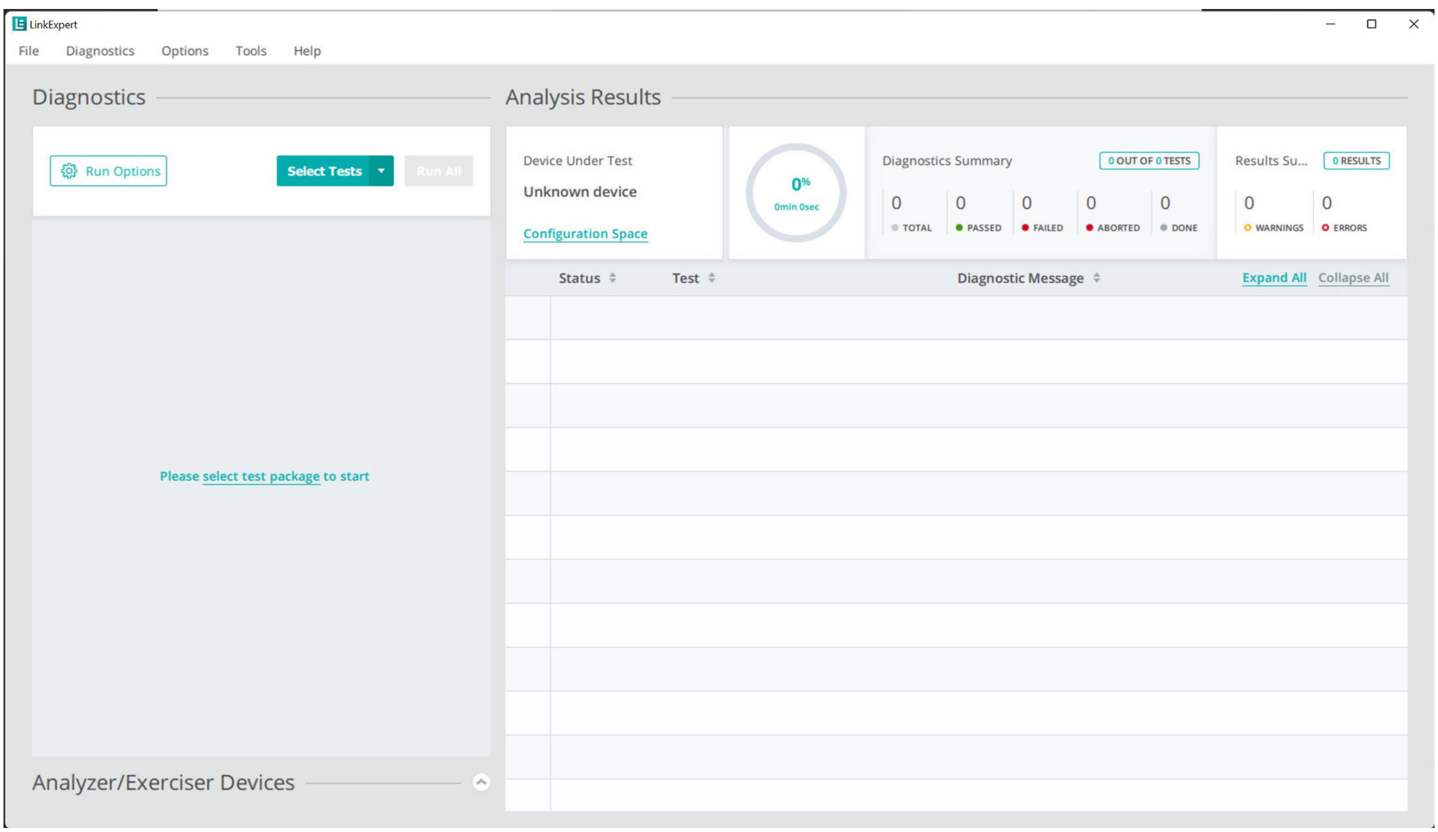
LinkExpert

User Manual



Software Version 5.30

Generated: March 16, 2026 7:55 pm

Teledyne LeCroy Protocol Solutions Group

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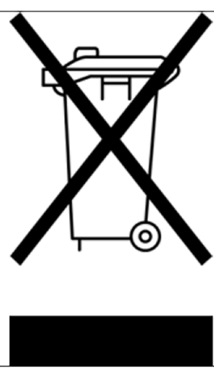

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Contents

Chapter 1

LinkExpert (LE)

1.1 Introduction

LinkExpert provides complete control and management of Teledyne LeCroy's family of protocol analyzer and exerciser hardware while displaying high-level diagnostic information about communication between the root complex (i.e. host systems) and end-points (i.e. devices). The LinkExpert software interface targets design and validation engineers who are responsible for testing and resolving connectivity, interoperability and performance issues as well as ensuring conformance to the design specification. The new interface takes a smart approach to testing Protocols and then displaying the results, including any identified errors, connectivity issues and/or overall performance metrics by using intelligent interpretations of bus traffic, eliminating the need for a deep technical knowledge of the various protocol specifications.

LinkExpert is compatible with the NVMe Conformance tests (Teledyne LeCroy edition) provided by the University of New Hampshire Interoperability Laboratory for official NVMExpress.org testing.

Note: NVMe-MI Tests are Official Conformance tests for NVMExpress.org.

1.2 Key Features

- PCIe Protocol Testing (see “PCIe LinkExpert (LE)” on page 83)
- SAS Compliance Testing (see “SAS LinkExpert (LE)” on page 257)

1.3 Quick Tour

In the Quick Tour of the LinkExpert application, PCIe for System Level Tests are used as an example of LinkExpert's capabilities.

Note: The Quick Tour uses PCIe tools and terminology, but other protocols will have similar concepts. System Level Tests are only available for PCIe.

Since LinkExpert is a brand new product, when you first bring up the tool there is a short Quick Tour section to explain it's main features. See Figure 1.1.

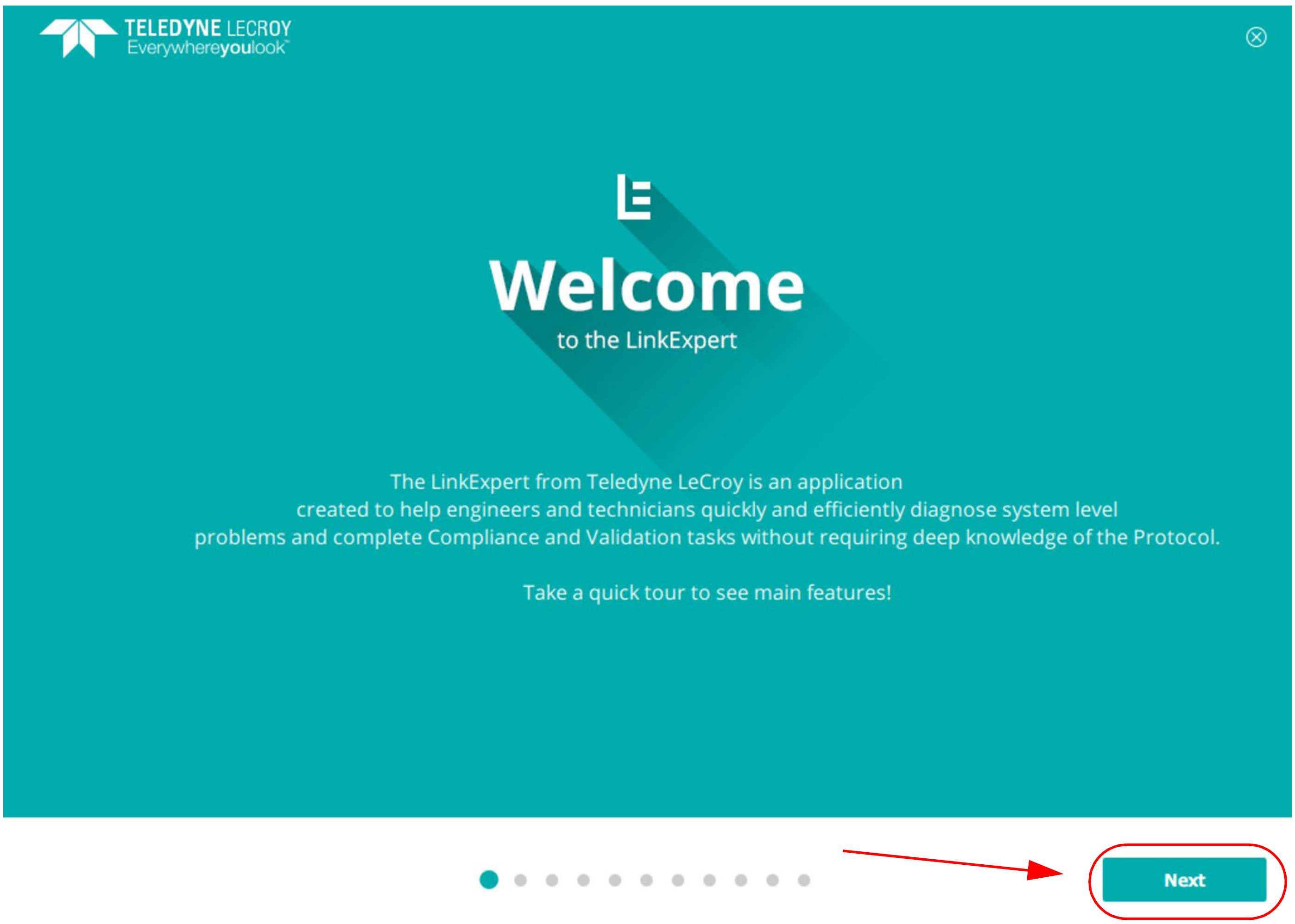


Figure 1.1: Quick Tour: Welcome Screen

After reading the Welcome screen click on Next to take you to the Connect to Analyzer screen. See Figure 1.2 on page 3.

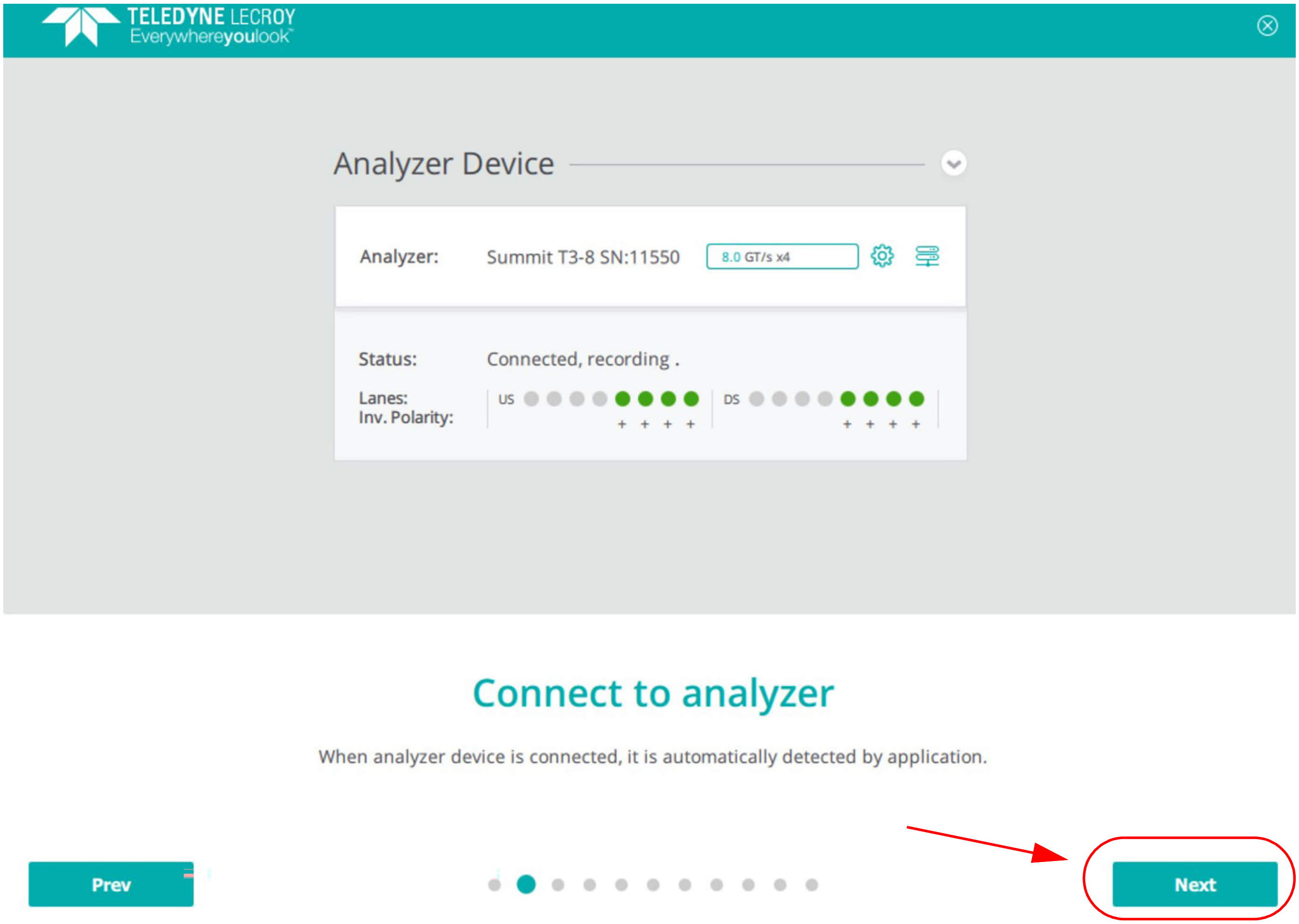


Figure 1.2: Quick Tour: Connect to Analyzer

The first step is to ensure you are connected to an analyzer. In this case we've connected to a Summit T3-8 Analyzer. Click next to go to the Select Test Package slide. See Figure 1.3 on page 4.

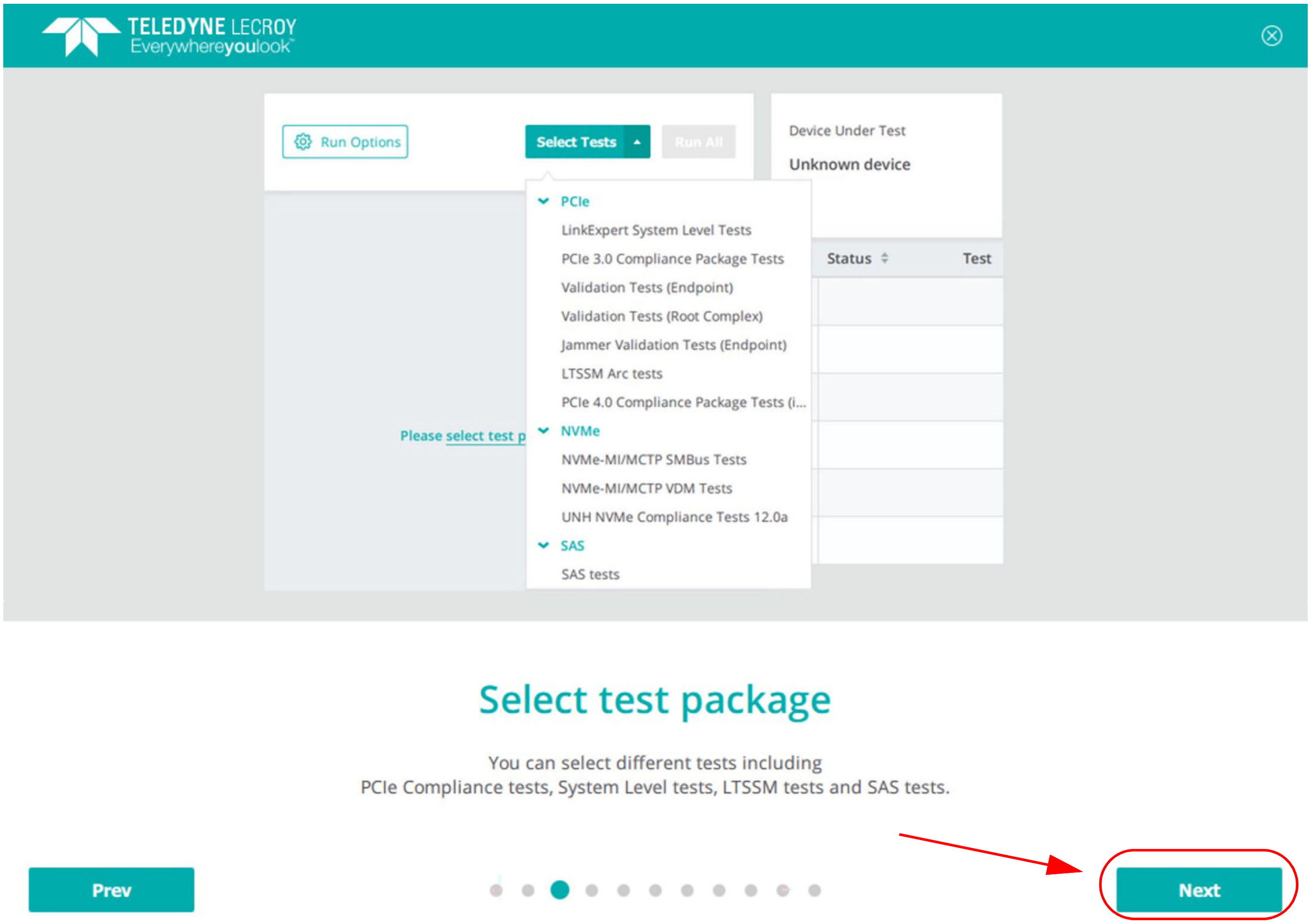


Figure 1.3: Quick Tour: Diagnostics -> Select Test Package

You can select from PCIe tests, NVMe tests or SAS test. Click on Next to see the Compliance test slide. See Figure 1.7 on page 8.

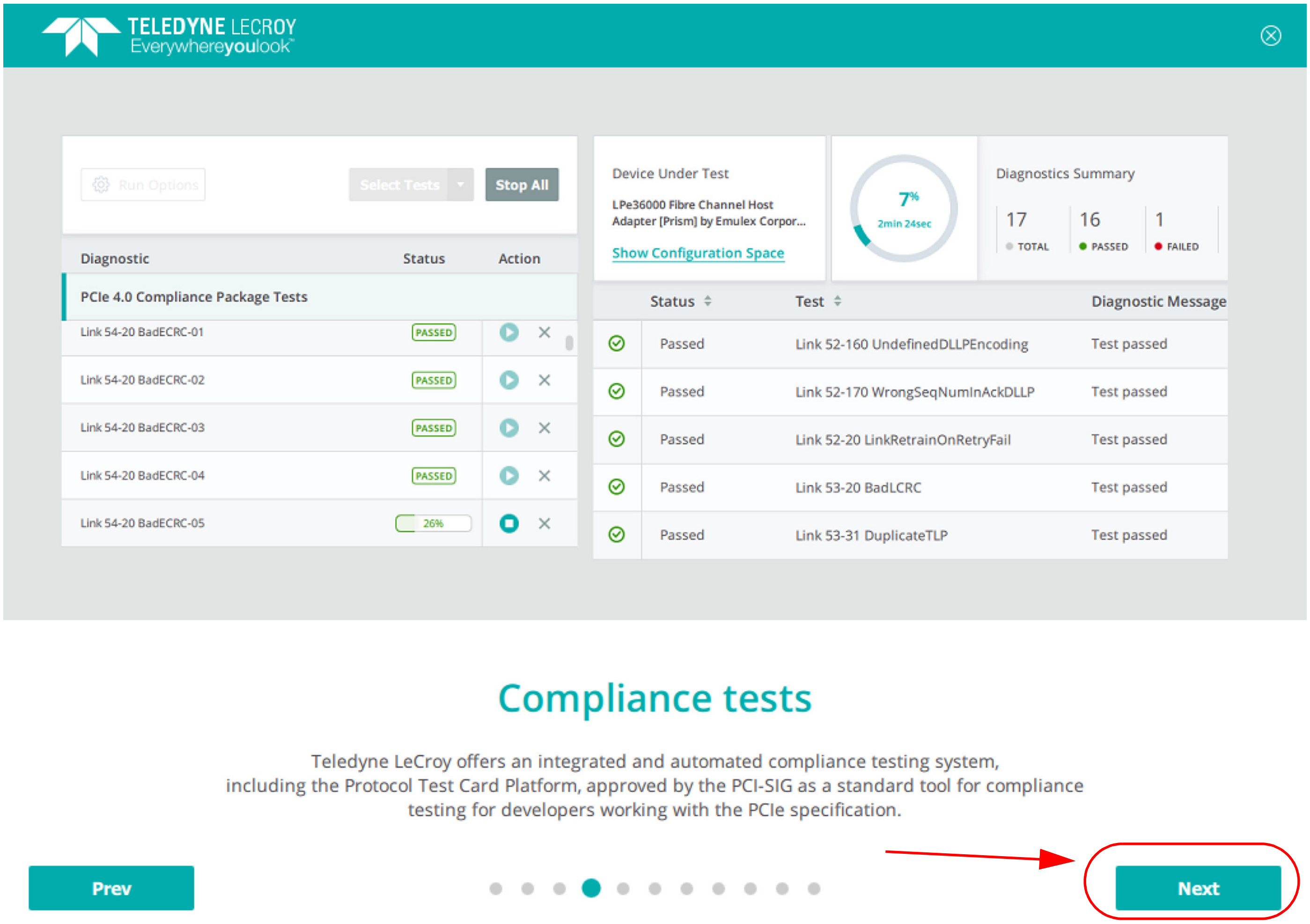


Figure 1.4: Quick Tour: Compliance Tests

Click on Next to see the SAS tests slide. See Figure 1.5 on page 6.

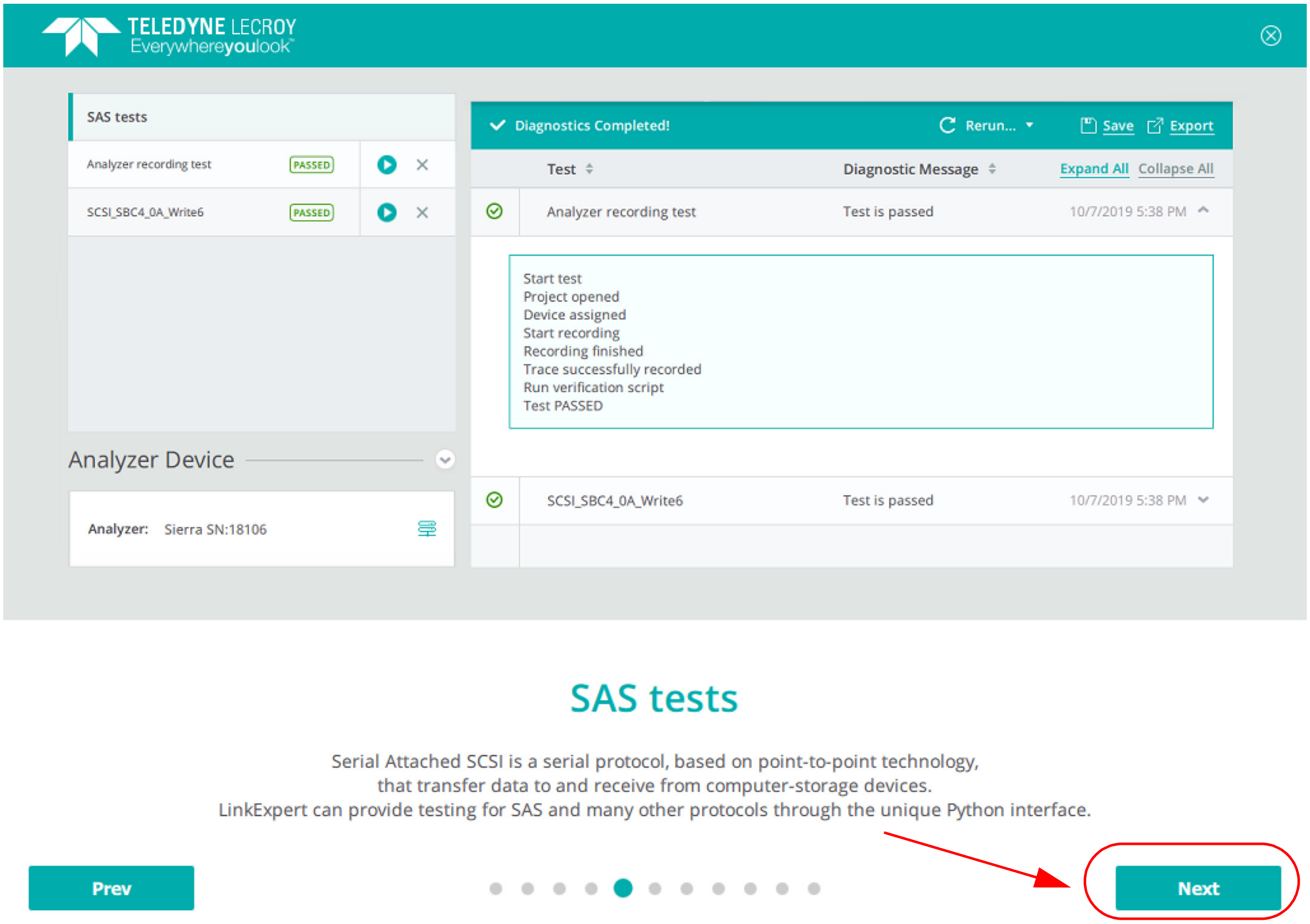


Figure 1.5: Quick Tour: SAS Tests

Click on Next to see the Run Tests slide. See Figure 1.6 on page 7.

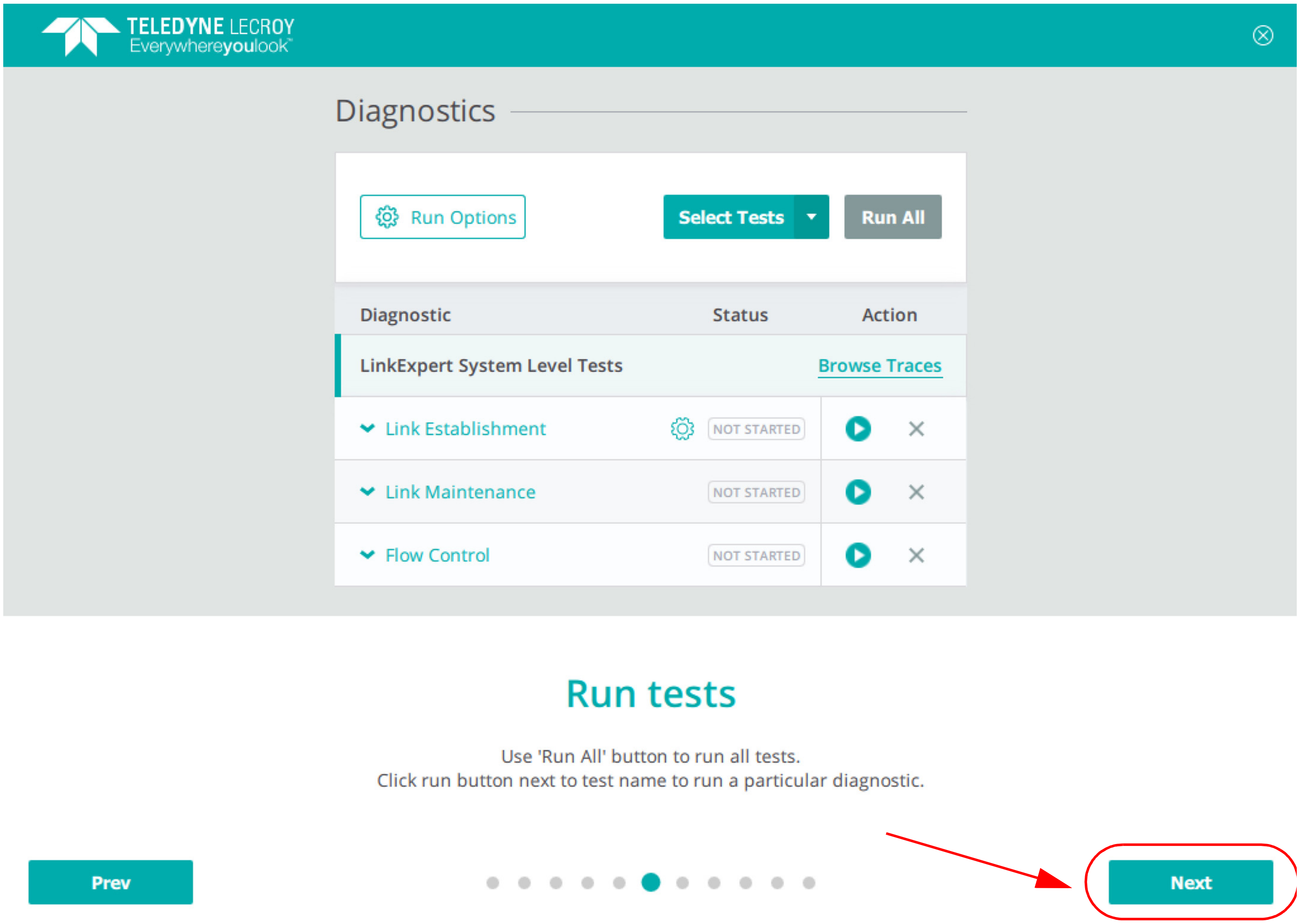


Figure 1.6: Run Tests Slide

Click on Next to run a particular diagnostic. See Figure 1.7 on page 8.

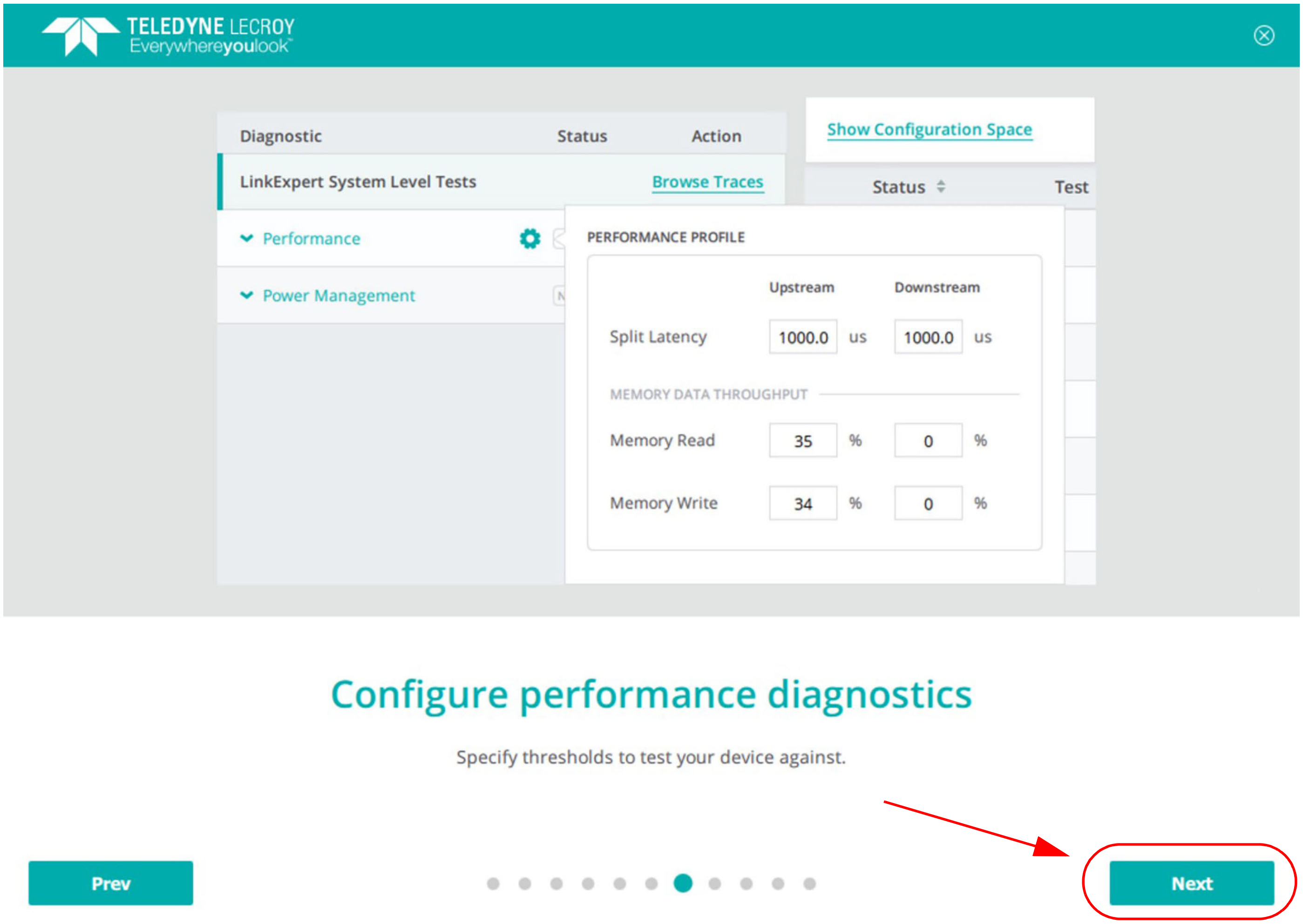


Figure 1.7: Quick Tour: Configure Performance Diagnostic

Now you can specify a Performance Profile for your device. Then click Next to bring up the next slide in the Quick Tour. See Figure 1.8 on page 9.

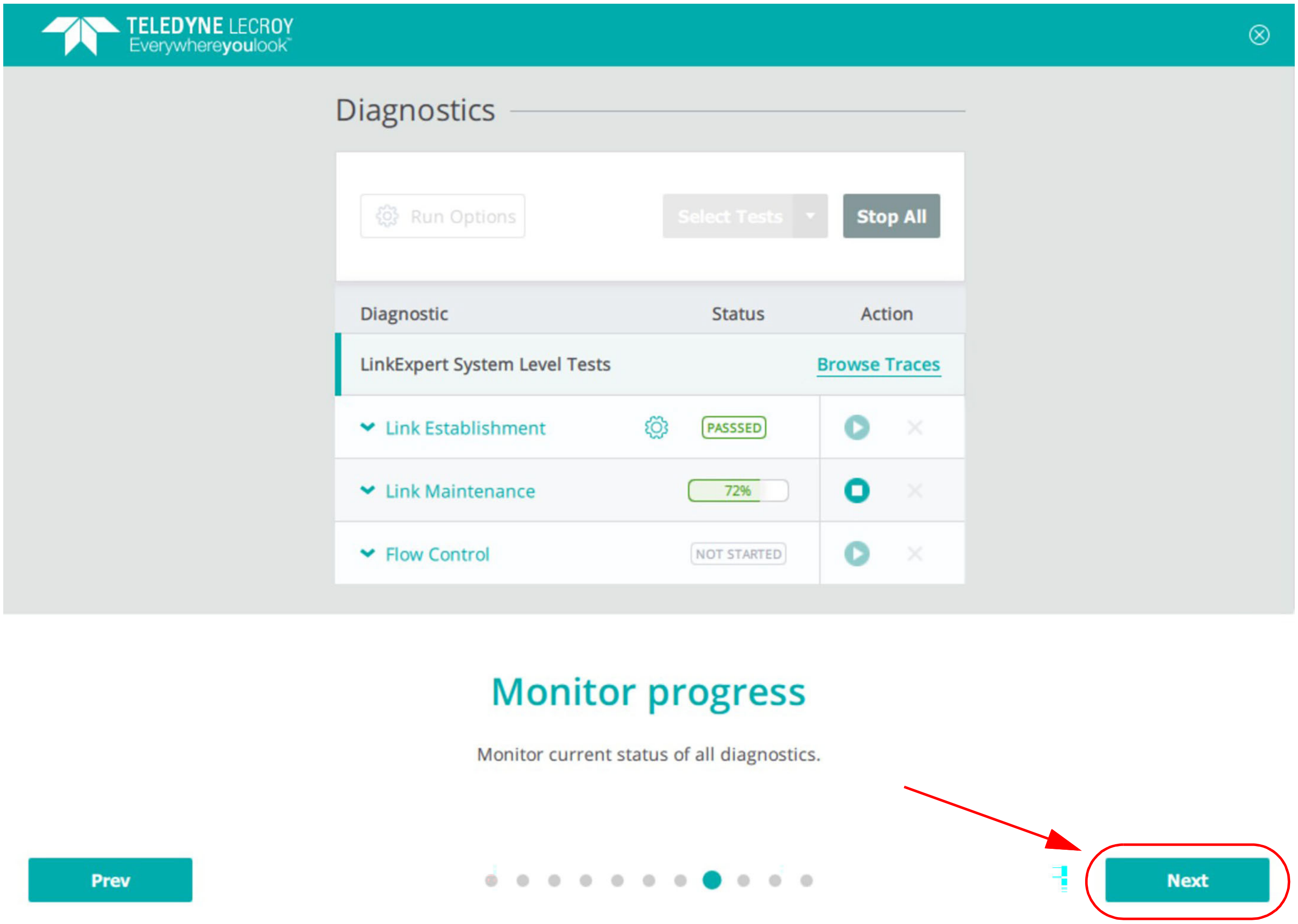


Figure 1.8: Quick Tour: Monitor the Progress of the Diagnostics

You can monitor the progress of the tests. Then click on Next to go to the next slide. See Figure 1.9 on page 10.

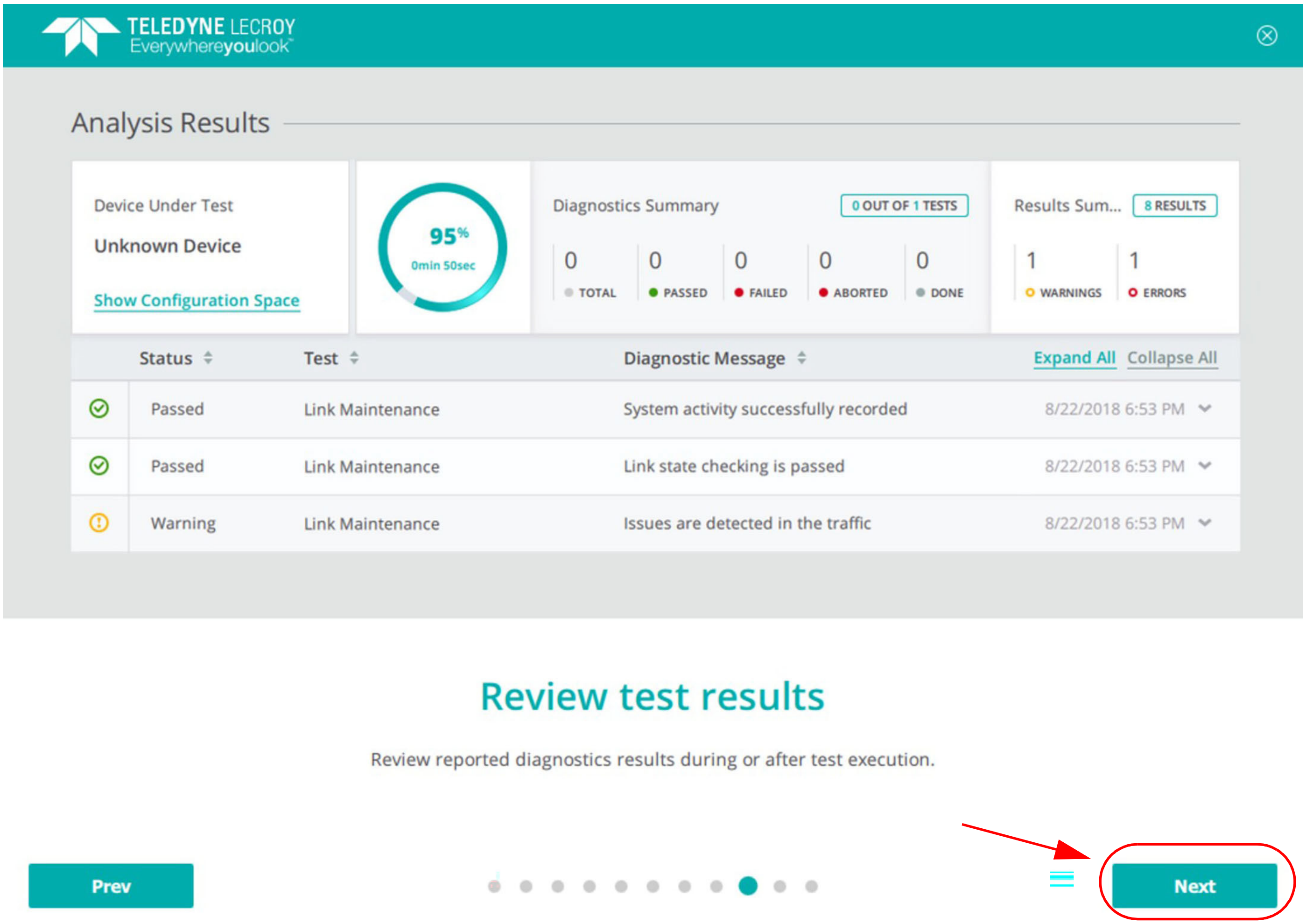


Figure 1.9: Quick Tour: Review Test Results

After the selected tests have been executed, you can review the test results. Click on Next to continue to the next slide in the Quick Tour. See Figure 1.10 on page 11.

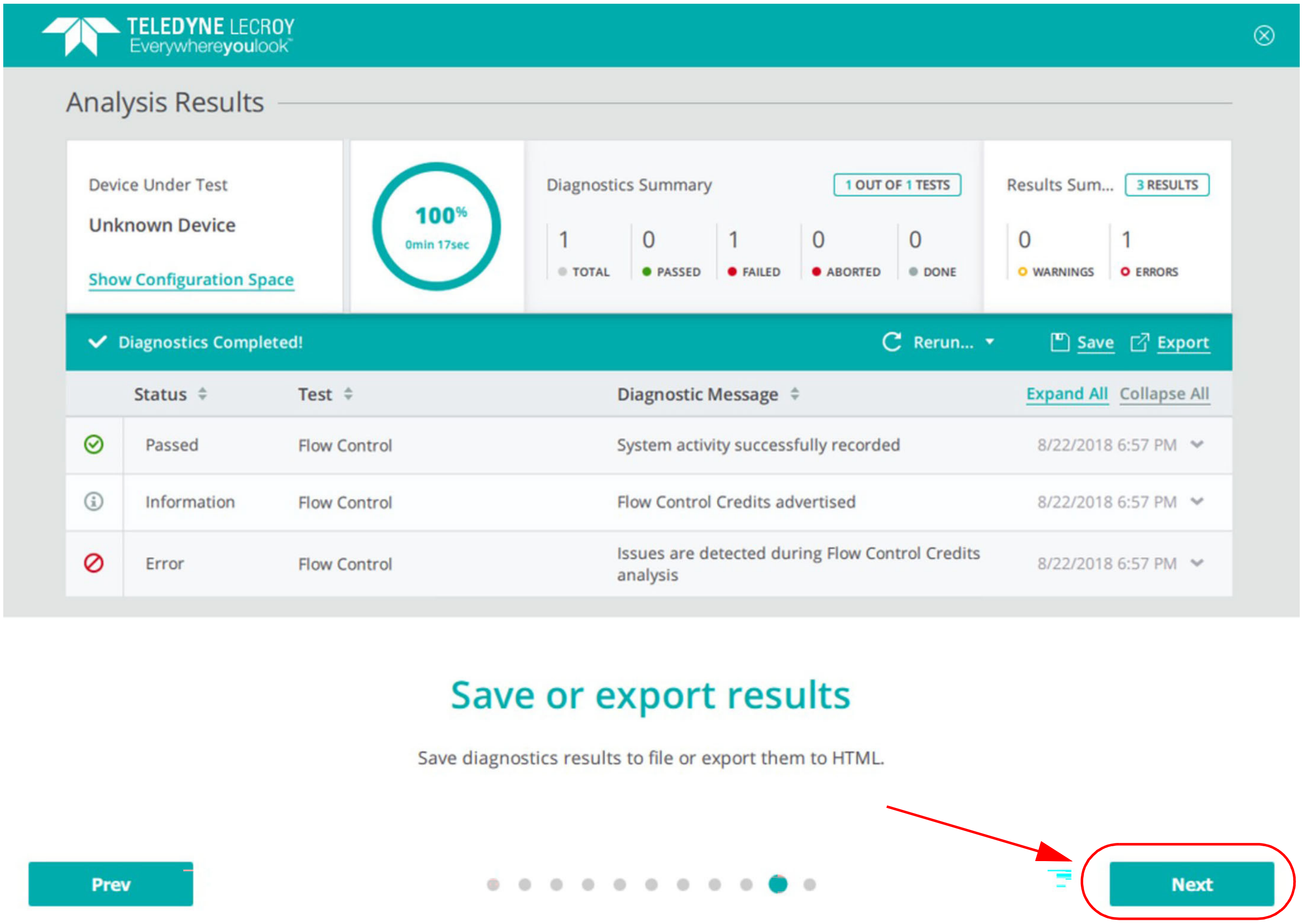


Figure 1.10: Quick Tour: Save or Export Test Results

Now you can Save the Results to a File or Export them to an HTML file. Click on Next to continue to the next slide in the Quick Tour. Figure 1.11 on page 12.

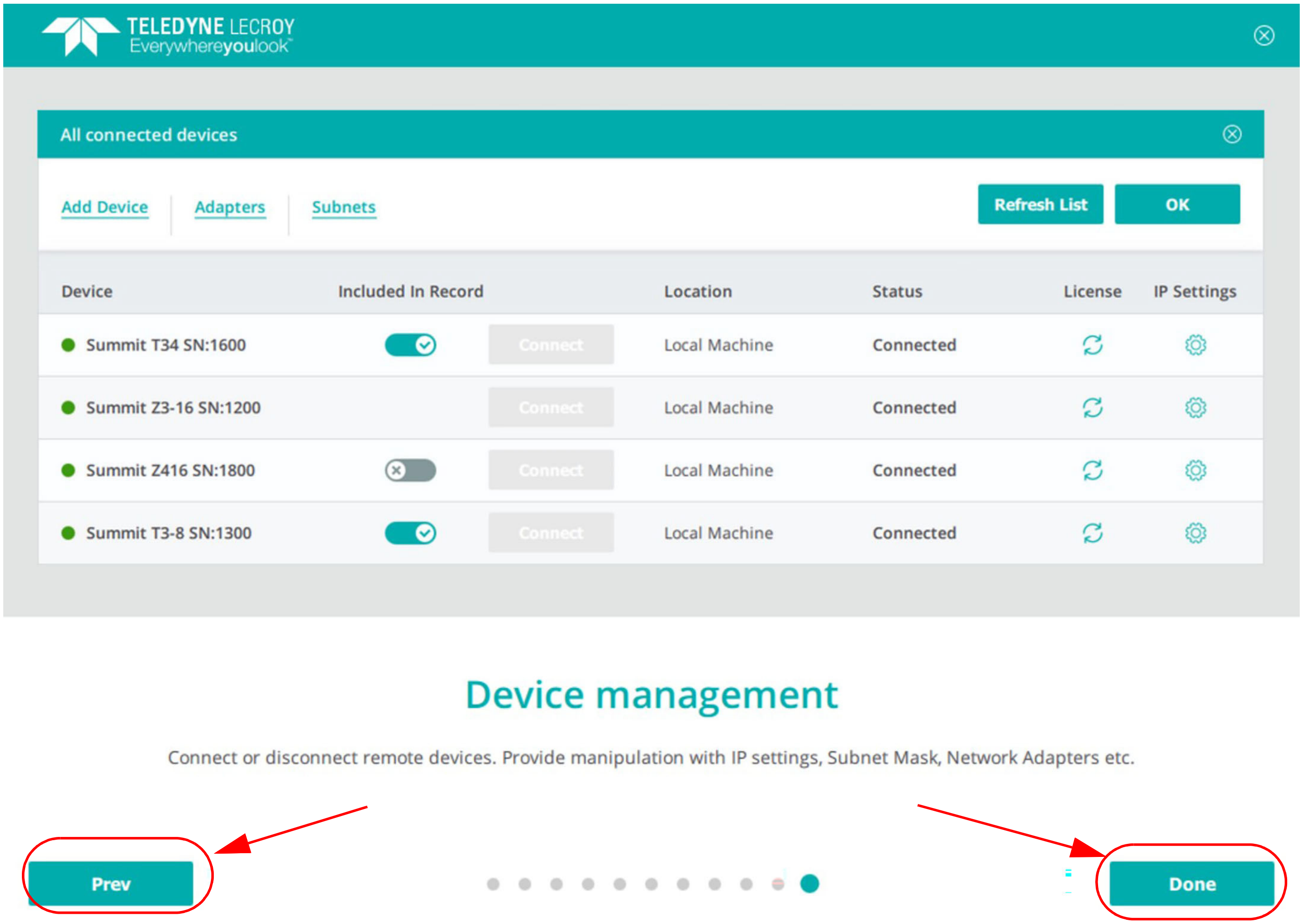


Figure 1.11: Quick Tour: Device Management

At this point you can either return to a Previous slide by clicking the **Prev** button or click on the “X” in the top right corner or click on **Done** to go to LinkExpert’s User Interface. See Figure 1.12 on page 13.

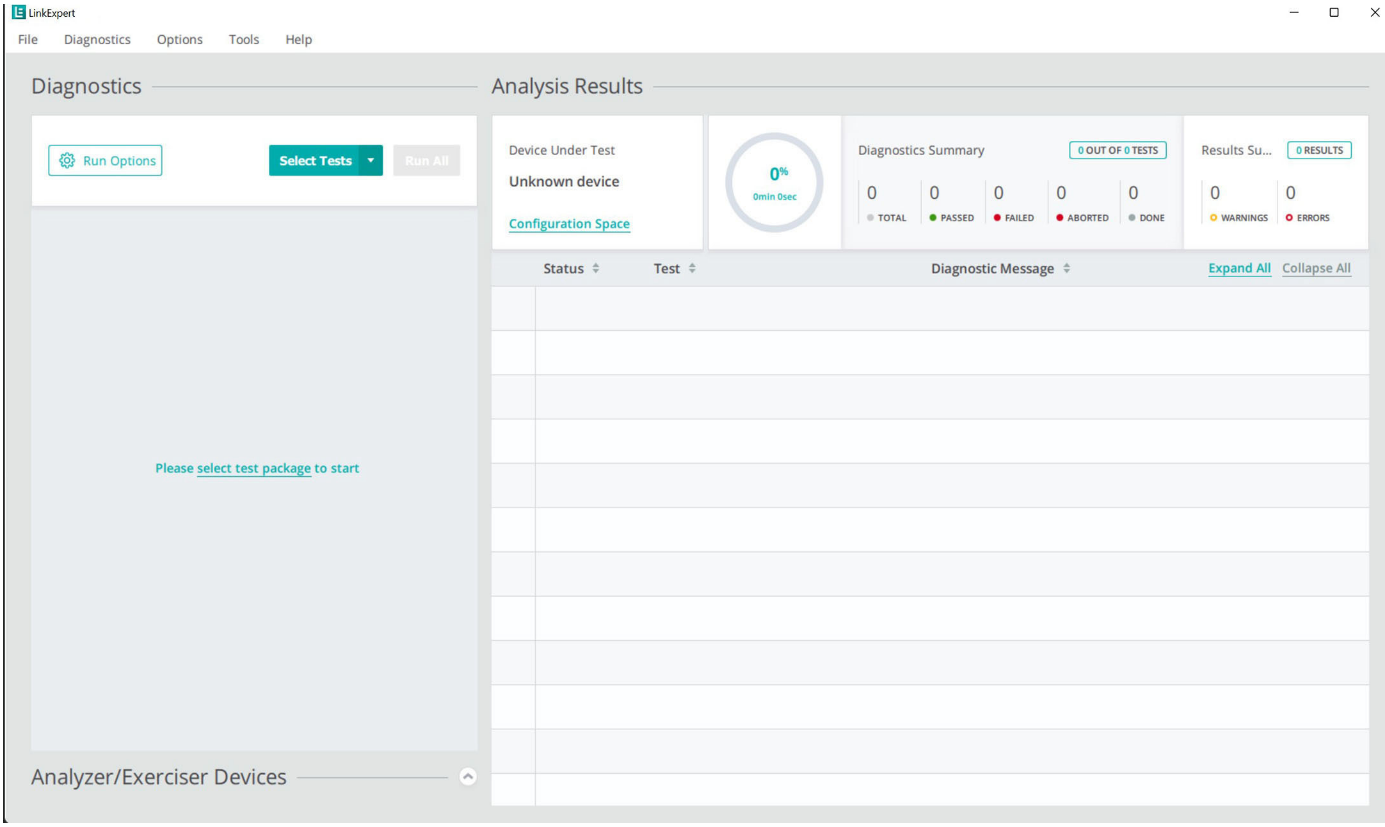


Figure 1.12: Quick Tour: Complete -> Go to LinkExpert User Interface

Chapter 2

Software Installation and Setup

2.1 LinkExpert Installation

LinkExpert software operates with all of Teledyne LeCroy's PCI Express and SAS Protocol analyzer products.

The LinkExpert software is installed on a Microsoft® Windows®-based host machine running 64-bit versions of the following operating systems:

- Windows Server 2016
- Windows Server 2019
- Windows 10

operating systems and serves as the interface for the Analyzer.

2.1.1 Downloading the LinkExpert Software

You can download the latest version of the LinkExpert Software from the following sites:

https://teledynelecroy.com/sw/pciexpress/

https://teledynelecroy.com/sw/sas/

2.1.2 Windows Server 2016/2019 Firewall Exceptions

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

To add the LinkExpert software application to the firewall exceptions perform the following steps.

1. Open the Control Panel. See Figure 2.1.

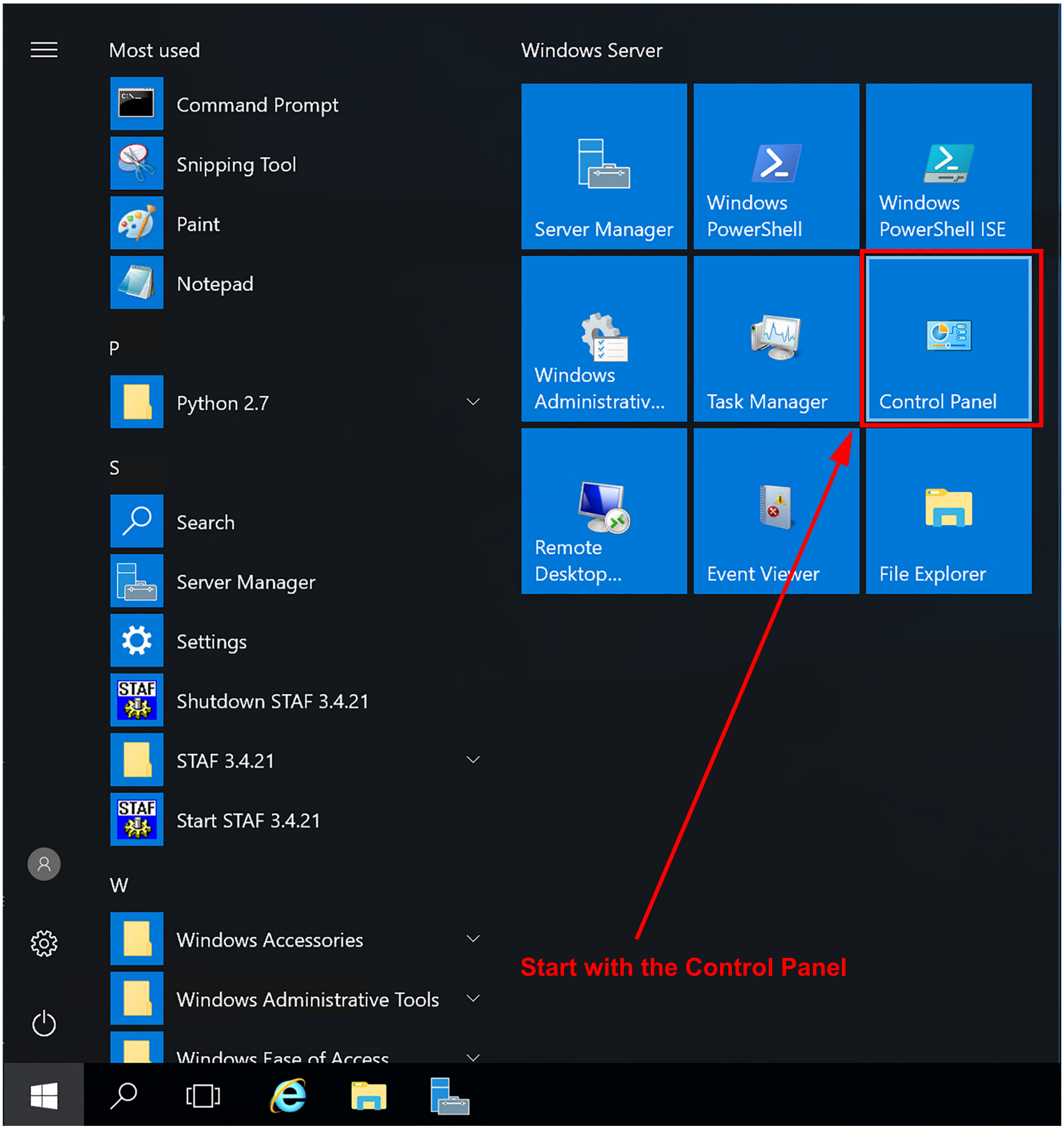


Figure 2.1: Windows Server 2016/2019: Start Menu -> Control Panel

2. From the Control Panel. select the "Systems and Security" screen. See Figure 2.2.

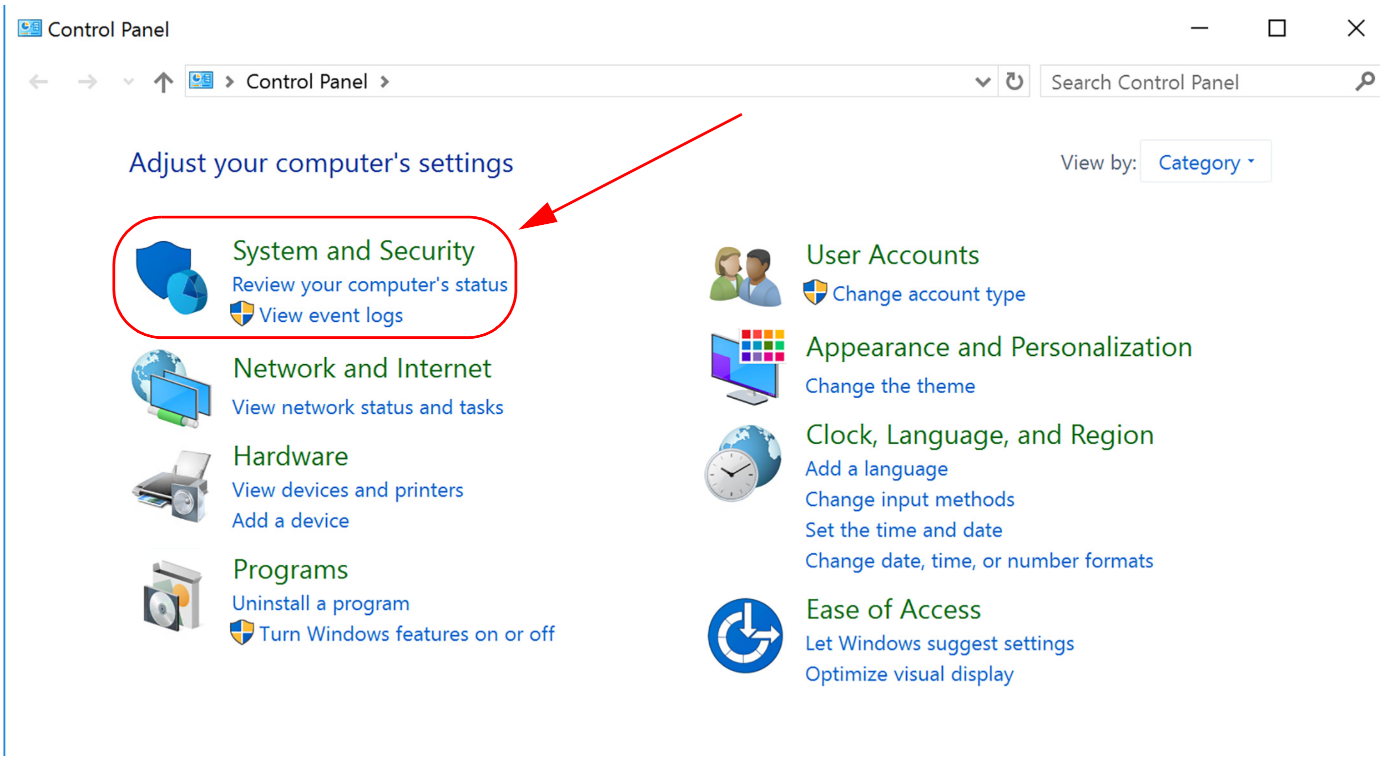


Figure 2.2: Windows Server 2016/2019: Control Panel -> System and Security Screen

3. From the Control Panel -> System and Security Screen, select "Allow an App through Windows Firewall". See Figure 2.3.

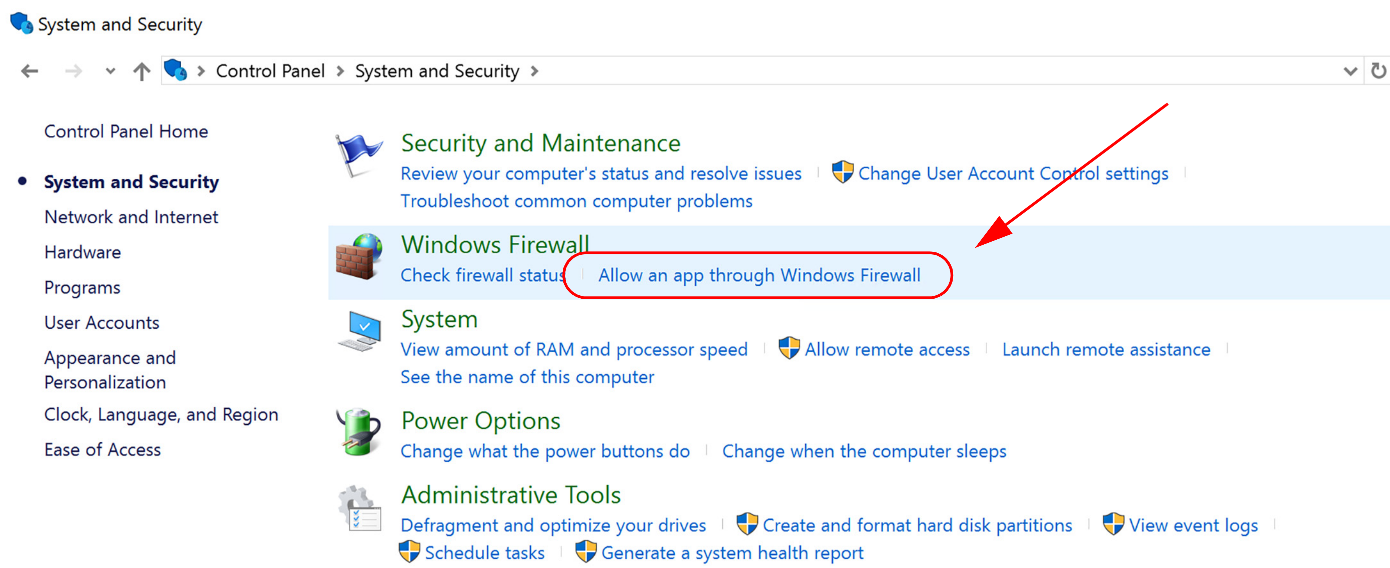


Figure 2.3: Windows Server 2016/2019: Allow an App Through Windows Firewall

4. From the Windows Firewall screen -> Allow apps to communicate through Windows Firewall, select “Change settings”, then select “Allow another program”. See Figure 2.4.

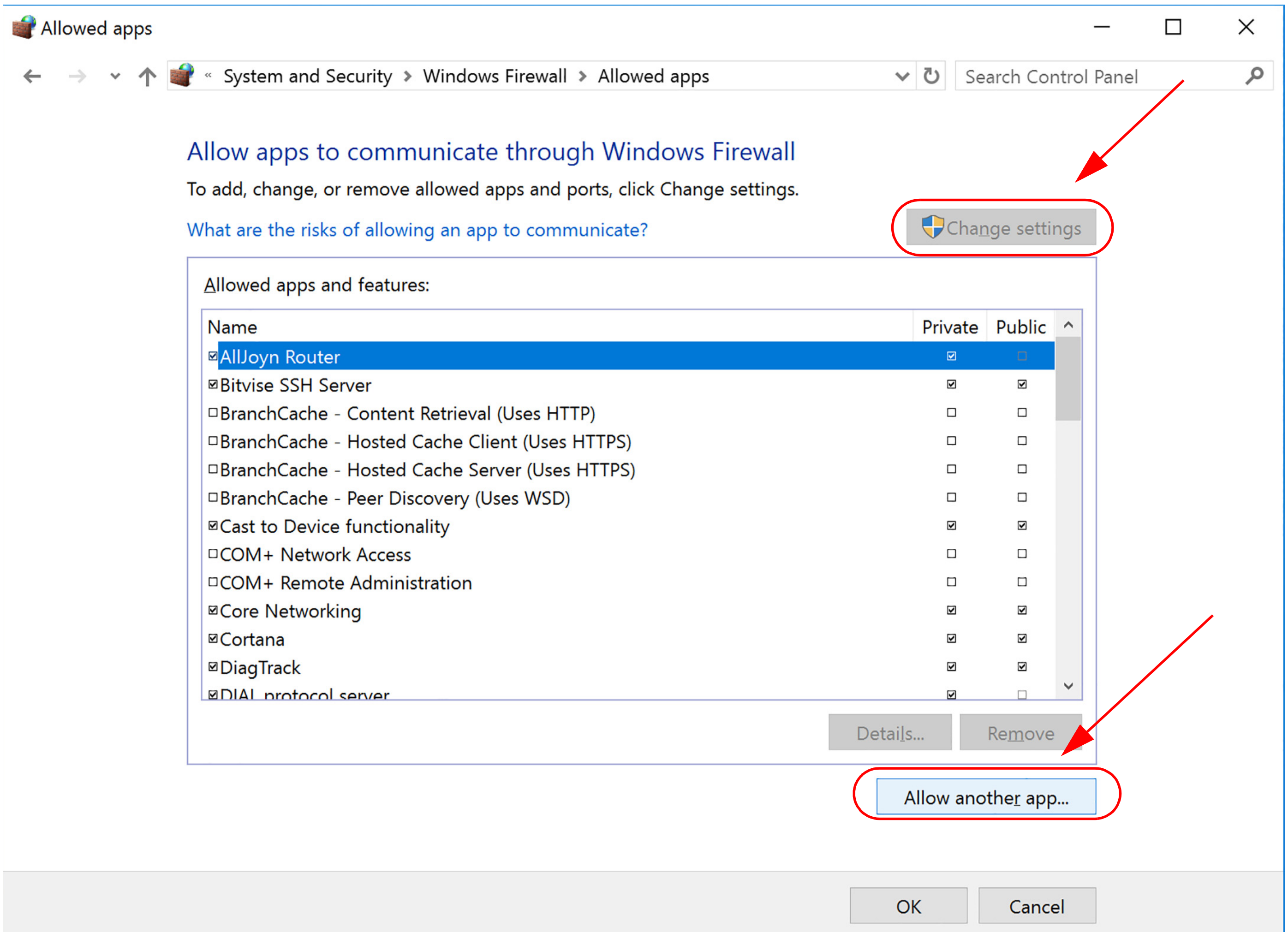


Figure 2.4: Windows Server 2016/2019: Change Settings -> Allowed Another app

5. From the User Account Control screen, select “Yes”. Figure 2.5.

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

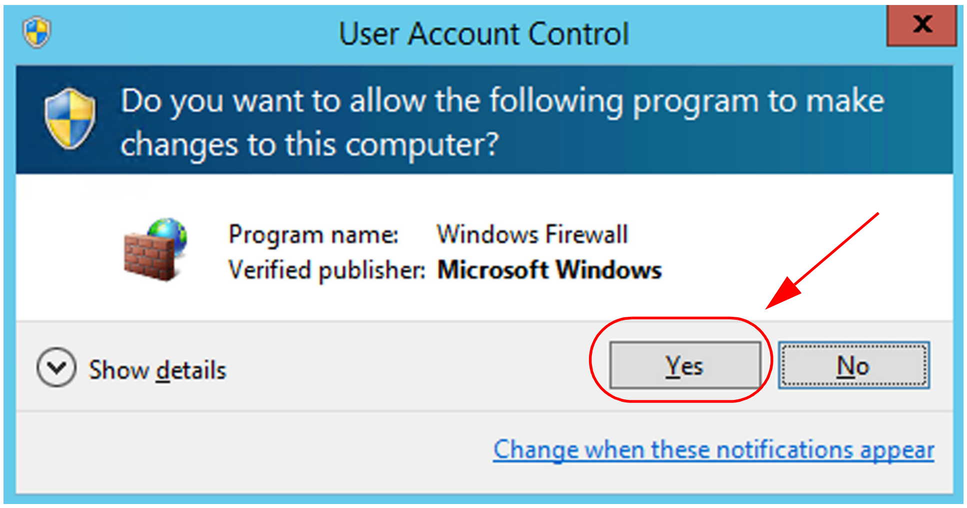


Figure 2.5: Windows Server 2016/2019: User Account Control

6. From the “Add an app” screen, select the Browse button. See Figure 2.6.

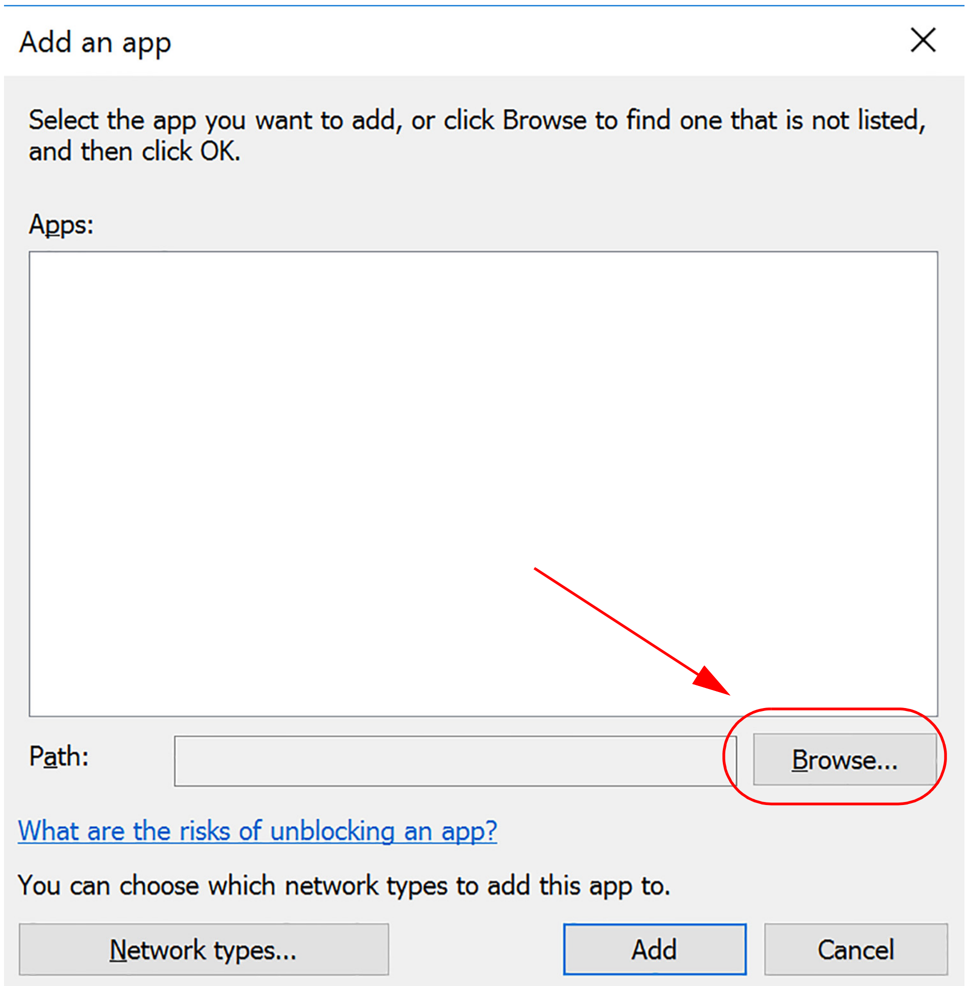


Figure 2.6: Windows Server 2016/2019: Add an App

7. In the Browse window navigate to the location of the installation directory for the LinkExpert you are installing. The Teledyne LeCroy LinkExpert is typically installed on your machine in the C:\Program Files\LeCroy\LinkExpert directory. See Figure 2.7.

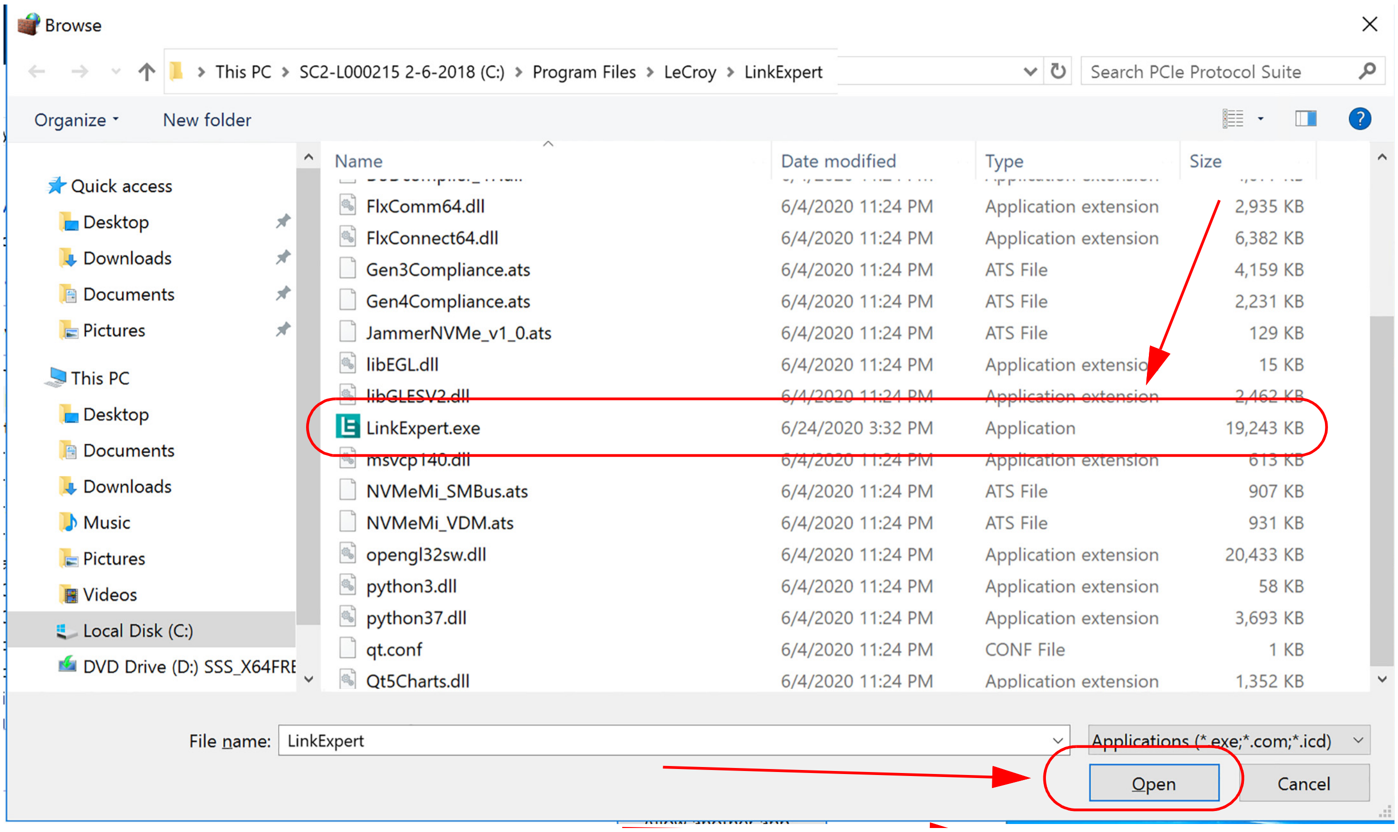


Figure 2.7: Windows Server 2016/2019: Browse to Find Application -> LinkExpert Application

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

9. If necessary, select the Teledyne LeCroy LinkExpert you want to add. Then click on "ADD", this will add the Teledyne LeCroy LinkExpert to the Apps allowed through the Firewall. See Figure 2.8.

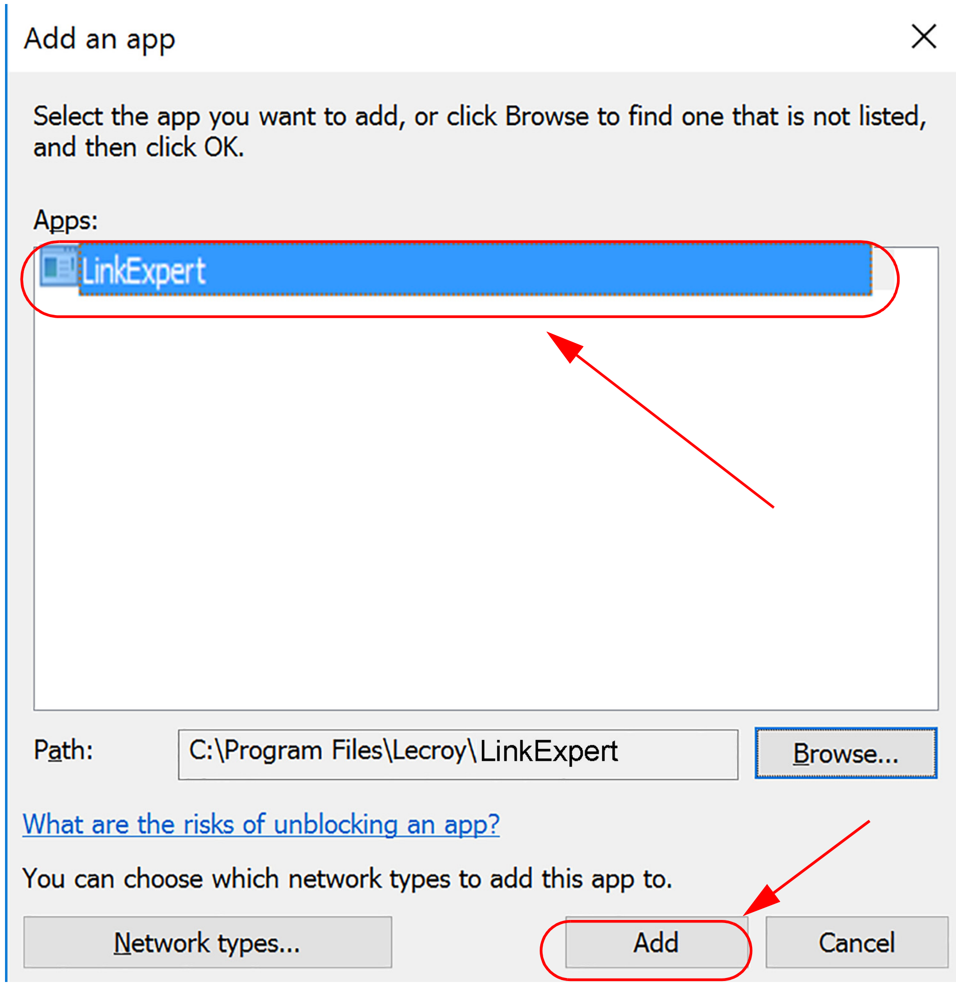


Figure 2.8: Windows Server 2016/2019: Add an Application to the Firewall Exceptions

10. After the Application has been added, you can see it in the “Allow apps to communicate through Windows Firewall” screen. See Figure 2.9.

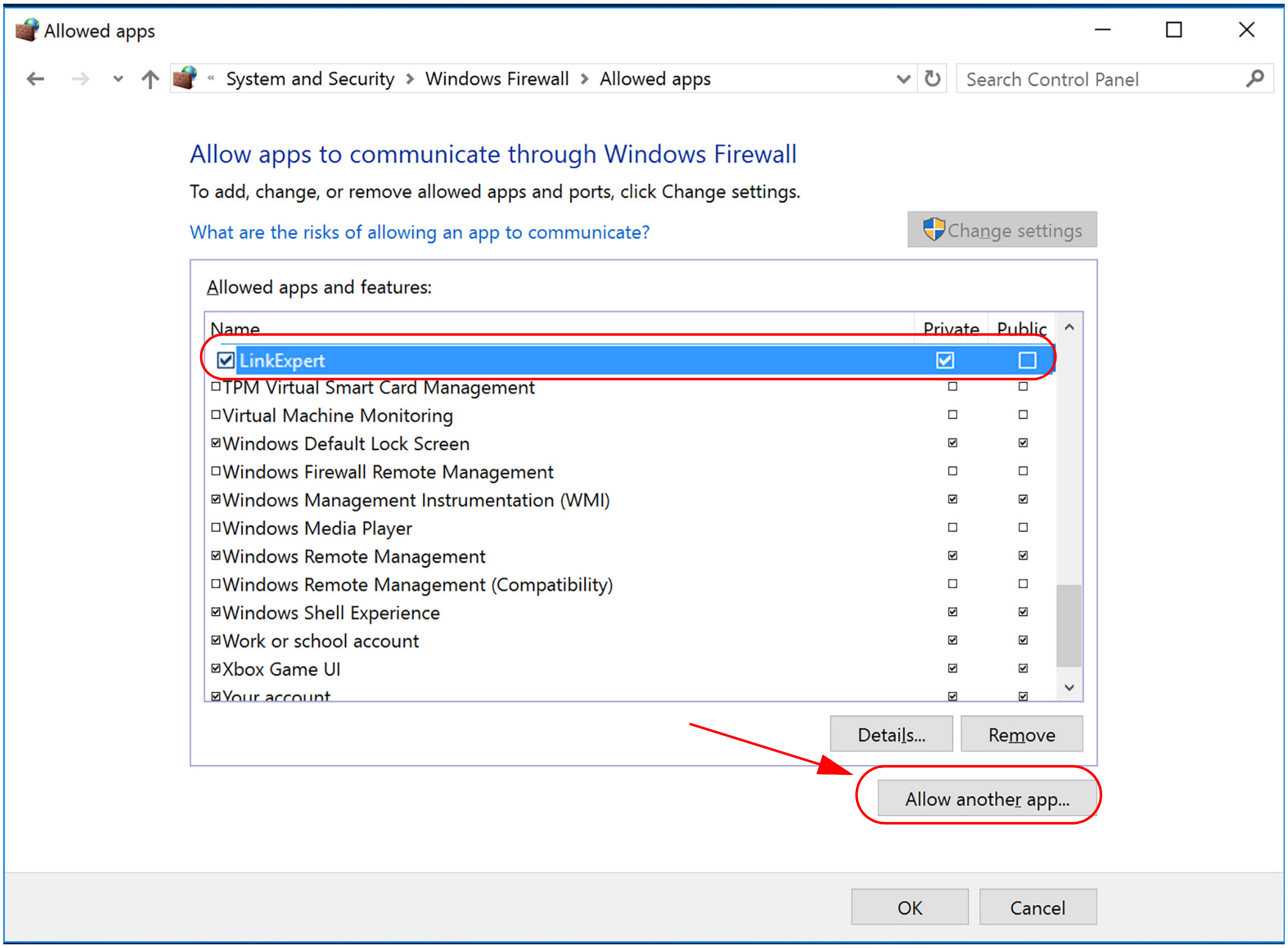


Figure 2.9: Windows Server 2016/2019: Add Teledyne LeCroy LinkExpert to Allowed Applications

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

11. Click on the LinkExpert icon and the following LinkExpert User Interface with be displayed. See Figure 2.10 on page 33.

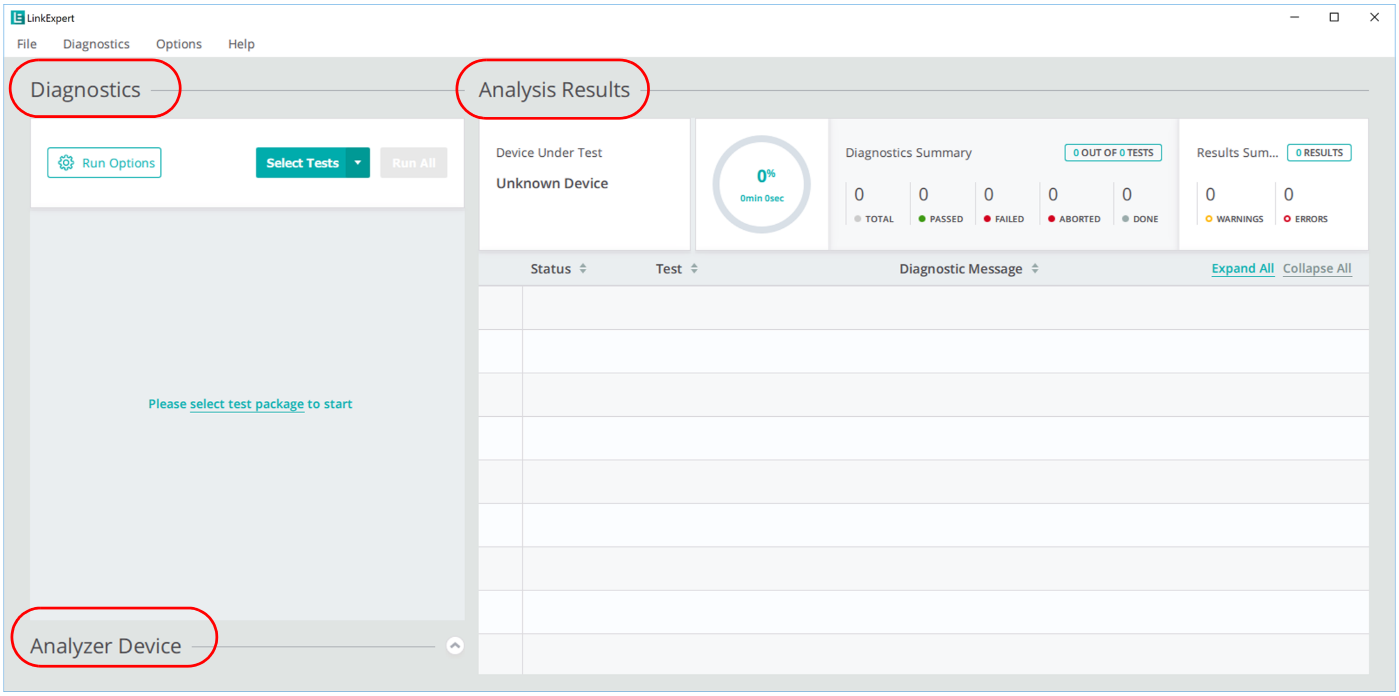


Figure 2.10: LinkExpert User Interface

The Diagnostics, Analysis Results and Analyzer devices sections of the User Interface for LinkExpert will be explained in more detail in the next section.

2.2 Connecting to Devices

2.2.1 Connecting to Devices using USB

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 “Connecting to Devices using Ethernet” on page 34 (below).

3. Turn on the front power switch.

Note: At power-on, the Analyzer initializes itself and performs an exhaustive self-diagnostic that lasts about forty seconds. The results are reflected by messages on the Analyzer 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 during your system by the 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.

2.2.2 Connecting to Devices using Ethernet

2.2.2.1 TCP Port Connections for Different Modes

In MultiPort Mode the Summit T416 and Summit T48 use different TCP ports for different configurations. Typical port assignments are shown below.

TABLE 2.1: TCP Port Configurations

Logical Unit	T416: 4 Port	T416: 2 Ports	T416: 1 Port	T48: 2 Ports	T48: 1 Port
Unit 0	4000 – 4003	4000 – 4003	4000 – 4003	4000 – 4003	4000 – 4003
Unit 1	4010 – 4013	N/A	N/A	4010 – 4013	N/A
Unit 2	4020 – 4023	4020 – 4023	N/A	N/A	N/A
Unit 3	4030 – 4033	N/A	N/A	N/A	N/A

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 4012, 4013 and 4014 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 Analyzer or Exerciser to the network. The Ethernet port is on the front of the Analyzer or Exerciser.

Note: To connect using USB, see “Connecting to Devices using USB” on page 33.

3. Turn on the front power switch.

Chapter 3

LinkExpert User Interface

3.1 The LinkExpert User Interface

The LinkExpert User Interface has the following sections. See Figure 3.1 below:

- A set of Drop Down Menus: File, Diagnostics, Options and Help (see “Drop Down Menus” on page 38)
- Diagnostics: A set of Tests to run (see “Diagnostics Menu” on page 86)

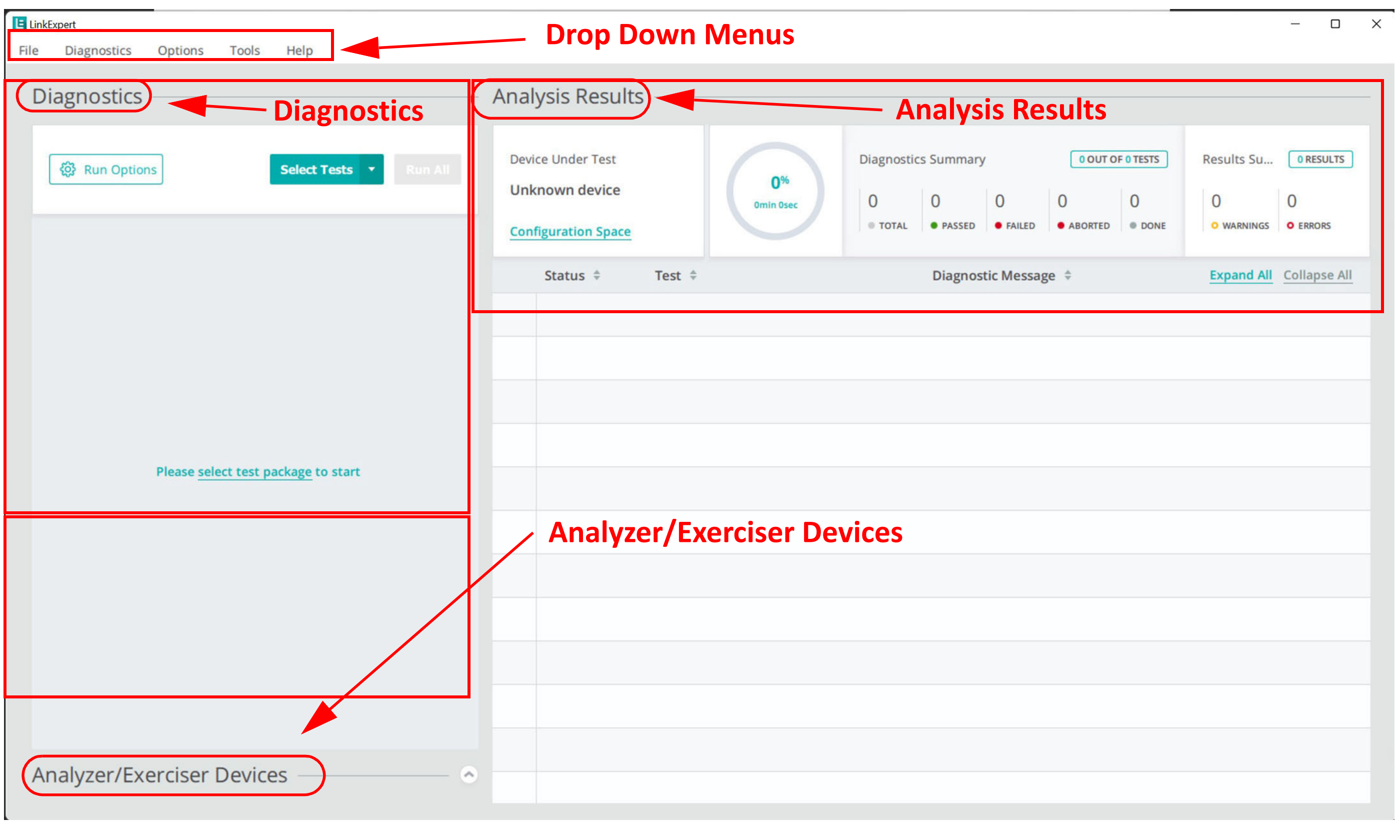


Figure 3.1: LinkExpert User Interface

3.2 Drop Down Menus

The LinkExpert application's main display includes the following set of pull-down menus:

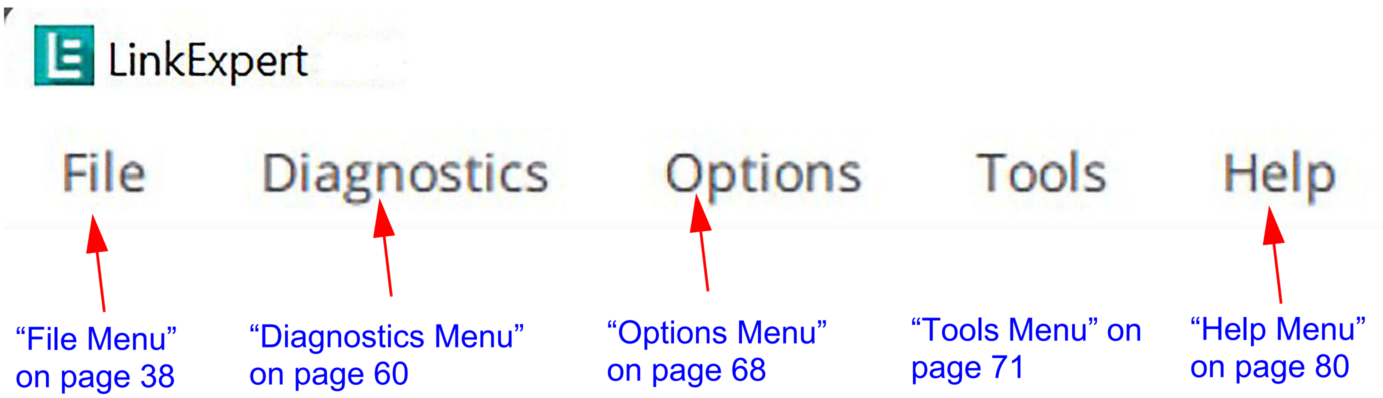


Figure 3.2: LinkExpert Drop Down Menus

3.2.1 File Menu

Clicking on the File menu displays the following choices:

Start New Session	Starts a new system diagnostic session. See "Start New Session" on page 39.
Open Test Results	Opens Test Results file. See "Open Test Results" on page 42.
Save Test Results	Saves the current Test Results. See "Save Test Results" on page 44
Export to TraceExpert	Exports trace information to Trace Expert in the respective Protocol Suite. See "Export to TraceExpert" on page 47.
Save Project	See details "Save Project" on page 54.
Open Project	See details "Open Project" on page 56.
Exit	Exit the LinkExpert application.

See Figure 3.3 on page 39.

Note: Most of the examples shown below involve PCIe specific tests but LinkExpert uses the same methodology for SAS Tests.

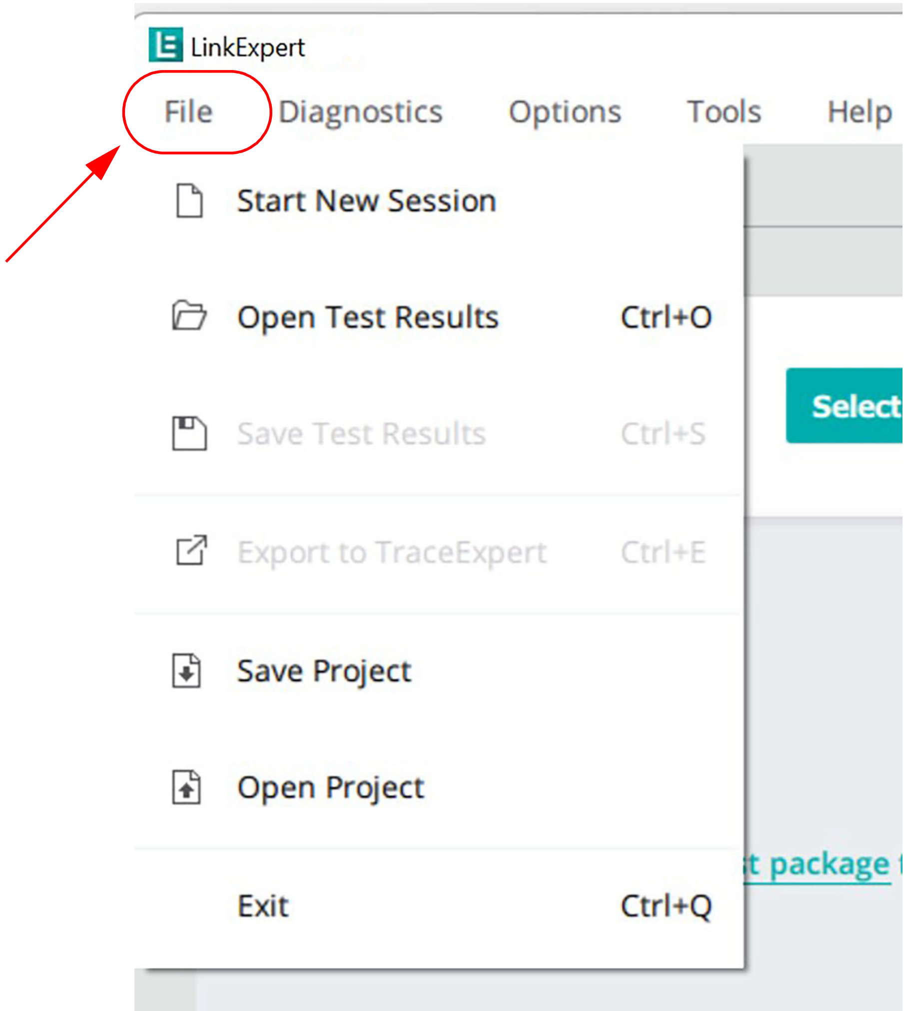


Figure 3.3: File Drop Down Menu

3.2.1.1 Start New Session

Selecting the "Start New Session" brings up the following warning message if you have run tests but haven't saved the results:

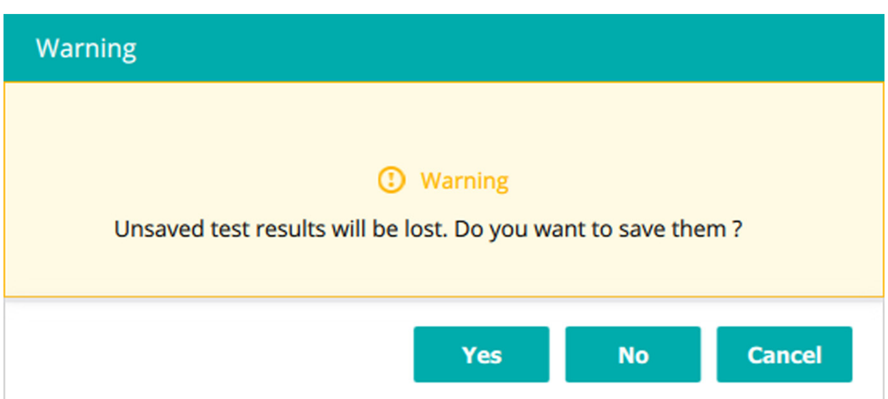


Figure 3.4: Start New Session: Warning Message

You can either Save the previous session's test results or discard them.

If you choose to save your existing Session, navigate to the following directory and select "Open". See Figure 3.5

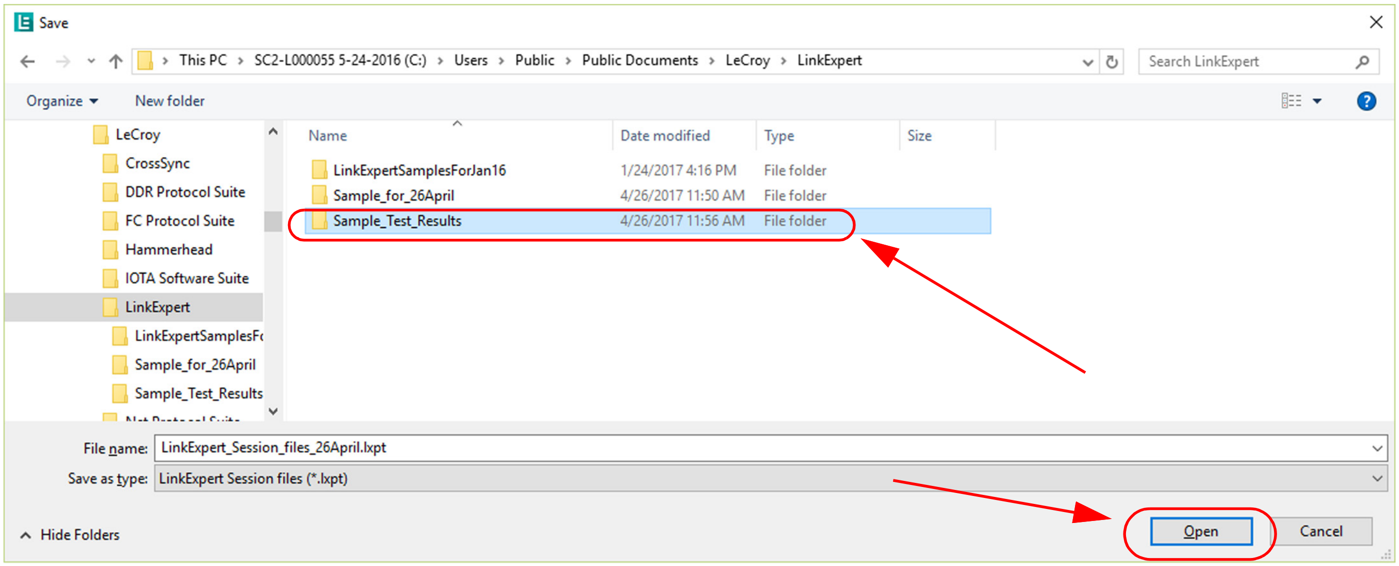


Figure 3.5: Results Folder Created and Session File Named

In this example, the "Sample_Test_Results" folder was created to store the session's Test Results.

Click on **Open** and the Test Results folder you just created will open and you can save your session's Test Results. See Figure 3.6.

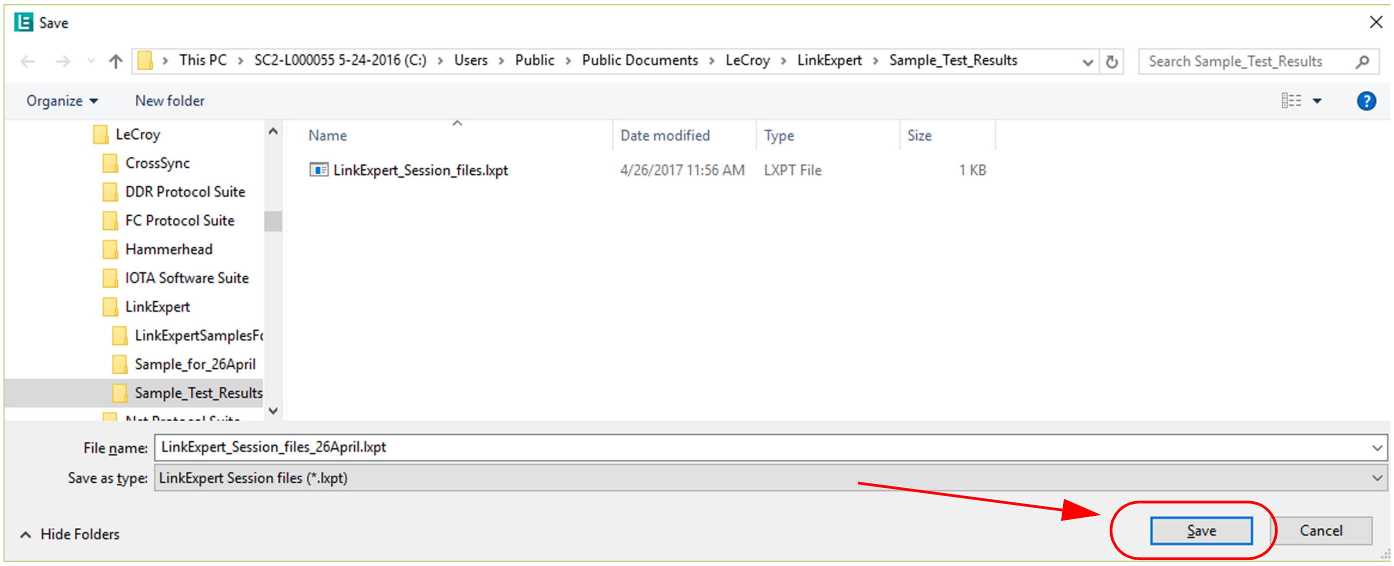


Figure 3.6: Save Session: LinkExpert_Session_files_26April

Click on Save and the session will be saved as a .lxpt file. See Figure 3.7.

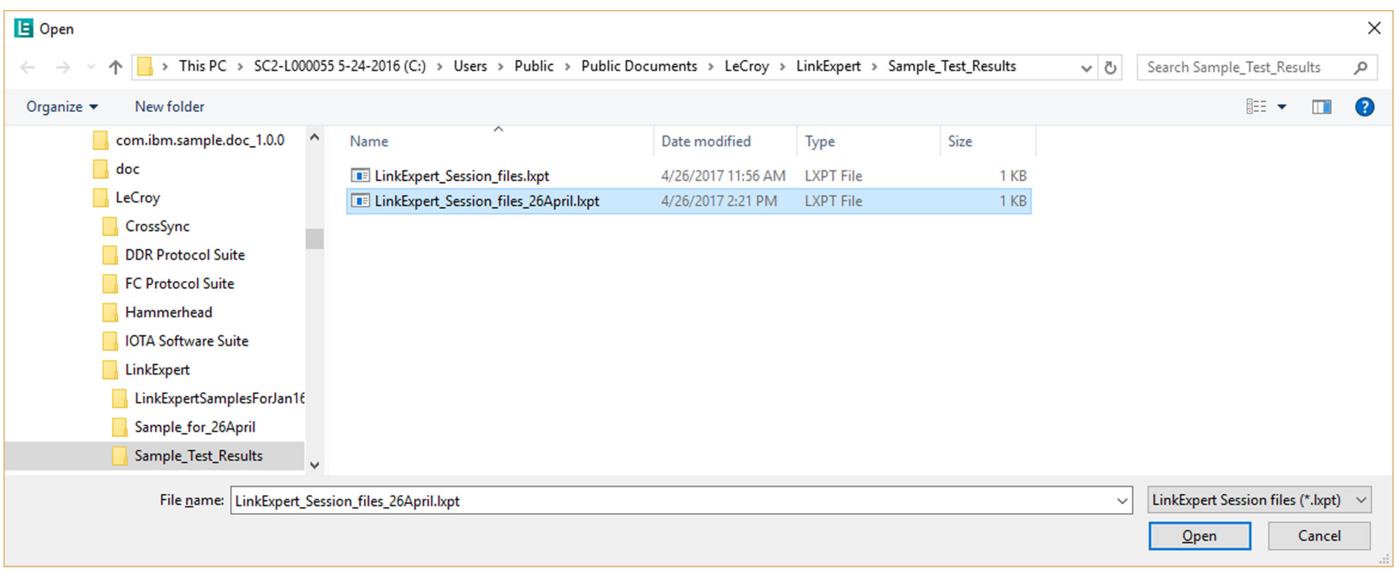


Figure 3.7: Results from Saving a Session

After you have saved a Session you can start a new session by running the tests you have selected. See "Diagnostics Menu" on page 60.

3.2.1.2 Open Test Results

If you select “Open Test Results” the assumption is that you have already run a session of system tests and stored them for future reference. When you select “Open Test Results” the Test Results folder (created in the previous section) will pop up. See Figure 3.8.

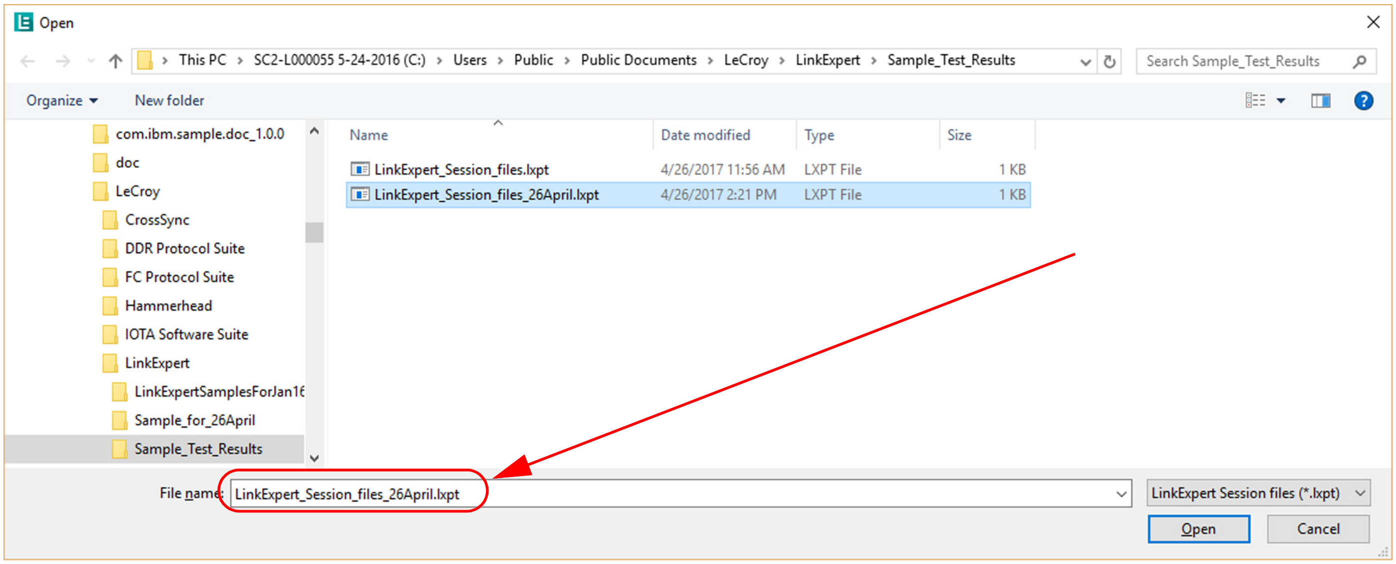


Figure 3.8: Open Test Results Dialog

Select the Test Results folder and you’ll see all the sessions you’ve saved. See Figure 3.9.

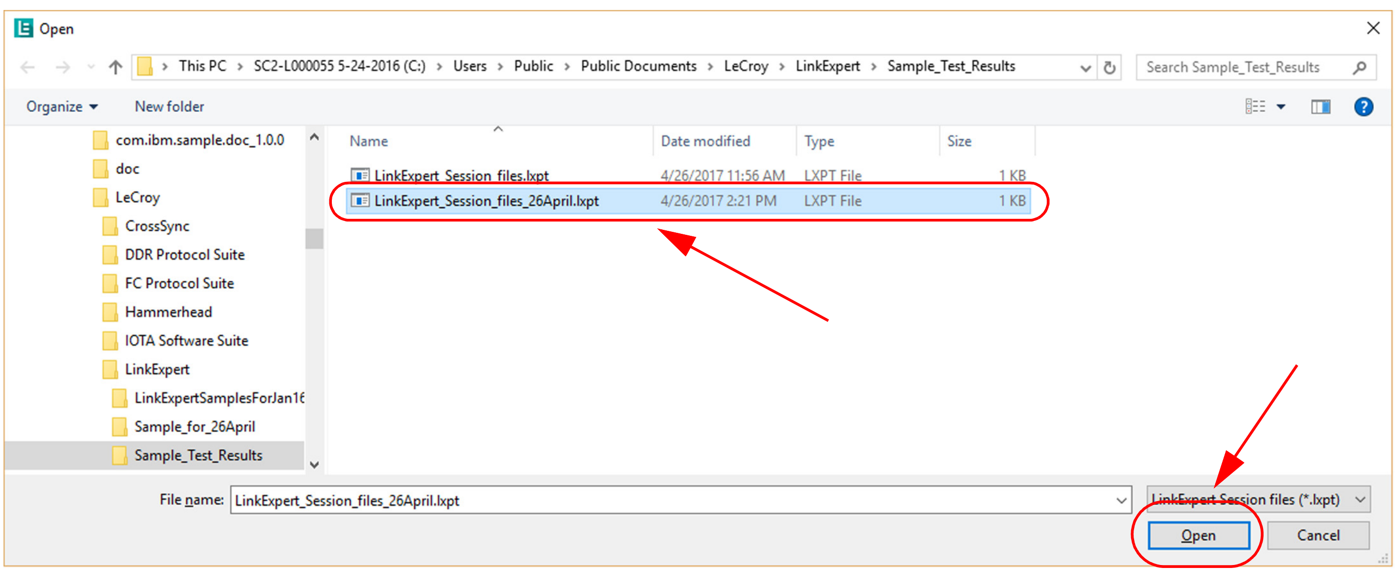


Figure 3.9: Session Files in Test Results Folder

Select the one you want to load into the application.

In this case, “LinkExpert_Session_files_26April” was chosen.

Then click on “Open”. The previously stored session will populate the LinkExpert User Interface. See Figure 3.10 on page 43.

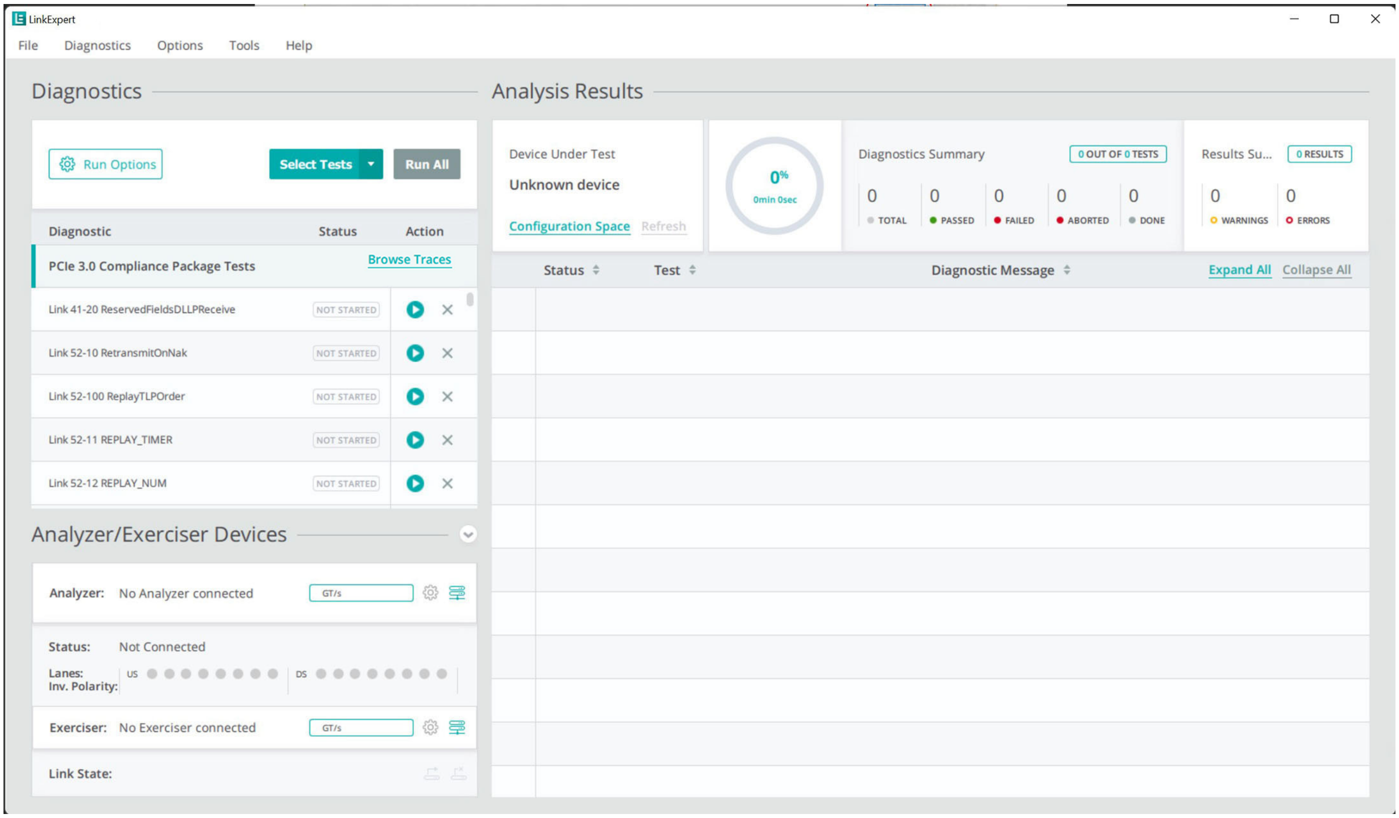


Figure 3.10: Open Test Results: LinkExpert User Interface Restored

3.2.1.3 Save Test Results

Select **File -> Save Test Results** and the following drop down menu will appear. See Figure 3.11.

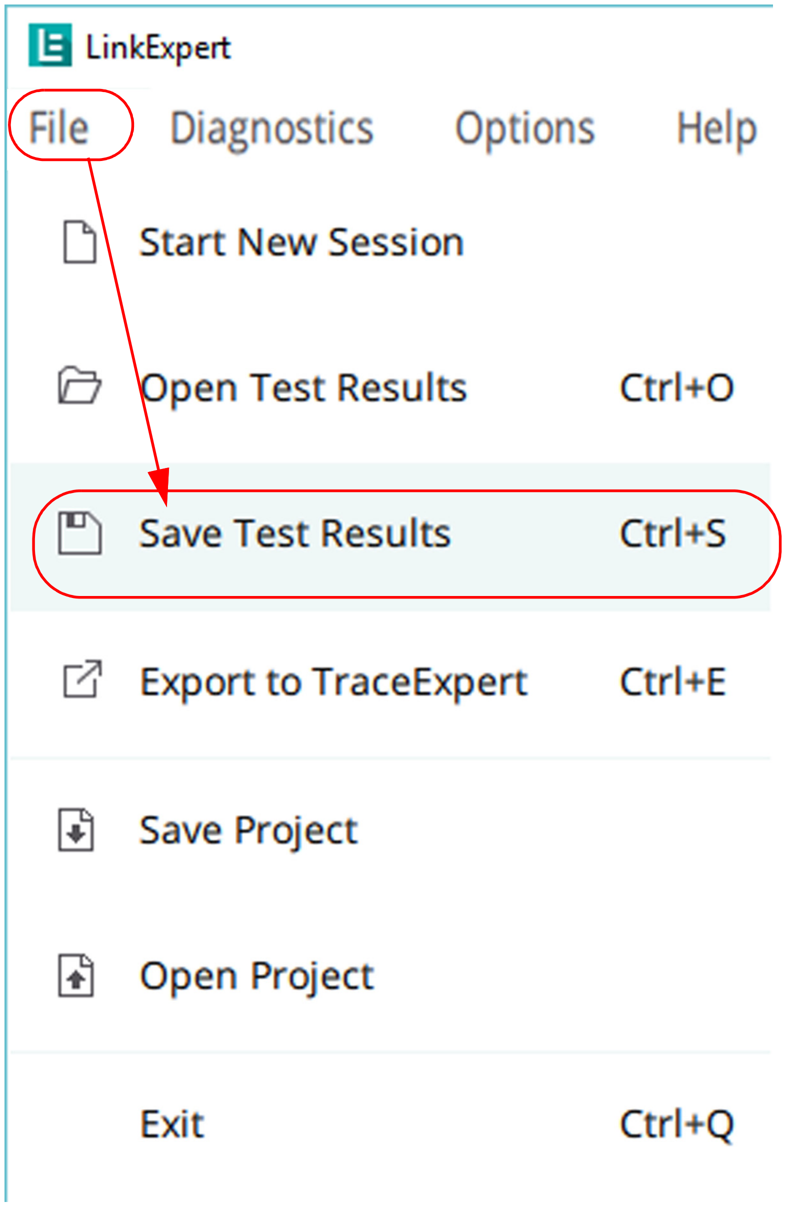


Figure 3.11: File -> Save Test Results

You can save the following types of test traces (see Figure 3.12):

- ❑ All Tests
- ❑ Failed Tests
- ❑ Warning Tests

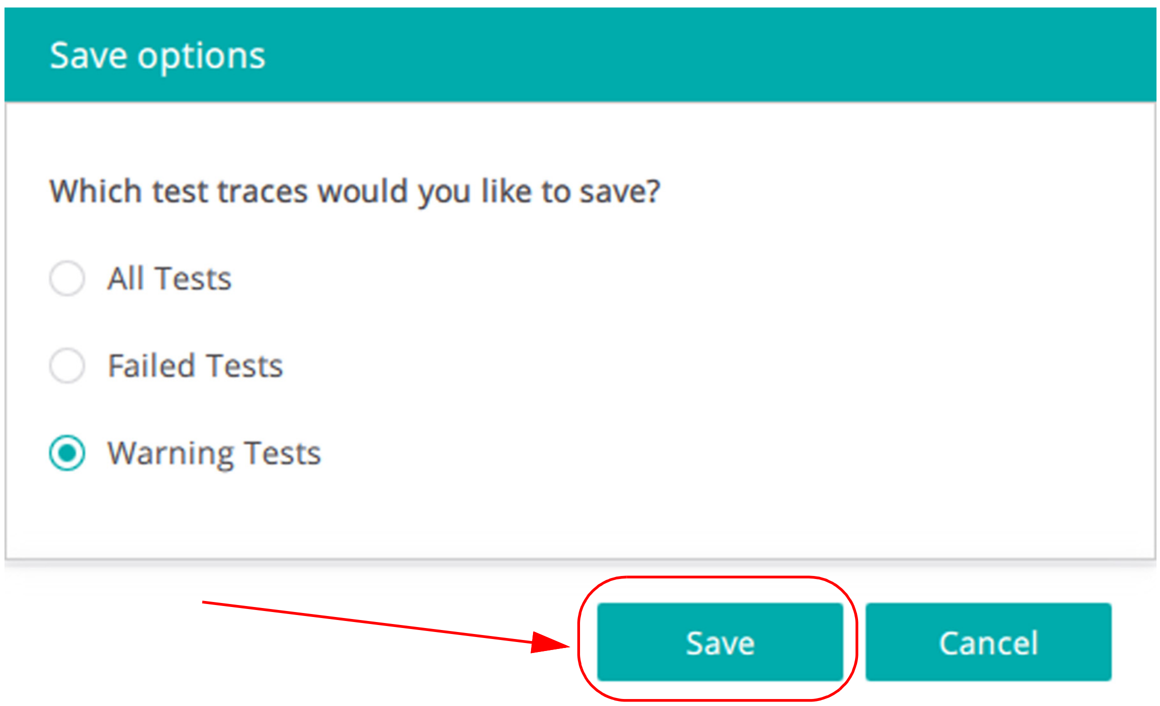


Figure 3.12: Saving Test Results:

In this example Link Maintenance was executed successfully. This time a more descriptive title for the Test Session was chosen. See Figure 3.13.

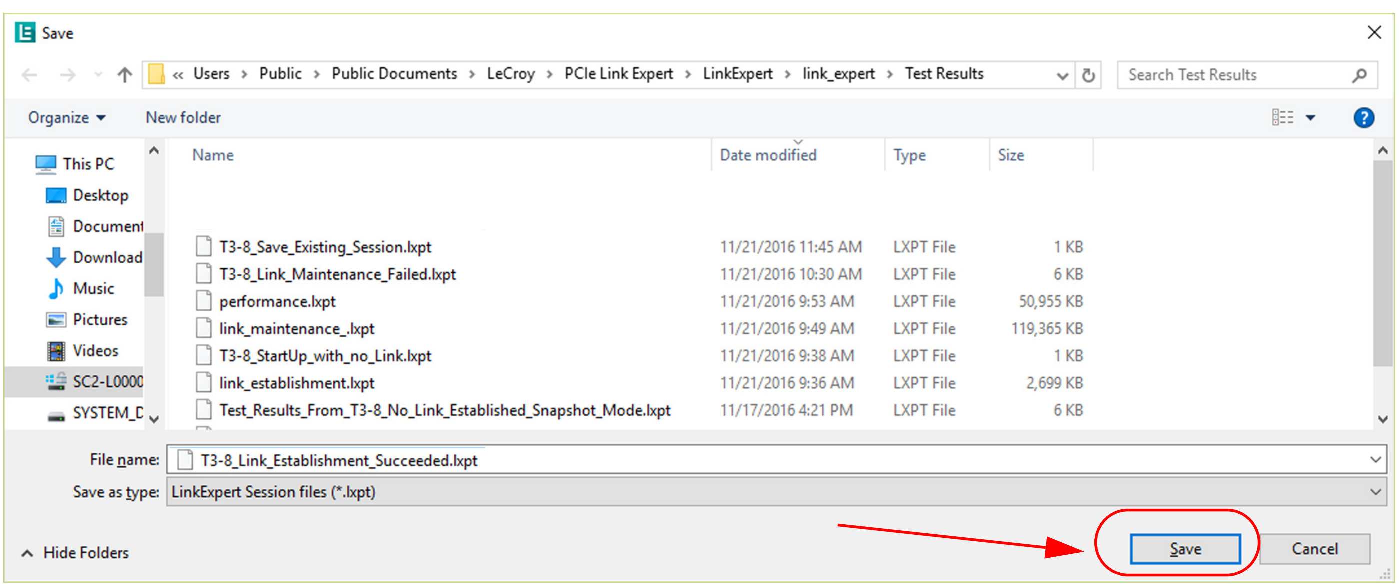


Figure 3.13: Test Results Folder Before Saving New Session

After you "Save" the session as an ".lxpt" file, when you select Open Test Results, you'll see the T3-8_Link_Establishment_Succeeded.lxpt file. See Figure 3.14.

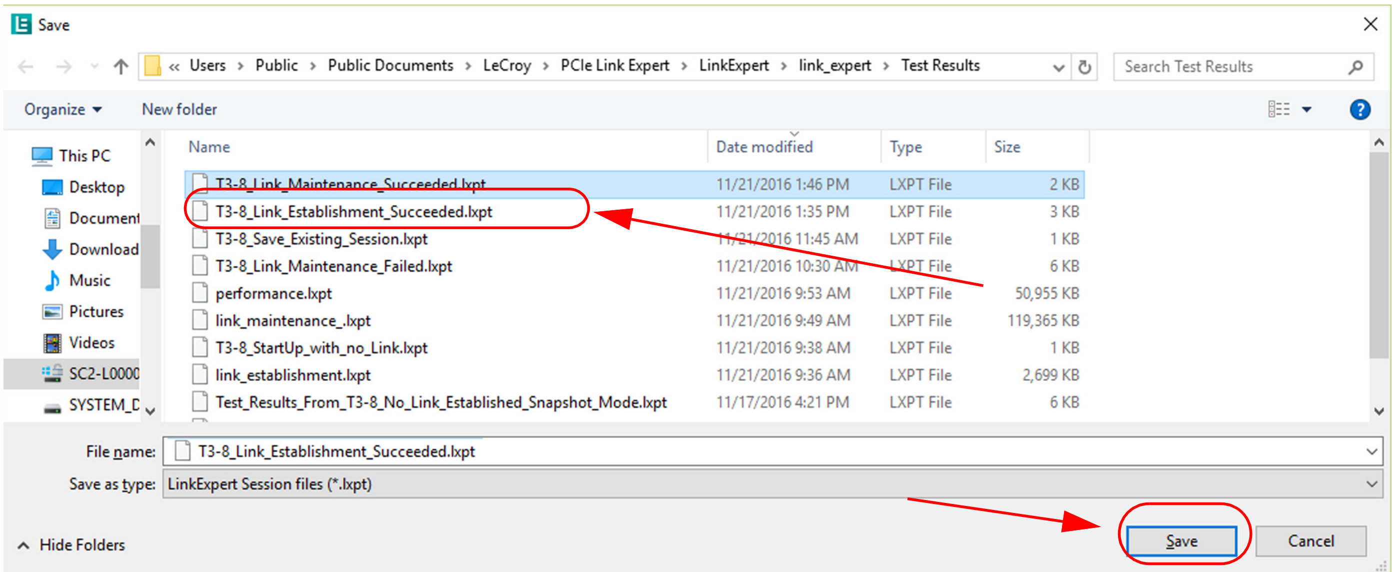


Figure 3.14: Test Results Folder

3.2.1.4 Export to TraceExpert

Selecting the “Export to TraceExpert” will generate HTML files as shown in Figure 3.15 to Figure 3.22 on page 53.

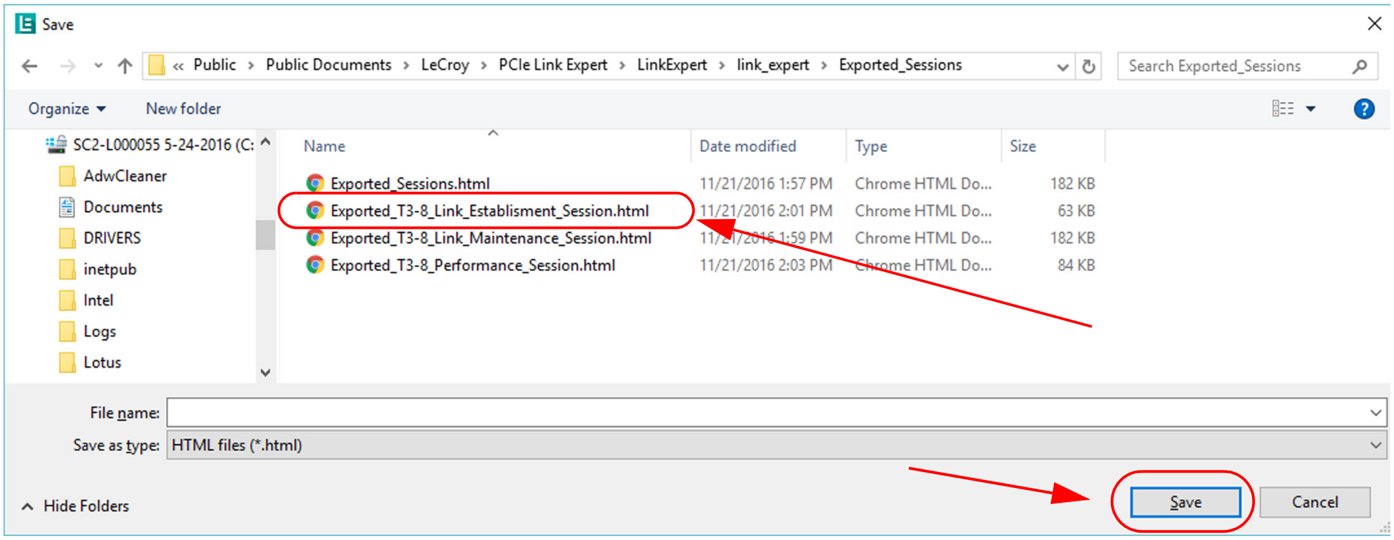


Figure 3.15: File -> Export to TraceExpert

Open an Exported to TraceExpert HTML File

If you open one of the Exported HTML files you’ll see all the information gathered during the session. In this case we selected the “Trace_expert.html” file (see Figure 3.16).

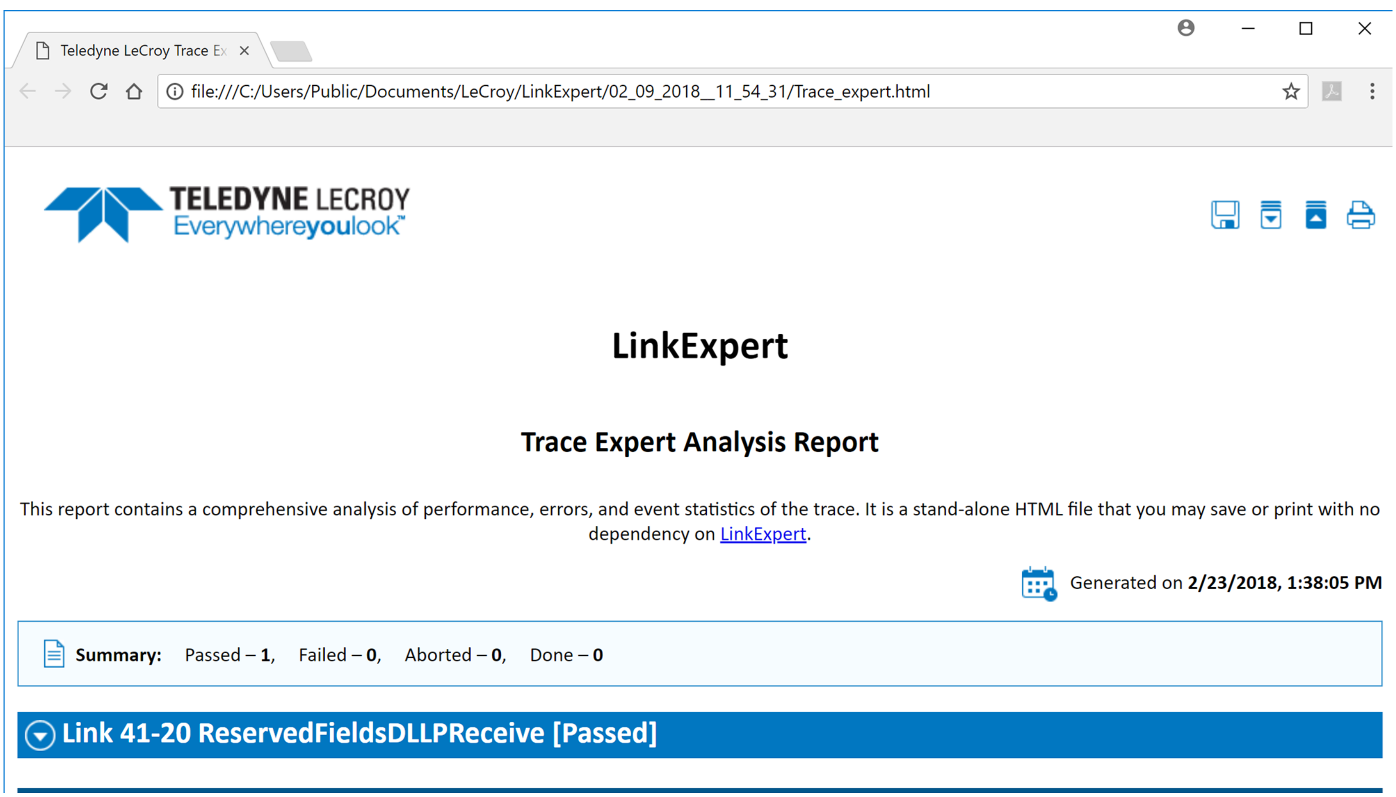


Figure 3.16: Opening an Export to Trace Expert File (Link 41-20 -- Passed)

If you scroll down you'll see all the information gathered by LinkExpert during that session. See Figure 3.17 to Figure 3.22 on page 53.

Note: These figures pertain to PCIe. Other protocols will have different information.

Main Page

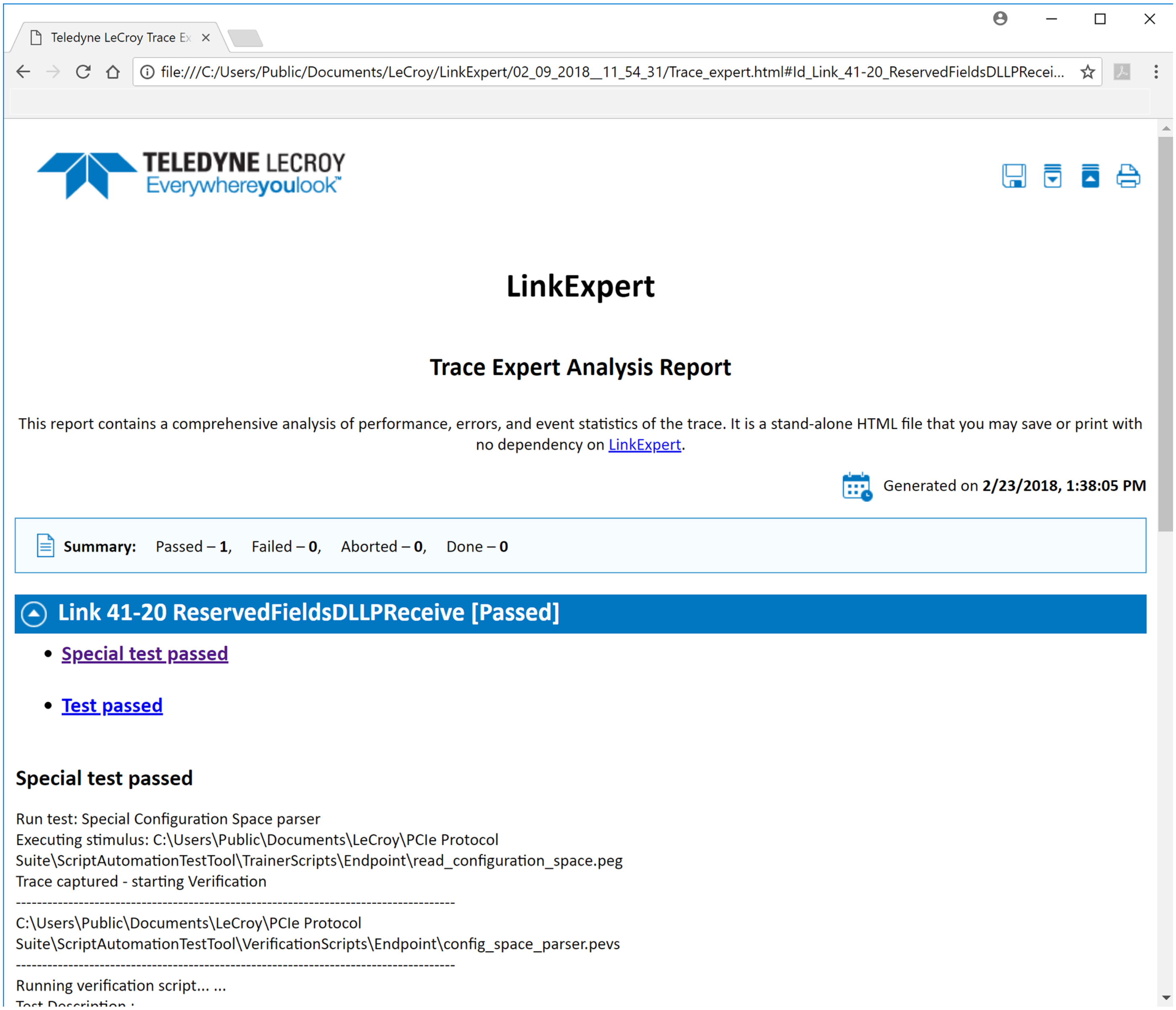


Figure 3.17: Opening an Export to Trace Expert File (List of Transactions)

Configuration Space

Note: These figures pertain to PCIe. Other protocols will have different information.

Configuration space

[003:00:0]

000h	Device ID 9530h		Vendor ID 8086h	
004h	Status 1000h		Command 4060h	
008h	Class Code 108020h			Revision ID 10h
00Ch	BIST 00h	Header Type 00h	Master Latency Timer 00h	Cache Line Size 00h
010h	Base Address Register 0 FB110000h			
014h	Base Address Register 1 00000000h			
018h	Base Address Register 2 00000000h			
01Ch	Base Address Register 3 00000000h			
020h	Base Address Register 4 00000000h			
024h	Base Address Register 5 00000000h			

Figure 3.18: Opening an Export to Trace Expert File (Configuration Space)

Boot Sequence

Boot sequence recorded but issues are detected in the traffic

Boot sequence was recorded but some errors were detected in L0 state. Certain issues during link training are normal, please check the trace to confirm.

The following issue(s) were detected in the captured trace

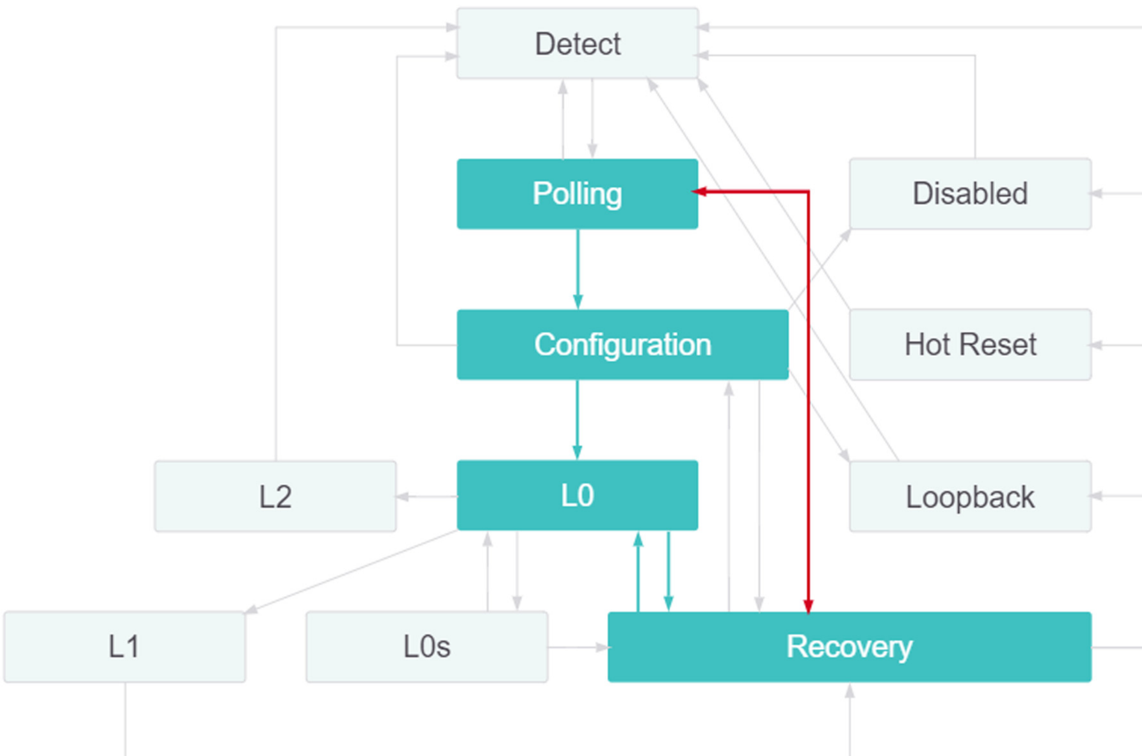
Error	Upstream	Downstream	Total
Bad packet length	0	1	1
Logical Idle data pattern error	24	5	29
Ordered Set format error	5	0	5
Symbol (10-bit Code) error	1	1	2
Training Sequence Data Rate error	58	3112	3170
Training Sequence format error	68	3111	3179
Training Sequence Parity error	7	0	7
Wrong Symbol (K or D)	15	3113	3128

Figure 3.19: Opening an Export to Trace Expert File (Boot Sequence)

Link Went Into Normal Operation

Link went into normal operational state through several invalid transitions

Both Upstream and Downstream sides successfully reached L0 state of the LTSSM (Link Training and Status State Machine). L0 is the normal operational state of the Link where data and control packets can be transmitted and received. Reaching L0 state means that the link between Host and Device is established successfully.



LTSSM transitions map

Upstream		Downstream	
2.5	Polling	2.5	Polling
		2.5	Recovery
		2.5	Polling
2.5	Configuration.Linkwidth.Start	2.5	Configuration.Linkwidth.Start

Figure 3.20: Opening an Export to Trace Expert File (Normal Operational State)

Invalid LTSSM State Transitions

Invalid LTSSM state transitions

Downstream

Polling -> Recovery
Recovery -> Polling

Retried LTSSM transitions

Upstream

Configuration.Linkwidth.Accept -> Configuration.Lanenum.Wait
Configuration.Lanenum.Wait -> Configuration.Complete
Configuration.Complete -> Configuration.Idle
Recovery.Equalization -> Recovery.RcvrLock
Recovery.RcvrLock -> Recovery.RcvrCfg (2 times)
Recovery.RcvrCfg -> Recovery.Idle (2 times)
Recovery.Idle -> Recovery.RcvrLock

Downstream

Configuration.Linkwidth.Accept -> Configuration.Lanenum.Wait
Configuration.Lanenum.Wait -> Configuration.Complete
Configuration.Complete -> Configuration.Idle
Recovery.Equalization -> Recovery.RcvrLock
Recovery.RcvrLock -> Recovery.RcvrCfg (2 times)
Recovery.RcvrCfg -> Recovery.Idle (2 times)
Recovery.Idle -> Recovery.RcvrLock

LTSSM state times

Upstream

Polling	12.147 ms
Configuration.Linkwidth.Start	48.160 ms
Configuration.Linkwidth.Accept	6.142 ms
Configuration.Lanenum.Wait	2.888 us
Configuration.Complete	3.400 us
Configuration.Idle	13.230 ms
L0	2.197 sec
Recovery.RcvrLock	843.000 ns
Recovery.Equalization	12.267 ms
Recovery.RcvrLock	298.000 ns
Recovery.RcvrCfg	327.000 ns
Recovery.Idle	211.000 ns
Recovery.RcvrLock	309.000 ns
Recovery.RcvrCfg	304.000 ns
Recovery.Idle	764.020 us
L0	16.480 sec

Downstream

Polling	408.000 ns
Recovery	192.000 ns
Polling	40.272 us
Configuration.Linkwidth.Start	16.000 ns
Configuration.Linkwidth.Accept	54.303 ms
Configuration.Lanenum.Wait	3.208 us
Configuration.Complete	392.000 ns
Configuration.Idle	13.231 ms
L0	2.197 sec
Recovery.RcvrLock	0.000 ns
Recovery.Equalization	12.268 ms
Recovery.RcvrLock	287.000 ns
Recovery.RcvrCfg	452.000 ns
Recovery.Idle	114.000 ns
Recovery.RcvrLock	277.000 ns
Recovery.RcvrCfg	500.000 ns
Recovery.Idle	0.000 ns
L0	16.480 sec

Figure 3.21: Opening an Export to Trace Expert File (Invalid LTSSM State Transitions)

Configuration Space Recorded, Link Established: Speed/Width

Configuration space trace successfully recorded

The recording successfully finished. This trace is used for filling configuration space data.

Device Configuration Space extracted

Configuration Space is one of the four address spaces within the PCI Express architecture. It contains a set of Read-Write registers to configure the Device. Link Establishment and Link Maintenance diagnostics rely on presence of the Device Configuration Space to achieve test results. Analysis won't be complete/accurate if no Configuration Space is detected. To open Configuration Space you can click SHOW button on the Device Under Test panel

Link established at 8.0 GT/s x4

Maximum Link Speed/Width supported

Maximum speed supported by Device	8.0 GT/s
Maximum speed supported by Host	8.0 GT/s
Maximum link width supported by Device	x4

Analyzer information

Analyzer:	Summit T3-8 SN:14836
Connected at:	8.0 GT/s, x4

Analyzer: Summit T3-8 SN:14836, connected at: 8.0 GT/s, x4

Lanes polarity

Lane	Upstream	Downstream
Lane 0	+	+
Lane 1	+	+
Lane 2	+	+
Lane 3	+	+
Lane 4		
Lane 5		
Lane 6		
Lane 7		

Figure 3.22: Opening an Export to Trace Expert File (Config Space, Device Config, Link Est)

This is the end of the information from Trace Expert. You can either continue working with LinkExpert running more tests or Exit out of the application.

3.2.1.5 Save Project

This feature allows you to select a subset of tests you are interested in and Save them with a Project name. In the example below the first five PCIe 3.0 Compliance Tests have been selected (see Figure 3.23) and then Saved as “First_Five_Compliance_Tests” (see Figure 3.24 on page 55.

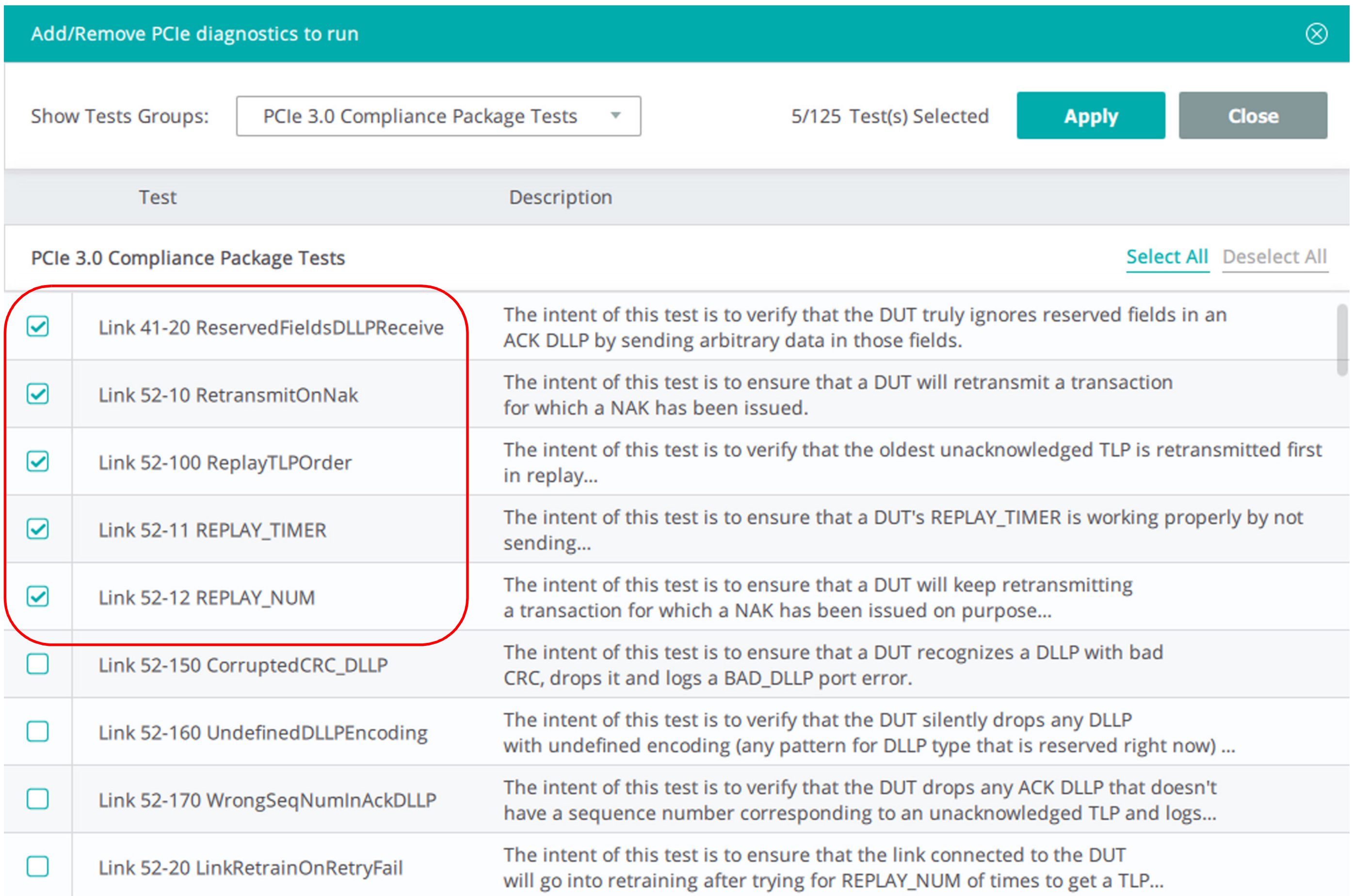


Figure 3.23: New Project: First Five PCIe 3.0 Compliance Tests

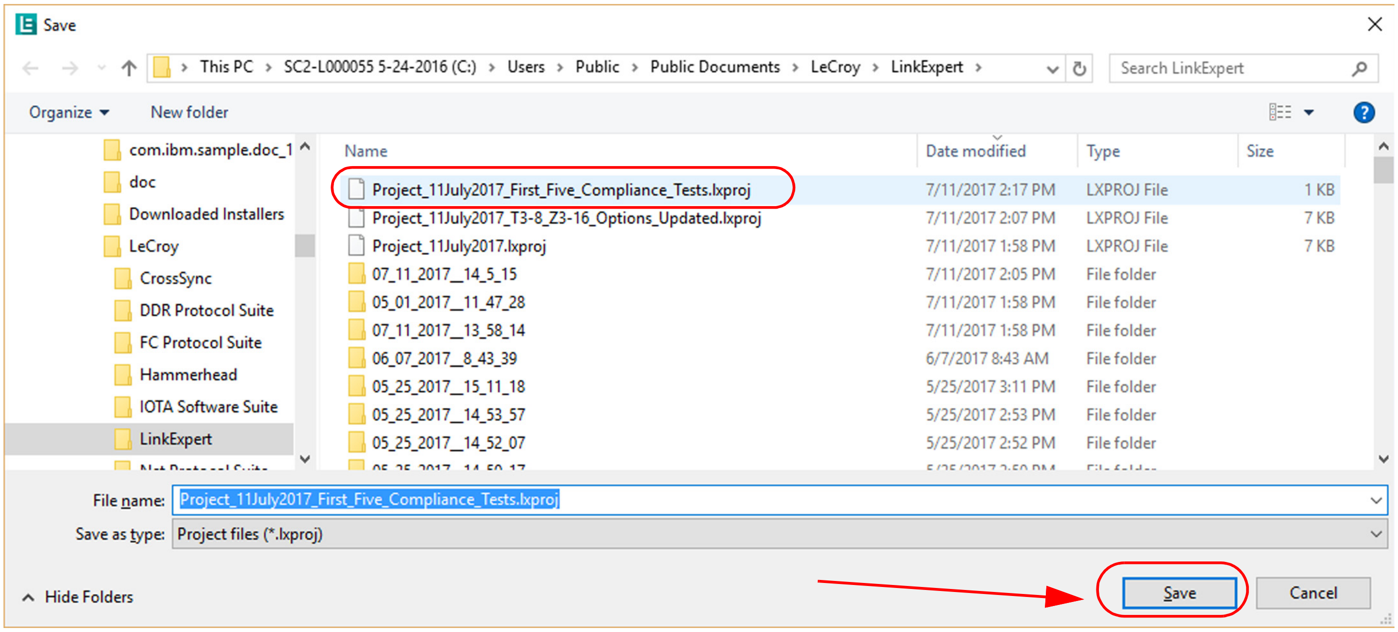


Figure 3.24: First Five PCIe Compliance Tests Saved as a Project

3.2.1.6 Open Project

To “Open” a Saved project, select **File -> Open Project** (see Figure 3.25).

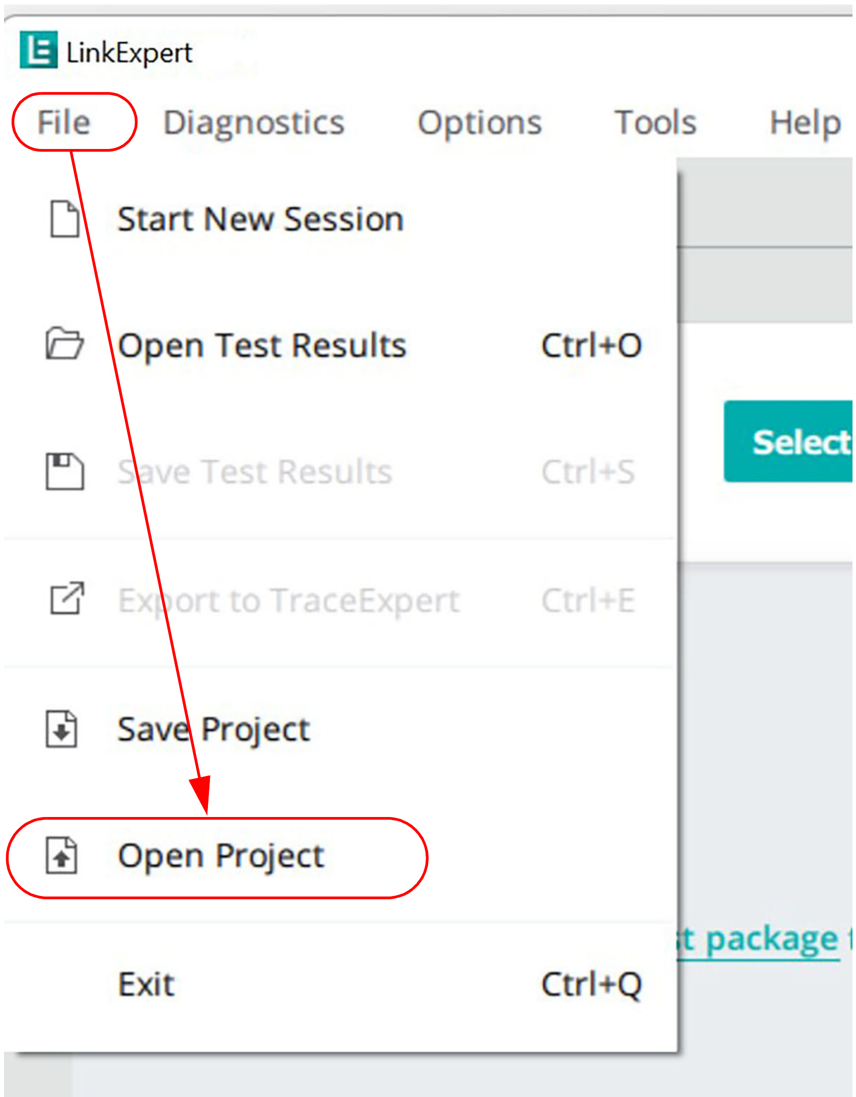


Figure 3.25: File -> Open Project

The Open dialog displays. Select the project from the Name list and select Open. See Figure 3.26 on page 57.

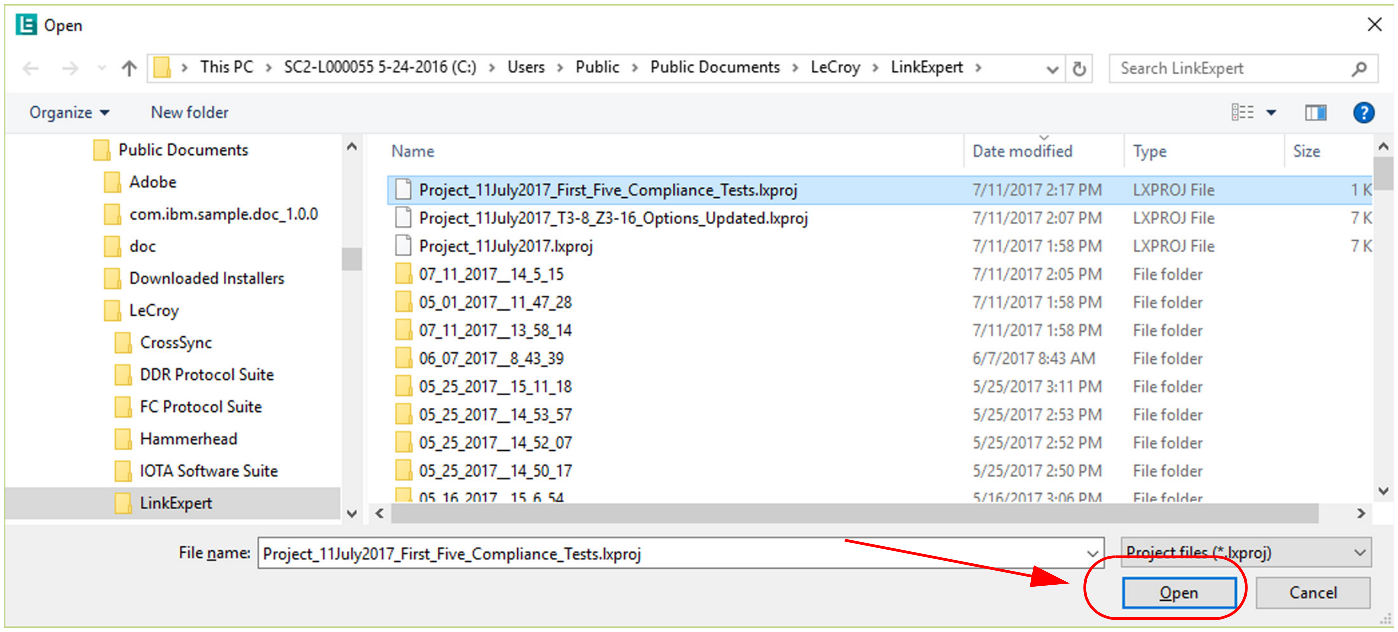


Figure 3.26: Location of Saved Project

The project loads into LinkExpert. See Figure 3.27 on page 58.

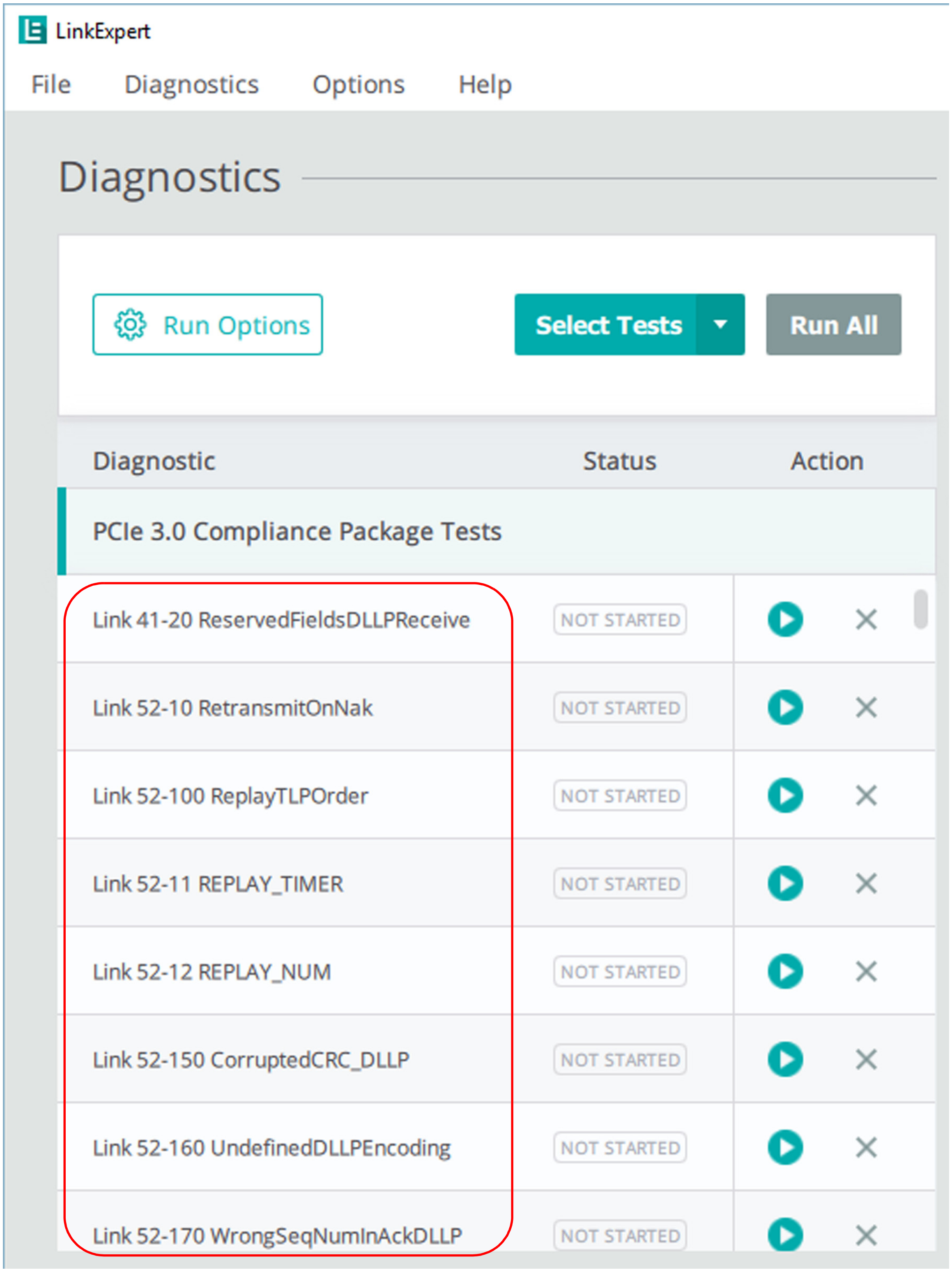


Figure 3.27: Open a Saved Project: First Eight PCIe Compliance Tests

3.2.1.7 Exit

Selecting "Exit" closes LinkExpert. See Figure 3.28.

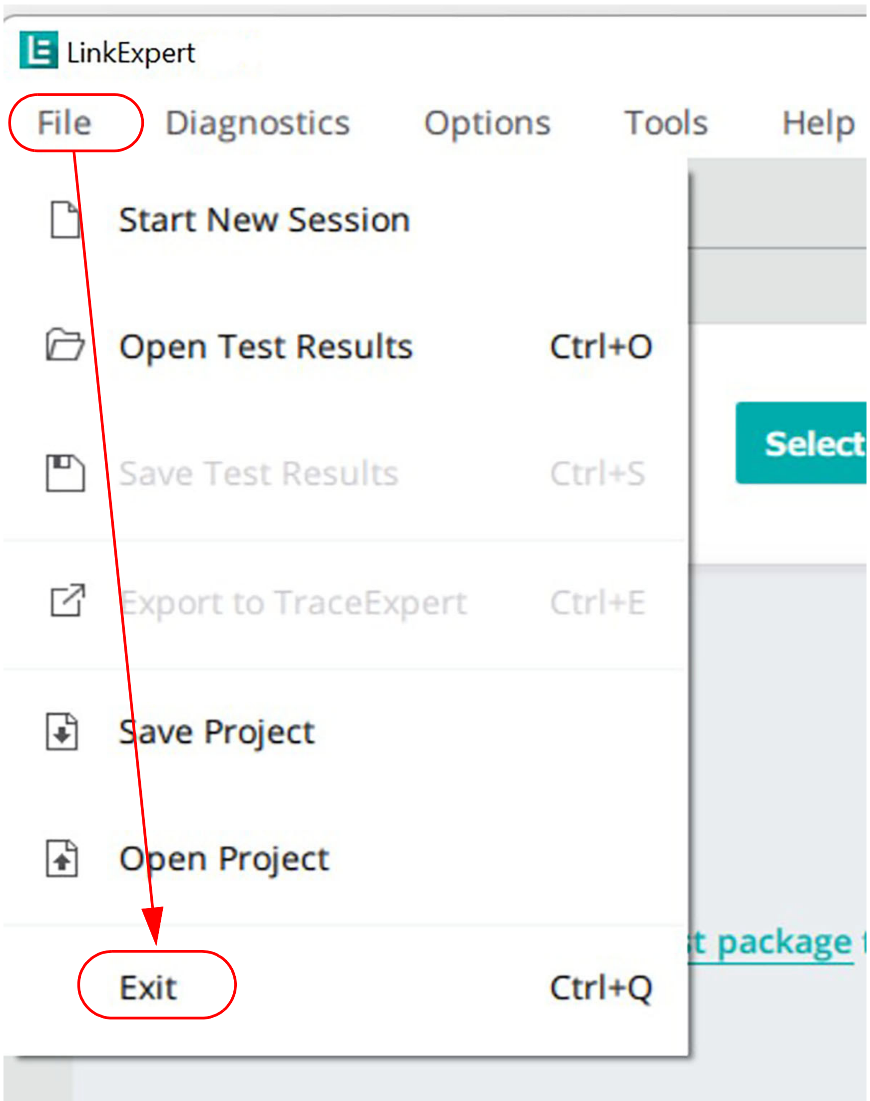


Figure 3.28: File Pull Down -> Exit

3.2.2 Diagnostics Menu

The Diagnostics menu allows you to Add/Remove Diagnostics or Run Diagnostics. The examples below show PCIe Tests but the same method can be used for other protocols' Tests. See Figure 3.29.

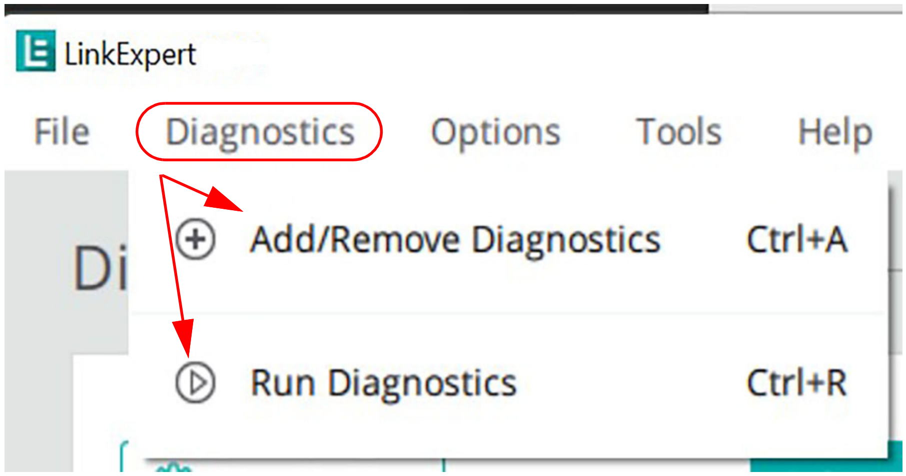


Figure 3.29: Diagnostics Dialog: Add

Add/Remove Diagnostics	Add/remove new diagnostics to current System Level list. See "Add/Remove Diagnostics" on page 60.
Run Diagnostics	Executes diagnostics in the current list. See "Run Diagnostics: Reset Link" on page 66.

3.2.2.1 Add/Remove Diagnostics

Add new diagnostics to current System Level list. From the Diagnostics menu, select **Add/Remove Diagnostics**. Or, alternatively, use the shortcut keys **Ctrl+A.** The **Add/Remove diagnostics tests to run** dialog displays. See Figure 3.30 on page 61.

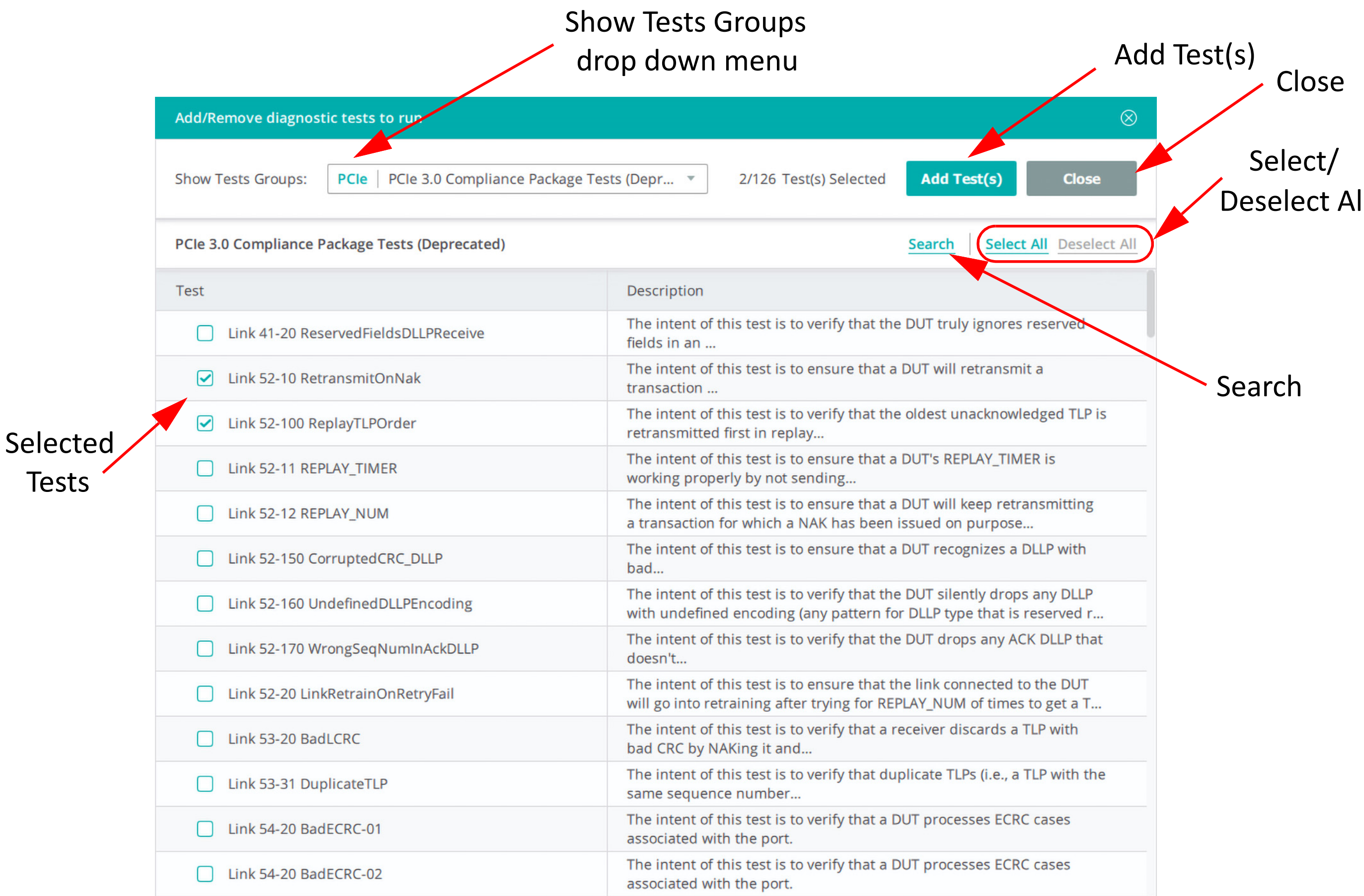


Figure 3.30: Add/Remove diagnostics tests to run dialog

Show Test Groups

Select a wide variety of tests types to run by using the **Show Tests Groups:** drop down menu, as shown in Figure 3.31 on page 62.

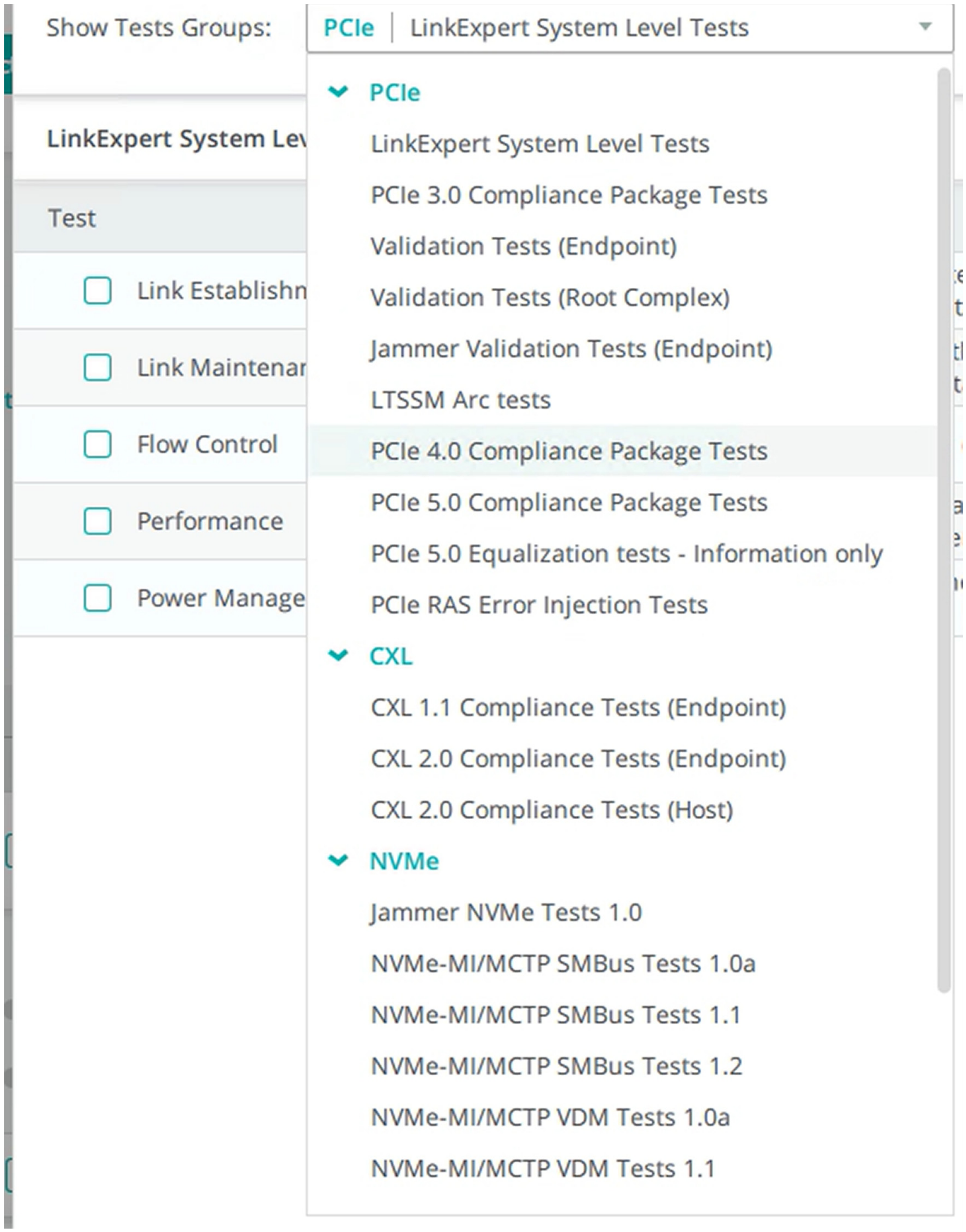


Figure 3.31: Show Tests Groups: drop down menu

PCIe Tests

- LinkExpert System Level Tests (see “LinkExpert PCIe System Level Tests” on page 124)
  - Link Establishment
  - Link Maintenance
  - Flow Control

- Performance
- Power Management

❑ PCIe 3.0 Compliance Package Tests

Note: Approved by PCI-SIG for official testing.

- 1 - 126 PCIe 3.0 tests (see “PCIe 3.0 Compliance Package Tests” on page 141)

❑ Validation Tests (Endpoint)

- 1 - 20 Endpoint Tests (see “PCIe Validation Tests (Endpoint)” on page 142)

❑ Validation Tests (Root Complex)

- 1 - 16 Root Complex Test (see “PCIe Validation Tests (Root Complex)” on page 147)

❑ LTSSM Arc Tests

- 1-106 LTSSM Arc Tests (See “PCIe LTSSM Arc Tests” on page 153)

❑ PCIe 4.0 Compliance Package Tests

Note: Approved by PCI-SIG for official testing.

- 1-226 PCIe 4.0 Compliance Package Tests (See “PCIe 4.0 Compliance Package Tests” on page 161)

❑ PCIe 5.0 Compliance Package Tests

- 1-93 PCIe 5.0 Compliance Package Tests (See “PCIe 5.0 Compliance Package Tests” on page 162)

❑ PCIe RAS Error Injection Tests

- 1-37 PCIe RAS Error Injection Tests (See “PCIe RAS Error Injection Tests” on page 164)

NVMe Tests Conformance Tests

Note: NVMe-MI Tests are Official Conformance tests for NVMExpress.org.

❑ NVMe-MI/MCTP SMBus Tests 1.0a

- 1 - 52 SMBus Tests 1.0a (see “NVMe-MI/MCTP SMBus Tests 1.0a” on page 179)

❑ NVMe-MI/MCTP SMBus Tests 1.1

- 1 - 162 SMBus Tests 1.1 (see “NVMe-MI/MCTP SMBus Tests 1.0a” on page 179)

❑ NVMe-MI/MCTP VDM Tests 1.0a

- 1 - 52 VDM Tests 1.0a (see “NVMe-MI/MCTP VDM Tests 1.0a” on page 181)

❑ NVMe-MI/MCTP VDM Tests 1.1

- 1 - 162 VDM Tests 1.1 “NVMe-MI/MCTP VDM Tests 1.1” on page 182

❑ Jammer NVMe Tests 1.0

- “Jammer NVMe Test 1.0” on page 183

SAS Tests

❑ SAS Verification Test Suite 1.0 Build 12-RC

❑ SAS Compliance Tests (see “Analysis Results: SAS Compliance Test” on page 269)

Search

After loading the tests, click the **Search** button to find specific tests. A drop down displays. See Figure 3.32 on page 64.

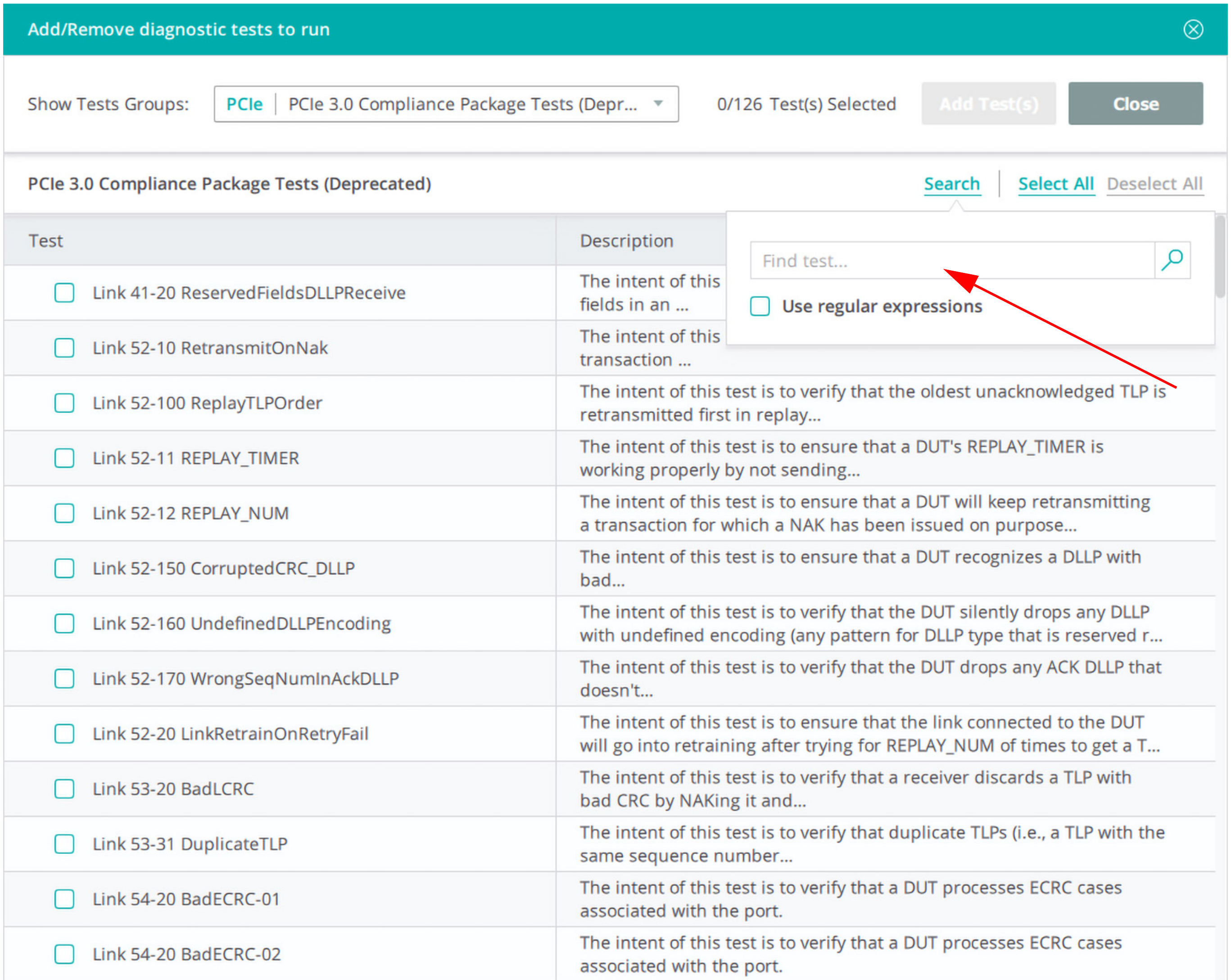


Figure 3.32: Add/remove Diagnostics Search Feature

In the Search field, type the search parameters and click the spyglass icon  to start the search. For an example, see Figure 3.33 on page 65.

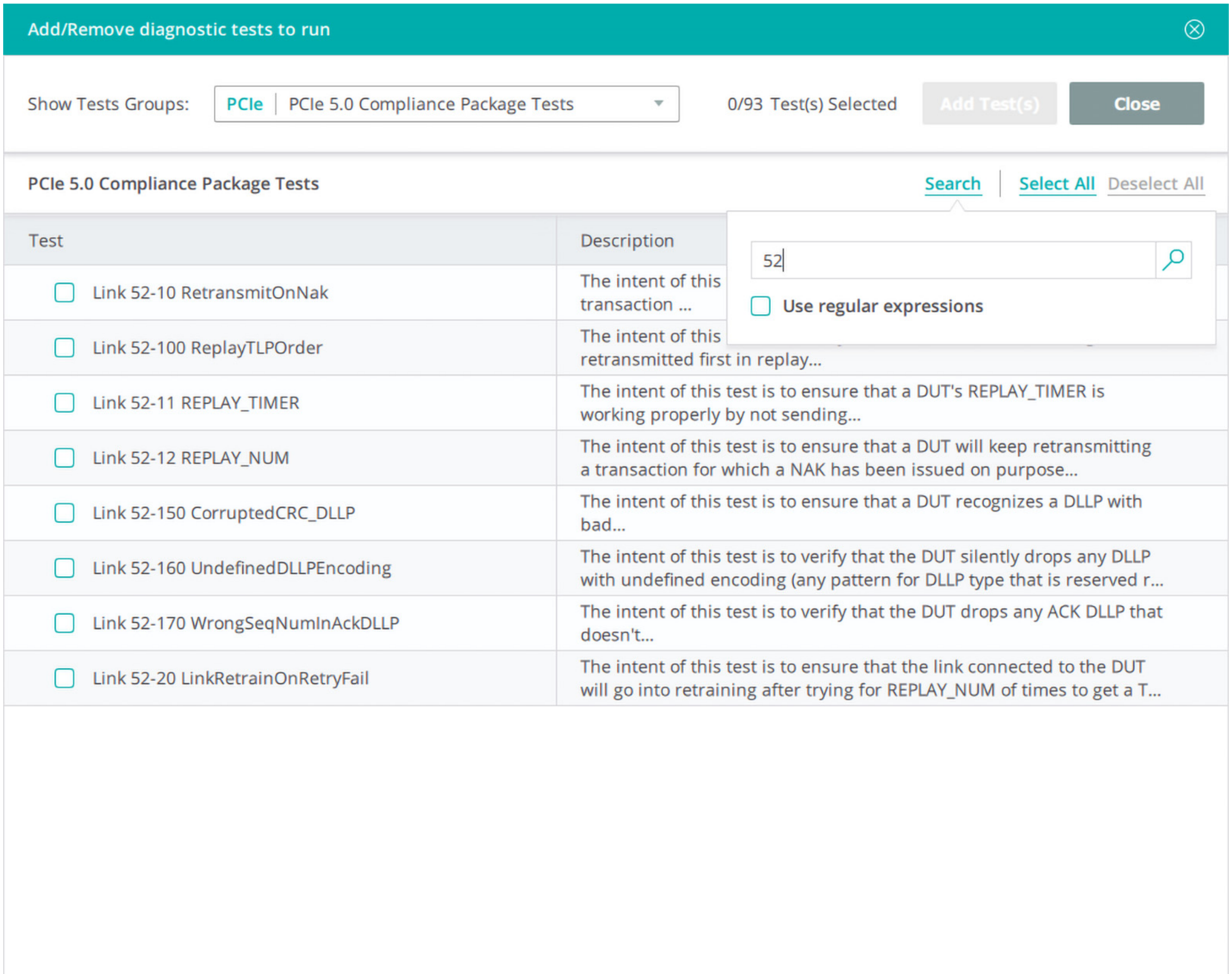


Figure 3.33: Search Example

3.2.2.2 Run Diagnostics

After you have added the Diagnostics you'd like to run, there is another button to execute the selected Diagnostics: Run Diagnostics.

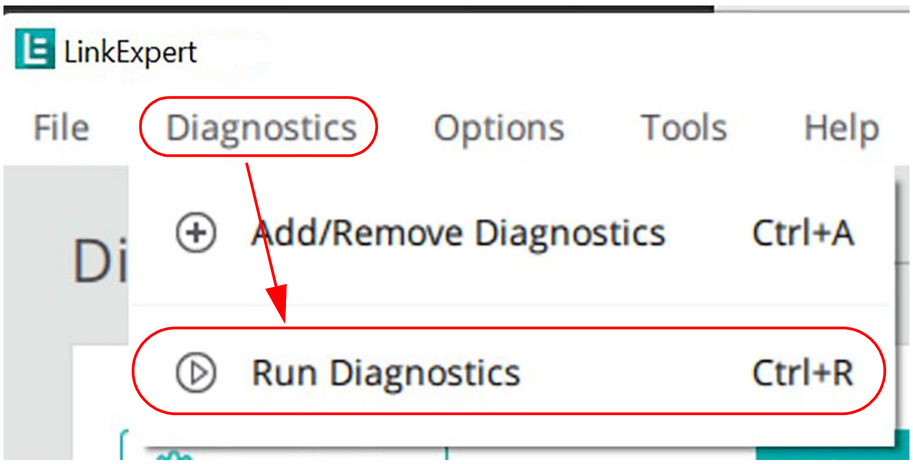


Figure 3.34: Diagnostics Dialog: Run

When you select this button the following dialog will pop up.

Run Diagnostics: Reset Link

Selecting "Run Diagnostics" will pop up a message window to Reset the Link by turning OFF your system and then clicking on the "Done" button. The example below shows the Link Establishment Tests have been loaded. See Figure 3.35

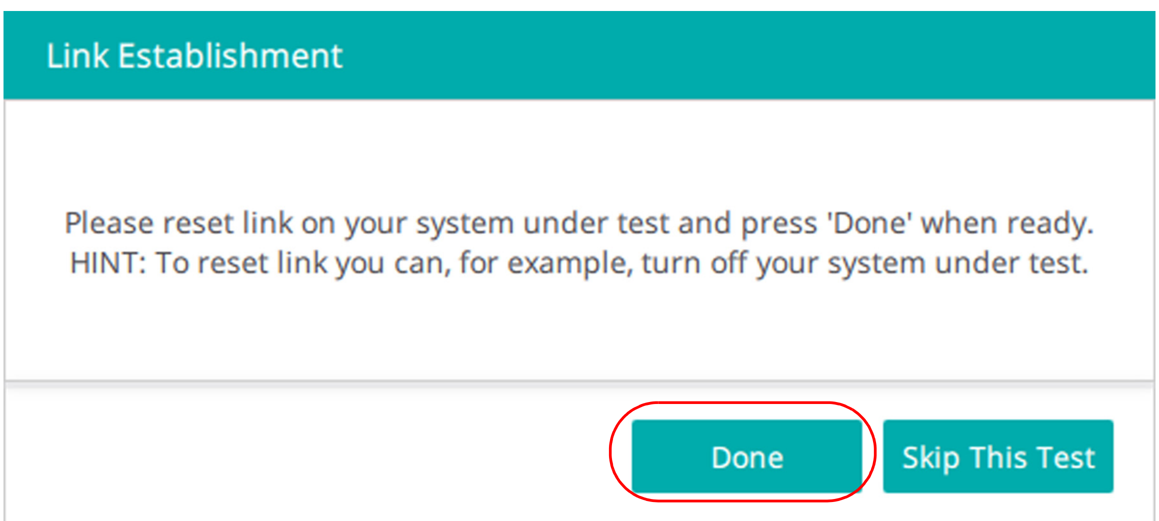


Figure 3.35: Run Diagnostics: First Pop-Up Message to Reset Link on System

The next window that pops up tells you to turn ON your system and click on the "Done" button. See Figure 3.36 on page 67. This will start the diagnostics running.

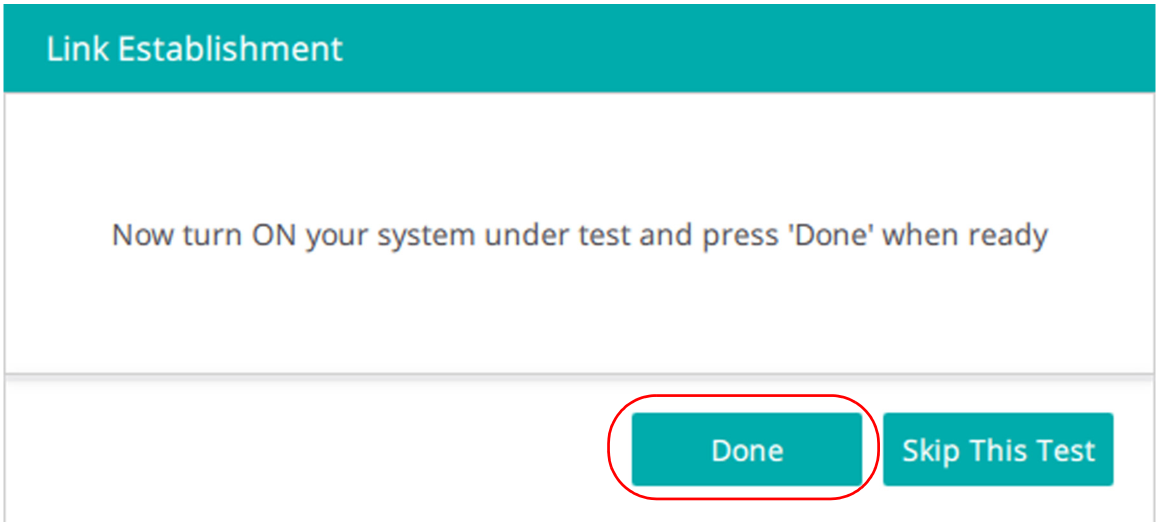


Figure 3.36: Run Diagnostics: Confirm that Power is Turned on to your System

After the diagnostics are executed, the results are shown in the Main LinkExpert User Interface in both the the Diagnostics section. In this case the LinkExpert System Level Tests: Link Establishment test has been executed See Figure 3.37.

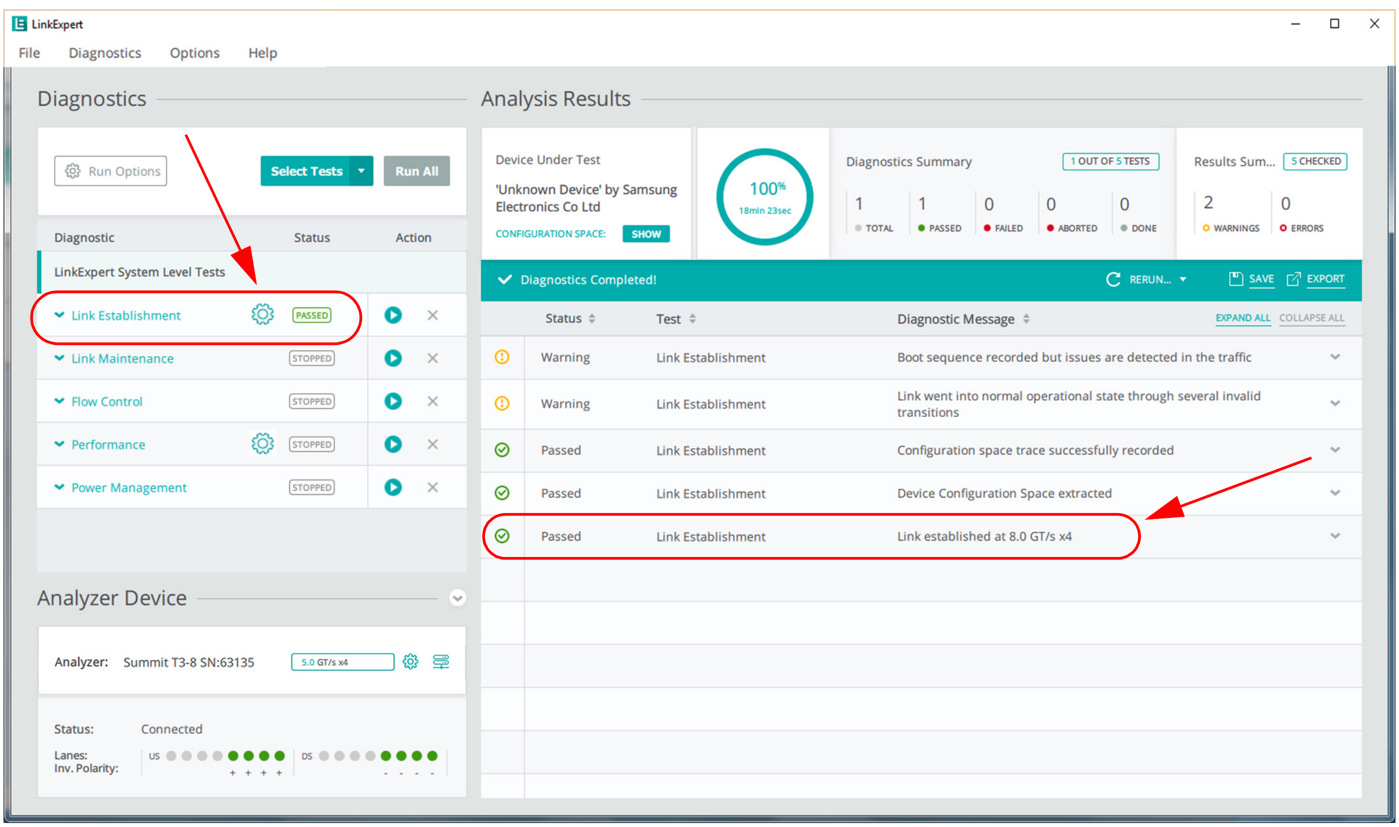


Figure 3.37: Diagnostic Executed: Link Establishment -> Passed, Results Displayed

3.2.3 Options Menu

Clicking on the Options menu displays the Disk Usage allocated to log files or All Connected Devices. See Figure 3.38.

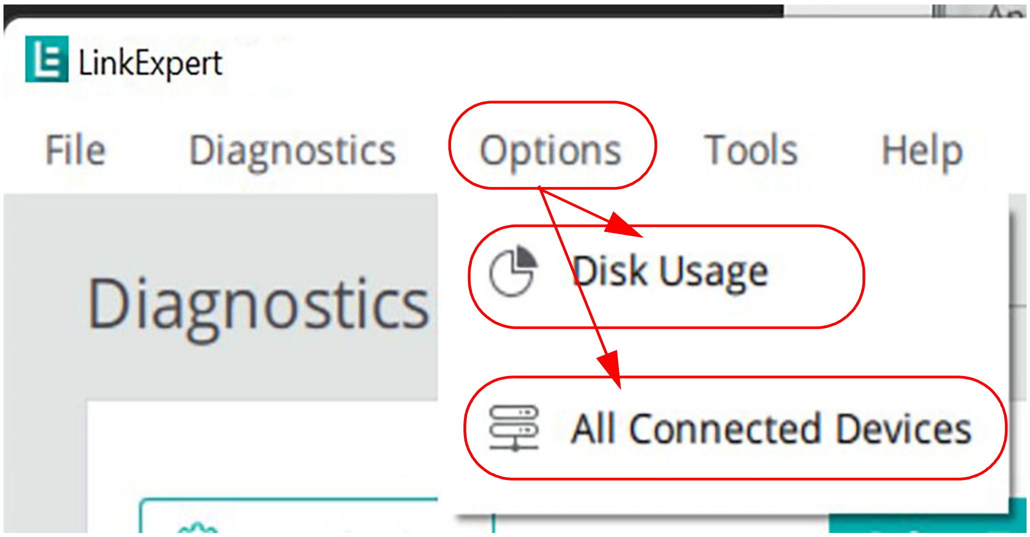


Figure 3.38: Options: Disk Usage

3.2.3.1 Disk Usage

Selecting the Disk Usage tab displays the default Disk Usage dialog (see Figure 3.39).

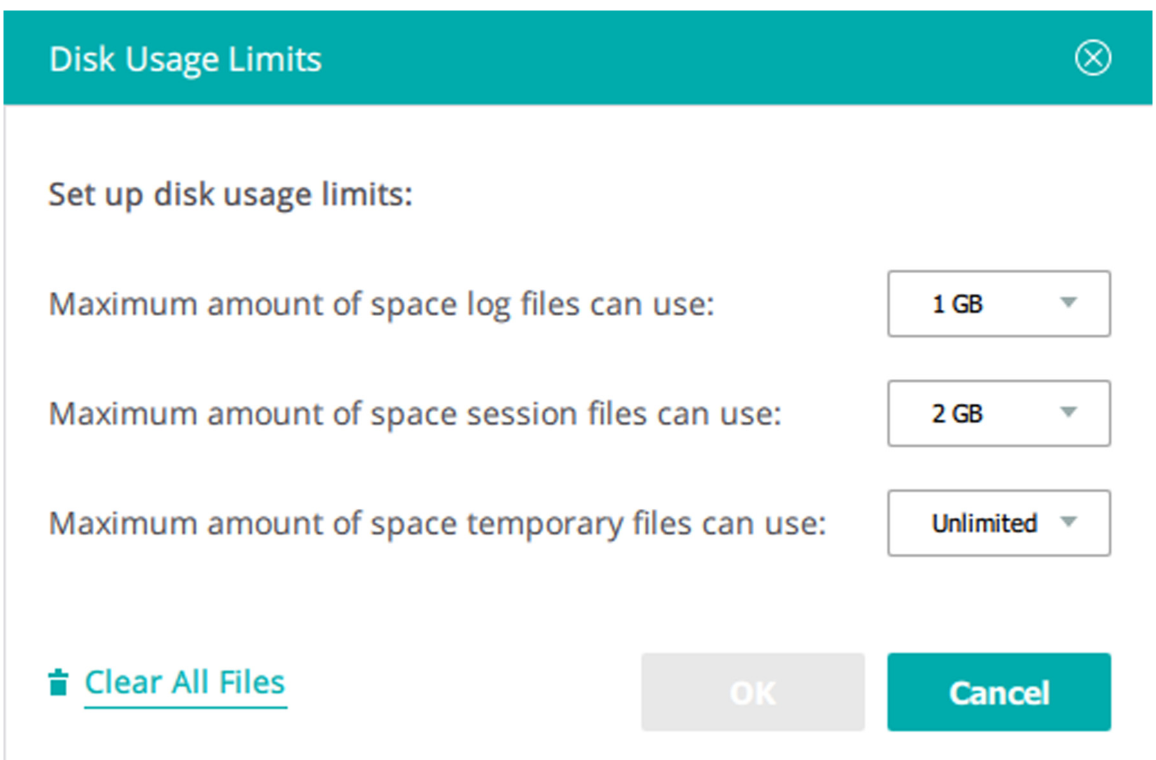


Figure 3.39: Disk Usage: Default Values

Disk Space Allocations

Log files, Session files and temporary files have drop down menus where you can set the amount of space allocated to each type of file. See Figure 3.40.

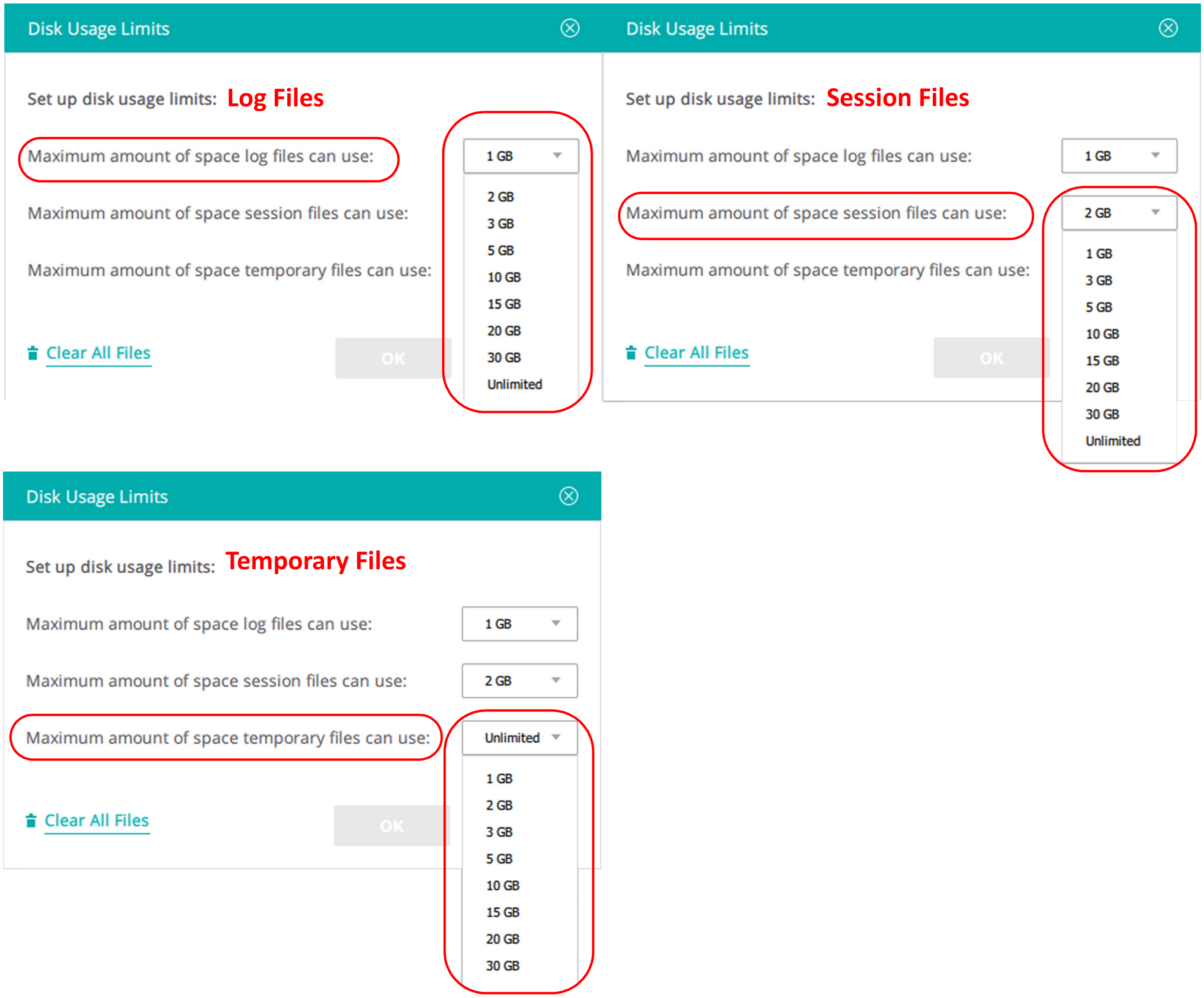


Figure 3.40: Disk Space Allocation for Log Files and Session Files

You can select the Maximum space for all files from 1 GB to Unlimited in the increments shown above.

If you've completed your testing you can also "Clear All Files".

When you select "Clear All Files" a Warning message will pop up, just to make sure you want to delete the selected log files. See Figure 3.41 on page 70

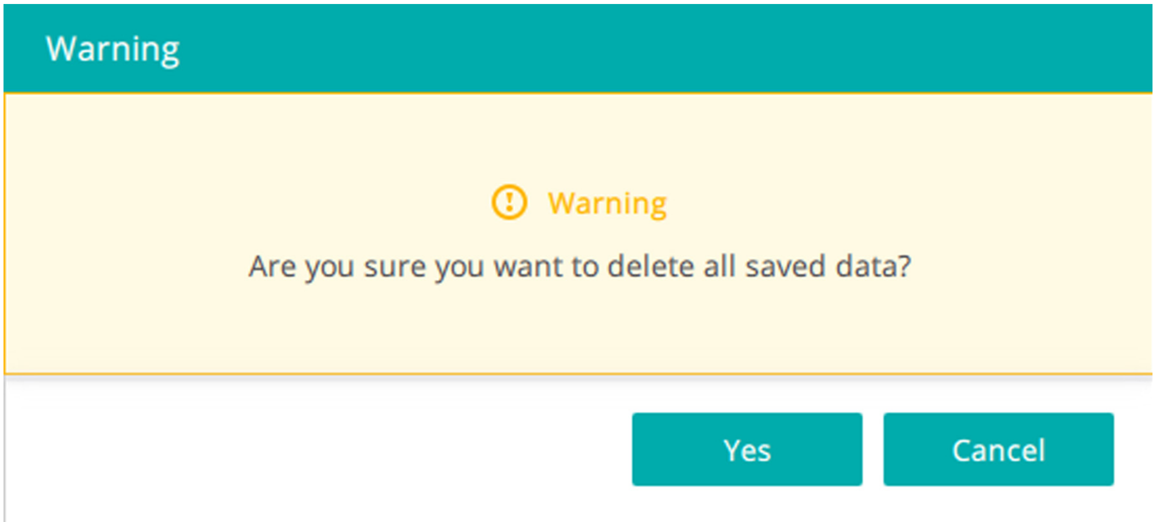


Figure 3.41: Warning Message

Select the appropriate response: “Yes” or “Cancel”.

3.2.3.2 All Connected Devices

If you select “All Connected Devices”, you’ll bring up a dialog box showing the devices available.

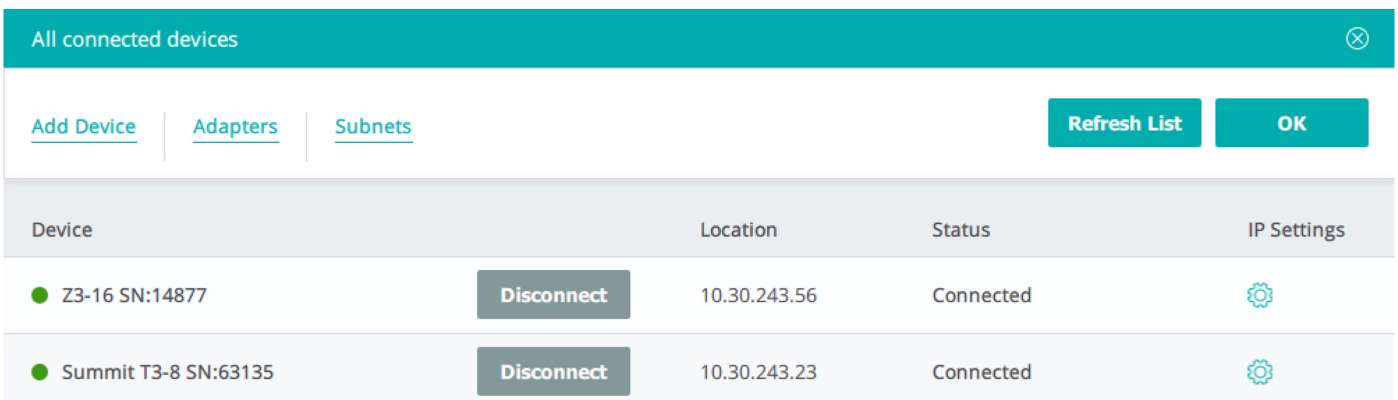


Figure 3.42: All Connected Devices Dialog Box

For more detail on “All Connected Devices” see “Drop Down Menus” on page 38.

3.2.4 Tools Menu

Since LinkExpert 3.60, the **Tools** menu was added so you can create your own dedicated packages in open format separately from the main "ScriptAutomationTestTool" folder. See Figure 3.43.

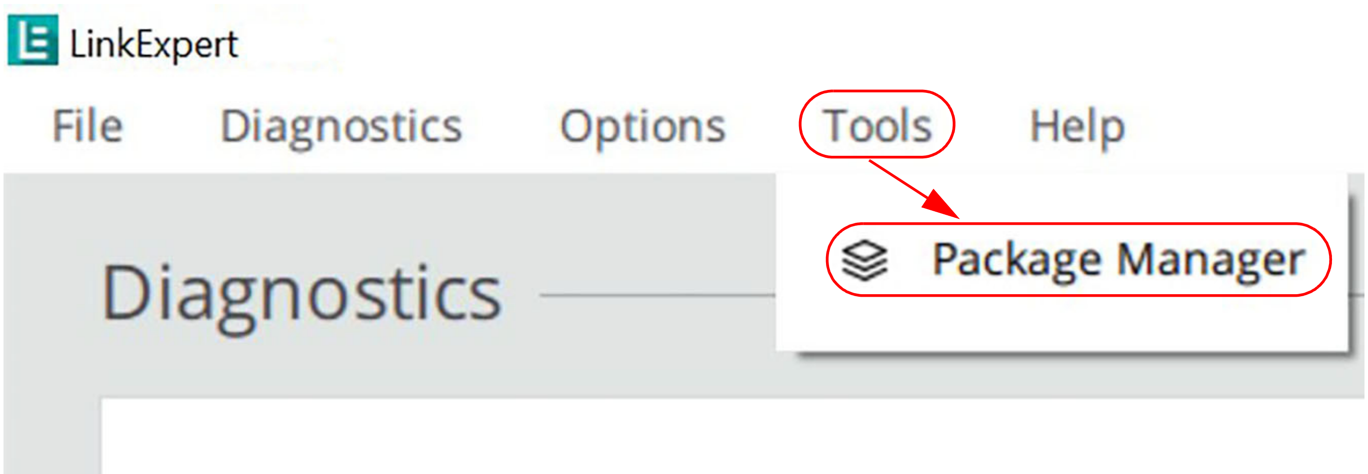


Figure 3.43: Tools Menu

3.2.4.1 Create a New Package

To create a new package, select the **Tools** menu, then click **Package Manager**. The **Package Manager** dialog displays, as shown in Figure 3.44 on page 72.

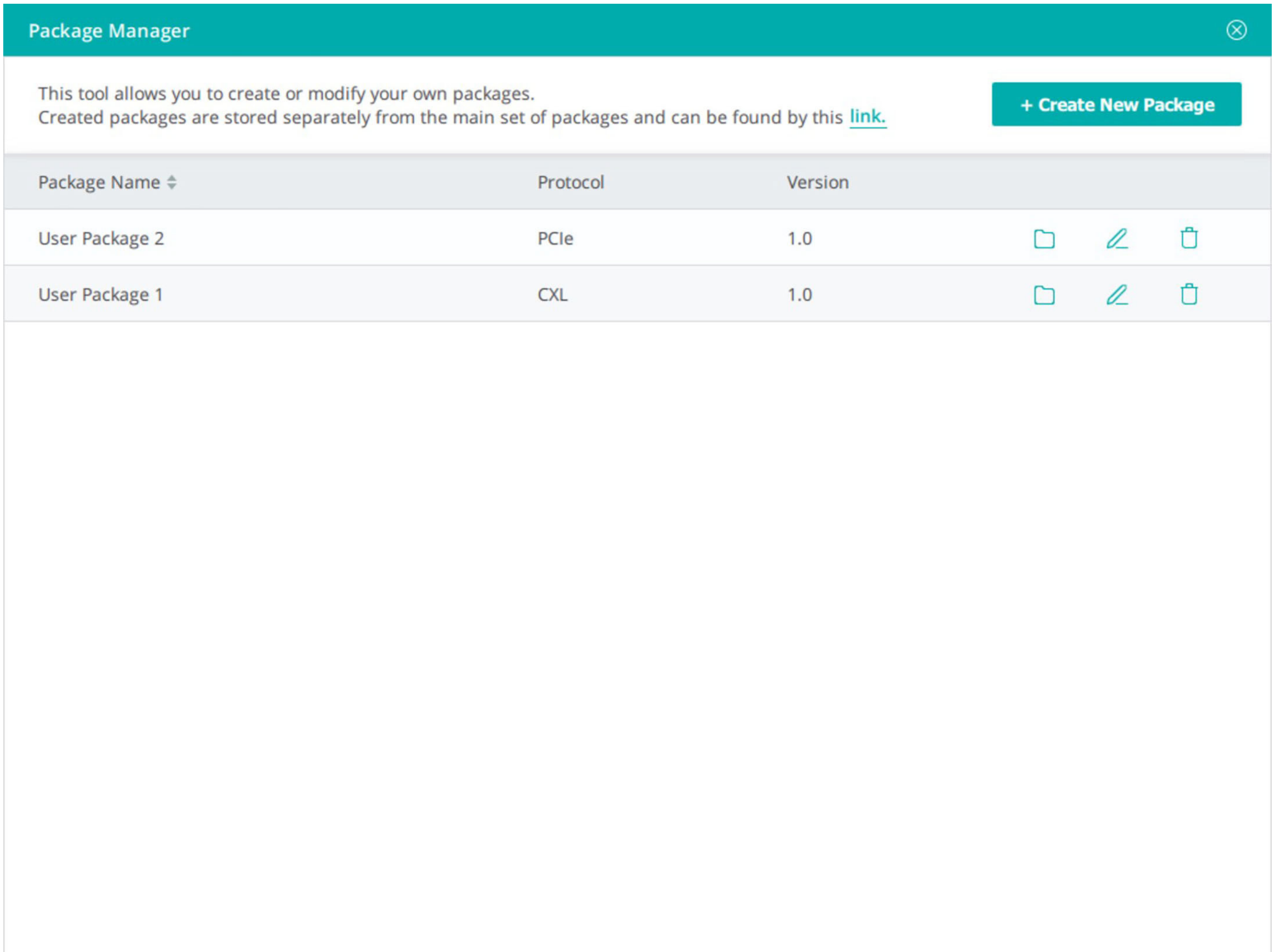


Figure 3.44: Package Manager

To create a new package:

1. Click the **+Create New Package** button.
2. Type in a unique name for your package in the **Package Name** field.
3. In the **Protocol** field, choose the desired Protocol from the list.
4. Optional: In the **Version** field, create a version. For help with this feature, a tooltip displays when you hover over the field.

See Figure 3.45 on page 73.

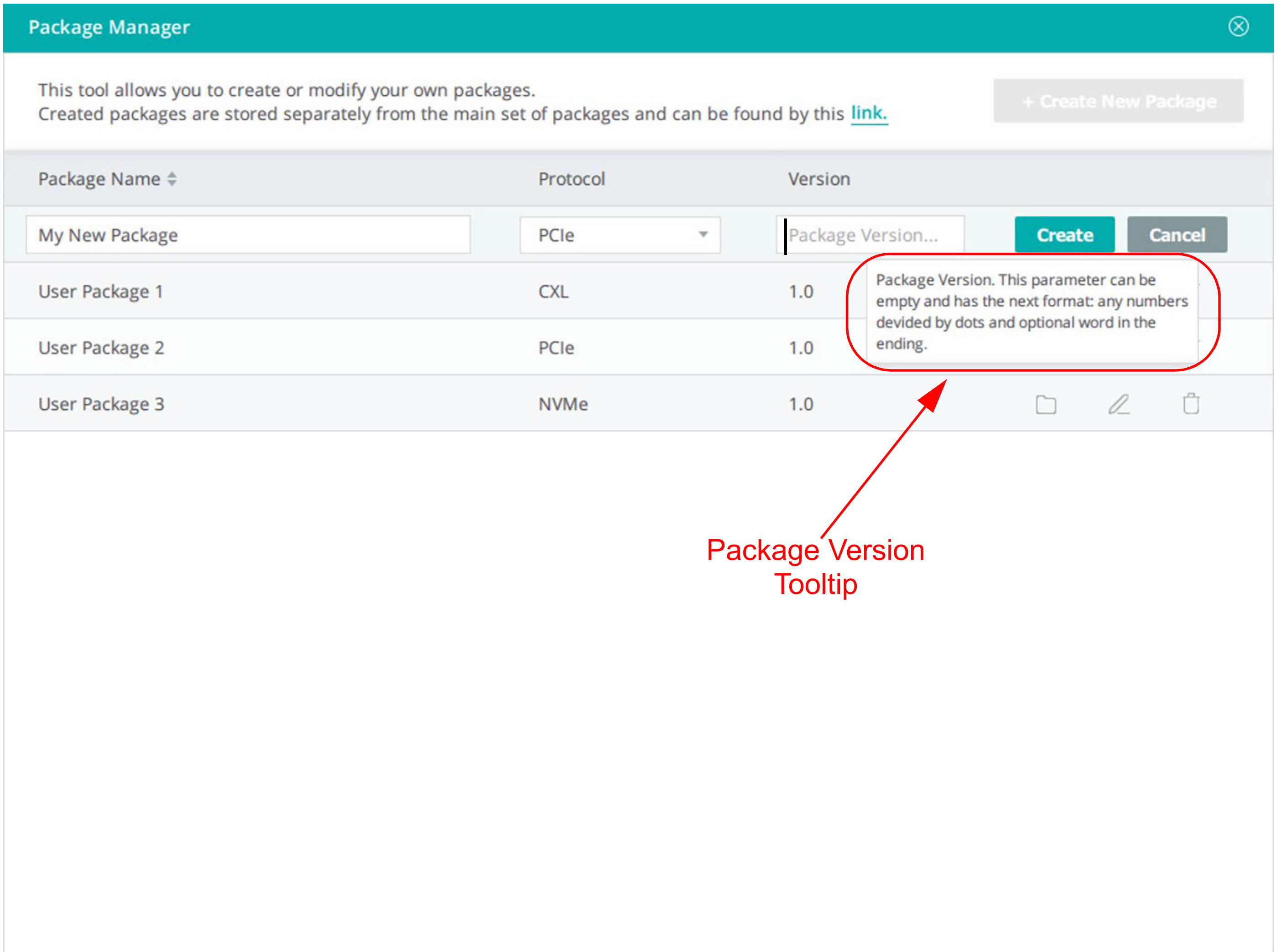


Figure 3.45: Package Manager: Create a Package

The newly created packages display in the **Select Tests** list. See Figure 3.46 on page 74.

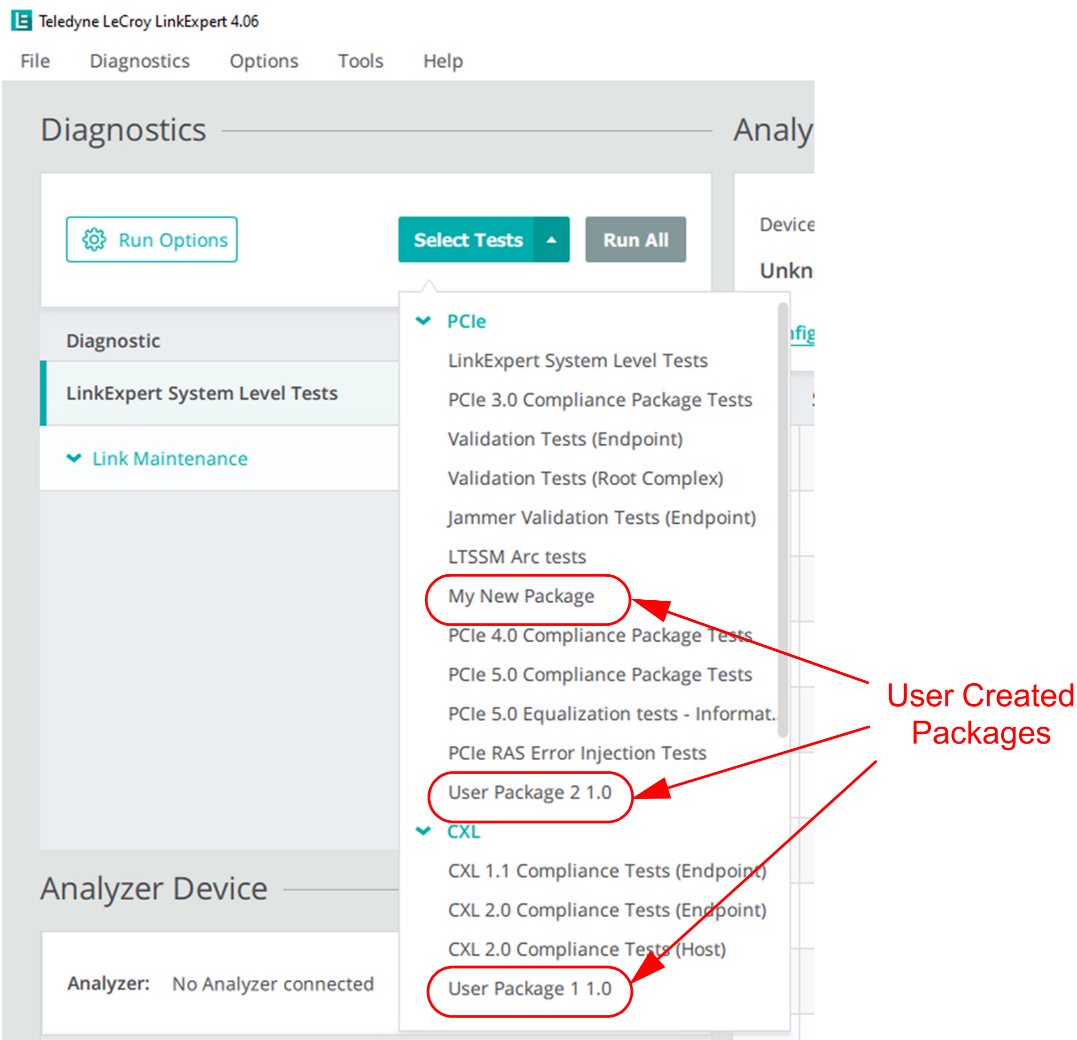


Figure 3.46: Select Tests with the user created packages

3.2.4.2 Package Options

Once you have created a package, you can view its location; edit the package name, test, and version; and delete the package. Refer to Table 3.2, Figure 3.47 on page 75, Figure 3.48 on page 76, and Figure 3.49 on page 77.

Note: WARNING! Delete is permanent! It will delete the package and all its folders.

TABLE 3.2: Package Options

Option	Description
View Location	Folder Icon: Displays the location of the newly created package. Linkexpert creates a folder for the package.
Edit Package	Pencil Icon: Allows you to edit the name, test, and version. Click **Save** to save changes.
Delete Package	Trash Can Icon: Deletes the package. Click **OK** on the Warning dialog to verify you want to permanently delete the package.

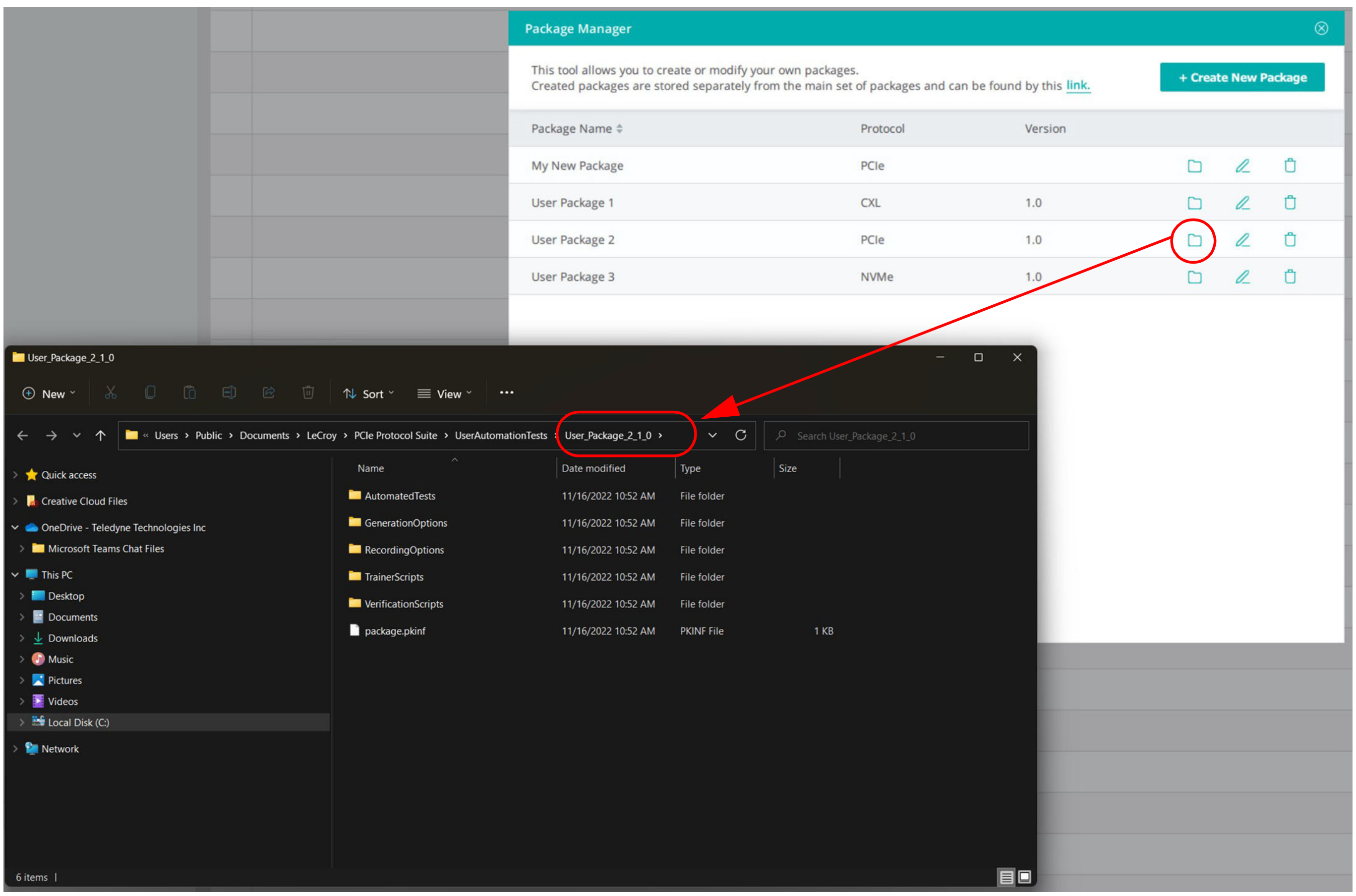


Figure 3.47: Package Manager: View Location

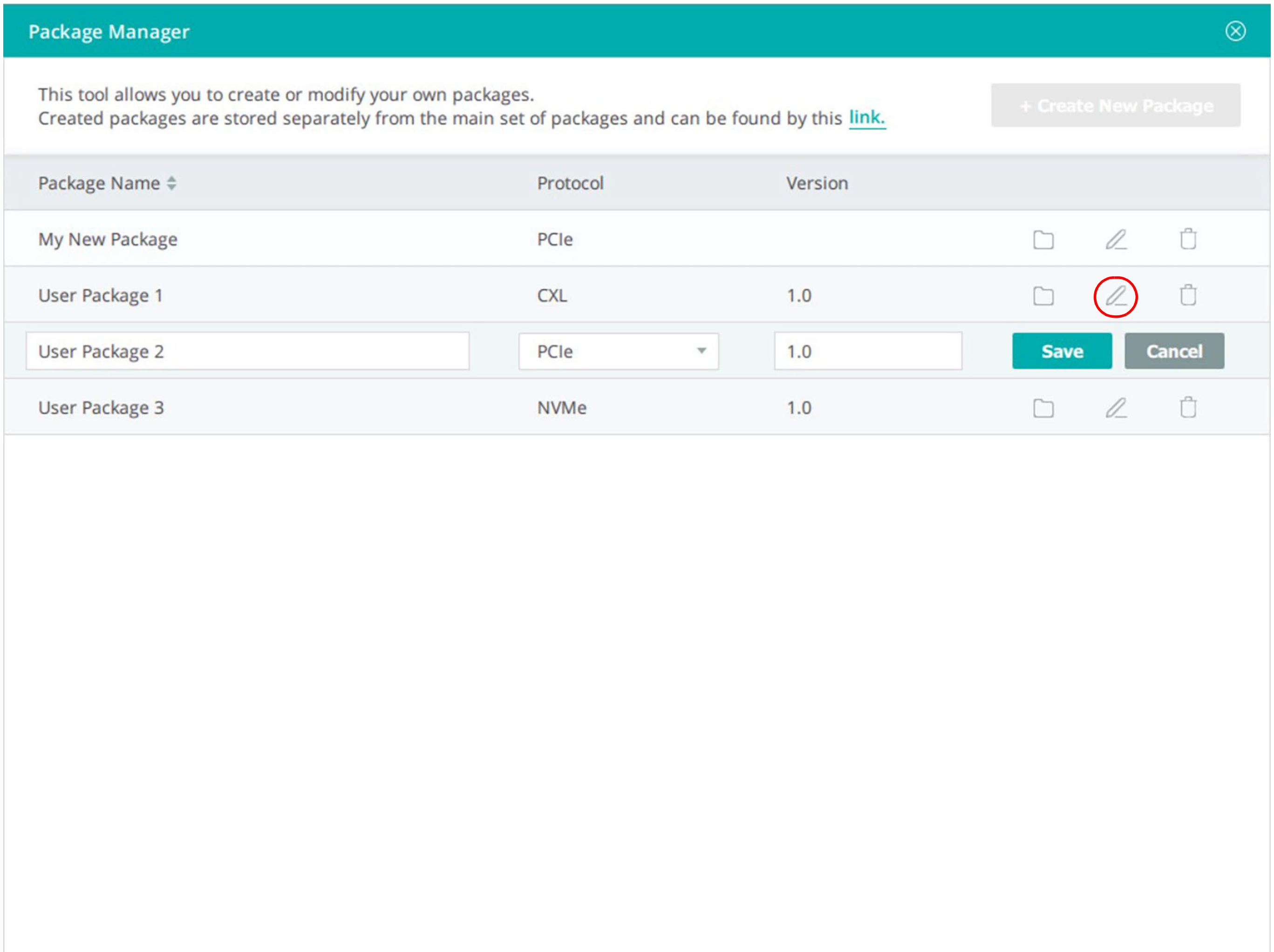


Figure 3.48: Package Manager: Edit Package

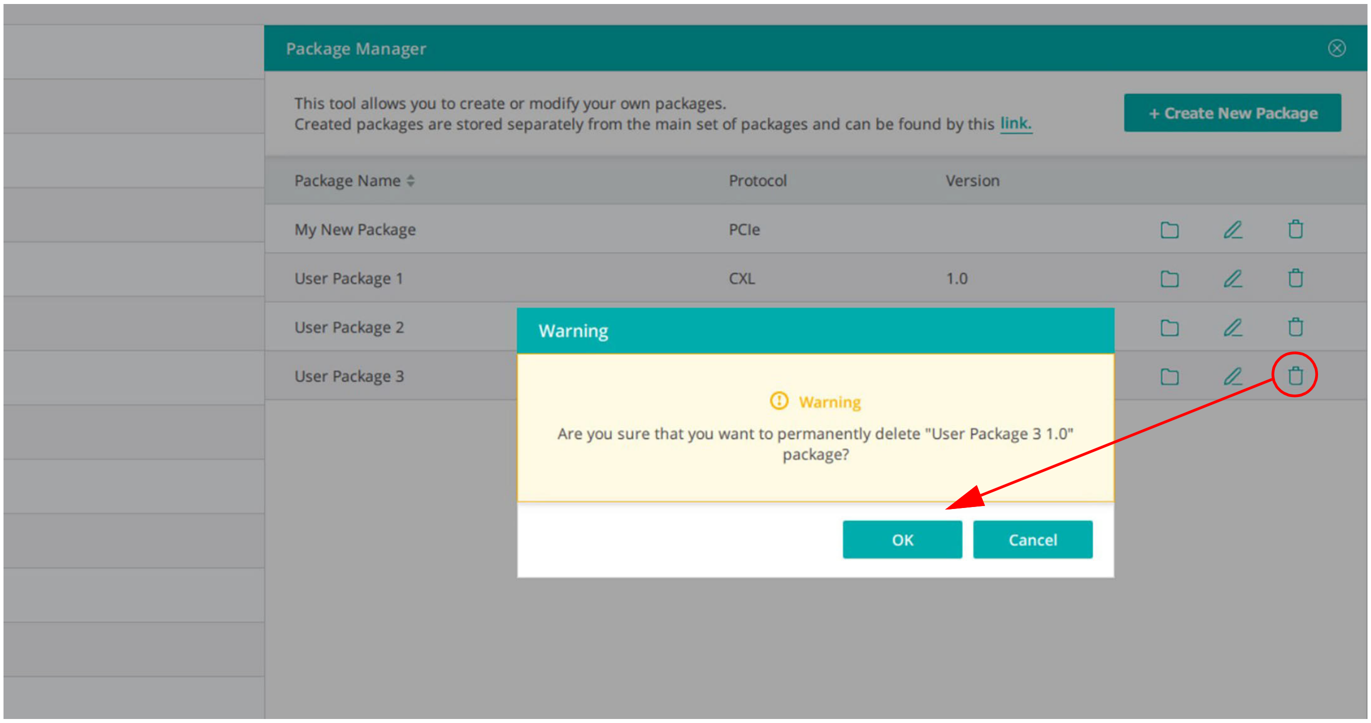


Figure 3.49: Package Manager: Delete Package

3.2.4.3 Sections

You can separate your tests scripts into sections and sub-sections as part of a User Tests Package.

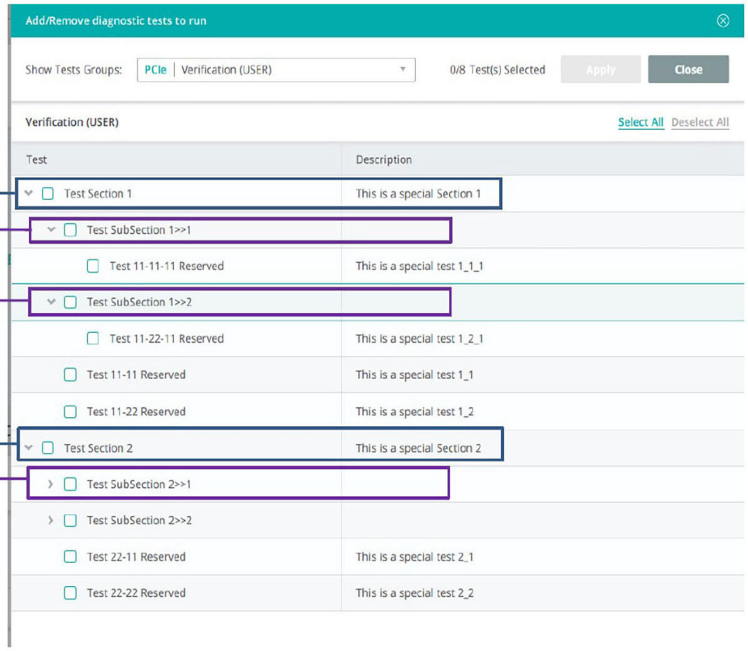
For implementing this feature, you create a new `ViewMap.xml` file and update the `.cts` files to point to a section/sub-section.

1. Create the `ViewMap.xml` file in the same location of the `package.pkinf` file. This is typically the package location, such as:

C:\Users\Public\Documents\LeCroy\PCIe Protocol Suite\UserAutomationTests\User_Package_1_1_0\

2. Edit the user's `*.cts` files adding the pointers to the Section or sub-section.

Refer to Figure 3.50 on page 78 and Figure 3.51 on page 79 for more details.



1. Create ViewMap.xml file in the same location of the package.pkinf
*C:\Users\Public\Documents\LeCroy\PCIe Protocol Suite\UserAutomationTests**User_Package_1_1_0***

ViewMap.xml should look like this:
** Comments are in RED, do not copy that text into the .xml file
<Root >
<Group id="Section1" name="Test Section 1" description="This is a special Section 1" > this is a section level 1
<Group id ="SubSection1_1" name="Test SubSection 1>>1" /> this is a sub-section level 2
<Group id ="SubSection1_2" name="Test SubSection 1>>2" /> this is a sub-section level 2
</Group>
<Group id="Section2" name="Test Section 2" description="This is a special Section 2" > this is a section level 1
<Group id ="SubSection2_1" name="Test SubSection 2>>1" /> this is a sub-section level 2
<Group id ="SubSection2_2" name="Test SubSection 2>>2" /> this is a sub-section level 2
</Group>
</Root>

id - A unique name for the section/subsection
name - The section name, will show in the list.
desctiption - Section description

**Starting Release 3.60

Figure 3.50: Package Manager Sections: Step 1

a. Example for pointing to a sub-section

** Comments are in RED, do not copy that text into the .cts file

TestAnalyzer = PETracer ;
TestGroup = "Link Layer";

TestName = "Test 22-22-22 Reserved"; This is the test name as shows in the list
TestCode = "Test 22-22-22"; This is a unique code for the test.
Section = "Section2/SubSection2_2"; The section ID/subsection ID Location in the list
.
TestDescription = "This is a special test 2_2_2"; This is the test description

b. Example for pointing to a section

** Comments are in RED, do not copy that text into the .cts file

TestAnalyzer = PETracer ;
TestGroup = "Link Layer";

TestName = "Test 22-11 Reserved"; This is the test name as shows in the list
TestCode = "Test 22-11"; This is a unique code for the test.
Section = "Section2"; The section ID Location in the list
.
TestDescription = "This is a special test 2_1"; This is the test description

**Starting Release 3.60

Figure 3.51: Package Manager Sections: Step 2

3.2.5 Help Menu

Clicking on the Help menu displays the following Help dialog. See Figure 3.52.

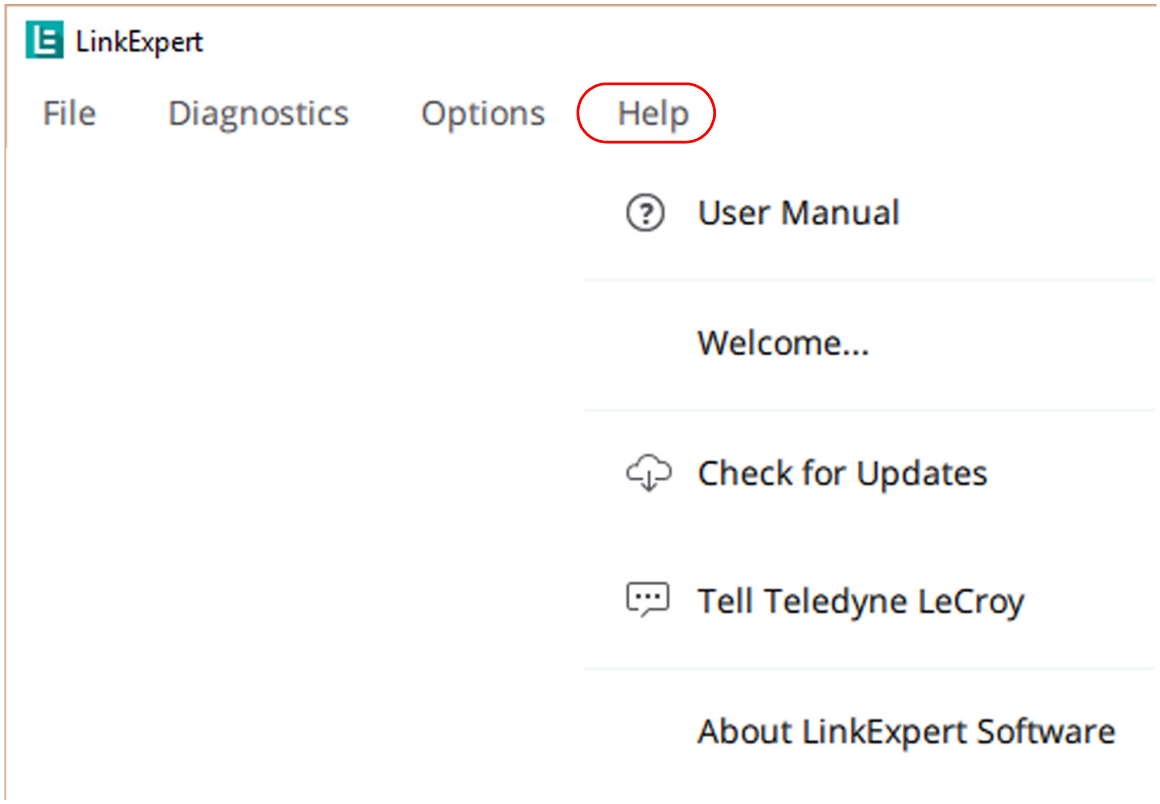


Figure 3.52: LinkExpert: Help Tab

The Help dialog includes:

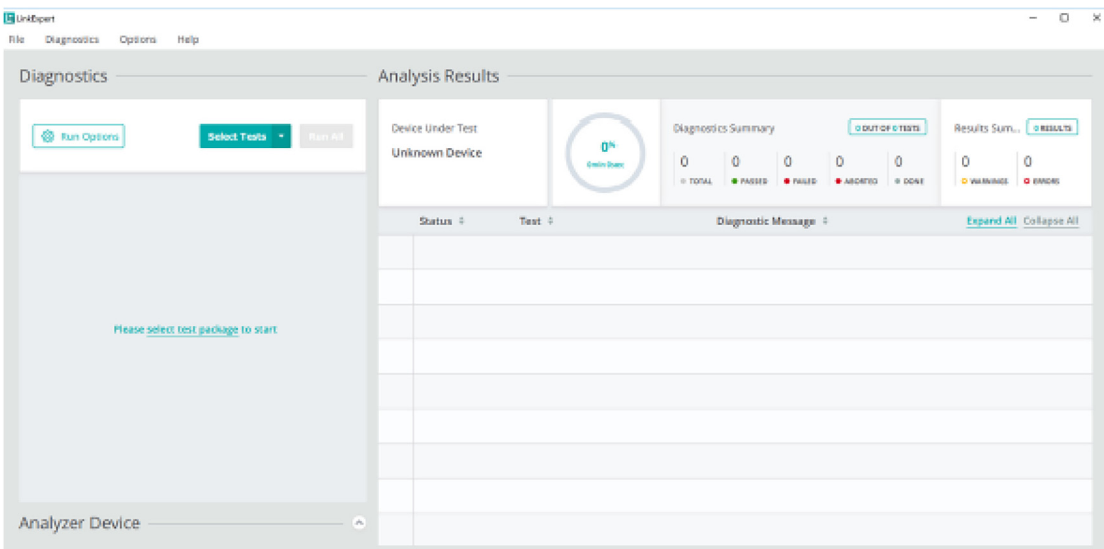
- Index: See "Help: LinkExpert User Manual" on page 81 (this document)
- Welcome: Gives you a Quick Tour of LinkExpert (see "Help: LinkExpert Welcome" on page 82)
- Check for Updates: Select this tab to check of more recent versions of the LinkExpert software. See "Help: Check for Updates" on page 83.
- Tell Teledyne LeCroy: Send an email message to Teledyne LeCroy Support. See "Help: Tell Teledyne LeCroy" on page 85
- About LinkExpert Software: Pops up a dialog with the LinkExpert software version and Build number. See "Help: About LinkExpert Software" on page 85.

3.2.5.1 Help: LinkExpert User Manual

TELEDYNE LECROY
Everywhereyoulook™

LinkExpert

User Manual



Software Version X.YZ

Generated: Date of SW Version X.YZ

Figure 3.53: LinkExpert: User Manual

3.2.5.2 Help: LinkExpert Welcome

.

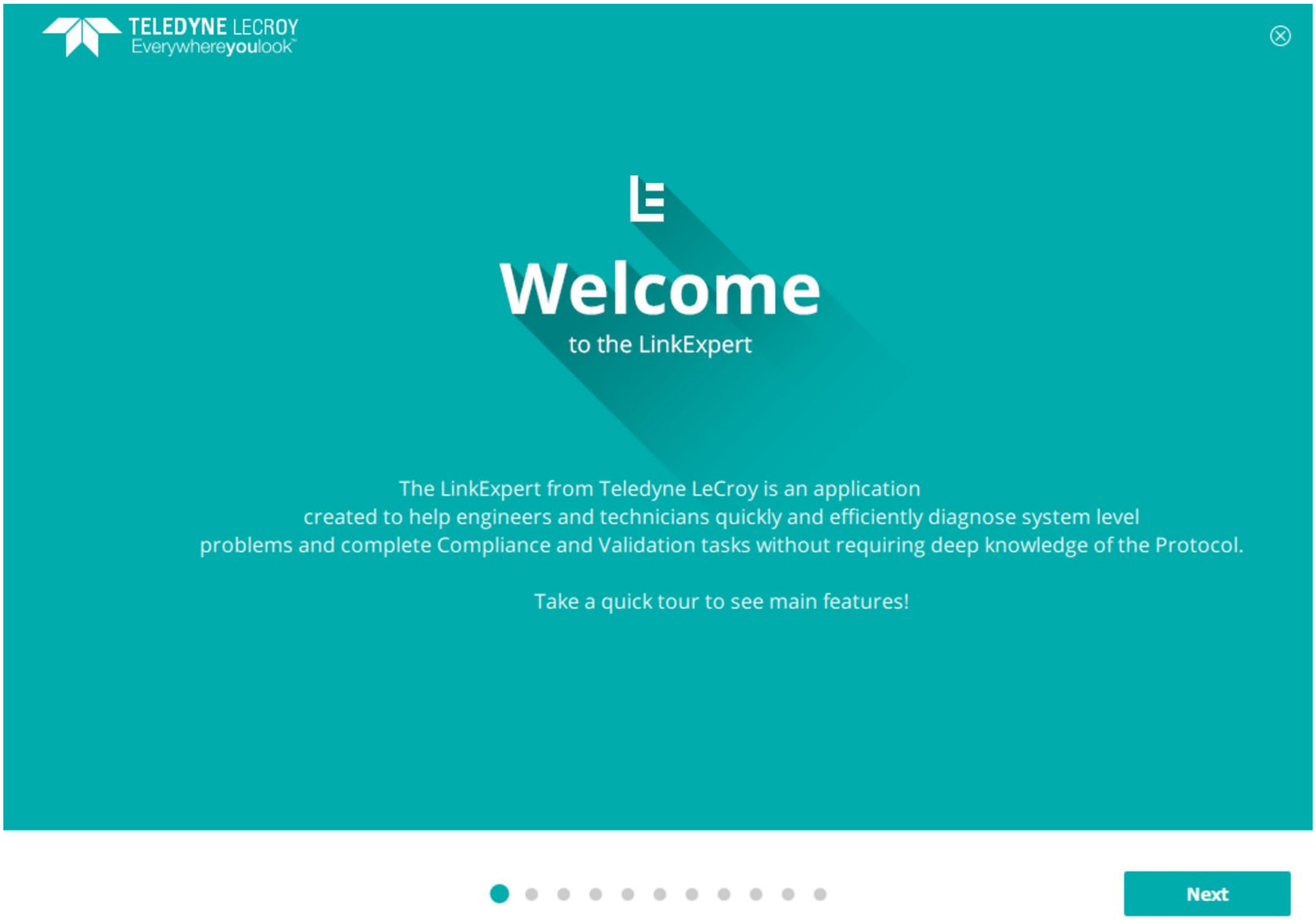


Figure 3.54: LinkExpert: Welcome (Quick Tour)

The LinkExpert Quick Tour is a series of slides that show you key features of the tool (see “Quick Tour” on page 2).

3.2.5.3 Help: Check for Updates

You can select this tab to see if there is a newer version of LinkExpert available. See Figure 3.55.

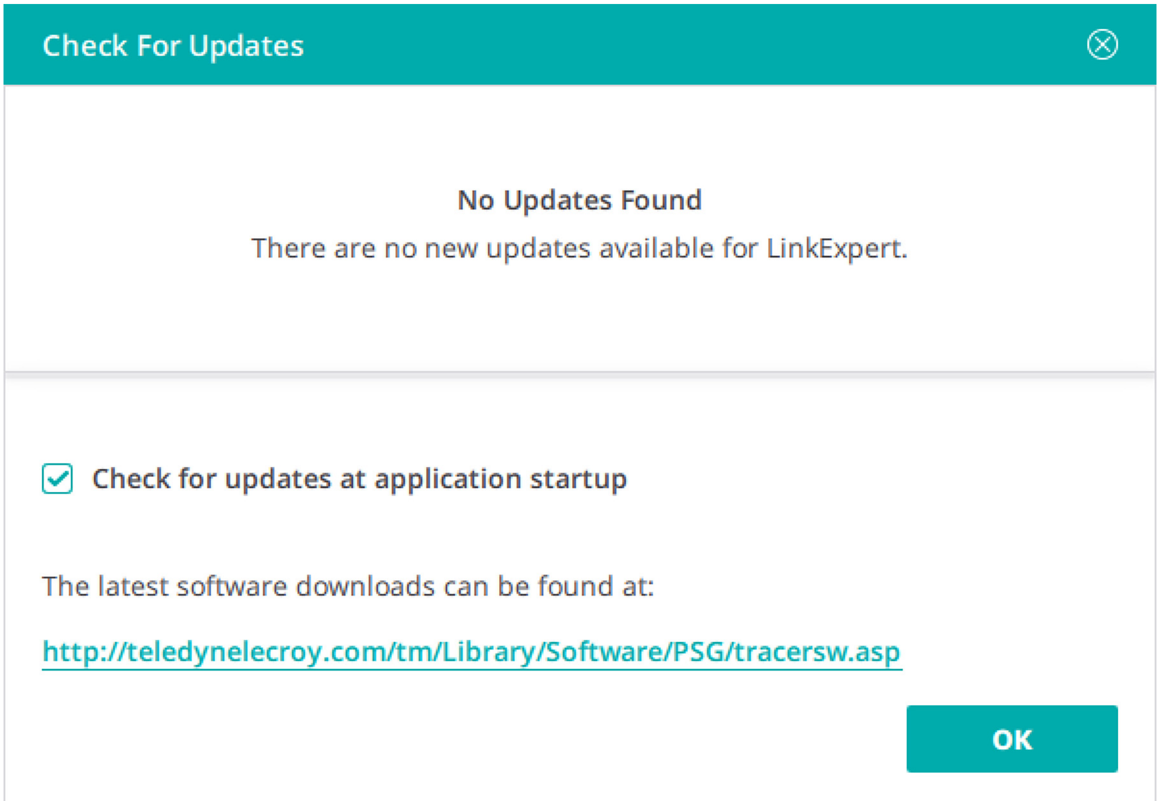


Figure 3.55: LinkExpert: Help -> Check for Updates

Select for Latest Software Downloads

Clicking on the www.teledynelecroy.com takes you to a generic site for Teledyne LeCroy products. To find software updates for PCIe Protocol Analyzers click on the following site:

http://teledynelecroy.com/sw/pciexpress

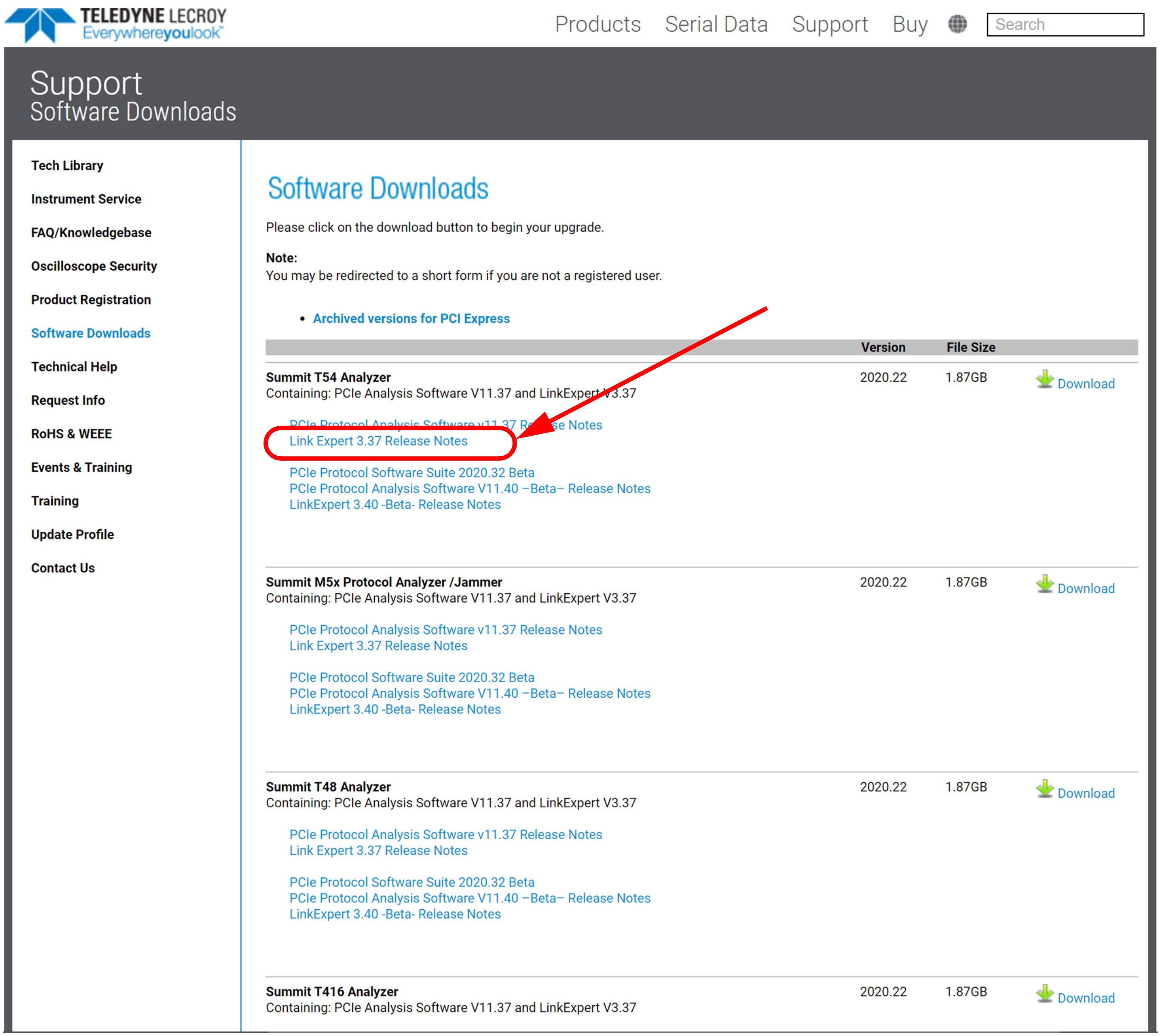


Figure 3.56: LinkExpert: PCIe Analyzer Software Downloads

3.2.5.4 Help: Tell Teledyne LeCroy

This tab will send an email to Teledyne LeCroy PSG Support:

psgsupport@teledynelecroy.com

3.2.5.5 Help: About LinkExpert Software

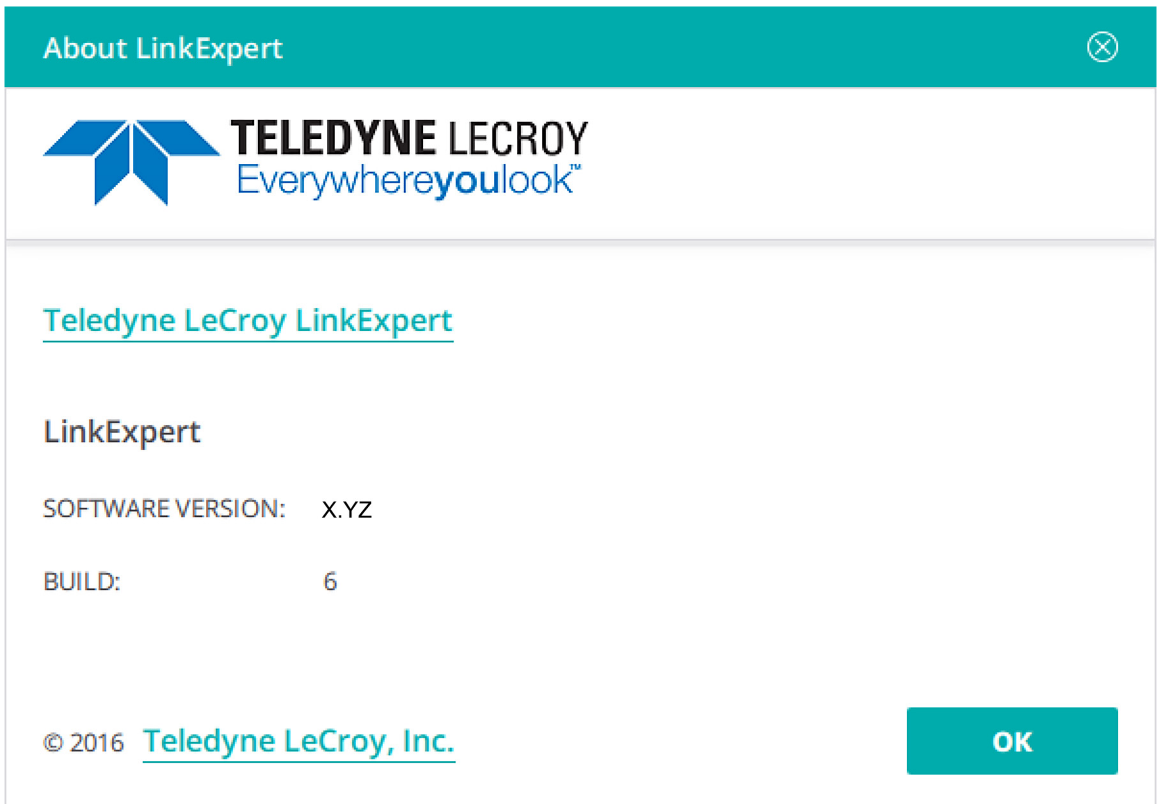


Figure 3.57: LinkExpert: Software Version and Build Number

3.3 Diagnostics Menu

The diagnostics section of LinkExpert's main menu shows the diagnostic tests that are available. See Figure 3.58.

Note: Not all tests will available for all protocols.

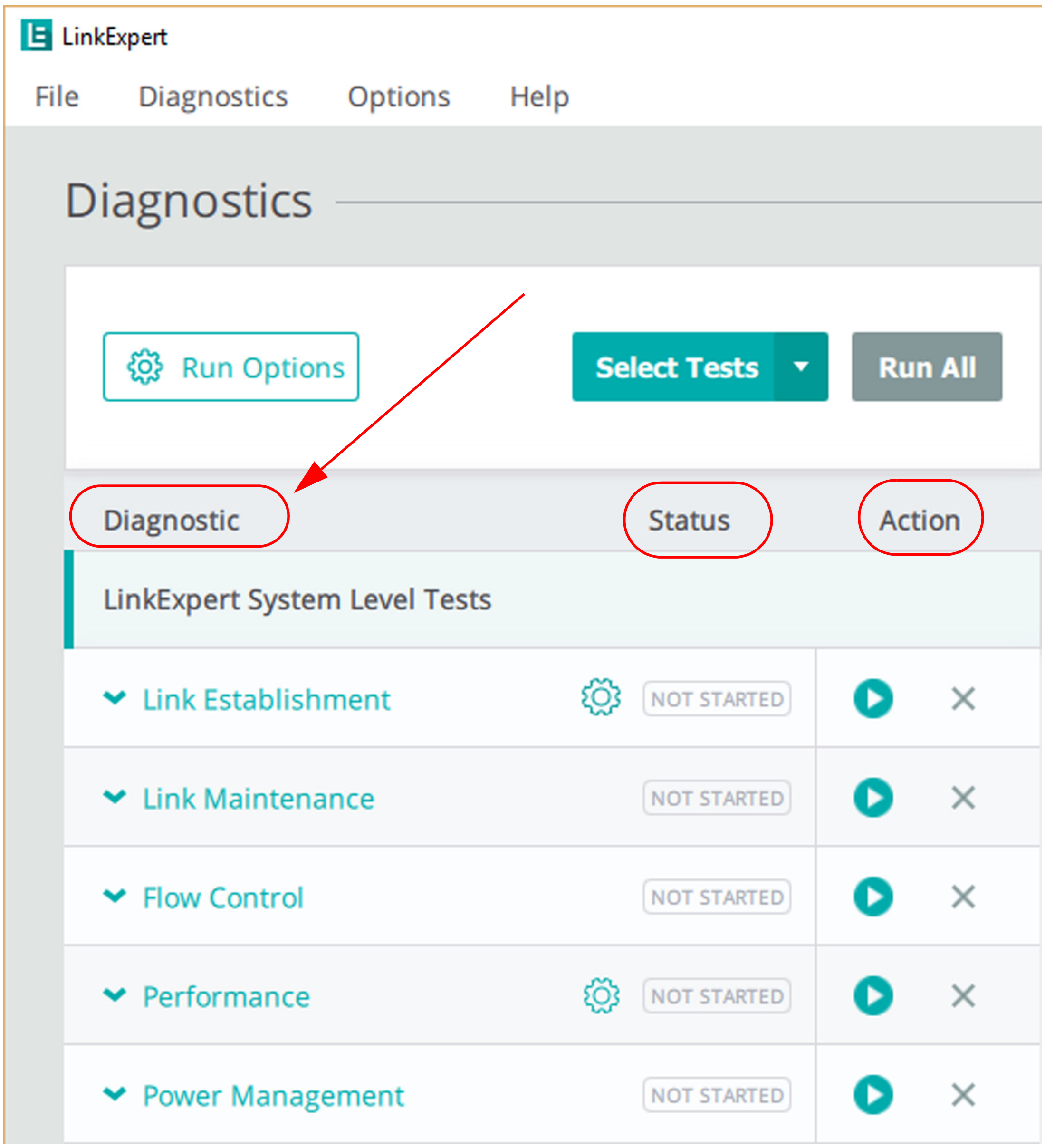


Figure 3.58: LinkExpert: Diagnostics Section

The Diagnostics Section of the Main LinkExpert Screen has the following sections:

Diagnostic -> List of LinkExpert System Level Tests

Status -> Not Started, Running, Stopped, Passed/Failed

Action -> Run a Test, Delete a Test

3.3.1 Run Options

You can select how many times you want the diagnostic to be executed from 1 to infinity times.

3.3.1.1 Run in a loop (Infinity)

See Figure 3.59.

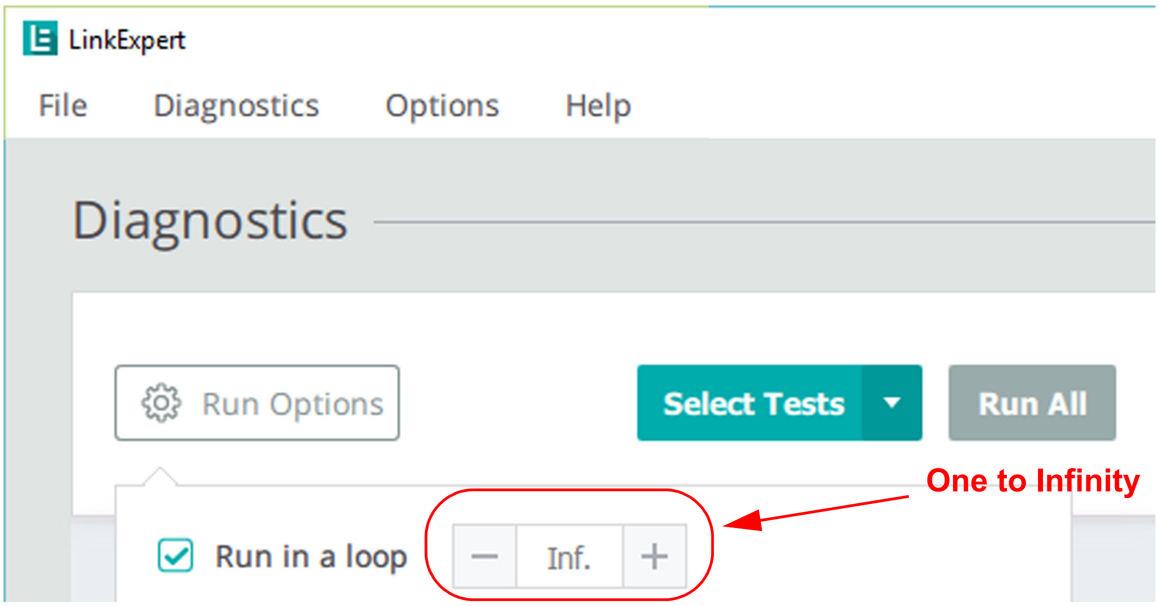


Figure 3.59: Run Options: Set to Infinity

3.3.1.2 Run in a loop (1)

See Figure 3.60 on page 87.

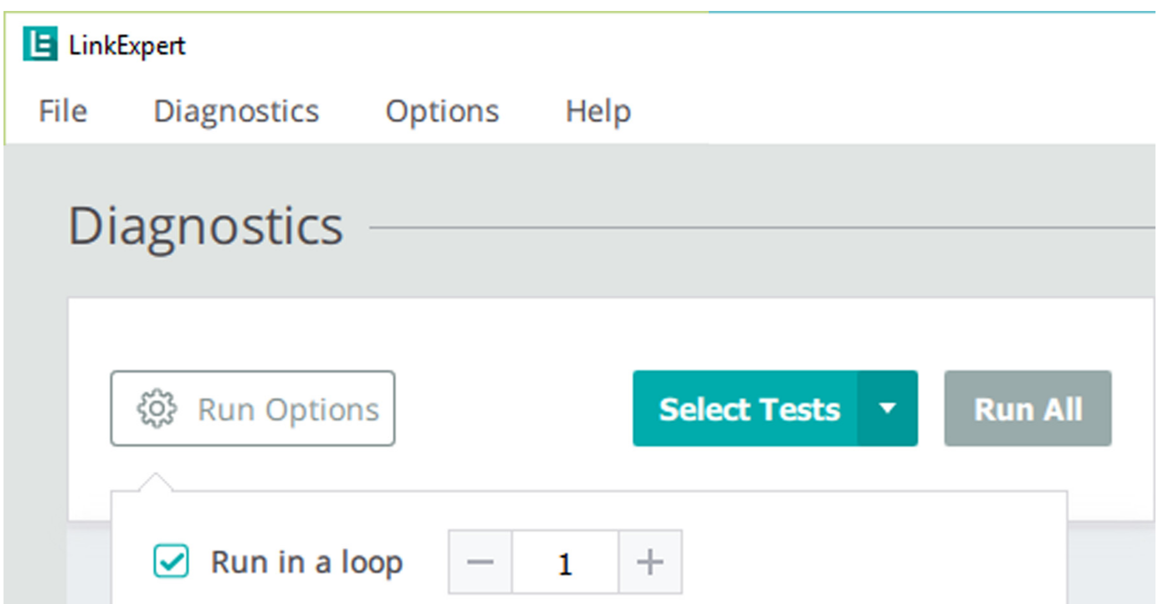


Figure 3.60: Run Options: Set to 1

3.3.1.3 Stop on Failed (While in Loop)

Execution of Testing Stops on First Failure (see Figure 3.61). You can also set the number of Loops you want to execute.

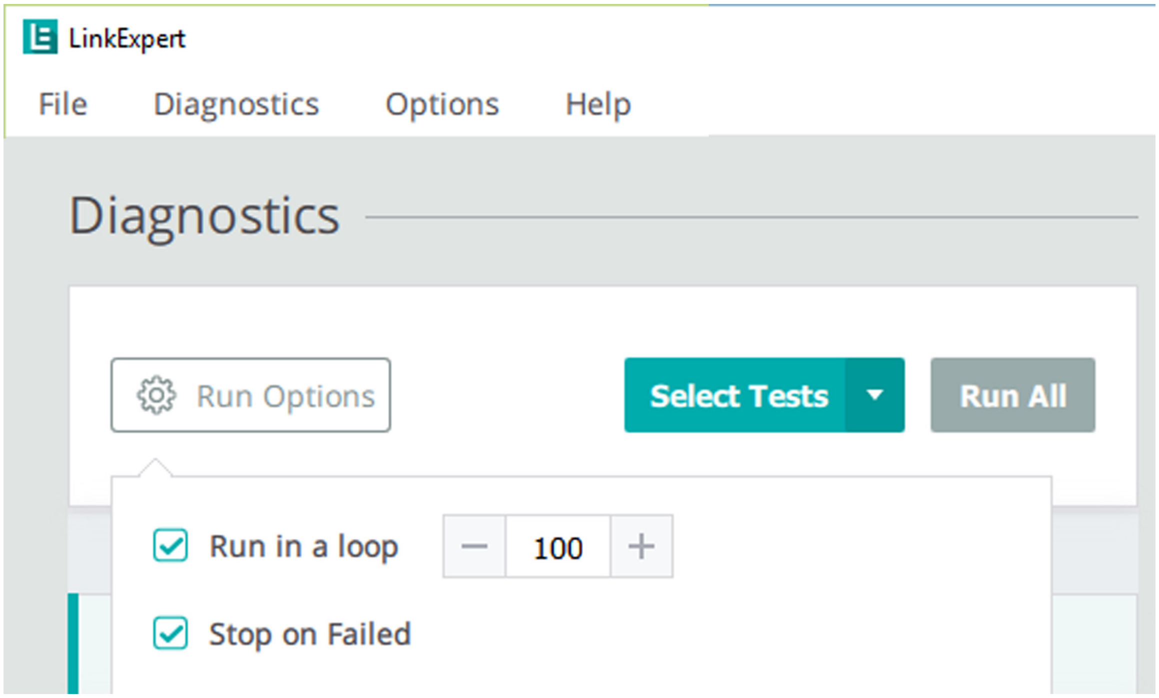


Figure 3.61: Run Options: Stop on Failure

3.3.2 Select Tests

Note: This is an alternative way to load the sets of tests, similar to the method described in “Diagnostics Menu” on page 60.

When you click the **Select Tests** button, a window pops up with all the sets of diagnostic tests available and a short description of their functionality. See Figure 3.62.

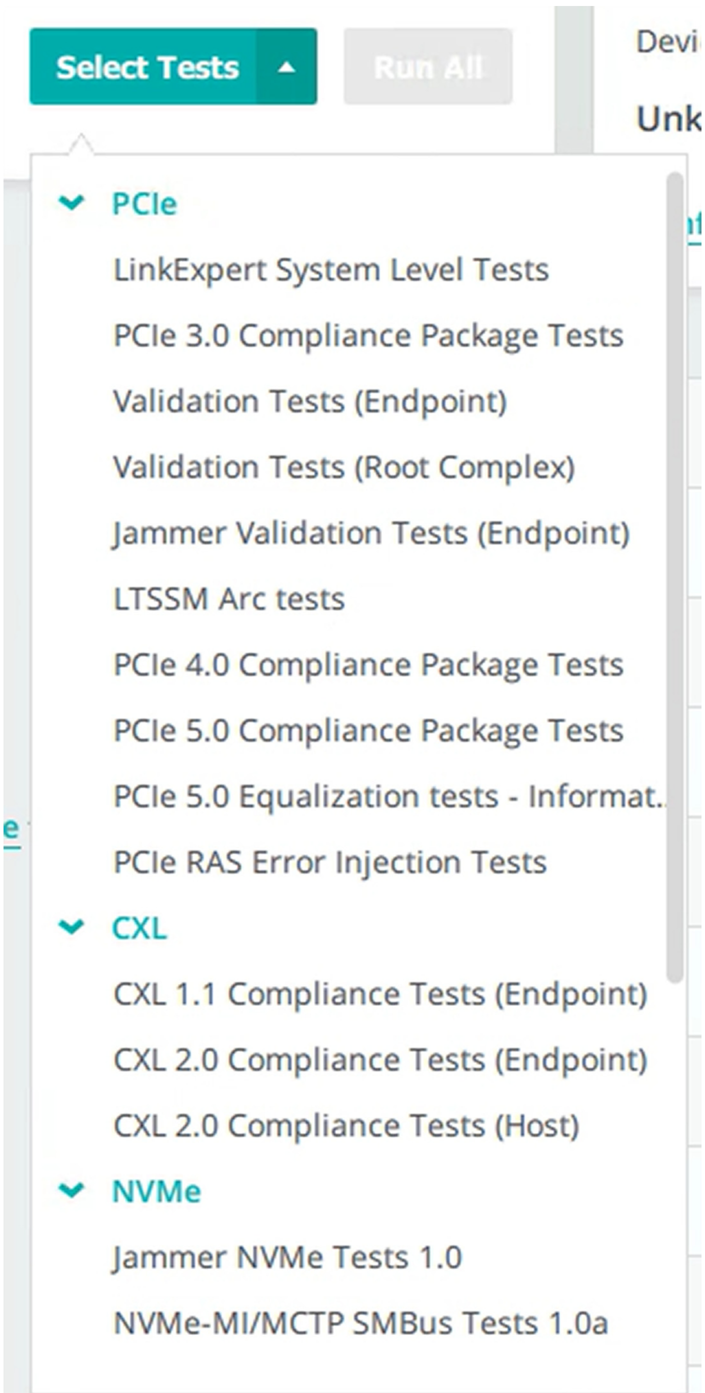


Figure 3.62: Diagnostics: Select Tests

From the **Select Tests** dialog, select from the following sets of test to run:

PCIe

- LinkExpert System Level Tests
- PCIe 3.0 Compliance Package Tests
- Validation Tests (Endpoint)
- Validation Tests (Root Complex)
- Jammer Validation Tests (Endpoint)
- LTSSM Arc Tests
- PCIe 4.0 Compliance Package Tests
- PCIe 5.0 Compliance Package Tests
- PCIe 5.0 Equalization Tests - Information Only
- PCIe RAS Error Injection Tests

CXL

- CXL 1.1 Compliance Package Tests (Endpoint)
- CXL 2.0 Compliance Package Tests (Endpoint)
- CXL 2.0 Compliance Package Tests (Host)

NVMe

- Jammer NVMe Tests 1.0
- NVMe-MI/MCTP SMBus Tests 1.0a
- NVMe-MI/MCTP SMBus Tests 1.1
- NVMe-MI/MCTP VDM Tests 1.0a
- NVMe-MI/MCTP VDM Tests 1.1

Net

- UNH Test Suite 1.0 Build 1-RC

SAS

- SAS Tests

3.3.3 Select Tests and Run All

The **Select Test** and **Run All** buttons have tooltips, which define the function of each button. To see the tooltip, hover the mouse over the button and the tooltip displays. See Figure 3.63.

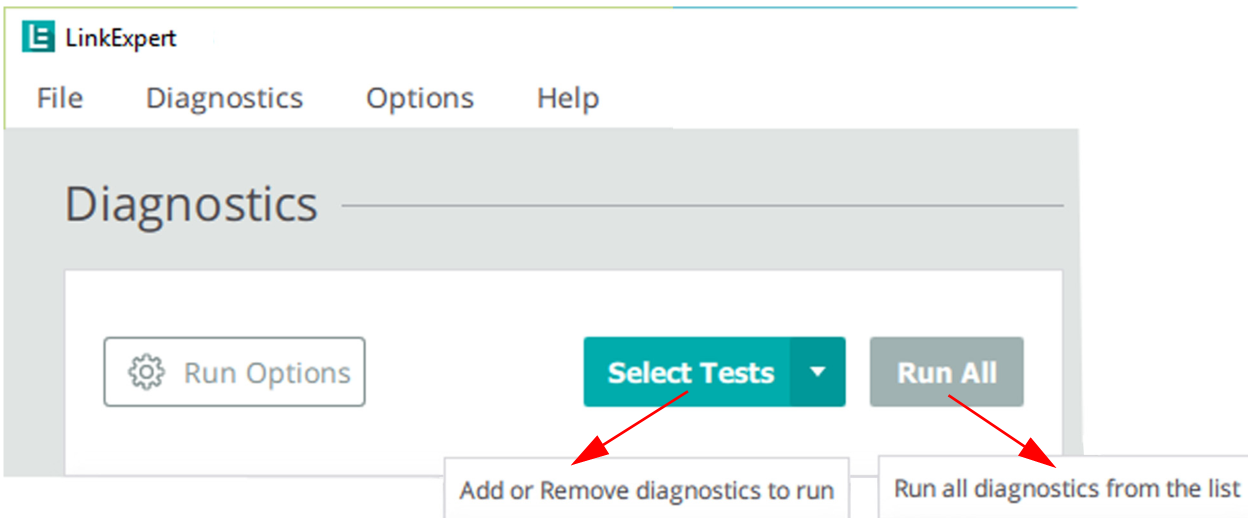


Figure 3.63: Diagnostics: Select Tests and Run All

After you have selected the Run Options and sets of tests to execute, click the "Run All" button and all of the tests selected will be executed sequentially.

In this case we've chosen to perform all the LinkExpert System Level Tests:

- Link Establishment
- Link Maintenance
- Flow Control
- Performance
- Power Management

The results of each test can be seen Analysis Results Section of the User Interface.

- For PCIe Tests: Summary and Details of Tests Run and Messages (see "PCIe Analysis Results" on page 191).
- For CXL Tests: Summary and Details of Tests Run and Messages (see "CXL Compliance Support" on page 251).
- For SAS Tests: Summary and Details of Tests Run and Messages (see "SAS Analysis Results" on page 269).

Chapter 4

PCIe LinkExpert (LE)

4.1 Introduction

LinkExpert provides complete control and management of Teledyne LeCroy's family of protocol analyzer and exerciser hardware while displaying high-level diagnostic information about communication between the root complex (i.e. host systems) and end-points (i.e. devices). Teledyne LeCroy continues to offer its industry favorite PCIe Protocol Analysis Software interface on its existing line of PCIe protocol analysis and test products. Link Expert also performs SAS Compliance Testing. The LinkExpert software interface targets design and validation engineers who are responsible for testing and resolving connectivity, interoperability and performance issues as well as ensuring conformance to the design specification. The new interface takes a smart approach to testing PCIe and SAS links and then displaying the results, including any identified errors, connectivity issues and/or overall performance metrics by using intelligent interpretations of bus traffic, eliminating the need for a deep technical knowledge of the various PCIe or SAS specifications. It provides easy-to-read information about five system-level test groups for PCIe:

- Link Establishment
- Link Maintenance
- Flow Control
- Performance
- Power Management

4.2 Key Features

LinkExpert is compatible with the NVMe Conformance tests (Teledyne LeCroy edition) provided by the University of New Hampshire Interoperability Laboratory for official NVMExpress.org testing.

PCIe Level Testing

- High Level Display of Traffic Information
- All results can be exported to TraceExpert and Reports
- Intelligent Reporting of Results
- Testing Framework for Additional Tests
- LinkExpert System Level Tests
- PCIe 3.0 Compliance Package Tests
- Validation Tests (Endpoint)
- Validation Tests (Root Complex)
- Jammer Validation Tests (Endpoint)
- LTSSM Arc Tests
- PCIe 4.0 Compliance Package Tests
- PCIe 5.0 Compliance Package Tests

- PCIe RAS Error Injection Tests

CXL

- CXL 1.1 Compliance Package Tests (Endpoint)
- CXL 2.0 Compliance Package Tests (Endpoint)
- CXL 2.0 Compliance Package Tests (Host)

NVMe

- Jammer NVMe Tests 1
- NVMe-MI/MCTP SMBus Tests 1.0a
- NVMe-MI/MCTP SMBus Tests 1.1
- NVMe-MI/MCTP VDM Tests 1.0a
- NVMe-MI/MCTP VDM Tests 1.1

Net

- UNH Test Suite 1.0 Build 1-RC

SAS

- SAS Verification Test Suite 1.0
- SAS Tests

4.3 Hardware Configurations for Specific Test Sets

Depending on testing needs, each compliance suite requires devices under test (host/root complex, device/endpoint, or both) and a specific combination of Teledyne LeCroy equipment.

Refer to Appendix D on page 301 for a list of recommended and valid configurations.

4.4 GPCIe Initial Connection

- ❑ Analyzer Devices: The analyzer/exerciser you have chosen to use (see "Initial Connection Process" on page 85)
  - ■ Initially, no analyzer has been connected

4.4.1 Initial Connection Process

Initially no devices will be connected after power up. See Figure 4.1.

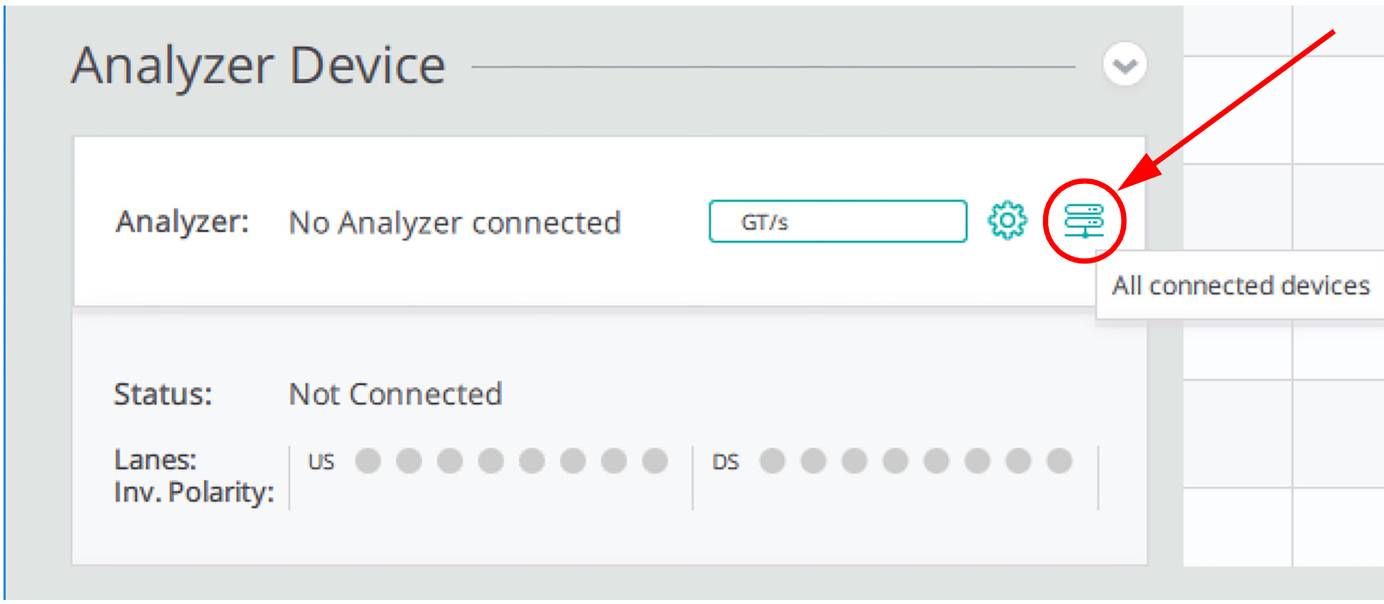


Figure 4.1: Initial Power Up: No Devices Connected

Select the All Connected Devices icon in the Analyzer Device portion of the LinkExpert main Menu (above).

This will pop up a dialog box showing all the devices available on the network. See Figure 4.2.

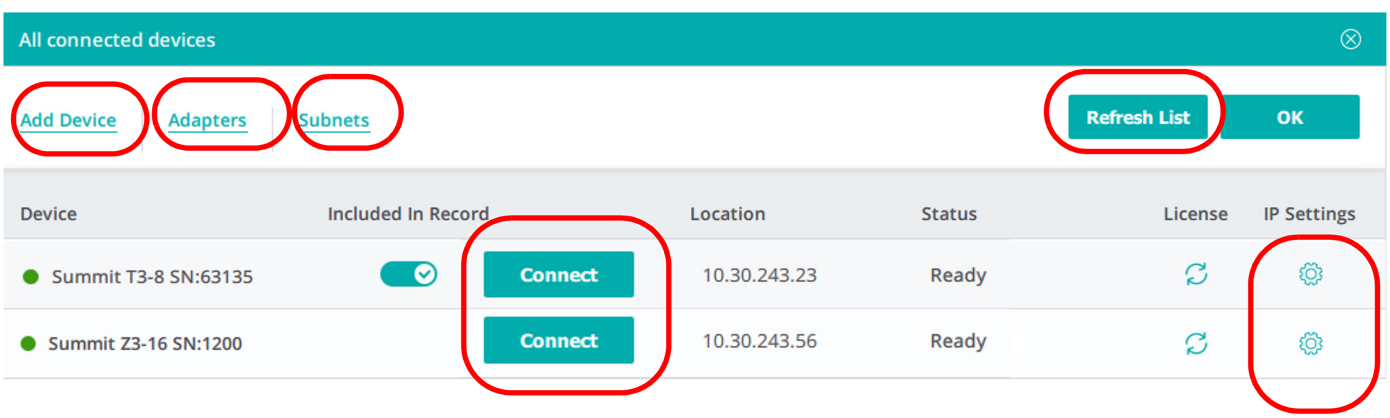


Figure 4.2: Dialog Box Showing All Devices Available on the Network

The All Connected Devices dialog box allows you to:

- Add a device (see Figure 4.3)
- Check on the adapter you are using
- Add Subnets to the network you are using
- Refresh the List of Devices
- Update IP Setting
- Check on the License for the device
- Include or excluded an Analyzer in the test process
- Connect to Analyzers and Exercisers to start using LinkExpert

Note: All of these topics are covered in much more detail in the User Manual for the specific Analyzer or Exerciser in use.

4.4.1.1 Add Device

When you select this tab the following dialog box displays, allowing you to add other devices to your test set. See Figure 4.3.

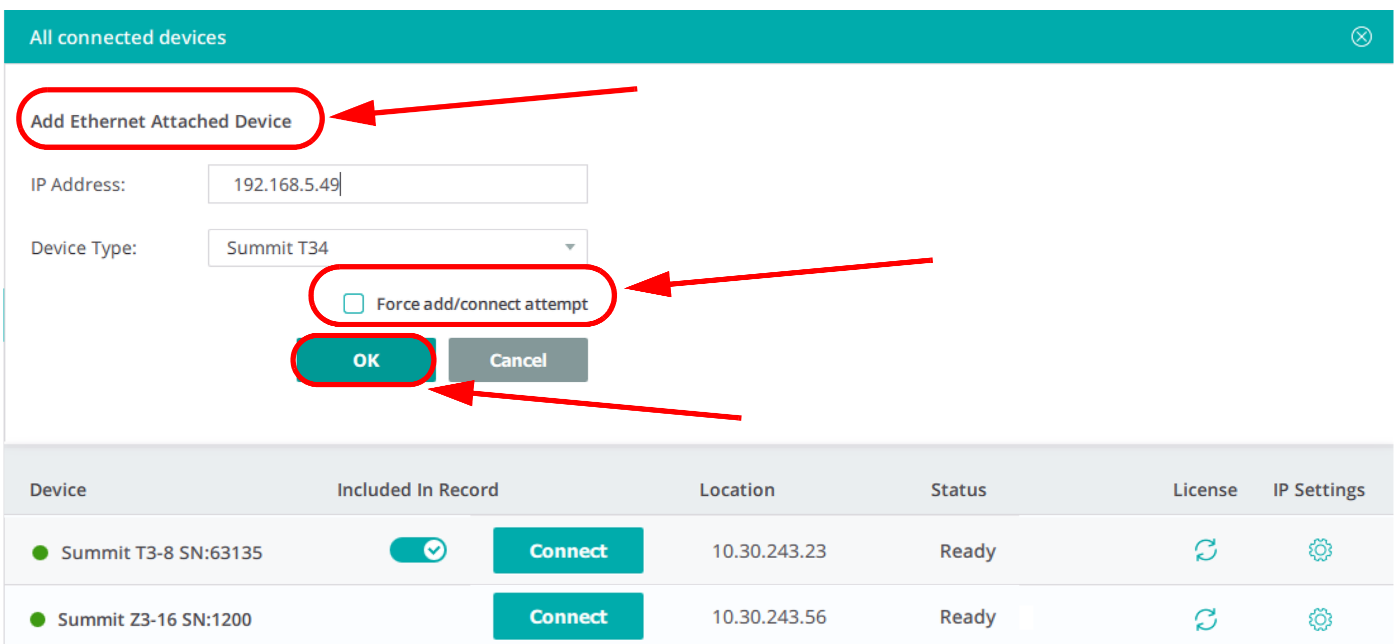


Figure 4.3: Add Device Dialog Box

4.4.1.2 Check Adapter

The **Check Adapter** tab displays information about the Adapter in use. See Figure 4.4.

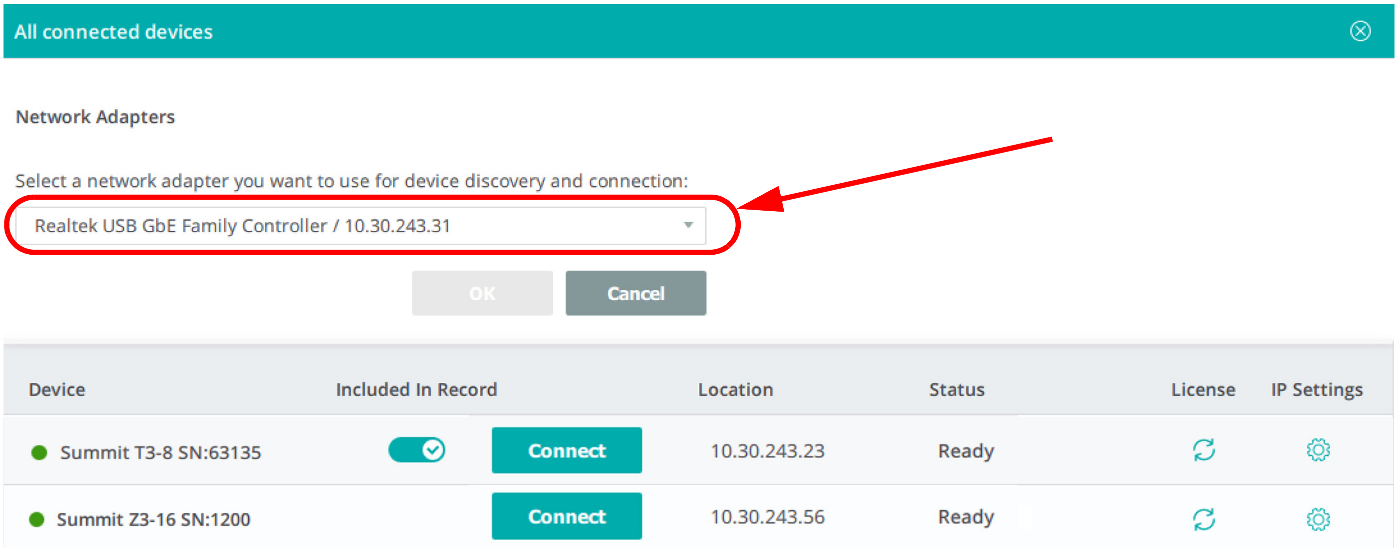


Figure 4.4: Check Adapter

4.4.1.3 Add Subnet

If you want to add a subnet to the system under test, select the **Add Subnet** tab. The **All connected devices** dialog box displays. See Figure 4.5.

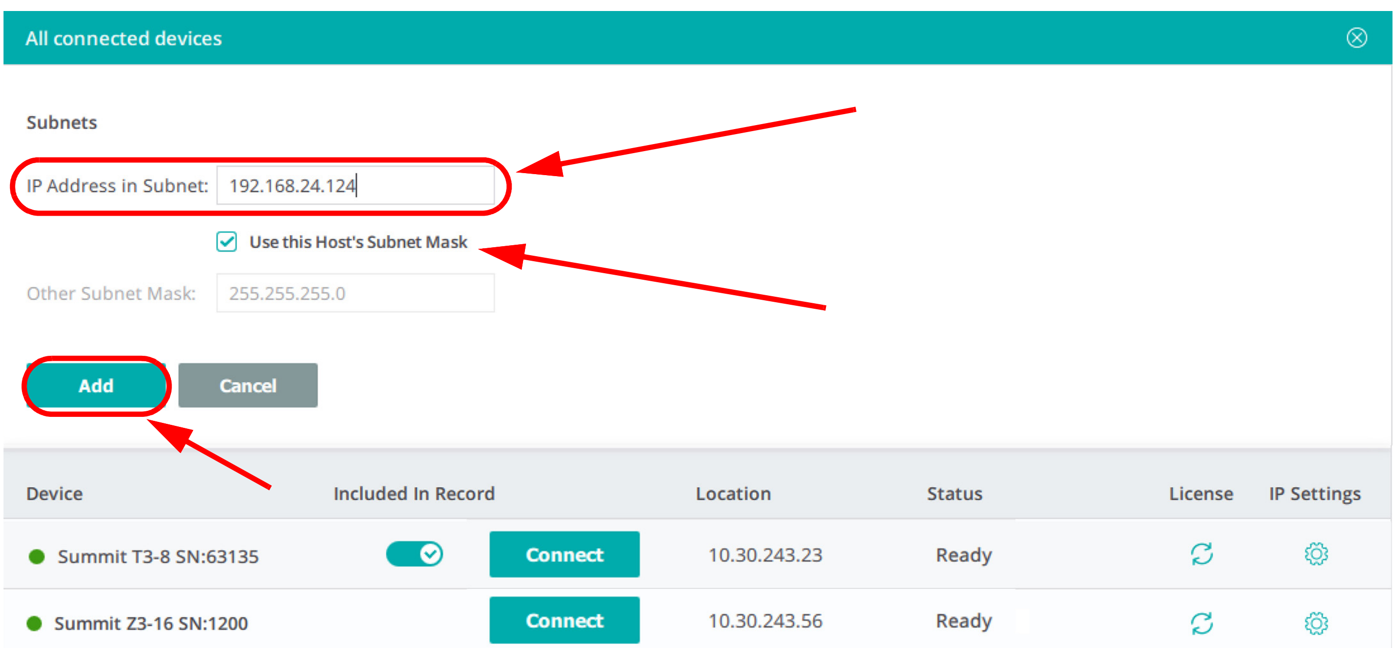


Figure 4.5: Add Subnet to System Under Test

4.4.1.4 Example: T3-8 Analyzer with Z3-16 Exerciser

For this example, the network "sees" both a Summit T3-8 Analyzer and a Z3-16 Exerciser. Let's connect to both using LinkExpert. See Figure 4.6.

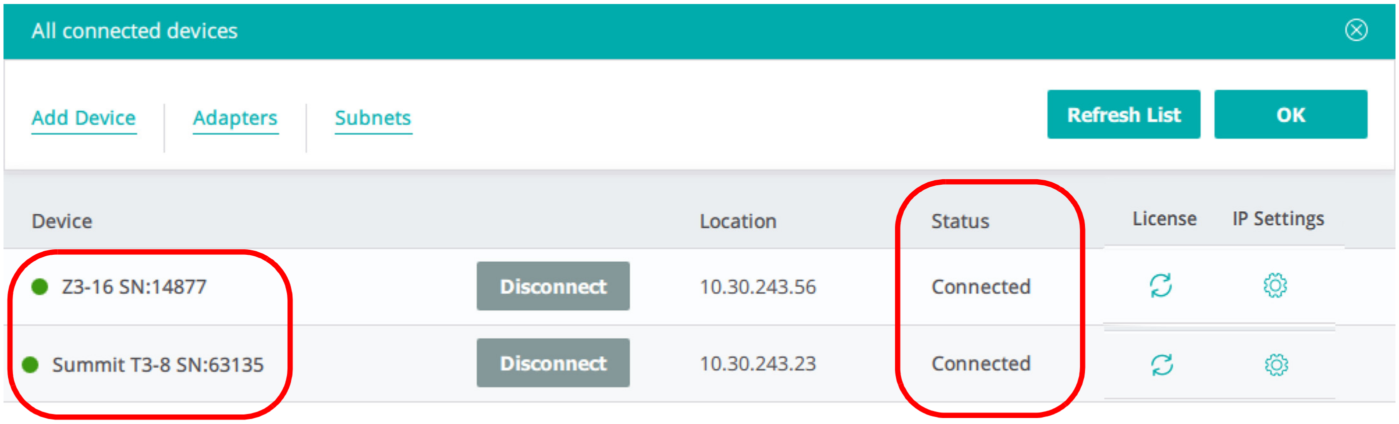


Figure 4.6: Connected to bothT3-8 and Z3-16

You'll notice the Status changes to "Connected" and the button in front of each device is green.

Click on OK to return to the Main Menu. You'll see that the Summit T3-8 and the Summit Z3-16 Exerciser are connected, but the Summit Z3-16 Exerciser is not in use. See Figure 4.7.

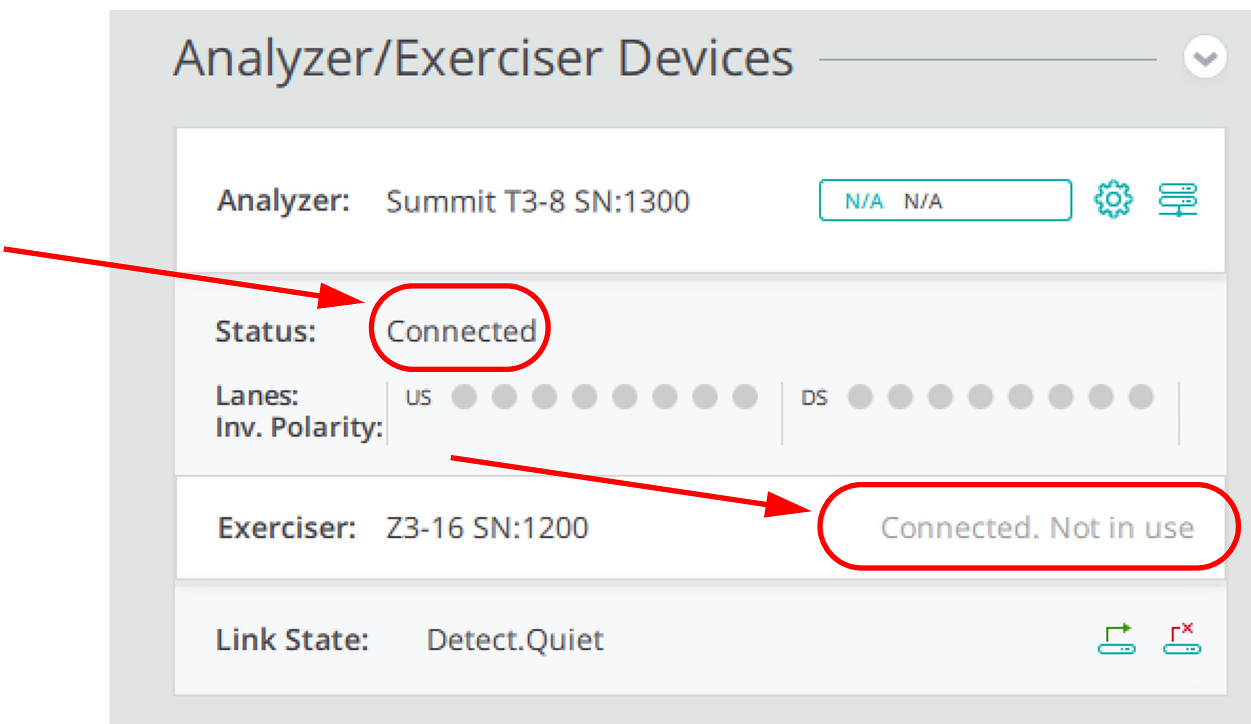


Figure 4.7: LinkExpert Main Menu: Analyzer

Once you load a set of tests, the Device pane updates. See Figure 4.8 on page 89.

4.4.2 Connecting Z3-16

If you select the PCIe 3.0 Compliance Package Tests, then the Z3-16 will be displayed in the Devices pane of the LinkExpert Main Menu (see Figure 4.8). The Z3-16 is currently disconnected and in the Detect.Quiet State.

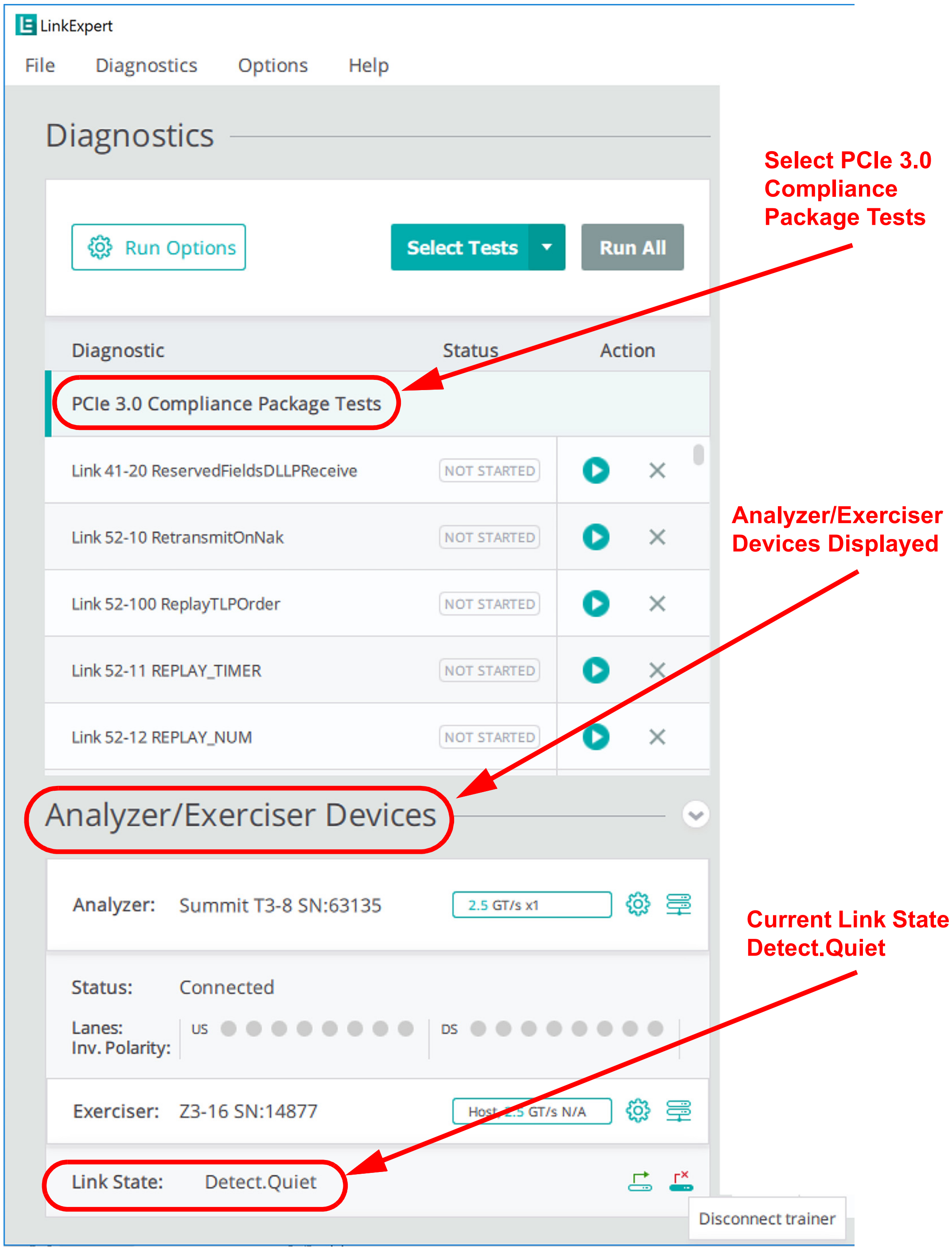


Figure 4.8: PCIe 3.0 Compliance Tests Selected: Summit T-8 and Z3-16 Shown in Devices

To start the PCIe 3.0 Compliance Package Tests you want the Z3-16 to be connected and in state L0. To do this select the Connect Icon at the bottom of the screen. See Figure 4.9.

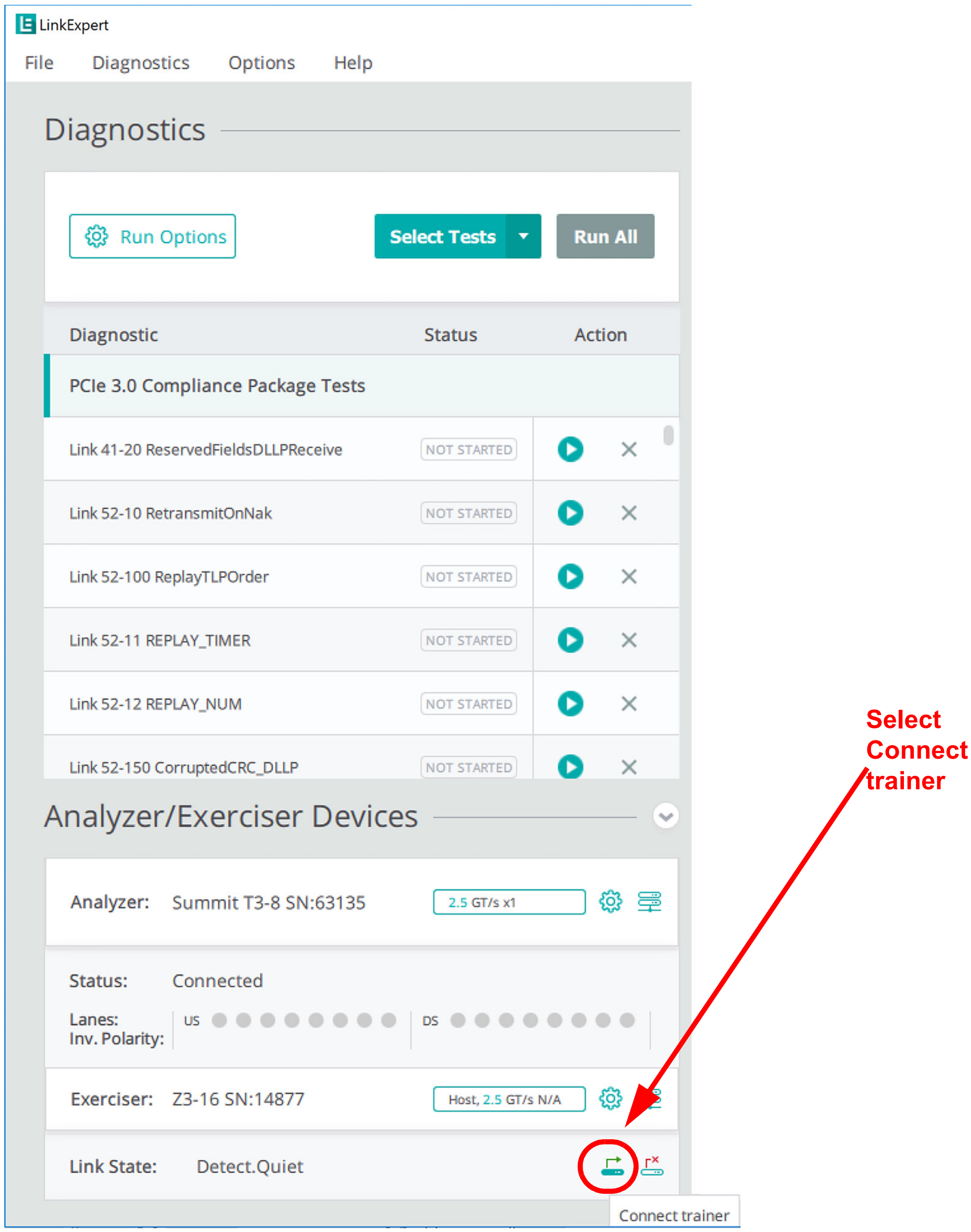


Figure 4.9: PCIe 3.0 Compliance Tests Selected: Z3-16 Shown in Devices: Ready to Connect

Once you have clicked on the Connect trainer icon, the Link State will change to L0 and you'll be ready to run the PCIe 3.0 Compliance Tests. See Figure 4.10.

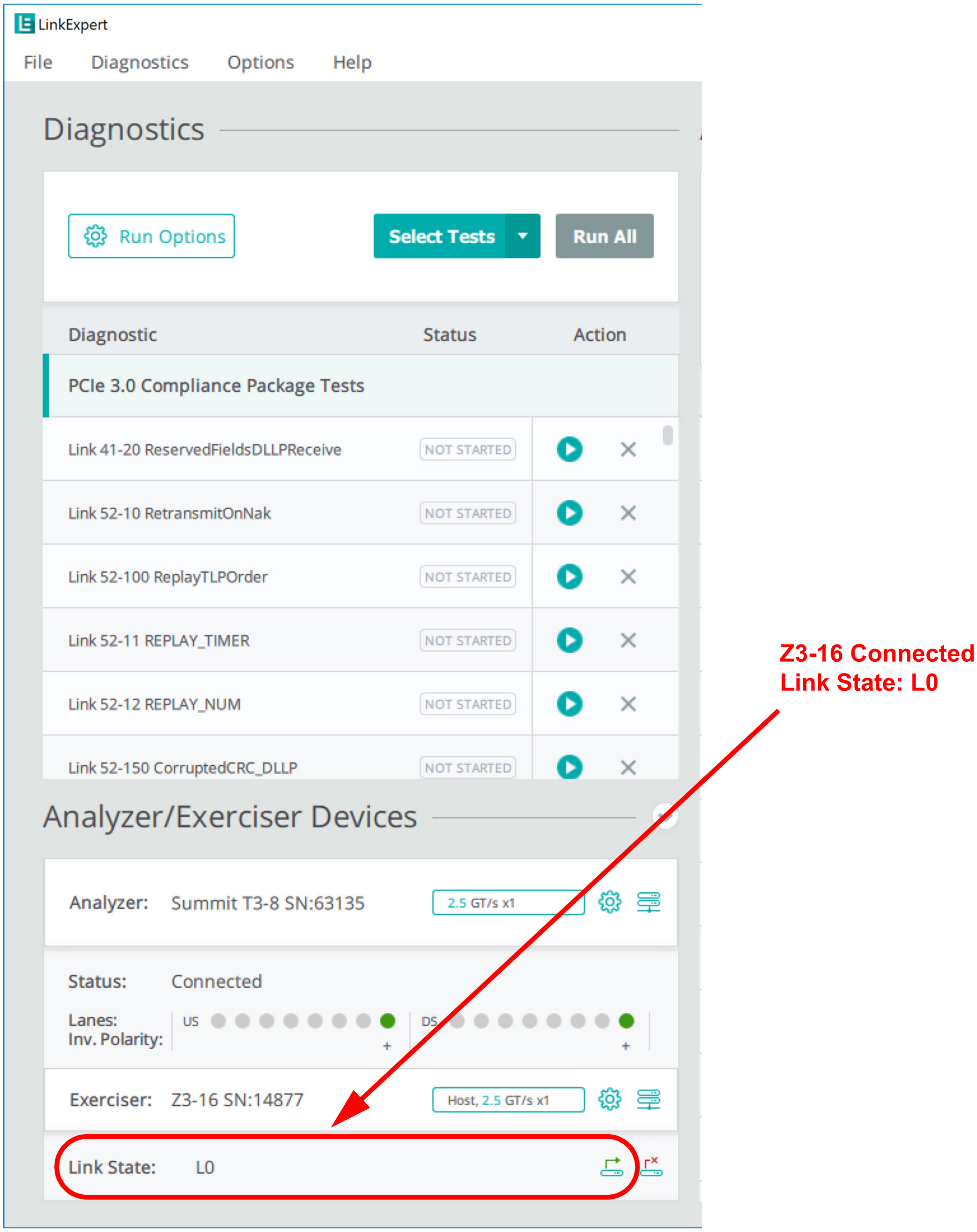


Figure 4.10: PCIe 3.0 Compliance Tests Selected: Trainer Connected -> L0 State

4.4.3 Z416 Exerciser / T416: Example

If you have a Z416 Analyzer/Exerciser attached as well as a T416 attached you'll get the following warning messages. See Figure 4.11.

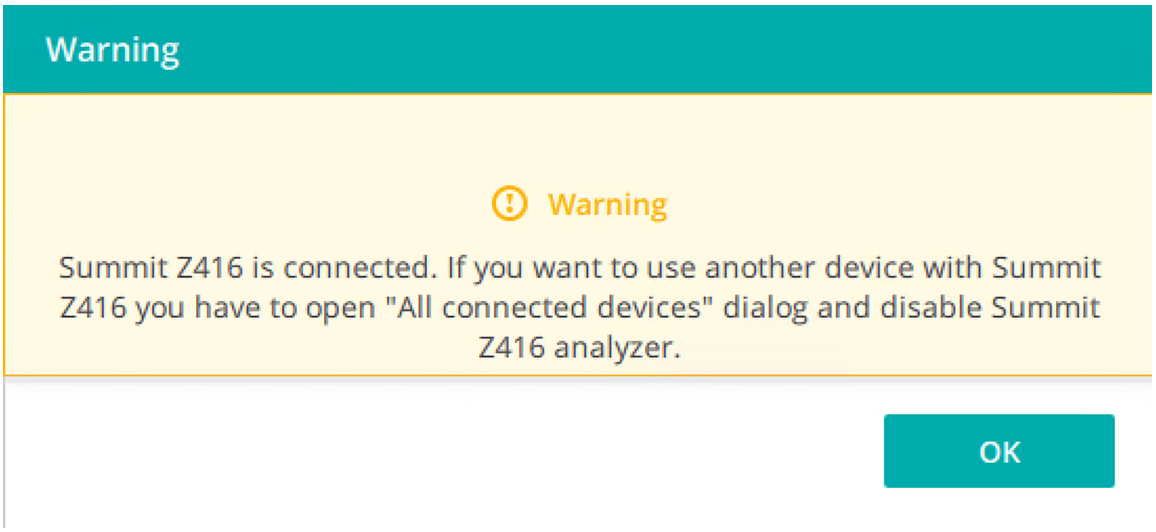


Figure 4.11: Z416 Warning Message

A similar message is shown in the Analyzer Device pane of the LinkExpert main menu. See Figure 4.12.

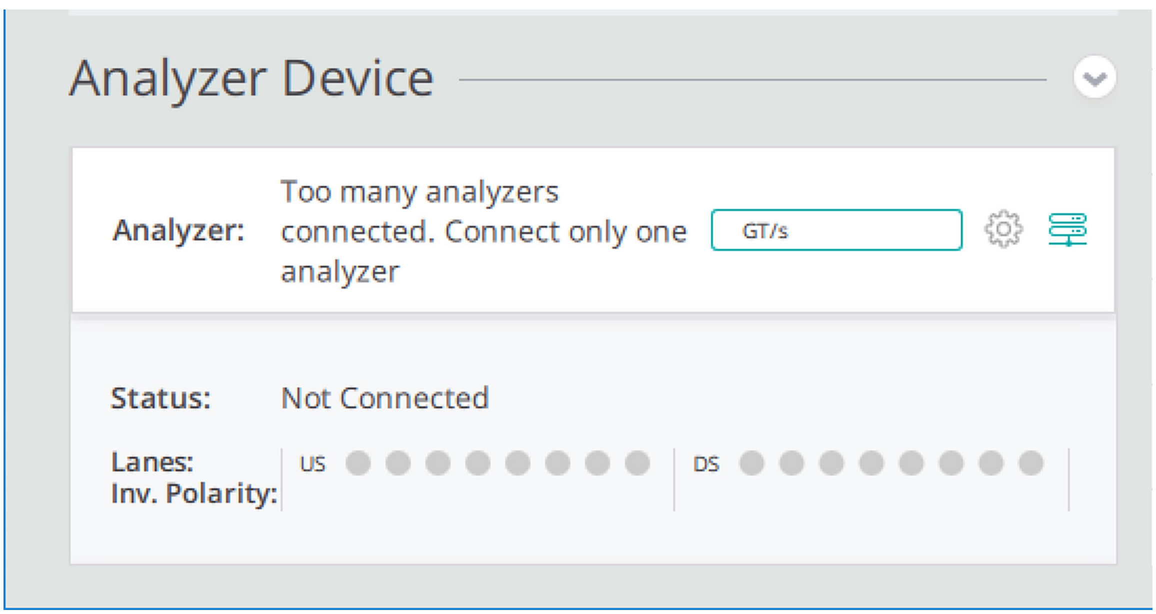


Figure 4.12: Warning Message: Too Many Analyzers Attached

Since the Z416 can act as both an Analyzer and an Exerciser you need to use only the Exerciser functionality. To do this click on the All Connected Devices icon (see Figure 4.13 on page 93).

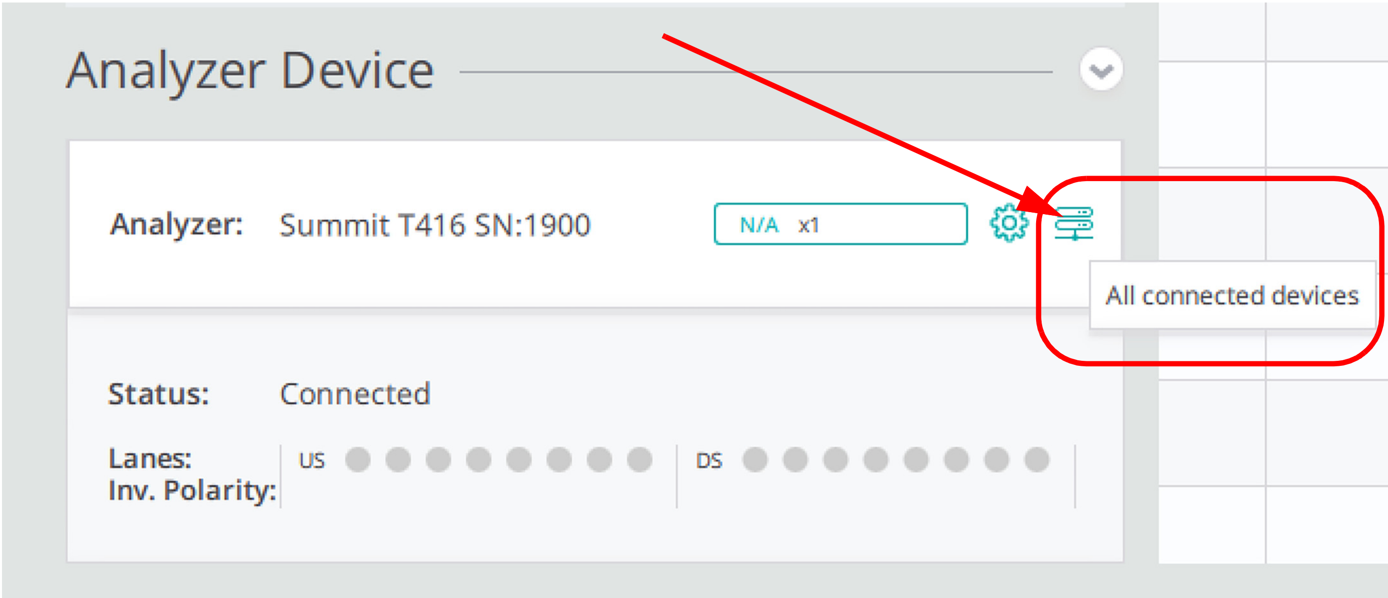


Figure 4.13: All Connected Devices with Tooltip

4.4.3.1 T416: All Connected Devices

The dialog showing all the connected devices will pop up and slide the switch over so the Z416 is not included as a Recording Device (Analyzer). See Figure 4.14 on page 93.

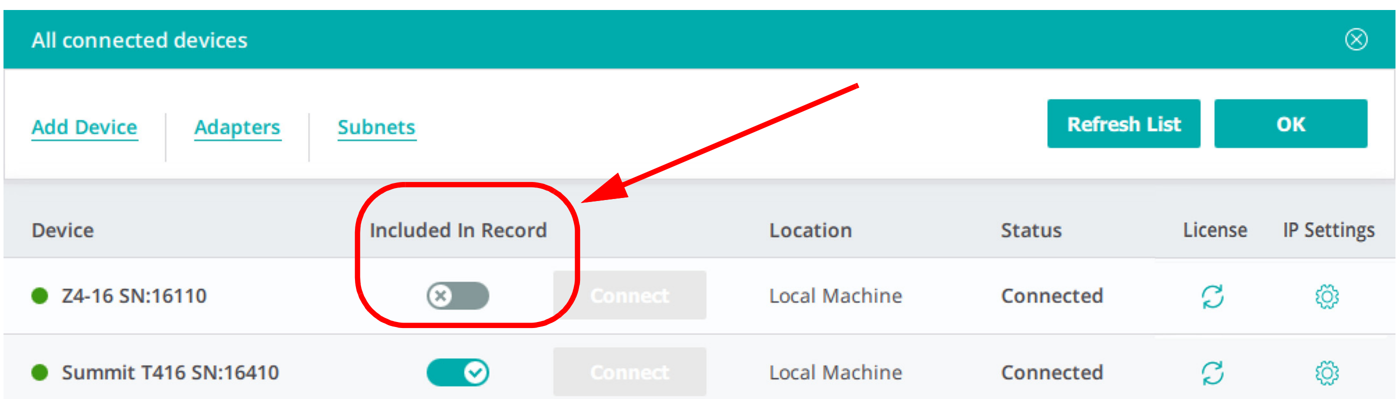


Figure 4.14: Slide Switch so Z416 not included as a Recording Device

Now hit “OK” and you’ll return to the main Link Expert dialog but the warning message will be gone.

If you select a set of tests that require the Z416 (such as the Validation (EndPoint) test set the Z416 will appear in the Analyzer/Exerciser pane (bottom left). See Figure 4.15 on page 94.

4.4.3.2 Z416 and T416 Connected

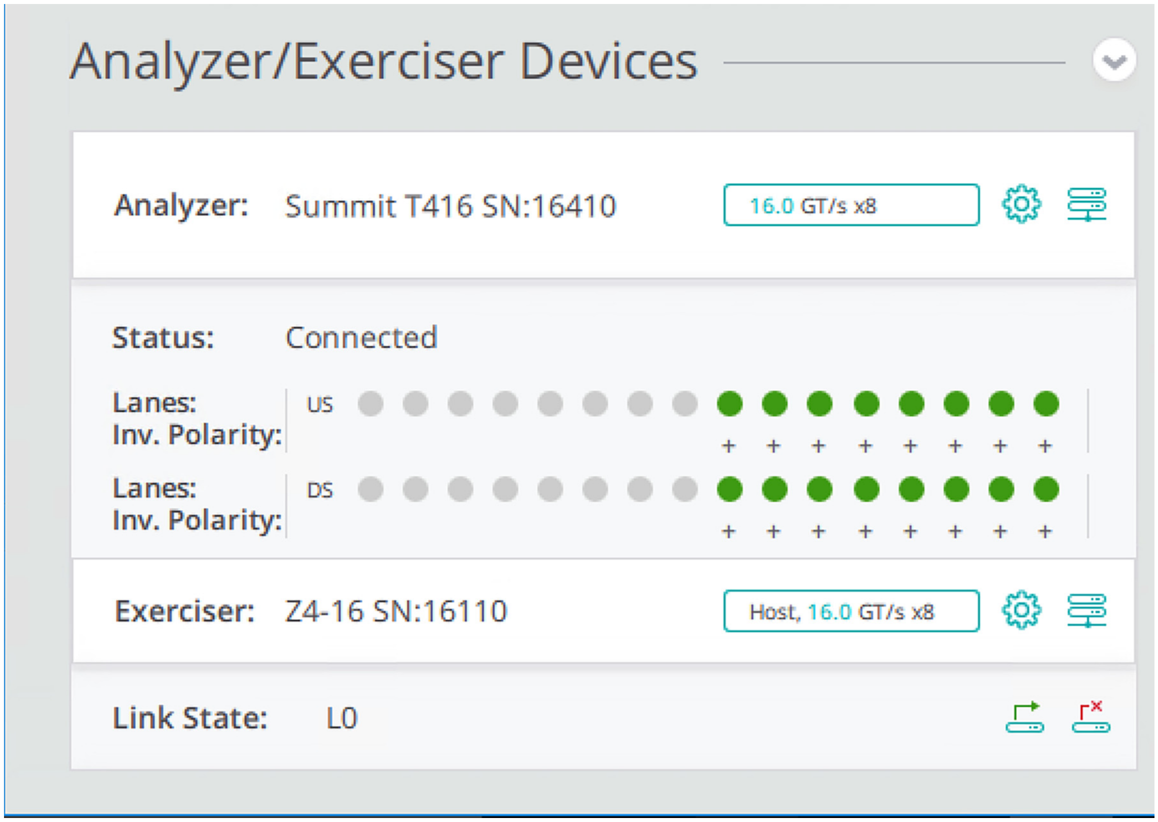


Figure 4.15: Analyzer/Exerciser with Z416 Connected

With the Z416 and T416 attached you can now run at up to 16 GT/s and a Link Width of up to x16. See Figure 4.16 on page 95 for the settings available with the Z416.

4.4.3.3 Z416 and T416 Settings

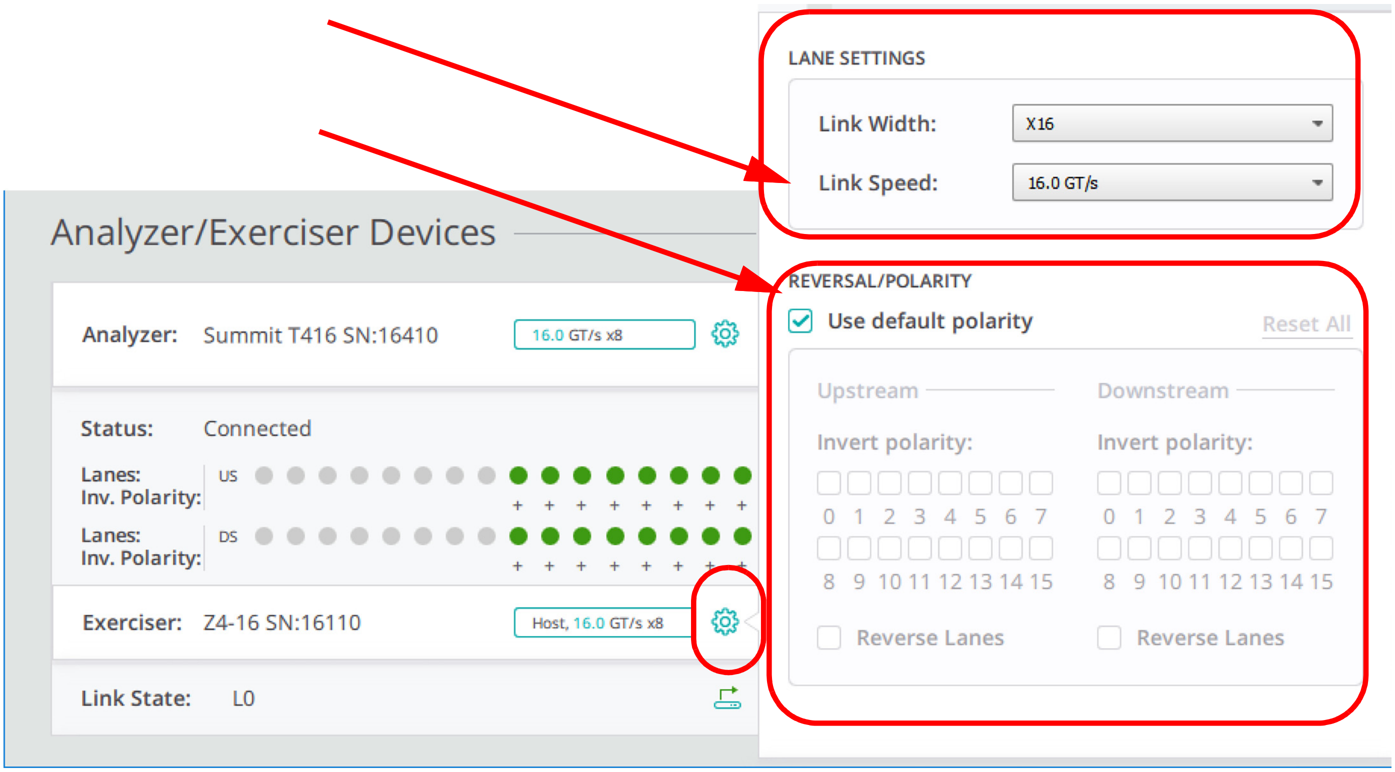


Figure 4.16: Setting Z416 to x16 Link Width and 16 GT/sec speed

With the Z416 you can set the following parameters:

- Lane Settings
  - Link Width (x1 to x16)
  - Link Speed (2.5 GT/s to 16.0 GT/s)
- Reversal/Polarity
  - Upstream
  - Downstream

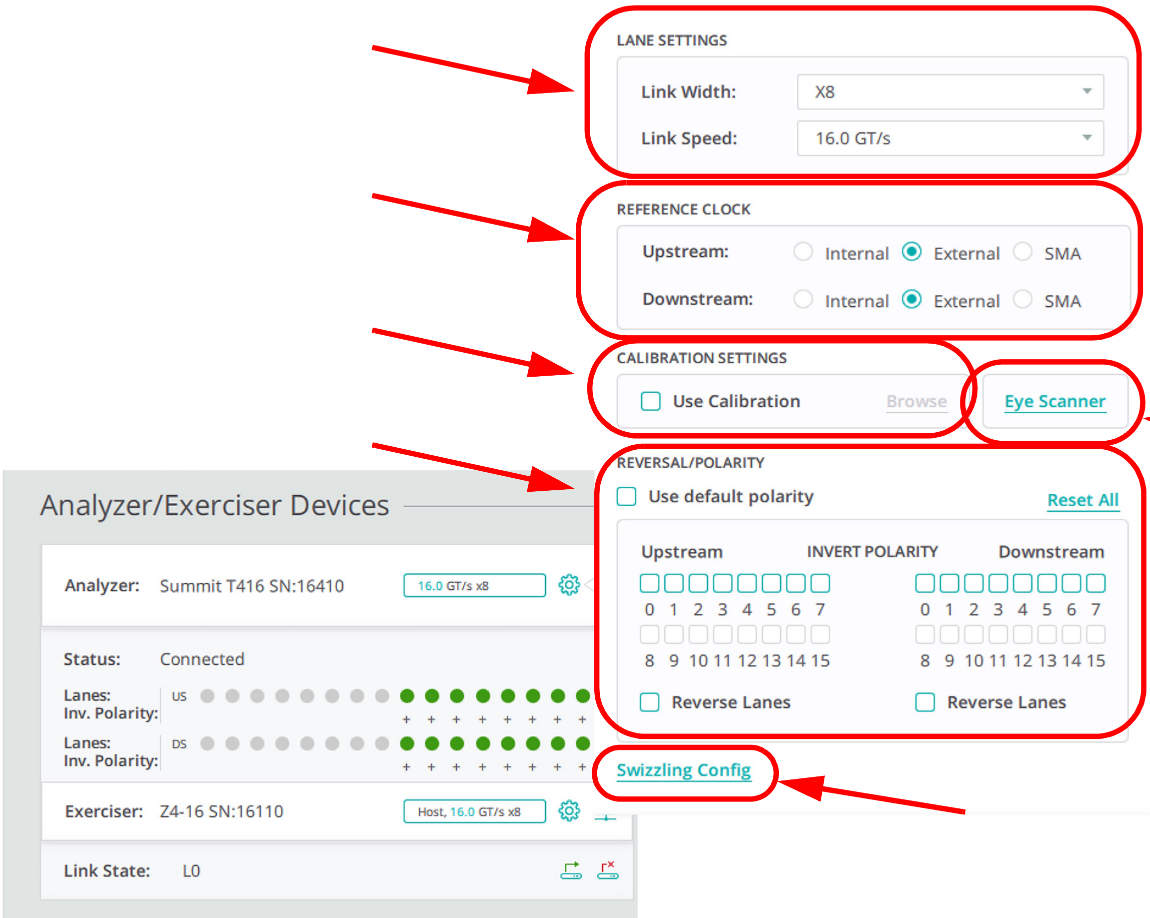


Figure 4.17: Settings Available for T416

With the T416 you can set the following parameters:

- Lane Settings
  - Link Width (x1 to x16)
  - Link Speed (2.5 GT/s to 16.0 GT/s)
- Reference Clock
  - Internal
  - External
  - SMA
- Calibration Settings (see“Probe Settings” on page 98)
- Eye Scanner (see “Eye Scanner” on page 100)
- Reversal/Polarity
  - Upstream
  - Downstream
- Swizzling Config (see “Swizzling Configuration” on page 103)

4.4.3.4 Probe Settings

You can "Use Calibration for Recording". If you click on browse, the Probe Settings dialog will pop up (see Figure 4.18).

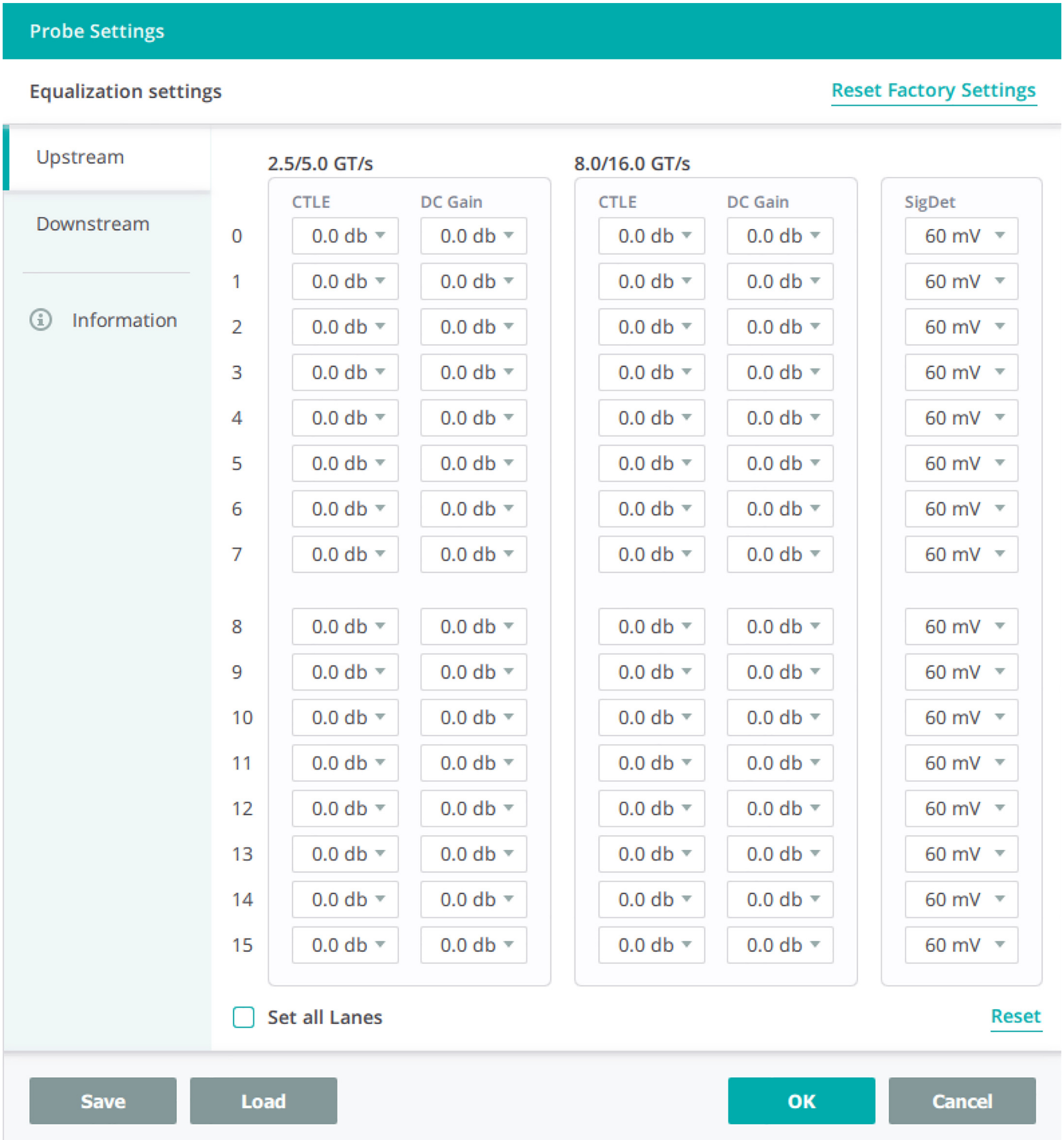


Figure 4.18: T416: Probe Settings

If you select the Information tab, you'll get a lot more information about the Probe Settings. See Figure 4.19.

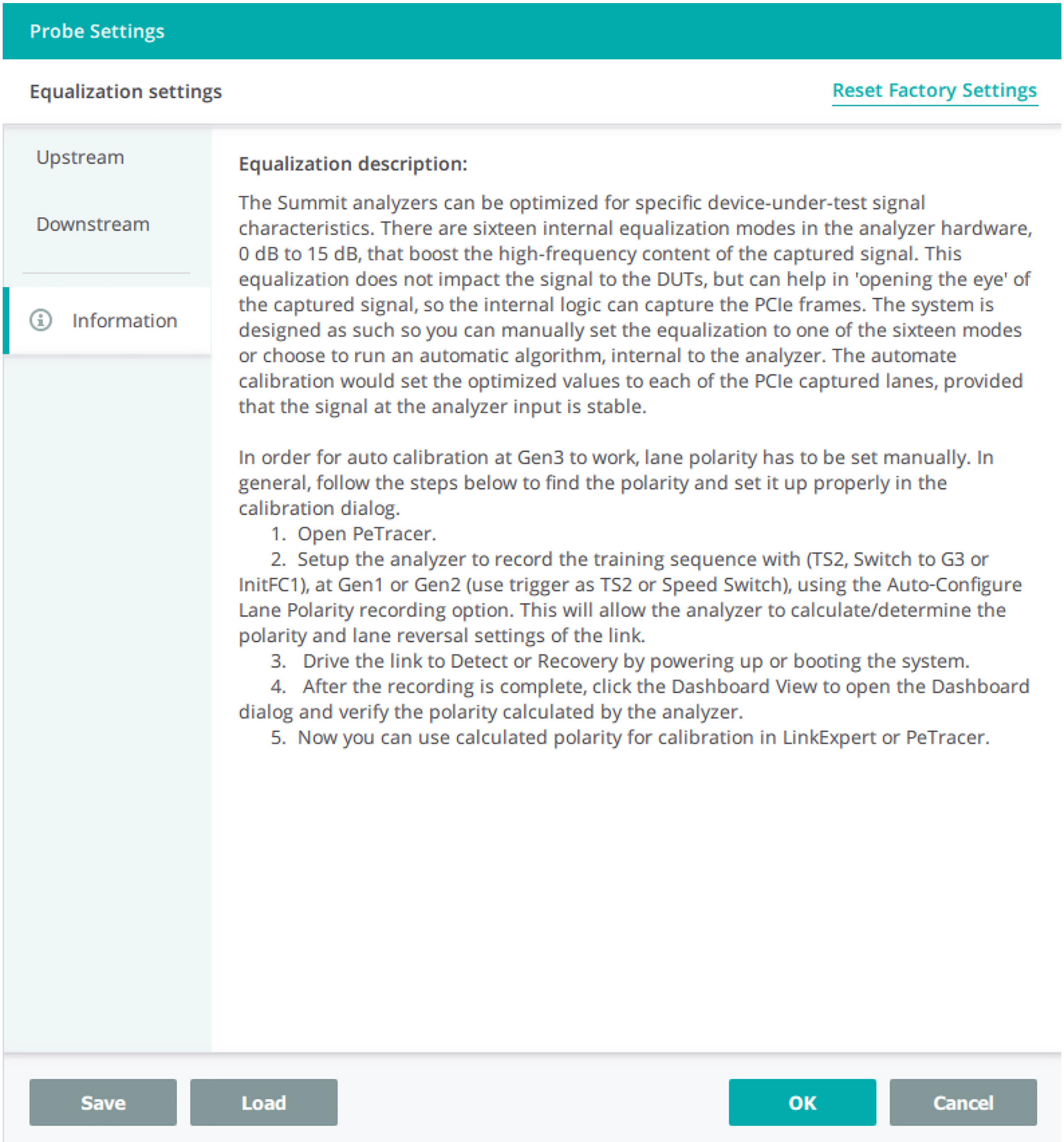


Figure 4.19: T416 Probe Settings: Information

4.4.3.5 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.

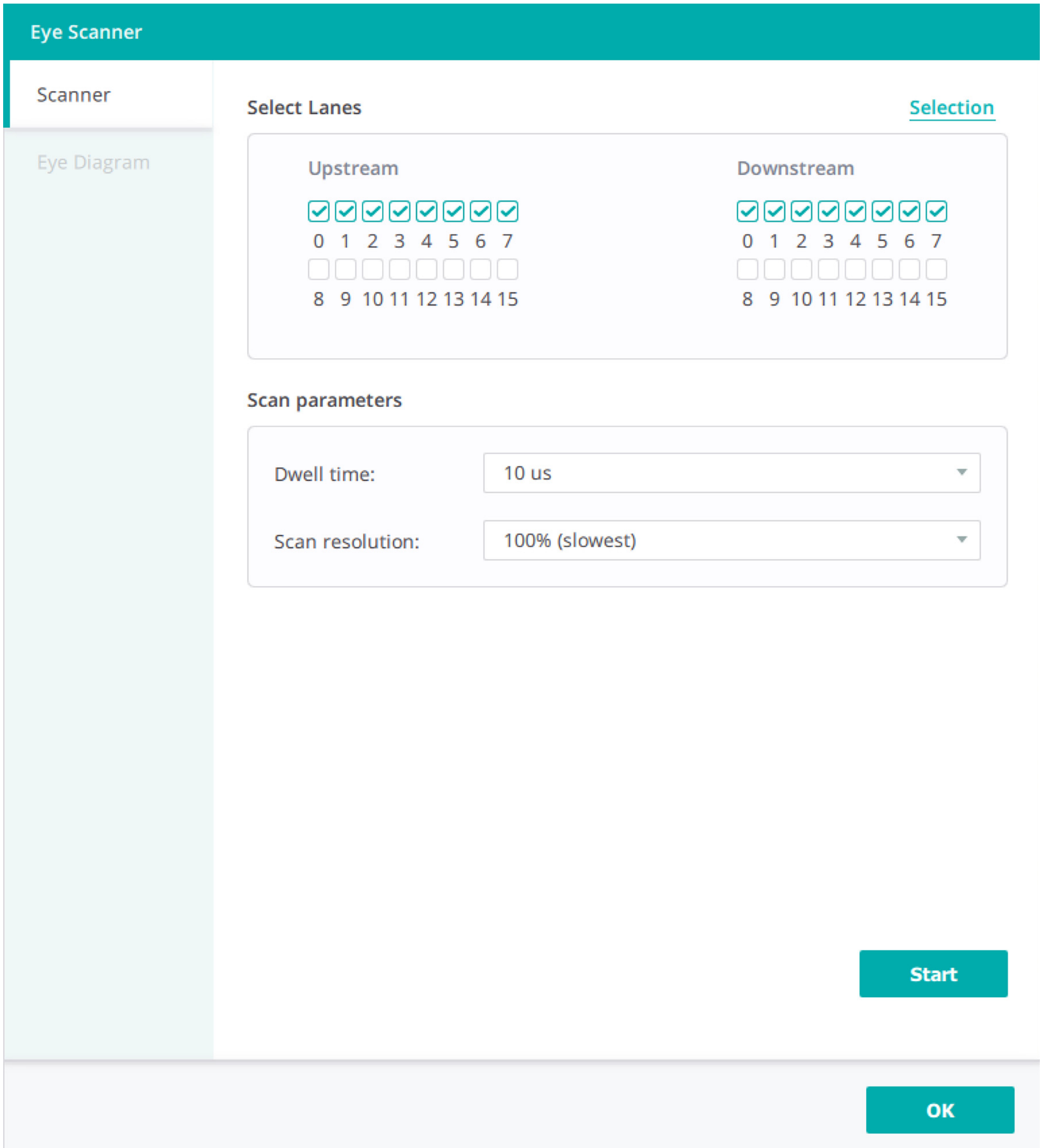
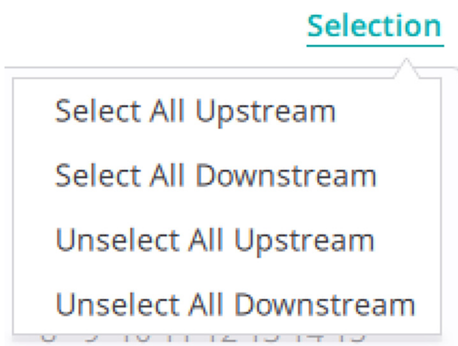


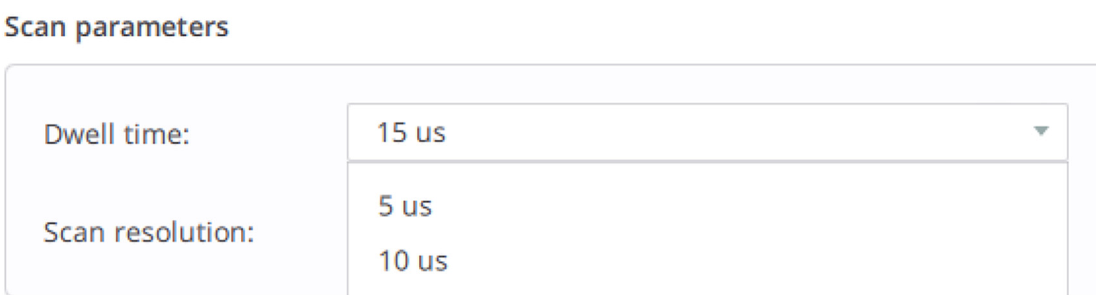
Figure 4.20: Eye Scanner Settings

You can select the following options:

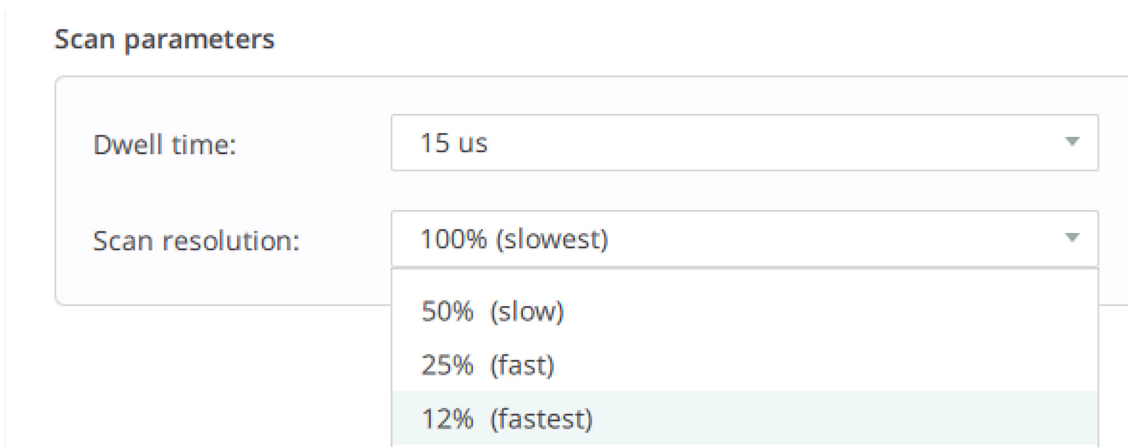
- ❑ Lanes to be scanned (Upstream/Downstream)

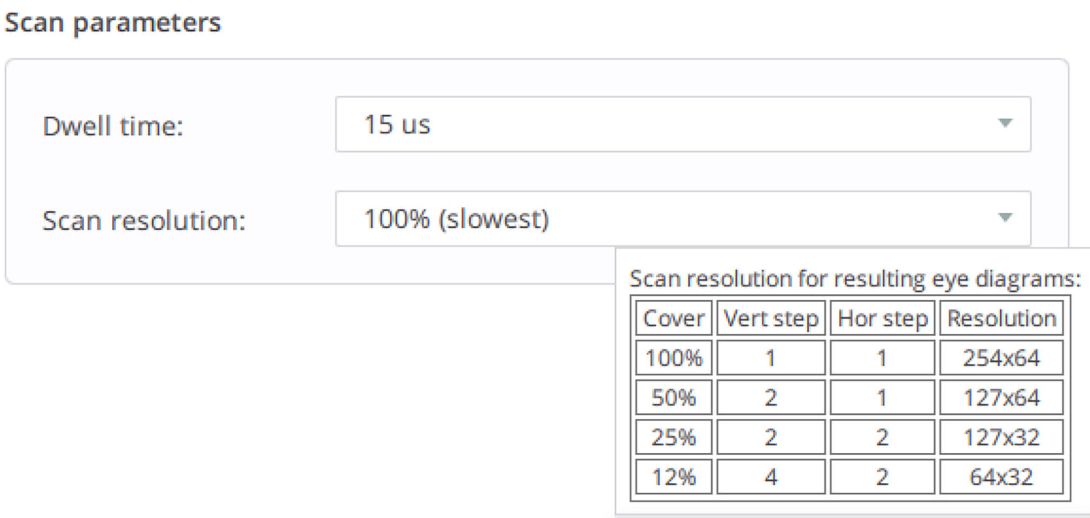


- ❑ Dwell Time (5/10/15 usec)



- ❑ Scan Resolution (Slowest to Fastest)





Cover	Vert step	Hor step	Resolution
100%	1	1	254x64
50%	2	1	127x64
25%	2	2	127x32
12%	4	2	64x32

4.4.3.6 Swizzling Configuration

The Swizzling Config dialog allows you to reconfigure the logical order of the lanes in a link separately for Upstream and Downstream PCIe directions. See Figure 4.21.

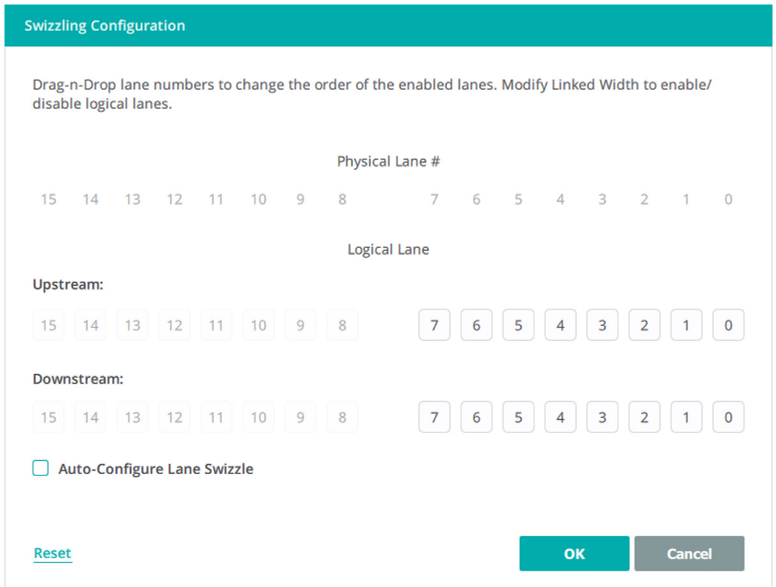


Figure 4.21: Swizzling Configuration Options: Default configuration

To move the lane assignments just drag and drop the lane number to new a location. See Figure 4.22.

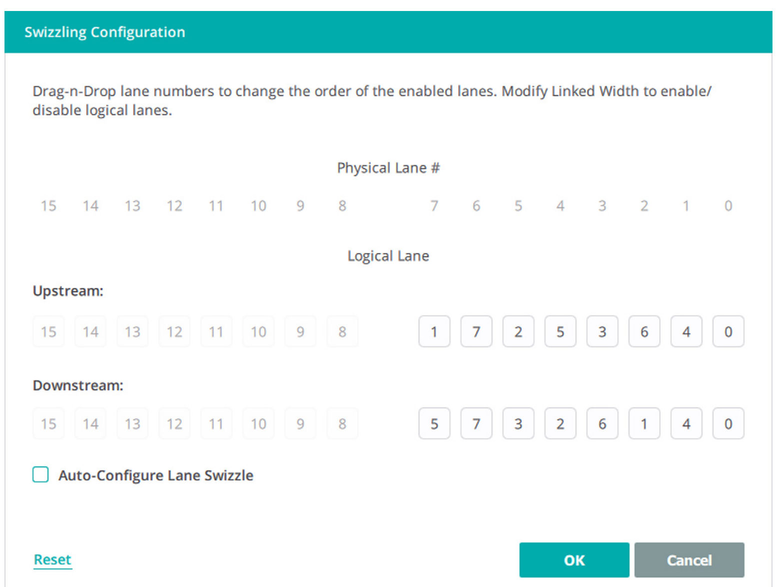


Figure 4.22: Swizzling Configuration Options: After Drag and Drop

4.4.4 T3-8 Analyzer / Z3-16 Exerciser Example

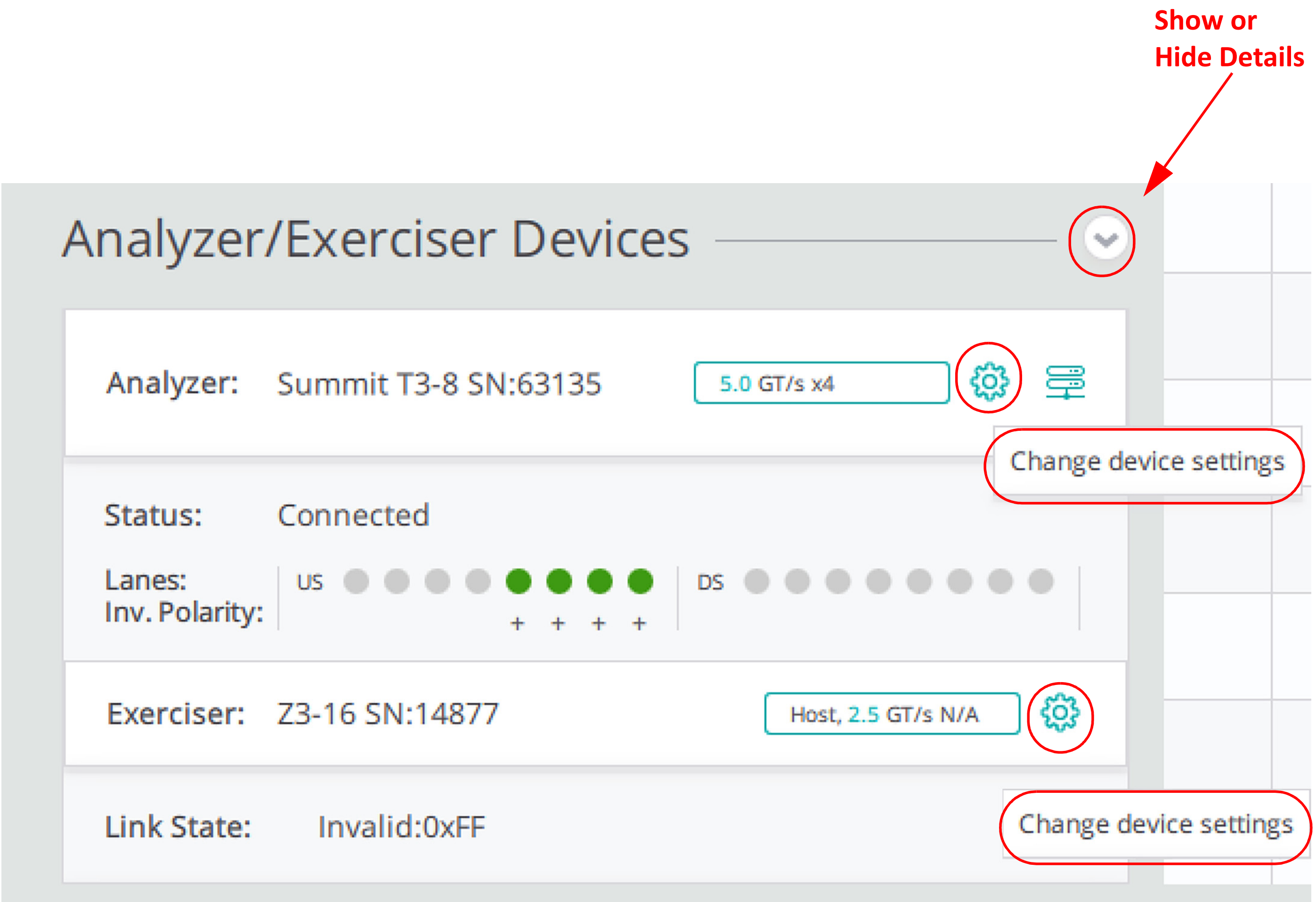


Figure 4.23: Analyzer Device Connected: Summit T3-8 Analyzer and Z3-16 Exerciser

There are also gear symbols to change the settings of the T3-8 Analyzer and the Z3-16 Exerciser. See Figure 4.24 on page 105

4.4.4.1 Change Device Settings: Z3-16

Reference Clock Setting

For the analyzer in use you can select the source of the Reference Clock. This varies depending on the analyzer being used. The options for the T3-8 analyzer are shown above. See Figure 4.24.

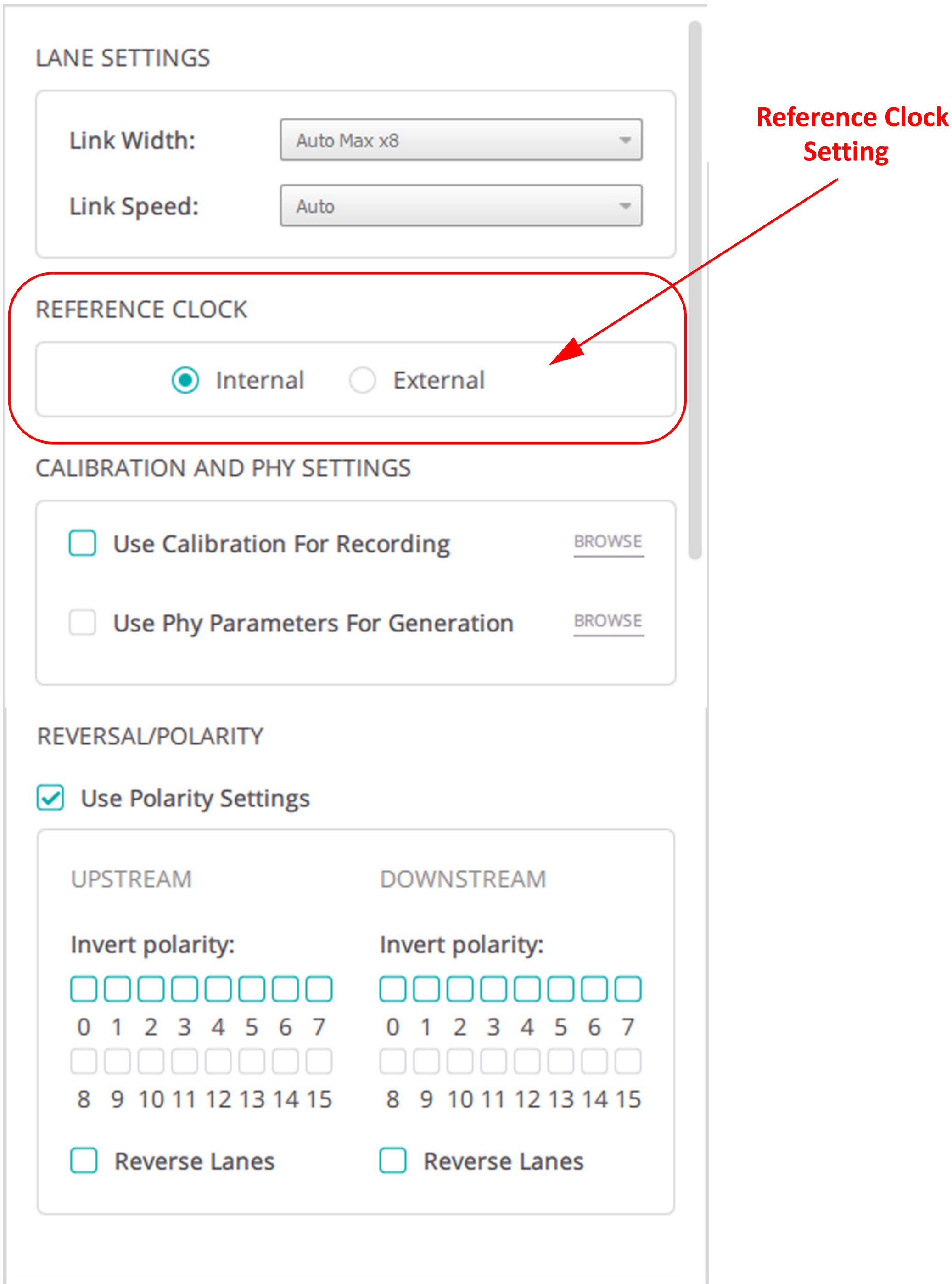


Figure 4.24: Options for Settings of T3-8 Analyzer

Other Settings

You can change the following analyzer/exerciser settings:

- Lane Settings
  - Link Width: x1, x2, x4, x8, Auto Max x2, Auto Max x4, Auto Max x8
  - Link Speed: Auto, 2.5 GT/s, 5.0 GT/s, 8.0 GT/s
- Reference Clock
  - T316: External Clock
  - T3-8: Internal or External
  - T34: Internal, External or SMA
  - T28: Internal, External or SMA
  - T24: Internal or External
- Calibration/Phy Settings
  - Use Calibration for Recording (Browse for file - analyzer only)
  - Use Phy Parameters for Generation (Browse for file - exerciser only)
- Reversal/Polarity Settings
  - Use Polarity Settings
    - Upstream
      - Invert polarity
      - Select lanes to Invert
      - Reverse Lanes
    - Downstream
      - Invert polarity
      - Select lanes to Invert
      - Reverse Lanes

4.4.4.2 Use Calibration for Recording

You can also set a number of optional Probe Settings by selecting the "Use Calibration for Recording" check-box and then selecting "Browse". See Figure 4.25.

This will pop up the "Probe Settings" dialog box. See Figure 4.26 on page 108.

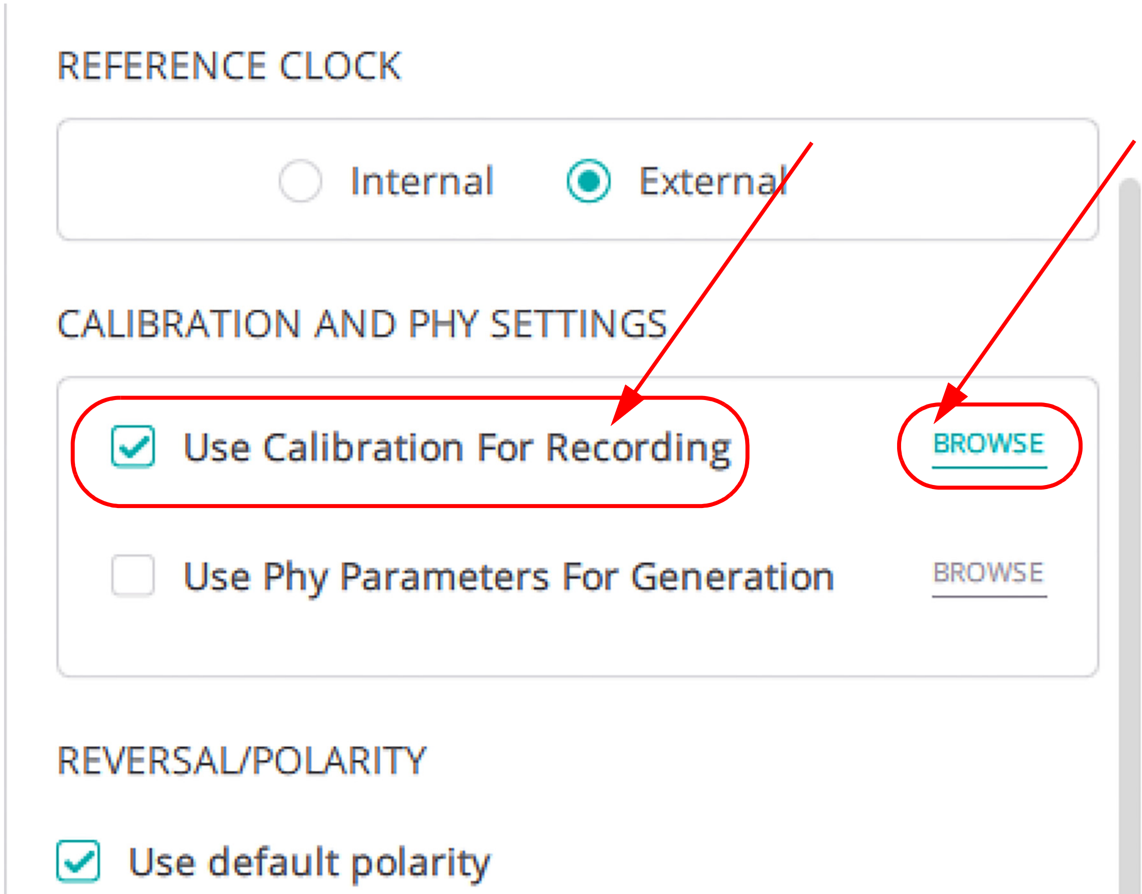


Figure 4.25: Use Calibration For Recording Dialog Box

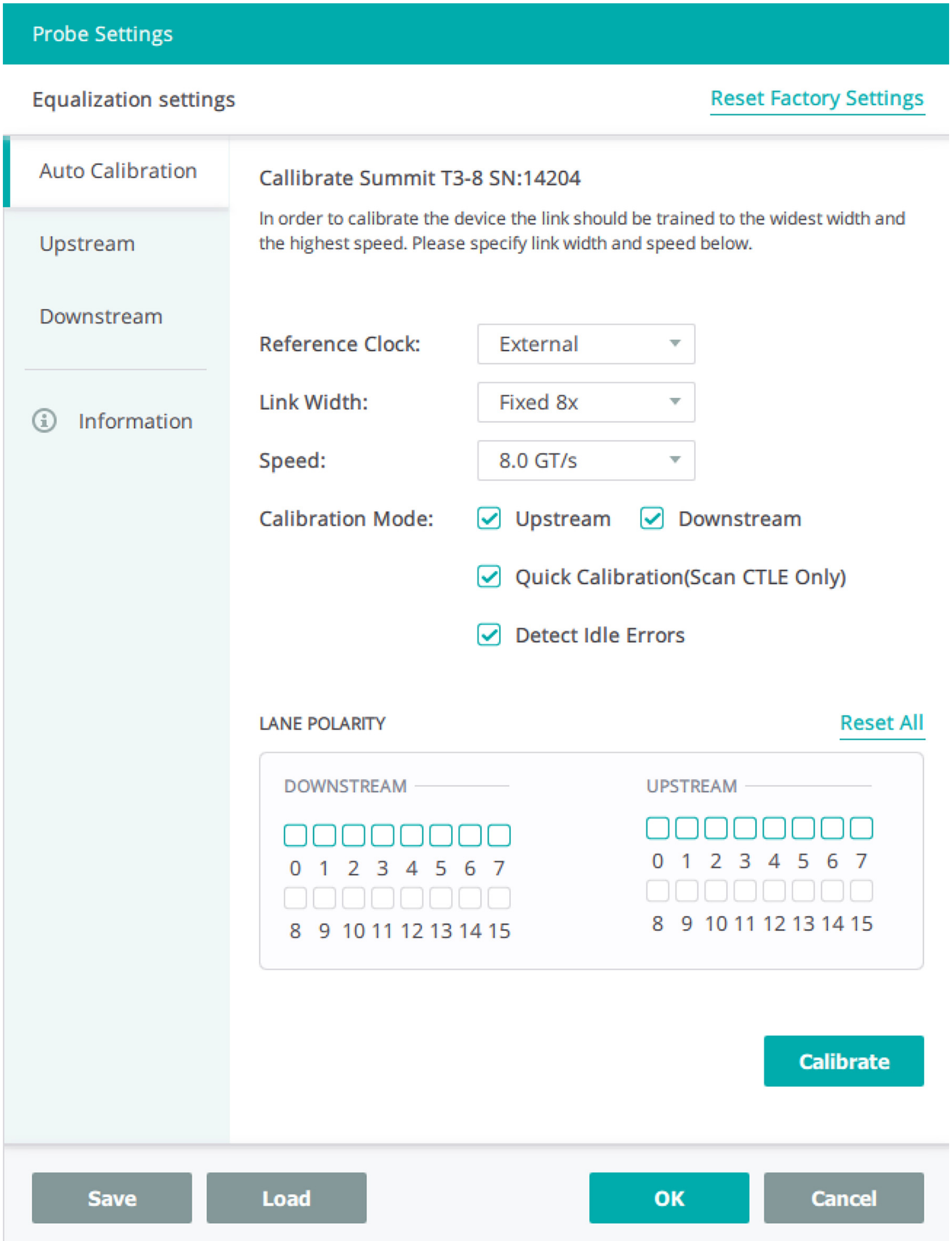


Figure 4.26: Probe Settings Dialog Box

Equalization Settings: Auto Calibration

Auto Calibration has the following options:

- Reference Clock: External or Internal

- Link Width: Fixed x8, Fixed x4, Fixed x2 or Fixed x1
- Speed: 8.0 GT/sec, 5.0 GT/sec or 2.5 GT/sec
- Calibration Mode: Upstream, Downstream, Quick Calibration (CTLE Only), Detect Idle Errors
- Lane Polarity: Select inversion on individual lanes (with the option to Reset All)

You can also select:

- Start Calibration (after you’ve set the options): You’ll see a progress bar pop up. See Figure 4.27 on page 110
- Save Calibration Settings to a file
- Load Calibration Settings from a file
- Cancel
- OK

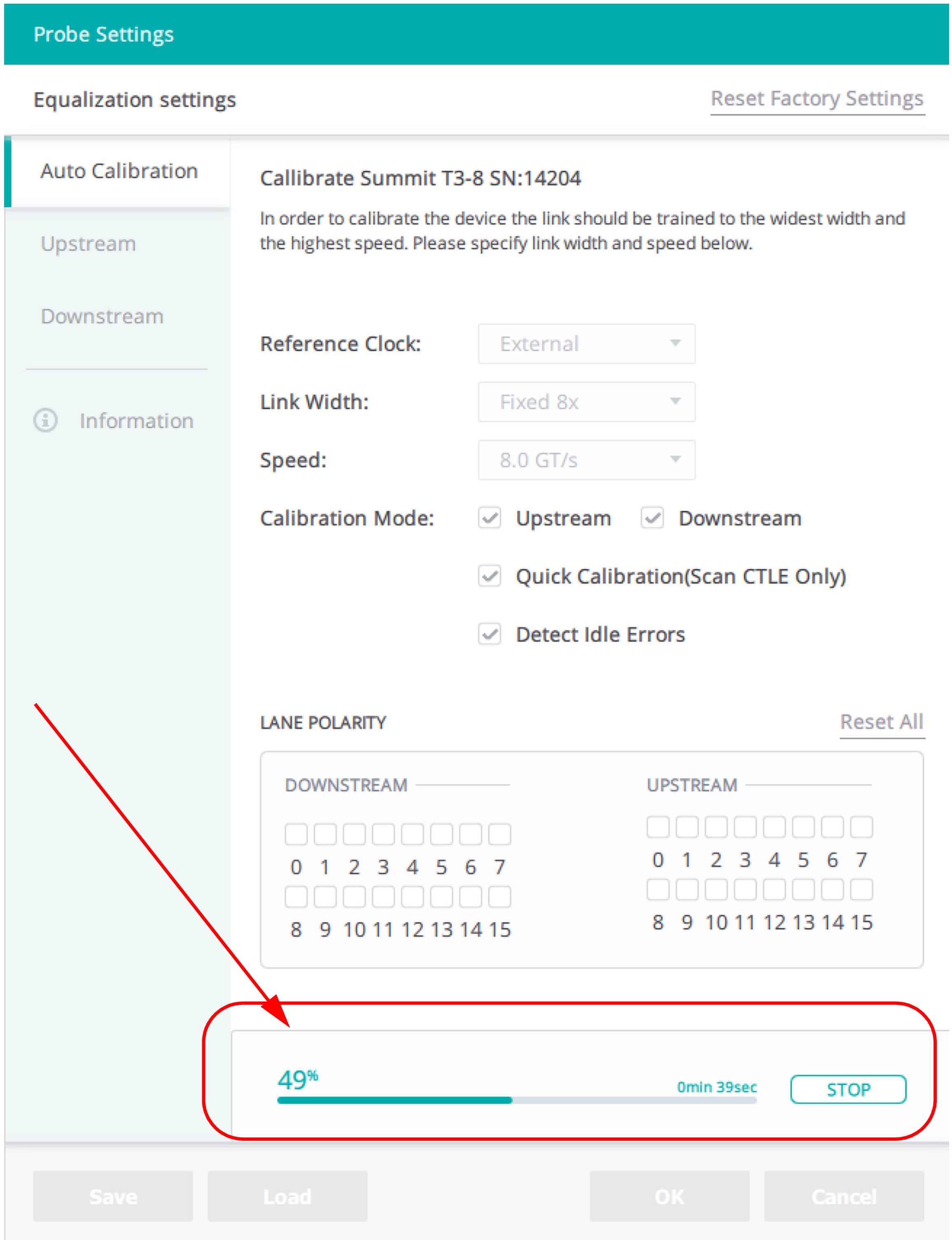


Figure 4.27: Calibration Running: Progress Bar

When Calibration Completes you should get the following message:

“Calibration Successfully Finished” see Figure 4.28 on page 111.

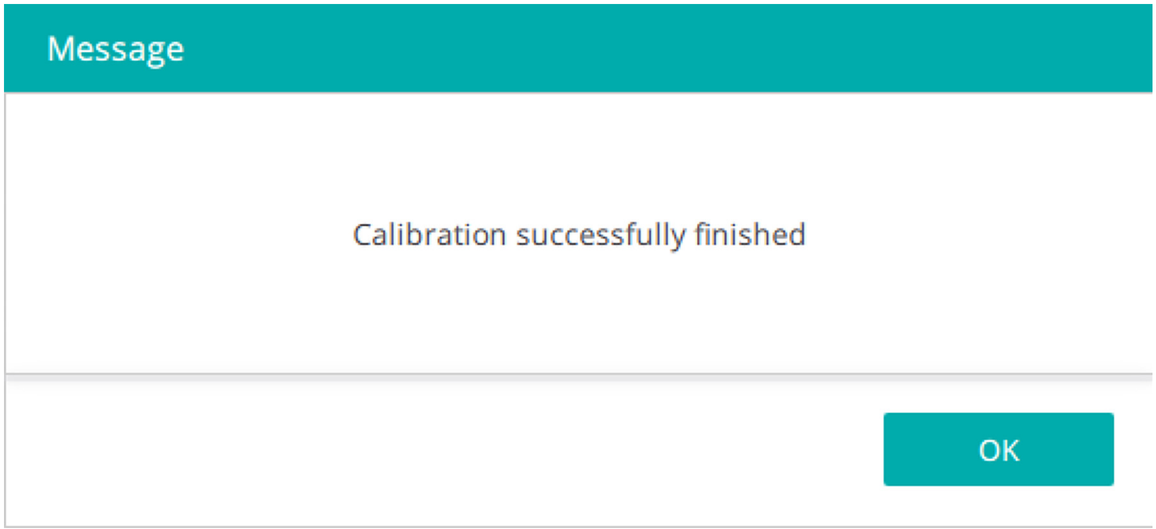


Figure 4.28: Calibration Finished Successfully message

Equalization Settings: Upstream

If you select the Upstream tab the following dialog box will pop up (see Figure 4.29).

This dialog box allows you to set the following options for each lane or all lanes:

- Continuous Time Linear Equalizer (CTLE): 2.5./5.0 GT/sec or 8.0 GT/sec
  - 0 to 15 db
- Decision Feedback Equalizer (DFE) Tap 1: 8.0 GT/sec
  - 0 to 7
- DC Gain: 8.0 GT/sec
  - None, 3 db, 6 db, 9 db or 12 db

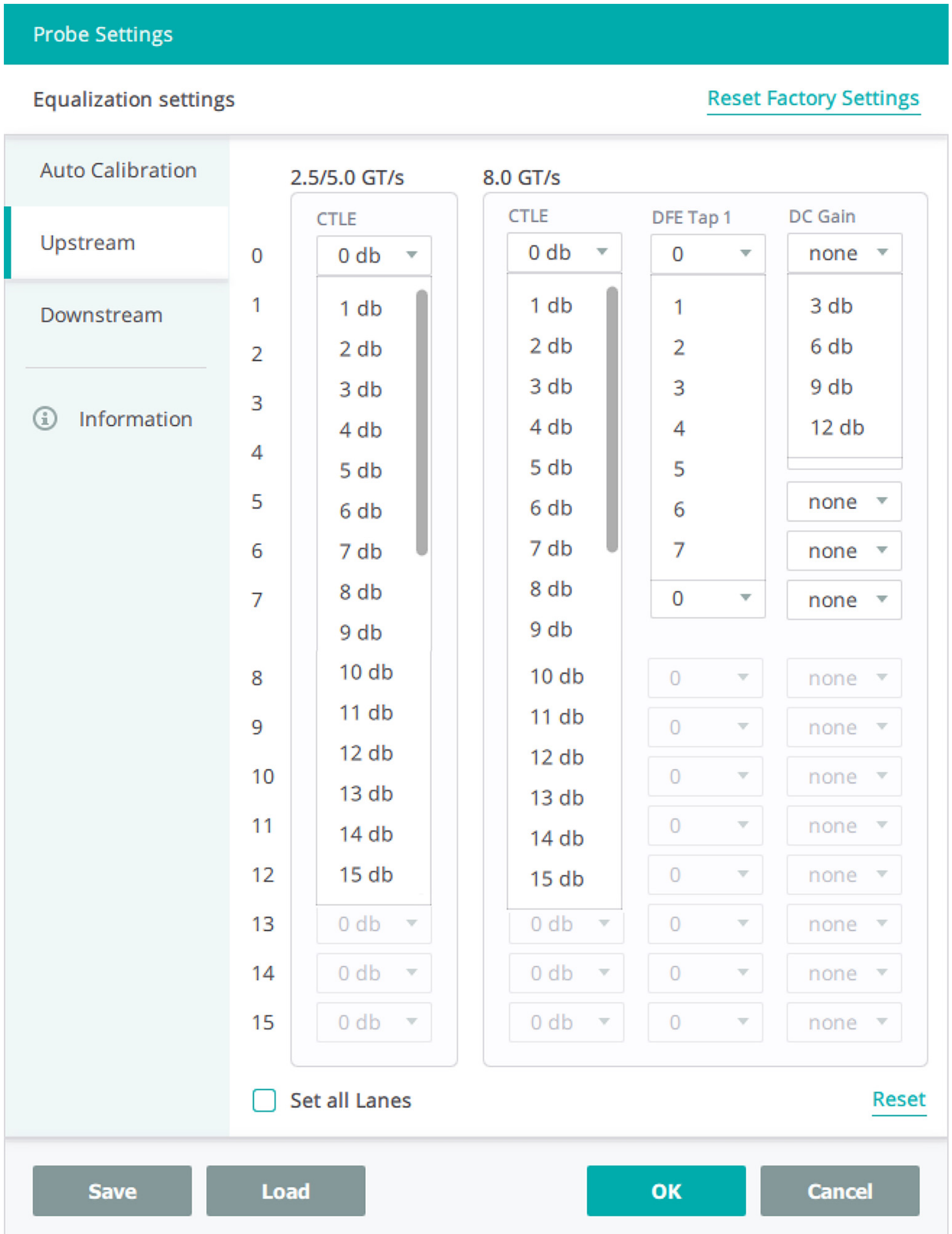


Figure 4.29: Equalization Settings: Upstream

Equalization Settings: Downstream

You have the same options for Downstream (see Figure 4.30).

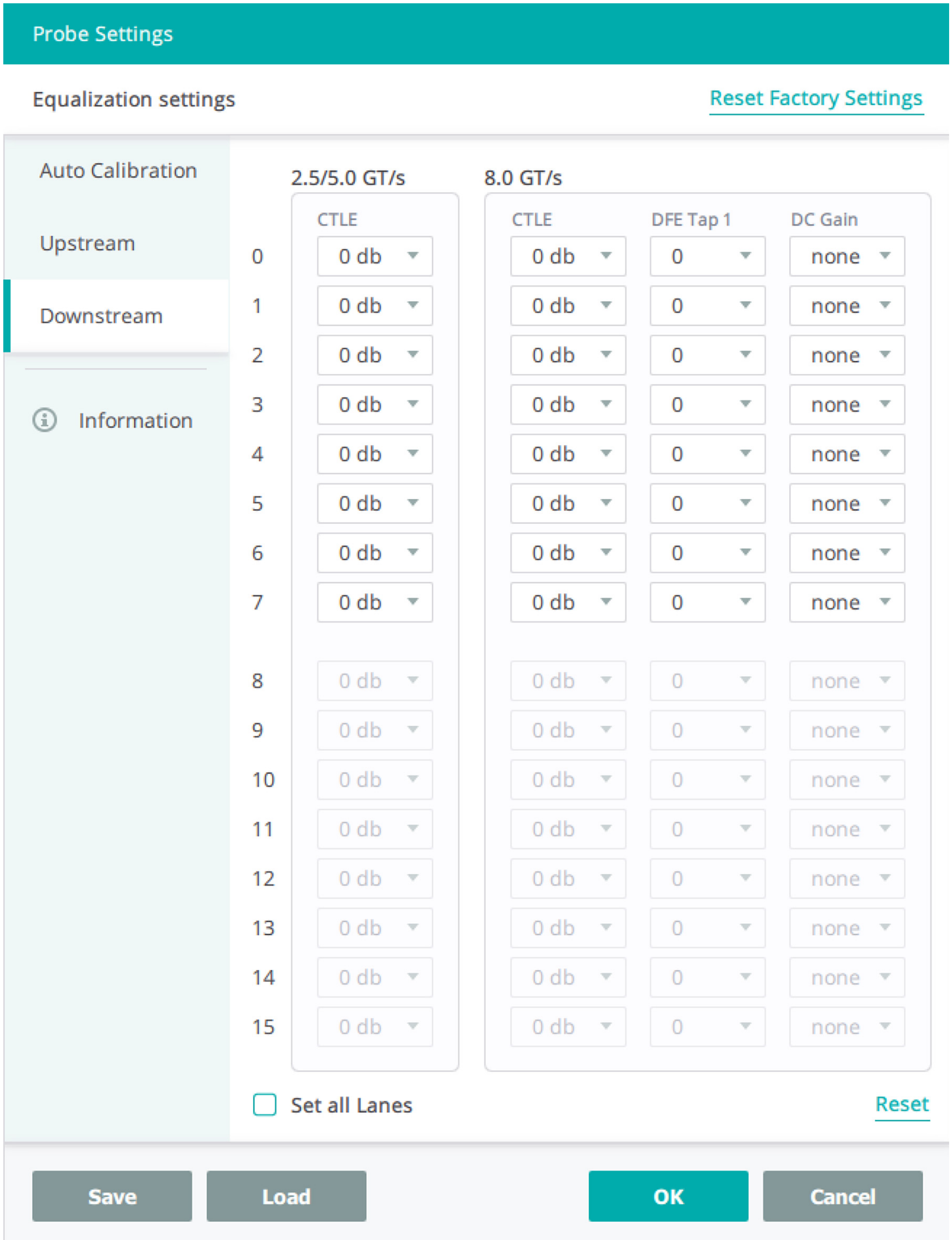


Figure 4.30: Equalization Settings: Downstream

Equalization Settings: Information Tab

There is also an Information tab (see Figure 4.31). The Equalization description tab provides you with more detailed information about the options and how calibration works.

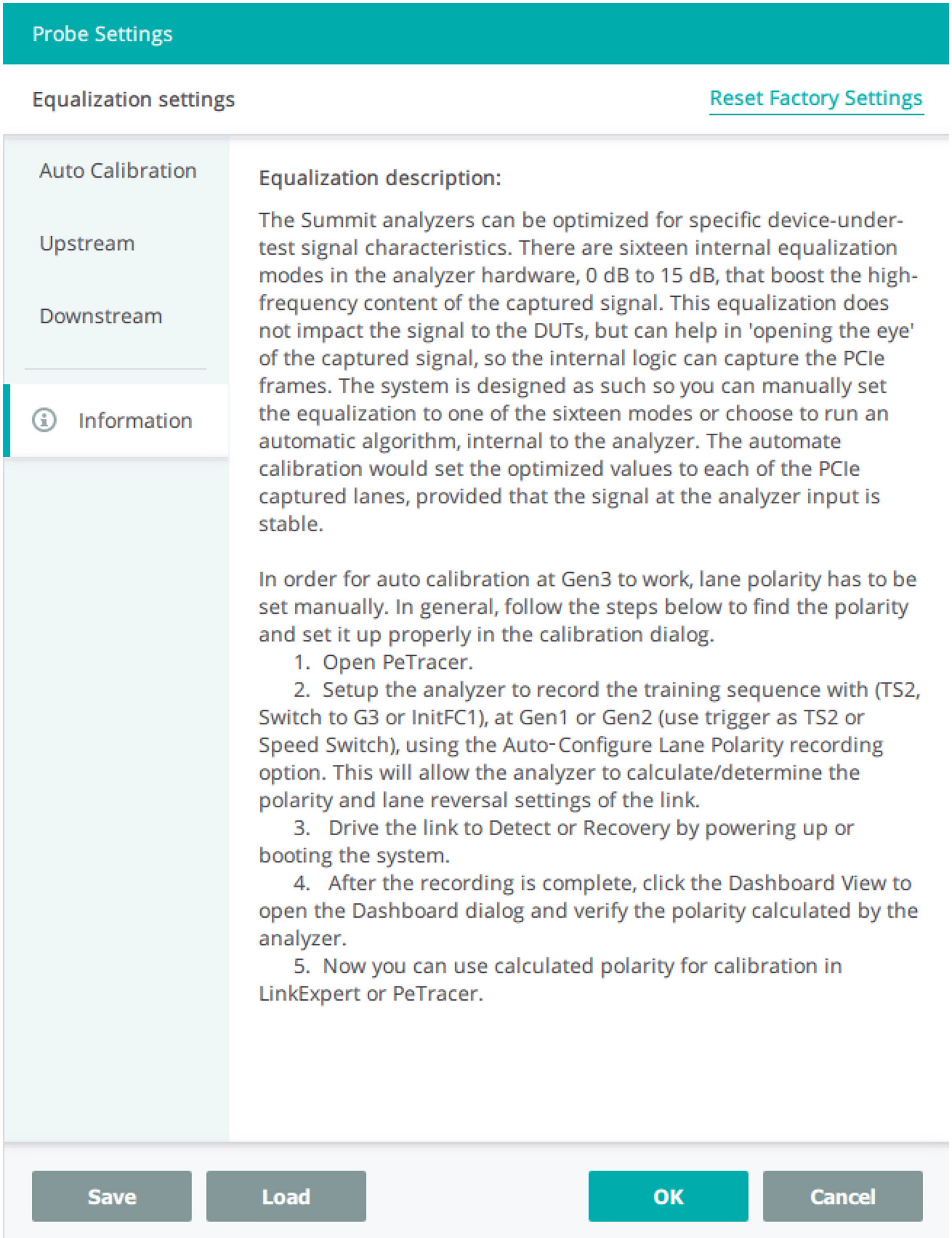


Figure 4.31: Equalization Settings: Information

After you've set up the equalization process (either manually or by running auto-calibration) your ready to start recording a trace.

A typical sequence of status states for the PCIe 3.0 Compliance Tests is shown below. See Figure 4.32 through Figure 4.36 on page 117.

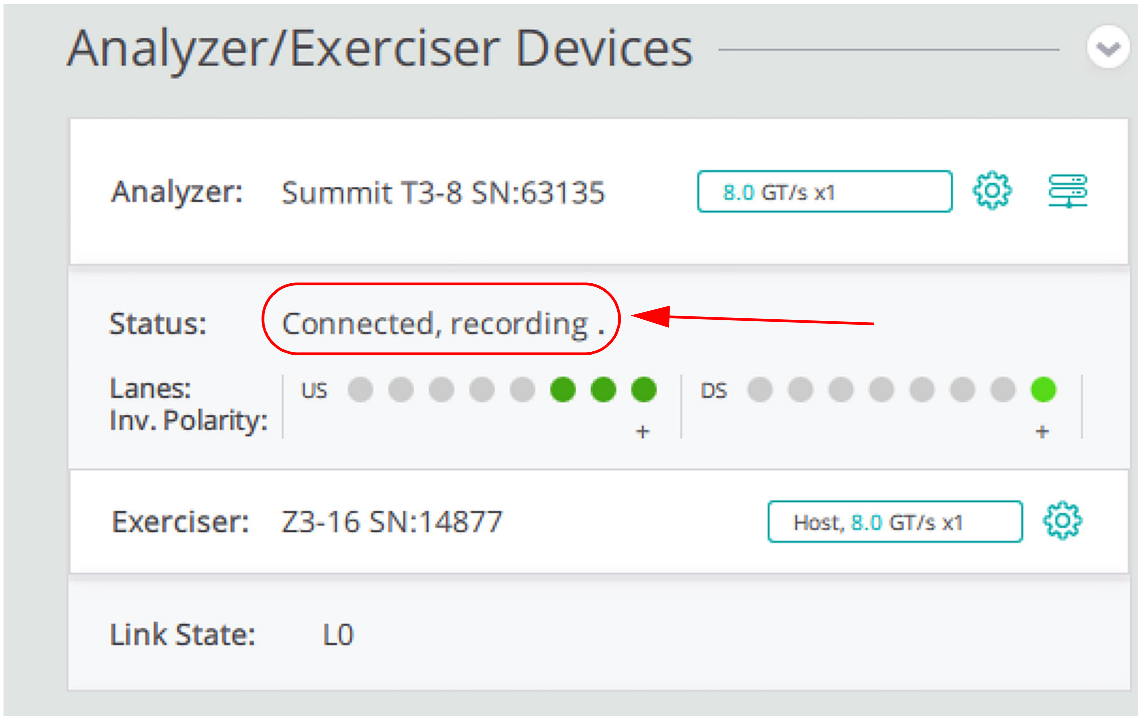


Figure 4.32: Devices Connected: T3-8 Analyzer and Z316 Exerciser

As a set of tests is being executed the status of the Devices (Analyzer and Exerciser will be updated). “Prepare Recording” is the first step. See Figure 4.33.

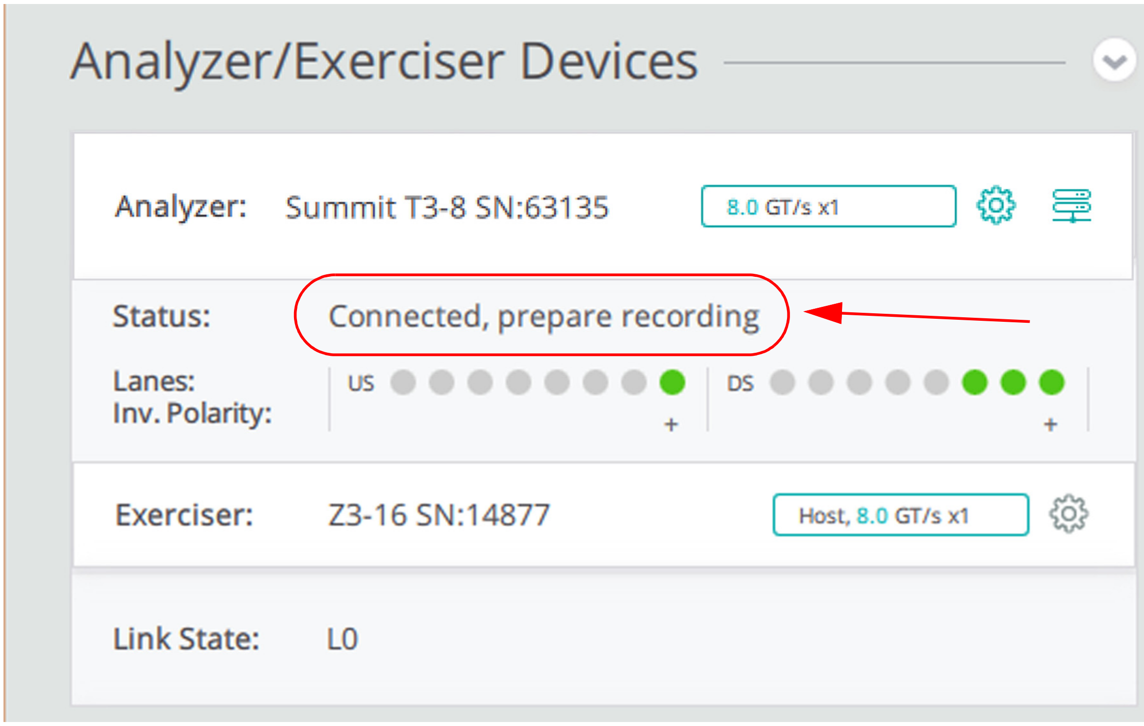


Figure 4.33: Devices Connected: T3-8 Analyzer and Z316 Exerciser (Prepare Recording)

“Waiting for Recording” is the second step. See Figure 4.34.

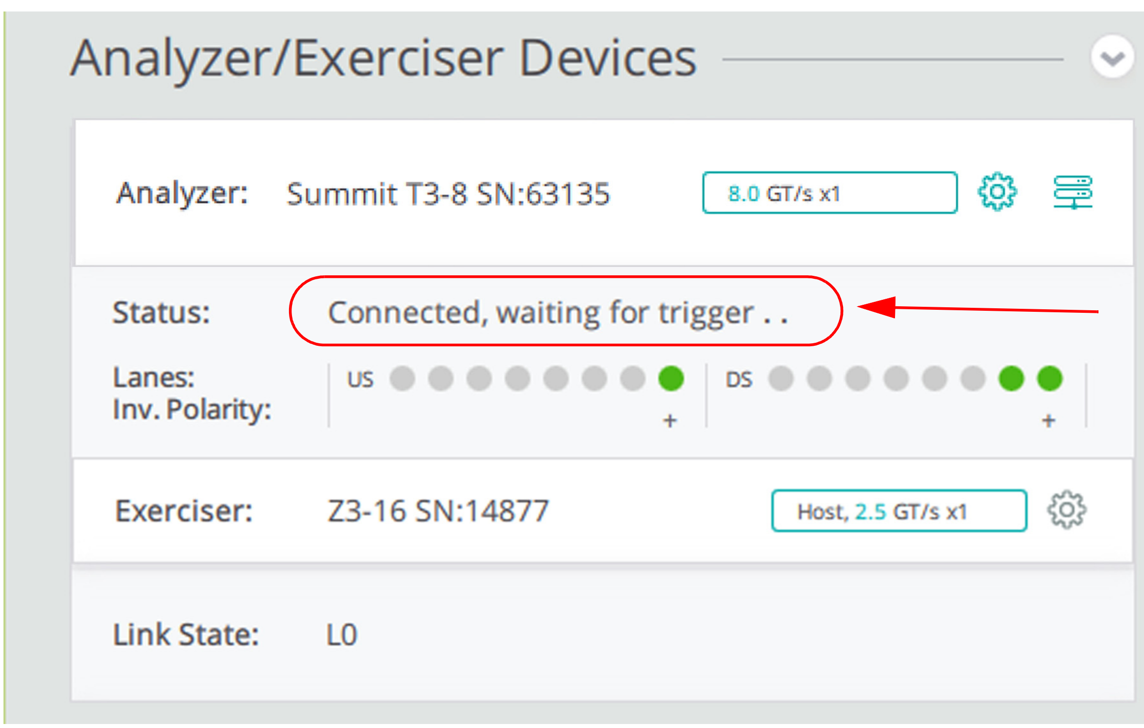


Figure 4.34: Devices Connected: T3-8 Analyzer and Z316 Exerciser (Waiting for Trigger)

After the trigger has occurred the analyzer will start recording. See Figure 4.35.

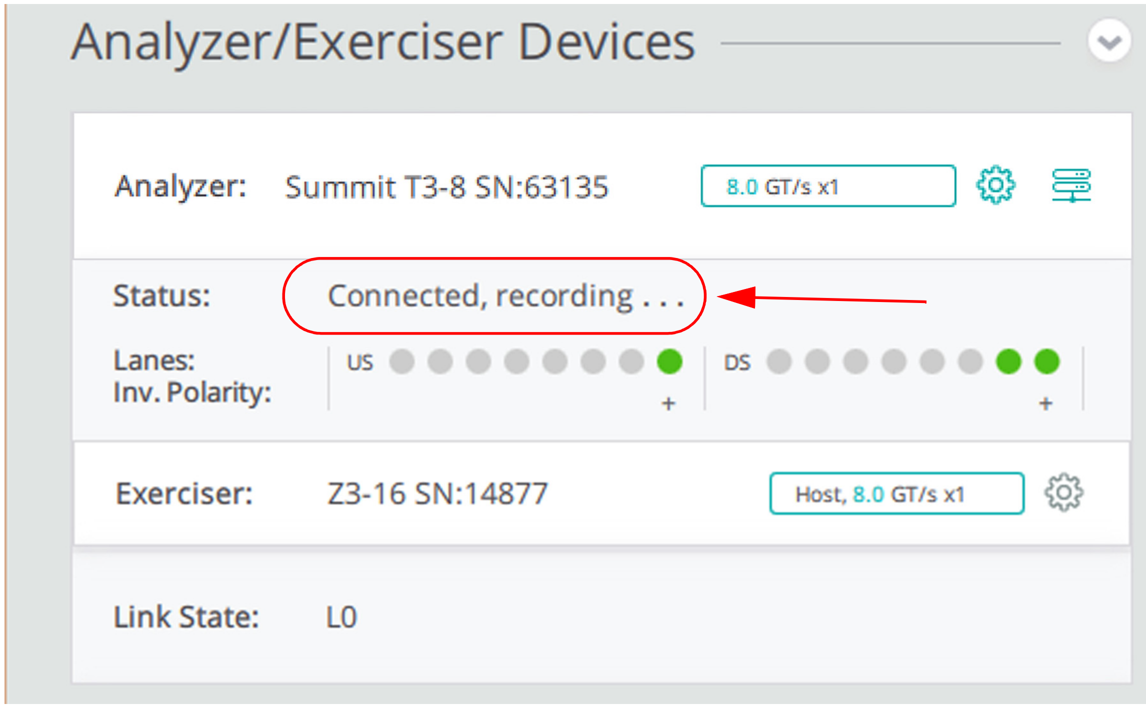


Figure 4.35: Devices Connected: T3-8 Analyzer and Z316 Exerciser (Recording)

After the trace has been recorded it will be uploaded to the analyzer. See Figure 4.36.

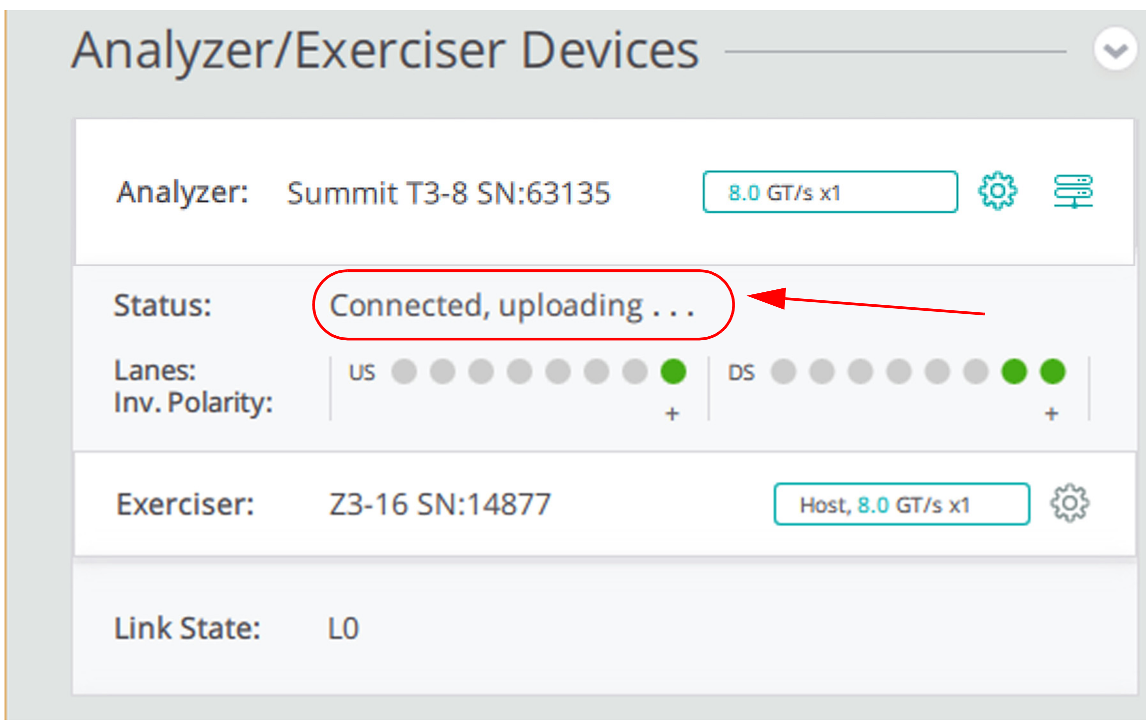


Figure 4.36: Devices Connected: T3-8 Analyzer and Z316 Exerciser (Uploading Data to Analyzer)

4.4.5 Dual T34 Example

In this case two T34 Analyzers were configured in expanded mode to use to record traffic. See Figure 4.37.

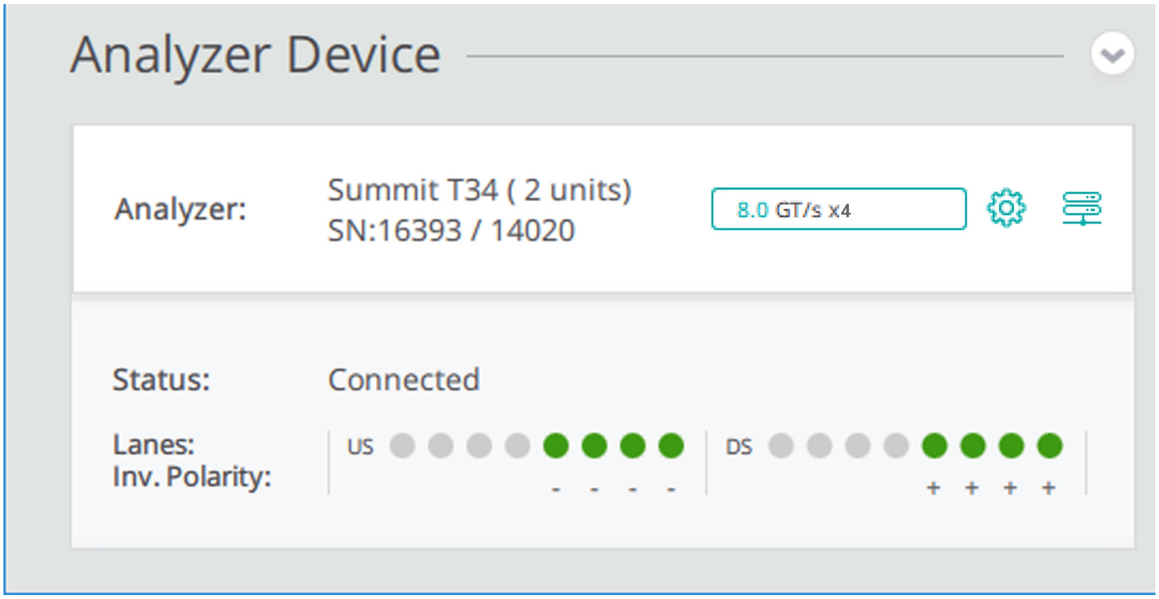


Figure 4.37: Dual T34 Analyzers Configured in Expanded Mode

4.5 Selecting and Running PCIe Tests

4.5.1 Use Shift-Click to Select a Subset of Tests

You can select a subset of all the tests in a group by clicking on the first test you want to run (see Figure 4.38).

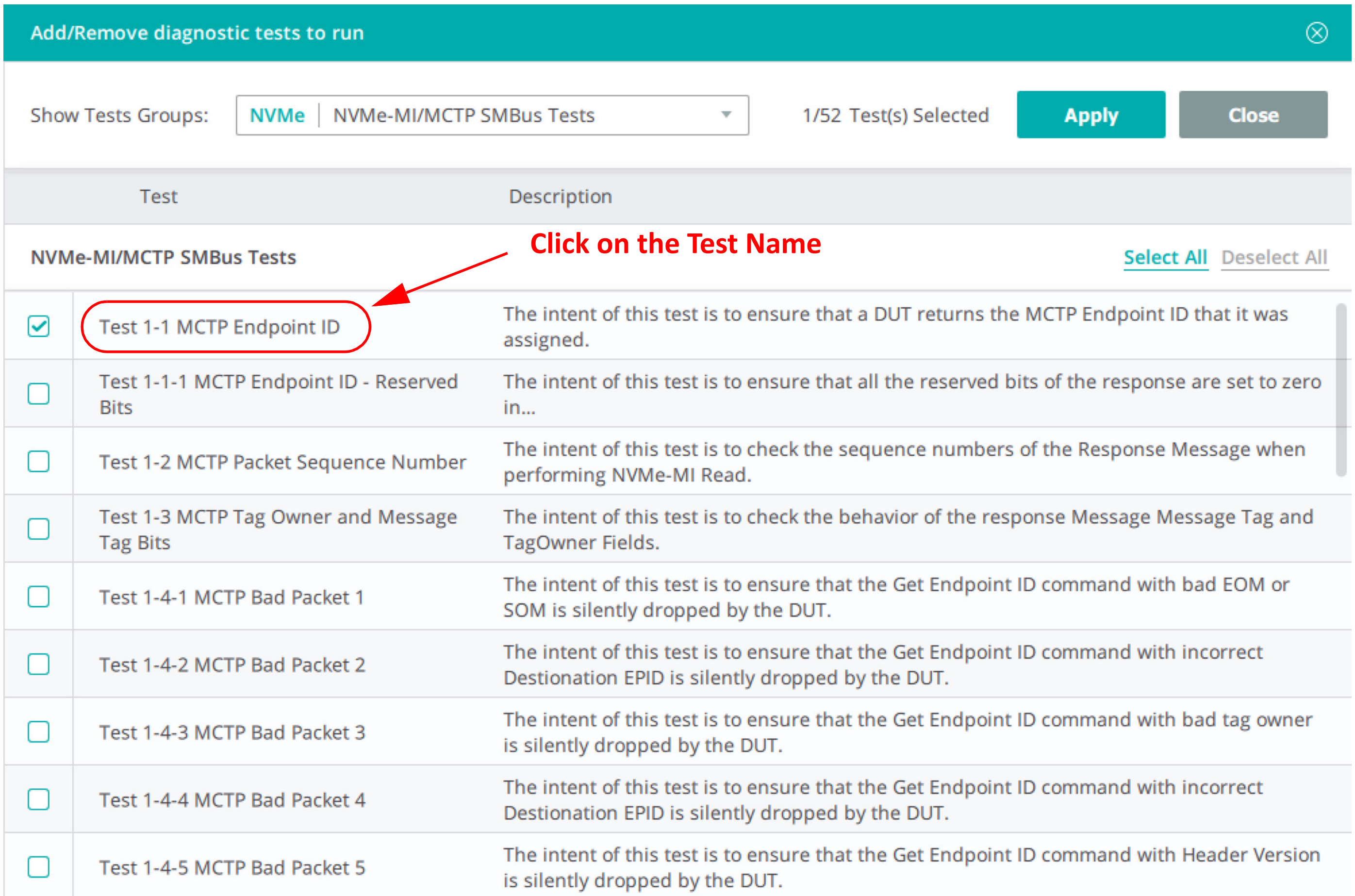


Figure 4.38: Click to Select the First Test in a Series

Now hold down the Shift key down and select the last test in the group you want to run. See Figure 4.39 on page 120. All the tests between the two (start and end) tests will be selected. This is just a quicker way of selecting a set of tests. You could have selected each one individually, but this method is a little faster.

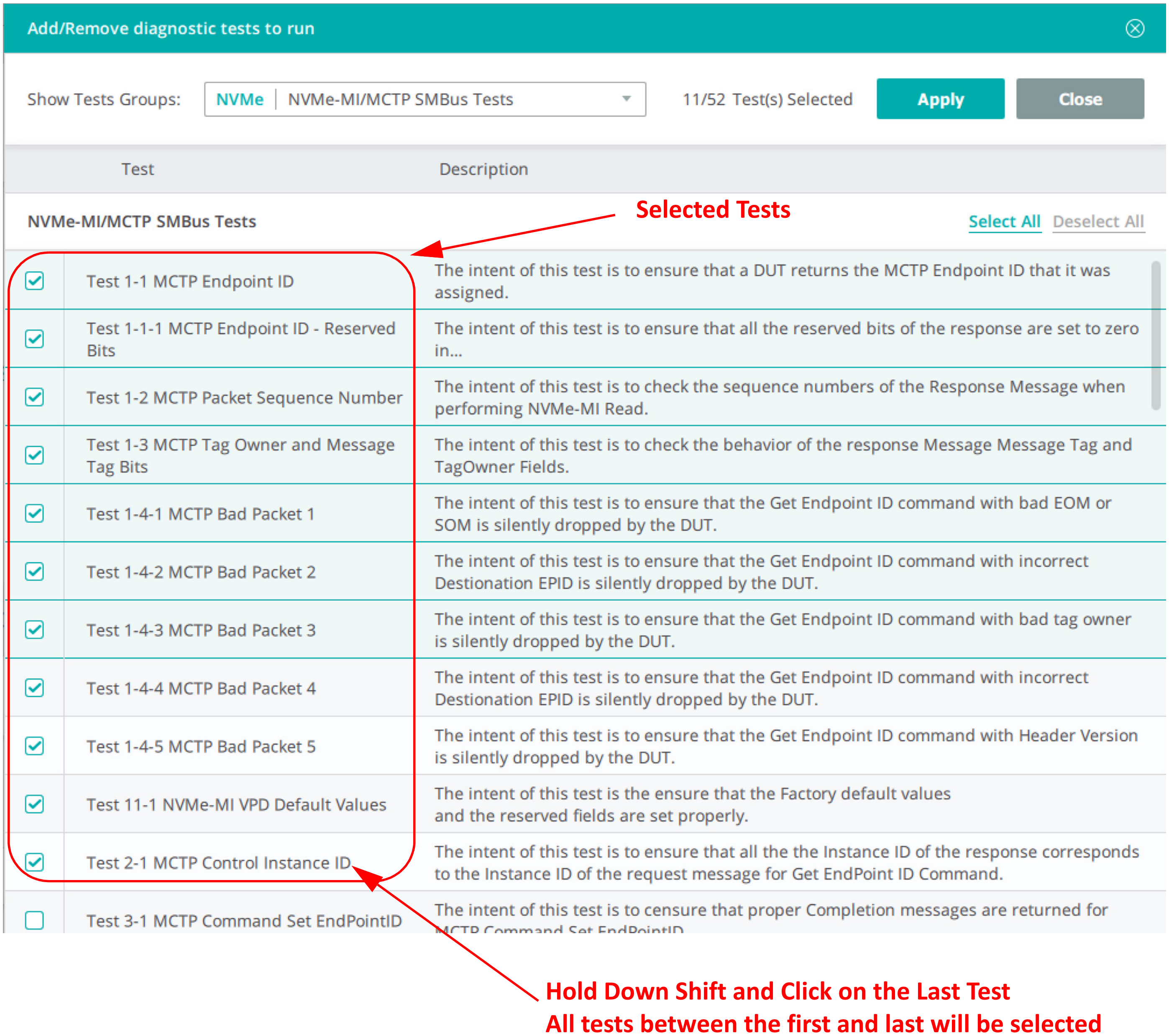


Figure 4.39: Shift Click to Select a Group of Tests

4.5.2 Click on Apply

When you click on “Apply” and you have selected tests from a different set, the following warning message will pop up, explaining that you can only run one type of tests at a time:

- LinkExpert System Level Tests
- PCIe 3.0 Compliance Package Tests
- NVMe-MI/MCTP SMBus Test
- NVMe-MI/MCTP VDM Tests
- Validation Tests (Endpoint)
- Validation Test (Root Complex)
- LTSSM Arc Tests
- PCIe 4.0 Compliance Package Tests
- PCIe RAS Error Injection Tests
- A subset of any of the above groups

See Figure 4.40.

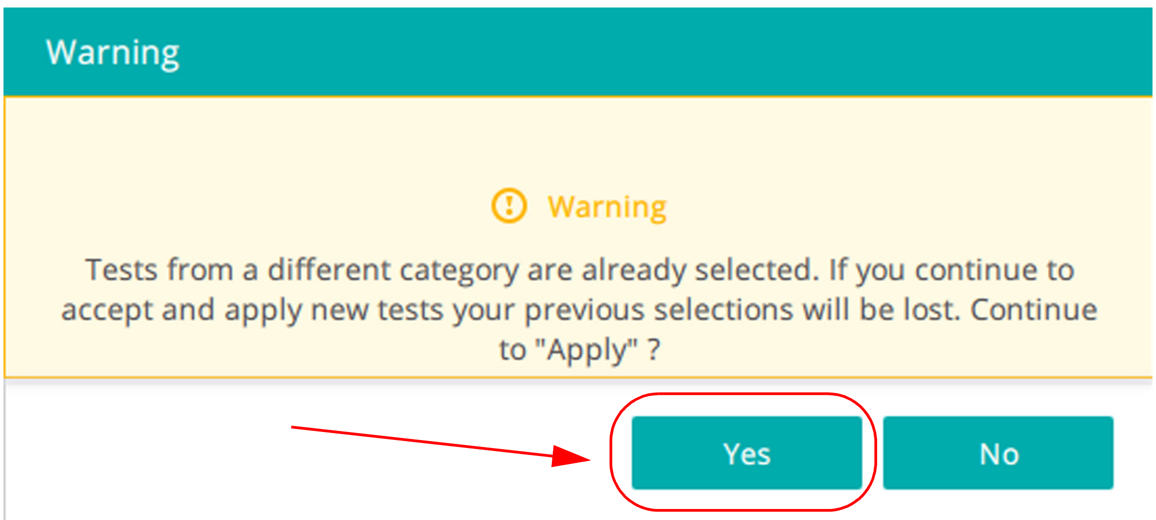


Figure 4.40: Warning Message: Perform One Type of Tests at a Time

Note: If you have already selected one set of tests and you select a new set, the old set will be lost.

After you have selected and applied the tests you want to run the test selection dialog will change to gray out the “Apply” button and only the “Close” button will be active.

The example shown below is after Selecting and Applying the PCIe 3.0 Compliance Test Package of tests, then clicking on the “Close” button. See Figure 4.41.

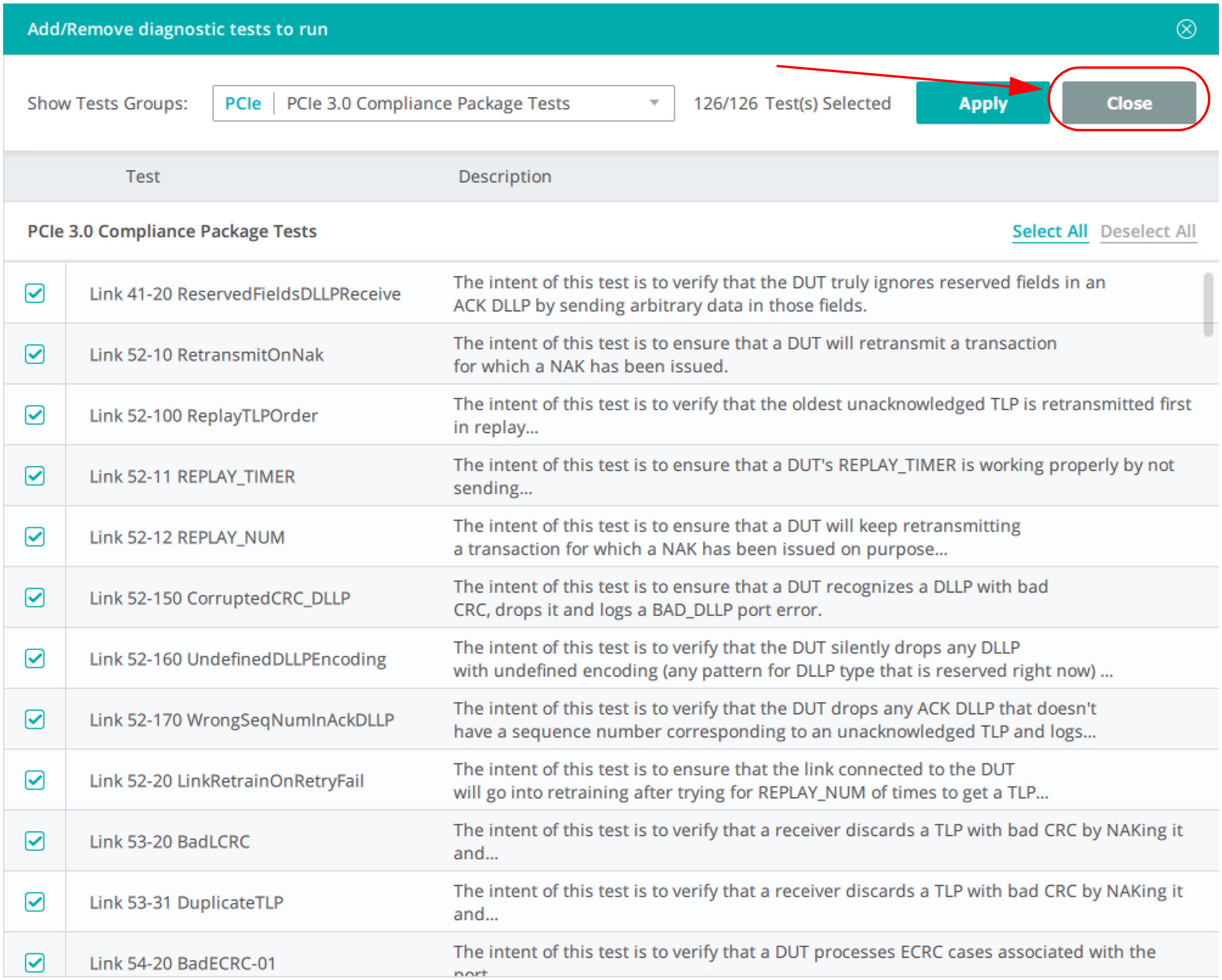


Figure 4.41: After Selecting and Applying a Test Set: Only Close Button is Active

Click on the “Close” button and the PCIe 3.0 Compliance Test Package tests are loaded and ready to be executed. See Figure 4.42.

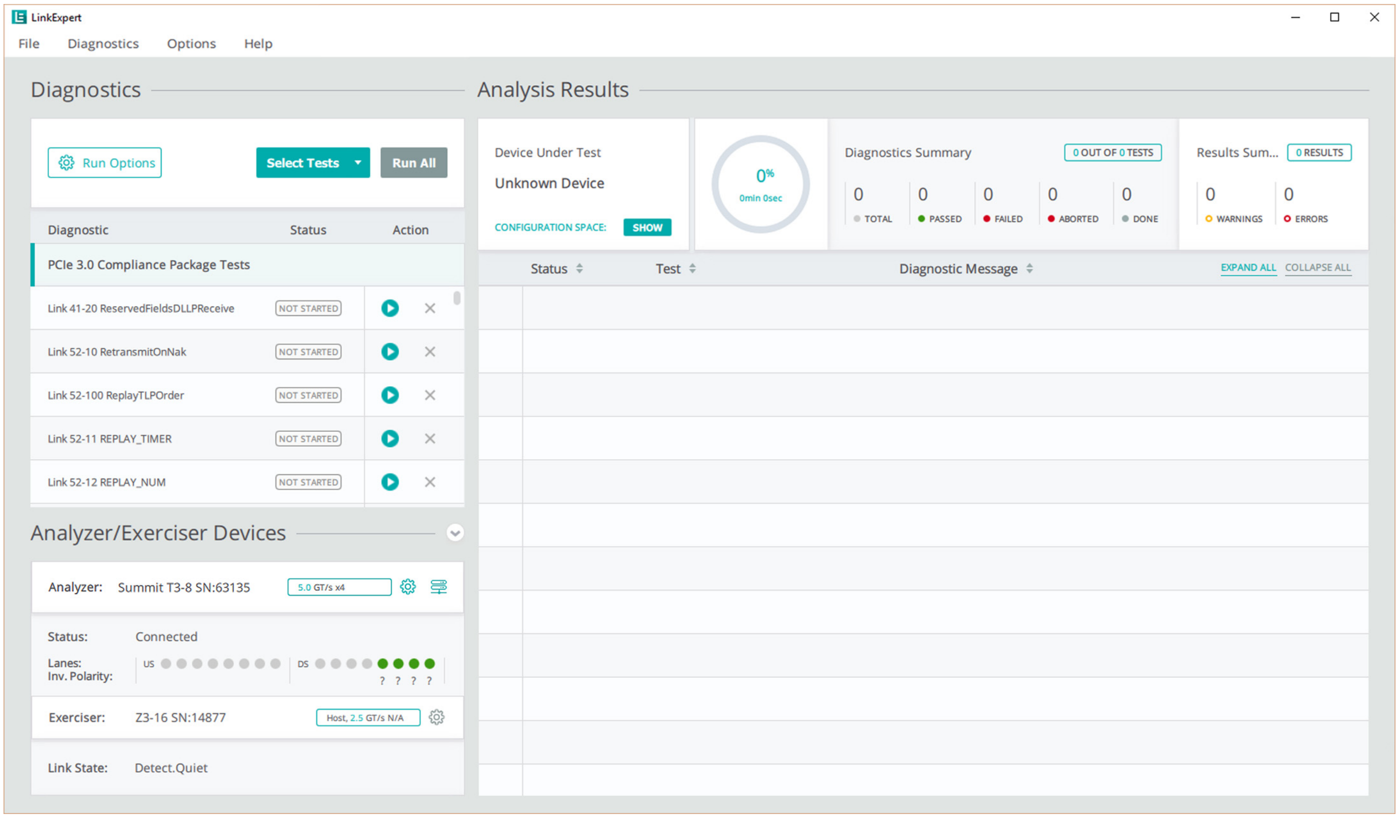


Figure 4.42: PCIe 3.0 Compliance Package Tests: Selected, Applied and Ready to be Executed

4.6 LinkExpert PCIe System Level Tests

You can select individual LinkExpert System Level Tests or all the LinkExpert System Level Tests. See Figure 4.43.

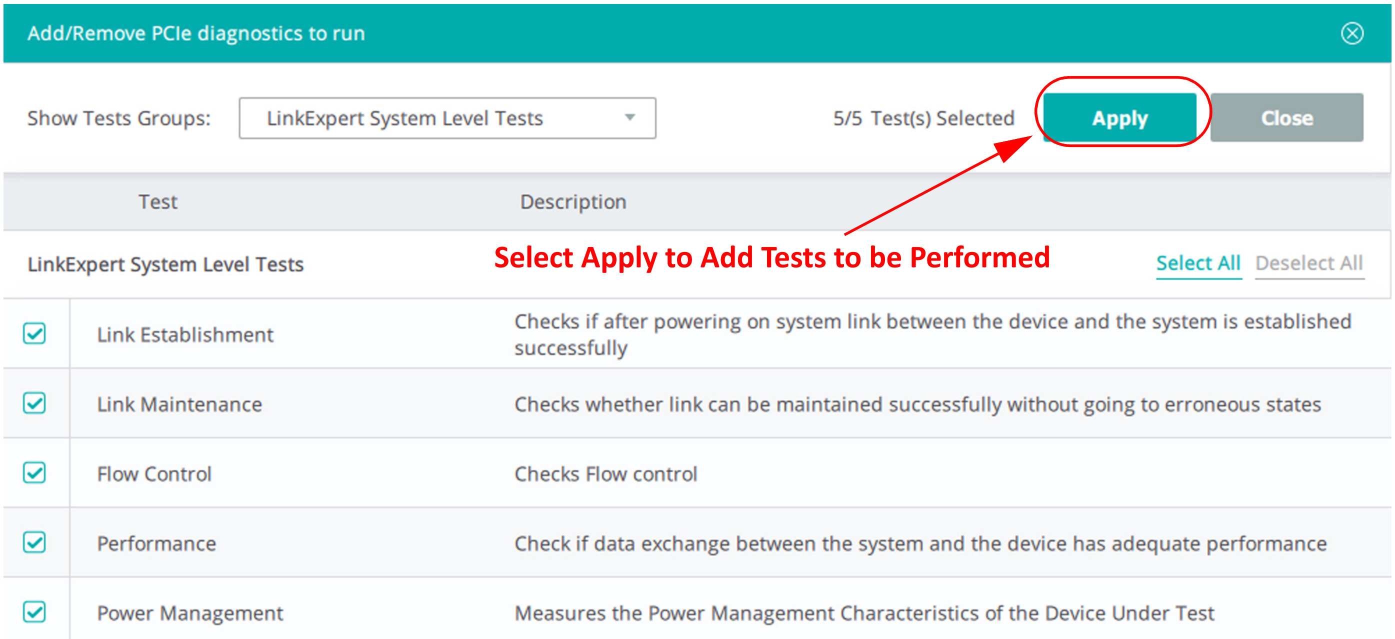


Figure 4.43: Select LinkExpert System Level Tests

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

Apply a Set of Tests

As an example, LinkExpert System Level Tests have been selected and applied, so those are the only tests that will be executed in this batch. See Figure 4.44 on page 125.

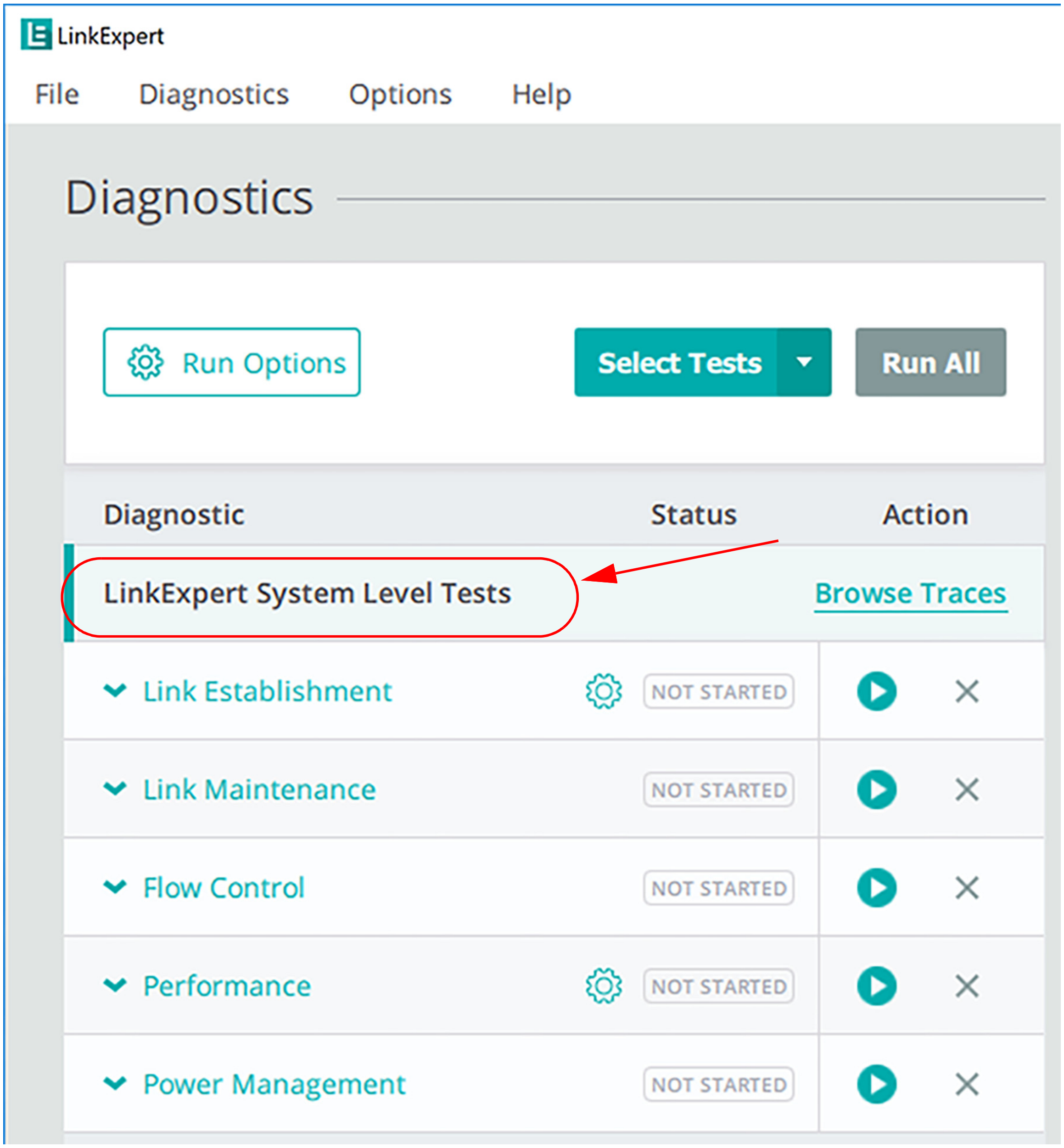


Figure 4.44: LinkExpert System Level Tests Applied

I you would rather run pre-recorded traces for portions of the System Level Test you can select Browse Traces. For more detail about this options see "Browse Traces Option" on page 137.

4.6.1 Link Establishment

If you click on the down arrow next to Link Establishment it will change to an up arrow and you'll see the following steps the test will go through:

- Boot Recording
- LTSSM Analysis
- Configuration Space Recording
- Configuration Space Analysis
- Link Speed/Width Parameters

See Figure 4.45.

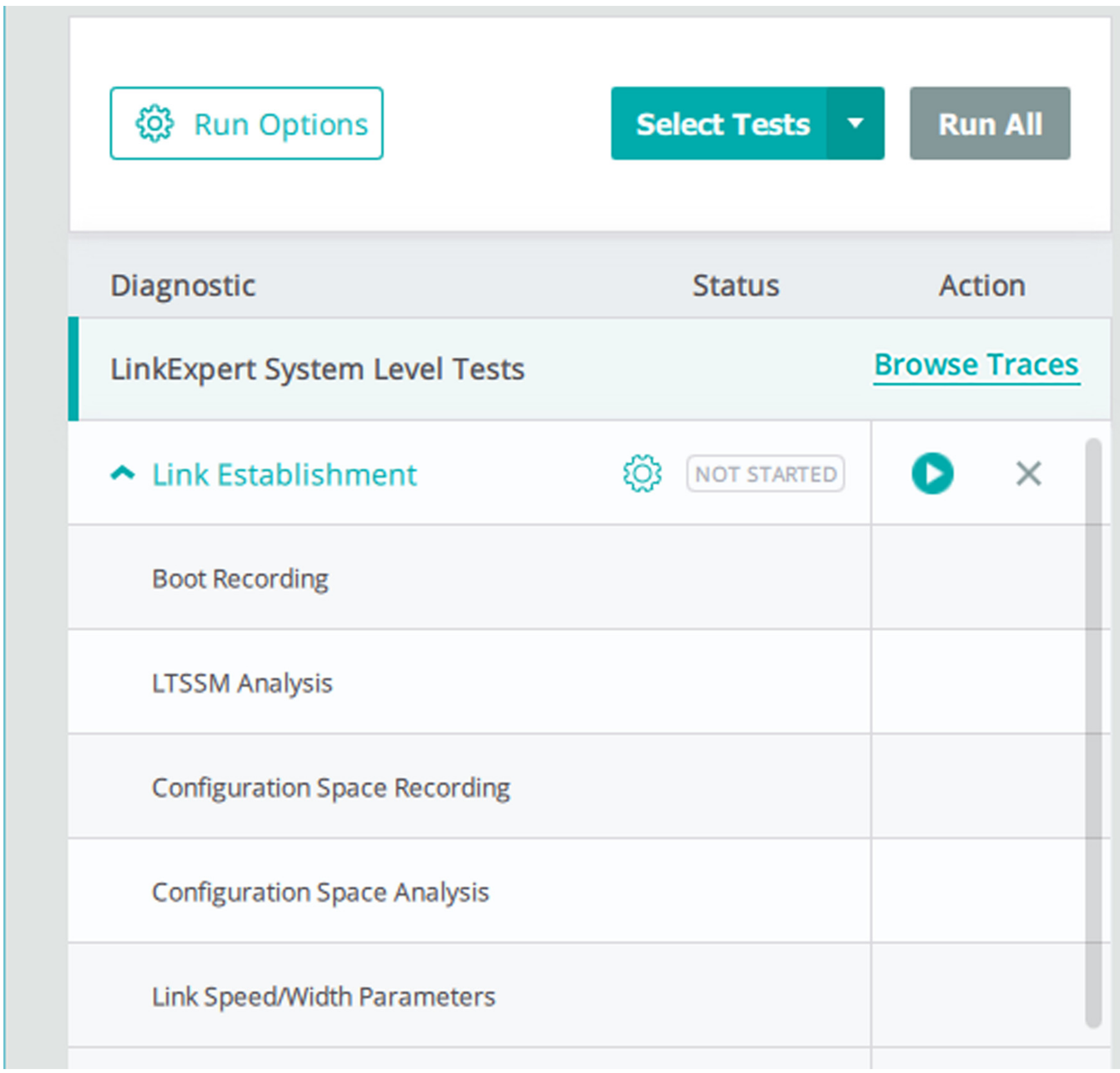


Figure 4.45: Link Establishment: Test Steps

4.6.1.1 Link Establishment Gear Options

Link Establishment also has a Gear Symbol. When you click on it, it shows the lane width configurations available. See

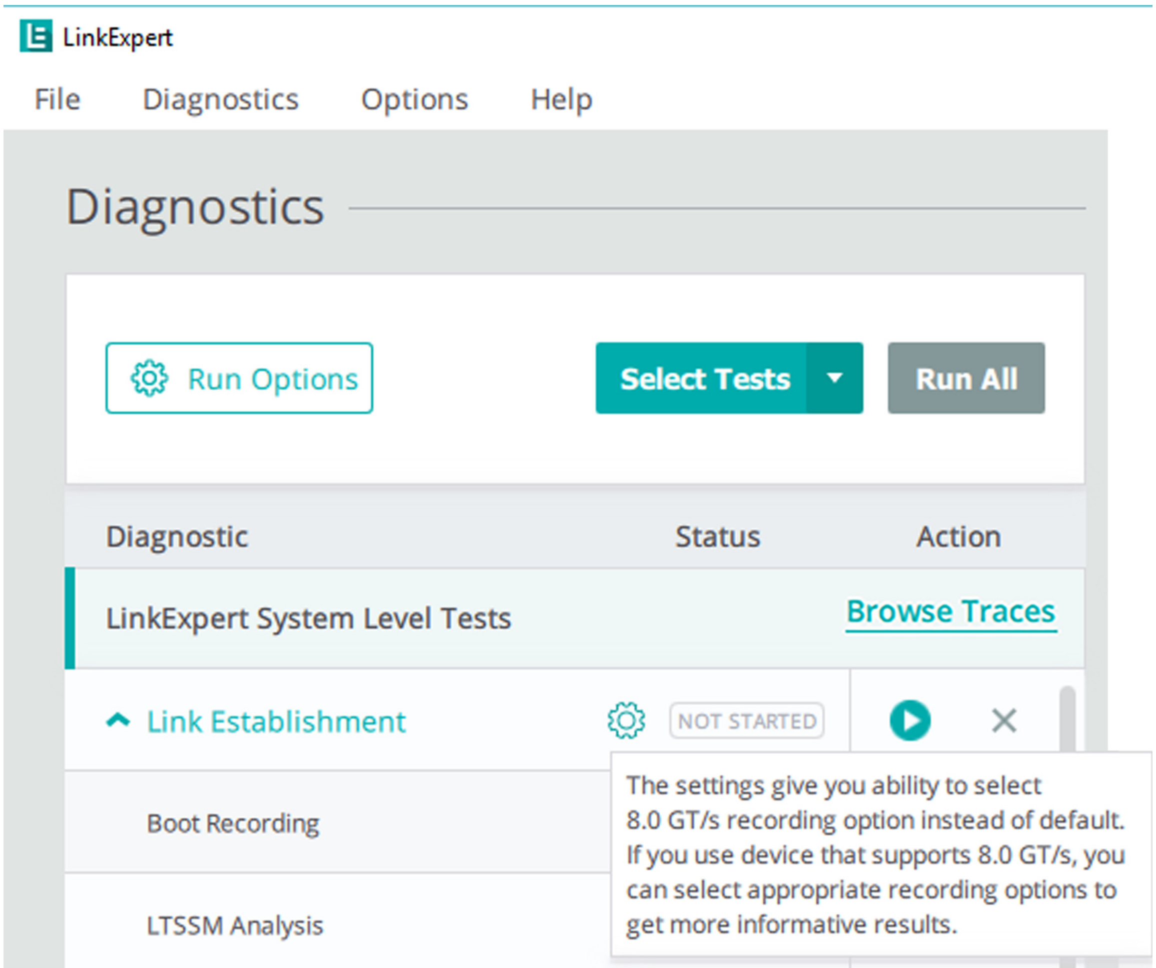


Figure 4.46: Link Establishment: Gear Tooltip

When you click on the Gear Symbol the following dialog will be displayed. See Figure 4.47 on page 128.

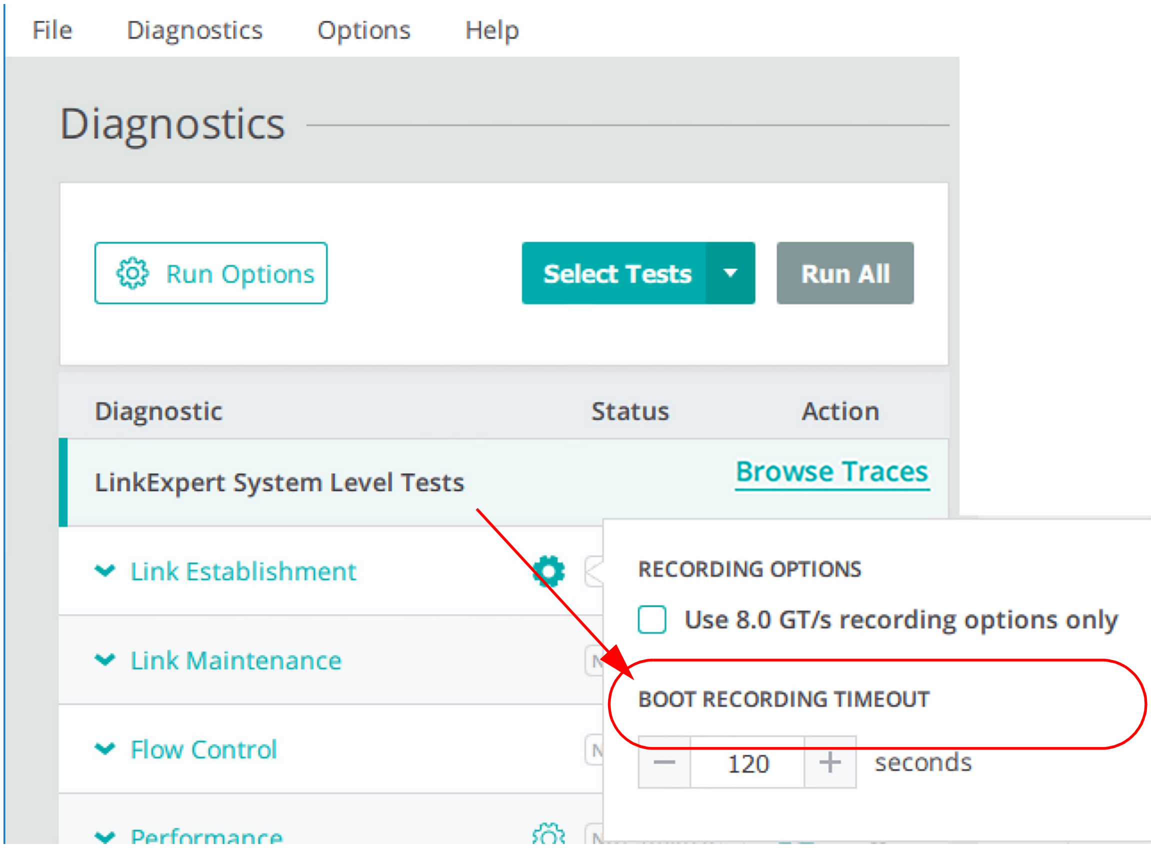


Figure 4.47: Link Establishment: Gear Symbol Dialog

If you want to use 8.0 GT/s as the recording option instead of the default setting select the checkbox.

You can also set the Boot Recording Timeout:

- Default: 120 seconds
- Minimum: 1 second
- Maximum: 999,999 seconds

4.6.2 Link Maintenance

The Link Maintenance test goes through the following steps:

- System activity recording check
- Traffic errors check
- Retries check
- Timings check
- Recoveries check
- NAKs check
- System activity recording check
- Recoveries check

See Figure 4.48.

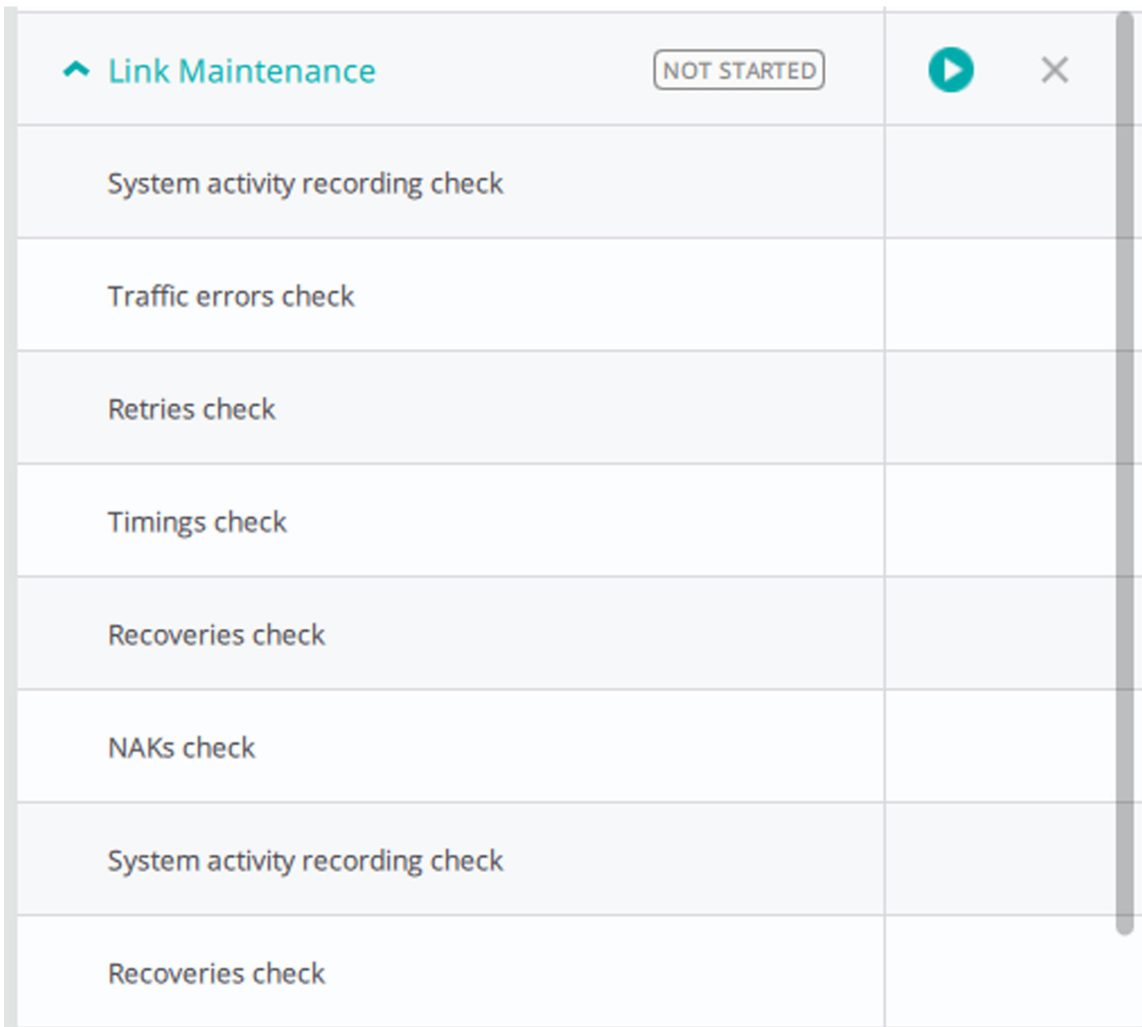


Figure 4.48: Link Maintenance: Test Steps

4.6.3 Flow Control

The Flow Control test consists of the following steps:

- System activity recording check
- Flow Control Credits advertised
- Flow Control analysis

See Figure 4.49.

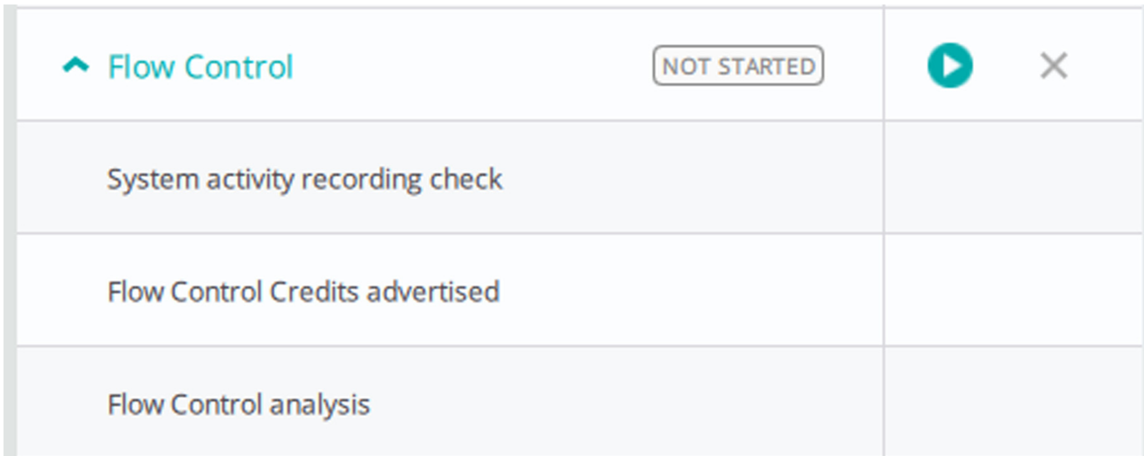


Figure 4.49: Flow Control: Test Steps

4.6.4 Performance Test

The Performance Test consists of the following steps:

- Settings: Set up Latency and Throughput
- System activity recording check
- Performance metrics
- Bus Utilization report
- Throughput report

See Figure 4.50.

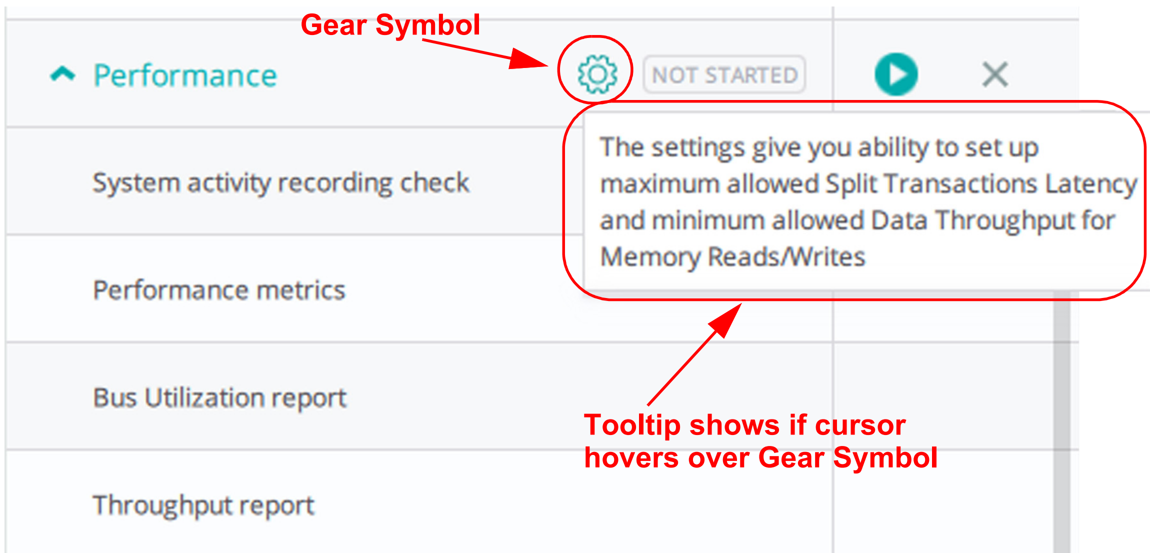


Figure 4.50: Performance: Test Steps

4.6.4.1 **Performance Setting** (See Figure 4.51).

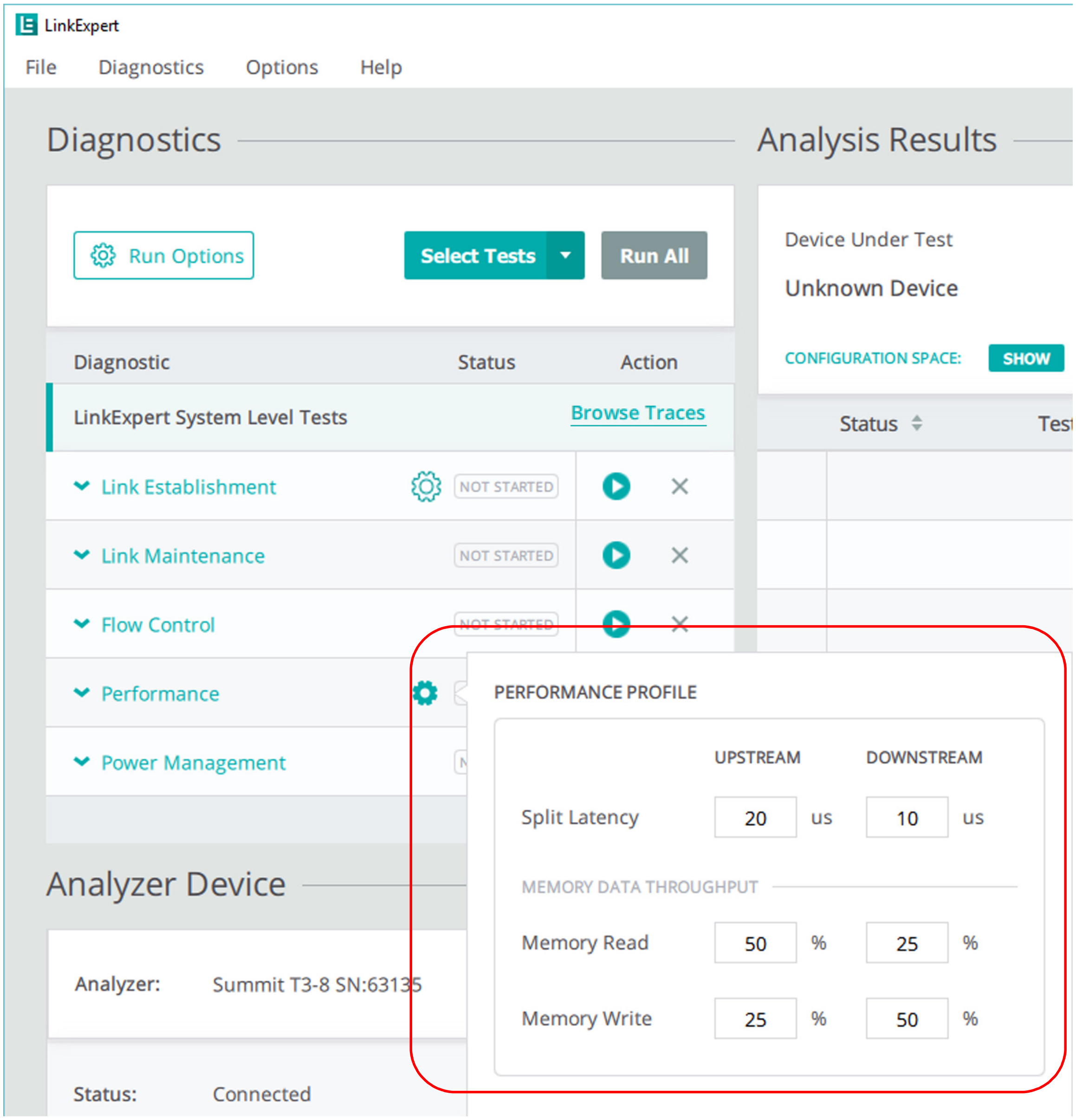


Figure 4.51: Setting Performance Parameters

4.6.4.2 Split Transaction Latency

You can specify maximum latency (in microseconds) for split transactions for each direction. The Performance diagnostics will fail if the value calculated during the test exceeds the specified value. This option gives you the ability to set different test conditions for different devices under test (DUT).

Split Transaction Latency Tooltip (Upstream or Downstream)

If you scroll over the Split Transaction Latency Upstream or Downstream window a tooltip will pop up explaining how Split Latency works. See Figure 4.52.

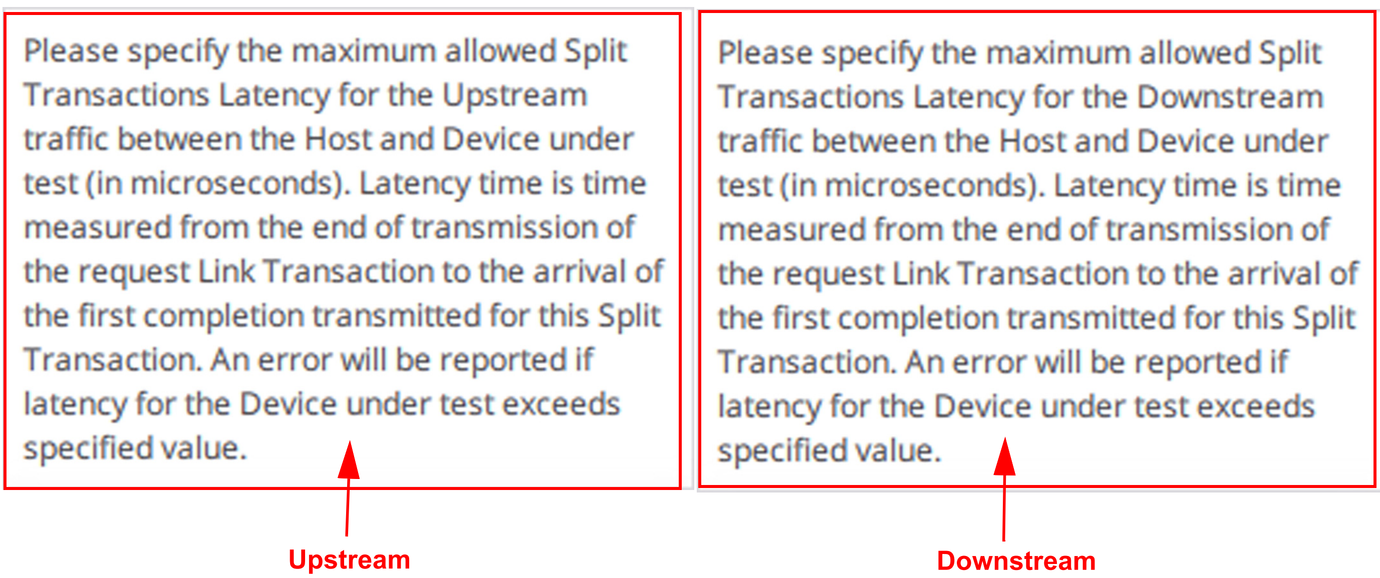


Figure 4.52: Split Latency Tooltips (Upstream/Downstream)

4.6.4.2.0.1 Memory Reads: Data Throughput Reads (Upstream/Downstream)

You can also specify minimum data throughput for each type of Memory Read for each direction. This value is specified as a percent from theoretical maximum for a given link speed and width. The Performance diagnostics will fail if the value calculated during the test exceeds the specified value. This option gives you the ability to set different test conditions for different devices under test (DUT).

4.6.4.2.0.2 Memory Reads: Data Throughput Tooltips (Upstream/Downstream)

If you scroll over the Memory Reads Upstream or Downstream windows a tooltip will pop up explaining how Memory Reads Throughput works. See Figure 4.53.

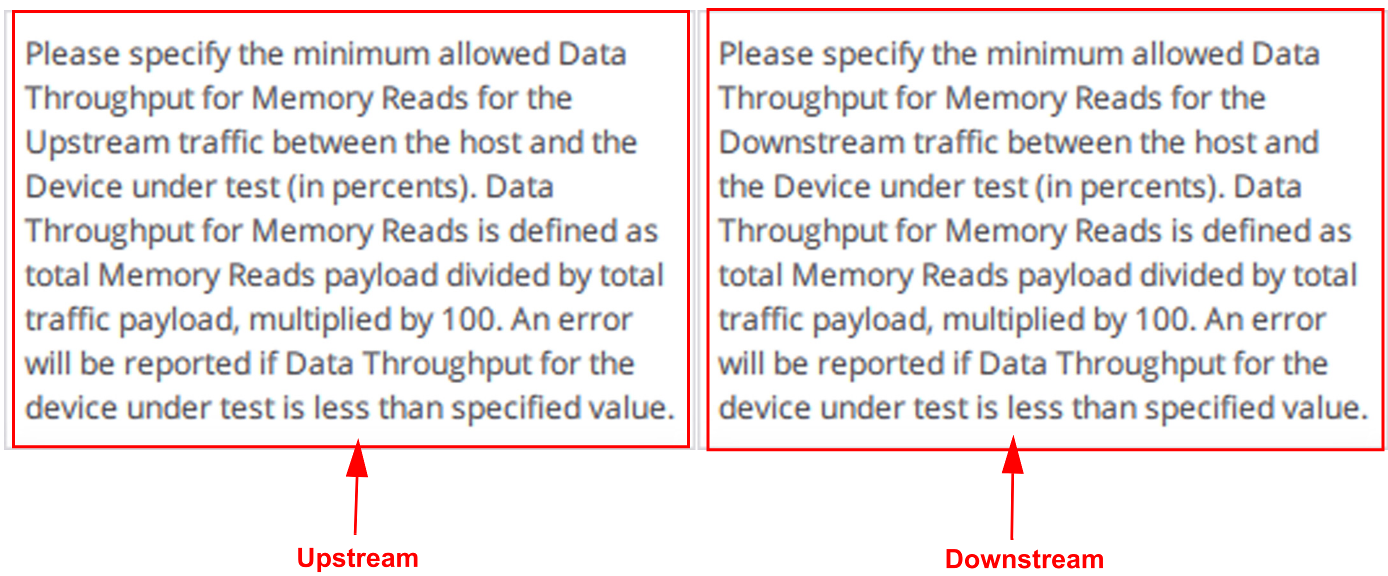


Figure 4.53: Memory Data Throughput (Minimum -> Upstream and Downstream)

4.6.4.2.0.3 Memory Writes: Data Throughput (Upstream/Downstream)

You can also specify minimum data throughput for each type of Memory Write for each direction. This value is specified as a percent from theoretical maximum for a given link speed and width. The Performance diagnostics will fail if the value calculated during the test exceeds the specified value. This option gives you the ability to set different test conditions for different devices under test (DUT).

4.6.4.2.0.4 Memory Writes: Data Throughput Tooltips (Upstream/Downstream)

If you scroll over the Memory Write Upstream or Downstream windows a tooltip will pop up explaining how Memory Write Throughput works. See Figure 4.54.

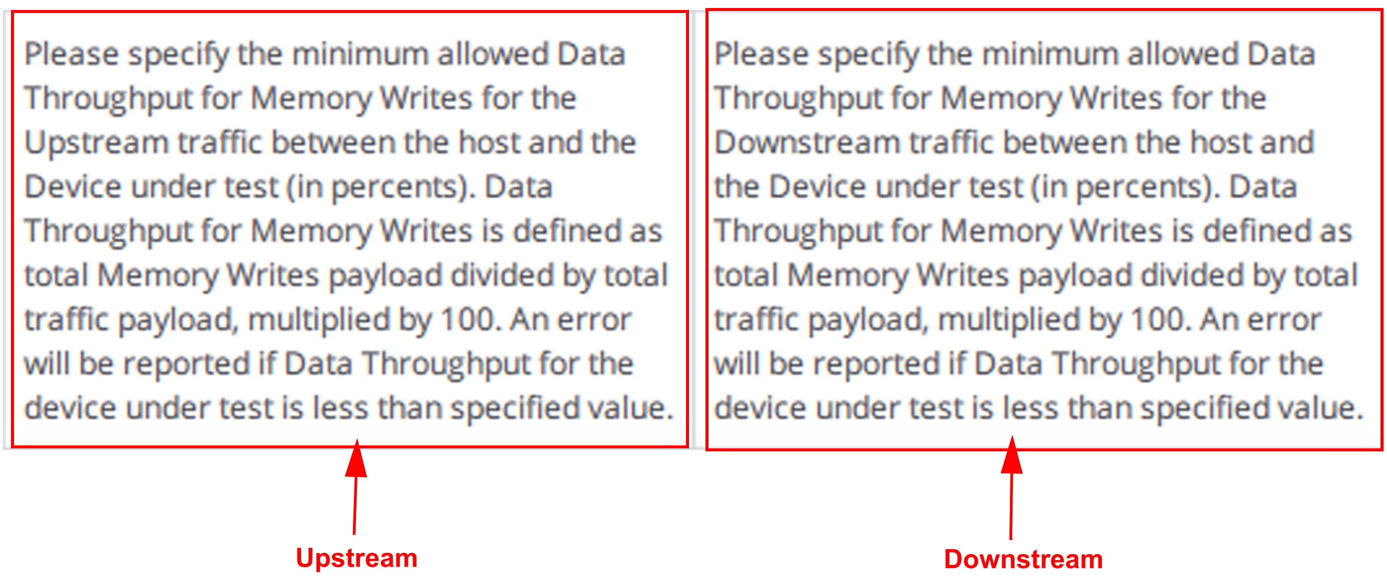


Figure 4.54: Memory Writes Data Throughput (Minimum -> Upstream and Downstream)

4.6.5 Power Management Test

The Power Management test consists of the following steps:

- System activity recording
- LTSSM PM analysis
- Device PM capabilities check

See Figure 4.55.

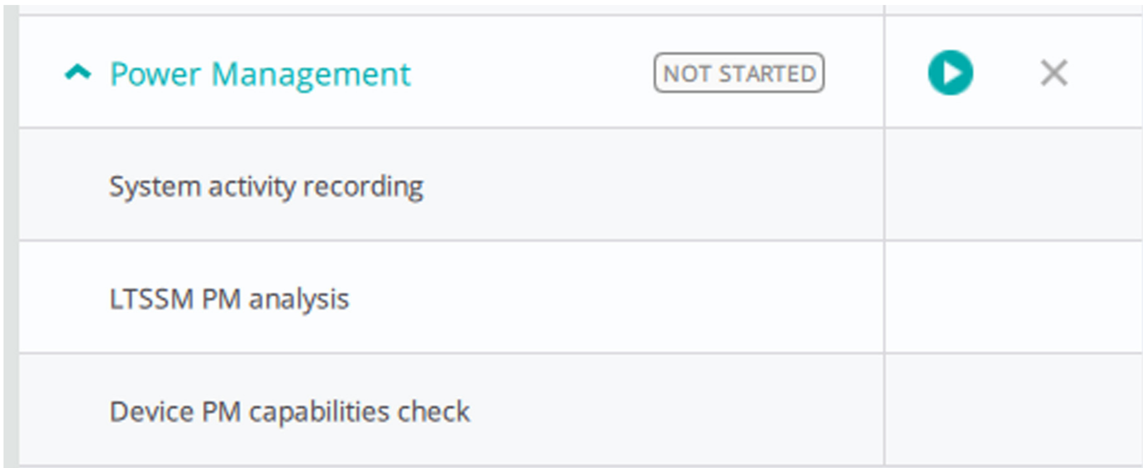


Figure 4.55: Power Management: Test Steps

4.6.6 Browse Traces Option

Rather than running the System Level Tests on an Exerciser and an Analyzer you can load previously recorded traces and have LinkExpert analyze their characteristics. See Figure 4.56.

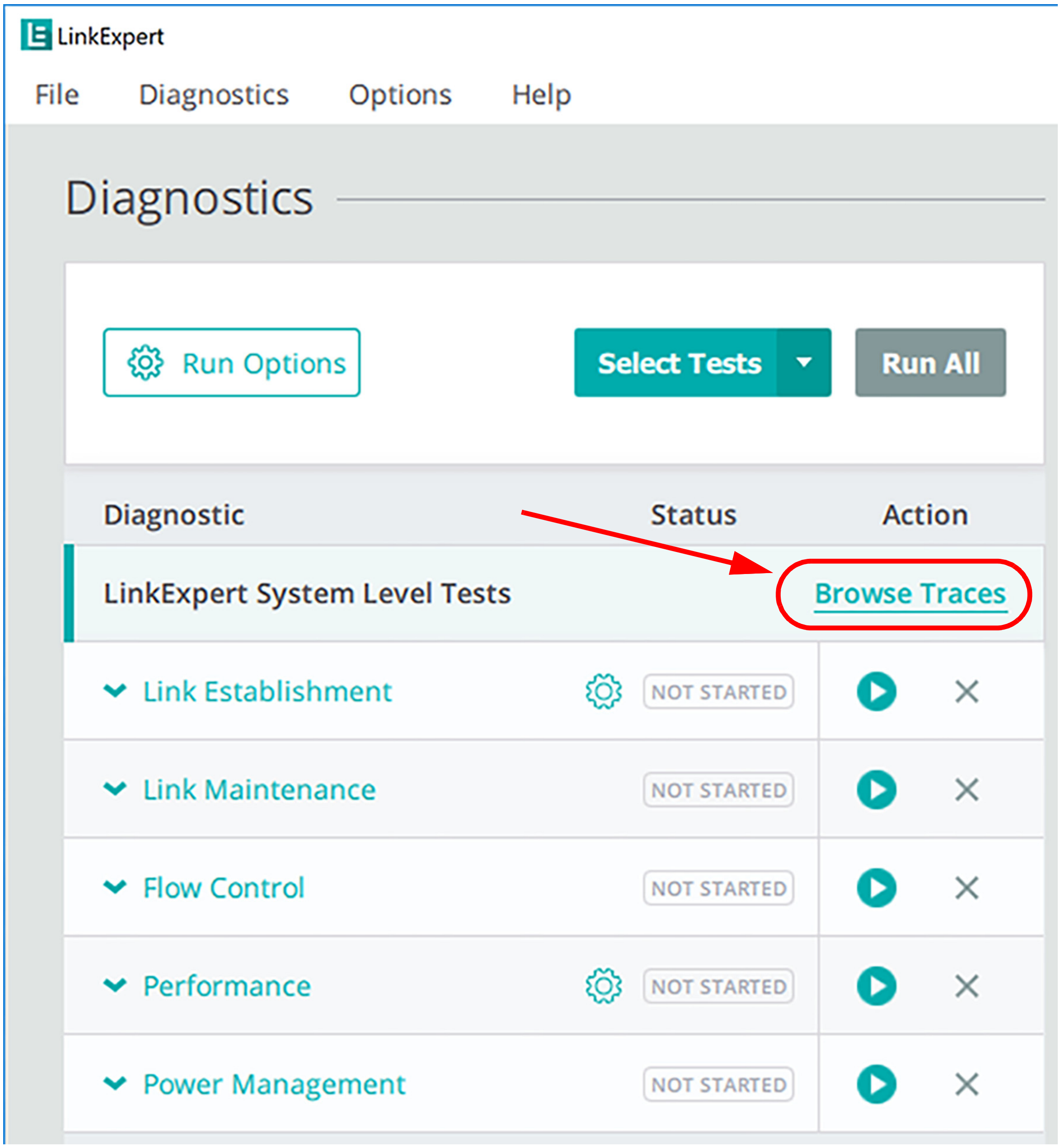


Figure 4.56: System Level Tests: Browse Option

If you select the Browse Trace option the following dialog box will pop up allowing you to choose the trace you want LinkExpert to analyze. See Figure 4.57 on page 138.

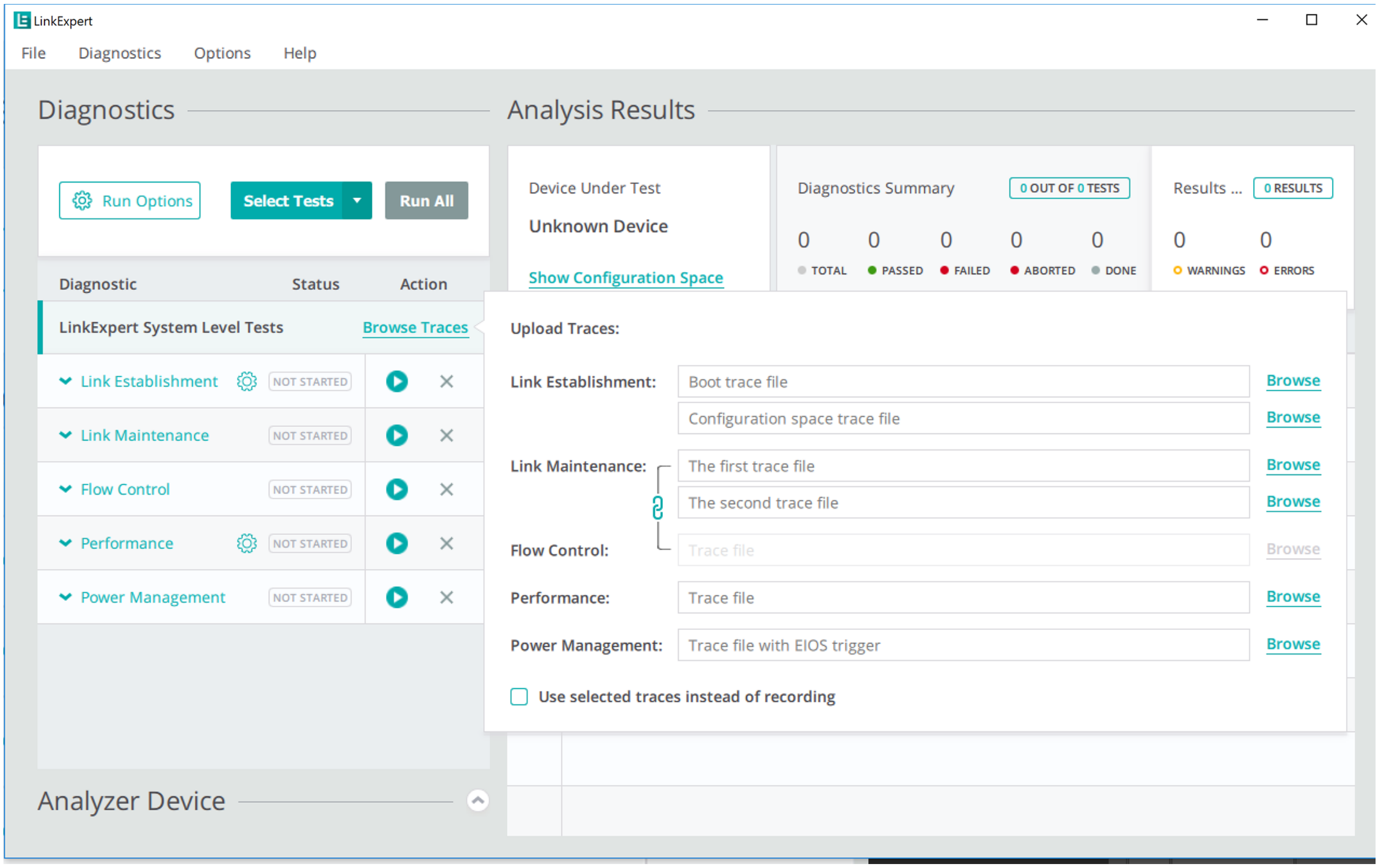


Figure 4.57: Browse Trace Option: Dialog Box

If you select the Link Establishment Browse button, the tool takes you to the directory where previously recored traces have been stored. See Figure 4.58 on page 139.

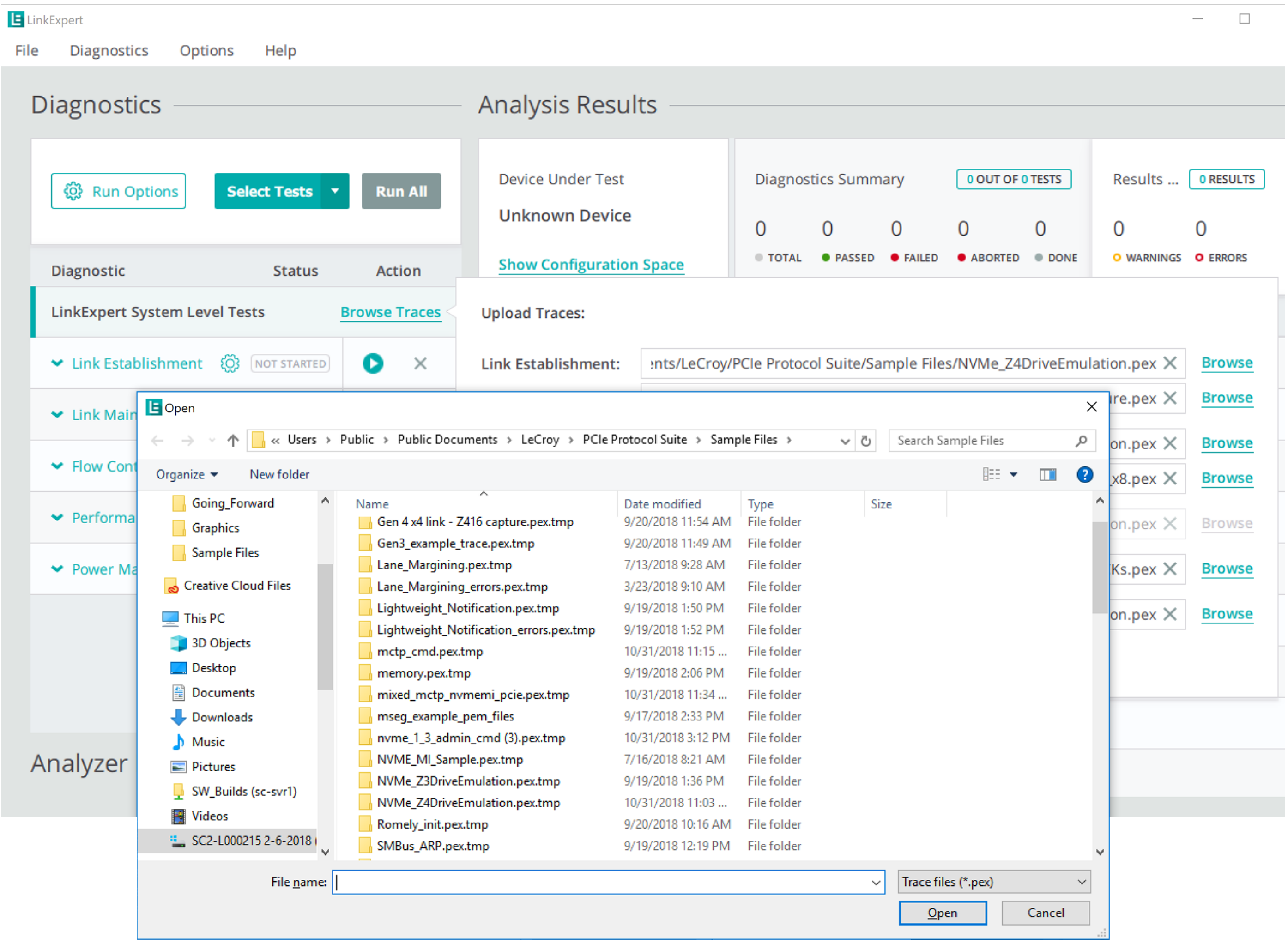


Figure 4.58: Select Previously Recored Trace for Analysis

You can select a previously recored trace for analysis of:

- Link Establishment
- Link Maintenance
- Flow Control
- Performance
- Power Management

After selecting the traces for analysis, select the checkbox for “Use selected traces instead of recording” and LinkExpert will use the selected traces for analysis instead of recording new traces. in this way you can use previously recording traces for analysis in case you don’t have current access to the Analyzer and Exerciser you are interested in. See Figure 4.59 on page 140.

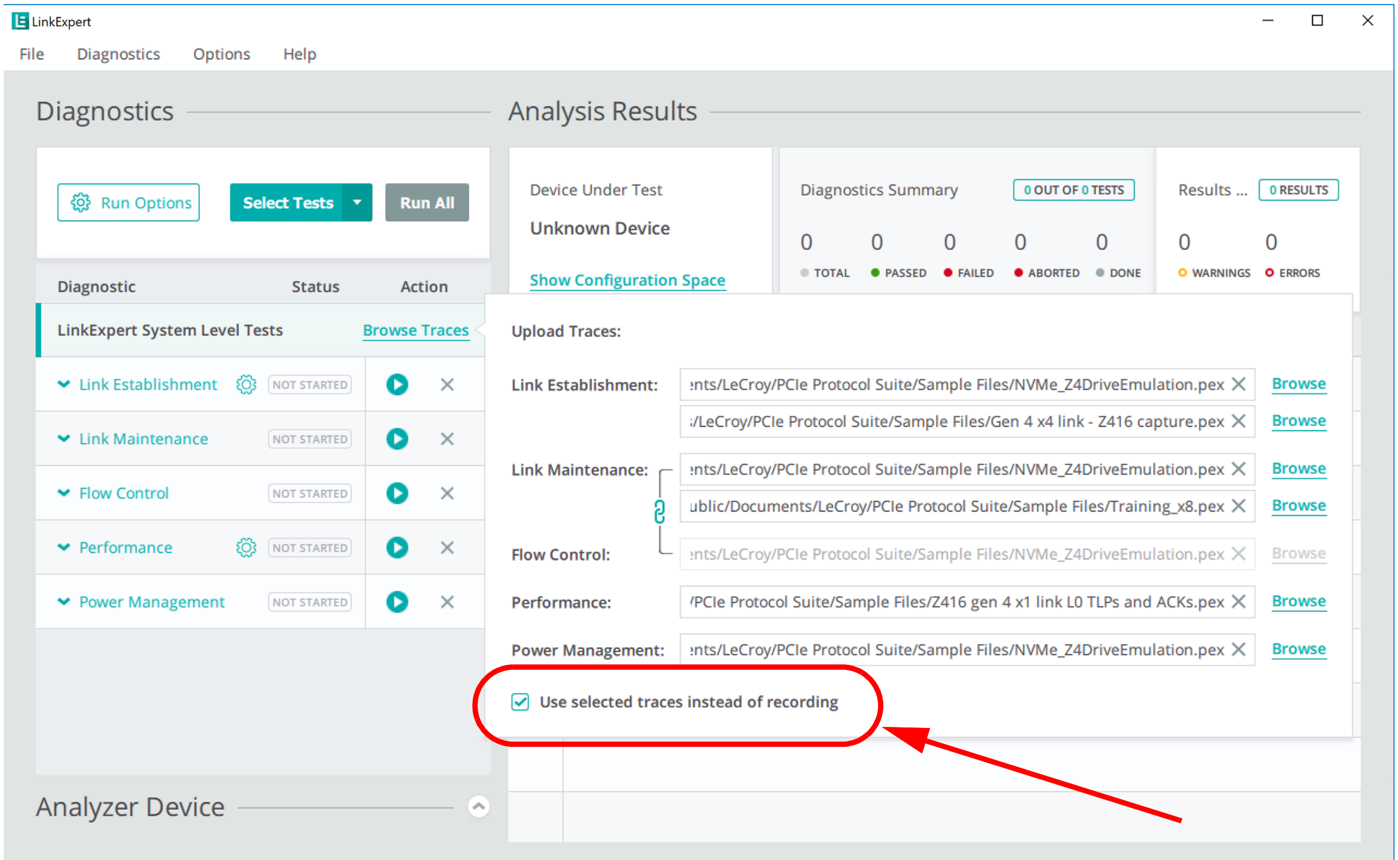


Figure 4.59: Use Selected Traces: Checkbox

Note: If you only have some of the traces needed for each step in the "System Level Tests" the LinkExpert will analyze only those traces and skip the other tests.

4.7 PCIe 3.0 Compliance Package Tests

Note: Approved by PCI-SIG for official testing.

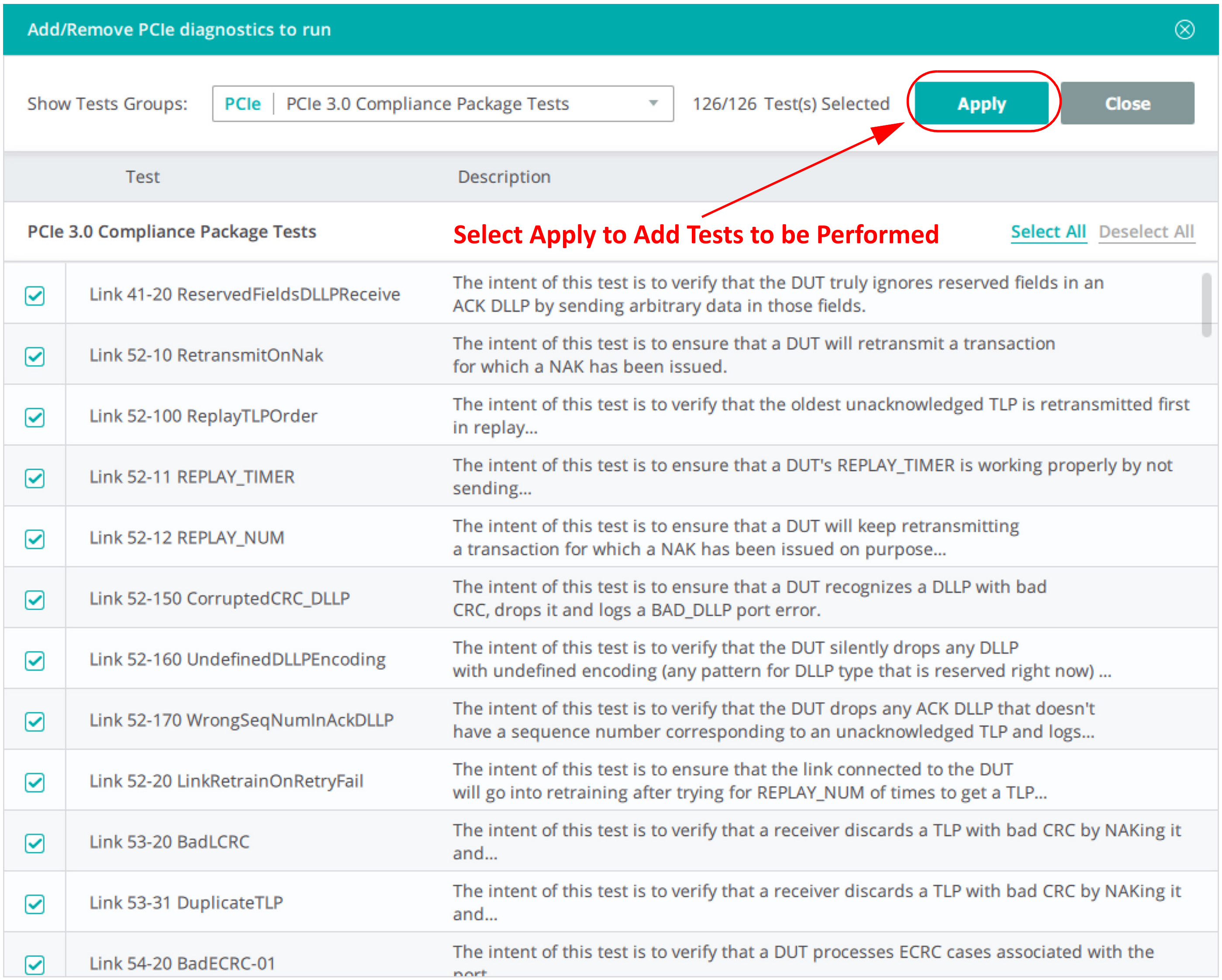


Figure 4.60: PCIe 3.0 Compliance Package Tests

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

Note: PCIe 3.0 Compliance is deprecated.

4.8 PCIe Validation Tests (Endpoint)

You can select as many of the Validation Tests (Endpoint) to be run separately.

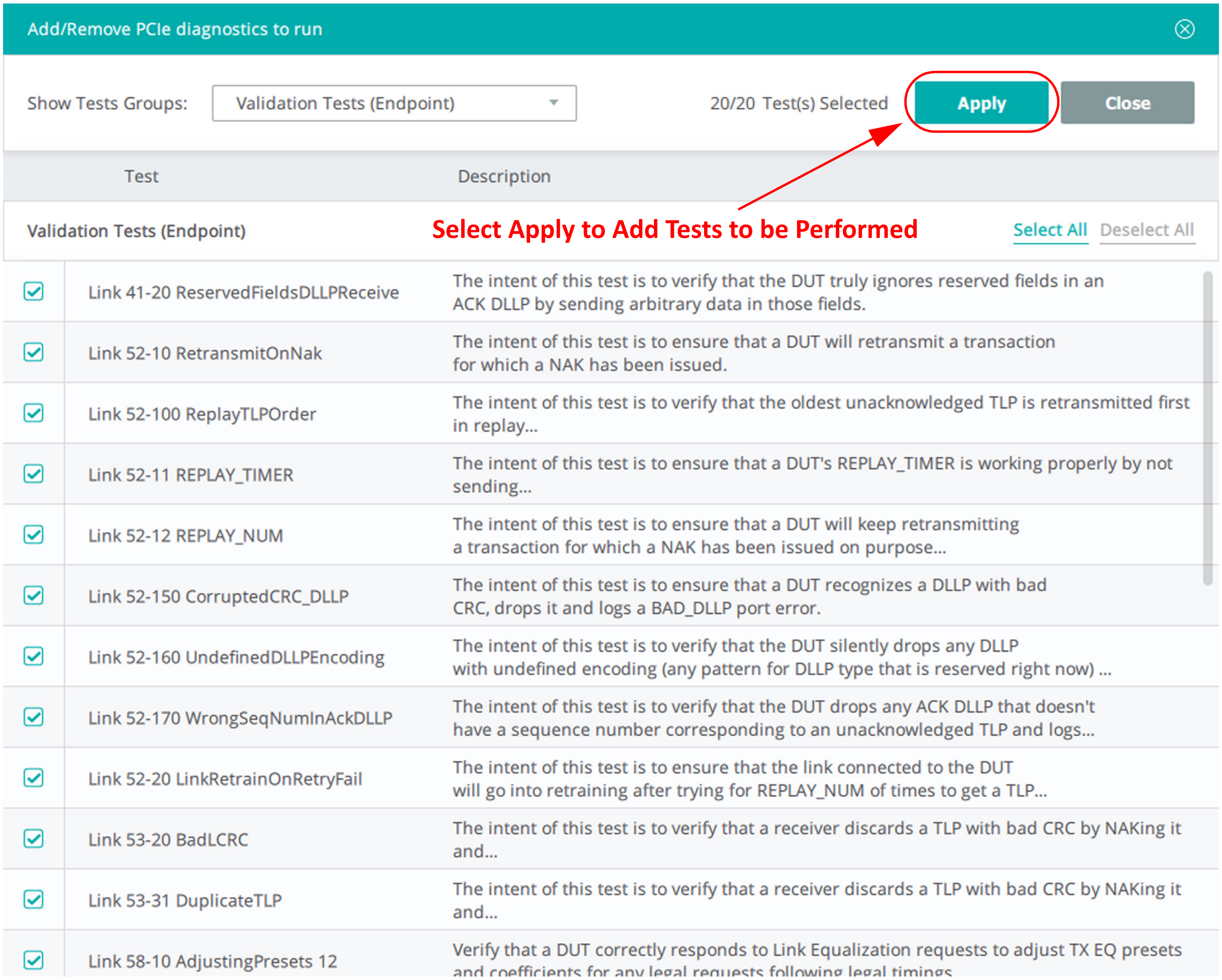


Figure 4.61: Validation Tests (Endpoint)

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

After you selected the Validation Tests (Endpoint) you want to run the Diagnostics list will include an icon to allow you to edit the Validation Tests (Endpoint). See Figure 4.62 on page 143.

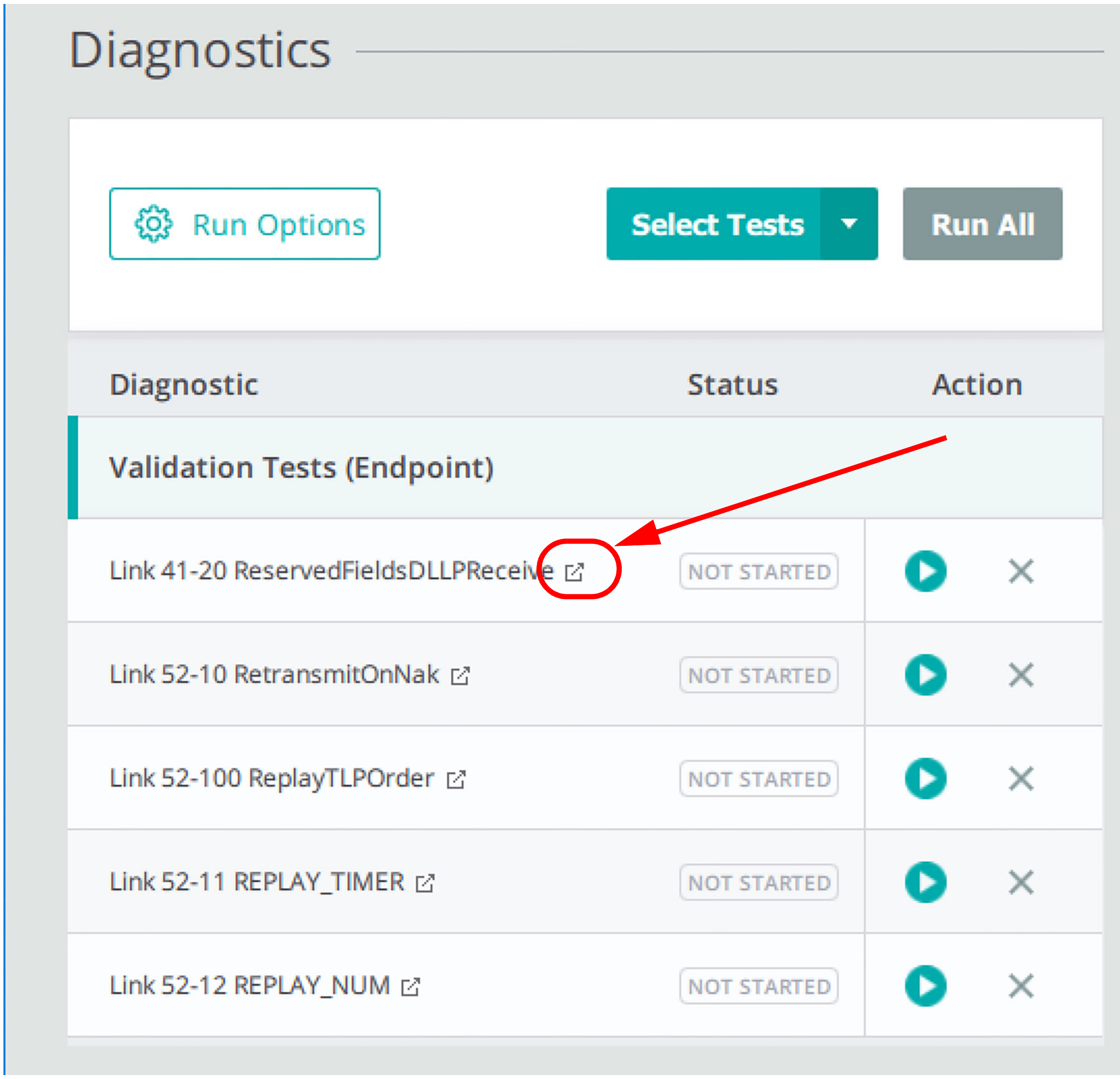


Figure 4.62: Validation Tests (Endpoint): Edit Icon

If you hover over the Edit Icon a tooltip will pop up. See Figure 4.63 on page 144.

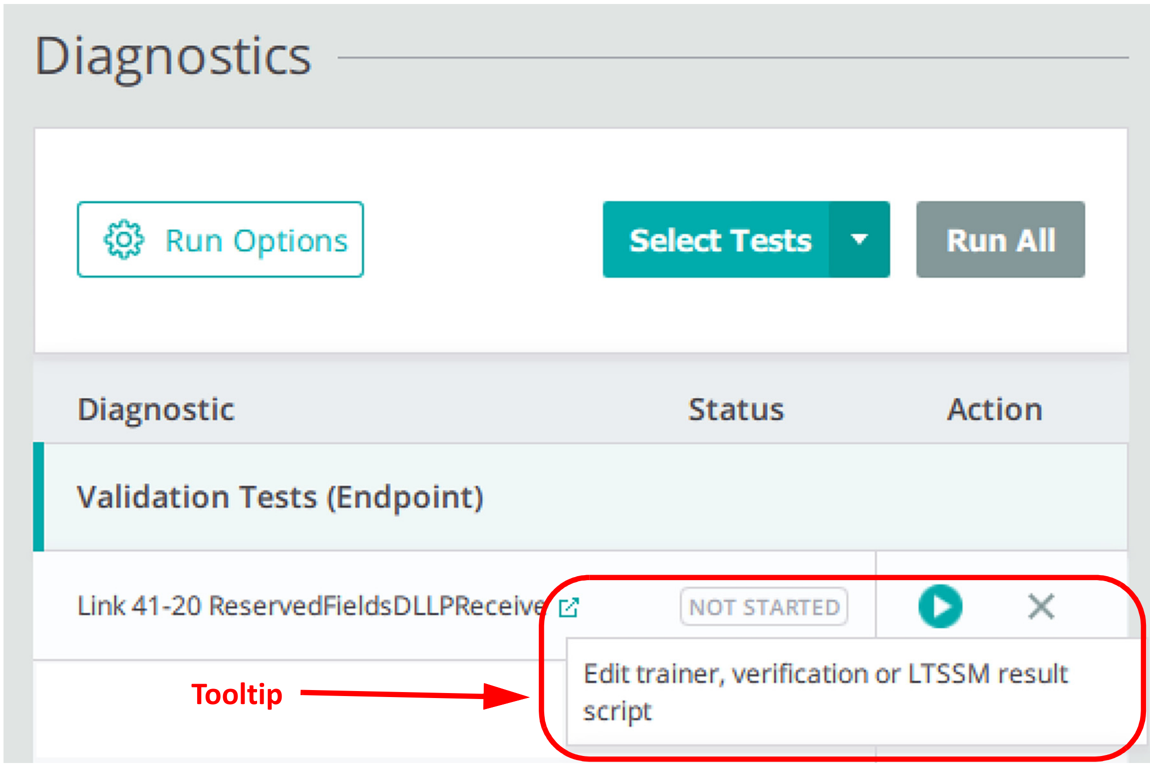


Figure 4.63: Edit Icon: Tooltip

If you select the Edit Icon you can edit the Verification script or the Trainer script. See Figure 4.64

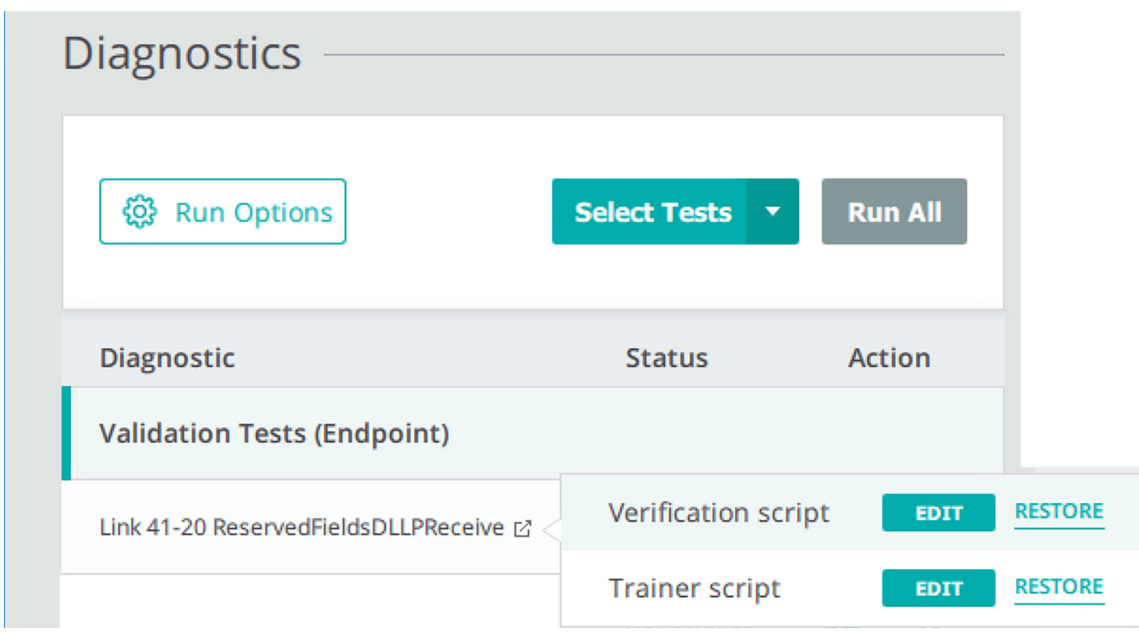


Figure 4.64: Edit Pop Up Menu

For the Validation Tests (Endpoint) you have two options:

- Editing the Verification script
- Editing the Trainer script

If you select the Verification script Edit tab, the source code of the Verification script for the selected test will pop up in an authoring tool (like Word Pad or Note Pad). See Figure 4.65.

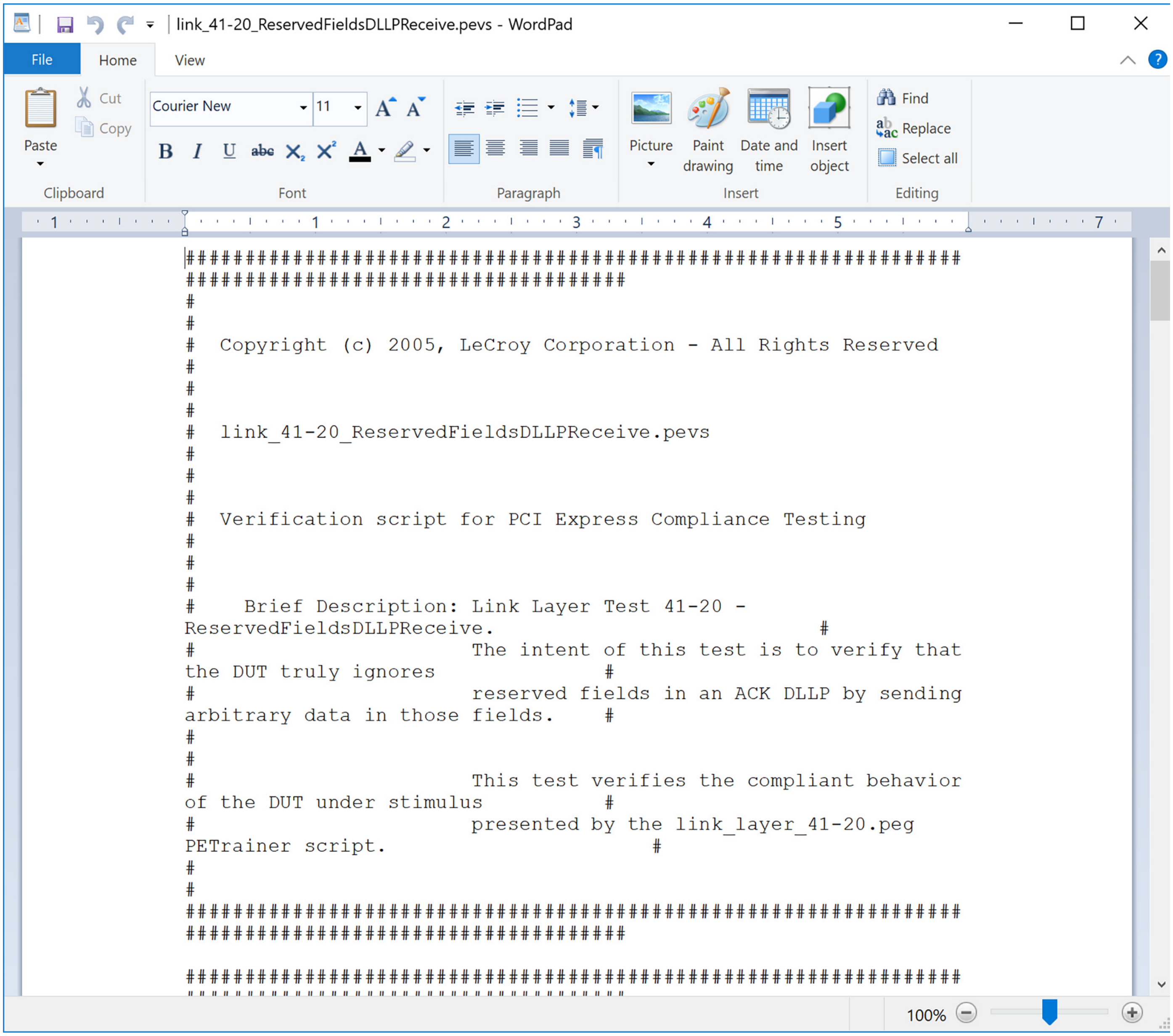


Figure 4.65: Source Code for Verification Test (Endpoint): link_41-20_ReservedFieldsDLLPReceive.pevs

If you had chosen to edit the Trainer Script, the PCIe Protocol Analysis software window will pop up showing you both the Trace View and the Generation Script Editor View. From here you can edit the link_41-20_ReservedFieldsDLLPReceive.pevs script. See Figure 4.66 on page 146.

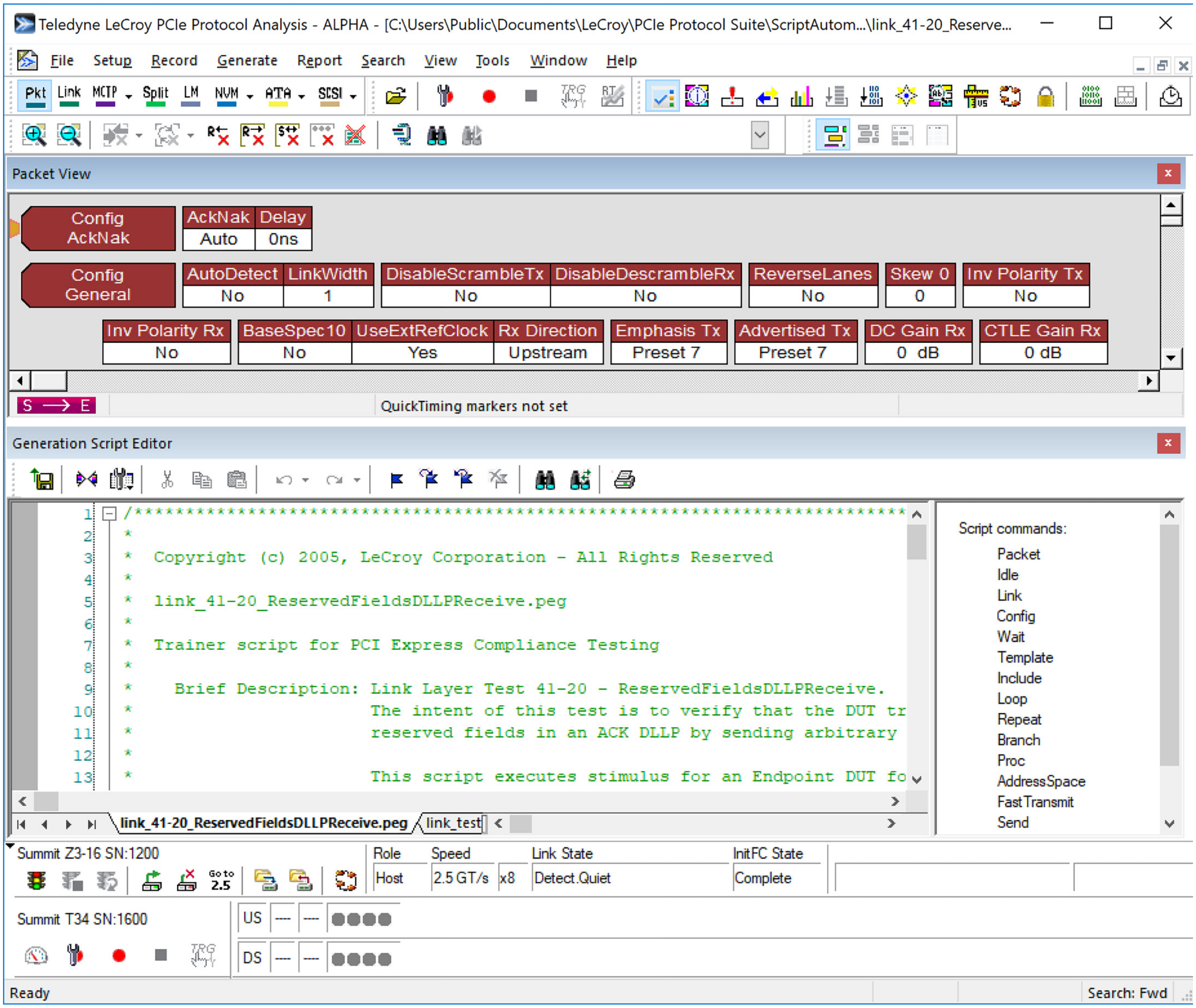


Figure 4.66: Generation Script Editor: link_41-20_ReservedFieldsDLLPReceive.peg file

Click on the “Restore” button to run the default script file.

4.9 PCIe Validation Tests (Root Complex)

You can select as many of the Validation Tests (Root Complex) to be run separately. See Figure 4.67.

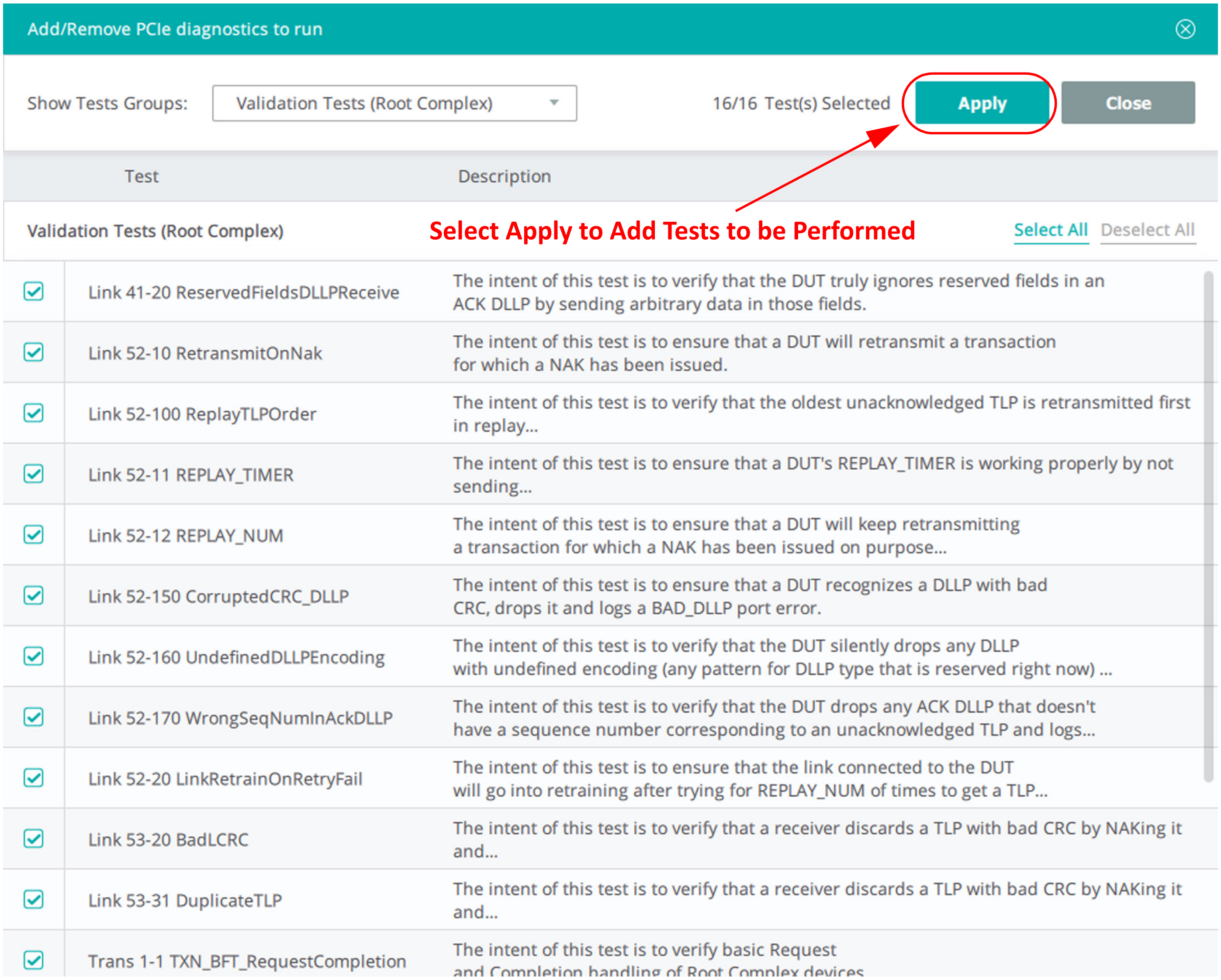


Figure 4.67: Validation Tests (Root Complex)

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

After you selected the Validation Tests (Root Complex) you want to run, the Diagnostics list will include an icon to allow you to edit the Validation Tests (Root Complex). If you hover over the Edit Icon a tooltip will pop up. See Figure 4.68 on page 148.

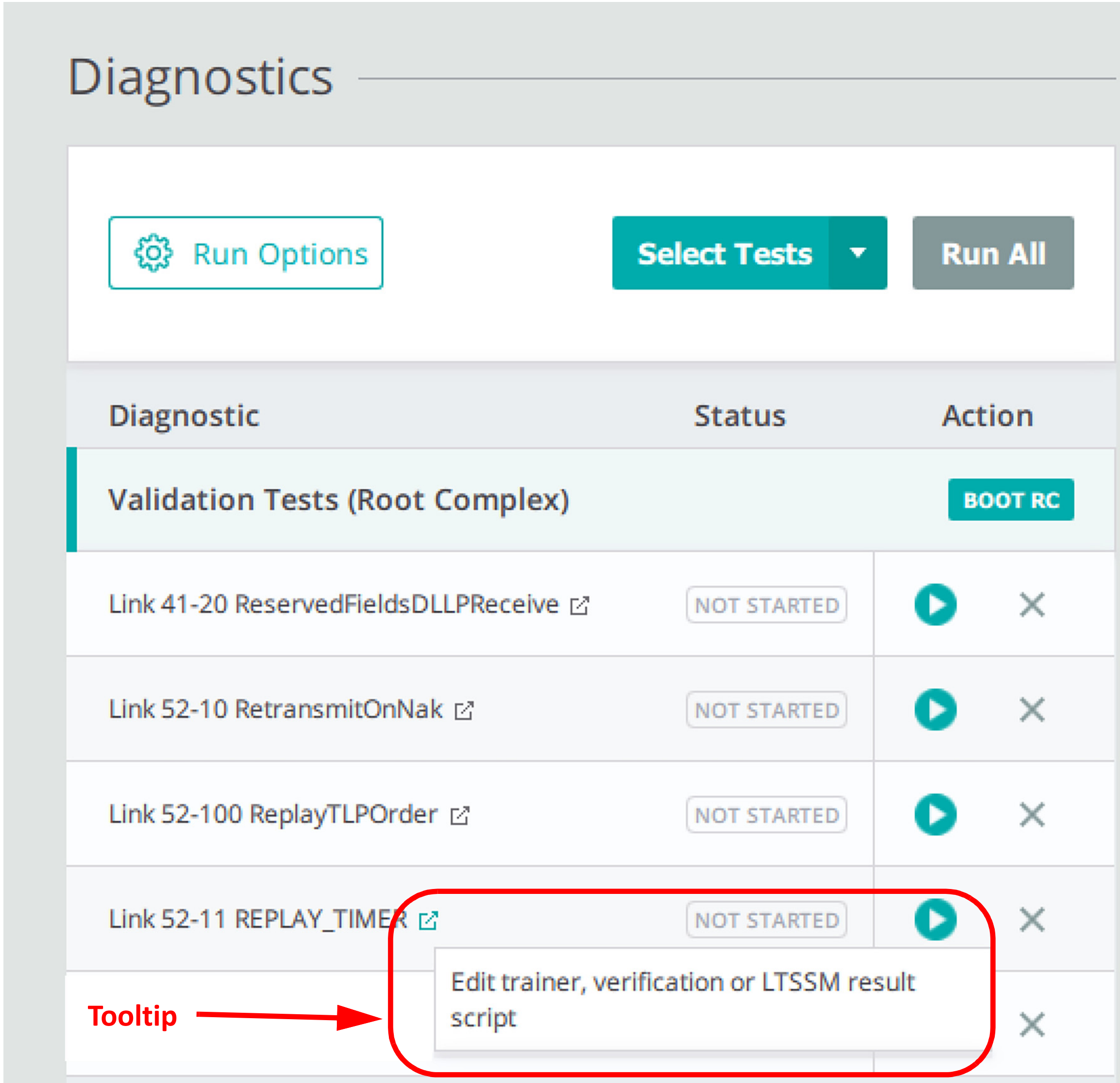


Figure 4.68: Validation Tests (Root Complex): Edit Icon

If you select the Edit Icon you can edit the Verification script or the Trainer script. See Figure 4.69 on page 149.

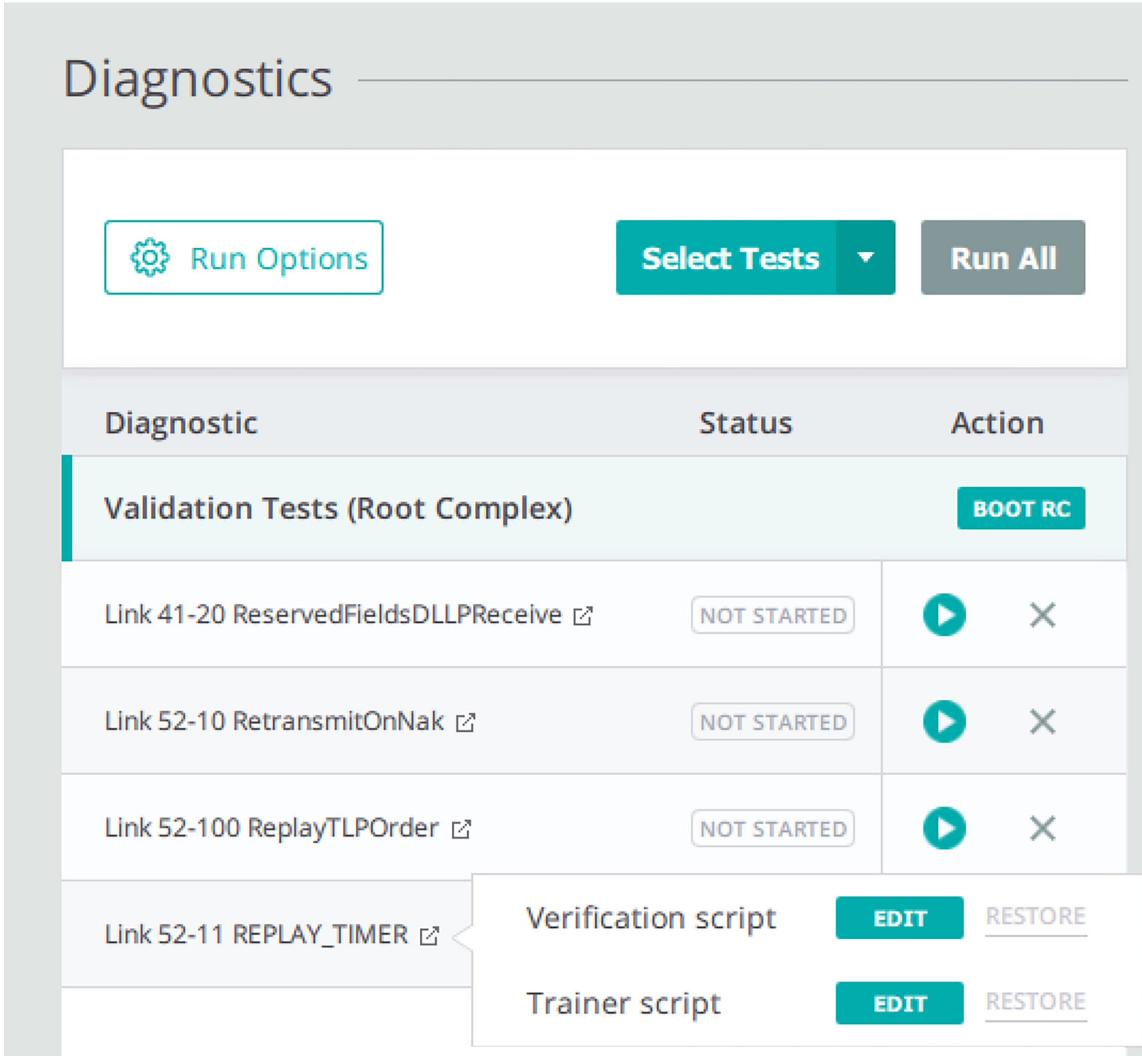


Figure 4.69: Edit Pop Up Menu

For the Validation Tests (Root Complex) you have two options:

- Editing the Verification script
- Editing the Trainer script

If you select the Verification script Edit tab, the source code of the Verification script for the selected test will pop up in an authoring tool (like Word Pad or Note Pad). See Figure 4.70 on page 150.

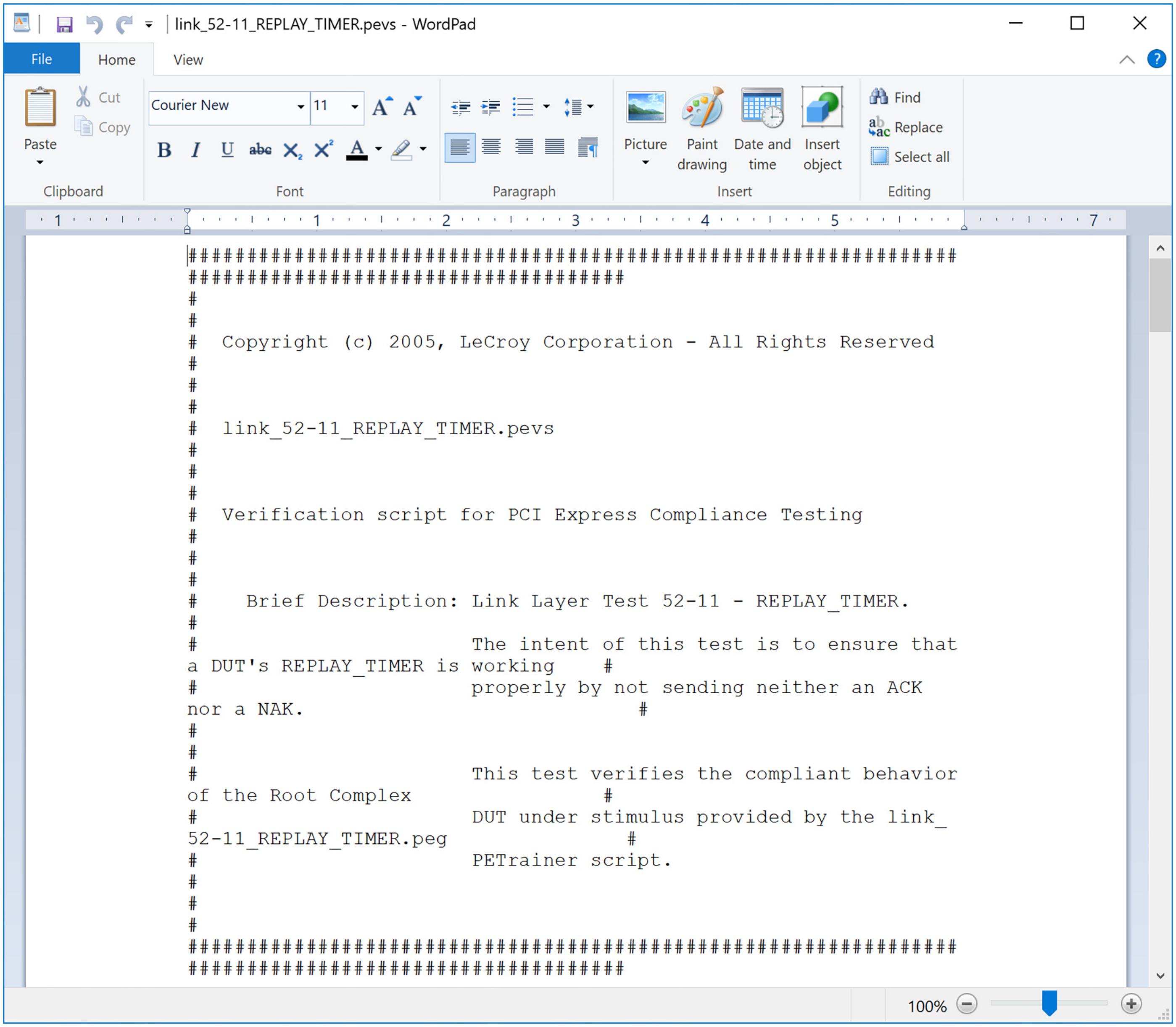


Figure 4.70: Source Code for Verification Test (Root Complex): link_52-11_REPLAY_TIMER.pevs

If you had chosen to edit the Trainer Script, the PCIe Protocol Analysis software window will pop up showing you both the Trace View and the Generation Script Editor View. From here you can edit the link_52-11_REPLAY_TIMER.peg script. See Figure 4.71 on page 151.

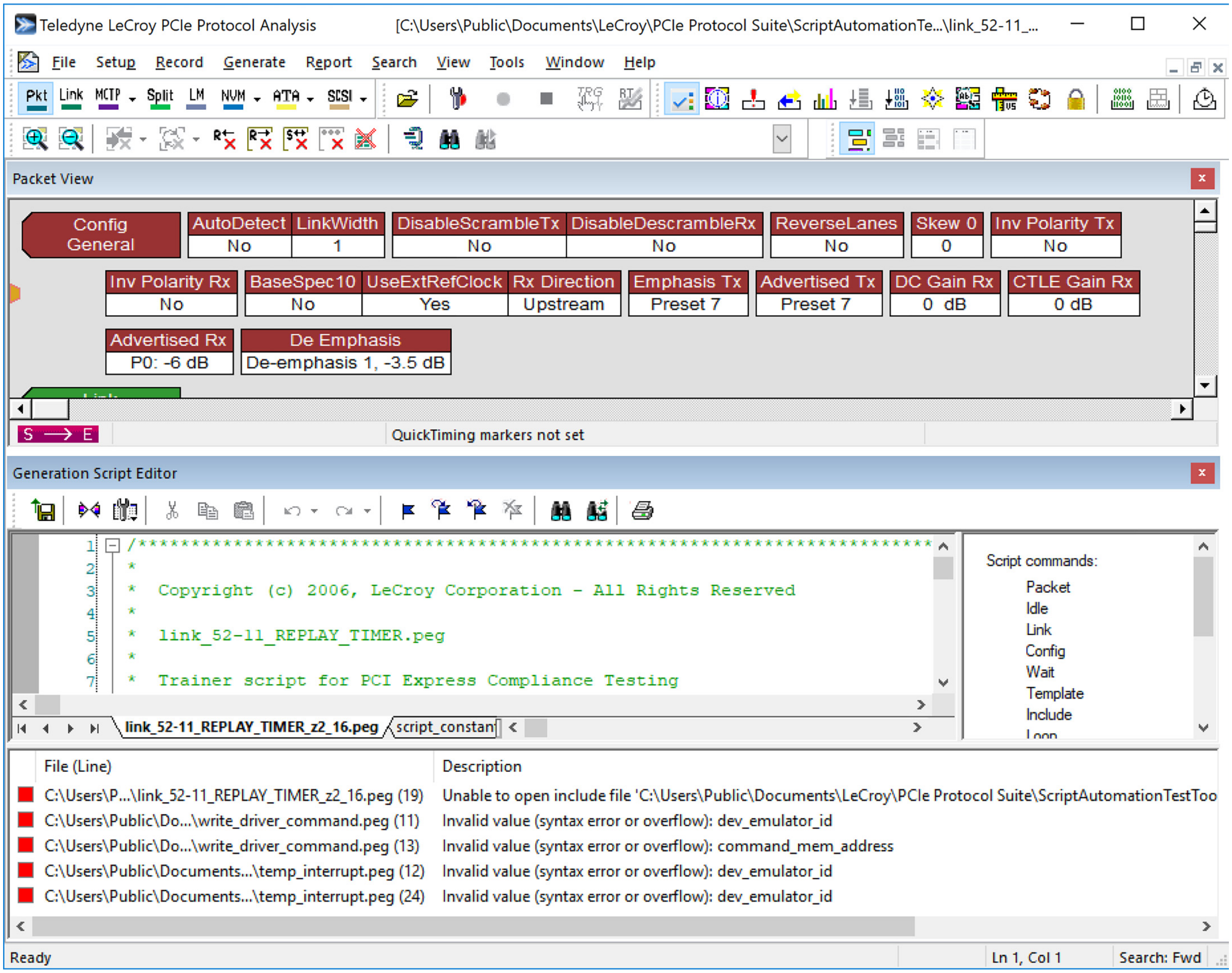


Figure 4.71: Generation Script Editor: link_52-11_REPLAY_TIMER.peg file

Click on the “Restore” button to run the default script file.

4.10 Jammer Validation Tests (endpoint)

You can select as many of the Jammer Validation Tests (endpoint) to be run separately. See Figure 4.72.

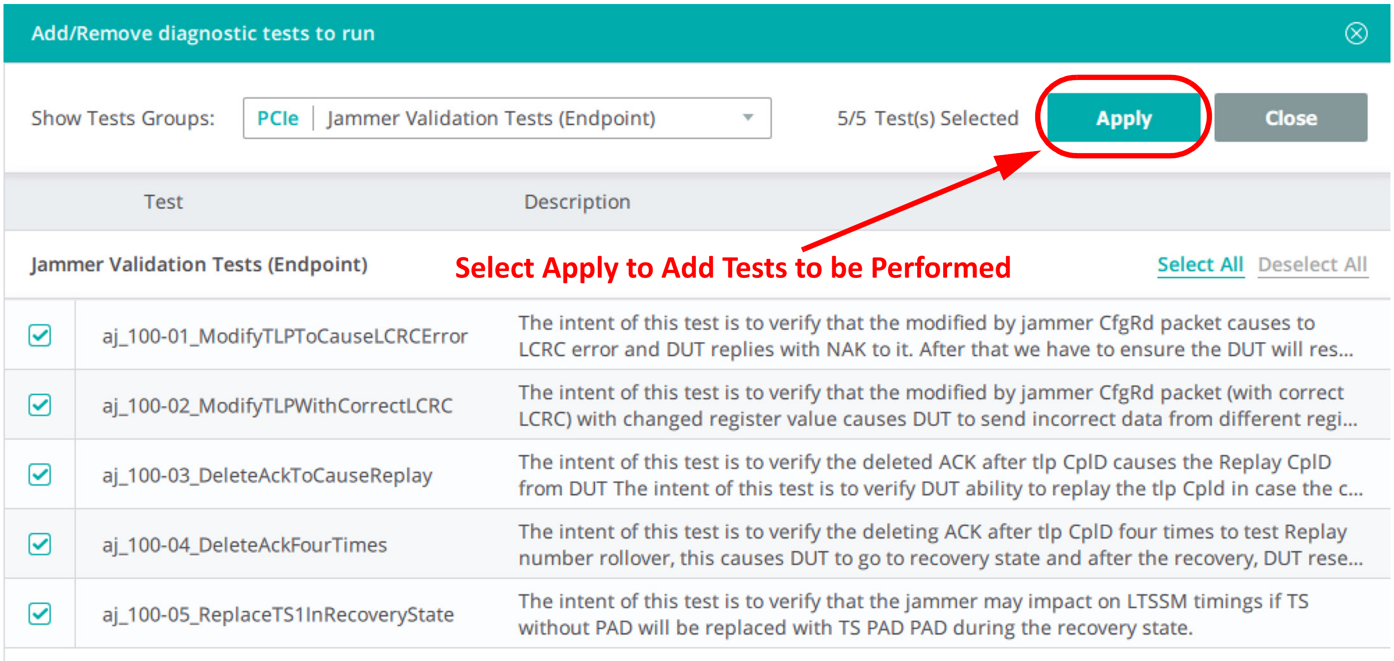


Figure 4.72: Select Jammer Validation Tests (endpoint) to be executed

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.11 PCIe LTSSM Arc Tests

You can select as many LTSSM Arc Tests as your Exerciser and DUT support. See Figure 4.73.

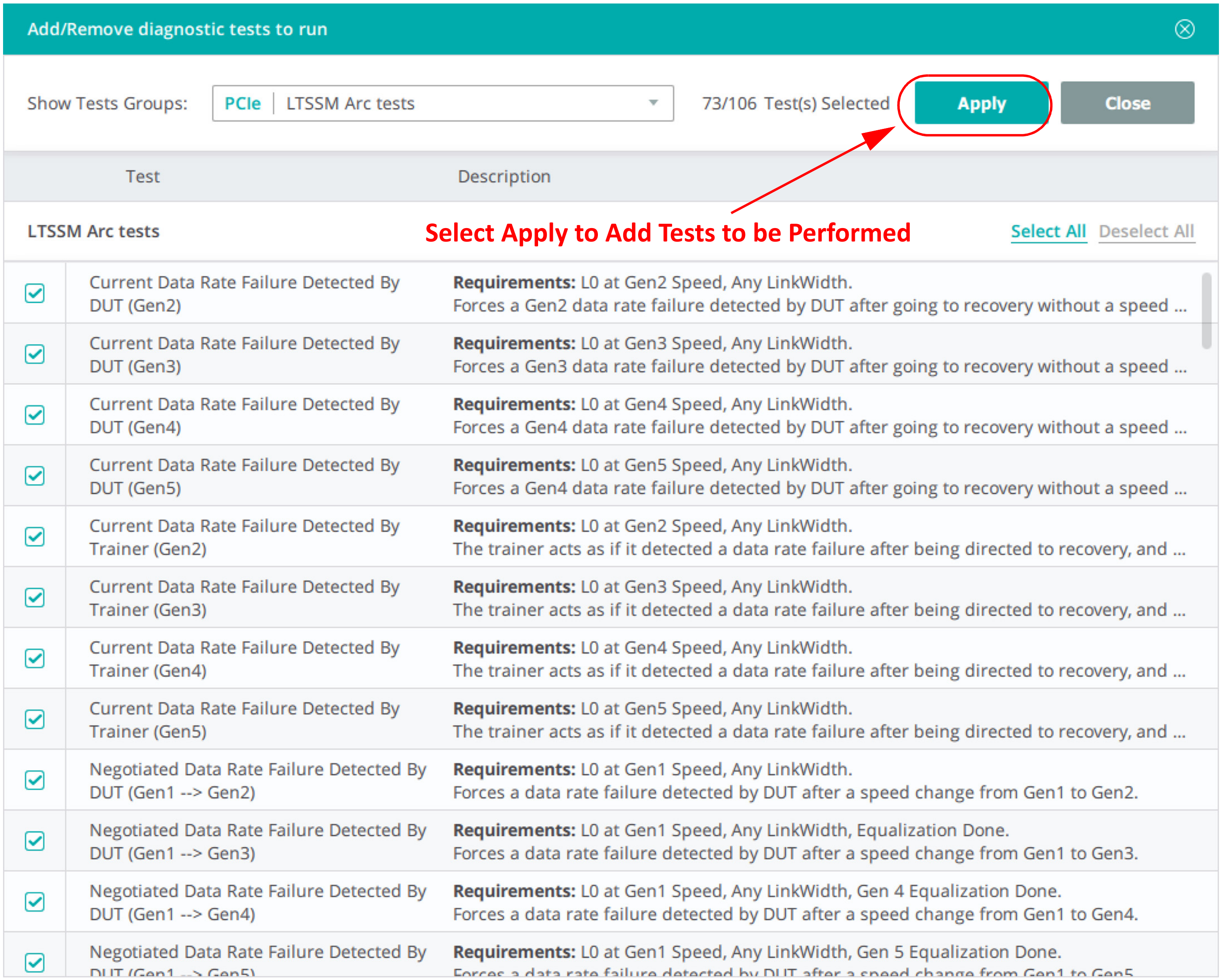


Figure 4.73: LTSSM Arc Tests: 6 of 38 Test Apply to the DUT

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

After you selected the LTSSM Arc Tests you want to run, the Diagnostics list will include an icon to allow you to edit the LTSSM Arc Tests and an icon for more information about each test. See Figure 4.74 on page 154.

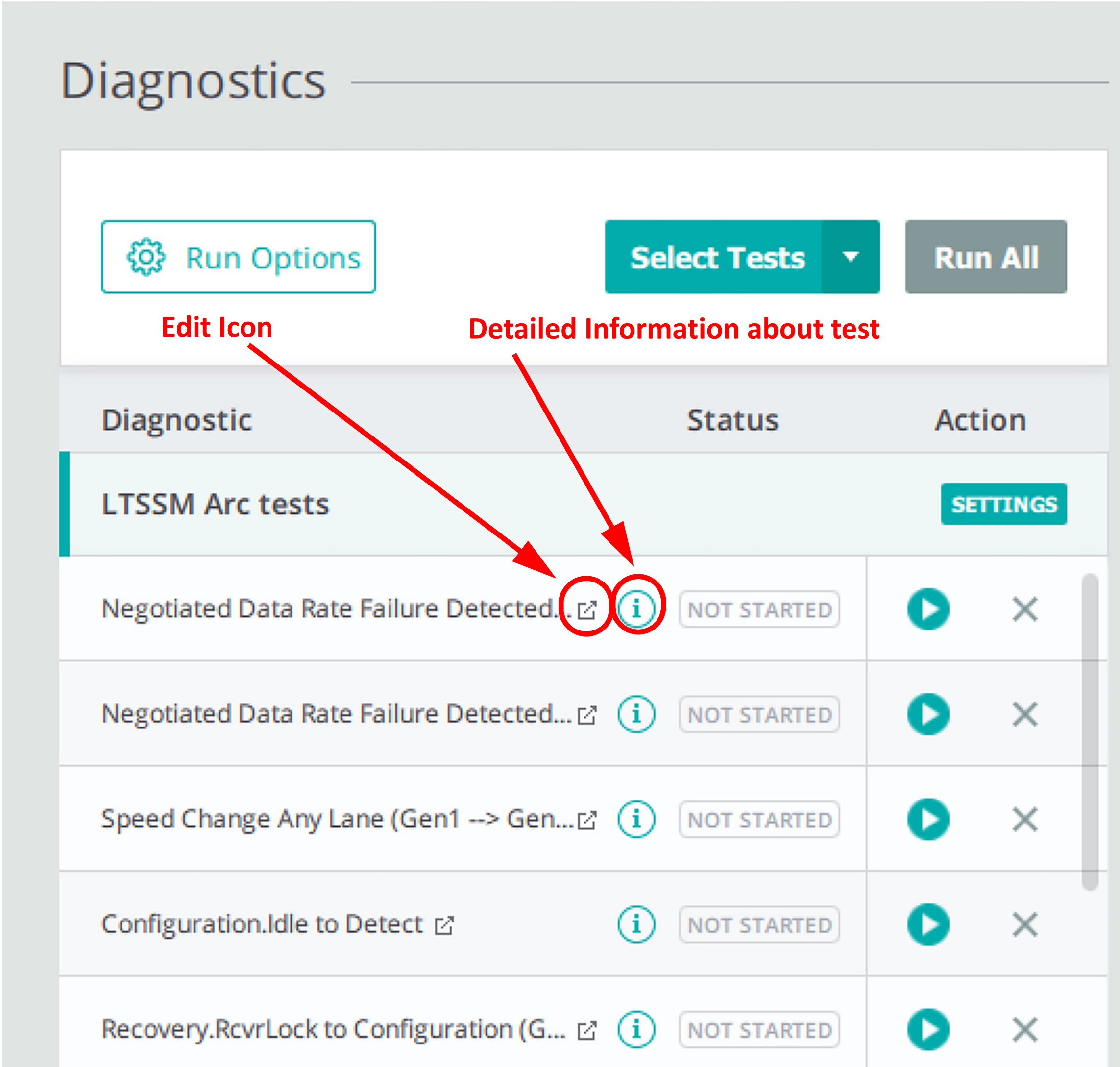


Figure 4.74: LTSSM Arc Tests: Edit Icon

If you hover over the Edit Icon a tooltip will pop up. See Figure 4.75 on page 155.

If you hover over the Information Icon a tooltip will pop up. See Figure 4.76 on page 155.

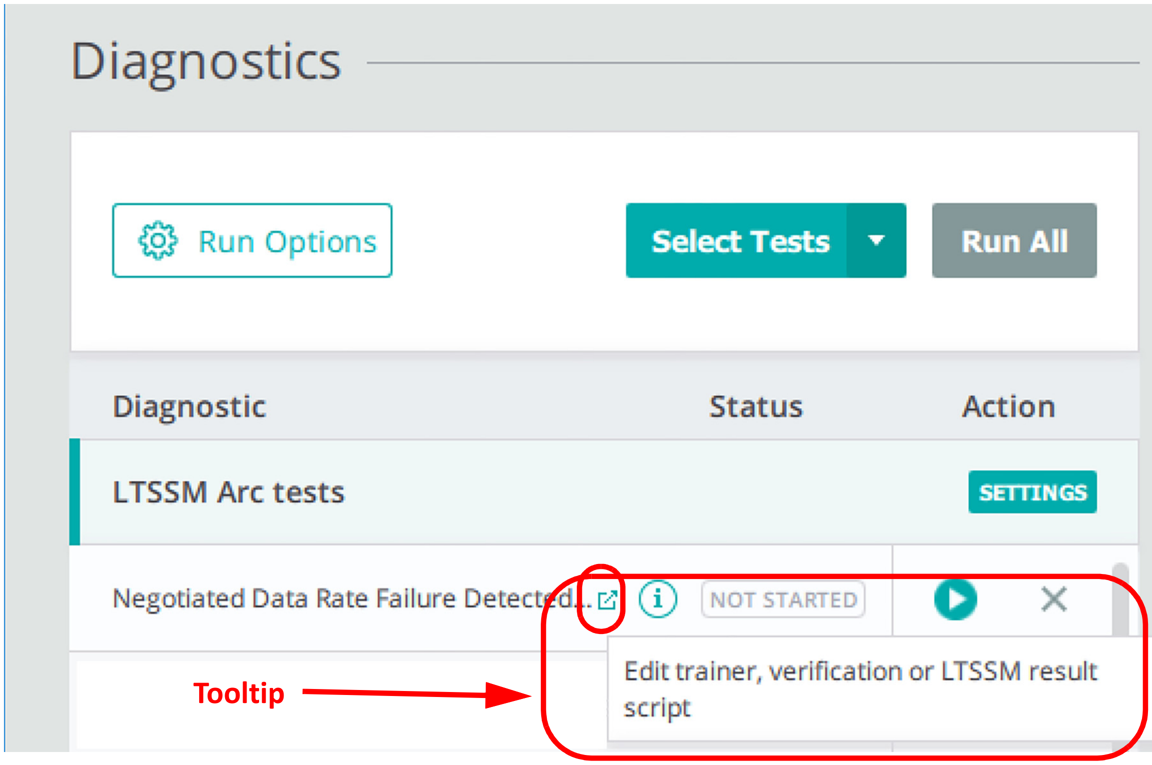


Figure 4.75: Edit Icon: Tooltip

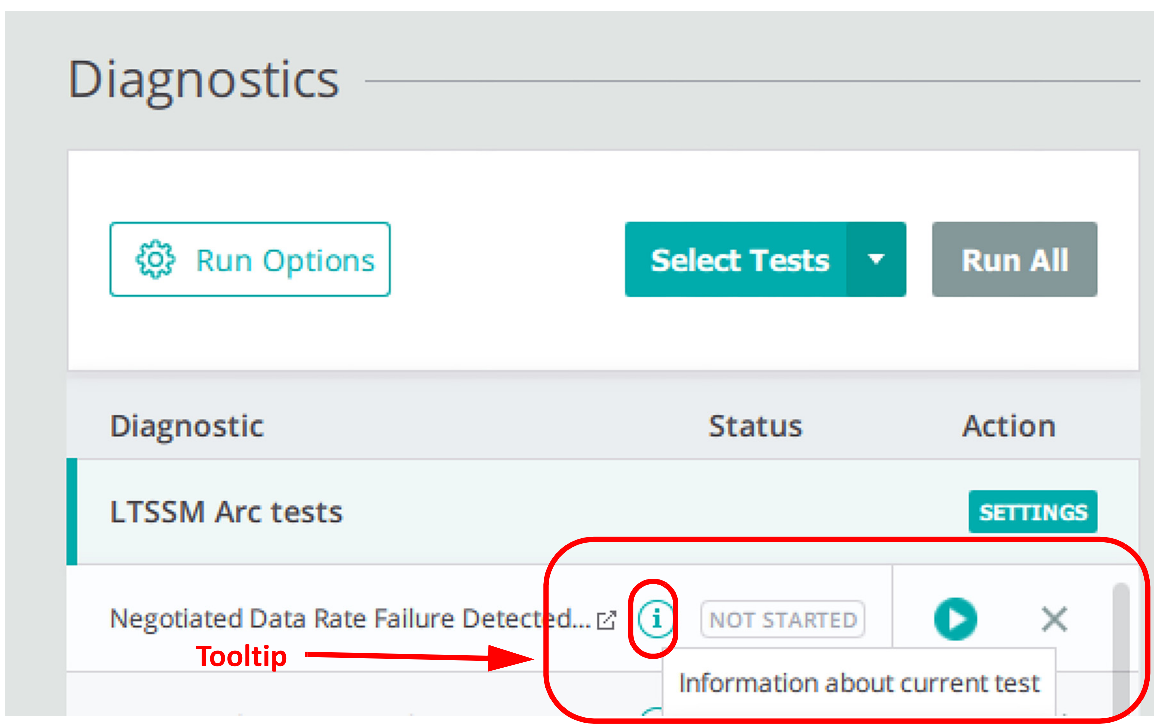


Figure 4.76: Information Icon: Tooltip

If you select the Information Icon you will get a popup window with the details of the test. See Figure 4.77 on page 156.

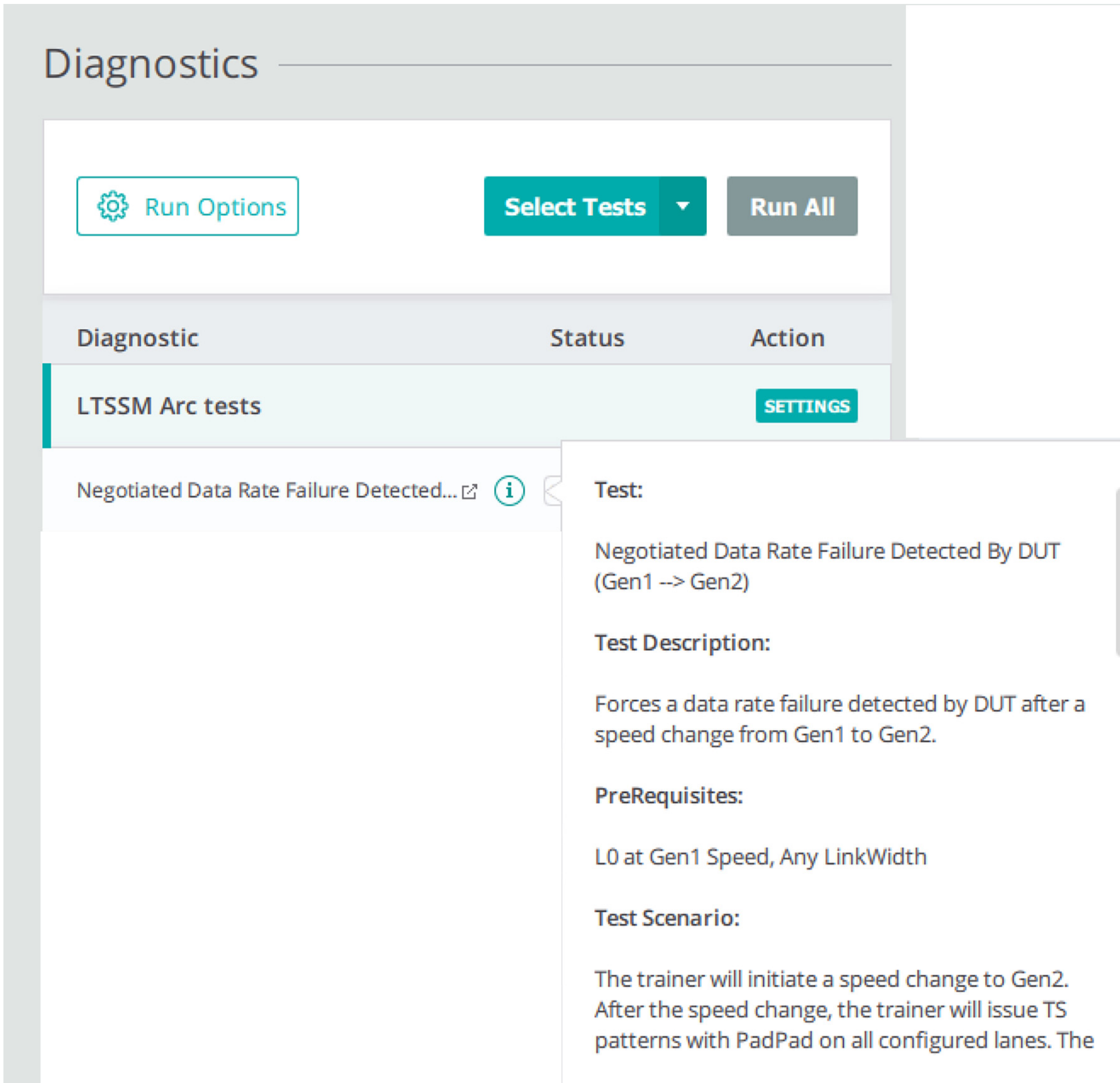


Figure 4.77: Information Icon: Details of Test

If you select the Edit Icon you can edit the LTSSM result script or the Trainer script. See Figure 4.78 on page 157.

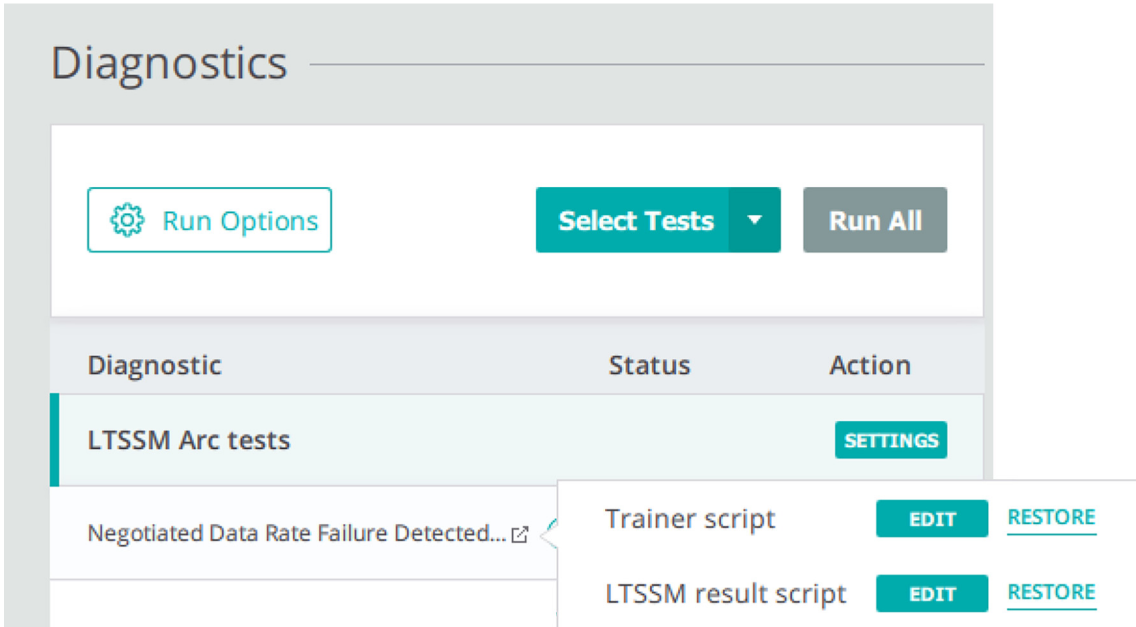


Figure 4.78: Edit Pop Up Menu

For the LTSSM Arc Tests you have two options:

- Editing the Trainer script
- Editing the LTSSM result script

If you chose to edit the Trainer Script, the PCIe Protocol Analysis software window will pop up showing you both the Trace View and the Generation Script Editor View. From here you can edit the selected Trainer script.

See Figure 4.79 on page 158.

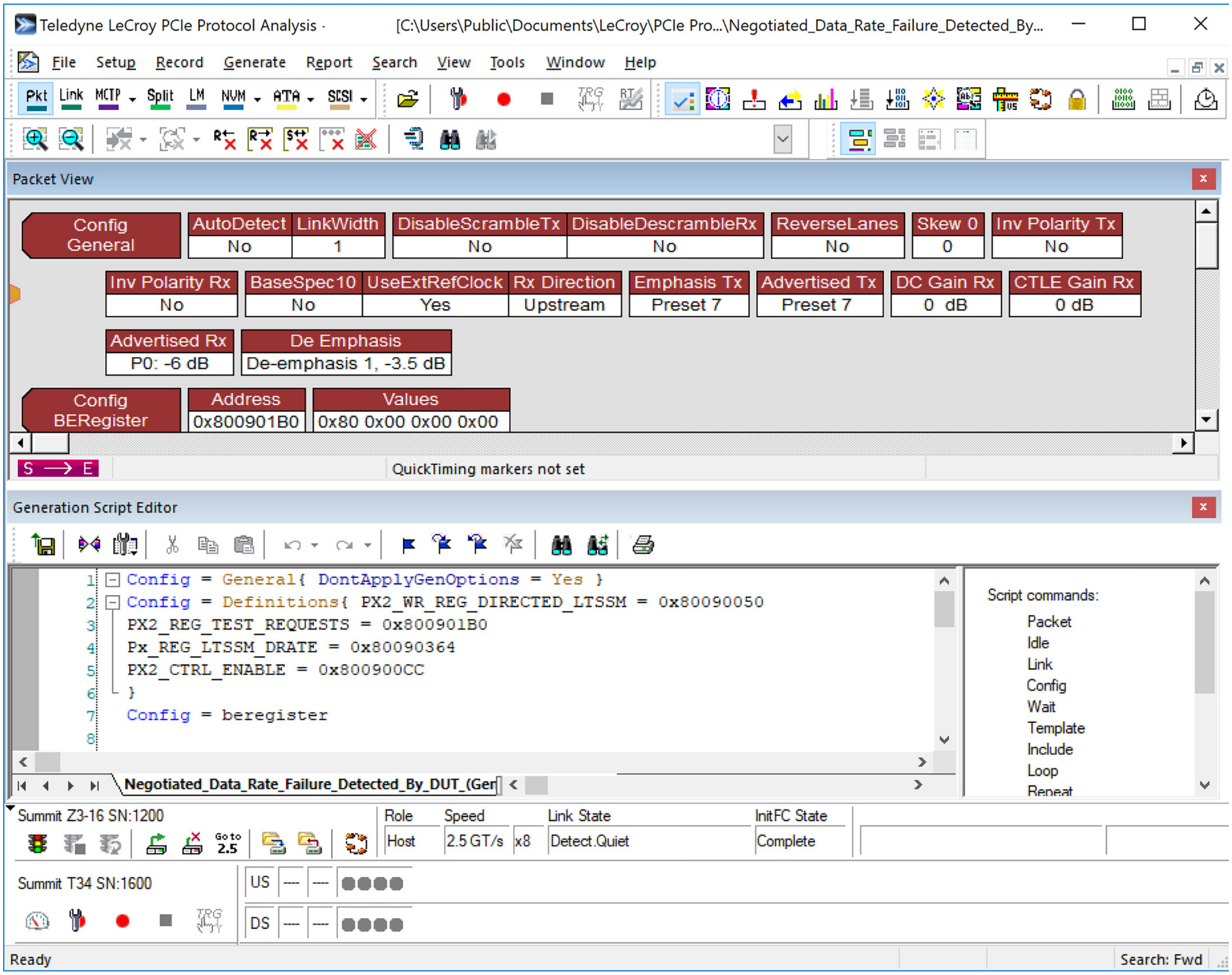


Figure 4.79: Use Generation Script Editor to edit the selected LTSSM Arc Test

For details on the register values see “Register Structure for PCIe LTSSM Arc Tests” on page 291.

If you had chosen to edit the LTSSM Arc Test result script, the script would open in an authoring tool like Word Pad. See Figure 4.80 on page 159.

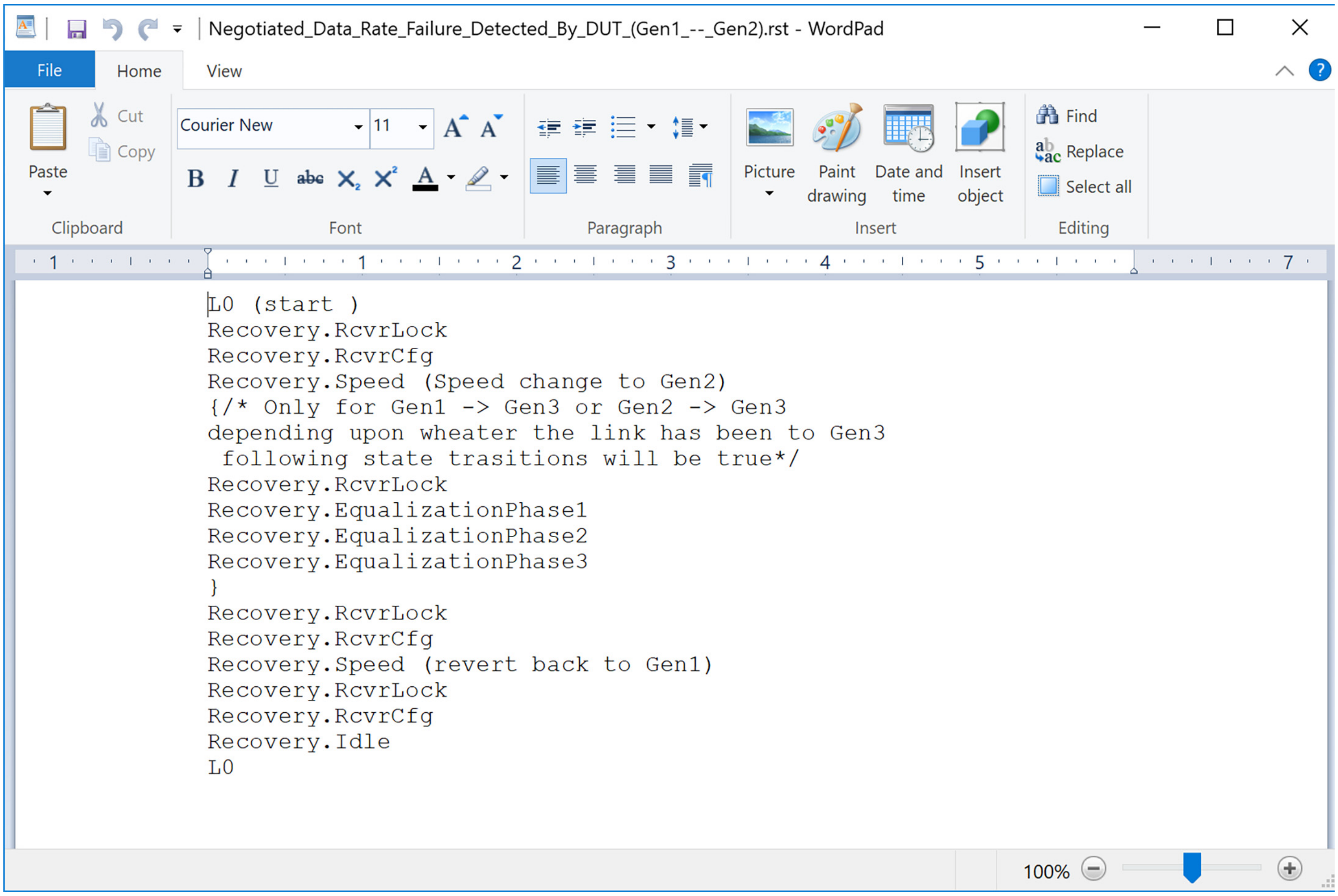


Figure 4.80: Edit LTSSM Arc Test result script opened in Word Pad

Click on the “Restore” button to run the default script file.

If you decide to go ahead with the LTSSM Arc Tests you’ll get the following Warning message (see Figure 4.81).

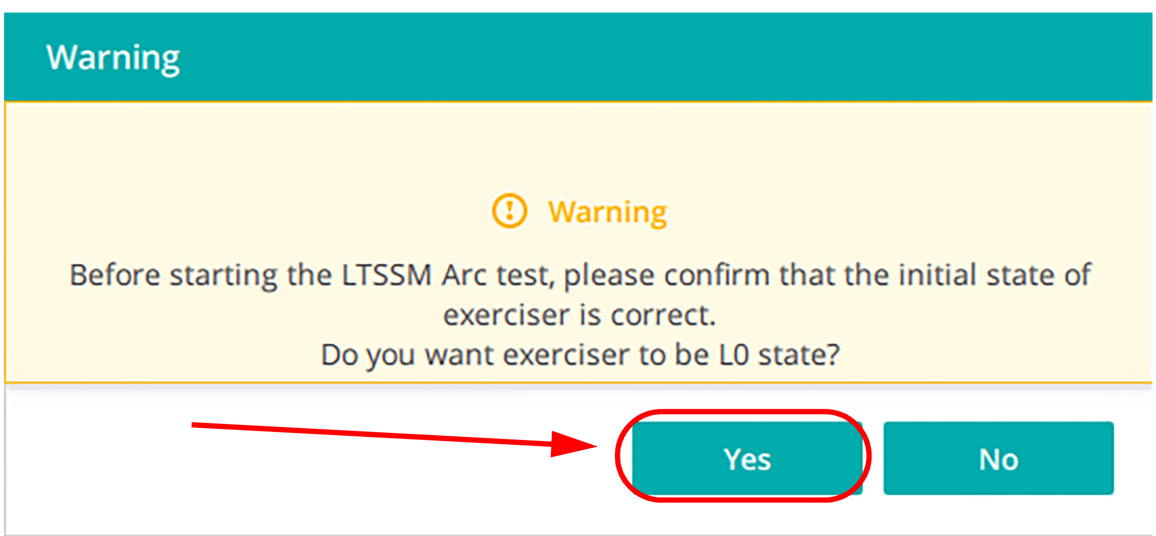


Figure 4.81: LTSSM Arc Tests: Warning Message

If you click on “Yes” the exerciser you are using will automatically update to State L0, so you can start the LTSSM Arc Tests. See Figure 4.82.

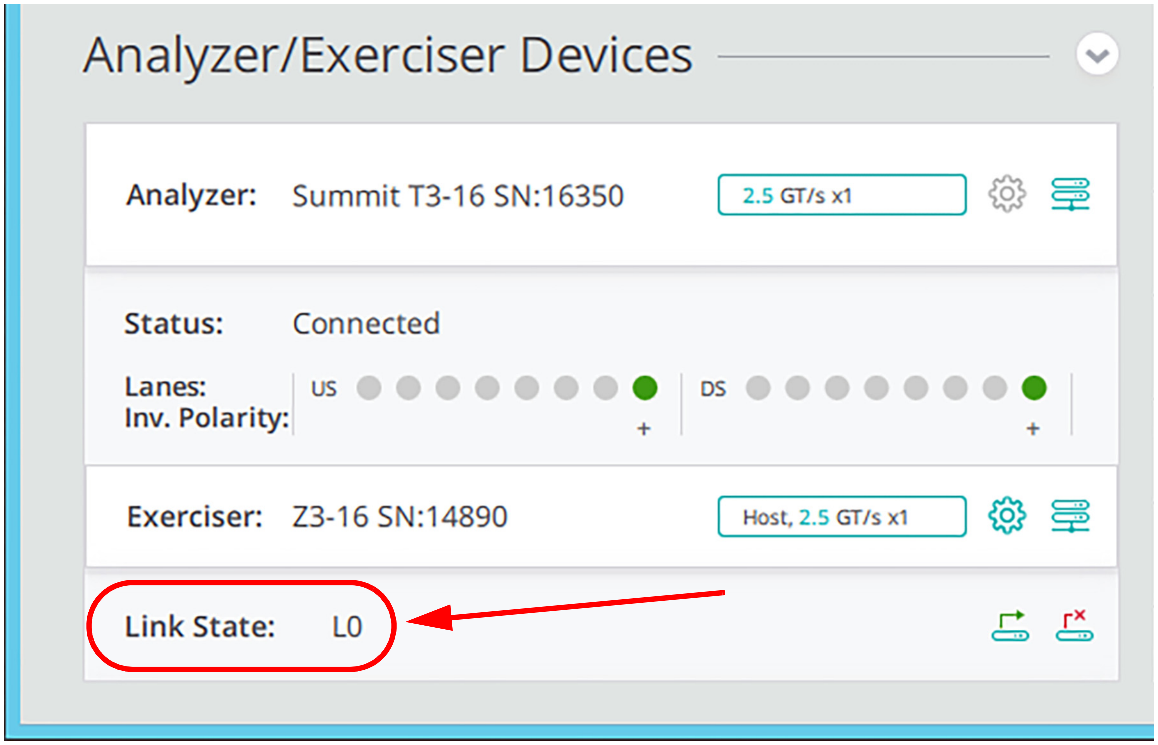


Figure 4.82: Analyzer Set to State L0

Now you can proceed with the LTSSM Tests you have selected.

4.12 PCIe 4.0 Compliance Package Tests

Note: Approved by PCI-SIG for official testing

You can select as many PCIe 4.0 Compliance Package Tests as your Exerciser and DUT support. See Figure 4.83.

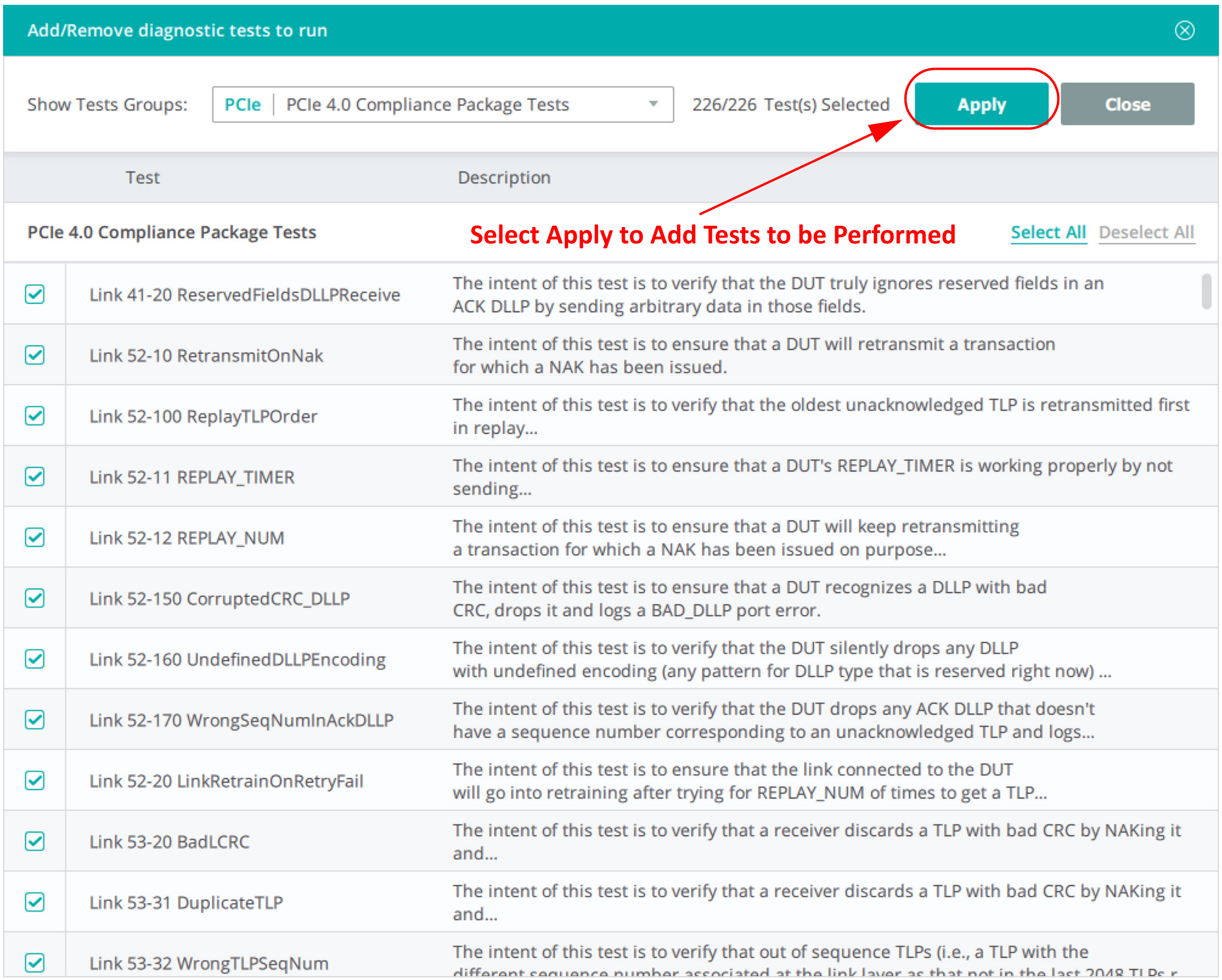


Figure 4.83: PCIe 4.0 Compliance Packet Tests

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.13 PCIe 5.0 Compliance Package Tests

You can select as many PCIe 5.0 Compliance Package Tests as your Exerciser and DUT support. See Figure 4.84.

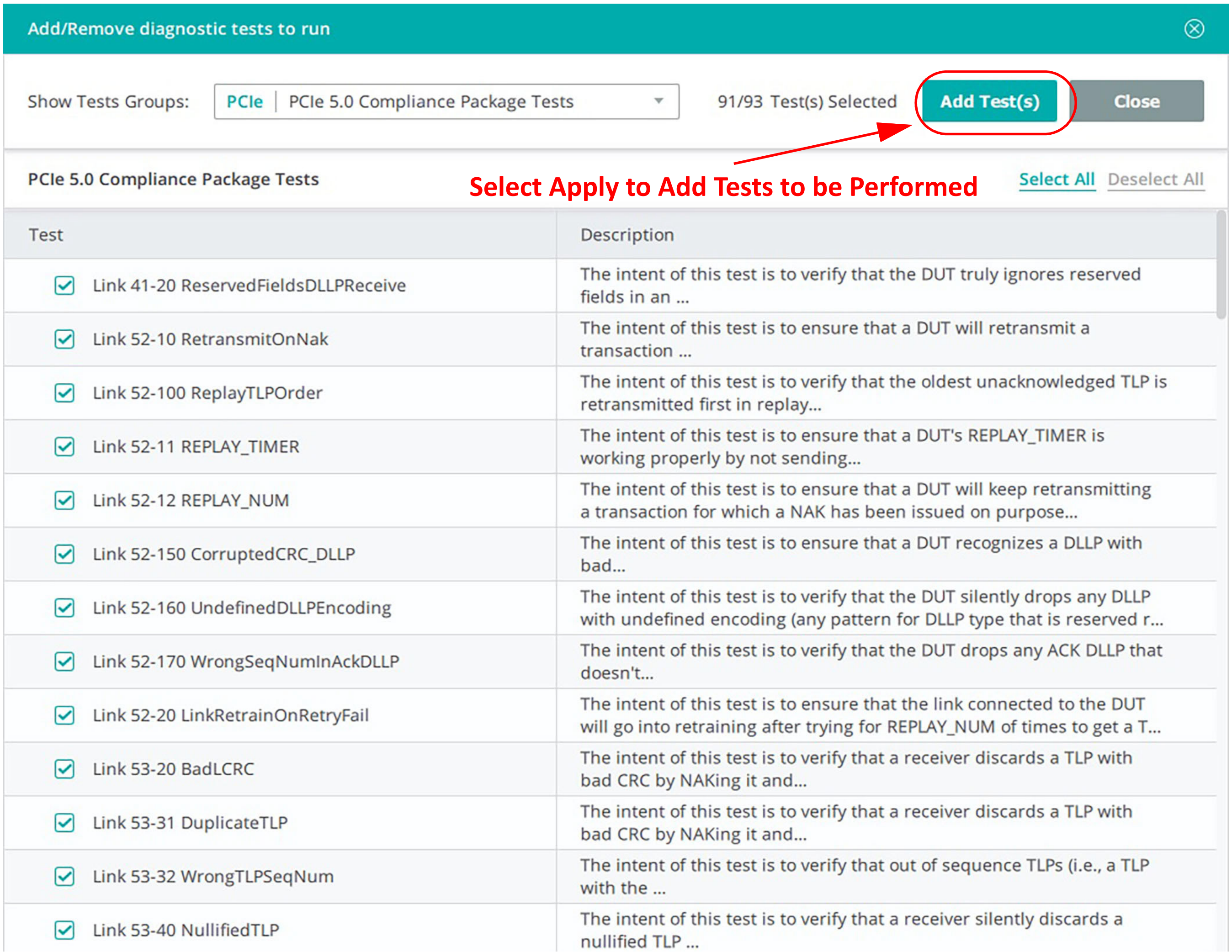


Figure 4.84: PCIe 5.0 Compliance Packet Tests

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.14 PCIe Compliance Tests using Test LTSSM Log

For tests related to Equalization and some other LTSSM features, LinkExpert compliance packages employ the Test LTSSM Log for faster and more reliable operation.

The Exerciser logic logs all the relevant LTSSM states and substates and (if needed) data link events. When all the relevant log data is captured, it is inserted into the Downstream traffic from the Exerciser in the form of Payload of Vendor Defined Message TLPs the exerciser transmits.

This allows the analyzer to capture only those message TLPs and parse the payloads to traverse through all the states the system went through and derive the pass/fail determination from that data.

The following tests currently employ the above Test LTSSM Log approach.

Gen5 Compliance:

- Test 55-10 Reserved Bits in TS;
- Tests 57-10,11,12 Adjusting Initial Presets for 8,16,32G;
- Tests 58-10,11,12 Adjusting Presets for 8,16,32G;
- Tests 59-10,11,12 Adjusting Coefficients for 8,16,32G;
- Tests 71-10 Equalization Redo at 8G from 2.5 and 5G, 71-11 Equalization Redo at 16G, 71-12 Equalization Redo at 32G;
- Tests 68-10 Data Link Feature.

Gen4 Compliance:

- Test 55-10 Reserved Bits in TS;
- Tests 57-10,11 Adjusting Initial Presets for 8,16G;
- Tests 58-10,11 Adjusting Presets for 8,16G;
- Tests 59-10,11 Adjusting Coefficients for 8,16G;
- Test 5x-11 Equalization Redo at 16G;
- Tests 68-10 Data Link Feature.

4.15 PCIe RAS Error Injection Tests

You can select as many PCIe RAS Error Injection Tests as your Jammer and DUT support. See Figure 4.85

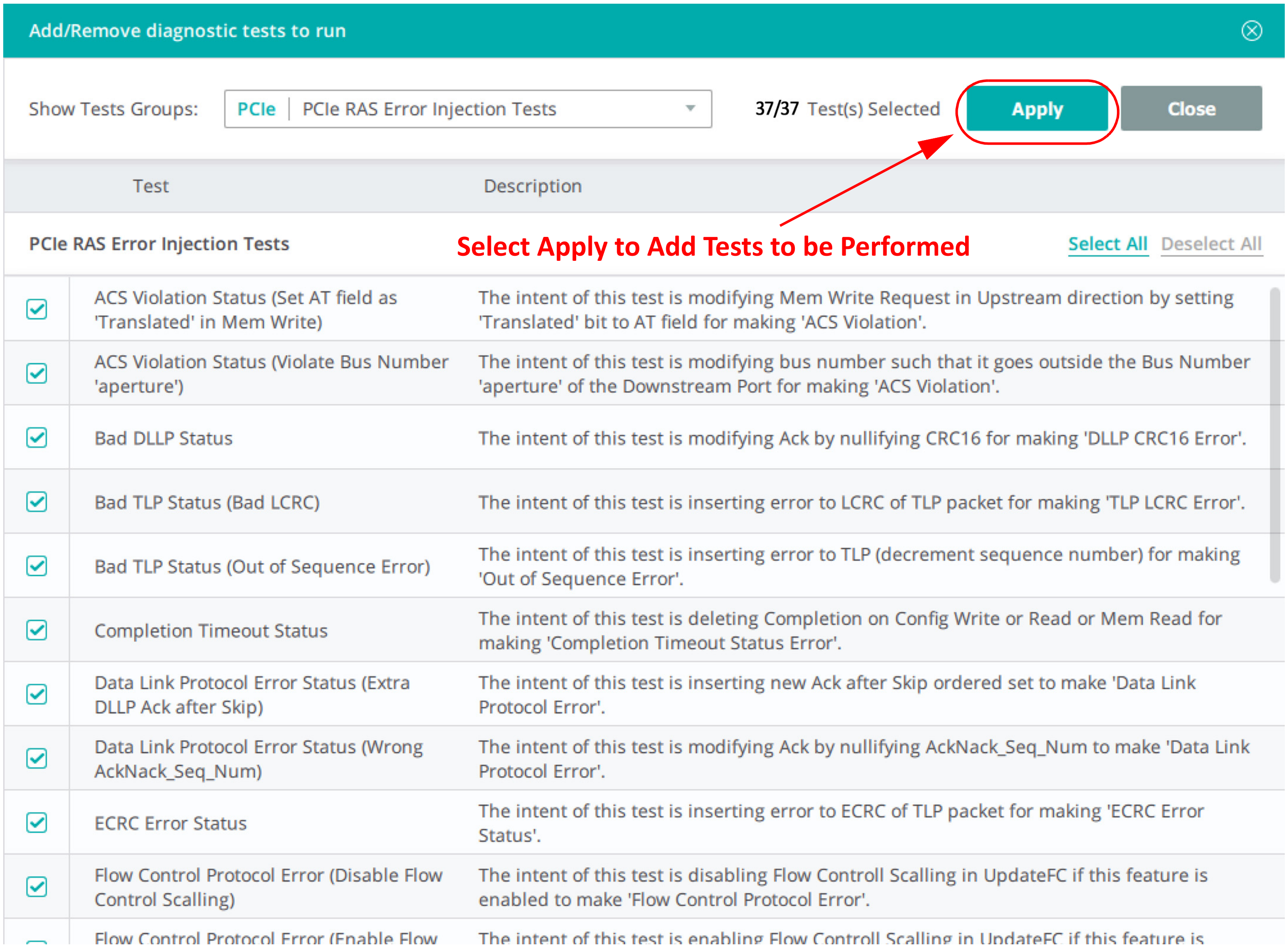


Figure 4.85: List of RAS Tests

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.15.1 RAS Testing using Summit M5x and LinkExpert

The Summit M5x can be used for Error Injection testing as defined in the PCIe RAS specification. The PCIe RAS Error Injection tests allow the user to create error scenarios that test the following:

- Ensure Advanced Error Reporting reports properly
- Ensure System logs errors appropriately

4.15.2 PCI Express Error Types

- Correctable
  - Rx Error
  - Bad TLP
  - Bad DLLP
  - Replay Timer Timeout
- Uncorrectable Non-Fatal
  - Poisoned TLP
  - Unsupported Request
  - Completer Abort
  - Unexpected Completion
  - Completion Timeout
  - ACS violation
- Uncorrectable Fatal
  - DLL Error
  - Surprise Link Down
  - Flow Control Protocol
  - Rx Buffer Overflow
  - Malformed TLP

4.15.3 PCIe “RAS” Error Injection Testing – List of Tests

- 1. Correctable Errors
  - 1.1 Receiver Error Status
  - 1.2 Bad DLLP Status
  - 1.3 Bad TLP Status
  - 1.4 Replay NUM Rollover Status
  - 1.5 Replay Timer Timeout Status
  - 1.6 Advisory Non-Fatal Error Status
  - 1.7 Correctable Internal Error Status
  - 1.8 Header Log Overflow Status
- 2. Uncorrectable Errors
  - 2.1 Data Link Protocol Error Status
  - 2.2 Surprise Down Error Status
  - 2.3 Poisoned TLP received Status
  - 2.4 Flow Control Protocol Error Status
  - 2.5 Completion Timeout Status
  - 2.6 Completer Abort Status
  - 2.7 Unexpected Completion Status

- 2.8 Receiver Overflow Status
- 2.9 Malformed TLP Status
- 2.10 ECRC Error Status
- 2.11 Unsupported Request Error Status
- 2.12 ACS Violation Status
- 2.13 Uncorrectable Error Status
- 2.15 AtomicOp Egress Blocked Status
- 2.16 TLP Prefix Blocked
- 2.17 Poisoned TLP Egress Blocked Status

4.15.4 RAS Tests Description

4.15.4.1 CORRECTABLE ERRORS

Receiver Error Status

4.15.4.1.0.1 Receiver Error Status (8b/10b Disparity Error):

The test will insert 8b/10b disparity error to Skip ordered set. This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Set the link-speed either 2.5 GT/s or 5.0 GT/s so that 8b/10b Disparity Jam can be applied.

4.15.4.1.0.2 Receiver Error Status (Sync Bits Zero Error):

The test will nullify sync bits in Skip ordered set. This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Set the link-speed as either to either 8.0 GT/s or 16.0 GT/s so that Sync block Error Jam can be applied.

4.15.4.1.0.3 Receiver Error Status (Sync Bits Invert Error):

The test will invert sync bits in Skip ordered set. This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Set the link-speed to either 8.0 GT/s or 16.0 GT/s so that Sync block Error Jam can be applied.

4.15.4.1.0.4 Receiver Error Status (Delete EDS):

The test will delete EDS.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Set the link-speed to 8.0 GT/s or 16.0 GT/s so that EDS Insert or Delete Error can be introduced to simulate PCIe Rule violation.

4.15.4.1.0.5 Receiver Error Status (Insert EDS):

The test will insert EDS.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Set the link-speed to 8.0 GT/s or 16.0 GT/s so that EDS Insert or Delete Error can be introduced to simulate PCIe Rule violation.

Bad DLLP Status:

The test will modify ACK by nullifying CRC16.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP from Host or End Point so that DLLP CRC16 Error can be applied on its ACK.

Bad TLP Status.

4.15.4.1.0.6 Bad TLP Status (Bad LCRC):

The test will insert an error in the LCRC of a TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated by doing the following:

Send any TLP from Host or End Point so that its LCRC can be modified to produce TLP LCRC Error.

4.15.4.1.0.7 Bad TLP Status (Out of Sequence Error):

The test will insert an error on the TLP (decrement sequence number).

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP from Host so that its sequence number can be modified to produce Out of sequence Error.

Replay Num Rollover:

The test will delete 4 ACKs after any TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP from Host or End Point so that its ACK can be deleted 4 times to reproduce Replay Num Rollover.

4.15.4.1.0.8 Replay Timer Timeout Error:

The test will delete ACK after any TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP from Host or End Point so that its ACK can be deleted once to create 'Replay Timer Timeout Error'.

Advisory Non-Fatal Error Status

4.15.4.1.0.9 Advisory Non-Fatal Error Status (Unsupported Request):

The test will modify address for a Memory Read Request.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send Mem Read or Write TLP from Host so that the Summit M5x Jammer can modify its address to a region that lies outside recipient BAR address range, resulting in Unsupported Request (UR).

4.15.4.1.0.10 Advisory Non-Fatal Error Status (ECRC Error):

The test will insert an error in the ECRC of a TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Send any TLP with ECRC from Host or End Point so that the Summit M5x Jammer can introduce ECRC error.

4.15.4.1.0.11 Advisory Non-Fatal Error Status (Poisoned TLP):

The test will modify a TLP EP bit.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any Write Request TLP or Msg with Data from Host so that this TLP can be poisoned by the Summit M5x Jammer by modifying the EP bit to 1.

4.15.4.1.0.12 Advisory Non-Fatal Error Status (Completion Timeout):

The test will delete a Completion TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP for which completion is expected so that the Summit M5x Jammer can delete the completion, thereby creating a completion timeout error.

Advisory Non-Fatal Error Status (Unexpected Completion):

The test will set MSB bit (9th bit) of Completion TAG.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP for which completion is expected so that the Summit M5x Jammer can modify its completion's Tag value resulting in an Unexpected Completion error.

Correctable Internal Error Status:

The test will simulate 'Correctable Internal Error Status'.

This test requires the traffic to be run from the Host system to the End Point device.

An Internal Error - an error associated with a PCI Express interface that occurs with a component and which may not be applicable to a event or packet on the PCI Express interface itself. The determination of this type of error is implementation specific.

Corrected Internal Error - an error that occurs within a component that has been masked or worked around by hardware without any loss of information or improper operation.

Test requirements: 'Advanced Error Reporting Capability Structure'.

There are no unique recording options for this type of error.

Header Log Overflow Status:

The test will delete some number of TLP Completions for causing 'Header Log Overflow Status'.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Ensure that AER capability is implemented, and 'Multiple Header Recording Enable Bit' is not set in BIOS SW. Send large number of TLPs for which completion is expected. Completions will be deleted resulting in Header log overflow.

4.15.4.2 UNCORRECTABLE ERRORS

Data Link Protocol Error Status

4.15.4.2.0.1 Data Link Protocol Error Status (Wrong ACKNack_Seq_Num):

The test will nullify ACKNack_Seq_Num In ACK DLLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP from Host or End Point so that sequence number present in its ACK can be modified corresponding to unacknowledged TLP.

4.15.4.2.0.2 Data Link Protocol Error Status (Extra DLLP ACK after Skip):

The test will insert ACK after Skip ordered set.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send SKIP from Host or End Point so that the Summit M5x Jammer can insert extra DLLP ACK.

Ordered Set Surprise Down Status Error:

The test will modify Skip ordered set by defining sideband signal.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Confirm that Host Downstream Port is 'Surprise Down Error Reporting Capable'.

Poisoned TLP:

The test will modify TLP EP bit.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any Write Request TLP or Msg with Data from Host so that this TLP can be poisoned by the Summit M5x Jammer by modifying EP bit to 1.

Flow Control Protocol Error

4.15.4.2.0.3 Flow Control Protocol Error (Enable Flow Control Scaling):

The test will enable Flow Control Scaling in UpdateFC if this feature is disabled.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Retrain the link as so that the Summit M5x Jammer can introduce a mismatch between Flow control type advertised in initFC and UpdateFCs.

4.15.4.2.0.4 Flow Control Protocol Error (Disable Flow Control Scaling):

The test will disable Flow Control Scalling in UpdateFC if this feature is enabled.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Retrain the link as so that the Summit M5x Jammer can introduce a mismatch between Flow control type advertised in initFC and UpdateFCs.

Completion Timeout Status:

The test will delete a Completion TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP for which completion is expected so that the Summit M5x Jammer can delete completion, thereby causing a completion timeout error.

Completer Abort Status:

The test will simulate 'Completer Abort Status'.

This test requires the traffic to be run from the Host system to the End Point device.

A status that applies to a posted or non-posted Request that the Completer is permanently unable to complete successfully, due to a violation of the Completer's programming model or to an unrecoverable error associated with the Completer.

A status indication returned with a Completion for a non-posted Request that suffered a Completer Abort at the Completer.

Rules for Received Requests handling related to 'Completer Abort':

If the Request violates the programming model of the device Function, the Function may optionally treat the Request as a Completer Abort, instead of handling the Request normally.”

1. If the Request is treated as a Completer Abort, this is a reported error associated with the Function.

2. If the Request requires Completion, a Completion Status of CA is returned.

Otherwise, process the Request.

If the Completer is permanently unable to process the Request due to a device-specific error condition the Completer must, if possible, handle the Request as a Completer Abort.

This is a reported error associated with the Receiving Function, if the error can be isolated to a specific Function in the component, or to the Receiving Port if the error cannot be isolated.

There are no unique recording options for this type of errors.

Unexpected Completion Status Error:

The test will set MSB bit (9th bit) of Completion TAG.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any TLP for which completion is expected so that the Summit M5x Jammer can modify its completion's Tag value resulting in an Unexpected Completion error.

Receiver Overflow Status

4.15.4.2.0.5 Receiver Overflow Status (Modify InitFC1/UpdateFC):

The test will modify InitFc1(HdrFC and DataFC = 1) and UpdateFC(HdrFC and DataFC = 0).

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Retrain the link so that credits advertised by initFC can be set to 1 and credits advertised by updateFC can be set to 0. After link-up few TLPs so that it will result in receiver overflow.

4.15.4.2.0.6 Receiver Overflow Status (Lot of TLPs inserted):

The test will insert extra TLPs.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send any Skip ordered set and/or UpdateFC DLLP to insert extra TLPs.

4.15.4.2.0.7 Malformed TLP Status (Wrong TLP length):

The test will insert a wrong length value to the TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Send any TLP from Host or End Point so that the Summit M5x Jammer can introduce TLP length error.

Malformed TLP Status

4.15.4.2.0.8 Malformed TLP Status (Set TD bit):

The test will set TD bit in TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Send any TLP without ECRC field from Host or End Point so that the Summit M5x Jammer can modify its Digest bit resulting in Malformed TLP.

4.15.4.2.0.9 Malformed TLP Status (Modify address to cross 4k boundary):

The test will modify address for a Memory Read Request.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Send any Memory read TLP from Host or End Point so that the Summit M5x Jammer can modify its address such that it crosses 4K boundary resulting in Malformed TLP.

ECRC Error Status:

The test will insert error on the ECRC of TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Send any TLP with ECRC from Host or End Point so that the Summit M5x Jammer can introduce ECRC error.

Unsupported Request Error Status.

4.15.4.2.0.10 Unsupported Request Error Status (BAR address range violation):

The test will modify address for a Memory Read Request.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send Mem Read or Write TLP from Host so that the Summit M5x Jammer can modify its address which lies outside recipient BAR address range, resulting in an Unsupported Request.

4.15.4.2.0.11 Unsupported Request Error Status (Nonexistent read address):

The test will modify address for a Config Read TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Send Type 0 Config Read or Write TLP from Host so that the Summit M5x Jammer can modify its address or bus, device or function number such that it is not supported by End Point, resulting in Unsupported request.

4.15.4.2.0.12 Unsupported Request Error Status (Malformed Message TLP):

The test will modify the Message Code and routing field in Message TLP.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure: Send any Msg TLP from End Point so that the Summit M5x Jammer can modify its Msg Code, routing field and Msg or MsgD combination to undefined combination, resulting in Unsupported Request.

ACS Violation Status

4.15.4.2.0.13 ACS Violation Status (Violate Bus Number 'aperture'):

The test will insert Bus Number outside 'aperture' for TLP Memory Request in Downstream direction.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send Memory Request from End Point side so that the Summit M5x Jammer can modify its bus number such that it goes outside Bus Number 'aperture' of the Host, resulting in ACS violation status.

4.15.4.2.0.14 ACS Violation Status (Set AT field as 'Translated' in Mem Write):

The test will modify AT field for Memory Write Request in Upstream direction.

This test requires the traffic to be run from the Host system to the End Point device.

Traffic can be generated using the following procedure:

Send Memory Write Request from End Point side so that the Summit M5x Jammer can modify its AT field resulting in ACS Violation status.

Uncorrectable Internal Error Status:

The test will simulate 'Uncorrectable Internal Error Status'.

This test requires the traffic to be run from the Host system to the End Point device.

An Internal Error - an error associated with a PCI Express interface that occurs with a component and which may not be applicable to a event or packet on the PCI Express interface itself. The determination of this type of errors is implementation specific.

An Uncorrectable Internal Error - an error that occurs with a component that results in improper operation of the component.

Recovering from an Uncorrectable Internal Error is reset or hardware replacement.

Test requirements: 'Advanced Error Reporting Capability Structure'.

There are no unique recording options for this type of errors.

MC Blocked TLP Status:

The test will simulate 'MC Blocked TLP Status'.

This test requires the traffic to be run from the Host system to the End Point device.

When a TLP is blocked by the MC_Block_All or the MC_Block_Untranslated mechanisms, the TLP is dropped. The Function blocking the TLP serves as the Completer. The Completer must log and signal this MC Blocked TLP error. In addition, the Completer must set the Secondary Status register or Signaled Target Abort bit in either its Status register. AER implementation is highly recommended.

The error is reported by Ingress Port if the error occurs with a TLP received by that Ingress Port. This rule applicable for Root Complex and Switch. Similar rule works for Endpoint. If the error occurs in an Endpoint Function preparing to send the TLP, the error is reported by that Endpoint Function.

Test requirements: 'MC_Enable' bit must be set.

There are no unique recording options for this type of errors.

AtomicOp Egress Blocked Status:

The test will simulate 'AtomicOp Egress Blocked Status'.

This test requires the traffic to be run from the Host system to the End Point device.

There are a few unique requirements for AtomicOps. The most important requirement for simulating 'AtomicOp Egress Blocked Status' described below.

For a Switch or an RC, when AtomicOp Egress Blocking is enabled in an Egress Port, and an AtomicOp Request targets going out that Egress Port, the Egress Port must handle the Request as an AtomicOp Egress Blocked error and must also return a Completion with a Completion Status of UR. If the severity of the AtomicOp Egress Blocked error is non-fatal.

Test requirements: 'AtomicOp Egress Blocking' bit must be set.

There are no unique recording options for this type of errors.

TLP Prefix Blocked Error Status:

The test will simulate 'TLP Prefix Blocked Error Status'.

This test requires the traffic to be run from the Host system to the End Point device.

The following rule apply to End-End TLP Prefixes:

For Routing Elements, the End-End TLP Prefix Blocking bit in each Egress Port determines whether TLPs containing End-End TLP Prefixes can be transmitted via that Egress Port. If forwarding is blocked the entire TLP is dropped and a TLP Prefix Blocked Error is reported. If the blocked TLP is a Non-Posted Request, the Egress Port returns a Completion with Unsupported Request Completion Status. The TLP Prefix Blocked Error is a reported error associated with the Egress Port.

Test requirements: 'End-End TLP Prefix Blocking' bit must be set.

There are no unique recording options for this type of errors.

Poisoned TLP Egress Blocked Status:

The test will simulate 'TLP Prefix Blocked Error Status'.

This test requires the traffic to be run from the Host system to the End Point device.

The following rule apply to End-End TLP Prefixes:

For Routing Elements, the End-End TLP Prefix Blocking bit in each Egress Port determines whether TLPs containing End-End TLP Prefixes can be transmitted via that Egress Port. If forwarding is blocked the entire TLP is dropped and a TLP Prefix Blocked Error is reported. If the blocked TLP is a Non-Posted Request, the Egress Port returns a Completion with Unsupported Request Completion Status. The TLP Prefix Blocked Error is a reported error associated with the Egress Port.

Test requirements: 'End-End TLP Prefix Blocking' bit must be set.

There are no unique recording options for these types of errors.

4.15.5 Summit M5x PCIe RAS Error Injection Testing Setup

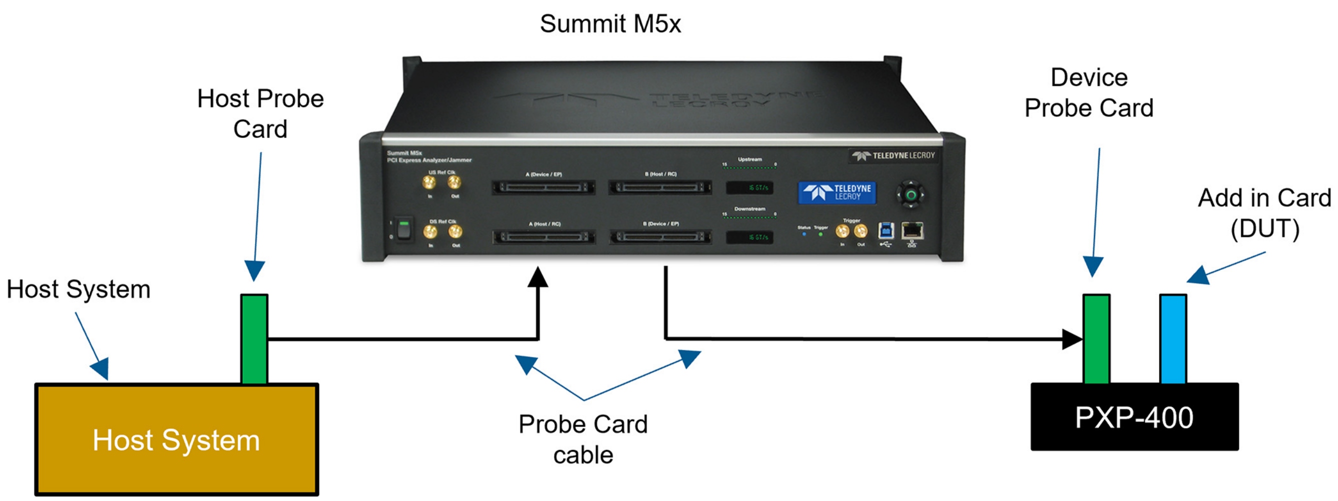


Figure 4.86: Test Setup: Summit M5x Jammer with Host and End Point (DUT)

4.15.6 Test Flow

1. Open LinkExpert
2. Select PCIe RAS Error Injection Tests from the “Select Tests” menu
3. Choose single or multiple tests
4. Test will present messages prompting the user what to do
5. Test will request that the user runs traffic on system under test
6. When required traffic is sent, the test will progress and confirm that the error was injected
7. The user will be prompted to check the system log to determine if error was handled properly

4.15.7 PCIe “RAS” Error Injection testing - LinkExpert

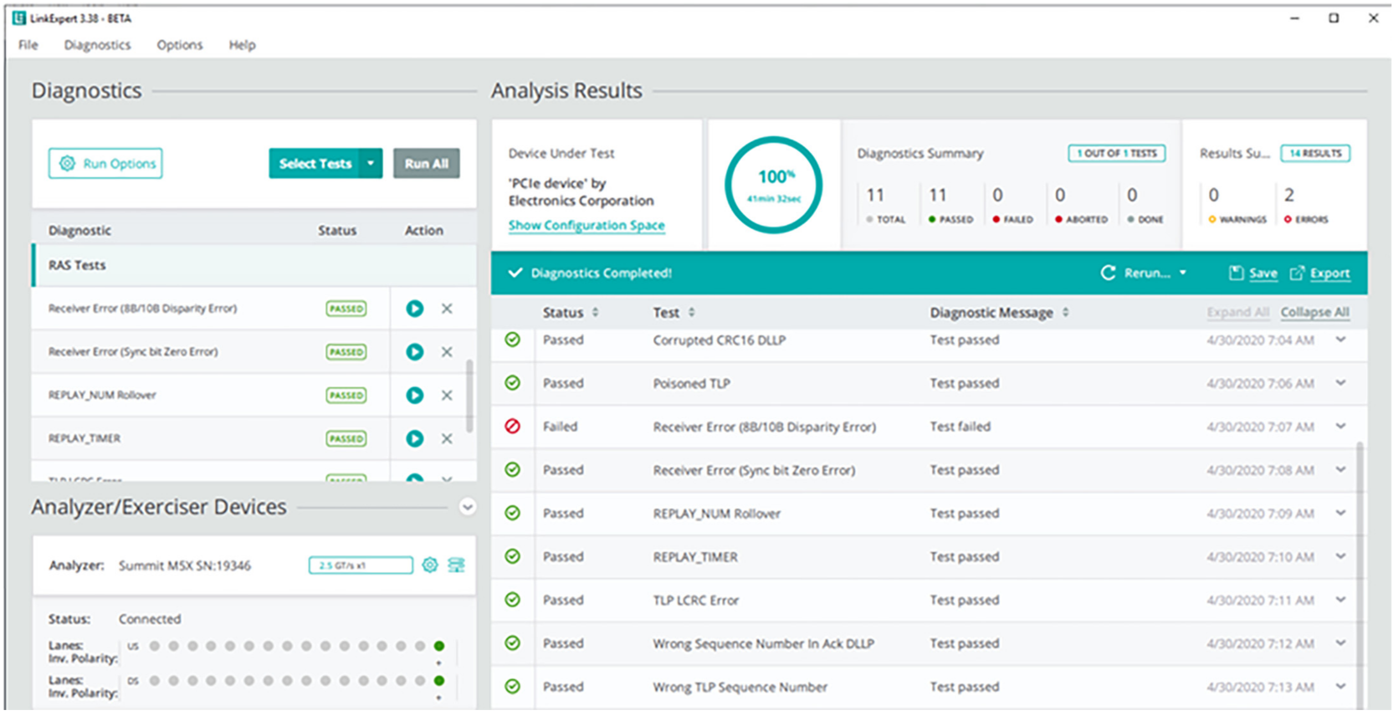


Figure 4.87: Typical RAS Tests Results from LinkExpert 1

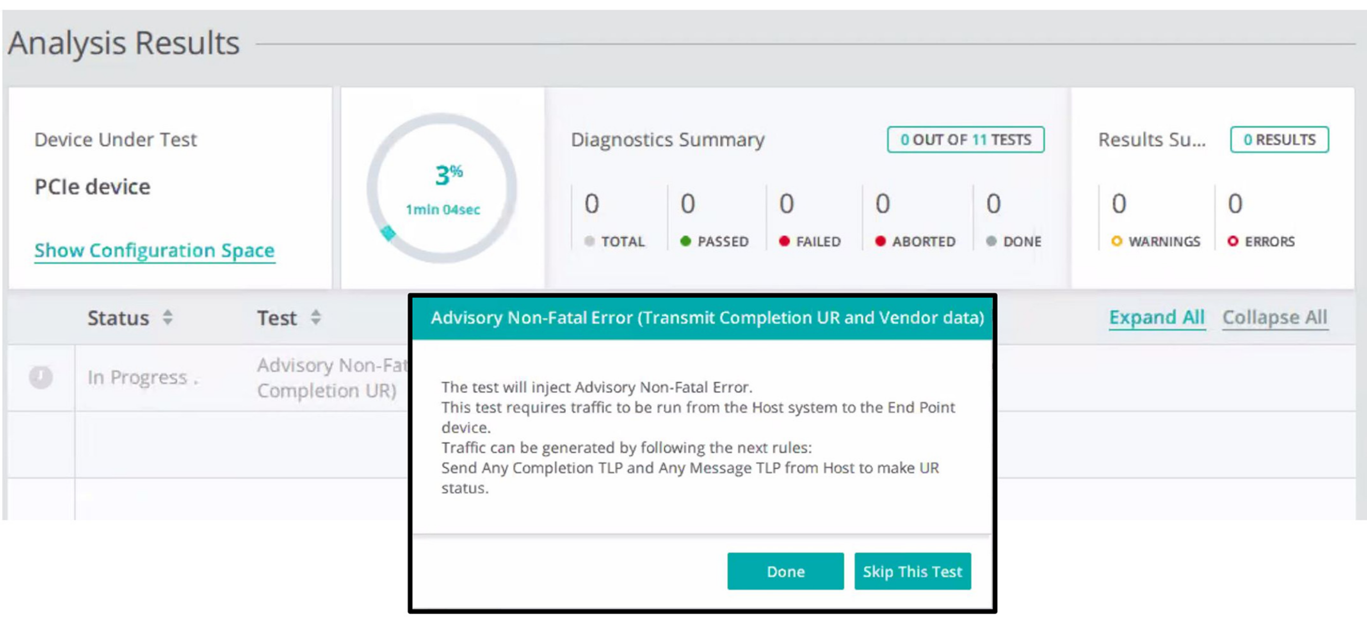


Figure 4.88: Typical RAS Tests Results from LinkExpert 2

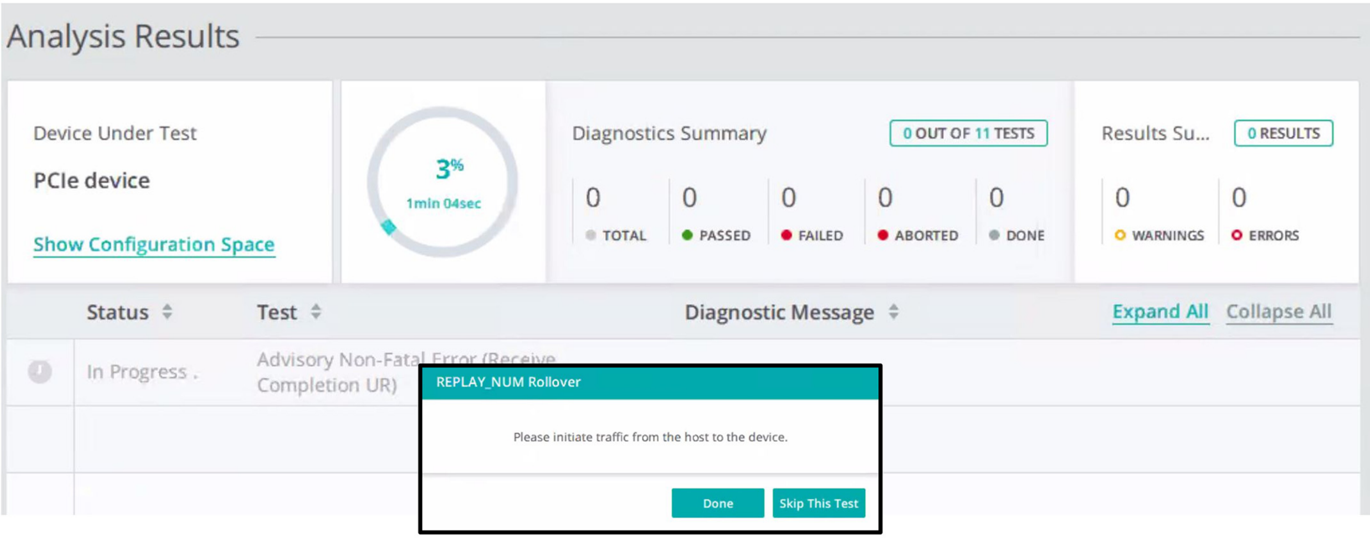


Figure 4.89: Typical RAS Tests Results from LinkExpert 3

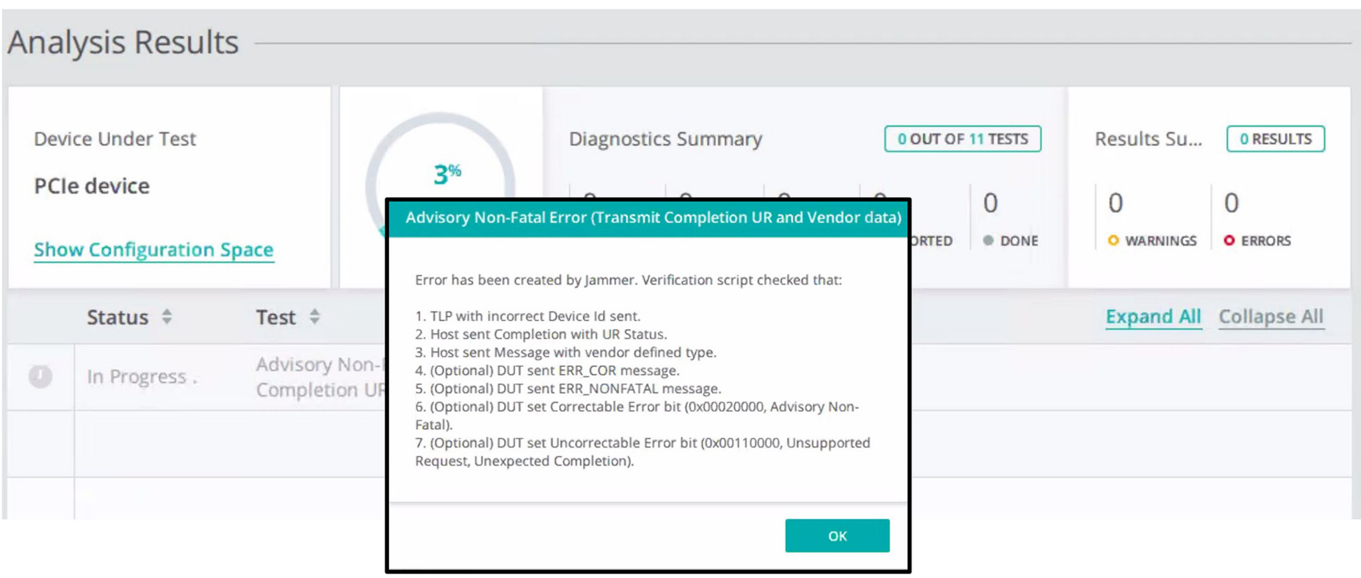


Figure 4.90: Typical RAS Tests Results from LinkExpert 4

4.16 NVMe-MI/MCTP SMBus Tests 1.0a

Note: NVMe-MI Tests are Official Conformance tests for NVMExpress.org.

You can select as many of the NVMe-MI/MCTP SMBus Tests 1.0a to be run separately. See Figure 4.91.

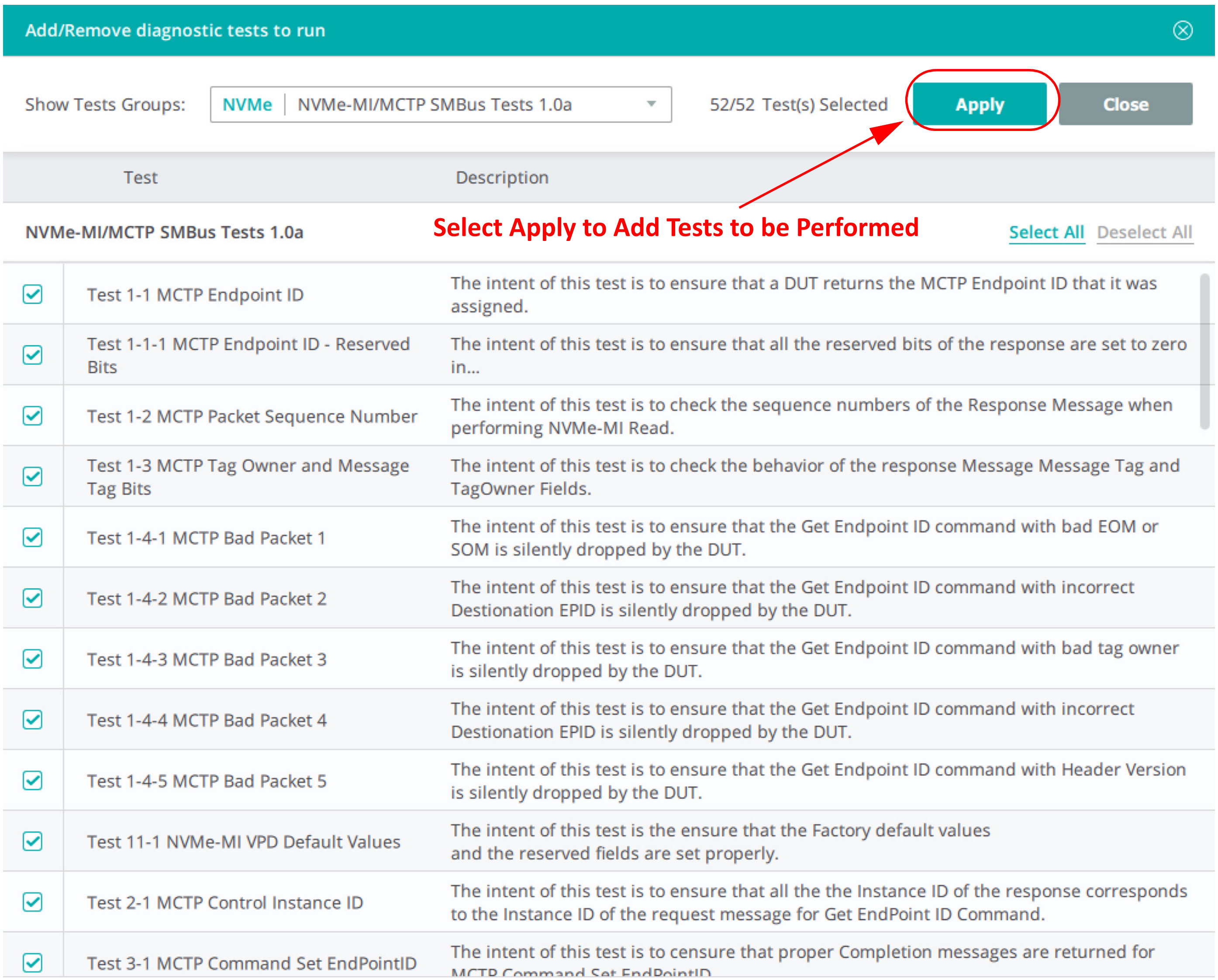


Figure 4.91: NVMe-MI/MCTP SMBus Tests 1.0a

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.17 NVMe-MI/MCTP SMBus Tests 1.1

Note: NVMe-MI Tests are Official Conformance tests for NVMExpress.org.

You can select as many of the NVMe-MI/MCTP SMBus Tests 1.1 to be run separately. See Figure 4.92.

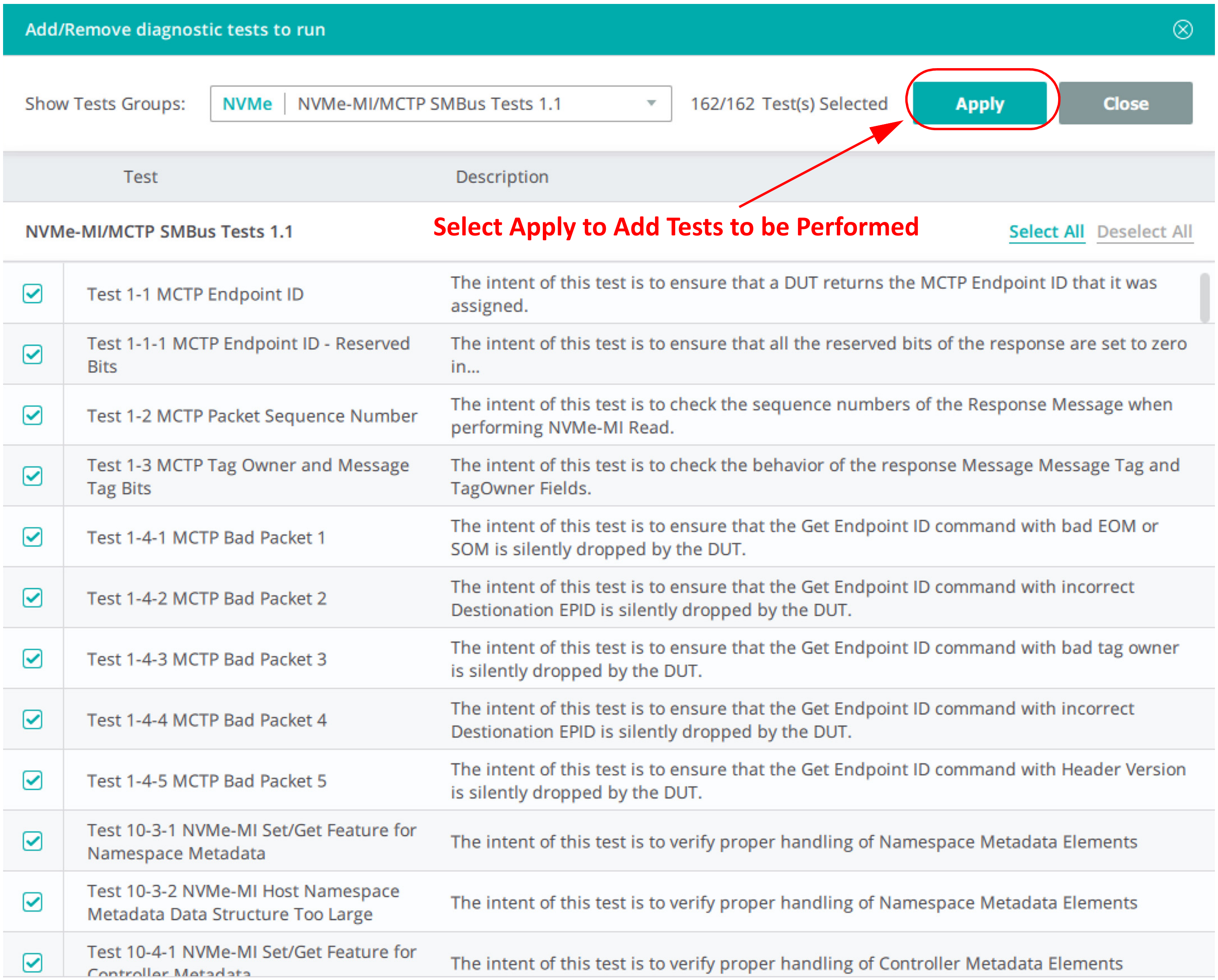


Figure 4.92: NVMe-MI/MCTP SMBus Tests 1.1

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.18 NVMe-MI/MCTP VDM Tests 1.0a

Note: NVMe-MI Tests are Official Conformance tests for NVMExpress.org.

You can select as many of the NVMe-MI/MCTP VDM Tests 1.0a to be run separately. See Figure 4.93.

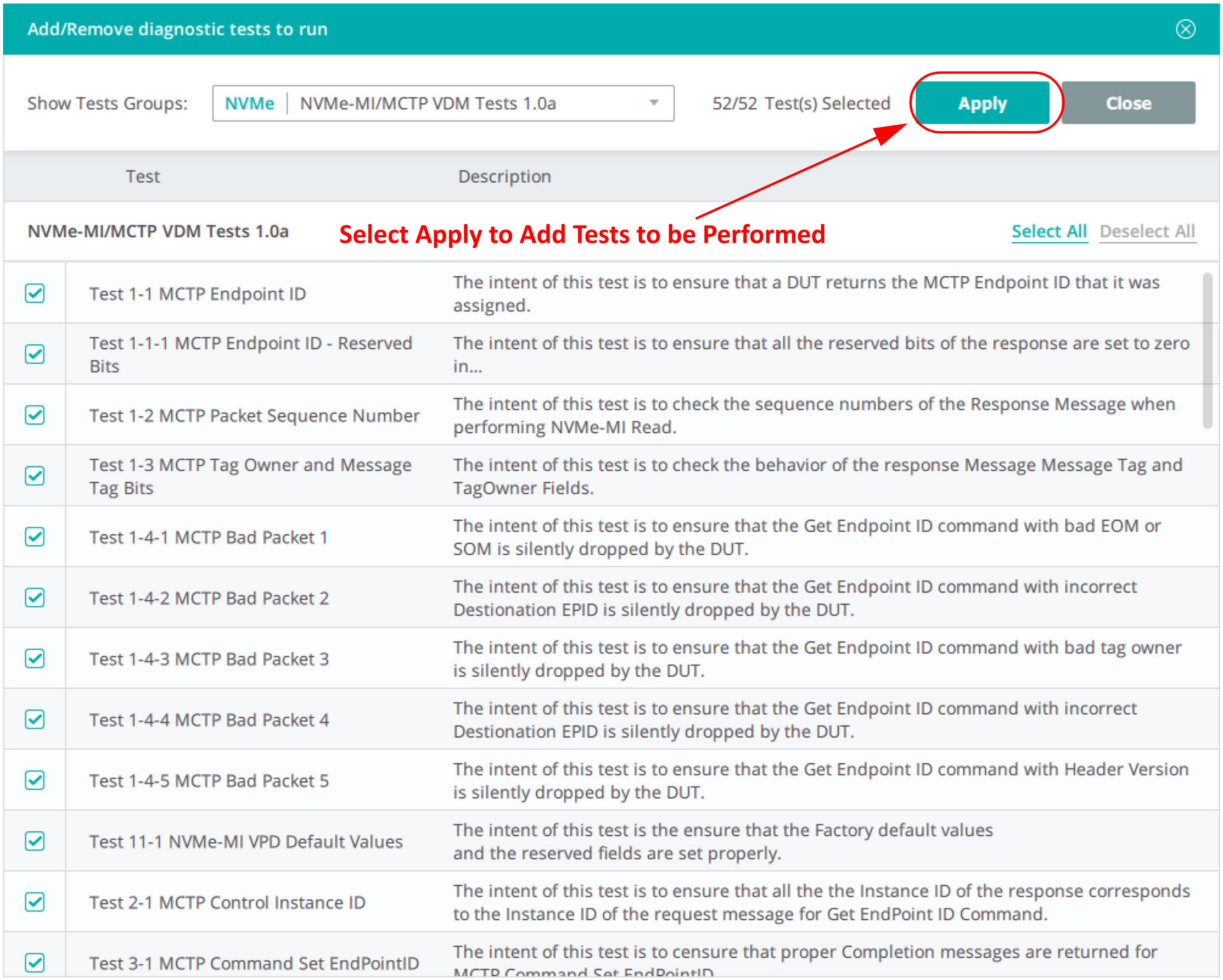


Figure 4.93: NVMe-MI/MCTP VDM Tests 1.0a

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.19 NVMe-MI/MCTP VDM Tests 1.1

Note: NVMe-MI Tests are Official Conformance tests for NVMExpress.org.

You can select as many of the NVMe-MI/MCTP VDM Tests 1.1 to be run separately. See Figure 4.94.

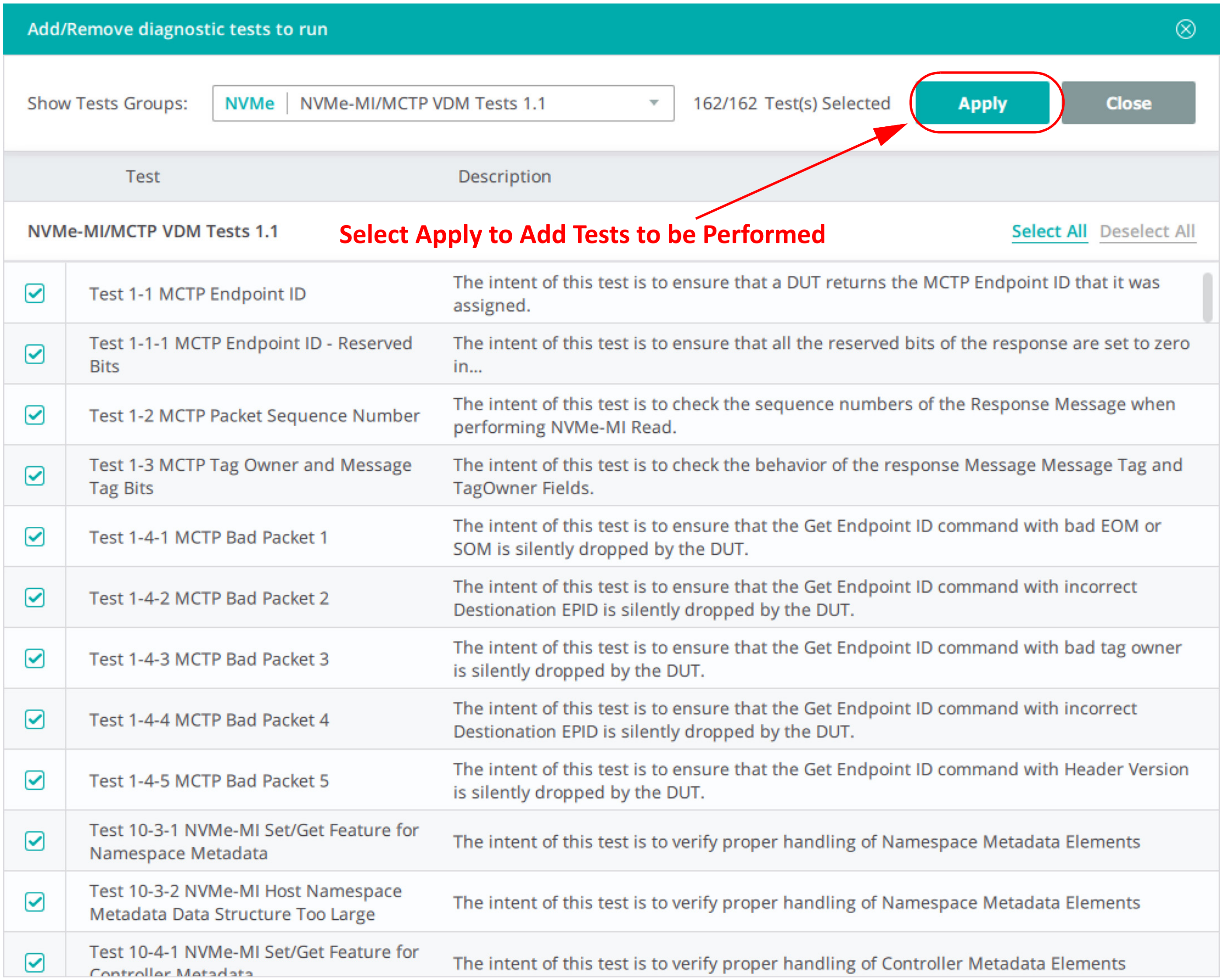


Figure 4.94: NVMe-MI/MCTP VDM Tests 1.1

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

4.20 Jammer NVMe Test 1.0

You can select as many of the Jammer NVMe Tests to be run separately. See Figure 4.95.

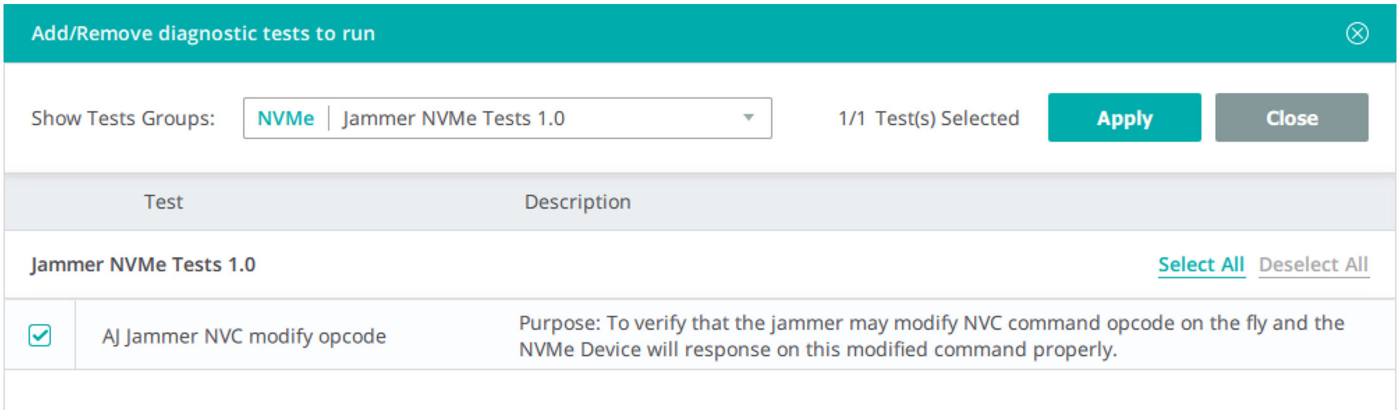


Figure 4.95: Jammer NVMe Tests

If you have other tests loaded you'll see a warning message when you hit the "Apply" button. See Figure 4.40 on page 121.

Chapter 5

PCIe Analysis Results

LinkExpert can provide analysis results for the following sets of tests:

- LinkExpert System Level Tests
- PCIe 3.0 Compliance Package Tests
- Validation Tests (Endpoint)
- Validation Tests (Root Complex)
- Jammer Validation Tests (Endpoint)
- LTSSM Arc Tests
- PCIe 4.0 Compliance Package Tests
- PCIe 5.0 Compliance Package Tests
- PCIe RAS Error Injection Tests
- NVMe-MI/MCTP SMBus Tests 1.0a
- NVMe-MI/MCTP SMBus Tests 1.1
- NVMe-MI/MCTP VDM Tests 1.0a
- NVMe-MI/MCTP VDM Tests 1.1
- Jammer NVMe tests 1.0

5.1 Analysis Results: LinkExpert System Level Tests

The results of the LinkExpert System Level Tests which have been run on the DUT are shown in the Analysis Results section.

5.1.1 Results: Link Establishment

The first System Level Test run was Link Establishment and the Results are shown in Figure 5.1 on page 192.

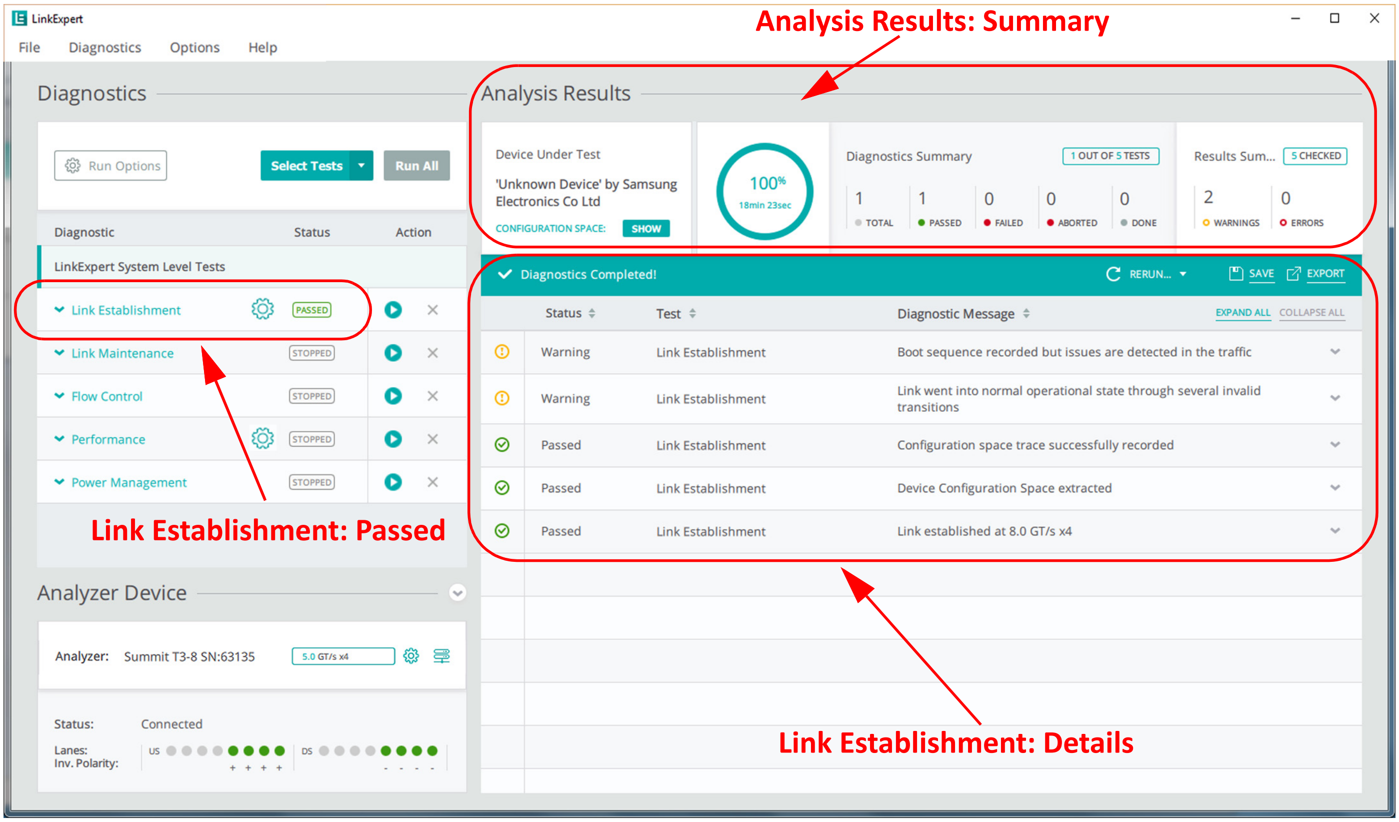


Figure 5.1: Analysis Results: Link Establishment

5.1.1.1 Analysis Results: Link Establishment Summary

The Link Establishment Results Summary is shown in Figure 5.2.

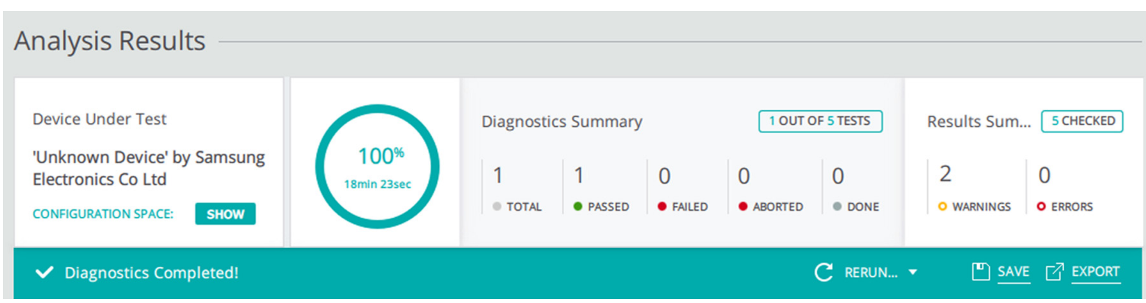


Figure 5.2: Analysis Results: Link Establishment Summary

- The DUT was an “Unknown Device” by Samsung Electronics Co Ltd
- The progress meter shows 100% complete: 18 minutes 23 seconds
- Diagnostic Summary: 1 out of 5 tests were executed (Only Link Establishment was selected)
  - Total Number of Tests: 1
  - Number of Tests Passed: 1
  - Number of Tests Failed: 0
  - Number of Tests Aborted: 0
  - Number of Tests Done: 0

Note: Some tests do not have Pass or Fail criteria, they simply need to be executed before other tests can be run.

- Results Summary: 5 parameters were checked (see “Link Establishment” on page 126)
  - Warnings: 2
  - Errors: 0

5.1.1.2 Analysis Results: Link Establishment Details

If you look at the Details Summary you can see the sequence of tests executed, whether they Passed, Failed or had Warning messages. See Figure 5.3.

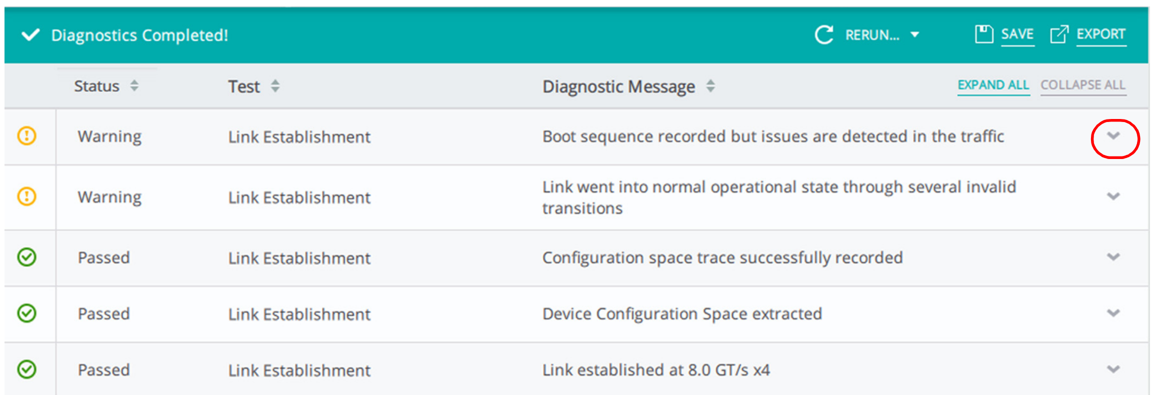


Figure 5.3: Link Establishment: Diagnostic Summary -> Details

In this case the first two tests resulted in Warnings and the last three all Passed.

If you click on the small arrow to the right of each test you see more details.

From the Link Establishment Analysis Results section we can see the following results:

- Link Establishment: Warning (1)
  - Boot sequence was recorded but issues are detected in the traffic (for more details see Figure 5.4).

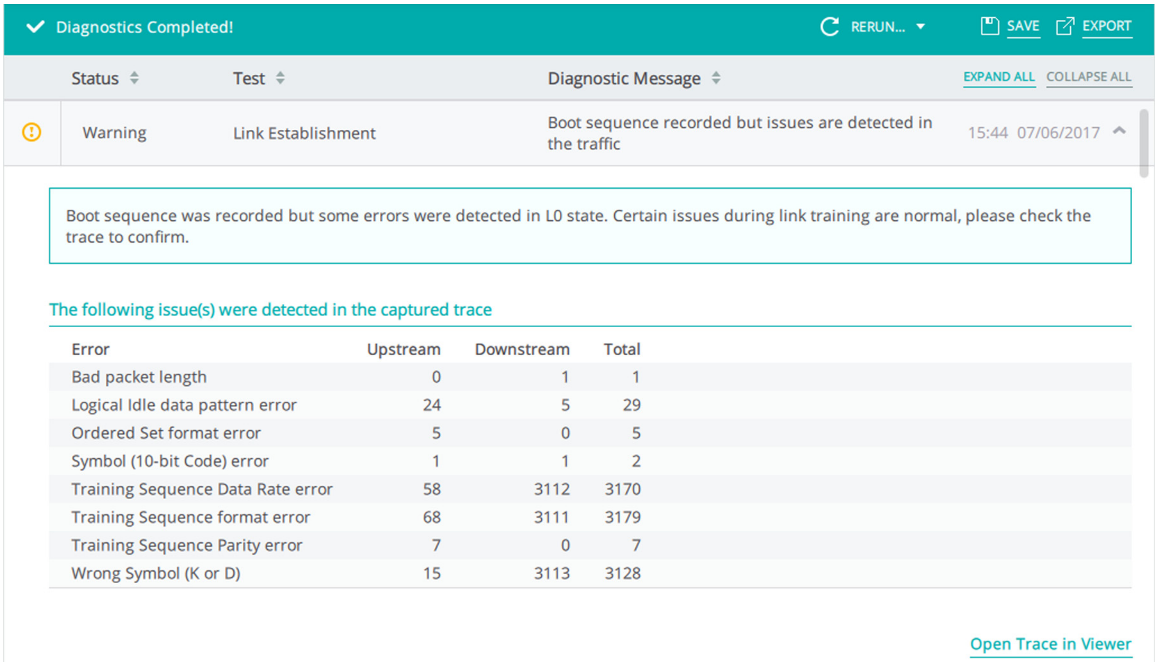


Figure 5.4: Link Establishment: Warning Message -> Boot Sequence

- Link Establishment: Warning (2)
  - Link went into normal operational state through several invalid transitions (for more details see Figure 5.5).

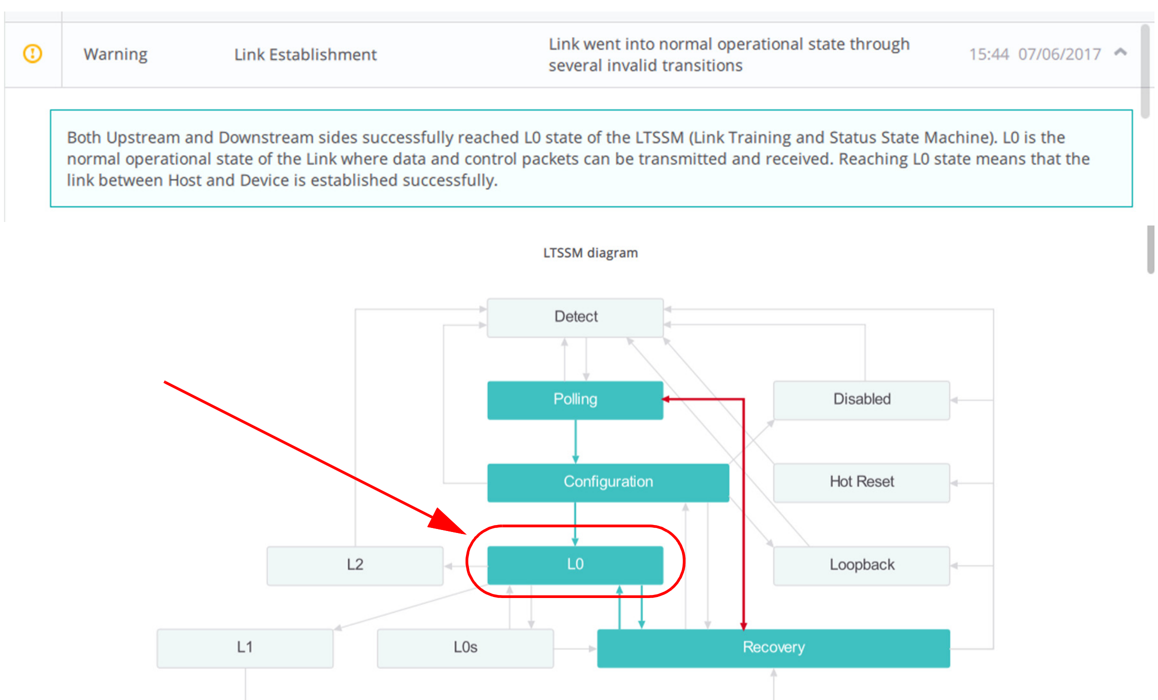


Figure 5.5: Link Establishment: Warning Message -> Invalid Transactions, Reached State L0

- LTSSM Transitions Map (see Figure 5.6 on page 195).

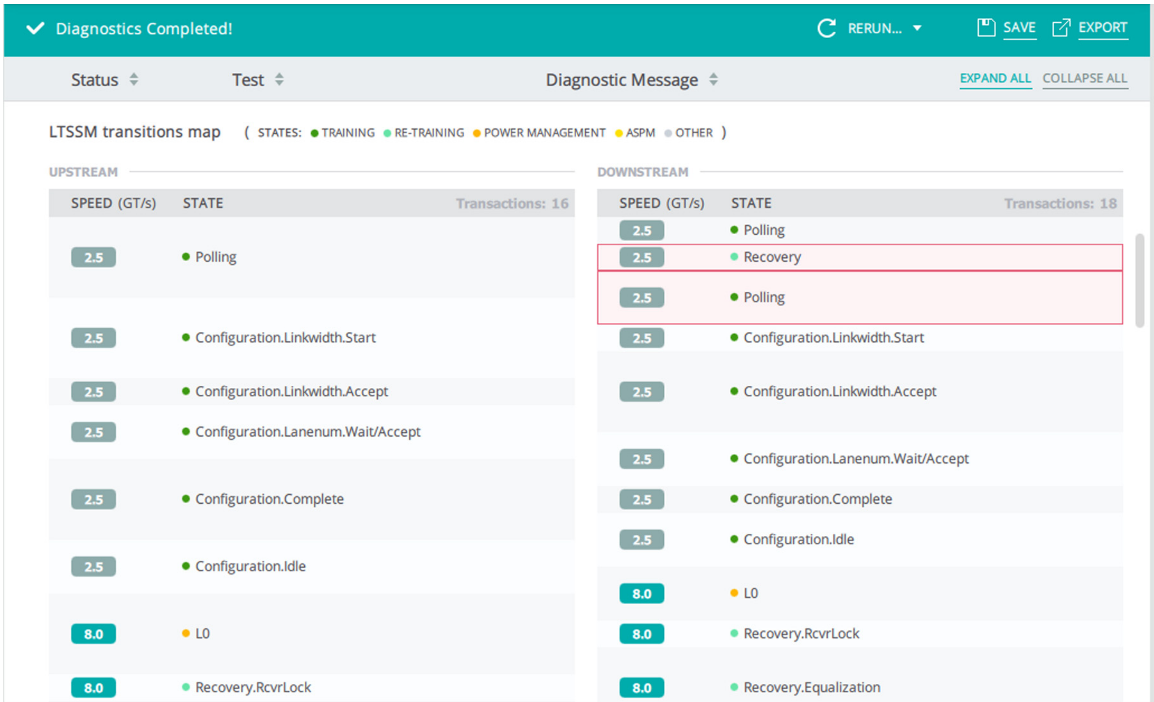


Figure 5.6: Link Establishment: Warning Message -> LTSSM Transitions Map

- Invalid LTSSM State Transitions and Retried LTSSM Transitions (see Figure 5.7).

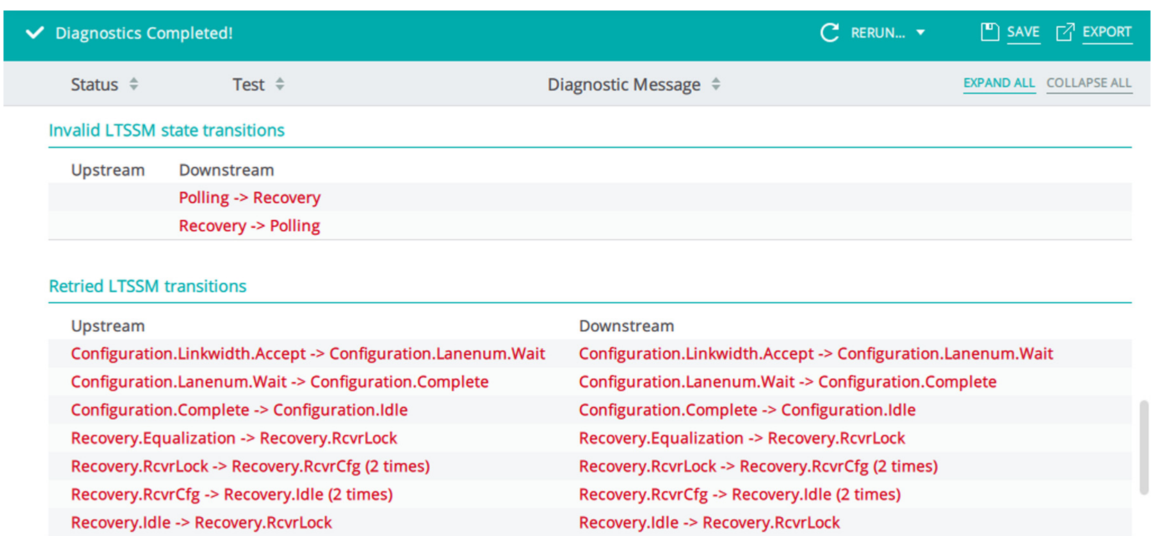


Figure 5.7: Link Establishment: Warning Message -> Retried LTSSM Transitions

- Details of LTSSM state times (see Figure 5.8 on page 196).

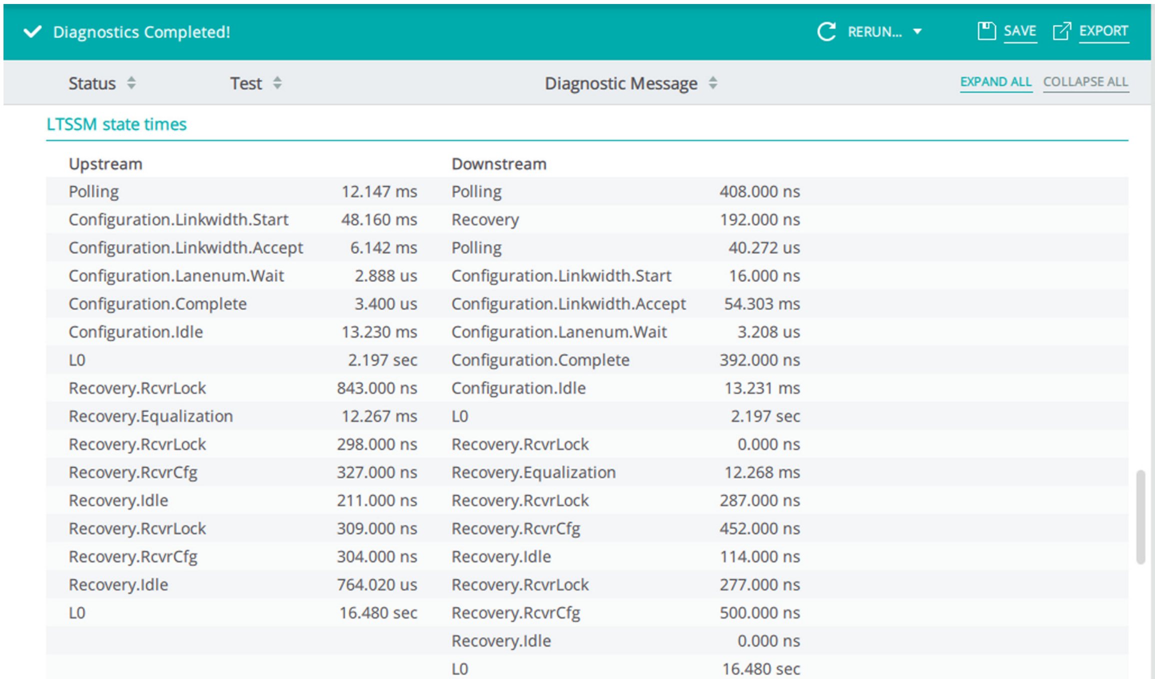


Figure 5.8: Link Establishment: Warning Message -> LTSSM State Times

- ❑ Link Establishment: Passed (1)
  - ■ Configuration space trace successfully recorded (see Figure 5.9).

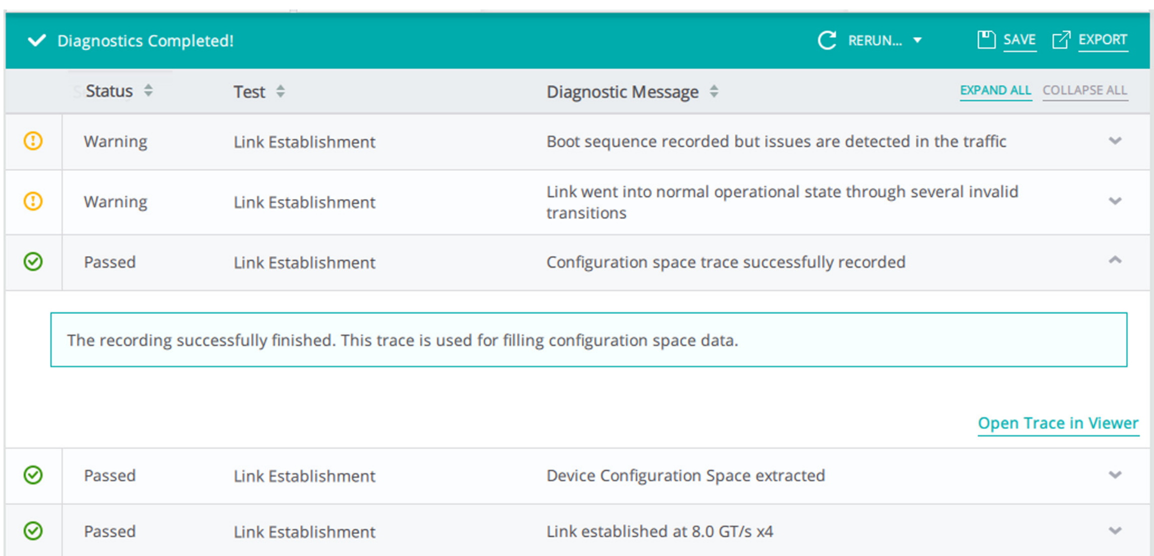


Figure 5.9: Link Establishment: Passed -> Configuration Space Recorded

- ❑ Link Establishment: Passed (2)
  - ■ Configuration space trace successfully recorded (see Figure 5.10 on page 197).

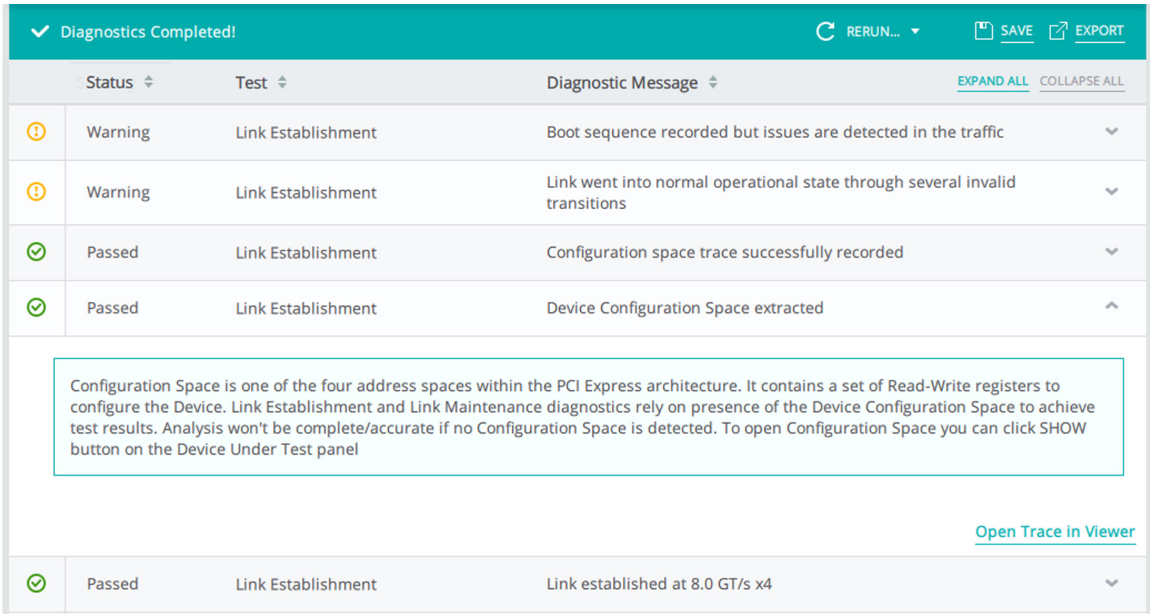


Figure 5.10: Link Establishment: Passed -> Configuration Space Recorded

5.1.1.3 Configuration Space

If you select the "Configuration Space: SHOW" button, a screen will pop up with the Configuration Space information. See Figure 5.11.

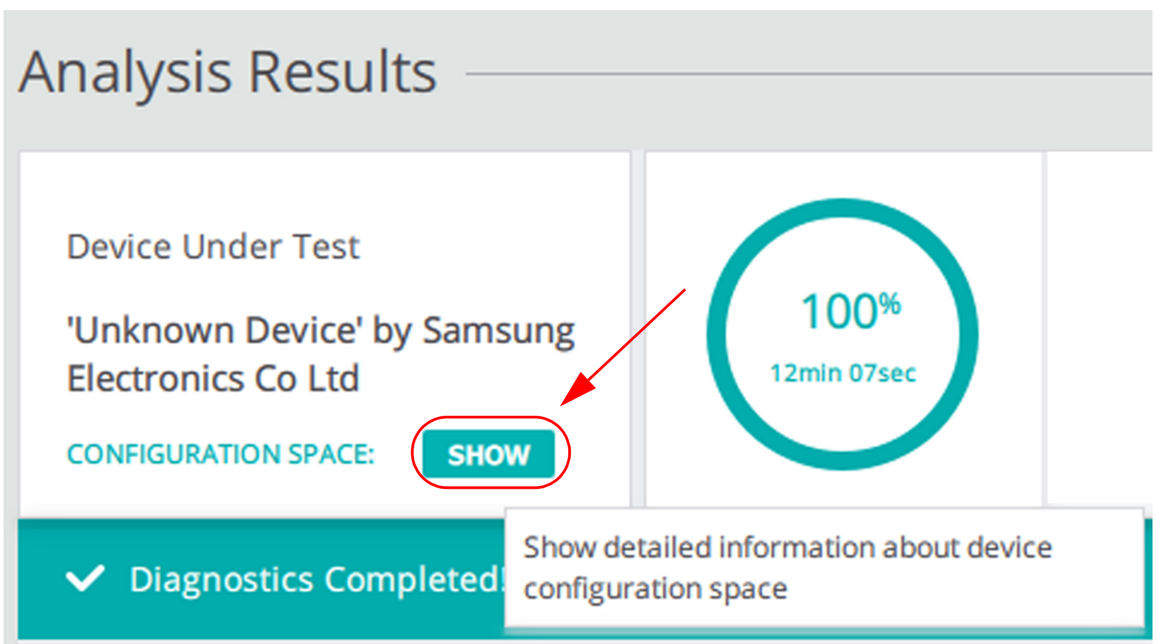


Figure 5.11: Analysis Results: Configuration Space -> SHOW

The results are shown in Figure 5.12 on page 198.

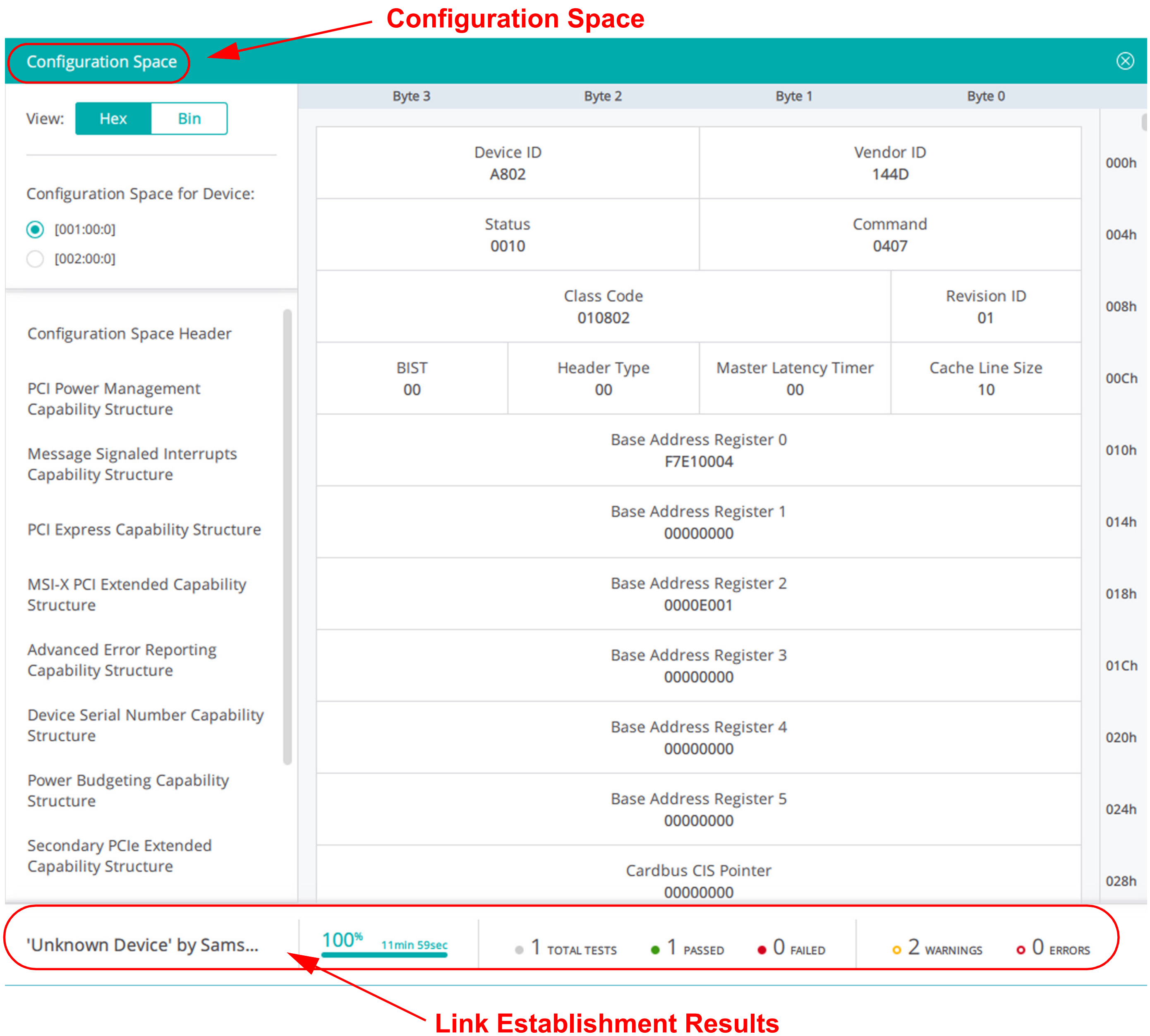


Figure 5.12: Analysis Results: Configuration Space -> Results

- Link Establishment: Passed (3)
  - Link Established at 8.0 GT/s x4 (see Figure 5.13).

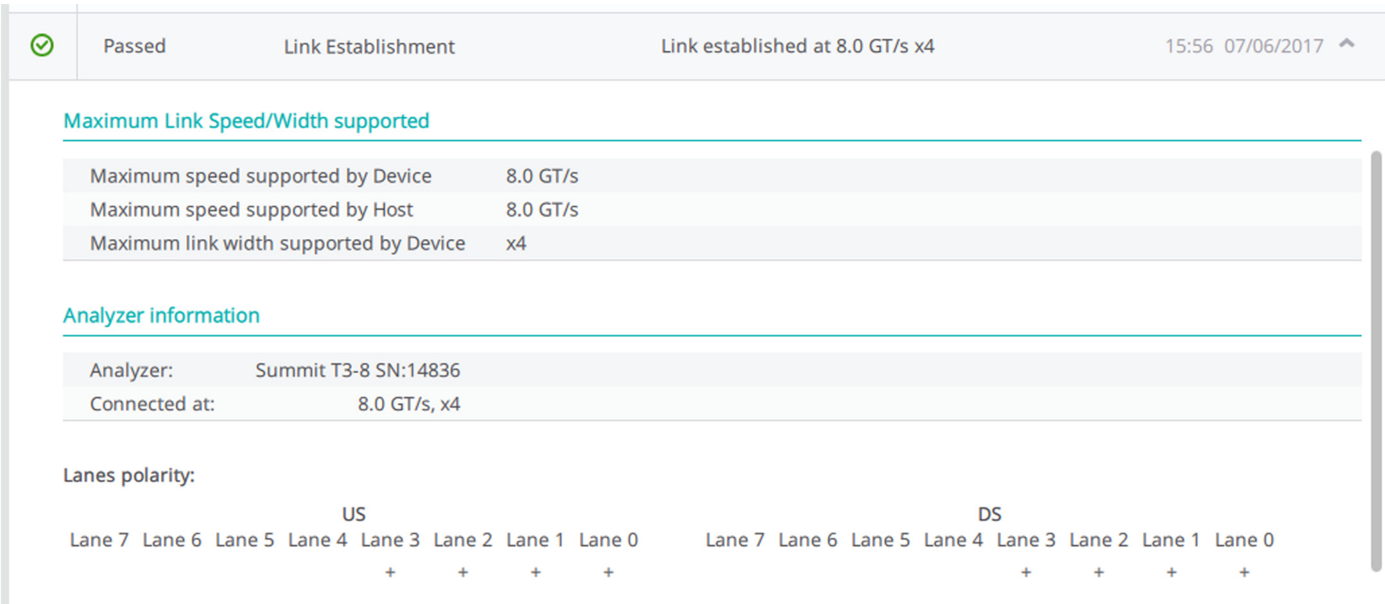


Figure 5.13: Link Establishment: Passed -> 8.0 GT/s x4

5.1.2 Results: Link Maintenance

The second System Level Test run was Link Maintenance and the Results are shown in Figure 5.14.

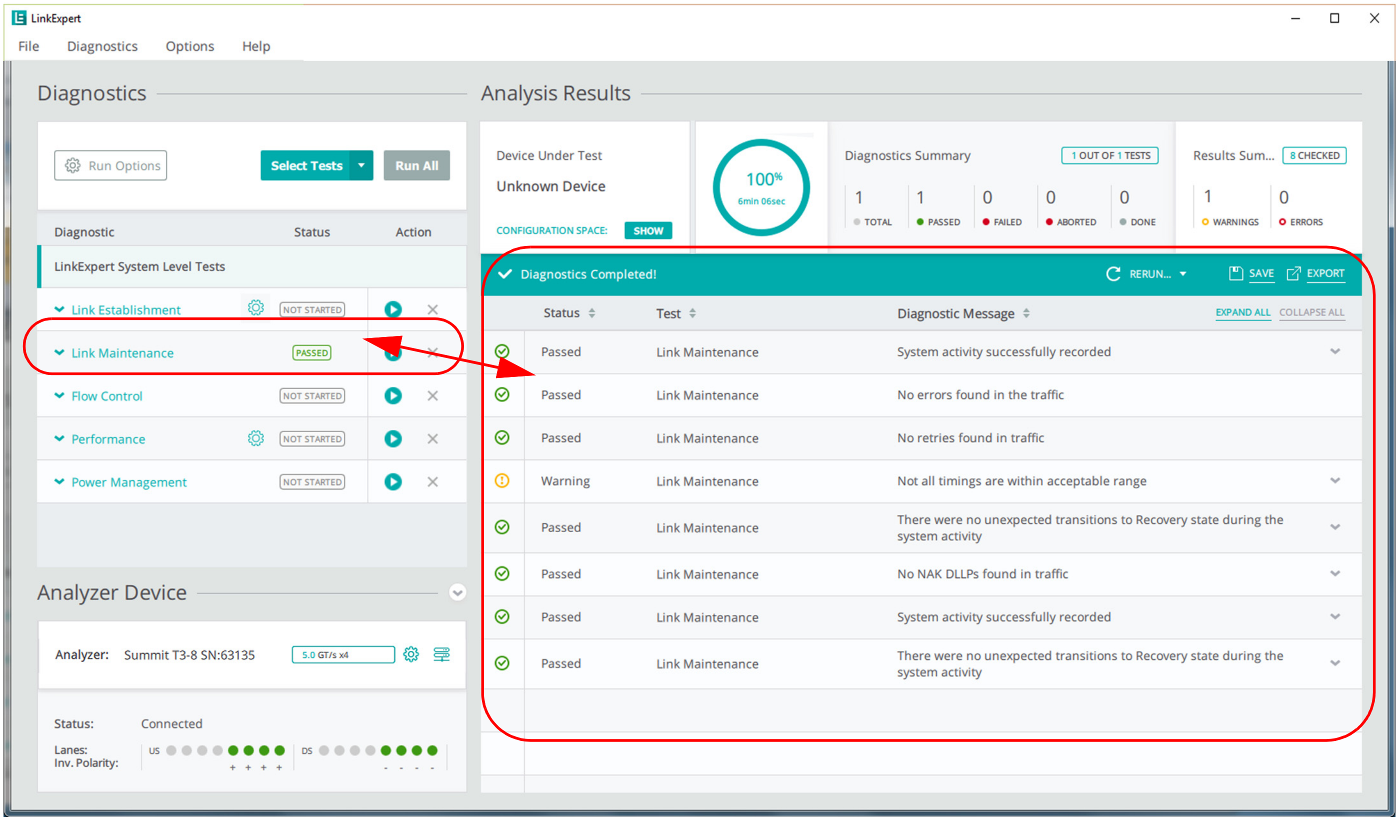


Figure 5.14: Analysis Results: Link Maintenance

Analysis Results: Link Maintenance Summary

The Link Maintenance Results Summary is shown in Figure 5.15.

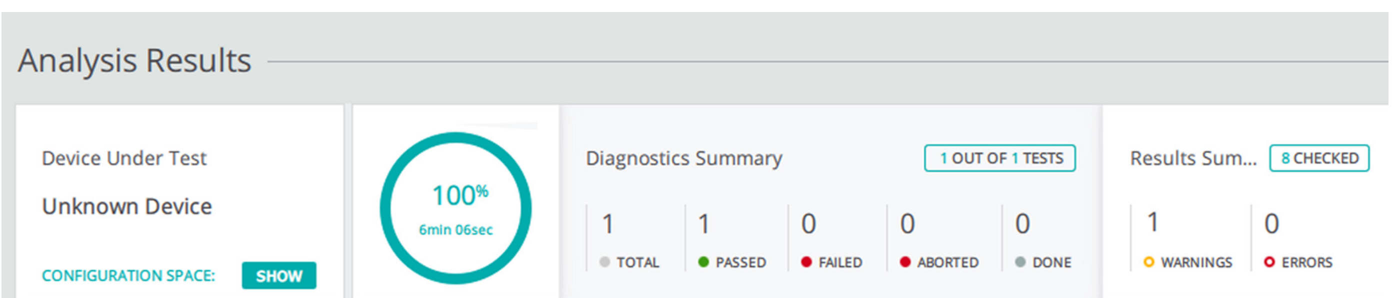


Figure 5.15: Analysis Results: Link Maintenance Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 6 minutes and 6 seconds
- 1 out of 1 tests PASSED
- 0 tests FAILED
- 0 tests were ABORTED

- 0 tests were DONE
- 8 Parameters were Checked during the test (see “Link Maintenance” on page 129)
- 1 Warning and 0 Errors were issued during the test (“Not all timings are within acceptable range”)

5.1.3 Results: Flow Control

The very first result shows that the device's activity is successfully recorded. All further analysis will be based on the recorded trace. See Figure 5.16.

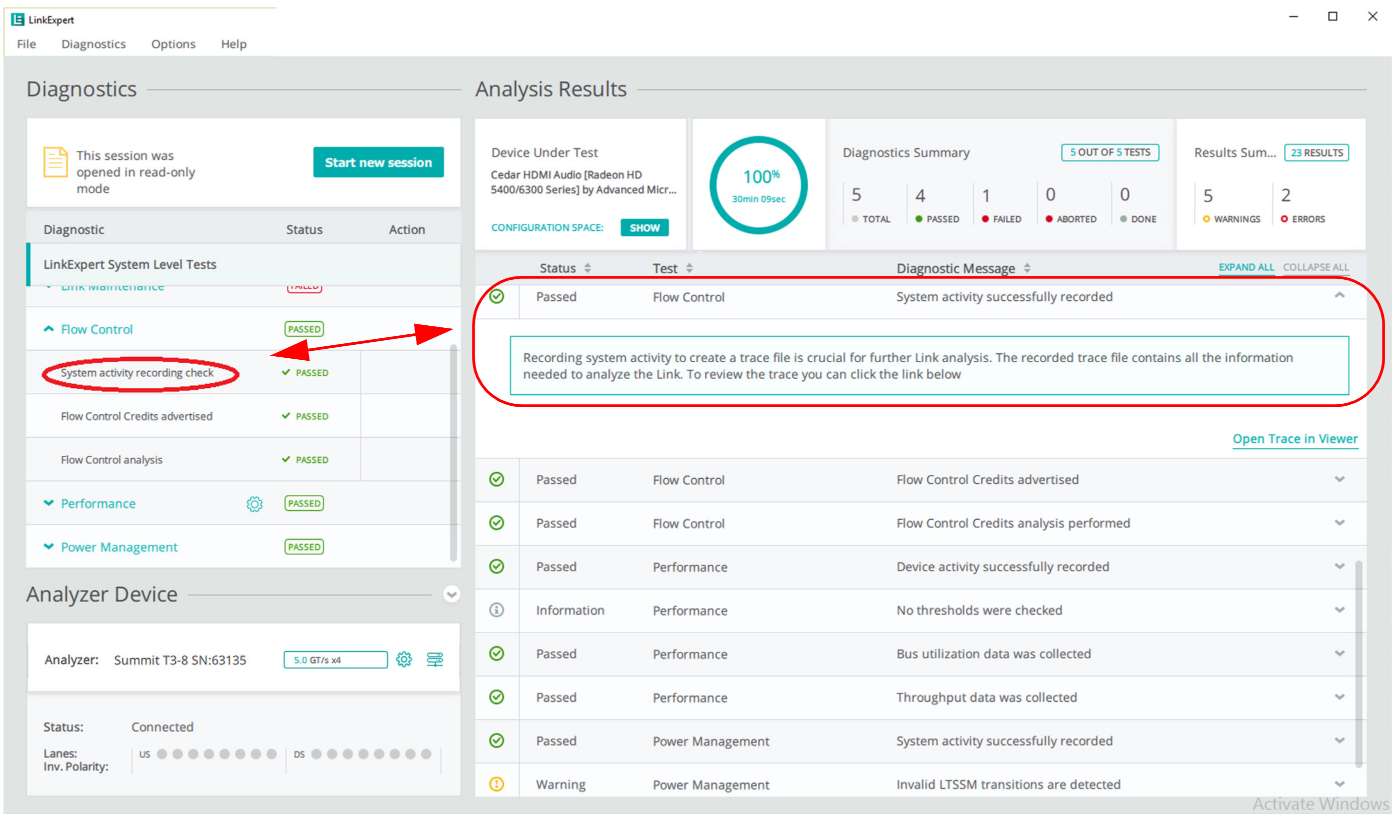


Figure 5.16: Flow Control: Device’s Activity Successfully Recorded

Second key result presents information about Flow Control units advertised by both sides for all types of Flow Control credits. Note, that the result requires Link Establishment to be run prior to Flow Control. See Figure 5.17 on page 202.

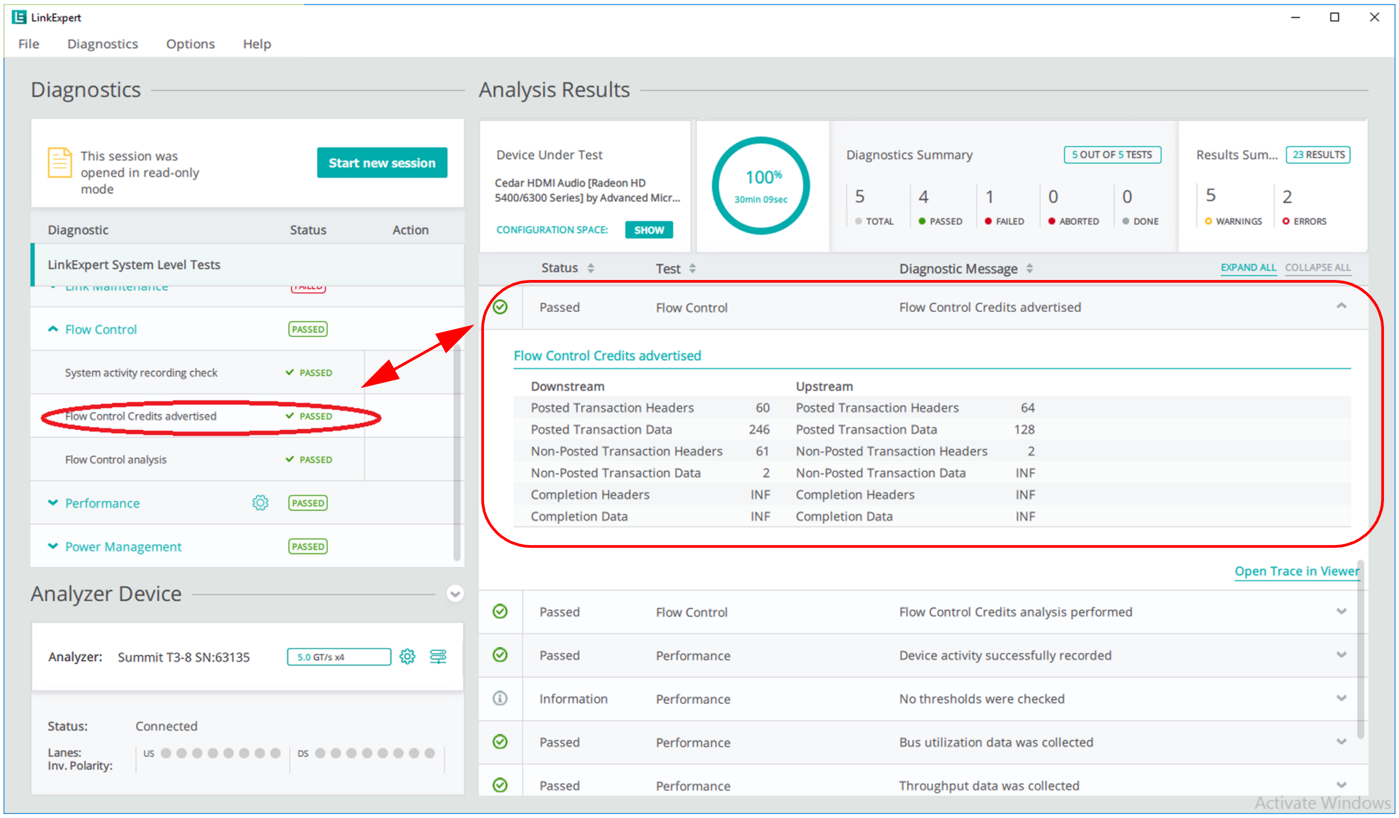


Figure 5.17: Flow Control: Credits Advertised

The last key result presents charts showing changes in available Flow Control credits over time. See Figure 5.18 on page 203.

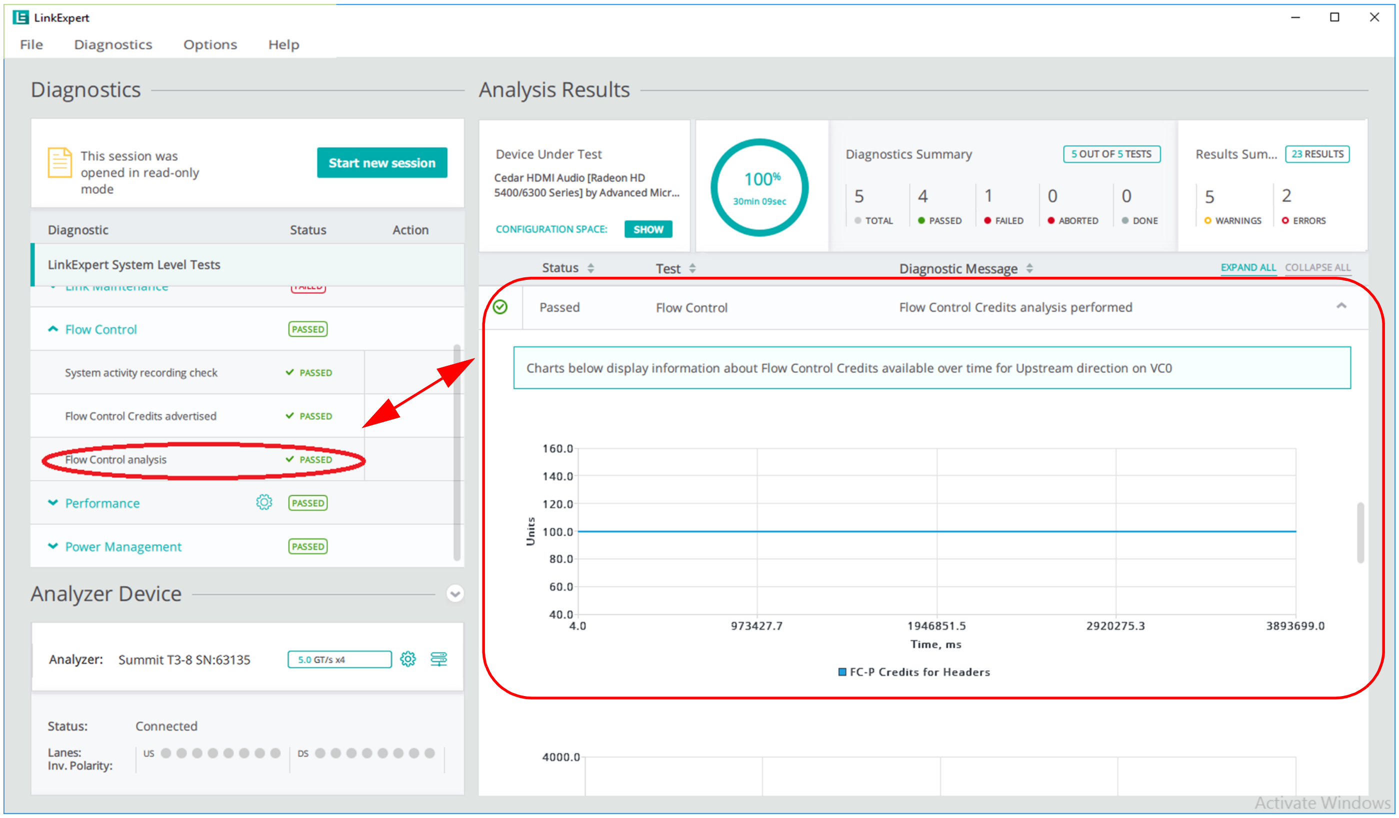


Figure 5.18: Flow Control: Credits over time

The complete set of the Flow Control Results are shown in Figure 5.19.

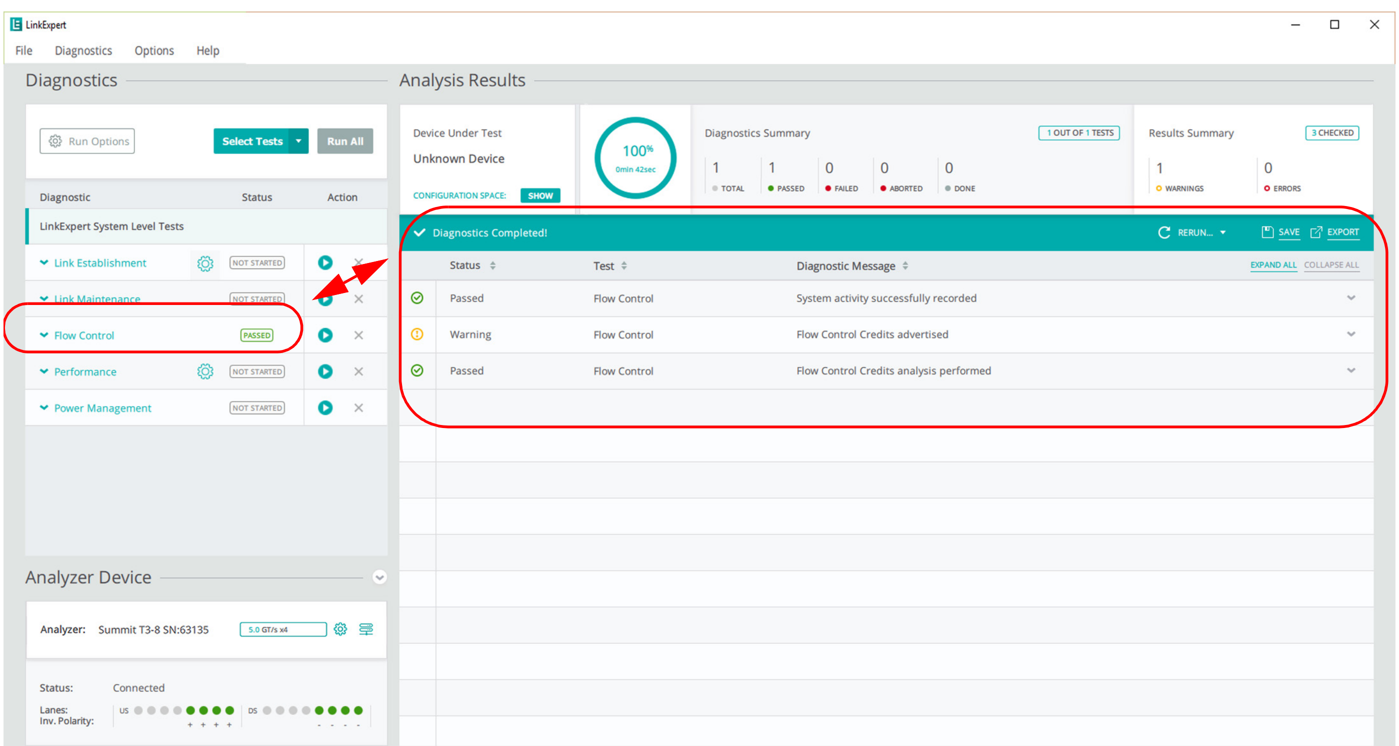


Figure 5.19: Analysis Results: Flow Control

5.1.3.1 Analysis Results: Flow Control Summary

The Flow Control Results Summary is shown in Figure 5.20.

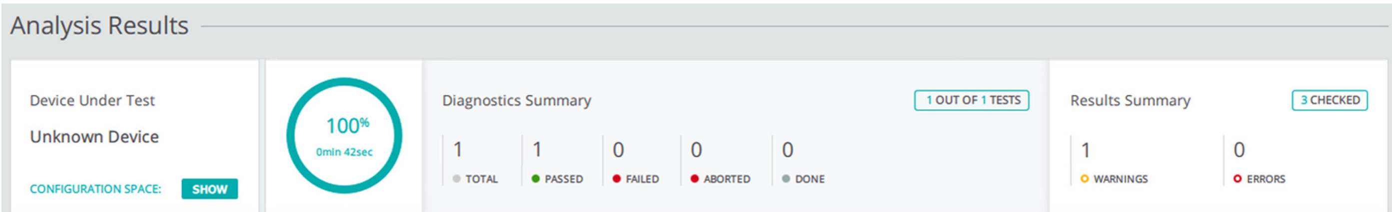


Figure 5.20: Analysis Results: Flow Control Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 42 seconds
- 1 out of 1 tests PASSED
- 0 tests were ABORTED
- 0 tests were DONE
- 3 Parameters were Checked during the test (see “Flow Control” on page 130)
- 1 Warning and 0 Errors were issued during the test (“Flow Control Credits Advertised”)

5.1.4 Results: Performance

5.1.4.1 Performance Test Results

The fourth System Level Test run was Performance and the Results are shown in Figure 5.21.

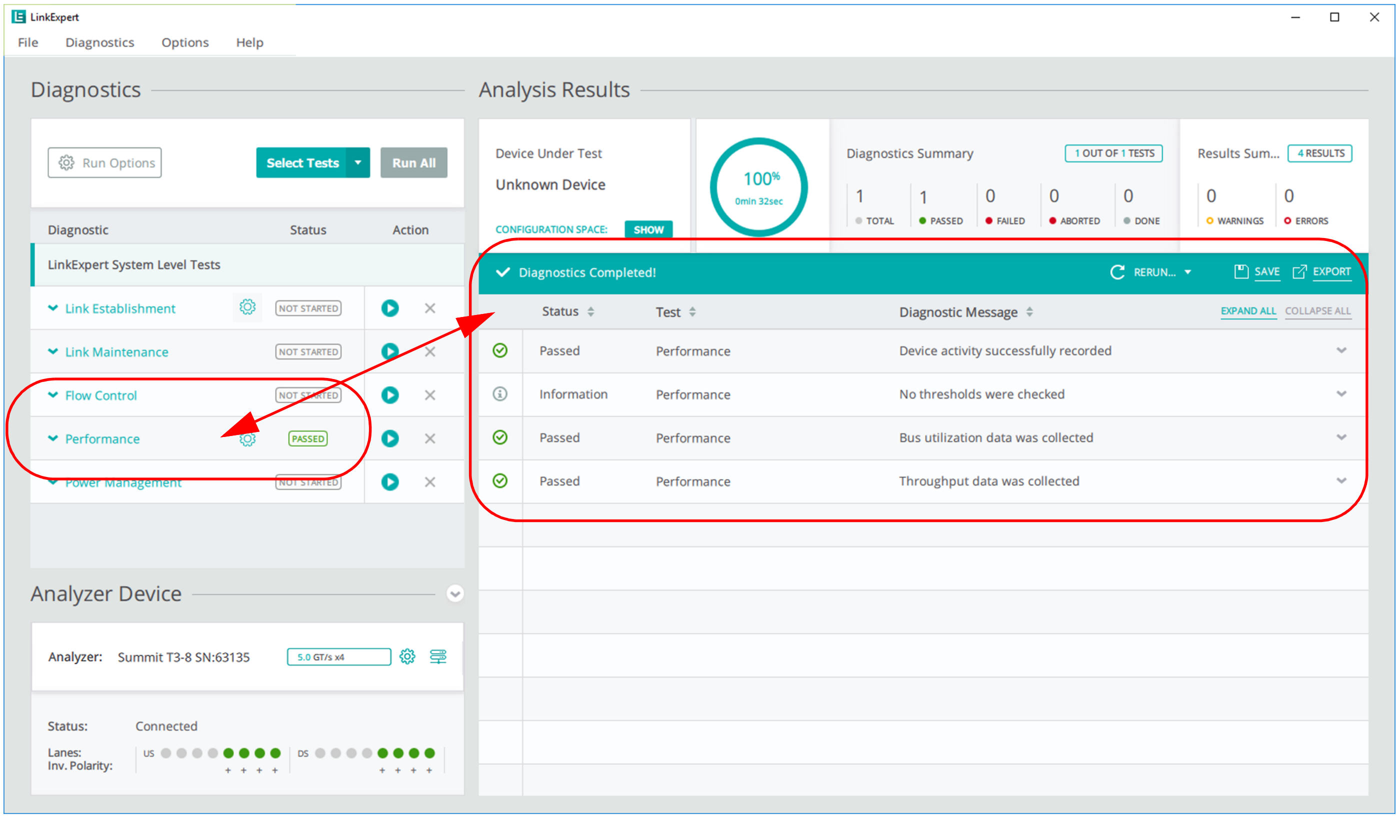


Figure 5.21: Analysis Results: Performance

5.1.4.2 Device Activity Successfully Recorded

The first part of the test is to establish a successful recording. See Figure 5.22.

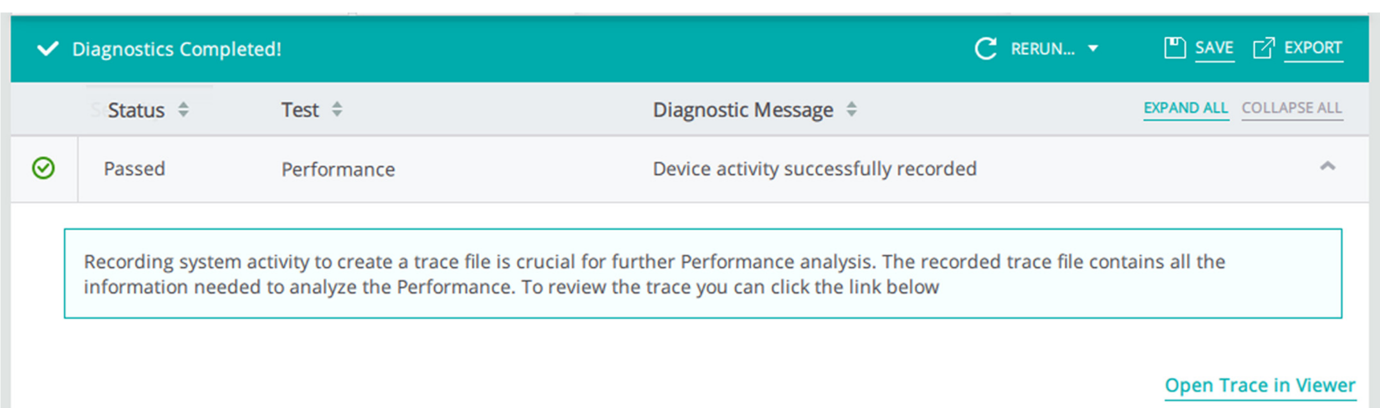


Figure 5.22: Performance Test: Part 1 -> Successful Recording

5.1.4.3 Performance Part 2: Information about Thresholds

The second part of the test is to check thresholds. In this case none were set. See Figure 5.23.

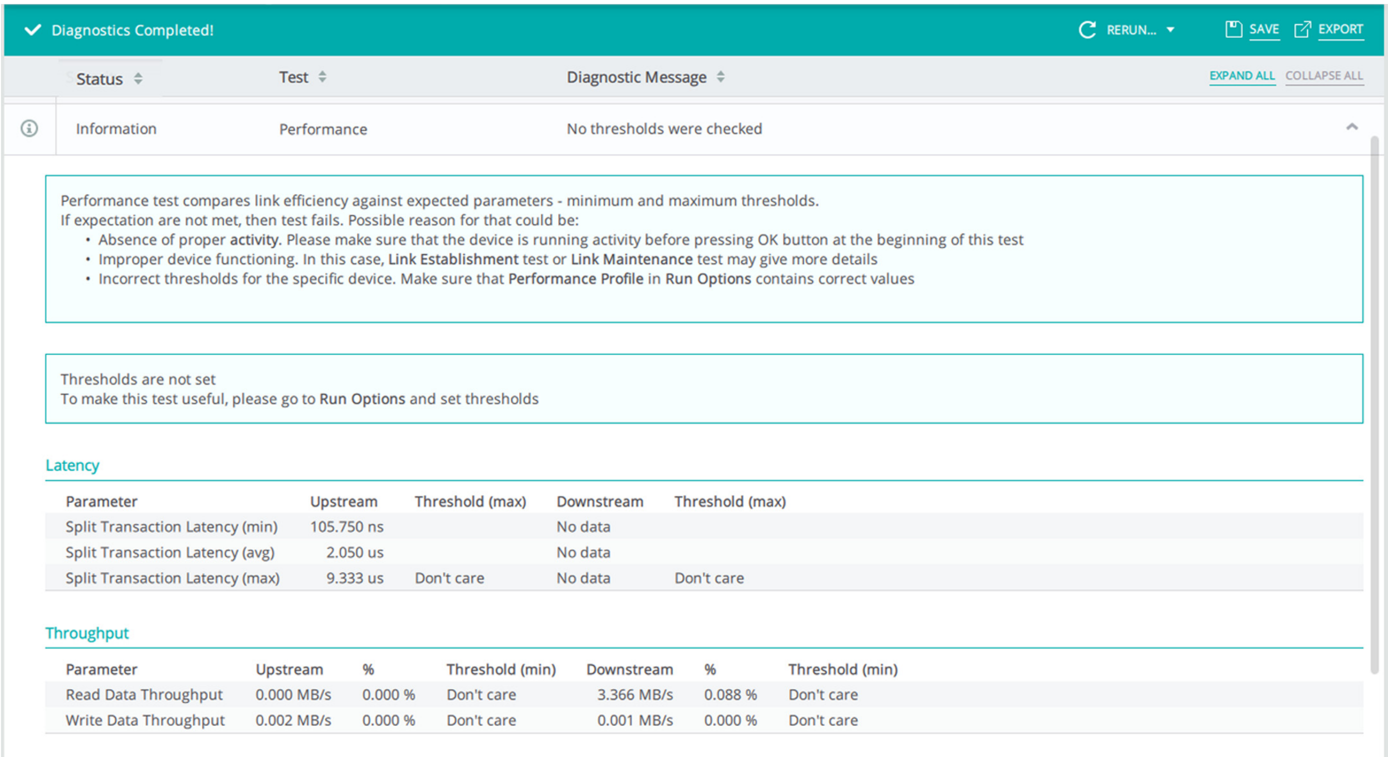


Figure 5.23: Performance Results: Thresholds Part 2a

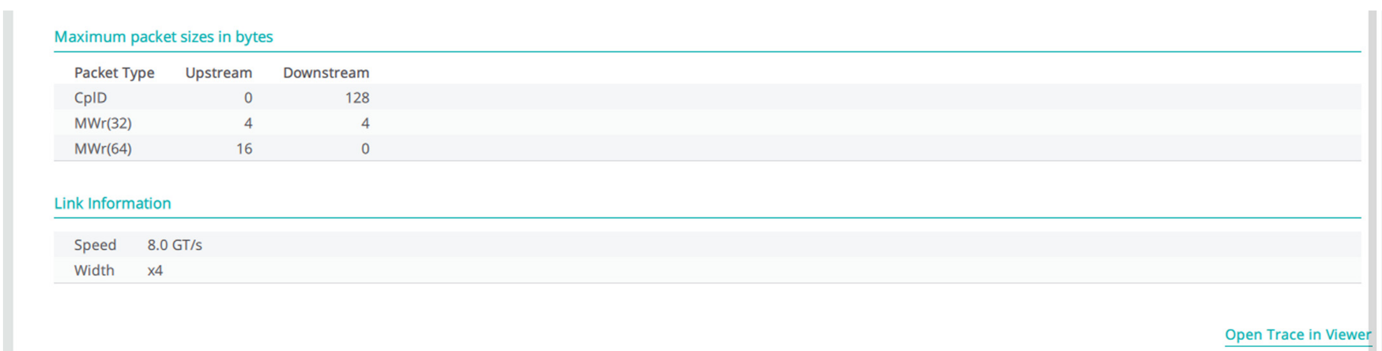


Figure 5.24: Performance Results: Thresholds Part 2b

5.1.4.4 Performance Part 3: Bus Utilization

The third part of the Performance Test is to collect bus utilization information. See Figure 5.25.

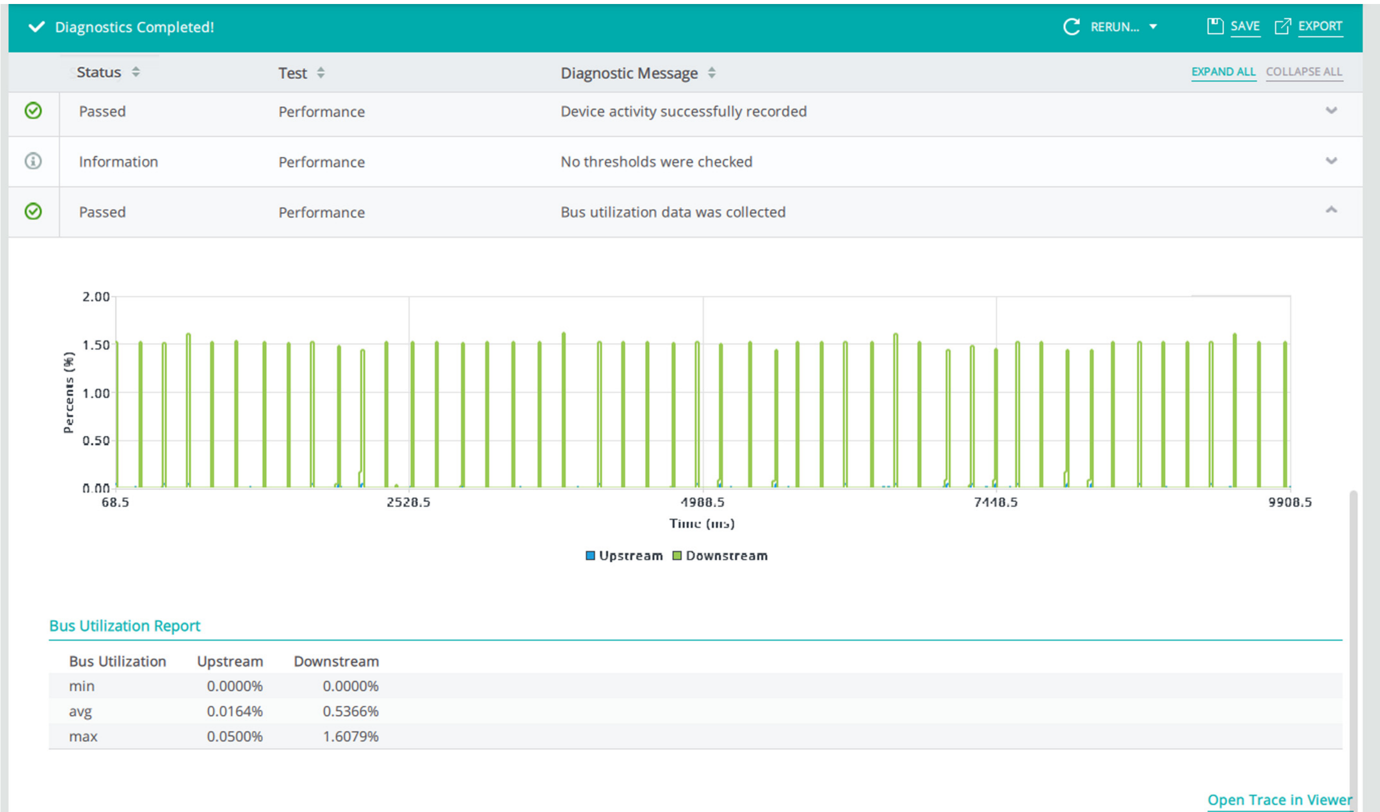


Figure 5.25: Performance Test: Bus Utilization

5.1.4.5 Performance Part 4: Throughput

The throughput of the system can be seen in Figure 5.26 on page 208.

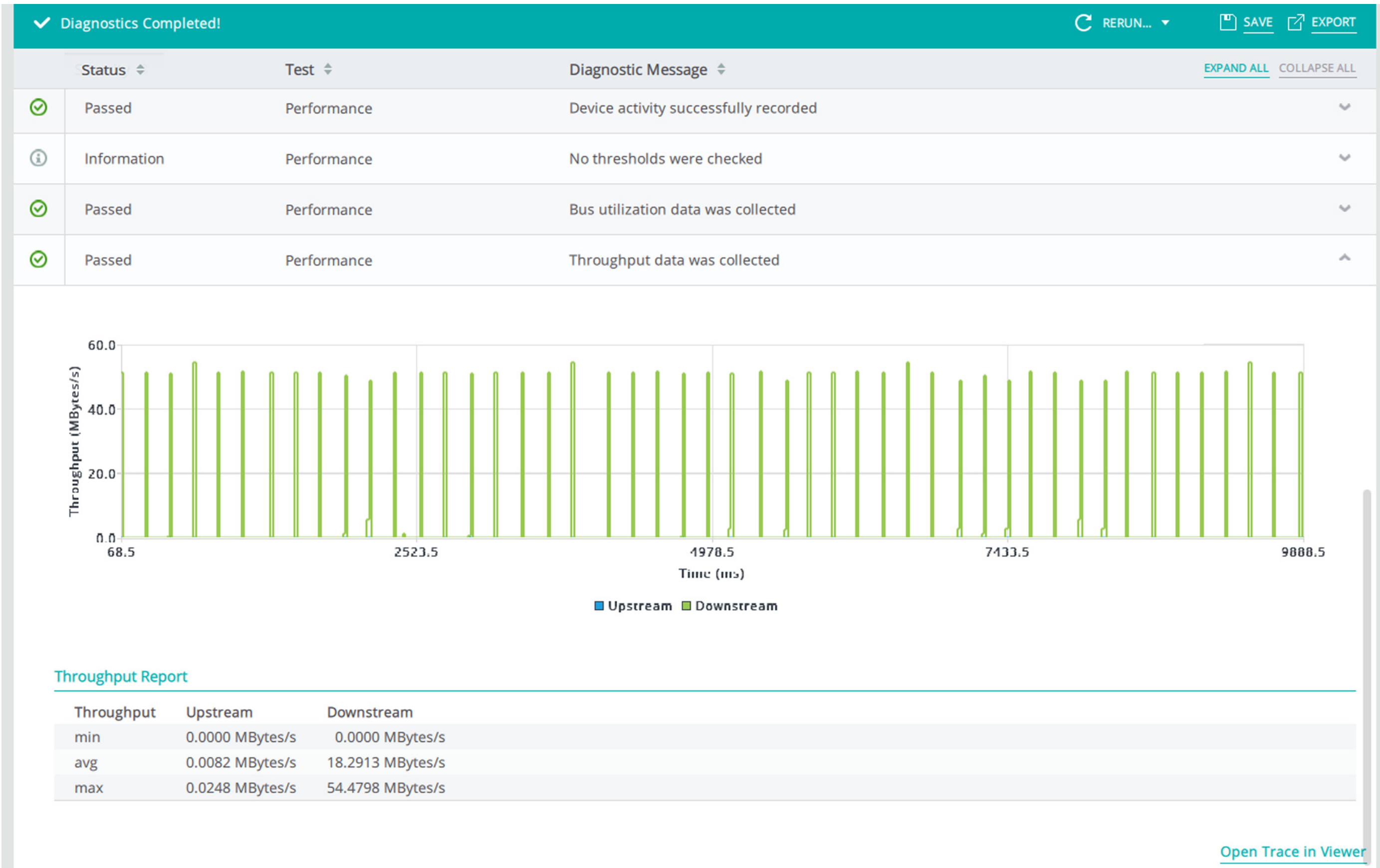


Figure 5.26: Performance Part 4: Throughput

5.1.4.6 Analysis Results: Performance Summary

The Performance Results Summary is shown in Figure 5.27.

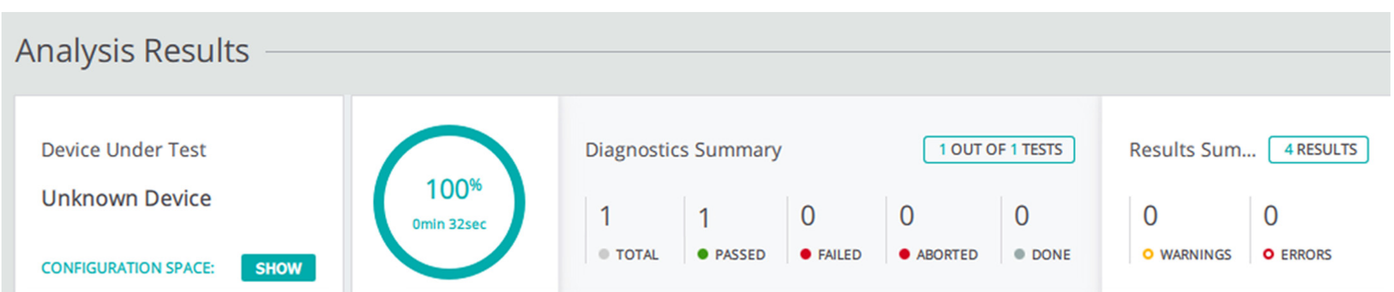


Figure 5.27: Analysis Results: Performance Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 16 minutes and 21 seconds
- 1 out of 1 tests PASSED, 0 tests were ABORTED, 0 tests were DONE
- 4 Parameters were Checked during the test (see “Performance Test” on page 131)
- 0 Warnings and 0 Errors were issued during the test

5.1.5 Results: Power Management

Power Management Results

The first result shows that the device's activity is successfully recorded. All further analysis will be based on the recorded trace. See Figure 5.28.

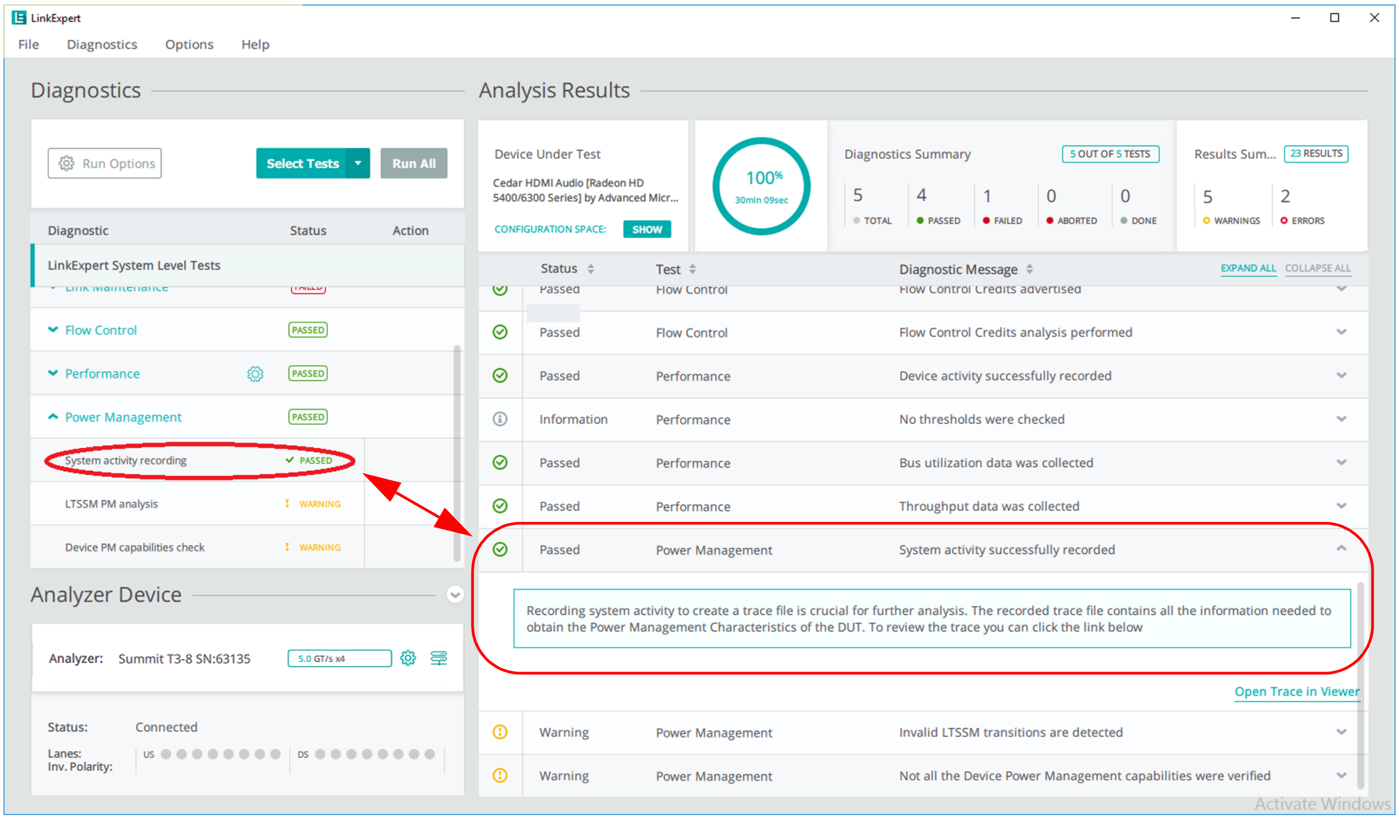


Figure 5.28: Power Management Test: Device's Activity Recorded

The second key result displays the LTSSM diagram for the recorded activity, and shows invalid transitions if any. It also shows the lowest Power state the system was in. See Figure 5.29 on page 210.

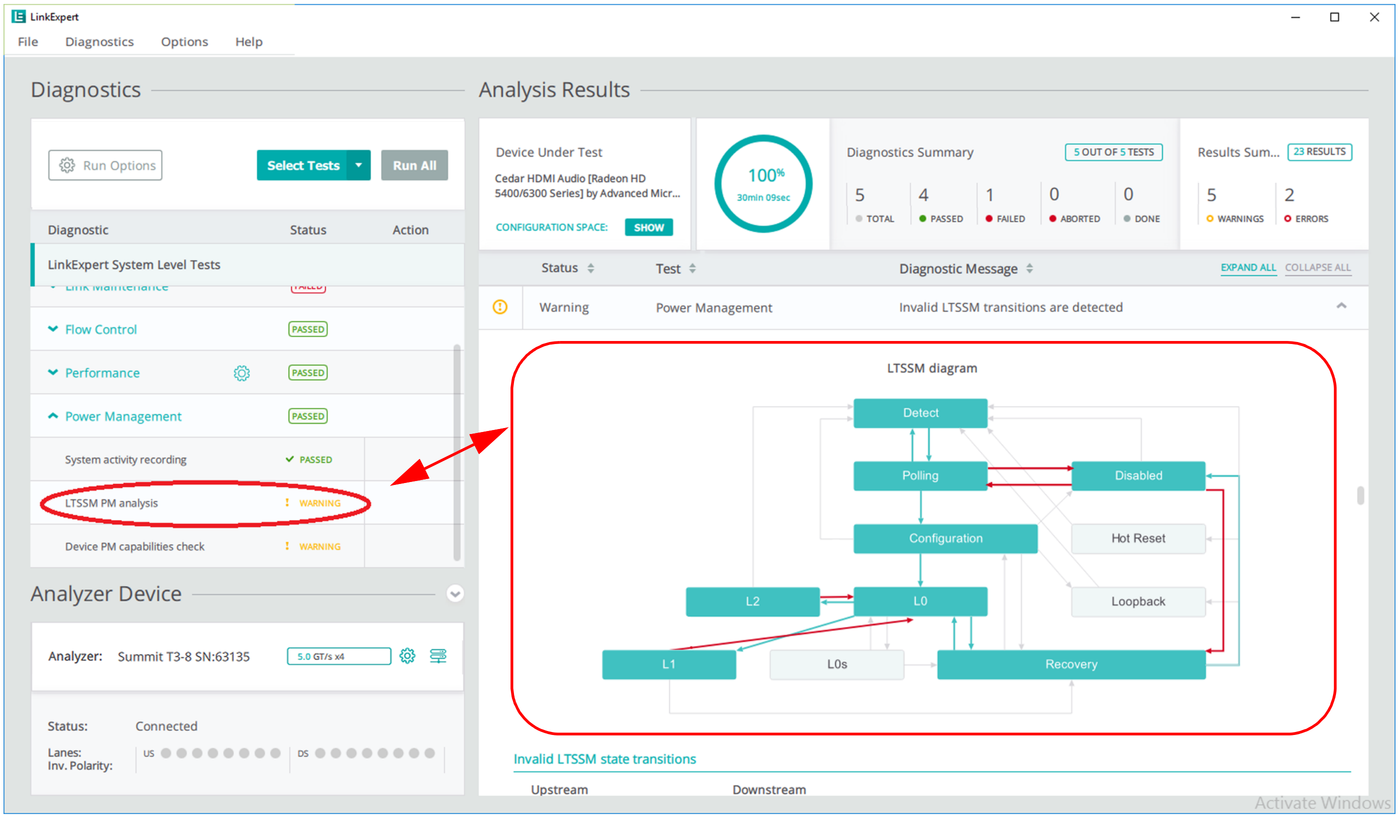


Figure 5.29: Power Management Test: LTSSM Diagram

The last key result shows information about Device Power Management states support, and about L1 sub-states support. This result also relies on Link Establishment diagnostic results. See Figure 5.30 on page 211

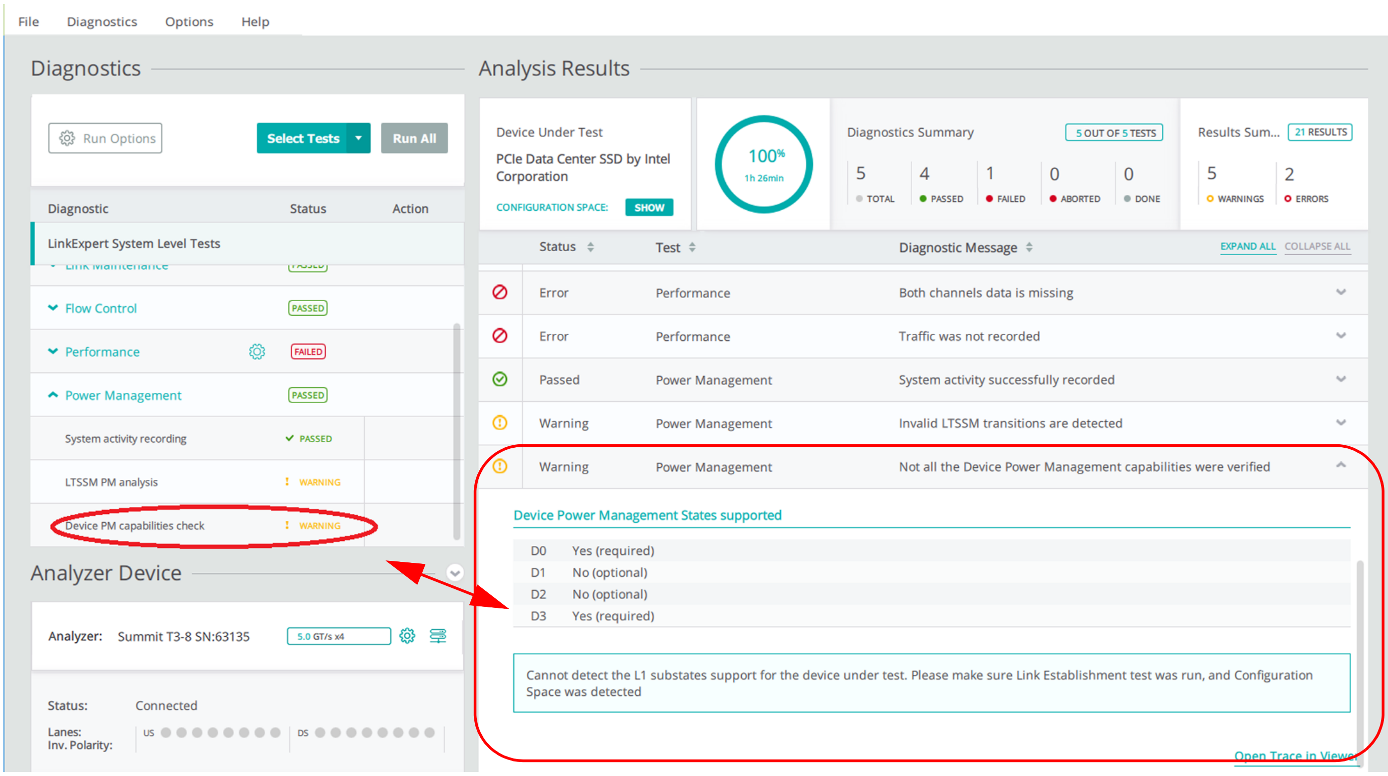


Figure 5.30: Power Management Test: L1 Sub-State Support

The complete set of Power Management Test and the Results are shown in Figure 5.31 on page 211.

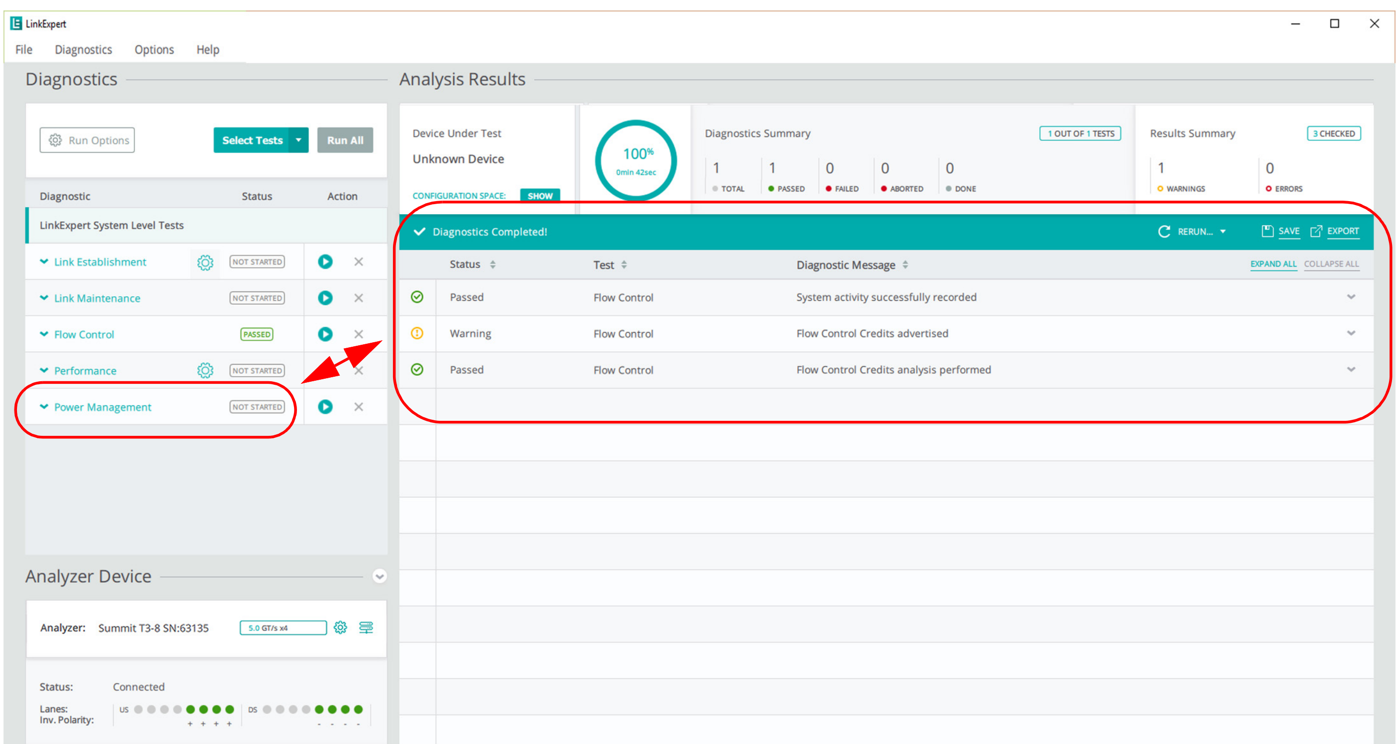


Figure 5.31: Power Management: Passed

5.1.5.1 Analysis Results: Power Management Summary

The Power Management Results Summary is shown in Figure 5.32.

Figure 5.32: Analysis Results: Performance Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 3 minutes and 53 seconds
- 1 out of 1 tests PASSED
- 0 tests FAILED
- 0 tests ABORTED
- 0 tests DONE
- 3 Parameters were Checked during the test (see “Power Management Test” on page 136)
- 2 Warnings and 0 Errors were issued during the test

5.2 Analysis Results: PCIe 3.0 Compliance Package Tests

5.2.1 Loading the PCIe 3.0 Compliance Package Tests

If you select the PCIe 3.0 Compliance Package Tests, the system will run up to 125 tests depending on which ones you select. When you select the PCIe tests a Warning message will pop up reminding you that if you select this set of tests the results from the previous set (LinkExpert System Level Tests) will be lost. This gives you the opportunity to Save the previous results if you have not already done so. See Figure 5.33.

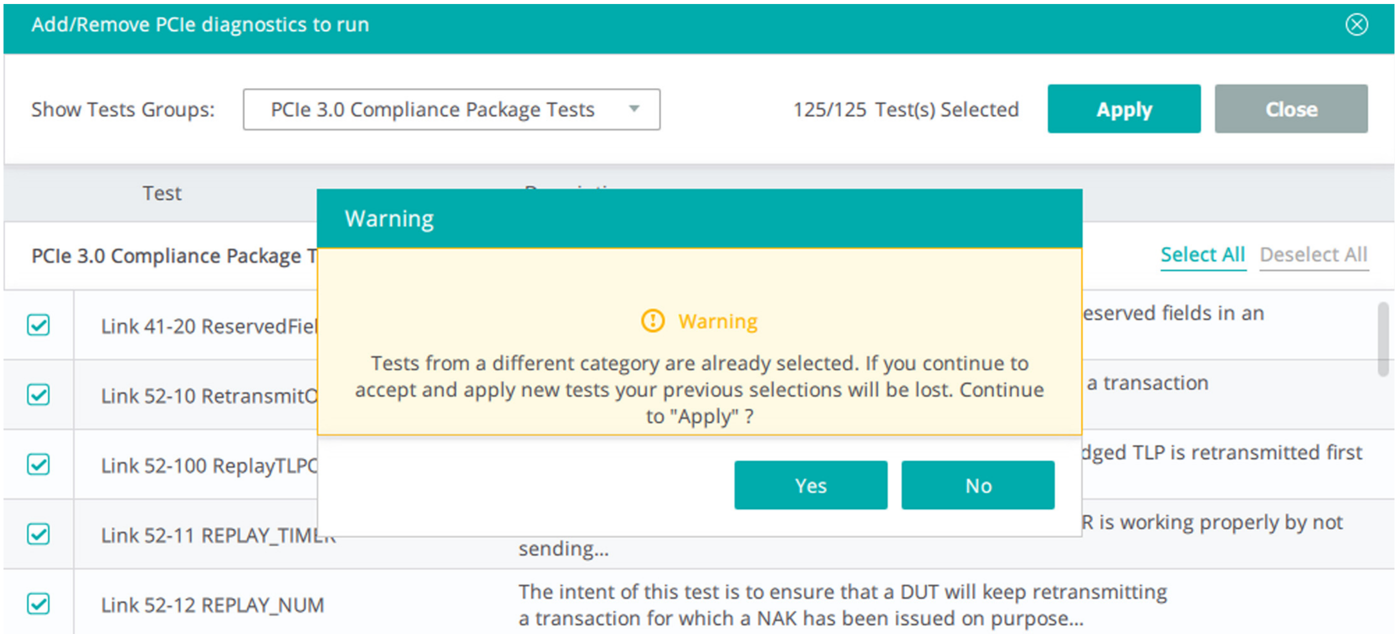


Figure 5.33: PCIe 3.0 Compliance Package Tests

If you select “Yes” the PCIe 3.0 Compliance Package Tests will be loaded and ready to run. See Figure 5.34 on page 214.

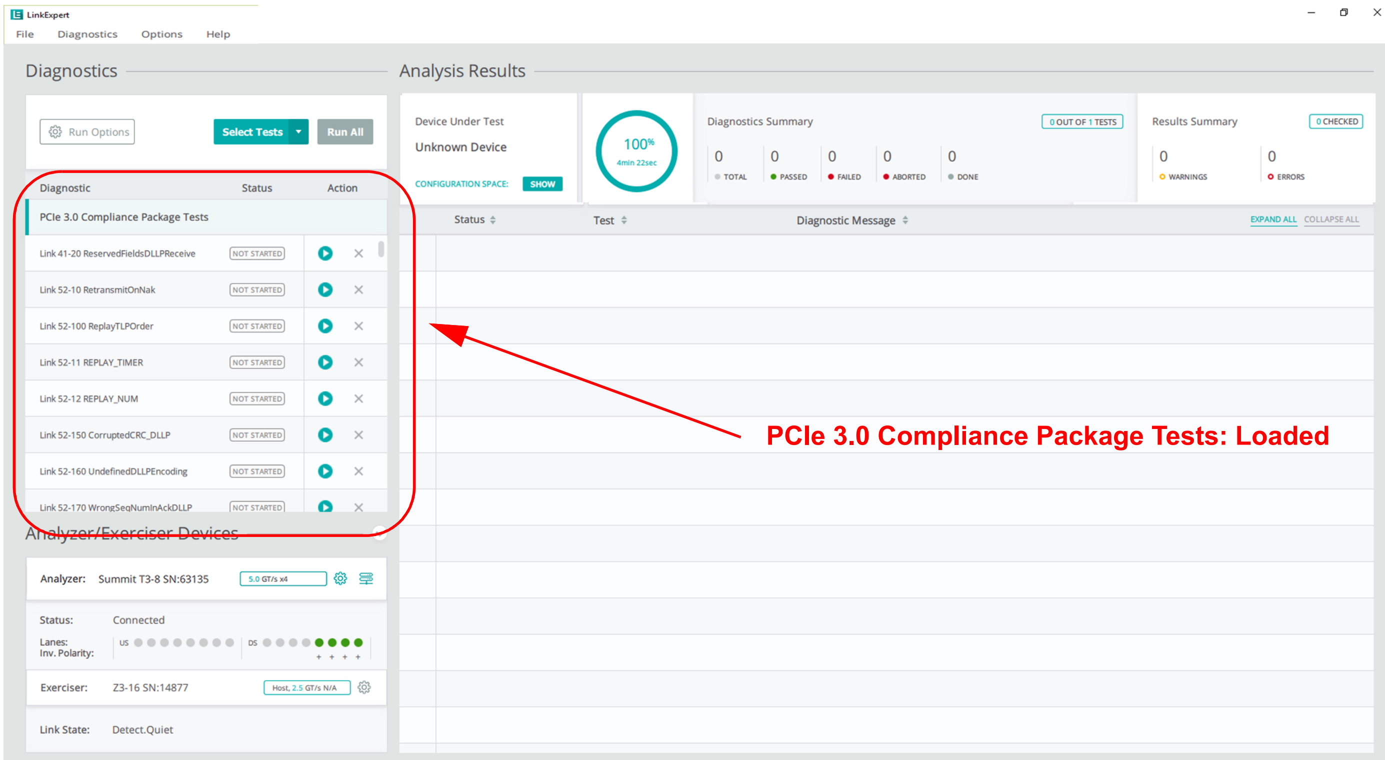


Figure 5.34: PCIe 3.0 Compliance Package Tests: Loaded

5.2.2 Results: PCIe 3.0 Compliance Package Tests

The results from running the 125 PCIe 3.0 Compliance Package Tests are shown in Figure 5.35 on page 215.

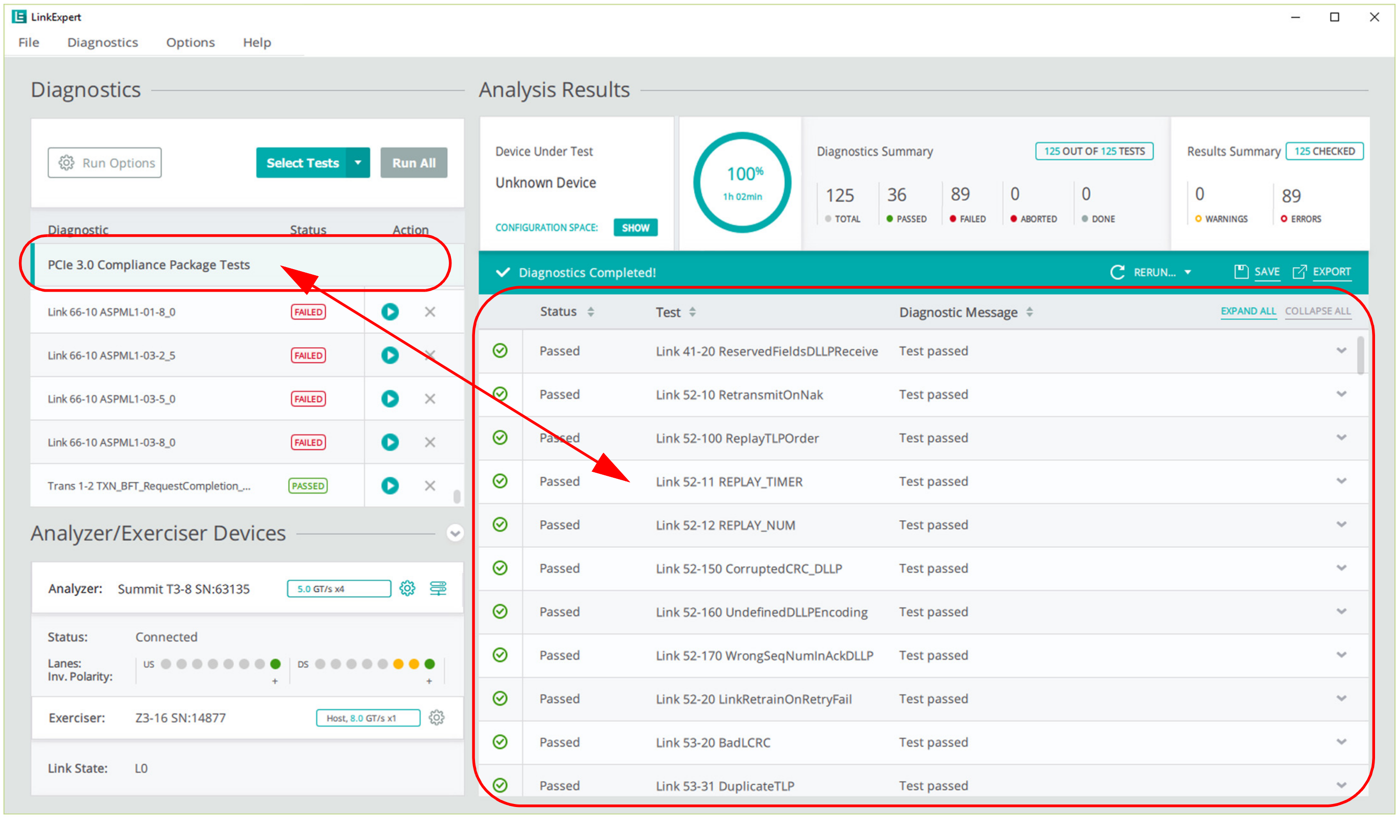


Figure 5.35: Results: PCIe 3.0 Compliance Package Tests

5.2.3 Summary of PCIe 3.0 Compliance Package Tests

Analysis Results Summary of PCIe Tests see Figure 5.36.

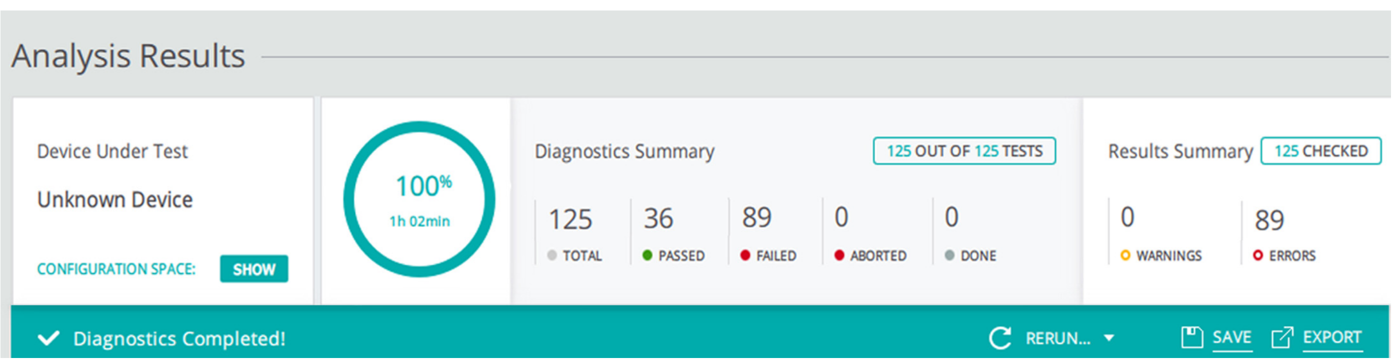


Figure 5.36: Analysis Results: Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 1 hour and 2 minutes
- 36 out of 125 tests Passed, 89 out of 125 tests had Errors
- 125 Parameters were Checked during the test
- 0 test ABORTED, 0 tests DONE
- 0 Warnings and 89 Errors were issued during the tests

5.3 Analysis Results: PCIe Validation Test (Endpoint)

5.3.1 Validation Tests (Endpoint) Loaded

The Validation Tests (Endpoint) have been loaded. See Figure 5.37.

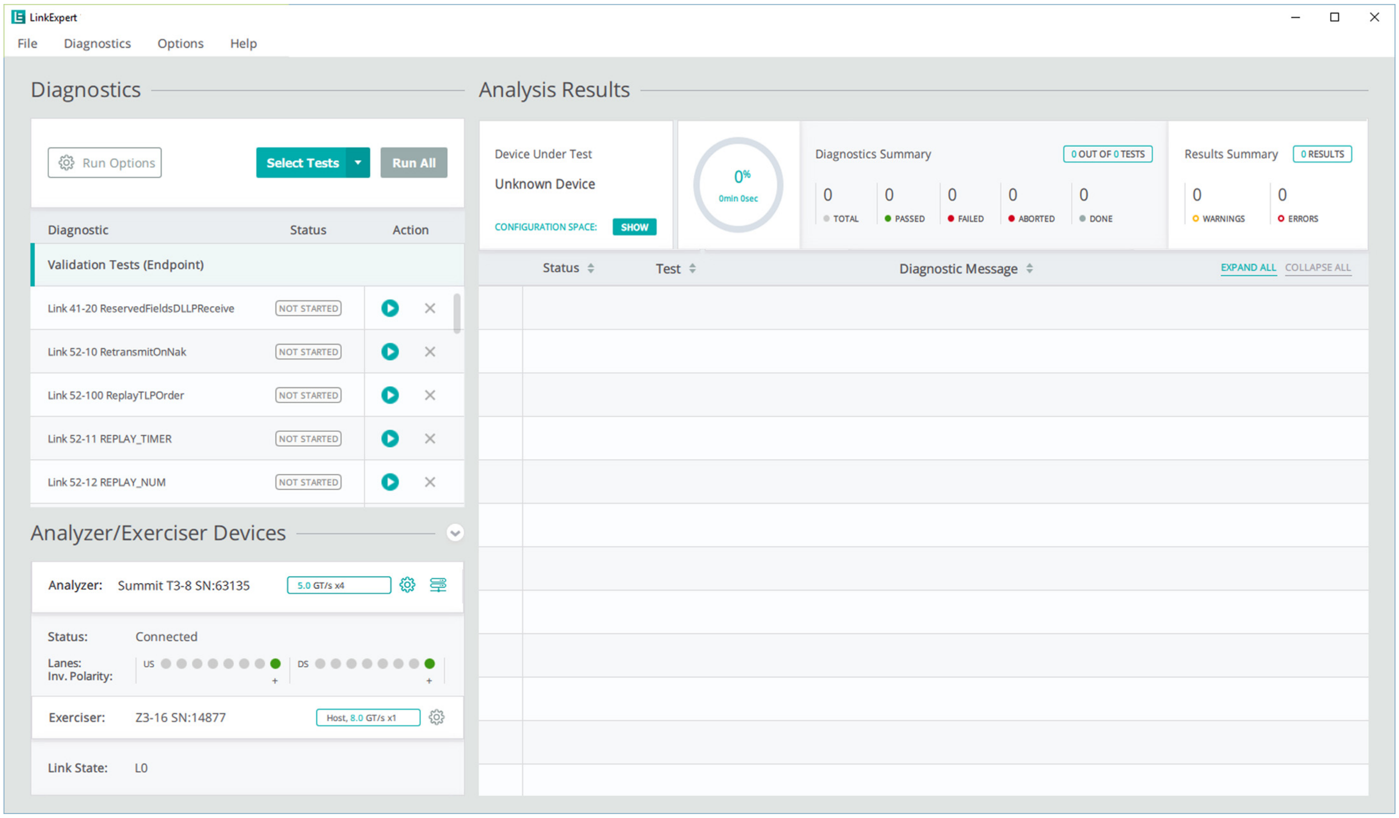


Figure 5.37: Validation Tests (Endpoint): Loaded

5.3.2 Validation Tests (Endpoint) Results

Analysis Results: Validation Tests (Endpoint) see Figure 5.38.

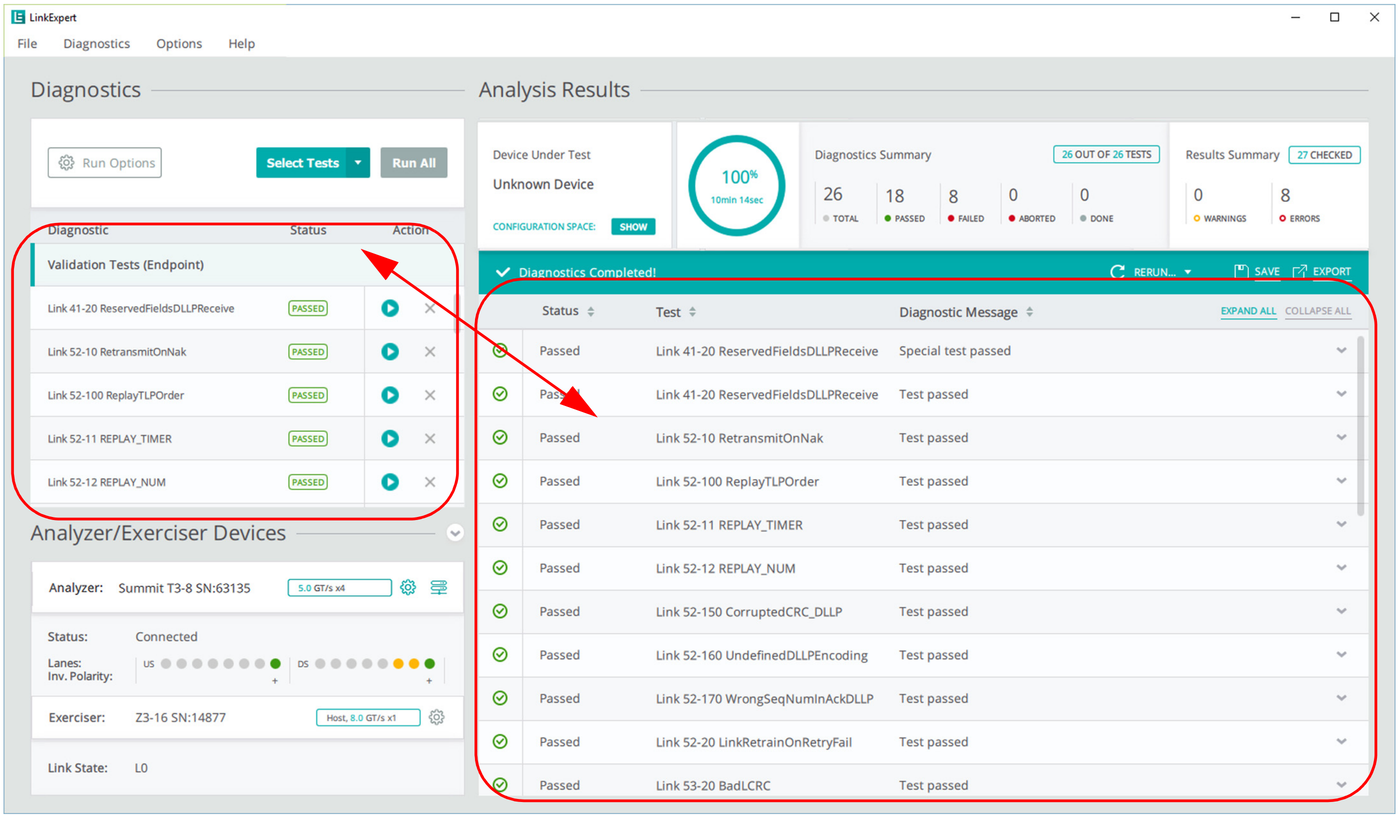


Figure 5.38: Validation Tests (Endpoint) -> Results

5.3.3 Summary of Validation Test (Endpoint)

Analysis Results: Validation Tests (Endpoint) -> Summary see Figure 5.39.

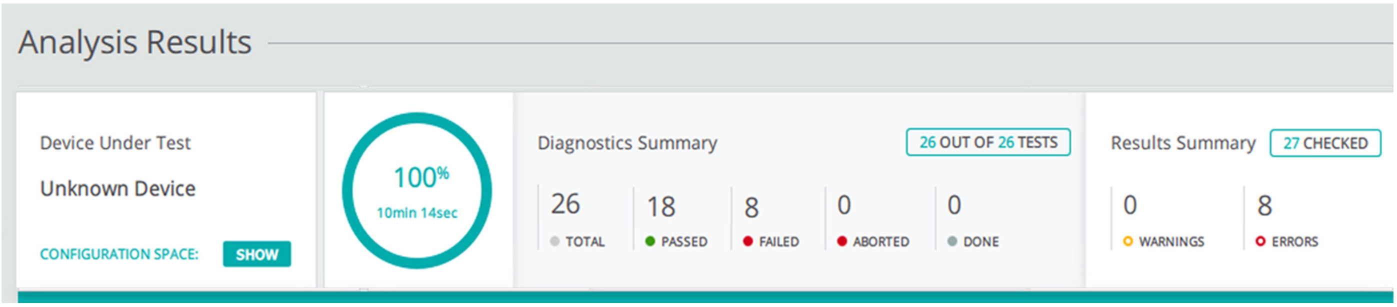


Figure 5.39: Validation Tests (Endpoint): Result Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 10 minutes and 14 seconds.
- 18 out of 26 tests Passed, 8 out of 26 tests Failed, 27 Parameters were Checked during the tests
- 0 tests ABORTED, 0 tests DONE
- 0 Warnings and 8 Errors were issued during the tests

5.4 Analysis Results: PCIe Validation Tests (Root Complex)

5.4.1 Validation Test (Root Complex) Loaded

The Validation Tests (Root Complex) have been selected and applied. See Figure 5.40.

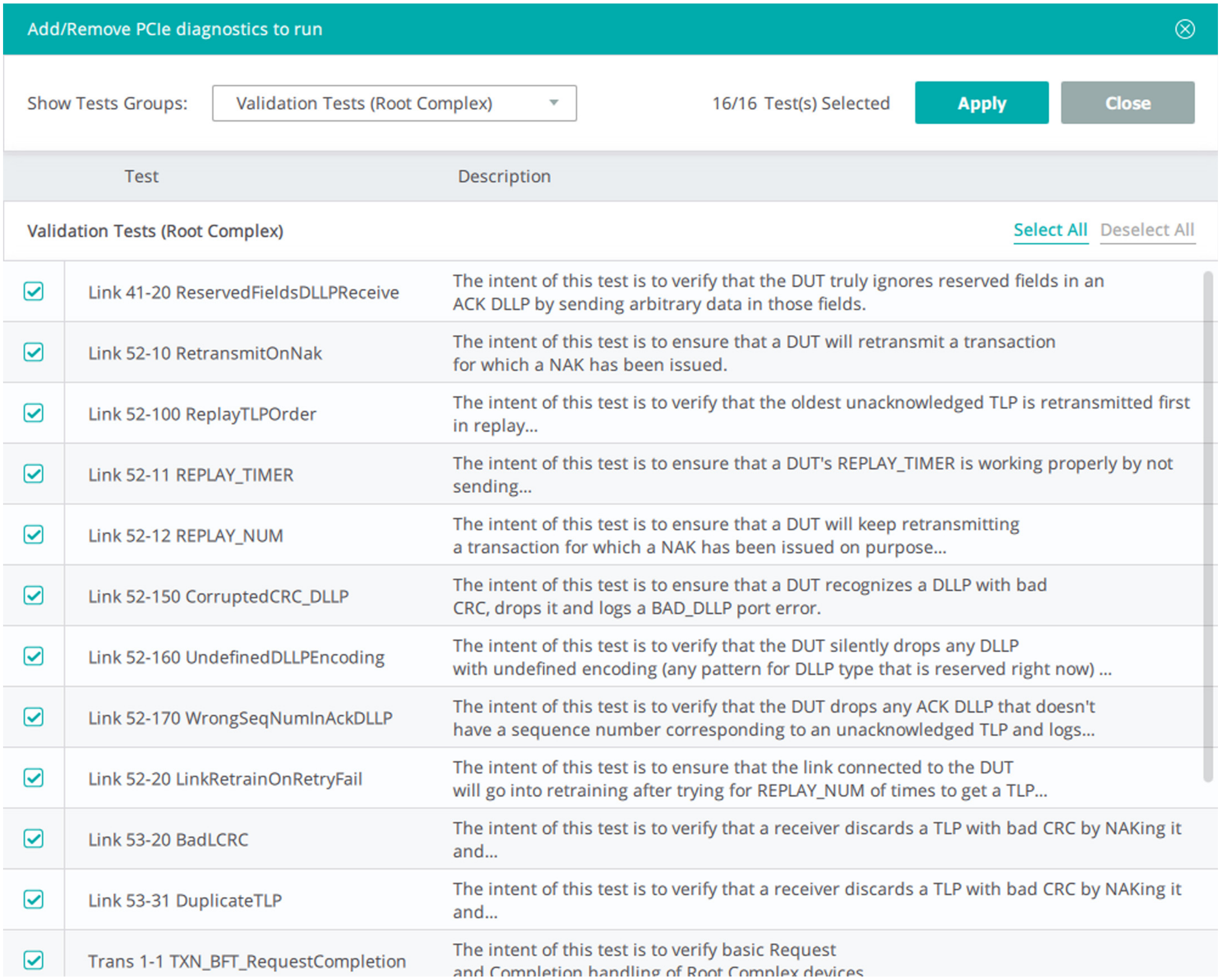


Figure 5.40: Validation Tests (Root Complex): Selected and Applied

5.4.1.1 Root Complex DUT

For Root Complex testing, perform the following steps to execute a test:

1. Turn OFF the DUT PC.
2. Insert the PCIe Exerciser Device Emulator card in the slot to be tested on the DUT system.
3. Connect the PCIe Exerciser system to the PCIe Device Emulator card using cables supplied by Teledyne LeCroy.

4. Connect the PCIe Analyzer system to the Device Emulator card using cables supplied by Teledyne LeCroy.
5. Connect the PCIe Application and PCIe exerciser systems to the USB ports of the PC on which the LinkExpert Test Tool is running.
6. Power ON the PC and the PCIe application and PCIe exerciser systems.
7. Open the LinkExpert Test Tool and select Root Complex tests, See Figure 5.40
8. Click the Boot RC button in the LinkExpert Test Tool.
9. Turn ON the DUT PC. 1
10. Boot the DUT PC into the operating system, supported ones are:
    - Windows 10 (x86 and x64)
    - Windows 11 (x86 and x64)
    - Windows Server 2016 (x64)
    - Windows Server 2019 (x64),
    - Linux distributions. (Ubuntu, CentOS, RedHat)
11. Install the Teledyne LeCroy PCIe Exerciser Device Emulator driver for the Device Emulator card using the installation instructions below.
12. Select Root Complex tests to execute.

5.4.2 Switch Downstream Port DUT The Root Complex

Setup can also be used to test a downstream port of a Switch device. Insert the Switch interface card in the PCI Express slot of the host PC. Insert the Device Emulator card in the downstream slot on the Switch. Otherwise, perform the same steps as in (above) Root Complex DUT.

5.4.3 Device Emulator Driver for Root Complex Testing

Root Complex testing requires installing a driver for the Device Emulator PCI Express Endpoint on the DUT system.

Currently supported operating systems are:

- Windows 10 (x86 and x64)
- Windows 11 (x86 and x64)
- Windows Server 2019 (x64)
- Windows Server 2016 (x64)
- Ubuntu,
- CentOS (see details below)

After installing the PCIe application suite, you can find the drivers in the folder:

```
C:\Users\Public\Documents\LeCroy\PCIe Protocol
Suite\ScriptAutomationTestTool\Drivers
```

Copy the \Drivers folder from the testing PC to a USB to use for installation on the DUT. The \Drivers \linux contains the files needed to install and build the driver under Linux distributions.

5.4.4 Installation Instructions under Windows

When you first boot the system for Root Complex testing, the New Device plug-and-play wizard appears for the Device Emulator PCI Express Endpoint. The Device Emulator presents itself to the system as an Ethernet Controller device. Follow the wizard instructions. When asked for the driver location, point to the appropriate subfolder of the \Drivers folder for your operating system.

The lcrypede.inf driver installs. The Device Emulator device appears in the Device Manager under a Sample Drivers group named LeCroy PETrainer Device Emulator Driver for PCI Express Root testing. After you install the driver, you can restart the DUT, if necessary, and perform testing.

If you move the Device Emulator to another PCI Express slot for testing, you must install the driver again. After the first test, you can use the Install the software automatically option of the New Device plug-and-play wizard to install the driver.

5.4.5 Note on enabling the “phantom” Advanced Error Reporting Capability

The Advanced Error Reporting Capability structure for the Root or Switch ports should be enabled by default. However, some Root Complex DUT setups may not enable the Advanced Error Reporting Capability structure for the Root or Switch ports. Advanced Error Reporting may be fully operational, but the Advanced Error Reporting Capability structure does not link within the Root or Switch port’s Enhanced Configuration Space.

The Device Emulator Driver includes an option to test Advanced Error Reporting features. After you install the driver, perform the following steps to perform the test: Teledyne LeCroy Running Tests 20 PCIExpress™ Script Automation Test Tool User Manual for Teledyne LeCroy Analyzer/Trainer™

1. Using a registry editor, locate the enumerator key for the Device Emulator under the HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Enum\PCI path. The name is based on the LeCroy Vendor ID (0x1570) and the Product ID used for Root testing (0xA239).
2. Under the enumerator key, find the key for the current device instance. That key includes a Control entry.
3. Open the DeviceParameters folder for the instance key. 4. Add a DWORD value named AdvancedErrorStructOffset in the DeviceParameters folder. Set the value for this entry to the byte offset of the “phantom” Advanced Error Reporting Capability structure within the Root or Switch port’s Enhanced Configuration Space. 5. Re-start the DUT. You can now perform full testing of the port, including Advanced Error Reporting

5.4.6 Installation Instructions under Linux

5.4.6.1 Dependencies

Root Access

Installation of the module requires root privileges. Preferably, grant sudo access tonormal users:

$ su -c "vi /etc/sudoers" (or editor of choice)

(You can also log in as the root user, or switch to root via the su command.) Add individual user access by adding your username and permissions. For example: <username> ALL=(ALL) ALL You can also add group access by uncommenting and/or modifying one of the provided examples. The sudoers file describes the various permissions.

GNU C Compiler (GCC)

Only a GNU C compiler can compile the Device Emulator module source code. Some Linux distributions install this compiler by default. To check whether your Linux distribution has installed GCC, type gcc to see if the command is found or not.

Ubuntu typically installs GCC by default.

Linux Kernel Headers

To compile the module for the particular kernel requires kernel headers. The kernel header version should match that of the kernel. The package management system usually manages kernel headers.

Ubuntu packages

When you are building the Root Complex test driver using Ubuntu distribution (latest official version used: 14.10) of Linux ensure that you have refreshed your libraries and added necessary modules/packages to the installation:

Run:

1. sudo apt?get install gcc
2. b.sudo apt?get update
3. sudo apt?get dist?upgrade (ONLY If applies)

Module Use

Source Installation

Choose a directory in which to place the module sources, change to that directory, and "untar" the source tarball.

```
$ tar xzf pcide_1_0.tar.gz
$ cd pcide
$ make
```

Module Installation

You must have root privileges to install the module. Preferably, use the sudo command to install the module with root privileges. During installation, you can pass optional commands to control the module.

```
$ sudo insmod pcide.ko <option=0|1>
```

The available options are:

TABLE 5.3: Installation Options

Option	Result
poll=1	**poll=1** is for module to poll Device Emulator commands. **poll=0** is for module to use an interrupt. If you omit this parameter, default is 0. Important: Use the poll=1 polling mode when testing with the Summit Z3 Trainer traffic generators.
msi=1	**msi=1** is for MSI mode interrupts. **msi=0** is for legacy interrupts. Legacy interrupts are ignored if you use the poll=1 option. If you omit this parameter, default is 0. Note: This setting is currently not in use.
debug=1	**debug=1** prints verbose debug messages to the system or kernel logging file. **debug=0** prints normal messages. If you omit this parameter, default is 0.
mcfg=<ADDRESS>	Use decimal or hexadecimal (prefixed with “0x”) for the root port configuration space address. The system uses this address only if the module does not find the value.
aer=<ADDRESS>	Use decimal or hexadecimal (prefixed with “0x”) for the root port advanced error reporting space address. The system uses this address only if the module does not find the value.

An example of module installation with options is:

```
$ sudo insmod pcide.ko debug=1 poll=1
```

5.4.7 Module Removal

To remove the module, type:

```
$ sudo rmmod pcide
```

Using the above methods, the module does not stay loaded in memory. You must install the module after each reboot.

To install the module so that it stays loaded in memory, you can:

- Call the `sudo insmod` ... command from a script run at boot time with root privileges.
- Copy the `pcide.ko` file into the path `/lib/modules/$(uname -r)` where it will load automatically. `$(uname -r)` will resolve into the particular kernel version number that is currently running.

5.4.8 Test Driver Functionality (Windows or Linux)

The driver does the following:

- Allocates a buffer in the system memory that is accessible by the Device Emulator for storing commands to the driver as well as for general DMA.
- Maps the Device Emulator memory and IO spaces for access.
- Locates the configuration space for the Root or Switch downstream port to which the Device Emulator attaches.
- Takes control of the named Root or Switch port and configures it so that no errors on that port result in an interrupt being forwarded to the system software.
- Implements a protocol with the Device Emulator that the CTP will use for executing the tests.

The driver locates the configuration space for the Root or Switch downstream port to which the Device Emulator attaches by following the ACPI structures created by the system BIOS. It looks for the MCFG structure (as defined by the PCI Firmware specification) to be pointed at by the ACPI RSDT or XSDT structures. The MCFG structure points to the location of the mapped PCI Express configuration spaces.

If the driver cannot find the MCFG structure, RSDT structure, XSDT structure, Device Emulator configuration space, or Root or Switch downstream port configuration space, the Script Automation Test Tool refuses to perform any of the normal tests. To indicate this case, the software reports that the Special test FAILED.

The Device Emulator communicates with the driver by:

1. Writing a command in the command area of the system buffer.
2. Interrupting the system using legacy PCI interrupt emulation.

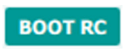
Upon receiving the interrupt, the driver acknowledges it, examines the command buffer contents, and executes the command.

The command types that the driver can execute are:

- Report information about system variables (such as the physical address of the command buffer) and the root/switch port found. The Special test for Root testing uses this command (the default command).
- Execute a Configuration Read transaction from the PCI compatible portion of the Device Emulator configuration space.
- Execute a Configuration Write transaction to the PCI compatible portion of the Device Emulator configuration space.
- Execute a Memory Read transaction to one of the two Memory spaces on the Device Emulator.
- Execute a Memory Write transaction to one of the two Memory spaces on the Device Emulator.
- Execute an IO Read transaction to the IO space on the Device Emulator.
- Execute an IO Write transaction to the IO space on the Device Emulator.
- Clear all error status bits for the Root or Switch port to which the Device Emulator attaches.
- Reflect the current values of the Error Reporting Registers for the Root or Switch port to which the Device Emulator attaches to the PCI Express link. This can use Configuration Writes or Memory Writes.

- Retrain or Hard Reset the link to the Device Emulator.
- Send a series of Memory Write transactions. The Device Emulator monitors those transactions and signals when the driver should stop sending them. (This command can ensure that the next transaction from the DUT has a specific Tag value, so that it can be completed from the Trainer script.)
- Read a specified register from the Configuration Space for the Root or Switch port to which the Device Emulator attaches.
- Write a specified register to the Configuration Space for the Root or Switch port to which the Device Emulator attaches.

5.4.9 Validation Tests Boot Root Complex

After the Validation Tests (Root Complex) tests have been loaded the Diagnostics pane will update to include a Boot RC tab 

to ensure that the Root Complex has been initialized before the Validation Tests are executed. See Figure 5.41 on page 226.

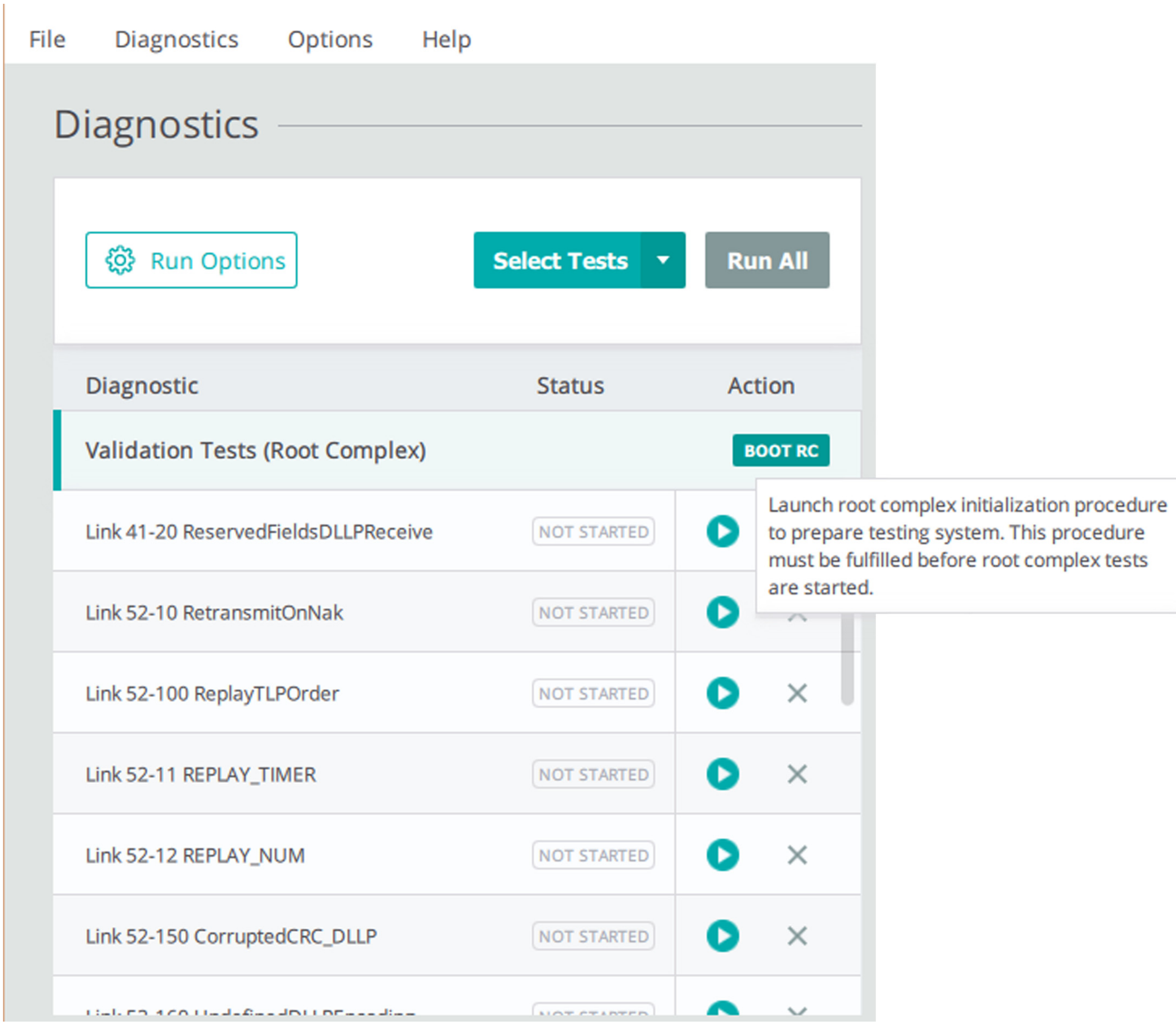


Figure 5.41: Validation Tests (Root Complex): Loaded

After the Root Complex has been initialized the Validation Tests can be started.

5.4.10 Results of Validation Tests (Root Complex)

Analysis Results -> Validation Tests (Root Complex) see Figure 5.42

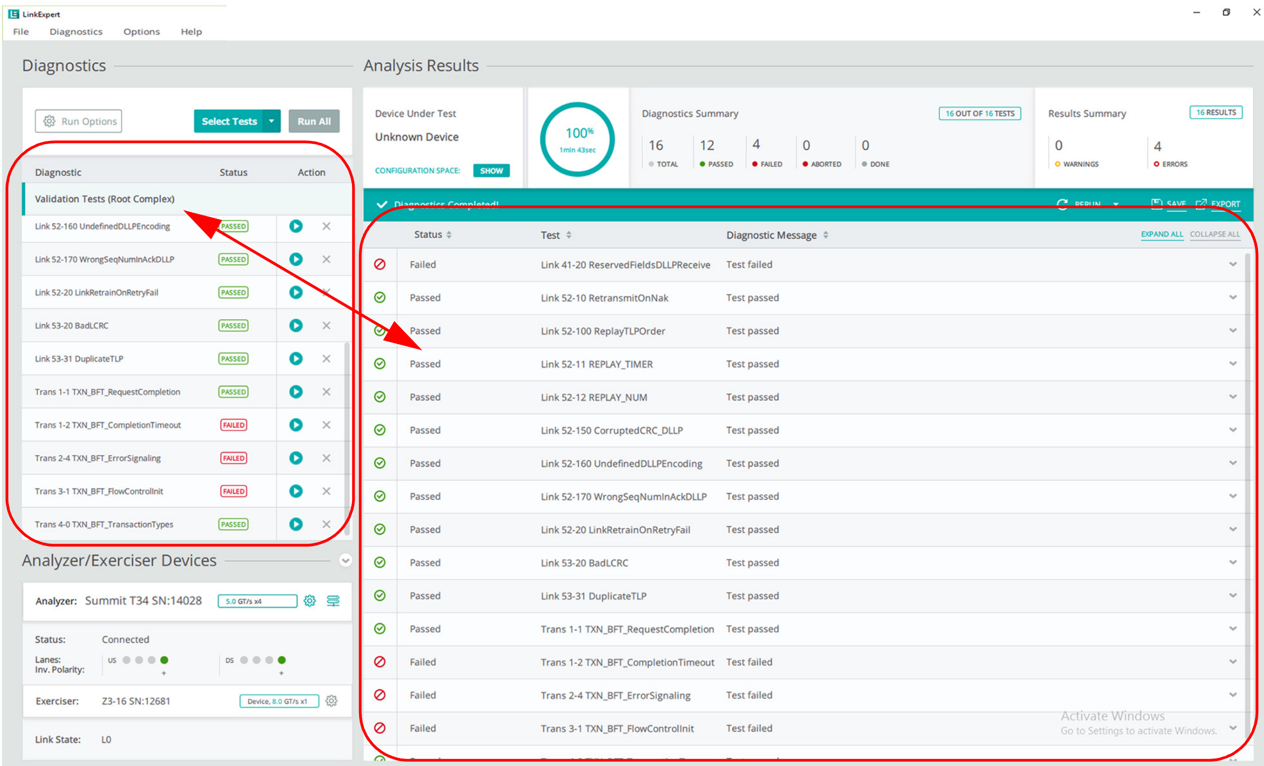


Figure 5.42: Validation Tests (Root Complex): Results

5.4.11 Validation Tests (Root Complex): Summary

See Figure 5.43.

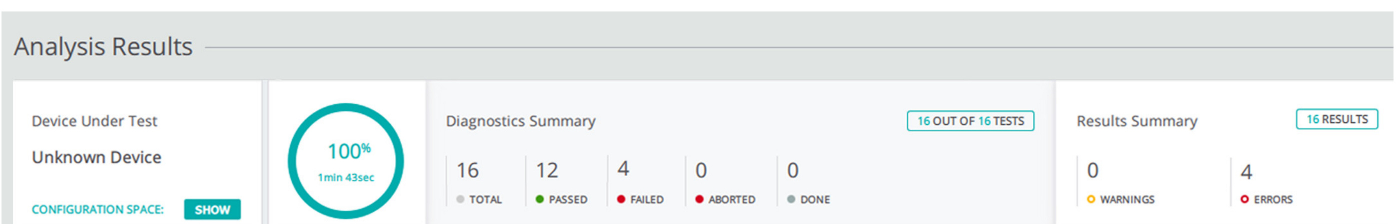


Figure 5.43: Validation Tests (Root Complex): Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 1 minute and 43 seconds.
- 12 out of 16 tests Passed, 4 out of 16 tests Failed, 16 Parameters were Checked during the tests
- 0 tests ABORTED, 0 test DONE
- 0 Warnings were issued during the tests

5.5 Analysis Results: Jammer Validation Tests (Endpoint)

Analysis Results -> Jammer Validation Tests (Endpoint) see Figure 5.42

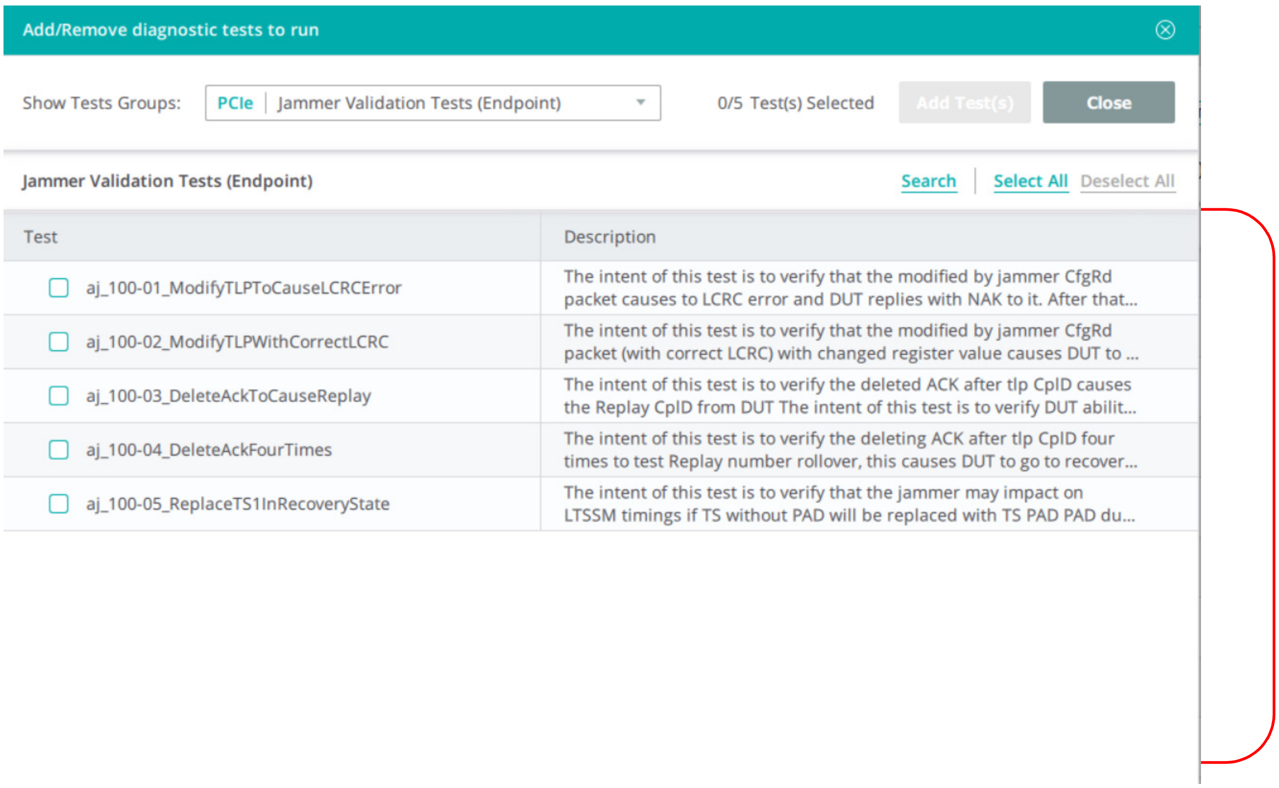


Figure 5.44: Jammer Validation Tests (Endpoint): Results

5.6 Analysis Results: PCIe LTSSM Arc Tests

5.6.1 LTSSM Arc Test Loaded: Settings Options

For the LTSSM Arc Tests there is a Settings button that allows you to set initial conditions for the test. See Figure 5.45.

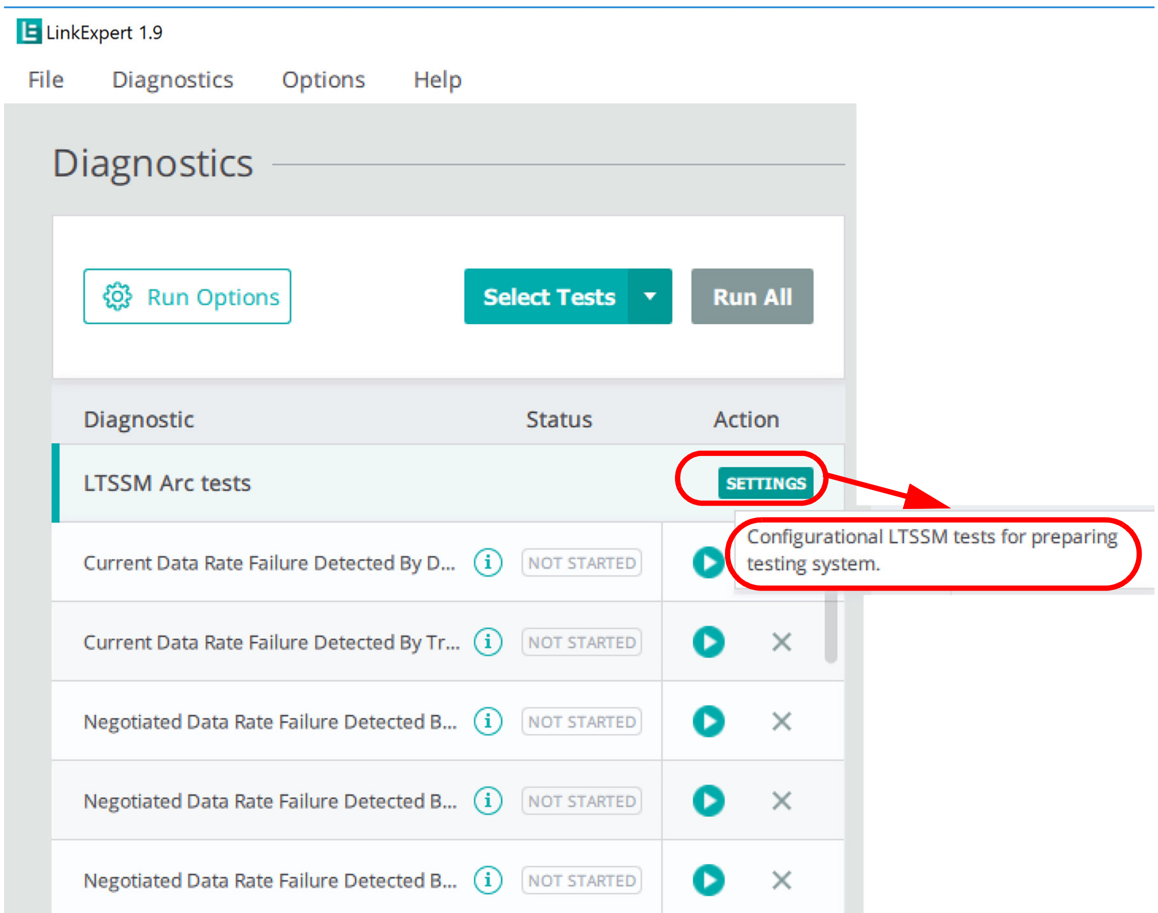


Figure 5.45: LTSSM Arc Test: Settings Tooltip

If you click on the SETTINGS button you have the following options:

- Link Speed Control (2.5, 5.0, 8.0, 16.0 or 32.0 GT/s)
- Link Width Control (x2, x4, x8 or x16)
- Link State Control

See Figure 5.46 on page 230.

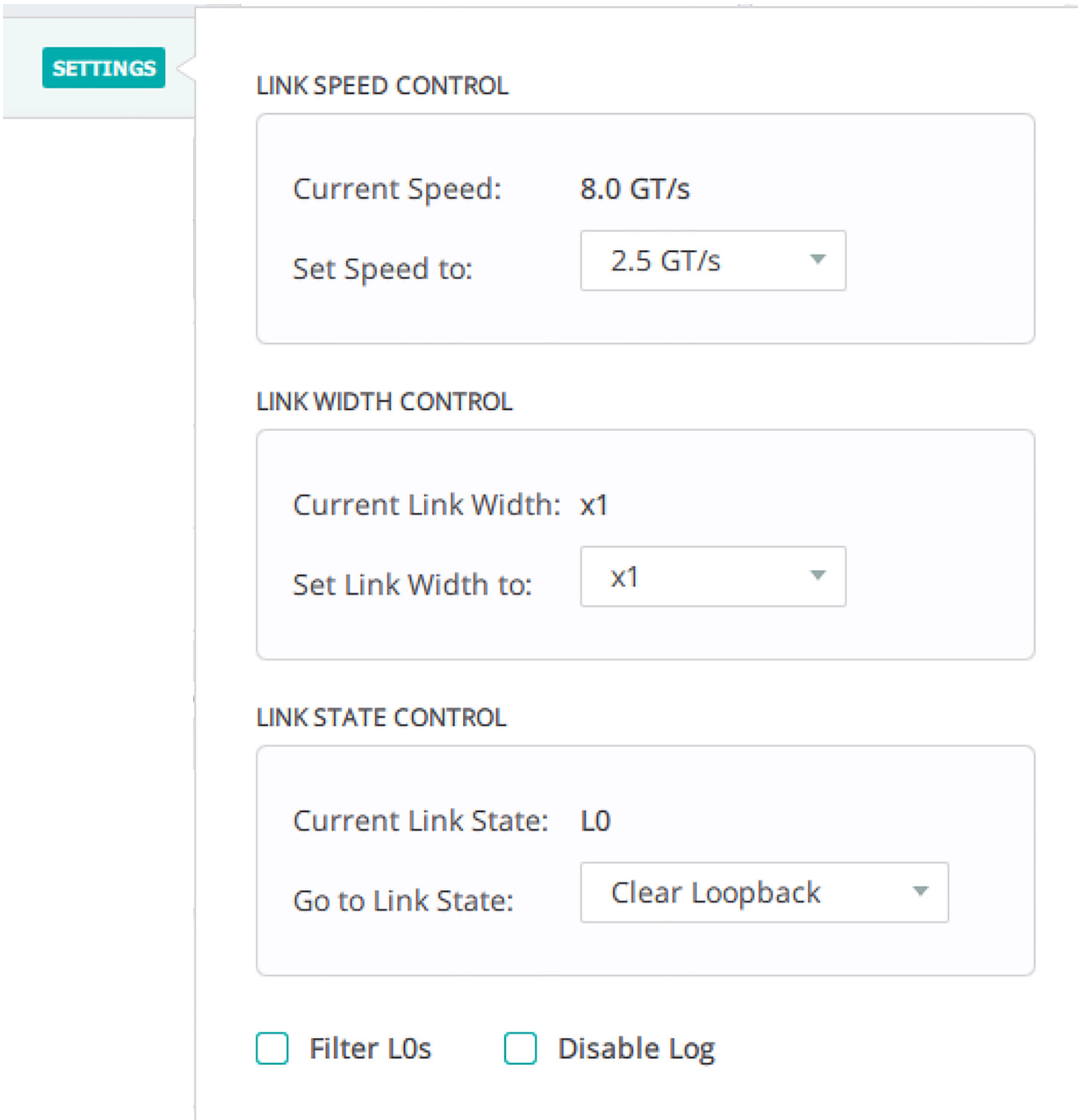


Figure 5.46: LTSSM Arc Tests: Settings -> Link State Control

If you select Link State Control you have a wide variety of initial states to start the test from (see Figure 5.47 on page 231).

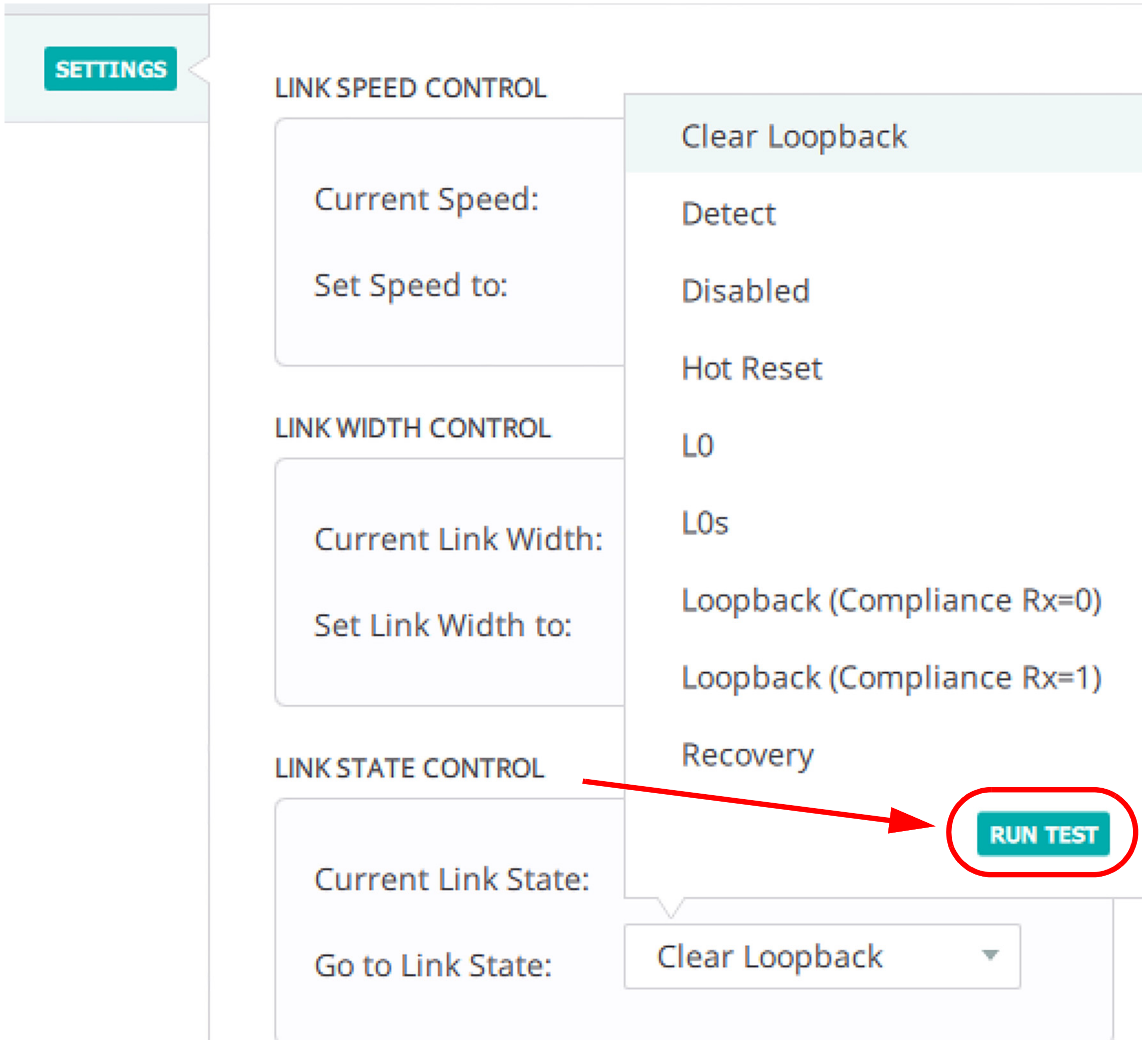


Figure 5.47: LTSSM Arc Tests: Settings -> Link State Control

If you hit the Run Test button the DUT will be programmed to end up in whatever state you choose.

If you select the Information button, you'll get the information about that test. See Figure 5.48 on page 232.

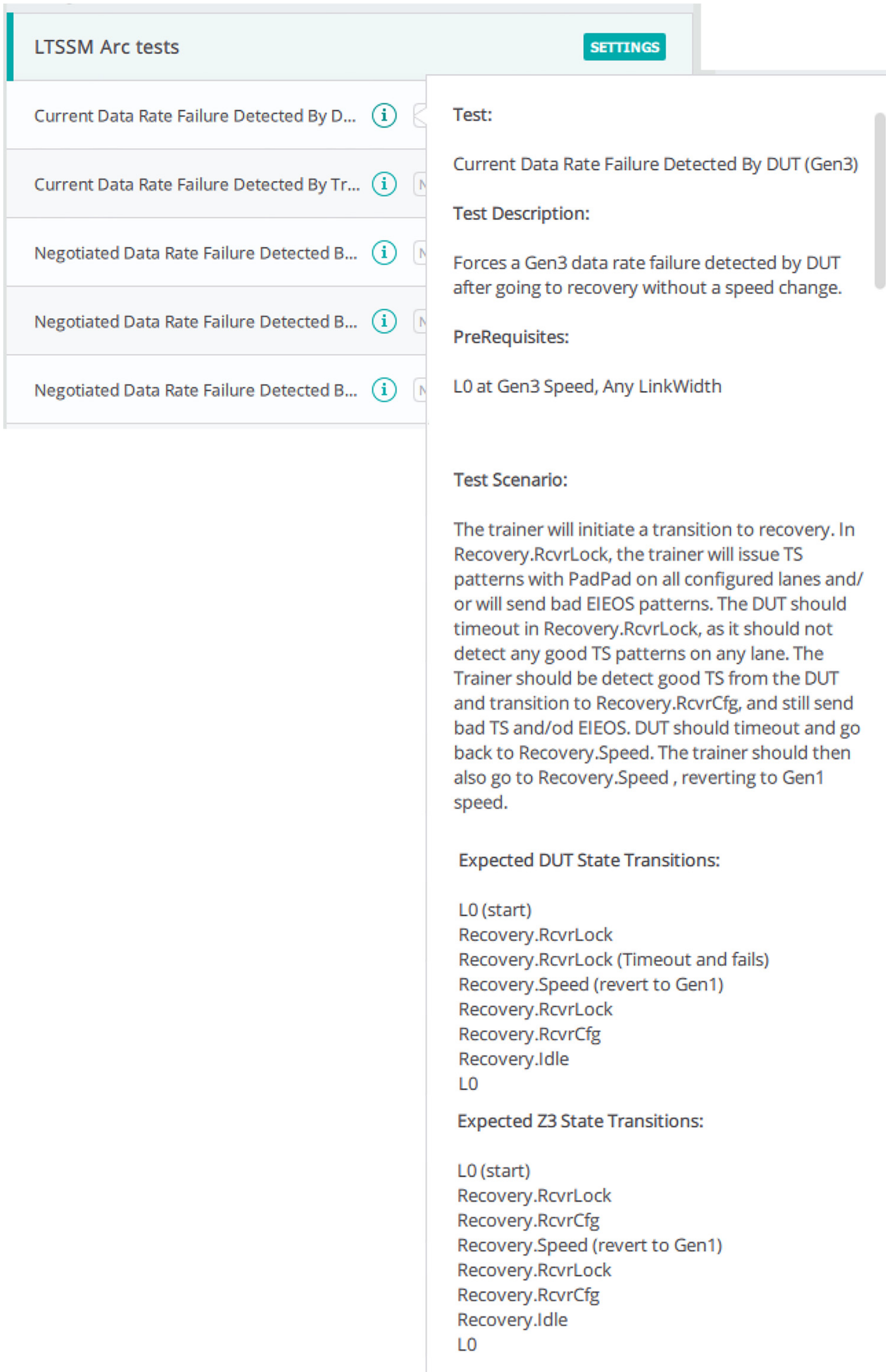


Figure 5.48: LTSSM Test Arc: Information

5.6.2 LTSSM Arc Tests Loaded

The LTSSM Arc Test which are applicable to your Analyzer and Exerciser are Selected and Applied.

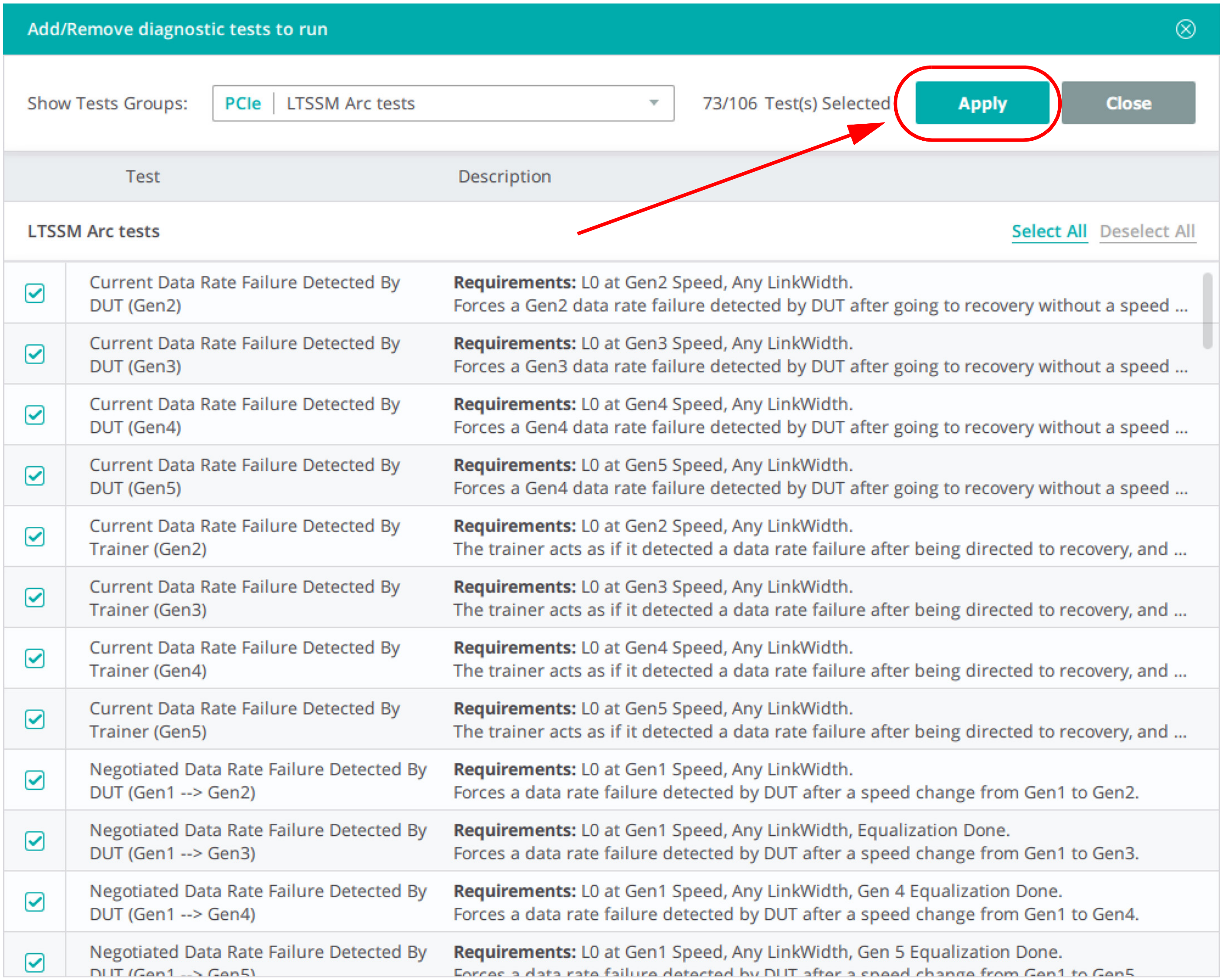


Figure 5.49: LTSSM Arc Tests: Selected

LTSSM Arc Tests applied. See Figure 5.50 on page 234.

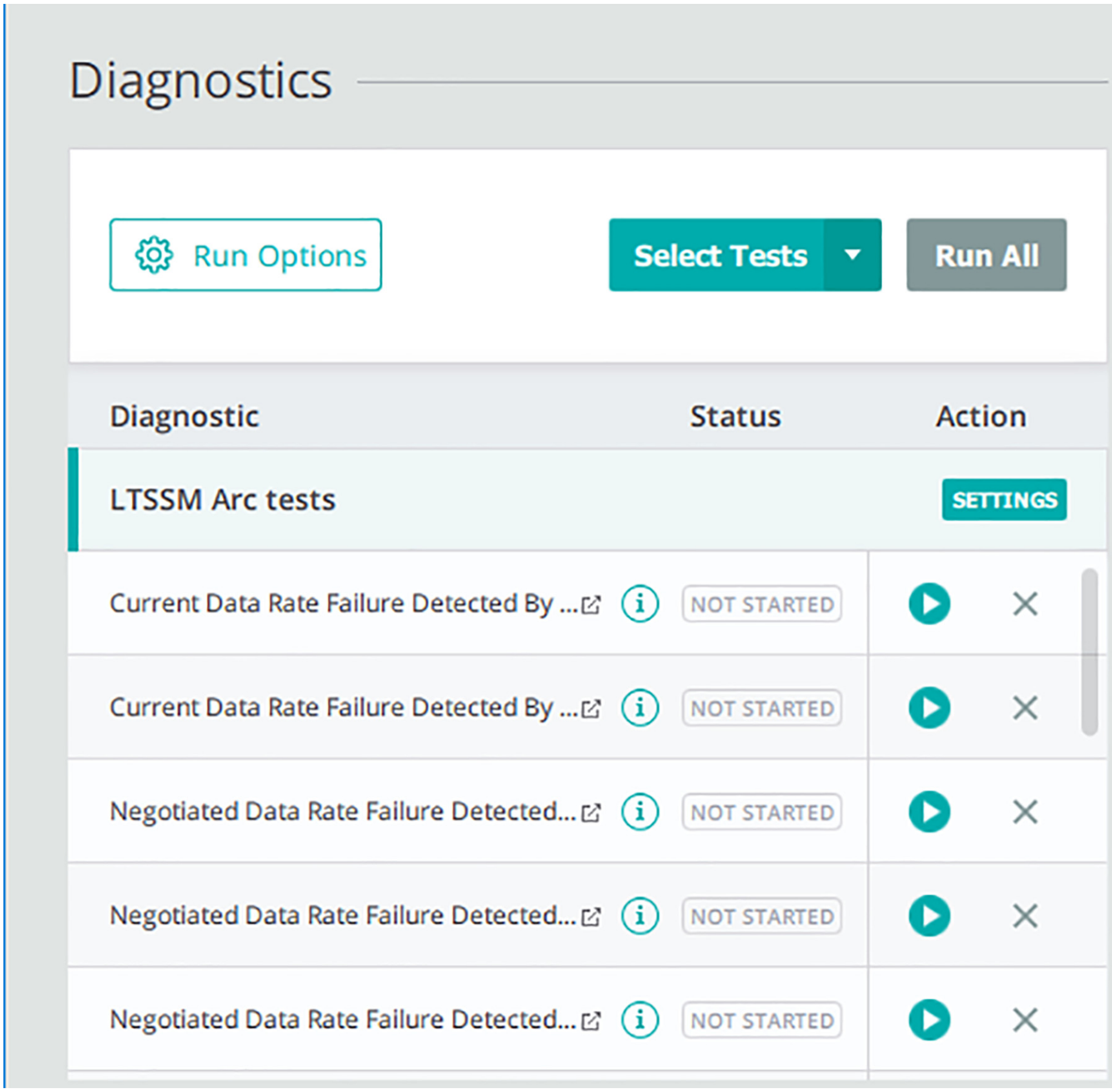


Figure 5.50: LTSSM Arc Tests: Applied

Now select the **Run All** button and wait for the Results.

5.6.3 Results of LTSSM Arc Tests

Analysis Results -> LTSSM Arc Tests (see Figure 5.51

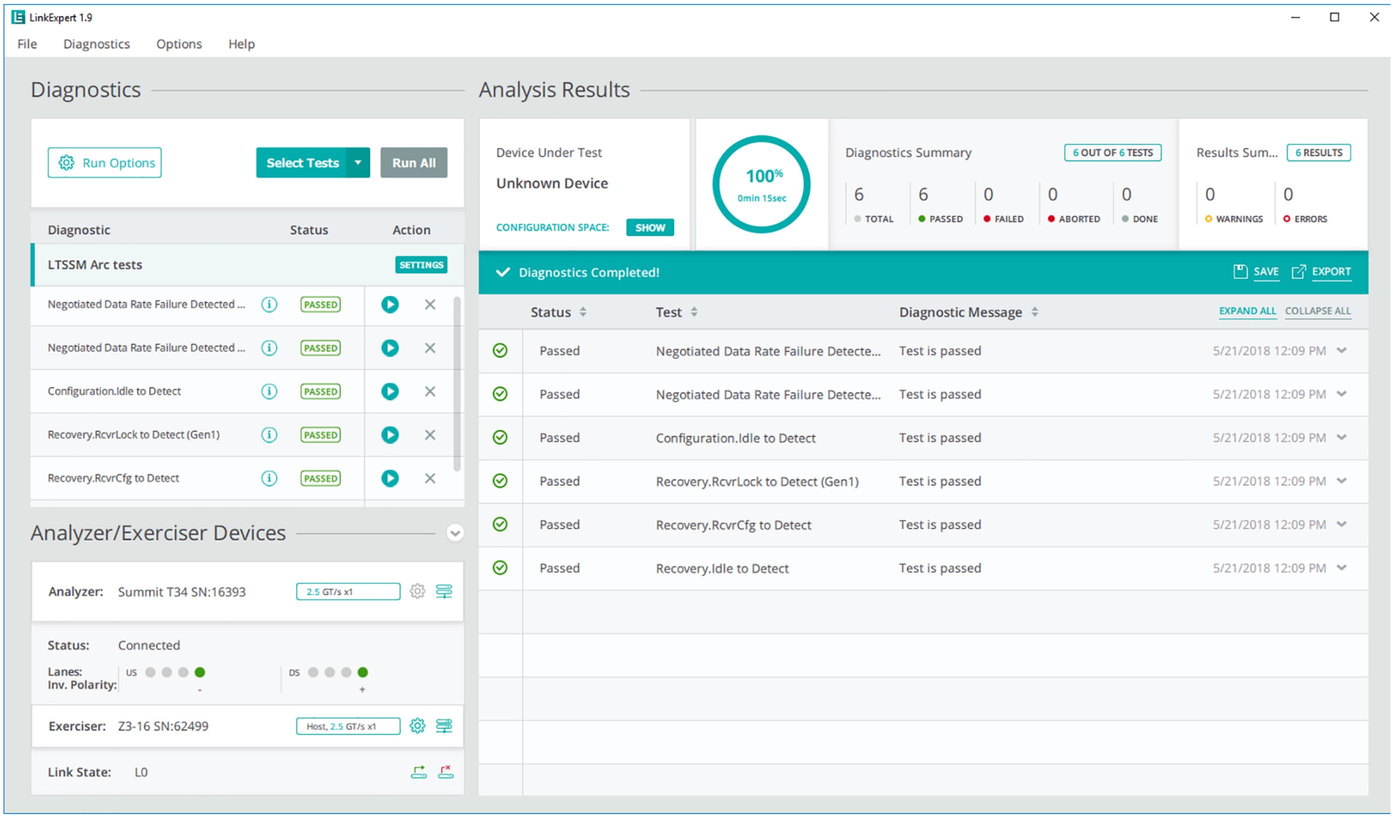
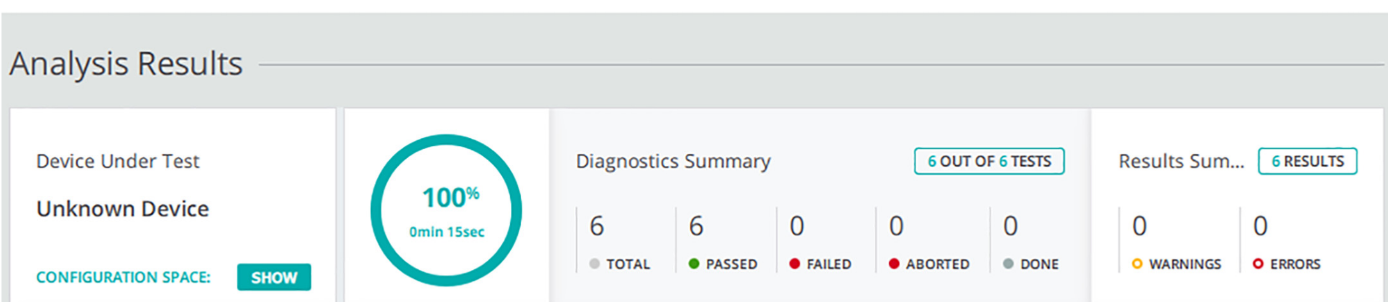


Figure 5.51: LTSSM Arc Test: Results

5.6.4 LTSSM Arc Tests: Summary

See Figure 5.51.



- The DUT for these tests was Unknown
- The progress meter show that 100% of the selected tests were completed in 15 seconds
- All six out of six tests passed
- 0 tests were ABORTED, 0 tests were DONE
- 0 Warnings and 0 Errors were reported

The details of a specific tests are shown in Figure 5.52.

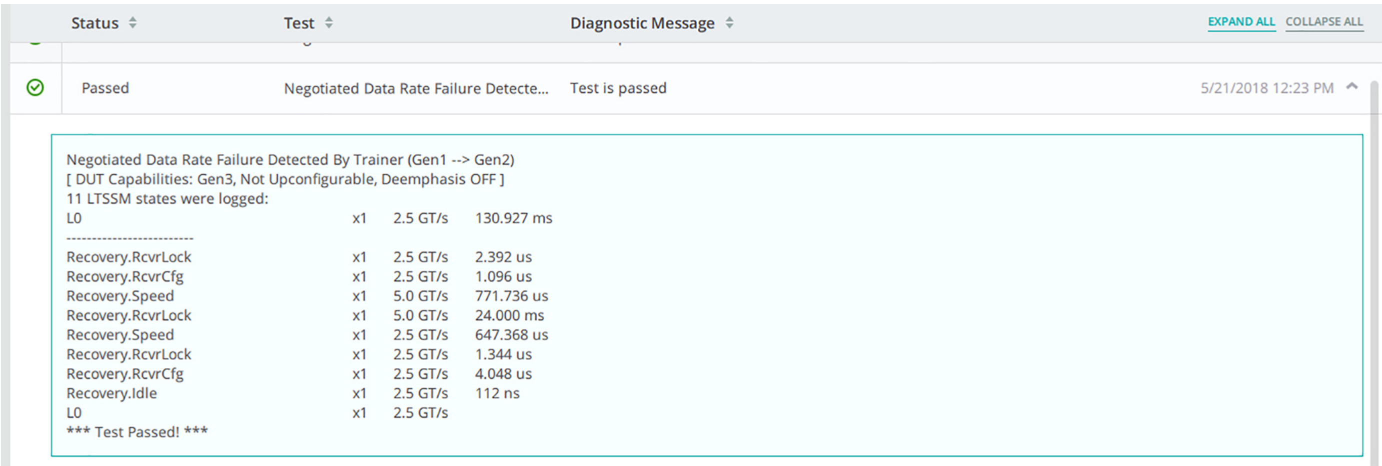


Figure 5.52: LTSSM Arc Test: Negotiated Data Rate Failure Detected

5.7 Analysis Results: PCIe 4.0 Compliance Package Tests

5.7.1 Loading the PCIe 4.0 Compliance Package Tests

If you select the PCIe 4.0 Compliance Package Tests, the system will run up to 226 tests depending on which ones you select. When you select the PCIe tests a Warning message will pop up reminding you that if you select this set of tests the results from the previous set (LinkExpert System Level Tests) will be lost. This gives you the opportunity to Save the previous results if you have not already done so. See Figure 5.53.

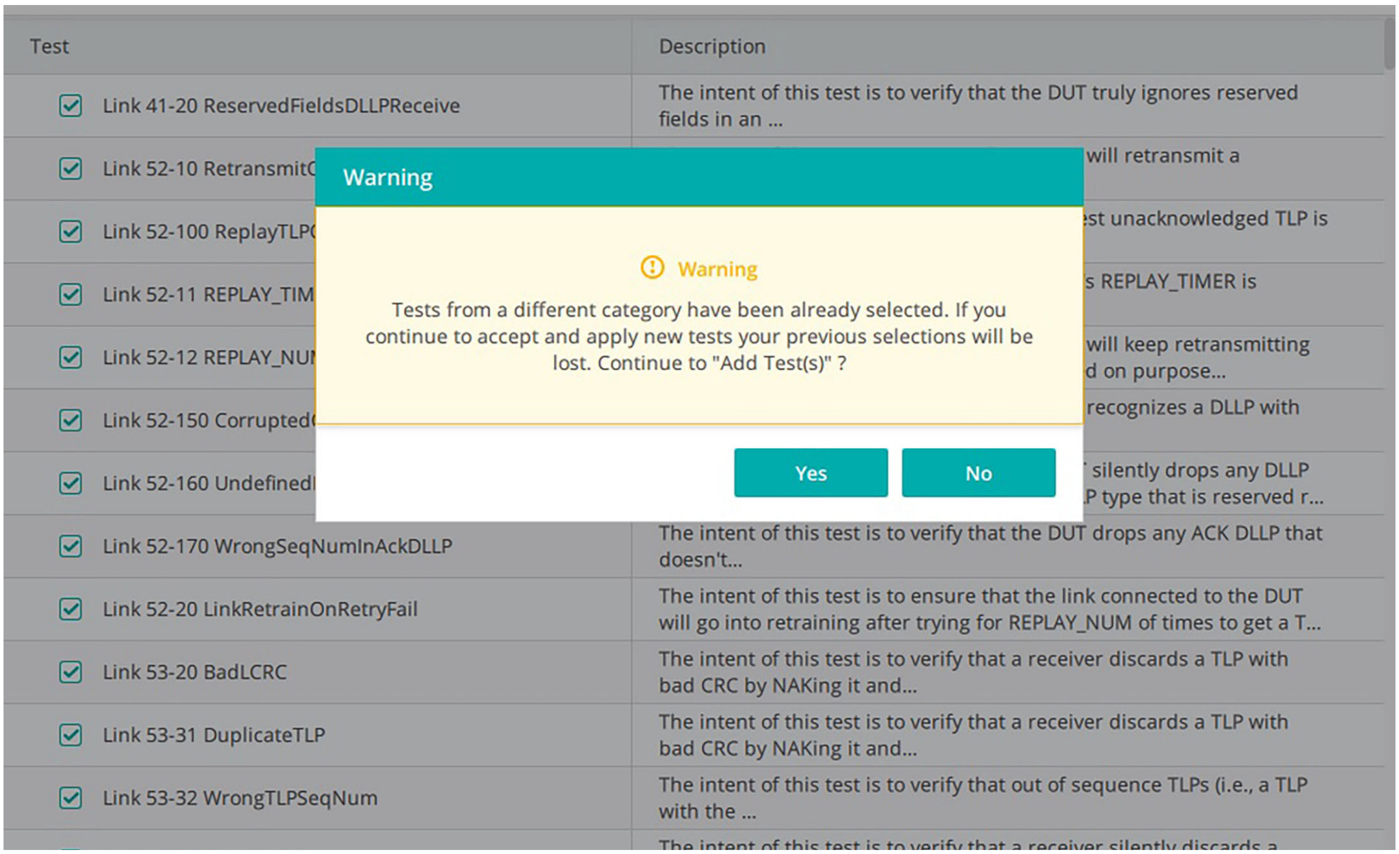


Figure 5.53: PCIe 4.0 Compliance Package Tests

If you select “Yes” the PCIe 4.0 Compliance Package Tests will be loaded and ready to run. See Figure 5.54 on page 238.

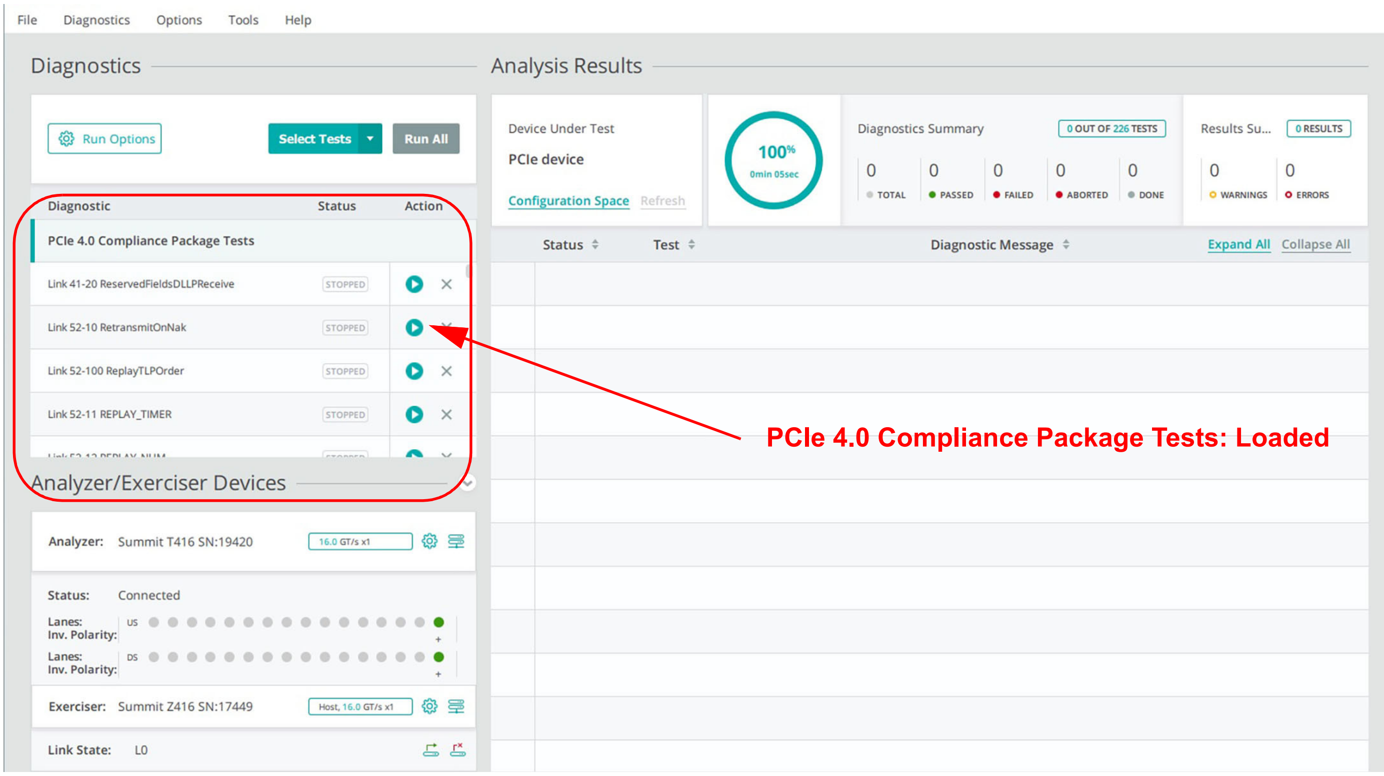


Figure 5.54: PCIe 4.0 Compliance Package Tests: Loaded

5.7.2 Results: PCIe 4.0 Compliance Package Tests

The results from running 8 of the total 226 PCIe 4.0 Compliance Package Tests are shown in Figure 5.55 on page 239.

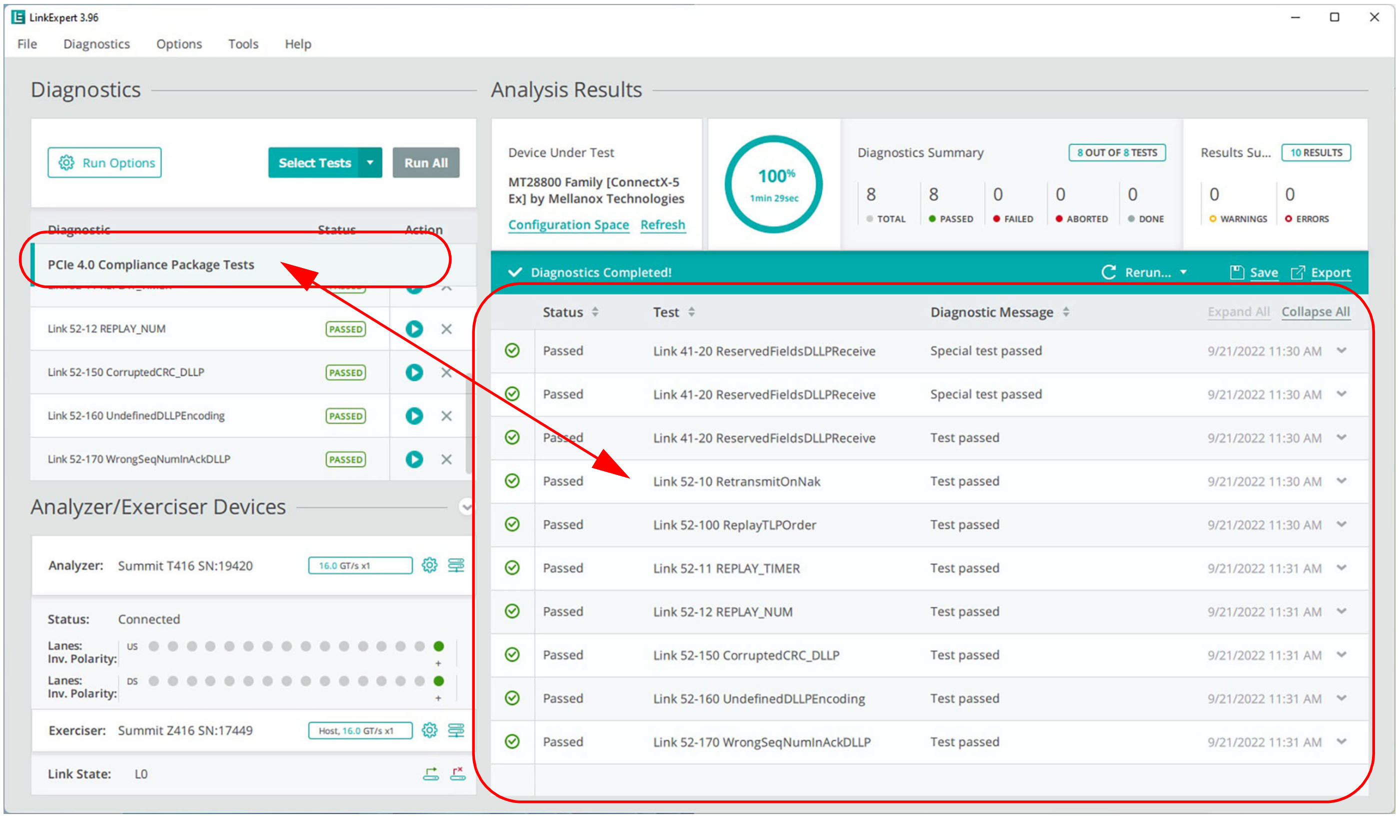


Figure 5.55: Results: PCIe 4.0 Compliance Package Tests

5.7.3 Summary of PCIe 4.0 Compliance Package Tests

Analysis Results Summary of PCIe4.0 Compliance Tests, see Figure 5.56.

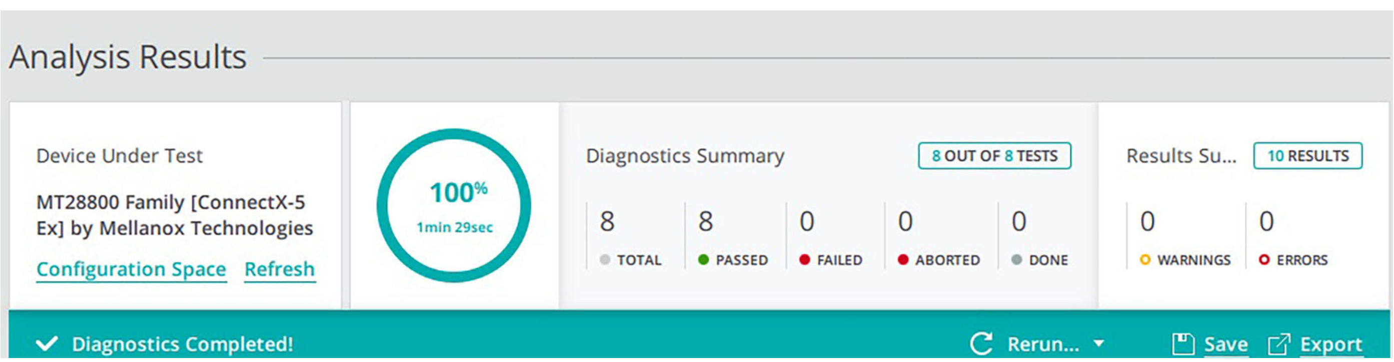


Figure 5.56: Analysis Results: Summary

- The DUT was an MT28800 Family by Mellanox
- The progress meter shows the test 100% complete taking 1 minute and 28 seconds
- 8 out of 8 tests Passed, 0 out of 8 tests had Errors
- 9 Parameters were Checked during the test
- 0 test ABORTED, 0 tests DONE
- 0 Warnings and 0 Errors were issued during the tests

5.8 Analysis Results: PCIe 5.0 Compliance Tests

If you select the PCIe 5.0 Compliance Package Tests, the system will run up to 93 tests, depending on which ones you select. When you select the PCIe tests, a Warning message displays, reminding you that if you select this set of tests the results from the previous set (for example, LinkExpert System Level Tests) will be lost. This gives you the opportunity to Save the previous results if you have not already done so. See Figure 5.57.

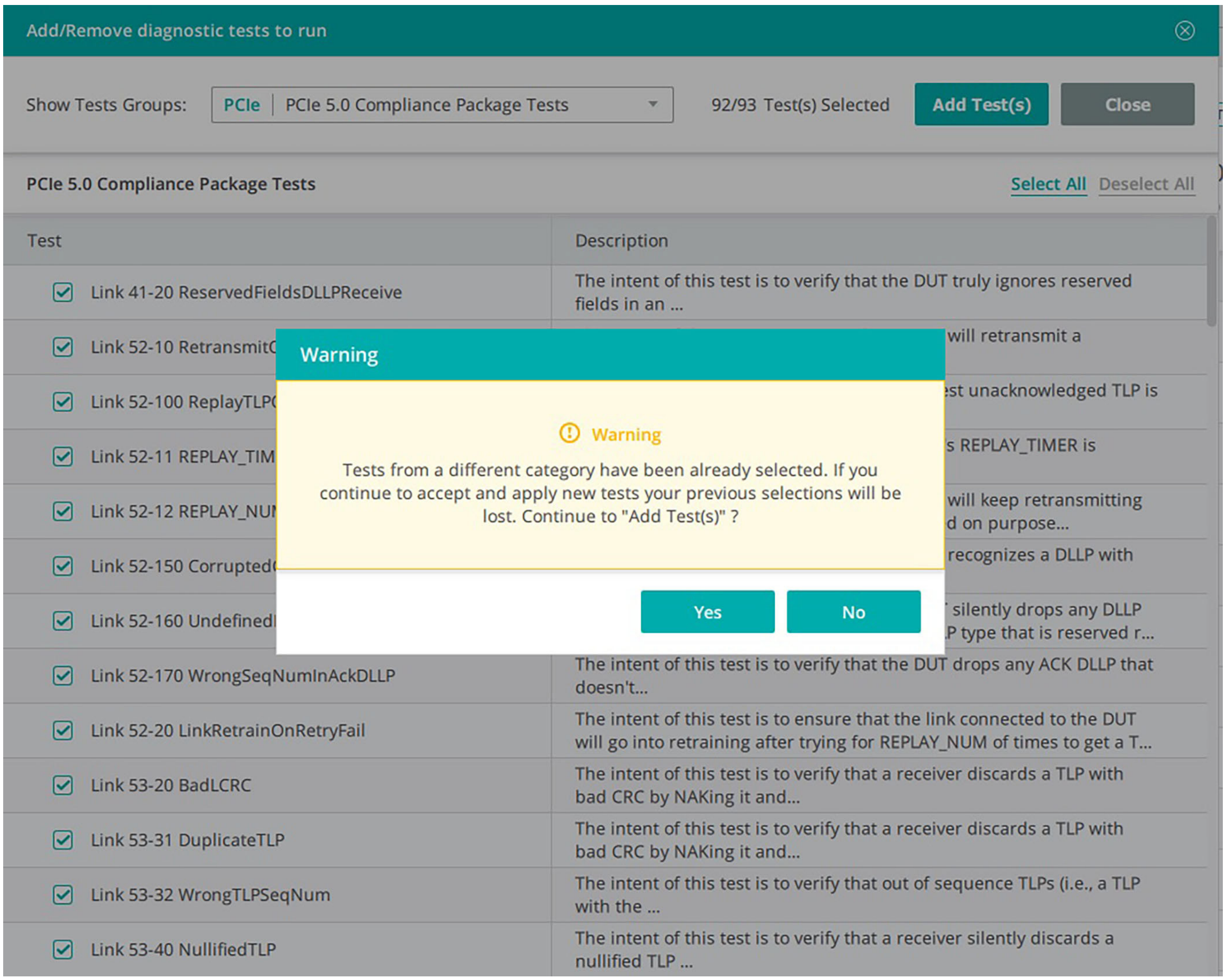


Figure 5.57: PCIe 5.0 Compliance Package Tests

If you select Yes, the PCIe 5.0 Compliance Package Tests loads, ready to run. See Figure 5.58 on page 241.

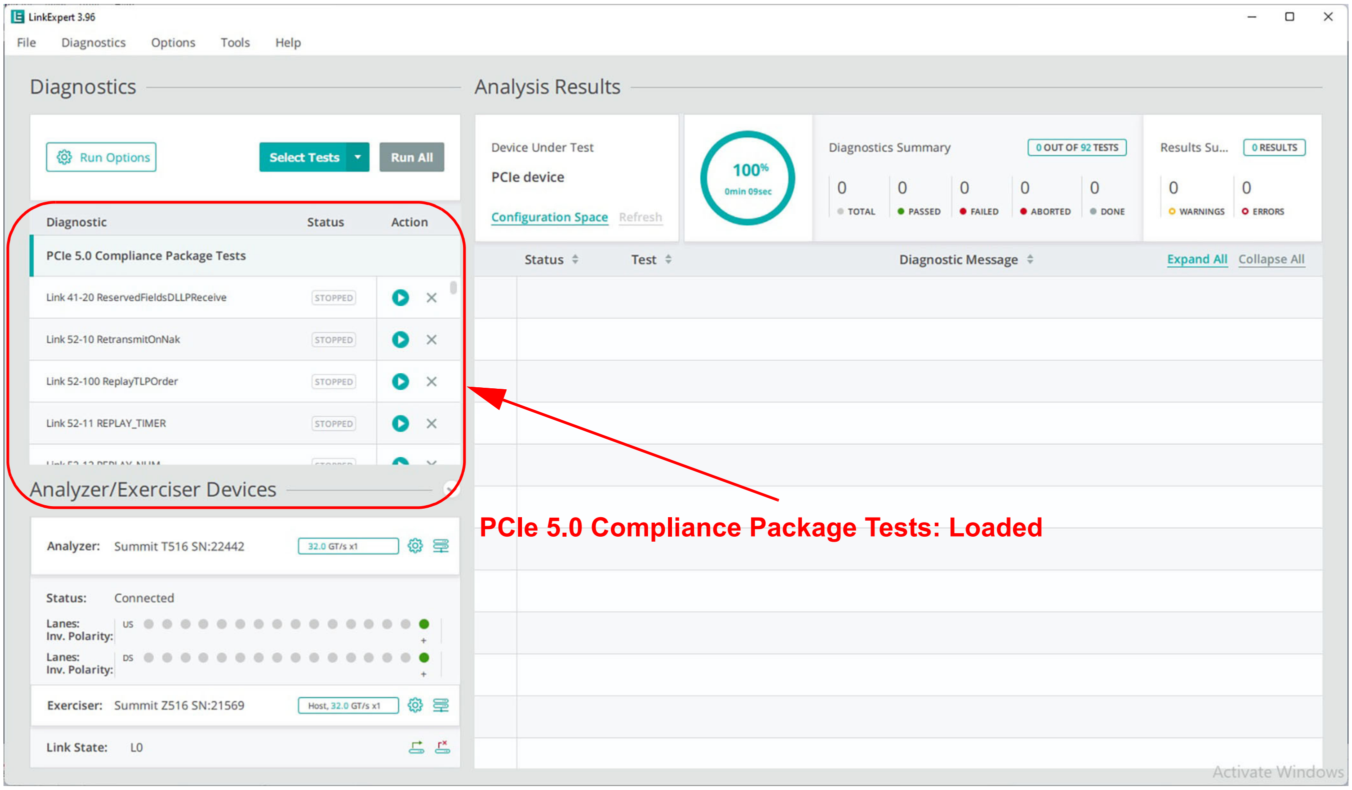


Figure 5.58: PCIe 5.0 Compliance Package Tests: Loaded

5.8.1 Results: PCIe 5.0 Compliance Package Tests

The results from running several of the total 92 PCIe 5.0 Compliance Package Tests are shown in Figure 5.59 on page 242.

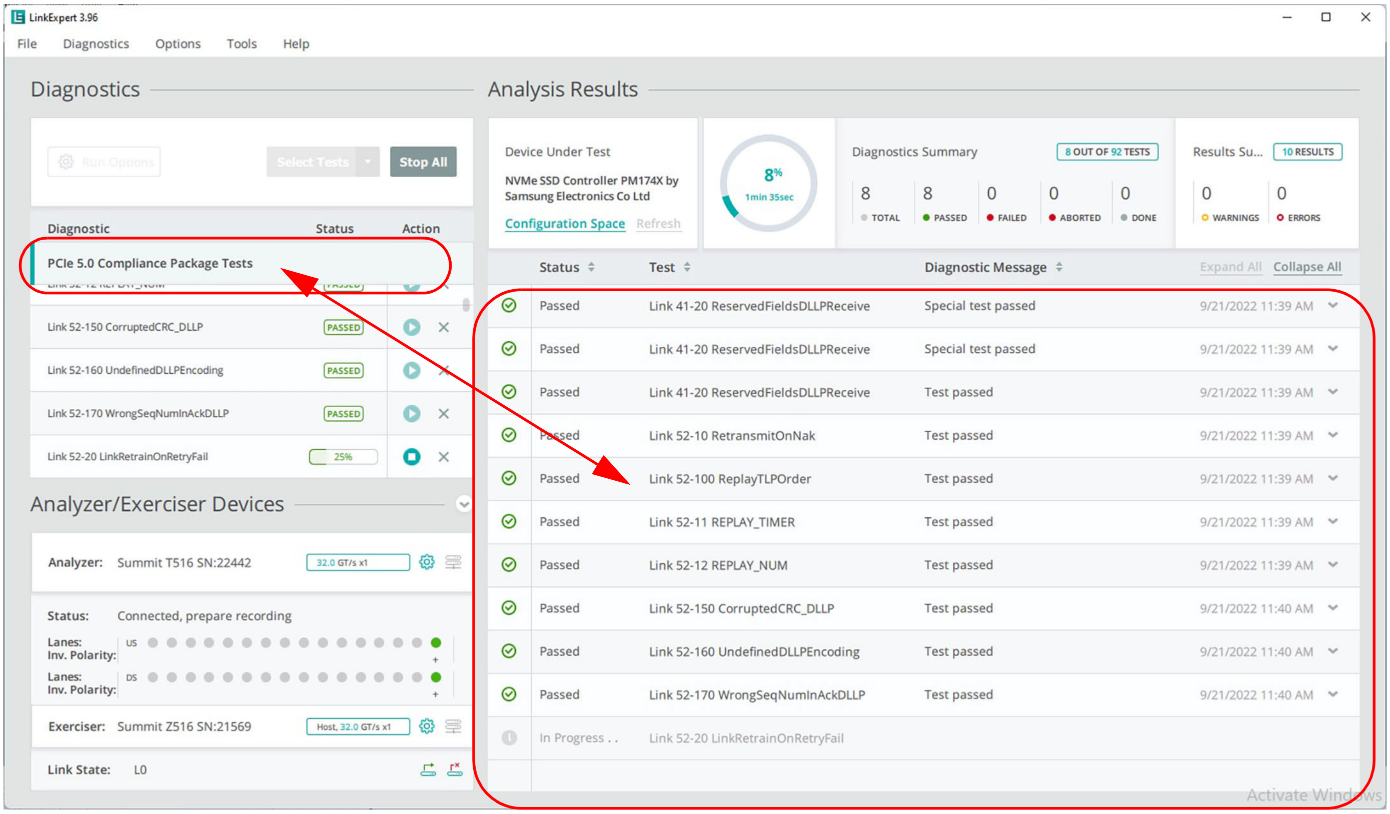


Figure 5.59: Results: PCIe 5.0 Compliance Package Tests

5.8.2 Summary of PCIe 5.0 Compliance Package Tests

Analysis Results Summary of PCIe 5.0 Compliance Tests, see Figure 5.60.

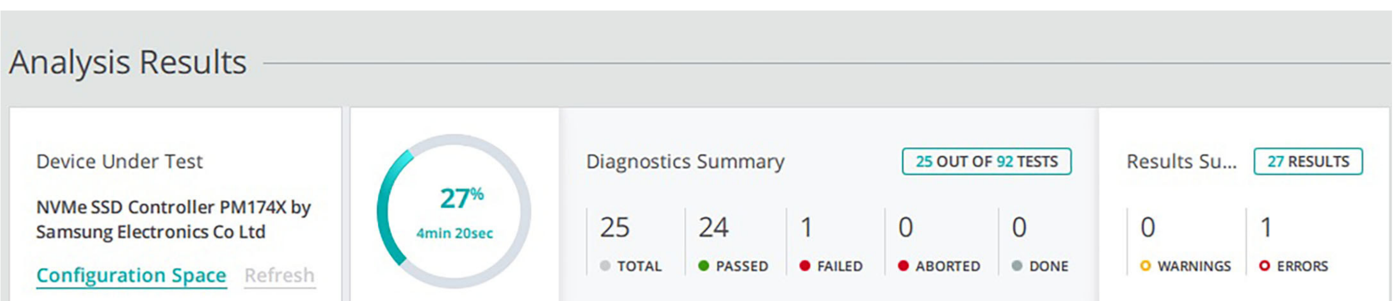


Figure 5.60: Analysis Results: Summary

- The DUT was an Samsung device
- The progress meter shows the test is 27% complete, taking 4 minutes and 20 seconds
- 25 out of 92 tests Passed, 1 out of 10 tests had Errors
- 24 tests PASSED, 1 test FAILED
- 0 test ABORTED, 0 tests DONE
- 0 Warnings and 1 Errors were issued during the tests

5.9 Analysis Results: PCIe RAS Error Injection Tests

5.9.1 PCIe RAS Error Injection Tests Loaded

The PCIe RAS Error Injection Tests have been loaded. See Figure 5.61.

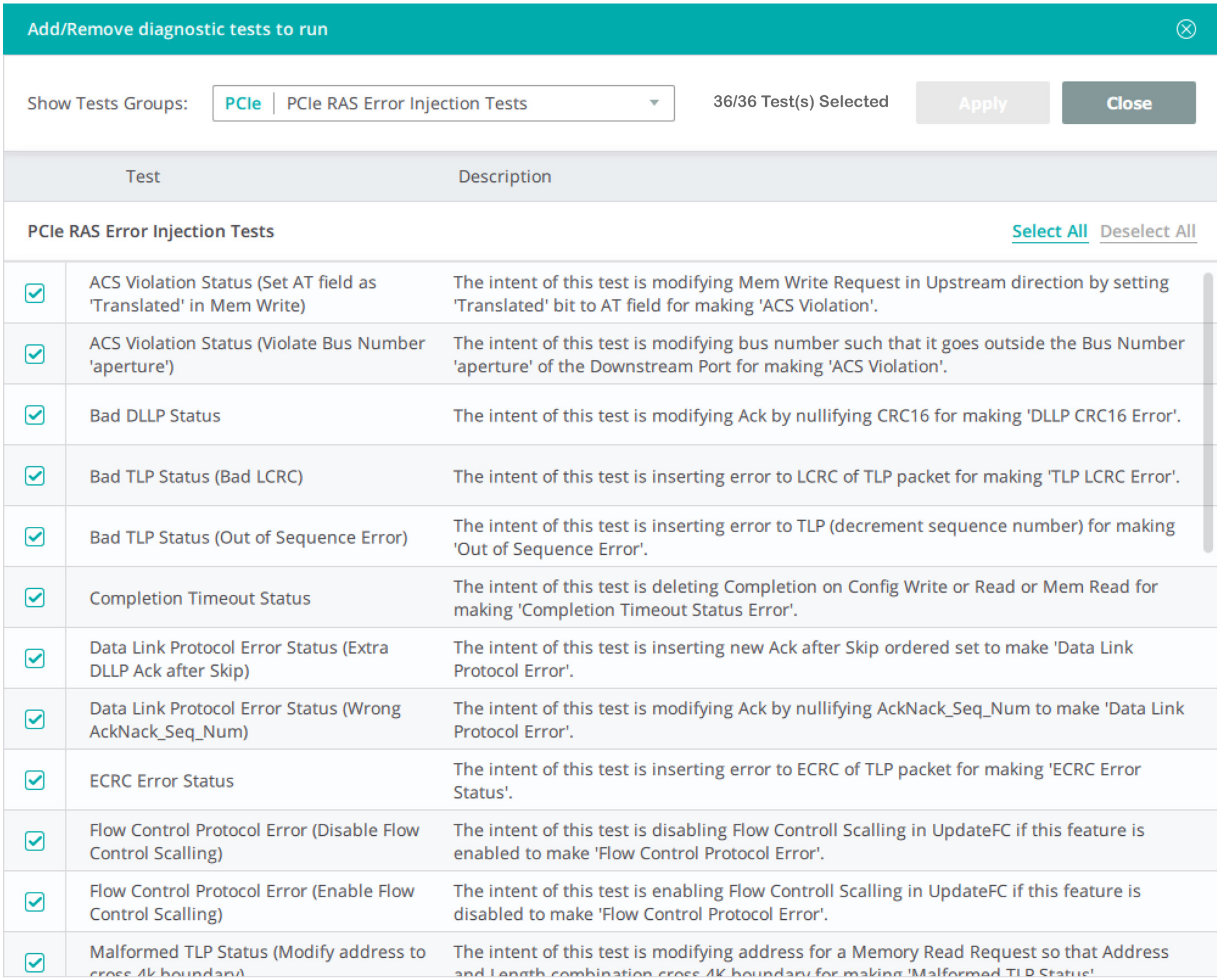


Figure 5.61: Analysis Results: PCIe RAS Error Injection Tests -> Loaded

5.9.2 PCIe RAS Error Injection Tests Results

The Results of the PCIe RAS Error Injection Tests are shown in Figure 5.62.

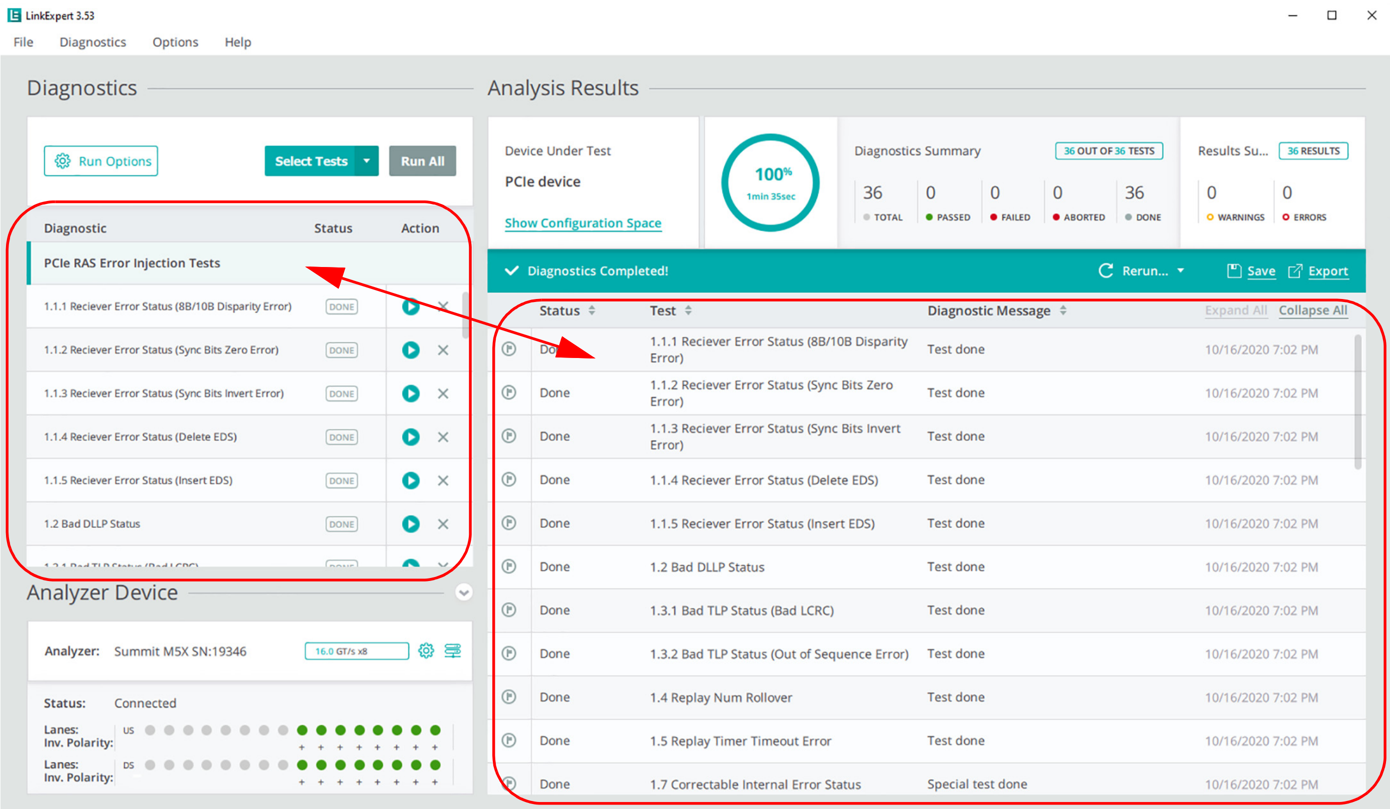


Figure 5.62: PCIe RAS Error Injection Tests Results

5.9.3 Summary of PCIe RAS Error Injection Tests

The summary of PCIe RAS Error Injection Tests are shown in Figure 5.63

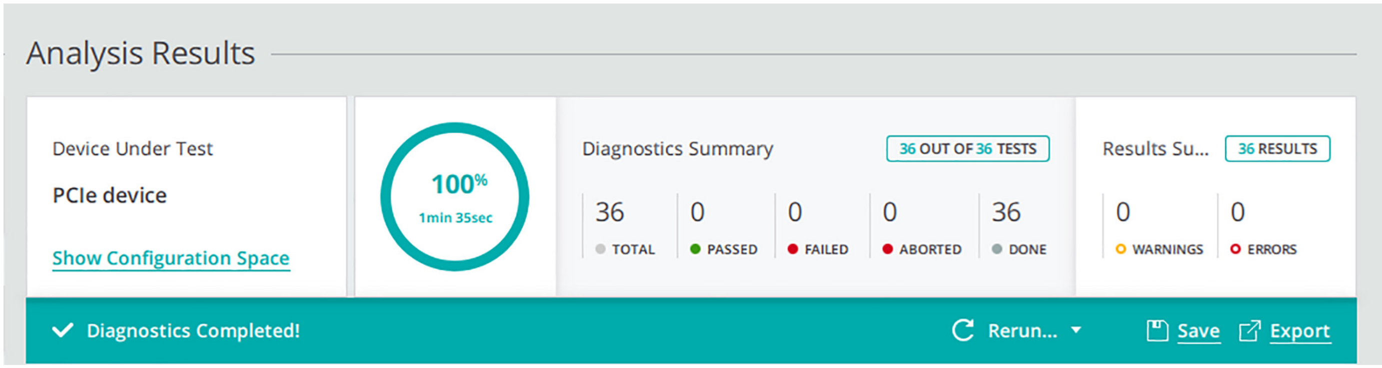


Figure 5.63: PCIe RAS Error Injection Tests: Summary

- The DUT PCIe device
- The progress meter shows the test 100% complete taking 1 minute and 35 seconds
- 0 out of 36 tests Passed, 0 out of 36 tests Failed
- 0 test ABORTED, 36 tests DONE
- Out of the 36 Results, 0 Warnings and 0 Errors were issued during the tests

5.9.4 RAS Testing using Summit M5x and LinkExpert

The Summit M5x can be used for Error Injection testing defined in the PCIe RAS specification

Inject PCI Express error using Jammer

- Ensure Advanced Error Reporting reports properly
- Ensure System logs errors appropriately

5.9.5 PCI Express Error Types

- Correctable
  - Rx Error
  - Bad TLP
  - Bad DLLP
  - Replay Timer Timeout
- Uncorrectable Non-Fatal
  - Poisoned TLP
  - Unsupported Request
  - Completer Abort
  - Unexpected Completion
  - Completion Timeout
  - ACS violation
- Uncorrectable Fatal
  - DLL Error
  - Surprise Link Down
  - Flow Control Protocol
  - Rx Buffer Overflow
  - Malformed TLP

5.9.6 PCIe “RAS” Error Injection Testing – List of Tests

- 1. Correctable Errors
  - 1.1 Receiver Error Status
  - 1.2 Bad DLLP Status
  - 1.3 Bad TLP Status
  - 1.4 Replay NUM Rollover Status
  - 1.5 Replay Timer Timeout Status
  - 1.6 Advisory Non-Fatal Error Status
  - 1.7 Correctable Internal Error Status
  - 1.8 Header Log Overflow Status
- 2. Uncorrectable Errors
  - 2.1 Data Link Protocol Error Status
  - 2.2 Surprise Down Error Status
  - 2.3 Poisoned TLP received Status
  - 2.4 Flow Control Protocol Error Status
  - 2.5 Completion Timeout Status
  - 2.6 Completer Abort Status
  - 2.7 Unexpected Completion Status

- 2.8 Receiver Overflow Status
- 2.9 Malformed TLP Status
- 2.10 ECRC Error Status
- 2.11 Unsupported Request Error Status
- 2.12 ACS Violation Status
- 2.13 Uncorrectable Error Status
- 2.15 AtomicOp Egress Blocked Status
- 2.16 TLP Prefix Blocked
- 2.17 Poisoned TLP Egress Blocked Status

5.9.7 Summit M5x PCIe RAS Error Injection Testing Setup

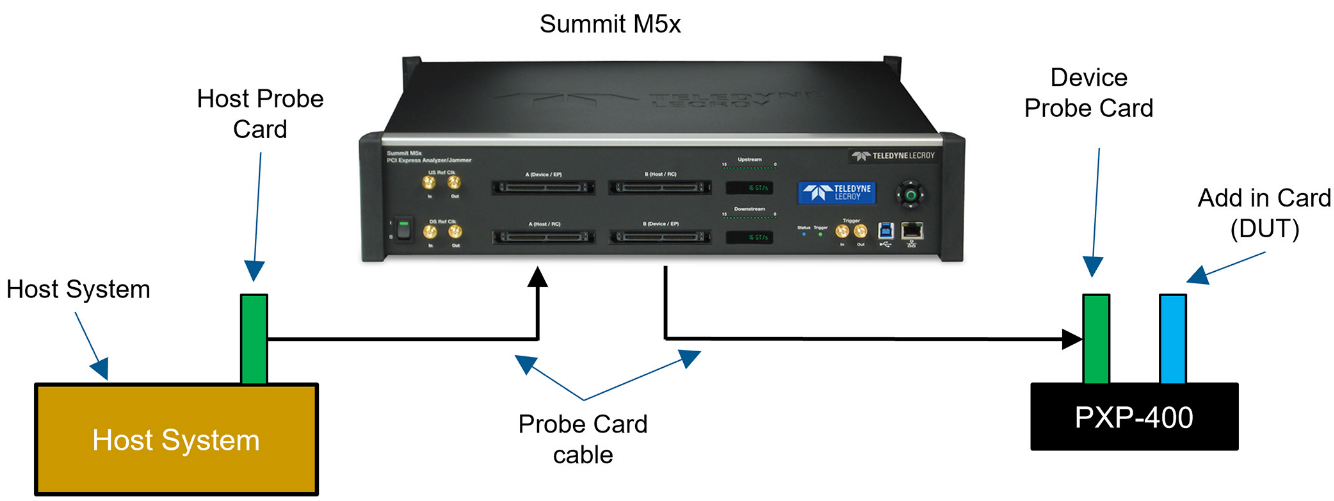


Figure 5.64: Test Setup: Summit M5x Jammer with Host and DUT

5.9.8 Test Flow

1. Open LinkExpert
2. Select PCIe RAS Error Injection Tests from the “Select Tests” menu
3. Choose single or multiple tests
4. Test will present messages prompting the user what to do
5. Test will request that the user runs traffic on system under test
6. When required traffic is sent, the test will progress and confirm that the error was injected
7. The user will be prompted to check the system log to determine if error was handled properly

5.9.9 PCIe “RAS” Error Injection testing - LinkExpert

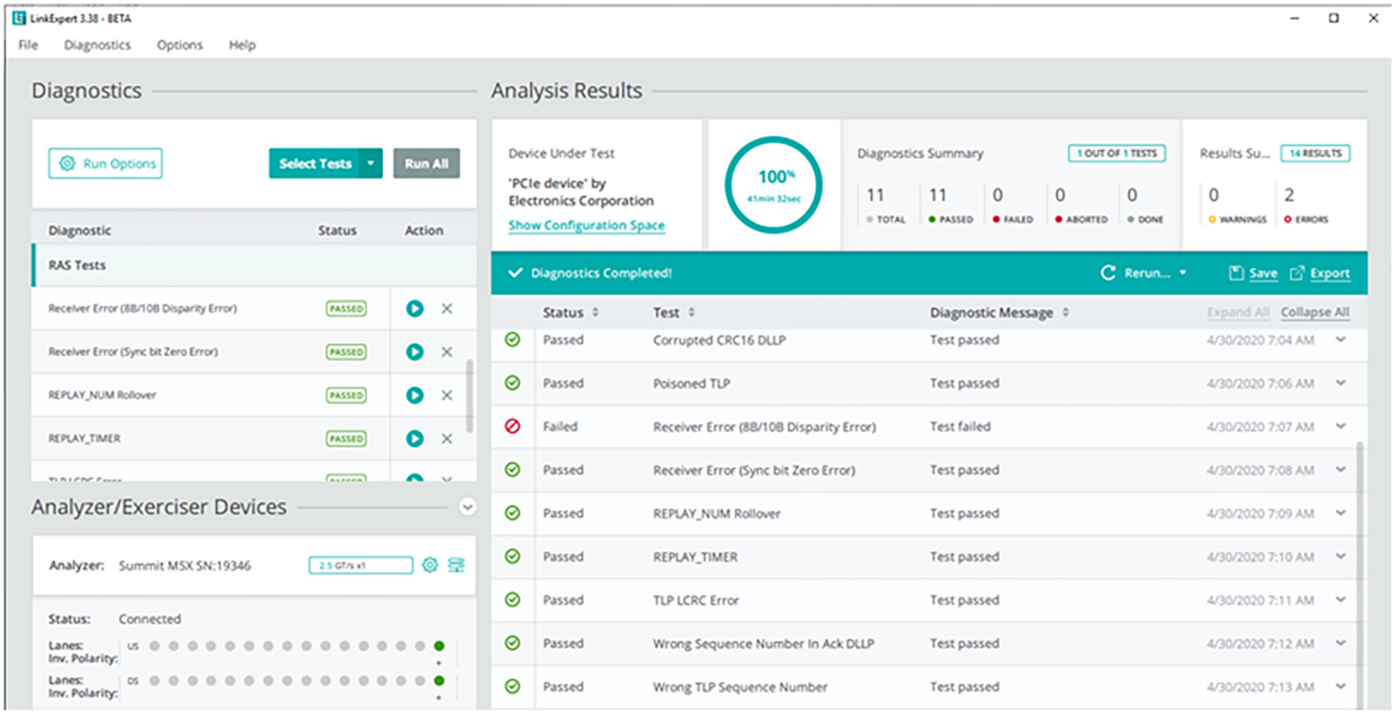


Figure 5.65: Typical RAS Tests Results from LinkExpert 1

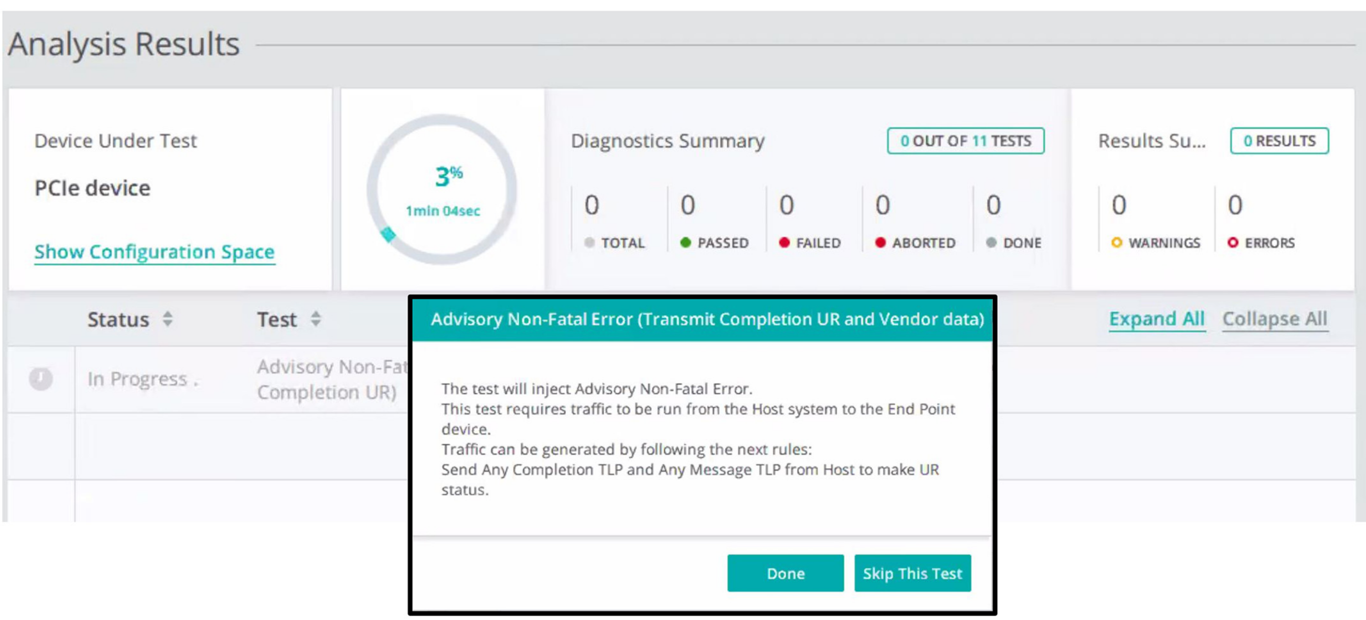


Figure 5.66: Typical RAS Tests Results from LinkExpert 2

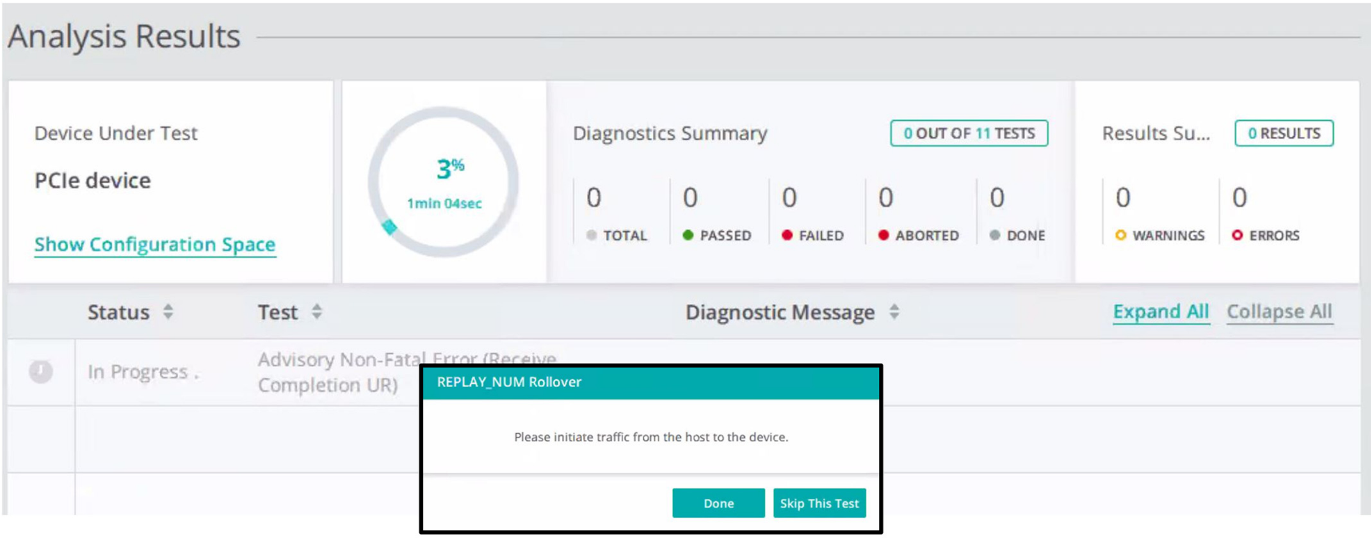


Figure 5.67: Typical RAS Tests Results from LinkExpert 3

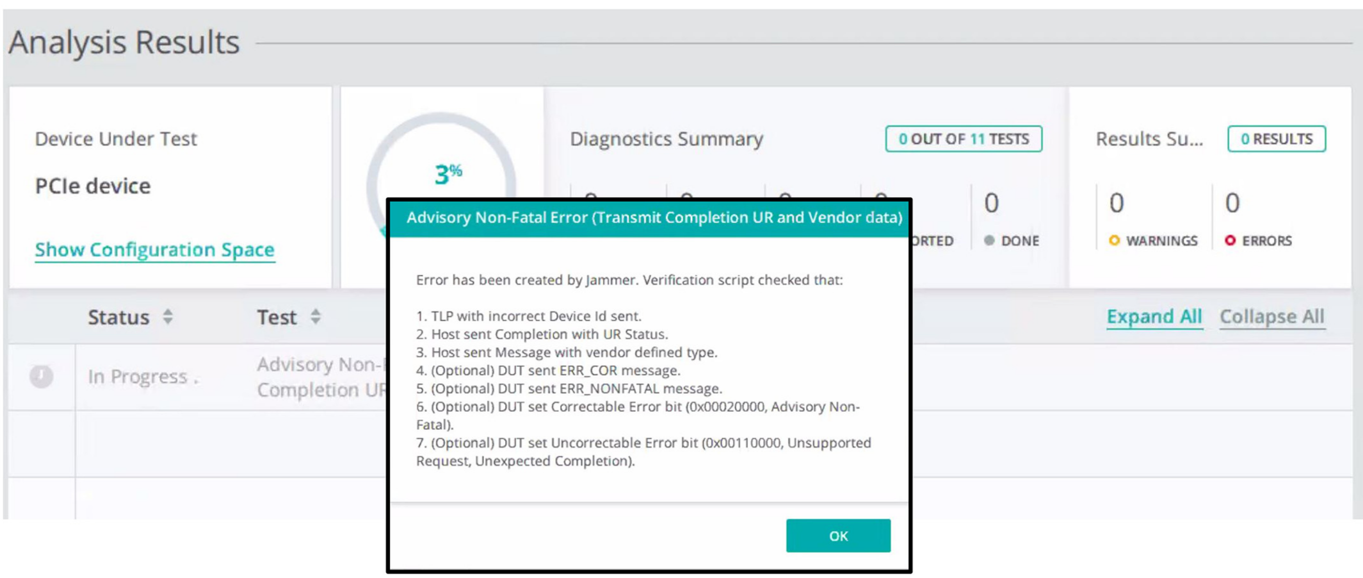


Figure 5.68: Typical RAS Tests Results from LinkExpert 4

5.10 Analysis Results: NVMe-MI/MCTP SMBus Tests

5.10.1 SMBus Tests 1.1 Loaded

The NVMe-MI/MCTP SMBus Tests 1.1 have been loaded. See Figure 5.69.

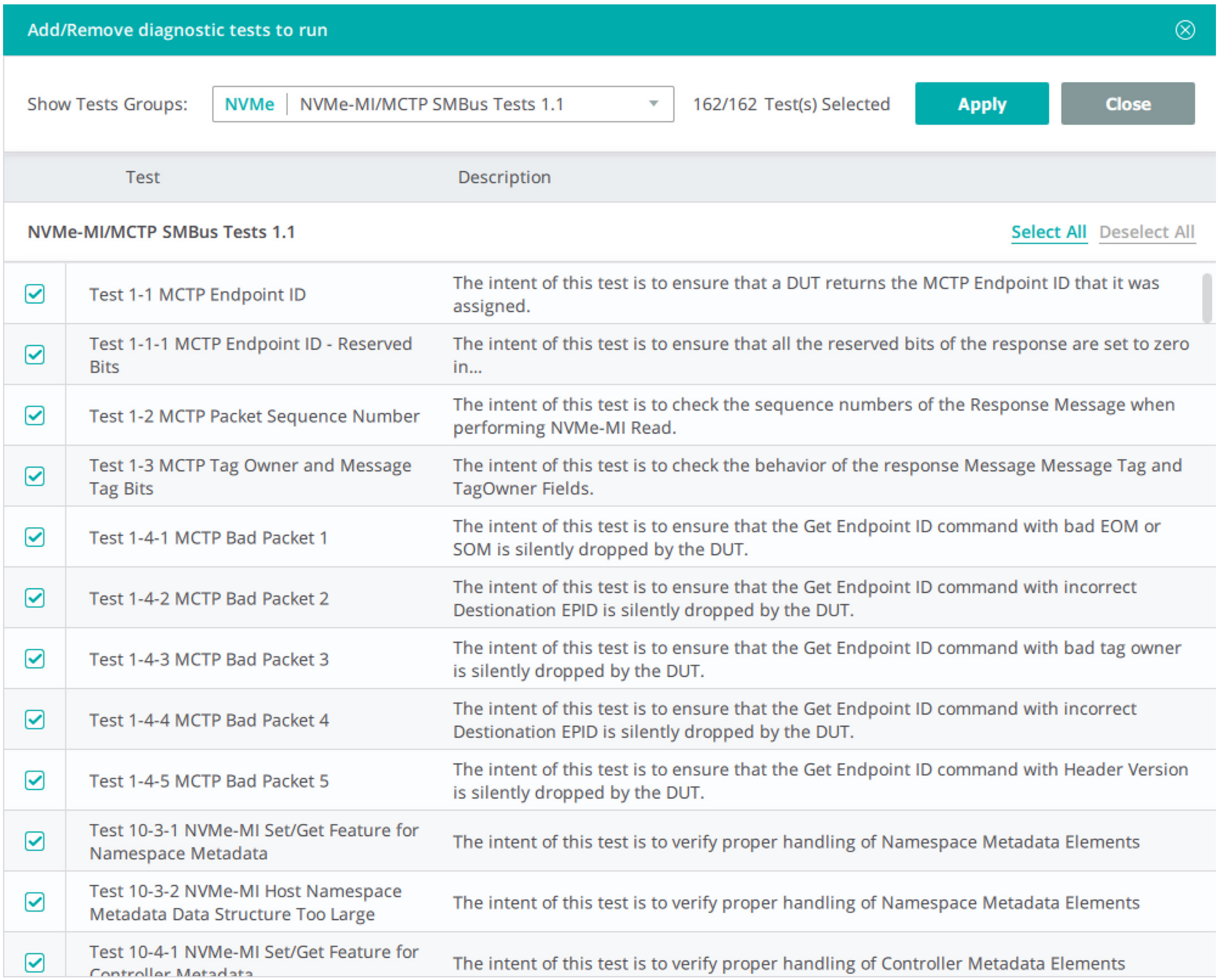


Figure 5.69: Analysis Results: NVMe-MI/MCTP SMBus Tests 1.1 -> Loaded

5.10.2 SMBus Test 1.1 Results

The Results of the SMBus Tests 1.1 are shown in Figure 5.37.

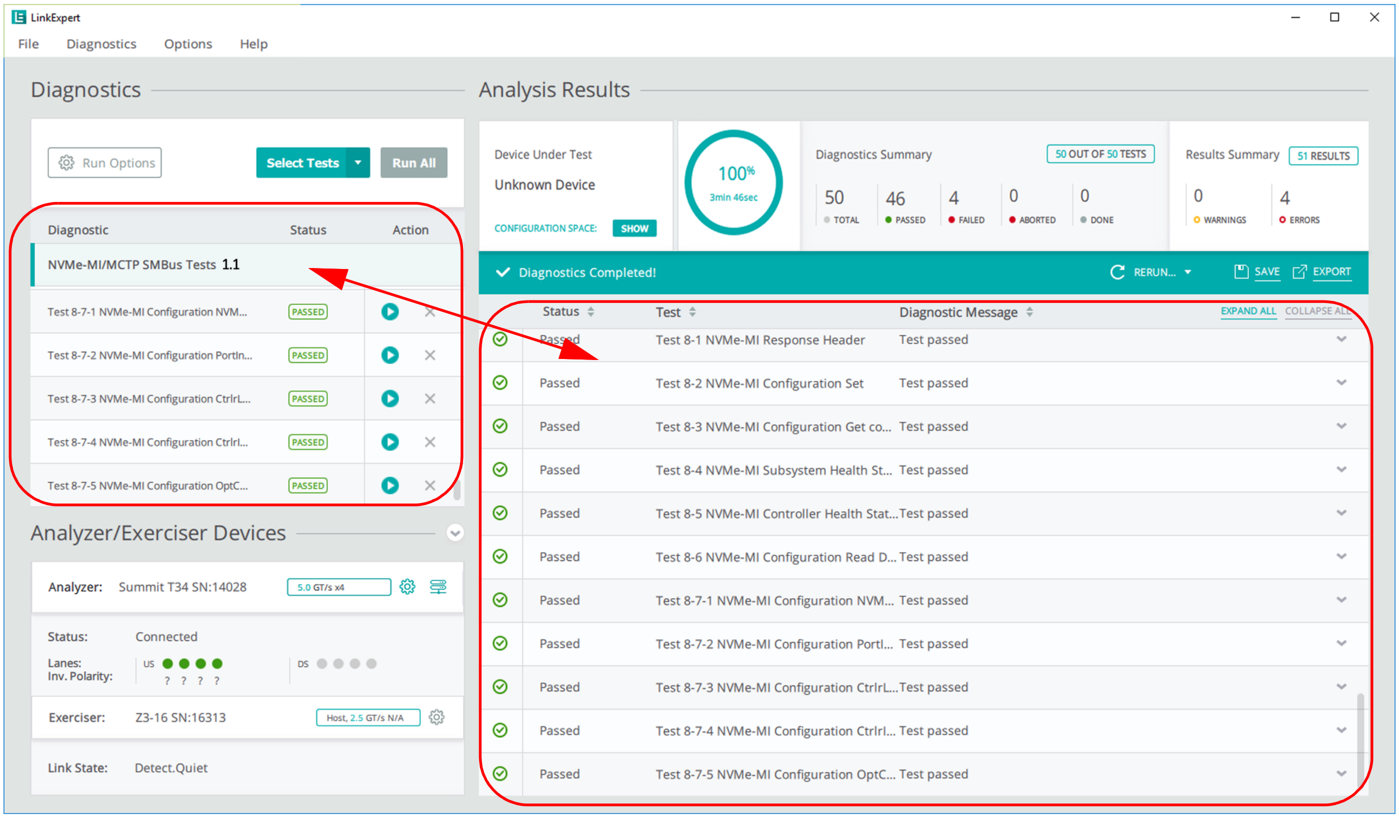


Figure 5.70: SMBus Tests Results

5.10.3 Summary of SMBus Tests 1.1

The summary of SMBus Tests 1.1 is shown in Figure 5.71

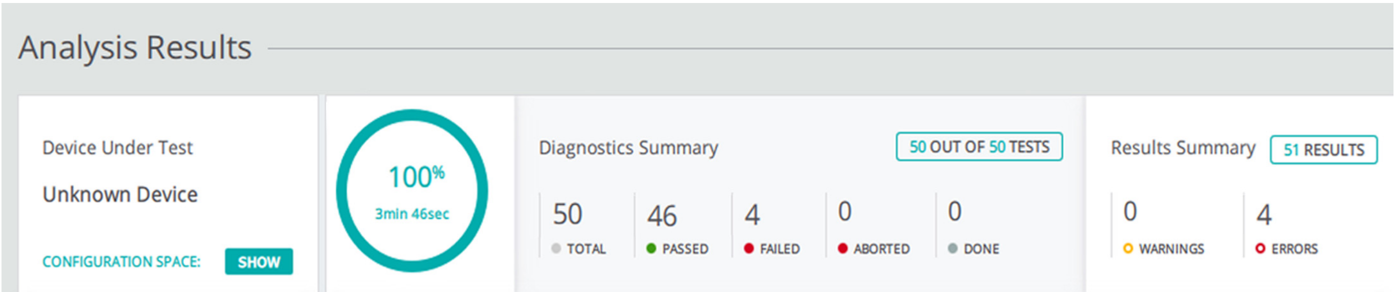


Figure 5.71: SMBus Tests: Summary

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 3 minutes and 46 seconds
- 46 out of 50 tests Passed, 4 out of 50 tests had Errors, 51 Parameters were Checked during the test
- 0 tests were ABORTED, 0 tests were DONE
- 0 Warnings and 4 Errors were issued during the tests

5.11 Analysis Results: NVMe-MI/MCTP VDM Tests 1.1

5.11.1 VDM Tests Loaded

The NVMe-MI/MCTP VDM Tests have been loaded. See Figure 5.72.

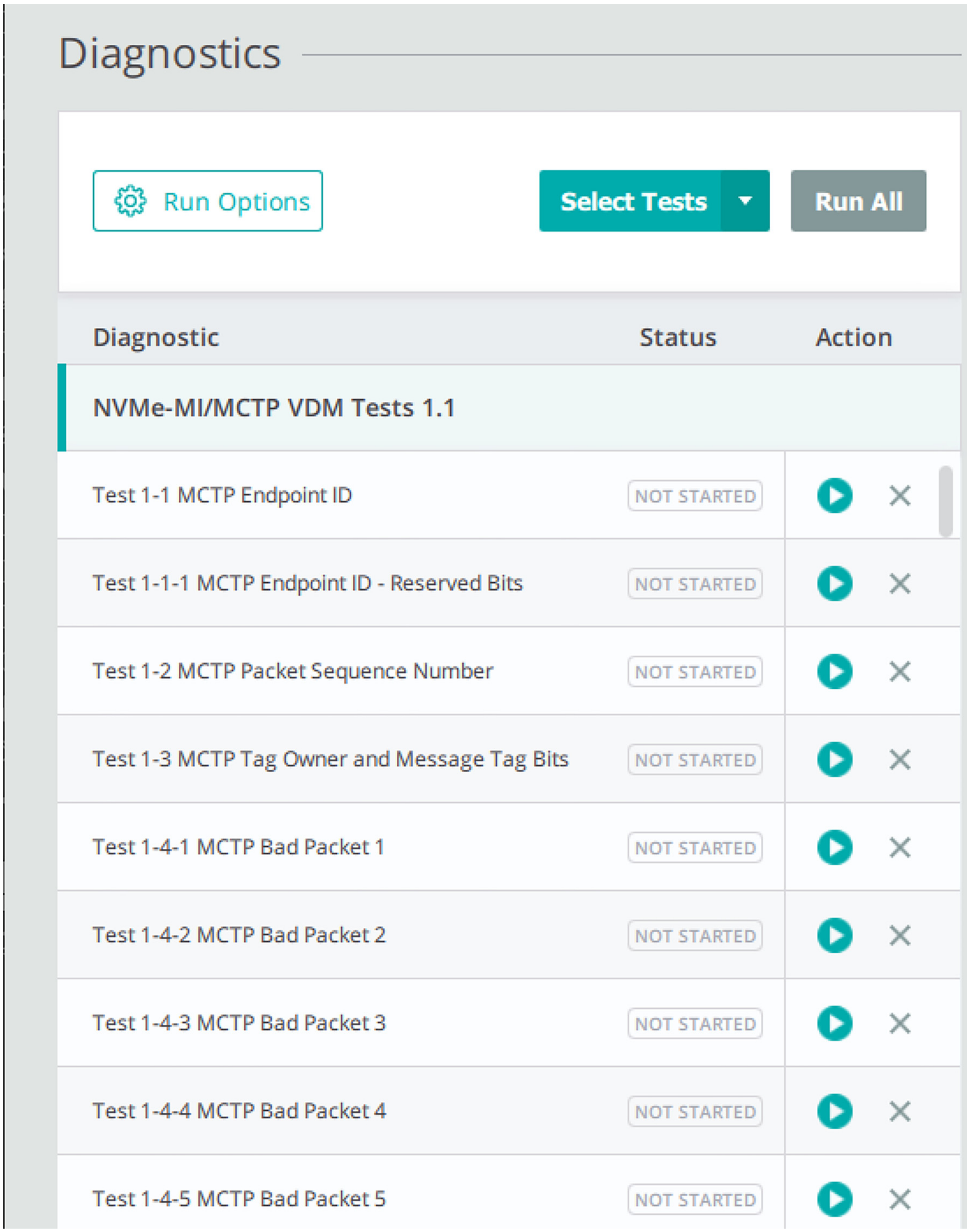


Figure 5.72: Analysis Results: NVMe-MI/MCTP VDM Tests 1.1 -> Loaded

5.11.2 VDM Tests 1.1 Results

The Results of the VDM Tests are shown in Figure 5.37.

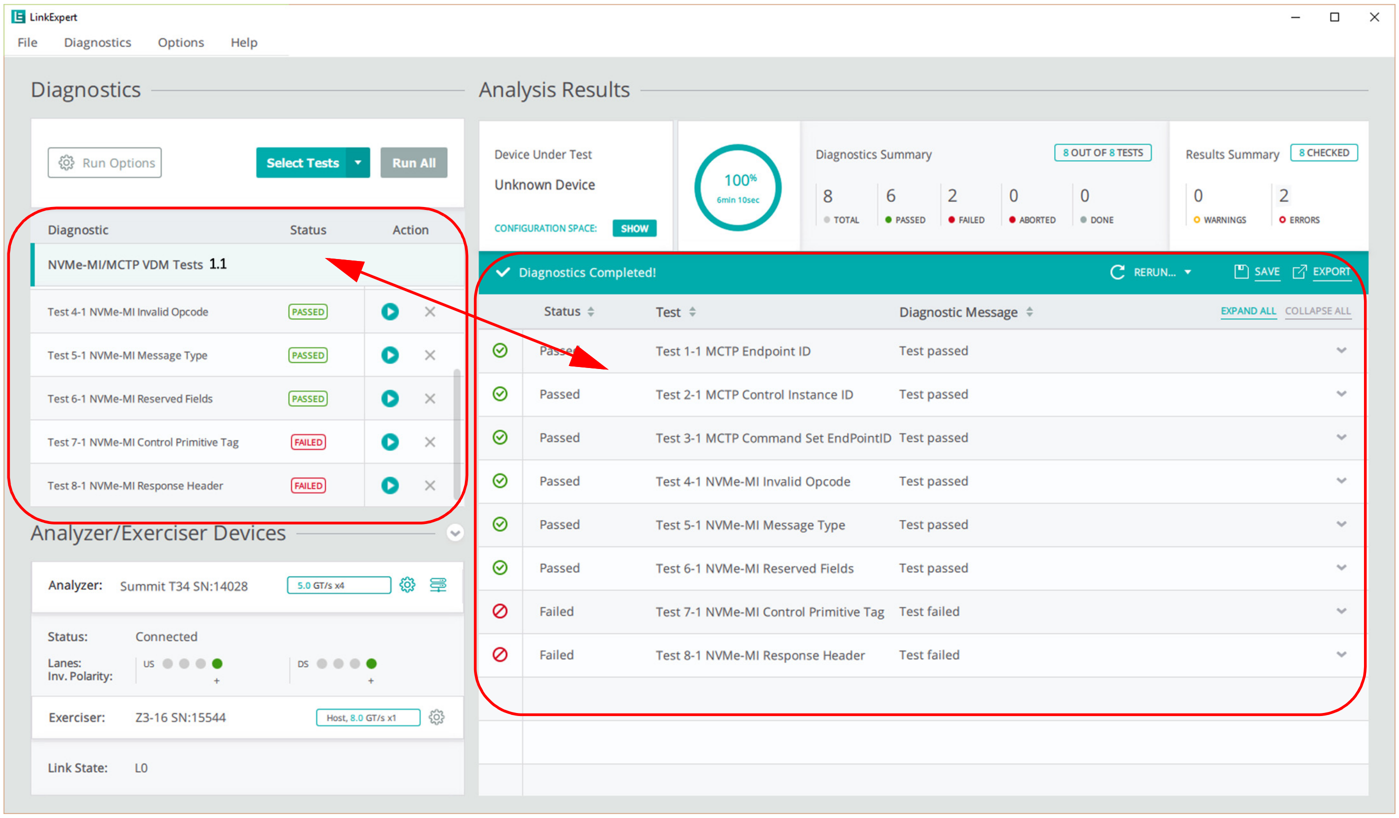


Figure 5.73: VDM Test Results

5.11.3 Summary of VDM Tests

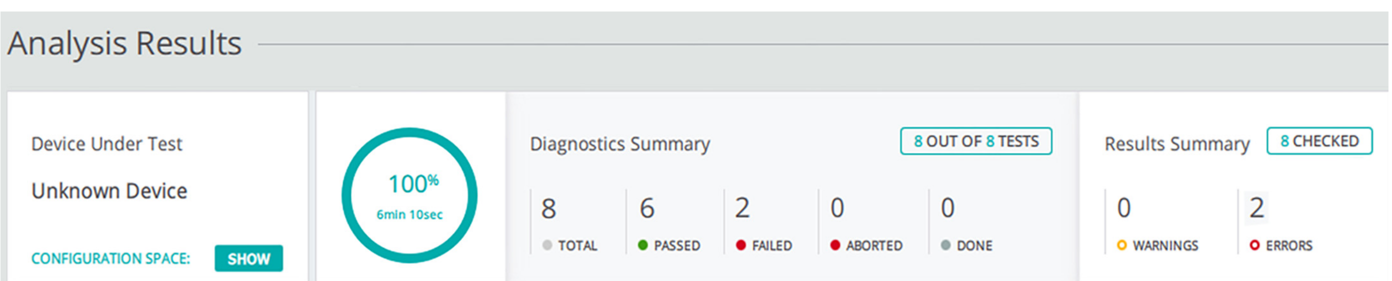


Figure 5.74: Summary of VDM Test Results

- The DUT was Unknown (Discovered during Link Establishment, but not part of this test)
- The progress meter shows the test 100% complete taking 6minutes and 10 seconds
- 6 out of 8 tests Passed
- 2 out of 8 tests had Errors
- 8 Parameters were Checked during the test
- 0 Warnings and 2 Errors were issued during the tests

5.12 Analysis Results: Jammer NVMe Tests 1.0

Chapter 6

CXL Compliance Support

6.1 Introduction

CXL compliance support is an integral and important element for LinkExpert™ technology.

While development is in progress to support all test cases, the current version of LinkExpert™ supports the following test cases, outlined in Table 6.1.

TABLE 6.1: Current CXL Compliance Support

CXL Package	Category	Number of Tests Supported
CXL v1.1	Endpoint	52
CXL v2.0	Endpoint	93
CXL v2.0	Host	37

6.2 CXL Compliance Tests in LinkExpert Software

In LinkExpert, the tests are divided into two different categories:

- Endpoint: Test cases targeted for device under test (DUT) as endpoint.
- Host: Test cases targeted for Host.

Note: Summit Z516 can be used as a CXL endpoint to perform the compliance tests. See the *Summit™ Z5 PCI Express® 5.0 Protocol Exerciser/Analyzer User Manual, Appendix H* for detailed instructions on setting up the Z516 in CXL Device Emulation mode. The User Manual can be found here: https://www.teledynelecroy.com/protocolanalyzer/pci-express/resources/product-manuals

6.2.0.1 Selecting CXL Tests

From the main screen, click **Select Tests**. This displays a list of tests. For CXL, there are:

- CXL 1.1 Compliance Package Tests (Endpoint)
- CXL 2.0 Compliance Package Tests (Endpoint)
- CXL 2.0 Compliance Package Tests (Host)

See Figure 6.75 on page 252.

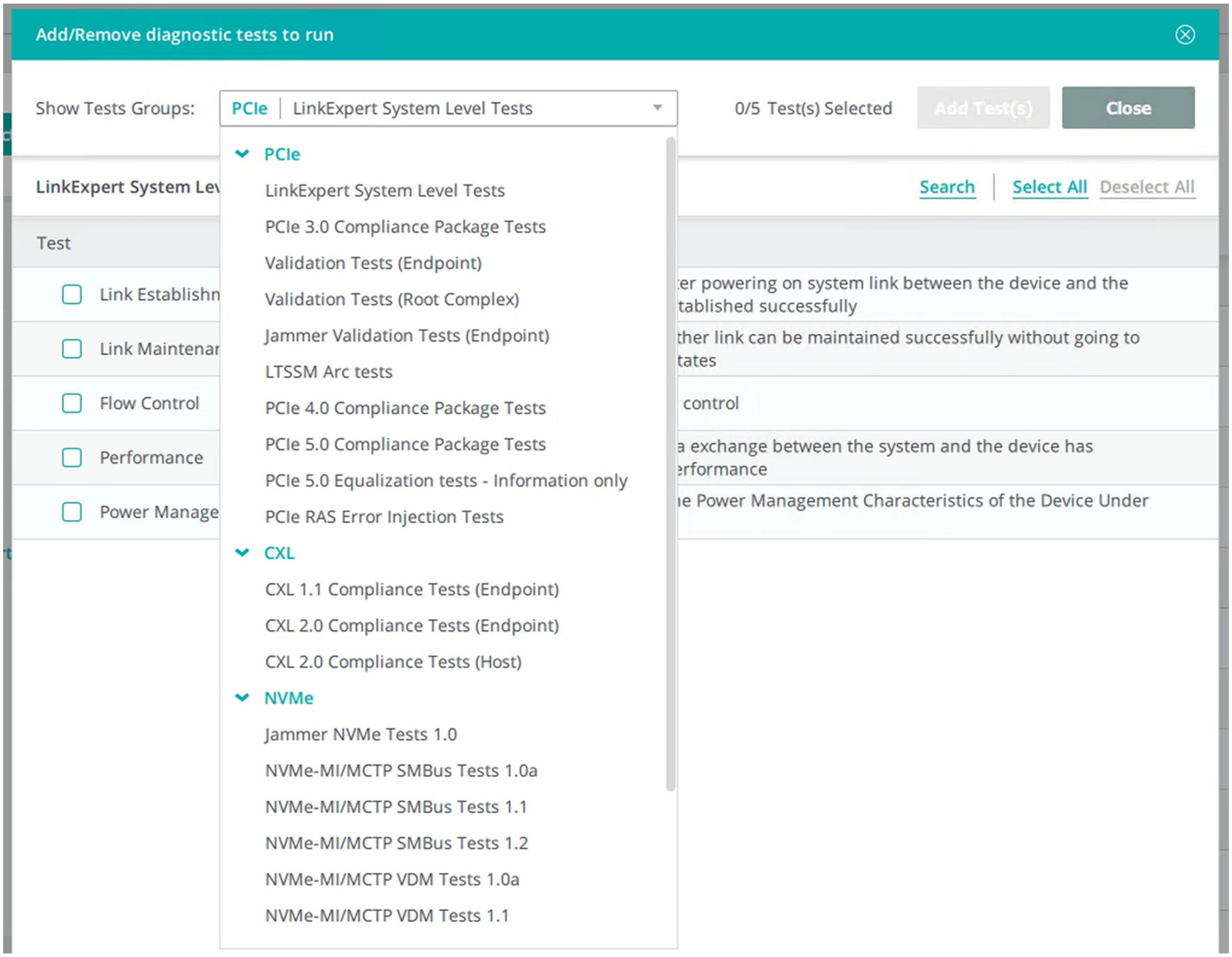


Figure 6.75: CXL Tests: Add/Remove Diagnostics Tests to Run

6.2.1 CXL 1.1 Compliance Tests (Endpoint)

If you select CXL 1.1 Compliance Tests (Endpoint), a list of the tests available with their description displays. See Figure 6.76 on page 253.

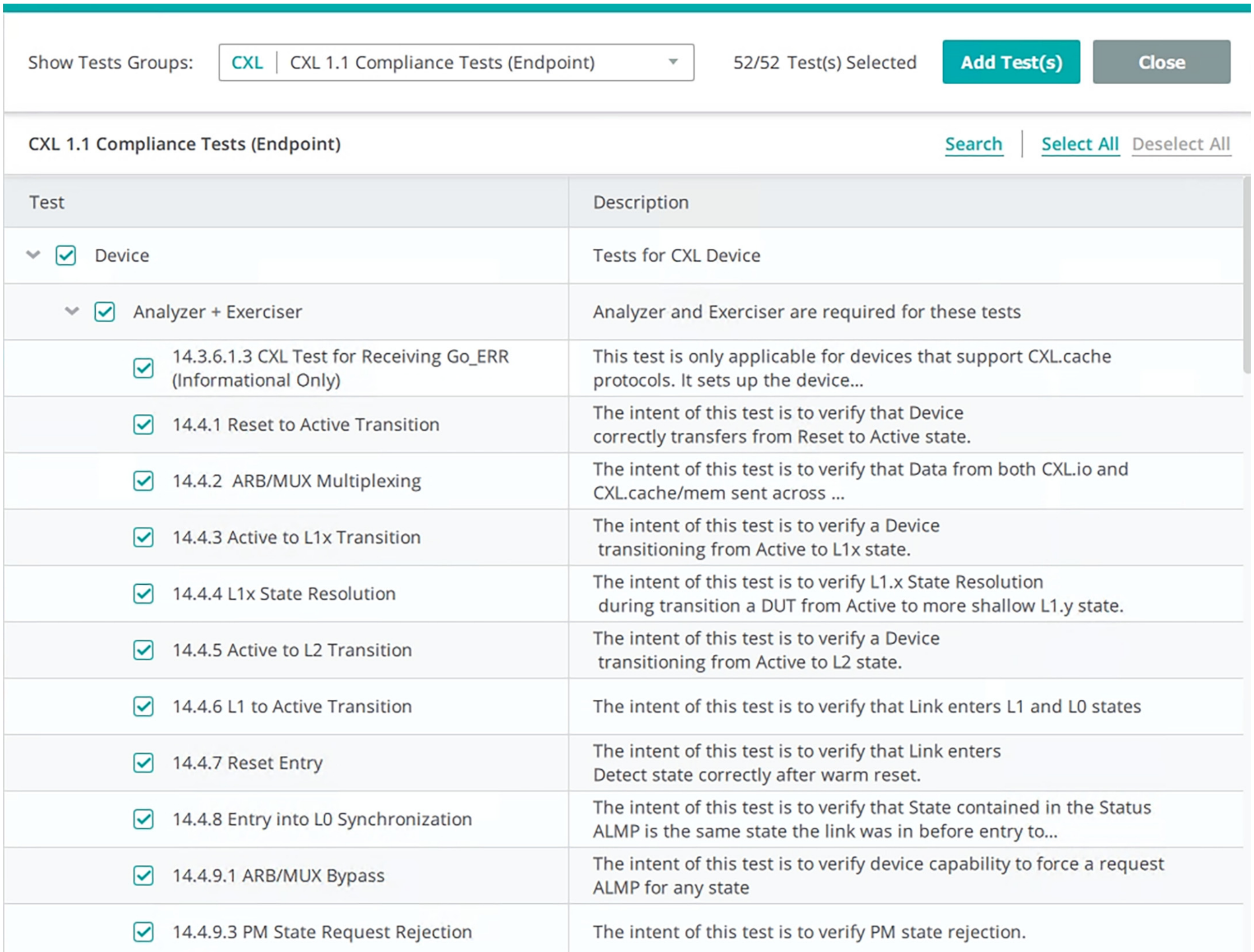


Figure 6.76: CXL 1.1 compliance Tests (Endpoint)

6.2.2 CXL 2.0 Compliance Tests (Endpoint)

If you select CXL 2.0 Compliance Tests (Endpoint), a list of the tests available with their description displays. See Figure 6.77 on page 254.

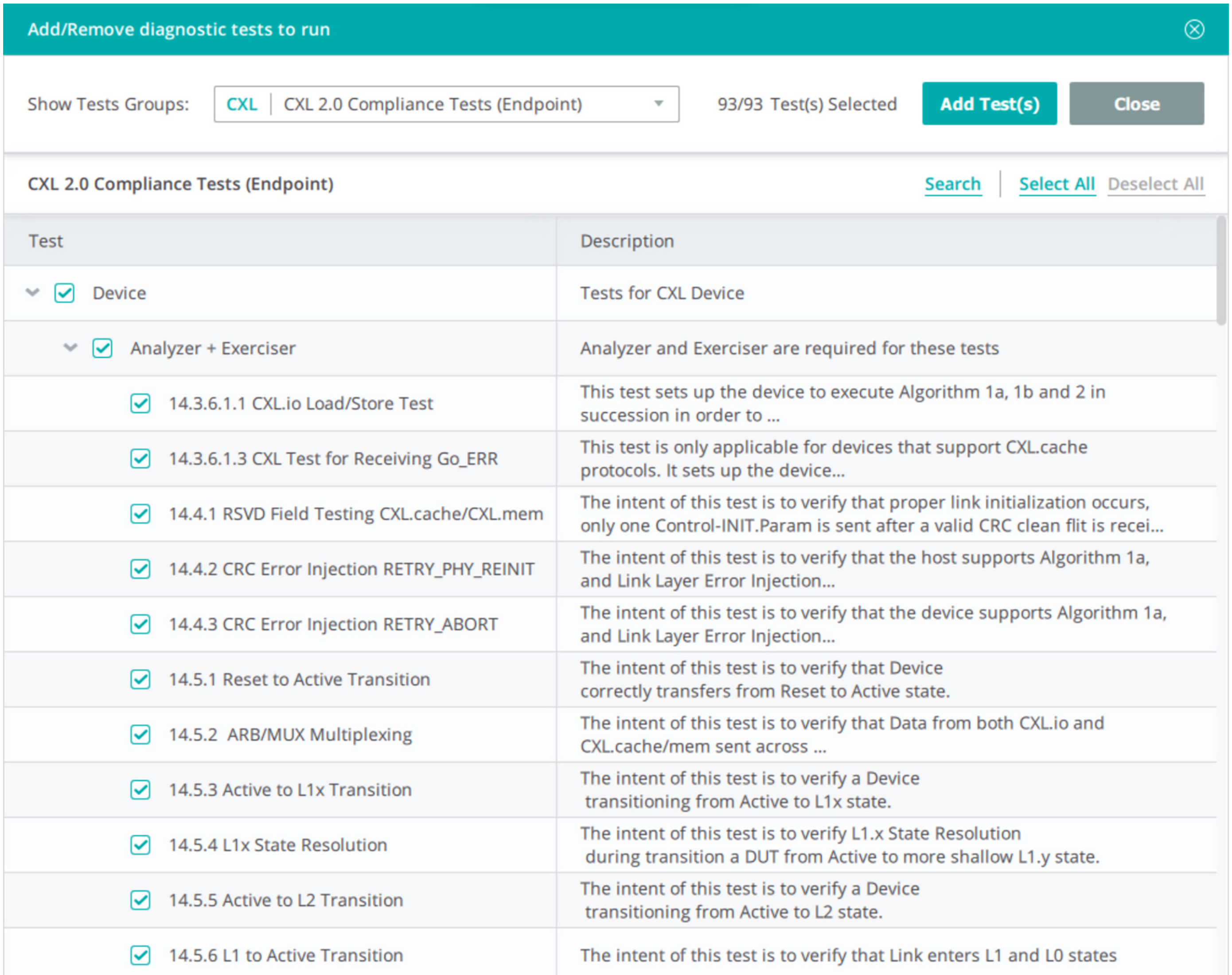


Figure 6.77: CXL 2.0 Compliance Tests (Endpoint)

6.2.3 CXL 2.0 Compliance Tests (Host)

If you select CXL 2.0 Compliance Tests (Host), a list of the tests available with their description displays. See Figure 6.78 on page 255.

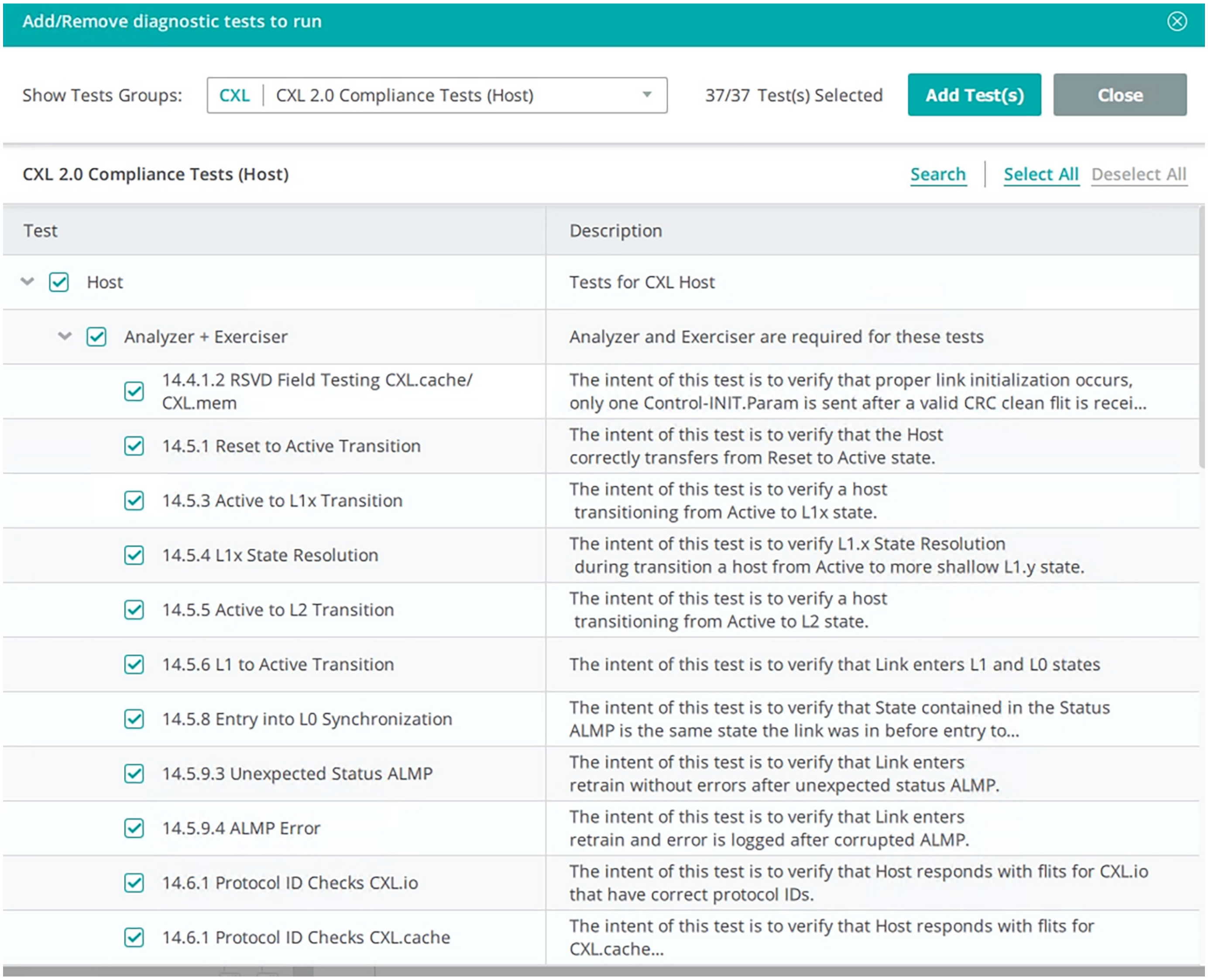


Figure 6.78: CXL 2.0 Compliance Tests (Host)

Chapter 7

SAS LinkExpert (LE)

7.1 Introduction

LinkExpert provides complete control and management of Teledyne LeCroy's family of protocol analyzer and exerciser hardware while displaying high-level diagnostic information about communication between the host systems and devices. Link Expert also performs SAS Compliance Testing. The LinkExpert software interface targets design and validation engineers who are responsible for testing and resolving connectivity, interoperability and performance issues as well as ensuring conformance to the design specification. The new interface takes a smart approach to testing SAS devices and then displaying the results, including any identified errors, connectivity issues and/or overall performance metrics by using intelligent interpretations of bus traffic, eliminating the need for a deep technical knowledge of the various SAS specifications. It provides easy-to-read information about Compliance testing for SAS:

7.2 Key Features

- SAS Testing
  - SAS Compliance Testing
- SAS Verification Testing
  - Speed Negotiation Test
  - Link Layer Test
  - Transport Layer Test
  - Application Layer Test
  - NACA Test

7.3 Hardware Configurations for Specific Test Sets

The following table shows the hardware configurations required to execute specific test sets.

TABLE 7.1: Test Set vs. Hardware Required

Test Set	Hardware Required
SAS Compliance Tests	Host PC DUT SAS Analyzer (M244, T244)
SAS Verification Tests	DUT SAS Analyzer (M244)

7.4 SAS Initial Connection

- ❑ Analyzer Devices: The analyzer/exerciser you have chosen to use (see “Initial Connection Process” on page 258)
  - ■ Initially, no analyzer has been connected

7.4.1 Initial Connection Process

Initially no devices will be connected after power up. See Figure 7.1.

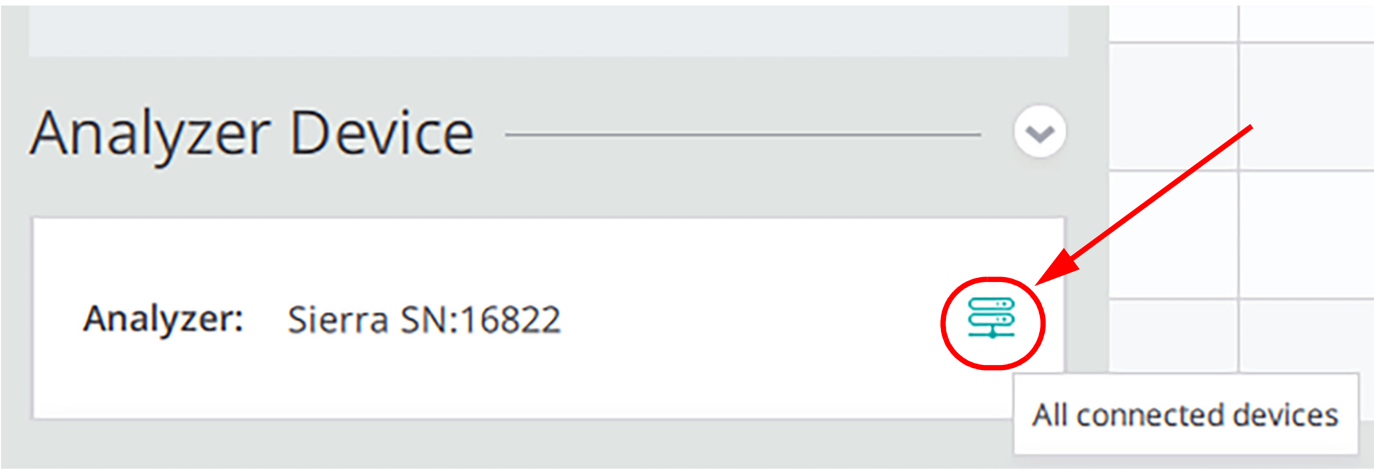


Figure 7.1: Initial Power Up: No Devices Connected

Select the All Connected Devices icon in the Analyzer Device portion of the LinkExpert main Menu (above).

This will pop up a dialog box showing all the devices available on the network. See Figure 7.2.

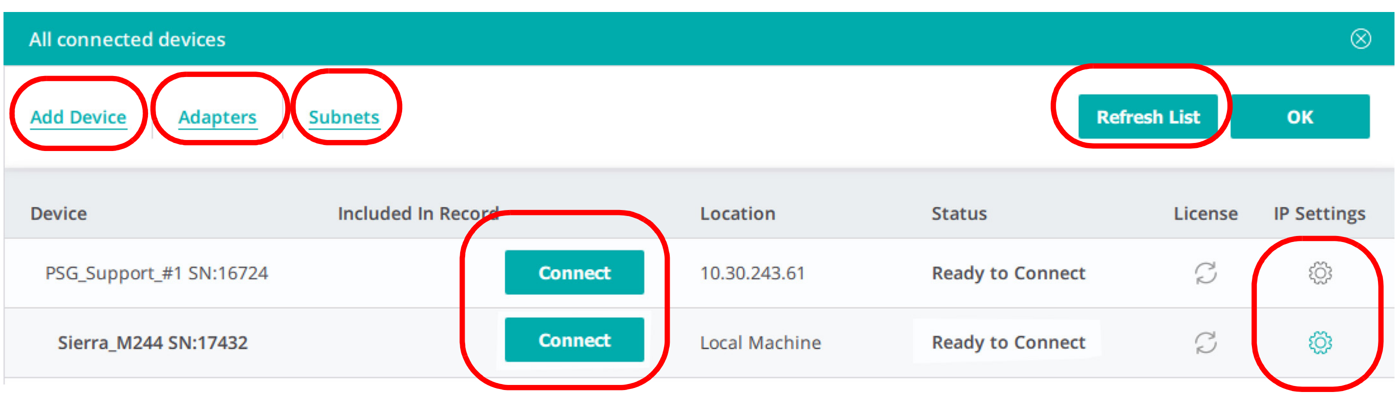


Figure 7.2: Dialog Box Showing All Devices Available on the Network

The All Connected Devices dialog box allows you to:

- Add a device (seeFigure 7.3)
- Check on the adapter you are using (see Figure 7.4 on page 260)
- Add Subnets to the network you are using (see Figure 7.5 on page 260)
- Refresh the List of Devices
- Update IP Setting
- Check on the License for the device
- Include or excluded an Analyzer in the test process
- Connect to Analyzers and Exercisers to start using LinkExpert

---

Note: All of these topics are covered in much more detail in the User Manual for the Analyzer or Exerciser you are using.

7.4.1.1 Add Device

When you select this tab the following dialog box will pop up, which allows you to add other devices to your test set. See Figure 7.3.

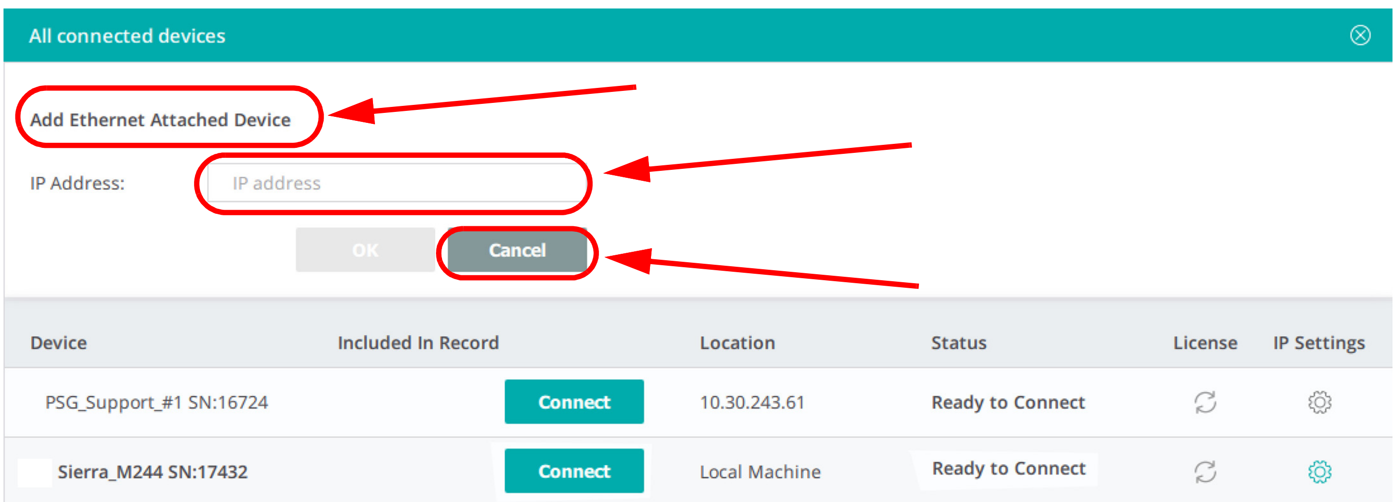


Figure 7.3: Add Device Dialog Box

7.4.1.2 Check Adapter

If you select this tab, the following information about the Adapter you are using will pop up. See Figure 7.4.

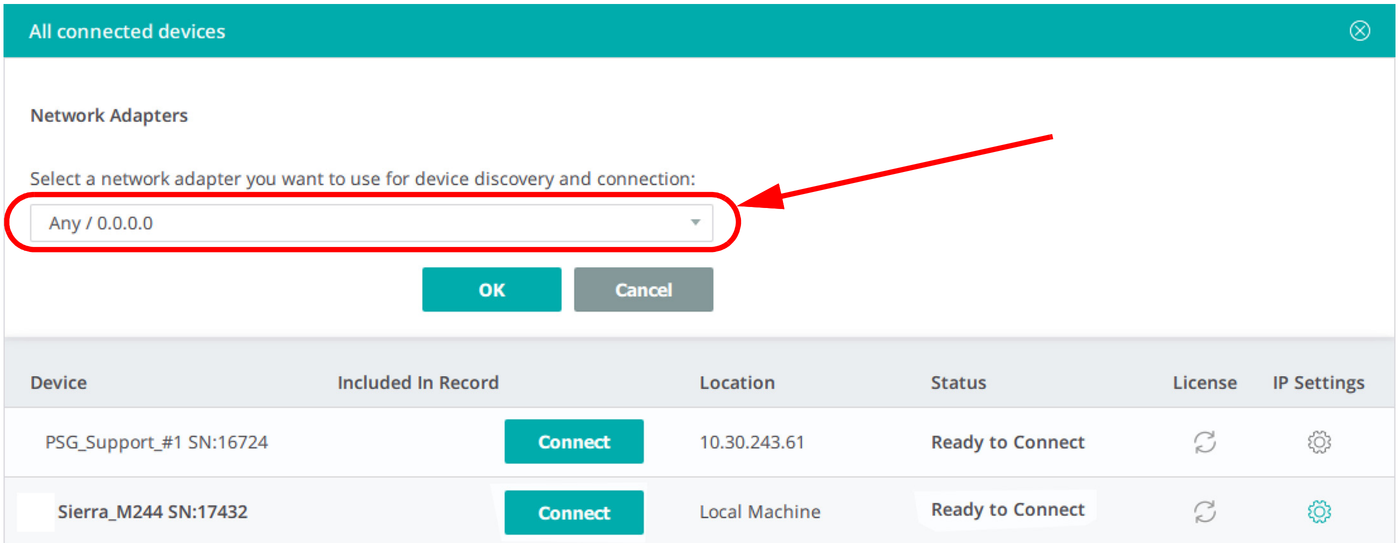


Figure 7.4: Check Adapter

7.4.1.3 Add Subnet

If you want to add a subnet to the system under test, select the Add Subnet tab and the following dialog box will pop up. See Figure 7.5.

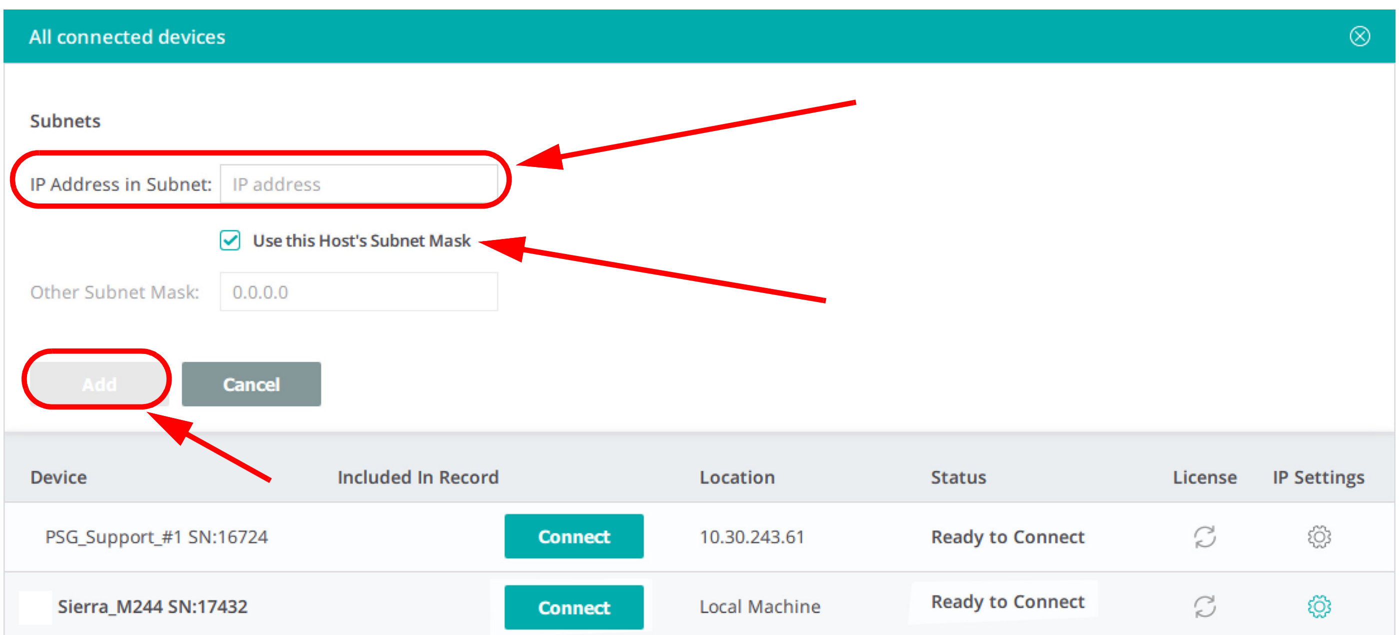


Figure 7.5: Add Subnet to System Under Test

7.4.1.4 Example: Sierra M244

For this example, the network "sees" a Sierra M244 and a PSG Support SAS analyzer. The Sierra M244 has been connected by LinkExpert. See Figure 7.6.

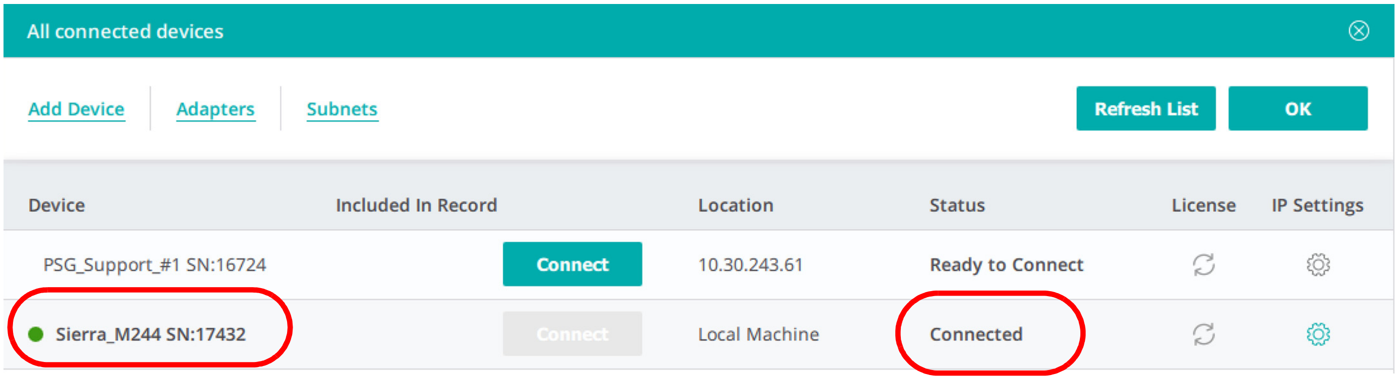


Figure 7.6: M244 SN: 17432 -> Connected

You'll notice the Status has changed to "Connected" and the button in front of each device is green.

Click on OK and you will return to the Main Menu. You'll see that the Sierra M244 SN: 17432 is connected. See Figure 7.7.

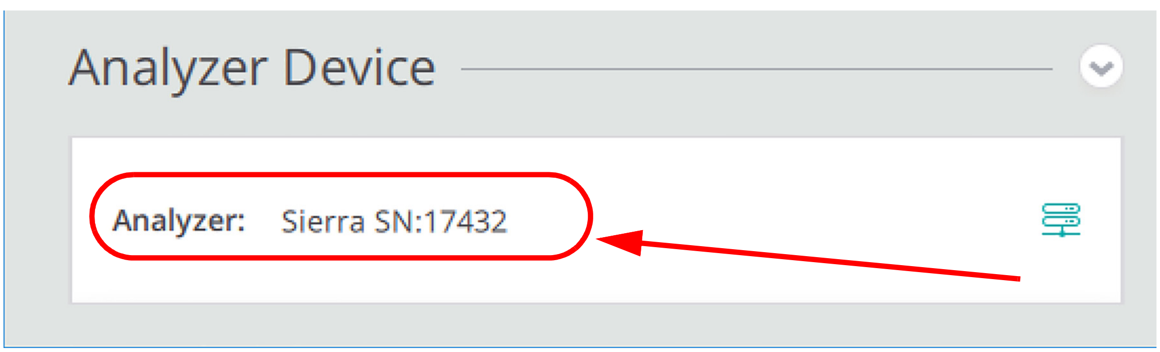


Figure 7.7: LinkExpert Main Menu: Analyzer: Sierra SN: 17432 Connected

7.5 Selecting and Running SAS Tests

You can select a subset of all the tests in a group by clicking on the first test you want to run (see Figure 7.8).

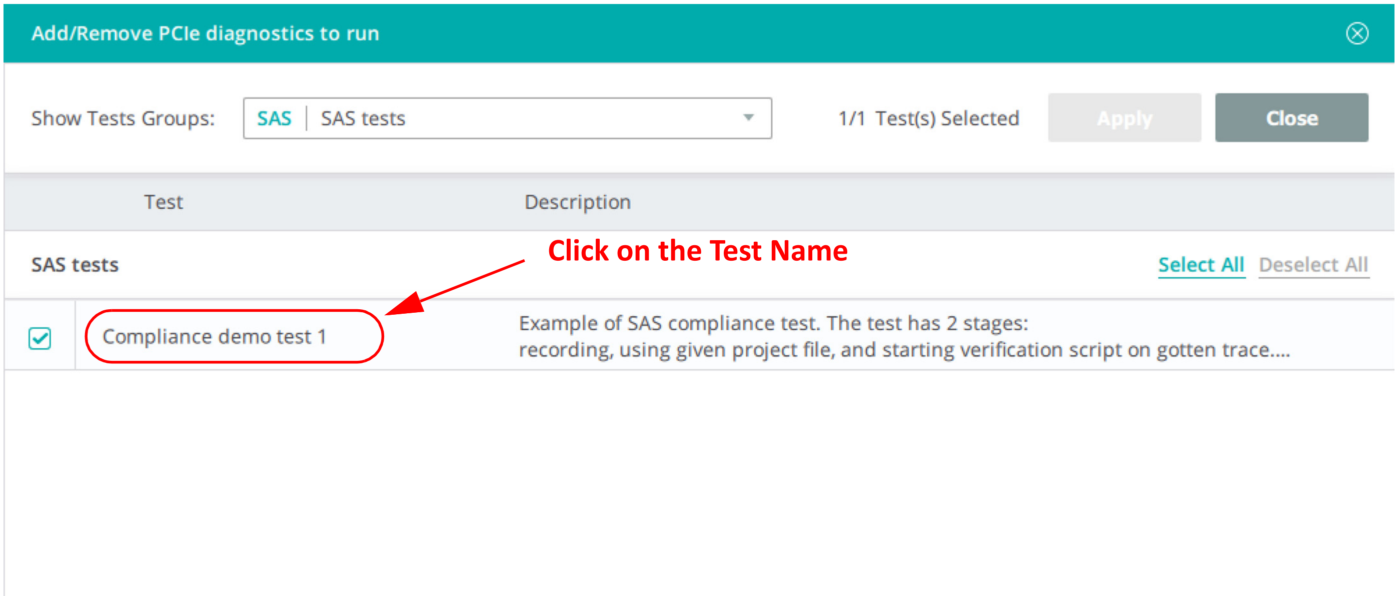


Figure 7.8: Click to Select the First Test in a Series

Once a subset of tests has been selected, click on Apply.

When you click on “Apply” and you have selected text from different set, the following warning message will pop up, explaining that you can only run one type of tests at a time:

See Figure 7.9.

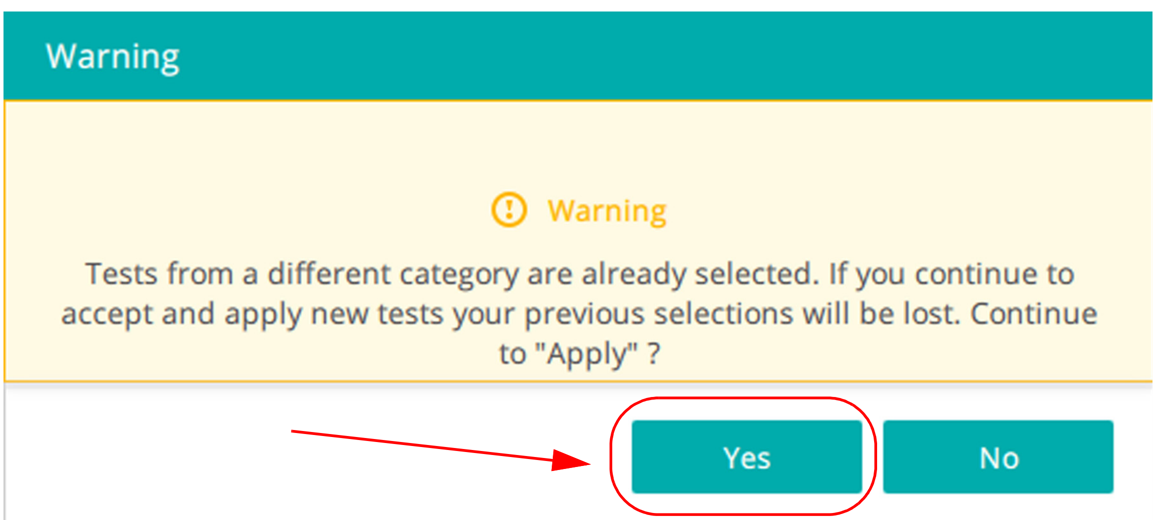


Figure 7.9: Warning Message: Perform One Type of Tests at a Time

Note: If you have already selected one set of tests and you select a new set, the old set will be lost.

After you have selected and applied the tests you want to run the test selection dialog will change to gray out the "Apply" button and only the "Close" button will be active.

The example shown below is after Selecting and Applying the PCIe 3.0 Compliance Test Package of tests, then clicking on the "Close" button. See Figure 7.10.

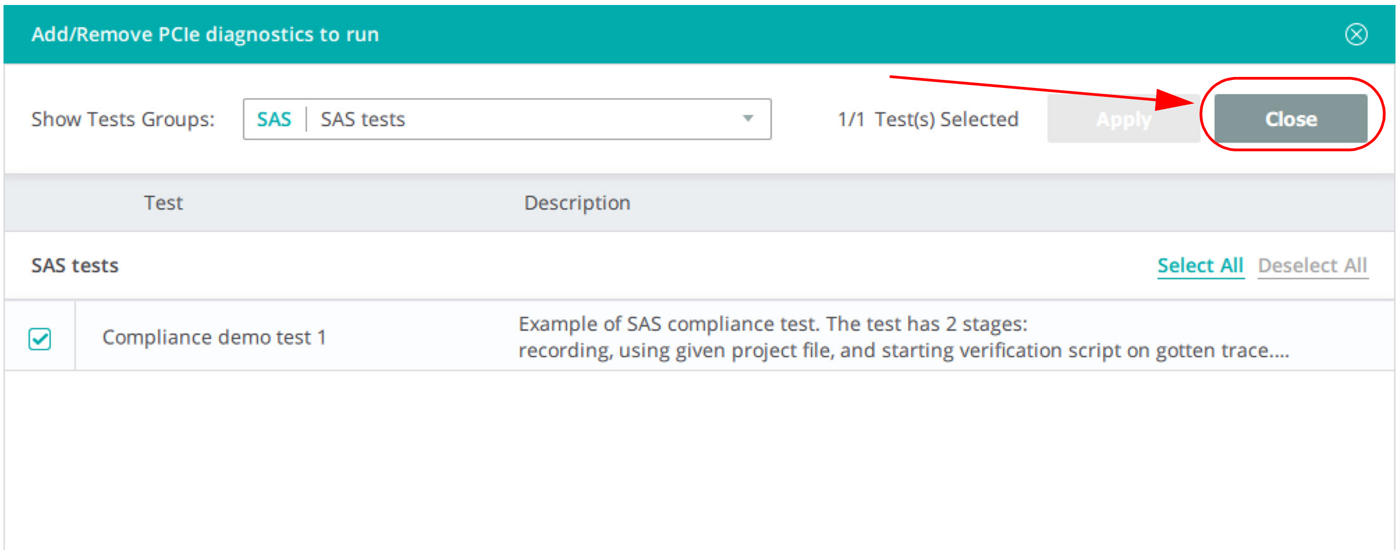


Figure 7.10: After Selecting and Applying a Test Set: Only Close Button is Active

Click on the “Close” button and the SAS Compliance tests are loaded and ready to be executed. See Figure 7.11.

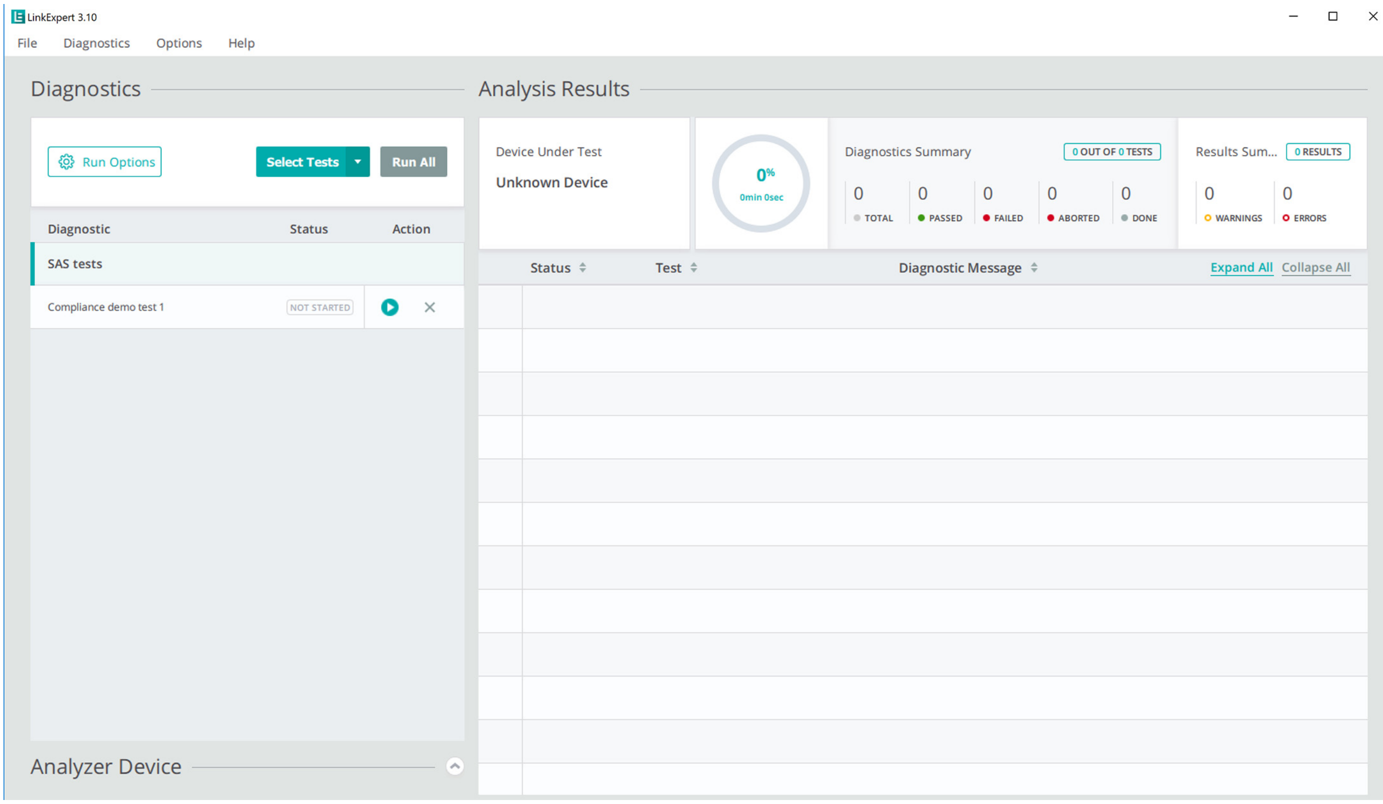


Figure 7.11: SAS Tests: Selected, Applied and Ready to be Executed

Once you load a set of tests, the Diagnostic pane will be updated see Figure 7.12 on page 265.

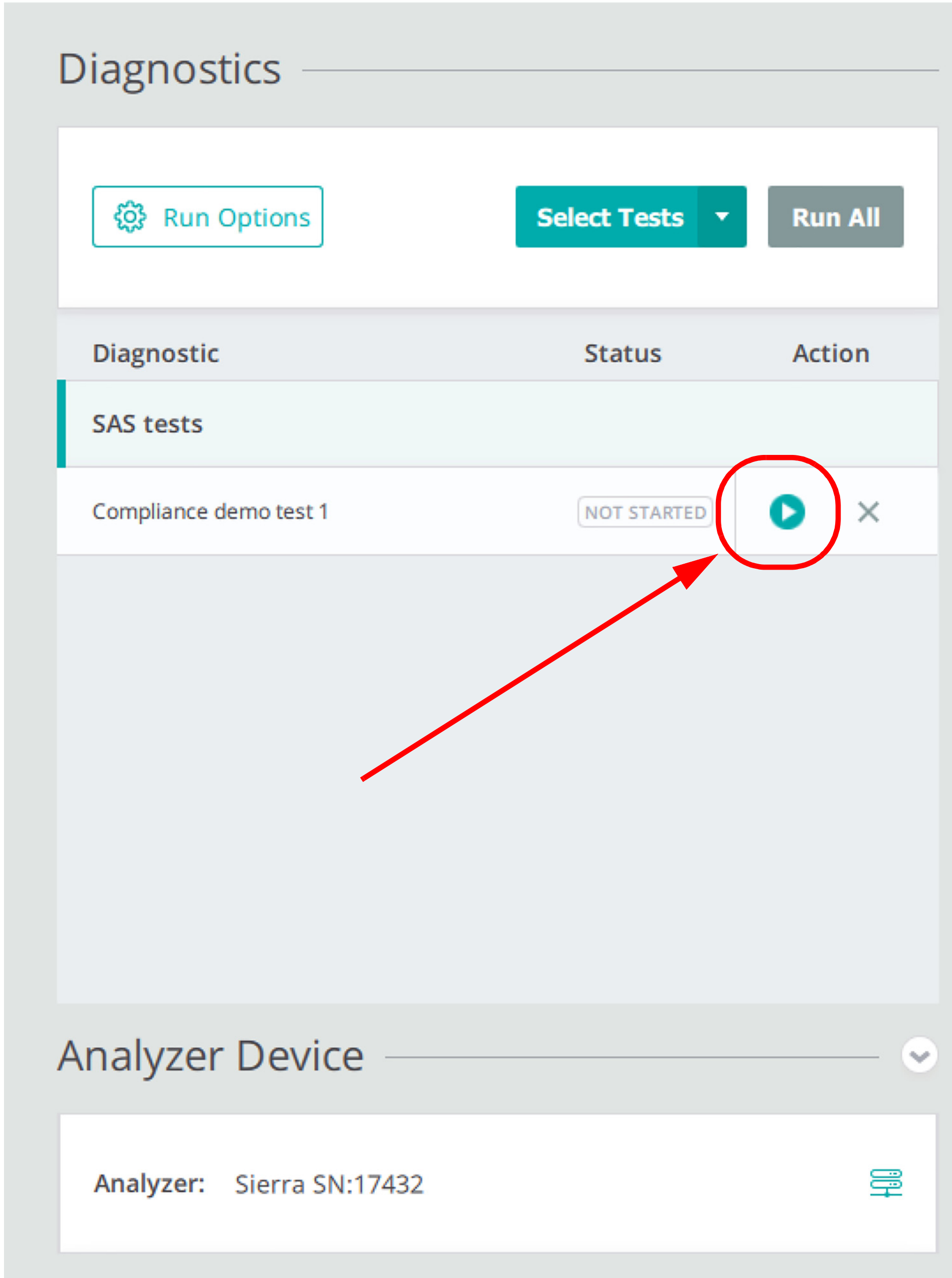


Figure 7.12: SAS Compliance Test Loaded: Sierra M244 Connected

Click on the white arrow to run the compliance test.

See "Analysis Results: SAS Compliance Test" on page 269 to see the results of the test.

7.6 SAS Verification Test Suite 1.0

The SAS Verification Test Suite requires a license, sold separately. The available test descriptions can be found under the SAS4 Protocol Suite Documents: look for SAS4_Verification_Test_Descriptions.pdf.

The SAS Compliance described in this manual is only a placeholder, to demonstrate the usage of SAS4 testing using Link Expert. It is available even without purchasing the SAS4 Verification license.

You can select as many of the SAS Verification Tests to be run separately. See Figure 7.13 and Figure 7.14 on page 267.

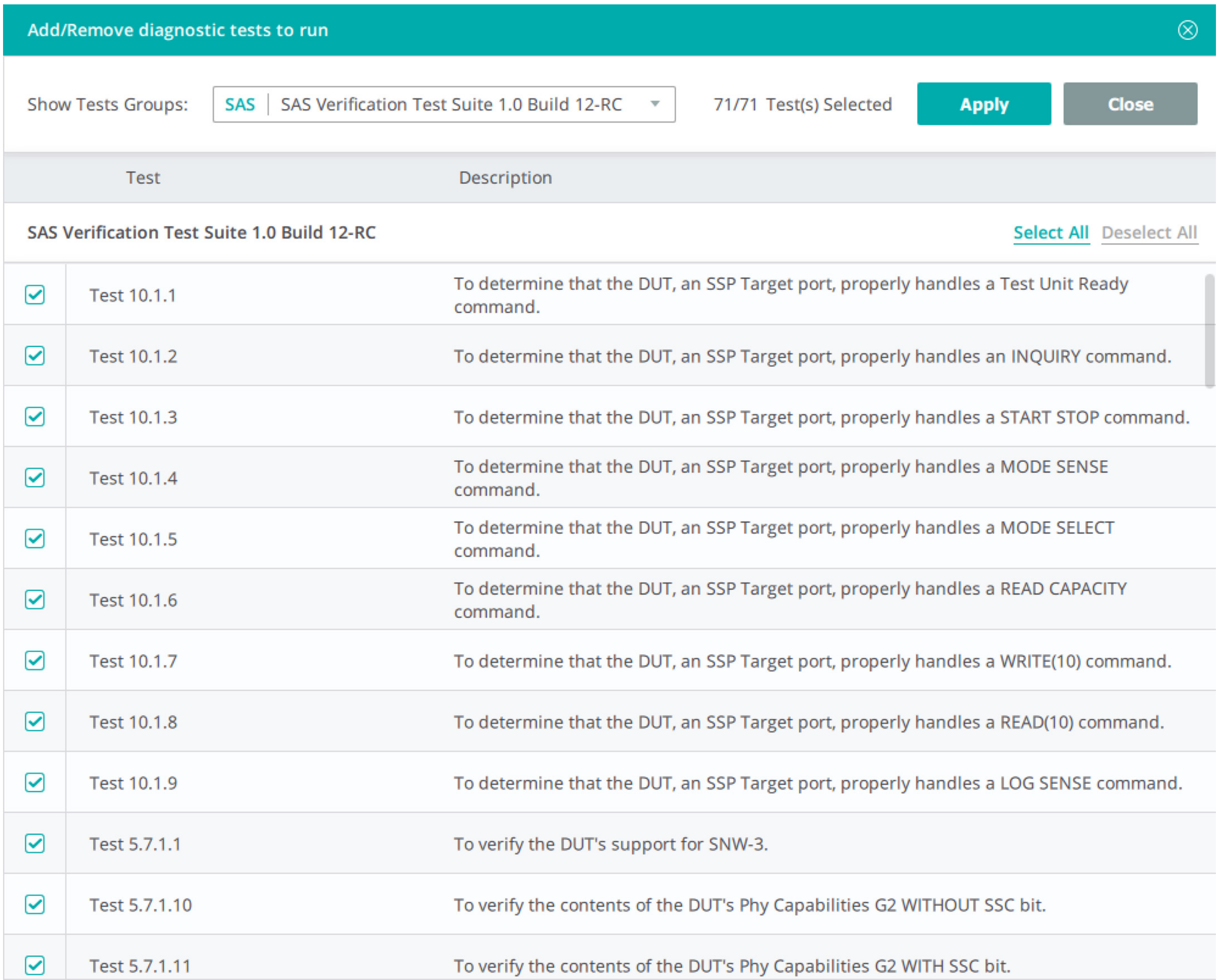


Figure 7.13: SAS Verification Test Suite 1.0

If you have other tests loaded, you'll see a warning message when you hit the "Apply" button. See Figure 7.9 on page 262.

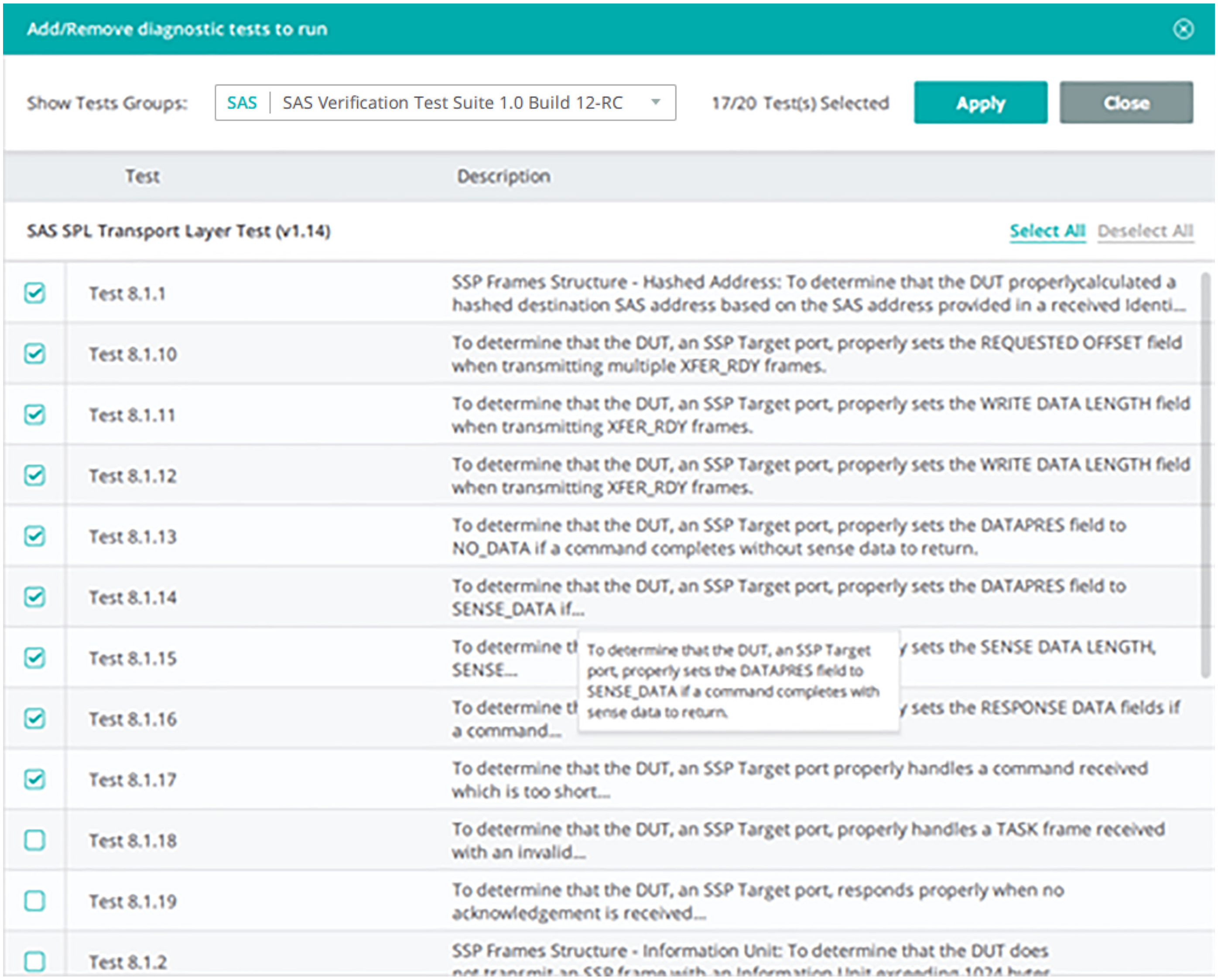


Figure 7.14: SAS Verification Test Suite 1.0 Build 12-RC

Chapter 8

SAS Analysis Results

LinkExpert can provide analysis results for the following sets of tests for the SAS Protocol Suite:

- SAS Compliance Tests
- SAS Verification Tests

8.1 Analysis Results: SAS Compliance Test

The results of the SAS Compliance Tests which have been run on the DUT are shown in the Analysis Results section.

8.1.1 Results: SAS Compliance Test

The first test run was SAS Compliance Test and the Results are shown in Figure 8.1.

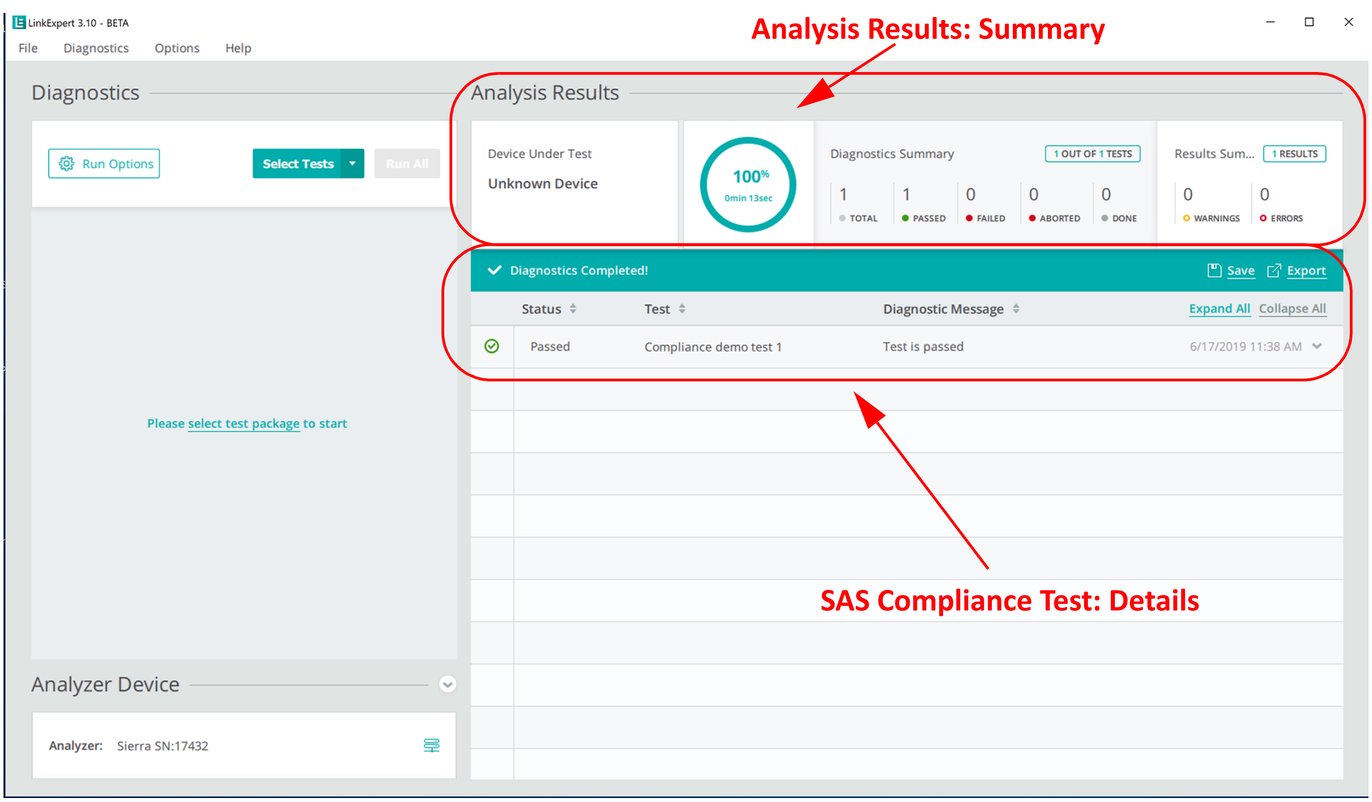


Figure 8.1: Analysis Results: SAS Compliance Test

8.1.2 Analysis Results: SAS Compliance Test Results Summary

The SAS Compliance Test Results Summary is shown in Figure 8.2.

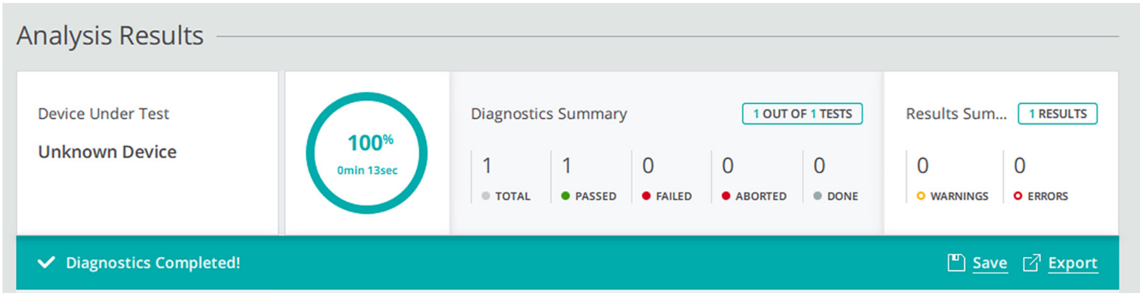


Figure 8.2: Analysis Results: Link Establishment Summary

- The DUT was an “Unknown Device”
- The progress meter shows 100% complete: 13 seconds
- Diagnostic Summary: 1 out of 1 tests were executed (Only Link Establishment was selected)
  - Total Number of Tests: 1
  - Number of Tests Passed: 1
  - Number of Tests Failed: 0
  - Number of Tests Aborted: 0
  - Number of Tests Done: 0

Note: Some tests do not have Pass or Fail criteria, they simply need to be executed before other tests can be run.

8.1.3 Analysis Results: SAS Compliance Test Results Details

The detailed results of the SAS Compliance test are shown in Figure 8.3.

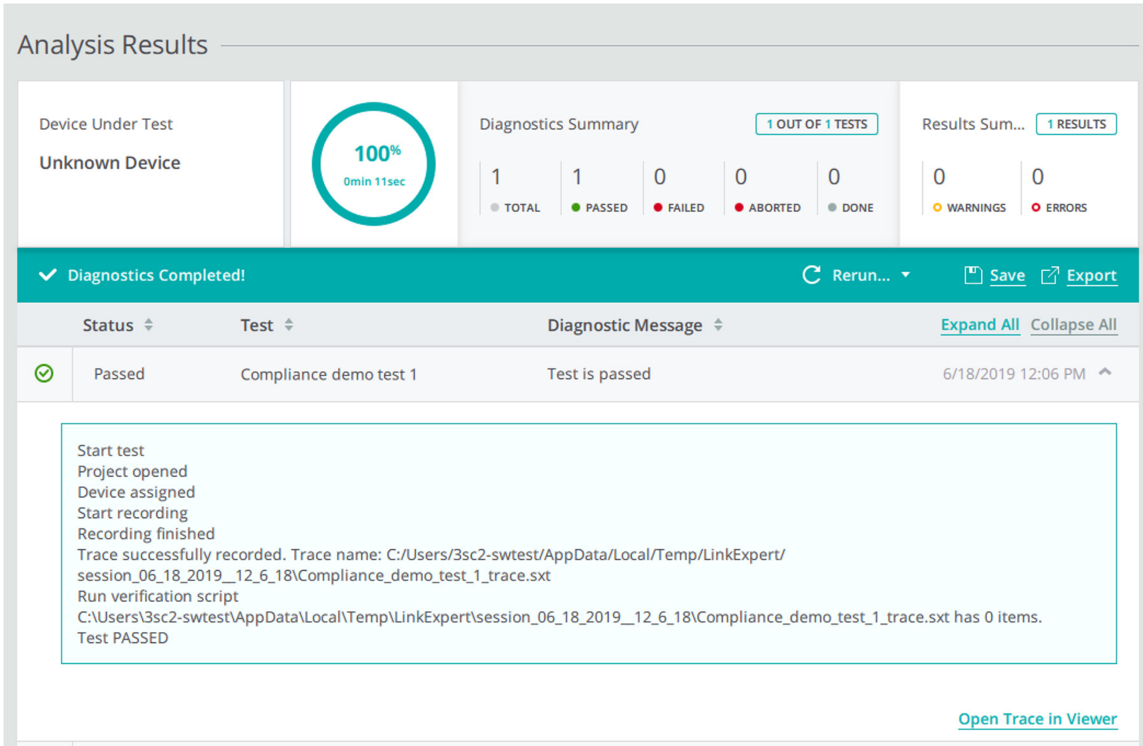


Figure 8.3: Detailed Results of SAS Compliance Test

8.2 Results: SAS Verification Tests

The first test set run was SAS Verification Tests and the Results are shown in Figure 8.4.

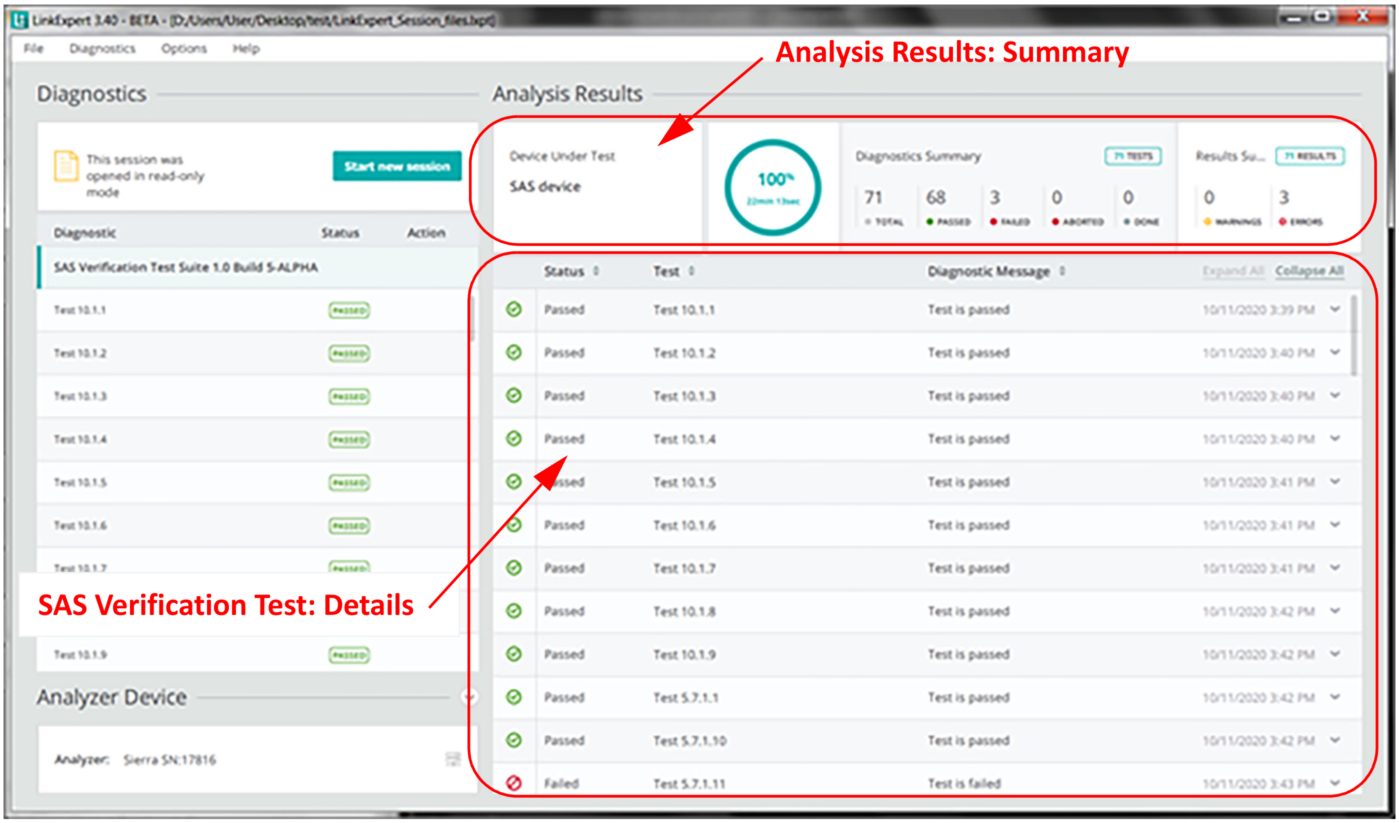


Figure 8.4: Analysis Results: SAS Verification Test

8.2.1 Analysis Results: SAS Verification Test Results Summary

The SAS Verification Test Results Summary is shown in Figure 8.5.

Figure 8.5: Analysis Results: Link Establishment Summary

- The DUT was a “SAS Device”
- The progress meter shows 100% complete: 22 minutes 13 seconds
- Diagnostic Summary: 71 tests were run
  - Total Number of Tests: 71
  - Number of Tests Passed: 68
  - Number of Tests Failed: 3
  - Number of Tests Aborted: 0
  - Number of Tests Done: 0

Note: Some tests do not have Pass or Fail criteria, they simply need to be executed before other tests can be run.

8.2.2 Analysis Results: SAS Verification Test Results Details

The detailed results of the SAS Verification test are shown in Figure 8.6.

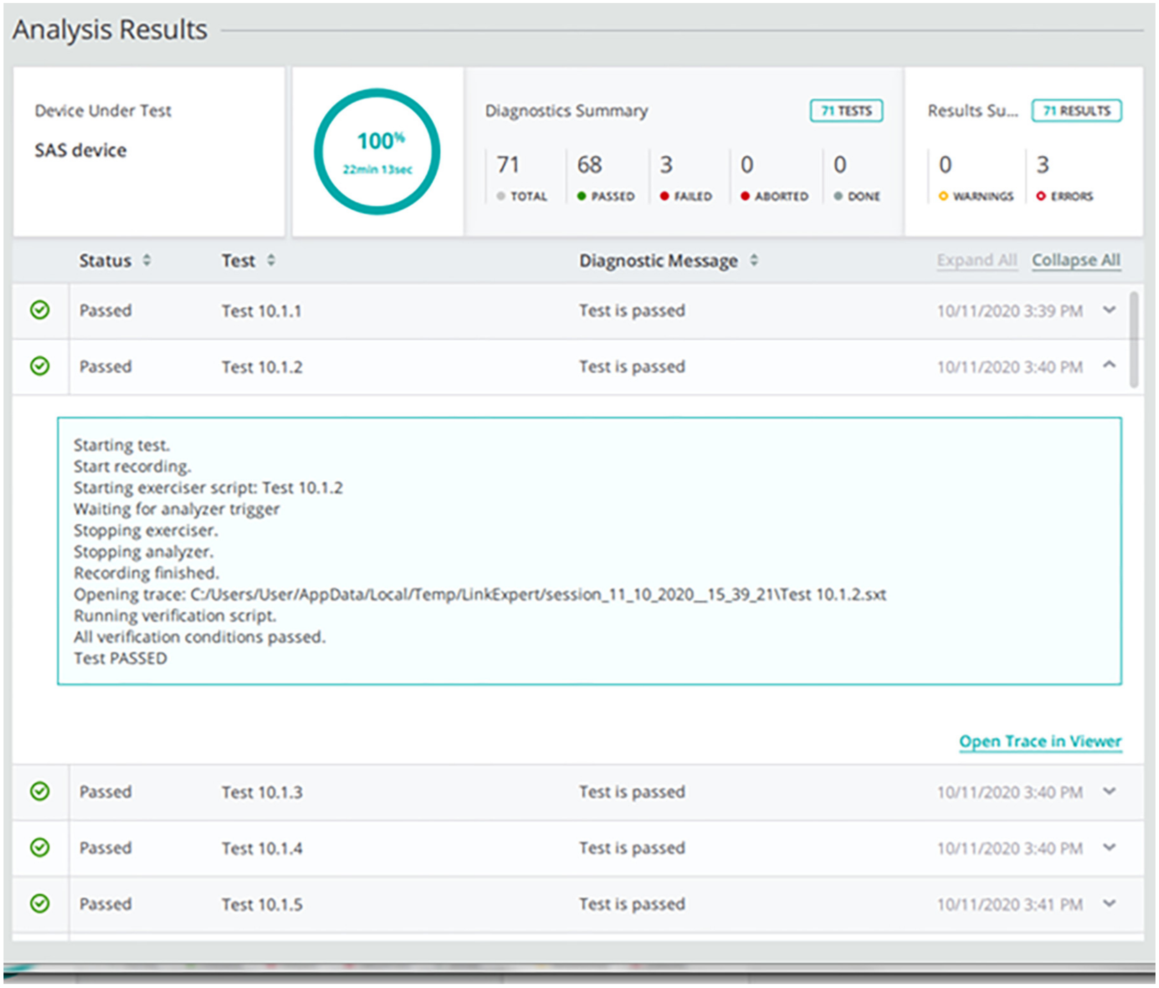


Figure 8.6: Detailed Results of SAS Verification Test

After the selected set of tests has been executed there are several options on how to continue.

- Rerun:
  - All Tests
  - Failed Tests
  - Select Tests
- Save
- Export

See Figure 8.7 on page 275.

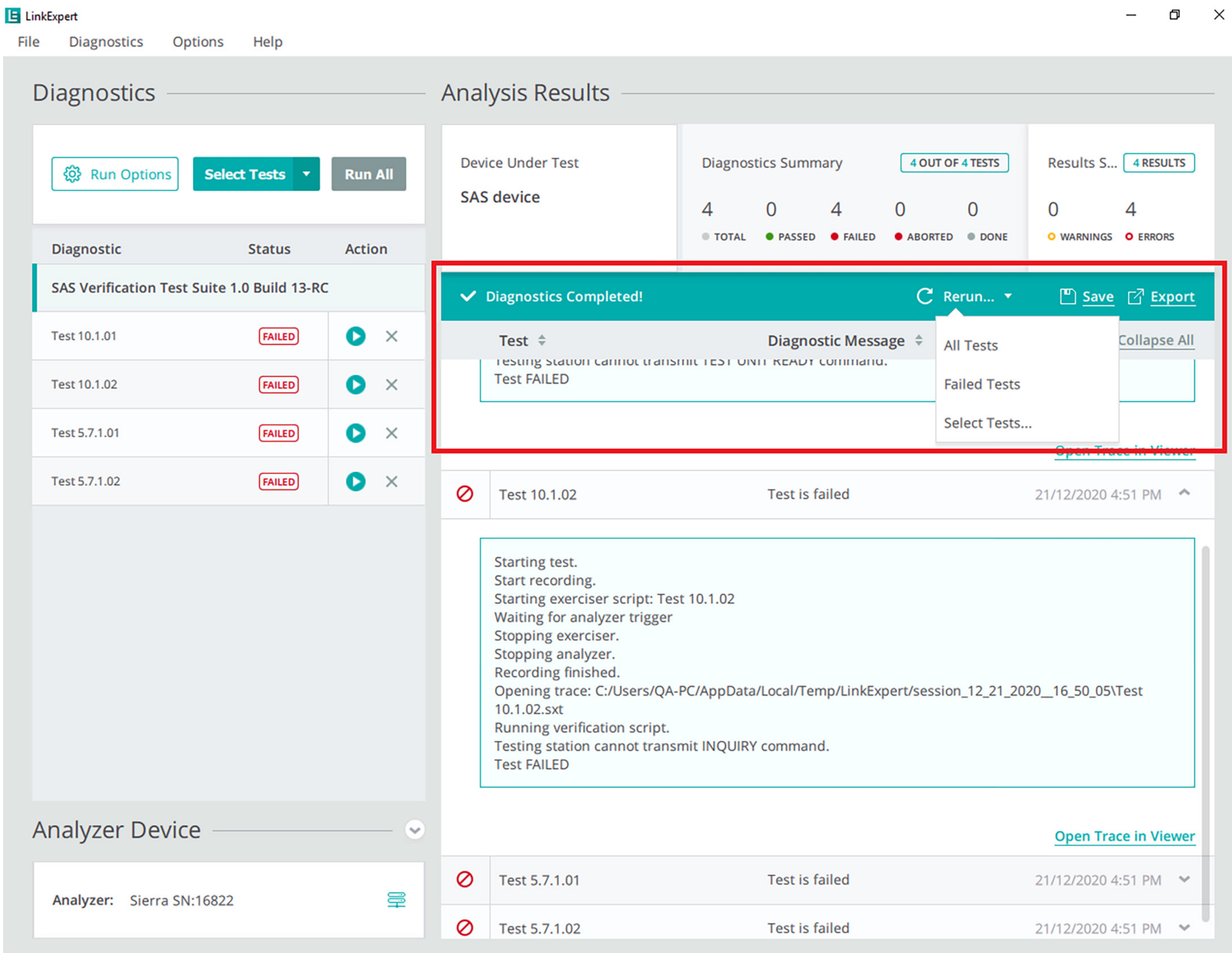


Figure 8.7: Rerun Options After Tests Complete

If you select Save the following dialog box pops up.

You can Save:

- All Tests
- Failed Tests
- Warning Tests

See Figure 8.8 on page 276.

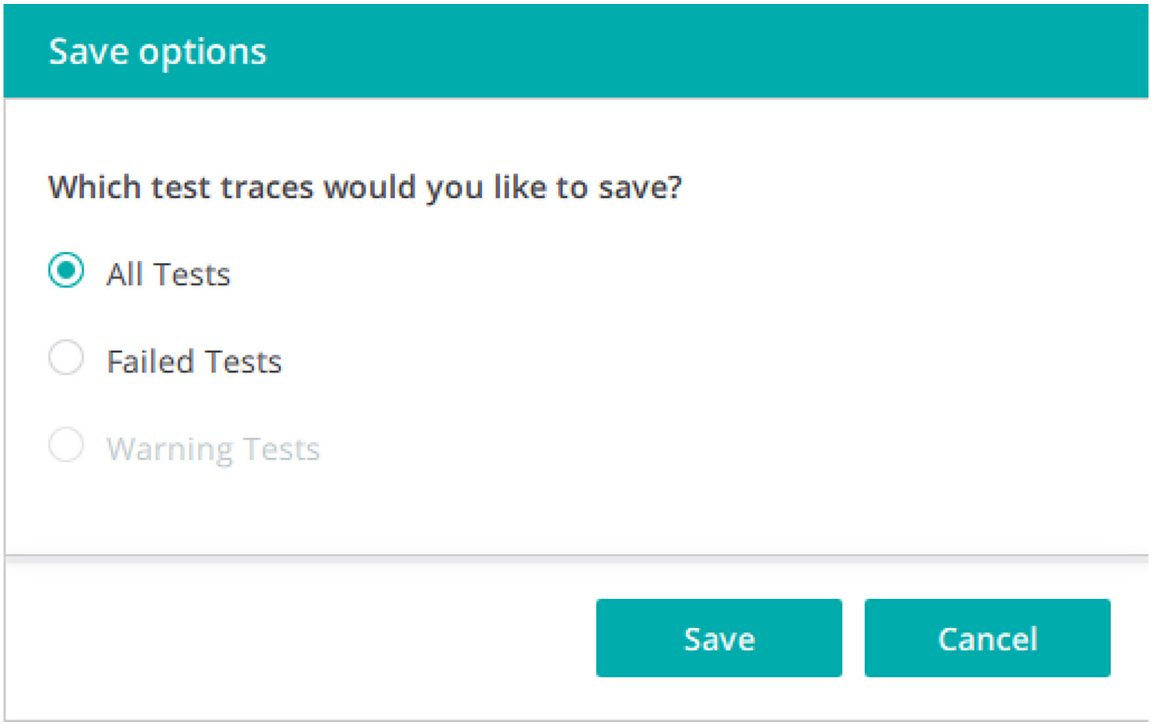


Figure 8.8: Save Options

After selecting the tests, click on Save and you can save your test result to a file. See Figure 8.9.

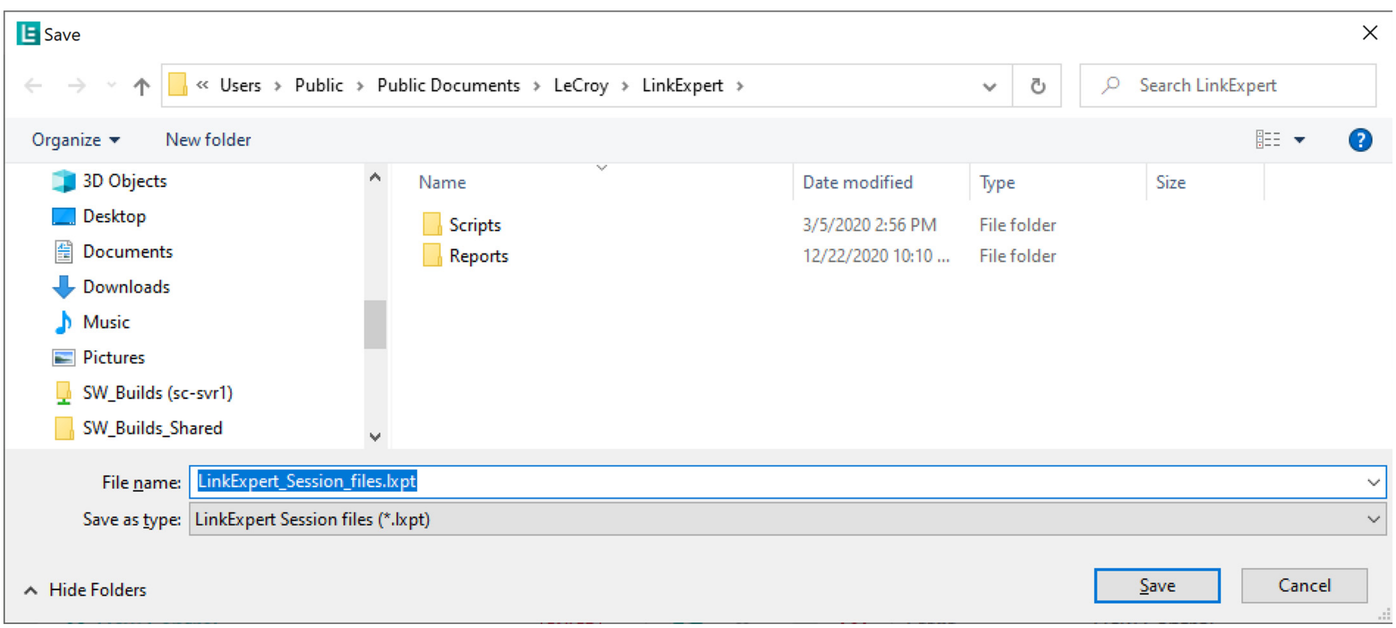


Figure 8.9: Save Selected Tests to a File

A similar dialog box pops up if you select Export (you can save your test results to a Trace Expert file). See Figure 8.10 on page 277.

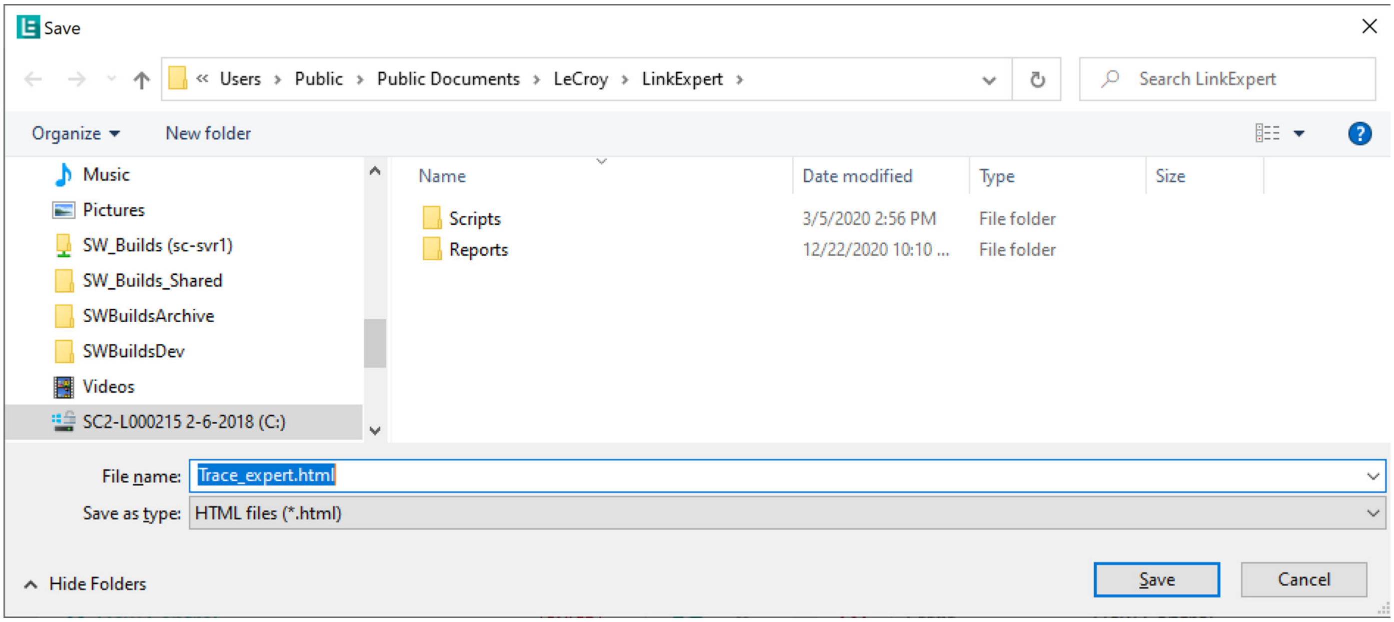


Figure 8.10: Export Test Results to Trace Expert File

Chapter 9

LinkExpert Python API

LinkExpert API allows you to control LinkExpert using a Python module. The API is based upon socket communications between the LEX server and the Python client, which is located at:

C:\Program Files\Lecroy\LinkExpert\LexAPI

The LinkExpert API is a high level API that can be used without using a socket routine.

9.1 Setup Requirements — Windows

1. For Python version 3.0 and above, the Python module “LexApi.py” must be located at: C:\Program Files\Lecroy\LinkExpert\LexAPI.
2. Before working with the LEX API, create an object with the default protocol ID.
3. LinkExpert server automatically closes when the last client socket disconnects from the process.

9.2 API Module Initialization

For creating the main API module, first setup a reference to the location of the API module:

C:\Program Files\Lecroy\LinkExpert\LexAPI

Then, initialize the module with the default protocol. Refer to the following code example:

```
import                                                                    sys
sys.path.append(r'C:\Program         Files\Lecroy\LinkExpert\LexAPI')
import LexApi
api = LexApi.LexApi("PCIe" )
```

Note: If there is only one protocol available, then the protocol_id field can be empty.

9.3 API List and Parameters

The following table lists the code and its parameters used in this API. See "API Sample Code" on page 284 for a sample.

Code	Description
GetLastError() `print(api.GetLastError())`	There is family of errors which cannot be handled by a simple API call and can be raised during some internal process asynchronously. For getting information about this errors use this method.
GetPackageManager() `package = api.GetPackageManager()`	Return object for working with selected package.
SetPackage(package_name, package_version) `package.SetPackage( "PCIe 5.0 Compliance Package Tests", "" )`	Select package for further manipulations where package_name is the selected package name and package_version is the selected package version. NOTE: This parameter has been DEPRECATED.
SetPackage2(package_id, test_ids) `package_id = PackageId.PackageId( "PCIe 5.0 Compliance Package Tests", "" )` `package.SetPackage2(package_id, ["test_id_1", "test_id_2"])])`	Select package for further manipulations, where: `package_id` = This class keeps information for package identification: package name and package version `test_ids` (optional) = The list of test identifiers (test codes) which must be added to the session. If list is empty all tests from the selected package will be added to the session
GetPackages() `packages = package.GetPackages( )`	Returns a list of available packages
SelectTest(test_code, is_selected)	Include or exclude the test in the currently selected package for session run. `test_code` = Test code. Unique test identifier `is_selected` = True - add the test to the session. False - exclude the test from the session
GetPackageInfo(package_id) `package_info = package.GetPackageInfo(package_id)`	Return information about requested package. The return type is "PackageInfo", where: `package_id` = This class keeps information for package identification: package name and package version
RunTests() `package.RunTests()`	Run all tests from the package. Asynchronous function. Must stop tests or wait for end of session before exiting.

Code	Description
RerunFailed() `package.RerunFailed()`	Some tests fail after the first run and pass after rerunning. With this command, you do not have to rerun whole session again. This method allows you to run only failed tests after a previous run. The function will throw an exception if session was not run previously or there are no failed tests for rerunning.
StopTests() `package.StopTests()`	Stop running session
IsRunning() `package.IsRunning()`	True = session running Otherwise, False
GetReport() `while package.IsRunning: report = package.GetReport() print( report.GetPassed() ) print( report.GetFailed() ) print(report.GetAborted() ) print( report.GetDone() ) print( report.GetTotal() ) for name, status in report.GetTests(): print( "{0}. {1}".format(name, status))`	Return state of current session. A snapshot of the current session is kept in the "TestReport" object
SaveTraceExpert(file_path) `package.SaveTraceExpert( r"C:\workspace\report.html")`	Save current session in HTML format, where file_path is the full path for saving in HTML format (*.html). Use when the session is finished.
SaveTraceExpertAsCSV(file_path) `package.SaveTraceExpertAsCSV( r"C:\workspace\report.csv")`	Save current session in CSV format, where file_path is the full path for saving in CSV format (*.csv). Use when the session is finished.
SaveTraceExpertAsExcel(file_path) `package.SaveTraceExpertAsExcel( r"C:\workspace\report.xml")`	Save current session in Excel format, where file_path is the full path for saving in Excel format (*.xml). Use when the session is finished.
SaveSession(file_path) `package.SaveSession( r"C:\workspace\session.lsxp")`	Save current session to the file. This function should be called when a session is finished. `file_path` = Full path to the session file (*.lxpt)
GetDeviceManager() `device = api.GetDeviceManager()`	Return device manager for manipulation with connected devices.
GetConnectedAnalyzer() `analyzer_name = device.GetConnectedAnalyzer()`	Returns the name of the connected analyzer. If the analyzer is not connected or not initialized, returns an empty string.
GetConnectedExerciser() `exerciser_name = device.GetConnectedExerciser()`	Returns the name of the connected exerciser. If the exerciser is not connected or not initialized, returns an empty string.

Code	Description
WaitConnectedDevices(timeout_s) `device.WaitConnectedDevices()`	Waits until analyzer and exerciser are connected. `timeout_s` (optional) = Timeout in seconds. By default this value is 300
WaitConnectedAnalyzer (timeout_s) `device.WaitConnectedAnalyzer (200)`	Wait until analyzer is connected. `timeout_s` (optional) = Timeout in seconds. By default this value is 300
WaitConnectedExerciser (timeout_s) `device.WaitConnectedExerciser()`	Wait until exerciser is connected. `timeout_s` (optional) = Timeout in seconds. By default this value is 300
EnableSingleDevice (serial, is_enable) `device.EnableSingleDevice( 1500, True )`	Enables or disables device for application. LinkExpert requires an analyzer and an exerciser or an exerciser only. If you have an inappropriate number of connected analyzers or exercisers, you can disable extra devices for LinkExpert. `serial` = device serial number `is_enabled` = true, selected device enabled
ConnectNetworkDevice (serial, ip, is_analyzer) `device.ConnectNetworkDevice(1500, "192.168.7.9" True)`	Connect network device by IP and serial number. This device should be discovered on the network by LinkExpert/PeTracer before connection. `serial` = device serial number `ip` = IP address of device which must be connected `is_analyzer` = True, it is an analyzer. False, it is an exerciser
DisconnectNetworkDevice (serial, is_analyzer) `device.DisconnectNetworkDevice(1500, True)`	Disconnect network device by serial number. `serial` = device serial number `is_analyzer` = True, it is an analyzer. False, it is an exerciser
ConnectEthernetDevice (ip, device_name, check_device_availability) `device.ConnectEthernetDevice("192.168.7.9", "Summit M5X", True)`	Connect undetected device by IP and device name. LinkExpert/PeTracer may not discover some devices on the network. Use this to directly connect remote device. `ip` = IP address of device which must be connected `device_name` = Name of the selected device: Summit T34, Summit T54, Summit Z58, Summit Z516, Summit Z416, etc. `check_device_availability` = Additionally check if device exists and connected to network
IsAnalyzerConnected() `device.IsAnalyzerConnected()`	Returns True if analyzer is connected.

Code	Description
IsExerciserConnected() `device.IsExerciserConnected()`	Returns True if exerciser is connected.
IncludeRecording (serial, is_analyzer, is_include) `device.IncludeRecording( 1500, True, True )`	Include or exclude device from recording by serial number. Some analyzers can be excluded from recording and as a result will be unavailable in the connected device list. There are some exercisers with embedded analyzers which visible as two independent devices. This method can turn off analyzer from connected exerciser for working only with single exerciser. `serial` = device serial number `is_analyzer` = True, it is an analyzer. False, it is an exerciser `is_include` = Include or exclude device from recording
GetSettingsManager() `settings = api.GetSettingsManager()`	Returns settings manager.
SetLinkWidth(lane_count) `settings.SetLinkWidth(1)`	Set link width for the session where lane_count is the number of lanes: 1 = 1 lane 2 = 2 lanes 4 = 4 lanes 8 = 8 lanes 16 = 16 lanes 20 = Auto (x2 maximum) 40 = Auto (x4 maximum) 80 = Auto (x8 maximum) 1600 = Auto (x16 maximum)
SetLinkSpeed(speed) `settings.SetLinkSpeed(0)`	Set link speed for the sesssion, where speed is the speed index: 0 = Auto 1 = 2.5 Gt/s 2 = 5.0 Gt/s 3 = 8.0 Gt/s 4 = 16.0 Gt/s 5 = 32.0 Gt/s
SetPrecoding (stream, is_enabled) `settings.SetPrecoding(EStream.UPSTREAM, False)` `settings.SetPrecoding(EStream.DOWNSTREAM, True)`	Set precoding settings. `stream` = EStream. Set precoding for particular stream. `is_enabled` = True - enable precoding.

9.4 Descriptions of Internal Types

Type	Type Name	Definition
Enum	EStream	EStream.UPSTREAM - corresponds to the upstream EStream.DOWNSTREAM - corresponds to the downstream
Enum	ESpeed	ESpeed.AUTO - Auto ESpeed.GEN1 - 2.5 Gt/s ESpeed.GEN2 - 5.0 Gt/s ESpeed.GEN3 - 8.0 Gt/s ESpeed.GEN4 - 16.0 Gt/s ESpeed.GEN5 - 32.0 Gt/s
int	Number of lanes	1 - 1 lane 2 - 2 lanes 4 - 4 lanes 8 - 8 lanes 16 - 16 lanes 20 - Auto (x2 maximum) 40 - Auto (x4 maximum) 80 - Auto (x8 maximum) 160 - Auto (x16 maximum)
class	PackageID	The class keeps information for package identification: package name and package version

9.5 API Sample Code

The figure on the next page shows a sample of the API code. The code shows how to run LinkExpert tests and save result to the CSV and LXPT files.

```
import sys
sys.path.append(r'C:\Program Files\Lecroy\LinkExpert\LexAPI')
import LexApi
import time
from Enums import ESpeed
import PackageId

def PrintSnapshot(report):
    print("####### Snapshot #######")
    print("Passed: {} | Failed: {} | Aborted: {} | Skipped: {} | Total: {}".format(report.GetPassed(),report.GetFailed(),report.GetAborted(),report.GetSkipped(),report.GetTotal()))
    if len(report.GetTests()) > 0:
        print("Tests:")
    for name, status in report.GetTests():
        print("{0}. {1}".format(name, status))
    print("")


api = LexApi.LexApi("PCIe" )

device = api.GetDeviceManager()
device.WaitConnectedDevices()
analyzer_name = device.GetConnectedAnalyzer()
exerciser_name = device.GetConnectedExerciser()
print(analyzer_name)
print(exerciser_name)

settings = api.GetSettingsManager()
settings.SetLinkWidth(1)
settings.SetLinkSpeed(ESpeed.GEN1)

package = api.GetPackageManager()
package_id = PackageId.PackageId("PCIe 3.0 Compliance Package Tests (Deprecated)")

# Get information about the package
package_info = package.GetPackageInfo(package_id)
selected_tests = []

# Select only the first 20 tests
current_tests_idx = 0
for test in package_info.TestList:
    selected_tests.append(test.TestCode)
    current_tests_idx = current_tests_idx + 1
    if current_tests_idx >= 20:
        break

# Set package. Leave the second parameter empty if you want to select all tests
package.SetPackage2(package_id, selected_tests)
# Exclude the last test from the session
package.SelectTest(selected_tests[-1], False)
package.RunTests()

while package.IsRunning():
    PrintSnapshot(package.GetReport())
    time.sleep(5)
PrintSnapshot(package.GetReport())

package.StopTests()
package.SaveTraceExpertAsCSV(r"C:\workspace\report.csv")
package.SaveSession(r"C:\workspace\session.lxpt")
```

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

Register Structure for PCIe LTSSM Arc Tests

C.1 Introduction for Writing to Registers

When writing to a Register,

- Append "Config = General{ DontApplyGenOptions = Yes }" to the start. This allows values from the script to be loaded instead of the Generation Options Gui.
- "Config = be register" should contain a "RegAddress" and a "RegValues" Field.

C.1.1 Format of RegValues:

RegValues = (0x11 0x22   0x33   0x44)

The first Byte refers to Bit positions [7:0]. The second Byte refers to Bit positions [15:8]

The third Byte refers to Bit positions [23:16]. The fourth Byte refers to Bit positions [31:24]

TABLE C.1: Bit Positions in Register

0x11							
D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]

0x22							
D[15]	D[14]	D[13]	D[12]	D[11]	D[10]	D[9]	D[8]

0x33							
D[23]	D[22]	D[21]	D[20]	D[19]	D[18]	D[17]	D[16]

0x44							
D[31]	D[30]	D[29]	D[28]	D[27]	D[26]	D[25]	D[24]

C.1.2 Example: Speed_Change_Any_Lane_(Gen3_--_Gen4)_Z4.gen

```
Config = General{ DontApplyGenOptions = Yes }
Config = Definitions{ PX2_WR_REG_DIRECTED_LTSSM = 0x00009050
PX2_REG_TEST_REQUESTS = 0x000091B0
Px_REG_LTSSM_DRATE = 0x00009364
PX2_CTRL_ENABLE = 0x000090CC
}
Config = beregister
{
    RegAddress = PX2_REG_TEST_REQUESTS
    RegValues = ( 0x00 0x01 0x00 0x00 )     ; Bit [8] (Speed Change Any Lane
                                                  ) of 0x91B0 is set
}
Config = beregister
{
    RegAddress = Px_REG_LTSSM_DRATE
    RegValues = ( 0x9E 0x00 0x00 0x00 )     ;     Bit [4:1] (Combination
                                                  of all speeds) and
                                                  bit [7](Speed Change)
                                                  are set
}
Config = beregister
{
    RegAddress = PX2_CTRL_ENABLE
    RegValues = ( 0x01 0x00 0x00 0x00 ) - ;   Bit [0] (Update Link Training
                                                  Settings ) of 0x90CC is set
}
```

C.1.3 Register Addresses and Definitions Z3

0x80090134

0x90134	PX2_WR_REG_TARGET_LINKWIDTH	Write	x06	Target Link Width to be achieved when directing to change link width.
				D[2:0] Target Link Width
				001 -> X1
				010 -> X2
				011 -> X4
				100 -> X8
				101 -> X12
				110 -> X16
				Others Reserved
				D[7:3] Reserved

0x80090050

0x90050	PX2_WR_REG_DIRECTED_LTSSM	Write	X10	When a 1 in a particular bit, the LTSSM will be directed to the state:
				D[0] DETECT
				D[1] COMPLIANCE
				D[2] CONFIGURATION (pulsed)
				D[3] RECOVERY (pulsed)
				D[4] TX.L0s
				D[5] Change Link Width (pulsed)
				D[6] DISABLED (pulsed)
				D[7] Reserved
				D[8] Reserved
				D[9] RECOVERY EQUALIZATION (Pulsed)
				D[10] L0 (pulsed)

0x80090368

0x90368	PX_REG_LTSSM_TCONTROL (Simultaneous Enabled)	Write	x00	Advertised Control in TS packets.
				D[0] Hot Reset
				D[1] RESERVED
				D[2] Loopback
				D[3] Disable Scrambling
				D[4] Compliance Receive
				D[7:5] Reserved

0x800900CC

0x900CC	PX2_CTRL_ENABLE	Control	na	Update link training settings at the same time.

0x800A00A4

0xA00A4	GEN2TRAINER_REG_LOWPOWER_CAPABILITIES	Write	0	D[0] Enable Gen2 trainer to go to L1 on DUT request. 0:Disabled. FW generates NAK TLP. 1:Enabled.
				D[1] Trainer initiates L1 sequence using PCI-PM protocol.
				D[2] Trainer initiates L1sequence using ASPM protocol.
				D[3] Trainer initiates L2/L3 sequence.
				NOTE: 0 -> 1 Trainer starts sequence as soon as scheduled TLPs are transmitted. And goes in to L1 if DUT acks.
				1 -> 0 Trainer exits L1 if still on that state.
				D[31:4] Reserved.

0x80090364

0x90364	PX_REG_LTSSM_DRATE (Simultaneous Enabled)	Write	x0E	Advertised Data Rate in TS packets.
				D[0] Reserved
				D[3:1] Advertised Data Rate
				000 -> Reserved
				001 -> Gen1 Only
				010 -> Gen2 Only
				011 -> Gen1 and Gen2
				111 -> Gen1 and Gen2 and Gen3
				D[5:4] Reserved
				D[6] Autonomous Change Selectable Deemphasis Link Upconfigure
				D[7] Speed Change

0x800901B0

0x901B0	PX2_REG_TEST_REQUESTS	WR/RD	x00	Test Requests D[0] Recovery Receiver Lock to Detect D[1] Recovery Receiver Lock to Cfg D[2] Recovery Receiver Cfg to Detect D[3] Recovery Idle to Detect D[4] Current Data Rate Fail Seen By Trainer D[5] Negotiated Data Rate Fail Seen By Trainer D[6] Current Data Rate Fail Seen By DUT D[7] Negotiated Data Rate Fail Seen By DUT D[8] Speed Change Any Lane D[9] Redo Equalization D[10] DUT Recovery EQ Phase 0 To Speed D[11] DUT Recovery EQ Phase 1 To Speed D[12] DUT Recovery EQ Phase 2 To Speed D[13] DUT Recovery EQ Phase 3 To Speed D[14] Trainer Timeout Recovery EQ Phase 0 D[15] Trainer Timeout Recovery EQ Phase 1 D[16] Trainer Timeout Recovery EQ Phase 2 D[17] Trainer Timeout Recovery EQ Phase 3 D[18] Cfg Idle To Recovery D[19] Preset Calibration D[20] Reserved Bits [17:10] are registered. Remaining bits are pulsed

C.1.4 Register Addresses and Definitions Z4:

0x9134

0x0_9134	PHY_TARGET_LINKWIDTH	Read/Write	x06	Target Link Width to be achieved when directing to change link width.
				D[2:0] Target Link Width
				001 -> X1
				010 -> X2
				011 -> X4
				100 -> X8
				101 -> X12
				110 -> X16
				Others Reserved
				D[7:3] Reserved

0x9050

0x0_9050	PHY_DIRECTED_LTSSM_STATE	Write	X10	When a 1 in a particular bit, the LTSSM will be directed to the state:
				D[0] DETECT
				D[1] COMPLIANCE
				D[2] CONFIGURATION (pulsed)
				D[3] RECOVERY (pulsed)
				D[4] TX.L0s
				D[5] Change Link Width (pulsed)
				D[6] DISABLED (pulsed)
				D[7] Reserved
				D[8] Reserved
				D[9] RECOVERY EQUALIZATION (Pulsed)
				D[10] L0 (pulsed)

0x9368

0x0_9368	PHY_ADVERTISE_LTSSM_TCONTROL (Simultaneous Enabled)	Read/Write	x00	Advertised Control in TS packets.
				D[0] Hot Reset
				D[1] RESERVED
				D[2] Loopback
				D[3] Disable Scrambling
				D[4] Compliance Receive
				D[7:5] Reserved

0x90CC

0x0_90CC	PHY_SIMULTANEOUS_CONTROL_ENABLE	Control	na	Update link training settings at the same time.

0xA0A4

0x0_A0A4	DLL_REG_LOWPOWER_CAPABILITIES D[3:1] Self Clearing	Write/Read	00000000	D[0] Enable Gen2 trainer to go to L1 on DUT request: 0=Disabled. FW generates NAK TLP. 1=Enabled.
				D[1] Trainer initiates L1 sequence using PCI-PM protocol.
				D[2] Trainer initiates L1 sequence using ASPM protocol.
				D[3] Trainer initiates L2/L3 sequence.
				NOTE: 0 -> 1 Trainer starts sequence as soon as scheduled TLPs are transmitted. And goes in to L1 if DUT acks. 1 -> 0 Trainer exits L1 if still on that state. D[31:4] Reserved.

0x00009364

0x0_9364	PHY_ADVERTISE_LTSSM_DRATE (Simultaneous Enabled)	Read/Write	x0E	Advertised Data Rate in TS packets.
				D[0] Reserved
				D[4:1] Advertised Data Rate
				[4] Gen4
				[3] Gen3
				[2] Gen2
				[1] Gen1
				Note: Normally the highest data rate requested along with all lower rates are sent, but this register allows any combination to be sent
				D[5] Reserved
				D[6] Autonomous Change Selectable Deemphasis Link Upconfigure
				D[7] Speed Change

0x000091B0

0x0_91B0	PHY_TEST_REQUESTS	Read/Write	x00	Test Requests
				D[0] Recovery Receiver Lock to Detect
				D[1] Recovery Receiver Lock to Cfg
				D[2] Recovery Receiver Cfg to Detect
				D[3] Recovery Idle to Detect
				D[4] Current Data Rate Fail Seen By Trainer
				D[5] Negotiated Data Rate Fail Seen By Trainer D[6] Current Data Rate Fail Seen By DUT
				D[7] Negotiated Data Rate Fail Seen By DUT
				D[8] Speed Change Any Lane
				D[9] Redo Equalization
				D[10] DUT Recovery EQ Phase 0 To Speed
				D[11] DUT Recovery EQ Phase 1 To Speed
				D[12] DUT Recovery EQ Phase 2 To Speed
				D[13] DUT Recovery EQ Phase 3 To Speed
				D[14] Trainer Timeout Recovery EQ Phase 0
				D[15] Trainer Timeout Recovery EQ Phase 1
				D[16] Trainer Timeout Recovery EQ Phase 2
				D[17] Trainer Timeout Recovery EQ Phase 3
				D[18] Cfg Idle To Detect
				D[19] Preset Calibration
				D[20] TestGen4EQ
				D[31:21] Reserved
				Bits [17:10] are registered.
				Remaining bits are pulsed
				Note: TestGen4EQ is used in conjunction with the existing EQ test bits. It should be cleared for Gen3 EQ phase tests and set when desiring to test Gen4 EQ.

Appendix D

PCIe Compliance Equipment Configuration

The following tables list the equipment configurations possible with PCIe.

Note: Configurations in **bold** are recommended.

TABLE D.1: PCIe 5.0 Compliance Equipment Configuration

Exerciser	Analyzer	Interposer	Test Platform	Cable	Cable SKU
Summit Z58	Summit T54 G5Phy	Gen5	PXP500	Gen5 Straight	PE027UCA-X
Summit Z516	Summit T54 G5Phy	Gen5	PXP500	Gen5 Straight	PE027UCA-X
Summit Z58	Summit M5x	Gen5	PXP500	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	Summit M5x	Gen5	PXP500	Gen5 Y Cable M5x	PE029UCA-X
Summit Z58	Summit T516	Gen5	PXP500	Gen5 Y	PE028UCA-X
Summit Z516	Summit T516	Gen5	PXP500	Gen5 Y	PE028UCA-X
Summit Z58	**Analyzer License**		**PXP500**		
Summit Z58	Summit T54 G5Phy		Summit Z5 Test Platform	Gen5 Straight	PE027UCA-X
Summit Z516	Summit T54 G5Phy		Summit Z5 Test Platform	Gen5 Straight	PE027UCA-X
Summit Z58	Summit M5x		Summit Z5 Test Platform	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	Summit M5x		Summit Z5 Test Platform	Gen5 Y Cable M5x	PE029UCA-X
Summit Z58	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X

TABLE D.1: PCIe 5.0 Compliance Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z516	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z58	**Analyzer License**		**Summit Z5 Test Platform**		

TABLE D.2: PCIe-CXL 1.1/2.0 Compliance Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z516	Summit T54 G5Phy	Gen5	PXP500	Gen5 Straight	PE027UCA-X
Summit Z516	Summit M5x	Gen5	PXP500	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	**Summit T516**	**Gen5**	**PXP500**	**Gen5 Y**	**PE028UCA-X**
Summit Z516	Summit T54 G5Phy	Gen5	Summit Z5 Test Platform	Gen5 Straight	PE027UCA-X
Summit Z516	Summit M5x	Gen5	Summit Z5 Test Platform	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	**Summit T516**	**Gen5**	Summit Z5 Test Platform	**Gen5 Y**	**PE028UCA-X**

TABLE D.3: PCIe 4.0 Compliance Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z416	Summit T48	Gen4	PXP400	Gen4 Y	PE021UCA-X
Summit Z416	Summit T416	Gen4	PXP400	Gen4 Y	PE021UCA-X
Summit Z416	**Analyzer License**		**PXP400**		
Summit Z416	Summit T54 G4Phy	Gen4	PXP400	Gen4 Straight	PE020UCA-X
Summit Z58	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z516	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z58	**Analyzer License**		**PXP500**		
Summit Z416	Summit T48		Summit Z4 Test Platform	Gen4 Y	PE021UCA-X

TABLE D.3: PCIe 4.0 Compliance Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z416	Summit T416		Summit Z4 Test Platform	Gen4 Y	PE021UCA-X
Summit Z416	**Analyzer License**		**Summit Z4 Test Platform**		
Summit Z58	Summit T54 G5Phy		Summit Z5 Test Platform	Gen5 Straight	PE027UCA-X
Summit Z516	Summit T54 G5Phy		Summit Z5 Test Platform	Gen5 Straight	PE027UCA-X
Summit Z58	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z516	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z58	**Analyzer License**		**Summit Z5 Test Platform**		

TABLE D.4: PCIe 3.0 Compliance Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z3-16	Summit T34	Gen3	PXP400	Gen3 Straight	PE013UCA-X
Summit Z3-16	Summit T3-8	Gen3	PXP400	Gen3 Y	PE010UCA-X
Summit Z3-16	Summit T3-16	Gen3	PXP400	Gen3 Y	PE010UCA-X
Summit Z416	Summit T48	Gen3	PXP400	G3/G4 Conversion Y	PE016UCA-X
Summit Z416	Summit T416	Gen3	PXP400	G3/G4 Conversion Y	PE016UCA-X
Summit Z416	**Analyzer License**		**PXP400**		
Summit Z416	Summit T54 G4Phy	Gen4	PXP400	Gen4 Straight	PE020UCA-X
Summit Z416	Summit T54 G5Phy	Gen4	PXP400	G4/G5 Conversion Straight	PE034UCA-X
Summit Z58	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z516	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z58	**Analyzer License**		**PXP500**		

TABLE D.4: PCIe 3.0 Compliance Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z3-16	Summit T34		Summit Z3 Test Platform	Gen3 Straight	PE013UCA-X
Summit Z3-16	Summit T3-8		Summit Z3 Test Platform	Gen3 Y	PE010UCA-X
Summit Z3-16	Summit T3-16		Summit Z3 Test Platform	Gen3 Y	PE010UCA-X
Summit Z416	Summit T48		Summit Z4 Test Platform		
Summit Z416	Summit T416		Summit Z4 Test Platform		
Summit Z416	**Analyzer License**		**Summit Z4 Test Platform**		
Summit Z58	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z516	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z58	**Analyzer License**		**Summit Z5 Test Platform**		

TABLE D.5: NVMe-MI/MCTP SMBus Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z3-16 w SMBus	Summit T34	Gen3 w SMBus	PXP400	Gen3 Straight (Blue)	PE015UCA-X
Summit Z3-16 w SMBus	Summit T3-8	Gen3 w SMBus	PXP400	Gen3 Y	PE010UCA-X
Summit Z3-16 w SMBus	Summit T3-16	Gen3 w SMBus	PXP400	Gen3 Y	PE010UCA-X
Summit Z416	Summit T48	Gen3 w SMBus	PXP400	G3/G4 Conversion Y	PE016UCA-X
Summit Z416	Summit T416	Gen3 w SMBus	PXP400	G3/G4 Conversion Y	PE016UCA-X
Summit Z416	**Analyzer License**		**PXP400**		
Summit Z416	Summit T54 G4Phy	Gen4	PXP400	Gen4 Straight	PE020UCA-X
Summit Z416	Summit T54 G4Phy	Gen4	PXP400	G4/G5 Conversion Straight	PE034UCA-X

TABLE D.5: NVMe-MI/MCTP SMBus Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z58	Summit M5x	Gen5	PXP400	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	Summit M5x	Gen5	PXP500	Gen5 Y Cable M5x	PE029UCA-X
Summit Z58	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z516	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z58	**Analyzer License**		**PXP500**		
Summit Z3-16 w SMBus	Summit T34		Summit Z3 Test Platform w SMBus	Gen3 Straight (Blue)	PE015UCA-X
Summit Z3-16 w SMBus	Summit T3-8		Summit Z3 Test Platform w SMBus	Gen3 Y	PE010UCA-X
Summit Z3-16 w SMBus	Summit T3-16		Summit Z3 Test Platform w SMBus	Gen3 Y	PE010UCA-X
Summit Z416	Summit T48		Summit Z4 Test Platform		
Summit Z416	Summit T416		Summit Z4 Test Platform		
Summit Z416	**Analyzer License**		**Summit Z4 Test Platform**		
Summit Z58	Summit M5x		Summit Z5 Test Platform	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	Summit M5x		Summit Z5 Test Platform	Gen5 Y Cable M5x	PE029UCA-X
Summit Z58	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z516	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z58	**Analyzer License**		**Summit Z5 Test Platform**		

TABLE D.6: NVMe-MI/MCTP VDM Equipment Configuration

Exerciser	Analyzer	Interposer	Test Platform	Cable	Cable SKU
Summit Z3-16	Summit T34	Gen3	PXP400	Gen3 Straight	PE013UCA-X
Summit Z3-16	Summit T3-8	Gen3	PXP400	Gen 3 Y	PE010UCA-X
Summit Z3-16	Summit T3-16	Gen3	PXP400	Gen 3 Y	PE010UCA-X
Summit Z416	Summit T48	Gen3	PXP400	G3/G4 Conversion Y	PE016UCA-X
Summit Z416	Summit T416	Gen3	PXP400	G3/G4 Conversion Y	PE016UCA-X
Summit Z416	**Analyzer License**		**PXP400**		
Summit Z416	Summit T54 G4Phy	Gen4	PXP400	Gen4 Straight	PE020UCA-X
Summit Z416	Summit T54 G5Phy	Gen4	PXP400	G4/G5 Conversion Straight	PE034UCA-X
Summit Z58	Summit M5x	Gen5	PXP500	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	Summit M5x	Gen5	PXP500	Gen5 Y Cable M5x	PE029UCA-X
Summit Z58	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z516	Summit T516	Gen4	PXP500	G4/G5 Conversion Y	PE033UCA-X
Summit Z58	**Analyzer License**		**PXP500**		
Summit Z3-16	Summit T34		Summit Z3 Test Platform	Gen3 Straight	PE013UCA-X
Summit Z3-16	Summit T3-8		Summit Z3 Test Platform	Gen 3 Y	PE010UCA-X
Summit Z3-16	Summit T3-16		Summit Z3 Test Platform	Gen 3 Y	PE010UCA-X
Summit Z416	Summit T48		Summit Z4 Test Platform		
Summit Z416	Summit T416		Summit Z4 Test Platform		
Summit Z416	**Analyzer License**		**Summit Z4 Test Platform**		

TABLE D.6: NVMe-MI/MCTP VDM Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z58	Summit M5x		Summit Z5 Test Platform	Gen5 Y Cable M5x	PE029UCA-X
Summit Z516	Summit M5x		Summit Z5 Test Platform	Gen5 Y Cable M5x	PE029UCA-X
Summit Z58	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z516	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z58	**Analyzer License**		**Summit Z5 Test Platform**		

TABLE D.7: Jammer NVMe Test 1.0 Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit M5x (Jammer)	Analyzer License		PXP400		

TABLE D.8: PCIe RAS Error Injection Tests Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit M5x (Jammer)	Analyzer License		PXP400		

TABLE D.9: LinkExpert System Level Tests Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
	Summit T34	Gen3		Gen3 Straight	PE013UCA-X
	Summit T3-8	Gen3		Gen 3 Y	PE010UCA-X
	Summit T3-16	Gen3		Gen 3 Y	PE010UCA-X
	Summit T48	Gen3		G3/G4 Conversion Y	PE016UCA-X
	Summit T416	Gen3		G3/G4 Conversion Y	PE016UCA-X
	Summit T54 G4Phy	Gen4		Gen4 Straight	PE020UCA-X

TABLE D.9: LinkExpert System Level Tests Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
	Summit T54 G5Phy	Gen5		Gen5 Straight	PE027UCA-X
	Summit T516	Gen5		Gen5 Y	PE028UCA-X

TABLE D.10: Validation Tests (Endpoint) Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z3-16	Summit T34	Gen3	PXP400	Gen3 Straight	PE013UCA-X
Summit Z3-16	Summit T3-8	Gen3	PXP400	Gen3 Y	PE010UCA-X
Summit Z3-16	Summit T3-16	Gen3	PXP400	Gen3 Y	PE010UCA-X
Summit Z416	Summit T48	Gen4	PXP400	Gen4 Y	PE021UCA-X
Summit Z416	Summit T416	Gen4	PXP400	Gen4 Y	PE021UCA-X
Summit Z416	**Analyzer License**		**PXP400**		
Summit Z58	Summit T54 G5Phy	Gen5	PXP500	Gen5 Straight	PE027UCA-X
Summit Z516	Summit T54 G5Phy	Gen5	PXP500	Gen5 Straight	PE027UCA-X
Summit Z58	Summit T516	Gen5	PXP500	Gen5 Y	PE028UCA-X
Summit Z516	Summit T516	Gen5	PXP500	Gen5 Y	PE028UCA-X
Summit Z58	Analyzer License		PXP500		
Summit Z3-16	Summit T34		Summit Z3 Test Platform	Gen3 Straight	PE013UCA-X
Summit Z3-16	Summit T3-8		Summit Z3 Test Platform	Gen3 Y	PE010UCA-X
Summit Z3-16	Summit T3-16		Summit Z3 Test Platform	Gen3 Y	PE010UCA-X
Summit Z416	Summit T48		Summit Z4 Test Platform		
Summit Z416	Summit T416		Summit Z4 Test Platform		
Summit Z416	Analyzer License		Summit Z4 Test Platform		
Summit Z58	Summit T54 G5Phy		Summit Z5 Test Platform	Gen5 Straight	PE027UCA-X
Summit Z516	Summit T54 G5Phy		Summit Z5 Test Platform	Gen5 Straight	PE027UCA-X

TABLE D.10: Validation Tests (Endpoint) Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z58	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z516	Summit T516		Summit Z5 Test Platform	Gen5 Y	PE028UCA-X
Summit Z58	Analyzer License		Summit Z5 Test Platform		

TABLE D.11: Validation Tests (Root Complex) Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z3-16	Summit T34	Gen3		Gen3 Straight	PE013UCA-X
Summit Z3-16	Summit T3-8	Gen3		Gen3 Y	PE010UCA-X
Summit Z3-16	Summit T3-16	Gen3		Gen3 Y	PE010UCA-X
Summit Z416	Summit T48	Gen4		Gen4 Y	PE021UCA-X
Summit Z416	Summit T416	Gen4		Gen4 Y	PE021UCA-X
Summit Z416	Analyzer License				
Summit Z58	Summit T54 G5Phy	Gen5		Gen5 Straight	PE027UCA-X
Summit Z516	Summit T54 G5Phy	Gen5		Gen5 Straight	PE027UCA-X
Summit Z58	Summit T516	Gen5		Gen5 Y	PE028UCA-X
Summit Z516	Summit T516	Gen5		Gen5 Y	PE028UCA-X
Summit Z58	Analyzer License				

TABLE D.12: LTSSM Arc Test (Endpoint) Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z3-16			PXP400		
Summit Z416			PXP400		
Summit Z58			PXP500		
Summit Z516			PXP500		
Summit Z3-16			Summit Z3 Test Platform		
Summit Z416			Summit Z4 Test Platform		

TABLE D.12: LTSSM Arc Test (Endpoint) Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z58			Summit Z5 Test Platform		
Summit Z516			Summit Z5 Test Platform		

TABLE D.13: LTSSM Arc Test (Root Complex) Equipment Configuration					
Exerciser	**Analyzer**	**Interposer**	**Test Platform**	**Cable**	**Cable SKU**
Summit Z3-16					
Summit Z416					
Summit Z58					
Summit Z516					
Summit Z3-16					
Summit Z416					
Summit Z58					
Summit Z516					

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