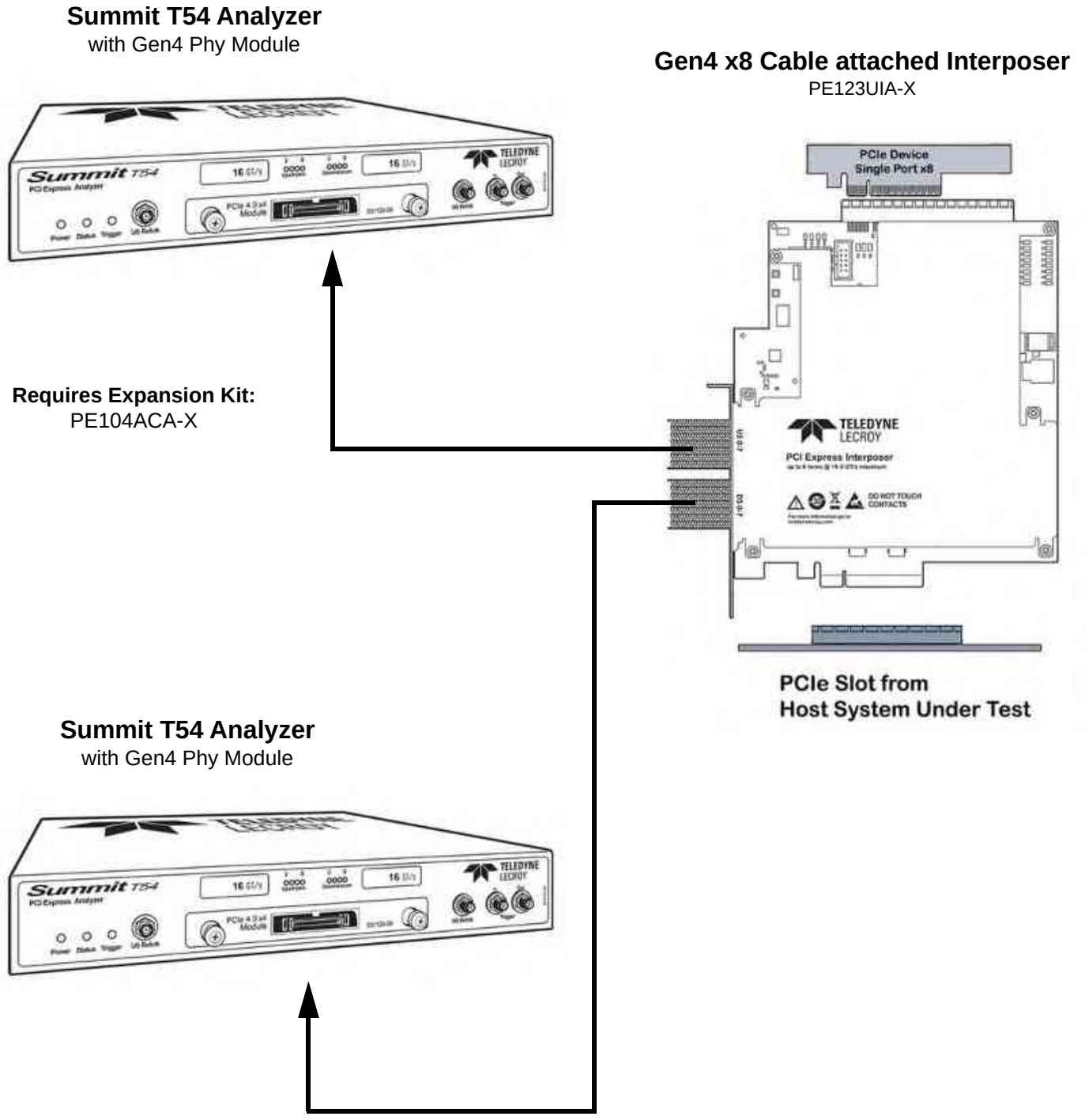


Figure 2.21: Expanded Mode T54s: Gen4 x8 Interposer cable attached connection

2.10.4 Summit T54 (with Gen4 PHY) Connection to Gen5 Interposer

Summit T54 (with Gen4 PHY) connected to Gen5 x4 Interposer (PE202UIA-X) with Gen4 to Gen5 x4 Straight Conversion Cable (PE030UCA-X).

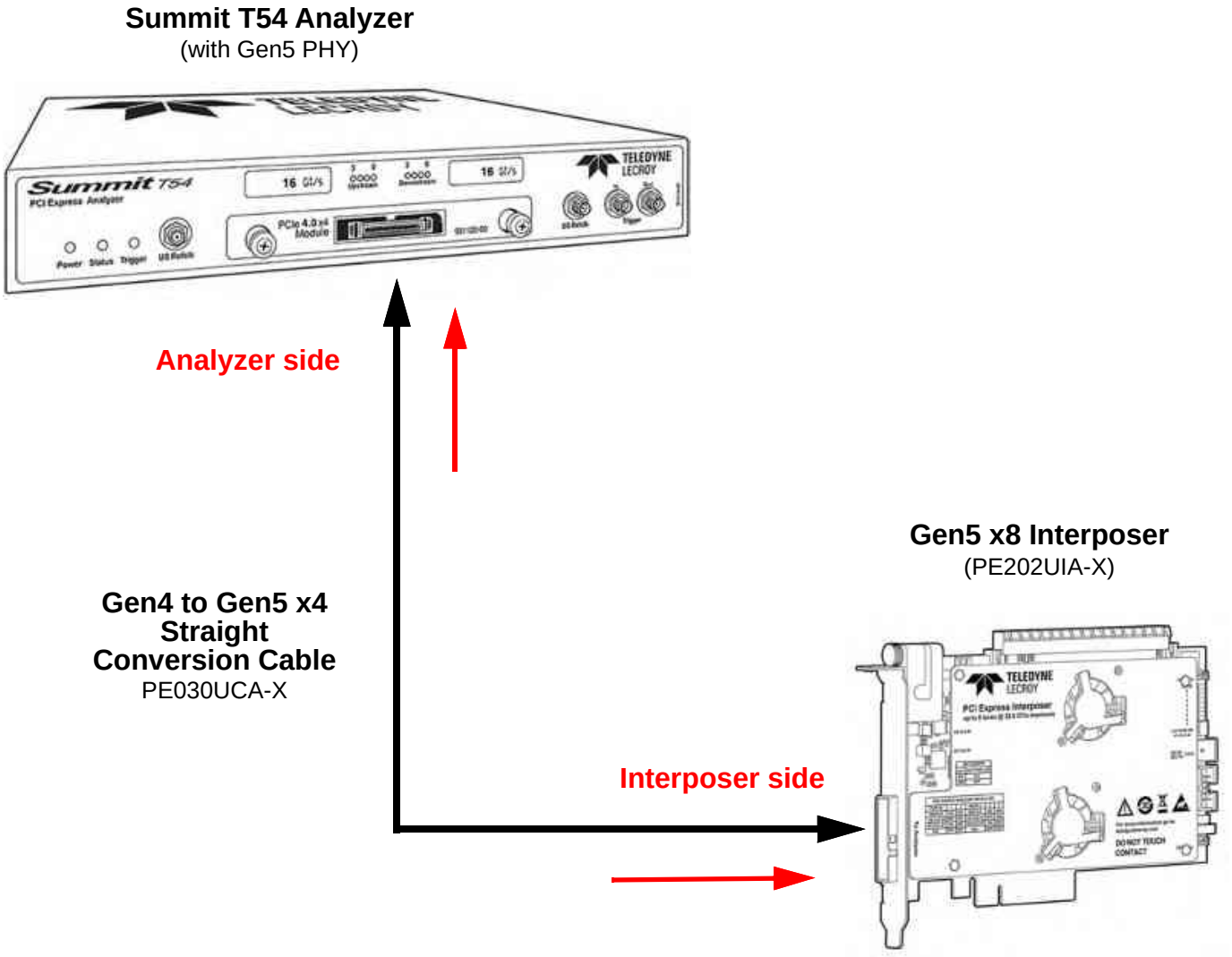


Figure 2.22: Connection diagram for a single port up to x4 using a Gen5 x4/x8 Interposer

2.10.4.1 Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen5 Interposer

Two Summit T54s (with Gen4 PHYs and in Expanded Mode) connected to Gen5 x8 Interposer (PE202UIA-X) with Gen4 to Gen5 Y Conversion Cable (PE031UCA-X). Up to 8 lanes can be analyzed in this configuration (x8 analysis).

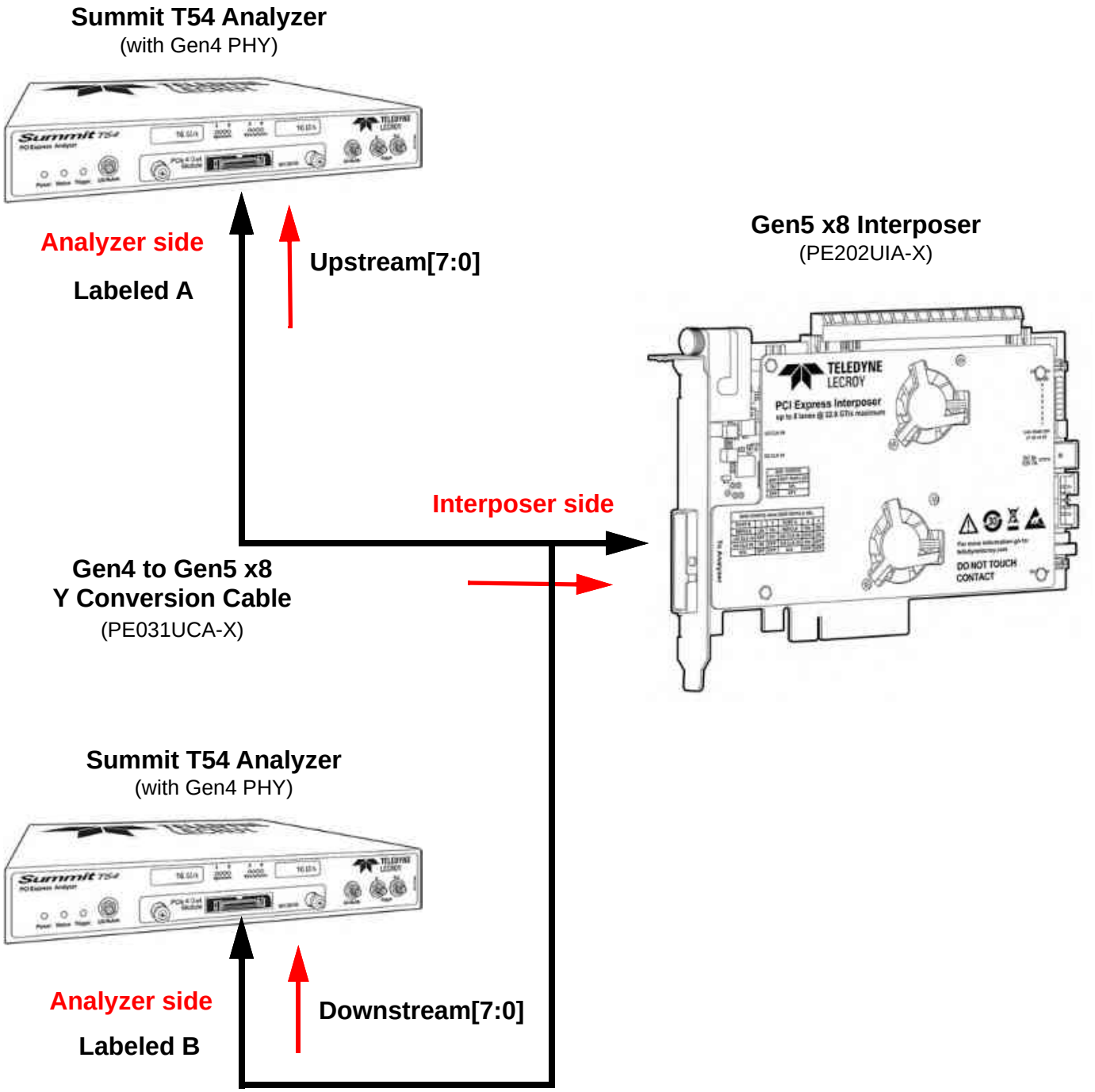


Figure 2.23: Connection diagram for single port up to x8 using a Gen5 x8 Interposer with two Summit T54s in Expanded Mode

2.10.4.2 Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen5 x16 Interposer

Two Summit T54s (with Gen4 PHYs and in Expanded Mode) connected to Gen5 x16 Interposer (PE207UIA-X) with Gen4 to Gen5 x8 Y Conversion Cable (PE031UCA-X). Up to 8 lanes can be analyzed in this configuration (x8 analysis).

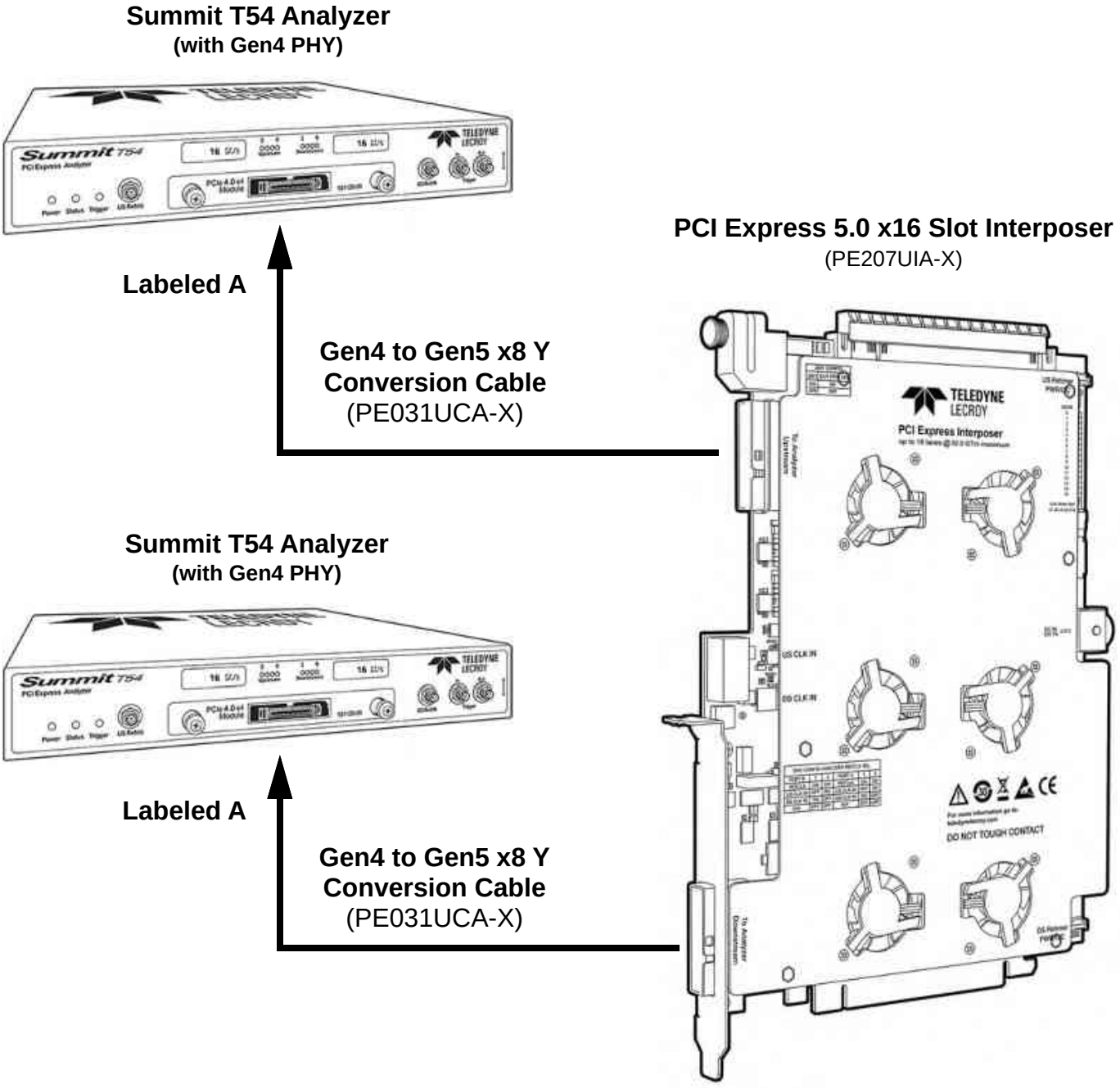


Figure 2.24: Summit T54 with Gen4 PHY connected in Expanded Link Mode

2.10.5 Summit T54 (with Gen4 PHY) Connection to Gen4 U.2/U.3 Interposer using Gen4 x4 U.3 Straight Cable

Summit T54 (with Gen4 PHY) can be connected to a Gen4 U.2/U.3 x4 Interposer (PE188UIA-X) with a Gen4 x4 U.3 Straight Cable (PE032UCA-X) is shown below (see Note for other configurations).

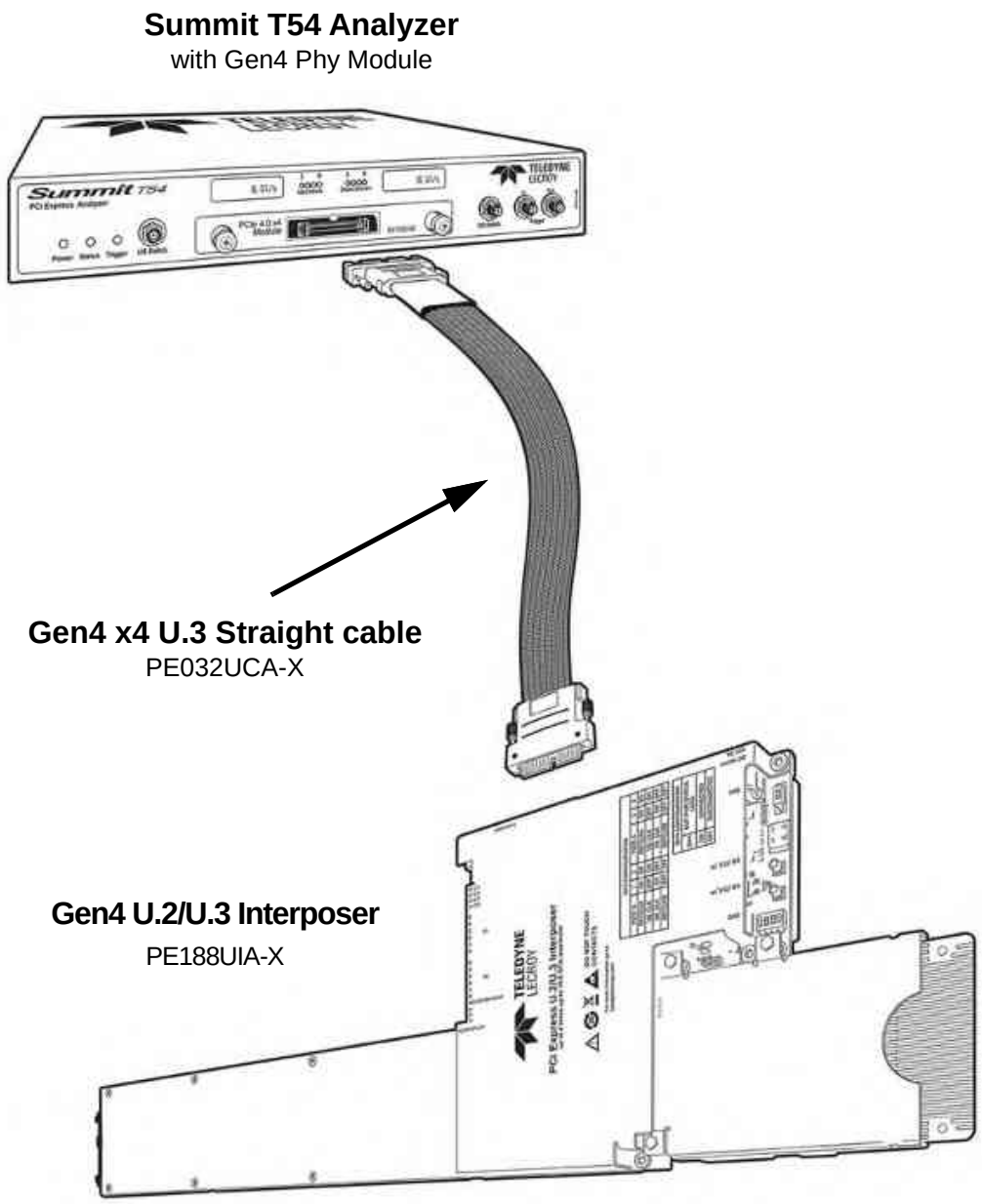


Figure 2.25: Gen4 U.2/U.3 x4 Interposer Connected to Summit T54 with Gen4 x4 U.3 Straight Cable

For more information see Figure 2.26 on page 33.

2.10.6 Summit T54 (with Gen5 PHY) Connection to Gen4 U.2/U.3 Interposer using Gen4 to Gen5 x4 Straight Conversion Cable

Summit T54 (with Gen5 PHY) can be connected to a Gen4 U.2/U.3 x4 Interposer (PE188UIA-X) with a Gen4 to Gen5 x4 Straight Conversion Cable (PE035UCA-X) is shown below.

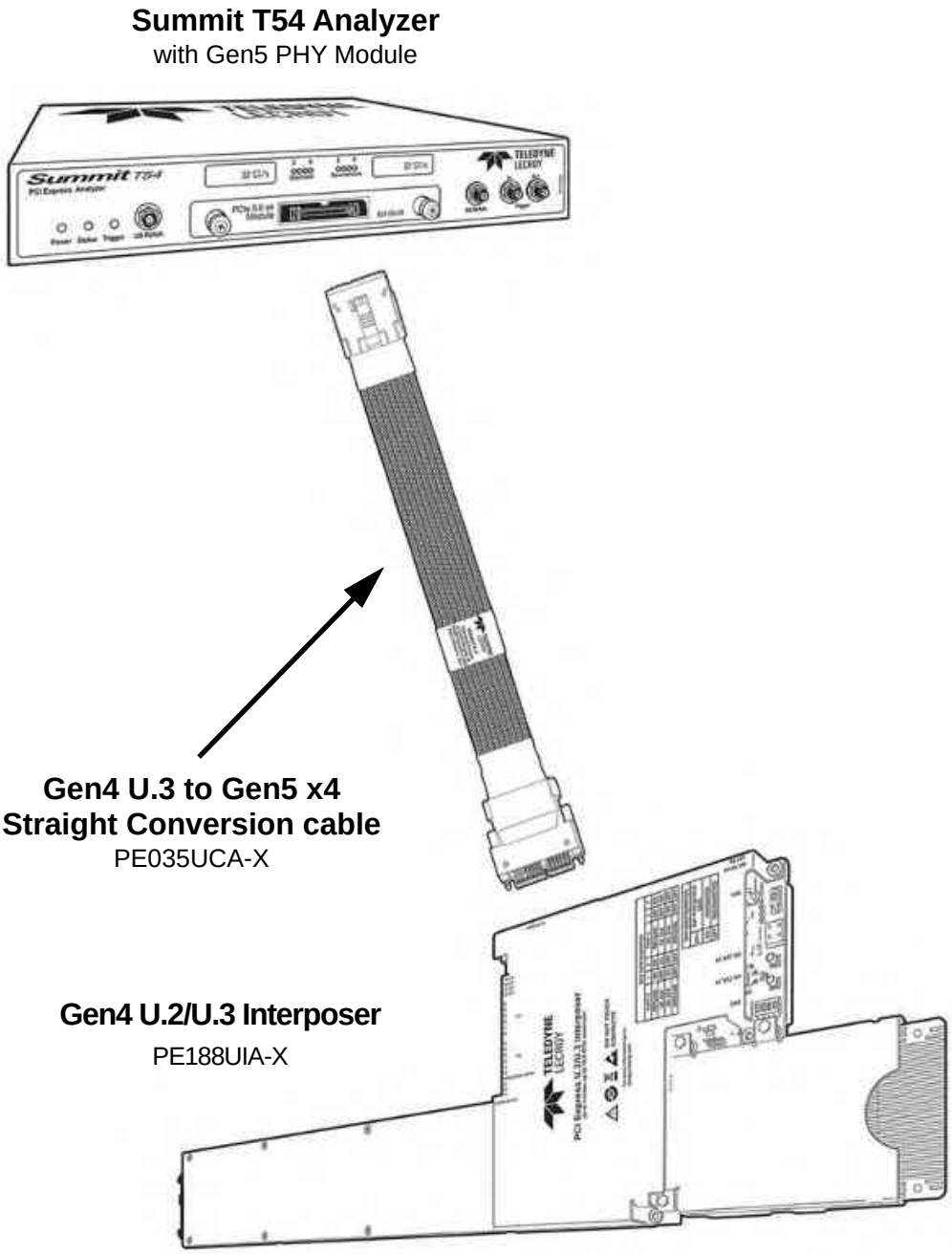


Figure 2.26: Gen4 U.2/U.3 x4 Interposer Connected to Summit T54 with Gen5 Phy x4 Straight Conversion Cable

2.10.7 Summit T54 (with Gen4 PHY) Connection to Gen3 Interposer

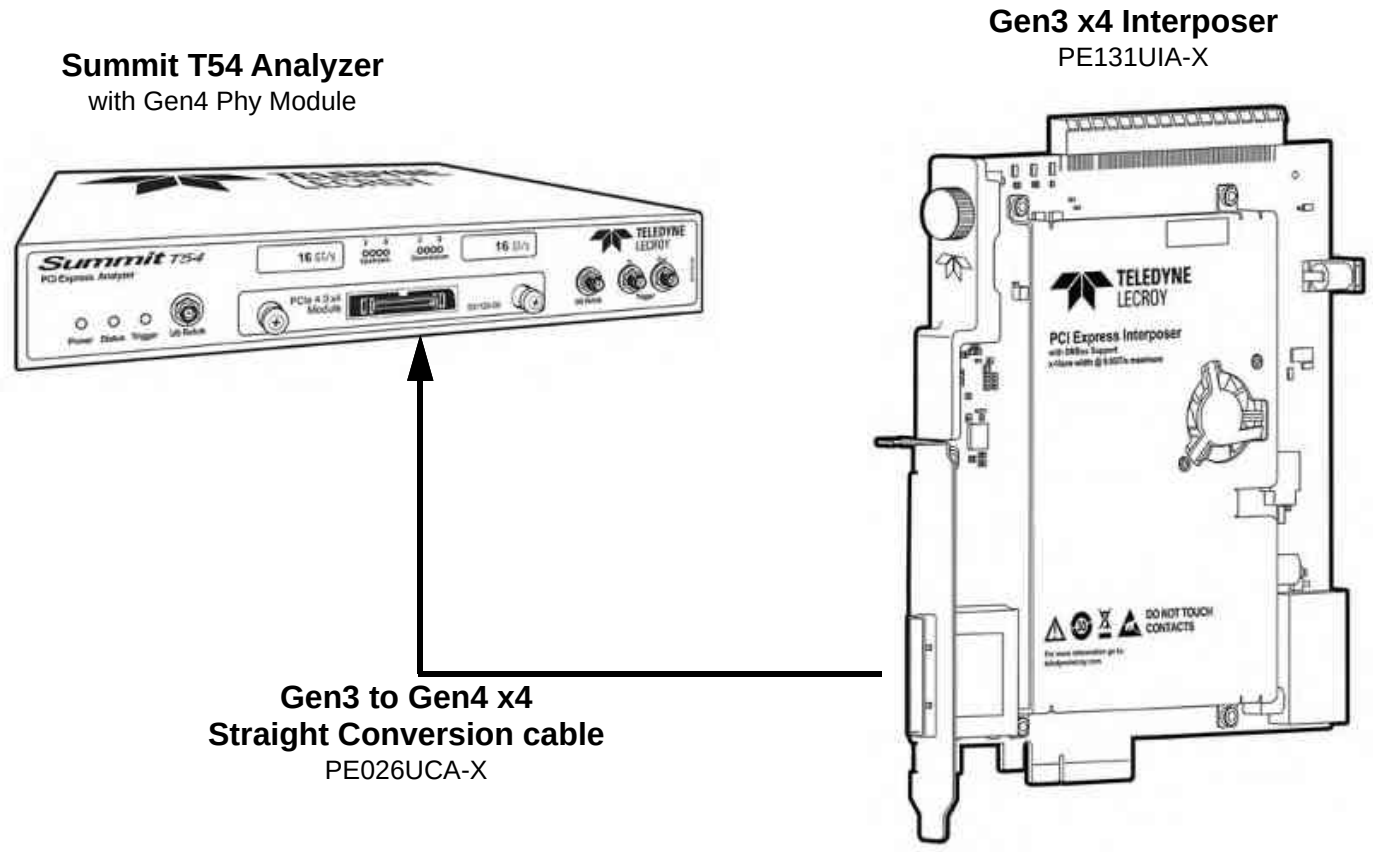


Figure 2.27: Gen3 x4 Interposer with straight conversion cable

2.10.7.1 Two Summit T54s (with Gen4 PHY) in Expanded Mode Connection to Gen3 x8 Interposer

Up to 8 lanes can be analyzed in this configuration (x8 analysis).

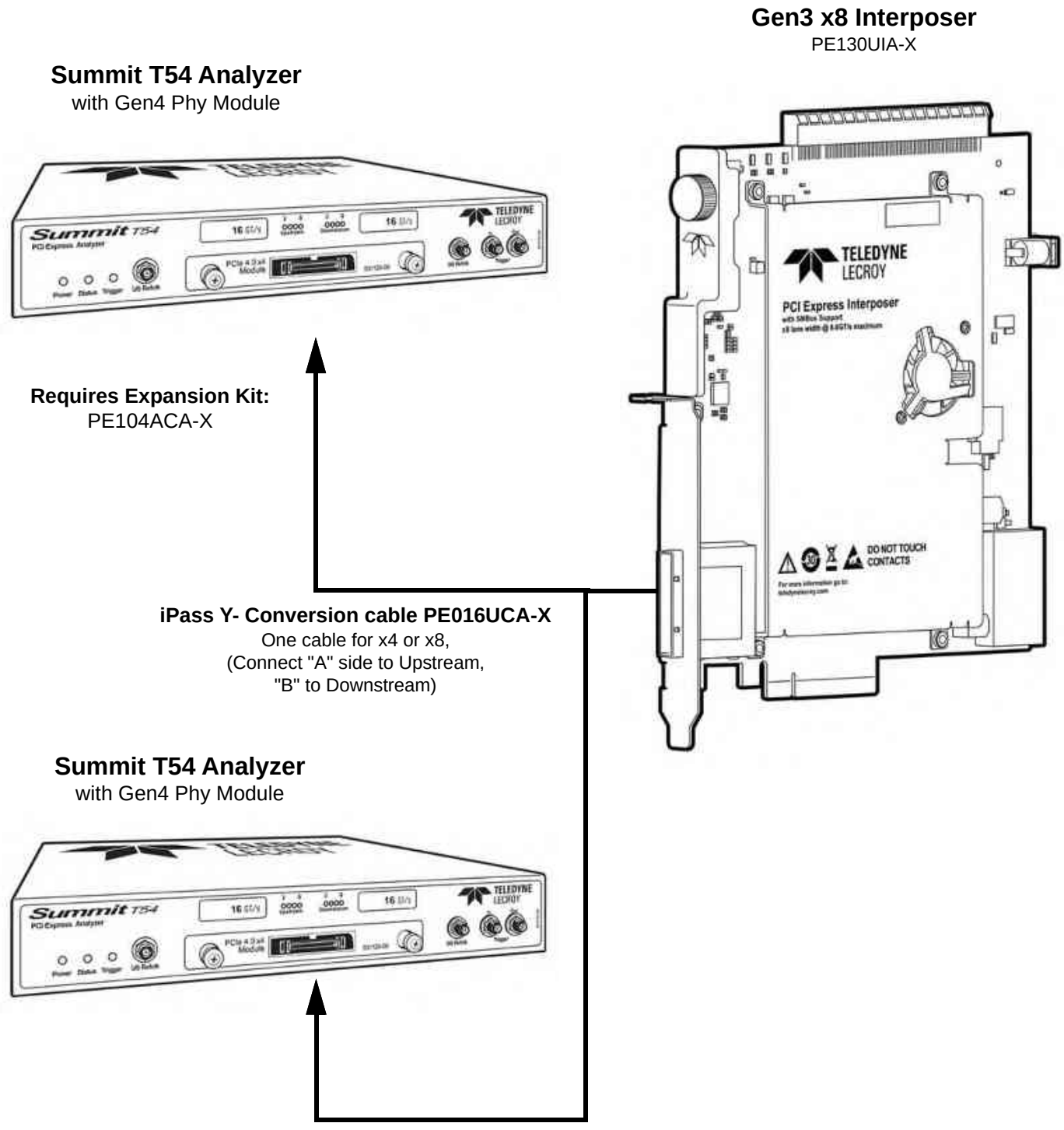


Figure 2.28: Expanded Mode T54s: Gen3 x8 Interposer with iPass Y- Conversion cable

2.11 Multiport Mode Configuration

MultiPort mode allows a single Summit T5 system to behave as multiple analyzer systems. This is achieved by connecting interposers as explained in this section. In the case of the Summit T516 you can analyze one x16 link from a single add-in card (standard mode), two x8 links from a single add-in card (bifurcated mode) or two x8 links from two separate devices (independent mode). You can also analyze four x4 links from a single add-in card (bifurcated mode) or four x4 links from four separate devices (independent mode).

In the case of the Summit T54 you can analyze one x4 link from a single add-in card (standard mode), two x2 links from a single add-in card (bifurcated mode).

Note: Multiport Mode requires a separate license.

Note: Both cables ends (A and B) from the Gen5 Y Cable carry a copy of the REFCLK signal from the PCIe bus. This is the clock used by the Summit T516 analyzer when selecting any of the "External Clock" options in the Protocol Analysis Software Recording Options menu.

2.11.1 Summit T516 MultiPort Configurations

You can configure the Summit T516 as follows:

- Standard Mode: Single link width up to x16 (see “Standard Mode Configuration using a Gen5 x16 interposer” on page 38).
- MultiPort 2 x8 Bifurcated: 2 bifurcated ports, link width up to x8 for each port.
  - Single add-in card with two ports connected to the analyzer through a single interposer (see “Bifurcated (2 x8 Ports) Mode using Gen5 x16 interposer” on page 39).
- MultiPort 2 x8 Independent: 2 independent ports, link width up to x8 for each port.
  - Two add-in cards connected to the analyzer through two interposers (see “Bifurcated (4 x4 Ports) Mode using Gen5 x16 interposer” on page 40).
- MultiPort 4 x4 Bifurcated: 4 bifurcated ports, link width up to x4 for each port.
  - Single add-in card with four ports connected to the analyzer through a single interposer (see “Independent (2 x 8 Ports) Mode using Gen5 x8 interposer” on page 42).
- MultiPort 4 x4 Independent: 4 independent ports, link width up to x4 for each port.
  - Four add-in cards connected to the analyzer through four interposers (see “Independent (4 x4 Ports) Mode using Gen5 x4 interposer” on page 43).
- MultiPort 4 x2 Bifurcated: 4 bifurcated ports, link width up to x2 for each port.
  - Two dual port add-in cards connected to the analyzer through two interposers (see “Bifurcated (4 x2 Ports) Mode using two Gen5 x4 interposers” on page 45).

Note: When analyzing multiple links, the labels in front of the analyzer do not necessarily correspond to the actual upstream/downstream and lane number connections. Explanation on how the cables should be connected is provided in the following sections.

2.11.1.1 Standard Mode Configuration using a Gen5 x16 interposer

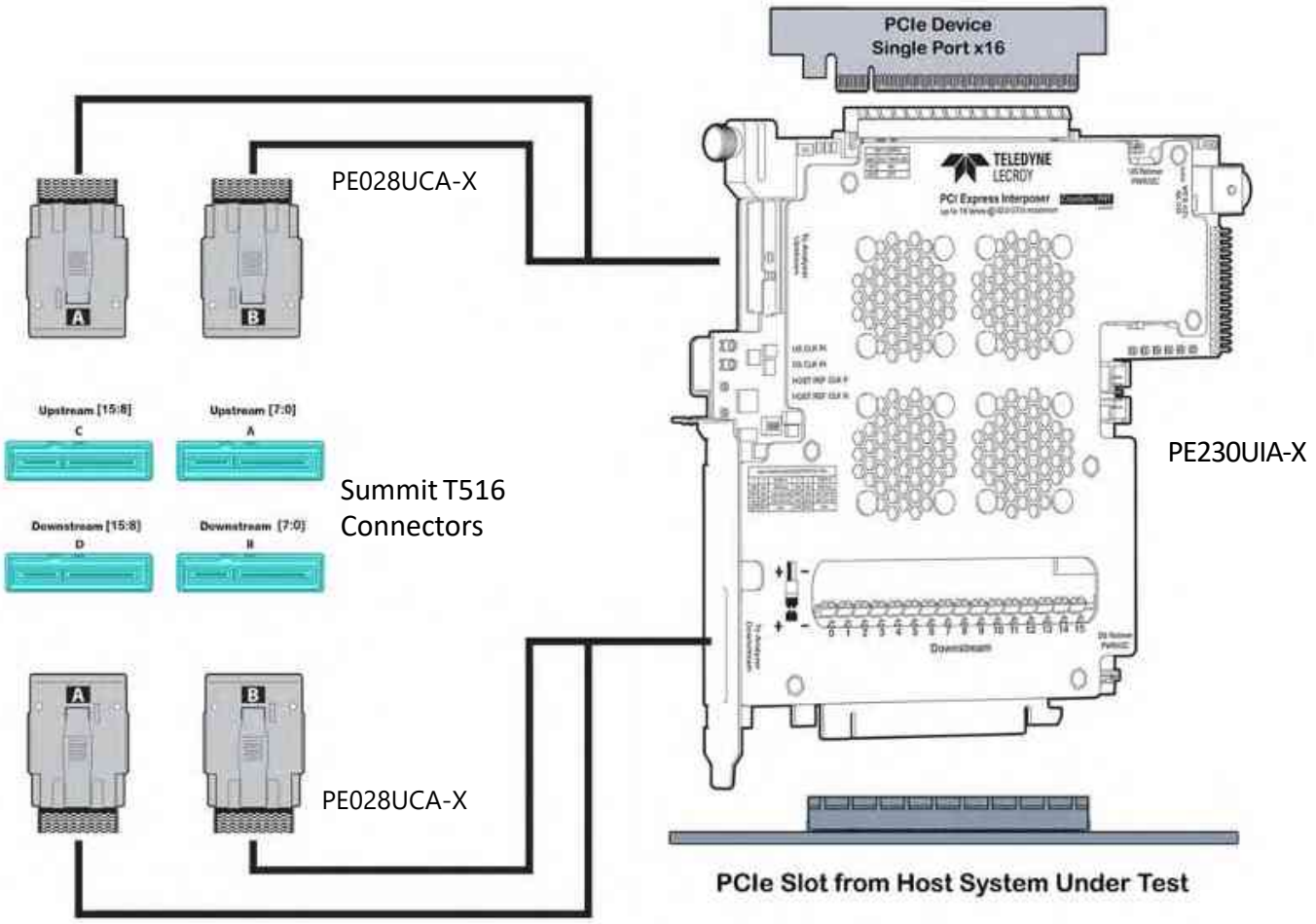


Figure 2.29: Standard Mode Configuration for Summit T516 using a Gen5 x16 interposer

- Uses Gen5 Y Cables: PE028UCA-X
- Any Gen5 interposer supporting x16 lanes can be connected similarly as shown in the figure above.
- Gen4 interposers supporting 16 lanes can be connected similarly using Gen4 Interposer to Gen5 Analyzer x8 Y Conversion Cables (PE033UCA-X).

2.11.1.2 Bifurcated (2 x8 Ports) Mode using Gen5 x16 interposer

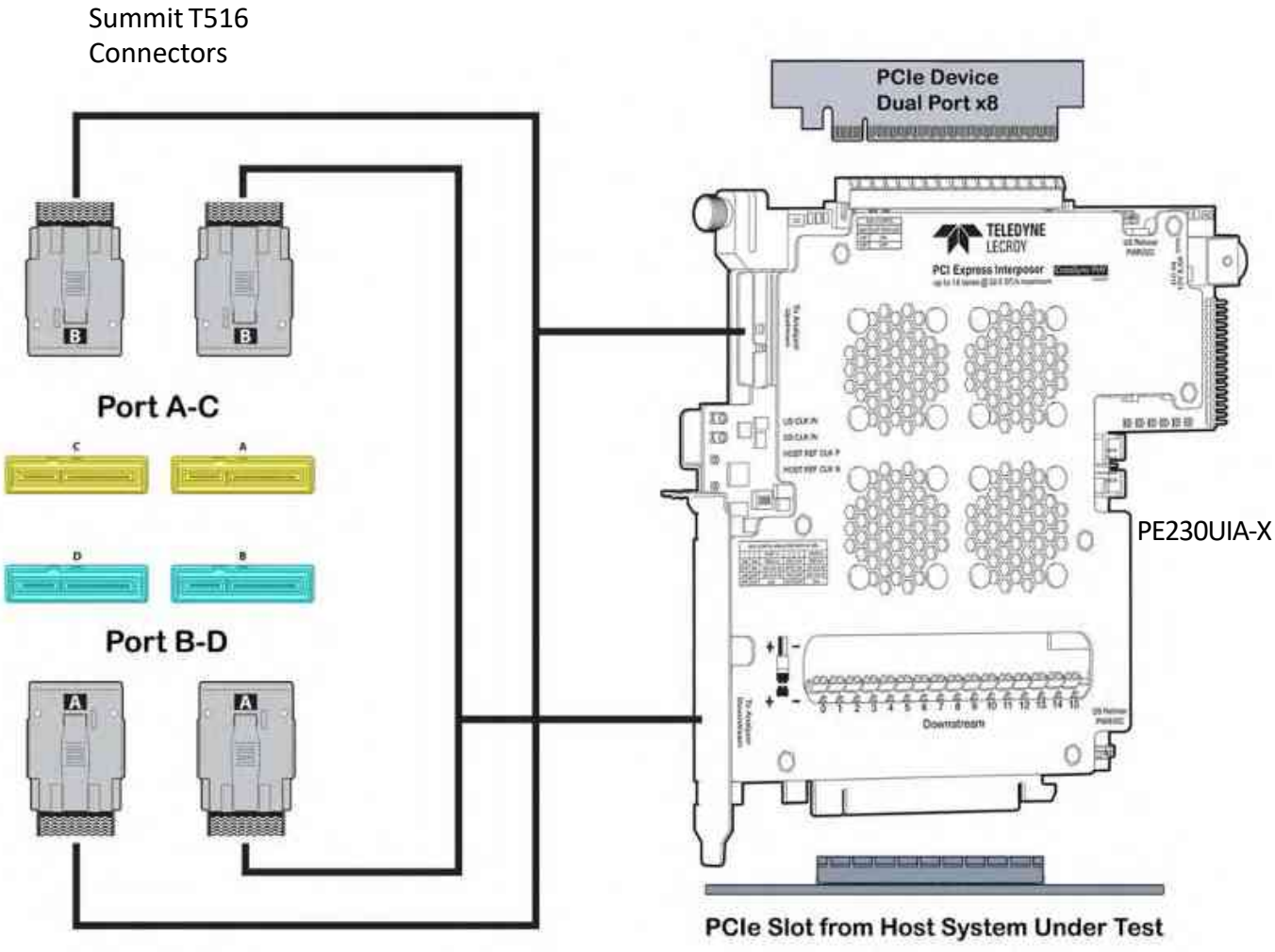
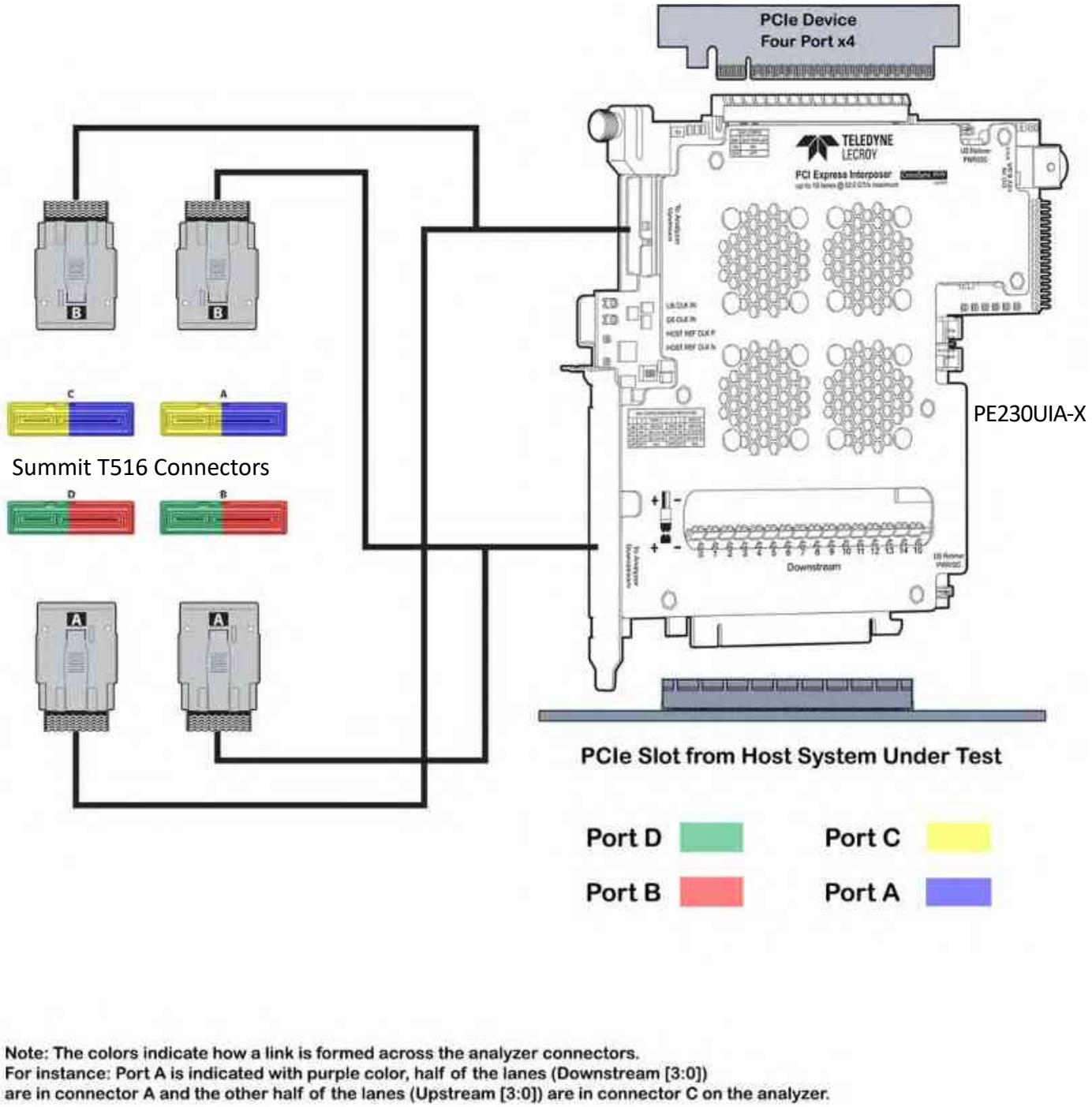


Figure 2.30: Bifurcated (2 x8 Ports) Mode for Summit T516 using Gen5 x16 interposer

- Uses Gen5 Y Cables: PE028UCA-X
- Port A-C records traffic from x8 Link created for lanes [7:0]
- Port B-D records traffic from x8 Link created for lanes [15:8]

2.11.1.3 Bifurcated (4 x4 Ports) Mode using Gen5 x16 interposer



Note: The colors indicate how a link is formed across the analyzer connectors.
For instance: Port A is indicated with purple color, half of the lanes (Downstream [3:0])
are in connector A and the other half of the lanes (Upstream [3:0]) are in connector C on the analyzer.

Figure 2.31: Bifurcated (4 x4 Ports) Mode for Summit T516 using Gen5 x16 interposer

- Uses Gen5 Y Cables: PE028UCA-X
- Port A records traffic from x4 Link created for lanes [3:0]
- Port B records traffic from x4 Link created for lanes [11:8]
- Port C records traffic from x4 Link created for lanes [7:4]
- Port D records traffic from x4 Link created for lanes [15:12]

2.11.1.4 Independent (2 x 8 Ports) Mode using Gen5 x8 interposer

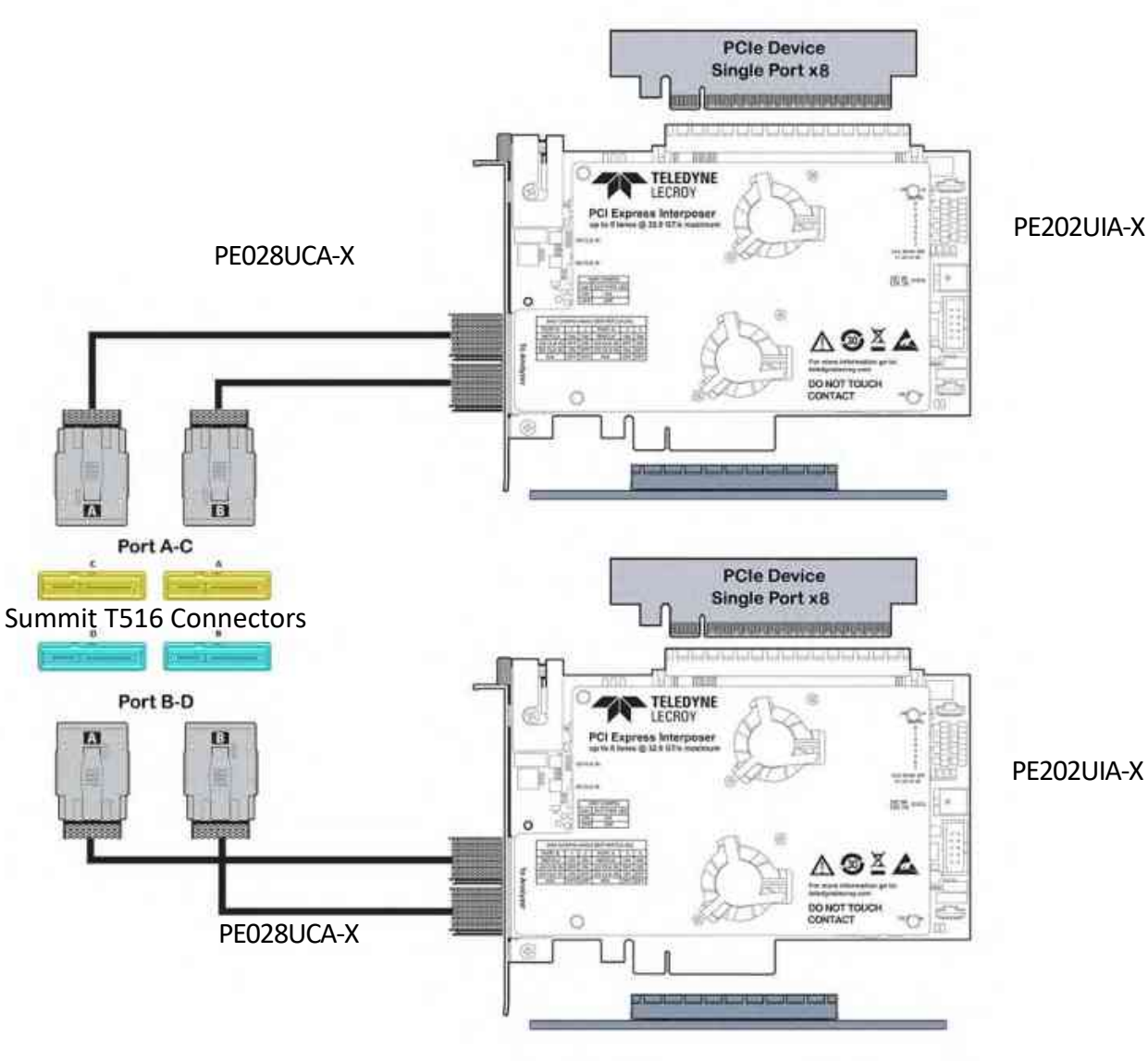


Figure 2.32: Independent (2 x8 Ports) Mode for Summit T516 using MultiPort x8 interposer

- Uses Gen5 Straight Cable: PE027UCA-X
- Other interposers that can be used for MultiPort mode:
  - PE221UIA-X PCIe Gen5 x4 U.2/U.3 Interposer
  - PE222UIA-X PCIe Gen5 x4 M.2 M-Key Interposer
  - PE243UIA-X PCIe Gen5 x4 EDSFF E1.S Interposer

2.11.1.5 Independent (4 x4 Ports) Mode using Gen5 x4 interposer

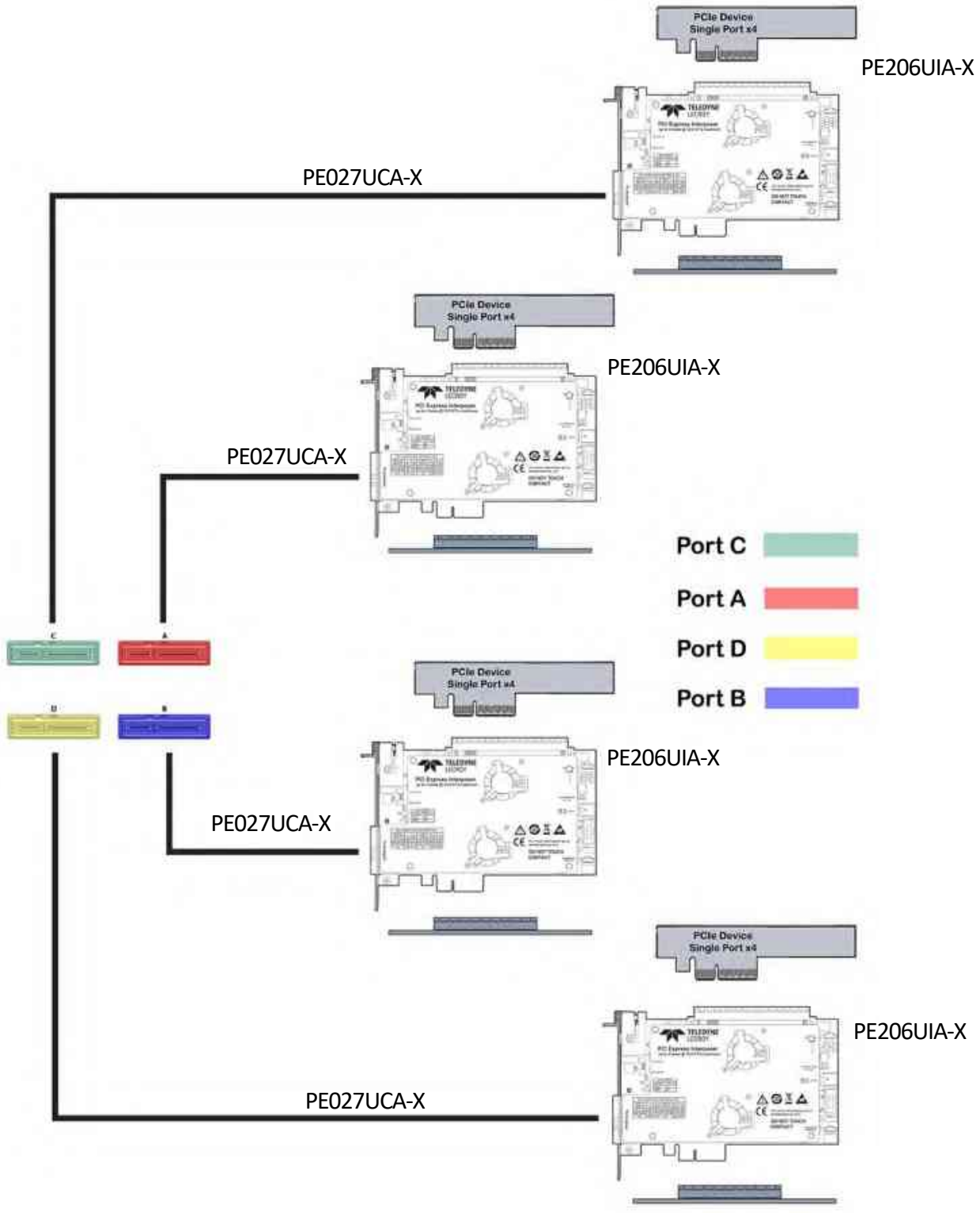


Figure 2.33: Independent (4 x4 Ports) Mode for Summit T516 using MultiPort x4 interposer

- Uses Gen5 Straight Cable: PE027UCA-X
- Other interposers that can be used for MultiPort mode:
  - PE221UIA-X PCIe Gen5 x4 U.2/U.3 Interposer
  - PE222UIA-X PCIe Gen5 x4 M.2 M-Key Interposer
  - PE243UIA-X PCIe Gen5 x4 EDSFF E1.S Interposer

2.11.1.6 Bifurcated (4 x2 Ports) Mode using two Gen5 x4 interposers

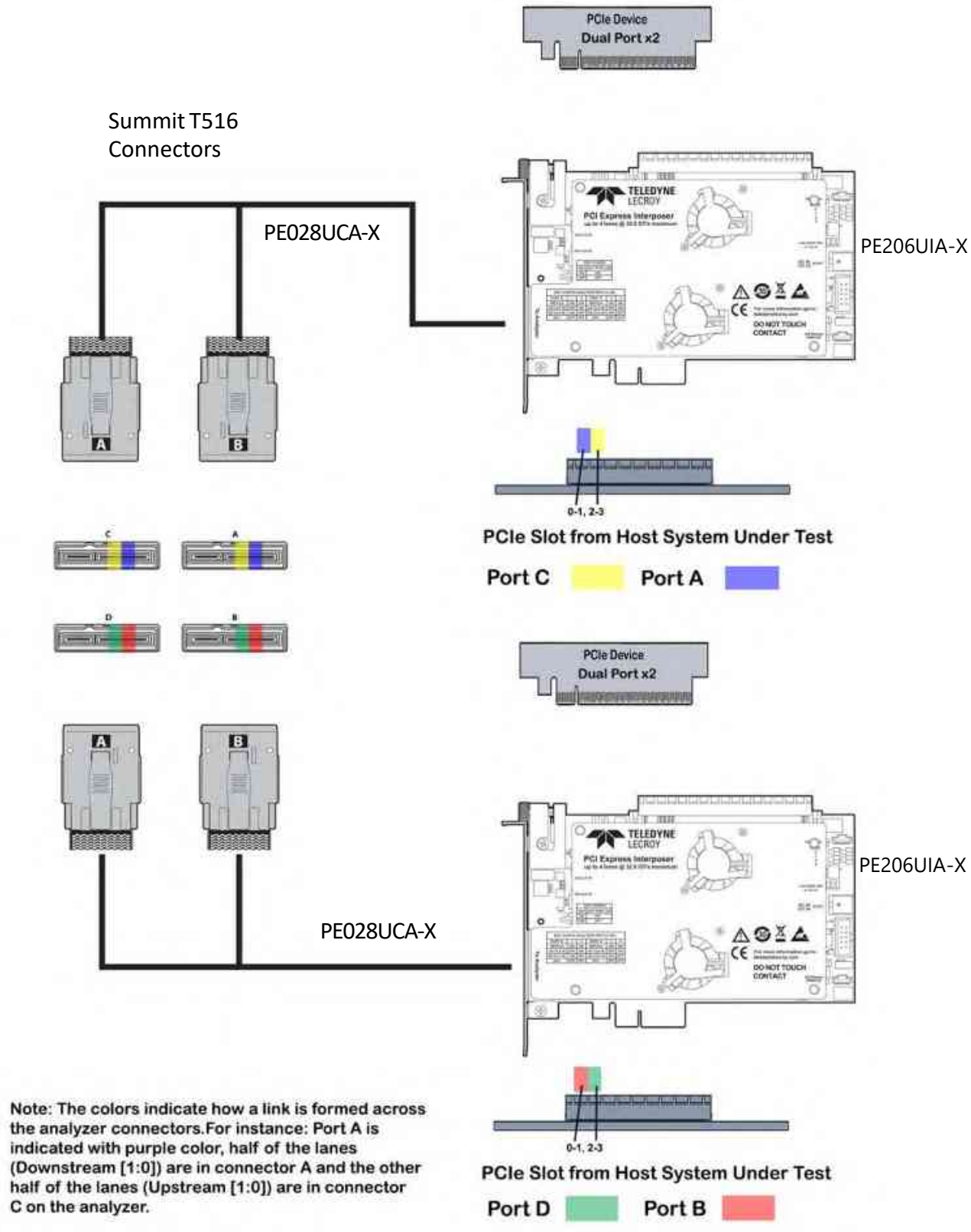


Figure 2.34: Bifurcated (4 x2 Ports) Mode for Summit T516 using Gen5 x4 interposer

- Uses Gen5 Y Cable: PE028UCA-X
- Other interposers and cables that can be used for MultiPort mode:
  - PE221UIA-X PCIe Gen5 x4 U.2/U.3 Interposer
  - PE222UIA-X PCIe Gen5 x4 M.2 M-Key Interposer
  - PE243UIA-X PCIe Gen5 x4 EDSFF E1.S Interposer

2.11.2 Summit T54 Configurations

You can configure the Summit T54 as follows:

- Standard Mode: Single link width up to x4
- Multiport 2 x2 Bifurcated: 2 bifurcated ports, link width up to x2 for each port.
  - Single add-in card with two ports connected to the analyzer through a single interposer (see “Bifurcated (2 x2 Ports) Mode using Gen5 x4 interposer” on page 48).

2.11.2.1 Bifurcated (2 x2 Ports) Mode using Gen5 x4 interposer

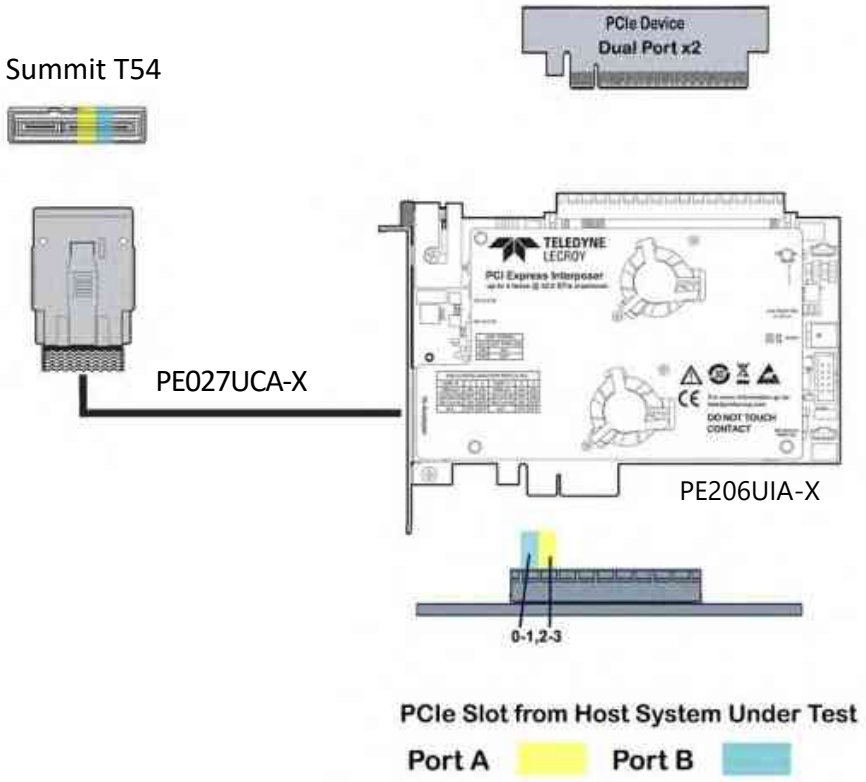


Figure 2.35: Bifurcated (2 x2 Ports) Mode for Summit T54 using Gen5 x4 interposer

- Gen5 x4 Straight Cable (PE027UCA-X). For Summit T54 with Gen4 Phy, use conversion cables or Gen4 cables.

2.11.3 Gen5 x4 U.2/U.3 Single/Dual Port Interposer Configurations

The Gen5 x4 U.2/U.3 Interposer can be used with Summit T516 and Summit T54 analyzers and the PCIe Protocol Analysis software in the configurations described below.

- U.2 x4 Single Port
  - Standard Mode (see Figure 2.36 and Figure 2.37 on page 50)
  - Multiport Mode (see Figure 2.38 on page 50, and Figure 2.39 on page 51)
- U.2 x2 Dual Port
  - Multiport Mode (see Figure 2.40 on page 52 and Figure 2.41 on page 52)
- U.3 x4 Single Port
  - Standard Mode See Figure 2.43 on page 53, Figure 2.44 on page 54 and Figure 2.45 on page 54)
- U.3 x2 Dual Port is currently not supported

2.11.3.1 U.2 x4 Single Port

When analyzing a U.2 x4 single port link the PCIe Protocol Analysis software should be used in Standard Mode and the interposer cables should be connected as shown in the diagrams below for Summit T516 and T54 See "Summit T516 MultiPort Configurations" on page 37 and "Summit T54 Configurations" on page 47 for more details.

For the cases described below, the clock options available are Internal, External and SMA.

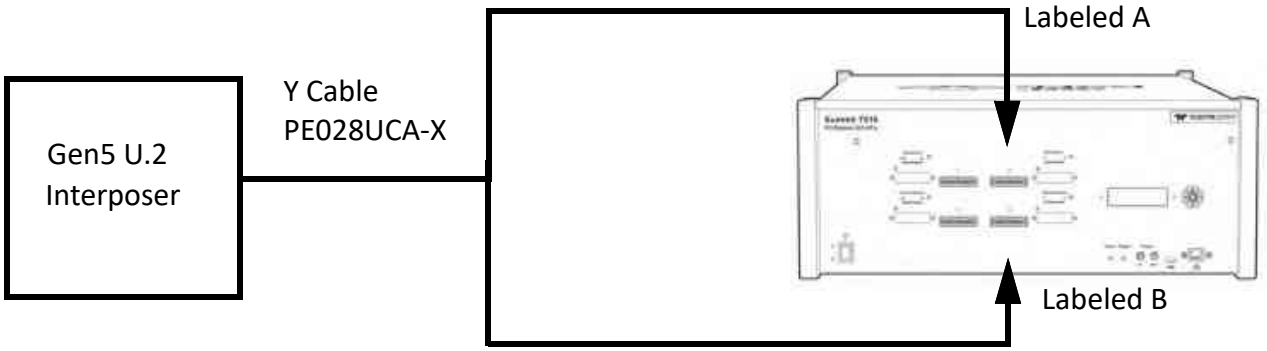


Figure 2.36: U.2 x4 Single Port with T516 in Standard Mode

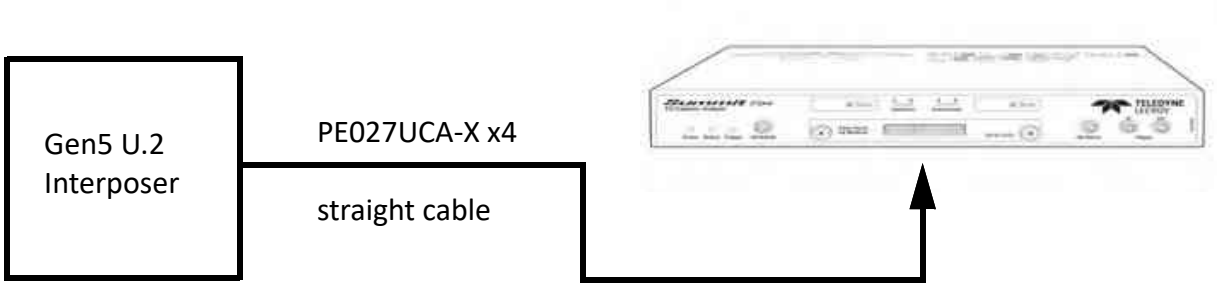


Figure 2.37: U.2 x4 Single Port with T54 in Standard Mode

2.11.3.2 Analyzing multiple x4 ports

When analyzing two independent U.2 x4 ports at the same time, two Gen5 U.2 interposers are required (see Figure 2.38). The PCIe Protocol Analysis software should be used in four ports independent option in MultiPort Mode for Summit T516 (see Figure 2.39 on page 51) or two ports independent option in Multiport Mode for Summit T48 (see Figure 2.39 on page 51) and the interposer cables should be connected as shown in the diagrams below for Summit T516 and T48. See "Summit T516 MultiPort Configurations" on page 37 and "Summit T54 Configurations" on page 47 for more details.

Please observe clocking restrictions for these configurations. PCIe Protocol Analysis will provide warnings on configurations not supported.

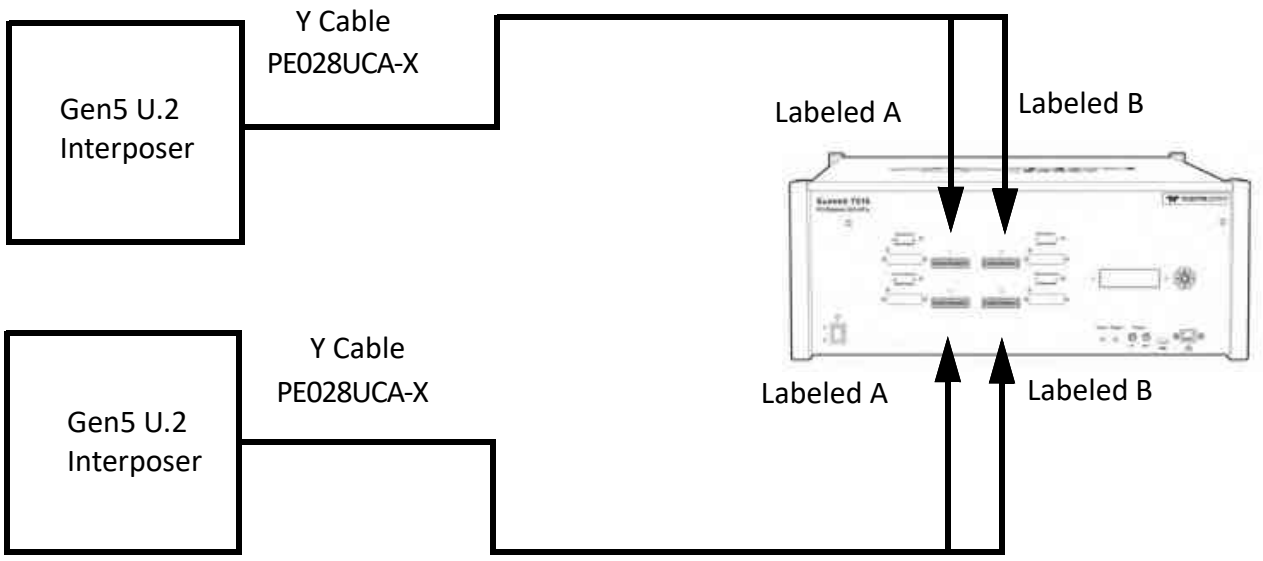


Figure 2.38: Analyzing up to two U.2 x4 independent ports with Summit T516 in MultiPort mode

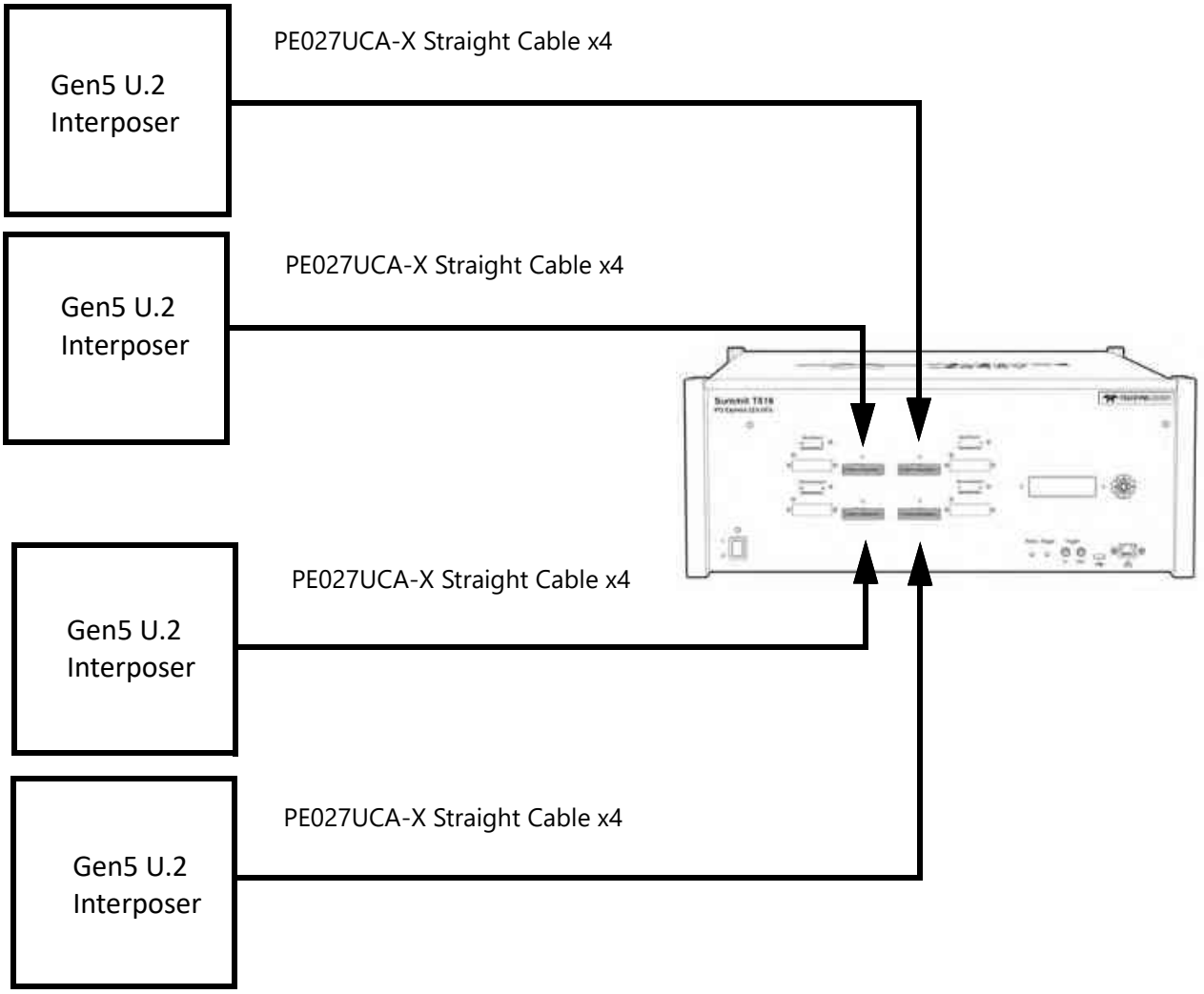


Figure 2.39: Analyzing up to four independent U.2 x4 ports with Summit T516 in Multiport mode

2.11.3.3 U.2 x2 Dual Port Analysis

When analyzing U.2 Dual Port (two x2 bifurcated ports) only one Gen5 U.2 interposer is needed. The PCIe Protocol Analysis software should be used in bifurcated x2 MultiPort Mode and the interposer cables should be connected as shown in the diagrams below for Summit T516 and T54. Up to four x2 ports can be analyzed this way using a Summit T516 and up to two x2 ports can be analyzed with Summit T54. See "Summit T516 MultiPort Configurations" on page 37 and "Summit T54 Configurations" on page 47 for more details.

Please observe clocking restrictions for these configurations. PCIe Protocol Analysis will provide warnings on configurations not supported

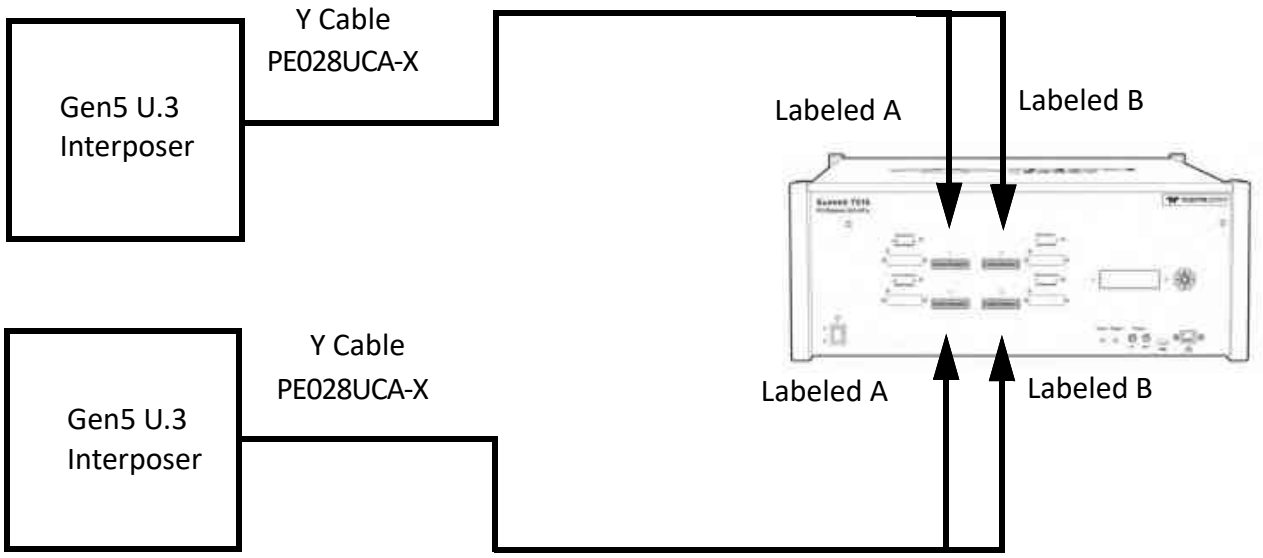


Figure 2.40: Analyzing two Dual x2 Ports with Summit T516 in MultiPort mode

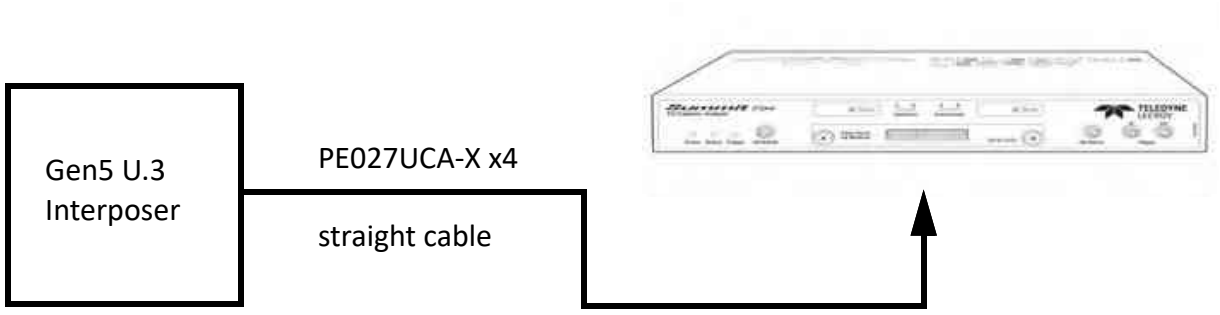


Figure 2.41: Analyzing Dual x2 Ports with Summit T54 in MultiPort mode

2.11.3.4 U.3 x4 Single Port Standard Mode

When analyzing a U.3 x4 single port link PCIe Protocol Analysis software should be used in Standard Mode and the interposer cables should be connected as shown in the diagrams for Summit T516 and T54. See "Summit T516 MultiPort Configurations" on page 37 and "Summit T54 Configurations" on page 47 for more details.

Note: In the PCIe Protocol Analysis software you must use the Swizzle function and map physical lanes 4 and 5 use the logical lanes 0 and 1. Physical lanes 1 and 2 must be mapped to logical lanes 2 and 3. See "Swizzling Config..." on page 233. Map physical lanes according to Table 2.1 and Figure 2.42.

TABLE 2.1: Logical to Physical Lane Mapping

U.3 x4 Logical Lane	Analyzer Physical Lane
0	4
1	5
2	1
3	2

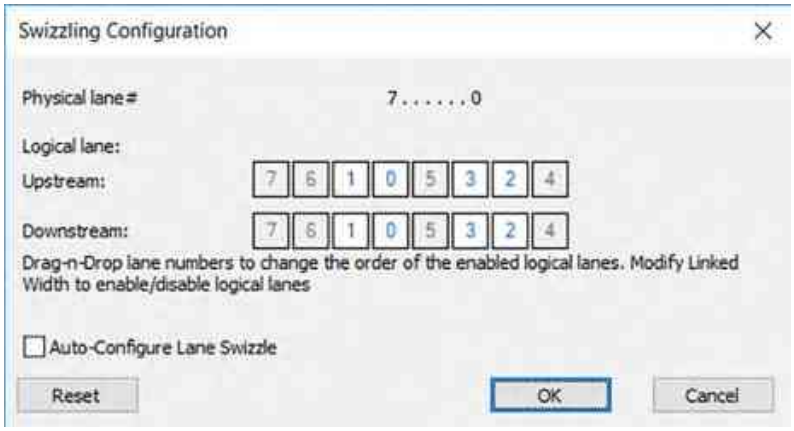


Figure 2.42: Logical to Physical Lane Mapping

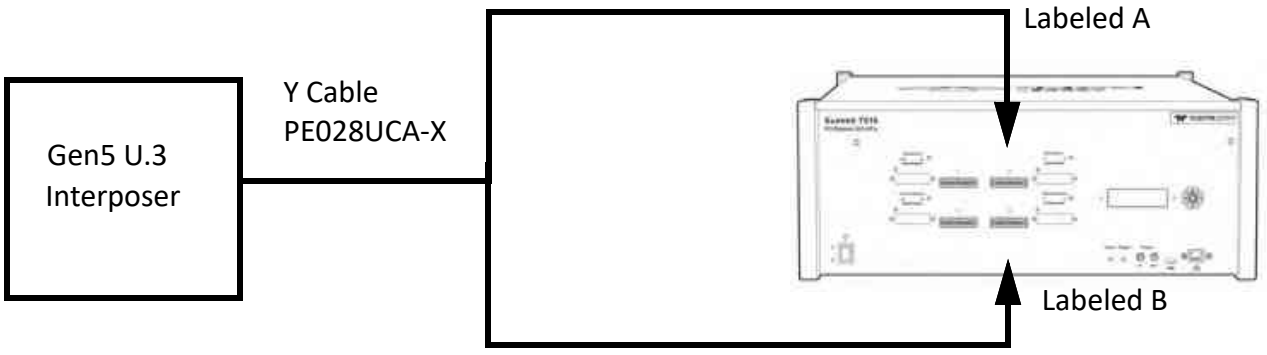


Figure 2.43: Analyzing a single U.3 x4 port with Summit T516 in Standard Mode

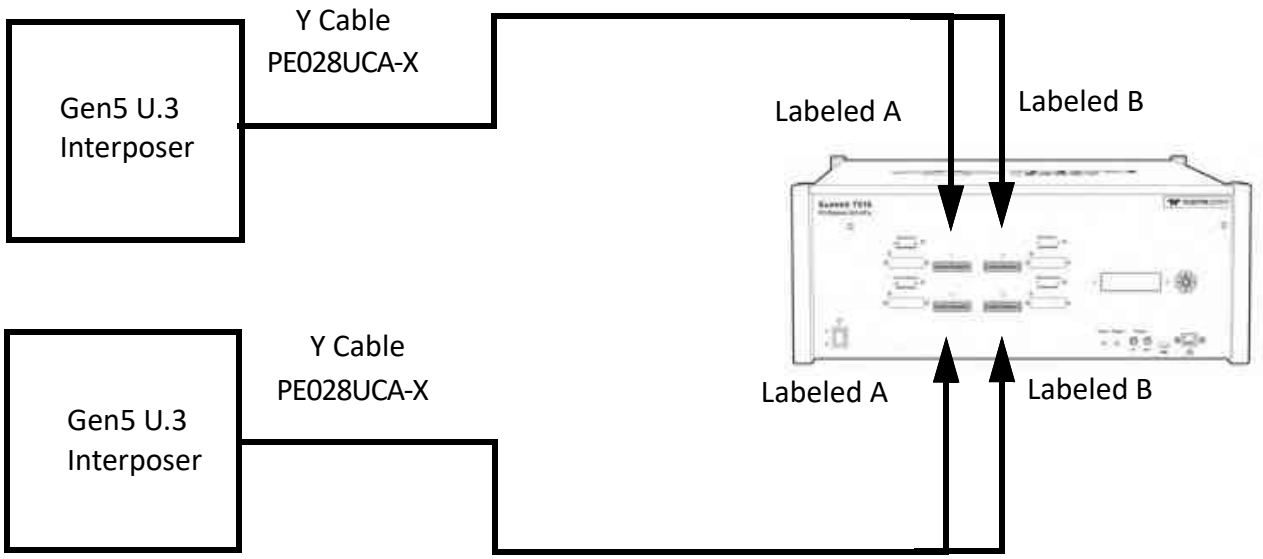


Figure 2.44: Analyzing up to two independent U.3 x4 ports with Summit T516 in MultiPort mode

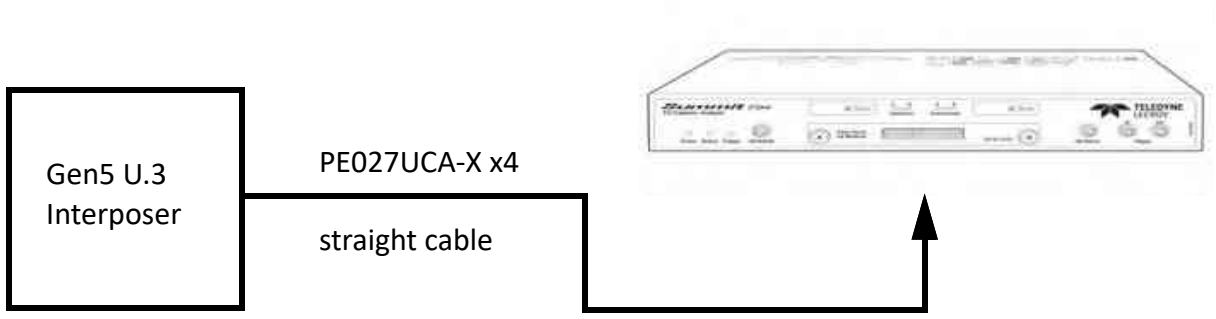


Figure 2.45: Analyzing single U.3 x4 port with Summit T54 in Standard Mode

2.12 Cabling Options for Tuning the Interposer

There are three different cabling options to tune the interposer connected to the Summit T5:

- You can install an FTDI serial cable from the interposer to your host computer (see "Installing the FTDI Serial Cable" on page 55).
- You can install a USB Type-C cable from the interposer to your host computer (see "Installing a USB Type-C Serial Cable" on page 57).
- You can use the serial bus within the data cable from the interposer to the Summit T54 analyzer (see "Using the Interposer Data Cable" on page 58).

2.12.1 Installing the FTDI Serial Cable

Install the Interposer per instructions in the appropriate User Manual or Quick Start Guide.

To use the Utility you must connect a special FTDI cable (Teledyne LeCroy PN: 929278-00) attached from the interposer to your laptop. The steps to install the cable follow:

- Ensure the interposer is powered down.
- Locate the 3 pin connector for the Programming cable near the SW4 switch upper left section of the interposer (see Figure 2.46 on page 55).
- Align the cable so the SCL wire is located near the top pin, the SDA wire is located near the middle pin and the GND wire is located near the bottom pin (see Figure 2.46 on page 55).
- Push the FTDI connector onto the pins on the Interposer (see Figure 2.47 on page 56).

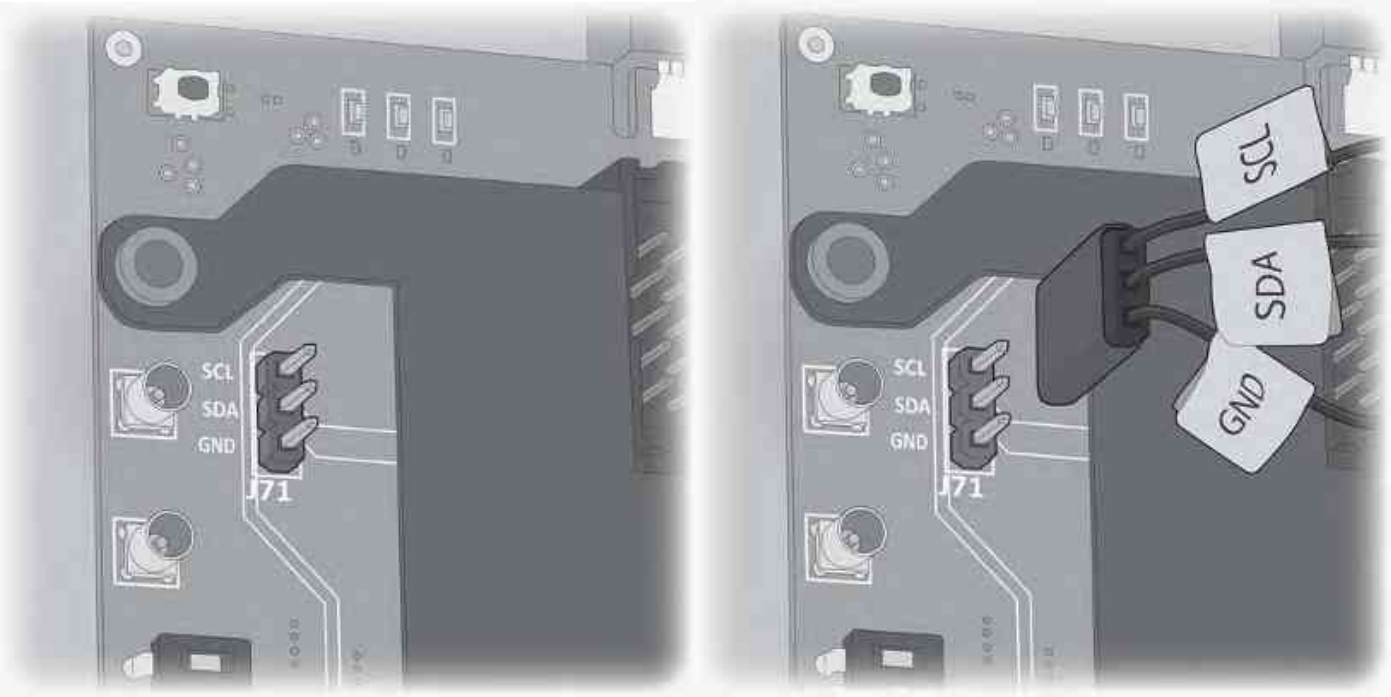


Figure 2.46: Typical Interposer: Programming Pins and Cable Ready to Attach

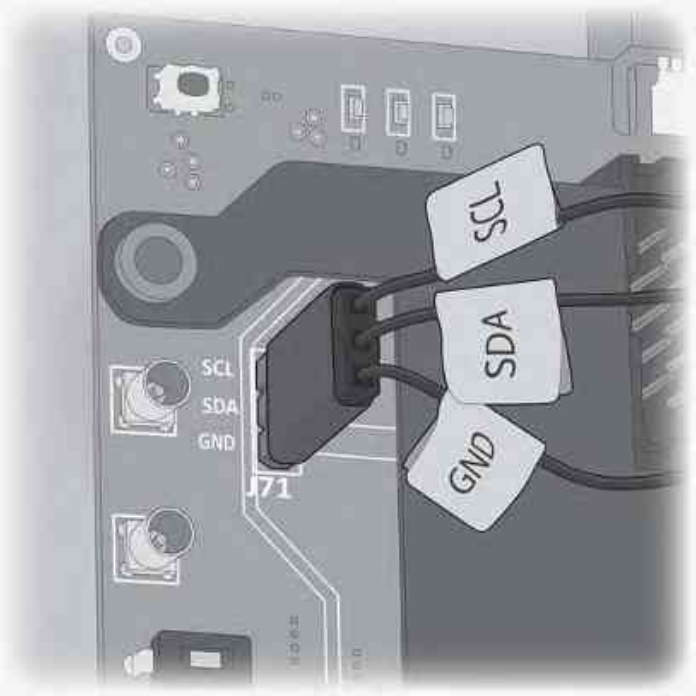


Figure 2.47: Typical Interposer: FTDI Serial Cable Attached to Interposer for Calibration

- After the cable has been attached to the Interposer, plug the other end of the cable into a USB connection on your laptop or computer.
- Power up the interposer.
- You can tune the interposer by adjusting the Continuous Time Linear Equalization (CTLE) values for each lane and the DC Gain (see "General Guidelines to do the Calibration and Auto-tuning" on page 278) to obtain the best signal.

2.12.2 Installing a USB Type-C Serial Cable

- ❑ Ensure the interposer is powered down.
- ❑ Install the Type-C end of the USB cable into the corresponding USB Type-C connector on the interposer. See Figure 2.48.

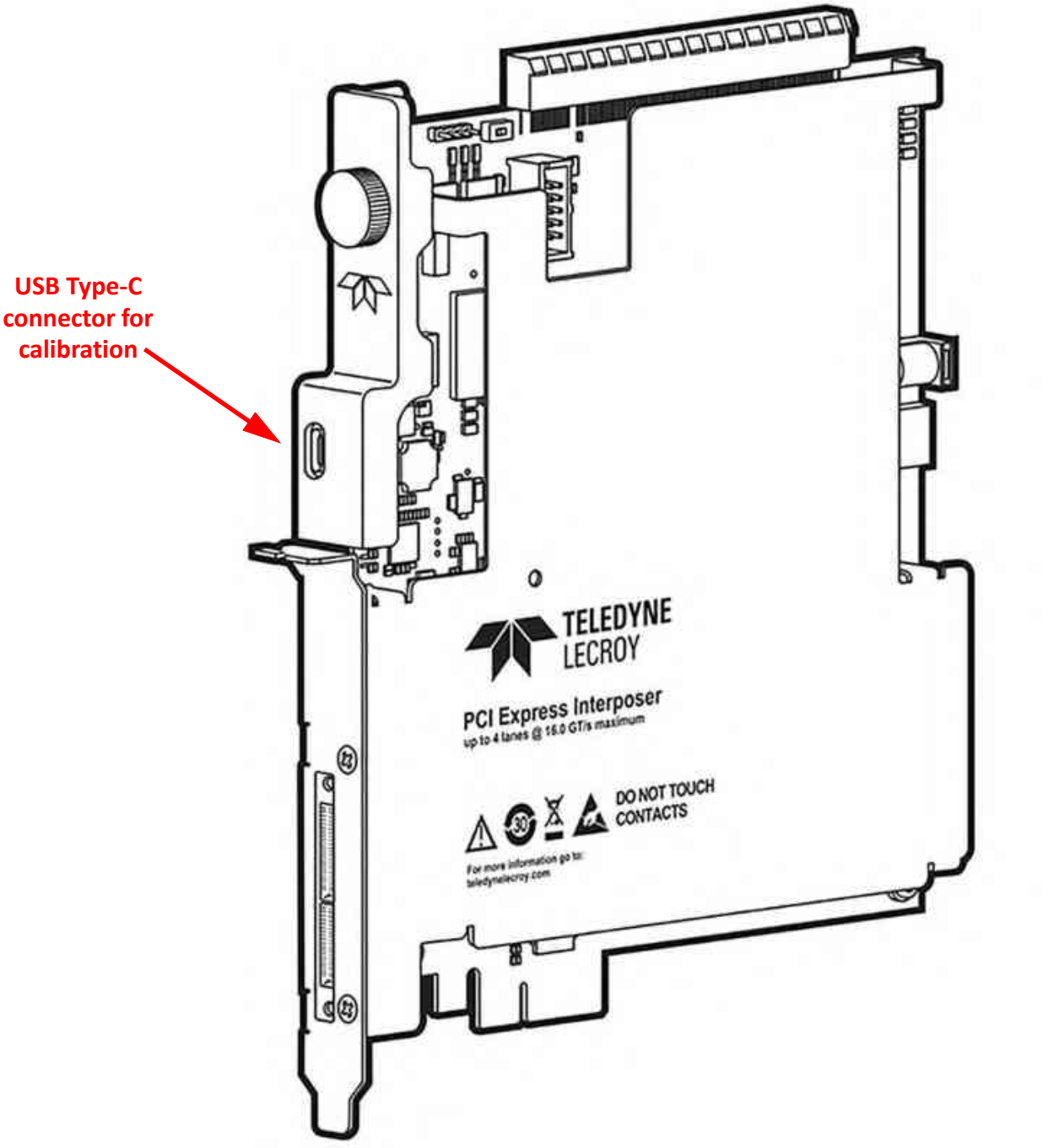


Figure 2.48: Gen5 Interposer with USB Type-C connector for calibration

- After the cable has been attached to the Interposer, plug the other end of the USB Type C cable into a USB connection on your host computer.
- Power up the interposer.
- You can tune the interposer by adjusting the Continuous Time Linear Equalization (CTLE) values for each lane and the DC Gain (see "General Guidelines to do the Calibration and Auto-tuning" on page 278) to obtain the best signal.

2.12.3 Using the Interposer Data Cable

The same data cable that connect the interposer to the T5 system has the required serial interface to configure the interposer. Depending on interposer being used, the following cables can be used to program the interposer:

Y Cable: Connects the interposer to the Summit T54 with both data signals and serial interface signals to program the interposer. See Figure 2.49.

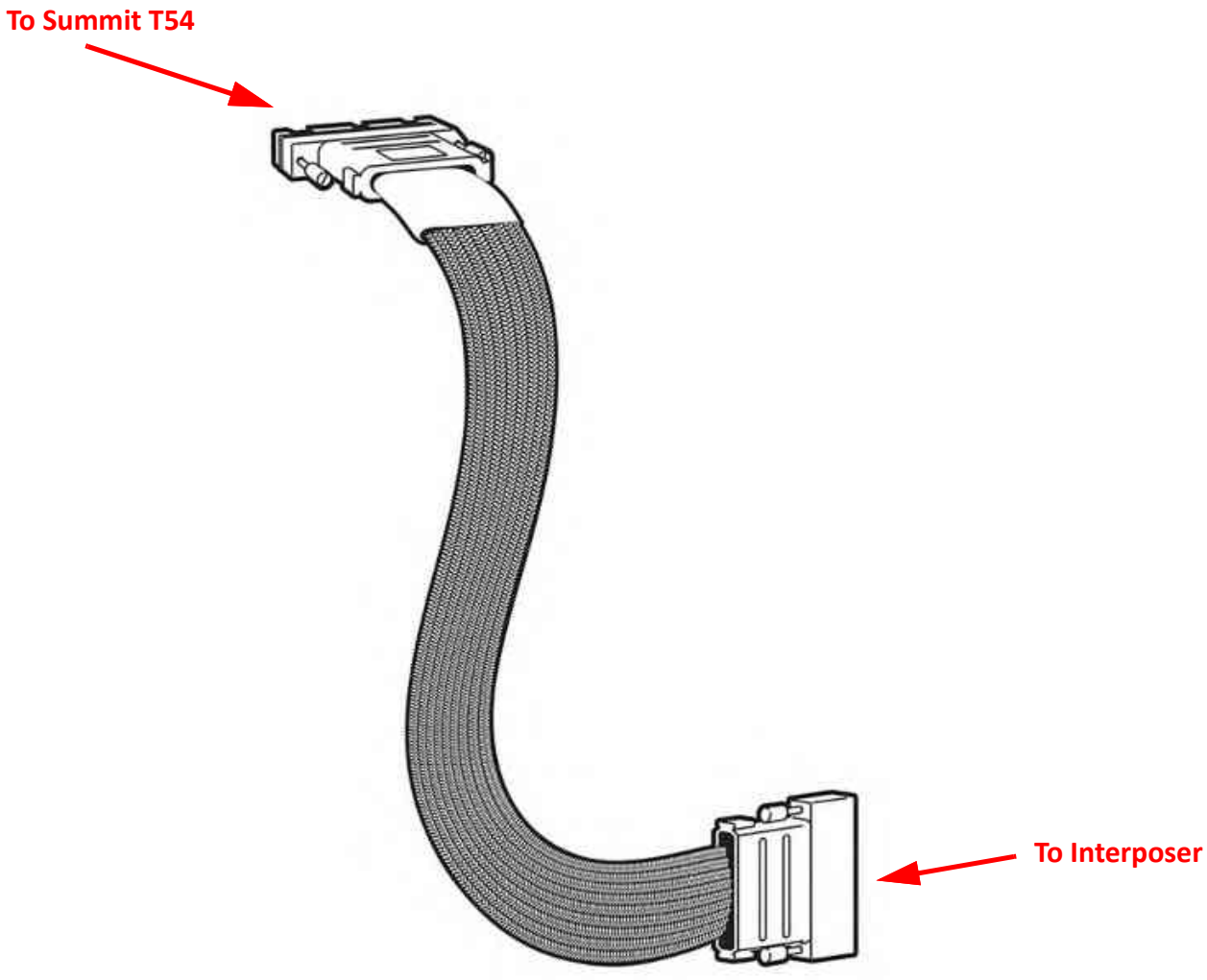


Figure 2.49: Straight Data Cable

Chapter 3

Installation and Setup

The Summit T516™ and T54™ Analyzers are standalone systems.

You can begin PCI Express™ recordings after following the steps in this chapter.

3.1 Installing the PCIe Protocol Analysis

PCIe Protocol Analysis operates all of Teledyne LeCroy's PCI Express protocol Analyzer and Exerciser products:

The PCIe Protocol Analysis is supported on systems using a Microsoft® Windows®-based host machine running Windows Server 2016, Windows Server 2019 and Windows 10 64-bit operating systems and serves as the interface for the Exerciser and/or Analyzer.

3.1.1 Downloading the PCIe Protocol Analysis

You can download the latest version of the PCIe Protocol Analysis software from the following site:

http://teledynelecroy.com/sw/pciexpress/

Note: First-time user registration is required.

3.1.2 Windows Server 2016/2019

If you are using Windows Server 2016/2019, the Teledyne LeCroy PCIe Protocol Suite needs to be added to the firewall exceptions to ensure that the application can find the analyzers over your Ethernet network.

To add the PCIe Protocol Suite application to the firewall exceptions perform the following steps.

1. Open the Control Panel. See Figure 3.1.

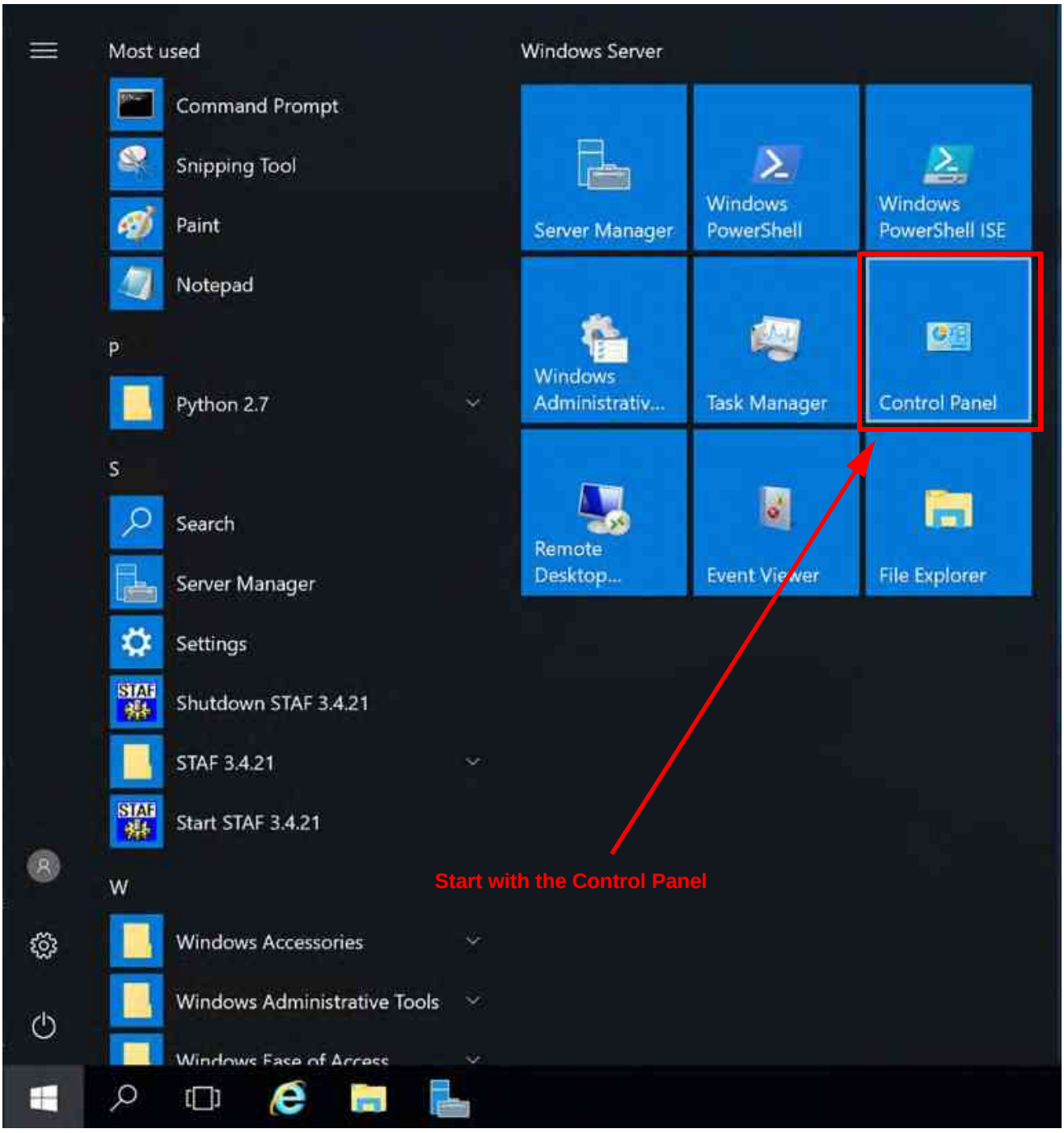


Figure 3.1: Windows Server 2016/2019: Start Menu -> Control Panel

2. From the Control Panel. select the “Systems and Security” screen. See Figure 3.2.

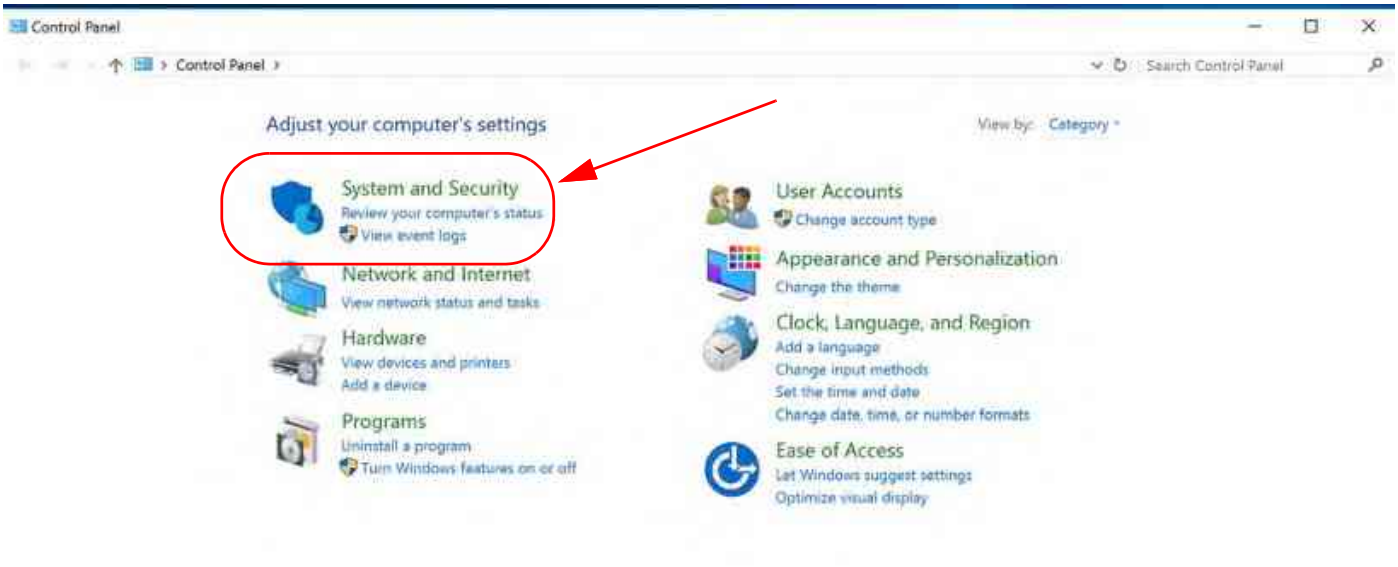


Figure 3.2: Windows Server 2016/2019: Control Panel -> System and Security Screen

3. From the Control Panel -> System and Security Screen, select “Allow an App through Windows Firewall”. See Figure 3.3.

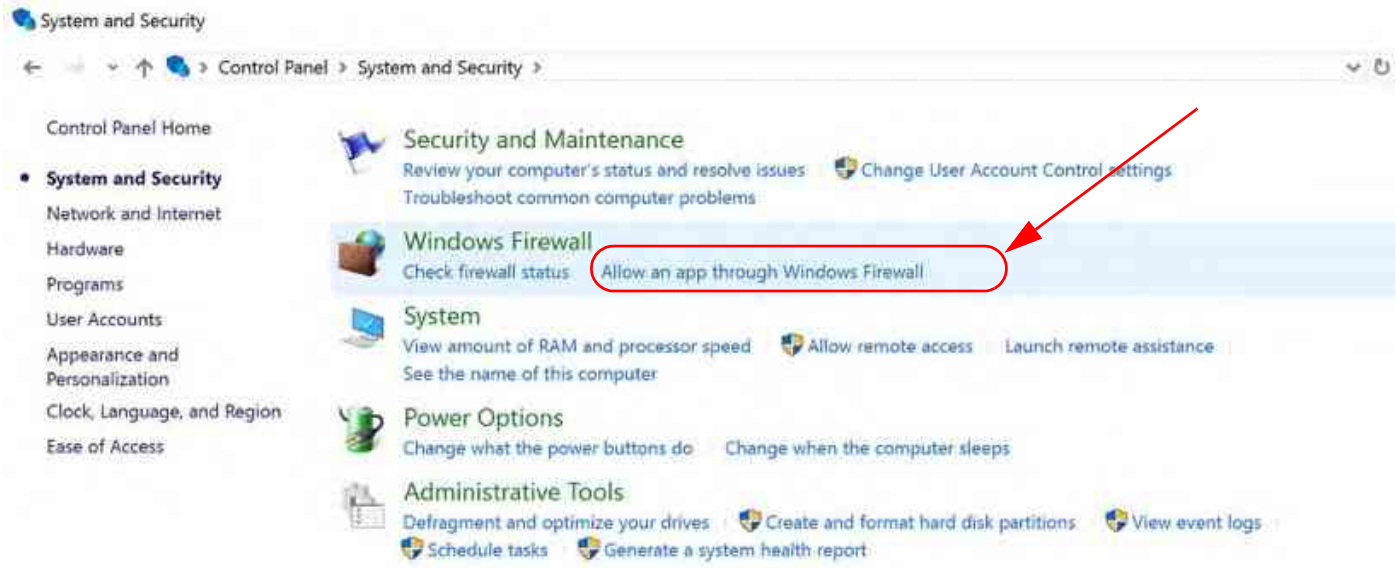


Figure 3.3: Windows Server 2016/2019: Allow an App Through Windows Firewall

4. From the Windows Firewall screen -> Allow apps to communicate through Windows Firewall, select “Change settings”, then select “Allow another app”. See Figure 3.4.

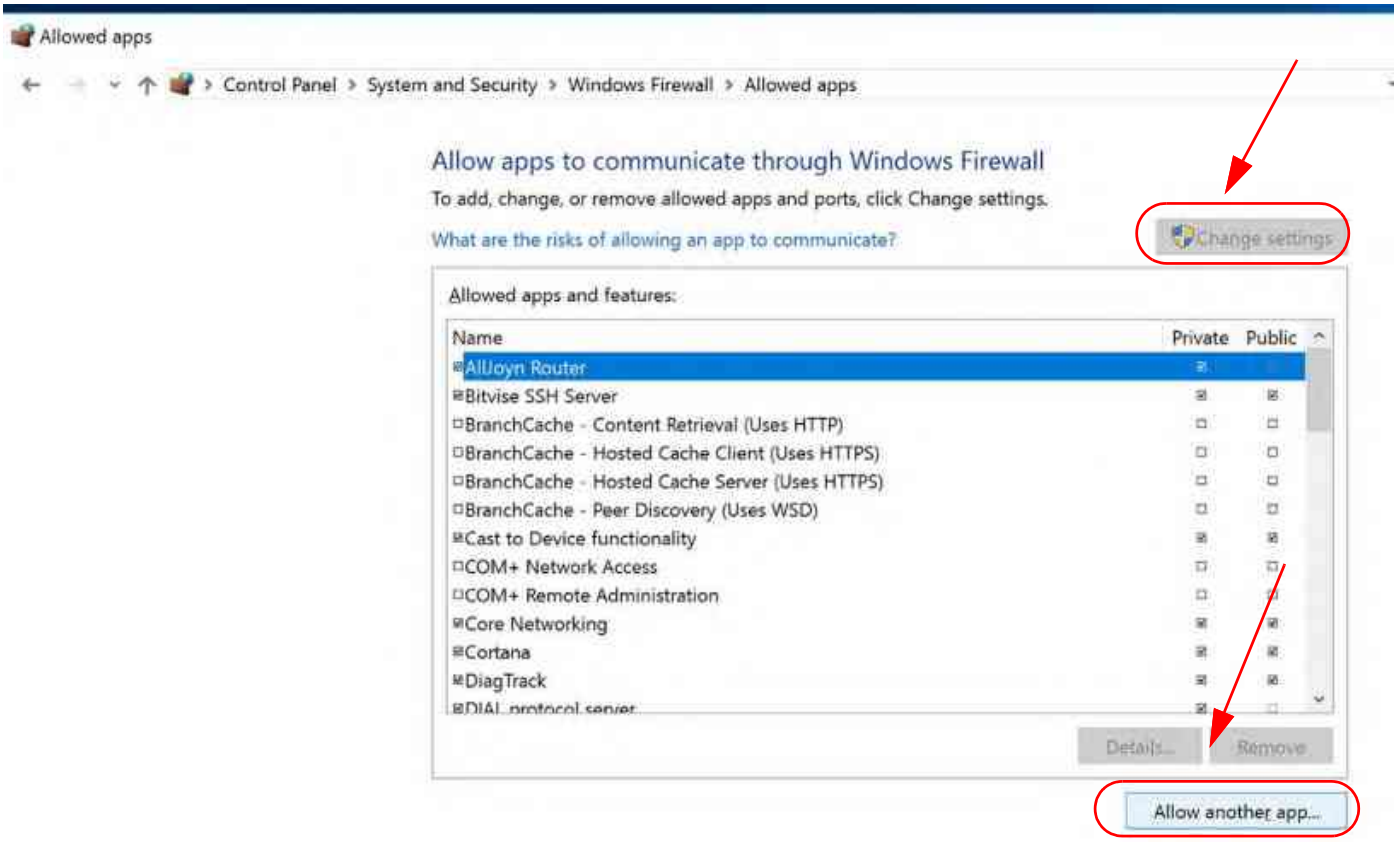


Figure 3.4: Windows Server 2016/2019: Change Settings -> Allowed Another app

5. From the User Account Control screen, select “Yes”. Figure 3.5.

Note: This screen may be optional if you have already allowed Microsoft Windows to make changes to your computer.

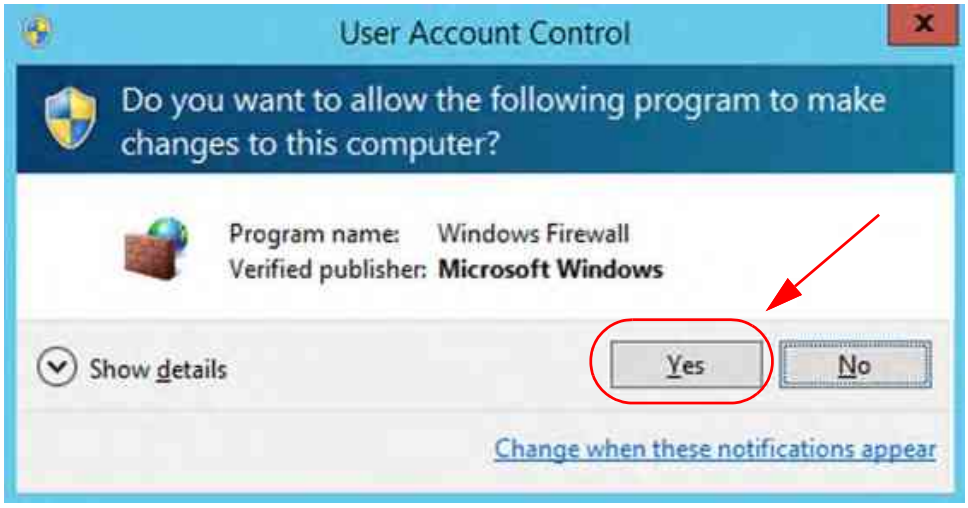


Figure 3.5: Windows Server 2016/2019: User Account Control

6. From the “Add an app” screen, select the Browse button. See Figure 3.6.

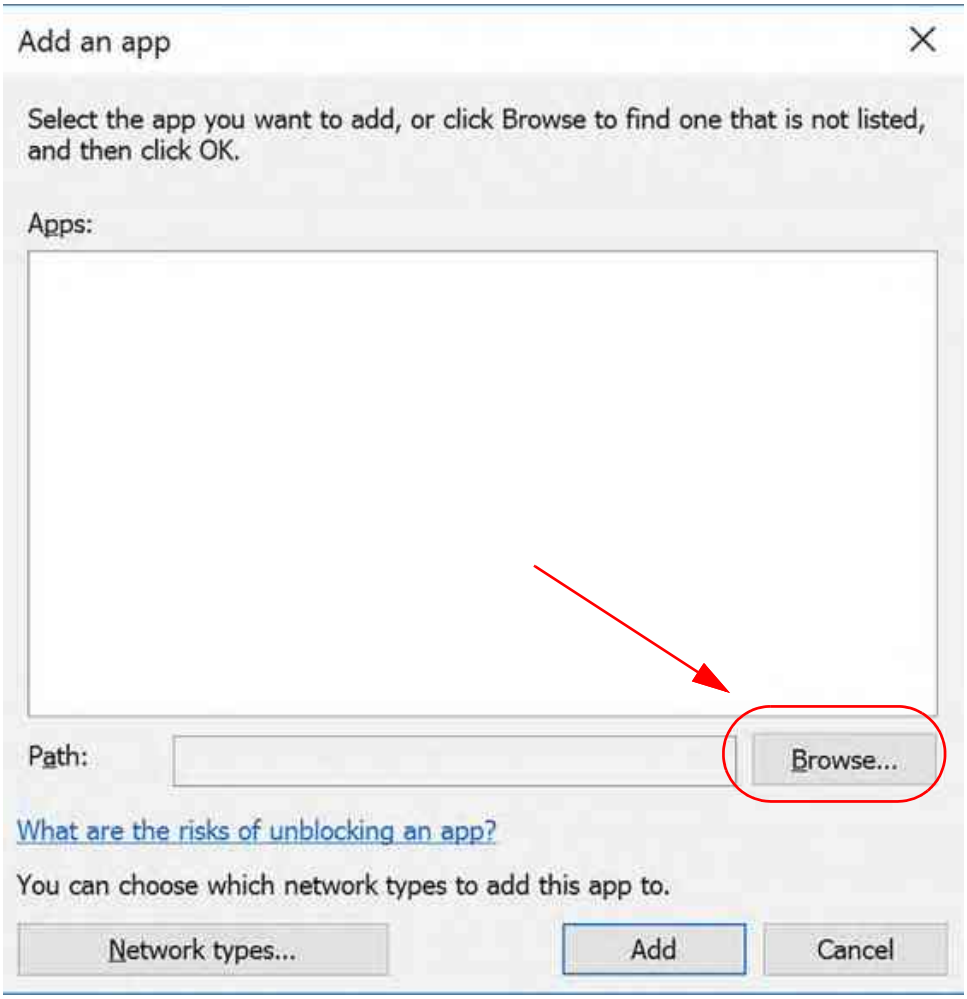


Figure 3.6: Windows Server 2016/2019: Add an App

7. In the Browse window navigate to the location of the installation directory for the PCIe Protocol Suite you are installing. The Teledyne LeCroy PCIe Protocol Suite is typically installed on your machine in the C:\Program Files\LeCroy\PCIe Protocol Suite directory. See Figure 3.7.

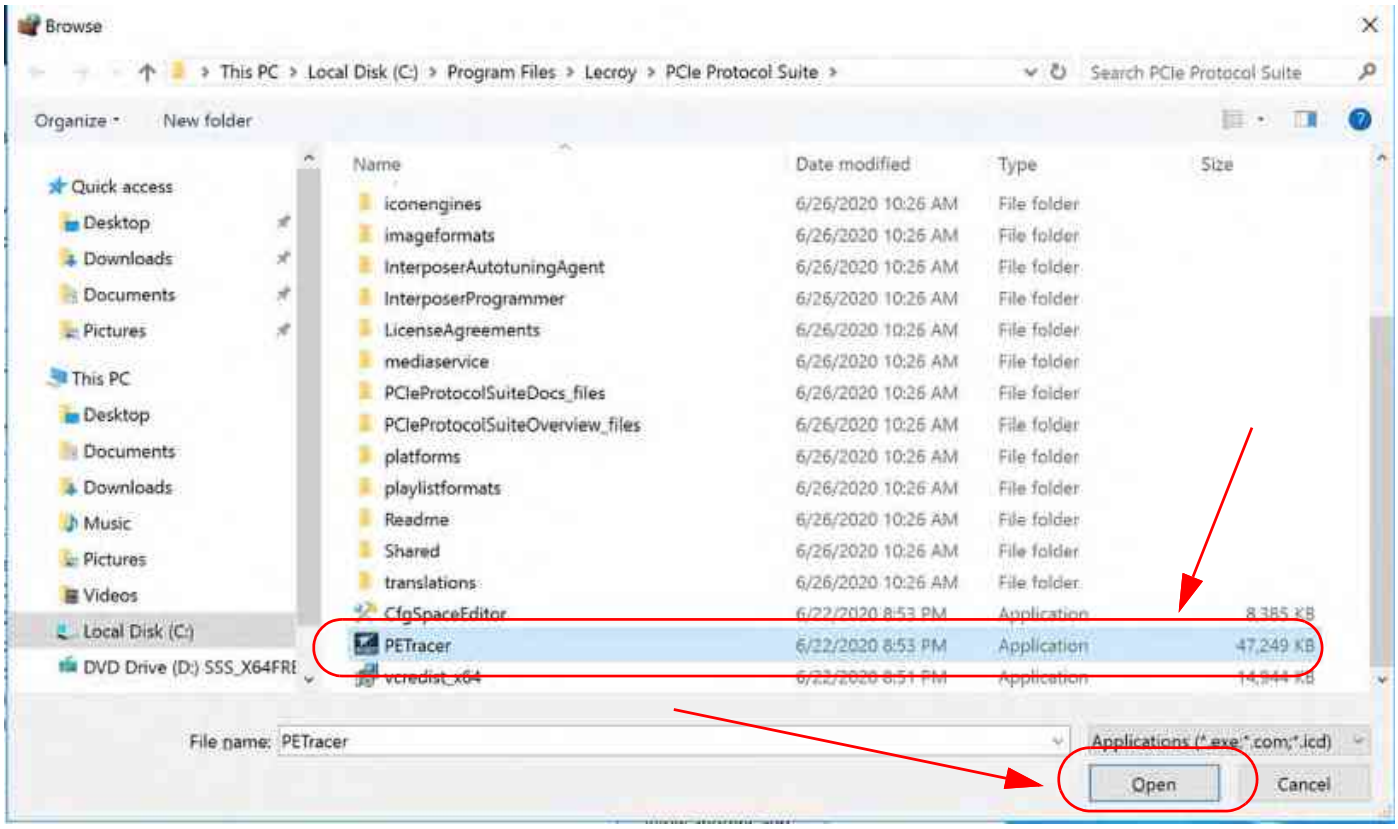


Figure 3.7: Windows Server 2016/2019: Browse to Find Application -> PCIe Protocol Analysis Application

8. Select the PCIe Protocol Analysis executable file (with the .exe extension) and click on “Open”.

9. If necessary, select the Teledyne LeCroy PCIe Protocol Suite you want to add. Then click on “ADD”, this will add the Teledyne LeCroy PCIe Protocol Suite to the Apps allowed through the Firewall. See Figure 3.8.

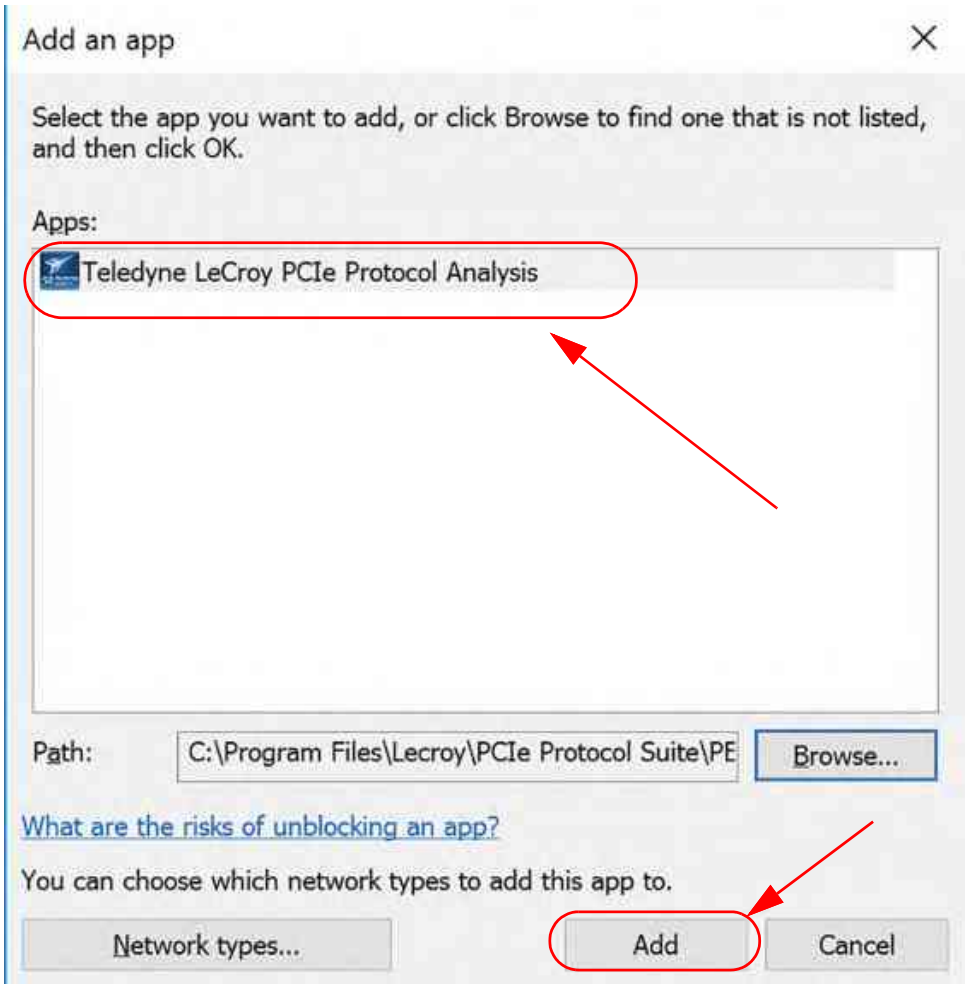


Figure 3.8: Windows Server 2016/2019: Add an Application to the Firewall Exceptions

10. After the Application has been added, you can see it in the “Allow apps to communicate through Windows Firewall” screen. See Figure 3.9.

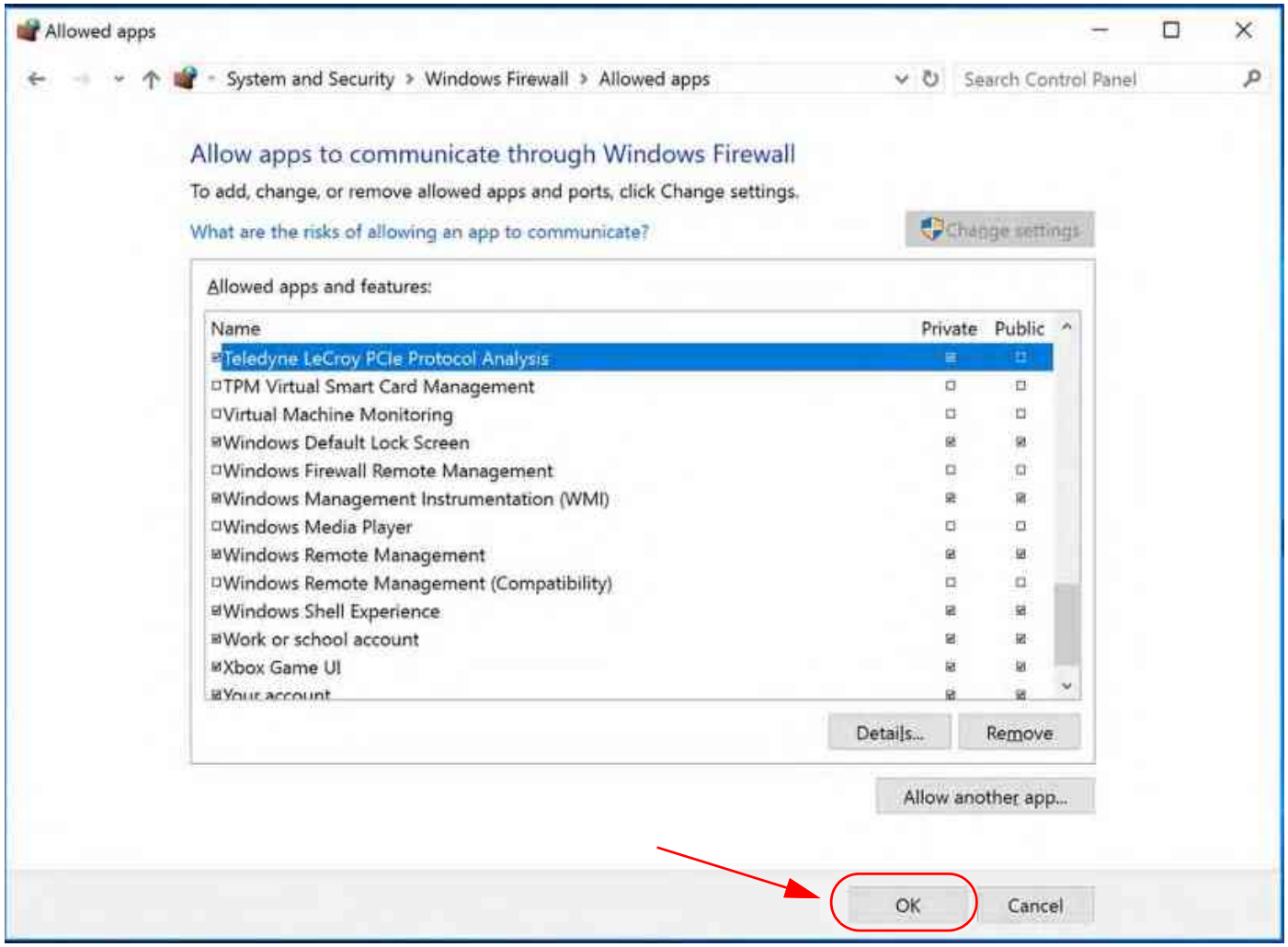


Figure 3.9: Windows Server 2016/2019: Add Teledyne LeCroy PCIe Protocol Suite to Allowed Applications

Click “**OK**” and you’re done with updating the Firewall.

3.1.3 Launching the PCIe Protocol Analysis

To start the application, launch the PCIe Protocol Analysis program from the Start menu:
Start > All Apps > LeCroy > PCIe Protocol Suite

Note: The above path is for Windows 10, the path may be different for other versions of Wndows.

The PCIe Protocol Analysis program displays, as seen below. See Figure 3.10.

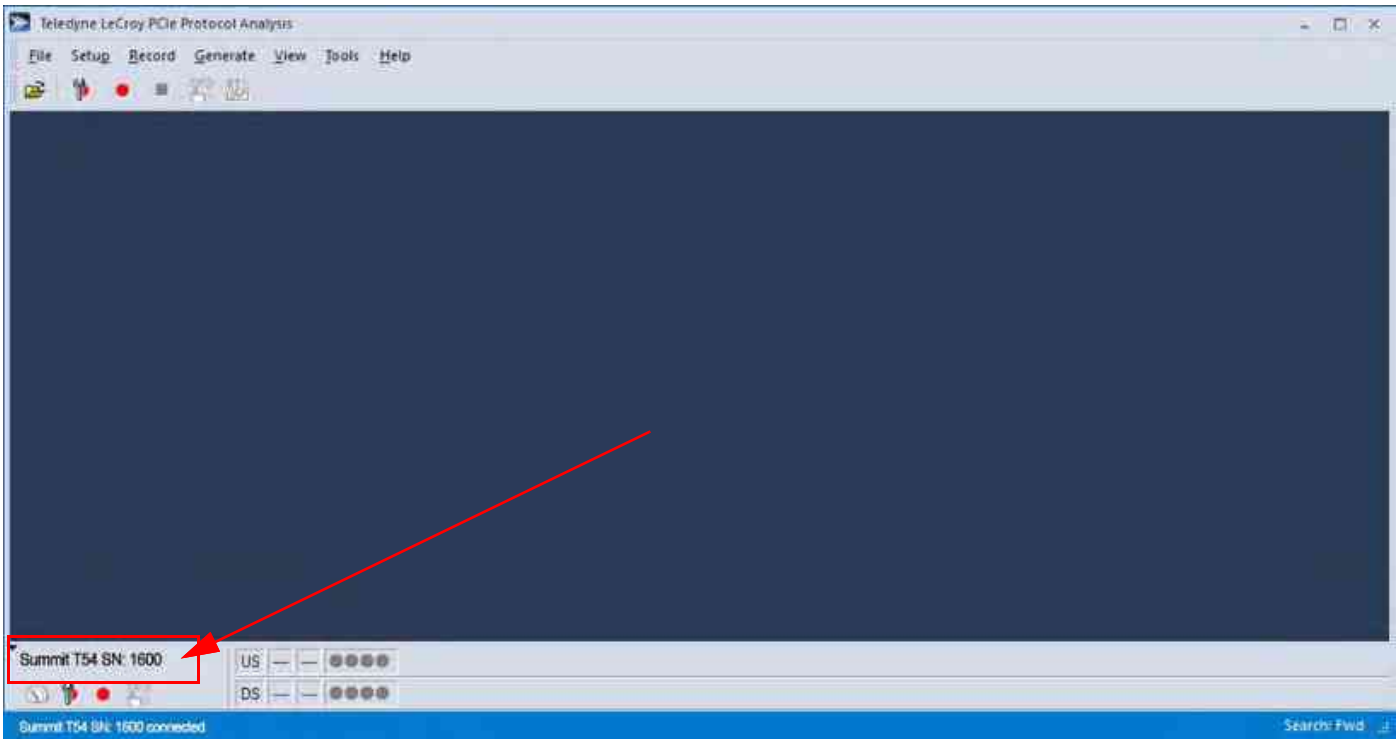


Figure 3.10: Teledyne LeCroy PCIe Protocol Analysis Application

Note: The image above shows the application with a Summit T54 attached. The software may be used with or without the Analyzer. When used without an Analyzer attached to the computer, the program functions as a CATC Trace Viewer to view, analyze and print captured traffic.

3.2 Setting Up the Summit T516 Analyzer using a USB Connection

To set up the Analyzer using a USB connection:

1. Install PCIe Protocol Analysis on the host machine.
2. Connect the Analyzer to a 100-volt to 240-volt, 50 Hz to 60 Hz, 1500 W power outlet using the provided power cord.
3. Connect the USB port to a USB port on the host machine using a USB cable.
4. Turn on the power switch on the front of the analyzer.

Note: At power-on, the Analyzer initializes and performs a self-diagnostic. The results are reflected by messages on the Summit T516 LCD display. If the LCD display indicates failure, call Teledyne LeCroy Customer Support for assistance.

5. Summit T516 will be recognized by the host machine as a USB device.
6. Follow the Microsoft® Windows® on-screen Plug-and-Play instructions for the automatic installation of the Analyzer as a USB device on your analyzing host machine. (The required USB drivers were installed on your system when you installed the software.)
7. Click **Finish** when you see the message that says “Windows has finished installing the software that your new hardware requires” and the file has been installed in your host machine.
8. Start the PCIe Protocol Analysis, so you can start working with Summit T516.

3.3 Setting Up the Summit T516 Analyzer using an Ethernet Connection

To set up the Analyzer using an Ethernet connection:

1. Install PCIe Protocol Analysis on the host machine.
2. Connect the Analyzer to a 100-volt to 240-volt, 50 Hz to 60 Hz, 1500 W power outlet using the provided power cord.
3. Connect the Ethernet cable between the Ethernet port on the Analyzer and a Ethernet port in the local network.
4. Turn on the power switch on the front of the analyzer.

Note: No driver installation is needed for Summit T516 to operate over a network.

Note: At power-on, the Analyzer initializes and performs a self-diagnostic. The results are reflected by messages on the Summit T516 LCD display. If the LCD display indicates failure, call Teledyne LeCroy Customer Support for assistance.

Note: Summit T516 is configured at the factory to use dynamic IP setting and will get all required network parameters from the DHCP server on your network. If the DHCP server is not available, or to connect Summit T516 directly to the host machine, you can reconfigure the network settings of Summit T516 using the menus in the LCD display on the front of the analyzer (see the “LCD Menus” part of section 4 of this document).

3.3.1 Connecting to Summit T516 in the PCIe Protocol Analysis

Start the PCIe Protocol Analysis and perform the following procedure to connect to a Summit T516 analyzer over the network.

1. Select the **Setup > All connected devices…** menu in the PCIe Protocol Analysis application to display the Analyzer Devices dialog. See Figure 3.11 on page 71.

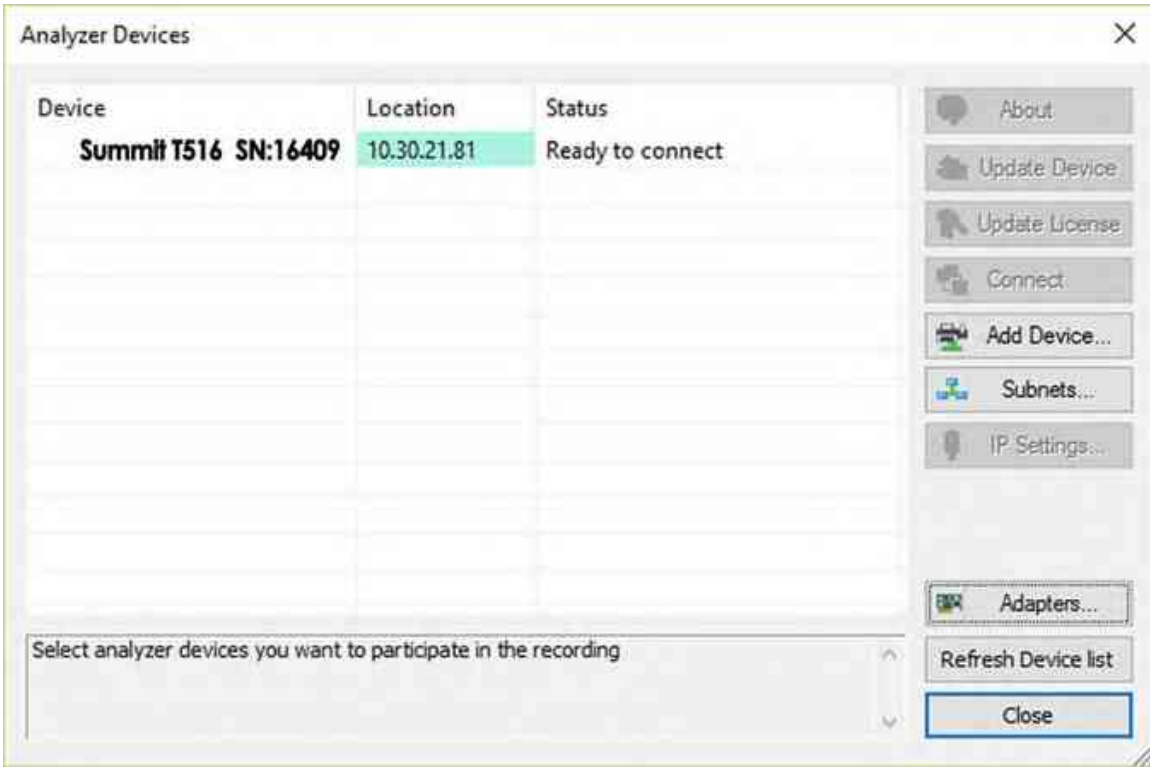


Figure 3.11: Analyzer Devices: T516 Ready to Connect

The Summit devices in the list are marked:

Locked: Some other client on the network is already connected to that device

Ready to connect: Available for connection

2. Select your Summit T516 device in the list and press the **Connect** button to execute the connection procedure. After the connection is established, the application displays the Connection Properties dialog.
3. Select an option:

Automatically connect to the device: When the application is started or when the named device appears on the network while the PCIe Protocol Analysis application is running on this computer, the PCIe Protocol Analysis application will try to connect to the named device.

Ask if I want to connect to the device: When the application is started or when the named device appears on the network while the PCIe Protocol Analysis application is running on this computer, the PCIe Protocol Analysis application will display a message box allowing you to connect to the named device.

Take no action: When you start the application or when the named device appears on the network while the PCIe Protocol Analysis application is running on this computer, you must connect manually to use the named device.

When you close the application on this computer (or you perform manual disconnect), the application disconnects from the device.

4. Press **OK** in the Connection Properties dialog. After you finish the connect procedure, the Summit T516 to which you have connected is marked as **Ready** and you can use it for recording. See Figure 3.12.

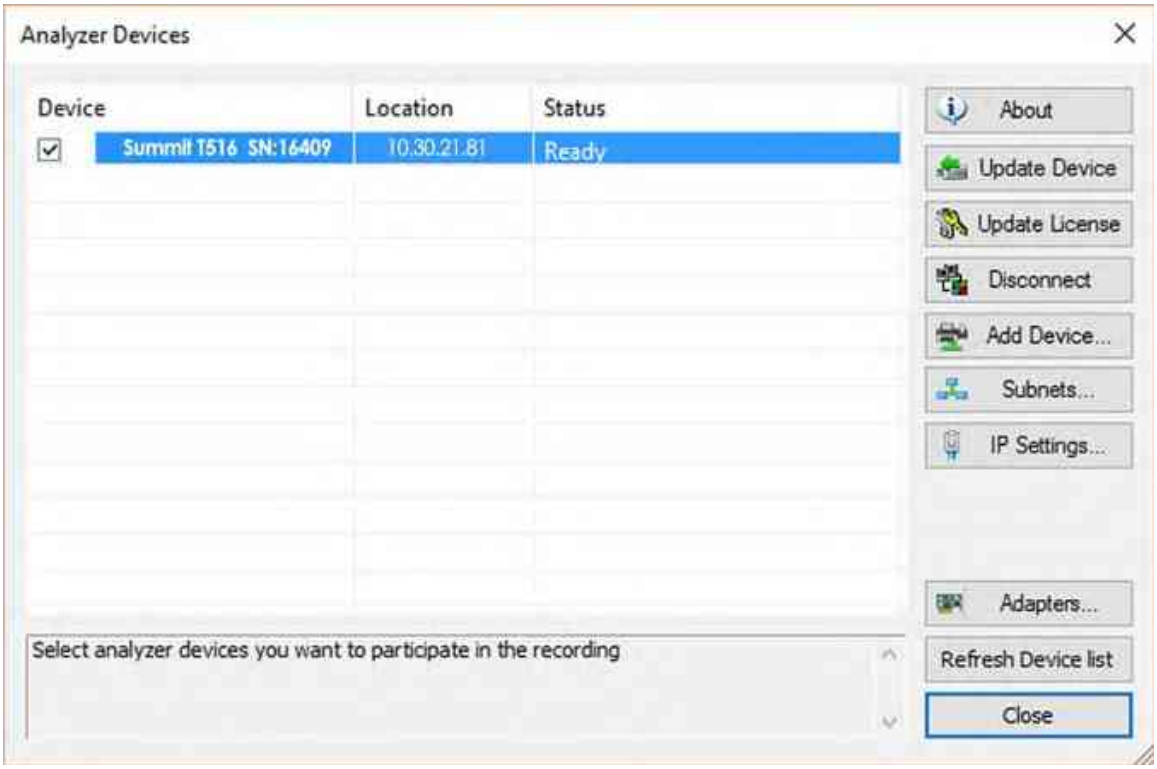


Figure 3.12: Analyzer Devices: T516 Ready

Note: To disconnect from a device, display this dialog, select the device, and click the **Disconnect** button.

Note: Summit T516 will not appear in the Analyzer Device dialog if it is connected on a different Subnet on your local network. You can connect to it on the Subnet by specifying its IP address in the Add Device dialog.

3.4 Setting Up the Summit T54 Analyzer using a USB Connection

To set up the Analyzer using a USB connection:

1. Connect the Analyzer to a 100-volt to 240-volt, 50 Hz to 60 Hz, 120 W power outlet using the provided power cord.
2. Connect the USB port to a USB port on the host machine using a USB cable.

Note: To connect using Ethernet, see "Setting Up the Summit T54 Analyzer using an Ethernet Connection" on page 73.

3. Turn on the front power switch.

Note: At power-on, the Analyzer initializes itself in approximately five seconds and performs an exhaustive self-diagnostic that lasts about forty seconds. The results are reflected by messages on the Summit T54 LCD display. If the LCD display indicates failure, call Teledyne LeCroy Customer Support for assistance.

4. Follow the Microsoft® Windows® on-screen Plug-and-Play instructions for the automatic installation of the Analyzer as a USB device on your analyzing host machine. (The required USB drivers are installed on your system by the PCIe Protocol Analysis installation.)

   Click **Finish** when you see the message that says "Windows has finished installing the software that your new hardware requires" and the file has been installed in your host machine.

3.5 Setting Up the Summit T54 Analyzer using an Ethernet Connection

Note: If your PC and the analyzer are both on the same subnet you should have no problem making a DHCP connection. If they are not, you may have to set appropriate subnet and gateway settings. Also, it is best if TCP ports 4000 to 4003 and UDP ports 4015 to 4017 are available on the network, but even if they are not you may be able to force a connection by checking the "Force add/connect attempt" box.

1. Connect the Analyzer to a 100-volt to 240-volt, 50 Hz to 60 Hz, 120 W power outlet using the provided power cord.
2. Connect the Summit T54 Analyzer to the network. The Ethernet port is on the rear panel of the Analyzer.

Note: To connect using USB, see "Setting Up the Summit T54 Analyzer using a USB Connection" on page 73.

3. Turn on the front power switch.

Note: At power-on, the Analyzer initializes itself in approximately five seconds and performs an exhaustive self-diagnostic that lasts about forty seconds.

4. After you have installed the PCIe Protocol Analysis application software, perform the following procedure to connect to a Summit T54 Analyzer in the local network.

   Select the **Setup > All connected devices…** menu in the PCIe Protocol Analysis application to display the Analyzer Devices dialog.

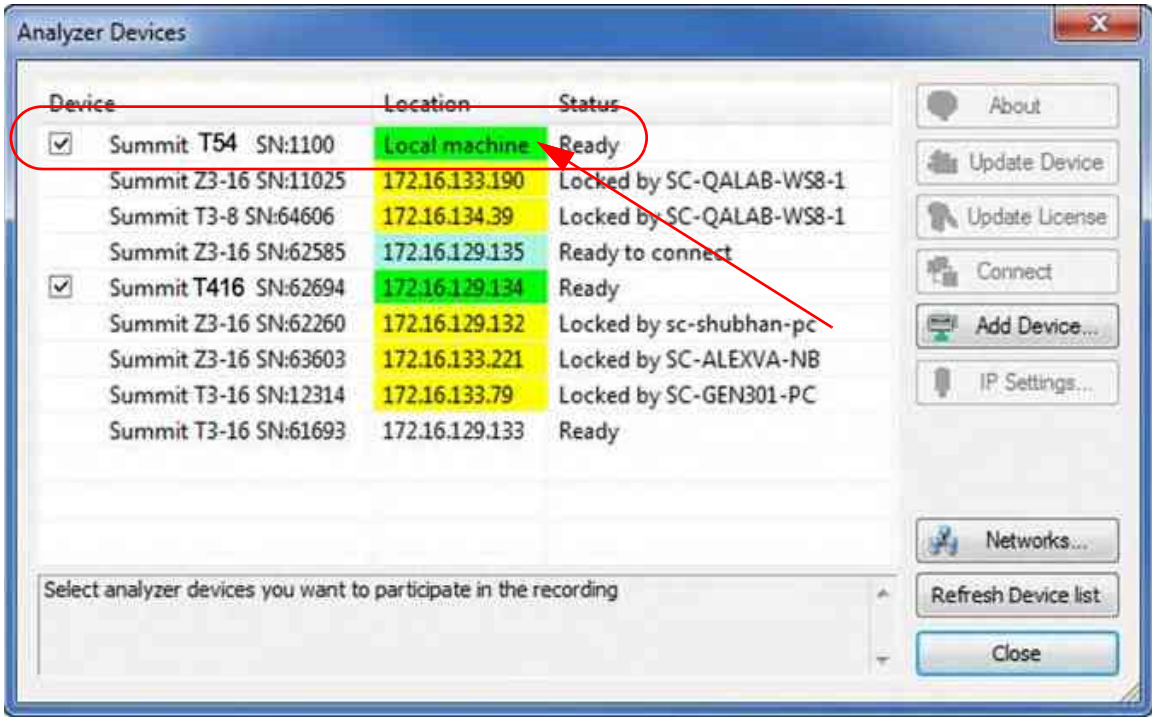


Figure 3.13: Analyzer Devices Dialog

The PCIe Protocol Analysis fills the list with devices that are connected over USB or discovered on the Ethernet network. The discovery mechanism works only within one network subnet. If a Summit is connected to the network on a different subnet, you can manually add the subnet to the list by clicking the **Add Device** button and specifying the IP address.

The Summit devices in the list are marked:

- **Locked**: Some other client on the network is already connected to that device
- **Ready to connect**: Available for connection

1. If a Summit device is marked Ready To Connect, you can select that device and press the **Connect** button to execute the connection procedure.

   After the connection is established, the application displays the Connection Properties dialog.



Figure 3.14: Connection Properties Dialog (Summit T54)

Note: The Connection Properties dialog will show either the Summit T54 detected.

2. Select an option:
   - **Automatically connect to the device**: When the application is started or when the named device is added to the network while the PCIe Protocol Analysis application is running on this computer, the PCIe Protocol Analysis application will try to connect to the named device.
   - **Ask if I want to connect to the device**: When the application is started or when the named device is added to the network while the PCIe Protocol Analysis application is running on this computer, the PCIe Protocol Analysis application will display a message box allowing you to connect to the named device.
   - **Take no action**: When you start the application or when you want to add the named device to the network while the PCIe Protocol Analysis application is running on this computer, you must connect manually to use the named device.

Note: When you close the application on this computer (or you perform a manual disconnect), the application disconnects from the device.

3. Press **OK** in the Connection Properties dialog.

   After you finish the connect procedure, the Summit device to which you have connected is marked as **Ready** and you can use it for recording (see Figure 3.15 and Figure 3.16 on page 77).

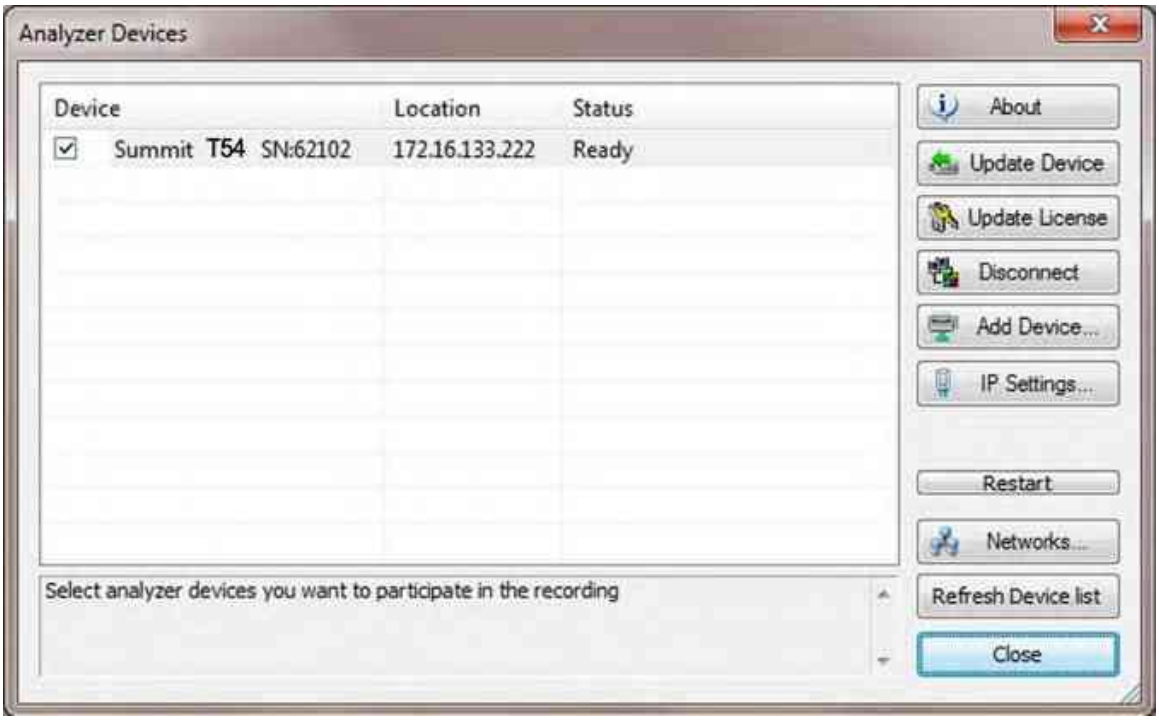


Figure 3.15: Analyzer Devices Dialog (Summit T54)

Note: To disconnect from a device, display this dialog, select the device, and click the **Disconnect** button.

Note: As of version PCIe Protocol Analysis version 7.34, the software is able to access a Summit analyzer via VPN solutions that require explicit bindings to PPP adapters that they create.

3.6 Adding Devices Manually

You can locate and add a Summit T516/T54 Analyzer located in a Ethernet subnet using the Add Device button. Perform the following steps:

Note: The images below show a Summit T54 Analyzer but the Summit T516 has similar images.

Click **Setup -> All Connected Devices -> Add Device ->** to display the Add Ethernet Attached Device dialog.



Figure 3.16: Add Ethernet Attached Devices Dialog (Summit T54)

Click the **Recent** button to display a list of recently added devices (up to 15) and quickly add a recently used device.

Click the **Ping** button to ping a device as a network node (prompting an error message if no response). Ping also allows PCIe Protocol Analysis to detect a device type before actually connecting to the device.

If the "Ping" feature discovers that the device is already connected and "locked" then it will inform the user and provide information about who locked the device.

Click **Setup -> All Connected Devices** to display the Analyzer Devices dialog.

If software fails to connect to a manually added device, a message displays notifying the user about the connection failure. The user is given the option to keep the failed device in the device list, in this case PCIe Protocol Analysis displays a "Failed to connect" status message in gray.

Square brackets for IP addresses are used for manually added devices to easily distinguish them from auto-discovered devices.

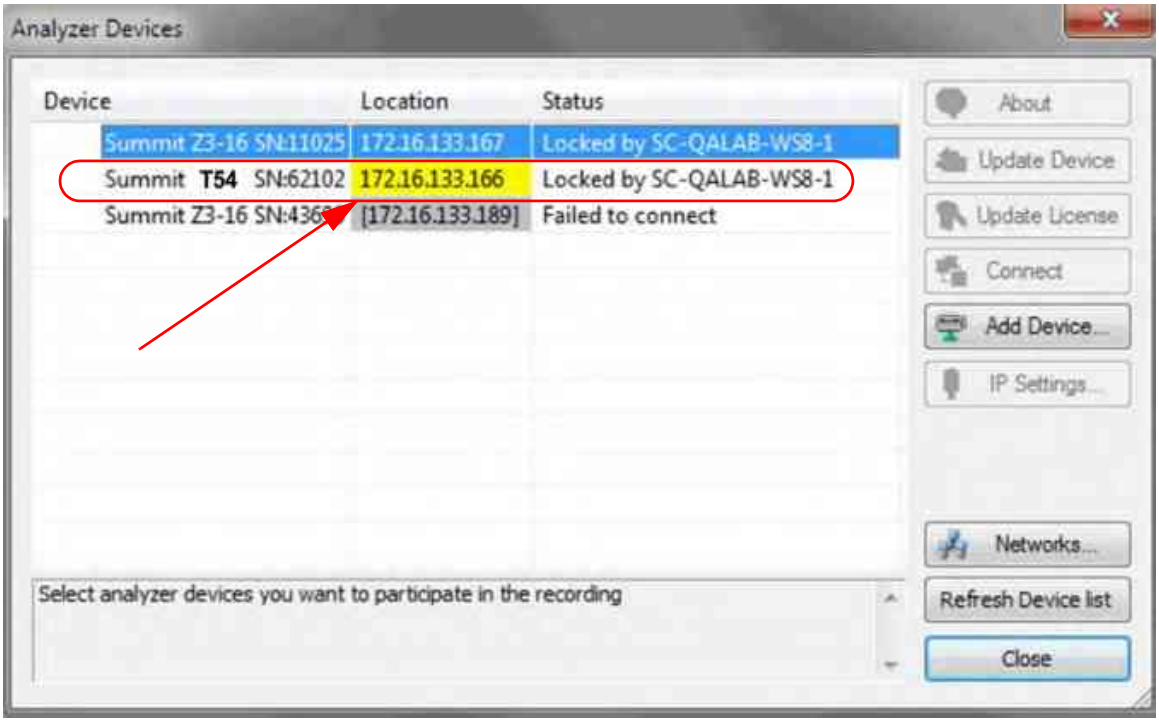


Figure 3.17: Add Ethernet Attached Devices Dialog (Summit T54)

3.6.1 Adding a Summit T516/T54 to an Ethernet Network

If you have a Summit T516/T54 and want to add it to an Ethernet Network but don't know it's IP address you can find out the IP address and add it to the Ethernet Network using the USB connection.

With the USB cable installed, start up the PCIe Protocol Analysis and select **Setup > All connected Devices.**

Note: The images below show a Summit T54 Analyzer but the Summit T516 has similar images.

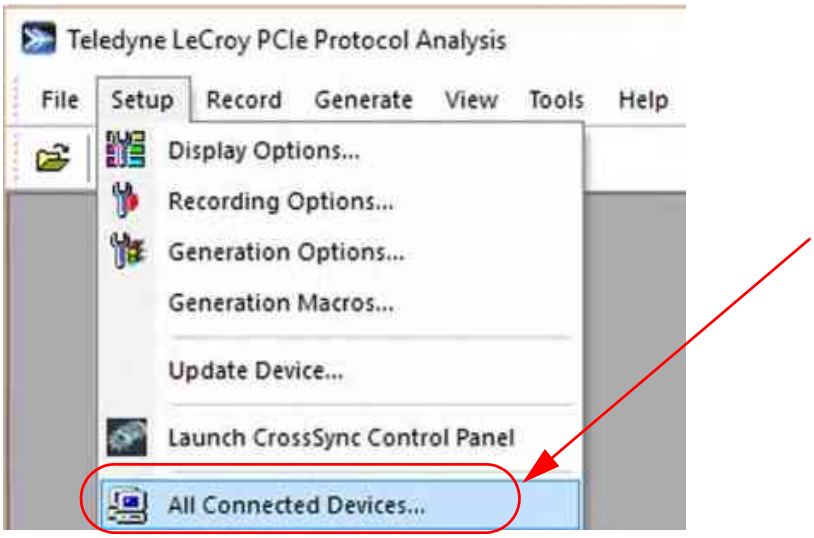


Figure 3.18: Setup > All Connected Devices

This will popup a dialog box showing all the connected devices on your network. See Figure 3.19 on page 80.

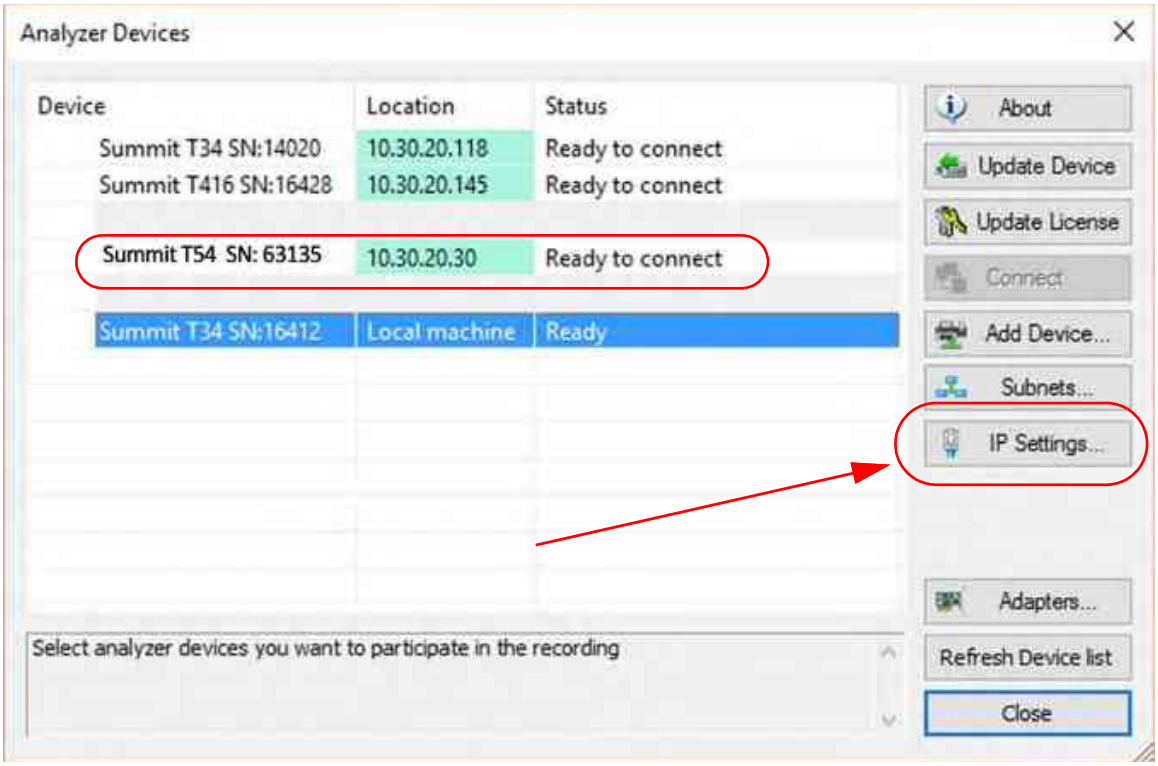


Figure 3.19: All Devices Connected on Your Network

To discover the IP address of the local Summit T516/T54 (attached via the USB cable to your Summit T516/T54), select the IP Settings tab. This will popup the Device Settings dialog box. See Figure 3.20.

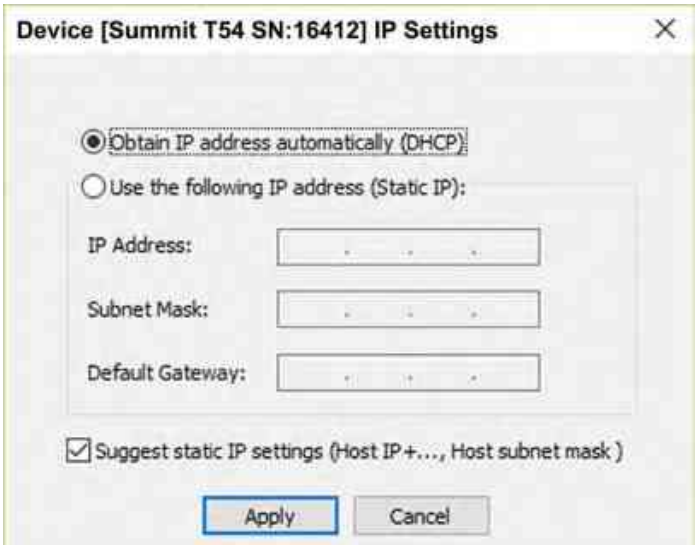


Figure 3.20: Device IP Settings (Summit T54)

From this dialog box you can either:

- Obtain an IP address automatically (DCHP)
- Use the following IP address (Static IP)
- Suggest Static IP Settings

If you choose the DCHP option the following dialog box will popup (see Figure 3.21).

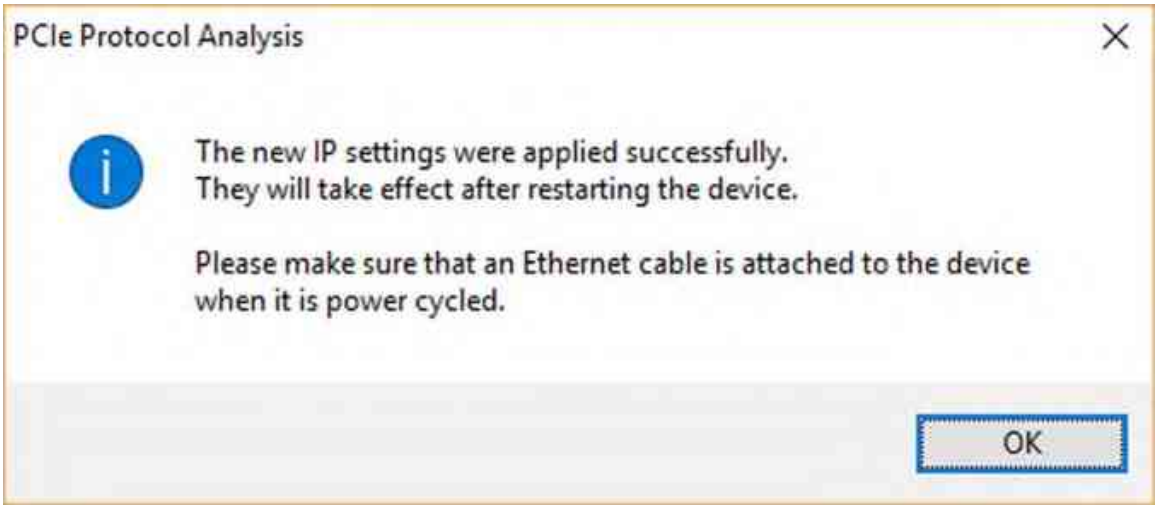


Figure 3.21: Use DCHP to Set IP Address

If you had chosen to use the Static IP address the following Dialog Box would popup (see Figure 3.22. You can either.

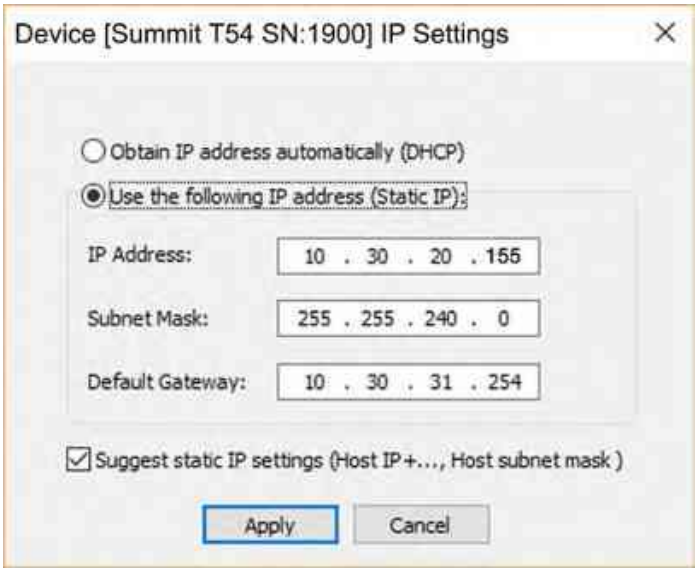


Figure 3.22: Use Static IP Address Summit T54

If you had chosen the Suggest static IP settings the following dialog box would popup (see Figure 3.23).

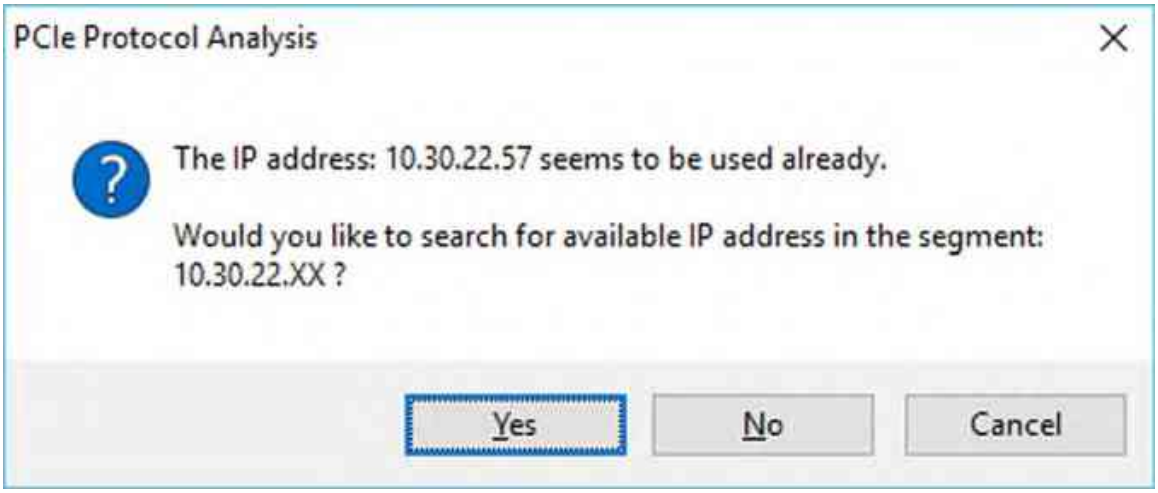


Figure 3.23: Suggest Static IP Settings

Select "Yes" and the system will select an unused IP address.

The the following dialog box will popup. See Figure 3.24.

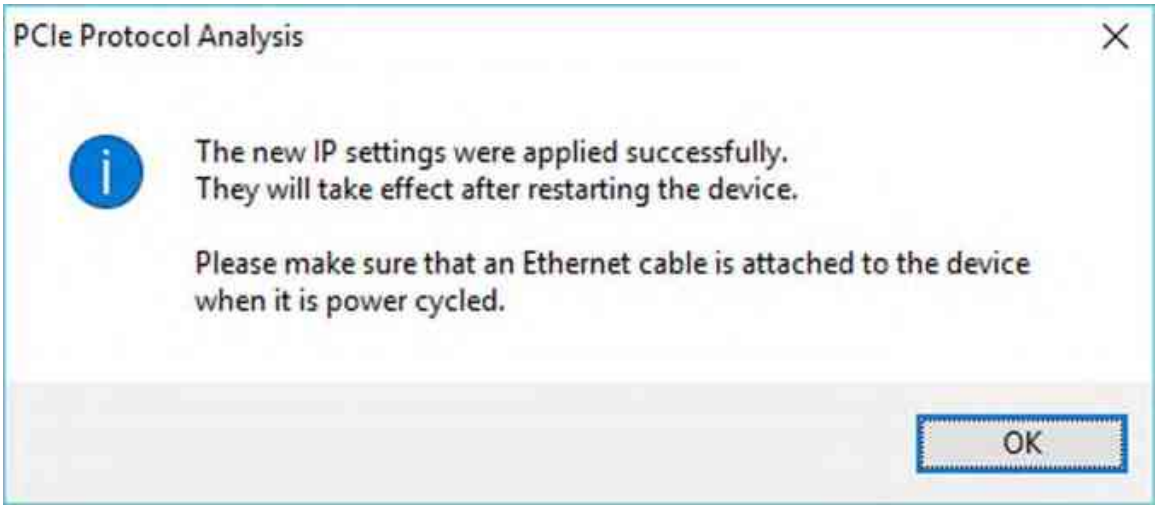


Figure 3.24: New IP Settings Applied

Now you should attach the Ethernet cable, disconnect the USB cable and cycle the power on the Summit T54 .

After the Summit T54 re-initializes and the Status LED goes from OFF to Green to Blue, restart the PCIe Protocol Analysis and select **Setup > All Connected Devices.**

Now the Summit T54 has an IP address and is Ready to Connect.

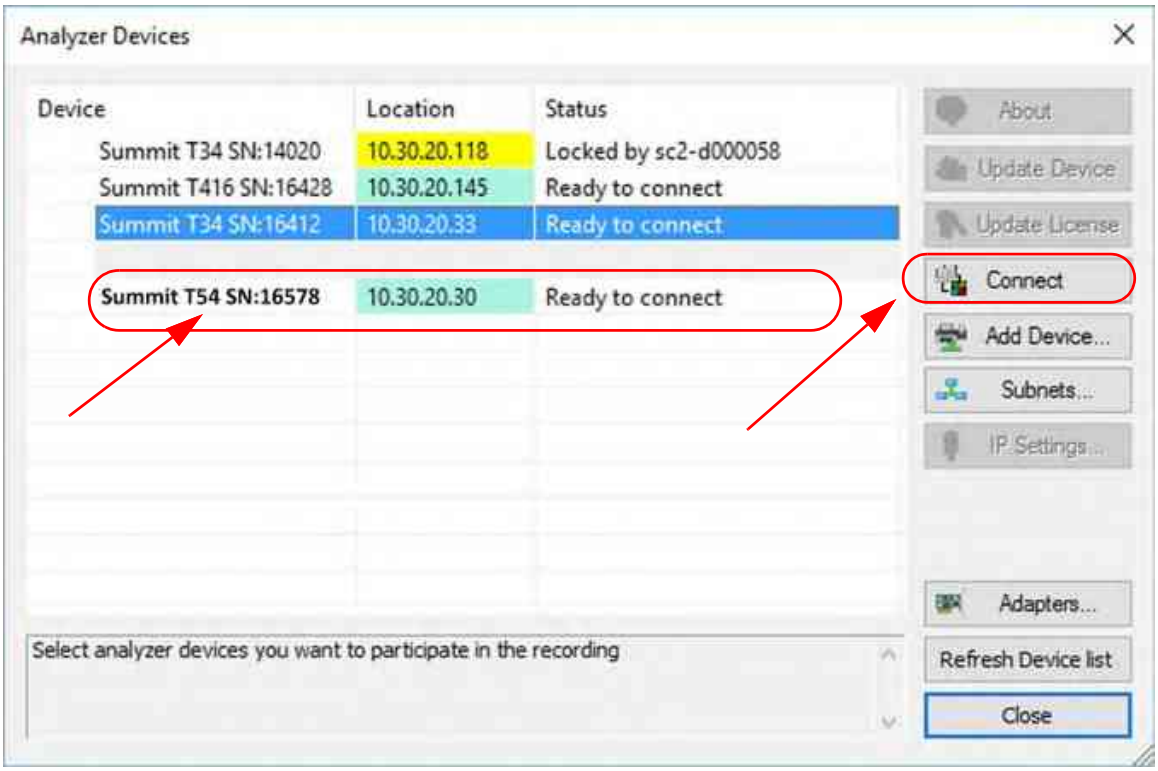


Figure 3.25: Analyzer Devices: Summit T54 Showing IP Address

Select the Connect tab and you are ready to start capturing data traffic with the Summit T54.

Chapter 4

Interposer Configuration and Setup

Interposers are part of the analyzer setup but they have become quite complex and have a lot of features and settings that can be used to improve performance when working with challenging DUTs. This chapter describes configuration and setup for the interposer subsystem.

4.1 Interposer Configuration and Setup

For TAP6 interposers (Gen6 CEM, Gen6 EDSFF, etc.) there is a new configuration button appearing at the bottom of the PCIe Protocol Analysis Software. Currently this button provides access to configure lane terminations in the interposer and provides a mechanism for the analyzer to downgrade the maximum link the host/device can achieve or for it not to interfere with the maximum link achievable for host-device.

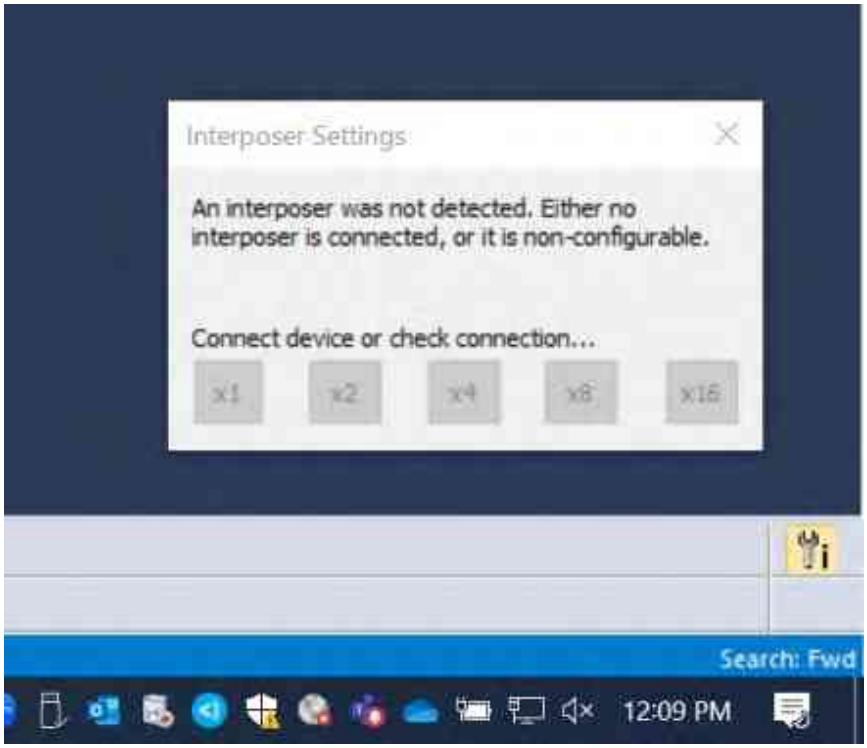


Figure 4.1: Interposer Configuration and Setup

Set the proper configuration using the buttons in the dialog.

For previous generation analyzers and interposers this button may appear but not allow for any change in configuration. This can be disregarded.

Chapter 5

Software Overview

5.1 The PCIe Protocol Analysis

The PCIe Protocol Analysis™ software administers Analyzer platforms and handles all CATC Trace analysis and display. The core software is thus the same for all of Teledyne LeCroy's PCI Express products.

The software runs on a Windows® based host machine that is attached to the Analyzer via an Ethernet or USB connection. PCIe Protocol Analysis can be used without the Analyzer as a CATC Trace viewer for viewing, analyzing and printing traces.

The PCIe Protocol Analysis operates on systems using Windows Server 2019 (x64), Windows Server 2016 (x64) and Windows 10 64-bit. The latest Service Pack available for the Windows OS in use is required. It is recommended that you use one of the supported 64-bit Windows versions listed above.

5.2 Application Layout

Figure 5.1 and Table 5.1 show the PCIe Protocol Analysis application components.

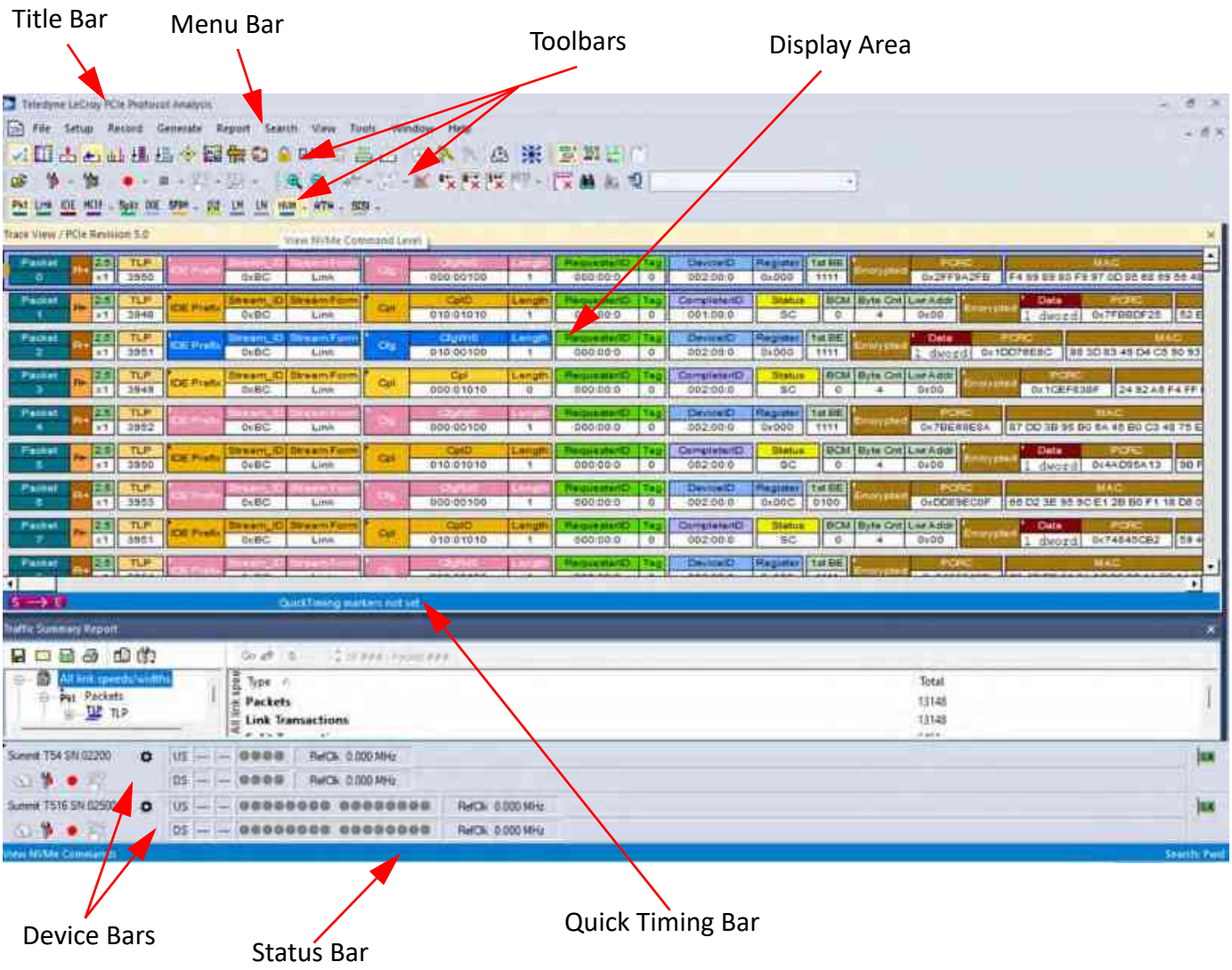


Figure 5.1: PCIe Main Screen with CATC Trace

TABLE 5.1: PCIe Components

Component	Description
Title Bar	The title bar is at the top of the application window and displays the CATC Trace file name or generation script name.
Menu Bar	The menu bar is located below the title bar. The menu bar can be moved by clicking a blank area of the bar and then dragging the menu to a new position. It can be docked in another part of the application window or moved outside of the window to become a floating menu.

TABLE 5.1: PCIe Components

Component	Description
Toolbars	The toolbars are icons that represent the commonly used commands. The toolbars are divided into smaller toolbars that can then be moved and docked in new positions or can float above the window.
Display Area	The display area is the main part of the application window that displays the CATC Traces.
Quick Timing Bar	The quick timing bar is located below the display area shows the delta time, bus utilization, and data throughput between quick timing marker start and end points. See Chapter 7, “Reading CATC Traces,” on page 189 for more information.
Device Bar(s)	Each device bar displays an attached device and provides quick access to device controls through buttons (hover over each to see their function).
Status Bar	The status bar is located at the bottom of the application window. The left end of the status bar displays setup status (Ready, Activating Device, Restarting, etc) and, when hovering over a button or a menu item, displays descriptions of the button or menu item. The right end of the status bar shows the search direction.

5.3 Toolbars

Use the PCIe Protocol Analysis application Toolbars as shortcuts to most of the operations that are typically found through the menus.

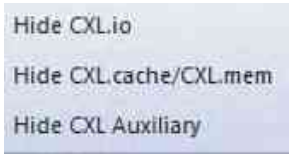


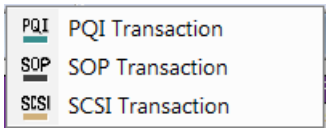
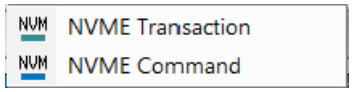
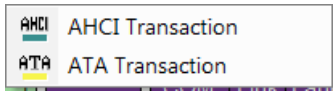
Figure 5.2: Summit T5 Toolbars

	Opens a previously recorded CATC Trace file.		Stop Recording.
	Setup Recording Options Opens the Recording Options dialog.		Real Time Statistics monitor Opens a window that displays real-time information.
	Start Recording.		

	Displays CATC Trace view.		Displays color spreadsheet view.
	Displays compressed CATC Trace view.		Displays black and white spreadsheet view.

	Zoom in display.		Advanced Hiding Options Opens a dialog box that allows you to select items to hide from view.
	Zoom out display.		Hide Unassociated Traffic Hides the lower-level transaction packets. Example: Link Transactions and Packets are considered “unassociated” when using Split Transaction Level view.

	Hide Training Sequence.		Compact View Toggles compacting of training sequences to analyze CATC Trace data faster, or no compacting to display more data. Compact View also compacts CXL NULL Flit Packets.
	Hide SKIP and Update FC packets.		Find Opens a dialog box that allows you to select one or more items to find in the recording, then searches to that point.
	Hide Upstream recording/ traffic.		Find Next. Repeats last Find or Search action.
	Hide Downstream traffic/ recording.		Hide Sideband traffic.
	Hide MCTP VDM and Hide SMBus MCTP		Hide CXL traffic
			
			Quick Search window: Allows user to search for pre-defined terms or type in their own term to search for. See “Quick Search Feature” on page 105.

	View Packet Level data.		View Link Transaction Level data.
	View Split Transaction Level data		View PQI, SOP and SCSI Transaction Level data pull down menus. 
	View NVME Transaction Level and Command data pull down menus 		View MCTP Transaction Level data
	View AHCI and ATA Transaction Level data pull down menus 		Lane Margining Commands/Responses
	IDE Decryption		Lightweight Notification Transaction Level data

	Trace Expert Generates data on Performance Analysis, Trace Analysis Statistics, Error Reports and Trace Information.		Opens the Data Flow window. Shows recorded data in a compressed tabular format.
	Trace Information Lists the conditions under which the recording was made.		Navigator. Shows/hides the Navigator bar - a utility that lets you easily navigate the CATC Trace
	Error Report Opens a window that lists all errors identified in the recording.		Detail View Shows the Detail view of the selected packet.
	Traffic Summary Opens a window that lists all events that occurred during the recording		Running Verification Scripts Runs selected Verification Scripts

	Bus Utilization Opens a window that graphically represents various information about the recording.		LTSSM Flow Graph Shows a state diagram of the Link Training and Status State machine.
	Link Tracker Opens a window that displays symbol information per lane.		Opens view for TCG Security Codes. TCG decoding is performed using NVMe Command Level option.
	IDE View Displays decrypted data, IDE-specific information and decrypting parameters		IDE Keys Opens IDE Keys View for setting decryption parameters
	Get Log Page View Opens Log Page View		

	CXL Flit Data View Opens window showing detailed view of CXL Flit Data		Displays the Data/Payload window for the current packet.
	Displays the Packet Header bar. Opens a window that displays the header information in the current packet, as it would be viewed in the specification.		Opens the Timing and Bus Usage Calculations window.

5.4 Multi-Segment Toolbar

	First Segment. Open first segment in the multisegment CATC Trace.		Index file. This button becomes active if a multisegment CATC Trace file is open and displays the index file for the recording.
	Previous segment. Open previous segment in the multisegment CATC Trace.		Next Segment. Open next segment in multisegment CATC Trace.
			Last segment. Open last segment in multisegment CATC Trace.

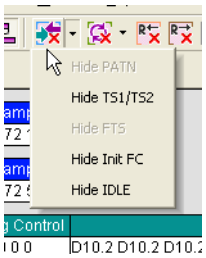
5.4.1 Toolbar Hide Buttons

The PCIe Protocol Analysis application toolbar has seven buttons related to show/hide of CATC Trace file contents. The buttons allow you to quickly adjust the display to your needs.



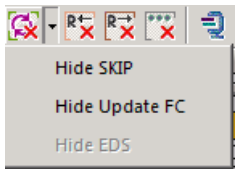


Hide Training: Brings up a drop-down menu that lets you to hide all or a portion of the packets in the training portion of the CATC Trace.





Hide SKIP, Update FC and Hide EDS: Brings up a drop-down menu that lets you hide SKIP, Update FC and hide EDS packets in a CATC Trace.



Hide Upstream: Hide all traffic from endpoint devices to the root complex.



Hide Downstream: Hide all traffic from the root complex to endpoint devices.



Hide Sideband: Hide all sideband traffic (includes SMBus traffic).



Hide MCTP: Hide MCTP VDM traffic (and/or) Hide SMBus MCTP traffic.



Advanced Hiding Options: Brings up the Level Hiding pane of the Display Options window. Use this pane to tune the show/hide options within the CATC Trace display.



5.4.2 Display Options: Level Hiding -> Direction

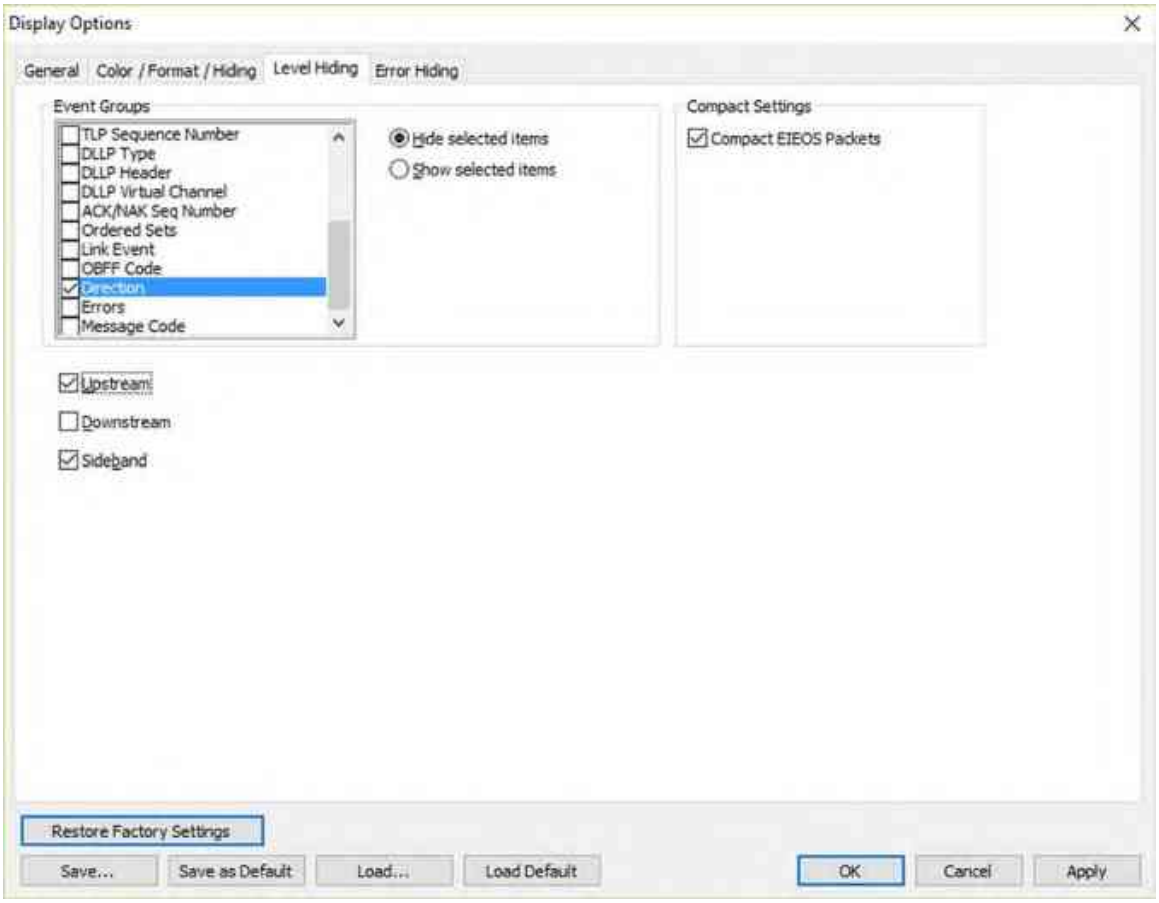


Figure 5.3: Display Options: Level Hiding -> Direction

You can select the Direction of traffic to Hide:

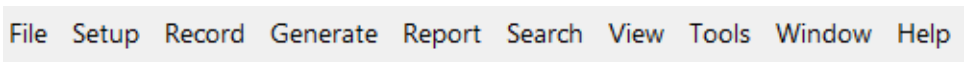
- Upstream
- Downstream
- Sideband (includes SMBus traffic)

Hide Unassociated Traffic: Hides the lower-level transaction packets. Example: Link Transactions and Packets are considered "unassociated" when using Split Transaction Level view.



5.5 Using the Menus

The PCIe Protocol Analysis application main display includes the following set of pull-down menus:



5.5.1 File Menu

TABLE 5.2: File Menu

Item	Description
New PETrainer Script	Creates a new Traffic Generation file.
Open	Opens a file.
Close	Closes the current file.
Save as	Saves all or a specified range of packets to a uniquely named file. Overwrites existing file name. See “Using the Save As Function” on page 125.
Save Copy As	Saves all or a specified range of packets to a uniquely named file. Original file remains the same and new file is created with the new file name. See “Save Copy As Function” on page 127.
Convert Old Files	Convert CATC Trace files made in previous versions of PE*Tracer* to the new format for PE*Tracer* version 5.0 and higher.
Print	Prints part or all of the current traffic data file.
Print Preview	Produces an on-screen preview before printing.
Print Setup	Setup your current or new printer.
Clean Up Decoder Temp Files	Let’s you selectively delete decoder temp files (see “Clean Up Decoder Temp Files” on page 97).
Edit Comment	Create or edit the comment field in a CATC Trace file.
Export >> to Text >> Packets to CSV Text >> to Generator File Format	Saves all or part of a CATC Trace to a text file or traffic generation file. This text file summarizes the traffic in the CATC Trace. Saves the CATC Trace to a text file in Comma Separated Value (CSV) format. Saves the CATC Trace to a generation file, which can be used Summit Exerciser (Z3-16 or Z416).
Exit	Exit the PCIe Protocol Analysis application.

5.5.1.1 File Dialog

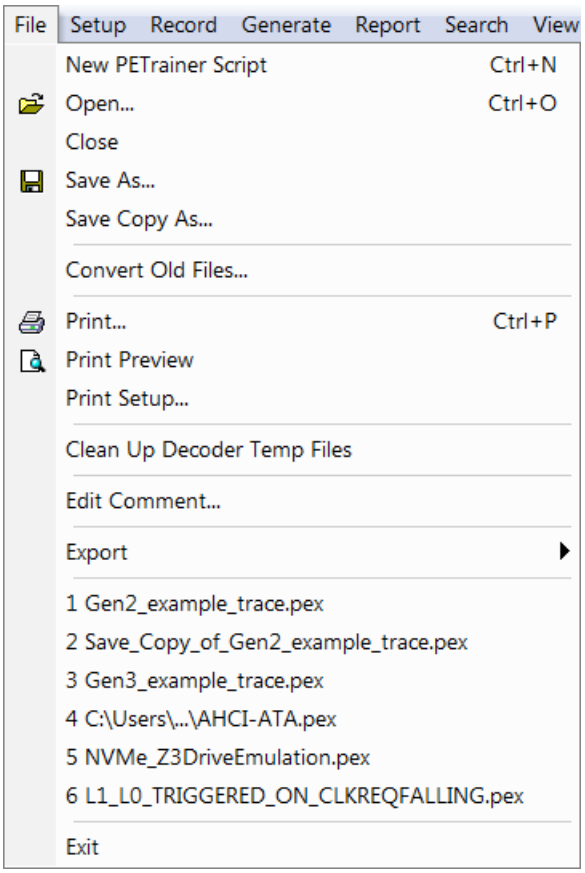


Figure 5.4: File Dialog

5.5.1.2 Clean Up Decoder Temp Files

This command deletes selected decoder temp files from the selected folder.

The file types effected by this command are:

- *.pem
- *.pex
- *.peraw
- *.mpex
- *.peg

To use this command follow the steps below:

1. The Sample File Folder has Temp files for every trace that has been opened: See Figure 5.5.

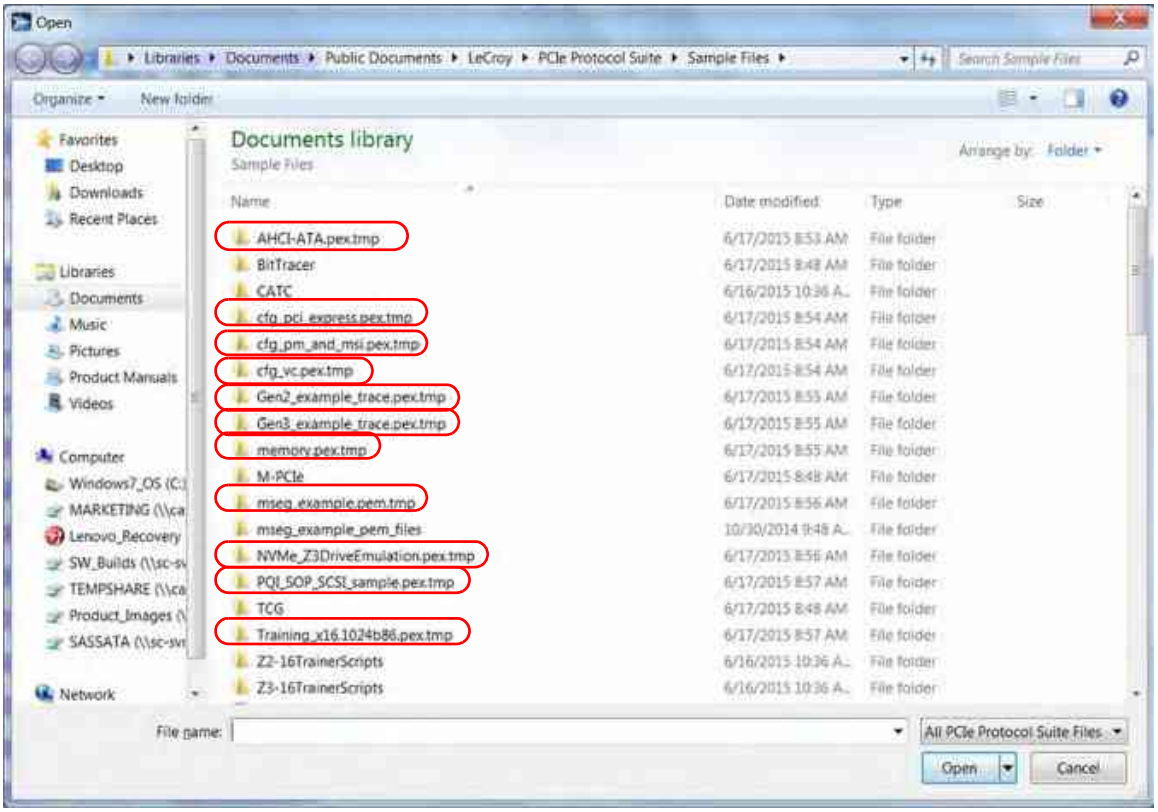


Figure 5.5: Sample Files Folder After Opening a Variety of Traces

2. Now select the File -> Clean Up Decoder Temp Files (see Figure 5.4 on page 97).
3. The following Dialog will pop up: See Figure 5.6 on page 98.

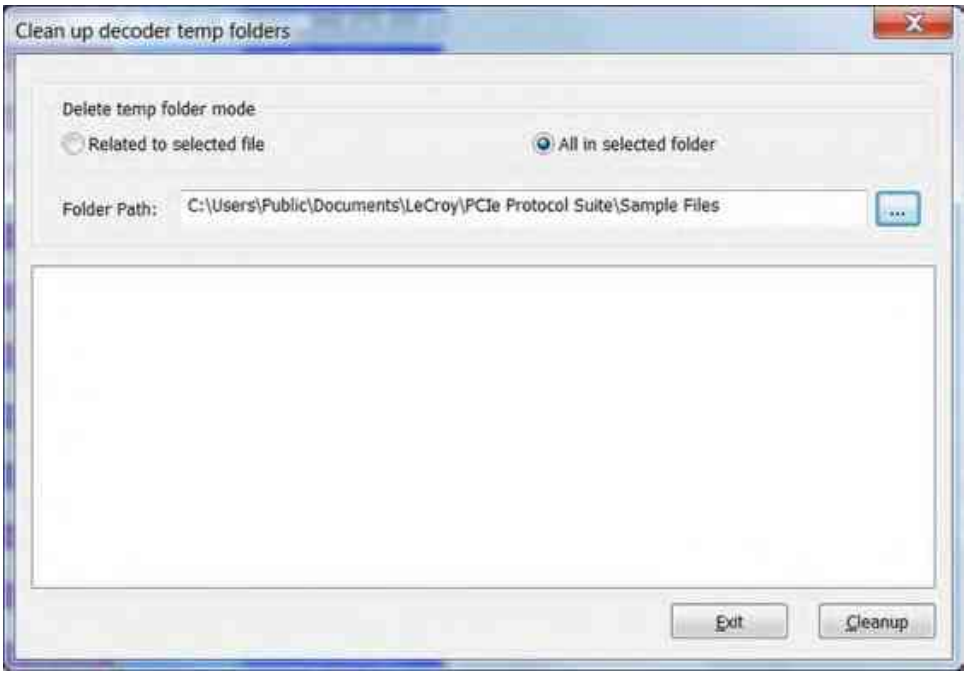


Figure 5.6: Clean Up Decoder Temp Files Dialog

4. Select C:\Users\Public\Documents\LeCroy\PCIe Protocol Site\Sample Files folder.

5. Select Cleanup and a Warning Dialog will pop up. See Figure 5.7.

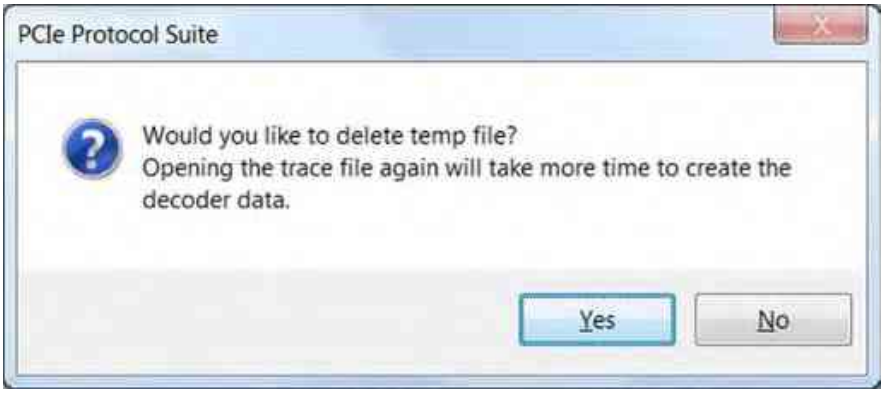


Figure 5.7: Clean Up Decoder Temp Files Warning Dialog

6. Click on Yes, (if files are still in use the Clean Up will Fail, see Figure 5.8 on page 99).

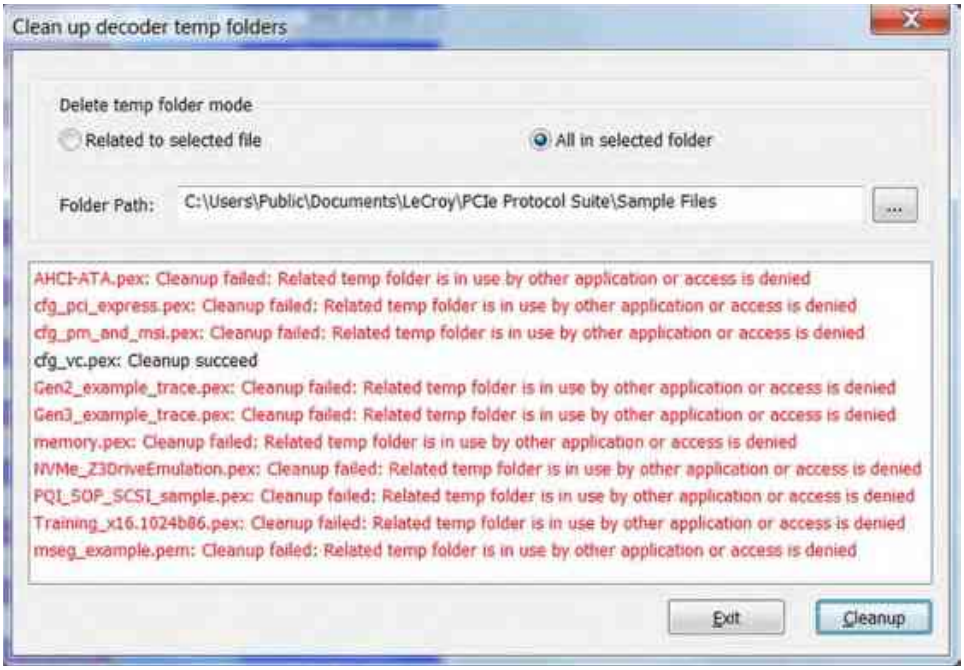


Figure 5.8: Clean Up Decoder Temp Files if Files are Still Open

7. Close Files you're not working with.
8. Select Clean Up Decoder Temp Files again.
9. Select Yes on the Warning Dialog.
10. With the files closed, the Clean Up Dialog will respond as shown below (see Figure 5.9).

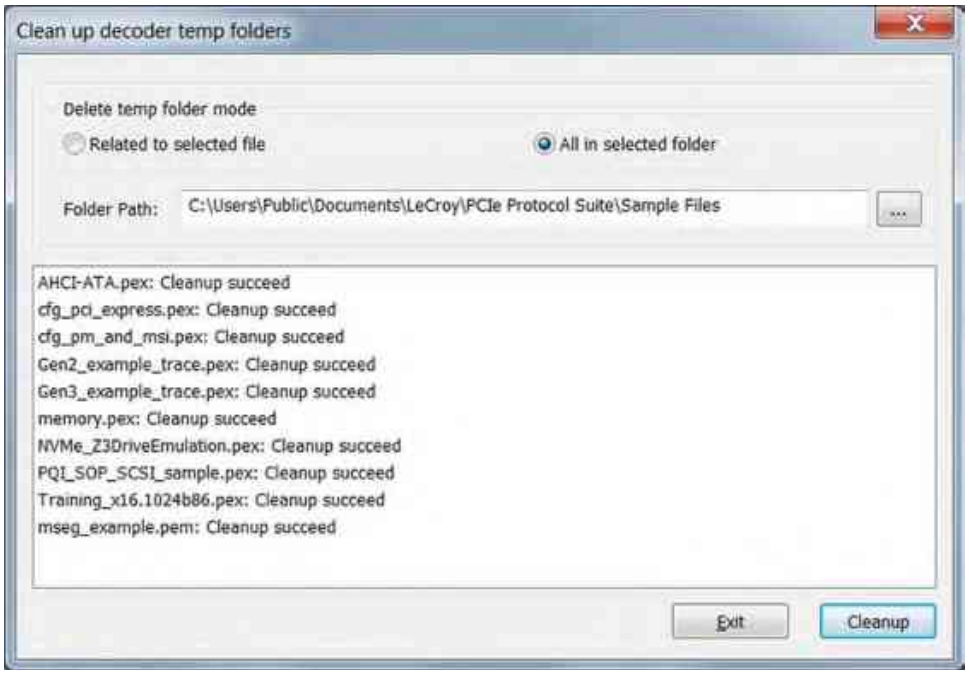


Figure 5.9: Results of Running Clean Up Command

11. Confirm that the Clean Up Command was successful by viewing the C:\Users\Public\Documents\LeCroy\PCIe Protocol Site\Sample Files folder contents, (see Figure 5.10).

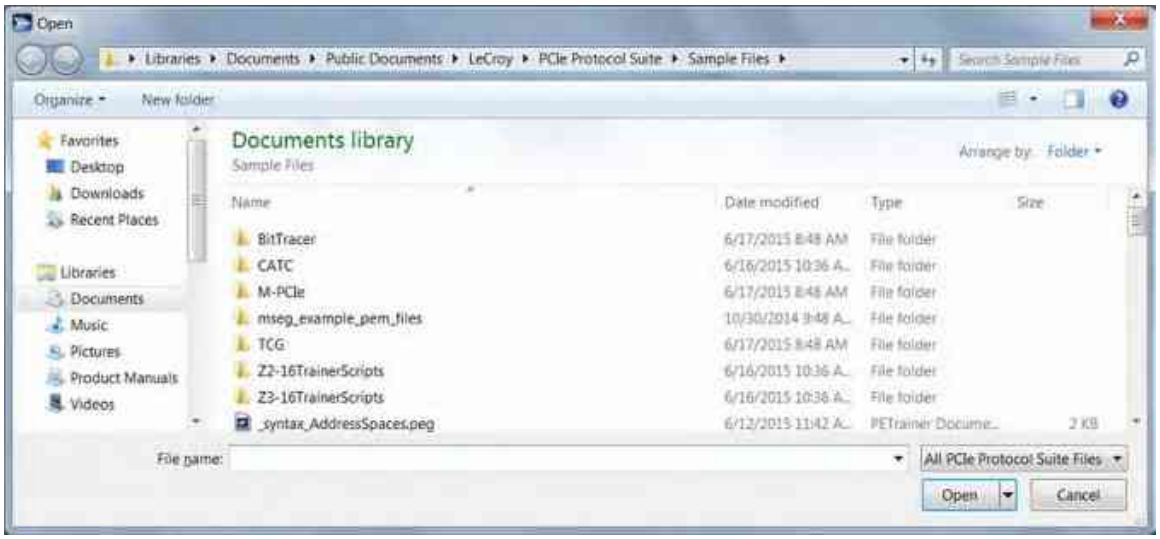


Figure 5.10: Sample File Folder After Temp File Clean Up

12. Compare Figure 5.5 on page 98 with Figure 5.10 to ensure that the .tmp files have been deleted.

5.5.2 Setup Menu

TABLE 5.3: Setup Menu

Item	Description
Display Options	Allows you to customize display options such as field colors, field formats and level hiding.
Recording Options	Allows you to customize control and setup features associated with recording, triggering, and filtering recorded events.
Generation Options	The Generation Options dialog is used to set configuration settings in a traffic generation script (*.peg). This dialog provides a convenient alternative means of editing a traffic generation file.
Generation Macros	Opens a dialog for creating buttons on the status bar that can be used to run traffic generation macros.
Update Device	Opens a dialog box that lets you update the BusEngine™ and Firmware.
Launch CrossSync™ Control Panel	Launches the CrossSync™ application. The CrossSync™ Control Panel allows you to select analyzers for synchronization and manage the recording process. See “Launching the CrossSyncTM Control Panel” on page 142.
All Connected Devices	Opens a dialog box with a list of locally or remotely connected devices. Allows you to update the BusEngine™, Firmware, and your licensing information.

5.5.3 Record Menu

TABLE 5.4: Record Menu

Item	Description
Start	Causes the Analyzer to begin recording traffic.
Stop	Causes the Analyzer to stop recording traffic.
Reupload	Causes the Analyzer to re-send all, or selected portions, of the CATC Trace from the Analyzer buffer to the host machine.
Manual Trigger	Trigger command for Analyzer is generated upon clicking this button.

5.5.4 Report Menu

Report Menu operations are only available when you are working with a CATC Trace file.

TABLE 5.5: Report Menu

Item	Description
Trace Information	Displays information about the file contents and describes the conditions of the file's recording (Recording Options, hardware information, and so on).
Error Summary	Displays an error summary of the current CATC Trace file and allows you to go to a specific packet, and save the error file to a uniquely named file.
Traffic Summary	Details the number and types of packets that were transferred during the recording. You can hide, save, send, text, print, and view.
Bus Utilization	Opens a window with graphs of bus usage for the open CATC Trace.
Link Tracker	Opens a window for displaying a detailed chronological view of traffic. The window provides view and navigation options.
Data Flow	Opens the Data Flow Window, providing a tabular view of transactions and their payload.
Trace Navigator	Shows the Navigator bar for navigating a CATC Trace. Shows a snapshot of the recording and allows you to adjust the memory area for the view.
LTSSM Flow Graph	Shows a state diagram of bus activity. Also allows you to navigate through the LTSSM, based on the current recording.
IDE View	Displays decrypted data, IDE-specific information and decryption parameters.
Packet Header	Opens the Packet Header bar, showing the Packet Header information as it would be viewed in the specification.
Packet Data	Opens the Data Window for the current packet or transaction, with the options: Hide, Save, Hexadecimal, ASCII, Decimal, Binary, MSB Format, LSB Format, Big Endian, and Little Endian. Format Line allows you to enter the number of bytes, words, or dwords per line.
Configuration Space	Presents a list of Configuration Spaces. Clicking an item displays the selected Configuration Space in a Configuration Table format.

5.5.5 Search Menu

Search Menu operations are only available when you are working with a CATC Trace file.

TABLE 5.6: Search Menu (Sheet 1 of 3)

Item	Description
Go to Trigger	Repositions the display to show the first packet following the trigger event.
Go to Selected Packet	Repositions the display to a specific packet, Link or Split transaction of PCI Express protocol or NVME, PQI, AHCI, ATA, SOP and SCSI command transaction levels.
Go to Segment/ Packet	Allows searching for specific link events packets or time.
Go to Time	Repositions the display to specific timestamp.
Go to Marker	Repositions the display to a previously marked packet, Link, Split, NVME, PQI, AHCI, ATA, SOP or SCSI command transactions.
Go to NVMe Transaction	Allows searching for Controller Registers, Other NVMe Entities, Doorbell Registers, Admin Submission Command Set, NVM Submission Command Set, Completion Queue Entry and NVMe Errors.
Go to NVMe Command	Allows searching for Admin Command Set NVM Command Set, Status, Errors, TCG Types, TCG Method, TCG Invoker, TCG Com ID and TCG Ext Com ID.
Go to SCSI	Allows searching for SCSI commands and sub-commands: SCSI Operation, Command Status, Task Management, Task Management Response, Error, SCSI Logical Unit Number.
Go to	Allows searching for specific link events: TLP Type, DLLP Type, Ordered Set, Link Event, Traffic Class, DLLP Virtual Channel, TLP Virtual Channel, Direction, Speed, Link Width, Requester ID, Completer ID, Data Lengths, Errors.

TABLE 5.6: Search Menu (Sheet 2 of 3)

Item	Description
Find	Displays the Find dialog to allow searching for various events within a CATC Trace. You can search by Display Level: Packets, Link or Split transaction of PCI Express protocol, Link Margining Commands or NVME, PQI, AHCI, SATA, SOP and SCSI protocol Transaction. You can search packets by Event Group: TLP Type, TLP Header, TLP Requester ID, TLP Completer ID, TLP Data Pattern, TLP Data Lengths, TLP Tag, TLP Sequence Number, DLLP Type, DLLP Header, DLLP Virtual Channel, ACK/NAK Seq Number, Ordered Sets, Link Event, Direction, Errors, TS1 Data, TS2 Data. You can search link transactions by Event Group: TLP Type, Traffic Class, Virtual Channel, Direction, Requester ID, Completer ID, Status, Tag. You can search for LM Commands: Event Groups -> Margin Command, Margin Type, Receiver Number or Errors. You can search Link, Split, NVMe and PQI transactions by Event Group: TLP Type, Traffic Class, Virtual Channel, Direction, Requester ID, Completer ID, Status, Tag, Address. You can search for LN transactions: Notification Reason, Cacheline Size, Cachelines, Completion Status, Read/Write, Directed/Broadcast and Errors. You can search NVMe transactions by the following Event Groups: Controller Registers, Queue IDs, Command IDs, Doorbell Registers, Admin Submission Command Set, NVMe Submission Command Set, Completion Queue Entry, and PRP. You can search PQI transactions by Event Group: PQI Register ID, PQI Admin Functions, PQI Errors. You can search AHCI transactions by Event Group: AHCI Register ID, AHCI Port Number, AHCI Slot Number, AHCI Port Multiplier Port, Raw Address, AHCI Direction, AHCI Errors. You can search ATA transactions by Event Group: ATA Register Type, ATA Port Number, ATA Slot Number, ATA Raw Address, ATA Port Multiplier, ATA Interruption Reason, ATA Error Type, ATA Input/ Output, ATA Payload Portion, ATA CFS Fields, ATA RFIS Device to Host Fields, ATA DSFIS Fields, ATA PSFIS Fields, ATA SDBFIS Fields. You can search SOP transactions by Event Group: SOP Information Unit ID, SOP Errors.

TABLE 5.6: Search Menu (Sheet 3 of 3)

Item	Description
	You can search NVMe Commands: Admin Command Set, NVM Command Set, Submission QID, Completion QID, Status, Errors, LBA, NVM Command, NVM Payload Portion, TCG Types, TCG Method, TCG Invoker, TCG Com ID, TCG Ext Com ID and RPMB. You can search SCSI transactions by Event Group: SCSI Operation, Command Status, Task Management, Task Management Response, Errors, SCSI Logical Unit Numbers. You can search IDE TLPs by prefix: stream and sub-stream identifiers. You can search IDE messages by type: Link/Selective Sync Message, Link/Selective Fail Message. Find allows you to create complex searches based on numerous criteria.
Find Next	Repeats the previous Find or Search operation.
Toggle Search Direction	Changes the current search direction from Forward to Backward or from Backward to Forward. Current search direction shown in lower right hand corner of main PCIe Protocol Analysis Menu.

5.5.6 Quick Search Feature

The Quick Search feature allows you to either search for a pre-defined term (see Figure 5.11) within a loaded Trace by clicking on the down arrow  or by typing your own term into the search window  and then moving the cursor into the window and hitting the Enter key. This feature will scroll through the entire Trace searching for the requested term and either stop at a highlighted Packet within the Trace or not move to a new position in the Trace if the term was not found. For more details see "Quick Search Feature Example" on page 614.

For a list of all possible terms, refer to "Quick Search Feature" on page 729.

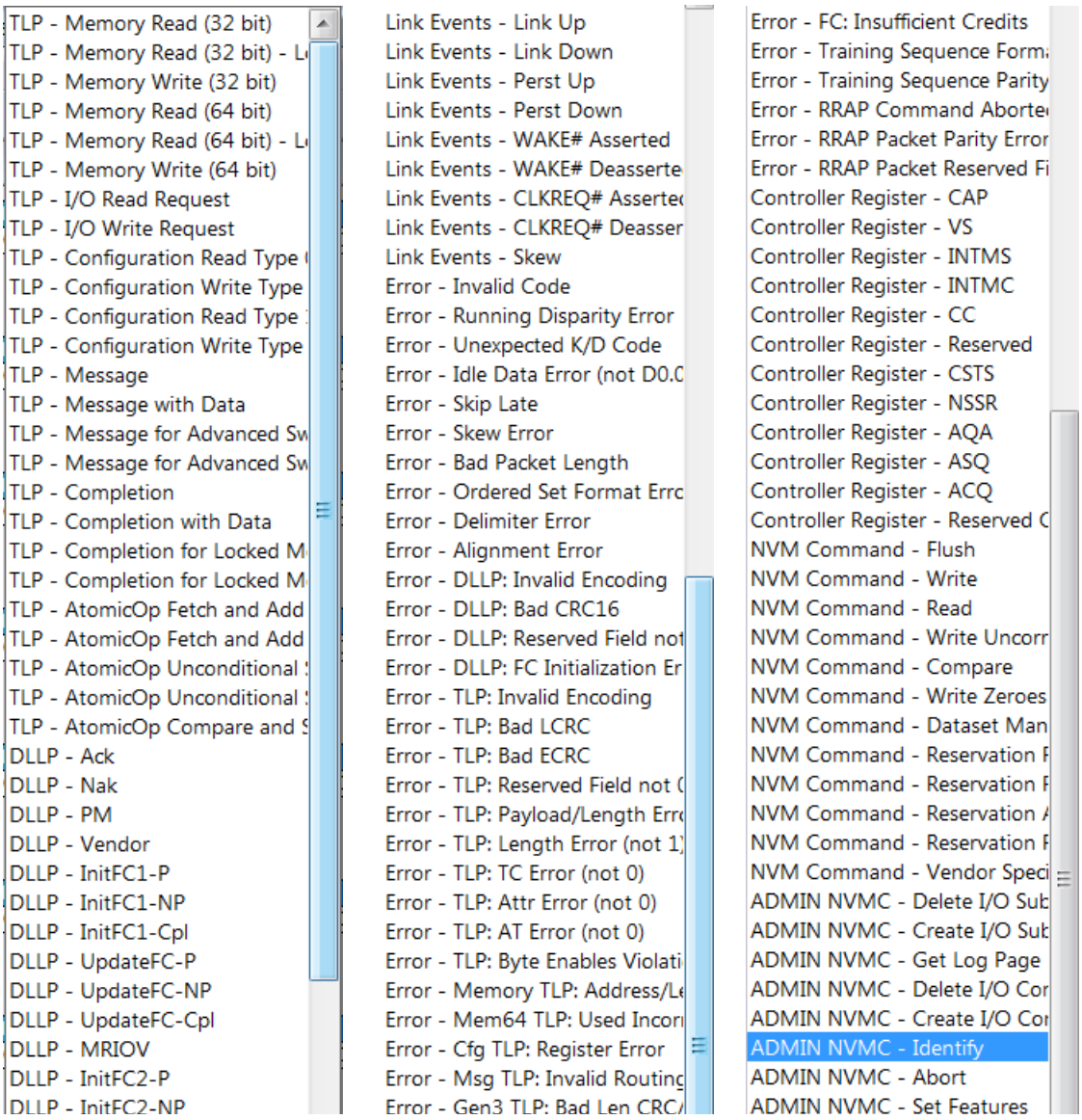
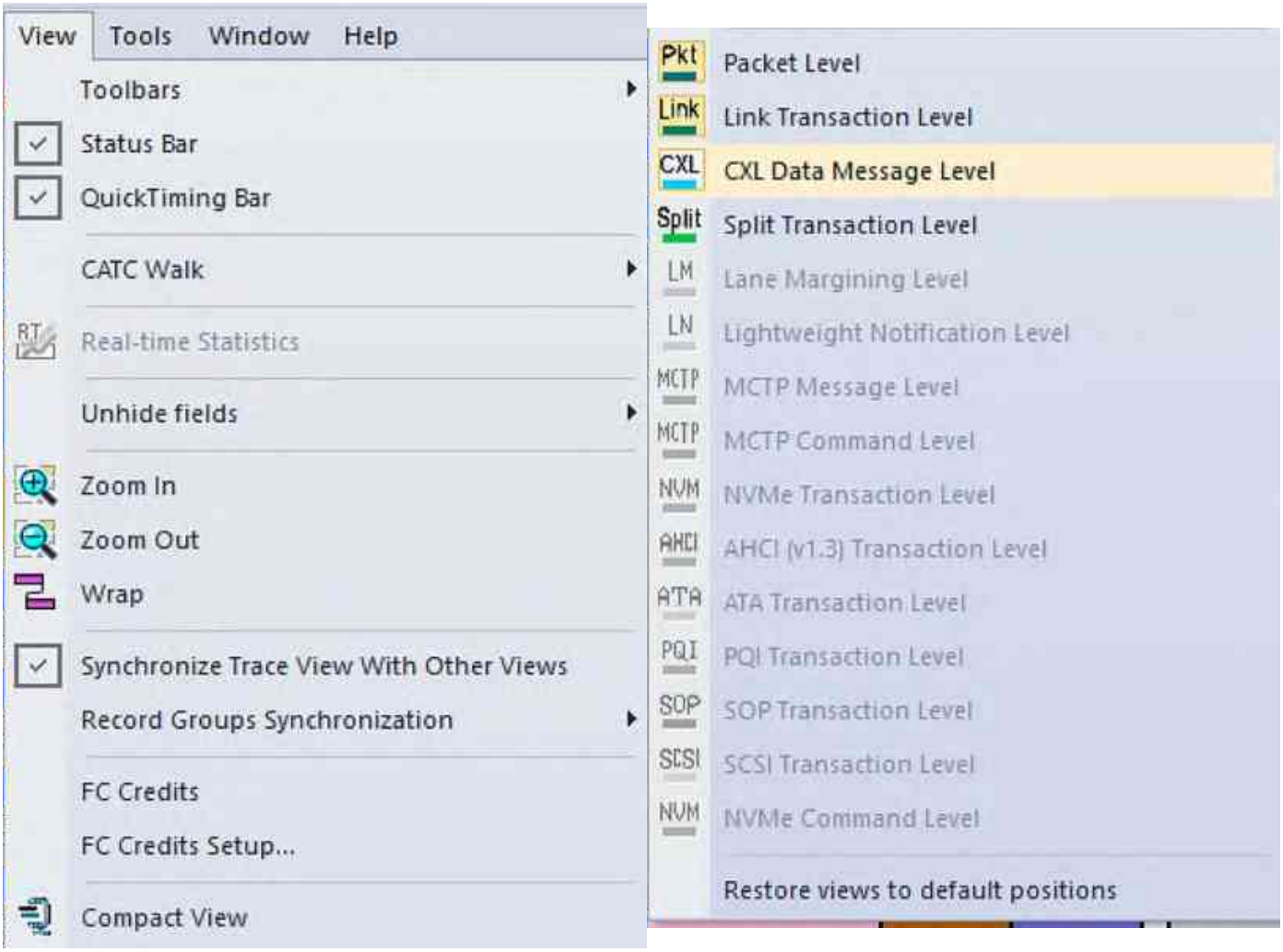


Figure 5.11: Quick Search: Pre-Defined Terms

5.5.7 View Menu

The View menu is shown graphically in Figure 5.12 and is summarized in Table 5.7 on page 108.



View Menu (top half) **View Menu (bottom half)**

Figure 5.12: View Menu: Options

TABLE 5.7: View Menu (Sheet 1 of 2)

Item	Description
Toolbars>>	Displays available toolbars: Standard, View Type, Frequently Used, Analysis, and Transaction Level. Use Customize to display the Windows Customize window.
Analyzer Network Chat Bar	Opens a chat window for communicating with persons working with networked Analyzers. This command requires that your host machine be attached to a LAN. The Chat window broadcasts messages to whatever host machines have been connected.
Status Bar	Switches display of the Status Bar on or off.
QuickTiming Bar	Switches display of the QuickTiming Bar on or off.
CATC Walk	Lets you play a playlist or manage Playlists (see "CATC Walk Playlist" on page 575).
Real Time Statistics	Opens the Real Time Statistics monitor dialog and displays a real-time graph of link activity.
Unhide Cells	Unhides PQI Reserved, PQI SGL Reserved and SOP reserved cells. You can also select Unhide all.
Script Editor	Displays the Script Editor (only appears if a **.peg** file is open).
Zoom In	Zoom in increases the size of the displayed elements.
Zoom Out	Zoom out decreases the size of the displayed elements.
Wrap	Wraps displayed packets within the window.
Synchronize Trace View With Other Views	Synchronizes the Trace view with other views.
FC Credits	Toggles a display for tracking Flow Control Credit update and consumption on a PCI Express link.
FC Credits Setup	Allows you to customize the display for tracking Flow Control Credits.
Compact View	Toggles compacting of the Link Training sequence to analyze CATC Trace data faster or no compacting to display more data.
Packet Level	View the current recording at the Packet Level.
Link Transaction Level	View the current recording at the Link Transaction Level.
Split Transaction Level	View the current recording at the Split Transaction Level.
Lane Margining Commands/ Responses Level	View the current recording with Lane Margining Commands and Responses.

TABLE 5.7: View Menu (Sheet 2 of 2)

Item	Description
Lightweight Notification Commands and Responses	View the current recording of Lightweight Notification Commands and Responses.
NVMe Transaction Level	View the current recording at the NVMe Transaction Level.
PQI Transaction Level	View the current recording at the PQI Transaction Level.
ACHI Transaction Level	View the current recording at the ACHI Transaction Level.
ATA Transaction Level	View the current recording at the ATA Transaction Level.
SOP Transaction Level	View the current recording at the SOP Transaction Level.
SCSI Transaction Level	View the current recording at the SCSI Transaction Level.
Restore views to default positions	Restores views to the default positions after you click **Yes** on the prompt.

5.5.8 Tools Menu

TABLE 5.8: Tools Menu

Item	Description
Configuration Space Editor	Displays the Configuration Space Editor dialog which allows you to either create a new Configuration Space File or open an existing Configuration Space File.
Memory/IO Space Editor	Displays the Memory/IO Space Editor dialog which allows you to either create a new Address Space File or open an existing Address Space File. Select the memory size from the drop-down menu.
Interposer Programmer	This utility allows you to program the Continuous Time Linear Equalizer (CTLE) and DCGain between the host (root complex) and device (end-point) on the interposer connected to your analyzer to achieve optimum link performance.
TC to VC Mapping	Allows Traffic Classes to be mapped to Virtual Channels for purposes of simplifying navigation (for example, Search > Go to > TLP Virtual Channel) and changing the way the CATC Trace is displayed (for example, in Split Transactions).
Timing Calculations	Starts the mode-less calculator dialog for calculating various timing and bandwidth parameters in the recording file.
PCIe SSD Base Address Mapping	Displays the PCIe SSD Base Address Mapping dialog.
Run Verification Scripts	Displays a list of verification scripts, from which you can run a verification script.

5.5.9 Window Menu (helps display the loaded traces)

TABLE 5.9: Window Menu

Item	Description
New Window	Opens a copy of the current CATC Trace window.
Cascade	Displays all open CATC Trace windows in an overlapping arrangement.
Tile	Displays all open CATC Trace windows as a series of strips across the display.
Arrange Icons	Arranges minimized CATC Trace windows at the bottom of the display.
Synchronize Traces	Synchronizes a BitTracer trace and a Protocol trace exported from it such that their views scroll together based on timestamps.
Windows	Displays all open windows. Select to display. See Figure 5.13 on page 111 and Figure 5.14 on page 111 as well as “Trace Display Options” on page 112.

For a more detailed explanation of the Window Menu options see Figure 5.13 and Figure 5.14 as well as “Trace Display Options” on page 112.

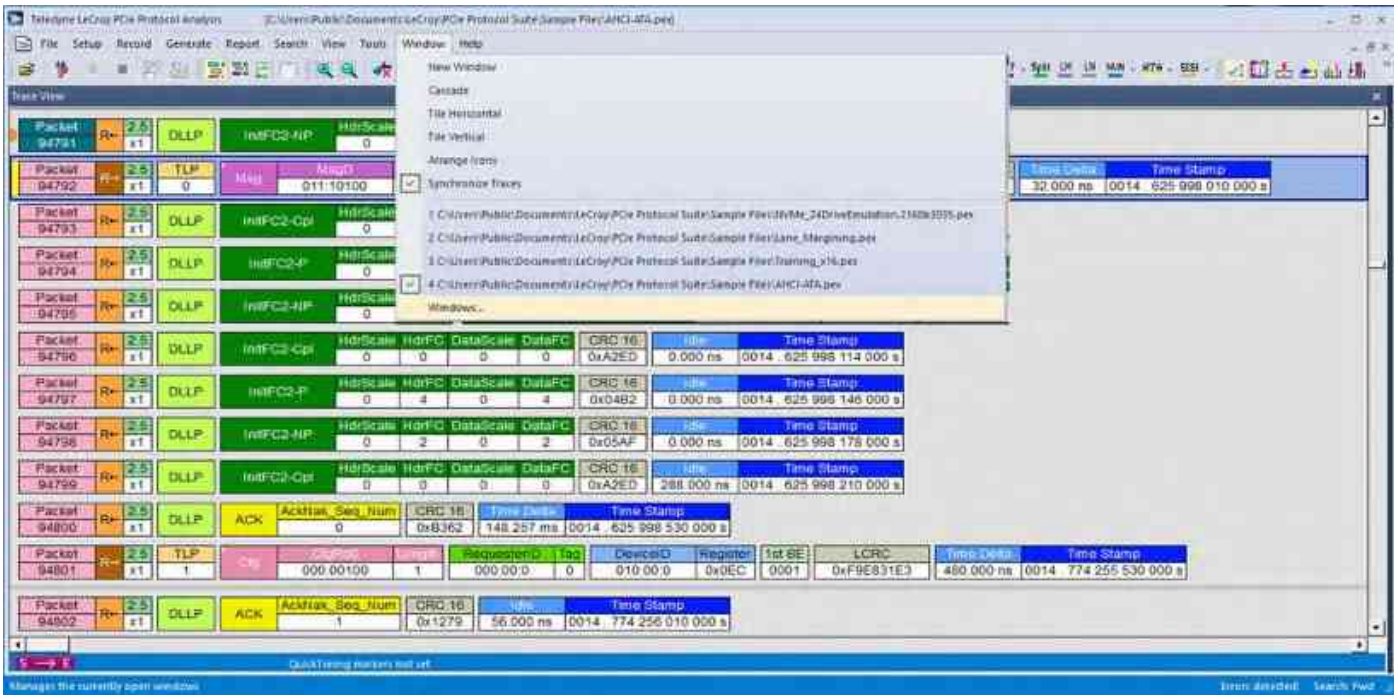


Figure 5.13: Window: Windows Menu with four traces loaded

If you select Windows from the options above a new menu will popup with the list of loaded traces. See Figure 5.14.

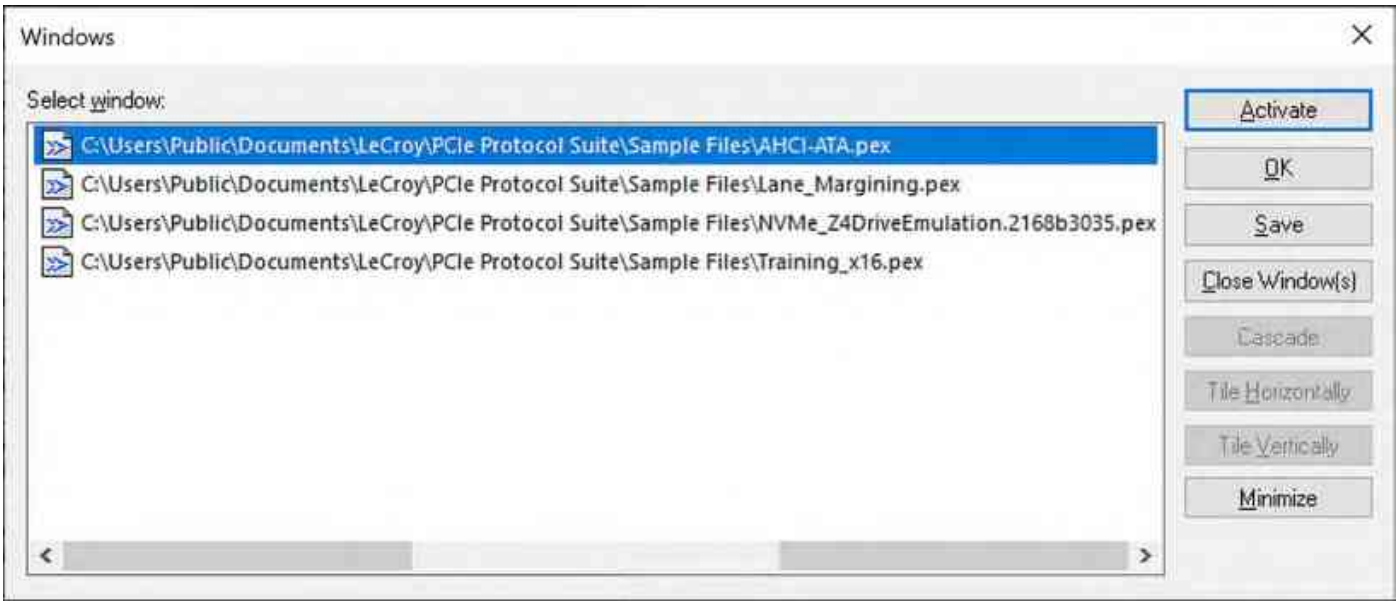


Figure 5.14: Window: Windows menu with four traces loaded

Trace Display Options

You have the following options on how the traces are displayed:

- Activate - makes selected trace active in a Trace View.
- OK - closes dialog.
- Save - This is useful for Generation Scripts, it brings up save dialog to save changes in generation script, for opened trace it does nothing.
- Close - closes selected window(s).
- Cascade, Tile Horizontally and Tile Vertically - enabled only when multiple windows are selected. Cascades or tiles selected windows.
- Minimize - minimizes selected window.

5.5.10 Help Menu

TABLE 5.10: Help Menu

Item	Description
User Manuals F1	Click User Manuals or press F1 to access the documentation guide for all Teledyne LeCroy PCIe products.
Display License Information	Opens an information box describing the current license information.
Register Product Online	Register at the Teledyne LeCroy website registration page.
Check for Updates	Check whether a new software version is available. If so, you can download from the Teledyne LeCroy web site. You can select to **Check for updates at application startup**
Tell Teledyne LeCroy	Report a problem to Teledyne LeCroy Support via e-mail. This requires that an e-mail client be installed and configured on the computer.
Shortcut List	Displays a list of Keyboard shortcuts.
About PCIe Protocol Analysis	Displays version information about the attached Analyzer and its Firmware and BusEngine™.

5.6 Dashboard View

Dashboard View shows state of the link that analyzer is tracking. Click the Dashboard View  icon to view the Dashboard View window for the selected device at the bottom left of the application.

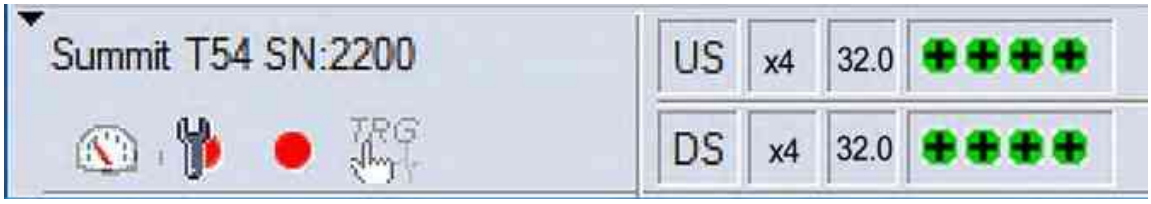


Figure 5.15: Dashboard View Icon Displaying Device

Dashboard (see Figure 5.16 on page 114) displays the following information for Upstream and Downstream:

- Link Width
- Link speed
- Per lane activity indication
  - Green - lane is active, analyzer does not detect any signal errors on this lane
  - Orange - lane is active, analyzer detects signal errors on this lane
  - Grey - lane is inactive
- Logical to physical lane mapping
- Lane polarity
- Link Number
- NFTS - The number of FTS advertised by the device for each speed

Note: The dashboard display depends on the Recording Options configuration and may not match the current actual link state. For example, if the analyzer is configured to track 2.5 GT/s speed only, the Dashboard View will display 2.5GT/s speed as a current tracking speed regardless of the actual speed of the link.

Note: The update to the status bar requires reading the current state of the analyzer. This happens at the end of the recording. In case the analyzer is power cycled, perform at-least one recording to have the updated status bar with current analyzer link information.

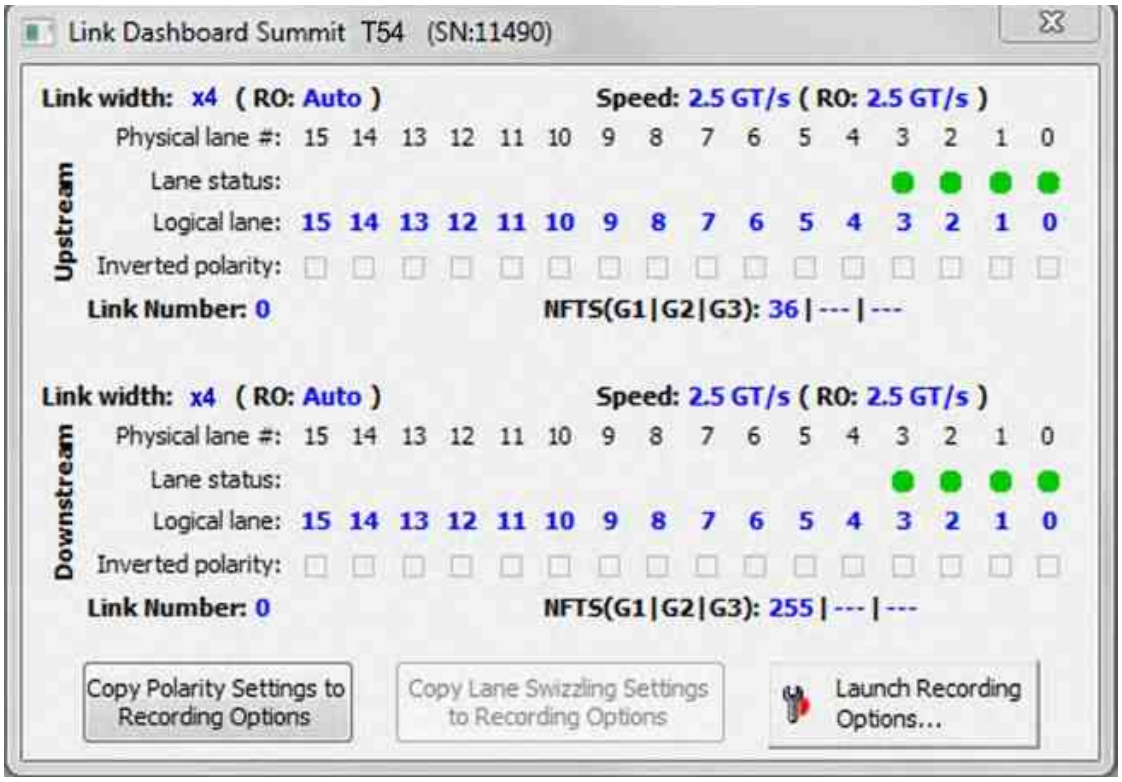


Figure 5.16: Dashboard View Dialog

You can launch Recording Options for the analyzer from the Dashboard View and adjust recording settings to match the current link configuration. The **Copy Polarity Settings to Recording Options** button allows you to copy the detected polarity into Recording Options. The **Copy Lane Swizzling Settings to Recording Options** button allows you to copy the detected Lane Swizzling Settings into Recording Options.

Note: Polarity auto detection and lane swizzling detection requires the link to go through link retraining at Gen1 or Gen2 speed. The analyzer has to be configured correctly to track this link retraining. For example, if the analyzer is configured to track only 8.0 GT/s speed, auto polarity detection will not work even if the link goes through the appropriate retrain.

5.6.1 Launching and Setting Recording Option from Dashboard View

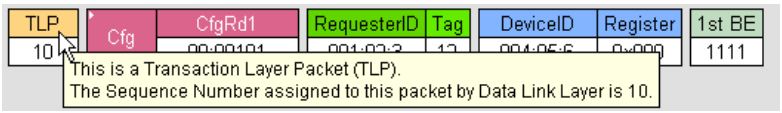
You can select a device and click the **Launch Recording Options as shown in** Figure 5.16 button to go to **Recording Options**. In the Recording Options window the Upstream and Downstream channels can be set manually by unchecking the **Auto-Configure Lane Polarity** checkbox, refer to Figure Note: on page 157 (3G). Click on the **Port Polarity Settings to Recording Options** to save the settings.

Note: The lane polarity values are dynamic so this feature allows the user to make the settings and save them for future use.

In the default setting the **Auto-Configure Lane Polarity** checkbox is selected, refer to Figure Note: on page 157 (3G).

5.7 Tool Tips

Tool tips provide details about fields within the CATC Trace. To see a tool tip, position your mouse pointer over a field within the CATC Trace.



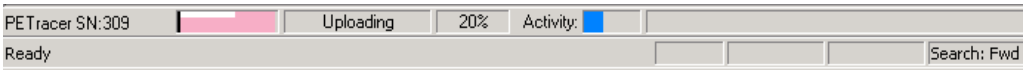
You can turn off this capability in the Display Options menu.

5.8 Keyboard Shortcuts

Keystrokes	Operation
Ctrl+N	New PCIe Protocol Analysis script
Ctrl+O	Open file
Ctrl+P	Print
Ctrl+S	Save file
Ctrl+R	Start Analyzer recording
Ctrl+T	Stop Analyzer recording
Ctrl+Home	Jump to first packet
Ctrl+End	Jump to last packet
Ctrl+G	Go to packet...
Ctrl+F	Open Find dialog
Ctrl+1	Access documentation
F3	Find next
F6	Next pane
Shift+F6	Previous pane
Ctrl+B	Search backward

5.9 Status Bar

The Status Bar is a gray bar that runs along the bottom of the application window.



From left to right:

PCIe Protocol Analysis SN:309: Analyzer Serial Number

Ready: Analyzer Status

Recording Progress Bar: The colored bar to the right of the serial number represents how much traffic has been recorded. The trigger point is indicated by the black line at the left side of the bar. In this example, the trigger occurred at the very beginning of the CATC Trace. If the trigger is set in the middle of the CATC Trace, the line is positioned in the middle of the bar. Additionally, the color of the bar is different on each side of the trigger point. For examples, see "Recording Progress Bar" on page 116. The white strip along the top edge of the color bar indicates how much traffic has been uploaded from the Analyzer buffer to the host machine.

Uploading and 20%: Indicates the Analyzer's recording status, what part of the recording process the Analyzer is now in. In this example, the Analyzer is in the upload stage and has completed 20% of the upload from the Analyzer to the host machine. See "Recording Status" on page 116 for details on other status messages.

Activity: The colored bar moves to indicate that the Analyzer is currently recording.

Search: Fwd: Indicates search direction. The direction can be toggled to **Search: Bwd** by double-clicking the search direction or by selecting **Toggle Search Direction** from the Search menu.

5.9.1 Recording Progress Bar

This indicator bar changes color to reflect the recording progress.

- Black vertical line is at the location of Trigger position.
- Black vertical line wiggles when Trigger Position is nearly reached.
- Field to right of Trigger Position changes color to indicate post-trigger activity.
- Upper half of progress indicator turns white when recording is complete.

5.9.2 Recording Status

The second segment from the left in the Status Bar indicates recording status.

During recording, the current Recording Status is in a segment. When you activate the **Record** function, this segment flashes a message depending on the selected Recording Options, such as **Waiting for Trigger**, **Uploading** or **Triggered**.

The status bar displays Waiting for Trigger while waiting for trigger to occur based on the settings defined in the Recording Options.



Figure 5.17: Status Bar - Waiting For Trigger

The status bar displays **Uploading** when recording is complete and is being uploaded (see Figure 5.18 on page 117).



Figure 5.18: Status Bar - Uploading

The status bar displays **Triggered** when the trigger condition has occurred, but uploading has not commenced yet.

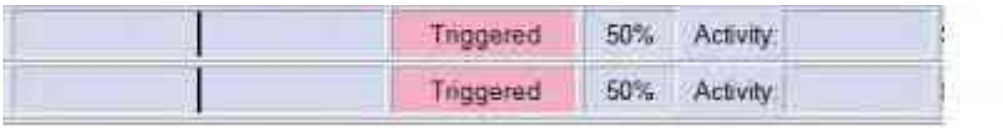


Figure 5.19: Status Bar - Triggered

As uploading progresses, the percent increases to 100. You can abort this upload if you wish by pressing the **ESC** button on your keyboard or

clicking  in the Tool Bar.

5.9.3 Recording Activity

The third segment displays recorded activity as a series of blue vertical bars. The more vertical bars that display, the greater the amount of activity recording. If there are no vertical bars, there is no recording activity.

During uploading, the percent of the completed upload displays.

5.9.4 Search Direction Indicator

The fourth segment in the status bar indicates search direction. The direction can be changed by selecting Toggle Search Direction from the Search menu.

5.10 Making a PCI Express Recording

When the analyzer is not yet detected, you can choose the analyzer from the drop-down menu which displays the following:

- **Summit T516:** Displays the options for the Summit T516 Gen5 Analyzer.
- **Summit T54** (2 units)**:** Displays the same options as Summit T54 but lists **Unit 1** and **Unit 2** in the Link Section on the right. In a two-unit setup, **Unit 1** and **Unit 2** are two separate Analyzers linked together.
- **Summit T54:** Displays the options for the Summit T54 Gen5 Analyzer.

- **Summit T416 Standard:** Displays the options for the Summit T416 Analyzer.
- **Summit T416 4 Ports:** Displays the options for the Summit T416 Analyzer used in Multiport mode.
- **Summit T416 2 Ports:** Displays the options for the Summit T416 Analyzer used in Multiport mode.
- **Summit T48 Standard:** Displays the options for the Summit T48 Analyzer.
- **Summit T48 2 Ports:** Displays the options for the Summit T48 Analyzer used in Multiport mode.
- **Summit T48** (2 Units): Displays the same options as Summit T48 but lists **Unit 1** and **Unit 2** in the Link Section on the right. In a two-unit setup, **Unit 1** and **Unit 2** are two separate Analyzers linked together.
- **Summit T3-16**: Displays the options for the Summit T3-16 Analyzer.
- **Summit T3-8** (2 Units): Displays the same options as Summit T3-8 but lists **Unit 1** and **Unit 2** in the Link Section on the right. In a two-unit setup, **Unit 1** and **Unit 2** are two separate Analyzers linked together.
- **Summit T3-8**: Displays the options for the Summit T3-8 Analyzer.
- **Summit T34** (2 Units): Displays the same options as Summit T34 but lists **Unit 1** and **Unit 2** in the Link Section on the right. In a two-unit setup, **Unit 1** and **Unit 2** are two separate Analyzers linked together.
- **Summit T34:** Displays the options for the Summit T34 Analyzer.
- **Summit Z416:** Displays the options for the analyzer portion of the Z416.
- **Summit T28**: Displays the options for the Summit T28 Analyzer.
- **Summit T24**: Displays the options for the Summit T24 Analyzer.

After connecting the Analyzer to the device(s), you must select Standard Mode (see "PCIe Protocol Analysis Files" on page 124). The default mode is usually Standard Mode.

To make this recording, follow these steps:

1. From the **Setup** menu, select **Recording Options** and click the **Switch to Simple Mode** button.
2. Select the **Simple Mode** tab (see Figure 5.20 on page 119).

   The following window displays the factory default settings in **Simple Mode**, such as Snapshot and 32-MB buffer size. For your first recording, select the proper speed and link width.

Note: The images below show a Summit T54 Analyzer but the Summit T516 has similar images. Recording Options for the Summit T516 are shown in more detail in "Select Interposer Type" on page 147.

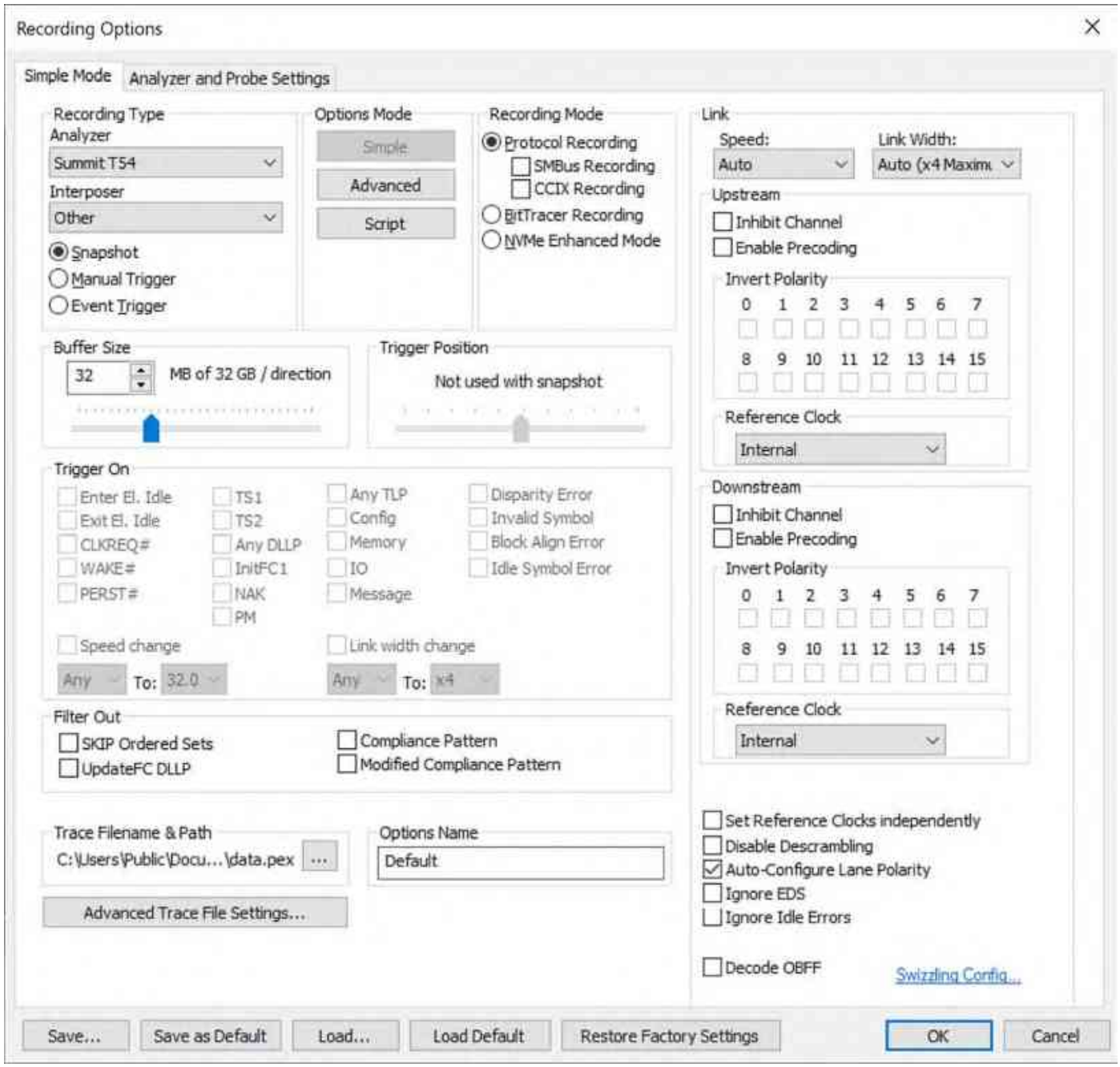


Figure 5.20: Summit T54 in Simple Recording Mode

3. In the **Link** section, specify the lane width of the PCI Express link to be analyzed. The rest of the settings in this section can be left at the factory defaults for most PCI Express systems.
4. For multi-lane PCI Express links when using Auto options, the Analyzer needs to observe link training in order to record link traffic correctly.
5. Click **OK** at the bottom of the Recording Options dialog to apply the Analyzer recording settings specified.
6. Click the **Record** button.

5.10.1 Stopping a Recording

You can stop the recording process at any time by pressing the **Stop** button ■ . This causes the Analyzer to stop the recording and upload the CATC Trace to the host machine. If you press the **Stop** button again, the Analyzer temporarily halts the upload process and opens the following dialog box.

Note: If the uploading process is stopped manually, the resulting trace may have significant periods of time where the traffic from upstream and downstream will seem like they are not interleaved. Teledyne recommends to always let the analyzer complete the upload process.



Figure 5.21: Abort Upload

This dialog presents options for stopping, continuing, or aborting the upload:

- **Stop**: Aborts further CATC Trace upload and displays whatever data that has already been uploaded.
- **Continue**: Resumes the upload. This command tells the Analyzer to finish uploading whatever CATC Trace data is still in its buffer.
- **Flush**: Flushes the CATC Trace without saving or displaying it.

If you allow the traffic data to be uploaded, it is automatically saved on the host machine's hard drive as a file named **data.pex** or the name you assign as the default filename in the recording options.

5.10.2 Saving a Recording

1. To save a current recording for future reference, select **Save As** from the File menu.
2. Give the recording a unique name, then save it to the appropriate directory.

5.10.3 Multiport Mode

MultiPort mode allows a Summit T5 system to behave as multiple analyzer systems. The first thing to configure in the Software is to decide how many ports will be analyzed.

Summit T5 analyzers can be run in Standard Mode or Multiport Mode.

Note: If the link width of the analyzer you are using is set to a larger value than the link width being used in Mutliport Mode a warning message will pop up asking you if you want to link width set to be compatible with the options selected in Mulitport mode. See "Trace Filename and Path" on page 172.

To configure the Summit T5 Analyzer in MultiPort mode select the Gear icon. See Figure 5.22.

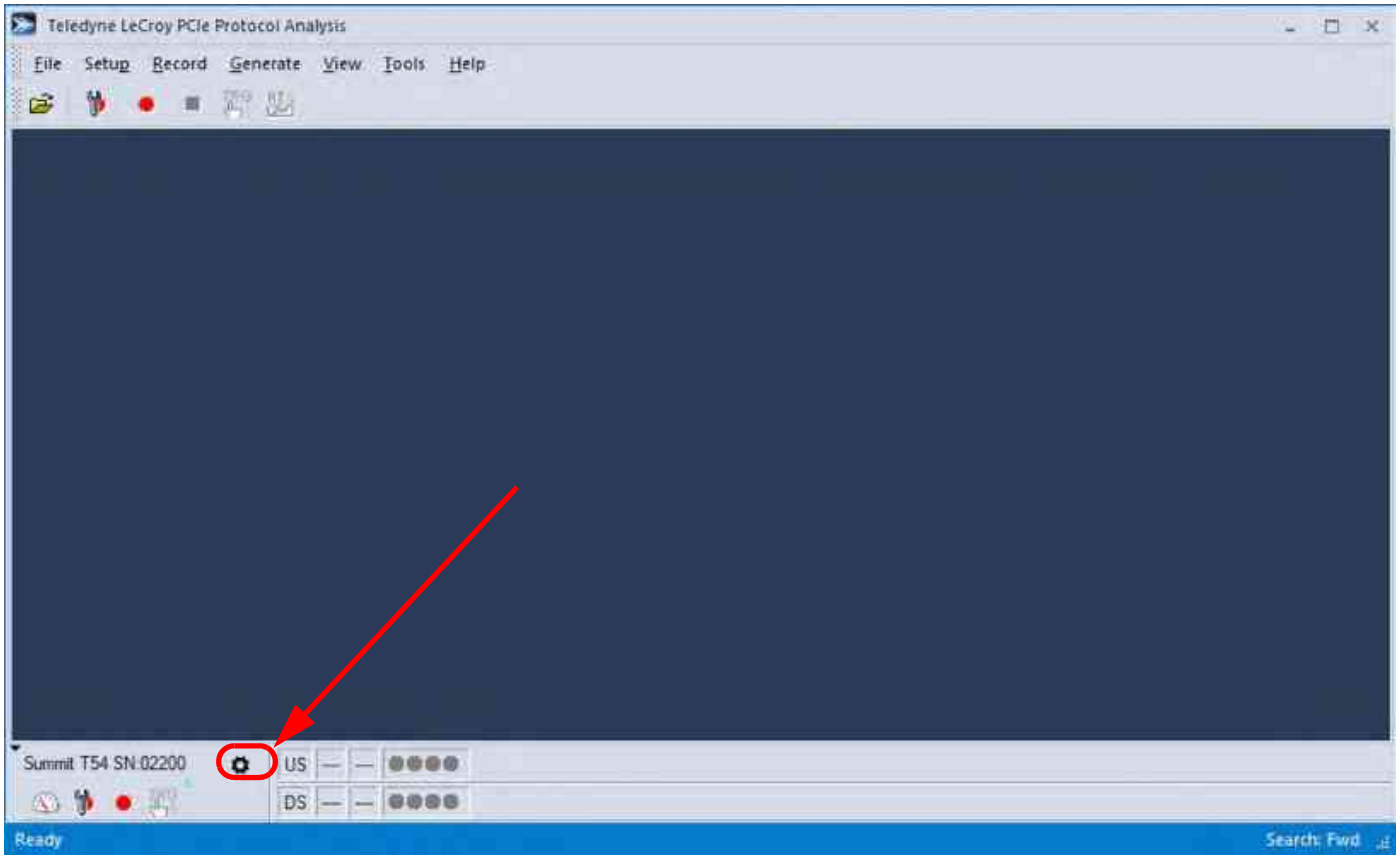


Figure 5.22: Summit T54 Multiport Gear Button shown

Select the gear icon and the Multiport Analyzer Settings dialog box will pop up. See Figure 5.23 on page 122.

5.10.4 Multiport Mode Configuration: Summit T54

Note: The images below show a Summit T54 Analyzer but the Summit T516 has similar images.

If you select Standard Mode the Multiport Analyzer Settings dialog box will show a single x16 port. See Figure 5.23.

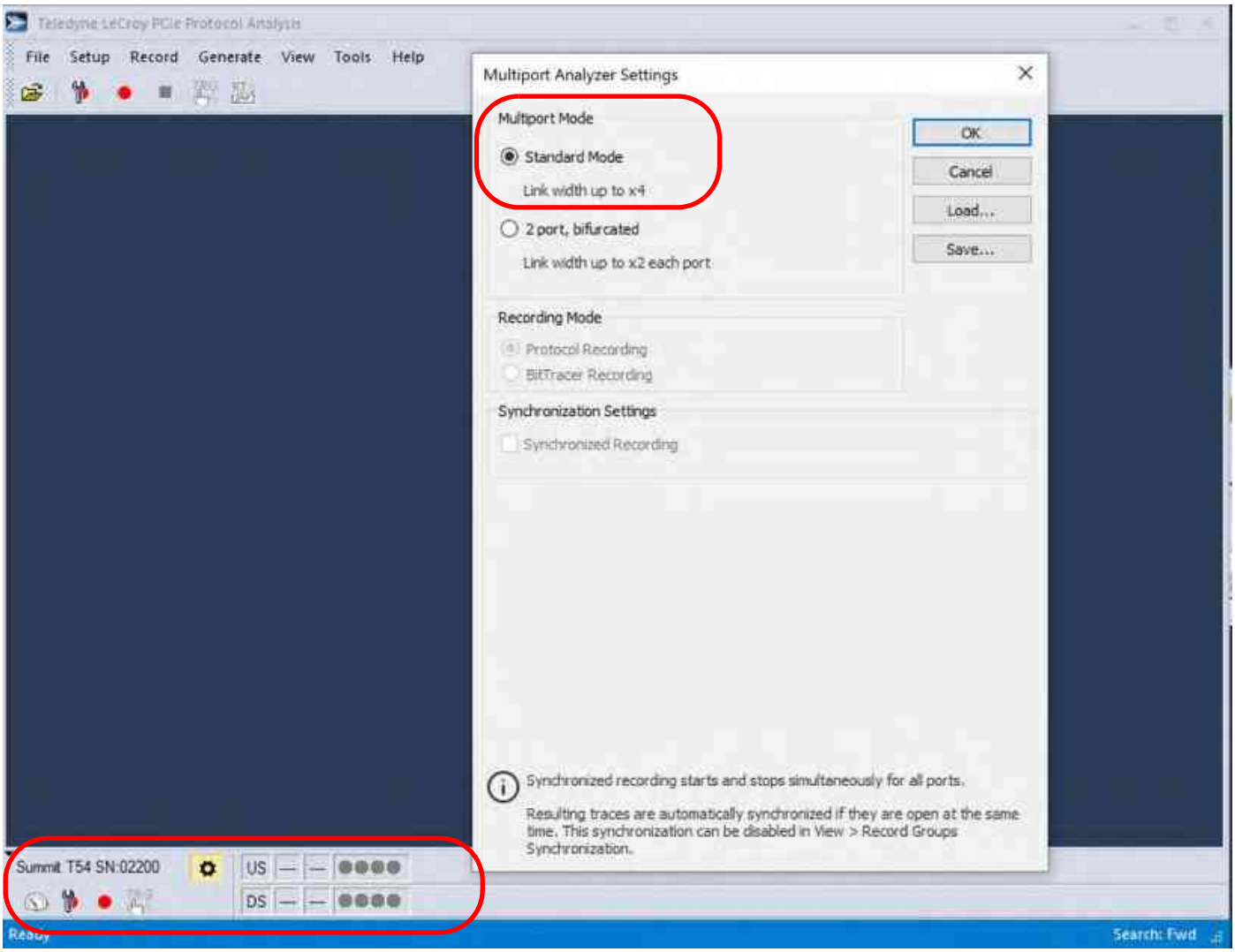


Figure 5.23: Multiport Mode Analyzer Settings: Summit T54 -> Standard Mode, single port x4

This configuration for Multiport Mode is discussed in more detail for the Summit T54 in "Summit T54 Analyzer/Cable/Interposer Connection Diagrams" on page 19.

If you select 2 ports, bifurcated the Multiport Analyzer Settings dialog box will show two x2 ports. See Figure 5.24.

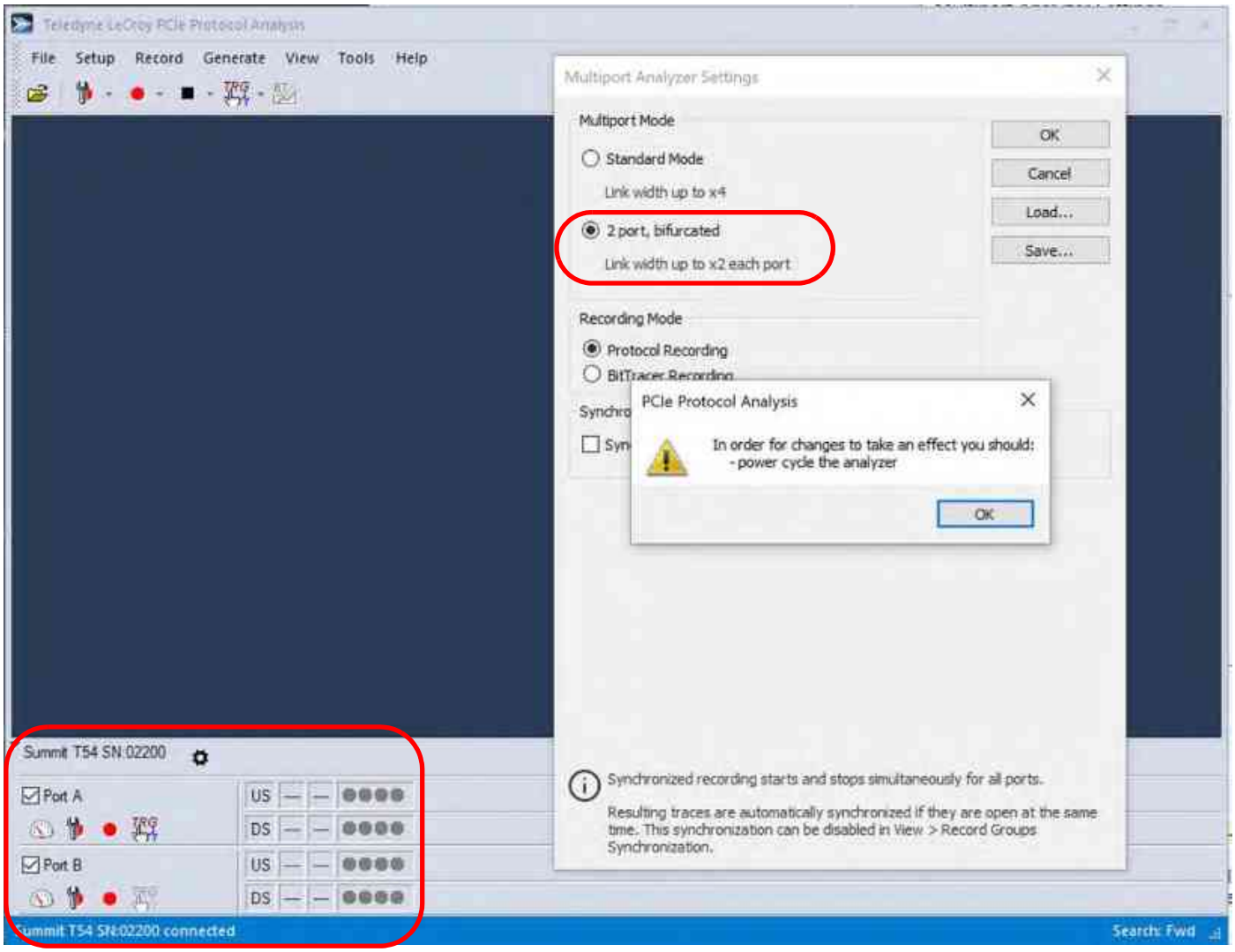


Figure 5.24: Multiport Mode Analyzer Settings: Summit T54 -> 2 ports x2, bifurcated

This configuration for Multiport Mode is discussed in more detail for the Summit T54 in "Summit T54 Analyzer/Cable/Interposer Connection Diagrams" on page 19.

The following information message will popup. See Figure 5.25 on page 123.

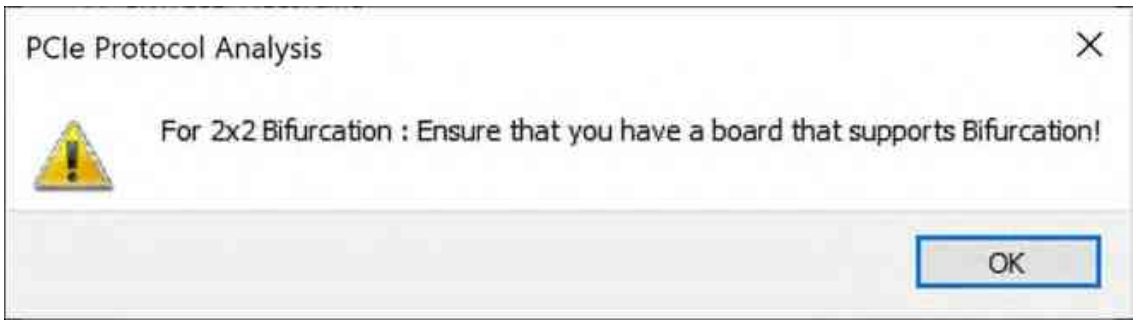


Figure 5.25: Summit T54: Check for Appropriate DUT

After the appropriate power cycling the Summit T54 will be configured for four ports x2. See Figure 5.26 on page 124.

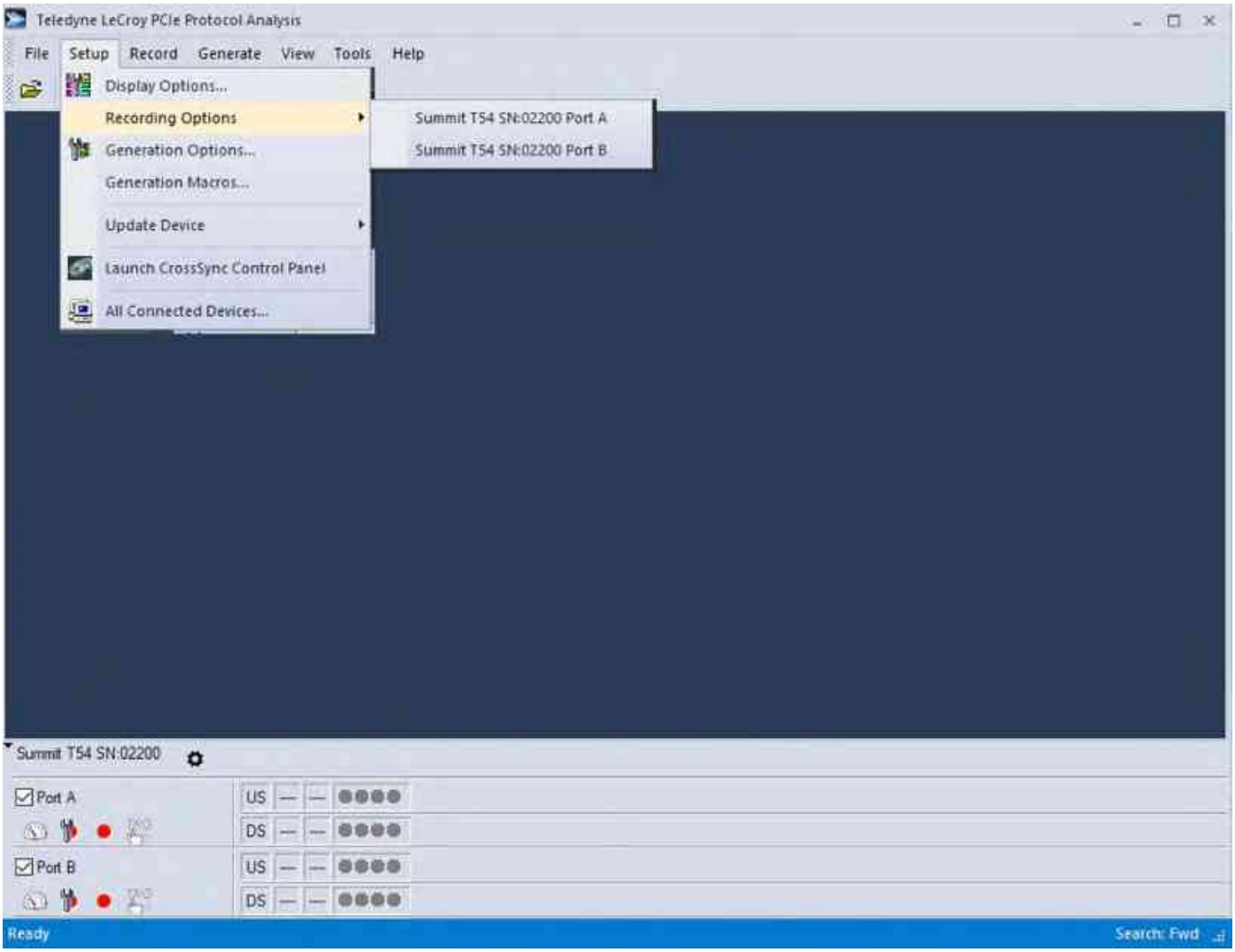


Figure 5.26: Summit T54 Configured for Two Ports x2

This configuration for Multiport Mode is discussed in more detail for the Summit T54 in "Summit T54 Analyzer/Cable/Interposer Connection Diagrams" on page 19.

5.11 PCIe Protocol Analysis Files

The PCIe Protocol Analysis creates and uses different kinds of files:

- **CATC Trace Files**: Recorded traffic
- **Recording Options Files**: Configuration file that contains the various options selected in the Recording Options dialog to configure the recording. See Chapter 6, "Saving and Loading Previously Saved Recording Options," on page 174.
- **Display Options Files**: Configuration file that contains the options selected in the Display Options dialog to configure how traffic is displayed

5.11.1 CATC Trace Files

PCIe Protocol Analysis records PCI Express traffic into a CATC Trace file with the default name **data.pex** or any other that you specified in the Recording Options. This file is overwritten with new data each time PCI Express traffic is recorded.

If you want to save a CATC Trace, use the **File > Save As** function. This option allows you to save the current CATC Trace to a unique file name, thereby ensuring that it is not overwritten. This option also allows you to save a range of packets in a CATC Trace file.

You can pre-define the name of the recorded CATC Trace file using the Trace Filename and Path option in Recording Options.

5.11.2 Recording Options Files

Recording Options files are created when you set recording options. These files use the **.rec** extension and contain recording option information. See Chapter 6, “Saving and Loading Previously Saved Recording Options,” on page 174.

5.11.3 Display Options Files

Display Options files are created when you set display options. These files use the **.opt** extension and contain the display options information.

5.12 Saving CATC Trace Files

5.12.1 Using the Save As Function

When you record a CATC Trace file, the Analyzer software provides a pre-defined name to the CATC Trace file (**data.pex** or any other that you specified in the Recording Options). If you do consecutive recordings, each time the previous recording is overwritten. If you see a recording you want to analyze later, you need to give a unique name to the CATC Trace file, so it is not overwritten with the next recording.

Also, when you analyze a recorded CATC Trace file, you might be interested in preserving just a part of the PCI Express traffic that was recorded. If you save a portion of a CATC Trace file, it can get significantly smaller, allowing you to attach it to an e-mail.

To save a portion of a CATC Trace file or the whole file to a unique name, select **Save As** from the File menu (see Figure 5.27 on page 126).

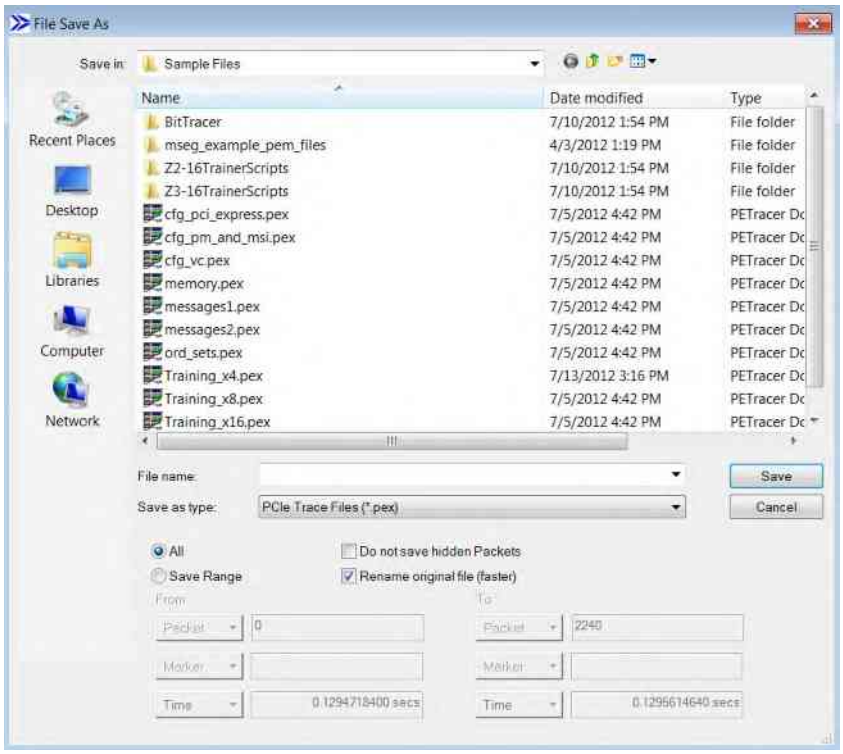


Figure 5.27: File Save As Dialog

If you want to give a unique name to the CATC Trace file, select the **All** option and keep **Rename original file** checked. This is the default setting for the dialog. The existing file will be overwritten with the new file name.

5.12.2 Saving a Portion of a CATC Trace

If you want to save a portion of a CATC Trace file, select **Save packet range**. Enter starting and ending packet numbers in the **From Packet** and **To Packet** fields. By default, it has the numbers of the first and the last packets in the file. The software is going to save all the packets in specified range to the new file, unless you have **Do not save hidden packets** checked. In this case it is going to save all packets in the range, EXCLUDING the currently hidden packets.

The User and Recorded Markers on packets within the saved range also are saved. Additionally, if the saved range includes the first packet of the trace, then all Recorded Markers prior to that will also be saved; if the saved range includes the last packet of the trace, then all Recorded Markers after that will also be saved.

5.12.3 Save Copy As Function

If you want to Save a trace (or a portion of a trace) to a new file name but keep the existing file name select Save Copy As. See Figure 5.28.

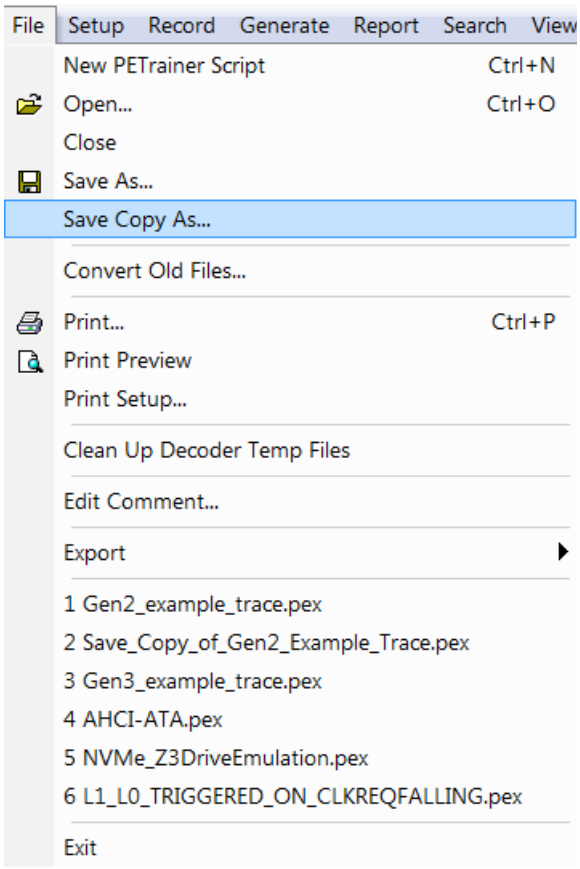


Figure 5.28: File -> Save Copy As Function

Select Save Copy As and the following dialog will pop up and you can enter a unique file name (see Figure 5.29 on page 128).

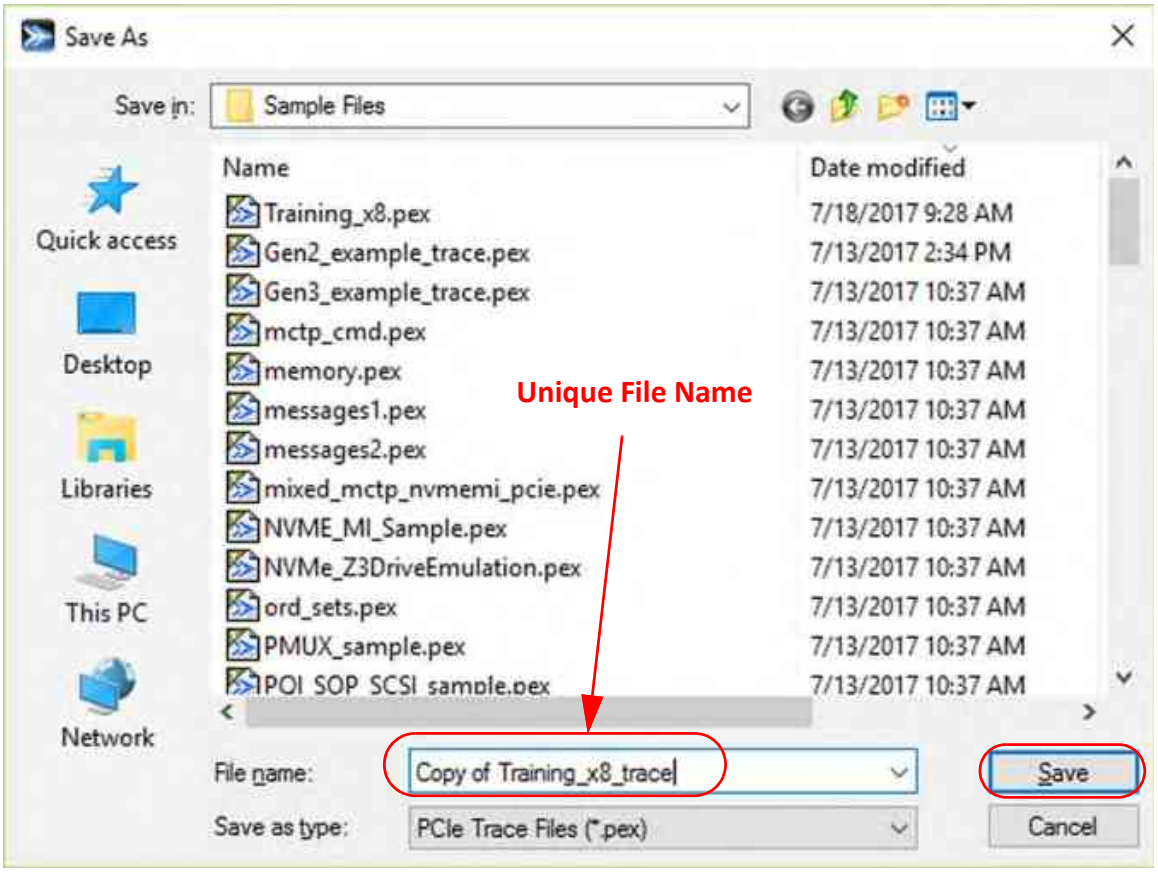


Figure 5.29: Save As Copy Dialog (Sample File Directory Before Save)

Click on the Save button and the trace will be saved with the new file name. This file can be loaded by Selecting File -> Open and selecting the new file and selecting the Open button. See Figure 5.30.

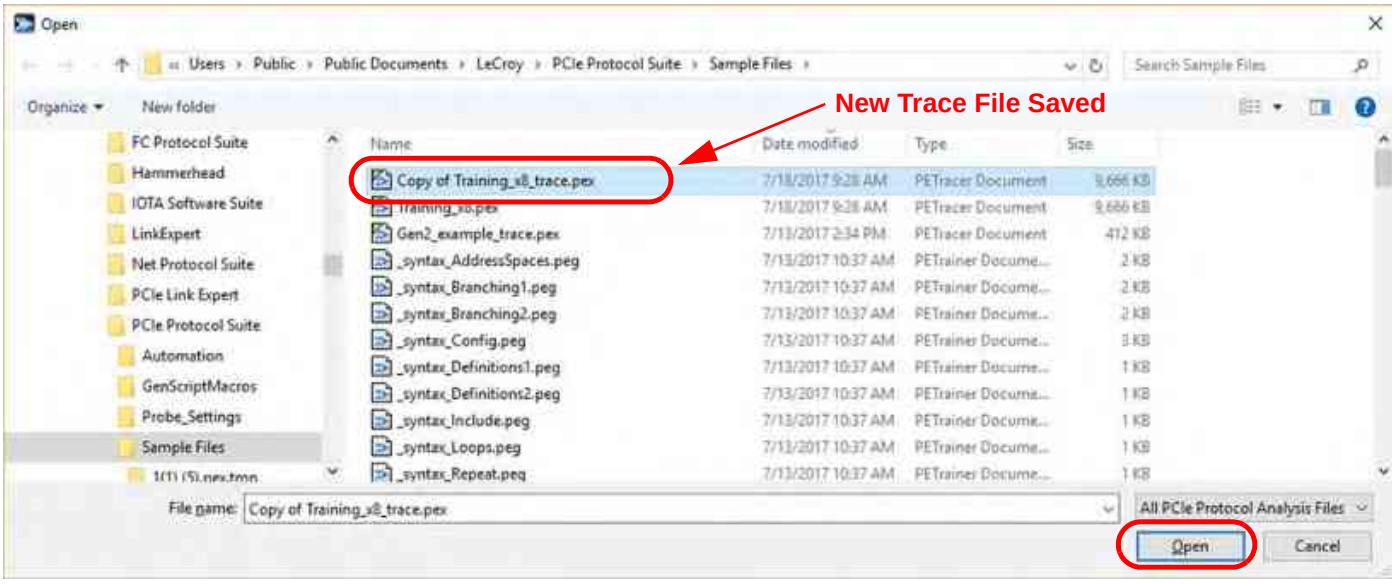


Figure 5.30: File -> Open: New Trace File Available

5.12.4 Trace File Structure

The captured trace file has an extension of ".pex". When the trace file is loaded, additional decoding and data reduction is done which results in additional files of data which are placed in a folder of the same name as the trace file (with the extension ".tmp"). This allows the trace file to be loaded and displayed quickly during subsequent viewings.

When copying a trace file, or sending it to someone, you can chose to send just the .pex file. In that case, the software re-generates the additional folder and files when the trace is first opened. The other choice is to send the additional folder with contents along with the .pex file, which will save the rebuilding effort when the file is opened again. The choice is up to the user. If you do NOT want these files kept, and don't mind the extra time it takes to re-build these every time you load a trace file, then you can select this in the Recording Options.

If the additional files ever become out of date (newer software structures from a new release, etc.) or if any of the files are lost or damaged, the software will rebuild a fresh version of the information.

5.13 Exporting a CATC Trace File

By default, PCIe Protocol Analysis saves CATC Trace files in the **.pex** format. However, you can export a CATC Trace to a file in any of the following other formats:

- Text
- Comma Separated Value (CSV)
- Generator file format

Exporting to Generator file format is a simple way to create a script file from your CATC Trace. Only PCI Express packets will be exported to a script. All transaction levels, including supported SSD decodes, can be exported to Text or CSV Text.

To export a CATC Trace file, select **File > Export**.

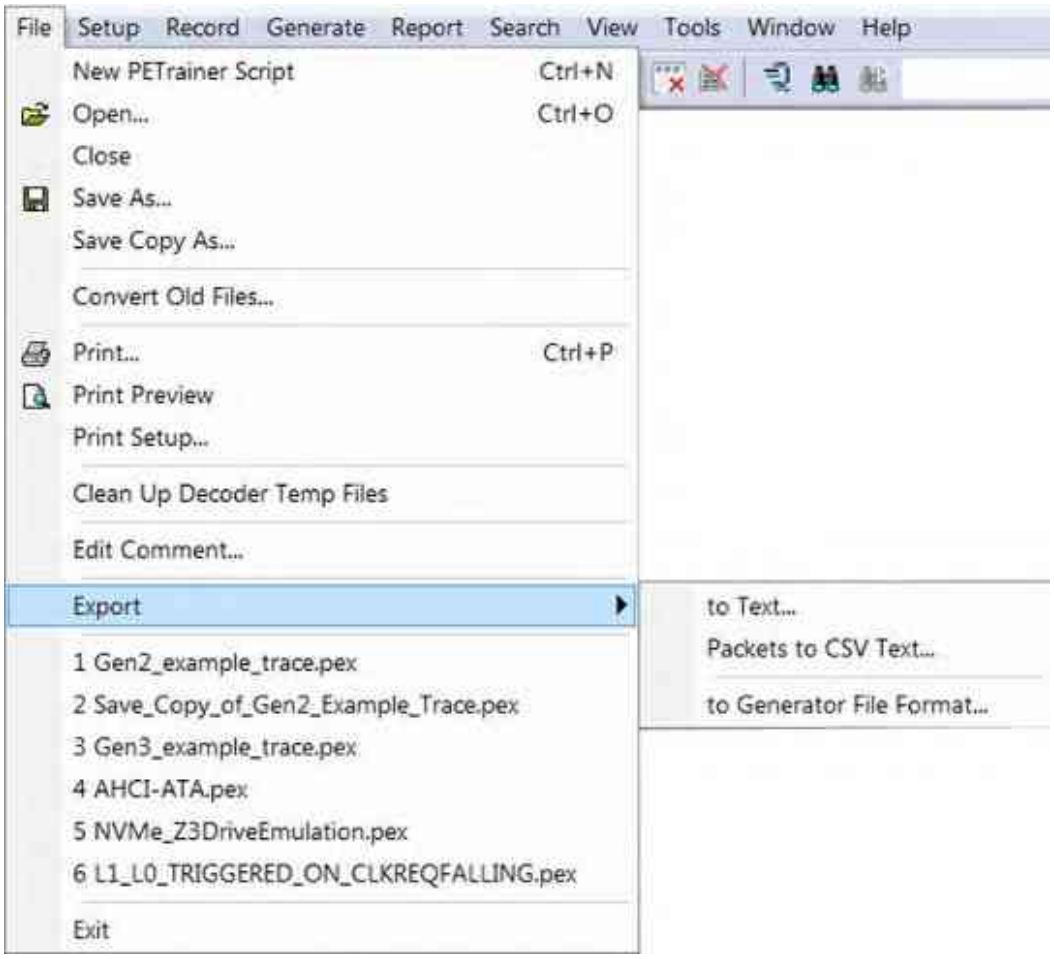


Figure 5.31: Exporting a File

5.13.1 Export: To Text

Select **Export => To Text**, a window pops up that has a button to select legacy format, which would not effect older scripts (see Figure 5.32) or to use the newer default format. See Figure 5.34 on page 132.

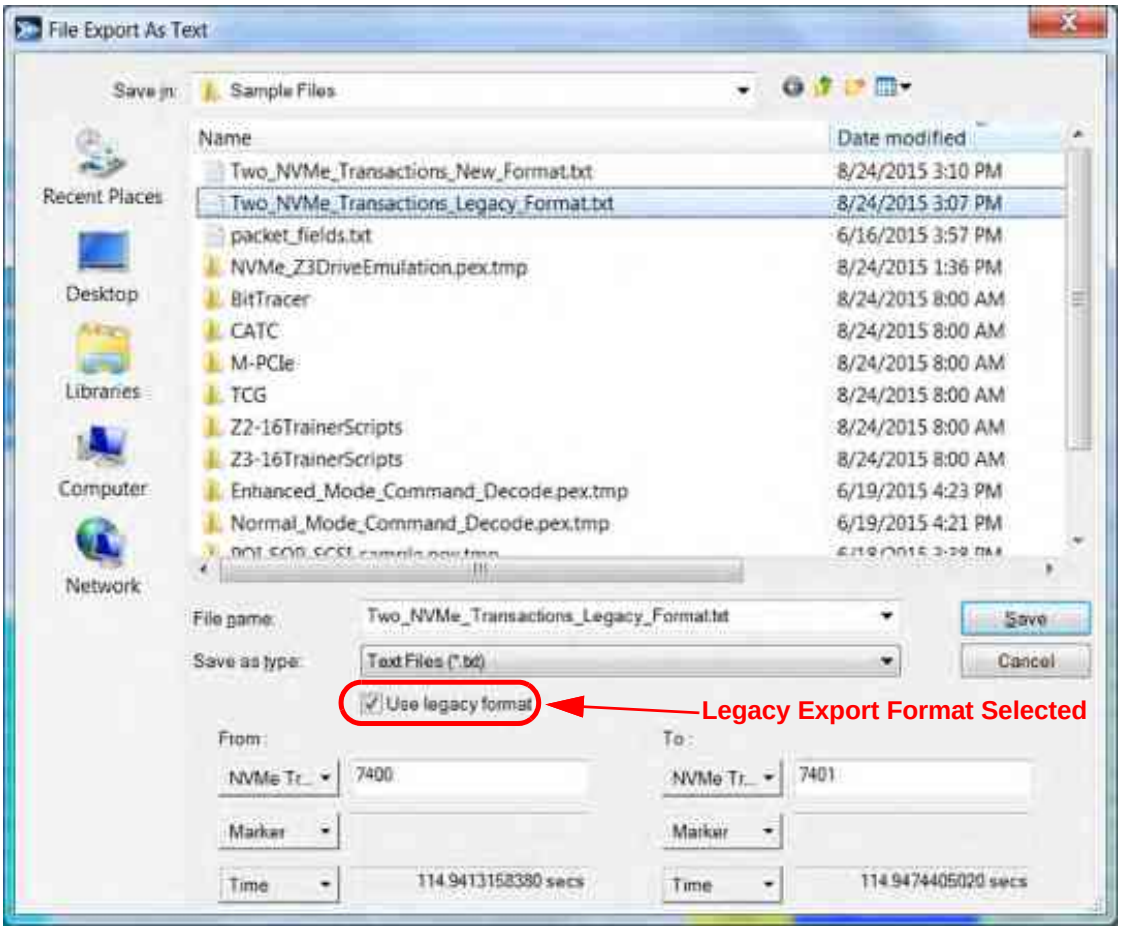


Figure 5.32: Export Two NVMe Transactions to Text File, Legacy Format

You can also select to Export only a portion of the Trace by setting the “From” and “To” menu items at the bottom of the dialog. You can select from Packets (or decoded Items, see Figure 5.33). For Markers or Time see Figure 5.34 on page 132.

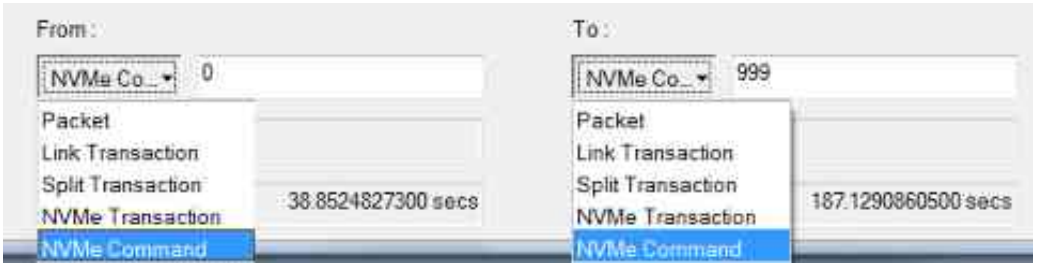


Figure 5.33: From and To Delimiters

The newer default format has the following characteristics:

- Removes spaces from time stamp format, i.e. "0002 . 742 651 908" -> 2.742651908
- Adds time delta value to the export
- Modifies 'Data' field to show '4 B' or 1 KB instead of '1 dword’
- QID / CID fields will be in decimal format rather than hexadecimal; i.e., 0x0007 -> 7

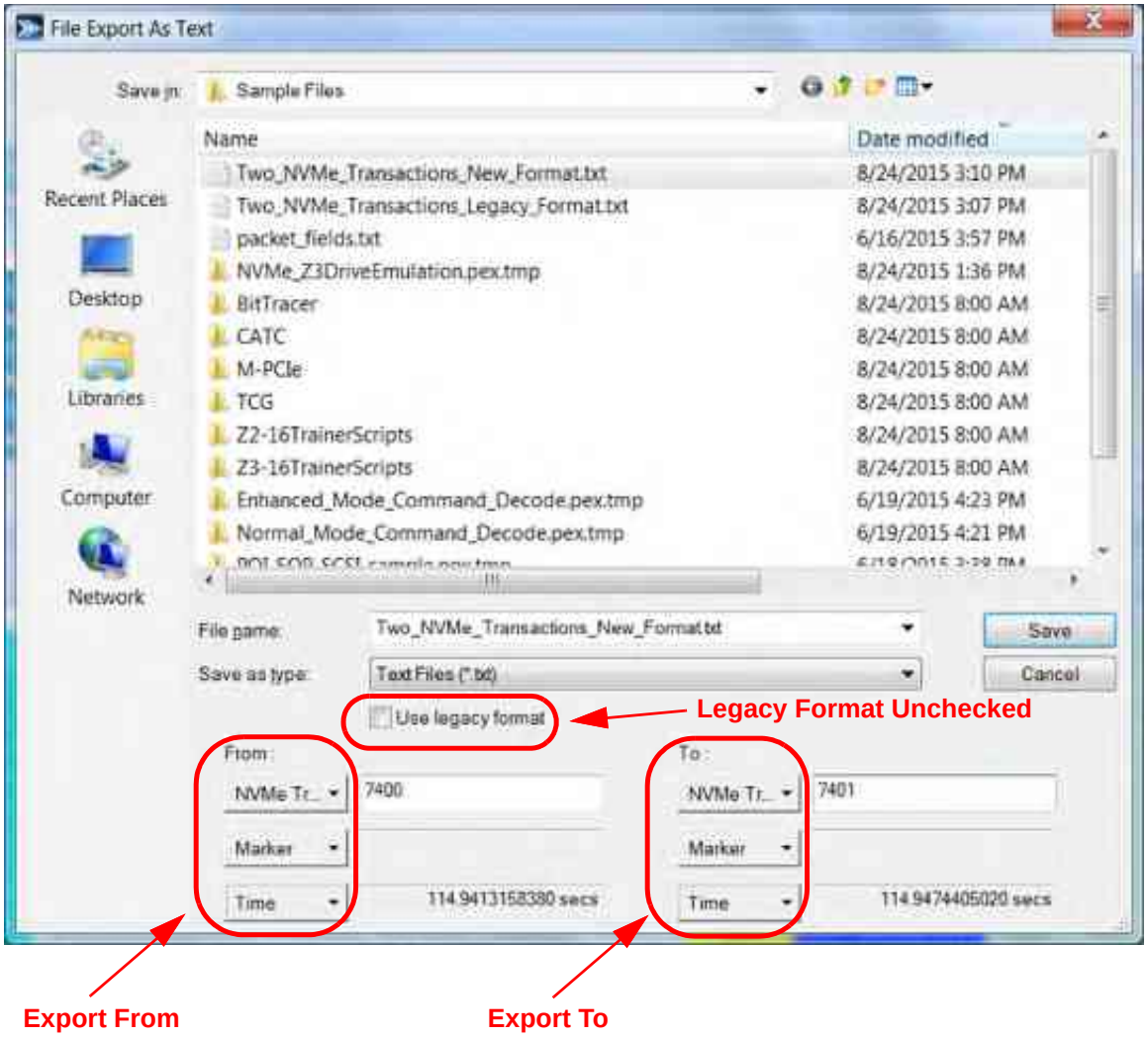


Figure 5.34: Export Two NVMe Transactions to Text File, New Format

You can see the differences in the two file formats below:

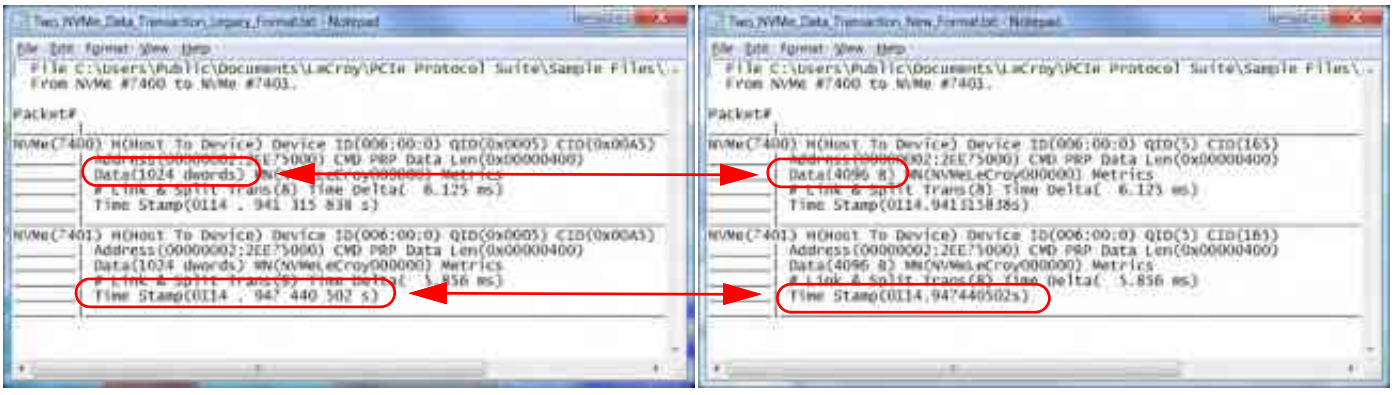


Figure 5.35: Export Trace Data to Text: Legacy vs New Format

5.13.2 Export: Packets to CSV Text

Now we'll Export Packets to CSV text using the legacy format, see Figure 5.36.

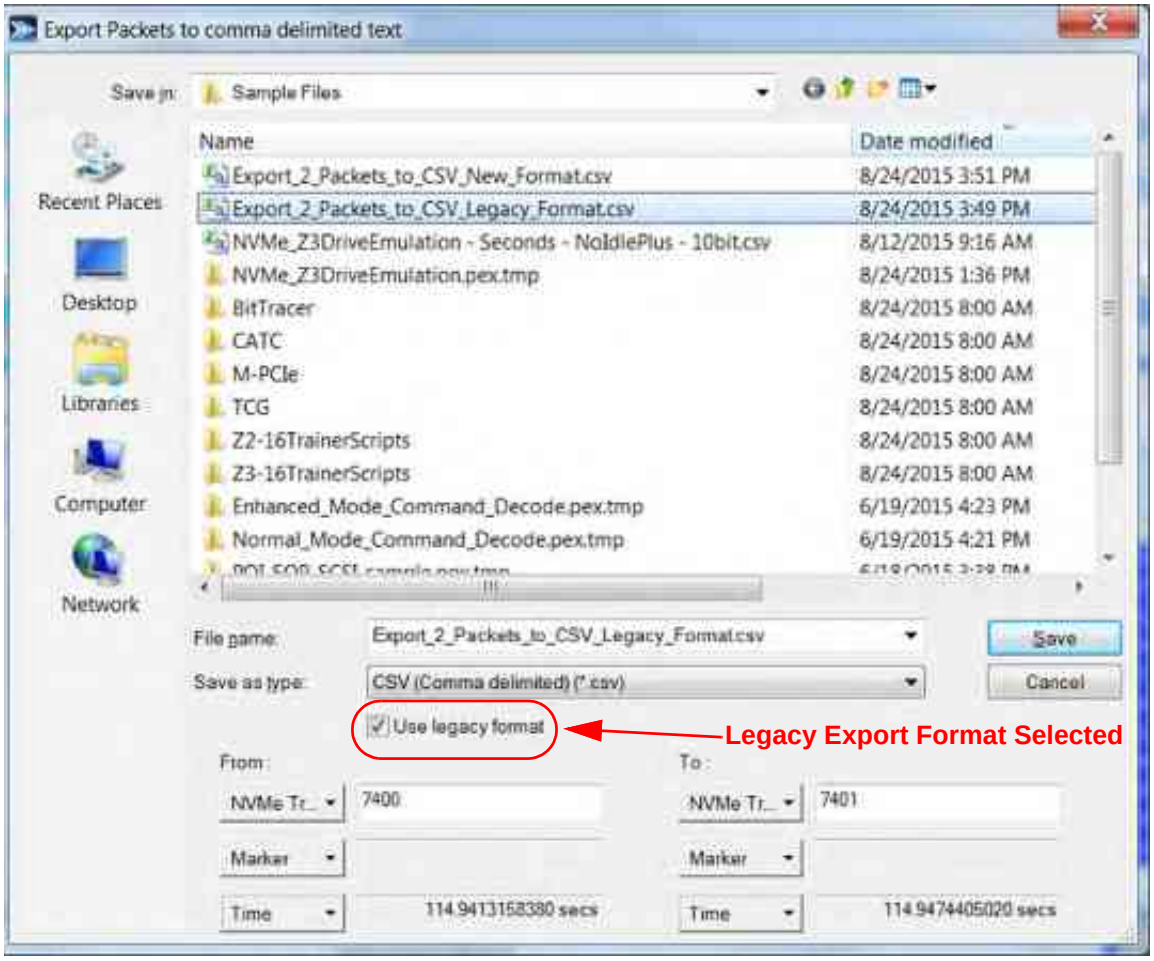


Figure 5.36: Export Packets to Comma Delimited Text: Legacy Format

Or we can export Packets to CSV text using the new format, see Figure 5.37.

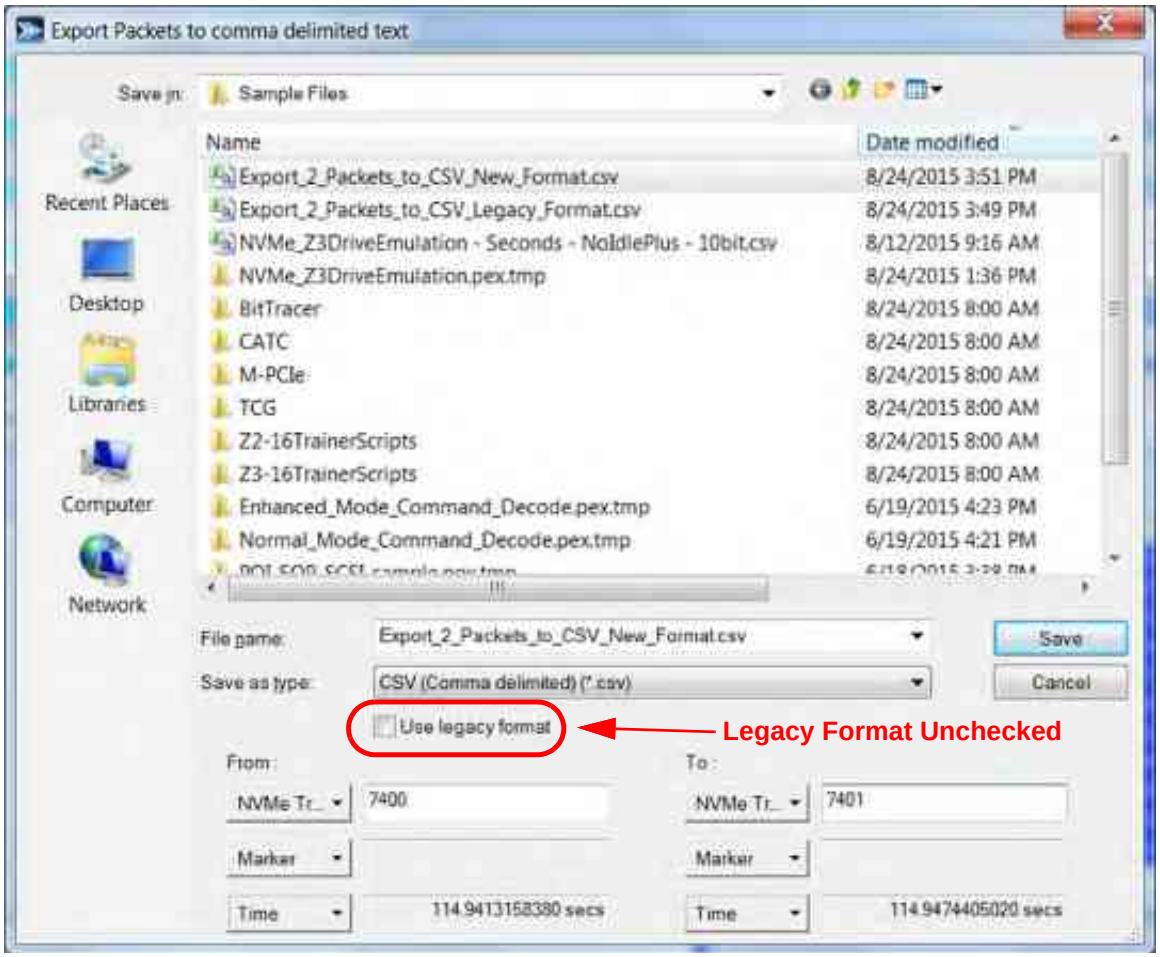


Figure 5.37: Export Packets to Comma Delimited Text: New Format

The differences in the two files can be seen in Figure 5.38.

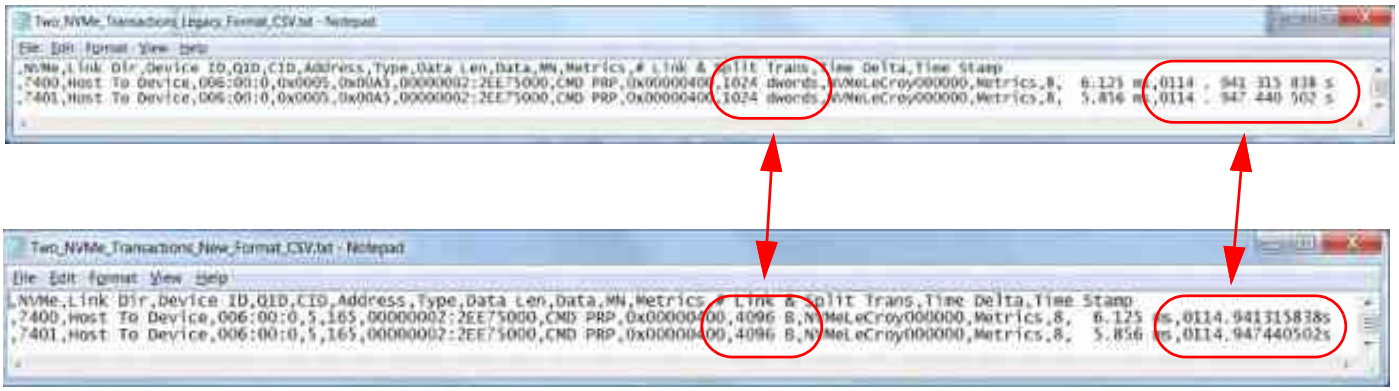


Figure 5.38: Export Packets to CSV Text: Legacy vs New Format

5.13.3 Export: To Generator File Format

To export a Trace File to Generator File format, choose that option. See Figure 5.39

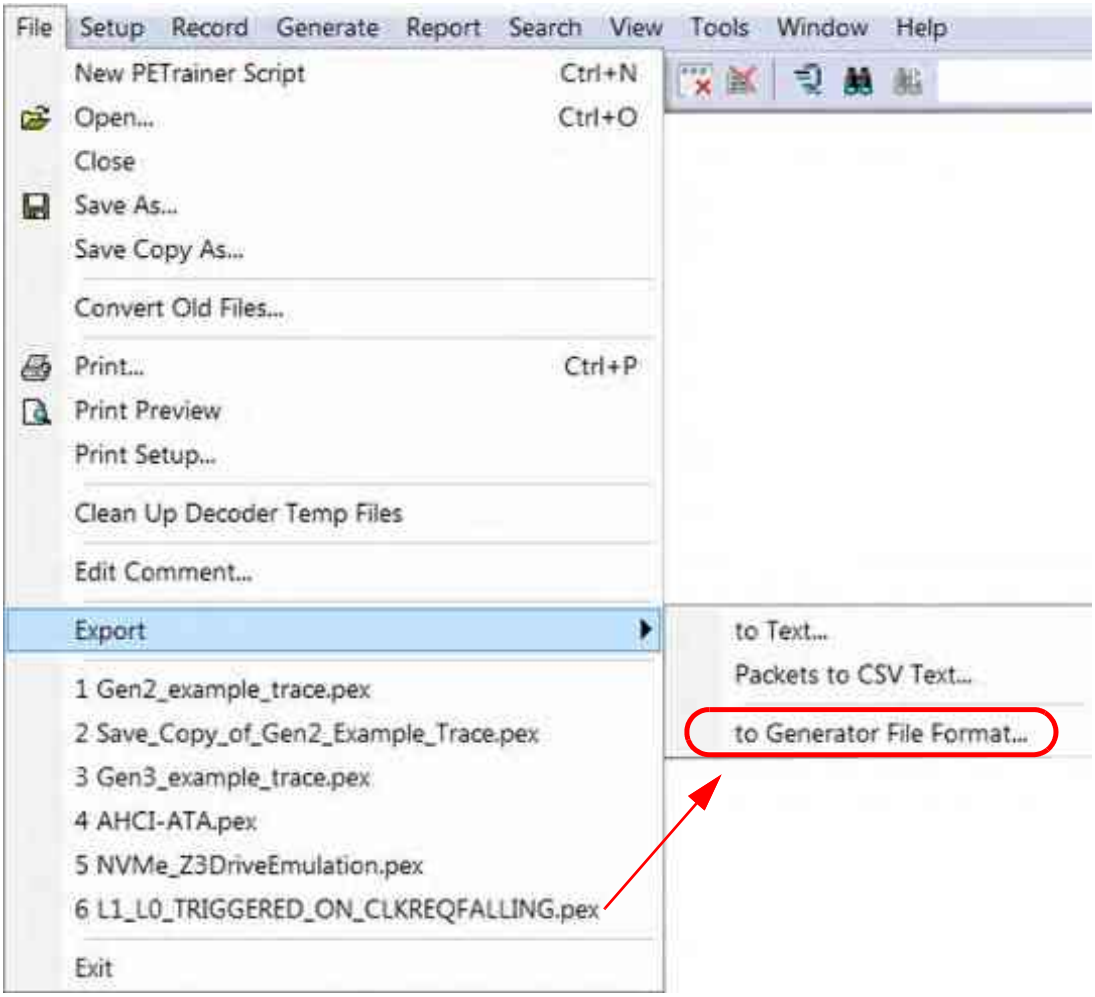


Figure 5.39: Export to Generator File Format

The purpose of Exporting a Trace file to Generator File Format is so that you can load that Generator file into a Teledyne LeCroy Exerciser (i.e. Z3-16 or Z416) to generate data traffic to test a device.

5.13.3.1 Exporting a CATC Trace to a Traffic Generation File

A simple way to create a script file is to open a CATC Trace and then to export the CATC Trace data to a generation file:

1. Open a CATC Trace file.
2. Select **File > Export > to Generator File Format**.
3. Select the desired options from the File Export dialog box as shown below. See Figure 5.40 on page 136.

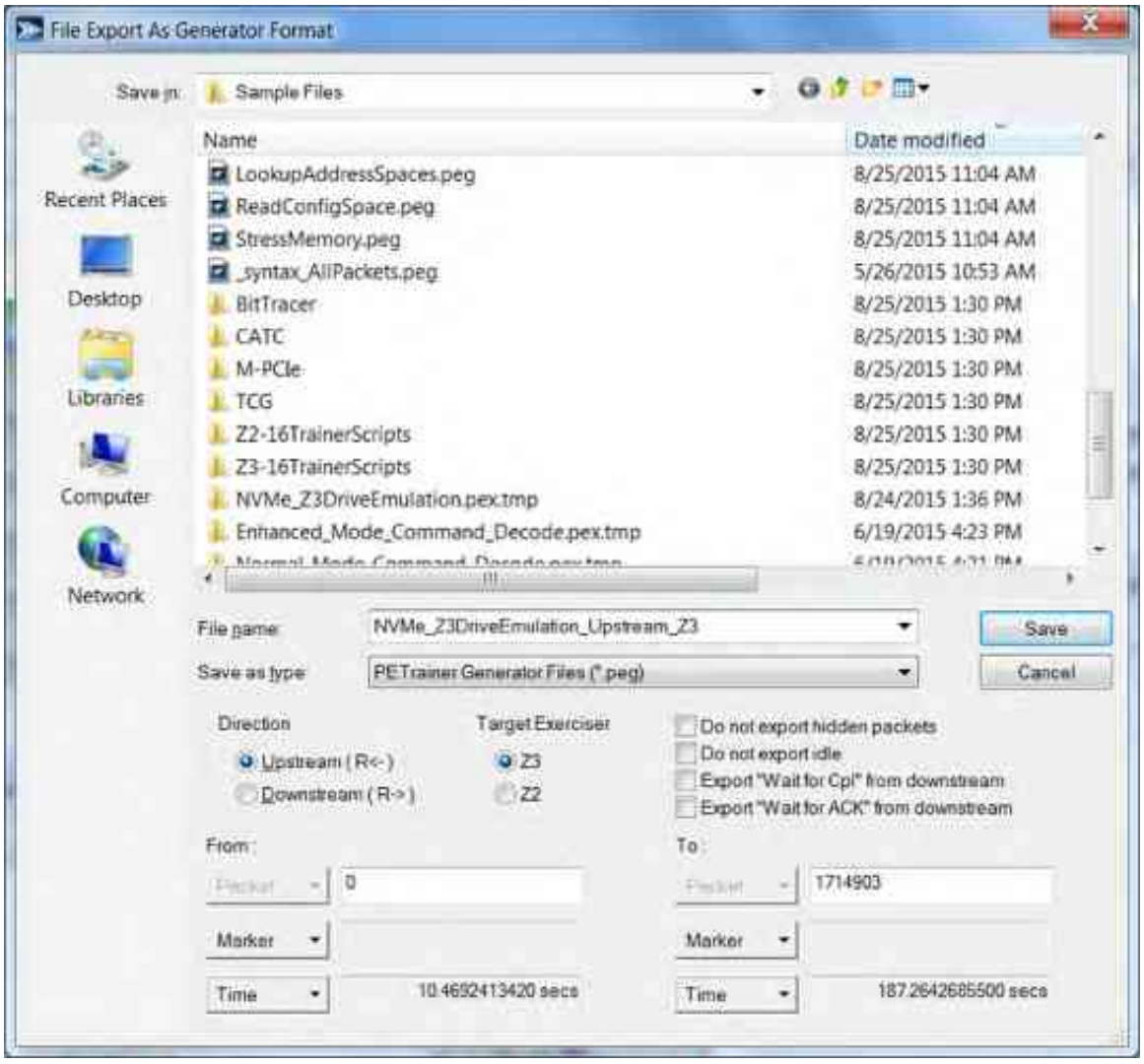


Figure 5.40: File Export As Generator Format Dialog.

Direction

Selects the direction of the traffic to be exported (Upstream or Downstream). In this case we chose Upstream. This will affect the Export “Wait for Cpl” and “Wait for ACK” options.

Target Exerciser

Select the type of Exerciser you plan to use (Z416, Z3-16 or Z2).

From and To

Selects a range for exporting. You can export all or part of the CATC Trace. You can select a range of Packets, Markers or Time.

Do not export hidden packets

Ignores any packets hidden through the various hide options.

Do not export Idle packets

Excludes Idles from the export.

Export “Wait for Cpl” from downstream

Exports all **Wait for Completions** from the opposite direction. **Wait = TLP** is a script command.

Export “Wait for ACK” from downstream

Exports all **Wait for ACK DLLPs** from the opposite direction.

5.13.4 Export From Data Flow View

You can also Export Trace Data from the Data Flow view (see Figure 5.41, Figure 5.42 on page 138 and Figure 5.43 on page 139) in either the Legacy or New data format.

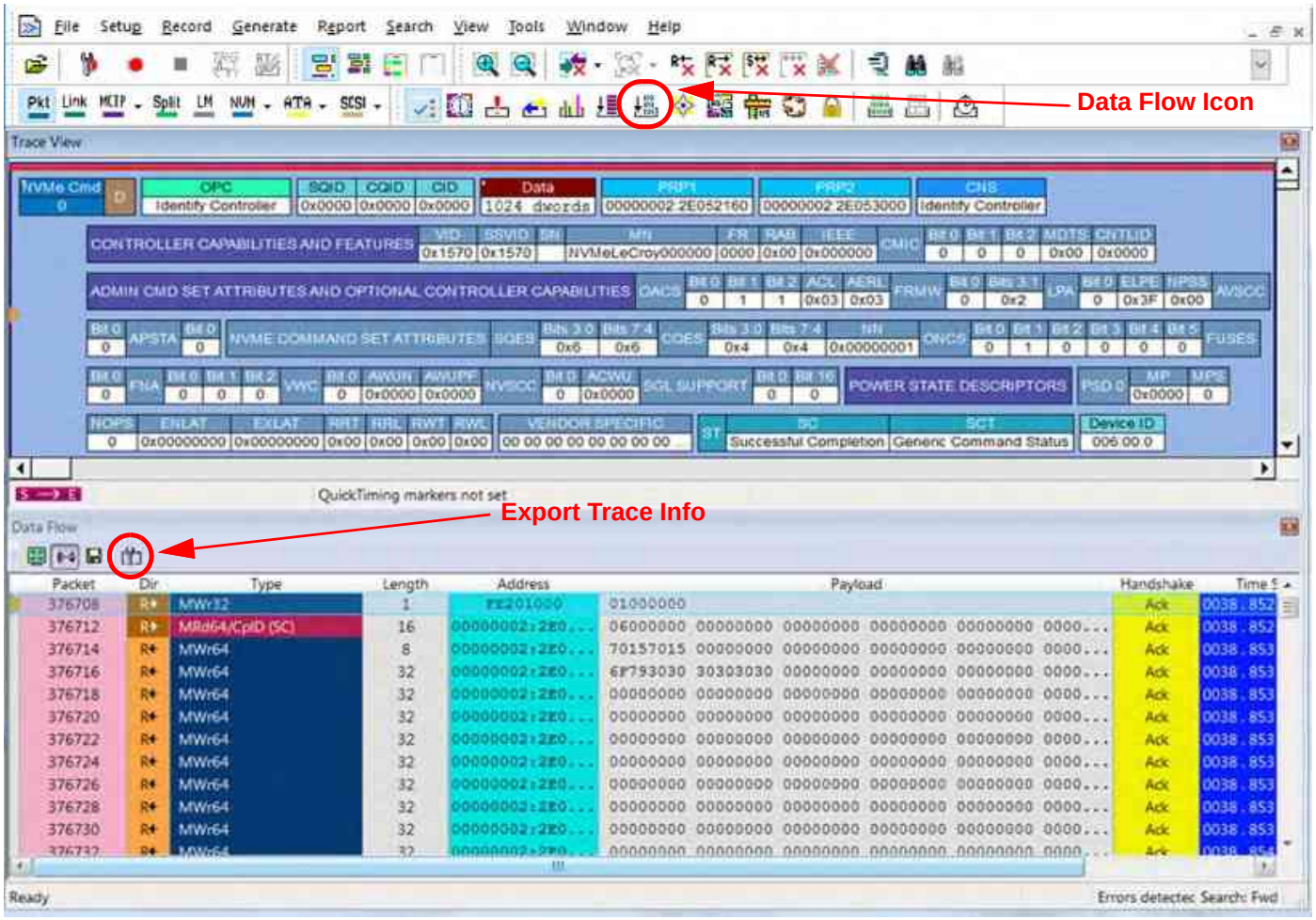


Figure 5.41: Data Flow View: Export by Selecting Save Icon

Export the Data Flow View information by selecting the Save icon. A new window will pop up where you can decide on the file name and path as well as whether the New data file format or the Legacy data file format is used. In this first example, we've chosen the Legacy format. See Figure 5.42.

5.13.4.1 Data Flow CSV File: Legacy Format

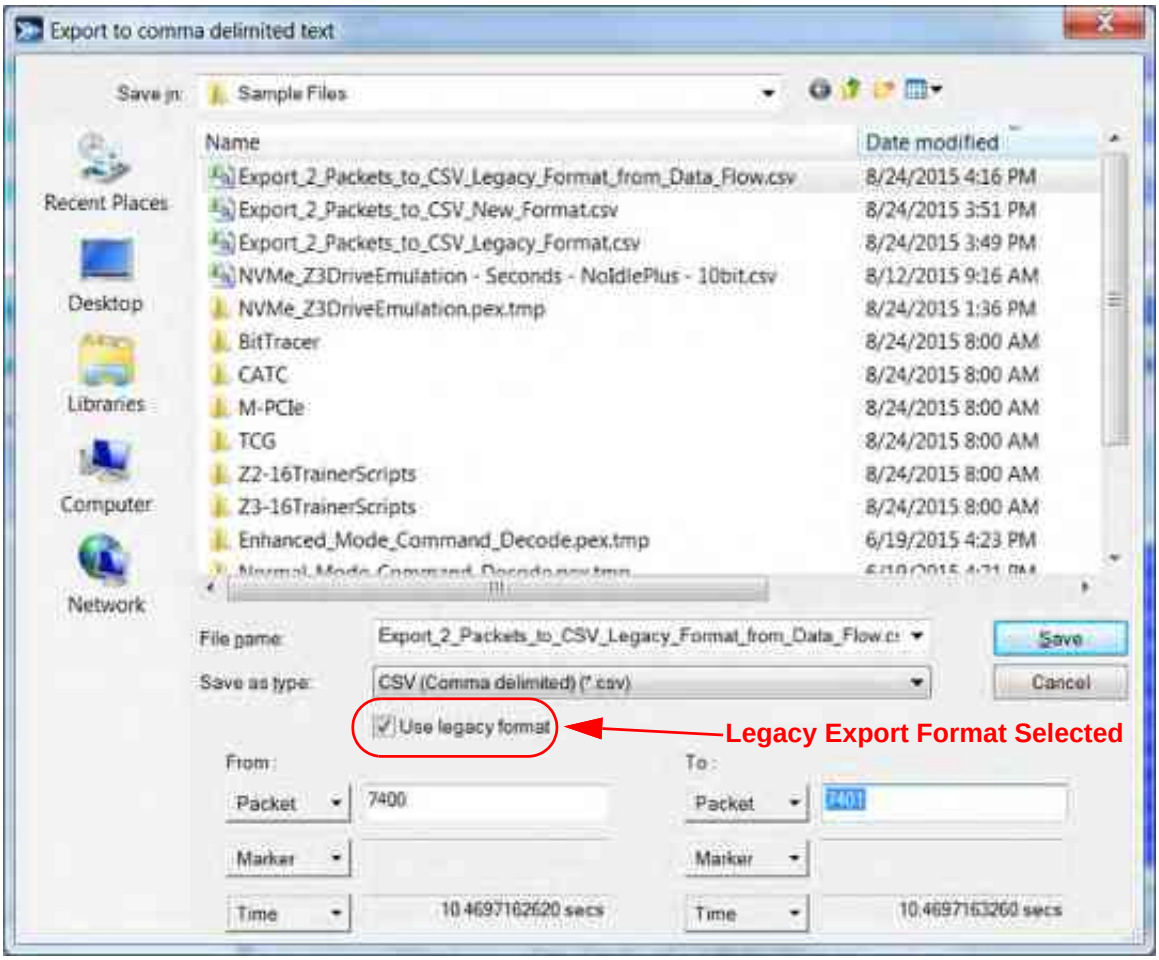


Figure 5.42: Data Flow View: Export Packets to Comma Delimited Text: Legacy Format

5.13.4.2 Data Flow CSV File: New Format

Next we'll chose the New Data format for the CSV file. See Figure 5.43.

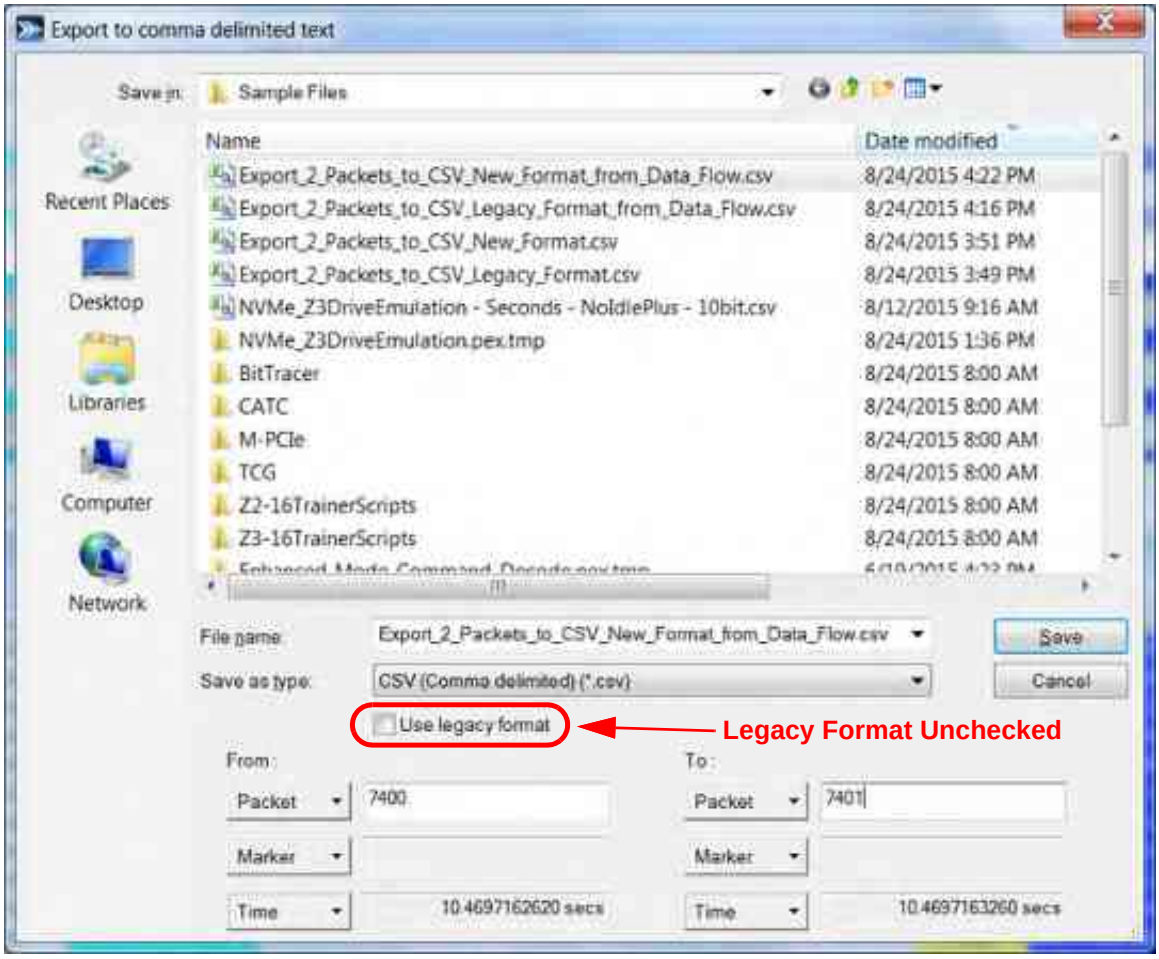


Figure 5.43: Data Flow View: Export Packets to Comma Delimited Text: New Format

5.14 Printing Data Files

To print all or part of the open CATC Trace:

1. Select **File > Print** from the menu or

   click the **Printer** button on the toolbar.

   The Print Packets dialog displays (see Figure 5.44 on page 140).



Figure 5.44: Print Packets Dialog

2. To select a range of packets, enter values in the **From packet #** and **To packet #** fields and click **Print**.
3. To print an entire file, leave the From and To fields empty and click **Print**.

The specified traffic information is printed as currently displayed, in color or gray scale as supported by your printer. Any CATC Trace File comments you entered are printed following the current document name at the top of each page.

Note: CATC Trace File comments can be created by using **Edit Comment** on the File menu.

5.15 Analyzer Chat Window

PCIe Protocol Analysis has a Chat window that allows you to communicate with users on remote host machines. For Chat to work, two conditions must be met:

- The host machines must have PCIe Protocol Analysis installed and running.
- The host machines must be listed in each other's All Connected Devices list. This means that your host machine must have the remote host machine listed in its Analyzer Devices window and the remote host machine must have your host machine listed in its Network Browse window. See Figure 5.45 on page 141.

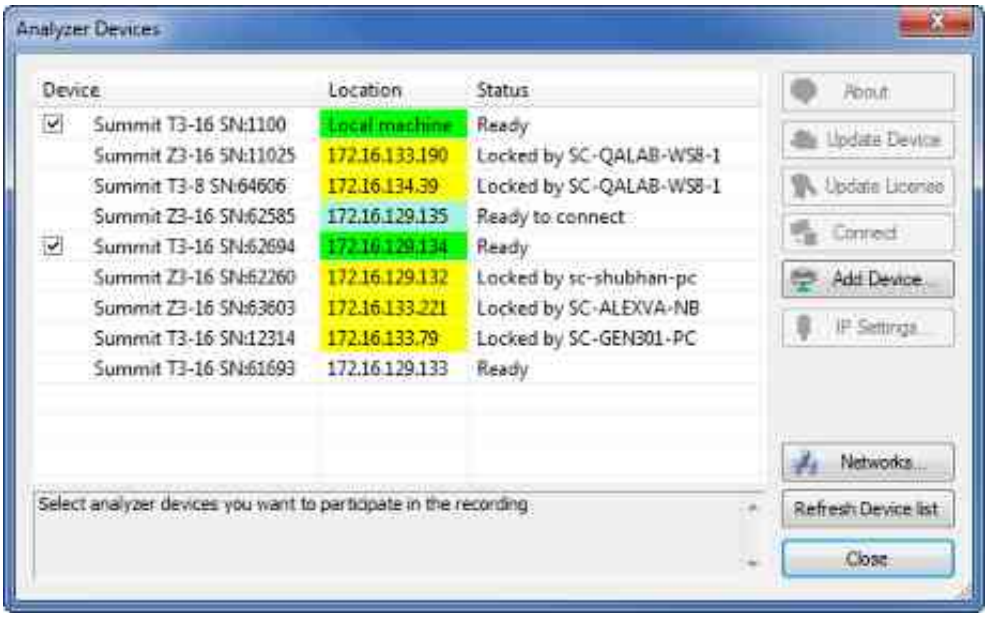


Figure 5.45: Analyzer Network Dialog

If the above conditions are met, a Chat session is initiated by running the command: **View > Analyzer Network Chat Bar**. The following dialog box opens.

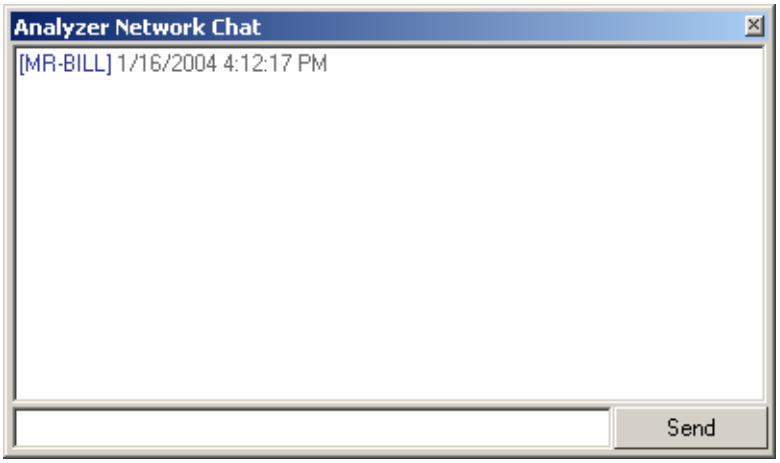


Figure 5.46: Analyzer Network Chat Dialog

Enter some text, then press **Send**. The message is then broadcast to all host machines listed in your network browse window. If a target host machine also lists your host machine in its Network Browse window, then it can receive your message. When the message arrives, the Chat window automatically opens.

5.16 CrossSync™ Control Panel

The CrossSync™ Control Panel allows you to select analyzers for synchronization and manage the recording process. It supports a wide combination of Teledyne LeCroy's flagship analyzers including PCI Express, USB, DDR, Serial ATA (SATA), Serial Attached SCSI (SAS), Fibre Channel (FC) and Ethernet.

CrossSync™ is Teledyne LeCroy's analyzer synchronization solution that enables time-aligned display of protocol traffic from multiple daisy-chained analyzers showing packet traffic from multiple high-speed serial busses. A lightweight software control panel allows users to select analyzers for synchronization and manage the recording process. Captured traffic is displayed using the latest analyzer software (in separate windows) with all the protocol specific search and reporting features.

Captured packets are displayed in separate windows that share a common time scale. Navigating the traffic in either direction will scroll to the same timestamp in a synchronized window. When using the CrossSync™ option, users can access the full complement of analysis capabilities available within the individual Teledyne LeCroy software. Search, reporting, and decoding all operate normally.

This feature is available with the Teledyne LeCroy PCIe Protocol Analysis application.

5.16.1 Launching the CrossSync™ Control Panel

To launch CrossSync™ from the PCIe Protocol Analysis application, select the **Launch CrossSync™ Control Panel** entry in the 'Setup' menu (see the screen below). Or, you can launch CrossSync™ from the '**Start**' menu.



Figure 5.47: Launching CrossSync™ from the PCIe Protocol Analysis Application

Please refer to the *CrossSync™ Control Panel User Manual* for more information.

Chapter 6

Recording Options

After installing the software and prior to recording, set the recording options. The recording options define the behavior of the Summit T5 Analyzer during recording. You can create, save and load previously saved recordings. This chapter explains how to define recording options on a Summit T5 Analyzer.

6.1 Recording Options Dialog

To open **Recording Options**, click  or select the command **Setup ⇨ Recording Options**.

The Recording Options dialog displays. See Figure 6.1 for the Summit T516 (Simple Mode) and Figure 6.2 for the Summit T54 (Simple Mode).

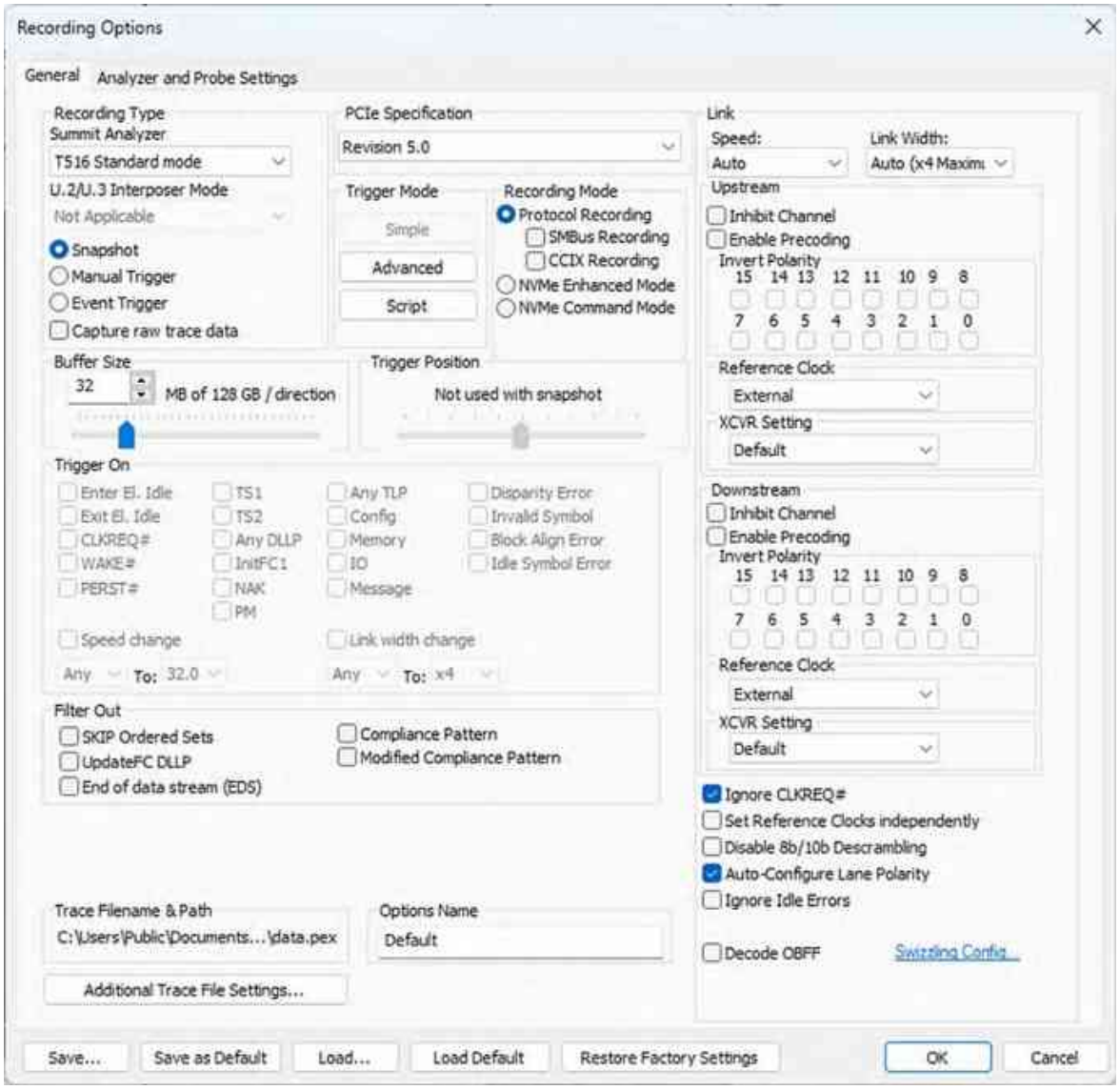


Figure 6.1: Recording Options Dialog: General Tab: T516 Standard mode: Simple Trigger Mode

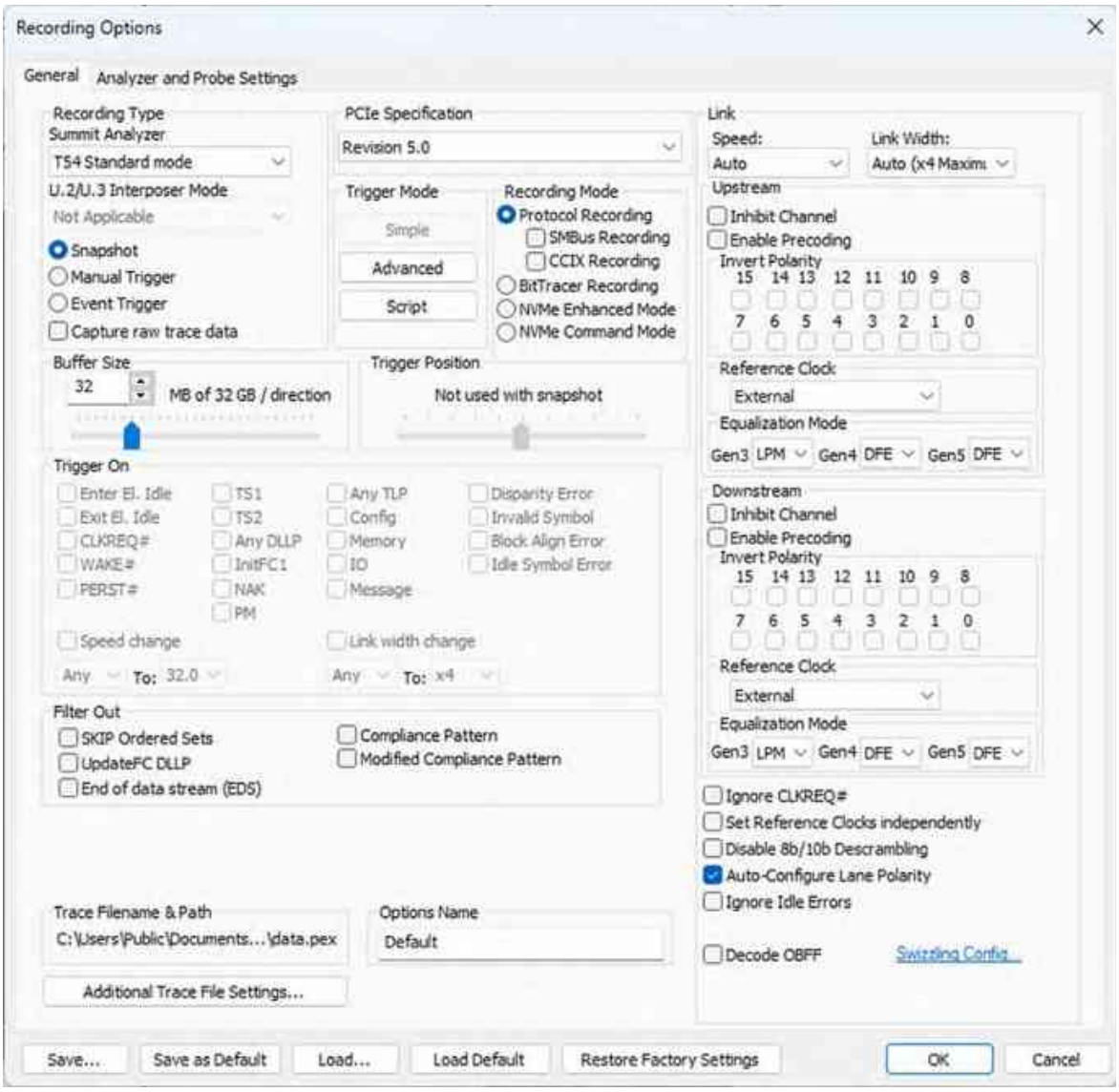


Figure 6.2: Recording Options Dialog: General Tab: T54 Standard mode: Simple Trigger Mode

6.2 Recording Type: Selecting the Summit Analyzer

The recording options available on each analyzer are different. A list of all analyzers and modes is shown below in Figure 6.3. When the Summit T516 Analyzer is selected through the toolbar (**Setup** → **Recording Options** → **Summit T516**), the recording options available are displayed as shown in Figure 6.13.

When the Summit T54 Analyzer is selected through the toolbar, the recording options available are displayed as shown in Figure 6.3.

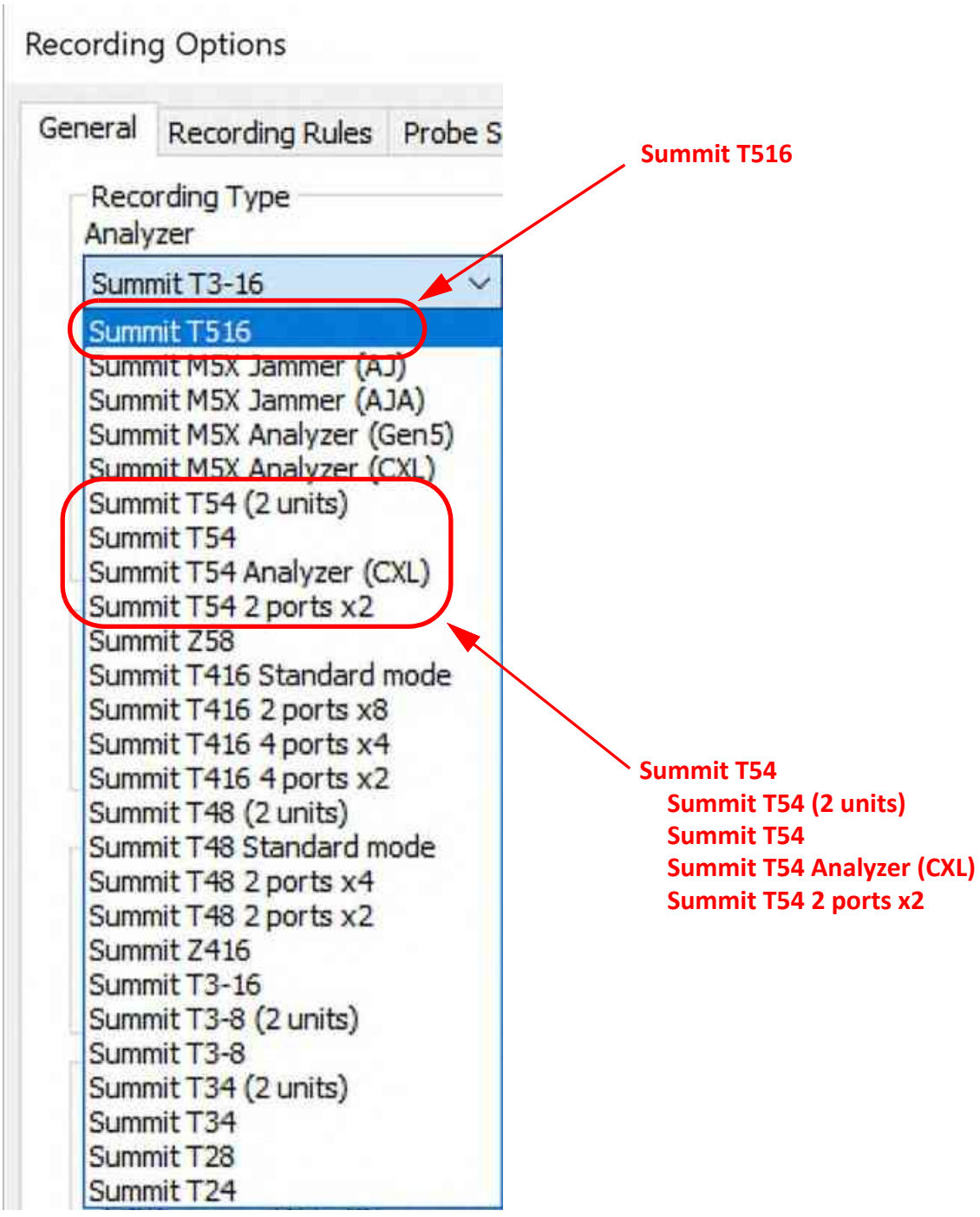


Figure 6.3: Analyzer Types

6.3 Select Interposer Type

If you have a U.2 or U.3 Interposer, you must select the type of interposer you are using.

If you are using another type of interposer, select **Not Applicable**. See Figure 6.4.

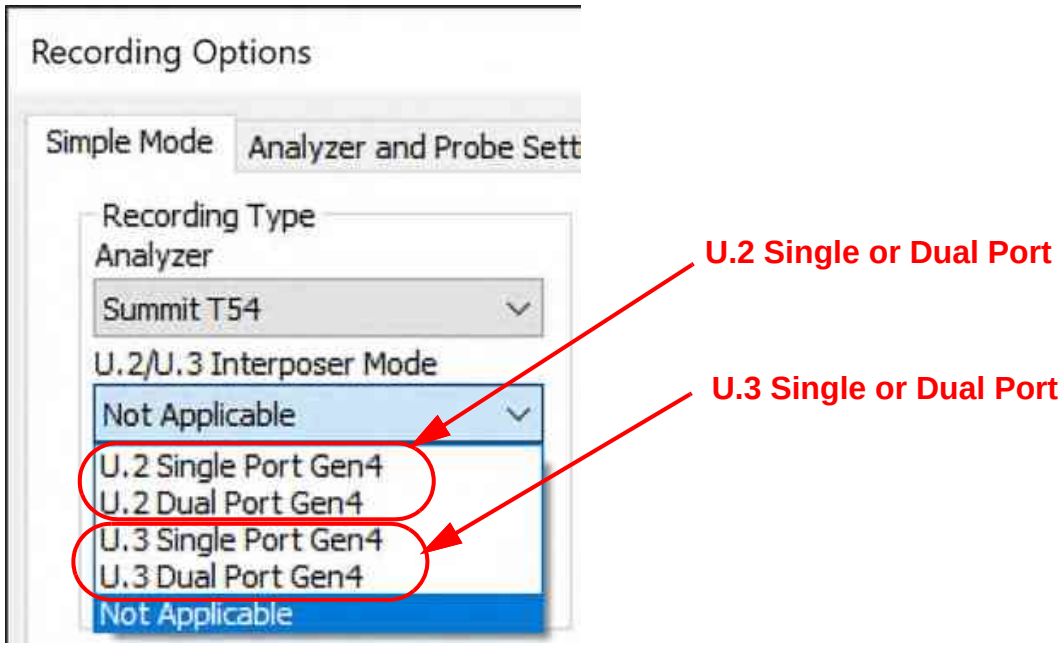


Figure 6.4: Selecting U.2 or U.3 Interposer

If you chose a different U.2/U.3 Interposer Mode from the one previously chosen a warning message will appear about saving your settings through a power cycle. See Figure 6.5.

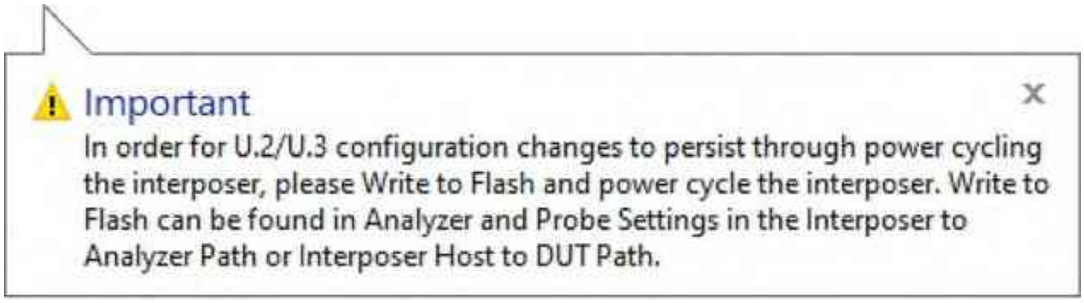


Figure 6.5: U.2/U.3 Interposer Configuration Settings Persist through Power Cycle

Another warning message will appear if the previous U.2/U.3 Interposer chosen has a different pin configuration (the physical lanes and logical lanes are different) and the bits need to be “swizzled” for the new interposer. See Figure 6.6.

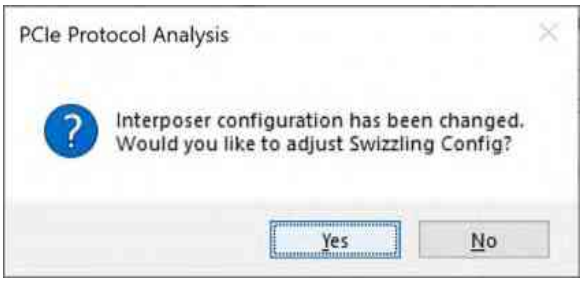


Figure 6.6: Swizzling Configuration Warning Message

As an example, if you had previously chosen an interposer that did not need the physical lanes and logical lanes to be swizzled, you would get the following message. See Figure 6.7.

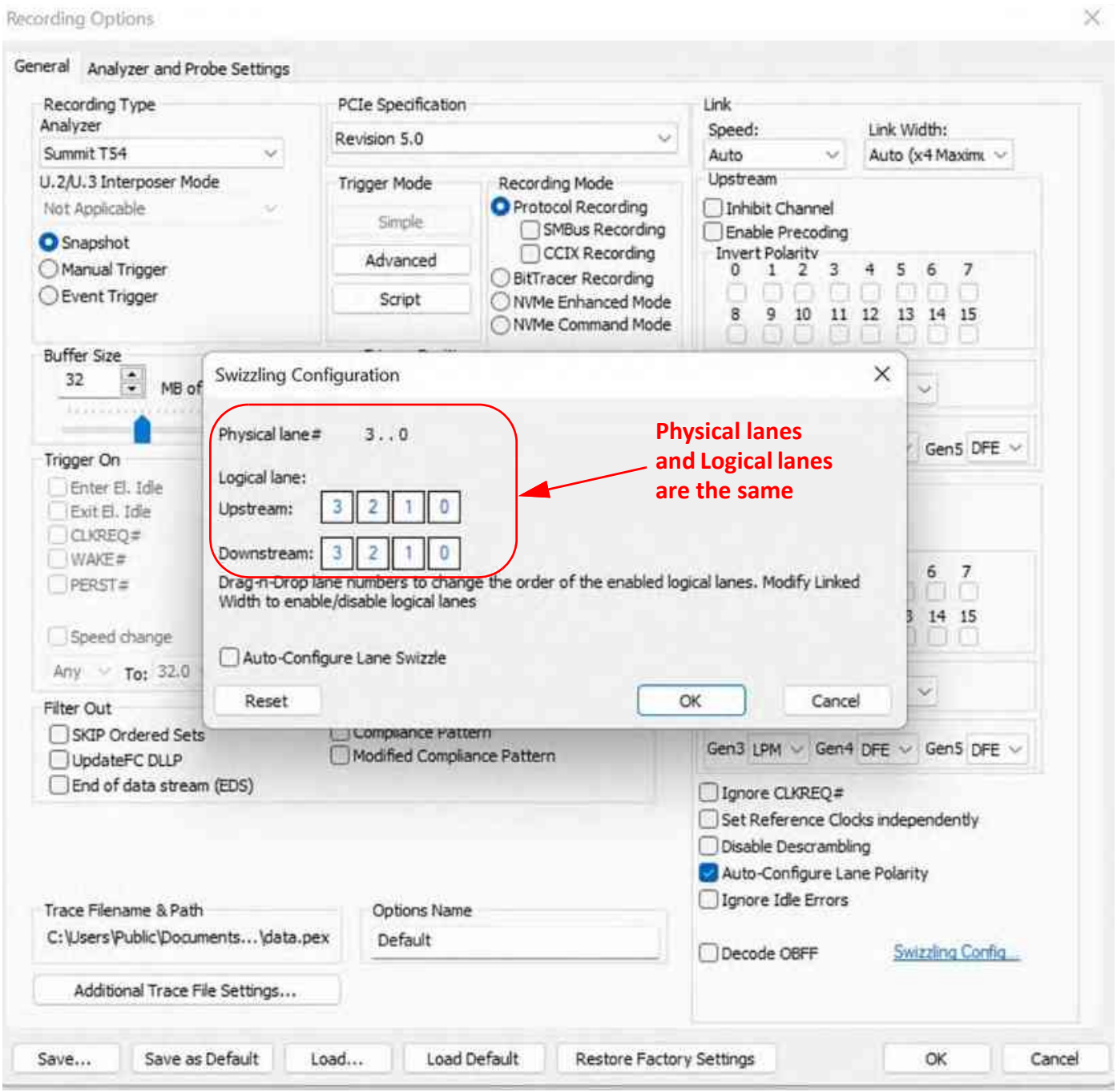


Figure 6.7: Physical Lanes and Logical Lanes are the Same

But if the physical lanes and the logical lanes are different, the analyzer needs to be told that. See Figures 6.9, 6.9 and 6.10.

For example, if you selected the U.3 Dual Port Gen4 the following warning message will appear.

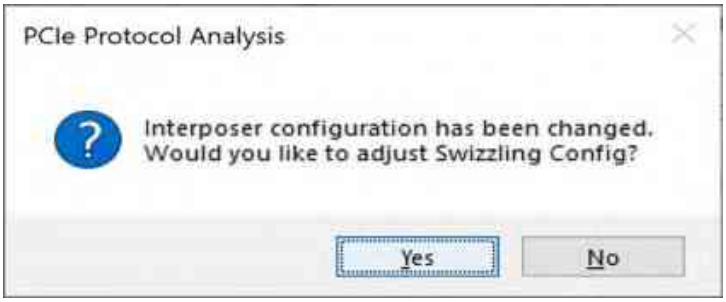


Figure 6.8: Warning Prompt for Configuration Change

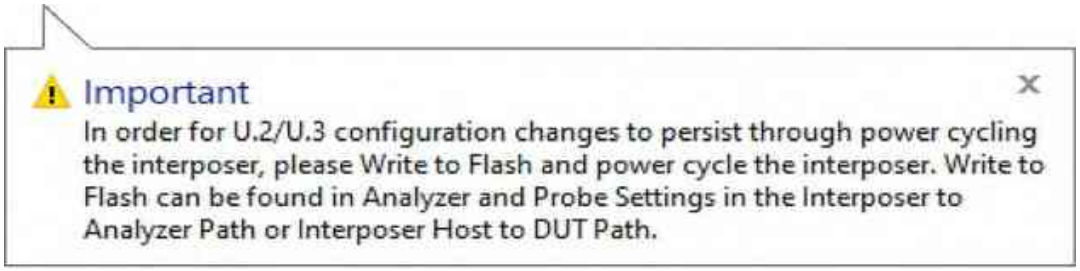


Figure 6.9: Warning Message: Keep Configuration Changes through Power Cycle

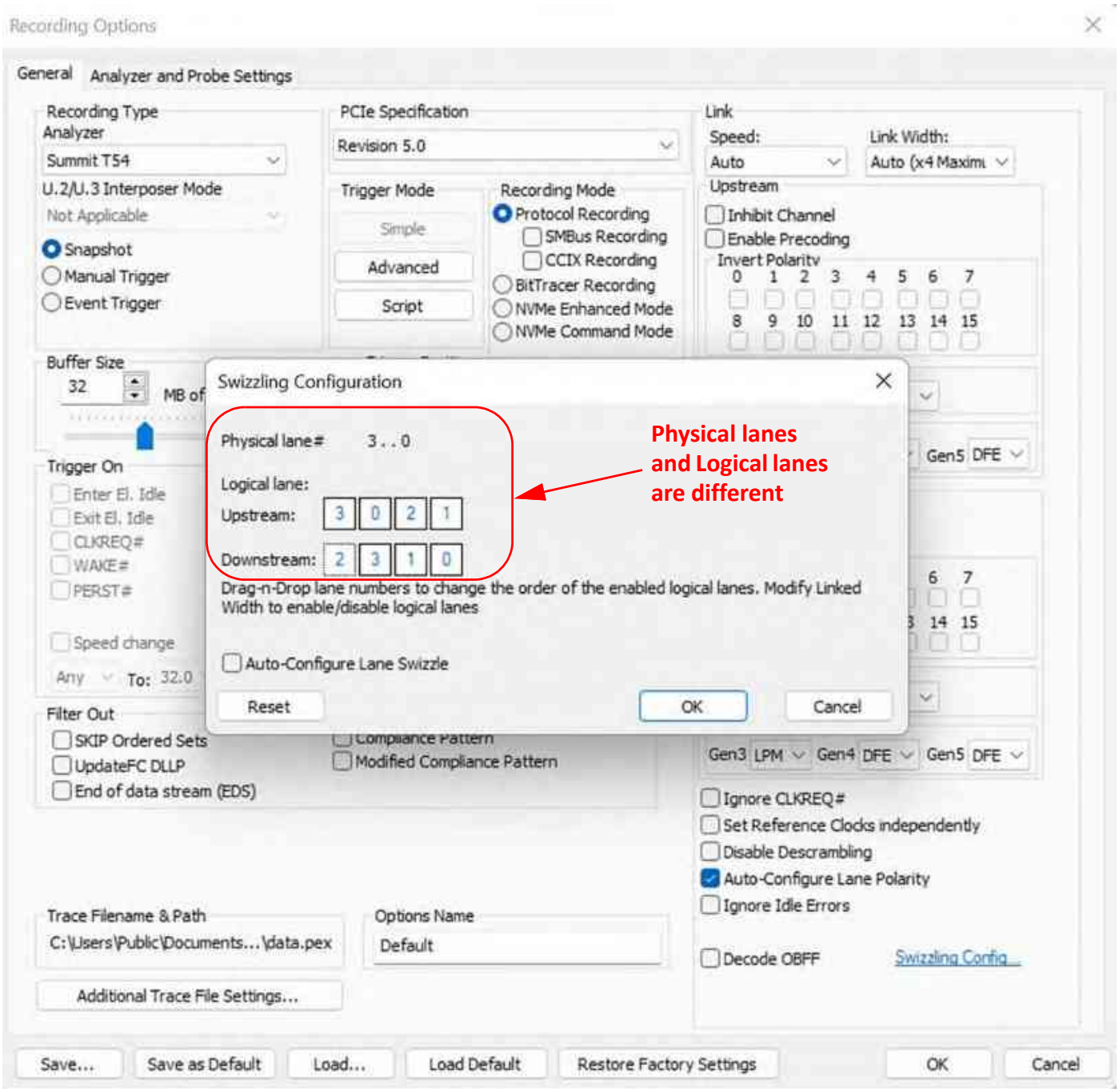


Figure 6.10: Physical and Logical Lanes are Different

For more on “Swizzling” Lanes see 6.15.8, *"Swizzling Config..."*.

6.4 Trigger Mode

6.4.1 Snapshot

A recording of a pre-determined length. You set the recording length in the Buffer Size box. Recording begins when you click the **Rec** button on the toolbar and ends when the selected buffer size is filled or when you press the **Stop** button.

6.4.2 Manual Trigger

Recording begins when you select **Start** in the application. Pressing the **Trigger** button allows the Analyzer to finish recording by switching between the pre-trigger buffer and the post-trigger buffer. Recording continues until the post-trigger buffer has been filled. You can also end the recording immediately by pressing the **Stop** button in the application.

Note: Consider that when filtering is enabled, pressing the Trigger button will not necessarily cause the post-trigger buffer to fill automatically, due to packets being filtered and not stored. In this case you will have to use the Stop button to immediately end the recording.

6.4.3 Event Trigger

A recording that switches between the pre-trigger buffer and the post-trigger buffer when it is triggered by an event in the CATC Trace. An Event Trigger begins when you select **Start** in the application and ends when the specified triggering event occurs in the CATC Trace or you press **Stop**. If an event triggers the end of the recording, the Analyzer records a predefined amount of post-trigger data (specified by Trigger Position and Buffer Size.)

You can also terminate an Event Trigger recording by pressing the Manual Trigger button on the front of the Analyzer. When the Manual Trigger button is pressed, the Analyzer continues to record until the specified post-trigger buffer has been filled. See 6.6.2, *"T54 Analyzer Event Trigger"* for more details.

6.5 Trigger Mode: Simple, Advanced or Script

The trigger modes are: Simple, Advanced or Script. The Simple Recording and Advanced Recording options are the same in functionality, only the interface displayed is different.

Script Mode enables the Recording Script tab. See 6.5.3, *"Trigger Mode: Script"*.

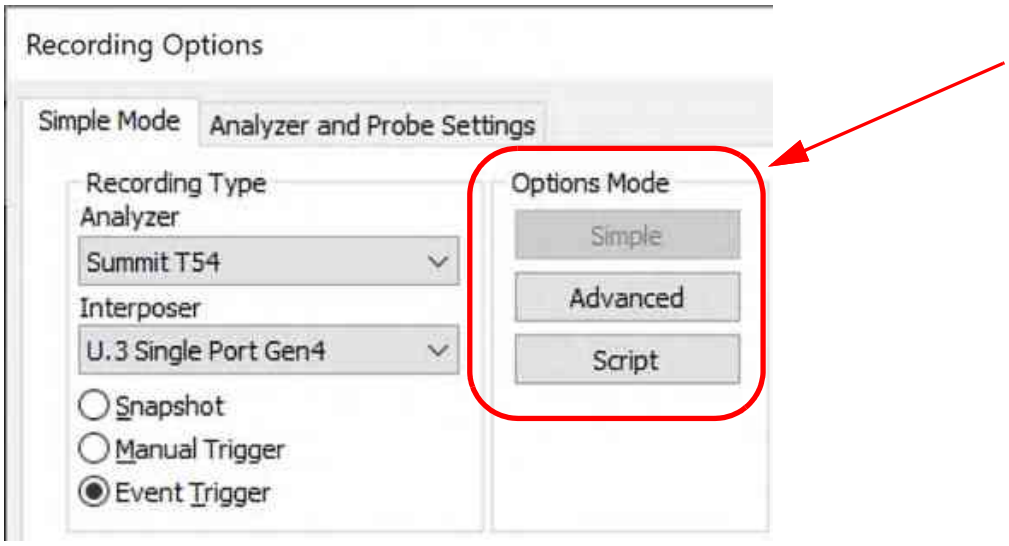


Figure 6.11: Recording Modes for Summit T54: Simple, Advanced or Script Mode

- Simple Mode Recording options are shown in Figure Note: and Figure 6.13
- Advance Mode Recording Options are shown in Figure 6.15 andFigure 6.16
- Script Mode Recording Options are shown in Figure 6.20.

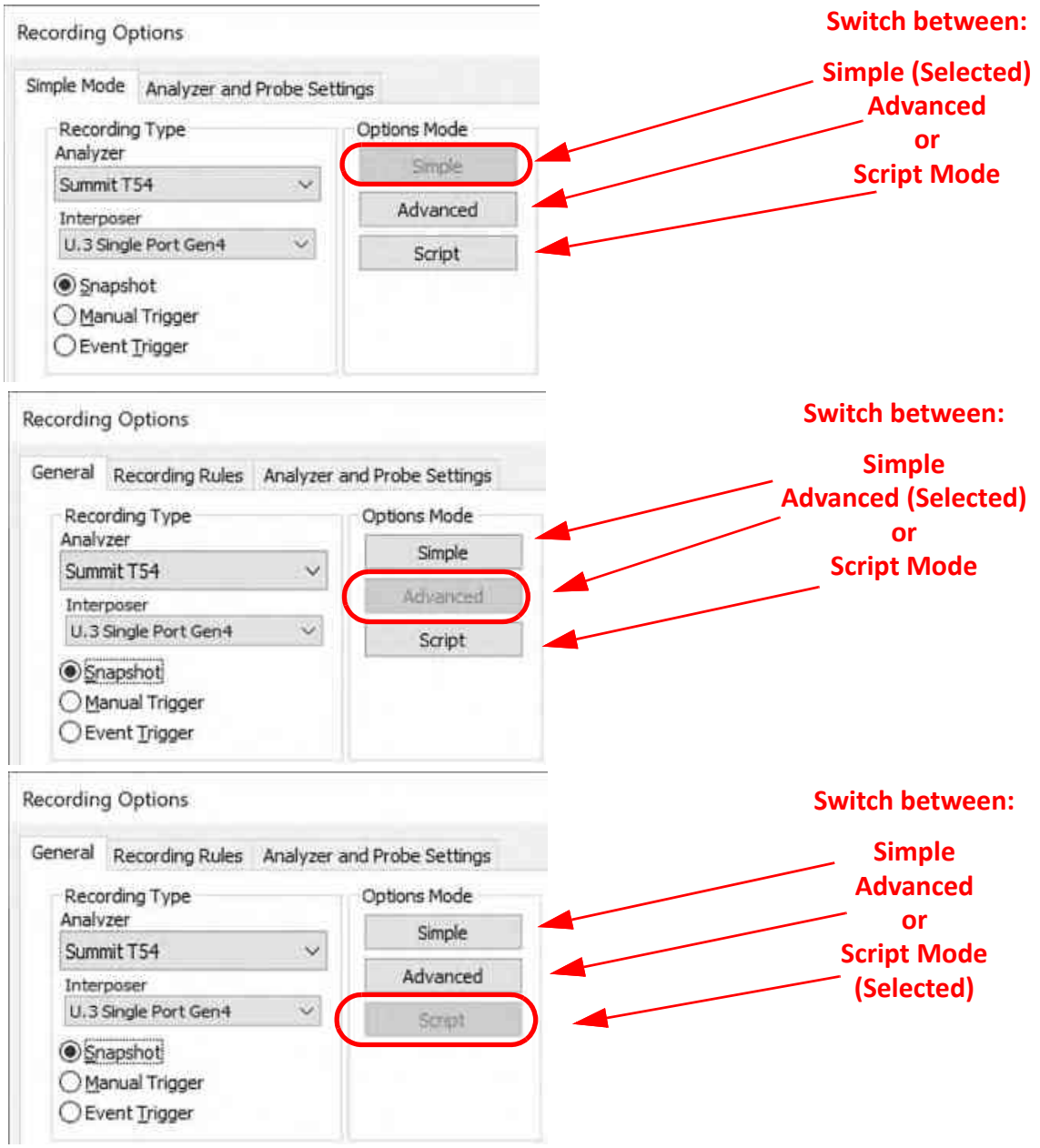


Figure 6.12: Switch to Simple, Advanced or Script Mode Buttons Summit T54

6.5.1 Trigger Mode: Simple

Simple Mode allows quick access to commonly used options. The recording options are the same in both modes (See Figure Note:: 2B and Figure 6.11 below).

6.5.1.1 Summit T516 Simple Mode

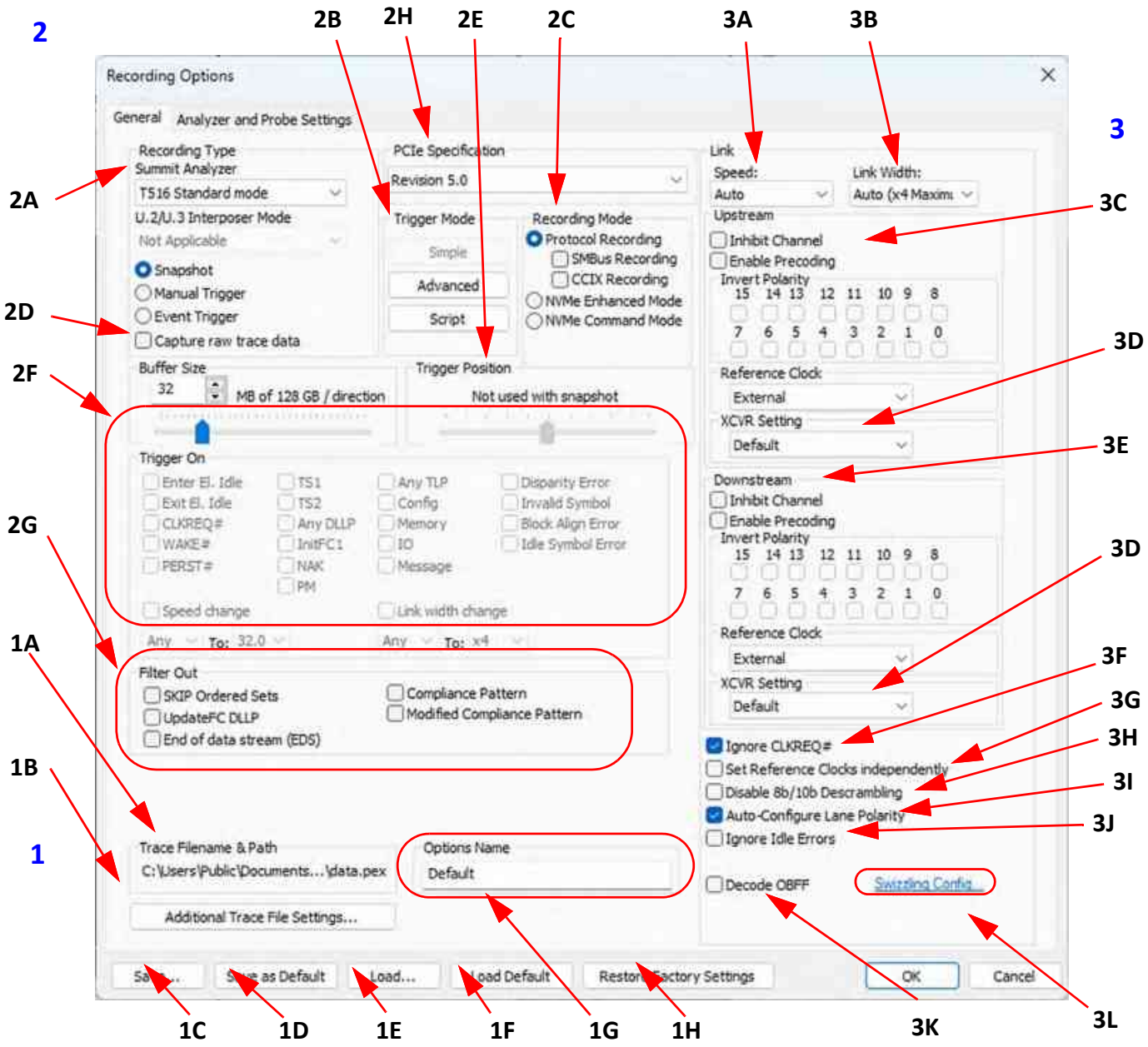


Figure 6.13: Summit T516 with Simple Recording Options

6.5.1.2 Summit T54 Simple Mode

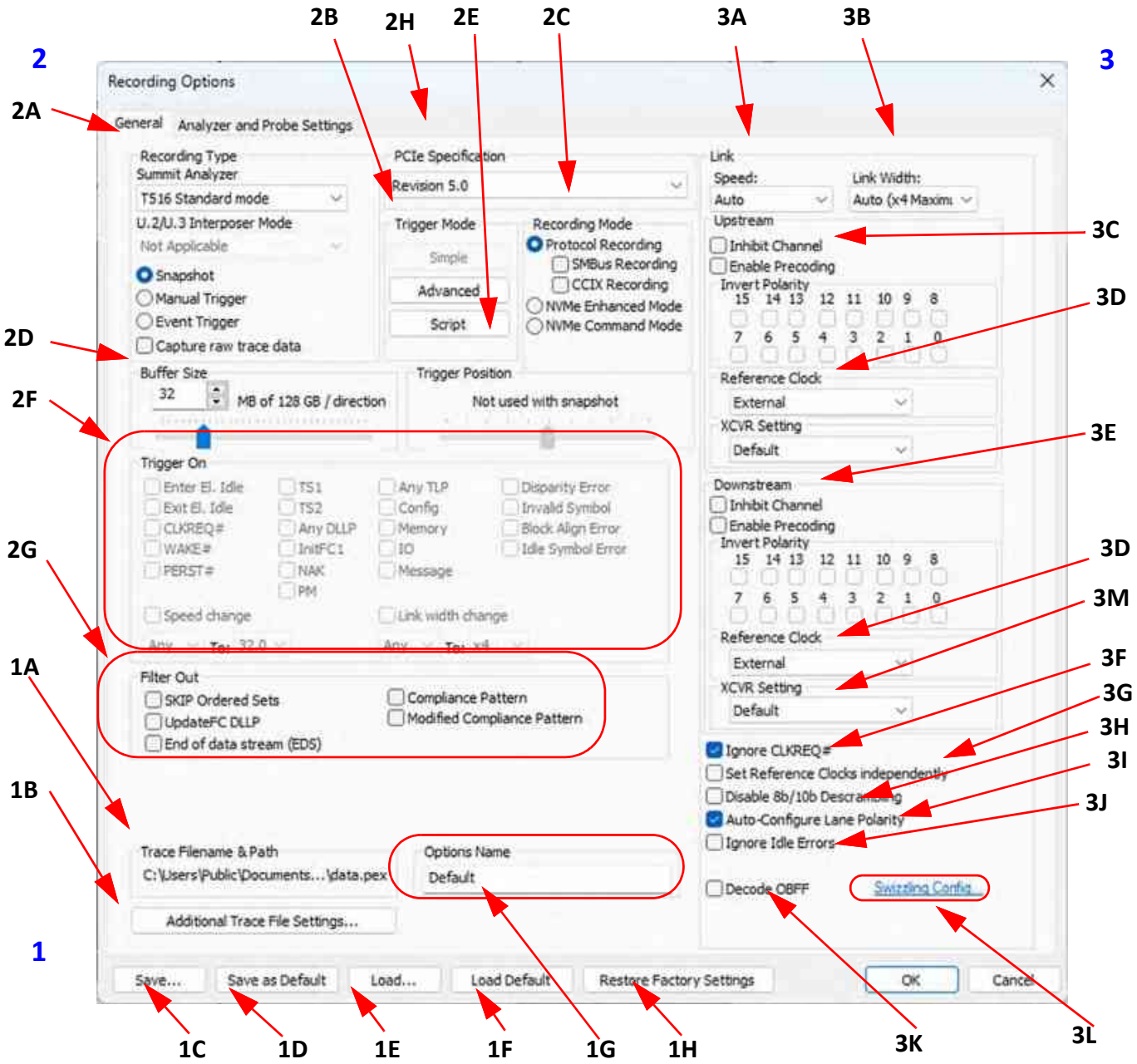


Figure 6.14: Summit T54 with Simple Recording Options

6.5.2 Trigger Mode: Advanced

Advanced Mode enables you can set complex recording rules. See 6.15.9, *"Decode Optimized Buffer Flush/Fill (OBFF)"* and 6.17.2, *"Defining Recording Rules"*.

6.5.2.1 Summit T516 Advanced Mode

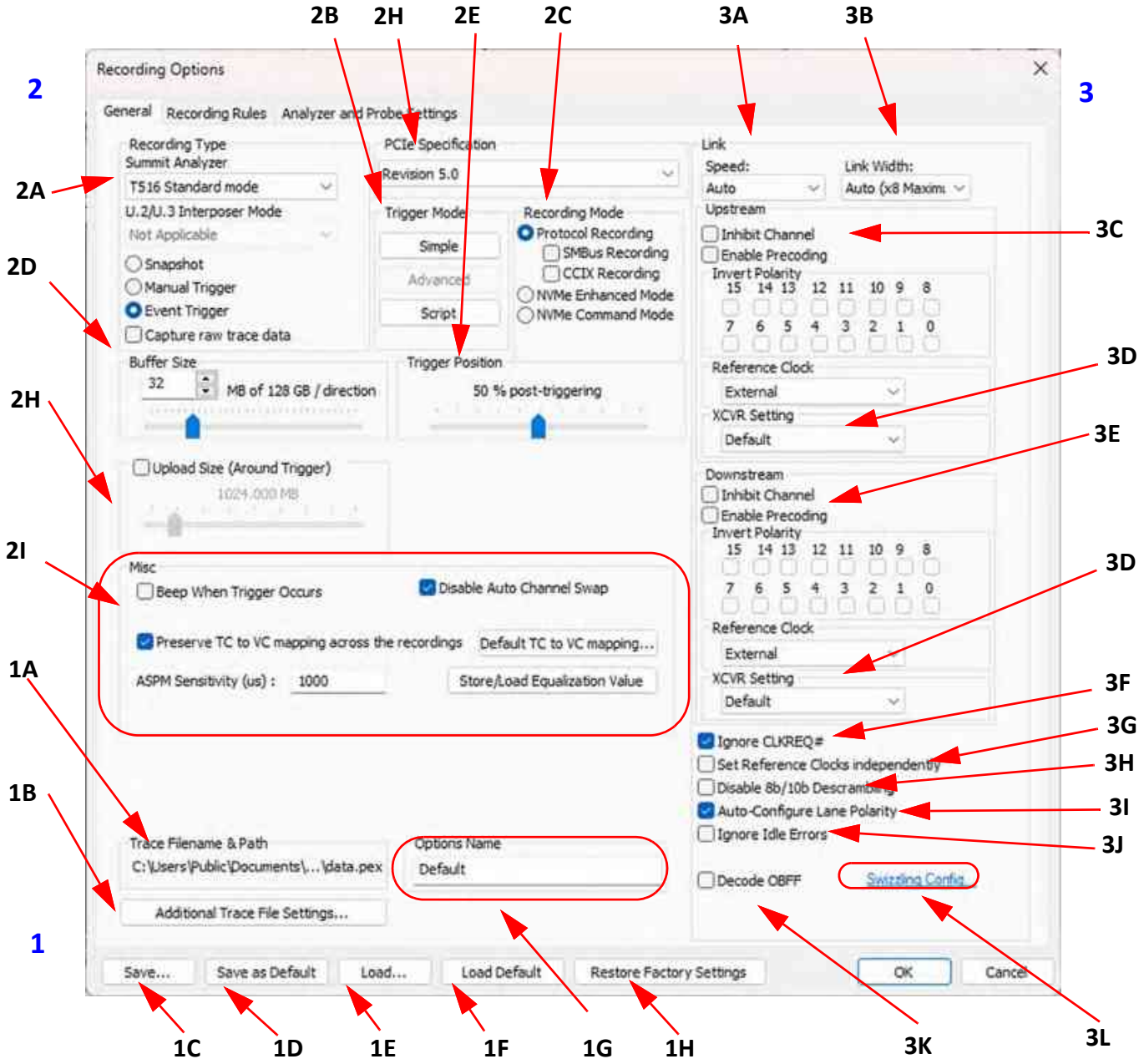


Figure 6.15: Summit T516 with Advanced Recording Options

Note: Please refer to the figure callout numbers in each of the sections below to correlate to Figure Note: shown above. For instance, for Simple and Advanced Mode, see Figure Note:: 2B.

6.5.2.2 Summit T54 Advanced Mode

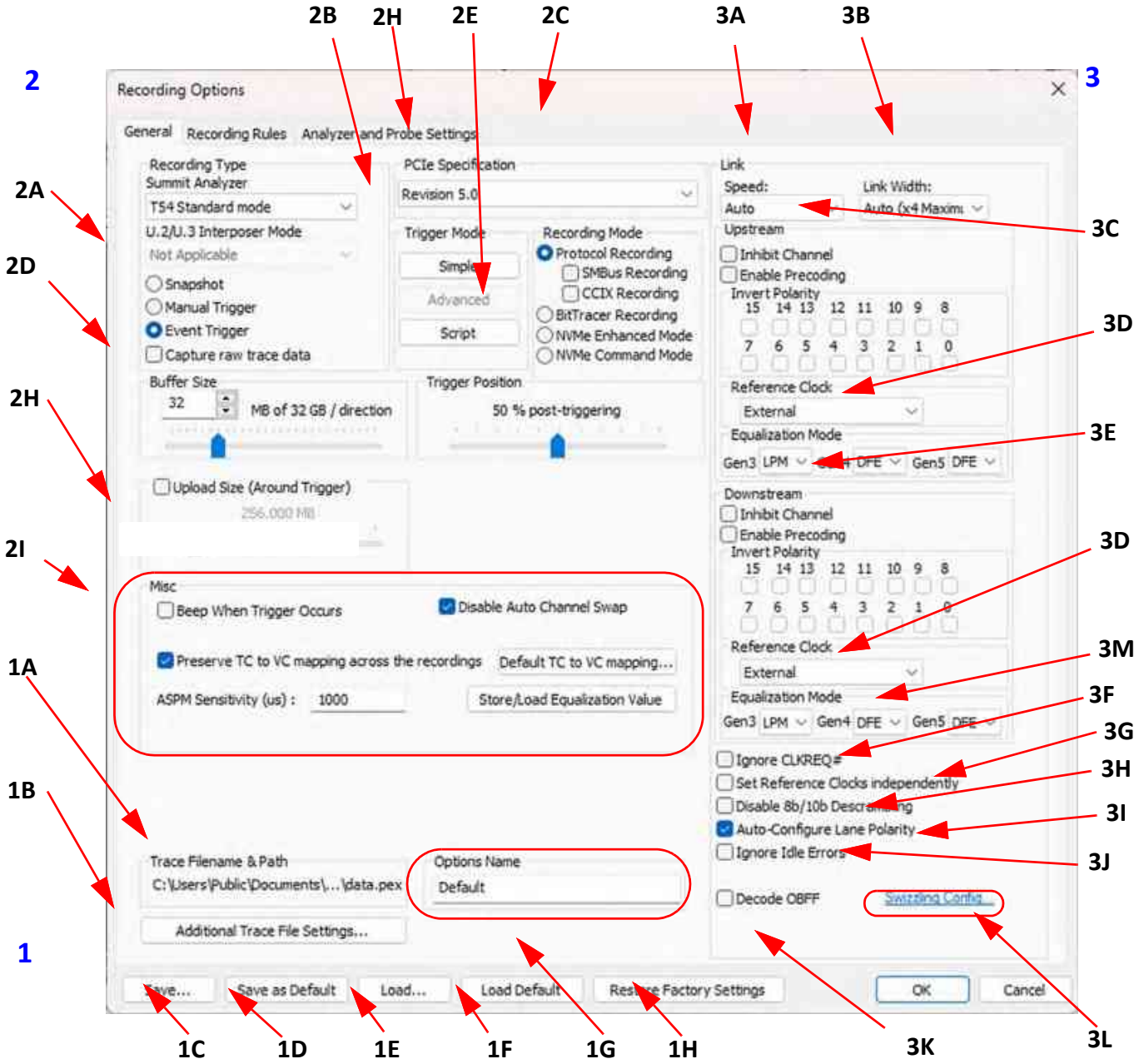


Figure 6.16: Summit T54 with Advanced Recording Options

6.5.2.3 Options in Advanced Mode: Misc Section

See 2I in Figure 6.15 and Figure 6.16.

Disable Auto Channel Swap

In **Disable Auto Channel Swap**, two options exist:

- **Unchecked:** The PCIe Analysis software swaps the direction of the traffic data based on its internal analysis of the traffic on the bus (channel direction swapping is enabled).

- **Checked:** The PCIe Analysis software records the traffic data as the Summit analyzer sees it - this depends on the way the connections were made to probe the bus (channel direction swapping is disabled).

TC to VC Mapping

If you select **Default TC to VC mapping**, the **Default TC to VC Mapping** dialog displays and you can manipulate the TC to VC mapping. See Figure 6.17.

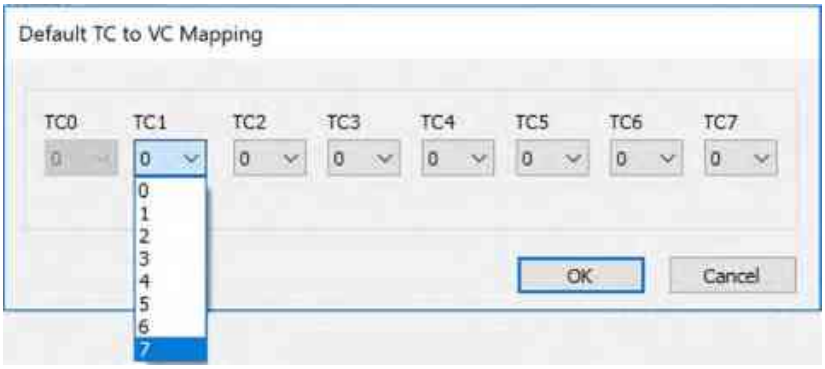


Figure 6.17: TC to VC Mapping

ASPM Sensitivity

ASPM Sensitivity for Summit T5 analyzers enhances the quality of trace captures for low-power traffic based on the L1_Idle time. The default value is set to 1000 µs, adjusting this value can improve capture quality.

If the captures are not satisfactory, a rough estimate of the appropriate value can be determined. To do this:

1. Record the time difference between the Link Down and Link Up events in the trace. This also displays at the lower left corner of the trace: Delta Time.
2. Enter the time observed in the **ASPM Sensitivity** field. Adjust ms to µs by multiplying the ms value by 1000.
3. Select **OK** to close recording options.
4. Start the recording.

Note: The value can be reset to the default value with a Power Cycle of the device.

See Figure 6.18and for Figure 6.19 examples.

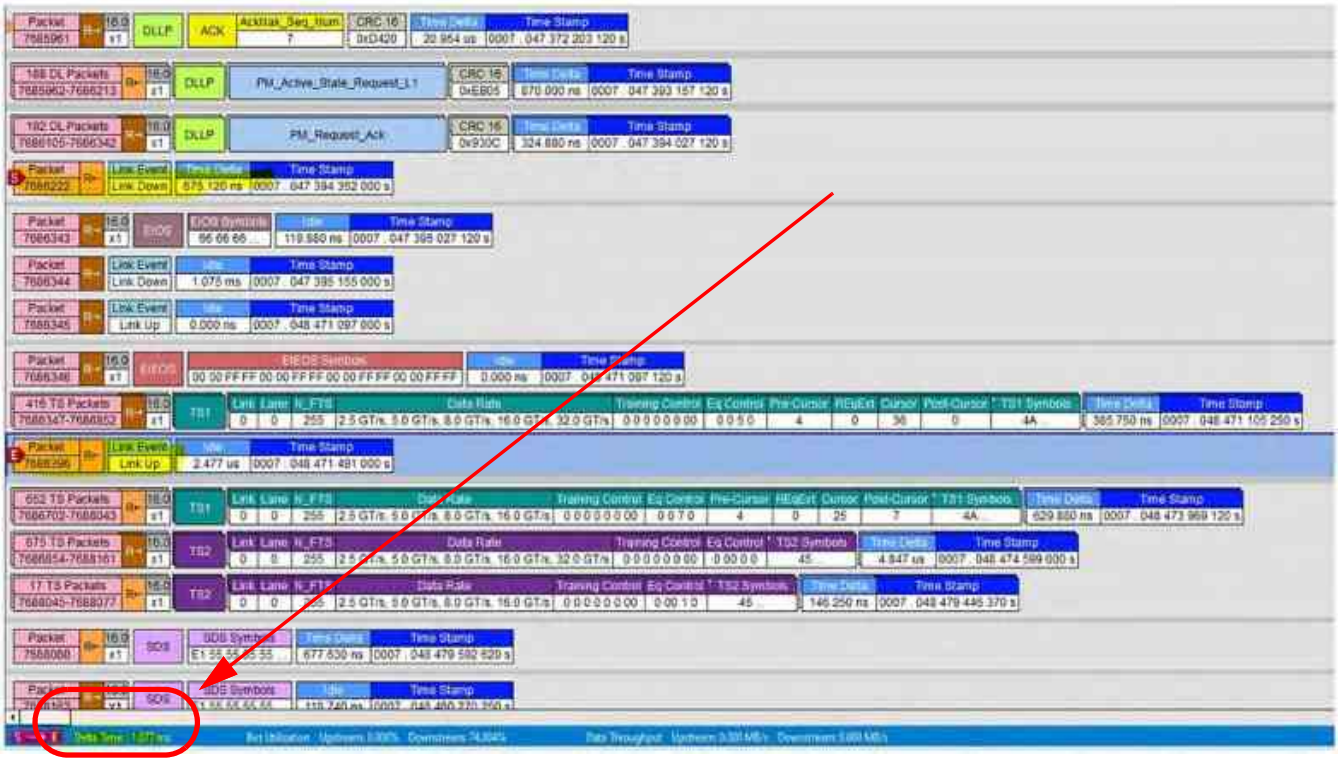


Figure 6.18: Trace Showing Delta Time

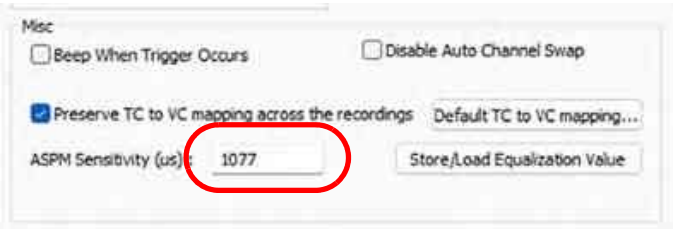


Figure 6.19: ASPM Sensitivity Adjusted

6.5.3 Trigger Mode: Script

If you select the Script, the ‘Recording Script’ tab becomes available. See Figure 6.20.

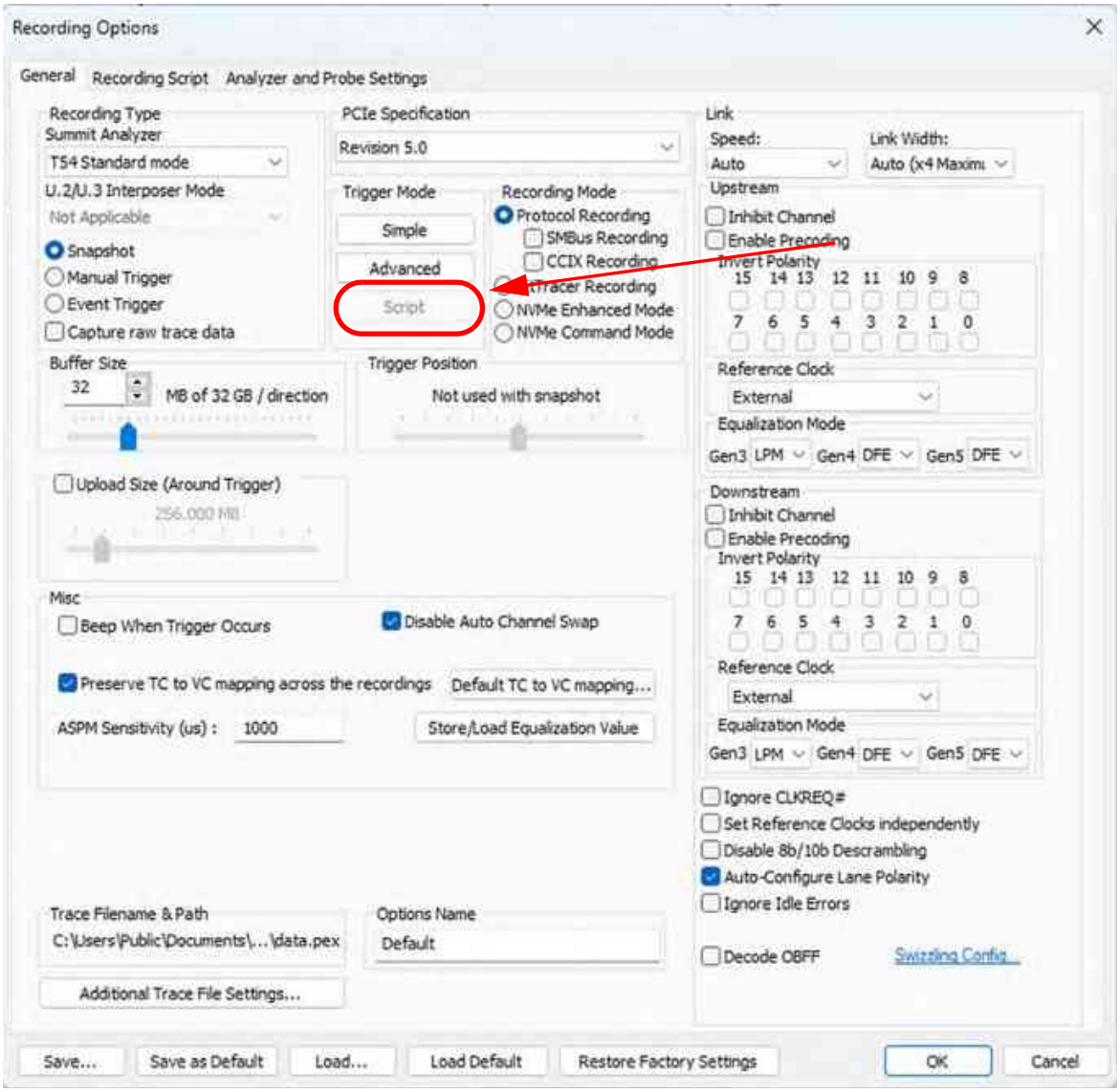


Figure 6.20: T54 Trigger Mode: Script

The **Recording Script** tab contains a menu of scripting options. See Figure 6.21 for a sample script.

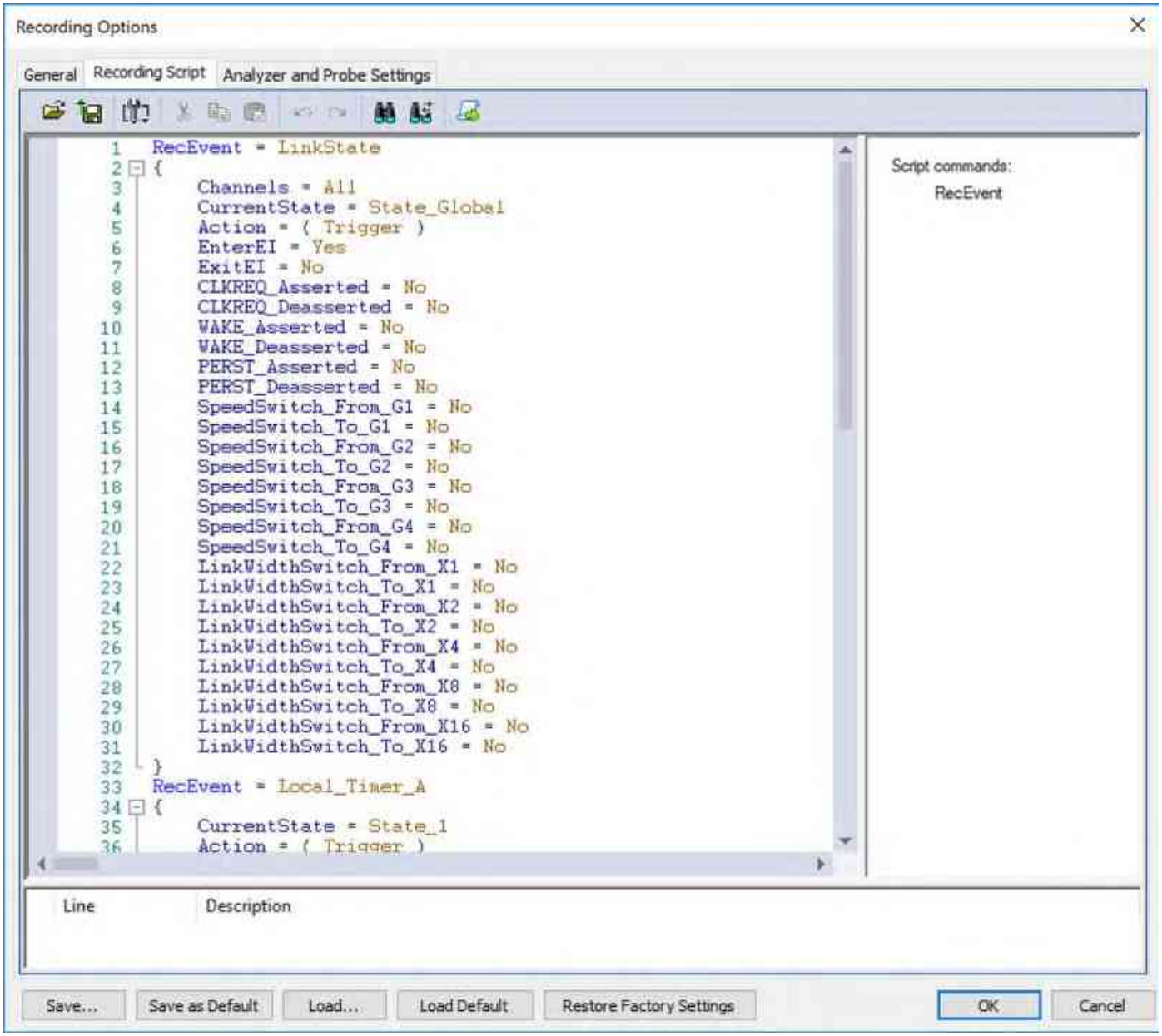


Figure 6.21: Recording Options: Script Mode → Typical Script

6.6 Recording Type: Event Trigger

Selecting **Recording Type** → **Event Trigger** enables the Trigger On Options for the Summit T5 analyzer.

6.6.1 T516 Analyzer Event Trigger

See Figure 6.23.

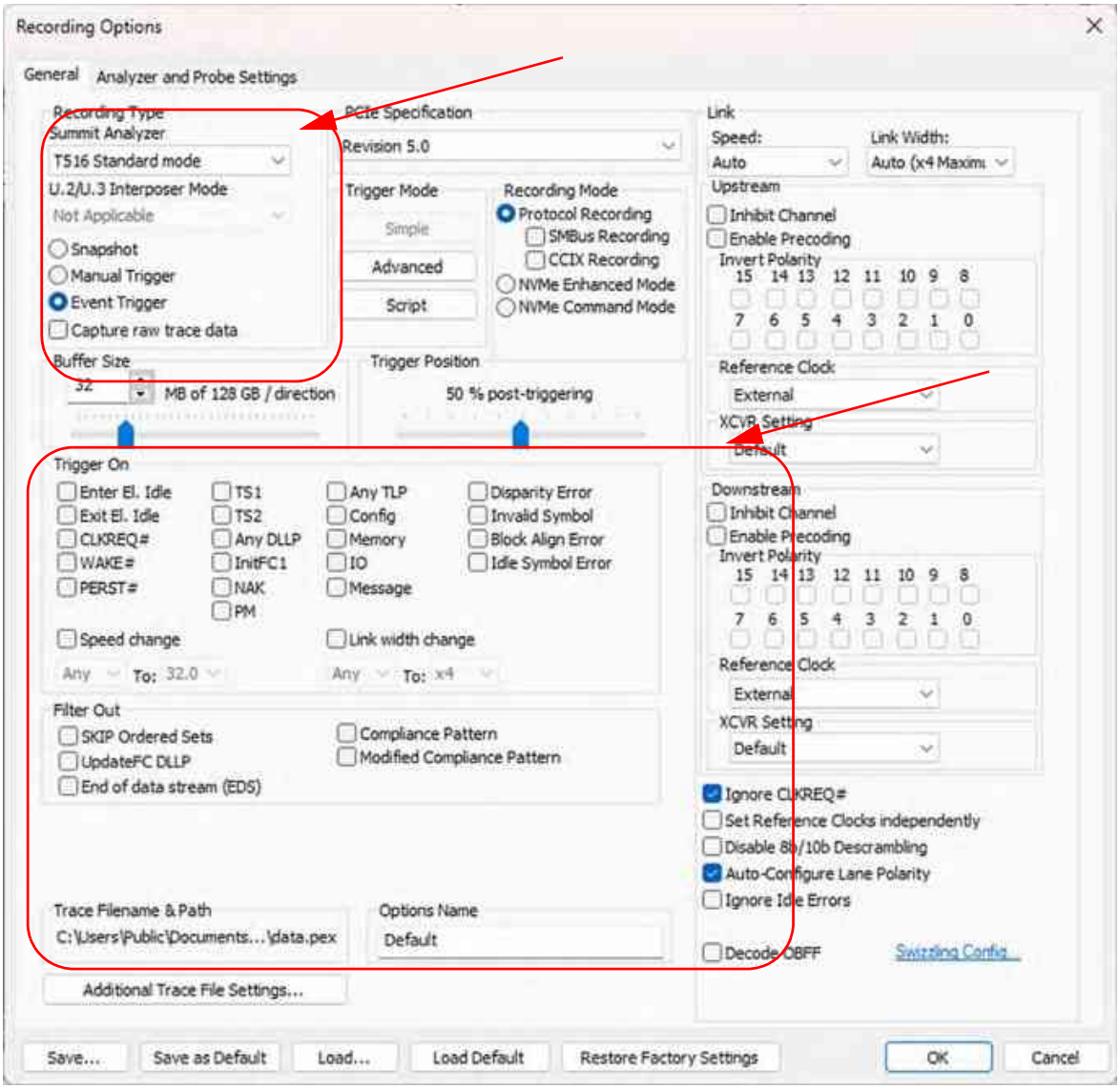


Figure 6.22: Summit T516 Simple Recording Options: Triggered Events

6.6.2 T54 Analyzer Event Trigger

See Figure 6.23.

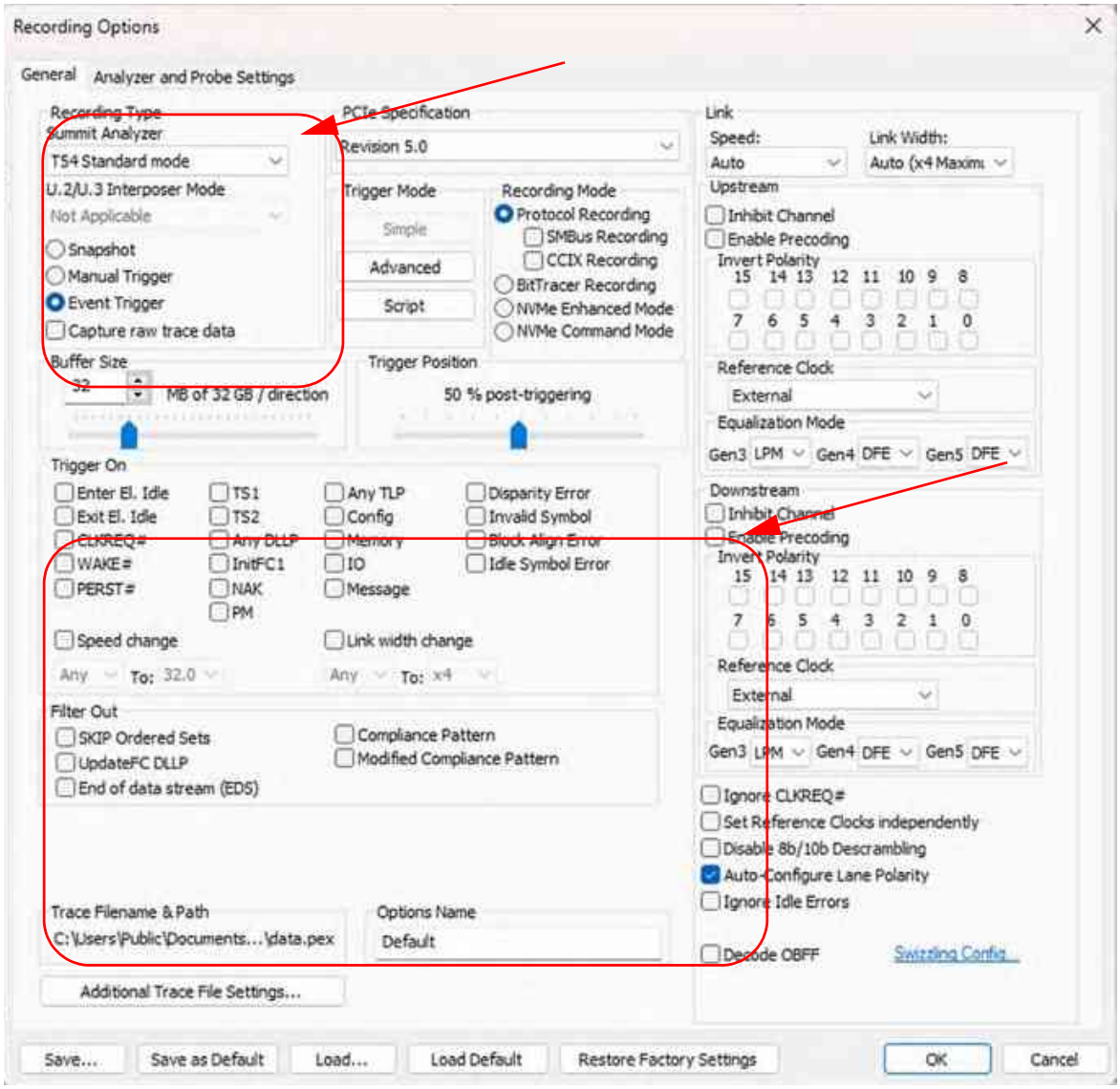


Figure 6.23: Summit T54 Simple Recording Options: Triggered Events

6.6.3 Trigger On Options (Simple Mode)

When in Simple Mode and Event Trigger selected, you can check any of the boxes shown in Table 6.1.

TABLE 6.1: Simple Mode Trigger On Events (Upstream or Downstream)

Enter Elec Idle	
Exit Idle	Any TLP
CLKREQ#	Config
WAKE#	Memory
PERST#	IO
TS1	Message
TS2	Disparity Error

TABLE 6.1: Simple Mode Trigger On Events (Upstream or Downstream)

Any DLLP	Invalid Symbol
InitFC1	Block Align Error
NAK	Idle Symbol Error
PM	Any TLP
Speed Change: Any, 2.5, 5.0. 8.0, 16.0, 32.0 To: Any, 2.5, 5.0, 8.0, 16.0, 32.0	Link Width Change: (see Note below) Any, x1, x2, x4, x8 or x16 To: Any, x1, x2, x4, x8 or x16

Note:
- Summit T54 can trigger on Link Width Changes from x1 to x4. The Summit T516 can trigger on Link Width changes from x1 to x16.
- Trigger Position slider becomes enabled only when Recording Type is set to Manual Trigger or Event Trigger.
- If you check 2 or more boxes the triggering will occur based on an OR condition, not AND condition.
- External Input Trigger is not configurable, it will always cause the analyzer to trigger on a toggle when using manual trigger or triggering on any event.

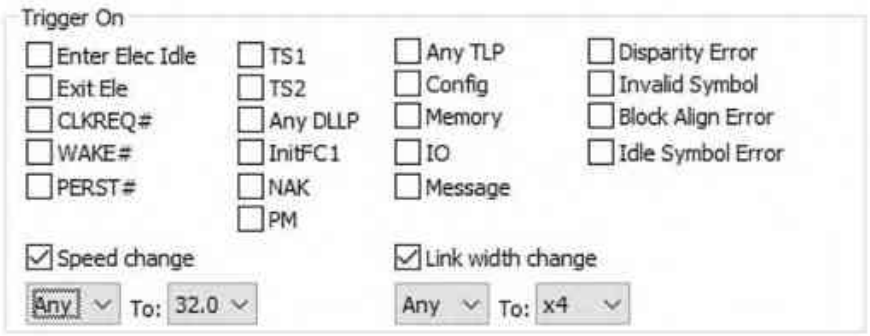


Figure 6.24: Simple Mode Triggering Options

Note: Summit T54 can trigger on Link Width Changes from x1 to x4. The Summit T516 can trigger on Link Width changes from x1 to x16.

6.7 Recording Mode

There are five recording options for Recording Mode with the T5 (see Figure Note:: 2C and Figure 6.25 below):

- Protocol Recording
  - SMBus Recording
  - CCIX Recording
- BitTracer Recording
- NVMe Enhanced Mode

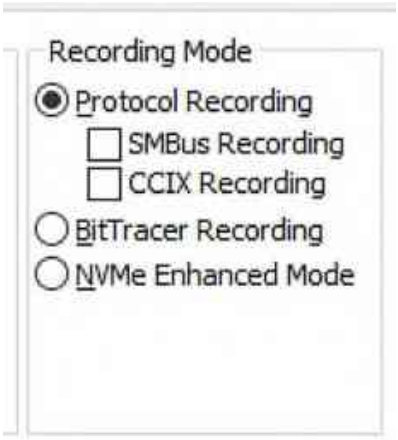


Figure 6.25: Recording Mode Options

6.7.1 Protocol Recording

The Protocol Recording mode is an intelligent mode that understands the protocol and displays the recorded data according to the specification. By default it uses the CATC Trace View to show the traffic happening on the wire.

You can use most of the triggering, filtering and sequencing features.

6.7.1.1 SMBus Recording

When this mode is also selected both Data traffic and SMBus traffic will be recorded for the following events:

- Any SMBus
- Any MCTP over SMBus

For an example of SMBus traffic see 7.11.15, *"Decoding MCTP Messages with SMBus Traffic"*.

6.7.1.2 Recording the CCIX Protocol (Simple and Advanced Mode)

Simple Mode

PCIe Protocol Analysis software can record the Cache Coherent Interconnect for Accelerators (CCIX) transaction protocol.

CCIX is a high-performance, low latency, chip-to-chip interconnect architecture that provides a cache coherent framework for heterogeneous system architectures. Cache coherency is automatically maintained at all time between the central processing unit and the various other accelerators in the system. Operating over standard PCIe, CCIX supports signaling rates between 16 GT/s and 25 GT/s per link with support for port aggregation for higher performance.

CCIX is largely an extension of the PCI Express architecture, consists of a number of stacked protocol layers.

- CCIX Protocol Layer - coherency protocol that manages memory reads and writes, provides a mapping for the on-chip architecture-dependent coherency protocols (e.g., AMBA CHI/ACE). This layer also defines the cache state (e.g. shared/unique, clean/dirty).
- CCIX Link Layer - formatting protocol for transport (e.g., PCIe). This layer also manages link aggregation.
- CCIX Transport Specification
- PCIe Transaction Layer - Handles PCIe transactions. The layer also supports virtual channels, permitting transmission for different data streams across a single shared link.
- CCIX Transaction Layer - Handles CCIX transactions. This layer optimizes out superfluous PCIe packet fields, reducing overhead.
- PCIe Data Link Layer - Handles standard data link layer (e.g., CRC, ACK).
- CCIX/PCIe Physical Layer - Handles standard PCIe physical layer. This layer also supports 25 GT/s ESM mode.

CCIX decoding relies on Traffic Class (TC) to Virtual Channel (VC) mapping to be configured. If not configured you'll get the warning message below when you select the CCIX checkbox in Simple Recording mode. See Figure 6.26.

CCIX decoding is also discussed in more detail in 7.11.25, *"Decoding CCIX Protocol"*.

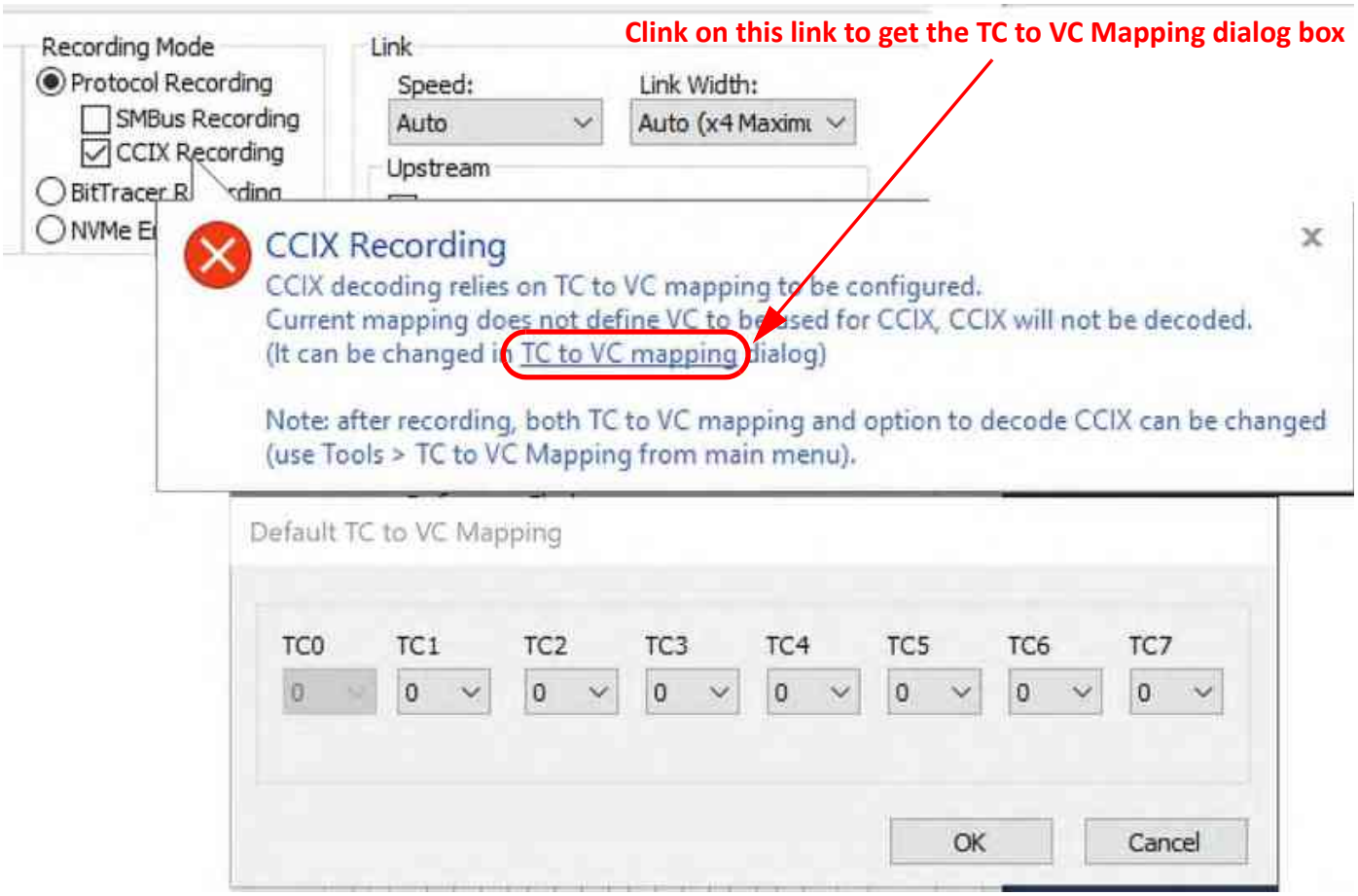


Figure 6.26: Selecting CCIX Recording Before Mapping from TC to VC

After mapping TC to VC the warning message goes away, as shown in Figure 6.27.

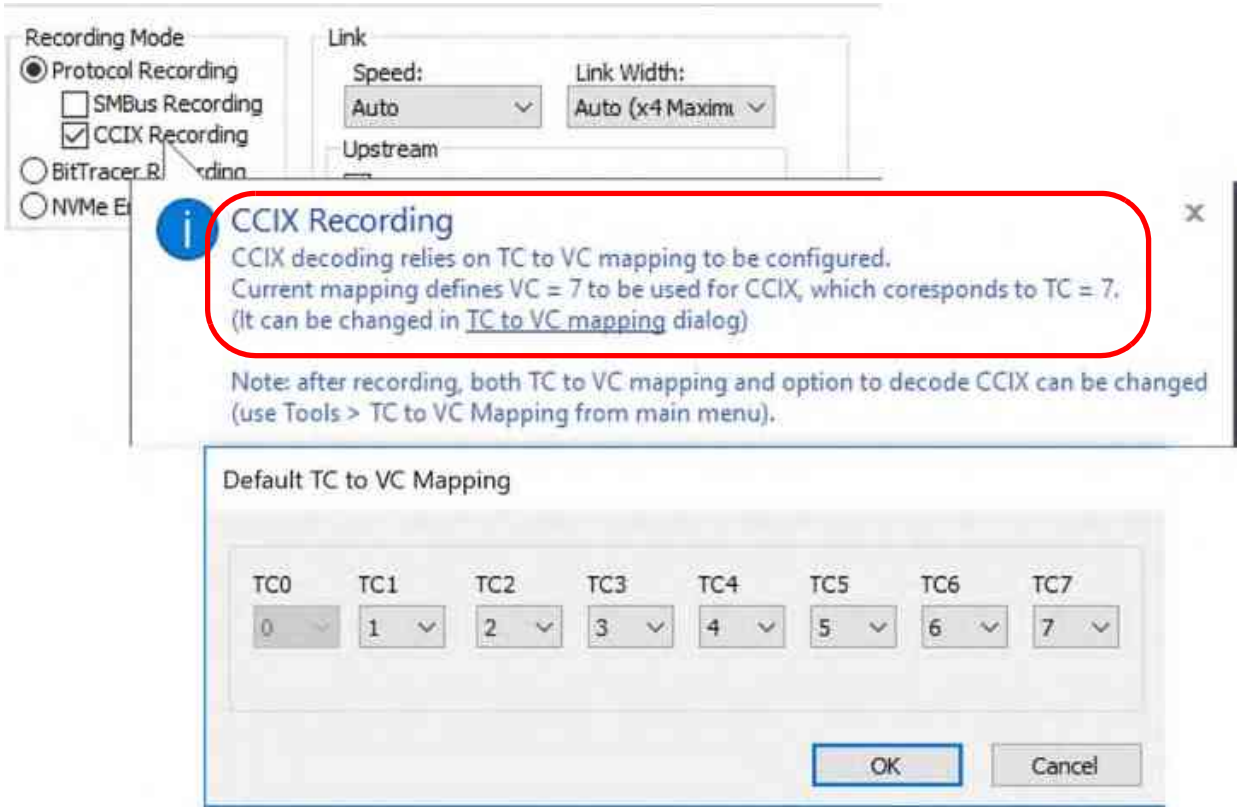


Figure 6.27: Selecting CCIX Recording After Mapping from TC to VC

6.7.2 Bit Tracer Recording

Note: Bit Tracer recording applies to the Summit T54 only.

When the Bit Tracer Recording box is checked, the recording behaves as a regular serial logic analyzer. The data is displayed in Bit Tracer view which displays the symbols being transmitted on each PCI Express lane. In this mode, you can trigger on the same events and use the sequencer as with Protocol Recording Mode but filtering is not allowed. The Bit Tracer mode will record all the traffic.

The option "Lane Deskew Bypass" is provided as a debug feature and limits the triggers to be used to only the basic resources and Packet Match using ordered sets. You can still use triggering for DLLPs and TLPs but since the data is not deskewed, it will trigger on a pattern that matches your selection but may not necessarily be a valid packet. See Figure 6.28.

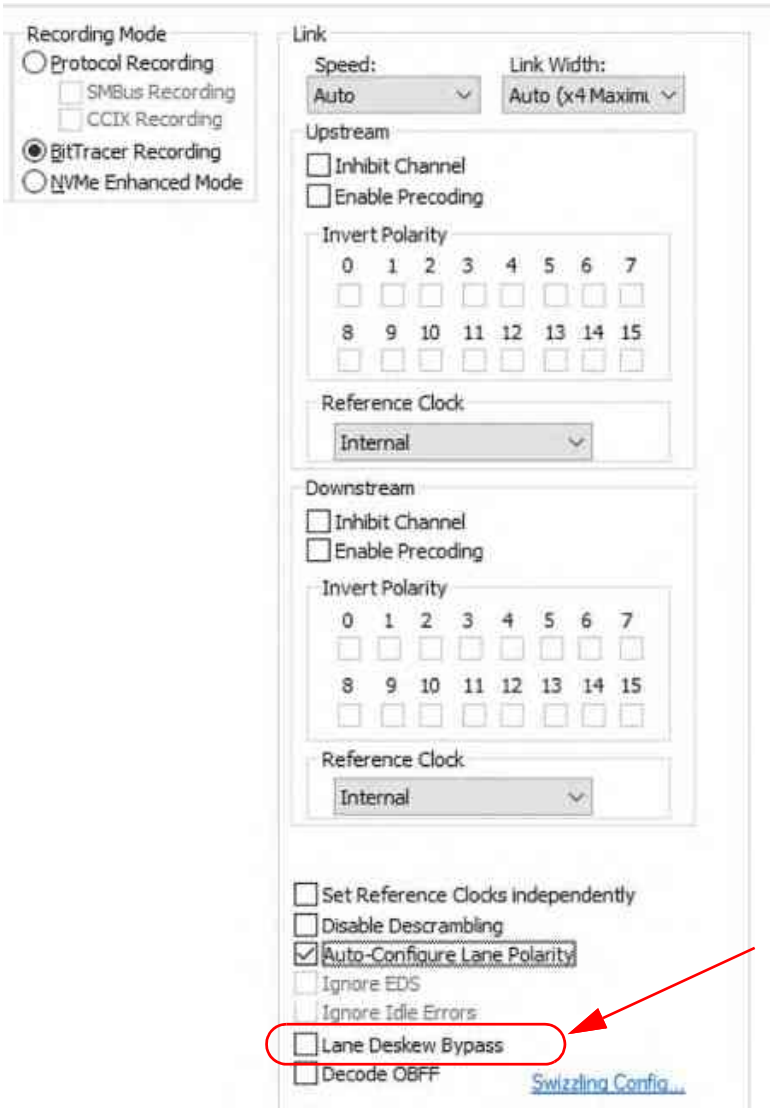


Figure 6.28: Bit Tracer Recording: Lane Deskew Bypass Mode (T5)

Note: Leaving all the boxes unchecked results in no trigger in that direction. For more information, see Chapter 8, *BitTracer Recording*.

6.7.3 NVMe Enhanced Recording

When this mode is selected and Simple Mode is used, the GUI will be configured optimally to allow recording of very long captures of PCIe traffic that will be decoded as NVMe.

Before using this mode, make sure all the PCIe Link parameters are selected properly. You can achieve this by recording a trace in Protocol Recording mode during L0 and confirm the trace looks

clean. Once you have found the correct Link parameters they will be used in NVMe Enhanced Recording mode.

For more details see 6.23, *"Preparing to Record in NVMe Enhanced Mode"*.

6.8 Buffer Size

The Buffer Size allows the Analyzer to record traffic to its buffer and then upload the CATC Trace to the host machine. Recordings are limited in size to the size of the Analyzer's buffer, see Figure Note:: (up to 32 GB per direction for the Summit T5). The Buffer Size slide-bar allows you to set the size of the recording buffer (see Figure 6.29).



Figure 6.29: Buffer Size Slide Bar (Summit T5)

The size selection is per direction. For example, selecting 32 MB creates two memory areas of that size.

After you have set the Buffer Size, you must set the Recording type and Trigger position options. These options determine how the buffer is used.

Note: The Buffer Size slide-bar does not precisely portray the buffer size because of the way the packets are stored in the Analyzer's memory.

6.9 Trigger Position

This Trigger Position slide-bar lets you adjust the amount of recording buffer allocated to recording pre-trigger and post-trigger traffic (See Figure Note: on page 157: 2E).



Figure 6.30: Trigger Position Slide Bar

For example, if you set the Trigger Position to 90% Post-Triggering Traffic, the Analyzer records 10% pre-trigger traffic and 90% post-trigger traffic.

Trigger Position is only available when Manual Trigger or Event Trigger is selected.

6.10 Filter Out

Filter Out allows you to filter out the following types of events (see Figure Note: on page 157: 2G):

- SKIP Ordered Sets
  - Training Sequence 1 (TS1)
  - Training Sequence 2 (TS2)
  - Electrical Idle (EI)
  - Fast Training Sequence (FTS)
  - SKIP
- Update Flow Control (FC) Data Link Layer Packets (DLLP): UpdateFC DLLP
  - Posted Requests
  - Non-Posted Requests
  - Completion
- Compliance Pattern
- Modified Compliance Pattern

6.11 Trace Filename and Path

The Trace Filename and Path button sets the path and CATC Trace name for the recording. It allows you to change the default file name and path for the recorded CATC Trace file. The pre-defined name is **data.pex**. See Figure Note: on page 157: 1A.

1. Select the **Recording File Name** button.
2. The Specify Trace File Name dialog opens to navigate to the directory you want.
3. Enter the new file name in the File name field.
4. Click the **Save** button.

   This action does not do any immediate save operation. It just changes the default name and uses it in subsequent recordings.

6.12 Advanced Trace File Settings

You can set the maximum number of traces that can be opened at one time when recording (from 1 to 10). You can also auto-delete traces if your recording session goes beyond the limit set (from 1 to 10). See Figure Note: on page 157: 1B or Figure 6.31 and Figure 6.32 on page 173.

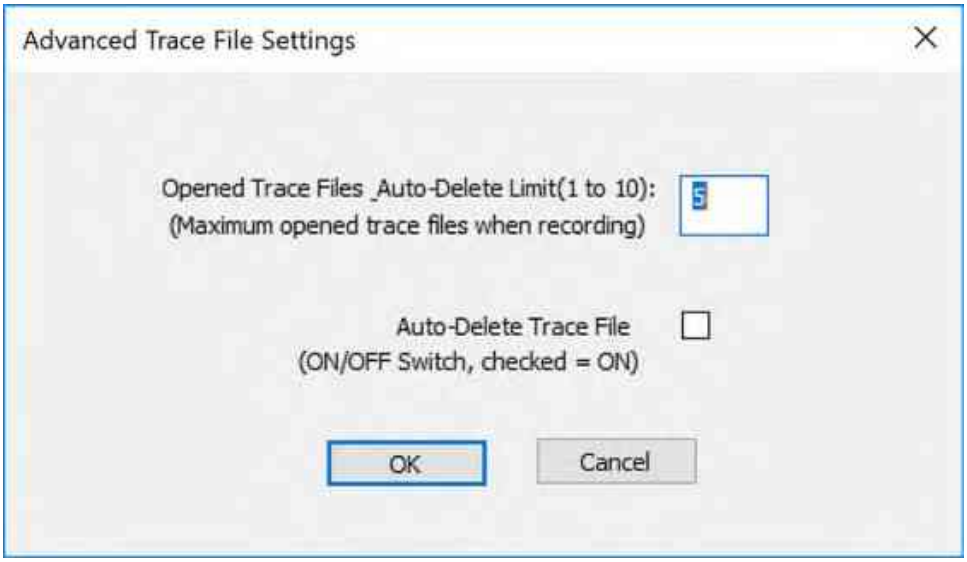


Figure 6.31: Advanced Trace File Settings: 5 Open Traces at a time

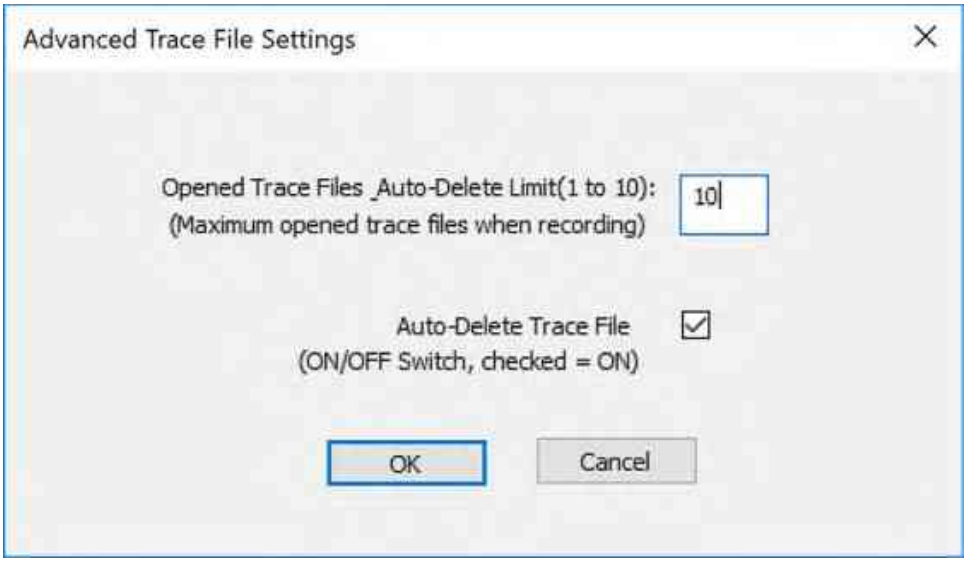


Figure 6.32: Advanced Trace File Settings: 10 Open Traces at a time, Auto-Delete when maximum number reached (10)

6.13 Saving and Loading Previously Saved Recording Options

In the Recording Options dialog the following Save options are available.

Recording Options settings can be saved and later reused by loading previously saved files. Recording options settings are stored in various file options. File options are:

- General Recording (**.rec** extension): A general recording options file containing settings from the 'General', and 'Recording Rules' tabs.
- Recording Options in XML format (**.xrec** extension): Recording options file in XML format containing settings from the 'General' and 'Recording Rules' tabs.
- Combined Recording (**.crec** extension): An extended recording options file containing everything in the .rec extension, as well as presets for an interposer (Interposer to Analyzer Path, Interposer Host to DUT Path). Available when an interposer is connected to the system.

6.13.1 Saving Recording Options

6.13.1.1 Buttons

TABLE 6.2: Buttons for Saving Recording Options

Button	Description
Save	Saves the current options. Choose a file name and a format.
Save As Default	Saves the current options into the default options file. This file is called **default.rec** or any other name assigned to the default options file. Whenever the Teledyne LeCroy PCIe Protocol Analysis begins execution, it automatically loads the default file, if one exists.

6.13.1.2 Steps

To save recording options:

1. Open the Recording Options dialog by clicking  or by selecting **Recording Options** from the **Setup** menu.
2. Select the Recording Options.
3. (optional) Use the **Options Name** box on the main Recording Options screen to add a descriptive label to this file to help remember the options set. For example: If the Recording Options file were named **StandardSettings.rec**, the Options Name could be a long descriptive label such as **Standard Record Options used for all normal Recordings**.
4. Select **Save**. The **Save As** dialog displays.
5. Enter a unique file name.

6. Choose the appropriate extension from **Save as type** (see Figure 6.33):

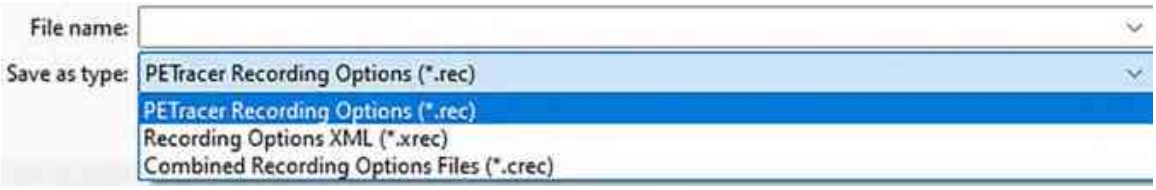


Figure 6.33: Save as type Extension Choices

Note: The **Save As type** extension .crec is available only for analyzers with an interposer connected to the system.

6.13.2 Loading Recording Options

6.13.2.1 Buttons

TABLE 6.3: Buttons for Loading Recording Options

Button	Description
Load	Loads a previously saved set of recording options.
Load Default	Loads the default set of recording options.
Restore Factory Settings	Select this tab to Restore the Factory Settings for Recording Options.

6.13.2.2 Steps

To load Recording Options:

1. Click  or select the menu **Setup** → **Recording Options**.
2. Click the **Load** button from the Recording Options dialog.
3. In the Open dialog, choose a file and its extension (see Figure 6.34) then select **OK**. The options file loads.

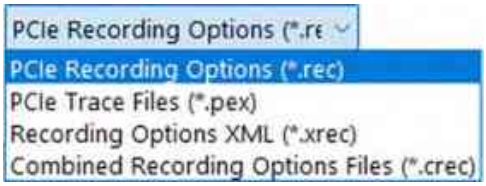


Figure 6.34: Load/Open File Extension Choices

6.14 Viewing Legacy Multi-Segmented CATC Traces

Current PCIe Protocol Analysis handles traces as large as the maximum buffer size selected. It does not need to generate segmented traces, but is able to open segmented traces generated with older software versions. Simply open the *.pem extension file and

the trace will be converted to a new format single trace. If opening a *.pex file part of a segmented trace make sure not to update the file in order for the original segmented index to work properly.

6.15 Link Settings

The Link options panel allows you to manage links. You can define the basic link speed parameter or leave it on Auto detect. The various link settings are described in this section (See Figure Note: on page 157: 3). The **Link -> Speed** and **Link Width** options are shown in Figure 6.35.

Link Speed Displayed

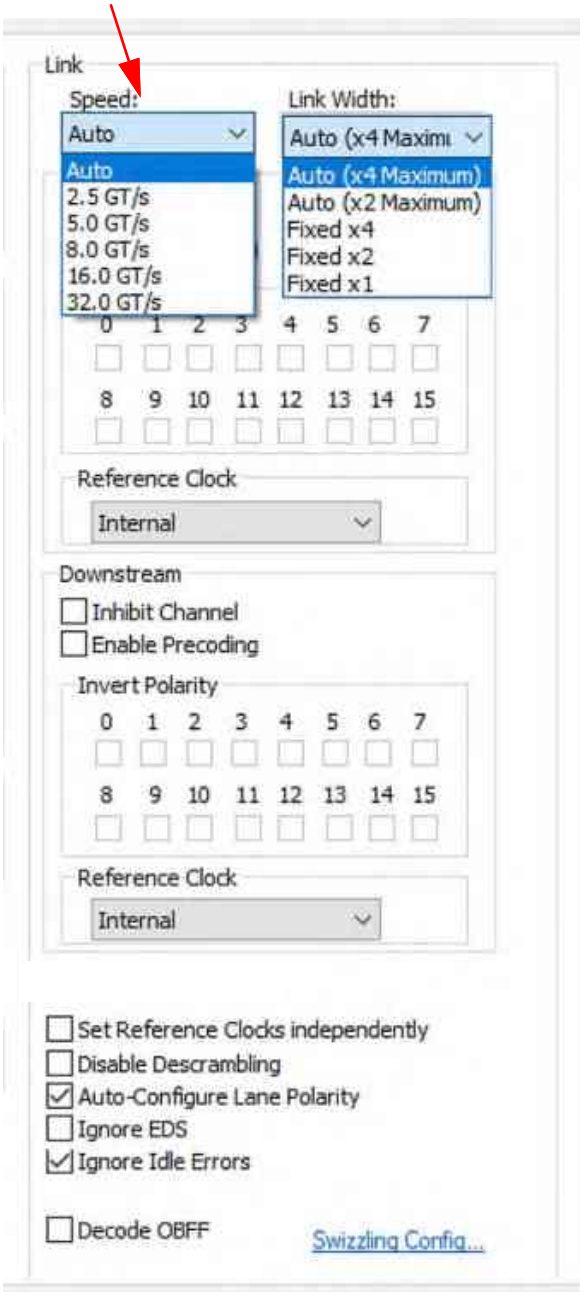


Figure 6.35: Link Options for Summit T5

6.15.1 Speed

The Speed can be set at Auto, 32.0 GT/s, 16.0 GT/s, 8.0 GT/s, 5.0 GT/s, or 2.5 GT/s for the

Summit T5 from the drop-down menu. The default is Auto (see Figure Note: on page 157: 3A or Figure 6.35 on page 177).

Note: When set to **Auto**, Teledyne LeCroy's embedded software auto-determines the speed. Disable Descrambling is also enabled.

When set to a specific speed (32.0 GT/s, 16.0 GT/s, 8.0 GT/s, 5.0 GT/s, or 2.5 GT/s) Teledyne LeCroy's software forces the analyzer to record at that speed.

Note: When set to a specific speed, Enable Precoding is disabled.

For Auto speed setting to work the polarity setting of lane 0 has to be correct. The polarity can be set manually if the link is already in L0 state, or, for automatic polarity detection, the bus has to go through a training sequence so the analyzer can track the polarity.

Note: When selecting Auto in the Speed drop-down list the embedded software is able to find the correct speed even if the link does not go through a training sequence.

6.15.2 Link Width

The Link Width sets the physical width of the link. Select the Link Width from the drop-down menu (see Figure Note: on page 157: 3B or Figure 6.35 on page 177 for the Summit T516/T54). The available options (and the default) will be shown according to the detected product.

Auto Max x16:	Calculates link width automatically up x16
Auto Max x8:	Calculates link width automatically up x8
Auto Max x4:	Calculates link width automatically up x4
Auto Max x2:	Calculates link width automatically up x2
Fixed x1:	Link is assumed to be always x1
Fixed x2:	Link is assumed to be always x2
Fixed x4:	Link is assumed to be always x4
Fixed x8:	Link is assumed to be always x8
Fixed x16:	Link is assumed to be always x16

Note: If the bus goes to a link width different from the one selected as fixed option, the trace will be full of errors. The appropriate Auto option needs to be selected in this case.

Note: When selecting Auto in the Link Width drop-down list the embedded software is able to find the correct link width even if the link does not go through a training sequence.

Note: If an Auto Link Width is selected, there is no Lane Reversal. If a Fixed Link Width is selected, the Reverse Lanes checkbox is enabled. See Figure 6.36 on page 179 for the Summit T54.

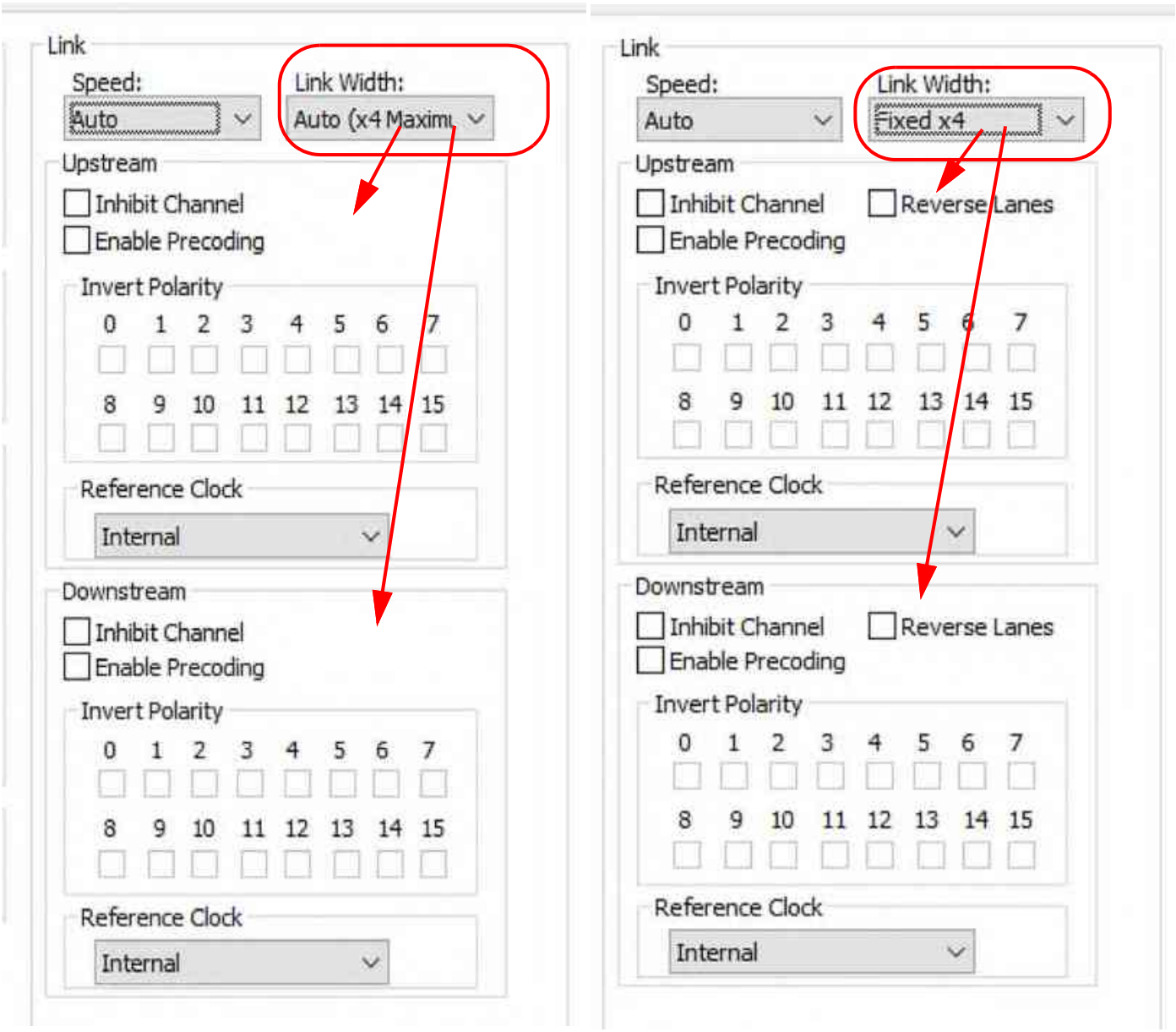


Figure 6.36: Summit T54 Link Width: Auto -> No Lane Reversal, Fixed Lane Width -> Lane Reversal Check Box is Enabled

6.15.3 Upstream and Downstream

Gives you low-level control over each link direction. The heading for these boxes indicates the port and/or unit to which the following options are applied based on the current Analyzer configuration (see Figure Note: on page 157: 3C and 3E for the Summit T5).

- Inhibit Channel: Do not record/upload this channel
- Enable Precoding: This is a feature that is being introduced for Gen5, which reduces the chance of a big string of 0s which might break the CRC mechanism. This is accomplished by balancing the number of zeros with the number of ones being transmitted. To analyze the data correctly the user must tell the analyzer if Precoding is being used by the transmitter.

Note: Only scrambled symbols are precoded.

6.15.3.1 Reference Clock

The reference clock is used by the analyzer to correctly track the traffic on the PCIe bus. The reference clock for each of the traffic directions (Upstream and Downstream) can be selected independently but usually both directions use the same clock option, this is why the recording option is not set by default. For more information about setting reference clocks, see section 6.15.4, *"Set Reference Clocks Independently"*.

The different clock options available for Analyzer Standard Mode are explained below.

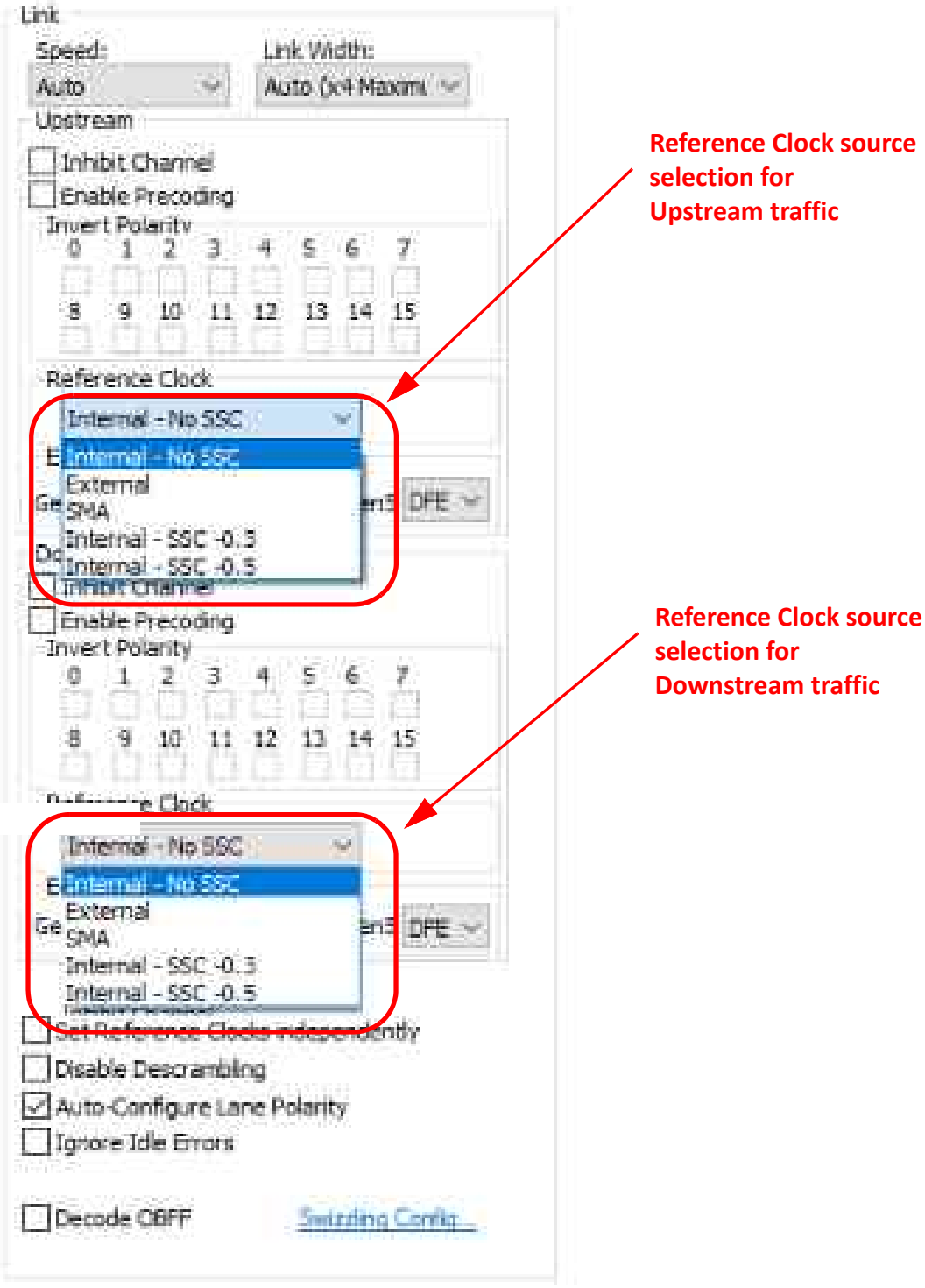


Figure 6.37: Reference Clock: Upstream and Downstream

Internal – No SSC

The analyzer has an internal clock generator that can be used for recording when the Device Under Test does not supply a reference clock. In this case, you select the Internal option. If you select this option the Internal clock will not have Spread Spectrum capability.

Internal – SSC-0.3

Fixed internally generated clock used for 3000ppm downspread SSC data recording.

Internal SSC-0.5

Fixed internally generated clock used for 5000ppm downspread SSC data recording.

Note: Due to long exit latency from low power sub states some loss of traffic has been observed when analyzer latency exceeds DUT latency using the common reference clock. Teledyne recommends the use of the internal reference clock setting for low power sub-states testing.

External

For the Summit T5, External Clock means to use the clock that is supplied through the cable from the Probe card. The Probe card cable gets its clock from the specific Host or Root Complex under test.

Teledyne LeCroy's Gen5 Interposers support separate clock sources for SRIS applications.

Note: If the PCI Express link under analysis uses spread-spectrum clocking, the external reference clock option is highly recommended as the clock source for the analyzer.

SMA

Summit T54 only. The SMA clock recording option refers to the **Ref Clk In** SMA input connectors on the front panel of the analyzer. Both the Upstream data and the Downstream data support using a clock from the SMA input connectors. When using the SMA option both clock cables must be connected and the clock must be supplied by the system in order for the recording to happen correctly. The standard PCI Express compliant reference clock is supported.

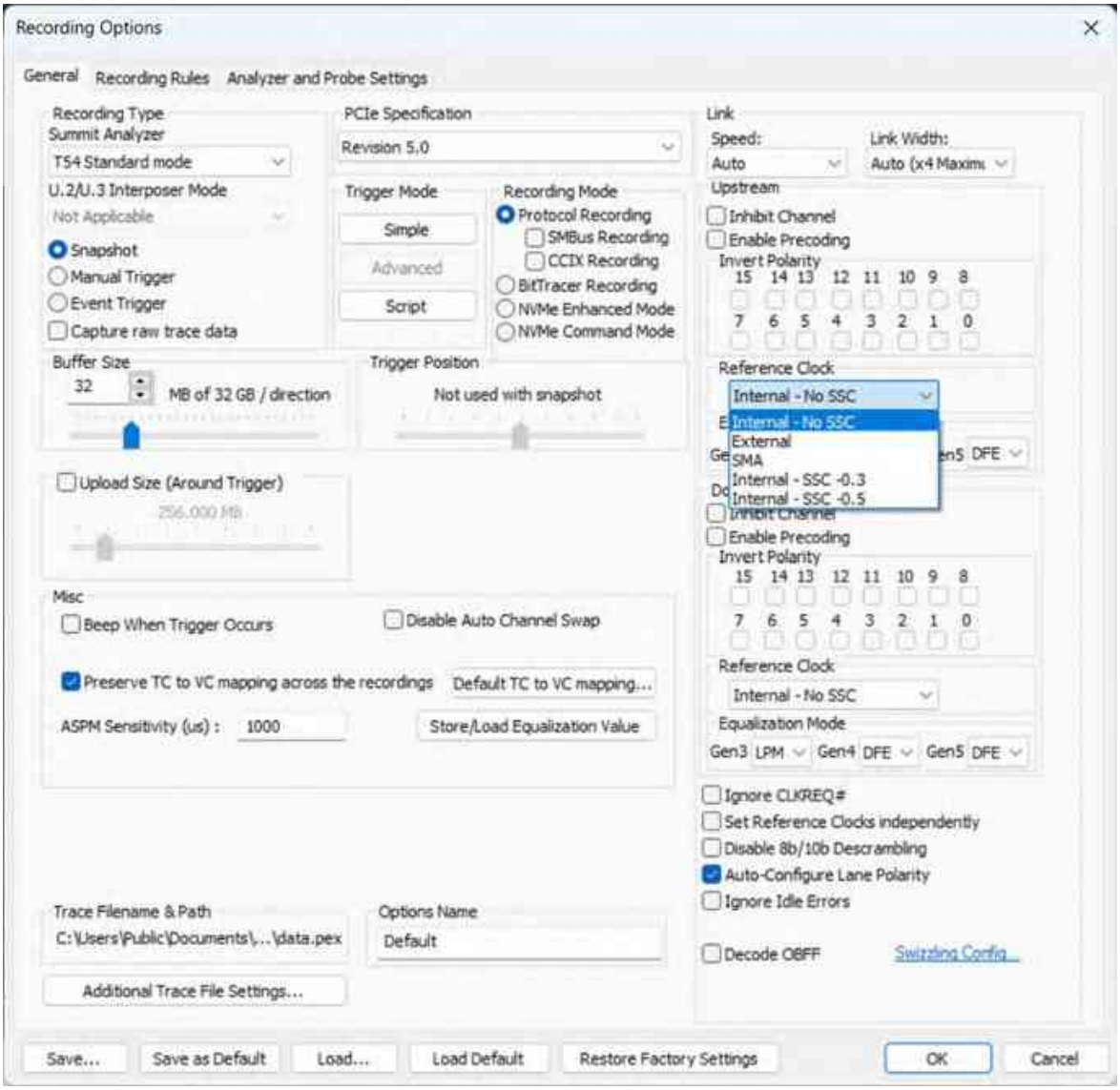


Figure 6.38: T54 Standard Mode Reference Clock Options

6.15.4 Set Reference Clocks Independently

If you select this option the source of the Upstream clock and the Downstream clock can be independent of each other. See Figure Note: on page 157: 3F and Figure 6.39 below.

Note: In the process of setting different Internal clock sources a warning message appears which explains that it is not supported.

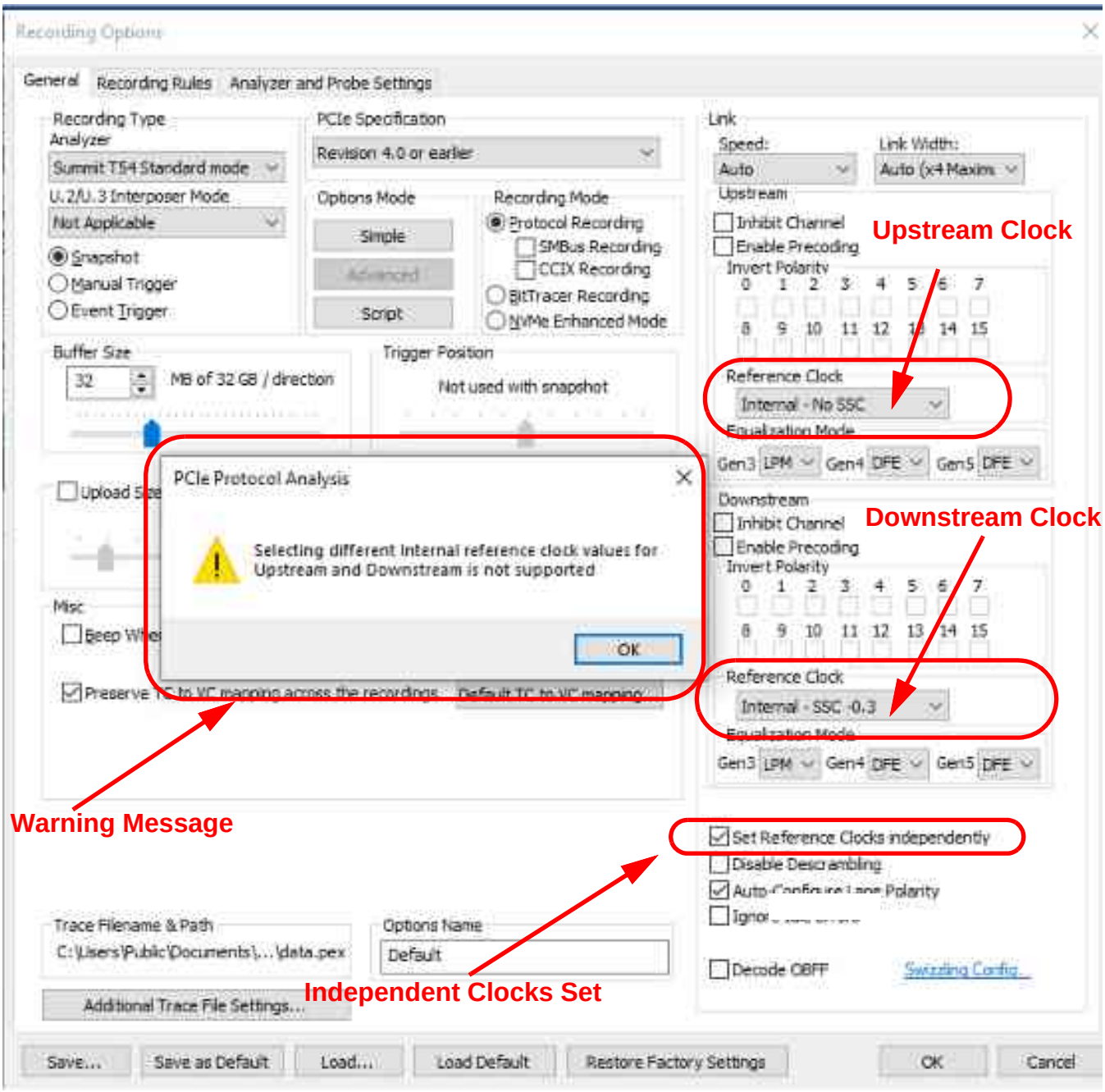


Figure 6.39: Setting Up Independent Reference Clocks

6.15.5 Disable Descrambling

If checked, causes the Analyzer to assume that none of the PCI Express traffic is scrambled. By default, the Analyzer determines the scrambling state of the devices under test (see Figure Note: on page 157: 3G).

6.15.6 Auto-Configure Lane Polarity

Lets the Analyzer determine lane polarity (see Figure Note: on page 157: 3H for the

Summit T5). Auto functions such as Auto Configure polarity rely on Gen1 or Gen2 training sequences to properly discover their values. If the speed option is set to fixed Gen3, the analyzer will never see these sequences and the polarity discovery will not be reported properly in the dashboard dialog.

6.15.7 Ignore Idle Errors

When set, the analyzer will not store errors in between packets into memory. This option helps to preserve analyzer memory to store more packets in cases where memory efficiency is critical. This option filters out Compliance Pattern as well. See Figure Note: on page 157: 3I for the Summit T5.

6.15.8 Swizzling Config...

The Swizzling Config dialog allows you to reconfigure the logical order of the lanes in a link separately for Upstream and Downstream PCIe directions. You can perform the logical to physical assignment manually or let the analyzer detect this on its own (Auto-Configure Lane Swizzle option checked). See Figure Note: on page 157: 3L for the Summit T5.

Note: Autoswizzle works only when the analyzer sees the LTSSM Configuration state link training sequence.

6.15.8.1 Manual Configure Lane Swizzle

If you know how your physical link is connected and the lane numbers advertised for each lane, then you can use the manual swizzle option (Auto-Configure Lane Swizzle option unchecked). On the Swizzling Configuration dialog, drag the number of the logical lane (in blue) to the desired lane physical position.

In the case shown below the Link Width is set to Auto (x4 Maximum) for the Summit T5, so all 4 lanes are available to be manually configured. See Figure 6.40 on page 186 for the Summit T5.

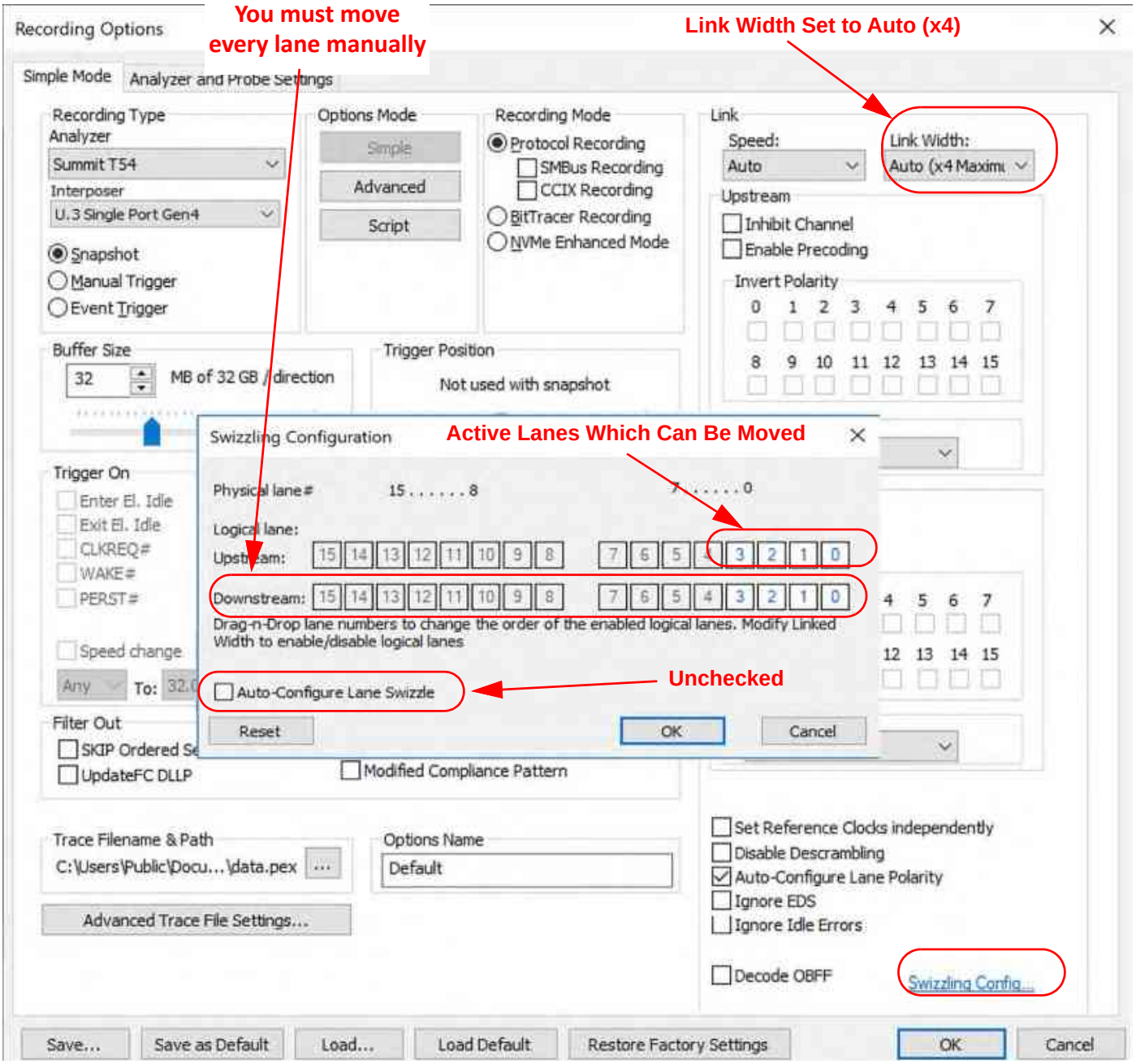


Figure 6.40: Manual Swizzle: Link Width Set to Auto (x4)

In the example shown below, we re-assigned the Upstream Physical lanes as follows:

- Lane 3 to Lane 0
- Lane 2 to Lane 1
- Lane 1 to Lane 2
- Lane 0 to Lane 3

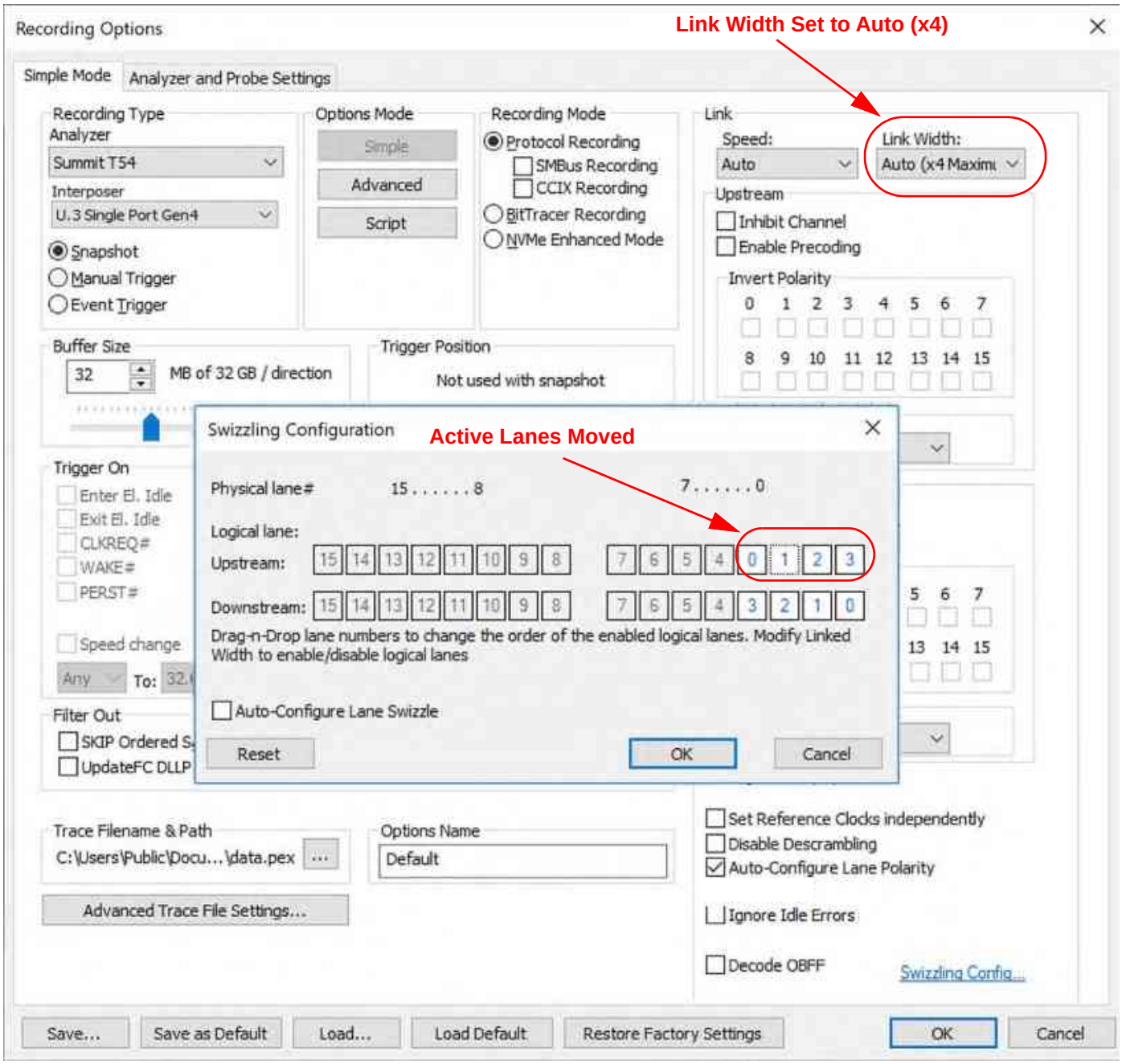


Figure 6.41: Manual Swizzle Configuration

Note: The simplest way to make new lane assignments is to always move the highest source lane number to the highest destination lane number.

Note: If the source lane has a lower number than the lane it is replacing, then the software performs a right shift to the higher numbered replaced lane. If the source lane has a higher number than the lane it is replacing the software performs a left shift to the lower numbered replaced lane.

6.15.8.2 Example: Move Lowest Source to the Highest Lane First

In the example below we moved the original Lane 3 to Lane 0 and Lanes 3, 2 and 1 were shifted to the right. Then Lane 3 was replaced Lane 1 and Lanes 0, 3 and 2 were shifted to the right. Then Lane 3 was replaced with Lane 2 and Lanes 1, 0 and 3 were shifted to the right. Finally Lane 3 was replaced with Lane 3 and Lanes 2, 1 and 0 were shifted to the right.

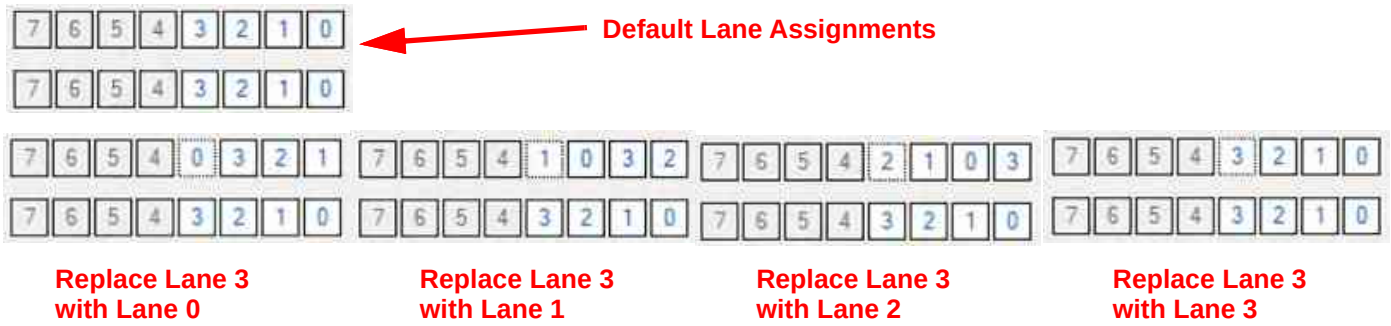


Figure 6.42: Manually Moving Lane Assignments: Lowest Numbered Lane First

We ended up with the same lane sequence that we started with.

6.15.8.3 Example: Move Highest Source Lane First

If you start moving higher number lanes into the lowest numbered lane, the lanes will be shifted left as shown below.

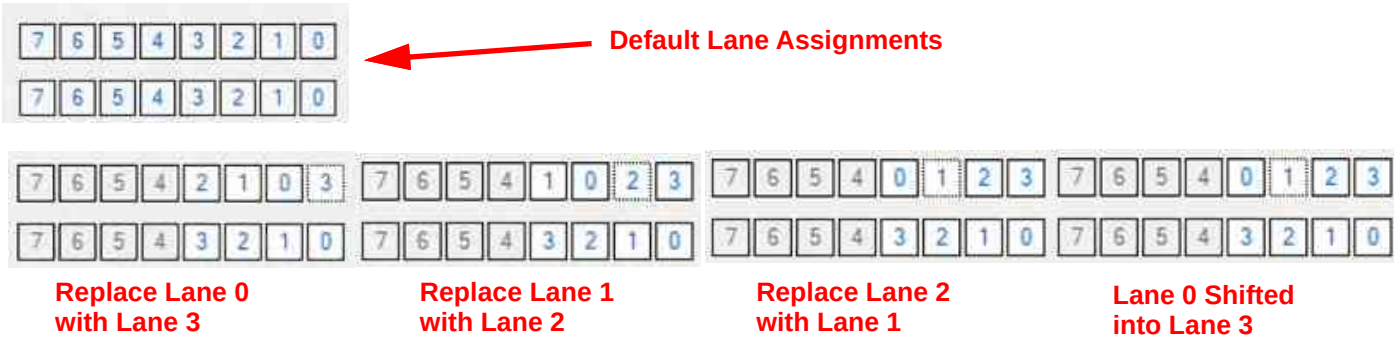


Figure 6.43: Manually Moving Lane Assignments: Highest Numbered Lane First

We ended up swapping the LSB with the MSB.

6.15.8.4 Auto-Configure Lane Swizzle

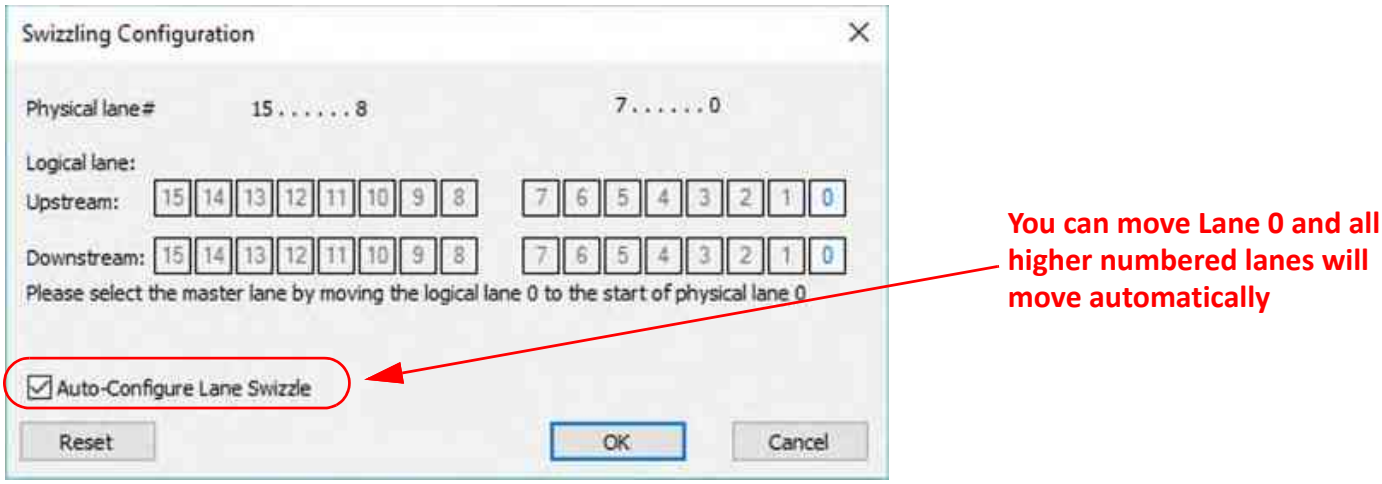


Figure 6.44: Swizzling Config Dialog

When the Auto-Configure Lane Swizzle option is checked the Summit Analyzer requires you to provide the physical location for at least one lane with active traffic. You can specify this by moving the enabled lane L0 to the physical location where either lane 0 is or any other active lane for the link. See Figure 6.45 on page 190.

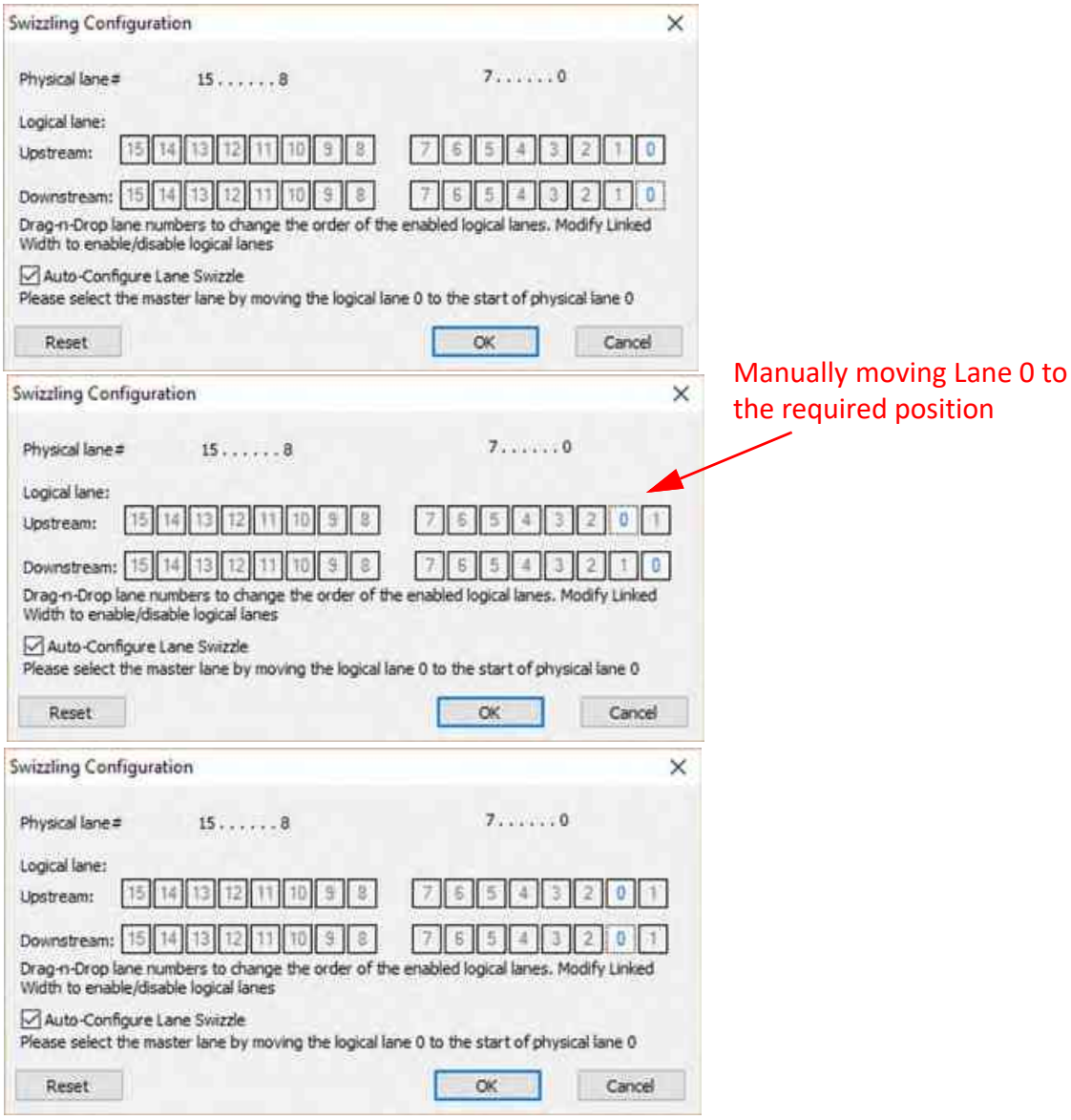


Figure 6.45: Manually Configuring Lane 0 when Auto-Configure Lane Swizzle is Checked

Note: Auto-Configure Lane Swizzle will not work properly if the link is bifurcating. Use manual swizzle instead.

6.15.9 Decode Optimized Buffer Flush/Fill (OBFF)

Select this checkbox to decode Optimized Buffer Flush/Fill (OBFF) events. See Figure Note: on page 157: 3M). As a system operates, each of its devices does not know the power state of each of the resources in the system. Without coordination, each of the devices will go in and out of their low-power states as necessary to execute the tasks they are assigned to do. This asynchronous behavior prevents the optimal power management of the CPU, host memory sub-system and other devices, because the intermittent traffic keeps the system permanently awake and unable to optimize power management across

the system.

As part of an implementation of a system-level power strategy, the idle time and low-power states of the devices must be optimized to enable them to stay in their low-power states longer. Basically, a host can provide information to all devices by broadcasting a message about the system power state. The devices can utilize this information to group a load of requests, wait until the system wakes up, and burst out all of the requests at the same time. By doing this, the device does not wake up a sleeping CPU and/or the system memory sub-system. Waiting creates extended periods of system inactivity which saves overall system power. The host utilizes the OBFF to give devices a "hint" so they can optimize their behavior, which improves power management at the system level.
Navigating Recording Rules

The Recording Rules window has three main areas, the Toolbar, Available Events panel and the Main Display panel (see Figure 6.48 on page 195).

6.15.10 Toolbar

The toolbar contains buttons such as the New Events button for issuing commands, Delete Current Event, Undo, Redo, Zoom in and out, Show/Hide Channels, Properties, and Lane Trigger Configuration.

6.15.11 Available Events Area

The Available Events area is in the left repository panel where you can park buttons that you intend to use in the Main display area. The events in this panel do not affect the recording. You can drag and drop events in the Main Display panel.

6.15.12 Main Display Area

The Main Display area is the right panel where you create trigger and filter conditions. You create conditions by dragging buttons onto the Main display area from the Available Events area. You then create additional conditions by right-clicking a button and selecting options from a pop-up menu. See Creating Recording Rules.

6.16 Recording Rules: Summit T516

When you select Advanced Mode and Event Trigger, you get additional flexibility to configure recording options in greater detail via the **Recording Rules** tab. See Figure 6.46 on page 192.

You can select from All Available Triggers and Filters and move individual Triggers/Filters into the Selected (Active) Triggers/Filters box with the **>>** button. You can move the Selected (Active) Triggers/Filters out of box with the **<<** button.

You can also select from the following:

- Direction (Upstream or Downstream)
- Speed Switch
- Linkwidth Change

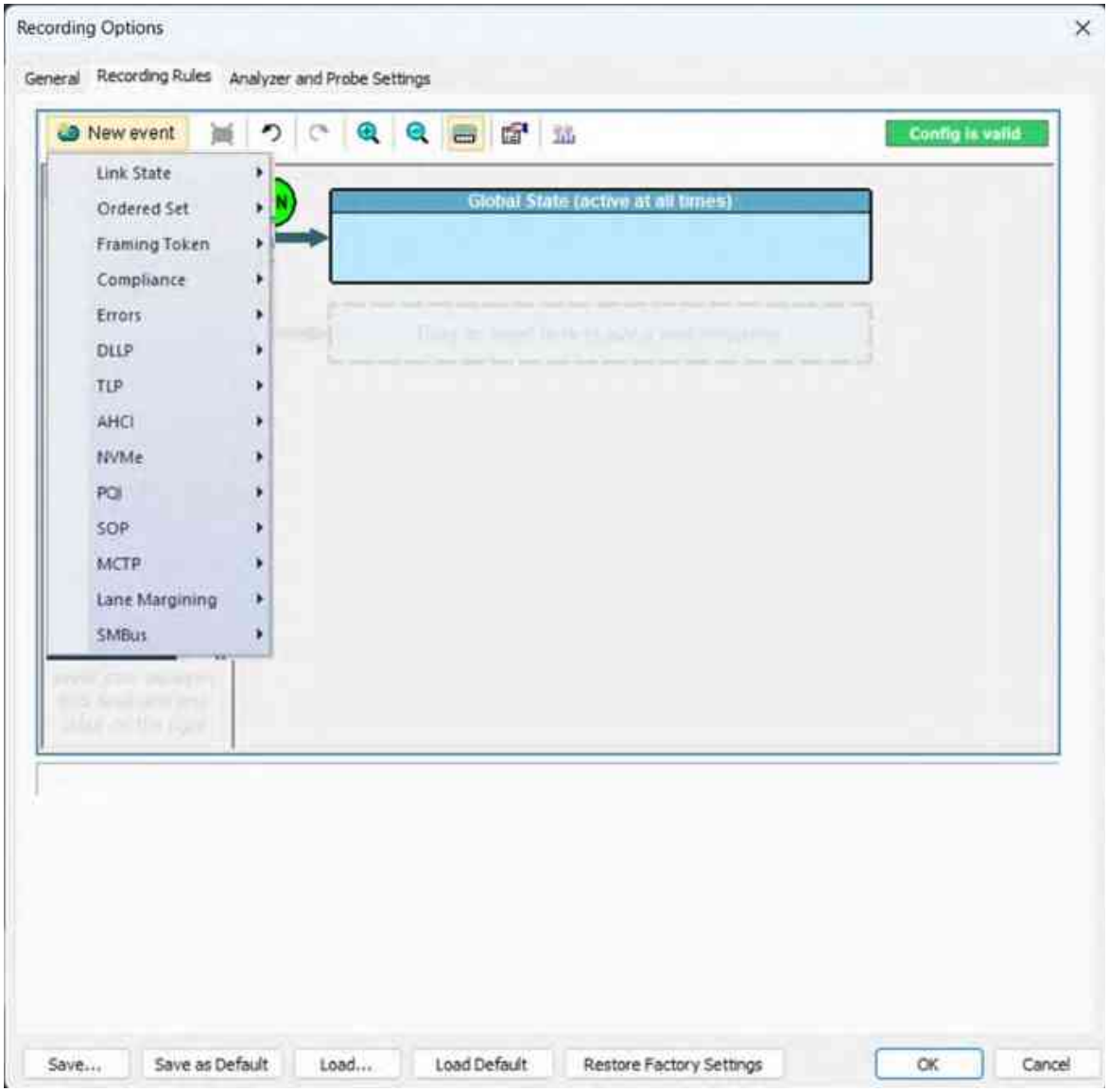


Figure 6.46: Event Trigger (Advanced Mode) Summit T516

You can also select a type of event to trigger on and then you have the following options:

- Channel: (Up or Down)
- Action: (Trigger/Filter Out or External Trigger)

See Figure 6.47.

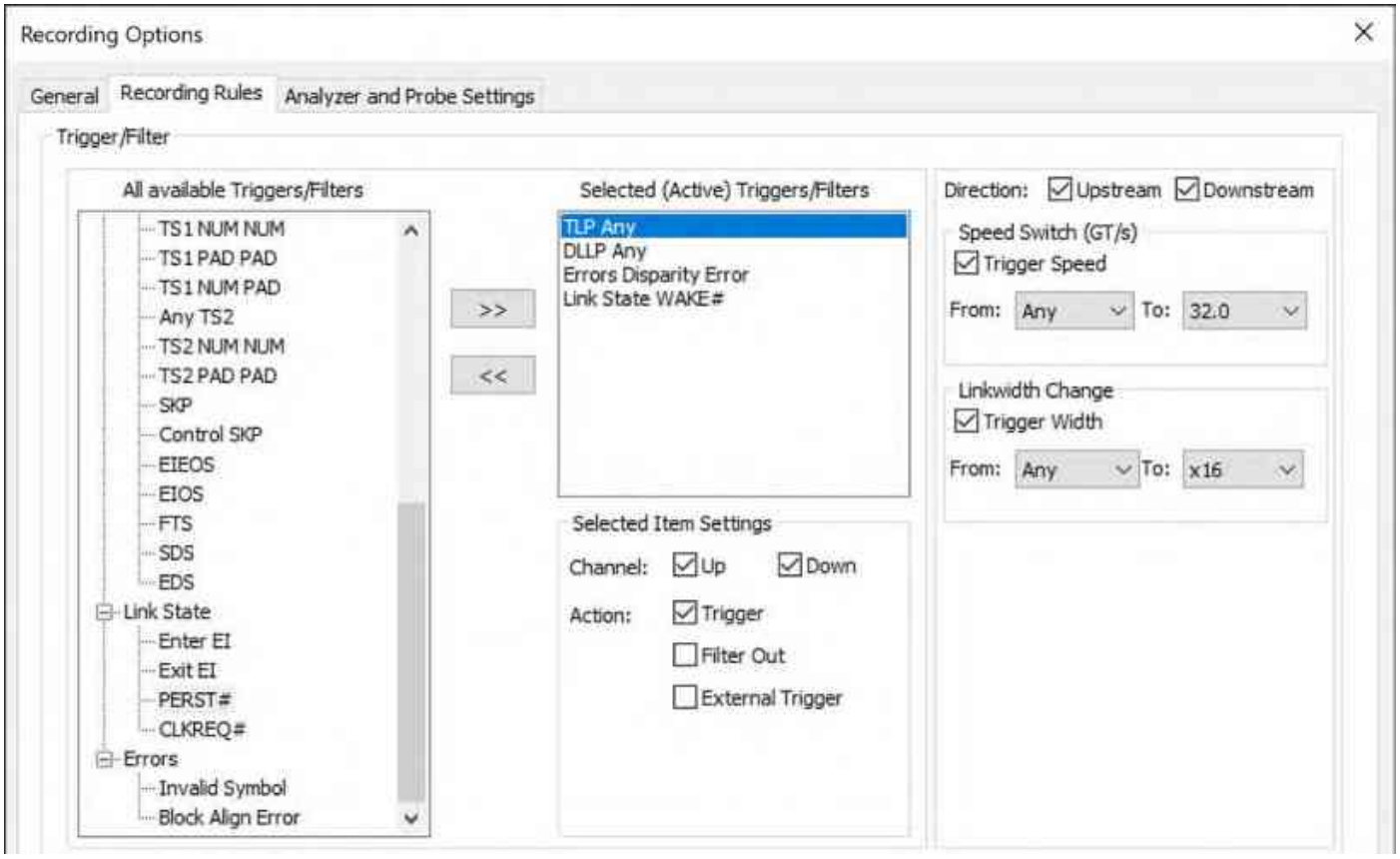


Figure 6.47: T516: Advanced Trigger Event → Select Event Type

6.17 Recording Rules: Summit T54

The Advanced Mode gives you additional flexibility to drill down and configure these options in greater detail via the Recording Rules dialog.

In the Advanced mode click on the Recording Rules tab to configure the settings. As shown in Figure 6.48, the ‘Recording Rules’ tab allows you to create New Events. For each event you can create Actions. As part of an implementation of a system-level power strategy, the idle time and low-power states of the devices must be optimized to enable them to stay in their low-power states longer. Basically, a host can provide information to all devices by broadcasting a message about the system power state. The devices can utilize this information to group a load of requests, wait until the system wakes up, and burst out all of the requests at the same time. By doing this, the device does not wake up a sleeping CPU and/or the system memory sub-system. Waiting creates extended periods of system inactivity which saves overall system power. The host utilizes the OBFF to give devices a "hint" so they can optimize their behavior, which improves power management at the system level. Navigating Recording Rules.

Note:
- In MultiPort mode, SMA trigger out is disabled.
- The External Input Trigger is combined with any other trigger defined in the sequencer.
- External Input Trigger is not configurable, it will *always* cause the analyzer to trigger on a toggle (change in level: Low to High or High to Low) when using “Manual Trigger” (see *Manual Trigger*) or triggering on any “Event Trigger” (see *Event Trigger*).

The same triggering options are available in the Advanced Mode as in the Simple Mode. The Advanced Mode gives you additional flexibility to drill down and configure these options in greater detail via the Recording Rules dialog.

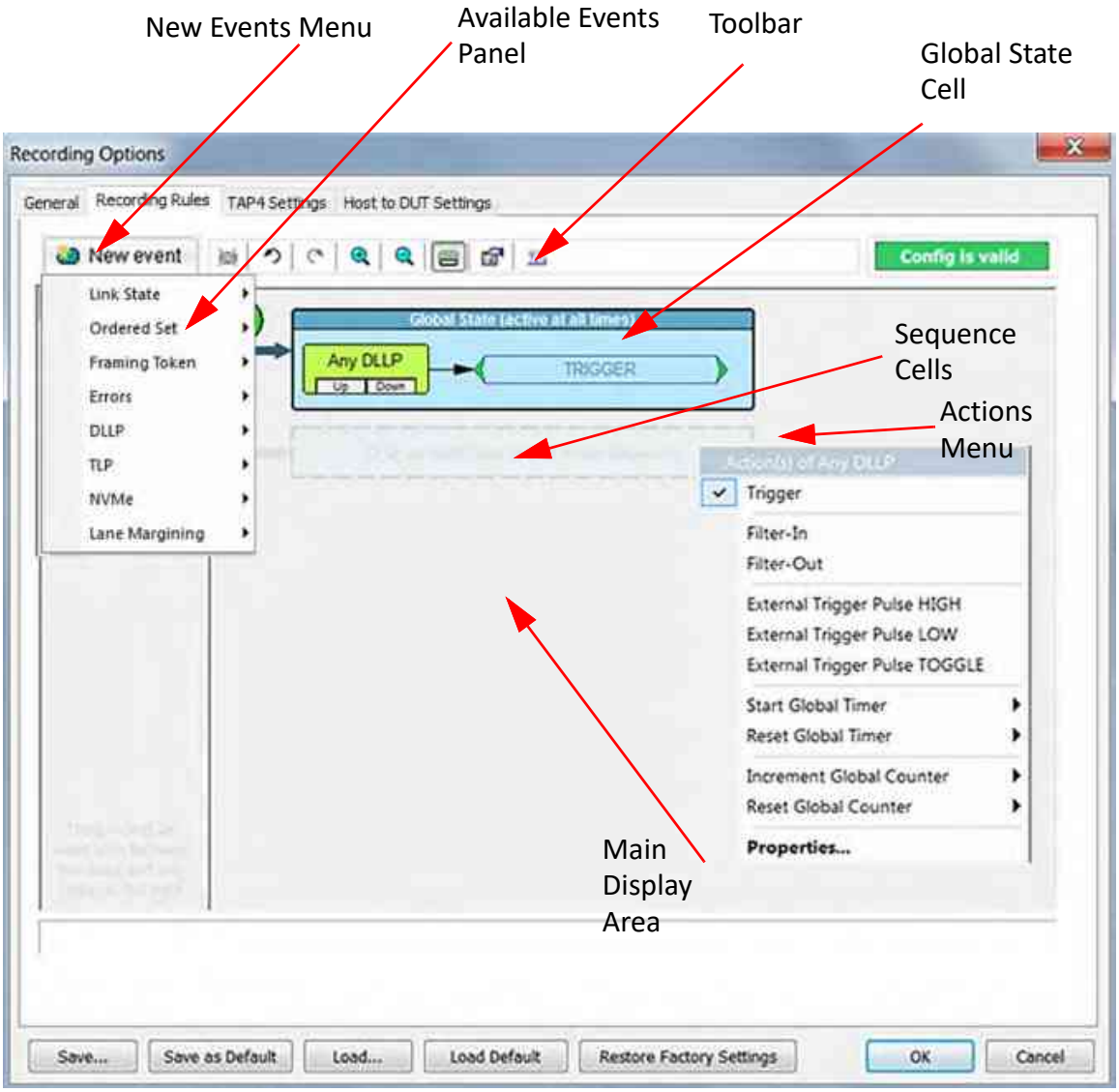


Figure 6.48: Recording Rules Tab

The Recording Rules allows you to specify complex triggering and filtering options. The Summit T54 monitors incoming traffic and looks for specified events. It performs actions like triggering and filtering. Complex options can be created by putting Events in a sequence.

Note: Complex options for Recording Rules apply to the Summit T54.

Events are based on Resources (see “Resources” on page 199).

6.17.1 Recording Rules Buttons

The Recording Rules toolbar allows you to create and edit recording rules:



TABLE 6.4: Recording Rules Toolbar Buttons

New event	New Event. Opens a drop-down menu with a list of events.		Zoom in
	Delete. Delete selected event.		Zoom out
	Undo. Undoes last action.		Show/Hide Channels. Shows/hides the channel buttons.
	Redo. Undoes last Undo command.		Show properties. Opens the Properties dialog for the selected item.
	Lane Trigger Configuration: Sets lane pre-conditions for event categories.		

6.17.2 Defining Recording Rules

To access the **New Event** menu, select **New Event** or right-click in the blue space in the Global State or in the Sequence State (see Figure 6.49).

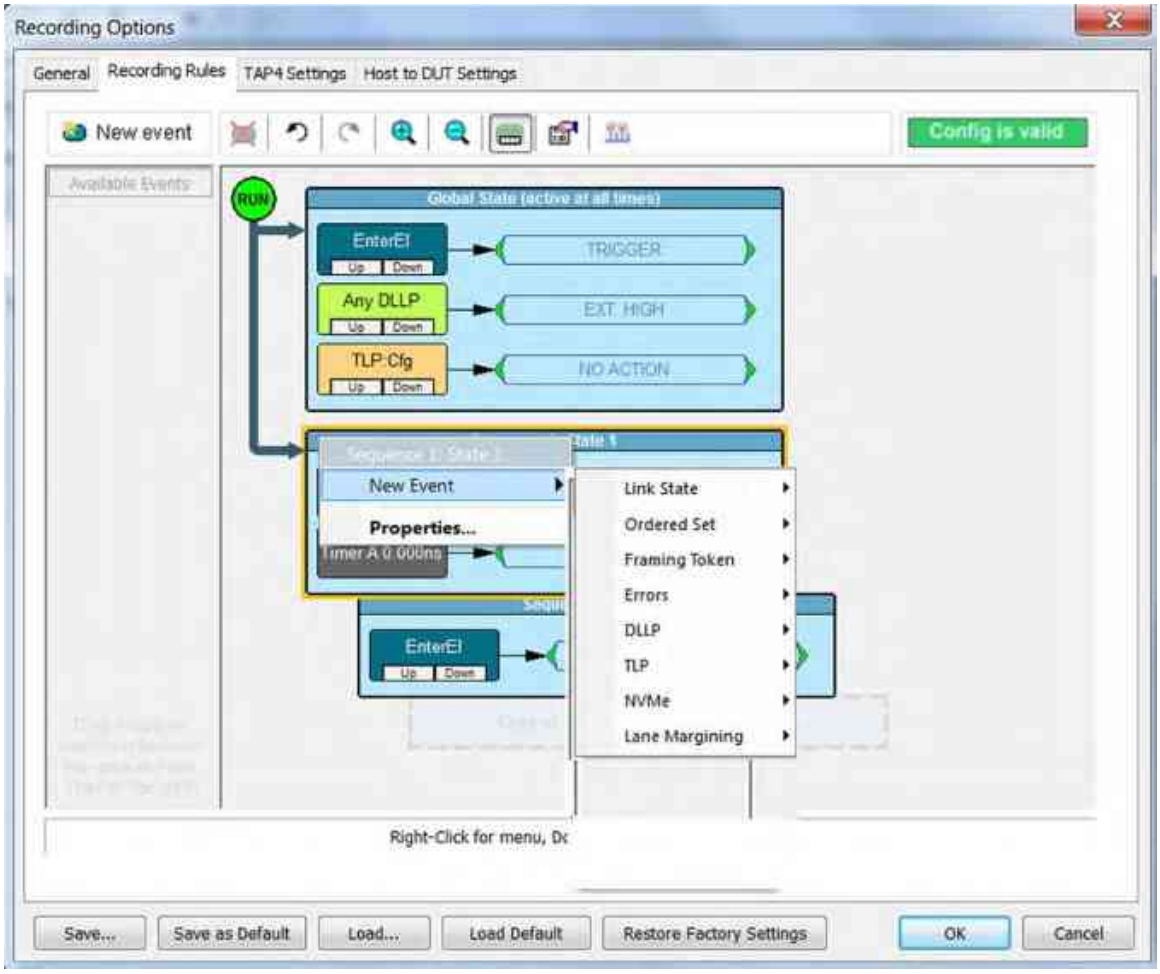


Figure 6.49: Defining New Events

6.17.2.1 Steps to Create a Recording Rule

There are three steps to creating a recording rule:

1. Select events.
2. Place the events in the Global State or Sequence cells.
3. Assign actions to the events.

Note: There are limits to the types of rules that can be created.

1. Click 

and select one or more events from the menu (see Figure 6.50). Selecting an event automatically places it in the Available Events area. This repository area serves as a parking lot where you can place event buttons without them having any effect on the Analyzer.

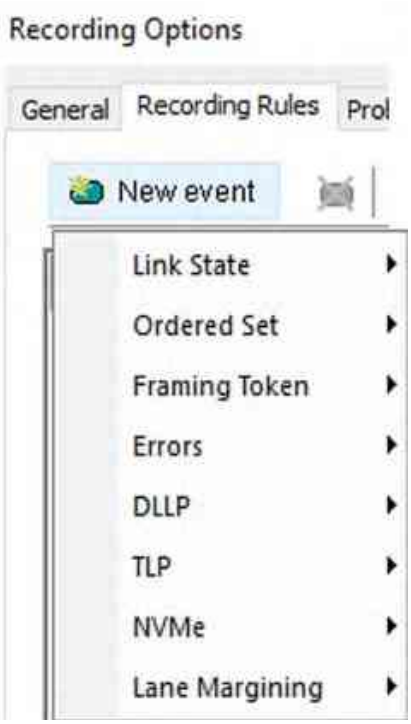
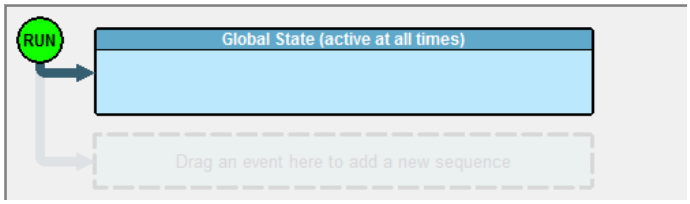


Figure 6.50: New Event Menu

2. Drag the selected events from the Available Events area into either the Global State Cell or the Sequence Cell.



Global State Cell

If you want the Analyzer to always search for the event, place it in the cell marked **Global State**.

Sequence Cell

To create an event sequence, place two or more events in the faintly marked cell that reads **Drag an event here to add a new sequence**. At this point, the selected events have no effect because an action has not been assigned.

3. To select a sub-set of your selected event, right-click it and choose **Properties**. A Properties dialog opens that presents additional options. For example, if you open the Properties dialog for Errors, you can set the specific types of errors the Analyzer should look for.
4. Assign an action to the selected events by right-clicking each of the events, selecting **Specify Action** from the pop-up menu, and assigning an action such as **Trigger, Filter**, or **Count**. Be sure to click the event itself and not the **State** cell that it is sitting in (which produces a different pop-up menu).

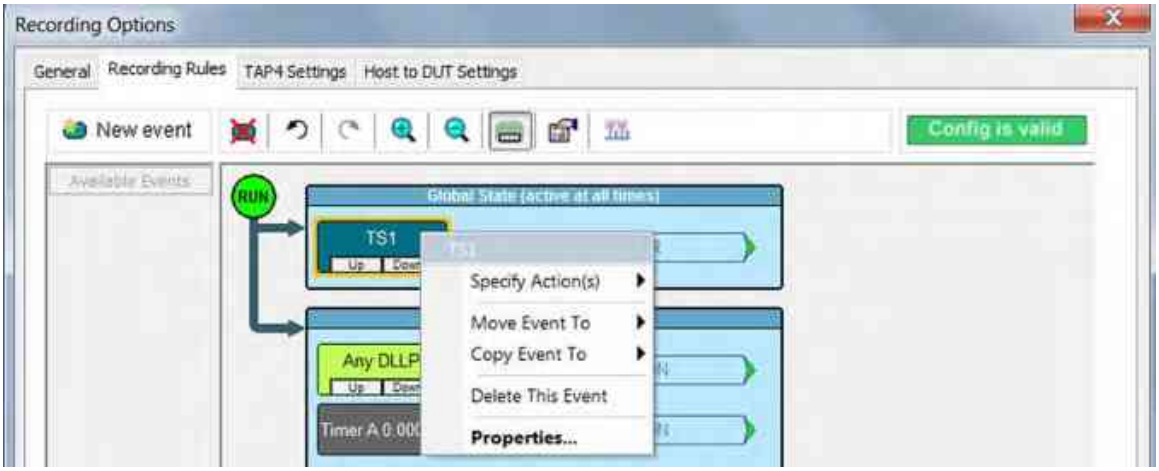


Figure 6.51: Assigning an Action

Note: You can also assign actions to events by double-clicking the event or action and selecting the Actions page when the Properties dialog opens (see "Event Properties Dialog Box Features" on page 213).

Click **OK** to close the dialog. At this point, assuming that the other options in the Recording Options dialog have been set (such as the General page), you can begin the recording by pressing the Start **Recording** button.

6.17.3 Resources

Events in Recording Rules are captured based on the Matching Resources available. There are four types of Matching Resources as follows:

- Basic Matchers (8 each)
- Ordered Set (OS) Matchers (8 each)
- Data Link Layer Packet (DLLP) Matchers (8 each)
- Transaction Layer Packet (TLP) Matchers (8 each)

These Matchers are hardware specific resources that are programmed internally to capture specified events and are not available to the user. Although they can be programmed to capture a wide variety of events you can define a very complex set of events which would need more resources than are available. It that case the Configuration button at the top right of the Recording Options dialog box will show Config is invalid .

If you click on the "Config is Invalid" box a detailed Warning message will pop up. See Figure 6.52 on page 200. In this case, too many basic resource events were defined in the Global State.

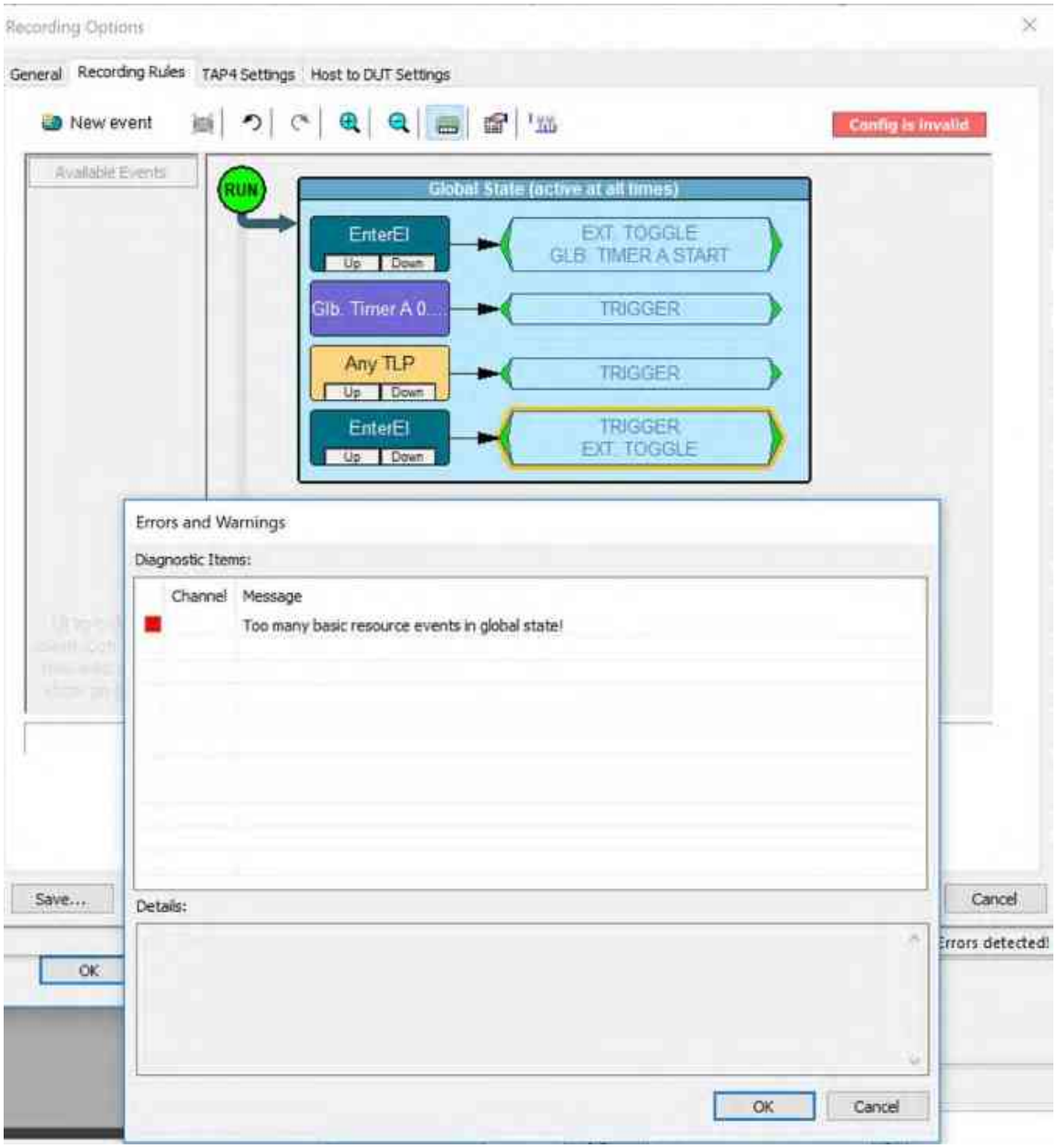


Figure 6.52: Config: Invalid -> Shows Warning Message

If you define a set of events that are missing actions or have inherent contradictions you'll see the Configuration button show Config warnings . If you click on the Configuration button it will produce a list of issues that will need to be corrected before you get the Config is valid .

6.17.3.1 Basic Matcher (x8)

The Basic Matcher generally are used internally to detect the Link State set of Events. See Figure 6.53.

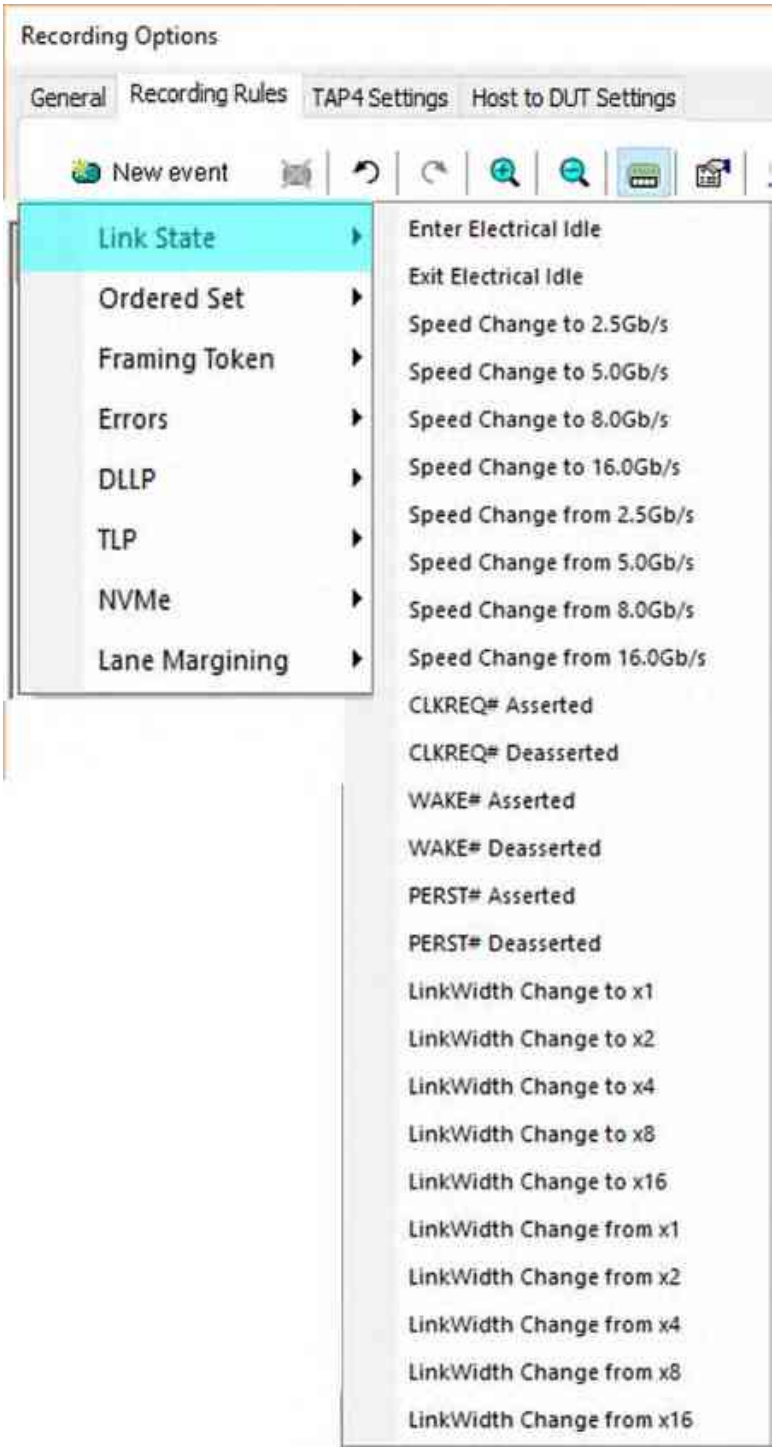


Figure 6.53: Setting Up a Packet Match Resource - Link State

6.17.4 Ordered Set (OS) Matcher (x8)

The Ordered Set Matcher is used internally to detect all of the Ordered Sets (OS). See Figure 6.54.



Figure 6.54: List of Ordered Sets (OS)

6.17.4.1 Trigger on Skip

With the Summit T54 Analyzer you can trigger on Gen5 Skips. Figure 6.55 and Figure 6.56.

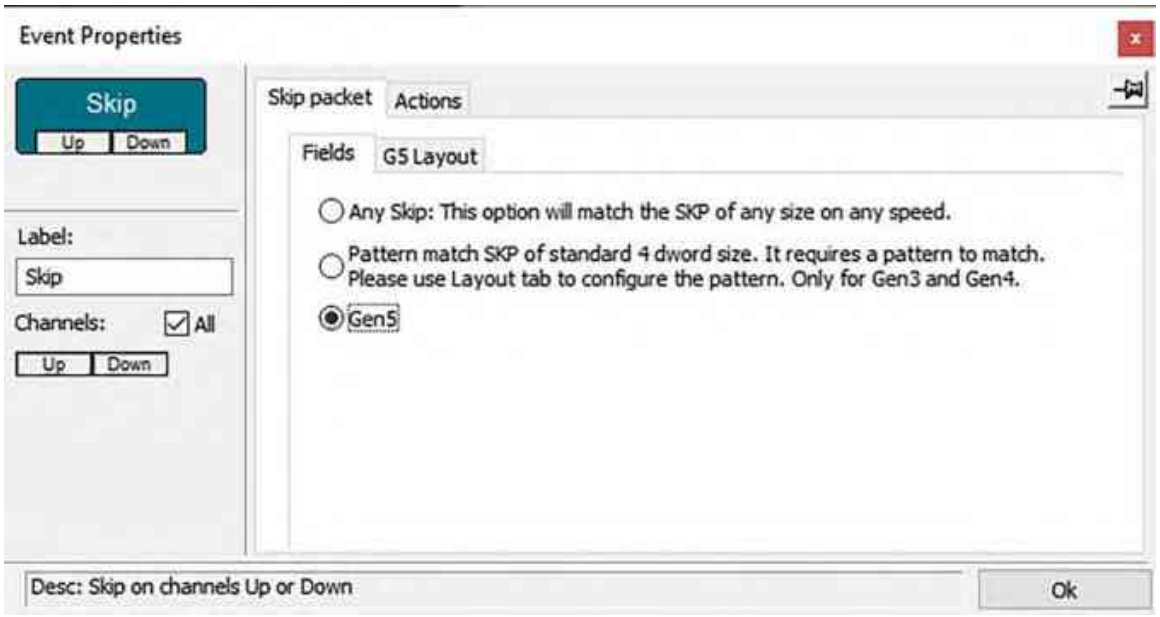


Figure 6.55: Trigger on Skips: Gen5

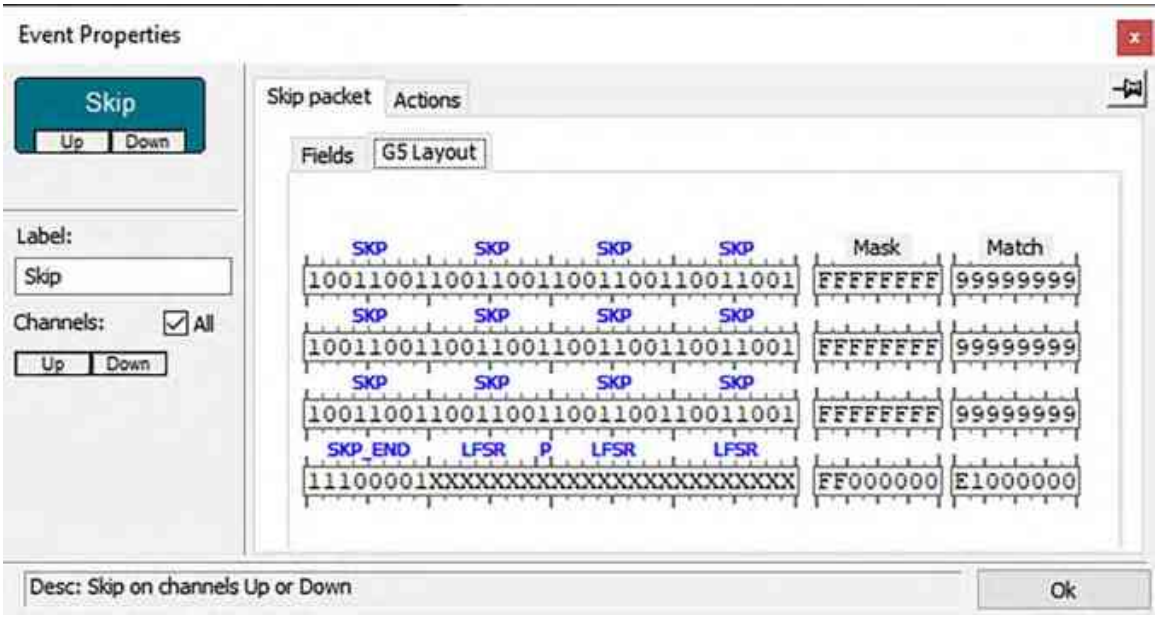


Figure 6.56: Trigger on Skip: G5 Layout

6.17.4.2 Trigger on Control Skip

You can trigger on Control Skips. See Figure 6.57 through Figure 6.61 on page 205.

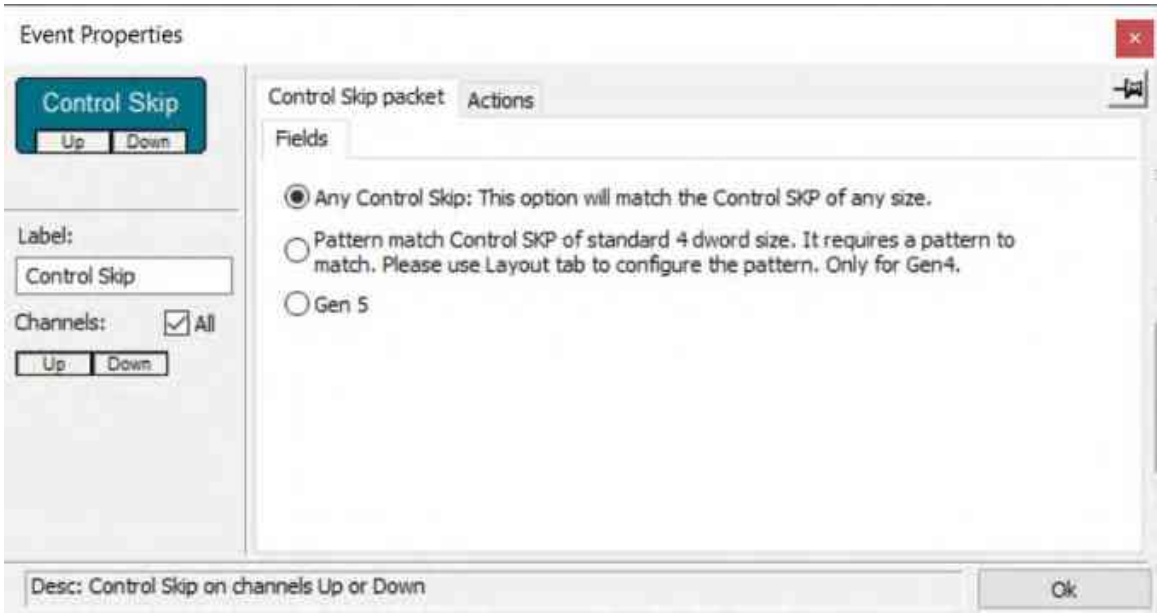


Figure 6.57: Trigger on Control Skips

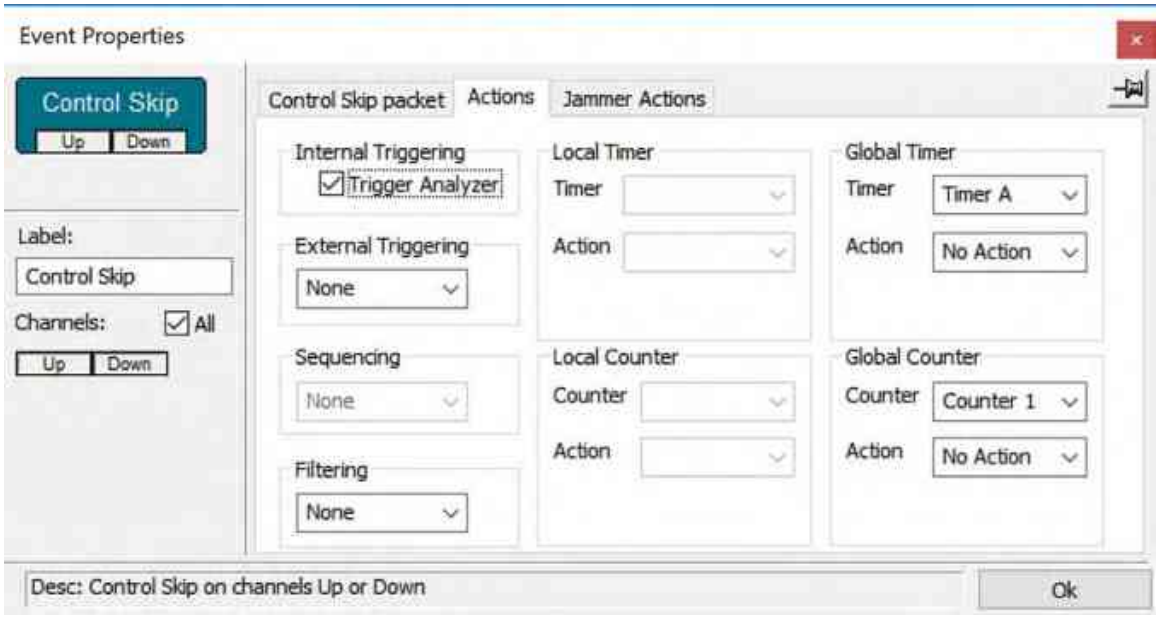


Figure 6.58: Trigger on Control Skip: Action -> Trigger Analyzer

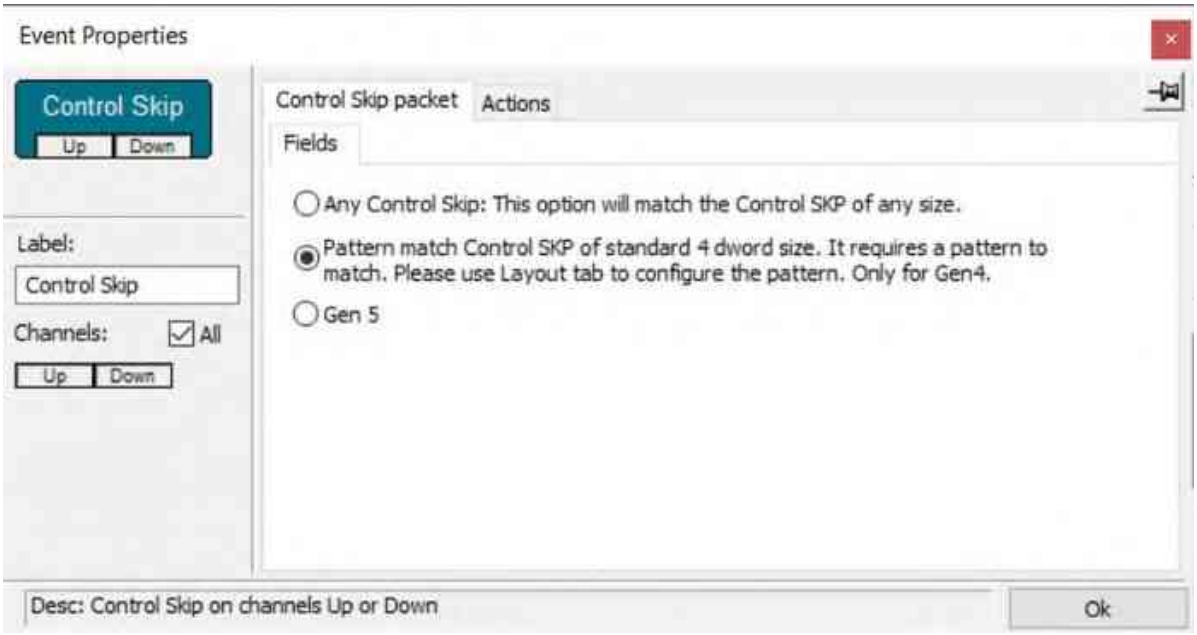


Figure 6.59: Trigger on Control Skip: Pattern Match

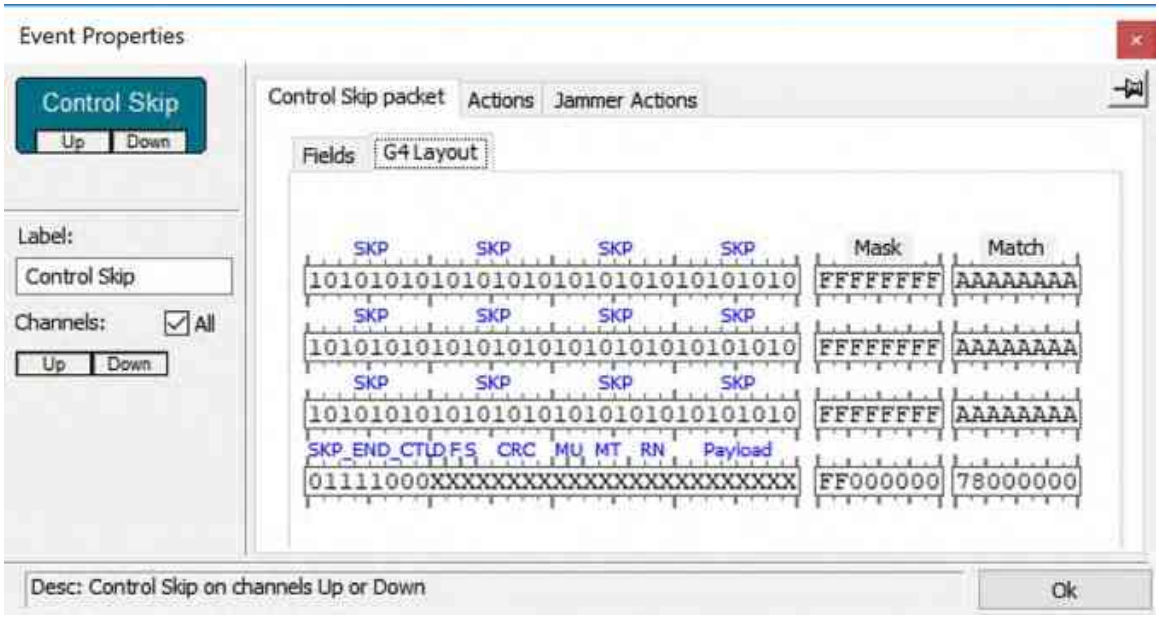


Figure 6.60: Trigger on Control Skip: Pattern Match -> G4 Layout

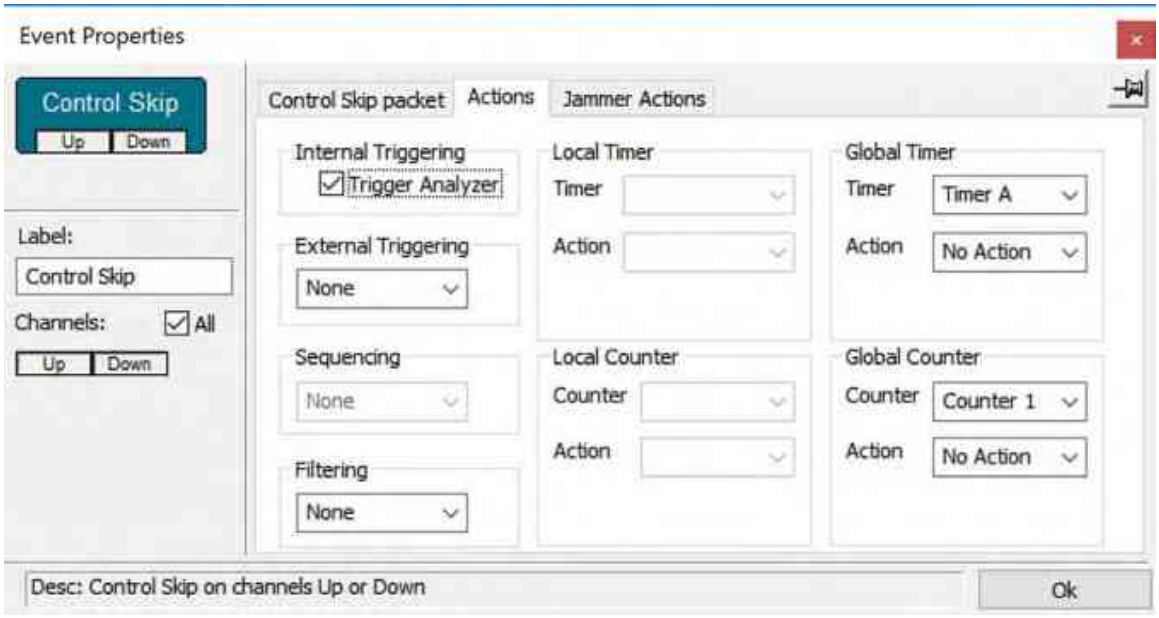


Figure 6.61: Trigger on Control Skip: Trigger Analyzer

6.17.5 Data Link Layer Packets (DLLPs) Matcher (x8)

The Data Link Layer Packets (DLLPs) Resource Matcher is used internally to detect DLLPs. See Figure 6.62.

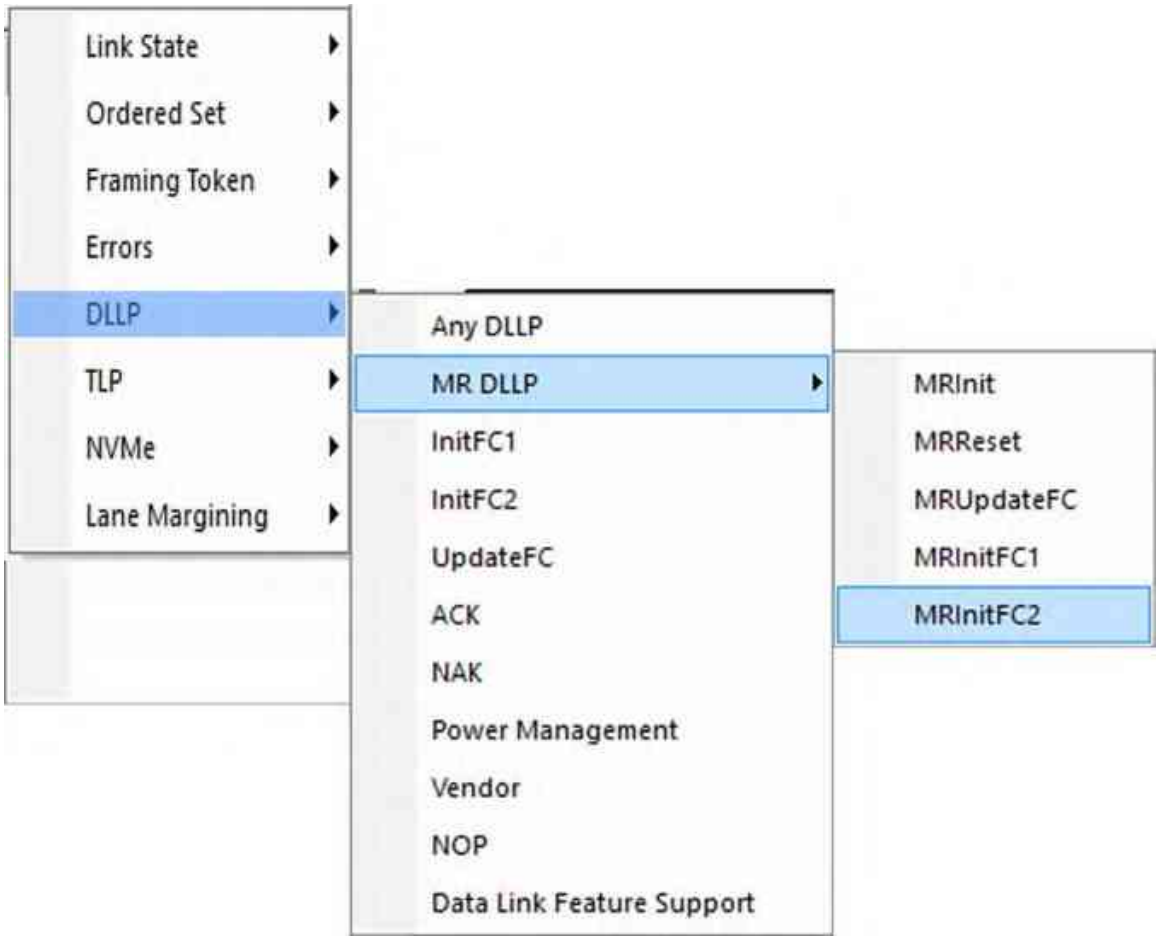


Figure 6.62: List of DLLPs

6.17.6 Transaction Layer Packets (TLPs) Matcher (x8)

The Transaction Layer Packets (TLPs) Resource Matchers are used internally to detect TLPs. See Figure 6.63.



Figure 6.63: Transaction Layer Packets

6.17.7 Global State and Sequence States

The Main Display area in the center of the Recording Rules window has two cells that affect events differently, they are the Global State and Sequence State.



Figure 6.64: Global State Cell and Sequence State Cell

In the Global and Sequence State you can add events by clicking on the New Event button and after the event is in the State you can right-click to Specify Actions, Move, Copy or Delete the event. You can view the Properties dialog to make additional changes to the Property of the event (see Figure 6.64 on page 207). The description of these actions are given in Table 6.6 on page 234.

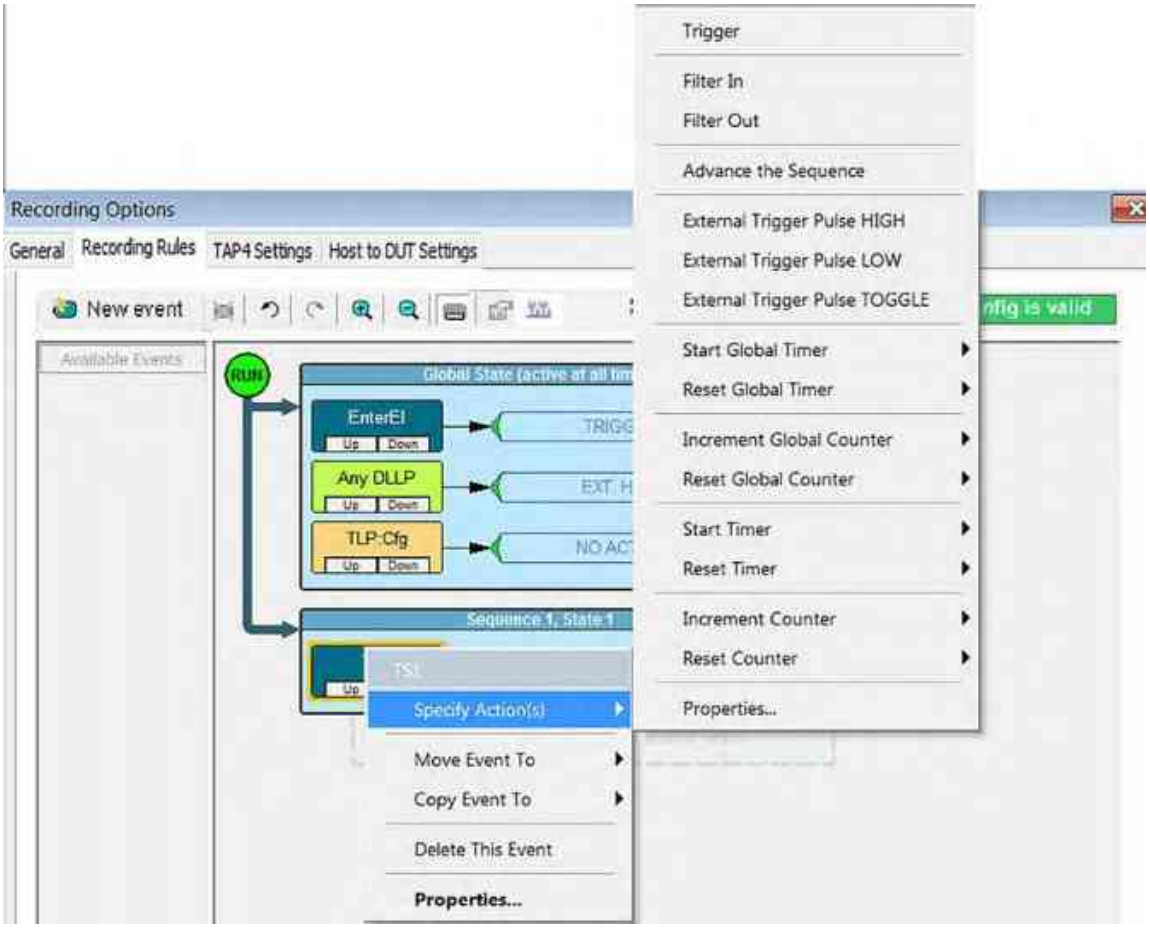


Figure 6.65: Global State Menu

6.17.7.1 Global State

The Global State is active all the time. The Summit T5 analyzers track all the Events and Actions defined in the Global State throughout the recording. In the Global State the Link State, Ordered Set (except TS1 and TS2), Errors, Counter and the Timer use Basic Resources while TLP, DLLP, TS1 and TS2 use Packet Match Resources. The Global State has two Timers and two Counters.

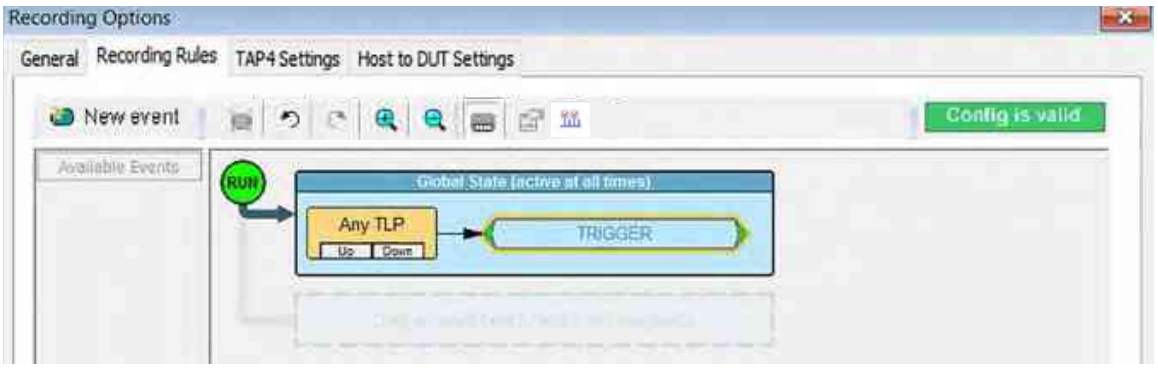


Figure 6.66: Global State

For the Global State there are only 2 Basic Resources for each Channel. Some optimization is done internally to accommodate additional resources. You can keep adding resources to the Global state so long as the **Config is valid** button stays green. If you add a new event which is not valid a window appears with a message prompting **Invalid Recording Rules Configuration** and the **Config is valid** button will turn red (see Figure 6.67 on page 209).

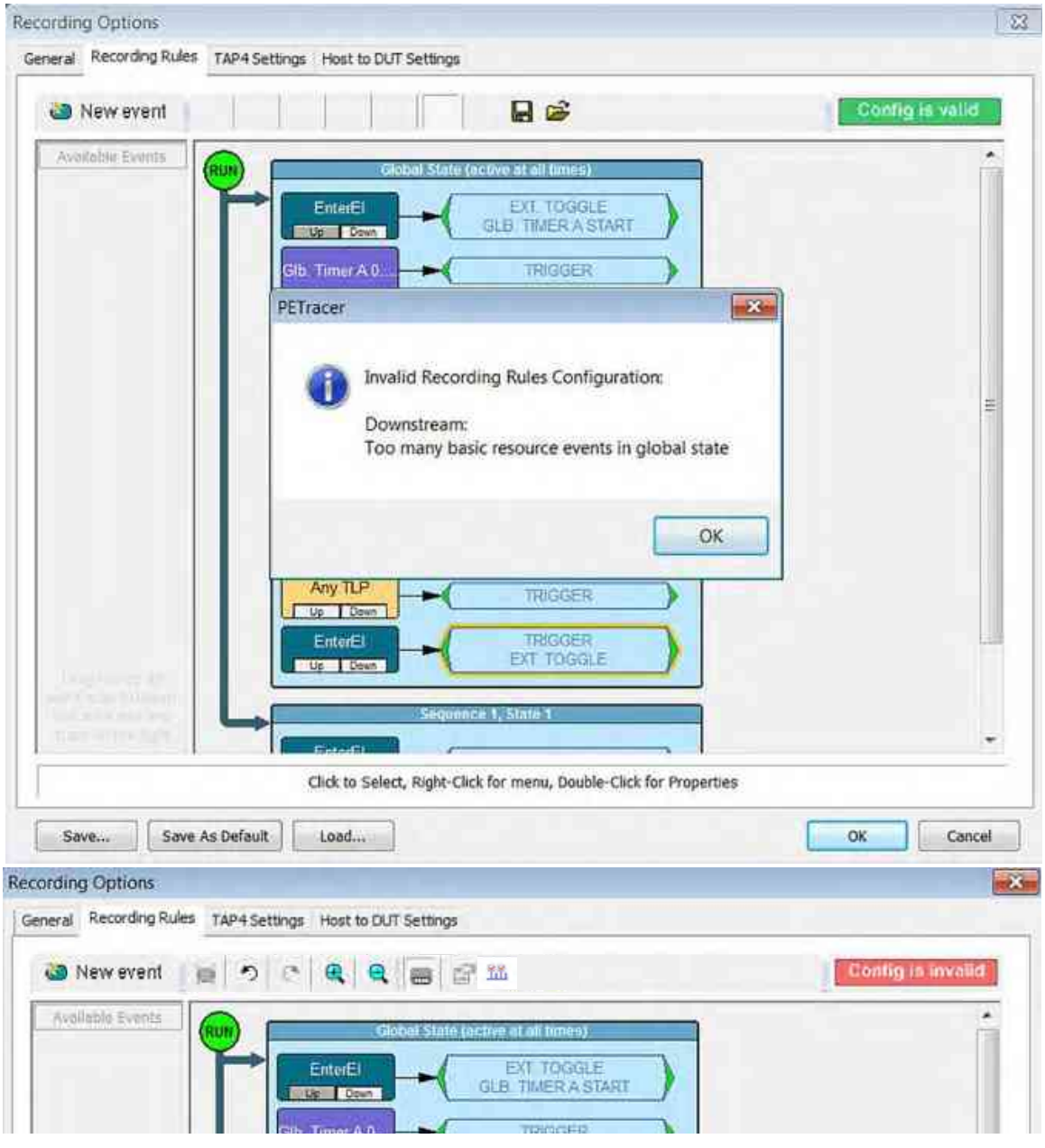


Figure 6.67: Valid and Invalid Recording Rules Configuration Dialogs

6.17.7.2 Sequence State

The cell marked **Drag an event here to add another sequence** is the Sequence State (see Figure 6.68). In the Sequence State you can define a sequence of Events and Actions

which the Summit T3-16 Analyzer looks for at pre-determined times. Sequences are chains of events culminating in a trigger or any other action. A sequence which is a separate chain of events can be created with up to 16 states. A state is an event condition with an action within a sequence. Once a Sequence State is added the cell marked will read **Drag an event here to add another state.**

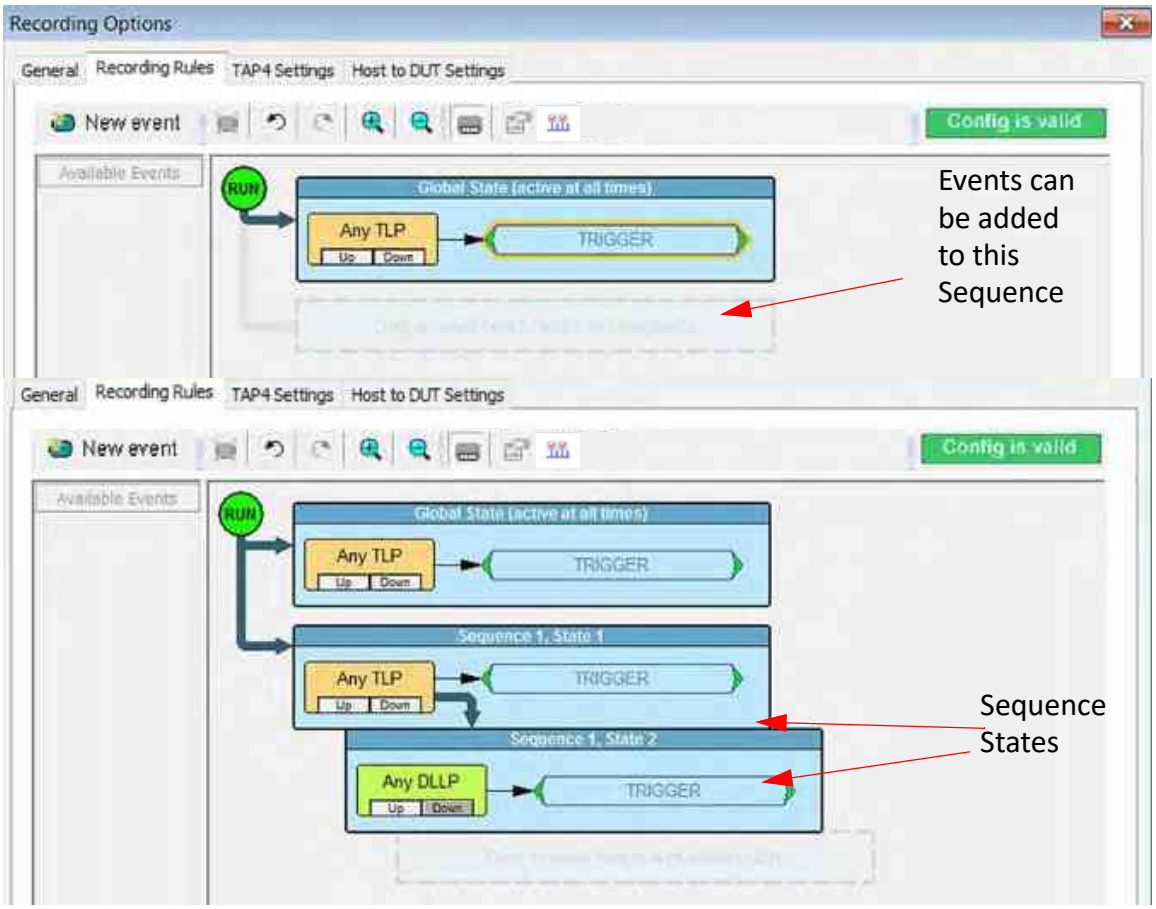


Figure 6.68: Sequence State Events

In the Sequence State the Link State, Ordered Set, Errors, Counter and the Timer use Basic Resources while DLLP and TLP use Packet Match Resources. There are four Timers and four Counters in the Sequence State.

Note: In each Sequence State up to eight Basic Resources and eight Packet Match Resources can be defined.

6.17.8 Recording Rules Events

There are eleven sets of Events that can configured and actions can be set for every

Event.

TABLE 6.5: Events and Event Actions

Event	Pre-Defined Event Actions
Link State	
	Enter Electrical Idle
	Exit Electrical Idle
	Speed Change to 2.5 GT/s
	Speed Change to 5.0 GT/s
	Speed Change to 8.0 GT/s
	Speed Change to 16.0 GT/s
	Speed Change to 32.0 GT/s
	Speed Change from 2.5 GT/s
	Speed Change from 5.0 GT/s
	Speed Change from 8.0 GT/s
	Speed Change from16.0 GT/s
	Speed Change from 32.0 GT/s
	CLKREQ# Asserted
	CLKREQ# Deasserted
	WAKE# Asserted
	WAKE# Deasserted
	PERST# Asserted
	PERST# Deasserted
	LinkWidth Change to x1
	LinkWidth Change to x2
	LinkWidth Change to x4
	LinkWidth Change from x1
	LinkWidth Change from x2
	LinkWidth Change from x4
Ordered Set	
	TS1
	TS2
	EIEOS
	EIOS
	Skip
	Control Skip
	FTS
	SDS

TABLE 6.5: Events and Event Actions (Continued)

Framing Token	
	EDS
	EDB
Errors	
	Disparity Error
	Symbol Error
	Block Align Error
DLLP	
	Any DLLP
	MR DLLP (MRInit, MRReset, MRUPdatFC, MRInitFC1, MRInitFC2
	InitFC1
	InitFC2
	UpdateFC
	ACK
	NAK
	Power Management
	Vendor
	NOP
	Data Link Feature Support
TLP	
	Any TLP
	Config Rd
	Config Wr
	IO Rd
	IO Wr
	Mem Rd
	Mem Wr
	Message
	Completion
NVME	
	NVME Register
	ACQ
	AQA
	ASQ
	CAP

TABLE 6.5: Events and Event Actions (Continued)

	CC
	CQyHDBL
	CSTS
	INTMC
	INTMS
	NSSR
	Reserved (0x18...0x1B)
	Reserved (0x40...0xEFF)
	Reserved Command Set Specific
	SQyTDBL
	VS
	CMBLOC
	CMBSZ
Lane Margining	
	LM Packets

Note: NVME Command, PQI Command and SCSI command sets are available for selection when Link Width option is set to X4 or lower in the Recording Options.

6.17.9 Properties Dialog Boxes for Events

Properties dialog boxes provide additional settings for Events, States, and Actions in the Recording Rules page. You can access a Properties dialog by double-clicking an **Event, State, Action** or any other object. It allows you to set triggers and filters. For example, to set a trigger on a specific type of error, you open the Properties dialog.

6.17.9.1 Accessing the Properties Dialog

To see the Properties dialog, first create an event button by clicking the **New Event** button and choosing an event from the menu. Open the Event Properties dialog by doing one of the following:

- Double-click an event.
- Right-click an event and select **Properties** from the pop-up menu.
- Click the **Properties** button on the toolbar.

6.17.9.2 Event Properties Dialog Box Features

The following features are displayed in the any Event Properties dialog box (see Figure 6.69 on page 214).

Event Icon Preview

This icon shows you which event properties you are editing. The Icon Preview looks

exactly like the icon in the Main Display area.

Icon Label

A text box for labeling the button. Whatever you type here appears on the button.

Channels

These controls allow you to select the channel(s) that the Analyzer should search when it is looking for the event.

Pin Button

The Pin Button on the top right corner of the dialog allows you to **pin** the Properties dialog to the application so that it does not go away when another object appears such as an event, state or action.

Description String

This area contains a textual description of the event.

Event-specific Settings

The largest part of the Event Properties dialog. The settings in this area vary for different events. Some events do not have any additional settings. After selecting the options you want click on the “OK” button.

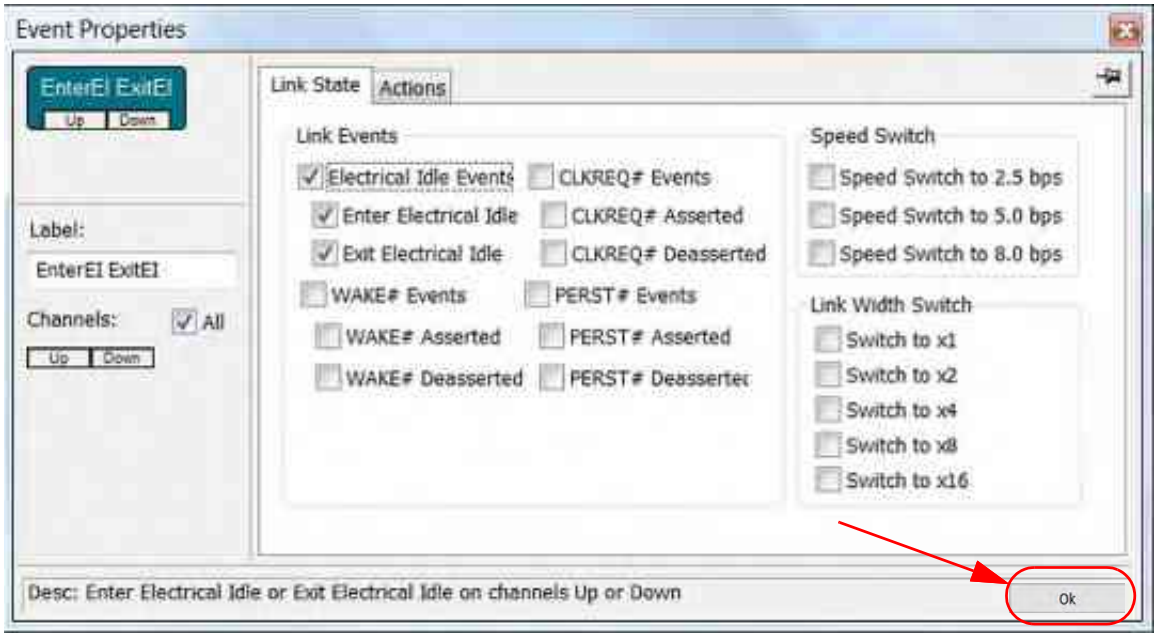


Figure 6.69: Properties Dialog Box

6.17.9.3 Link State Dialog

The Link Properties dialog lets you select the link state. In the case shown below, PERST# events are the Link States selected. See Figure 6.70. After selecting the options you want click on the “OK” button.

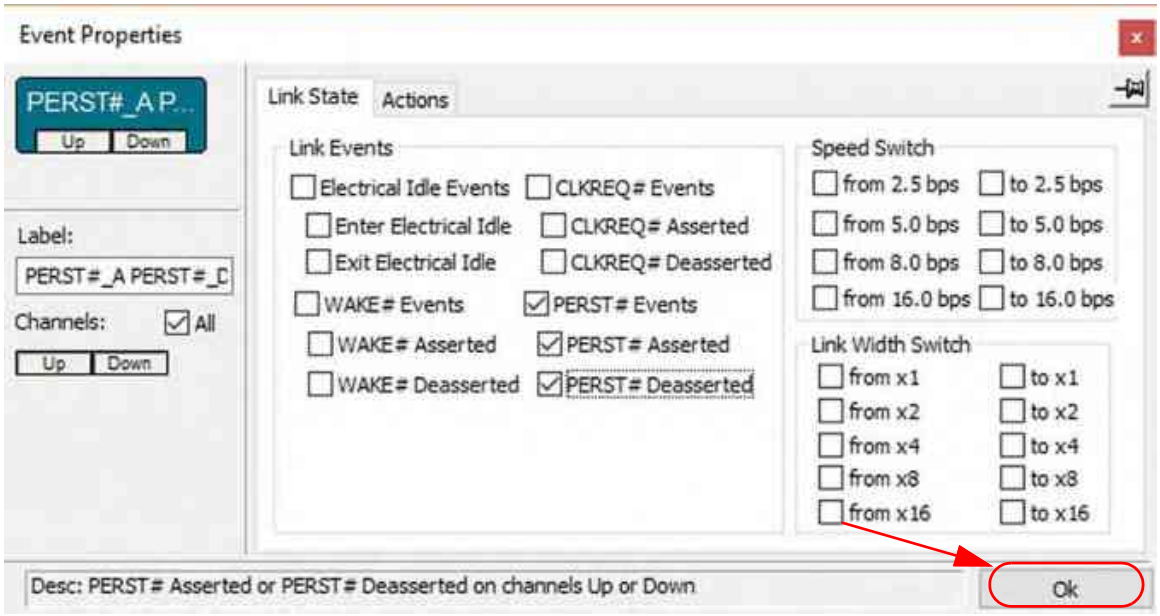


Figure 6.70: Link State Properties Dialog: PERST#.

Link State Actions

In this case, the Link State Action to be taken would be to trigger the analyzer. See Figure 6.71. After selecting the options you want click on the “OK” button.

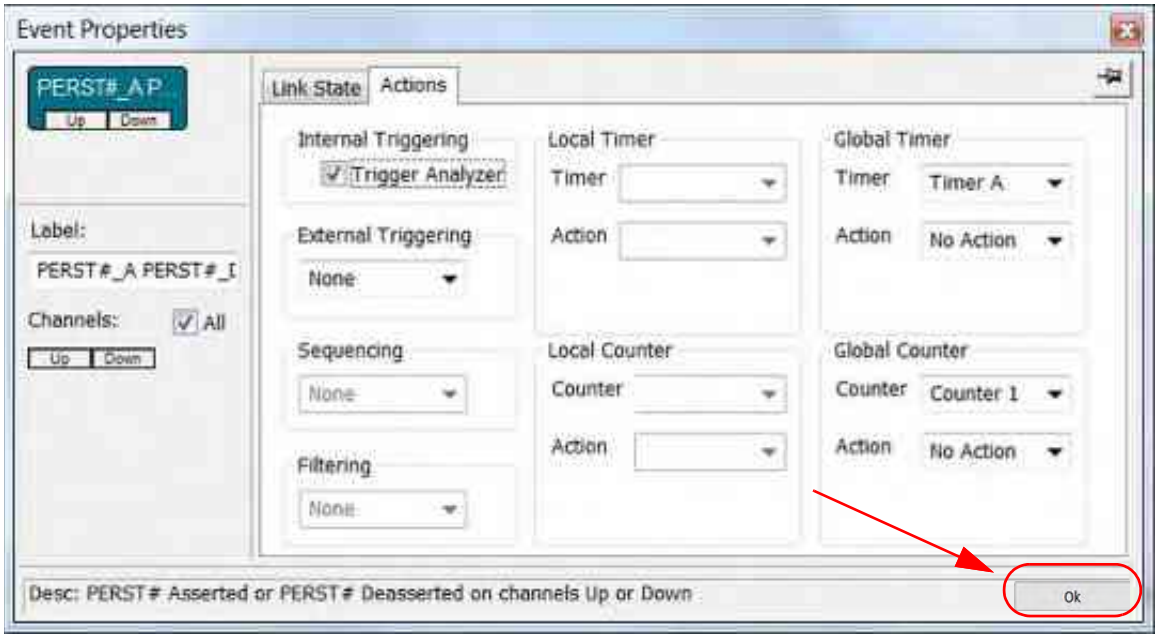


Figure 6.71: Event Properties: Link State Actions: Trigger Analyzer

Global State: CLKREQ# or PERST# Triggers

You could have either a PERST# or CLKREQ# event trigger the analyzer by applying those two conditions to the Global Settings. See Figure 6.72.

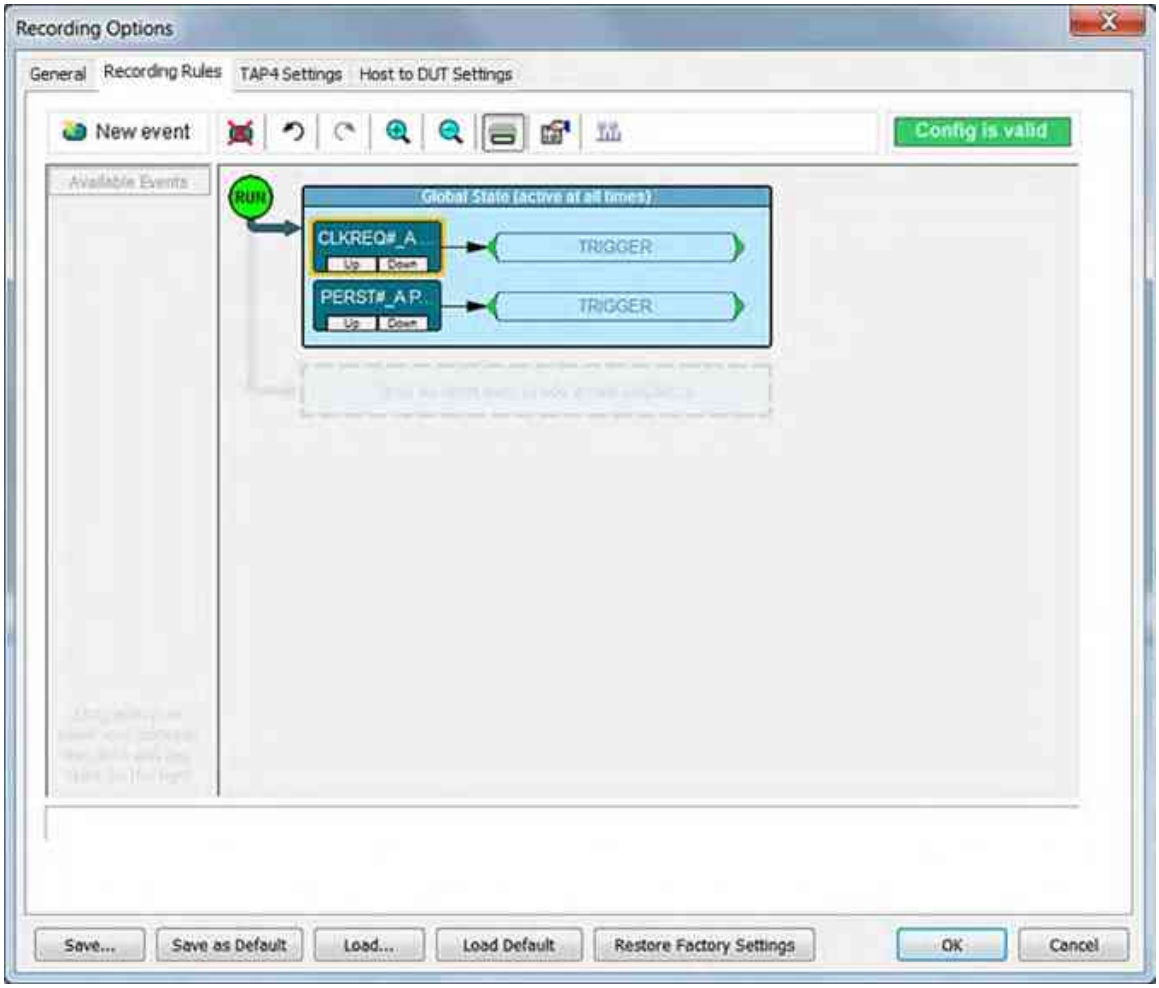


Figure 6.72: Global State: CLKREQ# or PERST# Triggers Analyzer

6.17.9.4 Ordered Sets

A typical Ordered Set Event would be a TS1 packet with the following fields:

- Link Number: Any or PAD
- Lane Number: Any, PAD or Use Lane Trigger
- N_FTS: Any
- Data Rate: Any, G1, G2, G3 or G4
- Atnms Change: Any, Set or Cleared
- Speed Change: Any, Set or Cleared
- Hot Reset: Any, Assert or De-Assert
- Disable Link: Any, Assert or De-Assert
- Loopback: Any, Assert or De-Assert
- Disable Scramble: Any, Assert or De-Assert

- Completion Received: Any, Assert or De-Assert
- Identifiers (6-15): Any, TS1(4Ah) or Custom

See Figure 6.73.

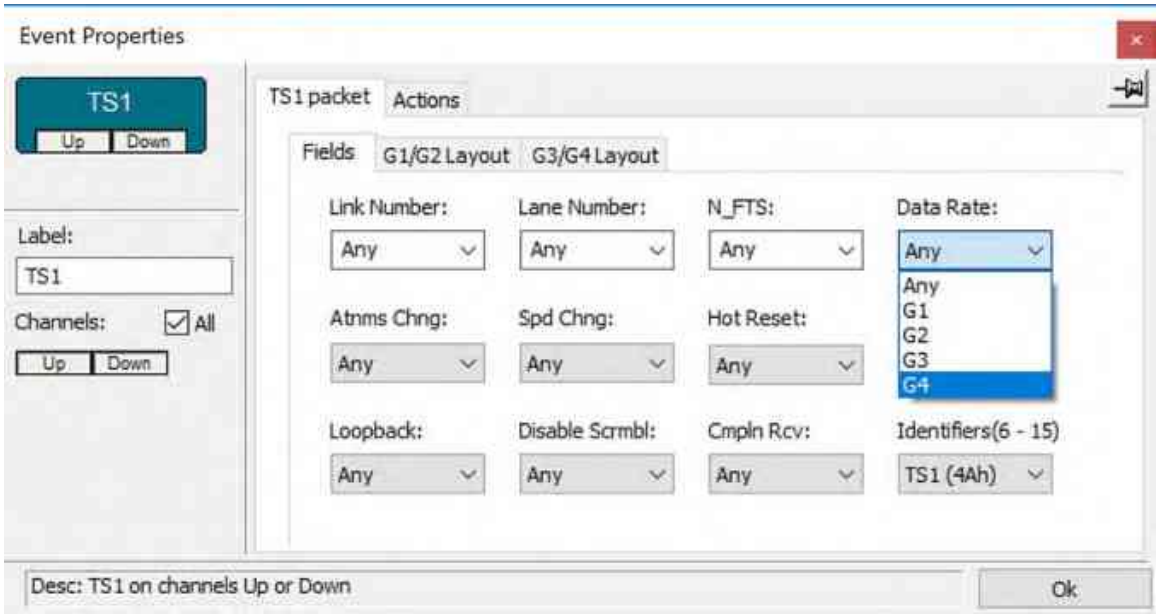


Figure 6.73: Typical Ordered Set: TS1 Event Fields

For G1/G2 Layout the options are shown in Figure 6.74 on page 218.

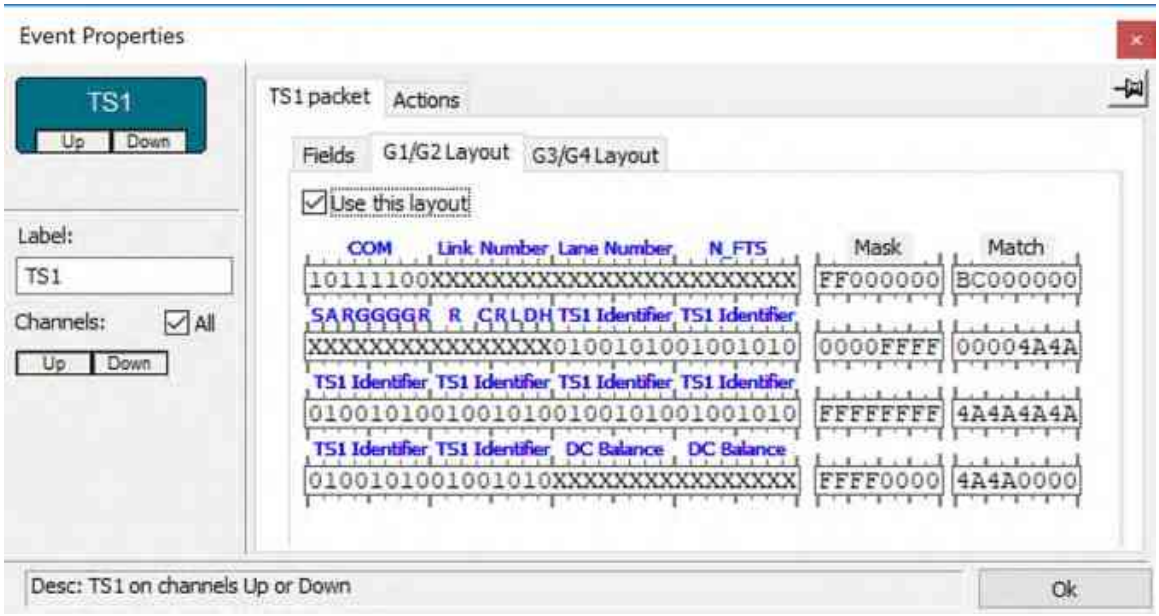


Figure 6.74: Ordered Set: TS1 -> G1/G2 Layout Options

For G3/G4 Layout the options are shown in Figure 6.75.



Figure 6.75: Ordered Set: TS1 -> G3/G4 Layout Options

TS1 Actions are shown in Figure 6.76 on page 219.

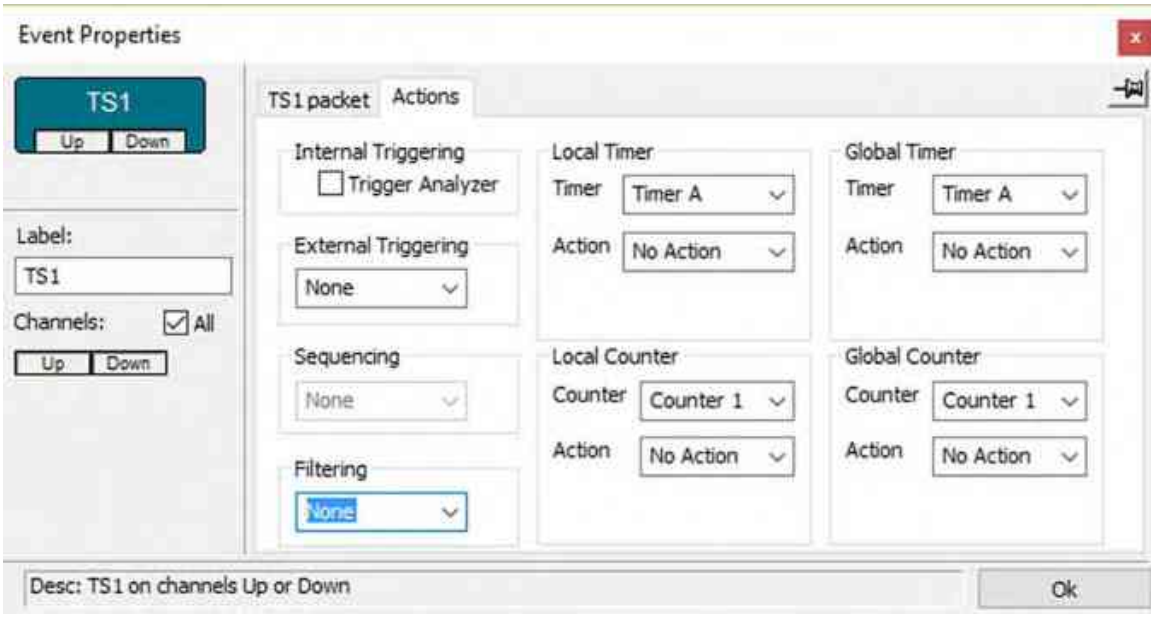


Figure 6.76: Ordered Sets: TS1 -> Actions

6.17.9.5 Framing Token

A Framing Token can be selected as shown in Figure 6.77.

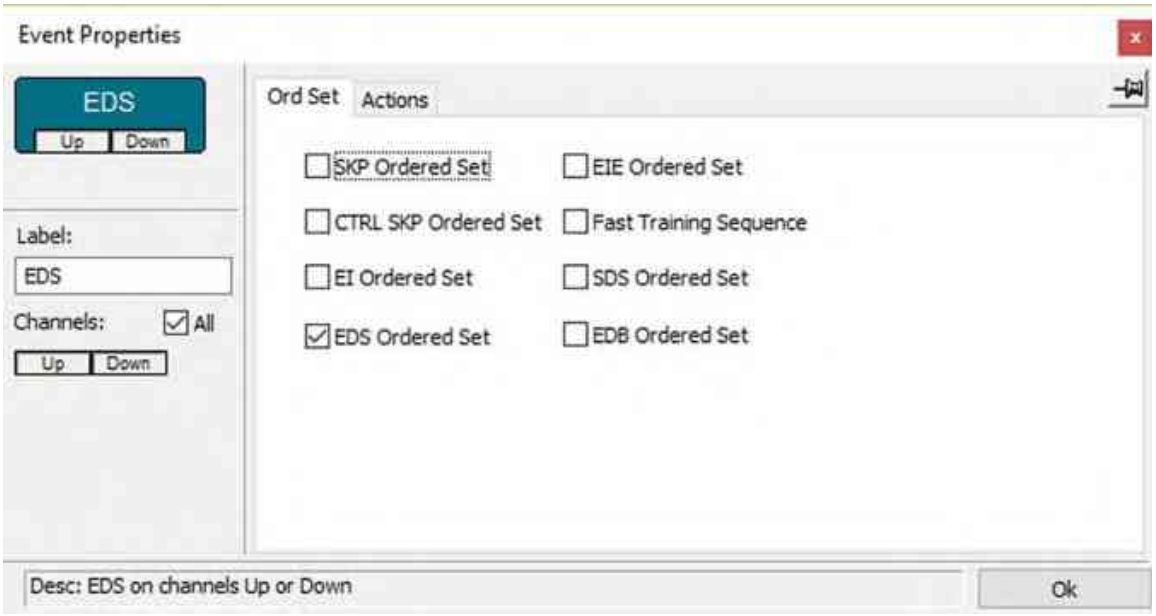


Figure 6.77: Framing Token: Event

The Framing Token Actions are shown below. See Figure 6.78 on page 221.

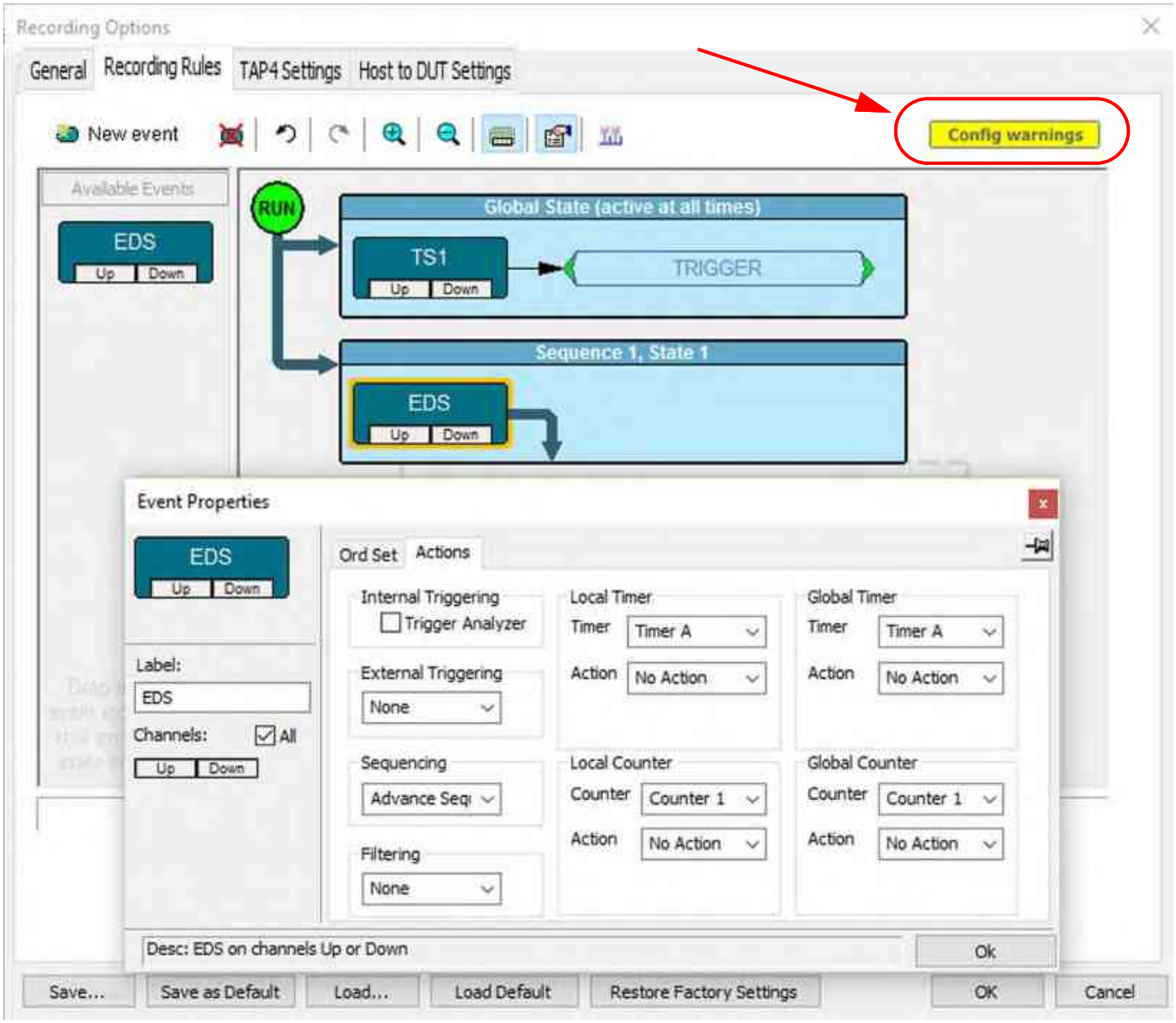


Figure 6.78: Framing Token: Actions

In this example the Advance Sequence was selected but no subsequent state was defined, so the Configuration button is showing: Config Warning. If you click on the Config Warning button a message dialog pops up, telling you what the problem is. See Figure 6.79 on page 222.

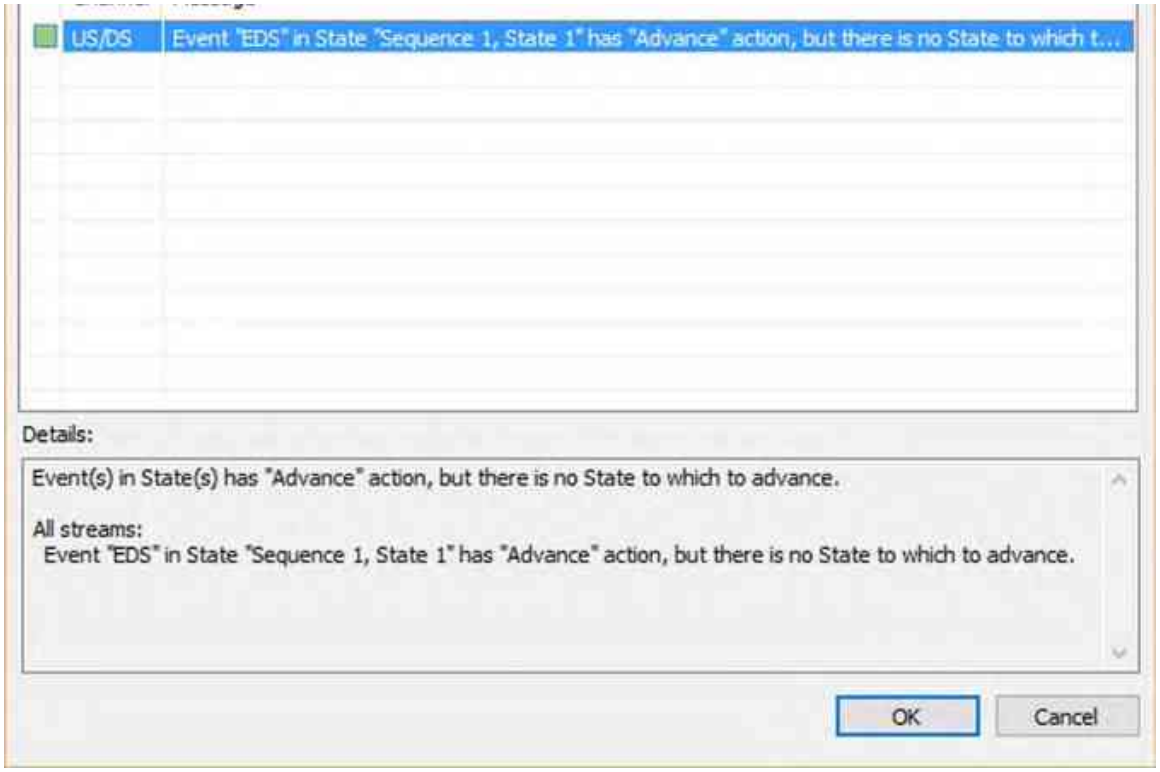


Figure 6.79: Configuration Warning Dialog

If you add another state, the Configuration will be valid. See Figure 6.80 on page 223.

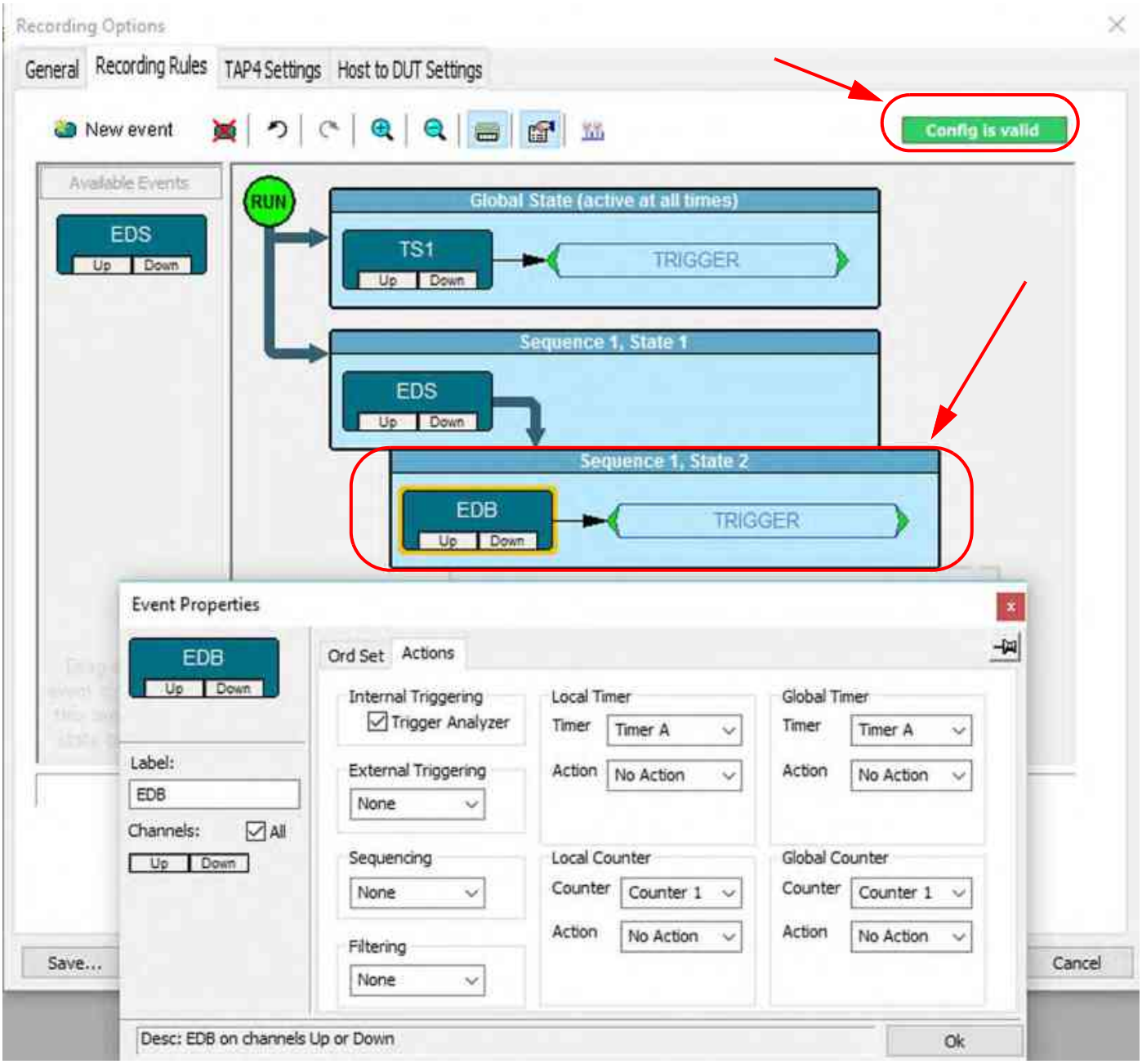


Figure 6.80: Add a State to get Valid Configuration

6.17.9.6 Error Properties Dialog

The Error Properties dialog lets you select specific error types for performing an action. There are three types of Errors:

- Disparity
- Symbol
- Block Align

Each Error type has it's own Event block and similar Actions that can be taken. See Figure 6.81.

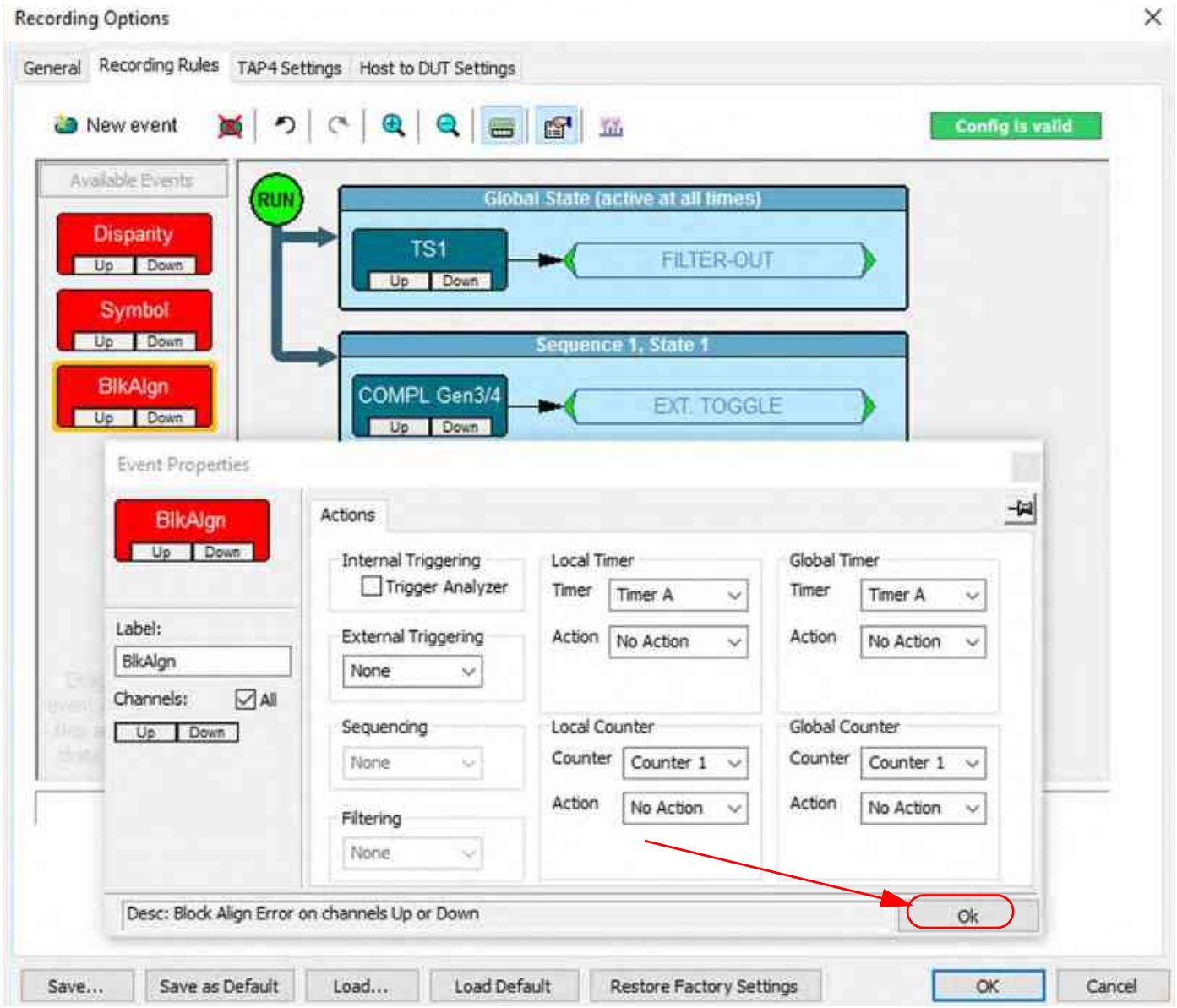


Figure 6.81: Error Events: Actions Dialog

6.17.9.7 DLLP Packet Properties Dialog

The DLLP Packet Properties dialog allows you to specify any DLLP field as shown below. After selecting the options you want click on the “OK” button. See Figure 6.82.

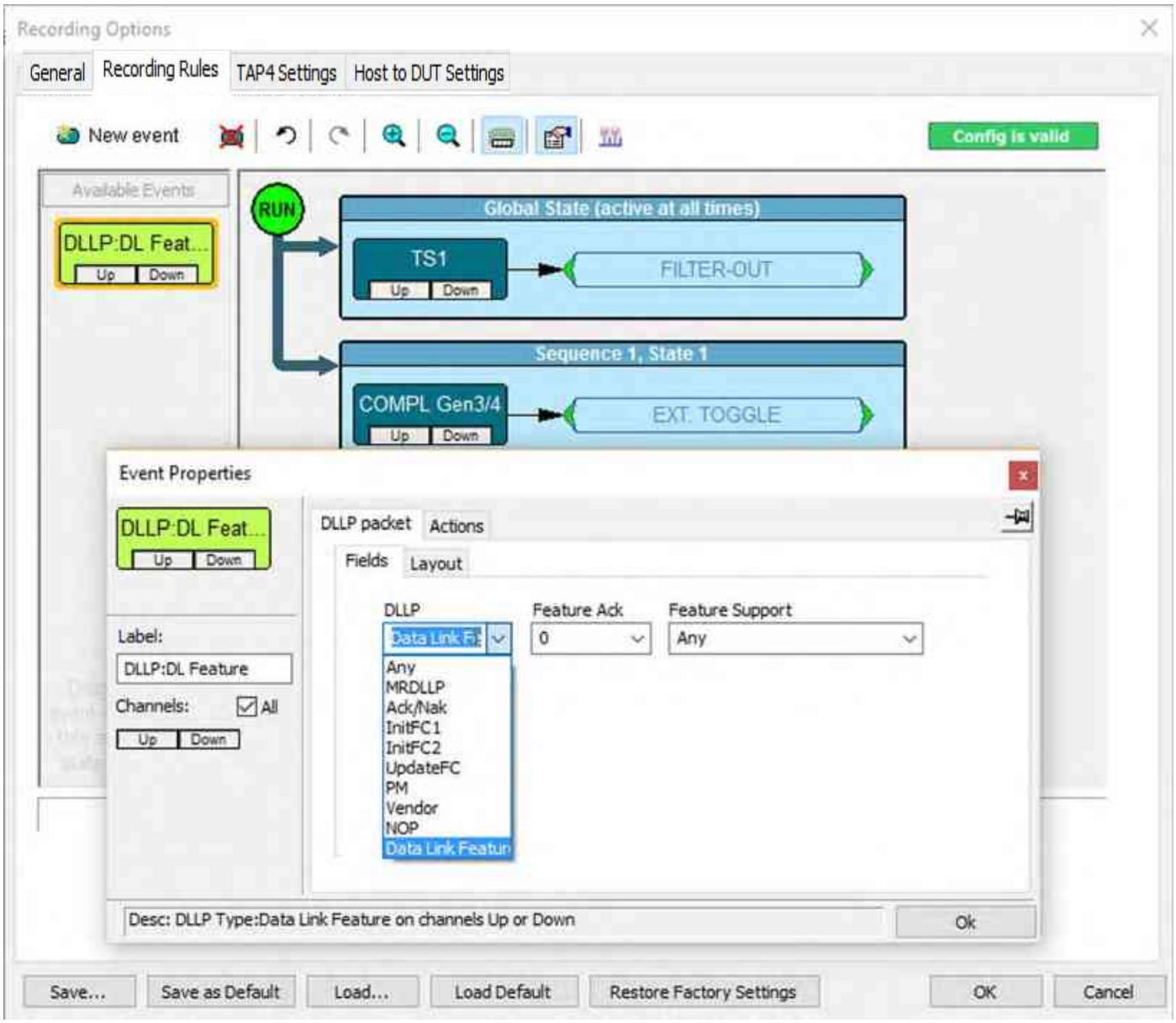


Figure 6.82: DLLP Packet Properties Dialog.

The Layout tab of the DLLP Packet Properties dialog allows you to change the pattern and customize it by defining each specific bit as shown in the figure below. After selecting the options you want click on the “OK” button.

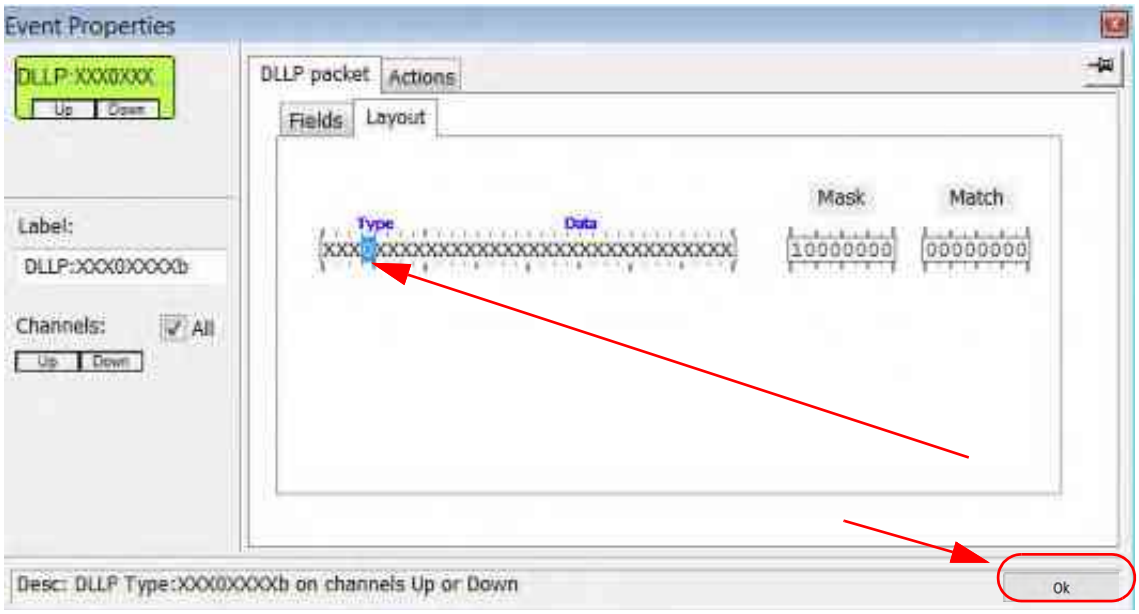


Figure 6.83: DLLP Packet Properties Dialog

Then you can choose the Action you want to occur after the Event is captured. See

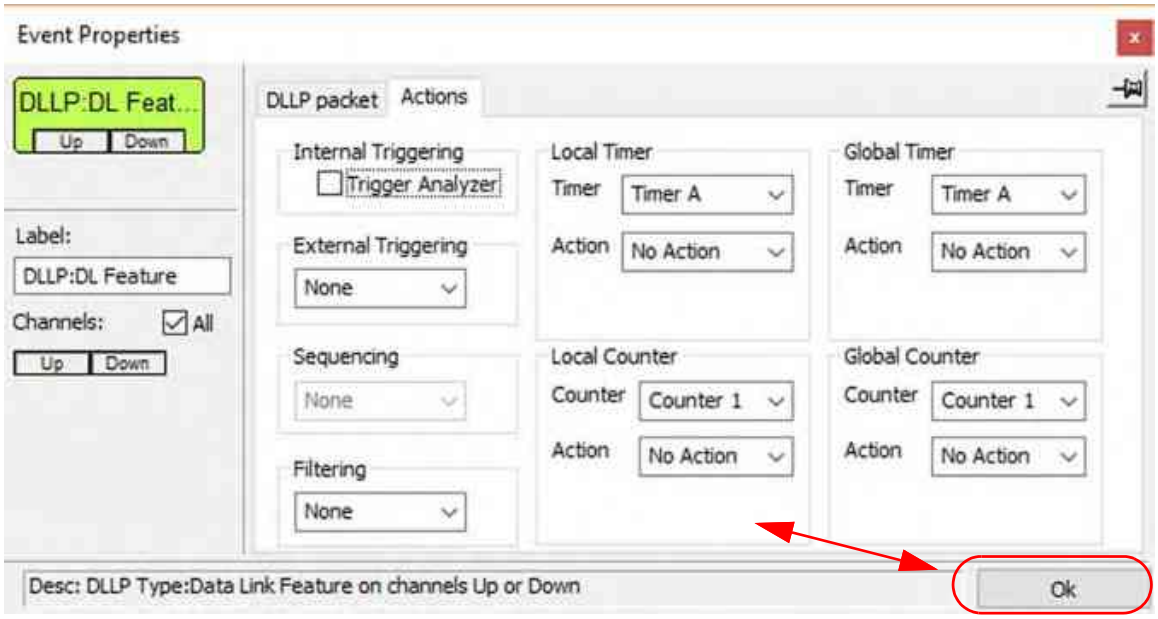


Figure 6.84: DLP Packet: Actions Available

6.17.9.8 TLP Header Properties Dialog

The TLP Header Properties dialog enables you to set the TLP Header Fields and Layout,

TLP Prefixes and Actions. You can manually change the Requester/Completer ID. After selecting the options you want click on the “OK” button.

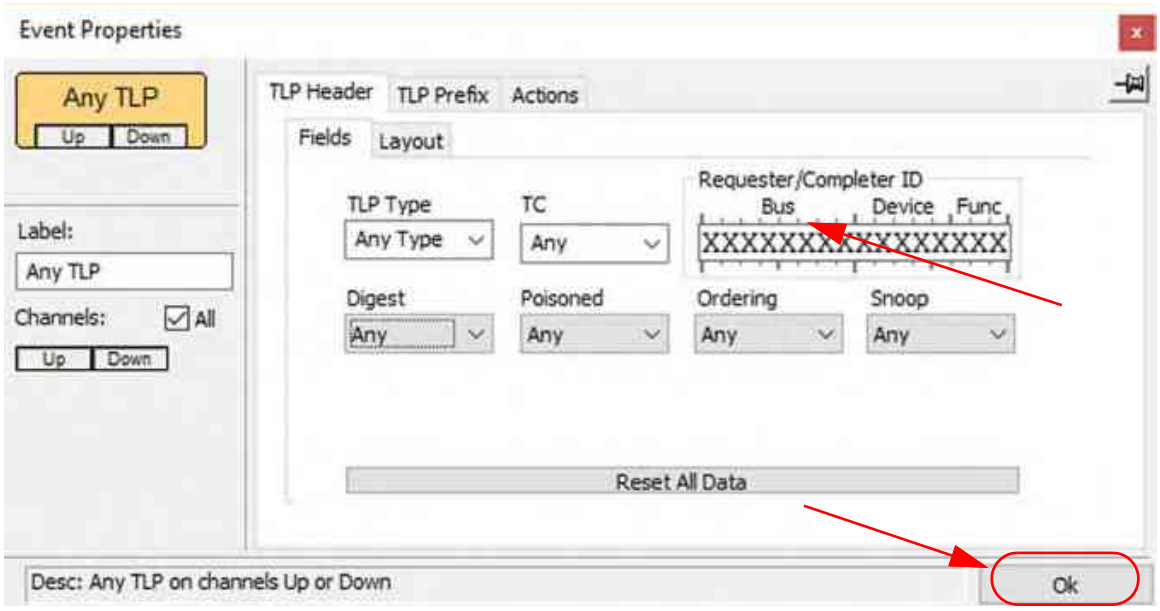


Figure 6.85: TLP Header Properties Dialog.

6.17.9.9 TLP Prefix Properties Dialog

The Layout tab of the TLP Prefix Packet Properties dialog allows you to change the pattern and customize it by defining each specific bit as shown in the figure below. After selecting the options you want click on the “OK” button.

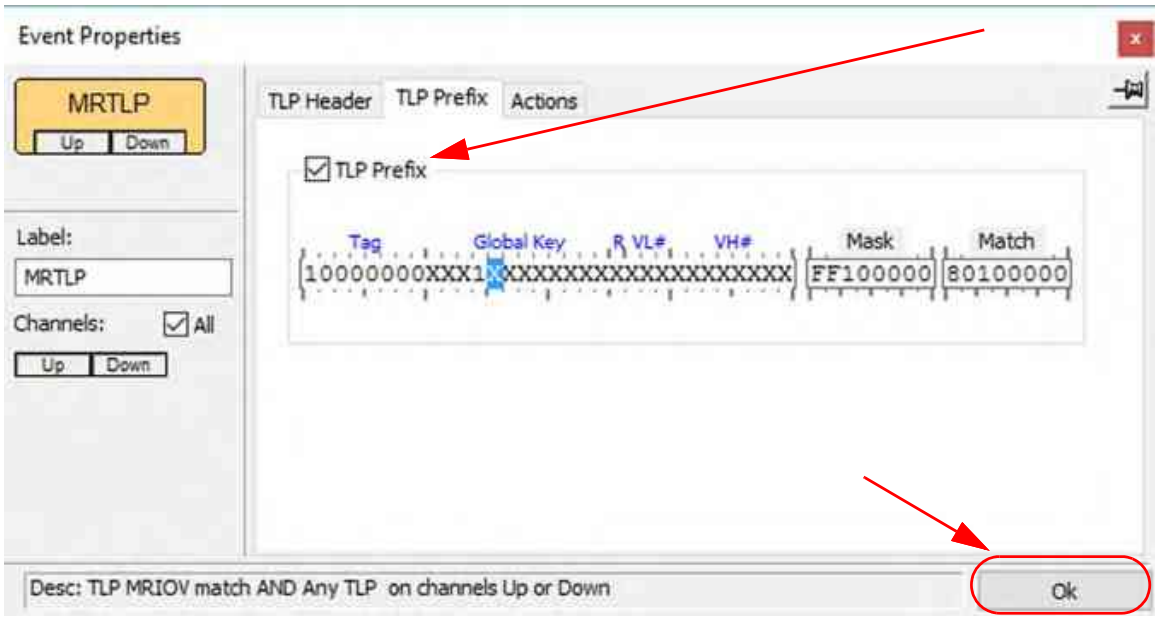


Figure 6.86: TLP Prefix Properties Dialog: (TLP MRIOV Match AND Any TLP)

TLP Actions are shown below in Figure 6.87.

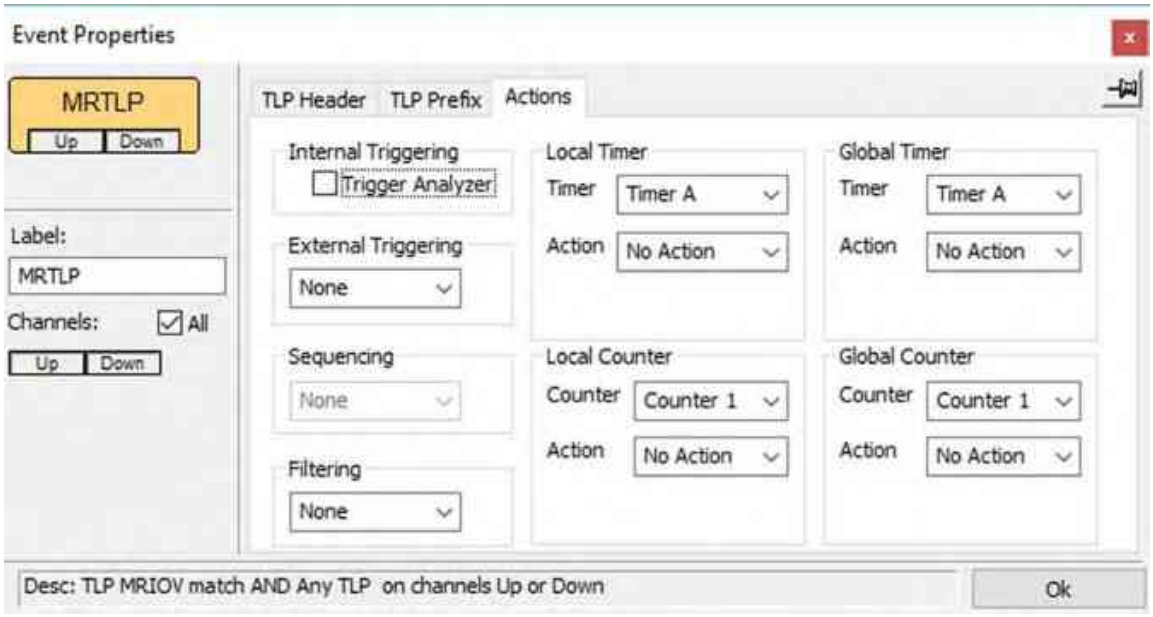


Figure 6.87: TLP MRIOV and Any TLP Event: Actions

TLP: Lightweight Notification -> Message Properties Example

You can set the analyzer to trigger on a TLP Lightweight Notification Protocol Message by selecting TLP -> Message and then setting the “L” bit to 1 in the TLP Header Layout field. See Figure 6.88.

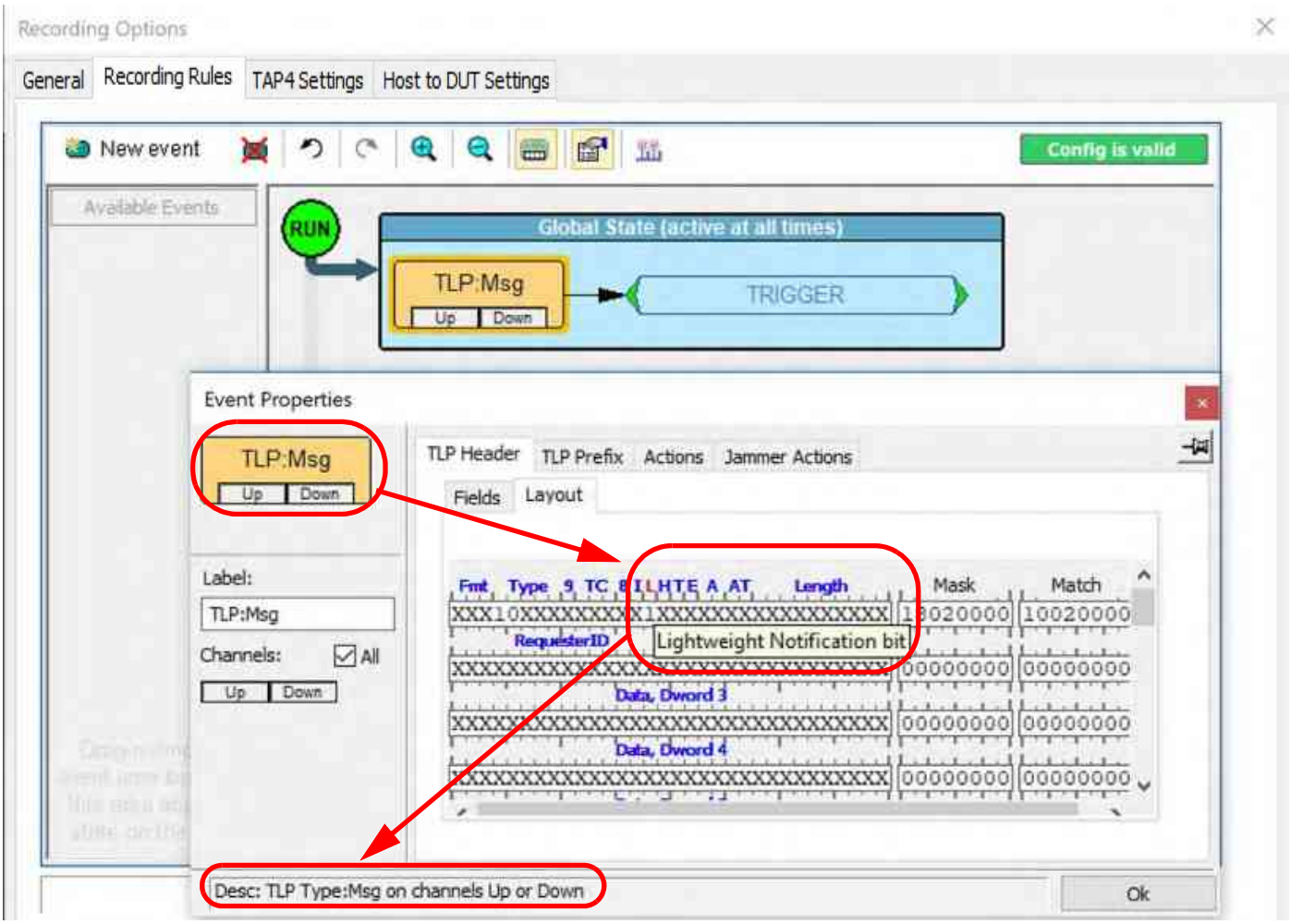


Figure 6.88: TLP: Lightweight Notification Protocol Message

TLP: Lightweight Notification -> Memory Read Example

You can set the analyzer to trigger on a TLP Lightweight Notification Protocol Memory Read by selecting TLP -> Memory Read and setting the “L” bit to 1 in the TLP Header Layout field. See Figure 6.89 on page 230.

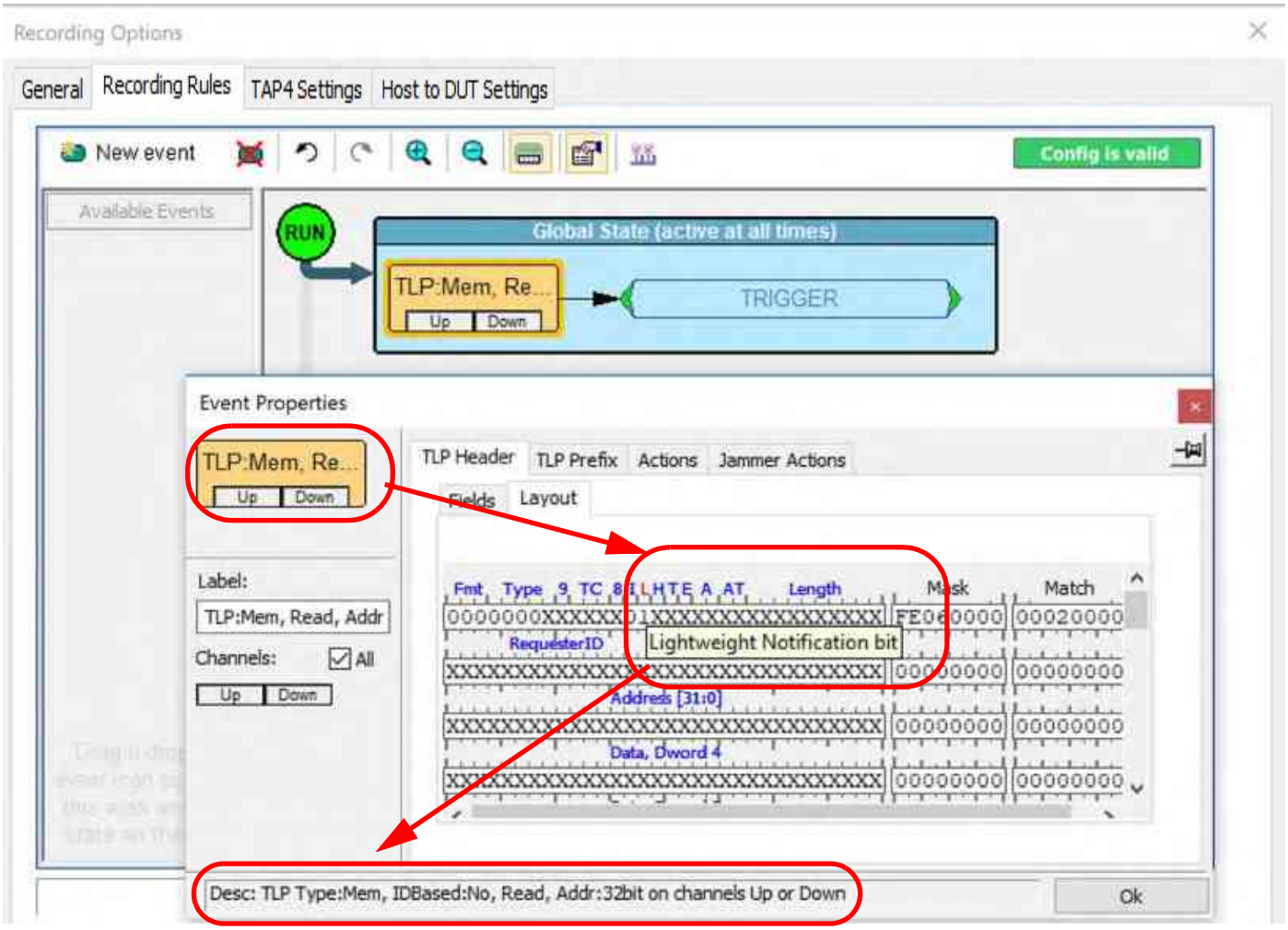


Figure 6.89: TLP: Lightweight Notification Protocol Memory Read

6.17.9.10 NVME Register Properties Dialog

Any of the NVMe Register options can be selected from the New Event list. The NVME Register options are shown in Figure 6.90 on page 231.

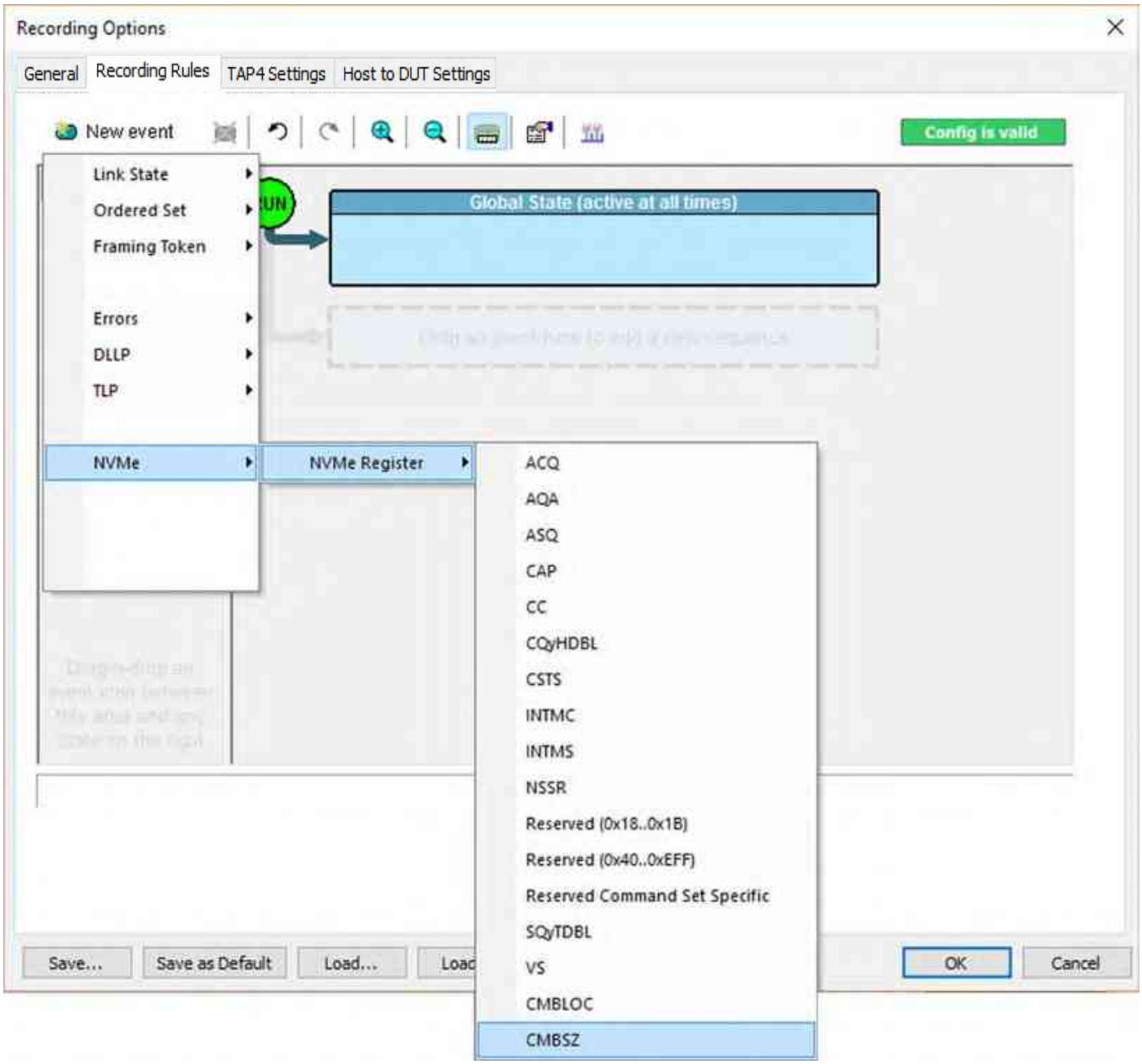


Figure 6.90: NVME Register Options Dialog

The NVME Register Properties dialog allows you to select the MBAR value, choose the Register and Address Type from the drop-down list and enter the offset. See Figure 6.91 on page 232.

The data pattern can be entered directly into the field, but some fields can be selected from the drop-down list. Click on the field name for a list of available registers as illustrated in and Figure 6.92 on page 232.

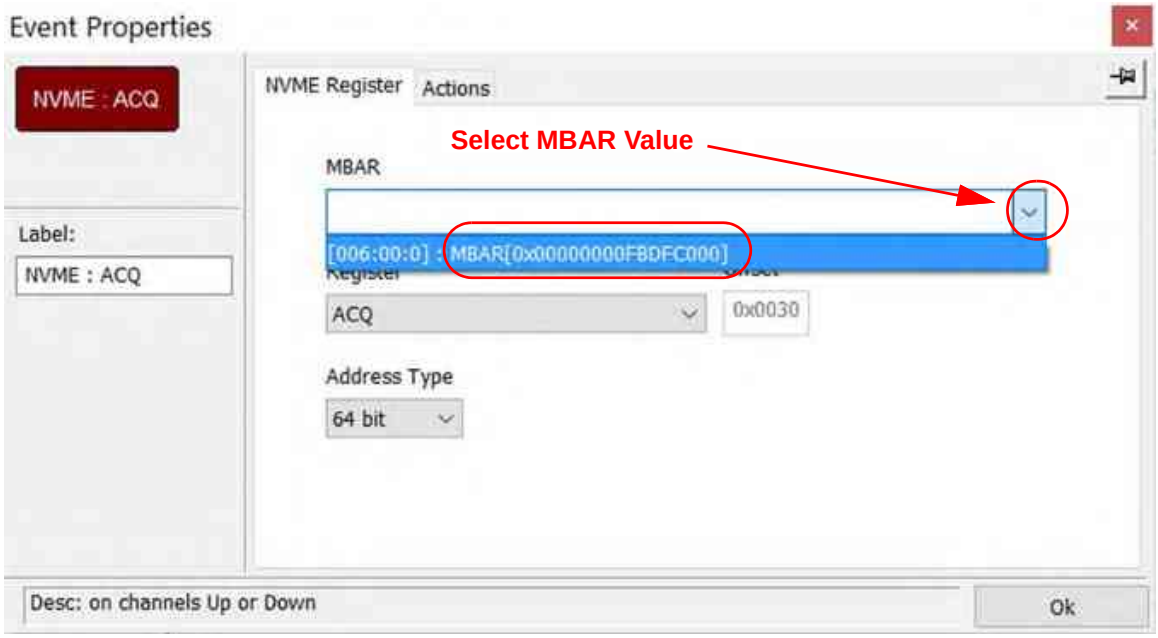


Figure 6.91: NVME Register Properties Dialog with MBAR Value Shown

Note: Triggering on register event with 32-bit address and payload defined is applicable to register write transactions only. After selecting the options you want click on the "OK" button.

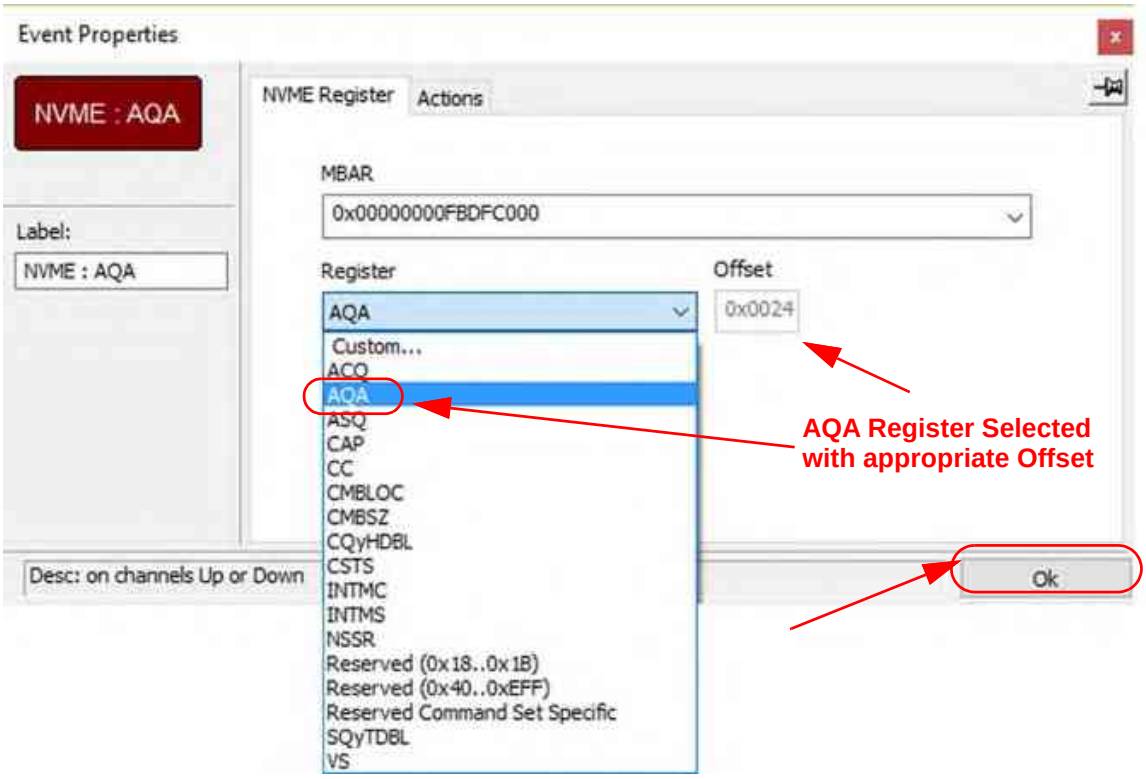


Figure 6.92: NVME Registers from Drop Down List

NVME Register Options: AQA Actions

Select an Action from the NVMe : AQA Actions dialog. See Figure 6.93 and click “OK”.

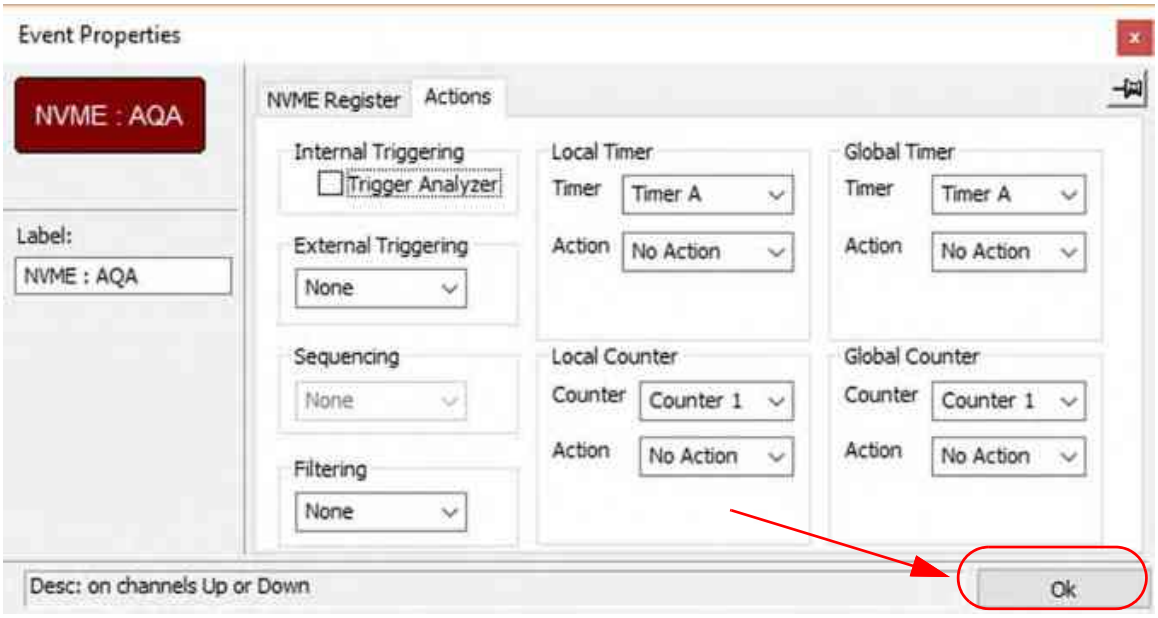


Figure 6.93: NVME Register Options: AQA Actions

6.17.9.11 PQI Register Properties Dialog

The PQI Register Properties dialog allows you to enter the MBAR value, choose the Register and Address Type from the drop-down list and enter the offset. After selecting the options you want click on the “OK” button.

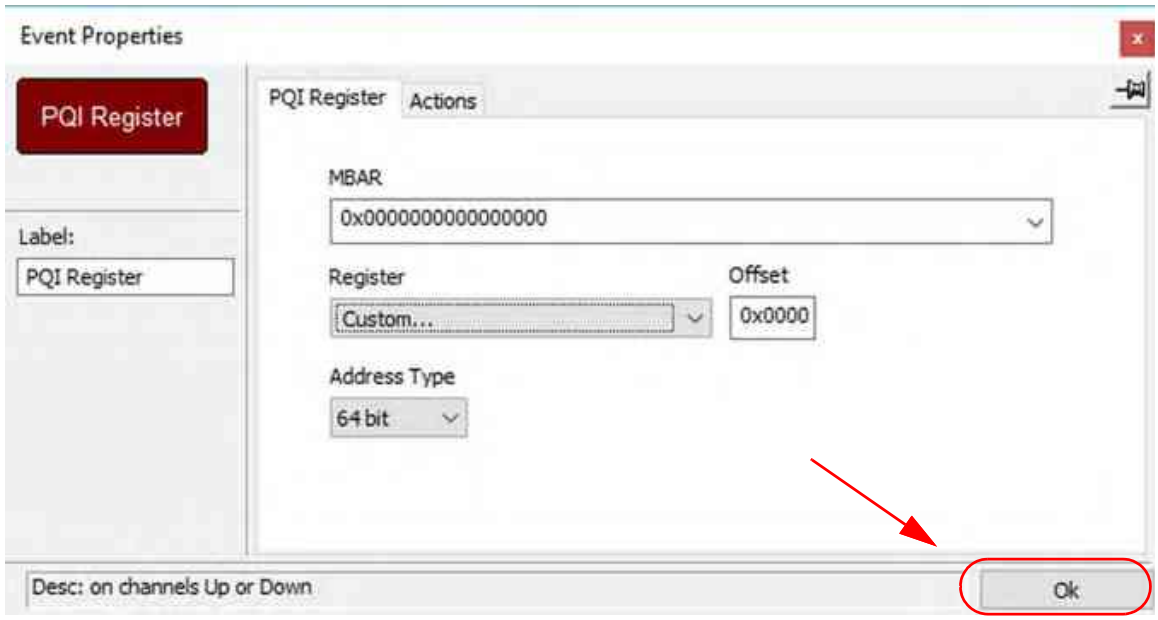


Figure 6.94: PQI Register Properties Dialog.

Note: Triggering on register event with 32-bit address and payload defined is applicable to register write transactions only.

The select an Action from the PQI register Actions dialog. See Figure 6.95 and click “OK”.

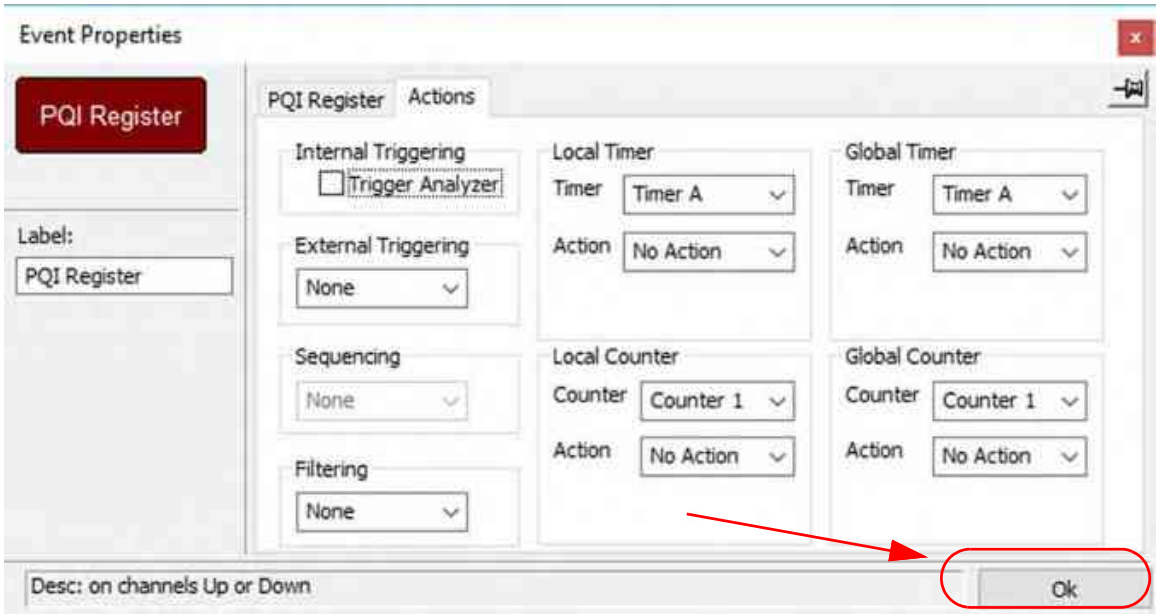


Figure 6.95: PQI Register: Actions Dialog

6.17.10 Actions Properties Dialog

Every Event has an Action tab as shown in Figure 6.96 on page 235.

The following tables describes the Actions for each Event.

TABLE 6.6: Event Actions

Action	Description
Label	Label the action.
Channels	Select Channels to go upstream or downstream.
Internal Triggering	Check the box to enable Internal Triggering from the Trigger In input. Any edge of the supplied signal will cause the analyzer to trigger.
External Triggering	Set the External Triggering to Low, High or Toggle. The default is None.
Sequencing	Set the Sequence to Advance. The default is None.
Filtering	Set the Filtering to Filter Out. You cannot Filter In in the Summit Z3-16. The default is None.
Local Timer	Set the Local Timer, there are four options available.
Action	You can set the Action of the timer to Start or Reset. When you reset the timer it resets to it’s initial value. The default is No Action.

TABLE 6.6: Event Actions

Local Counter	Set the Local Counter, there are four options available.
Local Counter Action	You can set the Action of the Counter to Increment or Reset. The Counter increments by one and resets to its initial value. The default is No Action.
Global Timer	Set the Global Timer, there are two options available.
Global Timer Action	You can set the Action of the timer to Start or Reset. When you reset the timer it resets to it's initial value. The default is No Action.
Global Counter	Set the Global Counter, there are two options available.
Global Counter Action	You can set the Action of the Counter to Increment or Reset. The Counter increments by one and resets to its initial value. The default is No Action.

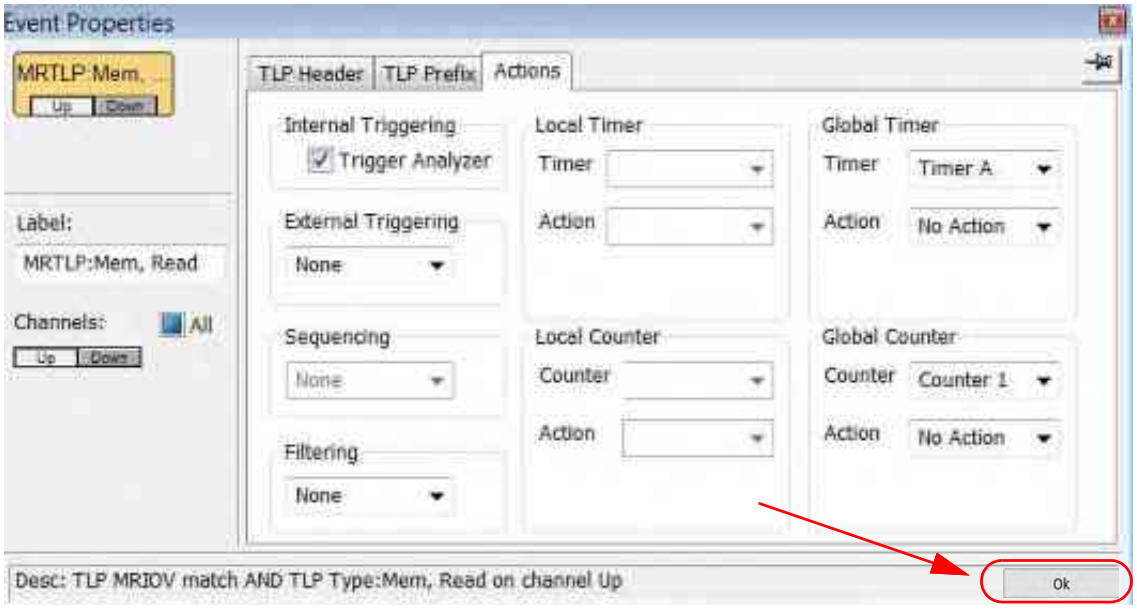


Figure 6.96: Actions Properties Dialog

6.17.10.1 Filter Out

A filter causes the Analyzer to filter out specified events from the recording. If events are filtered out of the recording, they are excluded from the Analyzer's buffer and not simply hidden from the CATC Trace. The purpose of "filtering out" is to preserve recording memory so you conduct longer recording sessions and exclude events that do not interest you.

6.17.10.2 Filter-Out In Simple Mode

In Simple Mode you can filter out:

- SKIP Ordered Sets
- UpdateFC DLLP
- Compliance Patterns

- Modified Compliance Patterns

You can also choose to Ignore EDS and Idle Errors. See Figure 6.97.

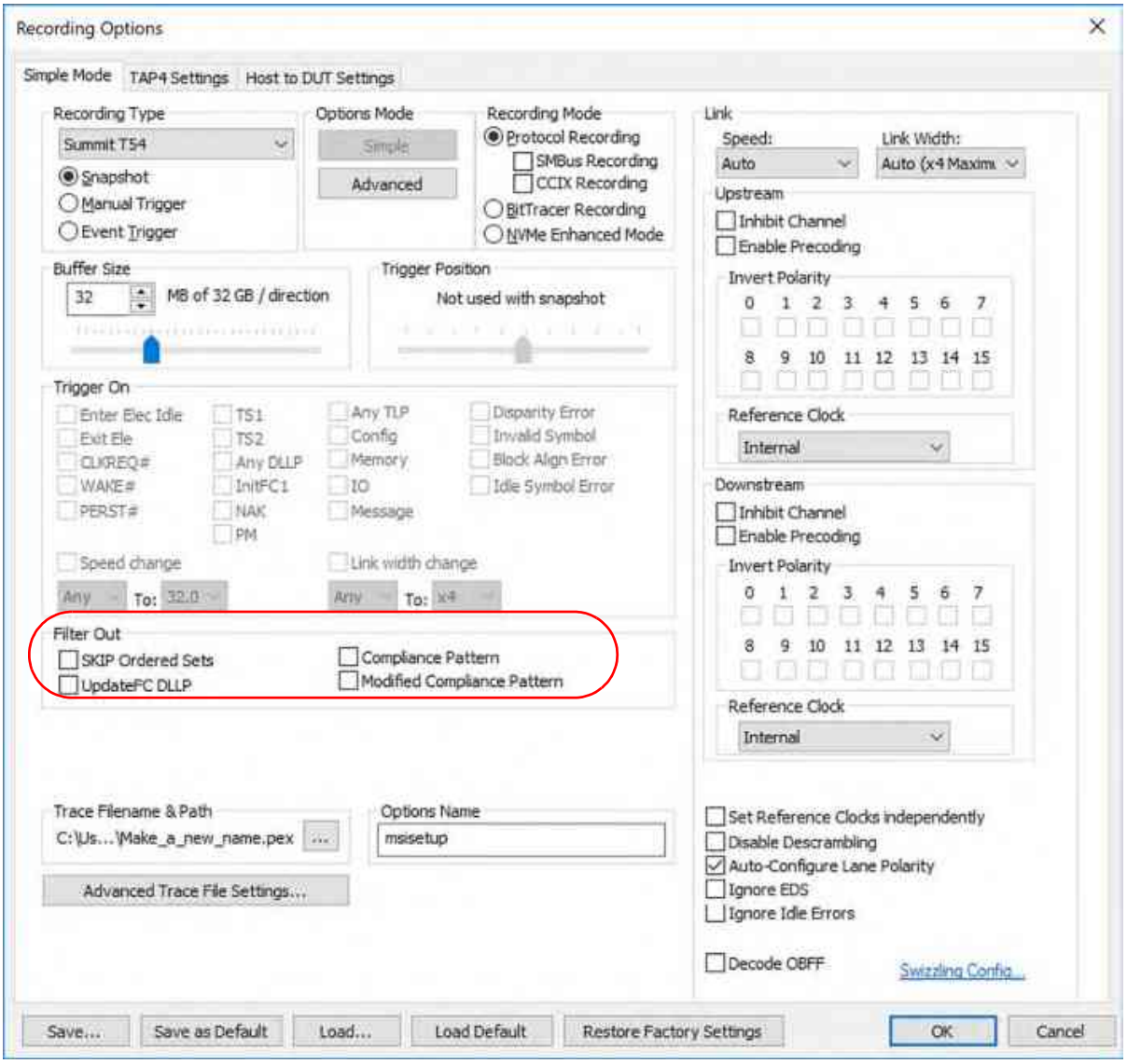


Figure 6.97: Simple Mode: Filter Out -> Summit T54

Note: If you did Filter-Out all the events shown above, you'd create an empty trace and get a warning message (see "Empty Trace File Warning: If you've chosen recording conditions which result in an empty trace (no traffic is recorded), a warning message is displayed." on page 618.)

6.17.10.3 Filter-Out in Advanced Mode

To enable "filter-out" in Advanced Mode, place an event button into either the **Global State** cell or the **Sequence** cell, then right-click the button and choose an **Action** (see

previous topic).

From the sub-menu, select **Filter-Out.** See Figure 6.98.

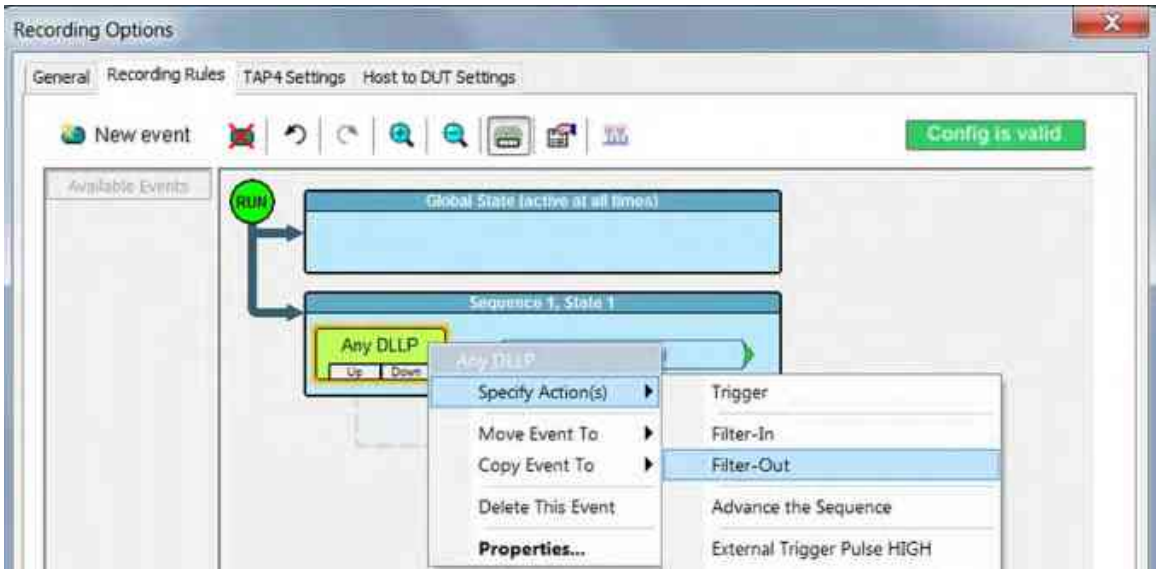


Figure 6.98: Filter Out Option

Note: The Filter-Out option is only available in the DLLP, TLP, TS1 and TS2 Ordered Sets for Link Events: Enter/Exit Electrical Idle, WAKE# Asserted/Deasserted, CLKREQ# Asserted/Deasserted, or Perst# Asserted/Deasserted.

Note: If you did Filter-Out all events by mistake, you create an empty trace and get a warning message. See “Empty Trace File Warning: If you’ve chosen recording conditions which result in an empty trace (no traffic is recorded), a warning message is displayed.” on page 618.

6.17.11 Filter In

“Filter in” is the logical opposite of “Filter Out”. In this case, you are specifically interested in capturing specific events or traffic and ignoring everything else. If events are filtered in to the recording, they are included in the Analyzer's buffer. The purpose of “filtering in” is to preserve recording memory so you conduct longer recording sessions and include only events that interest you. Filter -n is only available in Advanced Mode.

As an example, let’s say you want to capture **Any DLLP** and **Any NVMe:ACQ** Commands.

First switch to **Advanced Mode**.

To enable “Filter-In” place an event button (DLLP -> Any DLLP) into the **Global State** cell, then right-click the button and choose an **Action**. From the sub-menu select **Filter-In.**

Then select NVMe under New Event and NVMe Register:ACQ and place that event into the **Sequence 1, State 1** cell. Then right-click the button and choose an **Action**. From the sub-menu select **Filter-In.** See Figure 6.100 on page 238.

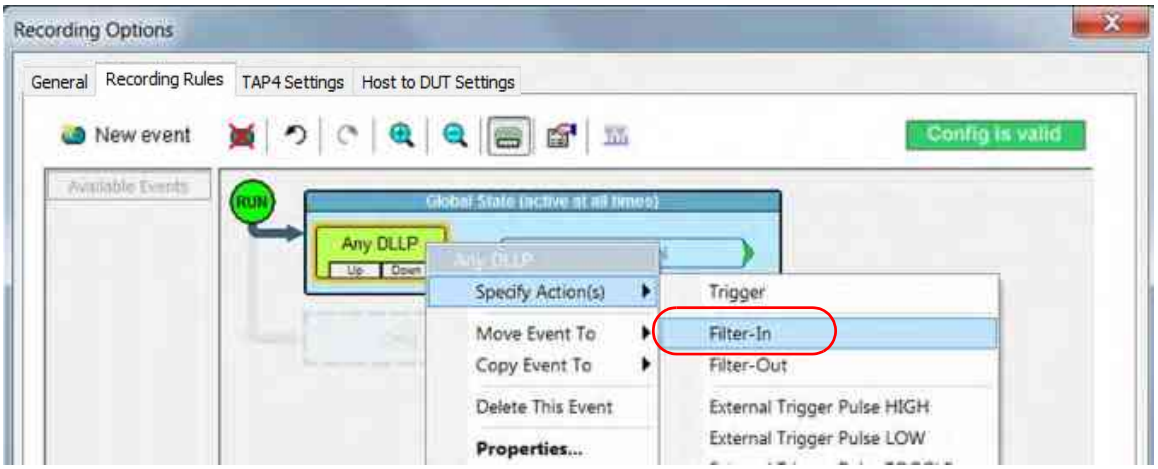


Figure 6.99: Filter In Option

Note: When a **Filter-In** is selected the analyzer filters out everything else by default.

6.17.12 Valid Configuration

In this case, you have chosen a Global State Filter-In on any DLLP and Sequence 1, State 1 to have an NVMe Command:ACQ Filter-In. This is a valid configuration as shown in Figure 6.100.

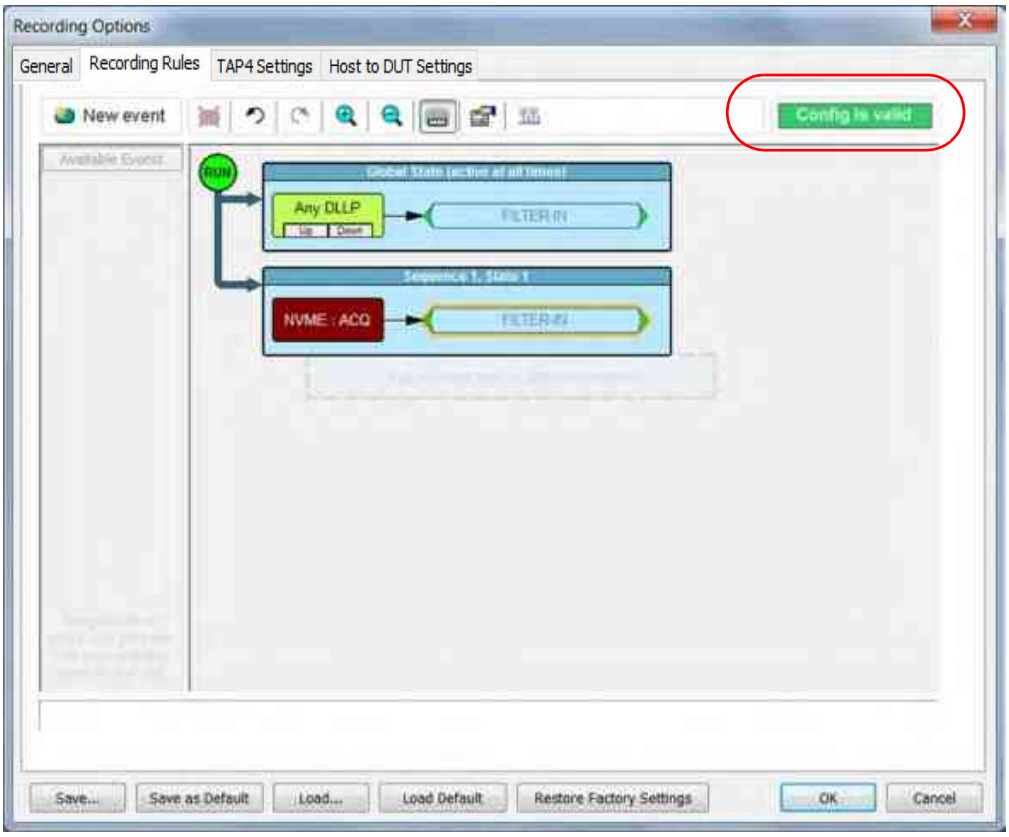


Figure 6.100: Filter In: Advanced Mode: Filter In Any DLLP and Any NVMe ACQ Command

Note: If you change the Global State to Any DLLP but switch to FILTER-OUT you'll get the following warning message: See Figure 6.101 on page 239.

6.17.13 Invalid Configuration

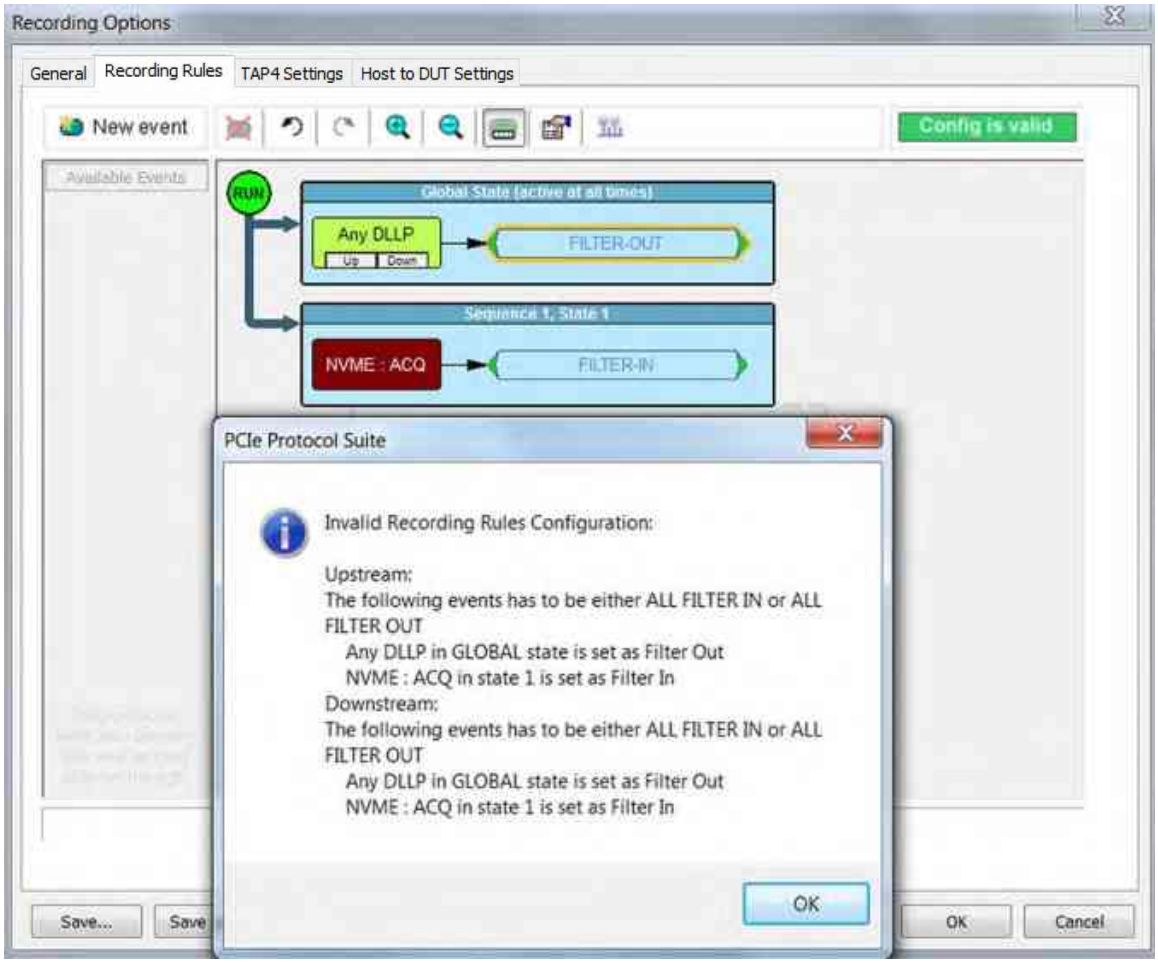


Figure 6.101: Warning Message for Invalid Configuration

The analyzer is warning you that you've set a Global Rule to Filter-Out Any DLLP and that condition will filter out the NVMe:ACQ Command you're looking for. So the recording rules have to be consistent. You'd get the same message if you set Any DLLP to Filter-In but set the NVMe:ACQ Command to Filter-Out. The warning message would pop up and if you hit OK, the **Config is Invalid** message will light up. See Figure 6.102 on page 240.

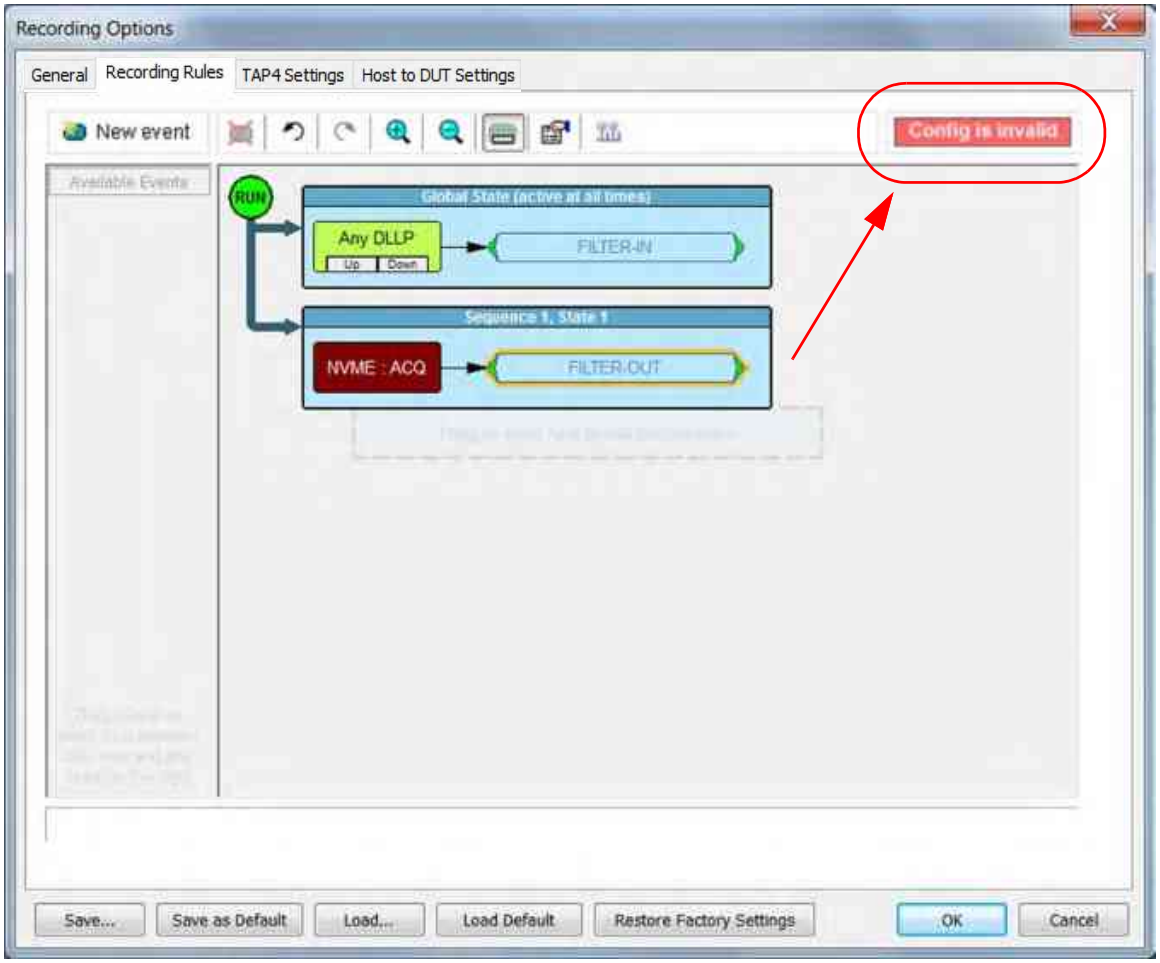


Figure 6.102: Filter In: Any DLLP, Filter Out Any NVMe:ACQ Command -> Invalid Config

So the tool won't let you try to set recording options that are logically inconsistent.

6.17.14 Filtering Events: (Electrical Idle, CLKREQ#, WAKE#, PERST#)

To be able to Filter-out the following events (Electrical Idle, CLKREQ#, WAKE#, and PERST#), the event must be in a global state.

6.17.14.1 Example of CLKREQ# Filtering Enabled

See Figure 6.103 on page 241 for an example of CLKREQ# events in the global state. The event may be both asserted and deasserted or only asserted/ deasserted. Then you will see that filtering of those events is enabled. After selecting the options, click the **OK** button.

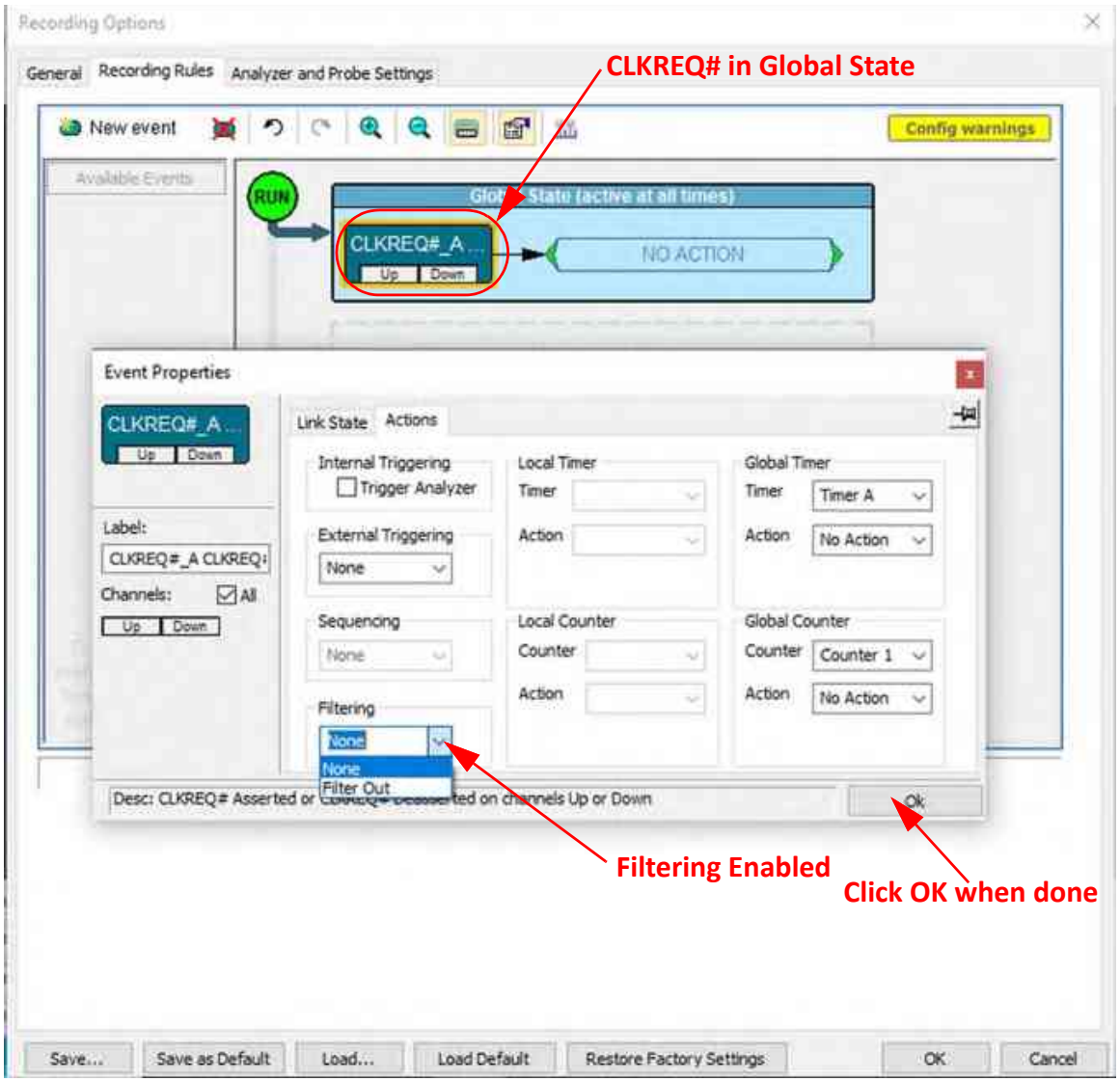


Figure 6.103: Link Event: CLKREQ# => Event in global state => Filtering Enabled

6.17.15 Filtering Out NVMe CSTS, DLLP Ack and TLP Completions

To enable longer recordings, you can filter out NVMe CSTS, DLLP Acks and TLP Completions in Global Options by using the Advanced Recording Options. See Figure 6.104.

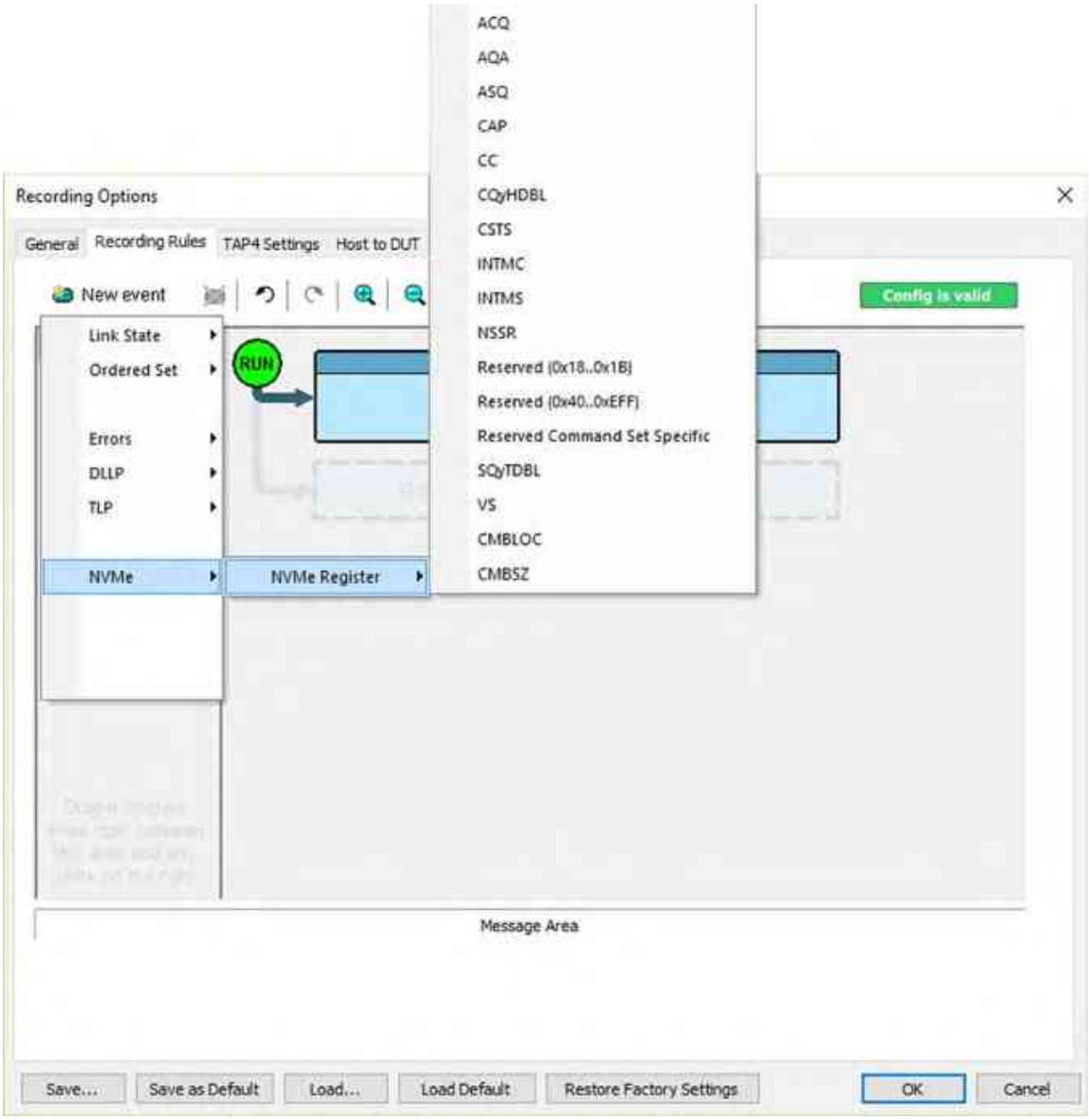


Figure 6.104: Filtering Out NVMe CSTS

If you select **New Event -> NVMe -> NVMe Register -> CSTS -> Actions** you'll have the option to filter out the CSTS events. See Figure 6.105 on page 243.

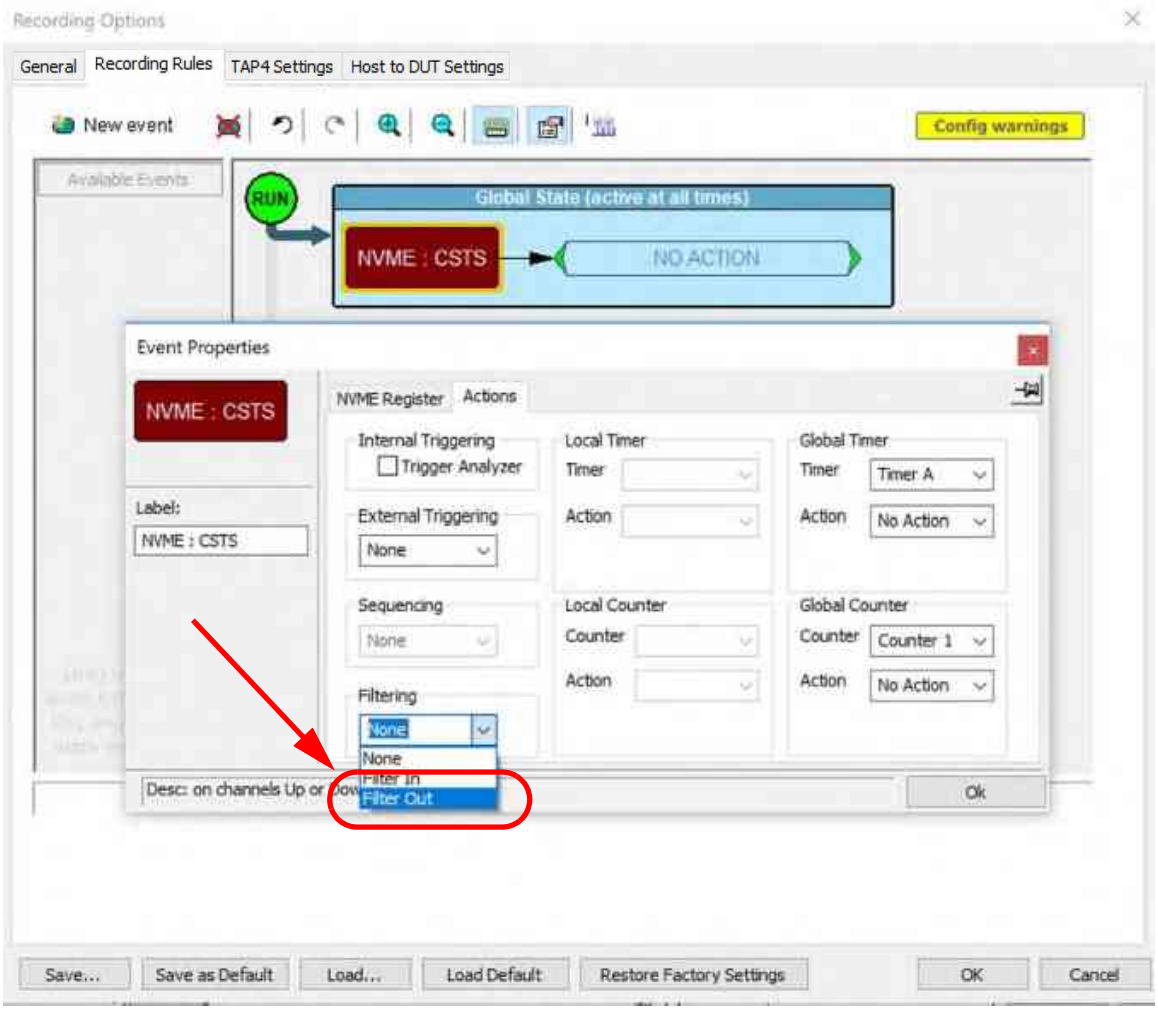


Figure 6.105: Selecting Recording Options: NVMe -> CSTS Event

Set the Action to Filter Out. Then click on “OK”. See Figure 6.106 on page 244.

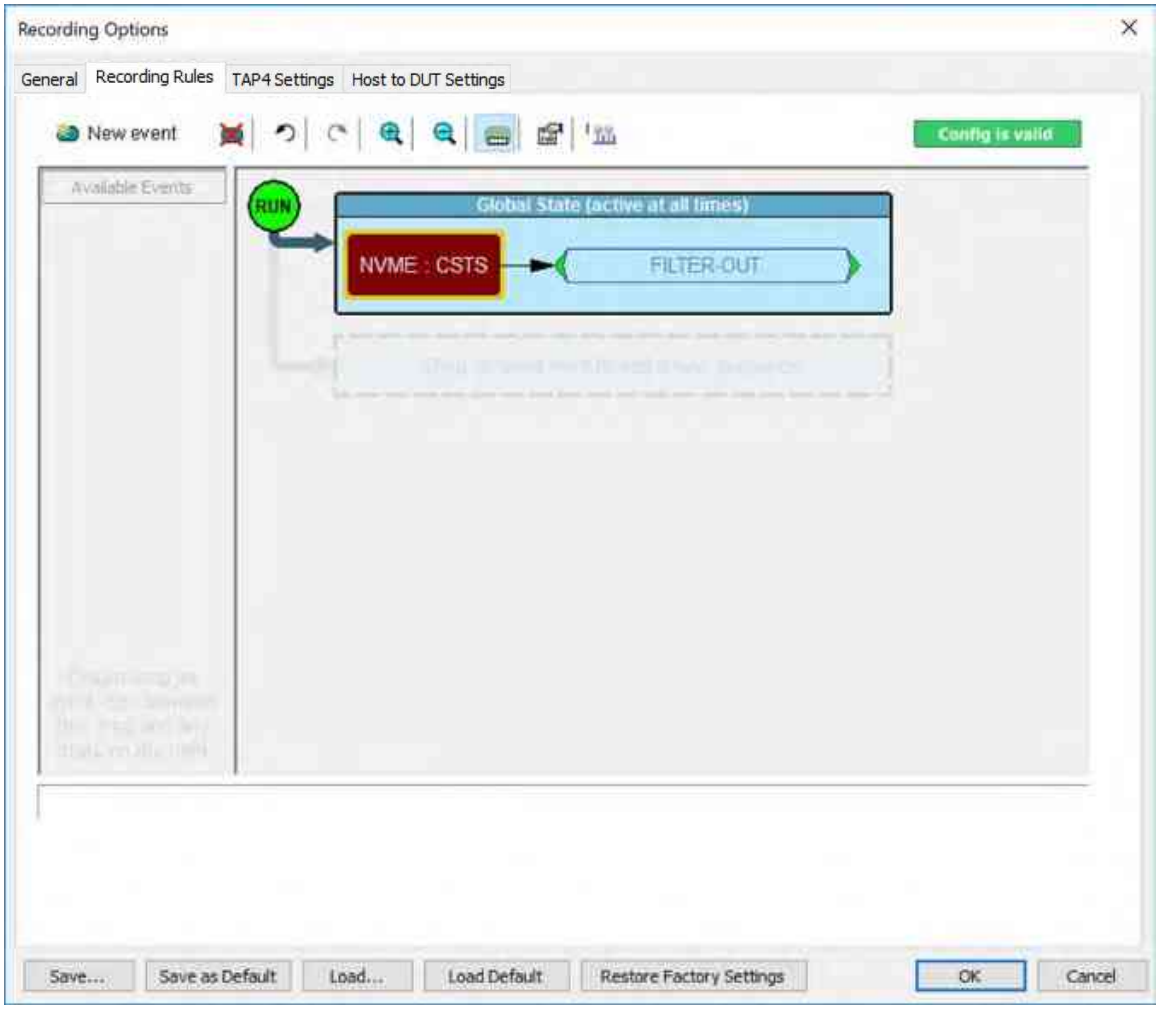


Figure 6.106: Recording Options: Filter Out NVME CSTS

Next add DLLP Acks to also be Filtered Out. See Figure 6.107 on page 245.

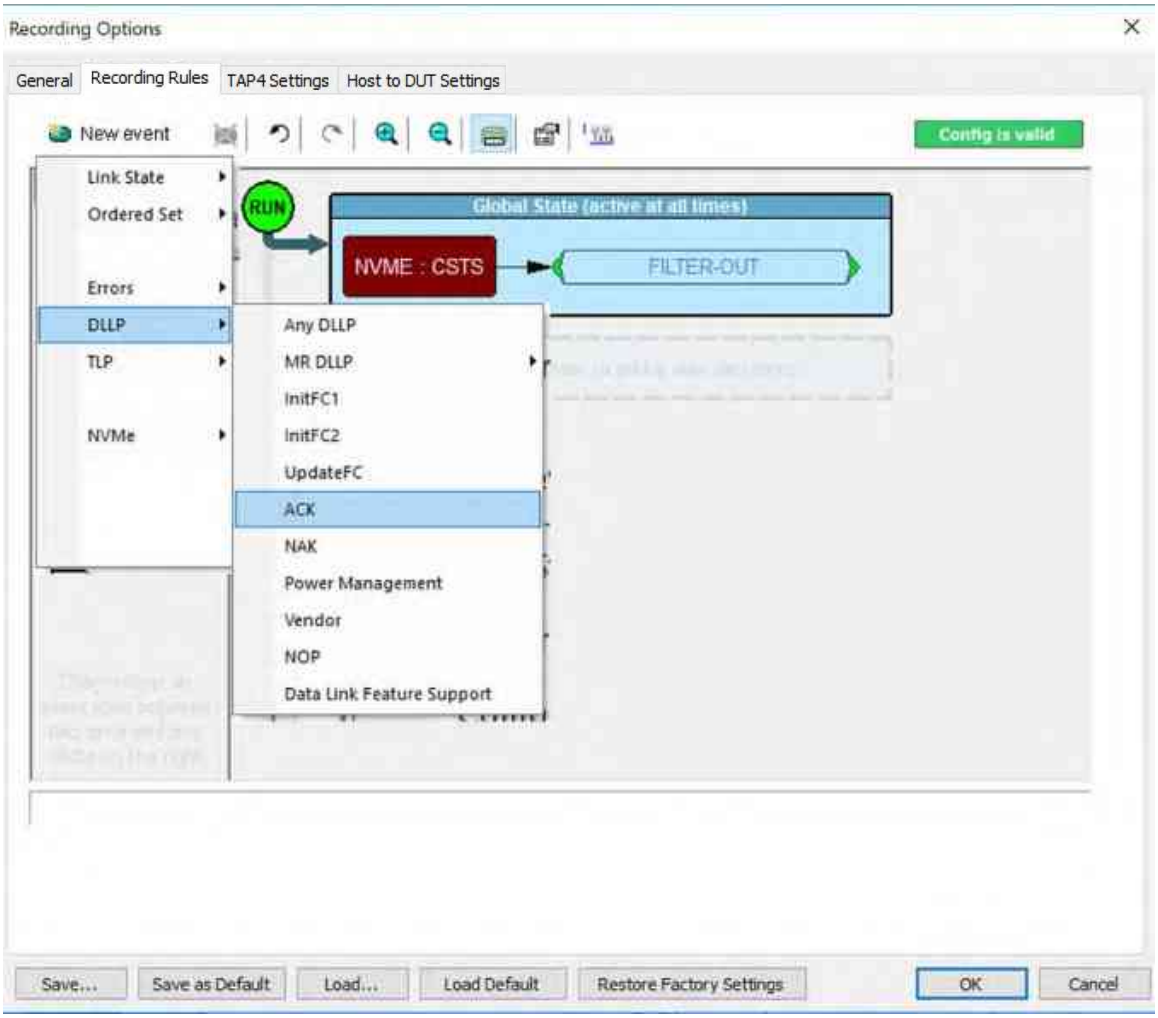


Figure 6.107: Recording Options: DLLP -> ACK

Click on “OK”, then add the Action -> Filter Out and place the DLLP in the Global State. See Figure 6.108 on page 246.

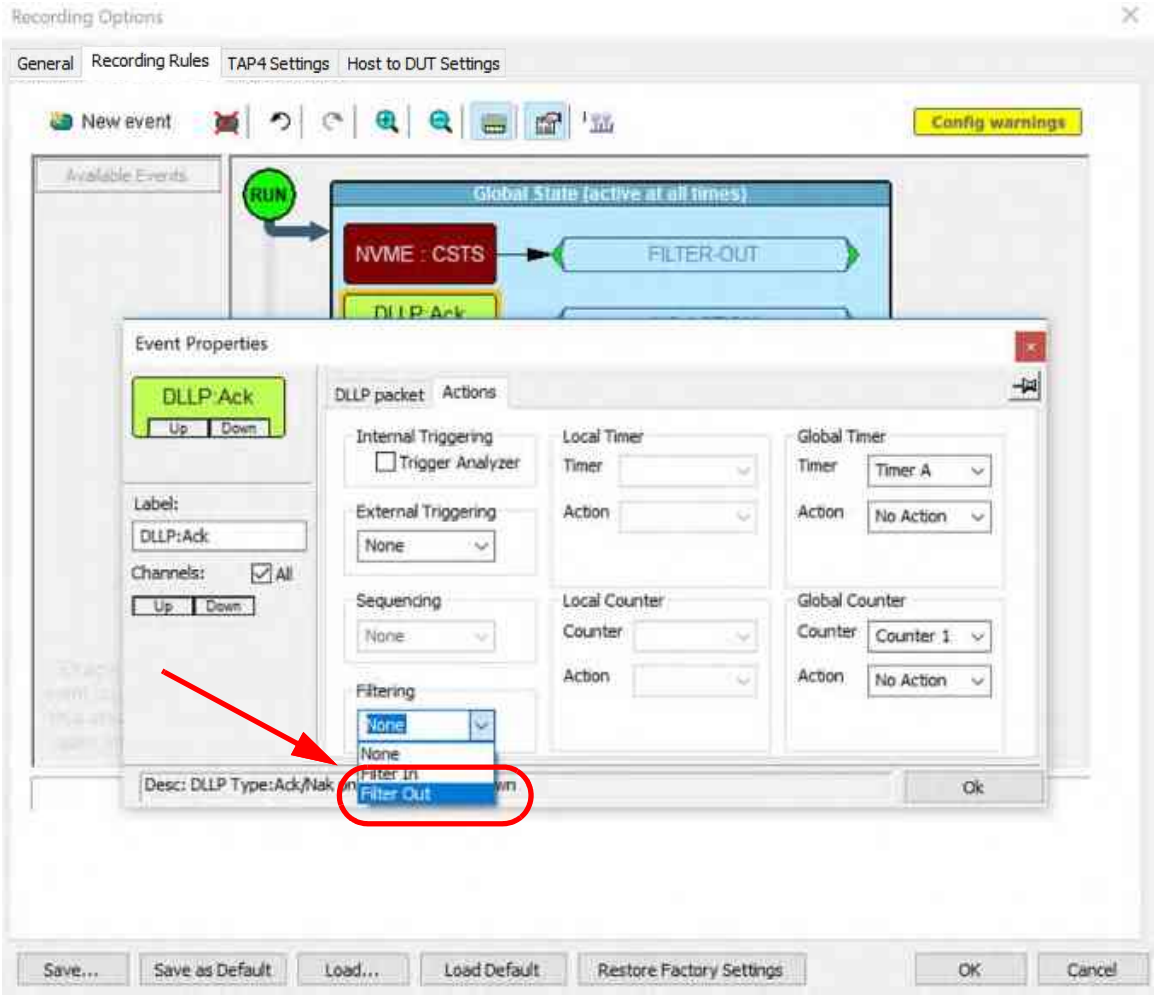


Figure 6.108: Select Action: Filter Out

Select Actions -> Filtered Out.

Click on “OK” and the DLLP:Ack with Action “Filter-Out” will be placed in the Global Options state. See Figure 6.109 on page 247.

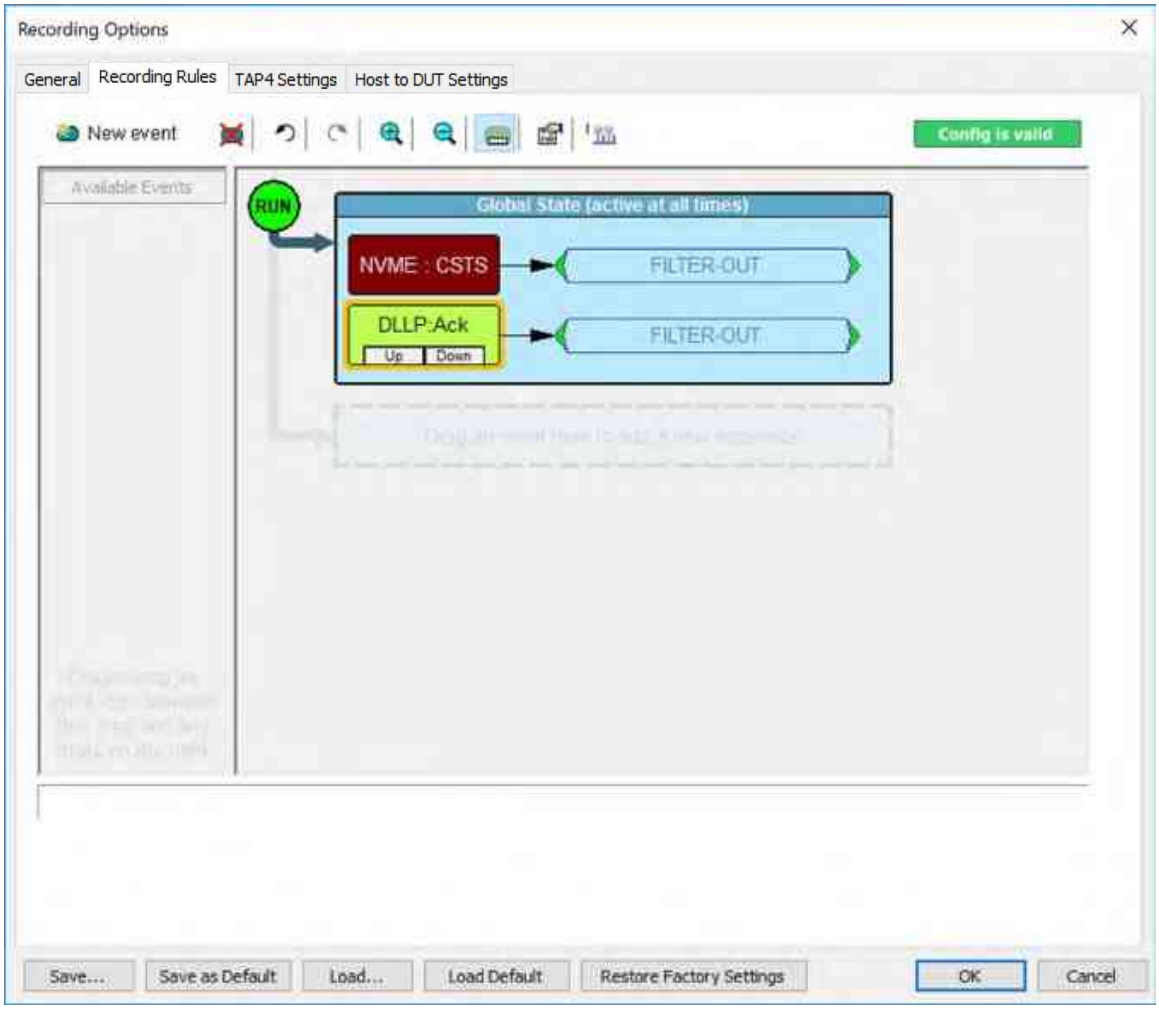


Figure 6.109: Place Recording Option: DLLP:Ack -> Filter-Out in the Global State

To these Recording Options you can add TLP Completions. See Figure 6.110 on page 248.

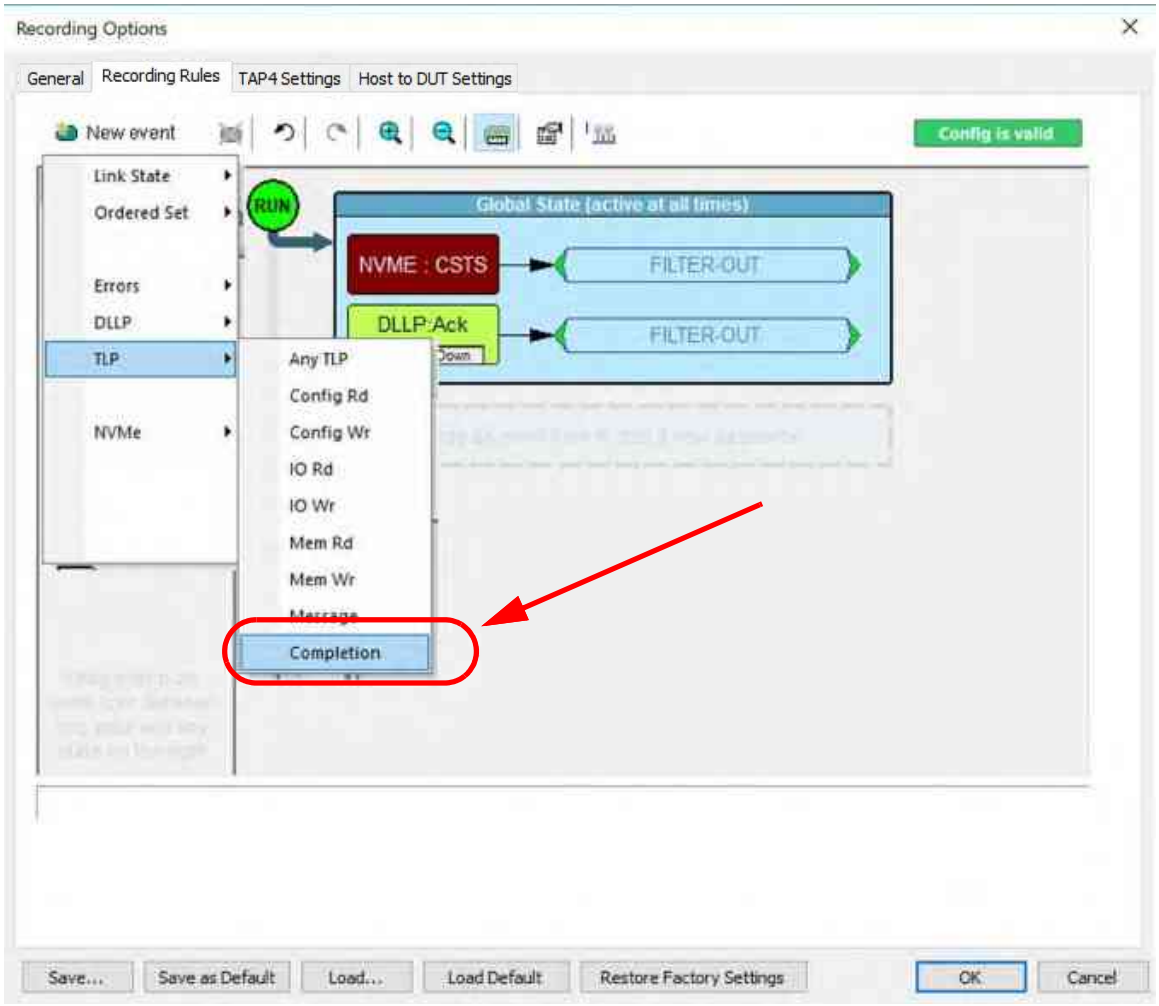


Figure 6.110: Recording Options: NVME, DLLP -> Filtered Out, Add TLP Completion

Then add the TLP Completion Layout Options. Set the Type to Cpl/CplD. See Figure 6.111 on page 249.

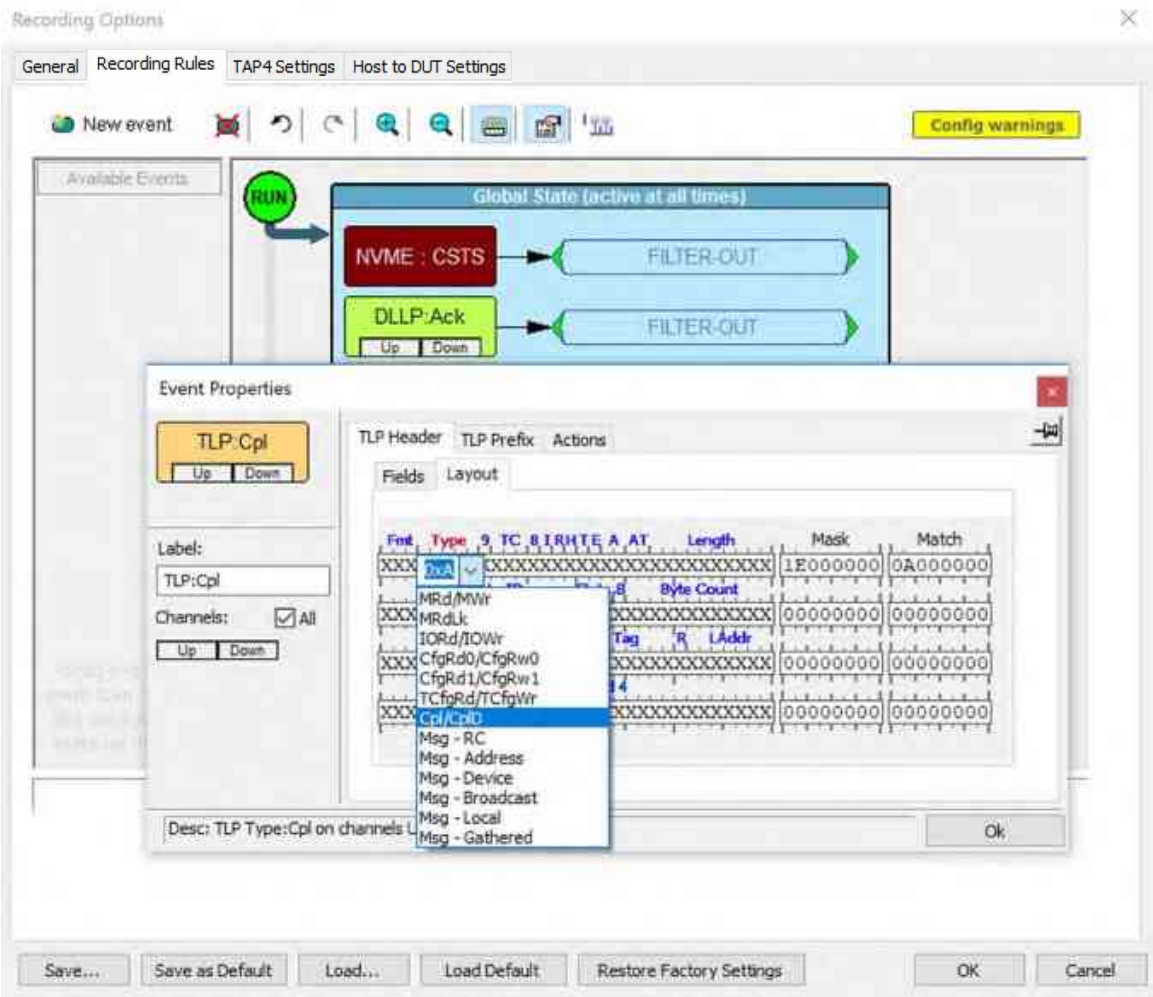


Figure 6.111: Recording Options: TLP:Cpl -> Select CPl/CplD

Next set the LAddr Layout Option to 0x1C. See Figure 6.112 on page 250

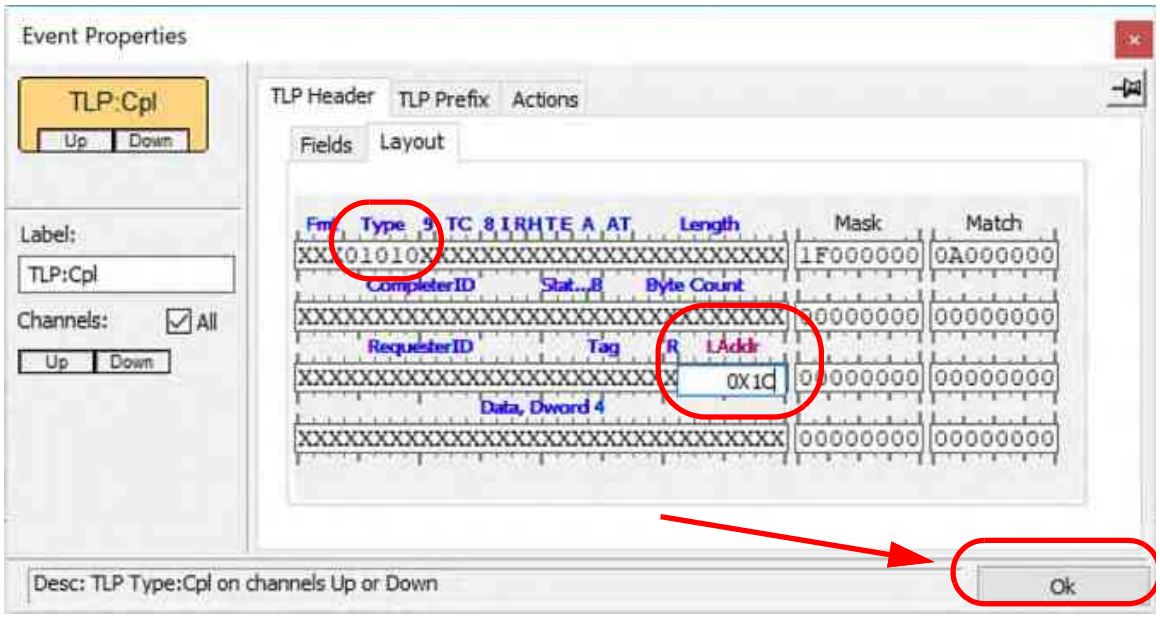
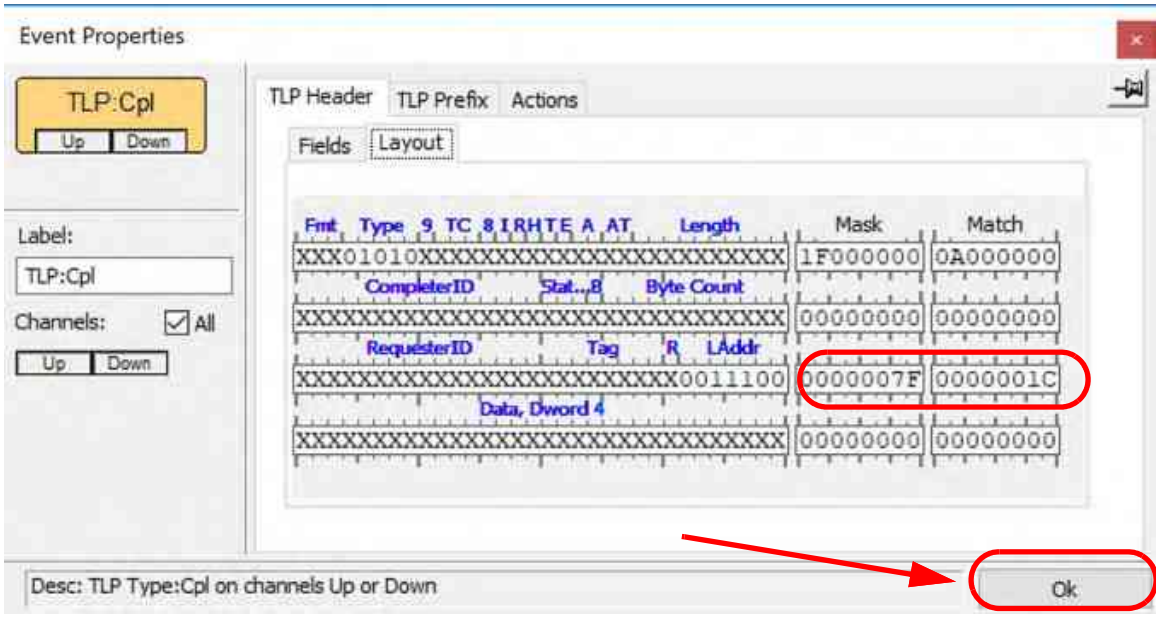


Figure 6.112: Recording Options: TLP:Cpl -> Layout Type: 01010, LAddr: 0x1C

This will set the Mask to 7F and the Match to 1C. See Figure 6.113.



Click on “OK” and then set the Action to Filter-Out. See Figure 6.113 on page 251.

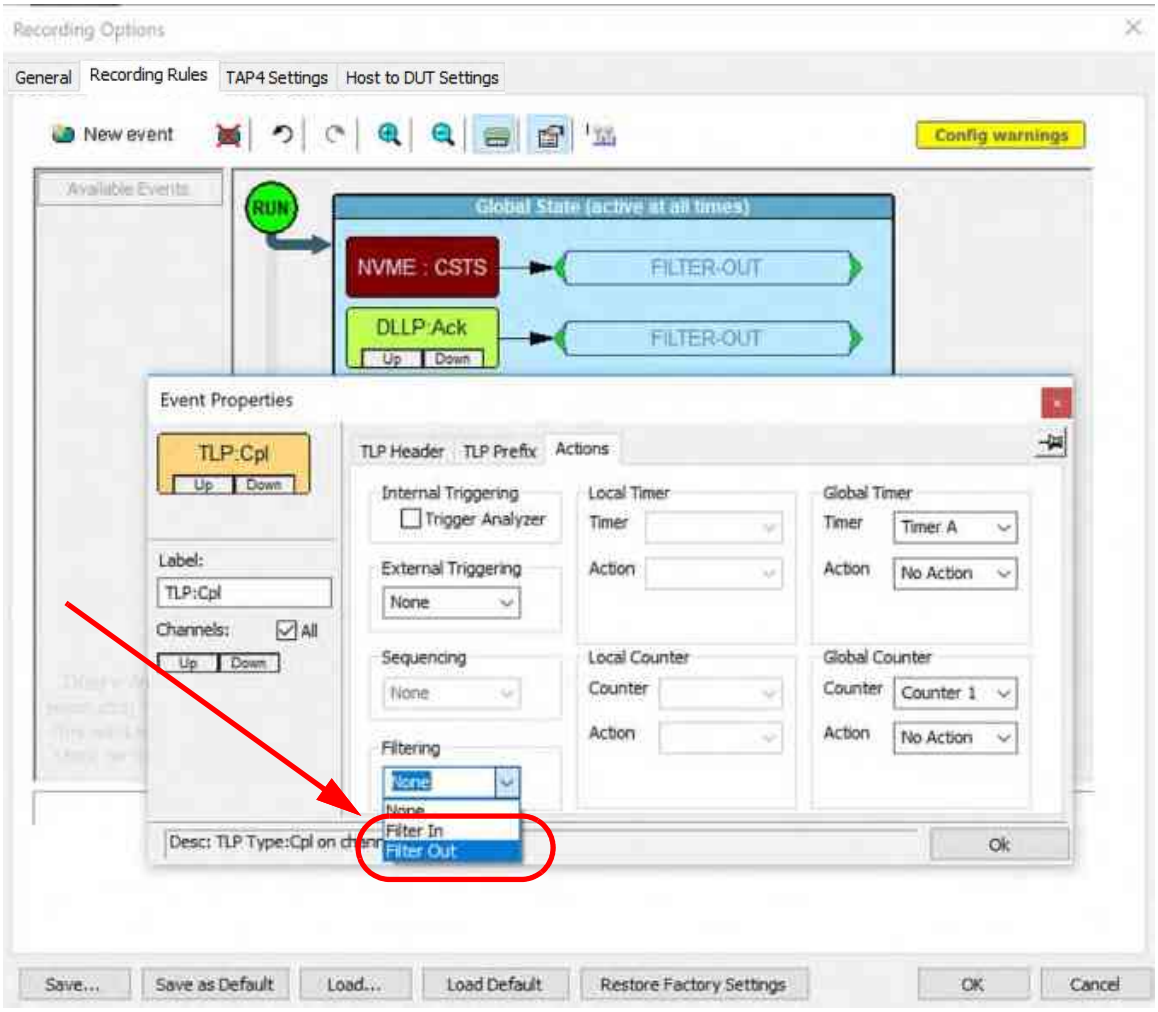


Figure 6.113: TLP:Cpl -> Actions: Filter-Out

Add this property to the Global State. See Figure 6.114 on page 252.

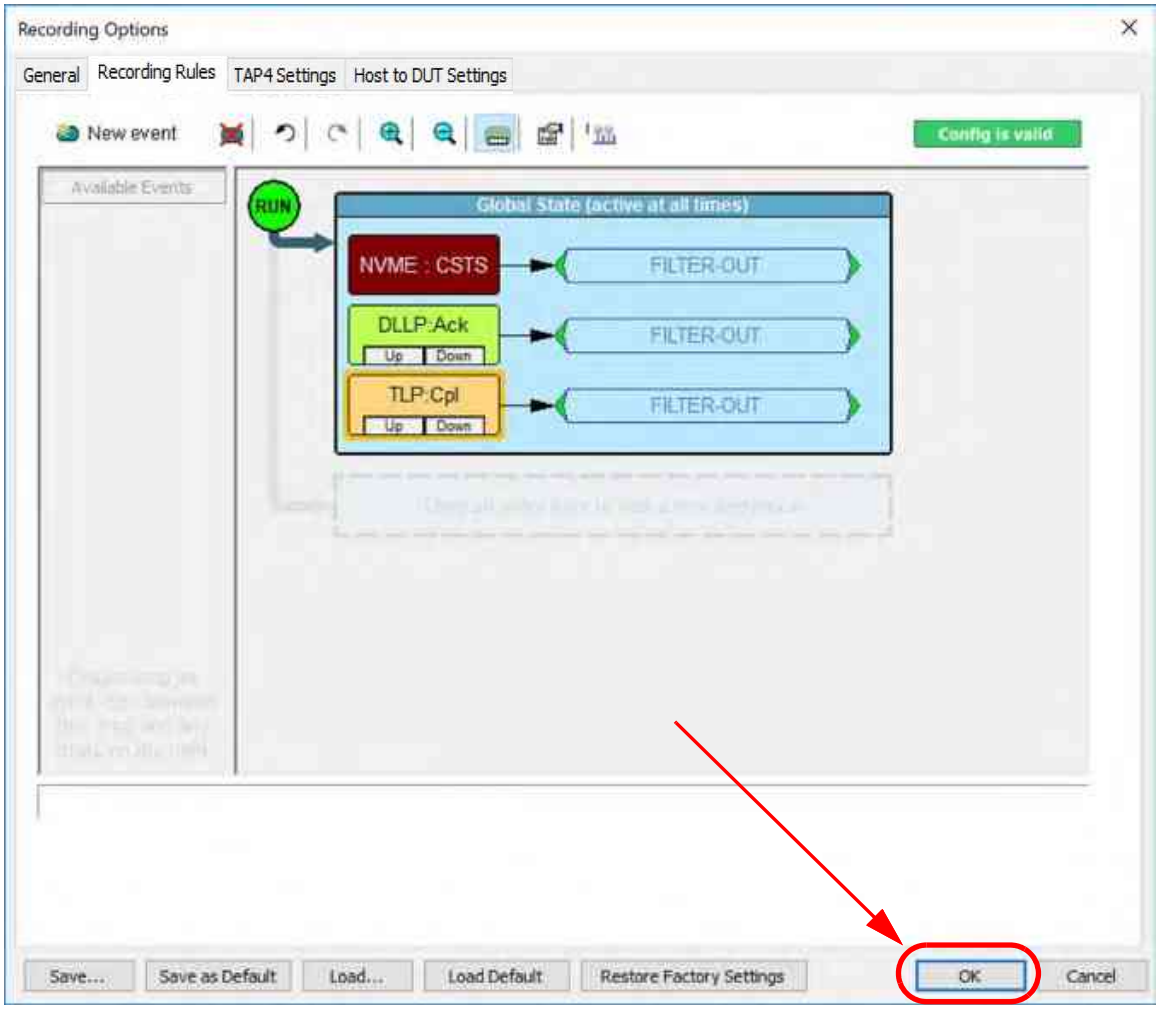


Figure 6.114: Recording Options: NVME, DLLP and TLP all Filtered-Out

Click on **OK** and these Properties will all be Filtered Out of the recording.

6.17.16 Triggering Configuration on a per Lane Basis

The Lane Trigger Configuration Icon (available on the Recording Options => Recording Rules toolbar see Figure 6.115) provides the user with the ability to add pre-conditions on specific lanes that the analyzer will use as an additional restriction on a defined triggering event.

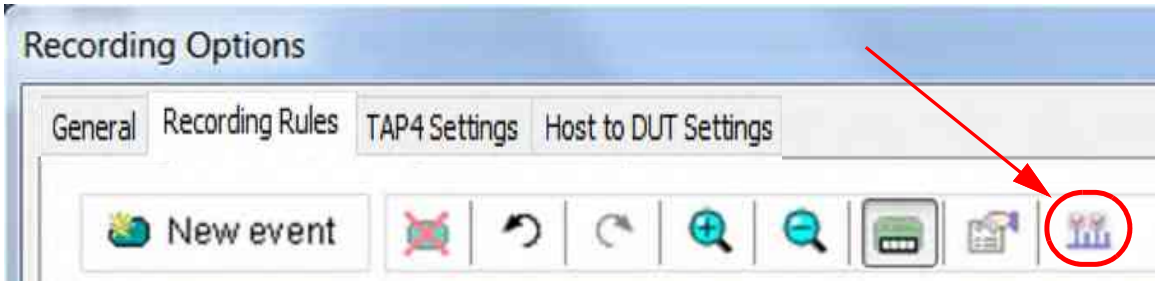


Figure 6.115: Lane Trigger Configuration

This option has three categories of events which can be made lane-based:

- DLLP/TLP Packets
- Errors
- Ordered Sets

Each of these events has restrictions on the lanes available, as spelled out in the GUI.

- These selections will be applied globally
- Lane selections will be applied to logical lane(s) and NOT physical lane(s)
- Default is “all Lanes”, but you can select one or more lanes as targets
- Filter-in/out will not function is you are using per lane triggering

6.17.16.1 DLLP/TLP Packets Category

For DLLP/TLP packets starting in selected lanes, the packet must start in lanes 0, 4, 8 or 12. One or more of these four lanes can be selected to look for the start of DLLP/TLP packets and the selection can be made for each direction by checking boxes.

See Figure 6.116.

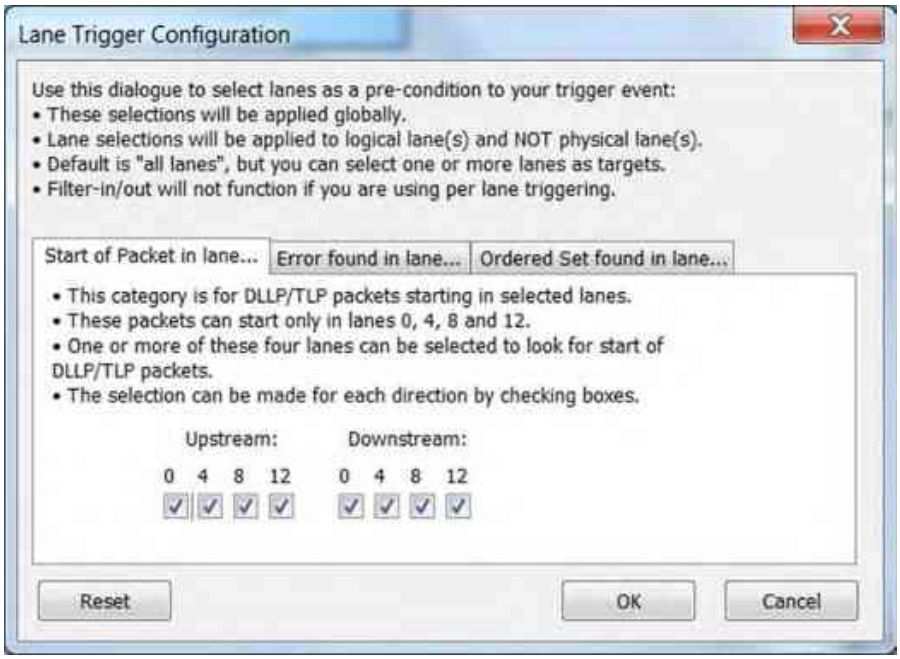


Figure 6.116: Start of Packet in lane GUI

6.17.16.2 Errors Category

Errors category can be used as a pre-condition to trigger on an event in selected Upstream or Downstream lanes. The types of errors that will be detected are limited to:

- Symbol errors
- Disparity errors
- Block errors

See Figure 6.117.

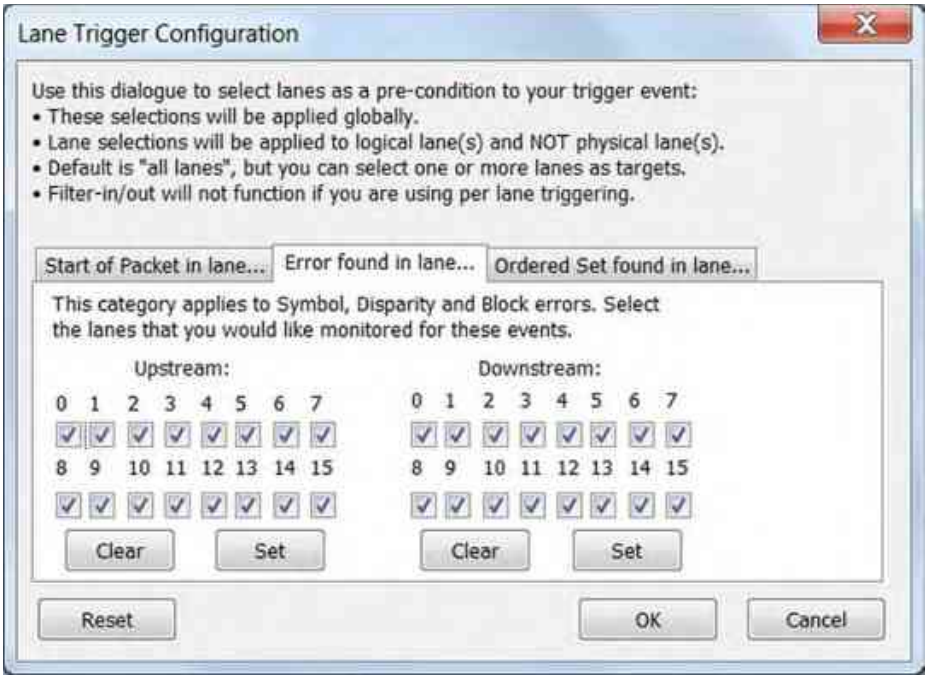


Figure 6.117: Error Found In Selected Lanes

6.17.16.3 Ordered Sets Category

This category includes all types of ordered sets (TS1, TS2, EIEOS, EIOS, Skip, FTS, and SDS).

If a specific lane is selected in the Event Properties dialog of a TS ordered set the same specific lane must be selected here or no triggering event will occur.

See Figure 6.118.

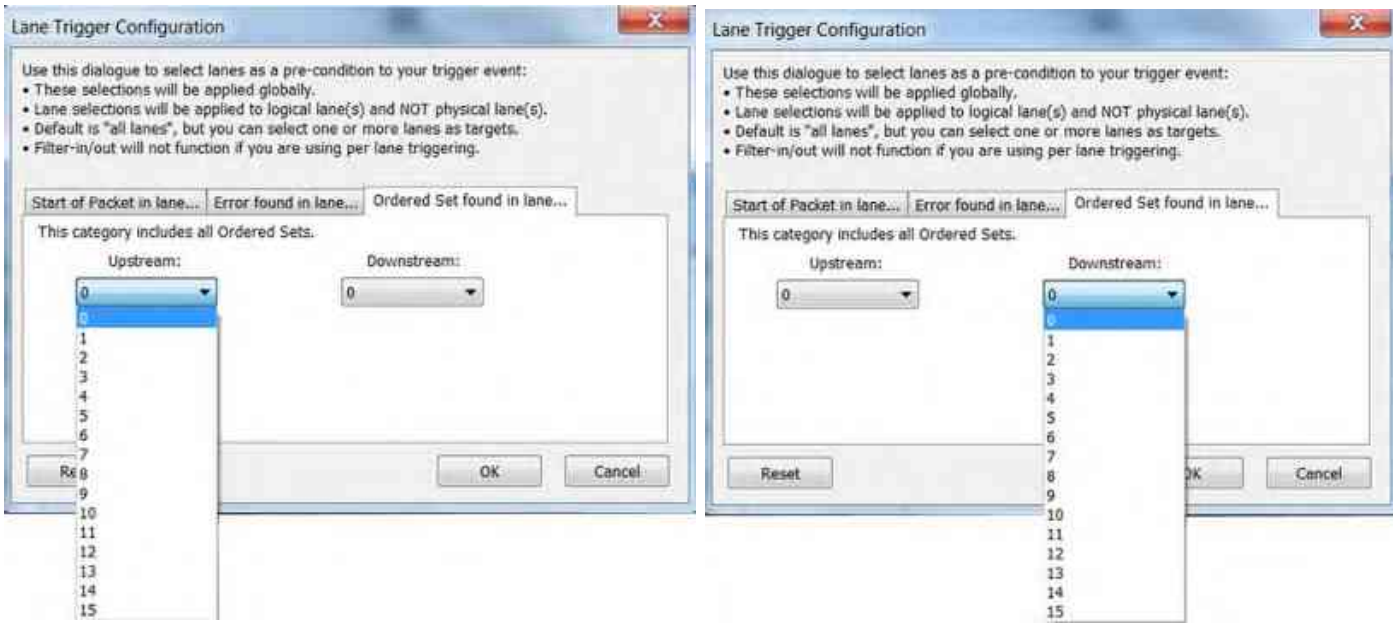


Figure 6.118: Ordered Sets Found in Upstream and Downstream Lanes

6.17.17 Lane Trigger Configuration

6.17.17.1 Example 1:

If you need to trigger on TLPs that start on lane 4 in the upstream direction perform the following selection (see Figure 6.119):

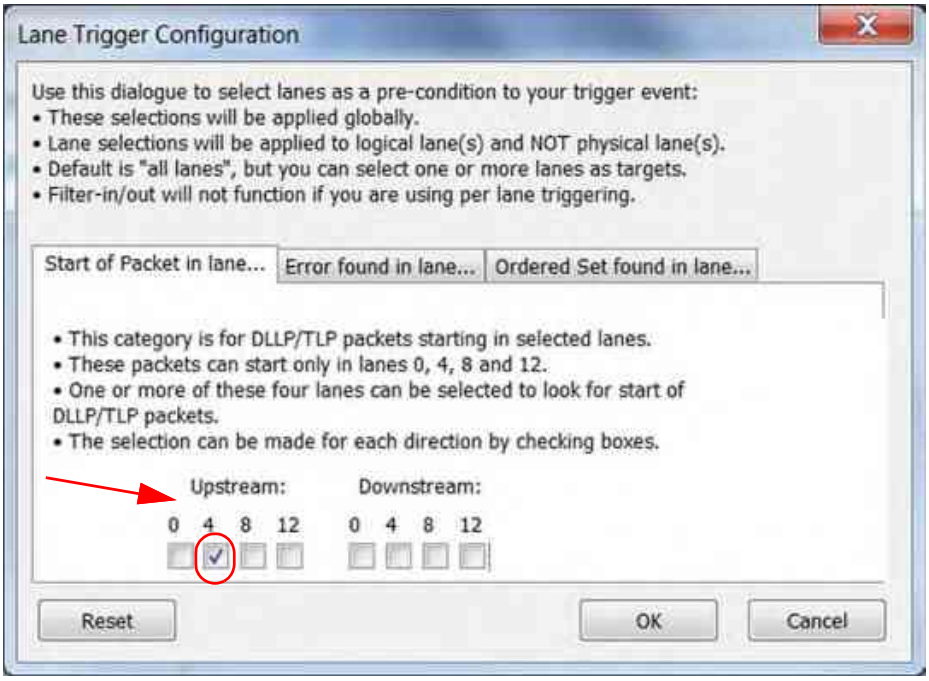


Figure 6.119: Lane Trigger Configuration: Example 1

Then select the appropriate event to trigger the analyzer.

6.17.17.2 Lane Trigger Configuration Example 2:

If you need to trigger the analyzer on errors happening on lanes 4 and 6 in the upstream direction, perform the following selections:

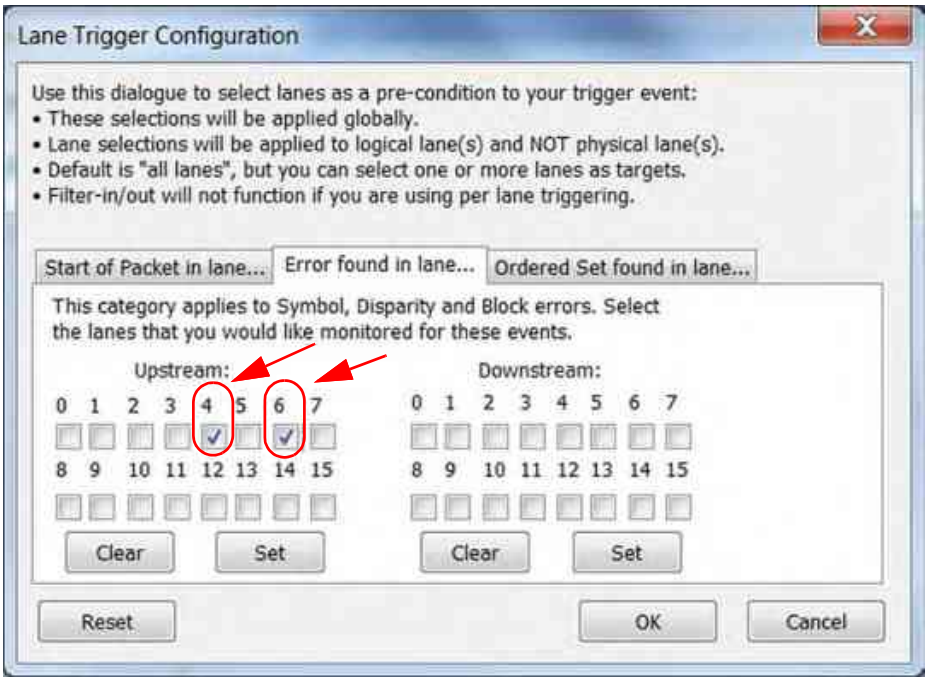


Figure 6.120: Lane Trigger Configuration: Upstream Errors on Lanes 4 and 6

Then select the appropriate event to trigger the analyzer.

6.17.17.3 Lane Trigger Configuration Example 3:

If you need to trigger on a TS1 Event with Link Number = 00 and Lane Number = PAD that happens on Lane 3 only in the Downstream direction, perform the following selections for Lane Triggering (see Figure 6.121):

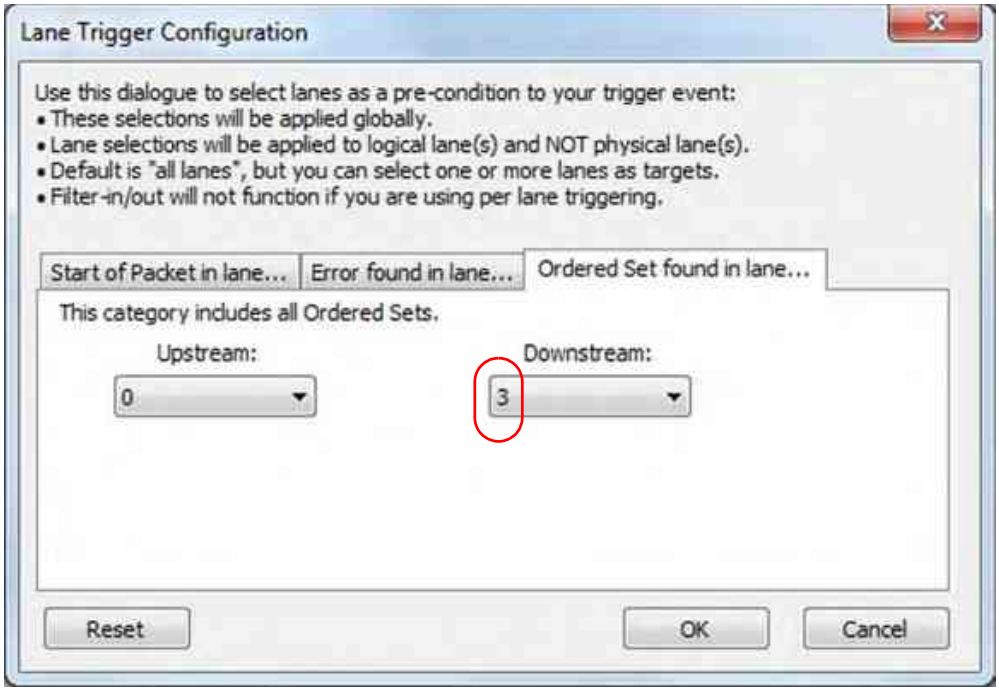


Figure 6.121: Lane Trigger Configuration: Downstream TS1, Downstream, Lane 3

Then select a TS1 Event and select only the Downstream direction, set Link Number = 00 and Lane number = PAD fields (see Figure 6.122). After selecting the options you want click on the “OK” button.

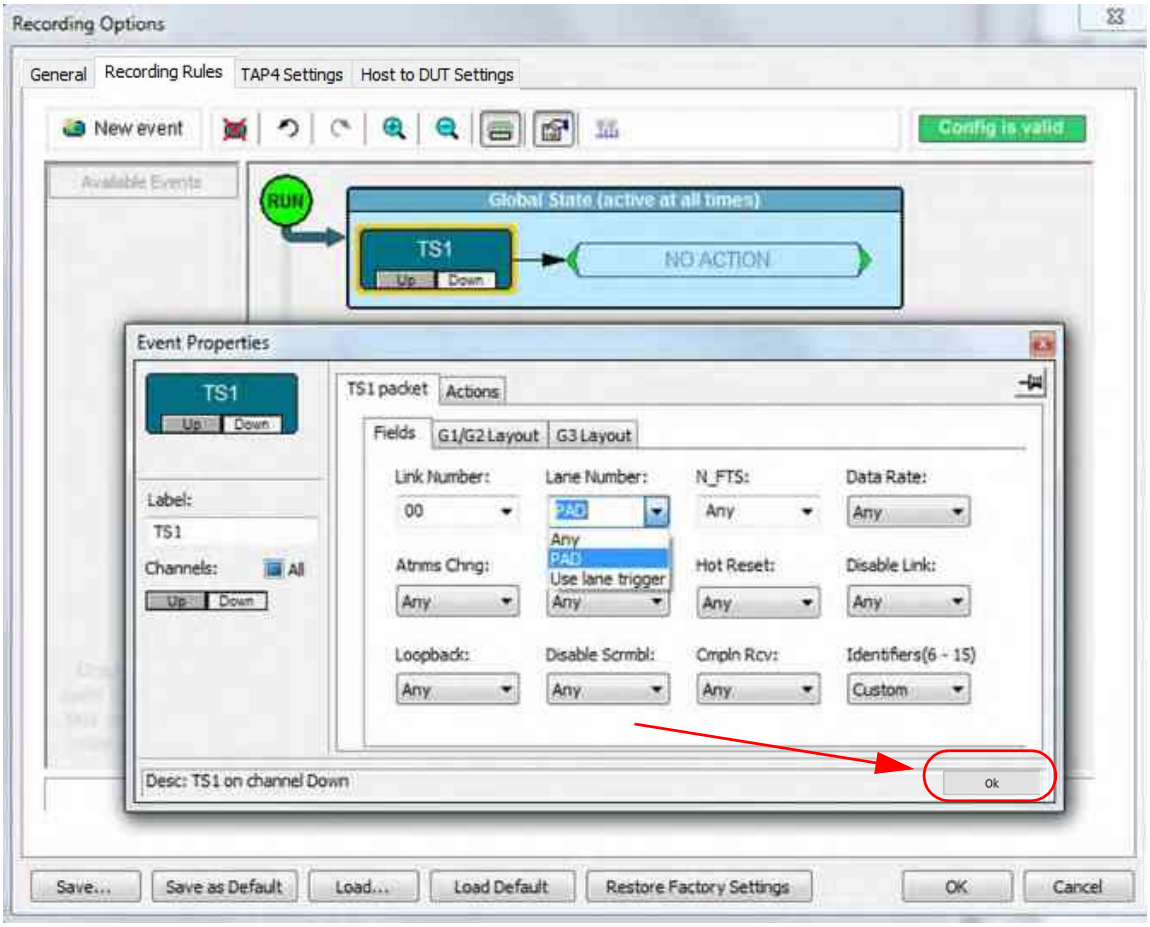


Figure 6.122: Setting the Event Properties for TS1 Downstream

Finally, set the Action Tab to trigger the analyzer (see Figure 6.123 on page 259). After selecting the options you want click on the “OK” button.

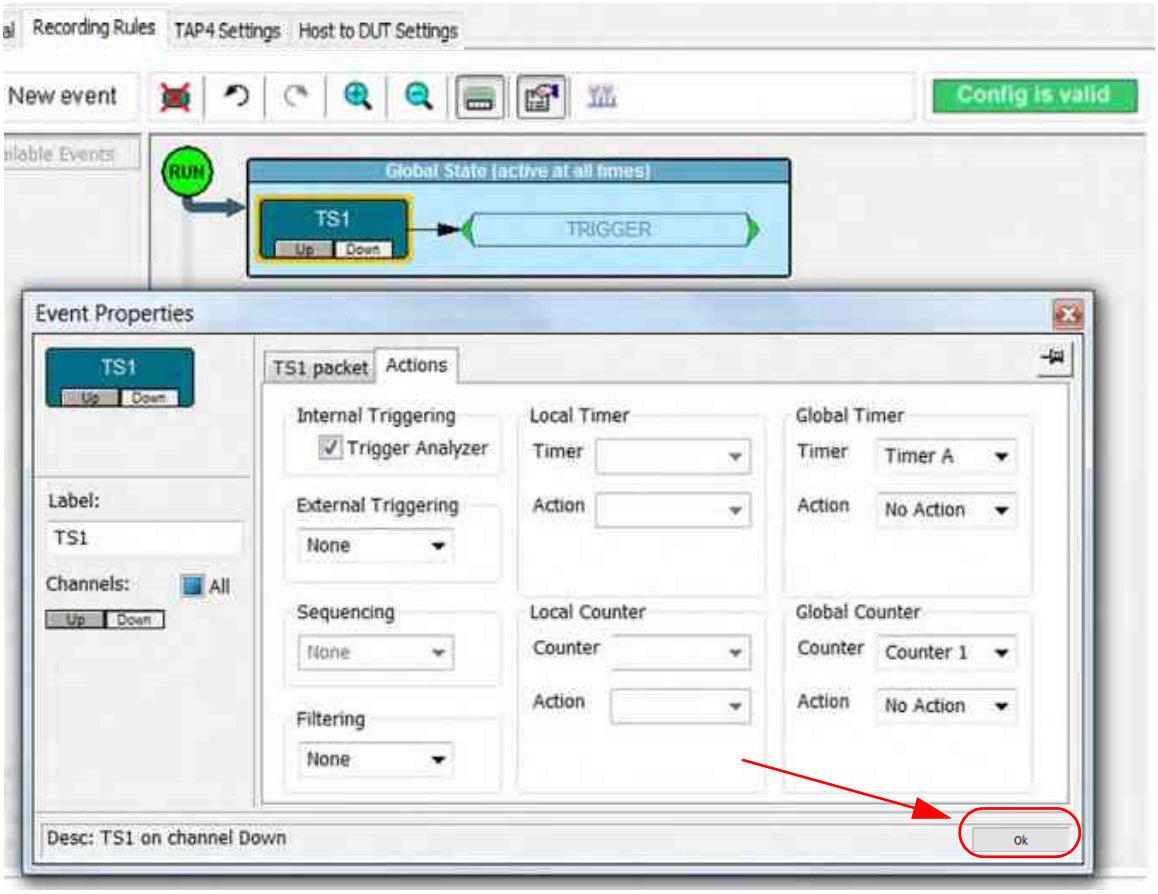


Figure 6.123: Event Properties: Actions = Trigger Analyzer

Now the analyzer will be triggered on a TS1 Event with Link Number = 00 and Lane Number = PAD that happens on Lane 3 only in the Downstream direction.

6.17.18 Counter

Counters can be created for any specific event or for multiple events (see Figure 6.124 on page 260). Counters function similar to an event and are independent of the event, thus allowing greater flexibility. You can select a counter for any event and if both channels are selected you can set the counter to count upstream and downstream. Counters can be reset providing further flexibility. The counter once set lives in the State. In an Advance to Sequence state once the action proceeds from one sequence state to the next, the counter in the preceding state will stop and the counter in the current state will start.

There are two Counters for the Global State and four Counters for the Sequence State.

The counters have different colors for the Global State and Sequence State. Each color signifies a different meaning in the Global and Sequence states.

Note: Counters can be controlled only from one direction not both, meaning starting, reset and incrementing must be done from events occurring in the same channel (upstream or downstream) of the selected counter.

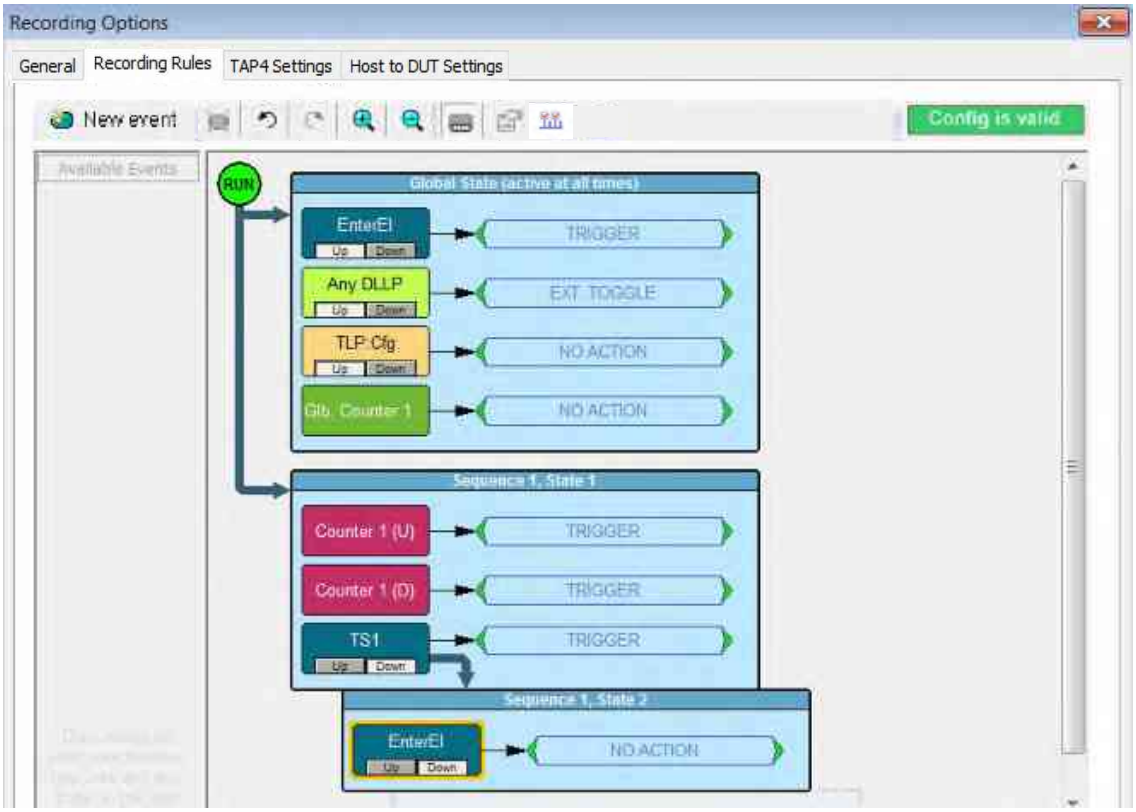


Figure 6.124: Global and Sequence State Counters

As shown in Figure 6.124 there is a Global Counter 1, set to the value of 2 on channel up displayed in green in the Global State and there are two counter 1s, set to the value of 2, one counting upstream and the other counting downstream displayed in pink in the Sequence State.

6.17.18.1 How to Set a Counter

Counters are events and you can add a counter to the Global State or the Sequence State as an event by doing the following:

Right-click in the blue space in the Global or Sequence State and **New Event > Counter > UpStream or DownStream**. See Figure 6.125 on page 261.

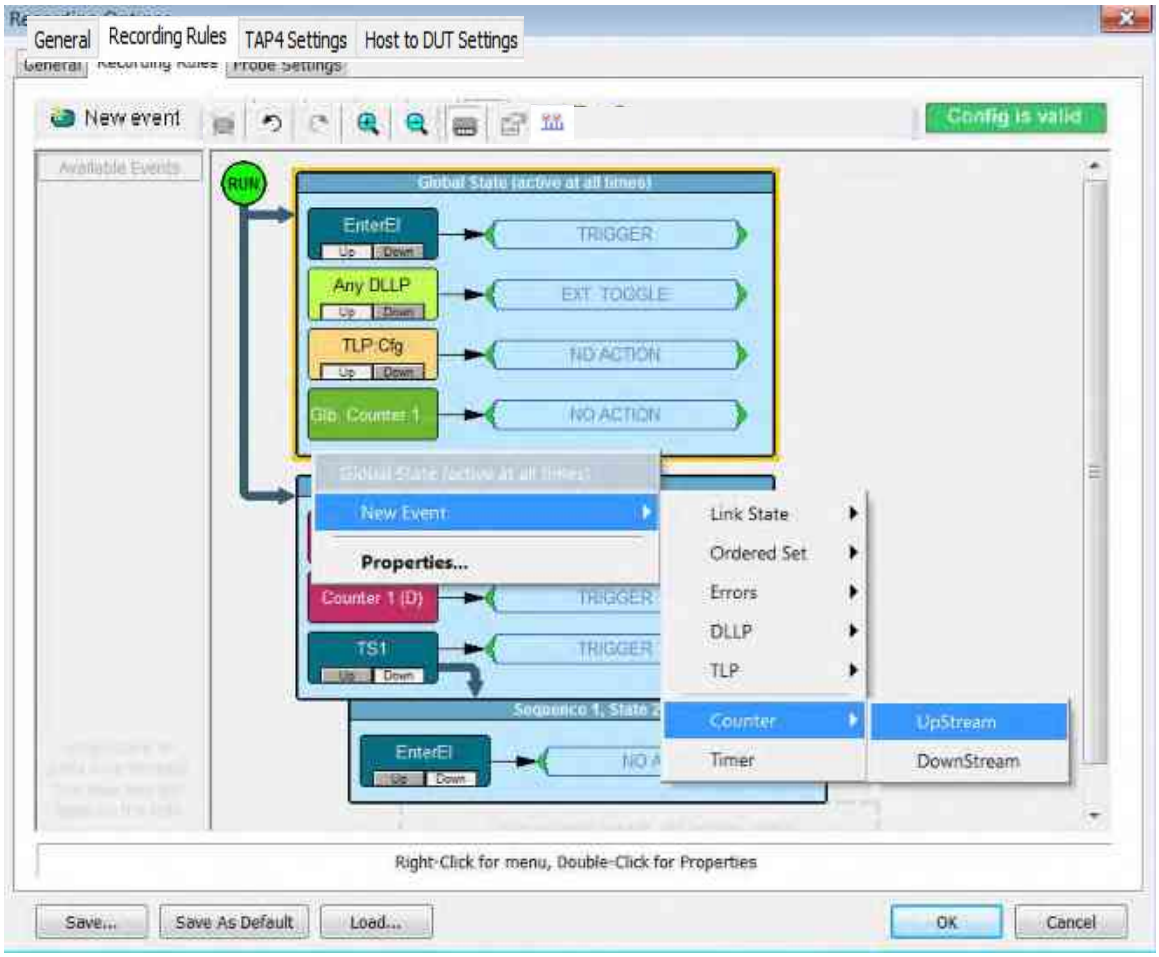


Figure 6.125: Setting Global and Sequence State Counter Events

6.17.18.2 How to Increment or Reset a Counter

You can Increment or Reset counters in the Global State and in the Sequence State by performing the following steps:

1. Open the Recording Rules page, select an event, and drag it to the **Global State** or **Sequence** cells. For details on these steps (see "Events with Channels" on page 267).
2. Right-click on an event and select **Specify Actions > Increment Global Counter > Global Counter 1** from the menu (see Figure 6.126 on page 262).

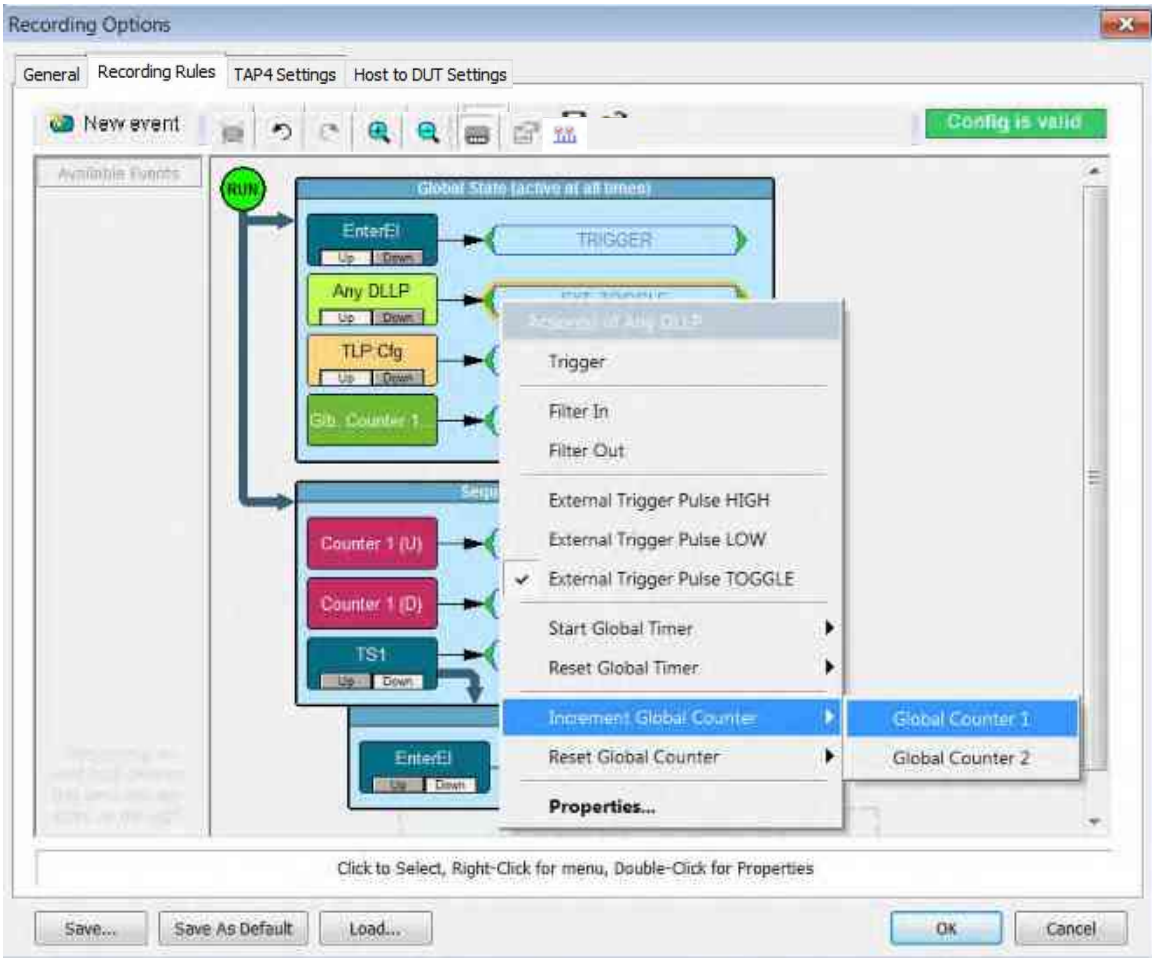


Figure 6.126: Incrementing and Resetting Global and Sequence State Counters

Note: Listed below are some of the considerations to note about the counter functionality.

1. If a counter is reset, it will restore to it's original value, in this case the value defined by the user.
2. Resetting a counter will stop it and set it to it's original value.
3. Local counters for a particular state will automatically reset if the sequencer advances to another state. Example: "Counter A" in State 1 and "Counter A" in State 2 are different timers not related to each other.
4. Local counters are controlled by events defined in the same state where the counters are defined.
5. In case of competing actions to control global counters using the same event from global and local states, the control from local states takes priority.

6.17.18.3 Changing the Value of the Counter

To change the value of the counter:

1. Double-click on the Counter.

2. Enter a new value in the pop-up dialog. This causes the new value to appear in the counter button.

6.17.18.4 Deleting a Counter

To delete a counter

1. Right-click on the Counter.
2. Select **Delete This Event.** The counter will disappear from the event.

6.17.19 Timer

The Timer has two options which are Start and Reset. When set to Start it starts the timer and when set to Reset it resets the timer to its initial value. When the timer count is down to 0 the action is triggered.

The Global State timer can trigger, start an action. It can also affect some other timers and counters.

The timers have different colors for the Global State and Sequence State. Each color signifies a different meaning in the Global and Sequence states.

There are two Timers for the Global State and four Timers for the Sequence State.

Note: Timers can be controlled (Start/Reset) deterministically from events happening in any channel (upstream or downstream direction) as long as these events are more than 380 ns apart. For timers controlled by events happening on a single direction the control happens at the line rate.

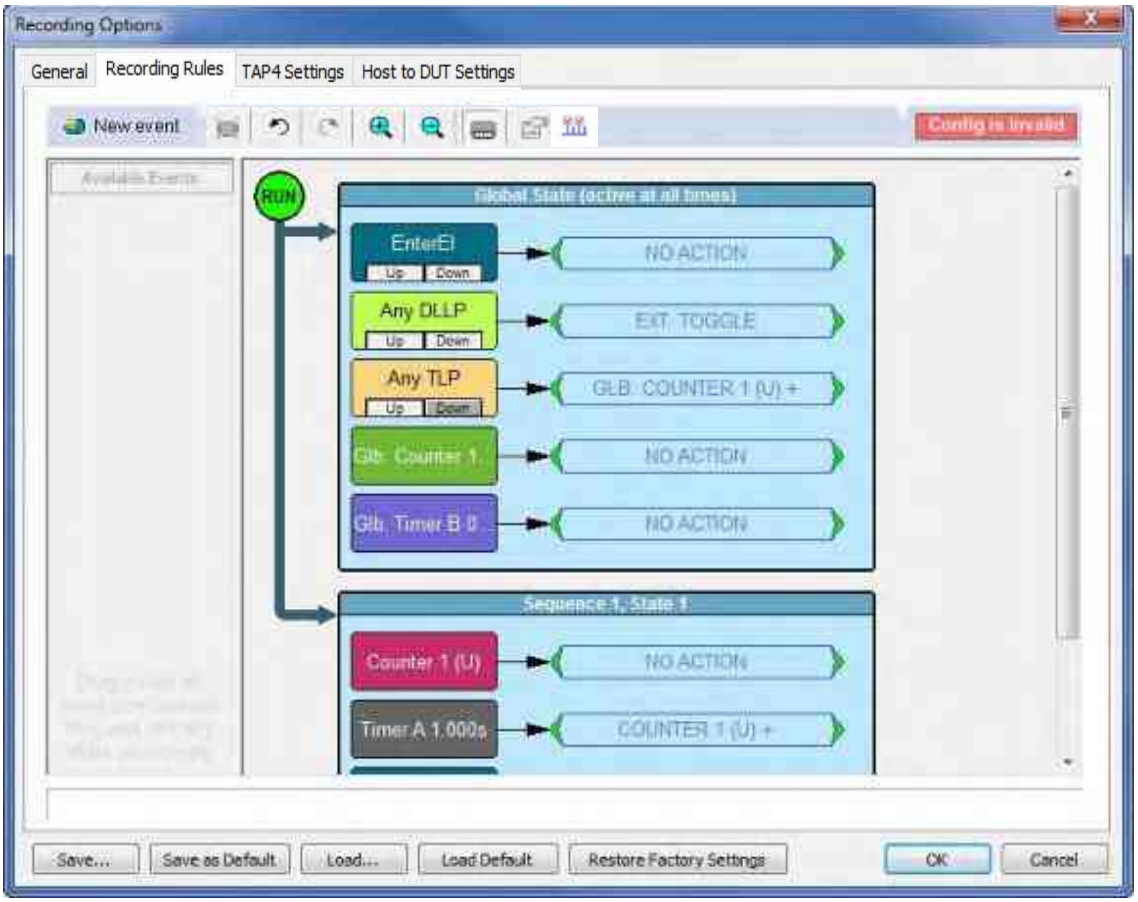


Figure 6.127: Global and Sequence State Timers

As shown in Figure 6.127 on page 264 there is a Global Timer A, set to the value of 1.000s on channel Up displayed in blue in the Global State and there is one timer A, set to the value of 1.000s on channel Down displayed in brown in the Sequence State.

6.17.19.1 How to Set a Timer

Timers are events and you can add a timer to the Global State or the Sequence State as an event by doing the following:

Right-click in the blue space in the Global or Sequence State and **New Event > Timer**.

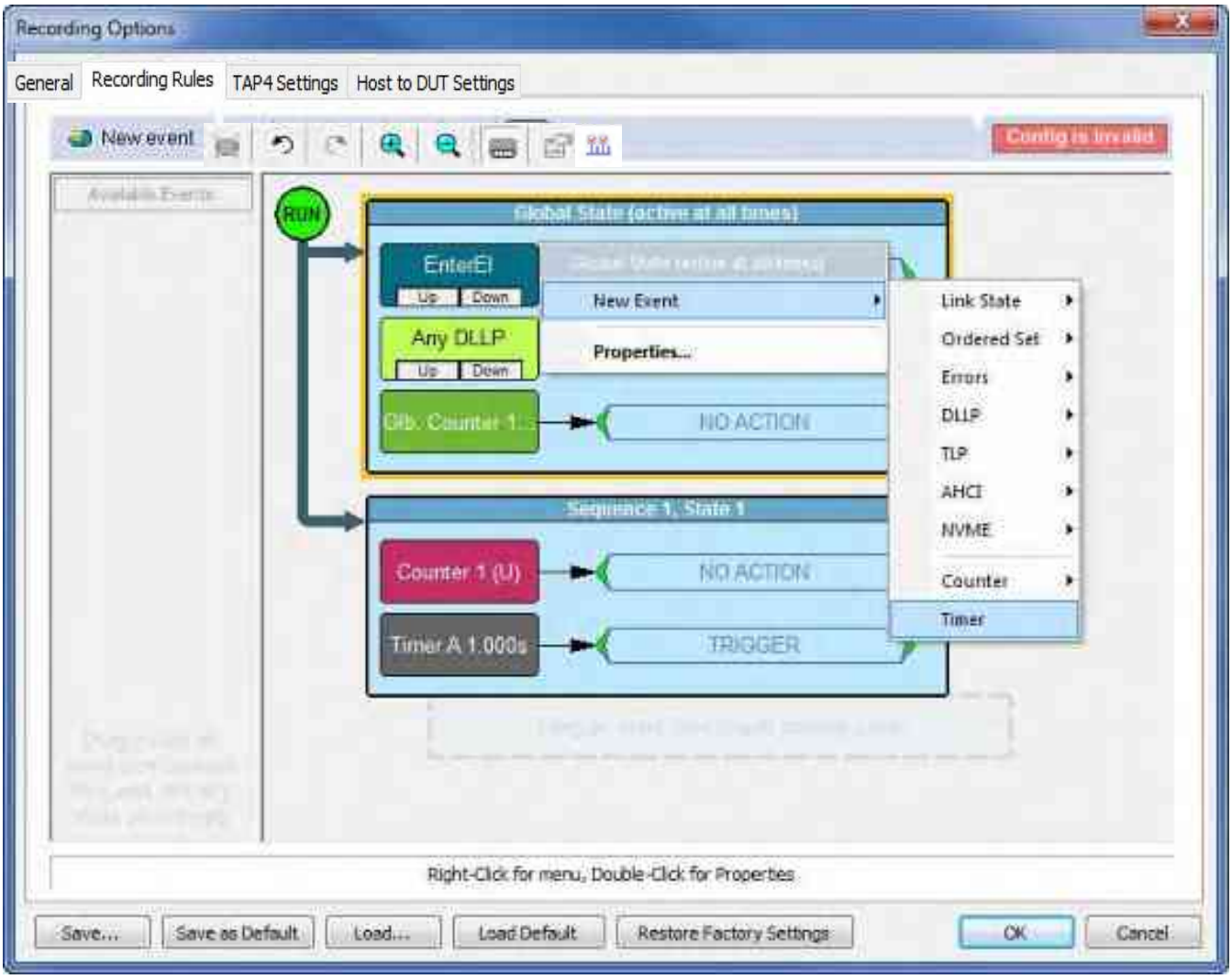


Figure 6.128: Setting Global and Sequence State Timer Events

6.17.19.2 How to Start or Reset a Timer

You can Start or Reset the Timer in the Global State and in the Sequence State by performing the following steps:

1. Open the Recording Rules page, select an event, and drag it to the **Global State** or **Sequence** cells. For details on these steps (see "Events with Channels" on page 267).
2. Right-click on an event and select **Specify Actions > Start Global Timer > Global Timer A** or **Timer B** from the menu (see Figure 6.129 on page 266).

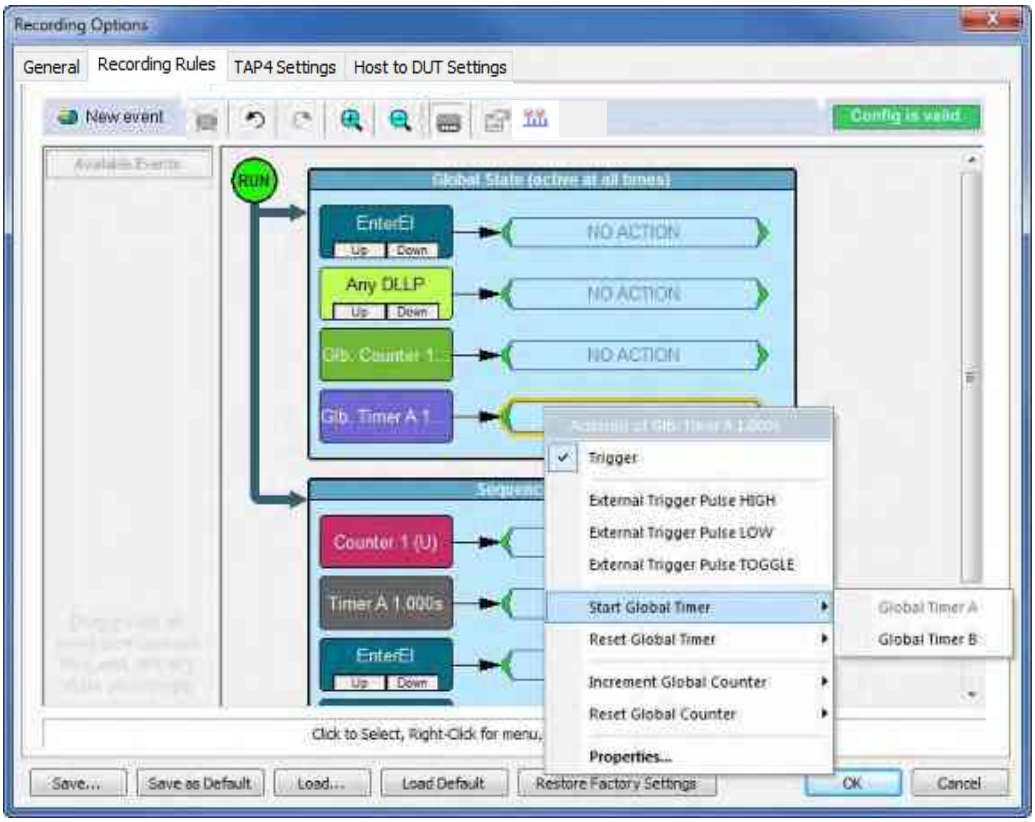


Figure 6.129: Starting and Resetting Global and Sequence State Timers

Note: Listed below are some of the considerations to note about timer functionality

1. If a timer is reset, it will restore to its original value, in this case the value defined by the user.
2. Resetting a timer will stop it and set it to its original value.
3. Local timers for a particular state will automatically reset if the sequencer advances to another state. Example: “Timer A” in State 1 and “Timer A” in State 2 are different timers not related to each other.
4. Local timers are controlled by events defined in the same state where the timers are defined.
5. In case of competing actions to control global timers using the same event from global and local states, the control from local states takes priority.

6.17.19.3 Changing the Value of the Timer

To change the value of the timer (see Figure 6.130 on page 267):

1. Right-click on the Timer.
2. Select **Properties**
3. Enter in values for the Timer in the fields provides in Secs, Millisecs, Microsecs and Nanosecs on the Timer tab. After selecting the options you want click on the “OK” button.

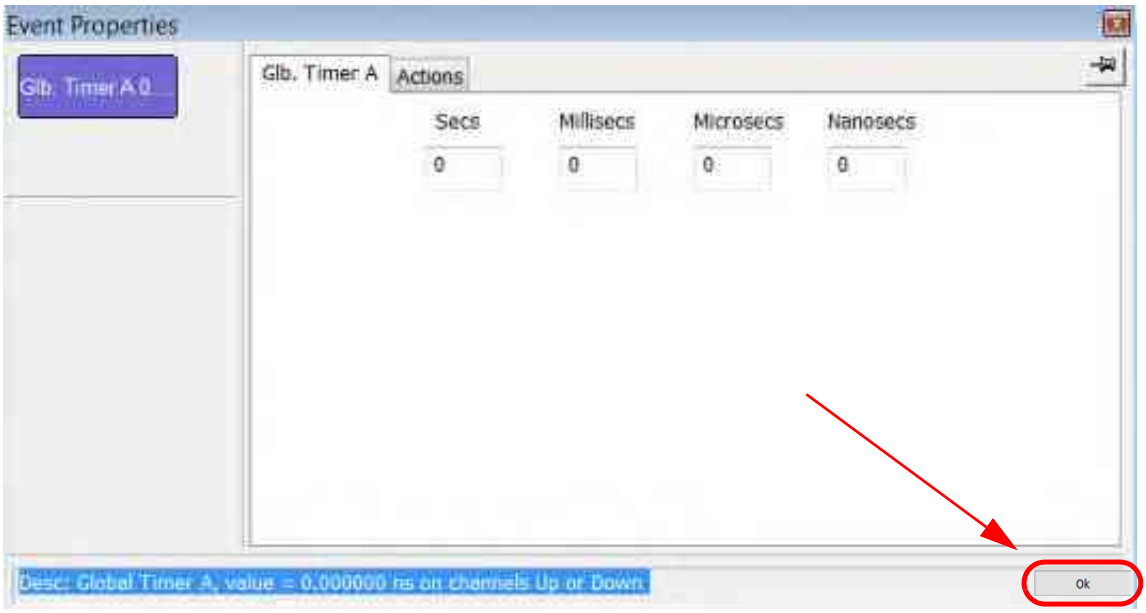


Figure 6.130: Setting the Timer Values

4. Click on the Actions tab and set the External and Internal Triggering, Sequencing and Filtering options. You can label the timer.

6.17.19.4 Deleting a Timer

To delete a Timer

1. Right-click on the Timer.
2. Select **Delete This Event.** The Timer will disappear from the event.

6.17.20 Channel

Every event has two channels, one upstream and the other downstream. You can use both channels with any event. The channels are independent of each other. If both channels are selected it is valid but no action occurs, and thus no timer and counter is created. Figure 6.131 shows three events in the Global State, the first event is on Channel Up and the 3rd event is on Channel Down.

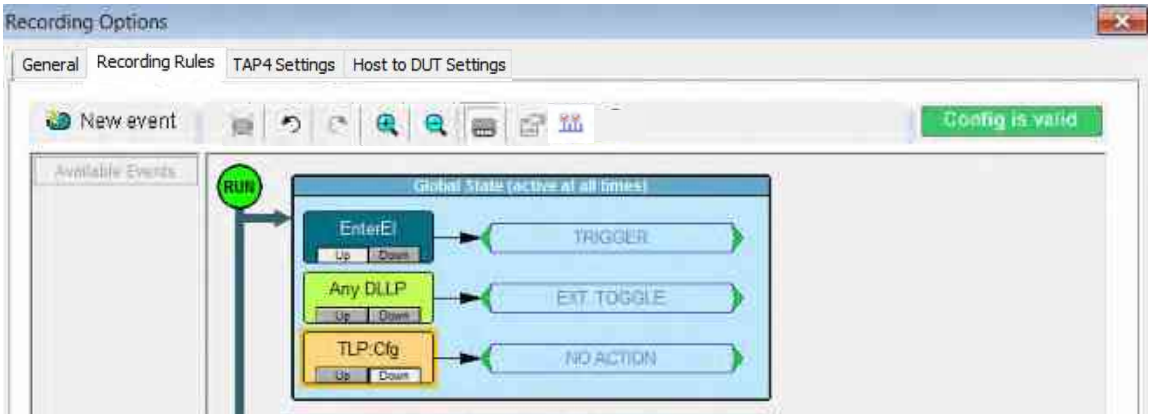


Figure 6.131: Events with Channels

6.17.21 Lane Margining

You can use Lane Margining as an Advanced Recording Rule. You need to define the following Fields:

- Margin Command
- Margin Type
- Receiver Name
- Margin Payload

See Figure 6.220 on page 356.

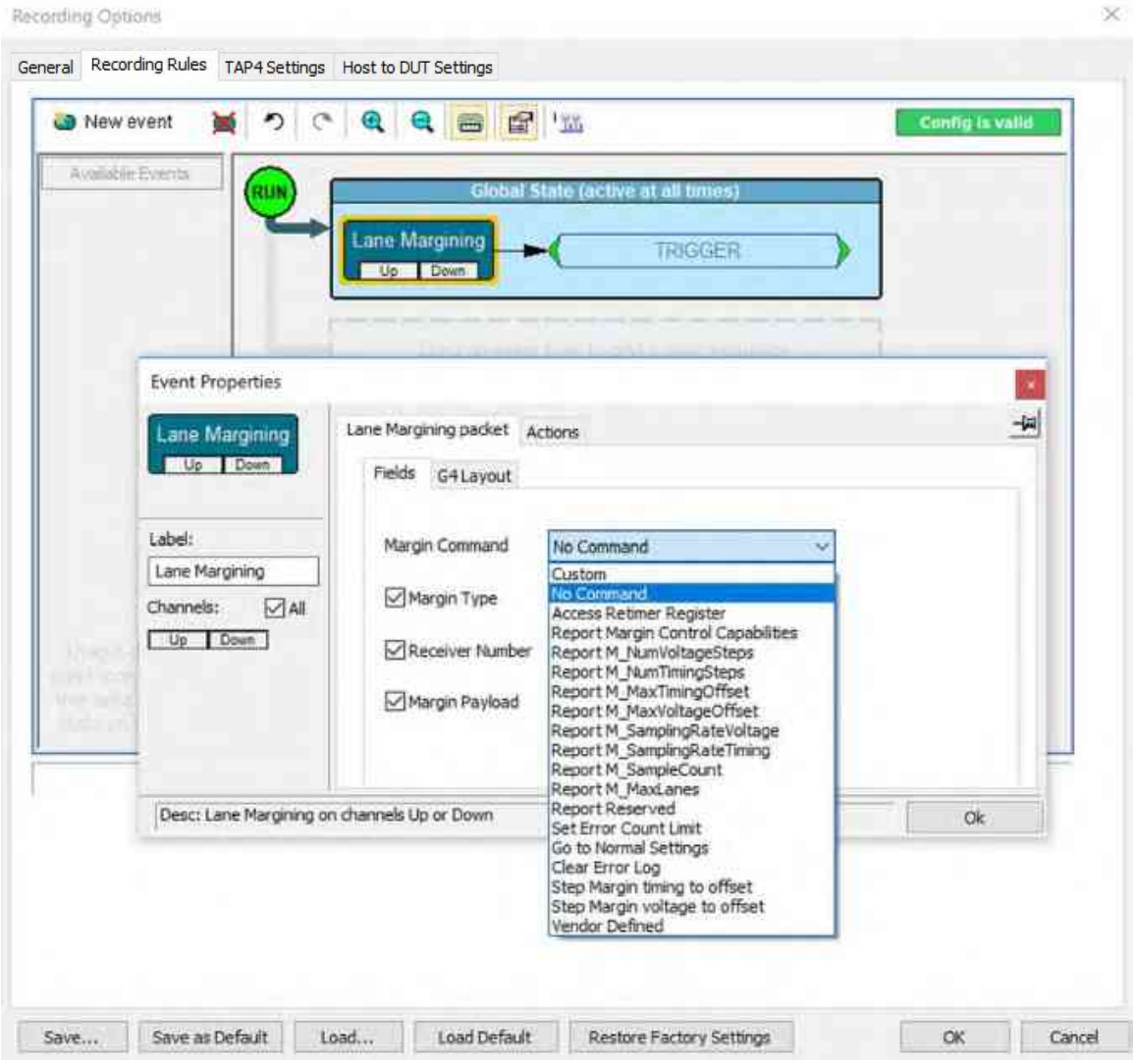


Figure 6.132: Lane Margining: Fields → Margin Commands

You can also update the four DWORDS in the G4 Layout dialog box.See Figure 6.221 on page 358.

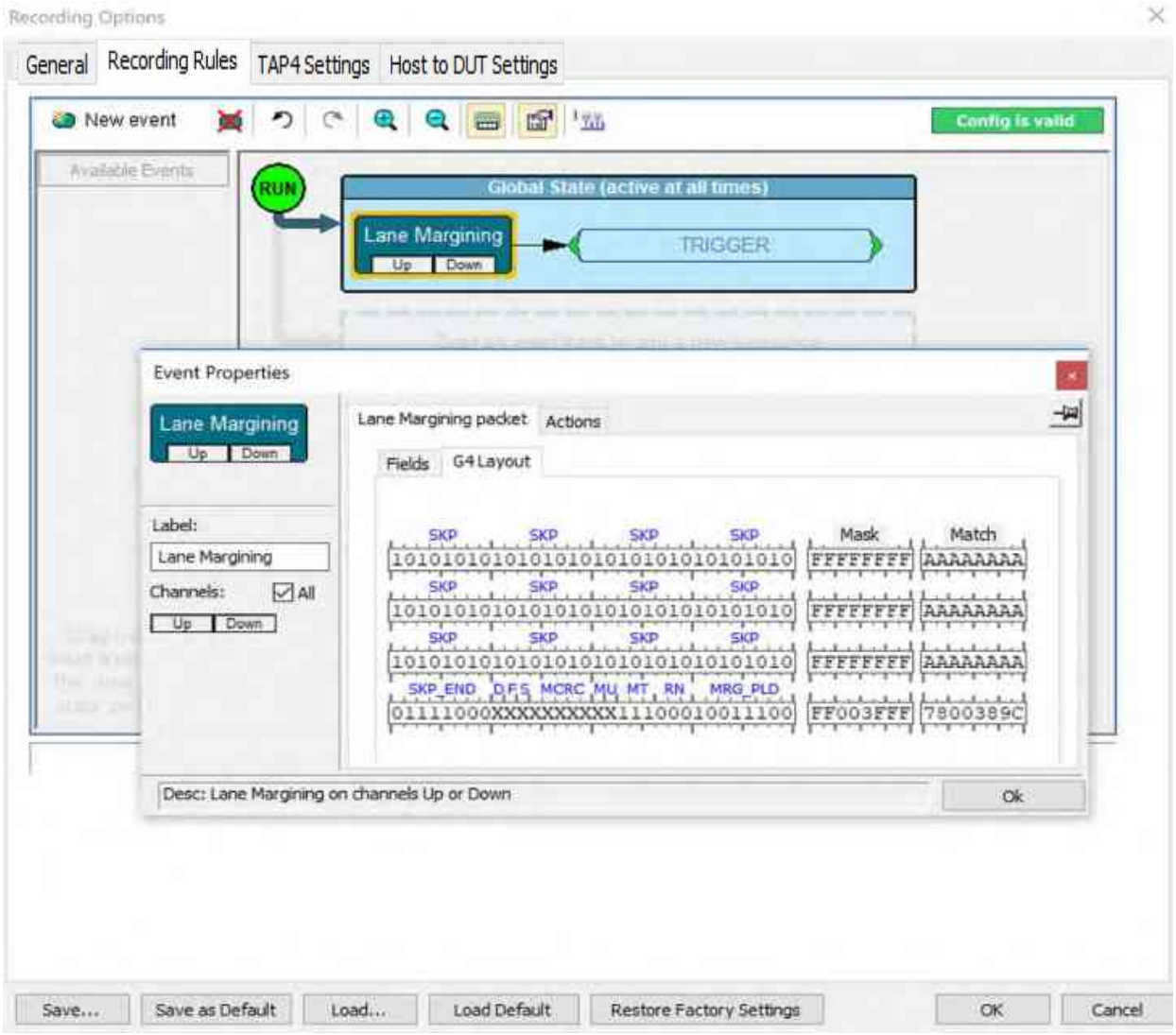


Figure 6.133: Four DWORDS Need to Define G4 Layout

6.18 Analyzer & Probe Settings

This tab allows you to access a list of presets, which can be selected from the library and immediately applied, and to view your connected Analyzer (Figure 6.134).

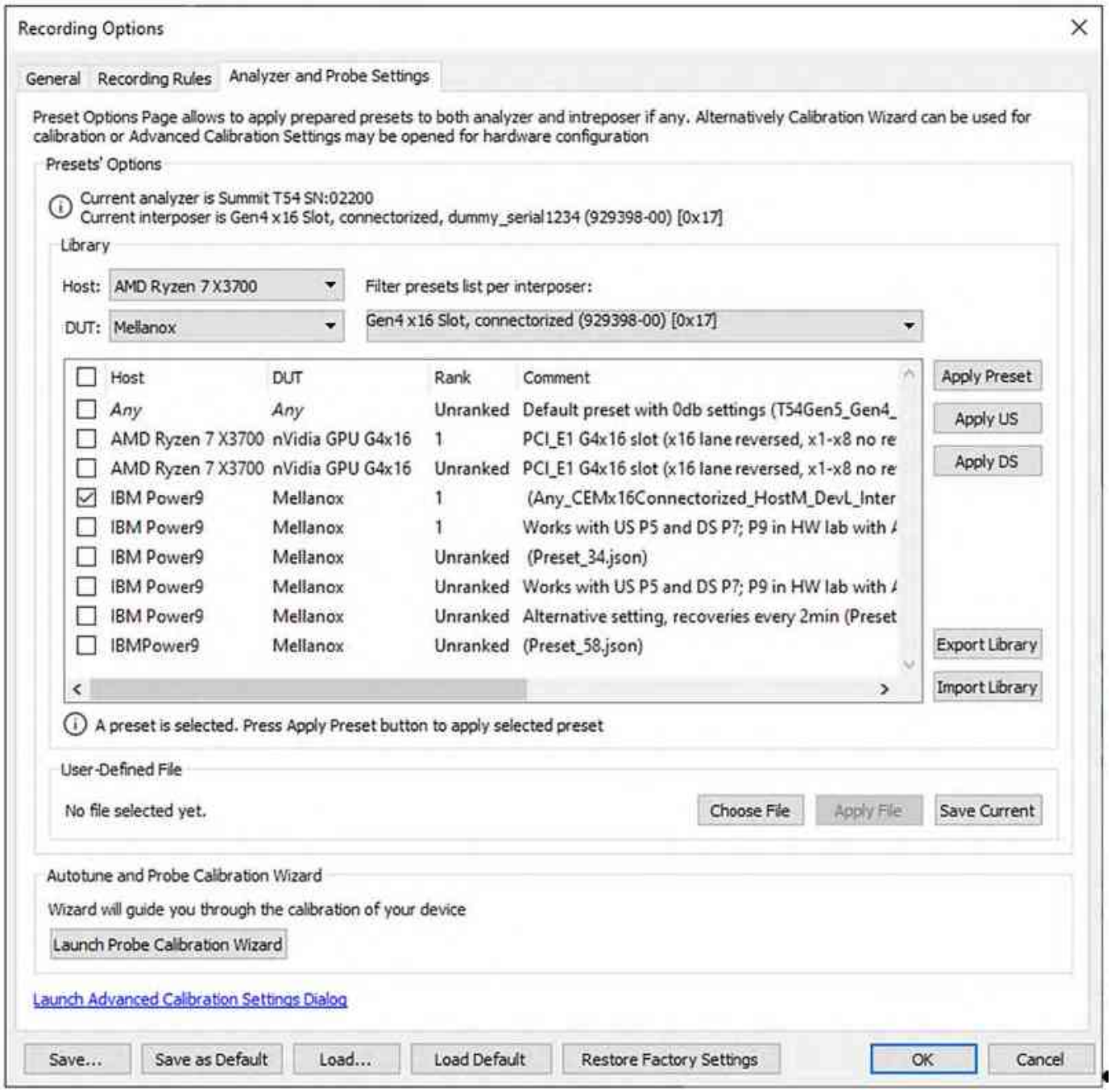


Figure 6.134: Recording Options Presets' Options

6.18.1 Library

The Library contains the presets you can apply and includes the following combo-boxes (Figure 6.135):

- Host – Lists all available Hosts
- DUT – Lists all available DUTs
- Interposer – Lists all available Interposers

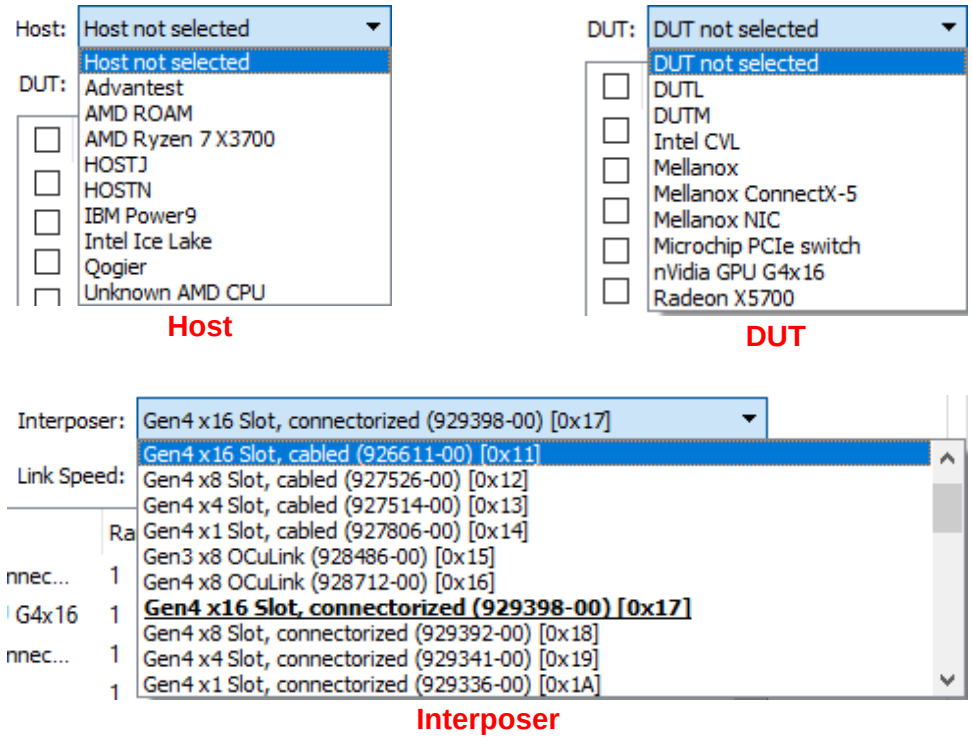


Figure 6.135: Combo-Boxes of Presets' Options

The Interposer connected to the setup is shown in bold and underlined.

When the Analyzer and Probe Settings tab is opened, the connected interposer is automatically displayed in Interposer combo-box. In this example, the list of available Hosts and DUTs is limited to those presets that support current Interposer.

6.18.2 Search Filter

When you select a Host and DUT for the connected Interposer, the presets are shown in the following order:

1. Presets with full match of Host and DUT (displayed in bold)
2. Presets with match in Host
3. Presets with Match in DUT

Note: Currently, only one preset can be selected.

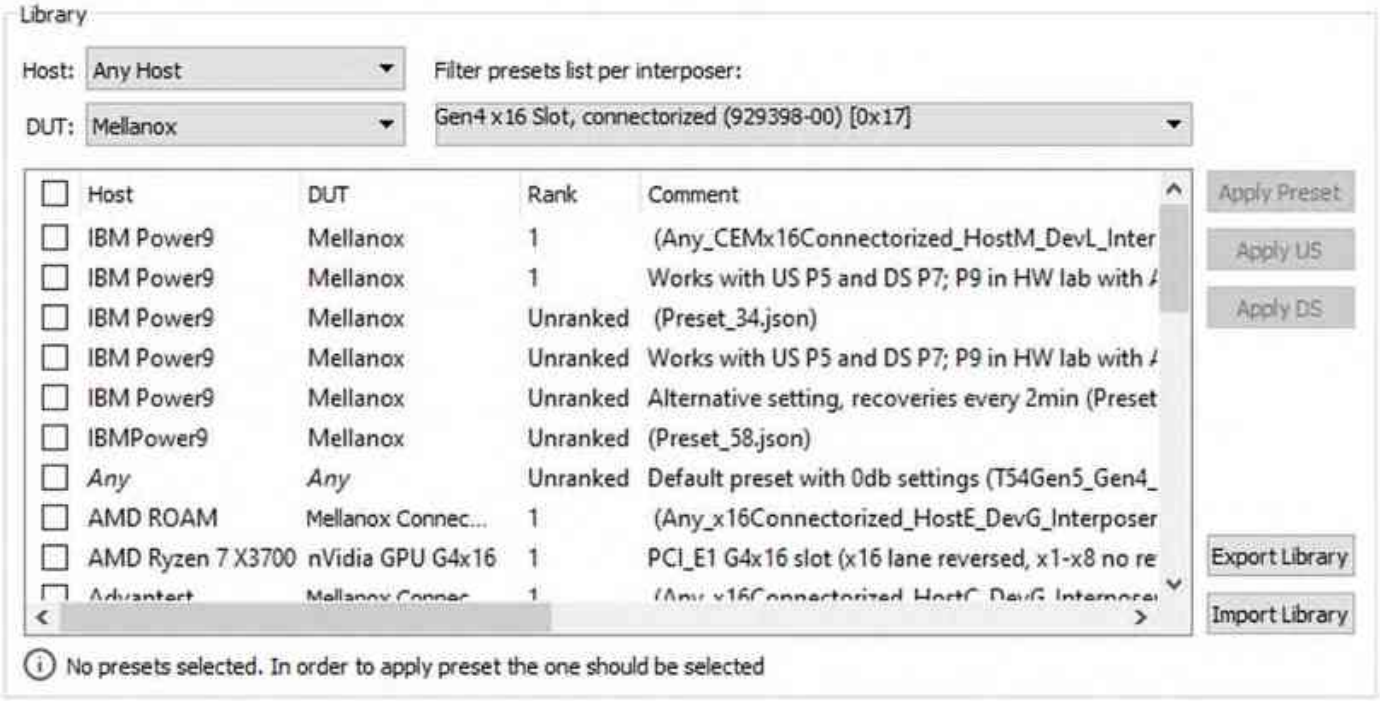


Figure 6.136: Presets' Match in DUT

Selected preset can be applied either on both channels using **Apply Preset** or separately, using **Apply US** or **Apply DS**. Applied presets are applied in Rec Options and written to the Interposer to all Calibration tables.

Note: The Host may need to be rebooted to ensure the DUT is able to reach the necessary speed.

Note: **Column Rank** shows the rate of errors on the link on the scale from 1 to 10, where 1 indicates that there are few or zero errors (Figure 6.137). The larger Rank number indicates that the Preset will contain more errors. It is not recommended to use a Preset with rank higher than 6, because the number of errors on the link will be high.

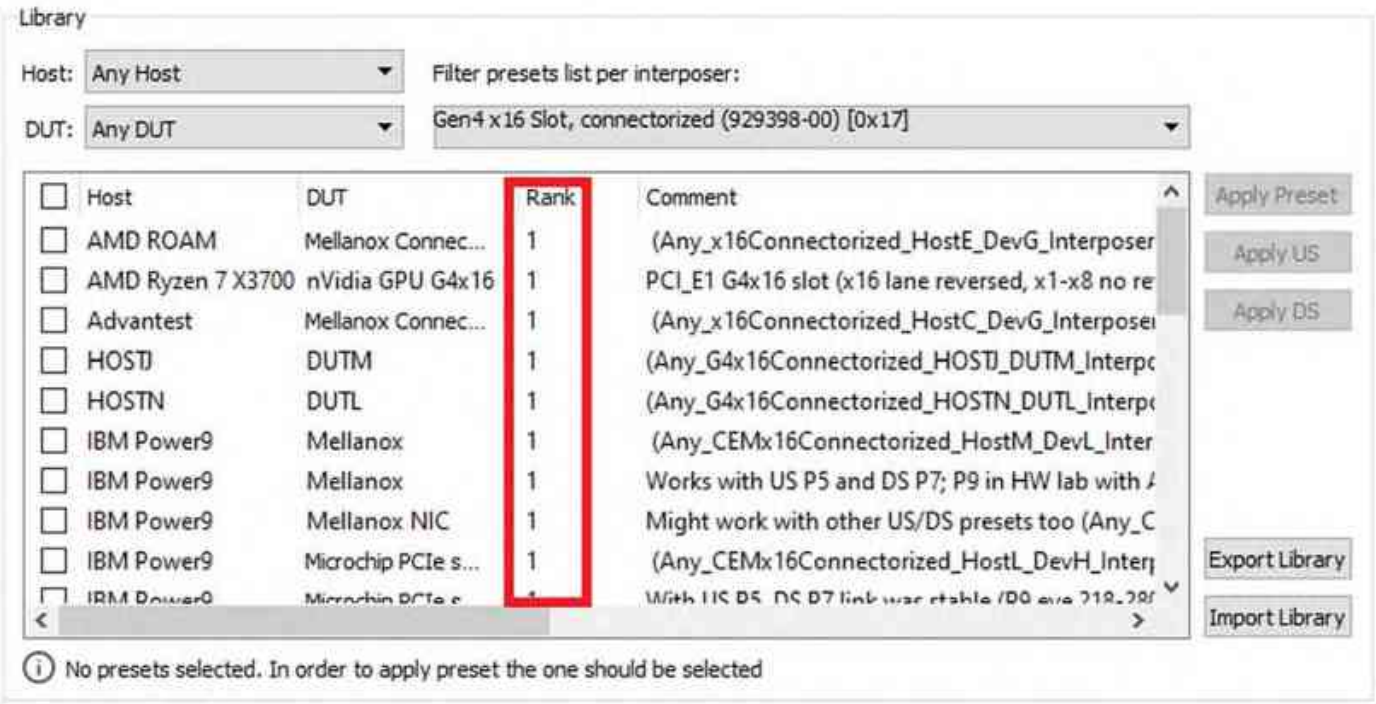


Figure 6.137: Preset with Low Rank Number

Note: It is not recommended that you apply a Preset with a different board ID as it will not be accurate.

6.18.2.1 Saving a Selected Preset

To save the selected Preset file:

1. Click the **Save Current** button (Figure 6.138) to save the selected Preset file. The Add Configuration File Info dialog box opens, where you can add more configuration details (Figure 6.139).

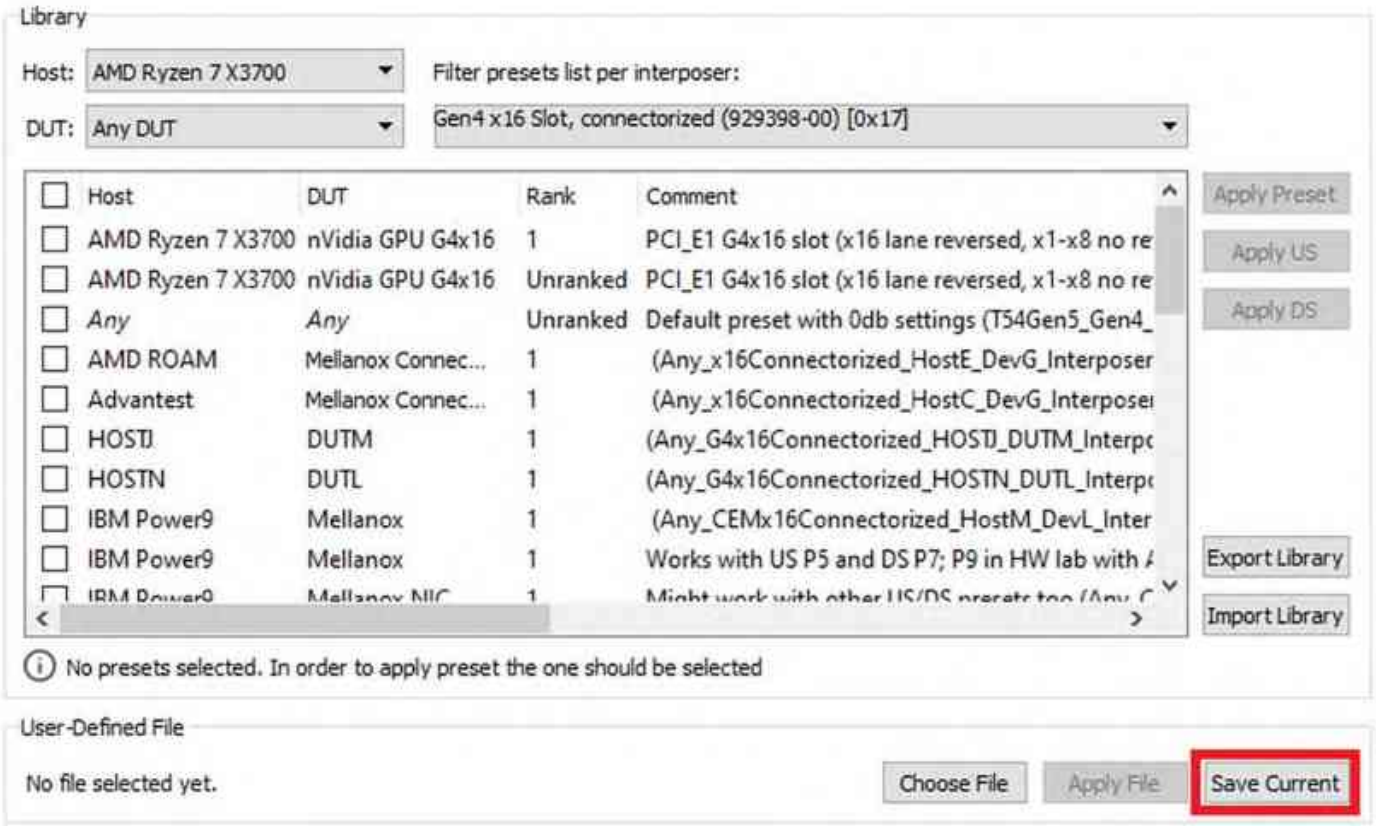


Figure 6.138: Save the Currently Selected Preset

2. Provide a Platform Name and all other details to ensure future searches find the saved values (Figure 6.139).

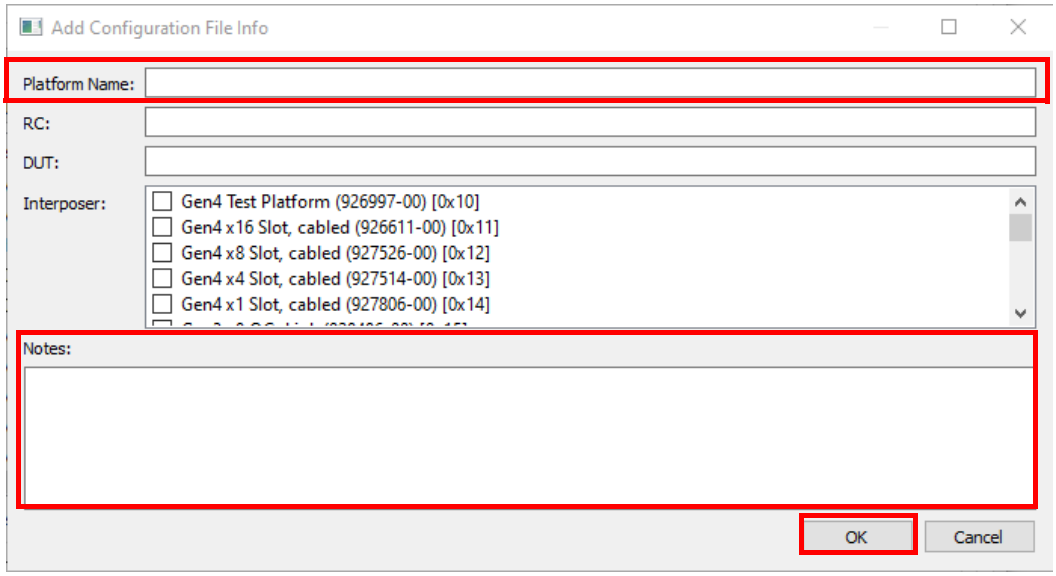


Figure 6.139: Add Configuration File Info Dialog Box

3. If desired, enter additional comments and information into the **Notes** field.
4. Click **OK**. The *Save settings file* window opens (Figure 6.140).

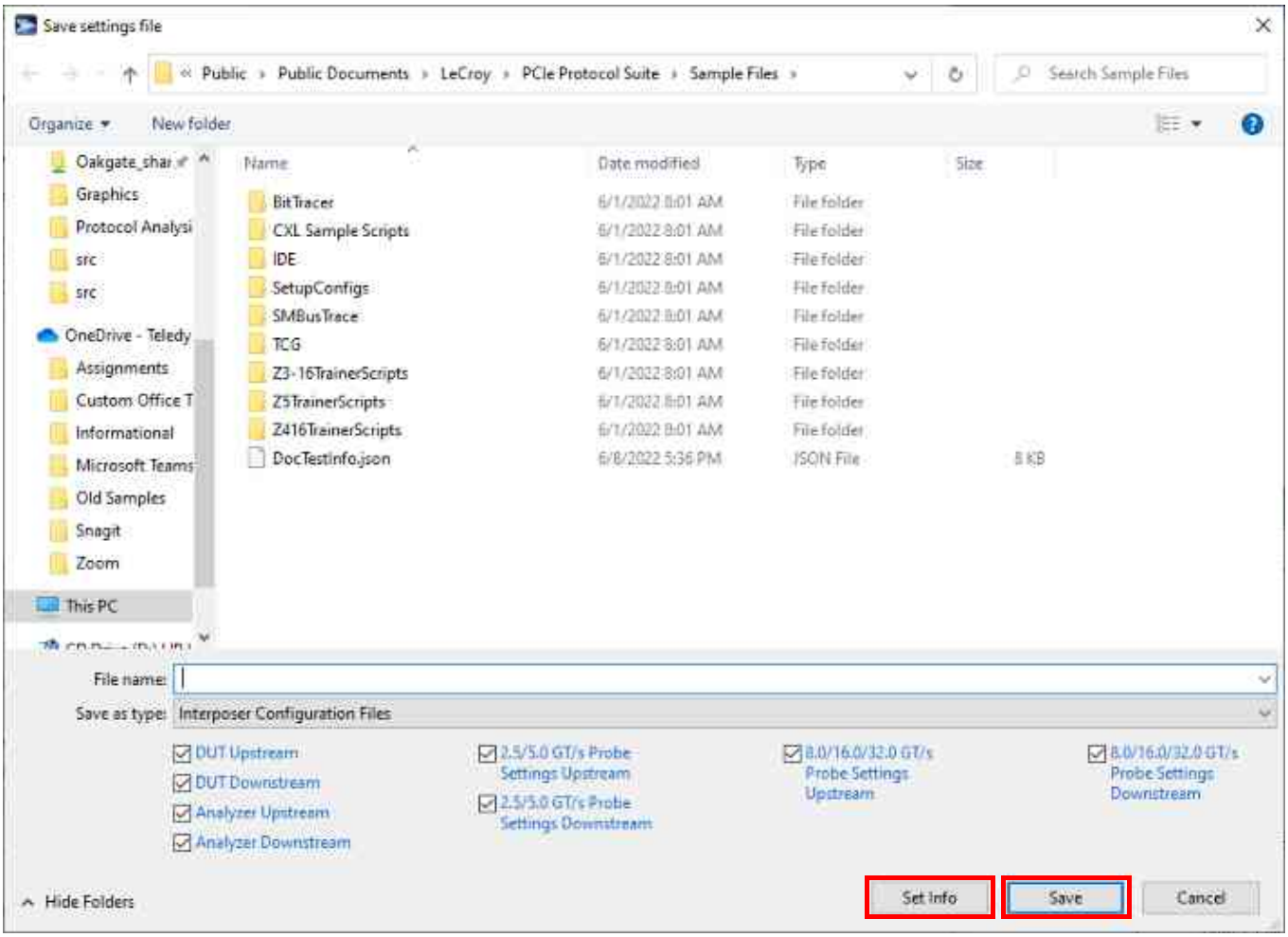


Figure 6.140: Save Settings File Window

5. Enter a file name and click **Save**.

Note: You can skip Step 5 to allow the software to automatically define the interposer.

6. If you wish to specify additional details to the Configuration File, click **Set Info** and follow the prompts.

Note: If you are saving the preset to C:\Users\Public\Documents\LeCroy\PCIe Protocol Suite\InterposerCfgPresets, it will appear in the library and will be exported along with other presets in the folder.

6.18.3 Library Operations

Teledyne LeCroy maintains an online database of presets.

If you are connected to the Internet when you launch the PCIe Protocol Analysis software, your local presets will be automatically updated with the latest information from the online database. If you have no Internet connection, you can easily import the exported library file into the application.

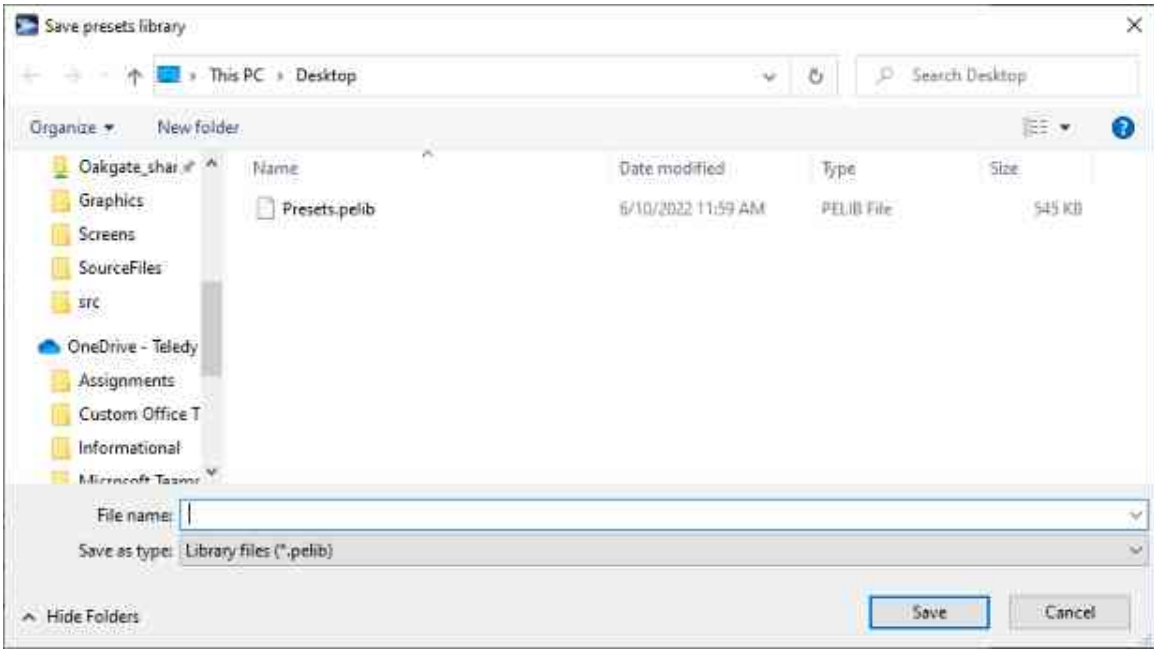


Figure 6.141: Export Library to Computer – User Defined File

6.18.3.1 Buttons & Functions

TABLE 6.7: Buttons – Analyzer & Probe Settings (Sheet 1 of 2)

Button	Function/Description
Apply Preset	Applies settings to both upstream and downstream channels for the selected Preset.
Apply US	Applies settings to upstream channels only for the selected Preset.
Apply DS	Applies settings to downstream channels only for the selected Preset[1].
Export Library	Creates a file in which all of the presets in the Library can be exported into one file in *.pelib format.
Import Library	Opens the Library with all of the presets without an Internet connection. It automatically rewrites the folder C:\Users\Public\Documents\LeCroy\PCIe Protocol Suite\InterposerCfgPresets
Choose File	Loads the preset. You can choose to load presets with all of the tables or only your selected presets.
Apply File	Saves Rec Options and writes the values to the Interposer from Presets on the selected tables. **Note:** If the Preset was created for a different Interposer board ID, the warning prompt shown in Figure 6.142 appears.

TABLE 6.7: Buttons – Analyzer & Probe Settings (Sheet 2 of 2)

Button	Function/Description
Save Current	Saves the manually selected values and writes to the interposer in all three tabs: • Interposer Host to DUT Path • Interposer to Analyzer Path • Analyzer Calibration both 2.5/5.0 GT/s and 8.0/16.0/32.0 GT/s
Launch Probe Calibration Wizard	Opens the Autotune and Calibration Wizard. This will lead you through the steps for both Autotuning the Analyzer and Calibrating the Probe. 6.19.4, *"Analyzer Path Calibration"*.
Launch Advanced Calibration Settings Dialog — Link that opens the Advanced Calibration Setting dialog window. Use this option to manually adjust the probes. See 6.19.3, *"Analyzer Calibration"*.	
Save...	Saves the Rec Options.
Save as Default	Saves the current Recording Options as default 1.
Load...	Opens File Explorer with a path to the PCIe Protocol Suite. Select a folder and click **Open** to apply the Rec Options.
Load Default	Loads the default Recording Options
Restore Factory Settings	Restores all Recording Options (including defaults) back to the original factory settings
OK	Applies the settings.
Cancel	Discards any changes that were made in Rec Options and closes Rec Options window

1. Once you click **Apply**, you will be prompted to reboot the Host to correctly apply the selected Preset.

Note: If you select a Preset, which was not developed for the current interposer, the interposer will try to map the values.

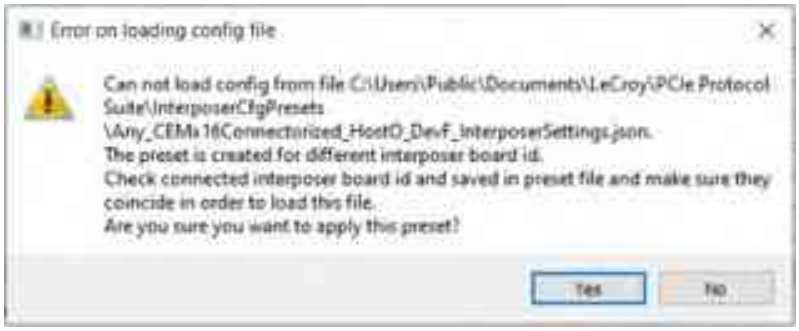


Figure 6.142: Warning Prompt – Error Loading Config File

6.19 General Guidelines to do the Calibration and Auto-tuning

Note: Examples shown below are for Gen4 Interposers. The process for Gen5 Interposers is similar but the specific examples may not be identical. Calibration and Auto-tuning is supported for T516 CXL mode and is similar to PCIe mode.

Following are some general guidelines to help stream line this process.

1. First make sure that the device is getting link up with underlying host, if needed set the BIOS parameters.
2. The device should be visible to the host OS, in order to do the auto-tuning and calibration. If not present, try the presets manually and reboot the Host OS, then check again - if device is getting detected then the auto-tuning / calibration routine works.

Note: it is not necessary to have the stable or clean link, just a link, may be a Gen1 x1 is good enough to start the calibration / tuning process. The process will bring the device to the max level possible in terms of Speed and Linkwidth.

3. Once the device is detected by Host OS, first start the Host to DUT path auto-tuning. (“Interposer Host to DUT Path” on page 278).
4. Once that is done, then start the “Interposer to Analyzer Path” autotuning (“Interposer to Analyzer Path” on page 325).
5. In the end if there are still errors, then try to do Analyzer Calibration (“Analyzer Calibration” on page 328).
6. Another approach to Auto Tuning and Probe Calibration is to use the Auto Tune and Probe Calibration wizard, which automates the process for you (“Analyzer Path Calibration” on page 338).

6.19.1 Interposer Host to DUT Path

This dialog box allows you to Calibrate and Autotune the Interposer Host to DUT path settings.

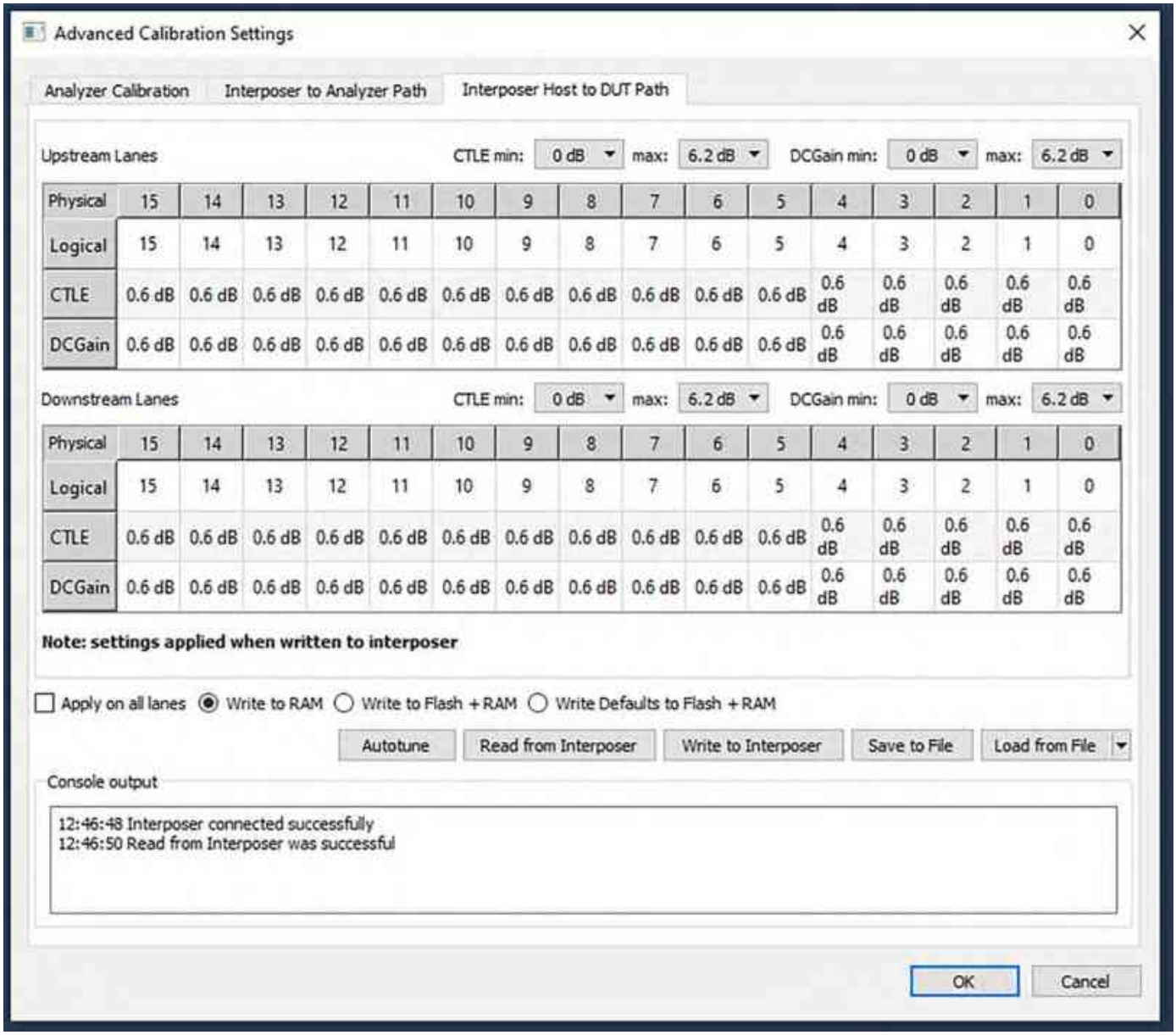


Figure 6.143: Interposer Host to DUT Path

6.19.1.1 Interposer Host to DUT CTLE and DCGain Settings

Combo-boxes are provided above the Upstream and Downstream lanes allowing you to specify CTLE and DCGain minimum and maximum value ranges.

If no custom ranges were saved in the RAM of the interposer, the system displays the full range that the current model supports.

To set a custom range, select the values from the CTLE and DCGain drop down menus, as shown in Figure 6.144.

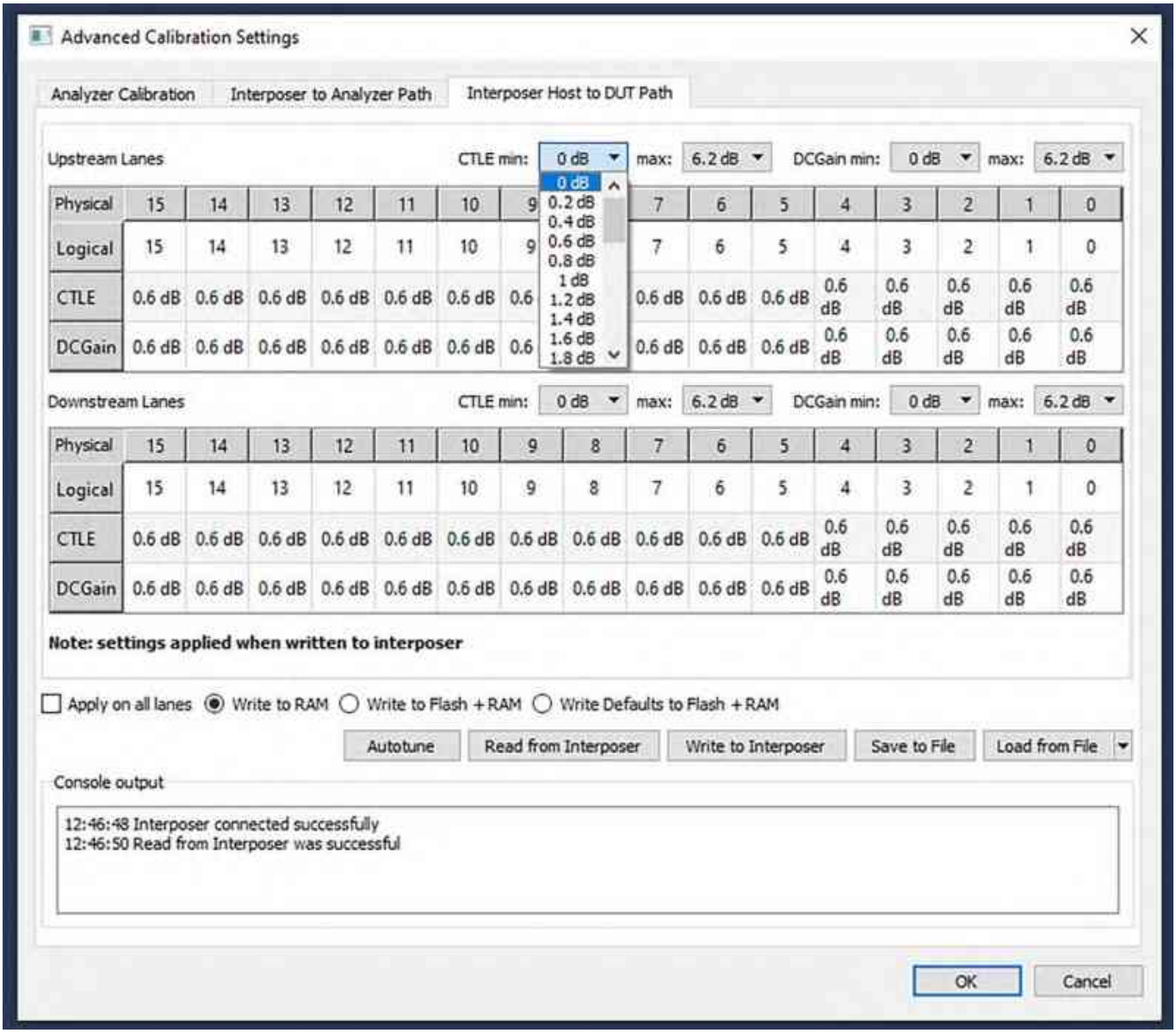


Figure 6.144: Advanced Calibration Settings: Selecting CTLE Range

You can only select numbers within the range available in the lane table. Selecting a the minimum or maximum range outside of the specified ranges causes the lanes to turn red (Figure 6.145).

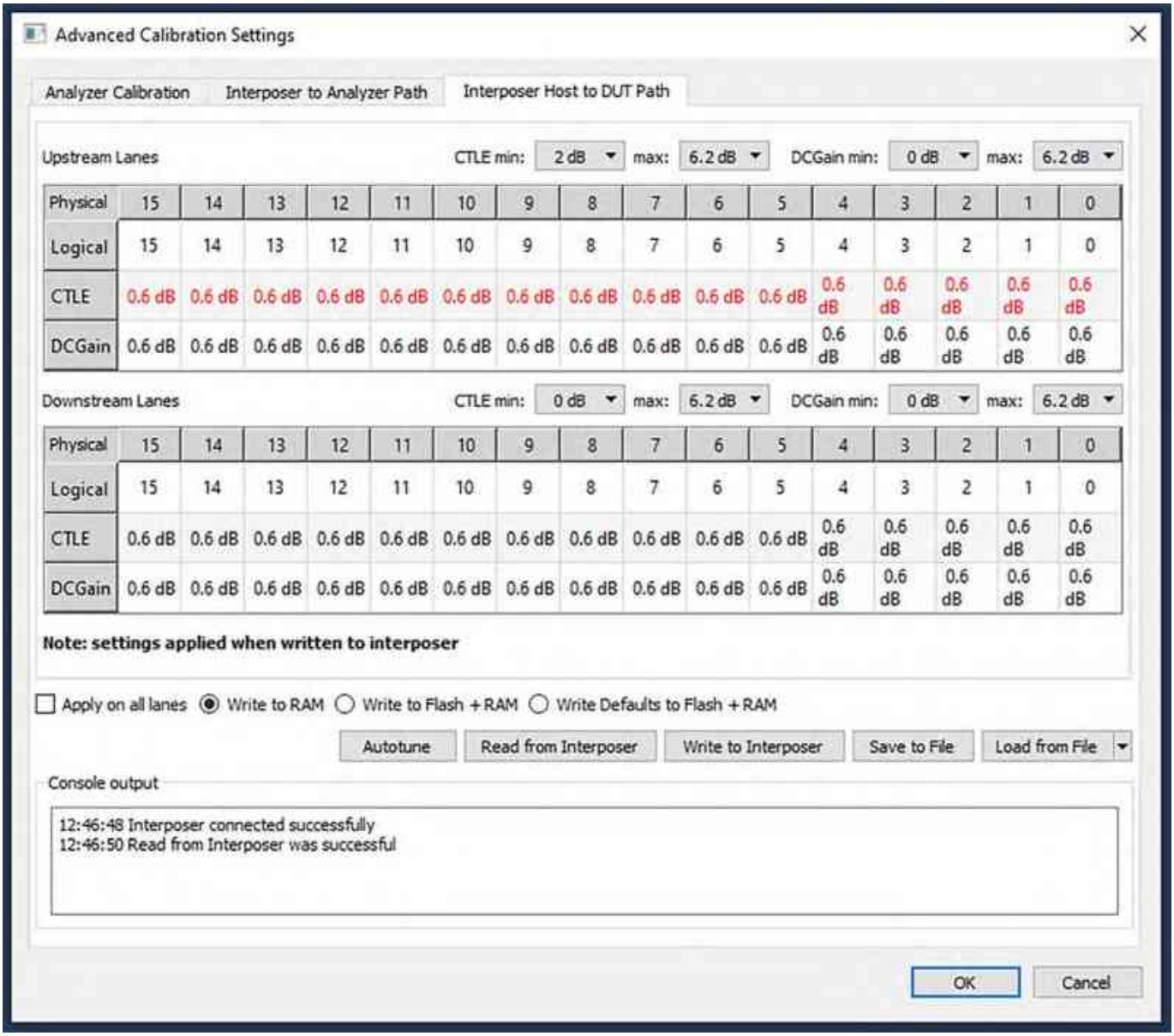


Figure 6.145: Advanced Calibration Settings: CTLE Outside of Range

A warning also displays, as shown in Figure 6.146.

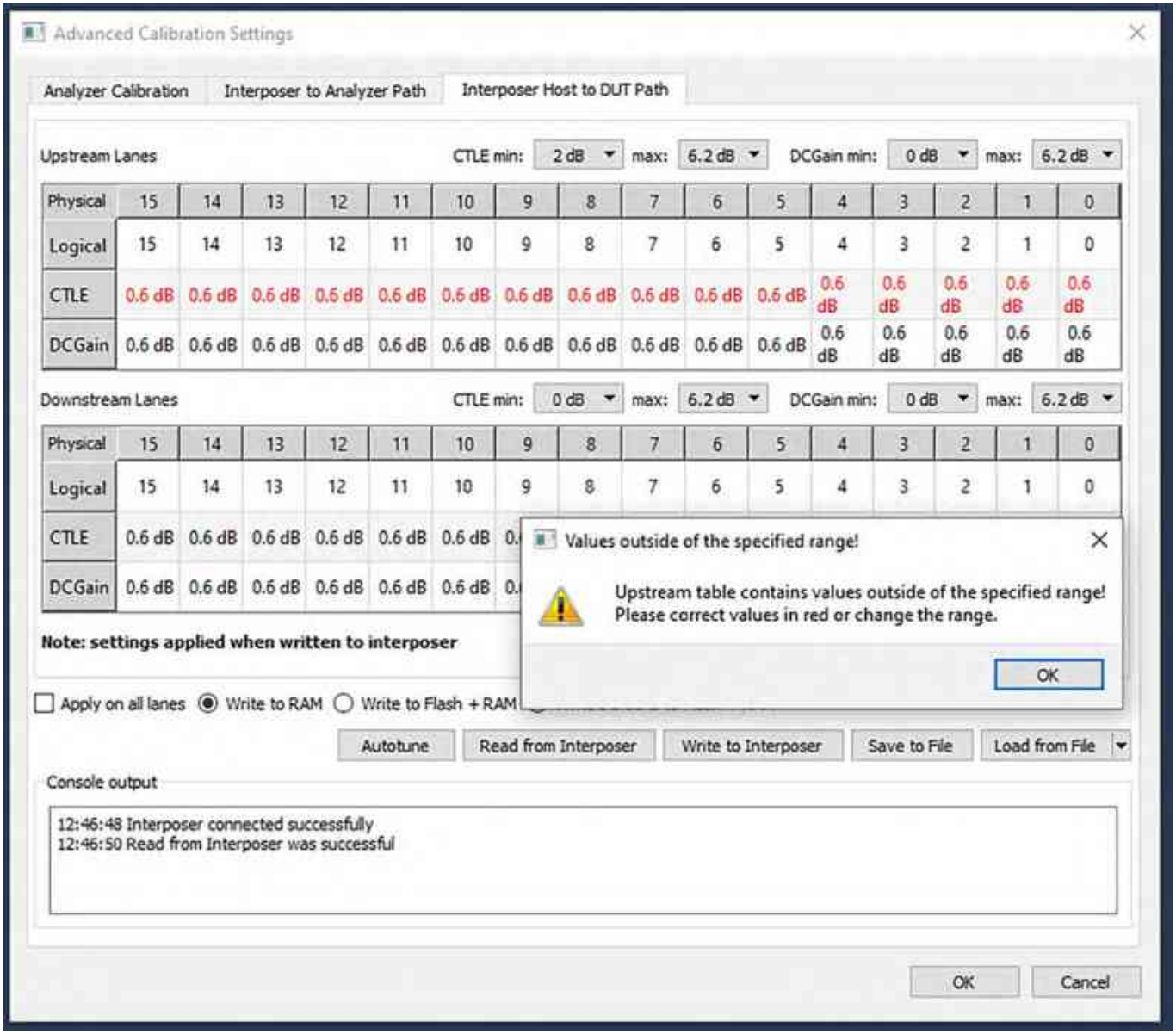


Figure 6.146: Advanced Calibration Settings: Values Outside Specified Range

You must fix the values before you can **Save to File**, **Write to Interposer**, **Read from Interposer**, or start the **Autotune** process.

To fix all the red values in the row to the minimum specified value within the range:

1. First, click the column of the values that need to change.
2. Change the values. Use the <tab> button to navigate between values.

Once the values are in range, you can select **Write to Interposer** or **Read from Interposer**. Clicking **Write to interposer** or **Read from Interposer** also writes /reads the selected ranges to the RAM / Flash.

Note: When selecting **Write to Interposer**, the selected Ranges will be reset to those supported by the current interposer.

6.19.1.2 Interposer Host to DUT Path Autotune

The goal of the DUT auto-tuning is to get the device to the target link speed and width with minimal error rate, by adjusting CTLE and DCGain values. Target link speed and width can be selected in the dialog before starting the auto-tuning.

The auto-tuning routine automatically sets and writes to the interposer CTLE and DCGain values, measures error rate and if necessary resets the DUT or reboots the host.

Typical Setup

Typical setup for this feature consists of two PCs as described below:

- Target Host PC where the interposer is connected.
- Client PC running the PCIe Protocol Analysis software application which can perform the following tasks:
  - adjust analyzer settings
  - adjust interposer settings
  - perform recording/analysis of a captured trace
  - manage the Target Host PC via client software:
    - queries list of installed hardware
    - queries of the DUT/Root complex settings
    - OS reboot

The Target Host PC may be managed either through Windows or Linux OS (Operating System). Depending on the host OS there are 3 possible solutions.

- SSH (Secure Shell -> Linux OS)
- SSL (Secure Sockets Layer -> Windows OS)
- SSH (TDY Provided -> Linux OS)

The choice of SSH vs. SSL depends on which method is easier for setting up the Target Host PC.

Secure Shell (SSH)

SSH (Secure Shell) uses public-key cryptography to authenticate the remote computer and allow it to authenticate the user, if necessary. There are several ways to use SSH; one is to use automatically generated public-private key pairs to simply encrypt a network connection, and then use password authentication to log on. Another is to use a manually generated public-private key pair to perform the authentication, allowing users or programs to log in without having to specify a password. In this scenario, anyone can produce a matching pair of different keys (public and private). The public key is placed on all computers that must allow access to the owner of the matching private key (the owner keeps the private key secret). While authentication is based on the private key, the key

itself is never transferred through the network during authentication. SSH only verifies whether the same person offering the public key also owns the matching private key. In all versions of SSH it is important to verify unknown public keys, i.e. associate the public keys with identities, before accepting them as valid. Accepting an attacker's public key without validation will authorize an unauthorized attacker as a valid user.

Secure Sockets Layer (SSL)

SSL (Secure Sockets Layer) is the standard security technology for establishing an encrypted link between a web server and a browser. This link ensures that all data passed between the web server and browsers remain private and integral. SSL is an industry standard and is used by millions of websites in the protection of their online transactions with their customers.

To be able to create an SSL connection a web server requires an SSL Certificate. When you choose to activate SSL on your web server you will be prompted to complete a number of questions about the identity of your website and your company. Your web server then creates two cryptographic keys - a Private Key and a Public Key.

The Public Key does not need to be secret and is placed into a Certificate Signing Request (CSR) – a data file also containing your details. You should then submit the CSR. During the SSL Certificate application process, the Certification Authority will validate your details and issue an SSL Certificate containing your details and allowing you to use SSL. Your web server will match your issued SSL Certificate to your Private Key. Your web server will then be able to establish an encrypted link between the website and your customer's web browser.

The complexities of the SSL protocol remain invisible to your customers. Instead their browsers provide them with a key indicator to let them know they are currently protected by an SSL encrypted session - the lock icon in the lower right-hand corner, clicking on the lock icon displays your SSL Certificate and the details about it. All SSL Certificates are issued to either companies or legally accountable individuals.

Typically an SSL Certificate will contain your domain name, your company name, your address, your city, your state and your country. It will also contain the expiration date of the Certificate and details of the Certification Authority responsible for the issuance of the Certificate. When a browser connects to a secure site it will retrieve the site's SSL Certificate and check that it has not expired, it has been issued by a Certification Authority the browser trusts, and that it is being used by the website for which it has been issued. If it fails on any one of these checks the browser will display a warning to the end user letting them know that the site is not secured by SSL.

Access to the Configuration Space

The Target Host PC with the installed Interposer, the DUT, and the client software (Auto-tuning process) **REQUIRES** access to the device configuration space, which is achieved by using a software program that runs on the Target Host PC:

- InterposerAutotuningAgent.exe if the Target Host PC OS is Windows.
- Bash scripts, if the Target Host PC OS is Linux.

Using Summit Z58/Z516 as Device

When using a Summit Z58 or Z516 as a device, the corresponding check box **The DUT is Z516 or Z58** must be selected and the connected host under test must be chosen from the list. See Figure 6.147.

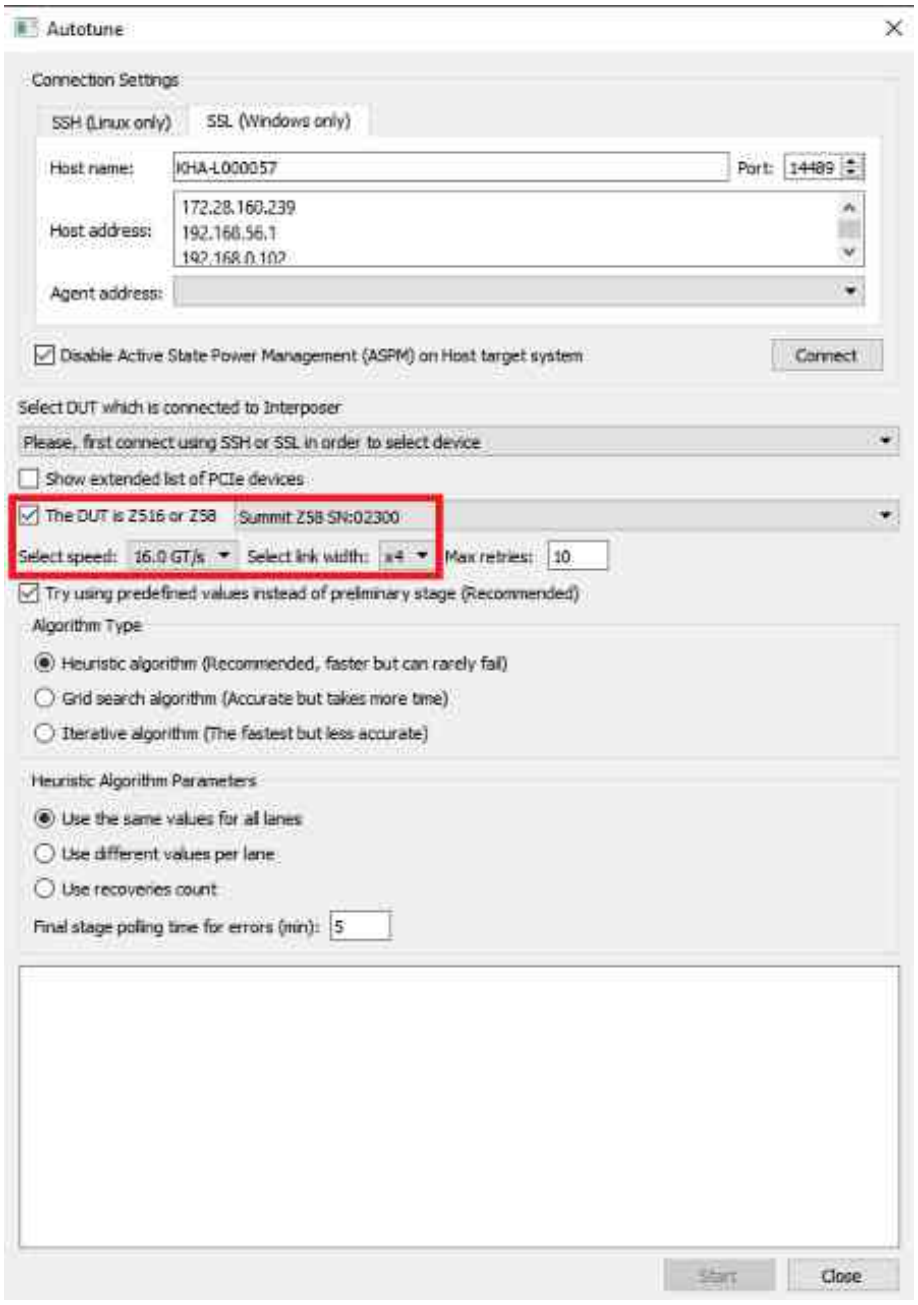


Figure 6.147: The DUT is Z516 or Z58 Option

If this option is enabled, during auto-tuning:

- Link state (current link width and link speed) is read from the register in the configuration space of the port of the selected DUT instead of the configuration space of the DUT.

- Connect macros is executed for the chosen Exerciser instead of performing software link reset.

Autotuning Algorithms

The Autotune dialog allows selecting one of several algorithms. The selected algorithm determines the steps that are performed during the process to find optimal CTLE and DCGain settings.

For most algorithms, the auto-tuning routine uses the number of correctable and non-fatal errors read from the device and port as a link quality metric (the read values are reported in the log after each measurement). Consult the PCI Express® Base Specification for the definition of correctable and non-fatal errors. Since this error number is a link-wide metric, all algorithms except Predictive with enabled **Use different values per lane** option use equal values of CTLE and DCGain for all lanes.

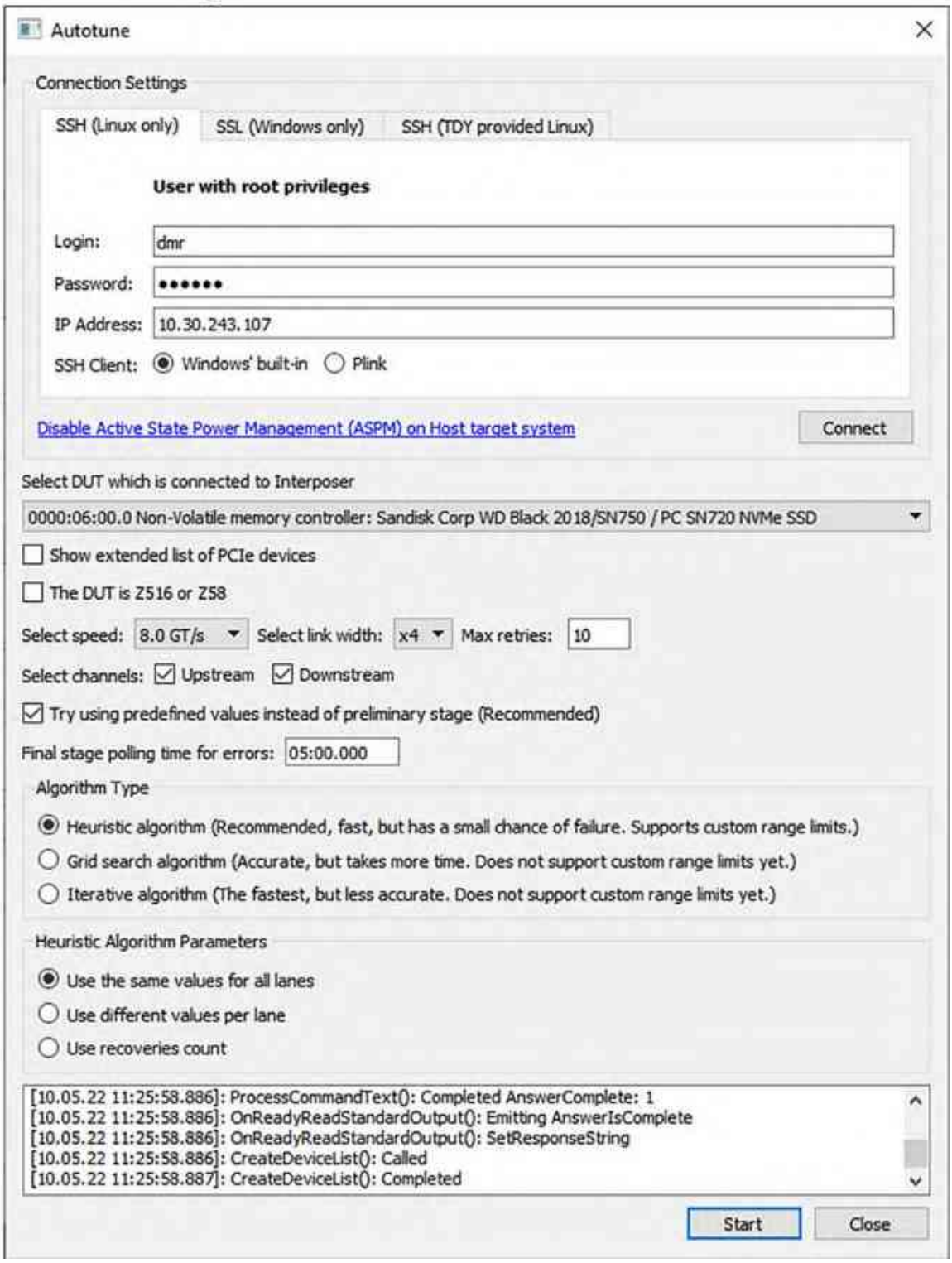


Figure 6.148: Auto-Tune: Algorithm Selection Options

Heuristic Algorithm

The heuristic search method utilizes information from the previous measurements to determine the direction of the settings with the lower number of errors.

Auto-tuning is performed separately for upstream and downstream. For each direction there are several stages. Each subsequent stage has a larger error polling interval. The advance to the next stage occurs when zero error rate is archived on the current stage. The found settings are used as the starting point for the algorithm in the next stage. If the routine cannot find settings with a zero error rate, then the auto-tuning stops.

First the routine performs an exhaustive search with large steps (which is described below) with a duration stage time 500 millisecond. As a result, it saves some best points (by error rates) and starts the next algorithm from them.

The durations of all stages but the last are predefined. The first stage is 500 milliseconds. Then error polling time gradually increases: 2, 5, 10, 20, 40 seconds and 1, 2, 5, 10, 20, 30 minutes. For the final stage the errors polling time may be configured using **Final stage polling time for errors (min)** option in the Autotune dialog. It may be from 1 to 60 minutes. Note that if, for example, 5 minutes is specified, then the stages with longer error polling time (10, 20 and 30 minutes stages) are not performed.

Note that this algorithm starts from the CTLE and DCGain produced by the first Grid search run. In case the algorithm fails to find good values from first point then the procedure starts again (without additional Grid search run) selecting next point until good values are found or all saved points are tested.

This algorithm also supports custom range limits. The only values within the appropriate range will be tested by the algorithm and during the checking for presets.

Note: For custom ranges to apply, the "Try using predefined Values …" option must be selected. Otherwise, the algorithm ignores the custom range.

In addition, after any write to interposer in scope of this algorithm DUT is reset to adopt to new line characteristics.

This algorithm allows you to configure how errors are measured. The following options are available in **Heuristic Algorithm Parameters** in the Autotune dialog:

- **Use the same values for all lanes**
  The same values for parameters (CTLE and DCGain) are set for all lanes on one channel. The number of correctable and non-fatal errors read from the device and port will be used to determine the link quality.
- **Use different values per lane**
  Parameters for each lane are tuned separately. In this case to determine number of errors on each lane an analyzer is used.
- **Use recoveries count**
  The same values for parameters are set for all lanes on one channel. The number of recoveries counted on the analyzer are used to determine the link quality. This number is applied for entire link so the same values should be used for each

lane. This is main algorithm which often produces accurate results and does not take as much time as Grid search.

Grid Search Algorithm

If this option is selected, then the auto-tuning routine performs an exhaustive search through the predefined subset of settings for both channels at the same time.

There are three stages. During the first stage the routine uses large steps to find spots with settings, with which the device is able to work at the target link width and speed (as specified in the Autotune dialog). Then the same process but with smaller steps is repeated in the found spots. Then on the final stage each value inside the found on the second stage good spots is checked to find zero error rate.

Note that since a lot of different combinations of CTLE and DCGain values are checked, this algorithm may take more time to complete than other algorithms but is more accurate because more values are tested..

Iterative Algorithm

In this algorithm, there are several calibration stages where the auto-tuning routine tries adjacent value combinations to minimize error rate. It is done separately for upstream and downstream.

For the first stage the step is 0.6 dB, and for all subsequent stages the step is 0.2 dB. Each stage beginning from the second stage uses a larger error-collection interval, which allows the algorithm to detect less frequent errors but also slows the tuning process. If at any stage except the first stage (that is, every stage with minimal steps) the algorithm cannot achieve zero error rates for its interval, tuning stops.

During this process DUT reset is done (without rebooting host), after that, error rate is re-checked, and the tuning stage is repeated if needed. This algorithm is the fastest of all but may not produce accurate results.

Note: The Autotune dialog allows selecting the target speed and width of the link. If the current speed or link width reported by the DUT does not match the target values and the selected Algorithm Type is **Predictive algorithm** or **Coordinate descent,** then an additional step is performed before starting the selected algorithm. On this step the software routine is trying to walk with large steps through the CTLE/DCGain space to find spots where the link is good enough for the device to switch to the target speed and link width. If the link width is less than required, then the host is rebooted. If the speed is less than required, then the DUT reset is performed without reboot. The software routine is careful not to disrupt the link so much that the device becomes unavailable, making a host reboot needed, but it can happen sometimes. At this stage, the software routine is checking very few CTLE/DCGain combinations in predefined patterns. The error rate is not checked on this stage.

Host PC is running Window OS

Prerequisites

1. On the client PC (where PCIe Software Suite is installed), go to the folder "C:\Program Files\LeCroy\PCIe Protocol Suite\" and copy InterposerAutotuningAgentLauncher.exe to the removable media.
2. Run PCIe Protocol Analysis software. Go to 'Recording Options' -> Interposer 'Auto-Tuning' tab.
3. Push 'Auto-Tune button'.
4. Open 'SSL (Windows only)' tab. Write down the values of 'Host address'/'Port' fields (see Figure 6.149 on page 291).

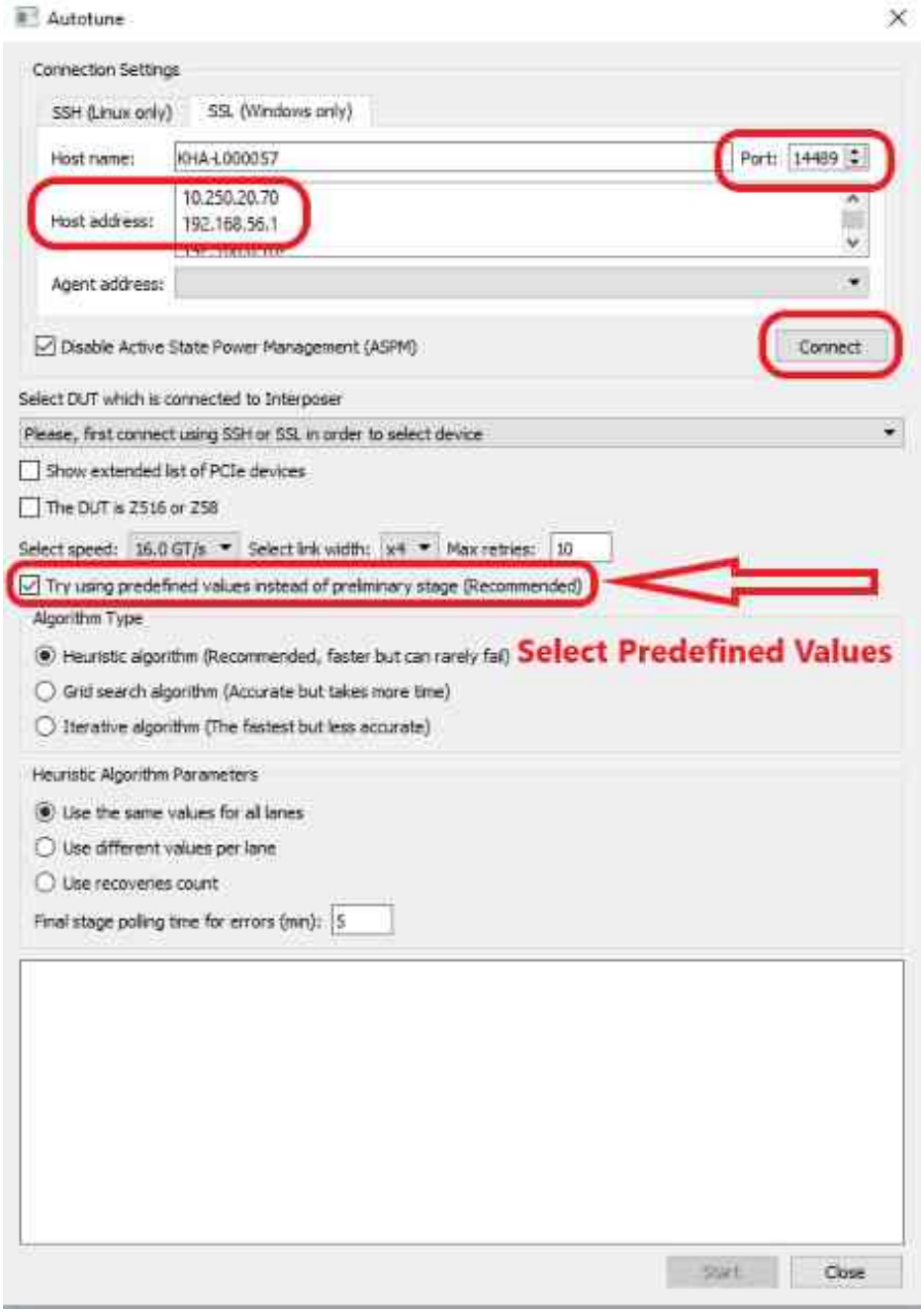


Figure 6.149: Autotune: Select Predefined Values

If you select the Predefined Values for Auto-Tune and return to the Host to DUT Settings dialog box, click on the Load from File tab (see Figure 6.150 on page 292) and you'll see a list of devices (see Figure 6.151 on page 292).

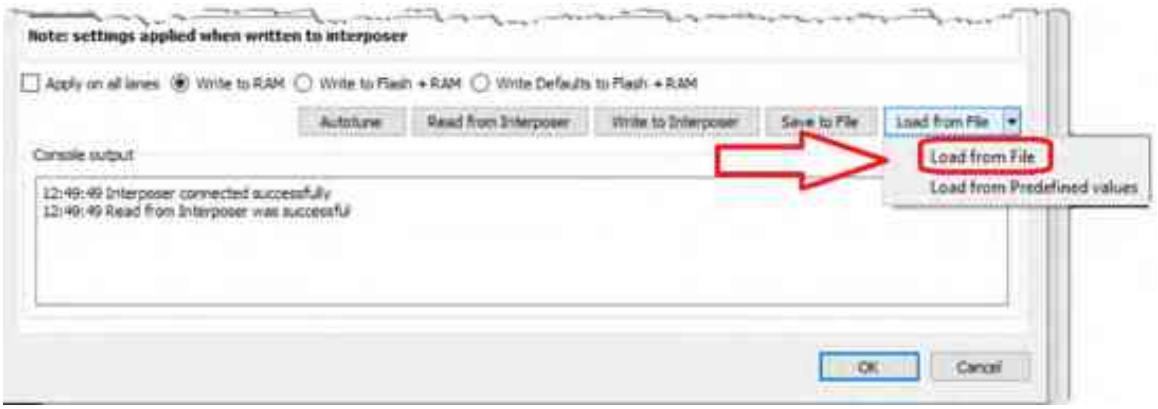


Figure 6.150: Host to DUT Settings: Load from File

If you select Load from File a List of DUT Settings will pop up. See Figure 6.151 on page 292.

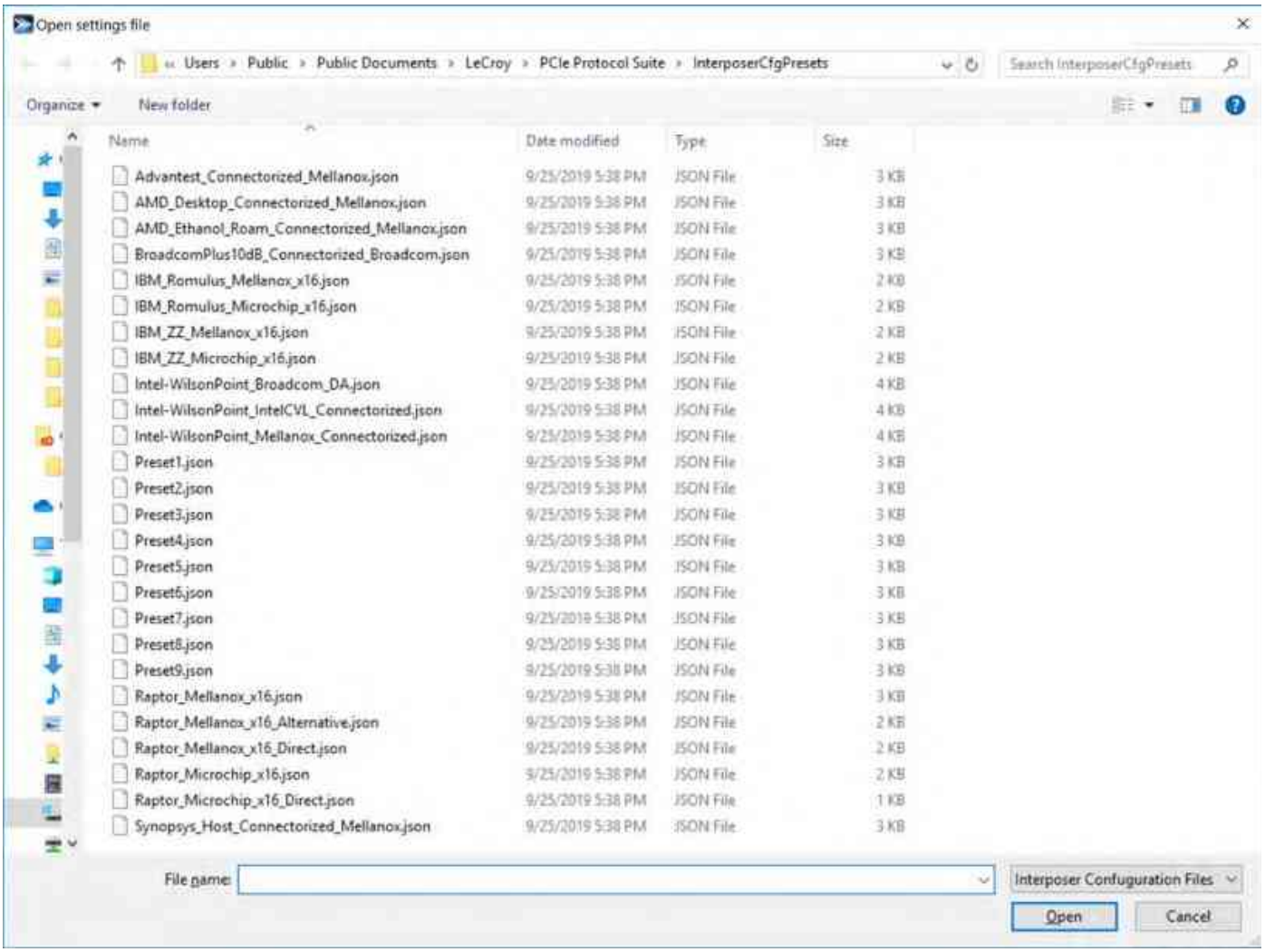


Figure 6.151: Load from File – List of Files

Another way to view the Predefined Values is to select Load from Predefined Values tab and the Choose Predefined values dialog box will pop up. See Figure 6.152 on page 293.

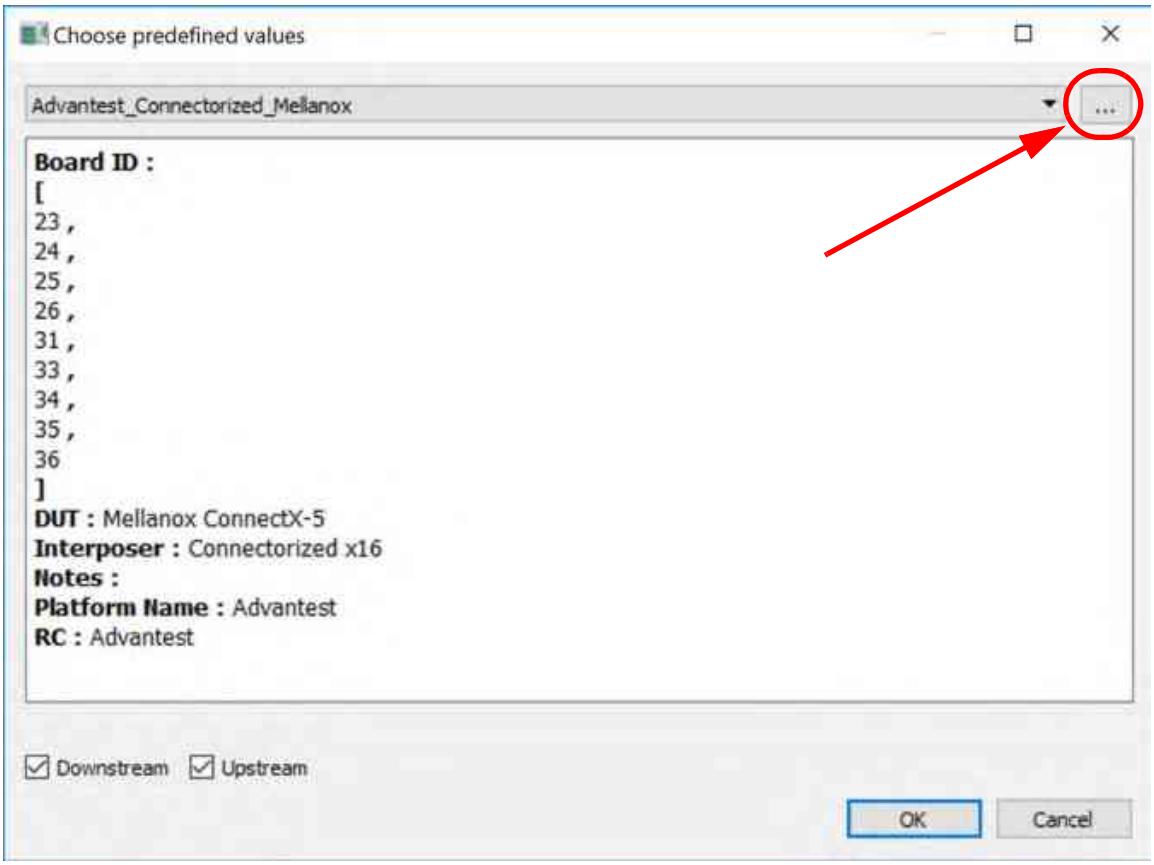


Figure 6.152: Chose predefined values

If you select the ... tab you'll see a list of all the predefined DUT Settings. See Figure 6.153 on page 294.

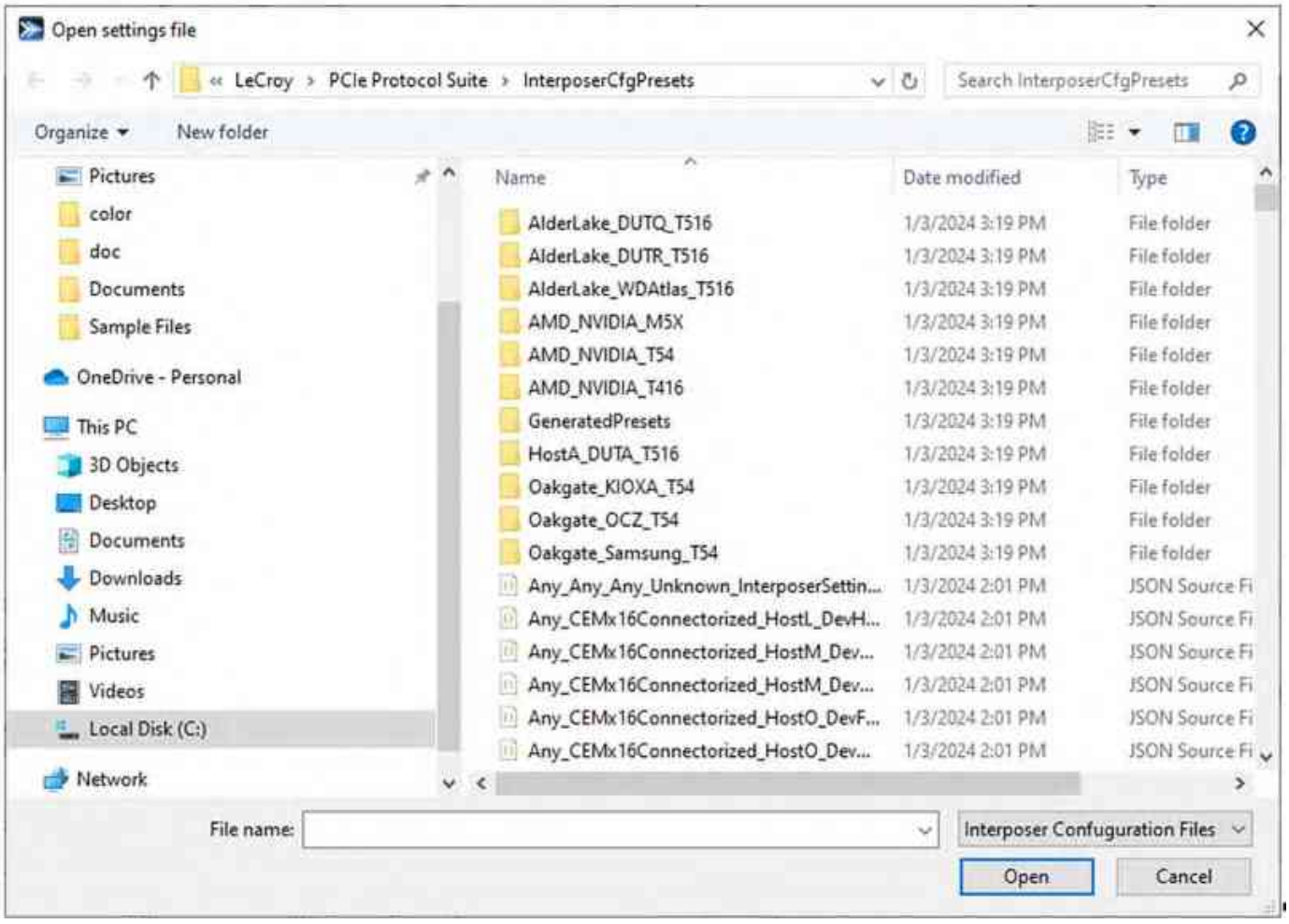


Figure 6.153: Set of Predefined DUT Settings

Another way to select a set of Predefined Values is to select the small black down pointing arrow and the list of predefined DUTs will appear. See Figure 6.154.

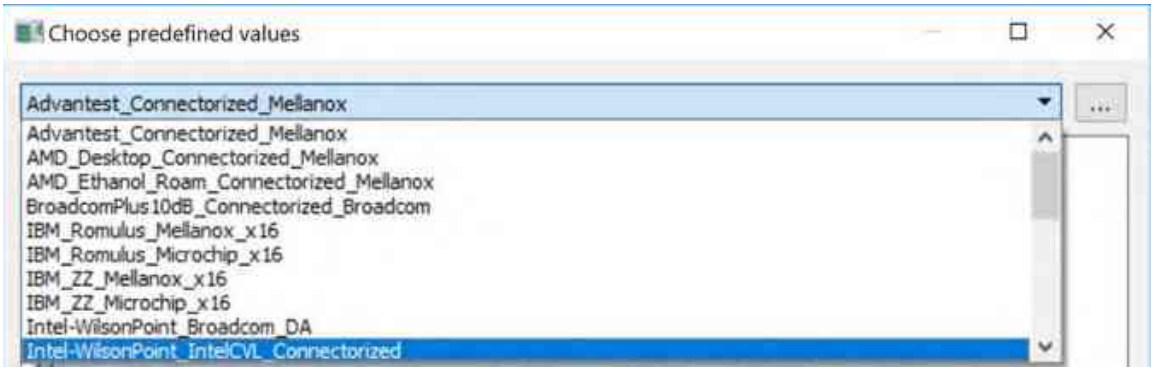


Figure 6.154: Choose predefined Values: Arrow

After you select a device (in this case the Intel-WilsonPoint_IntelCVL_Connectorized) the data for that device will pop up in the Choose predefined values dialog box. See Figure 6.155.

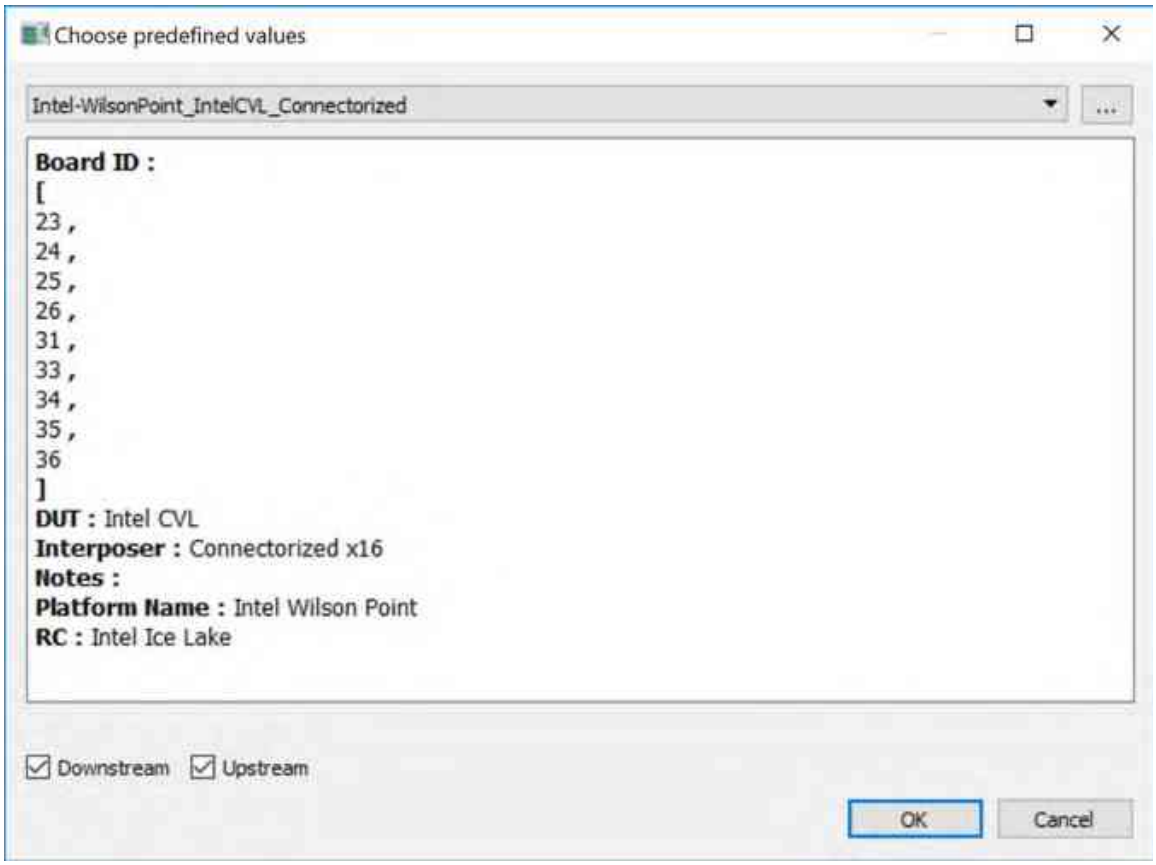


Figure 6.155: Choose predefined values: Intel-WilsonPoint...

InterposerAutotuningAgent installation on target host

1. Copy **InterposerAutotuningAgentLauncher.exe** to the target host PC.
2. Run **cmd.exe** with administrative credentials.
3. Run InterposerAutotuningAgentLauncher.exe.
4. Make sure that PMA driver installed successfully
5. Enter IP Main host and port address (see step 2 from prerequisites).
6. Press **Enter**. Make sure there are no warning and error messages. See Figure 6.156.
7. Close command prompt.

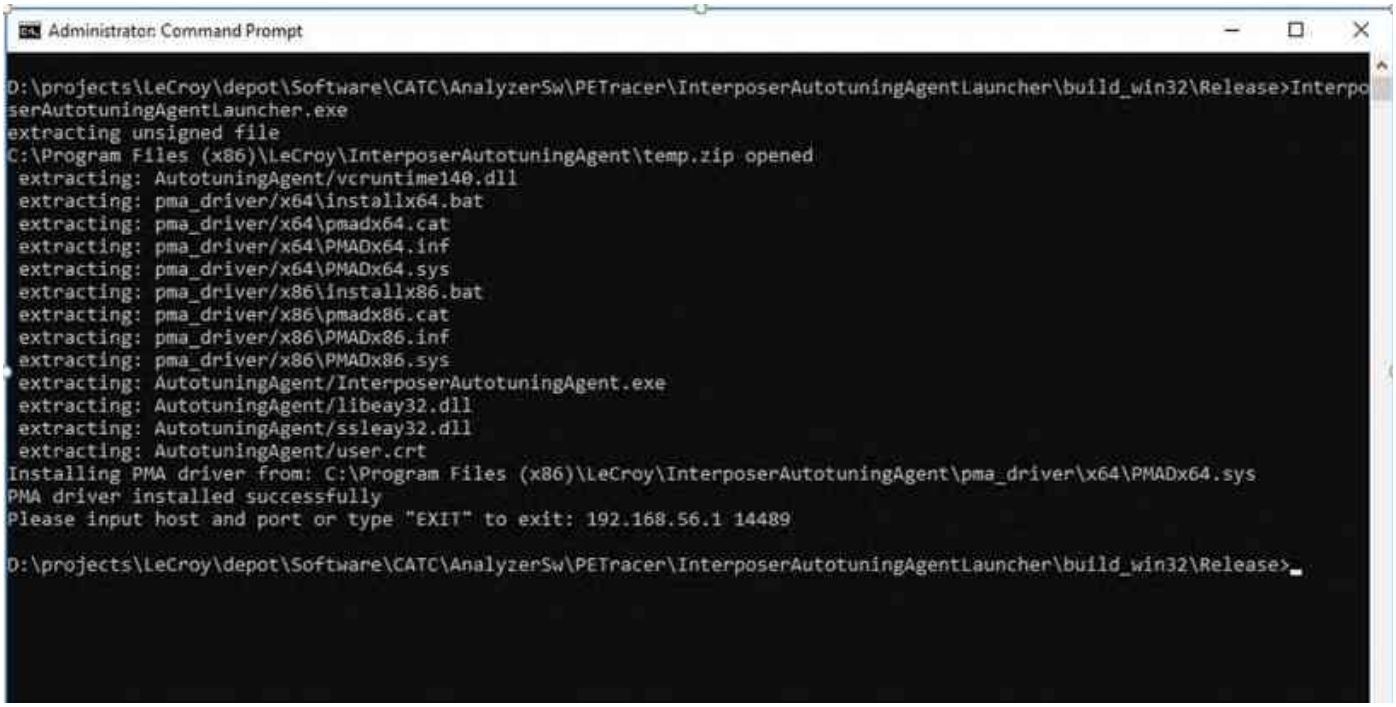


Figure 6.156: Administrator: Command Prompt

If something went wrong uninstall launcher using "Add/Remove Programs" and repeat again.

Uninstalling InterposerAutotuningAgent

1. Go to Windows settings -> 'Add or remove programs'.
2. Remove 'Interposer Autotuning Agent'.

Verify the service is correctly installed and running on target Host PC

After successful InterposeAutotuningAgent installation new windows service must appear and be “Running”. See Figure 6.157.

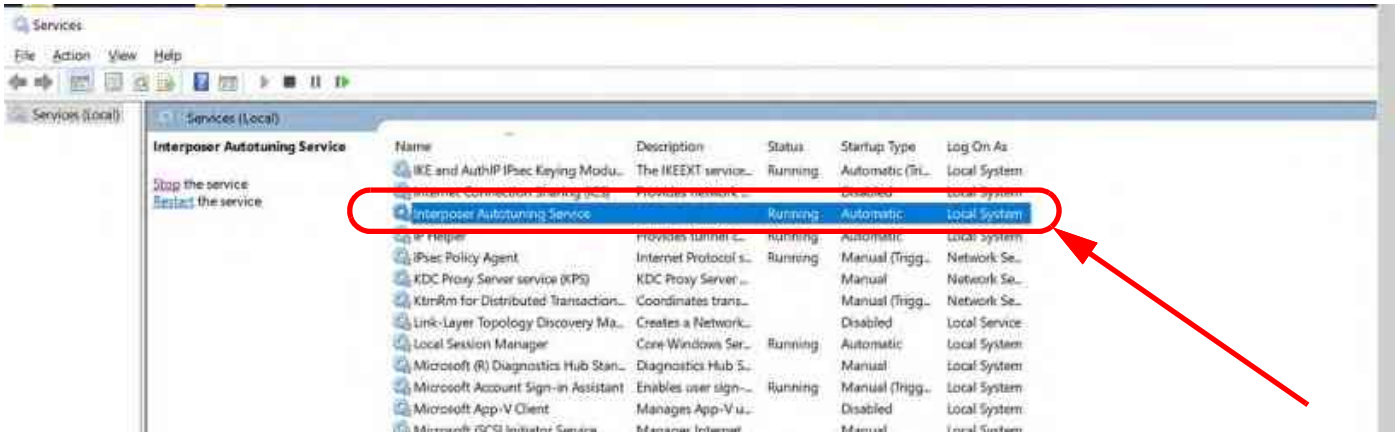


Figure 6.157: Services: Interposer Autotuning Service

After Agent startup, it immediately attempts to connect the client PC for every 5s. Such behavior may cause false positive warning of antivirus software or IDS (intrusion detection systems). It is recommended to uninstall/disable agent as soon as it is no longer needed.

User has option to stop Agent remotely from Auto-tuning dialogue. In such cases Agent stops service and tries to uninstall itself.

Start auto-tuning process:

1. From the PC where analyzer is connected, 0pen PCIe Protocol Analysis software.
2. Connect to the Analyzer.
3. Open the "Recording Options" dialog.
4. Switch to "Host-to-DUT settings" tab.

See Figure 6.158 on page 297.

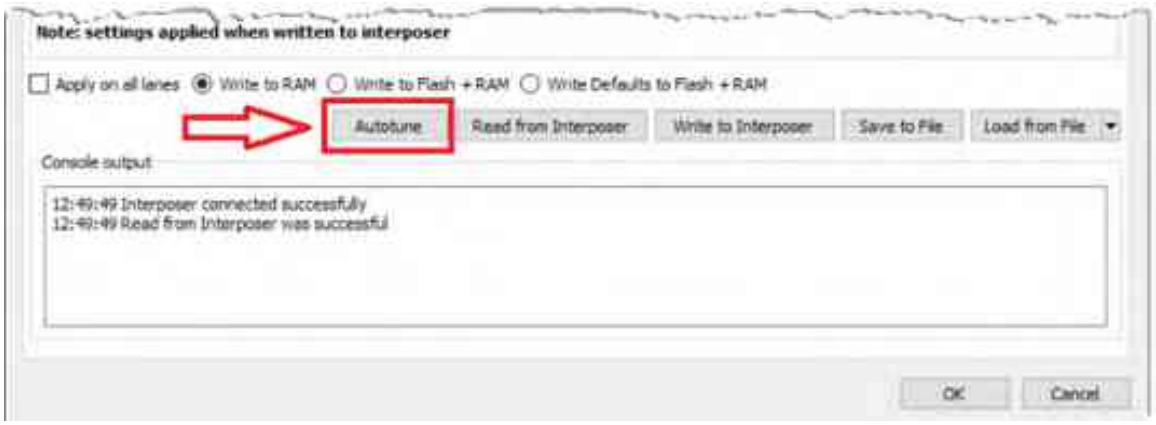


Figure 6.158: Recording Options: Interposer Host to DUT Path → Autotune

5. Click **Autotune** (Figure 6.158) to bring up the Autotune dialog. See Figure 6.159 on page 298.

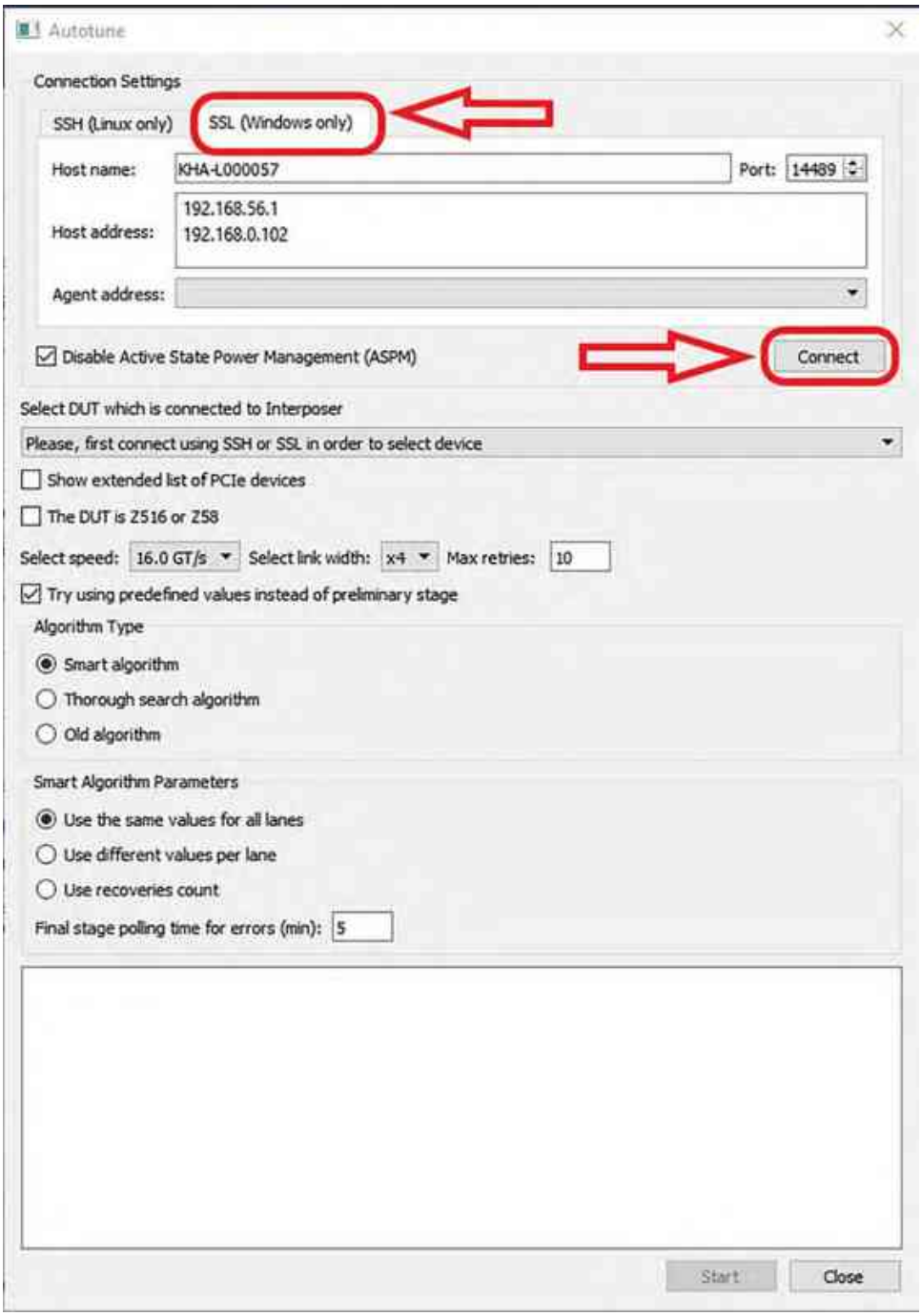


Figure 6.159: Auto-Tune Dialog

6. Select SSL (Windows only), complete the agent install process as describe above (put ref. mark here), before the next step.
7. Dialog window will open, with options to do DUT path.
8. Click "Connect" button. Connection to target host will be established (it may take several seconds) and then list of devices on host will appear. See Figure 6.160.

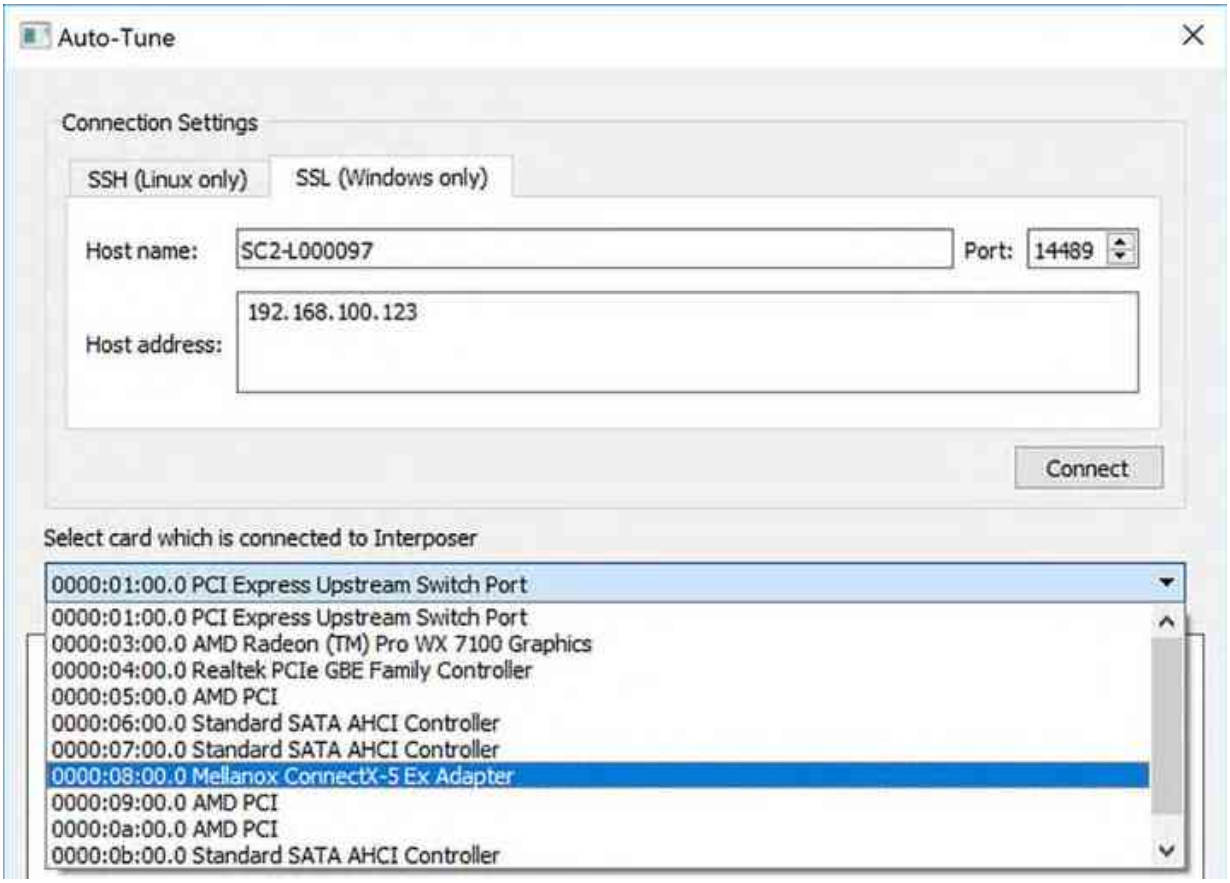


Figure 6.160: List of PCIe Devices

If the list of devices on the host does not appear and the error as shown on Figure 5.146 is reported in the log, then the InterposerAutotuningAgent should be reinstalled on the target host using the steps described in “Uninstalling InterposerAutotuningAgent” and “InterposerAutotuningAgent installation on target host” sections above.

This error may occur if the InterposerAutotuningAgent from one of the previous PCIe Protocol Analysis versions is installed on the target host.

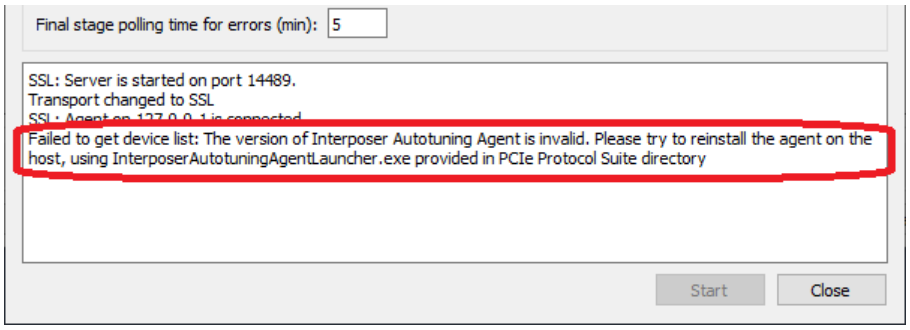


Figure 6.161: Incorrect Agent Version Error

9. Select desired link width, speed and algorithm parameters.
10. Select DUT in this list. There is no way for software to detect if selected device is a correct one or not. If wrong device was selected calibration will still start but of course will not do anything useful. In most cases it will stop after about two

minutes and then user can re-run it selecting correct device this time. In this case we chose the Mellanox PCIe card to Auto-Tune.

11.

Note: This is a critical step, please select a correct device not the bridge, otherwise the tuning will not work.

12. After clicking “OK” tuning begins, a detailed progress report displays in the log area. Press the “Stop” button to abort the tuning process, but this may leave the link unstable or absent. If this happens, setting some reasonable interposer parameters and rebooting of target host may be needed.

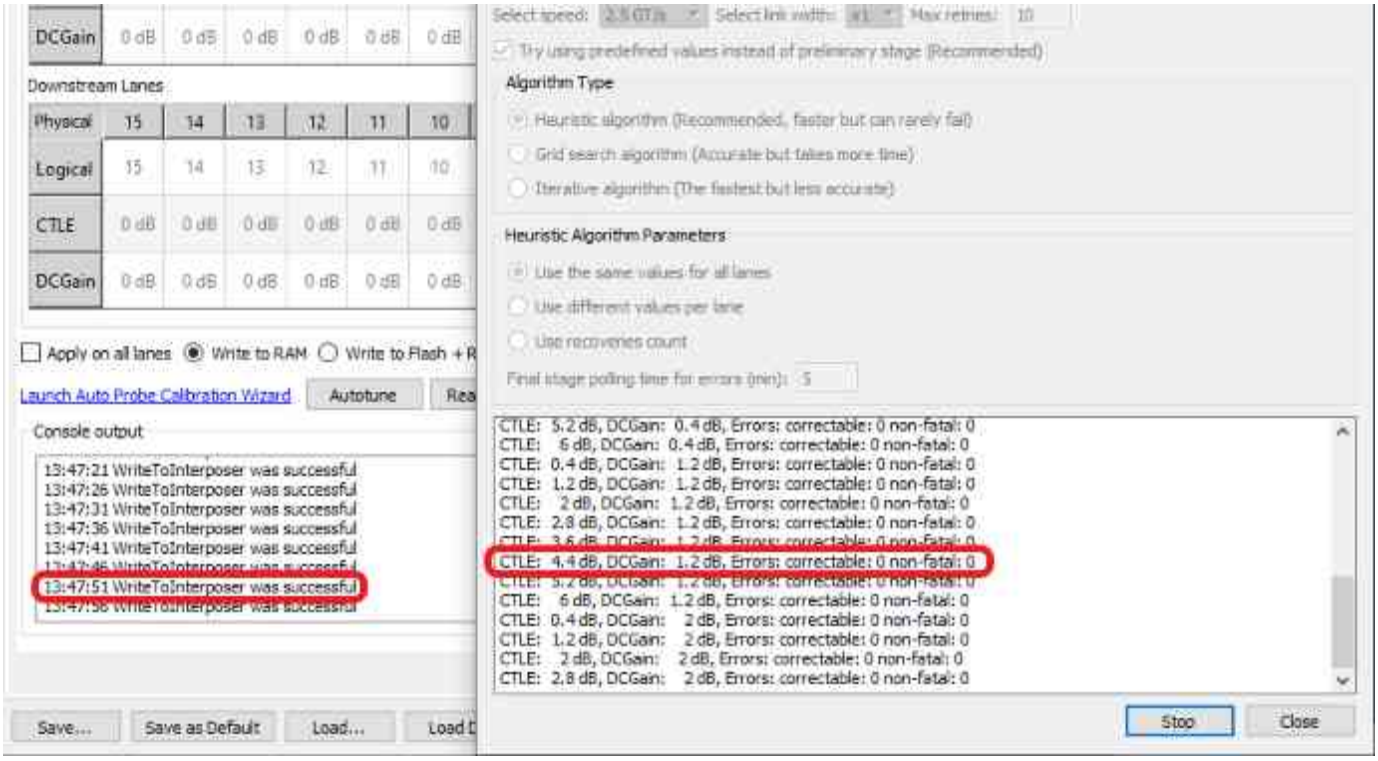


Figure 6.162: PCIe Card Selected: Auto-Tune Started

As you can see from Figure 6.162 as Auto-Tuning proceeds new CTLE and DC Gain values are written to the Interposer.

13. If any error occurs, it will be reported in dialog window as well as in the log area. It is meant as unattended process. There is no specific estimate of time it will take, but on most setups, it will be in the range from 3 to 30 minutes. On some setups it may take a lot longer (as long as several hours)
14. Depending upon the host, it is possible that the host reboot process hangs, in this case, if it cannot come back up even after 10 minutes, timeout popup will be shown with request to reboot host manually, but overall process is automatic.
15. When tuning is finished, a dialog is shown which allows users to keep newly-found settings or return to previous settings.

16. If SSL agent is used user will be prompted to stop auto-tuning agent on closing auto-tuning dialog. If agent is stopped user will need to reinstall it to do DUT path tuning again.

Host is on Linux OS:

For Linux hosts SSH connection, network connectivity to target host and SSH credentials are required. These credentials should either directly give root privileges on host or be enough to get root access using 'sudo' command. Required tools will be transferred to target host automatically. The target host PC may be rebooted several times during calibration and it should be connectible by SSH after reboots without manual intervention (i.e. SSH server should be started on boot, port should be opened in firewall and so on).

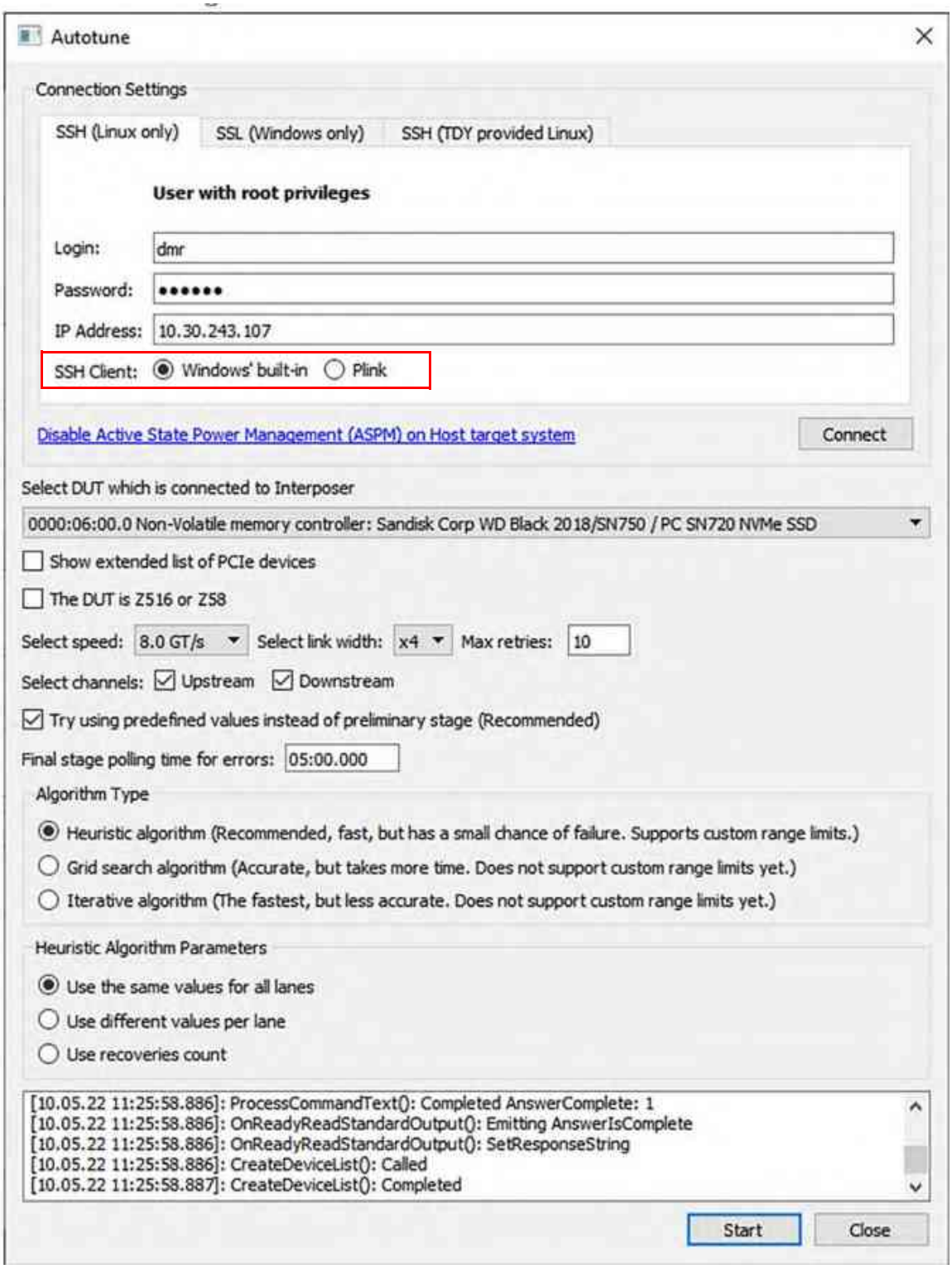


Figure 6.163: Autotuning Options

Autotuning uses one of two methods for communication with the Host with SSH Client:

- "Windows' built-in" - Autotuning uses an ssh.exe and scp.exe which are provided as part of the Windows installation.

- "Plink" - Autotuning uses a separate Plink utility. It is installed automatically together with PCIe Protocol Analysis software. This option may cause issues with connection to the Host if it uses ANSI escape sequences during SSH communication.

Commands to Validate the Setup:

Connecting to the Linux host from Windows cmd.exe: (see Figure 6.164)

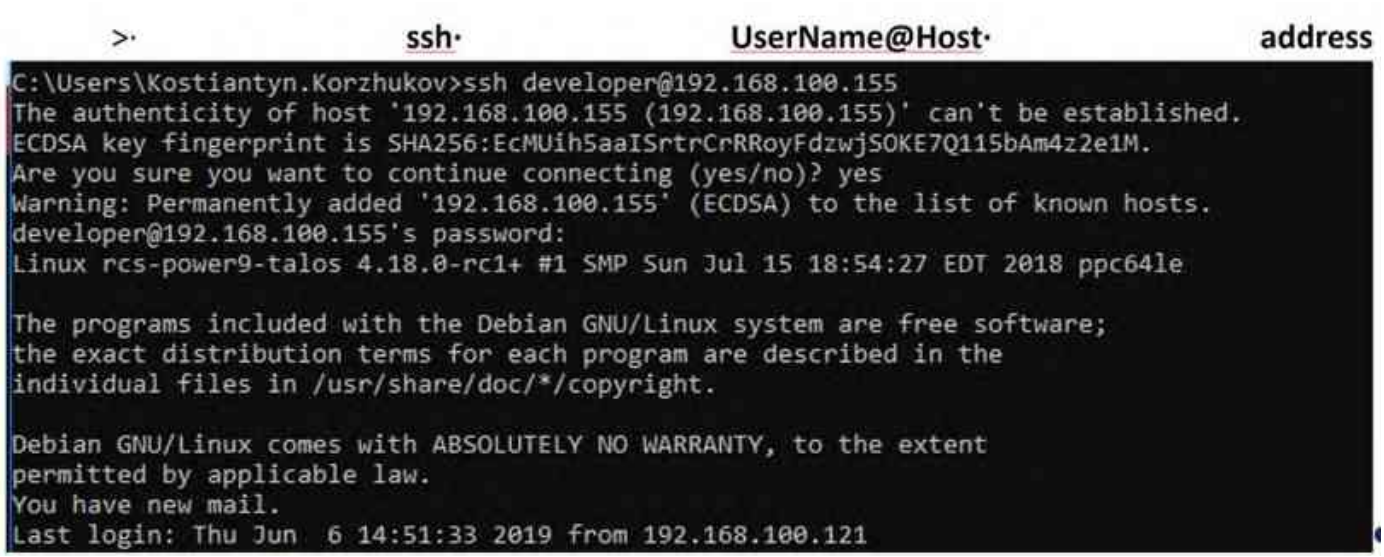


Figure 6.164: Connecting to Linux host from Windows cmd.exe

Get list all installed PCIe devices: # lspci (see Figure 6.165).

```
developer@rcs-power9-talos:~$ lspci
0000:00:00.0 PCI bridge: IBM Device 04c1
0001:00:00.0 PCI bridge: IBM Device 04c1
0001:01:00.0 SATA controller: Marvell Technology Group Ltd. 88SE9235 PCIe 2.0 x2 4-port SATA 6 Gb/s Controller (rev 11)
0002:00:00.0 PCI bridge: IBM Device 04c1
0003:00:00.0 PCI bridge: IBM Device 04c1
0003:01:00.0 USB controller: Texas Instruments TUSB73x0 SuperSpeed USB 3.0 xHCI Host Controller (rev 02)
0004:00:00.0 PCI bridge: IBM Device 04c1
0004:01:00.0 Ethernet controller: Broadcom Limited NetXtreme BCM5719 Gigabit Ethernet PCIe (rev 01)
0004:01:00.1 Ethernet controller: Broadcom Limited NetXtreme BCM5719 Gigabit Ethernet PCIe (rev 01)
0005:00:00.0 PCI bridge: IBM Device 04c1
0005:01:00.0 PCI bridge: ASPEED Technology, Inc. AST1150 PCI-to-PCI Bridge (rev 04)
0005:02:00.0 Multimedia video controller: ASPEED Technology, Inc. ASPEED Graphics Family (rev 41)
0030:00:00.0 PCI bridge: IBM Device 04c1
0030:01:00.0 VGA compatible controller: Advanced Micro Devices, Inc. [AMD/ATI] Ellesmere [Radeon Pro WX 7100]
0030:01:00.1 Audio device: Advanced Micro Devices, Inc. [AMD/ATI] Ellesmere [Radeon RX 580]
0031:00:00.0 PCI bridge: IBM Device 04c1
0031:01:00.0 Non-Volatile memory controller: Samsung Electronics Co Ltd NVMe SSD Controller SM961/PM961
0032:00:00.0 PCI bridge: IBM Device 04c1
0033:00:00.0 PCI bridge: IBM Device 04c1
```

Figure 6.165: Get List of all Installed PCIe Devices

Note: The device under test (DUT) should be present in this list, otherwise the auto-tuning will not work.

Reboot target host from command line

In some cases installed PCI hardware doesn't detect correctly, usually reboot attempts will help.

sudo reboot (see Figure 6.166).

```
developer@rcs-power9-talos:~$ sudo reboot
[sudo] password for developer:
Connection to 192.168.100.155 closed by remote host.
Connection to 192.168.100.155 closed.
```

Figure 6.166: Reboot Command

Start auto-tuning process

1. From the PC where analyzer is connected, open the Teledyne Lecroy PCIe Protocol Analysis software.
2. Connect to the Analyzer.
3. Open the “Recording Options” window.
4. Select the “Analyzer and Probe Settings” tab.
5. Click the “Launch Advanced Calibration Settings Dialog” text, located at the bottom.
6. The Advanced Calibration Settings dialog displays. Select the “Interposer Host to DUT Path” tab (see Figure 6.167 on page 305).

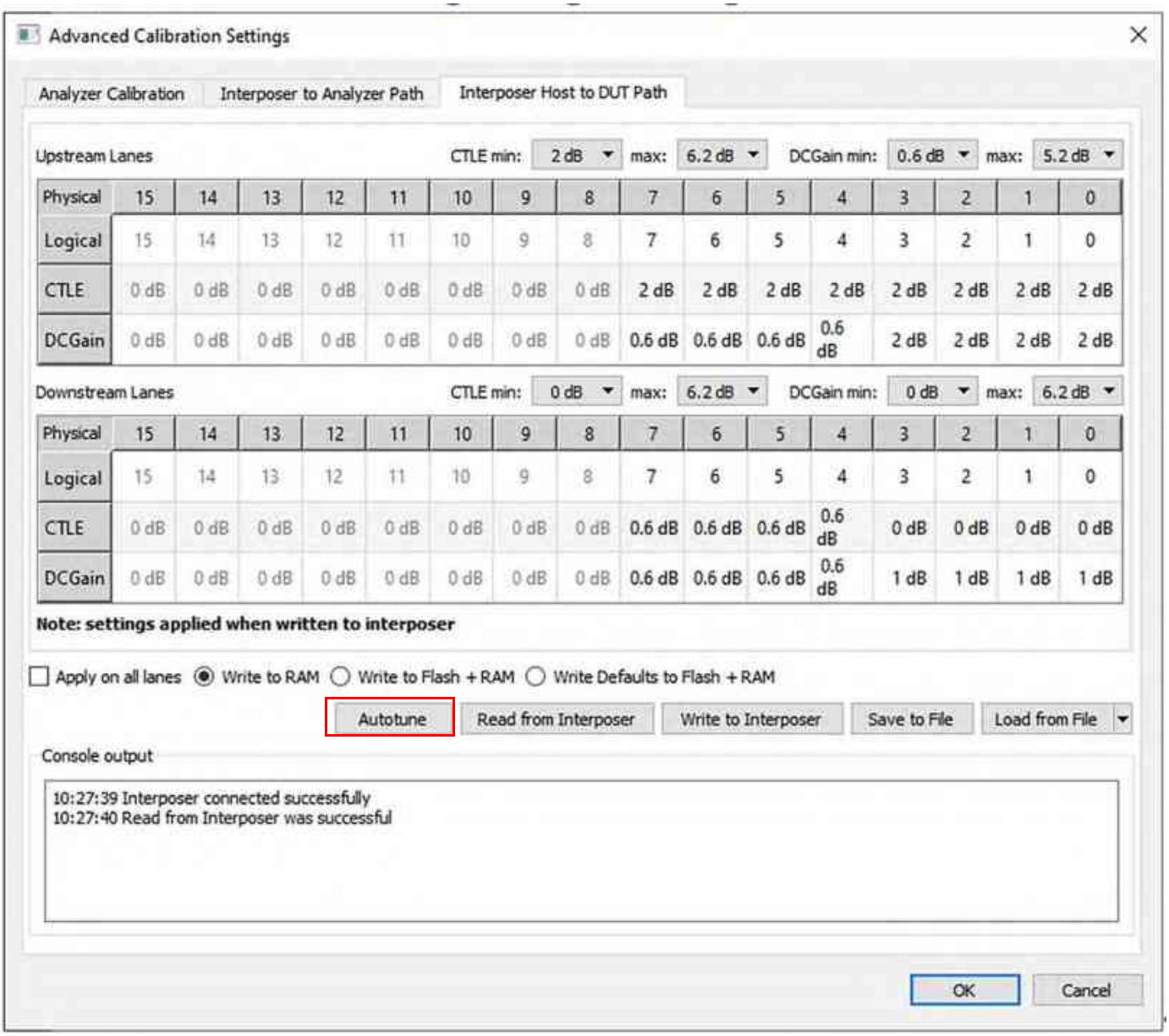


Figure 6.167: Host to DUT Settings

7. Click the **Autotune** button. The Autotune dialog box for the Host to DUT Settings appears, with options to do the DUT path (see Figure 6.168 on page 306).

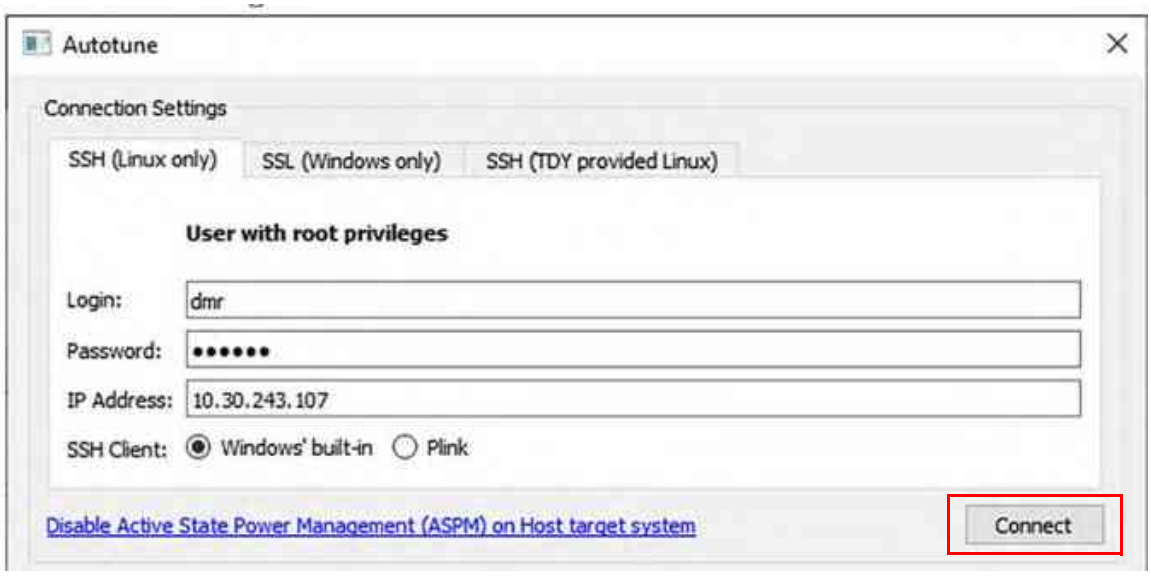


Figure 6.168: Options for Tuning the DUT Path

8. Enter target host settings:
   a. Select what kind of connection to remote host should be used from settings configured in the upper section:
   b. To auto-tune device connected to Linux host: Enter user, password and IP address of the target host and click **Connect**. (see Figure 6.168).
9. The connection to target host will be established (it may take several seconds), then list of devices on host will appear. Select the DUT from this list. There is no way for the software to detect if the selected device is the correct one. If the wrong device was selected, calibration will still start but will not do anything useful. In most cases, it will stop after about two minutes. Then, re-run it selecting the correct device.
10. Select desired link width, speed and algorithm parameters.
11. Click OK to begin the calibration.
    - A detailed progress report will be shown in the log area.
    - You can press the **Stop** button to abort the tuning, but this may leave the link unstable or absent. In this case, setting some reasonable interposer parameters and rebooting of target host may be needed.
12. If any error occurs, it will be reported in dialog window and duplicated in log area. It is meant as unattended process. There are no specific estimates time it takes to complete, but on most setups, it will be in the range from 3 to 30 minutes. On some setups it may take a lot longer (as long as several hours)
13. Under some conditions target host may reboot one or several times. As a last-resort option if it cannot come back up after 10 minutes timeout popup will be shown with request to reboot host manually, but overall process is automatic.
14. When calibration is finished dialog window will be shown which allows users to keep newly-found settings or return to previous settings.

15. If SSL agent is used user will be prompted to stop auto-tuning agent on closing auto-tuning dialog. IF agent is stopped user will need to reinstall it to do DUT path calibration again.
16. Perform Analyzer path calibration:
    a. Go to **TAP4Settings → Interposer Analyzer Path**.
    b. Press **Calibrate → OK**. The calibration begins and a detailed progress report will be shown in the log area.
    c. You can press **Stop** to abort tuning, but this may leave the link unstable or absent.

Auto-tuning cannot break host/DUT link. If error rate is high enough, small estimate is used which goes in 1dB intervals through CTLE/DC Gain, and search for a point with minimal error rate. This is done independently for upstream and downstream. Then final stage walks around this point finding per-lane error-free combination of CTLE/DC Gain. If zero error rate was achieved this stage will be repeated with increased error measurement interval, up to 60 seconds.

Write to Interposer

Press this button to write equalization settings to the interposer.

The result of this operation depends on selected radio button above.

Note: While writing is in progress, the Application title bar may show "Not Responding". This is normal and will go away after writing is complete.

Write to RAM

If "Write to RAM" radio button is selected then equalization settings will be written to interposer but would not remain on the interposer after power-cycling it.

Write to Flash + RAM

If "Write to Flash + RAM" radio button is selected then settings will be written and saved into Flash Memory on the interposer. These setting would remain on the interposer even after power-cycling it.

Write Default to Flash + RAM

If "Write Default to Flash + RAM" radio button is selected then write will restore the interposer to its default settings

Note: Writing to Flash takes several minutes to complete. While writing is in progress, the Application title bar may show "Not Responding". This is normal and will go away after writing is complete.

Read from Interposer

Press this button to read the equalization settings from the interposer.

Note: While reading is in progress, the Application title bar may show “Not Responding”. This is normal and will go away after reading is complete.

Set All Lanes

Check this box and change the values in Lane 0 to change all the values in the corresponding column.

Log

This log would also be saved in the same location as the ".exe" file. The log should provide some preliminary information about connection and display values read /written.

Save to File

You can save your settings to a file.

Load from File or Predefined Values

You can load predefined CTLE and DC Gain values from a file or load CTLE and DC Gain values from a set of Predefined values for a specific configuration of hardware. See Figure 6.169 on page 309.

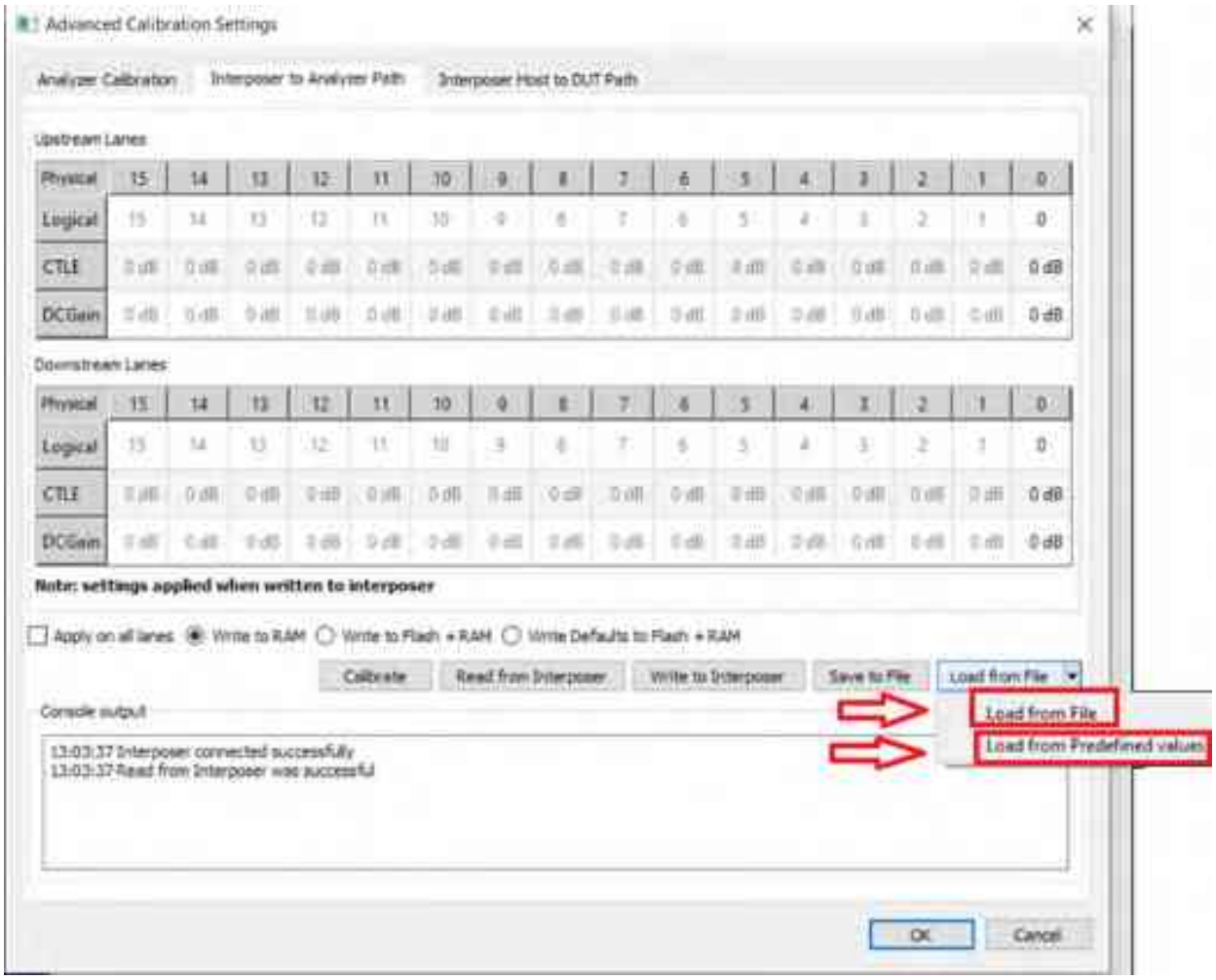


Figure 6.169: Load from File

You can choose from either:

- Load from File: Opens a dialog box to choose a file from where the application was loaded (see Figure 6.170 on page 310)
- Load from Predefined values: Opens a dialog box with a specific configuration of hardware (see Figure 6.171 on page 310)

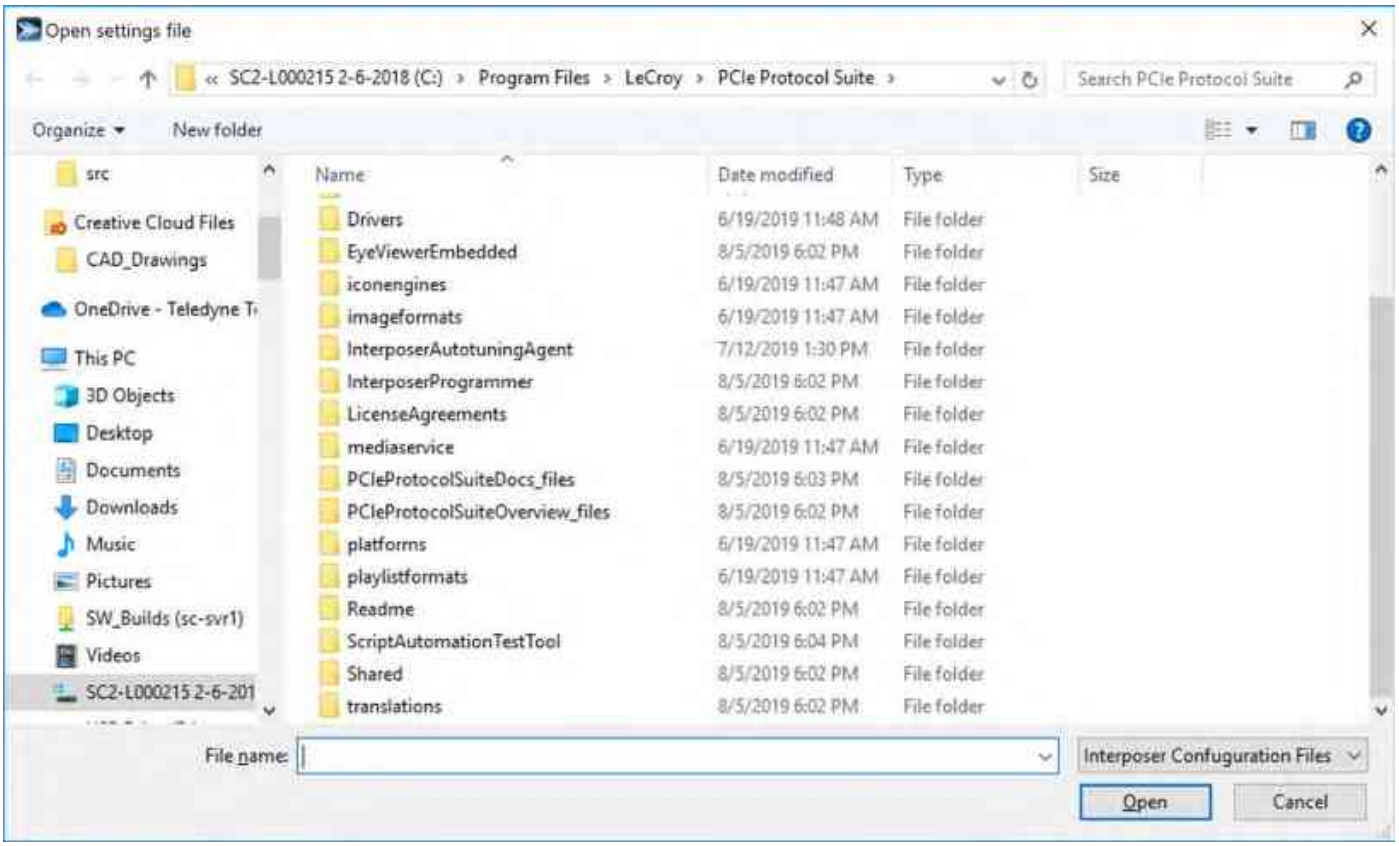


Figure 6.170: Load from File Dialog

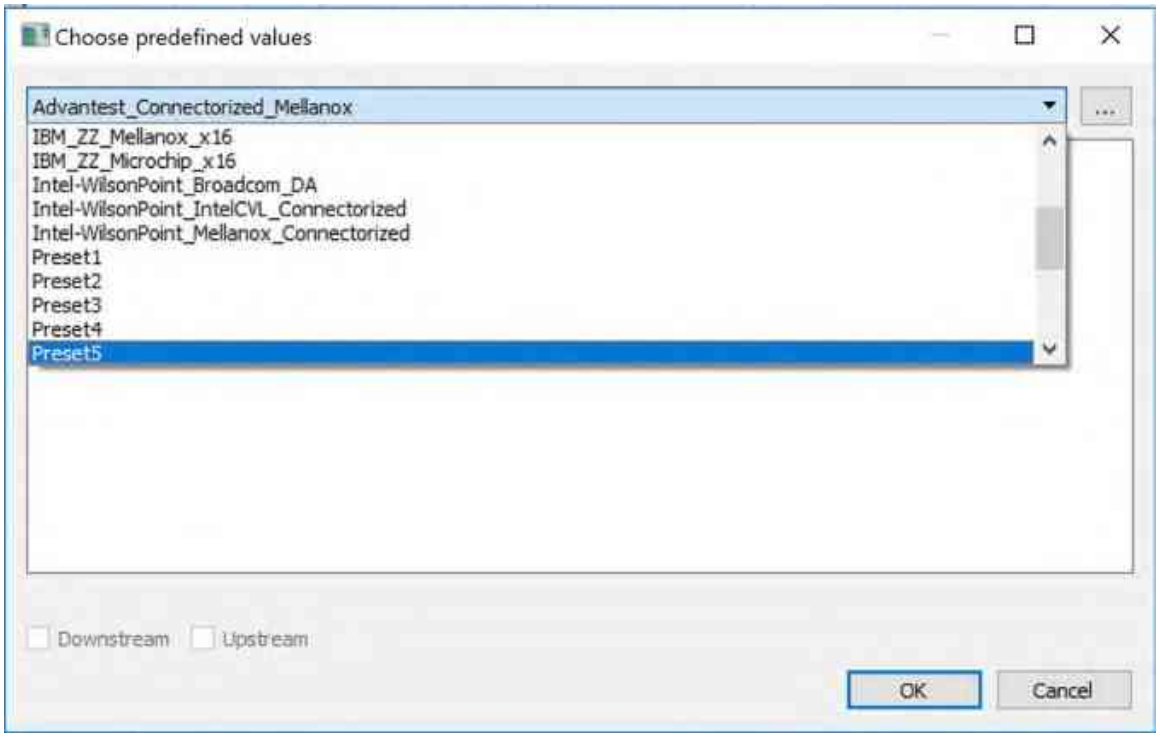


Figure 6.171: Load from Predefined values: Specific configurations or 1 of 9 Presets

6.19.1.3 Autotuning Preparation for “SSH (TDY provided Linux)”

This section describes how to use the “SSH (TDY provided Linux)” Connection Option to prepare your target system to participate in the PCIe Interposer Auto-tuning process. Because the process is automated and depends on feedback and interaction with your target system, and because the auto-tuning process itself might interfere with normal system operation, it is recommended that you use a known Operating System on the target booted from an external USB drive. This procedure covers the following:

- ❑ Preparing the USB boot drive
- ❑ Preparing the Target System
- ❑ First Time Boot
  - ■ Configure Networking
  - ■ Configuration Script
  - ■ Optional: Custom SSH Keys

After this procedure is completed, the boot drive is ready to use for auto-tuning on a target system. The “Preparing the Target System” section should be completed on each target system that needs to participate in auto-tuning.

Prerequisites

- ❑ USB drive with at least 32GB storage (will become bootable Operating System drive)
- ❑ Boot image file we provide
- ❑ Rufus Program (https://rufus.ie/en/)
- ❑ A Windows PC to run Rufus

Preparing the USB Boot Drive

To install the boot image file onto the USB drive, you will need a program such as Rufus (Figure 6.172) that can create bootable USB drives.



Figure 6.172: Rufus Utility Screen

1. Download the boot image from https://teledynelecroy.com/sw/pciexpress to your local hard drive on your Windows PC that will be running Rufus.
2. Unzip the contents to your local hard drive.
3. Install Rufus on the computer you are using to prepare the USB drive.
4. Launch Rufus.
5. Insert the USB drive you want to make bootable.
6. Select the USB drive from the drop-down list (Figure 6.173).

NOTE: Be sure to select the correct drive as all data on it will be erased.

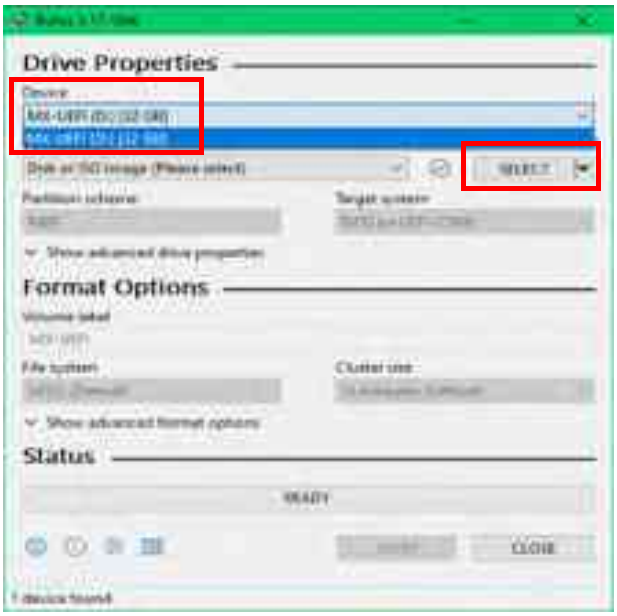


Figure 6.173: Rufus Drive Properties – Select Device

7. Click **SELECT**, then choose the boot image file from Step 1 (Figure 6.174).

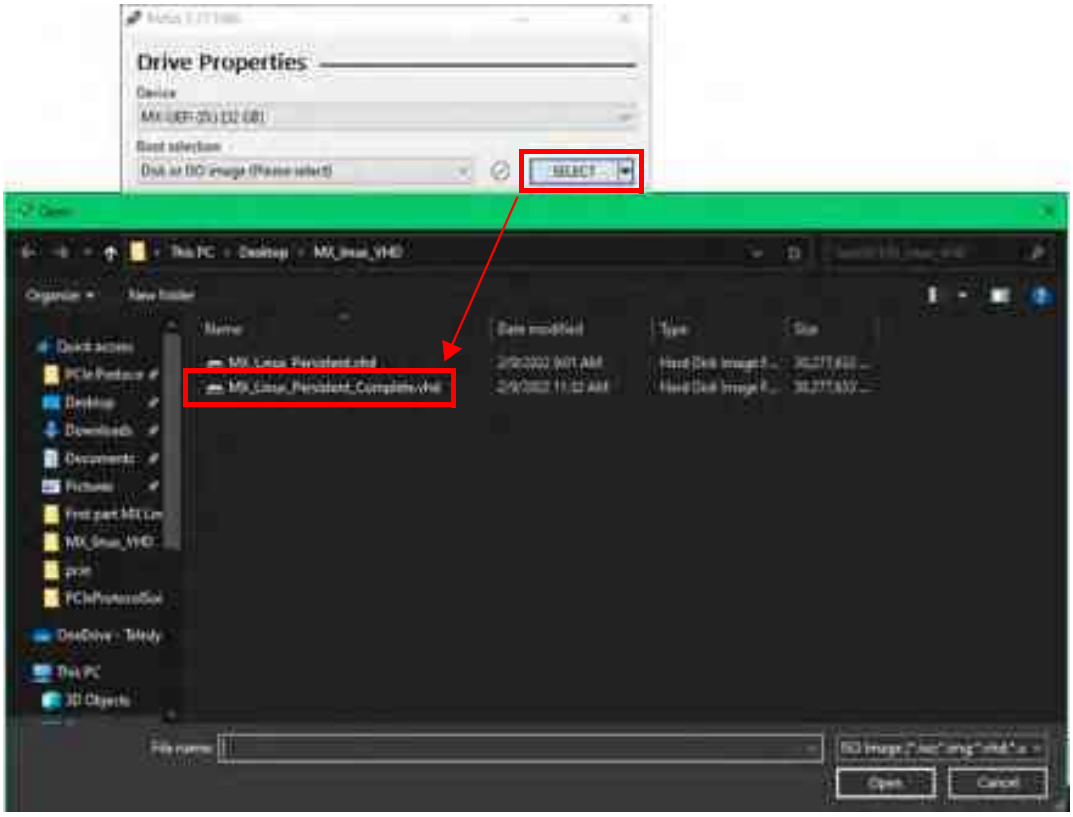


Figure 6.174: Select the Boot Image

8. Click **START**, then click **Yes** or **OK** to any following prompts (Figure 6.175).

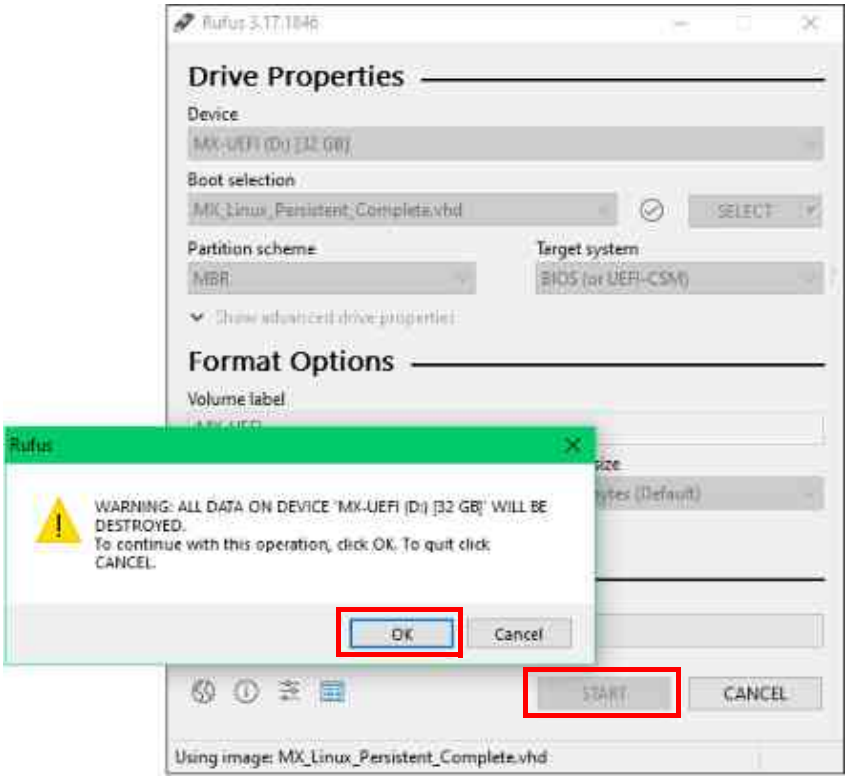


Figure 6.175: Load the Boot Image

9. Wait for the process to complete.
10. Once the process is completed, close Rufus and eject the USB drive.

The USB drive is now bootable with the provided MX Linux OS.

Preparing the Target System

The target system's BIOS settings must be configured to boot from the USB drive.

1. **IMPORTANT**: First insert the USB drive into the target system, then power on the system.
2. Enter the PC BIOS settings.
3. Set the boot settings to boot from USB by default.
4. Disable Secure Boot.
5. Save settings and reboot system.

Change the BIOS Settings

The exact method for changing the BIOS settings varies by PC manufacturer. A typical example is:

1. Power on system and press **F2** to enter the BIOS.
2. Select the **BOOT** tab. All of the available system devices are displayed in order of their boot priority. You can reorder the devices here.
3. Move the USB to be first in the boot sequence.

NOTE: If you cannot find USB or Removable Devices among the device options, your BIOS may list it under Hard Drive Devices. In that case, do the following:

1. Move Hard Drive Devices to the top.
2. Expand to show all hard drive device options.
3. Move the USB device to the top of that hard drive list.

---

4. Go to the **Security** tab → **Default Secure boot on** and set as **Disabled**.
5. Go to the **Save & Exit** tab → **Save Changes** and select **Yes**.
6. Go to the **Security** tab and enter **Delete All Secure Boot Variables**, then select **Yes** to proceed.
7. Save the changes and then exit the BIOS Setup.

NOTE: After the auto-tuning process is completed, you will need to return the BIOS settings to their previous state to boot and operate your system normally.

---

8. Boot into the MX Linux USB you have created.

First Time Boot

```
Root login
```

```
        User: root

        Password: root123

User login

        User: demo

        Password: demo123
```

NOTE: SSH and SSH using Root account is auto enabled to ensure easy access to our Autotuning functionality.

Configure Networking

MX Linux comes pre-configured for a standard LAN that uses DHCP to assign IP addresses and DNS resolution. This will work as-is, in most cases. You can change the configuration with Network Manager.

- When you boot MX Linux, network adapters are assigned a short interface name by **udev**, the kernel device manager. For normal wired adapters, this is usually **eth0** (with subsequent adapters **eth1**, **eth2**, **eth3**, etc.). USB adapters often come up on the **eth0** interface in MX Linux, but the interface name can also depend on the adapter chipset. For instance, *atheros* cards often show up as **ath0**, while *ralink usb* adapters may be **rausb0**. For a detailed list of all found network interfaces, open a terminal, become root, and enter: **ip a**.
- Full details for configuring networking as available at *MX Linux Users Manual* (mxmanuals.s3.us-east-2.amazonaws.com).
- If you make any changes to networking:
  a. Reboot MXLinux to save those changes to the USB boot drive.
  b. From its desktop, click the **Log Out…** button in the upper-left corner.
  c. Click **Restart**.
- After configuring networking:
  a. Locate your IP address by running the ‘`ip a`’ command from a terminal window.
  b. In the output, look for an entry such as *eth0* or *eth1*.
  c. Identify one that is “UP”, and find the *inet* field. See Figure 6.176 as an example:

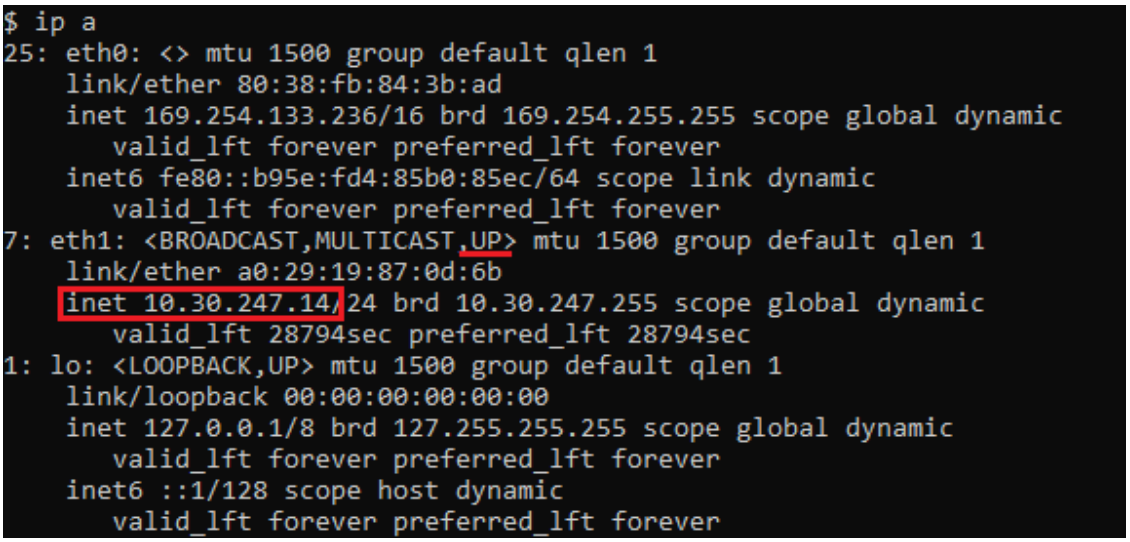


Figure 6.176: Example of UP Entry and *inet* Field

You will need to use this IP address later to connect to the Target System from the autotuning process. Use it to replace "<ip>" in any sample commands listed in the remainder of this document.

Run Configuration Script

Autotuning agent files need to be copied over to MXLinux. These files are specific to the installed PCIe Protocol Analysis Software version. This configuration needs to be done once for each new PCIe Protocol Analysis Software release.

1. Make sure current user is allowed to run Powershell scripts. If not, a corresponding policy needs to be set:
   a. Run Windows PowerShell as Administrator.
   b. Run **`Set-ExecutionPolicy RemoteSigned`**.
2. Run Windows PowerShell under current user and execute the following script with your Linux host IP address as a parameter:

```
C:\Program Files\LeCroy\PCIe Protocol
Suite\InterposerAutotuningAgent\linux\configure_tdy_linux.ps1
<ip>
```

Configuration should finish without errors and Linux host should be rebooted automatically.

NOTE: In case there is a prompt to eject the media before rebooting, ignore this prompt. Keep the USB drive inserted and then proceed with rebooting so that it will boot up again from the USB drive.

Default SSH Keys

Default SSH keys come pre-installed with the MX Linux image and with the PCIe Procotol Suite installation. These will work as-is without any user configuration. You can run the following command from a Windows command prompt to verify proper key configuration:

```
ssh demo@<ip> -i C:\Users\<username>\.ssh\tdy_autotune_id
```

When configured properly, the SSH command will not prompt for any password.

OPTIONAL: Generate Custom SSH Keys and Install Them

The instructions in this section are only necessary if you would like to overwrite the pre-installed SSH keys with your own, custom-generated keys.

NOTE: For the example commands below, be sure to use your actual folder/file names on your Windows PC running PCIe Analysis Software and the actual IP address of your target host that is booted from the Linux USB drive.

1. Generate keys using the PCIe Analysis Software Autotuning dialog (Figure 6.177).



Figure 6.177: PCIe Analysis Software Autotuning Dialog

2. To open a Command Prompt, right-click on the Windows Start button and select **Run** (Figure 6.178).

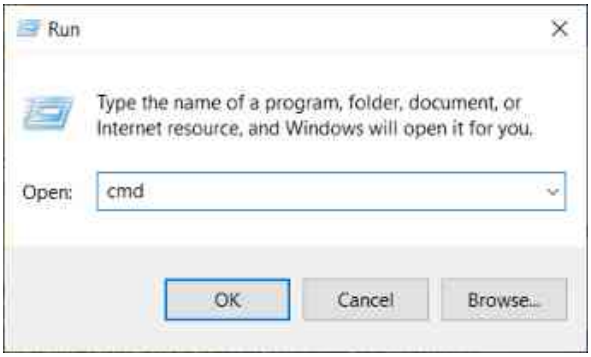


Figure 6.178: Command Prompt

3. Type **cmd** and click **OK**. A Command window becomes available (Figure 6.179).

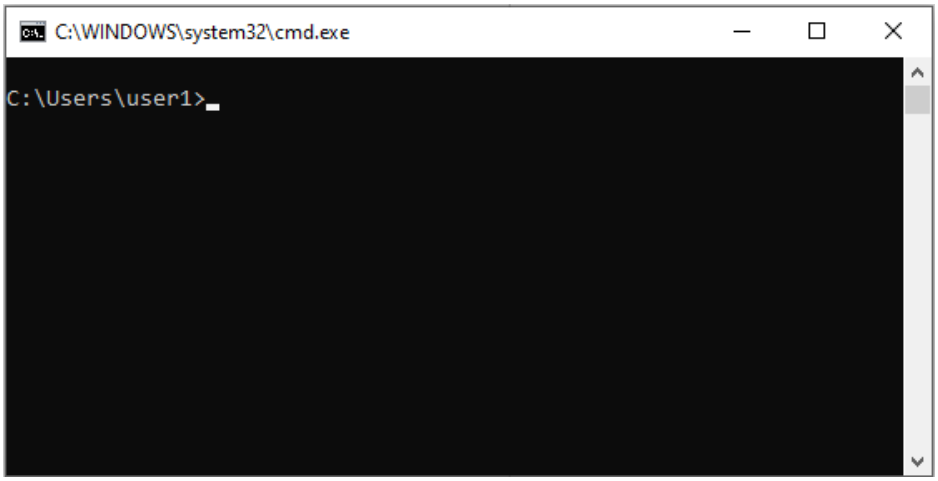


Figure 6.179: Command Window

4. Change directories to the location of your public key, shown in the SSH Key Configuration window. For example: `cd c:\Users\user1\.ssh`
5. Copy the public key over to Linux. **SFTP** or **SCP** can be used.
   - `scp <ssh_public_key_file> <user>@<ip>`:
     Example: `scp tdy_autotune_id.pub demo@1.2.3.4:`
   - `ssh to the linux`
     `ssh <user>@<ip>`
     Example: `ssh demo@1.2.3.4:`
6. If your account on the remote system doesn't already contain a **~/.ssh/authorized_keys** file, you need to create one:

```
mkdir -p ~/.ssh
touch ~/.ssh/authorized_keys
```

7. Add the content of the public key to `~/.ssh/authorized_keys`:

```
cat <ssh_public_key_file> >> ~/.ssh/authorized_keys
```

8. `<ssh_public_key_file>` can be safely removed or moved to `~/.ssh`:

```
rm <ssh_public_key_file>
```

9. Reboot MX Linux:
   a. From its desktop, click the **Log Out… button** in the upper-left corner.
   b. Click **Restart**.

6.19.1.4 ASPM Autotuning Procedure

Prerequisites

- ❑ USB boot drive and target system have been prepared according to the "PCIe Interposer Autotuning Preparation" procedure.
- ❑ L0 Autotuning on the target system has already been completed successfully.

- Results from the L0 autotuning have been saved in the form of interposer settings (JSON) and recording option (rec) files.

Procedure

Note: This utility is only supported with the Summit T54 analyzer.

1. Boot the target Host from a bootable Linux USB boot drive and note its IP address.
2. To run the utility, select **Tools** → **ASPM Autotuning Utility** (Figure 6.180). You should see Interposer settings and recording options files after L0 autotuning.

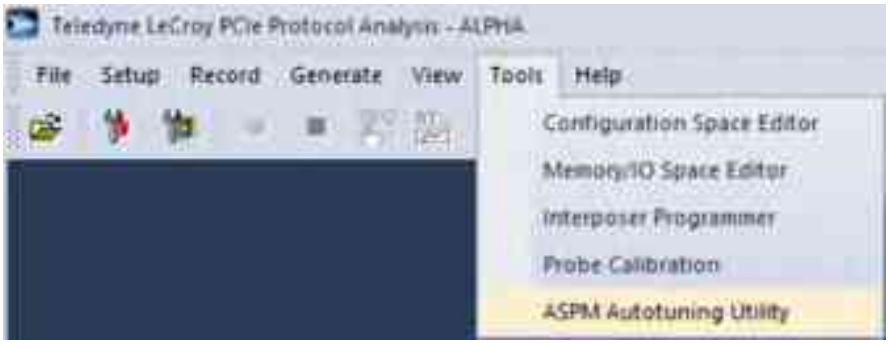


Figure 6.180: Select ASPM Autotuning Utility

3. Select Interposer Settings and Recording Options files in the corresponding fields in ASPM utility window (Figure 6.181).



Figure 6.181: CPEASPM Autotuning Utility Dialog Window

4. Provide same connection setting as L0 autotuning on **SSH (TDY provided Linux)** tab, then press the **Connect** button (Figure 6.182).

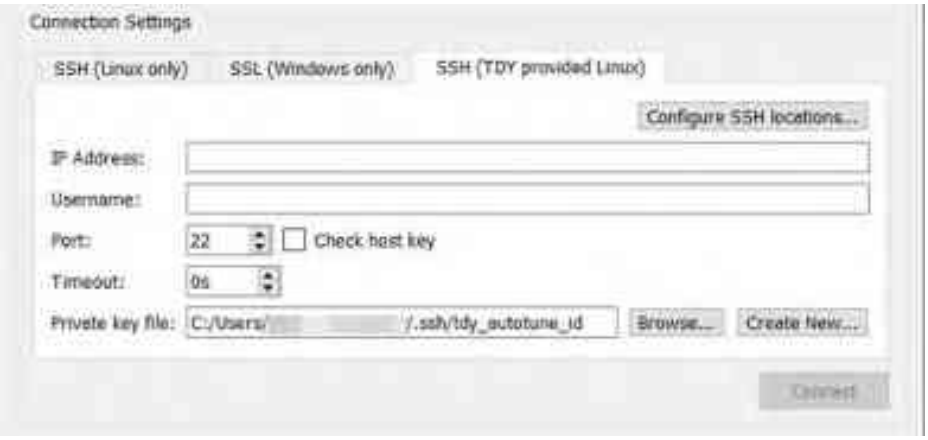


Figure 6.182: Autotuning from the SSH (TDY provided Linux) Tab

5. Click the down arrow in the **Select DUT which is connected to Interposer** field and select the DUT device from the drop-down list, then press the **Start ASPM Calibration** button (Figure 6.183).

   Let the ASPM utility finish, then check log window at the bottom to make sure it succeeded. In case of failure, repeat this step (if needed).

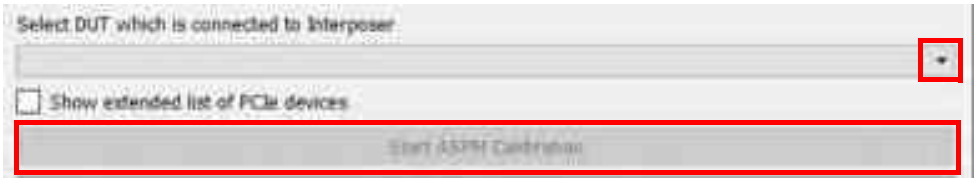


Figure 6.183: Select DUT then Start ASPM Calibration

6. To collect Interposer and analyzer settings files, go to **Recording options** → **Analyzer and Probe Settings**, then click the **Launch Advanced Calibration Settings** link at the bottom.
7. Select the **Interposer HOST to DUT Path** tab and press **Save to File** button (Figure 6.184).

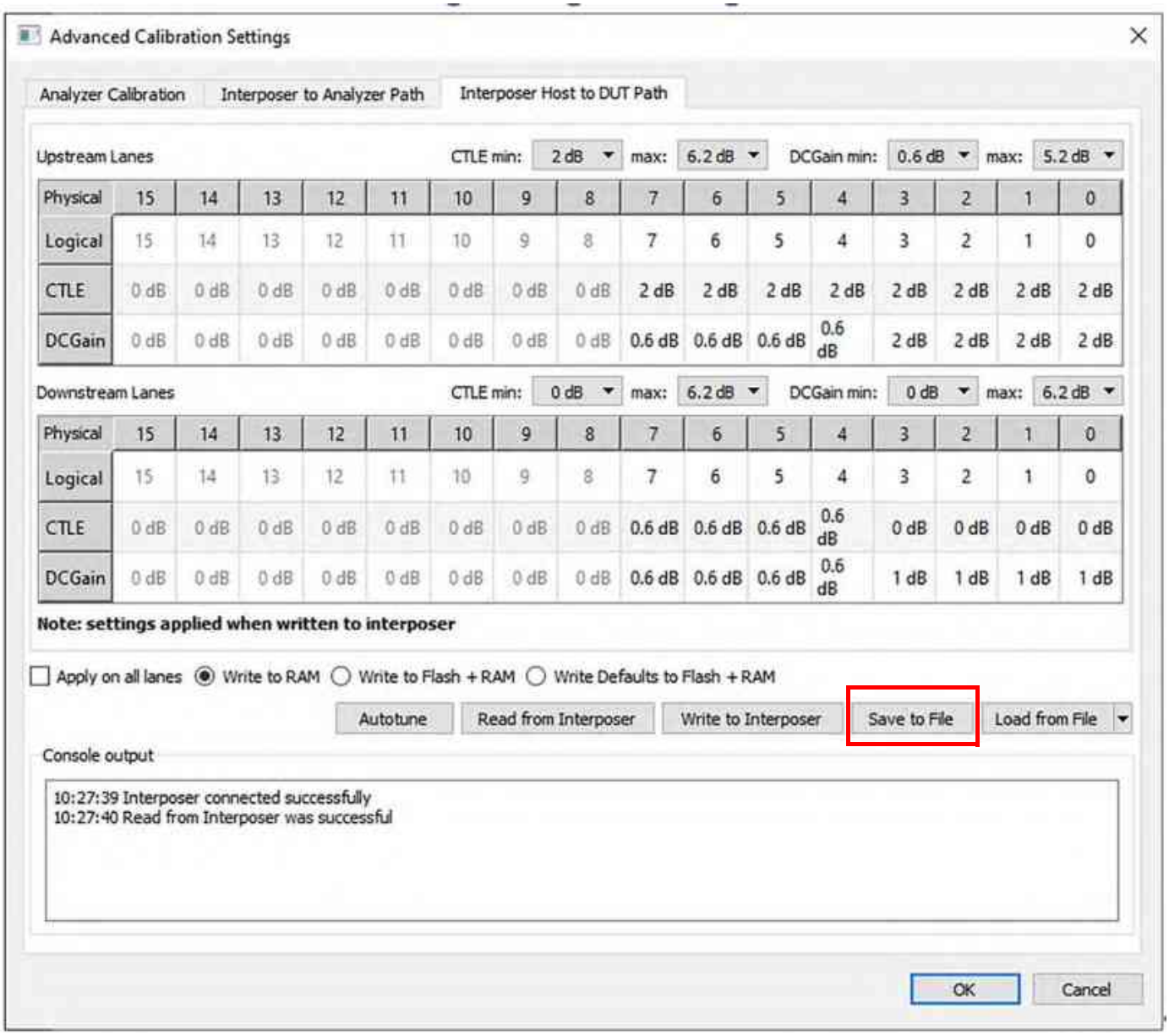


Figure 6.184: Advanced Calibration Settings Window

8. Optionally, you can manually verify the L1.1/L1.2 capturing:
   a. Recording option: snapshot, 1GB buffer, Rev4 PCIe, Filter out compliance pattern, clear **Auto-Configure Lane polarity**, select **Ignore Idle Errors** (Figure 6.185).

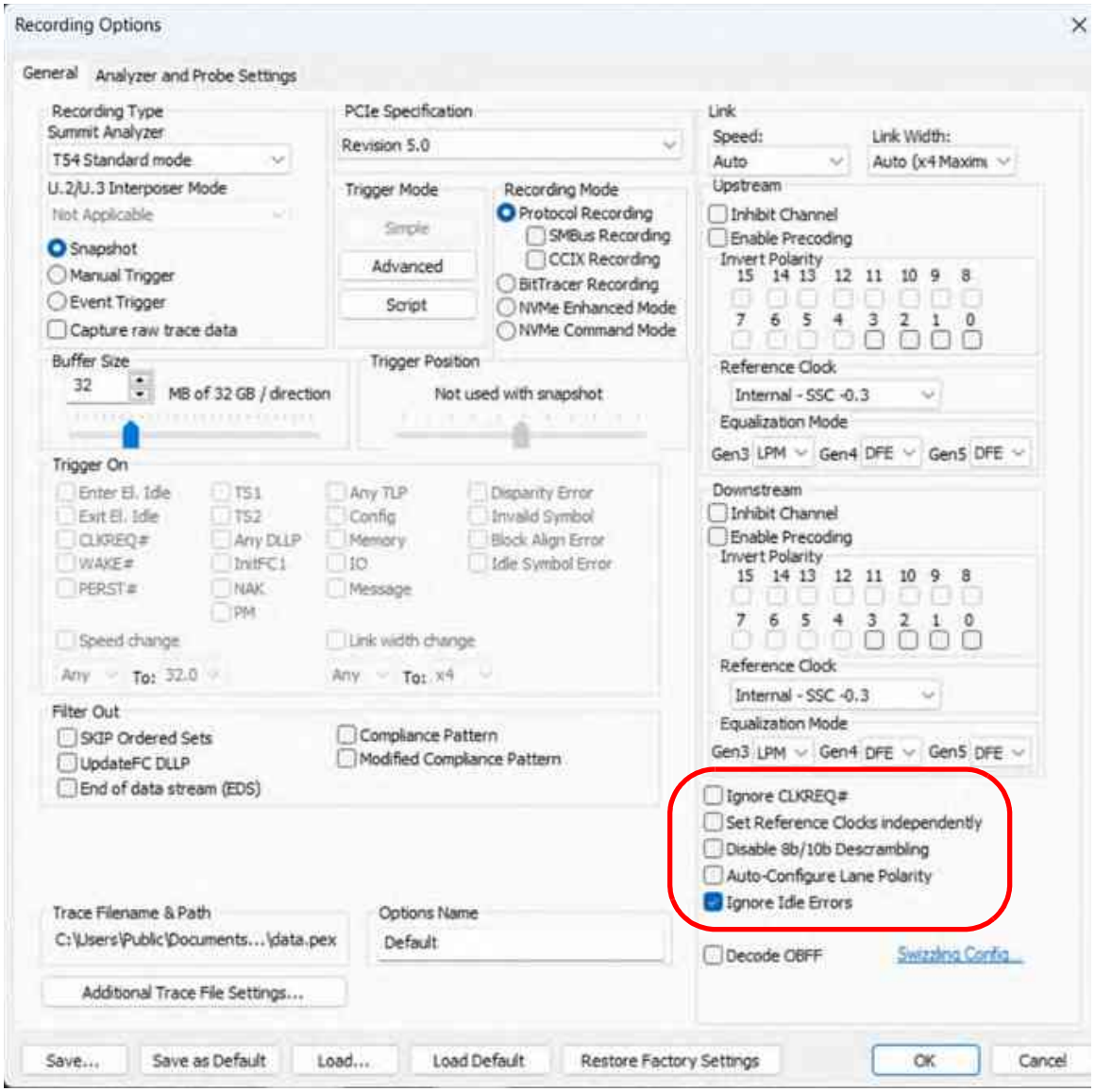


Figure 6.185: Get Recording Option Snapshot

b. To enable traffic on Linux HOST, execute '`sudo /opt/lqtools/lmlinux StartPolling`' from the Linux shell.

c. Start capturing and wait until buffer is full and uploaded into Trace. Check that there are 100+ L1.1/L1.2 transitions using LTSSM.

d. Run the TraceReport VSE script and check its output (Figure 6.186). It is expected that no errors will be reported.

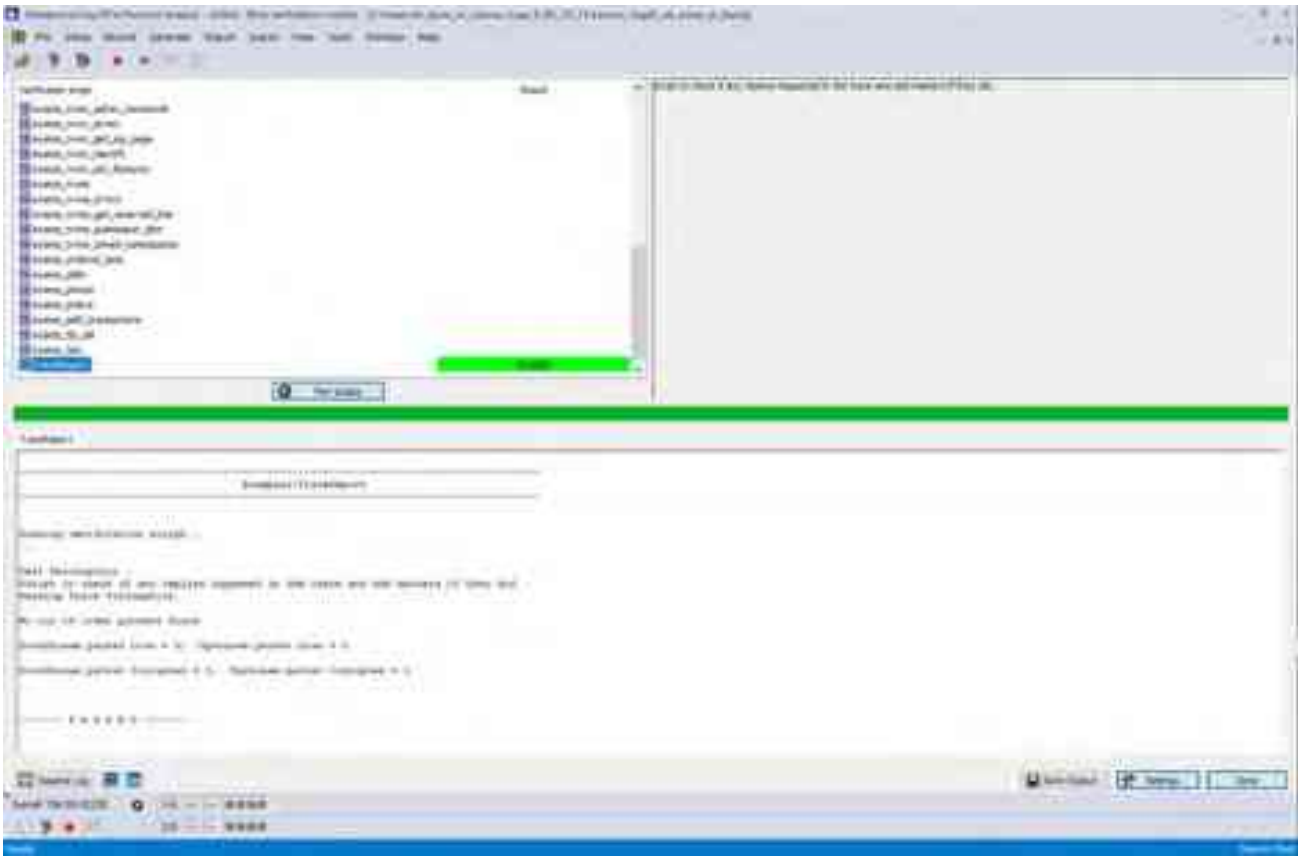


Figure 6.186: Trace Report VSE Script Output

Configuring SSH connection for TDY provided Linux

SSH connections are established via an OpenSSH (https://www.openssh.com) client. Because connection sharing is not supported on Windows, a new SSH connection is created for each issued command.

To create SSH connections, it is recommended that you use the default OpenSSH shipped with PCIe Protocol Analysis. Optionally, you can install the OpenSSH suite yourself, which includes the SSH and SSH-keygen tools on the recording PC. To tell the PCIe Protocol Analysis where it can find the tools, specify the paths to the directories where the tools are installed in SSH Tool Locations dialog box (Figure 6.187). (To launch, press the **Configure SSH locations…** button.)



Figure 6.187: SSH Tool Locations Dialog Box

1. In the Path to SSH executable field, enter the path to the directory where the OpenSSH executable is installed.

2. In the Path to ssh-keygen executable field, enter the path to the directory where the ssh-keygen executable is installed.
3. In the Path to known hosts files field, enter the path to the directory where the known hosts file is installed. By default, this file is located in the <USER_HOME>\.ssh directory. According to OpenSSH, only an administrator and current user should have access to this folder; otherwise, there will be an error message from SSH tool.



Figure 6.188: Autotune Connection Settings – SSH (TDY provided Linux) Tab

4. In the IP Address field, enter Linux host IP address.
5. In the Username field, enter the username to log into the Linux.
6. In the Port field, enter ssh port number. Default value is 22.
7. Select Check host key check box if host key verification is needed. See 'StrictHostKeyChecking' OpenSSH option for more details.
8. In the Timeout field, enter the connection timeout in seconds. 0 means default timeout.
9. In Private key file field, select a private key file to use for authentication. If you do not have a public-private key pair, select **Create New…** For more information see *Generating SSH Keys*.

Note: PCIe Protocol Analysis doesn't support password SSH authentication for "TDY Provided Linux". Only SSH key authentication is supported. Default SSH key are installed with PCIe Protocol Analysis <USER_HOME>\.ssh\tdy_autotune_id. SSH key can be re-configured to use user-generated ones if needed.

Generating SSH Keys

If you do not have an SSH public and private key pair, you can generate it in PCIe Protocol Analysis. The SSH connection widget can create the key pair.

Key length and the key algorithm can be specified in the SSH Key Configuration dialog box (Figure 6.189). To launch, press the **Create New…** button next to Private key file field.



Figure 6.189: SSH Key Configuration Dialog Box

1. In the Private key file field, select the location to save the private key.
2. The Public key file field displays the location to save the corresponding public key.
3. Select Generate And Save Key Pair to generate and save the key at specified locations.

Note: Default values would work fine for autotuning purposes.

6.19.2 Interposer to Analyzer Path

At this stage all the interposer-related tuning is complete. Now you can calibrate the "front end" of the analyzer by automatically finding the best presets for **Equalizer Settings** (see Figure 6.190).

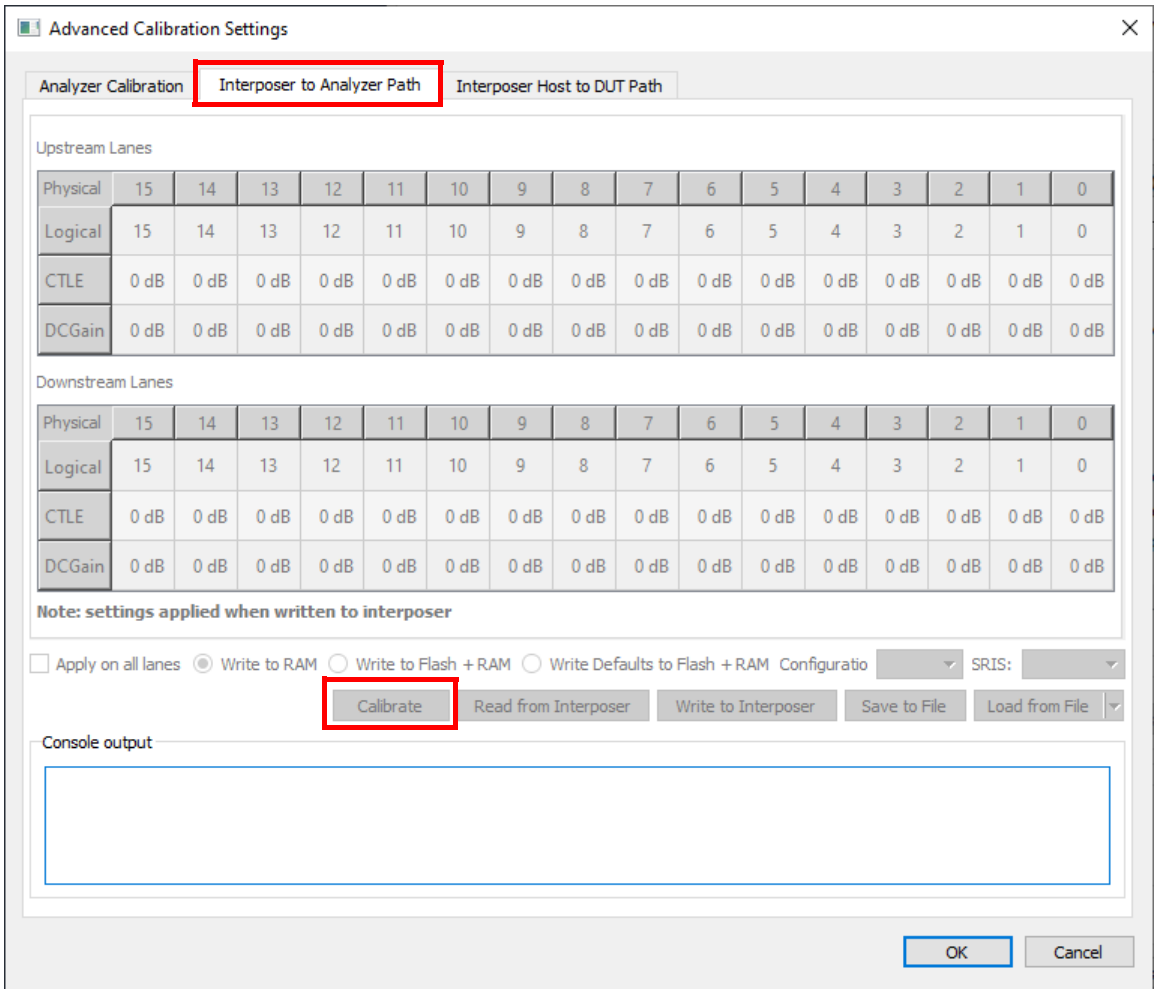


Figure 6.190: Interposer to Analyzer Path

6.19.2.1 Calibration Dialog – Algorithms

The dialog for calibration of Interposer to Analyzer Path allows selecting one of several algorithms. The selected algorithm determines the steps that will be performed during the process to find optimal CTLE and DCGain settings.

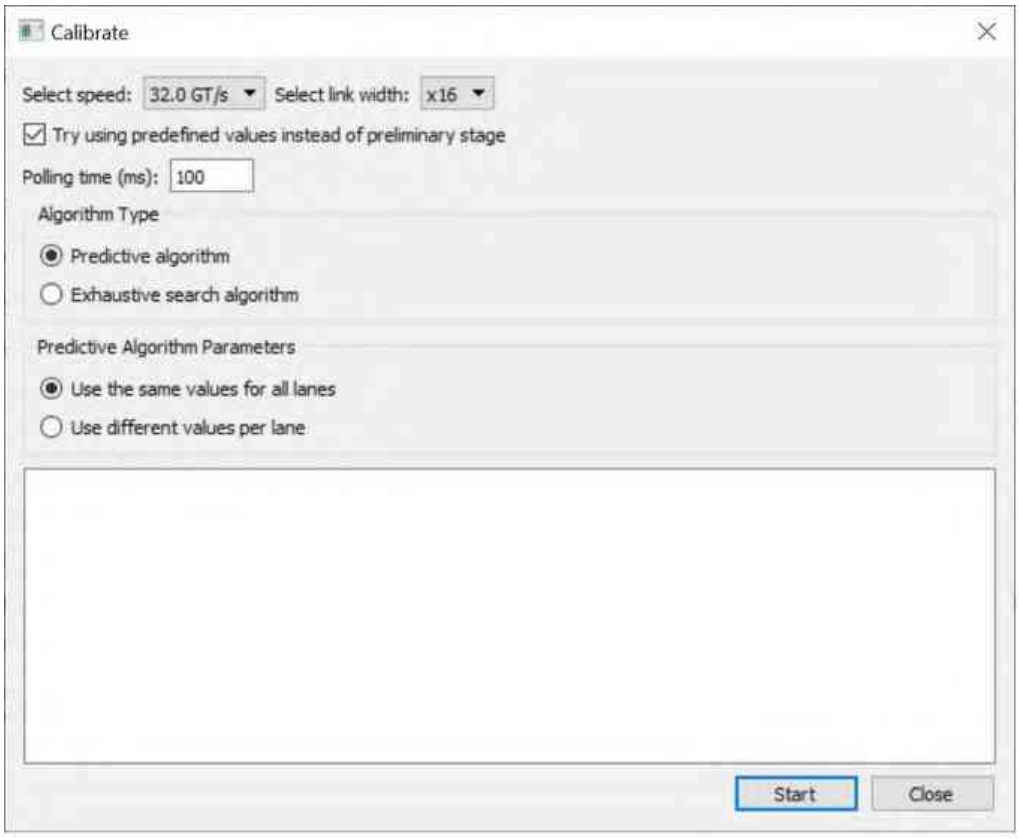


Figure 6.191: Interposer to Analyzer Path Calibration dialog

Below is a list of the available algorithms for calibration with descriptions:

Predictive algorithm

This option is similar to Heuristic algorithm for auto-tuning. It also uses the same heuristic search method and performs the calibration in several stages. Please see the algorithm details in “Autotuning Algorithms” on page 286.

The maximal error polling time is shorter for calibration and only four stages are performed: first 500 milliseconds and then 2-, 5-, and 10-second stages. Final stage polling time can be configured in milliseconds in appropriate option.

Exhaustive search algorithm

The calibration routine checks all possible combinations of CTLE and DCGain settings (the same value is used for all lanes).

There are two stages:

1. On the first stage errors are measured for combinations of each CTLE value and DCGain values with step 1dB.

2. On the second stage errors are measured for combinations of each CTLE value and each DCGain value.

Firstly, all values are checked with polling time 1 ms and then some best values are retested with selected polling time.

If the settings are found with which error rate is zero for each lane on both channels, then the calibration finishes without checking all combinations.

6.19.3 Analyzer Calibration

The Summit T5 can be calibrated to work with specific links. The T.A.P.5 is a proprietary Teledyne LeCroy technology that allows DUT signaling to be optimized for the purposes of recording a clean trace. The Analyzer and Probe Settings tab allows for this optimization to be performed on each lane of the link by modifying different settings such as CTLE, DC Gain and Signal Detection threshold.

Select **Recording Options** → **Analyzer and Probe Settings** → **Analyzer Calibration** from the **Setup** menu to display the available modes that can be used for Analyzer Calibration:

- Auto (See Figure 6.192 on page 329): Calibrating at 32.0 GT/s
- CTLE and DC Gain are selected
- Manual

6.19.3.1 Analyzer Calibration – Auto Option

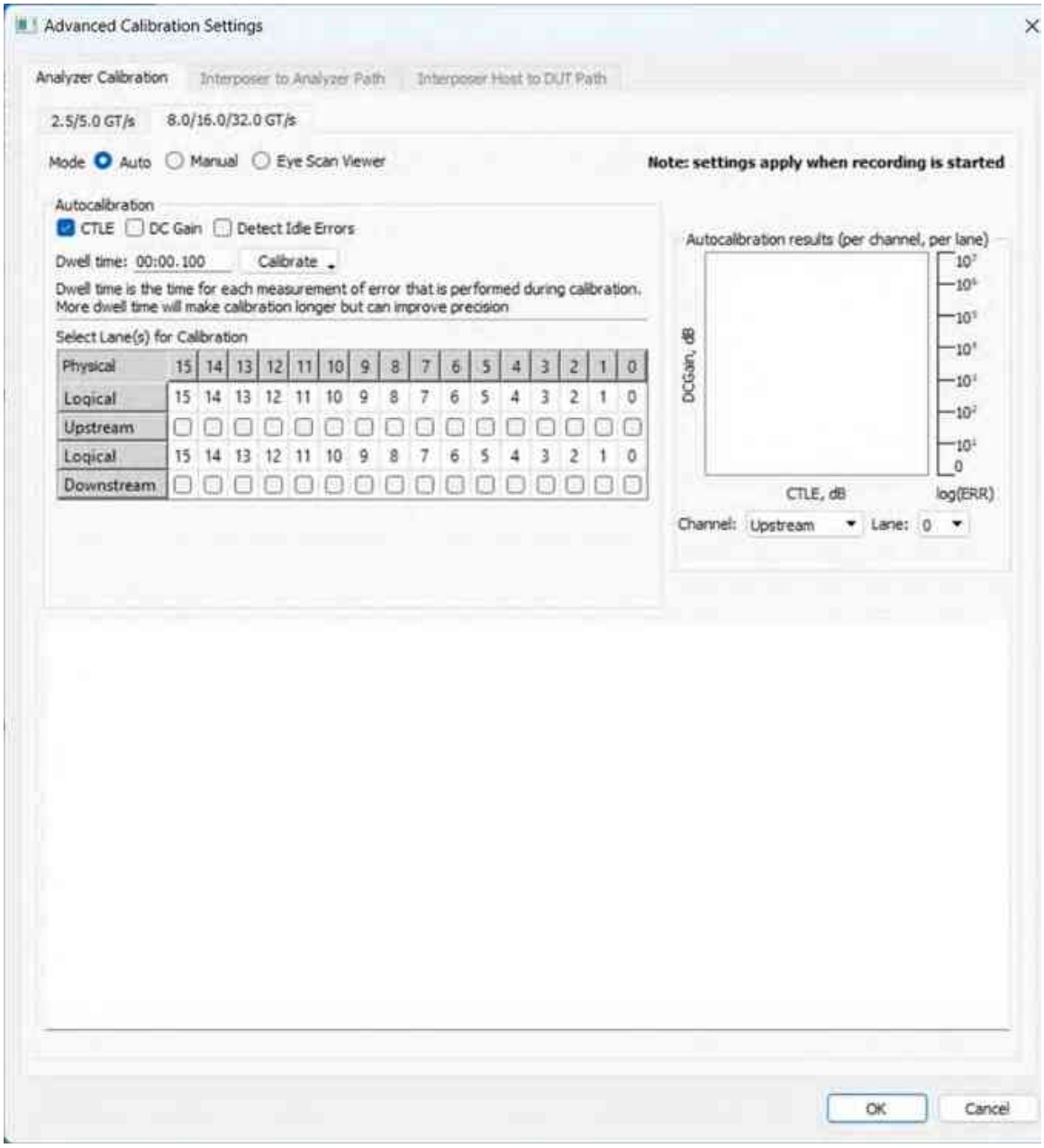


Figure 6.192: T5: Analyzer Calibration Auto Mode

There is a log area where all checked values with current and best number of errors are listed during calibration process. On right mouse button click context menu is opened where log can be cleared or saved to .txt file.

The Calibration is done in this sequence:

1. Correctly set the lane polarity manually, auto lane polarity is not supported.
2. Calibration requires a fixed speed, so, if the speed selection is “Auto”, then user is required to select the speed at the time of starting the calibration.
3. In “Auto-calibration” area check lanes that need calibration. Usually all lanes will need calibration. All lanes in some direction (upstream or downstream) can be

checked by clicking on accordingly named button in front of row of lane checkboxes.

4. Select some of checkboxes for CTLE, DC Gain and SigDet. It is recommended to check both CTLE and DC Gain to produce better results, but it will increase time needed for calibration because more values will be checked.

Note: The SigDet option is not available for all devices.

5. Decide if analysis of packets should be used to check their correctness instead of simpler checks. If so, select the **Detect Idle errors** checkbox. It is usually is recommended to enable these checks.
6. Select the interval during which errors will be counted on each calibration step. A longer interval will give more precise results, but calibration time will be increased linearly. Usually the default value (100 ms) is good enough for a quick check and to estimate how long calibration will take, but longer intervals might be preferable.

Note: All values will be tested with interval equal to 1 ms, then the best found values will be re-checked using the selected time.

7. Press **Calibrate**. The calibration process begins with progress bar shown.
8. After calibration finish per-lane error data are presented, separately for upstream and downstream.
9. To save calibration results, click **OK**.

After successful Analyzer Calibration in the L0 link state, do a recording with 1GB buffer and confirm the trace is error-free by looking into the Error Report in Traffic Summary. If any recalibration is needed, first power-cycle the analyzer, then follow the above process again.

6.19.3.2 Analyzer Calibration: Manual Option

In **Recording Options → Analyzer and Probe Settings → Analyzer Calibration → Manual Mode** each lane selected has the following options to achieve the best signal for detection and recording:

- CTLE (Continuous Time Linear Equalization): 0 to 12 dB in 0.2 dB steps
- DC Gain: -3 to 11 dB in 0.2 dB steps
- SigDetect (Signal detection threshold): 30 mV to 410 mV in 7 steps

The default is for SigDet 60 mV but you can vary the threshold from 30 mV to 410 mV depending on the amplitude of the signals being generated and correctly detected in your system. You can also set the CTLE value and the DC Gain in conjunction with the threshold SigDet level to get a high quality signal for recording and analysis. See Figure 6.193 on page 331.

- Measure: You can also set the Measure value to be 16.0 GT/s or 8.0 GT/s.

Note: When using the MidBus Probe, SigDet is recommended to be set at 40 mV for each lane.

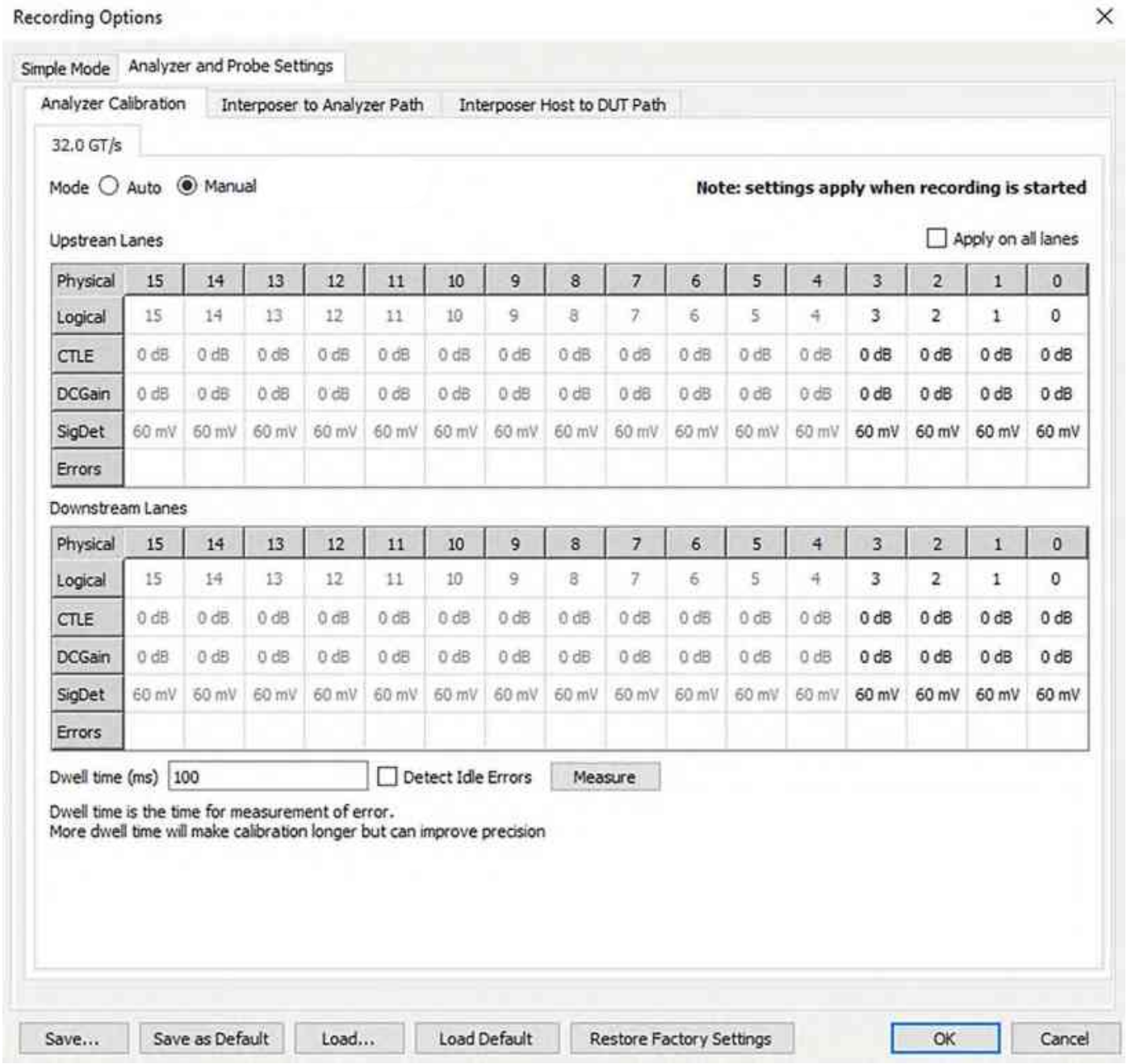


Figure 6.193: T5: Analyzer Calibration Manual Mode

6.19.3.3 Analyzer Calibration: Eye Scanner Option

In **Recording Options > Analyzer and Probe Settings -> Analyzer Calibration -> Eye Scanner View** you can take measurements of the “Eye” of the signal. See Figure 6.194.

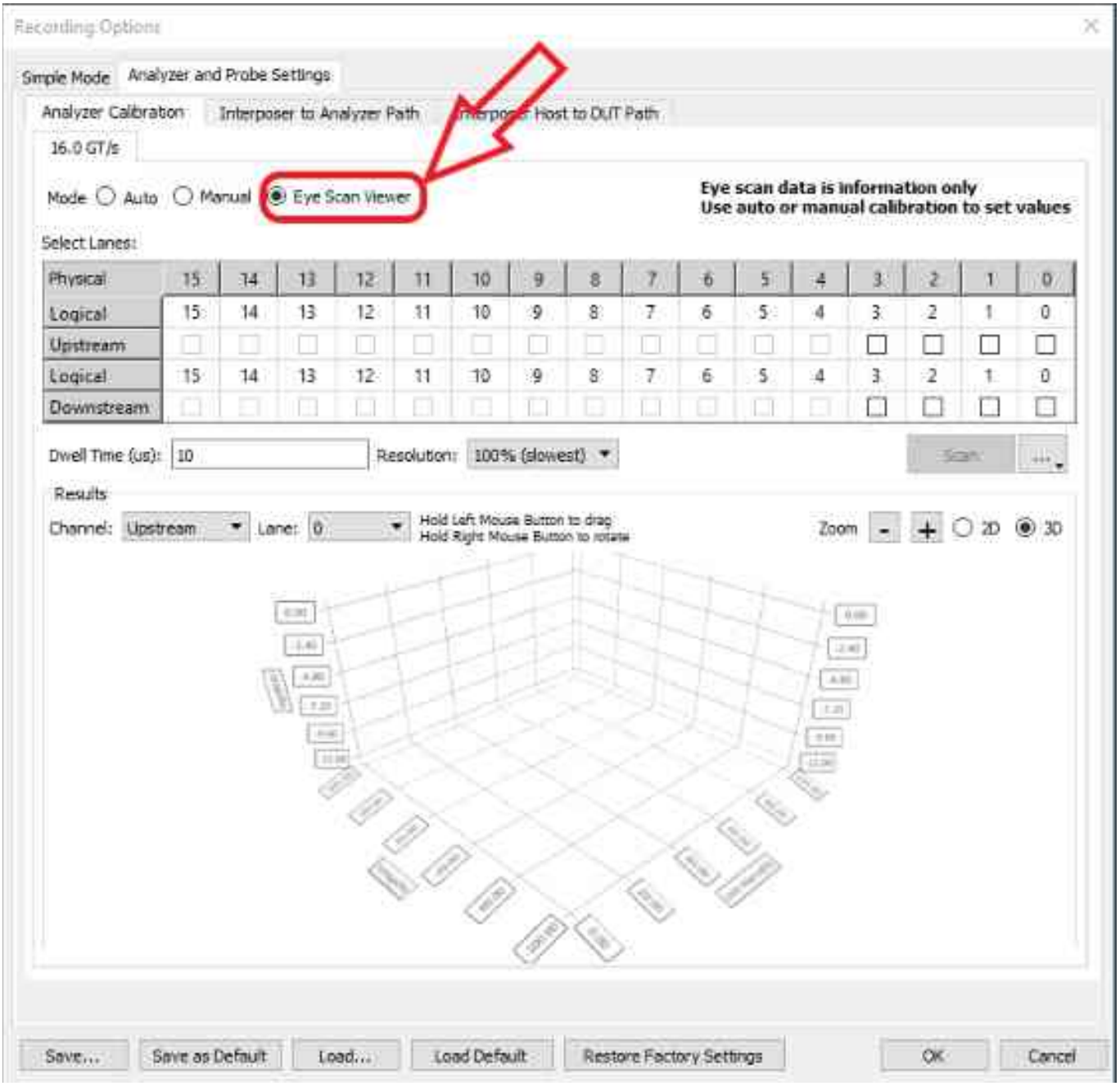


Figure 6.194: Summit T54: Analyzer Calibration -> Eye Scanner View

Eye Scanner

Eye Scanner allows you to generate a diagram of the relative signal quality of received signals at the receiver of the analyzer being used.

Using the Eye Scanner Feature

To use the Eye Scanner feature the user's host system must be connected to an analyzer in the "ready" state and the link under test must be operational, but does not have to be generating data traffic.

Select **Recording Options** → **Analyzer and Probe Settings** → **Eye Scanner** from the **Recording Options** menu (see Figure Note: on page 157 for the Summit T5 to display Eye Scanner Settings (see Figure 6.195 on page 334).

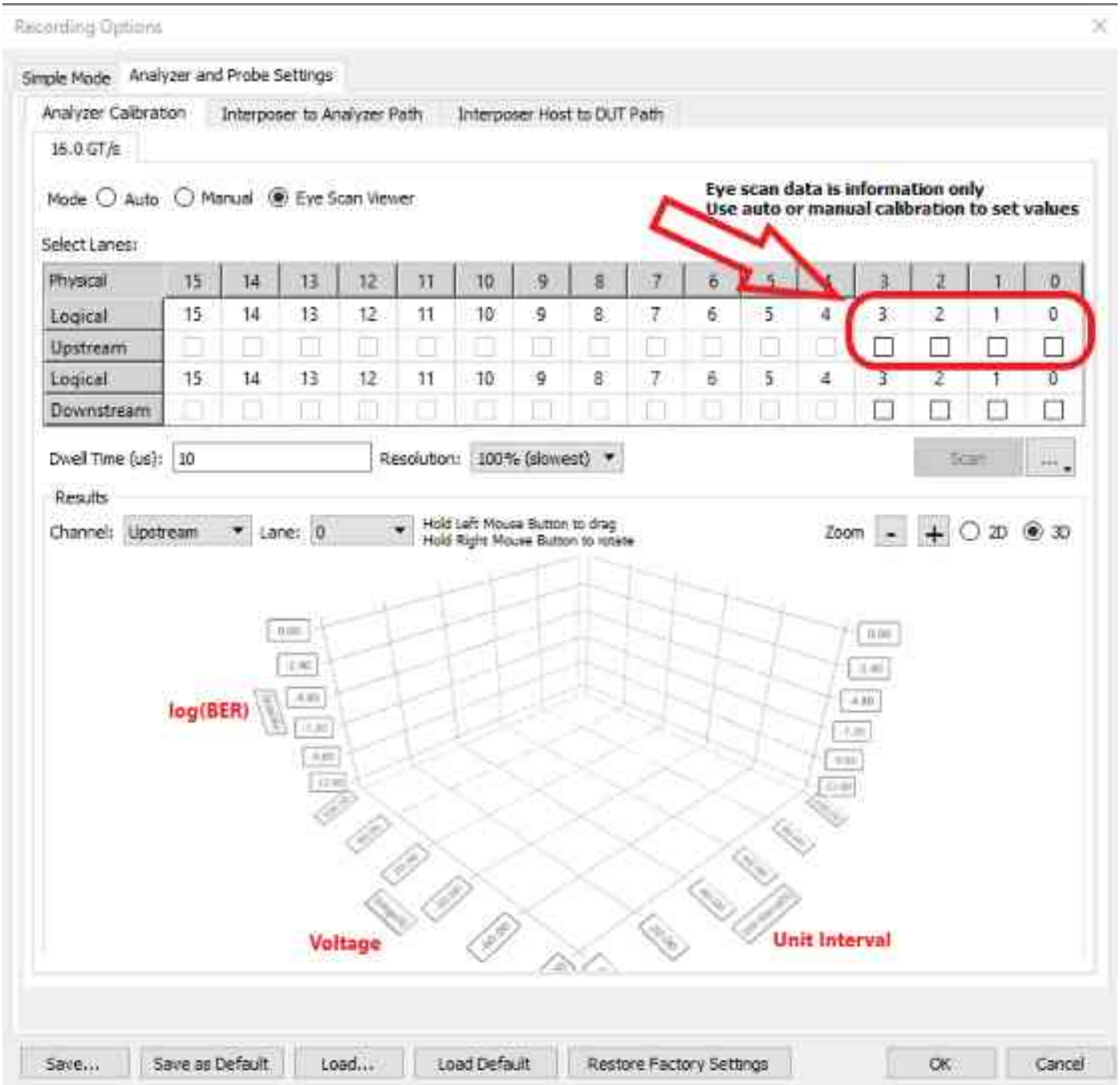


Figure 6.195: Eye Scanner Settings

Set up the options you want:

- Channels: Number of active lanes
- Dwell Time: Time spent at each data point
- Resolution: 100%, 50%, 25%, 12% (slowest to fastest)
- Dimensions: 2D or 3D

For our example we used a Summit T54 with a single channel operating, 10 usec dwell time, 100% Resolution (slowest) and 3D capture.

Click on the Scan button and the analyzer starts the process. See Figure 6.196.

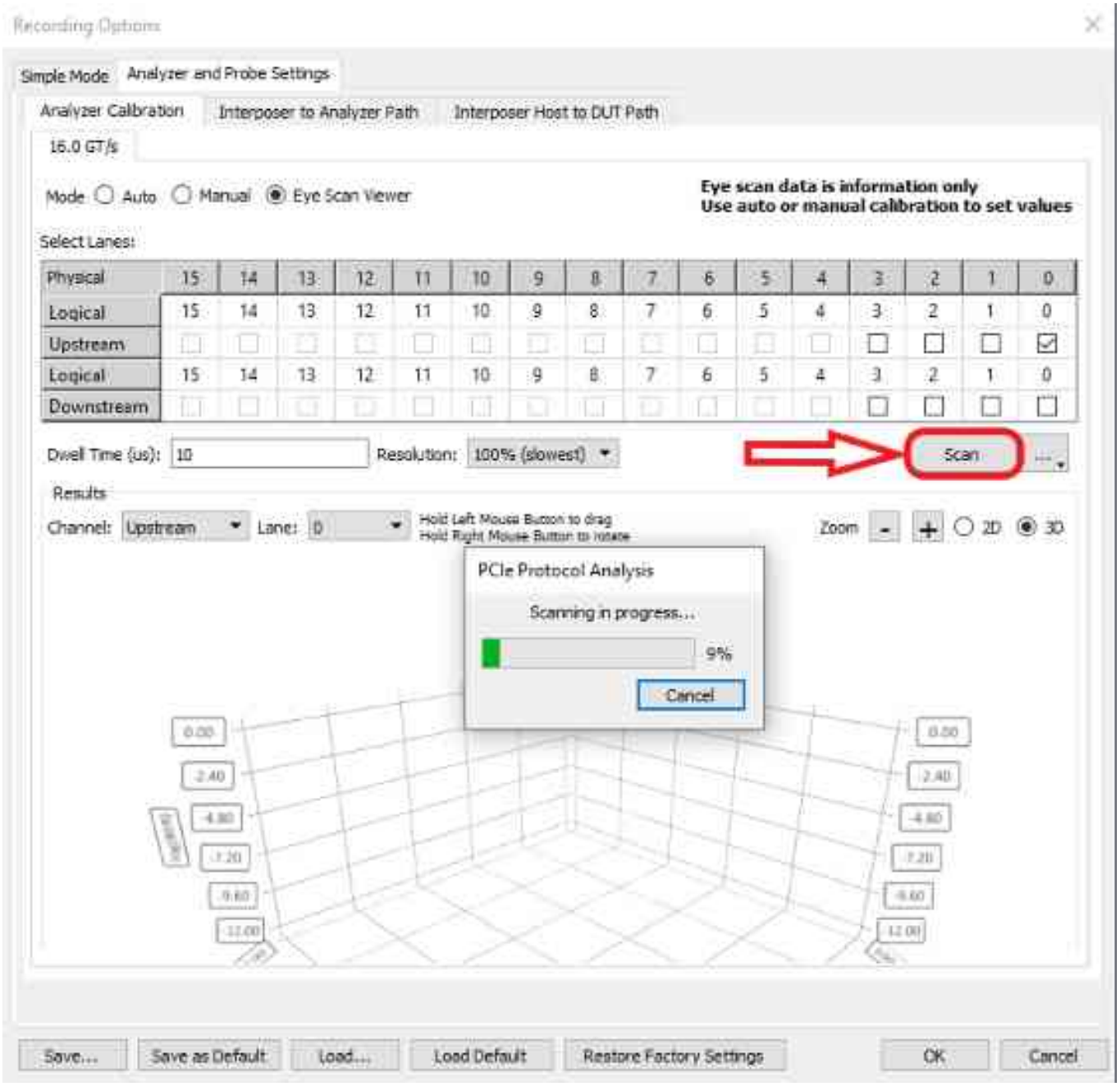


Figure 6.196: Eye Scanner in Process

The results can be seen in Figure 6.197 on page 336.

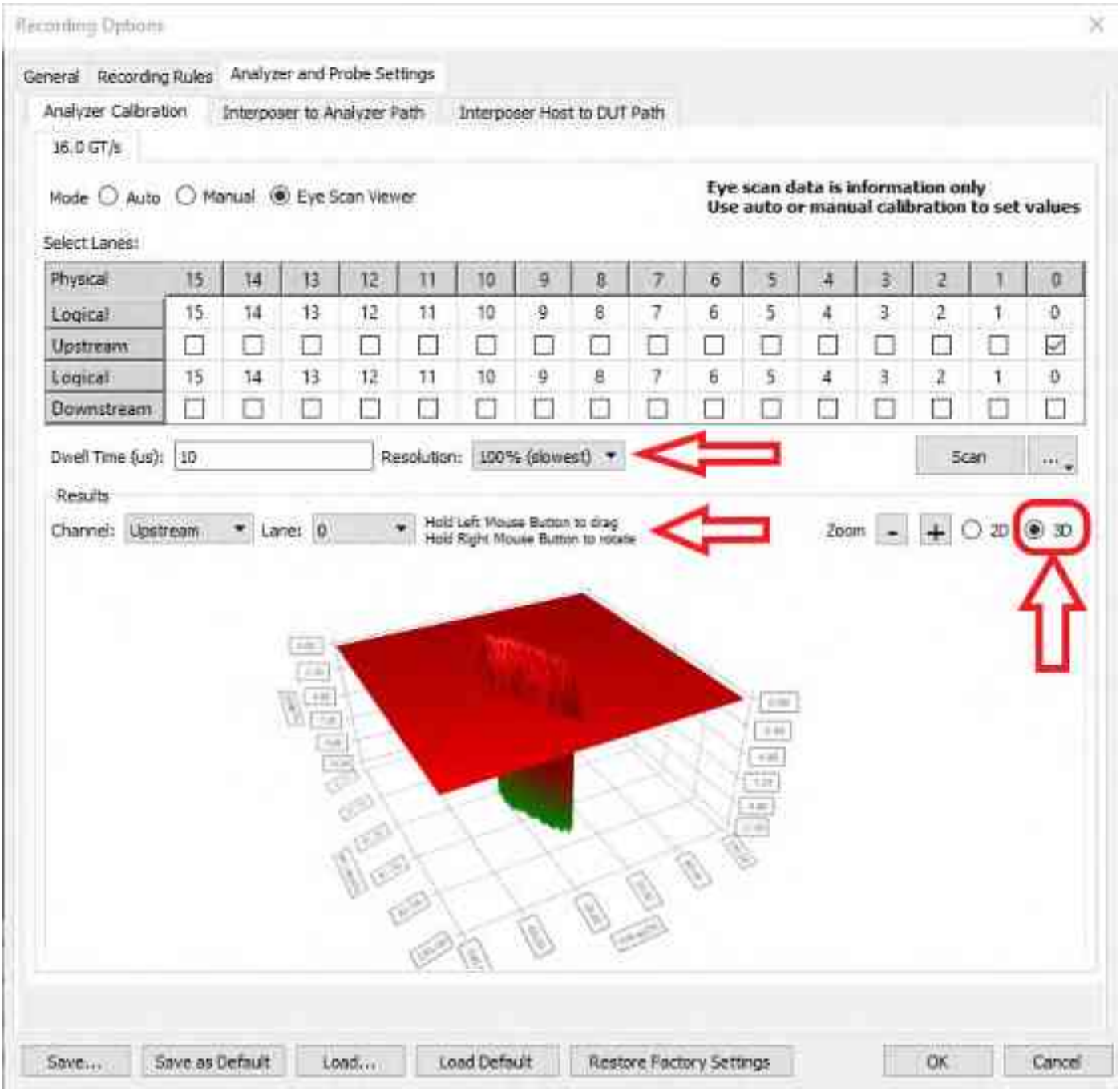


Figure 6.197: Results of Eye Scanner

You manipulate the resulting diagram in the following ways:

- Zoom In/Out
- Rotate the diagram
- Move the diagram

If you want a two dimensional view of the “eye”, select 2D and you’ll get a 2 dimensional representation. See Figure 6.198.

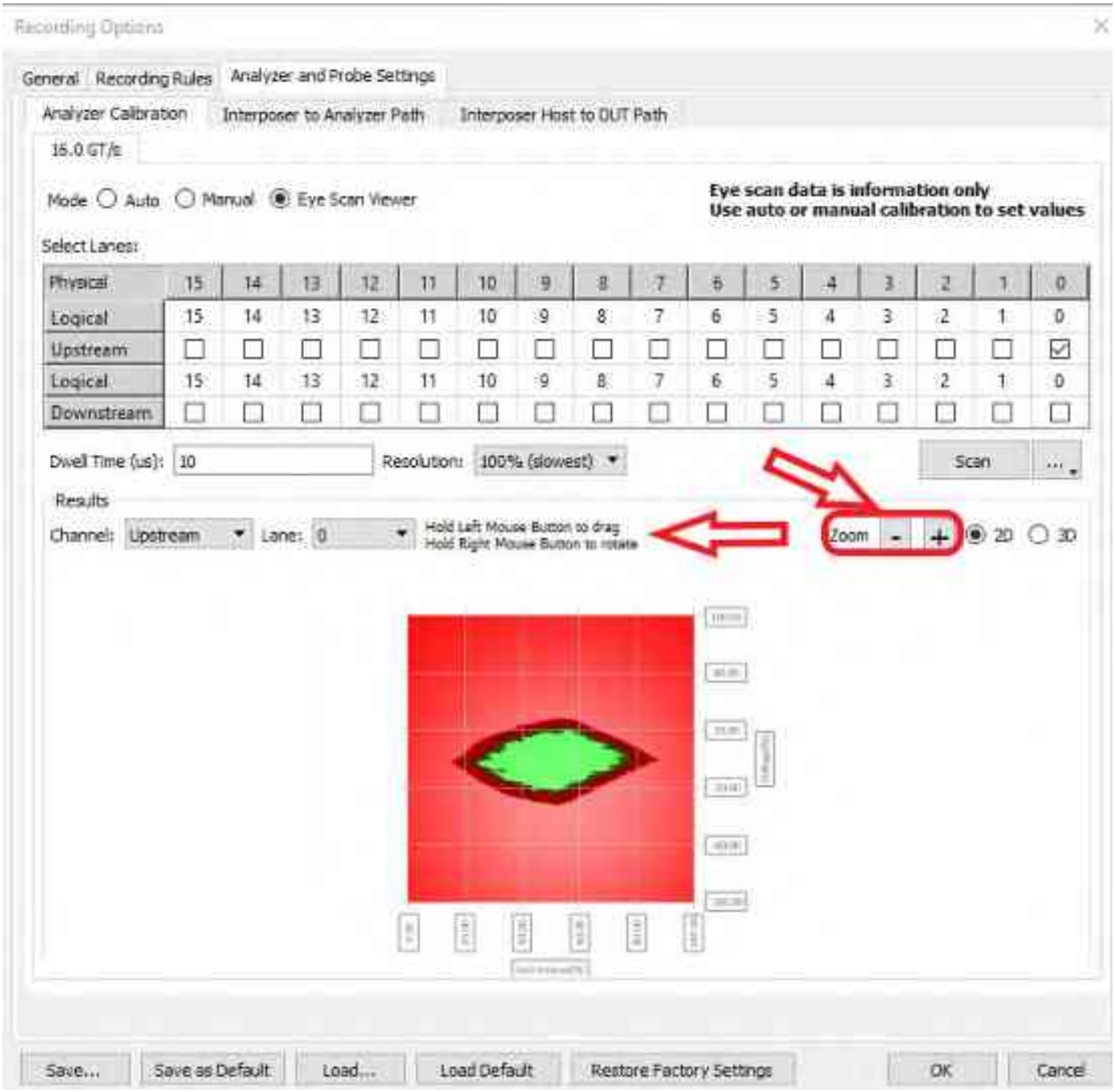


Figure 6.198: Two Dimensional View of “Eye”

Interpreting the Eye Diagram

The X-Axis is the relative phase of the Eye and the Y-Axis is the relative height of the Eye based on the number of steps taken. If the dwell time is increased or decreased the accuracy is increased or decreased. A longer dwell time interval will result in additional data samples being captured and longer rendering times for the eye diagram display.

Probe Settings and the Eye Diagram

The probe settings can be manipulated for better signal quality per "General Guidelines to do the Calibration and Auto-tuning" on page 278. The Eye Diagram will show the results of the updated probe settings.

6.19.4 Analyzer Path Calibration

The Analyzer Path Calibration Utility replaces the auto-calibration functions of the Recording Options "Analyzer Calibration" and "Interposer to Analyzer Path" tabs, performing both functions in a single step.

When you have one of the supported configurations listed below, invoking auto-calibration from these tabs starts the same Analyzer Path Calibration Utility as the Tools menu. Other than that, auto-calibration from these tabs is the same as it has always been.

Supported analyzer configurations:

- Summit T54 Standard PCIe Protocol mode
- Summit T516 Standard PCIe Protocol mode
- Gen5 interposers, Gen4 M.2 M-Key CrossSync PHY Capable Interposer
- 8.0GT/s, 16.0GT/s, and 32.0GT/s speeds

6.19.4.1 Usage

1. Open the PCIe Protocol Analysis Software and connect to an Analyzer.
2. Start the Analyzer Path Calibration Utility from the Tools menu.

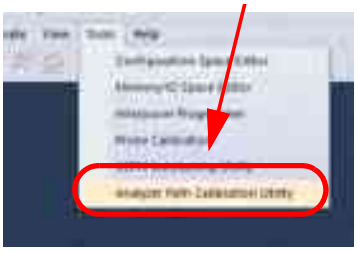


Figure 6.199: Analyzer Path Calibration Utility

3. Select the desired Analyzer, Target Speed, and Target Link Width to be calibrated.
4. Select the Upstream and Downstream Lanes to be calibrated.

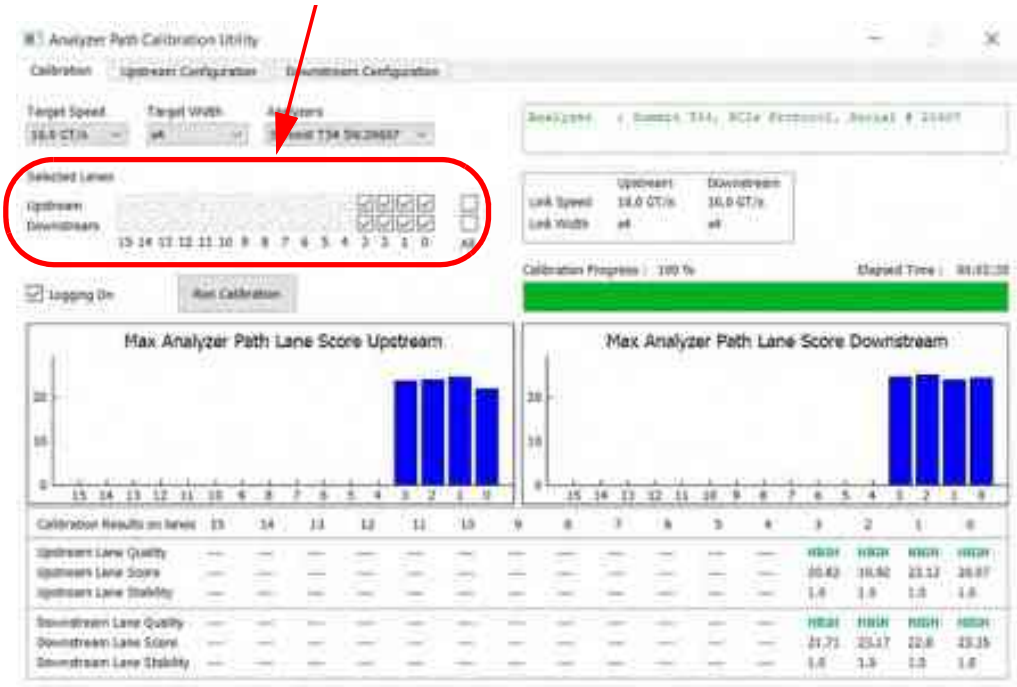


Figure 6.200: Select Lanes for Calibration

5. Check the Upstream Configuration and Downstream Configuration tabs. Ensure those configurations match your setup, otherwise, calibration will not succeed. These settings have the same effects as the Link settings in the Recording Options. They default to the Recording Options settings, but you may check and change them here before starting calibration.

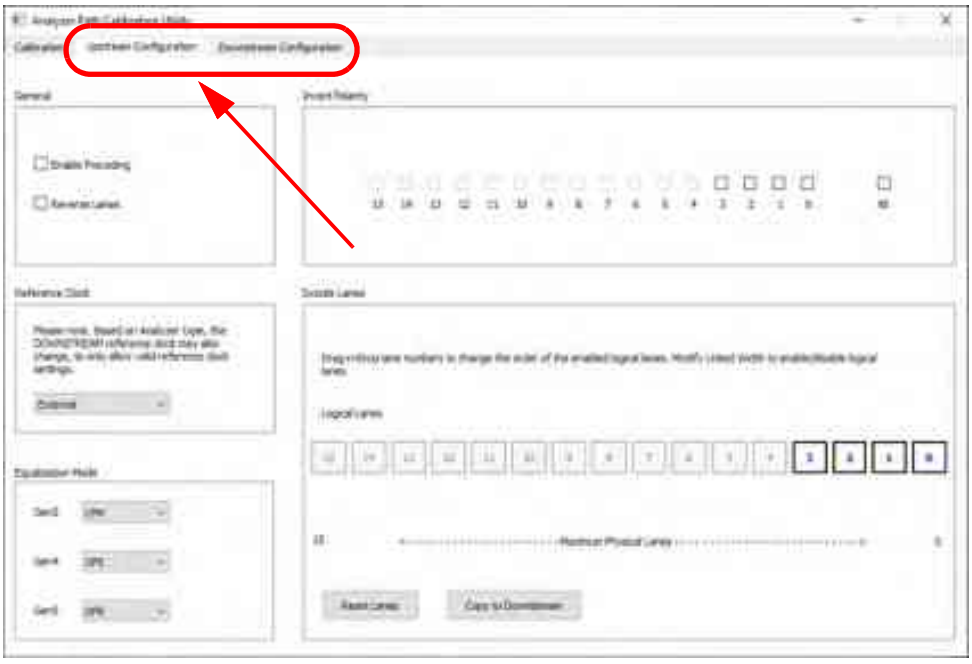


Figure 6.201: Check Configuration Tabs

6. Go back to the Calibration tab. Click Run Calibration.
7. During the Calibration process, real-time results are shown on a per-lane basis.

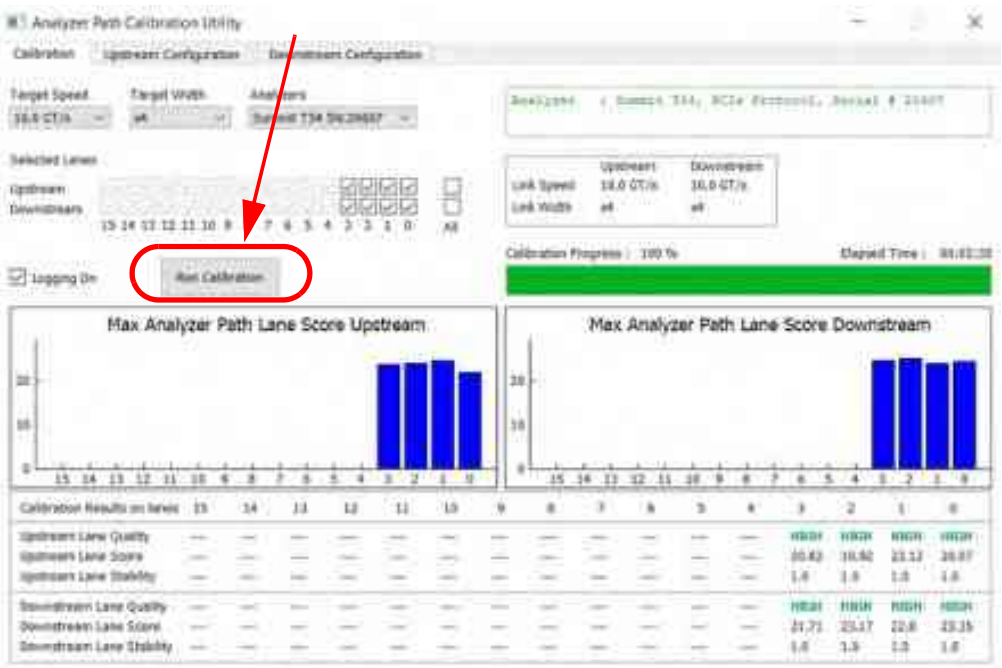


Figure 6.202: Real-Time Results

8. Upon completion, the full results are updated.

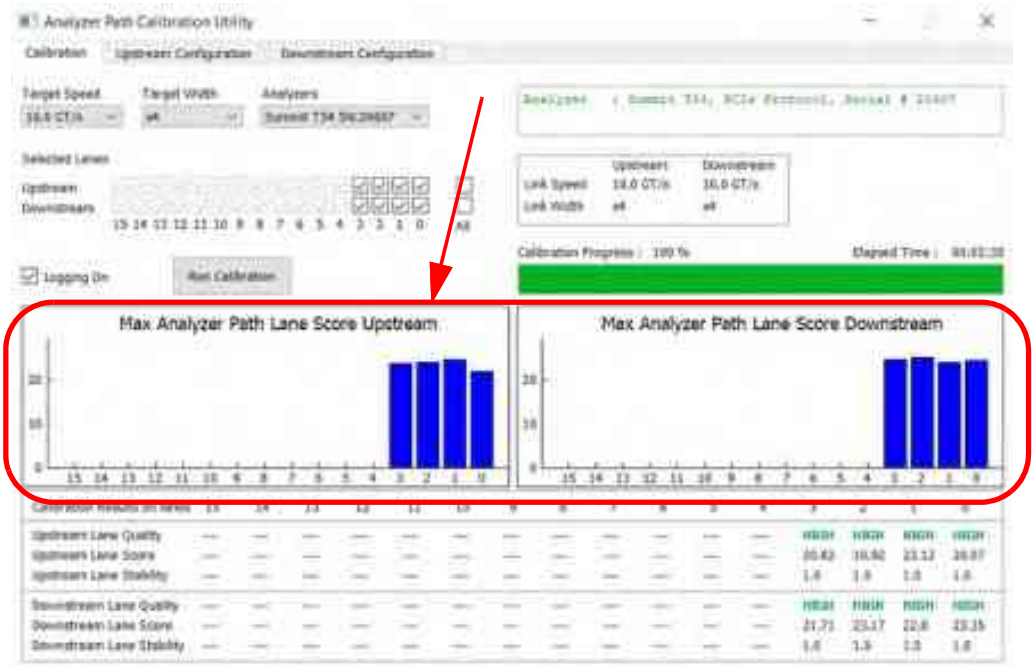


Figure 6.203: Full Results Updated

9. Calibrated settings are automatically applied to the analyzer and interposer and they are saved to the Recording Options.
10. Close the Analyzer Path Calibration Utility.
11. Return to PCIe Protocol Analysis Software and record as usual.

6.19.4.2 Results Definitions

- Lane Quality - High, Med, Low. Qualitative summary of Score and Margin.
- Lane Score - a calculated metric 0-100 combining various measurements of the physical and logical layers.
- Lane Stability - a percentage that indicates stability of results. Ideally, they should be > 50%.

6.19.4.3 Logging

If Logging is enabled on the Calibration tab, logs are generated and stored in timestamped folders under “C:\Users\Public\Documents\LeCroy\PCIeProtocol Suite”.

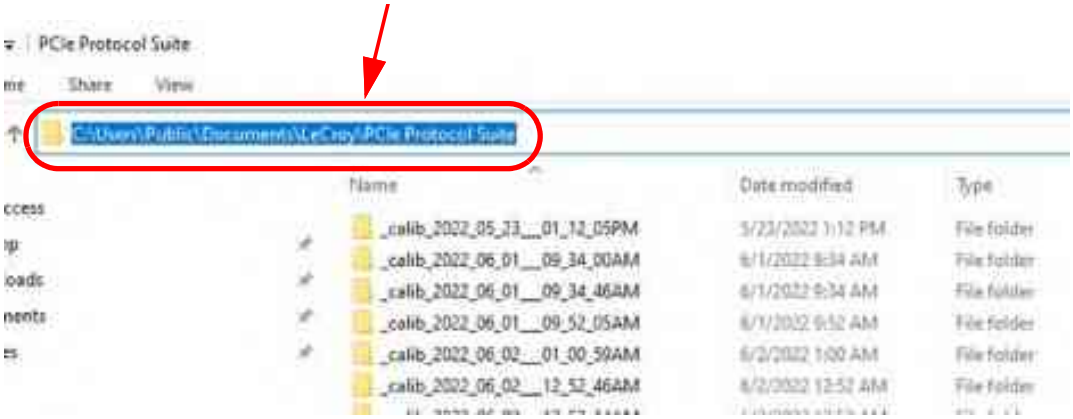


Figure 6.204: Logs Location

6.19.5 Using the Autotune and Probe Calibration Wizard

The Autotune and Probe Calibration wizard guides you through both the Autotune and Probe Calibration process steps as outlined below:

- Analyzer Verification
- Interposer Verification
- Setting Parameters
- Setting Polarity
- Precalibration
- Calibration Finished

Note: The Autotune wizard does not support lane reversal.

To start the Autotune and Calibration Wizard select **Recording Options → Analyzer and Probe Settings → Launch Probe Calibration Wizard** (Figure 6.205).

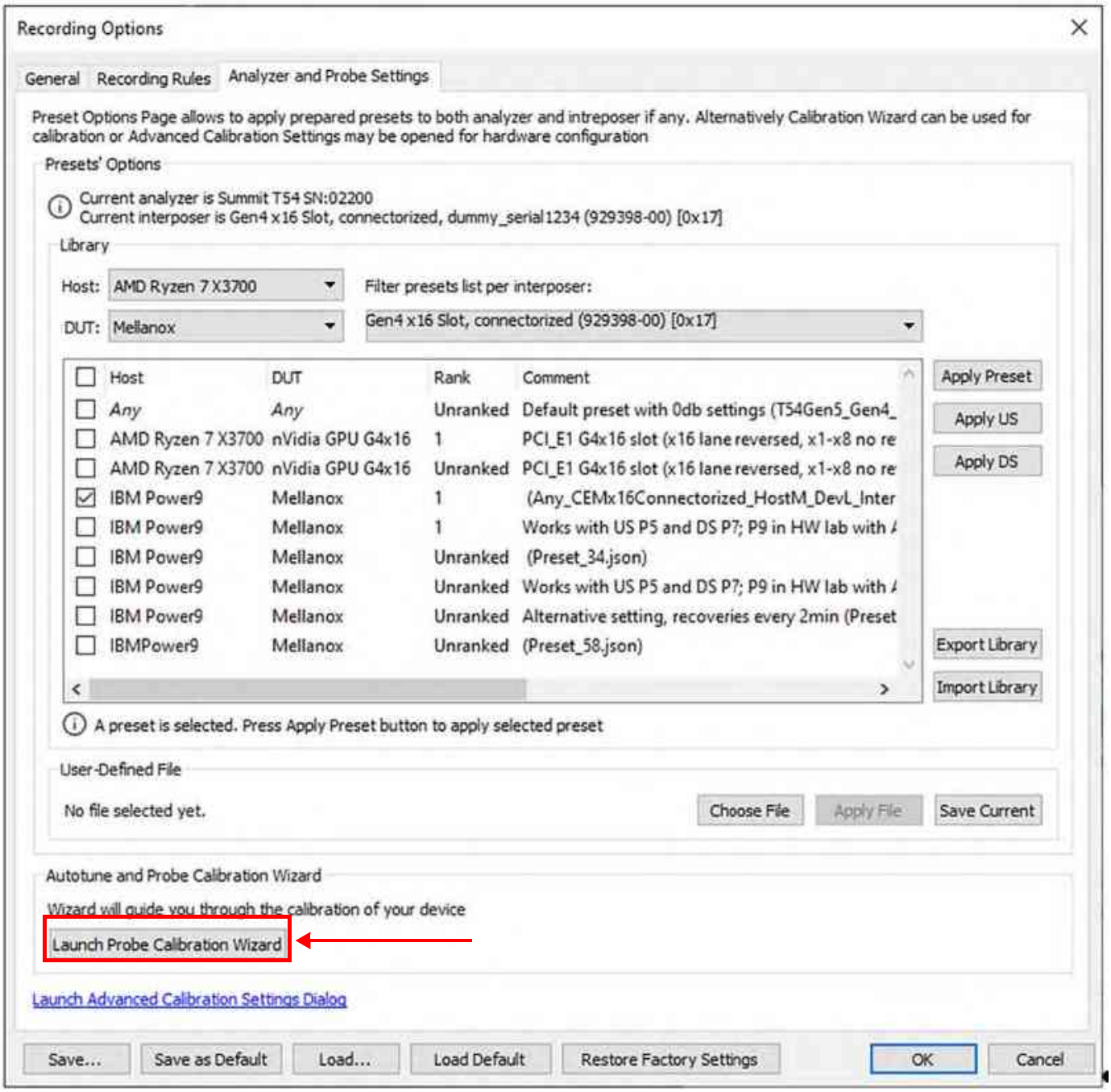


Figure 6.205: Select Recording Options → Launch Probe Calibration Wizard

Select the Probe Calibration Wizard link. The following dialog box will pop up and lead you through the steps for both Autotuning the analyzer and Calibrating the Probe. See Figure 6.206 on page 343.

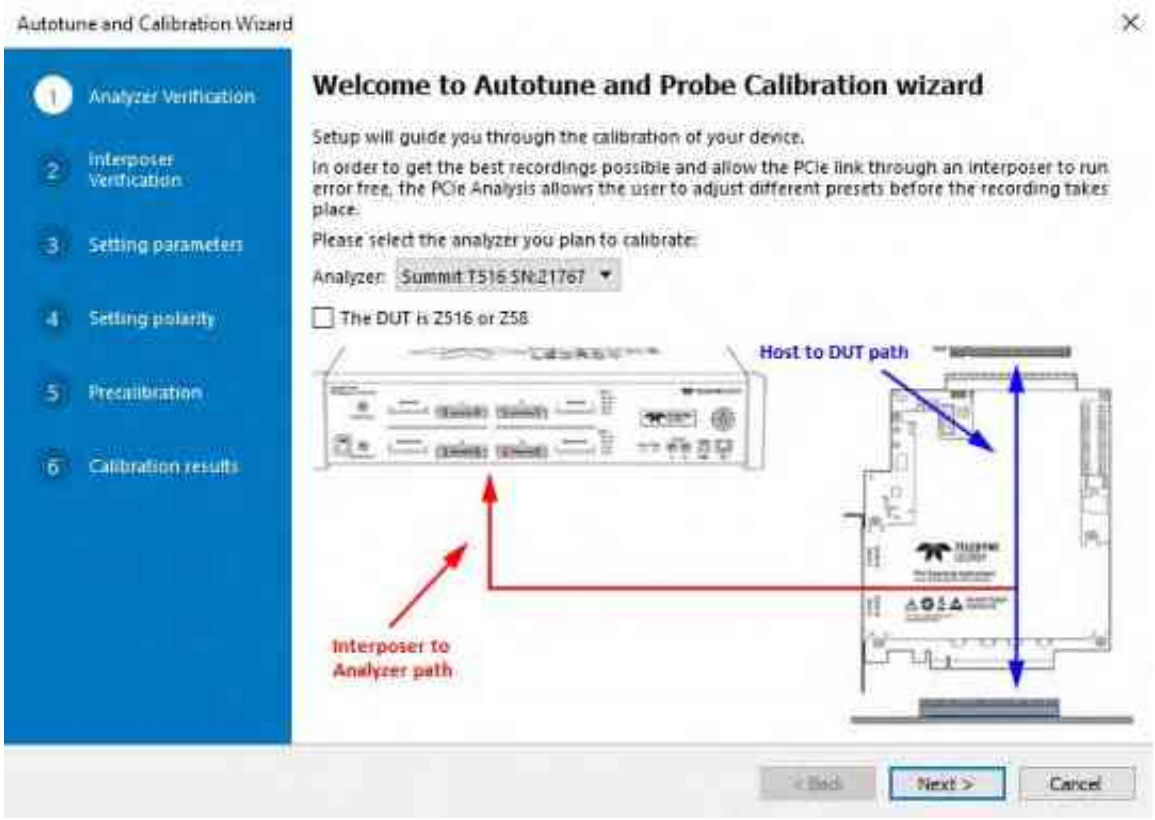


Figure 6.206: Autotune and Probe Calibration Wizard: Step 1 -> Analyzer Verification

First you choose the Analyzer you plan to calibrate.

Then click on next to go to Step 2: Interposer Verification (see Figure 6.207 on page 344).

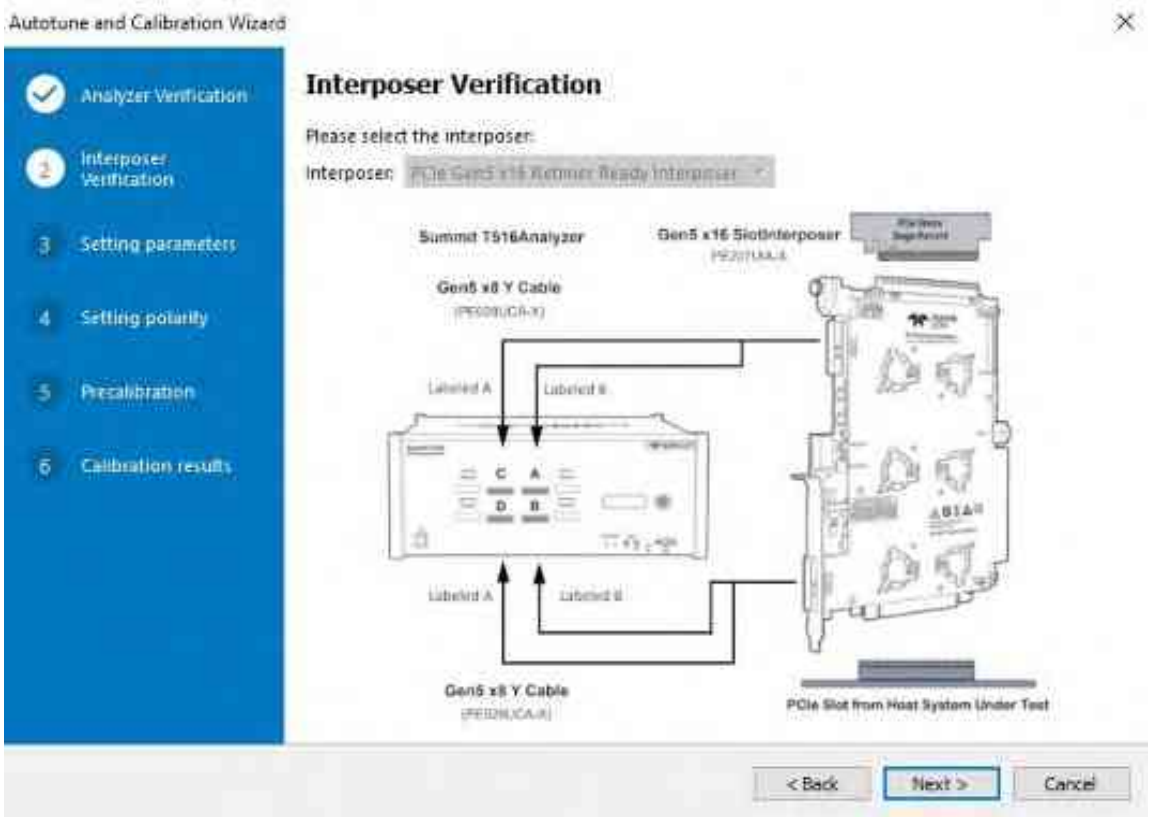


Figure 6.207: Autotune and Probe Calibration Wizard: Step 2 -> Interposer Verification

In this case we are working with the Gen5 x8 Slot.

Click on Next to go to Step 3: Setting parameters (see Figure 6.208 on page 345).

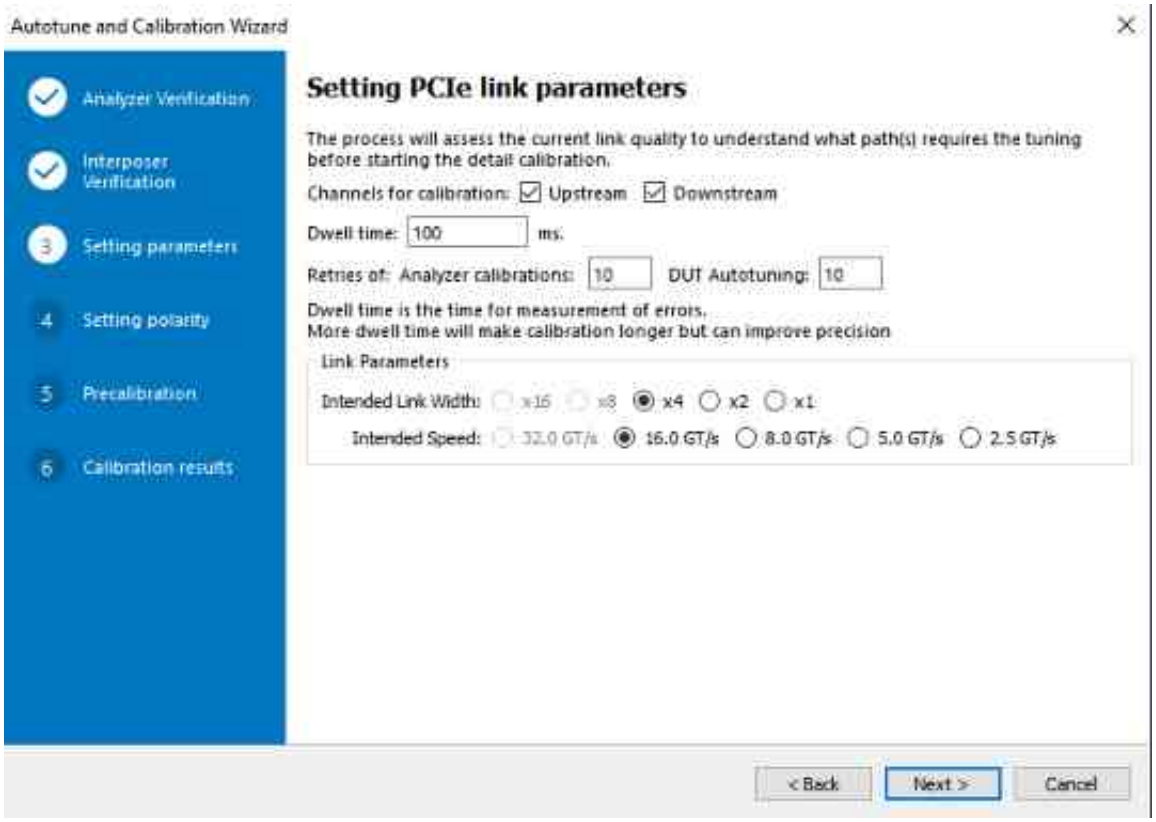


Figure 6.208: Autotune and Probe Calibration Wizard: Step 3 -> Setting Parameters

In this step you can set Channels for calibration, the Dwell time for measurement errors, select maximum number of retries of Analyzer calibration and DUT Autotuning and set up the link parameters.

Then click on Next to Set polarity (see Figure 6.209).

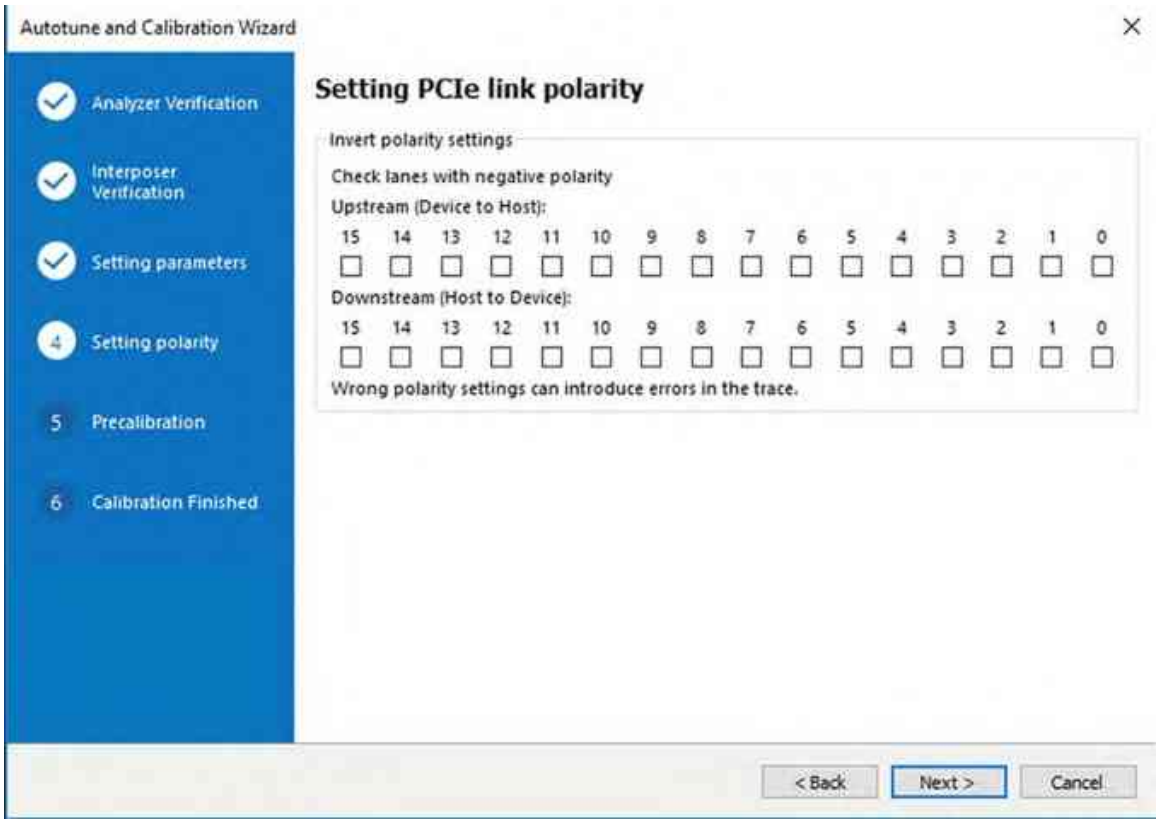


Figure 6.209: Autotune and Probe Calibration Wizard: Step 4 → Setting Link Polarity

Here you can invert the polarity of Upstream or Downstream lanes.

Then click on Next to go to the Precalibration step (see Figure 6.210).

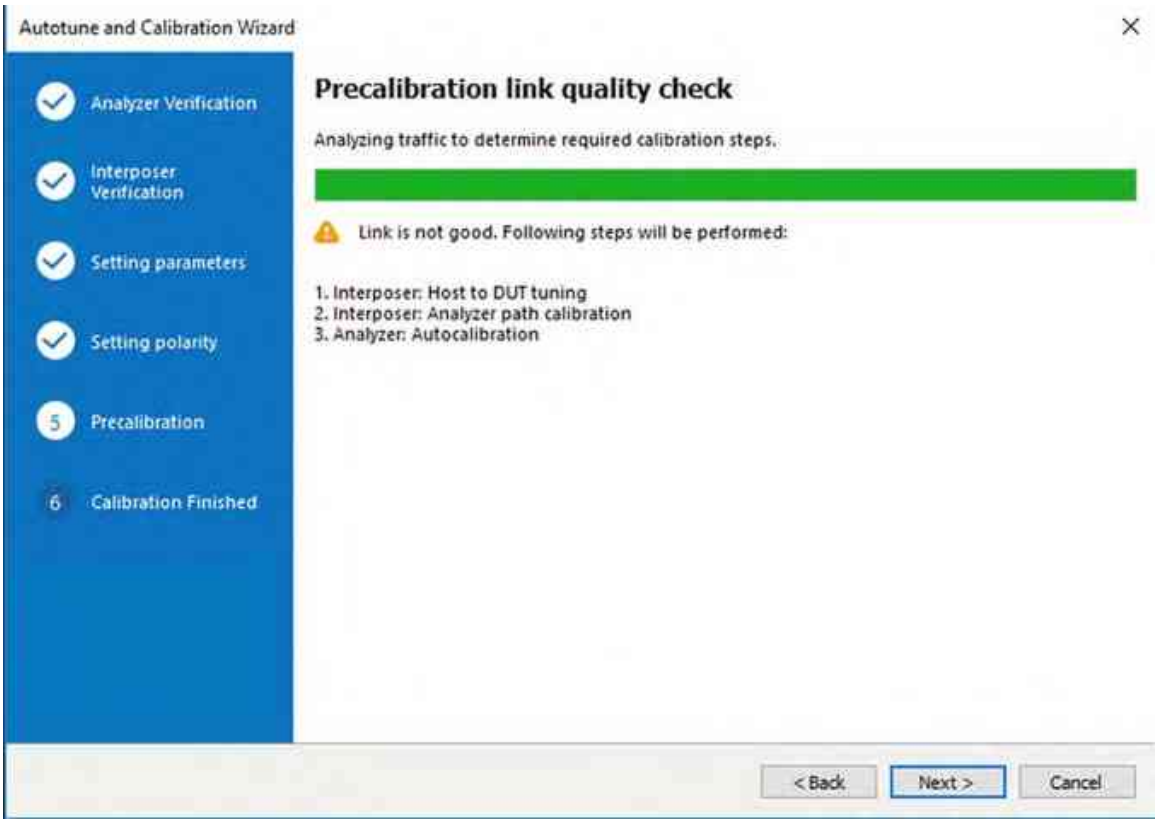


Figure 6.210: Autotune and Probe Calibration Wizard: Step 5 -> Precalibration Link Quality Check

This step check the quality of the link before calibration.

In this case the Link Quality was not good, so the following steps were taken:

- Interposer: Host to DUT Tuning
- Interposer: Analyzer path calibration
- Analyzer: AutoCalibration

To perform the steps outlined above the DUT, Host and operating system must be selected (see Figure 6.211 on page 348).

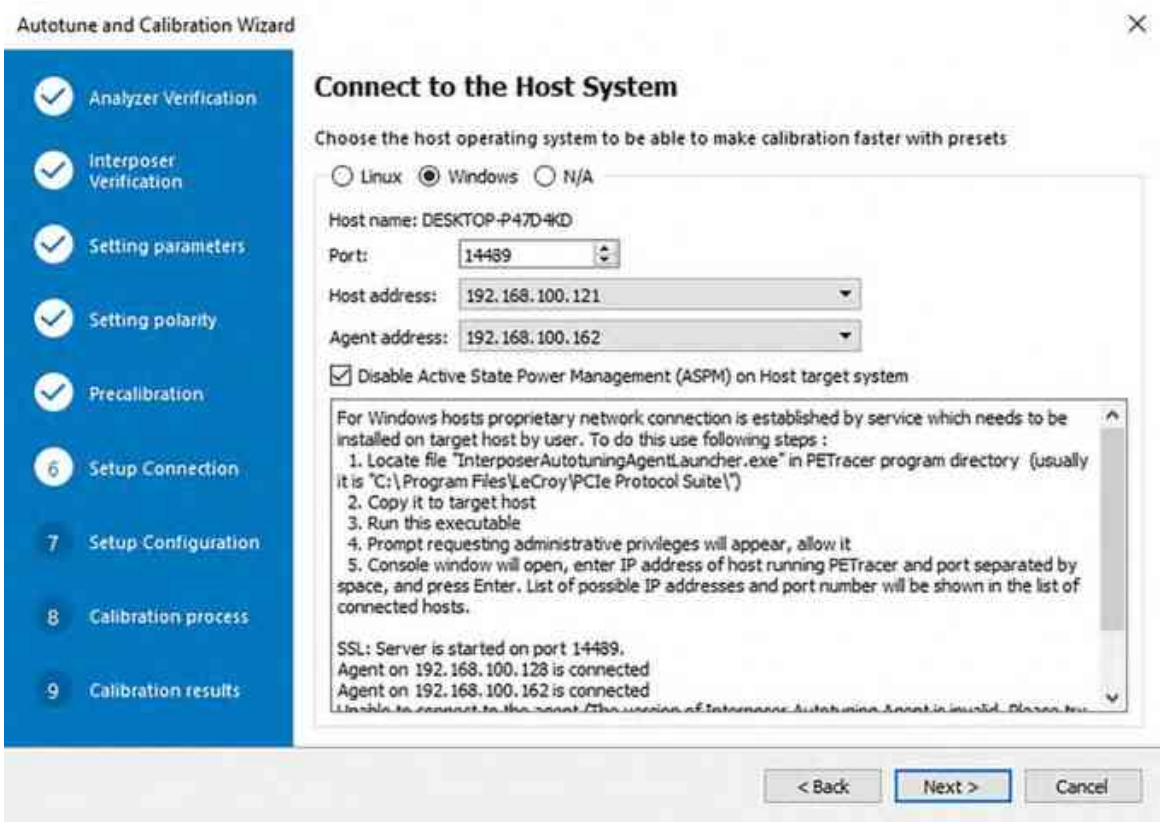


Figure 6.211: Autotune and Probe Calibration Wizard: Step 6 -> Setup Connection

Select the Host operating system and enter the Host system information. Different Host system information must be specified depending on the selected Host operating system:

- For Windows: Agent address must be selected;
- For Linux: Login, Password and IP Address must be entered;
- For N/A: no additional system information is required.

Once you have selected the Host operating system and specified the Host system information, click on Next and proceed to the step, which involves selecting the DUT and presets. See Figure 6.212 on page 349).

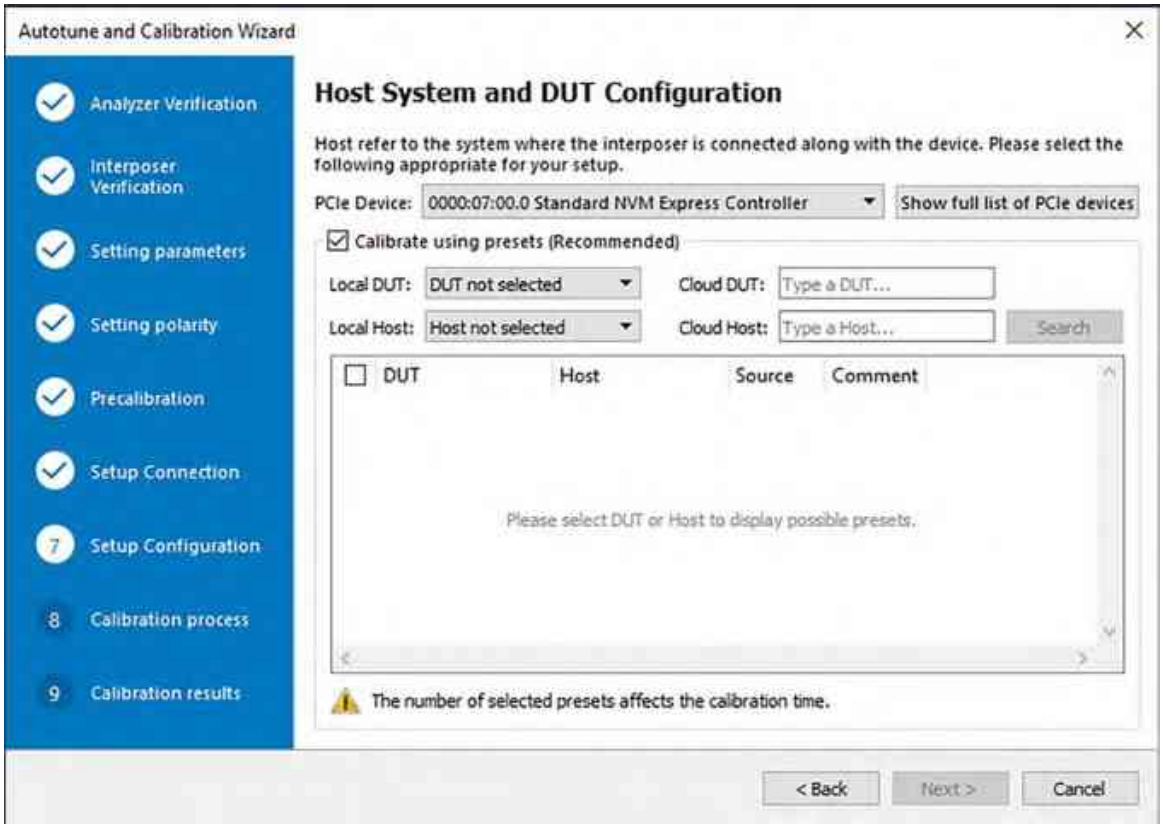


Figure 6.212: Autotune and Probe Calibration Wizard: Step 7 -> Host System and DUT configuration

If Windows or Linux operating system was chosen on the previous step, then you must select the DUT you are using. In this case the DUT is a Standard NVM Express Controller.

Some PCIe devices, for example Root Complex Root Ports, Event Collectors, etc., will not be shown in the list. Click Show full list of PCIe devices to view all connected PCIe devices that are detected.

Also in this step you can select the presets which will be used during the Calibration process. Presets may be:

- Local – presets which are stored on the local computer in C:\Users\Public\Documents\LeCroy\PCIe Protocol Suite\InterposerCfgPresets folder;
- Cloud – presets which are stored in the cloud in the Internet.

Select names in Local DUT and/or Local Host to add local presets to the list. Enter names in Cloud DUT and/or Cloud Host fields and click on Search to add cloud presets to the list. Then check one or more presets in the list. The checked presets will be used during the Calibration process.

By default, the option Calibrate using presets is enabled, so you must check at least one preset. Uncheck Calibrate using presets option to be able to start the Calibration process without selecting presets.

Click on Next and the Calibration process will begin. See Figure 6.213 on page 350.

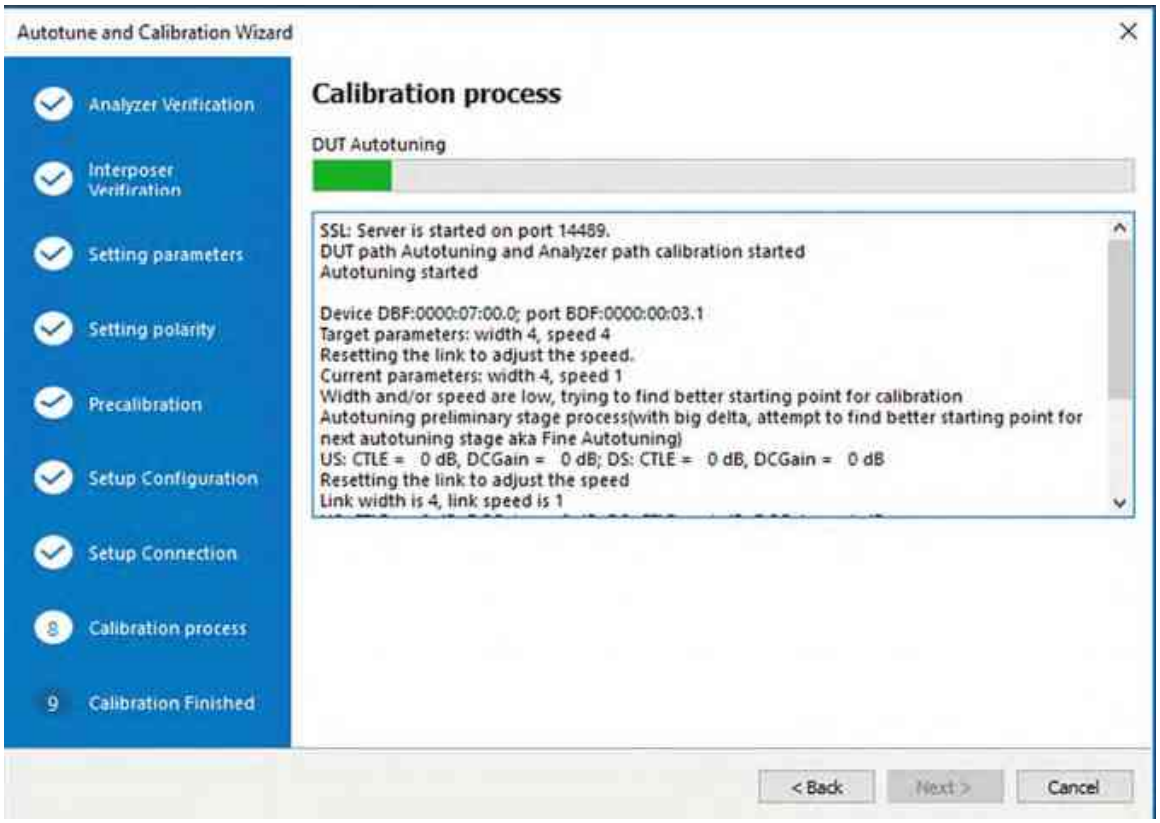


Figure 6.213: Autotune and Probe Calibration Wizard: Step 8 -> Calibration Process

In this step you can see from the log window the Autotuning and Calibration steps being taken by the PCIe Analysis software. After the Calibration process has completed (and this make take awhile), select Next and a dialog box will pop up that shows a link to the Calibration results. See Figure 6.214 on page 351.

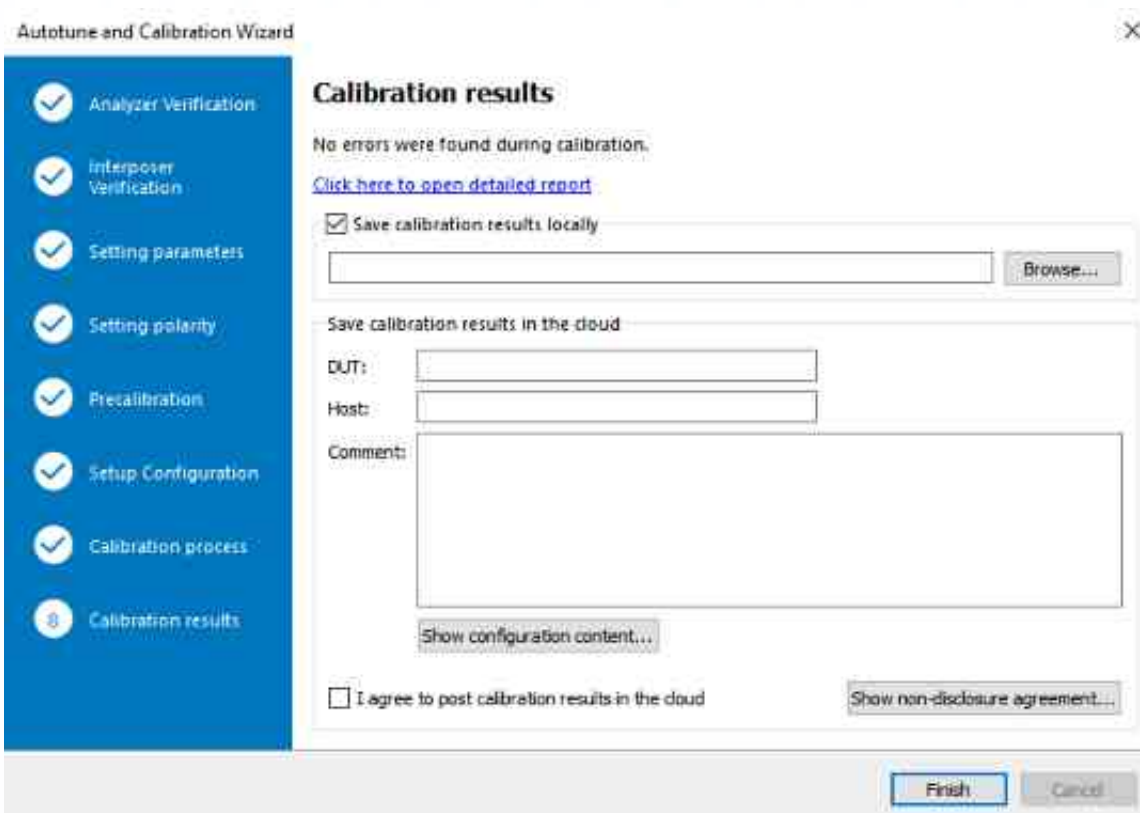


Figure 6.214: Autotune and Probe Calibration Wizard: Step 9 -> Calibration Results

Click on the link to view the Calibration results. See Figure 6.215 on page 352.

In case of successful calibration (no errors were found during the Calibration process) the Calibration results may be saved locally to the specified file and/or in the cloud with the specified DUT and Host names and optional Comment.

The Calibration results will be saved as a preset after clicking Finish:

- Locally, if Save calibration results locally is checked. The locally saved preset can be accessed on this PC or copied to another;
- In the cloud, if I agree to post calibration results in the cloud is checked. The preset saved in the cloud can be accessed from any PC connected to the Internet and will be shown in the list on the Step 7 (“Setup Connection”) when searching for cloud presets.

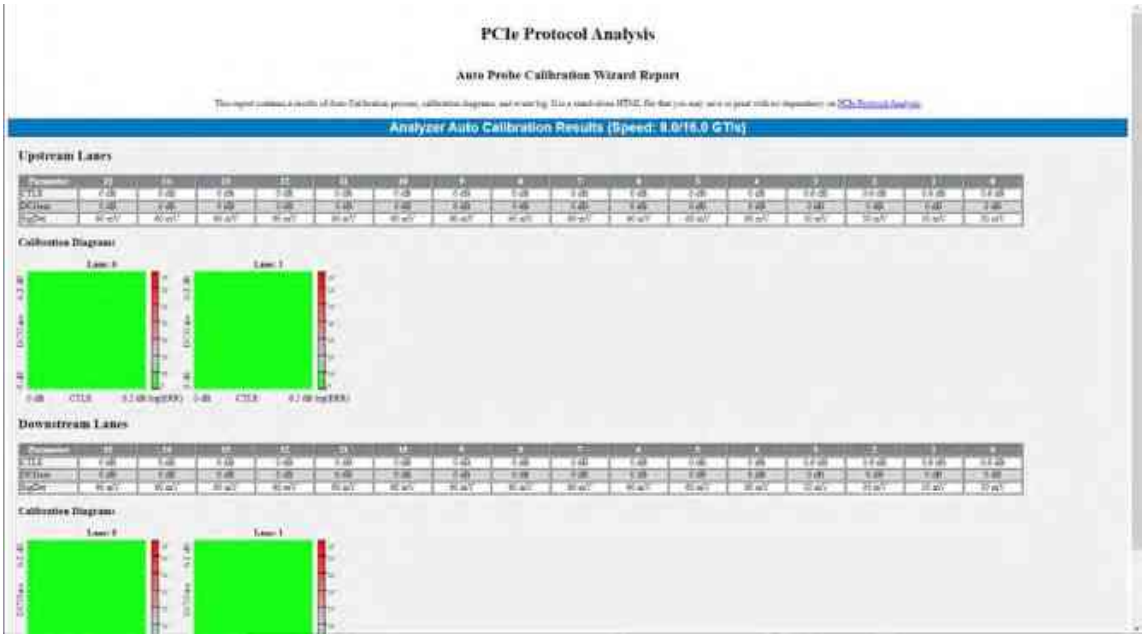


Figure 6.215: Autotune and Probe Calibration Wizard: Step 10 -> Calibration Results

From the Calibration Report you can see the values used for each lane (Upstream and Downstream):

- CTLE
- DCGain
- SigDet

6.20 Tools: Options

6.20.1 Interposer Settings for Bifurcated Multiport Link

Currently the only possible option to change the presets of a Bifurcated multiport link is to use the USB connection, to do this the user can bring the dialog by selecting "**Tools -> Interposer Programmer**" (see Figure 6.216).



Figure 6.216: Tools: Interposer Programmer

This will bring the dialog with an option to connect the interposer via USB. See Figure 6.217.

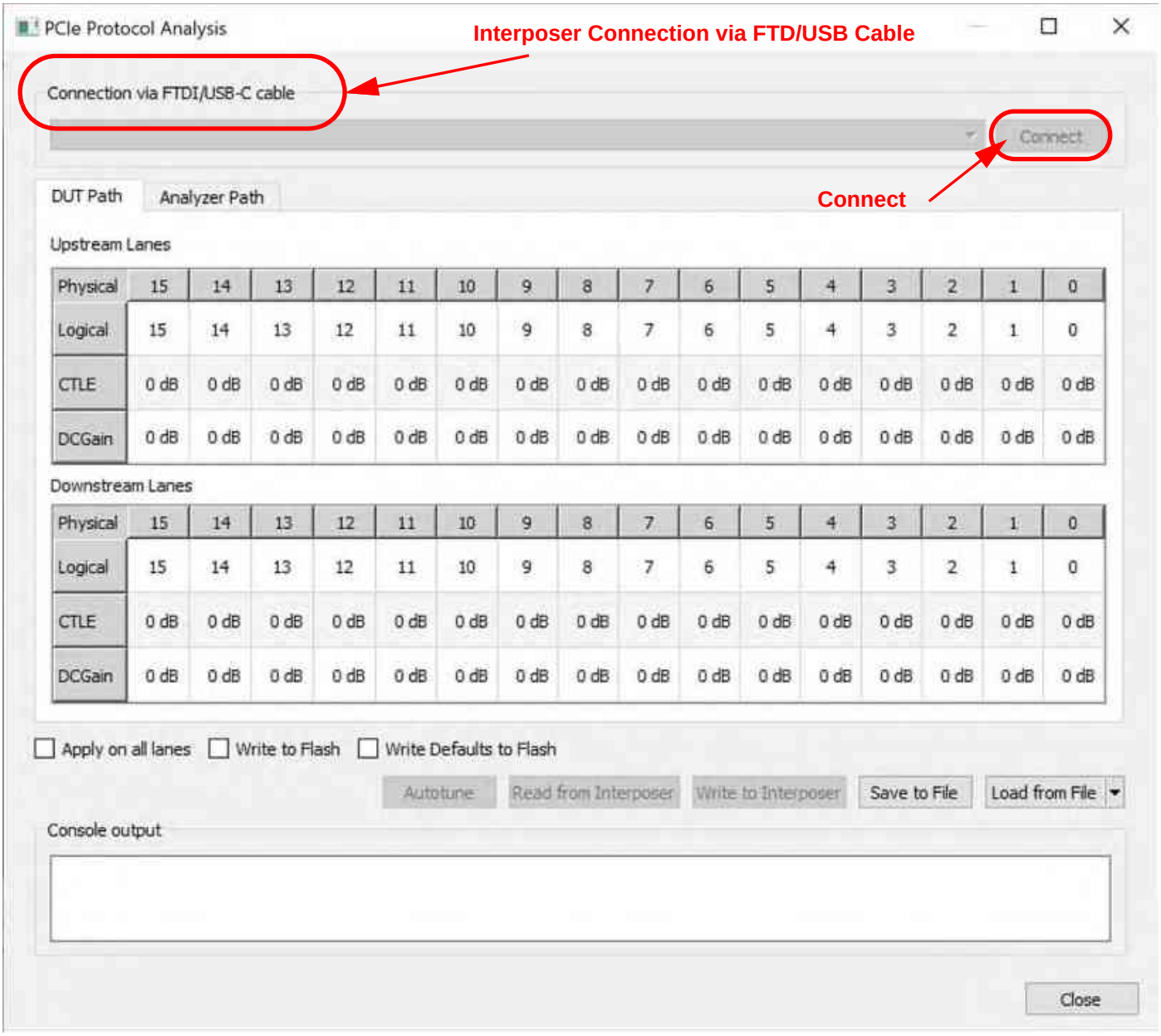


Figure 6.217: PCIe Interposer Programmer Utility

1. Power on the Interposer (if not already powered up).
2. Select the Connect button on the right side of the dialog box. See Figure 6.217.

Again, this is only needed for bifurcated link setups and if there is an error on the recoding option dialog i.e. on "Host-To-DUT" tab. The dialog control will work the same as described earlier in the section (*Start auto-tuning process:*).

6.20.1.1 Saving Auto-Tune and Calibration Results

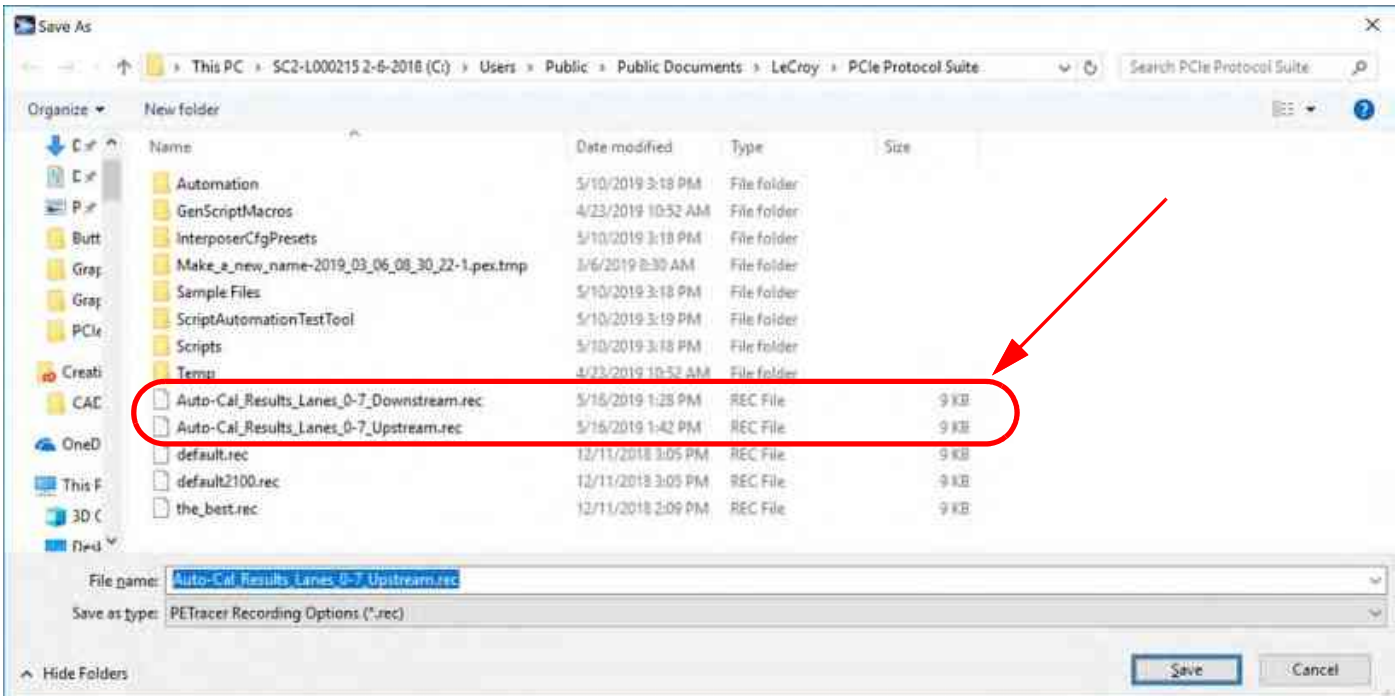


Figure 6.218: Directory of Saved Auto-Calibration Results

You can also Save, Save as Default, Load, Load Default or Restore Factory Settings. See Figure 6.219.

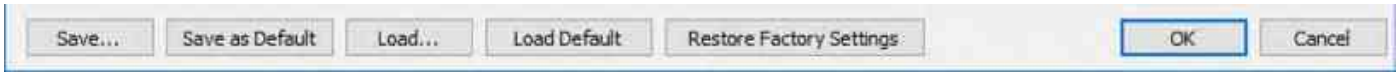


Figure 6.219: Save, Save as Default, Load, Load Default or Restore Factory Settings

6.21 Lane Margining

You can use Lane Margining as an Advanced Recording Rule. You need to define the following Fields:

- Margin Command
- Margin Type
- Receiver Name
- Margin Payload

See Figure 6.220.

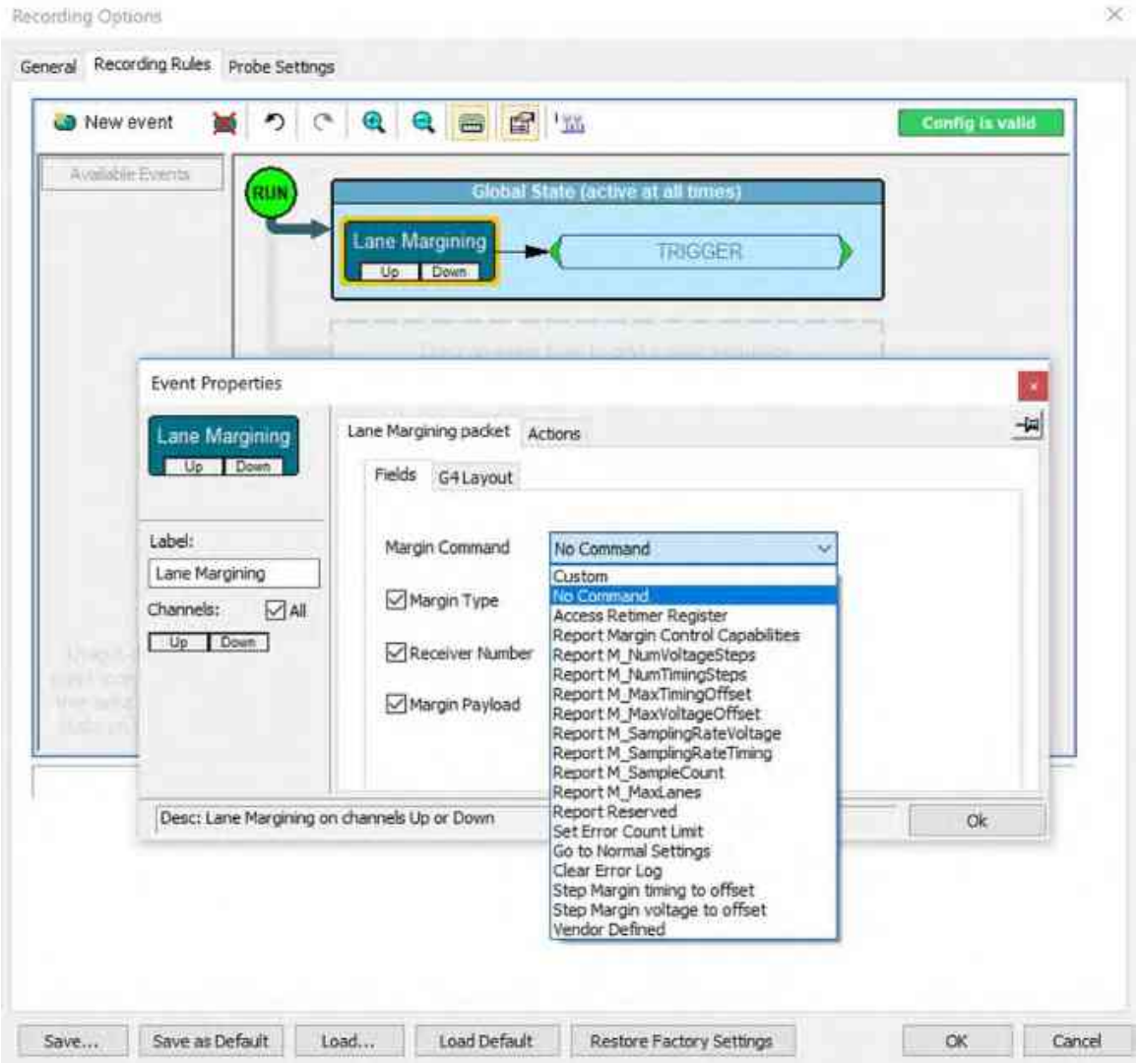
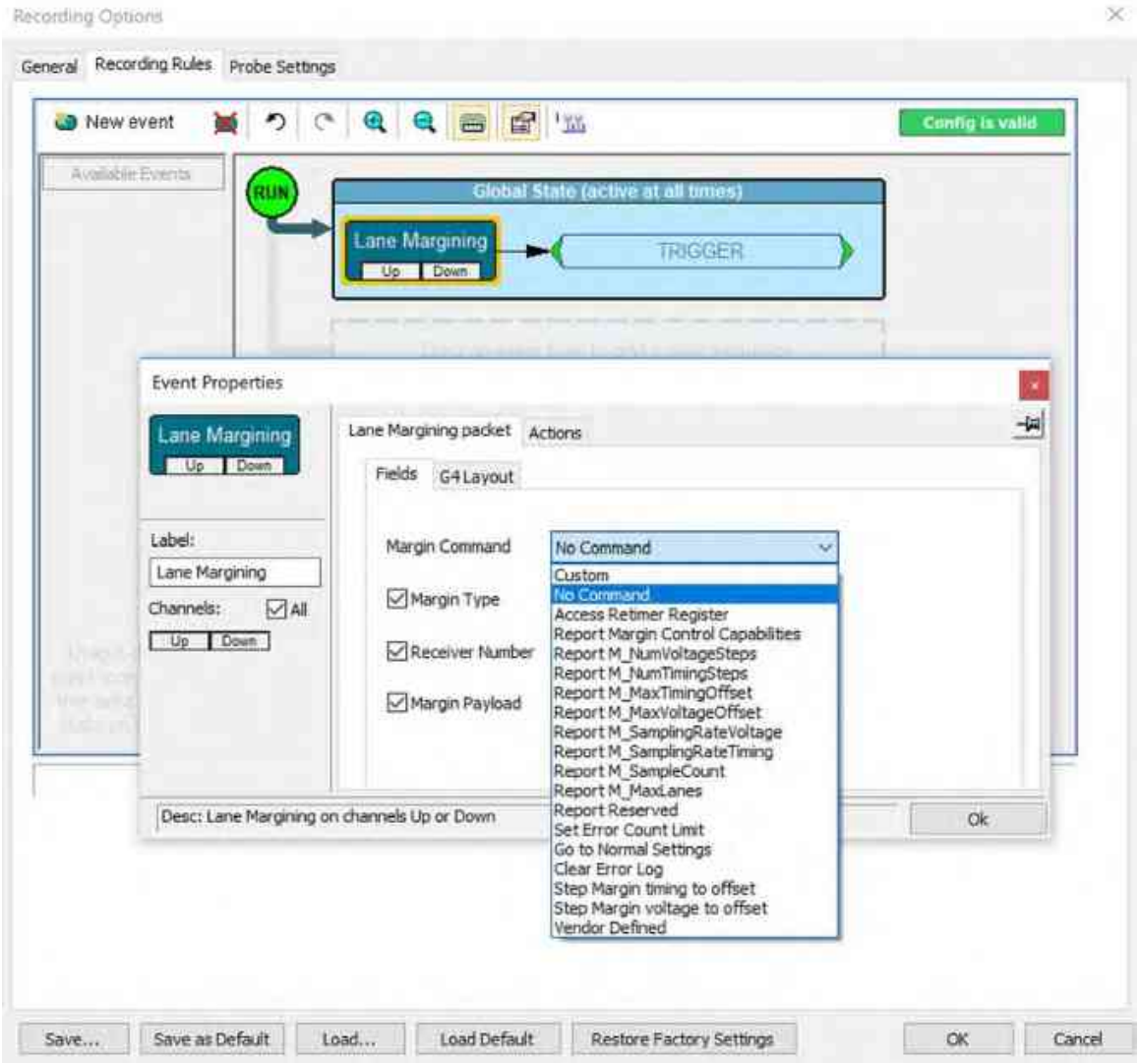


Figure 6.220: Lane Margining: Fields → Margin Commands

You can also update the four DWORDS in the G4 Layout dialog box. See Figure 6.221.


Recording Options
General
Recording Rules
Probe Settings
New event
Config is valid
Available Events
RUN
Global State (active at all times)
Lane Margining
Up
Down
TRIGGER
Event Properties
Lane Margining
Up
Down
Label:
Lane Margining
Channels:
All
Up
Down
Lane Margining packet
Actions
Fields
G4 Layout
Margin Command
No Command
Margin Type
Receiver Number
Margin Payload
Custom
No Command
Access Retimer Register
Report Margin Control Capabilities
Report M_NumVoltageSteps
Report M_NumTimingSteps
Report M_MaxTimingOffset
Report M_MaxVoltageOffset
Report M_SamplingRateVoltage
Report M_SamplingRateTiming
Report M_SampleCount
Report M_MaxLanes
Report Reserved
Set Error Count Limit
Go to Normal Settings
Clear Error Log
Step Margin timing to offset
Step Margin voltage to offset
Vendor Defined
Desc: Lane Margining on channels Up or Down
Ok
Save...
Save as Default
Load...
Load Default
Restore Factory Settings
OK
Cancel

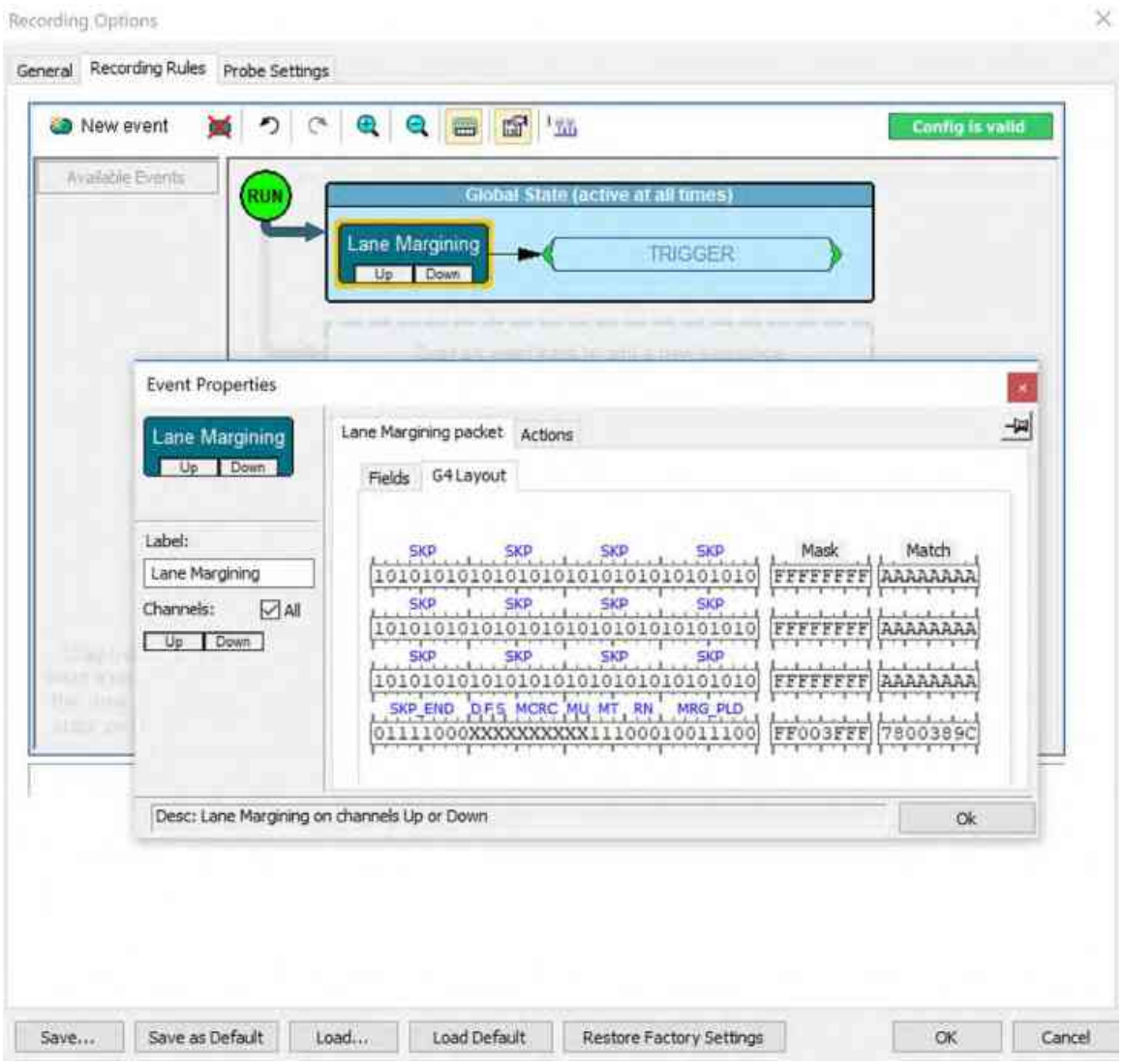


Figure 6.221: Four DWORDS Need to Define G4 Layout

6.22 Probe Settings

Probe Settings are the same as in Simple Mode (see “General Guidelines to do the Calibration and Auto-tuning” on page 278).

6.23 Preparing to Record in NVMe Enhanced Mode

Several prerequisite steps are required to ensure the system is configured properly for recording in NVMe enhanced mode. A PCI Protocol recording should be taken in L0 to determine that all the PCIe link parameters are selected correctly to record without errors. Once that is done the link parameters should not be changed for later recordings.

Secondly, a PCIe protocol recording should be taken of the complete power up and connection sequence between the NVMe device and host. This boot recording is required to map all of the configuration registers, devices, submission and completion command queues and other resources to the correct address spaces. These mappings will be used automatically by NVMe Enhanced Mode to create a set of filters to only filter in and record traffic from the correct set of devices and resources.

A boot recording will be automatically recognized by the software and saved for later sessions. It is recommended to capture a new boot recording for each session because resources can be created and deleted in the gap between a boot recording and an NVMe Enhanced Mode recording and those resources created in the interim will not be recognized correctly.

There are three separate methods to use the NVMe Enhanced Recording Mode.

- Snapshot – Simple Mode
- Snapshot – Advanced Mode
- Event Trigger – Advanced Mode

The simplest is the Snapshot in Simple mode as described below.

6.23.1 Snapshot – Simple Mode

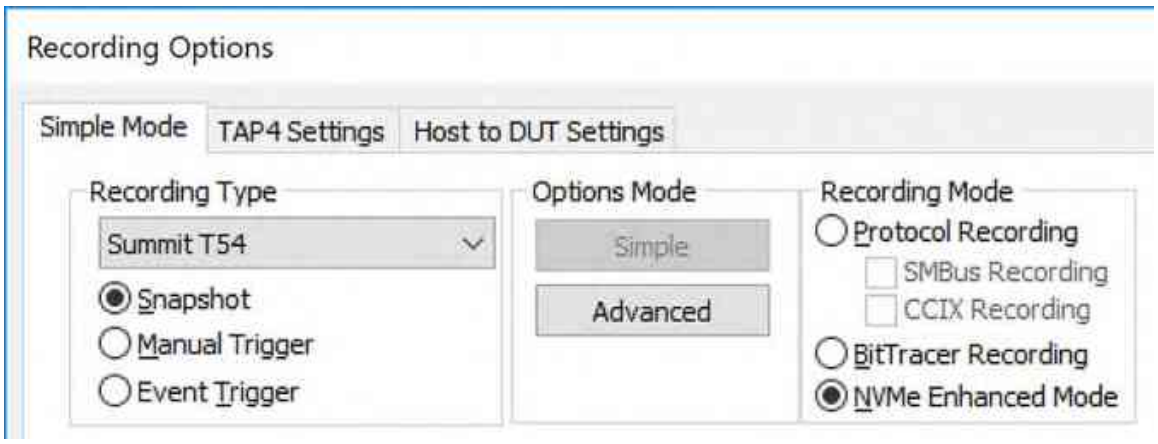


Figure 6.222: NVMe Enhanced Recording Mode

When the NVMe Enhanced Mode button is selected the following warning will popup in the Recording Panel (under NVMe Device ID#) if an SSD Device Configuration File has not been stored.

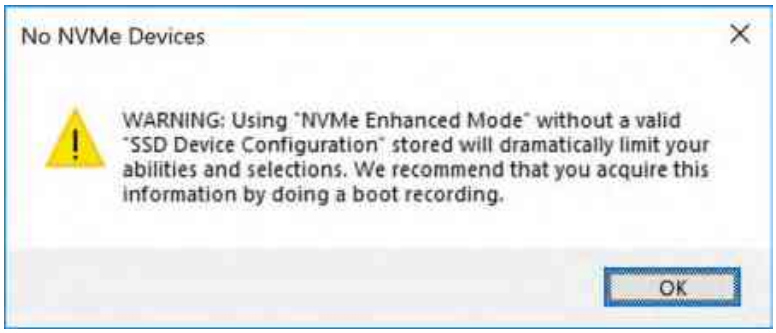


Figure 6.223: Warning Message if no SSD Device Configuration file is stored

To generate and store an SSD Device Configuration File is a two step process:

1. Record a boot trace
   (see http://teledynelecroy.com/doc/capture-of-an-nvme-boot-up-trace-appnote).
2. Export the SSD Device Configuration File.

6.23.1.1 Features

NVMe Enhanced Recording Mode allows filtering of all traffic except the exact traffic desired by the user. This will extend the potential recording depth to millions of commands and allow recording over time intervals that were previously impossible.

Simple recording mode is shown below (Figure 6.224) and shows the available resources to filter in: NVMe Commands, Doorbells, Controller Registers, MSI interrupts, ACKs and Device Config, along with all the available devices detected in the boot recording. Selecting a check box will include that type of traffic in the recording.

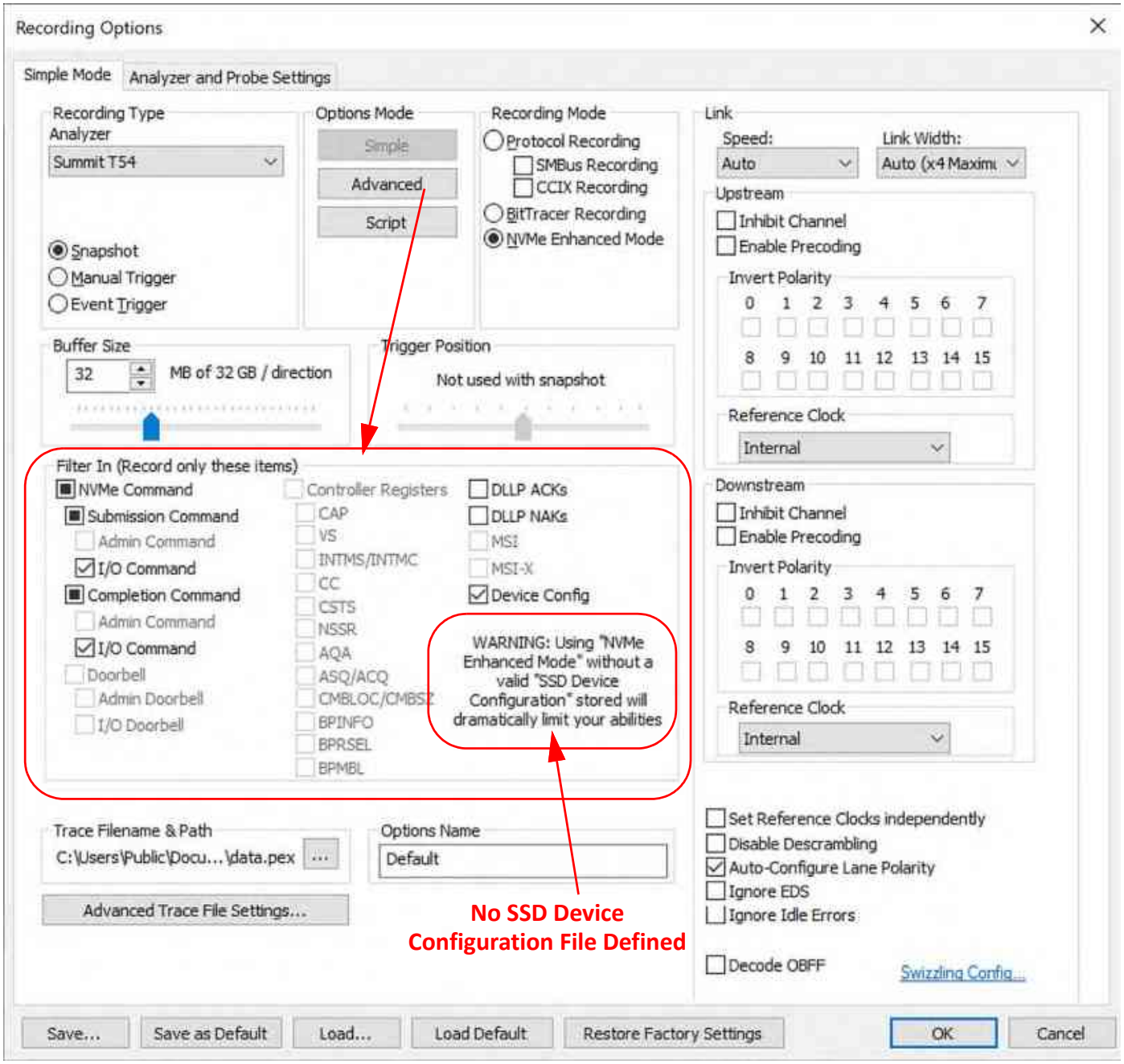


Figure 6.224: NVMe Enhanced Recording Mode: Snapshot - Simple Mode, Device not Defined

If you had defined a valid SSD Device Configuration the Recording Menu would display the device under test. See Figure 6.225 on page 363. A sample SSD Device Configuration file is shown in "SSD Device Configuration File" on page 369.

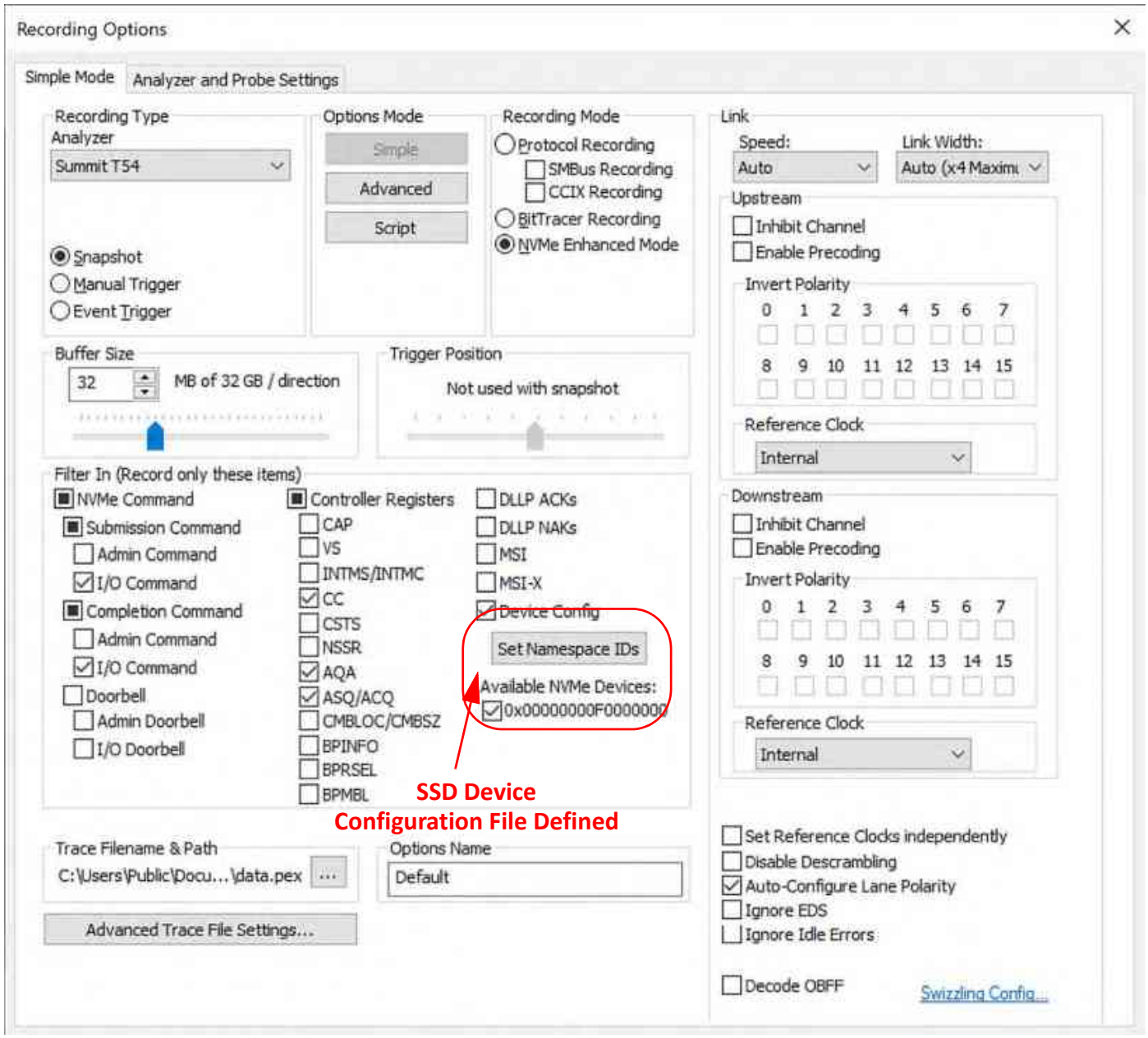


Figure 6.225: NVMe Enhanced Recording Mode: Snapshot – Simple Mode, Device Defined

Note: If you try and go to Event Trigger - Simple mode the following warning message pops up:

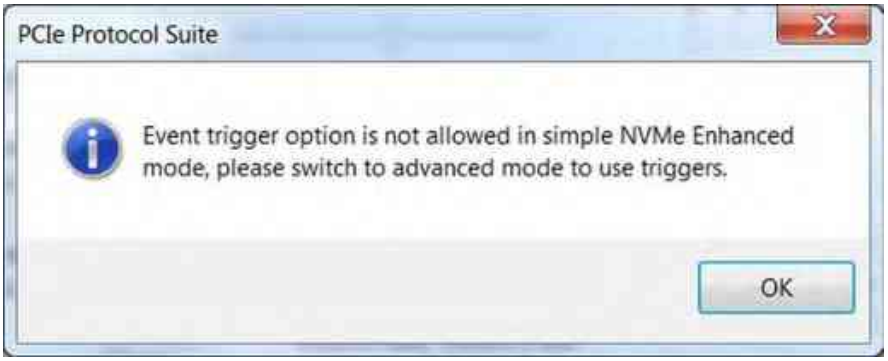


Figure 6.226: NVMe Enhanced Mode: Event Trigger – Simple Mode

6.23.2 Snapshot – Advanced Mode

The General options in Snapshot – Advanced Mode are shown in Figure 6.227, below:

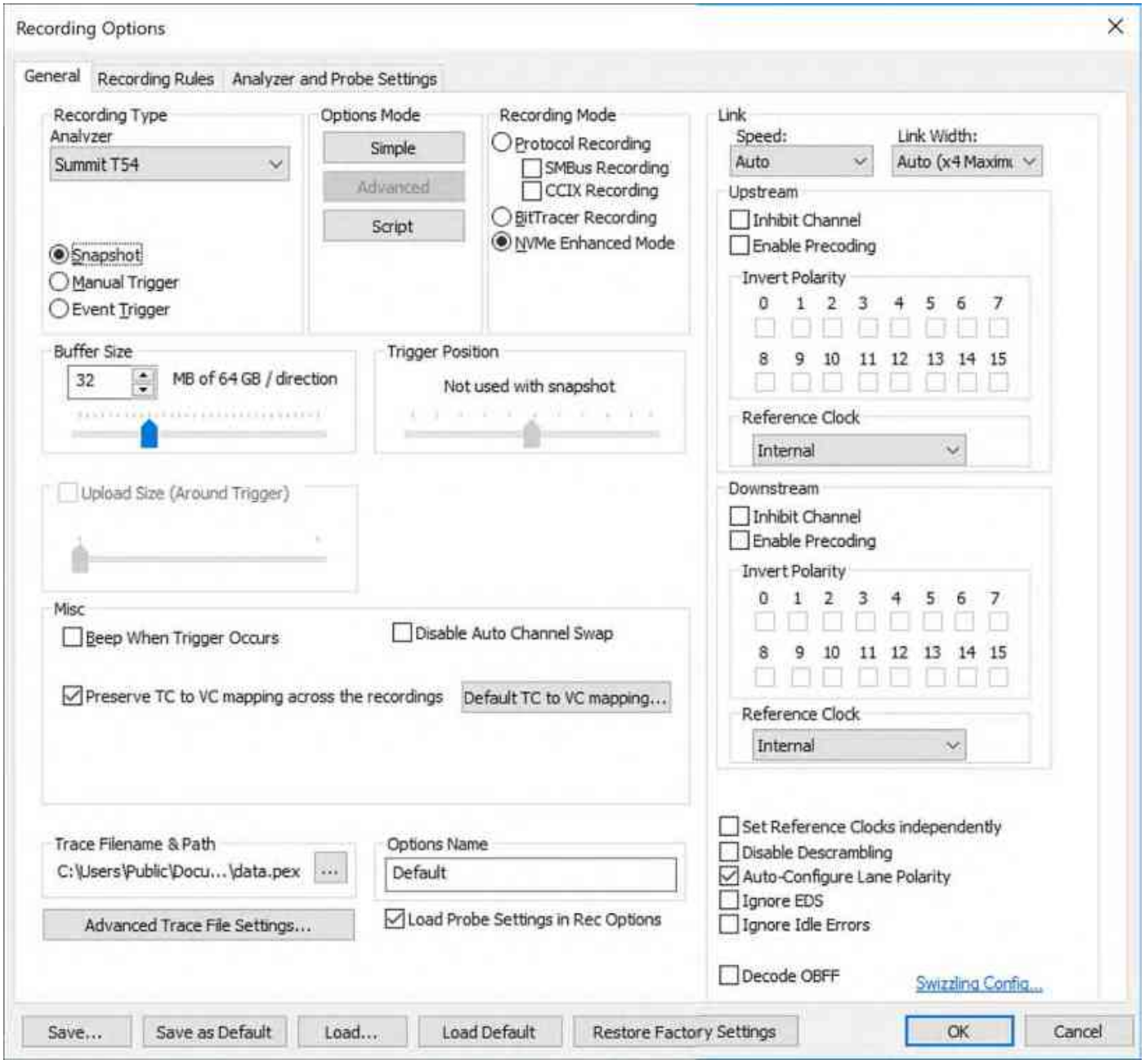


Figure 6.227: NVMe Enhanced Mode: Snapshot – Advanced Mode

Open the Recording Rules to see that an NVMe Enhanced Mode Event has been automatically added to the Recording Rules (see Figure 6.228 on page 366).

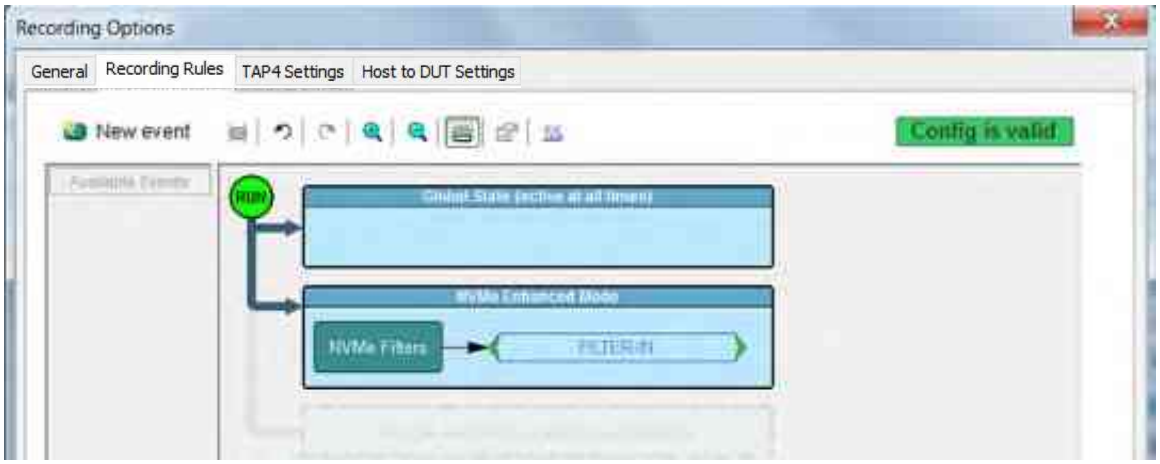


Figure 6.228: NVMe Enhanced Mode: NVMe Filters Event Added

Select the NVMe Filters box to bring up the following dialog. After selecting the options you want click on the "OK" button.

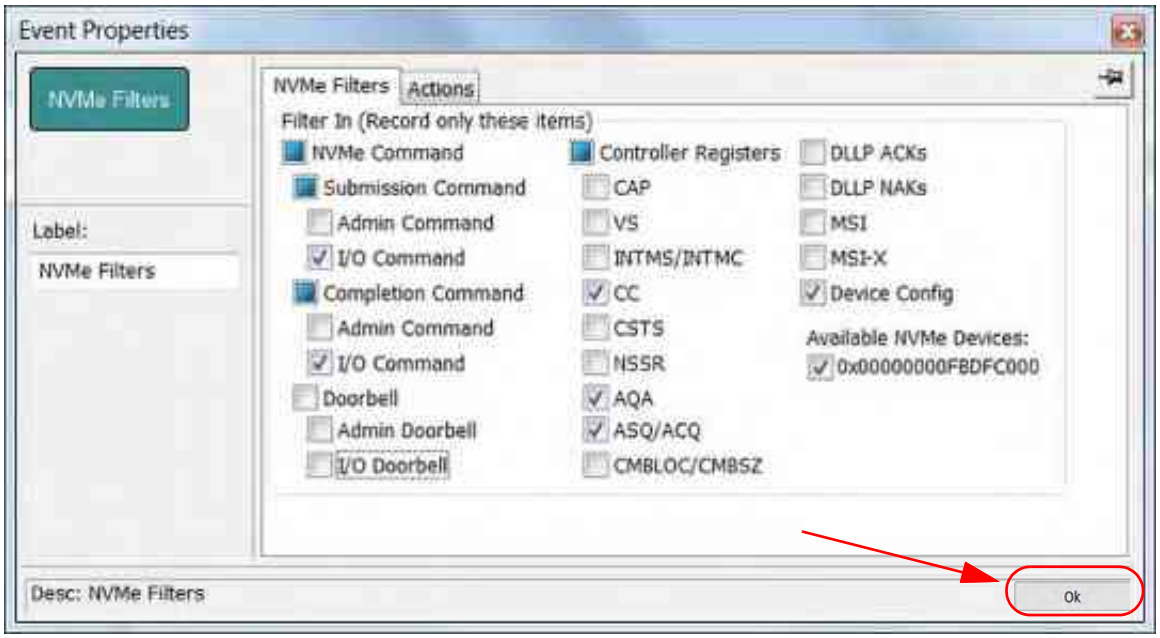


Figure 6.229: NVMe Enhanced Mode: NVMe Filters

Note: No Actions are available at this time.

6.23.3 Event Trigger – Advanced Mode

Changing to **Event Trigger -> Advanced Mode** will pop up the following dialog. See Figure 6.230.

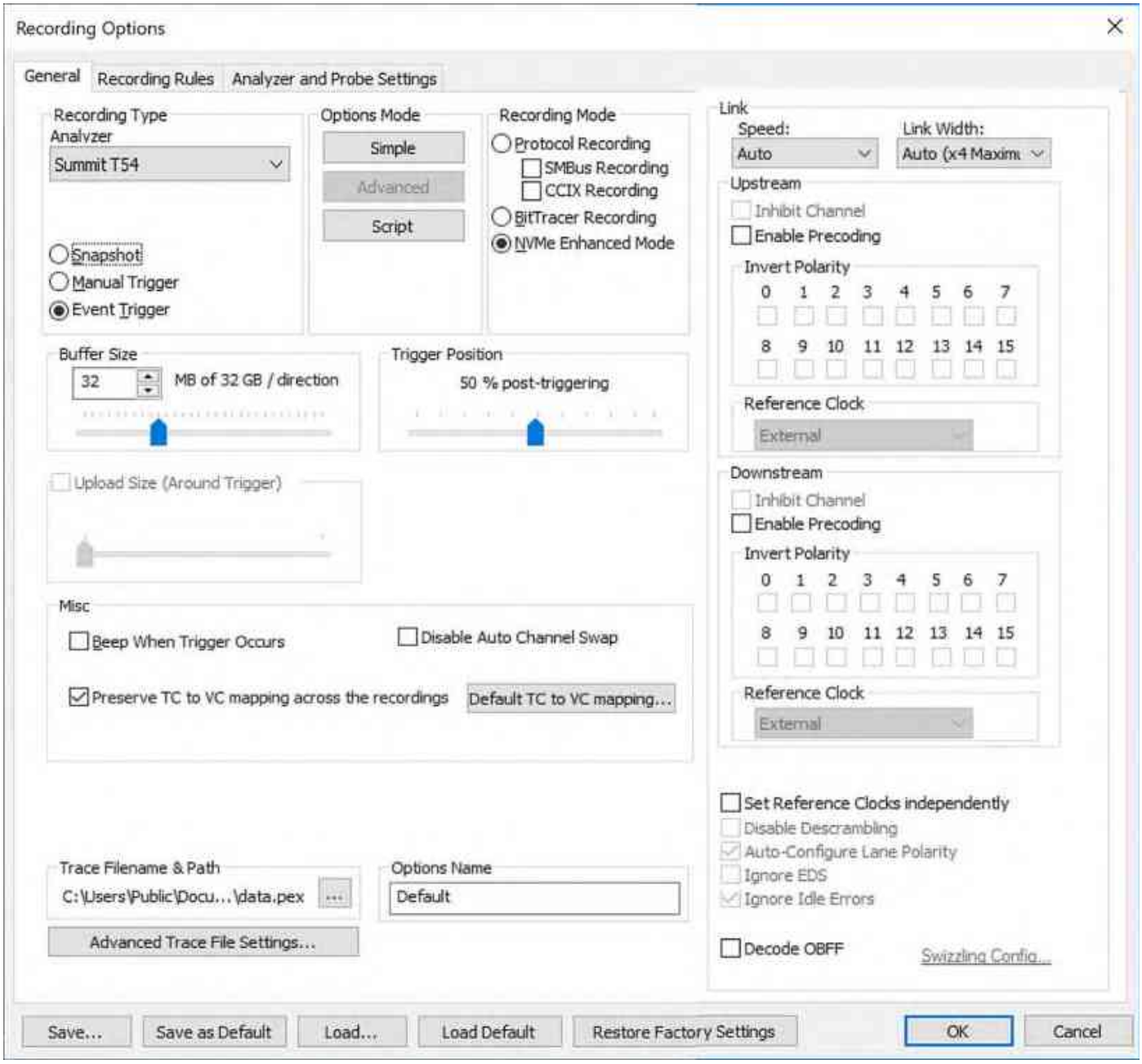


Figure 6.230: NVMe Enhanced Recording: Event Triggered → Advanced Mode

Selecting Recording Rules will pop up the same warning message if a boot trace and SSD Device Configuration File have not been generated (see Figure 6.224).

The next step is to continue defining your Recording Rules:

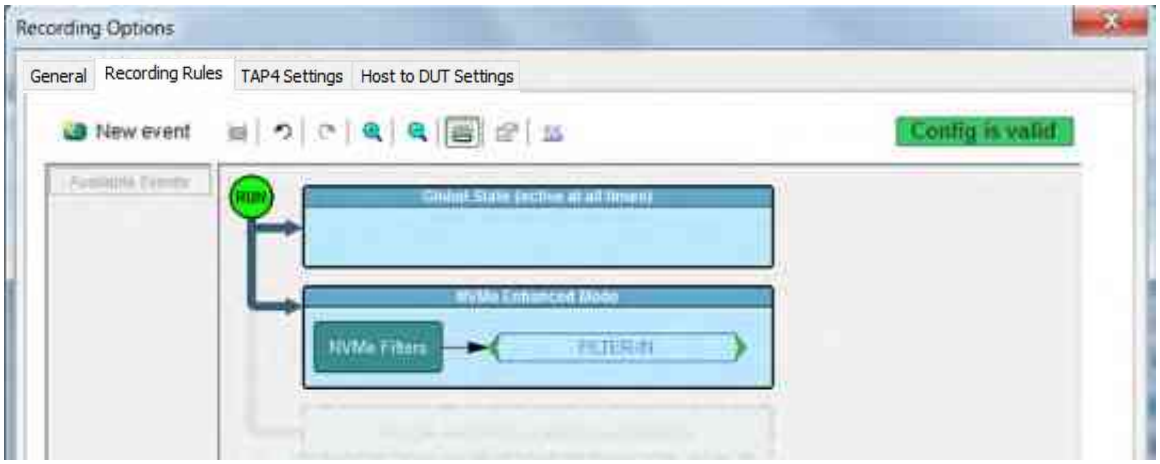


Figure 6.231: NVMe Enhanced Recording Mode: Defining Recording Rules

The NVMe Filters in Enhanced Mode are the same in both Snapshot - Advanced Mode and Triggered Event - Advanced Mode: See Figure 6.232. After selecting the options you want click on the "OK" button.

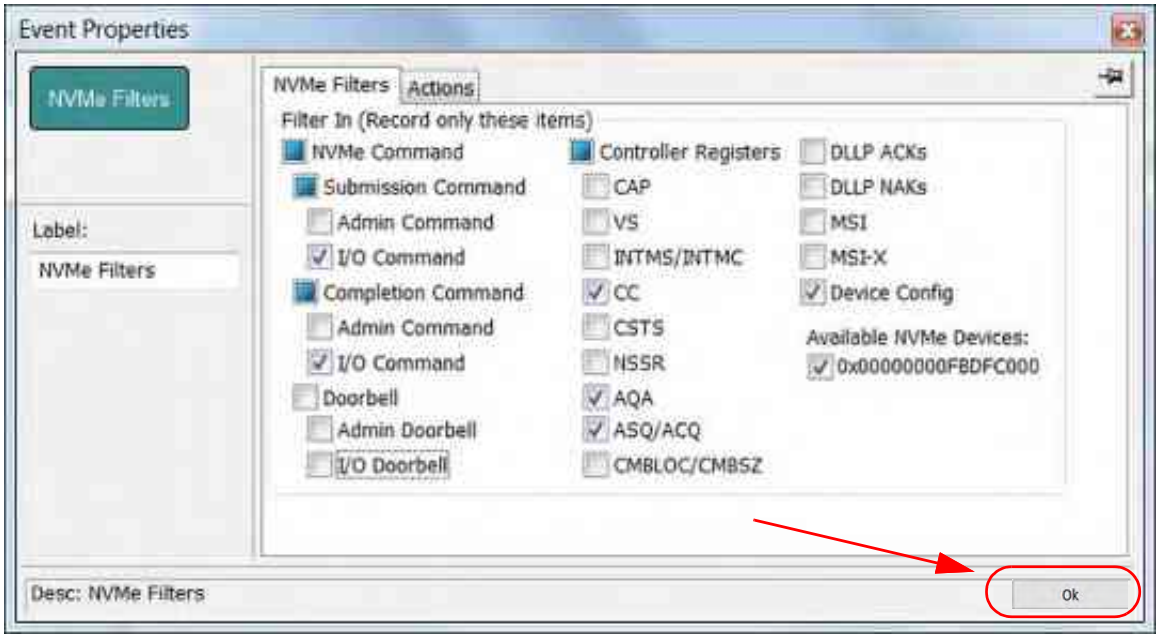


Figure 6.232: Triggered Event - Advanced Mode: Filter Options

Note: No Actions are available at this time.

Now that you have the NVMe Enhanced Mode/NVMe Filters in place, you can continue refining your triggering criteria and then start recording data.

Note: If you try and return to Event Trigger - Simple mode, the GUI automatically changes to Simple Mode - Snapshot, see Figure 6.233 on page 369.

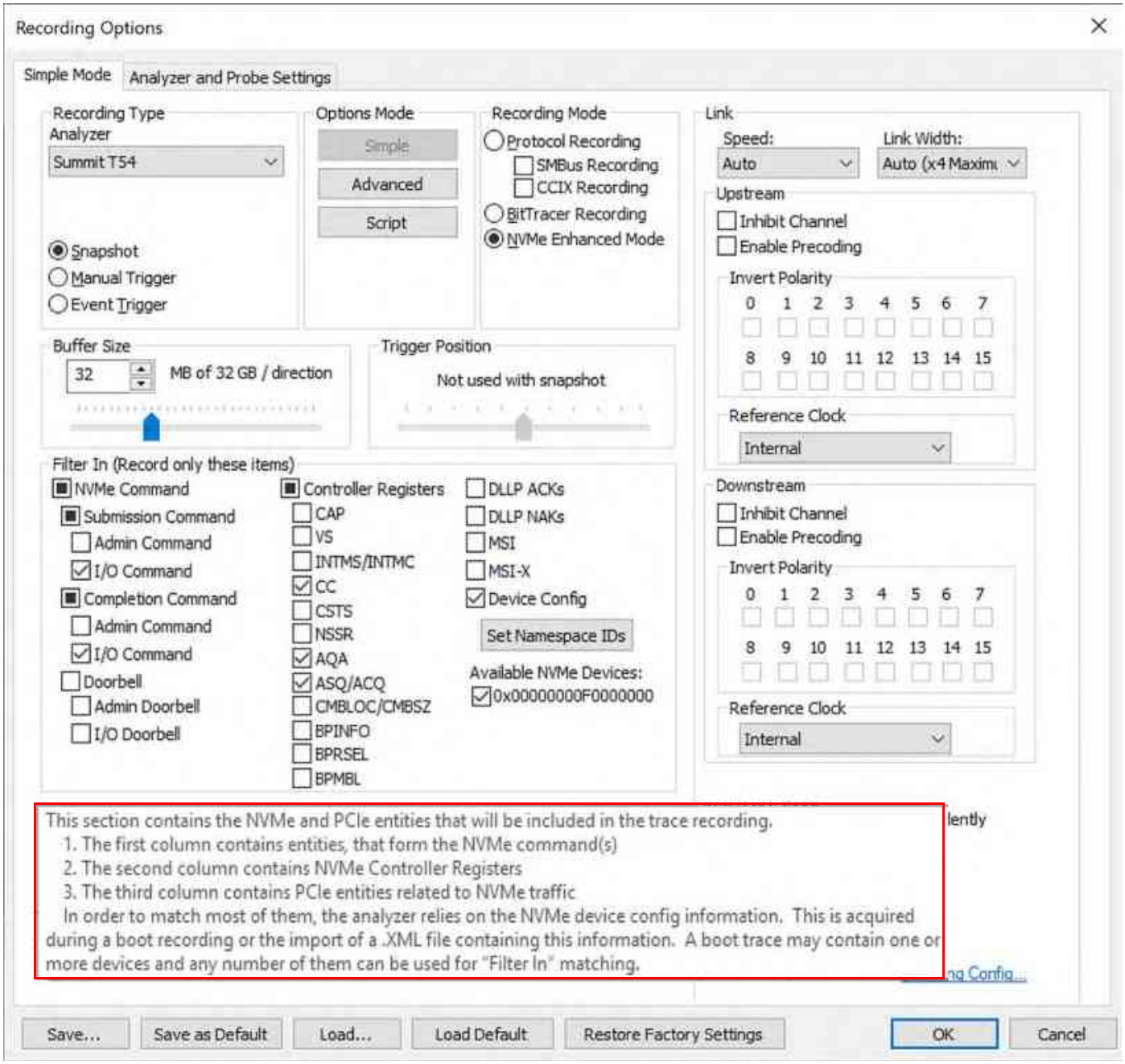


Figure 6.233: NVMe Enhanced Mode: Simple Mode - Snapshot

6.23.4 SSD Device Configuration File

As explained earlier in "Preparing to Record in NVMe Enhanced Mode" on page 360 an XML file is one way to enable the analyzer to run in NVMe Enhanced Mode. A typical XML file, which works in both Simple and Advanced Mode is shown below:

This XML file would be located in the C:\Users\Public\Documents\LeCroy\PCIe Protocol Suite\Temp directory.

```
<?xml version="1.0"?>
```

<DEVICES XML_FORMAT_VERSION="1.0"><DEVICE GUID="{1B105360-2808-4A07-AFE4-AF49F1D61CC6}"
ENABLE="0x1" DEVICEID="006:00:0" VENDORID="0" CLASSCODE="67586" DEVICENAME=""
TRANSACTION_LIFETIME_NS="0">

<BARS><MBAR ID="0" VALUE="0xFBDFC000"/><BAR ID="2" VALUE="0x00000000"/><BAR ID="3"
VALUE="0x00000000"/><BAR ID="4" VALUE="0x00000000"/><BAR ID="5" VALUE="0x00000000"/></BARS>

<PROTOCOL IOSQES="6" MQES="64" ASQS="127" PROTOCOL="NVME" ACQS="127" DSTRD="4" IOCQES="4"
LBASIZE="512" MPS="4096"/><Queues><Queue IR_VECTOR="0" ADDRESS="0x23F3BC000" SIZE="64" QID="0"
IR_ENABLED="0" TYPE="ASQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E641000" SIZE="1024" QID="8"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E76D000" SIZE="1024" QID="11"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E7D1000" SIZE="1024" QID="12"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F143000" SIZE="1024" QID="4"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E6A5000" SIZE="1024" QID="9"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E709000" SIZE="1024" QID="10"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F07B000" SIZE="1024" QID="2"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F1A7000" SIZE="1024" QID="5"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23EFCB000" SIZE="1024" QID="7"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F1CA000" SIZE="1024" QID="6"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F0DF000" SIZE="1024" QID="3"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F3DD000" SIZE="1024" QID="1"
IR_ENABLED="0" TYPE="IOSQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F3BE000" SIZE="16" QID="0"
IR_ENABLED="0" TYPE="ACQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E651000" SIZE="1024" QID="8"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E6B5000" SIZE="1024" QID="9"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F3ED000" SIZE="1024" QID="1"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E77D000" SIZE="1024" QID="11"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E7E1000" SIZE="1024" QID="12"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F153000" SIZE="1024" QID="4"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23E719000" SIZE="1024" QID="10"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F08B000" SIZE="1024" QID="2"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F1B7000" SIZE="1024" QID="5"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23EFDB000" SIZE="1024" QID="7"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F1DA000" SIZE="1024" QID="6"
IR_ENABLED="0" TYPE="IOCQ"/><Queue IR_VECTOR="0" ADDRESS="0x23F0EF000" SIZE="1024" QID="3"
IR_ENABLED="0" TYPE="IOCQ"/></Queues><Namespaces/><Interrupts/></DEVICE></DEVICES>

6.24 NVME Command Mode

6.25 NVME Command Mode

Note: NVME Command Mode is available only for the following Summit T5 modes:

- T516 Standard Mode
- T54 Standard Mode
- T54 (2 units)

NVME Command mode is a Recording Option and is similar to NVMe Enhanced mode. However, NVME Command Mode allows you to filter in specific NVMe commands and registers. It also supports some PCIe filtration, such as DLLPs and interrupts. NVME Command Mode supports commands according to NVMe 2.0 specification.

NVME Command Mode has options for Simple Mode and Advanced Mode.

6.25.1 NVME Command Mode - Simple verses Advanced Mode

When you select Simple mode while in NVME Command Mode then commands, warnings, and the **Set Namespace ID** button display in the General tab in Recording Options. See Figure 6.234.

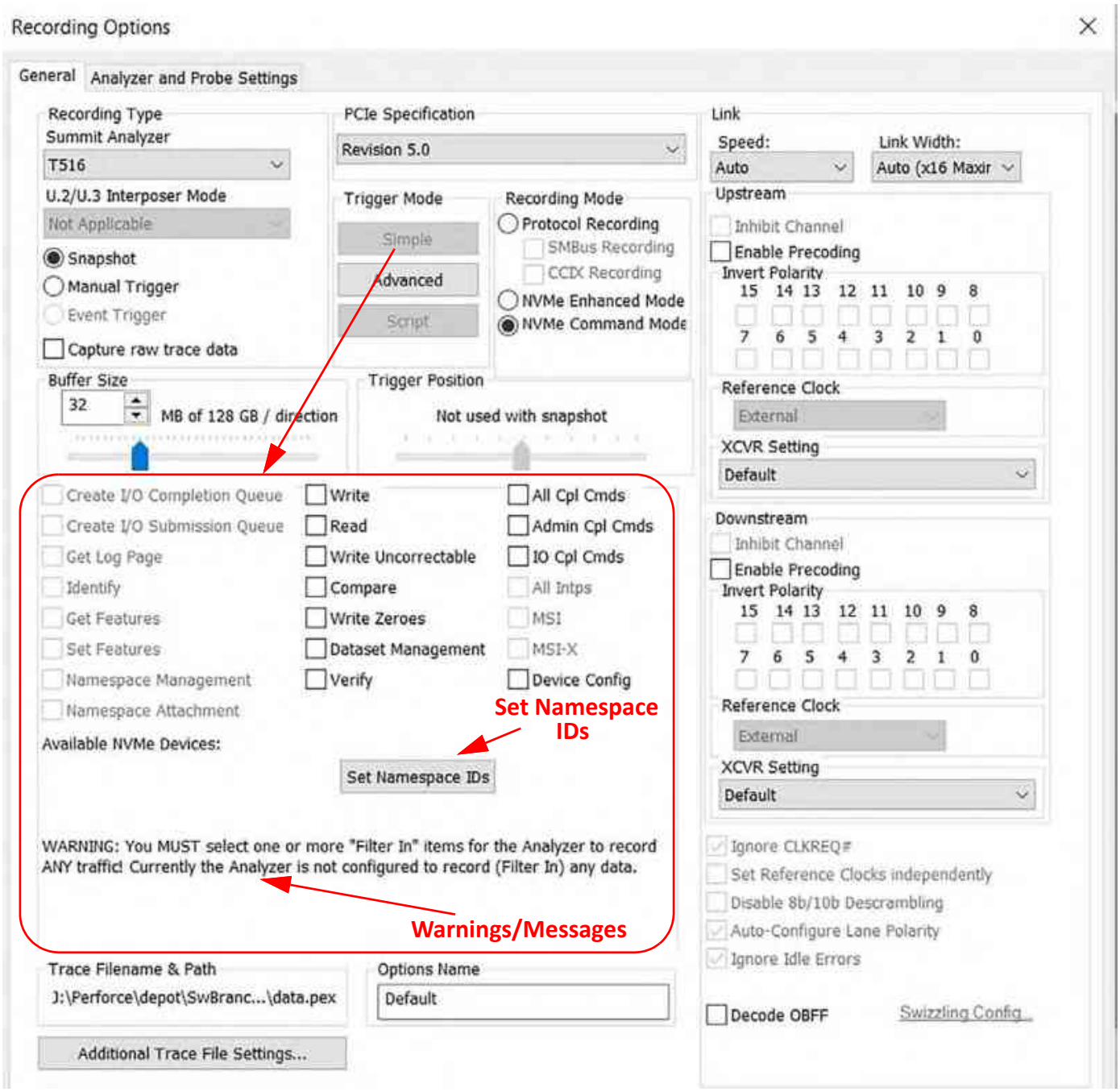


Figure 6.234: NVME Command Mode: Simple Mode

When selecting Advanced Mode in NVME Command Mode, the Recording Rules tab appears. Commands, warnings, and the **Set Namespace IDs** button are on the Recording Rules tab. See Figure 6.235 and Figure 6.236.

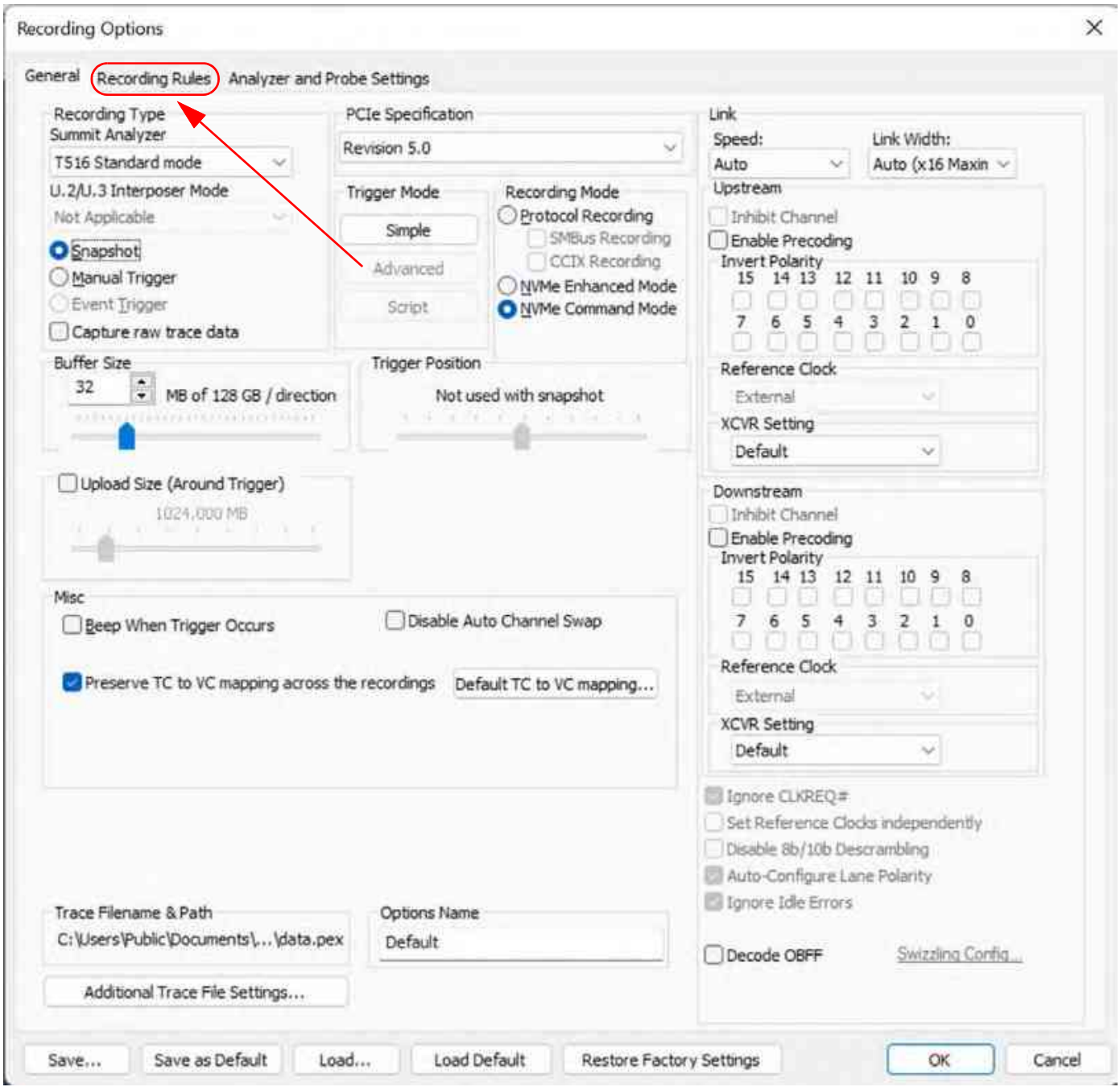


Figure 6.235: NVME Command Mode: Advanced Mode

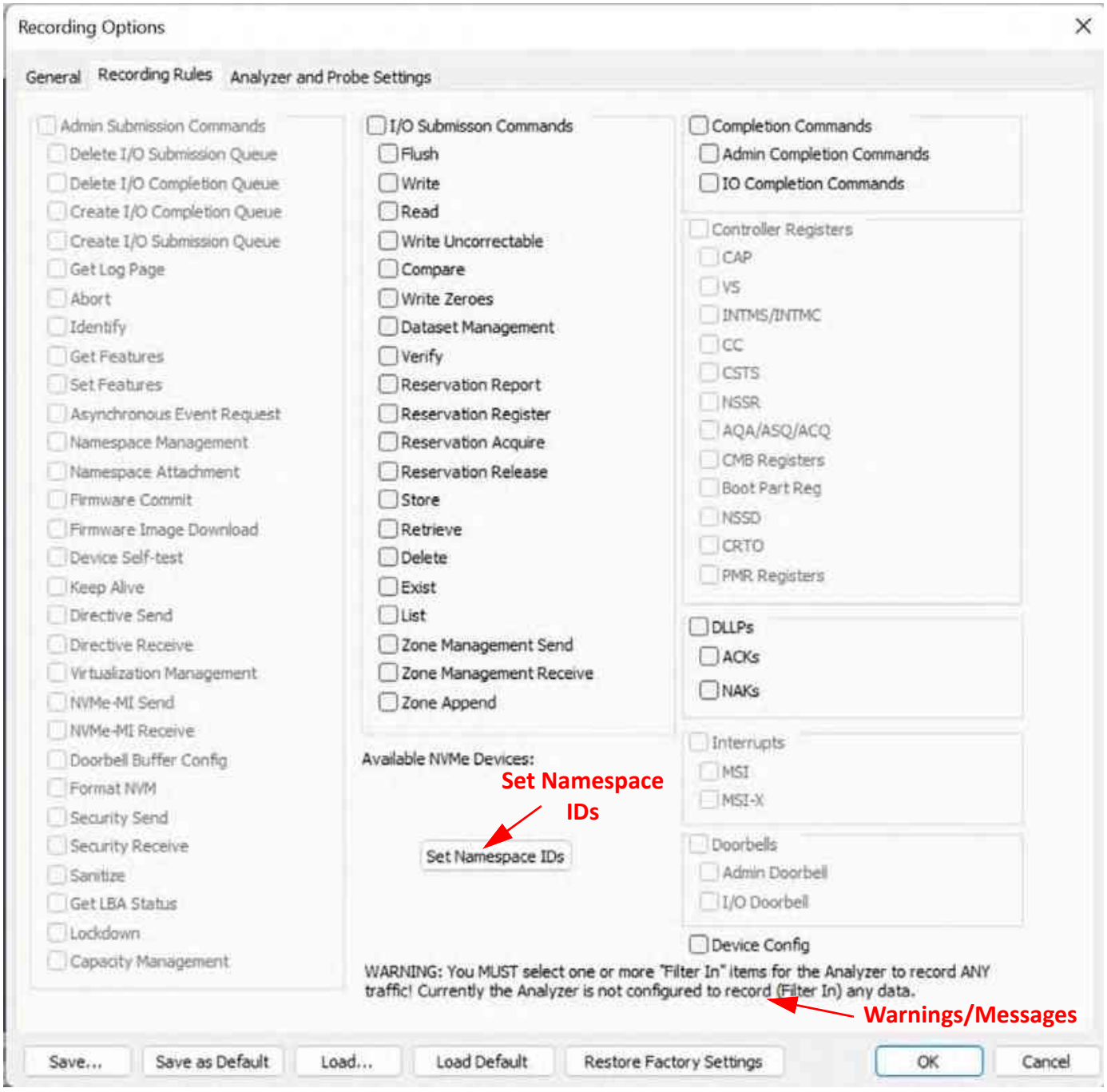


Figure 6.236: NMVE Command Mode: Advanced Mode Recording Rules

6.25.2 Set Namespace IDs

With NVME Command Mode, you can set namespace identifications using the **Set Namespace IDs** button. See Figure 6.237.



Figure 6.237: NVME Command Mode: Set Namespace IDs

6.25.3 NVME Command Mode Warnings

Warnings exist within NVME Command Mode to help you create the best recordings for your devices.

When you first click on NVME Command Mode and do not have a valid SSD Device Configuration, a warning displays. See Figure 6.238.

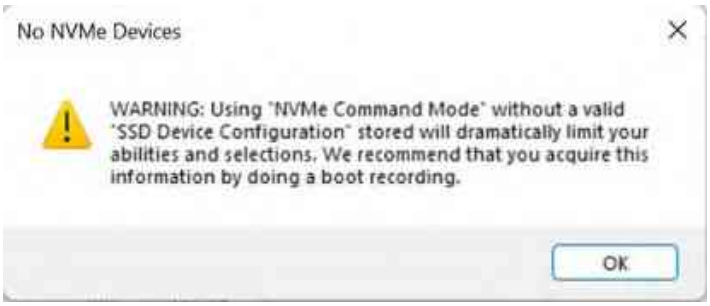


Figure 6.238: Warning: No valid SSD Device Configuration

If you do not select any NVME Command Space filters, then the following message displays:

Warning: You MUST select one or more "Filter In" items for the Analyzer to record ANY traffic! Currently the Analyzer is not configured to record (Filter In) any data.

If you select too many filters, then the following message displays:

Not enough bus engine resources to fit this item. Precision can decrease.

6.26 Recording Options for Compute Express Link (CXL) Mode

Compute Express Link™ (CXL™) is a high-speed CPU-to-Device and CPU-to-Memory interconnect designed to accelerate next-generation data center performance. CXL technology maintains memory coherency between the CPU memory space and memory on attached devices, which allows resource sharing for higher performance, reduced software stack complexity, and lower overall system cost. This permits users to simply focus on target workloads as opposed to the redundant memory management hardware in their accelerators.

CXL is designed to be an industry open standard interface for high-speed communications, as accelerators are increasingly used to complement CPUs in support of emerging applications such as Artificial Intelligence and Machine Learning.

The Summit T5 Analyzer is fully capable of recording and decoding CXL configurations.

To record in CXL mode, select the Summit T5 Analyzer (CXL) from the Recording Type option and Event Trigger. See Figure 6.239.

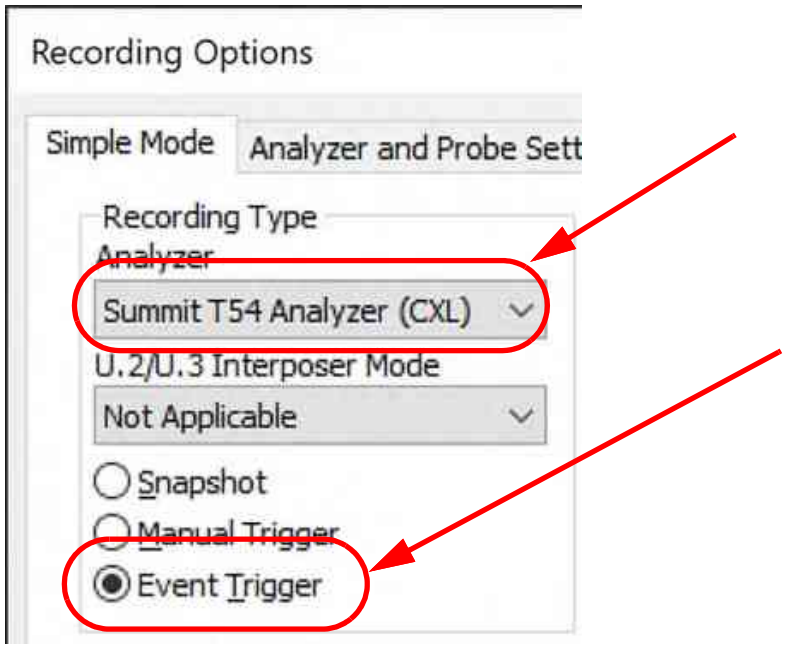


Figure 6.239: Recording Type: Summit T5 Analyzer (CXL) with Event Trigger selected

Selecting these options will bring up all the CXL options to select from. See Figure 6.240 on page 378.

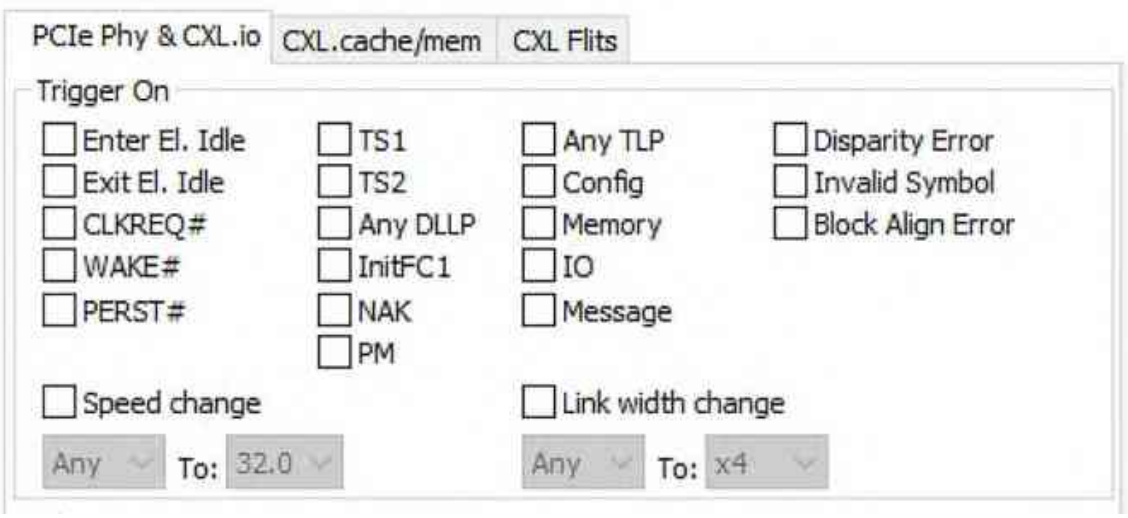


Figure 6.240: CXL Trigger Event Options

6.26.1 Triggering On (Simple Mode): PCIe Phy & CXL.io

You can check any of the boxes shown in Table 6.8 for Trigger On in Simple Mode (see Figure 6.240 on page 378).

TABLE 6.8: Simple Mode Trigger On Events (Upstream or Downstream)

Enter Elec Idle	Any TLP
Exit Idle	Config
CLKREQ#	Memory
WAKE#	IO
PERST#	Message
TS1	Disparity Error
TS2	Invalid Symbol
Any DLLP	Block Align Error
InitFC1	
NAK	
PM	
Speed Change: Any, 2.5, 5.0. 8.0, 16.0, 32.0 To: Any, 2.5, 5.0, 8.0, 16.0, 32.0	Link Width Change: Any, x1, x2 or x4 To: Any, x1, x2 or x4

Note:

Note: Trigger Position slider becomes enabled only when Recording Type is set to Manual Trigger or Event Trigger.

Note: If you check 2 or more boxes the triggering will occur based on an OR condition, not AND condition.

Note: External Input Trigger is not configurable, it will always cause the analyzer to trigger on a toggle when using manual trigger or triggering on any event.

6.26.2 Trigger On CXL.cache/mem

You can also trigger on CXL.cache/memory events as shown in Figure 6.241.

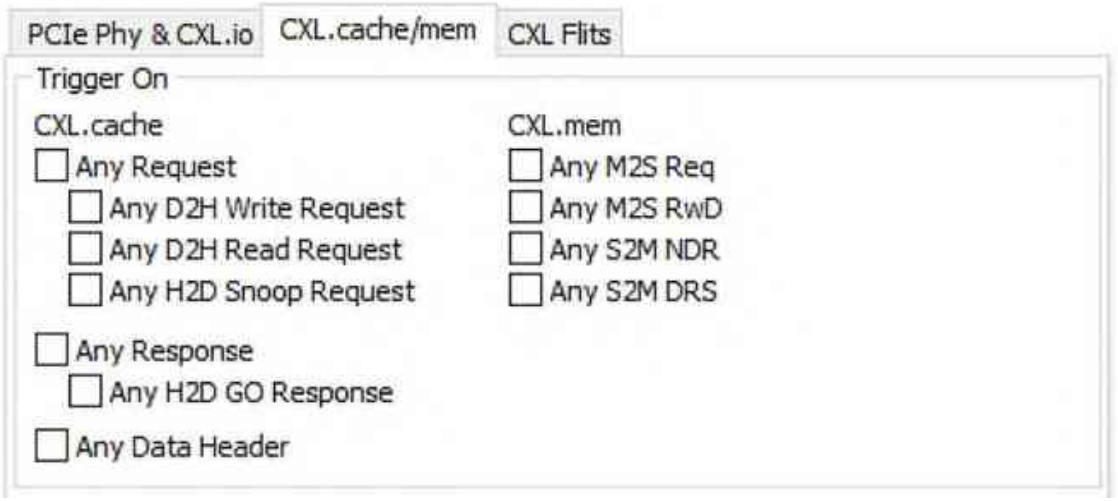


Figure 6.241: Trigger On CXL.cache/memory events

TABLE 6.9: Simple Mode Trigger On Events (CXL.cache/memory)

CXL.cache	CXL.memory
Any Request	Any M2S Req
Any D2H Write Request	Any M2S RwD
Any D2H read Request	Any S2M NDR
Any H2D Snoop Request	Any S2M DRS
Any Response	
Any H2D GO Response	
Any Data Header	

6.26.3 Trigger On CXL Flits

You can also trigger on CXL Flits. See Figure 6.242.

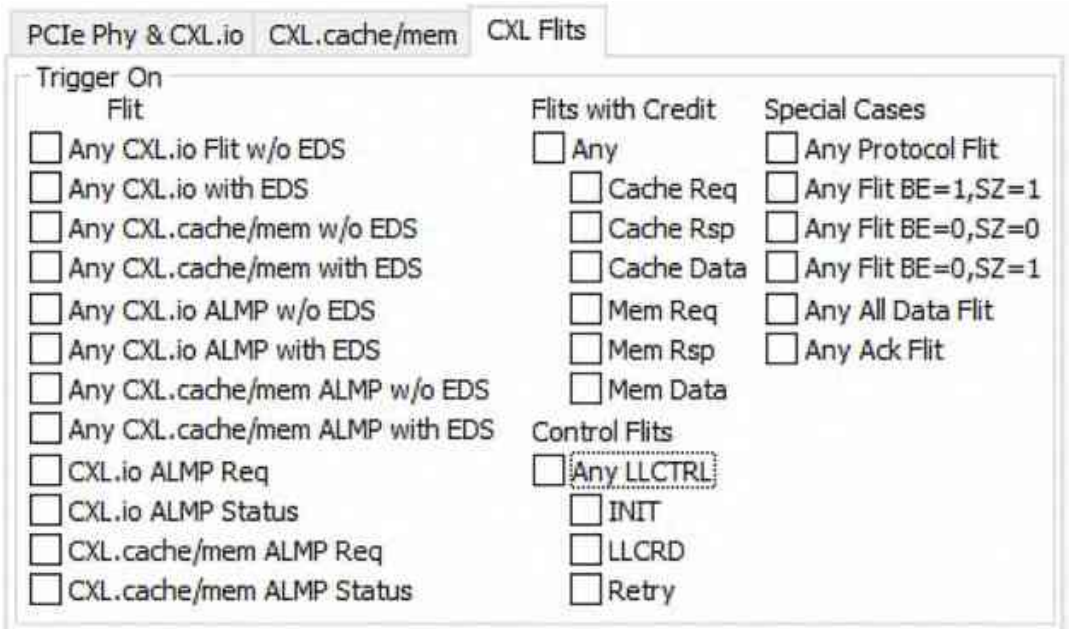


Figure 6.242: Trigger On CXL Flits

The options can also be seen in Table 6.10.

TABLE 6.10: Simple Mode Trigger On Events (CXL Flits)

Flits	Flits with credit	Special Cases
Any CXL.io Flit w/o EDS	Any	Any Protocol Flit
Any CXL.io with EDS	Cache Req	Any Flit BE = 1, SZ = 1
Any CXL.cache/mem w/o EDS	Cache Rsp	Any Flit BE = 0, SZ = 0
Any CXL.cache/mem with EDS	Cache Data	Any Flit BE = 0, SZ = 1
Any CXL.io ALMP w/o EDS	Mem Req	Any All Data Flit
Any CXL.io ALMP with EDS	Mem Rsp	Any Ack Flit
Any CXL.cache/mem ALMP w/o EDS	Mem Data	
Any CXL.cache/mem ALMP with EDS	Control Flits	
Any CXL.io ALMP Req	Any LLCTRL	
Any CXL.io ALMP Status	INIT	
Any CXL.cache/mem ALMP Req	LLCRD	
Any CXL.cache/mem ALMP Status	Retry	

6.26.4 CXL: Filter Out for PCIe Phy and CXL.io

For PCIe Phy and CXL.io mode you can also Filter Out traffic you may not want to see in the trace. See Figure 6.243.

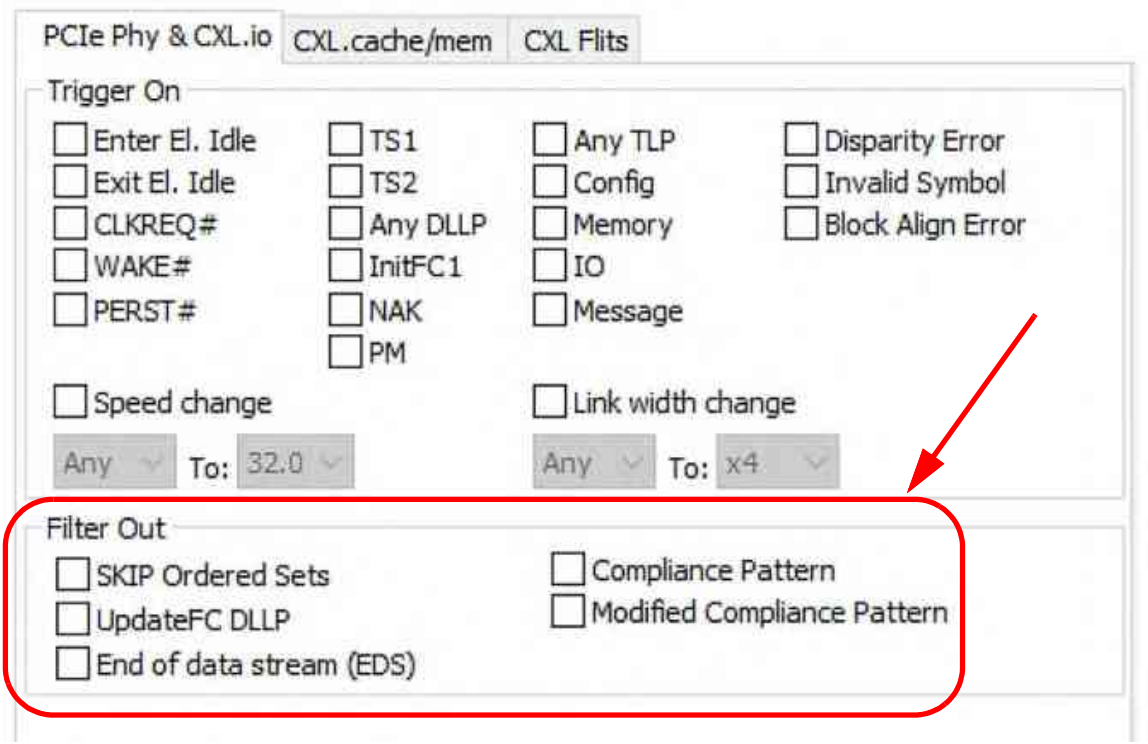


Figure 6.243: PCIe Phy and CXL.io Filter Out Options

These Filter Out options are also shown in Table 6.11.

TABLE 6.11: PCIe Phy and CXL.io Filter Out Options

SKIP Ordered Sets	Compliance Pattern
UpdateFC DLLP	Modified Compliance Pattern
End of data stream (EDS)	

6.26.5 CXL: Filter Out for CXL.cache/mem

For CXL.cache/mem mode, you can also Filter Out traffic.
(Invalid packets in slots is selected by default). See Figure 6.244.

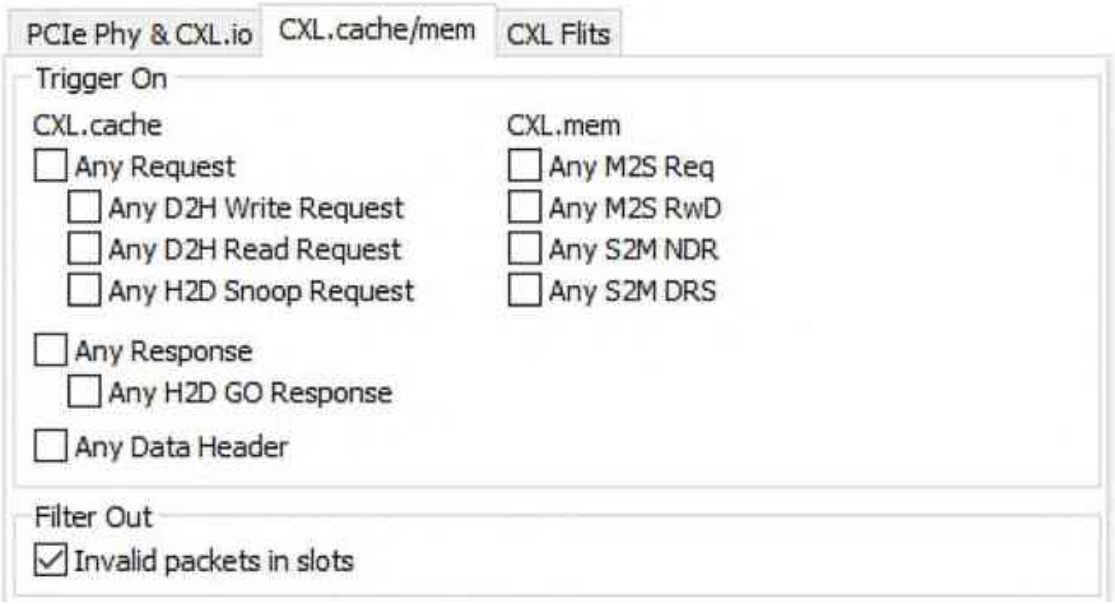


Figure 6.244: CXL.cache/mem Filter Out Options

6.26.6 CXL: Filter Out for CXL Flits

For CXL Flits mode, you can also Filter Out NULL Flit traffic. See Figure 6.245.

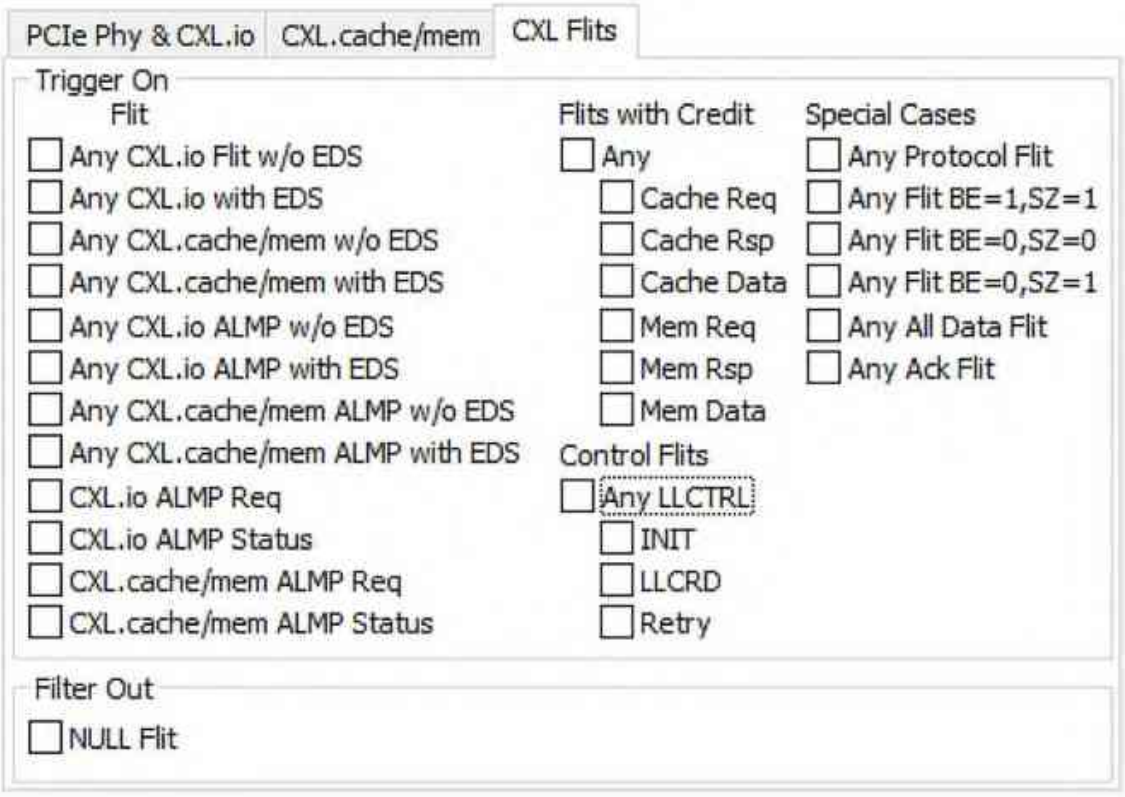


Figure 6.245: CXL Flits Filter Out Options

6.26.7 CXL: SMBus Recording

SMBus recording is available for T5 Analyzers in CXL mode. Check the "SMBus Recording" checkbox in the Recording Mode area, as shown in Figure 6.246.

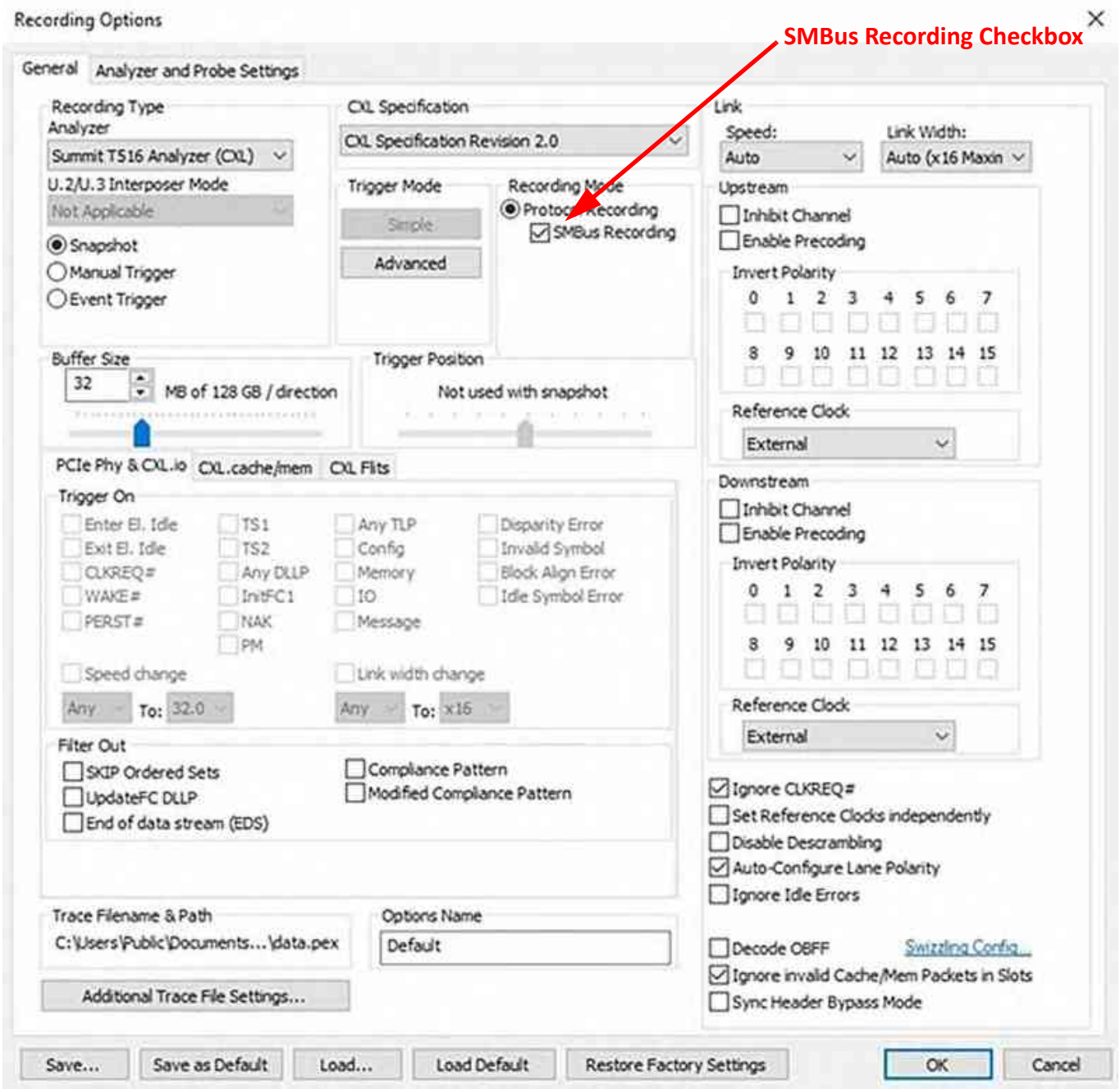


Figure 6.246: SMBus Recording Selection for CXL Mode

With SMBus selected, both Data traffic and SMBus traffic will be recorded for the following events:

- Any SMBus

- Any MCTP over SMBus

Figure 6.247 shows an example of the SMBus traffic.

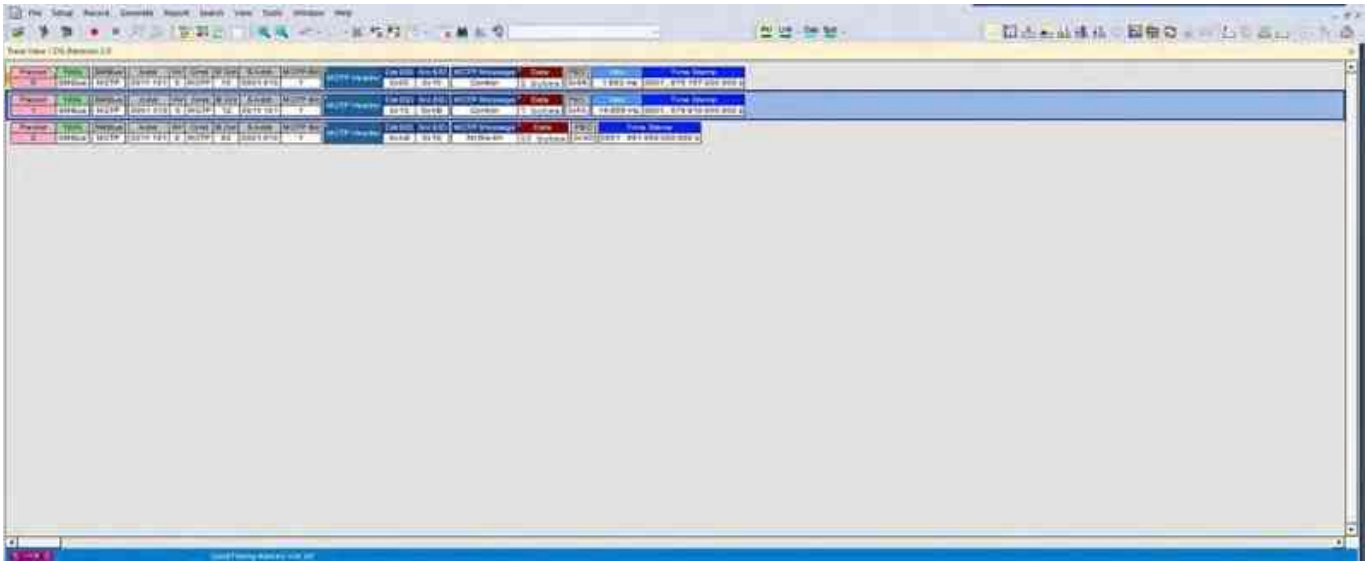


Figure 6.247: SMBus Traffic Example

Chapter 7

Reading CATC Traces

7.1 Viewing PCI Express CATC Traces

PCIe Protocol Analysis™ displays traffic as labeled, color-coded, and time-stamped rows.

Note: The time stamp resolution is 1 nano second and the accuracy is 16 nano seconds.

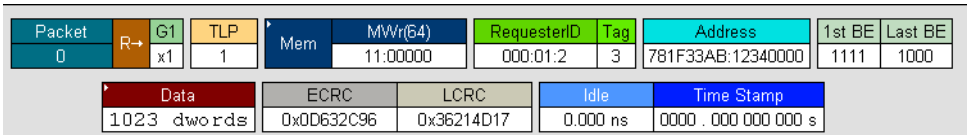


Figure 7.1: Typical CATC Trace

Tool tips provide details about fields within the CATC Trace. Hold the mouse cursor over a field to see a tool tip.

Additional information is available from pop-up menus. For example, if you click the left mouse button on the first cell in a packet a menu appears with an option to view Raw 10b Codes.

7.2 Expand and Collapse Data Fields

Packet data fields are displayed in a short format by default.

You can view a data field's long format by performing one of the following three actions:

- Click the **small triangle** in the left corner.
- Double-click anywhere in the data field.
- Click once in the Data Field with the left mouse button, then choose **Expand Data** from the pop-up menu.

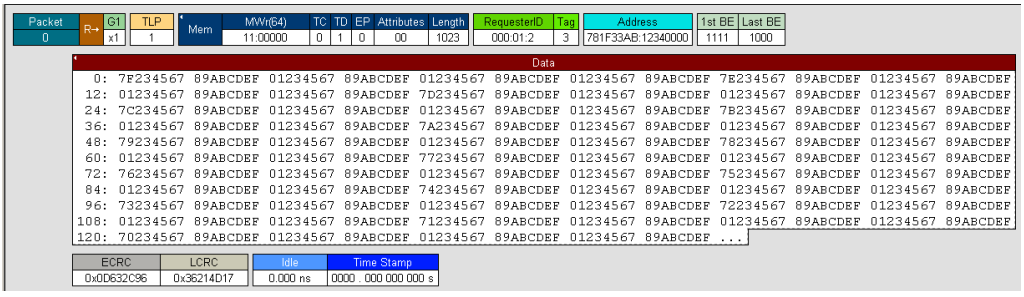


Figure 7.2: CATC Trace: Expanded Data View

A repeat of any above methods causes the display to return to a Short Data format.

7.3 Resizing Cells

Data cells can be resized by pointing the mouse pointer on the edge of a data cell, depressing and holding the left mouse button, and then repositioning the mouse pointer while keeping the mouse button depressed.

7.4 Pop-up Menus

The Analyzer software makes extensive use of pop-up menus. In some instances, pop-up menus provide the only means of accessing dialogs that contain detailed information about cells within the CATC Trace, for example, the Show Configuration Space dialog.

To see a pop-up menu, left-click or right-click a **cell** within the CATC Trace. Right-click or left-click behavior depends on the Display Options setting. For default left-click, the right-click menu is not cell-dependent. For other left-click behavior, the type of menu that opens varies depending on the type of cell that is selected. Take some time to explore CATC Traces and the various pop-up menus.

7.5 View Data Block

To view the raw bits that make up the data in a data field, left-click a data field, then click  or select **View Data Block** from the pop-up menu to display the Data Block window

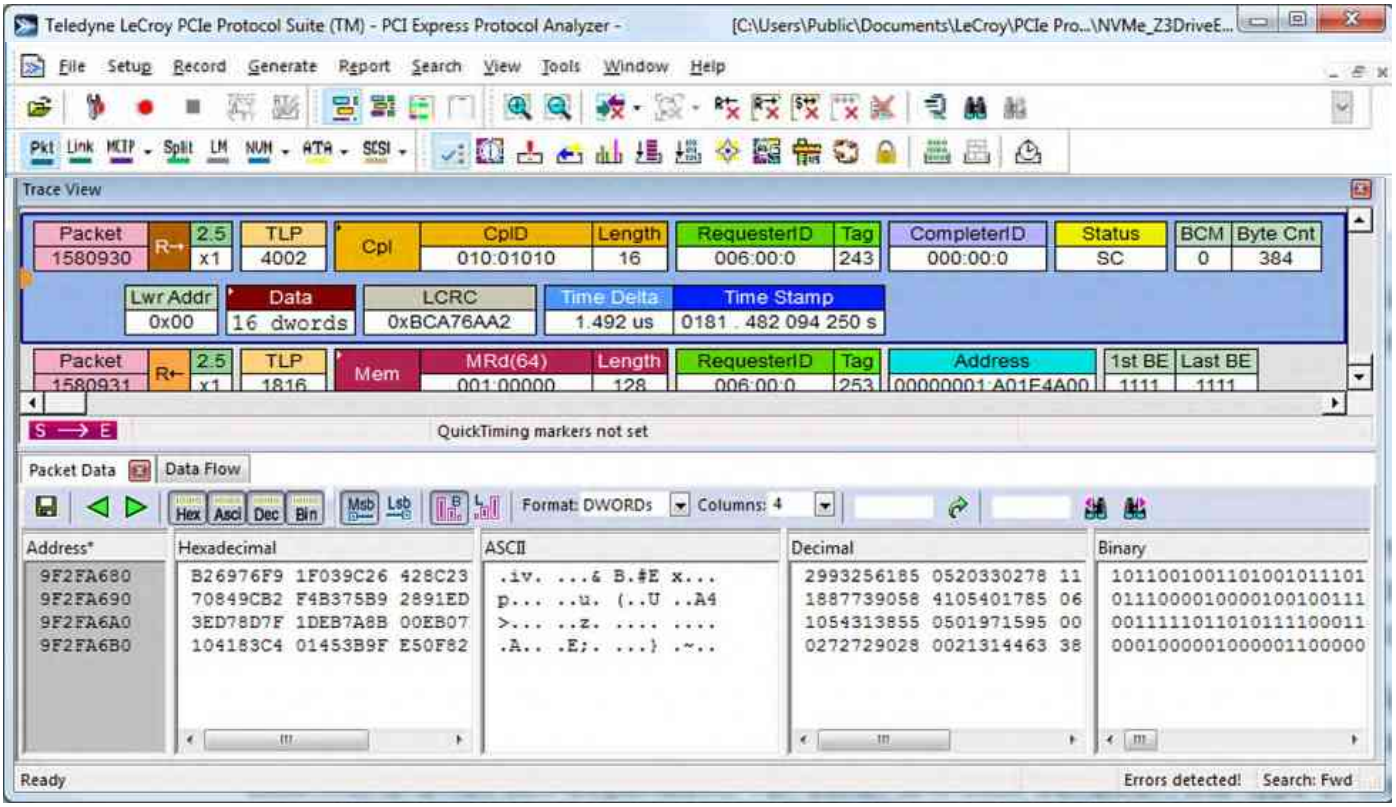


Figure 7.3: Viewing a Data Block

You can display data in Hexadecimal, ASCII, Decimal, or Binary formats.

Bit Order is Most Significant Bit or Least Significant Bit.

You can display data in Big Endian or Little Endian.

Format lets you display data as BYTEs, WORDs, or DWORDs.

Columns lets you select the number of columns.

You can enter hexadecimal offset values.

You can go to or search Previous or Next.

7.5.1 Save Data Block

You can also **Save** the data in Hexadecimal, ASCII, Decimal, or Binary formats. See Figure 7.4.

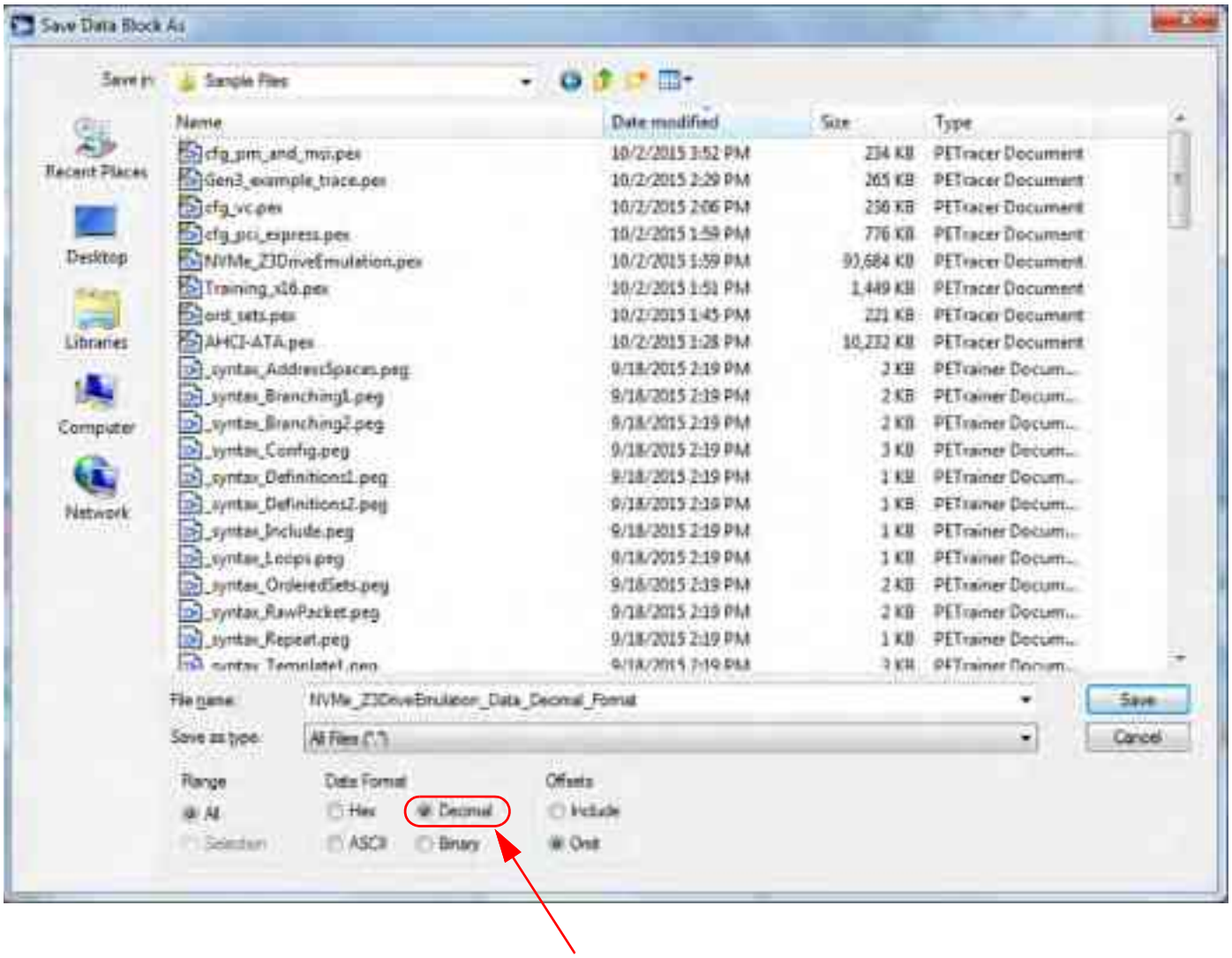


Figure 7.4: Save Data Block In Hex, Decimal, ASCII or Binary

The Saved file is shown in Figure 7.5 on page 396.

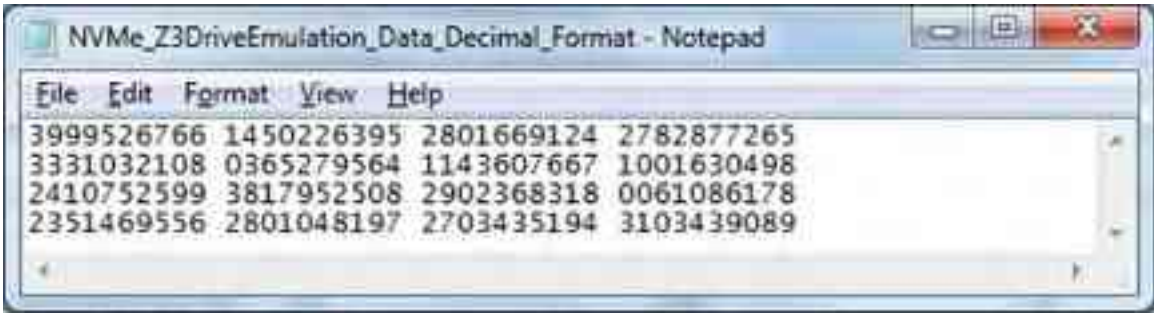


Figure 7.5: Saved Data File in Decimal Format

7.6 Show Raw 10b Codes

You can view the raw bits that make up the data field by right-clicking the field and selecting **View Data Block** from the pop-up menu.

To view Raw 10b Codes:

1. Right-click the **first cell** in a packet.
2. Select **Show Raw 10b Codes** from the pop-up menu to display the Raw 10b Codes window.

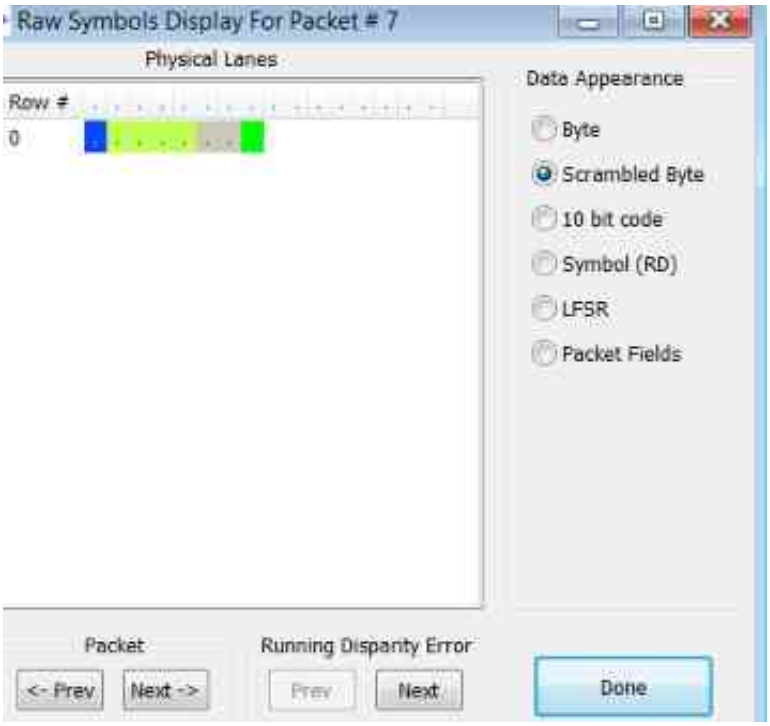


Figure 7.6: Show Raw 10b Codes Dialog

3. To change the format of the data, use the options along the right side of the dialog.
4. To navigate the CATC Trace, use the **Prev** and **Next** buttons.

7.7 Show Header Fields

You can view details about header fields by opening the Show Header Fields dialog.

1. Click a **header.** A pop-up menu displays (see the following figure).

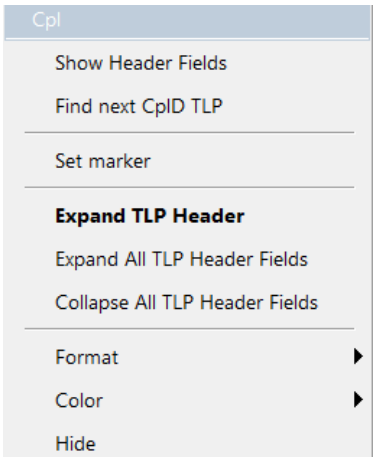


Figure 7.7: CATC Trace View: Header Popup Menu

2. Select **Show Header Fields**. The following dialog opens.

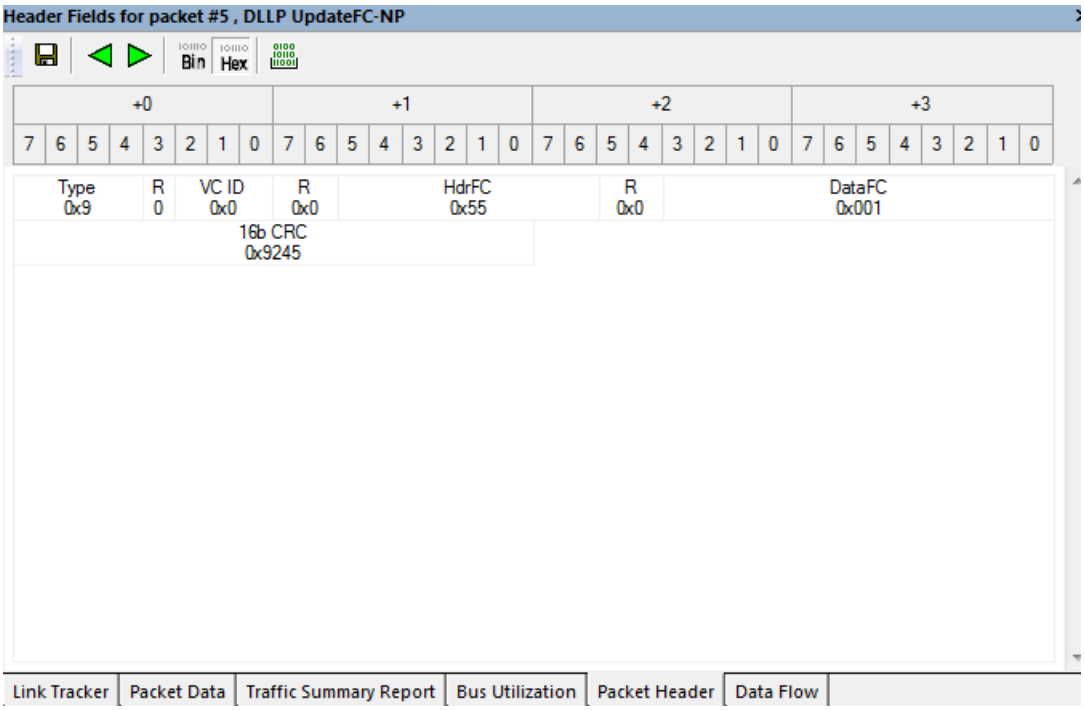


Figure 7.8: Viewing Packet Fields

3. Use the **Prev** and **Next** buttons to navigate to other headers.

7.8 Packet Cell Popup Menus

The Packet cell has a right-click pop-up menu that includes the following topics. See Figure 7.9.

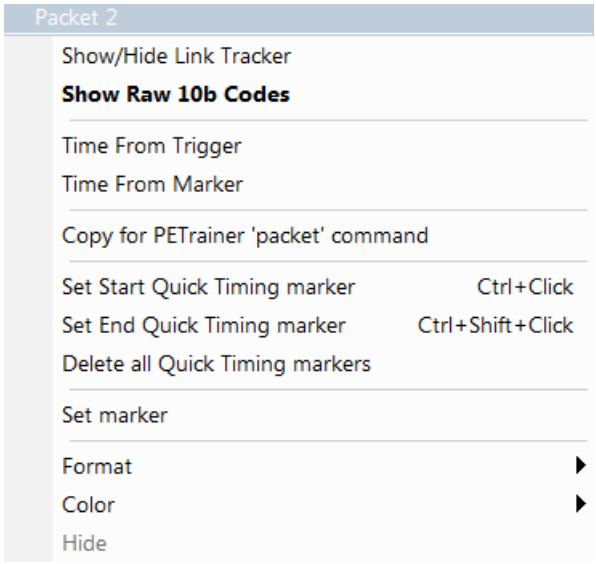


Figure 7.9: Packet Cell Popup Menu

Each topic can be selected and generate more information about the topic. The following sections describe each of the topics in the menu.

7.8.1 Show/Hide Link Tracker

Click on the “Show/Hide Link Tracker” and the Link Tracker View will show up in the Main Display window. See Figure 7.10.

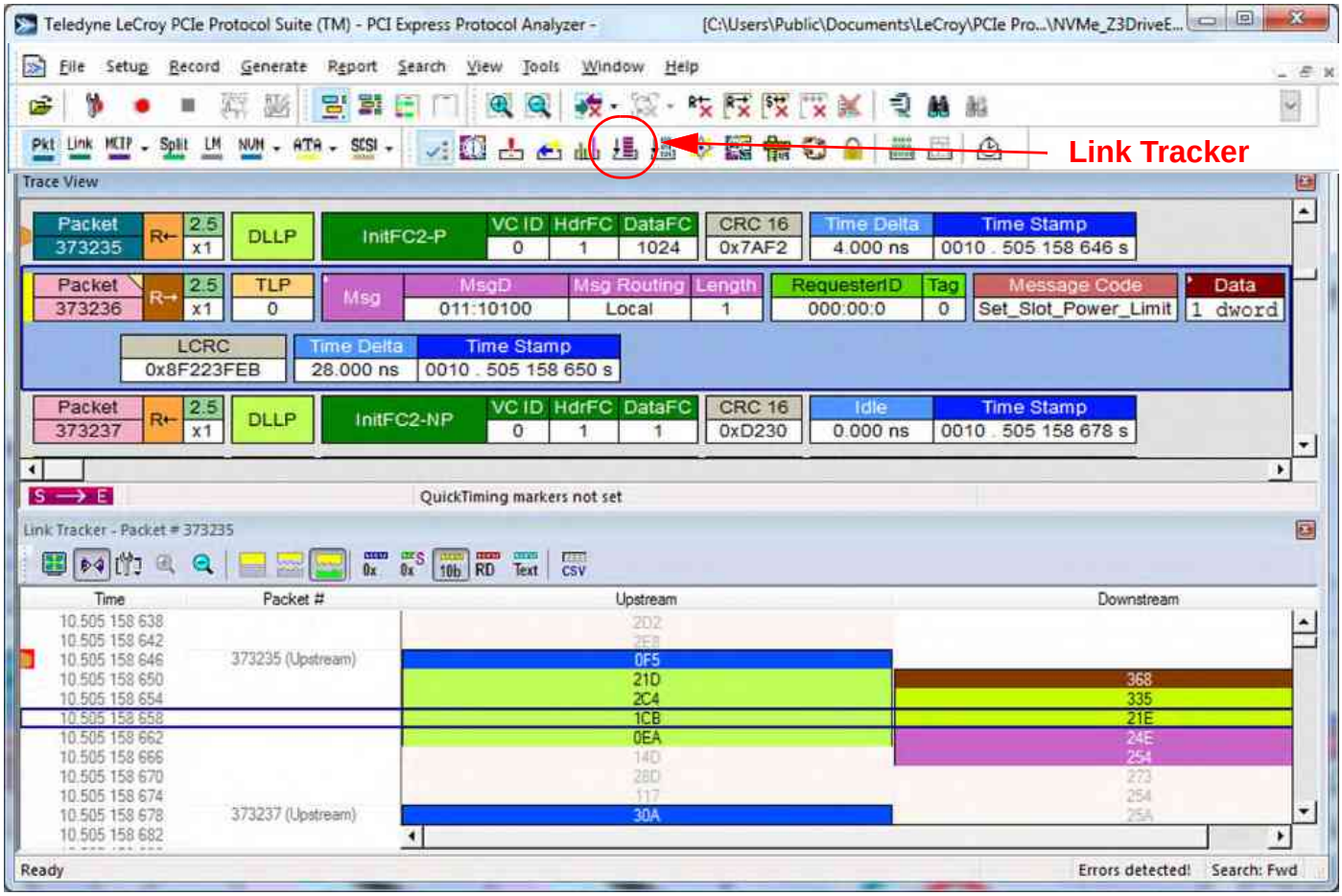


Figure 7.10: Packet Cell Popup Menus: Trace View and Link Tracker View

Link Tracker is discussed in more detail in “Link Tracker” on page 681.

7.8.2 Show Raw 10b Codes

Click on Show Raw 10b Codes and the Raw Symbols Display for the selected Packet pops up. See Figure 7.11.

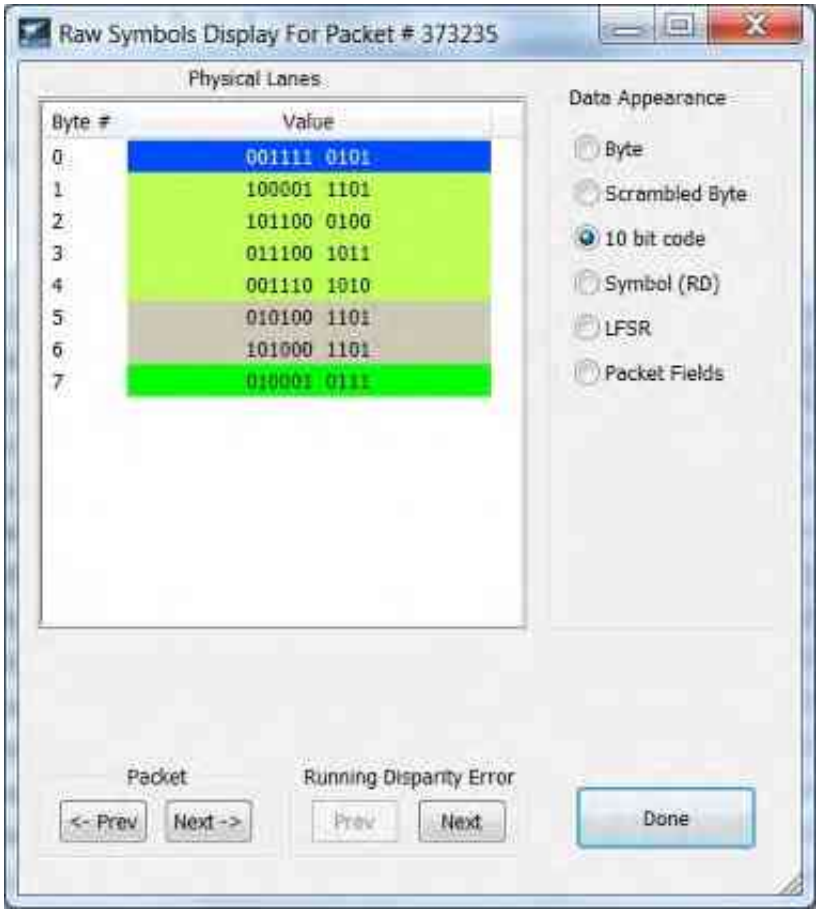


Figure 7.11: Packet Cell Popup Menus: Show Raw 10b Codes

Raw 10b Codes is discussed in more detail in “Show Raw 10b Codes” on page 396.

7.8.3 Time From Trigger

Select Time From Trigger and the Timing Calculator pops up. See Figure 7.12.

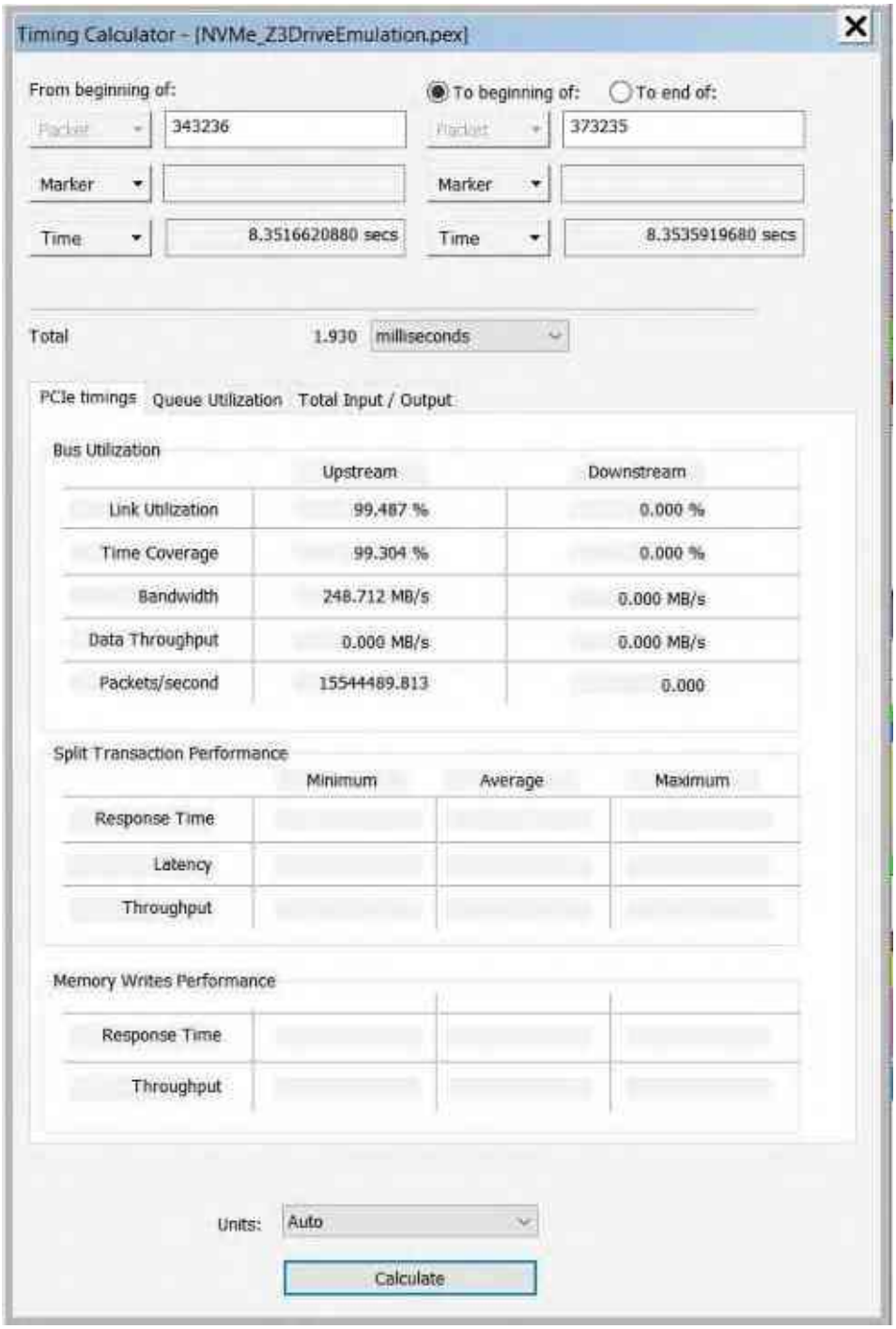


Figure 7.12: Packet Cell Popup Menus: Timing Calculator

The Timing Calculator is discussed in more detail in "Timing Calculator" on page 725.

7.8.4 Time From Marker

Click on Time From Marker and the following menu pops up along with the Timing Calculator. See Figure 7.13.

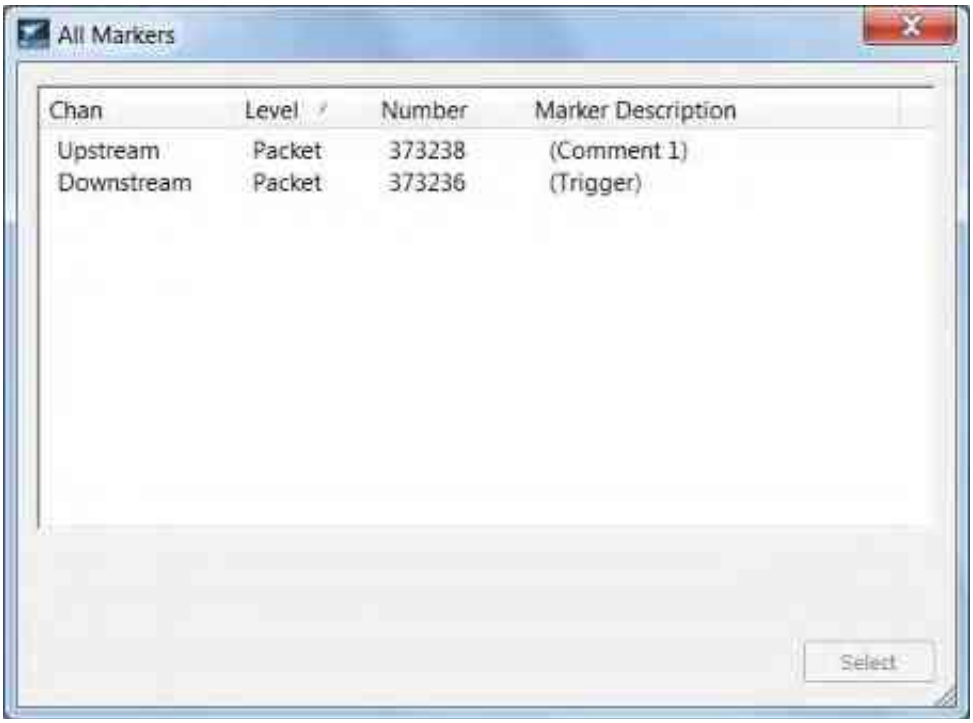


Figure 7.13: Packet Cell Popup Menus

Markers are discussed in more detail in “Set Marker” on page 406 and the Timing Calculator is discussed in more detail in “Timing Calculator” on page 725.

7.8.5 Copy for PETrainer ‘packet’ command

Select a packet, right click to bring up the Packet Cell Popup Menu, select the Copy for PETrainer ‘packet’ command and the tool will copy the Packet information which can then be copied into a PETrainer script for use with Teledyne LeCroy exercisers (Z3-16 etc.).

An example is shown below of a typical Packet and the PETrainer commands generated:

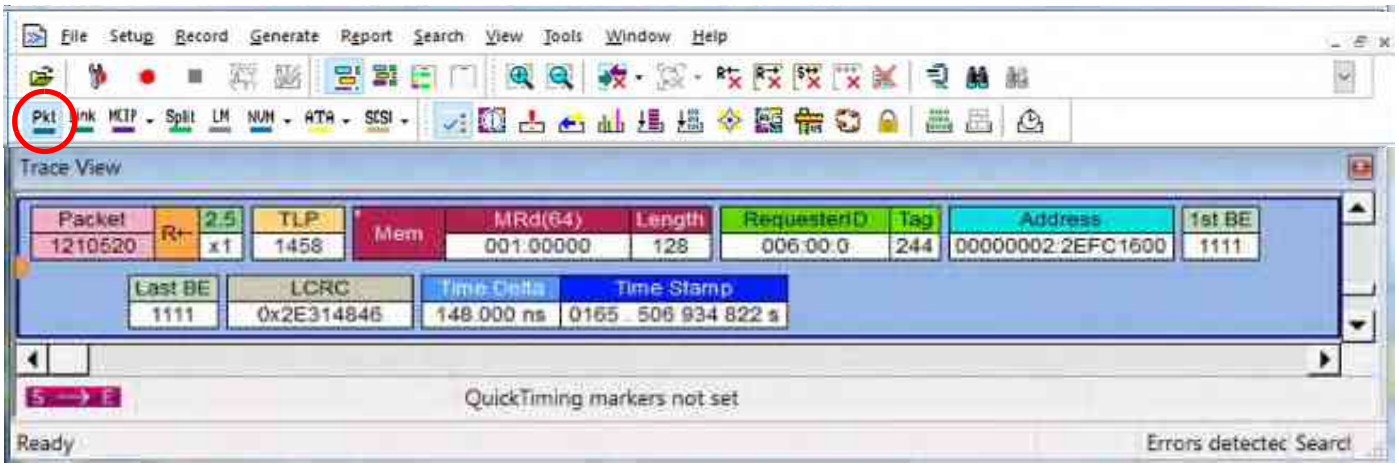


Figure 7.14: Packet Cell Popup Menus: Copy for PETrainer ‘packet’ Command

The script produced looks like this and can be copied into an existing trainer script:

```
packet = TLP {
    PSN = 0x5B2
    TLPType = MRd64
    TC = 0x0
    TD = 0x0
    TH = 0x0
    EP = 0x0
    IDBasedOrdering = 0x0
    Ordering = 0x0
    Snoop = 0x0
    AT = 0x0
    Length = 0x80
    RequesterId = (6:0:0)
    Tag = 0xF4
    LastDwBe = 0xF
    FirstDwBe = 0xF
    AddressHi = 0x2
    AddressLo = 0x2EFC1600
}
```

7.8.6 Set Start Quick Timing Marker

Sets the start packet for the Quick Timing marker. An S symbol is displayed at the packet.

Quick Timing provides immediate time deltas and bandwidth calculations. If the Start is placed on a packet that contains an Address and Endpoint, the bandwidth for that combination is displayed in the Status Bar below the trace data.

Quick Timing Markers are special ""Start"" and ""End"" markers used to mark the boundaries of the calculations. The results are shown in a special Quick Timing Bar at the bottom of the TraceView. The markers are set from a context sensitive menu.



Figure 7.15: Packet Cell Popup Menus: Set Start Quick Timer Marker

7.8.7 Set End Quick Timing Marker

Sets the end packet for the Quick Timing marker. An E symbol is displayed at the packet.

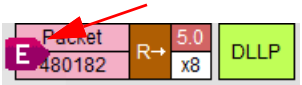


Figure 7.16: Packet Cell Popup Menus: Set End Quick Timer Marker

7.8.8 Tag Pop Up Menu

You can get a "Tag" pop up menu if you scroll over a RequesterID and it's associated Tag block as shown below (see Figure 7.17). The Summit T5 can decode the following tags:

- Use 5/8/10 bit tag (no phantom functions)
- Use 9 bit phantom function tag
- Use 10 bit phantom function tag
- Use 11 bit phantom function tag

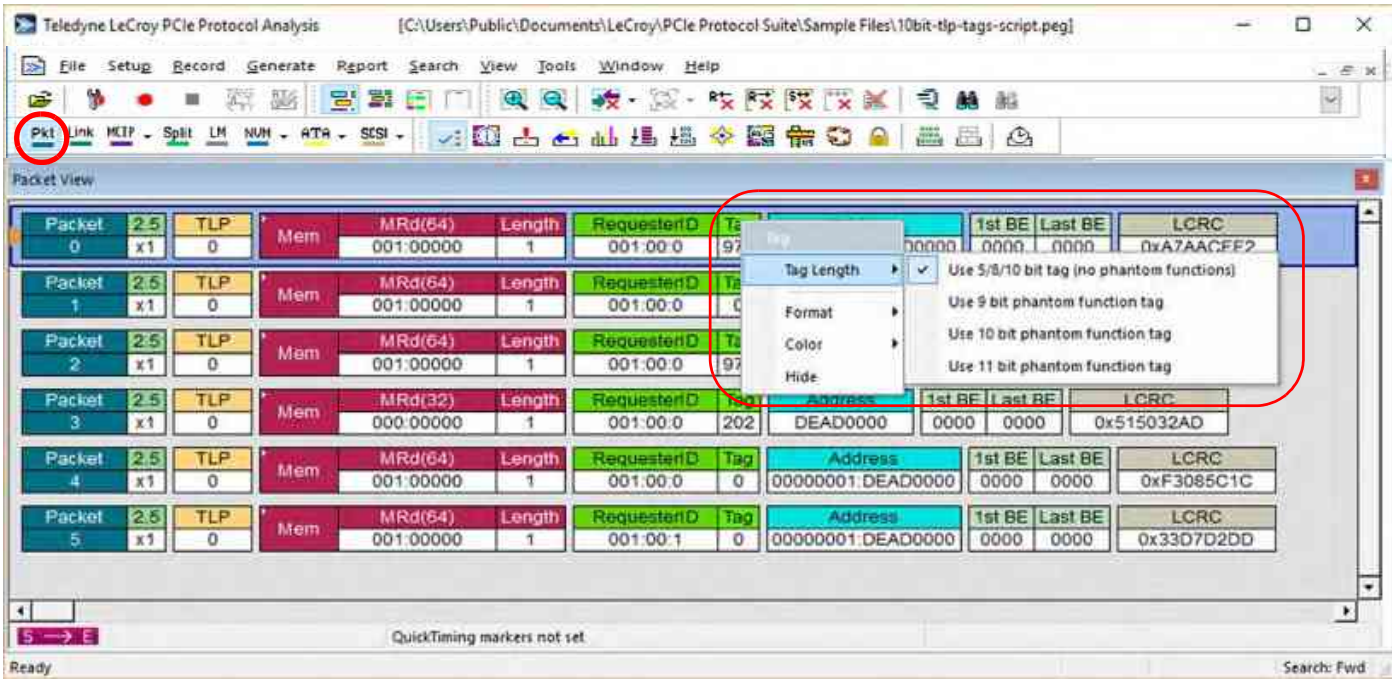


Figure 7.17: Packet Cell Popup Menus: Tag Length Pop Up Menu selections

The tag also has a tooltip associated with it to give you more information about the Packet's RequesterID Tag. See Figure 7.18 on page 405 and Figure 7.19 on page 405.

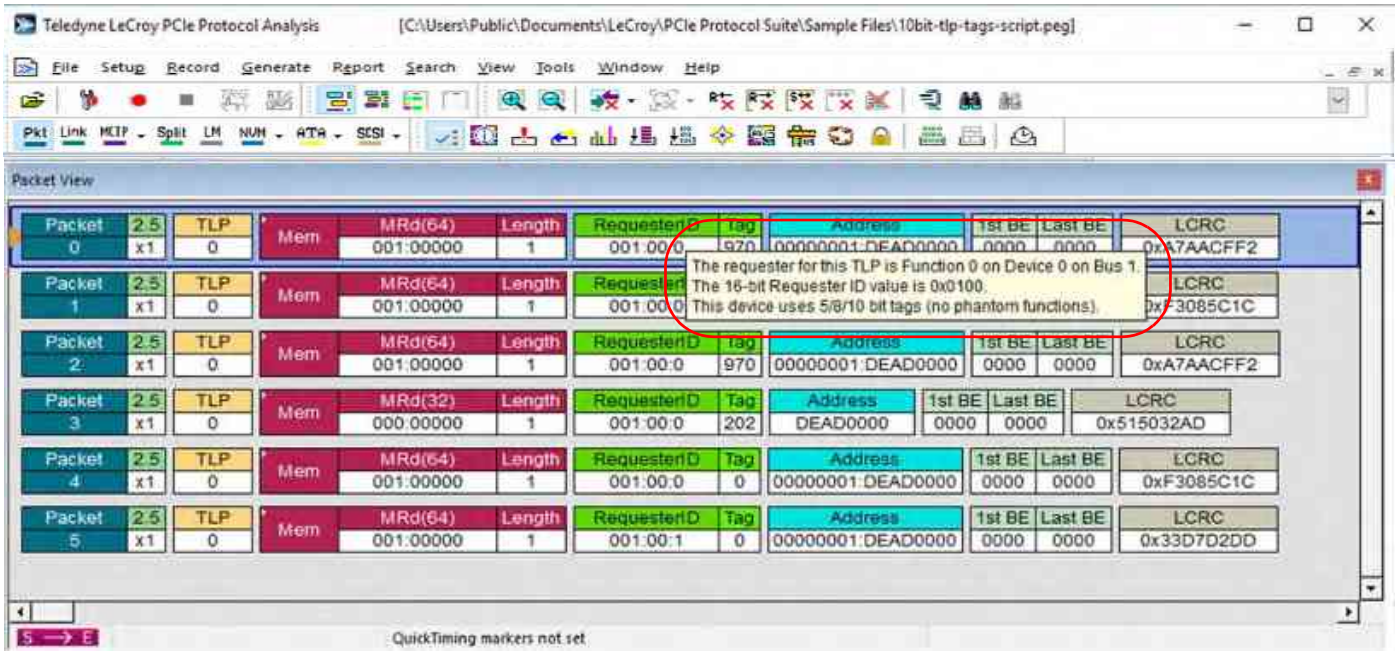


Figure 7.18: Packet Cell: Tag Tooltip

The Summit T5 can also decode RegisterID blocks that use phantom function tags. As shown in the figure below. See Figure 7.19.

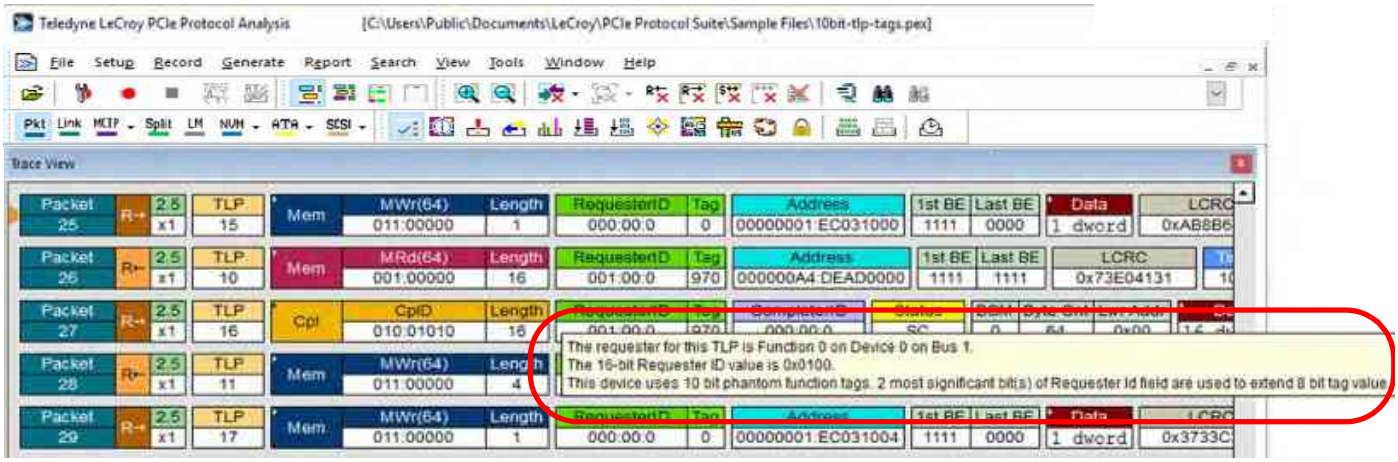


Figure 7.19: Packet Cell: Phantom Function Tag Tooltip

7.8.8.1 Quick Timing Bar

The Quick Timing Bar (see Figure 7.20 on page 406) at the bottom of the Trace View display window shows the following data between Markers:

- Delta Time
- Bus Utilization (both from Device to Host and from Host to Device)
- Data Throughput (both from Device to Host and from Host to Device)

Right click in the Quick Timing Bar to pop-up the menu to include or exclude the last selected packet/transaction from the timing, bus utilization and throughput calculations.

The data can be displayed in any available selection unit. Each value is described in bytes or bits value, to be comparable. Auto mode will select MB or GB automatically depending on result value so that values are more readable. The same units can be selected in theTiming Calculator dialog.

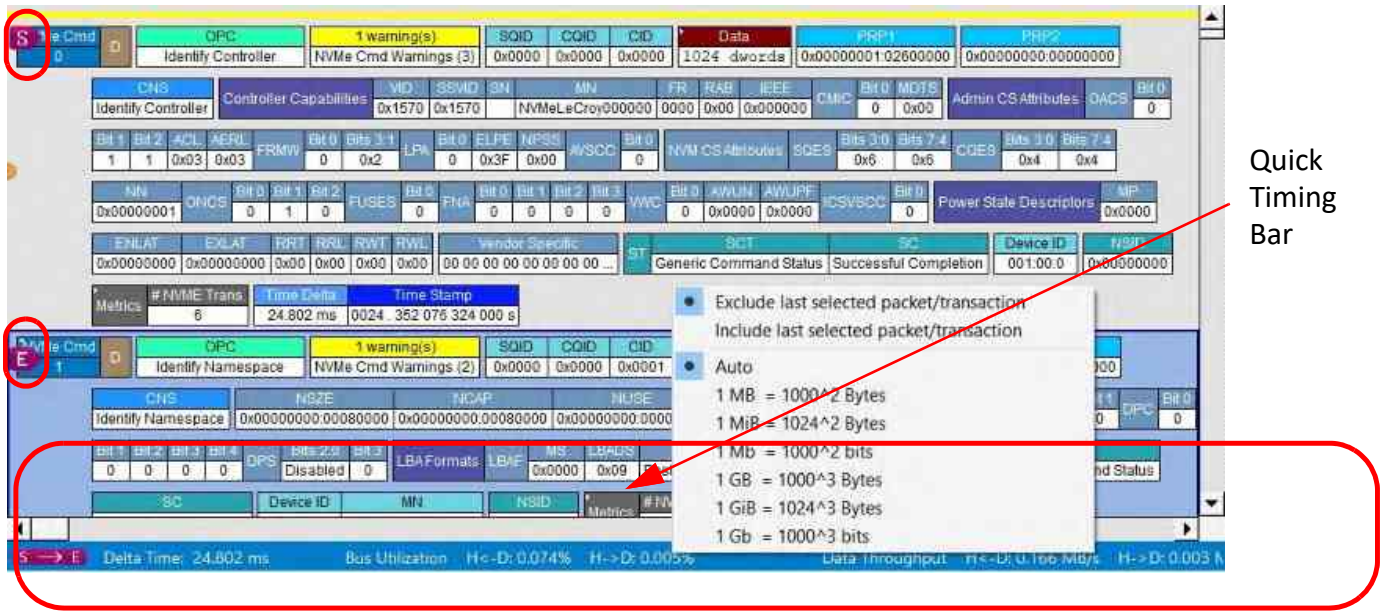


Figure 7.20: Quick Time Bar

7.8.9 Delete All Quick Timing Markers

Deletes all Quick Timing markers.

7.8.10 Set Marker

A marker is a unique label for a packet that allows you to go to that packet and also serves as a **comment string** for a specific packet. When you select a marker, the identified packet appears at the top of the screen. Packets that have been **marked** have a red bar on the left edge.

To set a marker, perform the following steps:

1. Right-click the **Packet** field of the packet you want to mark (see Figure 7.21 on page 407) or hover over the packet and click **Ctrl+K,** or select the packet and click **Ctrl+L**.

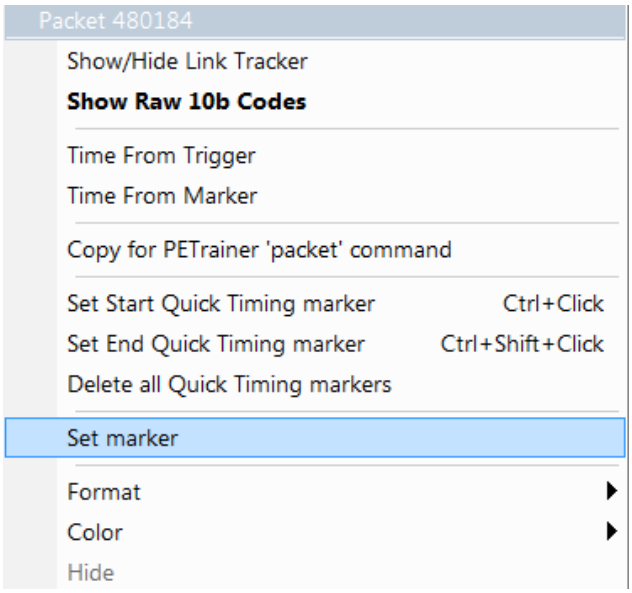


Figure 7.21: CATC Trace: Set Marker

2. Click **Set Marker**.
3. When the Create Marker for Packet # pop-up displays (see Figure 7.22), enter a unique identifier for the packet in the Comment field.

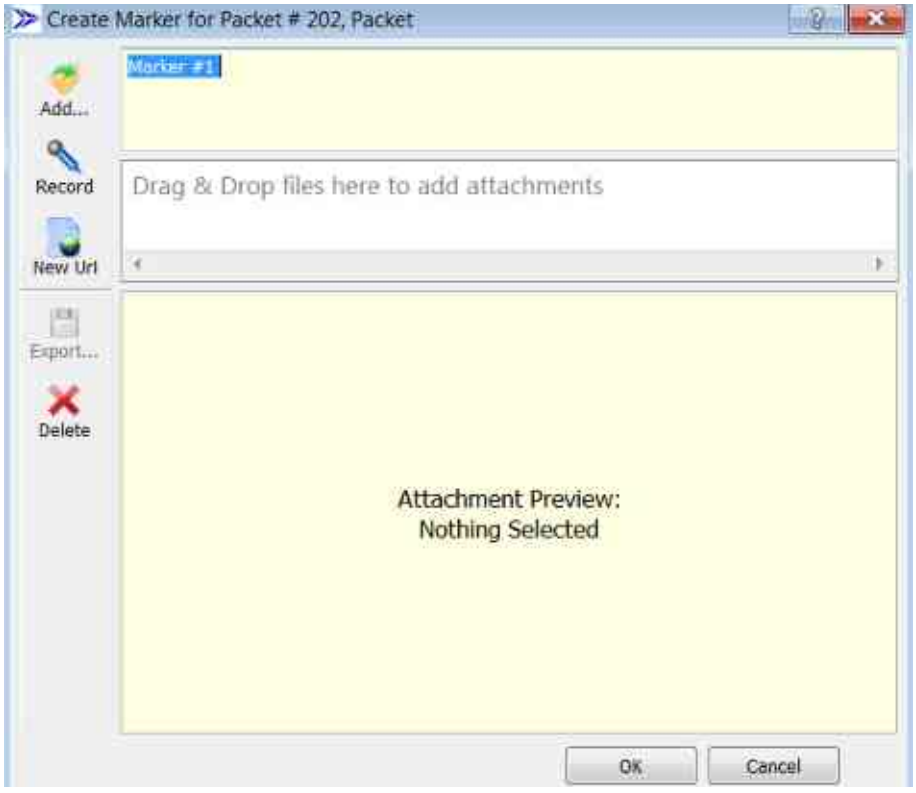


Figure 7.22: Create Marker for Packet Dialog

Later, you can go directly to this packet using the Go To Marker operation in the Search Menu.

7.8.11 Edit or Clear Marker

To change a markers identifier, or clear (delete) the marker:

1. Right-click the **Packet** field of the desired packet to display a pop-up menu (see Figure 7.23).

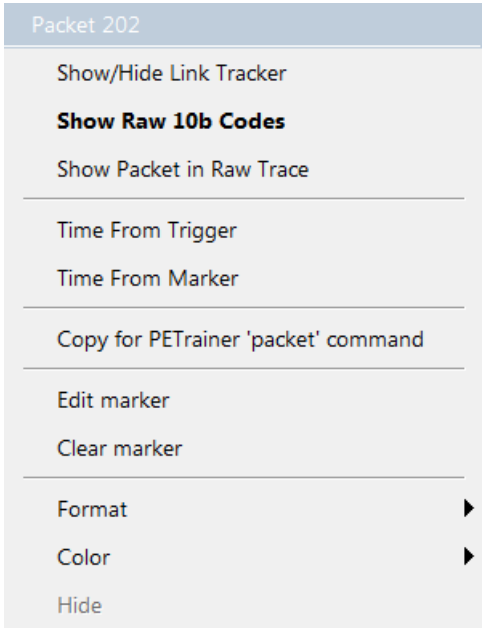


Figure 7.23: Edit Marker Pop-up Menu

2. Choose **Edit Marker** and enter a new identifier into the Edit Marker for Packer # pop-up, or
   choose **Clear Marker**. When you choose Clear Marker, the marker is removed and the red line disappears.

7.8.12 Format

Selecting Format from the Packet Cell Popup Menus will allow you to change the format of the data from Hex, Decimal, Binary or ASCII. See Figure 7.24.

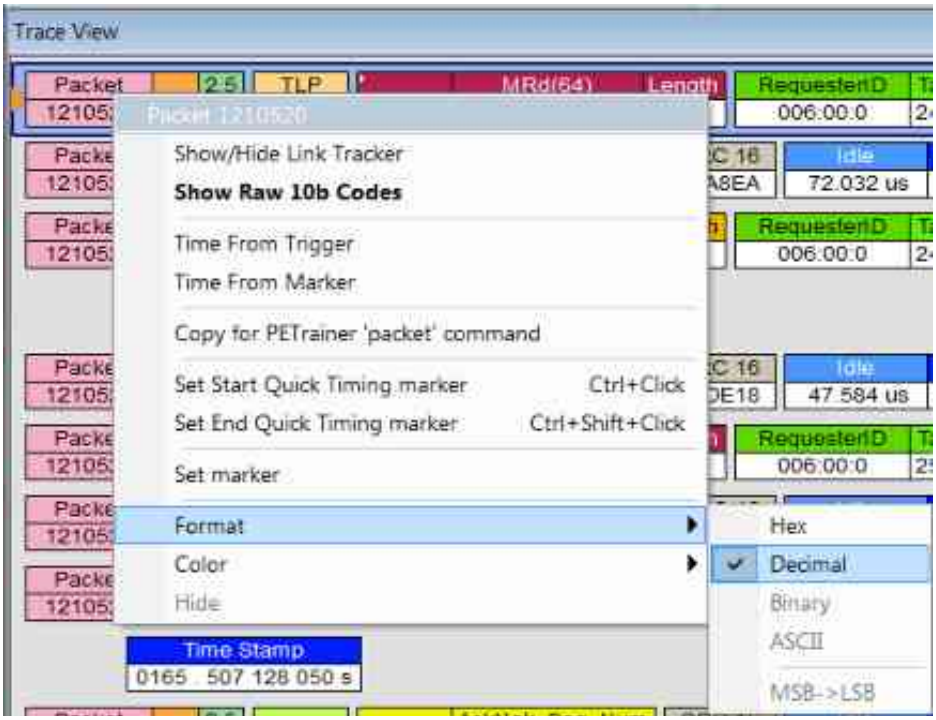


Figure 7.24: Packet Cell Popup Menus: Format

7.8.13 Color

Selecting the Packet Cell Popup Menu Color allows you to change the color of the Packet Cell. See Figure 7.25. Choose one of the twenty standard colors or pick Other for more choices.

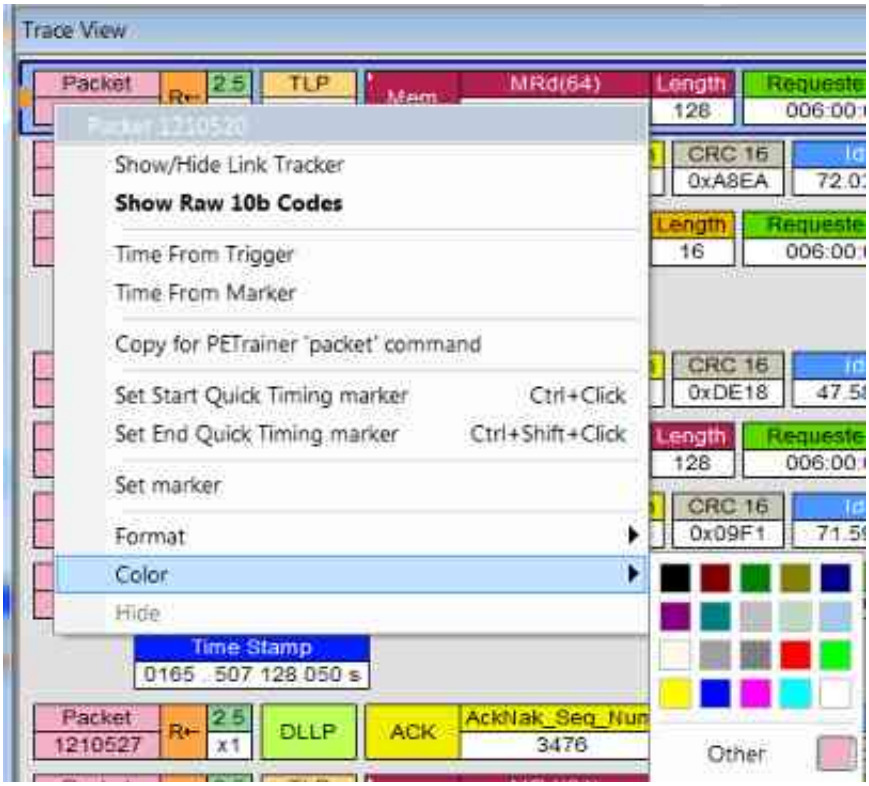


Figure 7.25: Packet Cell Popup Menus: Color

7.8.14 Other Packet Cell Popup Menus

7.8.14.1 Packet Header R-> Cell Popup Menu

The Packet Header R-> cell has a pop-up menu (see Figure 7.26) with the Swap Upstream/ Downstream command, which changes the directionality of the packets in the CATC Trace.

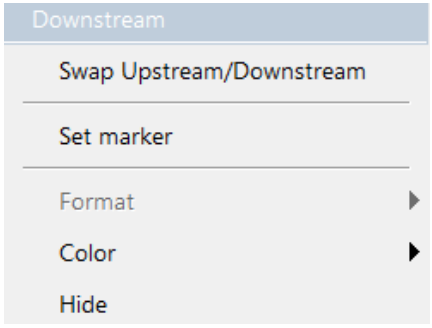


Figure 7.26: CATC Trace View: Packet Header Direction Popup Menu

7.8.14.2 Packet Header Speed Cell Popup Menu

The Packet Header Speed cell has a pop-up menu with the Show Header Fields command (see "Show Header Fields" on page 397), which exposes a detailed view of the selected Header field (see the following figure).



Figure 7.27: CATC Trace View: Packet Header Speed Popup Menu

7.9 Compressed CATC Trace View

The Compressed CATC Trace view shows fields in the format “Attribute: Value”, whereas the normal CATC View shows the attribute name on top and the value below.

The Compressed CATC Trace view has almost all the information of the normal CATC View and behaves mostly the same way, while displaying more information on each window (see Figure 7.28 on page 412).

To compress the CATC Trace:

- Click  on the toolbar.

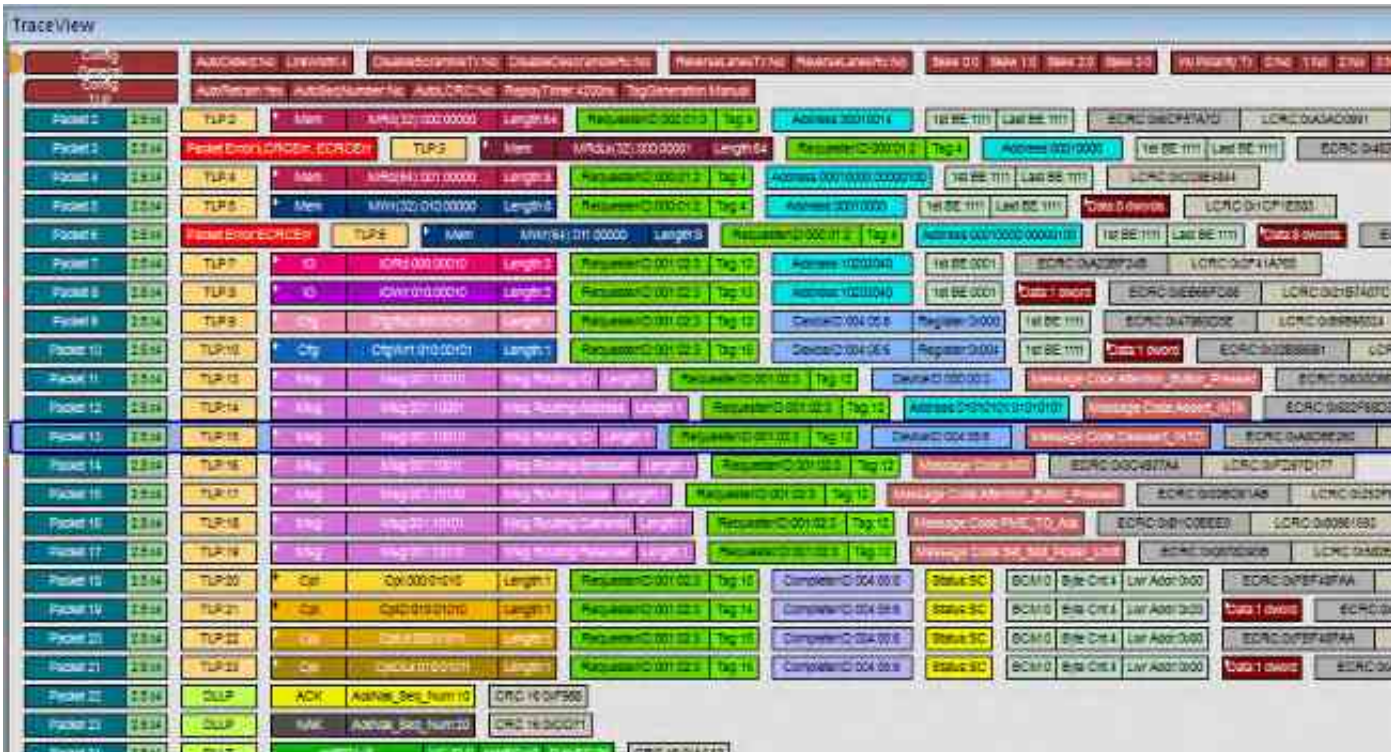


Figure 7.28: Compressed CATC Trace

- Click  on the toolbar to return to the normal CATC Trace View, or Select **View > Trace Views > CATC Trace.**

7.10 Spreadsheet View

You can view the CATC Trace as a spreadsheet in color or black and white.

Click  on the toolbar to display the Spreadsheet View (see Figure 7.29 and Figure 7.30).

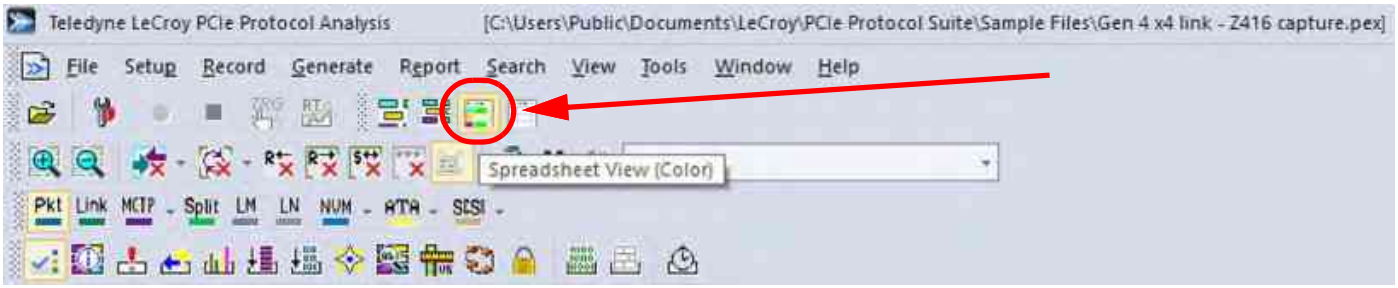


Figure 7.29: Spreadsheet View Icon in Toolbar

You can see the resulting Spreadsheet View of the trace below.



Figure 7.30: Spreadsheet View (Color)

- Click  on the toolbar to display the Spreadsheet View B/W.

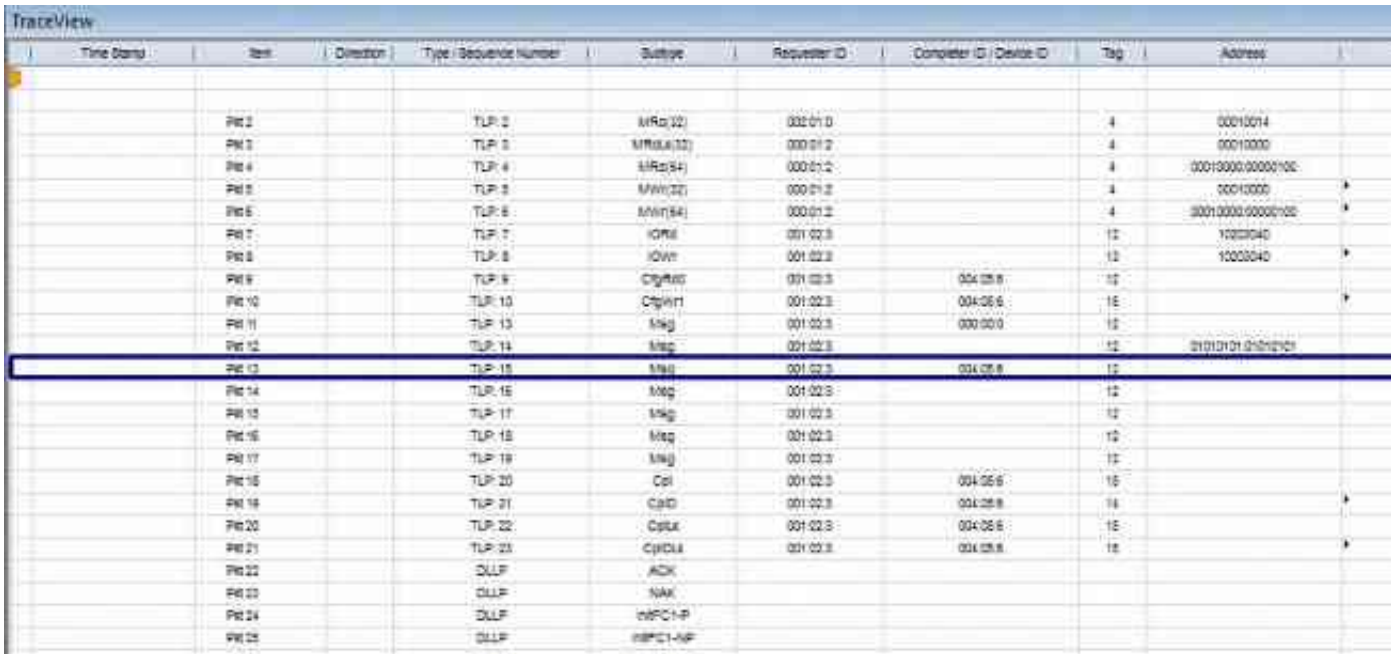


Figure 7.31: Spreadsheet View (Black And White)

7.10.1 Columns

Right click on any column and the following options pop up. See Figure 7.32.

You can perform the following options:

- Add a Standard Column if one has been deleted
- Add a column with specific types of information for the current row selected
- Remove a column
- Restore the default columns

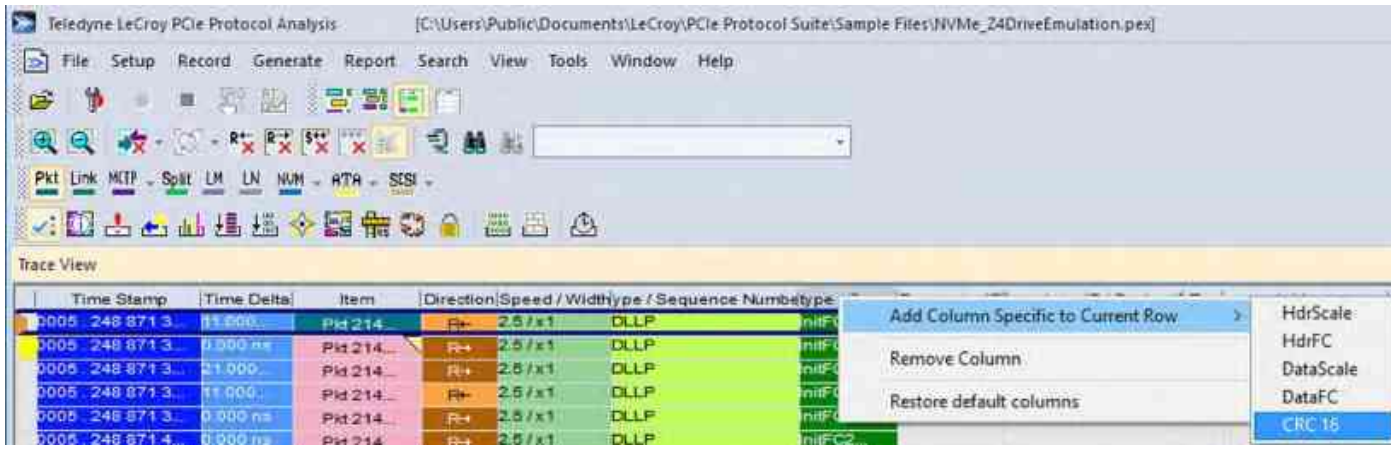


Figure 7.32: Add Columns Specific to Current Row

You can add a column with the CRC 16 values. See Figure 7.33

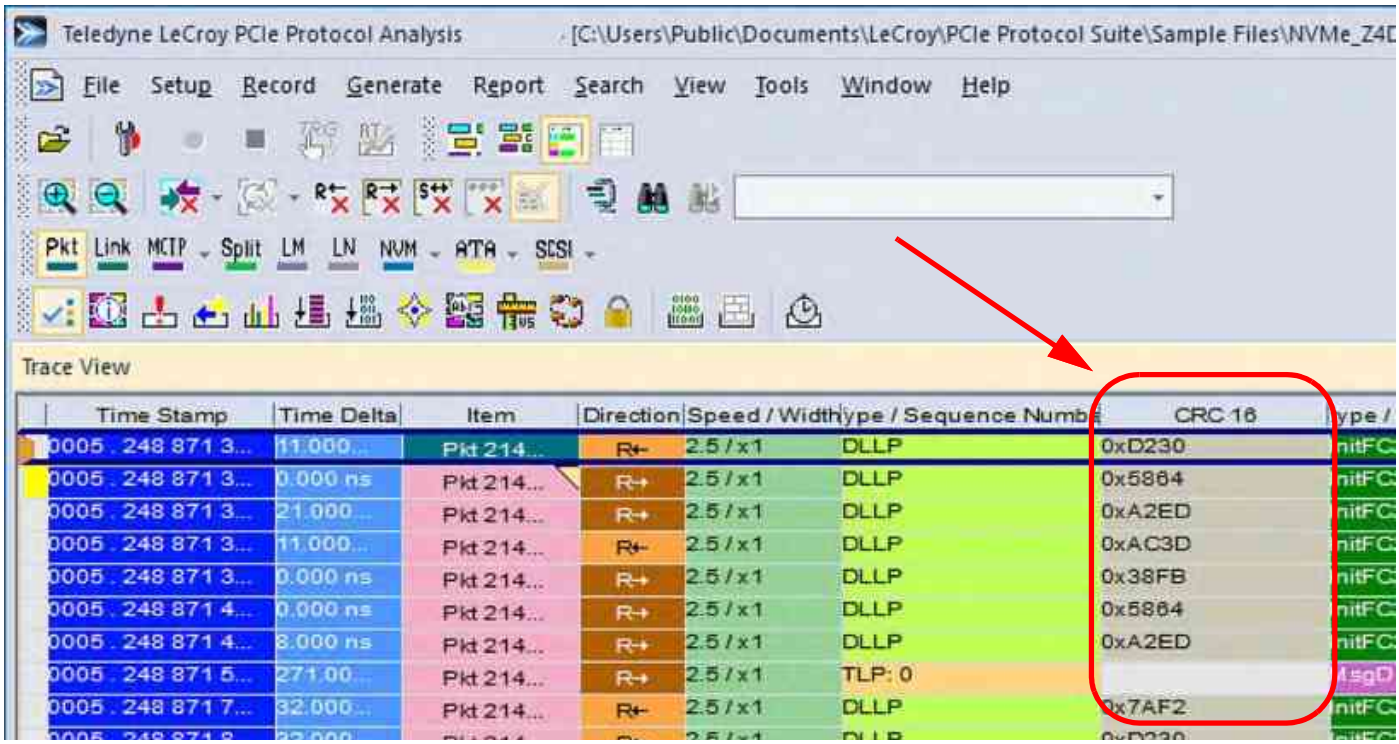


Figure 7.33: Added Column with CRC 16

You can delete the column that you right clicked on. See Figure 7.34.

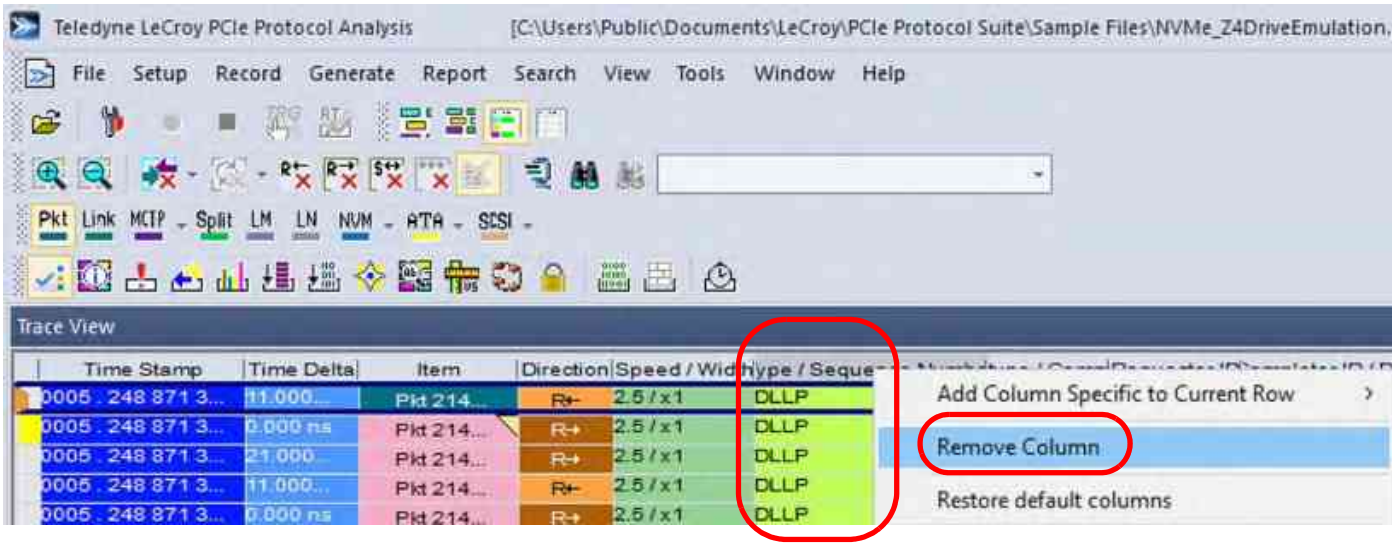


Figure 7.34: Right Click on Type/Sequence Number Column

Click on Remove Column and it's deleted from Spreadsheet View. See Figure 7.35.

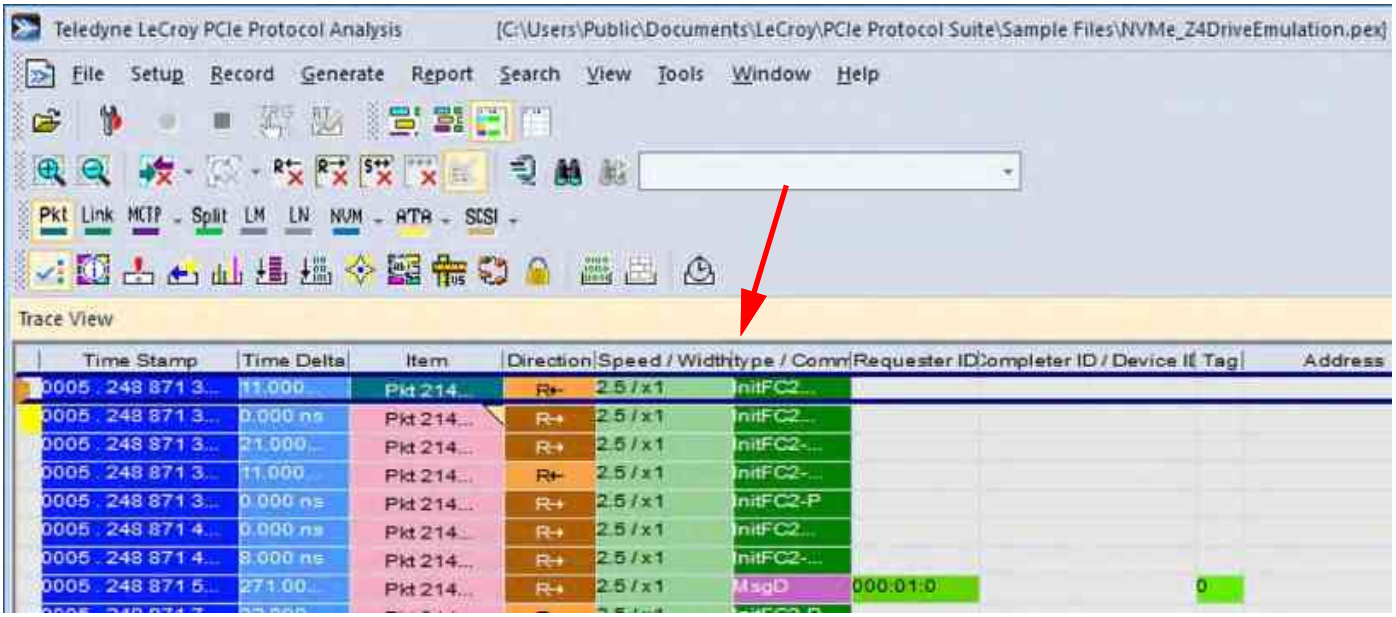


Figure 7.35: Selected Column Removed

You can also Restore the set of system Default columns. See Figure 7.36 on page 416.

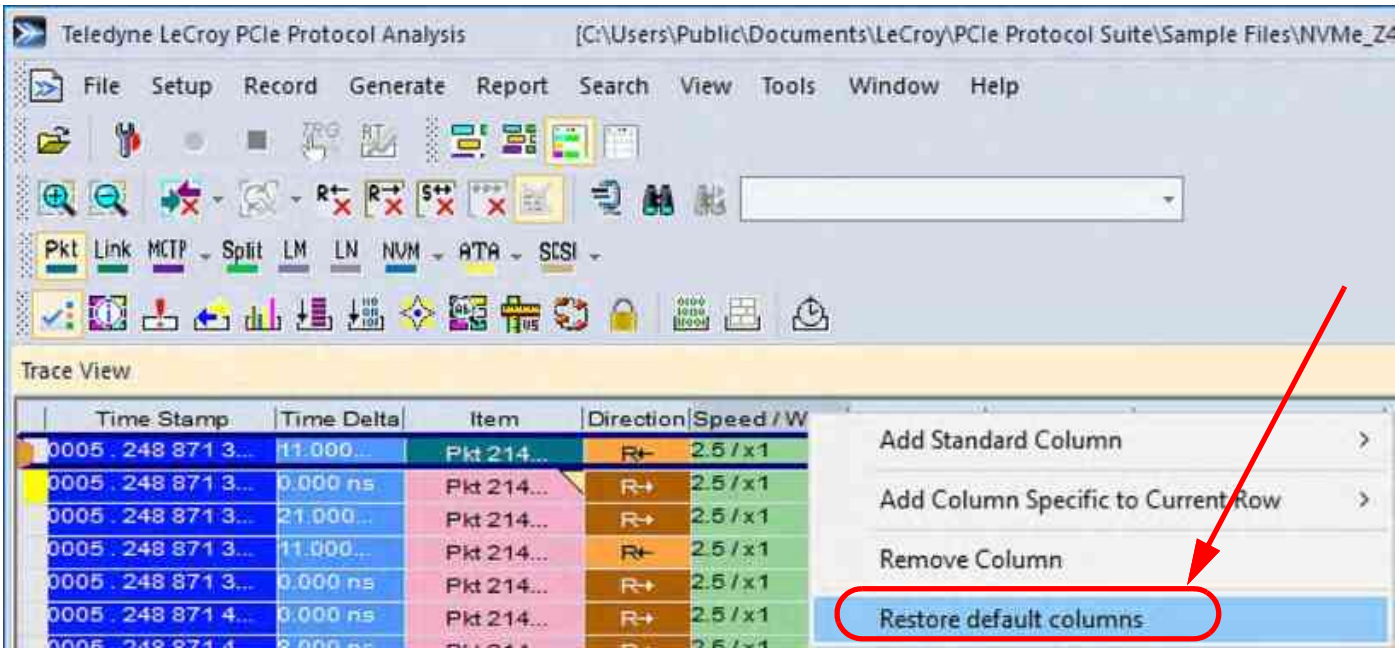


Figure 7.36: Restore Default Columns

If you select Restore default columns you'll get a Warning message. See Figure 7.37.

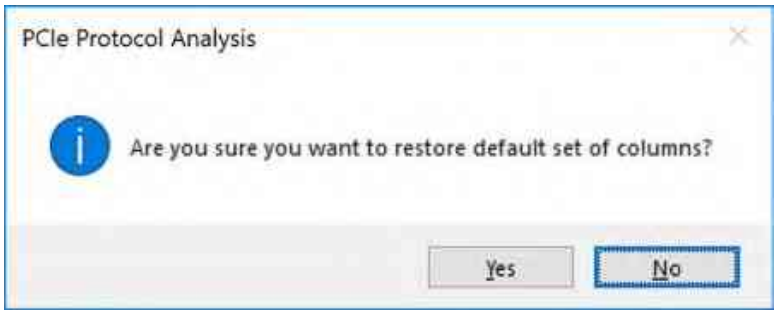


Figure 7.37: Warning Message about Restoring Default Set of Columns

Click on Yes and you'll get the default set of columns. See Figure 7.38 on page 417.

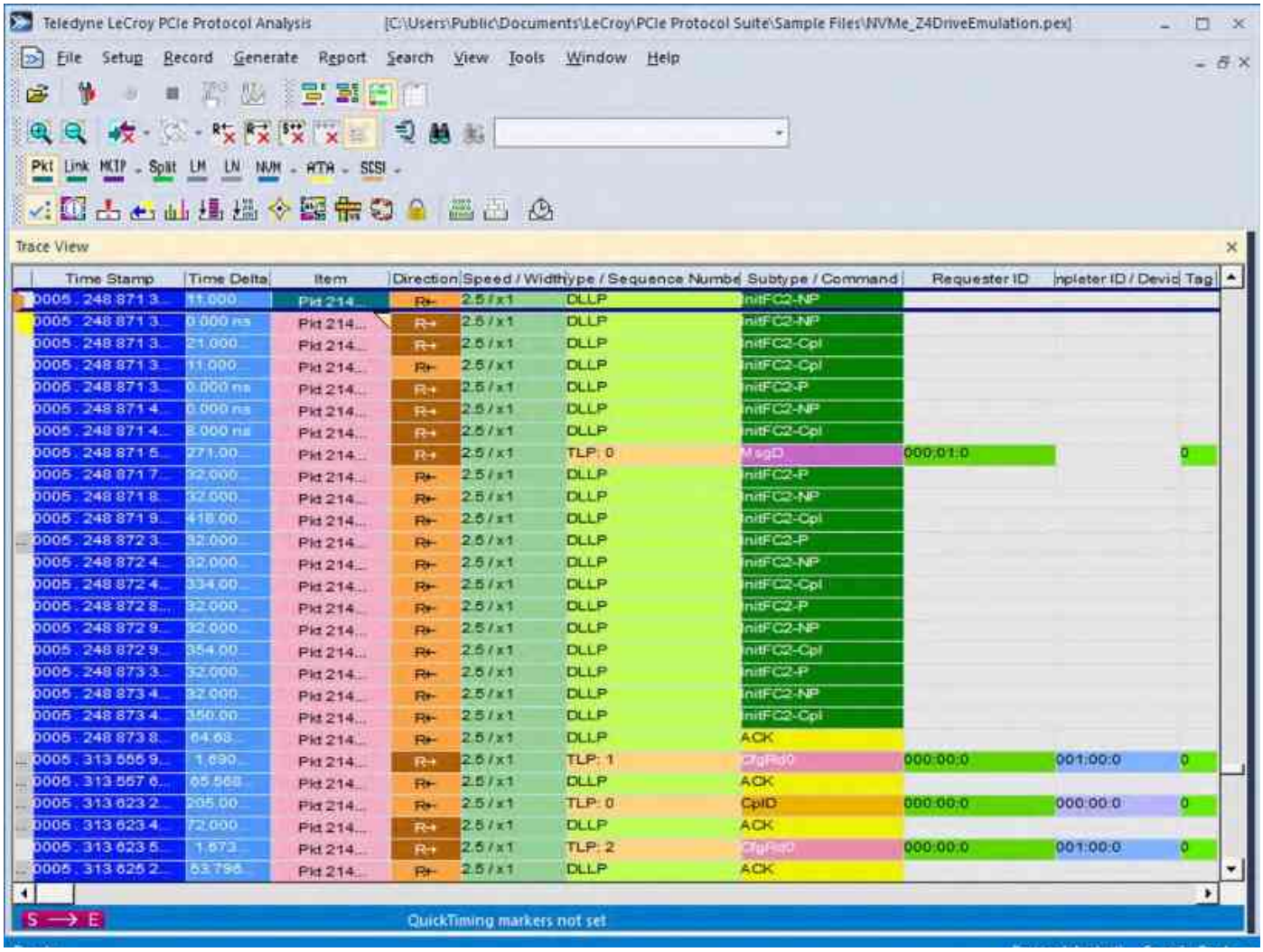


Figure 7.38: Default Set of Columns

7.10.2 Detail View and Spreadsheet View

In the Spreadsheet View, double-click a packet, transaction, or transfer, or select a field and then click on the toolbar, to display the Detail View (see Figure 7.39 on page 418).

To put a Detail View header as a column in the Spreadsheet View, drag the header to a column divider in the Spreadsheet View.

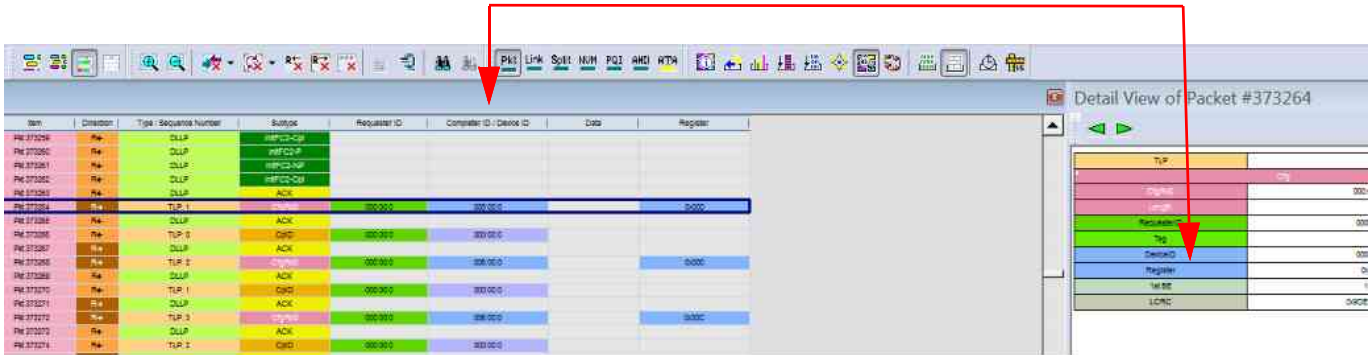


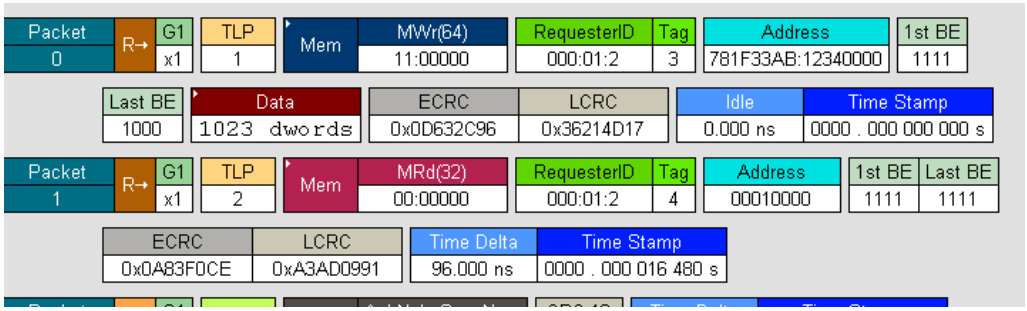
Figure 7.39: Detail View in Spreadsheet View

7.11 Decoding Traffic

The PCIe Protocol Analysis has several decode levels:

7.11.1 Packet

Packet level decode Pkt includes all TLP packets, DLLP packets, and all ordered sets.



Note: The PCI-E 3.0 (and 2.1 with Errata) specifications state that there are two formats of the AER capability structure, and the AER_CAP_VER field indicates if format 1 or format 2 is used.

The difference between format 1 and format 2 is whether or not the TLP Prefix Header section is present in the AER capability, even if it is not actually implemented.

This means that:

- If AER_CAP_VER = 1 and it is not a Root Port or RC Event Collector, there are 11

DWs (00h to 24h)in the total AER Capability structure.

- If AER_CAP_VER = 1 and it is a Root Port or RC Event Collector, there are 14 DWs (00h to 34h)in the total AER Capability structure.
- If AER_CAP_VER = 2 then, there are 18 DWs (00h to 44h) in the total AER Capability structure.

In fact, there are PCI-E 3.0 compliant devices that have AER_CAP_VER=1.

Example H/W:

A PCI-E 3.0 device that supports Multiple Header Recording, but does NOT support TLP Prefixes. This device is allowed to have AER_CAP_VER=1, and Multiple_Header_Recording_Capable=1

Therefore, the Teledyne LeCroy software decodes the Multiple_Header_Recording_Capable field regardless of the value of AER_CAP_VER.

Note: The Protocol Mode of the CATC View may show individual symbols grouped as a "packet" such as in the case where electrical symbols arrive before fast training sequences. Such group of symbols will also be reported in the summary. See Figure 7.40 on page 420.

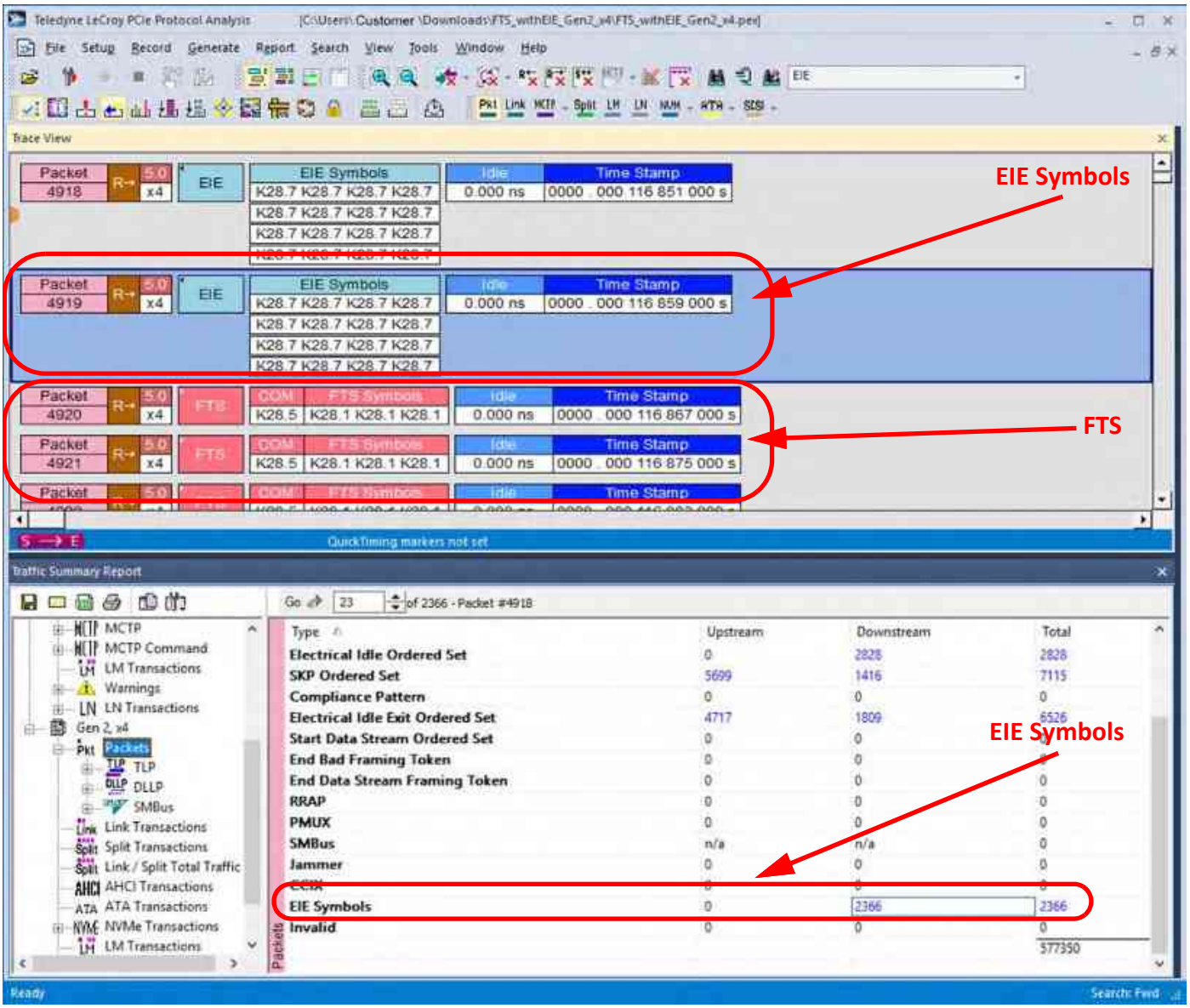
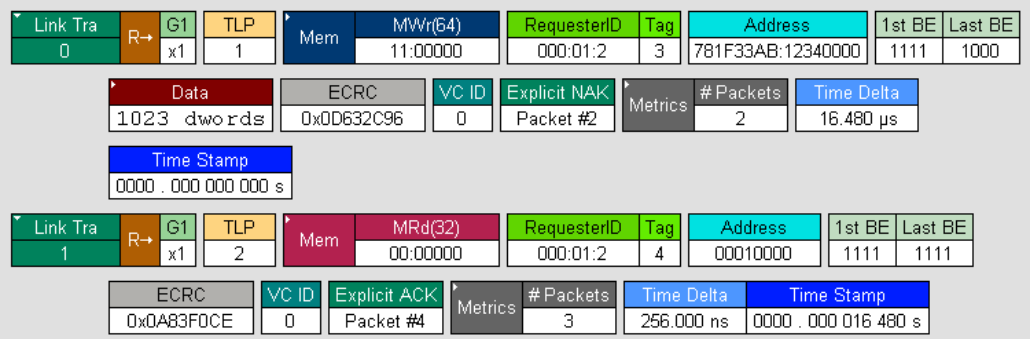


Figure 7.40: EIE Symbols Decoded before FTS

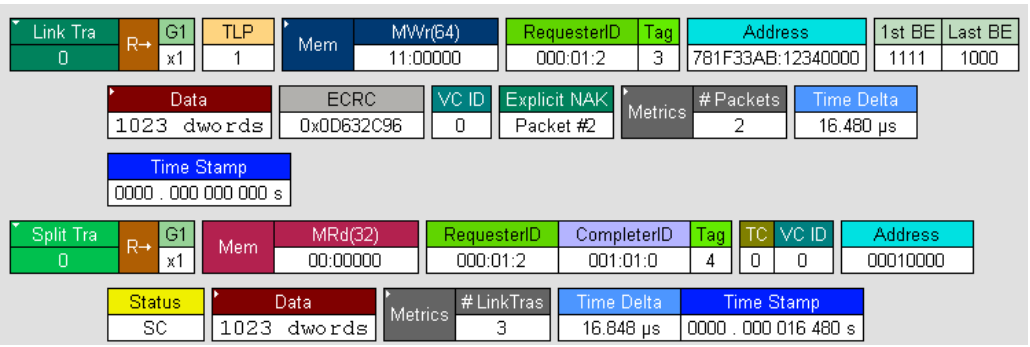
7.11.2 Link

Link level decode Link is composed of TLP packets matched with a corresponding ACK or NAK coming from the opposite direction.



7.11.3 Split

Split level decode Split is composed of two Link transactions, the Request TLP and the Completion TLP from the other direction.



7.11.4 Lane Margining Decoding

The purpose Lane Margining LM is to determine if the PCIe Protocol Analysis software can run a series of commands to do the equivalent of moving the sampling point of the transceiver backwards or forwards in time (time margining) or at a higher or lower voltage (voltage margining). If there is enough margin to still reliably capture data without errors at that new sampling point then the system software can determine how much margin exists within the system. An example trace that shows some of the commands and response is shown below. See Figure 7.41.

7.11.4.1 Typical Lane Margining Commands and Responses

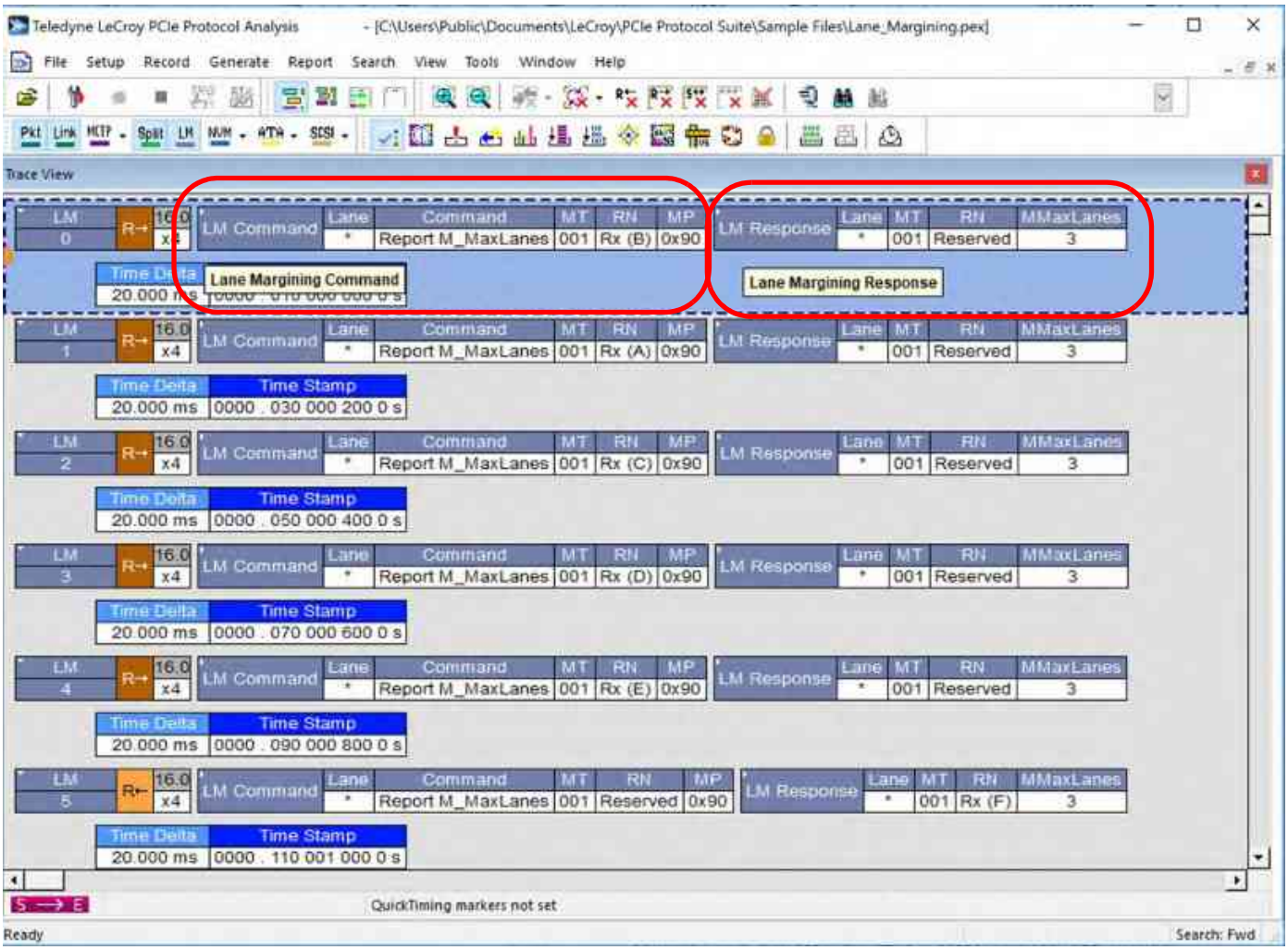


Figure 7.41: Lane Margining Decoding: Command and Response

More Lane Margining Commands and Responses are shown in Figure 7.42 on page 423.

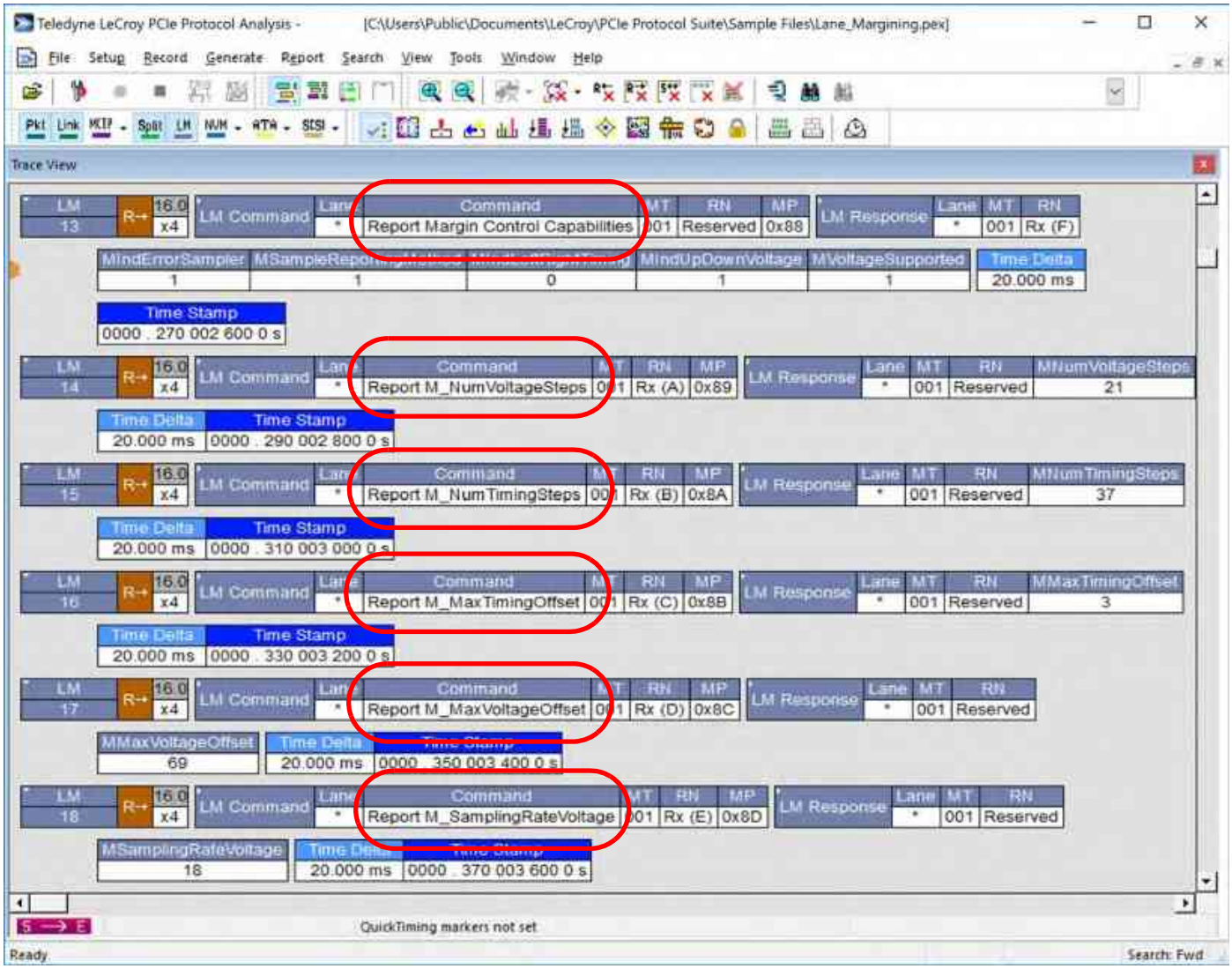


Figure 7.42: More Lane Margining Commands and Responses

7.11.4.2 Lane Margining Command: Step Margin to Timing Offset

The Lane Margining Command: Step Margin to Timing Offset in shown in Figure 7.43.

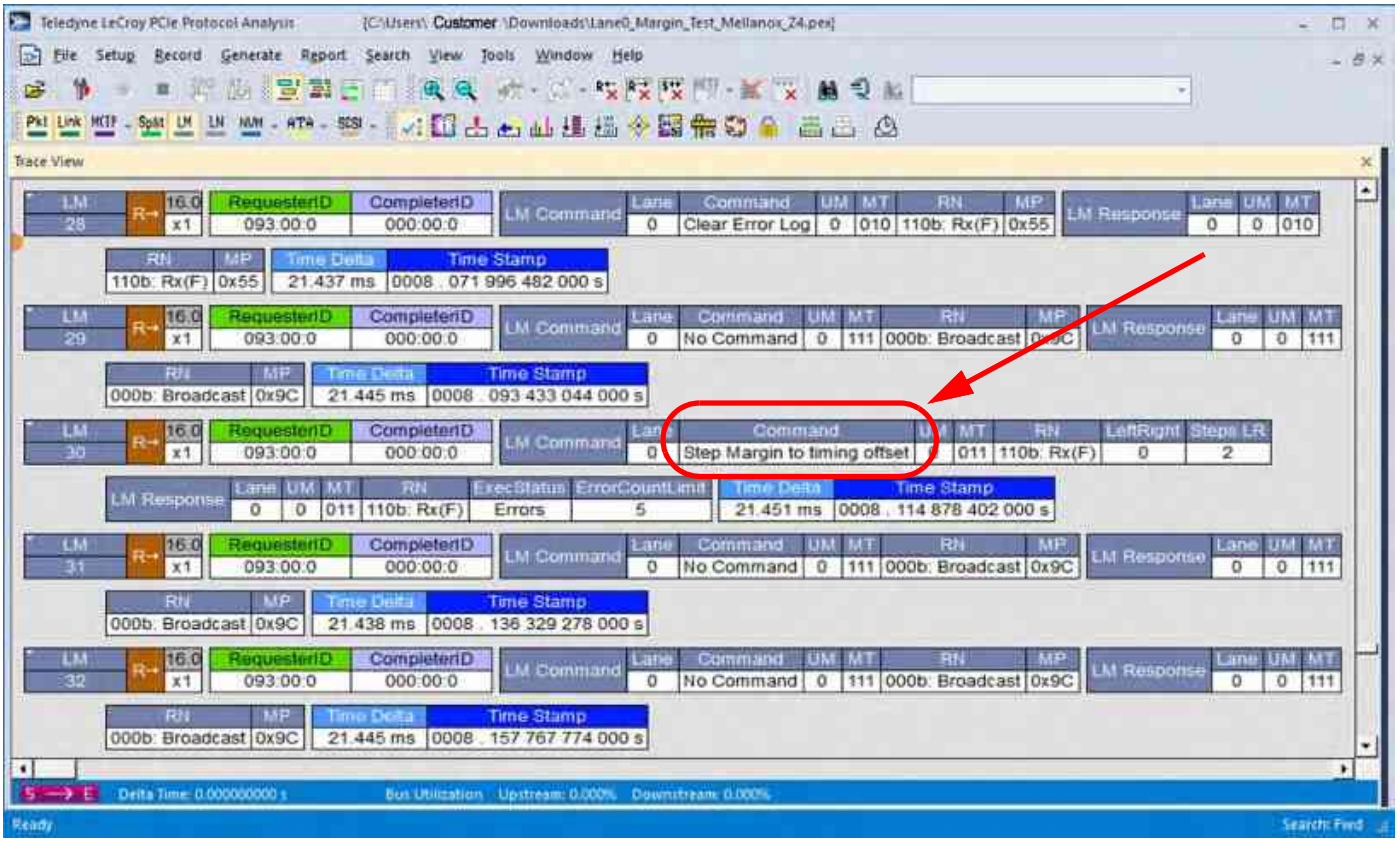


Figure 7.43: Lane Margining Command: Step Margin to Timing Offset

7.11.4.3 Lane Margining Errors

Lane Margining errors can also be decoded. As shown in the sample below (see Figure 7.44).

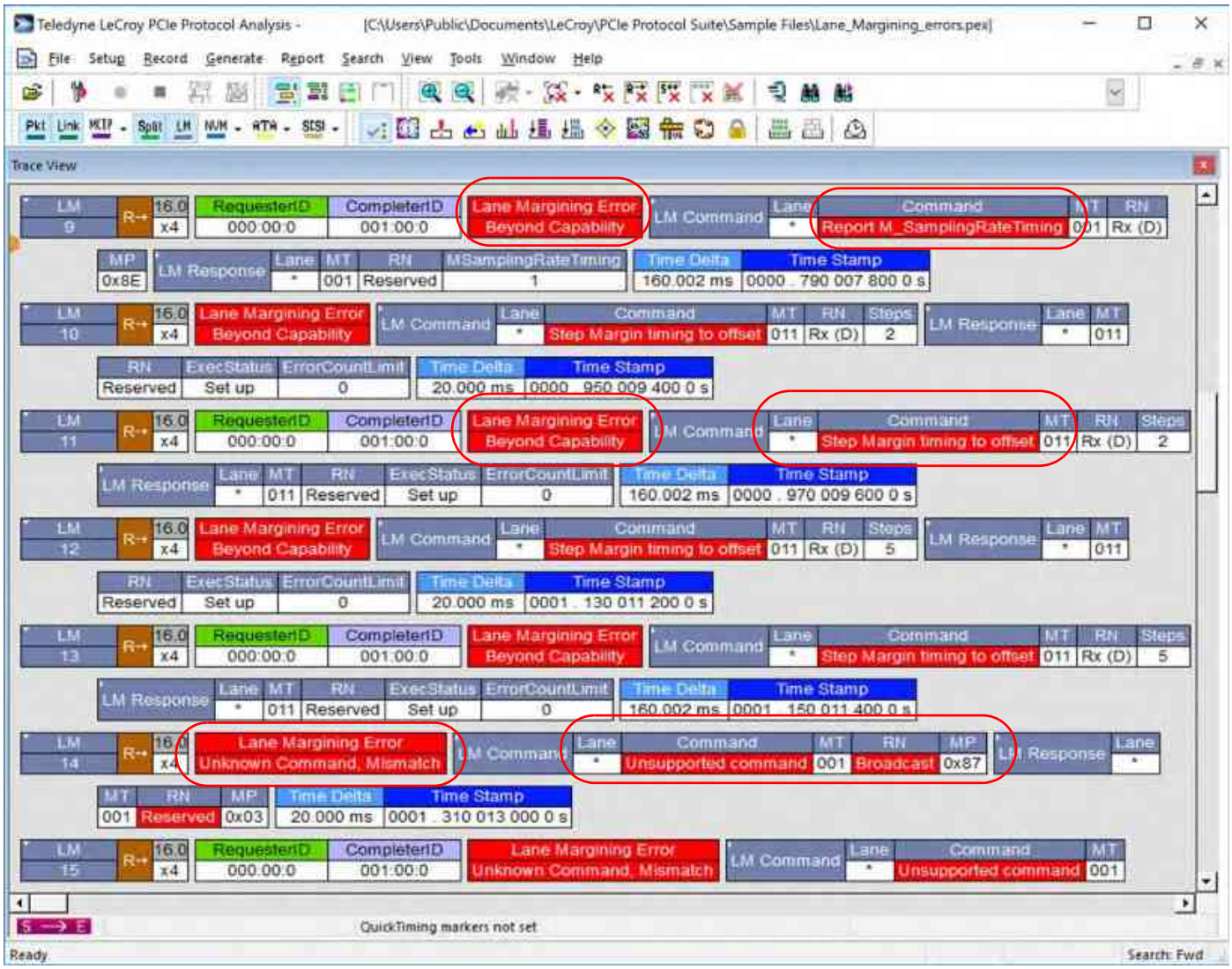


Figure 7.44: Lane Margining Errors: Decoded

7.11.5 NVMe Decoding

The PCIe Protocol Analysis software supports decoding of NVMe 1.4.

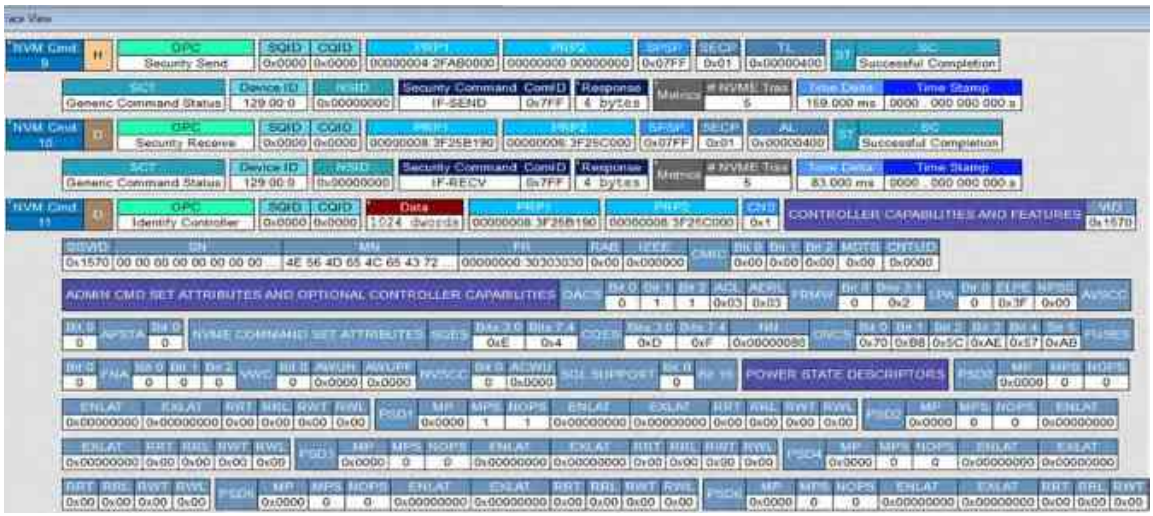
To decode the NVMe protocol there are two levels available: NVMe Transaction level, which decodes the individual NVMe transactions from the PCI Express protocol and NVMe Command level, which gathers NVMe transactions into a single command. If the top level button 

is selected, it will decode the NVMe Command level directly.

The NVMe Transaction level option displays NVMe transactions. PCIe Protocol Analysis decodes the storage commands starting from lower PCI Express Transaction Layer decodes. In the case of NVMe, it will decode first the Packet Level, then the Link Transaction level, then the Split Transaction Level and finally the NVMe Transaction decode level.



The NVMe Command level option displays NVMe Commands. The NVME commands decode all the lower level decodes first.



Note: As of software version 7.34, the NVMe decoding will be performed properly even if the ACK DLLPs have been filtered.

Note: As of software version 7.34, once the NVMe decoding has been applied, it will be kept in a separate temporary file not the Trace file (see "Trace File Structure" on page 129). The next time the trace is opened for review there will be no need to re-decode, making opening of the file in NVMe mode faster.

Note: As of software version 7.36 Beta, the NVMe decoding can handle multiple controller resets within the same recording.

7.11.5.1 NVMe: Device ID and Model Name Decoded

As of software version 7.34, the Device ID and Device Model Name field is displayed in the decoded command (see Figure 7.45 and Figure 7.46 on page 427).

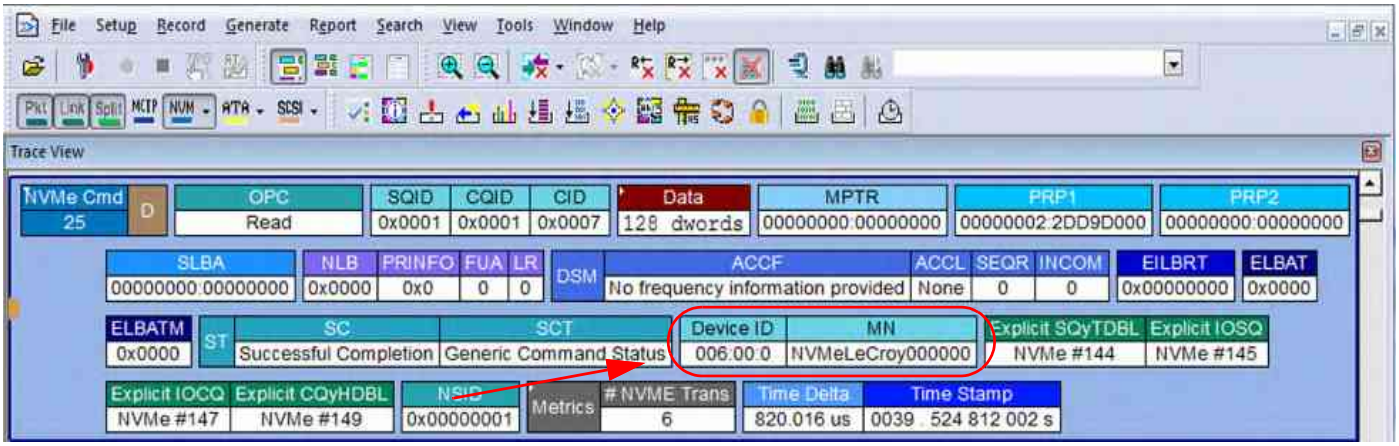


Figure 7.45: Device ID and Model Number Decoded from NVMe Trace

The trace must contain the device enumeration sequence so the decoding picks up the associated base addresses and NVMe transactions can be properly decoded. If the enumeration sequence is not available the base addresses must be manually entered in the PCIe SSD Configuration dialog from the Tools menu. See Figure 7.46 on page 427.

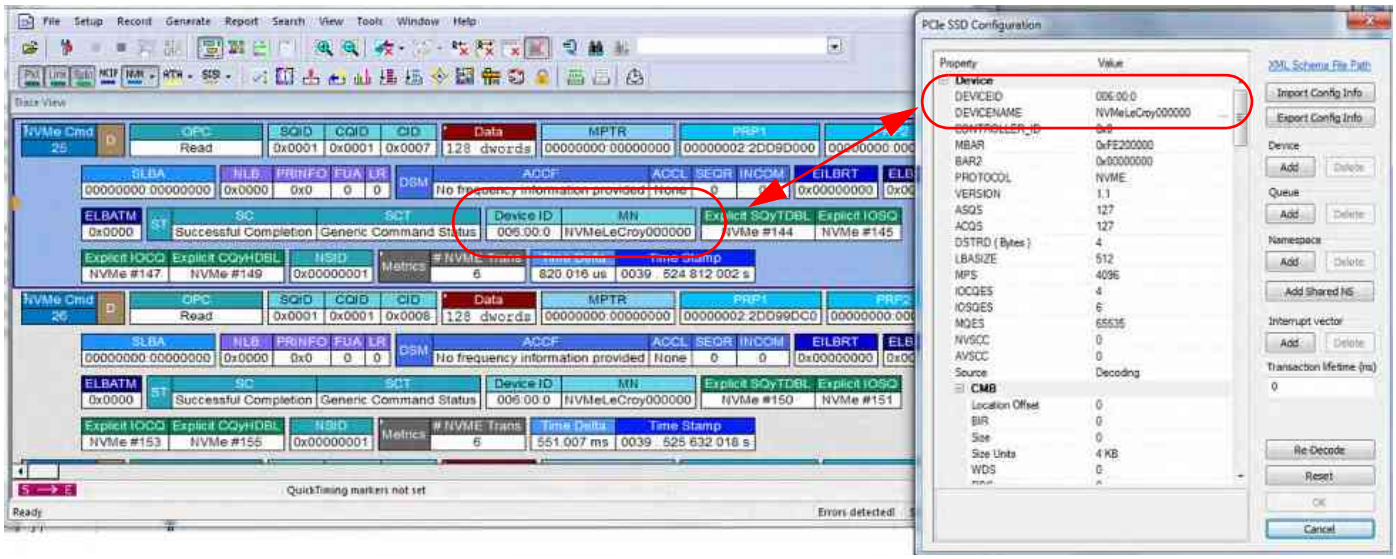


Figure 7.46: Device ID and Device Model Name Shown in SSD Configuration Dialog

7.11.5.2 NVMe: Data Field on Packets

While the data field section displayed for a PCIe packet shows the actual payload for that PCIe packet (as shown below):

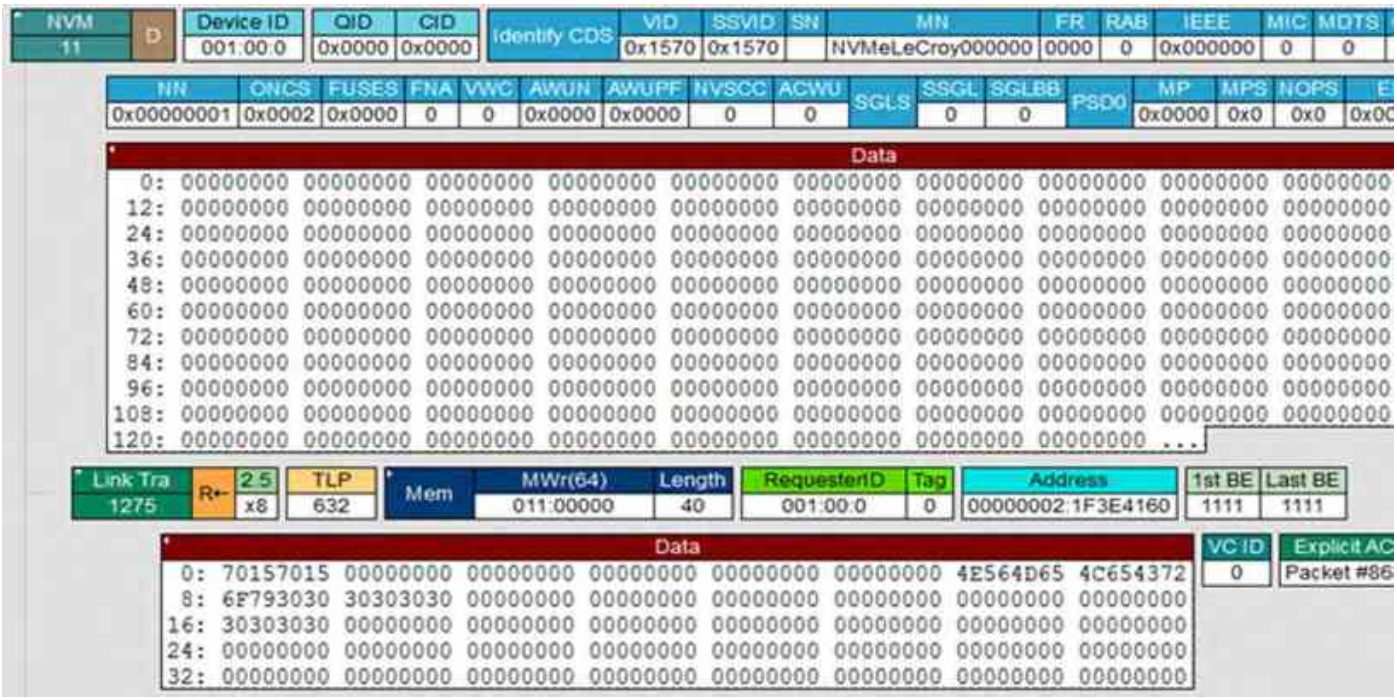


The content for this field changes depending on the decode level selected and the particular command decoded.

For example, at the PCIe transaction level, this field still reflects the PCIe payload field involved in the PCIe transaction (as shown below):

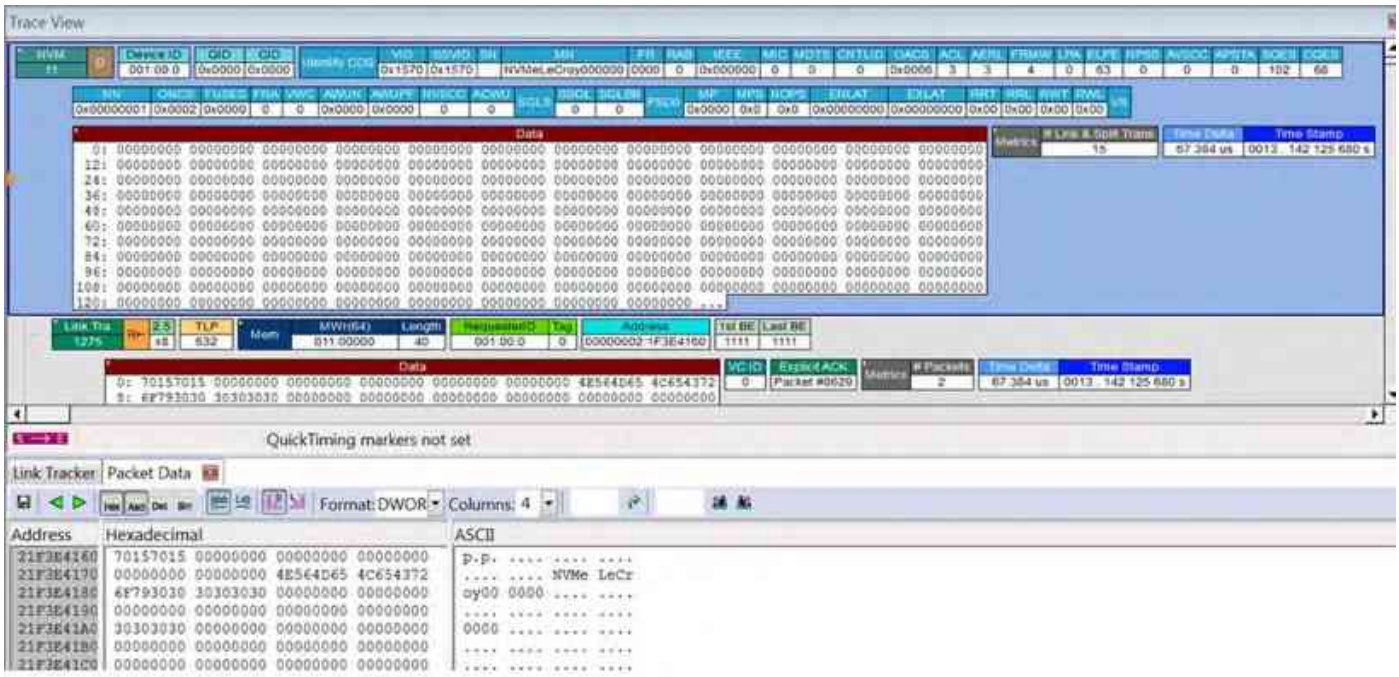


At the NVMe transaction level for identify command is shown below:



The data is shown according to NVMe specification. The portion of data that can be parsed into fields is parsed and drawn in named cells. The portion of data that cannot be parsed (i.e. 'vendor specific' portion is not parsed and is shown as a plain data).

In case you need to see this plain data (not parsed by named fields) the packet data view can be used. (as shown below):



7.11.5.3 NVMe: Trusted Computing Group Decode

Trusted Computing Group decodes are shown using the NVMe Command Level if they are present in the trace, as shown in Figure 7.47.

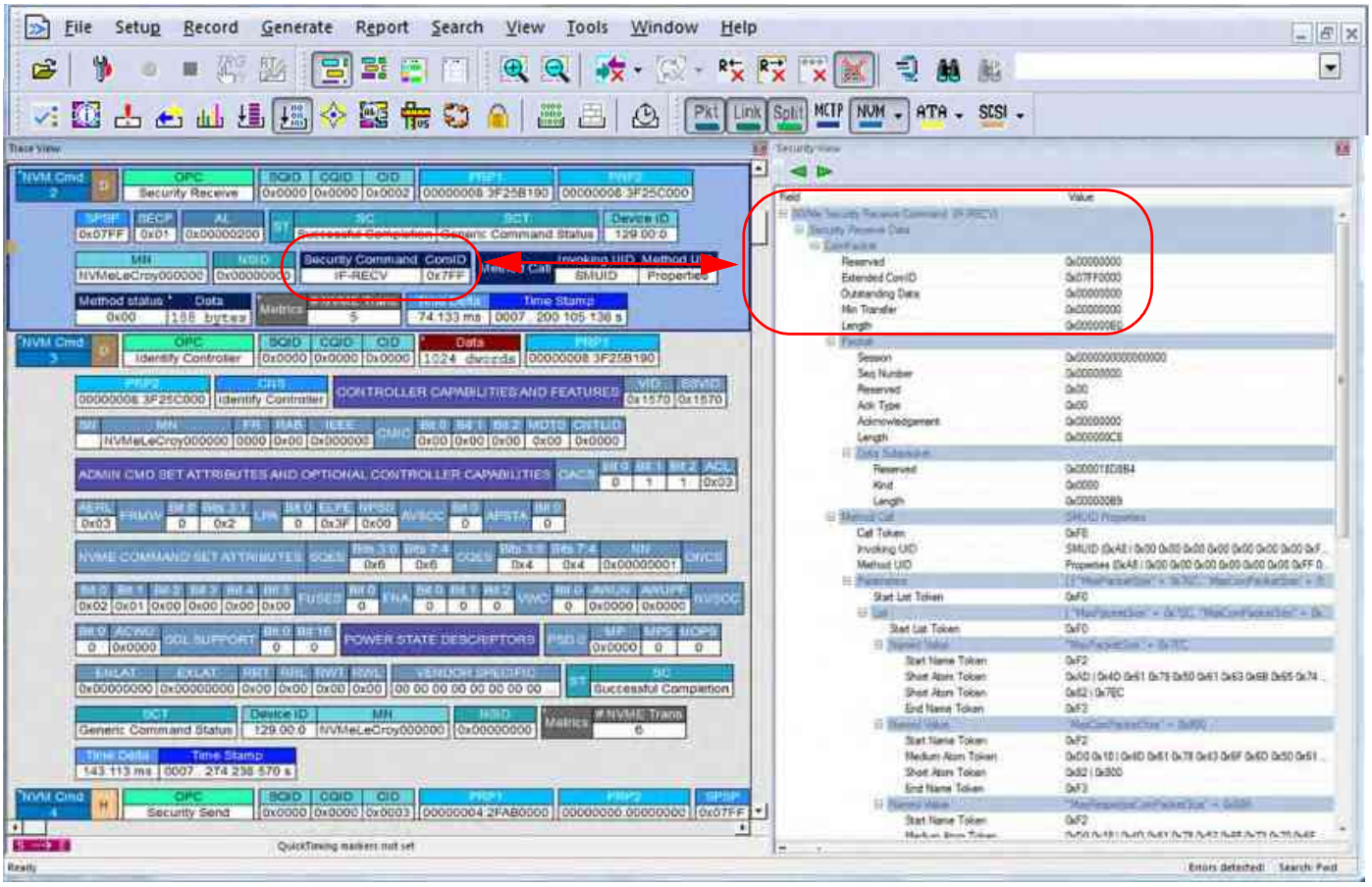


Figure 7.47: NVMe Command with TCG Details

7.11.5.4 The Opal Storage Specification

The Opal Storage Specification is a set of specifications for features of data storage devices (such as disk drives) that enhance their security. For example, it defines a way of encrypting the stored data so that an unauthorized person who gains possession of the device cannot see the data. That is, it is a specification for self-encrypting drives (SED).

The specification is published by the Trusted Computing Group Storage Workgroup.

The Opal SSC (Security Subsystem Class) is an implementation profile for Storage Devices built to:

- Protect the confidentiality of stored user data against unauthorized access once it leaves the owner's control (involving a power cycle and subsequent deauthentication).
- Enable interoperability between multiple SD vendors.

NVMe: TCG Opal Decoded

The PCIe Protocol Software can decode and display Opal TCG fields. See Figure 7.48.

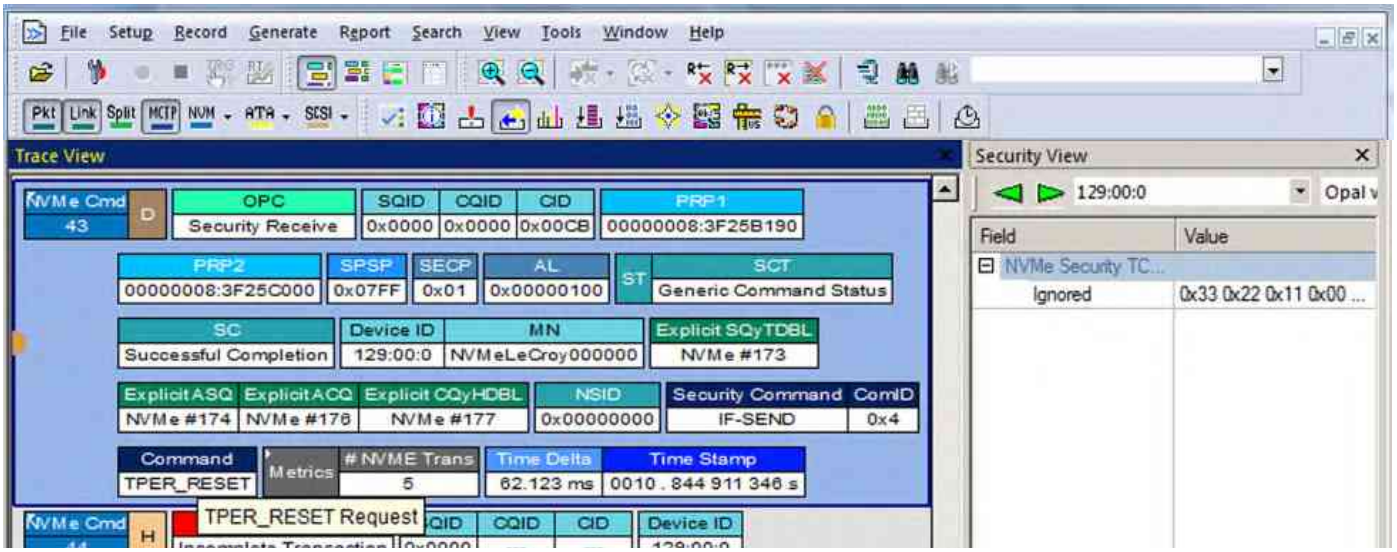


Figure 7.48: NVMe Trace: Opal TCG Security Fields Decoded

A more detailed view of the security field is shown in Figure 7.49 on page 432.

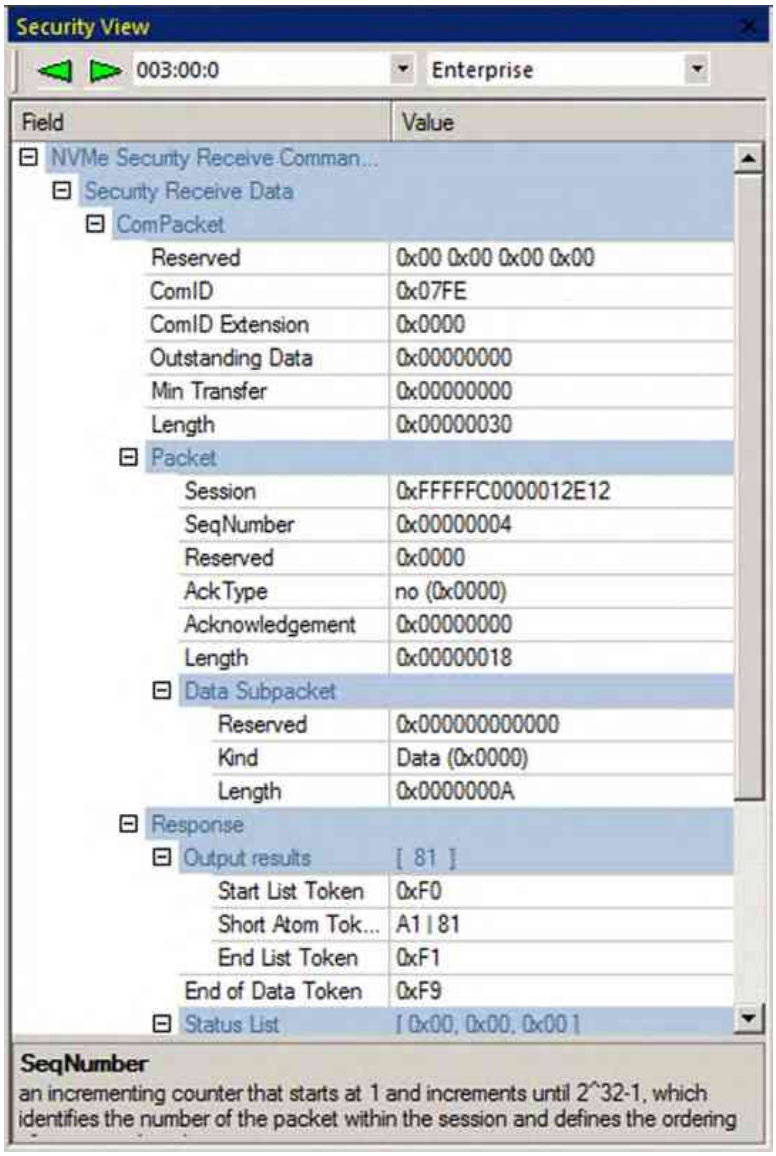


Figure 7.49: NVMe Trace: Opal TCG Security Fields Decoded in Detail

7.11.5.5 Opalite Version 0.1: Decoded

The PCIe Protocol Analysis software can decode the TCG transaction: Opalite Security Version 0.1 (as shown in Figure 7.50 and Figure 7.51 on page 434 below):

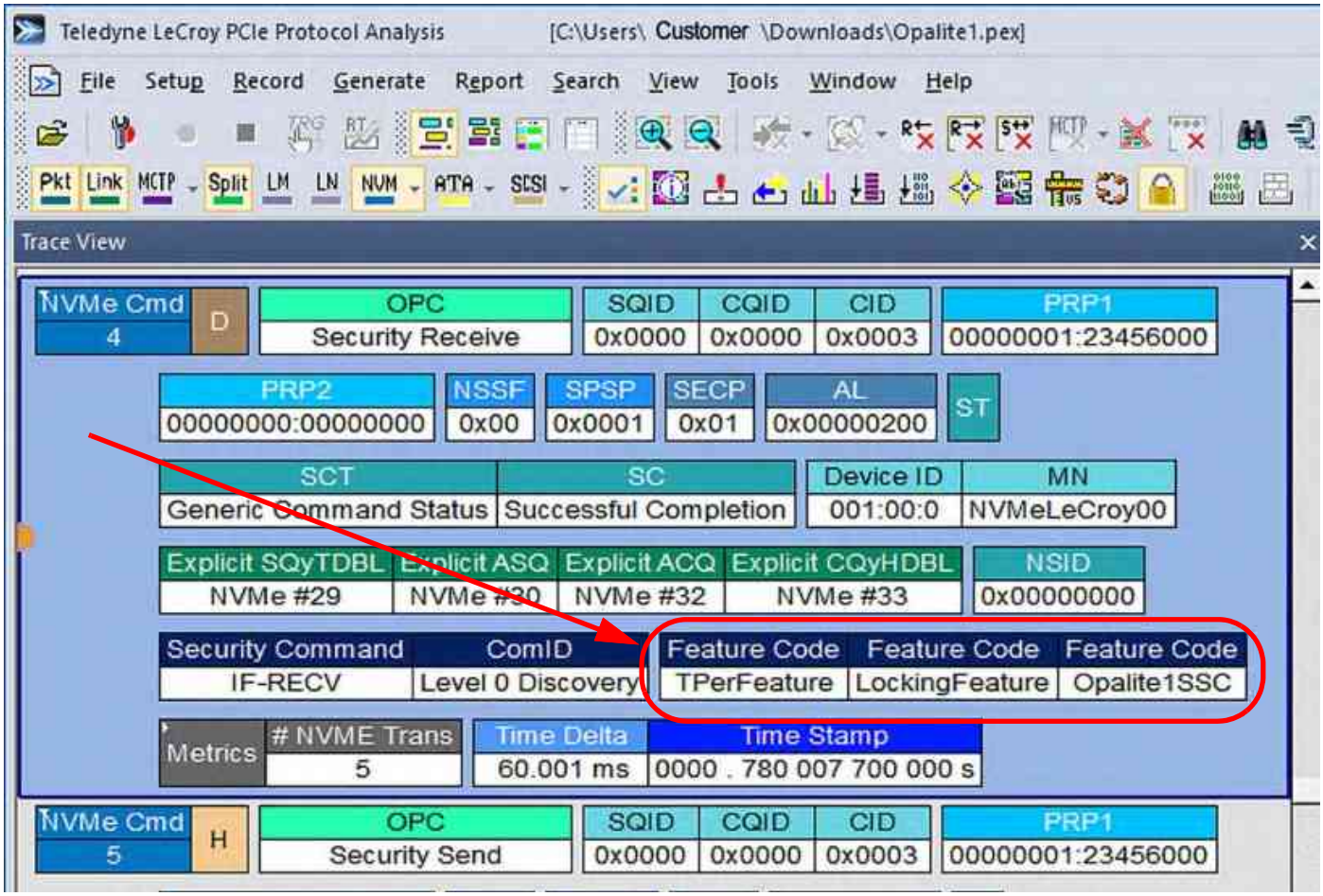


Figure 7.50: NVMe Trace: Opalite v0.1 TCG Security Fields Decoded

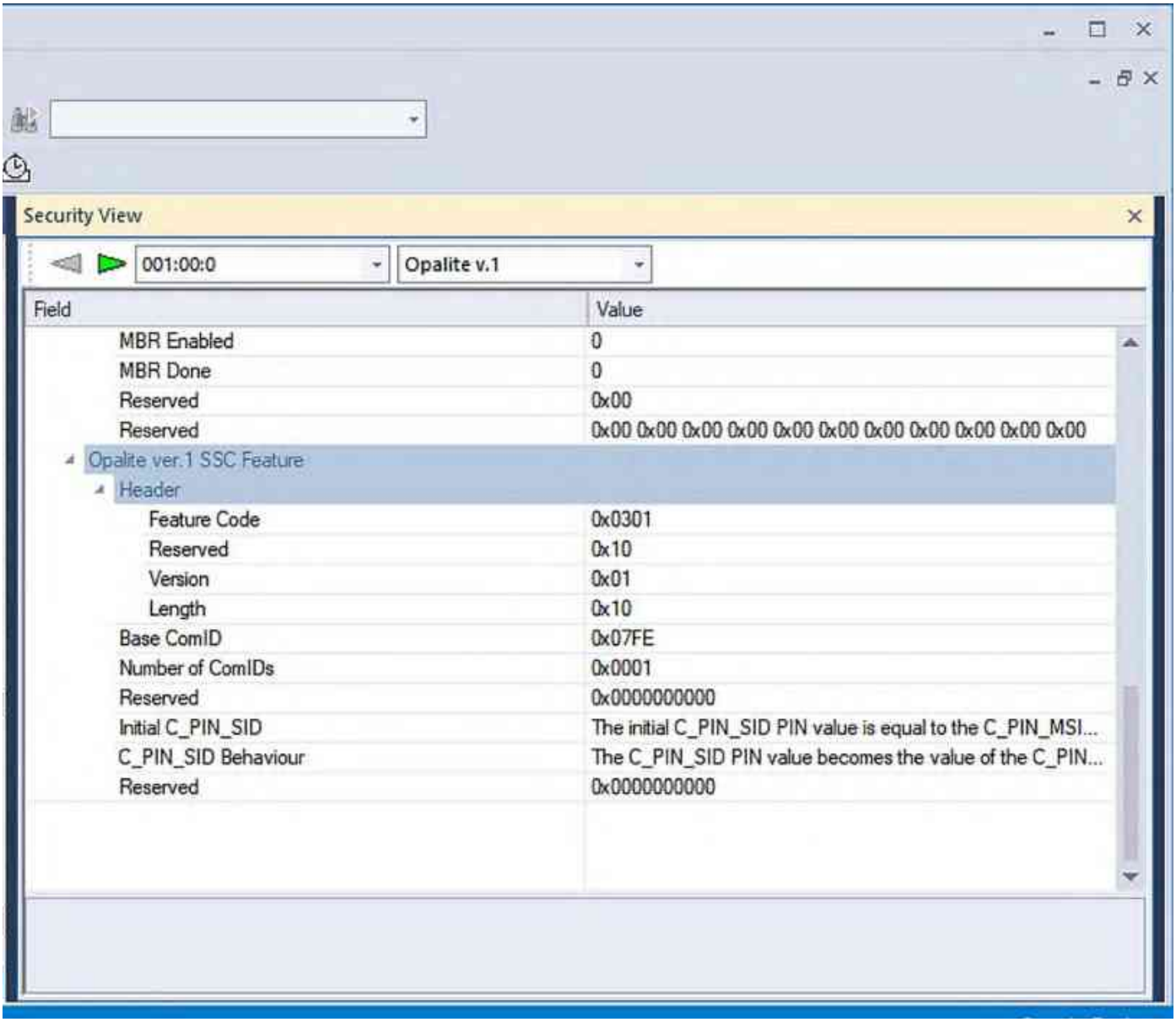


Figure 7.51: NVMe Trace: Opalite v0.1 TCG Security Fields Decoded -> Details

7.11.5.6 NVMe: Command IOPS and Doorbell Statistical Information

IOPS and Doorbell statistical information can be displayed from an NVMe Trace by selecting an NVMe Packet with a Read or Write Command and viewing the Metrics box. See Figure 7.52 and Figure 7.53 on page 435.

The Doorbell statistics include:

- SQdoorbell to CQdoorbell,
  (time from Submission Doorbell to Completion Doorbell)
- SQDoorbell to CQentry,

(time from SQ doorbell to command completion)

- SQentry to CQentry,
  (time from submission command to command completion

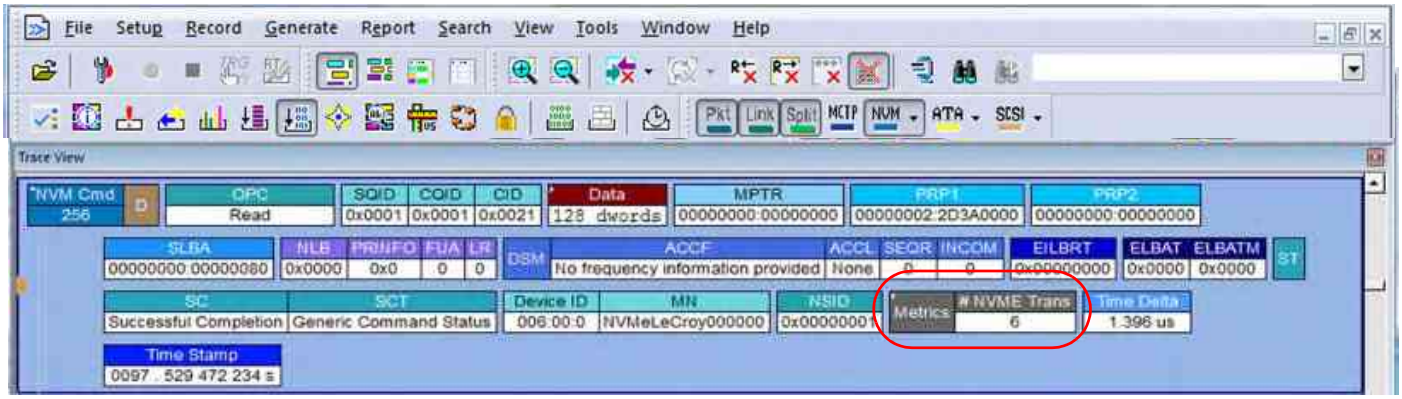


Figure 7.52: NVMe Read Command Packet with Metrics Box

Move the cursor over the Metrics box to display the information about the NVMe Command. See Figure 7.53.



Figure 7.53: NVMe Read Command Packet with Metrics Displayed

If you click on the white arrow in the Metrics box, the information about the packet will be displayed in the Trace. See Figure 7.54.

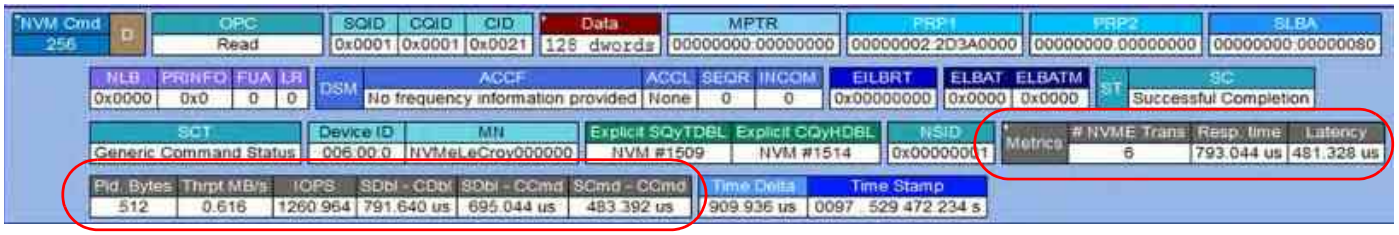


Figure 7.54: NVMe Read Command Packet with Metrics Displayed in Trace

The IOPS value is defined when you move the cursor over the IOPS box. See Figure 7.55.

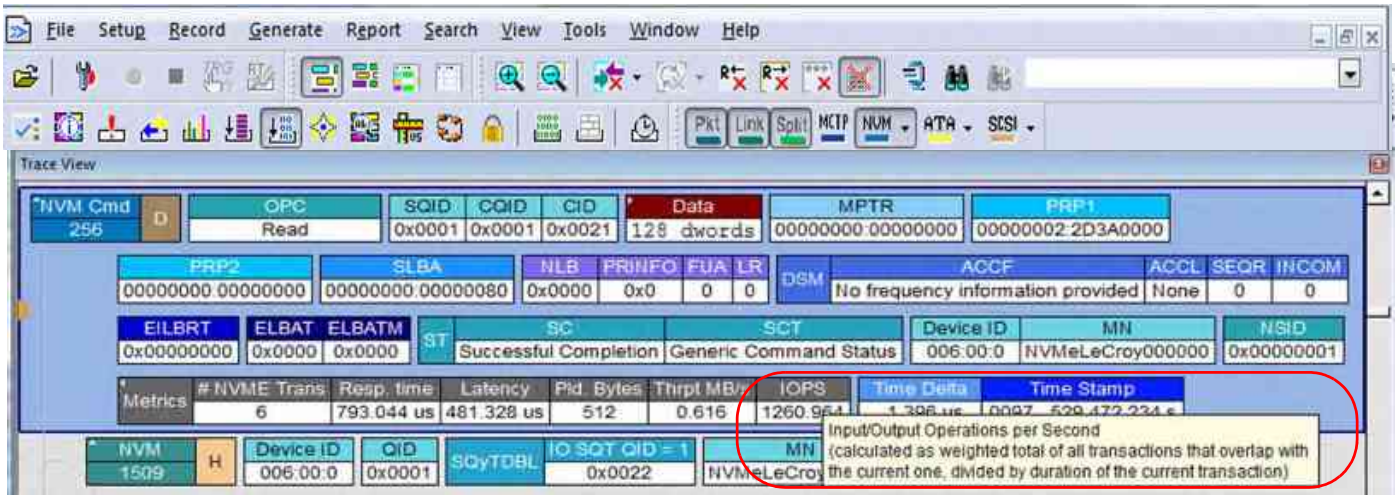


Figure 7.55: NVMe READ Command: IOPS Defined

The NMV Command IOPS can be viewed in Bus Utilization mode by selecting the Bus Utilization icon in the toolbar and selecting the Graph areas icon. See Figure 7.56.

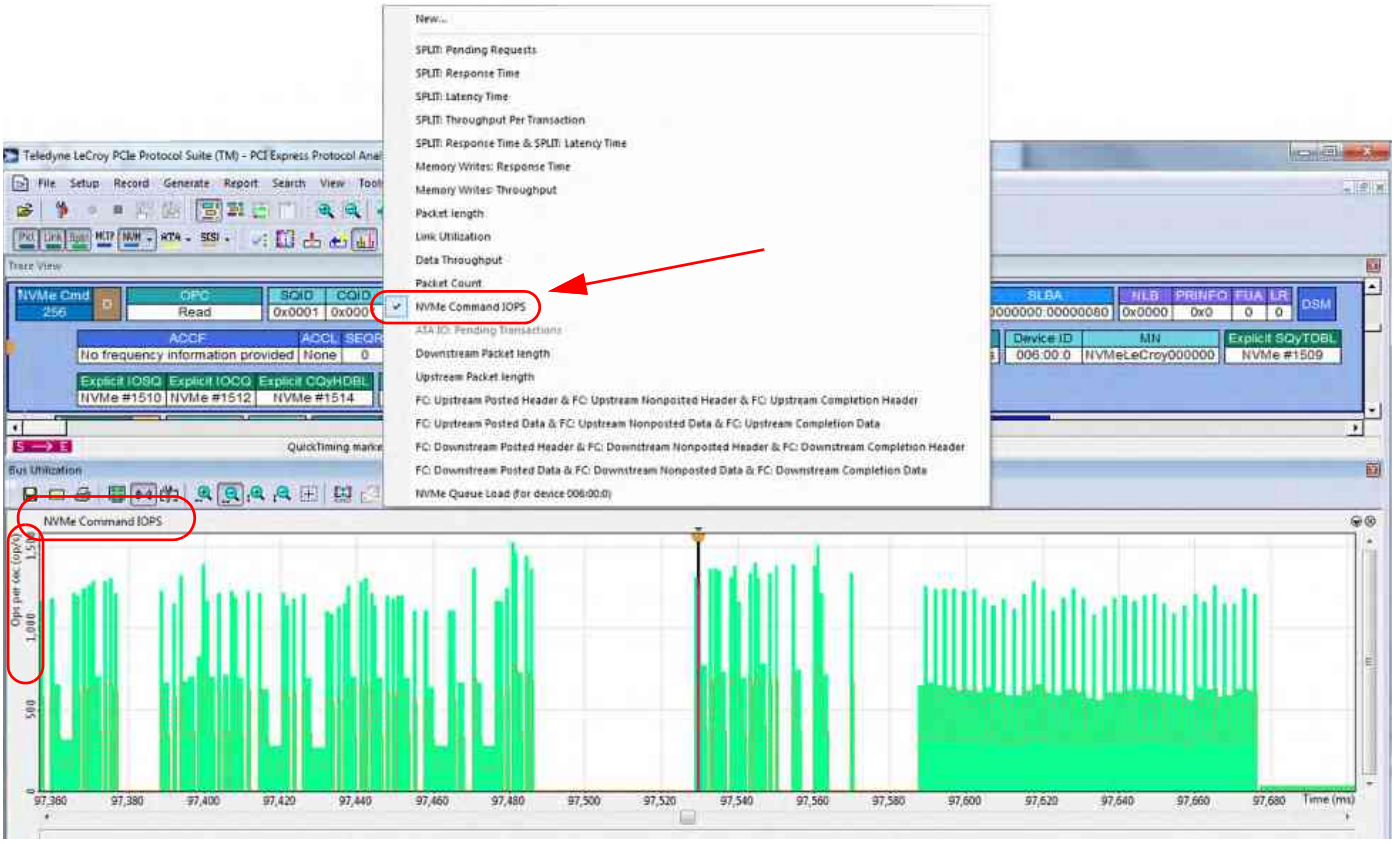


Figure 7.56: NVMe READ Command: Bus Utilization -- IOPS

NVMe Command IOPS is also displayed in the Spreadsheet and Detailed Views. See Figure 7.57.

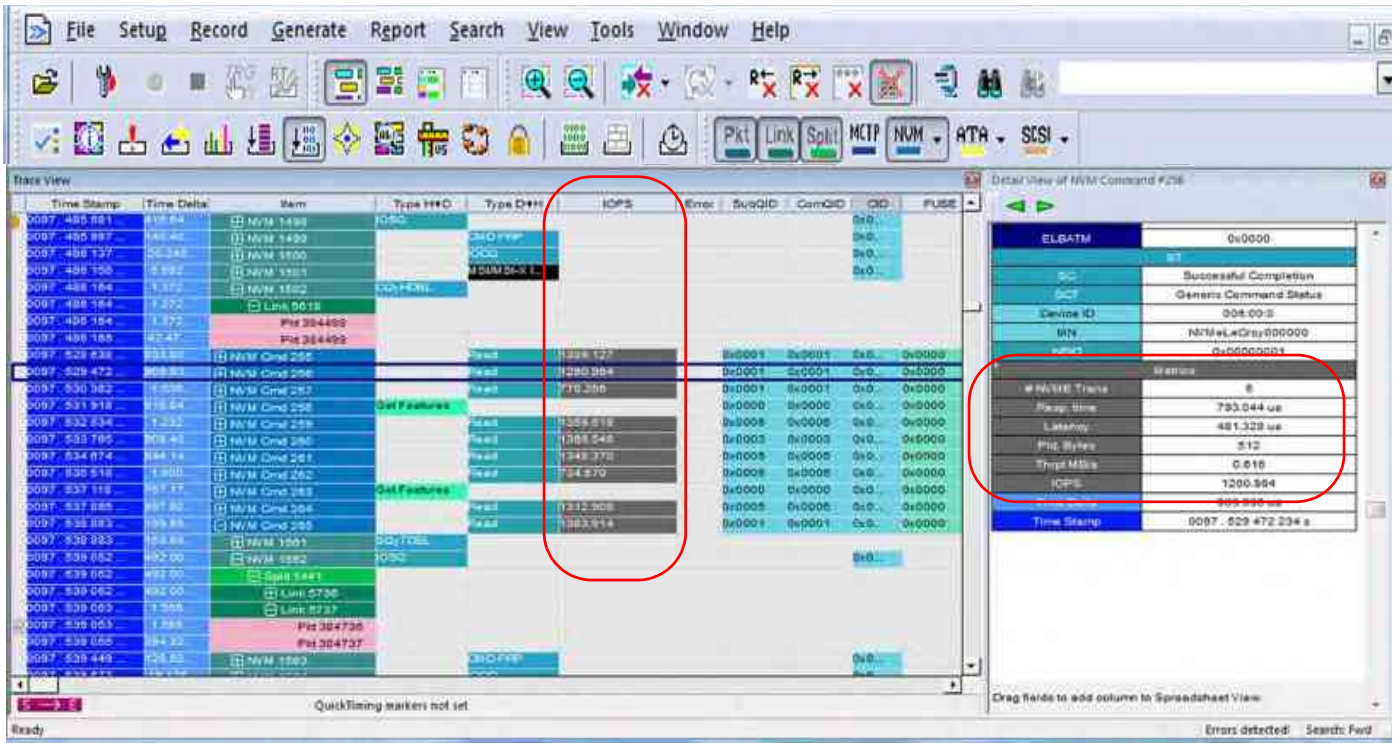


Figure 7.57: NVMe READ Command: IOPS Statistics

7.11.5.7 NVMe: Decode for Doorbells

Each type of doorbell's cell of an NVMe command is able to represent 1 of 4 states:

- Explicit (NVMe command contain concrete DBL). See Figure 7.58 on page 438.
- Implicit (Some doorbells implicitly complete previous commands. Such commands do not have a doorbell that can be associated one to one. This will be indicated in the trace.)
- Missing (NVMe cmd Is Incomplete, and DBL missing)
- Filtered (DBL is filtered out in Recording rules)

Tooltips:

- For SQyTDBL: Command was explicitly/implicitly initiated by SQyTDBL in NVMe #number (See Figure 7.58 on page 438)
- For CQyHDBL: Command was explicitly/implicitly finished by CQyHDBL in NVMe #number
- For Missing Doorbells: Doorbell is missing
- For Filtered: Doorbells are filtered out

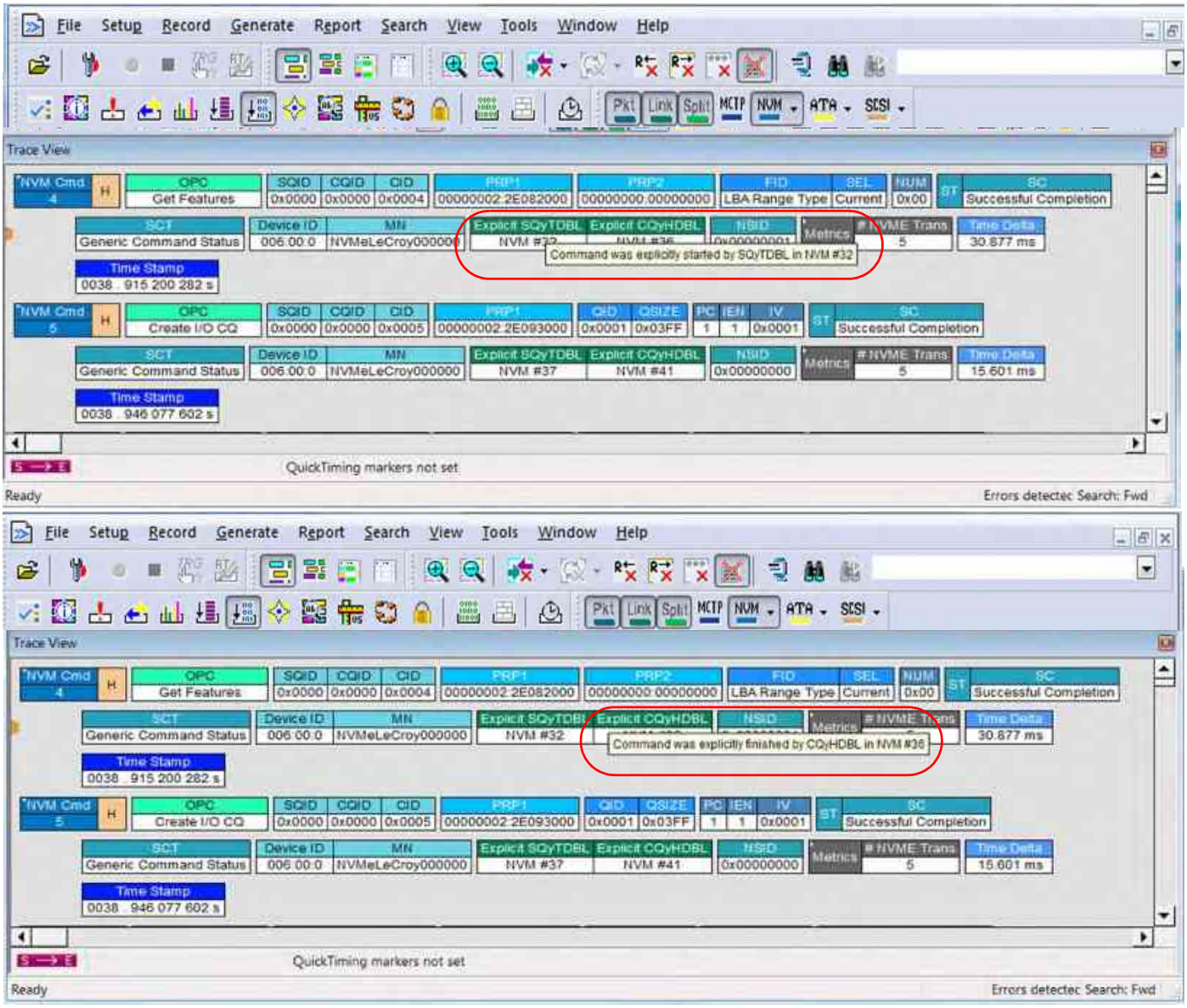


Figure 7.58: NVMe Decoding: Example of Explicit Doorbell in Trace with Tool Tips

7.11.5.8 Time Stamp from Implicit Start

The time stamp for an NVMe command can either be referenced from the recorded trace start time (see Figure 7.59) or from the implicit start of the command (see Figure 7.60). If you right click on the Time Stamp, the Time Stamp Context Menu will pop up. This allows you to Check or Uncheck the “Calculate Timestamp from implicit start if present” box.

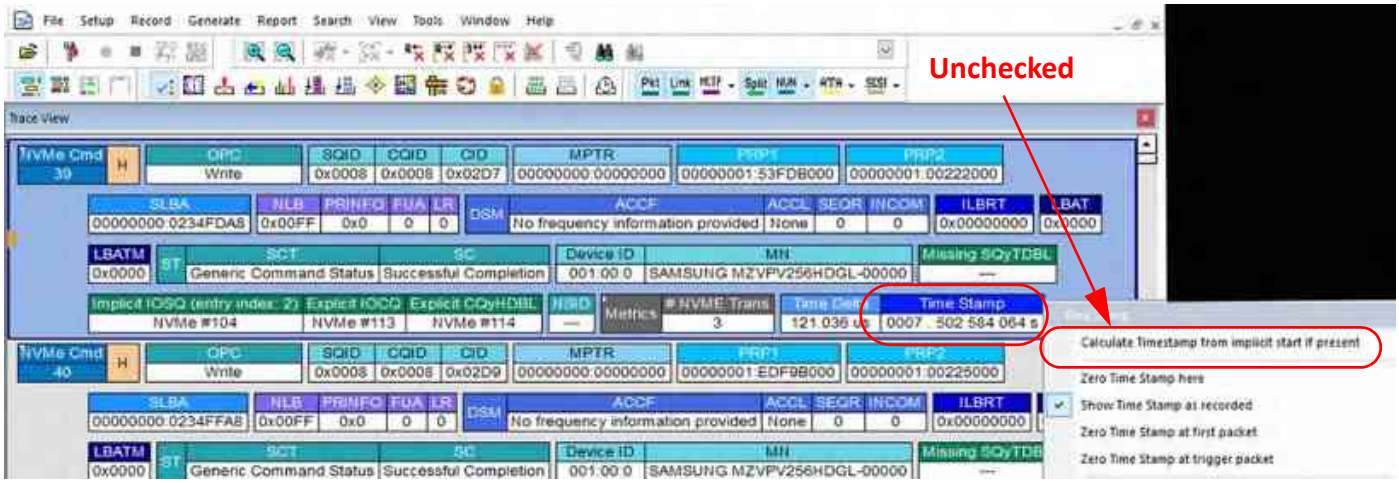


Figure 7.59: Timestamp Referenced from Start of Trace = 7.502584064 seconds

If you select “Calculate Timestamp from implicit start if present” you’ll get the following results. In this case, the Implicit Start was earlier in the trace than the NVMe command so the timestamp for the NVMe command is earlier (see Figure 7.60).

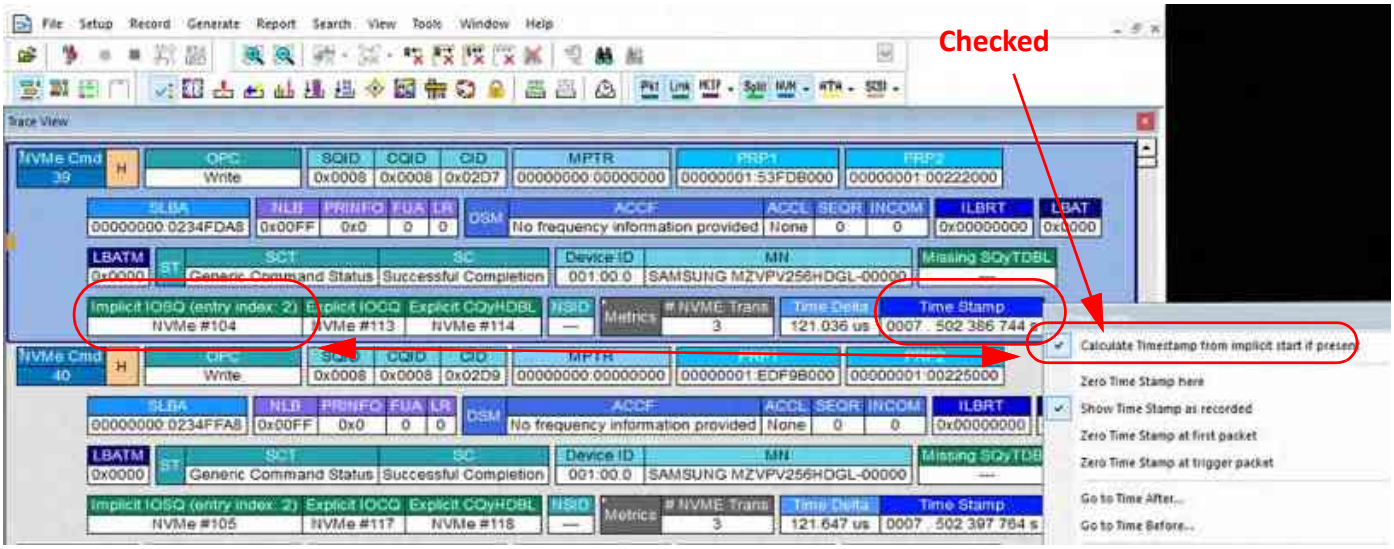


Figure 7.60: Timestamp Referenced from the Implicit Start = 7.502386744 Seconds

7.11.5.9 NVMe Commands and Transactions: Data Throughput

Data Throughput is defined as the Payload divided by response time, expressed in MB per second (MB = 1024*1024 bytes) for both Commands and Transactions. See Figure 7.61 and Figure 7.62.

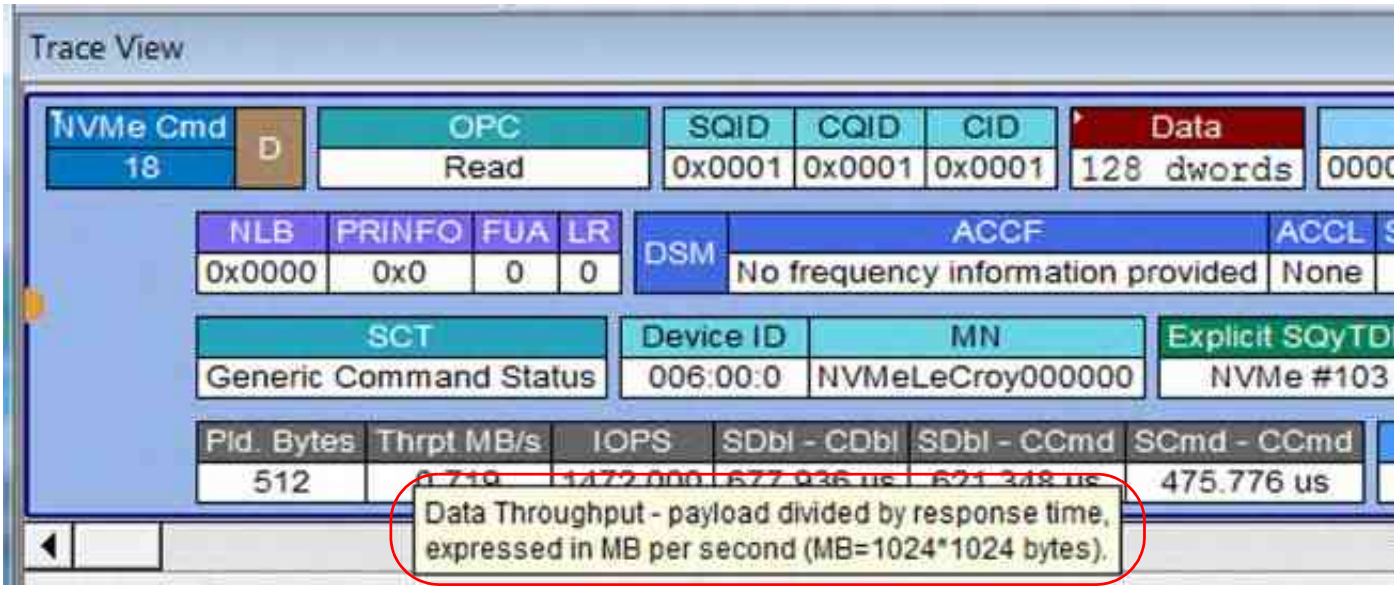


Figure 7.61: NVMe Command: Data Throughput

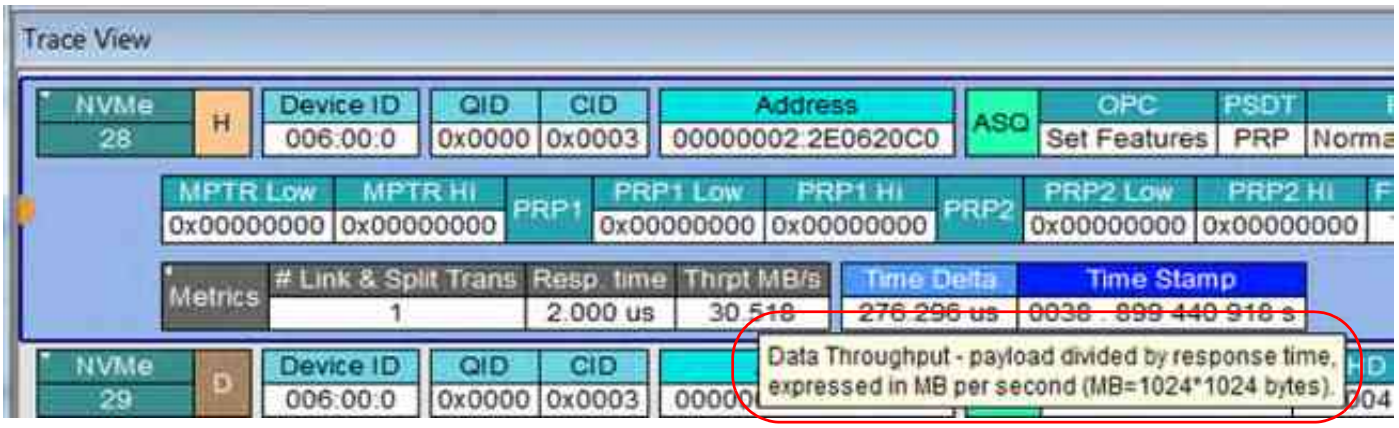


Figure 7.62: NVMe Transaction: Data Throughput

7.11.5.10 NVMe Decoding vs. NVMe Specification

After decoding an NVMe Trace you can view both the NVME data traffic in the Trace View as well as formatted per the NVMe Specification. The NVMe Specification View is brought up by selecting the NVMe Specification icon  in the tool bar (see Figure 7.63).

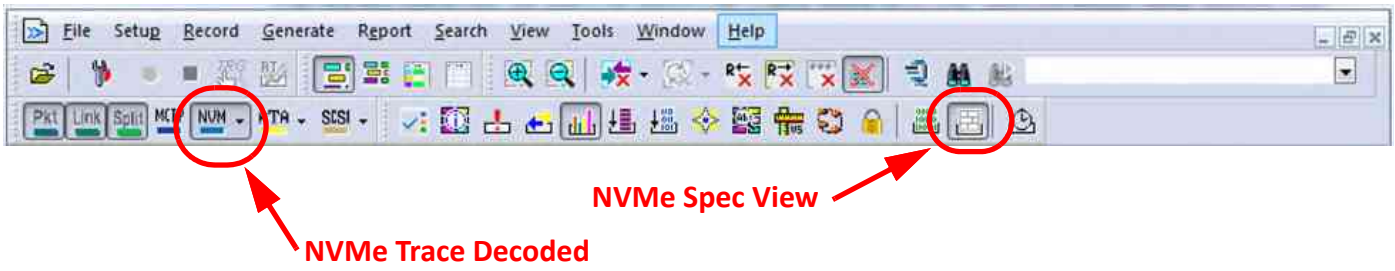


Figure 7.63: PCIe Protocol Analysis Toolbar -> NVMe Specification View

The NVMe data can be seen in both the Trace View and the Specification view below (see Figure 7.64 and Figure 7.65 on page 442).

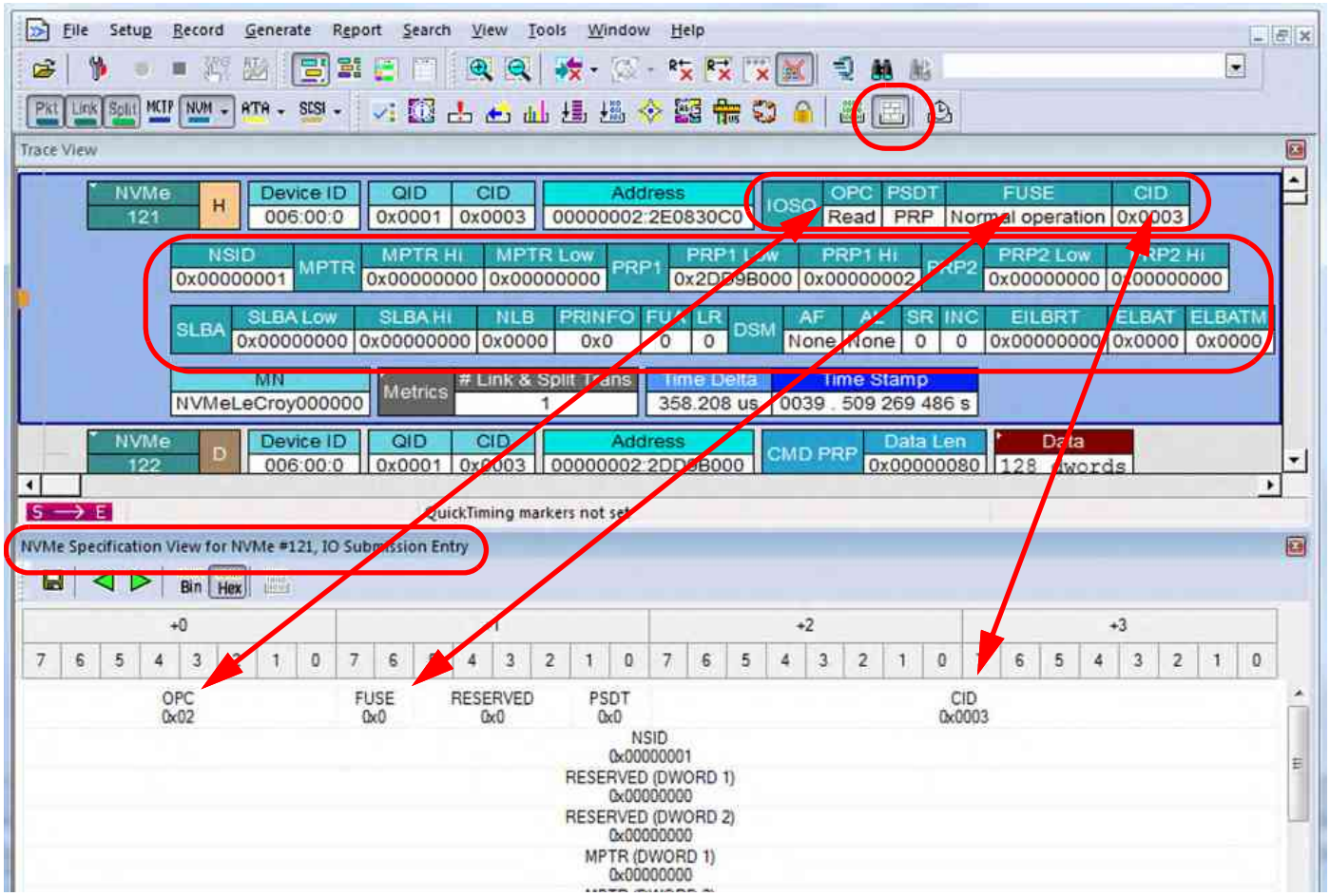


Figure 7.64: Decoding NVMe Trace -> Trace View vs. Spec View (Part 1)

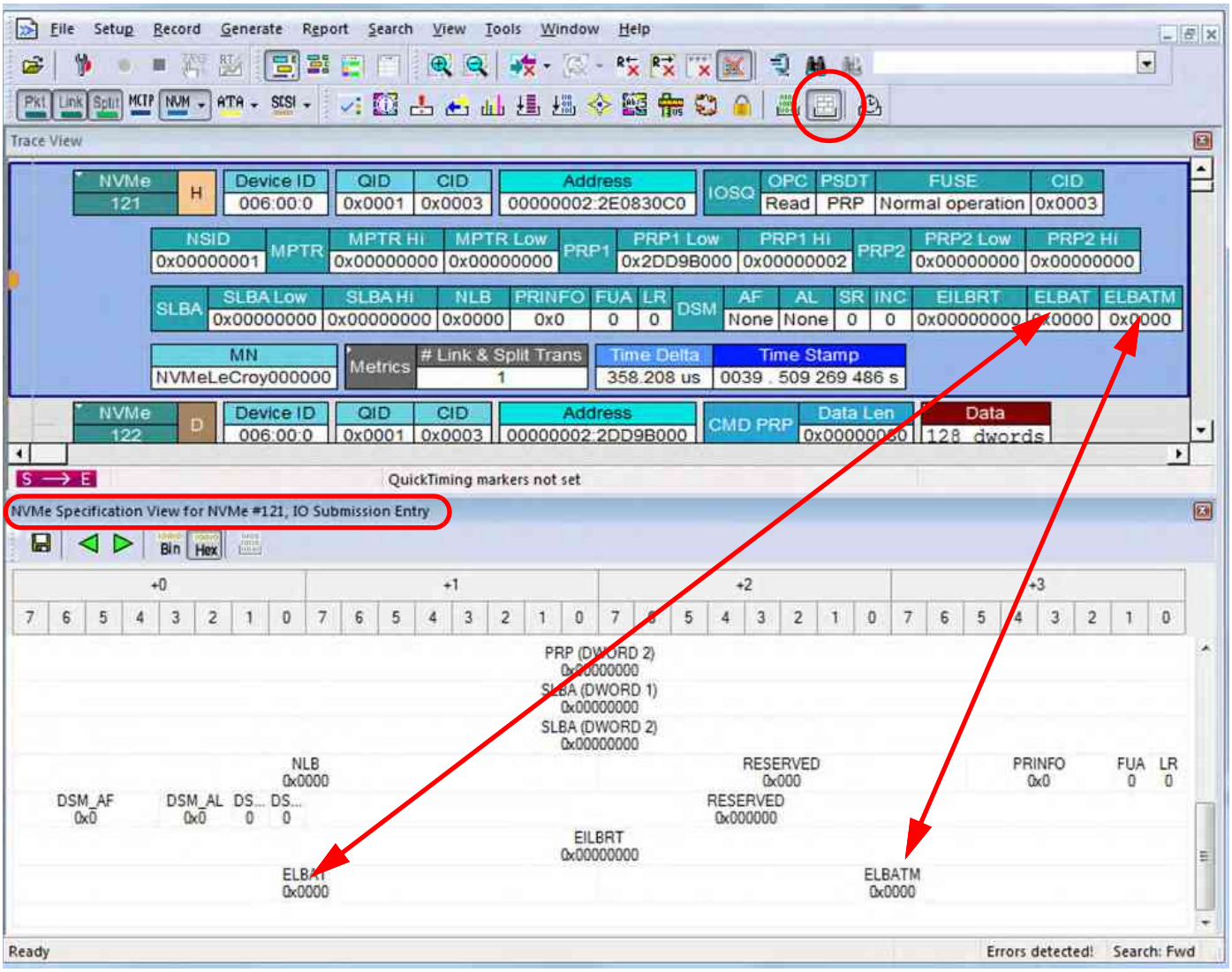


Figure 7.65: Decoding NVMe Trace -> Trace View vs. Spec View (Part 2)

If you move the cursor over a specific data block a Tool Tip will pop up with more information about the data block. See Figure 7.66

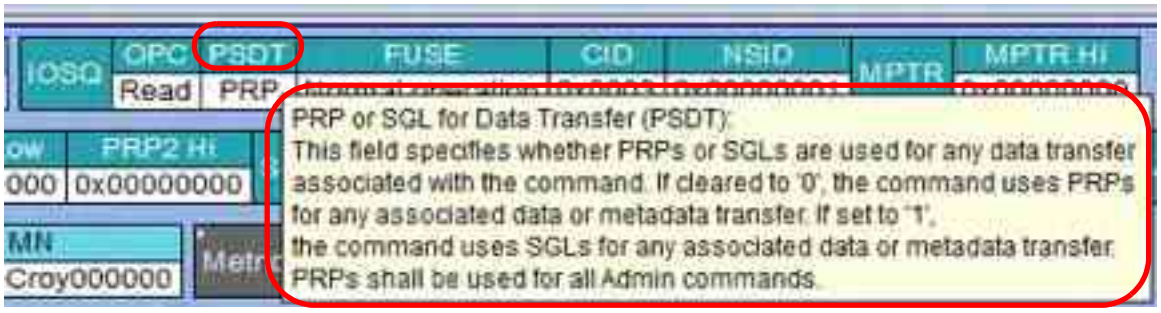


Figure 7.66: NVMe Specification: Trace View Tool Tip

Similar Tool Tips are available in the NVMe Specification View. See Figure 7.67 on page 443.

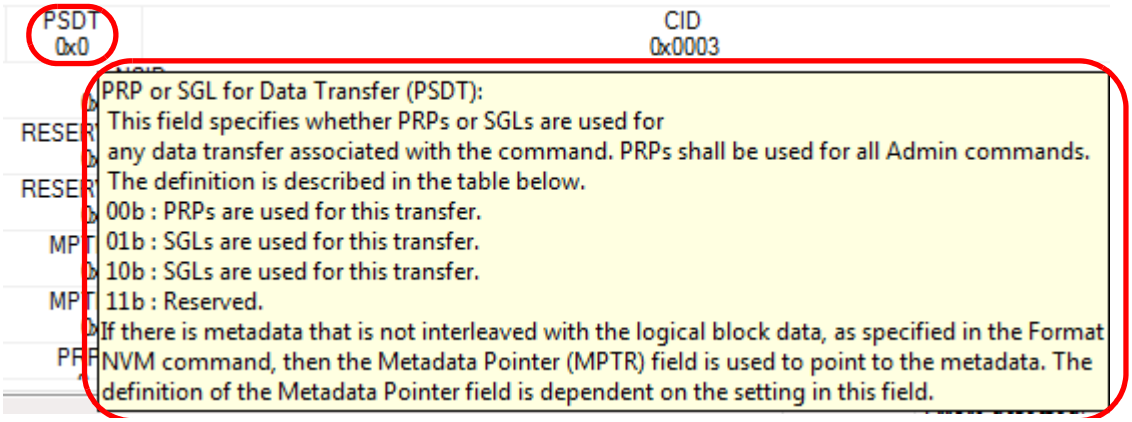


Figure 7.67: NVMe Specification View: Tool Tip

The NVMe Specification View is also available from the Main Toolbar under Report -> NVMe Specification. See Figure 7.68.

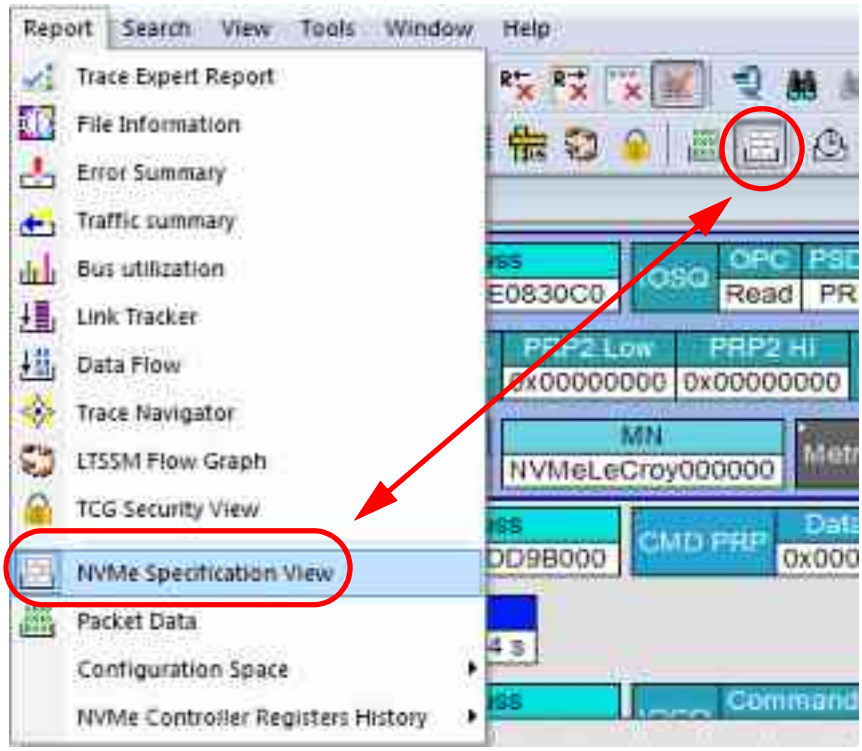


Figure 7.68: Report: NVMe Specification

7.11.5.11 NVMe Controller Register

To view the NVMe Controller Registers perform the following steps:

1. Load a trace with NVMe data traffic.

2. Select Packet, Link, Split, NVMe, Hide Unrelated Traffic and View -> Wrap to produce the following display (see Figure 7.69).

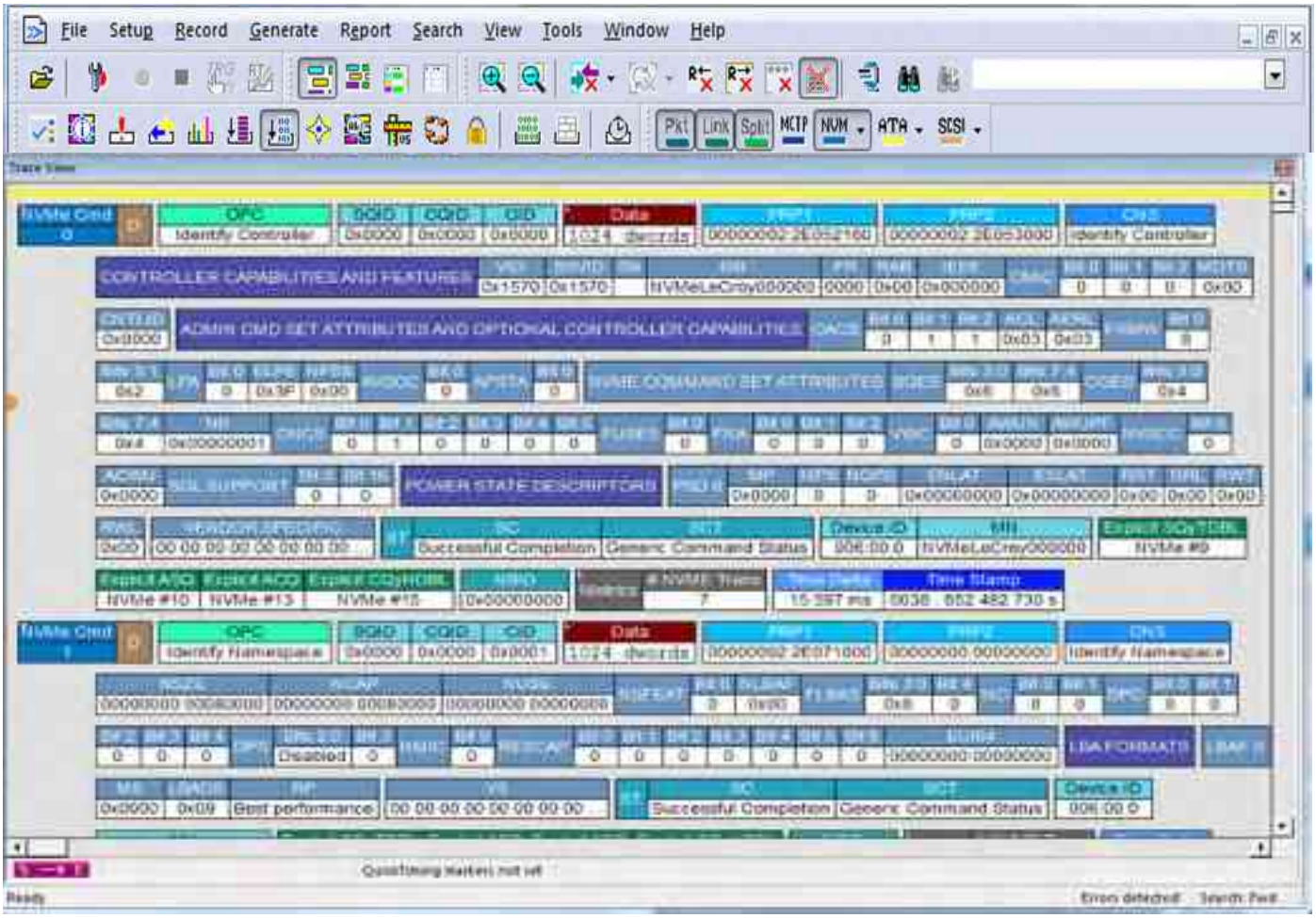


Figure 7.69: NVMe Trace Loaded

3. Select Reports -> NVMe Controller Registers History (see Figure 7.70 on page 445).

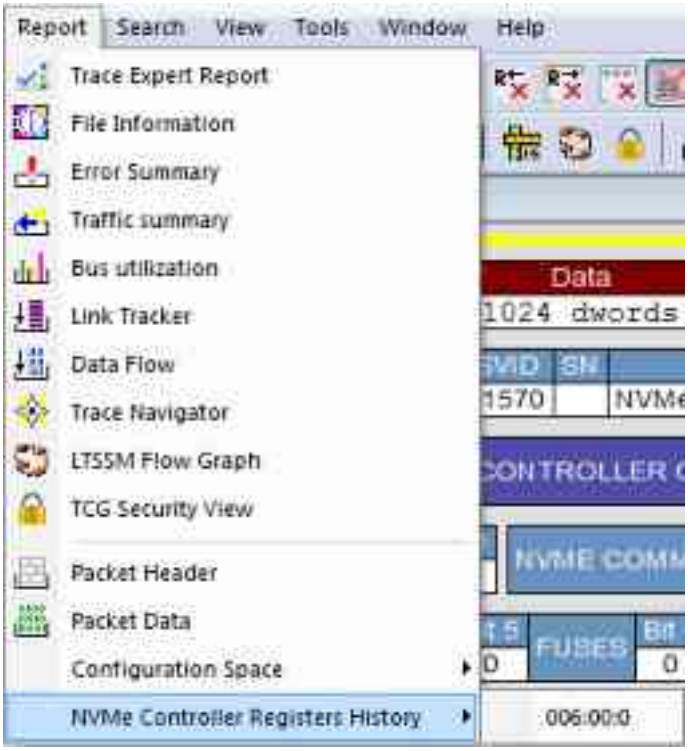


Figure 7.70: Reports -> NVMe Controller Registers History

4. Select the time shown (006:00:0) and the following display will pop up. See Figure 7.71 on page 446.

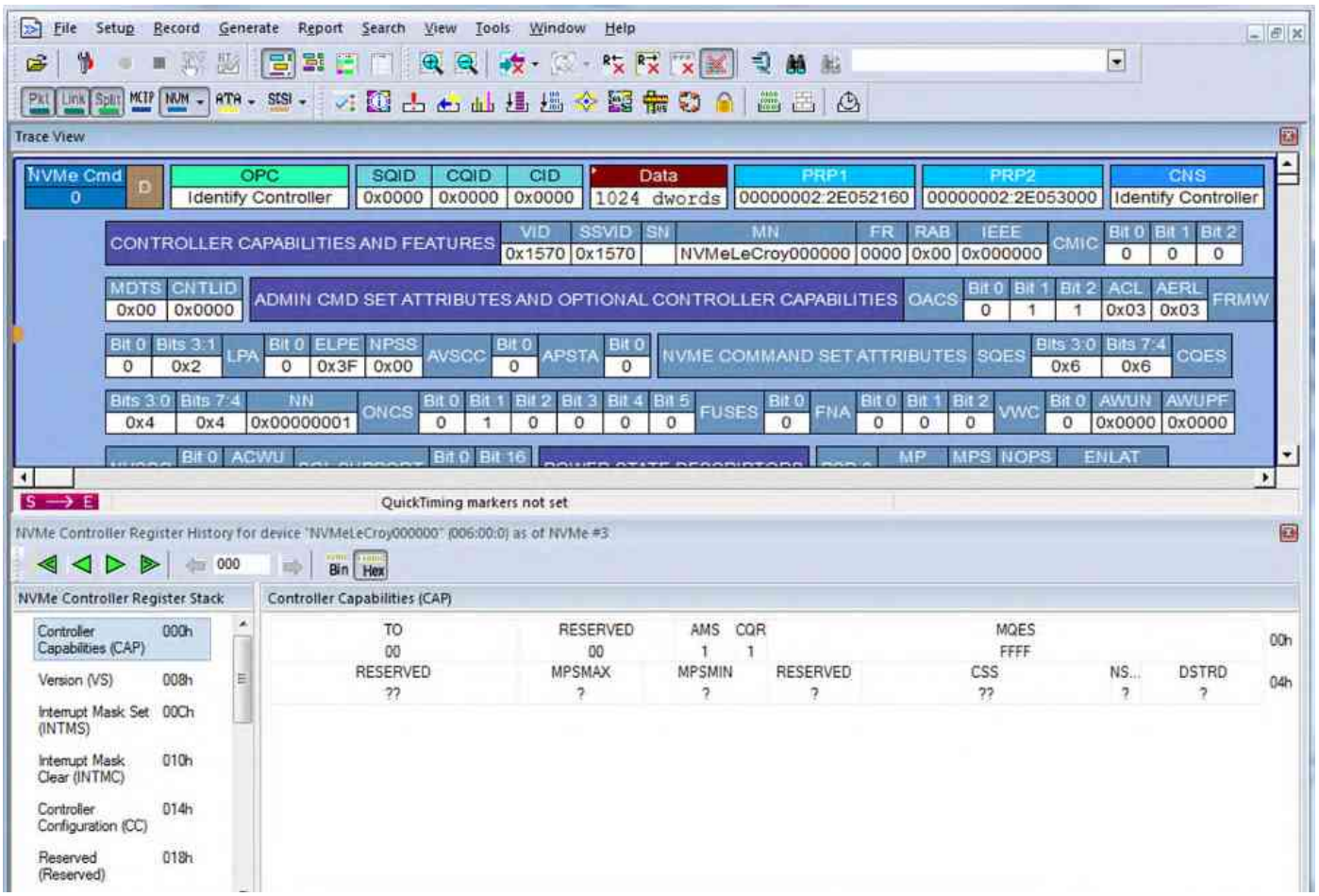


Figure 7.71: Reports -> NVMe Controller Registers History Displayed

5. If you zoom in on the green arrows, you can:
   a. Go to the First NVMe Controller Register
   b. Go to the Previous NVMe Controller Register
   c. Go to the Next NVMe Controller Register
   d. Go to the Last NVMe Controller Register

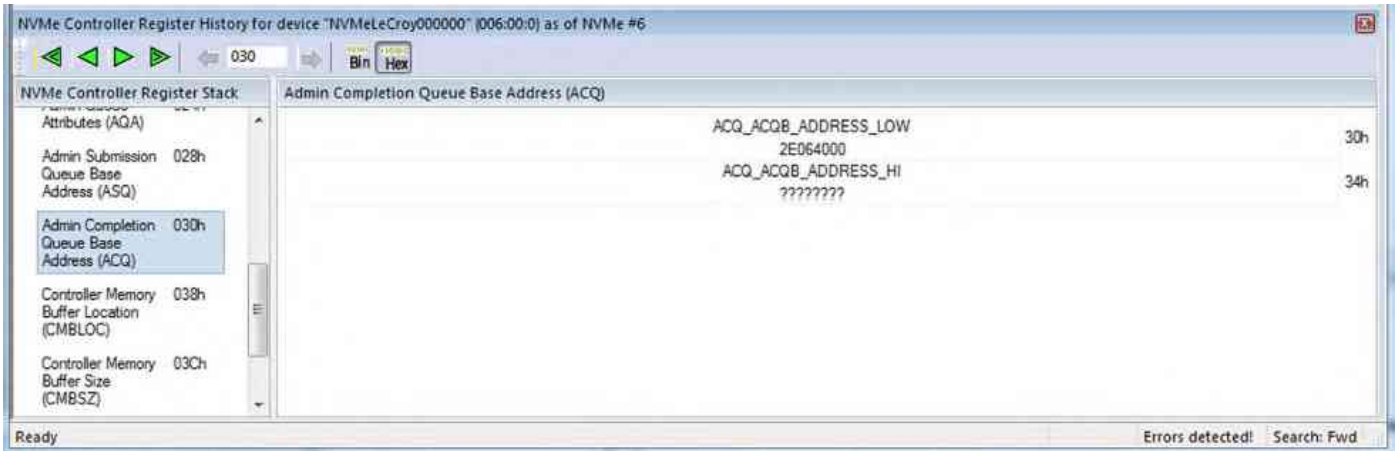


Figure 7.72: NVMe Controller Registers: Admin Completion (ACQ) 30h Displayed

6. As an example you could click on the Next NVMe arrow and the Admin Queue Attributes would be displayed (see Figure 7.73).



Figure 7.73: NVMe Controller Registers: Admin Queue Attributes (AQA) 024h Displayed

7. You can continue clicking the Green arrow to see more of the NVMe Controller Register Stack. See Figure 7.74 on page 447.



Figure 7.74: NVMe Controller Registers: Controller Status (CSTS) 01Ch

7.11.5.12 Decoding Multiple NVMe Commands for a Single MemRead or MemWrite

In some cases, a controller may fetch multiple NVMe commands in a single Memory Read or Write. At the NVMe Command level, the Analyzer software will decode this and show that there is an Implicit I/O Submission Queue Entry for that command and refer to the NVMe Transaction where the command was fetched from the Submission Queue. See Figure 7.75. NVMe transactions that are part of the current NVMe command are labeled as Explicit. In this case, the I/O Completion Queue contains NVMe transaction 311924 and it's labeled as an Explicit entry (also shown in Figure 7.75).

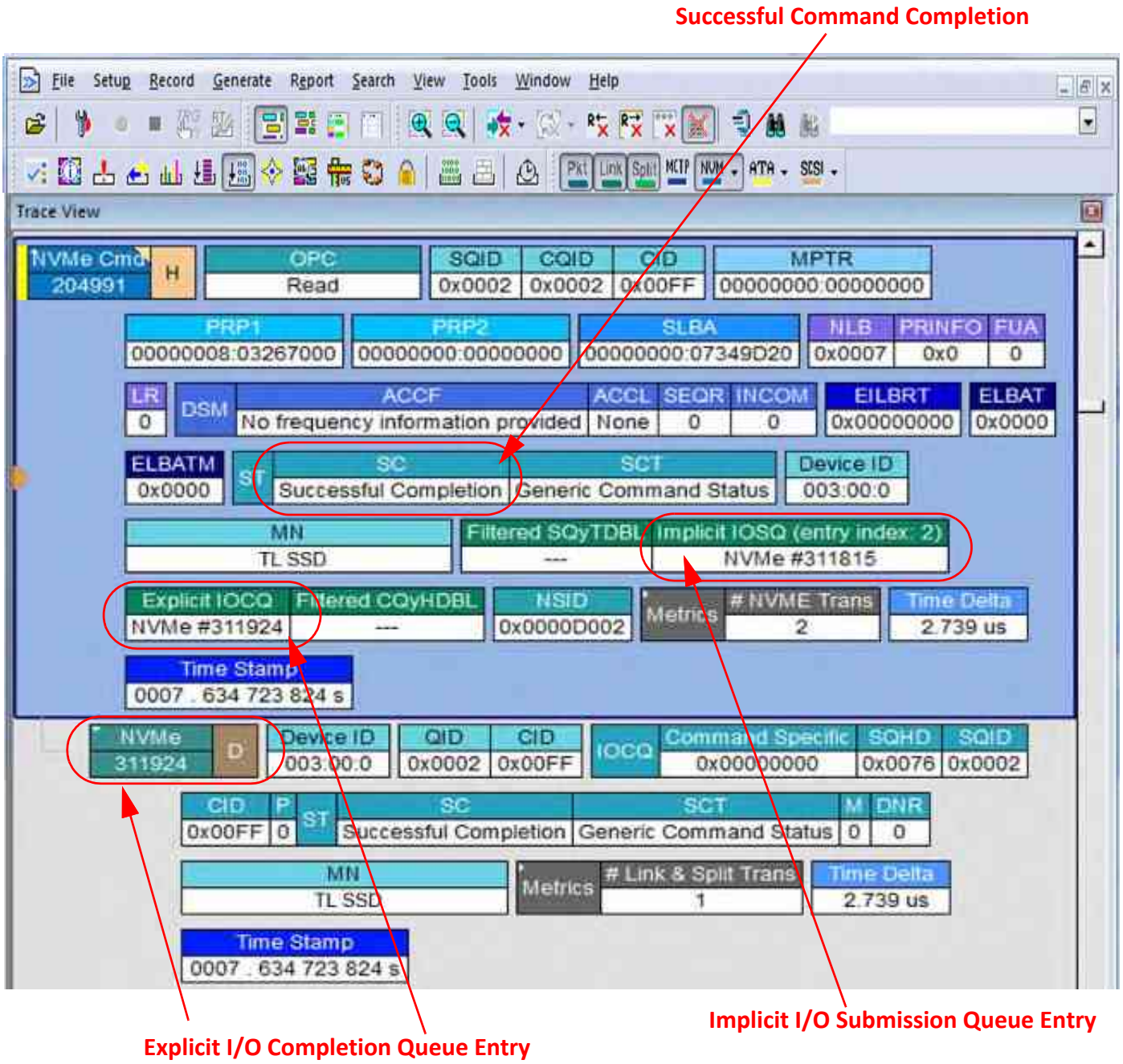


Figure 7.75: Implicit I/O Submission Queue Entry (IOSQ) and Explicit I/O Completion Queue Entry (IOCQ)

NVMe Transactions Decoded for NVMe Read Command:

- Implicit IOSQ: NVMe Transaction #311815 (entry index: 2)
- Explicit IOCQ: NVMe Transaction #311924 (part of this NVMe command: 204991)

The Implicit NVMe transaction (referenced by the Implicit label vs. Explicit label) can be found by right clicking on the NVMe transaction number in the trace display (see Figure 7.76).

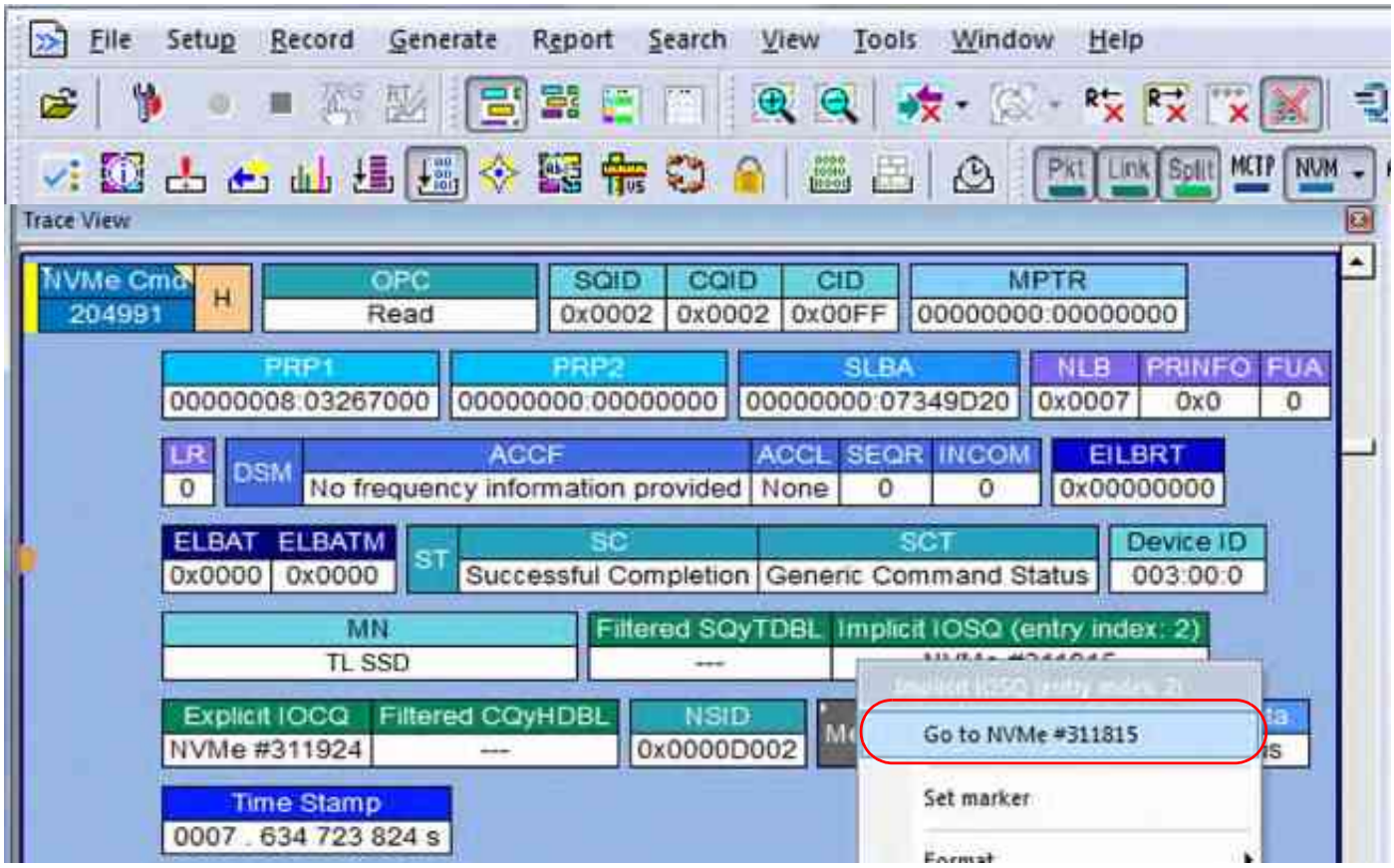


Figure 7.76: Implicit IOSQ Command

The display will be updated to that NVMe Transaction Number (and show the NVMe Command that it's a part of. In this case the Implicit NVMe Transaction (311815) is part of NVMe Command Number 204918. See Figure 7.77 on page 450)

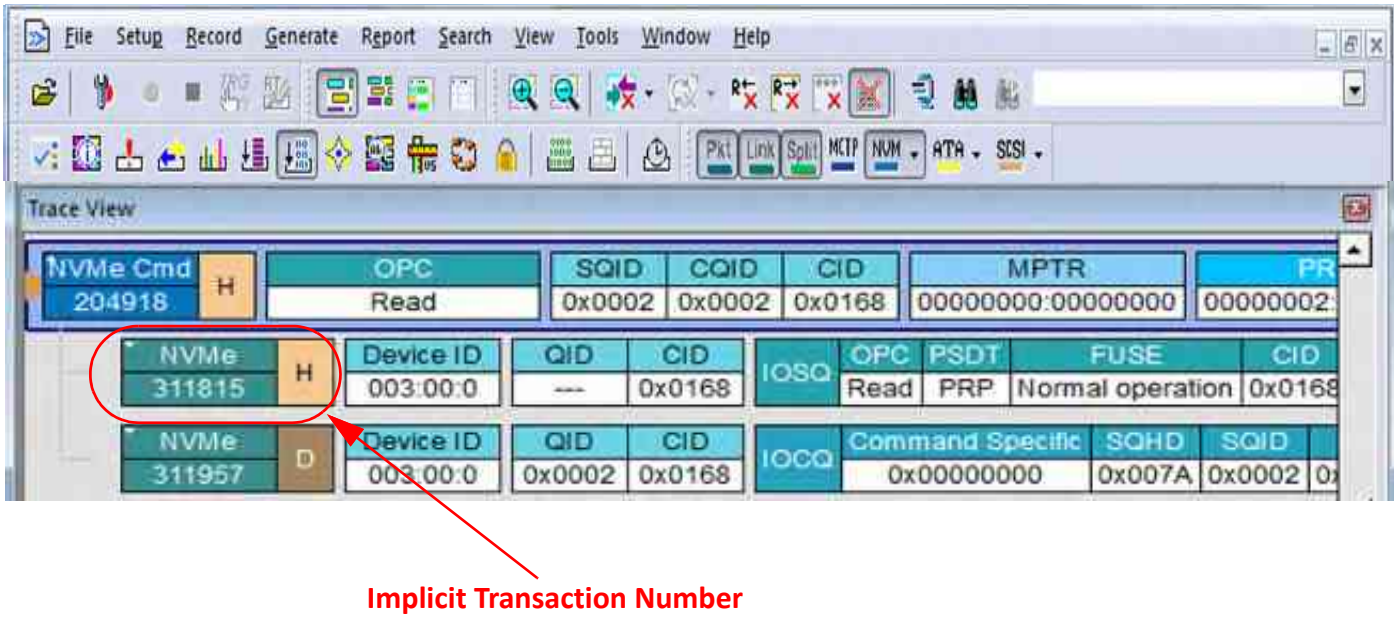


Figure 7.77: NVMe Transaction #318815: Part of NVMe Command 204918

If you expand the NVMe Transaction 311815 down to the Packet level (312224), you'll see two commands (32 DWORDS). See Figure 7.78.

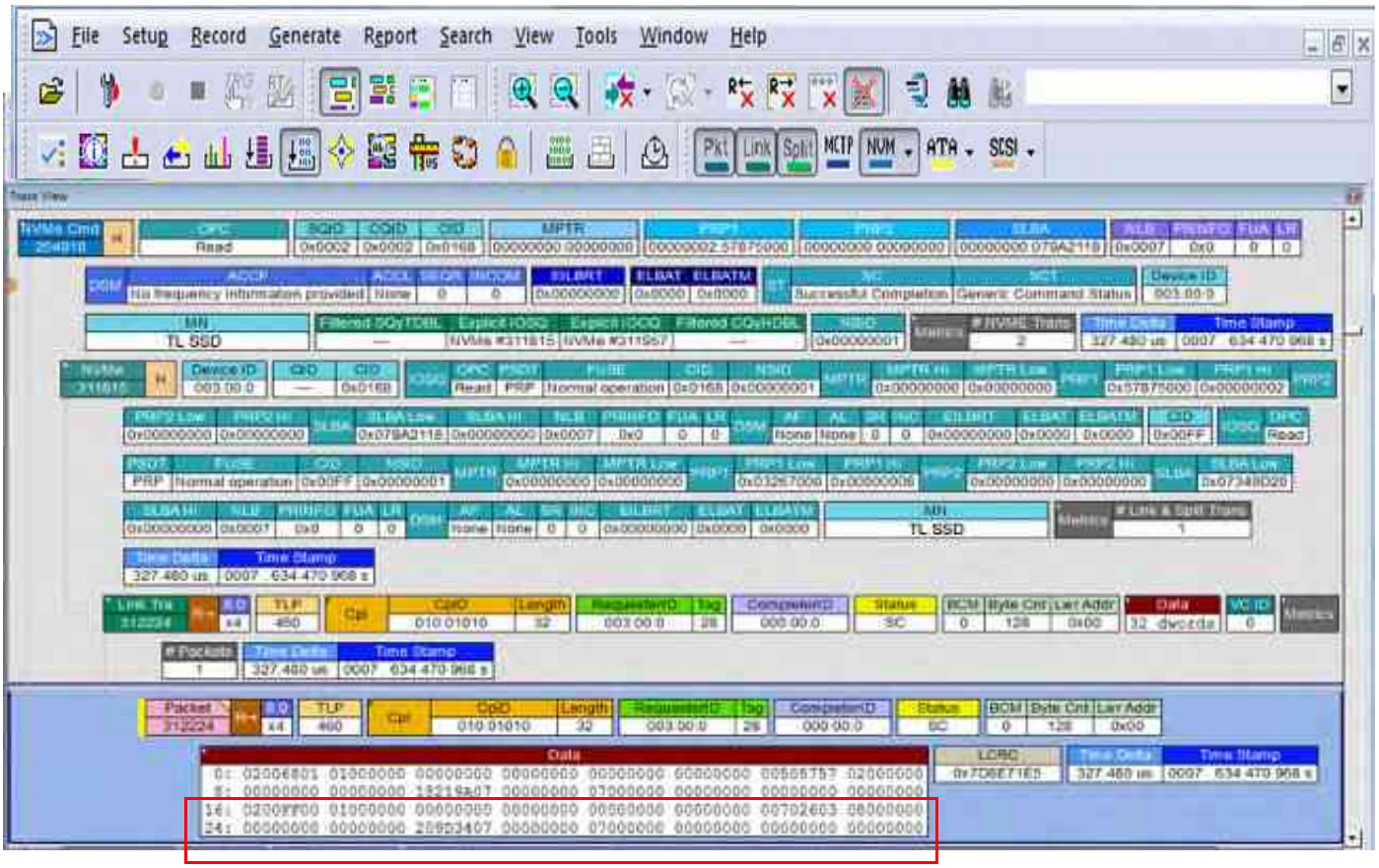


Figure 7.78: Implicit NVMe Transaction Decoded to Packet Level with Two Commands

7.11.6 NVMe 1.2 Specification Decoding

The PCIe Protocol Analysis has several enhancements to decode the NVMe 1.2 Specification (as seen in the following figures: Figure 7.79, Figure 7.80, Figure 7.81 on page 453 and Figure 7.82 on page 454).

- Name Space Management
- Replay Protected Memory Blocks
- SSD Dialog Shared NameSpace
- SSD Dialog Version and CMB Configurations

The figure below (Figure 7.79) shows the support added for decoding of the namespace management commands in NVMe data traffic.

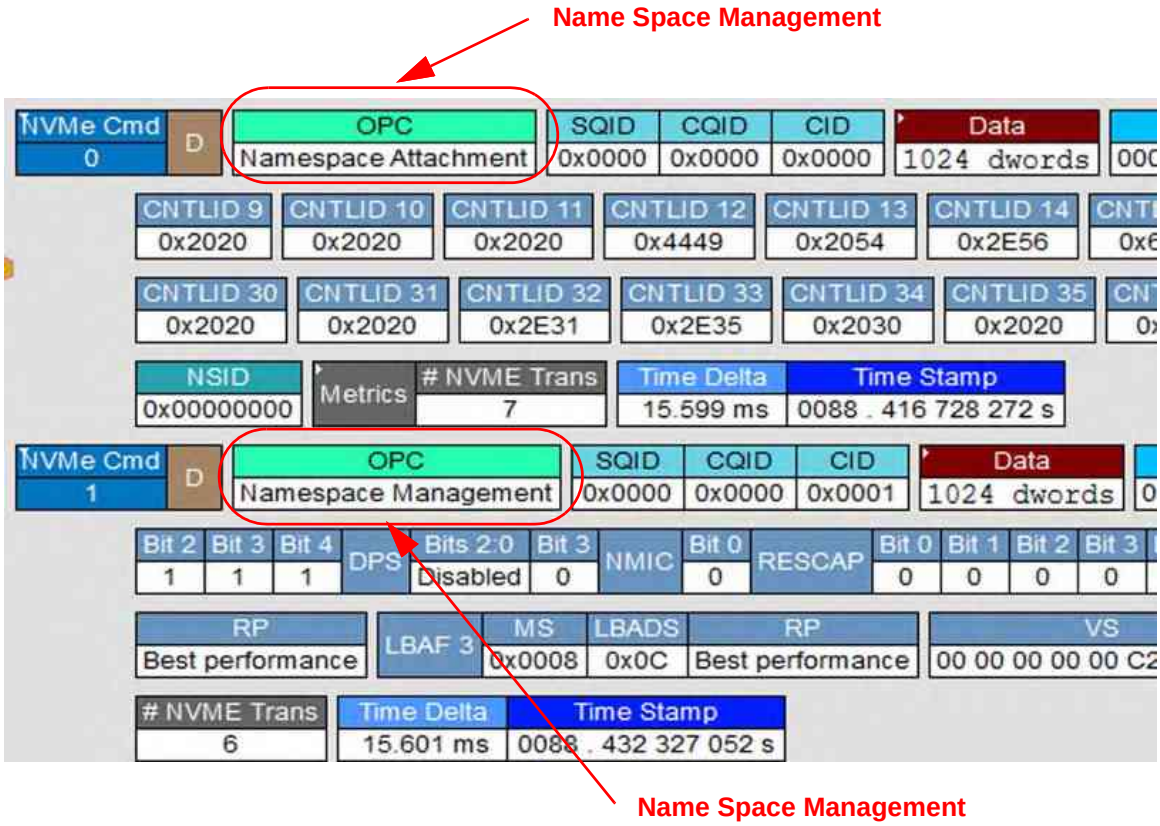


Figure 7.79: NVMe 1.2 Specification: Name Space Management

The Namespace Management command is used to create a namespace or delete a namespace. The Namespace Attachment command is used to attach and detach controllers from a namespace. Namespace management is intended for use during manufacturing or by a system administrator.

When a namespace is detached from a controller or deleted it becomes an inactive namespace on that controller. Previously submitted but uncompleted or subsequently submitted commands to the affected namespace are handled by the controller as if they were issued to an inactive namespace.

The figure below (Figure 7.80) shows the support added for the Replay Protected Memory Block (RPMB) command in NVMe data traffic.

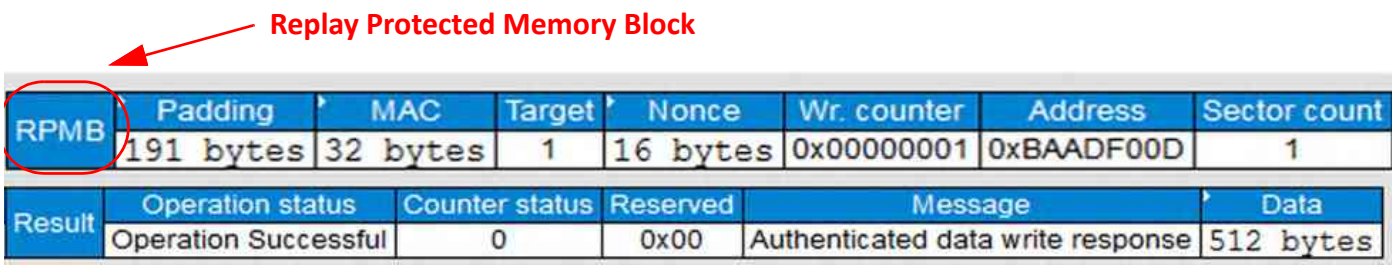


Figure 7.80: NVMe 1.2 Specification: Replay Protected Memory Block

The Replay Protected Memory Block (RPMB) provides a means for the system to store data to a specific memory area in an authenticated and replay protected manner. This is provided by first programming authentication key information to the controller that is used as a shared secret. The system is not authenticated in this phase, therefore the authentication key programming should be done in a secure environment (e.g., as part of the manufacturing process). The authentication key is utilized to sign the read and write accesses made to the replay protected memory area with a Message Authentication Code (MAC). Use of random number (nonce) generation and a write count register provide additional protection against replay of messages where messages could be recorded and played back later by an attacker.

The figure below (Figure 7.81) shows the support added for the Shared Namespace command in NVMe data traffic.

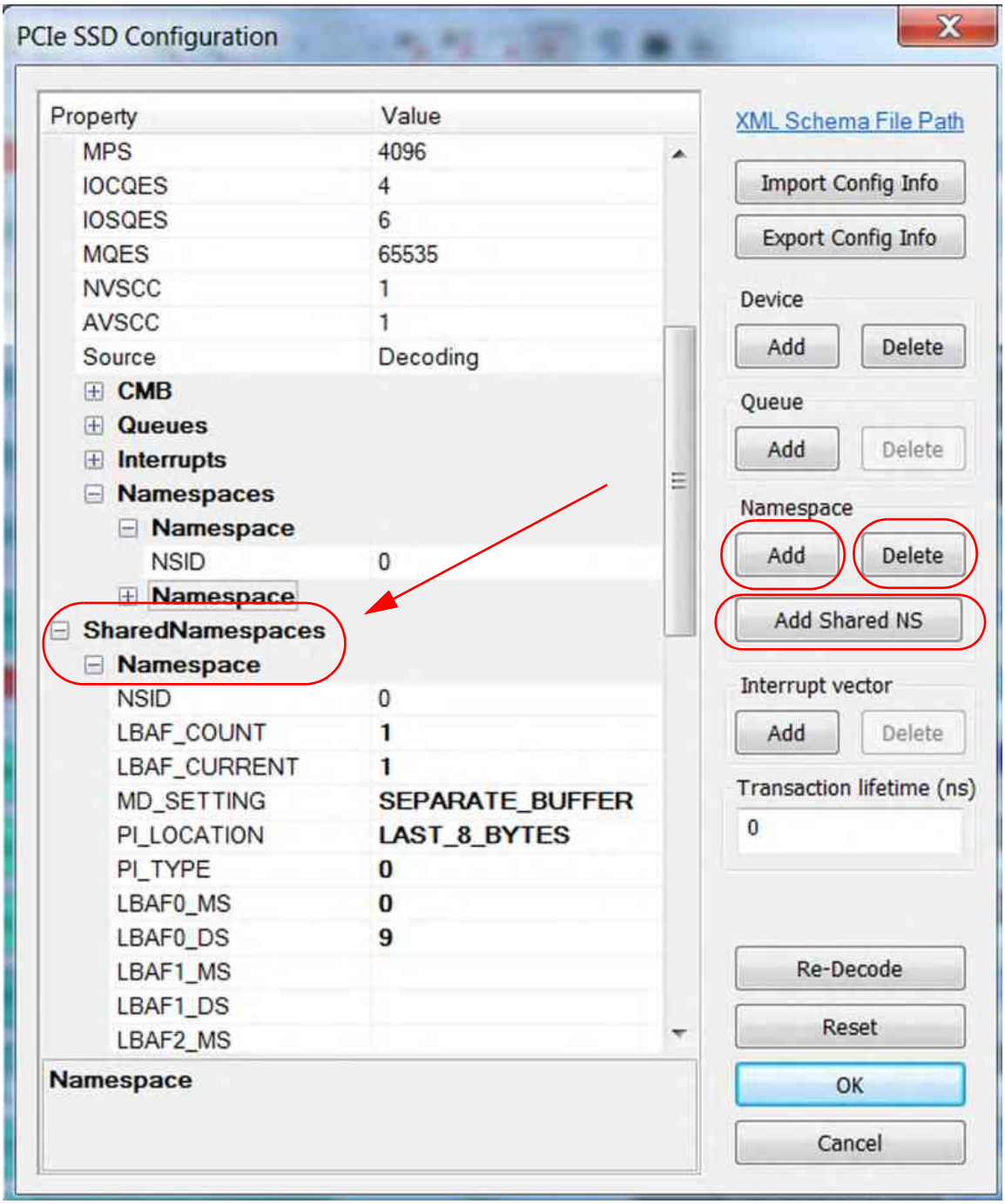


Figure 7.81: NVMe 1.2 Specification: Shared Namespaces

You can “Add” or “Delete” a namespace or Add a Shared namespace. A shared namespace is defined as a namespace that is accessible by two or more controllers in an NVM subsystem. A host may determine whether a namespace is a private namespace or may be a shared namespace by the value of the Namespace Multi-path I/O and Namespace Sharing Capabilities (NMIC) field in the Identify Namespace data structure.

The figure below (Figure 7.82) shows the added support for the Controller Memory Buffer (CMB) as defined in the NVMe 1.2 Spec.

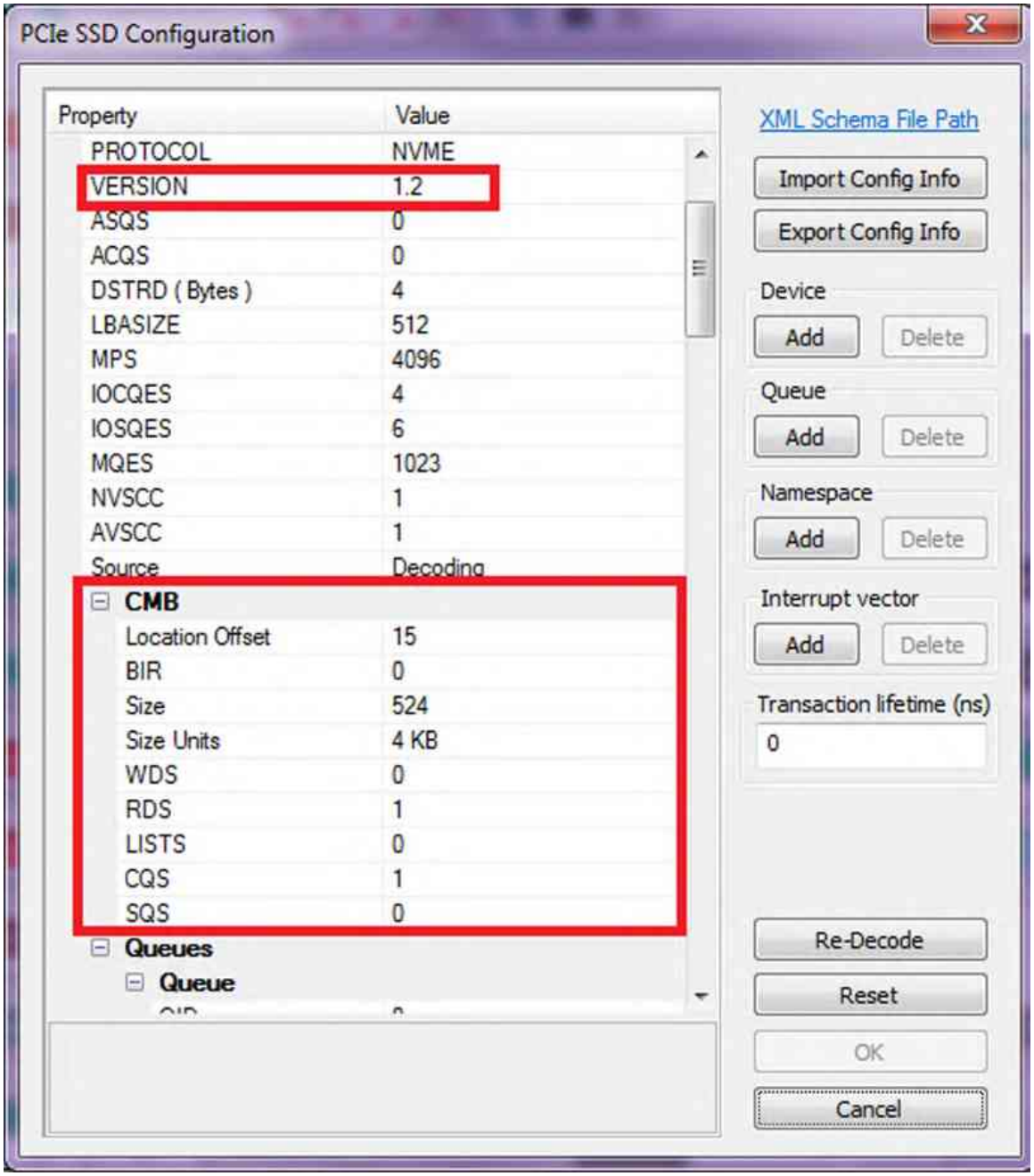


Figure 7.82: NVMe 1.2 Specification: SSD Dialog Version and CMB Configuration

The Controller Memory Buffer (CMB) is a region of general purpose read/write memory on the controller that may be used for a variety of purposes. The controller indicates which purposes the memory may be used for by setting support flags in the CMBSZ register.

7.11.7 Support for Physical Region Page (PRP) and Scatter Gather List (SGL) in Controller Memory Buffer (CMB)

The PCIe Protocol Analysis software supports PRP and SGL in CMB. See Figure 7.83 through Figure 7.85 on page 457.

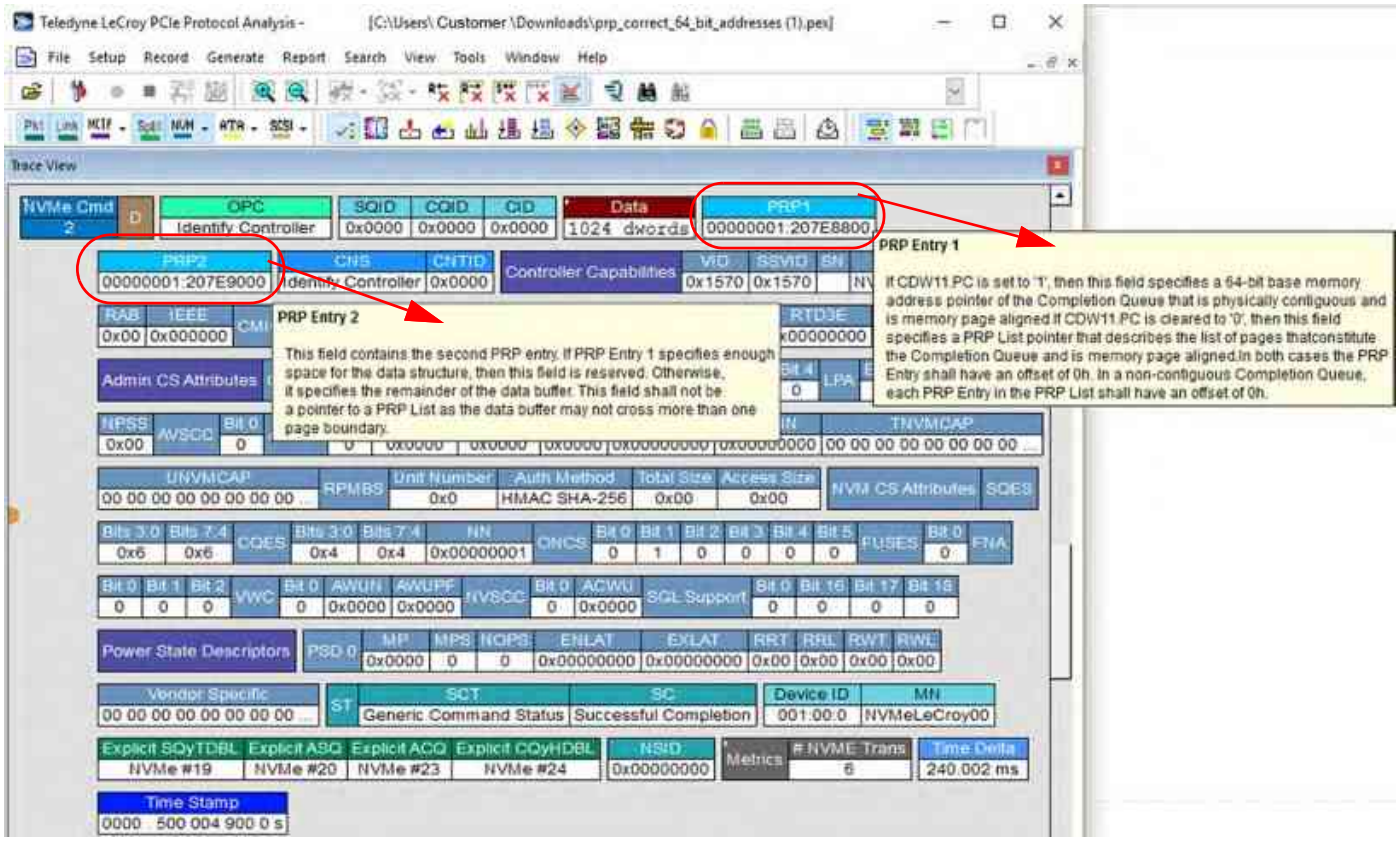


Figure 7.83: PRP1 and PRP2 in CMB Supported in PCIe Protocol Analysis Software

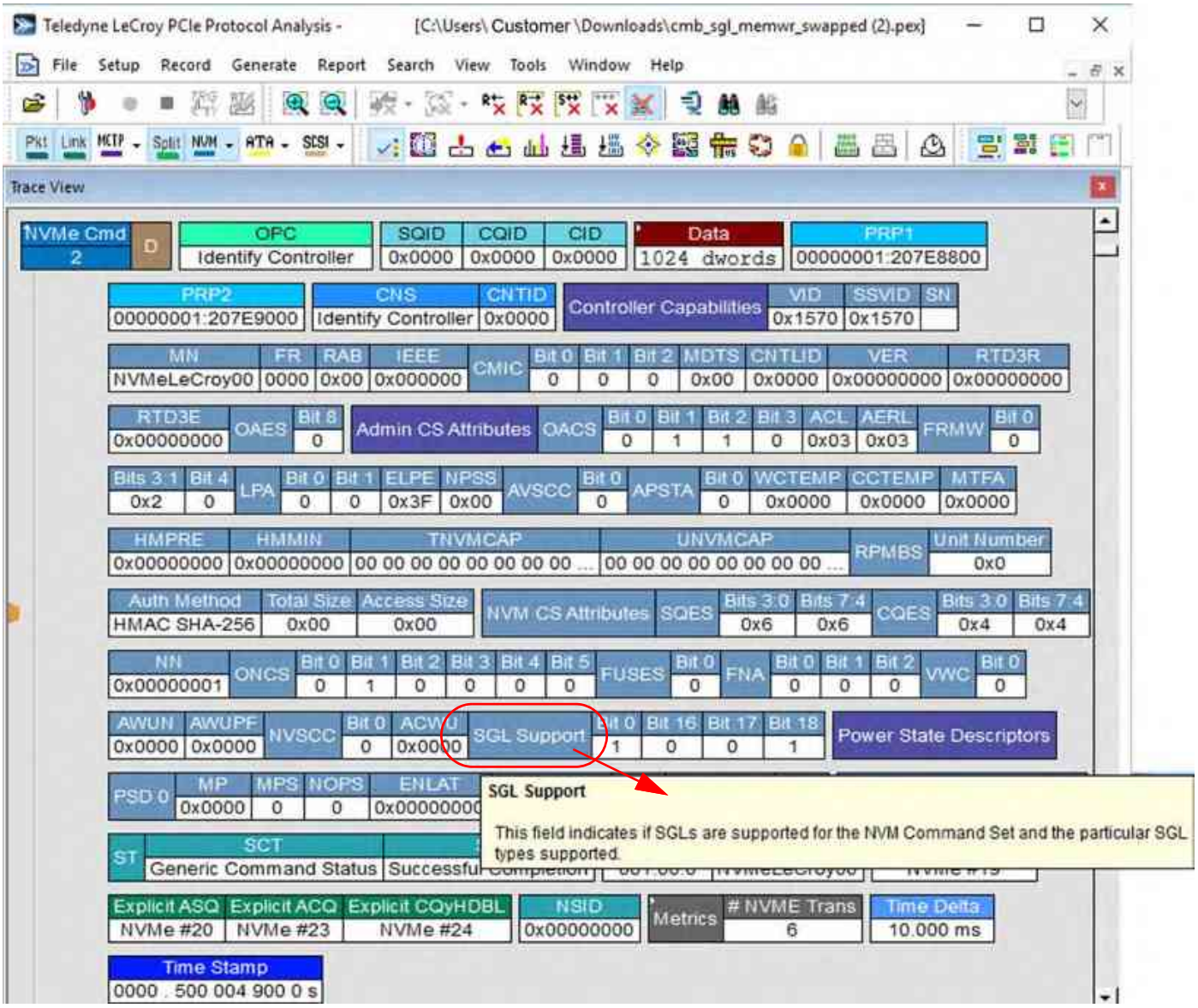


Figure 7.84: SGL Descriptor Supported in PCIe Protocol Analysis Software

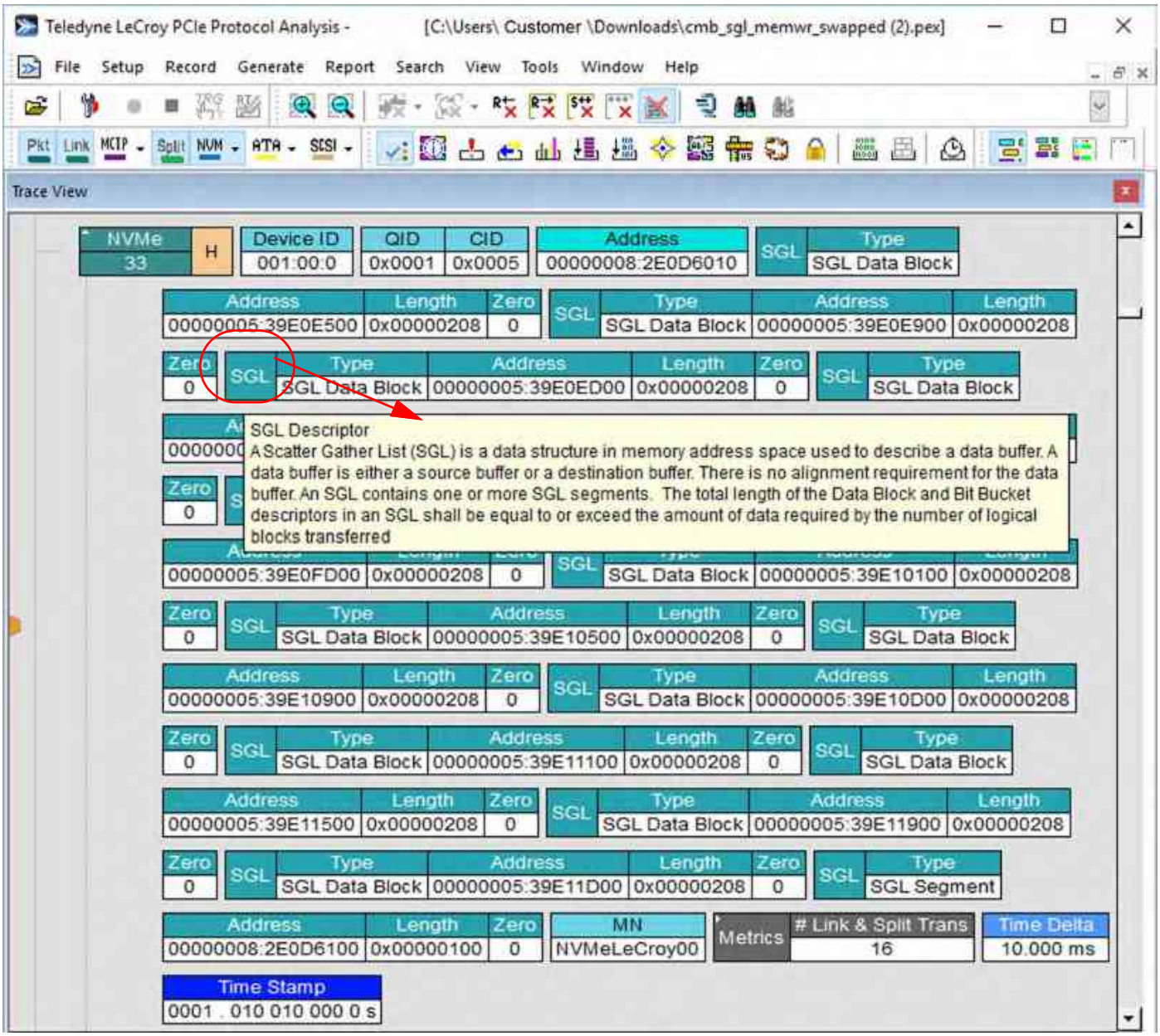


Figure 7.85: SGL Descriptor Tooltip

7.11.8 NVMe Decoding for Host Memory Buffer FID

The PCIe Protocol Analysis software can decode NVMe Host Memory Buffer FID as shown in Figure 7.86.

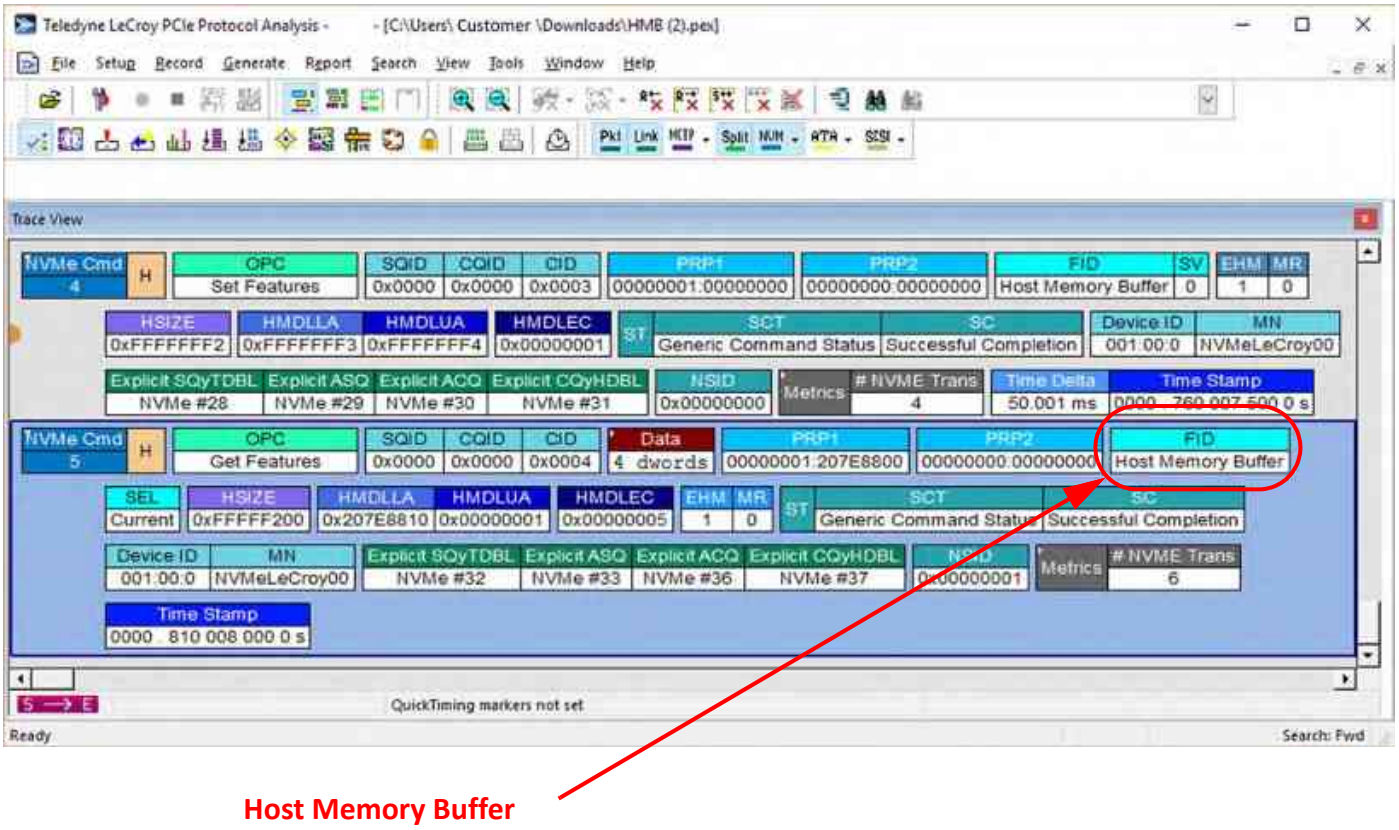
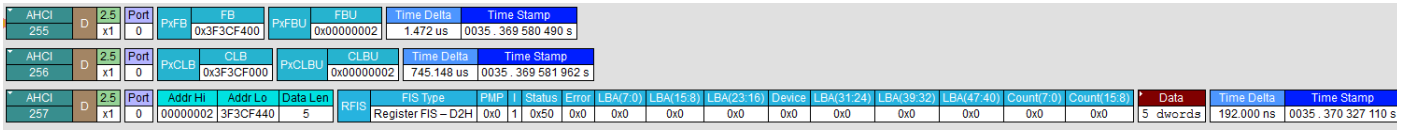


Figure 7.86: NVMe Trace with Host Memory Buffer FID Properly Decoded

7.11.9 AHCI

AHCI level decode AHCI displays AHCI transactions. PCIe Protocol Analysis decodes the storage commands starting from lower Transaction Layer decodes. In the case of AHCI, it will decode first the Packet Level, then the Link Transaction level, then the Split Transaction Level and finally the AHCI decode level.



Note: The trace must contain the device enumeration sequence so the decoding picks up the associated base addresses and AHCI transactions can be properly decoded. If the enumeration sequence is not available the base addresses must be manually entered in the PCIe SSD Configuration dialog from the Tools menu.

7.11.10 ATA

ATA level decode displays ATA transactions. PCIe Protocol Analysis decodes the storage commands starting from lower Transaction Layer decodes. In the case of ATA, it will decode first the Packet Level, then the Link Transaction level, then the Split Transaction Level, then AHCI level and finally the ATA decode level.

ATA		Port	Slot	Protocol	Command	Input	Features	Count	LBA	LBA Ext	Device	7	6	5	4	0-3	Output	BSY
4	H	0	3	ND	SET FEATURES		0x0002	0x0000	0x000000	0x000000		1	0	1	0	0x0		0

ATA		Port	Slot	Protocol	Command	Input	Sector Count	Count	PRIO	NCQ Tag	RARC	LBA	LBA Ext	ICC
5	D	0	4	DMQ	READ FPDMA QUEUED		0x0001		00	4	0	0x000000	0x000000	00000000

ATA		Port	Slot	Protocol	Command	Input	Sector Count	Count	PRIO	NCQ Tag	RARC	LBA	LBA Ext	ICC
6	D	0	5	DMQ	READ FPDMA QUEUED		0x0001		00	5	0	0x000000	0x000000	00000000

Note: The trace must contain the device enumeration sequence so the decoding picks up the associated base addresses and ATA transactions can be properly decoded. If the enumeration sequence is not available the base addresses must be manually entered in the PCIe SSD Configuration dialog from the Tools menu.

7.11.10.1 ATA IO: Pending Transactions Statistical Report

ATA IO Pending Transactions statistical information can be displayed from an ATA Trace by selecting an ATA Packet and viewing the Metrics box. See Figure 7.87.

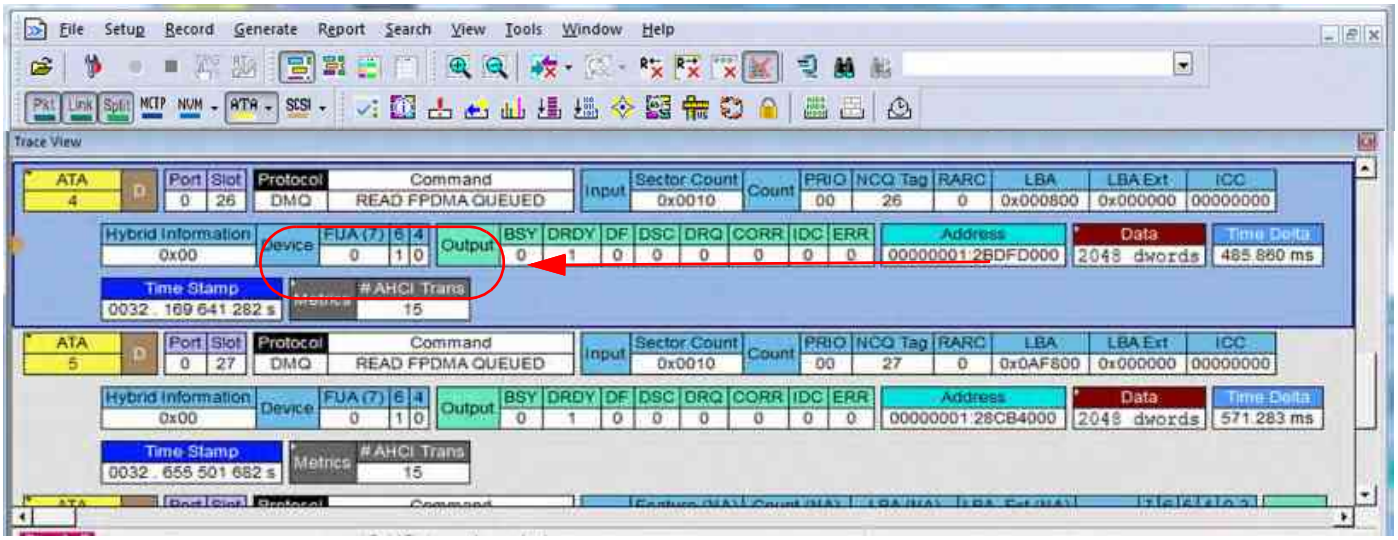


Figure 7.87: ATA IO Pending Transactions: Metrics Box

Move the cursor over the Metrics box to display the information about the ATA Packet. See Figure 7.88 on page 460.

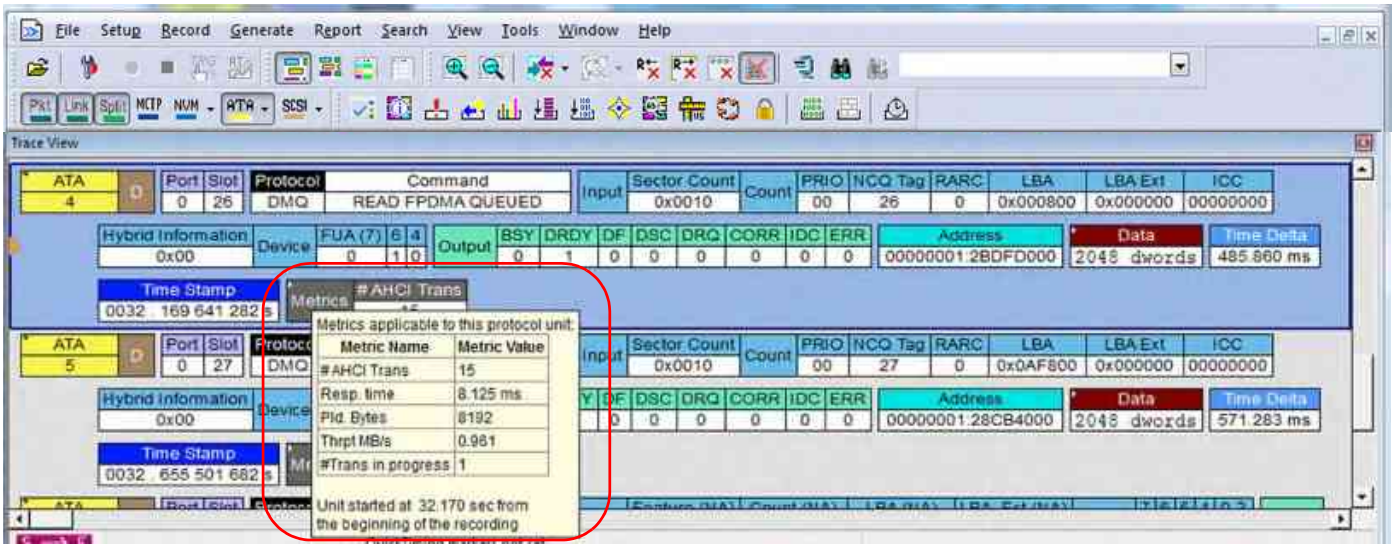


Figure 7.88: ATA IO Pending Transactions: Metrics Box -- Information Displayed

You can click on the small white arrow in the Metrics box to display the information in the Trace. See Figure 7.89 on page 460.

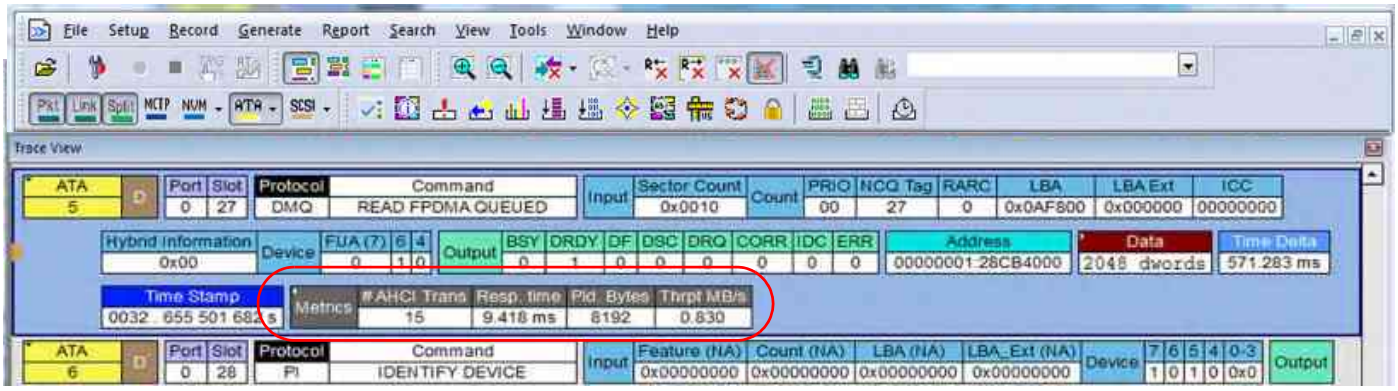


Figure 7.89: ATA IO Pending Transactions: Metrics Displayed in Trace

You can also view the ATA IO Pending Transactions by selecting the Bus Utilization icon in the toolbar and selecting the Graph Areas icon. See Figure 7.90 on page 461.

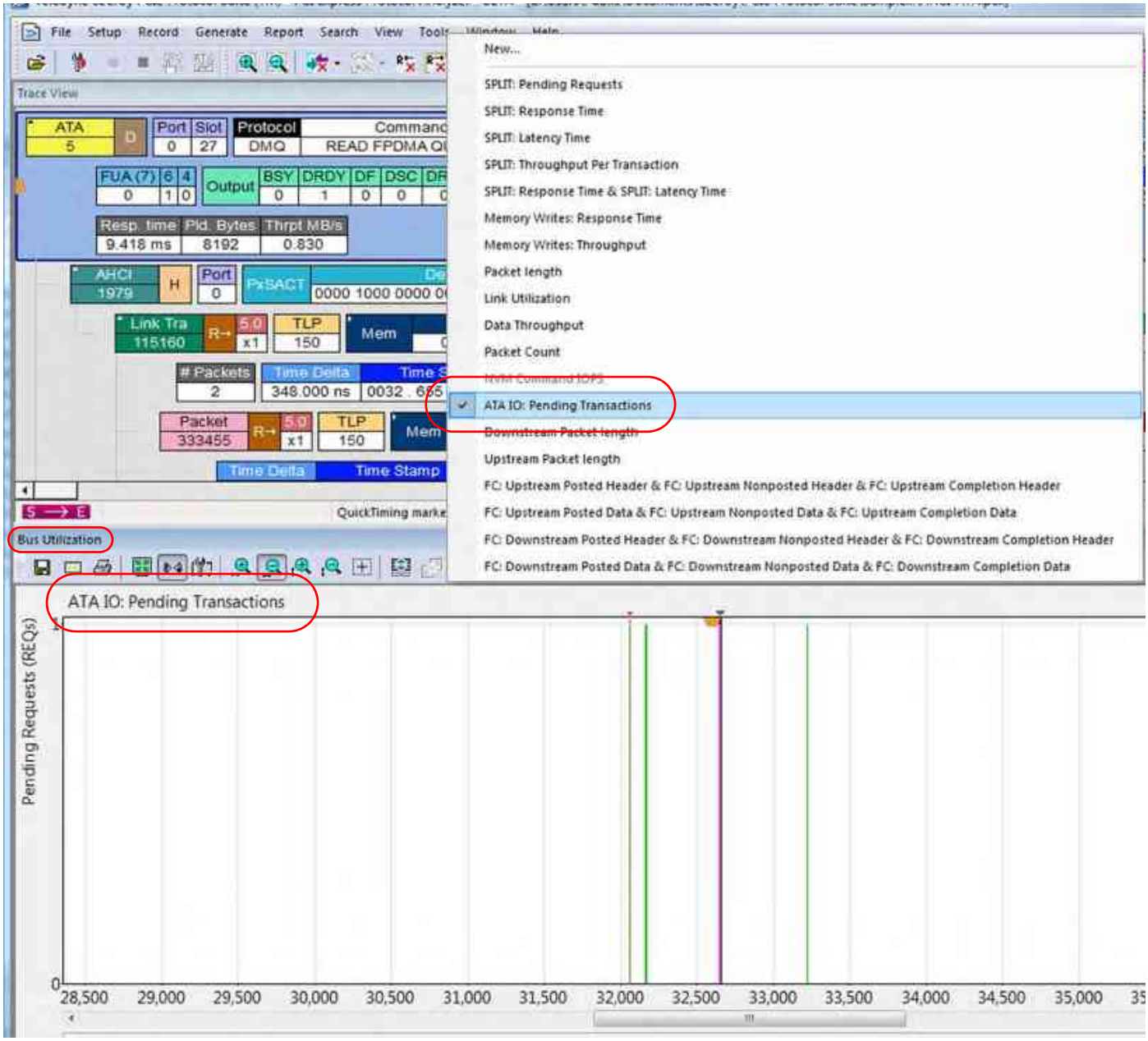
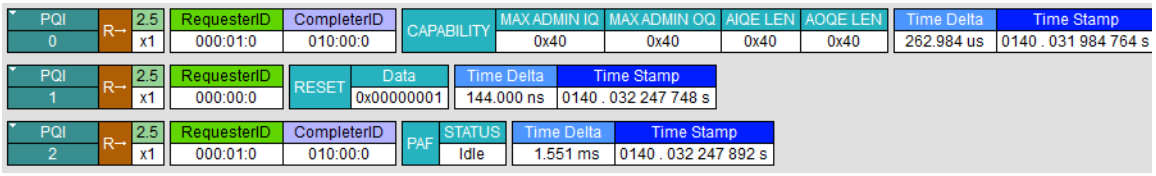


Figure 7.90: ATA IO Pending Transactions: Bus Utilization View

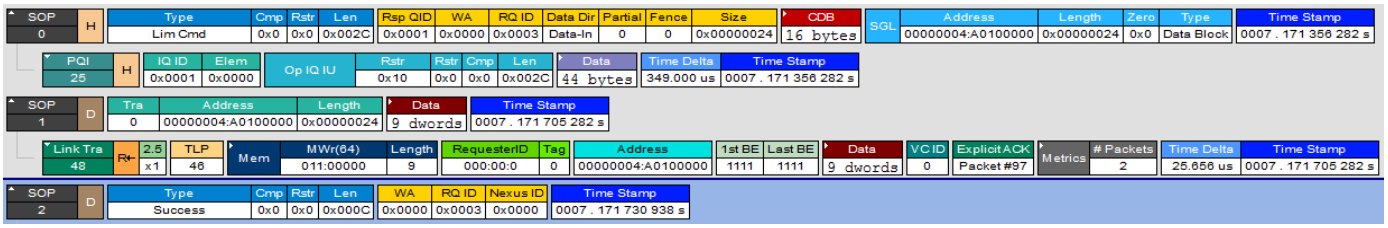
7.11.11 PQI

PQI level decode PQI displays PQI transactions. PCIe Protocol Analysis decodes the storage commands starting from lower Transaction Layer decodes. In the case of PQI, it will decode first the Packet Level, then the Link Transaction level, then the Split Transaction Level and finally the PQI decode level.



7.11.12 SOP

SOP level decode SOP displays SOP transactions. PCIe Protocol Analysis decodes the storage commands starting from lower Transaction Layer decodes. In the case of SOP, it will decode first the Packet Level, then the Link Transaction level, then the Split Transaction Level, then PQI level and finally the SOP decode level.



Note: The trace must contain the device enumeration sequence so the decoding picks up the associated base addresses and SOP transactions can be properly decoded. If the enumeration sequence is not available the base addresses must be manually entered in the PCIe SSD Configuration dialog from the Tools menu.

7.11.13 SCSI

SCSI level decode SCSI displays SCSI transactions. PCIe Protocol Analysis decodes the storage commands starting from lower Transaction Layer decodes. In the case of SCSI, it will decode first the Packet Level, then the Link Transaction level, then the Split Transaction Level, then PQI level and finally the SCSI decode level.



Note: The trace must contain the device enumeration sequence so the decoding picks up the associated base addresses and SCSI transactions can be properly decoded. If the enumeration sequence is not available, the base addresses must be manually entered in the PCIe SSD Configuration dialog from the Tools menu.

7.11.14 Decoding MCTP (Management Component Transport Protocol)

Note: The Summit T5 can decode MCTP traffic per specifications outlined in the *Readme* file.

7.11.14.1 MCTP Levels in Floating Transactions Bar Window

To decode MCTP traffic you must first load a trace containing MCTP traffic. You can get a visual representation of the MCTP Command structure by pulling the Transaction Level Toolbar (see Figure 7.91) down into the trace and the Floating Transaction Level Bar Window will be shown (see Figure 7.92). The Transaction Level Window shows that the MCTP Command is made up of Links and Packets. You can also see that NVMe, ATA and SCSI traffic consists of Link and Split transactions.



Figure 7.91: Transaction Level Toolbar

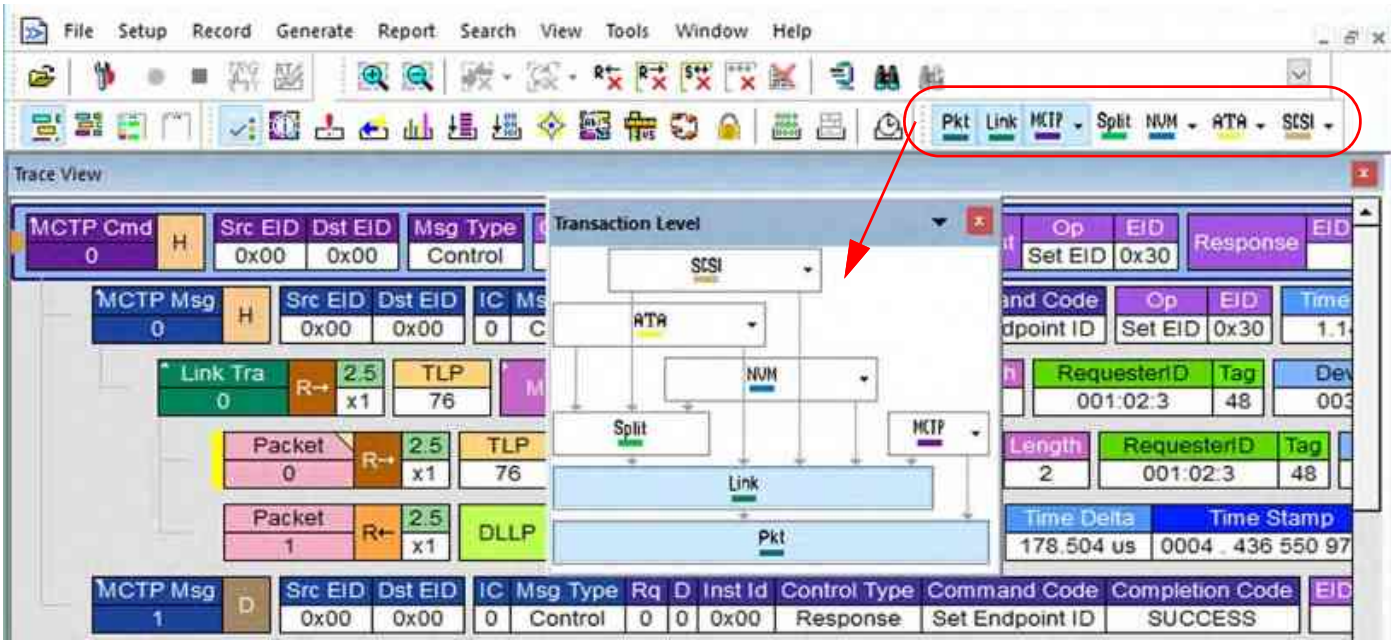


Figure 7.92: MCTP Levels in Floating Transaction Bar Window

7.11.14.2 Decoding MCTP Commands

MCTP traffic can be decoded and displayed as either MCTP Commands or MCTP Messages.

To decode MCTP traffic you must first load a trace containing MCTP traffic. Then click the MCTP icon on the toolbar and select MCTP Commands. See Figure 7.93.



Figure 7.93: MCTP Decoding Icon on Toolbar

This will decode MCTP Commands in the trace. The following types of MCTP Message Types can be decoded:

- MCTP Control: See Figure 7.94 on page 464
- NC-SI: See Figure 7.94 on page 464
- PLDM: See Figure 7.95 on page 465
- PLDM: Firmware Commands Decoded -> See Figure 7.96 on page 466 and Figure 7.97 on page 467.

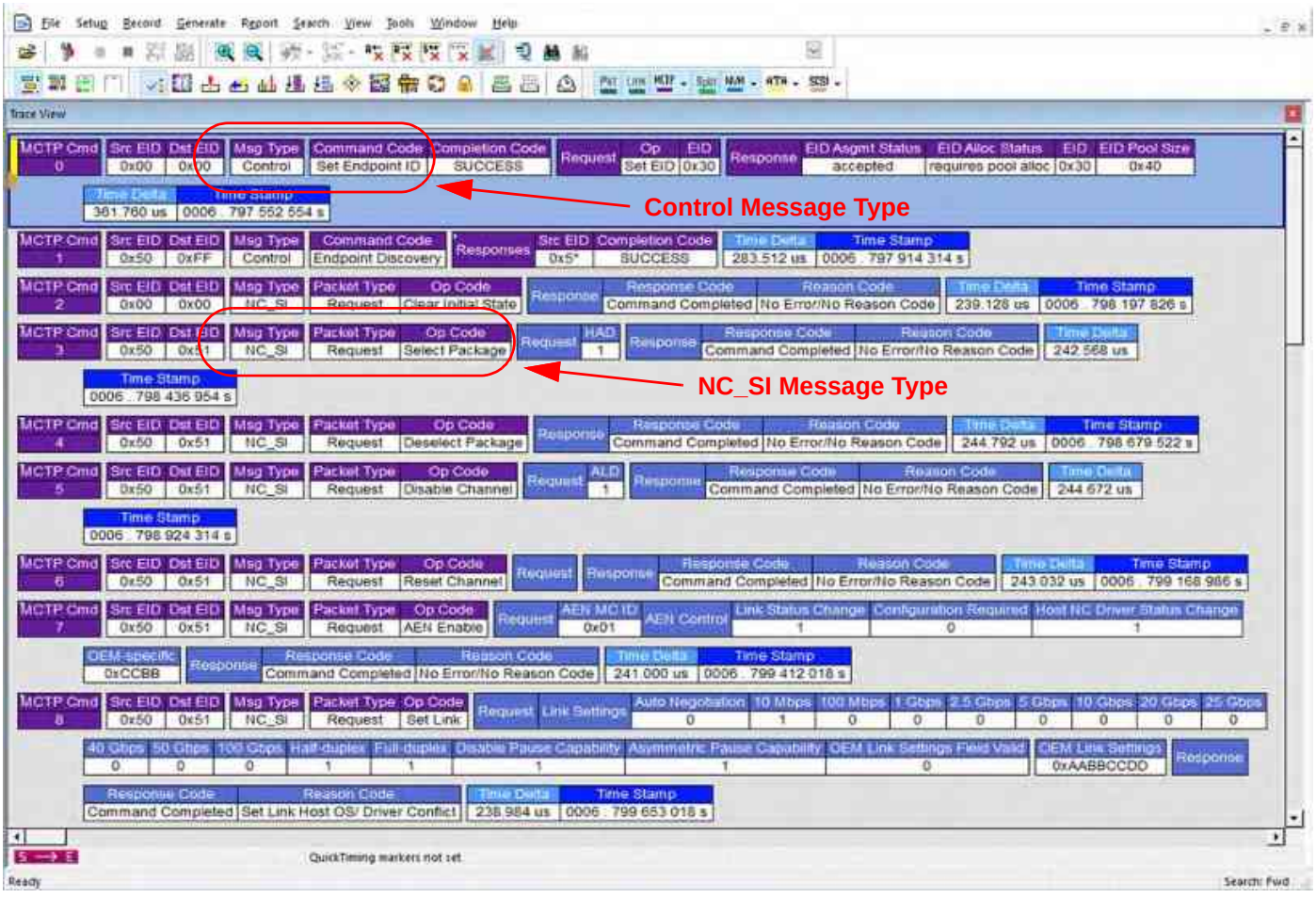


Figure 7.94: MCTP Commands Decoded: Control and NC_SI Types

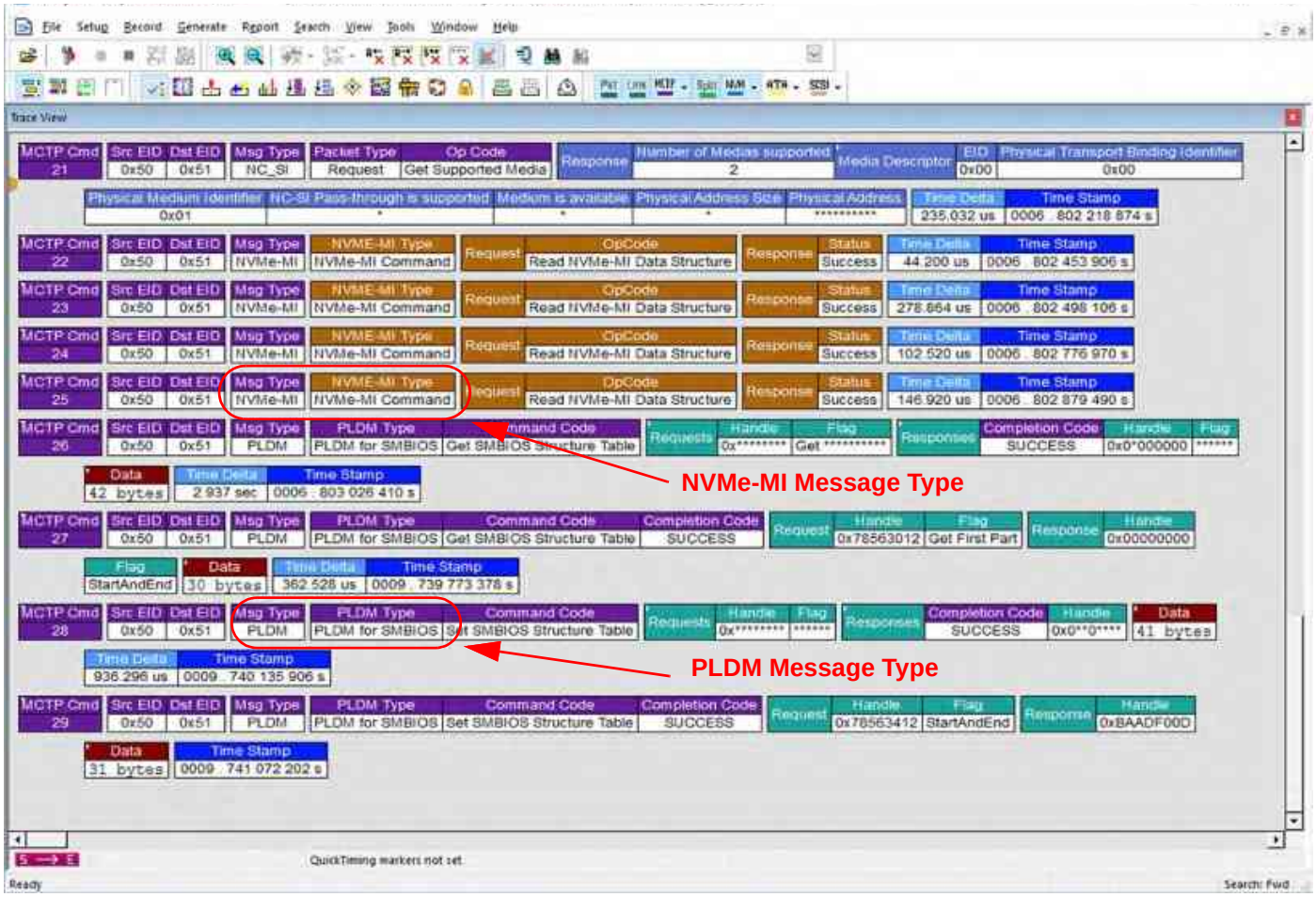


Figure 7.95: MCTP Commands Decoded: NVMe-MI and PLDM Types

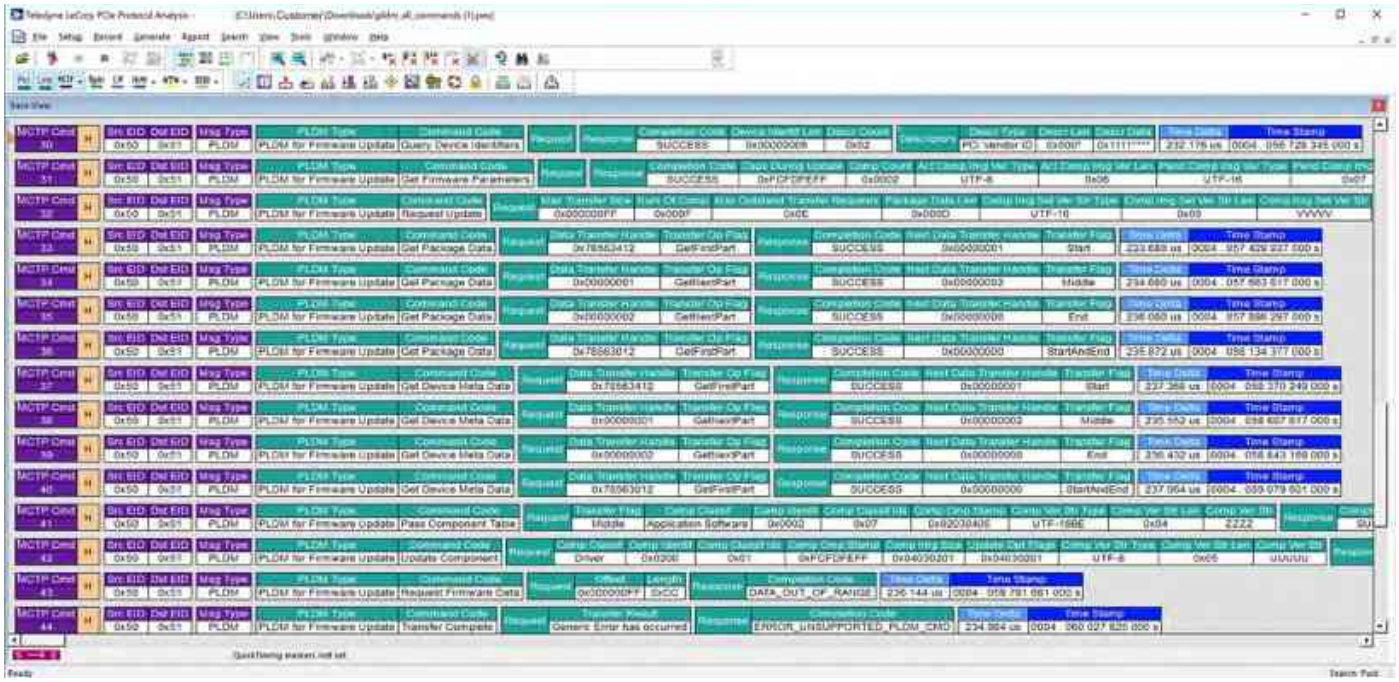


Figure 7.96: PLDM Firmware Update Commands Decoded

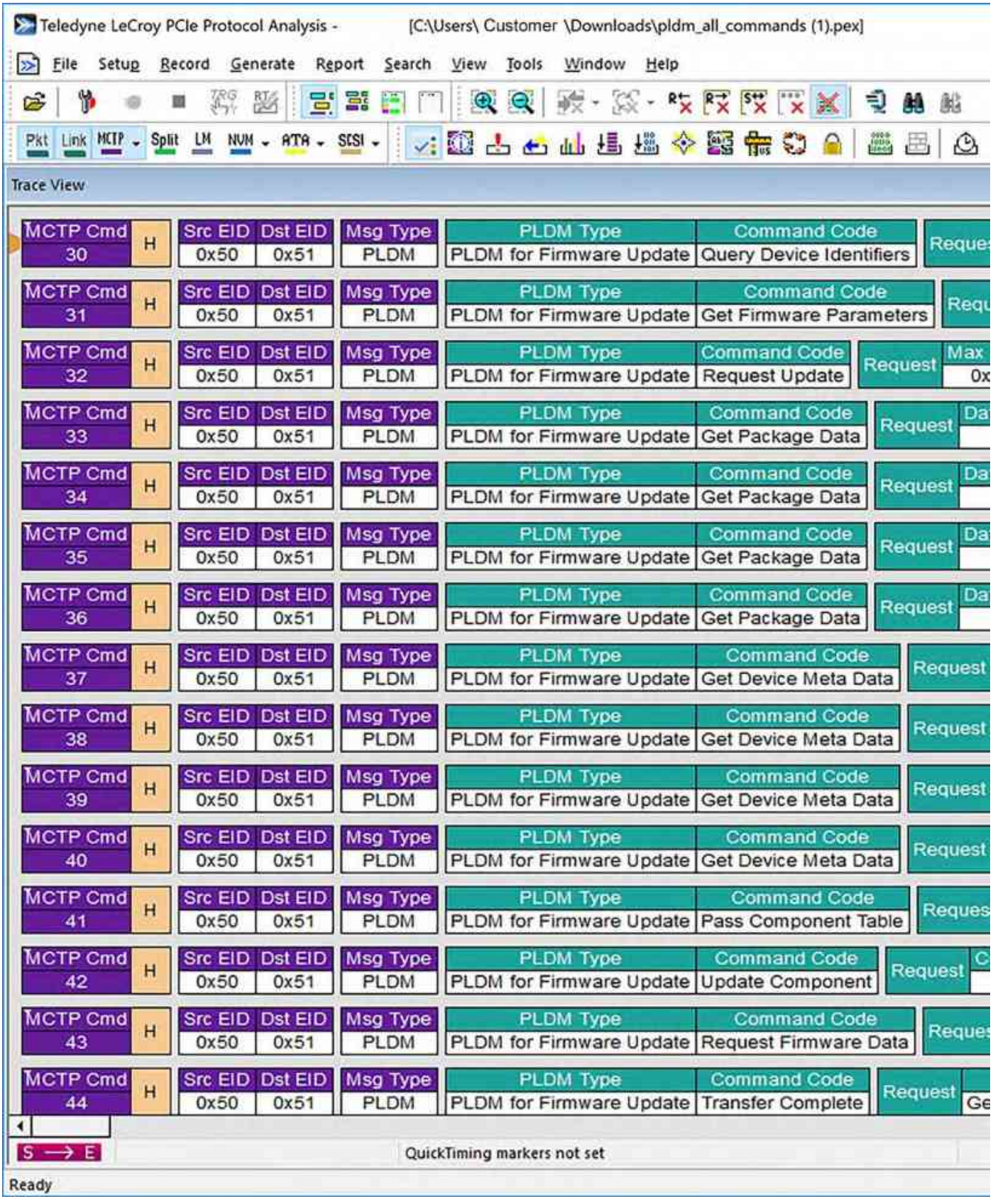


Figure 7.97: PLDM Firmware Update Commands Decoded (Details shown)

7.11.14.3 Expanding MCTP Commands

If you expand any MCTP command, you'll see all of the MCTP messages and lower level packets that make up the command. In this case we expanded MCTP Command 0. It consists of MCTP Message 0 from the Host and MCTP Message 1 from the Device. If you expand MCTP Message 0, you'll see that it consists of Link Transaction 0, which can be expanded down to Packet 0 and Packet 1. Notice that MCTP Command 0, MCTP Message 0, Link Transaction 0 and Packet 0 all have the same Timestamp: 0006.797.552.554 seconds. The response from the Device occurs as 0006.797.553.698 seconds. See Figure 7.98 on page 467.

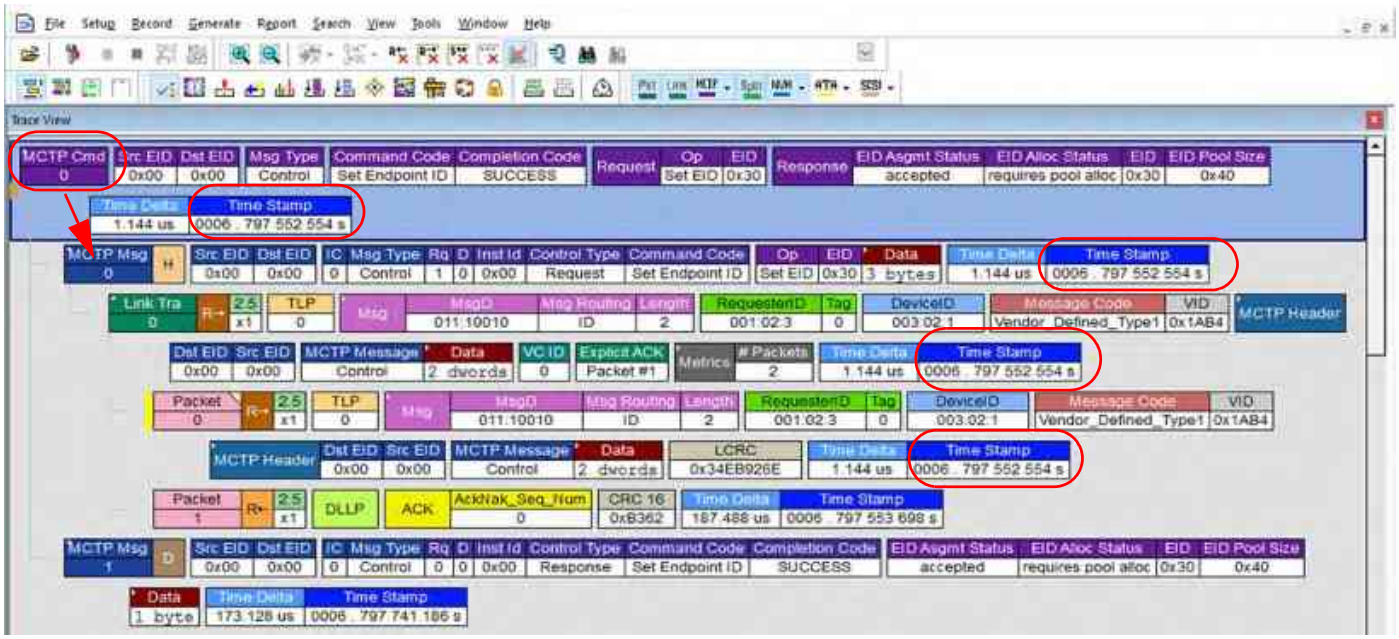


Figure 7.98: MCTP Command 0 Expanded

7.11.14.4 Decoding MCTP Messages

If you had selected MCTP Messages to be decoded instead of Commands, only the MCTP Messages would be displayed. See Figure 7.99.

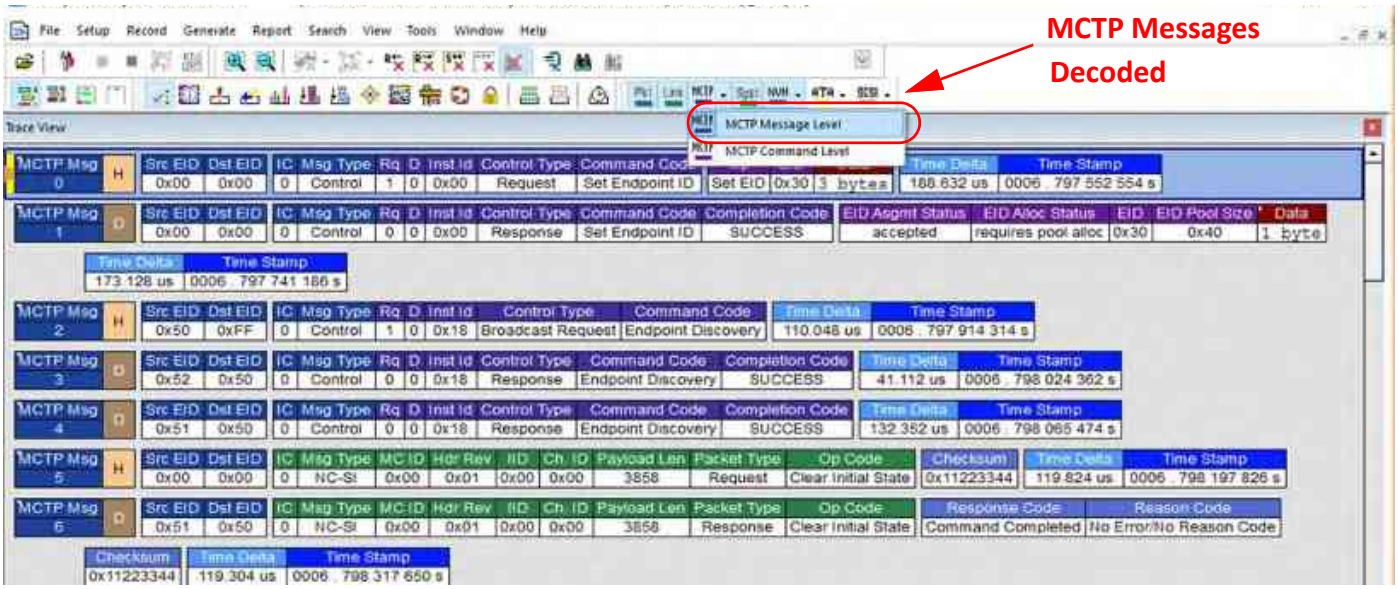


Figure 7.99: MCTP Messages Decoded

If you expand the MCTP Message you'll see the same information you saw by expanding the MCTP Command. See Figure 7.100 on page 468.

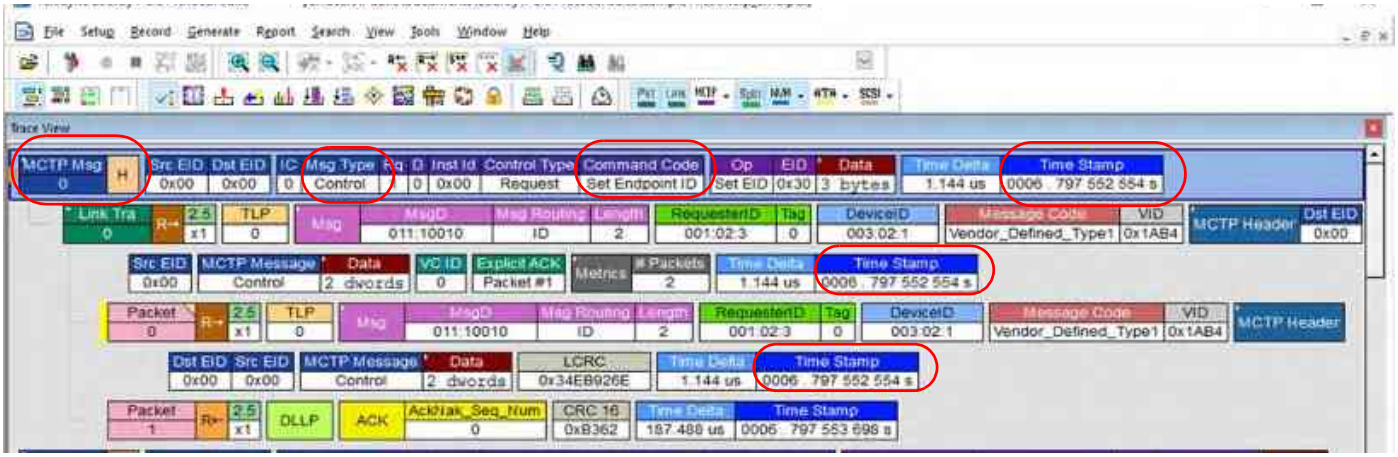


Figure 7.100: Expanding MCTP Message

7.11.14.5 MCTP Commands with SMBus Traffic

To decode an MCTP command with SMBus traffic you must first load a trace with the appropriate traffic. Then decode MCTP traffic by clicking on the MCTP icon in the toolbar. In the example shown below we've loaded a trace that has SMBus traffic within an MCTP message that is part of an MCTP command. See Figure 7.101.

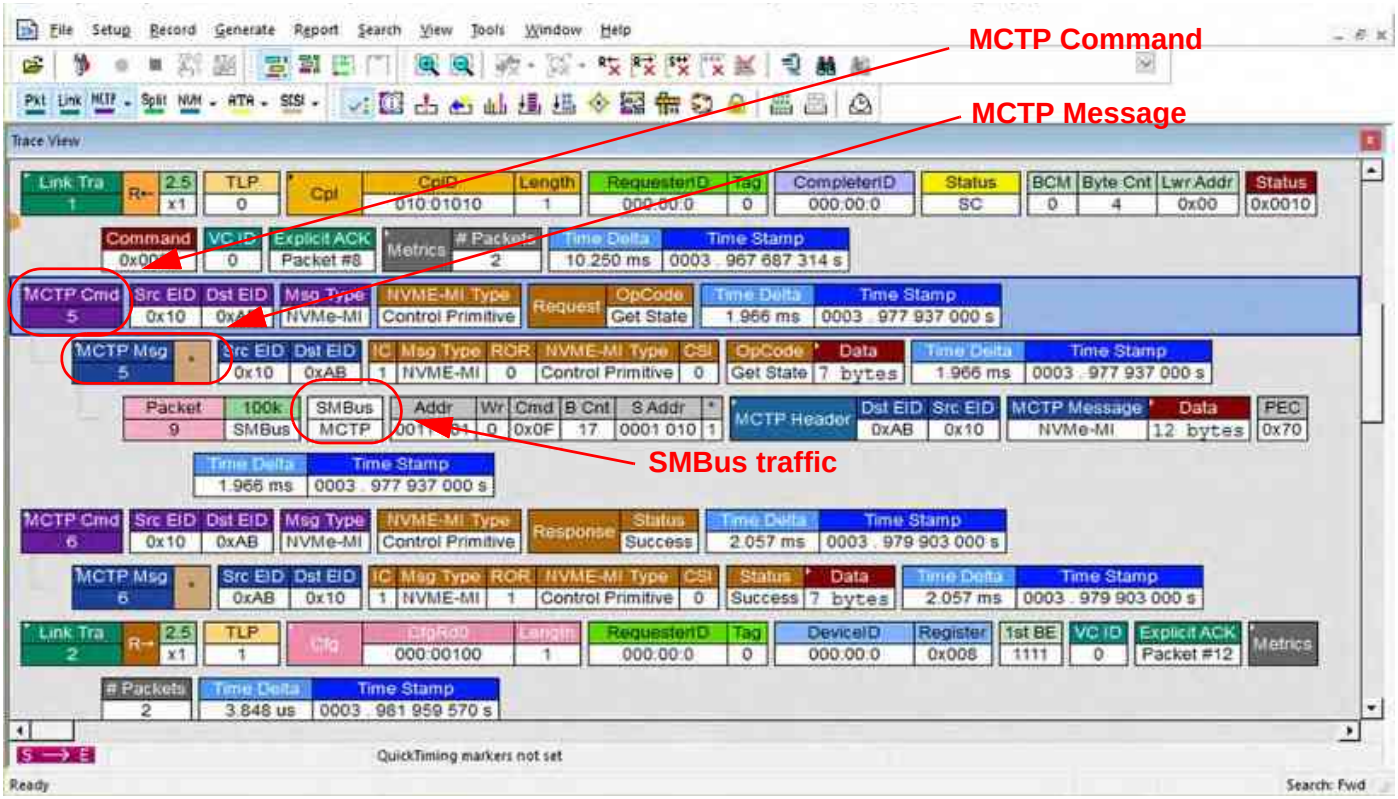


Figure 7.101: MCTP Command with SMBus Traffic

7.11.14.6 MCTP Commands: Request from Host, Response from Device

MCTP commands can be decoded as shown below (see Figure 7.102). As you can see the MCTP Command is made up of MCTP messages. One is from the Host the response is from the Device.

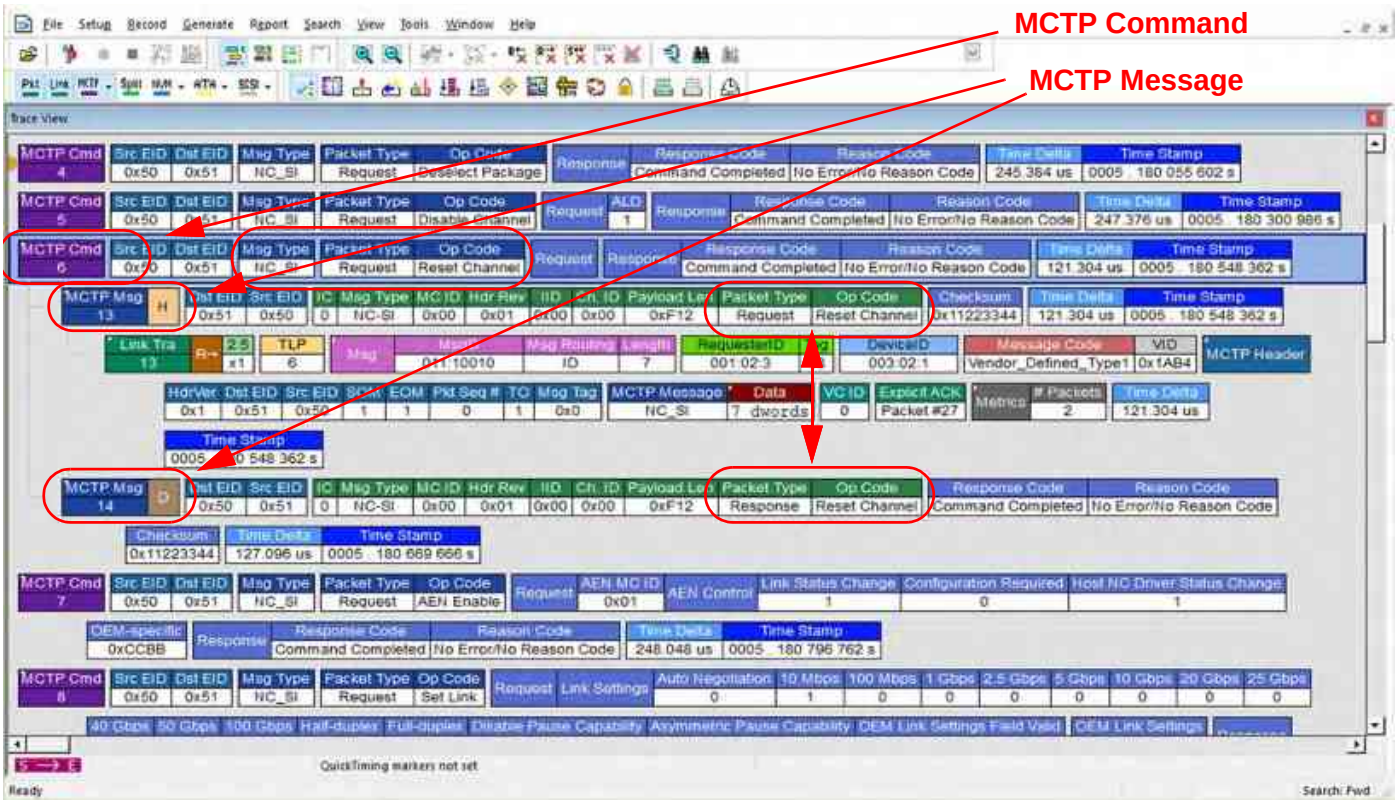


Figure 7.102: Decoding MCTP Commands

7.11.14.7 Decoding MCTP Messages and Transactions

Note: To decode MCTP messages and transactions you'll need a license for your analyzer. If you don't have a MCTP license a warning message will pop up. See Figure 7.103.

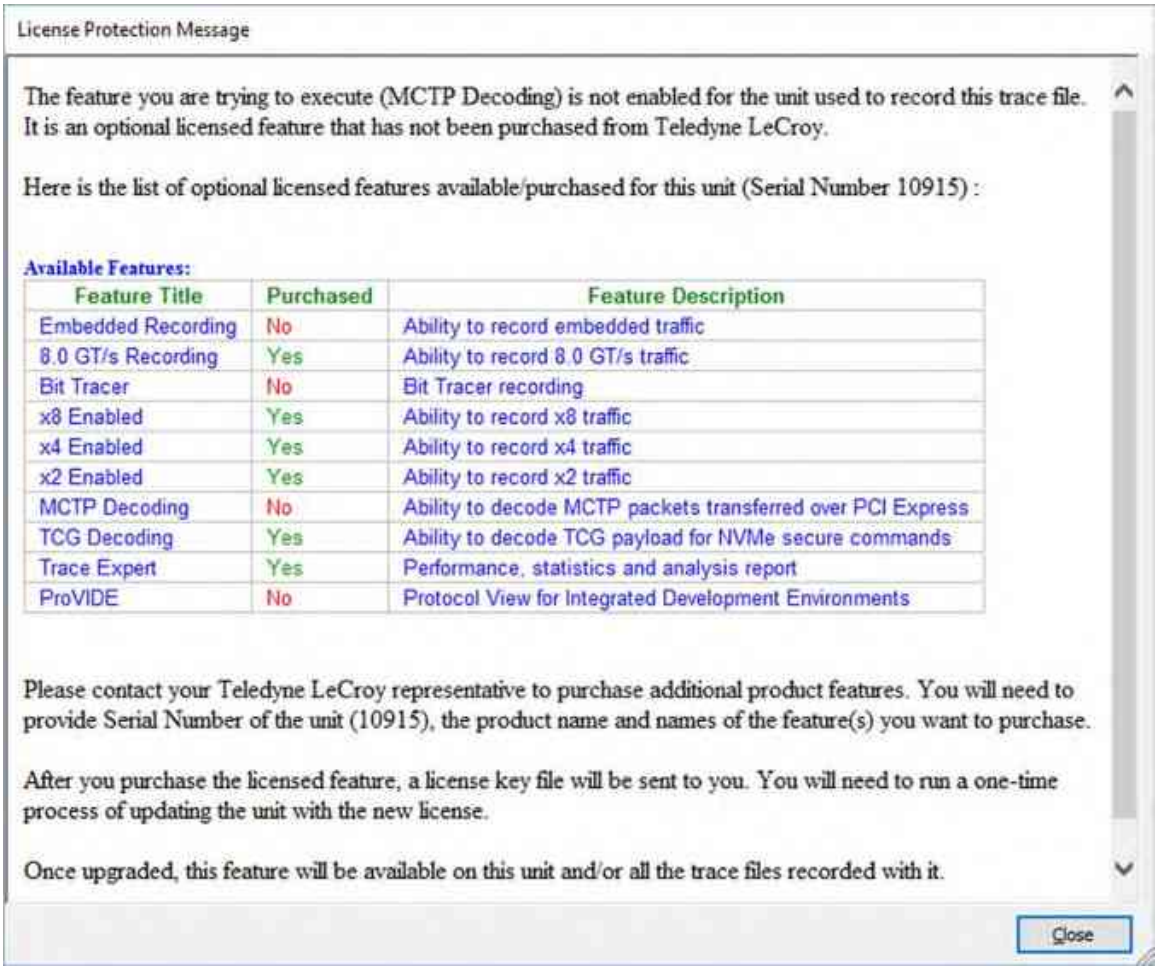


Figure 7.103: Warning Message: No MCTP License

You can decode both MCTP messages and transactions within traces by selecting CATC Trace View, Decoding Packets, Links and MCTP 

. You'll see that the transaction contains an MCTP Header and an MCTP Message. See Figure 7.104 on page 472.

7.11.14.8 MCTP Messages

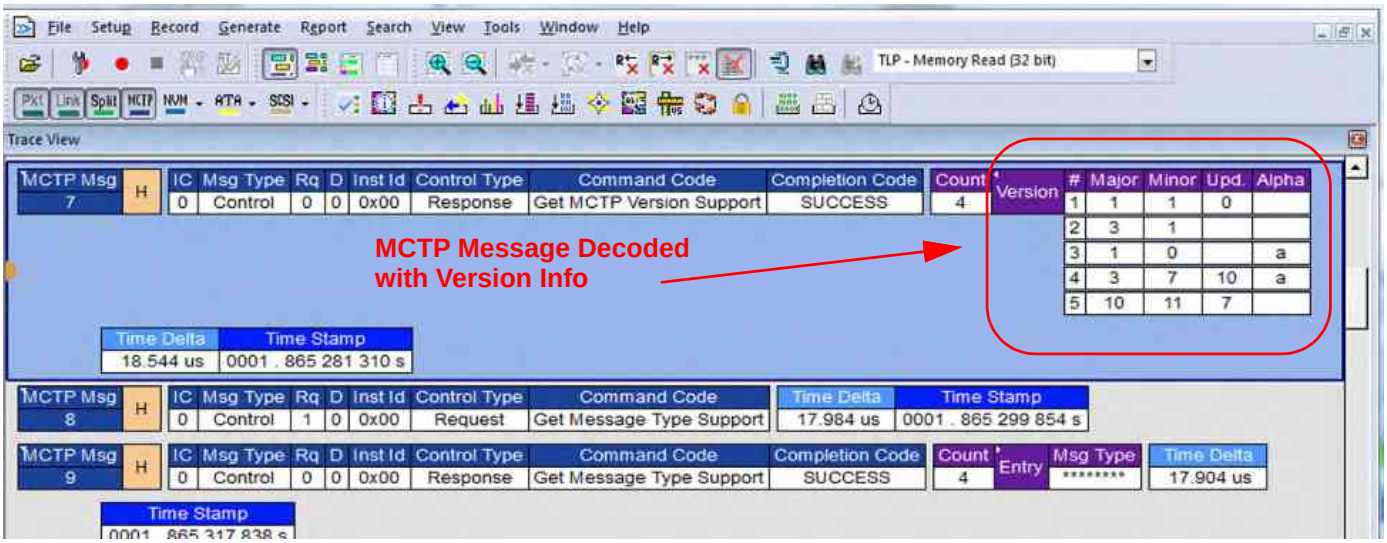


Figure 7.104: MCTP Message Decoded

7.11.14.9 MCTP Transactions

The Link Transaction will decode an MCTP Header and an MCTP Message containing a Msg Type, a Control Type and a Command Code. See Figure 7.105.

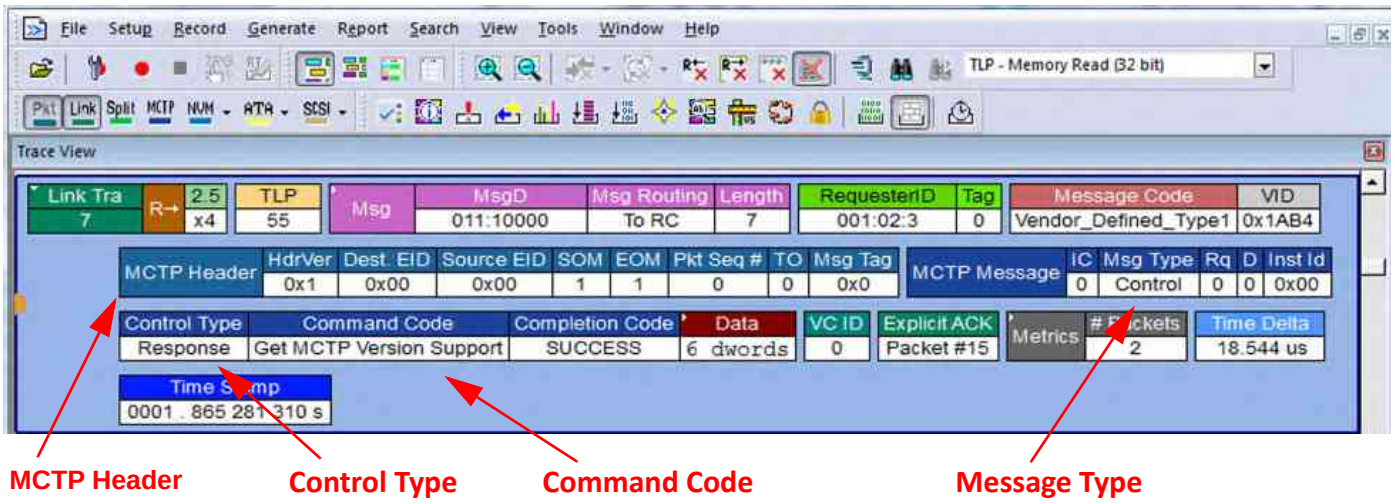


Figure 7.105: Decoding MCTP Transactions

7.11.14.10 MCTP Errors Reported

You can also display the following types of Errors from the Detailed View of the Trace:

- RsvdNotNull: RSVD field shall be 0
- InvalidHdrVer: Header version field should be set to 1
- InvalidDstEId: Destination Endpoint IDs 1 through 7 are reserved for future definition
- InvalidSrcEId: Source Endpoint IDs 1 through 7 are reserved for future definition
- ICNotNull: IC bit shall always be 0 for MCTP control messages

See Figure 7.106 on page 473.

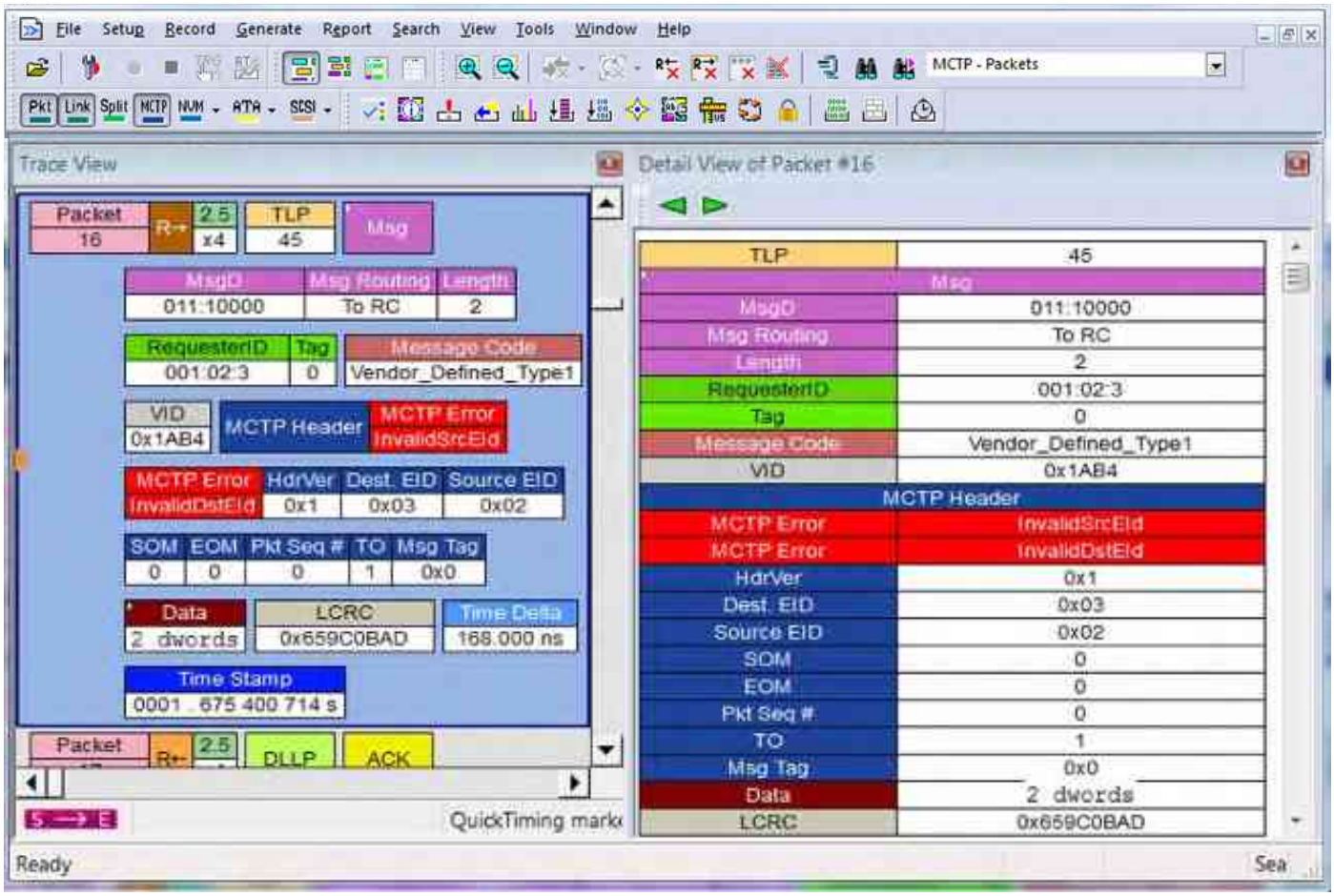


Figure 7.106: MCTP Transaction Errors Reported

7.11.14.11 MCTP Trace In Spreadsheet View

MCTP Traces can be displayed in Spreadsheet View. See Figure 7.107.

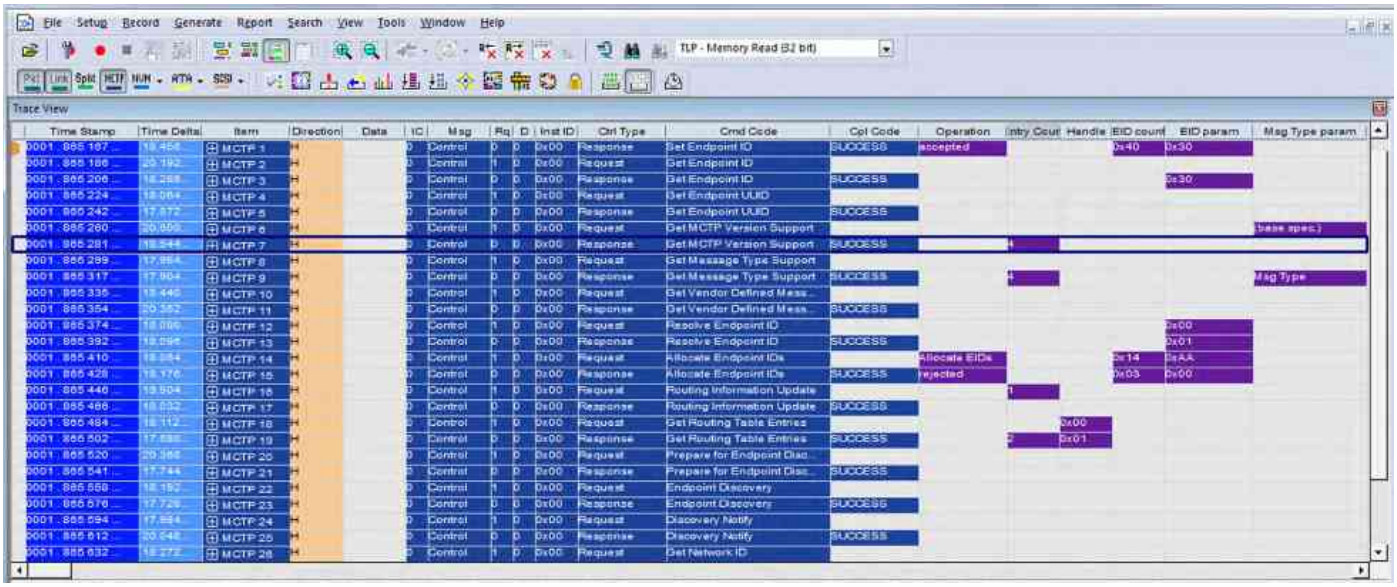


Figure 7.107: MCTP Trace in Spreadsheet View

7.11.14.12 Decoding MCTP Messages with PLDM Message Types

You can decode MCTP Messages with Platform Level Data Model (PLDM) Message types within traces by selecting CATC Trace View, Decoding Packets, Links and MCTP 

. You'll see that the message contains an MCTP Header and an PLDM Message. See Figure 7.108. In the example shown below there are both PLDM Requests and PLDM Responses.

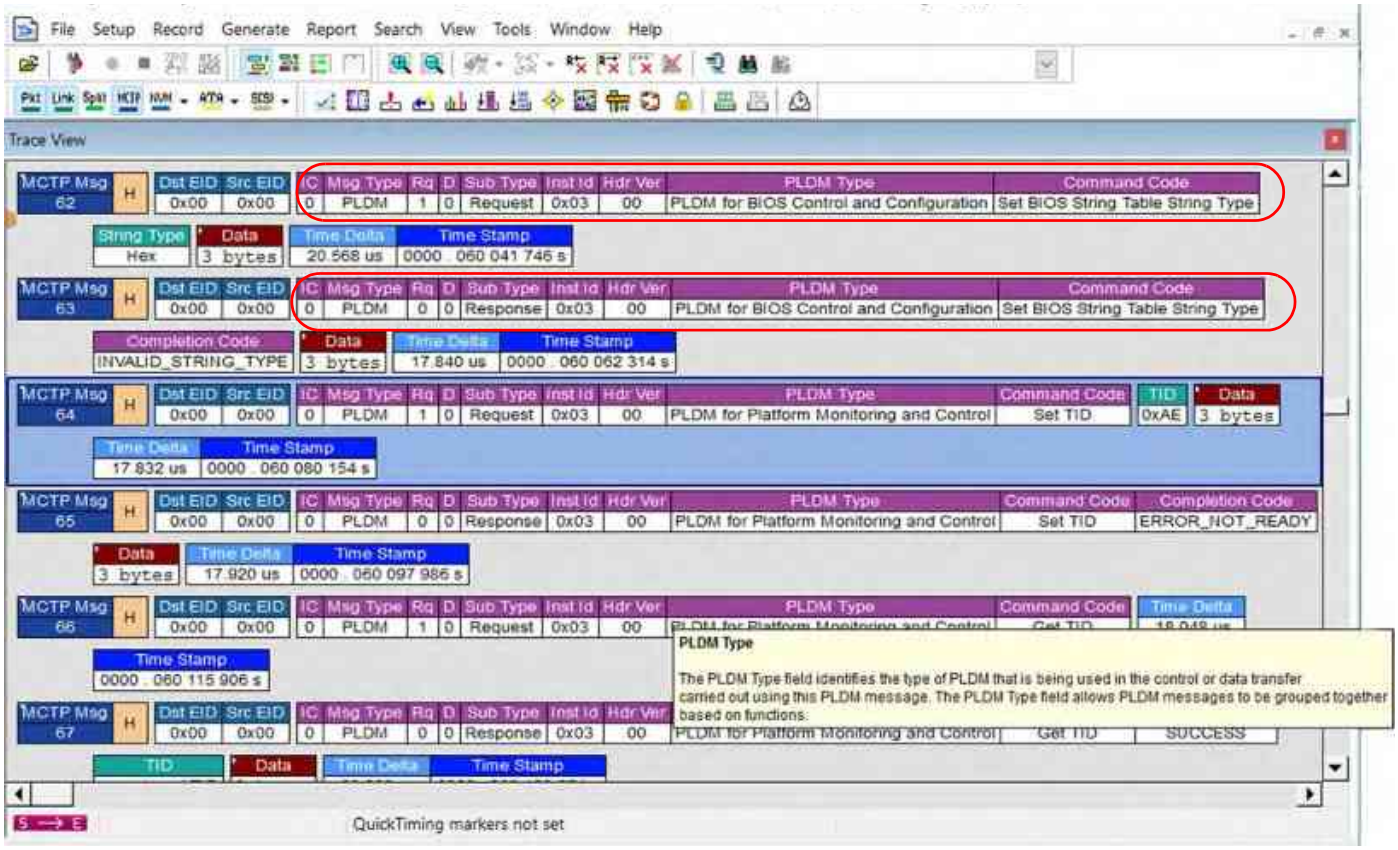


Figure 7.108: MCTP Message with PLDM Message Type

7.11.14.13 Decoding MCTP Messages with NC-SI Message Types

You can decode MCTP Messages with Network Controller Side Band Interface (NC-SI) Message types within traces by selecting CATC Trace View, Decoding Packets, Links and MCTP 

. You'll see that the message contains an MCTP Header and an NC-SI Message. See Figure 7.109. In the example shown below, there is an NC-SI Request packet type followed by the NC-SI packet Response.

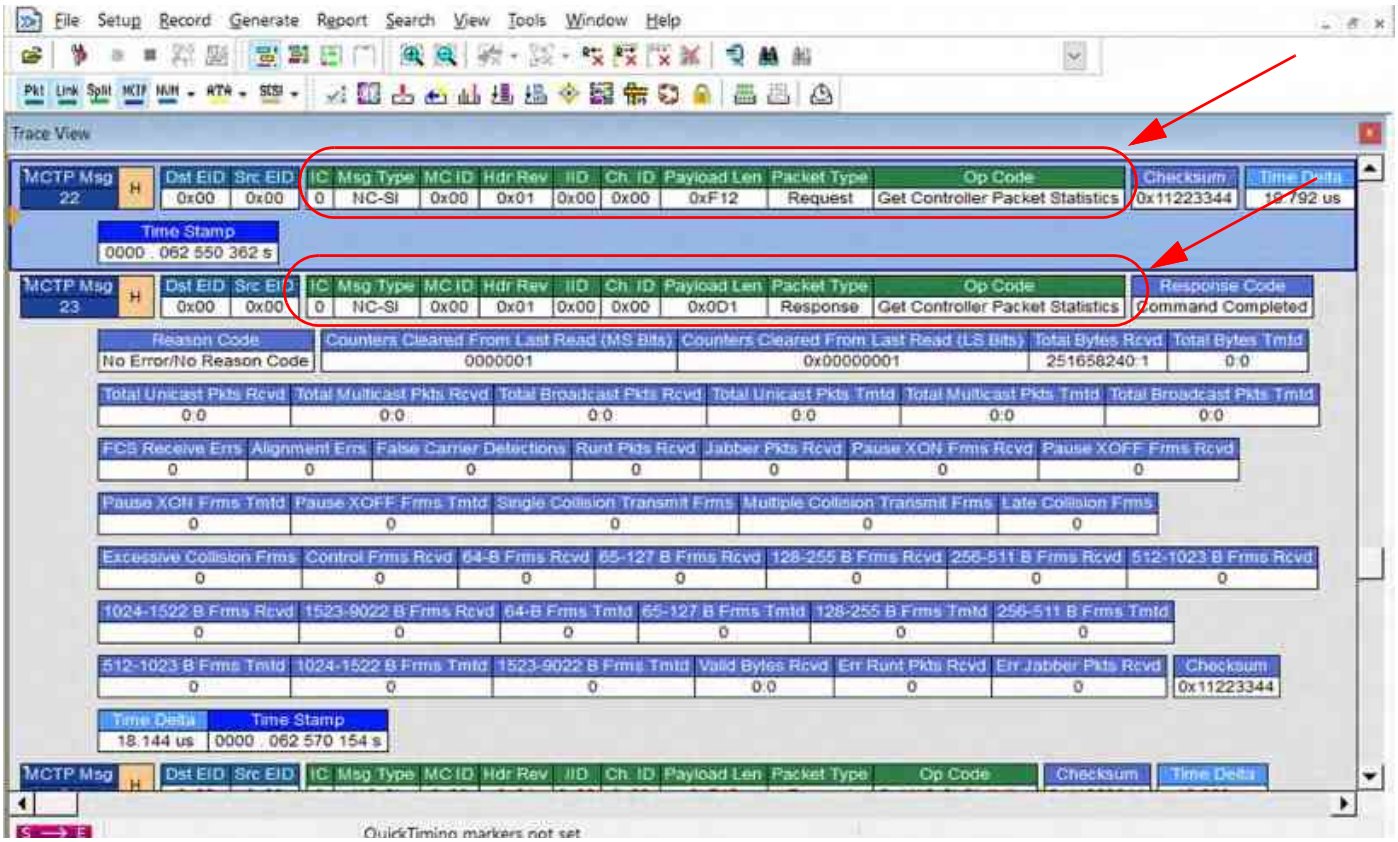


Figure 7.109: MCTP Message with NC-SI Message Type

7.11.14.14 MCTP Command with NVMe-MI Errors Decoded

The PCIe Protocol Analysis can detect, decode and display NVMe-MI errors in MCTP traffic, as shown below in Figure 7.110.

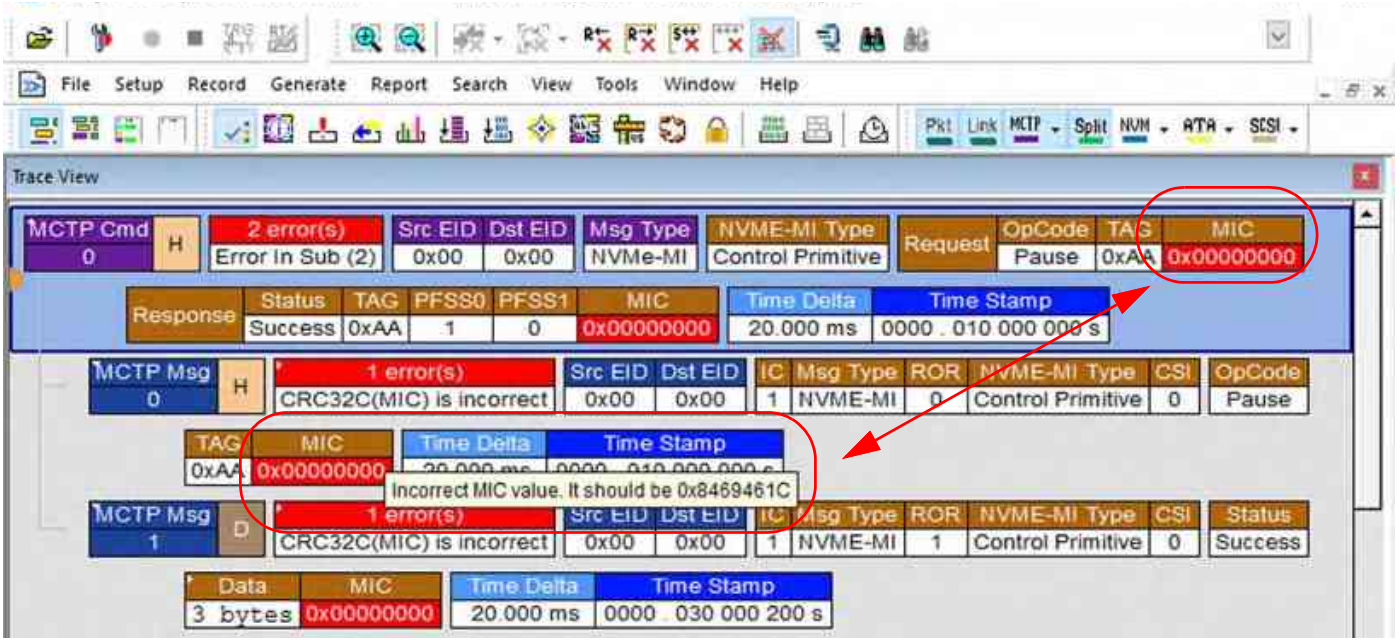


Figure 7.110: Errors Decoded In MCTP/NVMe-MI Traffic

7.11.14.15 MCTP Message Type and IC Cells

You can decode MCTP Messages and IC cells. See Figure 7.153.

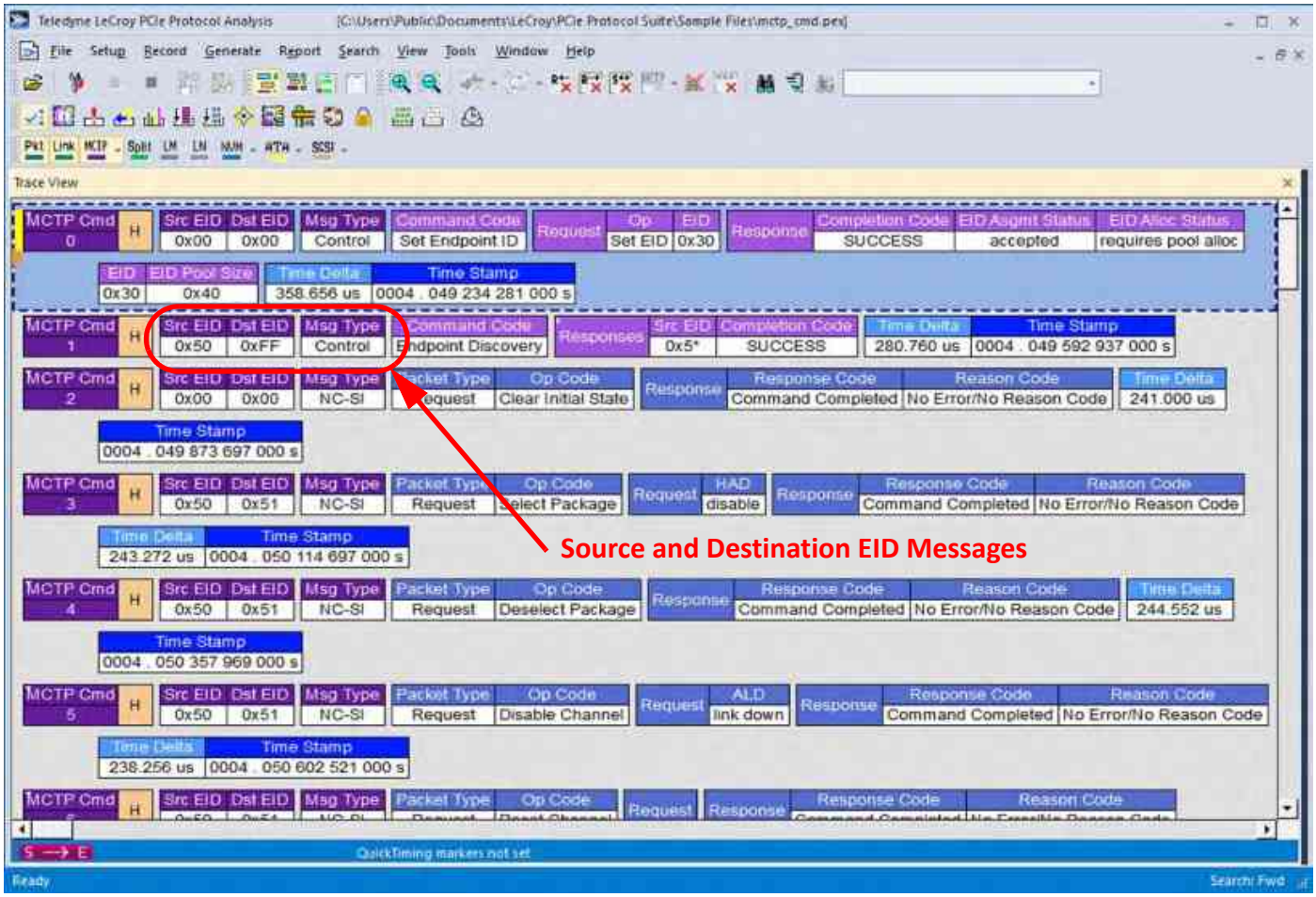


Figure 7.111: MCTP Messages Types and IC Cells Decoded

The colors of the MCTP Messages can be seen in the Display Options. See Figure 7.154 on page 516

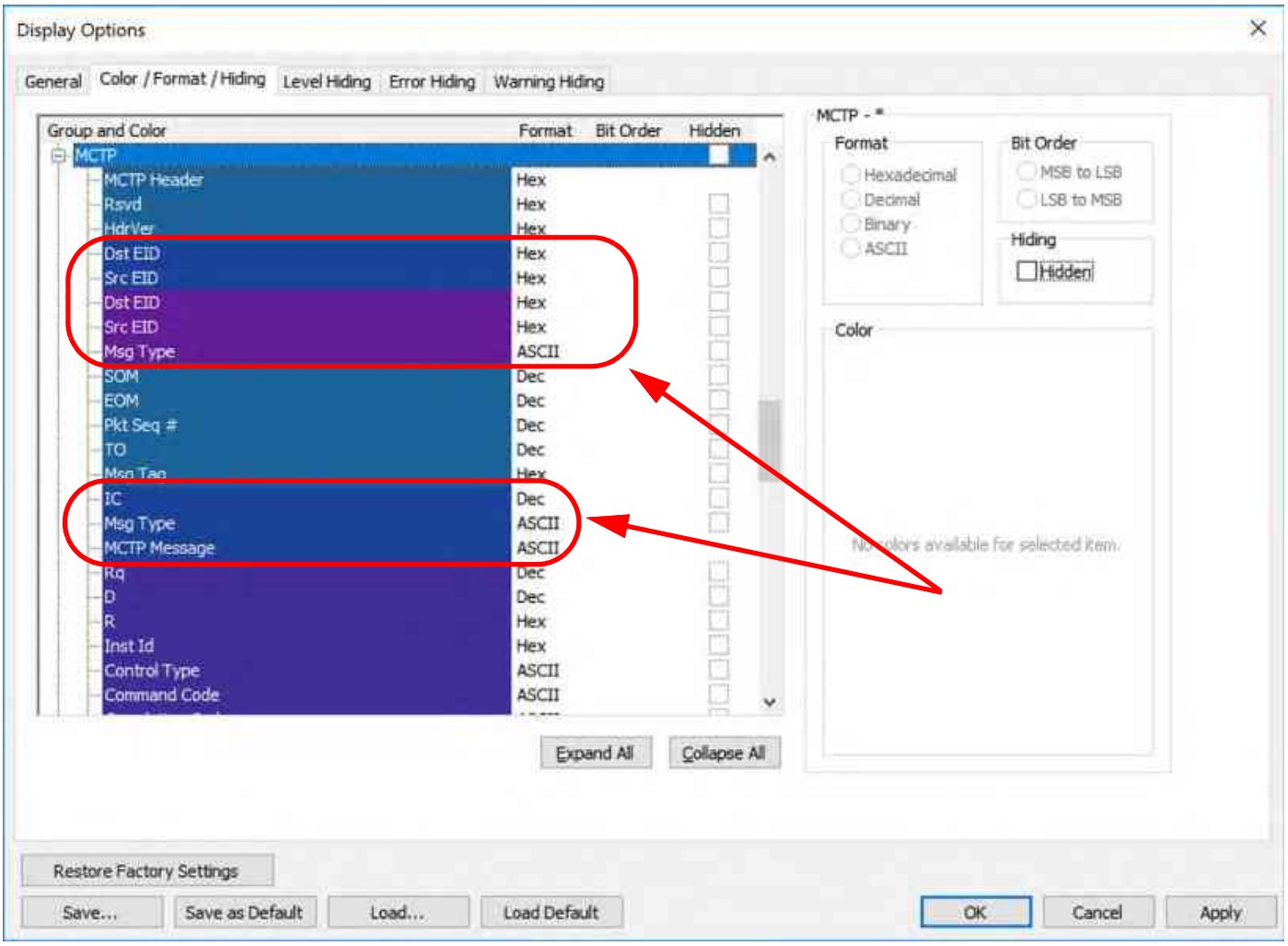


Figure 7.112: MCTP Commands and Transaction Colors from Display Options

7.11.15 Decoding MCTP Messages with SMBus Traffic

The System Management Bus (abbreviated to SMBus or SMB) is a single-ended simple two-wire bus for the purpose of lightweight communication. Most commonly it is found in computer motherboards for communication with the power source for ON/OFF instructions.

It is derived from I^2C for communication with low-bandwidth devices on a motherboard, especially power related chips such as a laptop's rechargeable battery subsystem (see Smart Battery System). Other devices might include temperature, fan or voltage sensors, lid switches and clock chips. PCI add-in cards may connect to an SMBus segment.

A device can provide manufacturer information, indicate its model/part number, save its state for a suspend event, report different types of errors, accept control parameters and return status. The SMBus is generally not user configurable or accessible. Although SMBus devices usually can't identify their functionality, a new PMBus coalition has extended SMBus to include conventions allowing that.

The Summit T5 can capture SMBus traffic and display it as part of an MCTP message along with normal PCIe Data traffic, as shown in Figure 7.155 and Figure 7.156 on page 518.

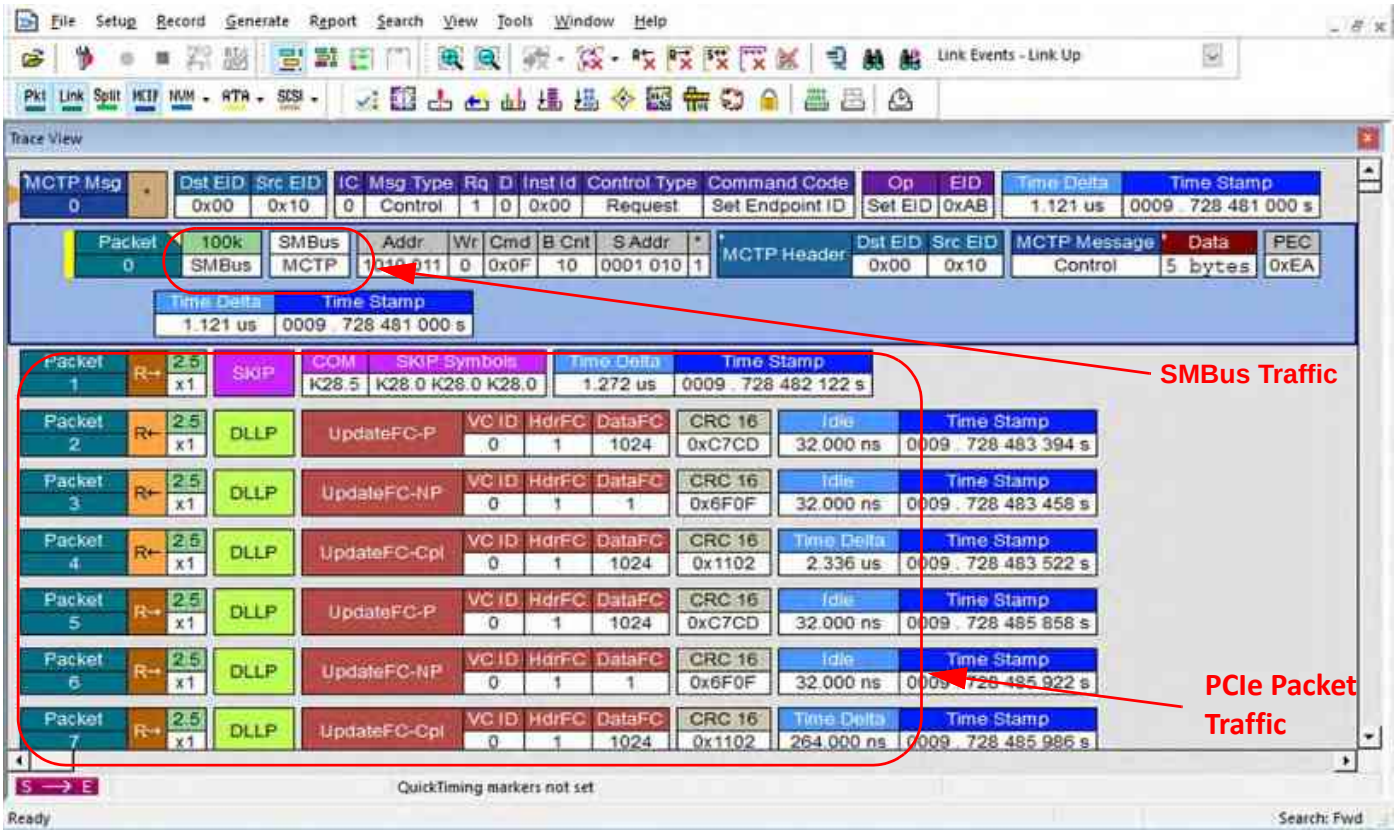


Figure 7.113: MCTP Message with SMBus Sideband Traffic and PCIe Packet Traffic

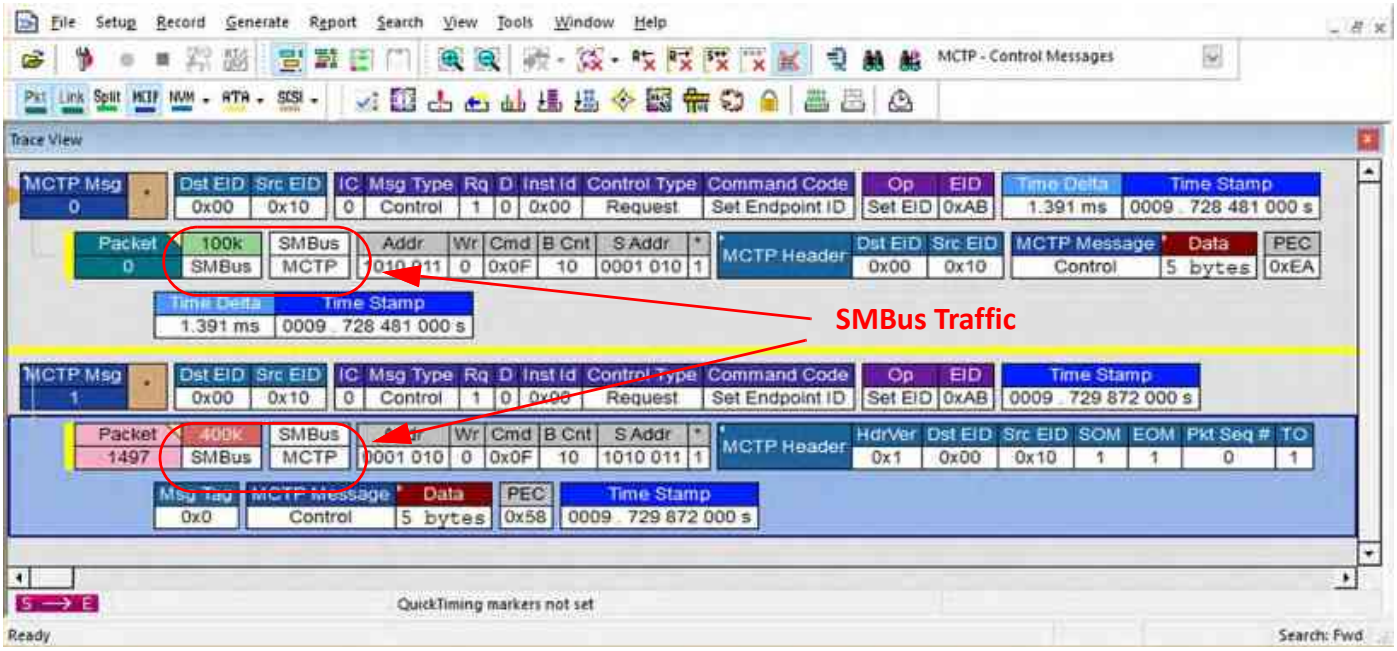


Figure 7.114: SMBus Traffic within two MCTP Messages

7.11.15.1 Sideband Traffic: Displayed or Hidden

You can decide to Display or Hide Sideband traffic (this includes SMBus traffic) by selecting the Hide Sideband icon in the toolbar. This will Hide the SMBus Traffic. Figure 7.115 shows Sideband traffic displayed. Figure 7.116 on page 481 shows the SMBus traffic Hidden.

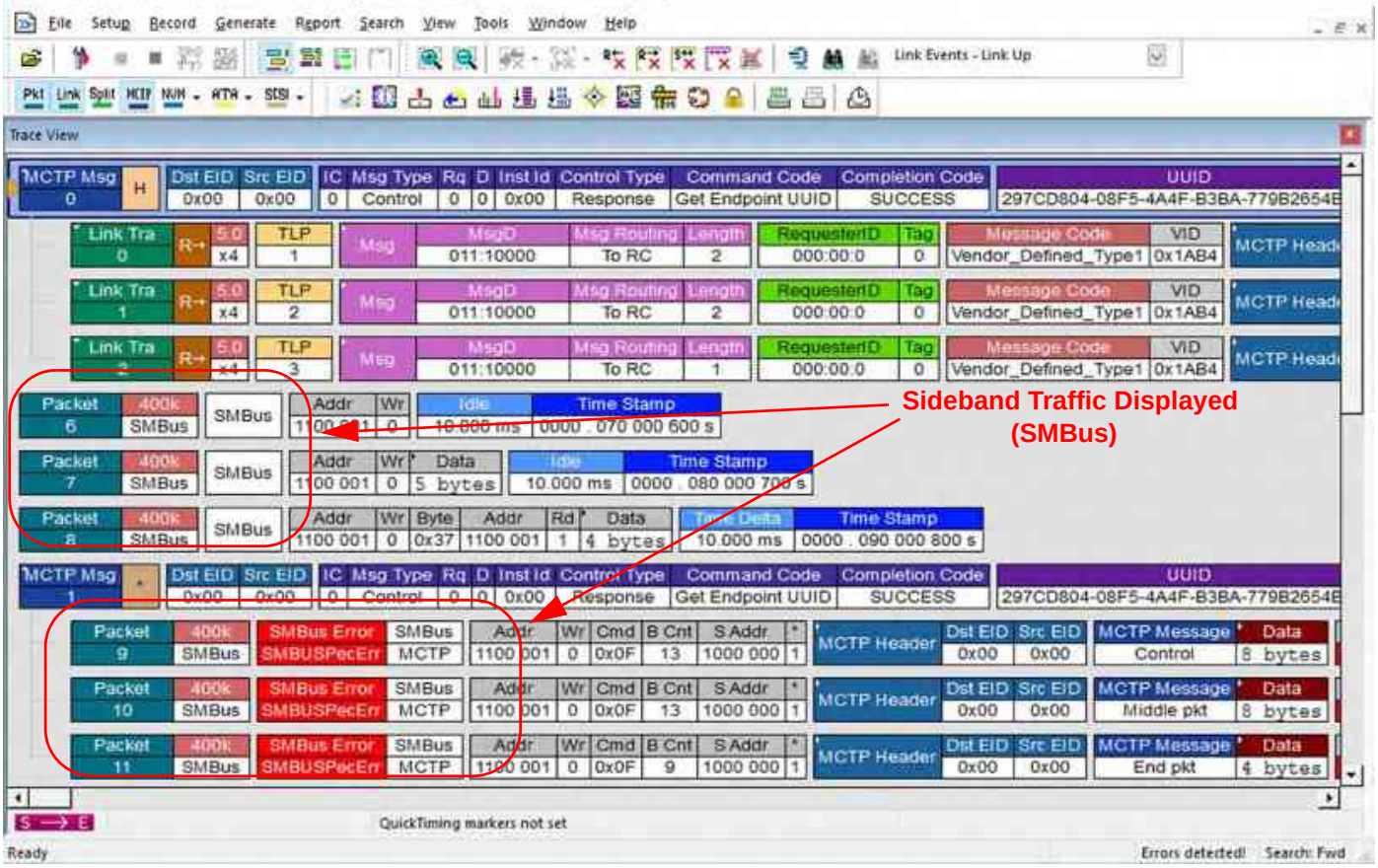


Figure 7.115: Displaying Sideband Traffic (SMBus)

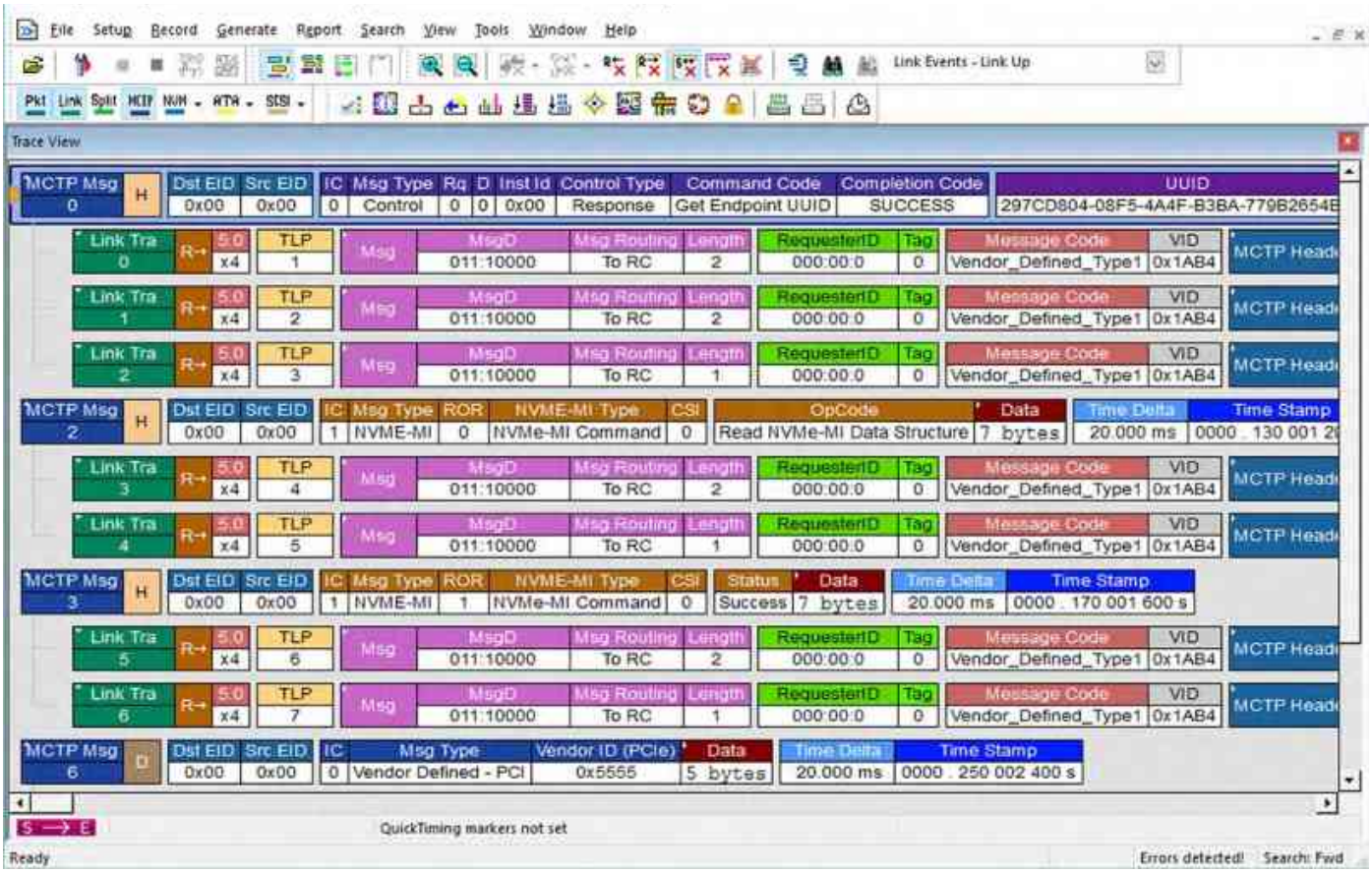


Figure 7.116: Hiding Sideband Traffic (SMBus)

If you compare Figure 7.115 on page 480 and Figure 7.116 you'll see that all the SMBus traffic has been hidden in Figure 7.116. Specifically, Packets 6 - Packet 8 are hidden, which had SMBus traffic and the SMBus traffic in Packets 9 and 10, which were part of MCTP Message 1 are also hidden.

7.11.15.2 SMBus Errors

The Summit T5 analyzer can detect a wide variety of SMBus errors (as shown in Figure 7.117 and Figure 7.118 on page 483).

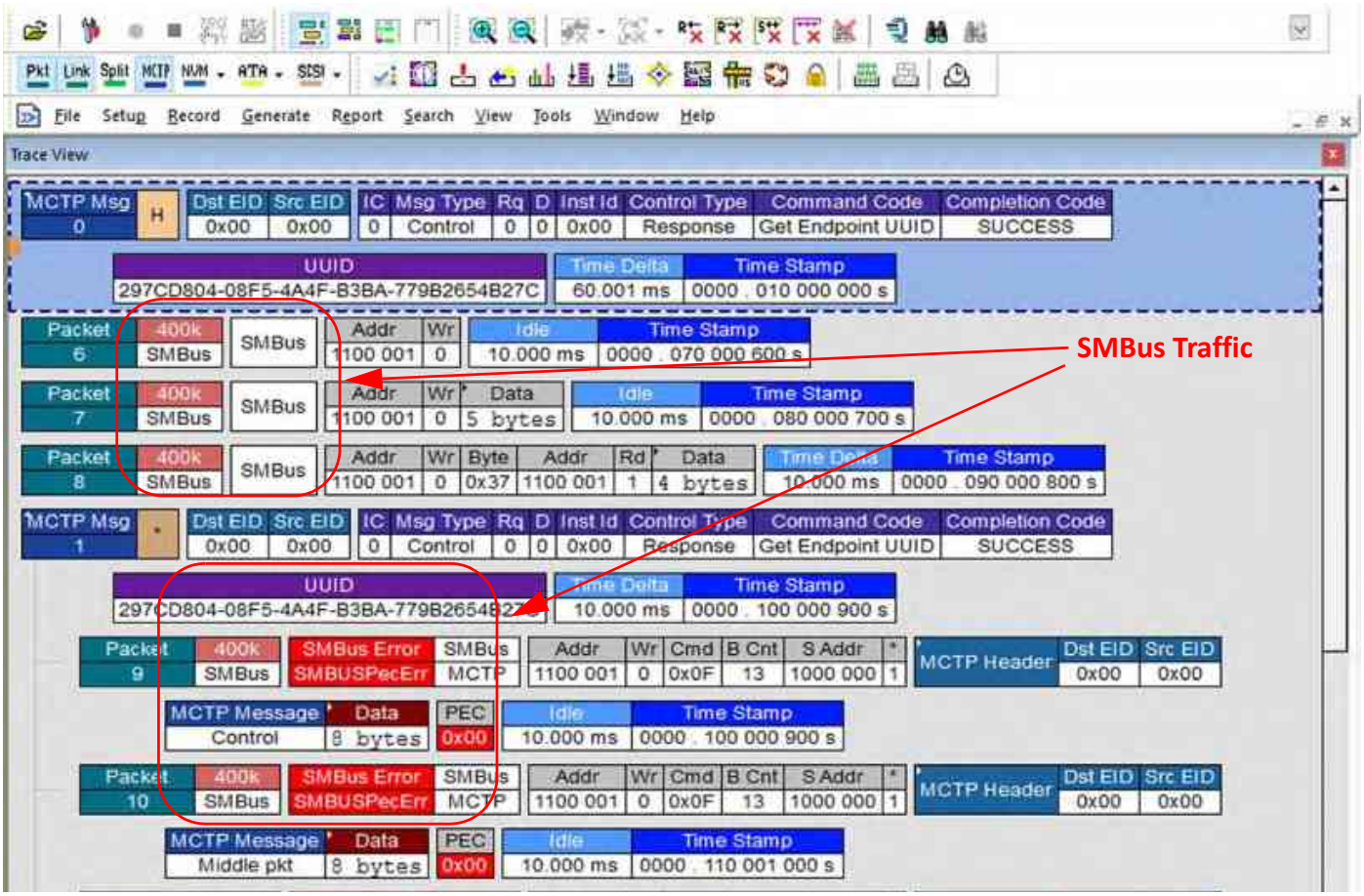


Figure 7.117: SMBus Traffic within two MCTP Messages with Errors

7.11.15.3 SMBus Error Tooltip

If you scroll over each SMBus Error a tooltip with a detailed explanation of the error will popup. See Figure 7.118.

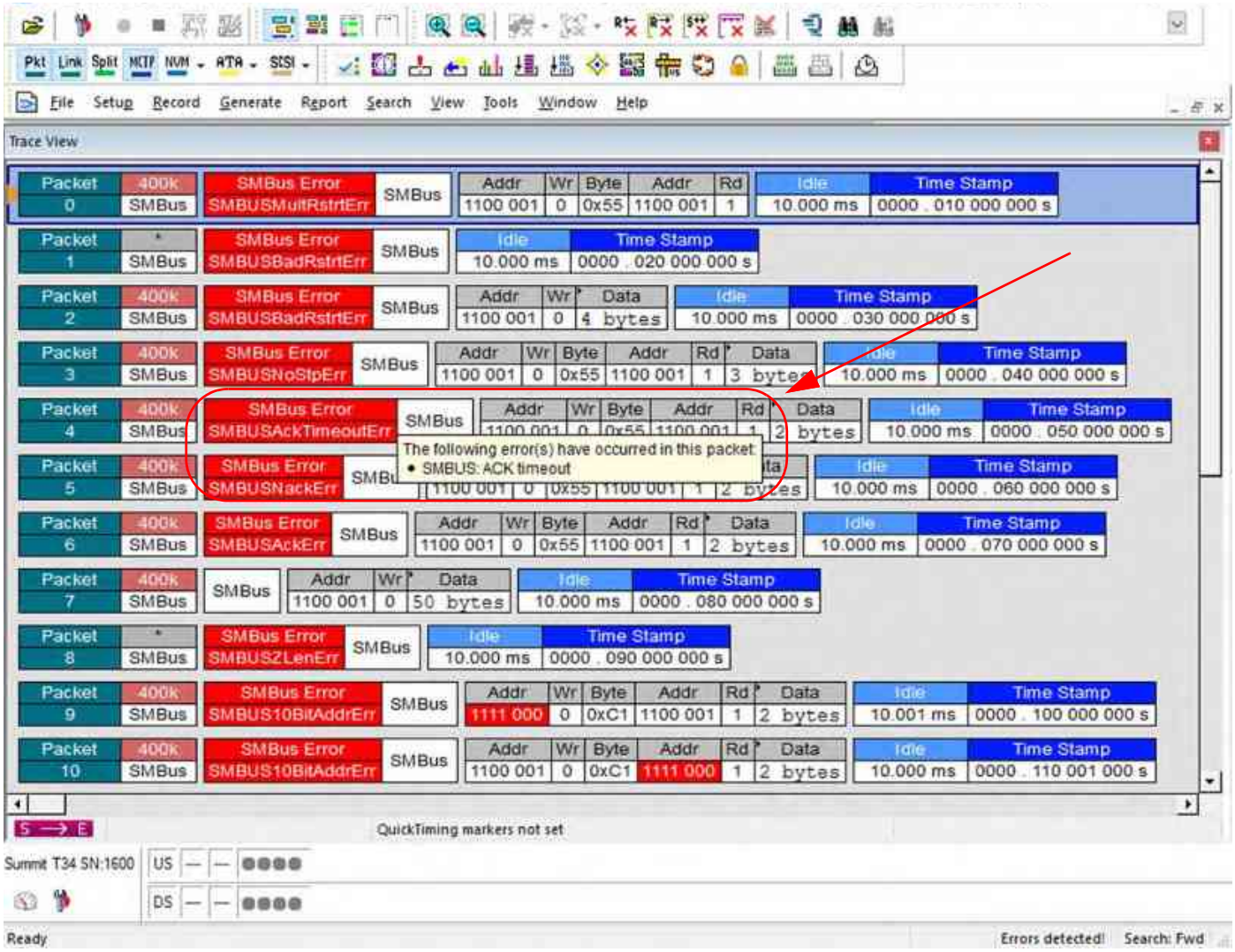


Figure 7.118: Decoding SMBus with Errors

7.11.15.4 Traffic Summary Report: SMBus Errors

Another way of displaying the SMBus errors is to select the Traffic Summary Report (as shown in Figure 7.119).

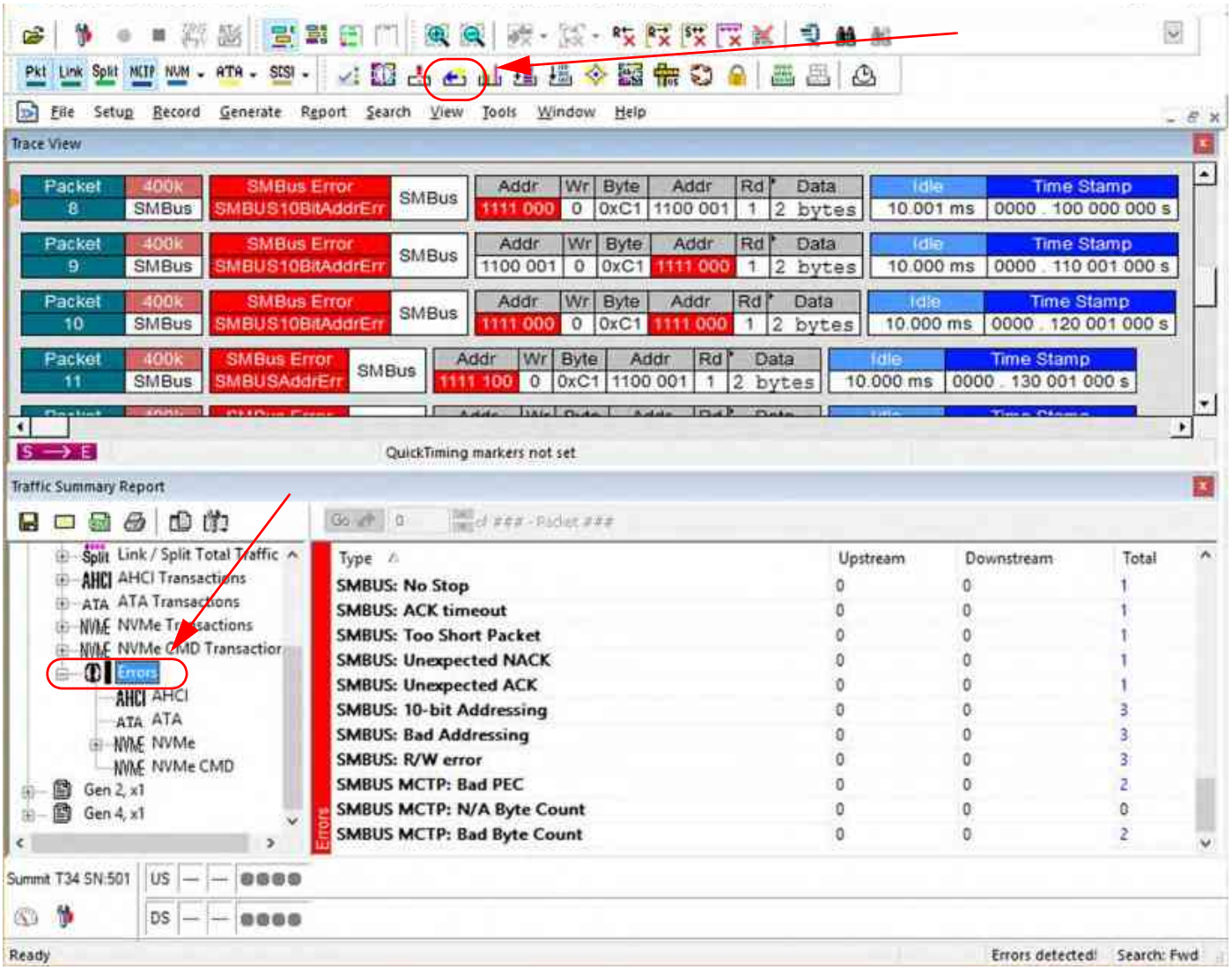


Figure 7.119: Traffic Summary Report: SMBus Errors

The complete set of SMBus errors that the Summit T5 can detect is contained in the table below: Table 7.1.

TABLE 7.1: SMBus Errors

Bus Error	Description
SMBUSLongPktErr	SMBUS: Too Long Packet
SMBUSMultRstrtErr	SMBUS: More Than One Restart
SMBUSBadRstrtErr	SMBUS: Bad Restart
SMBUSNoStpErr	SMBUS: No Stop
SMBUSAckTimeoutErr	SMBUS: ACK Timeout
SMBUSZLenErr	SMBUS: Too Short Packet
SMBUSNackErr	SMBUS: Unexpected NACK
SMBUSAckErr	SMBUS: Unexpected ACK
SMBUS10BitAddrErr	SMBUS: 10-bit Addressing
SMBUSAddrErr	SMBUS: Bad Addressing
SMBUSRwErr	SMBUS: R/W error
SMBUSPecErr	SMBUS MCTP: Bad PEC
SMBUSNaByteCntErr	SMBUS MCTP: N/A Byte Count
SMBUSByteCntErr	SMBUS MCTP: Bad Byte Count

7.11.16 Decoding SMBus with Address Resolution Protocol (ARP)

The PCIe Protocol Analysis can decode SMBus traffic with Address Resolution Protocol as shown below in Figure 7.120.

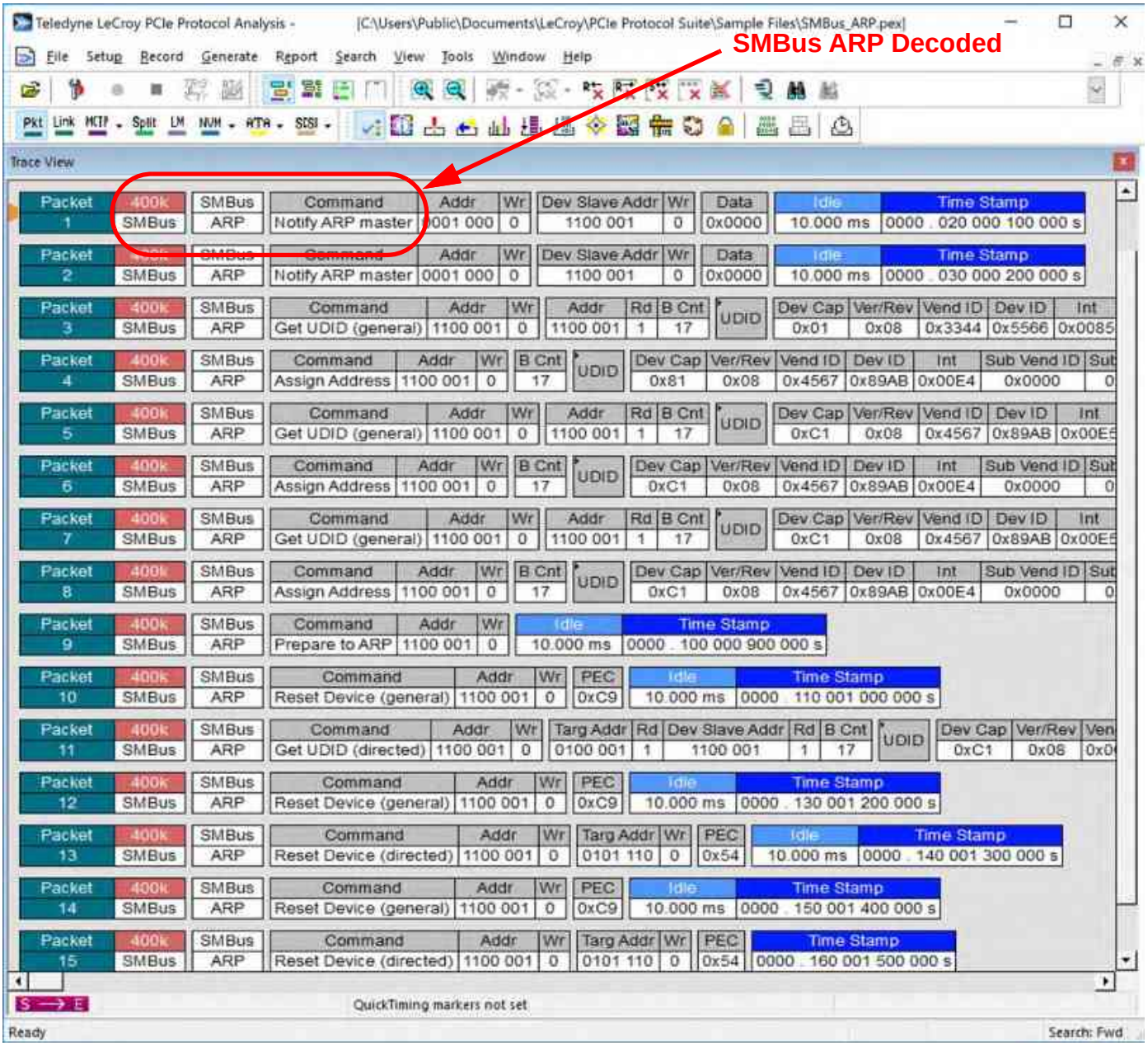


Figure 7.120: SMBus Address Resolution Protocol Decoded

7.11.17 Decoding MCTP Traffic with Vendor Defined Messages (VDM)

The PCIe Protocol Analysis can decode MCTP traffic with Vendor Defined Messages (VDM) as shown below in Figure 7.121.

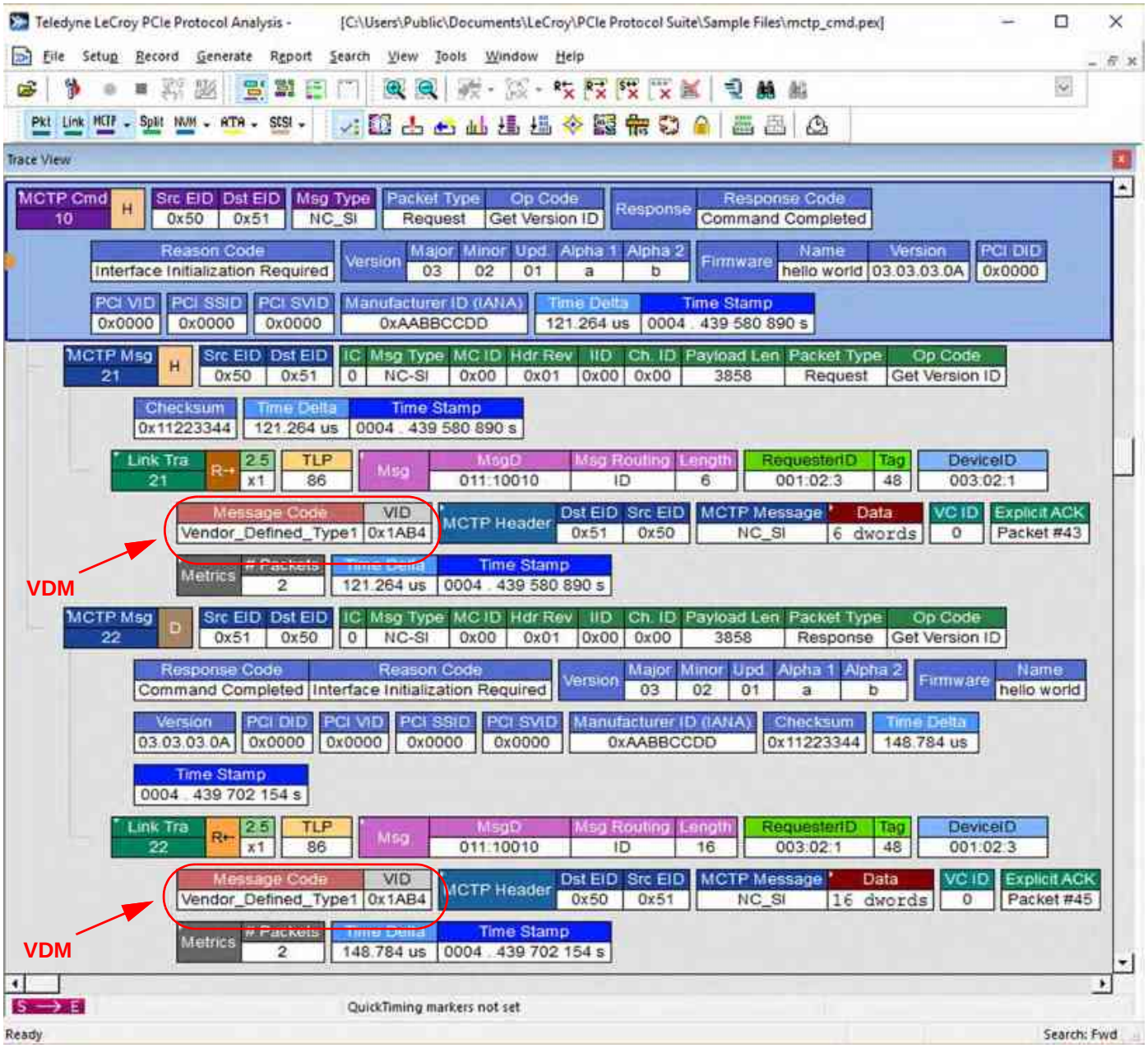


Figure 7.121: MCTP Traffic: Decoding Vendor Defined Messages (VDM)

7.11.18 Decoding Side Band Signals

There are a number of side band signals which are decoded by the PCIe Protocol Analysis and will be displayed in the Trace View:

- PERST# (Asserted and Deasserted)
- WAKE# (Asserted and Deasserted)
- CLKREQ# (Asserted and Deasserted)

These signals are displayed as Link Events. They can be found in the trace by using the **Search -> Go to -> Link Event** function from the Main Toolbar.

Since these signals have no direction they will be displayed once in the upstream direction and once in the downstream direction.

Note: If left floating in the bus, PERST#, WAKE# and CLKREQ# may show up in the trace as events. Make sure these signals are pulled up according to the specification. During beacon phase there might be transitions of WAKE# that will show up in the trace.

7.11.19 PMUX Channel ID Found and PMUX Packet Error Decoded in Trace

In the trace both the PMUX Channel ID was found and a Packet PMUX Error was decoded. See Figure 7.122.

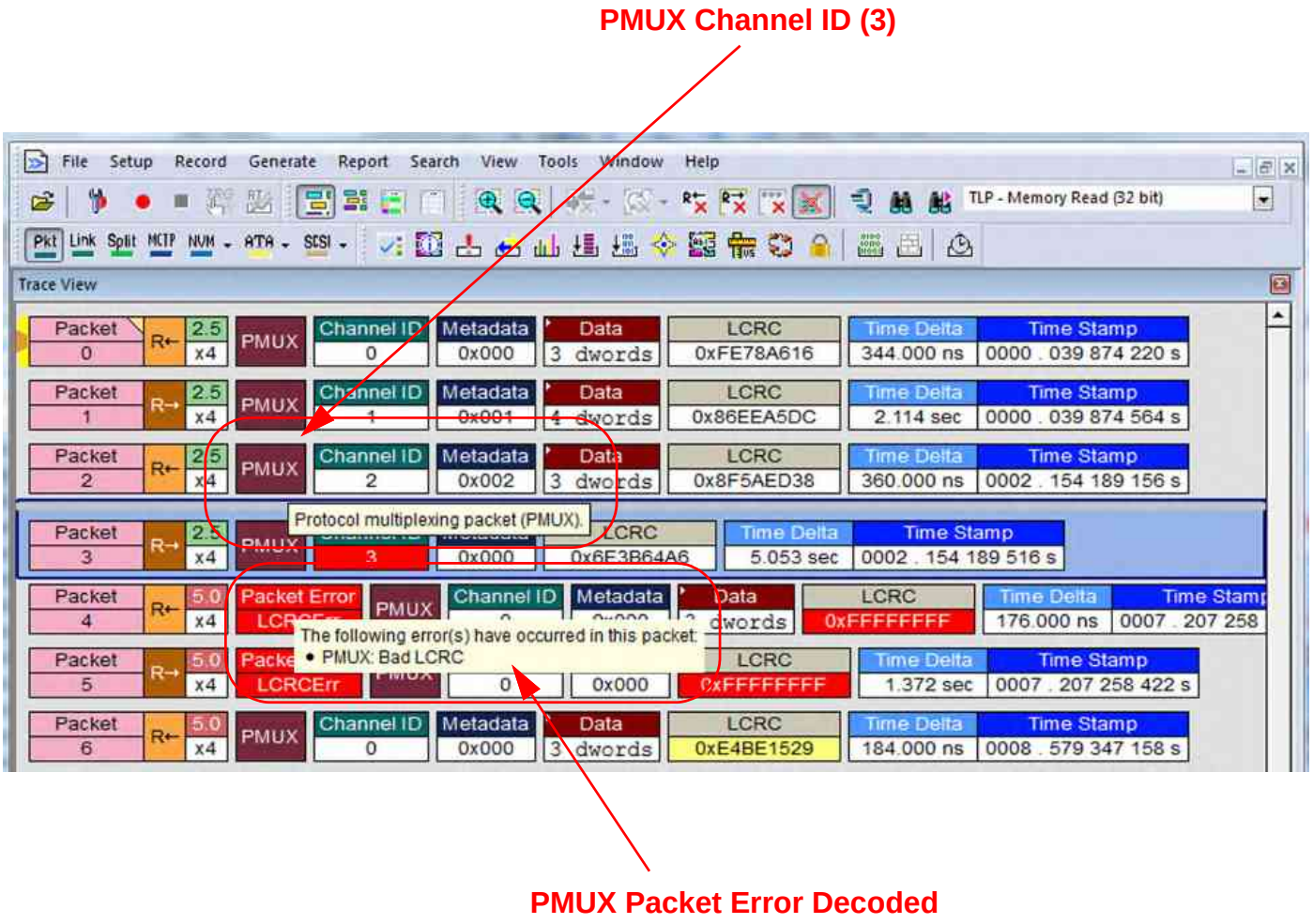


Figure 7.122: PMUX Channel ID (3) Found in Trace and Packet Error Decoded

7.11.20 Decoding Traces with Different Class Codes

PCIe Protocol Analysis initially assumes all traces have unknown class codes and that the decoder selected and trace class codes are the same. If after decoding the trace, the class codes of the trace and the decoder selected are different, a warning message pops up showing the correct class code of the trace.

7.11.20.1 Example: Loading an NVMe Trace and Decoding for ATA

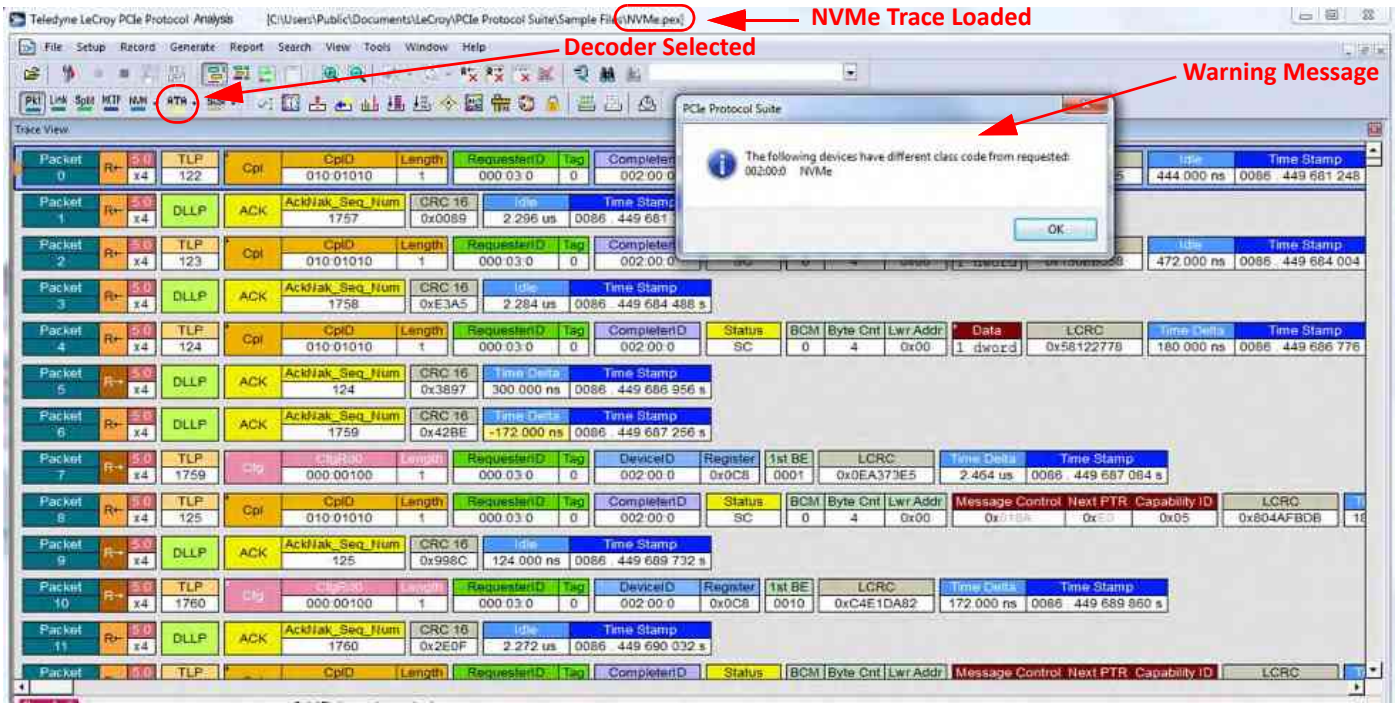


Figure 7.123: NVMe Trace Loaded Different Than ATA Decoder Selected

7.11.20.2 Example: Loading a PQI Trace and Decoding for NVMe

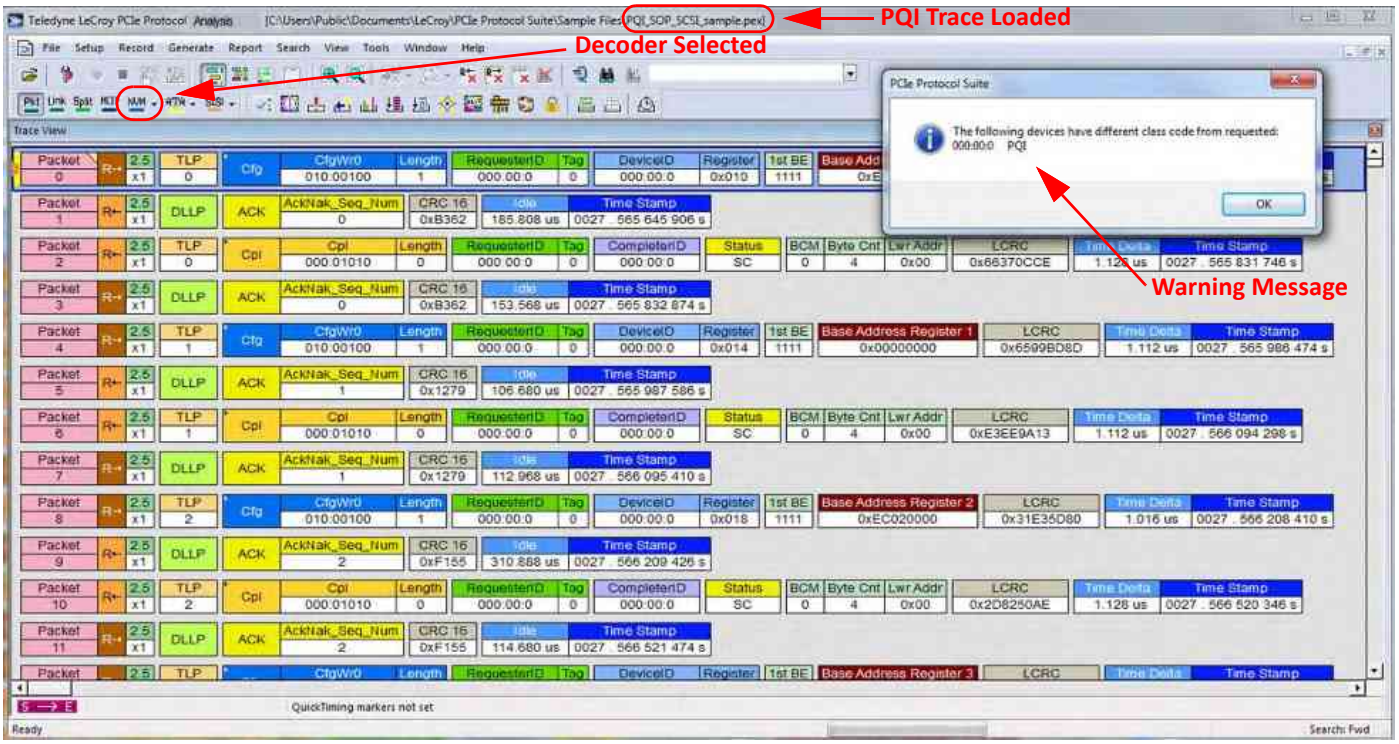


Figure 7.124: PQI Trace Loaded Different Than NVMe Decoder Selected

7.11.21 Data Link Features

The Summit T5 can decode Data Link Features as shown in Figure 7.125.

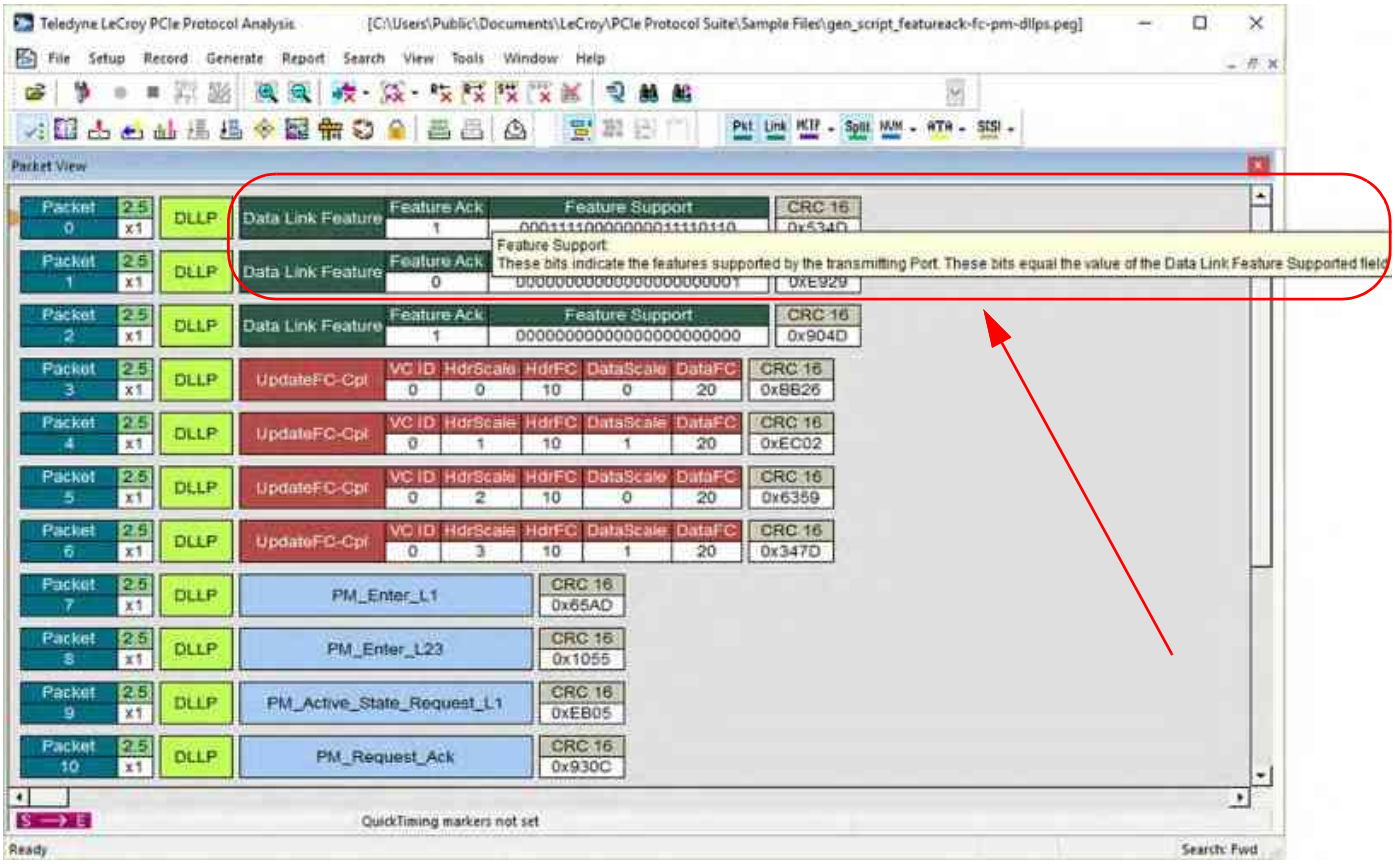


Figure 7.125: Decoding Data Link Features

The supported Data Link Features are defined in the PCIe Specification:

PCI Express® Base Specification Revision 4.0 Version 0.7 dated 11 November 2016.

They are outlined in Table 3.1 on page 202 and are shown below:

TABLE 7.2: Data Link Feature Supported Bit Definition

Bit Location	Description
0	**Scaled Flow Control** – indicates support for Scaled Flow Control. Scaled Flow Control must be supported in Ports that support 16.0 GT/s or higher operation.
Others	Reserved

7.11.22 Decode for NVMe 1.3c Specification

The PCI Express Analysis includes decoding for the following NVMe 1.3c Specification:

- Command Specific Status Code
- Opcodes for Admin commands

- Doorbell Buffer Config commands
- Device Self-Test command
- Directive Receive command
- Directive Send command
- Firmware Commit
- Features
- Get Log Page
- Identify command
- NVMe-Mi Receive command
- NVMe-MI Send command
- Format NVM
- Sanitize command
- Write
- Write Zeros
- Identifier Format 7.10

Some examples are shown below (see Figure 7.126 through Figure 7.129 on page 495).

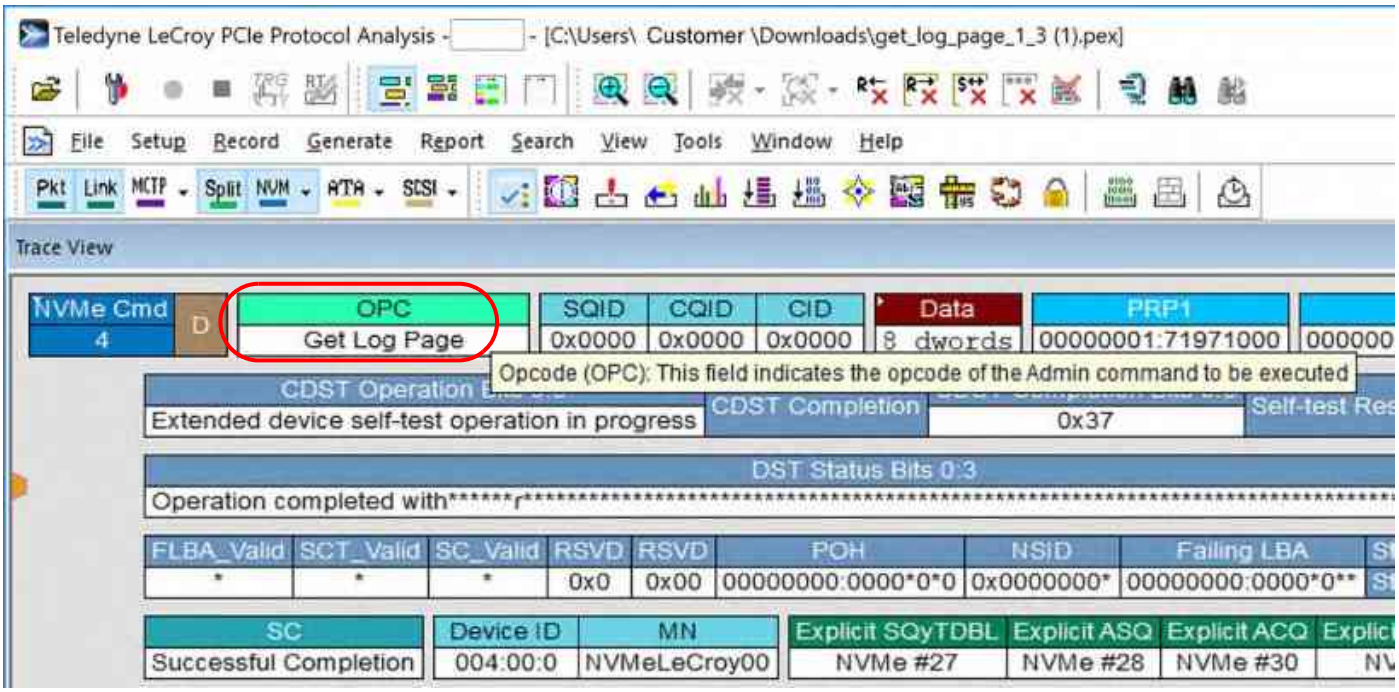


Figure 7.126: NVMe 1.3c Spec: Decodes --> Get Log Page

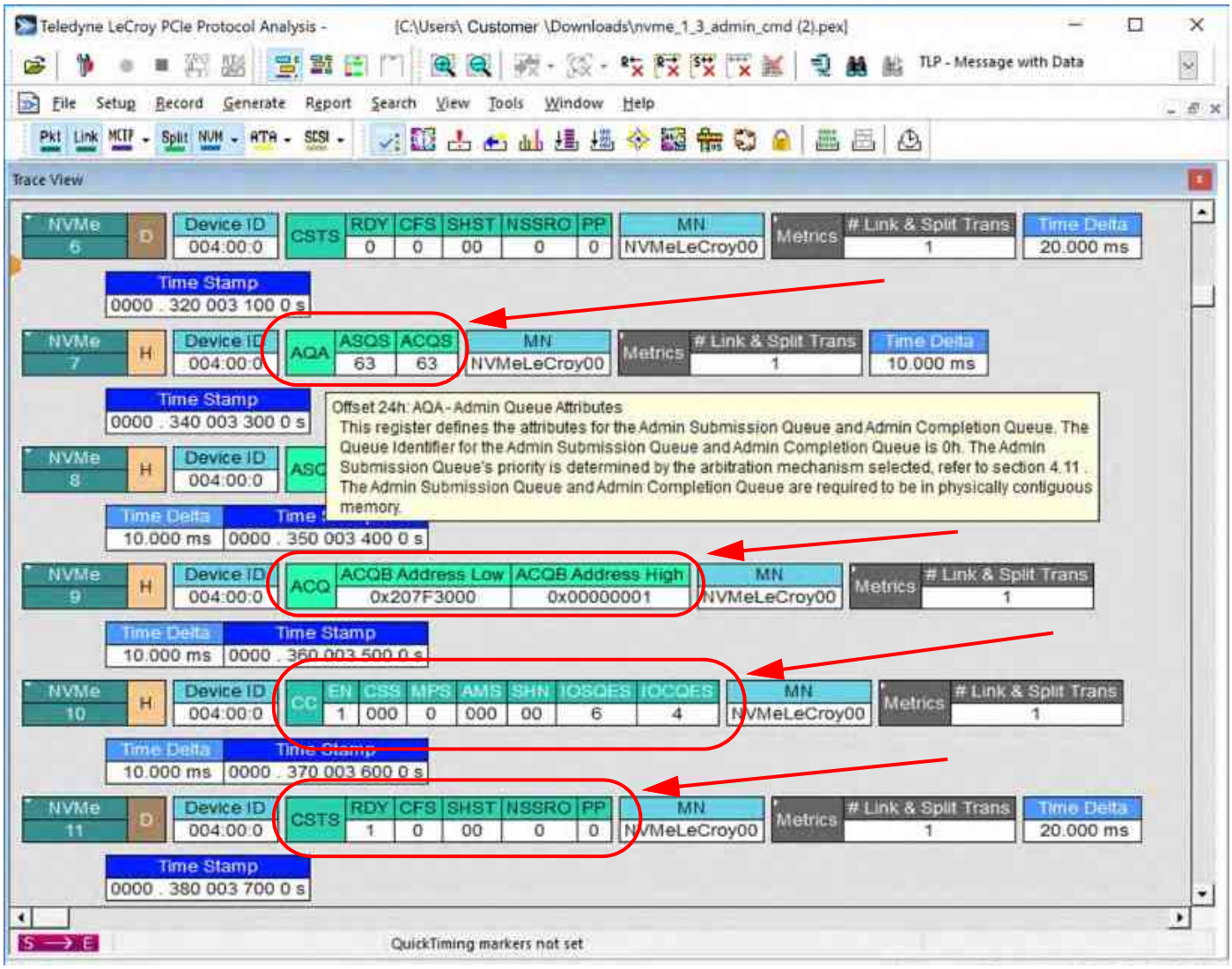


Figure 7.127: NVMe 1.3c Spec: Decodes --> Admin Commands

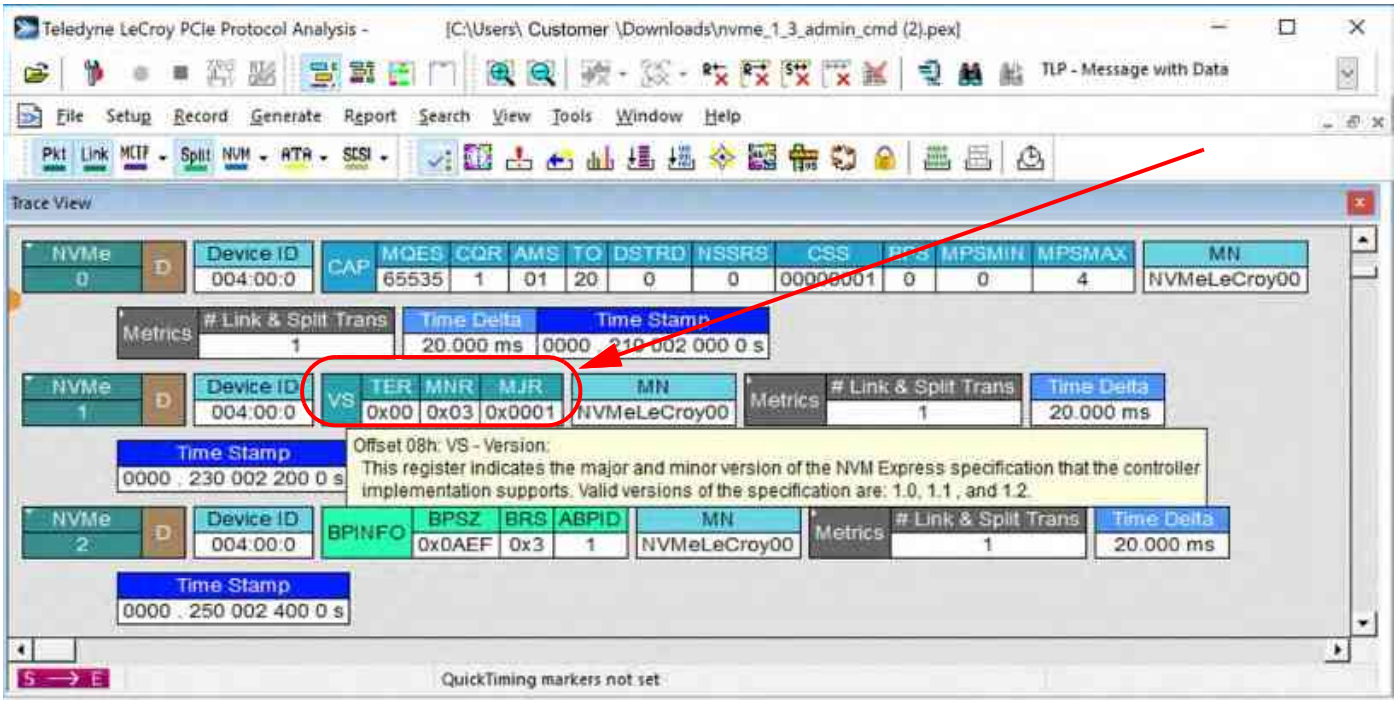


Figure 7.128: NVMe 1.3c Spec: Decodes --> Spec Version 1.3c

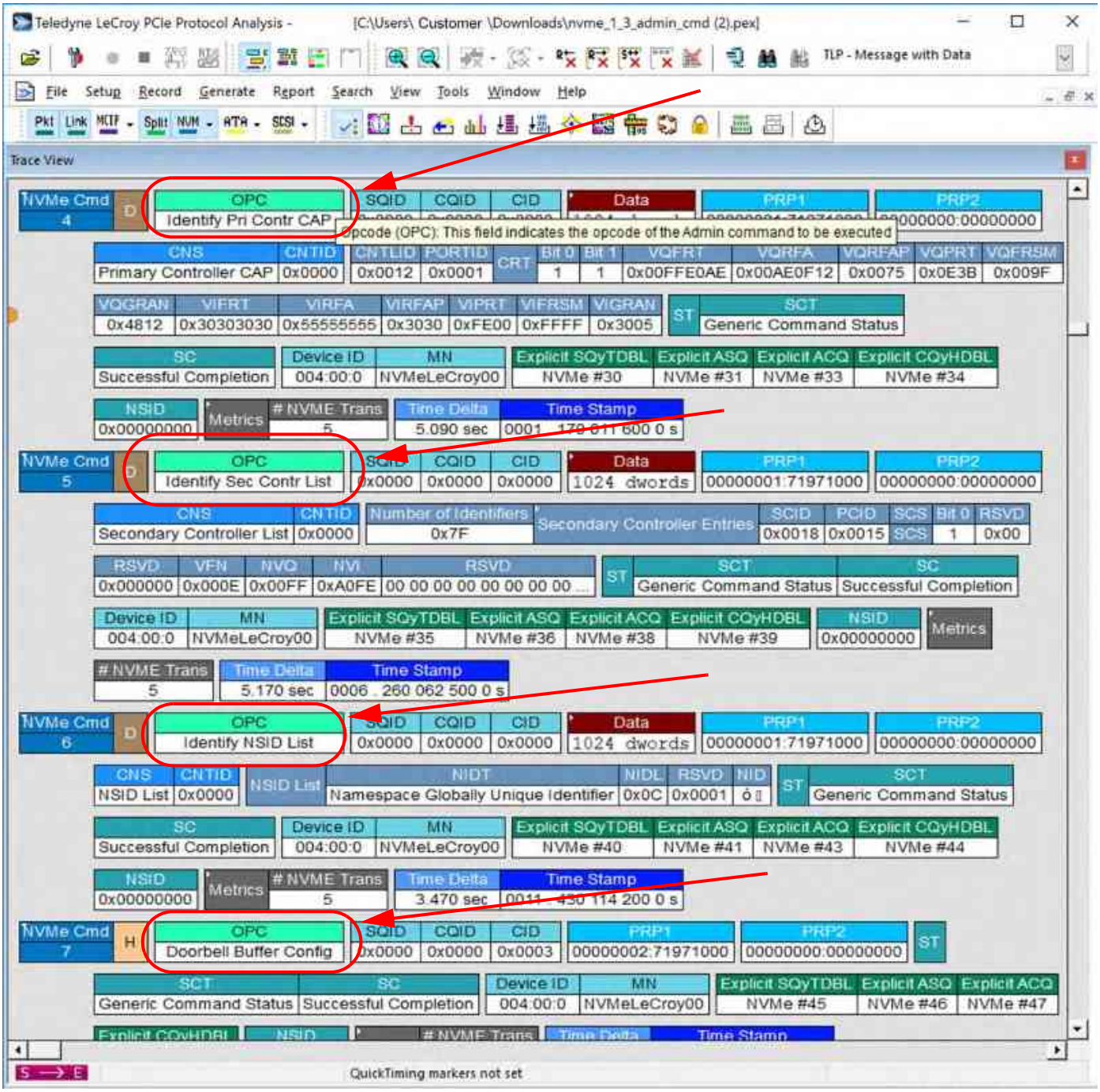


Figure 7.129: NVMe 1.3c Spec: Decodes --> Opcodes

7.11.23 NVMe Warning Messages

The PCIe Protocol Analysis software is capable of decoding the following NVMe Warning messages:

- Trace View
- Traffic Summary
- Search for NVMe Commands

- Search for NVMe Transactions
- Hiding Options

7.11.23.1 Trace View

If you decode for NVMe Commands and Transactions you'll see the following types of warning messages: See Figure 7.130, Figure 7.131 on page 497, Figure 7.132 on page 497.

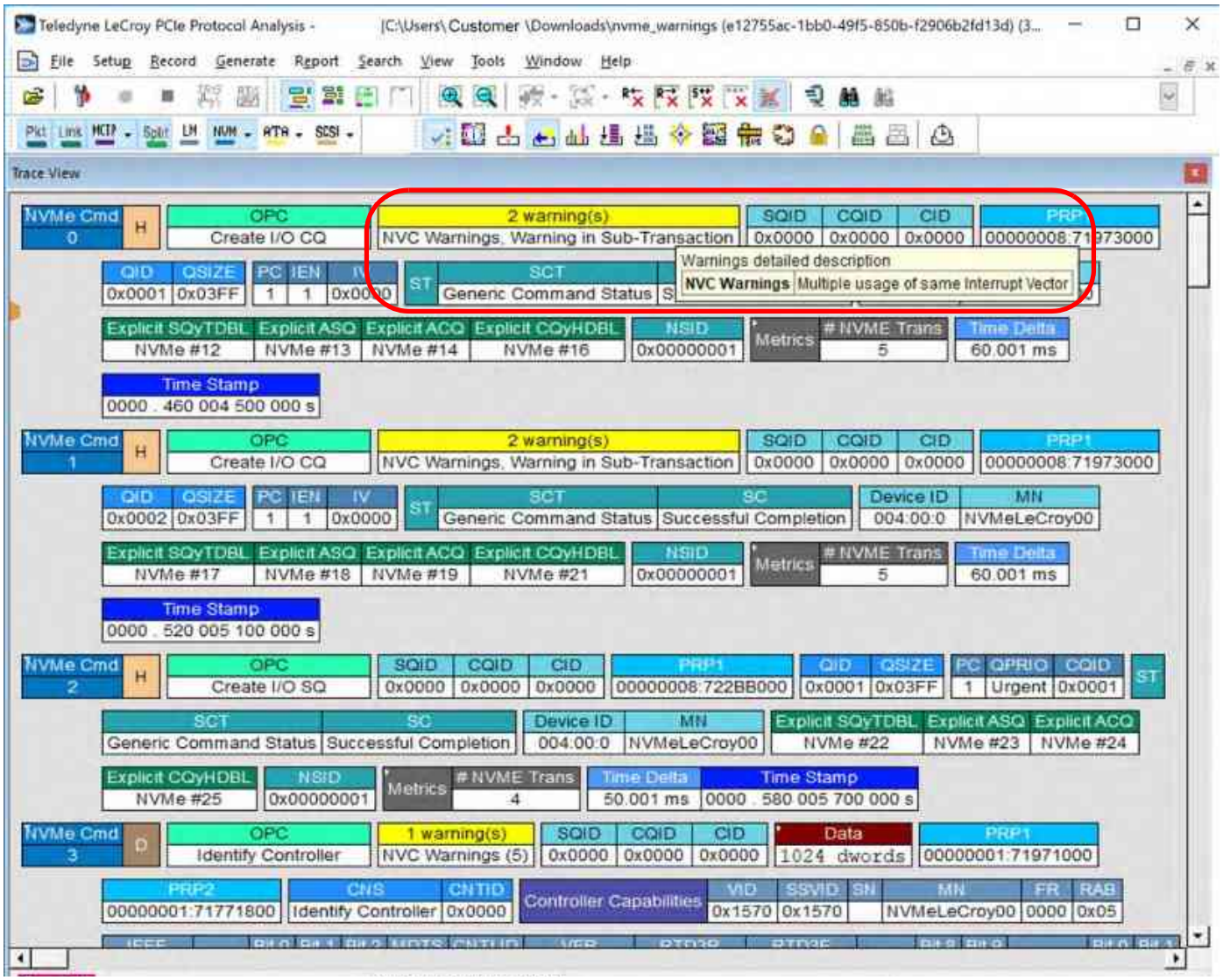


Figure 7.130: NVMe Command: Warning Message 1

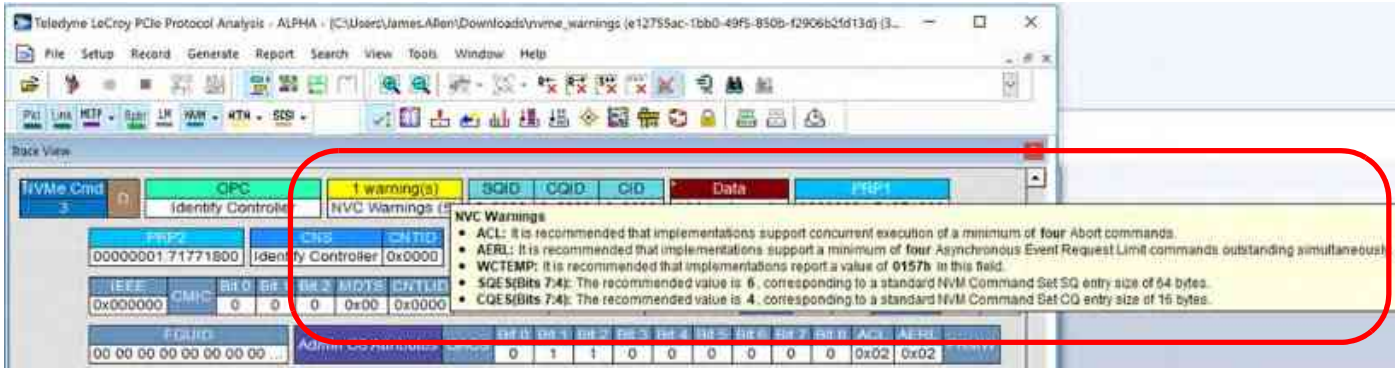


Figure 7.131: NVMe Command: Warning Message 2

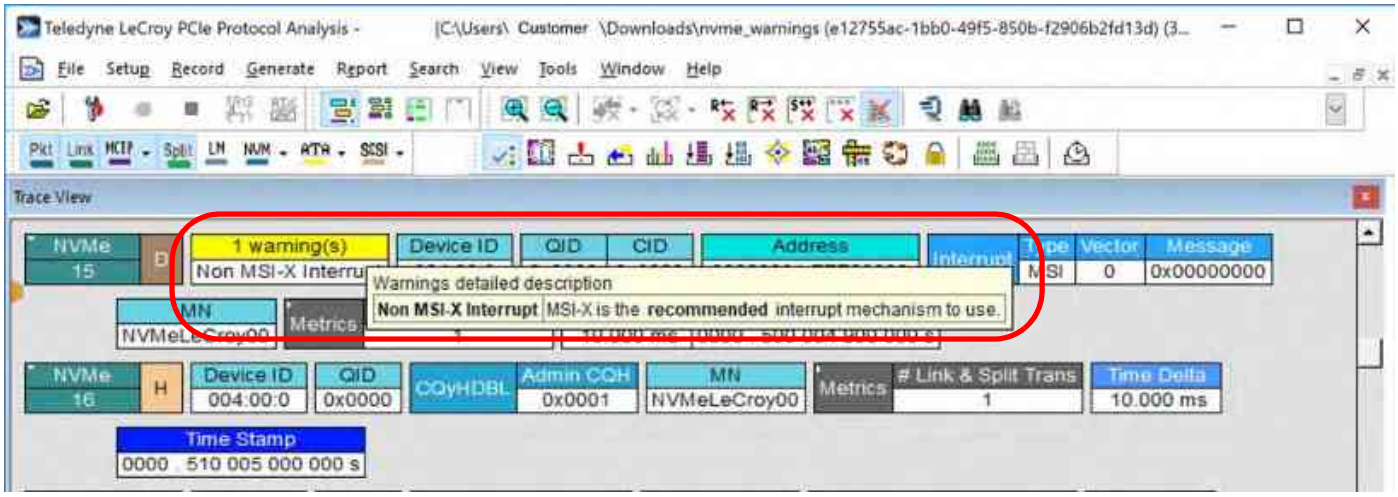


Figure 7.132: NVMe Transaction: Warning Message

7.11.23.2 Traffic Summary View

The NVMe Warning Messages can be seen in the Traffic Summary Reports (see Figure 7.133, Figure 7.134 on page 499, Figure 7.135 on page 500 and Figure 7.136 on page 501) below:

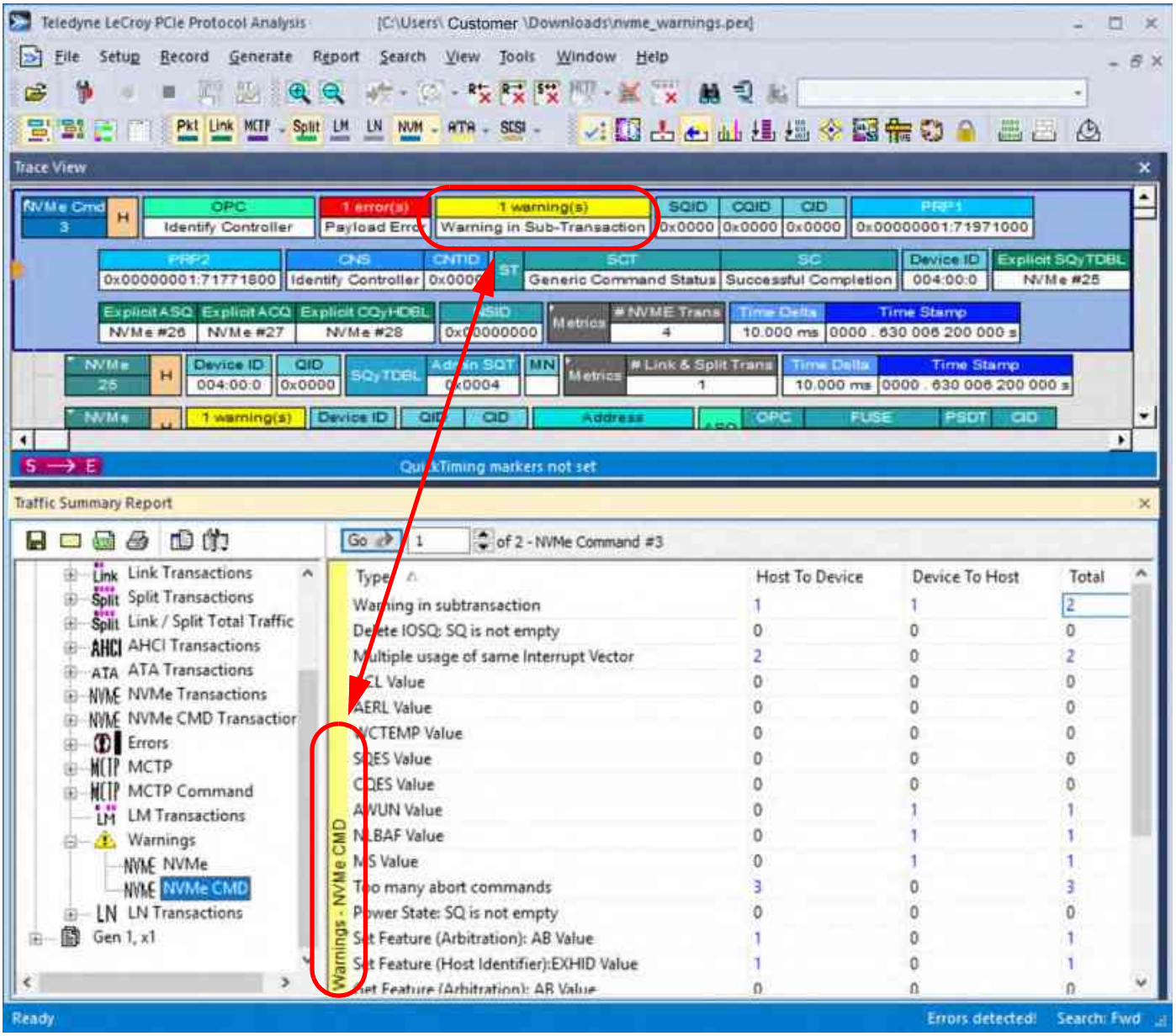


Figure 7.133: Warnings: NVMe CMD

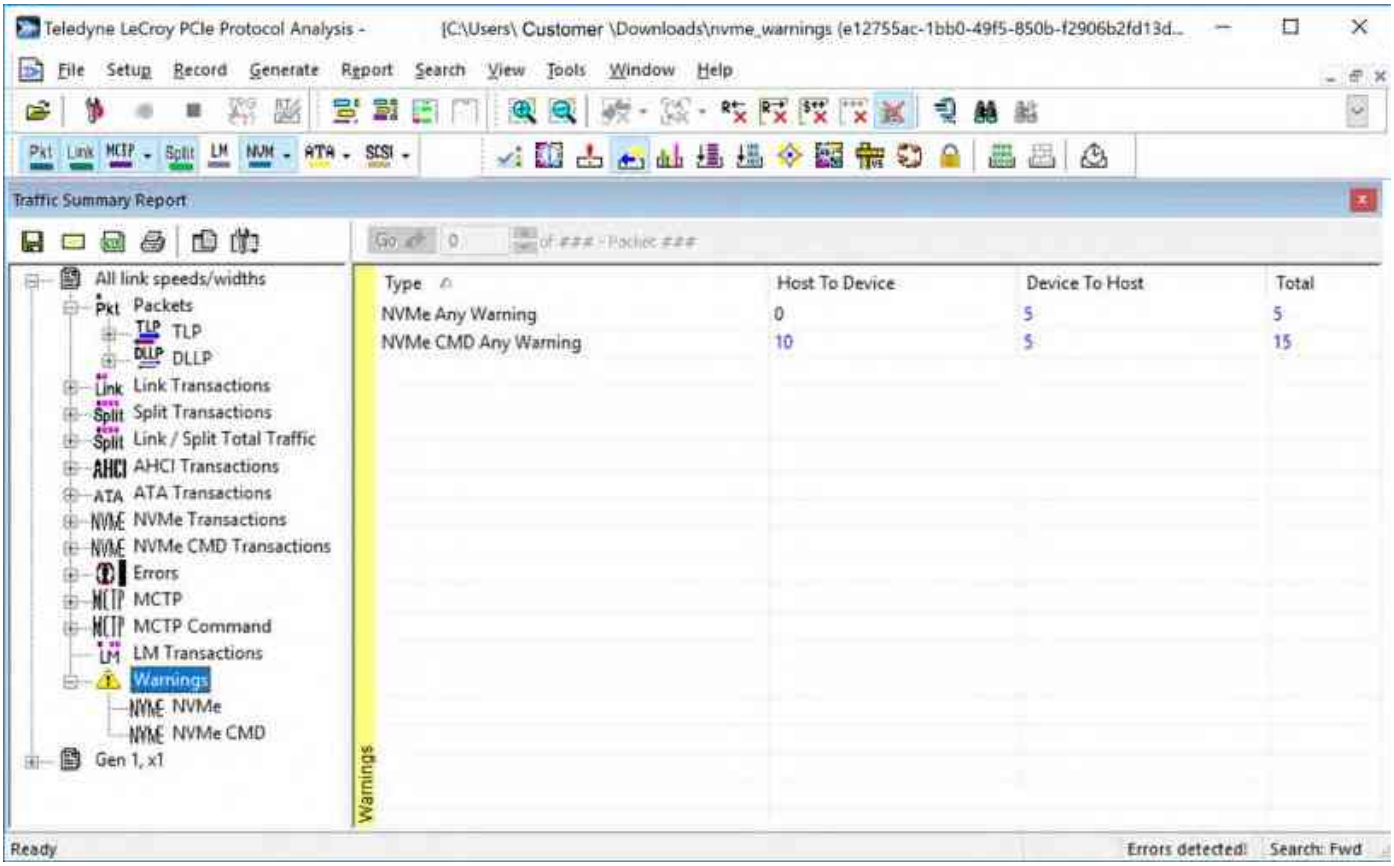


Figure 7.134: NVMe Warning Messages: Traffic Summary

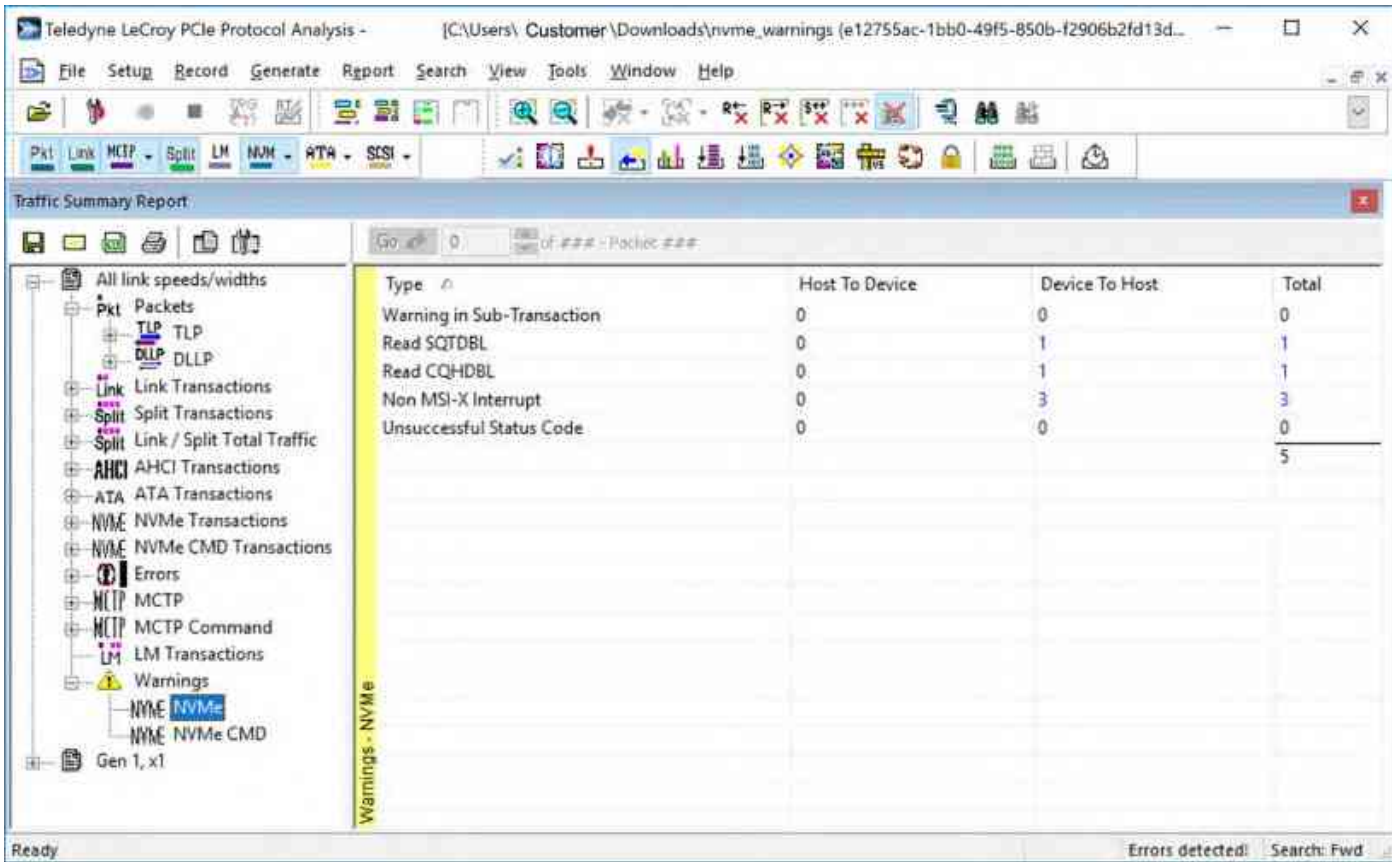


Figure 7.135: NVMe Warning Messages: Traffic Summary NVMe

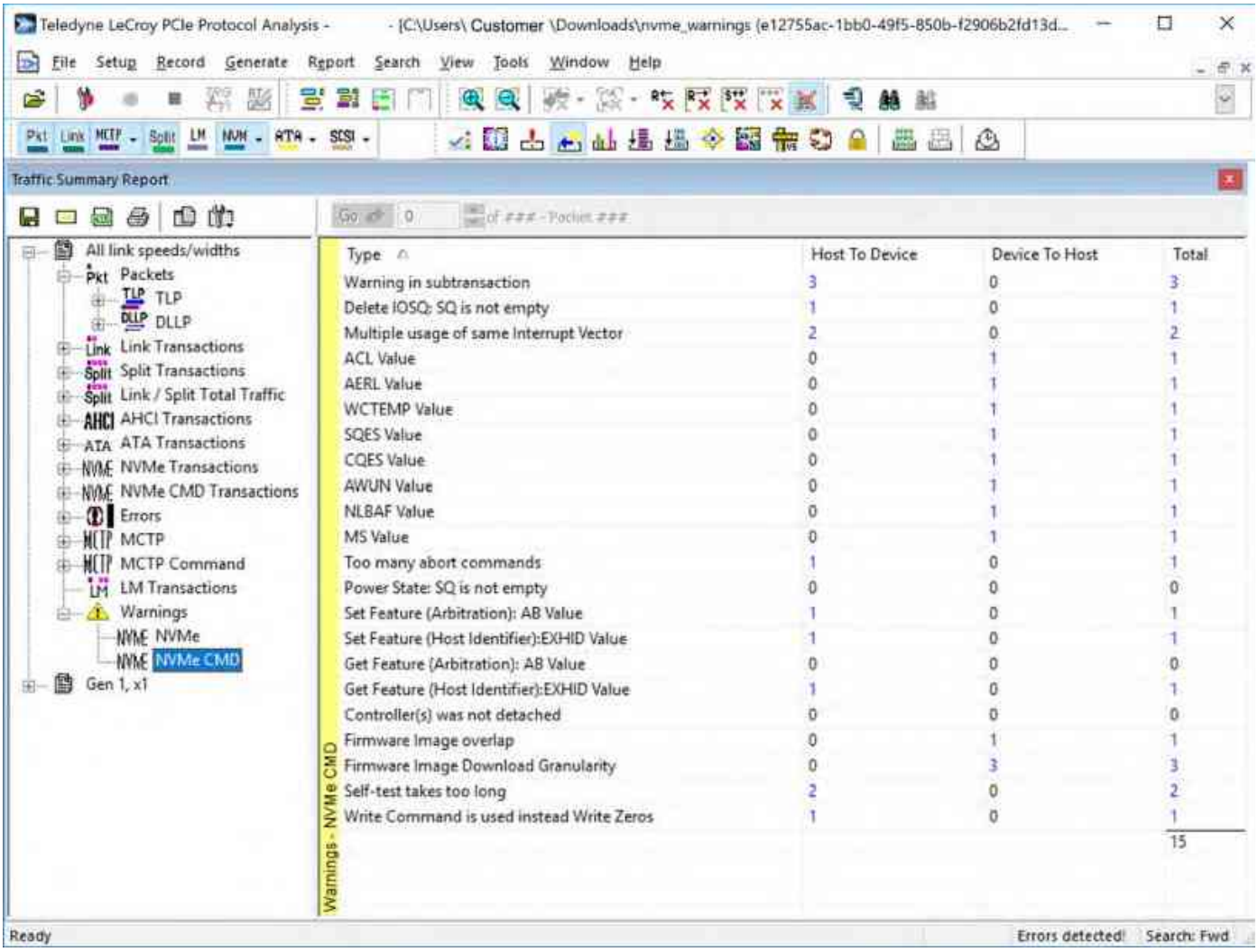


Figure 7.136: NVMe Warning Messages: Traffic Summary NVMe CMD

7.11.23.3 Find NVMe Commands and Transactions

You can use the “Find” function to display the NVMe Commands and Transactions Warning Messages. See Figure 7.137 on page 502 and Figure 7.138 on page 503.

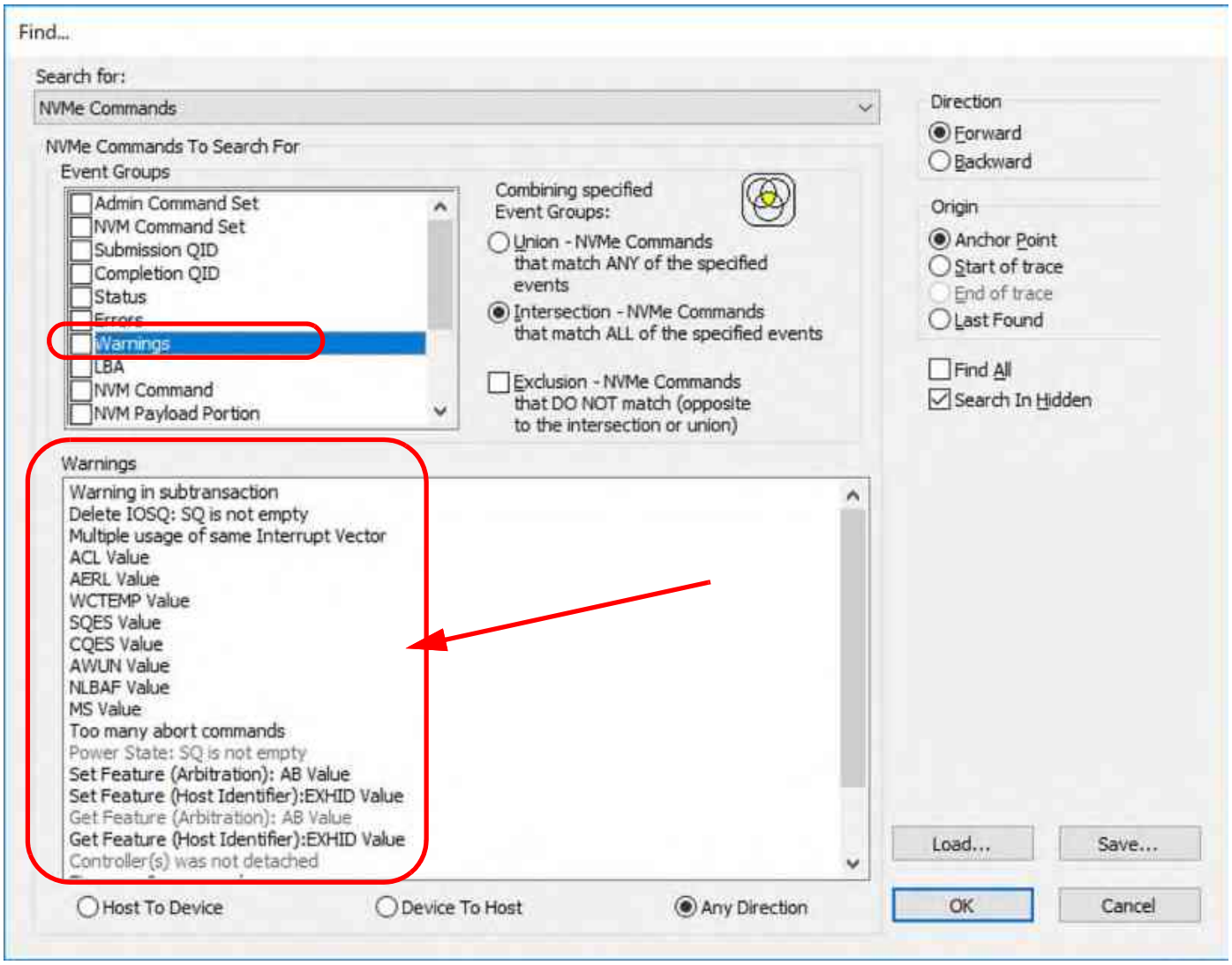


Figure 7.137: Find: NVMe Commands -> Warning Messages

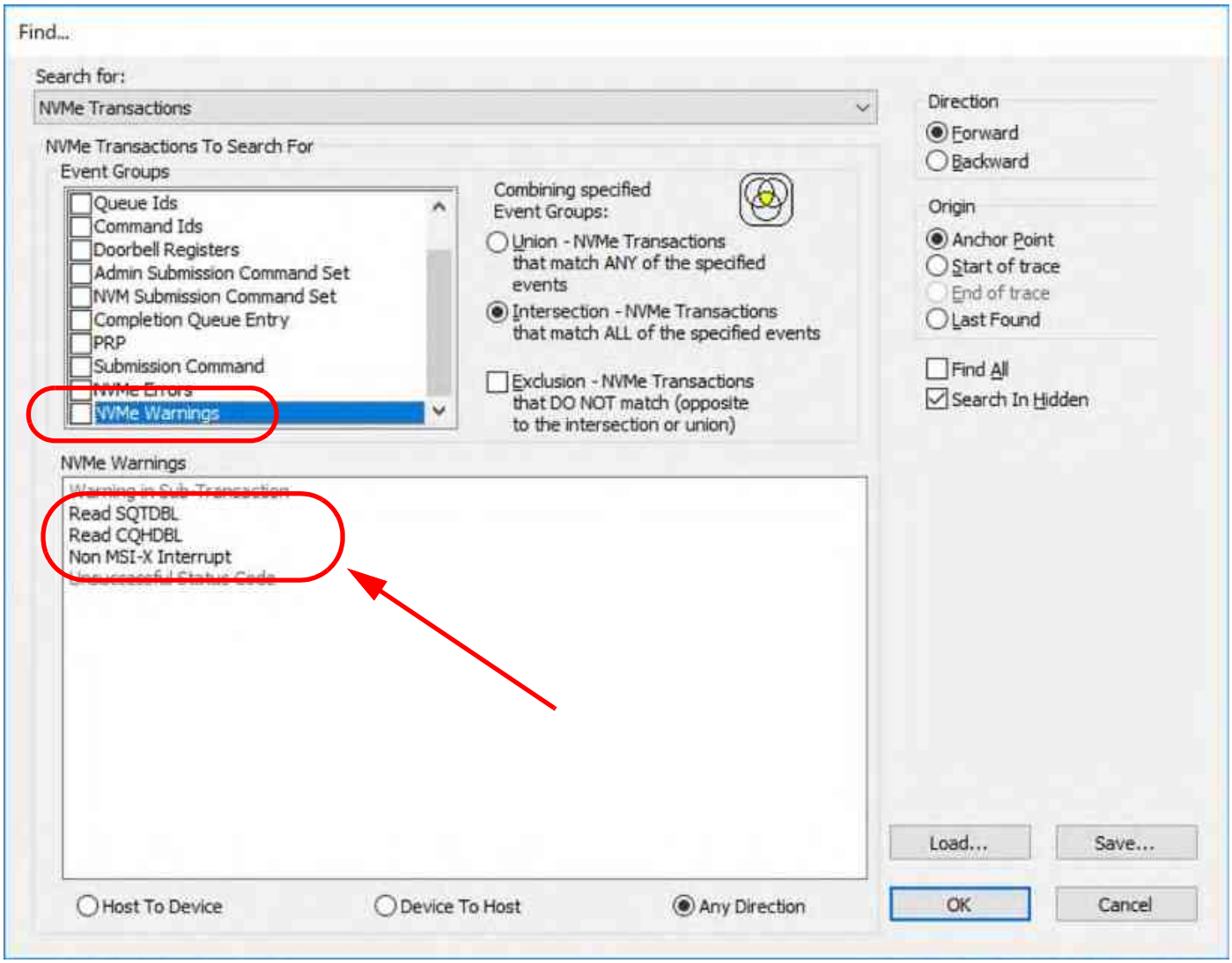


Figure 7.138: Find: NVMe Transactions -> Warning Messages

7.11.23.4 Hiding NVMe Warning Messages

You can also Hide  NVMe Warning Messages to remove them from the traffic. See Figure 7.139 on page 504.

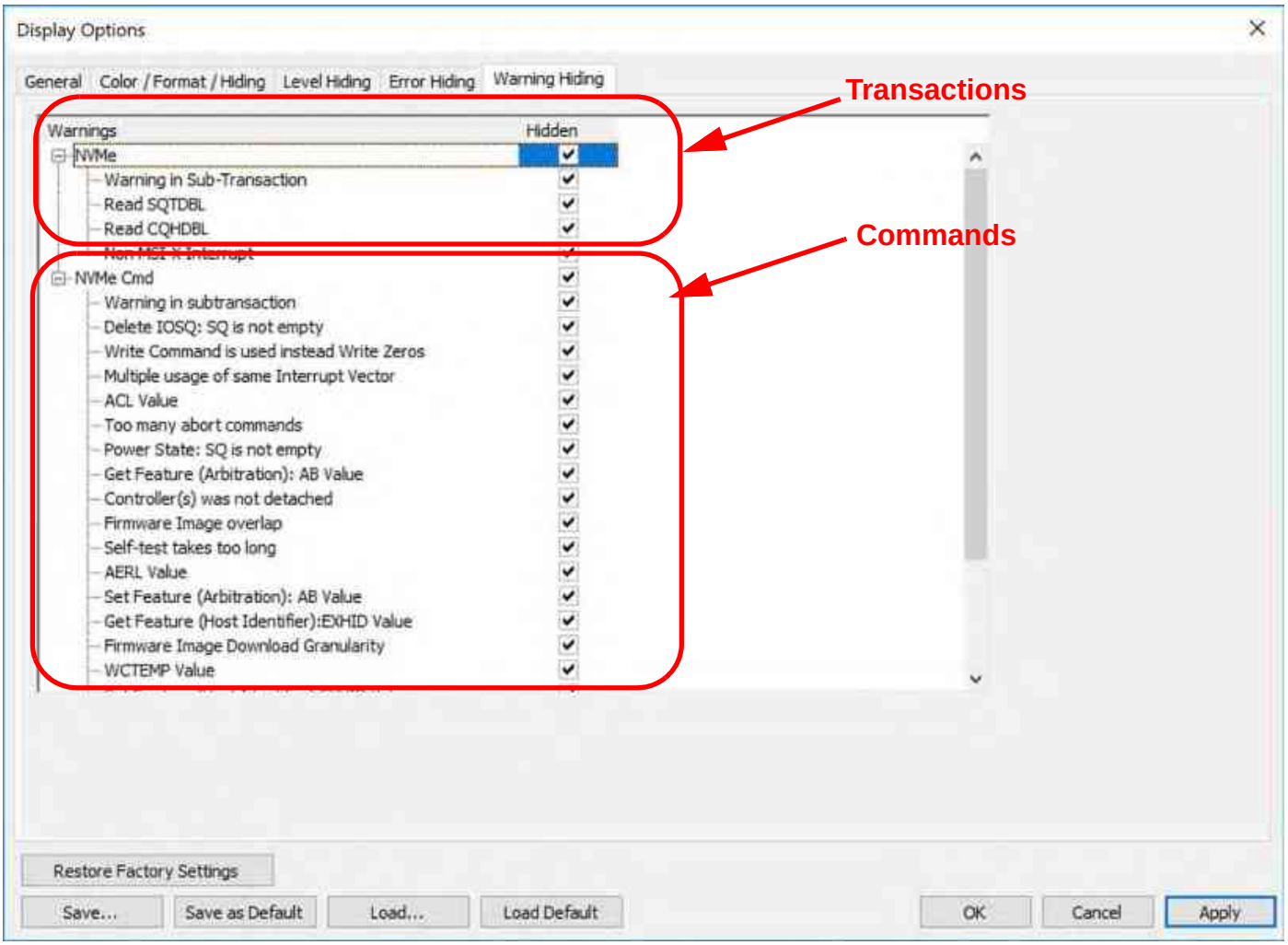


Figure 7.139: Hide -> NVMe Warning Messages

7.11.24 Decoding Lightweight Notification (LN) Protocol

The Lightweight Notification Protocol extension would allow co-processors or peripheral chips to talk to each other through system memory using a PCIe transaction without interrupting a host processor. For example, an Ethernet switch could respond to commands to encrypt and decrypt specific data packets while a host processor is inactive.

The PCIe Protocol Analysis software supports the decoding of Gen4 1.0 Lightweight Notification (LN) Protocol as shown in Figure 7.140 as well as the Traffic Summary Report.

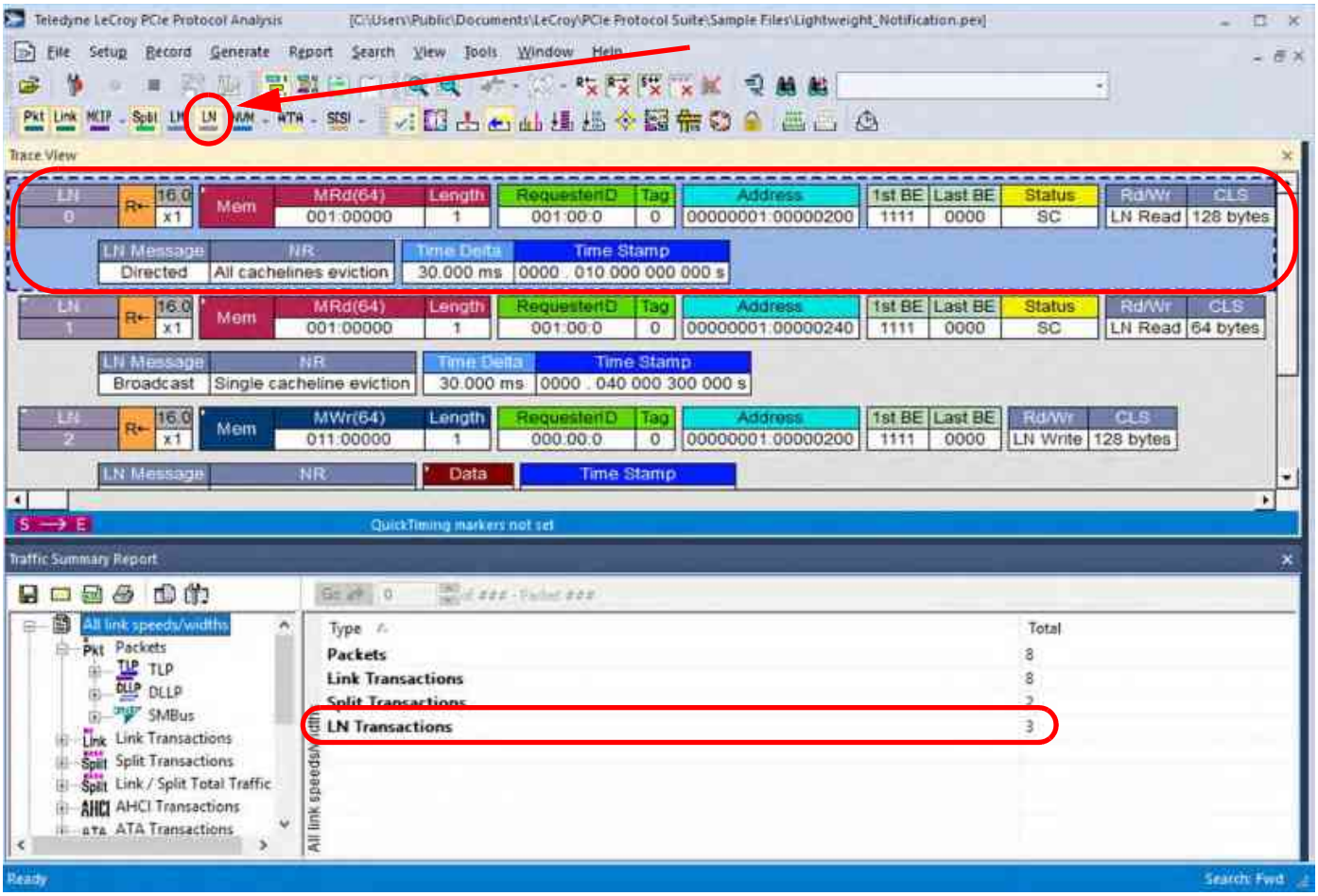


Figure 7.140: Decoding Lightweight Notification (LN) Protocol

7.11.24.1 Lightweight Notification Protocol Errors

The PCIe Protocol Analysis software also decodes any errors in the LN protocol. See Figure 7.141

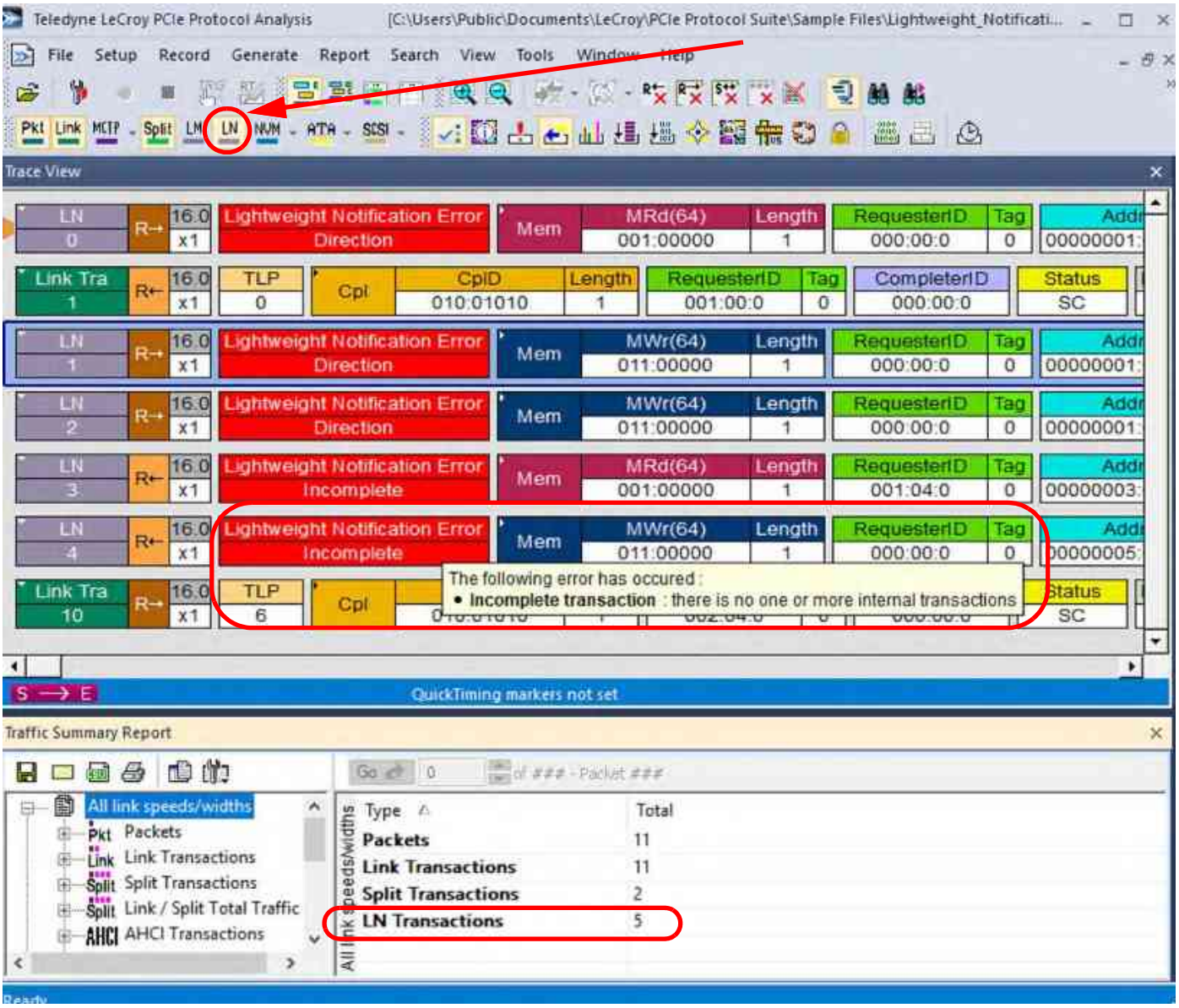


Figure 7.141: Decoding Errors in Lightweight Notification Protocol

7.11.24.2 Lightweight Notification Protocol in Trace Expert

The LN Protocol is also shown in the Trace Expert View (see Figure 7.142).

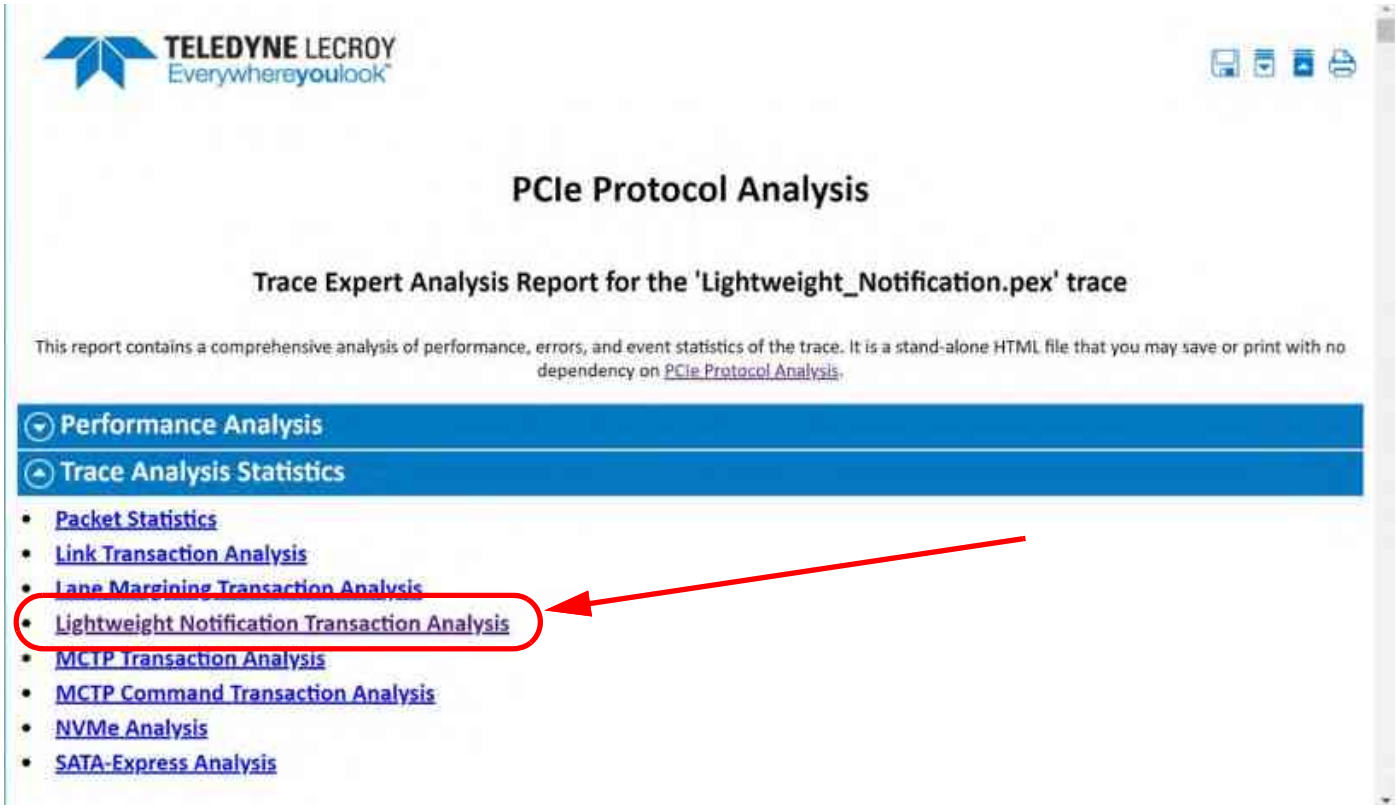


Figure 7.142: Lightweight Notification Transaction Analysis

The details of that LN Transaction Analysis can be seen in Figure 7.143 on page 508.

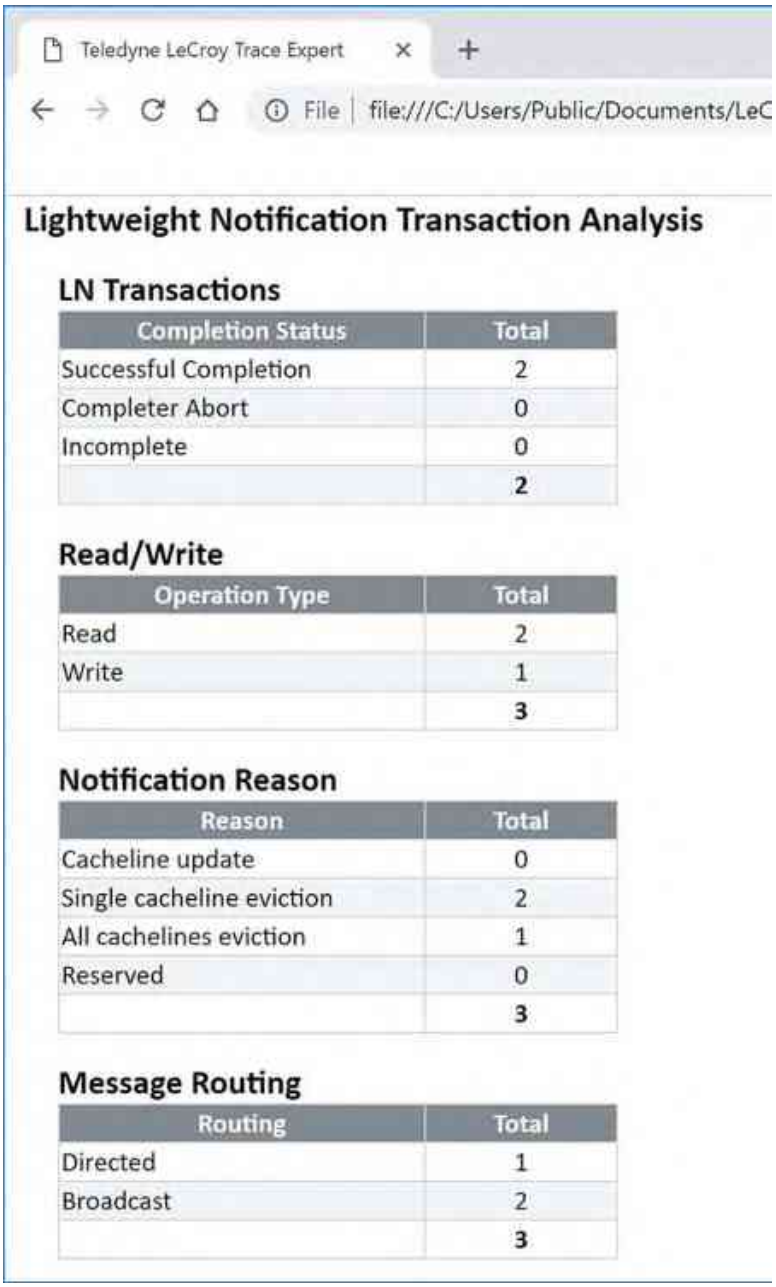


Figure 7.143: LN Transaction Analysis

7.11.24.3 Lightweight Notification Transaction Analysis Errors: Trace Expert

Lightweight Notification Transaction Analysis Errors can also be seen in Trace Expert. See Figure 7.144.

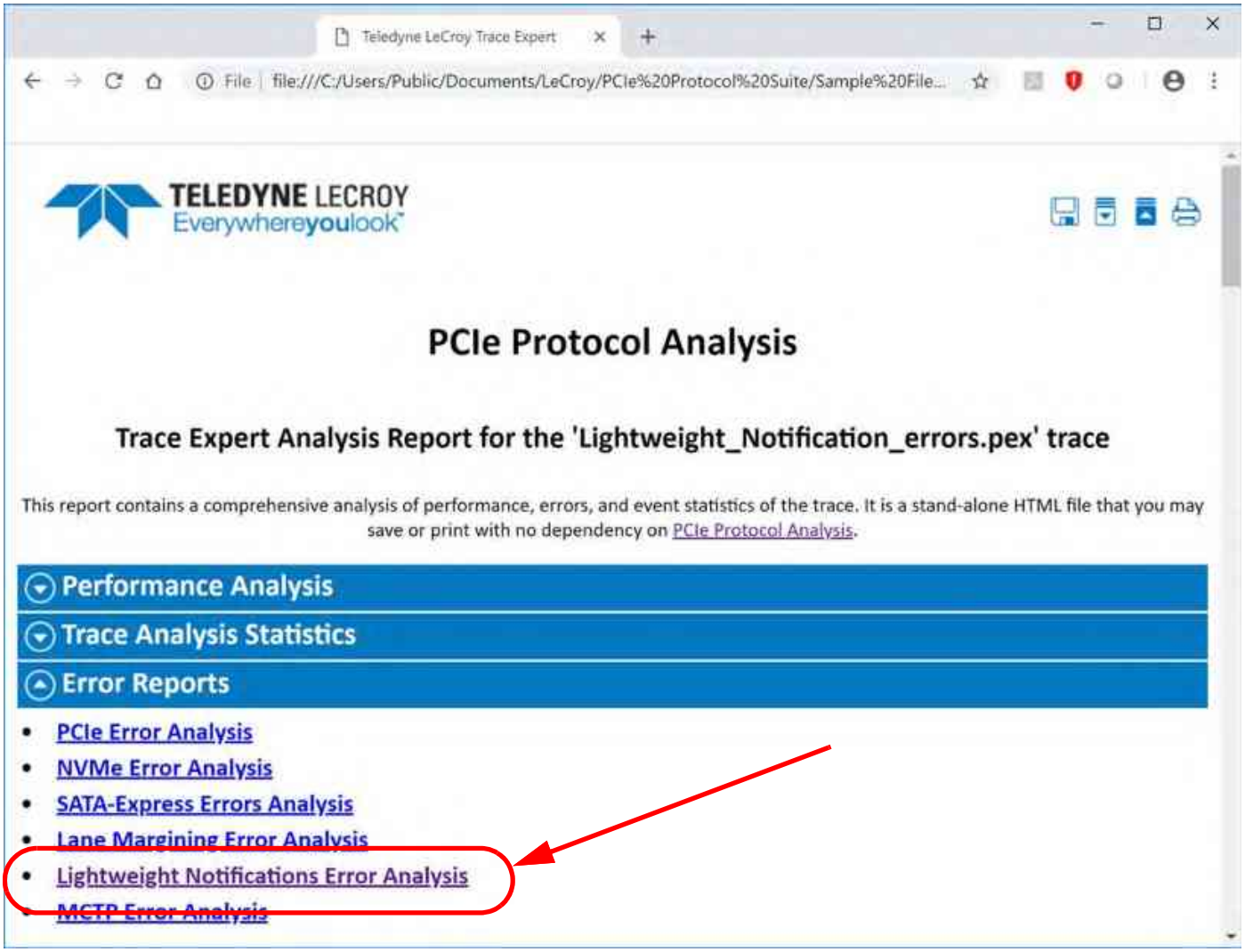


Figure 7.144: Trace Expert: Lightweight Notification Transaction Analysis Errors

Those errors can be seen in detail in Trace Expert (see Figure 7.145 on page 510).

Lightweight Notifications Error Analysis

Lightweight Notifications Errors

Error	Total
Incomplete Transaction	2
Wrong Read/Write Direction	3
Wrong Message Direction	1
Any Error	5

Figure 7.145: Lightweight Notification Errors from Trace Expert

7.11.24.4 Find: Lightweight Notification Transactions

You can use the Find tool to locate Lightweight Notification transactions. See Figure 7.146.

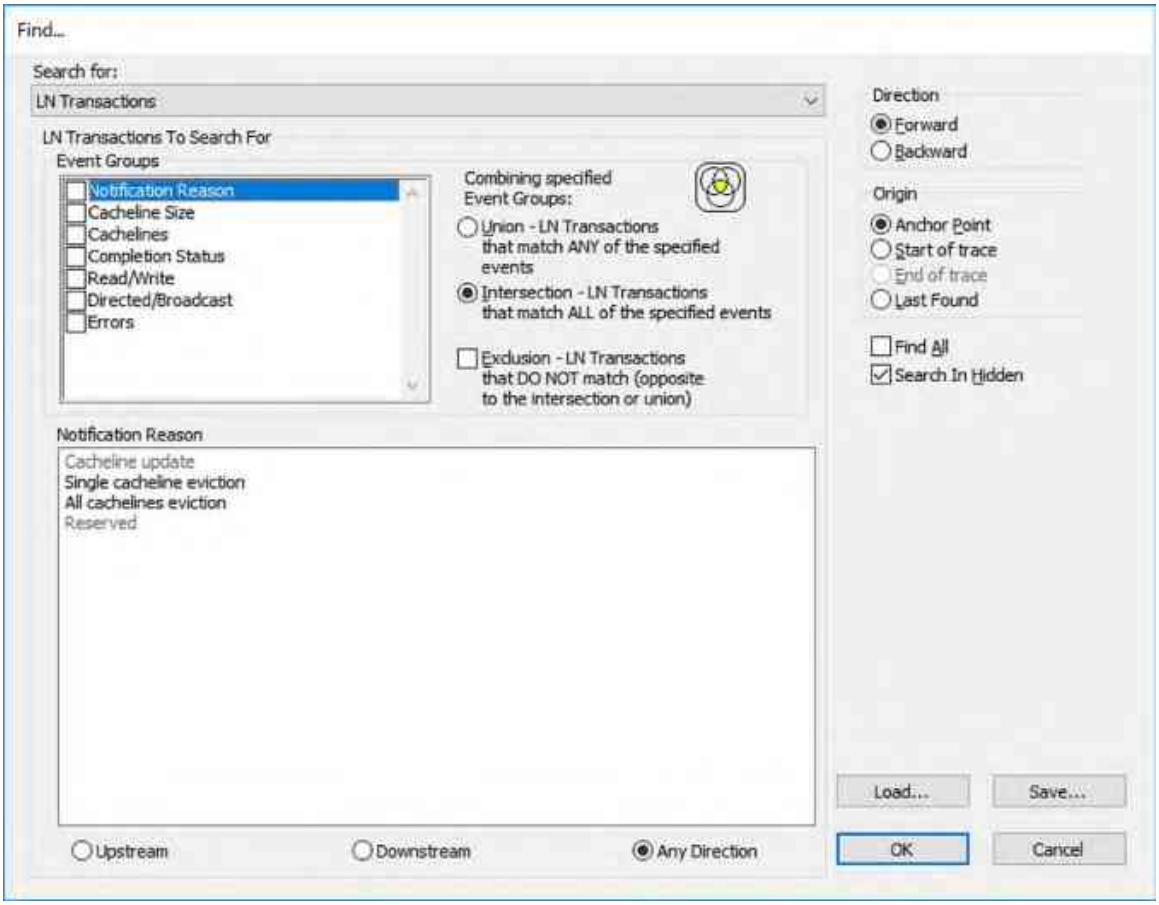


Figure 7.146: Lightweight Notification transactions

7.11.25 Decoding CCIX Protocol

PCIe Protocol Analysis software can decode the Cache Coherent Interconnect for Accelerators (CCIX) transaction protocol.

CCIX is a high-performance, low latency, chip-to-chip interconnect architecture that provides a cache coherent framework for heterogeneous system architectures. Cache coherency is automatically maintained at all time between the central processing unit and the various other accelerators in the system. Operating over standard PCIe, CCIX supports signaling rates between 16 GT/s and 25 GT/s per link with support for port aggregation for higher performance.

CCIX is largely an extension of the PCI Express architecture, consists of a number of stacked protocol layers.

- CCIX Protocol Layer - coherency protocol that manages memory reads and writes, provides a mapping for the on-chip architecture-dependent coherency protocols (e.g., AMBA CHI/ACE). This layer also defines the cache state (e.g. shared/unique, clean/dirty).

- CCIX Link Layer - formatting protocol for transport (e.g., PCIe). This layer also manages link aggregation.
- CCIX Transport Specification
- PCIe Transaction Layer - Handles PCIe transactions. The layer also supports virtual channels, permitting transmission for different data streams across a single shared link.
- CCIX Transaction Layer - Handles CCIX transactions. This layer optimizes out superfluous PCIe packet fields, reducing overhead.
- PCIe Data Link Layer - Handles standard data link layer (e.g., CRC, ACK).
- CCIX/PCIe Physical Layer - Handles standard PCIe physical layer. This layer also supports 25 GT/s ESM mode.

7.11.26 Decoding TCG Support of Pyrite

The PCIe Protocol Analysis software is capable of decoding Trusted Computing Group (TCG) Pyrite transactions. See Figure 7.147.

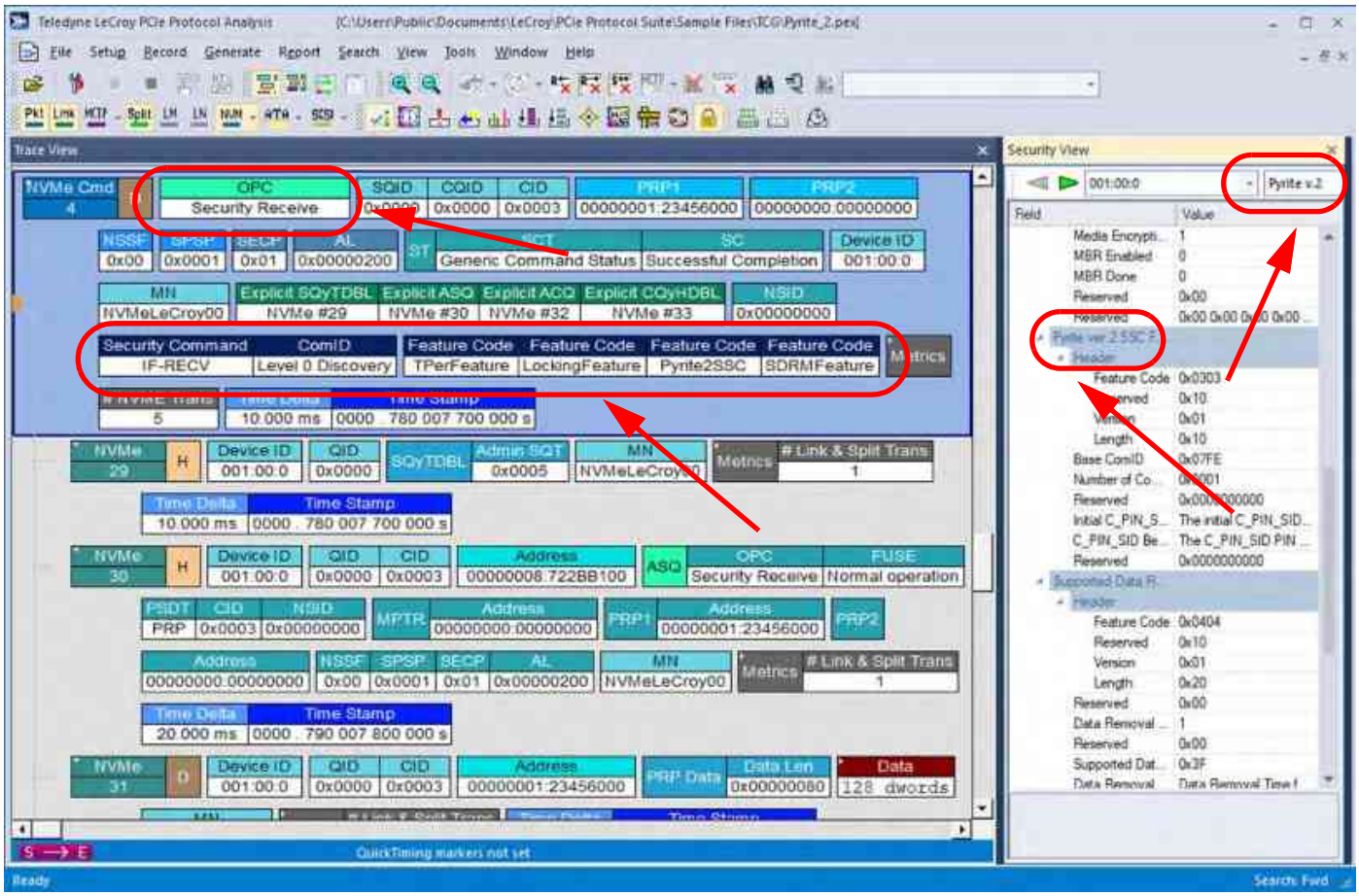


Figure 7.147: TCG Transactions: Decoded -> Pyrite

7.11.27 MCTP: Simple Hiding

You can hide (or filter out) either MCTP VDM traffic or SMBus MCTP traffic or both by using the MCTP Hide button on the toolbar. See Figure 7.148.



Figure 7.148: MCTP: Simple Hiding Icon

7.11.27.1 MCTP: Hide VDM Traffic

If you chose to hide only the MCTP VDM traffic a sample trace is shown below without the VDM traffic hidden (see Figure 7.149) and with VDM traffic hidden (see Figure 7.150 on page 513).

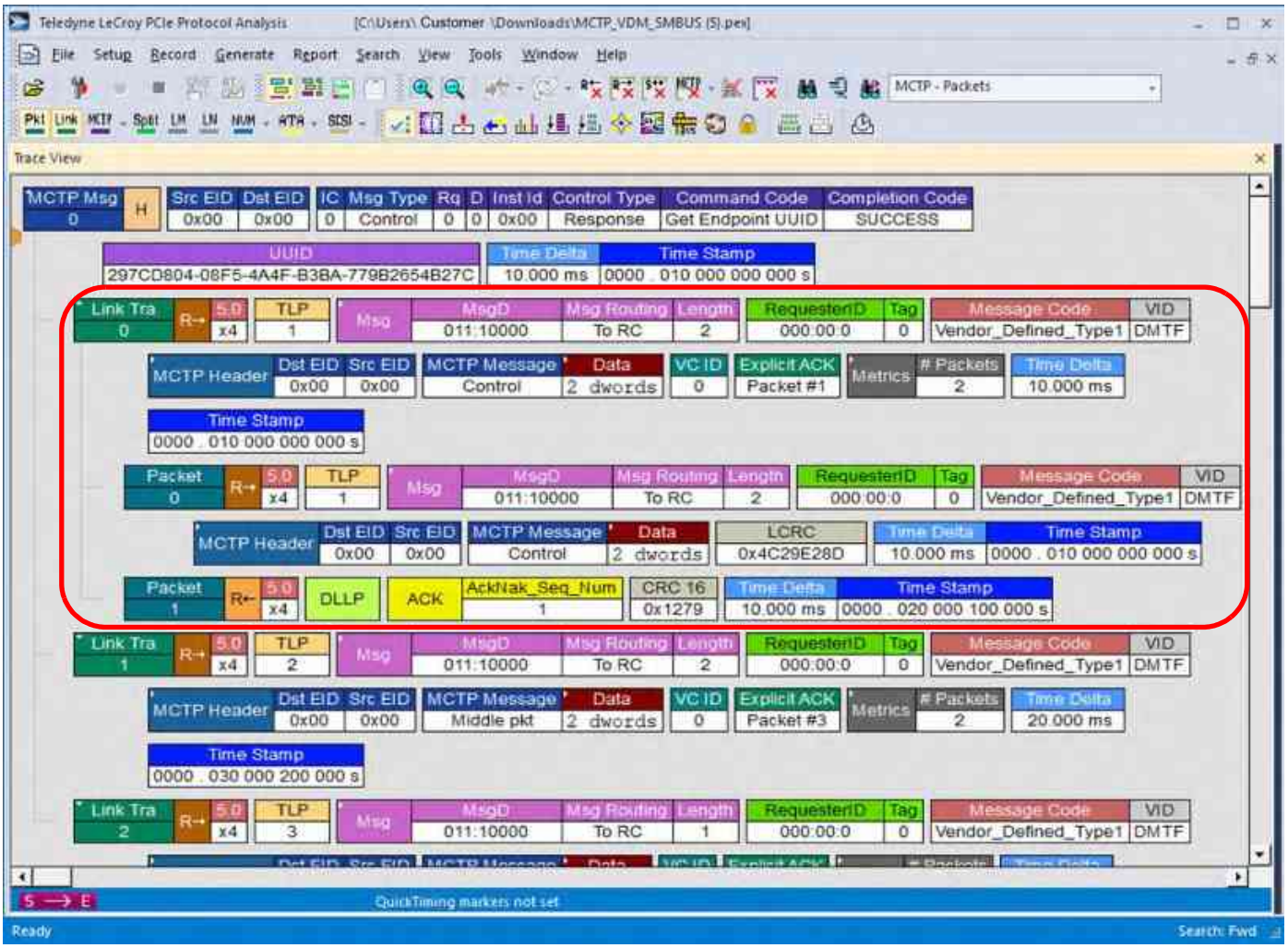


Figure 7.149: MCTP VDN Traffic: Link 0, Packet 0 -> Shown

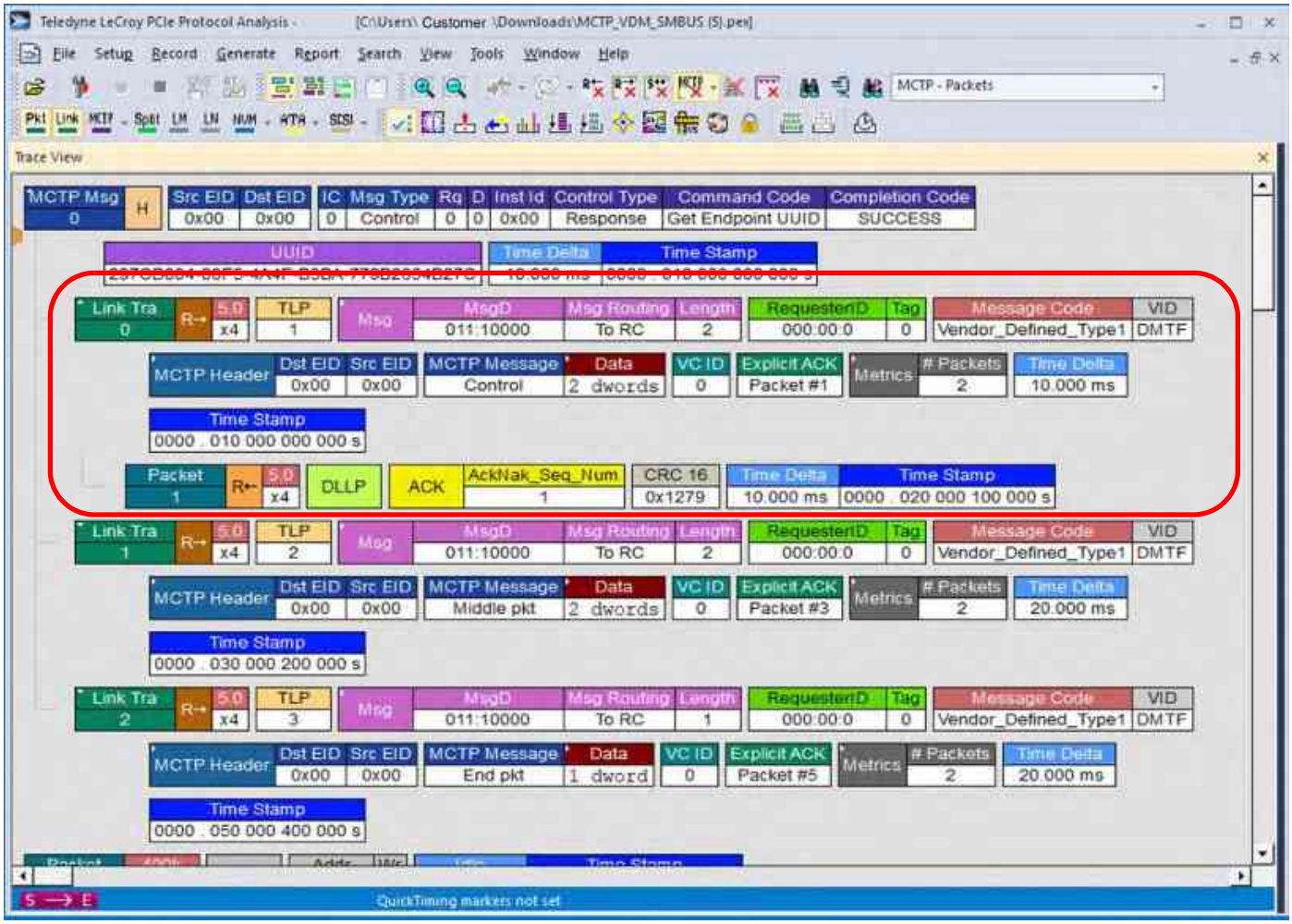


Figure 7.150: MCTP VDN Traffic: Link 0, Packet 0 -> Hidden

7.11.27.2 MCTP: Hide SMBus Traffic

If you chose to hide only the SMBus MCTP traffic a sample trace is shown below without the SMBus traffic hidden (see Figure 7.151) and with SMBus MCTP traffic hidden (see Figure 7.152 on page 514).

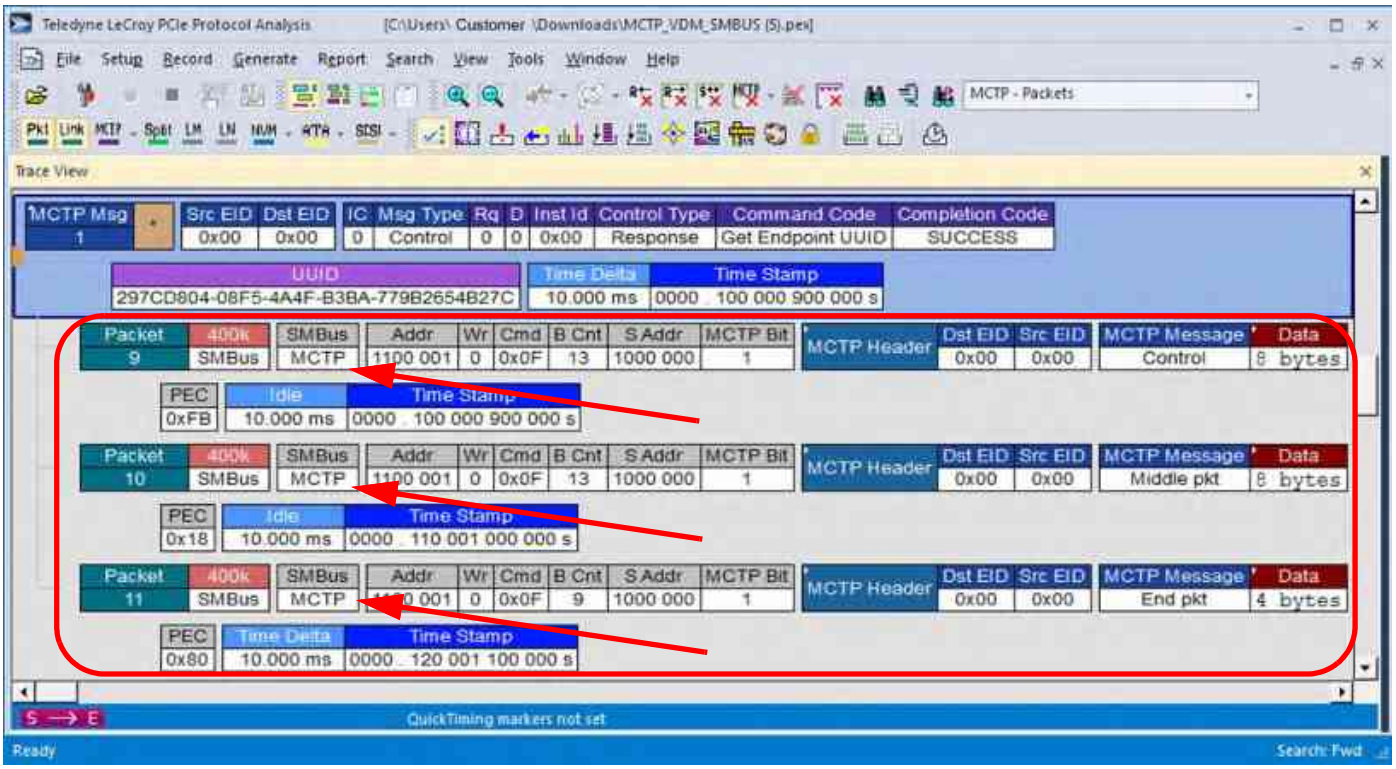


Figure 7.151: MCTP SMBus Traffic: Shown

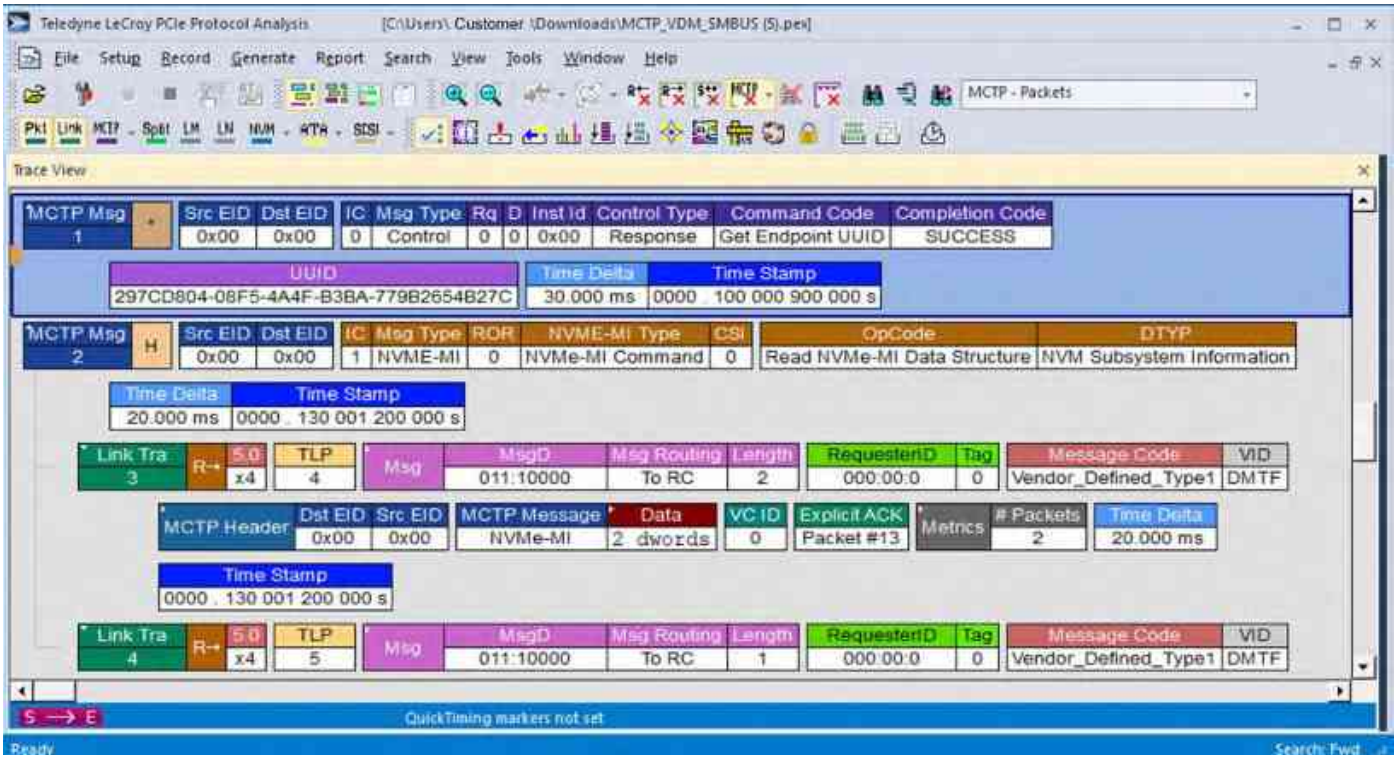


Figure 7.152: MCTP SMBus Traffic: Hidden

7.11.27.3 MCTP Message Type and IC Cells

You can decode MCTP Messages and IC cells. See Figure 7.153.

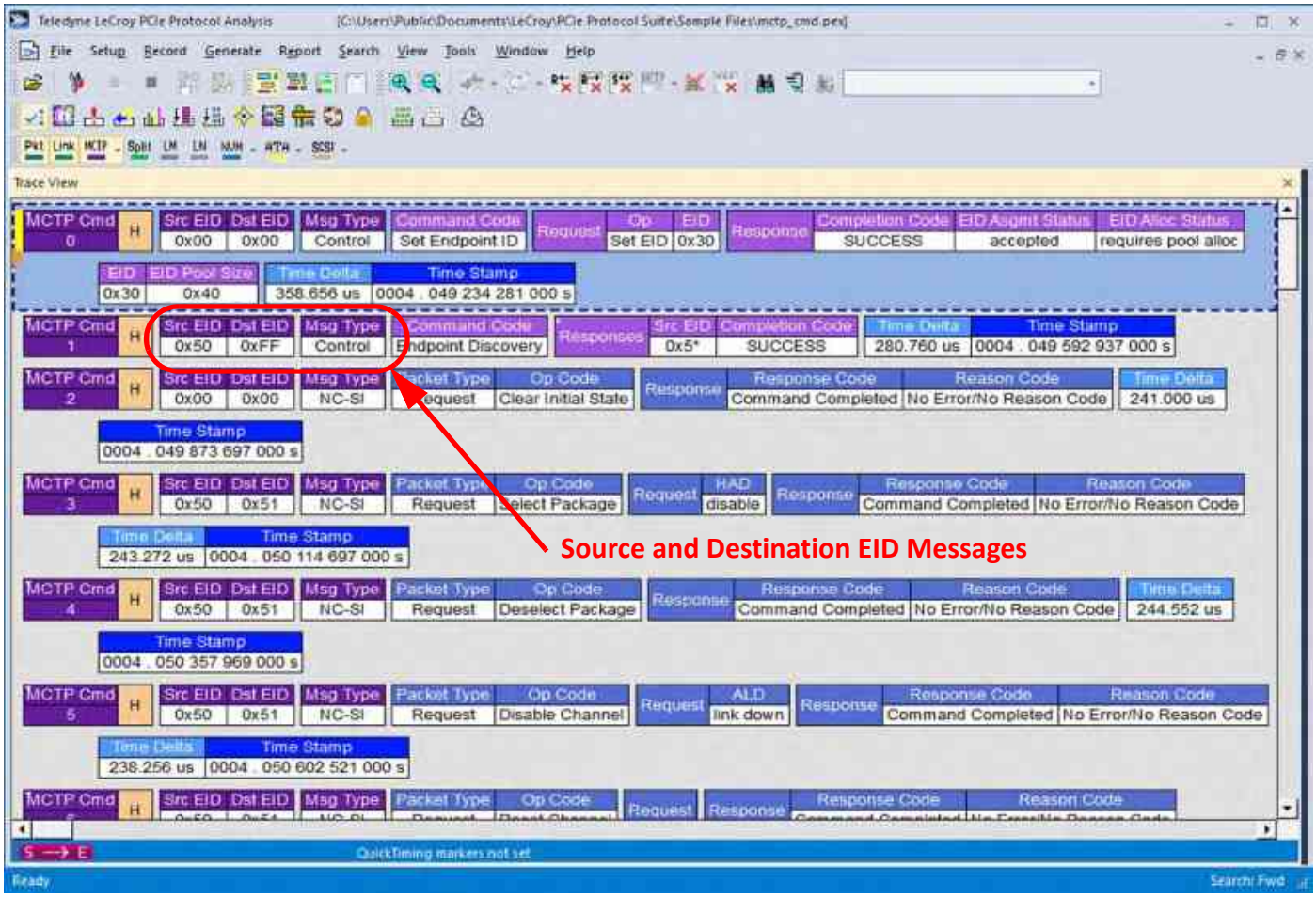


Figure 7.153: MCTP Messages Types and IC Cells Decoded

The colors of the MCTP Messages can be seen in the Display Options. See Figure 7.154 on page 516.

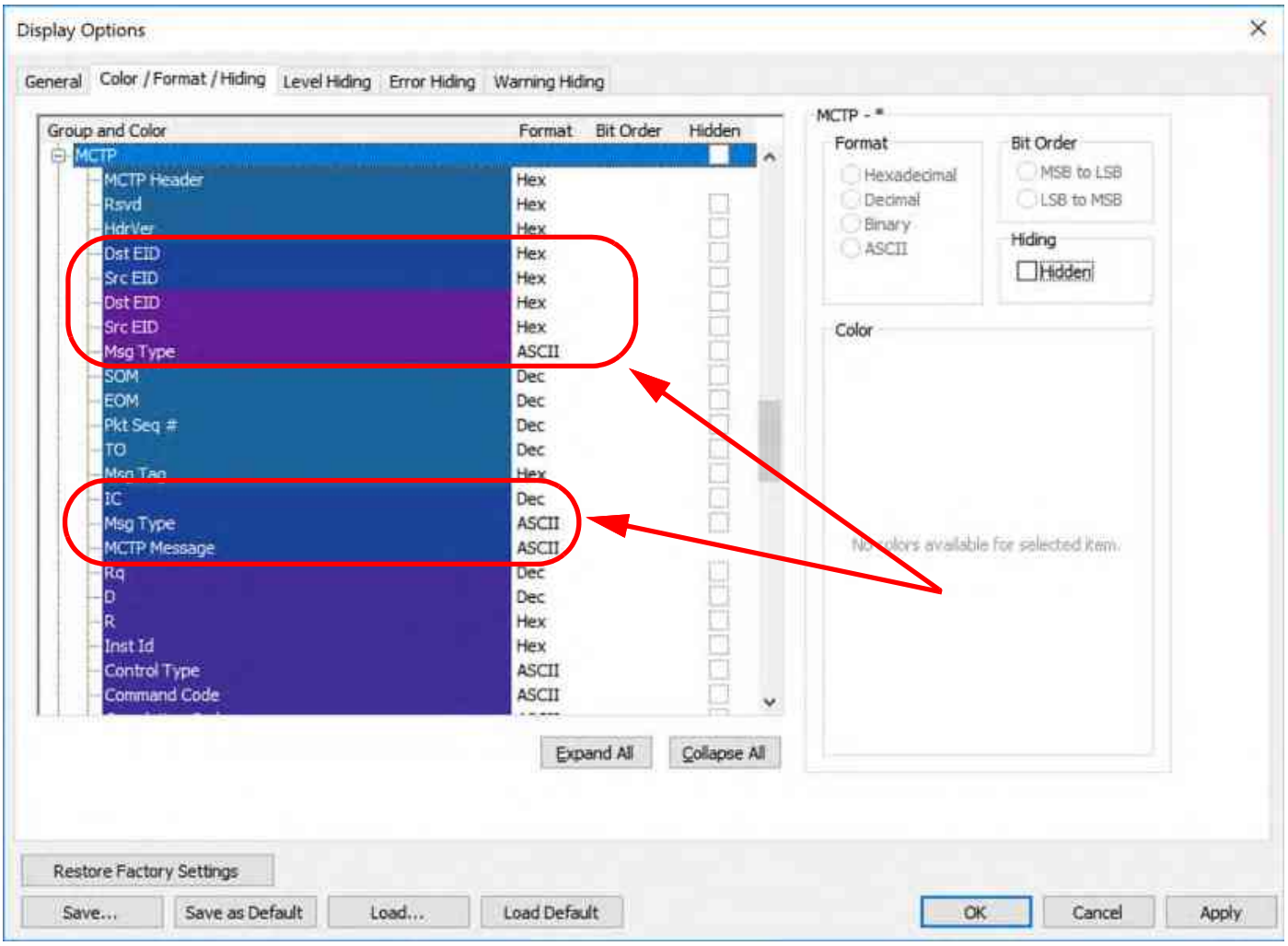


Figure 7.154: MCTP Commands and Transaction Colors from Display Options

7.11.28 Decoding NVME-MI Version 1.1

The PCIe Protocol Analysis software can decode NVME-MI Version 1.1 traffic. See Figure 7.155.

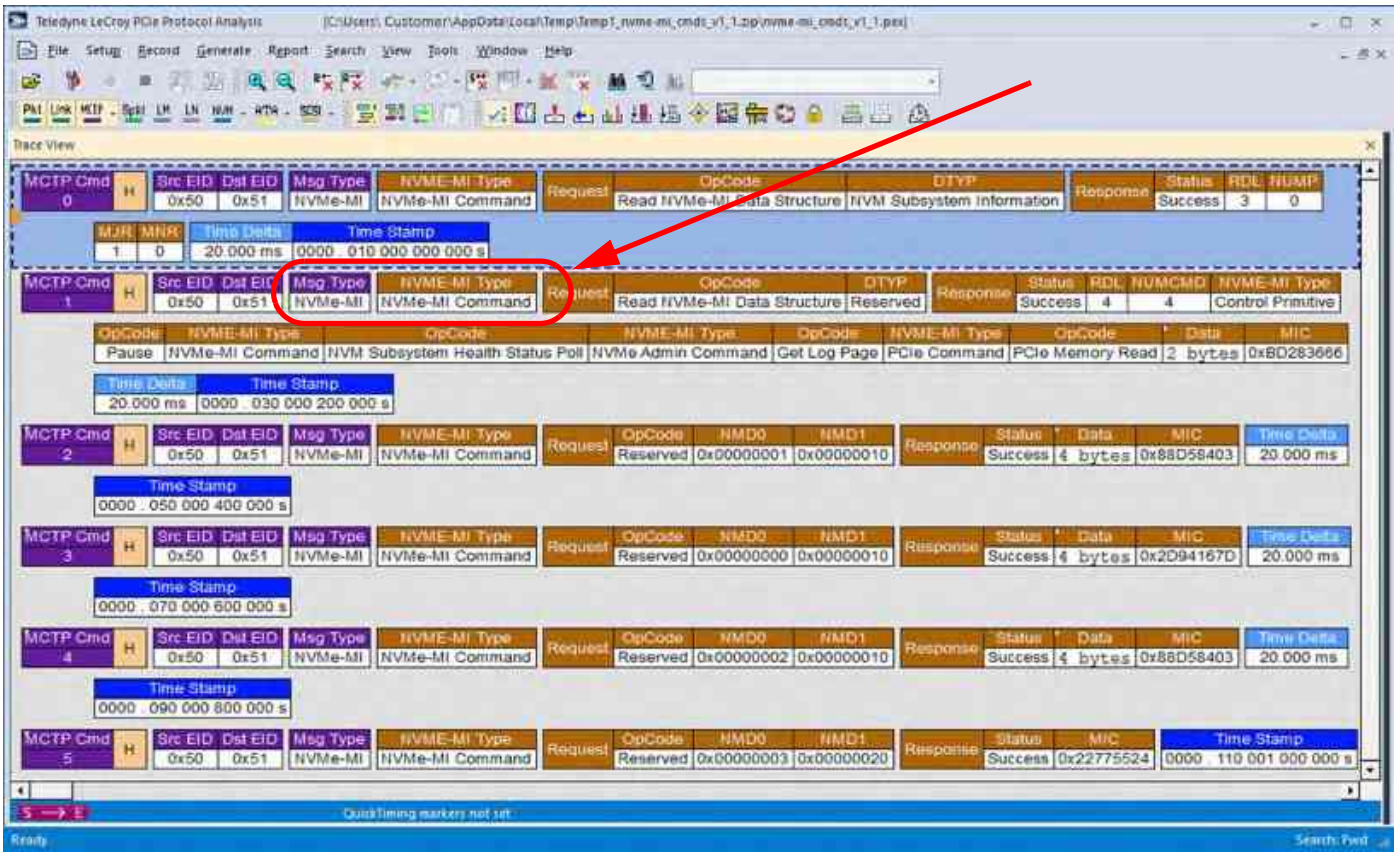


Figure 7.155: Decoding NVME-MI Version 1.1

7.11.29 Swapping Direction of Recorded Traffic Data

Swapping Upstream/Downstream direction of traffic gives you the ability (in a recorded trace) to reverse the direction of the traffic which was recorded. See Figure 7.156.

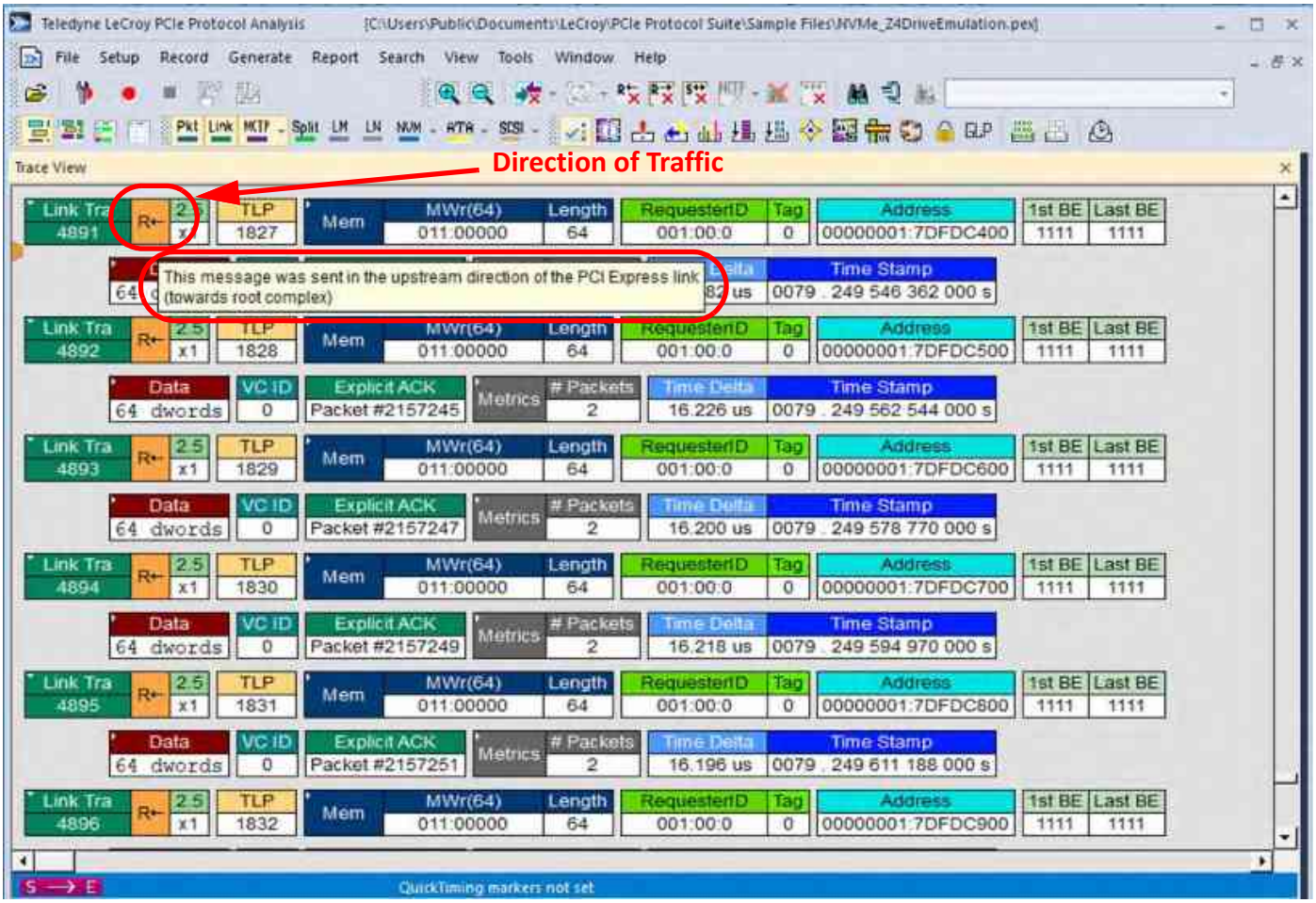


Figure 7.156: Recorded Trace: Traffic Flows in Direction it was Recorded

If you hover over the direction box (just to the right of the Link Transaction number) and perform a right click a context menu will pop up. See Figure 7.157 on page 518.



Figure 7.157: Context Menu Showing Traffic Direction

If you select Swap Upstream/Downstream the direction of the traffic will change and the tooltip will reflect that change. The color of the direction block will also change. See Figure 7.158 on page 519.

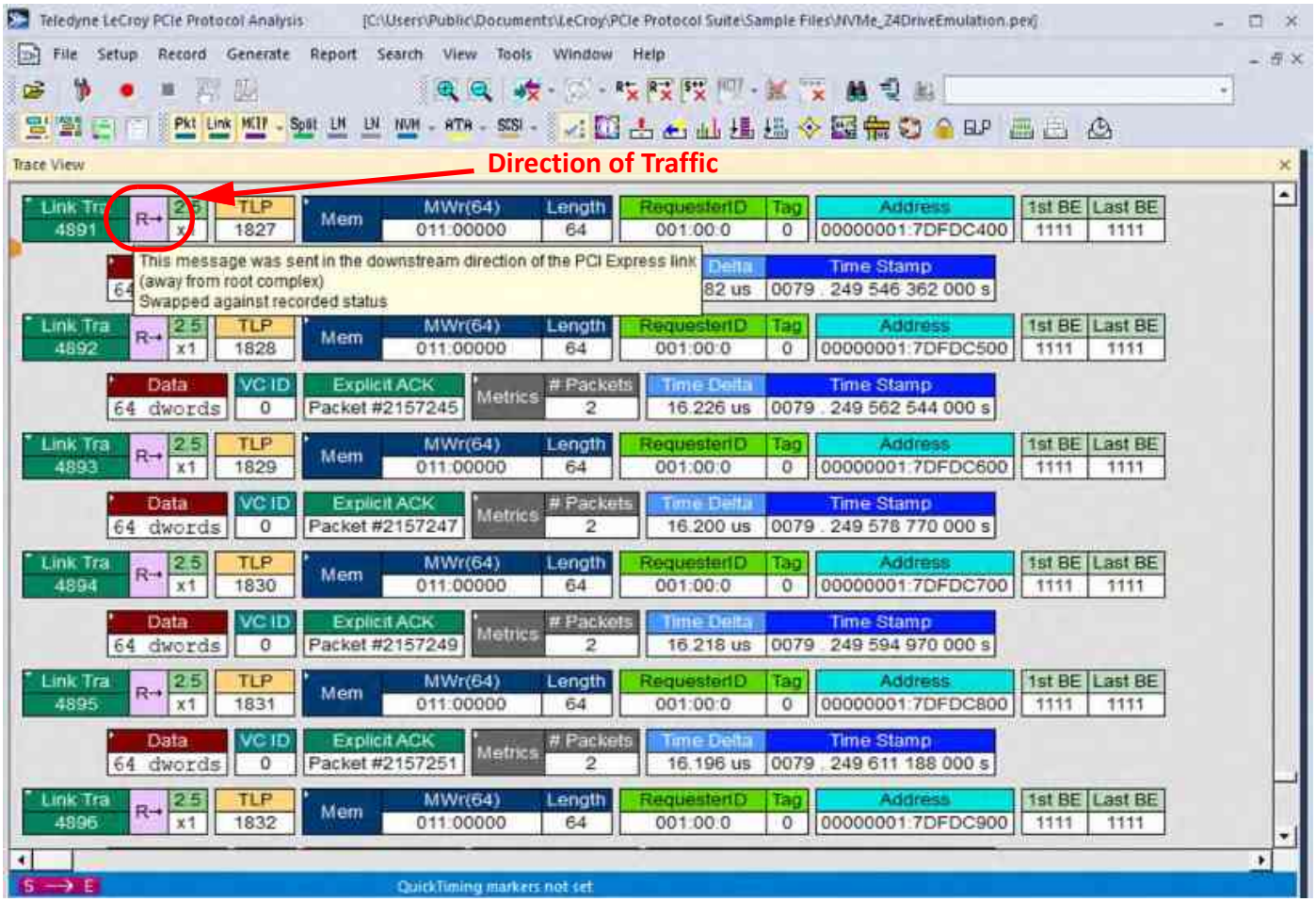


Figure 7.158: Direction of Traffic has been Swapped

If you want to swap the traffic direction back to the way it was originally recorded simply bring up the context menu (left click in the direction block) and select “Restore Upstream/ Downstream”. See Figure 7.159.

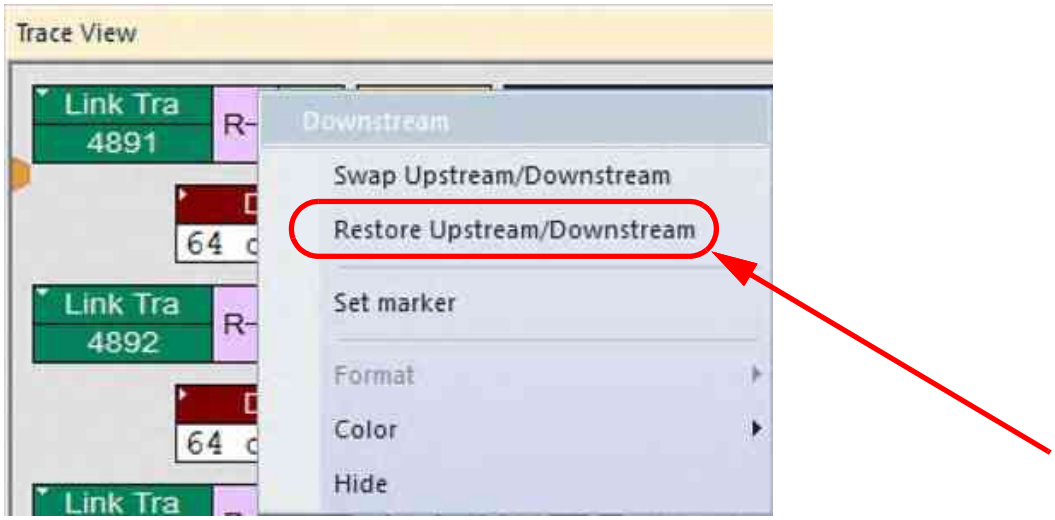


Figure 7.159: Context Menu Showing Traffic Direction: Downstream with Restore Option

7.11.30 Decoding Traces Exported from USB4 Traces with Tunneled PCIe Traffic

The PCIe Protocol Analysis Suite software is capable of decoding traces exported from USB4 traces which have tunneled PCIe Traffic.

A sample USB4 trace with PCIe tunneled traffic is shown in Figure 7.160. The highlighted Packets #6 and #7 contain Tunneled PCIe traffic with a timestamps of 7.848357050 and 7.848357082 containing DLLP types UpdateFC_Cpl and UpdateFC_NP.

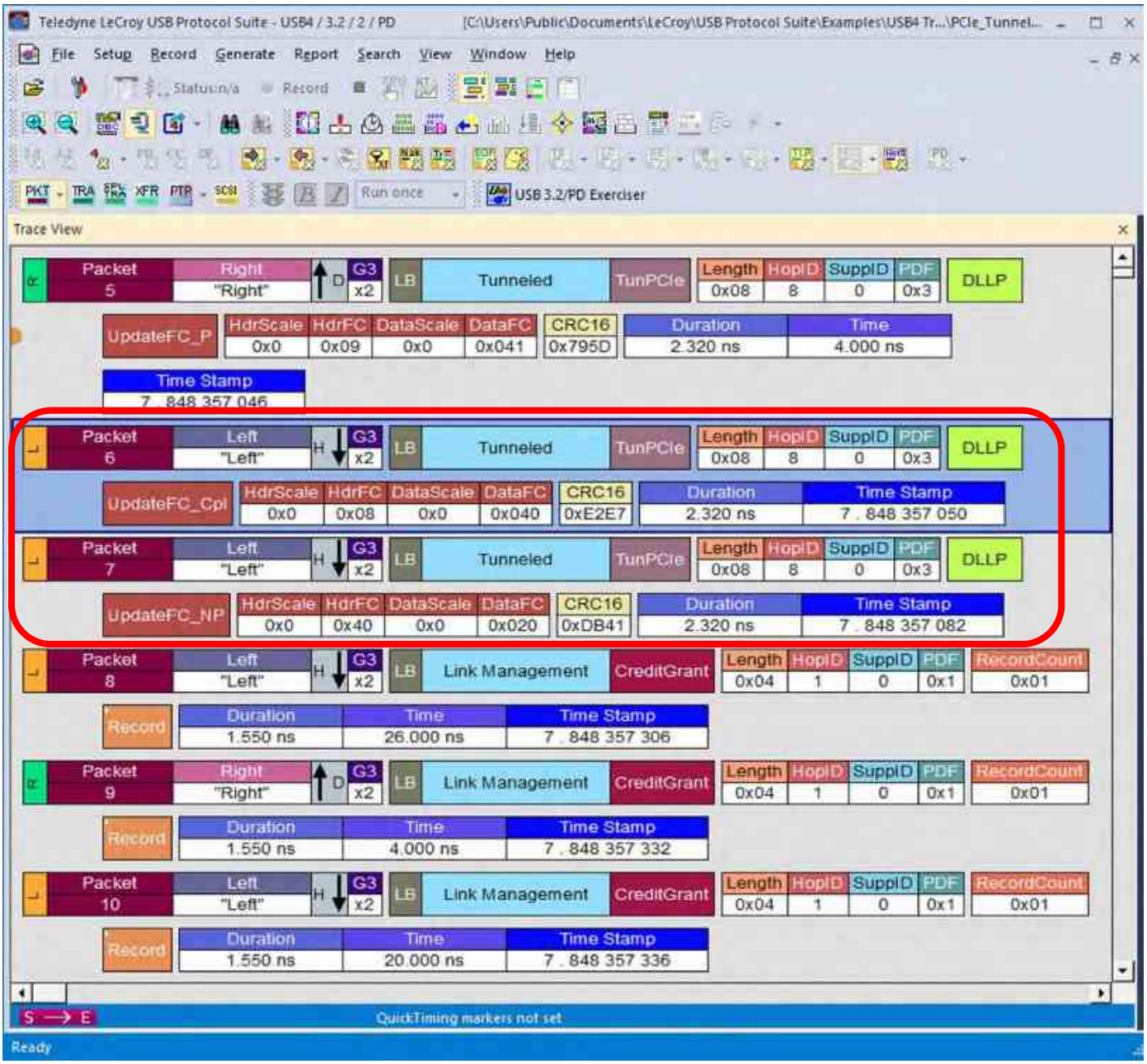


Figure 7.160: USB4 Trace with PCIe Tunneled Traffic

The PCIe Tunneled Traffic from the USB4 trace can be exported to a PCIe trace and decoded and analyzed with the PCIe Protocol Analysis software. See Figure 7.161 on page 522.

The highlighted Packets #4 and #5 contain Tunneled PCIe traffic with a timestamps of 7.848357050 and 7.848357082 containing DLLP types UpdateFC_Cpl and UpdateFC_NP.

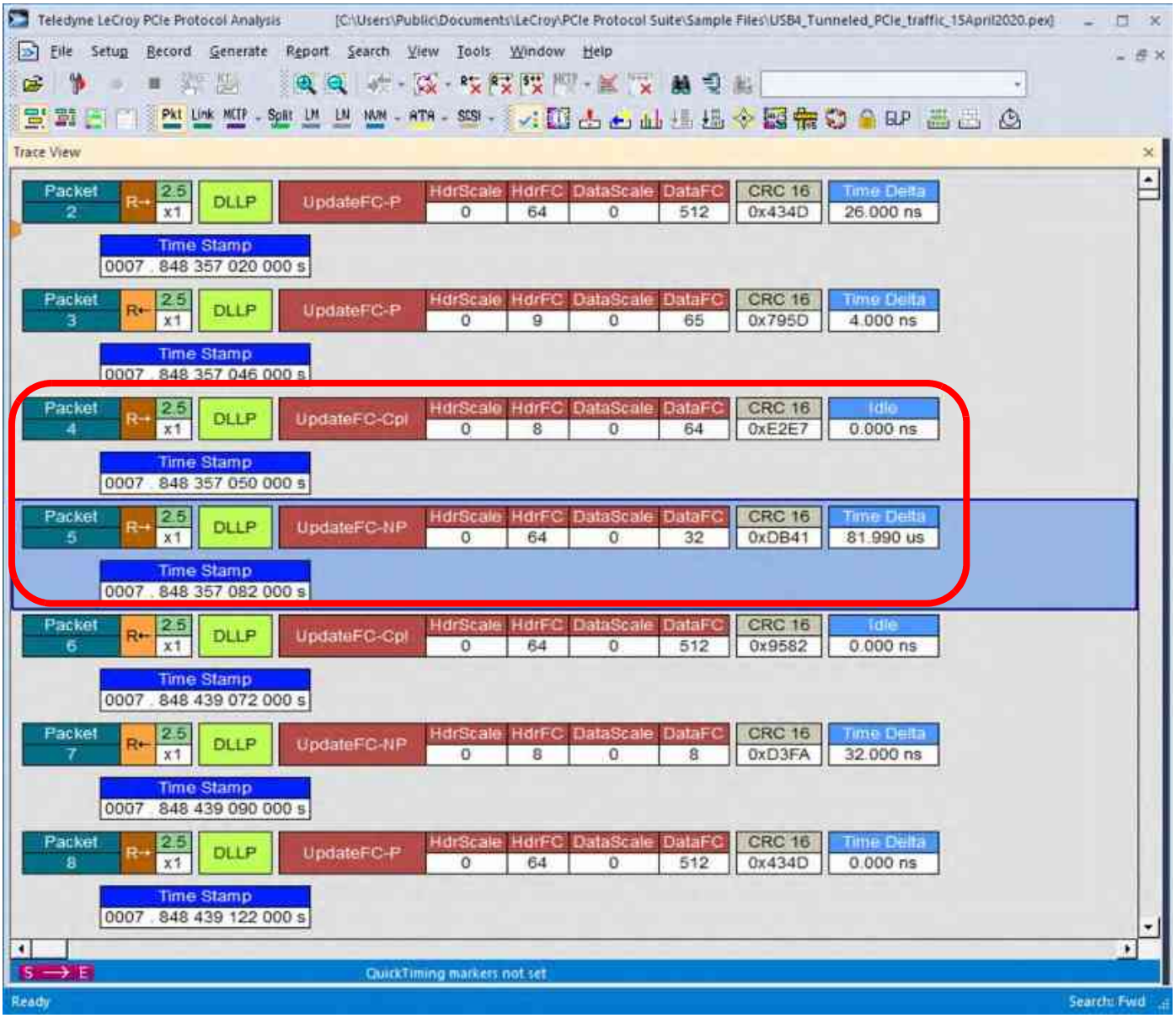


Figure 7.161: PCIe Tunneled Traffic from USB4 Trace Decoded and Analyzed by the PCIe Protocol Analysis Software

Note: Link Tracker is disabled for tunneled PCIe packets intentionally, because there is no information about the PCIe link (Link Width, etc.) in USB4 tunnel.

7.11.31 Decoding CXL Traffic

The PCIe Protocol Analysis Suite software is capable of decoding traces with CXL traffic. See Figure 7.162 and Figure 7.163 on page 524.

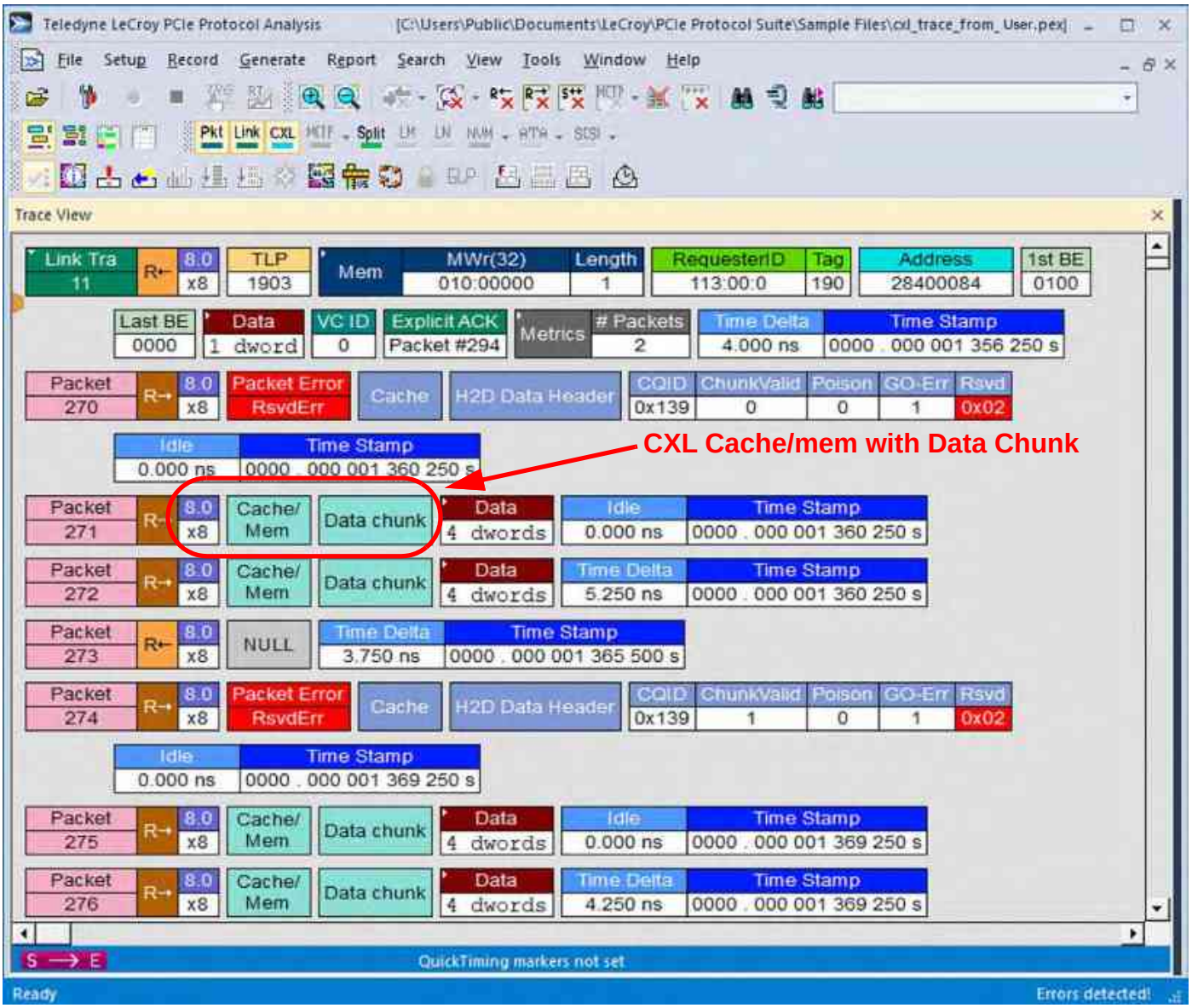


Figure 7.162: Decoding CXL Traffic

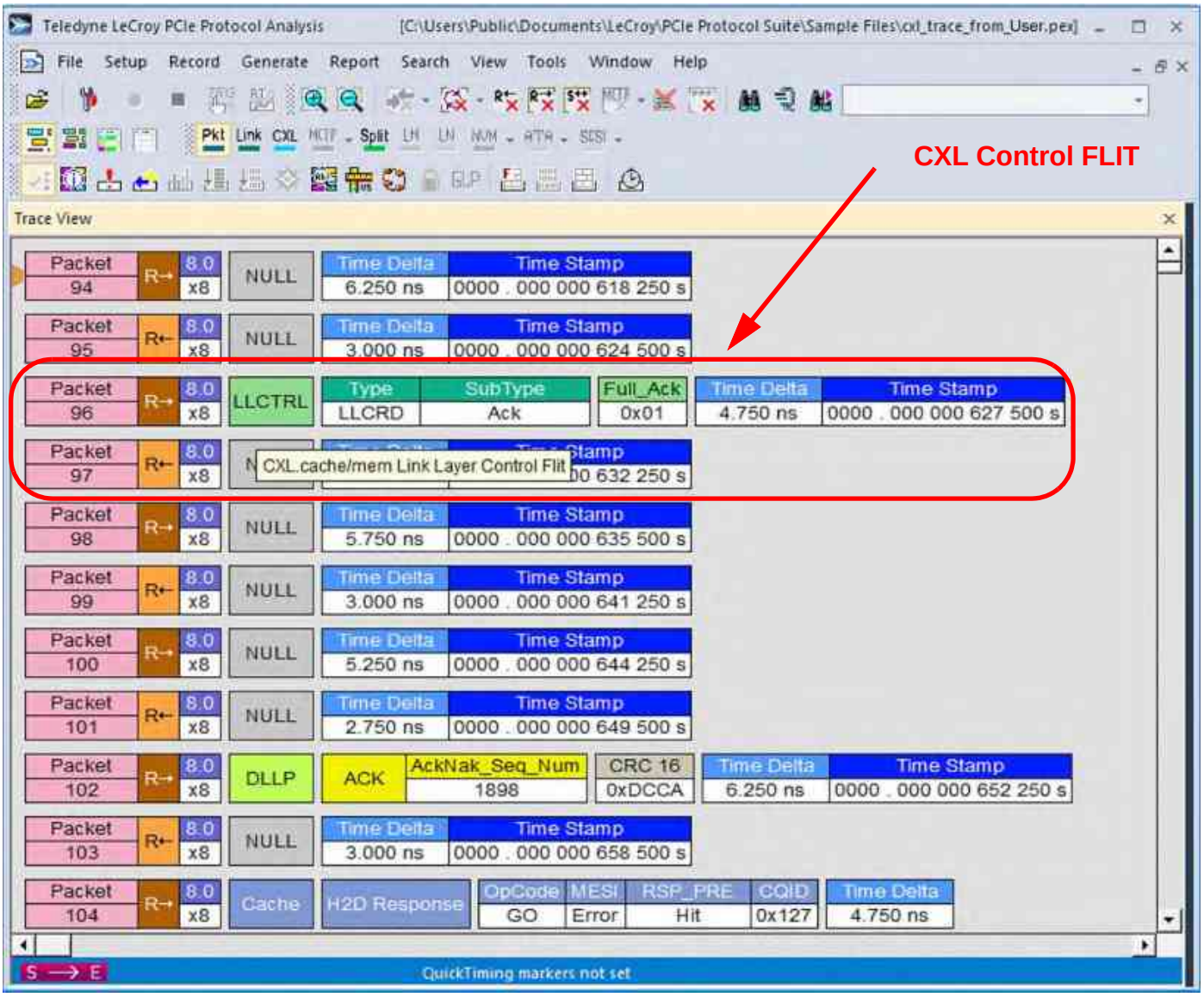


Figure 7.163: CXL Traffic: CXL.cache/mem Link Layer Control FLIT

7.11.32 Decoding DOE Traffic

The PCIe Protocol Analysis Suite software is capable of decoding traces with DOE traffic. See Figure 7.164.

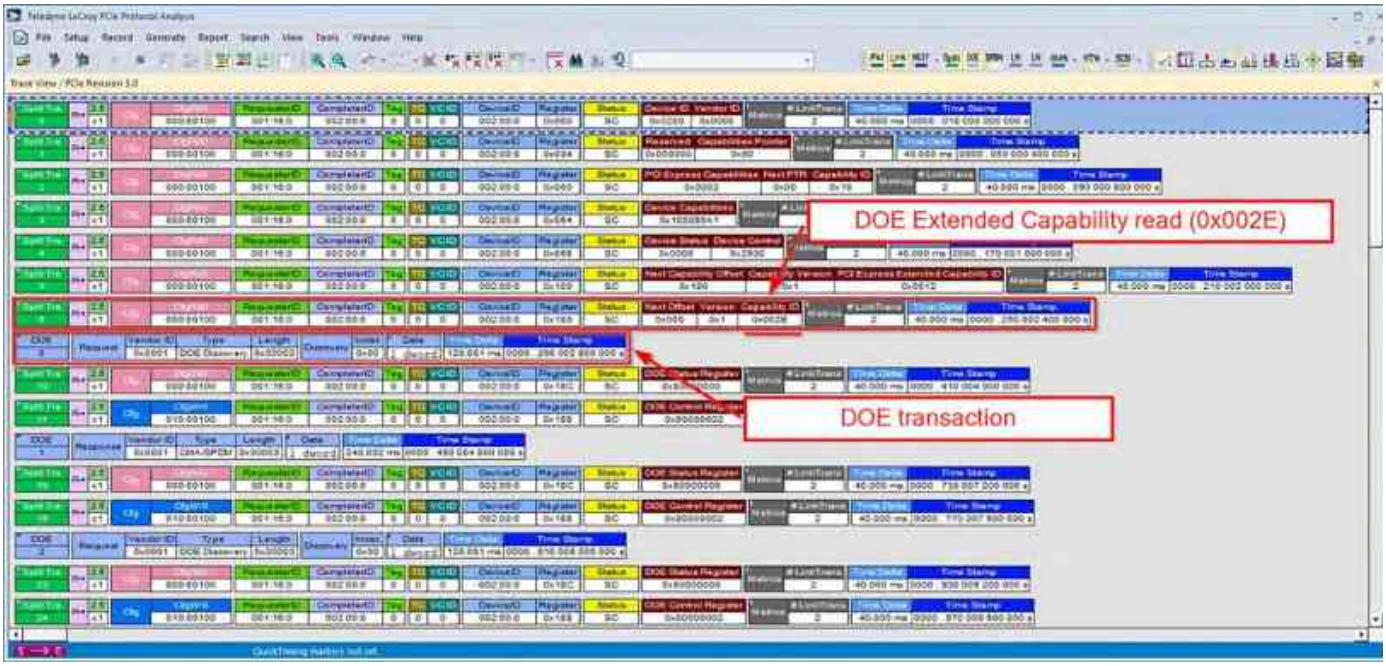


Figure 7.164: Decoding DOE Traffic

If your trace file is invalid, broken or partial - you can open “DOE Device Configuration” from the Tools menu - see Figure 7.165 on page 526. The DOE Device Configuration window displays, as shown in Figure 7.166 on page 527. To decode this trace properly to the DOE level, manually set valid DOE DEVICEID, DOE_CAPABILITY_ADDRESS and/or other parameters .

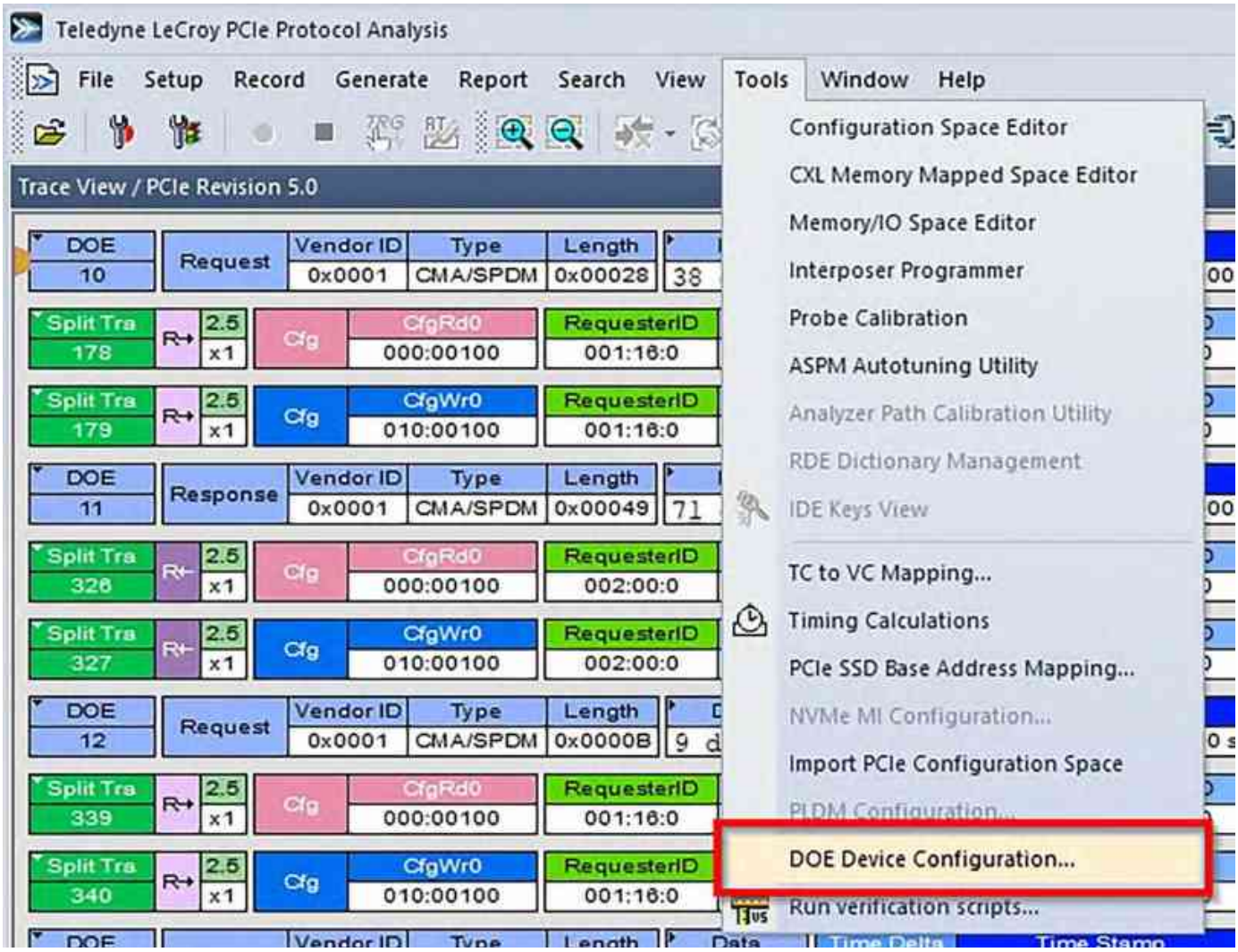


Figure 7.165: Selecting DOE Device Configuration Option

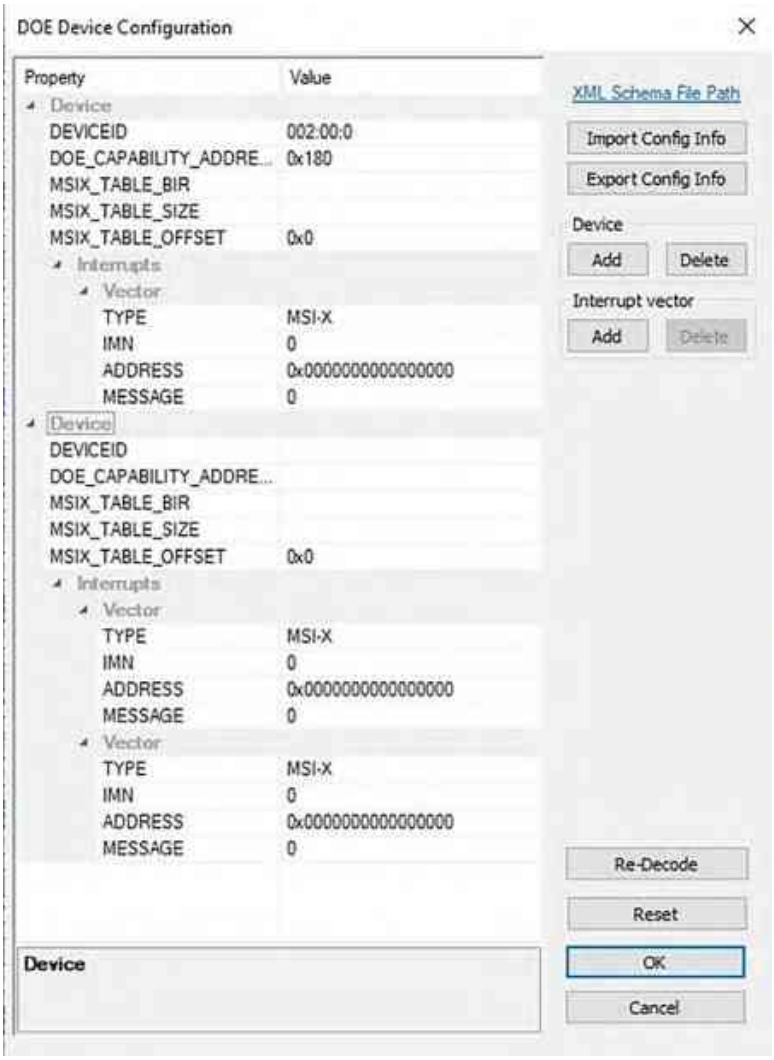


Figure 7.166: DOE Device Configuration Window

7.11.33 Decoding SPDM Traffic

The PCIe Protocol Analysis Suite software is capable of decoding traces with SPDM traffic. The SPDM decoding toolbar button shows one of two levels:

- SPDM Transactions (Figure 7.167), or
- SPDM Commands (Figure 7.168). SPDM Commands displays the relationship between requests and responses.

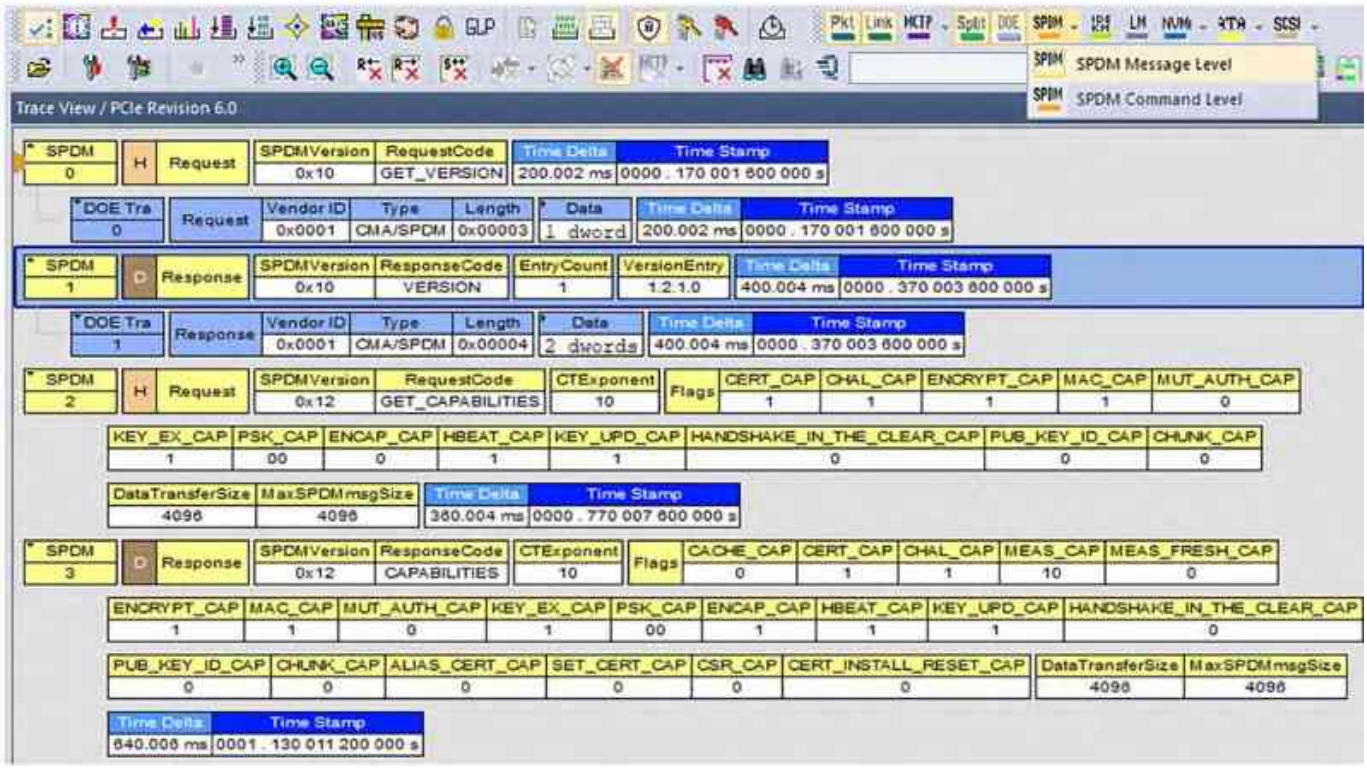


Figure 7.167: SPDM Transaction Messages

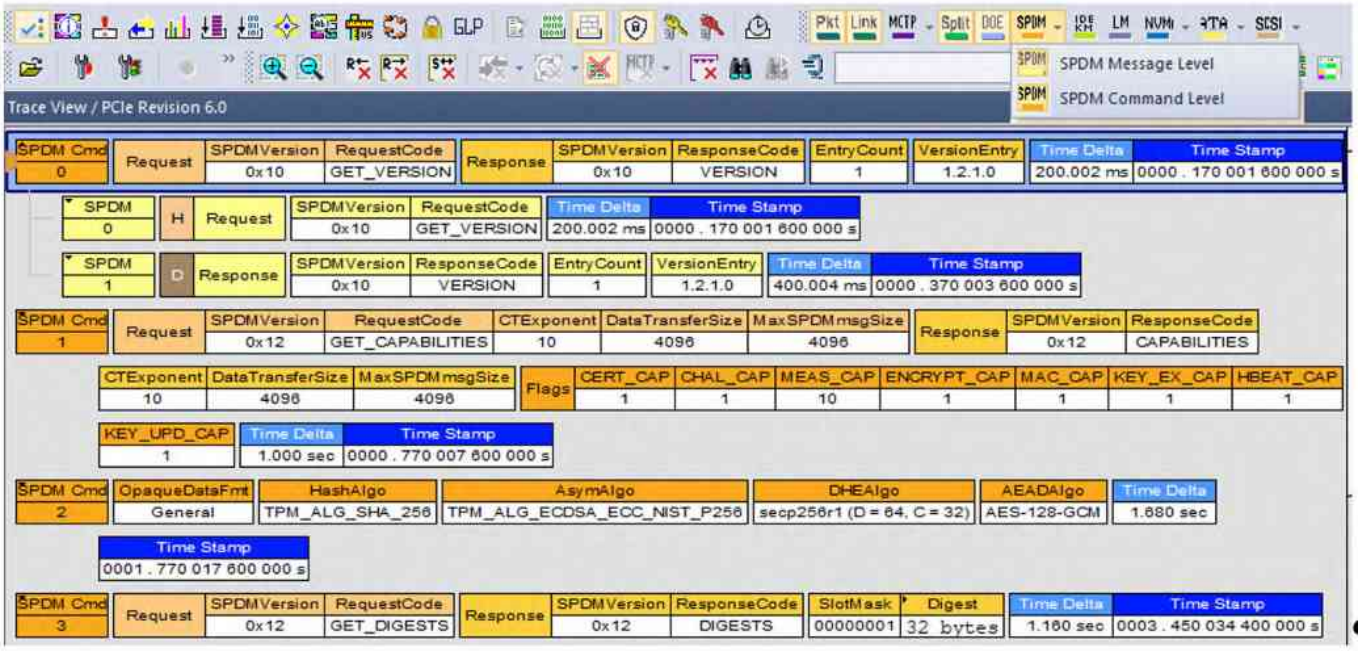


Figure 7.168: SPDM Commands: SPDM Messages

Note: Decoding SPDM over MCTP messages requires MCTP decoding license.
Decoding SPDM over DOE messages requires IDE/DOE decoding license.
Decoding Secured SPDM messages requires IDE/DOE decoding license.

7.11.34 Decrypting Secured SPDM Messages

Secured SPDM functionality is implemented according to DSP0274 version 1.2.1 and DSP0277 version 1.0.0.

These analyzer mechanisms providing Secured SPDM functionality are implemented:

- Key Schedule and session establishment using KEY_EACHANGE and FINISH request messages, collecting VCA, certificate, TH1 and TH2;
- Major secrets update with KEY_UPDATE processing;
- Error detection for SPDM and Secured SPDM protocols;
- Decryption and authentication of secure messages.

To perform decryption of secured messages:

1. Decode a trace to the SPDM level.
2. Open the SPDM Keys dialog.
3. Enter correct DHE secrets and click decrypt.
4. View the decrypted data displayed on the Trace View.

Figure 7.169 shows the Secured SPDM Messages. Fields specific to secured messages have a different color.

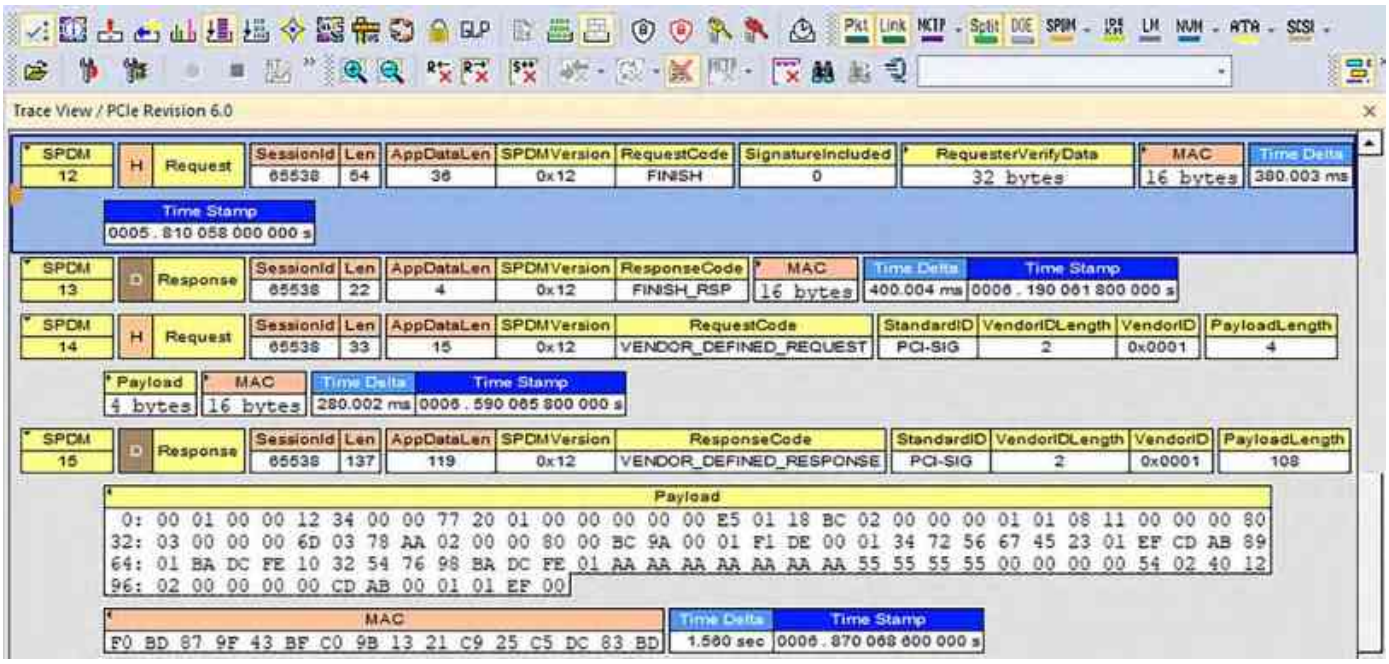


Figure 7.169: Secured SPDM Messages

7.11.34.1 Entering SPDM DHE Secrets and Pre-shared Keys

SPDM DHE secrets and pre-shared keys are entered using the SPDM Keys View window.

1. Open the SPDM Keys View widow by clicking the SPDM Keys toolbar button (See Figure 7.170). The button is active if:
   - ❑ There are SPDM messages in the trace, and
   - ❑ You first click the SPDM decoding button.



Figure 7.170: Open SPDM Keys View Window Button

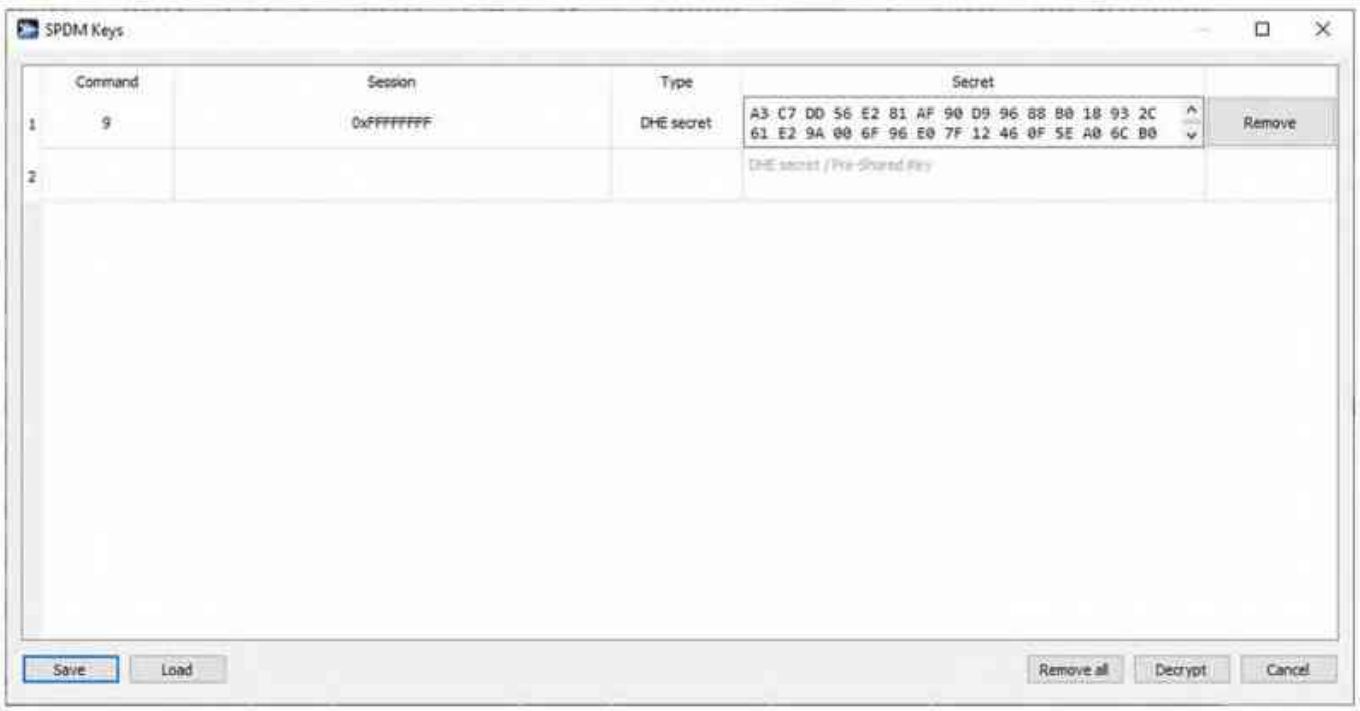


Figure 7.171: SPDM Keys View

2. Clicking the Decrypt button:
   - ❑ Saves the DHE secrets and pre-shared keys to the trace,
   - ❑ Derives Secured SPDM keys, and
   - ❑ Decrypts Secured SPDM messages.
3. To add a new secret, click on the empty row at the bottom of the table.
4. Command selects the index of the SPDM KEY_EXCHANGE or PSK_EXCHANGE command. Each table row must have a unique command field value.
5. To Save SPDM DHE secrets and pre-shared keys, click the Save button.
6. To Load SPDM DHE secrets and pre-shared keys, click the Load button.

Note: DHE secrets can only be changed on writable files. Ensure the trace file isn't read-only before entering the secrets. If the keys are unchanged, a read-only file can decrypt secure messages.

If decryption is unsuccessful, check if:

- ❑ The trace is incomplete or some messages involved in Key Schedule are missing.
- ❑ Secure messages or messages involved in Key Schedule contain errors.
- ❑ SPDM commands involved in Key Schedule are incomplete or contain error responses.

7.11.35 Decoding IDE KM traffic

IDE KM protocol decoding is done with the toolbar button shown in Figure 7.172.

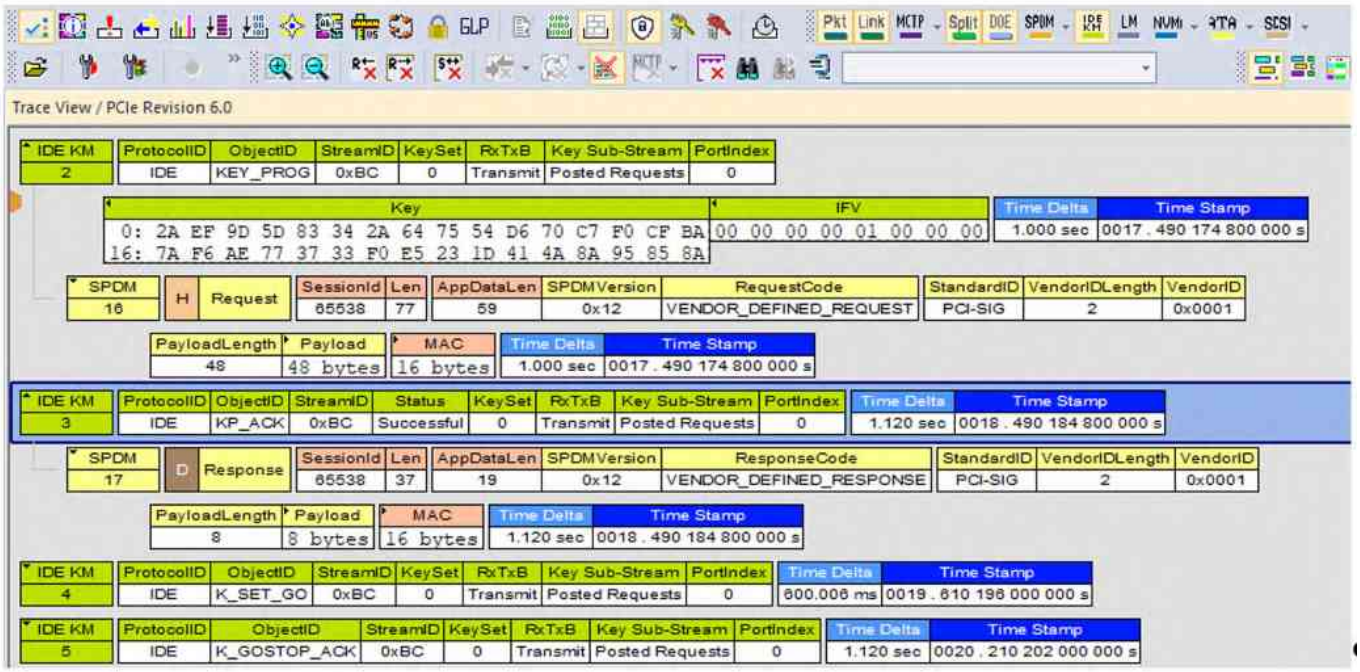


Figure 7.172: IDE KM data objects over Encrypted Secure Messages

KM data objects consist of decrypted payloads of Secured SPDM encrypted vendor-defined requests and responses. This means Secured SPDM decoding must be performed prior to IDE KM decoding. Secure messages with errors and non-encrypted messages (when ENCRYPT_CAP is 0) do not result in IDE KM data objects.

IDE KM protocol processing mechanism collects IDE keys from KEY_PROG data objects. If at least one key was successfully collected and there are no other errors decoding, the PCIe Protocol Express software offers to replace IDE keys with the collected ones. After updating IDE keys, press the "Decode" button to decrypt IDE packets and decode IDE-dependent levels in IDE Keys View.

Note: Decoding may cause errors if decryption of IDE packets affects SPDM decoding.

Chapter 8

BitTracer Recording

Note: BitTracer Recording is an optional feature.

Note: Bit Tracer recording applies to the Summit T54 only.

The Summit T54 analyzer has an optional **BitTracer** data capture mode, which captures bi-directional link traffic in raw format. The BitTracer recording mode captures and displays traffic before lane-to-lane de-skew operations and before descrambling of 10b bytes. The BitTracer mode includes support for multiple logical links (bifurcations) on a single physical link.

The BitTracer recording mode has its own user interface, which provides characterizations of link traffic that are not available in the standard protocol analyzer mode. You can export BitTracer recordings for viewing in CATC Trace format.

Note: This feature can be included at initial purchase or added in the field with a software upgrade license. To obtain a software license key to add this feature, contact Teledyne LeCroy.

Lane Deskew Bypass in recording options prevents lanes from being bonded by the analyzer, allowing you to troubleshoot problems with physical layer.

8.1 Enabling BitTracer Recording

To enable the BitTracer recording mode, open the **Recording Options**.

In the Target Analyzer section of the General tab, select **Summit T54.**

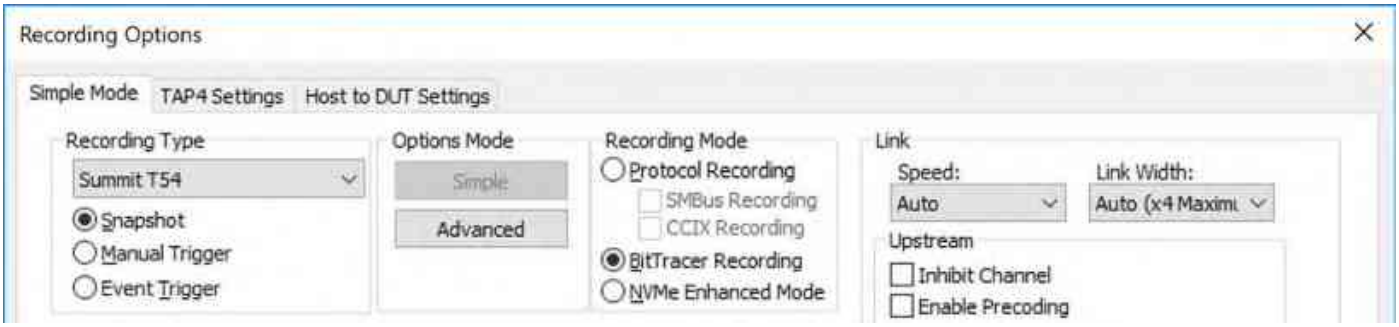


Figure 8.1: Recording Mode

In the Recording Mode section, select **Bit Tracer Recording.**

.

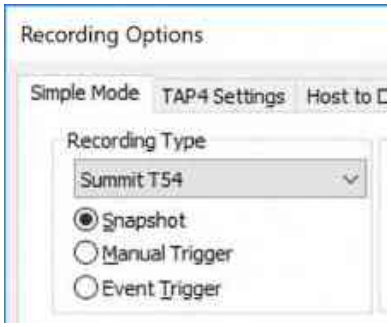


Figure 8.2: Recording Type

In Bit Tracer Recording, you can use the Snapshot, Manual Trigger, and Event Trigger recording types.

Note: You can also use other standard Recording Options, such as Link Width, Buffer Size, and Lane Polarity Settings, to characterize the link.

8.2 Trigger Modes

If you select Event Trigger, you may select basic trigger settings in the Trigger On dialog.

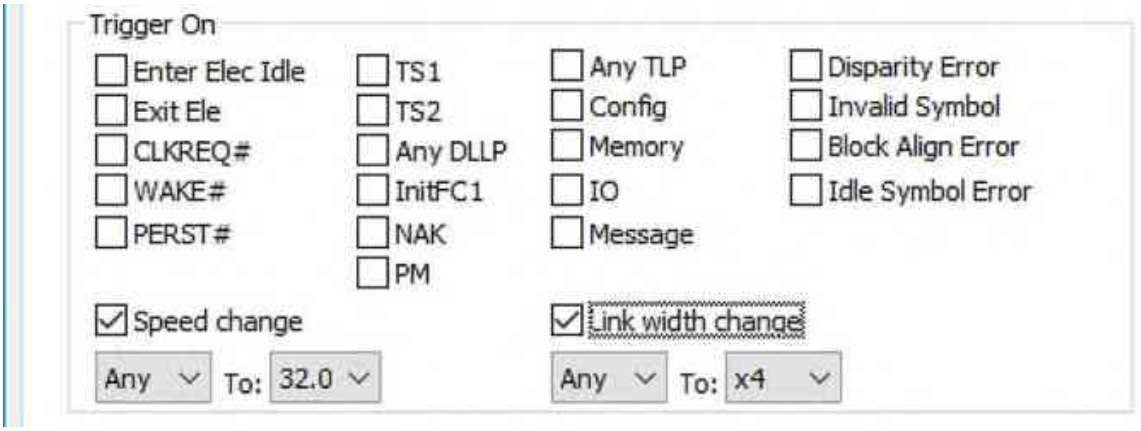


Figure 8.3: Trigger On Dialog

8.3 Views Available for Captured Data

BitTracer mode displays captured data lane-by-lane and byte-by-byte in each direction (upstream and downstream), with the time scale progressing left to right.

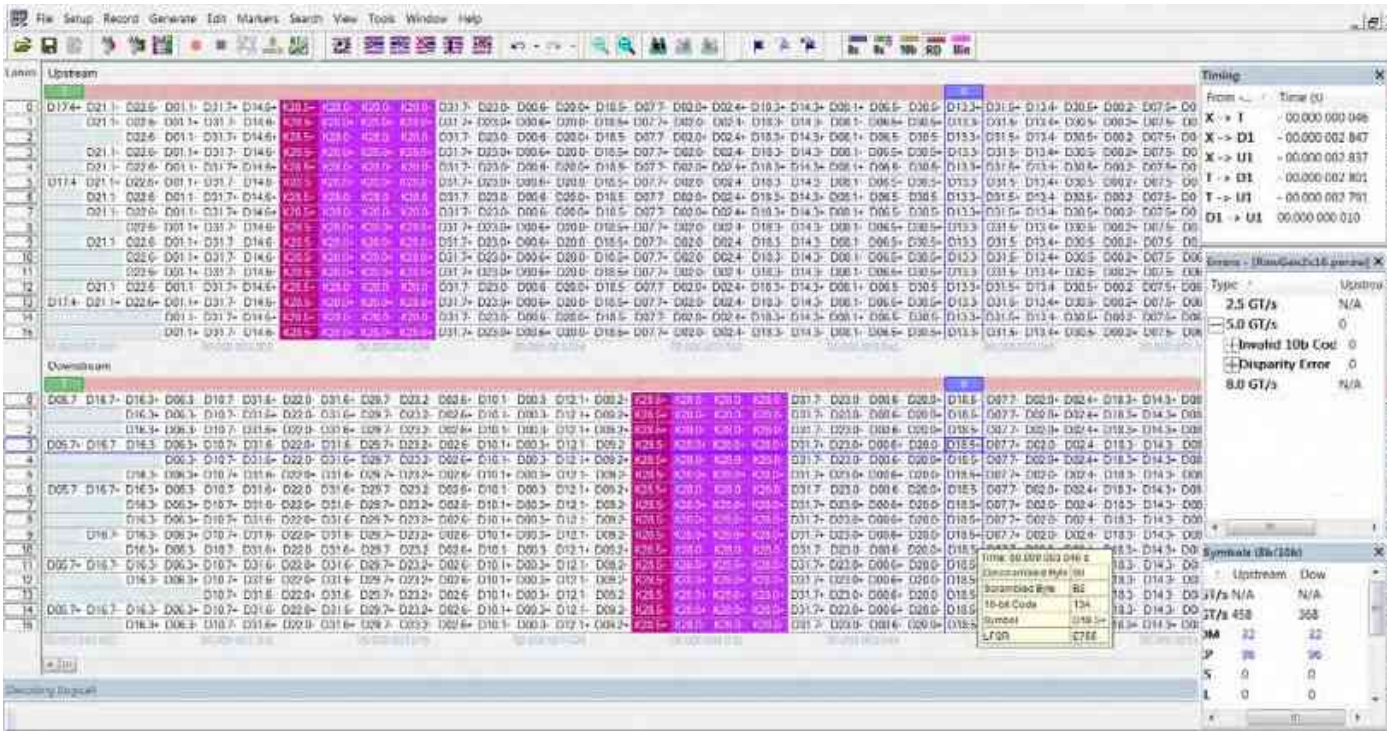


Figure 8.4: Captured Data

Other views are provided for timing measurements, marker placement, physical layer errors, captured symbol types, packets, events, and decoding of ordered sets and packets. You can view any or all displays simultaneously, using the **Windows** selection in the View menu.

8.4 De-skewing Data

By default, BitTracer recordings display captured data in time de-skewed format, across all lanes for both directions. But it is possible, for debug purposes, to bypass this de-skew using the **Lane De-skew Bypass** check box in **Recording Options**.

When lanes are not de-skewed, individual bytes are as they were captured on the recorded link, before the receiver device on the link (or the receiver logic on the PCIe Protocol Analysis analyzer) has performed lane-to-lane de-skew operations. You can manually skew the captured data, left or right, in increments of one symbol time (for Gen2 this is one byte) using the associated toolbar buttons. See Figure 8.5 on page 508.

Note: For Gen3 you can manually skew the captured data, left or right, in increments of 1 bit using the associated toolbar buttons.

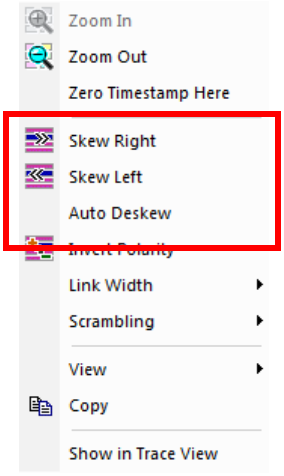


Figure 8.5: Skewing Data

You can automatically de-skew an entire lane direction. First, left-click on the direction in the data window. Then right-click to display a popup menu. Then select **Auto De-Skew.**



Figure 8.6: De-Skew Data

You can de-skew only one direction for each right-click operation. To automatically de-skew the opposite direction, first left-click on that direction in the data window.

Note: The skew observed in the bit tracer is the actual skew of the lanes in the link plus the skew introduced by the analyzer interface. The De-skew Bypass option is not intended for skew measurements or estimations.

8.5 Data Display Formats

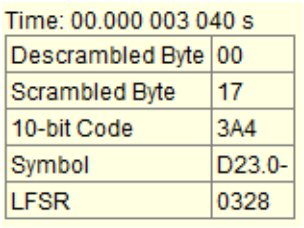
To display traffic in K/D symbol (with Running Disparity indicated), scrambled, descrambled, 10-bit, and Binary code formats:

- Use the toolbar.



Figure 8.7: Data Formats

- Right-click to display a menu.
- Place the cursor over any given byte to display all byte formats (including an LFSR value) in pop-up list.



Time: 00.000 003 040 s

Descrambled Byte	00
Scrambled Byte	17
10-bit Code	3A4
Symbol	D23.0-
LFSR	0328

Figure 8.8: Pop-up List

Note: Descrambled values can only be displayed after the first recorded skip ordered set. Data prior to the skip is displayed in scrambled values, due to the unknown LFSR.

Note: For Binary Data Display Format, bits are shown in order of transmission on the bus.

8.6 Color-Coding of BitTracer Contents

To increase visual understanding of BitTracer displays, different symbol types have color-coding:

- Presence or non-presence of a lane's byte-lock
- Idle data characters (D0.0)
- K codes
- Invalid 10b symbols
- Signal presence
- Background of the Markers Bar (see "Markers/Speed Bar" on page 511). (color coded according to traffic speed).
- All symbols of a TS1/TS2 ordered set

By default, these color selections match the standard color selections used in the CATC Trace format. You can modify them in the Display Options menu, accessible from the Main toolbar or the Setup menu.

8.7 Report and Analysis Windows

In the report windows, BitTracer mode provides several functions to analyze traffic:

- Statistical information
- Timing measurements
- Packet decoding

To activate/deactivate a report window, use **Views > Windows,** see Figure 8.9 on page 510.

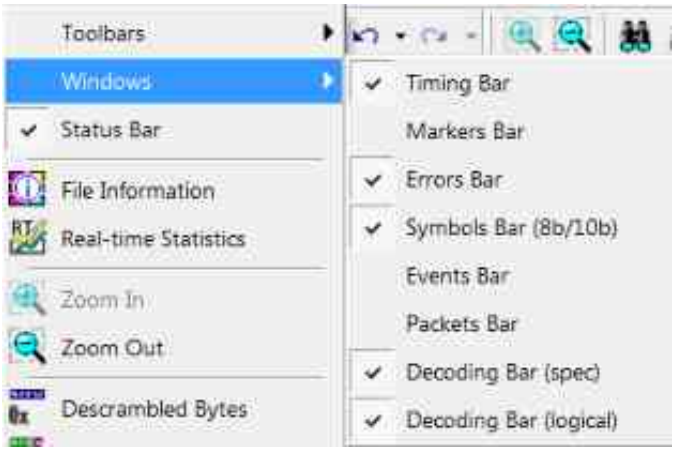


Figure 8.9: Activate/Deactivate Reports

You can rearrange the report windows.

All report windows are dockable.

8.8 Timing Measurements Bar

BitTracer mode provides timing measurements on captured data:

- Measurements from the Trigger position relative to user-selected X and Y markers
- X-Y measurements
- Measurements between user-defined markers

8.8.1 Markers/Speed Bar

Markers are displayed in the speed bar above the data. Place your cursor in the speed bar and the Current speed will be displayed. In this case, the traffic was running at 5.0 GT/s when the trace was taken. See Figure 8.10.

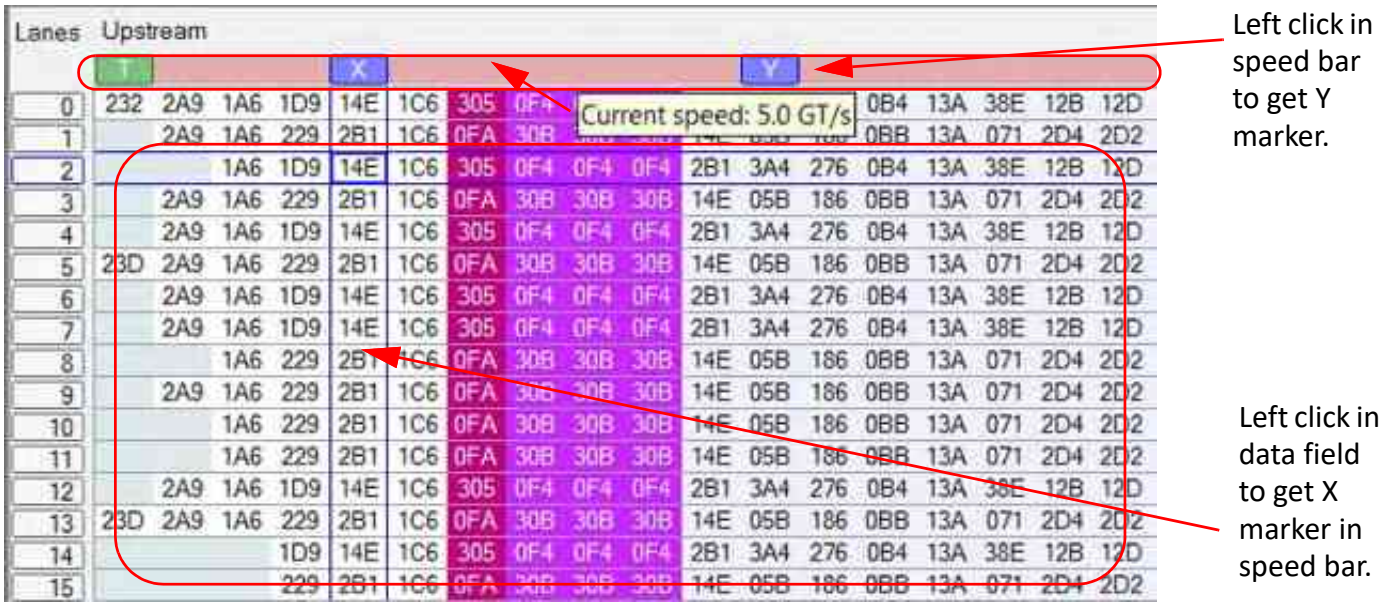


Figure 8.10: Marker/Speed Bar Example

The Trigger marker T is at the point where BitTracer recognized the user-defined trigger condition.

To set an X marker X, left-click anywhere in the data display, see Figure 8.10.

To set a Y marker Y, left-click in the narrow speed bar where the T and X markers are displayed. See Figure 8.10.

8.8.2 Defining a Marker

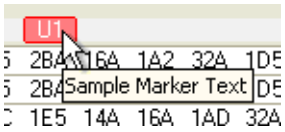
To define a marker, select the **Set Marker** command in the Markers menu or use the **Toggle Marker** icons in the toolbar. You can also use the Jump to Next or Previous marker icons in the toolbar.



User-defined markers are numbered in the order they were placed:

- U1 U1, U2, and so on in the upstream direction
- D1, D2 D2, and so on in downstream direction.

You can set a marker with text using the **Set Marker with Text...** command in the Markers menu. After setting the marker, when the mouse pointer is on the marker symbol, the marker text displays as a tooltip.



You can also display the Markers window, which lists all markers and their locations. See Figure 8.11 on page 513.

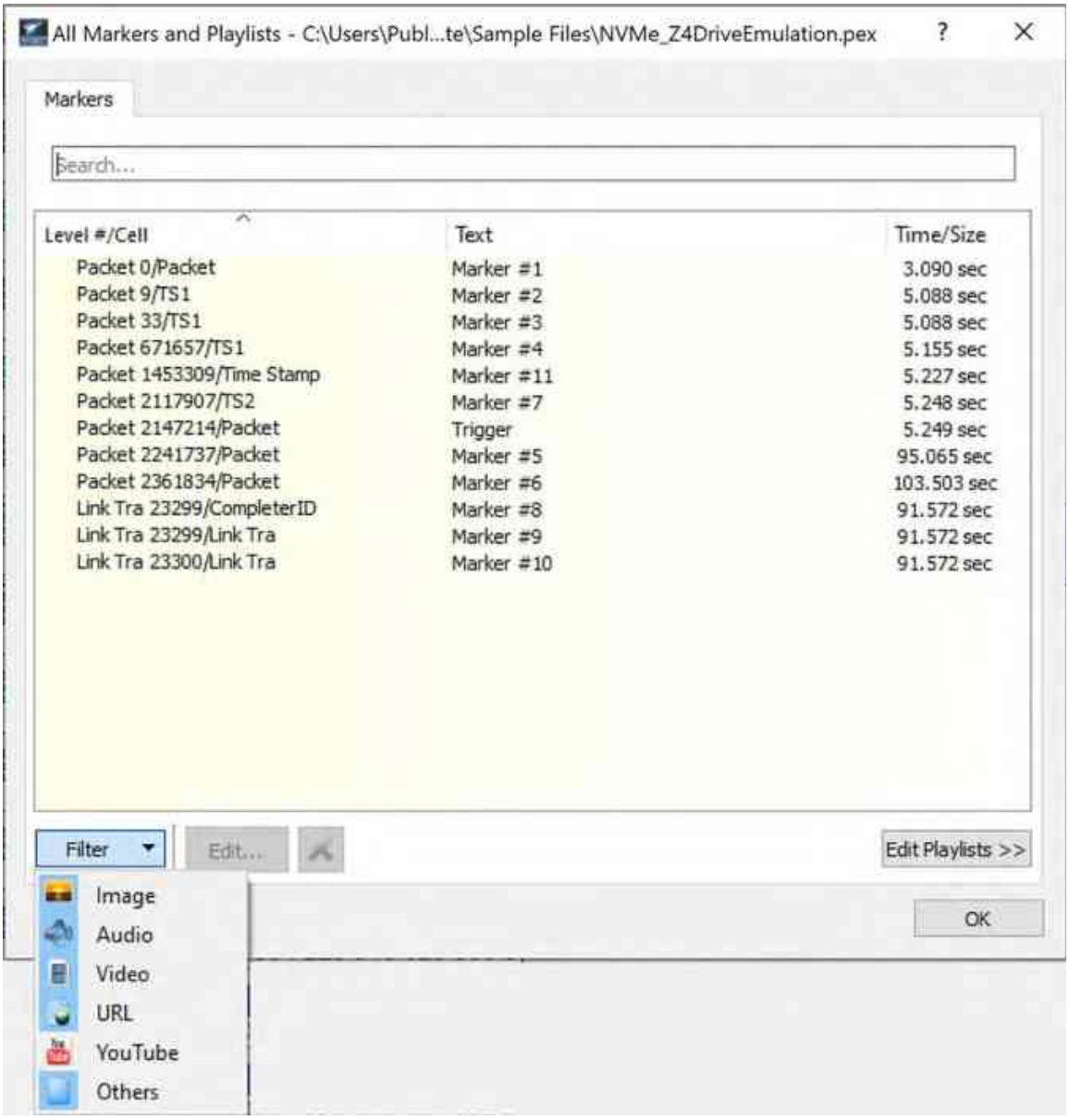


Figure 8.11: Markers Window

Timing measurements between all combinations of X, Y, U, and Trigger cursors are in the Timing window.

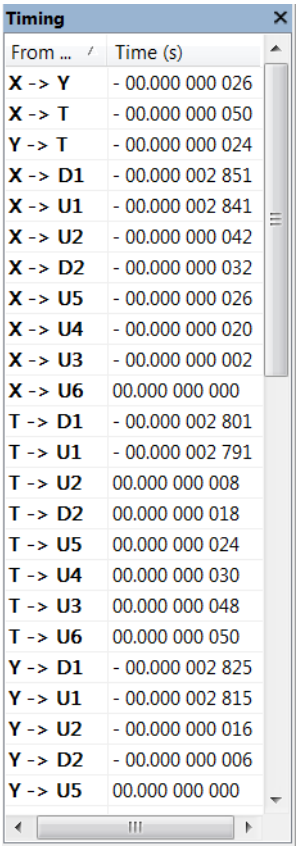


Figure 8.12: Timing Window

8.9 Errors Bar

BitTracer mode provides a summary of 10b errors (invalid symbols) and disparity errors in the Errors window. The window shows the total error count and errors per-lane for each error type. Hyperlinks allow jumps to selected errors.

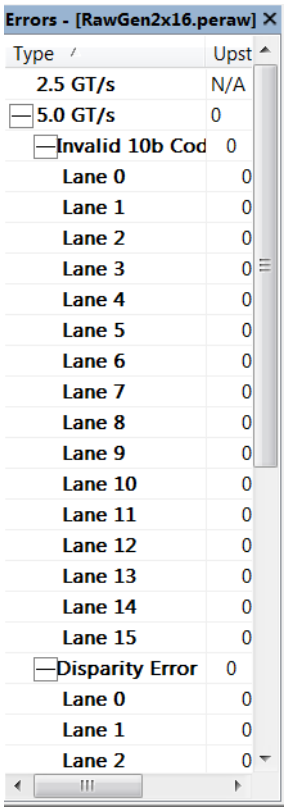


Figure 8.13: Errors Window

BitTracer mode also highlights errors:

- Invalid symbols have a black background.
- Bytes with incorrect running disparity have red borders.

8.10 Symbols Bar

The Symbols window provides a summary of the different symbol types captured, by quantity and direction, and includes hyperlinks for jumps to selected symbols.
Expanding the **+** sign at the left of each symbol provides a summary of symbols by lane.

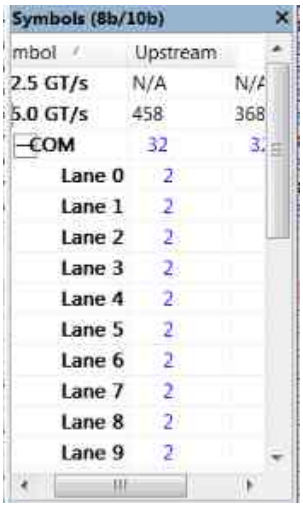


Figure 8.14: Symbols Window

8.11 Events Bar

The Events report window summarizes Link Up, Link Down, and Speed Switch events for Upstream and Downstream.

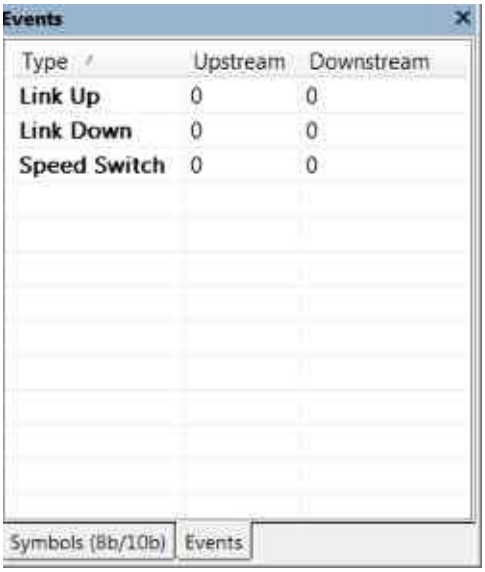


Figure 8.15: Events Window

Note: The table entries are hyperlinks.

8.12 Packets Bar

The Packets report window summarizes packet types detected in the file.

Note: To obtain packet types, you must perform a post-capture "Analyze" step. After capture, when you open the Packets Bar for the first time, items can display the command "Analyze". To start the analysis, click the word **Analyze**. After analysis finishes, the results are saved with the file. Therefore, you do not need to click **Analyze** the next time.
The table entries are hyperlinks.

Note: If you edit anything, the results are no longer valid, and the system requires you to click **Analyze** again.

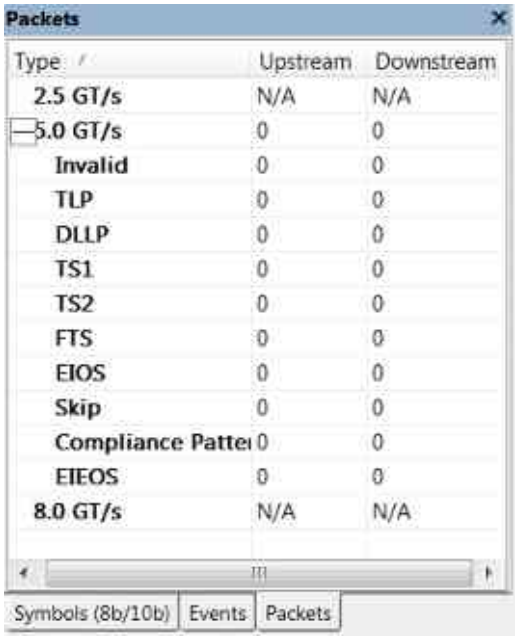
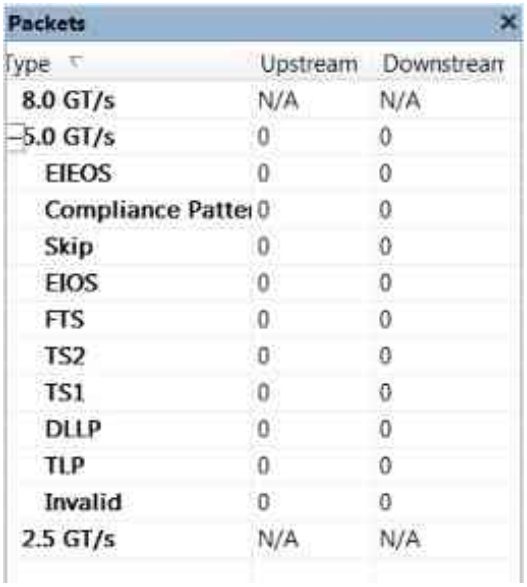


Figure 8.16: Packets Window

After analysis, the Packets Bar looks like the following (see the following figure):



8.13 Decoding Bar

If you select them in the data view, or search or jump locates a feature, BitTracer mode displays ordered sets and packets in the Decoding dialog (see Figure 8.17 on page 519).

- **Logical view** is identical to CATC Trace format.
- **Specification view** provides a more elementary display. The Specification view includes an option to display data in hex or binary format.

Note: Packets and ordered sets translate directly to this view from data capture and use any post-capture skew manipulations you add, or use natural lane-to-lane skew present on the link if you have not added post-capture skew manipulations. Typically, you would perform an Auto De-Skew before viewing ordered sets and packets in this view.

Use the left and right arrows to search for the next or previous symbol type.

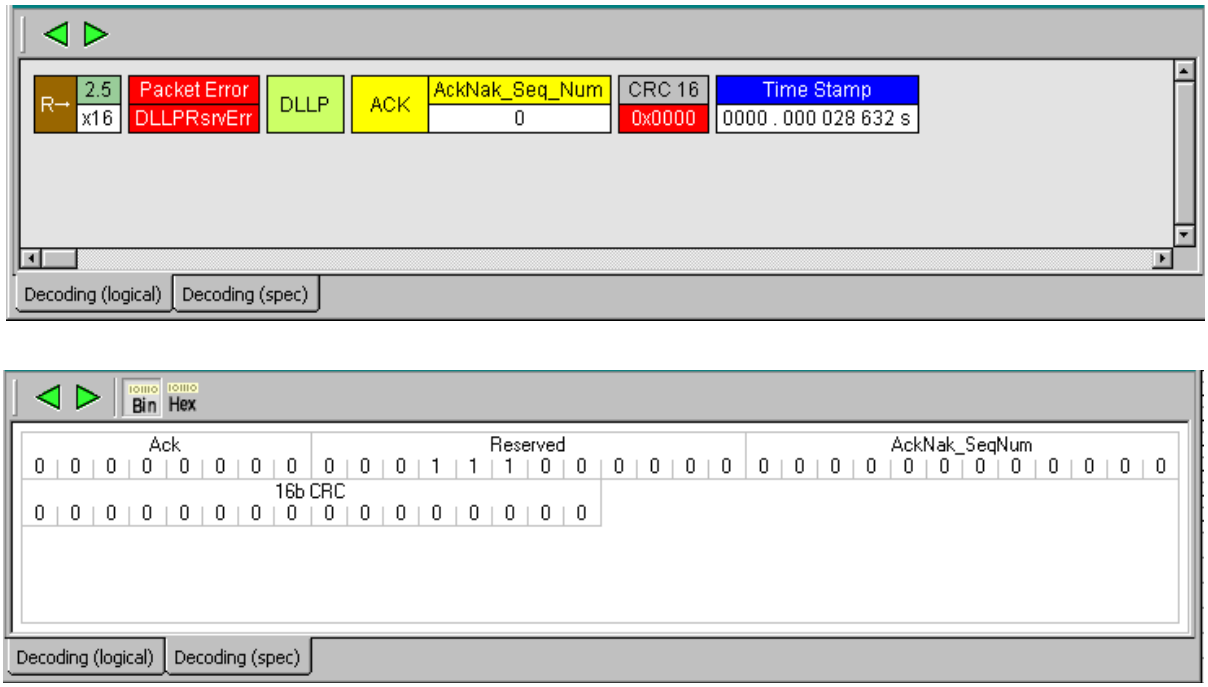


Figure 8.17: Decoding Dialog

8.14 Search

To search, use the Search toolbar.



Clicking the **Search** icon displays the Search dialog (see Figure 8.18 on page 520).

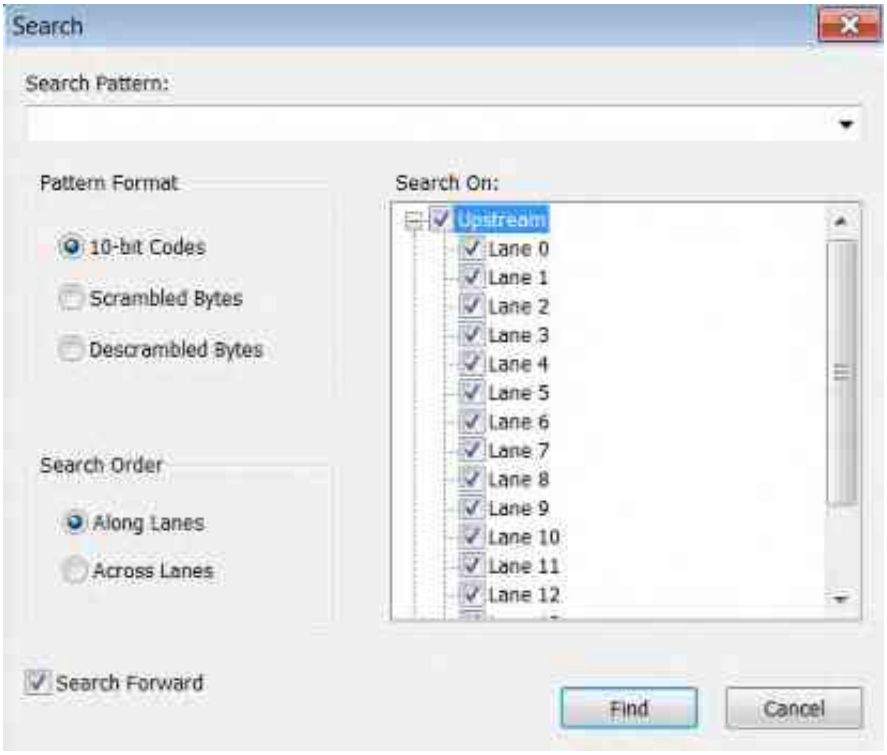


Figure 8.18: Search Dialog

You can copy data shown in the BitTracer display across a lane (horizontally) or across multiple lanes (vertically), and then paste it into the Search Pattern window.

The Search Pattern window stores previous search values, which you can recall by selecting the Search Pattern drop-down button.

In the Pattern Format section, select to search in 10-bit Codes, Scrambled Bytes, or Descrambled Bytes format.

In the Search Order section, select to search Across Lanes (multiple lanes, vertically) or Along Lanes (individual lanes, horizontally).

To define the direction (upstream or downstream) and the lanes on which to search, use the Search On section.

8.15 Link Configuration

Use the toolbar icon or right-click in the data views to display the Link Configuration dialog (see the following figure). This dialog allows you to associate logical lanes with physical lanes, thereby providing support for lane bifurcation (multiple logical links on the same physical link).

After logical lanes map to physical lanes, BitTracer mode reconfigures the display to show the selected logical link (and the logical link width, as the link width selected in the dialog).

Use the arrows to force symbol time skew on any lane.

Use the polarity checkbox to invert lane polarity on the selected lane or use the **+/-** toolbar icon.



Use the scrambling option to select a scrambling algorithm, as per specification 1.0a or legacy specification 1.0.

Select **Edit > Edit Link** or click the  icon to display the Link Configuration for Upstream dialog (see Figure 8.19).

Note: This dialog applies to one direction at a time (upstream or downstream). Left-click in the direction in the data display to edit the configuration for that direction.



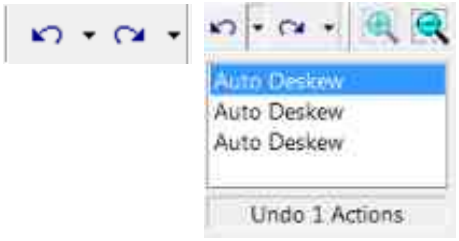
Figure 8.19: Link Configuration for Upstream Dialog

As you perform operations that affect display configurations, the application records them. To undo or redo operations, use the Undo and Re-do icons on the toolbar.

8.16 Export of BitTracer Capture to CATC Trace Format

You can export BitTracer captures to standard CATC Trace file formats, selecting the **Export** option from the File menu.

Note: If the bit trace is not deskewed, you should use the Auto De-skew feature before using the export feature.



The exported CATC Trace keeps association information with the original BitTracer file. Such traces scroll synchronously when you select the **Synchronize Traces** option in the Windows menu.

You can navigate between BitTrace and CATC Trace using the **Show in Trace View/ Show Packet in Raw Trace** context menu.

8.16.1 Exports Involving Multiple Logical Links on One Physical Link

If a single BitTrace capture contains more than one logical link, you can export each logical link to CATC Trace format. You may then cascade or tile the various BitTracer exports, which then scroll together in linked fashion, along with the original BitTracer file. The Export dialog provides options to export a limited range within the BitTrace capture and to automatically open the exported capture in CATC Trace format.

8.16.2 Export To CSV Text

Select **File > Export > Packets to CSV Text** to display the Export Packets to comma delimited text dialog. Select desired options from the From and To Segment, Marker and Time drop-down lists (see Figure 8.20 on page 523).

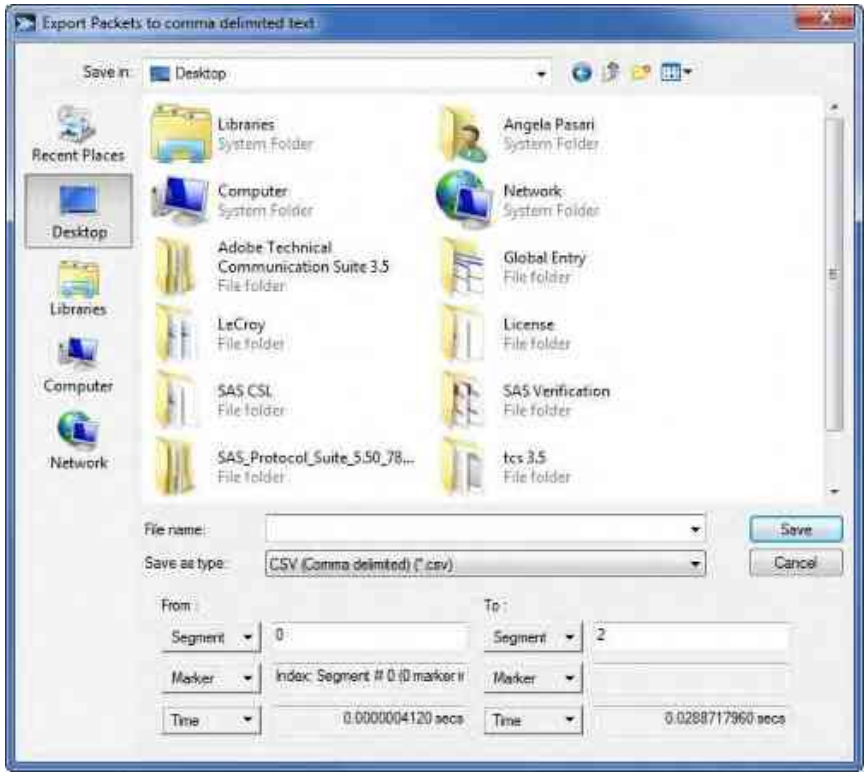


Figure 8.20: Export Packets to Comma Delimited Text Dialog

8.16.3 Exporting Data from Bit Tracer to a Trace File

Matching Link Width

Note: To export data correctly from Bit Tracer to a Trace file the Link Width of the recorded data traffic must match the Link Width of the Trace. If the Link Width is altered the result will be a Trace with errors in it.

In the example below, a raw data file is loaded with a recorded Link Width of x16 (see Figure 8.21).

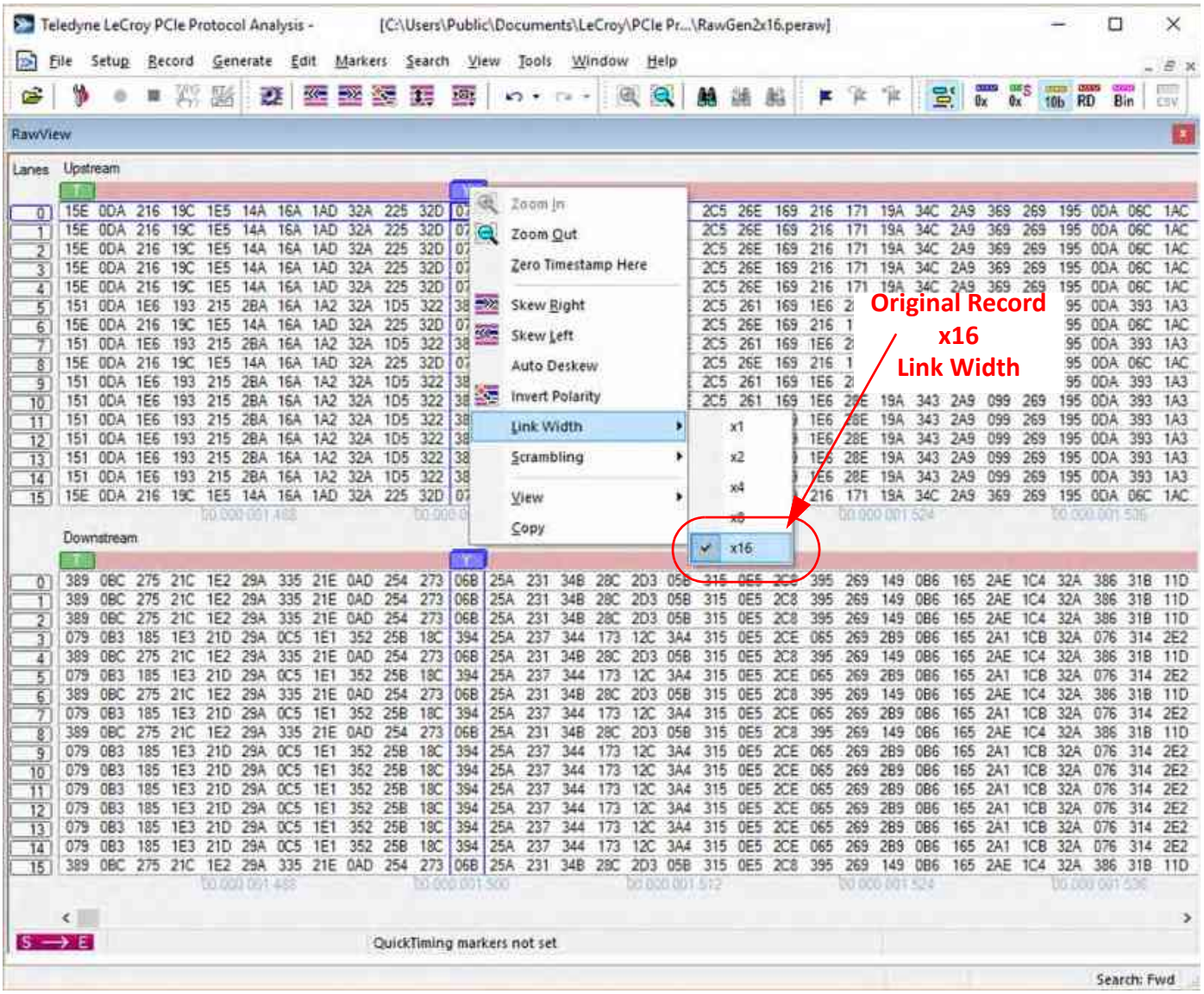


Figure 8.21: Raw Data File Loaded with x16 Link Width

Then the Raw Data File is Exported to Trace (see Figure 8.22 on page 525).

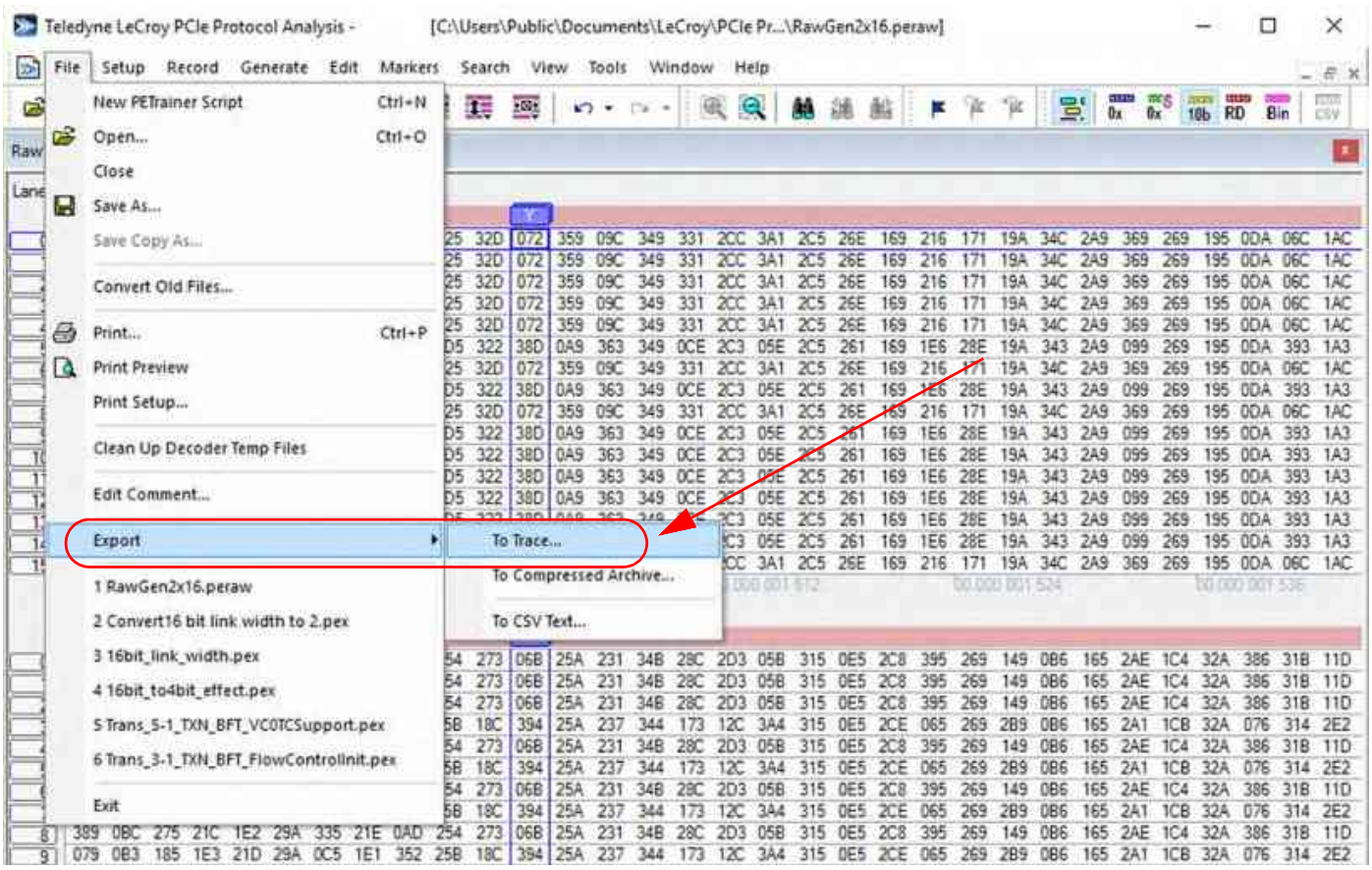


Figure 8.22: Raw Data File Exported from Bit Tracer to Trace File

The resulting trace file shown in CATC View (see Figure 8.23 on page 526).

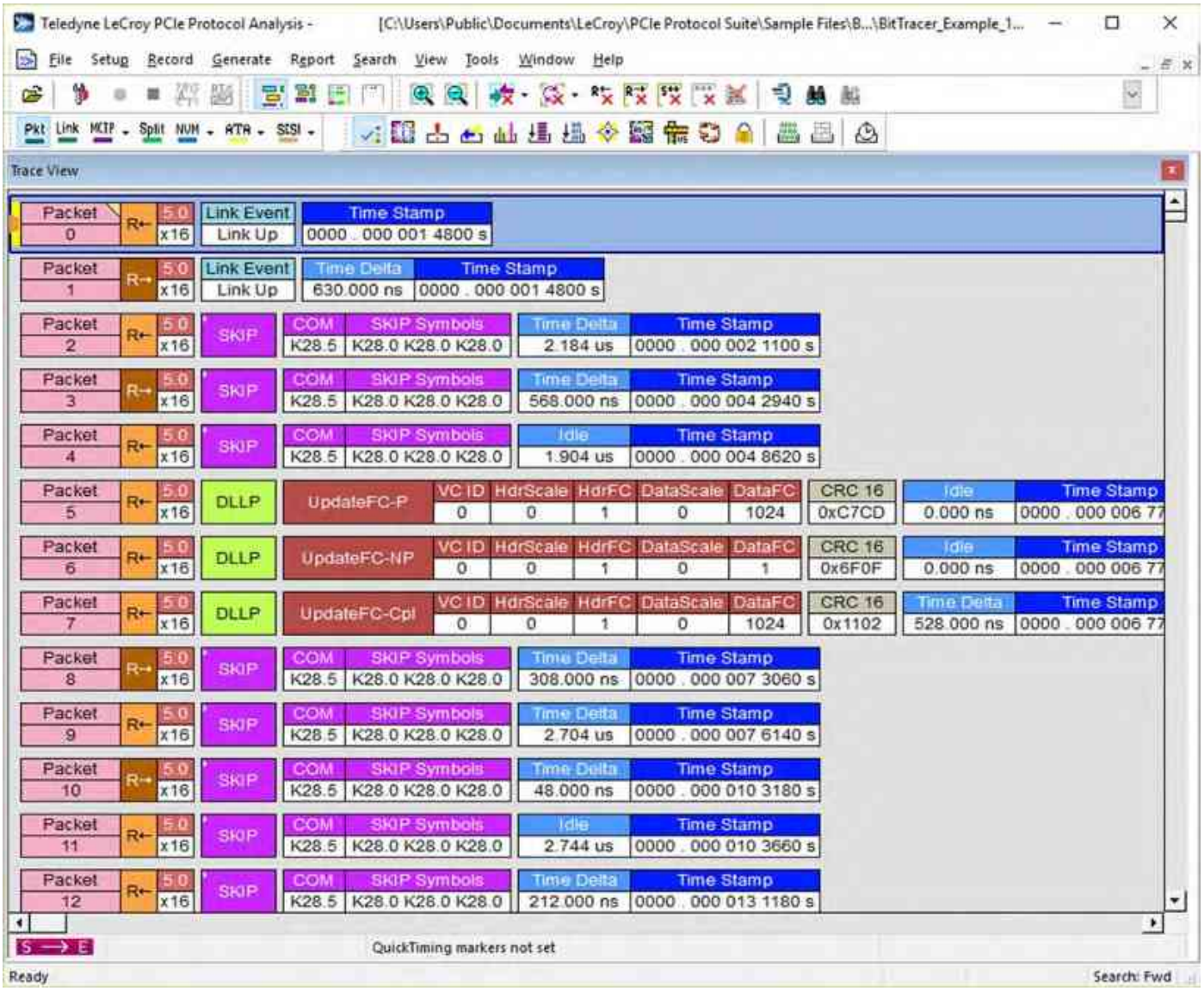


Figure 8.23: Exported Trace File from Bit Tracer

Changing Link Width from Original Recording

If you change the Link Width of the data traffic from the original recording and Export that data traffic to a Trace, the Trace will be decoded with errors. See Figure 8.24 and Figure 8.25 on page 528.

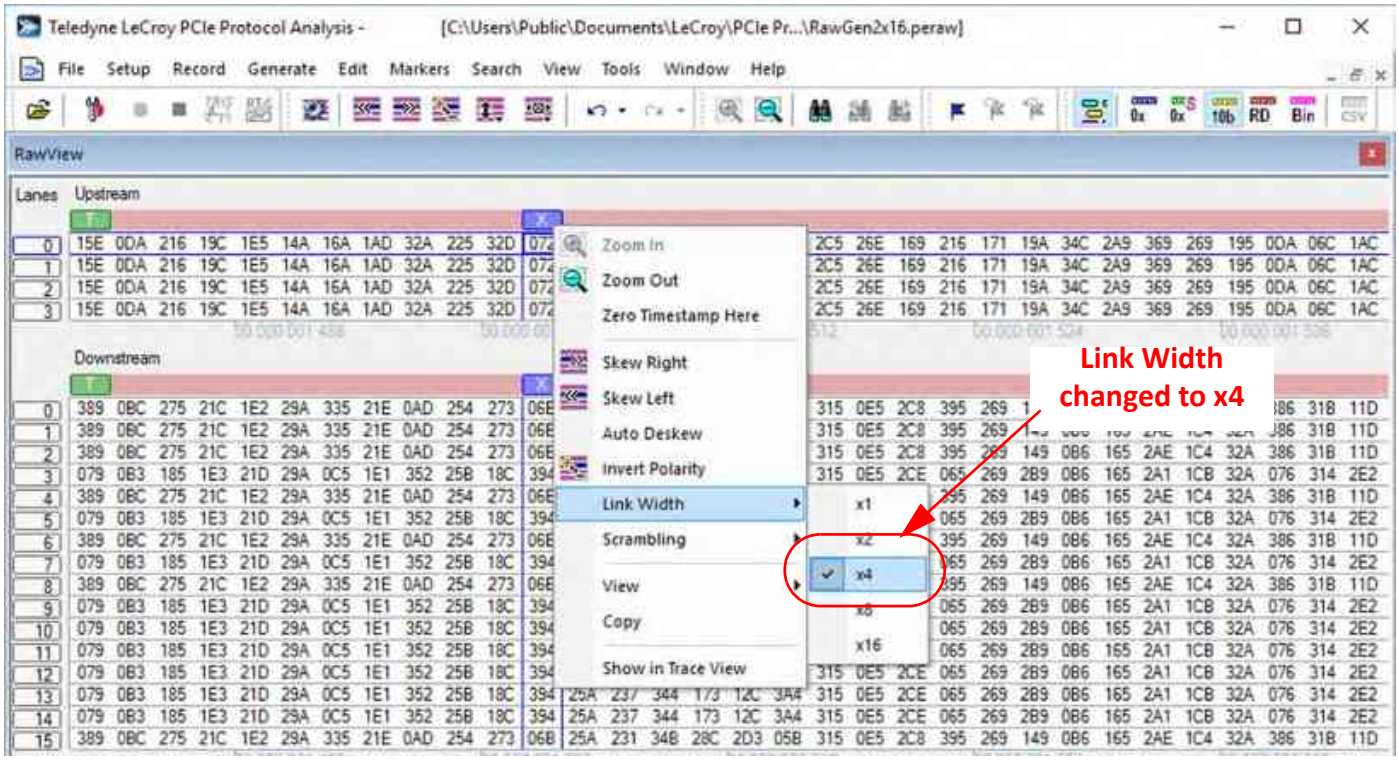


Figure 8.24: Link Width Changed From x16 to x4

Exporting the Data Traffic to a Trace will result in decoding errors (see Figure 8.25 on page 528.

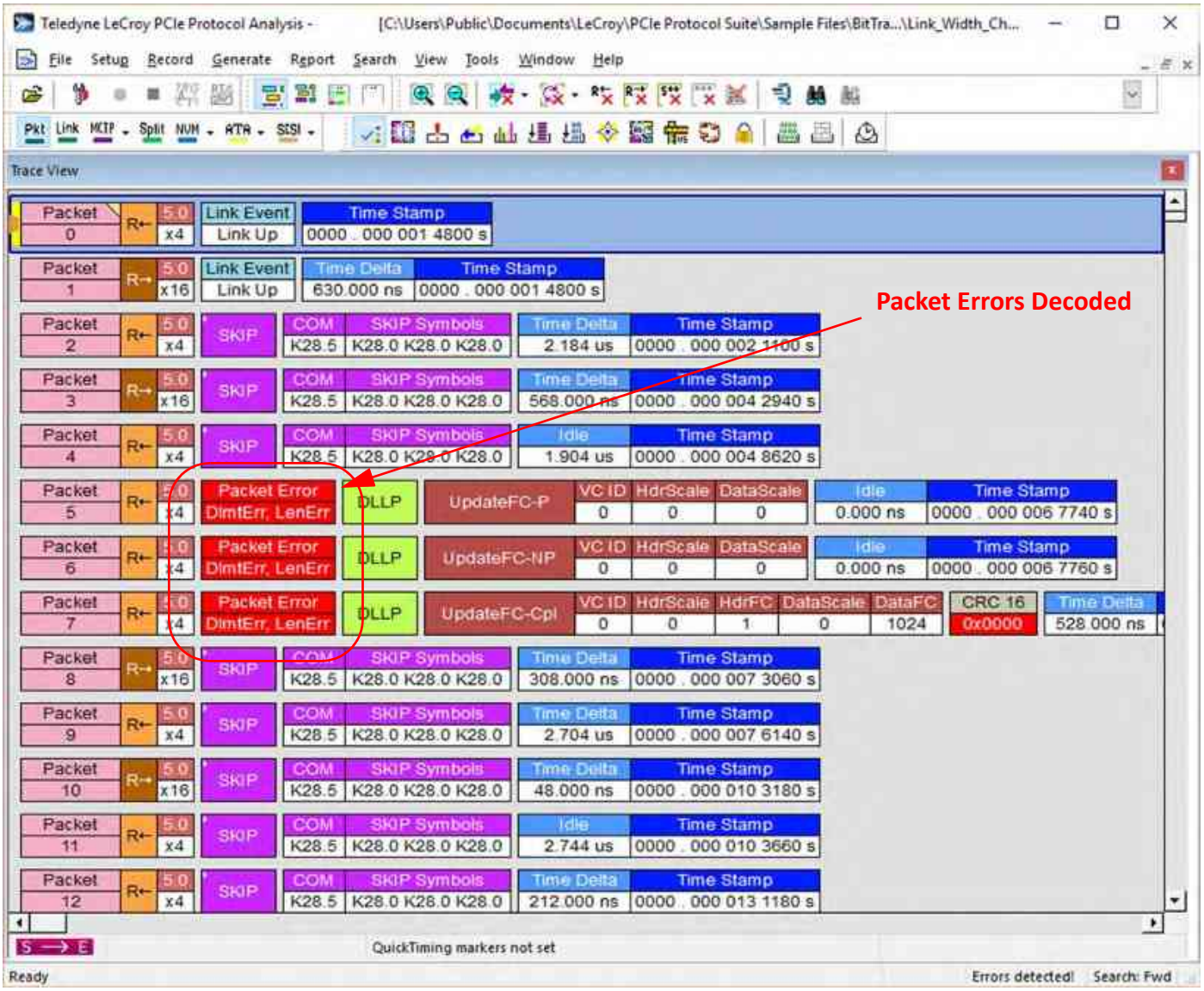


Figure 8.25: Export Data File with Changed Link Width (from x16 to x4)

8.17 Compressing and Expanding the Data View

You can compress (zoom out) the horizontal timing of the displayed data to view higher-order link behaviors. You can expand (zoom in) to examine higher-resolution views.

To zoom in or zoom out, right-click the data view, then select a command or select a zoom icon on the toolbar.



Alternatively, to zoom in, left-click and drag across a desired range of data.

8.18 Opening and Saving BitTracer Captures

You can save BitTracer captures in various file types.

You can collate and archive these files for transport, using the **Export to Compressed Archive** feature in the File menu.

The main BitTracer files have a ***.peraw** extension.

You can open these files in the PCIe Protocol Analysis application using the **File > Open** command.

Chapter 9

Searching CATC Traces

This chapter describes how to search for CATC Trace events.

9.1 CATC Trace Search Overview

Several search commands let you navigate a CATC Trace view to search for key events, such as errors and triggers.

To view the search options, click **Search** in the Menu bar. See Figure 9.1 on page 560.

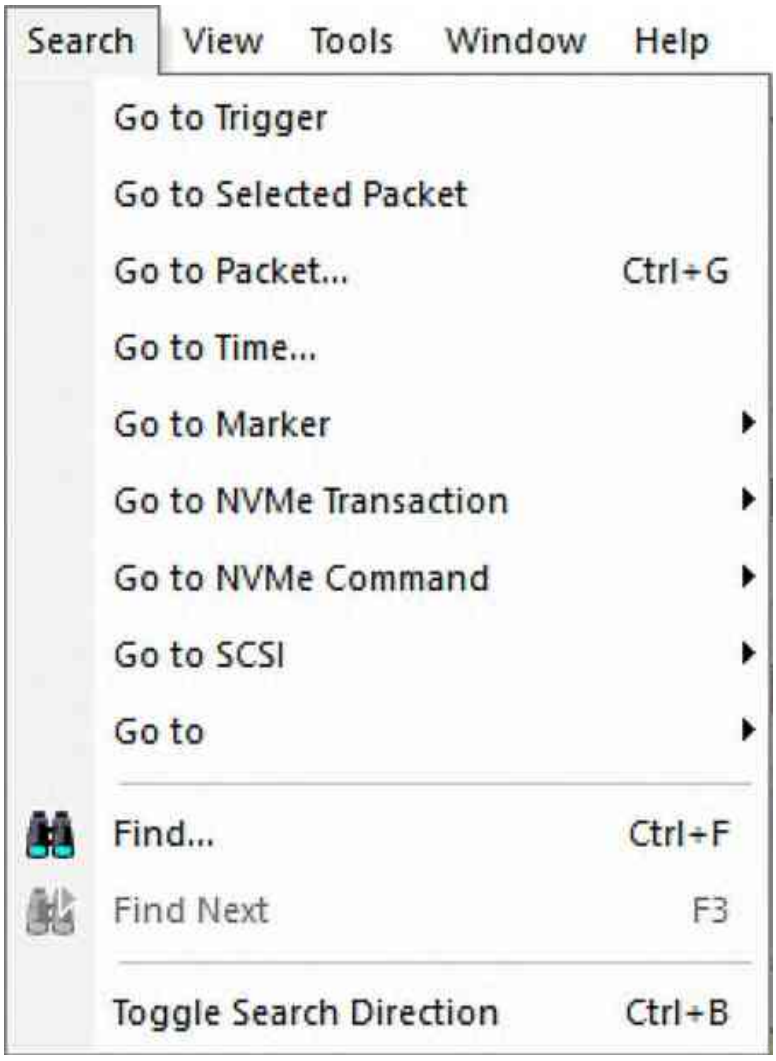


Figure 9.1: Search Menu Options

9.2 Go to Trigger

To position a trigger packet at the top of the screen:

Select **Search > Go to Trigger**.

9.3 Go to Selected Packet

To position a selected packet at the top of the screen:

Select the packet and Select **Search > Go to Selected Packet**.

9.4 Go to Packet

To position a specific packet at the top of the screen:

1. Select **Go to Packet** from the Search menu. A pop-up menu prompts you for the packet number, marker, or time (see the following figure).

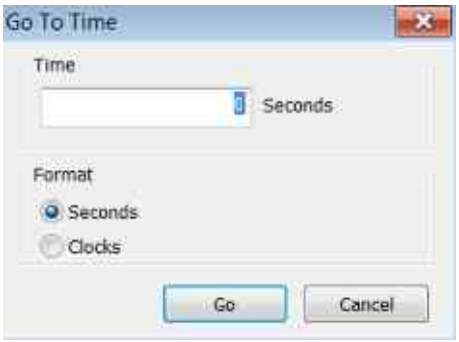
2. Choose the needed transaction level from the Packet drop-down list and enter the transaction number. Please note that transaction levels is added to list if corresponding level is decoded for current trace file.
3. Click **OK**.



9.5 Go to Time

To position a specific time at the top of the screen:

1. Select **Go to Time** from the Search menu. A pop-up menu prompts you for the time in Seconds or Clocks.



2. Enter the time and format (seconds or clocks).
3. Click **Go**.

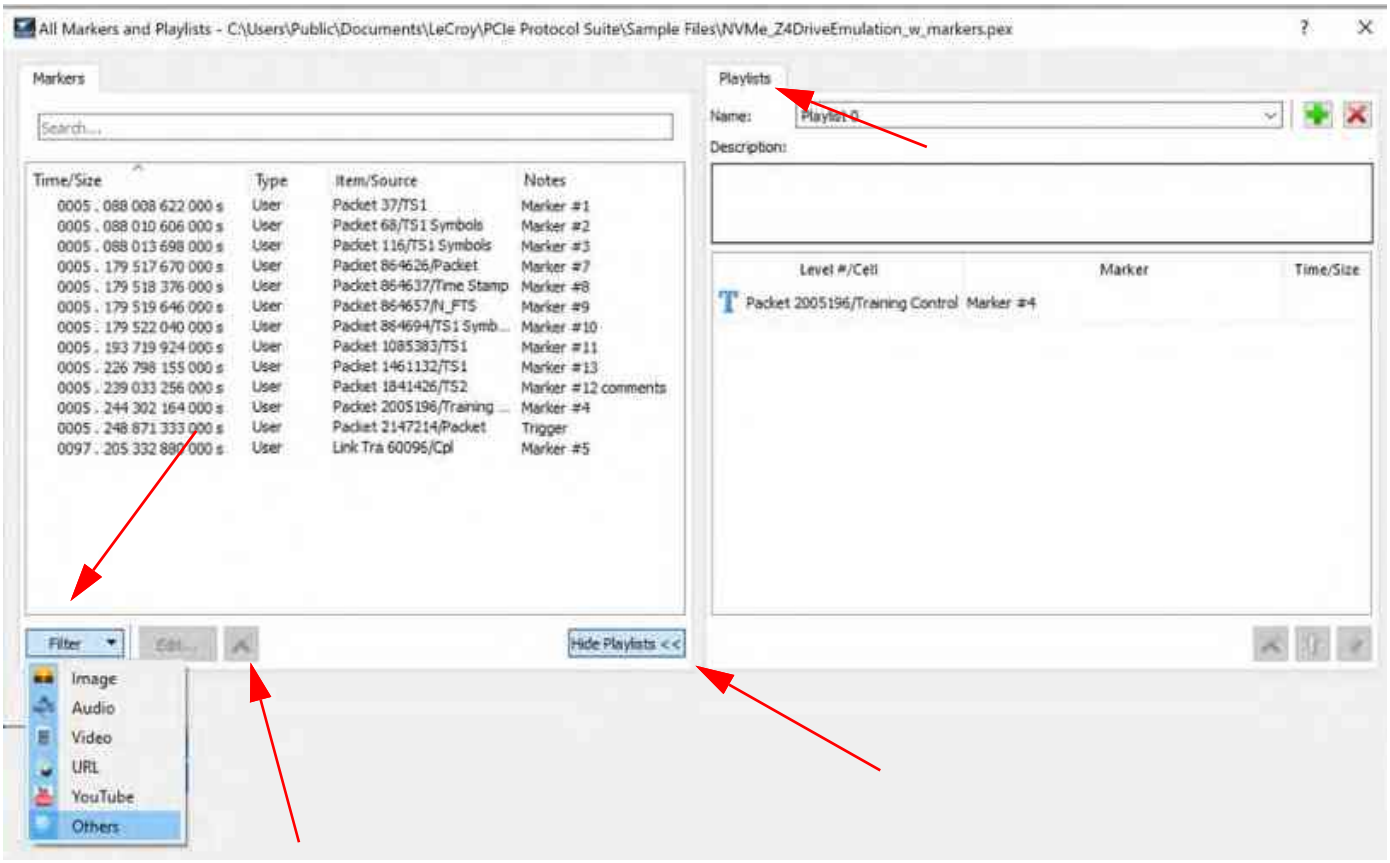
9.6 Go To Marker

Use this operation to go directly to a specific packet or transaction that has been marked with a unique marker by the Set Marker operation.

To go to a marker:

1. Select **Go To Marker** from the Search Menu.
2. Select the marker you want from the fly-out menu.
   Alternatively, select **All Markers** to display the All Markers and Playlists dialog, then select a marker and click **OK** (see Figure 9.2 on page 562).

.



Deletes selected Marker

Figure 9.2: All Markers and Playlists

9.6.1 Markers

This section explains the features of Markers. A marker is an entity that flags a physical or logical item of interest within a trace file. A marker contains one or more attachments. There are User Markers and Recorded Markers.

User Markers are added manually by the user to note items/events of interest. Users may add/remove User Markers as needed.

Recorded Markers are inserted by the Analyzer based on Recording Rules set in the Recording Options. Events that have the Ext Trig Out action set will have a Recorded Marker inserted at that event. Recorded Markers cannot be removed from the trace file.

Note: Recorded Markers are available only on the Summit T54 in Standard PCIe Protocol Recording mode.

Markers are represented graphically in a different way in the application.You can not only add markers to the packets but it is granular enabling you to also add markers to individual cells.

9.6.1.1 Markers Overview

This functionality provides the user an easy way to navigate through attachments which is a discrete piece of information or data added to a marker, for example, a text description or file, an attachment of a trace file by a predefined order, video or audio files, URL links or any other files.

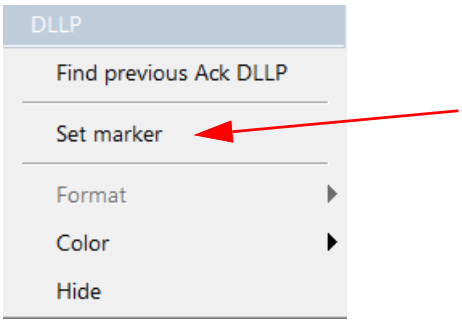
9.6.1.2 Functionality of Markers

The markers functionality allows you to add markers to:

- Whole packets or frames
- Specific Cells
- Specific values within a cell: Bytes, words, etc.
- The Timestamp of a Packet

You can add attachments to markers.

Right-click on any cell of a packet and select **Set Marker** from the menu as shown below.



The Create Marker dialog displays (see Figure 9.3 on page 564).

9.6.1.3 Set New Marker

Markers are useful to identify specific points in the data. By default markers follow a numbering convention but can be renamed. Markers can also be inserted by using the keyboard (see Figure 9.3 on page 564):

- Hover your mouse pointer over a packet and press **Ctrl+K** to insert a marker for that packet.
- Click a packet to select it and press **Ctrl+L** to insert a marker for that packet.

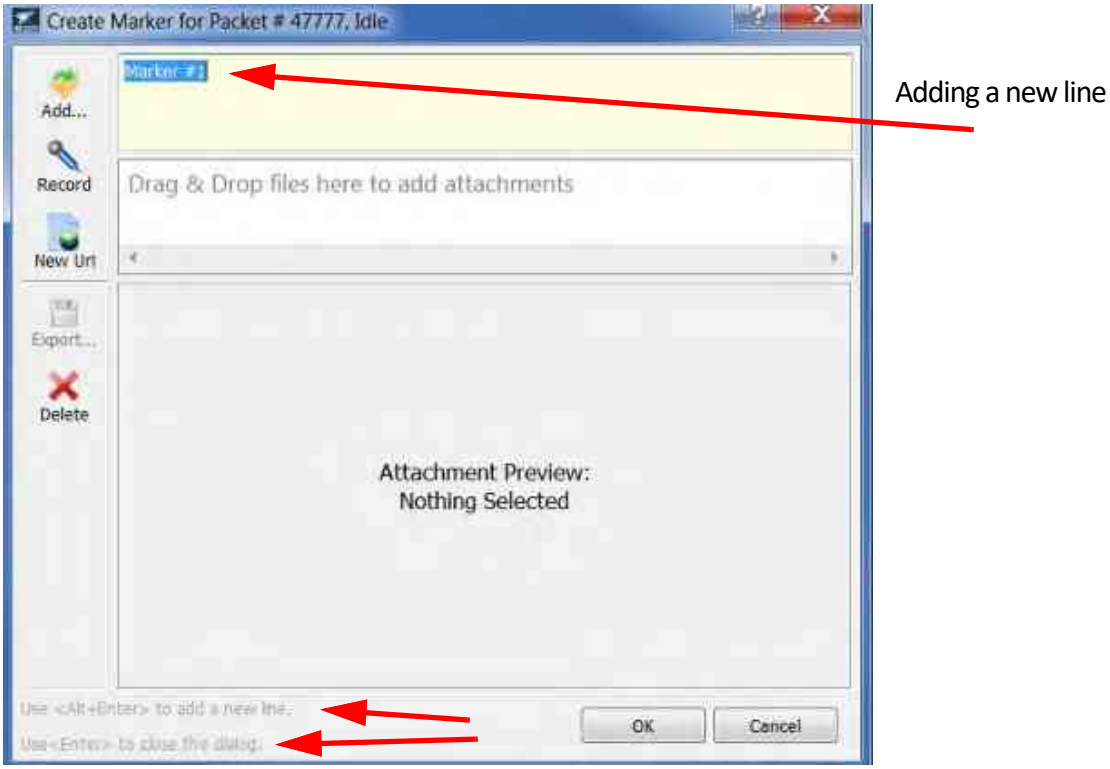


Figure 9.3: Create Marker for Packet Dialog

Click **Enter** to close the Marker dialog.

Click **ALT > Enter** to add a new line.

As shown above you can:

Add...	Add icon. Click on this icon to add any file. See "Adding an Attachment" on page 565.	Export...	Export icon. Click on this icon to export an attachment.
Record	Record icon. Click on this icon to record audio. See "Recording an Audio File" on page 565.	Delete	Delete icon. Click on this icon to delete an attachment
New Url	New URL icon. Click on this icon to add any URL.		

9.6.2 Attaching Markers

You can attach a discrete piece of information/data to a marker, for example, a text description or file, an attachment of a trace file by a predefined order, video or audio files, URL links or any other files. You can also remove an attachment from a Marker.

9.6.3 Adding an Attachment

Perform the following steps to add an attachment to a marker:

1. Right-click on any cell in the trace and select **Set Marker.**
   The Create Marker window displays (see Figure 9.4 on page 565).
2. Click on the **Add** icon.
   The **Add File to the Marker** dialog displays.
3. Go to the file and select it to add it to the marker as an attachment.
4. Click **Open**.
   The file will appear in the Create Marker for Packet... dialog. The Marker # appears in the top panel, the icons are displayed in the second panel and you can click on the icon on the third panel to view the file you are about to attach.
5. Click **OK** to add the attachments.

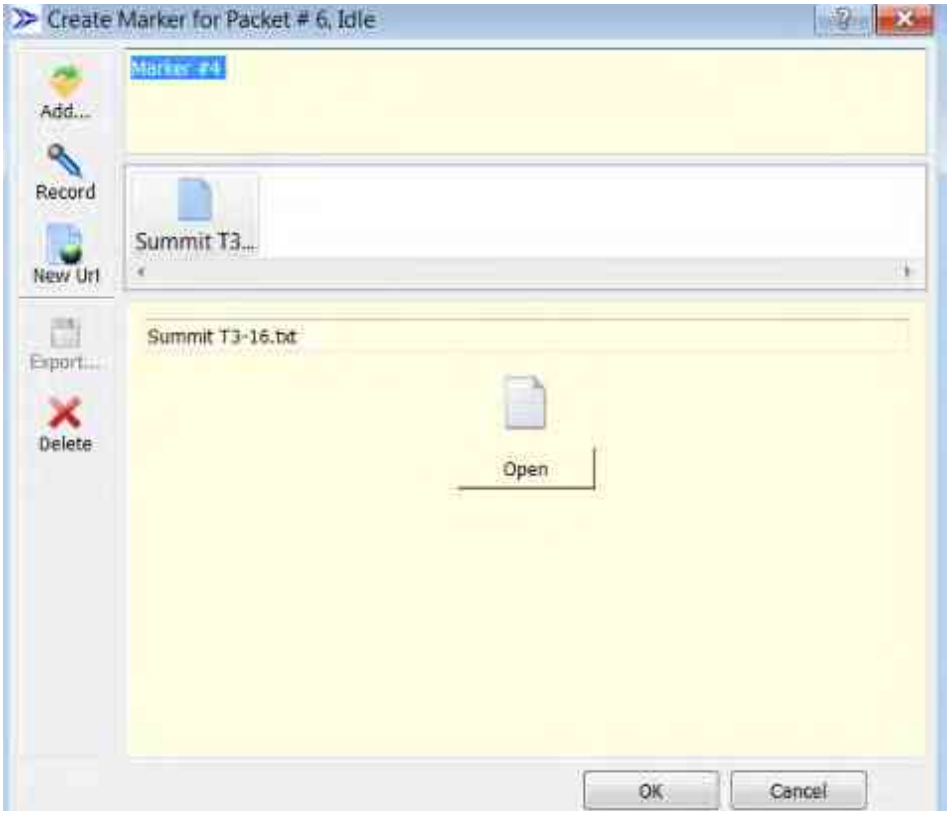


Figure 9.4: Create Marker for Packet Dialog

9.6.4 Recording an Audio File

The audio quality supports voice attachment and is not designed for high-quality audio Playback of audio content is not limited and depends on the formats supported by the installed playback engine.

Click the record icon and speak into the microphone to record an audio file.

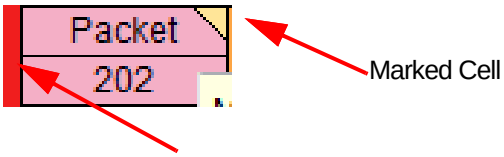
Note: This functionality is disabled if a microphone is not installed.

9.6.5 Video Files Supported

The user can attach video clips to the trace file ("add to the marker"). The playback of the Video clips is limited to the formats that are supported by the video codecs installed in the system.

9.6.6 Attachment Types and Visualization

The markers are represented graphically by a yellow triangle at the top right of the marked item and a red vertical bar at the left-most cell of a packet as shown below.



A marker may comprise any number of attachments of any types.

9.6.7 Embedded Attachments to a Marker

Embedded files are attached to the item marked and transported with the trace. You can embed the following types of files to a marker:

- Audio Files
- Video Files
- Image Files
- YouTube Files
- Web Pages
- Text Attachments
- Other Attachments

Attachments are embedded in the marker and saved in the trace file. Once attachments are placed in a marker, the marker can then be presented to a user in a story structured form. On opening the marker the window resembles the marker editing dialog.

Note: The use of Audio and Video markers is limited to the file types supported on a user's system. CATC Walk has been tested with .mp3 and .wmv files, which are supported by Windows as installed. If additional codecs are installed, they should also work, but it is the user's responsibility to choose formats that will work for whomever they intend to exchange CATC trace files (no different than email attachments in this regard). Because of this dependency on installed codecs, there are situations where bugs in the codecs supplied by Microsoft or third-party applications can prevent proper operation of the Teledyne LeCroy PCIe Protocol Analysis application. See the Teledyne LeCroy PCIe Protocol Analysis Application Read-Me file for more information if you have problems with application crashes, etc.

9.6.8 Viewing Attachments of a Marker

If you hover over the marked cell (yellow triangle at the top right of the marked item), refer to "Attachment Types and Visualization" on page 566, a window pops up displaying the contents of the marked cell (see Figure 9.5 on page 567).

While hovering over the marked cell, it can start playing the start of the audio or video file, but it will stop after a short time due to the Analyzer's host system timeout for Tooltips. You must click on it to open the audio or video attachment for further listening or viewing.

To view an attachment you can click on any of the icons in the attachment bar and or you can double-click on the icon itself to open the attachment.

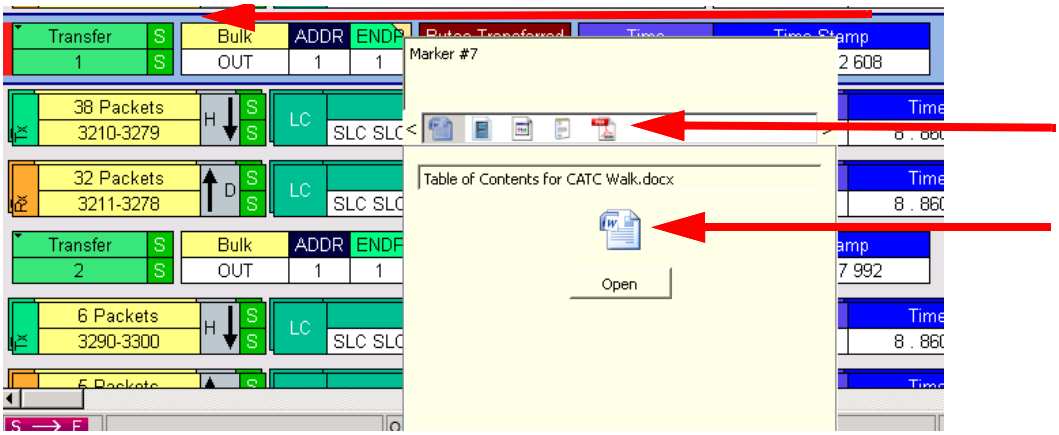


Figure 9.5: Pop-up Displaying Marker Contents

9.6.8.1 Text

The text attachment is displayed in the icon bar and in the main pop-up window. Text attachments are always shown at the top. The attachment file name is displayed in the field as shown below.

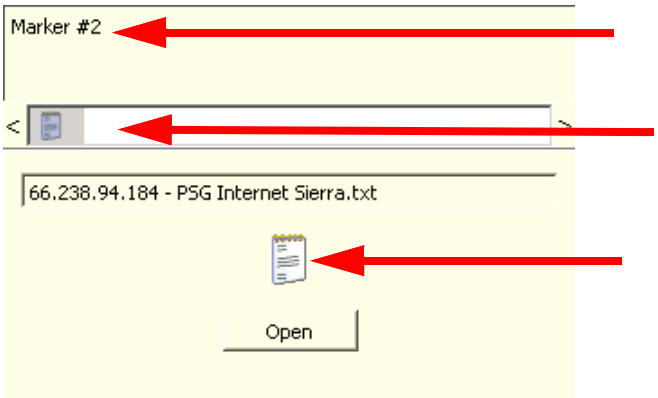


Figure 9.6: Text Attachment Pop-up Window

If there is no attachment, **No Attachments** displays in the status bar at the bottom.



Figure 9.7: No Attachments Pop-up Window

If there are attachments, the status bar is hidden. You can move the cursor to an attachment icon in the list view and a preview of the attachment starts (see Figure 9.8 on page 568).



Figure 9.8: Preview Attachments Pop-up Window

9.6.8.2 Audio

Audio snippets that are recorded and attached to certain point of interest in a trace can be played. The basic Play, Start, Stop, Pause buttons are displayed to listen to the audio file.

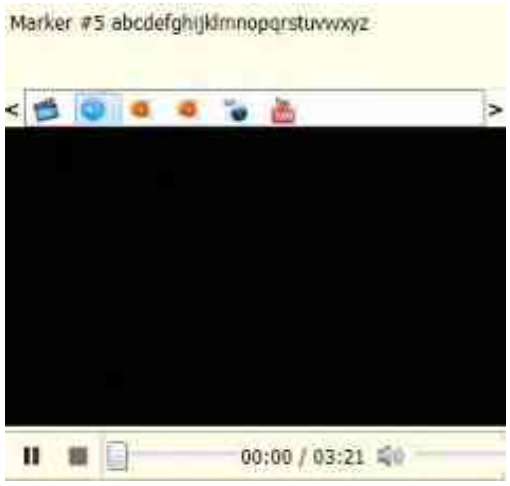


Figure 9.9: Adding a Marker that is an Audio Snippet

9.6.8.3 Video

Video clips that are recorded and attached to certain point of interest in a trace can be played. The video is embedded in the tooltip with simple playback controls.



Figure 9.10: Adding a Marker that is a Video Clip

9.6.8.4 File Attachment

You can attach any kind of file, including images, PDFs, documents, media files, etc.

9.6.8.5 URL Link

You can specify a URL that links to a web page (i.e., YouTube), a network location, or a local file-system location. See Figure 9.11.

Web Link

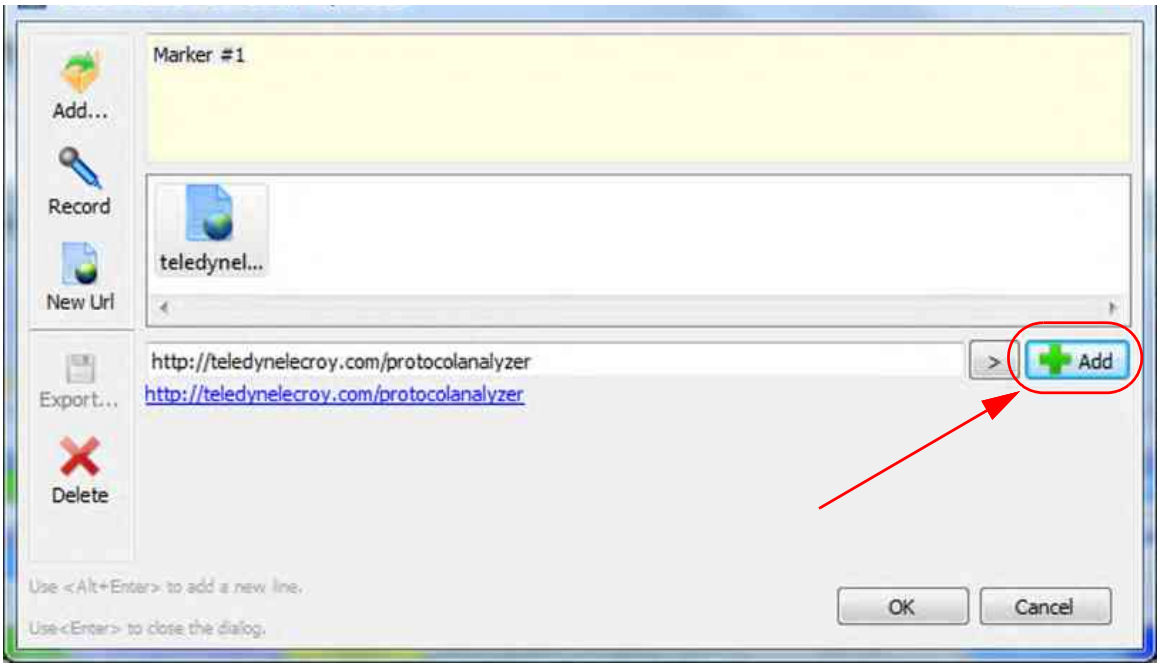


Figure 9.11: Marker: URL Link

After you add the URL marker to the Packet, when you click on the URL it will open in a separate browser window. See Figure 9.12.

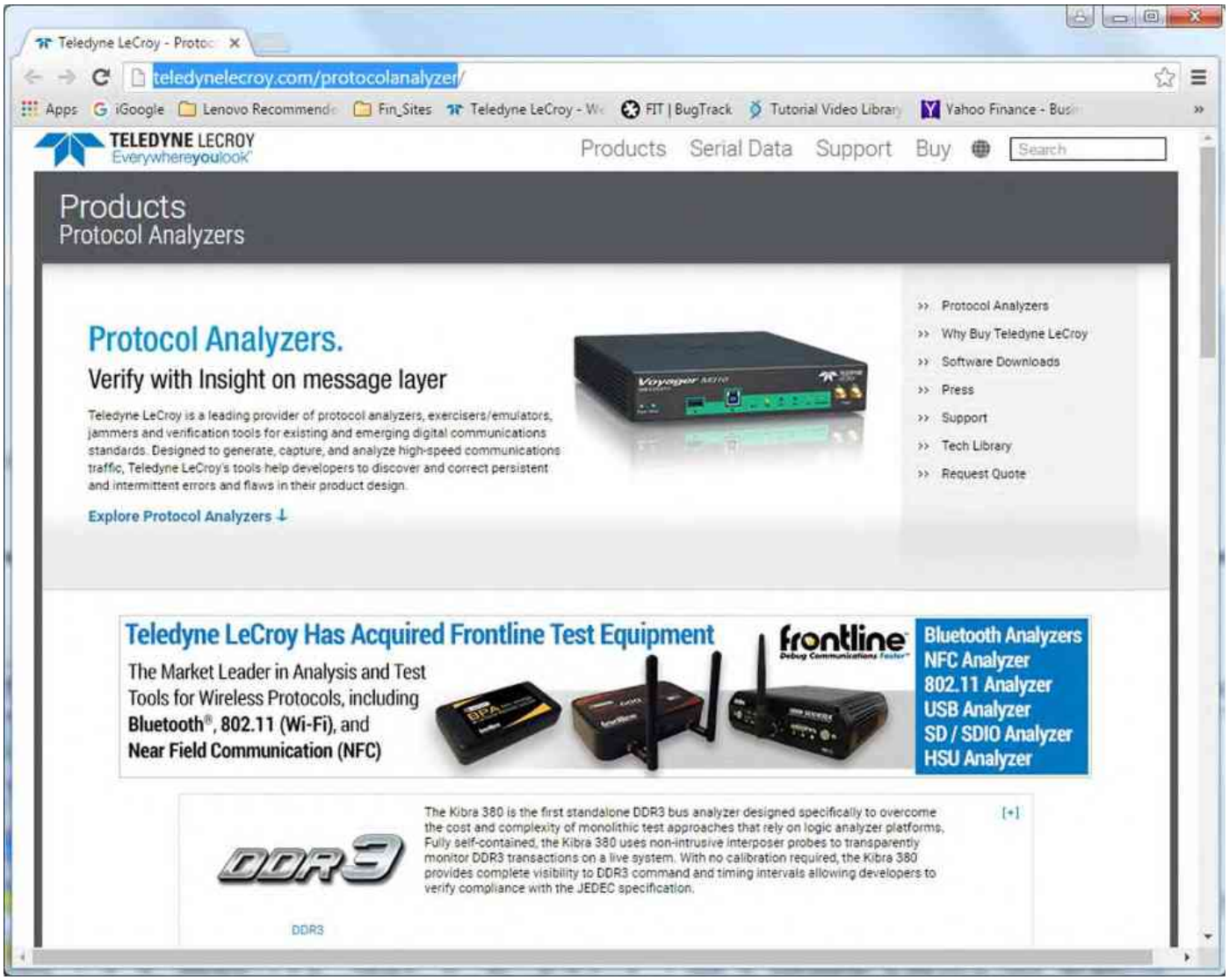


Figure 9.12: Opening a URL Marker in a Separate Window

9.6.8.6 YouTube Video

YouTube's video player is embedded for YouTube Video playback. See Figure 9.13.



Figure 9.13: Adding a Marker that is a YouTube Video

9.6.8.7 Images

The image is embedded in the trace. See Figure 9.14.



Figure 9.14: Adding a Marker that is an Image

9.6.8.8 Other Attachments

Click the **Open** button to open the attachment file with the system's default application for that file type. See Figure 9.15



Figure 9.15: Adding a Marker: System Default

9.6.9 Edit Marker

To edit a marker, right-click on the marked item and select **Edit marker** from the menu or **Ctrl + L**. The Edit Marker dialog displays. This Edit Marker window can be used to edit one marker at a time.

You can do the following in the Edit Marker dialog:

- Edit text attachment.
- Record audio attachment.
- Add URL link attachment
- Add a file attachment. Click on **File** and click the **Open** button or drag and drop the file.
- Preview audio/video/image/URL/YouTube attachment or open other files with system default application.
- Save an attachment to a file.
- Remove attachment.

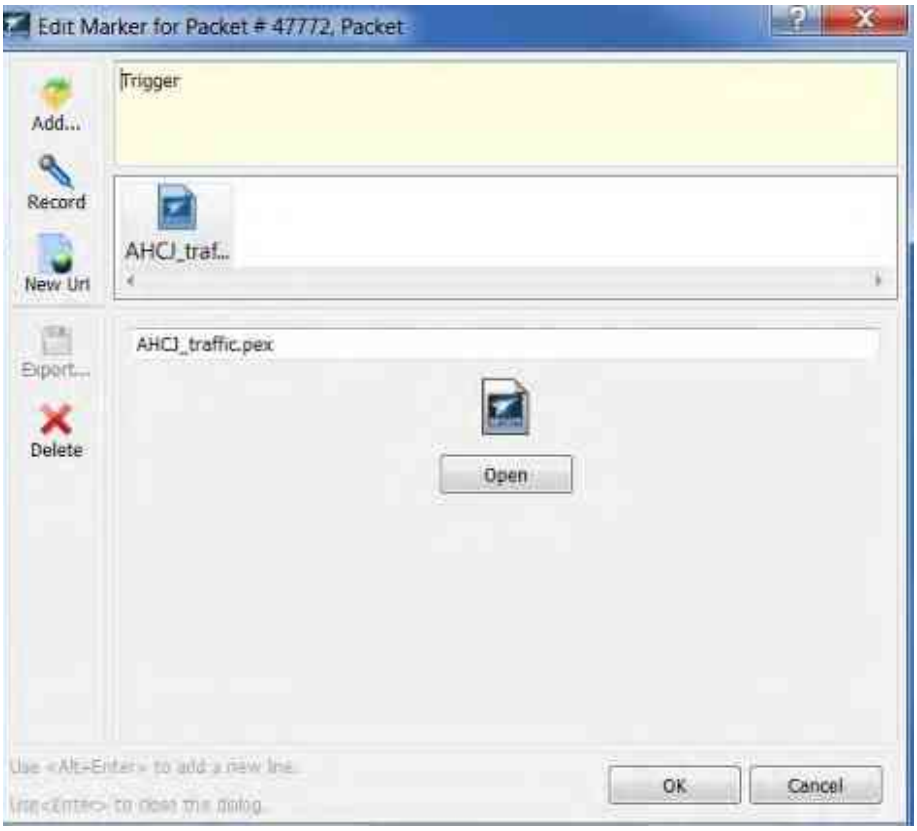


Figure 9.16: EDIT Marker for Packet Dialog

9.6.10 All Markers Dialog

Select **Search > Go to Marker > All Markers** or press **Ctrl + M** to display a list of all the markers in the file. The dialog uses a tree structure to show packets, fields and markers (see Figure 9.17 on page 574). The features of the Markers dialog are:

- All Markers are displayed.
- All attachments within the marker are displayed. Hovering over the marker displays a tool-tip displaying the size of all the attachments.
- You can collapse or expand the item marked to view the attachments.
- The Time and size of audio and video files are displayed.
- You can edit Playlists from this window.
- You can edit, delete a marker or delete all markers from this location.
- You can filter attachments within the marker.
- You can select a range of markers by clicking **Shift** and selecting a range.
- You can select multiple markers by clicking **Ctrl** and selecting individual markers.
- Double-click on a marker to go to that marker in the trace and close the dialog.
- You can sort by Timestamps (or any other displayed title) in ascending or descending order. See Figure 9.18 on page 574.

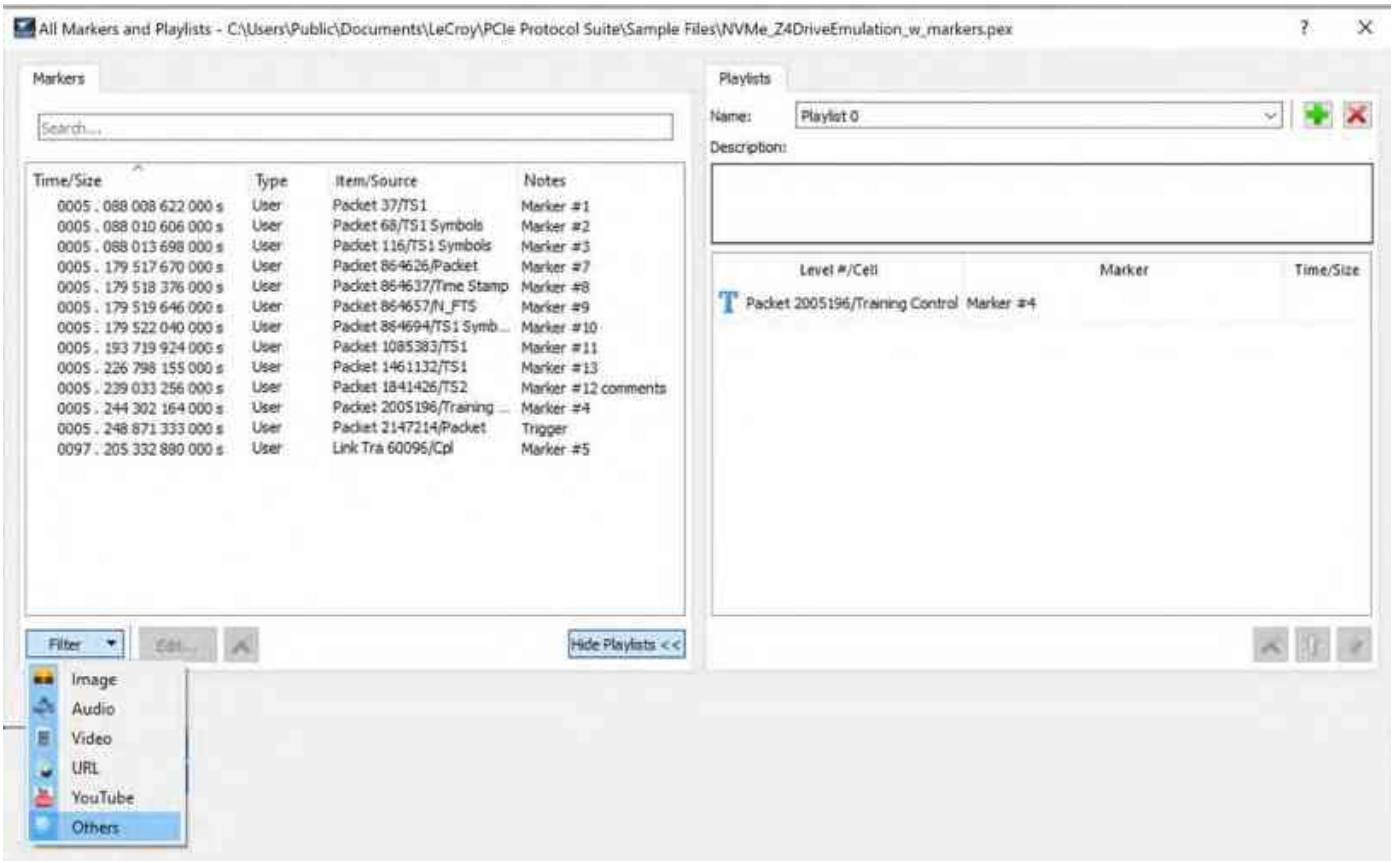


Figure 9.17: All Markers and Playlists Dialog

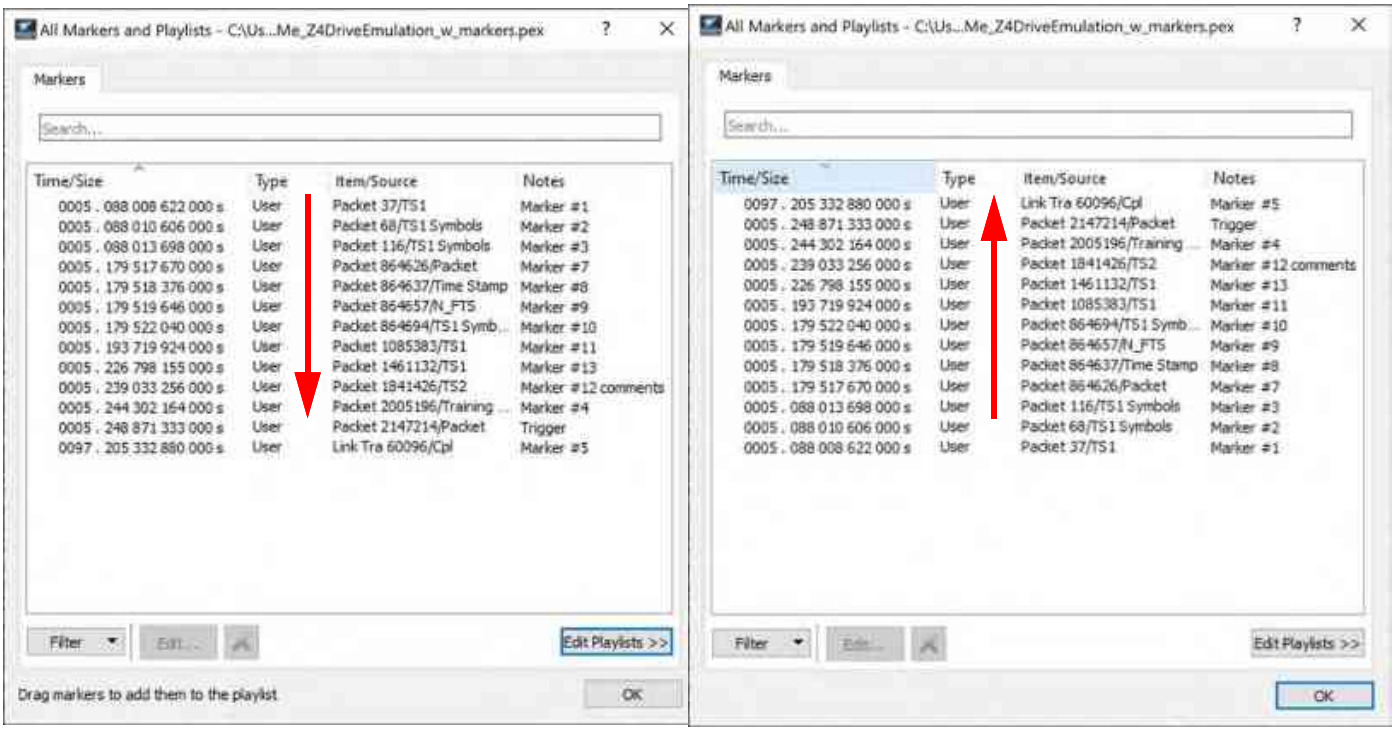


Figure 9.18: Markers Sorted by Timestamps in Ascending and Descending Order

You can filter to show or hide text, image, audio, video, URL, YouTube videos and other files.

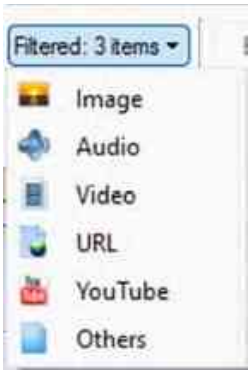


Figure 9.19: Filter Dialog

Clicking delete on markers to delete markers with attachments displays the Delete Marker(s) dialog. Checking the "Don't ask again" checkbox will not display this confirmation dialog again.



Figure 9.20: Confirmation Dialog

9.6.11 CATC Walk Playlist

This feature allows users to configure sequences of attachments into playlists. Any arbitrary order of attachments are allowed, and there are no limits on the number of playlists supported. This feature can be used for collaborating among developers as well for training, support and marketing purposes.

To access a playlist click on the **View** menu in the top toolbar of application, select **CATC Walk** and then select **Manage Playlists** as shown below.

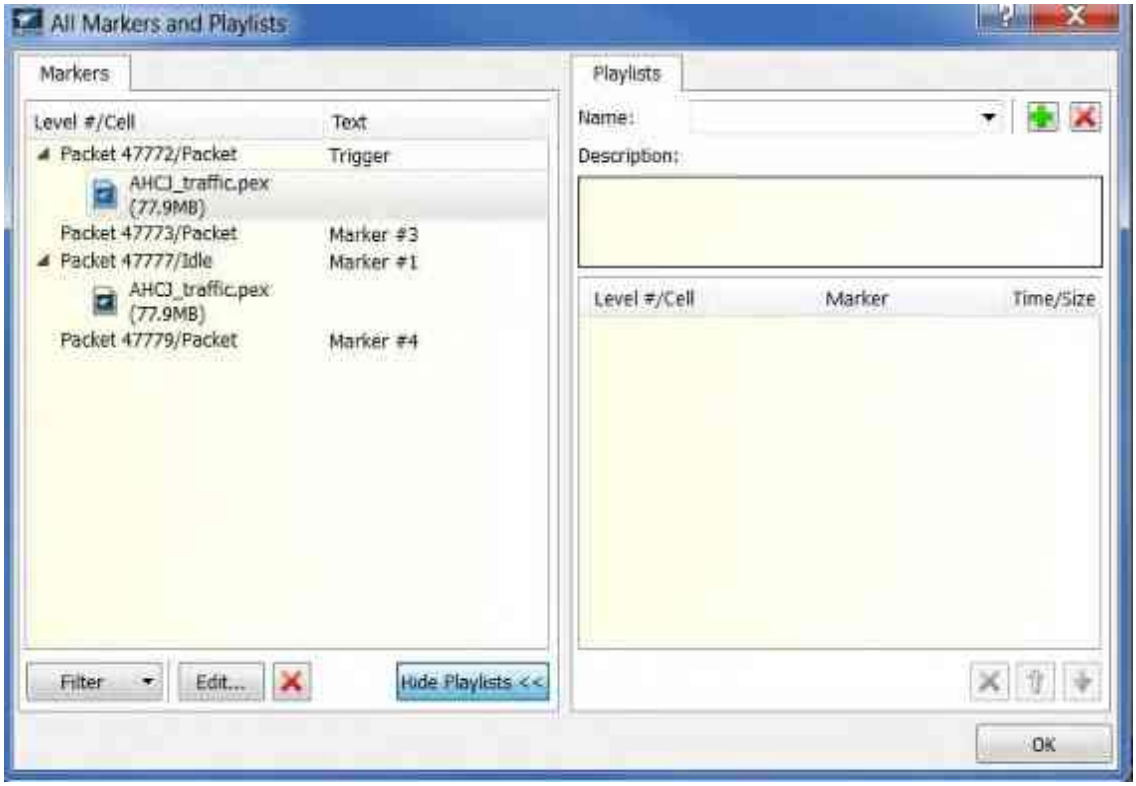


Figure 9.21: Edit CATC Walk Playlists Dialog

9.6.12 Playlist Functionality

You can do the following to manage playlists:

- Remove or edit current playlists
- Edit the playlist name
- Edit the playlist description
- List the sequence of attachments in current playlist
- List of all available attachments and drag/drop to a playlist.

As shown in the previous figure the Playlist window lists the markers with their attachments on the left and the playlist on the right.

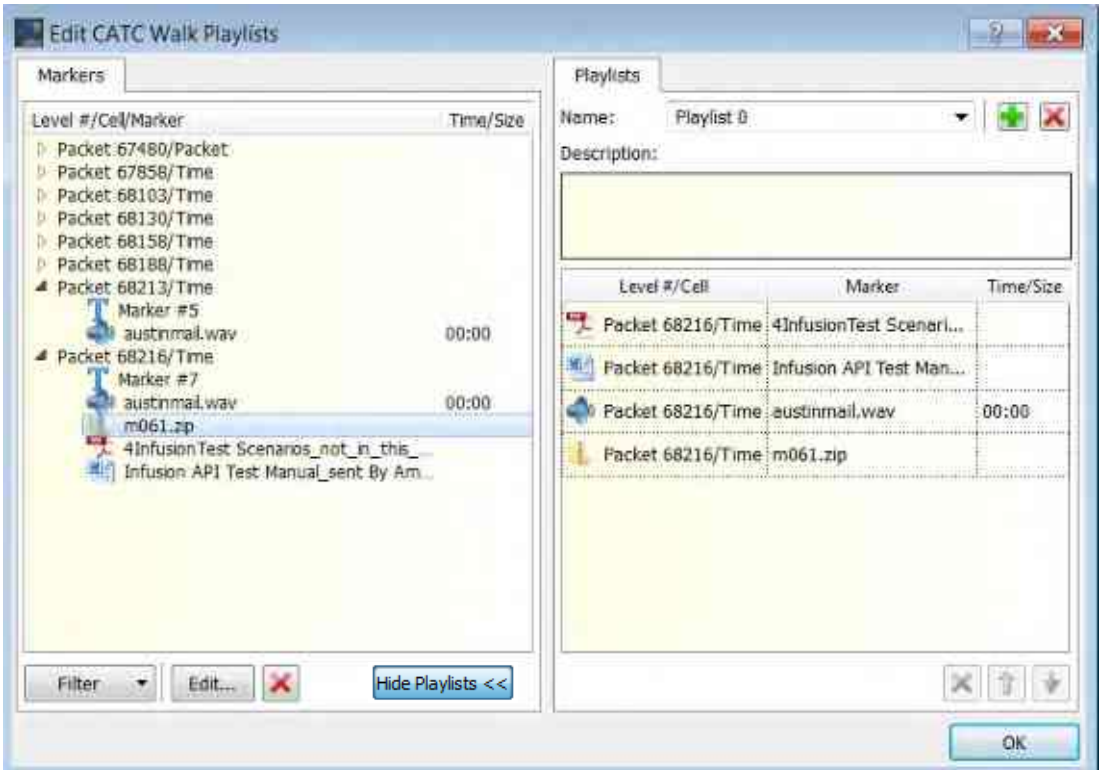


Figure 9.22: Edit CATC Walk Playlists Dialog

You can drag and drop and item or attachment from the **Marker** panel into the **Playlist** panel and build a story. Give a description of the playlist in the **Description** field and you can give a name to the playlist in the **Name** field.

You can add a new playlist by clicking on the green plus sign (+) on the right top corner of the Playlist panel, or delete a playlist by clicking the red (x) button.

If you have more than one playlist saved click on the Name drop-down arrow to select it. The drop-down menu lists all the available playlists

9.6.13 Playback Window

To playback a playlist, click on the **View** menu in the top toolbar of application, select **CATC Walk** and then select **Play > Playlist 1** as shown below.

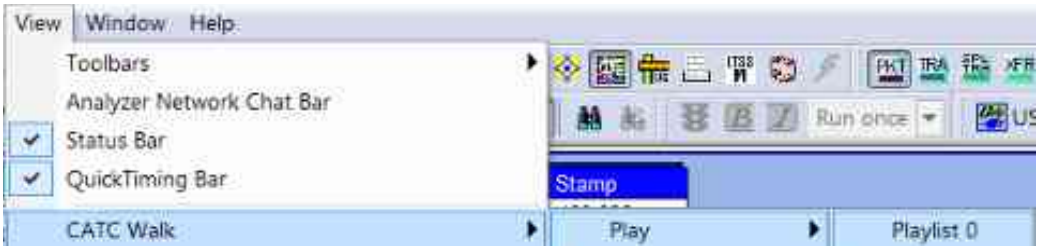


Figure 9.23: View Dialog

The attachment item starts to play in the Playback window (see Figure 9.24).



Figure 9.24: Playback Window

The playback window is re-sizable. The close button at the top right corner and the size grip for resizing at the bottom right corner will hide automatically when moving the cursor out of the window.

Users can provide commentary to a captured trace, converting it into a script or a story and can transfer this meta-information to others.

9.6.13.1 Playlist Playback Controls

The playlist playback control buttons are (see the screen capture on the next page):

- Play/Pause
- Stop
- Jump to Next attachment
- Jump to Previous attachment
- Seek slider for seeking to positions in media streams
- Volume slider
- Playback speed slider (for text attachments)

As a playlist is played back, the playback window is displayed in close proximity to the marked area, just like a regular tooltip window.

As the playback progresses, the view jumps to the element corresponding to the current attachment being played and the marked element is highlighted. During playback the user is prevented from interacting with the trace. To reinforce this restriction, the trace view is grayed-out visually, and only the packet with the item corresponding to the current attachment is colorized.



Playlist Playback View

9.7 Go to NVMe Transactions and Commands

The Go to NVMe Transaction and NVMe Command tabs in the Search menu provides a quick way to search for both NVMe Transactions and NVMe Commands.

9.7.1 NVMe Transaction

The NVMe search capability can also search for the following types of NVMe Transactions:

- Controller Registers
- Other NVMe Entities
- Doorbell Registers
- Admin Submission Command Set
- NVM Submission Command Set
- Completion Queue Entry
- NVMe Errors

As shown in Figure 9.25 on page 580

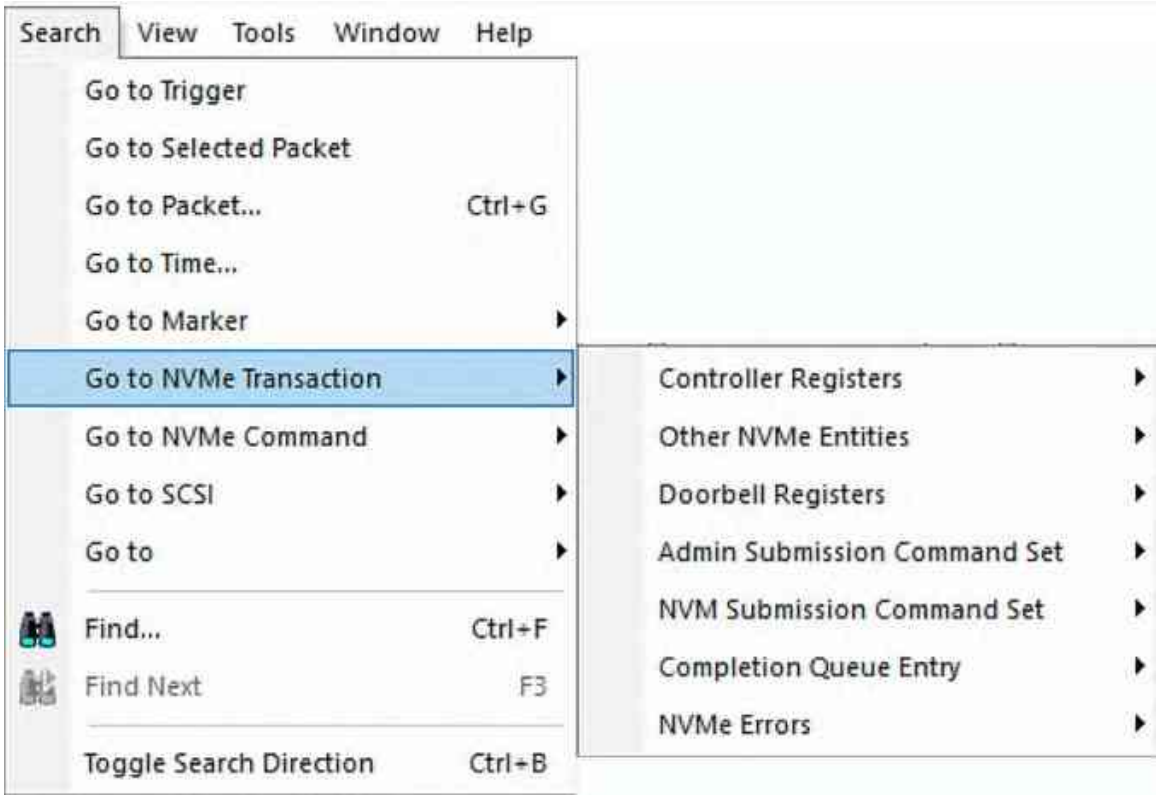


Figure 9.25: Search: NVMe Transaction Types

9.7.2 NVMe Command

The NVMe search capability can also search for the following types of NVMe Commands:

- Admin Command Set
- NVM Command Set
- Status
- Errors
- TCG Types
- TCG Method
- TCG Invoker
- TCG Com ID
- TCG Ext Com ID

As shown below in Figure 9.26 on page 581.

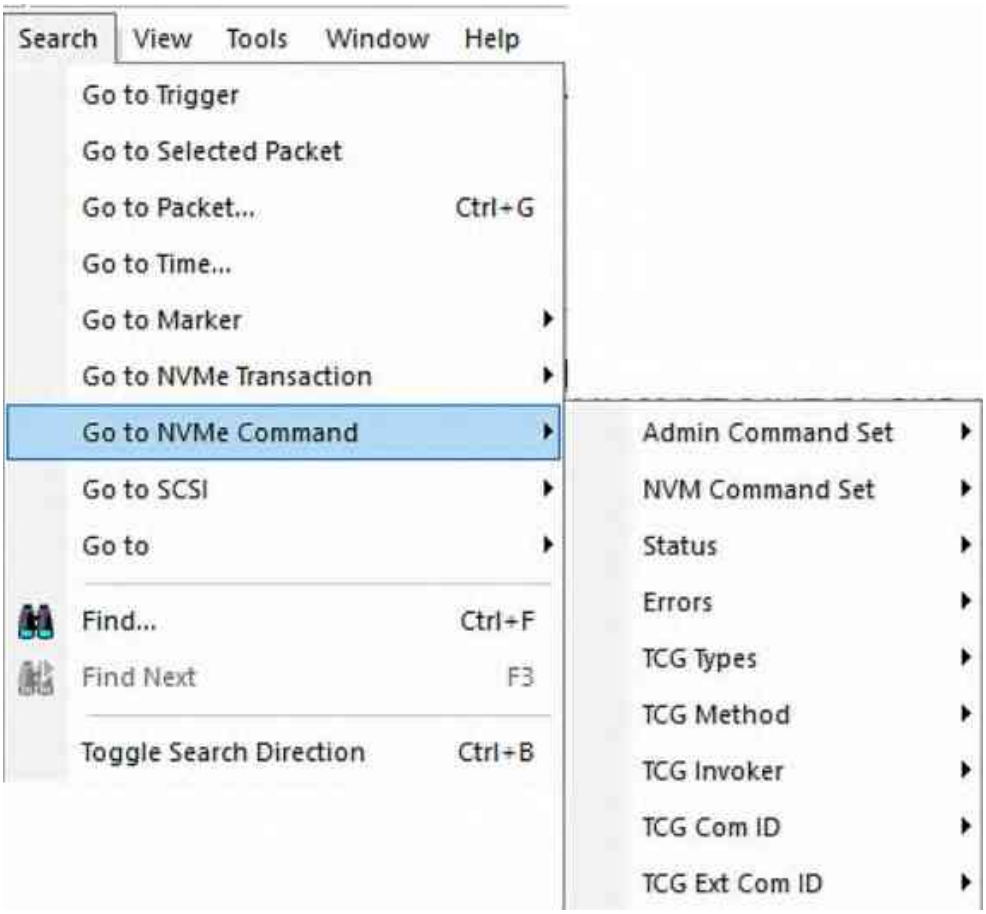


Figure 9.26: Search: NVMe Command Types

9.8 Go To SCSI Menu

The **Go To SCSI** menu in the Search menu provides a quick way to search for a packet based on a SCSI commands and sub-commands. You can search for the following types of events:

- SCSI Operation
- Command Status
- Task Management
- Task Management Response
- Error
- SCSI Logical Unit Number

9.9 Go To Menu

The **Go To menu** in the Search menu provides a quick way to search for a packet based on a simple condition. You can search for the following types of events:

- TLP Type
- DLLP Type
- Ordered Set
- Link Event
- OBFF Message
- Traffic Class
- DLLP Virtual Channel
- TLP Virtual Channel
- Direction
- Speed
- Link Width
- Requester ID
- Completer ID
- Data Lengths
- Errors

9.9.1 Example: Search -> Go to -> Link Event -> Link Up/Link Down

Use the Search -> Go to function to find Link Event: Link Up or Link Down.

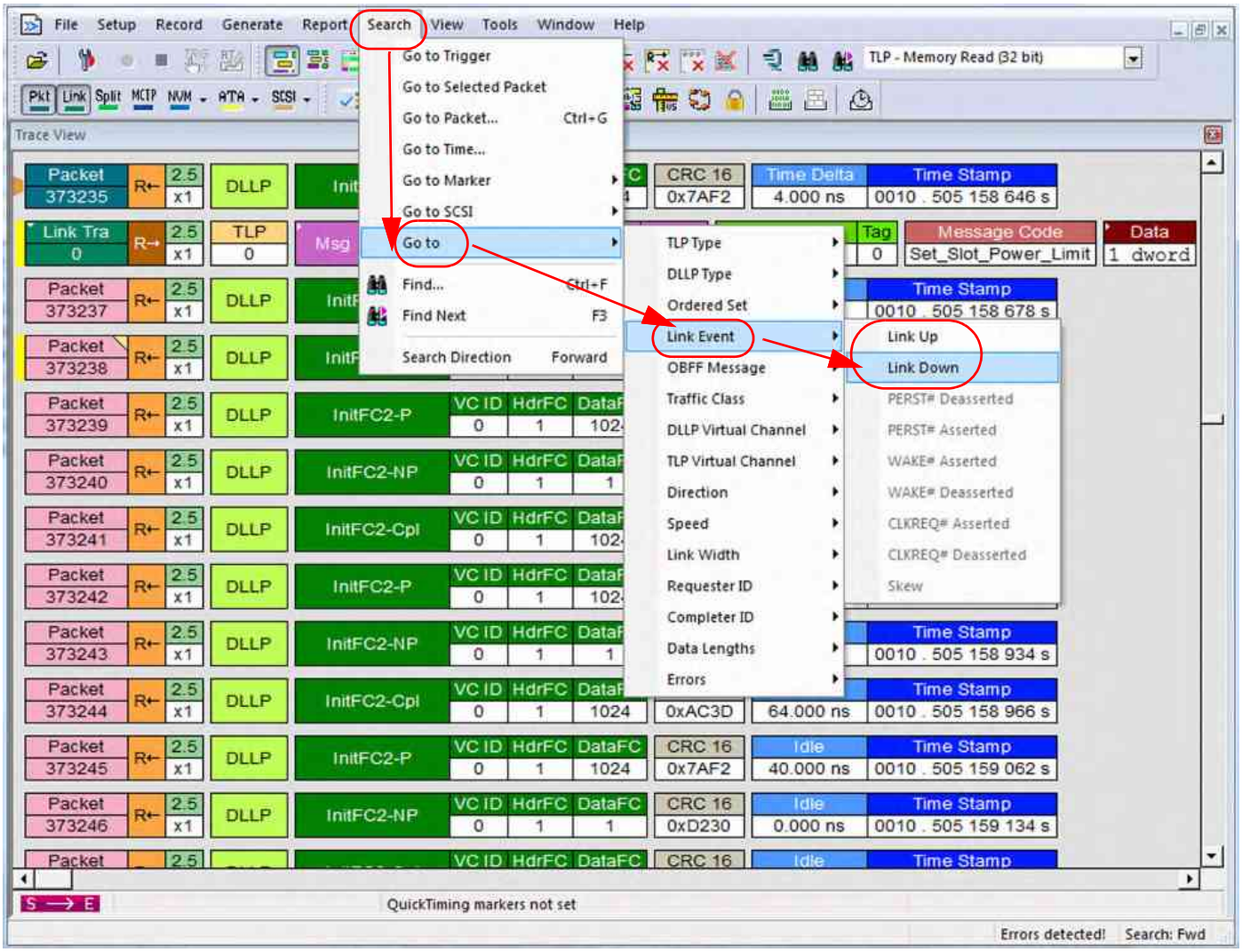


Figure 9.27: Search -> Go to -> Link Event -> Link Up / Link Down: Set Up Search

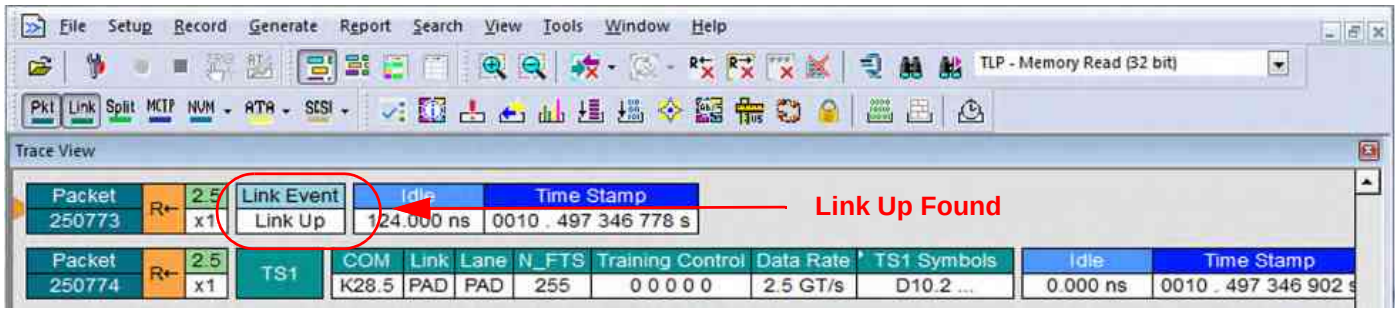


Figure 9.28: Search → Go to → Link Event → Link Up: Found

9.9.2 Example: Search → Go To → Direction

The Search → Go To → Direction option will show you Upstream, Downstream and Sideband.

See Figure 9.29.

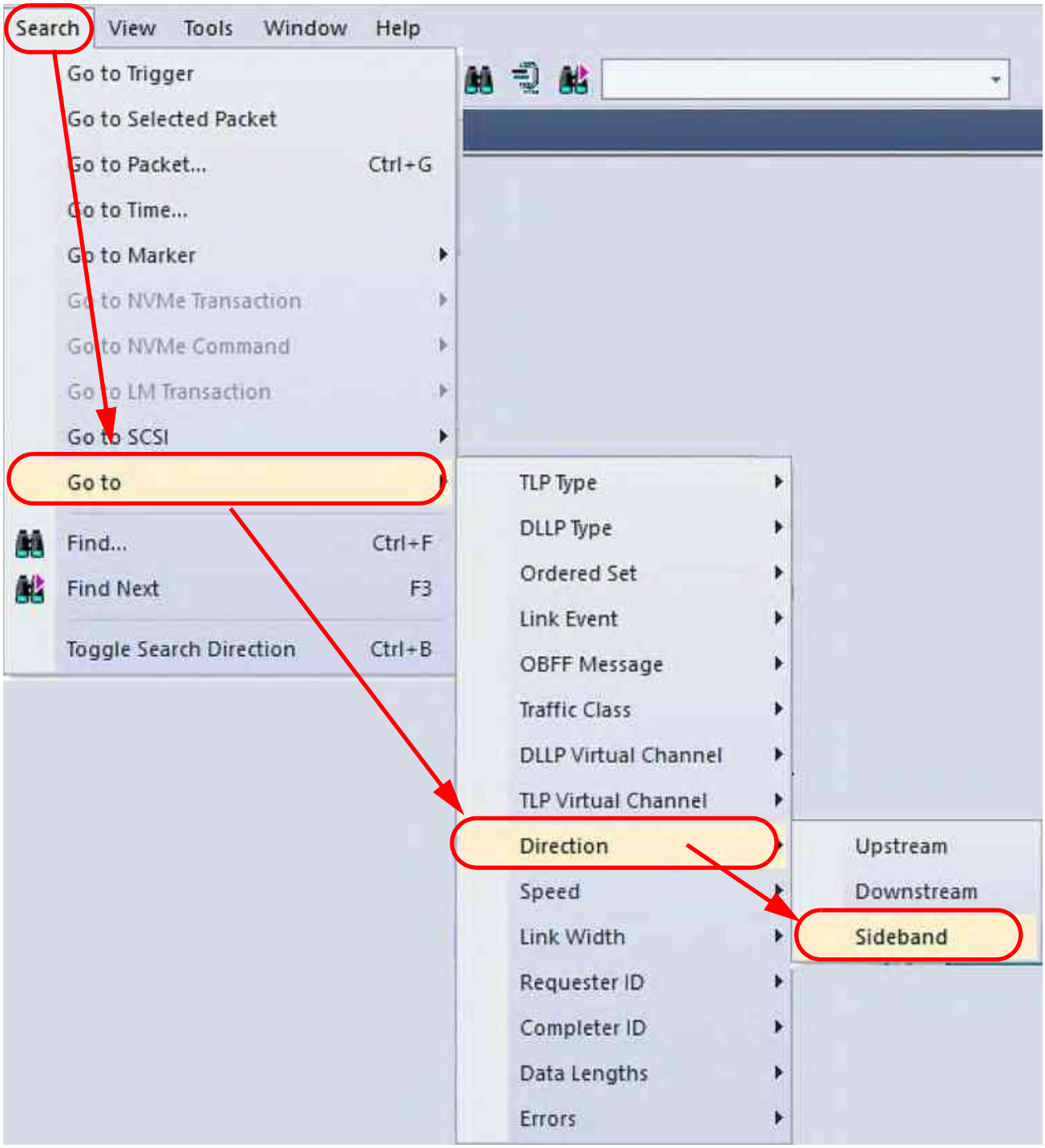


Figure 9.29: Search -> Go To -> Direction -> Sideband

9.9.3 Example: Go To CXL

Another example of the Search capability is Search -> Go to -> CXL Type. See Figure 9.30

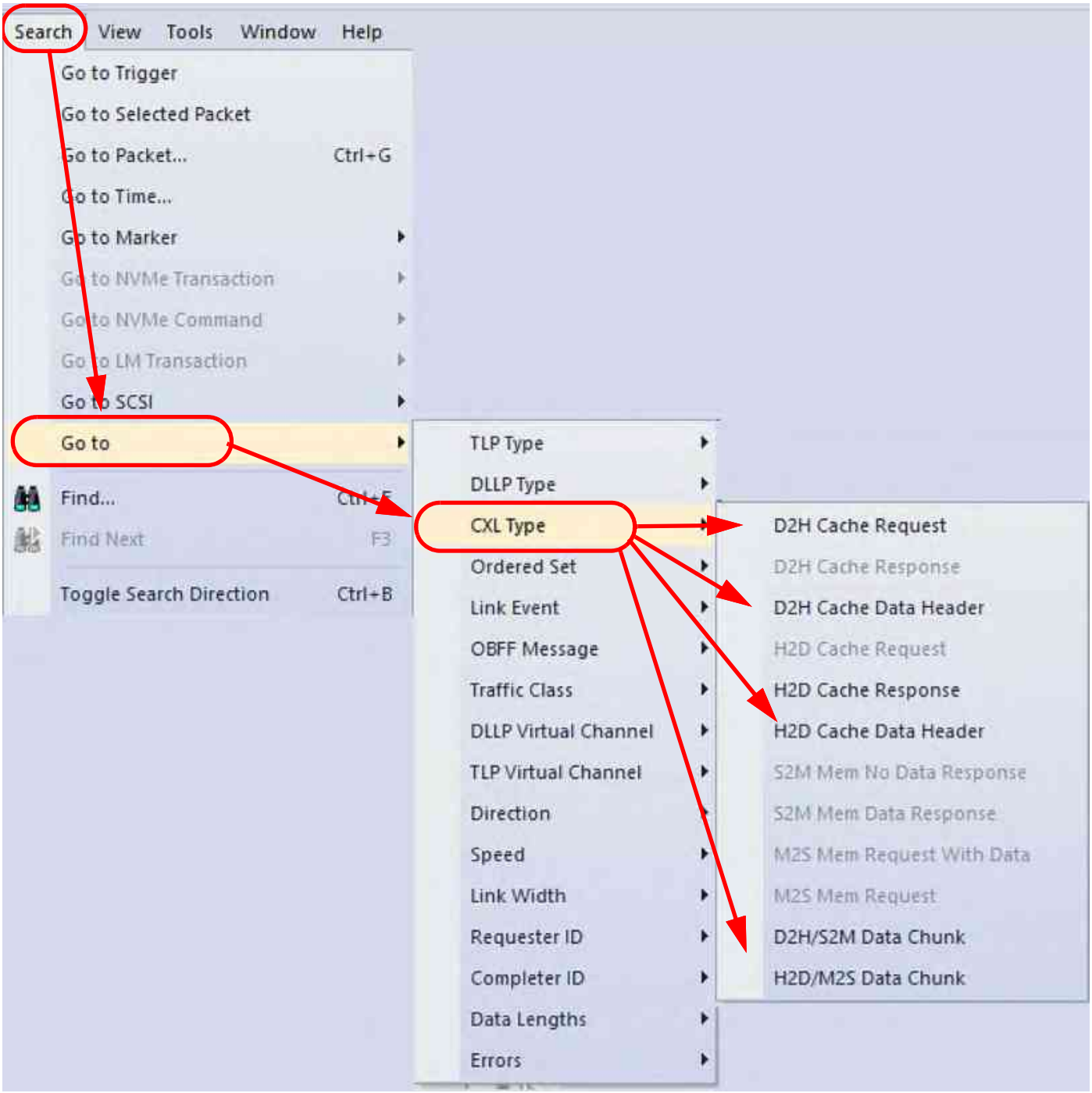


Figure 9.30: Search -> Go to -> CXL Type

9.10 Find

Find allows you to conduct complex searches in a CATC Trace. This option is located under the Search menu. You can search by protocol level (Packets, Link Transactions, Split Transactions, NVMe, PQI, AHCI, ATA, etc.). The full list is shown in Figure 9.31.

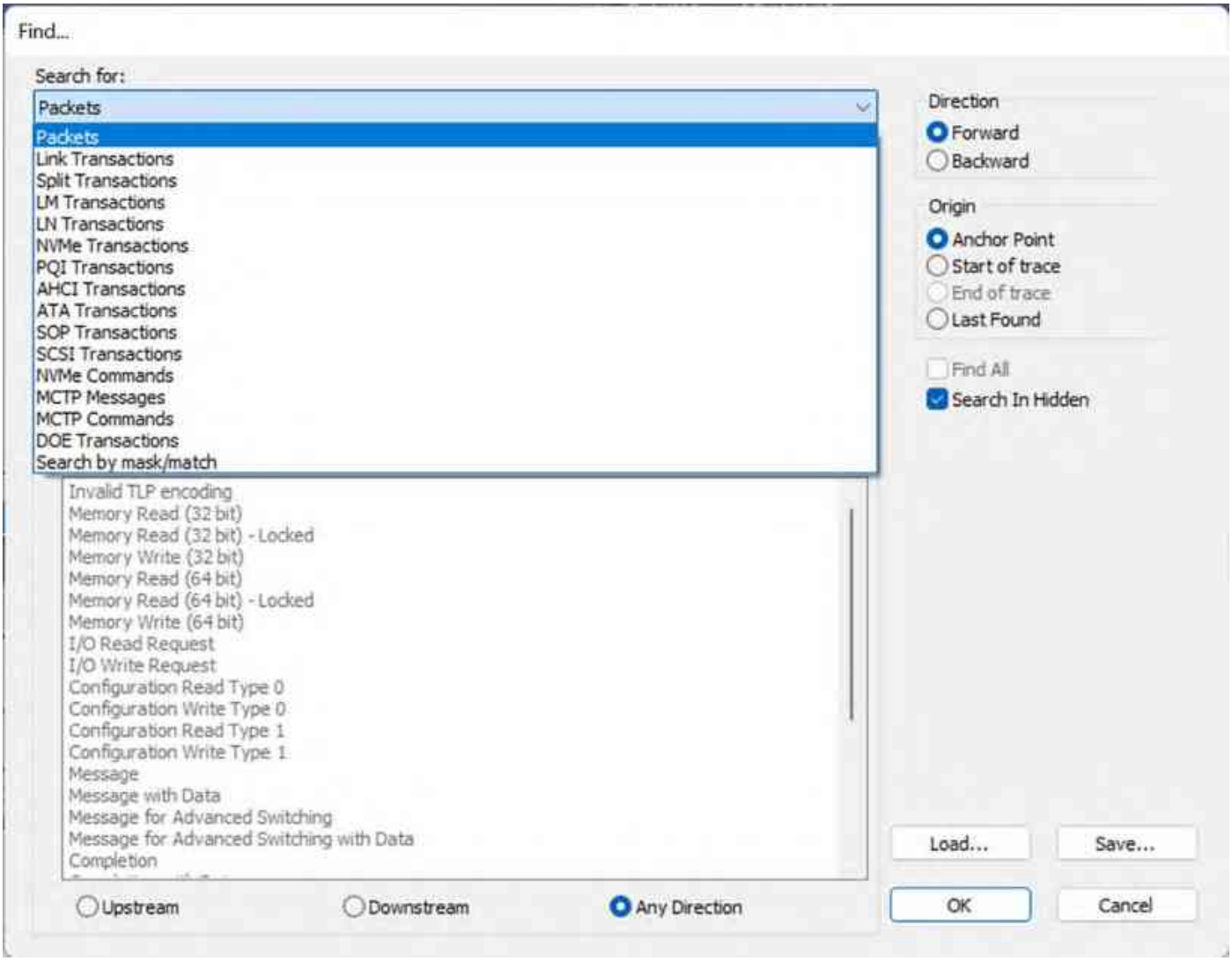


Figure 9.31: Find: Search for: Field

You can search for packets by Event Group: TLP Type, TLP Header, TLP Prefix, TLP Requester ID, TLP Completer ID, TLP Data Pattern, TLP Data Lengths, TLP Tag, TLP Sequence Number, PMUX Channel ID, DLLP Type, DLLP Header, DLLP Virtual Channel, ACK/NAK Seq Number, Ordered Sets, Link Event, OBFF Code, Direction, Errors, TS1 Data, TS2 Data.

You can search for link transactions by Event Group: TLP Type, Traffic Class, Virtual Channel, Direction, Requester ID, Completer ID, Status, Tag.

You can search for split transactions by Event Group: TLP Type, Traffic Class, Virtual Channel, Direction, Requester ID, Completer ID, Status, Tag, Address.

You can search for Lane Margining transactions by Event Group: Margin Commands, Margin Type, Receiver Number or Errors. Each of these Event Groups has a numbers of different event types. See Figure 9.51 on page 603.

You can search for NVMe transactions by the following Event Groups: Controller Registers, Queue IDs, Command IDs, Doorbell Registers, Admin Submission Command Set, NVMe Submission Command Set, Completion Queue Entry, and PRP.

You can search for PQI transactions by Event Group: TLP Type, Traffic Class, Virtual Channel, Direction, Requester ID, Completer ID, Status, Tag, Address.

You can search for AHCI transactions by Event Group: AHCI Register ID, AHCI Port Number, AHCI Slot Number, AHCI Port Multiplier Port, AHCI Raw Address AHCI Direction and, AHCI Errors.

You can search for ATA transactions by Event Group: ATA Register Type, ATA Port Number, ATA Slot Number, ATA Raw Address, ATA port Multiplier Port, ATA Interruption Reason, ATA Error Type ATA Input/Output, ATA Payload Portion, ATA CFIS Fields, ATA RFIS Device to Host Fields, ATA DSFIS Fields, ATA PSFIS Fields, ATA SDBFIS Fields.

You can search for SOP transactions by Event Group: SOP Information Unit ID, SOP Errors.

You can search for SCSI transactions by Event Group: SCSI Operation, Command Status, Task Management, Task Management Response, Errors, SCSI Logical Unit Numbers.

You can search for NVMe Commands by Event Group: Admin Command Set, NVM Command Set, Submission QID, Completion QID, Status, Errors, NVM Command, NVM Payload Portion, TCG Types, TCG Method, TCG Invoker, TCG Com ID or TCG Ext Com ID. See “Example: Search for NVMe Command” on page 605.

The options Union, Intersection, and Exclusion allow you to create complex searches such as “Find x OR y” or “Exclude all x or y.”

To find an item:

1. Open a CATC Trace.
2. Open Find by selecting **Search > Find** from the menu or clicking  (see the following screen capture).

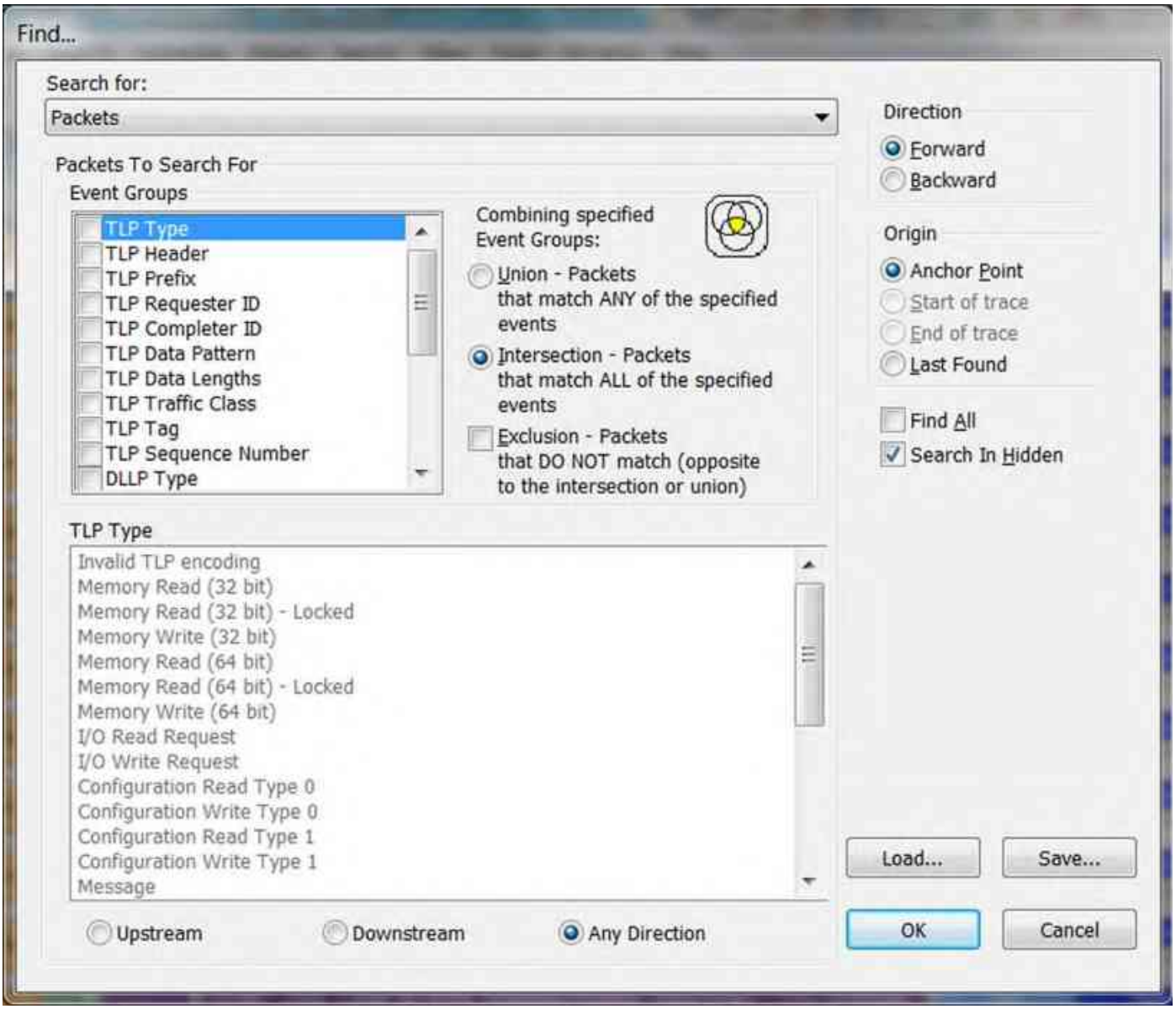
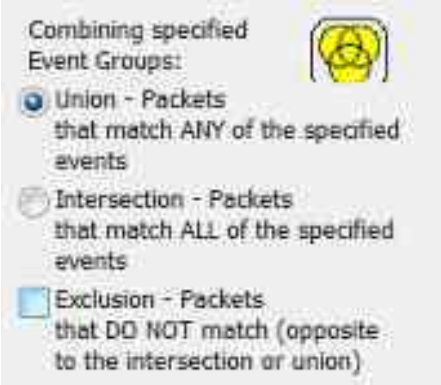


Figure 9.32: Find Dialog

3. From the Search For menu, select a display level such as **Packets**. To search multiple levels, finish steps 3 to 9, and then repeat 3 to 9 for each additional display level.
4. From the Event Groups menu, select an **Event Group**. The menu in the far right of the dialog is context sensitive and changes to reflect the options for that group.
5. In the menu in the far right, select one or more items.
6. Repeat Step 5 for each Event Group of interest for the selected display level.

7. Under Scope, select Current Segment or All Segments to reduce the scope of the search. This applies to old segmented traces, for newer traces leave this option in Current Segment.
8. Under Direction, select **Forward** or **Backward** to select a search direction.
9. Under Origin, select a starting point for the search.
10. Under **Combining Specified Event Groups**, select an option.



The options Union, Intersection, and Exclusion let you set conditions on your searches:

- **Union**: To search for **any** of the selected criteria.
  Example: “Find packets with ANY of the following characteristics …”
- **Intersection**: To search for **all** of the selected criteria.
  Example: “Find packets with ALL of the following characteristics …”
- **Exclude**: To **exclude** items from a search. This option works in conjunction with Union and Intersection. You select Union and Exclude to exclude any of the specified traffic. You select Intersection and Exclude to exclude all of the specified traffic.
  Example: “Exclude packets with ANY of the following …” or
  “Exclude packets with ALL of the following …”

11. Repeat Steps 3 through 9 for additional display levels.
12. **Find All** displays all matching packets or transactions in a separate view.
    NOTE: When **Find All** is checked, the reports display the information for the main trace, however, they do not include Search results.
13. **Search in Hidden** includes hidden packets or transactions in the search.
14. Click **OK**.

9.10.1 Event Groups for Packets

The Event Groups for Packets are:

- TLP Type
- TLP Header
- TLP Prefix
- TLP Requester ID
- TLP Completer ID
- TLP Data Pattern

- ❑ TLP Data Lengths
- ❑ TLP Traffic Class
- ❑ TLP Tag
- ❑ TLP Sequence Number
- ❑ PMUX Channel ID
- ❑ DLLP Type
- ❑ DLLP Header
- ❑ DLLP Virtual Channel
- ❑ ACK/NAK Seq Number
- ❑ Ordered Sets
- ❑ Link Event
- ❑ OBFF Code
- ❑ Direction
- ❑ Errors
- ❑ TS1 Data (see “Example: TS1 and TS2 Event Groups” on page 591)
- ❑ TS2 Data (see “Example: TS1 and TS2 Event Groups” on page 591)
- ❑ Message Code

9.10.1.1 Example: TS1 and TS2 Event Groups

Selecting TS1 Data or TS2 Data options allows further definition of the exact field contents to match via the three dialogs show below. The search algorithm will find the specified TS ordered set on any lane.

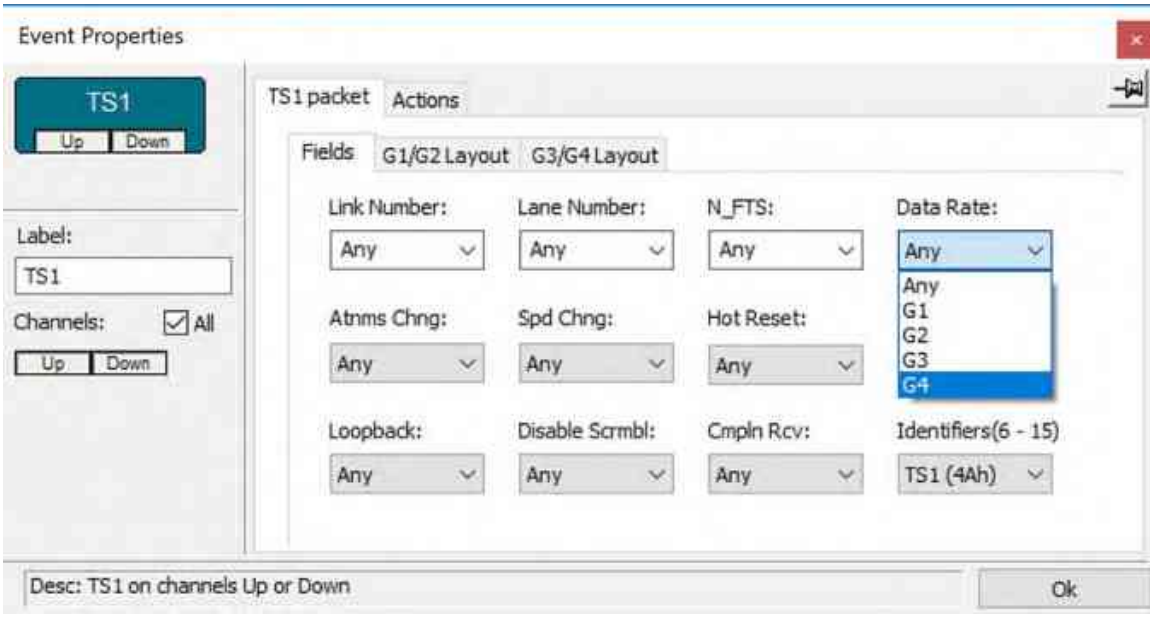


Figure 9.33: TS Data Fields Tab

Select parameters from the drop-down lists to use.

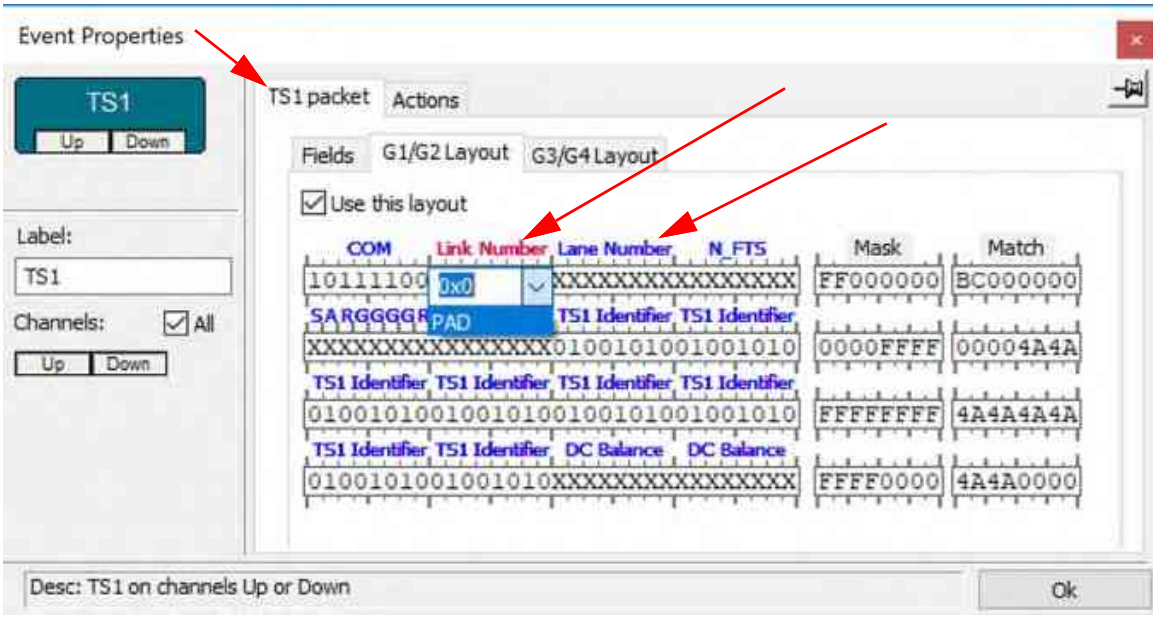


Figure 9.34: TS G1/G2 Layout Tab

Select parameters from the links to use and enter the mask and match values.

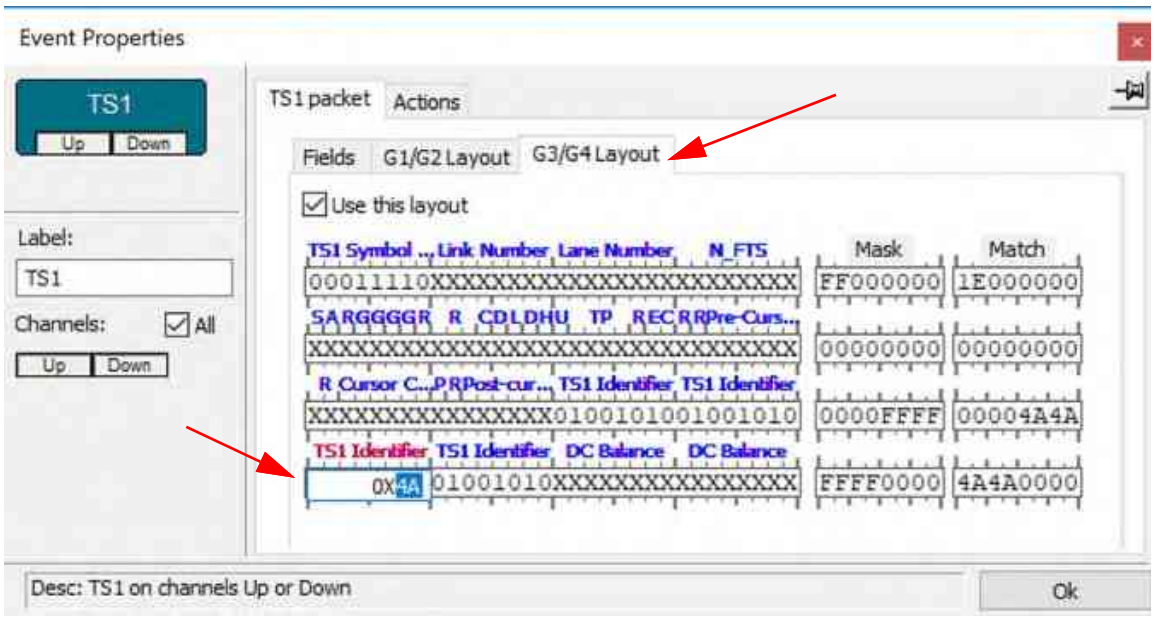


Figure 9.35: TS G3/G4 Layout Tab

Select parameters from the links to use and enter the mask and match values.

Example: TS1 Packet with G3 Speed and G3 Data Rate

In order to select TS1/TS2 packets for search/triggering on G3/G4 speed you need to set data for search/triggering to G3 (see Figure 9.36).

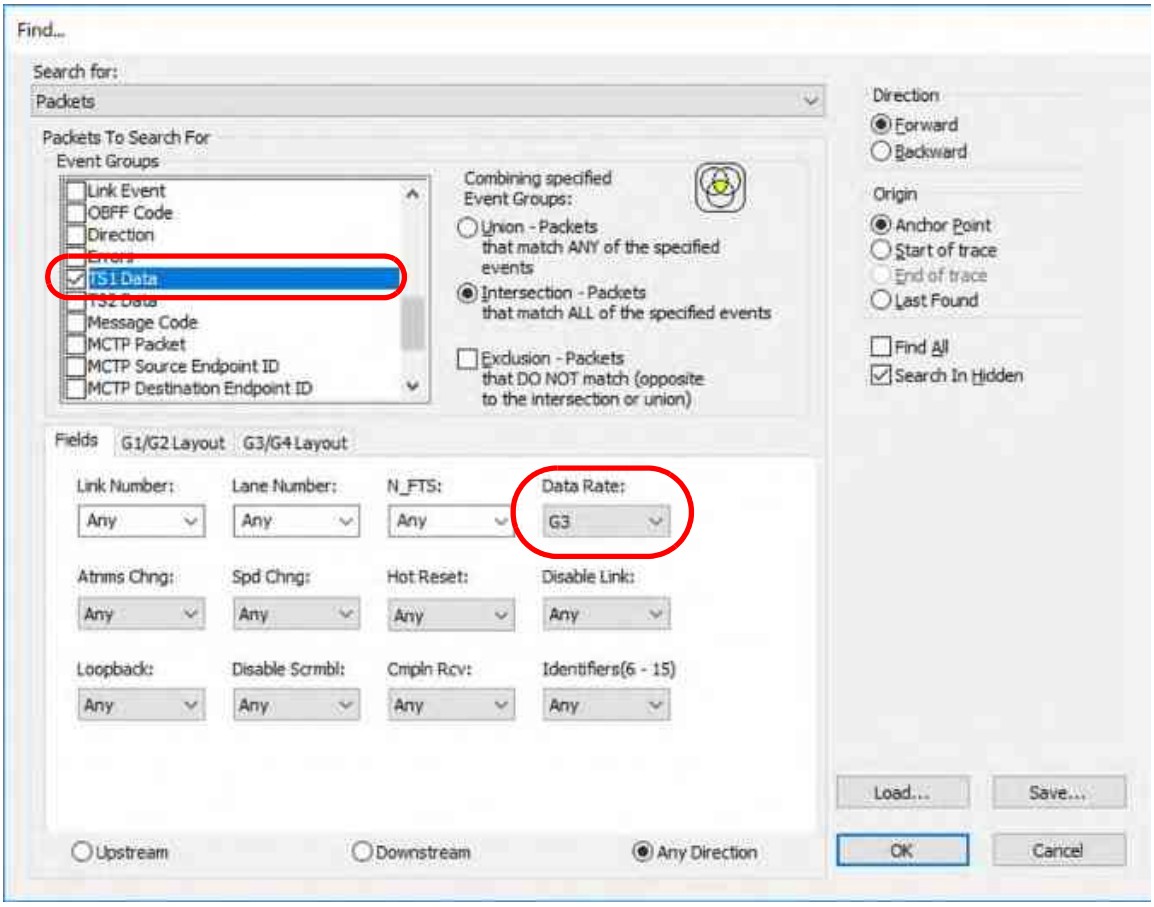


Figure 9.36: Set Search for: Packets -> TS1 Data and Data Rate G3

Set the Recording Options -> TS1 -> Event Properties with the same options. See Figure 9.37 on page 594.

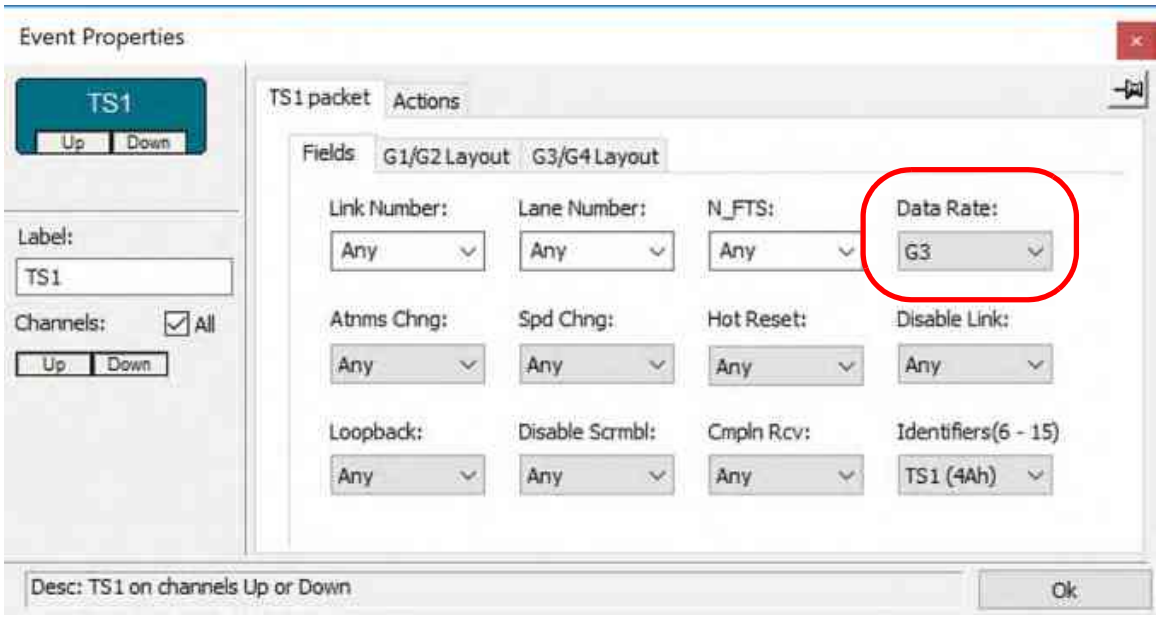


Figure 9.37: Recording Options: Event Properties -> TS1 Data Rate = G3

Uncheck the checkbox “Use this layout” in G1/G2 Layout tab (see Figure 9.38 on page 594).

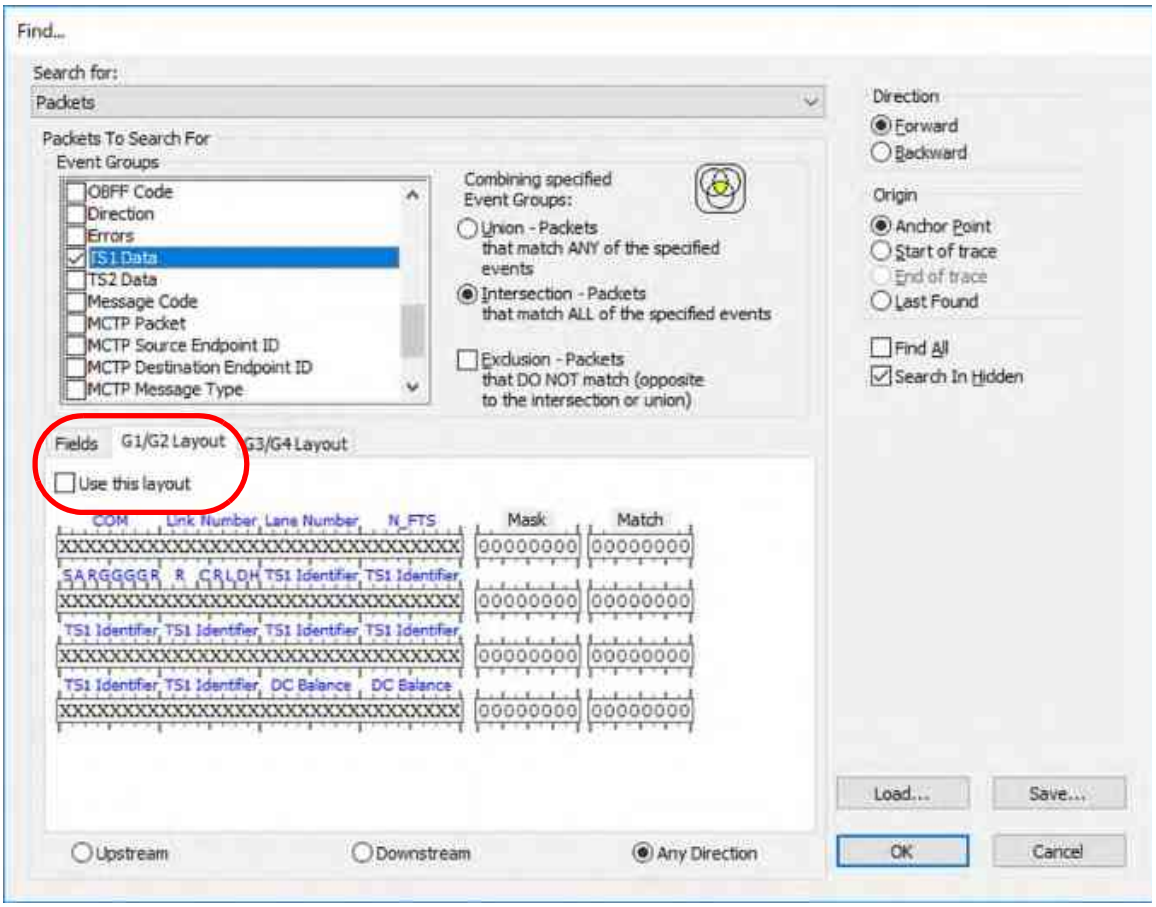


Figure 9.38: Find: Search for Packets -> TS1 G1/G2 Layout

Set the Recording Options -> TS1 packet -> Event Properties with the same options (see Figure 9.39).

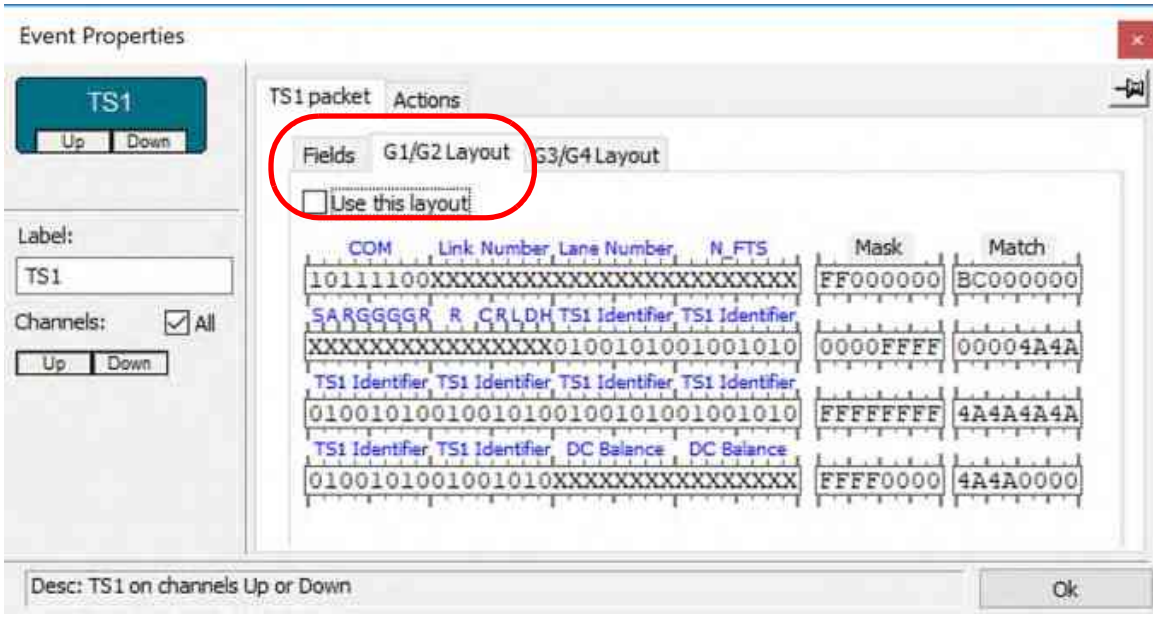


Figure 9.39: Set Recording Options: TS1 Event Properties

Keep the checkbox "Use this layout" in G3/G4 Layout tab checked. See Figure 9.40.

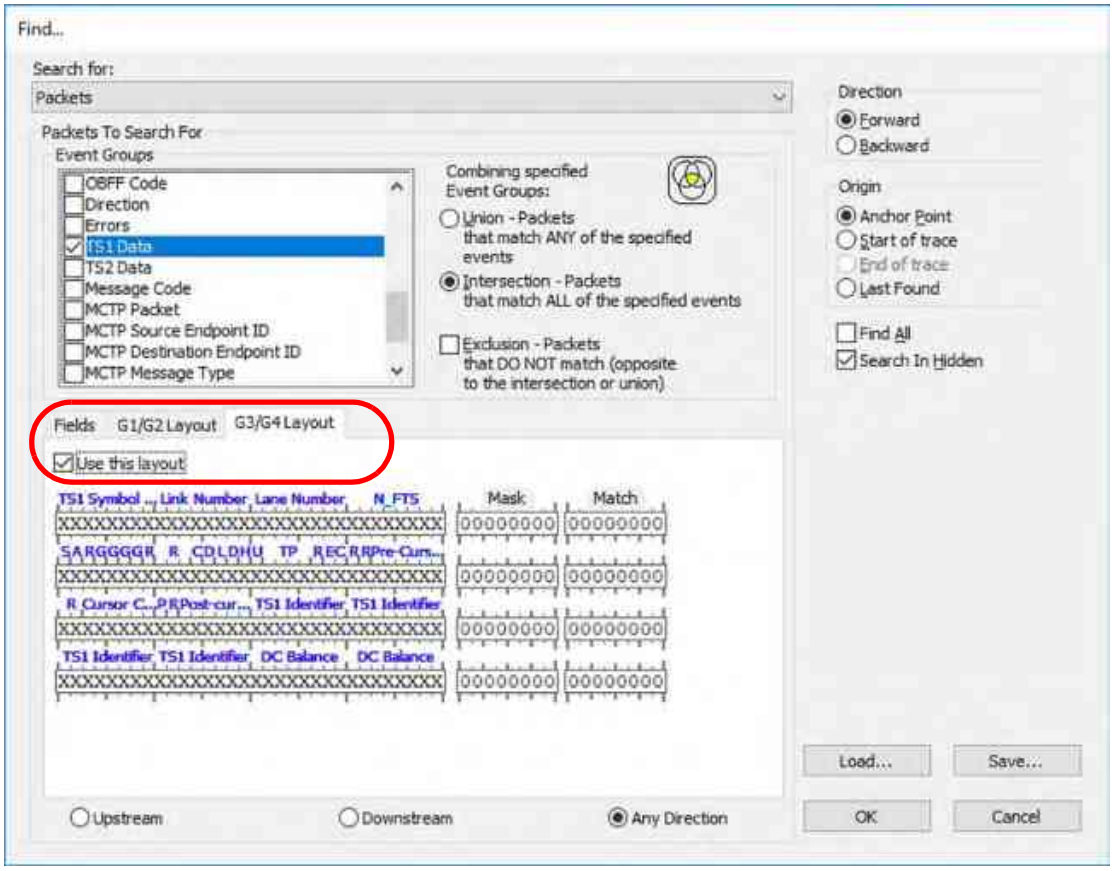


Figure 9.40: Find: TS1 Data -> G3/G4 Layout

Set the Recording Options, TS1 Event Properties with the same options. See Figure 9.41.

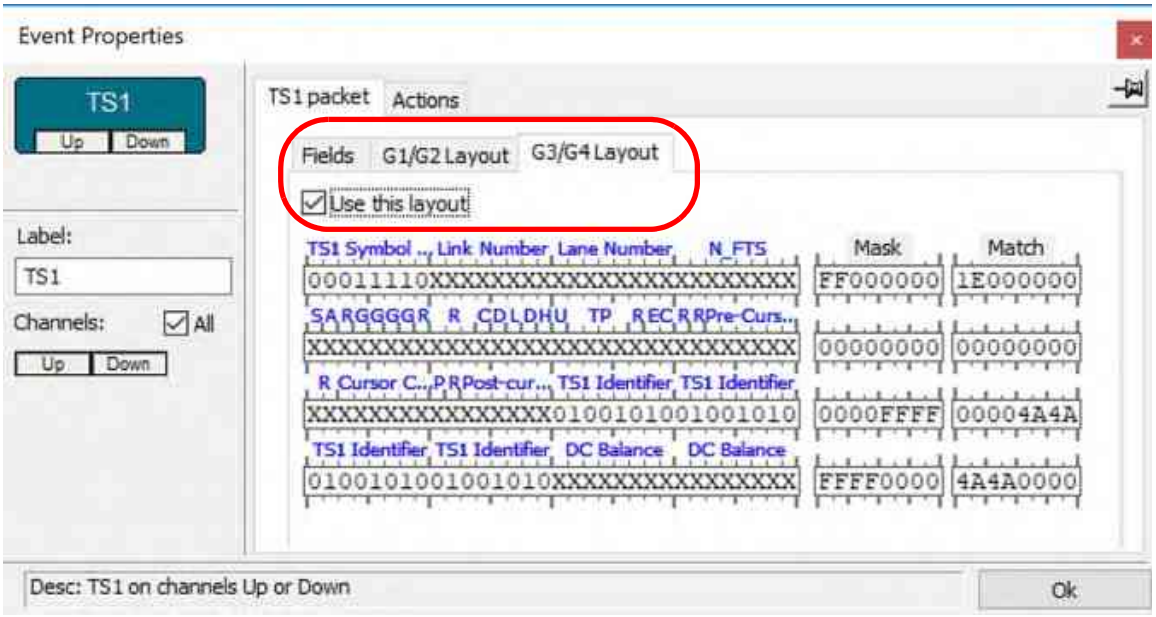


Figure 9.41: Recording Options; TS1 -> Event Properties

Search results example is shown in Figure 9.42.

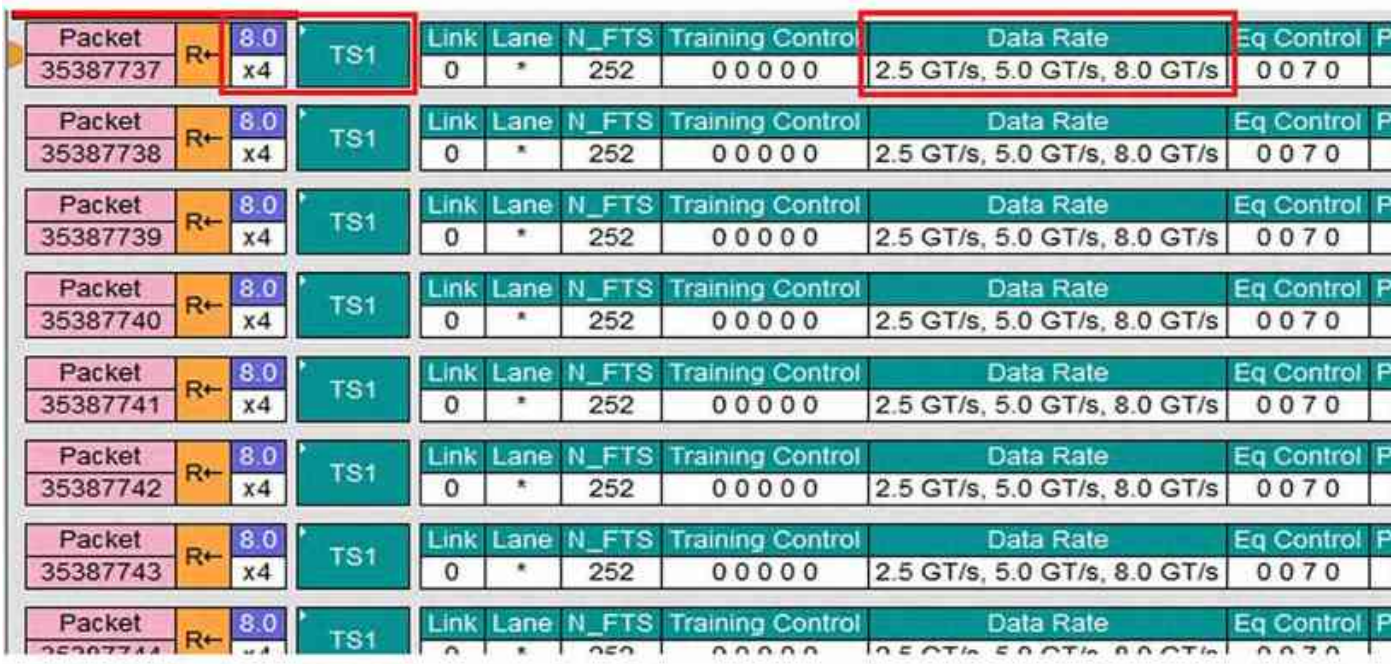


Figure 9.42: Example of Finding TS1 Packet with G3 Speed and G3 Data Rate

Example: TS1 Packet with G1 Speed and G3 Data Rate

In order to select TS1/TS2 packets for search/triggering on G1/G2 speed you need to set the data rate for searching/triggering to G3. See Figure 9.43.

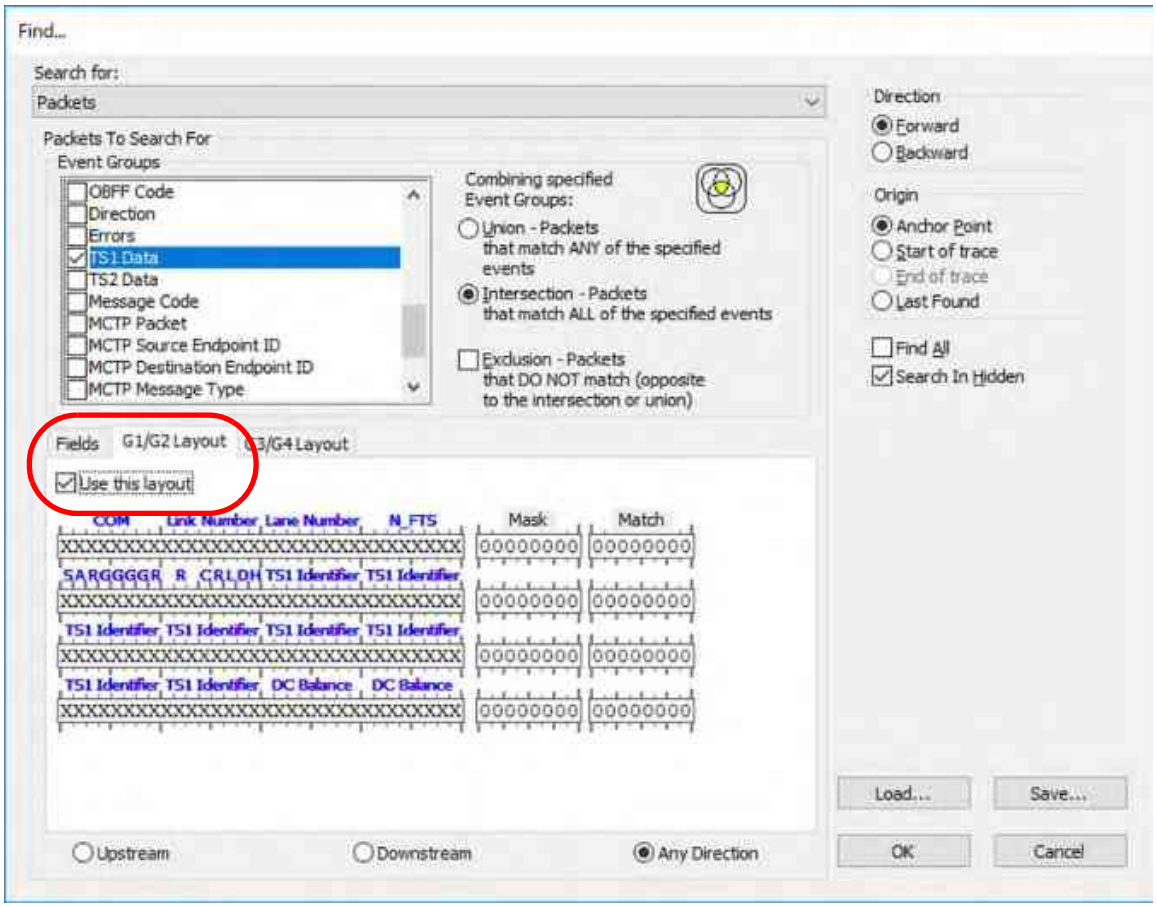


Figure 9.43: Find: TS1 Data -> G1/G2 Layout

Set the Recording Options with the same options. See Figure 9.44 on page 598.

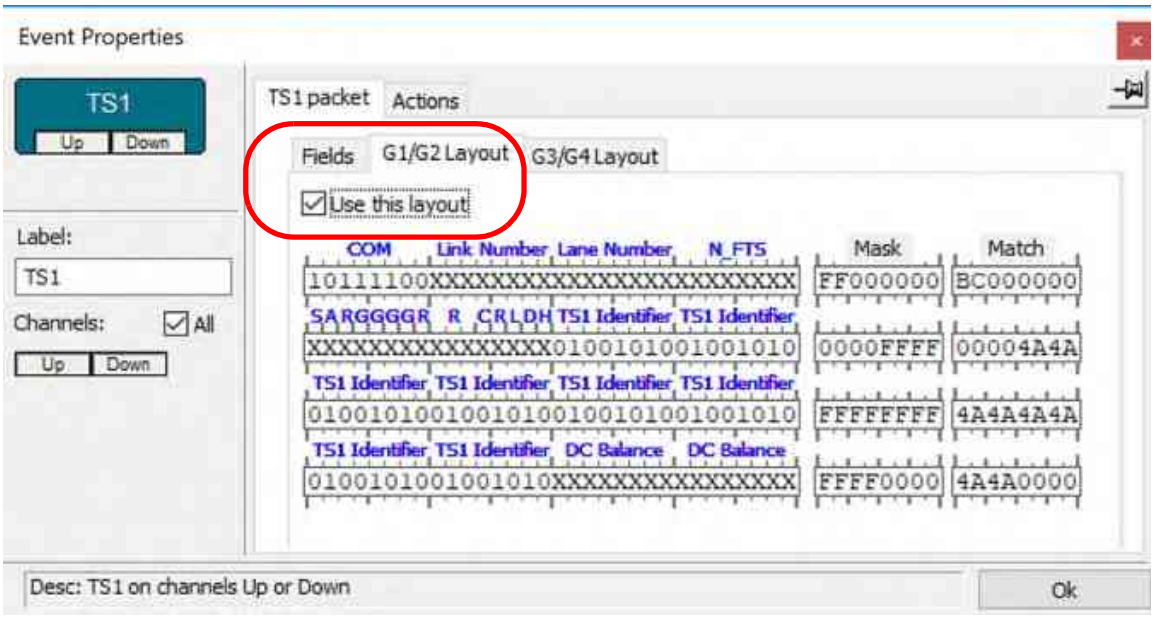


Figure 9.44: Recording Options: TS1 -> Event Properties

Uncheck the checkbox “Use this Layout” in the G3/G4 tab in the Find -> Search for dialog box. See Figure 9.45.

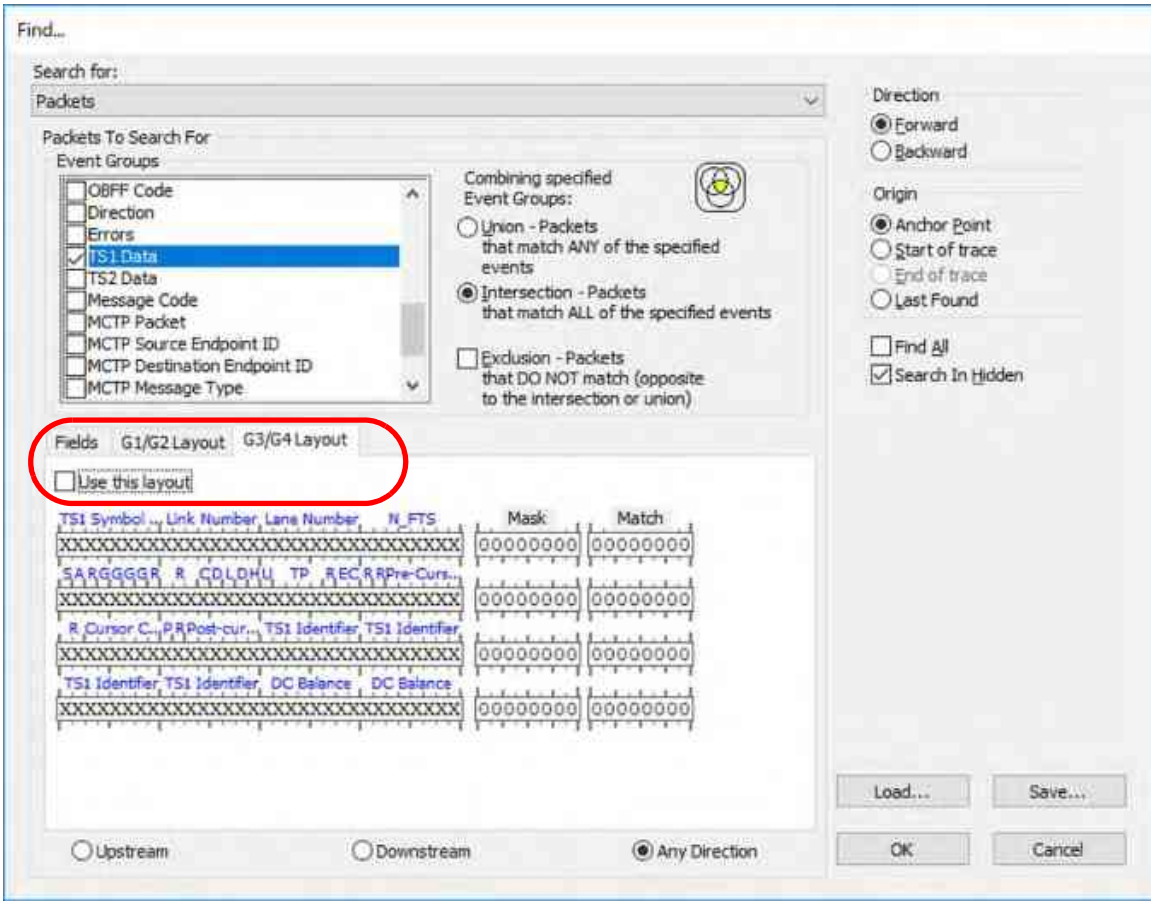


Figure 9.45: Find: TS1 Data -> G3/G4 Layout

In a similar fashion uncheck the checkbox in Recording Options, TS1, Event Properties. See Figure 9.46.

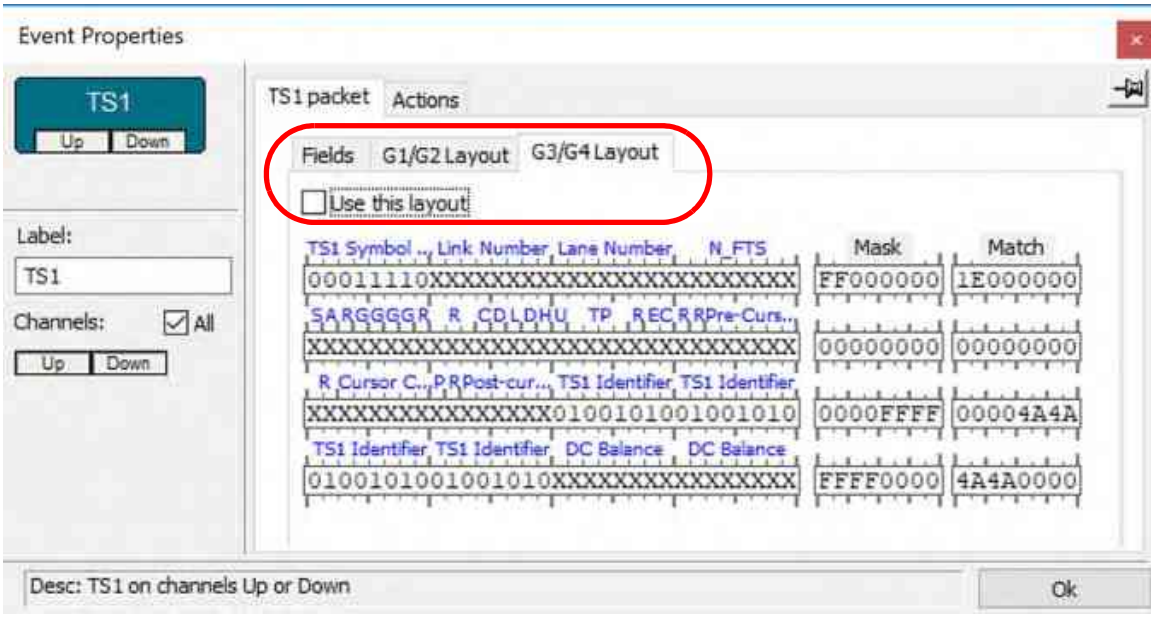


Figure 9.46: Recording Options: TS1 -> Event Properties

An example of a captured trace with TS1 at G1 speed and Data at Gen3 Data Rate is shown below. See Figure 9.47.



Figure 9.47: TS1 Packet with G1 Speed and G3 Data Rate

9.10.1.2 Example: Search for PMUX Channel ID

In this case, we are searching for the following event: PMUX Channel ID (see Figure 9.48).

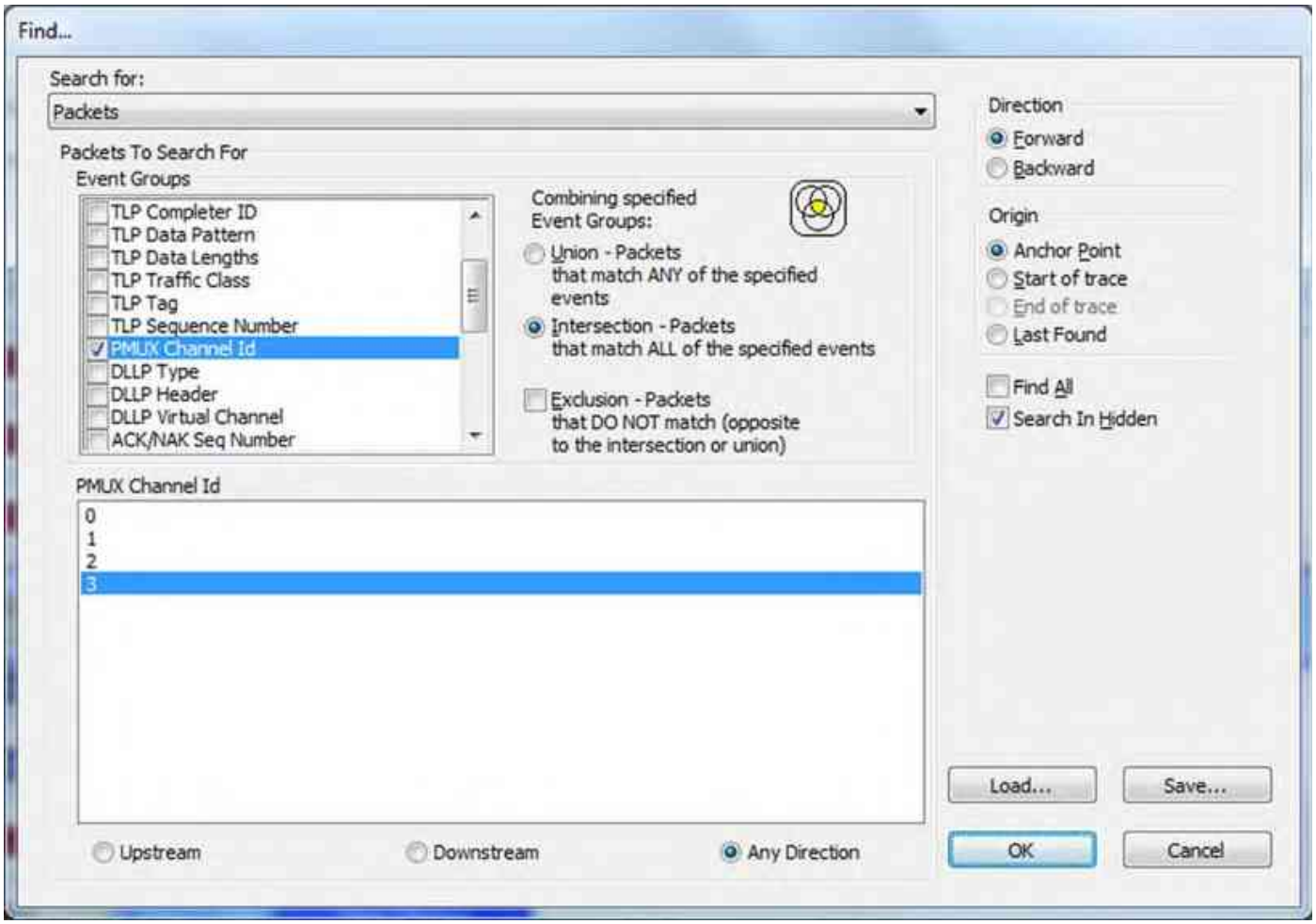


Figure 9.48: Search for: PMUX Channel ID (3)

PMUX Channel ID Found and PMUX Packet Error Decoded in Trace

In the trace both the PMUX Channel ID was found and a Packet PMUX Error was decoded. See Figure 9.49.

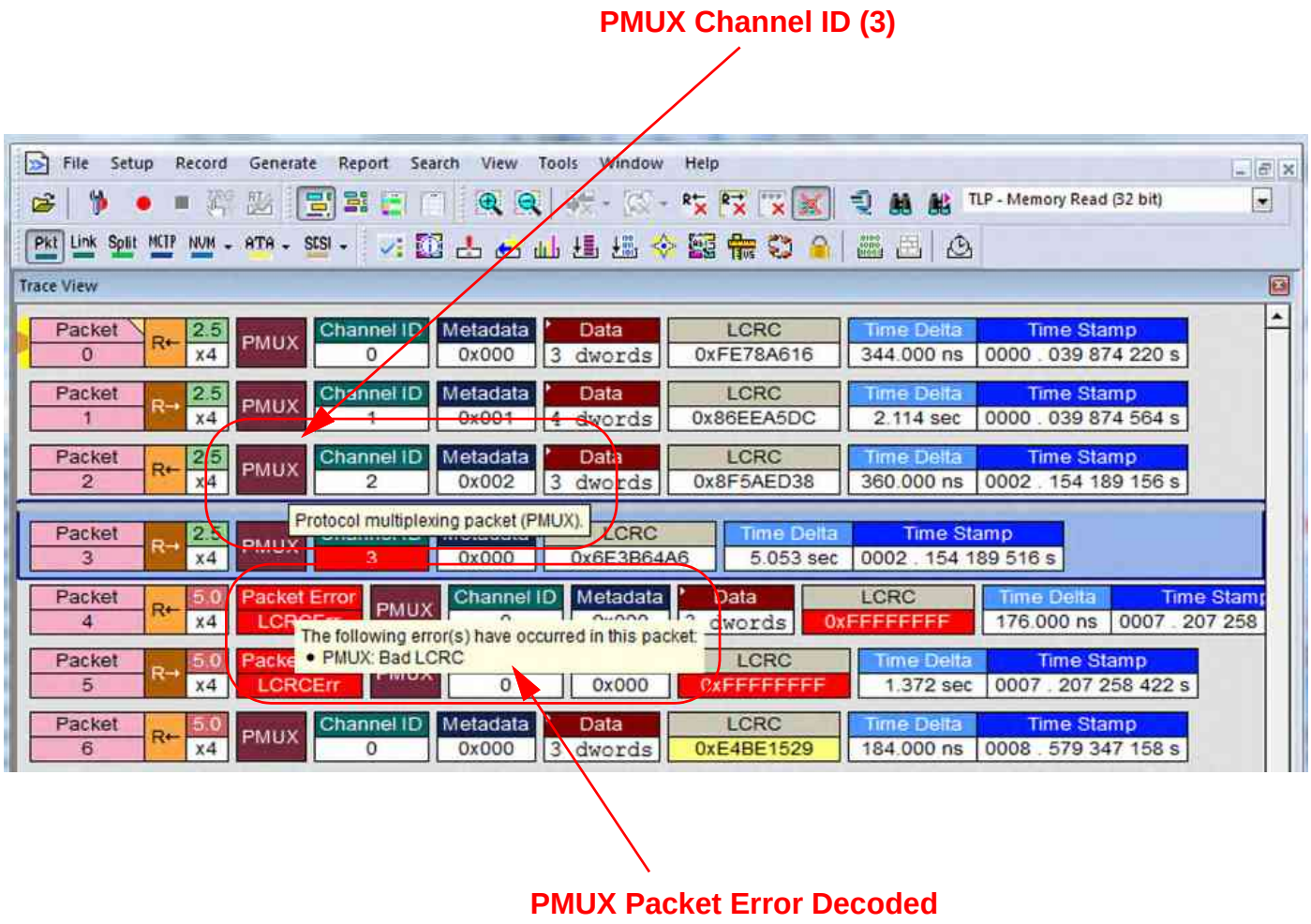


Figure 9.49: PMUX Channel ID (3) Found in Trace and Packet Error Decoded

9.10.1.3 Find Function and CXL Packets

The Find function includes CXL packets. See Figure 9.50.

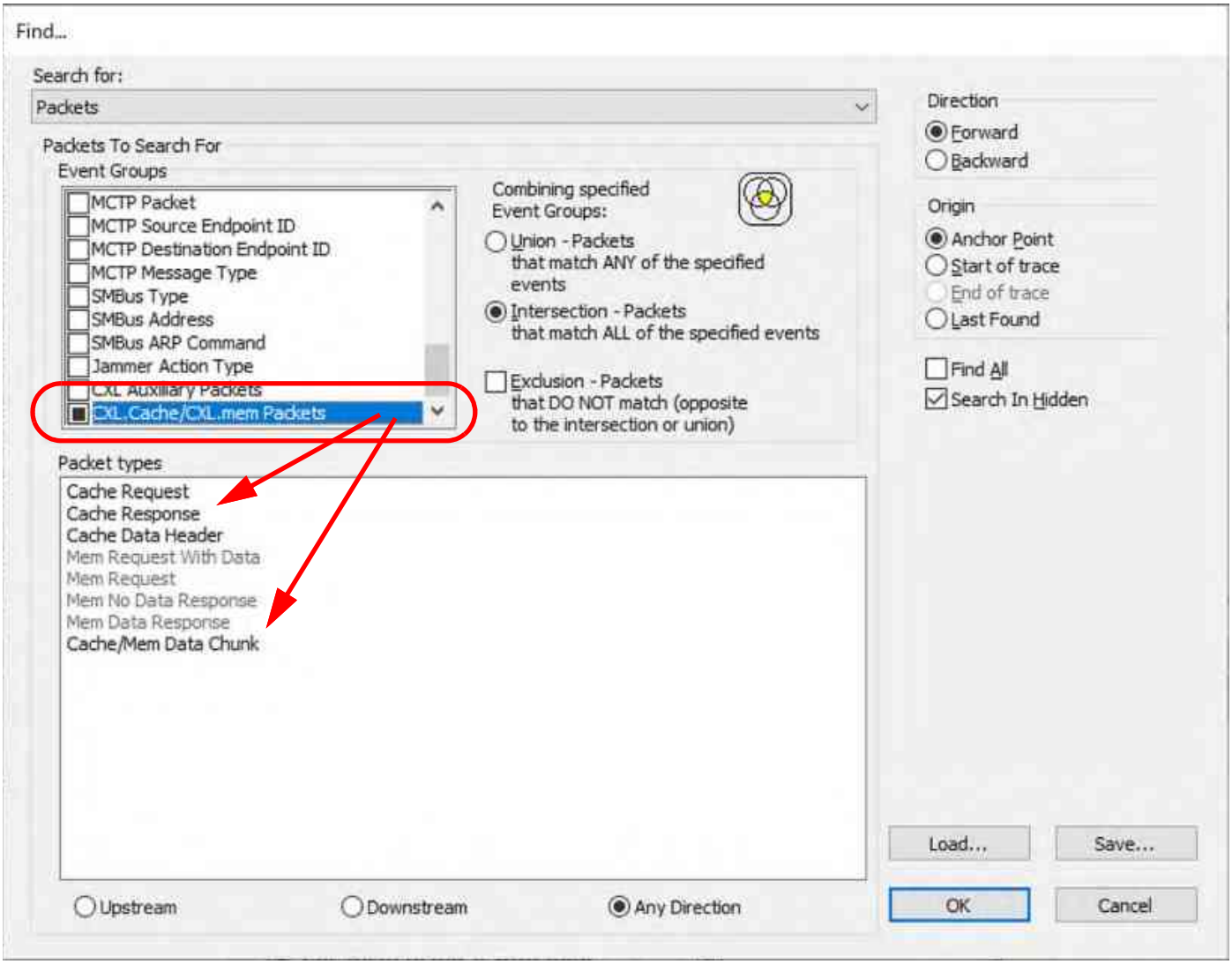


Figure 9.50: Find CXL Packet types

9.10.2 Event Groups for Link Transactions:

- TLP Type
- Traffic Class
- Virtual Channel
- Direction
- RequesterID
- CompleterID
- Status
- Tag

9.10.3 Event Groups for Split Transactions:

- TLP Type
- Traffic Class
- Virtual Channel

- Direction
- Requester ID
- Completer ID
- Status
- Tag
- Address

9.10.4 Event Groups for LM Commands

- Margin Command
- Margin Type
- Receiver Number
- Errors

Figure 9.51 on page 603 shows a Lane Margin example of:

Search for LM Transactions: Margin Command: ReportLM_SamplingRateVoltage.

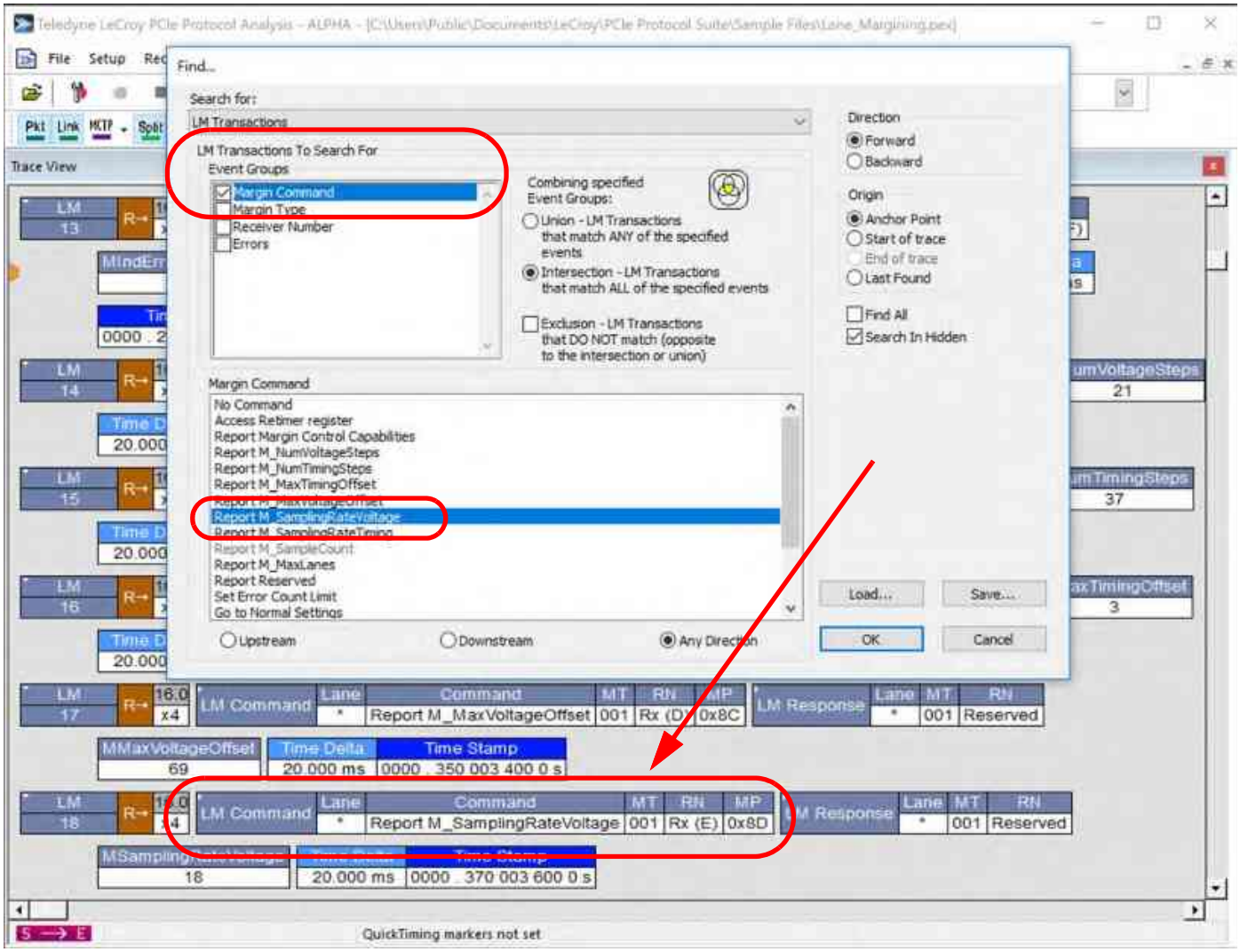


Figure 9.51: Find: Lane Margining Transaction → Margin Command → ReportLM_SamplingRateVoltage

9.10.5 Event Groups for NVMe transactions:

- ❑ Controller Registers
- ❑ Other NVMe Entities
- ❑ Queue IDs
- ❑ Command IDs
- ❑ Doorbell Registers
- ❑ Admin Submission Command Set
- ❑ NVMe Submission Command Set
- ❑ Completion Queue Entry
- ❑ PRP
- ❑ Submission Command
- ❑ NVMe Errors

9.10.6 Event Groups for PQI Transactions:

- ❑ PQI Register ID
- ❑ PQI Admin Functions
- ❑ PQI Errors

9.10.7 Event Groups for AHCI Transactions:

- ❑ AHCI Register ID
- ❑ AHCI Port Number
- ❑ AHCI Slot Number
- ❑ AHCI Port Multiplier Port
- ❑ AHCI Raw Address
- ❑ AHCI Direction
- ❑ AHCI Errors

9.10.8 Event Groups for ATA transactions:

- ❑ ATA Register Type
- ❑ ATA Port Number
- ❑ ATA Slot Number
- ❑ ATA Raw Address
- ❑ ATA Port Multiplier Port
- ❑ ATA Interruption Reason
- ❑ ATA Error Type
- ❑ ATA Input/Output
- ❑ ATA Payload Portion
- ❑ ATA CFIS Fields
- ❑ ATA RFIS Device to Host Fields
- ❑ ATA DSFIS Fields
- ❑ ATA PSFIS Fields
- ❑ ATA SDBFIS Fields

9.10.9 Event Groups for SOP Transactions:

- ❑ SOP Information Unit ID
- ❑ SOP Errors

9.10.10 Event Groups for SCSI Transactions:

- ❑ SCSI Commands
- ❑ Command Status
- ❑ Task Managements
- ❑ Task Management Responses
- ❑ Errors
- ❑ SCSI Logical Unit Numbers

9.10.11 Event Groups for NVMe Commands:

- ❑ Admin Command Set
- ❑ NVM Command Set
- ❑ Submission QID
- ❑ Completion QID
- ❑ Status
- ❑ Errors
- ❑ LBA
- ❑ NVM Command
- ❑ NVM Payload Portion
- ❑ TCG Types
- ❑ TCG Method
- ❑ TCG Invoker
- ❑ TCG Com ID
- ❑ TCG Ext Com ID
- ❑ RPMB

Note: When searching for a LBA range, it finds commands with LBAs that intersect with the selected address range.

9.10.11.1 Example: Search for NVMe Command

In this example, we are searching for the following event (see Figure 9.52 on page 606):

- ❑ NVMe Command
- ❑ Event Group NVM command
- ❑ Command = 0x02, Read
- ❑ Value = 1
- ❑ Fields = SQID [SELECTED: 1]

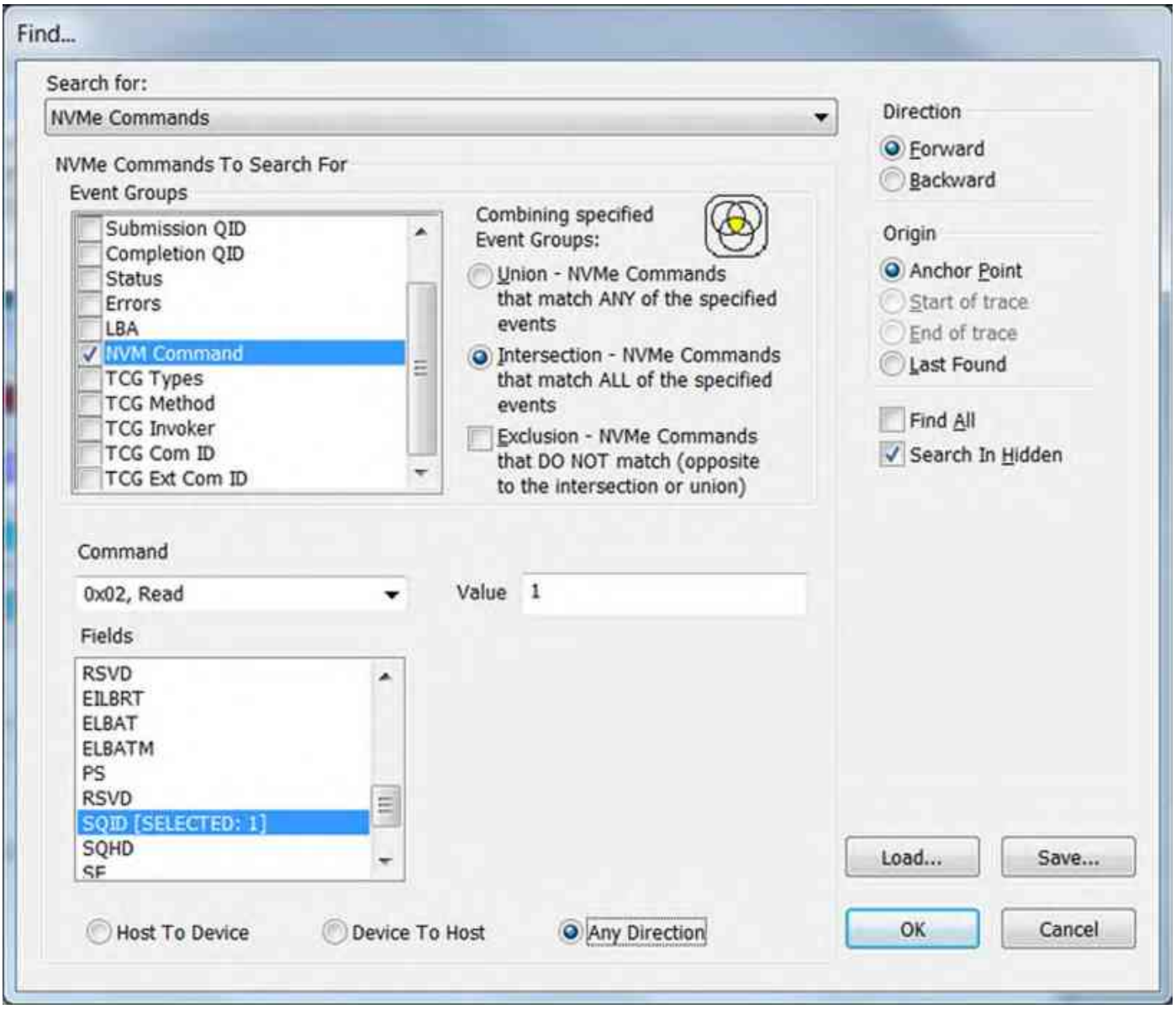


Figure 9.52: Find: Search for NVMe Command

Select **OK**.

Figure 9.53 on page 607 shows that NVMe Command #67 is a Read Command that has an SQID value of 1.

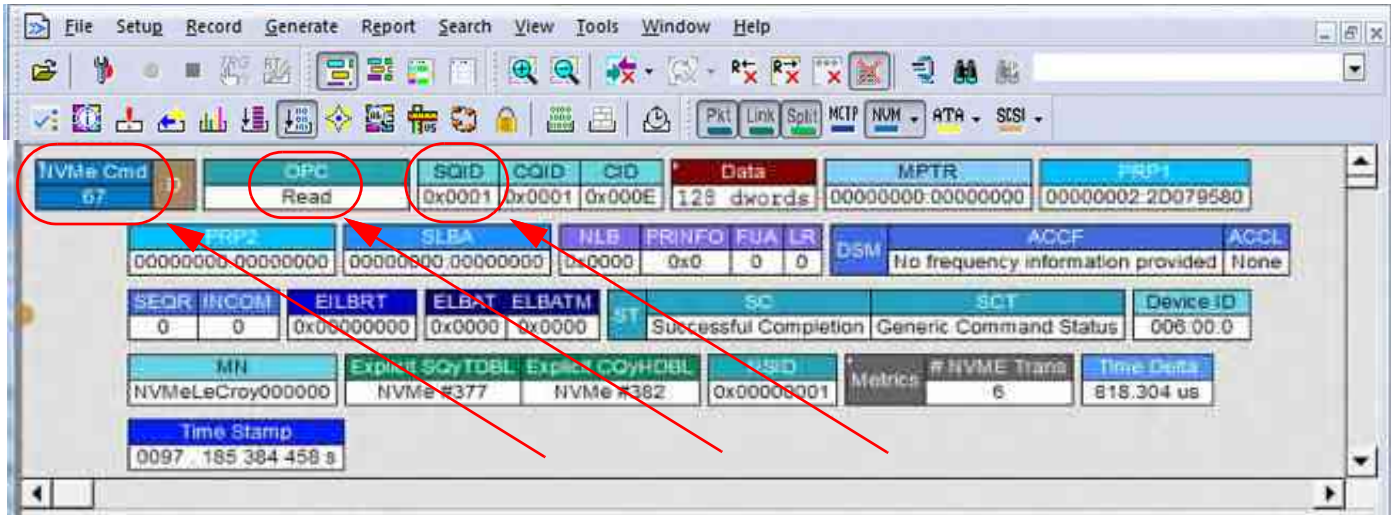


Figure 9.53: Find => Search for NVMe Command => Found

9.10.11.2 Example: Search for NVMe Command: NVM Payload Portion

The Find → Search for: NVMe Commands → Event Groups → NVM Payload Portion will search the currently loaded trace for an NMV Payload. See Figure 9.54.

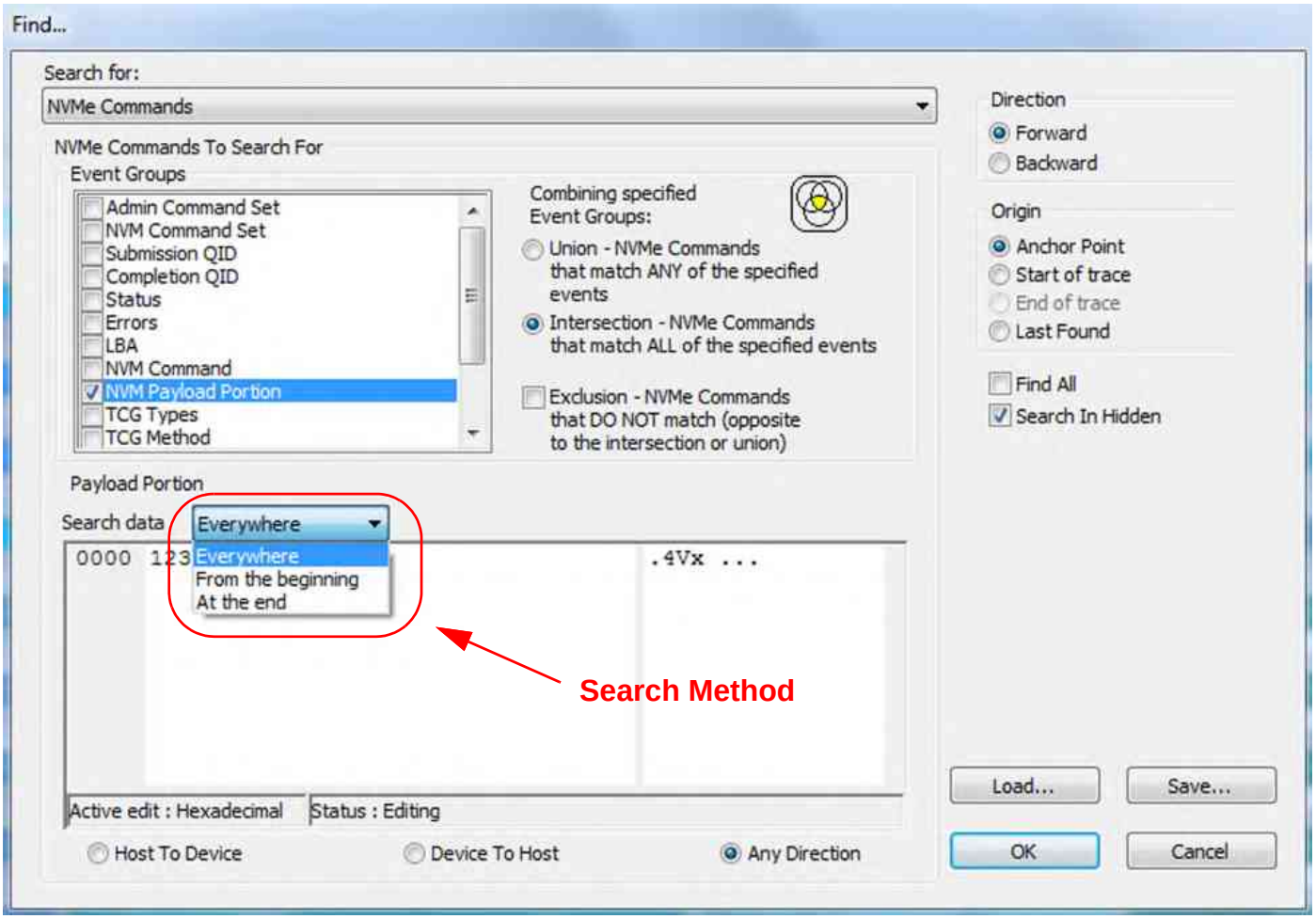


Figure 9.54: Find: Search for NVMe Commands -> NVM Payload Portion

There are several methods which can be used to search the NVM Payload for a particular data pattern:

- Everywhere - matching the set pattern anywhere in the payload
- From the beginning - matching the set pattern in the payload at offset 0
- At the end - matching the set pattern with the offset calculated by the length of the pattern from the end of the payload.

The different search methods are illustrated in Figure 9.55 on page 609.

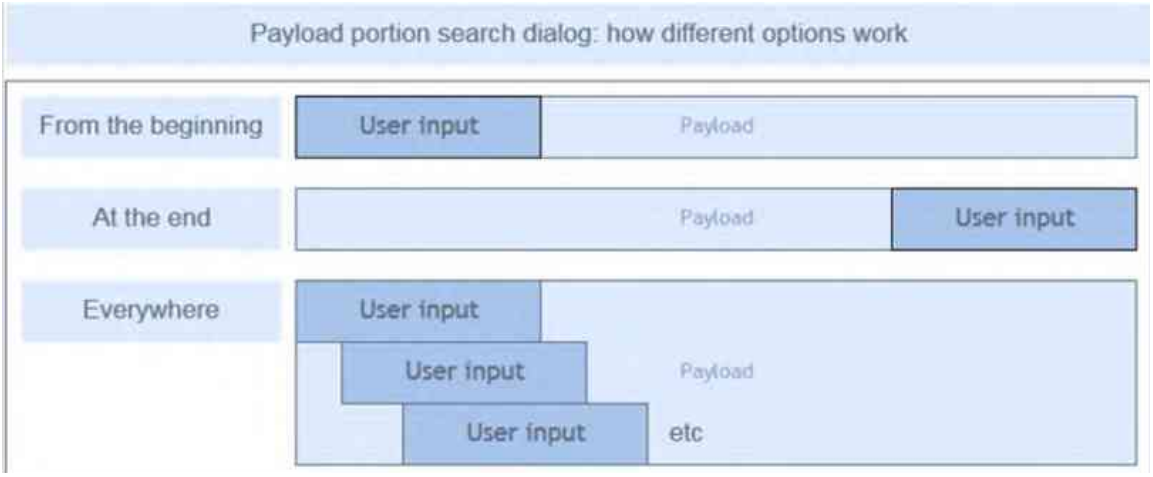


Figure 9.55: Search NVM Payload: Different Methods

9.10.11.3 Example: Search for DLLP Header → Flow Control Feature

In this case, we are searching for the following event:

- DLLP Header → Data Link Feature → Flow Control Packet: Fields and Layout (see Figure 9.56 and Figure 9.57 on page 610)

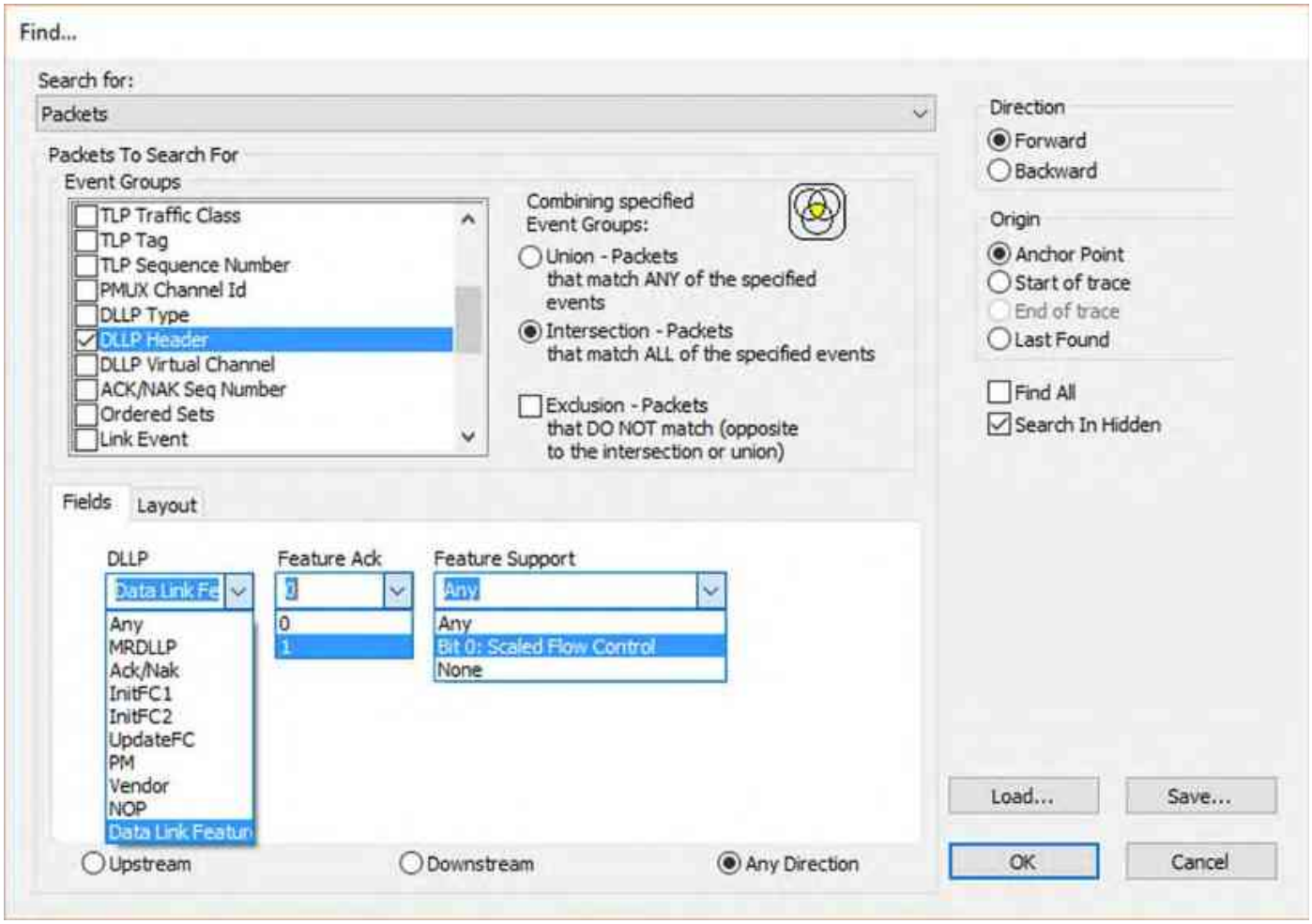


Figure 9.56: Search for: Flow Control Packet → Fields

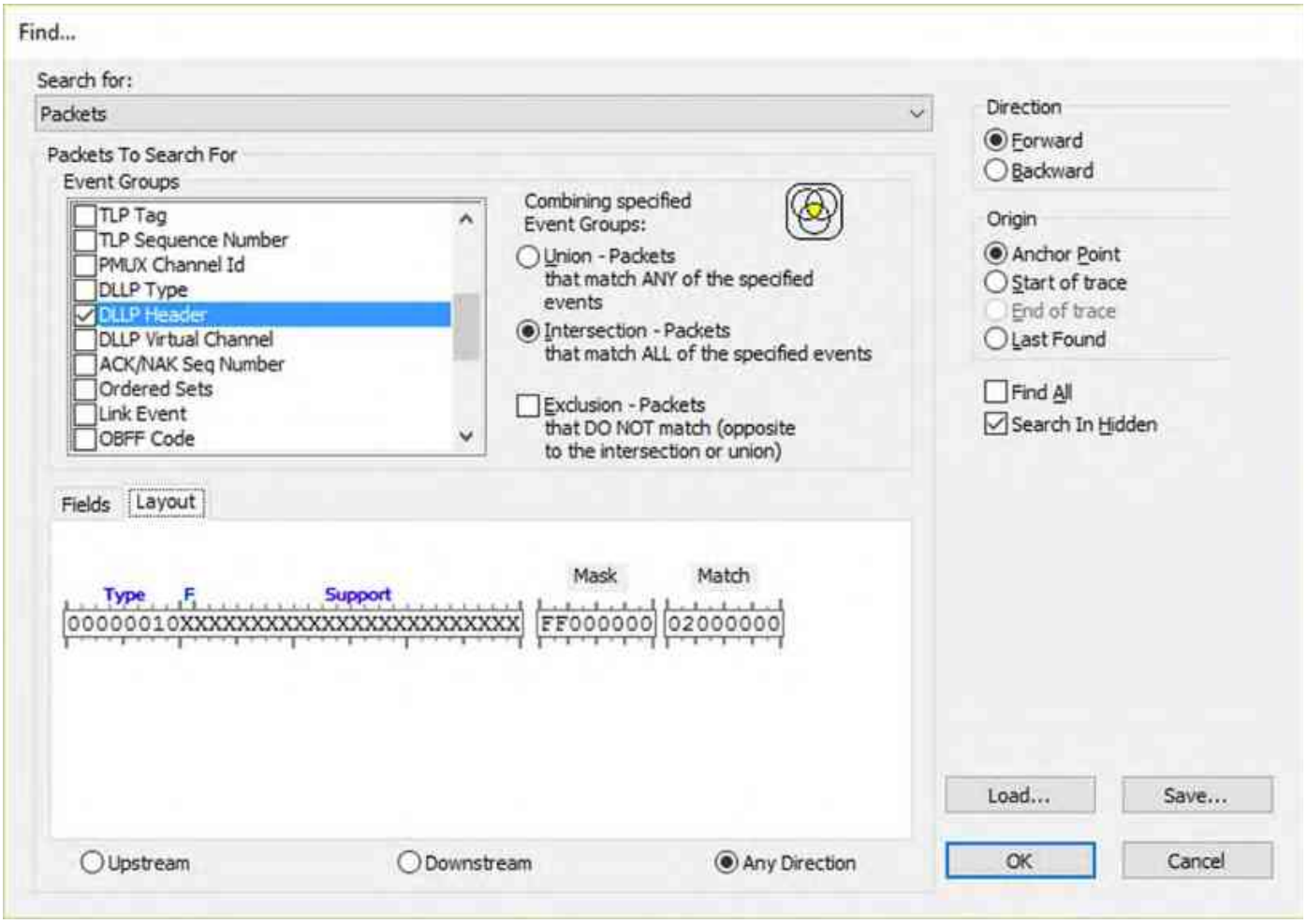


Figure 9.57: Search for: Search for: Flow Control Packet → Layout

9.10.12 Find for DOE Transactions

You can find DOE Transactions by DOE Type Name, DOE Error, and DOE Warning.

See Figure 9.58.

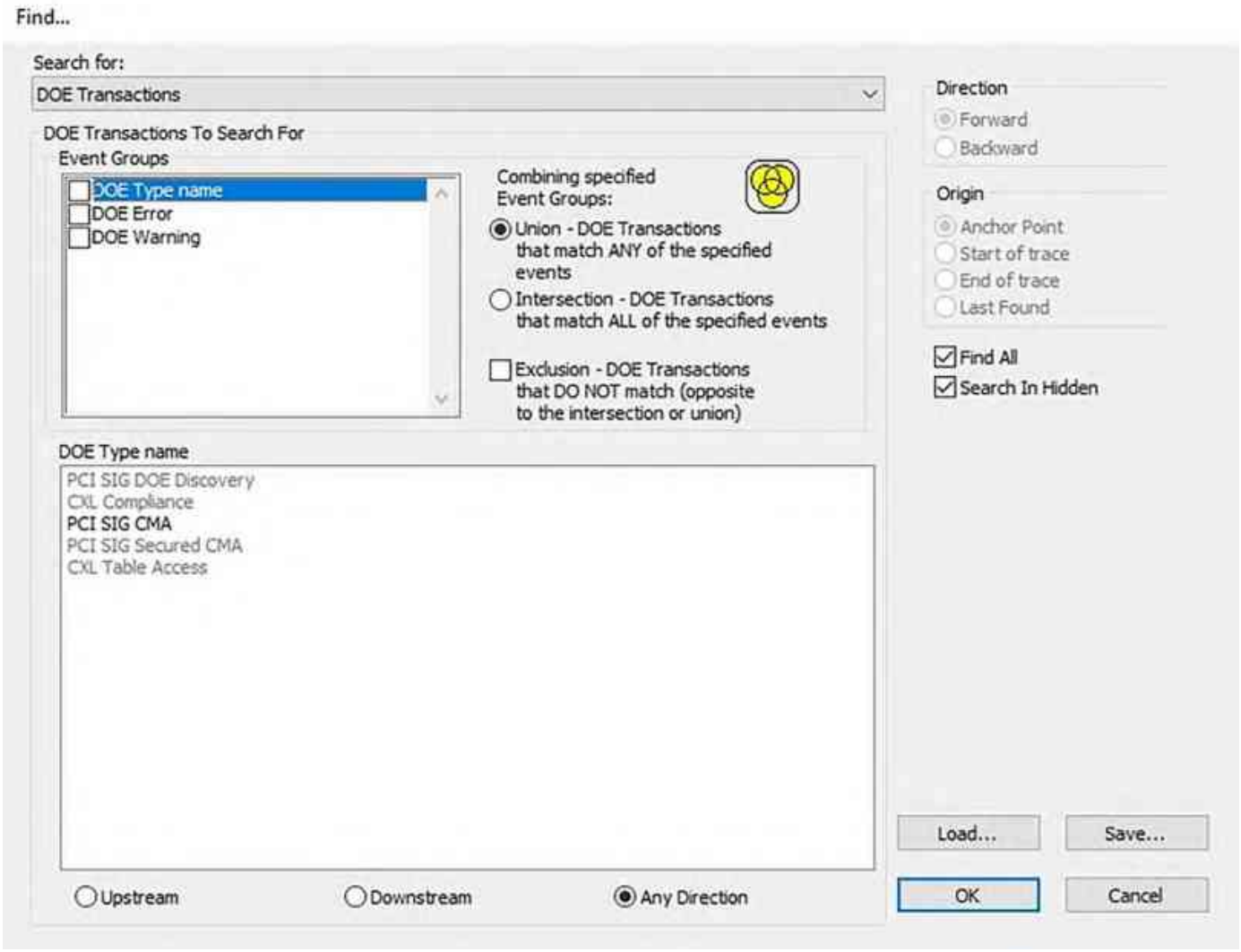


Figure 9.58: DOE Find

Additionally, each find is broken down into the following:

- DOE Type name:
  - PCI SIG DOE Discovery
  - CXL Compliance
  - PCI SIG CMA
  - PCI SIG Secured CMA
  - CXL Table Access
- DOE Error
  - Length Error
  - Incomplete Transaction Error

- Header Error
- Reserved Not Zero
- Sub-Transaction Error
- Discovery Length Error

- DOE Warning
  - Transaction Aborted
  - DOE Error

9.10.13 Search for IDE TLPs

IDE search allows searching by the following categories:

- IDE Errors
- IDE TLP Decrypted Data Pattern
- IDE Message codes
- IDE Stream ID and sub-stream ID combinations - searches for any IDE TLP that matches any Stream ID and any sub-stream ID from the corresponding lists.

See Figure 9.59 on page 613.

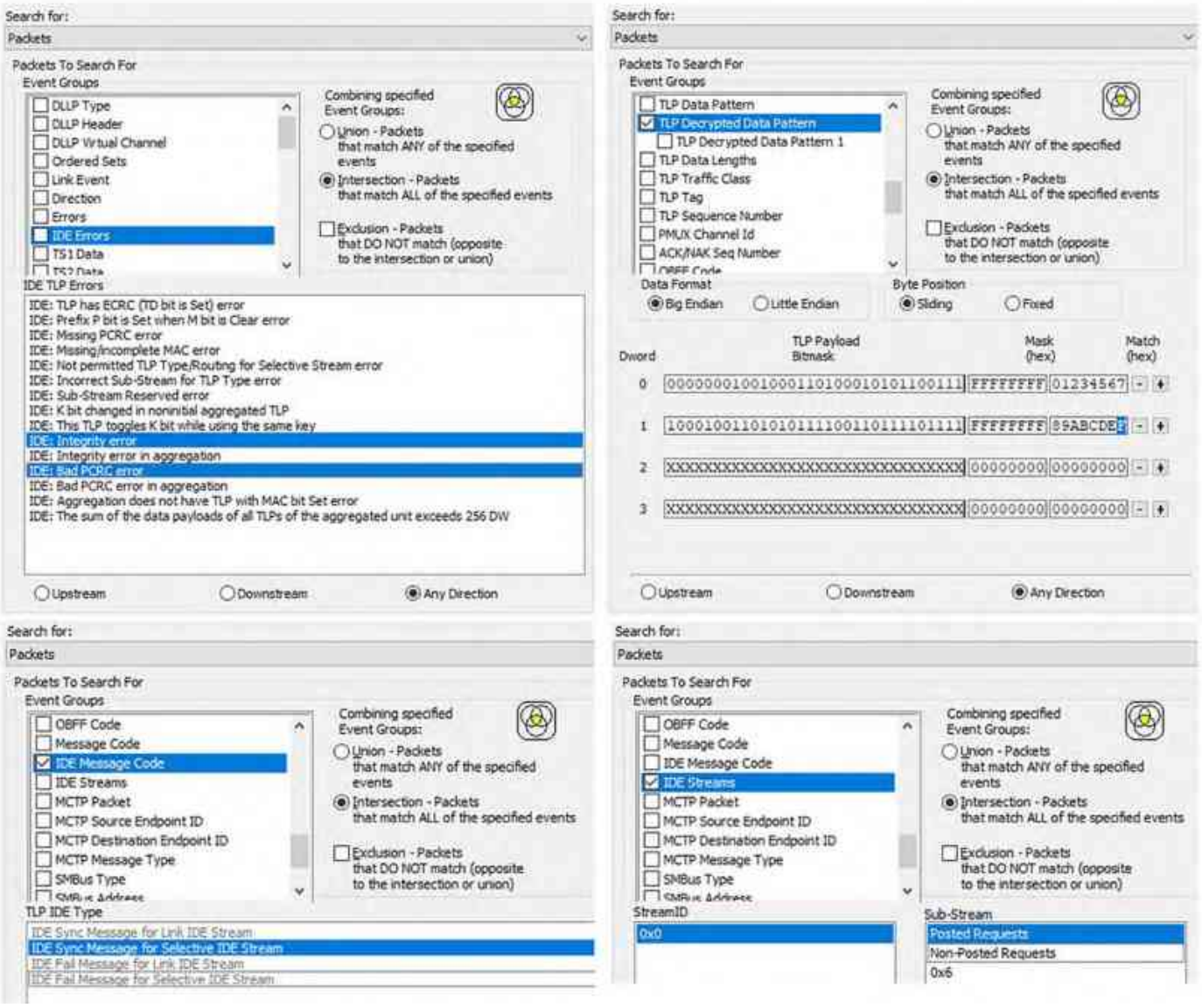


Figure 9.59: IDE TLP Searches

9.11 Find Next Packet Type

Use Find Next or click  to search for the next packet meeting the search criteria.

9.11.1 Quick Search Feature Example

1. Load the NVMe_Z3DriveEmulation Trace from C:\Users\Public\Documents\LeCroy\PCIe Protocol Suite\Sample Files (see Figure 9.60).

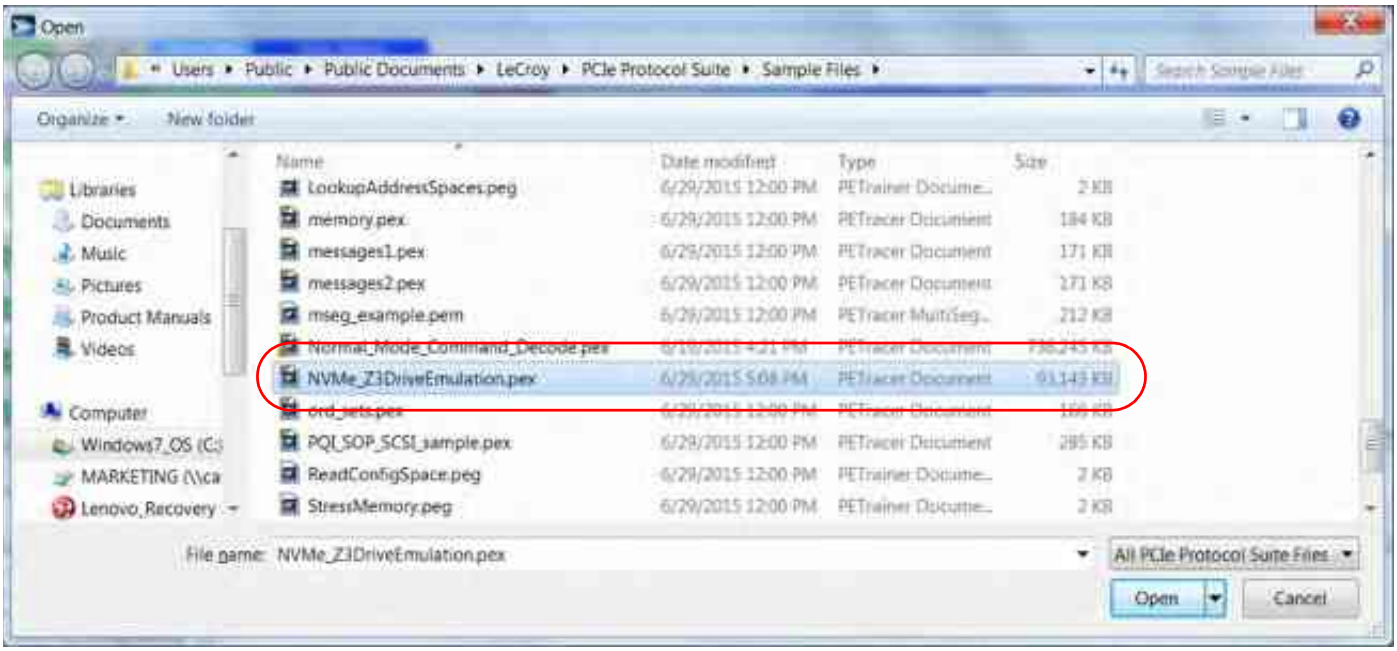


Figure 9.60: Location of Trace File to be Loaded

2. Select the NVMe_Z3DriveEmulation.pex file and click Open.
3. Select the NVMe commands and remove unrelated traffic. The main screen should look like Figure 9.61.

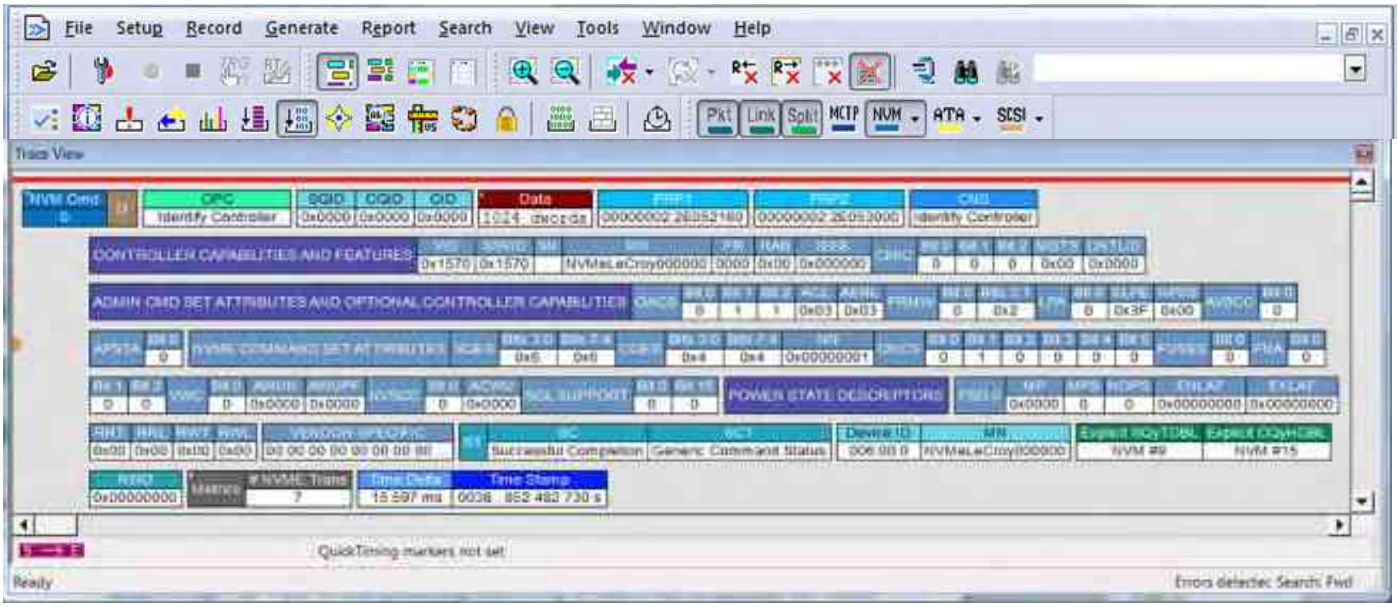


Figure 9.61: Main Menu with NVMe_Z3DriveEmulation Trace Loaded

4. Enter a term to search for in the Quick Search Window, such as “NVM #66.”



The results are shown below (see Figure 9.62).

.



Figure 9.62: Search for NVM #66

5. NVM #66 can be seen to be part of a doorbell event (Explicit SQyTDBL: NVM #62 with the response of Explicit CQyHDBL NVM #66).

This was just an example, you can search for any of the pre-defined terms (Figure 5.11 on page 106) or chose your own term or event to search for.

If you started Searching in the middle of the Trace the following windows will pop up:

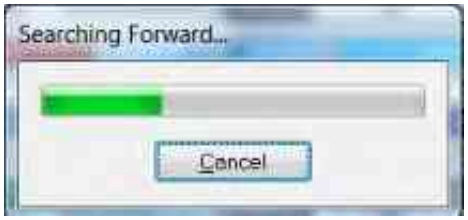


Figure 9.63: Search Progress Window

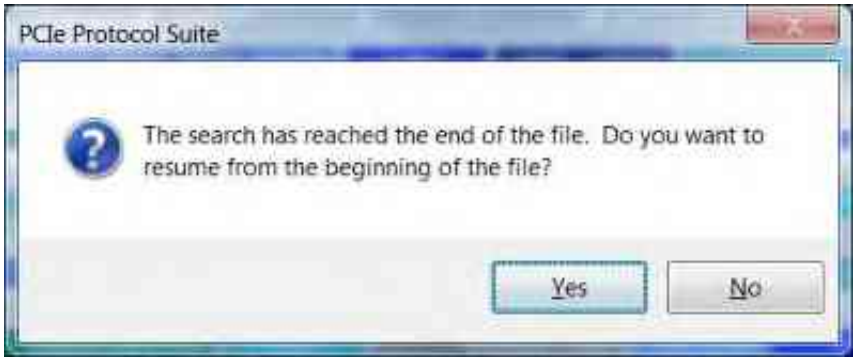


Figure 9.64: Resume Searching From Beginning of Trace

If you select Yes, the tool will continue searching from the start of the Trace, then the following window will pop up:



Figure 9.65: Finished Searching Trace

If the tool hasn't moved to a new Packet, the term being Searched for was not found.

9.12 Toggle Search Direction

Search direction can be toggled back and forth by using the command under the Search menu. Search Direction controls the direction of the search. Each time Toggle Search Direction is selected, the search order is reversed. For example, if the previous search was **forward**, choosing **Toggle Search Direction** toggles the current search to **backward**.

To verify the direction of a search look at the lower right corner of the screen. **Search: Bwd** or **Search: Fwd** should appear. If a direction is not indicated, it means that the status bar is turned off.

To turn on the Status bar, select from the menu **View > Status Bar**.

Keyboard shortcuts can also be used to control search direction: Ctrl+b toggles the search direction.

Chapter 10

Display Options

10.1 Setting Display Options

Display Options allow you to customize the colors and formats of displayed traffic.

To open the Display Options dialog at the General tab, Select **Setup > Display Options** from the menu or click the **Display Options** button on the toolbar. See Figure 10.1.

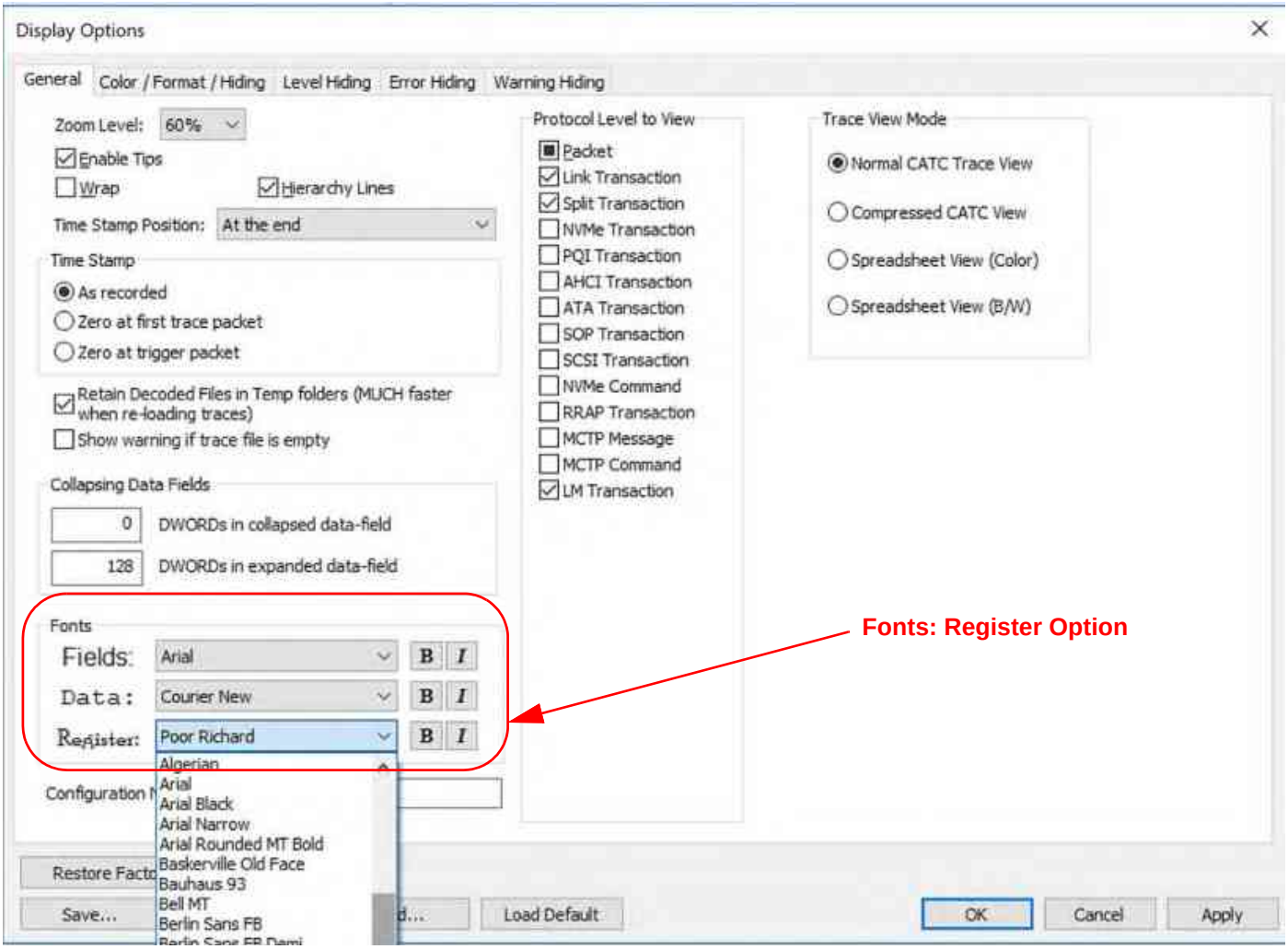


Figure 10.1: Display Options Dialog - General Tab

10.2 Specifying General Display Options

The Display Options General tab allows you to specify:

Zoom Level: Defines the size of packet fields in the packet view. Zoom level is adjustable as 10, 20, 40, 60, 80, 100, 120, 140, 160, 180 and 200 percent.

Enable Tool tips: Allows information to be displayed on a packet by resting your mouse pointer over it.

Wrap: Allows packets, Link Transactions, and Split Transactions to wrap within the display.

Hierarchy Lines: Adds lines to the trace view indicating relations between packets, Link Transactions, and Split Transactions.

Timestamp position: Moves timestamp location from end of packet to beginning of packet, or merges it with the packet number.

Retain Decoded Files: Decoded Files are retained in Temp folders, which makes re-loading the trace much faster.

Empty Trace File Warning: If you've chosen recording conditions which result in an empty trace (no traffic is recorded), a warning message is displayed.

Protocol Level to View: Allows the CATC Trace to be displayed in different hierarchical levels: Packets, Link Transactions, Split Transactions, PQI, AHCI, ATA, SOP, SCSI command, NVMe Commands, RRAP, MCTP and LM transactions.

Time Stamp: Gives you options for setting the timestamp to zero for either the first CATC Trace packet or the trigger packet or for leaving the stamp unchanged as it was originally recorded.

Trace View Mode: Displays Normal CATC Trace View, Compressed CATC View, Spreadsheet View (Color), and Spreadsheet View (B/W).

10.2.1 Collapsing Data Fields

This affects the “Data” field in the TLP packets when using the collapse feature (see Figure 10.2 on page 619).

0 in the collapsed field means no data will be shown. 128 in the expanded field means 128 DWords will be shown when the data field is expanded.

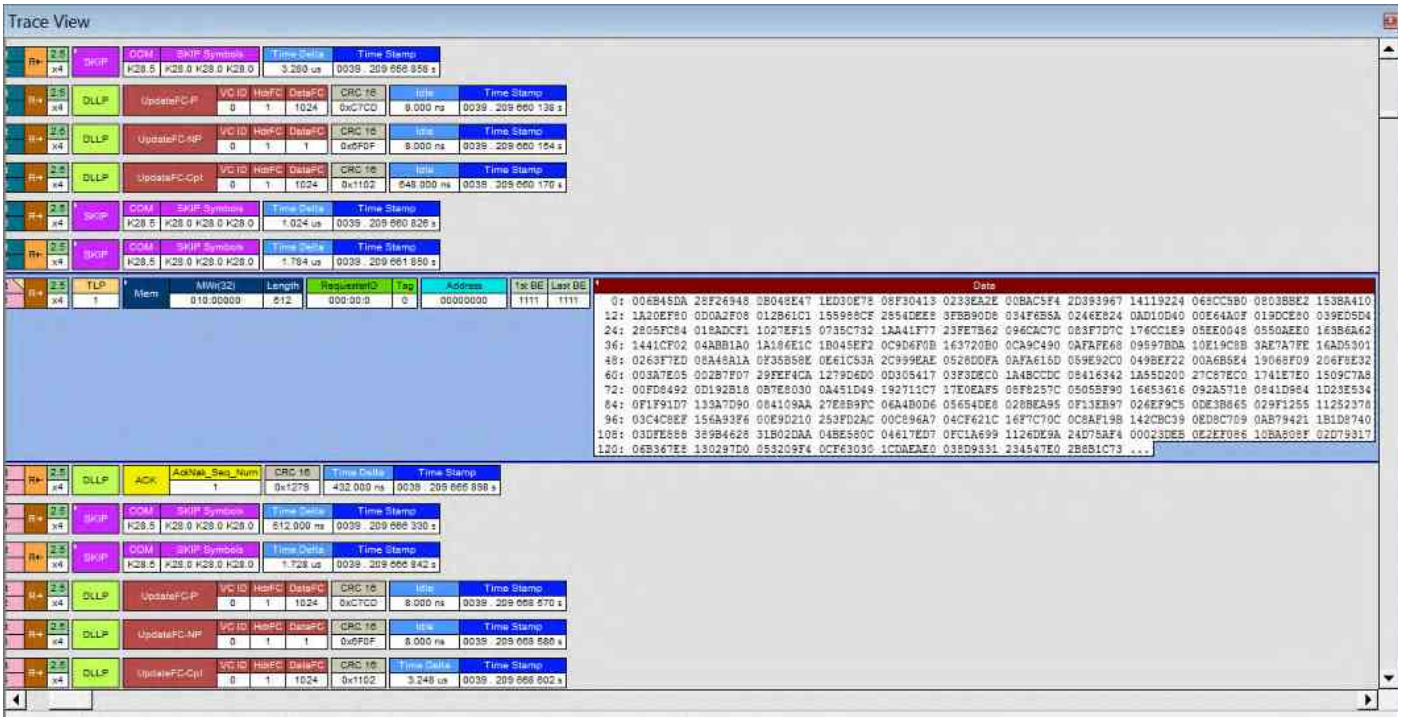


Figure 10.2: Expanded Data Field

10.2.2 Fonts

Fonts: Allows the appearance of field text and/or data text as well as Registers to be defined.

10.2.3 Configuration Name

Display Configuration Name: This field is used to enter a text string to be associated with the current set of Display Options. This name is saved with the Display Options file, and appears as part of the title of the packet view window that uses this set of Display Options.

10.2.4 Color, Format, and Hiding Options

The Color/Format/Hiding tab allows you to customize the colors and formats associated with each field in the CATC Trace and to selectively hide fields or packets. You access these display options by selecting **Setup > Display Options > Color/Format/Hiding** tab (see Figure 10.3 on page 620).

The Color/Format/Hiding property page lets you set how fields display in a CATC Trace. This property page lets you set field color and data format (binary, hex, decimal, ASCII), and lets you hide selected fields from the display.

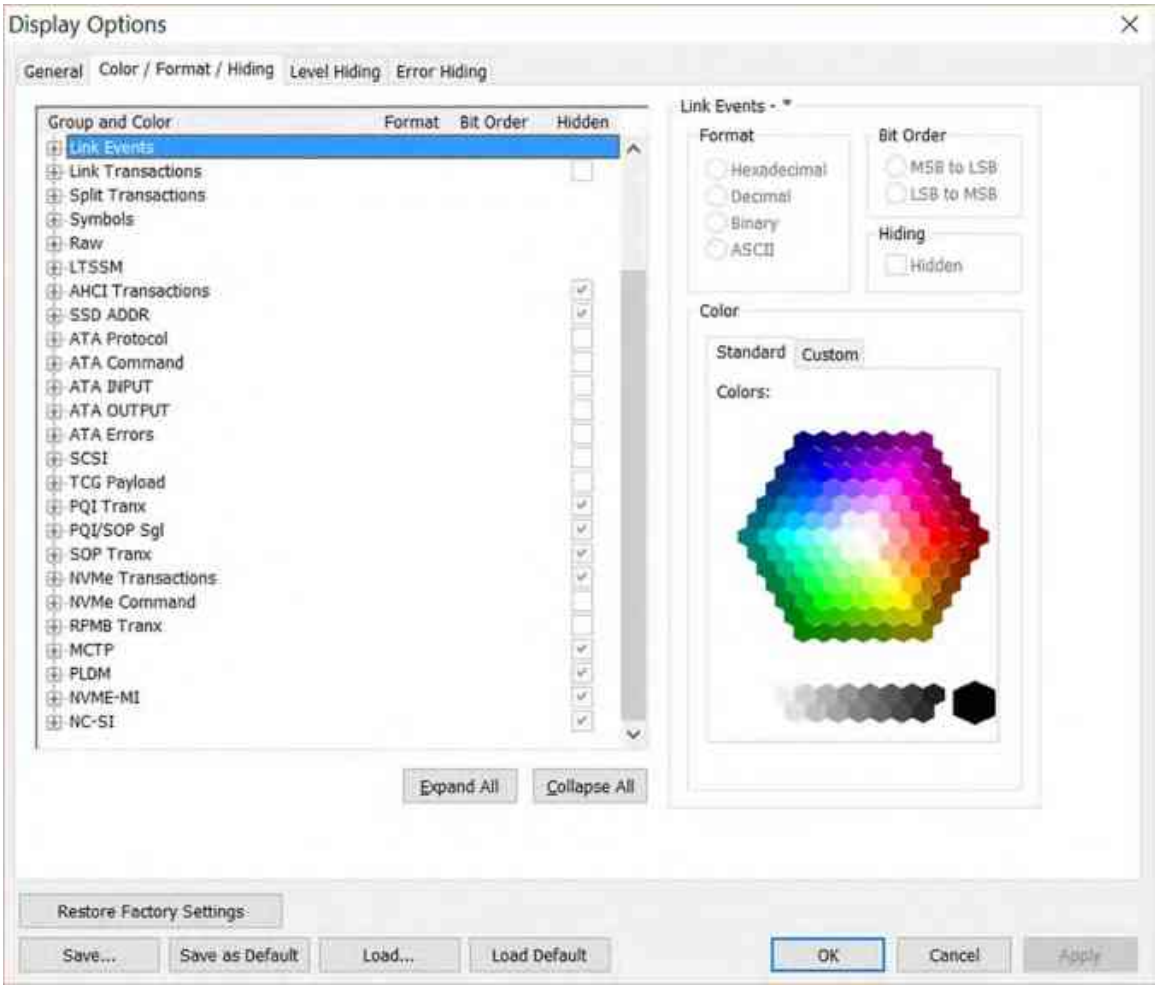


Figure 10.3: Display Options Dialog - Color/Format/Hiding Tab

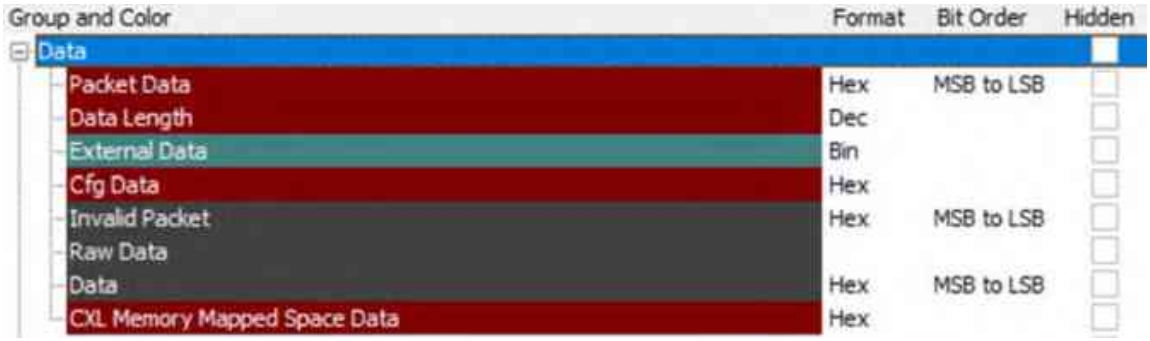
10.2.5 Setting Field Colors

The Field Colors tab allows you to customize the colors associated with each field used in the packet view. You can experiment with this option to achieve a color combination that suits you.

Select or change the trigger color using the color buttons labeled **- Packet #** and **+ Packet #** (before and after trigger) found under the Packet# section of the Field Colors window.

You select or change a color by clicking the appropriate color button. This action causes a color palette to pop up. Select the desired color and press OK.

1. Click **View > Set Display Options** to open the Display Options dialog.
2. Select the **Color/Format/Hiding** property page (see following figure).
3. Under the Group and Colors column, click the **plus** symbol (**+**) next to the group you want to reformat. The group expands to show the individual fields within the group. Each field has a color, as shown below:



4. Click the colored cell that you want to change. A color palette appears.
5. Click a color in the palette, then click **Apply** or **OK**.

Note: Invalid Data (frame error) field (red) and **Softbit Errors** (yellow) colors cannot be changed.

You can also change color by right-clicking a field in the CATC Trace and selecting Color from the pop-up menu.

10.2.6 Changing Field Formats

The Field Formats tab allows you to define the way various numeric fields are shown in the packet display. You can select Hexadecimal, Decimal, Binary, or ASCII for certain fields or groups of fields.

To change a field's format, click the plus sign (+) next to a field in the list. This causes the selected item to expand so you can see its constituent sub-fields. Select a sub-field, and then choose the format from the formatting choices that appear at the bottom right of the window (see Figure 10.4 on page 622).

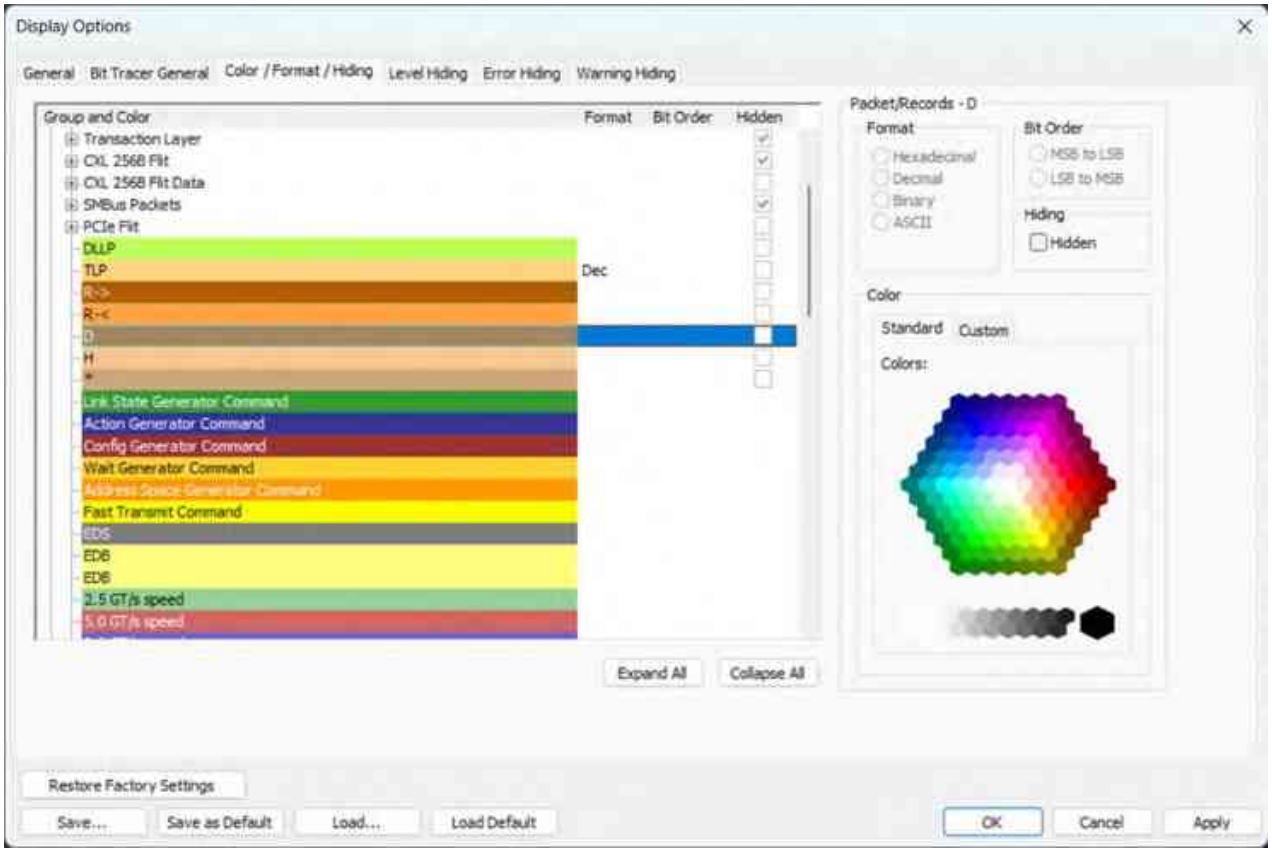
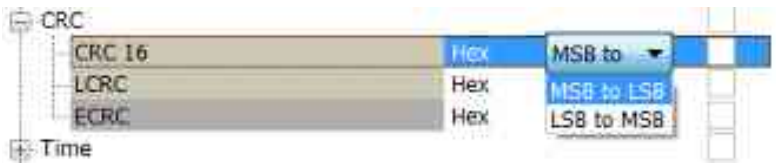


Figure 10.4: Display Options Dialog: Color/Format/Hiding Tab: Color Picker enabled

To change the format of alphanumeric characters in a field:

1. Under the Group and Colors column, click the **plus** symbol (**+**) next to the group you want to reformat. The group expands to show the individual fields within the group (as shown above).
2. Click the **row** representing the field that you want to reformat. If the field can be reformatted, the format options become active, and choose an option from the list as shown below:



3. Select a **format**.

4. Specify the bit order in the displayed fields by selecting or clearing the **MSB > LSB** checkboxes.
5. Click **Apply** or **OK**.

10.2.7 Hiding Fields

To hide a field:

1. Under the Group and Colors column, click the **plus** symbol (**+**) next to the group that has the field(s) you want to hide. The group expands to show the individual fields within the group (as shown above).
2. Click the **checkbox** in the row representing the field that you want to hide.
3. Click **Apply** or **OK**.

10.2.8 Level Hiding

The Level Hiding tab lets you hide traffic by Event Groups (see Figure 10.5). If you select one or more event types from the Event Group list, the selected types are hidden from the CATC Trace.

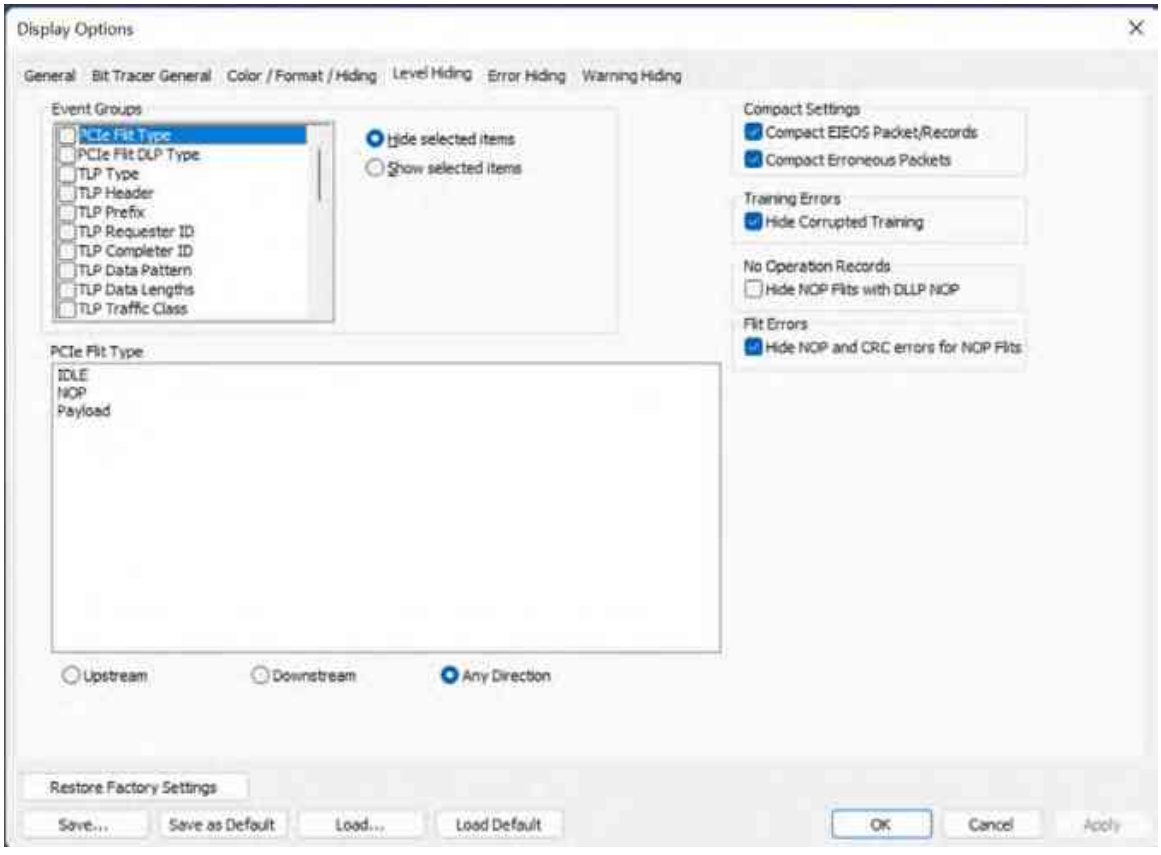


Figure 10.5: Display Options Dialog: Level Hiding Tab

To hide a level:

1. Select an Event Group.
2. Select whether to **Hide** or **Show selected items**.
3. Select **Upstream, Downstream**, or **Any Direction**.

4. (Optional) Select **Sideband** signals. (These include SMBus signals).
5. (Optional) Select **Compact EIEOS packets** and/or **Compact Erroneous Packets**.
6. (Optional) Select **Hide Corrupted Training**.
7. (Optional) Select **Hide NOP Flits with DLLP NOP.**
8. (Optional) Select **Hide NOP and CRC Errors for NOP Flits.**
9. Click **OK**.

The Event Groups for Packets are:

- TLP Type
- TLP Header
- TLP Requester ID
- TLP Completer ID
- TLP Data Pattern
- TLP Data Lengths
- TLP Traffic Class
- TLP Tag
- TLP Sequence Number
- DLLP Type
- ACK/NAK Seq Number
- Ordered Sets
- Link Event
- OBFF Code
- Direction
- Errors
- TS1 Data
- TS2 Data
- DLLP Header
- DLLP Virtual Channel

The Event Groups for Link Transactions are:

- TLP Type
- Traffic Class
- Virtual Channel
- Direction
- RequesterID
- CompleterID
- Status
- Tag

The Event Groups for Split Transactions are:

- TLP Type
- Traffic Class
- Virtual Channel
- Direction
- RequesterID
- CompleterID
- Status
- Tag
- Address

The Event Groups for NVMe transactions are:

- Controller Registers
- Other NVMe Entities
- Queue IDs
- Command IDs
- Doorbell Registers
- Admin Submission Command Set
- NVMe Submission Command Set
- Completion Queue Entry
- PRP
- Submission Command
- NVMe Errors

The Event Groups for PQI Transactions are:

- PQI Register ID
- PQI Admin Functions
- PQI Errors

The Event Groups for AHCI Transactions are:

- AHCI Register ID
- AHCI Port Number
- AHCI Slot Number
- AHCI Port Multiplier Port
- AHCI Raw Address
- AHCI Direction
- AHCI Errors

The Event Groups for ATA transactions are:

- ATA Register Type
- ATA Port Number
- ATA Slot Number
- ATA Raw Address
- ATA Port Multiplier Port
- ATA Interruption Reason
- ATA Error Type
- ATA Input/Output
- ATA Payload Portion
- ATA CFIS Fields
- ATA RFIS Device to Host Fields
- ATA DSFIS Fields
- ATA PSFIS Fields
- ATA SDBFIS Fields

The Event Groups for SOP transactions are:

- SOP Information Unit ID
- SOP Errors

The Event Groups for SCSI transactions are:

- SCSI Operation
- Command Status
- Task Management
- Task Management Response
- Errors
- SCSI Logical Unit Numbers

The Event Groups for NVMe Commands are:

- Admin Command Set
- NVME Command Set
- Submission QID
- Completion QID
- Status
- Errors
- TCG Types
- TCG Method
- TCG Invoker
- TCG Com ID
- TCG Ext Com ID

10.2.9 Error Hiding

The Error Hiding page lets you hide errors by Transaction Types (see Figure 10.6). If you select one or more transaction types from the list, the selected types are hidden from the CATC Trace.

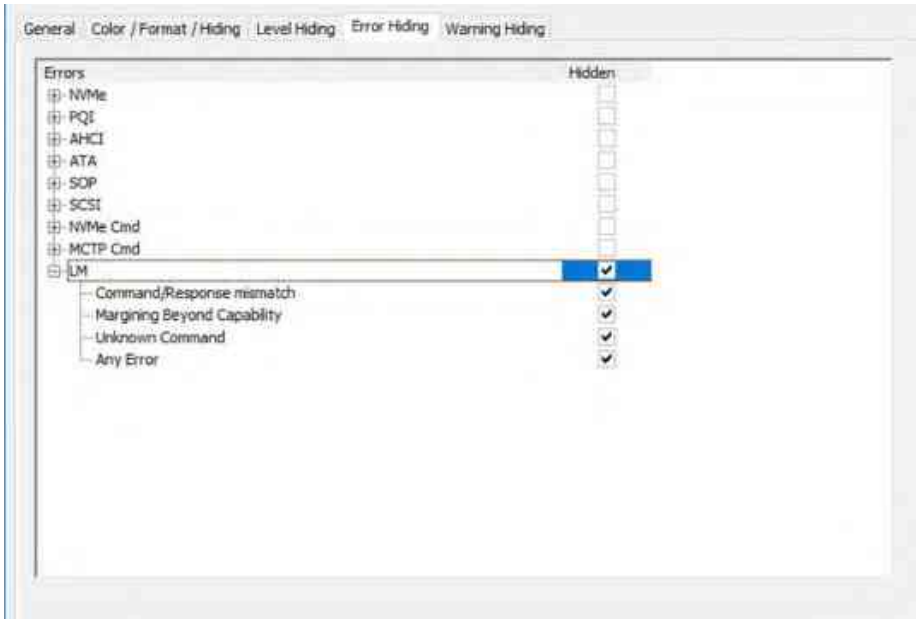


Figure 10.6: Display Options: Error Hiding: Lane Margining Error Hiding shown

10.2.9.1 Transaction Types

The Transaction Types which can have their errors hidden include:

- NVMe
- PQI
- AHCI
- ATA
- SOP
- SCSI
- NVMe Cmds
- LM

Each Transaction Type has a large selection of errors that can be selectively hidden. See Figure 10.7, Figure 10.8 on page 627 and Figure 10.9 on page 628.

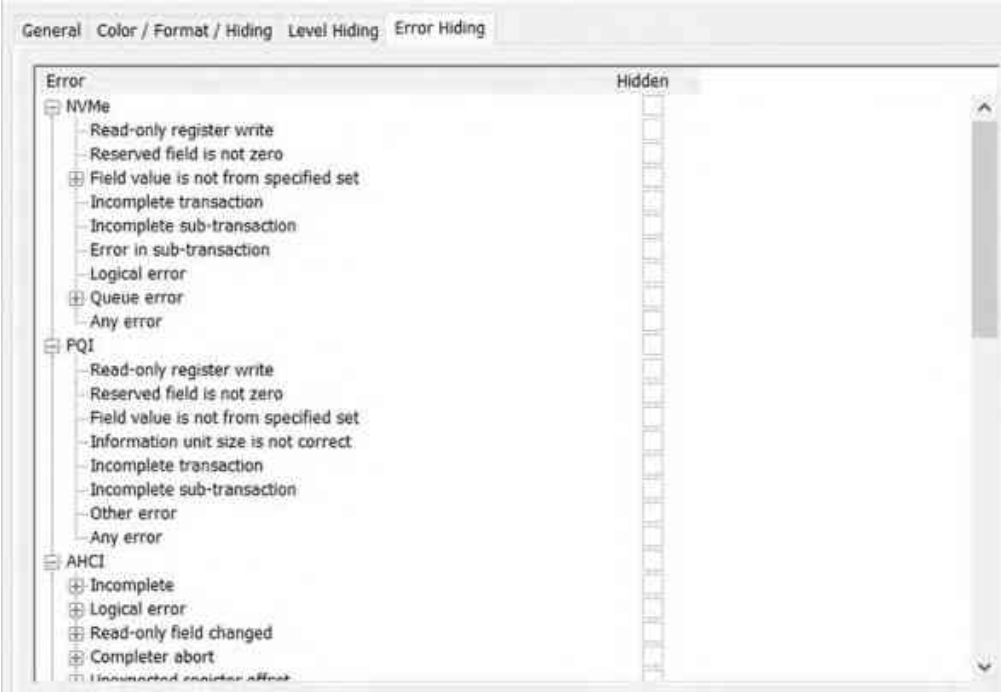


Figure 10.7: Display Options: Error Hiding: Transaction Types: NVMe/PQI/AHCI

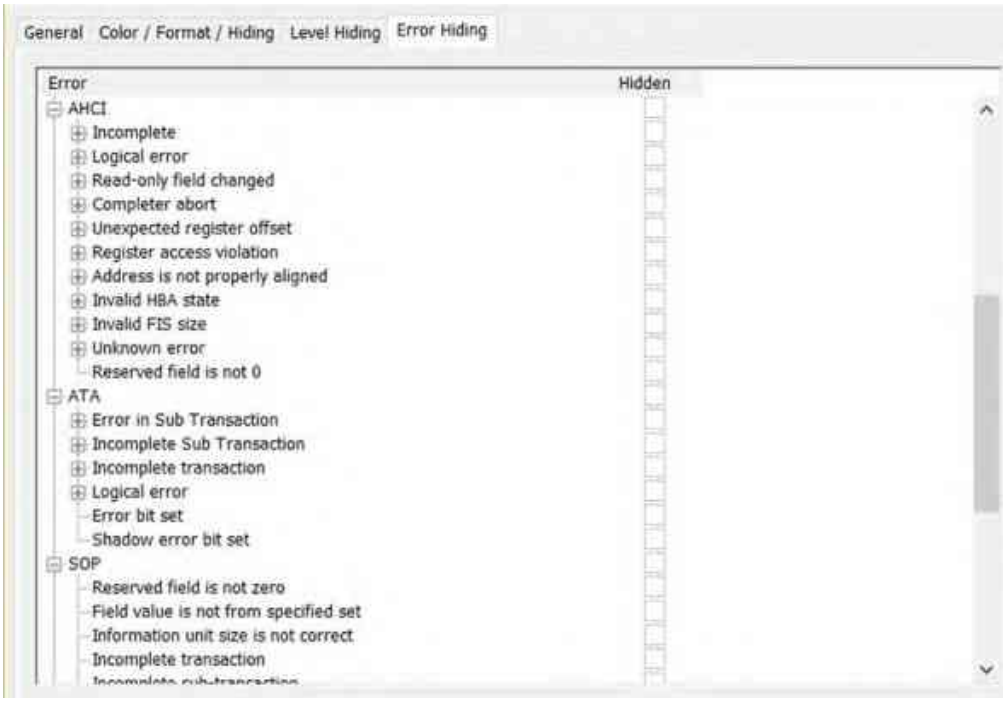


Figure 10.8: Display Options: Error Hiding: Transaction Types: AHCI/ATA/SOP

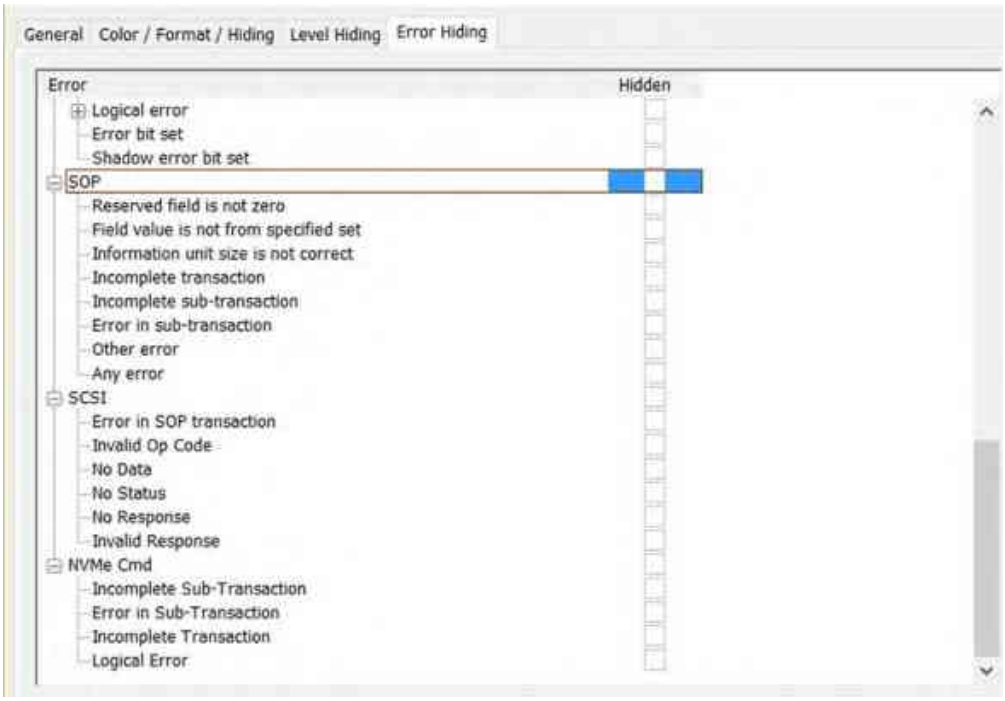


Figure 10.9: Display Options: Error Hiding: Transaction Types: SOP/SCSI/NVMe Cmd

10.2.10 Warning Hiding

The Warning Hiding page lets you hide warnings by Transaction Types (see Figure 10.10). If you select one or more transaction types from the list, the selected warnings are hidden from the CATC Trace.

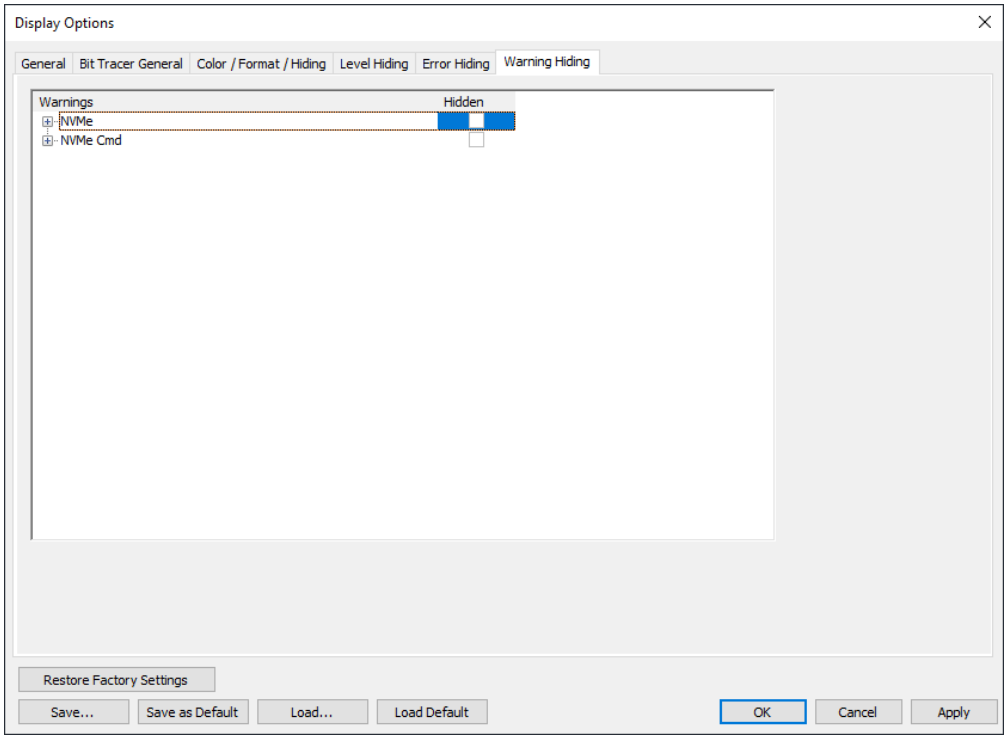


Figure 10.10: Display Options: Warnings Hiding

10.2.10.1 Transaction Types

The Transaction Types which can have their warnings hidden include:

- NVMe
- NVMe Cmds

10.3 Load a Previously Saved Display Options File

If you have previously saved Display Options, you can load them by opening the Display Options dialog and clicking the **Load** button. A dialog opens to let you load a previously saved display options file.

1. Click **Load** to use a previously defined display options file.
2. When you see the Open File pop-up window, enter the name of the file you want to load and click **Open**.
3. When the PCIe Protocol Analysis™ returns you to the Recording Options menu, click **OK** to activate the display options you selected.

10.4 Saving Display Options

If you have customized the Display Options and wish to save them, you can do so by clicking the **Save** button, then entering a unique file name. The **.opt** extension is added by default.

Setting the Defaults: Save the currently specified Display Options to the file name: **default.opt** by clicking **Save As Default.** When the Analyzer software begins execution, it automatically loads the **default.opt** file, if one exists.

Chapter 11

Reports and Tools

Reports assist you in analyzing traffic recorded by the Analyzer. See Figure 11.1.



Figure 11.1: Reports Pull Down Menu

The available reports are:

- **Trace Information**: To view general information about the CATC Trace file. See "Trace Information" on page 643.
- **Error Summary**: To view a count of errors in a CATC Trace file. See "Error Summary" on page 645.
- **Traffic Summary**: To view a summary of protocol-related information in the CATC Trace file summary information about a selected group of items in the

CATC Trace file (such as a count of particular frame or packet types). See “Traffic Summary” on page 657.

- **Bus Utilization**: To display information on bandwidth usage for the transmit and receive channels. See “Bus Utilization” on page 673.
- **Link Tracker**: Displays a detailed chronological view of events. See “Link Tracker” on page 681.
- **Data Flow**: Shows marker, packet, direction, type, length, address, payload, handshake, and timestamp information. See “Data Flow Window” on page 687 and “Flow Control Tracking” on page 688.
- **Trace Navigator**: Navigates within the CATC Trace to view the location of errors and triggers, narrow the range of traffic on display, and jump to any point in the CATC Trace. See “Using the CATC Trace Navigator” on page 689.
- **Detail View**: Shows the detail view of the selected packet. See“Detail View” on page 694.
- **LTSSM Flow Graph**: Shows a state diagram of bus activity. See “LTSSM Flow Graph” on page 695
- **TCG Security View:**
- **IDE View:** Displays decrypted data, IDE-specific information and decryption parameters. See “IDE View” on page 758
- **LM Eye Diagram:** Displays the samples taken during Lane Margining. See “Lane Margining: Eye Diagram” on page 699
- **Packet Header**: Shows packet header information. See “Packet Header Bar” on page 702
- **Packet Data**: Shows packet or transaction payload. See “Packet Data Window” on page 702.
- **Configuration Space**: Displays a Configuration Space. See “Configuration Space View” on page 703.
- **Metrics**: Measures key operating parameters. See “Using Unit Metrics” on page 716 through “Show Metrics in the Bus Utilization Window” on page 720.
- **Real Time Statistics**: To display statistical information for the channels. See “Memory I/O Space Editor” on page 723.
- **Memory I/O Space Editor**: Displays the Memory I/O Space Editor dialog. See “Memory I/O Space Editor” on page 723.
- **TC to VC Mapping**: To display how Traffic Classes are mapped to Virtual Channels (to simplify navigation) and how the CATC Trace display was changed (for example, in Split Transactions). See “TC to VC Mapping” on page 723.
- **Timing Calculations**: To view timing measured between two events set within the CATC Trace file. See “Timing and Bus Usage Calculations” on page 725.
- **PCIe SSD Base Mapping**: Displays the PCIe SSD Base Address dialog. See “PCIe SSD Base Address Mapping” on page 737.
- **Run Verification Scripts**: Allows you to check errors, link transactions, split transactions, metrics, ordered sets, replays, DLLPs, and TLPs. See “Running Verification Scripts” on page 748.
- **Trace Expert**: Generates reports on Performance Analysis, Trace Analysis Statistics, Error Reports and Trace Information. See “Trace Expert” on page 752.

Note: In addition to these Reports and Tools, if you select the CXL Flit Data View  a detailed view of the select CXL packet will be shown below the trace view see "CXL Flit Data View" on page 665.

Reports are available from the Report menu and buttons on the Tool bar. Tools are available from the Tools menu.

11.1 Trace Information

The Trace Information window provides a summary on the currently displayed file.

Select **Reports > Trace Information**  to display the Trace Information window.

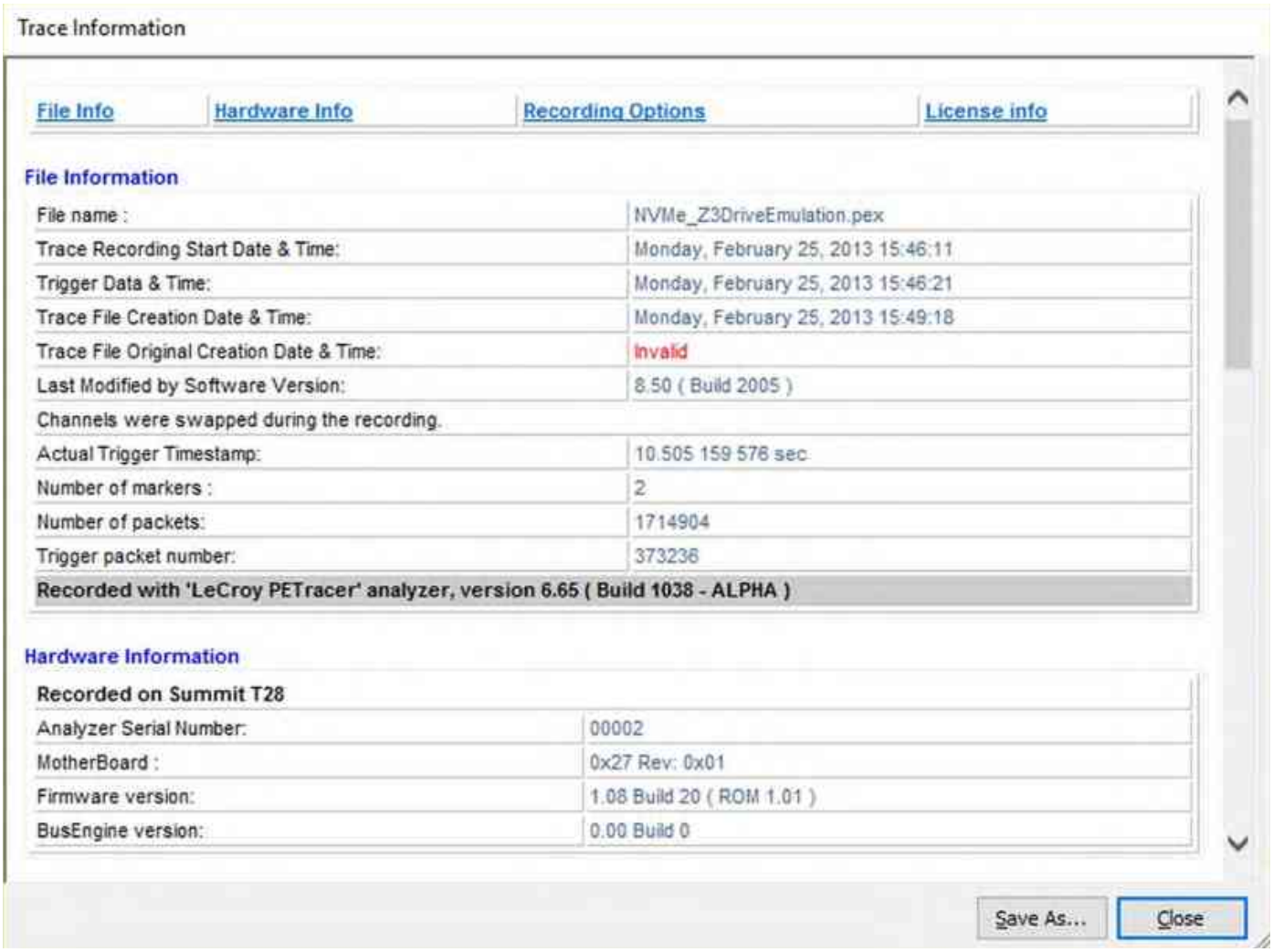


Figure 11.2: Trace Information Part 1

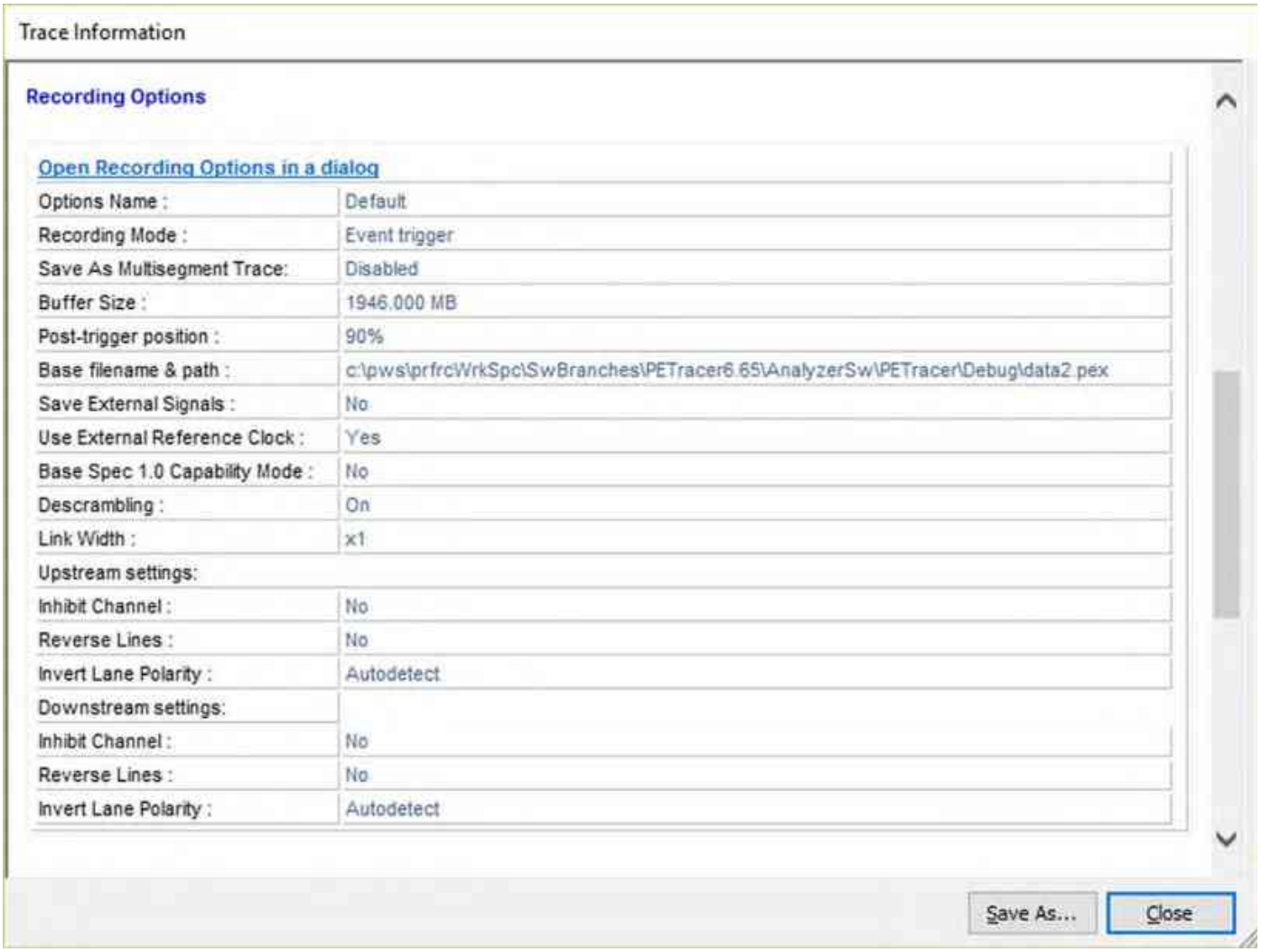


Figure 11.3: Trace Information Part 2

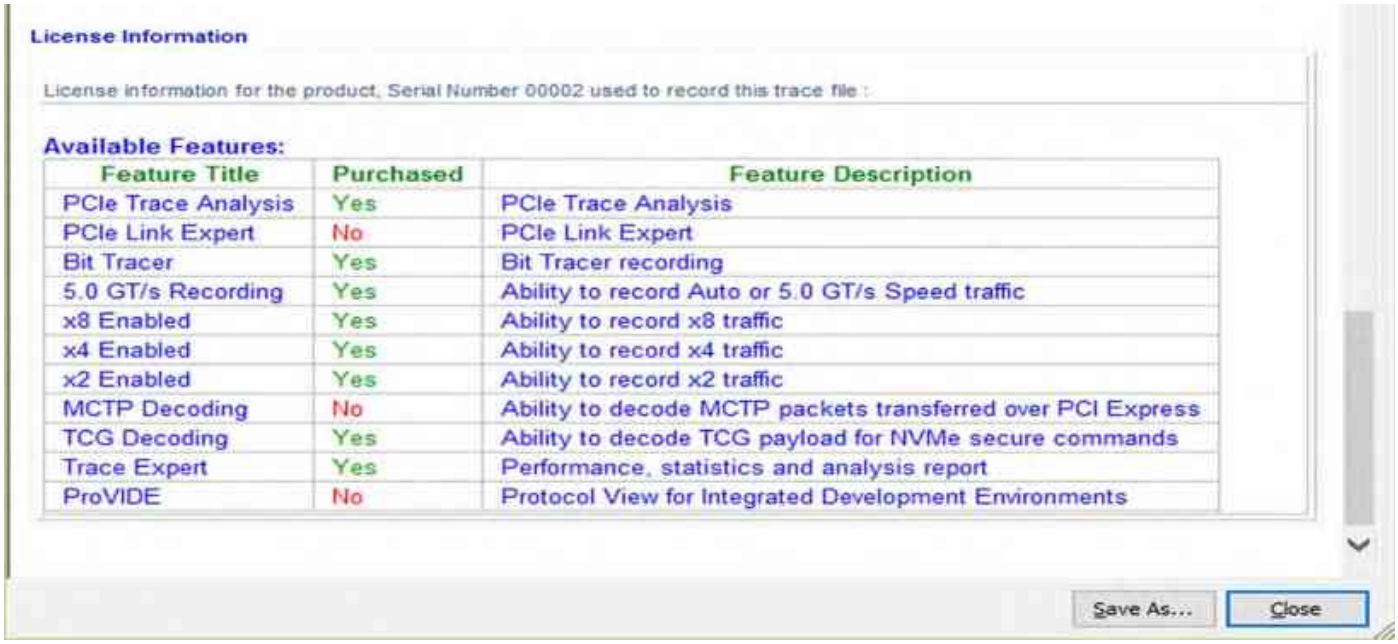


Figure 11.4: Trace Information Part 3

11.2 Error Summary

The Error Summary dialog displays the number of errors for each event and the packet containing the errors.

Select **Reports > Error Summary** or click  to open the Error Summary dialog (see Figure 11.5 on page 645).

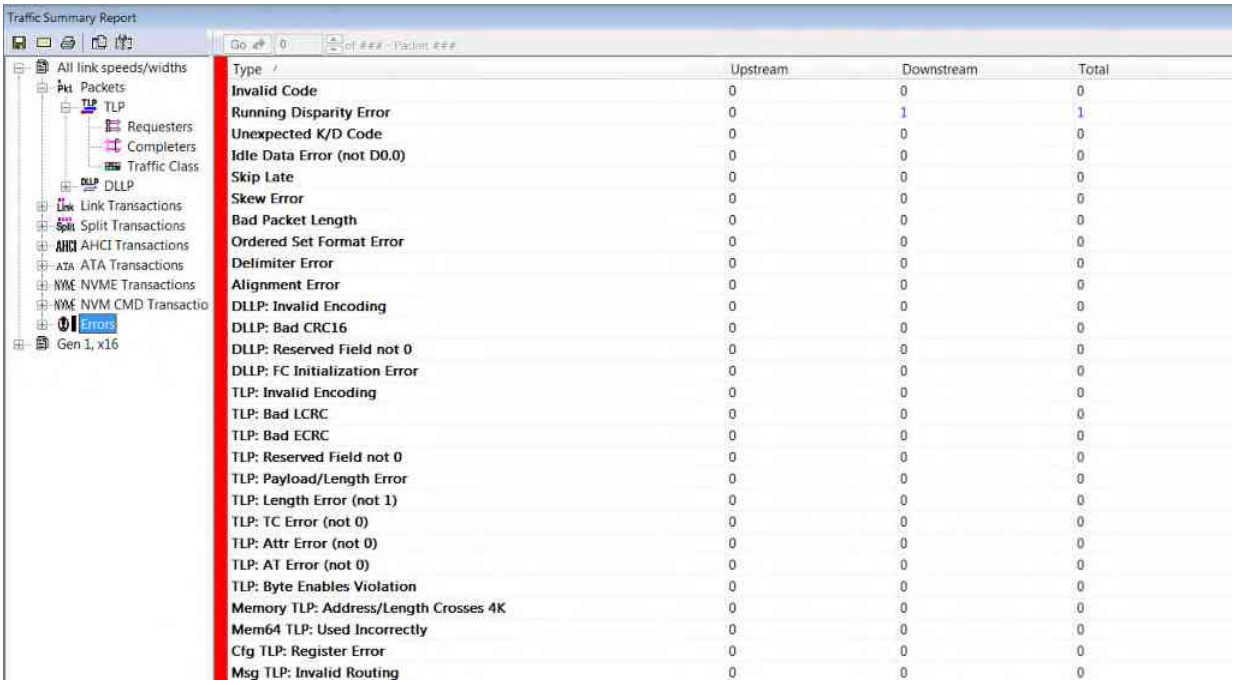


Figure 11.5: Error Summary Dialog.

11.2.1 Error Summary for Storage Protocols

After decoding a trace for the corresponding storage protocol, the CATC Trace will have a summary ready of the errors found for the trace. Example: The AHCI Error Summary dialog is a sub-entry for the main Error Summary dialog. It displays the number of errors for each AHCI transaction containing the errors.

Select **Reports > Error Summary** to open the Error Summary dialog.



Figure 11.6: AHCI Error Summary Dialog.

The five types of AHCI errors are describe below:

Reserved Field not Zeroes

One or more fields inside the AHCI transaction are not filled with all 0s. The AHCI specification states that all reserved fields and registers must be filled with 0s.

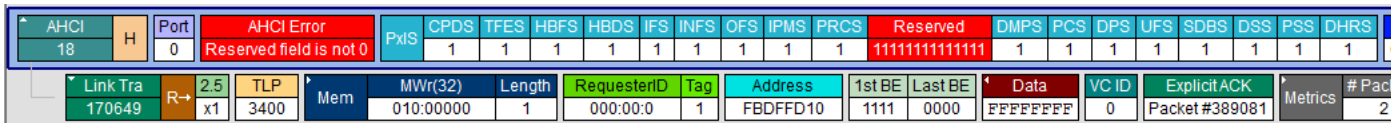


Figure 11.7: Reserved Field Not Filled With Zeroes

Note: Reserved fields for AHCI level are not displayed when filled with all 0s.

Incomplete

The AHCI transaction does not contain enough data or lower-level transactions (Link or Split) are marked as incomplete.

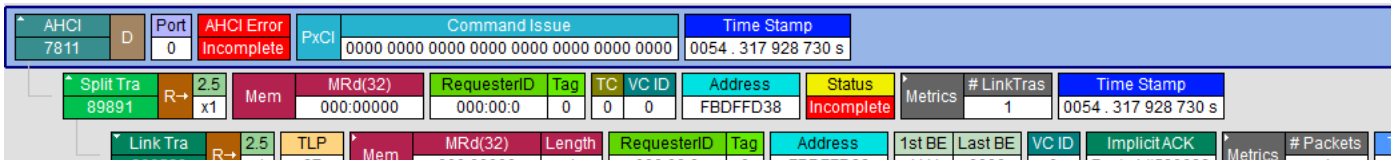


Figure 11.8: Incomplete

Logical Error

One or more fields are in an inconsistent state relative to the other fields in the same or other registers.

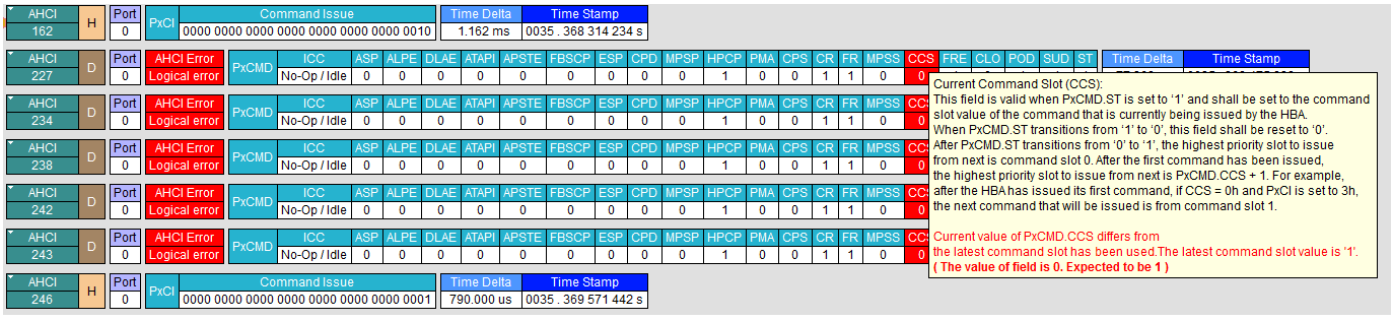


Figure 11.9: Logical Error

Read-only Field Changed

The value of the read-only field differs from the previous one.

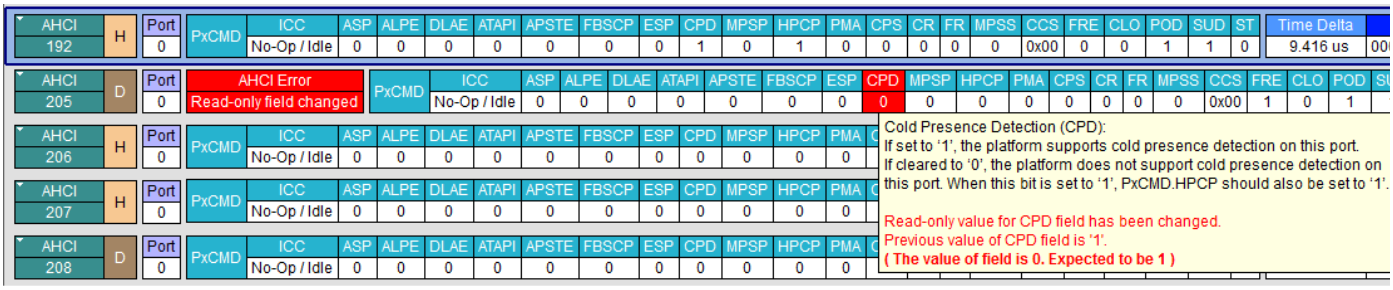


Figure 11.10: Read-only Field Changed

Unknown

The AHCI decoder is unable to decode a particular transaction correctly. This can be caused by missing base address information. Make sure the enumeration phase has been recorded in the trace or provide base address information by selecting **Tools > PCIe SSD Base Address Mapping**.



Figure 11.11: Unknown

Checks for Logical error and Read-only field depending on the values obtained from previous registers. It can result in false-positive or false-negative detections in case of partially saved trace file. The AHCI transaction can be marked as incomplete in case of saving a portion.

11.2.2 Error Summary for Storage Protocols — NVMe

The NVMe sub-entry of the Error Summary dialog displays the number of NVMe errors found while decoding the trace at the NVMe level as shown in Figure 11.12, Figure 11.13 and Figure 11.14.

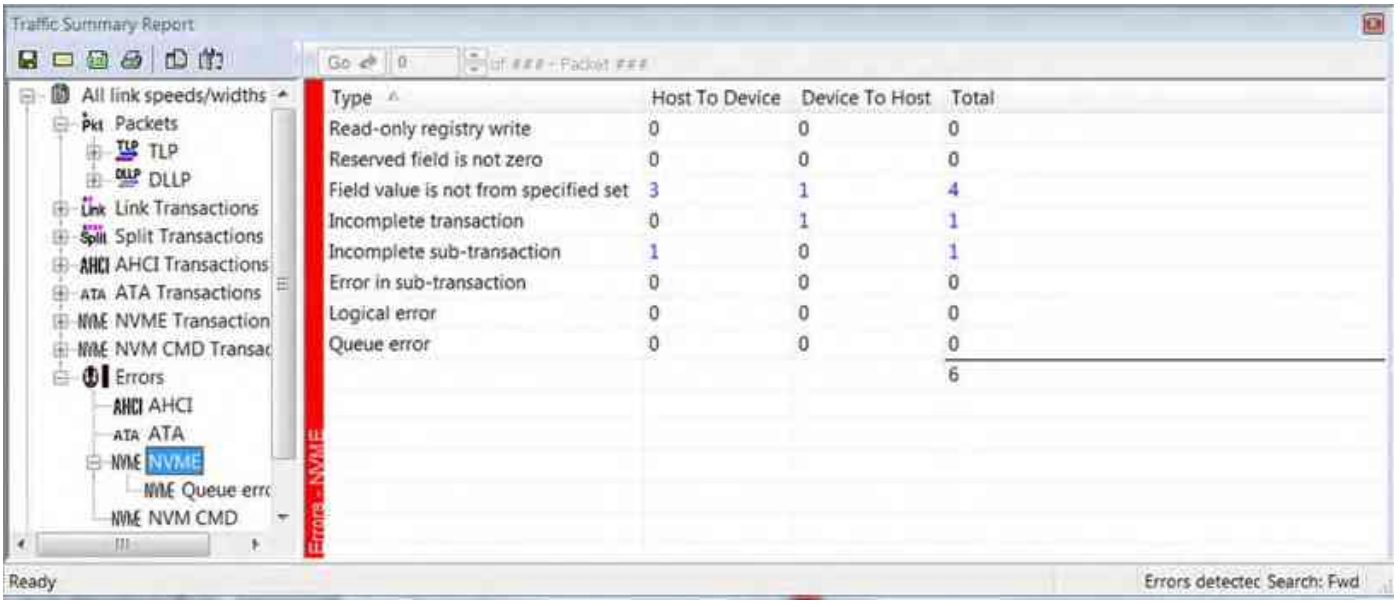


Figure 11.12: NVMe Errors After Decoding the Trace

11.2.2.1 Types of NVMe Errors:

1. Read-only register write: An attempt to write to a read only register was made.
2. Reserved field is not zero: One (or more) of the fields set as reserved in the current spec revision is not zero - this could indicate a problem such as reversed bit ordering, or it could be intentional such as working with unreleased version of the next specification or user debug bits.
3. Field values is not from specified set: There is a value used in the indicated field that is not used in the currently released specification. If working with an early release of the next specification, or a proprietary feature this could be valid otherwise it would normally indicate a problem.
4. Incomplete transaction: One or more of the steps for a NVMe transaction is missing eg no completion queue entry after submission queue submission.
5. Incomplete sub-transaction: Some NVMe transactions have sub states and this indicates that within a substate part of the expected sequence is missing.
6. Error is sub-transaction: Some NVMe transactions have sub states and this indicates that within a substate an error in the sequence or value was detected.
7. Logical error: Groups any potential logic errors, such as declaring a payload of 64 bytes (0) but sending 0 bytes.

8. Queue error: There was an error in writing to the queue. Eg writing to a queue before it was created or trying to write additional entries to a queue that was full. There are a series of specific errors available on the NVMe Queue error report.

11.2.3 NVMe Queue Errors

The NVMe Queue Error sub-entry of the Error Summary dialog lists NVMe errors which are specific to interacting with the NVMe queues.

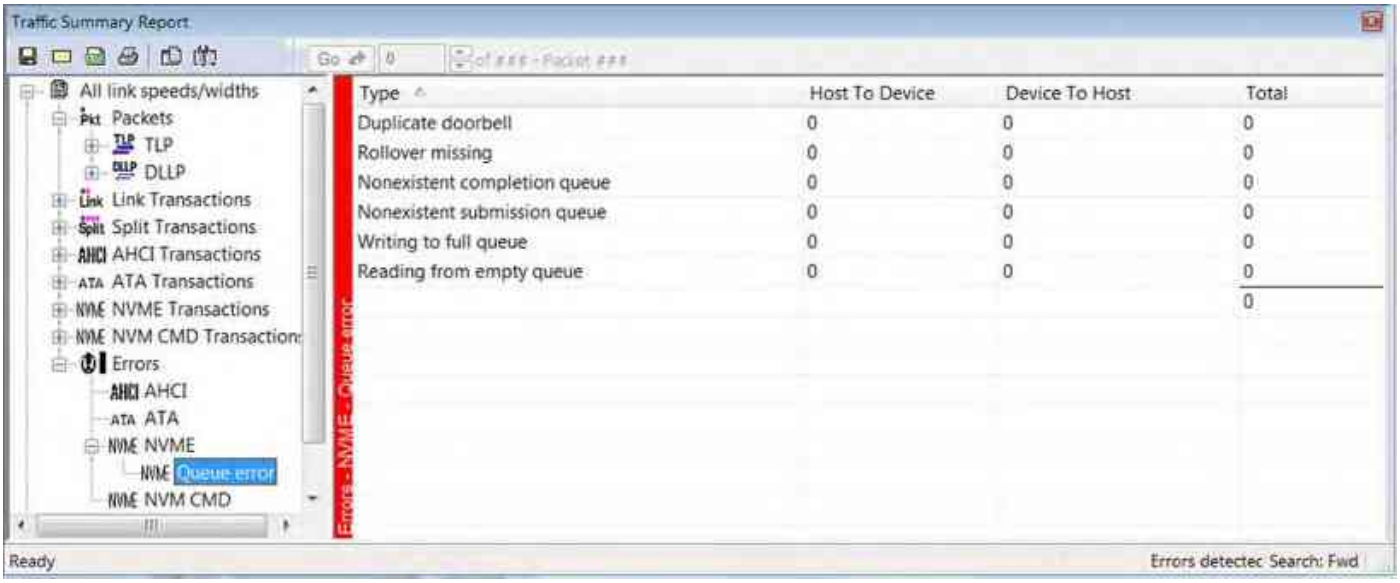


Figure 11.13: NVMe Errors Specific to NVMe Queues

11.2.3.1 Types of NVMe Queue Errors

1. Duplicate doorbell: The same doorbell was used consecutively.
2. Rollover missing: The queue rollover was missed.
3. Nonexistent completion queue: A completion queue was attempted to be used before it had been created.
4. Nonexistent submission queue: A submission queue was attempted to be used before it had been created.
5. Writing to full queue: All possible entries in the queue were previously filled and have not been cleared yet and the current write would add more entries than the declared size of the queue.
6. Reading from empty queue: A queue has had no entries submitted or all previous entries have already been read such that there are no entries in the queue to be read, however a read was attempted even though there are no entries.

11.2.4 NVMe CMD Errors

The NVMe CMD sub-entry of the Error Summary dialog lists errors which are specific to NVMe command decoding. See Figure 11.14.

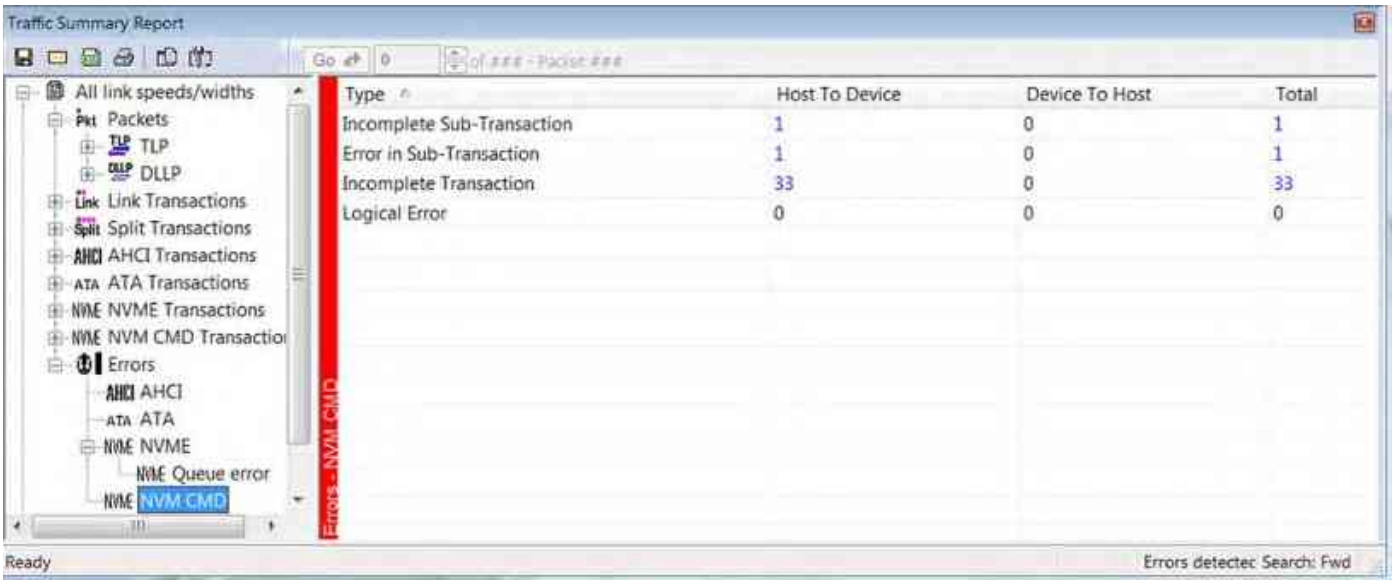


Figure 11.14: NVMe Errors Specific to NVMe Commands

11.2.4.1 Types of NVMe CMD Errors

1. Incomplete Sub-Transaction: Some NVMe transactions have sub states and this indicates that within a substate the required sequence was not completed.
2. Error in Sub-Transaction: Some NVMe transactions have sub states and this indicates that within a substate an error in the sequence or value was detected.

3. Incomplete Transaction: One (or more) of a transactions steps are missing, example shows a transaction missing the doorbell and the preceding one that has all the transaction steps. See Figure 11.15.

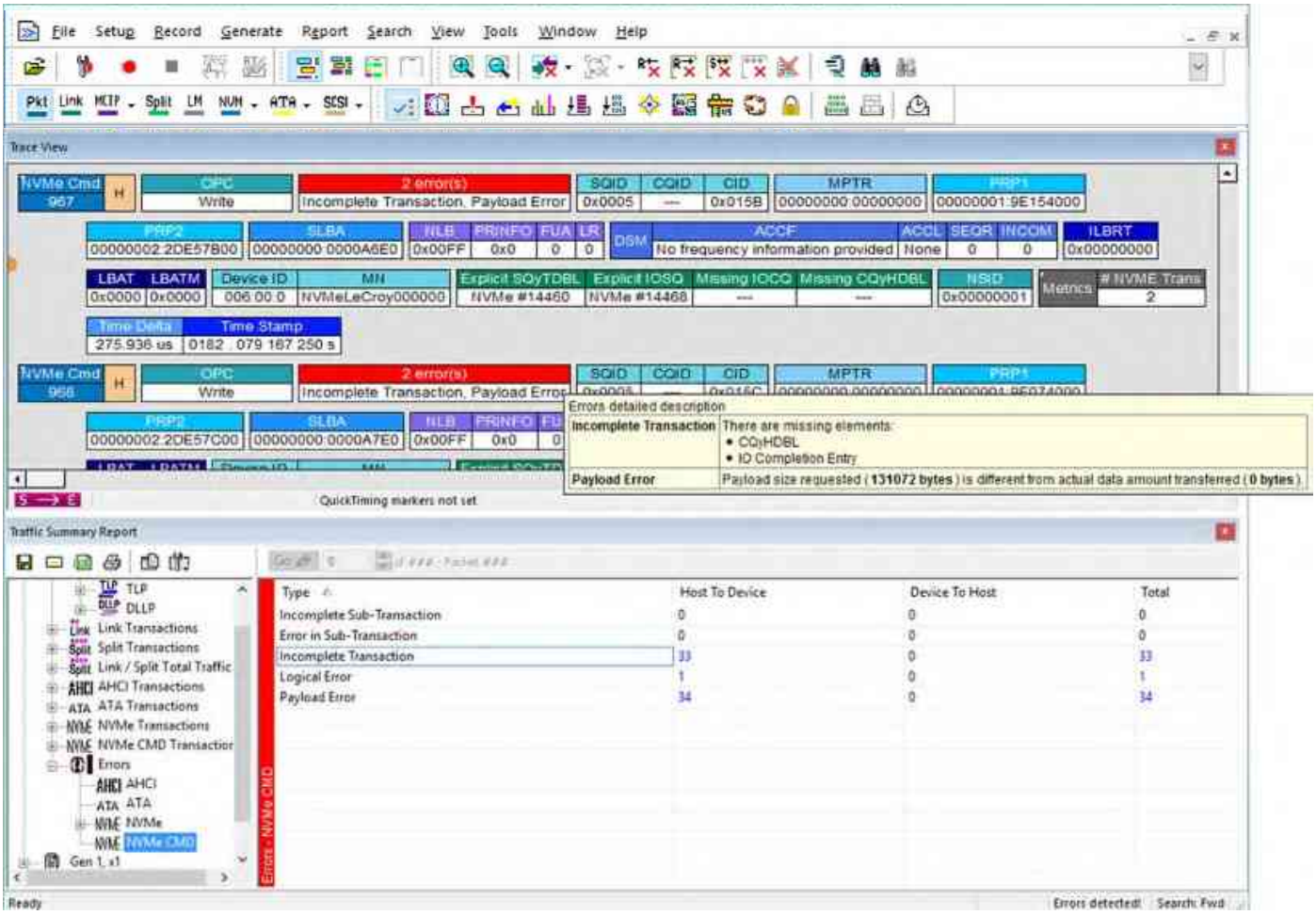


Figure 11.15: NVMe CMD Error -> Incomplete Transaction with Tooltip

4. Logical Error: Groups any potential logic errors, such as declaring a payload of 64 bytes (0) but sending 0 bytes. See Figure 11.16.

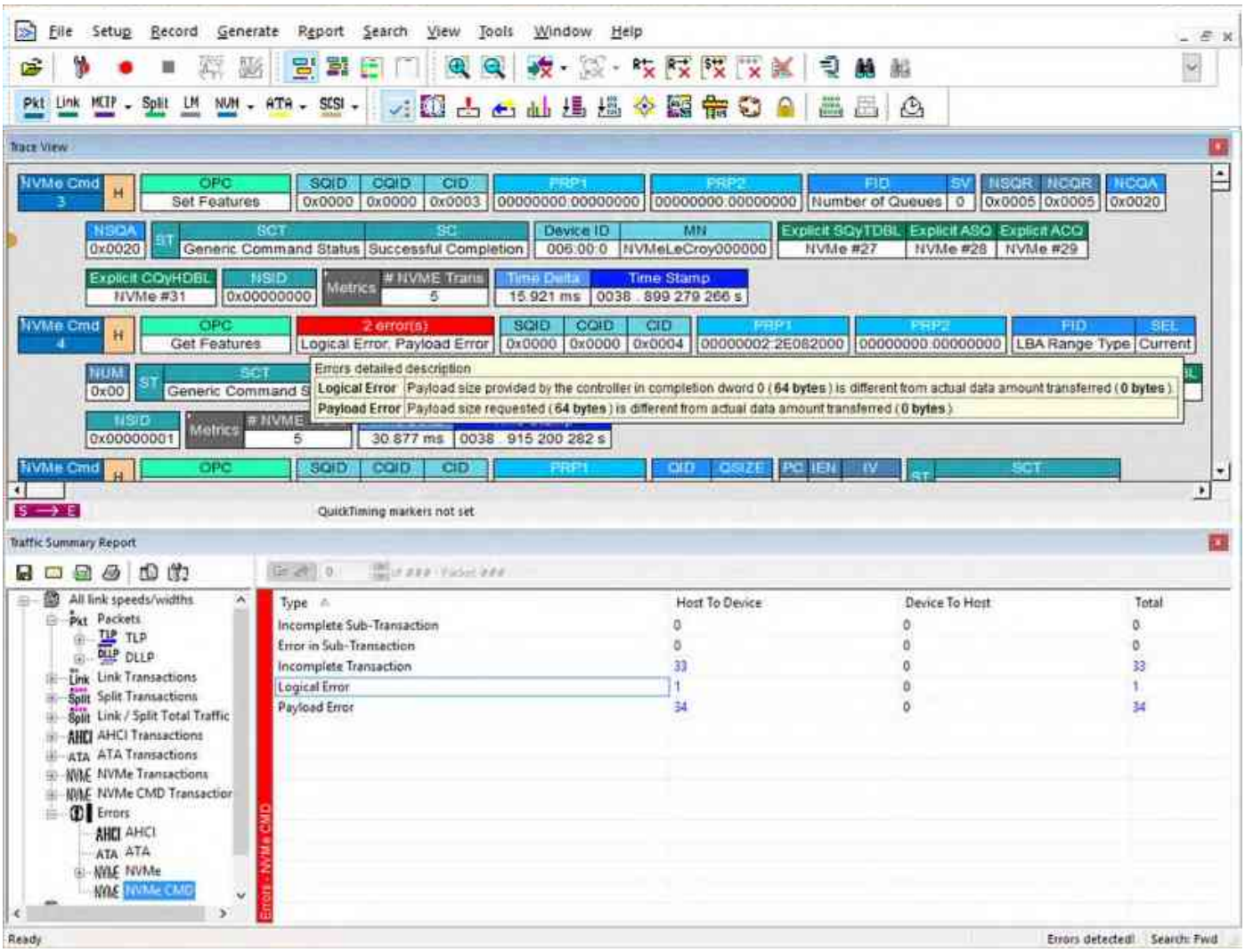


Figure 11.16: NVMe CMD Error -> Logical Error with Tooltip

11.2.5 Physical Layer Errors

11.2.5.1 128b/130b Decoding Error

During a speed change, the invalid packets are shown, but it doesn't specify the decoding error type.

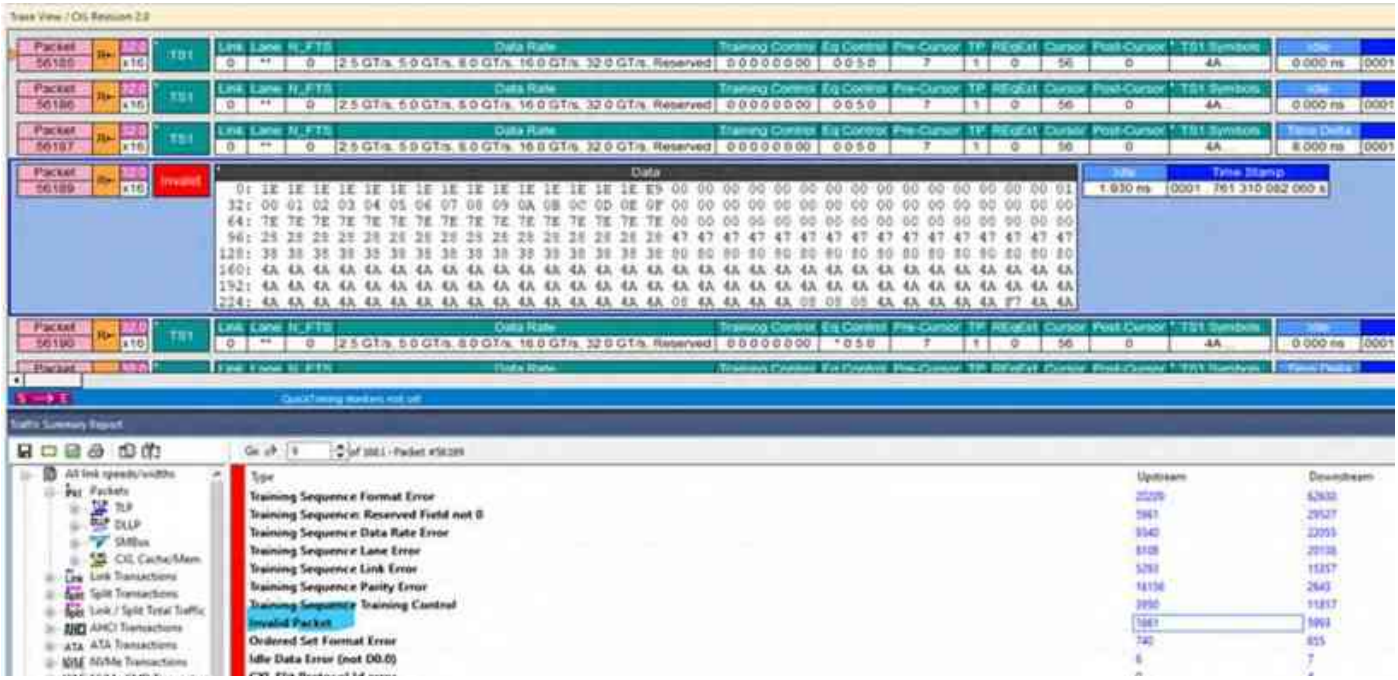


Figure 11.17: Invalid Packet Error

11.2.5.2 Framing Token Error in L0

This error displays when the analyzer receives bad TLP.

Type	Upstream	Downstream
TLP	0	0
DLLP	210993	755649
TS1 Ordered Set	221796	317864
TS2 Ordered Set	250	27118
Fast Training Sequence	0	0
Electrical Idle Ordered Set	1	1
Standard SKP Ordered Set	350648	350987
Control SKP Ordered Set	308690	308690
Compliance Pattern	0	0
Electrical Idle Exit Ordered Set	6939	10783
Link Event	2	2
Start Data Stream Ordered Set	1	1
End Bad Framing Token	0	0
End Data Stream Framing Token	0	0

Figure 11.18: Framing Token Errors

11.2.5.3 Receiving an OS Block Immediately Following an SDS Ordered Set

The analyzer doesn't show this as an error. During a speed change, we can see EIEOS and EIOS immediately after SDS. In Figure 11.19, an EIEOS is Sent/Received after SDS but is not marked as an error.



Figure 11.19: OS Block Error

11.2.5.4 Ordered Set other than EIE/EI/SKP In Data Stream

The analyzer doesn't show this error in a trace. If recovery happens and EIEOS is not captured and subsequently we see TS1 after TLPs/DLLPs, the TS1 is not marked as error.

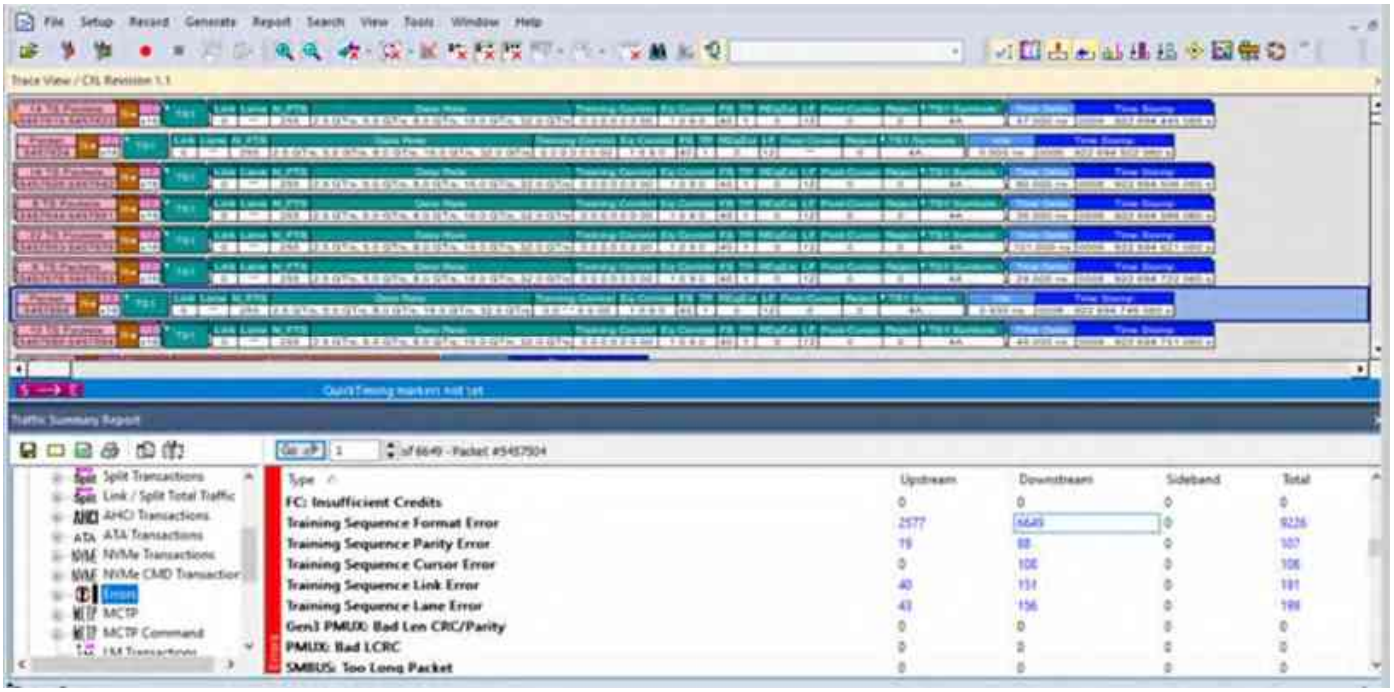


Figure 11.20: Ordered Set Error

11.2.5.5 Idle Data Error Detection

Idle data error is shown in Error summary. A red line appears in the trace indicating the same.

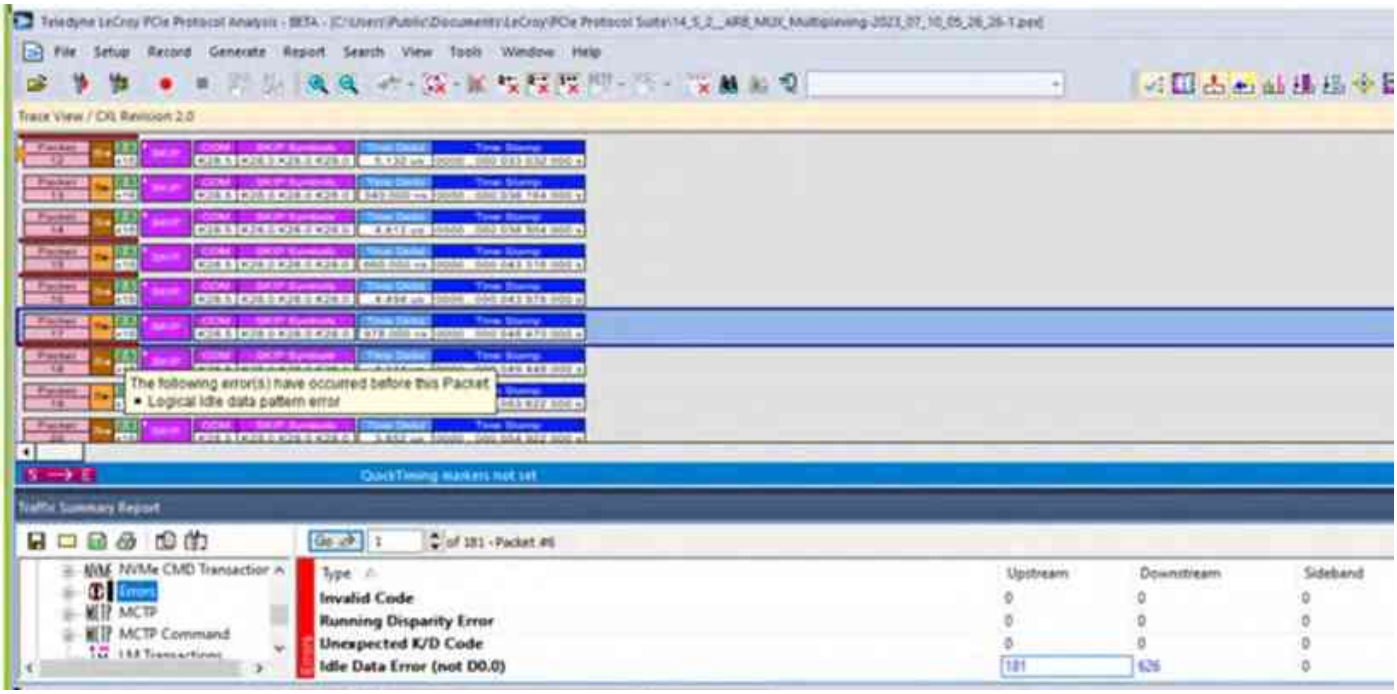


Figure 11.21: Idle Data Error

11.2.5.6 Logical Idle Pattern Error

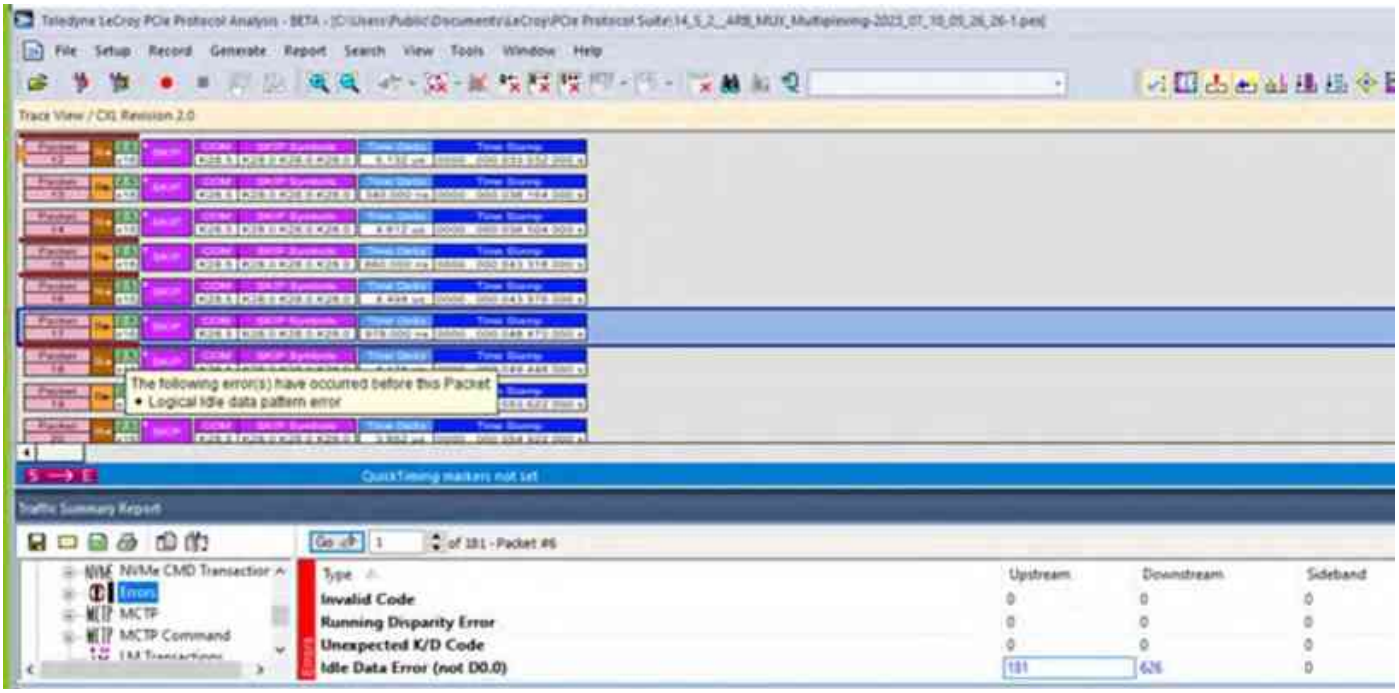


Figure 11.22: Logical Pattern Error

11.2.5.7 Non-0 Value That Is Not a STP/SDP/EDS/EDB

All of these packets are shown as invalid packets, and they are reported in the error summary.

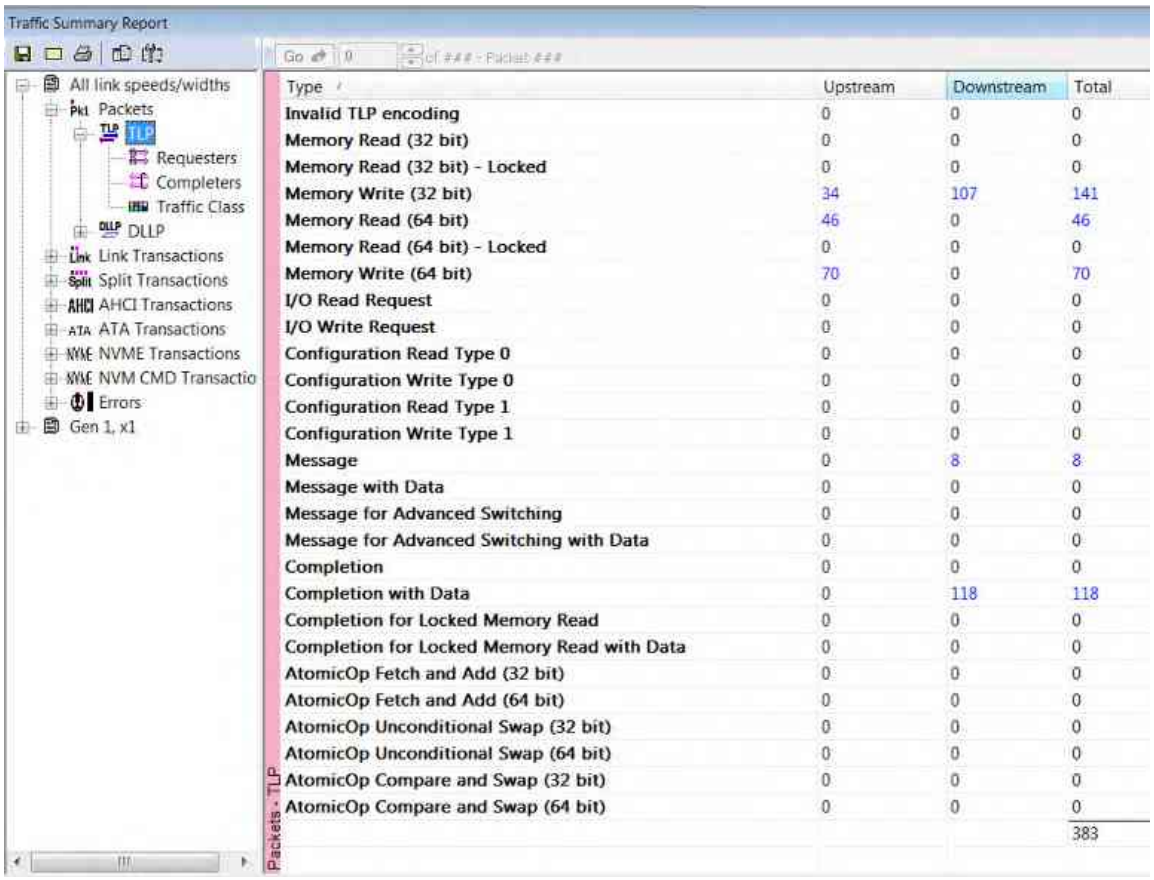
11.2.5.8 Parity Error in Received Standard SKP OS on all 16 Lanes

This should be shown in error summary. This error is shown for SKPs when the link is bad.

11.3 Traffic Summary

The Traffic Summary window summarizes the traffic in the current CATC Trace. The left side of the window displays a tree of protocol levels. The right side displays a summary of traffic for the displayed levels.

Select **Report > Traffic Summary** or click  to display the Traffic Summary window.



Type	Upstream	Downstream	Total
Invalid TLP encoding	0	0	0
Memory Read (32 bit)	0	0	0
Memory Read (32 bit) - Locked	0	0	0
Memory Write (32 bit)	34	107	141
Memory Read (64 bit)	46	0	46
Memory Read (64 bit) - Locked	0	0	0
Memory Write (64 bit)	70	0	70
I/O Read Request	0	0	0
I/O Write Request	0	0	0
Configuration Read Type 0	0	0	0
Configuration Write Type 0	0	0	0
Configuration Read Type 1	0	0	0
Configuration Write Type 1	0	0	0
Message	0	8	8
Message with Data	0	0	0
Message for Advanced Switching	0	0	0
Message for Advanced Switching with Data	0	0	0
Completion	0	0	0
Completion with Data	0	118	118
Completion for Locked Memory Read	0	0	0
Completion for Locked Memory Read with Data	0	0	0
AtomicOp Fetch and Add (32 bit)	0	0	0
AtomicOp Fetch and Add (64 bit)	0	0	0
AtomicOp Unconditional Swap (32 bit)	0	0	0
AtomicOp Unconditional Swap (64 bit)	0	0	0
AtomicOp Compare and Swap (32 bit)	0	0	0
AtomicOp Compare and Swap (64 bit)	0	0	0
			383

Figure 11.23: Traffic Summary Dialog

Buttons at the top of the Traffic Summary window change the display format and enable data to be exported to email, file, or the printer.

11.3.1 Traffic Summary for Storage Protocols

After decoding a trace for the corresponding storage protocol, the CATC Trace will have a summary ready of the commands existing in the trace. Example: The AHCI Traffic Summary window summarizes the AHCI traffic in the current CATC Trace. The right side displays a summary of AHCI transactions and errors.

Select **Reports > Traffic Summary** to open the Traffic Summary dialog.

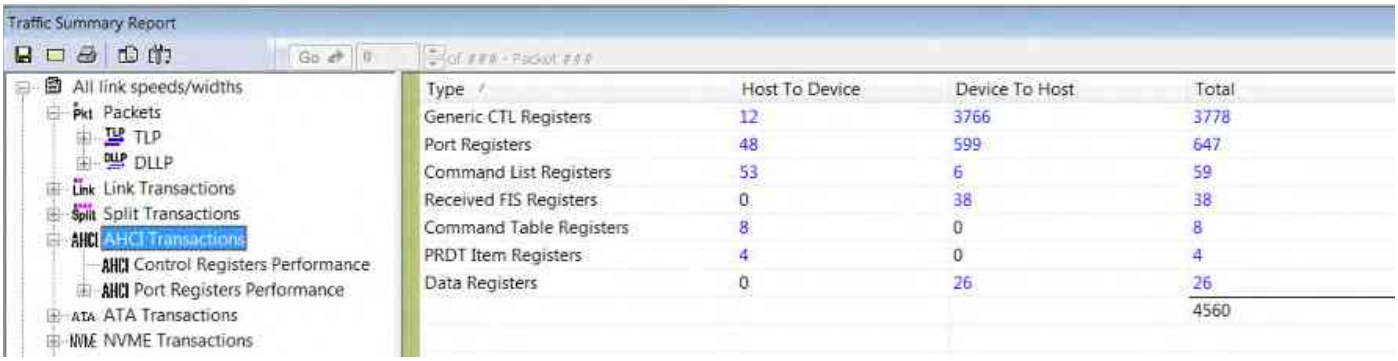


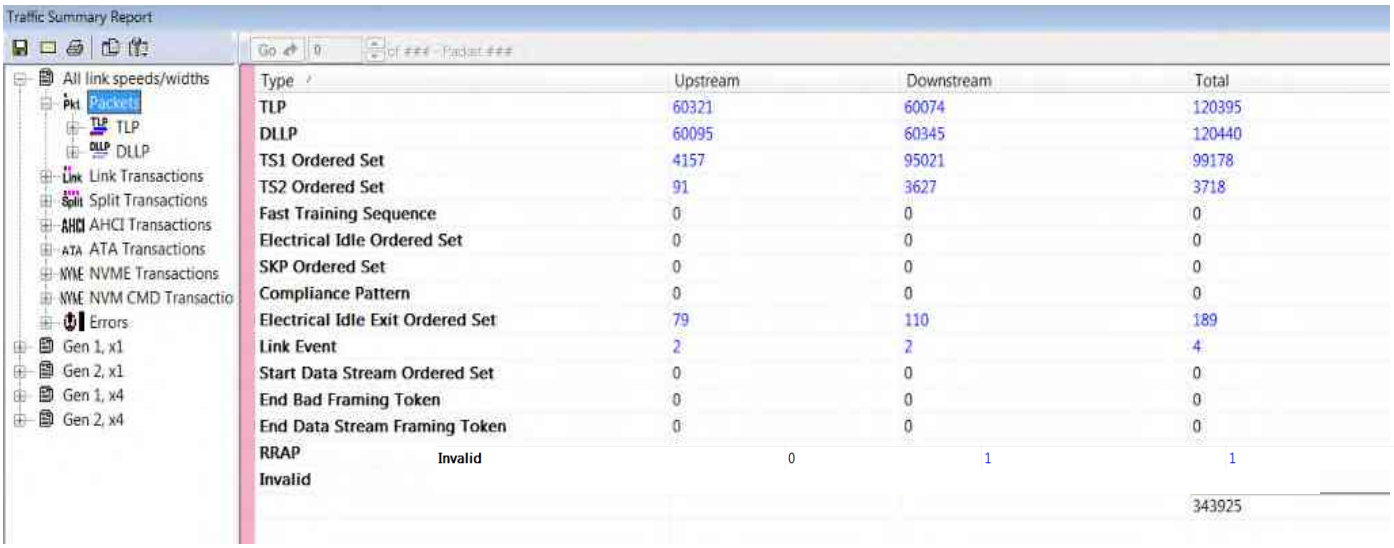
Figure 11.24: AHCI Traffic Summary Dialog

11.3.2 Using the Traffic Summary Window to Search the CATC Trace

You can use the Traffic Summary window to move the CATC Trace to packets of interest:

1. Click one of the numbers in the right side of the Traffic Summary window (see the following figure).

   The CATC Trace jumps to the first instance of the selected protocol.



2. Click the **up** or **down** arrows 

. The CATC Trace jumps forward or backward through the display to the next instance of selected protocol level.

11.3.3 NVMe Queue Time Metrics

NVMe Queue Time Metrics can be seen in the Traffic Summary, which includes all of the Doorbell Metrics (see Figure 11.25).

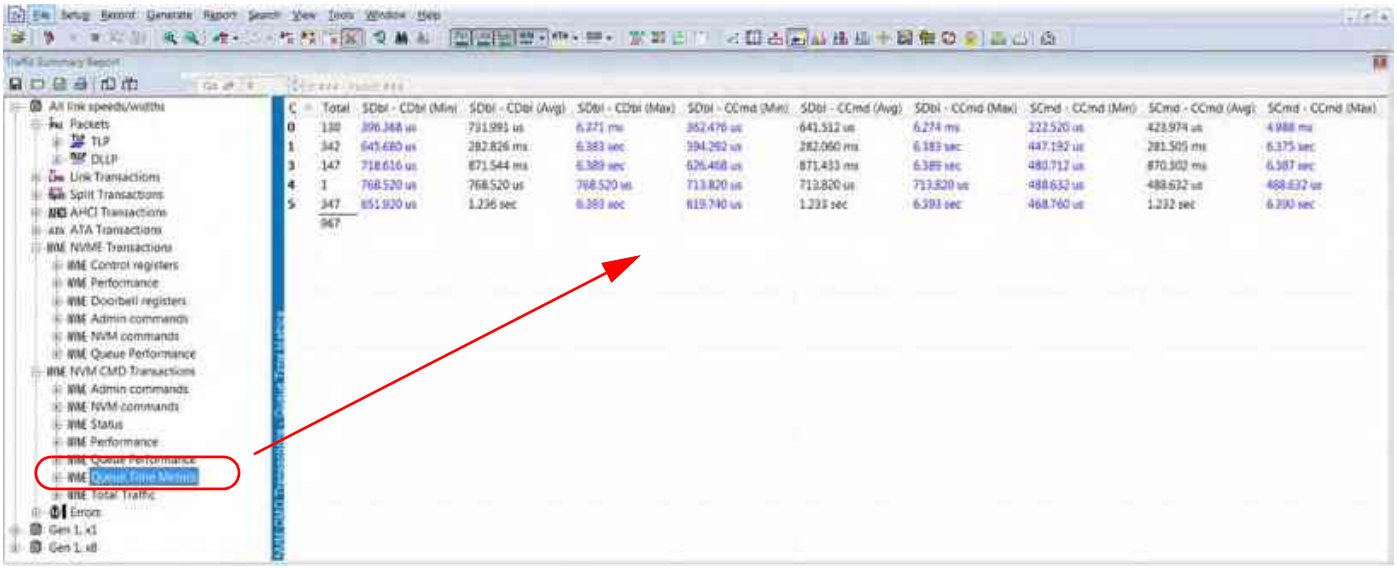


Figure 11.25: NVMe Queue Time Metrics for Doorbell Operations

11.3.3.1 NVMe Queue Time Metrics Defined (Commands/Transactions)

TABLE 11.1: NVMe Queue Time Metrics (Commands/Transactions)

NVMe Queue Time Metrics	Definition
# NVME Trans	Number of NVME Transactions - the total number of NVME Transactions that compose this NVME Command
# Link & Split Trans	Number of Link & Split Transactions - the total number of Link & Split Transactions that compose this NVME Transaction
Response Time	Time it took to transmit this NVME Command/Transaction on the link, from the beginning of the first packet in the NVME Command/Transaction to the end of the last packet in the NVME Command/Transaction
Latency Time	Time measured from the end of transmission of the NVMe submission command to start of transmission of the NVMe completion command
Pld. Bytes	Payload: Number of payload bytes this NVME Command transferred
Thrpt MB/s	Data Throughput: Payload divided by response time, expressed in megabytes (MB = 1024*1024 bytes) per second (applies to both Commands and Transactions)
IOPS	Input/Output Operation per Second: Calculated as weighted total of all transactions that overlap with the current one, divided by duration of the current transaction
SDbl - CDbl	Time measured between Submission Doorbell and Completion Doorbell
SDbl - CCmd	Time measured between Submission Doorbell and Completion Command
SCmd - CCmd	Time measured between Submission Command and Completion Command

These definitions are readily available by loading an NVMe Trace, Decoding the NVMe Commands or Transaction, locating the Metrics block in the Trace View and hovering the cursor over each of the NVMe Queue Time Metrics to bring up the Tool Tip.

11.3.3.2 NVME Command Example

As an example for NVMe Command: For SDbl - CDbl see Figure 11.26.

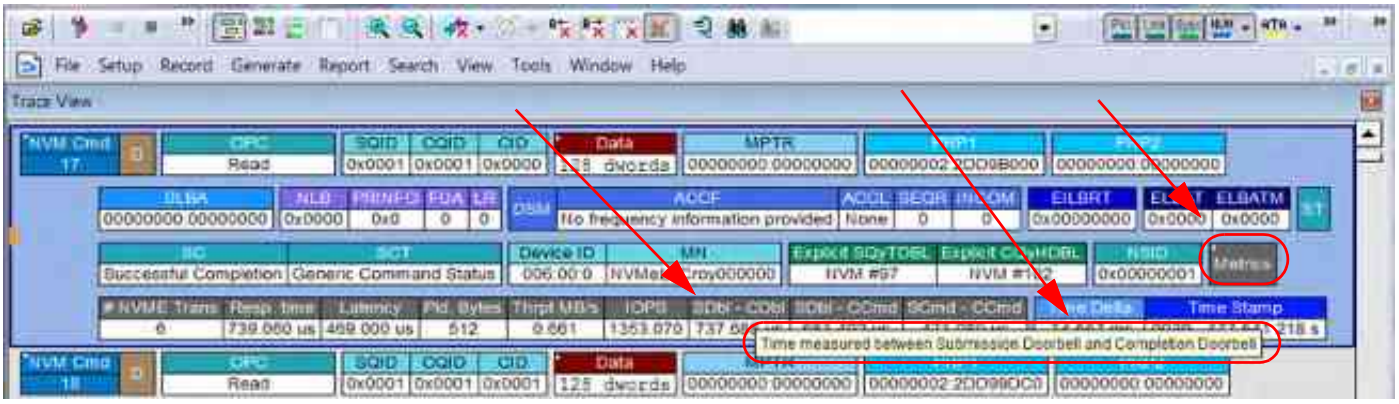


Figure 11.26: NVMe Queue Time Metrics Defined: SDbl - CDbl

11.3.3.3 NVME Transaction Example

As an example for NVMe Transactions: For Resp time: see Figure 11.27.

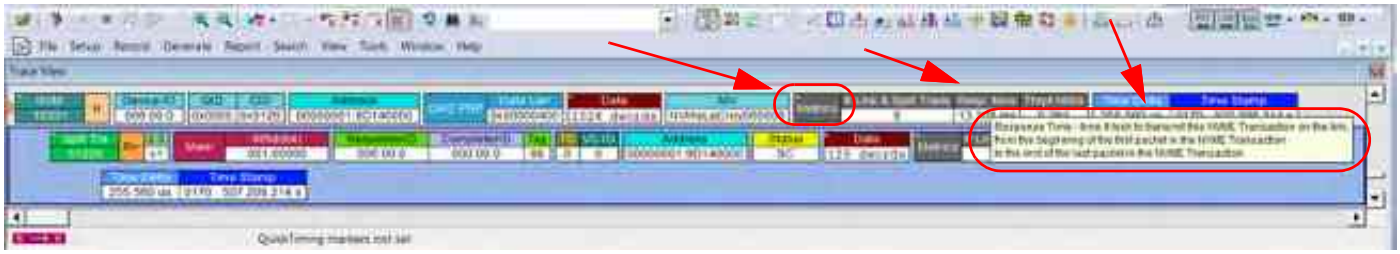


Figure 11.27: NVMe Transactions Metrics: Response Time

11.3.4 Traffic Summary Buttons

Buttons at the top of the Traffic Summary dialog provide options for exporting the data or formatting its appearance:

	Save. Saves Traffic Summary results into an HTML format.
	Email. Attaches an HTML file of the results to a new email.
	Print. Prints results.
	Text. Displays results in HTML format.
	Options. Opens a drop-down menu with the following options: **Grid Lines**: Displays/Hides grid lines **Row Selection**: Allows entire rows to be selected **Tight Columns**: Reformats column widths to match data **Event Navigation**: Skip Hidden Items Show Hidden Items Prompt each time

11.3.5 Traffic Summary for Flow Control

After loading a trace with Flow Control packets in it, you can display the packets which have flow control data and the associated trace as shown below (see Figure 11.28).

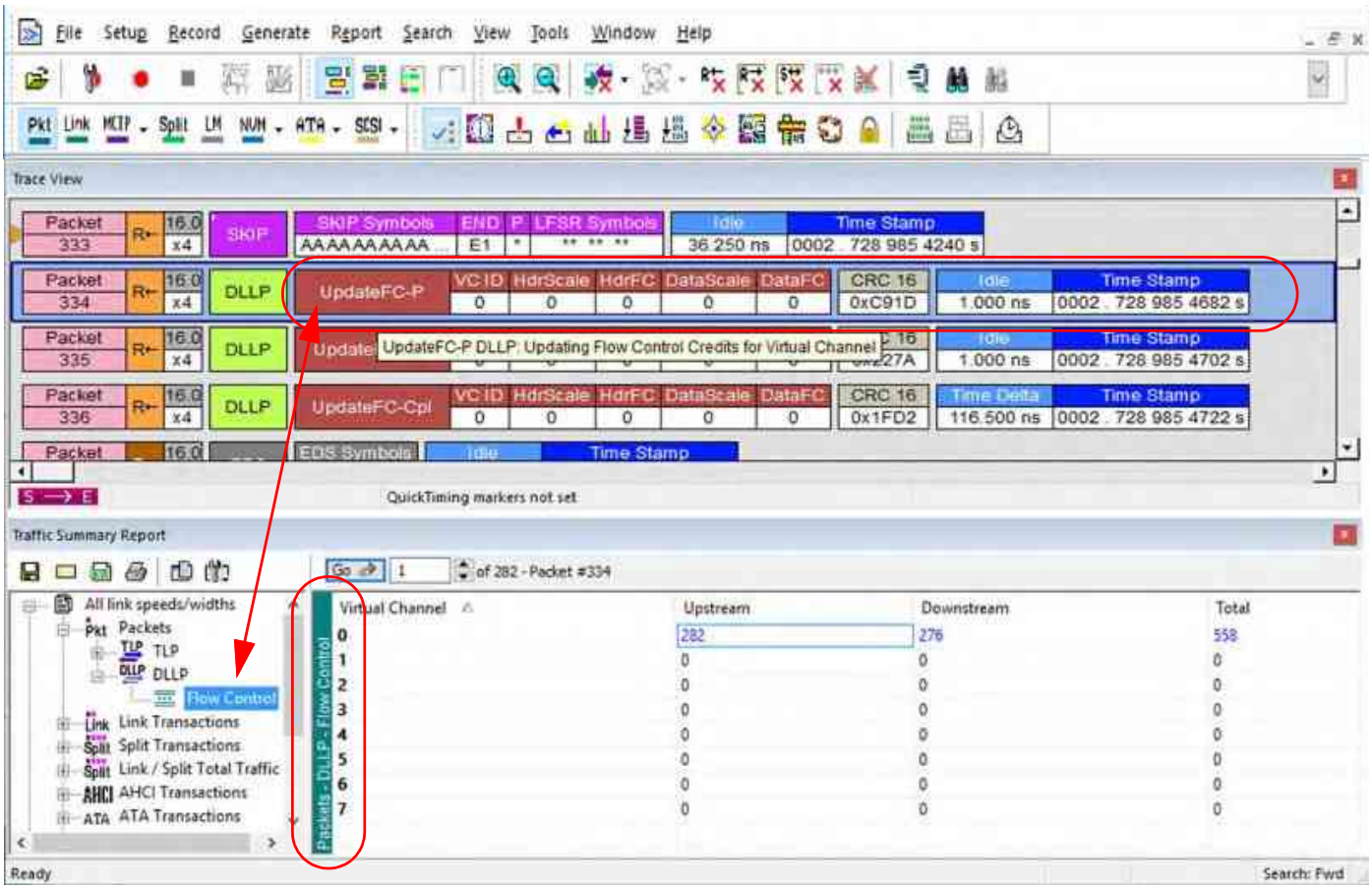


Figure 11.28: Flow Control Trace Showing Traffic Summary

11.3.6 Example: CXL in Traffic Summary

When you have a trace with CXL traffic, you can see that traffic in the Traffic Summary Report. See Figure 11.29.

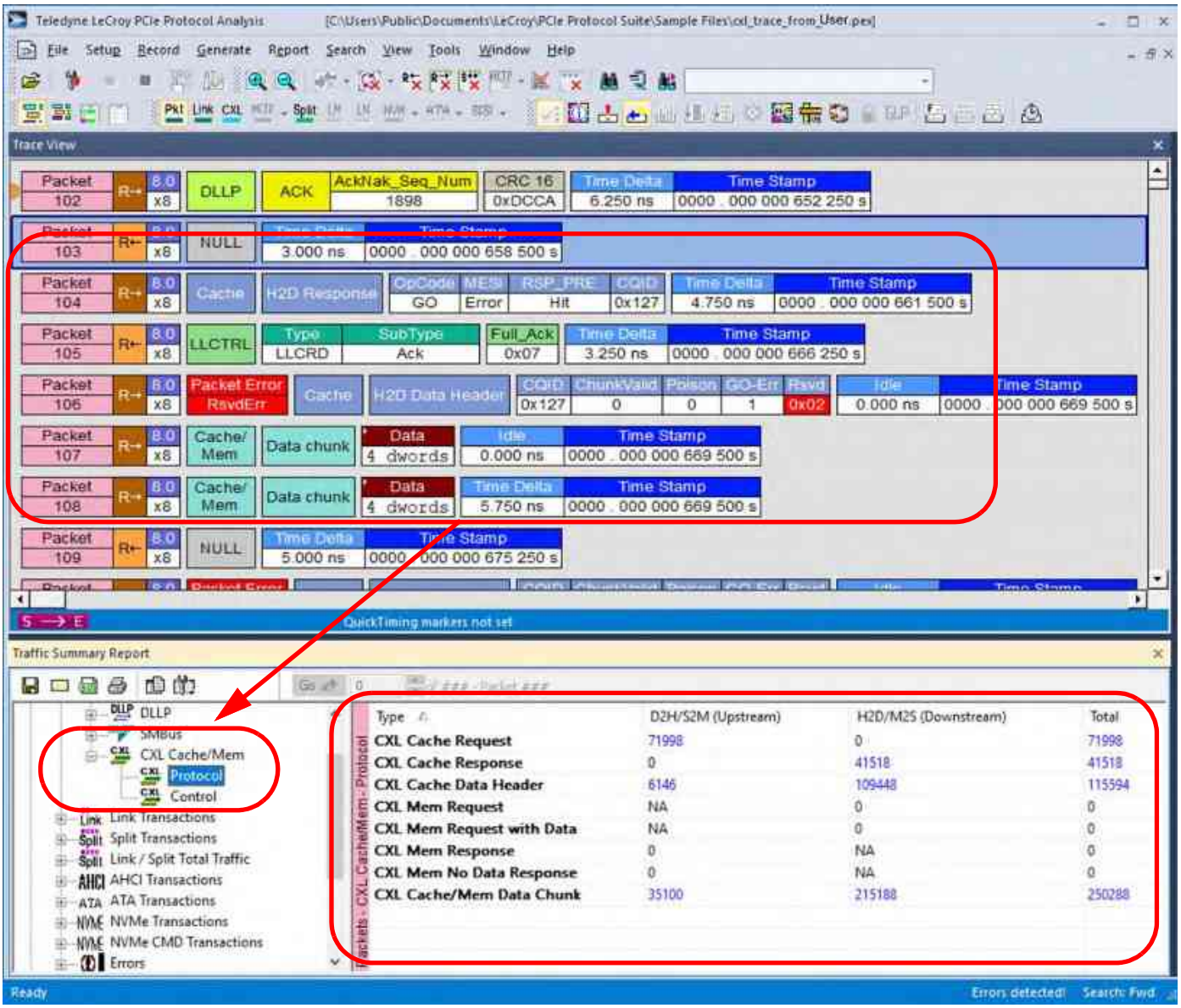


Figure 11.29: Traffic Summary: CXL traffic

11.3.7 Example: CXL Errors Shown in Traffic Summary Report

The PCIe Protocol Analysis software can decode and display a wide variety of CXL errors in the Traffic Summary Report. See Figure 11.30.

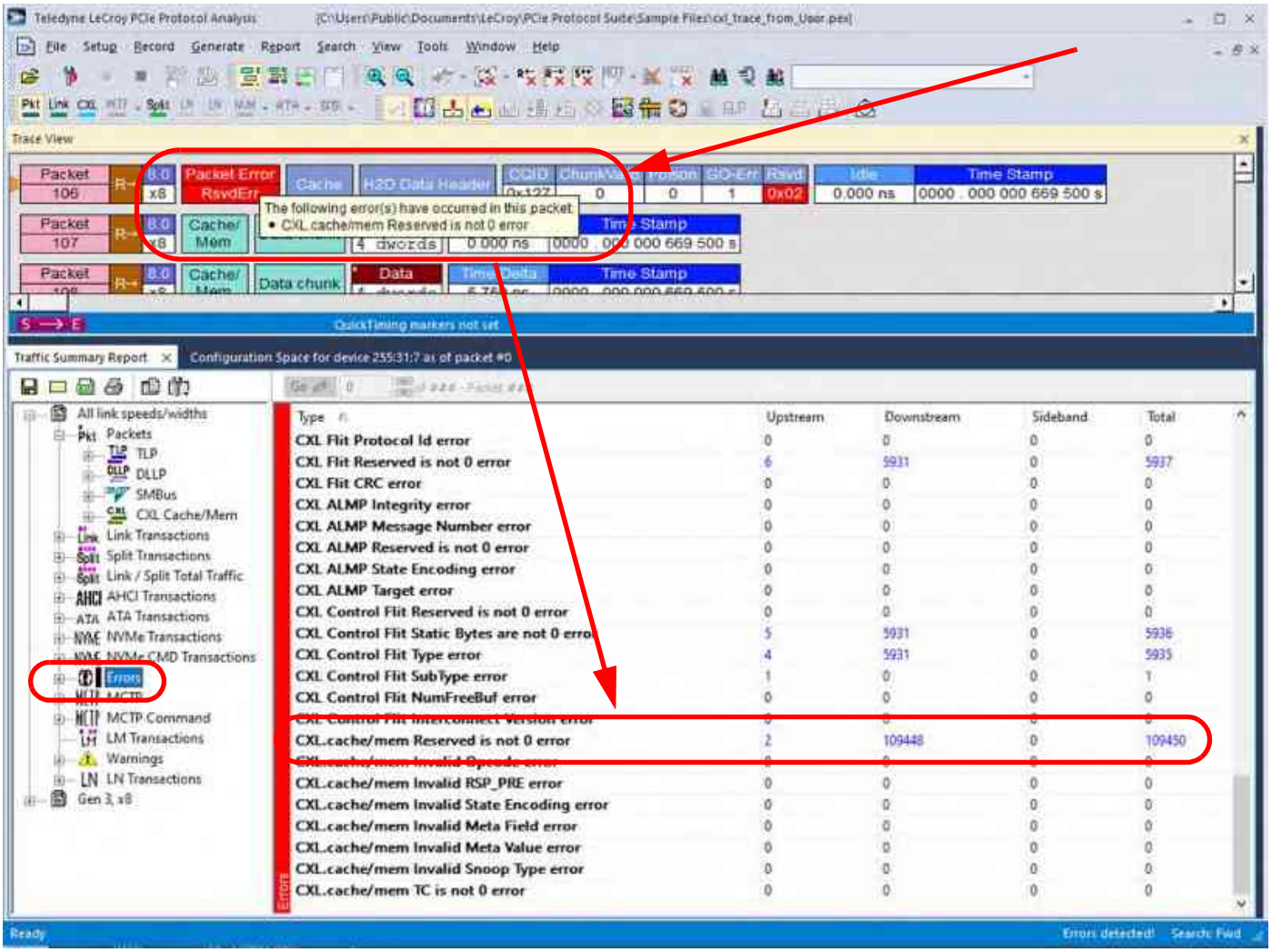


Figure 11.30: CXL Errors: Shown in Traffic Summary Report

11.3.8 CXL Flit Data View

If you select the CXL Flit Data View icon from the main toolbar you'll get a detailed view of the CXL Flit data. See Figure 11.31 and Figure 11.32 on page 667.

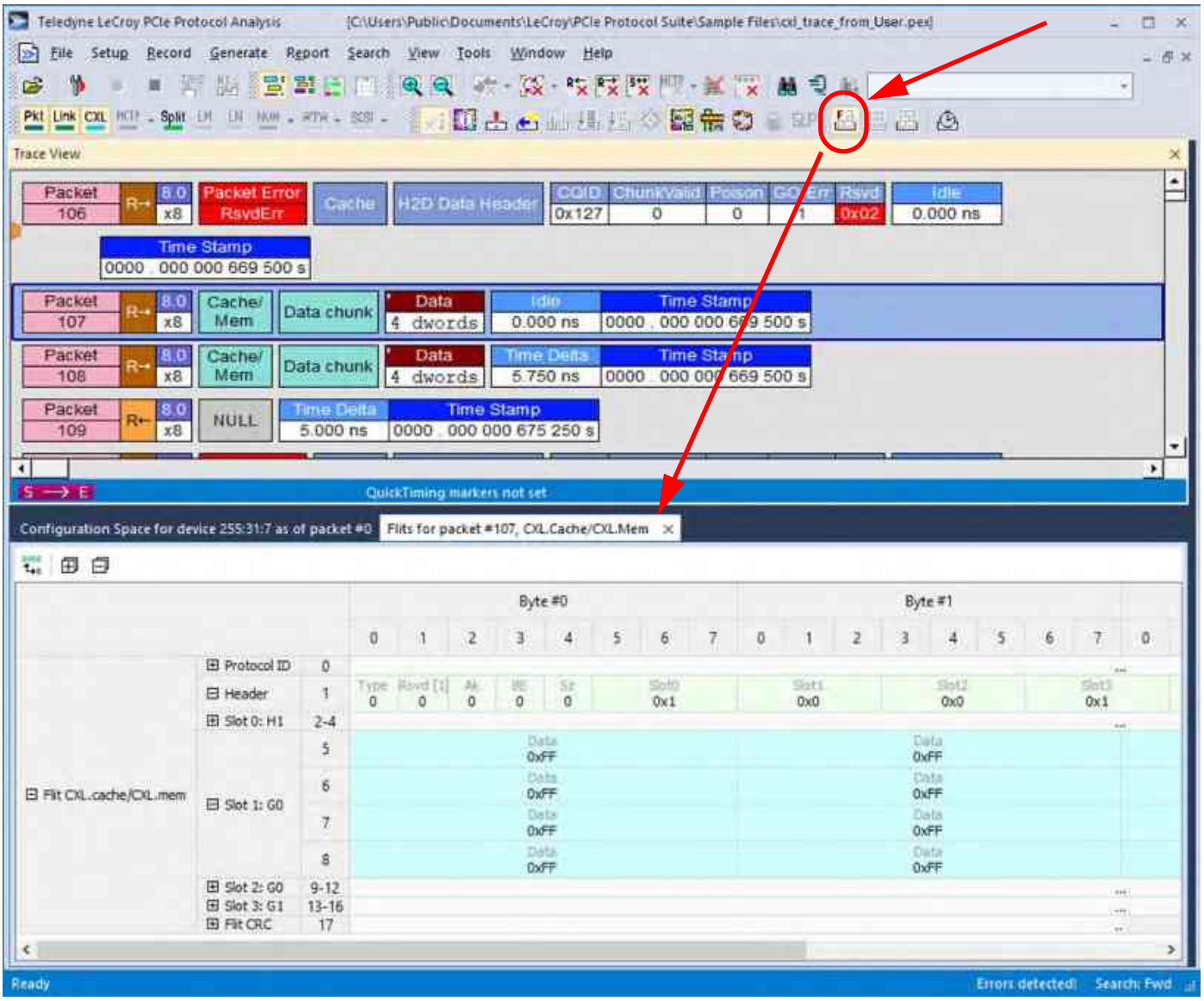


Figure 11.31: CXL Flit Data View: Close Up View Left side of Display

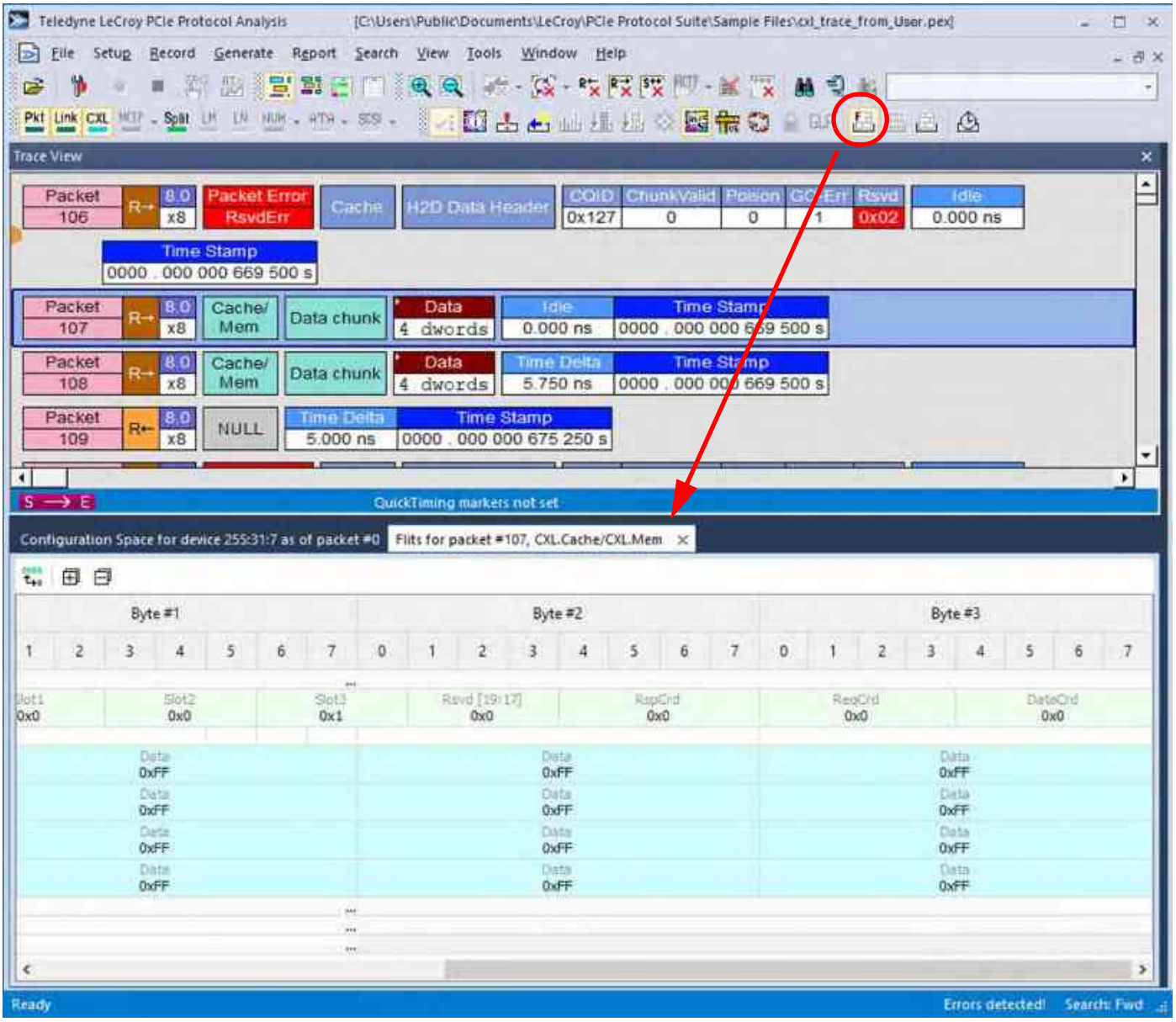


Figure 11.32: CXL Flit Data View: Close Up View Right side of Display

A second way to show the CXL Flit Data view is to select a CXL as shown below and the packet Flit view can also be opened from the menu "Show Flit Fields" once one does a right-click at the packet carried by a flit. See Figure 11.33.

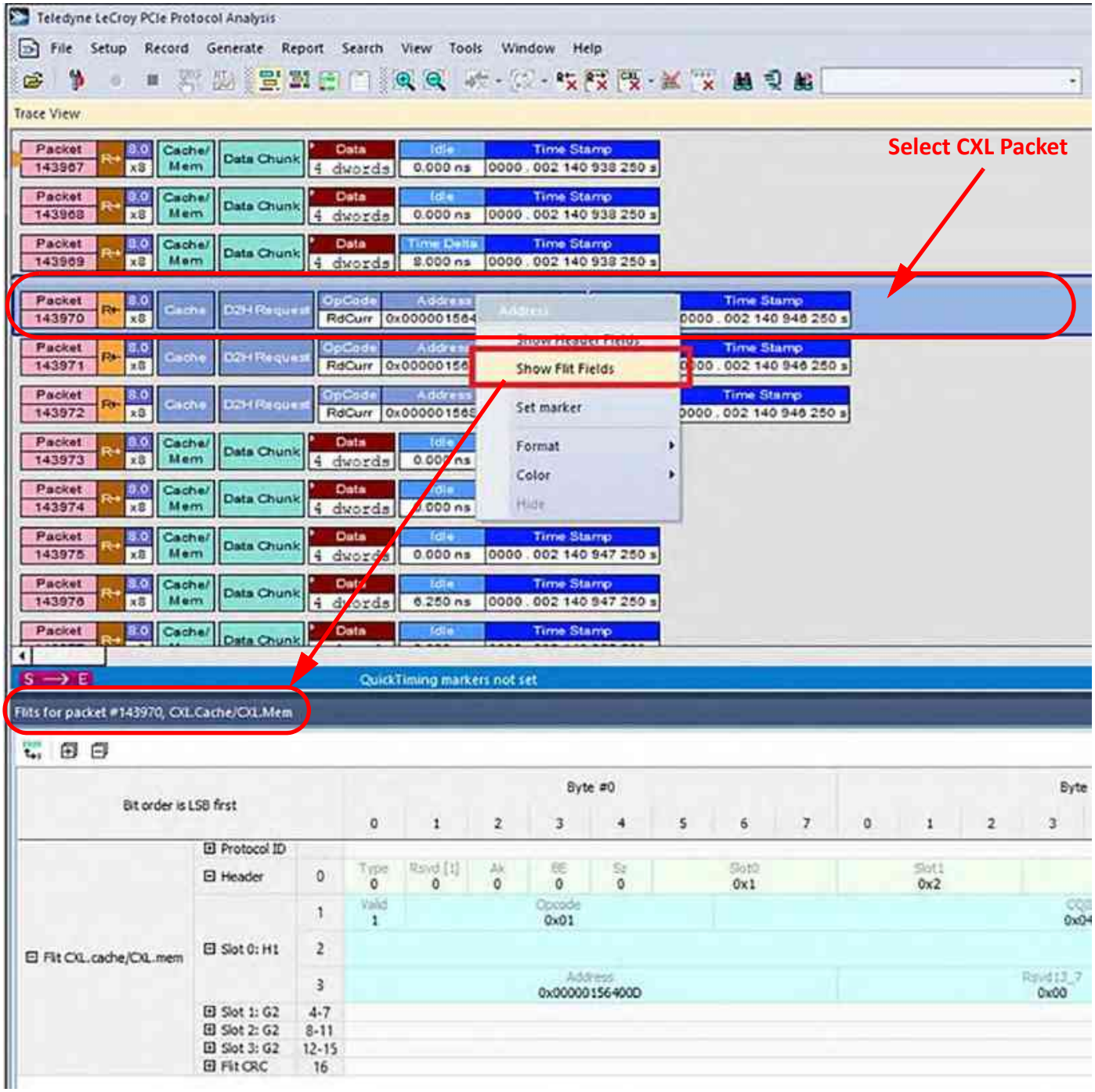


Figure 11.33: CXL Flit Data View from selecting packet and right-click

The CXL Flit Data view can be toggled from DWORD view to Byte view by clicking on the icon at the far left of the screen. See Figure 11.34.

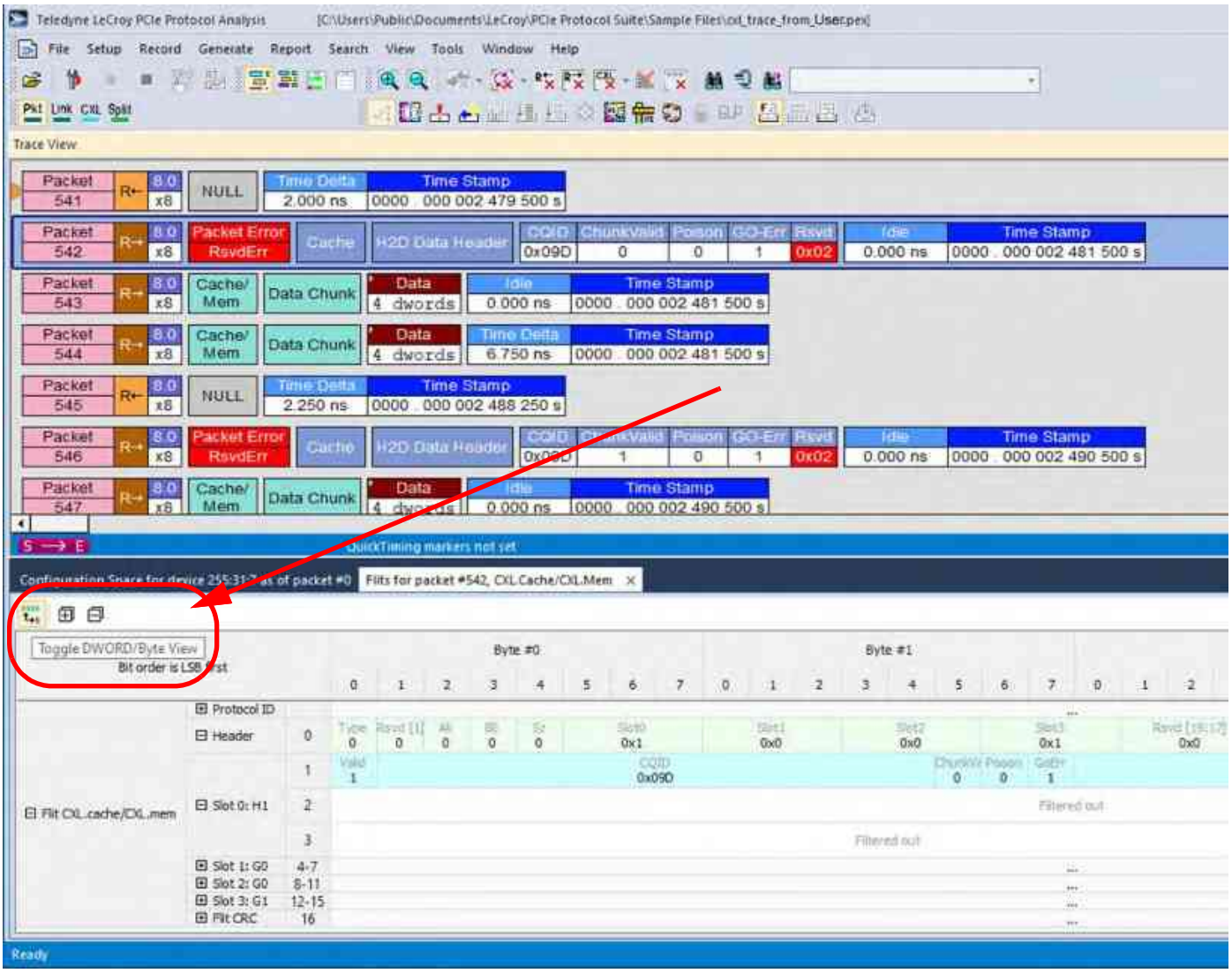


Figure 11.34: Toggle Display from DWORD to Byte View

Tooltips are available in the trace display by scrolling the cursor over a cell in the packet. See Figure 11.35.

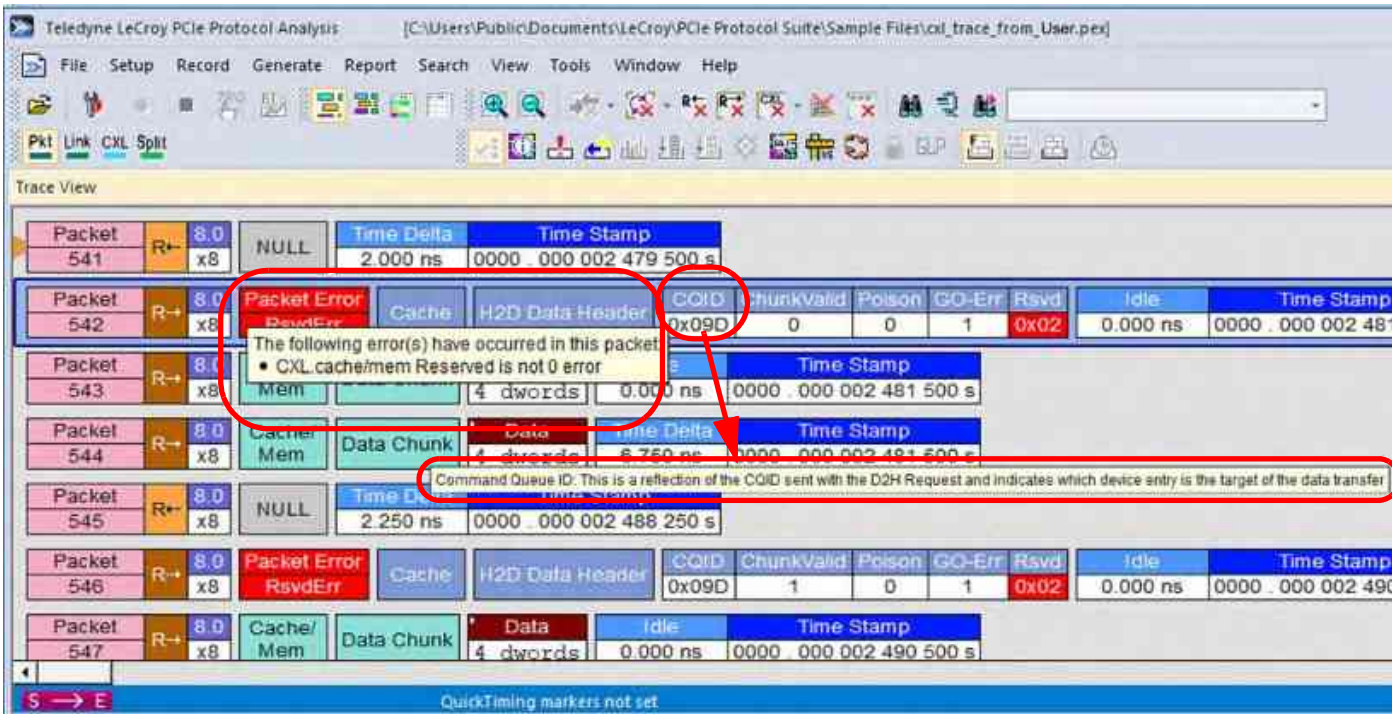


Figure 11.35: Tooltip for CXL Error

11.3.9 Example: DOE in Traffic Summary

When you have a trace with DOE traffic, you can see that traffic in the Traffic Summary Report. See Figure 11.36, Figure 11.37, and Figure 11.38.

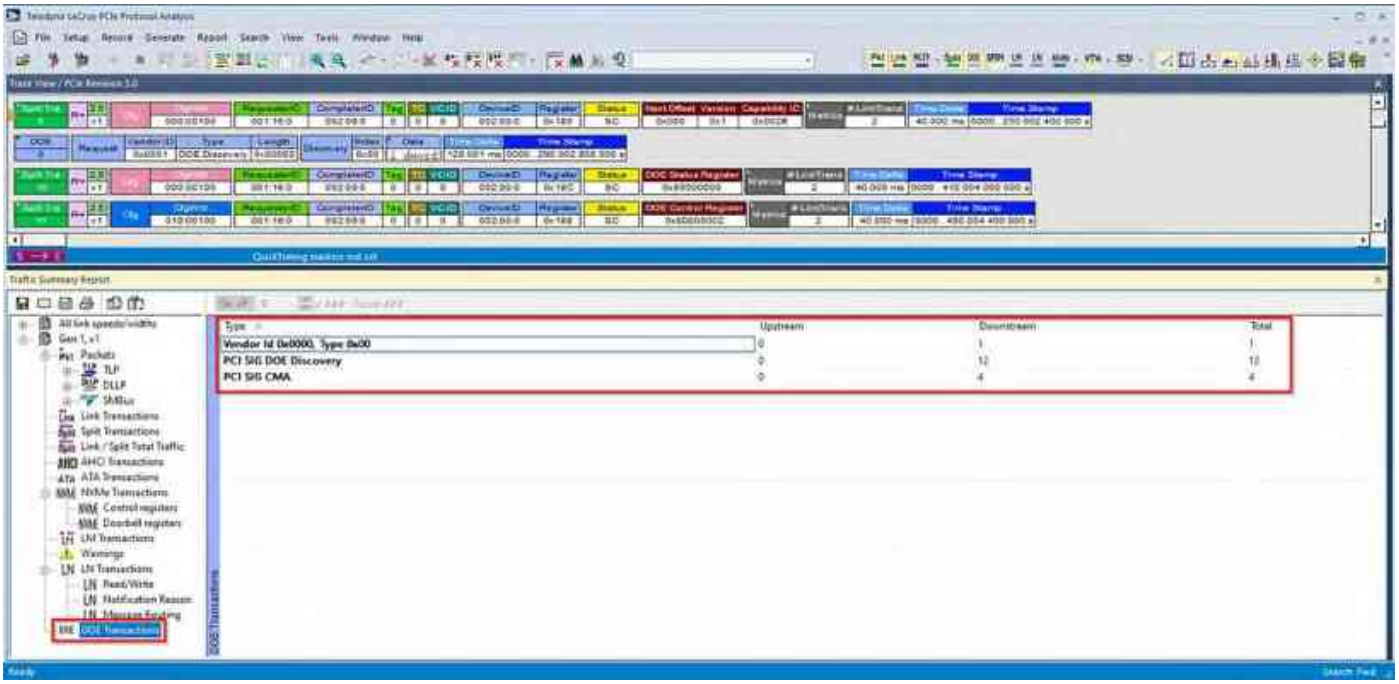


Figure 11.36: DOE Transactions

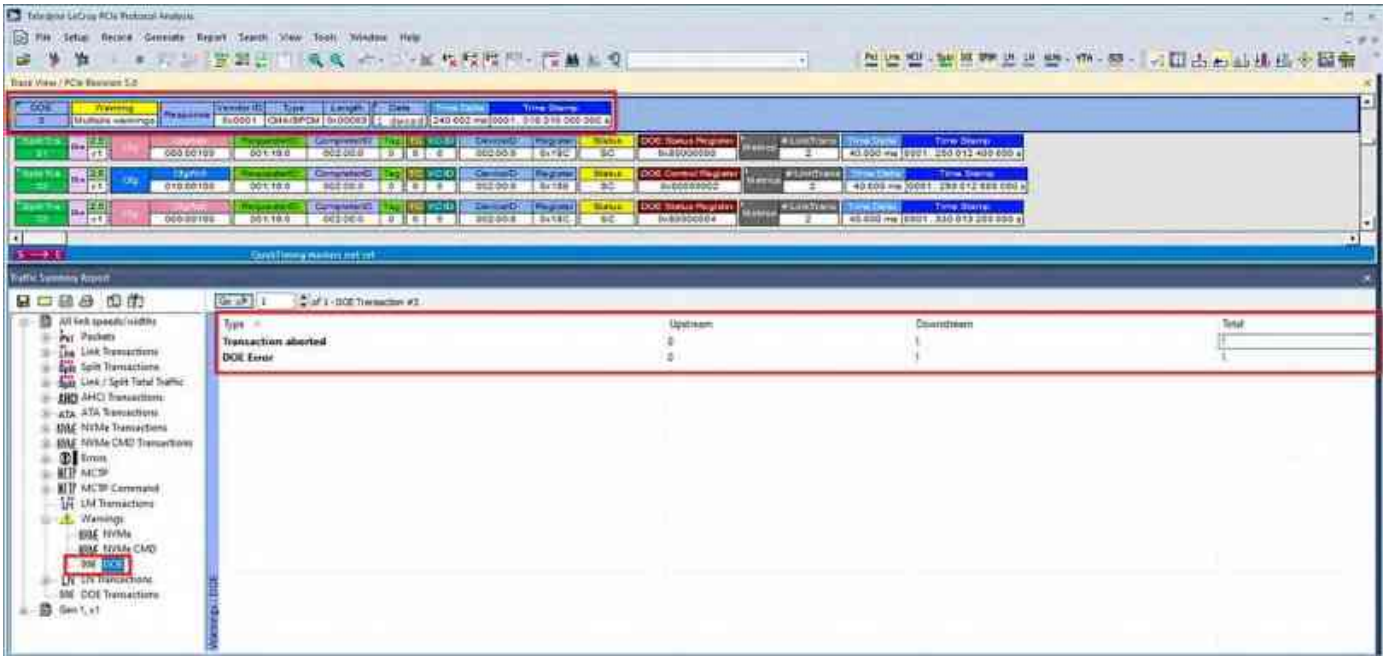


Figure 11.37: DOE Warnings

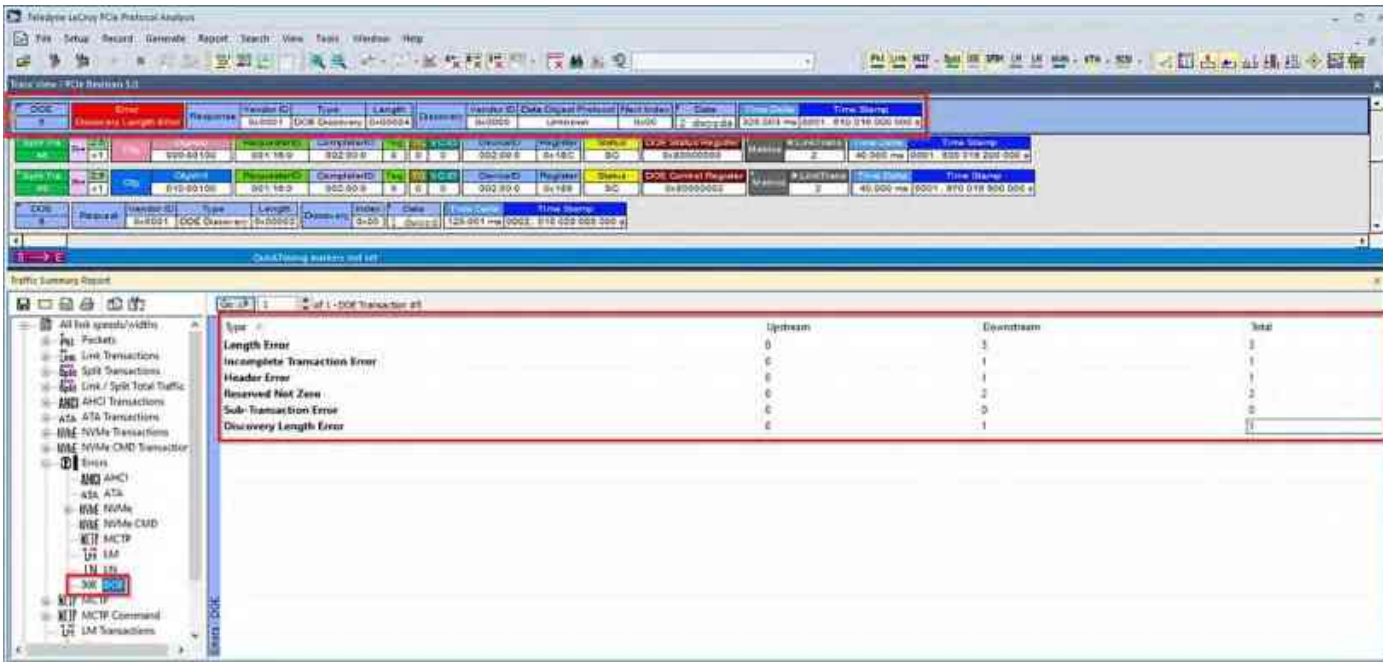


Figure 11.38: DOE Errors

11.3.10 IDE Traffic Summary Report

Two IDE traffic summary reports display information on IDE traces:

- IDE Stream ID/Sub-Stream Traffic Summary Report: The number of all present IDE stream ID and sub-stream ID combinations by channel.
- IDE TLP and Decryption Errors Traffic Summary Report: The number of IDE TLP errors and decryption errors by channel.

Note: IDE errors are only available after full trace decryption.

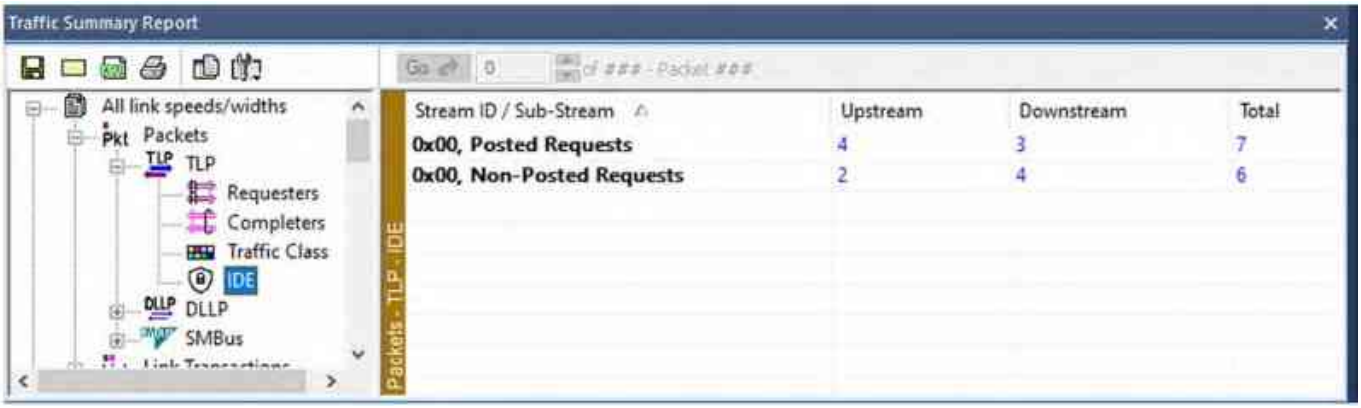


Figure 11.39: IDE Stream ID/Sub-Stream Traffic Summary Report



Figure 11.40: IDE TLP and Decryption Errors Traffic Summary Report

11.4 Bus Utilization

Select **Report > Bus Utilization** from the menu or press  to open the Bus Utilization dialog.

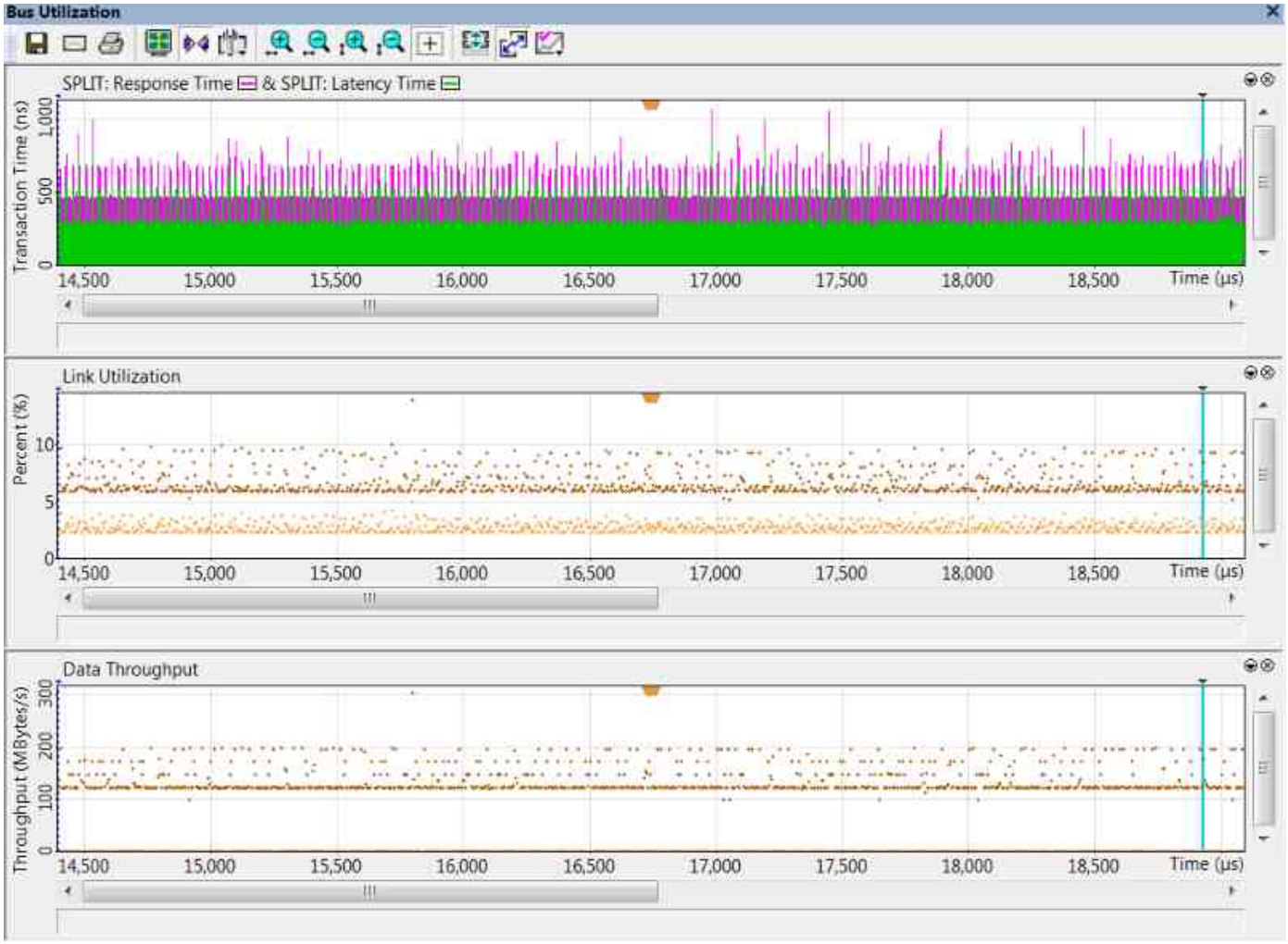


Figure 11.41: Bus Utilization Dialog

The Bus Utilization window displays information on bandwidth use for the transmit and receive channels.

11.4.1 Bus Utilization Pop-up Menu

You can reformat the display by right-clicking a graph and making a selection from the Bus Utilization pop-up menu.

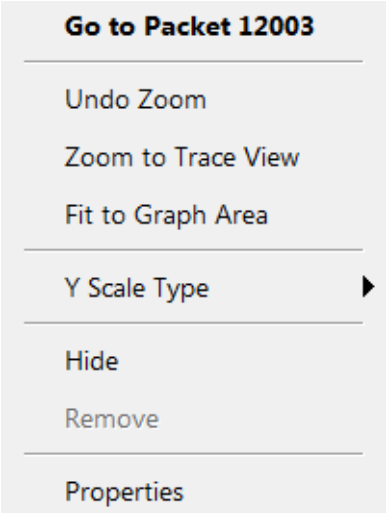


Figure 11.42: Bus Utilization Menu

Go to Packet #: Relocates the CATC Trace to the selected packet number.

Undo Zoom: If you have zoomed in, this command undoes the zoom.

Zoom to Trace View: Zooms in on graph to show traffic currently displayed in the CATC Trace screen.

Fit to Graph Area: Redisplays graph so that the entire CATC Trace fits inside graph area.

Y Scale Type:

- **Linear**: Converts display to linear format
- **Logarithmic**: Converts display to logarithmic format

Hide: Hides the selected graph

Remove: Allows you to add any graph that you created via the **Graph areas**  command.

Properties: Opens a dialog with options for changing the Title, Type, Appearance, Color and Properties of the graphs (see Figure 11.43 on page 675).

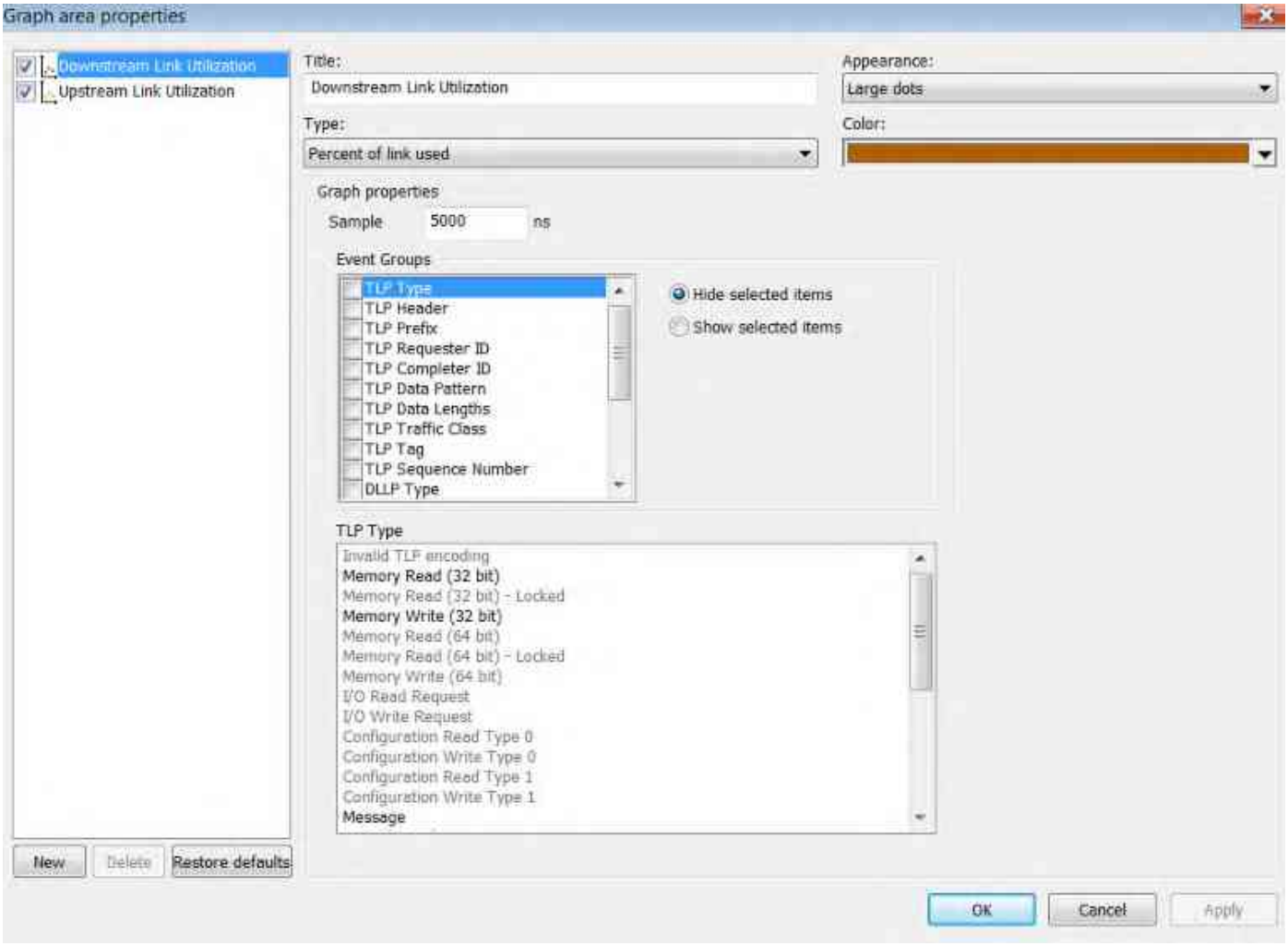
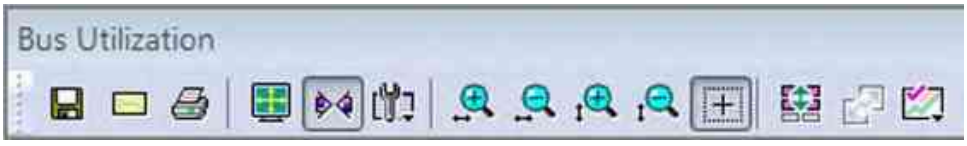


Figure 11.43: Graph Area Properties Dialog

11.4.2 Bus Utilization Buttons

The Bus Utilization window buttons allow you to reformat the display and export data.



Button	Function
	Save. Saves Bus Utilization data to a bitmap file (***.bmp**).
	Email. Opens an email and attaches a bitmap file of the Bus Utilization data.

	Print. Prints the Bus Utilization data.
	Full Screen. Maximizes the Bus Utilization window.
	Synchronize Views.Synchronize the current view with other open views.
	View Settings. Opens a sub-menu with the following choices: • Orient Horizontally • Tile Vertically • Show Markers • Show Plumb Line • Status >> • Bar • Tool tips • None • Grid Lines >> • Both Axes • X Axis • Y Axis • No Grid • Grid on Top • Fonts & Colors
	Horizontal zoom in
	Horizontal zoom out
	Vertical zoom in
	Vertical zoom out
	Click and Drag zoom. Click and drag to zoom in on a part of the graph.
	Select Range. Displays a dialog for selecting a packet range.

	Synchronize Graph Areas. If two or more graphs are displayed, this button synchronizes the graphs to one another. Once synchronized, the positioning slider of one graph moves the other graphs.
	Graph Areas. Provides options for creating and displaying additional graphs of data lengths, packet lengths, and percentage of bus used (see Graph Area Options below).

11.4.2.1 Graph Area Options

The available graphs are shown in Figure 11.44:



Figure 11.44: Graph Area Options Dialog

- New - Opens Graph Area Properties dialog to specify a new graph
- SPLIT: Pending Requests
- SPLIT: Response Time
- SPLIT: Latency Time
- SPLIT: Throughput Per Transaction
- SPLIT: Response Time & SPLIT: Latency Time

- Memory Writes: Response Time
- Memory Writes: Throughput
- Packet Length
- Link Utilization
- Data Throughput
- Packet Count
- NVMe Command IOPS
- ATA IO: Pending Transactions
- Downstream Packet Length
- Upstream Packet Length
- FC: Upstream Posted Header & FC: Upstream Nonposted Header FC: Upstream Completion Header
- FC: Upstream Posted Data & FC: Upstream Nonposted Data FC: Upstream Completion Data
- FC: Downstream Posted Header & FC: Downstream Nonposted Header FC: Downstream Completion Header
- FC: Downstream Posted Data & FC: Downstream Nonposted Data FC: Downstream Completion Data
- NVMe Queue Load

11.4.2.2 Example: NVMe Queue Load Graph Feature

This enhancement adds new Bus Utilization graph that indicates how many NVMe queue slots are occupied through the trace. There are separate graphs for each device, present in a trace, each queue is represented by a line. User can select queues to show. See Figure 11.45.

This graph can only be built after the NVMe level is decoded. Trace has to contain doorbells and submission/completion queues. If any of these conditions is not fulfilled, "Graph Areas" popup menu will have "NVMe Queue Load" item disabled. If required transactions are filtered out (for instance, using NVMe Enhanced Mode), user will be additionally prompted in popup menu entry.

Note: If trace with the graph is re-opened with persistent decoding disabled, empty graph area will be shown. After NVMe level decoding graph area gets deselected. Showing graph right after required levels are decoded should be considered as enhancement.



Figure 11.45: Bus Utilization: NVMe Queue Load

11.4.2.3 Graph Legend

Graph legend can be viewed by moving mouse pointer over graph title. See Figure 11.46 on page 679.

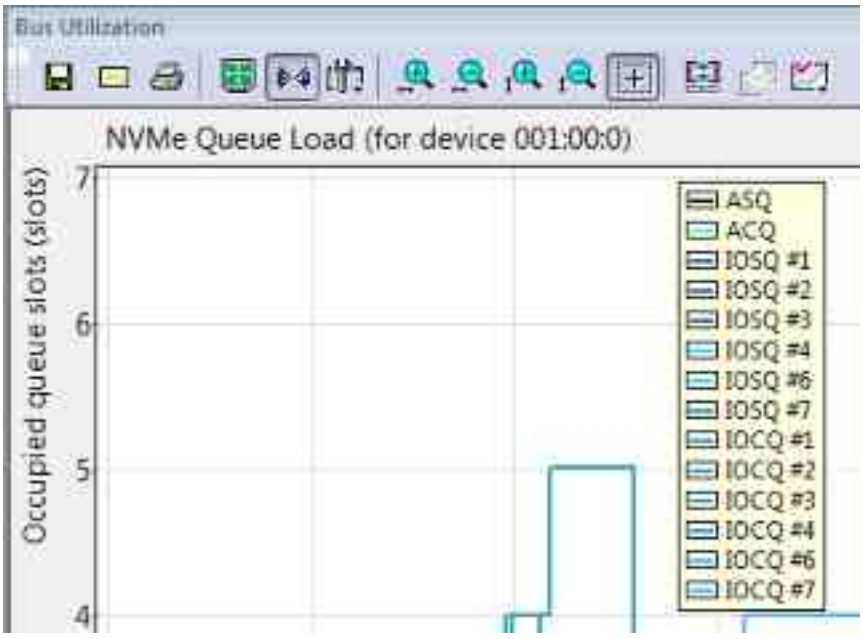


Figure 11.46: Bus Utilization: Graph Legend Details

11.4.2.4 Graph Properties

Queues to show can be selected in Graph Properties (as well as line colors). See Figure 11.47.

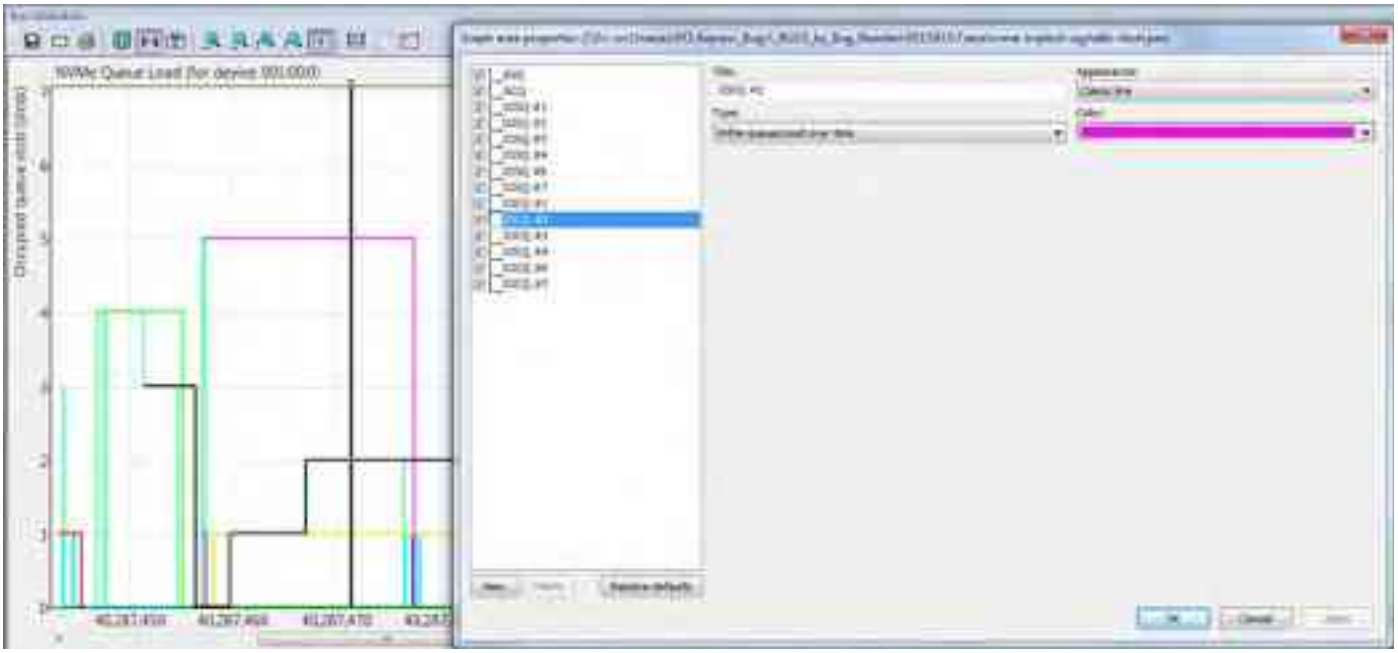


Figure 11.47: Bus Utilization: NVMe Queues => Selected in Graph Properties

11.5 Link Tracker

Open the Link Tracker window by selecting the Link Tracker Icon (to the right of the Bus Utilization Icon in the main toolbar)  .

The Link Tracker window displays a detailed chronological view of events. Events are shown on a channel-by-channel basis in columns within the window.

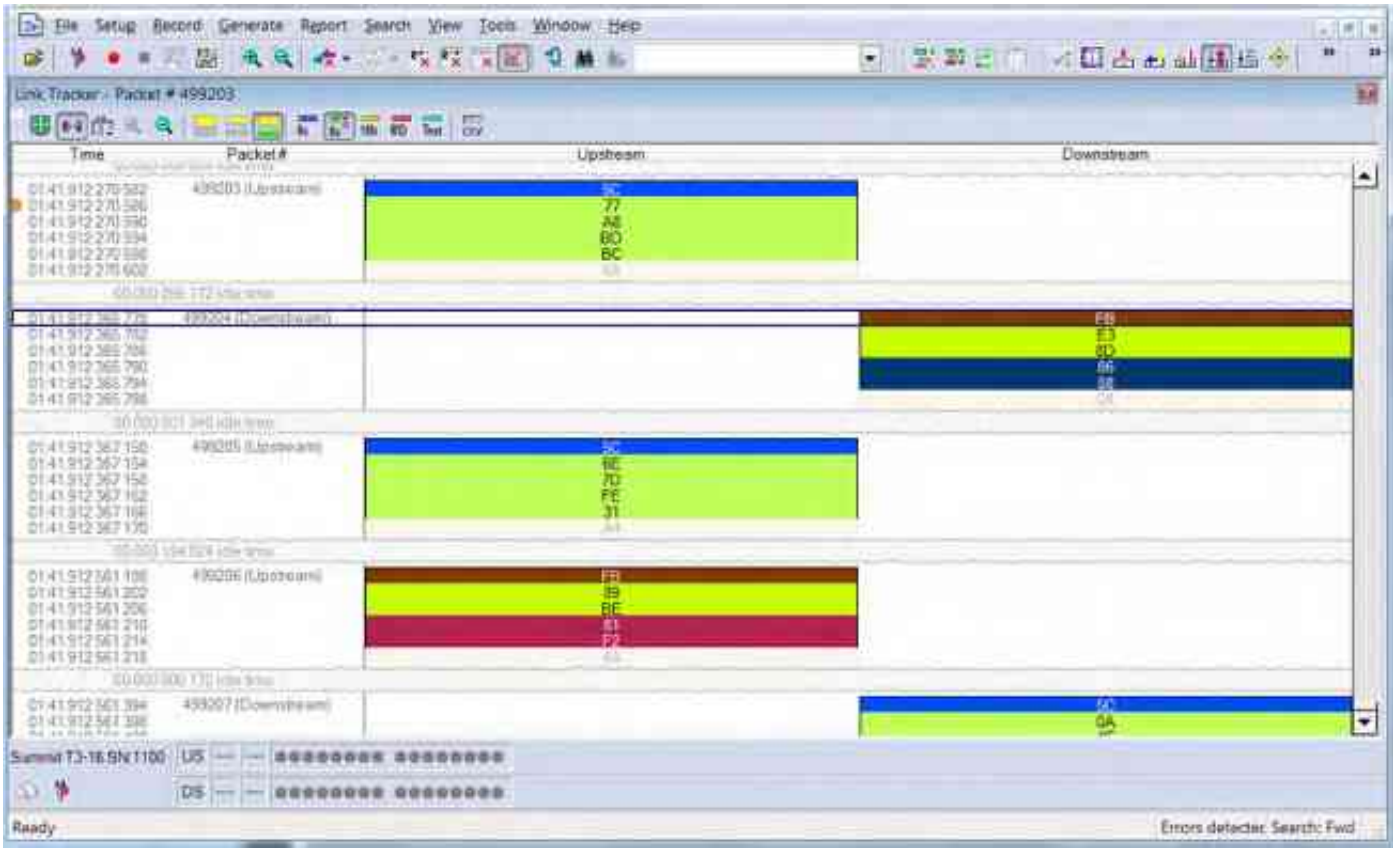


Figure 11.48: Link Tracker Window

Each time slot in the vertical axis represents the minimum time that a DWORD requires to traverse the bus.

Toolbar: Presents buttons for changing the format of the Link Tracker window.

Main Display Area: Displays traffic chronologically as it occurred in the recording. The window divides into columns: the first column shows time and traffic is shown on a channel-by-channel basis in the columns on the right.

11.5.1 Using the Link Tracker Window

The Link Tracker window can be reformatted in several ways.

11.5.2 Zooming In and Out

Zooming out can give you a quick, high-level view of a CATC Trace. A fully zoomed out CATC Trace only shows columns and colored lines. Using the colors, you can see what types of traffic run through the CATC Trace.

Further information can be obtained on any point of interest in the CATC Trace by positioning your mouse pointer over it. Tool tips provide detailed description of events.

When fully zoomed out, the smallest graphical unit is the DWORD, represented by a single line. Zooming out makes the CATC Trace appear smaller and increases the time scale in the first column.

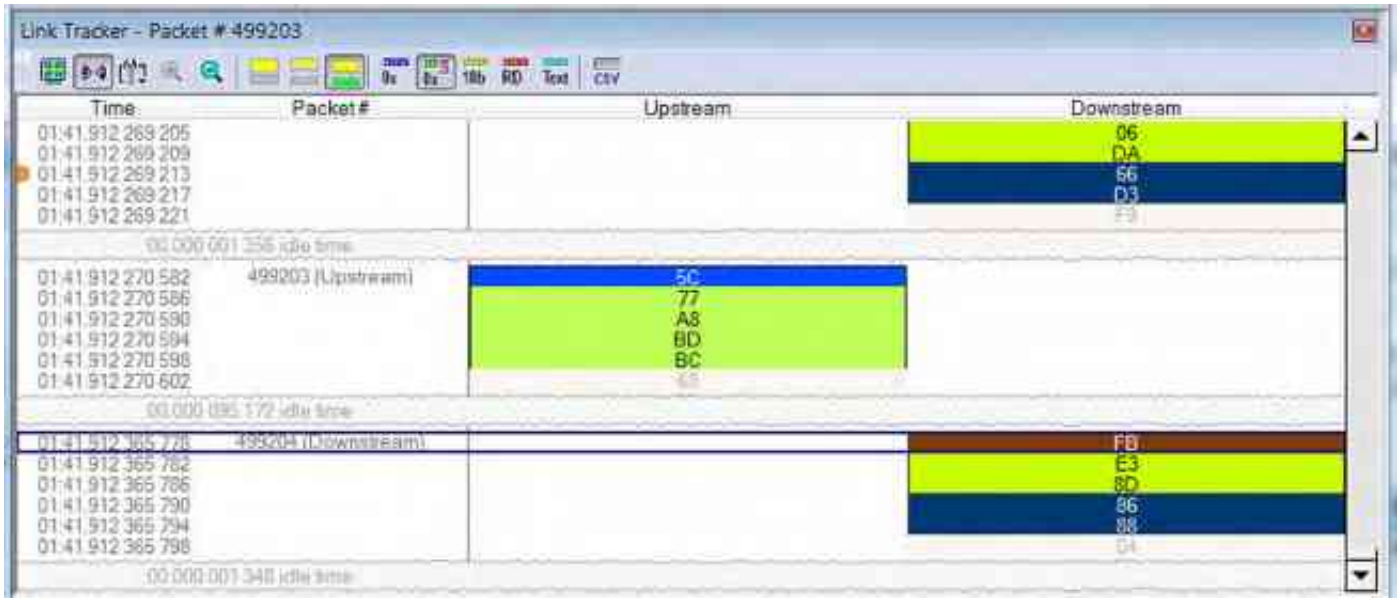


Figure 11.49: Link Tracker: Zoomed Out

11.5.3 Collapsing Idle Time, Enabling Tool tips, and Resetting Column Widths

Click the **View Options** button  to open a menu with options for formatting the display. Three options are presented:

Collapsible Idle Time: Opens a dialog box for setting the Idle time value. Setting a value tells the Analyzer when to collapse Idle times and display them as grayed out strips within the Bus View window.

Tooltip Display: Opens a menu with options for adding content to Tooltips. Tooltips display when you position the mouse pointer over an item in the Bus View window. The options are:

- Tooltips Display Values
- Tooltips Display Scrambled Values
- Tooltips Display 10-bit Codes
- Tooltips Display Symbols

Time Format: Seconds or Clock

Reset Column Widths: This option resets column widths to their defaults and enables columns to resize themselves automatically any time the application window is resized. Normally, columns automatically resize themselves if the application window is made larger or smaller. However, if you manually resize any columns in the Bus View window, column widths become static. Thereafter, if you resize the application window, the Bus View columns do not adjust automatically. Reset Column Widths re-enables the automatic resizing capability.

Reset Columns Order: Return to default column sequence.

11.5.4 Docking and Undocking the Window

You can undock the Link Tracker window by double-clicking the blue title bar along the left side of the window. Once undocked, the window can be dragged anywhere in the application. To re-dock double-click again on the title bar.

11.5.5 Setting Markers

Markers can be set on any event within the Link Tracker window.

To set a marker, right-click an event, then select **Set Marker** from the pop-up menu.

Once marked, you can navigate to events with the **Go to Marker** command in the Search menu.

Markers set in the Link Tracker window display the packet number and DWORD number. In contrast, markers set in the CATC Trace window just show the packet number.

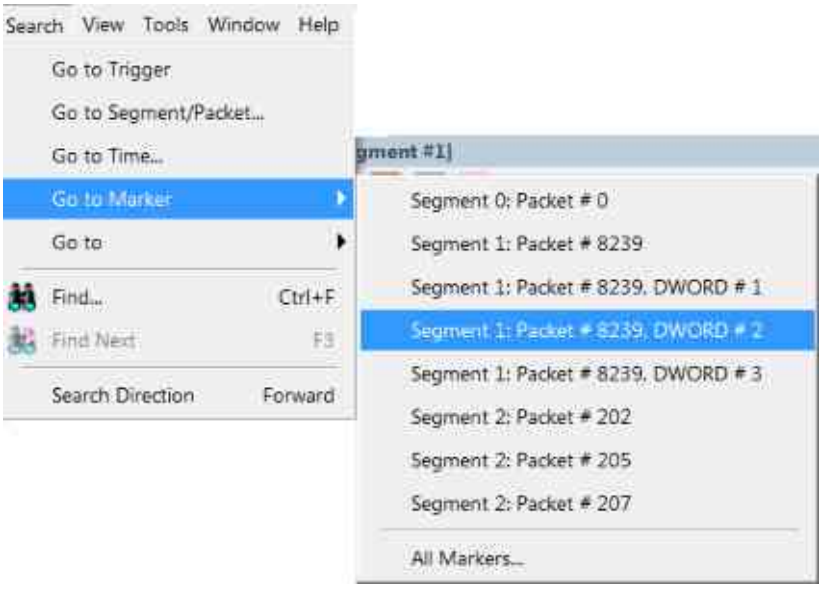


Figure 11.50: Selecting the Go to Marker Option

11.5.6 Calculating Time between DWORDs

You can calculate time between DWORDs by clicking an event and then positioning your mouse pointer over a second event and reading the ensuing Tool tip.

Click the **time value** for the first event. Scroll down through the CATC Trace to the second event and position the mouse pointer above its time value. A Tool tip appears showing the time interval between the first and second events.

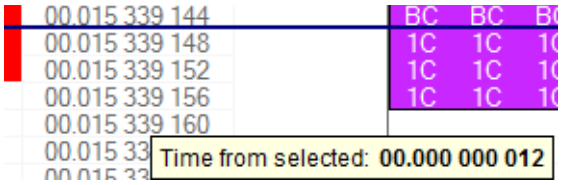


Figure 11.51: Viewing Time Values

11.5.7 Hiding Traffic

You can hide Idles and other data from the Link Tracker window by clicking the **Hide** buttons on the toolbar.

11.5.8 Link Tracker Buttons

The Link Tracker window has a row of buttons for changing the format of the displayed data and for exporting data: The buttons have the following functions:

	Full Screen. Expands the Link Tracker window to fill the entire screen.
	Synchronize Trace View. Synchronizes the Trace View and Link Tracker windows so that a move in one window repositions the other. Because of the differences in scale and logic between the Link Tracker and Trace view window, scrolling produces different effects depending on which window is being scrolled. Scrolling in the CATC Trace window causes the Link Tracker window to rapidly jump from event to event. Long periods of idle time are thus skipped. Scrolling in the Link Tracker window, in contrast, produces modest movements within the CATC Trace window. Scrolling in the Link Tracker window causes the CATC Trace window to pause until the beginning of a packet is displayed. At that point, the CATC Trace window repositions itself. While scrolling long Idle periods or through the contents of a packet, the CATC Trace window does not move.

	View Options. Opens a menu with three options: • **Collapsible Idle Time** (Collapse Idle Bigger Than **n** nanoseconds. **Note:** Does not affect Collapse Idle Plus.) • **Tooltip Display** (Values, Scrambled Values, 10-bit Codes, Symbols) • **Time Format** (Seconds, Clock) • **Reset Columns Widths** (return to default widths) • **Reset Columns Order** (return to default column sequence) See "Using the Link Tracker Window" on page 681 for further details.
	Zoom In
	Zoom Out
	Continuous Time Scale. No collapsing.
	Collapse Idle. Do not show some periods of Link being idle.
	Collapse Idle Plus. Do not show periods of Link being idle.
	Show Descrambled Bytes
	Show Scrambled Bytes
	Show 10b Codes
	Show Symbols
	Show Text
	Show Binary values
	Export to CSV file

11.5.8.1 Exporting to CSV File

To export trace file information to a CSV file, select the variables you want in the file and select the CSV Icon. A window with your variables will pop up that also shows you the file name and path. See Figure 11.52.

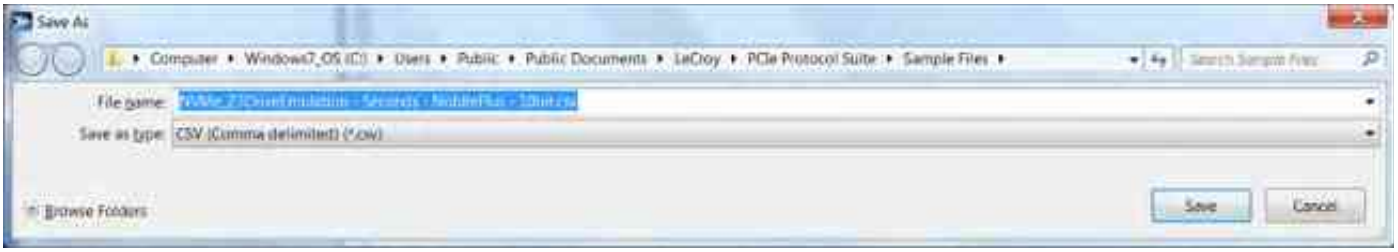


Figure 11.52: Link Tracker: CSV File to be Saved and Location

Select Save and the tool will start. See Figure 11.53.

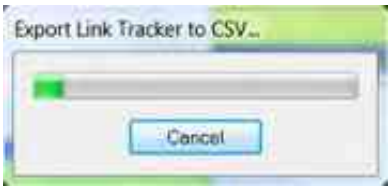


Figure 11.53: Tool Exporting Link Tracker Data to CSV File

The generated CSV file can be viewed in Excel.

11.6 Data Flow Window

The Data Flow window shows marker, packet, direction, type, length, address, payload, handshake, and timestamp information.

To obtain the Data Flow window, select **Report > Data Flow** or click the  Data Flow toolbar icon.

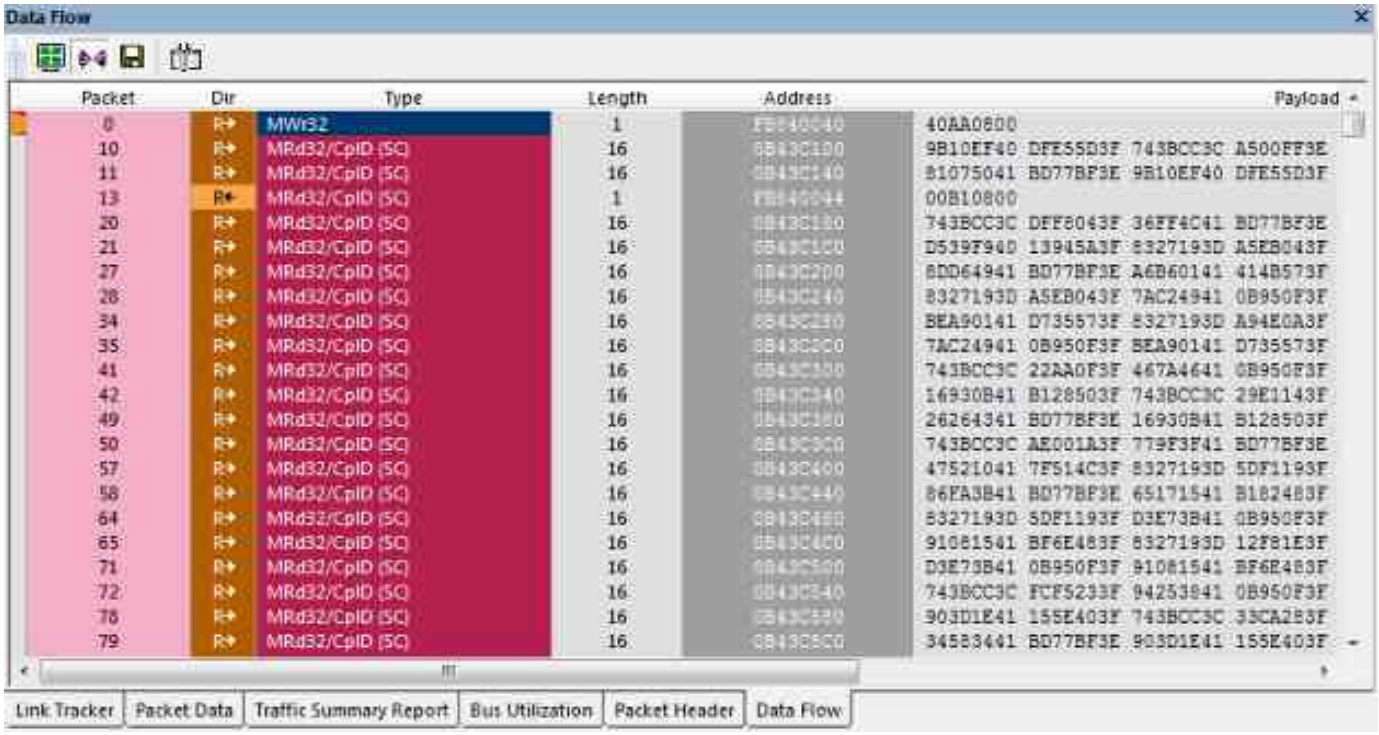


Figure 11.54: Data Flow Window



The toolbar allows you to (see Figure 11.55 on page 688):

- Expand the window to full screen or Collapse to a smaller window.
- Synchronize.
- Save.
- Select Data Flow columns to display and their widths:
  - Marker
  - Packet
  - Direction
  - Type
  - Length
  - Address
  - Payload
  - Handshake
  - Time Stamp

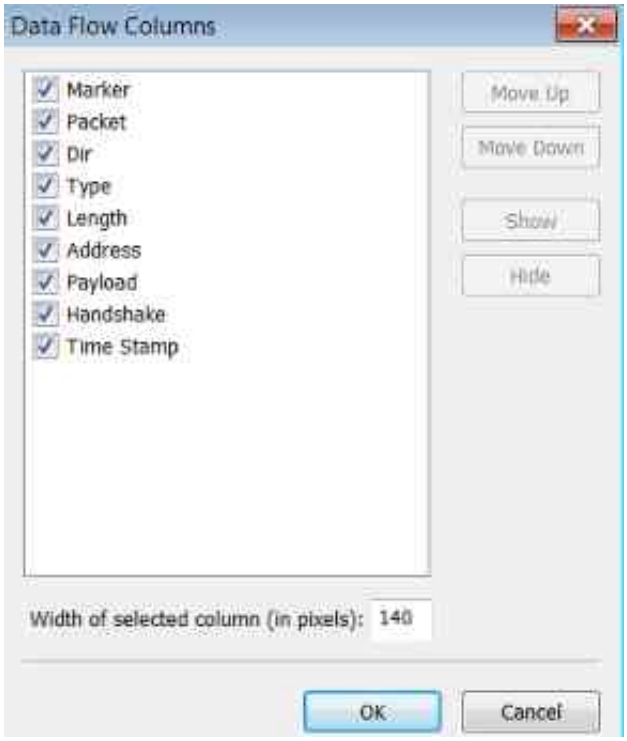


Figure 11.55: Data Flow Columns Dialog

11.7 Flow Control Tracking

The Flow Control View mode highlights portions of the packets that affect flow control and displays flow control values. Flow control values shown at the beginning of Link Transaction display the credit values that were available prior to TLP transmission. Flow control values shown at the end of the Link Transaction display the credit values that were available after TLP was transmitted. Hover the mouse over the field to display tool-tips. Refer to the following screen capture.



Figure 11.56: Flow Control Display

If the trace includes Flow Control initialization, PCIe Protocol Analysis detects the amount of available credits based on the values advertised in InitFC packets. If the InitFC packets are not in the trace, the amount of available credits can be set using the FC Credit Setup dialog. Select **View > FC Credits Setup...** displays the FC Credit Setup dialog (see the following screen capture).

For each virtual channel that is present in the trace you need to specify the amount of available credits before the beginning of the trace. You can also specify the values of credit fields for UpdateFC packets before the beginning of the trace. If the values of the UpdateFC credit fields are different than the values in the first UpdateFC packet, Flow Control tracking view will show that

the first UpdateFC packet is releasing appropriate amount of credits. By default, PCIe Protocol Analysis sets these values to match the first UpdateFC packets in the trace.

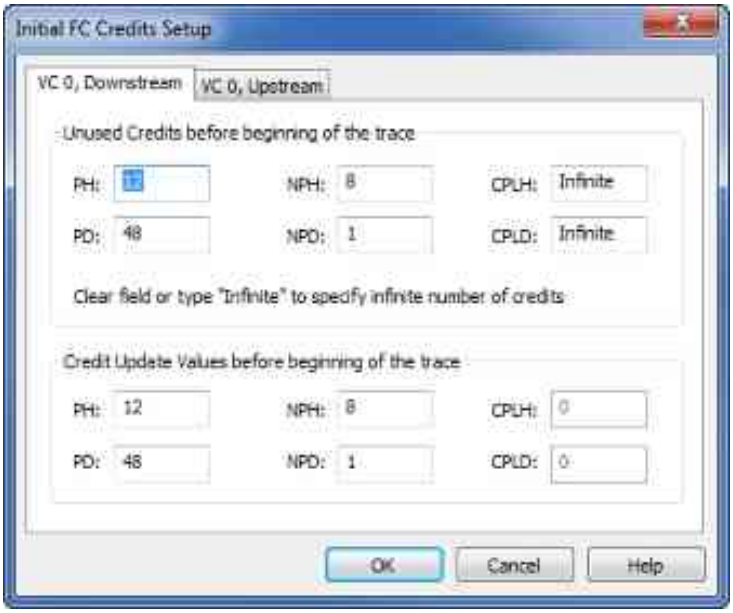


Figure 11.57: Flow Control Setup Dialog

11.8 Using the CATC Trace Navigator

The CATC Trace Navigator is a tool for navigating within the CATC Trace. It allows you to view the location of errors and triggers in a CATC Trace and to narrow the range of traffic on display. It also allows you to quickly jump to any point in the CATC Trace.

11.8.1 Displaying the Navigator

Click  in the toolbar to display the Navigator. The Navigator appears on the right side of the Main window. It has a two-button toolbar and a vertical slider bar. It also has colored panes for navigating the CATC Trace in different ways. You set which panes are displayed through Navigator pop-up menus (see Figure 11.58 on page 690).

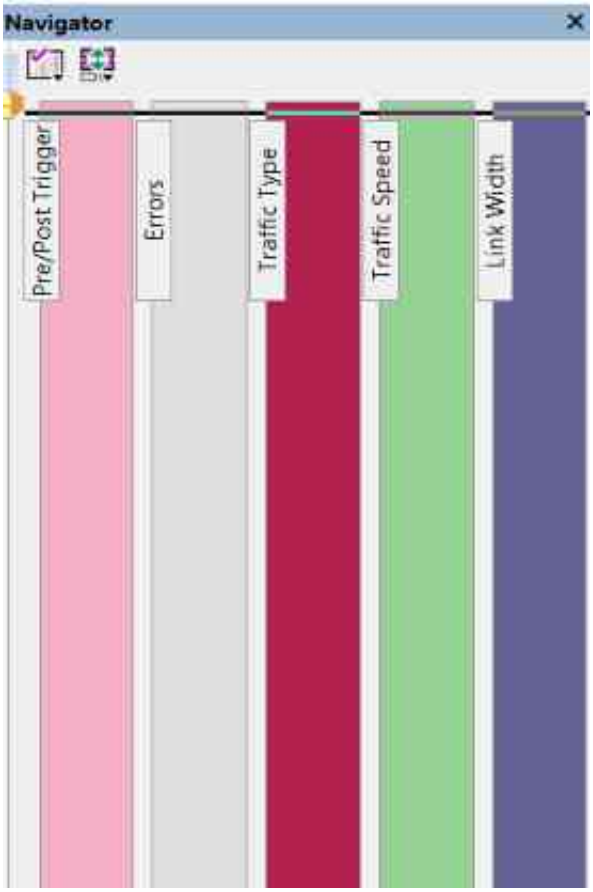


Figure 11.58: Navigator Dialog

11.8.2 Navigator Toolbar

The Navigator toolbar lets you quickly set Navigator features. The toolbar has two buttons.





Navigator Ranges: This button brings up a pop-up menu that lets you reset the Navigator range. The range determines what packets are viewable in the CATC Trace display.

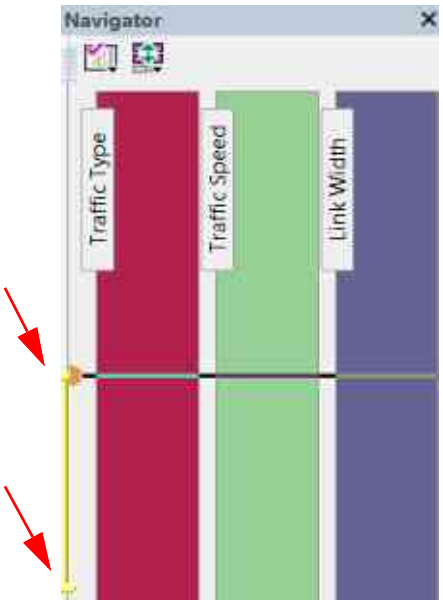


Navigator Panes: This button has two purposes: To select which Navigator panes appear and to bring up the Navigator legend. The legend determines how information is shown in the panes.

11.8.3 Navigator Ranges

You set the viewing range by dragging the **yellow range delimiters** along the slider. To set the lowest packet viewable, drag the **top delimiter up**. As you do so, a tool tip appears to indicate the current range. Stop dragging when you reach the desired lowest packet.

To set the highest packet viewable, drag the **bottom delimiter down**. Stop when the tool tip indicates you are at the desired highest packet.



11.8.4 To Determine Current Position

In addition to the two range delimiters, the slider has a **blue current-position** indicator (see above). The current-position indicator shows where you are in the CATC Trace display with respect to the possible viewing range.

For example, suppose you set viewing range to packet 0 through packet 500 (the top range delimiter is at packet 0, and the bottom range delimiter is at packet 500). If you then move the current-position indicator on the slider to midway between the top and bottom delimiters, then packet 250 appears in the middle of the CATC Trace display.

11.8.5 To Reset Navigator Range

You can reset the Navigator range using the toolbar **Navigator Range** button. Press the button to bring up the Navigator Range drop-down menu.



The menu has the following options:

- **Set Range to Whole Trace**: Allows you to reset the range to include the entire CATC Trace file contents. The top range delimiter is placed at the lowest packet number in the CATC Trace. The bottom range delimiter is placed at the highest packet number in the CATC Trace.
- **Set Range Near Packet xxx**: Allows you to collapse the range so that only the packets immediately above and below the xxx packet are displayed. The xxx packet is whatever packet is currently at the top in the CATC Trace display.
- **Recently Used Ranges**: Allows you to reset the range to any of a number of recently used (previously set) ranges.

11.8.6 Navigator Panes

You can display any combination of CATC Trace Navigator panes.



From left to right, the panes are: Pre/Post Trigger, Errors, Traffic Type, Traffic Speed, and Link Width. Each pane represents the entire CATC Trace with respect to different types of information. The top of each pane represents the start of the CATC Trace file, and the bottom represents the end of the CATC Trace file.

- **Pre/Post Trigger:** To view the trigger event in the CATC Trace and the relative size of pre-trigger and post-trigger portions of the CATC Trace. The two portions are set apart as different colors. The trigger event occurs at the point the two colors meet.
- **Errors:** To view any errors in the CATC Trace. A thin red line represents each error in the pane.
- **Traffic Type:** To view the types of packets that occur in the CATC Trace. A different color represents each packet type in the pane. The relative size of colored portions in the pane corresponds to the amounts of the various packet types in the CATC Trace. As described below, you can use the Navigator legend to change the types of packets that take precedence in the display.
- **Traffic Speed:** To view the speed that occurs in the CATC Trace.
- **Link Width:** To view the link width that occurs in the CATC Trace.

11.8.7 To Show/Hide Nav55igator Panes

You can show/hide any of the panes using pop-up menus accessible through left-click the **Navigator Panes** button or by right-click anywhere in any CATC Trace Navigator pane.

11.8.8 Navigator Slider

The Navigator slider appears at the left of Navigator panes. The slider has **yellow upper and lower range delimiters** and a **blue current-position** indicator.

The Navigator slider lets you to set the range of packets viewable in the CATC Trace display. In other words, it sets scrolling range of the display. You can scroll the display up to the lowest packet number in the viewing range. You can scroll the display down to the highest packet number in the viewing range.

11.8.9 CATC Trace Navigator Legend

The Navigator legend lets you control the display of content in Navigator panes.

You bring up the legend through the Navigator Pane's drop-down menu. Press the toolbar **Navigator Panes** button to access the menu. Select the **Legend** option to bring up the Navigator Legend dialog (see Figure 11.58 on page 690).

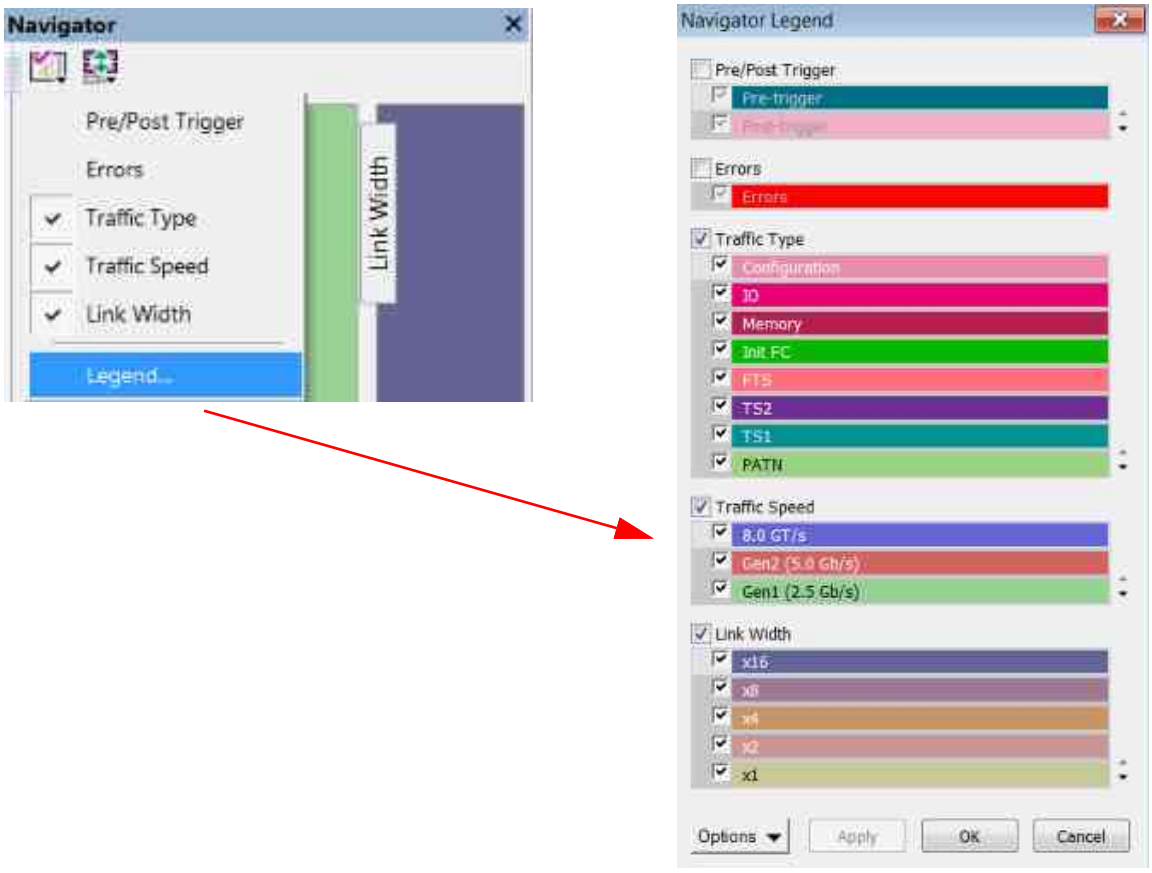


Figure 11.59: Navigator Pane and Navigator Legend Dialog

The Navigator Legend dialog has areas corresponding to each of the panes. Each area has check boxes that allow you to hide/display information in the pane. You can set the priority of information displayed in the panes using the up and down triangles on the right.

11.8.10 Using the Legend to Show/Hide Navigator Panes

To use the legend to show/hide an entire pane, use the **checkbox** next to the name of each pane in the legend.

In the case of the Pre/Post Trigger and Errors areas, the action of show/hide in the legend is identical to that provided by CATC Trace Navigator pop-up menus.

In the case of the Traffic Types pane, there is no equivalent show/hide available through the pop-up menus.

11.8.11 Using the Legend to Set the Priority of Information Display

You can use the legend to set the priority of information displayed in the Pre/Post Trigger Traffic Type panes. This is a two-step process.

1. For a particular item in a pane, click the **column next to the checkbox** for the item. That labels the item as currently active.
2. Next, use the **up-down** at the lower-right of the area to move the item higher or lower in priority.

In the case of the Traffic Type pane, priority determines display priority of each packet type. For portions of the CATC Trace that are dominated by a particular packet type, this setting no effect: only the color corresponding to that packet type is displayed in that portion of the pane. Suppose, however, that part of the CATC Trace includes equal or near equal numbers of several types of packets. In that case, you can use the legend to select which among those types is represented in that portion of the Traffic Types pane. This allows you to view only packets of interest in crowded portions of the CATC Trace display.

11.9 Detail View

Click  to show the Detail View of the selected packet.

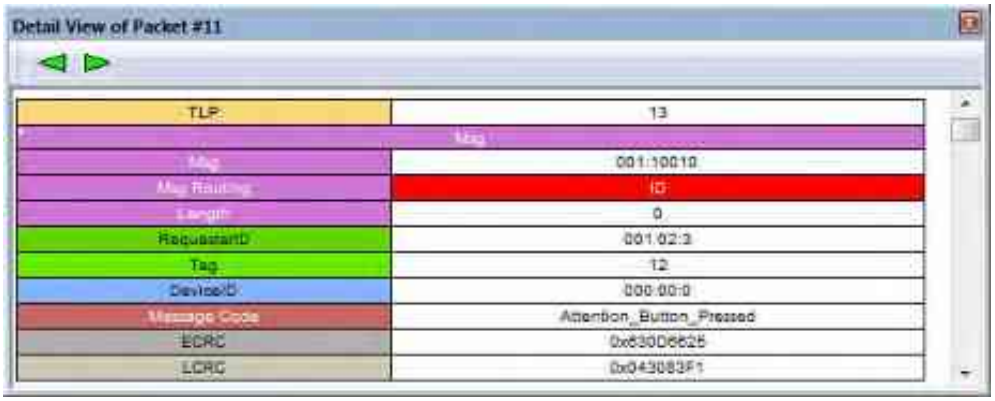


Figure 11.60: Detail View

11.10 LTSSM Flow Graph

The LTSSM Flow Graph shows link state transitions that the link goes through, as recorded in the CATC Trace file.

To obtain the LTSSM Flow Graph (see Figure 11.61 on page 695), select **Report > LTSSM Flow Graph.**

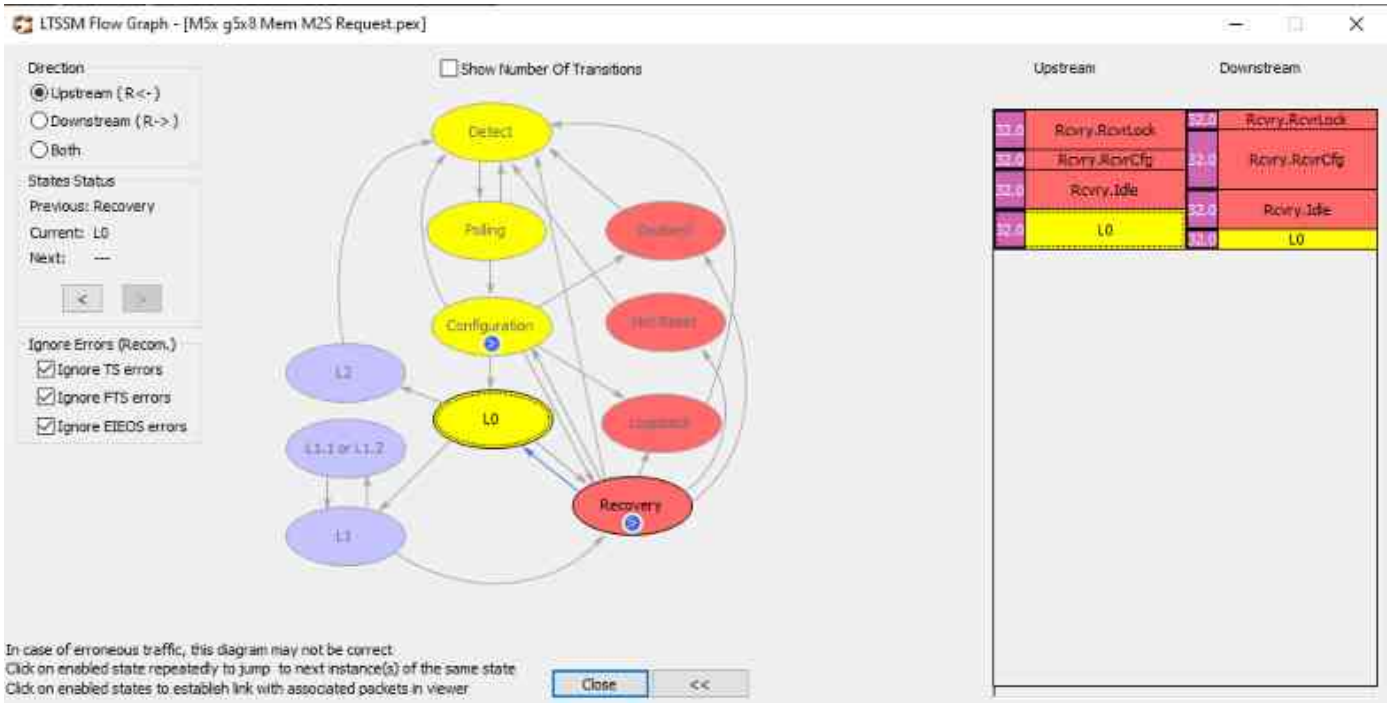


Figure 11.61: LTSSM Flow Graph Dialog

You can enable or disable ignoring of TS/FTS/EIEOS packets with errors so they will not affect the diagram if enabled.

You can display the following directions:

- Upstream
- Downstream
- Both

You can **Show Number of Transitions**.

11.10.1 LTSSM Dynamic Equalization

You can review the PreCursor, Cursor and PostCursor values that the analyzer has used during the dynamic equalization phase of the LTSSM process by selecting the LTSSM icon on the toolbar and checking the following steps: See Figure 11.62.

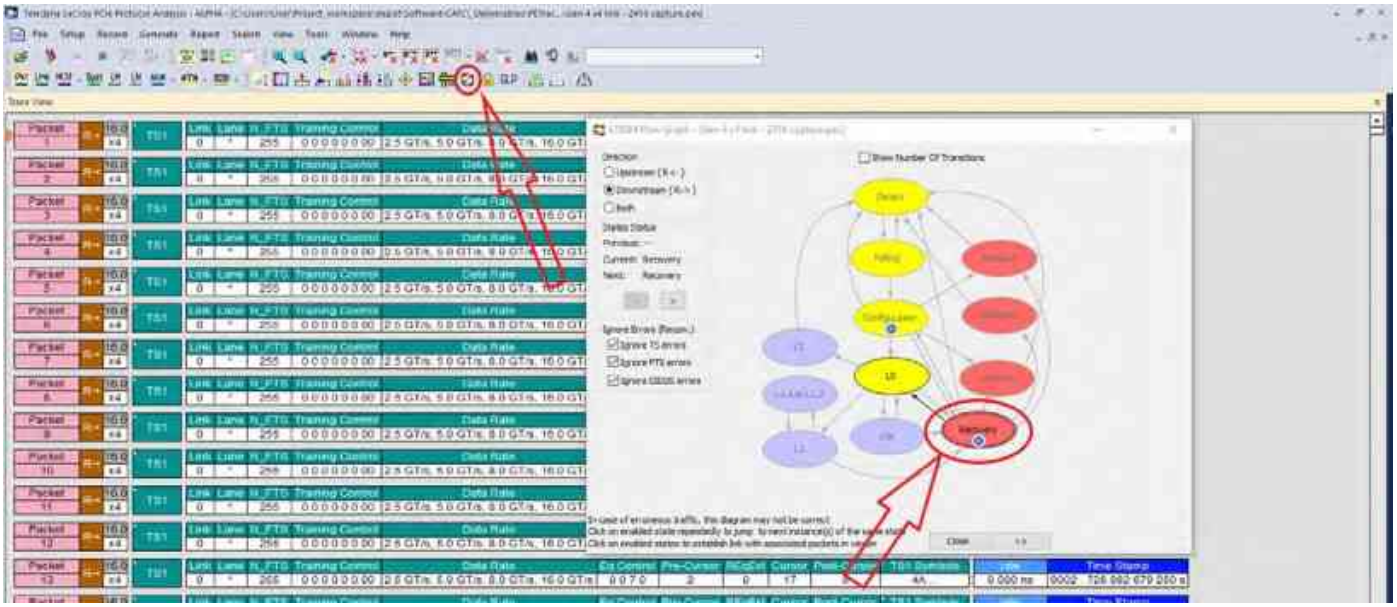


Figure 11.62: Recovery Phase of LTSSM

Click on the arrow in the blue circle in the Recovery state to see more detail. See Figure 11.63 on page 697.

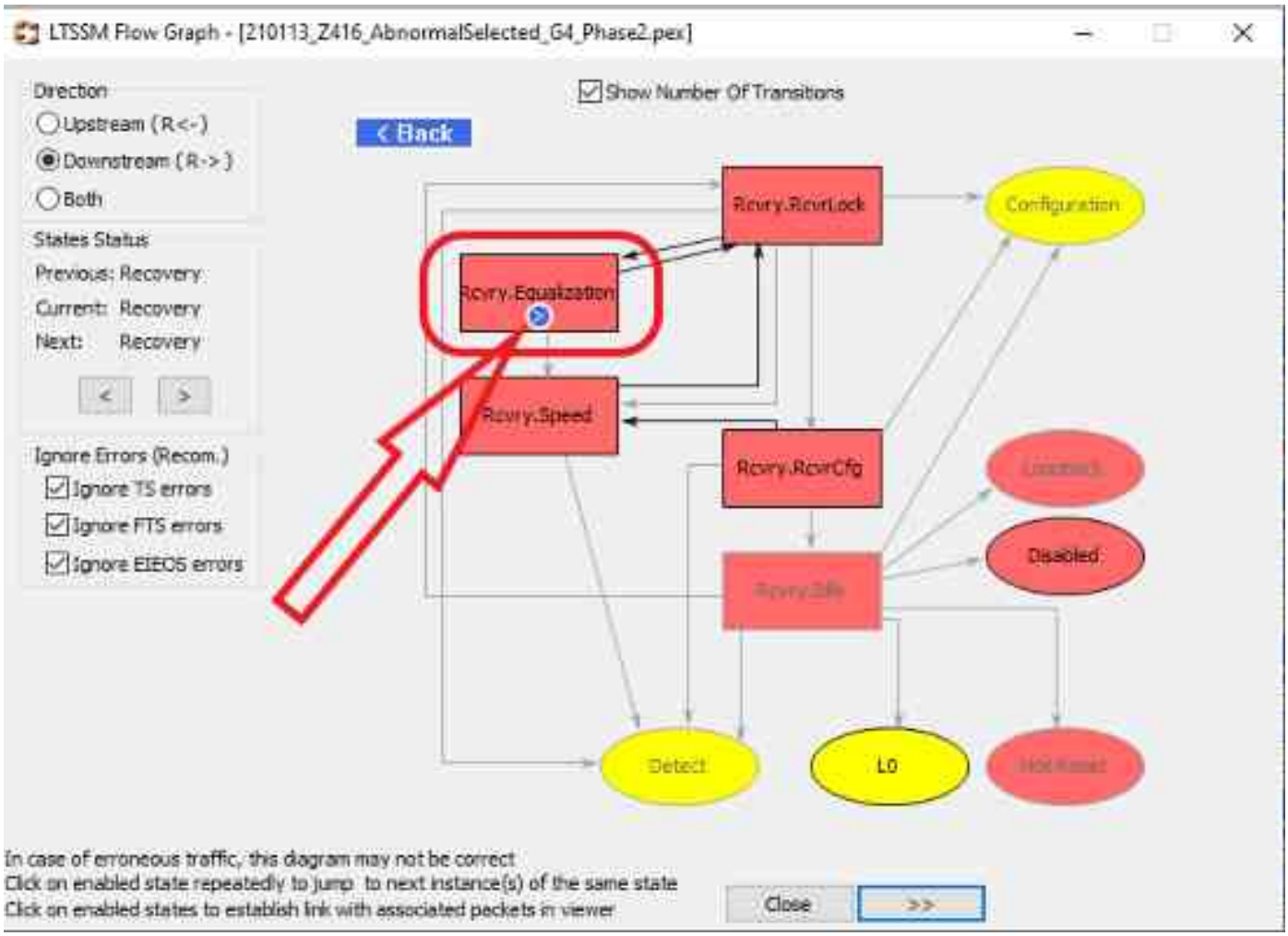


Figure 11.63: Recovery Equalization State

Click on the blue circle with the white arrow in the Recovery.Equalization state to review the PreCursor, Cursor and PostCursor values. See Figure 11.64 on page 698.

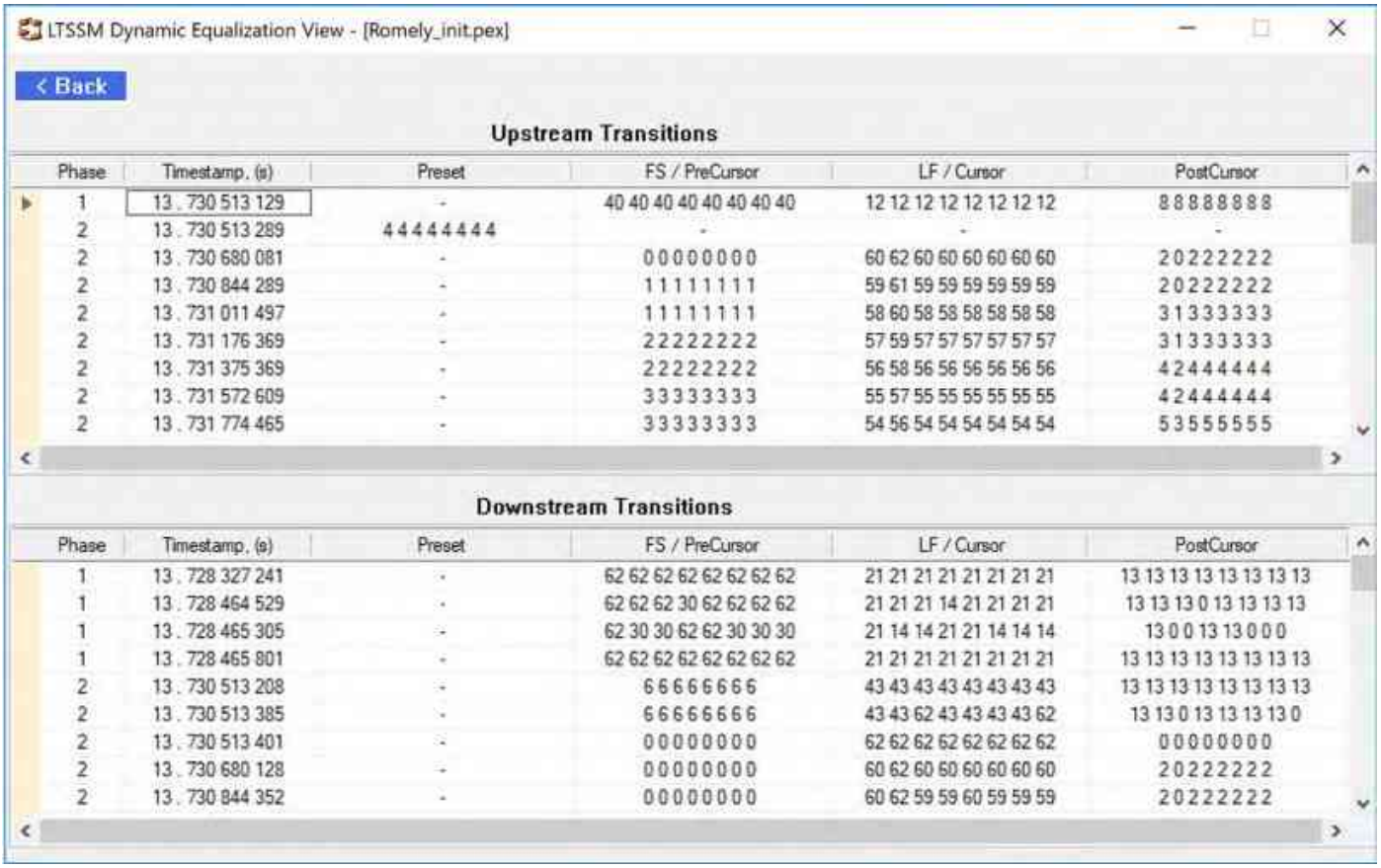


Figure 11.64: LTSSM Dynamic Equalization: PreCursor, Cursor and PostCursor Values

11.11 Lane Margining: Eye Diagram

A simulated eye diagram for Gen4 analyzers can be generated using the Rx Lane margining parameters delivered through CSR accesses and control skips.

To margin a Receiver, Software moves the target Receiver to a voltage/timing offset from its default sampling position. Simulated eye diagram will help follow stepping through the margin settings and tracking lane margin changes, using right/left offset timing margin steps and up/down offset voltage margin Steps relative to default.

After the trace has been generated select **Report -> LM Eye Diagram** and the following display will pop up. See Figure 11.65.

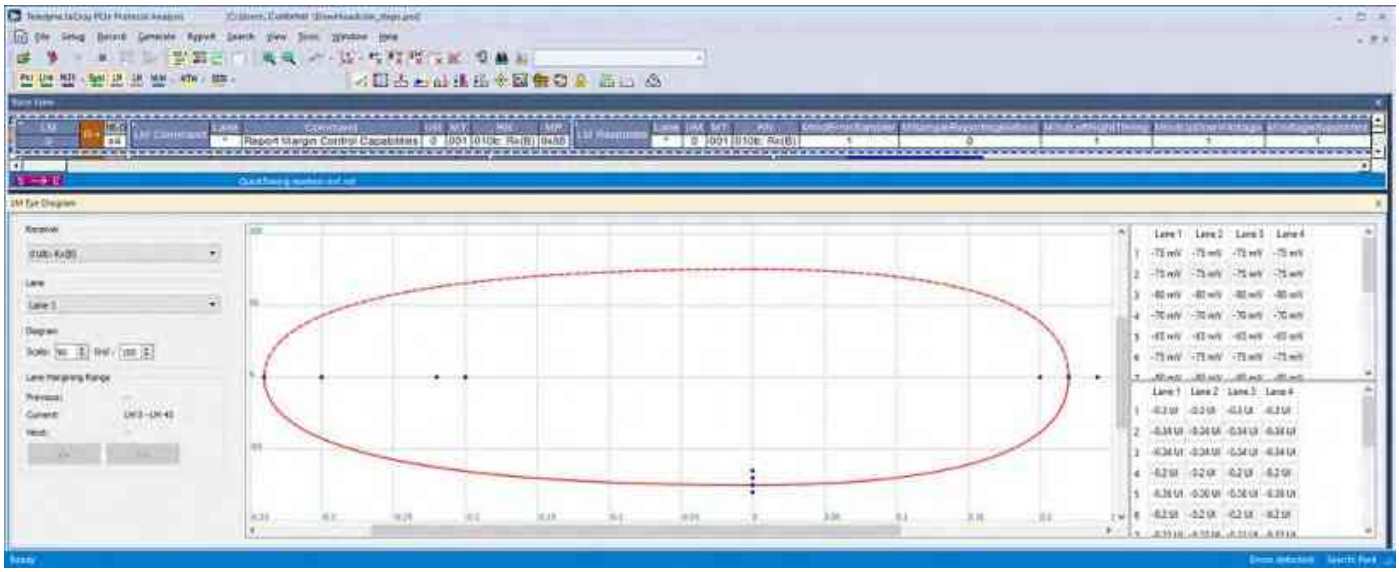


Figure 11.65: Decoded Lane Margining Trace: Eye Diagram

There are a number of controls to manipulate the “Eye Diagram”. Each one has a tooltip to explain its use. On the left side of the Eye Diagram there are the following options:

- Receiver: Choose receiver to be shown in Eye Diagram view and Timing and Voltage tables
- Lane: Choose lane to be shown in Eye Diagram view
- Diagram: Scale Factor -> Set scale factor for Eye Diagram
- Diagram: Grid -> Change grid size of Eye Diagram
- Lane Margining Range: Navigate over existing L0 states in trace

See Figure 11.66 on page 700.

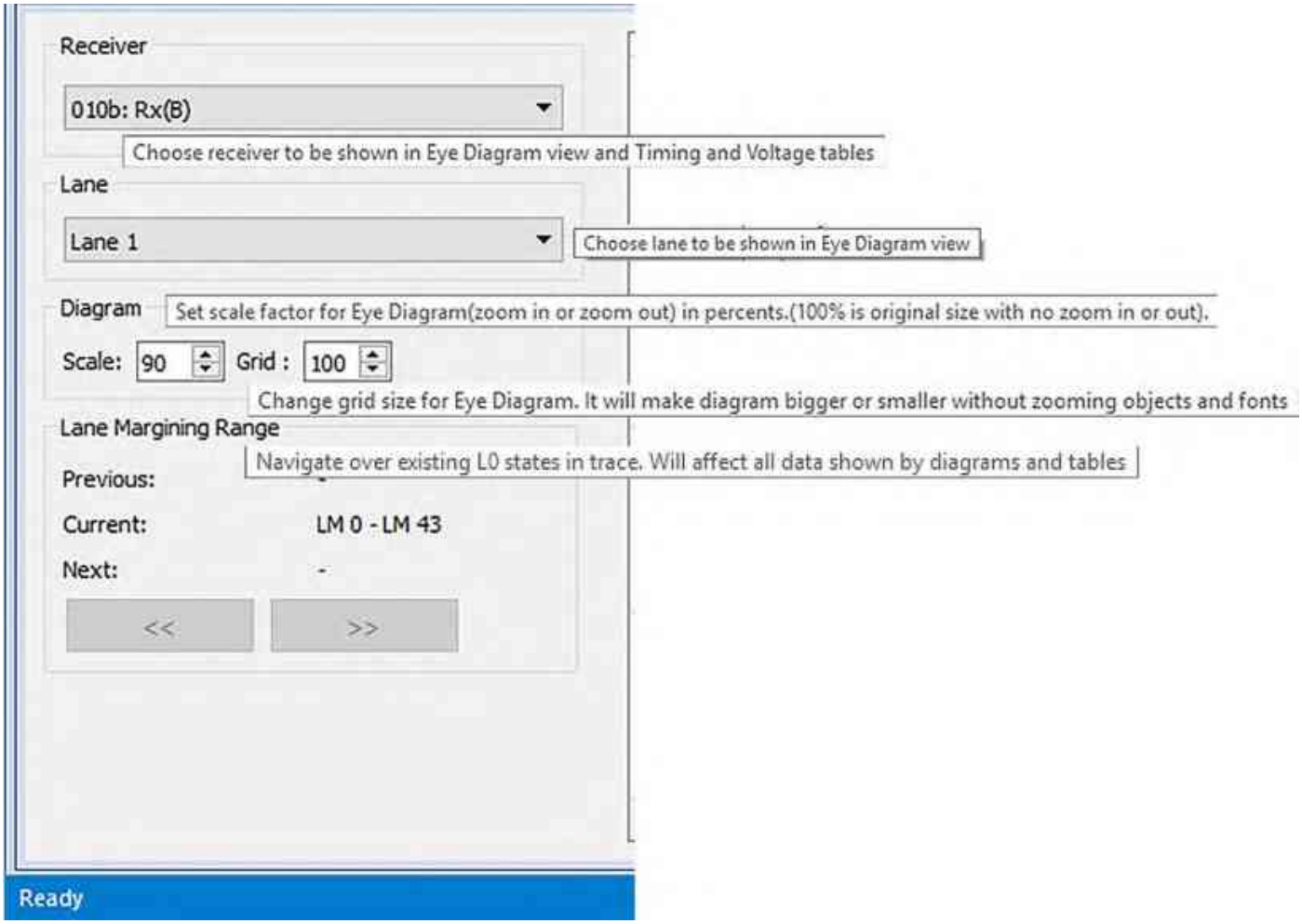


Figure 11.66: Options and Tooltips: Left side of Eye Diagram

On the right side of the Eye Diagram there are the following options:

- Lane 1 - Lane 4: Shows voltage transactions for given receiver
- Lane 1 - Lane 4: Shows timing transactions for given receiver

See Figure 11.67 on page 701.

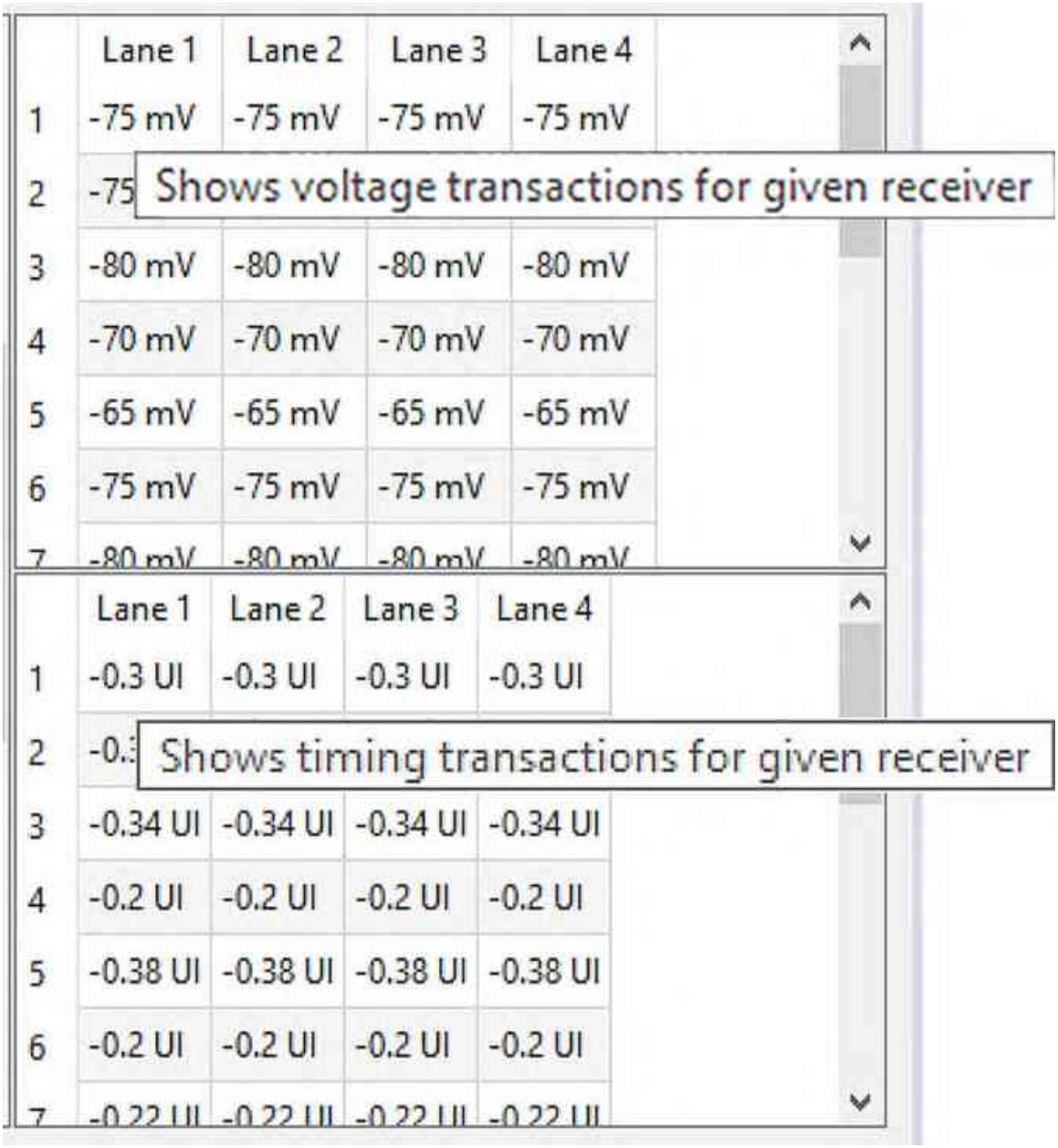


Figure 11.67: Options and Tooltips: Right side of Eye Diagram

11.12 Packet Header Bar

The Packet Header bar shows packet header information.

To display the Packet Header bar (see Figure 11.68 on page 702), select **Report > Packet Header** or click the  toolbar icon.

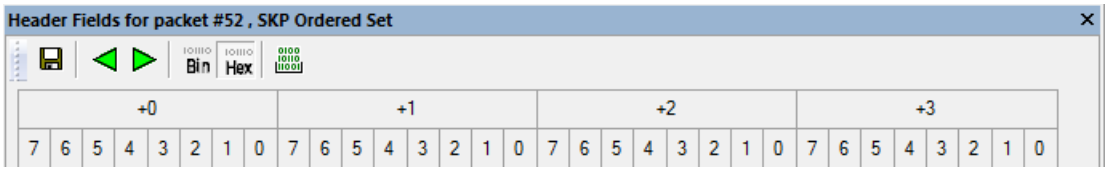


Figure 11.68: Packet Header Bar

The toolbar allows you to Save, go to Previous or Next, display Hexadecimal or Binary, and show the Packet Data window.



11.13 Packet Data Window

The Packet Data window shows packet or transaction payload.

To display the Packet Data window, select **Report > Packet Data** or click the  toolbar icon.

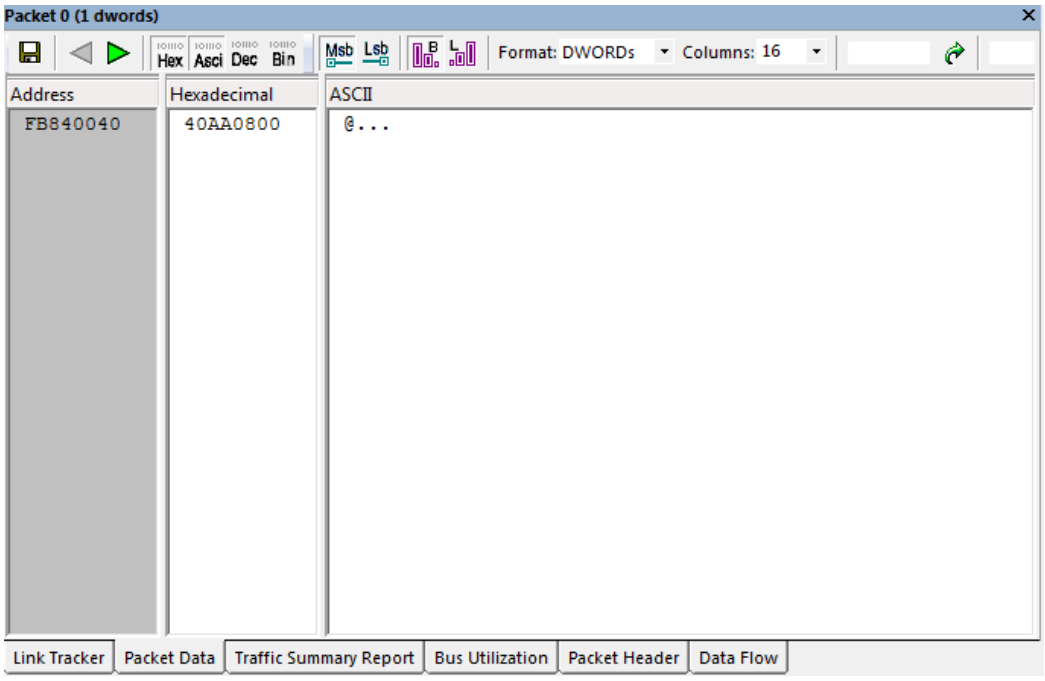
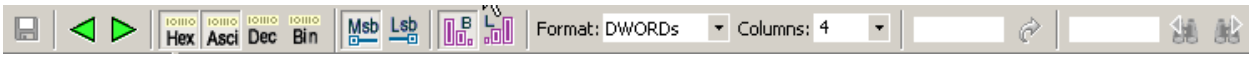


Figure 11.69: Packet Data Window

The toolbar allows you to Save; go to Previous or Next; display Hexadecimal, ASCII, Decimal, or Binary; use MSB Format or LSB Format; and use Big Endian or Little Endian.



Format and Columns allows you to enter the number of bytes, words, or dwords per line.

You can enter an Offset and scroll to it.

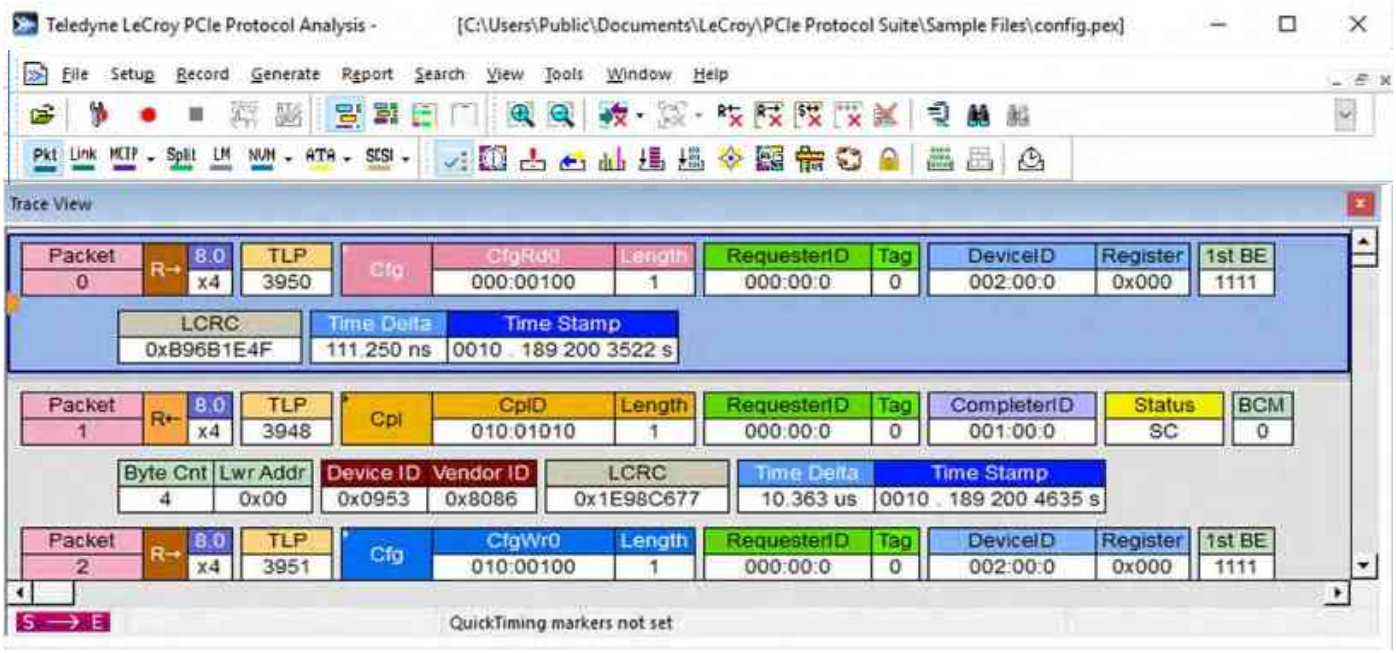
You can enter text and Search Previous or Search Next.

11.14 Configuration Space View

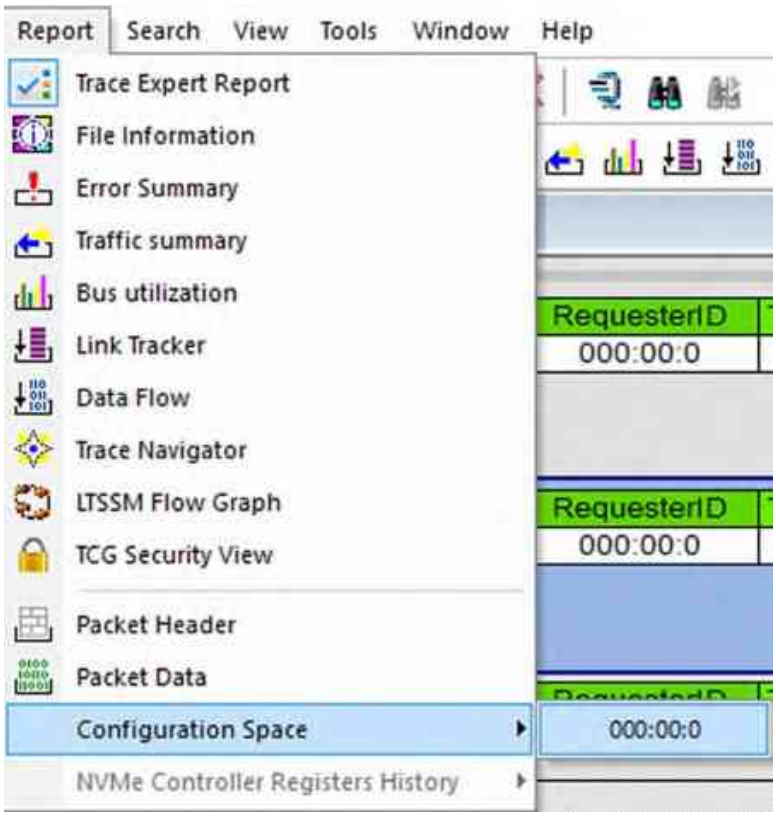
The Configuration Space View displays information about the Configuration Space state as of the current packet of the currently selected device. The view shows the Configuration Space Header and the PCI-compatible or PCI Express Capability Structures.

To display the Configuration Space View for a device at a packet:

1. Open a CATC Trace, such as the sample file **config.pex**.
2. Scroll to a packet with a Configuration header.



3. Select **Report > Configuration Space > <device>** to display the Configuration Space View.



Select **Show Configuration Space for xxxx** from the menu, where **xxxx** is the device number. The Configuration Space View displays (see Figure 11.70 on page 705).

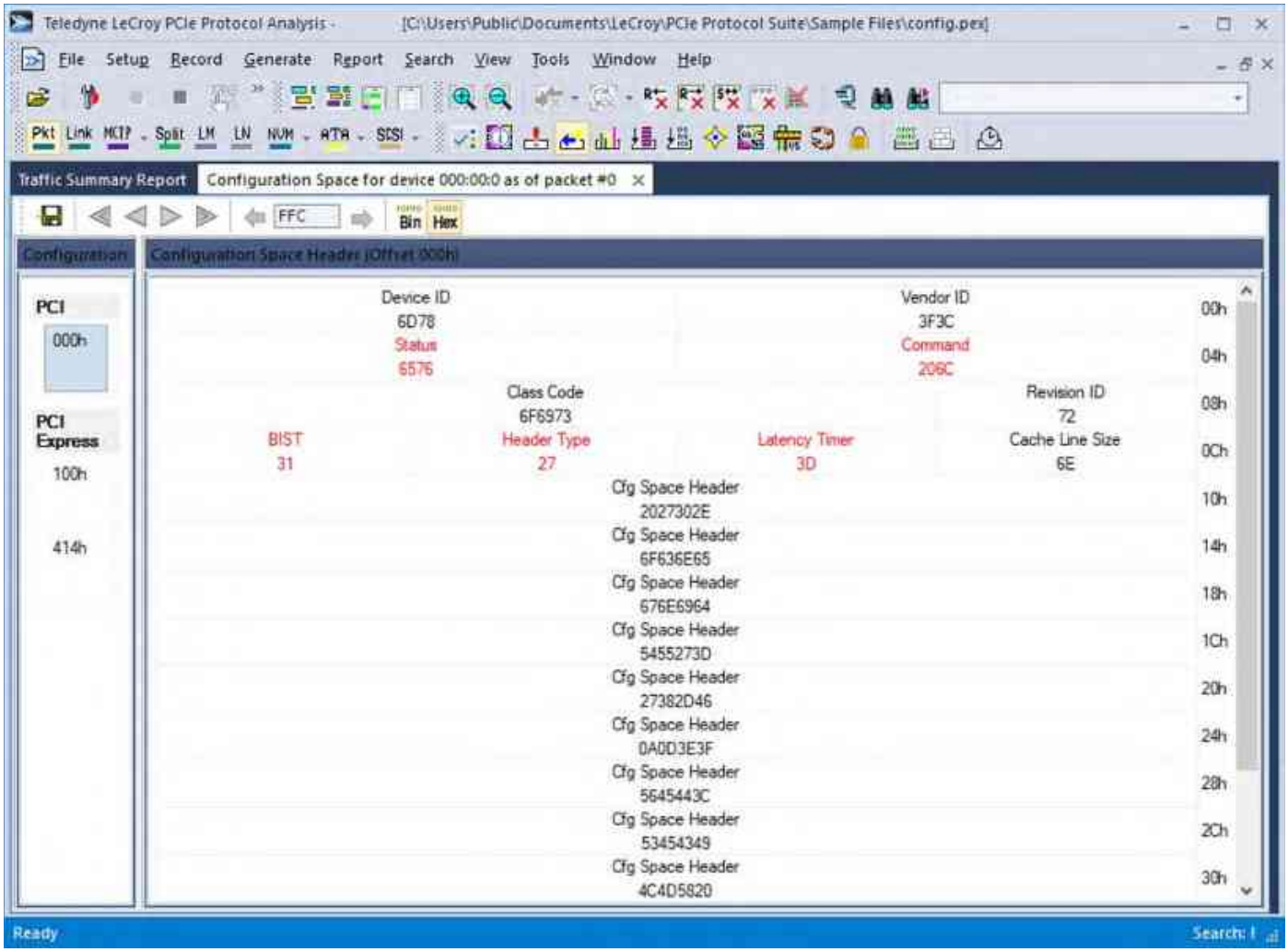


Figure 11.70: Configuration Space View

On the left, the view displays the Configuration Space for the selected CompleterID or DeviceID at the current packet. You can select **Configuration Space Header** or a **Capability Structure.**

The right displays the decoded data of the selected Configuration Space Header or a Capability Structure, up to the current packet. (The decoding builds while navigating through the next packets.)

The Configuration Space View toolbar allows you to save, go to First, go to Previous, go to Next, go to Last, go to Previous Access to Selected Configuration Space Register, go to Next Access to Selected Configuration Space Register, and display Hexadecimal or Binary.

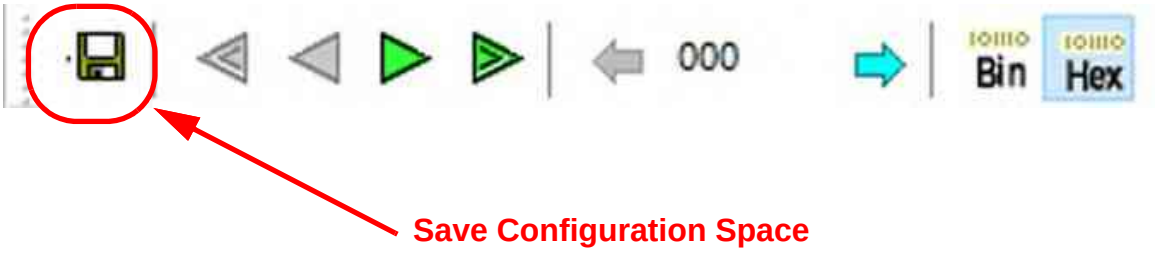


Figure 11.71: Saving Configuration Space File

If you select to Save the Configuration Space file, a dialog box will pop-up and you can save the file for future use in either of two formats:

- PCIe Trainer Configuration Space files
- HTML files

See Figure 11.72.

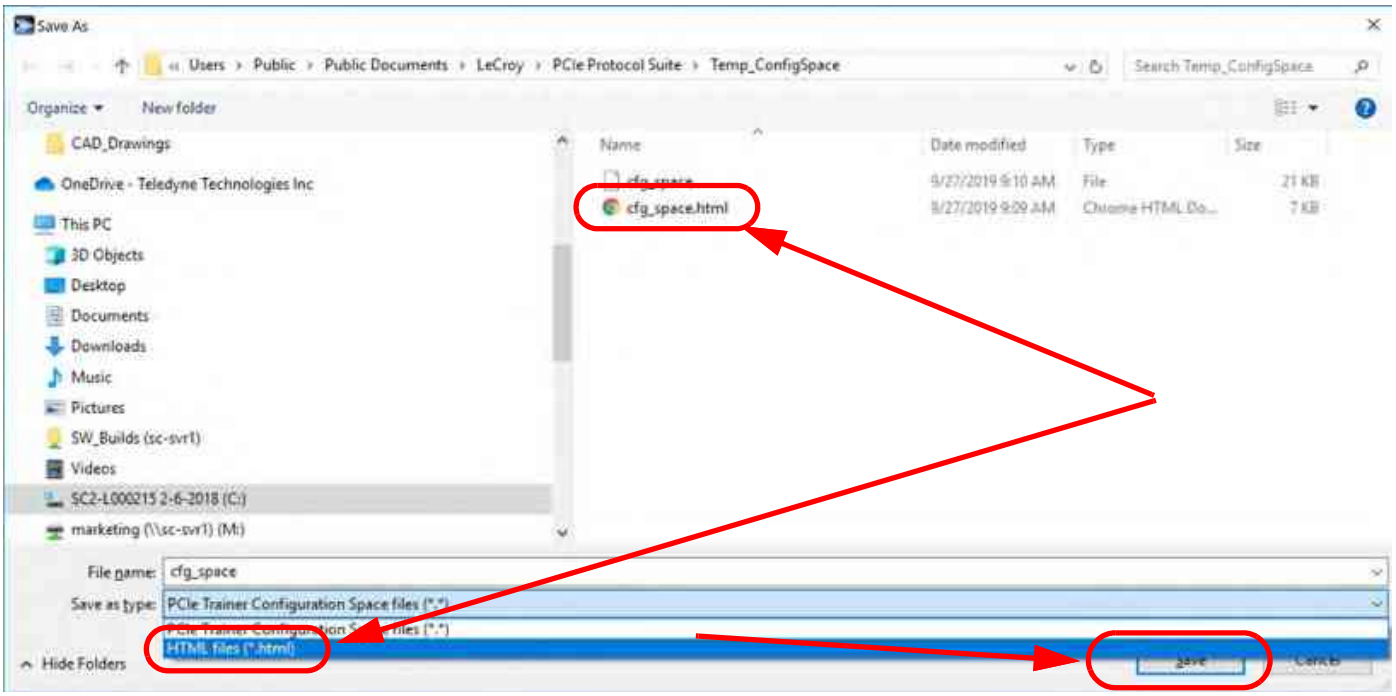


Figure 11.72: Location of Configuration Space File: PCIe Protocol Suite/Temp

Click on the **Save** button to save the file.

If you had selected Saving As -> HTML and you open that file, you will see the following information about the Configuration Space in HTML format. See Figure 11.73 on page 707.

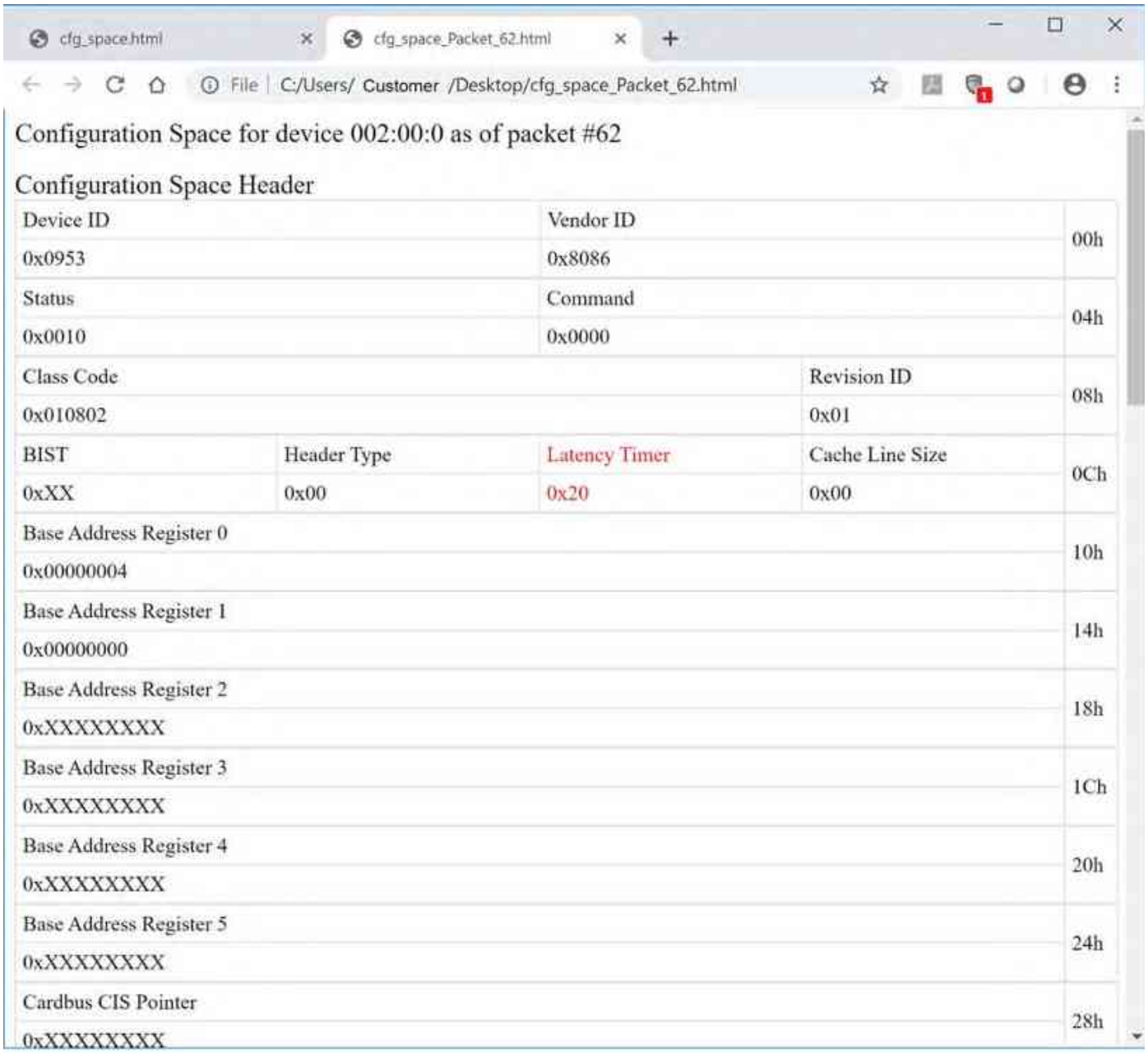


Figure 11.73: Saving Configuration Space File As: HTML

11.14.1 Tools -> Import Configuration Space File

Import Configuration Space dialog can be launched from Tools menu after PCIe trace file is opened. See Figure 11.74.

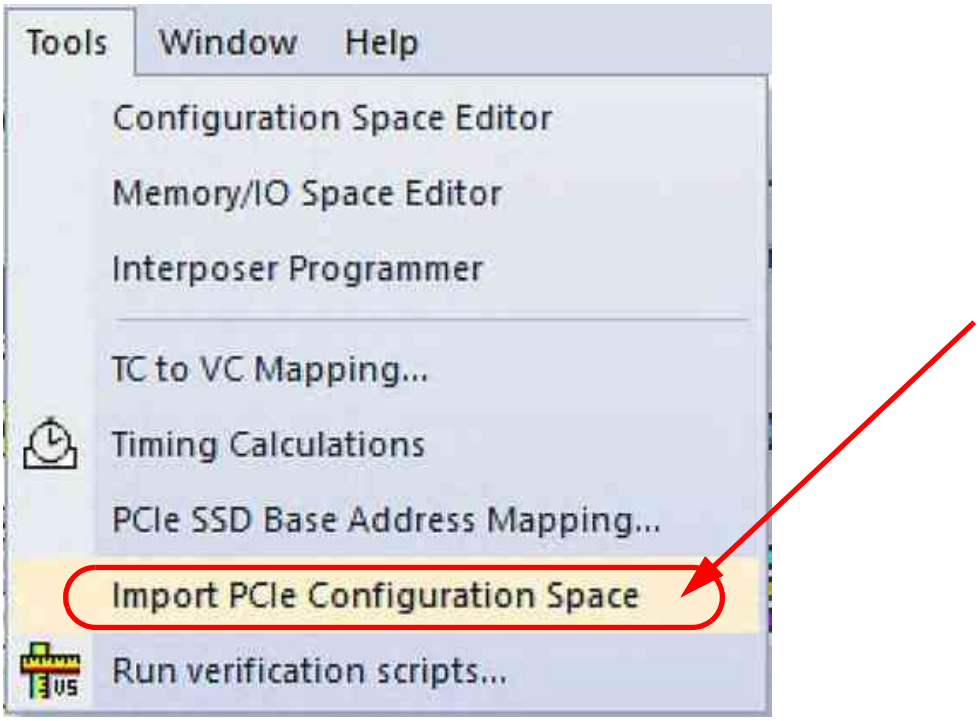


Figure 11.74: **Tools -> Import PCIe Configuration Space**

The main purpose of importing a configuration space is to overwrite existing configuration space or to add configuration space information to a trace without it in order to help decoding.

Select Import PCIe Configuration Space and the following window pops up with previously saved Configuration Space files. See Figure 11.75.

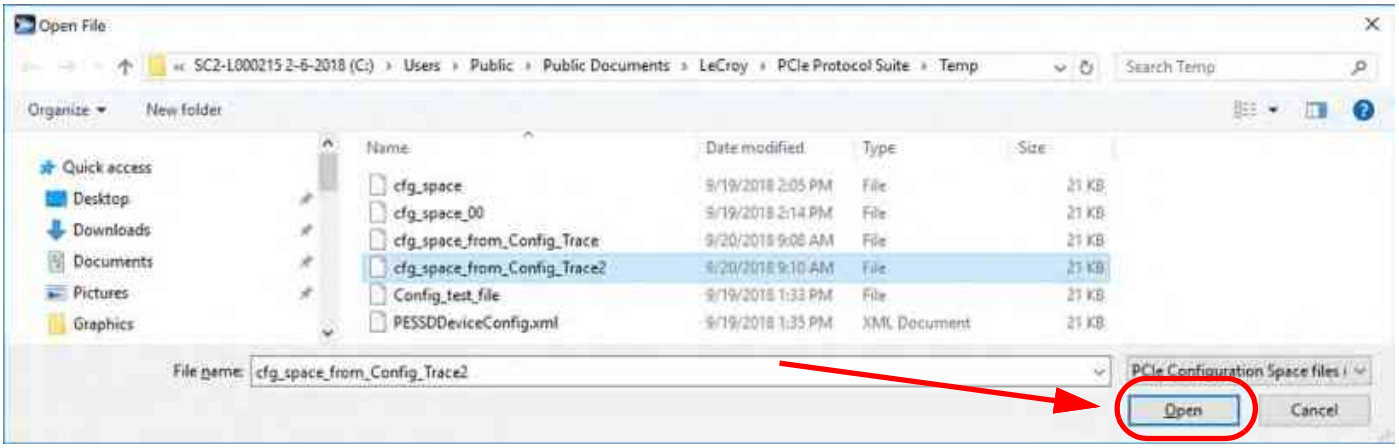


Figure 11.75: Saved Configuration Space files

Select **Open** and the Import PCIe Configuration Space dialog pops up. See Figure 11.76.

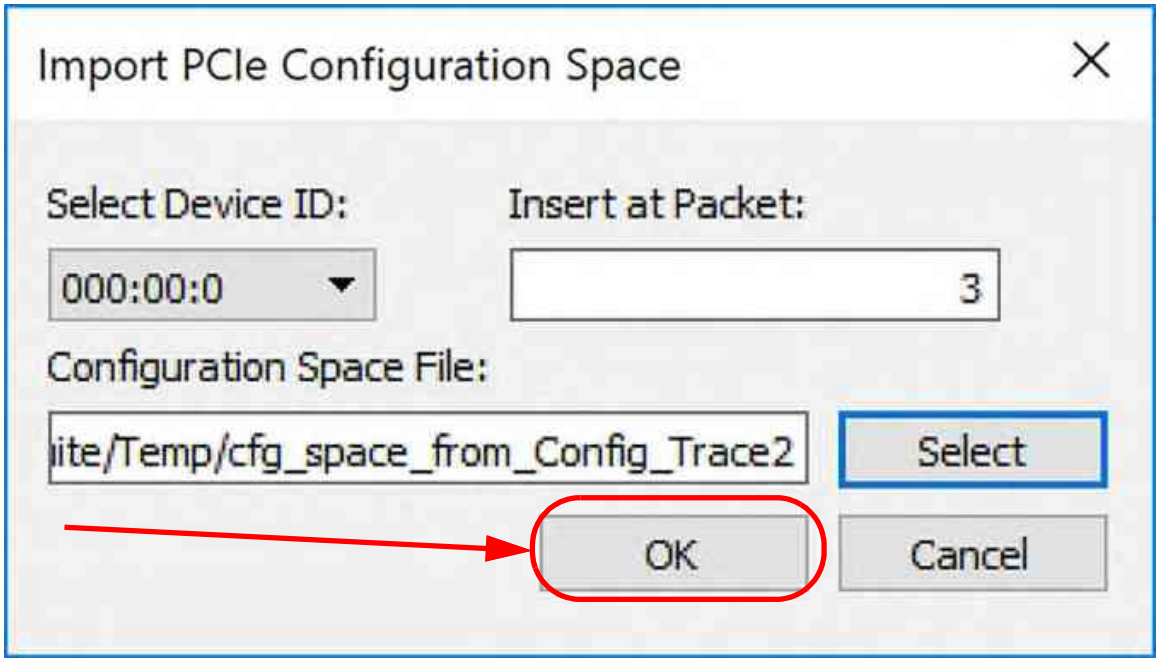


Figure 11.76: Import PCIe Configuration Space Dialog

In this dialog box you can select the following options:

- Device TD
- Insert at Packet
- Select the Configuration Space File you want to use

After making your choices, click on OK and the Configuration File will be inserted into the Trace you have open at the before the Packet you have chosen.

The next section shows how to edit a Configuration Space.

11.14.2 Configuration Space Editor

The Configuration Space Editor allows you to create a new Configuration space file or open an existing Configuration Space file. It is used in conjunction with Teledyne LeCroy Trainer products. Select **Tools > Configuration Space Editor** to display the Configuration Space Editor dialog (see Figure 11.77 on page 709).

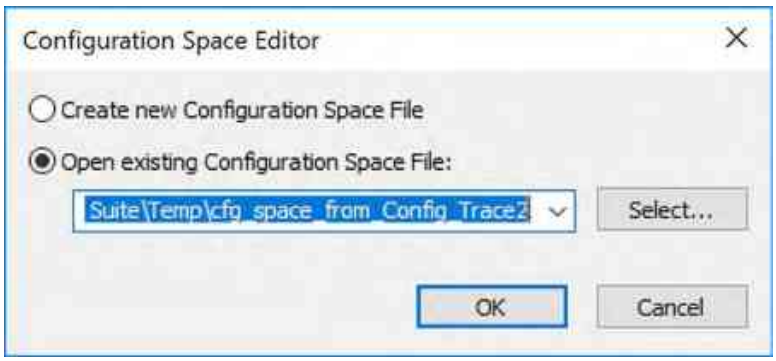


Figure 11.77: Configuration Space Editor Dialog

Click on **OK** and the Editor will popup. Edit the Configuration Space file manually, then save it, and import it. See Figure 11.78.

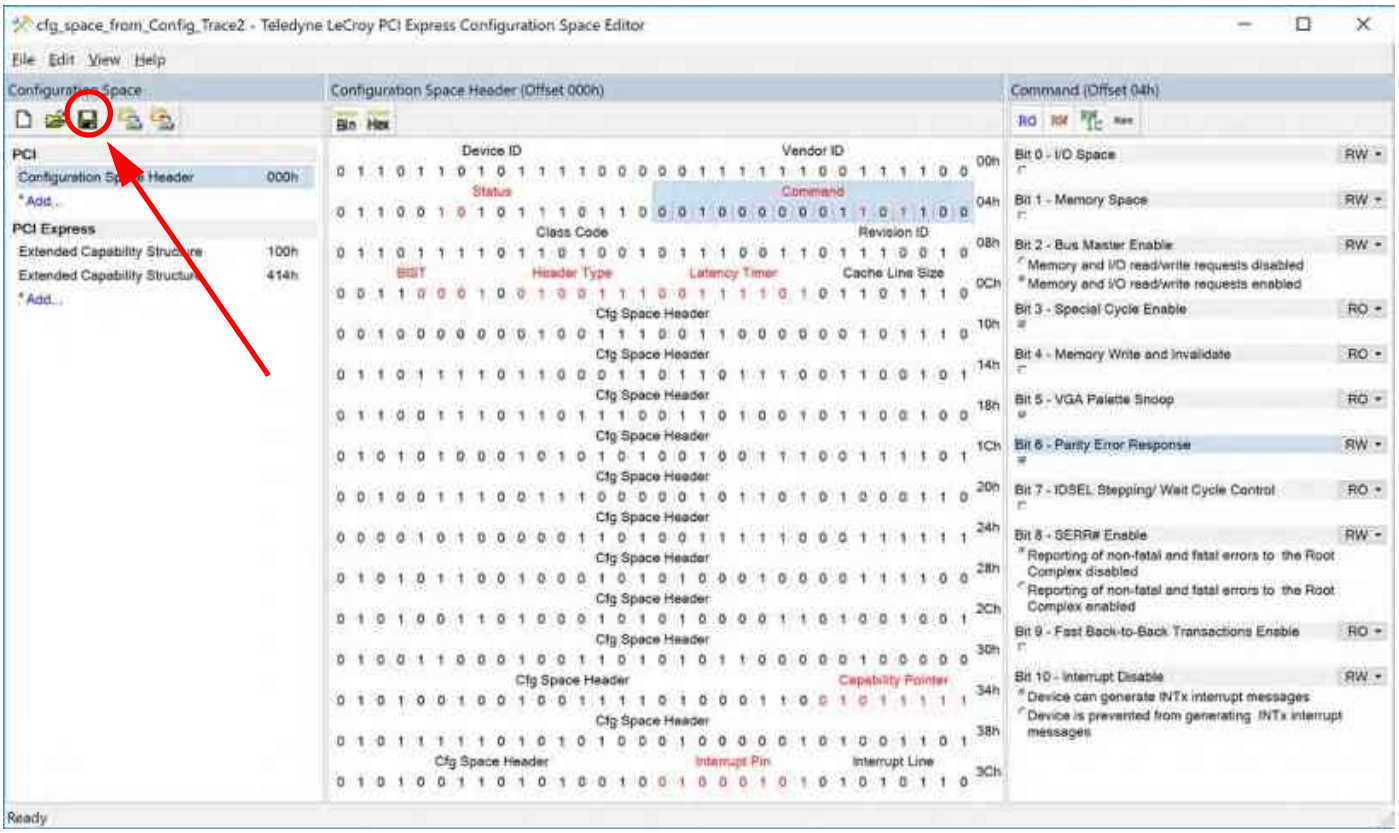


Figure 11.78: Configuration Space File: Example

Note: See "Configuration Space Decoding" on page 733 for details of the Configuration Space file.

11.15 CXL Memory Mapped Space View

The CXL Memory Mapped Space View displays information about the CXL Memory Mapped Space state as of the current packet of the currently selected device. The view shows the Memory Mapped Space registers located in six general regions.

To display CXL Memory Mapped Space:

1. Open CXL CATC Trace which contains boot recording.

Note: This may be a sample file with CXL Memory Mapped Space.

2. Wait until the trace is decoded to Split Transactions Level.
3. Select **Report**, then **CXL Memory Mapped Space View**. See Figure 11.79 on page 711.
4. Select the **Device Number**. The CXL Memory Mapped Registered Space screen displays for the device. See Figure 11.80 on page 712.

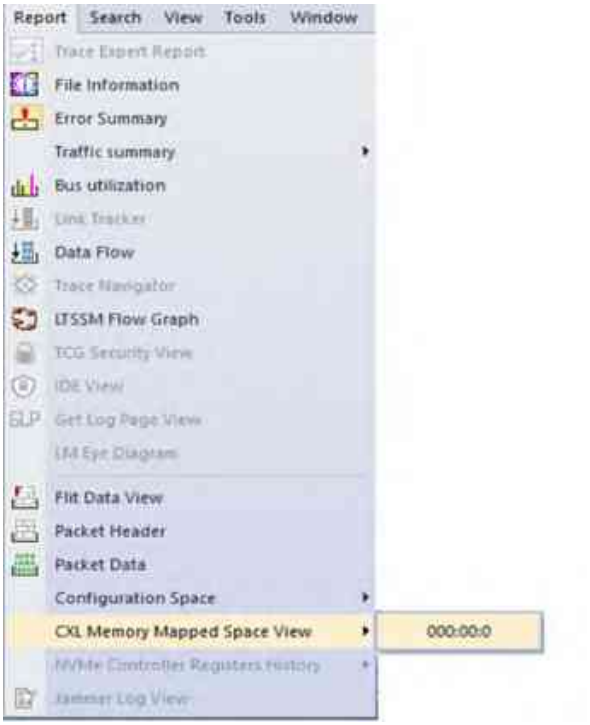


Figure 11.79: CXL CATC Trace Report Menu

11.15.1 CXL Memory Mapped Registers - Left Side

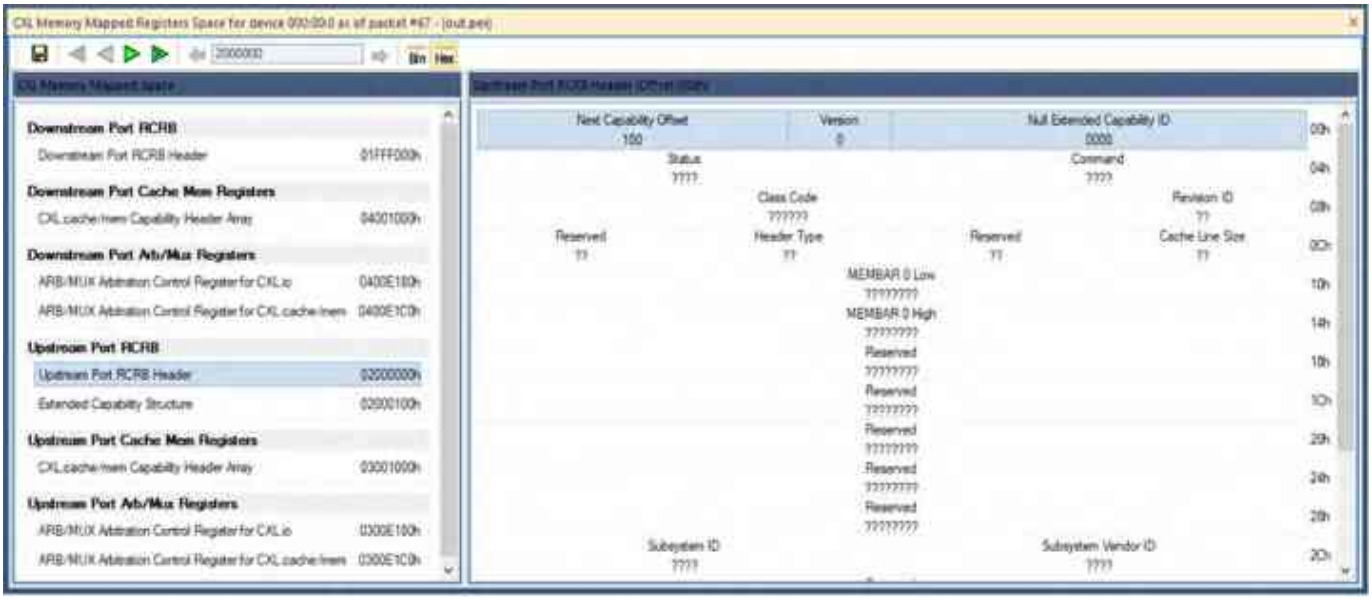


Figure 11.80: CXL Memory Mapped Registers Space Screen

The left side view shows the capabilities according to their locations in the Memory Mapped Space. For CXL 1.1, there are 6 regions:

- Downstream Port RCRB
- Downstream Port Cache Mem Registers
- Downstream Port Arb/Mux Registers
- Upstream Port RCRB
- Upstream Port Cache Mem Registers
- Upstream Port Arb/Mux Registers

Note: The CXL 1.1 Downstream Port and CXL 1.1 Upstream Port are not discoverable through PCIe Configuration Space. Instead, the CXL 1.1 Downstream and Upstream Port registers are implemented using PCIe root complex registers blocks (RCRBs).

The CXL 1.1 Downstream and Upstream ports each implement an MEMBAR0 region (also known as Component Registers) to host registers for configuring the CXL subsystem components associated with the respective Port.

Table 11.2 on page 713 shows the structure of the CXL MEMBAR0/Component Registers.

Range	Size	Destination
0000_0000h - 0000_0FFFh	4K	CXL.io registers
0000_1000h - 0000_1FFFh	4K	CXL.cache and CXL.mem registers
0000_2000h - 0000_DFFFh	48K	Implementation Specific
0000_E000h - 0000_E3FFh	1K	CXL ARB/MUX registers
0000_E400h - 0000_FFFFh	7K	Reserved

TABLE 11.2: CXL MEMBAR0/Component Registers

This table displays the following:

- The Memory Mapped Space View CXL.cache/mem registers (range 0000_1000h - 0000_1FFFh) are shown for Downstream Port as Downstream Port Cache Mem Registers.
- ARB/MUX registers (range 0000_E000h - 0000_E3FFh) are shown as Downstream Port Arb/Mux Registers.
- The same representation is used for the Upstream Port as well.

11.15.2 CXL Memory Mapped Registers - Right Side

The right side of the view displays decoded data of the selected capability structure, up to the current packet - the decoding builds while navigating through the next packets. The Capability shows data in two modes: Hex or Bin.

Note: If the value is not known or was not read during the Memory Mapped Space reading process, a **?** displays.

Each capability may contain a different number of registers with different attributes specified. To see the detailed decoding of each capability register, hover the cursor over the register field until the tooltip shows the register's description, as shown in Figure 11.81 on page 714. The tooltip contains the sub-fields and their corresponding values of the Table of Registers.Table 11.1 on page 660

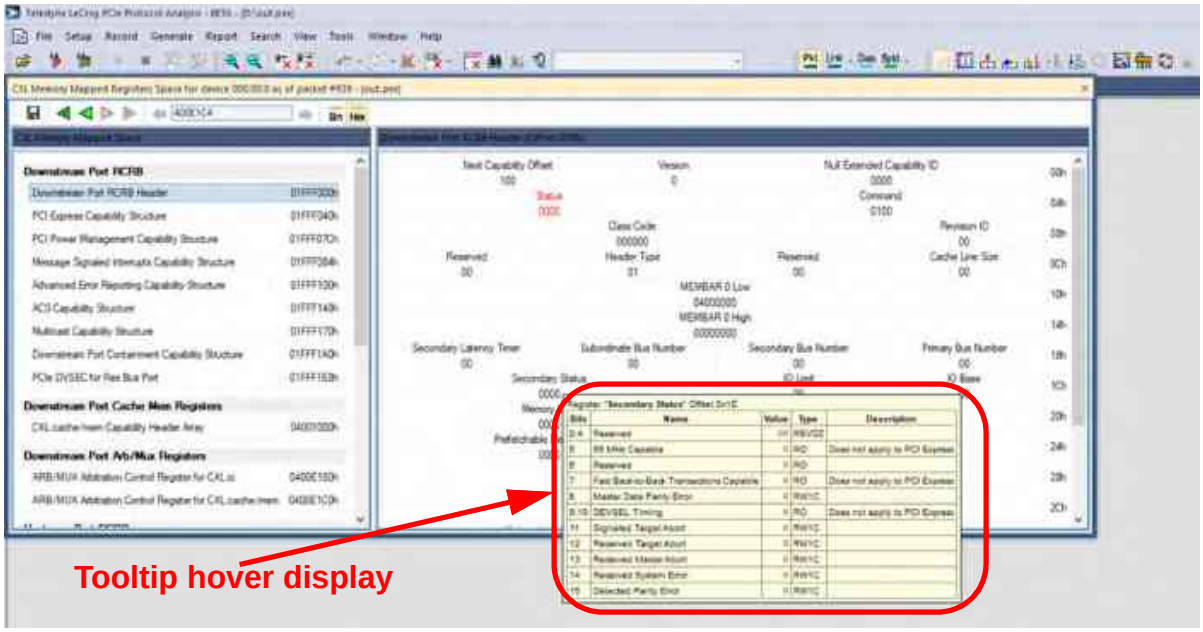


Figure 11.81: Tooltip Display for the Table of Registers

11.15.3 CXL Memory Mapped Registers - Toolbar

The Memory Mapped Space View Toolbar has selections to:

- Save the Memory Mapped Space to an external file by clicking the Save icon.
- Go to First, go to Previous, go to Next, and go to Last using the arrow keys.
- Search for the registers address by entering the address in the text box. To see Previous/Next address, use the arrow keys next to the address text box.
- Choose between Binary (Bin) and Hexadecimal (Hex) mode by clicking the Bin or Hex icon, respectively.

See Figure 11.82 on page 714.



Figure 11.82: CXL Memory Mapped Registers Space Toolbar

11.15.4 Save

To Save the Memory Mapped Space file, click on the Save icon. If saving the space for the first time, the Save As dialog box displays. From the Save as Type drop down, select the format. There are two formats available:

- HTML Files (*.html)
- CXL Trainer Memory Mapped Space Files (*.*)

Type in the file name in the File Name text space. Click the Save button on the dialog box once all selections are complete.

Note: If necessary to save the file in another version or name, select **Save As** under the **File** menu.

See Figure 11.83 on page 715 for an example.

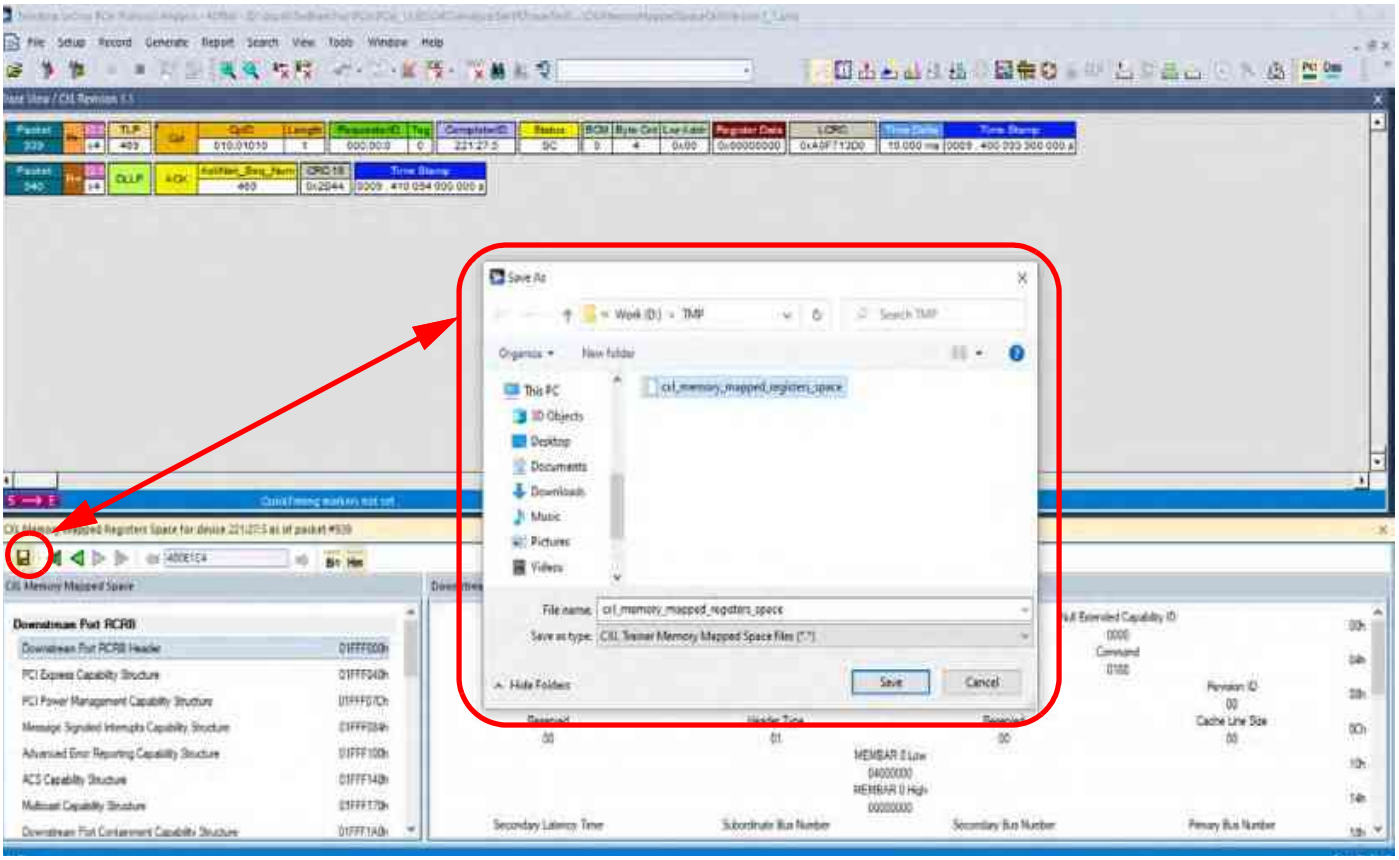


Figure 11.83: Saving the CXL Memory Space

Figure 11.84 on page 716 shows an example of a CXL Memory Space file saved in HTML output.

CXL Memory Mapped Registers Space for device 000:00:0 as of packet #939

Downstream Port RCRB Header

Next Capability Offset		Version	Null Extended Capability ID	00h
0x100		0x0	0x0000	
Status			Command	04h
0x0000			0x0100	
Class Code			Revision ID	08h
0x000000			0x00	
Reserved	Header Type	Reserved	Cache Line Size	0Ch
0x00	0x01	0x00	0x00	
MEMBAR 0 Low				10h
0x04000000				
MEMBAR 0 High				14h
0x00000000				
Secondary Latency Timer	Subordinate Bus Number	Secondary Bus Number	Primary Bus Number	18h
0x00	0x00	0x00	0x00	

Figure 11.84: CXL Memory Mapped Registers Space HTML File

11.16 Using Unit Metrics

For every protocol unit at the Link or Split transaction level, PCIe Protocol Analysis™ calculates and displays a set of metrics. Metrics are measurements of key operating parameters. You can use metrics to evaluate performance of traffic in the CATC Trace stream.

You can view metrics information in the CATC Trace display, the Traffic Summary window, and the Bus Utilization window.

PCIe Protocol Analysis defines different metrics for Link and Split transactions.

11.17 Metrics Defined for Link Transactions

- **Number of Packets**: The total number of packets that compose this Link transaction.
- **Payload**: The number of data payload bytes this Link transaction transferred.
- **Response Time**: The time it took to transmit this Link transaction on the PE link, from the beginning of the first packet in the transaction to the end of the last packet in the transaction.
- **Data Throughput**: The payload divided by response time, expressed in megabytes (MB) per second (MB = 1024*1024 bytes).

Note: Usually, the Number of Packets metric for a link transaction is two (in case of explicit acknowledge) or one (in case of implicit acknowledge). However if Naks/link level retries are involved, this metric might be higher. As a result, the Number of Packets metric is useful in highlighting unusual link transactions.

11.17.1 Metrics Defined for Split Transactions

The following types of metrics currently are defined for Split transactions:

Number of Link Transactions: The total number of Link transactions that compose this Split transaction.

Payload: The number of payload bytes this Split transaction transferred.

Response Time: The time it took to transmit this Split transaction on the PE link, from the beginning of the first packet in the Split transaction to the end of the last packet in the Split transaction;

Data Throughput: The transaction payload divided by response time, expressed in megabytes (MB) per second (MB = 1024*1024 bytes).

Latency Time: The time measured from the end of the request transaction to the first completion transmitted in response to the request within this Split transaction.

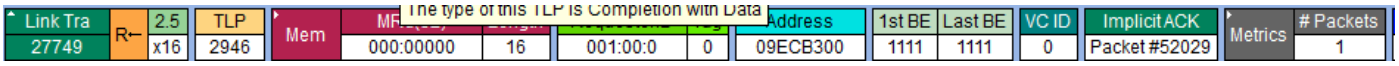
Note: The Number Of Link Transactions metric for a Split Transaction usually is two for a Configuration or IO request. It can be bigger then two for a Memory Read request.

11.18 Show Metrics in the CATC Trace Display

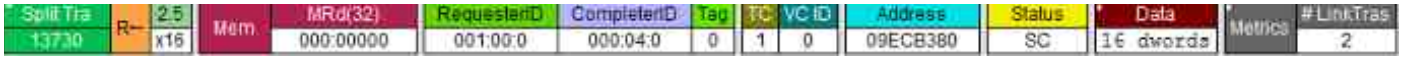
In the CATC Trace view display of Link Transaction or Split Transaction levels, all metrics information applicable to a specific protocol unit is displayed in a Metrics header. The header is located close to the end of the unit, in front of the Time cell. You can expand and collapse the header to show or hide the metrics information.

11.18.1 Collapsed Metrics Header Display

Following is a collapsed metrics display for a unit of Link Transaction. The collapsed header display shows only the metrics cell representing the Number of Packets.

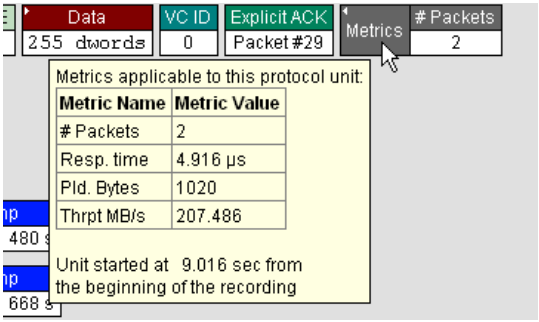


Following is a collapsed metrics display for a unit of Split Transaction. The collapsed header display shows only the metrics cell representing Number of Link Transactions.



11.18.2 Metrics Tool Tip Display

In both CATC Trace level views, you can view the summary of all the unit metrics in the Metrics header tool tip. To view the tool tip, simply place the mouse cursor over the Metrics header. Following is the tool tip for a unit in the Link Transaction view.



Note: The tool tip also presents information for time passed from the start of the recording till the beginning of this Link or Split Transaction.

11.18.3 Expanded Metrics Header Display

When you expand the Metrics header, the display creates a separate cell for each applicable metric:

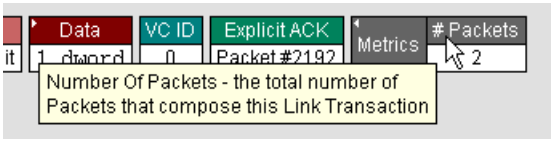
The following is the expanded Metric header for a unit in the Split Transaction view.

Metrics	# LinkTras	Resp. time	Latency	Thrpt MB/s	Pld. Bytes
	2	7.460 µs	6.736 µs	2.145	16

The following is the expanded Metric header for a unit in the Link Transaction view.

Metrics	# Packets	Resp. time	Pld. Bytes	Thrpt MB/s
	2	536.000 ns	64	119.403

Note: Each of the metric cells pops up a tool tip window with the explanation of what the metric means.

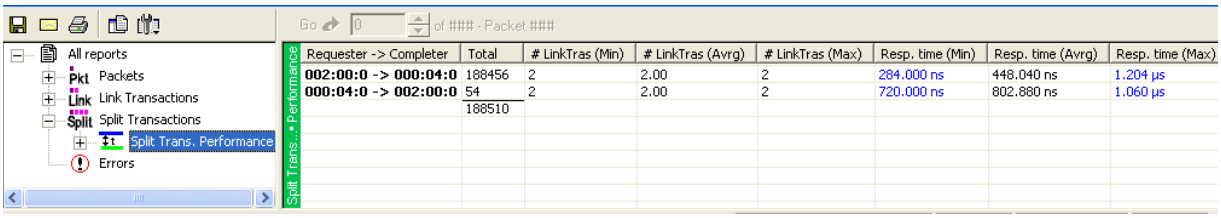


11.19 Show Metrics in the Traffic Summary Window

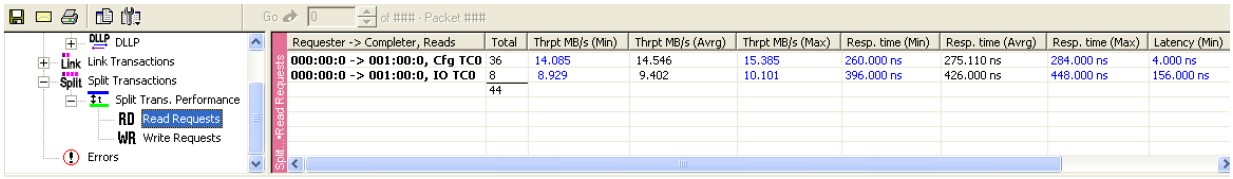
Some of the Traffic Summary reports at the Link and Split Transaction levels are based on metrics collected for the corresponding protocol units in the CATC Trace.

11.19.1 Reports at Split Transaction Level

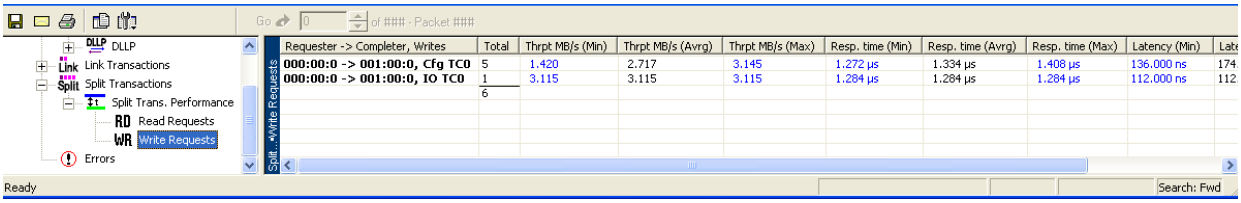
Split Transaction Performance: This report table groups the Split Transactions by Requester-Completer pair and displays Minimum/Average/Maximum data for Number Of Link Transactions and Response Time metrics.



Read Requests Performance: This report table includes only the Split Transactions that present Read Requests (Configuration, IO and Memory). It groups them by the combination of Requester-Completer pair, request type, and Traffic Class and displays Minimum/Average/Maximum data for Throughput, Response Time, and Latency metrics (see the following figure).



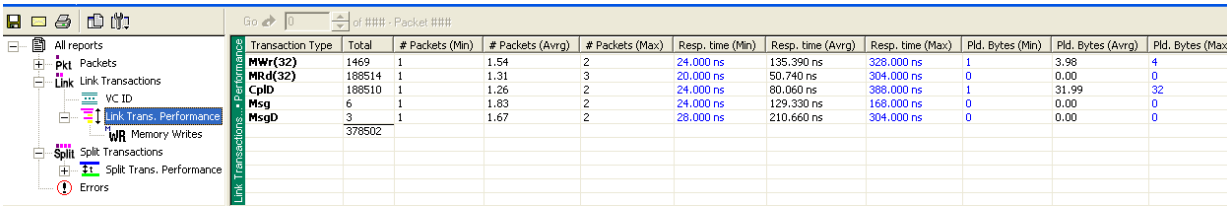
Write Requests Performance: This report table includes only the Split Transactions that present Write Requests (Configuration and IO). It groups them by the combination of Requester-Completer pair, request type, and Traffic Class and displays Minimum/Average/Maximum data for Throughput, Response Time, and Latency metrics.



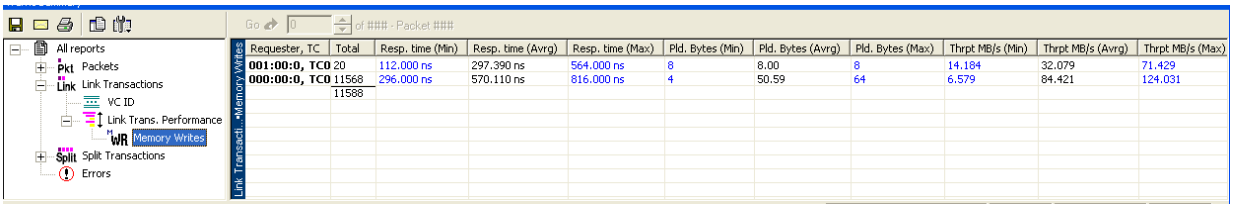
11.19.2 Reports at the Link Transaction Level

The following metric-based reports are displayed at the Link Transaction level:

Link Transaction Performance: This report table groups the Link Transactions by TLP Type and displays Minimum/Average/Maximum data for Number Of Packets, Response Time and Payload Bytes metrics.



Memory Writes: This report table includes only the Link Transactions that present Memory Write Requests. Memory Writes are the only (posted) requests that don't get promoted to the Split transaction level, therefore their performance should be viewed at the Link transaction level. The table groups Memory Writes by the combination of Requester ID and Traffic Class and displays Minimum/Average/Maximum data for Response Time, Payload and Throughput metrics.



The following features apply to all of the report tables described above for the Split Transaction and Link Transaction levels:

- Each report row for the defined tables contains the total number of units in this group for the CATC Trace (total number of units for Split Transaction performance, Read Requests performance, Memory Writes, and so on).
- In many cases, the Maximum and Minimum values in the report tables are navigable. By clicking table cells, you reposition the corresponding CATC Trace view to the Split or Link Transaction that has yielded this maximum or minimum value. This can help you to find specific units in the CATC Trace, such as transactions that produced spikes in Response Time or Throughput.

11.20 Show Metrics in the Bus Utilization Window

The Bus Utilization window provides graphs for packet-level information in the CATC Trace. The window also provides graphs for information on Split and Link Transaction levels, plotted over time. The graphs for Split and Link Transaction levels are based on metrics collected for the transactions throughout the CATC Trace.

The seven graphs related to Split and Transaction levels are:

1. Pending Requests at Split Transaction level.
2. Response Time at Split Transaction level.
3. Latency Time at Split Transaction level.
4. Throughput Per Transaction at Split Transaction level.
5. Response Time and Latency Time at Split Transaction level (combined graph).
6. Response Time at Link Transaction level, for Memory Writes only.
7. Throughput at Link Transaction level, for Memory Writes only.

The following is an example of Bus Utilization window display of graph numbers 1, 4, 5, 6 and 7 (see the following figure):



11.20.1 Unit-Based Averaging

The Analyzer builds metric graphs using unit-based averaging (as opposed to time-based averaging). For the total duration of a certain request (or Memory Write transaction), the graph value is assumed equal to the corresponding metric for this request (transaction). If there are overlapping operations for a certain time period, then the value is calculated as an average of metric values for all the overlapped requests (transactions).

It is important to remember that the Analyzer uses unit-based averaging rather than time-based averaging. Time-based averaging can be misleading in some situations. For example, consider the Throughput Per Transaction graph. Sometimes, while many outstanding requests are in progress, latency (and response time) grows for each of the transactions, resulting in a lower throughput per transaction over time (which is reflected in the graph). This happens even though aggregated throughput across all the transactions is constant.

11.20.2 Bus Utilization Window Features

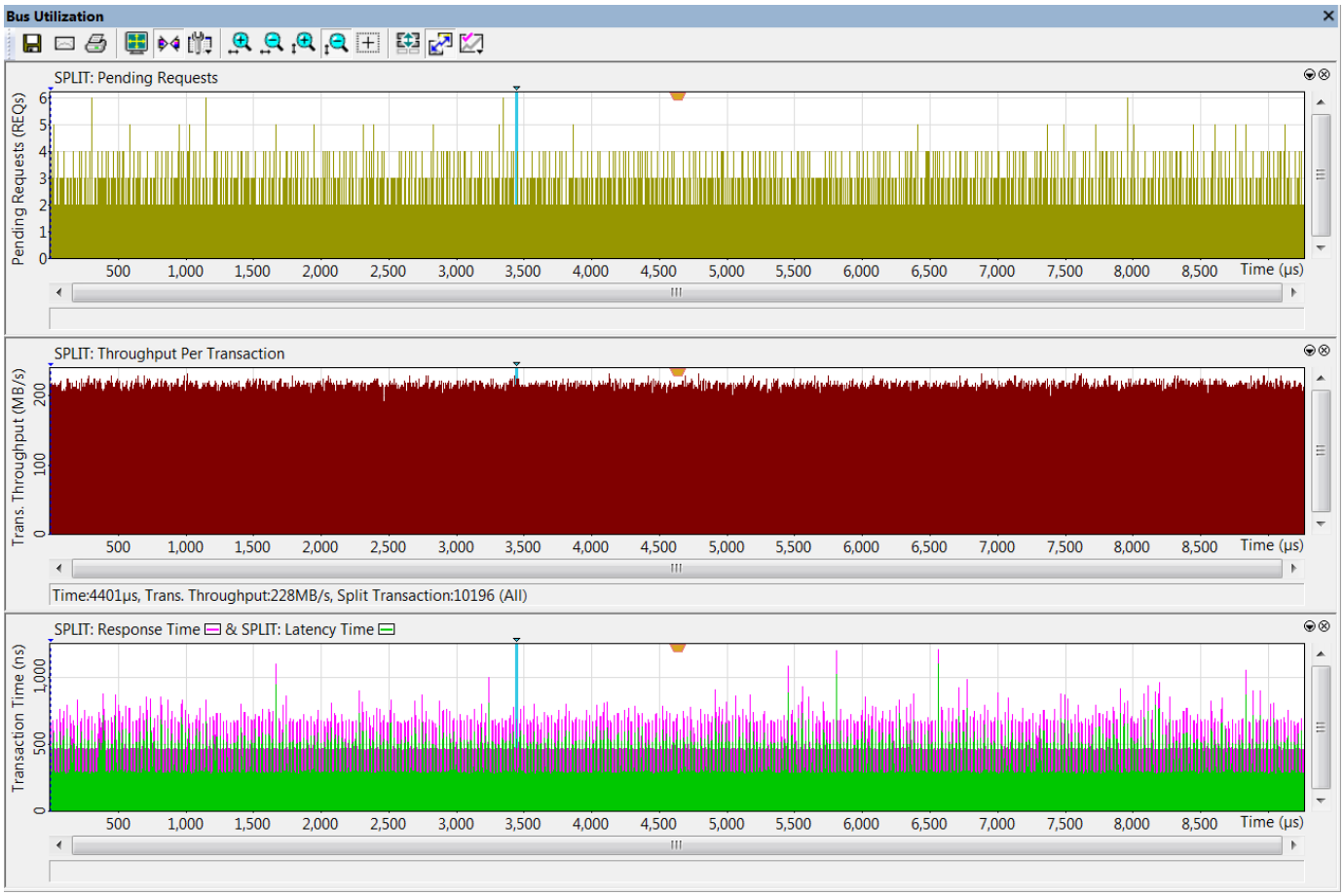
For the seven Split- and Transaction-level graphs listed, all Bus Utilization window features are available, such as zooming in/out, changing scale type, scrolling, context-sensitive status, and graph synchronization. See Bus Utilization and Bus Utilization Buttons for more on these features.

Note: Clicking a certain place within a graph area repositions the CATC Trace display at the Link or Split transaction level to the transaction that was in progress at that time.

11.20.3 Split Transaction Level Graphs

Transactions at the Split level combine all the non-posted requests with corresponding completions. This includes Configuration and IO Read and Write requests, as well as Memory Read requests.

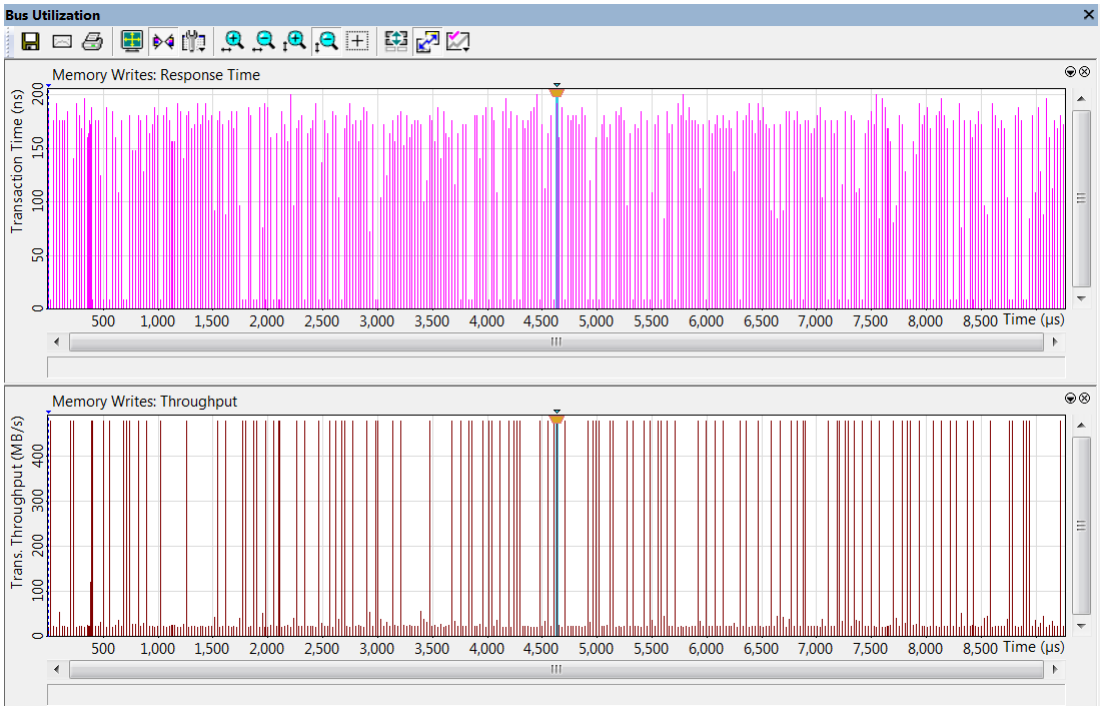
The following shows the graphs for the Split level:



Note: The Pending Requests graph is not directly defined by metrics, but it is useful when considering metrics. The Pending Requests graph presents the unit-averaged number of requests that were pending (in progress) at any moment of time. It allows you to correlate the number of requests posted to a completer with other performance metrics.

11.20.4 Link Transaction Level Graphs

Memory Writes are the only (posted) requests that do not get promoted to the Split transaction level. Therefore, Memory Write performance should be viewed at the Link Transaction level. That is the reason graphs at the Link level only present the Memory Write-related metrics and are titled **Writes: Response Time:** and **Writes: Throughput** (see the following figure).



11.21 Memory I/O Space Editor

The Memory I/O Space Editor allows you to create a new Memory I/O Space file or open an existing Memory I/O Space file. It is used in conjunction with Teledyne LeCroy Trainer products. Select **Tools > Memory I/O Space Editor** to display the Memory Space Editor dialog.

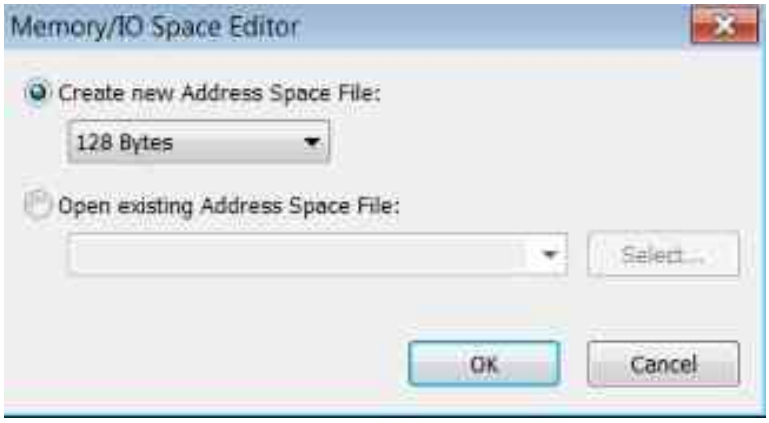


Figure 11.85: Memory I/O Space Editor Dialog

11.22 TC to VC Mapping

Select **Tools > TC to VC Mapping** displays how Traffic Classes are mapped to Virtual Channels (to simplify navigation) and how the CATC Trace display was changed (for example, in Split Transactions).



Figure 11.86: TC to VC Mapping Dialog

11.23 Timing and Bus Usage Calculations

11.23.1 Timing Calculator

Select **Tools > Timing Calculations** to obtain the Timing Calculator dialog.

The Timing and Bus Usage Calculator calculates PCIe timings, Queue Utilization and Total Input/Output. You can decide how much of a Trace you want analyzed. You can select the segment of the Trace you want analyzed by Packet (beginning to ending), Markers (chosen from the drop down) or Time (in seconds or clocks).

In this first case, we have an NVMe Trace loaded and are looking at the entire trace from the beginning of Packet 0 to the end of Packet 1714903. See Figure 11.87.

11.23.1.1 PCIe Timing Information: Entire Trace

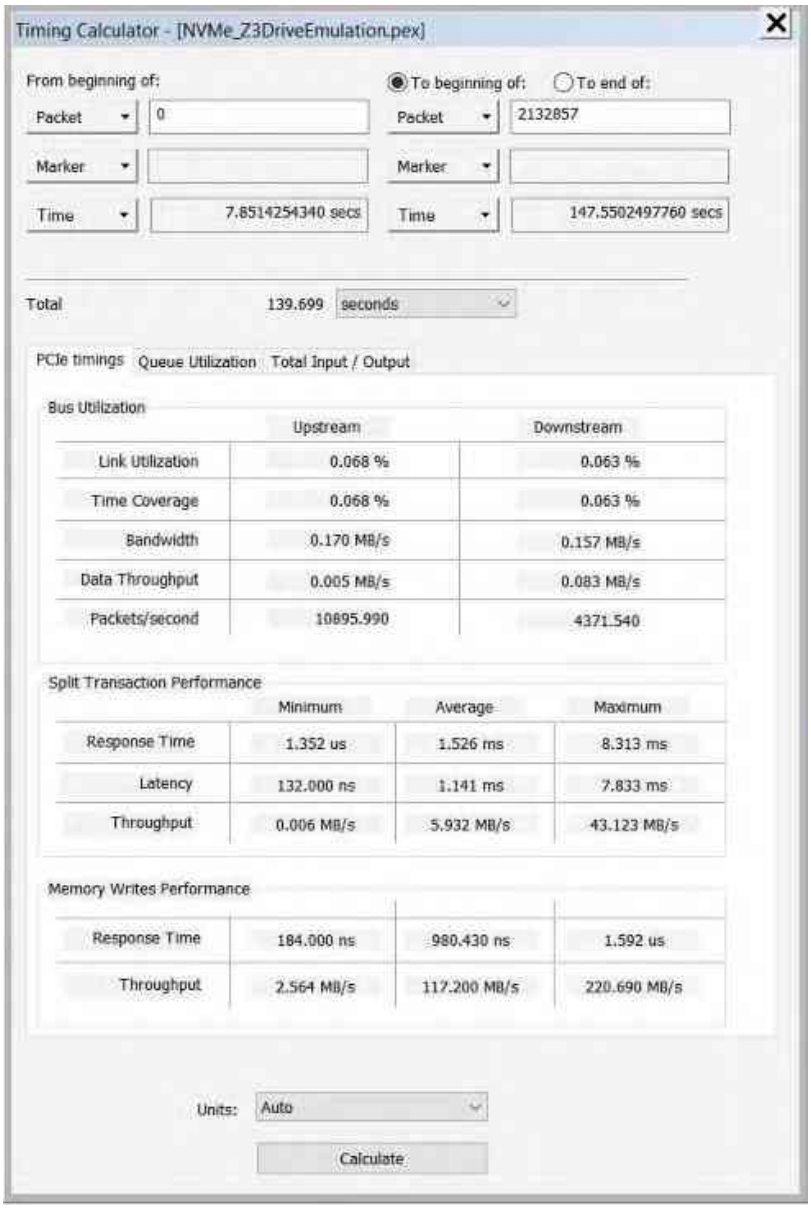


Figure 11.87: Timing Calculator for Entire Trace

The major portions of the PCIe Timings are discussed below:

11.23.1.2 Bus Utilization

This portion of the Timing Calculator window gives values that are cumulative for all packets during the timing period. For example, throughput is combined throughput of all packets during the timing period.

Upstream is from endpoint devices to the root complex. Downstream is from the root complex to endpoint devices.

Link Utilization: Percentage of non-idle symbols in total number of symbols transferred.

Time Coverage: Percentage of non-idle symbol times in total number of symbol times. (Non-idle symbol time occurs when at least on one of the lanes there were non-idle symbols transferred.)

Bandwidth: Number of non-idle symbol bits transferred per second.

Formula (Gen1/Gen2): (packet_symbols * byte_bits) / total_time in seconds. byte_bits is 10 when 1 MB or 1 GB unit is selected and 8 otherwise.

Formula (Gen3/Gen4/Gen5): (packet_symbols * 8) / total_time in seconds.

Data Throughput: Number of TLP payload bytes transferred per second, expressed in MB per second (MB = 1024*1024 bytes).

Packets/second: Number of packets transferred per second.

11.23.1.3 Split Transaction Performance

This portion of the Timing Calculator window gives minimum, maximum, and average values for all Split transactions during the timing period. For example, minimum throughput is throughput of the Split transaction that passes the least amount of data. Maximum throughput is throughput of the Split transaction that passes the most amount of data. Average throughput is the average calculated for all Split transactions during the timing period.

Response Time: The time it took to transmit this Split transaction on the PE link, from the beginning of the first packet in the Split transaction to the end of the last packet in the Split transaction.

Latency: The time measured from the end of the request transaction to the first completion transmitted in response to the request within this Split transaction.

Throughput: The transaction payload divided by response time, expressed in megabytes per second, expressed in MB per second (MB = 1024*1024 bytes).

11.23.1.4 Memory Writes Performance

This portion of the Timing Calculator window gives minimum, maximum, and average values for all Memory Write transactions during the timing period. For example, minimum throughput is throughput of the Memory Write transaction that passes the least amount of data. Maximum throughput is throughput of the Memory Write transaction that passes the most amount of data. Average throughput is the average calculated for all Memory Write transactions during the timing period.

Response Time: The time it took to transmit this Memory Write on the PE link, from the beginning of the first packet in the Memory Write to the end of the last packet in the Memory Write.

Throughput: The Memory Write payload divided by response time, expressed in megabytes (MB) per second (MB = 1024*1024 bytes).

The Timing Calculator also has tabs for Queue Utilization and Total Input/Output. For the entire Trace the results are displayed below:

11.23.1.5 Queue Utilization

The Queue Utilization tool allows you to visualize the traffic on the submission queues (SQ) and command queues (CQ) within a time interval. The default interval is the entire trace. The graph is generated using the Calculate button at the bottom of the dialog (see Figure 11.88) below.

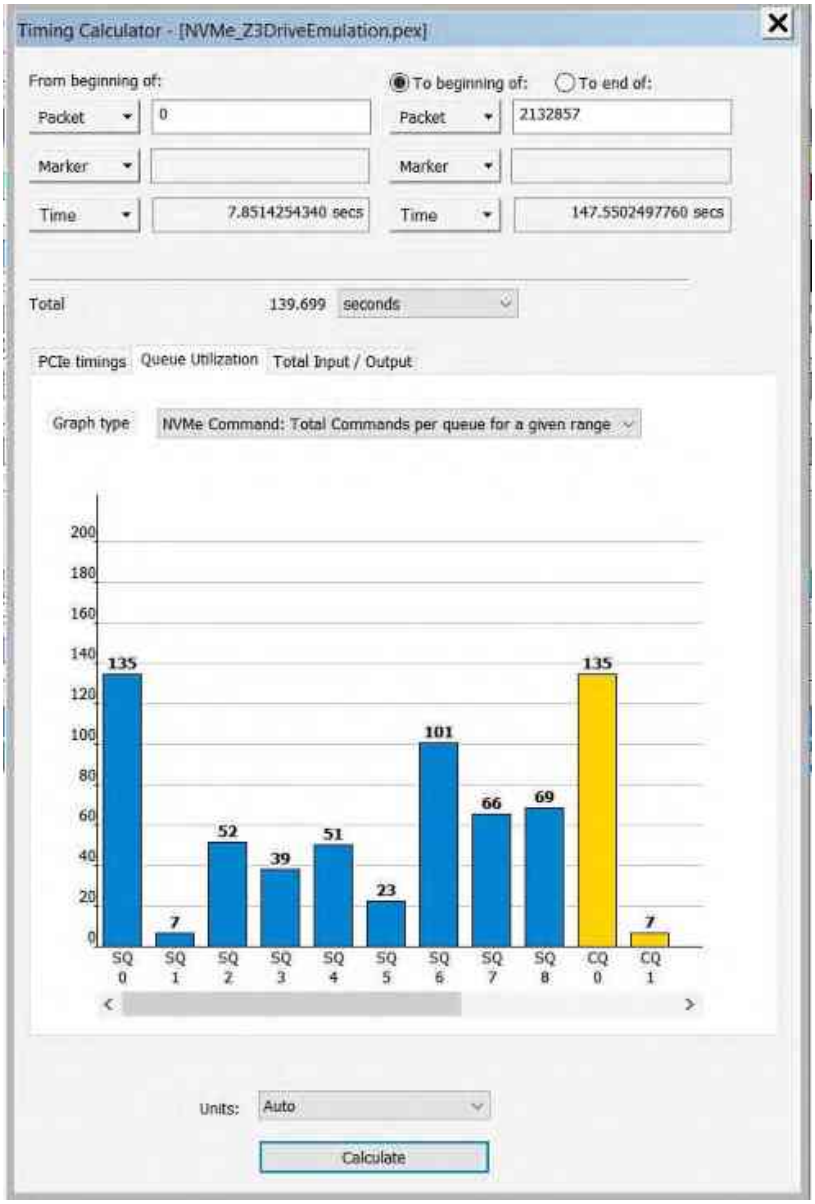


Figure 11.88: Timing Calculator: Queue Utilization

11.23.1.6 Total Input/Output

The Total Input / Output has two sections:

- Link/Split Total Traffic
- NVMe Command Total Traffic

See Figure 11.89

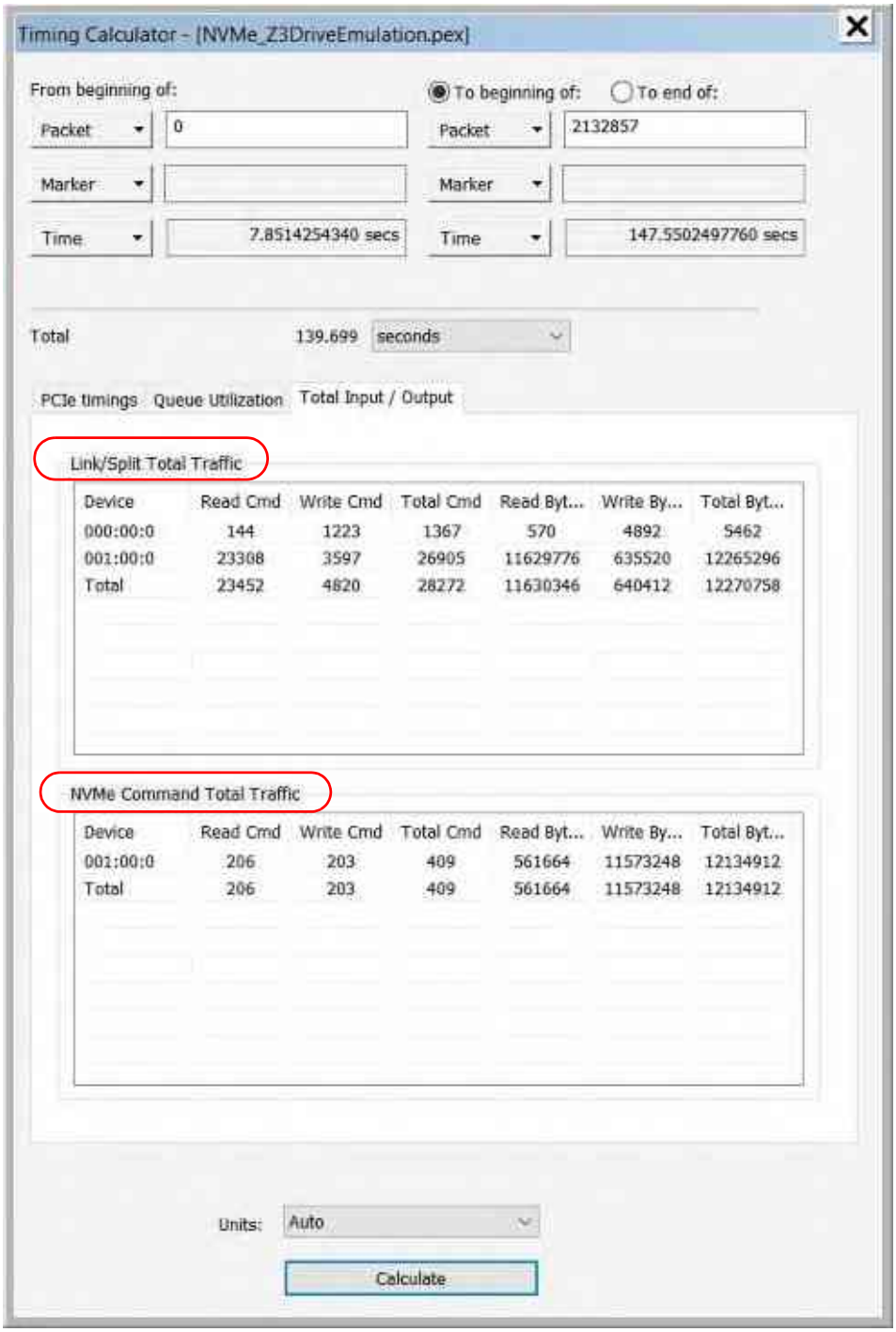


Figure 11.89: Timing Calculator: Total Input / Output

11.23.1.7 Timing Calculator Display units

The Timing Calculator can display data in several different units by selecting the appropriate combo box value and hitting the Calculate button (see Figure 11.90)

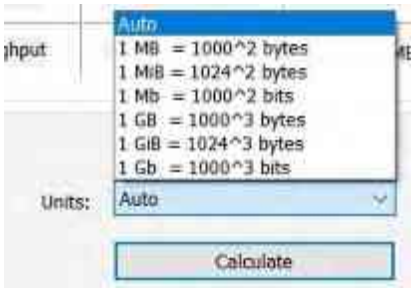


Figure 11.90: Unit Selection

The results are displayed as shown in Figure 11.91.

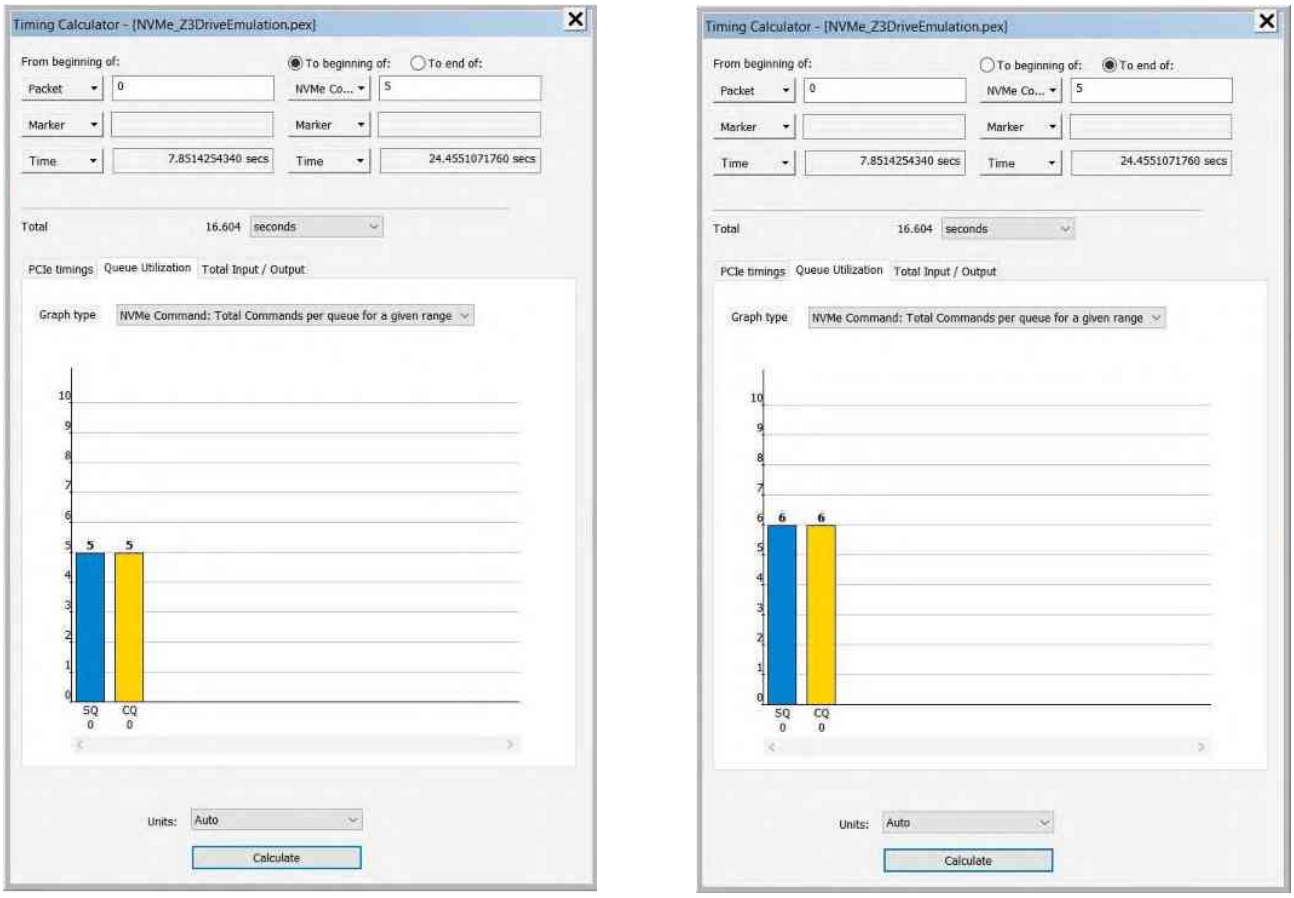


Figure 11.91: Timing Calculator: PCIe Timing Displayed in MB and Mb

11.23.2 Details of Timing Calculations

11.23.2.1 Timing From Beginning of Event to Beginning of Event or to End of Event

The Timing Calculator can calculate trace timing from the beginning of an event to either the beginning of another event or to the end of another event. See Figure 11.92.

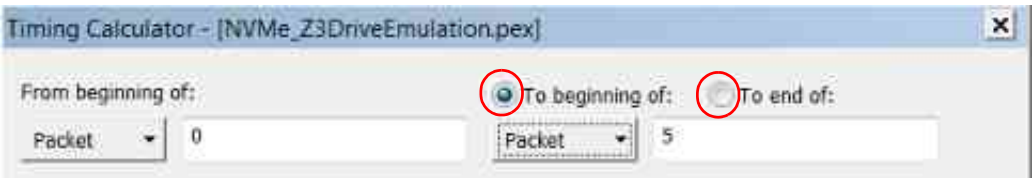


Figure 11.92: Timing Calculator: Beginning of Event to Beginning of Event or to End of Event

11.23.2.2 Types of Events

The Timing Calculator can also be used to look at specific events in more detail and has a variety of commands to help you parse the entire trace into segments of interest. The Timing Calculator can look at just Packets, Link Transactions, Split Transactions, NVMe Transactions or NVMe Commands. In this case, we have chosen NVMe Commands to explore in detail. See Figure 11.93.

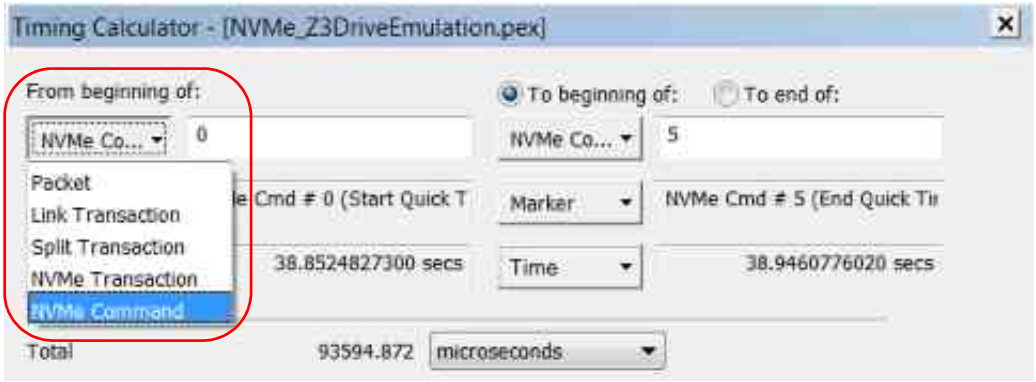


Figure 11.93: Timing Calculator: Types of Events

11.23.2.3 Displaying Time

The time can be displayed in nanoseconds, microseconds, milliseconds and seconds. See Figure 11.94.

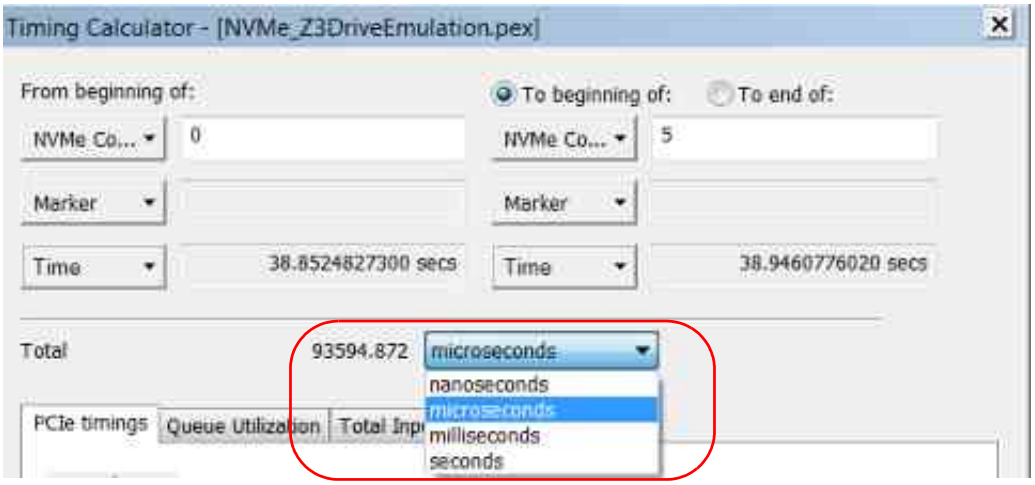


Figure 11.94: Timing Calculator: Timing Units

11.23.2.4 Markers

If Markers were set, they would be visible in the Marker pull-down (see Figure 11.95).

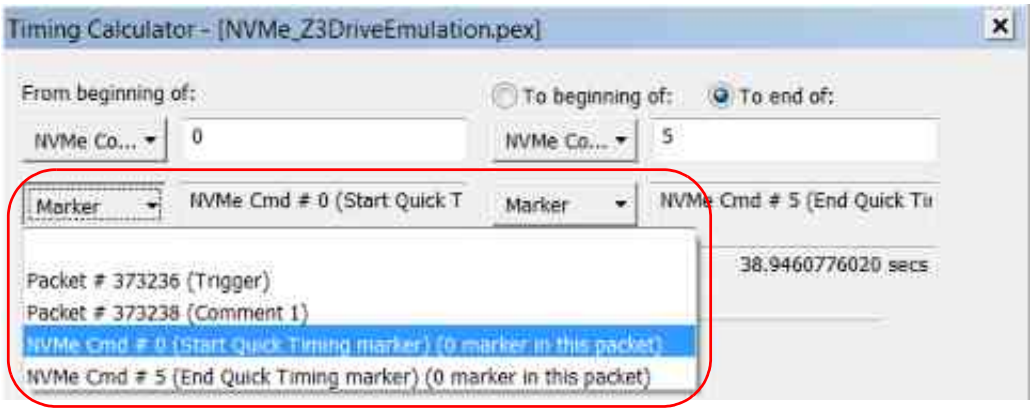


Figure 11.95: Timing Calculator: Markers Set

If the Trigger and Comment 1 Markers were chosen, the Timing Calculator would come up with the following results: see Figure 11.96 on page 733. As you can see from the results, the markers were only two packets apart.



Figure 11.96: Timing Calculator: Results Between Markers

11.23.2.5 Timing To Beginning of NVMe Command

If NVMe Commands are selected the tool calculates timing information from the beginning of NVMe Command 0 to the beginning of NVMe Command 5. You can see that Total time is 93594.872 microseconds. See Figure 11.97.

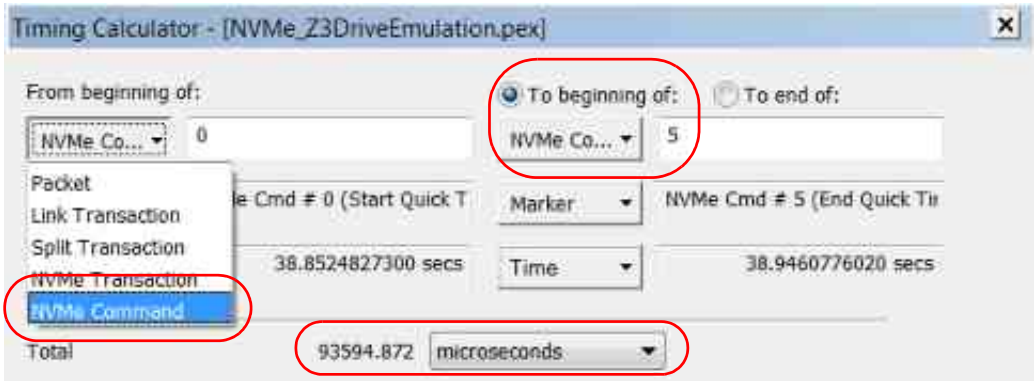


Figure 11.97: Timing Calculator: Selections for Timing Calculations

11.23.2.6 Timing To End of NVMe Command

If we had chosen to calculate the timing parameters “To end of”: NVMe Command 5, the Total time would have included the NVMe Command 5 and the Total time is 93594.968 microseconds. See Figure 11.98 on page 734.

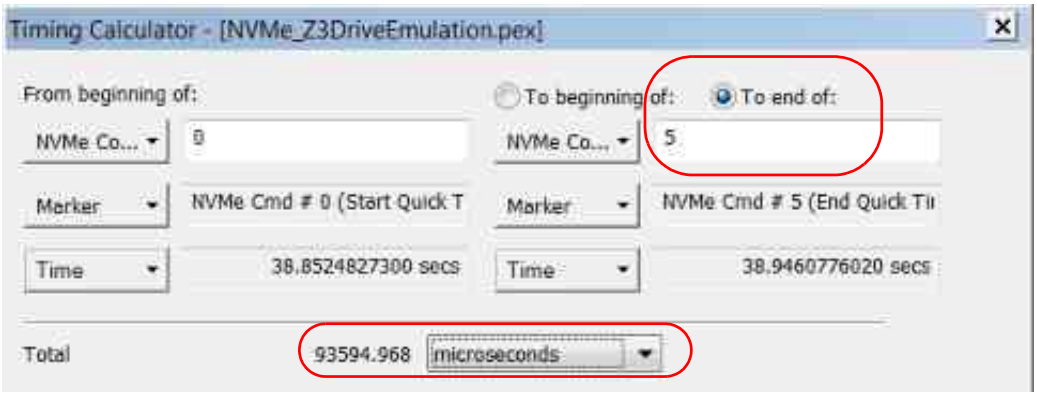


Figure 11.98: Timing Calculator: To end of NVMe Command 5

11.23.2.7 Results from Timing Calculator

The differences between the Timing Calculator results from the beginning of NVMe Command 0 to the beginning of NVMe Command 5 and to the end of NVMe Command 5 can be seen in Figure 11.99.

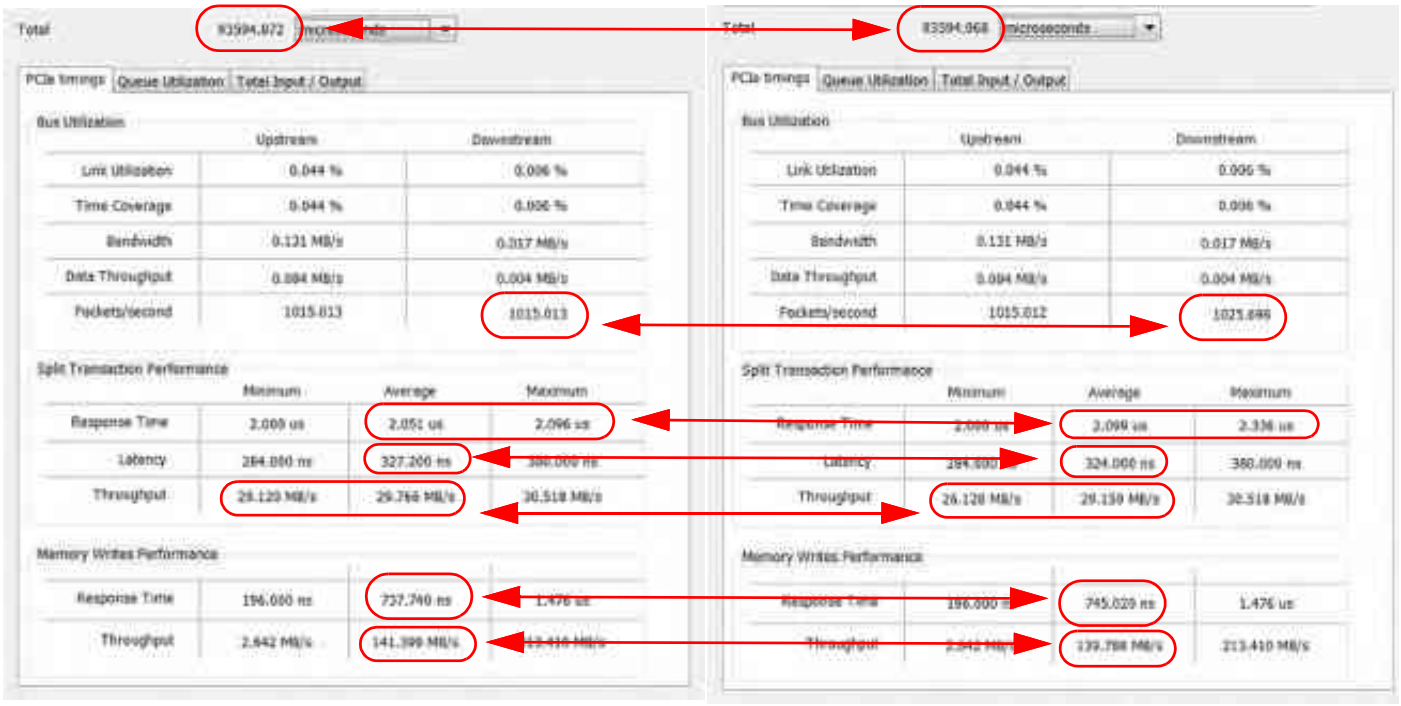


Figure 11.99: Timing Calculator: Beginning of NVMe Cmd 5 and Ending of NVMe Cmd 5 (MB)

Most of the results are the same except for Total time, Downstream Packets/second, Split Transaction Performance (Response Time, Latency and Throughput) and Memory Write Performance (Response Time: Average and Throughput: Average).

11.23.2.8 Timing to Beginning and End of Events: Effect on Queue Utilization

If we look at the differences between the Queue Utilization from the beginning of NVMe Command 0 to the Beginning of NVMe Command 5 and to the Ending of NVMe Command 5 you'll see one more NVMe Command in the Queue. See Figure 11.100.

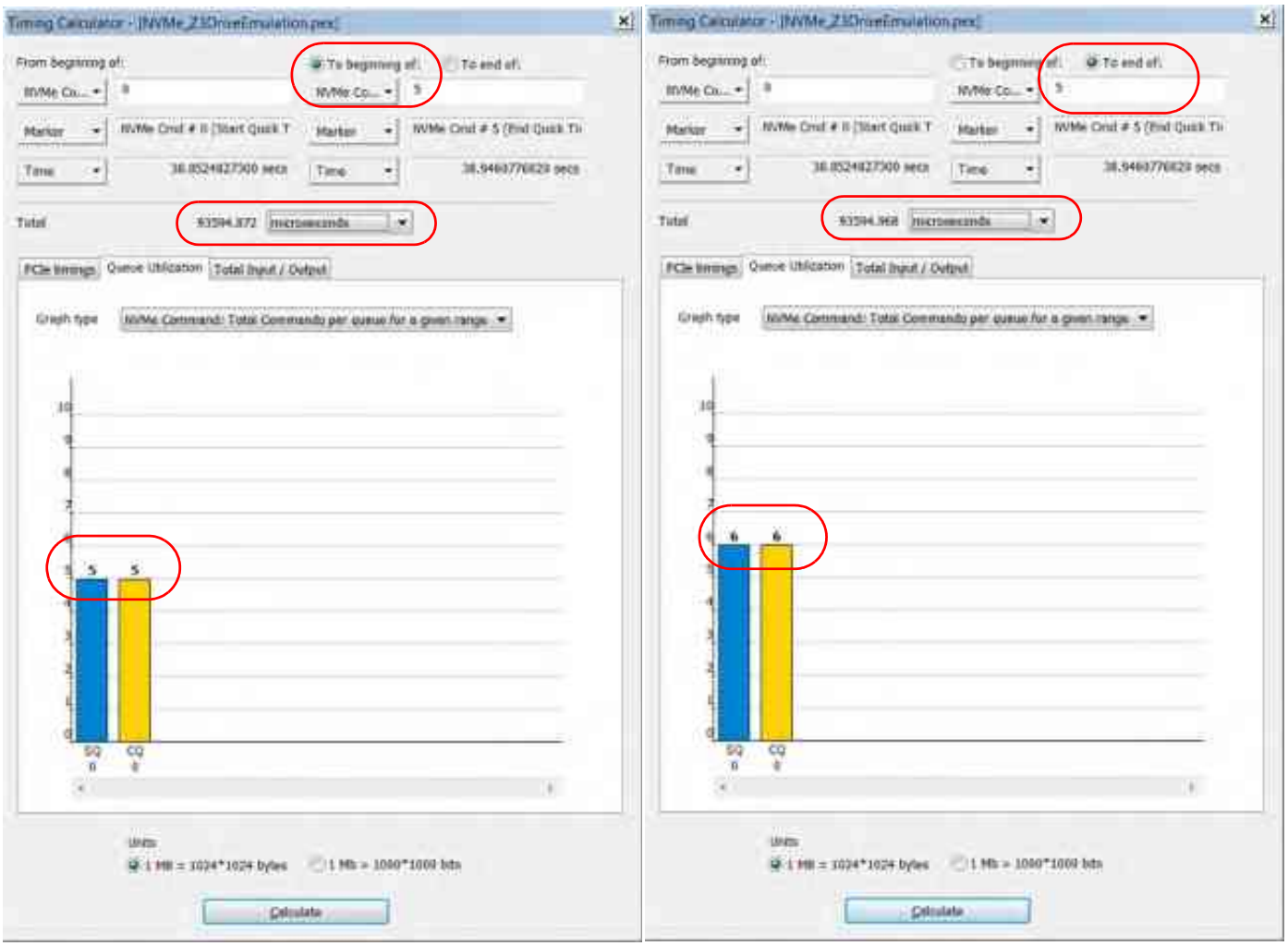


Figure 11.100: Timing Calculator: Queue Utilization

11.23.2.9 Timing to Beginning and End of Events: Effect on Total Input / Output

If we look at the differences between the Total Input / Output graphs from the beginning of NVMe Command 0 to the Beginning of NVMe Command 5 and Ending of NVMe Command 5 you'll see one more Write Command. See Figure 11.101.

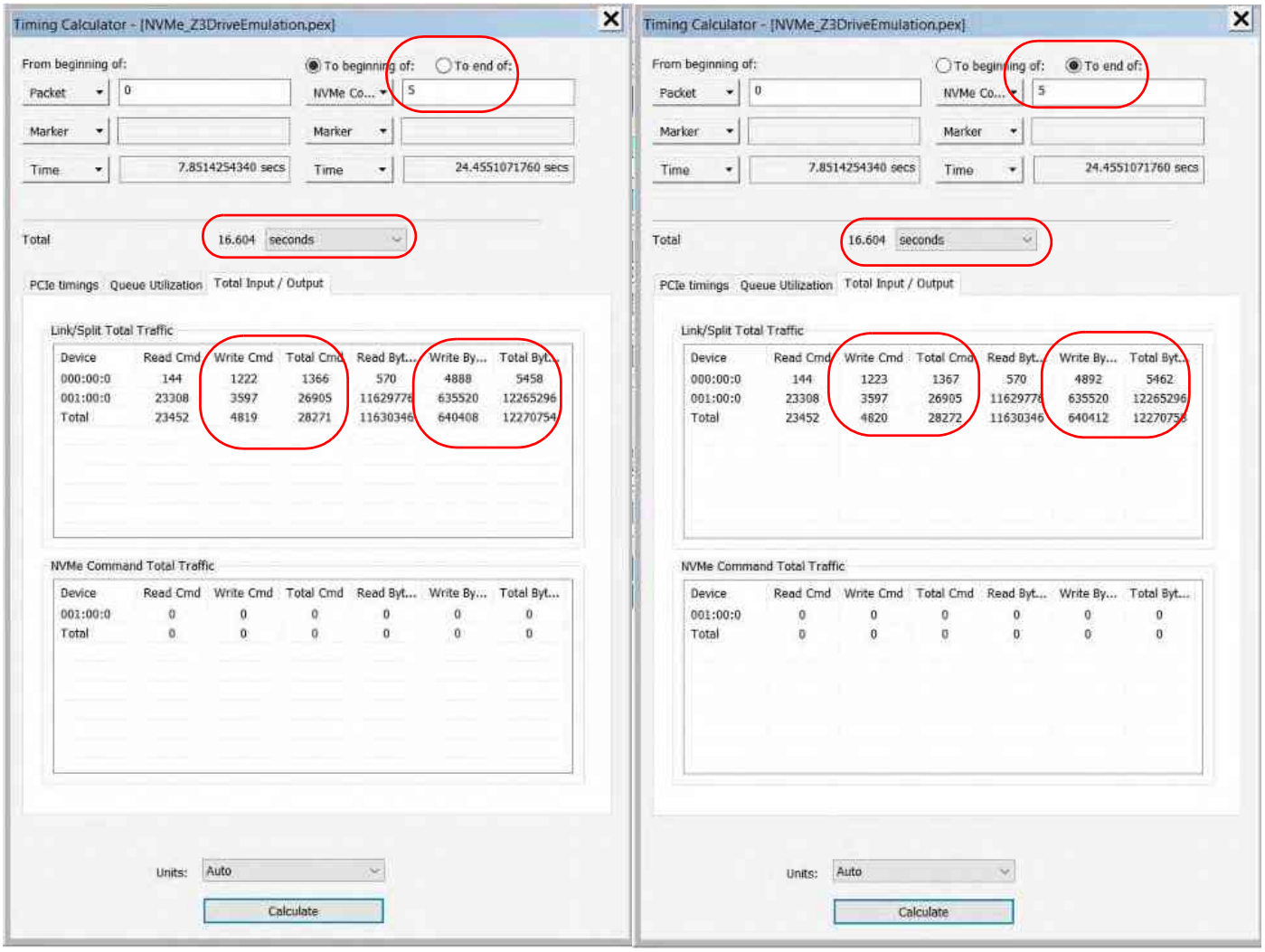


Figure 11.101: Timing Calculator: Differences in Total Input / Output

The two displays show that including NVMe Command 5 adds one more Write Command and it's associated number of bytes.

11.24 PCIe SSD Base Address Mapping

In order for NVMe, PQI, AHCI, ATA, SOP and SCSI decoding to work correctly, the PCIe Protocol Analysis needs to know the Memory Base Address of the device.

If the Base Address assignment is not present in the trace, you can specify the values manually using this dialog. You need to select the type of the device (NVMe, PQI, AHCI, ATA, SOP or SCSI) and set the value of the Base Address by selecting **Tools > PCIe SSD Base Address Mapping.** See Figure 11.102.

11.24.1 Base Address Not Record in Trace

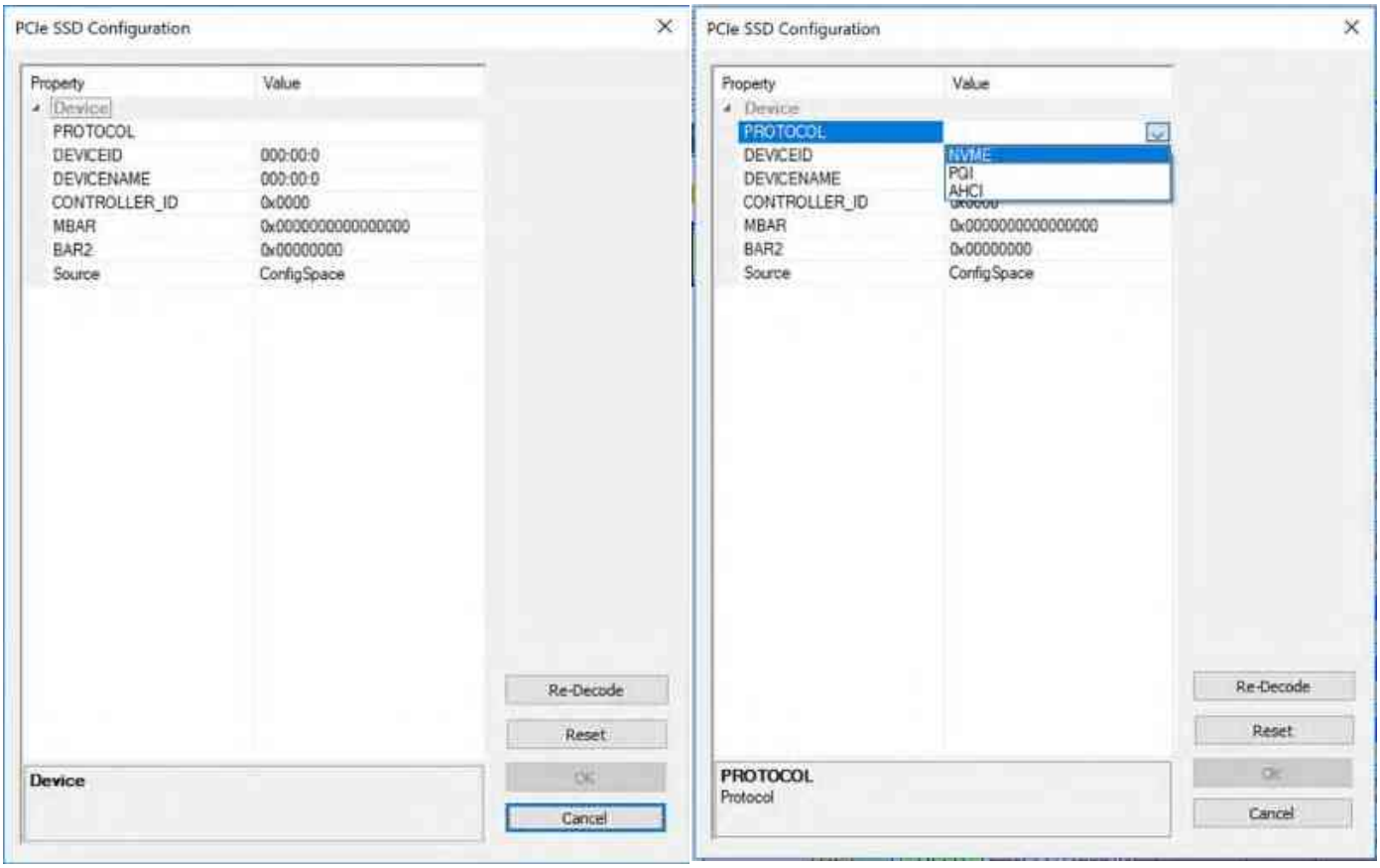


Figure 11.102: Trace without Protocol Type Specified

You must select the type of trace your recorded. In this case we selected NVME and the PCIe SSD Configuration dialog box is fully populated with all the NVME. See Figure 11.103 on page 738.

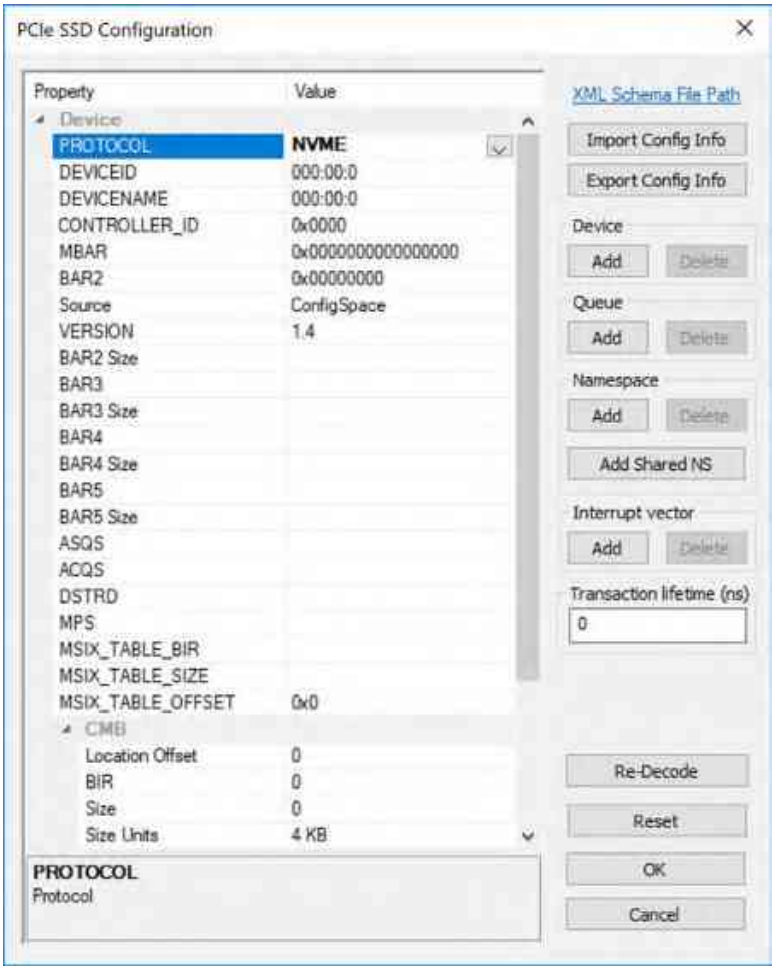


Figure 11.103: PCIe SSD Configuration dialog box populated with NVME options

11.24.2 Base Address Recorded in Trace

In cases when Base Address assignment is recorded in the trace, the software will determine all the values automatically. I. The PCIe SSD Configuration dialog displays (see Figure 11.104 on page 741).

Note: From software release 6.63 onwards, users are able to decode NVMe/PQI traces which are lacking configuration space and administration information, from release 6.70 this is applicable to AHCI traces, from release 7.00 this is applicable to ATA traces and from release 7.10 this is applicable to SOP and SCSI traces.

Note: From software release 7.30 onwards, multiple NVMe devices can be decoded from the same trace.

Note: From software release 7.34 onwards, the SSD Dialog displays the Device Name as read in the configuration accesses.

Note: From software release 7.38 onwards, while the SSD Dialog is open, the Trace View is scrollable.

Follow the steps below to perform the applicable storage decoding:

1. Record the trace for NVMe, PQI, AHCI, ATA, SOP or SCSI device boot and decode it.
   This saves the configuration space and administration information in .xml format, which is used to decode traces that do not include configuration and administration commands.
2. Record the trace of the same NVMe, PQI, AHCI, ATA SOP or SCSI device without rebooting and the application will decode it.

You can keep recording and decoding until rebooting. On reboot repeat steps 1 and 2 above.

11.24.3 NVMe PCIe SSD Device Configuration

The PCIe SSD Configuration dialog is used to add missing information to decode the trace without the configuration space and queue administration information. See Figure 11.104 on page 741 for NVMe PCIe SSD Device Configuration.

Prior to decoding, if all the required information is available in Configuration Space then the Source field in the PCIe SSD Configuration will be set to "Config Space" (see Figure 11.104 on page 741). The description for important fields and buttons are given below:

1. DEVICE ID: Represents the device ID in the bus/device/function address from the PCIe specification (ID Based routing).
2. DEVICENAME: Device Name
3. MBAR: The MBAR field in this dialog is required and editable. Make sure that the information entered is correct. Click on any field and the description displays in the bottom read-only box. The 64-bit main address bar (i.e. BAR1:BAR0). Without this value decoding cannot be done. It should be in "0x" hex format.
4. BAR2:
5. PROTOCOL: Displays the current storage protocol decoded.
6. ASQS: Defines the size of the Admin Submission Queue in entries. Refer to the controller registers section of the NVMe specification. The minimum size of the Admin Submission Queue is two entries. The maximum size of the Admin Submission Queue is 4096 entries. This is a 0’s based value.
7. ACQS: Defines the size of the Admin Completion Queue in entries. Refer to the controller registers section of the NVMe specification. The minimum size of the Admin Completion Queue is two entries. The maximum size of the Admin Completion Queue is 4096 entries. This is a 0’s based value.
8. DSTRD: This register indicates the stride between doorbell registers. The stride is specified in bytes. This may be used to separate doorbells by a number of bytes in memory space. It may be useful in software emulation of an NVMe Express controller. For hardware implementations of NVMe Express, the expected doorbell stride value is 4.
9. LBASIZE: Size for Logical Block Addressing.

10. MPS: This field indicates the host memory page in bytes.
11. IOCQES: I/O Completion Queue Entry Size. This field defines the I/O Completion Queue entry size that is used for the selected I/O Command Set. The required and maximum values for this field are specified in the Identify Controller data structure for each I/O Command Set. The value is in bytes and is specified as a power of two (2^n).
12. IOSQES: I/O Submission Queue Entry Size. This field defines the I/O Submission Queue entry size that is used for the selected I/O Command Set. The required and maximum values for this field are specified in the Identify Controller data structure for each I/O Command Set. The value is in bytes and is specified as a power of two (2^n).
13. MQES: Maximum Queue Entries Supported. Defines the maximum individual queue size that the controller supports. This is a 0's based value. The minimum value is 1h, indicating two entries.
14. Source: Source of the data.
15. Queues: Under this node the user can add more missing nodes to decode the current trace. Click the **Add Queue** or **Delete Queue** button to add or delete a queue node. Type based on the user selection.
16. XML Schema File Path: Selecting this link pops up a window with the location of the XML Schema File. It is also available in TechBrief_Use_of_NVMe_xml_schema.pdf in the installation AppNotes\ directory (or installation path).
17. Import Config Info: Click to Import configuration information.
18. Export Config Info: Click to Export configuration information.
19. Add Device/Delete Device: Click to add/delete device (NVMe/PQI only).
20. Add Queue/Delete Queue: Click to add/delete queue (NVMe/PQI only).
21. Add Namespace/Delete Namespace: Click to add/delete a new namespace if this information is not present in a trace file (NVMe/PQI only).
22. Interrupt Vector: Add/Delete an Interrupt Vector to a selected Device (see "Interrupts" on page 742).
23. Re-Decode: Click to re-decode.
24. Reset: Click to reset.
25. OK: Click to accept the settings.
26. Cancel: Click to cancel the settings.

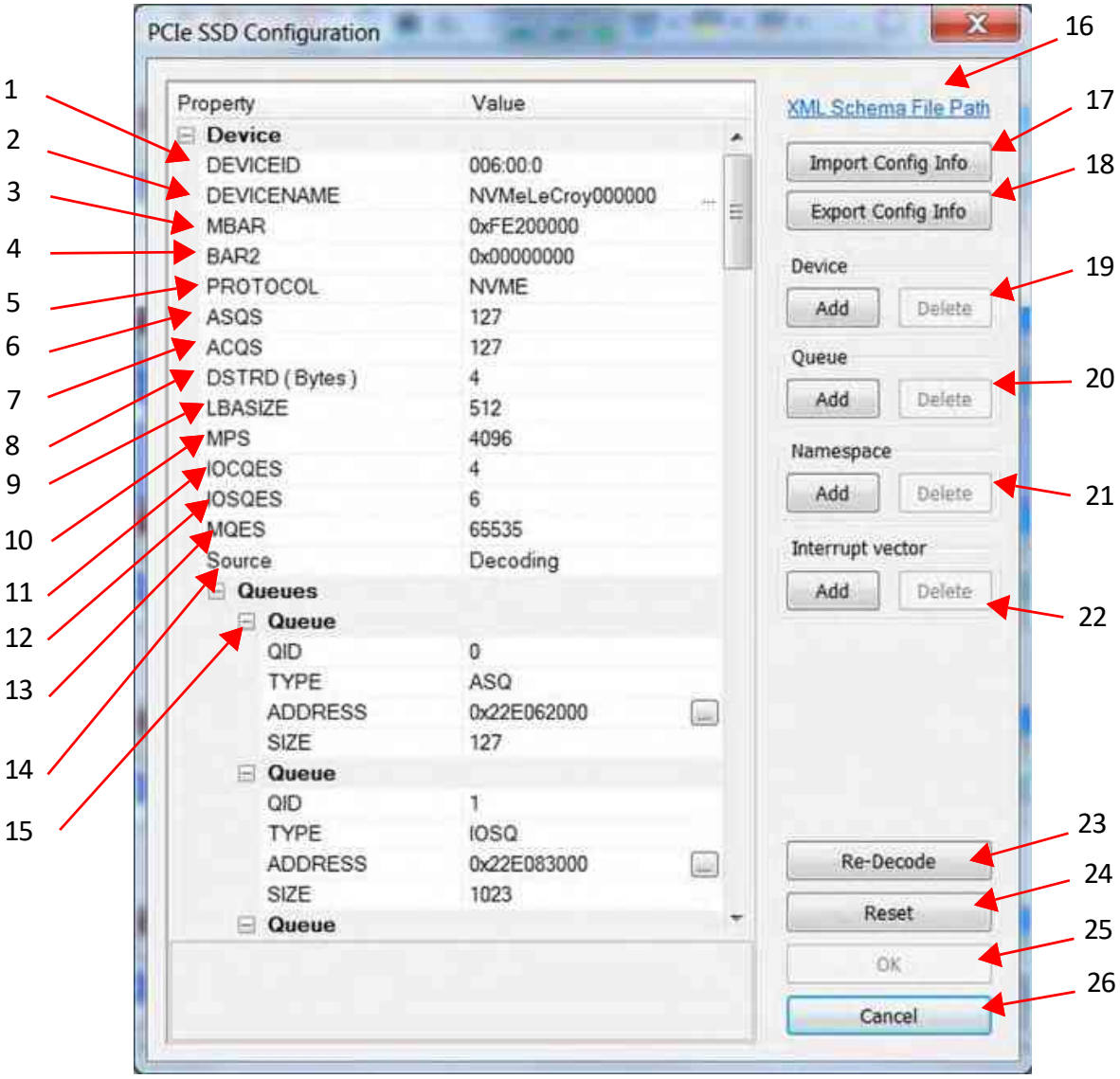


Figure 11.104: PCIe SSD Configuration Dialog Pre-decoding

Select any of the options in the 

drop down menu item to decode the trace and select **Tools > PCIe SSD Base Address Mapping** (see "AHCI PCIe SSD Configuration Dialog").

Note: When opening a trace file created with 7.0X or older versions of PCIe Protocol Analysis, these new fields are not present and the application tries to export the configuration information to XML before decoding NVMe transaction level. In this case a message box will show claiming that a value for this field is required.

Note: In case of problems when opening older traces try the following: a) Decode NVMe transaction level before exporting XML file. This will apply the default value for the new fields and export can be performed. b) Manually enter the values for the new fields. c) In case the trace contains submission entries which are not decoded, add a new Queue and set the corresponding address in the PCIe SSD Configuration dialog.

11.24.3.1 Interrupts

MSI and MSI-x interrupts are decoded at configuration time and include the vector offset and address. These values can be added/deleted/modified by the user to add data that may not have been captured in the trace. See Figure 11.105.

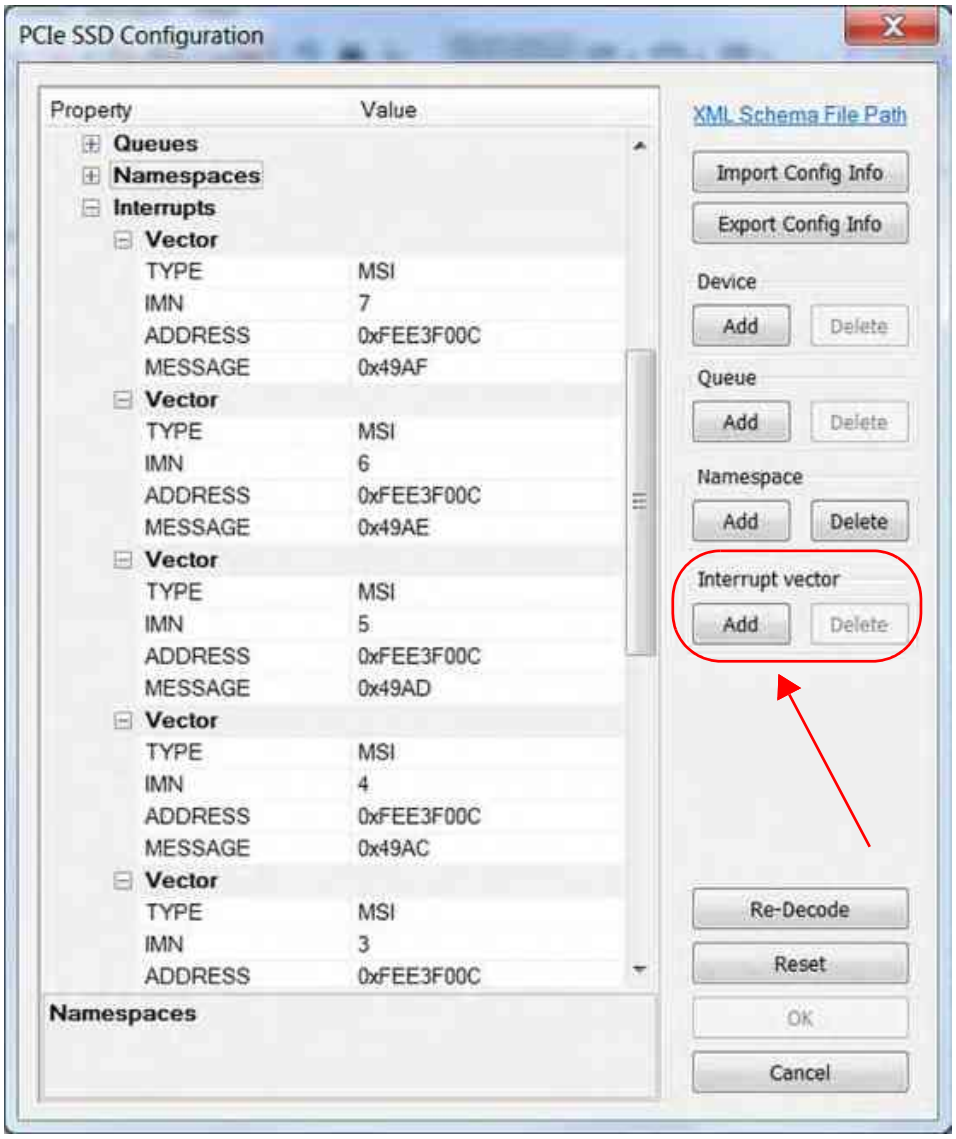


Figure 11.105: MSI and MSI-x Interrupts

11.24.4 AHCI PCIe SSD Device Configuration

The PCIe SSD Configuration dialog is used to add missing information to decode the trace without the configuration space and queue administration information. See Figure 11.106 for AHCI PCIe SSD Device Configuration.

Prior to decoding if every thing is available in Configuration Space then Source equals Config Space (see Figure 11.106).

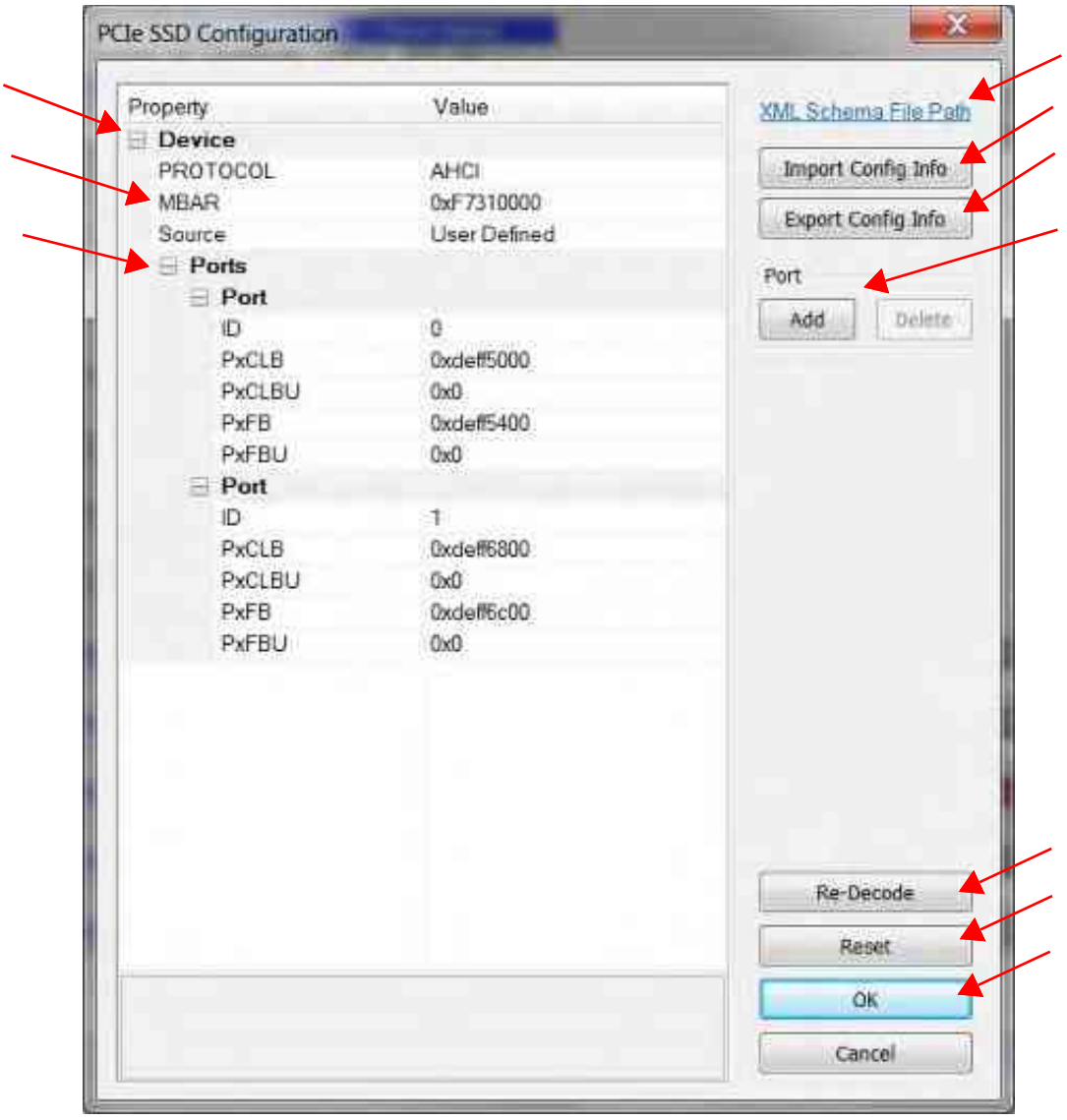


Figure 11.106: AHCI PCIe SSD Configuration Dialog

The MBAR field in this dialog is required and editable. Make sure that the information entered is correct. Click on any field and the description displays in the bottom read-only box (see Figure 11.108 on page 746). Some important fields are described below:

- Device: There is only one device node, (support for multiple device trace decoding will be available in a later release).
- MBAR: The 64-bit main address bar (i.e. BAR1:BAR0). Without this value decoding cannot be done. It should be in "0x" hex format.
- Ports: Under this node the user can add more missing nodes to decode the current trace. Click the **Add Port** or **Delete Port** button to add or delete a port node. Enter CLB, CLBU and FB, FBU address fields. The address is 32 bit and should be in "0x" hex format. Please use the right value for size as it is an important attribute. Consult the AHCI specifications for the correct value.

Clicking the **Re-Decode** button erases the current configuration from this dialog box and attempts to re-decode based on the information present in the open trace and/or saved on the disk with the last decode.

Click the **Import Config Info** button to import the configuration information as an .xml file, instead of adding it individually. Click the hyper-link **XML Schema File Path** to access the required format to generate the .xml file. This schema provides the detailed format for the imported file. All modern languages are equipped to generate an .xml file on a specific xml schema. The driver software accepts this schema and generates the .xml file with all the required information.

Click the **Export Config Info** button to export the configuration information as an .xml file.

Click the **Reset** button to reset the values to the original values. Press the **OK** button to save all the values.

11.24.5 PQI PCIe SSD Device Configuration

The PCIe SSD Configuration dialog is used to add missing information to decode the trace without the configuration space and queue administration information. See Figure 11.107 for PQI PCIe SSD Device Configuration.

Prior to decoding if every thing is available in Configuration Space then Source equals Config Space (see Figure 11.107).

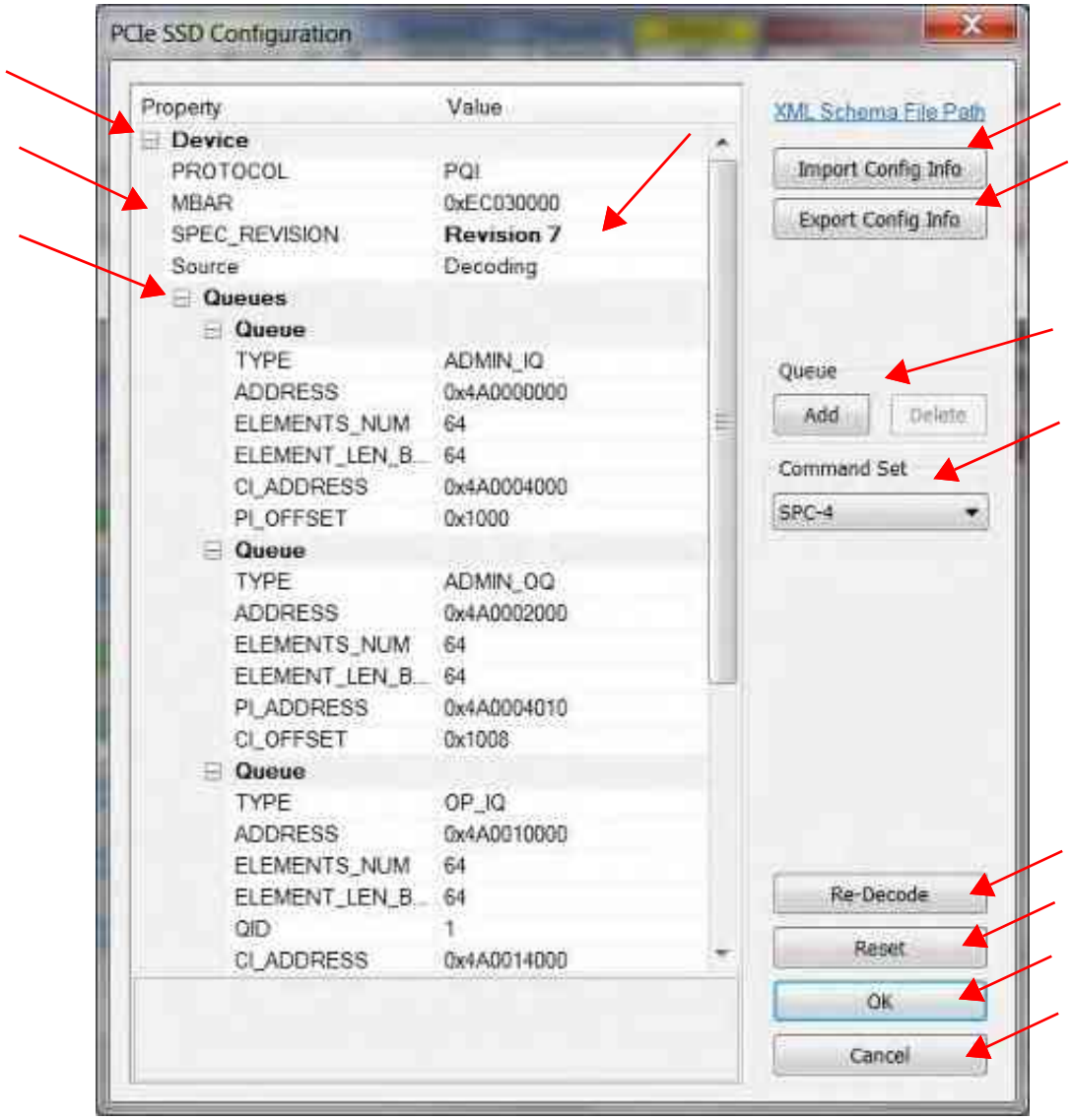


Figure 11.107: PQI PCIe SSD Configuration Dialog Pre-decoding

All the fields in this dialog are required and editable. Make sure that the information entered is correct. Click on any field and the description displays in the bottom read-only box (see Figure 11.108). Some important fields are described below:

- **Device**: There is only one device node, (support for multiple device trace decoding will be available in a later release). You can choose the spec revision from the drop down list.
- **MBAR**: The 64-bit main address bar (i.e. BAR1:BAR0). Without this value decoding cannot be done. It should be in "0x" hex format.
- **Queues**: Under this node the user can add more missing nodes to decode the current trace. Click the Add Queue or Delete Queue button to add or delete a queue node. Type based on the user selection. The following Node types are known.

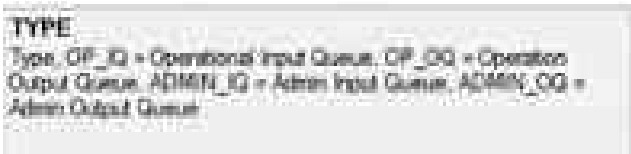


Figure 11.108: Node Types

The address is 64-bit and should be in "0x" hex format. Please use the right value for each size as it is an important attribute. Consult the NVMe specifications for the correct value. Clicking the **Re-Decode** button erases the current configuration from this dialog box and attempts to re-decode based on the information present in the open trace and/or saved on the disk with the last decode.

Click 

button to decode the trace and select **Tools > PCIe SSD Base Address Mapping** (see Figure 11.107 on page 745).

The two figures figure below show the BAR information for PQI and AHCI. If this information is present in the trace then it is not editable, otherwise it can be edited. Decoding is done only when configuration space and administration information is available.

Note: Only one device should be marked with the appropriate BAR, multiple BARs do not work.

11.24.6 SCSI PCIe SSD Device Configuration

The PCIe SSD Configuration dialog is used to add missing information to decode the trace without the configuration space and queue administration information. See Figure 11.109 on page 747 for SCSI PCIe SSD Device Configuration. The base is the same as PQI Device Configuration but you can additionally choose the SCSI Command Set.

Prior to decoding if every thing is available in Configuration Space then Source equals Config Space (see Figure 11.109 on page 747).

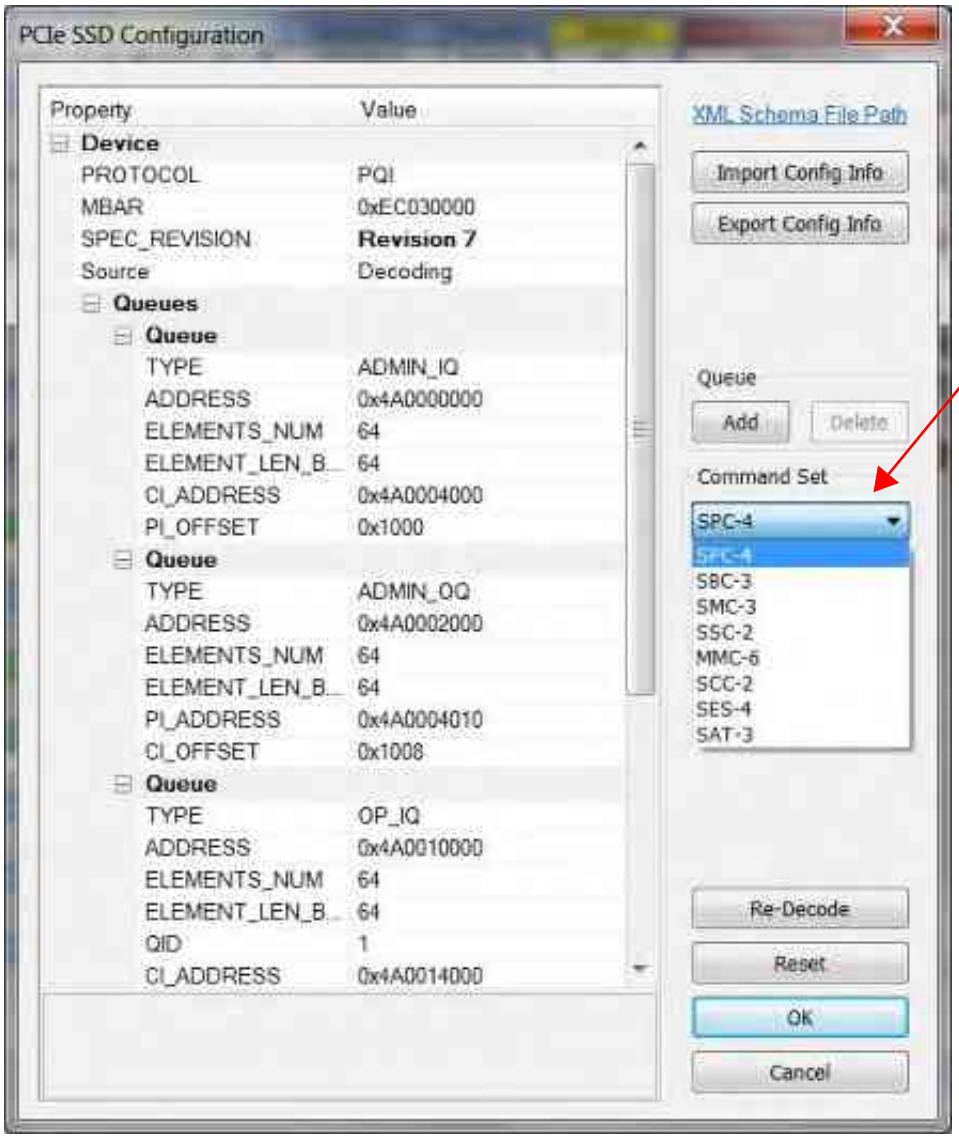


Figure 11.109: PCIe SSD Configuration Dialog - SCSI

See “Example of XML File Format for SSD Decodes” on page 737 for a template of the XML files.

11.25 Running Verification Scripts

You can run verification scripts to check errors, link transactions, split transactions, metrics, ordered sets, replays, DLLPs, and TLPs.

To display the Verification Script dialog (see Figure 11.110 on page 748), select **Tools > Run verification scripts**

or click the  icon.

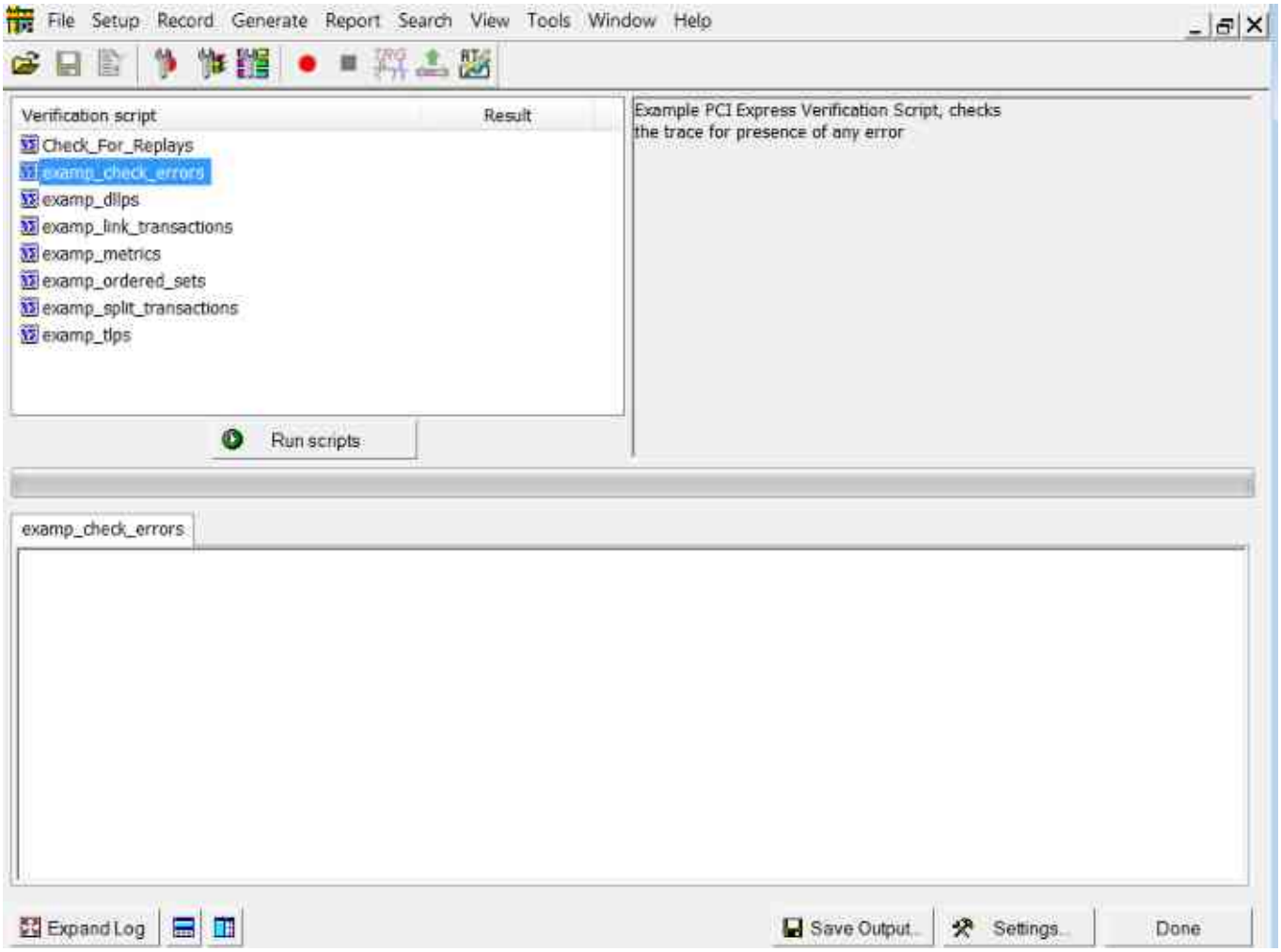


Figure 11.110: Verification Scripts Dialog

If you select examp_ltssm you'll get the following output. See Figure 11.111.

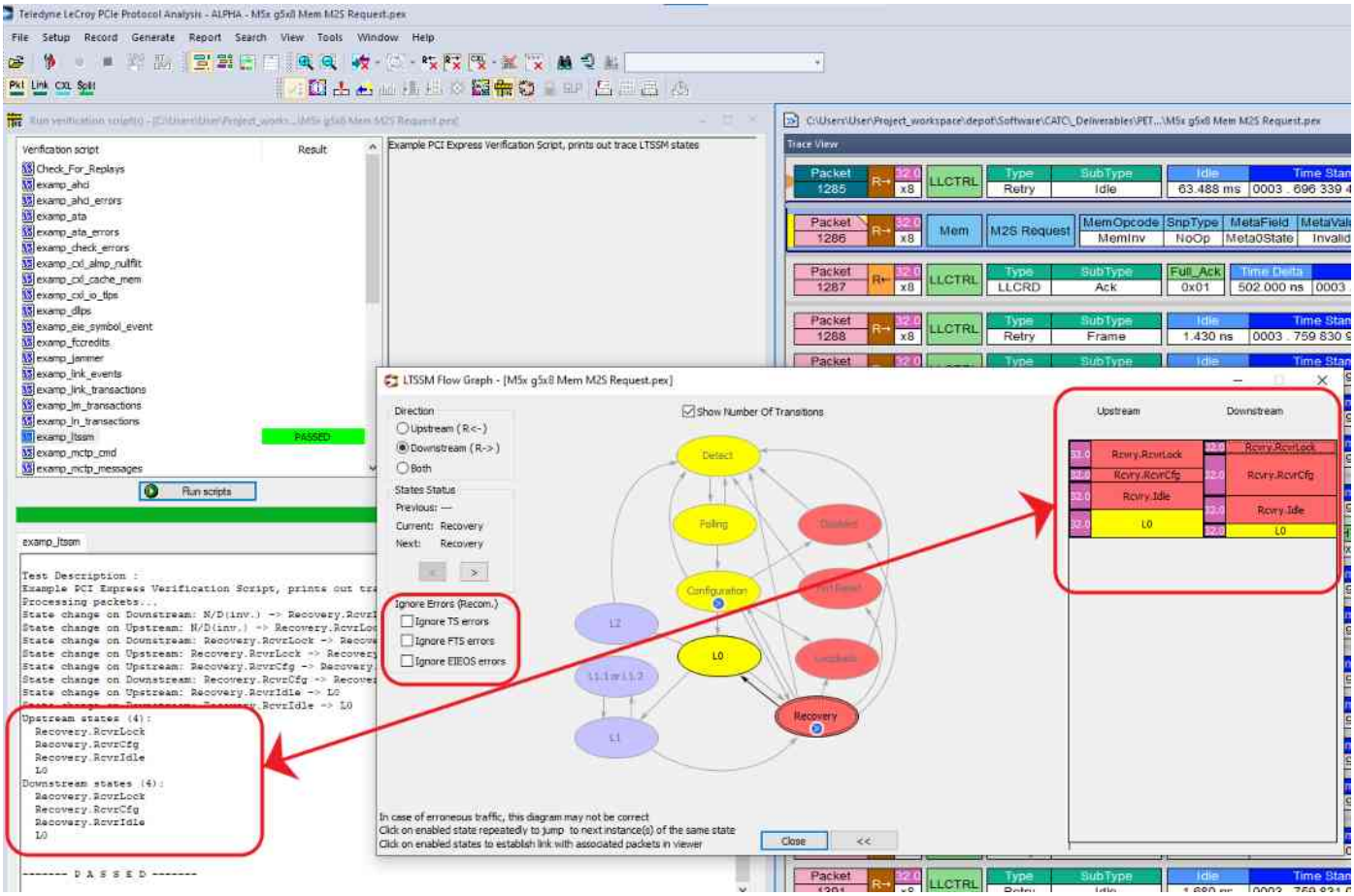
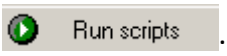


Figure 11.111: Run Verification Script: examp_ltssm

The available verification scripts are in the Verification script section.

Note: Verification scripts are not ignoring TS/FTS/EIEOS errors, so values may be different if some of the ignore options are enabled.

To run a script, select it, then click the **Run Scripts** button 

.

The results appear in the bottom window. You can expand or collapse this window. You find a view related to the CATC Trace and place this window under or to the right of it. Click **Save** to save the results.

Click the **Settings** button to display the Settings Dialog (see Figure 11.112 on page 750).



Figure 11.112: Settings Dialog

You can choose the editor, display settings, and saving settings.

11.25.1 NVMe Performance: Doorbell Timing

You can run verification scripts to determine Doorbell performance, see Figure 11.113.

The Doorbell statistics include:

- SQdoorbell to CQdoorbell,
  (time from Submission Doorbell to Completion Doorbell)
- SQDoorbell to CQentry,
  (time from SQ doorbell to command completion)
- SQentry to CQentry,

(time from submission command to command completion

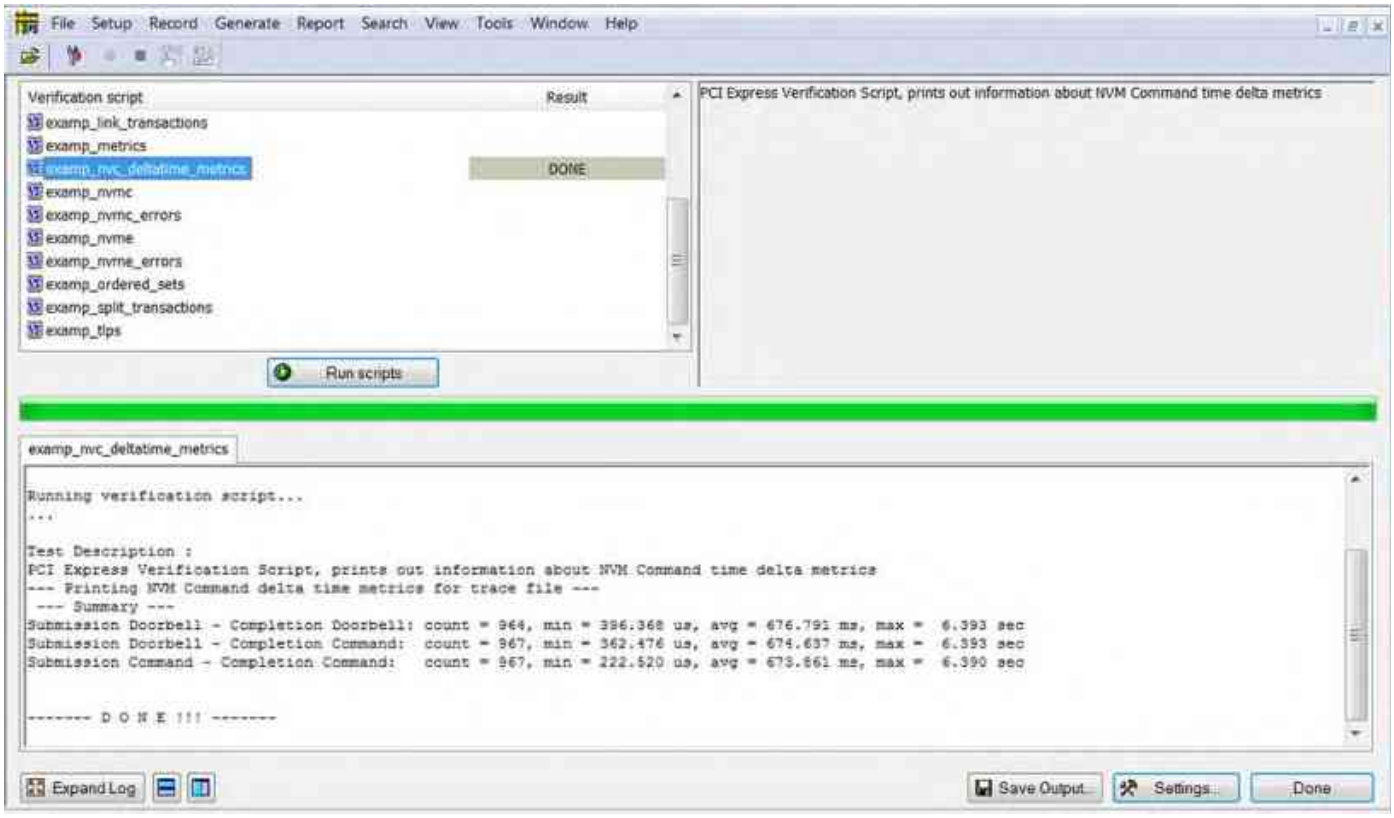


Figure 11.113: NVMe Performance Script Verification

11.26 Trace Expert

Trace Expert is a reporting tool that is used to create a portable, customized summary and report of a PCI express trace. The generated report groups the selected data and statistics into four groups:

- Performance Analysis
- Trace Analysis Statistics
- Error Reports
- Trace File Information

After a Trace has been loaded, Trace Expert is available from the Main Toolbar as shown in Figure 11.114.

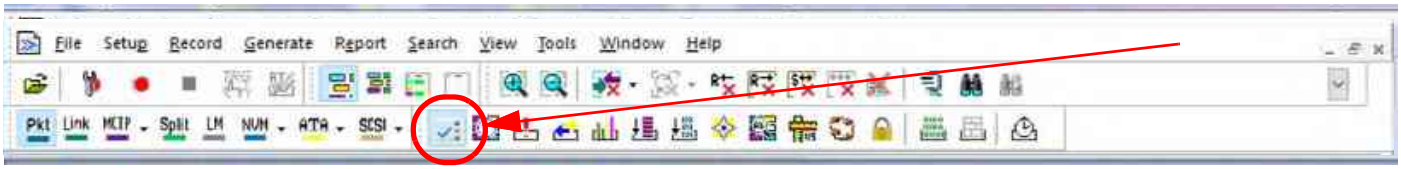


Figure 11.114: Main Toolbar: Trace Expert

To launch the Trace Expert dialog click on the icon. Different report sections can be selected for inclusion into the final report using the dialog. The path where the report will be generated can be set at the bottom of the dialog (see Figure 11.115 on page 753). Any additional decoding required to generate the report will be done automatically.

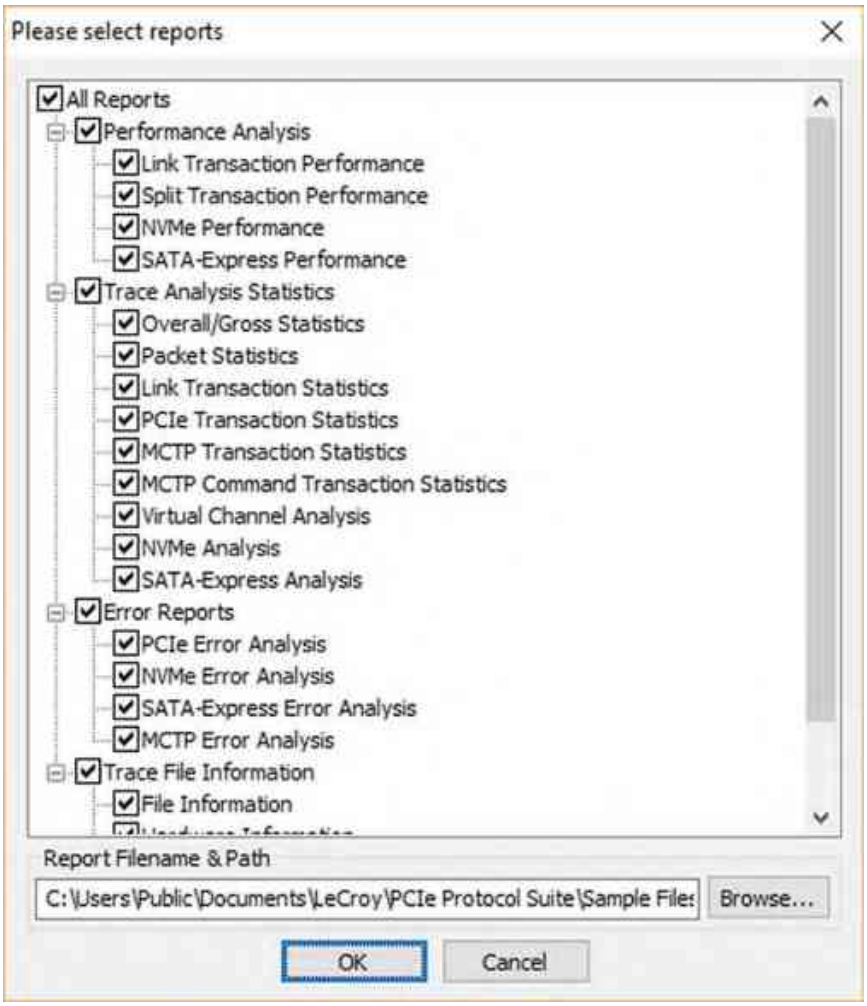


Figure 11.115: Trace Expert Report Types and Path

The generated report (see Figure 11.116 on page 754) has sections which can be expanded to show the associated data. The generated file is self-contained and portable so it can be safely emailed or archived. It will open automatically in the default browser once it is successfully generated. Icons on the top right can be used to:

- Save All (Saves to User's Download folder)
- Expand All
- Collapse All
- Print All of the currently displayed view.

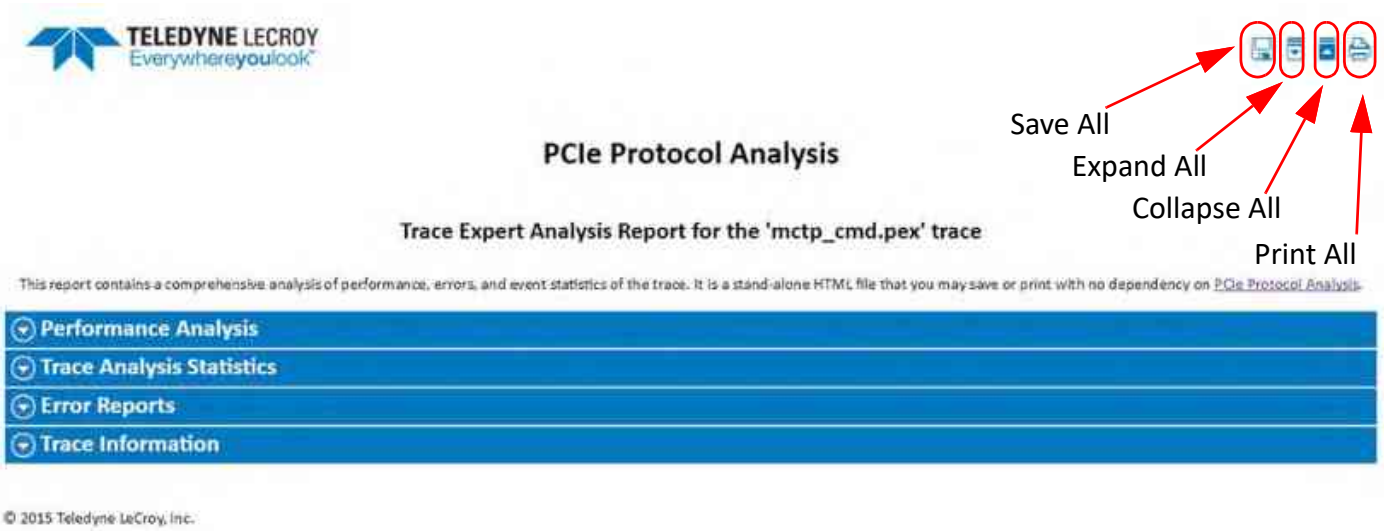


Figure 11.116: Trace Expert Main Menu

Select “Performance Analysis” on page 754 to bring up the respective dialog.

Select “Trace Analysis Statistics” on page 755 to bring up the respective dialog.

Select “Error Reports” on page 756 to bring up the respective dialog.

Select “Trace Information” on page 757 to bring up the respective dialog.

11.26.1 Performance Analysis

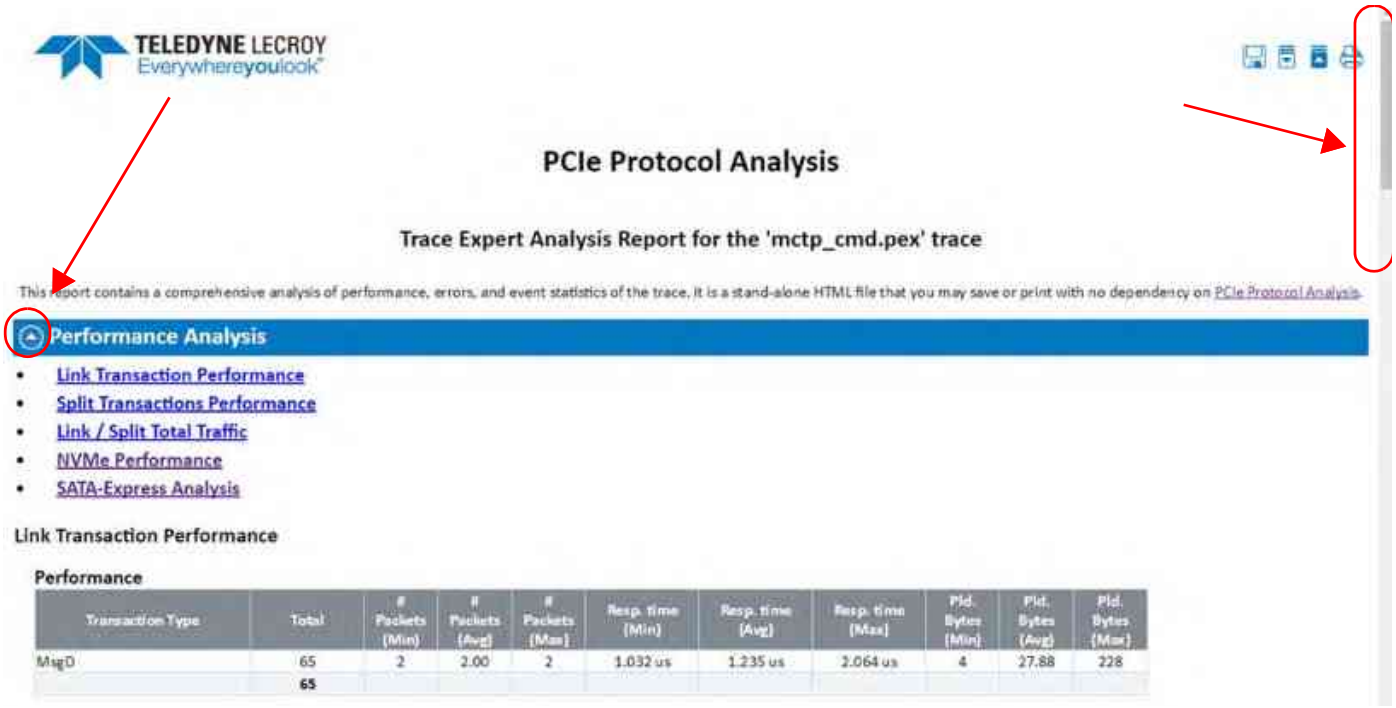


Figure 11.117: Trace Expert - Performance Analysis

You can select other types of transactions to see the other reports.

- Link Transaction Performance
- Split Transaction Performance
- Link / Split Total Traffic
- NVMe Performance
- SATA-Express Analysis

Scroll down to see the other reports and information.

11.26.2 Trace Analysis Statistics

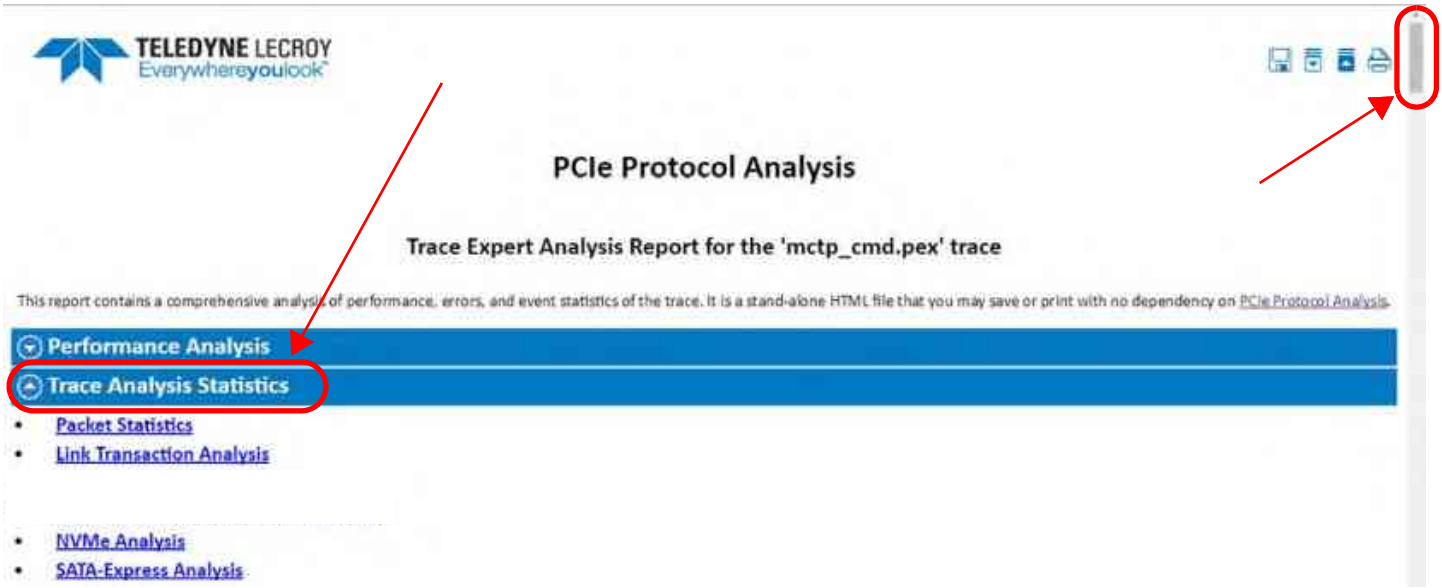


Figure 11.118: Trace Analysis Statistics

Selecting Trace Analysis Statistics will produce the following reports:

- Packet Statistics
- Link Transaction Analysis
- NVMe Analysis
- SATA-Express Analysis

Scroll down to see the other reports and information.

11.26.3 Error Reports

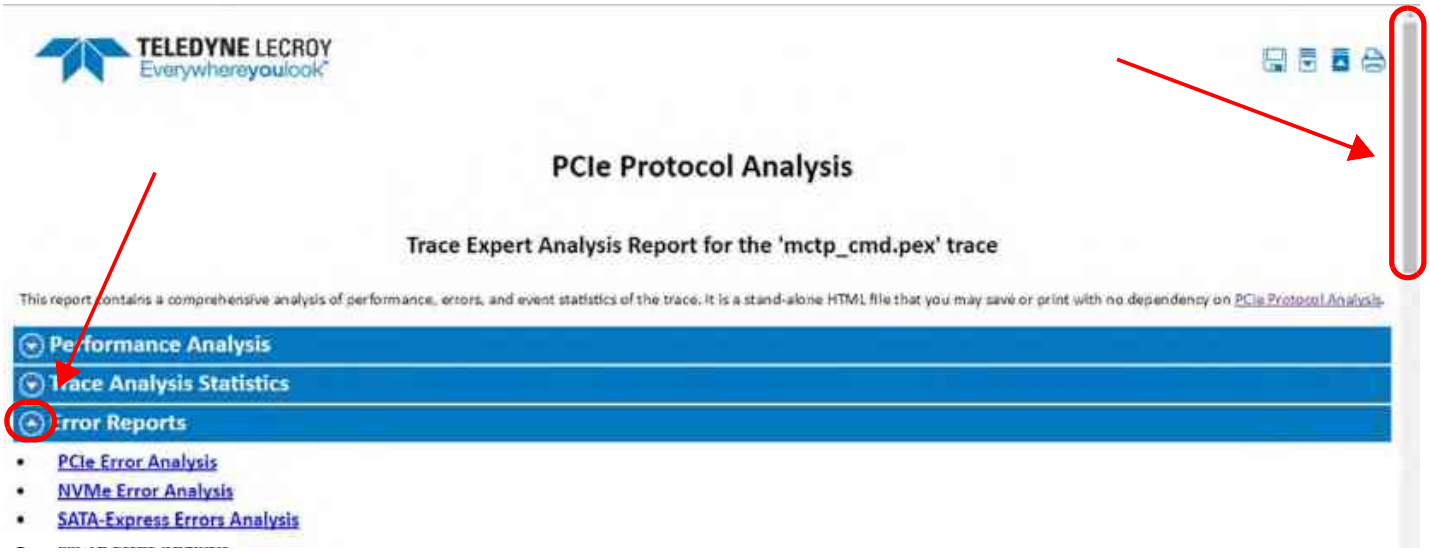


Figure 11.119: Error Reports

Selecting Error Reports generates the following reports:

- PCIe Error Analysis
- NVMe Error Analysis
- SATA-Express Errors Analysis

Scroll down to see the other reports and information.

11.26.4 Trace Information

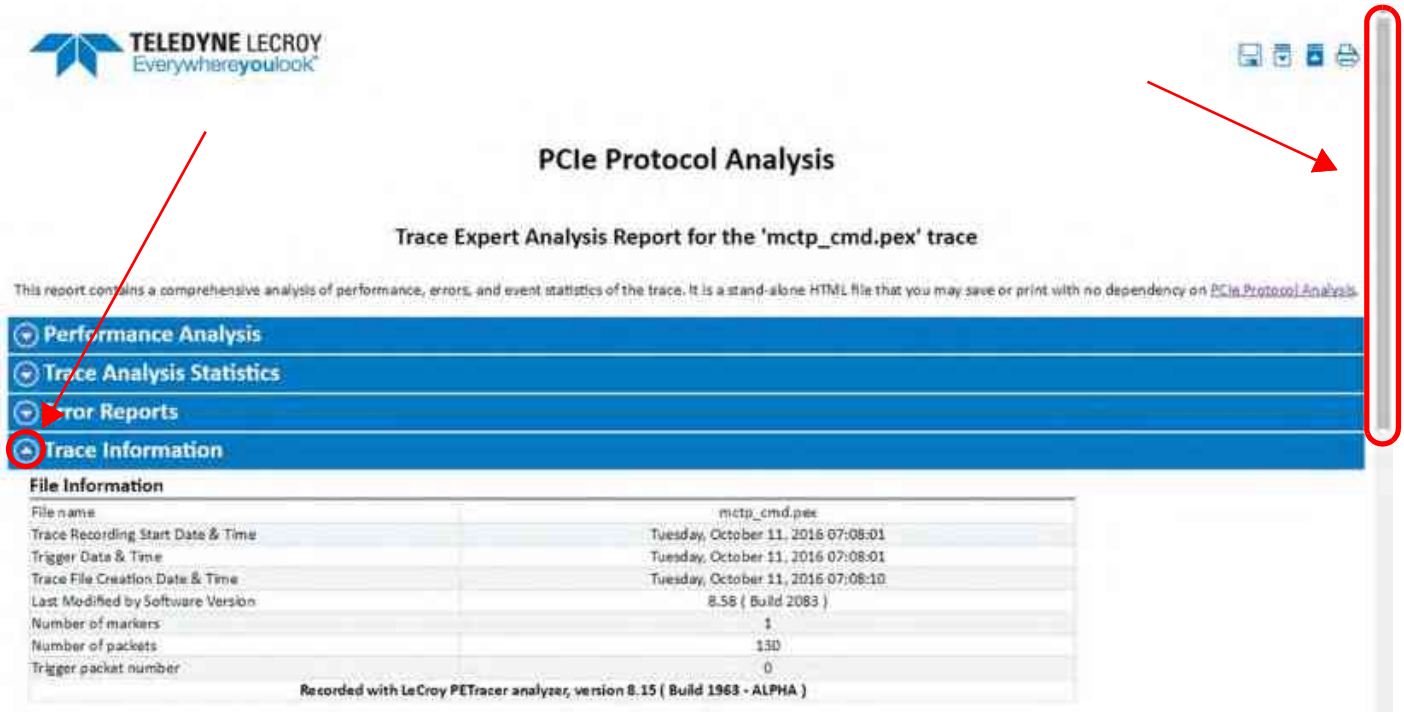


Figure 11.120: Trace Information

Selecting Trace Information generates the following reports:

- File Information
- Hardware Information
- Recording Options
- License Information
- IDE Keys—shown only for IDE Traces

Scroll down to see the other reports and information.

11.27 IDE Decryption

The PCIe Protocol Analysis software (version 5 and later) includes Integrity and data encryption (IDE). IDE provides confidentiality, integrity, and replay protection for TLPs.

The software allows decrypting encrypted IDE TLPs and uses their decrypted payload in transaction level decoding, various views and reports:

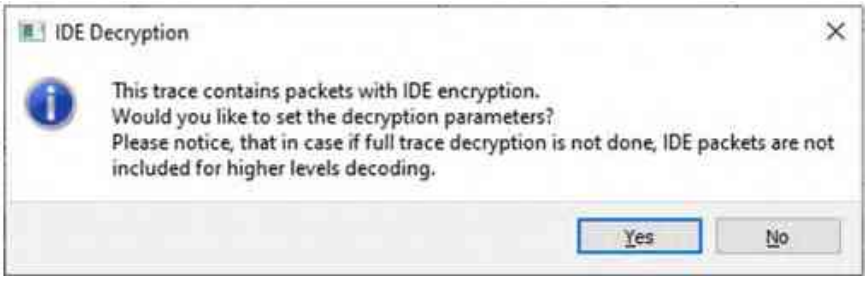
- Trace View
- Traffic Summary report (see "IDE Traffic Summary Report" on page 671)
- Search (see"Search for IDE TLPs" on page 612)
- VSE scripts (see For IDE TLPs only in the VSE Manual)
- IDE View (see "IDE View" on page 758)

To set IDE Keys and decrypt the trace, all of the following conditions must be met:

- The trace has at least one valid (without any critical errors) IDE TLP,
- The trace is at PCIe version 5, and
- The IDE decoding license is present.

To enable all IDE-related operations, perform an IDE decryption:

1. Open a trace containing valid IDE TLPs.
2. From the toolbar, select the IDE button.
3. If the trace contains no saved IDE decryption keys, the following message displays:



4. Select **Yes** to set the parameters in the IDE Keys View window.

Note: To change the keys and re-decrypt the trace at any point, use the IDE Keys button.

5. After the keys are specified and decrypting the trace is done for the first time, then using the IDE button will start IDE processing - there is no need to set the parameters each time.

11.27.1 IDE View

The IDE View (Figure 11.121) shows IDE information for a packet. It displays information only after specifying the key covering the packet.

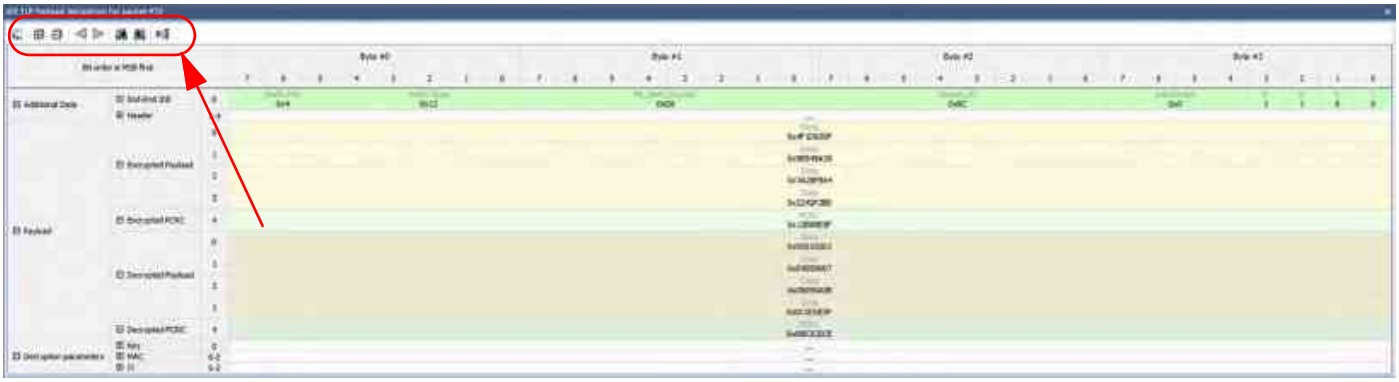


Figure 11.121: IDE View

The buttons, located at the top left of the screen, allow you to:

- Switch to the previous/next packet in the current aggregation;
- Switch to the previous/next aggregation on the current channel, stream, or sub-stream; and
- Switch the display mode - single packet or aggregation.

11.27.2 IDE Keys View

The Keys View (Figure 11.122 on page 760) window allows you to set the decryption parameters. Click on the empty row at the bottom of the table to add a new key. Before saving the keys, ensure that packet ranges for any channel-stream-substream combination do not overlap. Once you apply the parameters, the system performs the Trace decryption.

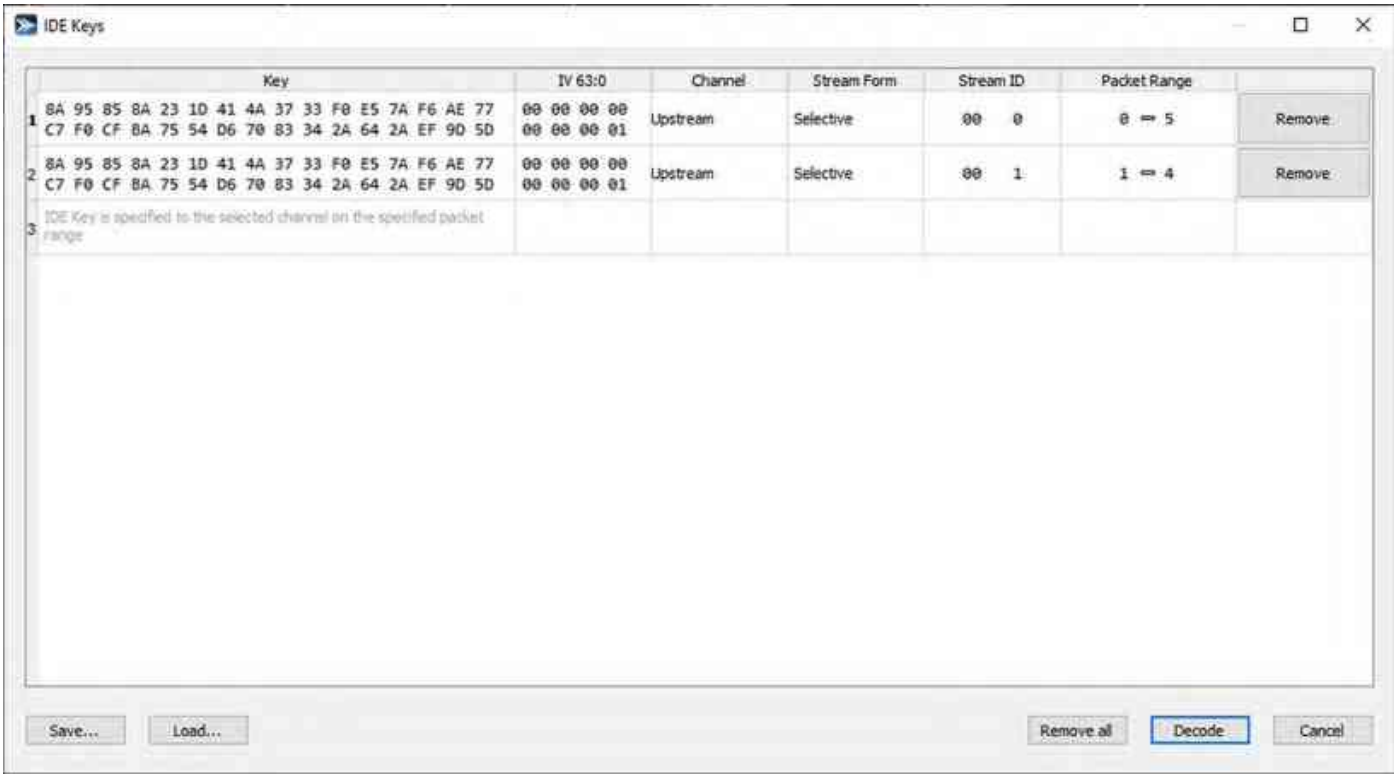


Figure 11.122: IDE Keys View

Each row of the table contains:

- Encryption key
- Initialization vector (IV)
- Channel
- Stream Form
- Stream and sub-stream identifiers
- Packet Range: The packet range for the parameters
- Remove: Removes that row from the table

All of these parameters have default values defined by the software. You will need to edit these values.

TABLE 11.3: Buttons for IDE Keys View

Button	Description
Save	Save a file with a .pekeys extension.
Load	Load keys from a file with a .pekeys extension.
Remove all	Removes all keys from key view. Changes are applied after clicking the Decode button.
Decode	Writes the parameters to the current trace file and starts the full trace decryption process.

Note: No security mechanism is used to store cryptographic keys, please DO NOT store the keys to secret data.

11.27.3 IDE View for CXL Mode

11.27.3.1 IDE View for CXL.io

IDE View for CXL.io works identically to IDE View in PCIe mode. Please refer to "IDE View" on page 758 for more information.

11.27.3.2 IDE View for CXL.cacme/mem

The IDE View for CXL.cache/mem operates on a flit level. It shows IDE information for a flit for the selected packet. The IDE View only displays information if a key is specified for the selected flit. See Figure 11.123 on page 762.

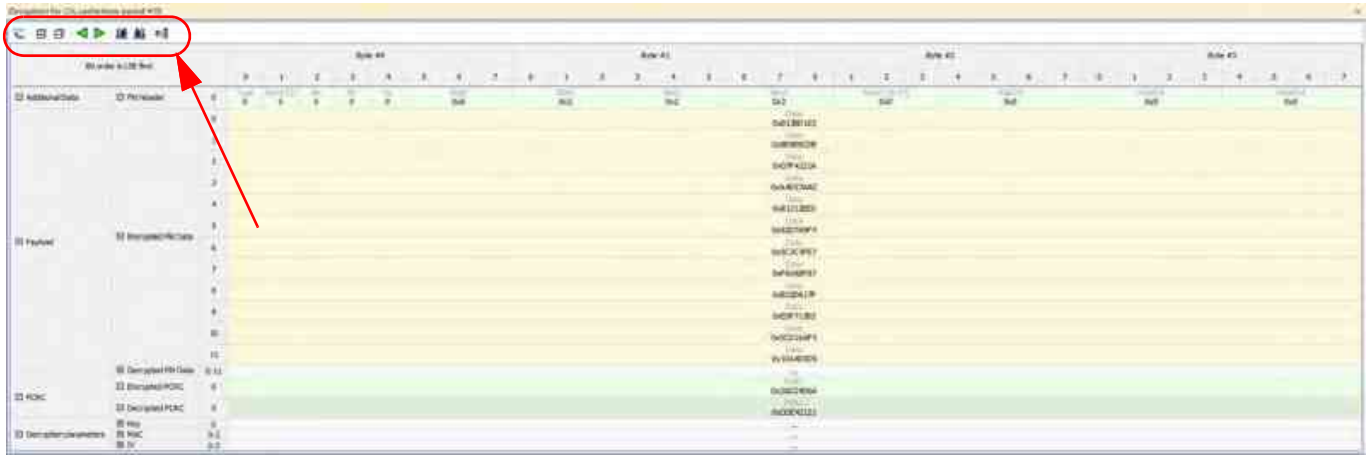


Figure 11.123: IDE View for CXL.cache/mem

The buttons, located at the top left of the screen, allow you to:

- Switch to the previous/next packet in the current aggregation;
- Switch to the previous/next aggregation on the current channel, stream, or sub-stream; and
- Switch the display mode - single packet or aggregation.

11.27.4 IDE Keys View for CXL Mode

IDE Keys View for CXL mode sets the cryptographic parameters used for decryption of CXL.io and CXL.cache/mem. There are two tabs: 'CXL.io IDE keys' and 'CXL.cache/mem IDE keys', as shown in Figure 11.124 on page 763 and Figure 11.125 on page 763. Clicking the tab switches between the CXL.io and CXL.cache/mem IDE Keys views.

Note: If no traffic exists for one of the modes in the trace file, that tab will be greyed out.



Figure 11.124: IDE Keys View for CXL.io mode

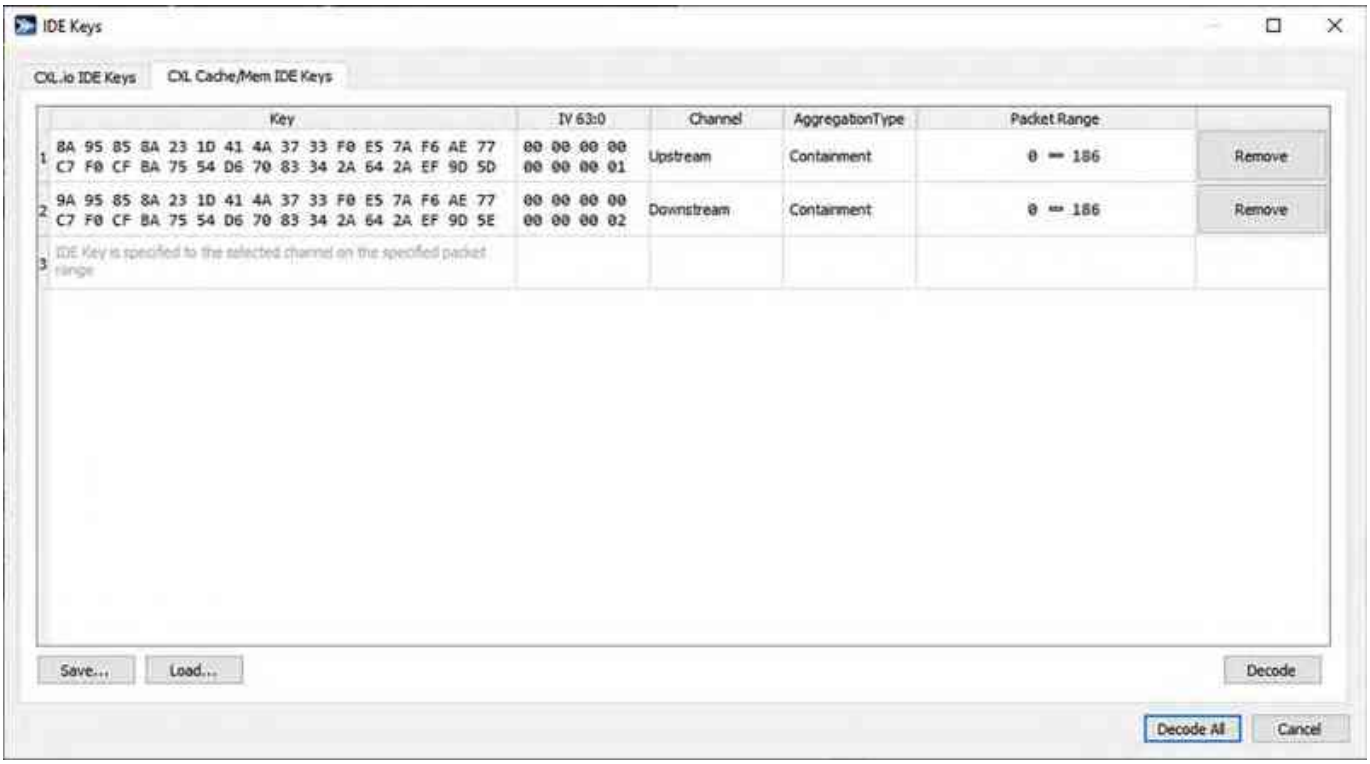


Figure 11.125: IDE Keys for CXL.cache/mem

Table 11.4 describes the buttons for the IDE Keys CXL.io and CXL.cache/mem tabs.

TABLE 11.4: Buttons for IDE Keys CXL.io and CXL.cache/mem Tabs

Button	Description
Save	Save a file with a .pekeys extension.
Load	Load keys from a file with a .pekeys extension.
Decode	Writes the parameters to the current trace file and starts the full trace decryption process.
Apply (CXL.io keys view only)	Only saves keys to the trace file.
Decode All (applies to both tabs at the same time)	Applies changes to both tabs and performs a full trace decryption for both CXL.io and CXL.cache/mem.

CXL.io Keys and CXL.cache/mem parameters are organized in a table. All of these parameters have default values defined by the software. You will need to edit these values.

11.27.4.1 CXL.io Parameters

For CXL.io, each row of the table contains:

- Encryption key
- Initialization vector (IV)
- Channel
- Stream Form
- Stream and sub-stream identifiers
- Packet Range: The packet range for the parameters
- Remove: Removes that row from the table

11.27.4.2 CXL.cache/mem Parameters

For CXL.cache/mem, each row of the table contains:

- Encryption Key
- Initialization Vector
- Channel
- Aggregation Type
- Packet Range: The packet range for the parameters.
- Remove: Removes that row from the table.

11.28 SPDM View

Open the SPDM View window by clicking the toolbar button. The button becomes visible after pressing the SPDM decoding button. See Figure 11.126 and Figure 11.127.



Figure 11.126: Open SPDM View Button



Figure 11.127: SPDM Keys View

Select a Secured SPDM message containing no decryption errors. You can see all parts of the message in SPDM View as well as the key and IV used for decryption.

Note: SPDM View displays the initial IV derived from the major secret.

Use the buttons located at the top left of the screen to go to the previous/next Secured SPDM message.

Chapter 12

Updates and Licensing

12.1 Updating the Analyzer

BusEngine™ and/or Firmware updates are now automatic processes that run anytime a new version of the PCIe Protocol Analysis™ is installed that is incompatible with the currently installed BusEngine or Firmware. The update process generates on screen instructions.

If, however, you need to manually perform BusEngine or Firmware updates, follow these steps:

1. Select **Setup > Update Device** … from the menu to display the Update Analyzer dialog box for **Summit T5™.**
2. Select the appropriate file locations for the Firmware and/or BusEngine, using Browse, if necessary.
3. Check the appropriate options (if in doubt, check all options).
4. Click **Update** to initiate the updating of the Analyzer.

12.2 License Keys

A License Key is necessary to enable software maintenance. If you attempt to record with the Analyzer without an installed License Key, a message appears to indicate that a License Key is necessary in order to record traffic.

A License Key must be obtained from Teledyne LeCroy for each Analyzer.

After you obtain the License Key, follow these steps to install it:

1. Select **Setup > All Connected Devices > Update License** from the menu bar. to display the Select License Key File dialog box.
2. Enter the **path** and **filename** for the License Key or use the Browse button to navigate to the directory that contains the License Key.
3. Select the **.lic** file, and then click **Update Device**.

12.3 License Information

You can view Licensing information for your Analyzer by selecting **Help > Display License Information**… from the menu bar. The License Information window displays data about the maintenance expiration and purchased features.

Appendix A

How to Contact Teledyne LeCroy

Send e-mail to Support	psgsupport@teledyne.com
Contact Support	teledynelecroy.com/support/contact
Visit Teledyne LeCroy's website	teledynelecroy.com
Tell Teledyne LeCroy	Report a problem to Teledyne LeCroy Support via e-mail by selecting **Help > Tell Teledyne LeCroy** from the application toolbar. This requires that an e-mail client be installed and configured on the host machine.

Appendix B

China Restriction of Hazardous Substances Table

The following tables are supplied in compliance with China's Restriction of Hazardous Substances (China RoHS) requirements:

部件名称	有毒有害物质和元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr^{6+})	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
PCBAs	X	O	X	X	X	X
机械硬件	O	O	X	O	O	O
金属片	O	O	X	O	O	O
塑料部件	O	O	O	O	X	X
电源	X	X	X	O	X	X
电源线	X	O	X	O	X	X
保护外壳(如有)	O	O	O	O	X	X
电缆组件(如有)	X	O	X	O	X	X
风扇(如有)	X	O	X	O	X	X
交流滤波器和熔丝组件(如有)	X	O	X	O	O	O
外部电源(如有)	X	X	X	O	X	X
探头(如有)	X	O	X	O	X	X
O: 表明该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T11363-2006 标准规定的限量要求之下。						
X: 表明该有毒有害物质至少在该部件的某一均质材料中的含量超过 SJ/T11363-2006 标准规定的限量要求。						

EFUP (对环境友好的使用时间) 使用条件:
温度: 5摄氏度到40摄氏度
湿度: 5% - 95%最大相对湿度 (无冷凝)
高度: 最高2000米

Part Name	Toxic or Hazardous Substances and Elements					
	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Hexavalent Chromium (Cr^{6+})	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
PCBAs	X	O	X	X	X	X
Mechanical Hardware	O	O	X	O	O	O
Sheet Metal	O	O	X	O	O	O
Plastic Parts	O	O	O	O	X	X
Power Supply	X	X	X	O	X	X
Power Cord	X	O	X	O	X	X
Protective Case (if present)	O	O	O	O	X	X
Cable Assemblies (if present)	X	O	X	O	X	X
Fans (if present)	X	O	X	O	X	X
AC Filter/Fuse Assy (if present)	X	O	X	O	O	O
Ext Power Supply (if present)	X	X	X	O	X	X
Probes (if present)	X	O	X	O	X	X
O: Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement specified in SJ/T11363-2006.						
X: Indicates that this toxic or hazardous substance contained in at least one of the homogenous materials used for this part is above the limit requirement specified in SJ/T11363-2006.						

EFUP (Environmental Friendly Use Period) Use Conditions:

Temperature	5C to 40C
Humidity	5% to 95% max RH (non-condensing)
Altitude	Up to 2000 meters

Appendix C

Quick Search Feature

C.1 Quick Search Feature: Pre-Defined Terms

The Quick Search feature allows you to either search for a pre-defined term within a loaded Trace by clicking on the down arrow  or by typing your own term into the search window  and then moving the cursor into the window and hitting the Enter key.

A complete list of pre-defined terms is shown in Table .

TABLE C.1: Pre-Defined Searchable Terms (Sheet 1 of 3)

TLP - Memory Read (32 bit)	Error - TLP: Payload/Length Error
TLP - Memory Read (32 bit) - Locked	Error - TLP: Length Error (not 1)
TLP - Memory Write (32 bit)	Error - TLP: TC Error (not 0)
TLP - Memory Read (64 bit)	Error - TLP: Attr Error (not 0)
TLP - Memory Read (64 bit) - Locked	Error - TLP: AT Error (not 0)
TLP - Memory Write (64 bit)	Error - TLP: Byte Enables Violation
TLP - I/O Read Request	Error - Memory TLP: Address/Length Crosses 4K
TLP - I/O Write Request	Error - Mem64 TLP: Used Incorrectly
TLP - Configuration Read Type 0	Error - Cfg TLP: Register Error
TLP - Configuration Write Type 0	Error - Msg TLP: Invalid Routing
TLP - Configuration Read Type 1	Error - Msg TLP: Invalid Function Number field
TLP - Configuration Write Type 1	Error - Gen3 TLP: Bad Len CRC/Parity
TLP - Message	Error - Invalid Packet
TLP - Message with Data	Error - FC: Invalid Advertisement
TLP - Message for Advanced Switching	Error - FC: Insufficient Credits
TLP - Message for Advanced Switching with Data	Error - Training Sequence Format Error
TLP - Completion	Error - Training Sequence Parity Error
TLP - Completion with Data	Error - RRAP Command Aborted Error
TLP - Completion for Locked Memory Read	Error - RRAP Packet Parity Error

TABLE C.1: Pre-Defined Searchable Terms (Sheet 2 of 3)

TLP - Completion for Locked Memory Read with Data	Error - RRAP Packet Reserved Fields Not Nullified Error
TLP - AtomicOp Fetch and Add (32 bit)	Controller Register - CAP
TLP - AtomicOp Fetch and Add (64 bit)	Controller Register - VS
TLP - AtomicOp Unconditional Swap (32 bit)	Controller Register - INTMS
TLP - AtomicOp Unconditional Swap (64 bit)	Controller Register - INTMC
TLP - AtomicOp Compare and Swap (32 bit)	Controller Register - CC
DLLP - Ack	Controller Register - Reserved
DLLP - Nak	Controller Register - CSTS
DLLP - PM	Controller Register - NSSR
DLLP - Vendor	Controller Register - AQA
DLLP - InitFC1-P	Controller Register - ASQ
DLLP - InitFC1-NP	Controller Register - ACQ
DLLP - InitFC1-Cpl	Controller Register - CMBLOC
DLLP - UpdateFC-P	Controller Register - CMBSZ
DLLP - UpdateFC-NP	Controller Register - Reserved
DLLP - UpdateFC-Cpl	Controller Register - Reserved Command Set Specific
DLLP - MRIOV	NVMe I/O Cmd - Flush
DLLP - InitFC2-P	NVMe I/O Cmd - Write
DLLP - InitFC2-NP	NVMe I/O Cmd - Read
DLLP - InitFC2-Cpl	NVMe I/O Cmd - Write Uncorrectable
DLLP - NOP	NVMe I/O Cmd - Compare
Link Events - Link Up	NVMe I/O Cmd - Write Zeroes
Link Events - Link Down	NVMe I/O Cmd - Dataset Management
Link Events - PERST# Deasserted	NVMe I/O Cmd - Reservation Register
Link Events - PERST# Asserted	NVMe I/O Cmd - Reservation Report
Link Events - WAKE# Asserted	NVMe I/O Cmd - Reservation Acquire
Link Events - WAKE# Deasserted	NVMe I/O Cmd - Reservation Release
Link Events - CLKREQ# Asserted	NVMe I/O Cmd - Vendor Specific
Link Events - CLKREQ# Deasserted	NVMe ADMIN Cmd - Delete I/O Submission Queue
Link Events - Skew	NVMe ADMIN Cmd - Create I/O Submission Queue
Error - Invalid Code	NVMe ADMIN Cmd - Get Log Page
Error - Running Disparity Error	NVMe ADMIN Cmd - Delete I/O Completion Queue
Error - Unexpected K/D Code	NVMe ADMIN Cmd - Create I/O Completion Queue

TABLE C.1: Pre-Defined Searchable Terms (Sheet 3 of 3)

Error - Idle Data Error (not D0.0)	NVMe ADMIN Cmd - Identify
Error - Skip Late	NVMe ADMIN Cmd - Abort
Error - Skew Error	NVMe ADMIN Cmd - Set Features
Error - Bad Packet Length	NVMe ADMIN Cmd - Get Features
Error - Ordered Set Format Error	NVMe ADMIN Cmd - Asynchronous Event Request
Error - Delimiter Error	NVMe ADMIN Cmd - Firmware Activate
Error - Alignment Error	NVMe ADMIN Cmd - Firmware Image Download
Error - DLLP: Invalid Encoding	NVMe ADMIN Cmd - Format NVM
Error - DLLP: Bad CRC16	NVMe ADMIN Cmd - Security Send
Error - DLLP: Reserved Field not 0	NVMe ADMIN Cmd - Security Receive
Error - DLLP: FC Initialization Error	NVMe ADMIN Cmd - I/O Command Set specific
Error - TLP: Invalid Encoding	NVMe ADMIN Cmd - Vendor specific
Error - TLP: Reserved Field not 0	

Appendix D

Configuration Space Decoding

The decoded capability structures in the Configuration Space Viewer and Editor are based on programmed definitions in the PCIe Protocol Analysis and on Configuration Space Decode Scripts.

Configuration Space Decode Scripts are tools to define capability structures and instruct the Configuration Space Viewer or Editor how to decode them. These scripts are in the **\CfgSpaceScripts** sub-directory below the **\Scripts** directory in the application directory.

You can write Configuration Space Decode Scripts using the CATC Scripting Language (CSL). See the *Teledyne LeCroy Analyzers File Based Decoding Manual* for reference.

PCI Express Configuration Space Decode Scripts have the file extension **.pecfgdec**.

D.1 Mandatory Definitions

Configuration Space Decode Scripts must set the following reserved variables.

- **CapabilityName**: Name of the capability structure
- **CapabilityID**: ID of the capability structure
- **ExtAddSpace**: Set to 1 if Extended Configuration Space. Else, set to 0 for PCI.

D.2 Mandatory Module Functions

Modules are collections of functions and data dedicated to decoding a specific capability structure. Each module has one primary Configuration Space Decode Script file (extension **.pecfgdec**) and optionally has include files (**.inc**).

A module function is an entry-point into a decoding module. To help display a capability structure, the application calls a module function.

The Configuration Space Editor and Viewer support only the **DecodeRegister(offset)** and **GetSize( )** functions.

D.2.1 DecodeRegister(offset)

The application calls this function while decoding a specific DWORD offset of the specified CapabilityID. The offset is the decoding entry point, where the decoding path starts.

The Configuration Space Editor calls this function to determine how to decode the assigned configuration space. The **offset** parameter is the DWORD to decode.
An offset of 0 indicates bytes 00h-03h, an offset of 1 indicates bytes 04h-07h, and so on.

Note: The Configuration Space Editor can only decode one DWORD at a time.

D.2.2 GetSize()

This function returns the size of the capability structure specified by CapabilityID.

D.3 Configuration Register Types

The following reserved variables are defined global constants.

- CFGREG_UNDEFINED
- CFGREG_HWINIT
- CFGREG_RO
- CFGREG_RW
- CFGREG_RW1C
- CFGREG_ROS
- CFGREG_RWS
- CFGREG_RW1CS
- CFGREG_RSVDP
- CFGREG_RSVDZ

Note: These reserved variables match the Configuration Register Types of Table 7-2 in Section 7.4 of the PCI Express Base Specification, Rev. 2.1.

D.4 Primitives

Decoding uses the following primitives.

D.4.1 GetRegisterField

GetRegisterField(dword_offset, bit_offset, field_length)

This function returns a register field of length **field_length**, starting at bit position **bit_offset** in DWORD **dword_offset**.

- **dword_offset**: DWORD offset of the register field location
- **bit_offset**: Bit offset of the register field location
- **field_length**: Length of the register field

For example, **GetRegisterField(1, 9, 2);** means: Go to DWORD 1, bit offset 9, and returns 2 bits.

D.4.2 AddField

AddField(field_name, field_length, configuration_reg_type, tooltip, encoding_table = NULL)

This function adds a register field to the Capability View and returns a pointer to the field, for adding subfields.

- **field_name**: Name of the register field to display in the Capability View
- **field_length**: Length of the register field
- **configuration_reg_type**: Configuration register type of the register field. Note: If subfields are defined, their configuration register types override this setting for their specified bits.
- **tooltip**: Tooltip displayed for the register field in the Capability View
- **encoding_table**: Optional. Displays encodings as lists for select values.
- For example, user input becomes a combo box for the field in the Field View.

As examples:
AddField("PCI Express Extended Capability ID", 16, CFGREG_RO, "");
means: Add the field “PCI Express Extended Capability ID” with length 16 and cfg register type CFGREG_RO.

capability_reg = AddField("Capability Register", 32, CFGREG_RW, "");
means: Added the field “Capability Register” with length 32 and cfg register type CFGREG_RW and stored a pointer to this field in variable capability_reg, which can be used to add subfields to this field.

D.4.3 AddSubField

AddSubField(parent_field, subfield_name, subfield_length, configuration_reg_type, tooltip, encoding_table = NULL);

This function adds a subfield to a register field in the Capability View. Subfields are modifiable and visible in the Field View and appear in the tooltips of register fields.

- **parent_field**: Pointer to a register field in the Capability View
- **subfield_name**: Name of the subfield, displayed in the Field View
- **subfield_length**: Length of the subfield
- **configuration_reg_type**: Configuration register type of the subfield field. Note: This overrides the configuration_reg_type of the parent field.
- **tooltip**: Tooltip displayed for the subfield in the Capability View
- **encoding_table**: Optional. Displays encodings as lists for select values.
- For example, user input becomes a combo box for the field in the Field View.

For example,
AddSubField(capability_reg, "Mode Supported", 4, CFGREG_RO, "Indicates the Function modes,"), ModeEncodings);
means: Add the subfield “Mode Supported” to the parent field “capability_reg” with length 4, type CFGREG_RO, a tooltip in the Capability View, and a combo box displaying “mode encodings” for input in the Field View.

D.5 Helper File

ConfigSpaceCommon.inc include file contains useful functions for script decoding.

Appendix E

Example of XML File Format for SSD Decodes


```
<DEVICES XML_FORMAT_VERSION="1.0">
<DEVICE ENABLE="0x1" VENDORID="0" CLASSCODE="67586" GUID="{9C9654A1-B693-4F30-912F-125059814C42}"
  DEVICEID="000:00:0">
<BARS>
<MBAR ID="0" VALUE="0xF0000000"/>
<BAR ID="2" VALUE="0x00000000"/>
<BAR ID="3" VALUE="0x00000000"/>
<BAR ID="4" VALUE="0x00000000"/>
<BAR ID="5" VALUE="0x00000000"/>
</BARS>
<PROTOCOL ASQS="64" DSTRD="4" ACQS="16" LBASIZE="512" PROTOCOL="NVME" MPS="4096"
  ADDEDBY="DECODING"/>
<Queues>
<Queue SIZE="10" QID="2" TYPE="IOSQ" ADDRESS="0x11B210300" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="3" TYPE="IOSQ" ADDRESS="0x11B210340" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="5" TYPE="IOSQ" ADDRESS="0x11B210380" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="7" TYPE="IOSQ" ADDRESS="0x11B2103C0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="9" TYPE="IOSQ" ADDRESS="0x11B210400" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="11" TYPE="IOSQ" ADDRESS="0x11B210E80" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="14" TYPE="IOSQ" ADDRESS="0x11B210E40" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="16" TYPE="IOSQ" ADDRESS="0x11B210E00" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="6" TYPE="IOSQ" ADDRESS="0x11B233040" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="8" TYPE="IOSQ" ADDRESS="0x11B233080" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="10" TYPE="IOSQ" ADDRESS="0x11B233B40" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="12" TYPE="IOSQ" ADDRESS="0x11B233B00" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="13" TYPE="IOSQ" ADDRESS="0x11B233AC0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="15" TYPE="IOSQ" ADDRESS="0x11B233A80" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="17" TYPE="IOSQ" ADDRESS="0x11B233A40" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="1" TYPE="IOSQ" ADDRESS="0x11B25F080" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="4" TYPE="IOSQ" ADDRESS="0x11B28B040" ADDEDBY="DECODING"/>
```

<Queue SIZE="10" QID="3" TYPE="IOCQ" ADDRESS="0x11B2200C0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="5" TYPE="IOCQ" ADDRESS="0x11B2200E0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="7" TYPE="IOCQ" ADDRESS="0x11B2200F0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="9" TYPE="IOCQ" ADDRESS="0x11B220100" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="11" TYPE="IOCQ" ADDRESS="0x11B2203A0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="14" TYPE="IOCQ" ADDRESS="0x11B220390" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="16" TYPE="IOCQ" ADDRESS="0x11B220380" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="6" TYPE="IOCQ" ADDRESS="0x11B243010" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="8" TYPE="IOCQ" ADDRESS="0x11B243020" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="10" TYPE="IOCQ" ADDRESS="0x11B2432D0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="12" TYPE="IOCQ" ADDRESS="0x11B2432C0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="13" TYPE="IOCQ" ADDRESS="0x11B2432B0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="15" TYPE="IOCQ" ADDRESS="0x11B2432A0" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="16" TYPE="IOCQ" ADDRESS="0x11B243290" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="1" TYPE="IOCQ" ADDRESS="0x11B26F020" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="2" TYPE="IOCQ" ADDRESS="0x11B26F030" ADDEDBY="DECODING"/>
<Queue SIZE="10" QID="4" TYPE="IOCQ" ADDRESS="0x11B29B010" ADDEDBY="DECODING"/>
</Queues>
</DEVICE>
</DEVICES>

Appendix F

Expandability

F.1 Link Width Expansion using Two Summit T54 Analyzers

Another type of expansion, which can be implemented with two Summit T54 Analyzers, can double the link width of the combined analyzers.

Two Summit T54 analyzers can be combined to form a single device with a link width of 8 bits.

F.1.1 Two Summit T54s Configured in Link Width Expansion Mode

You can set up two Summit T54 analyzers to work together as one analyzer, in Expansion Mode, to support x8 recording capability (see Figure F.3 on page 742).

To set up the hardware configuration, perform the following steps:

1. Before setting up the hardware configuration, turn power off on both analyzers.
2. Locate the PE104ACA-X Expansion Kit for two Summit T54 Analyzers.
3. Using a MicroD CATC-Sync Cable, connect the Sync/Data port from one Summit T54 analyzer to the Sync/Data port connector of the second Summit T54 analyzer. See Figure F.1.
4. Using a x8 Expansion Cable, connect the Expansion connector on the back of one Summit T54 analyzer to the Expansion connector on the back of the other Summit T54 analyzer. See Figure F.1.

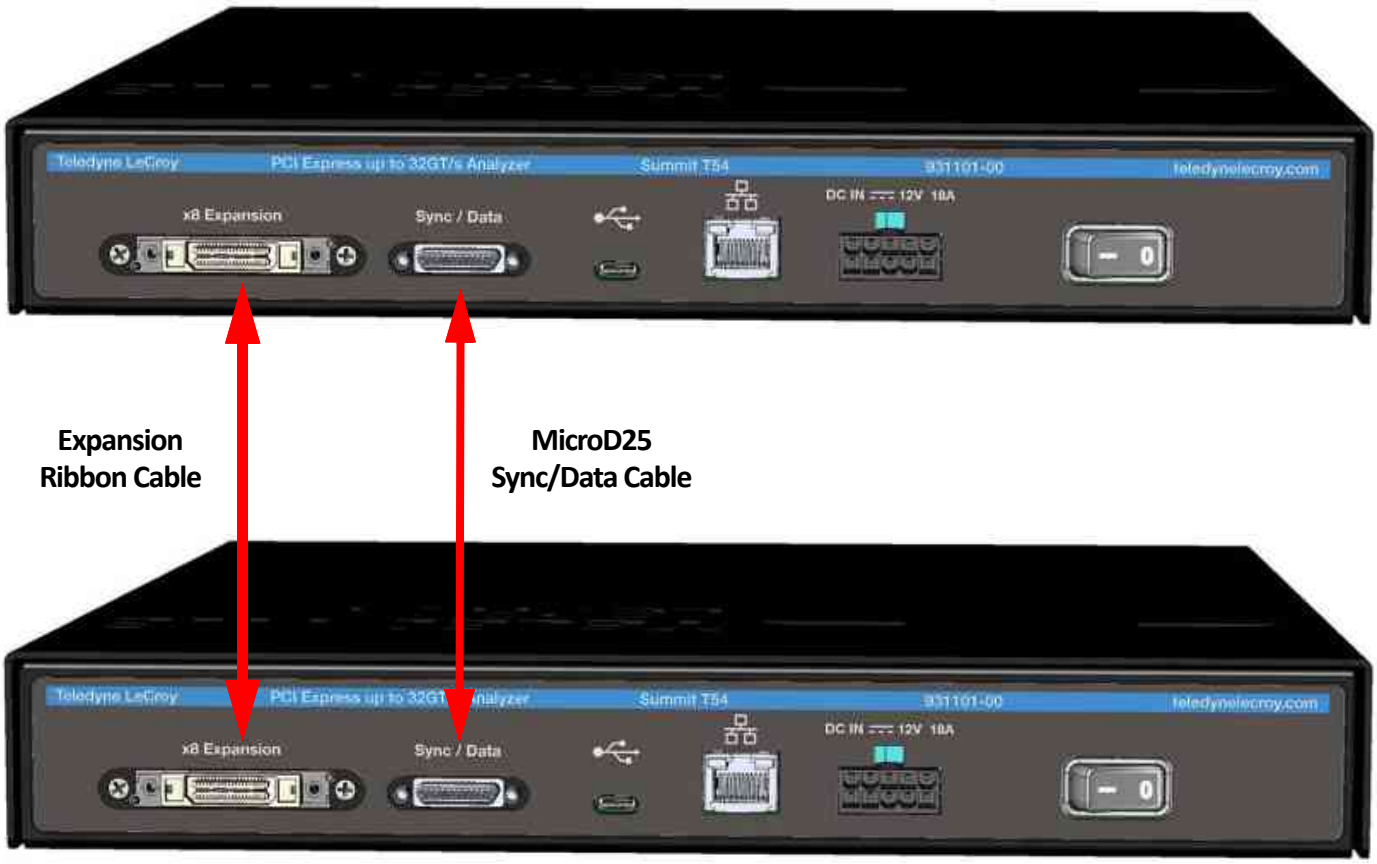


Figure F.1: Connecting x8 Expansion Connectors and Sync/Data connectors on T54

5. Connect both analyzers to the host machine that has the PCIe Protocol Analysis application.
6. After completing the hardware configuration, apply power to both Summit T54 analyzers.
7. Open the PCIe Protocol Analysis application on the host machine.
   - ❑ The software automatically detects and configures the analyzers to work as one x8 - capable analyzer. See Figure F.2.

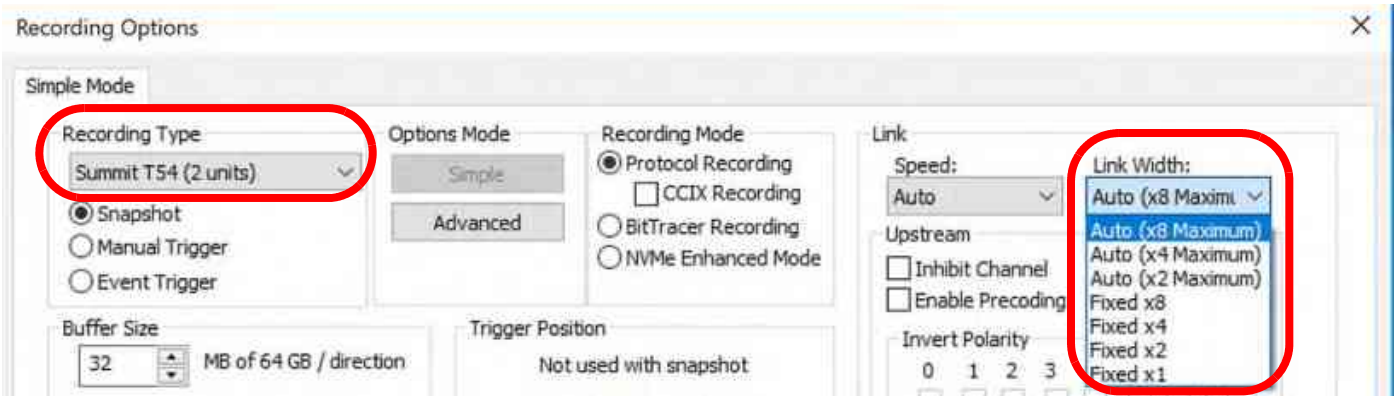


Figure F.2: Summit T54 (2 Units) Recording Options: Link Width up to x8

- One Summit T54 analyzer is assigned the Upstream direction, and the other analyzer is assigned the Downstream direction.
- The Speed LEDs will illuminate on the appropriate side of each analyzer to indicate the direction in which each Summit T54 is recording. The Speed LED in one of the Summit T54 analyzers will illuminate only on the left side, to indicate the PCIe lanes are being recorded from the Upstream direction. The other T54 analyzer will have the Speed LED illuminating only on the right side, to indicate the PCIe lanes are recorded from the Downstream direction.

8. Connect an iPass Y cable (PE028UCA-X) between the x8 interposer and the T54 analyzers, making sure the part A of the Y cable is connected to the upstream direction (indicated as described in previous step) and the part B of the cable is connected to the downstream direction. See Figure F.3 on page 742.

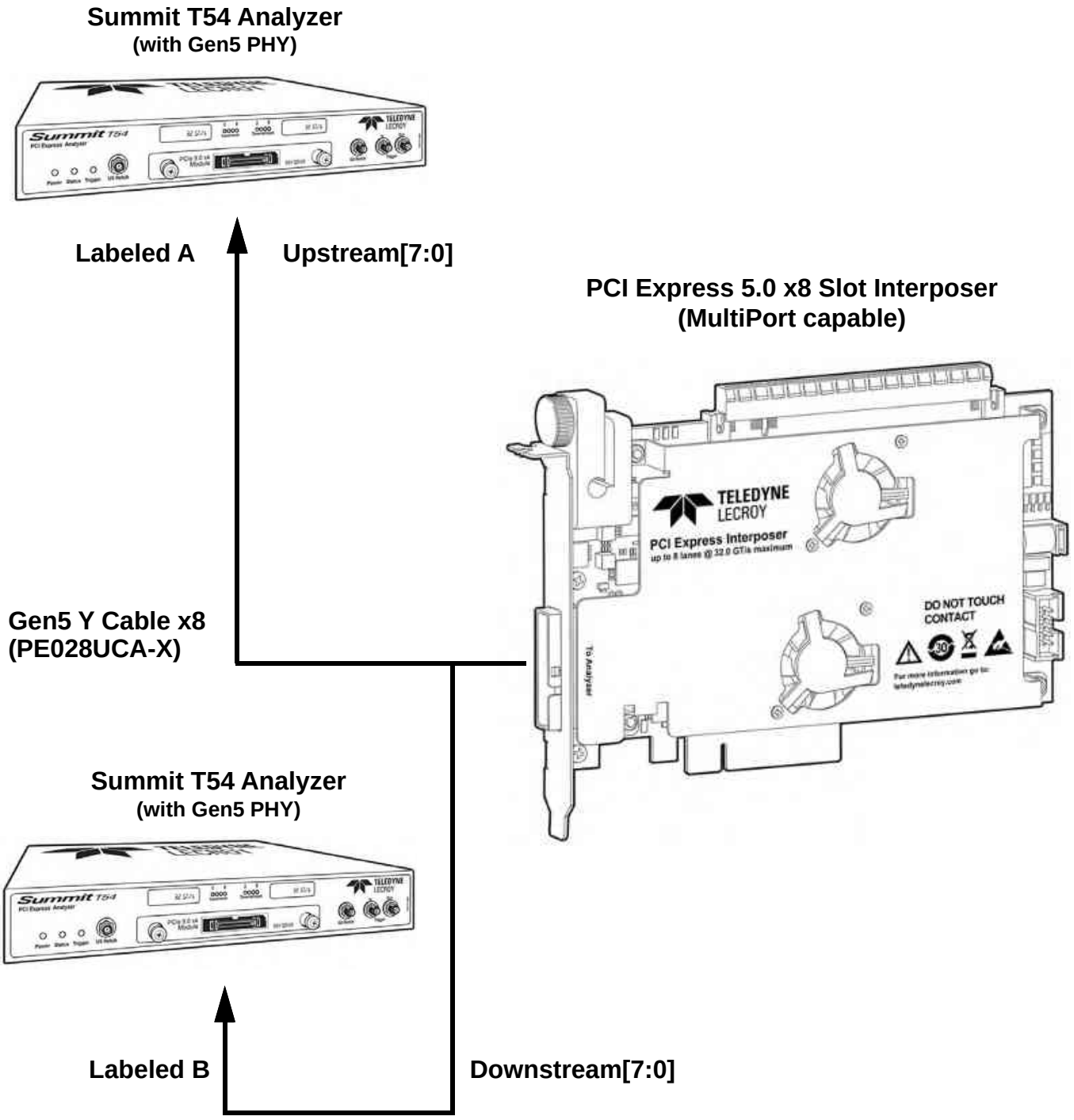


Figure F.3: Summit T54 in Expanded Link Mode x8

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