PROTOCOL INSIGHT

Falcon Series - User Manual

Contact Protocol Insight at:

sales@protocolinsight.com
support@protocolinsight.com
www.protocolinsight.com

Contents

Safety Information

Observe the following precautions to avoid fire or injury and prevent damage to this product or any products connected to it.

Use this product only for its intended purpose as specified.

Use only the power adaptor specified for this product and certified for the country of use.

Ensure that the power source provides the power level supported by the power adaptor.

To avoid fire or shock hazard, observe all ratings and markings on the product and power supply and ensure the product is properly grounded.

Do not connect or disconnect probes or test leads while they are connected to a voltage source. Connect the probe reference lead to earth ground only.

Do not block the power cord, it should always be accessible to the user.

Do not operate this product with covers or panels removed.

If you suspect that there is damage to this product, have it inspected by qualified service personnel. Do not operate with suspected failures.

Do not operate in wet/damp conditions. Do not operate in an explosive atmosphere. Keep product surfaces clean and dry. Provide proper ventilation for operation of product.

Only qualified Protocol Insight personnel or representatives should perform service procedures.

Calibration Requirements

Protocol Insight declares calibration is not required to maintain the accuracy or normal operating parameters for the Falcon series UFS/UniPro Exerciser/Analyzers. Ensure the device is used in accordance with the **OPERATING CONDITIONS** for the instrum/ent.

Product Overview

The Falcon series are the established industry standard with powerful protocol analyzer and exerciser capabilities and unprecedented flexibility.

- The **Falcon G500C** is an analyzer that can capture x2 bi-directional links as a "sniffer". It supports UFS 4.0, UniPro 2.0 and M-PHY 5.0 HS-G5.

- The **Falcon G550C** is an exerciser/analyzer; it is identical to the G500C analyzer but is also a protocol exerciser that can generate link traffic on a x2 bi-directional link while simultaneously capturing the response traffic from the DUT. The Falcon G550C exerciser can perform host emulation and execute the UniPro and JEDEC Compliance/Conformance Test Suites (CTS).

Key Features

Smart Tune™ equalization

Capturing the signal from the DUT can be problematic when trace routing or the cabling to the test fixture causes poor signal integrity or probing issues. Smart Tune™ equalization optimizes signal acquisition at the analyzer to ensure error-free MPHY symbol capture.

Eye Monitor

Eye Monitor constructs an eye diagram of the link to determine link quality. Qualitative measurements can be done on the eye diagram for jitter, noise, and eye opening.

Streaming capture

Streaming capture uses the full 40Gbs bandwidth of Thunderbolt3 to store link traffic directly to disk in real time.

Trace Validation™ (TV) analysis

Trace Validation uses state machine logic to analyze captured traces algorithmically without user intervention. It analyzes bi-directional UniPro and UFS traffic, performing protocol sequence and timing analysis and packet header and payload inspection.

Events view

Displays events on the bus in a unique time-aligned display, and includes fillers, Prepare, SYNC, Hibern8, sleep, stall and other M-PHY level packets. Events view presents a complete picture of all events and allows drill-down to the lowest level bytes.

Compliance (CTS) Testing (Falcon G550C only)

Test executive performs compliance verification of UFS 3.1/2.1 and conformance verification of UniPro 1.8 with Compliance/Conformance Test Suites (CTS). UFS 4.0 and UniPro 2.0 support is planned. It executes a range of CTS test cases, analyzing results using the Trace Validation engine and generating pass/fail and summary reports.

Stimulus for corner case and margin testing (Falcon G550C only)

Stimulus with full UniPro stack in HW allows creation of specific traffic on the link, offers extensive error injection and is capable of full protocol emulation.

Test executive stress testing (Falcon G550C only)

Test executive stress testing executes hundreds of thousands of tests automatically. Stop after any number of loops or No Result Test Cases.

Custom test case creation

Design custom tests to test corner cases or introduce errors for margin, stress, or error recovery testing. Editors allow complex test creation, error injection, device control, and protocol sequence and packet state machine construction for stimulus and Trace Validation.

Instrument Description

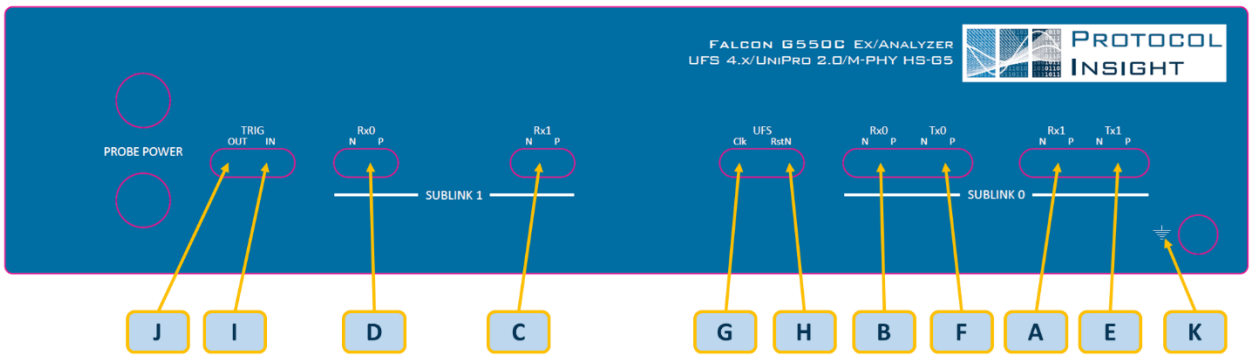
The Falcon G500 series consists of an instrument and a power brick. A controller PC with Thunderbolt 3 connectivity is required and is not included. Other components required for instrument operation that are not supplied include 50 ohm matched-length cables and power splitters, or a solder-down probe. See **ACCESSORIES** for more information.

The Falcon G500 front panel connectors are used to probe links at the Tx, Rx, or the midpoint. The "Sublink 0 Analyzer" connectors are used to capture and analyze one direction of link traffic while the "Sublink 1 Analyzer" connectors capture the other direction of link traffic.

The Falcon G550 "Sublink 1 Tx Exerciser" front panel connectors generate traffic on the link and the "Sublink 0 Exerciser/Analyzer" connectors are used to capture and analyze the response traffic. When using the instrument as an exerciser the "Sublink 1 Analyzer" connectors are not used.

The connectors on the front panel are labeled from the instrument perspective, not the DUT perspective. So, the connectors labeled Rx are for capturing signals from the bus and connectors labeled Tx are for generating traffic on the bus.

Exerciser/Analyzer Front Panel - Falcon G500C/G550C



Front panel connectors:

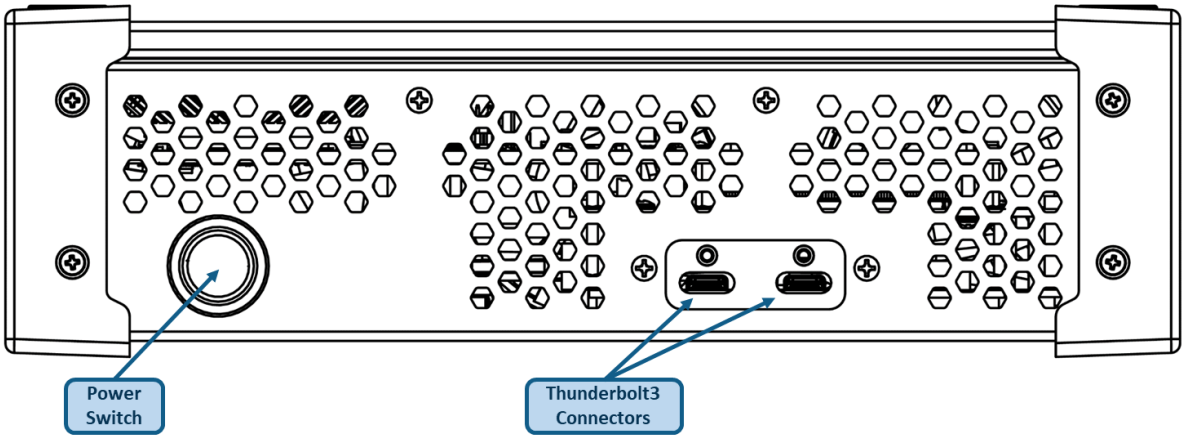
A. Connect the TxDN and TxDP from device M-Tx lane 1 here.
B. Connect the TxDN and TxDP from device M-Tx lane 0 here.
C. Connect the RxDN and RxDP from device M-Rx lane 1 here. This is used for the analyzer only, for the exerciser these connectors are not used.
D. Connect the RxDN and RxDP from device M-Rx lane 0 here. This is used for the analyzer only, for the exerciser these connectors are not used.
E. Connect to the RxDN and RxDP from device M-Rx lane 1 here. This is used for the exerciser only, for the analyzer these connectors are not used.
F. Connect to the RxDN and RxDP from device M-Rx lane 0 here. This is used for the exerciser only, for the analyzer these connectors are not used.
G. Generates a UFS reference clock on 19.2, 26, 38.4 and 52 MHz at 1.2V.
H. Generates a 1.2V reset signal.
I. Trigger in to the analyzer.
J. Trigger out from the analyzer.
K. Ground

Connectors are SMP male.

NOTE: use of connector savers on the instument front panel SMP connectors is strongly recommended to avoid damage to the connectors. See THIRD PARTY ACCESSORIES for recomended connector saver accessories.

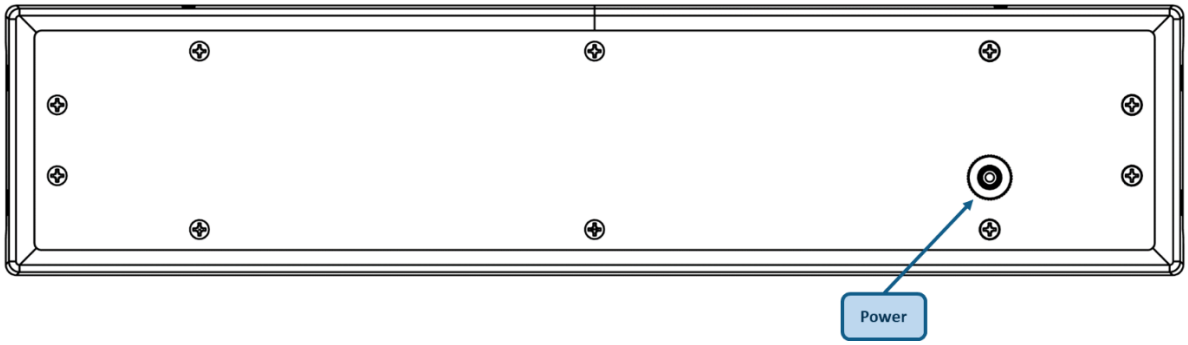
Side Panels

Right



The Thunderbolt 3 connectors, which are USB Type-C connectors, do not support USB3.0.

Rear



The power connector type is IEC, center pin is +12V.

Licenses Available

Full

Falcon Instruments utilize an embedded HW key and no SW license is required. This key is configured at the factory, floats with the instrument and works with any PC.

Offline

If the application software is launched with no SW or HW key present, the application will enable Offline-only capabilities. When Offline the user can open previously saved trace files to analyze the trace. The analysis windows available in Offline include the list, protocol decode and events windows. Offline-only does not enable the Trace Validation Results window or Trace Validation Editor.

Offline Viewer with Trace Validation and TV Editor

This license is a SW license available from support@protocolinsight.com. SW license keys are node-locked to a PC and are not transferable. *Offline with TV and TV Editor* operates like the standard Offline but enables the Trace Validation Results window and TV Editor to create custom TV tests.

Offline Viewer with Trace Validation and all Editors

This license is a SW license available from support@protocolinsight.com. SW license keys are node-locked to a PC and are not transferable. *Offline with TV and all Editors* operates like the standard Offline but enables the Trace Validation Results window plus all Editors, including the TV, advanced trigger, and stimulus Editor.

Options and Upgrades

Contact your local representative for list of available instrument SW/FW upgrades.

Accessories

FG5PSD2	HS-G5 x2 solder probe – 4 signal cables, 2 amplifiers/power cables, 4 probe tips
FG5PSD01	HS-G5 Probe Amplifier
FG5PSD05	HS-G5 Probe Tip
FG5PSD07	HS-G5 Power Cable
FG5PSD08	HS-G5 Signal Cable
FG4PSD2B	HS-G4B x2 Bundle – 2 pigtail cables with power connectors and probe tips
FG4PSD05	HS-G4B Coax Multi-lead Probe Tip (6 inch)
FG4PSD07	Pigtail cable with power connector
FSWOVTVE	Offline Viewer with Trace Validation and TV Editor
FSWOVTVEDITORS	Offline Viewer with Trace Validation and all Editors
EnhanceConn	Enhanced connectivity kit – Thunderbolt 3 6ft/2m 40Gbps active cable and retention device
FAECase	Field carry bag

Third Party Accessories

The following accessories are available from third party suppliers:

HS-G5

- Accessories recommendations will be provided in the future.

HS-G4

- Connector savers: Adapter Coaxial Connector SMP Plug, Male Pin To SMP Jack, Female 50 Ohm Amphenol SV Microwave 1112-4012 CONN ADAPT PLUG-JACK SMP 50 OHM ADAPTER COAXIAL CONNECTOR or equivalent
- SMP-to-SMA cables: ≥18GHz, ≤225mm/9” length, phase-matched
  Centric RF C572-086-09B or equivalent
- SMA to SMA cables: ≥18GHz, ≤225mm/9” length, phase-matched
  Centric RF C581-086-09 or equivalent
- Power splitter, DC-18 GHz
  Mini-Circuits ZFRSC-183-S+ or equivalent

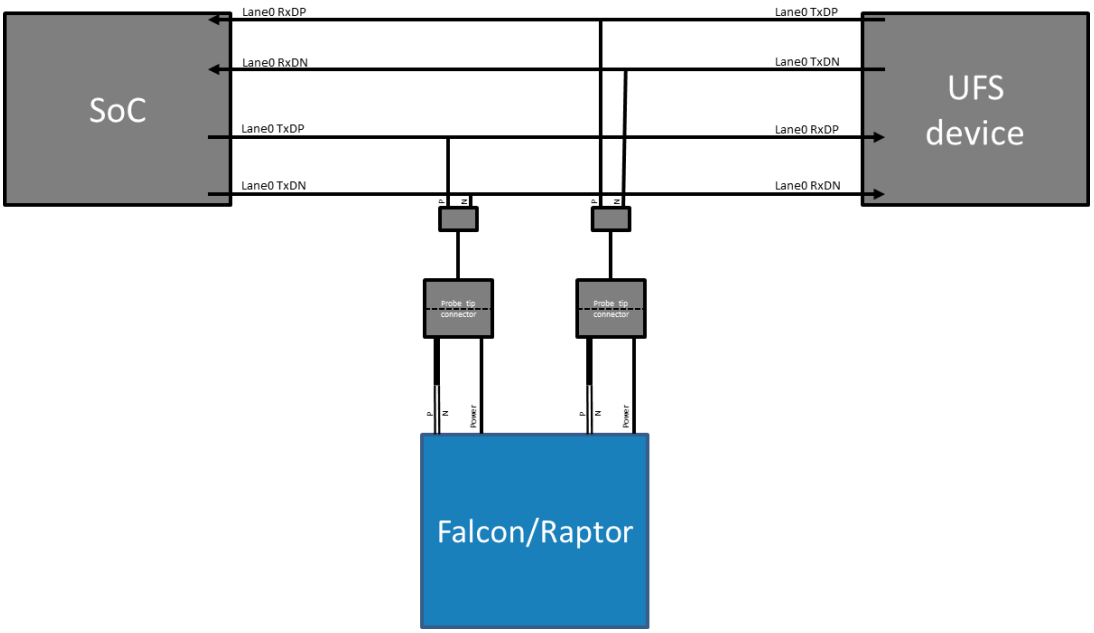
Probing Configuration Options

Depending on the application, analyzer or exerciser/analyzer, there are several different recommended probing options for connecting to the DUT provided below.

Analyzer

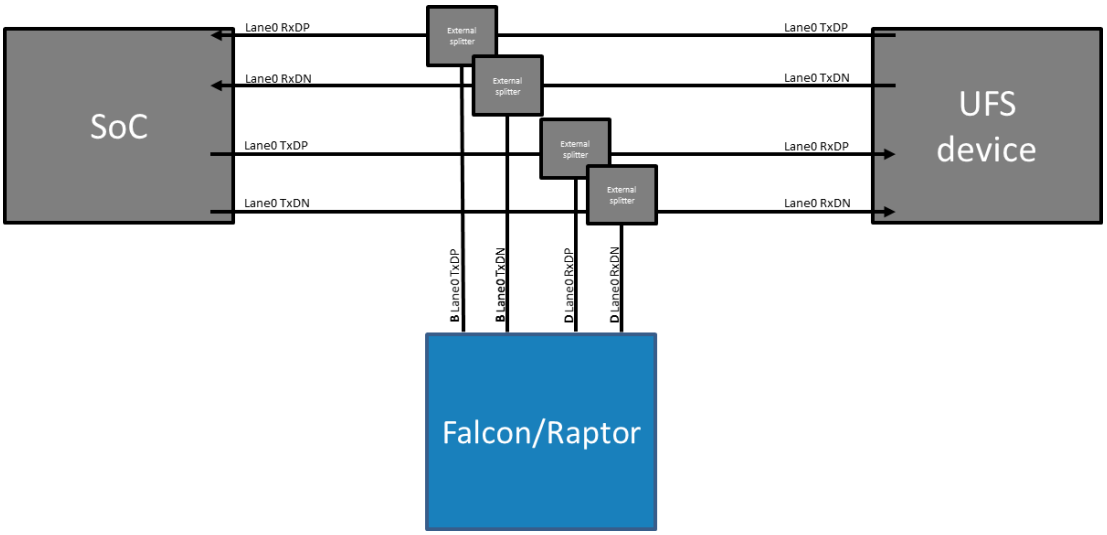
Solder-down

x1 link shown



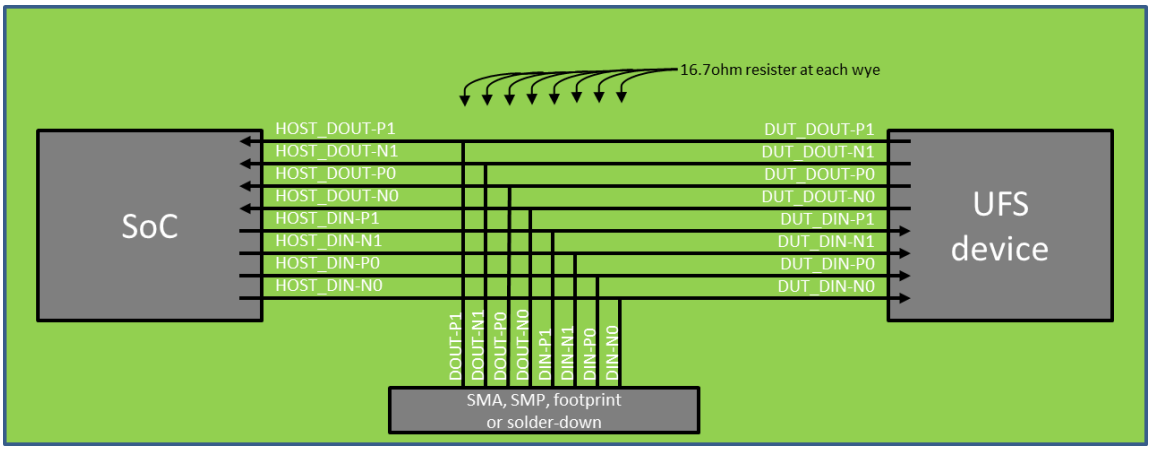
Splitters

For speeds up to HS-G4B, off-the-shelf power splitters such as the Mini-Circuits DC-18 GHz ZFRSC-183-S+ can be used with standard SMP to SMA cables of ≥18GHz and maximum of 12 inches in length. Each link requires four power splitters and 12 cables as shown in this x1 link example:



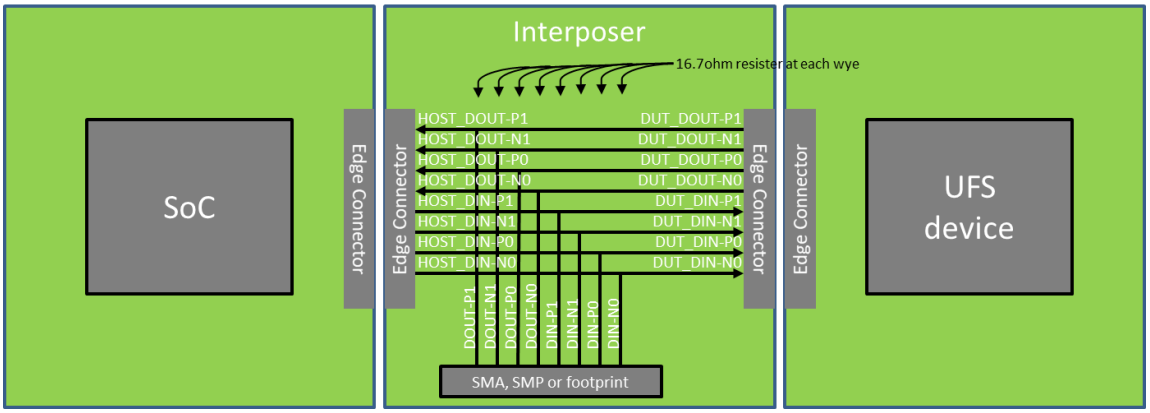
Breakout DUT

For speeds up to HS-G4B, 50% split = 16.7Ω ± 1Ω resistor



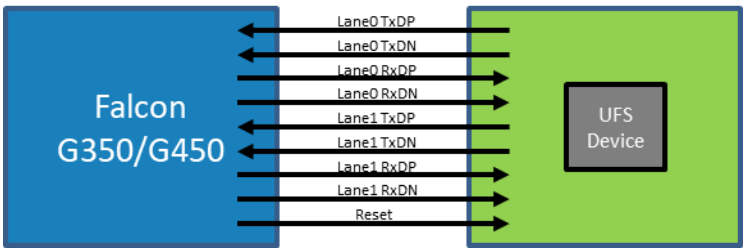
Interposer

For speeds up to HS-G4B, 50% split = 16.7Ω ± 1Ω resistor



Exerciser

Direct connection



Setup and Operation

General Instrument Configuration

All general instrument, device and user preference settings can be accessed from either the Settings menu or by clicking  from the toolbar. See **SETTINGS WINDOW** for information on how to change general settings.

Analyzer Configuration

To configure for general debug analysis or for Trace Validation follow these steps:

Step 1: Connect the probes

Note: the labels on the analyzer front panel are from the instrument perspective.

1. Connect the Sublink 0 Rx_1N to TxDN from the device M-Tx lane 1.
2. Connect the Sublink 0 Rx_1P to TxDP from the device M-Tx lane 1.
3. Connect the Sublink 0 Rx_0N to TxDN from the device M-Tx lane 0.
4. Connect the Sublink 0 Rx_0P to TxDP from the device M-Tx lane 0.
5. Connect the Sublink 1 Rx_1N to RxDN from the device M-Rx lane 1.
6. Connect the Sublink 1 Rx_1P to RxDP from the device M-Rx lane 1.
7. Connect the Sublink 1 Rx_0N to RxDN from the device M-Rx lane 0.
8. Connect the Sublink 1 Rx_0P to RxDP from the device M-Rx lane 0.

See **PROBING CONFIGURATION OPTIONS** for more information on how to connect to the DUT.

Step 2: Configure the analyzer

1. Select Analyzer mode on the toolbar (G550C only)
2. Under Instrument Configuration select the desired memory Capture Options.
3. Under Instrument Configuration set the Connected Link Width for each direction to x1 or x2.
4. Under User Preferences determine if UFS packets are decoded when the trace capture is complete.

Step 3: Capture the trace

1. Configure the trigger from the Tools menu if desired.
2. Press Analyzer Connect, then Start, and capture the trace.

Step 4: Configure and run Trace Validation tests

1. Go to the TV Configuration window.
2. Select which Trace Validation Tests to run.
3. Press the Start button and watch the TV Results windows fill with Pass, Fail, Warning, or Info results.

Exerciser Configuration (G550C only)

To configure for compliance/conformance (CTS) testing, corner case, margin or automated stress testing follow these steps:

Step 1: Connect probes

Note: the labels on the analyzer front panel are from the instrument perspective.

1. Connect the Sublink 0 Rx_1N to TxDN from the device M-Tx lane 1.
2. Connect the Sublink 0 Rx_1P to TxDP from the device M-Tx lane 1.
3. Connect the Sublink 0 Rx_0N to TxDN from the device M-Tx lane 0.
4. Connect the Sublink 0 Rx_0P to TxDP from the device M-Tx lane 0.
5. Connect the Sublink 1 Tx_1N to RxDN from the device M-Rx lane 1.
6. Connect the Sublink 1 Tx_1P to RxDP from the device M-Rx lane 1.
7. Connect the Sublink 1 Tx_0N to RxDN from the device M-Rx lane 0.
8. Connect the Sublink 1 Tx_0P to RxDP from the device M-Rx lane 0.
9. Connect the UFS RST_N to the DUT reset signal
10. If desired, connect the UFS REF CLK to the DUT ref clock input.

See **PROBING CONFIGURATION OPTIONS** for more information on how to connect to the DUT.

Step 2: Configure the exerciser/analyzer

1. Select Exerciser + Analyzer or CTS mode on the toolbar
2. Under Instrument Configuration select the desired memory Capture Options.
3. Under Instrument Configuration set the Connected Link Width for each direction to x1 or x2.
4. Under User Preferences determine if UFS packets are decoded when the trace capture is complete.

Step 3: Configure Device Under Test

1. Default device values are pre-set for the DUT in the Device Configuration tab of the Settings window, and CTS tests will poll the device for any required changes. If necessary, update the Device Configuration values for any settings that are unique to your device.
2. A UniPro and/or UFS link connection between the exerciser and DUT is required for the exerciser to perform compliance/conformance (CTS) testing, corner case, margin or automated stress testing. Press the “Boot” button in the tool bar to boot the DUT. If UniPro is the Default Protocol in Settings->User Preferences->Display Preferences or is the selected Protocol in the Device Control section of the Configuration windows pressing “Boot” will initiate the Link Startup Sequence. If UFS is the selected protocol a boot will be completed including UniPro LSS and UFS.

Step 4: Configure tests

1. Go to the CTS Configuration or Exerciser & TV Configuration window.
2. Select which Speeds, Link Widths and other device configurations to test. If testing UFS the appropriate LUNs must be selected.
3. Select which test Categories and Tests to run.

Step 5: Configure stress testing

Test Run Order controls the order in which tests are executed.

1. **Loop Order:** loop order specifies the nested order of test execution. Tests will be run from the bottom up, with all tests in each loop executed before the next higher loop is begun. So, if the Loop Order is Speeds, Link Widths, Tests then all Tests will be completed for a Link Width before being executed for the next Link Width, etc. The loop order can be adjusted by dragging categories up or down in the Loop Order box.
2. **Ascending, Descending, Random Seed:** this specifies which order the tests are executed within the Loop. If Random Seed is selected a value can be entered to generate a random but reproducible test order based on the seed value.

Step 6: Configure Run Control

Test Run Control specifies the number of iterations of the test configuration to run, dictated by Test Run Order. Test execution will stop after the specified Number of Loops (outer loops on Test Run Control) or No Result Test Cases have occurred.

The user can specify the number of test configuration loops to run OR the number of No Result Test Cases to allow before terminating the test run. When Number of No Result Test Cases field is blank or 0, tests are run for the given number of loops. If values are provided for both conditions, then tests are run until any ONE of the conditions is met.

Step 7: Run the configured tests

Press the Start or Start CTS button to run the configured tests, and watch the Results windows fill with Pass, Fail, Warning, or Info results.

Running concurrent instances of the application software

Two instances of the application software can be used concurrently, however only one instance of the application can communicate with the analyzer hardware at a time. If you attempt to start more than two instances of the application software concurrently you will see a message box informing you that only two concurrent instances are supported.

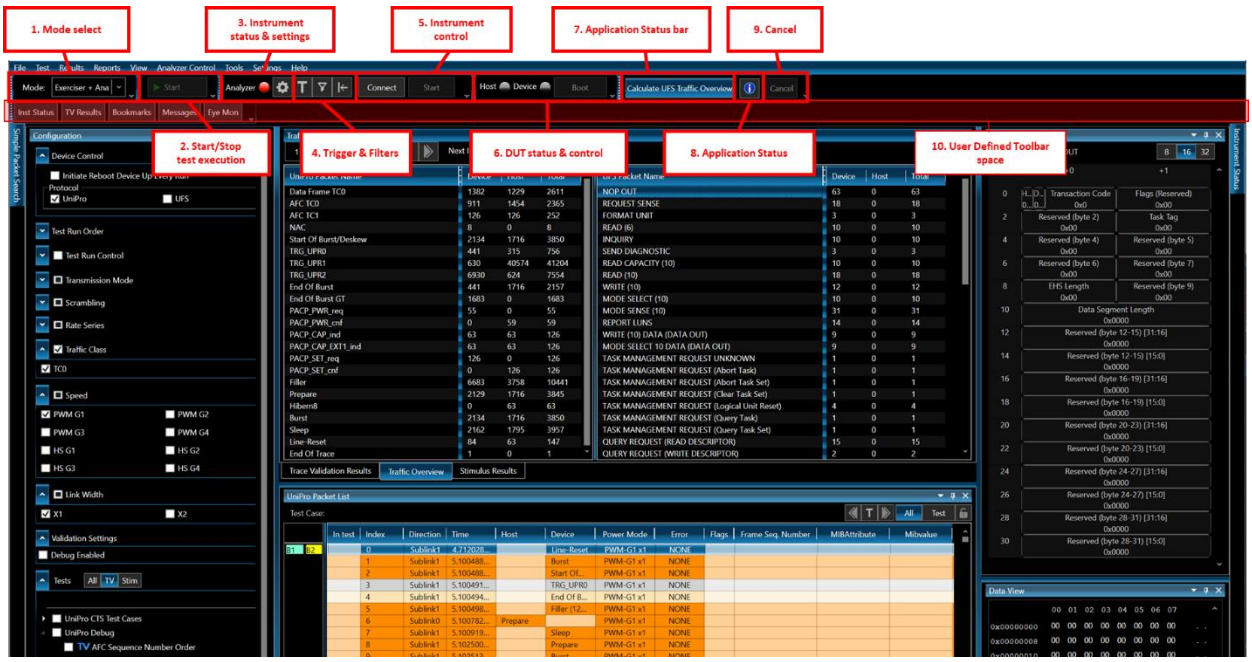
When a second instance is started it will show "OFFLINE" in the title bar and its Connect button will be disabled. If you close the first instance, which has the Connect button enabled, the second instance remains an OFFLINE instance and to Connect to hardware you will need to start another instance to enable the Connect button.

You can also start the application software by double-clicking on an .pitx file. If the application is already running, it will start a second instance which will load the file.

You can load the same .pitx file in two instances and, for example, view different areas of the trace side-by-side in the two instances.

Navigating the User Interface

Tool Bar



The tool bar allows selection of analysis view modes and run control for the test executive and the analyzer and status update information:

Modes (1) allow the user to select a set of three pre-defined windows based on the instrument configuration and type of analysis being conducted (see **Windows** below).

Start (2) initiates Trace Validation, stimulus or test case execution for selected tests.

Instrument status and settings (3) displays the status of the instrument hardware/software connection and opens the Settings tabs.

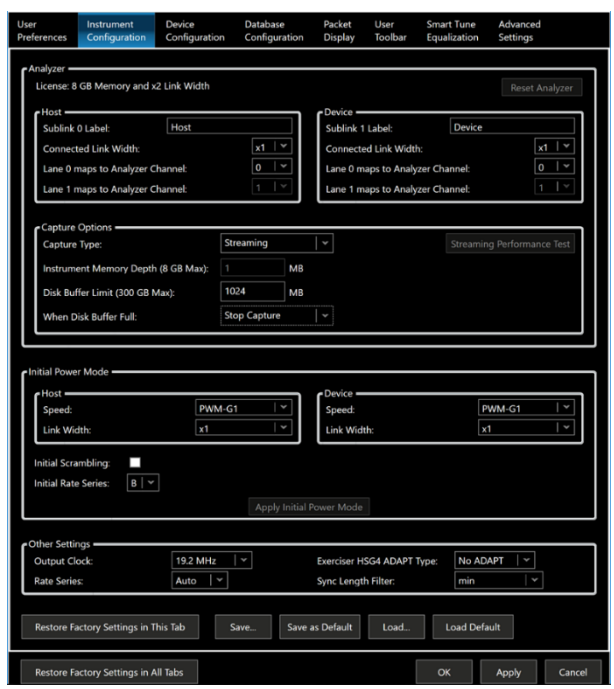
Instrument status:

Red = software application is not connected to instrument hardware and the software is offline.

Yellow = software application is connected to the instrument hardware and the software is online.

Green = the instrument is connected and capturing traces.

Settings (3) configures user preferences, the instrument hardware, and the device under test (G550C only). Settings can also be accessed from the menu.



Clicking on the Trigger or Filter buttons (4) will open the Trigger Setup and Filter windows. Choosing the  button will expand or collapse related task packets in the UFS Packet List window. See also Enable UFS Task Collapsing under **FILTER WINDOW**.

By clicking Connect (5) the software will initiate connection with the hardware and go online. Clicking Start or Stop will begin or end a trace capture.

The DUT status and control (6) indicators show the status of the DUT. One indicator is used for each direction of a link, so a x1 link will show two indicators and a x2 link will have four indicators. Indicator colors are as follows: grey = not connected, yellow = device operating at PWM speeds, green = device operating at HS speeds. Clicking Boot will initiate a UniPro or UFS boot of the DUT.

The application status bar (7) indicates progress during common activities such as file open/save and test case execution. Clicking the blue info icon (8) will open the **APPLICATION STATUS** window.

Pressing cancel (9) will stop any background processes being performed, such as calculating Traffic Overview or Events, and can cancel test executive and trace validation execution.

Custom toolbars (10) can be added to the main application, see **USER TOOLBAR TAB** for more information. Custom toolbars are added to the row below the factory default toolbar

Windows

Selection of one of three display modes (1 above), Analyzer, CTS, or Exerciser + Analyzer, will activate a set of pre-defined windows:

> **Analyzer mode** will open the Trace Validation Results and Traffic Overview windows, UniPro and UFS Packet List and Events windows, TV Configuration, Packet Decode and Data View. Instrument Status is positioned on the right side as a tab, and Simple Packet Search is a tab on the left side.
>
> **CTS mode** opens the TV Results and Traffic Overview windows, the Packet List and Events windows, and Packet Decode and Data View. It also opens the CTS Configuration window to set up and run CTS test cases. Available for the G550C only.
>
> **Exerciser + Analyzer mode** opens the TV Results and Traffic Overview windows, and the UniPro and UFS Packet List and Events windows, Packet Decode and Data View. It also opens the Stimulus Results and Exerciser & TV Configuration windows. The Exerciser & TV Configuration window provides access to all configuration settings and the permits the running all tests, including differing stimulus and Trace Validation tests, in one single test run. This can result in the creation of one test result trace file with many types of link traffic. Available for the G550C only.

Figure 1: Exerciser + Analyzer window layout

All windows are dock-able inside or outside of the application framework, using standard docking paradigms. Windows can be restored to the default mode configurations by selecting View->Restore Default Layout from the main menu.

Configuration window – Analyzer mode

Device Control

Protocol: Selecting either UniPro or UFS Protocol determines which tests are listed in the Tests section below. This also dictates the action of the Boot button on the toolbar.

Validation Settings

Debug Enabled: turns on Trace Validation test debugging. Messages that are generated by the Trace Validation test are output to the Trace Validation Results window to help users track progress in the Trace Validation analysis. See Debug under **INTERPRETING TRACE VALIDATION RESULTS** for more information.

Tests

Select the test cases to be executed. The following test categories are available for execution in Analyzer mode:

UFS CTS Test Cases: The Test Cases in this category verify compliance to the UFS CTS. A Trace Validation result of "Pass" indicates the DUT meets the CTS Test Case criteria. In Analyzer mode these tests are run as Trace Validation tests against existing traces.

UFS Debug: This category contains general UFS debug tests.

UniPro CTS Test Cases: The Test Cases in this category test the DUT for compliance to the UniPro CTS. A Trace Validation result of "Pass" indicates the DUT meets the CTS Test Case criteria. In Analyzer mode these tests are run as Trace Validation tests against existing traces.

UniPro Debug: This category contains debug test cases to check UniPro behavior. For example, to verify that the Link Startup Sequence ran correctly.

Search TVs: These Trace Validation tests can be used to search a trace for specific conditions. The application software library includes three search TVs, "Find UniPro Error Packets", "Find UFS Error Packets" and "Find Protocol Insight CTS Markers".

Advanced Trigger Offline TVs: Advanced Triggers that have been defined with Test Editor can be run against any previously captured trace to find trigger events in existing traces, or to test newly constructed advanced triggers. If no Advanced Triggers have been defined this category won't appear.

***Custom Tests*:** Custom test directories are displayed in *italics* at the bottom of the list; with Trace Validation custom tests shown in Analyzer mode. If no custom test cases exist in a directory the directory will not be displayed. The tests listed can be refreshed from the File menu as new custom test case are created.

Configuration window – CTS mode

Available for the G550C only.

Device Control

Initiate Reboot Device Up Every Run: If this box is checked, the reset line (see line 9 of **STEP 1: CONNECT PROBES**) is asserted and a UFS boot and/or UniPro Link Startup Sequence is executed before every test case. This should be used for early testing to verify the tests work with a known device state, once this has been verified it is recommended to deselect this option.

Protocol: Depending on this selection, the test list in the Tests section of the Configuration windows is filtered for UniPro or UFS tests and the Configured LUNs section is hidden or displayed for device and run control choices.

This selection also controls the action of the Boot button in the tool bar. The Boot button will either boot the device through LSS if UniPro is selected, or to UFS if UFS is selected.

The primary (default) protocol for this selection can be set in Settings->User Preferences->Display Preferences

Test Run Order

Control the order in which tests are executed. Run order is specified by Loop Order in Ascending, Descending, or Random Seed order. See **STEP 5: CONFIGURE STRESS TESTING** for more information.

Test Run Control

Specify the number of test cycles of the test configuration to run. Test execution will stop after the specified number of full test loops (outer loops on Test Run Control) or No Result Test Cases have occurred. See **STEP 6: CONFIGURE RUN CONTROL** for more information.

Transmission Mode

Controls Auto/NonAuto power modes during Test Run operation.

Scrambling

Enable or disable data scrambling during Test Run operation.

Rate Series

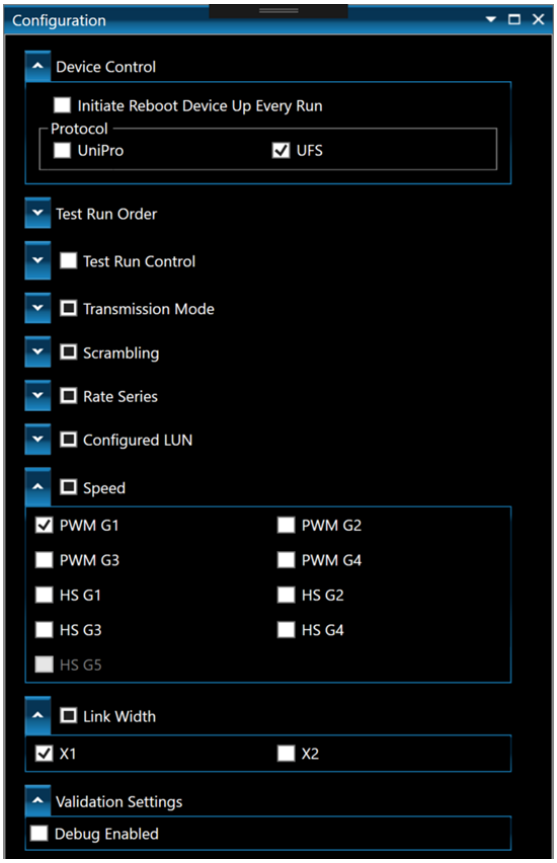
Enable or disable Rate Series A and/or B.

Configured LUN

If UFS Protocol is selected under Device Control in the Configuration windows or as the Primary (default) Protocol in Settings->User Preferences->Display Preferences, this section will be visible and is used to choose the Configured LUNs to control and test with test executive Run Control.

All UFS tests in the Configuration windows are associated with a LUN. The tests that have a LUN value of 255 correspond to the NONE (LU agnostic) selection in the Configured LUN selector. For requests that do not target a specific LUN (e.g. a Query Request with the Read Descriptor Opcode) the NONE LUN is used.

The NONE (LU Agnostic) LU is specific to the Protocol Insight test Configuration windows, they aren't mentioned in the UFS spec. Since every test is associated with a LU this is how to define a test that is LU agnostic.



Speed

Configure the speeds to be tested.

Link Width

Configure the link widths to be tested. UniPro and UFS widths up to x2 are supported.

Validation Settings

Debug Enabled: turns on Trace Validation test debugging. Messages that are generated by the Trace Validation test are output to the Trace Validation Results window to help users track progress in the Trace Validation analysis. See Debug under **INTERPRETING TRACE VALIDATION RESULTS** for more information.

Tests

Select the CTS test cases to be executed.

Configuration window - Exerciser + Analyzer mode

Available for the G550C only.

This configuration window replicates all the functionality of the **CONFIGURATION WINDOW – CTS MODE**, with the following additions to the Tests section:

Tests

The list of available tests can be filtered:

All Selecting "All" will display all tests in the list, including Stim, TV and CTS tests. The type of test is identified by an icon as either a legacy Stimulus Builder test with a red S, a Stimulus Test Editor test with an orange S, a Trace Validation test TV, or a test containing both Stimulus and Trace Validation TVS.

Selecting All permits the running of all tests, including differing Stimulus and Trace Validation tests, in one single test run, resulting in the creation of one trace result file with many types of link traffic and analysis.

TV Selecting "TV" will display only Trace Validation tests.

Stim Selecting "Stim" displays only stimulus tests.

Filter Linked Tests: Checking the "Filter Linked Tests" box when All is selected will filter the list and only display those tests that include both a Stim and associated TV test. Tooltips identify the Stim test linked to each TV test listed.

Depending on the display mode selected the following test categories and tests may be available for execution in the Tests section:

UFS CTS Test Cases: The Test Cases in this category test the DUT for compliance to the UFS CTS. Execution of the linked Stimulus with a Trace Validation result of "Pass" indicates the DUT meets the CTS Test Case criteria.

UFS Debug: This category contains general UFS debug tests.

UniPro CTS Test Cases: The Test Cases in this category test the DUT for compliance to the UniPro CTS. Execution of the linked Stimulus with a Trace Validation result of "Pass" indicates the DUT meets the CTS Test Case criteria.

UniPro Debug: This category contains general UniPro debug test cases to check UniPro behavior. For example, to verify that the Link Startup Sequence ran correctly.

Search TVs: These Trace Validation tests can be used to search a trace for specific conditions. The application software library includes three search TVs, "Find UniPro Error Packets", "Find UFS Error Packets" and "Find Protocol Insight CTS Markers".

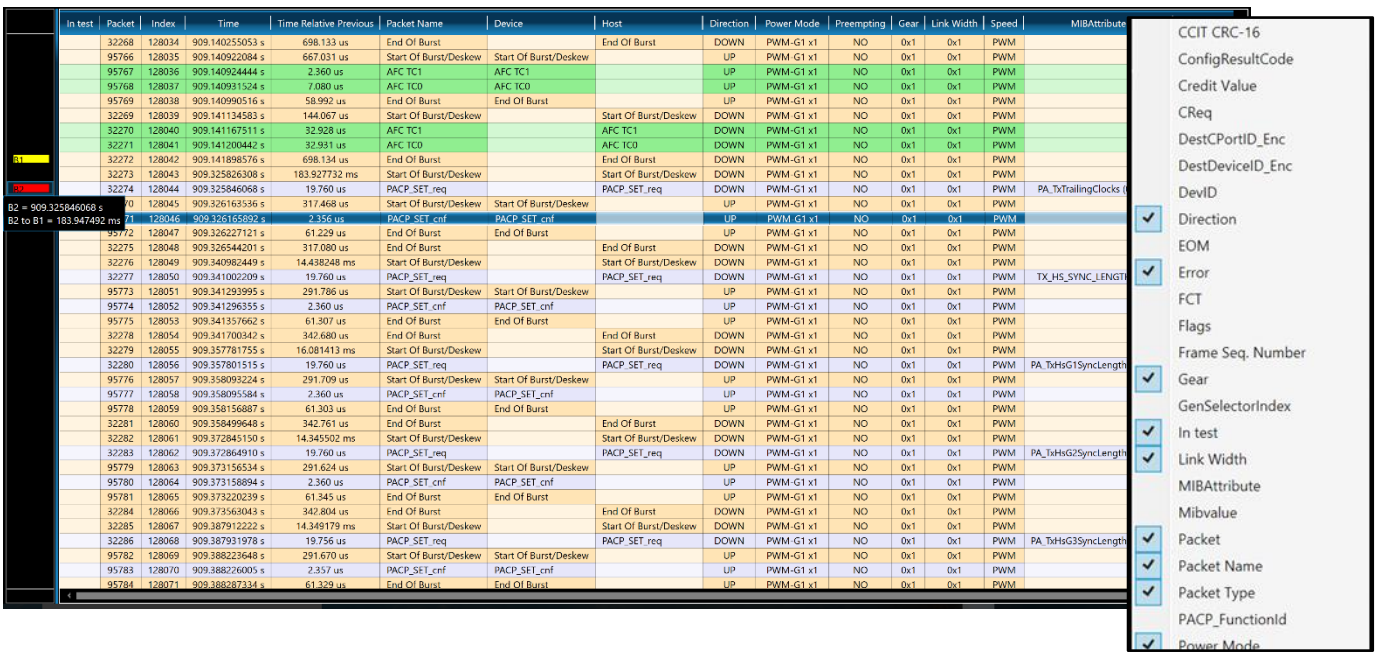
Advanced Trigger Offline TVs: Advanced Triggers that have been defined with Test Editor can be run against any previously captured trace to find trigger events in existing traces, or to test newly constructed advanced triggers. If no Advanced Triggers have been defined this category won't appear.

***Custom Tests*:** Custom test directories are displayed in *italics* at the bottom of the list; if no custom test cases exist in a directory the directory will not be displayed. Depending on the display mode selected, Stimulus and/or Trace Validation custom tests will be shown. The tests listed can be refreshed from the File menu as new custom test case are created.

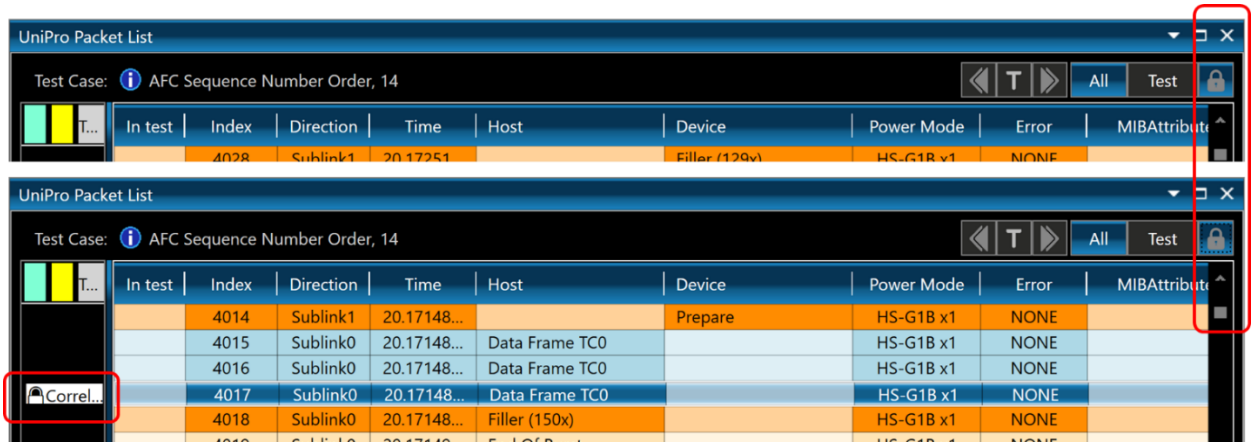
UniPro and UFS Packet List windows

The Packet List windows display all packets in a trace. If Trace Validation is used, clicking on a result in the Trace Validation Results window will position the cursor in the Packet List window on the packet of interest in the test sequence.

The information displayed in the Packet List can be changed by right-clicking in the column header bar and selecting different columns from the list available.



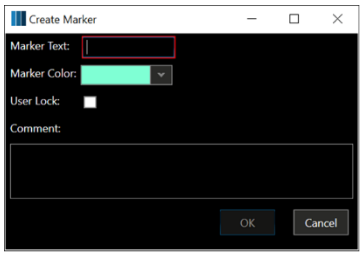
Correlated views: The Packet List views can be locked so that the active cursor correlates to the same packet in each view. Clicking the Lock icon in the upper right corner of a List view will lock all windows, and a "Correlated" bookmark will identify the active cursor in each window view.



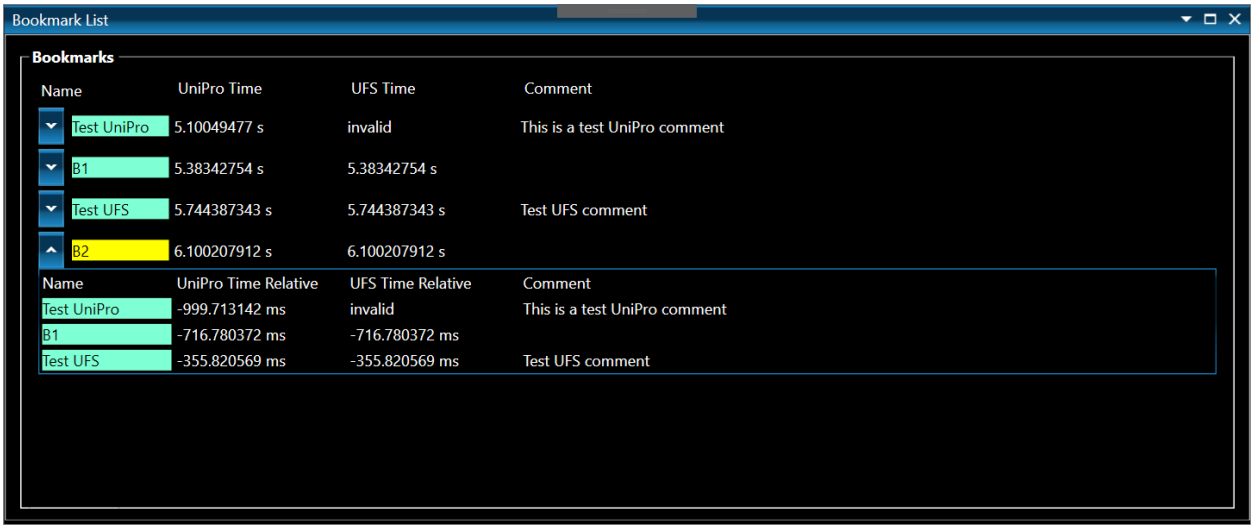
Color Coded packets: Common packet types in the list window are color-coded the same, for example, all End_of_Burst, PACP_SET_cnf or PACP_GET_cnf packets are of the same color. Color selections can be changed from the menu from Setting->Packet Display or by clicking the Settings icon on the toolbar.

All error packets are highlighted in red. For more info about error packets see "What is the difference between Symbol Errors in the Instrument Status window and red error packets in the UniPro and UFS Packet listing windows?" in the app note PDF "*App Note Tech Support FAQs*".

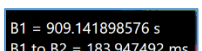
Bookmarks can be added to any packet in a Packet List or Event view window by right-clicking and selecting Add Bookmark. By right-clicking and selecting Edit Bookmark an existing bookmark can be renamed or given a different color.



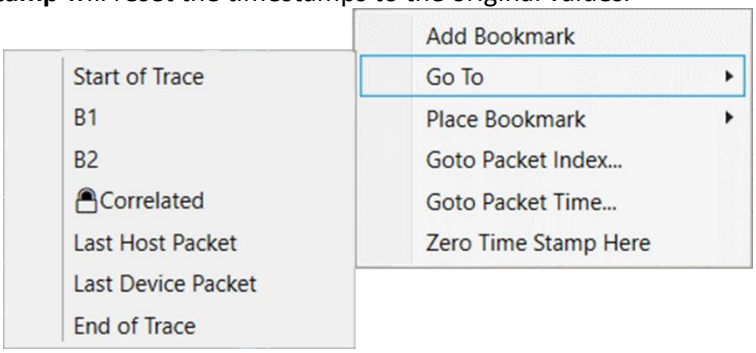
Bookmarks can be used to add comments to traces in the Comments field. Comment are tied to a bookmark, which can be locked to a specific packet so it can't be moved. All comments in a trace can be viewed in the **BOOKMARK LIST WINDOW**; if the comment has multiple lines the full comment is displayed in the tooltip when hovering over the comment:



Hovering over a bookmark will display a tooltip indicating timestamp and delta time to other bookmarks. If **Zero Time Stamp Here** is selected, all timestamps are recalculated from the selected packet, with negative timestamps before and positive timestamps after that packet. Selecting **Restore Original Time Stamp** will reset the timestamps to the original values.



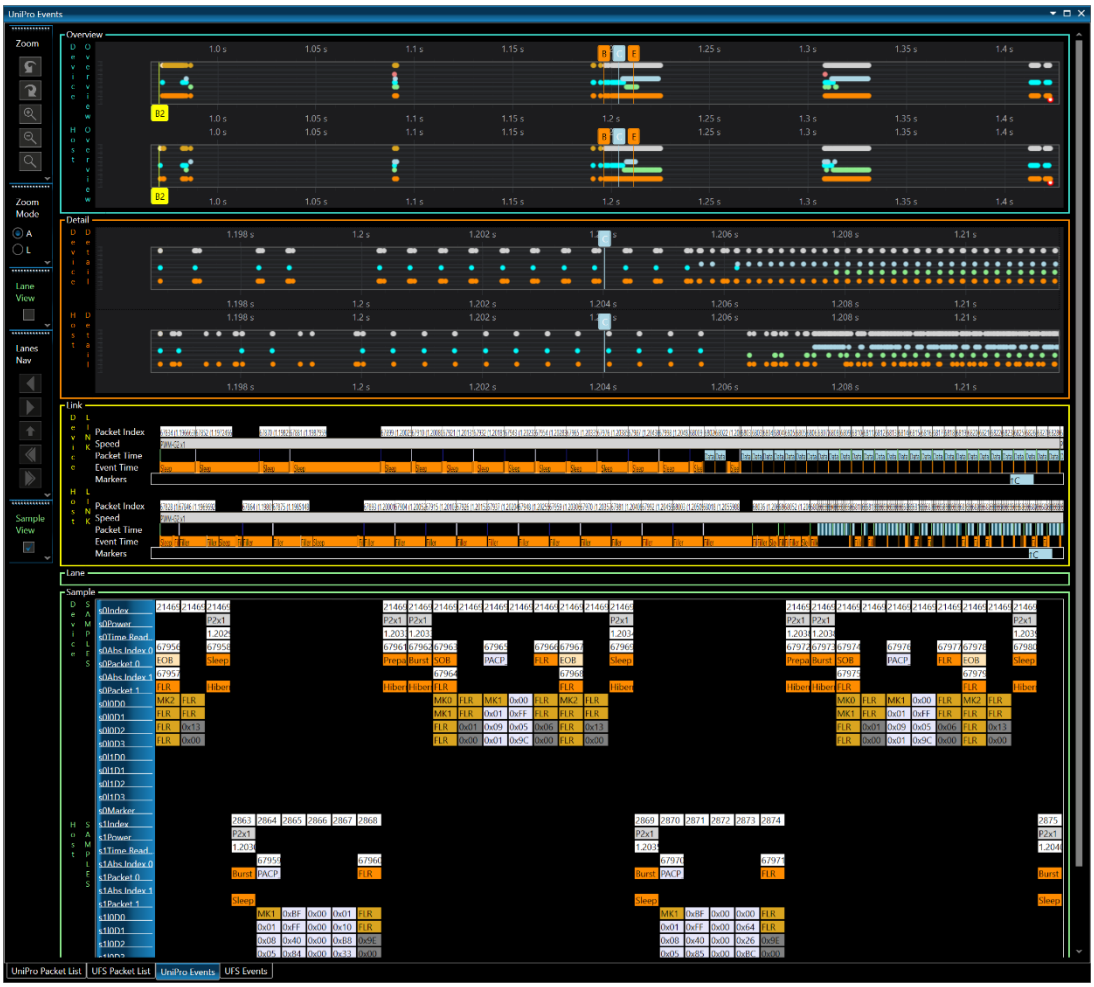
Navigating a Packet List window can be accomplished in several ways activated by right-clicking anywhere in a Packet List or Event window:



Go To permits navigation to Start of Trace, End of Trace, last packet or bookmarks.

UniPro Events window

The UniPro Events window contains four panes, the Overview, Detail, Link, and Sample panes, that allow drill-down from the full trace to the lowest level packet information:



Overview pane

The Overview pane, in the blue box, consist of two scatter charts (one for each direction) that represent each packet in the trace with its time position as a dot. Since there are usually more packets in a trace than horizontal pixels in the view, each dot in the view will usually represent multiple packets.

The numbers along the X-axis represent time since the beginning of the trace and each row along the Y-axis represents a set of packet types.

The top row is the Speed row and is always present when any packet is present. It is the only multi-color row, changing color when the speed changes. The speed colors are:

PWM-G0 x1

PWM-G0 x1, PWM-G0 x2, PWM-G1 x1, PWM-G1 x2

PWM-G2 x1

PWM-G2 x1, PWM-G2 x2

PWM-G3 x1

PWM-G3 x1, PWM-G3 x2

PWM-G4 x1

PWM-G4 x1, PWM-G4 x2

PWM-G5 x1

PWM-G5 x1, PWM-G5 x2

PWM-G6 x1

PWM-G6 x1, PWM-G6 x2

PWM-G7 x1

PWM-G7 x1, PWM-G7 x2

HS-G1A x1

HS-G1A x1, HS-G1A x2, HS-G1B x1, HS-G1B x2

HS-G2A x1

HS-G2A x1, HS-G2A x2, HS-G2B x1, HS-G2B x2

HS-G3A x1

HS-G3A x1, HS-G3A x2, HS-G3B x1, HS-G3B x2

HS-G4A x1

HS-G4 x1, HS-G4 x2

HS-G5 x1

HS-G5 x1, HS-G5 x2

UNKNOWN

Unknown speed

The remaining rows are presented in this order:

BAD

DataFrame_BadTC, AFCBadTC

NAC

NAC

DATA

DataFrame_TC0, DataFrame_TC1

PACP

PACP_PWR_req, PACP_PWR_cnf, PACP_CAP_ind, PACP_CAP_EXT1_ind, PACP_EPR_ind, PACP_TEST_MODE_req, PACP_GET_req, PACP_GET_cnf, PACP_SET_req, PACP_SET_cnf, PACP_TEST_DATA_0, PACP_TEST_DATA_1, PACP_TEST_DATA_2, PACP_TEST_DATA_3

AFC

AFC_TC0, AFC_TC1

TRG

TRG_UPR0, TRG_UPR1. TRG_UPR2

Event

SOB, EOB, FLR, SKIP, PREPARE, SYNC, HIBERN8, BURST, SLEEP, STALL, LINE_RESET, LINE_CFG

End_Of_Trace

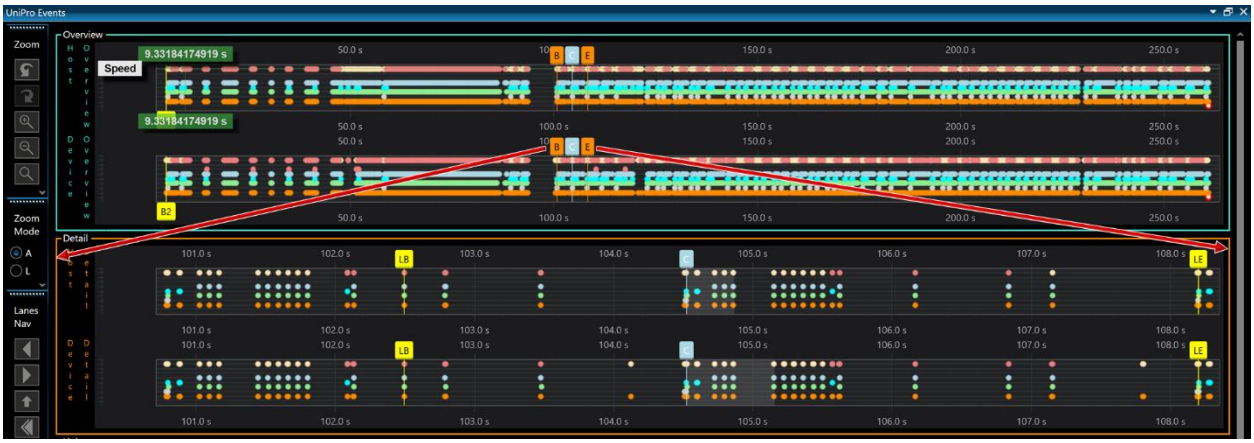
End of trace is marked with a white dot with a red border. There can be multiple End_Of_Trace events.

In the Overview pane there are 3 special markers, B, E, and C, which are drawn above each direction chart. The orange color of the B and E markers correspond to the range in the orange Detail pane (see red arrows below) while the C marker is always light blue. Hover over a marker to see its long name and time:

- B – Begin – Where the Detail pane Begins in the Overview pane
- E – End – Where the Detail pane Ends in the Overview pane
- C – Center – The location of the packet that is at the Center in all Event views

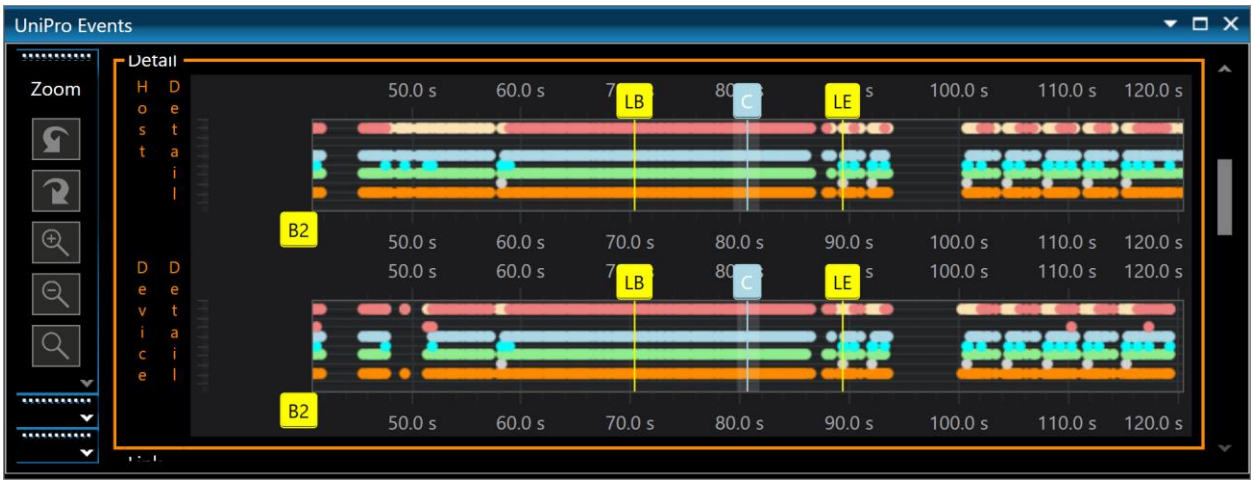
Bookmarks (e.g. B1 and B2) are drawn below each direction and tie to the same bookmarked packets in the other display windows. If additional bookmarks are added by the user, they will also be displayed in all Events panes. If you hover over a bookmark it will display its time and the time to other markers.

By clicking/dragging in the Overview pane or by moving the B/E markers or by selecting a button in the Zoom Tool Bar on the left the range that is displayed in the Detail pane below can be changed. The C marker moves to the center of the B/E range when you change the B/E range with any method:



Detail pane

The Detail pane is similar in appearance to the Overview pane, but it displays only the range currently selected in the Overview pane. It uses the same colors and row arrangement as the Overview pane. A dot typically indicates multiple packets of the type for the row, but you can zoom in to a point where a dot represents a single packet.



You can change the range that is displayed in the Link and Lanes panes, which are the panes below the Detail pane, by clicking/dragging in the Detail pane.

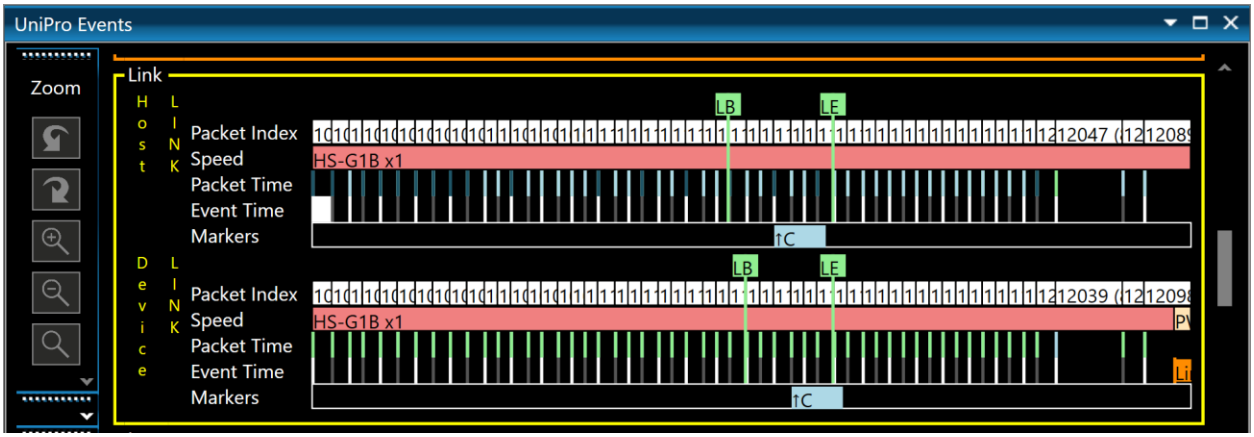
In the Detail pane there are 3 special markers, LB, LE and C. The LB/LE/C markers are not moveable. The yellow color of the LB and LE markers correspond to the range in the yellow Link pane below, while the C marker is always light blue. Hover over a marker to see its long name and time:

- LB – Link Begin – Where the Link pane Begins in the Detail pane
- LE – Link End – Where the Link pane Ends in the Detail pane
- C – Center – The location of the packet that is at the Center in all Event views

The range of packets displayed in the Link pane below are indicated by the yellow LB and LE markers and with an area of shading in the Detail pane.

Link pane

The Link pane creates an intermediate view between the Overview and Detail scatter charts and the byte-detailed raw Lane and Sample panes.



In the Link pane the X-axis is a modified time scale. A packet time may be so small in comparison to a Sleep that a true time scale for the packet would be less than a pixel in width, and the packet "rectangles" appear as a line with a minimum width. Events are shown on a separate row from Packets. Where possible, packets are grouped together to make a single rectangle. The tool tip for the rectangle shows the packets and time that the rectangle represents.

In the Link pane there are 3 special markers, LB, LE and C. The LB/LE/C markers are not moveable. The green color of the LB and LE markers correspond to the green Lane pane below, while the C marker is always light blue. Hover over a marker to see its long name and time:

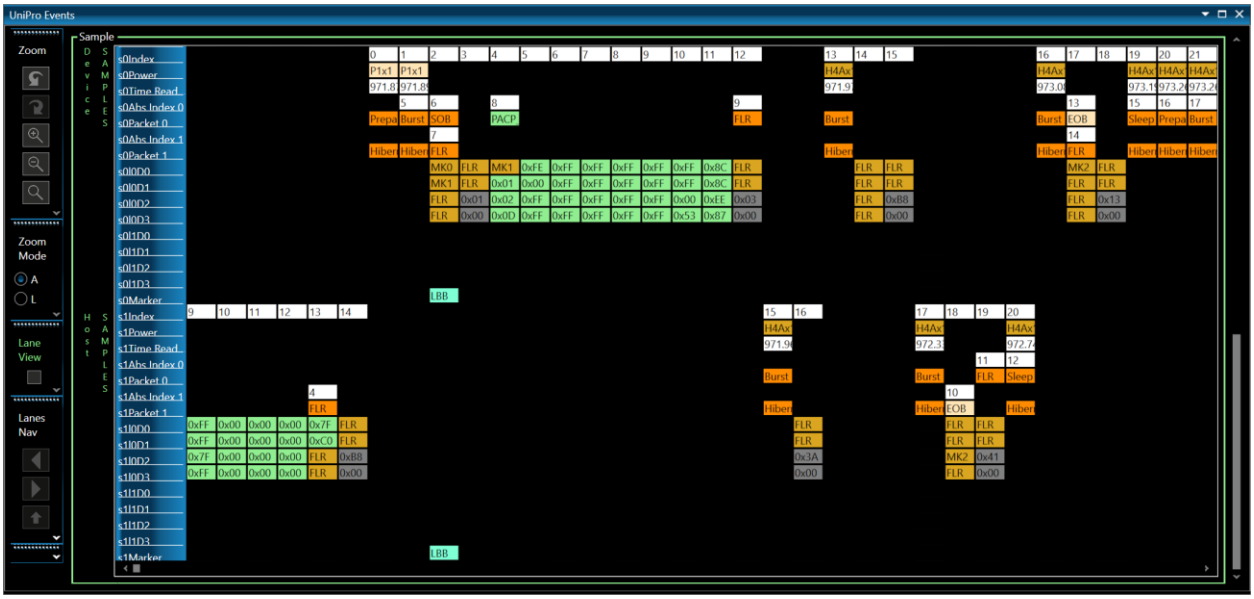
- LB – Link Begin – Where the Lane pane Begins in the Link pane
- LE – Link End – Where the Lane pane Ends in the Link pane
- C – Center – The location of the packet that is at the Center in all Event views

The range of packets that are displayed in the Lane pane are indicated by the green LB and LE markers.

Sample pane

The Sample pane shows byte level detail for the first 2 billion samples. The X-axis is based only on the width of the displayed bytes, it is not time-based, and the only time component is the displayed time. The packets in the two lanes are interleaved to show their Packet Index order.

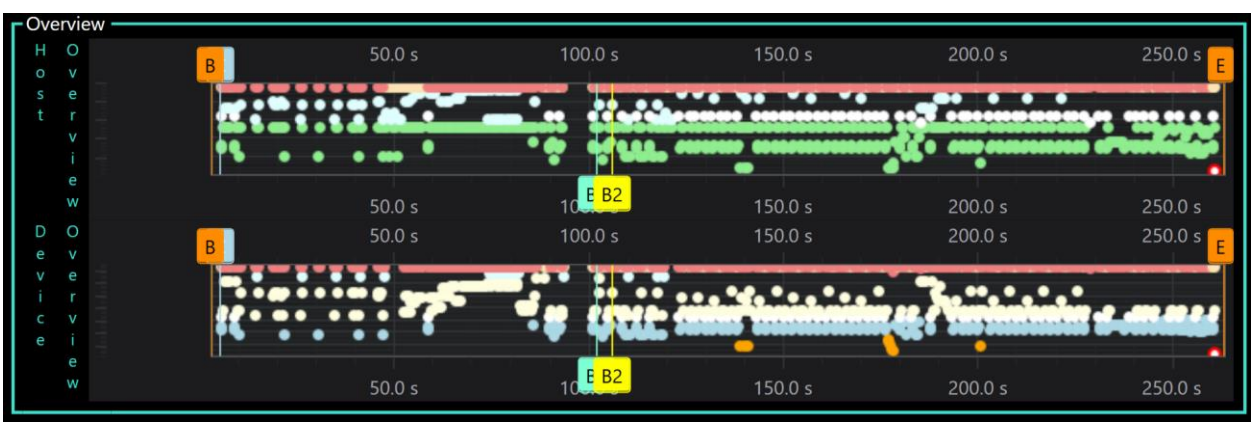
The higher level panes in Events (Overview, Detail, and Link) display decoded packet data from the UniPro Packet List window. In contrast the Sample pane is built from the raw trace data.



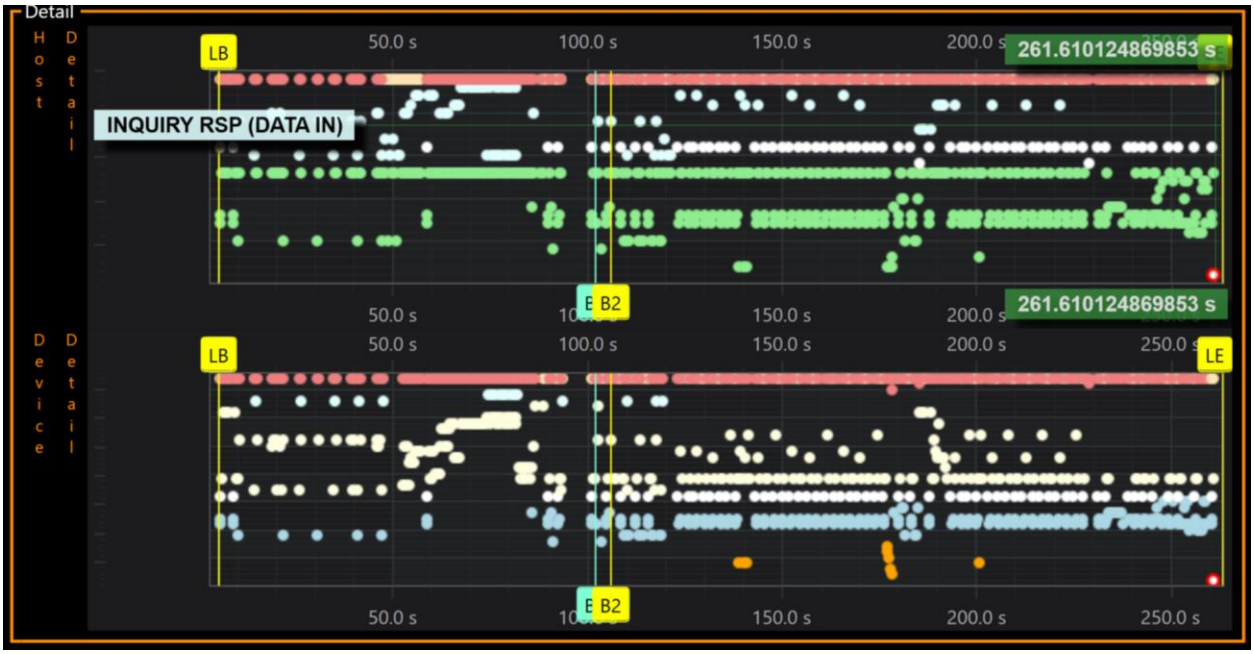
UFS Events window

The UFS Events panes are very similar to the UniPro Events panes. See **UNIPRO EVENTS WINDOW** for more information. An important difference is that in UFS Events, each row represents a single packet type.

There are many possible packet types in UFS but in practice a trace tends to contain a subset of all the possible packets that could be displayed. By dragging the blue bar at the bottom of the Detail pane the scatter chart height can be increased to display more packet types.

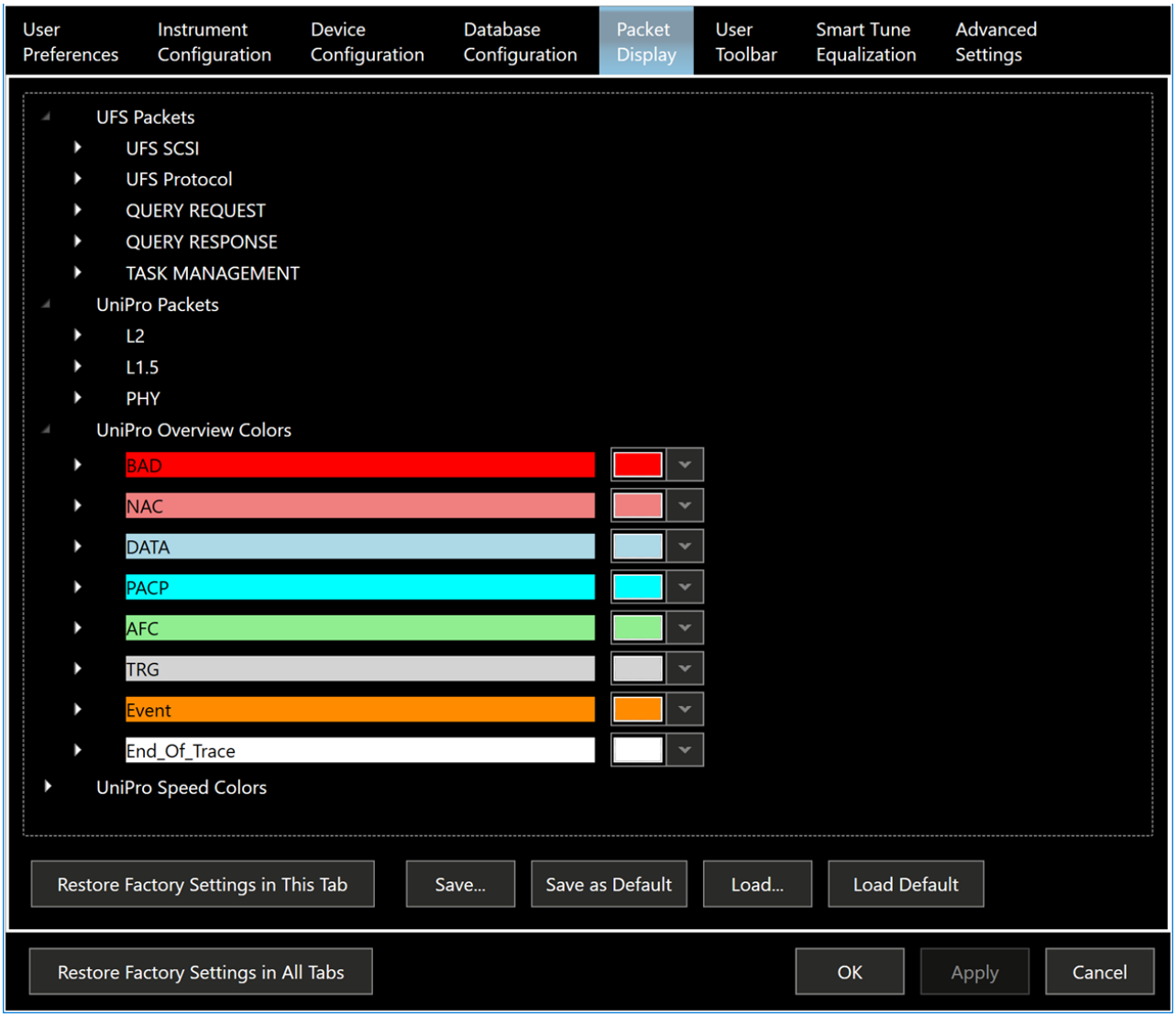


The Detail pane is a zoomed view of the Overview chart that works just like the UniPro Events pane:

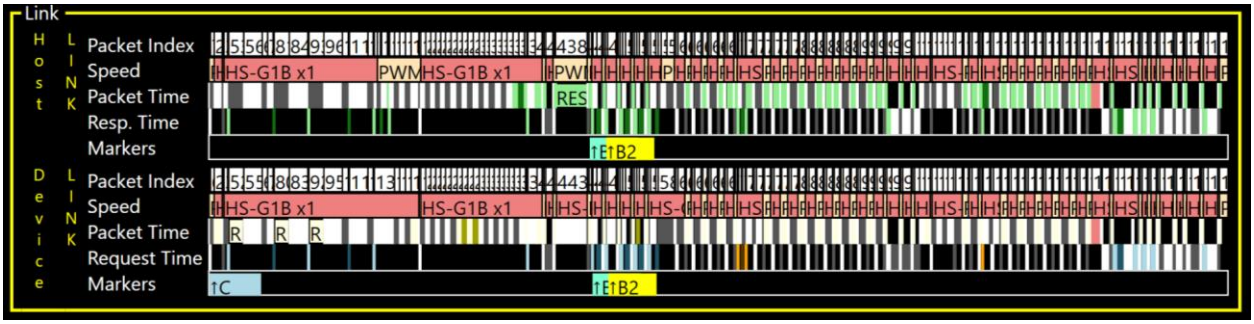


This chart is sized larger because packet level details will be more important to users in this view.

In both the Overview and Detail panes the packet colors are the same as in the UFS Packet List window and can be changed from the Settings menu:

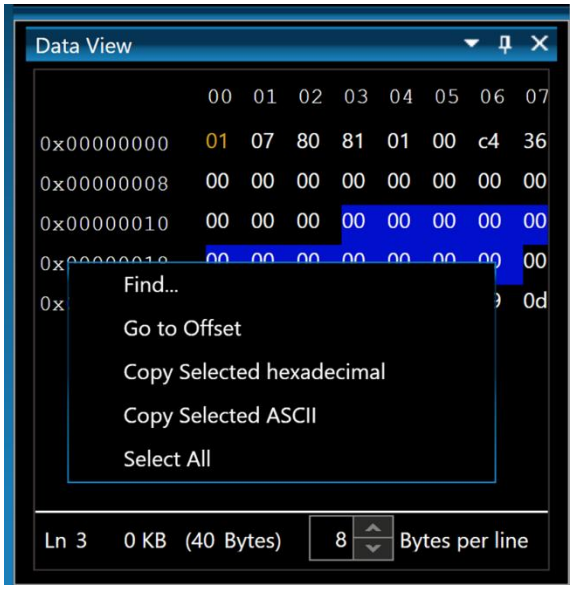


The Link panes are similar to the Link panes in UniPro Events. The important difference is that rather than having an Events time row, they have either a Request or Response packet row, depending on direction:



Packet Decode window

To display the protocol decode of a packet of interest in the Packet Decode window, click on the packet in the appropriate Results window or in a Packet List window. Hovering over a bit displays additional decode information. Selecting 8, 16, or 32 defines the bit width of the display.

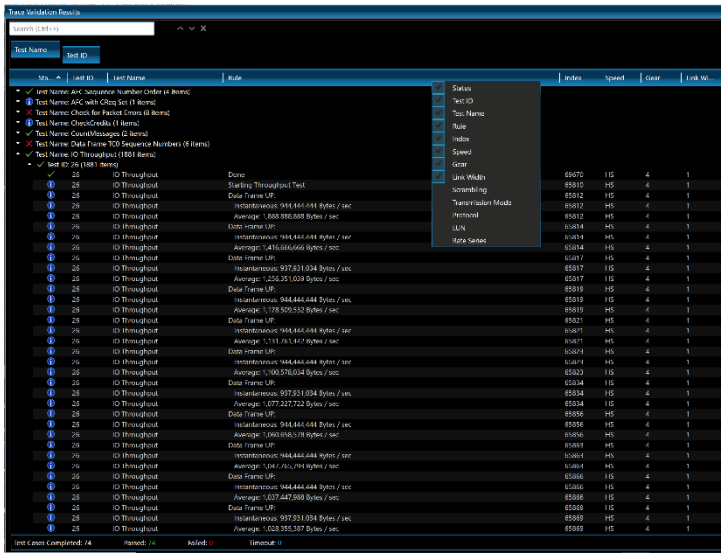


Data View window

The Data View window displays the entire packet, including header and payload for a selected packet. While the first 160 bytes of data are fully decoded in the Packet Decode window, the remainder of the packet payload is displayed in the Data View window only. Up to 16 bytes can be displayed per line.

By right-clicking anywhere in the Data View window the user can choose from several options to copy the data for pasting into other applications.

Trace Validation Results window



Since CTS test cases use the Trace Validation engine for protocol sequence and packet inspection, the Trace Validation Results window is used in the Analyzer, CTS and Exerciser + Analyzer modes to display test or analysis results.

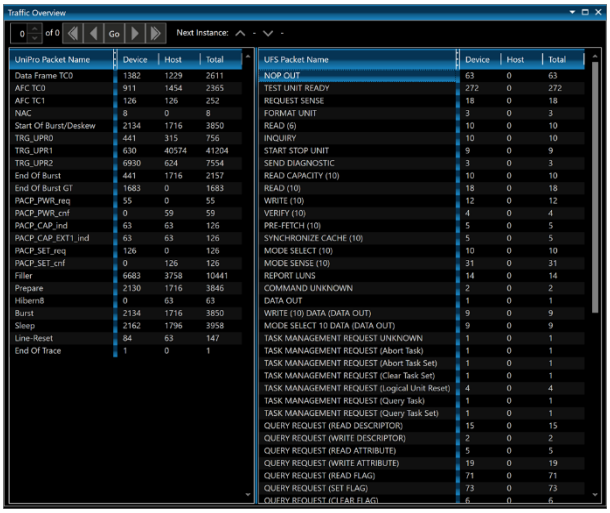
The TV Results window allows extensive quantitative analysis of results data. Results can be grouped and summarized, sorted, and filtered by any header column. To turn on or off a column, right click in the column header area.

Key words can be searched from the Search bar.

To group and summarize, click on any column header and drag into the Test Results field. This will summarize the results with an item count of occurrences.

Clicking on a TV Results message in the Results window will center that packet in the Packet List and Packet Decode windows for further analysis.

Traffic Overview window

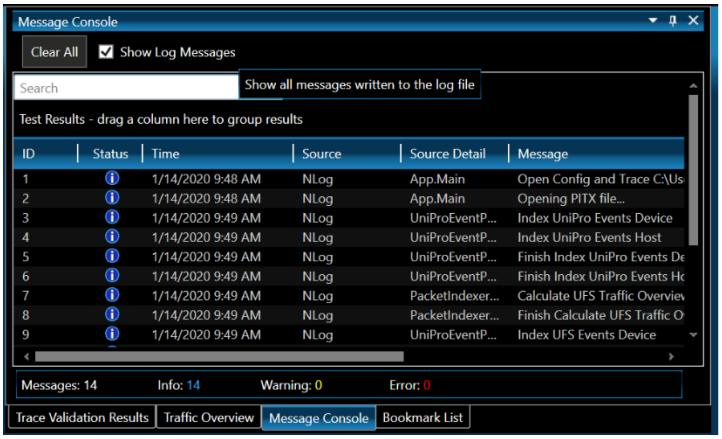


Traffic Overview offers a summary of all packets found in the trace. Any packet can be found by selecting that packet type in the Traffic Overview window, clicking on either Host, Device or Total, and clicking the up or down buttons to go to the next or previous packets, or <| and |> to go to the first or last packets.

Stimulus Results window

The Stimulus Results window provides success/fail information on the stimulus test cases executed. This window does not display analysis results but only whether the stimulus test ran successfully. Information in this window is not saved with the File->Save function.

Message Console



Messages generated by the NLog debug logging tool are automatically sent to the Message Console. These are the same messages that are stored to the NLog default log file at C:\Users\[user name]\AppData\Local\Protocol_Insight\Falcon\Temp\logs\ logfile.txt.

Messages output from Stimulus Editor can also display in the Message Console if implemented by the user.

The NLog messages can be disabled by unchecking "Show Log Messages".

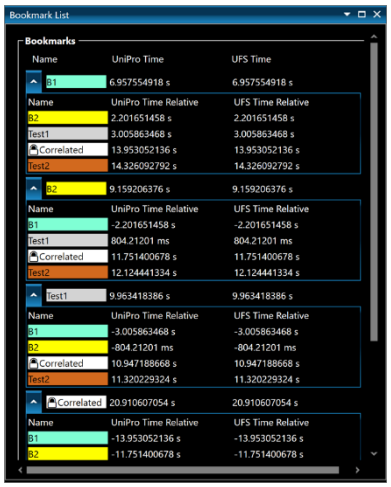
Simple Packet Search window

Simple Packet Search will search forwards or backwards on any sublink for any packet type, packet header or payload value. A gated search range can be created by positioning bookmarks in the trace and using the **From** dropdown under Search Options.

Select any active packet from the list in "Select Event for Search from this List" and use the Search Options to navigate to packets that meet the search criteria. Note: until Traffic Summary calculation is completed Simple Packet Search cannot be used since the available packets will not be populated in the search list.

Double-clicking on the packet type of interest will bring up the Packet Editor (the same used for Simple Trigger) to edit the header or payload values to search for. These packet values can be saved as Favorite Packets for later re-use with either Simple Packet Search or Simple Trigger.

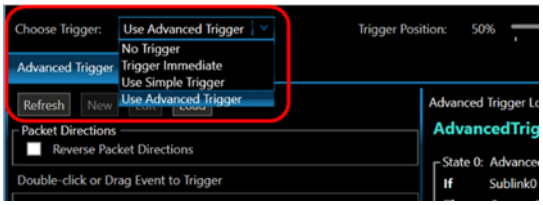
Bookmark List window



Bookmark List window will display all bookmarks in the trace, with the timestamp, delta time to every other bookmark, and comments. Right clicking within the list will enable navigation to any bookmark in the trace. The Bookmark List window can only be accessed from Menu->View->Bookmark List.

Trigger Setup window

The Trigger Setup window is accessed from the Tools menu. The Choose Trigger dropdown allows selection of different trigger actions.

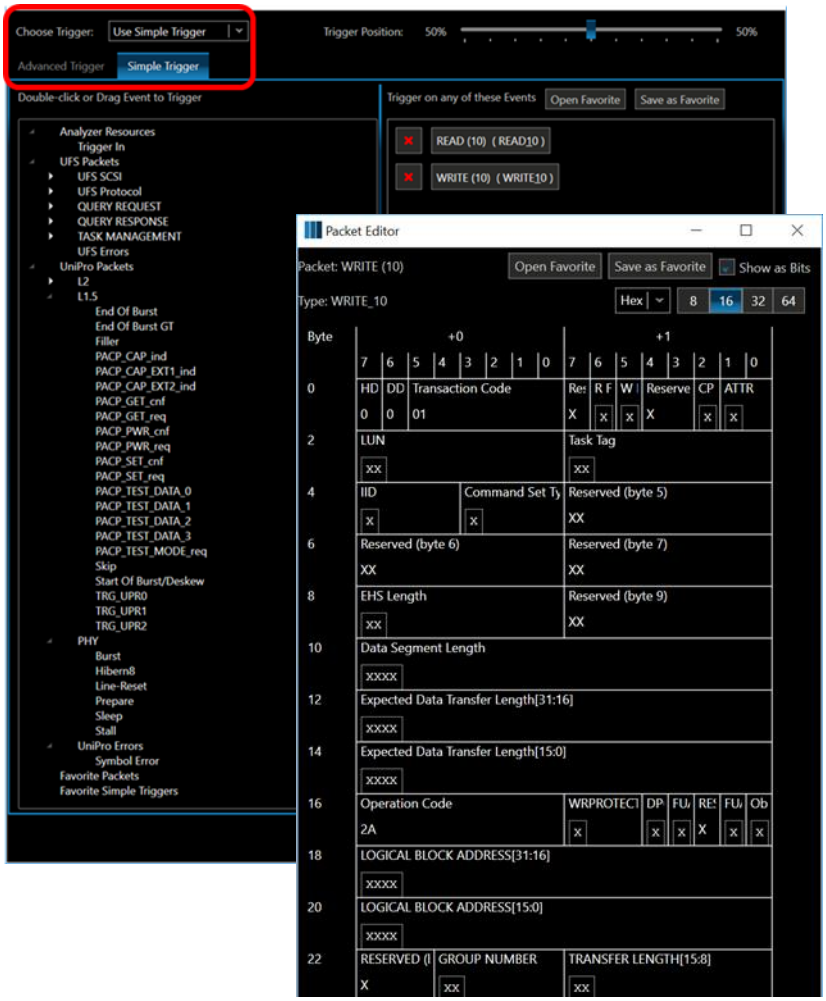


No Trigger will cause the analyzer to continue to run until the Stop button is clicked.

Trigger Immediate will cause the analyzer to immediately start filling the capture memory and acquisition will stop when memory is full.

Simple and **Advanced Triggers** will monitor all sublinks for any packet type, packet header or payload value and trigger the analyzer to stop capturing when the trigger criteria are met.

The **Trigger Position** is used to set how much acquisition memory is reserved to save trace data prior to the trigger event vs. after the trigger event. If a 20% trigger position is set the analyzer will reserve 80% of the memory for post-trigger fill. This means that if the trigger occurs deep in the trace then 100% of the buffer will fill, 20% before and 80% after. But if the trigger event occurs very early in the trace, say after only filling 5% of the total memory, the capture will total less than 100% because 5% will be before the trigger and 80% after the trigger for 85% total.



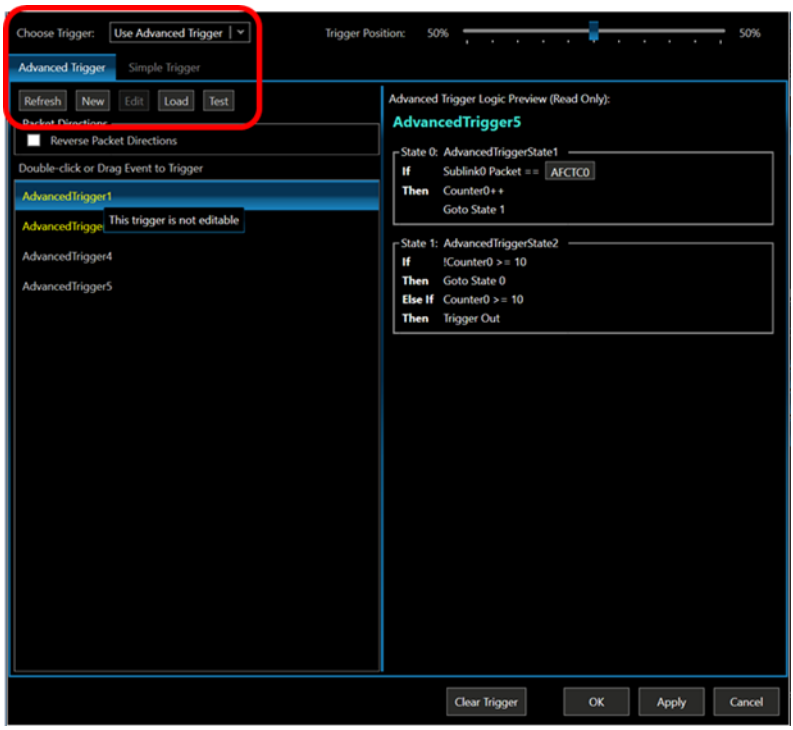
Simple Trigger

To set a Simple Trigger select Use Simple Trigger from the Choose Trigger dropdown. Double click on the packet of interest from the left-side packet list and it will appear in the right-side "Trigger on any of these Events" area. Alternatively, the packets can be dragged/dropped. If multiple packets are chosen, the trigger machine will use OR logic.

Double-clicking on a packet in the "Trigger on any of these Events" area will bring up the Packet Editor (the same used for Simple Packet Search) to edit the header or payload values to trigger on. These packet values can be saved as Favorite Packets for later re-use with either Simple Trigger or Simple Packet Search. Simple Triggers can also be saved as Favorite Simple Triggers for future use.

Advanced Trigger

Advanced Triggers are created and edited using the Test Editor, which can be accessed from the Tools menu or by selecting Advanced Trigger from the Choose Trigger dropdown in the Trigger Setup window and clicking New or Load.



Once created Advanced Triggers are automatically added to the list of available triggers in the left pane of the Advanced Trigger tab. Clicking Refresh will update the list of available Advanced Triggers.

Advanced Triggers that were saved with and then loaded from a .pitx trace do not include the full .piat Advanced Trigger information and thus are not editable; these are listed in yellow with a ToolTip "This trigger is not editable". To modify a non-editable Advanced Trigger the user must open the .piat file in the \AdvancedTriggers directory.

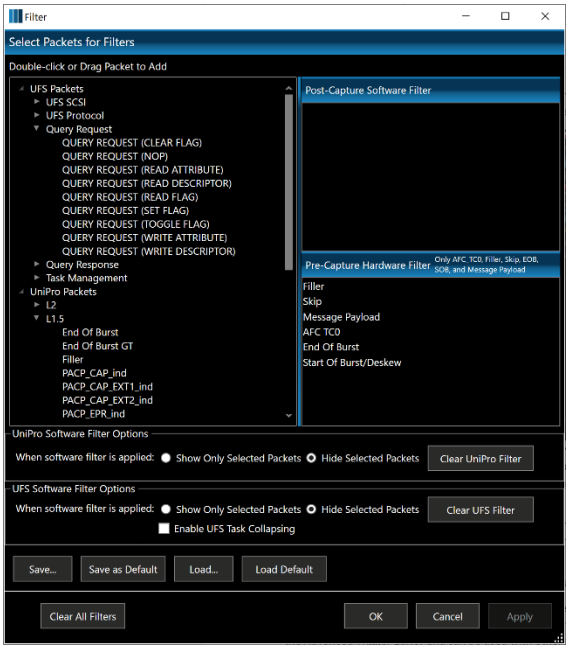
To set an Advanced Trigger, double click or drag the trigger of interest from the left pane into "Drag Advanced Trigger Here" in the right pane.

See the Advanced Trigger Editor User Manual for details on how to construct an advanced trigger.

The TRG IN connector on the instrument front panel (see ERROR! REFERENCE SOURCE NOT FOUND.) can be selected as an Analyzer Resource in the Simple Trigger window or in the Advanced Trigger Editor and can be used with other packet events. When a trigger event has occurred a TRG OUT is always asserted to the front-panel TRG OUT connector as a 1.8V ±0.3V signal.

Filter window

The Filter window, accessed from the Tools -> Filter menu or from the Tool Bar  , permits the filtering of specific packet types either before or after the trace has been stored and saved.



The Pre-Capture Hardware Filter can eliminate Fillers, Skips, Start of Bursts, End of Bursts and AFC_TC0 packets. The L2 Message Payload filter keeps the first 272 bytes of the Message (a Message is the UniPro packet containing a UFS packet) and removes the remaining contents of the packet.

Since these are filtered out prior to trace capture they are not stored or saved with the .pitx trace.

Packets can still be used as a trigger resource even if that packet is filtered out with the HW filter. This is because the trigger engine is before the filter block.

Post-Capture Software Filter will capture and store all packets, but it will suppress the selected packet types from the List window. The Traffic Summary window will still display all packets but highlight and deactivate those that have been filtered.

If Traffic Overview, Simple Packet Search or Bookmark navigation is used to go to a software filtered packet the active packet displayed will be the packet just before the filtered packet. In TV Results the "In Test" markers will disappear with the filtered packet and the user won't be able to go to those filtered packets. Simple Triggers can still be constructed with Filter enabled; if the trigger packet is filtered out the Trigger bookmark will mark the closest unfiltered packet prior to the trigger event.

If the Enable UFS Task Collapsing box is checked the UFS Packet List window will suppress all related task packets associated with a UFS Command packet. This can also be enabled from the Toolbar.

Settings window

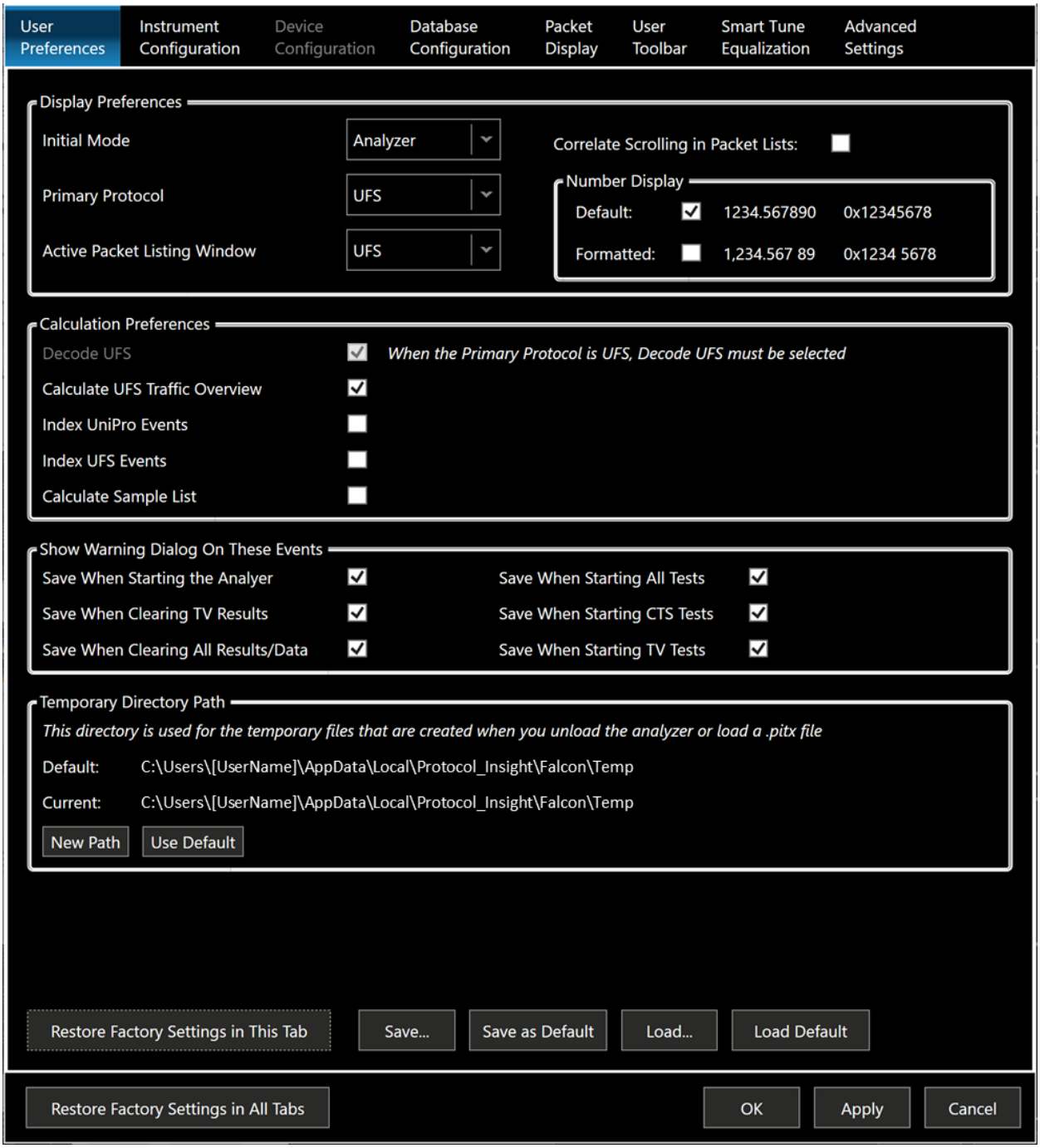
The Settings window is accessed from the Settings menu or the settings icon on the toolbar. The Settings window has separate tabs for User Preferences, Instrument Configuration, Device Configuration, Database Configuration, Packet Display, User Toolbar, Smart Tune Equalization and Advanced Settings.

Settings can be customized for each tab and saved and loaded from files located at <User>\Documents \Protocol Insight\Falcon\Settings. Customized settings for a given tab are saved to a .set file. These files can be copied so that users can carry their own personal configuration setting with them from PC to PC.

Note that all settings in the Settings tabs except for User Preferences and User Toolbar are saved with the trace when File->Save is used, and when a trace is opened the settings saved with the trace will override the settings in the Settings window. This allows the user to preserve the exact settings used when the trace was captured.

User Preferences tab

User Preferences allows the user to tailor their experience and optimize application software performance based on their typical application and most common use models. For example, a user who is primarily interested in using the listing window to debug UniPro may choose to set the default mode to Analyzer, turn off automatic decode and calculation of UFS packets, and set the default Packet Listing Window and calculation settings exclusively for UniPro.



Display Preferences

Setting the **Initial Mode** controls which display mode is active when the software application is launched (see WINDOWS for more information). The **Primary Protocol** controls whether UFS packets are decoded (if selected in Calculation Preferences), what the default protocol is for the device Boot/Reboot button in the toolbar, and the selected test list under Device Control in the Configuration window. The **Active Packet Listing Window** sets the default Packet List window, for example selecting UniPro will cause the UniPro Packet List window to be the active Packet List window upon completion of a trace capture.

Correlate Scrolling in Packet Lists locks the UniPro and UFS List windows by default when scrolling.

Number Display makes large numbers more readable if the Formatted box is checked. It adds comma separators before the decimal place and spaces after every three digits or every four hex values. This applies only within the GUI and does not affect exported data.

Calculation Preferences

After the instrument has captured a trace it is off-loaded to the application software and the UniPro Packet List, Packet Decode and Data View windows are immediately populated with decoded trace data.

The UFS Packet List, Packet Decode and Data View windows are also populated with decoded UFS data if the Decode UFS box is checked under Calculation Preferences.

Background calculations then are initiated to update the UFS Traffic Overview, Events windows and Sample List if those boxes are checked in Calculation Preferences.

The background calculations can take time and during background calculation you cannot save the trace file unless you cancel calculations from the toolbar. To disable automatic background calculation of some or all of the automatic calculations deselect those under “Calculation Preferences”.

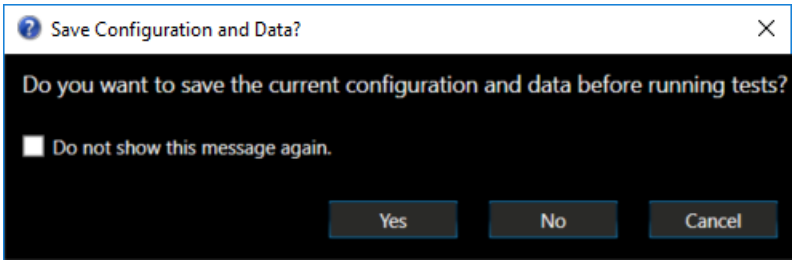
If a trace has been saved without completing some or all calculations, when the file is re-opened it will automatically start calculating in the background if a box is checked under “Calculation Preferences”.

You can force a calculation of an uncalculated trace by selecting Calculate Options from the Results menu.

The application software will still be highly responsive while it is doing background calculation, and Packet List, Packet Decode and Data View windows are fully functional. However, until Traffic Overview is calculated the Simple Packet Search functionality will not be available.

Show Warning Dialog On These Events

This section can be used to change warning dialog preferences if the “Do not show this message again” box has been checked in any warning dialog.



For example, the Save Configuration and Data warning dialog will appear anytime the following actions are performed: opening a new trace file, exiting the application, starting the analyzer, clearing results and data, clearing Trace Validation results, or running tests.

Temporary Directory Path

When unloading trace data from the instrument to the application software, large files are temporarily created that can grow to be 5-10x larger than the actual .pitx file. This can affect the performance of the

application if the target directory is located on a drive that has slower write speeds and/or insufficient disk space.

The path where these temporary files are stored can be changed to point to another location, typically a faster larger drive.

Instrument Configuration tab

This tab is used to configure the Falcon instrument. To display status information about the analyzer and exerciser instrument and UniPro link see the **INSTRUMENT STATUS WINDOW**. To configure analyzer and exerciser tests see the **CONFIGURATION WINDOW**.

In the **Host** and **Device** sections the sublinks can be renamed and mapped and the channels can be defined.

Capture Options

Capture Options are used to define where traces are stored during capture. Choosing *Standard* will store the trace in instrument memory, up to the maximum amount specified in the Instrument Memory Depth field. Once the specified amount of memory has been filled, the oldest data will be discarded, and capture will continue with a circular buffer until the analyzer is stopped or a trigger event occurs.

Choosing *Streaming* will immediately output the trace via the Thunderbolt3 interface and store the data on the controller PC hard drive. The size of the capture can be defined. Once the *Disk Buffer Limit* has been reached, the oldest data will be discarded and capture will continue with a circular buffer if *Wrap Buffer* is selected, otherwise the capture will stop. Note that streaming capture requires HW filtering of fillers, skips and UFS TC0 message payload to ensure optimum bandwidth.

With streaming capture the entire trace is stored to disk before any processing, so if there is an error during processing the trace is still on disk and the "Save debug File" will save the whole trace. If there is an error during capture the trace will be lost.

Streaming Performance Test evaluates the Thunderbolt3 and host PC performance for the two fundamental functions required for streaming: interface Bandwidth from instrument to the PC and Disk Write bandwidth. 2100MB/s is considered the minimum, any test not achieving this speed is evaluated as failing.

See **APPENDIX F: STEAMING CAPTURE** for more details on how streaming capture works, or **APPENDIX 2: SYSTEM REQUIREMENTS** for a description of the minimum PC requirements for streaming capture.

Initial Power Mode

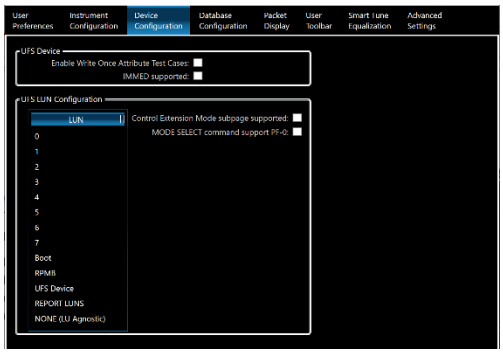
The Initial Power Mode settings are used to tell the analyzer the initial power mode to assume for sync to the link, if the analyzer is capturing a link in mid-transmission. The analyzer can capture a trace from an existing UniPro link, but the analyzer needs to be told what power mode the UniPro link is operating at.

Once the initial power mode is configurated in the Instrument Configuration window and the analyzer syncs to the current power mode, the analyzer will continue to track the link power mode.

Other Settings

Selecting a UFS clock with the Output Clock selection is only necessary if you are using the UFS external reference clock signal on the front panel of the instrument.

Device Configuration tab (G550C only)



The Device Configuration tab allows configuration of the device parameters necessary for CTS testing.

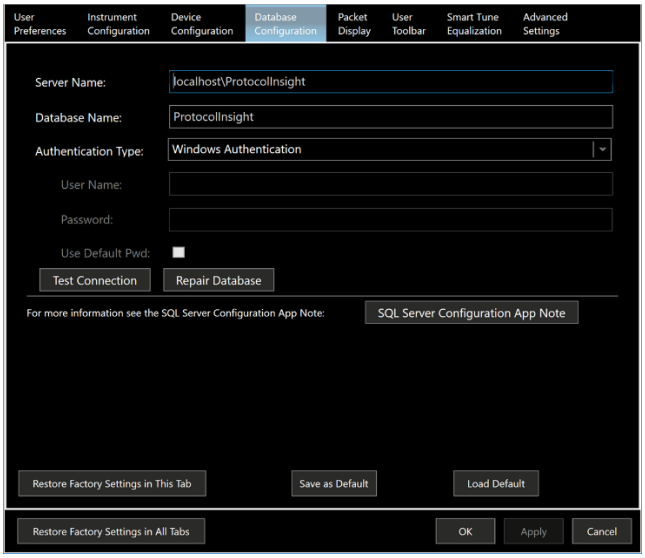
Beginning with v2.2.1 most of the device parameters are now queried from the device directly by the CTS test case and, if necessary, correct updated values are sent to the device. The device parameters that must still be set manually are

- UFS Device:
  - Enable Write Once Attribute Test Cases: Enables CTS test cases that write a Write Once Attribute, this prevents users from accidentally writing these attributes.
  - IMMED Supported: the device supports IMMED flag
- UFS LUN Configuration:
  - Control Extension Mode Subpage Supported: The device supports the Control Extension Mode subpage
  - Mode Select Command Support PF=0: The device supports the Mode Select Command with PF=0

To change UFS LUN Configuration for multiple LUNs, hold the shift key while selecting LUNs from the list on the left side in UFS LUN Configuration.

Note: when a trace file is saved as a .pitx file, the device configuration information is saved with the file. After opening a .pitx file if changes are made to the device configuration using the Device Configuration window these changes will overwrite the settings in the trace file.

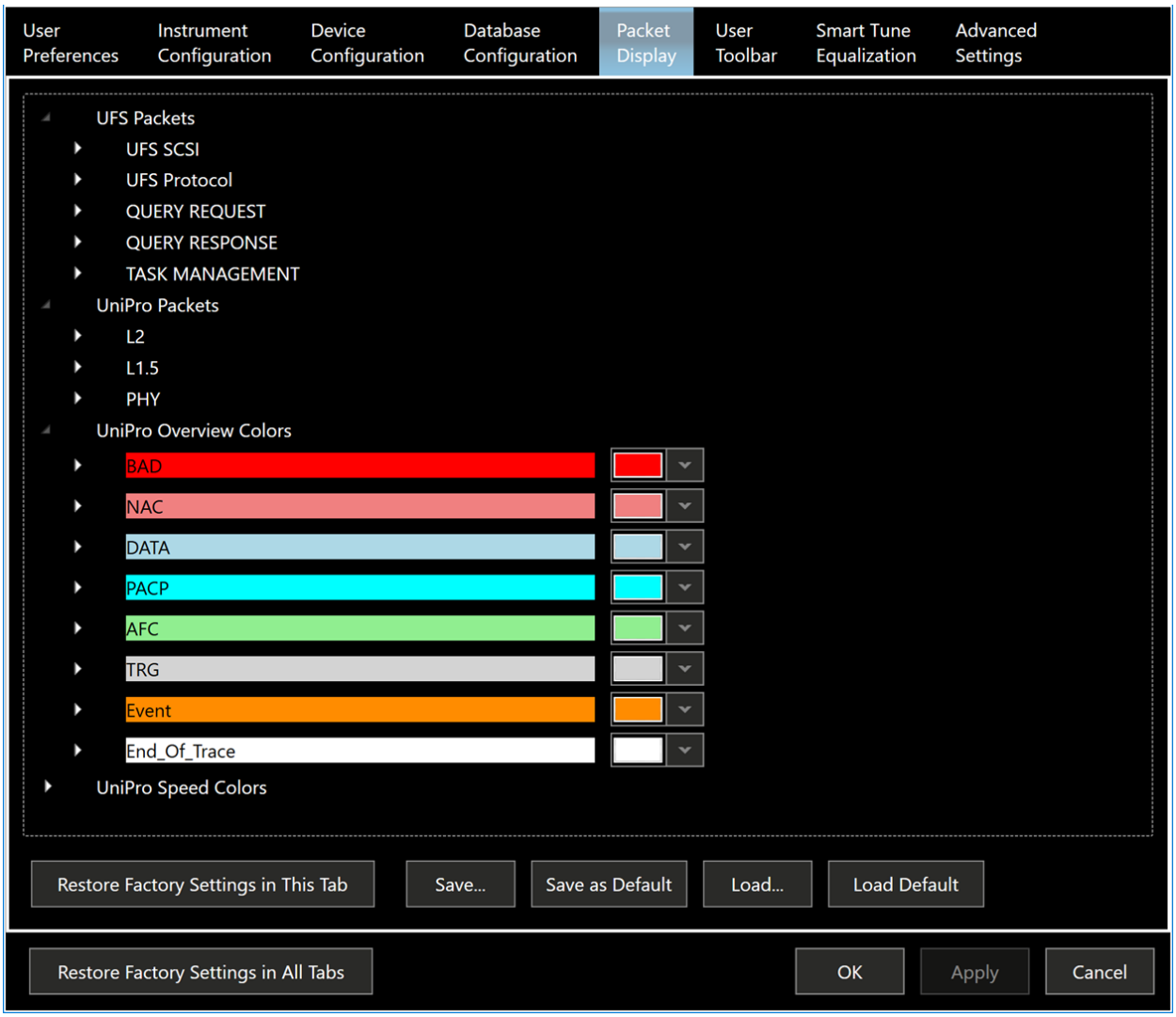
Database Configuration tab



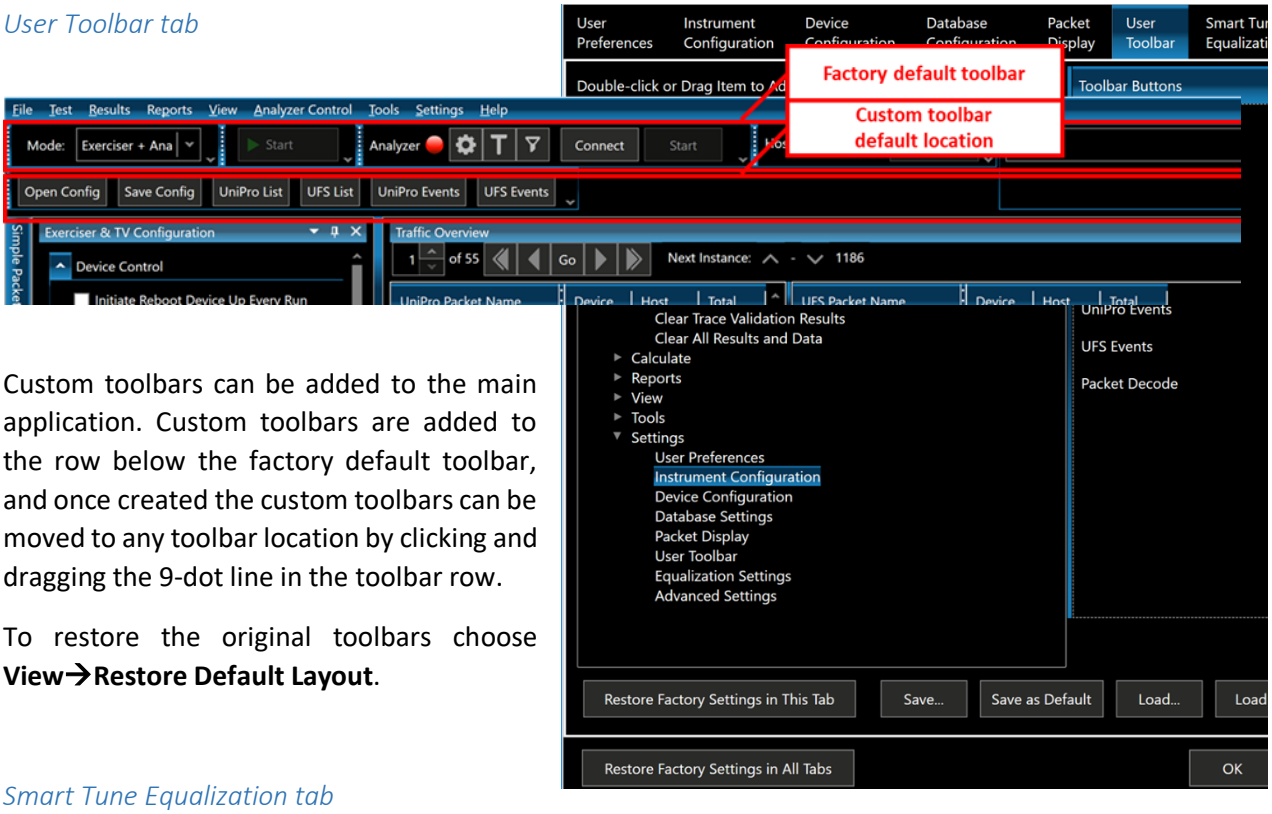
The Database Configuration tab is used to update and save settings to repair the SQL database. See **APPENDIX A: RESETTING YOUR SQL DATABASE** thru **APPENDIX C: MANUALLY INSTALLING MICROSOFT SQL SERVER** for more information on how to configure the SQL database using this tab.

Packet Display tab

This tab allows the user to customize most packet colors used in the List and Event views.



User Toolbar tab



Custom toolbars can be added to the main application. Custom toolbars are added to the row below the factory default toolbar, and once created the custom toolbars can be moved to any toolbar location by clicking and dragging the 9-dot line in the toolbar row.

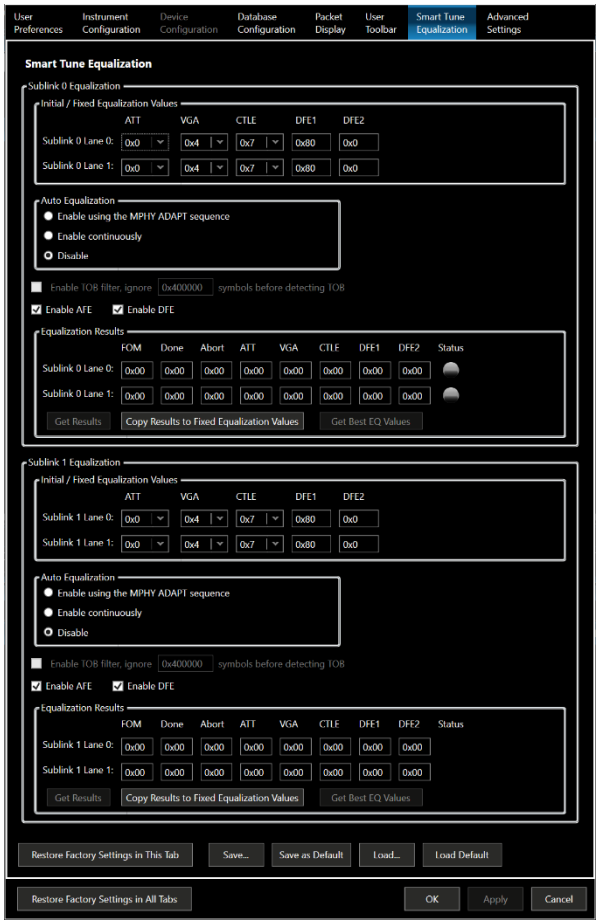
To restore the original toolbars choose **View→Restore Default Layout**.

Smart Tune Equalization tab

Default ATT (Attenuation), VGA (variable-gain amplification), CTLE (continuous time linear equalization), and DFE (decision feedback equalization) settings are loaded into instrument hardware when the application software initially connects to the Falcon instrument.

In some instances acquiring the signal from the DUT can be problematic when test fixture trace routing or the cabling required to connect to the test fixture causes poor signal integrity or probing issues. To optimize signal acquisition in the case of poor signal integrity or probing issues the Falcon Series offers **Smart Tune™ equalization** capability.

Smart Tune allows the user to choose between setting fixed equalization values manually for the front-end PHY, auto equalizing using the M-PHY4.1/5.0 ADAPT capability or running auto equalization continuously each time a Burst is opened on the link.



To **set equalization values manually** individual values can be entered in the Sublink 0 and Sublink 1

Initial/Fixed Equalization Values section or saved values can be loaded from a file. Since the mapping of each of the PHY equalization settings to a physical parameter is complex, manual entry of values should only be done on the advice and recommendation of Protocol Insight Support.

To run **Auto Equalization using the MPHY ADAPT sequence** check the box *Enable Auto Equalization using the MPHY ADAPT sequence*, then execute a Link Startup Sequence on the DUT and run the ADAPT sequence between the Host and Device. Return to the *Equalization* tab and click "*Get Results*". Verify that a successful Smart Tune was achieved, see *Verifying Smart Tune Results* section. If successful, Smart Tune can safely be left with *Enable Auto Equalization using the MPHY ADAPT sequence* checked, in this mode it will equalize every time ADAPT is ran. Optionally, the results can be saved and used as fixed values, see the *Saving and Applying Results* section. If the Smart Tune was unsuccessful, see *Verifying Smart Tune Results* section, try repeating the entire process by running the ADAPT sequence again. If the Smart Tune results continue to be unsuccessful refer to the *Troubleshooting Auto Equalization using the MPHY ADAPT sequence* section. Note that because ADAPT is only supported in M-PHY 4.1 and 5.0 for HS-G4 and HS-G5, this capability does not support lower HS speeds.

Troubleshooting Auto Equalization using the MPHY ADAPT sequence: These troubleshooting instructions are intended for Analyzer mode.

- If the results show Abort > 0 and Done == 0: This indicates that PHY is not seeing enough symbols to complete a Smart Tune. Verify that the Host and Device ADAPT sequence length is long enough, Falcon has a RX_HS_ADAPT_LENGTH_COARSE_Capability value of 0x91 (course,17), thus the Host and Device must both use an ADAPT_length of 0x91. If either Host or Device is does not use an ADAPT_length of 0x91 you can change the value after Link Startup but before the power mode change. Set the attribute PA_PeerRxHsAdaptInitial (0x15D3) to 0x91 in both the local and peer DME's.
- If the host and device ADAPT sequences length is long enough but still Abort > 0, it could be caused but the PHY falsely detecting a Tail of Burst to soon. Select the *Enable TOB Filter*, start with the default value of 0x100000 for symbols to ignore. You can increase or decrease the symbols to ignore based on the ADAPT length. If you continue to have issues you can try *Auto Equalization continuously* or contact Protocol Insight Support with traces that show link startup, power mode change and the ADAPT sequence. Also take screen captures of the Equalization Results after each attempt.

To run **Auto equalization continuously** select *Enable Auto Equalization continuously*. Then execute a Link Startup Sequence on the DUT and change power mode to the fastest mode supported and begin sending a good equalization data pattern. To achieve the best results Smart Tune typically requires ~10MB of random data to be sent in a single burst. The recommended way to send random data for Smart Tune is in fast mode with scrambling enabled, because scrambled fillers are a pseudorandom data pattern. Verify that the analyzer is seeing data by observing the Hardware Counters increasing in the Instrument Status window. Return to the Equalization tab and click "*Get Best EQ Values*". This will determine the maximum FOM value by observing equalization results for 5 seconds, then it will save the equalization values with the best FOM Quality. Once completed you should observe successful results, see *Verifying Smart Tune Results* section. If successful, the results should be saved and used as fixed values, see the *Saving and Applying Results* section. *Auto Equalization continuously* mode should only be used to get equalization

results and it is not recommended to leave Smart Tune in the *Auto Equalization continuously* mode. This capability supports all HS speeds.

The **Equalization Results** section shows the value of the equalization settings that are currently being applied in the PHY. When running Smart Tune equalization, the PHY will try to find the ideal equalization values (ATT, VGA, CTLE, DFE). The status information (FOM (Figure of Merit), Abort, Done) will indicate the quality of the Smart Tune equalization. The **Done** counter indicates how many times equalization tuning successfully completes. When running Smart Tune this counter should increment every time a new Smart Tune is ran. The **Abort** counter indicates how many times equalization tuning fails, failures typically occur because the PHY did not see enough bytes of data in a single burst, typically ~10MB are required to be sent in 1 burst for the PHY to correctly equalize. The **FOM** value indicates how good the equalization values are. The larger FOM value the better the equalization is, see Table 1 below for FOM Value to FOM Quality mapping. ***Poor*** FOM Quality typically indicates poor signal integrity which results in errors being captured. The FOM value is the perceived quality of the equalization, the only definitive test is if the RX can capture error free. There are instances where the FOM is a false large value, meaning the FOM Quality is a ***Good*** value but errors are still captured. This typically happens when the data pattern that was used for tuning is not random data, FILLERS that are NOT scrambled is the worst data for Smart Tuning.

Verifying Smart Tune Results: A successfully Smart Tune is indicated by the Done counter value >= 1, values for all the PHY values should have changed from the previous value and the Figure of Merit value (FOM) should be Good quality, see **Error! Reference source not found.**.

- Successful Smart Tune is indicated by (Done >= 1 and FOM Quality = Good)
- Failed Smart Tune is indicated by (Done == 0 and Abort >= 1).
- Poor quality Smart Tune is indicated by (Done >= 1 and FOM Quality = Poor).
- Smart Tune did not run if Done == 0 and Abort == 0.

FOM Quality	FOM Value
Good	**>=0x60**
Poor	**<0x60 & >= 0x50**
Bad	**<0x50**

Table 1 FOM Value to FOM Quality Mapping

Saving and Applying Results: To save the values select "Copy Results to Fixed Equalization Values" to load the values into the PHY and switch to Fixed Equalization mode by unchecking the *Enable Auto Equalization using the MPHY ADAPT sequence* and *Enable Auto Equalization continuously.*

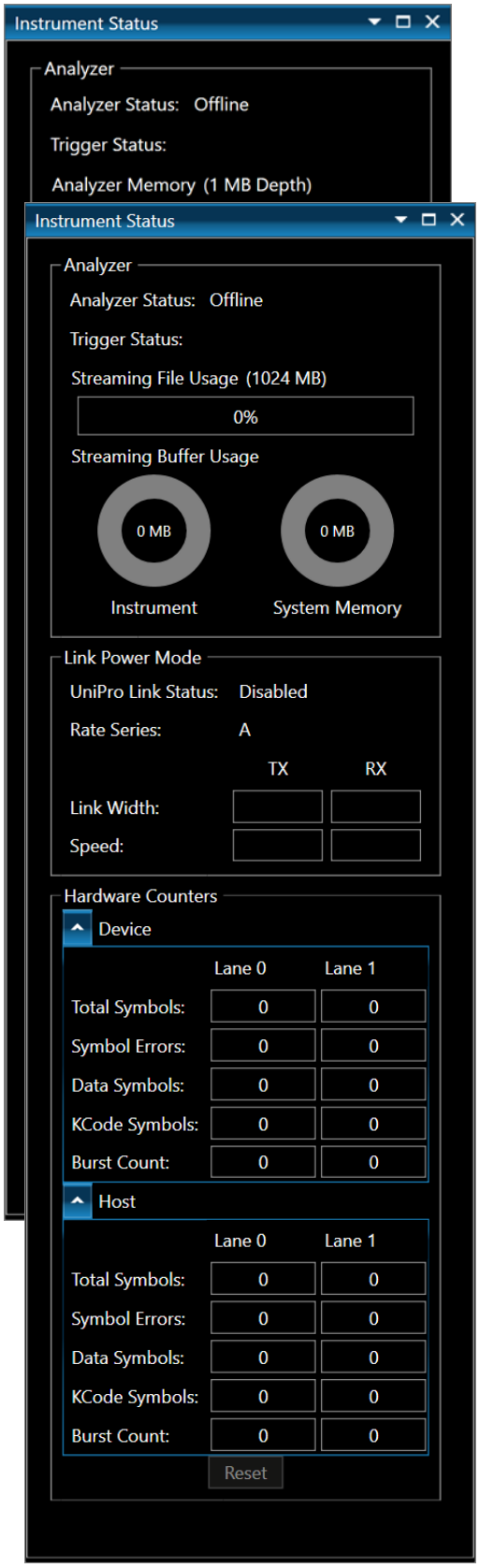
Advanced Settings tab

CAUTION: the Advanced Settings tab requires expert knowledge of the instrument and the Device Under Test and test fixture configurations. The Advanced Settings tab should only be used on the advice and recommendation of Protocol Insight Support. Before beginning the user must acknowledge this by checking the box that "I understand how to use Advanced Settings".

For information on how to use the Advanced Settings tab contact your local Protocol Insight representative or support@protocolinsight.com.

Instrument Status window

This window is used to display status information about the analyzer and exerciser instrument and UniPro link operation. To configure the instrument see the **INSTRUMENT CONFIGURATION TAB** under Setting on the menu. To configure analyzer and exerciser tests see the **CONFIGURATION WINDOW**.



The **Analyzer section** of Instrument Status is used to display analyzer and trigger status and the configured analyzer memory Capture Options.*Analyzer Memory* is displayed if Standard is selected as the Capture Type in Capture Options in the Instrument Configuration tab of the Settings window. The amount of embedded Instrument Memory Depth selected is displayed along with a percentage representing the amount of memory filled relative to the amount of memory allocated.

The analyzer always reserves the amount of memory after the trigger that is set with the Trigger Position; if a 20% trigger position is set the analyzer will reserve 80% of the memory for post-trigger fill. What this means is that if the trigger occurs deep in the trace then 100% of the memory buffer will fill, 20% before and 80% after. But if the trigger event occurs very early in the trace, say after only filling 5% of the total memory, the capture will total less than 100% because 5% will be before the trigger and 80% after the trigger for 85% total. See **TRIGGER SETUP WINDOW** for more information.

The **Link Power Mode section** provides real-time link status and power mode information.

The **Hardware Counters section** provides insight into the real-time traffic on the link by counting the number of M-PHY symbols and symbol errors observed on each sublink/lane. Symbol errors in the Instrument Status window are KCode raw bit capture errors, typically caused by signal integrity problems, probing issues or M-PHY issues. The Hardware Counters will increment independently of if the analyzer Run button is selected.

Streaming File Usage is displayed if Streaming is selected as the Capture Type in Capture Options in the Instrument Configuration tab. Streaming File Usage shows the amount of Disk Buffer Limit allocated and the percentage of that buffer that has been filled by the capture. Streaming Buffer Usage displays a graphical representation of the amount of the instrument's embedded memory and the controller PC's RAM that is being used as a buffer as the trace is being written to the Streaming File on disk. See **APPENDIX F: STEAMING CAPTURE** for more information.

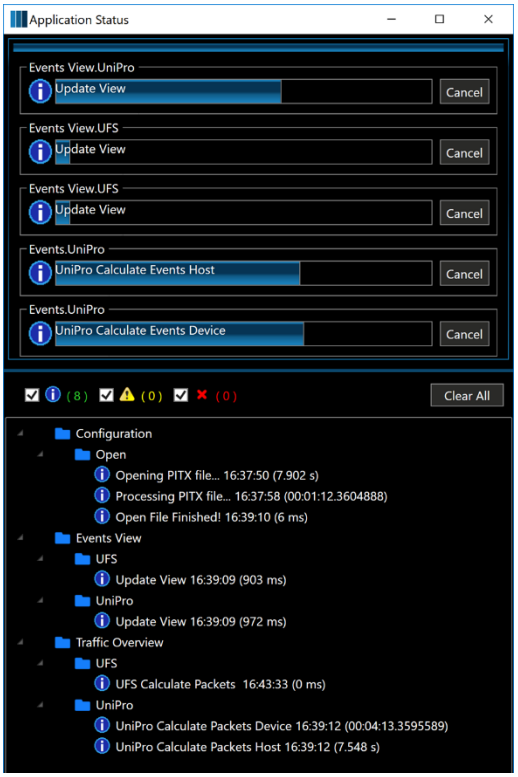
Application Status

The Application Status window can be accessed from the toolbar by clicking on the blue info icon to the right of the application status bar in the Tool Bar.

The Application Status window will display progress on any computationally intensive functions being performed by the application, such as file opens, Traffic Overview and Events indexing, zooms, searches, and Trace Validation runs.

If the Application Status window is opened before a Configuration/Analyzer Capture file is opened the status window will display all computations while the trace file is being opened.

Application Status messages will be automatically cleared when a new trace is captured or loaded from a file.



Eye Monitor

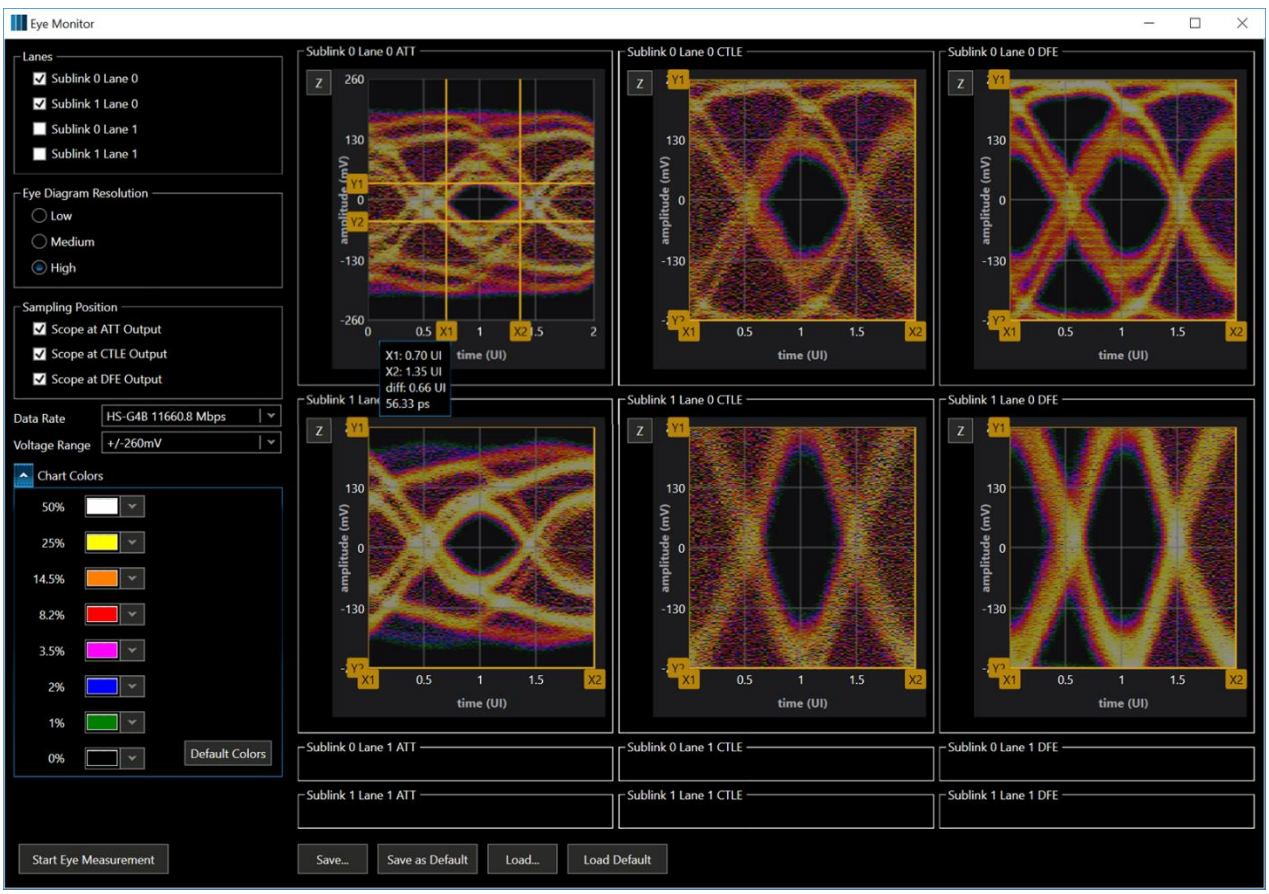
The Eye Monitor window, accessed from **Menu→Tools→Eye Monitor**, constructs an eye diagram of the link to determine the link quality.

To develop useful eye diagram measurements Eye Monitor must be run against high speed traffic with lots of transitions, preferably HS-G4 or HS-G5 in NonAuto mode with Scrambling enabled.

To perform an eye diagram measurement:

1. Click Connect on the toolbar. The application will connect to the instrument hardware and begin tracking symbols on the link.
2. Initiate suitable traffic across the link and verify that the analyzer is seeing that traffic by observing the counters increasing under Hardware Counters in the Instrument Status window.
3. Open the Eye Monitor tool and choose which Lanes to measure, choose what Eye Diagram Resolution to run the measurement at, and which Sample Points to measure the eye at.
4. Click Start Eye Measurement.

After the measurement is complete the results can be saved and shared by clicking the Save… button. Qualitative measurements can be done for jitter, noise, and eye opening by dragging the X and Y cursors in each eye measurement panel, delta values will be displayed in the cursor tooltip.



Menu Functions

Many menu functions are duplicated on the easy to access **TOOL BAR**. This section provides additional detail for the more complex functions.

File Menu

All trace data, including trace indexing for Traffic Overview and Events window, Trace Validation results, and any settings from the Configuration windows are saved in a file with file extension of .pitx (Protocol Insight Test).

→Open Configuration…

This function is used to open a previously saved .pitx configuration file to restore all of the Settings dialog configurations except User Preferences and User Toolbar.

File→Open Configuration/Analyzer Capture…

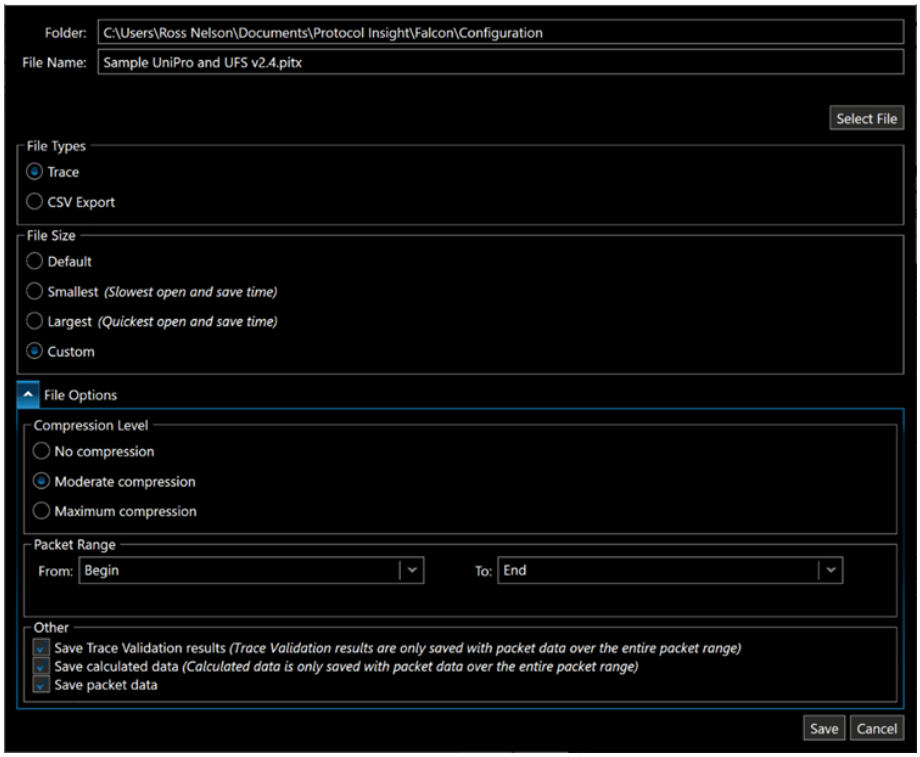
This function is used to open a previously saved .pitx file including the instrument and device configuration, the trace capture, trace indexing for Traffic Overview and Events views, and Trace Validation results.

File→Open Recent Configuration/Analyzer Capture…

This function is used to open recently used traces and/or configuration files.

File→Save or Export Trace

With this dialog the user can chose between saving a .pitx trace or a CSV export. When saving a trace the user can select what data to include in the trace and the level of compression. Default saves all trace data and the settings in all Settings dialog tabs except for User Preferences and User Toolbar.



File→Refresh Advanced Trigger Tests

Updates the list of advanced triggers in the Advanced Trigger window with the advanced triggers in <User>\Documents\Protocol Insight\Falcon\ AdvancedTrigger.

File→Refresh Trace Validation Test List

Updates the list of Trace Validator test categories and custom Trace Validator test cases in the Configuration windows from the categories and test cases in <User>\Documents\Protocol Insight\Falcon\CustomTests.

Directories in <User>\Documents\Protocol Insight\Falcon\CustomTests are displayed in *italics* as categories in the Configuration window test lists, appended to the bottom. For example, the directory <User>\Documents\Protocol Insight\Falcon\CustomTests\ProjectX would appear in the test lists as the category *ProjectX*. Custom tests must be saved in categories (sub-directories). New categories can be created by adding new sub-directories in <User>\Documents\Protocol Insight\Falcon\CustomTests with File Explorer.

File→Refresh Stimulus Test List

Updates the list of custom stimulus test categories and custom stimulus test cases in the Configuration windows from the categories and test cases in <User>\Documents\Protocol Insight\Falcon\CustomTests.

Directories in <User>\Documents\Protocol Insight\Falcon\CustomTests are displayed in *italics* as categories in the Configuration window test lists, appended to the bottom. For example, the directory <User>\Documents\Protocol Insight\Falcon\CustomTests\ProjectX would appear in the test lists as the category *ProjectX*. Custom tests must be saved in categories (sub-directories). New categories can be created by adding new sub-directories in <User>\Documents\Protocol Insight\Falcon\CustomTests with File Explorer.

File extensions:

Here is a complete list of all file extensions:

Traces (including the configuration & analyzer captures) *.pitx

Settings

Settings (for a given tab in the settings windows) *.set:

Advanced.set
SmartTune.set
Device.set
Instrument.set
PacketDisplay.set
UserPreferences.set
UserToolbar.set
Default settings for each tab are stored in a file with the same name but with a .dft extension.

These individual Settings file extensions used prior to 2.4.0.10628 are still supported:

User Preferences *.prf
Instrument Configuration *.ins
Device Configuration *.dev

Database Configuration *.dbc
Packet Display *.pcl
User Toolbar *.utb
Smart Tune Equalization *.equ
Advanced Settings *.ads
These settings can be opened and then saved as a *.set file.

Triggers
Advanced Trigger File *.piat
Simple Trigger File *.smp
Packet File *.pkt

Simple Search
Packet File *.pkt

Trace Validation
Validation, state machine and diagram files *.pitv

Stimulus Editor/Builder files
Stimulus Editor Files *.pie

Some file extensions changed with v1.8.0, however legacy file extensions are still supported for backward compatibility.

Test Menu

Test→Run

Starts the Stim and Trace Validation tests selected and configured in the Configuration windows.

Test→Stop

Stops the tests that are currently running.

Results Menu

Results→Clear Stimulus Results

Results→Clear Trace Validation Results

Results→Clear All Results and Data

Selecting these menu options will clear the respective Results window or windows of all test results.

Results→Calculate Options

This forces a calculation of any uncalculated trace data. Only valid options that have not been calculated will be active.

Reports Menu

Reports→Trace Validation Results
Reports→Stimulus Results

Summary reports can be created by configuring the TV Results and Stimulus Results windows (grouping, summarizing, sorting, filtering and expanding levels) and then printing them from this menu. This menu will reproduce exactly what is reflected in the Results window to a PDF file. Reports can also be exported to a CSV or XML file.

Reports→UniPro Packet List
Reports→UFS Packet List

A Packet List report can be generated from a Packet List window.

This menu will reproduce exactly what is reflected in the Packet List window to a PDF file.

View Menu

Any windows that have been closed will be opened by selecting these options. Restore Default Layout will restore the default window and toolbar layout.

Analyzer Control Menu

Analyzer Control→Connect
Analyzer Control→Start
Analyzer Control→Stop

These menu items provide the same functionality as the Analyzer status/control tool bar. Clicking Connect will establish a connection between the analyzer application and the instrument hardware if it is available. Clicking Start or Stop will begin or end a trace capture.

Tools Menu

Tools→ Trigger

The Trigger dialog is used to create, modify and set triggers.

Tools→ Filter

Selecting this menu option will open the Filter window. See FILTER WINDOW for more information.

Tools→ Eye Monitor

Selecting this menu option will open the Eye Monitor dialog to perform eye measurements on the link. See EYE MONITOR for more information.

Tools→ Editor

Editor→ Open Editor

This launches Protocol Insight's Visual Studio Editor tool as a separate application for editing existing or creating new Advanced Triggers, Trace Validation or Stimulus tests.

Editor→New Advanced Trigger

This launches Protocol Insight's Visual Studio Editor tool as a separate application and opens a new Advanced Trigger file.

Editor→New Trace Validator

This launches Protocol Insight's Visual Studio Editor tool as a separate application and opens a new Trace Validator project.

Editor→New UniPro Stimulus

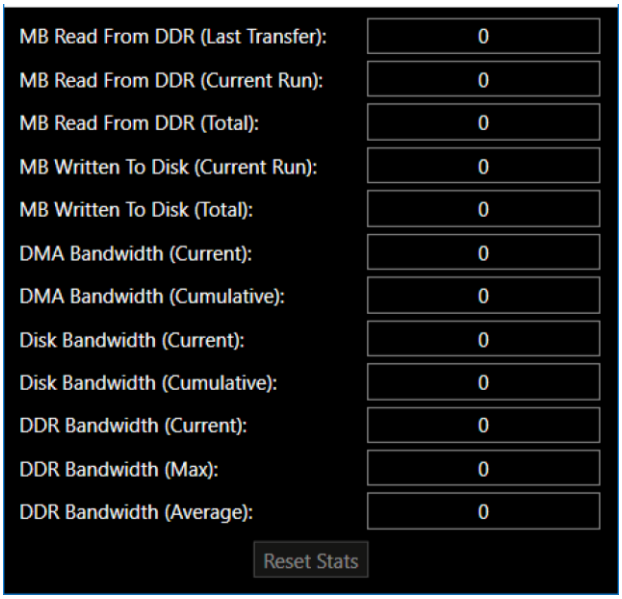
This launches Protocol Insight's Visual Studio Editor tool as a separate application and opens a new UniPro Stimulus test project.

Editor→New UFS Stimulus

This launches Protocol Insight's Visual Studio Editor tool as a separate application and opens a new UFS Stimulus test project.

Tools→ Streaming Statistics

The Streaming Statistics dialog displays information on the streaming performance (bandwidth and bottlenecks) of the Thunderbolt3 connection between the instrument and the controller PC. This streaming data is collected continuously any time Streaming Capture is used.



Tools→ Save Debug File

Settings Menu

Settings → User Preferences

See USER PREFERENCES for more information.

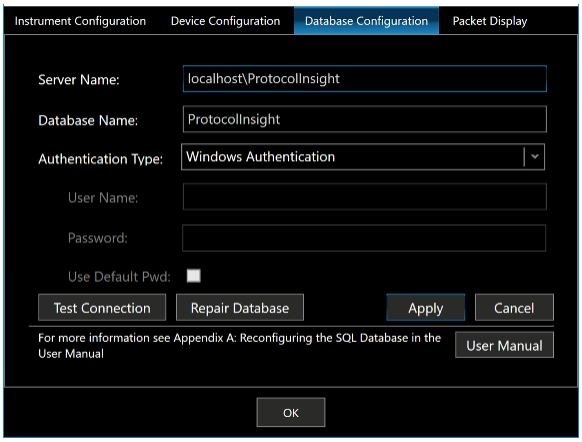
Settings → Instrument Configuration

See INSTRUMENT CONFIGURATION TAB for more information.

Settings → Device Configuration

See DEVICE CONFIGURATION TAB (G550C ONLY) for more information. This will be greyed out and inactive if Analyzer mode is selected.

Settings → Database Configuration



See DATABASE CONFIGURATION TAB for more information.

The Microsoft SQL Server and instrument-specific database settings are configured automatically with the initial software installation. However, in some instances it may be necessary to reset your database settings, reconfigure your database or re-install it manually from scratch. The Database Configuration dialog is used to update and save settings to repair the database.

See APPENDIX A: RESETTING YOUR SQL DATABASE thru APPENDIX C: MANUALLY INSTALLING MICROSOFT SQL SERVER for more information.

Settings → Packet Display

See PACKET DISPLAY TAB for more information.

Settings → User Toolbar

See USER TOOLBAR TAB for more information.

Settings → Smart Tune Equalization

See SMART TUNE EQUALIZATION TAB for more information.

Settings → Advanced Settings

See ADVANCED SETTINGS TAB for more information.

Help Menu

Help → User Manuals

User Manuals are provided for the instrument, Advanced Trigger, Trace Validation Editor, and Stimulus Editor.

Help → Compatibility-> Test Case Revisions and Interpretations…

Selecting **Test Case Revisions and Interpretations…** will launch a web browser and navigate to a web page which provides regularly updated information on test cases that have been revised or required interpretation to develop.

Protocol Insight may revise certain test cases from the strict interpretation of the UniPro or UFS CTS to facilitate effective and accurate test execution. Any revisions are described here.

Interpretation of some test cases may have been required to account for ambiguities in the UFS spec, the UniPro spec, and/or the CTS specs. To complete the development of the CTS tests Protocol Insight may have made certain interpretations which could alter the results of the test cases; those interpretations are described here.

Help → Compatibility->Known Issues…

Selecting **Known Issues…** will launch a web browser and navigate to a web page which provides regularly updated information on any known issues with the application software or firmware.

Post-Capture Analysis

Trace Validation

Trace Validation (TV) is a state machine analysis tool that analyzes captured traces using specific and|or logic and states to find problems and events. TV tests can be run against any captured trace as a complete post-capture analysis tool for search, pass/fail testing, stress test analysis or for general debug.

There are generally four types of TV tests that can be run: pre-defined CTS tests, debug tests, SearchTVs and custom tests. The application software library includes hundreds of pre-defined CTS, debug and search TVs that can be used as-is or modified and saved as their own unique analysis test cases. And the user can use Trace Validation Editor to create their own custom TV tests.

Pre-defined CTS tests are supplied with the application software library for most UniPro and UFS CTS tests defined by the respective standards organizations.

When these CTS tests are executed the Exerciser/Analyzer inserts a specific Protocol Insight marker packet into the trace to indicate the beginning of each CTS test in the trace (see **Test execution and Trace Validation analysis for Falcon** for more information). If TV does not find the marker packet TV will not complete and will instead generate the message "State machine did not run".

For this reason, the TV CTS tests supplied with the application software library should only be used to analyze traces generated with the exerciser with the matching CTS Stim test case containing a marker packet.

The pre-defined CTS tests are designed to follow the exact packet sequence defined in each CTS. For example, in JESD224A, the CTS test 8.1.3 "UFS_ContextManagement_03" requires the following specific packet sequence:

1. Issue Query Request Write Attribute command to set wContextConf for read and write operation
2. Issue READ (10) command
3. Issue WRITE (10) command
4. Issue Query Request Write Attribute command to clear wContextConf (INDEX = N).

Therefore, the TV test for UFS CTS 8.1.3 specifically requires a Query Request Write Attribute command followed by a Read (10) followed by a Write (10) followed by another Query Request Write Attribute command. If these packets are not found in this sequence the test will fail.

Debug tests are designed to analyze any trace, not just ones generated by the exerciser for CTS, to find issues that are commonly associated with UniPro or UFS turn-on problems. Examples include Link Startup problems and Powermode Change failures. Debug tests are intended to be used with traces captured in either exerciser or analyzer mode. If no states in the captured trace match the criteria of the debug TV, the message "State machine did not run" will be generated. See **Appendix E: Debug Test Descriptions** for a list and explanation of these tests.

SearchTVs are tests created by Protocol Insight to search a trace for specific conditions. The application software library includes three search TVs, "Find UniPro Error Packets", "Find UFS Error Packets" and "Find Protocol Insight CTS Markers".

Custom TV tests can be created by the user, either from scratch or from a pre-defined test in the application software library. See the separate Trace Validation Editor User Manual for more information.

Trace Validation Results - Group and Summarize

Analysis of results in the TV Results window can be done with grouping. To group click on any column header and drag into the Test Results field. This will summarize the results with an item count of occurrences. Multiple column headers can be dragged into the Test Results field (**1**) to create tiered groupings for analysis:

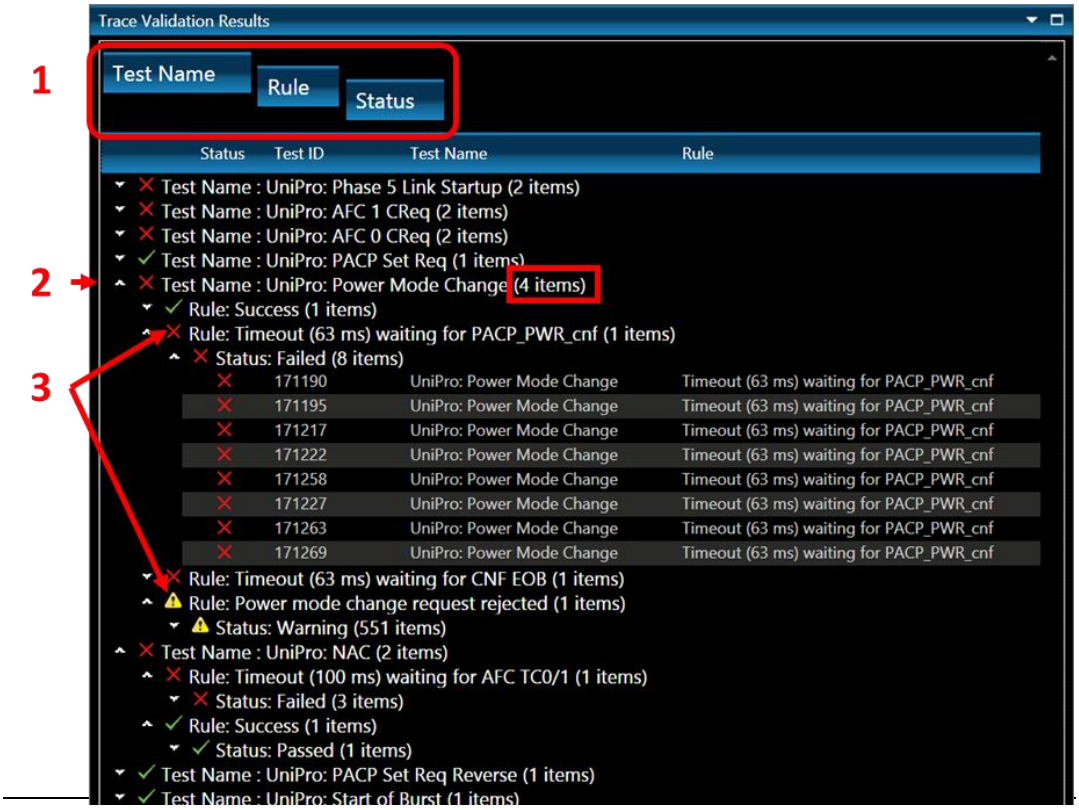


Figure 2: Grouping and Summarizing

The item count represents the number of items in the grouping below, so in this example (**2**) "Test Name: UniPro: Power Mode Change" counted 4 items, representing 4 different test results. This item count summing function can be manipulated with a high degree of flexibility by reordering the groupings to count different items in addition to tests, such as number of Failures (Status) or Rules.

Summary Status flag: for any grouping of results the summary status flag represents the worst-case result of the grouping (**3**). In this example, 4 results were determined for "Test Name: UniPro: Power Mode Change", and the worst result was a Failure so "Test Name: UniPro: Power Mode Change" is marked as Failure.

Trace Validation Results - Sort and Filter

In the TV Results window any column header can be clicked to filter out results or to sort results by that column:

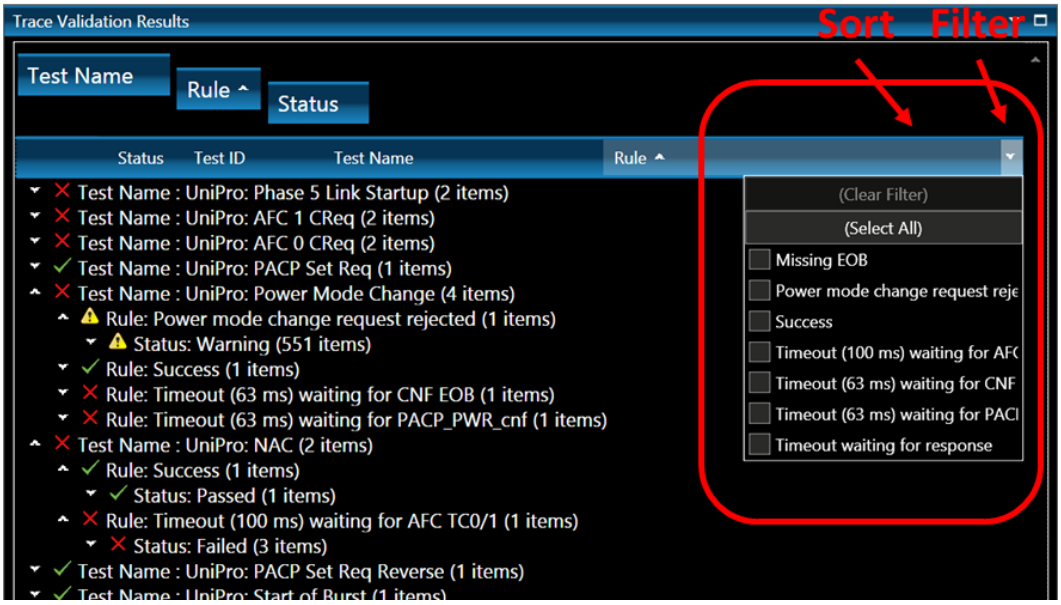


Figure 3: Sorting and Filtering

UniPro and UFS Packet List windows

The Packet List windows display all packets. See **UNIPRO AND UFS PACKET LIST WINDOW** for more details.

UniPro and UFS Events windows

The Events windows display all events in a trace, with separate rows for significant events such as speed changes, UniPro packets and UFS READs and WRITEs. Zooming is can be accomplished by dragging a zoom box in the Events window, and the controls on the left side of the Events window can undo zoom or otherwise control display zooming. See **UNIPRO EVENTS WINDOW** for more details.

Packet Decode and Data View windows

To display the protocol decode of a packet of interest in the Packet Decode window click on the packet in the TV Results window or in the appropriate Packet List window. Hovering over a bit in the Packet Decode window displays additional decode information Selecting 8, 16, or 32 defines the bit width of the display. Full payload is displayed in the Data View window. See **PACKET DECODE WINDOW** and **DATA VIEW WINDOW** for more details.

Analysis Reports

TV Results and Packet List reports can be created by configuring the appropriate window and then printing it. See **REPORTS MENU** for more information.

Operational Overview and Theory of Operation

Trace Validation is the analysis engine for compliance/conformance testing (CTS), corner case, margin and automated stress testing, and sniffer-style trace capture, analysis and debug.

Trace Validation is a complex state machine system that processes analyzer traces algorithmically and applies state machine logic to packet sequences to verify conformance or compliance to the specifications.

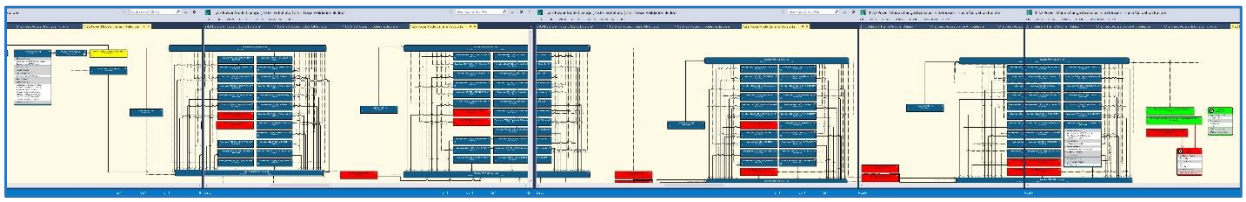


Figure 4: Example UniPro Power Mode Change Trace Validation State Machine

Interpreting Trace Validation Results

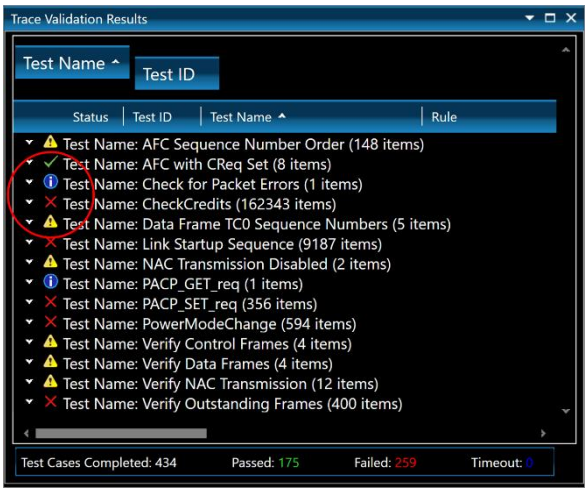
The Trace Validation engine performs protocol sequence and packet inspection with five possible status results for each rule check displayed in the Trace Validation Results window:

Failure ✕

Any protocol sequence or packet that does not meet a rule specified in MIPI UniPro v1.1 CTS, the JEDEC JESD224 or JESD224A CTS, or as defined in a custom test case

Warning ⚠

Any protocol sequence or packet that does not conform to a "shall" specified in MIPI UniPro spec, JEDEC JESD220x spec, or as defined in a custom test case



Pass ✓

Any protocol sequence or packet that conforms to the UniPro spec and CTS and JEDEC spec and CTS.

Info ⓘ

Info messages communicate the progress during the test or information about the packets, and are typically followed by a status result such as Pass or Failure. See example to the right, where there are several Info messages followed by a Success message and Pass status.

Debug 🔍 **(TV mode only)**

Provides information on state machine execution of an inspection rule in Trace Validation <u>if</u> debug hooks were placed in the TV test case:

- A — Indicates an Action was executed. This could be a Log Message Action, Counter Action, or a Set or Modify Variable Action run by either a State or an Event.
- E — Indicates that an Event fired and triggered a transition to a new State. Events fire when all their Validators are true.
- S — Indicates that the Trace Validation engine transitioned into a new State.
- V — Indicates that a Validator was tested and the result was true.
- V — Indicates that a Validator was tested and the result was false.

The results can be grouped, summed, sorted and filtered by various test parameters or packet characteristics. See **Trace Validation Results - Group and Summarize** and **Trace Validation Results - Sort and Filter** for more information.

Test execution and Trace Validation analysis for Falcon Exerciser/Analyzer

To execute compliance/conformance testing (CTS), corner case, margin and automated stress testing in "CTS and Exerciser + Analyzer" mode the test cases are initiated by the exerciser and the Trace Validation engine is used to verify the results. Trace Validation examines the trace to verify that the protocol sequences and packets conform to the UniPro or UFS CTS, specifications or custom tests. This flowchart shows the operation:

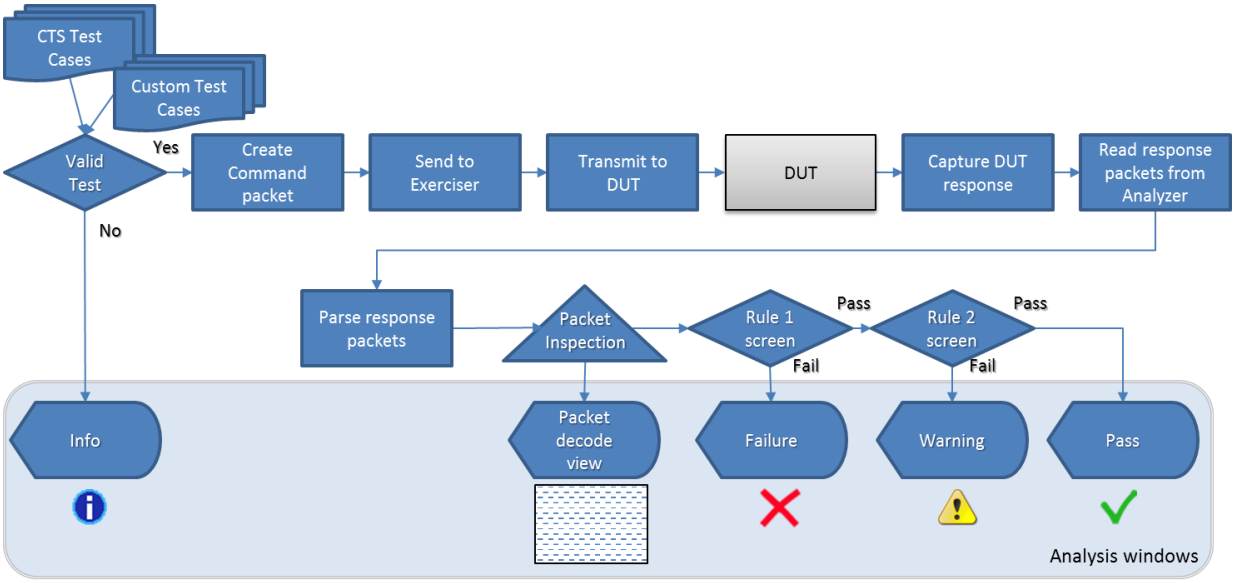


Figure 5: Test executive exerciser operation

For UniPro CTS testing, to locate the beginning of each test case in the trace a PACP_SET_req marker packet is inserted followed by the packet(s) necessary to commence the test. The marker packet contains a value that uniquely identifies the test case:

- The PACP_SET_req **MIBattribute** value identifies the author of the test case. The predefined ranges are listed below.
  - **0xFFFF** – Test case authored by Protocol Insight
  - **0xFF00-0xFFFE –** This range reserved
  - **0xF000-0xFEFF –** Range available range for customer defined test cases.
- The **MIBvalue** identifies the specific test being executed:
  - **Domain (8 bits)** – Used to define a category of test case for the given owner. Existing Protocol Insight domains are:
    - **01** - CTS specific test cases
    - **02** - Power mode tests

- **Case ID** (24 bits) – Identifies a specific test case within a given domain. Protocol Insight test cases follow a major, minor, revision style using 8 bits for each.

For example, the CTS test case 1.1.4 Invalid Configuration Request written by Protocol Insight would have a complete ID of 0x01010104.

For UFS CTS testing, to locate the beginning of each test case in the trace a NOP OUT packet is inserted with the follow reserved bits set:

- **Reserved Bytes 12 & 13** – Place the Protocol Insight Flag - 0xFFFF
  - **0xFFFF** – Test case authored by Protocol Insight
  - **0xFF00-0xFFFE** – This range reserved
  - **0xF000-0xFEFF** – Range available range for customer defined test cases.
- **Reserved Bytes 14 – 17** –The four parts of the test case ID
  - **Domain (8 bits)** – Used to define a category of test case for the given owner. Existing Protocol Insight domains are:
    - **01** - CTS specific test cases
    - **02** - Power mode tests
  - **Case ID (24 bits)** – Identifies a specific test case within a given domain. Protocol Insight test cases follow a major, minor, revision style using 8 bits for each.

Test execution and Trace Validation analysis for analyzer

This flow charts shows the operation of the test executive for "sniffer" style Trace Validation analysis:

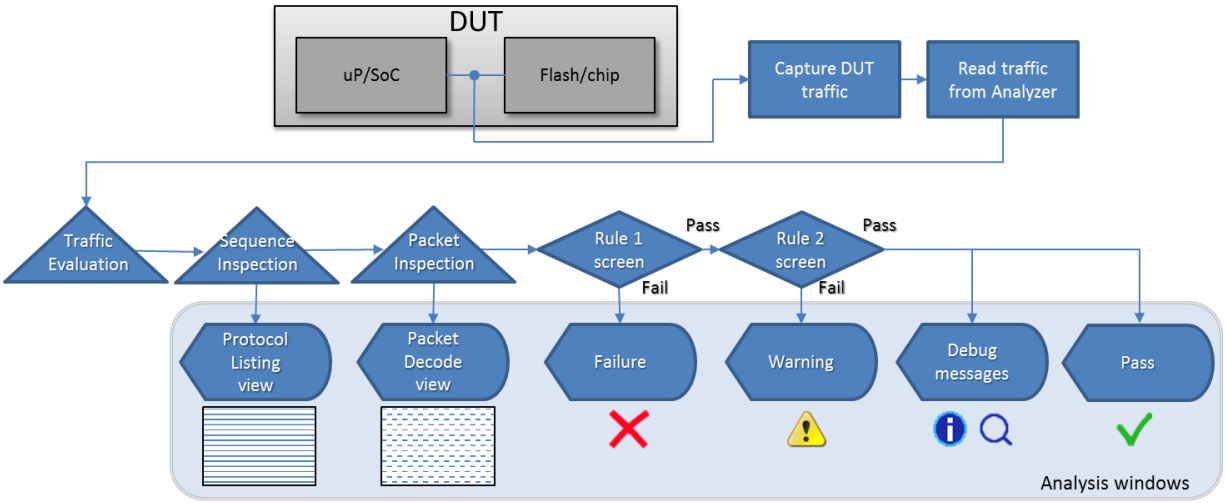


Figure 6: Trace Validation operation

Warranty

For Product(s):

Protocol Insight warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, Protocol Insight, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. Parts, modules and replacement products used by Protocol Insight for warranty work may be new or reconditioned to like new performance. All replaced parts, modules and products become the property of Protocol Insight.

In order to obtain service under this warranty, Customer must notify Protocol Insight of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the location designated by Protocol Insight, with shipping charges prepaid. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. THIS WARRANTY SHALL NOT APPLY TO ANY DAMAGE TO INSTRUMENT FRONT-PANEL CONNECTORS. Protocol Insight shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Protocol Insight representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Protocol Insight supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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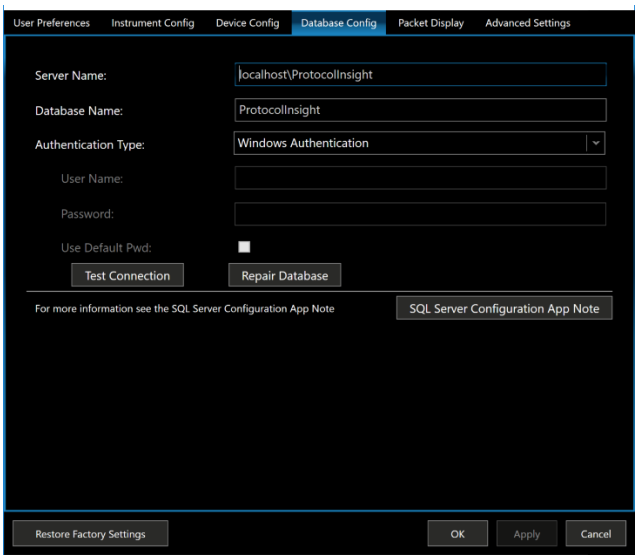
Appendix A: Resetting Your SQL Database

Follow these steps to reset your SQL database:

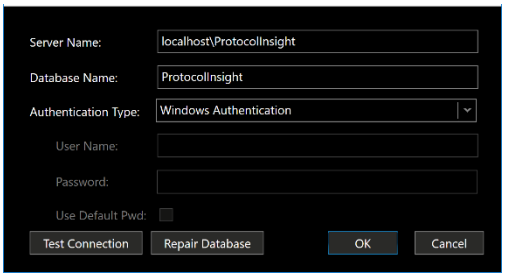
1. Launch Protocol Insight application software
2. Select Settings → Database Settings
3. Enter the following
    a. Server Name: "localhost\ProtocolInsight"
    b. Database Name: "ProtocolInsight"
    c. Authentication Type: "Windows Authentication"
4. Click **Repair Database**.



5. Click **Yes** on the warning message box
6. You should get a dialog box saying "Database was restored successfully"
7. You can now use the software normally

Appendix B: Reconfiguring your SQL Database

Follow these steps to reconfigure your SQL database:



1. Launch Protocol Insight application software
2. Select Settings → Database Settings
3. Enter the following

   Server name: Enter the SQL Server instance to connect to. By default this should be localhost\Protocolinsight.

   Database Name: The name of the database on the server. By default this is Protocolinsight.

   Authentication Type: Two authentication modes are available when connecting to an instance of the Database Engine:

   Windows Authentication - Microsoft Windows Authentication mode allows a user to connect through a Windows user account.

   SQL Server Authentication - When a user connects with a specified login name and password from a non-trusted connection, SQL Server performs the authentication itself by checking to see if a SQL Server login account has been set up and if the specified password matches the one previously recorded. If the Authentication Type selected is SQL Server Authentication:

   User Name: The SQL Server login id to connect to SQL Server should be "sa" if you are using the Default Password (see below).

   Password: The Password to connect to SQL Server with.

   Use Default Password: This will override the password with the default password for the sa account. User Name must be "sa" and the SQL Server install must be the default from installing the software.

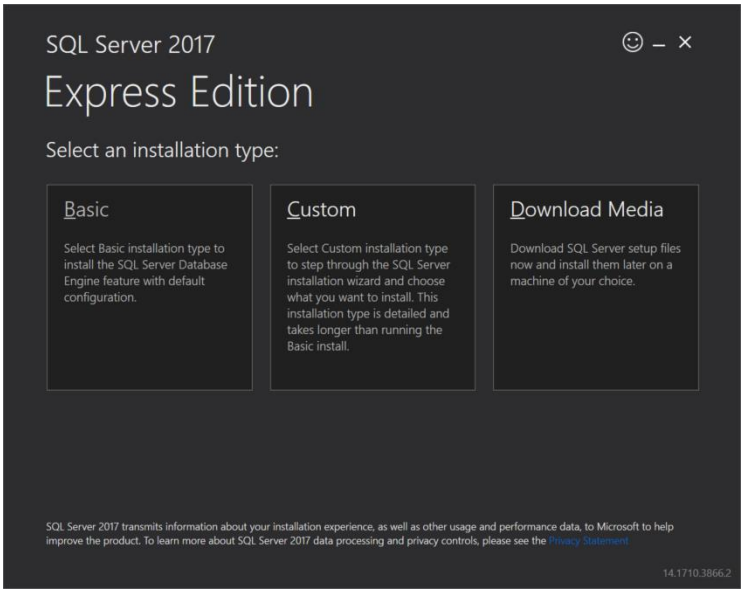
   When you have entered all the data, click Test Connection to make sure the server, database, and security are valid.

Appendix C: Manually Installing Microsoft SQL Server

Follow these steps to manually install and configure your SQL database:

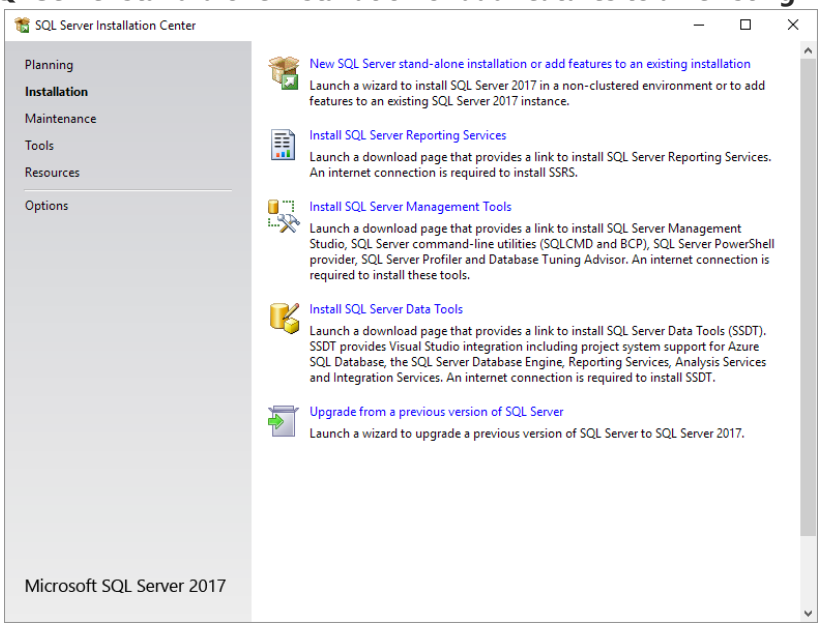
NOTE: If you are manually installing during setup, start with Step 3.

1. Obtain the SQL Server 2017 Express edition installation media from Microsoft
    a. https://www.microsoft.com/en-us/download/details.aspx?id=55994
    b. Click Download
2. Run SQLServer2017-SSEI-Expr.exe from your download location.
3. On the "Select an installation type" screen, choose Custom

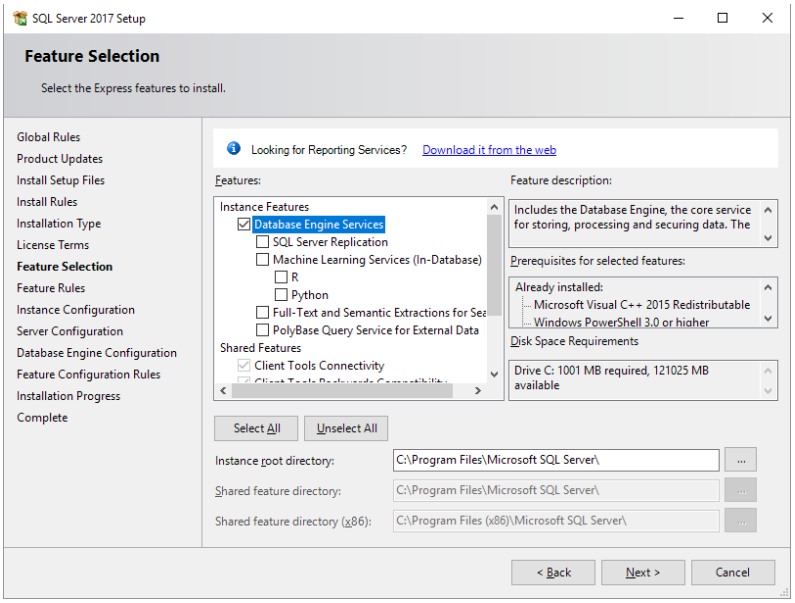


4. Select a download media location and Click Install
   At this point the installation files will be downloaded from Microsoft. Once complete, the installation should start.
5. SQL Server Installation Center - Click Installation on the list of options in the left pane

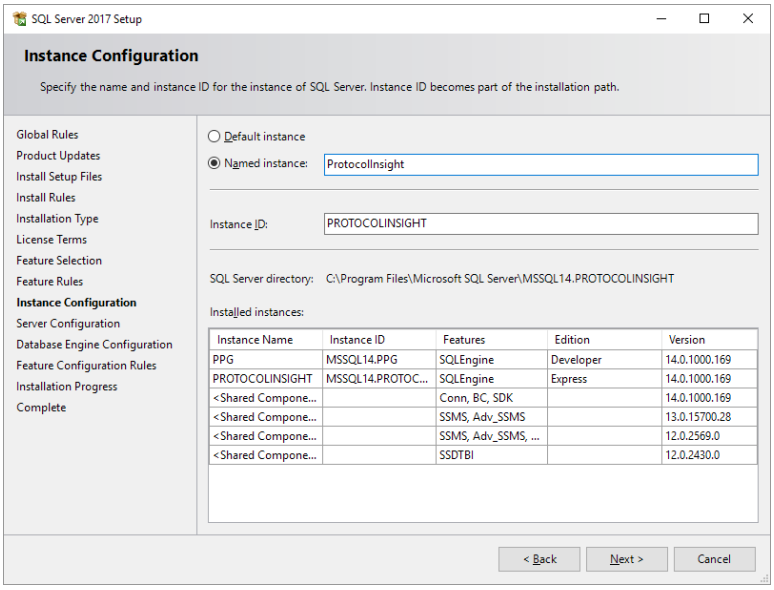
6. Click " **New SQL Server stand-alone installation or add features to an existing installation"**



7. Install Rules – Verify that you don't have any required updates and click Next
8. Installation Type – Choose **Perform a new installation of SQL Server 2017** and click Next
9. License Terms – Check **I accept the license terms** and click Next
10. Features Selection – Click the **Unselect All** button and then choose only the "Database Engine Services" feature. Click Next (You can optionally change the installation drive if you need to install to a drive other than C:\)



11. Instance Configuration – Choose **Named Instance** and Enter "ProtocolInsight" as the instance name. The Instance ID should automatically update to "PROTOCOLINSIGHT". Click Next.



12. Server Configuration – Leave the default options, click Next.
13. Database Engine Configuration – Click the **Add Current User** button if the current windows user is not listed in the **Specify SQL Server Administrators** box. Click Next.
14. Wait for the installation to complete and click Finish.

Appendix D: Blank

Appendix E: Debug Test Descriptions

UFS Debug Tests

UFS Stimulus

The following stimulus tests perform as the test name implies. For example, the "Read BusyRTC Flag" reads the BusyRTC flag.

Read BackgroundOpsEn Flag
Read BusyRTC Flag
Read Configuration Descriptor
Read Device Descriptor
Read Device Health Descriptor
Read Device Init Flag
Read DeviceLifeSpanModeEn Flag
Read Geometry Descriptor
Read Interconnect Descriptor
Read Manufacturer Name String Descriptor
Read OEM ID String Descriptor
Read PermanentWPEn Flag
Read PermanentlyDisableFwUpdate Flag
Read PhyResourceRemoval Flag
Read Power Parameters Descriptor
Read PowerOnWPEn Flag
Read Product Name String Descriptor
Read Product Rev Level String Descriptor
Read PurgeEnable Flag
Read RPMB Unit Descriptor
Read RefreshEnable Flag
Read Serial Number String Descriptor
Read Unit Descriptor
Read bActiveICCLevel Attribute
Read bBackgroundOpStatus Attribute
Read bBootLunEn Attribute
Read bConfigDescrLock Attribute
Read bCurrentPowerMode Attribute
Read bDeviceCaseRoughTemperature Attribute
Read bDeviceFFUStatus Attribute
Read bDeviceTooHighTempBoundary Attribute
Read bDeviceTooLowTempBoundary Attribute
Read bMaxDataInSize Attribute
Read bMaxDataOutSize Attribute
Read bOutOfOrderDataEn Attribute
Read bPSAState Attribute
Read bPurgeStatus Attribute
Read bRefClkFreq Attribute
Read bRefClkGatingWaitTime Attribute
Read bRefreshFreq Attribute
Read bRefreshMethod Attribute
Read bRefreshUnit Attribute
Read dDynCapNeeded Attribute
Read dPSADataSize Attribute
Read dSecondsPassed Attribute
Read wContextConf Attribute
Read wExceptionEventControl Attribute
Read wExceptionEventStatus Attribute

UFS Trace Validation

Command Response

This test checks that every Command sent by the tester receives a Response from the DUT.

Latency

This Trace Validation test is a generic framework which can be customized to measure latency response between packets. It will measure and compute the min, max, and average latency between packets of interest. In addition, it has a threshold value, vLatencyThreshold, defined in the Idle state that can be used to set a Pass/Fail criteria on the measured latency. It looks for packets in either direction but can be

modified to look only in one direction by using Metadata Validators. This framework was used to create the **Command Response** and **DataIn Packet** latency tests.

Latency Command Response

This test measures the latency between a Command transaction code and a Response transaction code. It looks for packets in both directions. The vLatencyThreshold variable in the Idle state can be modified to set a Pass/Fail criteria. The resulting measurement value is in pSec.

Latency DataIn Packet

This test measures the latency between a Read Command and the DATAIN response. It looks for packets in both directions. The vLatencyThreshold variable in the Idle state can be modified to set a Pass / Fail criteria. The resulting measurement value is in pSec.

READ(10)

This test will check for the correct response to READ(10) / WRITE(10) commands from the tester to the DUT. It looks for errors and verifies the correct number of DATA IN / DATA OUT packets.

Transaction Response

This test verifies all UFS commands sent by the tester have an appropriate response. It returns the number of commands it finds.

WRITE(10)

This test will check for the correct response to READ(10) / WRITE(10) commands from the tester to the DUT. It looks for errors and verifies the correct number of DATA IN / DATA OUT packets.

UniPro Debug Tests

UniPro Stimulus

FrameSeqNumNAC

This stimulus test generates data frames with an invalid Frame Sequence Number. It tests the DUTs ability to respond correctly to invalid Frame Sequence Numbers.

Generate Eye Monitor Traffic

This stimulus test can be used to generate suitable traffic for building eye patterns using the Eye Monitor under Tools → Eye Monitor

HS-Gx-RateX_Terminated (multiple tests)

HS-Gx-RateX_Unterminated (multiple tests)

PWM-Gx (multiple tests)

The above three stimulus test groups test the ability to send and receive one data packet at the specified settings.

TTCErr

Type4Err

Type7Err

TypeAFCErr

TypeEOFEvenErr

TypeEOFOddErr

TypeNACErr

The above seven Err stimulus tests generate the type of error implied in their name. They are useful for verifying the DUT response to error conditions.

UniPro Trace Validation

AFC Sequence Number Order

This test case verifies that AFC sequence numbers are in order. It accounts for Hibernate and AFC frames with errors.

AFC with CReq Set

This test verifies that an AFC with CReq set to 0 is sent in response to an AFC with the CReq bit set.

Check for Packet Errors

Checks entire trace for any UniPro packet errors.

CheckCredits

This test tracks the number of credits sent between the tester and DUT and reports errors if there are too many credits available or too many bad data frames

CountMessages

This trace validation counts the number of data frames seen both up and down and reports that number.

Data Frame TC0 Sequence Numbers

This test tracks the sequence numbers of the data frames and checks for proper replay of NAC'd data frames.

IO Throughput

This trace validation calculates the instantaneous and average Data Frame throughput from and to the DUT. Clicking on an IO Throughput message (Rule) in the TV Results window will move the cursor to the Data Frame packet that is the subject of that throughput measurement.

Link Startup Sequence

This test verifies proper progression through the seven phases of link startup, in both directions.

NAC Transmission Disabled

This test verifies that NAC transmission is disabled until the DL Layer receives one Data or Control frame without any error.

PACP_GET_req

This test verifies that all get requests are acknowledged with a PACP_GET_cnf.

PACP_SET_req

This test verifies that all set requests with the cnf bit set are acknowledged with a PACP_SET_cnf.

PowerModeChange

This test verifies that a PACP_PWR_req power mode change request is properly handled.

Verify Control Frames

This test verifies all of the fields in a control frame and checks for any error.

Verify Data Frames

This test verifies all of the fields in a data frame and checks for any error.

Verify NAC Transmission

This test looks for bad packets and checks for a corresponding NAC. It also looks for unexpected NACs.

Verify Outstanding Frames

This test verifies that there is no more than 16 outstanding data frames that are unacknowledged.

Appendix F: Steaming Capture

If Streaming is selected as the Capture Type in Capture Options in the Instrument Configuration tab from Menu→Settings the instrument will write the captured trace to the controller PC's SSD drive.

Streaming performance is dependent on a verity of factors including M-PHY gear, PC load, SSD speed, link bandwidth utilization and hardware filtered packets. To increase streaming efficiency the pre-capture hardware filter should be used to remove as many unnecessary packets as possible before transmission over the Thunderbolt 3 interface.

As a trace is captured it is buffered through the instrument memory (8GB) to the controller PC's system RAM (configurable, with default value of 4x1GB=4GB) and then saved to the SSD disk. The application software will DMA data from the instrument memory to System RAM over the thunderbolt cable; with a x4 Thunderbolt connection and compliant cable the transfer speeds should be ~2.4GB/s. In parallel the application moves data from the System RAM to disk. The transfer rate from System Ram to disk is dependent on system and the disk performance; with the best NVMe disks speeds of > 5.0GB/s are typical.

Streaming Buffer Usage in the Instrument Status window displays a graphical representation of the amount of the instrument's embedded memory and the controller PC's system RAM that is being used as a buffer as the trace is being written to the Streaming File on disk. On a controller PC with a slower SSD write speed, the system RAM will fill up first, then the instrument's buffer. Once the analyzer capture has stopped the Streaming Buffer Usage will gradually decrease down to zero as all data is written from the buffers to the disk, and Streaming File Usage will stop incrementing and show the final trace size.

Instrument Configuration→Streaming Performance Test can be used to characterize the system. This reports the achievable DMA bandwidth instrument to System RAM and from System RAM to disk. If the system does not meet the needed performance the System RAM buffer can be increased in Streaming Settings in the Settings→Advanced Settings tab. The max size of the System RAM buffer is only limited by the amount of RAM on the system; we recommend leaving at least 16GB of RAM for the application SW and other programs to use, so on 16GB we recommend using the default values of 4GB, on a 32GB system you can use up to 16GB.

Appendix 1: Hardware Specifications

Product specifications are subject to change without notice.

Instrument

Analyzer
M-PHY Type-I
Speeds:
High-Speed (HS) Gear1, Gear2, Gear3, Gear4, and Gear5 modes
Low-speed Pulse-width Modulation (PWM) Gear1 to Gear4 in Type-I LS implementation
Link Width: x1 and x2
Trace capture memory depth: 8 GB
Probing:
Falcon G500C/G550C: solder-down

Exerciser
M-PHY Type-I
Speeds:
High-Speed (HS) Gear1, Gear2, Gear3, Gear4, and Gear5 modes
Low-speed Pulse-width Modulation (PWM) Gear1 to Gear4 in Type-I LS implementation
Link Width: x1 and x2
Trace capture memory depth: 8 GB, shared between exerciser and analyzer
Probing:

Falcon G500C/G550C: SMP

Advanced Trigger
States: 4 N way branching, Trigger In, Trigger Out, Go To State
Packet Matchers: 5 per direction (8 Symbol Matchers each).
Additional State/FLR/SKP matcher: 2 per direction
Counters: 2
Compare Actions: < (Less Than), == (Equal), > (Greater Than), >= (Greater Than OR Equal)
Modify Actions: Hold (No Change), Count + 1 (Increment), Count - 1 (Decrement)

Only one Compare Action per Counter can be defined in a trigger. That one Compare Action is available in all states. You can't program "Counter1 < 5" in one state and then "Counter1 > 5" in another state. If you program "Counter1 < 5" in one state then that is the only Compare Action available for Counter1 in any state of the trigger. Either or both counters can be incremented or decremented in each state.

DUT Requirements to sync analyzer to a UniPro link

Attribute	Protocol Analyzer PHY Spec	Typical
TxHsG1SyncLength (0x1552)	256 Symbols, 0x48 Capability value	128 Symbols, 0x47 Capability value
TxHsG2SyncLength (0x1555)	256 Symbols, 0x48 Capability value	128 Symbols, 0x47 Capability value
TxHsG3SyncLength (0x1556)	256 Symbols, 0x48 Capability value	128 Symbols, 0x47 Capability value
TxHsG4SyncLength (0x15D0)	256 Symbols, 0x48 Capability value	128 Symbols, 0x47 Capability value
TxHsG5SyncLength (0x15D6)	256 Symbols, 0x48 Capability value	256 Symbols, 0x48 Capability value
TxHsG1PrepareLength(0x1553)	0xA Capability value	0x3 Capability value
TxHsG2PrepareLength(0x1554)	0xA Capability value	0x3 Capability value
TxHsG3PrepareLength(0x1557)	0xA Capability value	0x3 Capability value
TxHsG4PrepareLength(0x15D1)	0xA Capability value	0x3 Capability value
TxHsG5PrepareLength(0x15D7)	0xA Capability value	0x3 Capability value
RxLsPrepareLength	0xA Capability value	0x1 Capability value
RxPwmBurstClosureLength	0x1F Capability value	0x1 Capability value
To sync to existing link	one Start of Burst	one Start of Burst

The typical settings assume configuration with 50/50 splitter and recommended cables. Actual performance may vary depending on the probing and the signal integrity of the DUT.

DUT Requirements to establish a UniPro link with the Falcon exerciser
The device must execute a UniPro 2.0 or 1.8 compliant Link Startup Sequence.

I/O Signals and Voltage Outputs

Falcon G400B/C and G500B/C series

UFS reference clock output: 19.2, 26, 38.4 and 52 MHz at 1.2V
UFS_Reset_N or RST: 1.2V output ± 0.3V

JESD220x requires CLK and RST voltage of 0.65*VCCQ - VCCQ+1.3. This is 0.715-1.6V min and max VCCQ and 0.78-1.5V typical VCCQ. The output voltage changes depending on the load impedance of the DUT; open circuit voltage is 1.3V and at 50Ω a voltage of 0.90V is supported.

Trigger in to the analyzer: 1.8V ±0.3V required.
Trigger out from the analyzer: 1.8V ±0.3V generated.
Front panel probe power ±4V

Physical Characteristics

Falcon G500C/G550C

Dimensions	12.7” x 2.7” x 9.9”, 32.4cm x 6.9cm x 25.0cm
Weight	[4.6 lbs, 2.1kg]
Package Dimensions	18" x 18" x 11", 45.72cm x 45.72cm x 27.94 cm
Package Weight	9.0lbs, 4.08kg

Operating Conditions

Falcon series instruments are suitable for use in dry indoor lab locations. They should be installed in accordance with local and national code requirements. They are not intended for use in hazardous locations.

Operating Ambient Temperature: 0° to 35° C
Non-operating Temperature: -20° to 45° C

Safety, Compliance and Environmental Information

Falcon C Series
Conforms to UL STD 62368-1
Certified to CSA STD C22.2 No. 62368-1
ETL Control Number: 5009155

Complies with IEC 60950-1:2005 (Second Edition) + Am 1:2009 + Am 2:2013
Manufacturer's Declaration of Conformity to European Directive 2014/35/EU (Low Voltage Directive)
Compliant with the European Union directive 2002/95/EC and 2011/65/EU on the Restriction of the use of certain hazardous substances in electrical and electronic equipment and components (RoHS).

Compliant with
CISPR 16-2-3:2016 – radio disturbance and immunity measuring apparatus and methods
CISPR 16-2-1: 2014/AMD 1:2017 – specifies the methods of measurement of disturbance phenomena in general in the frequency range 9 kHz to 18 GHz
FCC 47CFR 15: 2012 – radio frequency devices
EN 55032:2015, A11:2020 - Electromagnetic compatibility of multimedia equipment
EN 55035:2017, A11:2020
IEC 61000-3-2:2020 – limits For Harmonic Current Emissions
IEC 61000-3 Ed: 5.1, 2020-07-14
IEC 61000-3-3:2021
IEC 61000-3 Ed. 3.2, 2021-03-25
ICES-003: 2020 - Information Technology Equipment - Limits and Methods of Measurement
ANSI C63.4:2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment
IEC 61000-4-2:2008 – (EMC) discharge immunity
IEC 61000-4-3:2006 – (EMC) Radiated, radio-frequency, electromagnetic field immunity
IEC 61000-4-5:2 – (EMC) surge immunity test
IEC 61000-4-6:2008 – (EMC) immunity to conducted distubances
IEC 62368-1:2020+A11:2020 – Audio/video, information and communication technology equipment

Falcon B Series
Conforms to UL STD 60950-1
Certified to CSA STD C22.2 # 60950-1
ETL Control Number: 5009155

Complies with IEC 60950-1:2005 (Second Edition) + Am 1:2009 + Am 2:2013
Manufacturer's Declaration of Conformity to European Directive 2014/35/EU (Low Voltage Directive)

Compliant with
CISPR 24:2015 Issue:2015 Ed:2.1 Information technology equipment - Immunity characteristics - Limits and methods of measurement
CISPR 32 2015 COR 1 2016 Electromagnetic compatibility of multimedia equipment - Emission requirements
EN 55024:2010 Information technology equipment - Immunity characteristics - Limits and methods of measurement
EN 55032:2012 Electromagnetic compatibility of multimedia equipment - Emission requirements
EN 61000-3-2:2014 Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
EN 61000-3-3:2017 Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to Conditional Connection
IEC 61000-3-2(Ed:4.0): 2014-05, EN 61000-3-2: 2014-08 Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits For Harmonic Current Emissions (Equipment Input Current <= 16 A Per Phase)
IEC 61000-3-3 Ed. 3.1 b:2017 Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to Conditional Connection
FCC 47CFR 15: 2016 Telecommunication, Radio Frequency Devices
ICES-003: 2016 Issue 6, Information Technology Equipment (Including Digital Apparatus) — Limits and Methods of Measurement

Compliant with the European Union directive 2002/95/EC and 2011/65/EU on the Restriction of the use of certain hazardous substances in electrical and electronic equipment and components (RoHS).

Patents

This product is protected under US Patent No. 10,613,963

Export Control Classification Number (ECCN) and Schedule-B Harmonization Code

No. 3B992 b.4.b.1, No License Required

US Export Schedule-B harmonization code: 9030.89.0100

Country of Manufacture: USA

Appendix 2: System Requirements

Power Requirements – External Power Supply

The Falcon B and C series use an external power brick to provide power to the device. The polarity is shown in Figure 7 and the plug dimensions are shown in Figure 8.

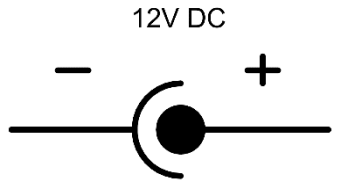


Figure 7: Back Panel Plug Polarity

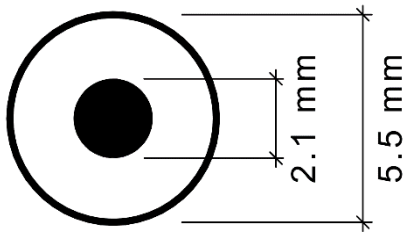


Figure 8: Male Power Plug Specifications

Falcon B Series Power Supply

- EDAC Power Electronics Co., Ltd model EA1068
- Universal AC input 100 to 240V AC
- Output: DC +12V/6A
- Frequency: 50 to 60Hz
- Safety: UL/CUL, TUV, CB, FCC, CCC, CE, PSE
- Meets RoHS and WEEE

Figure 9: EDAC Power Supply

Falcon C Series Power Supply – USA, Europe, and China

- Cincon TRH100A120-12E12
    - ECCN EAR99, 8504.40.9520
- Universal AC input 100 to 240V AC
- Output: DC +12V/8.34A (100W)
- Frequency: 47 to 63Hz
- Safety: UL/CUL, TUV, FCC, CCC, CE, PSE
- Meets RoHS and WEEE

Figure 10: Cincon Power Supply

Falcon C Series Power Supply – Japan, Korea, China, Taiwan

- GlobTek GTM961200P10812-T3 (P/N TR9CE9000YL4CIMR6B)
    - ECCN EAR99, HTSUS 8504.40.9520
- Universal AC input 100 to 240V AC
- Output DV + 12V/9A (108W)
- Frequency: 50 to 60 Hz
- Safety: UL, CE, Taiwan BSMI, China CCC, Korea KC Mark, Japan PSE
- Meets RoHS and WEEE

Figure 11: GlobTek Power Supply

- Ships with Mean Well DC PLUG-R7BF-P1M (DC 4-pin to 2.5 mm barrel adapter)
    - ECCN EAR99, HTSUS 8536.69.8000

Figure 12: Mean Well Adapter

Host PC Requirements

Basic configuration:

- Intel® Core™ i7 or i9 processor or equivalent.
- 32 GB RAM recommended, 16 GB minimum.
- NVMe solid state drive with 500GB free space recommended, 256GB minimum free space.
- Thunderbolt 3 enabled type-c connector required.

To take full advantage of streaming capture with v2.0.0 and later FW/SW we recommend:

- The fastest processor available, e.g. Intel i9-8950HK Processor (4.8GHz turbo)
- 64GB of RAM recommended, 32GB minimum
- **1TB NMVe SSD with Sustained Write Bandwidth of 5.0GB/s recommended, 2.5GB/s minimum**
- Thunderbolt 3 enabled type-c connector required.

Software Requirements

- Windows 10 64-bit operating system
- Microsoft SQL Server 2014 or later
- Microsoft Visual Studio 2015 Community or Professional editions
  or
  Microsoft Visual Studio 2015 Isolated Shell
- Protocol Insight application software and firmware version 1.0.4872 or later.
  Note: v1.4.4.6327 or later software and firmware are required to support the Falcon G400 series.

Revision 3.0.1, January 20, 2022