Protocol Insight®

Falcon G600R and G650R Series Instruments

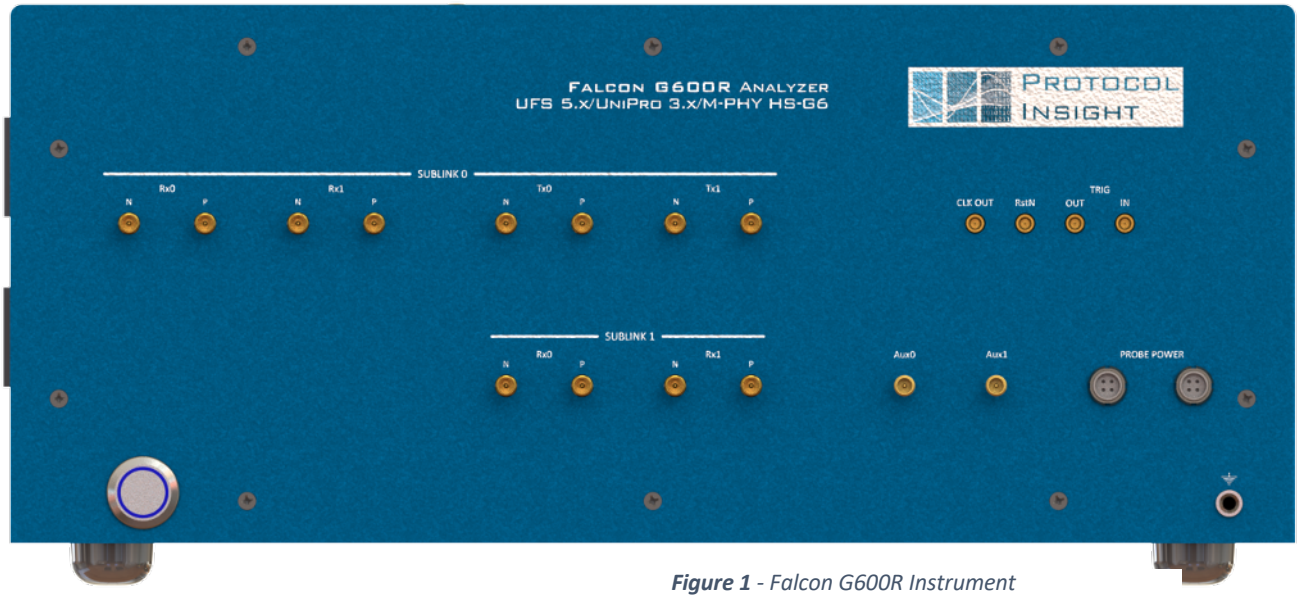


Figure 1 *- Falcon G600R Instrument*

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

UFS/UniPro Analyzers and Exerciser/Analyzers with Trace Validation™ and RAD (real-time analog display)

Protocol Insight is a recognized expert in UFS, UniPro, and M-PHY protocols. We are the market leaders in protocol analysis and traffic generation for UFS and UniPro. We have been distributing UFS and UniPro debug and analysis tools since 2014.

We are a contributing company to the development of the UniPro specs and Conformance Test Specs (CTS), and a member of the JEDEC J64 Embedded Memory Storage and Removable Memory Card committee.

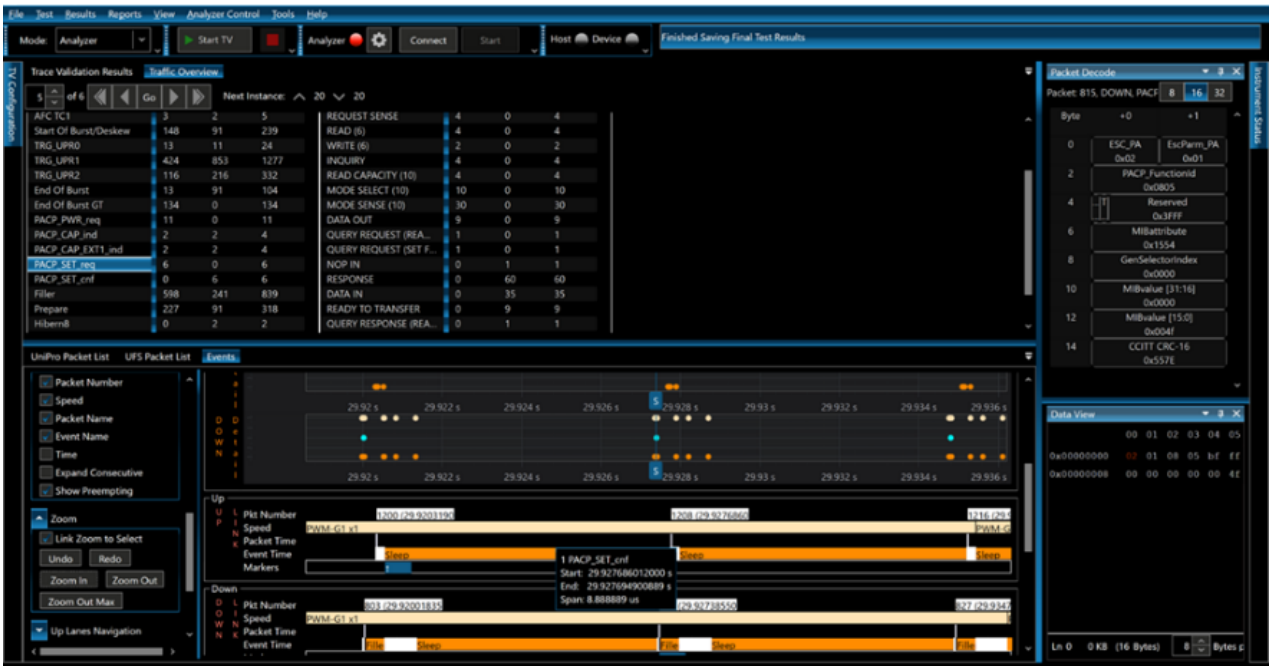
Protocol Insight offers the only protocol test tool for verifying compliance to the UFSA Compliance Test Matrix and we have supported all UniPro and UFS Interoperability (IOT) workshops since the initial events in early 2015.

Protocol Insight offers unsurpassed product leadership across multiple product generations.

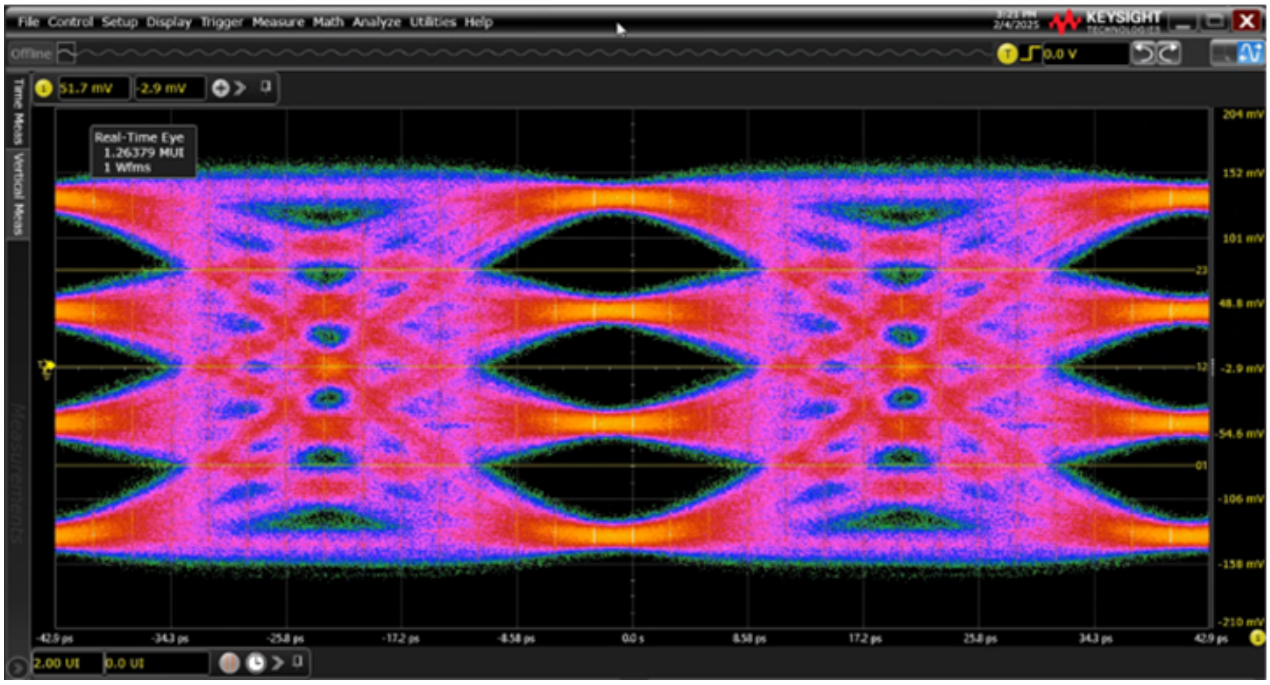
Capabilities included with the Falcon 600R and 650R series of instruments include:

- Real-time analog display, RAD, captures raw signal data on four channels at 48 Gsps, 1 Gpt capture memory per channel. This enables real-time information on overall signal quality, SNR and slicer eye viewer. This allows users to view packets and quickly identify system connectivity issues all with a single connection in one instrument. The captured analog data is displayed and centered around the instrument trigger point for all four channels. The captured analog data and UniPro and UFS packets are all time correlated together.
- SmartTune™ Calibration quickly calibrates the instrument with the customer system in under a minute, dramatically improving the SNR for captures from the target, host or device.
- An Eye Slicer provides real-time eye quality and SNR statistics. Eye Monitor constructs an eye diagram to determine relative link quality.
- Trace Validation™, a patented Artificial intelligence (AI) tool that uses complex state machine logic to analyze traces algorithmically without user inference.
- Streaming capture uses the full 40Gb/s bandwidth of Thunderbolt™ 4 to save traces to disk in real time.
- Events Views displays raw symbols as packet events in a unique time correlated display with UniPro and UFS packets. This provides a complete picture of all events with drill-down to the lowest level bytes.
- Protocol generation and exerciser capability for both UFS 5.0 and UniPro 3.0.
- Test Editors to creation custom triggers, Trace Validation, and Stimulus tests.

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025



Analyzer debugging a PACP_SET command using Events window and Traffic Overview



Eye Monitor viewed with the offline viewer

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Product Family Description

The Falcon series of UniPro/UFS Protocol Analyzers/Exercisers are the established industry standard with powerful protocol analyzer and exerciser capabilities and unprecedented flexibility.

- The **Falcon G600R** is an analyzer that can capture x2 bi-directional MIPI M-PHY 6.0 links. It supports UFS 5.0, UniPro 3.0 and M-PHY 6.0 HS-G6. The G600R simultaneously performs a real-time capture of the M-PHY 6.0 analog signal, known as Real-time Analog Display (RAD). This information is presented time correlated with the protocol analyzer packet data.
- The **Falcon G650R** is an exerciser/analyzer; it is identical to the G650 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 G600 exerciser can perform host emulation and execute the UniPro and JEDEC Compliance/Conformance Test Suites (CTS). The G650R simultaneously performs a real-time capture of the M-PHY 6.0 analog signal, known as Real-time Analog Display (RAD). This information is presented time correlated with the protocol analyzer packet data.

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Key Features and Benefits

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.

Real-time Analog Display (RAD) captures raw signal data on four channels at 48 Gsps, 1 Gpt capture memory per channel. This enables real-time information on overall signal quality, SNR and slicer eye viewer. This allows users to view packets and quickly identify system connectivity issues all with a single connection in one instrument. The captured analog data is displayed and centered around the instrument trigger point for all four channels.

SmartTune™ Calibration calibrates the instrument with the customer's system in under a minute, dramatically improving SNR for captures from the target, host or device.

Eye Slicer provides real-time BER, eye quality and SNR statistics, along with a rolling history of these statistics. The **Eye Monitor**, available in the offline viewer, constructs an eye diagram to determine relative link quality.

Trace Validation is an expert system that uses complex 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 views displays raw UniPro symbols as packet events on the bus in a unique time-aligned display. UniPro Events view displays fillers, Prepare, SYNC, Hibern8, sleep, stall and other M-PHY level packets. UFS Events display each individual UFS packet type separately. UniPro and UFS Events view presents a complete picture of all events and allows drill-down to the lowest level bytes.

Compliance/Conformance Verification executes JEDEC and MIPI CTS test cases. Performs corner case, margin and stress testing. Users are also able to create custom test cases.

Verify compliance of UFS devices with the UFSA UFS Compliance Test Matrix. UFSA-certified for the UFSA Compliance Test Matrix v1.3.

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

Run Time Control stress testing controls the DUT and executes tests automatically. Stop after any number of loops or No Result Test Cases, then analyze the results with Trace Validation.

Design custom test cases to introduce errors for corner case, margin, or stress testing.

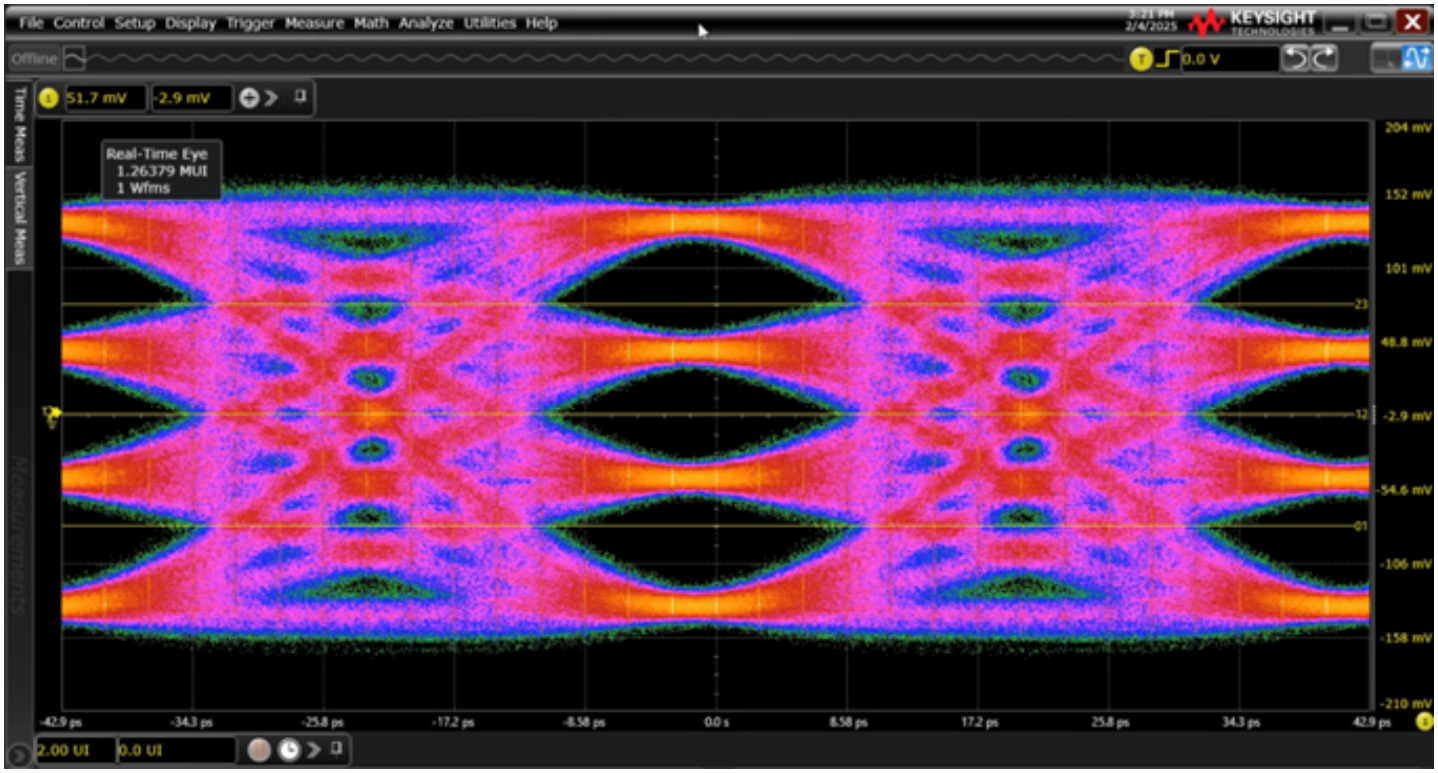
Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Slicer Eye and Eye Monitor

The Slicer Eye Viewer provides real-time BER, relative eye quality and SNR statistics. The Slicer Eye Viewer window shows real-time data on the varying voltage levels for PAM4 and NRZ data. The gaps between these data slices provide relative eye quality measurements. The SNR is dynamically calculated and displayed, along with a rolling history of the SNR. The Real-Time Analog Display window shows the raw signal data sampled by the 48 Gsps ADC on each channel.

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

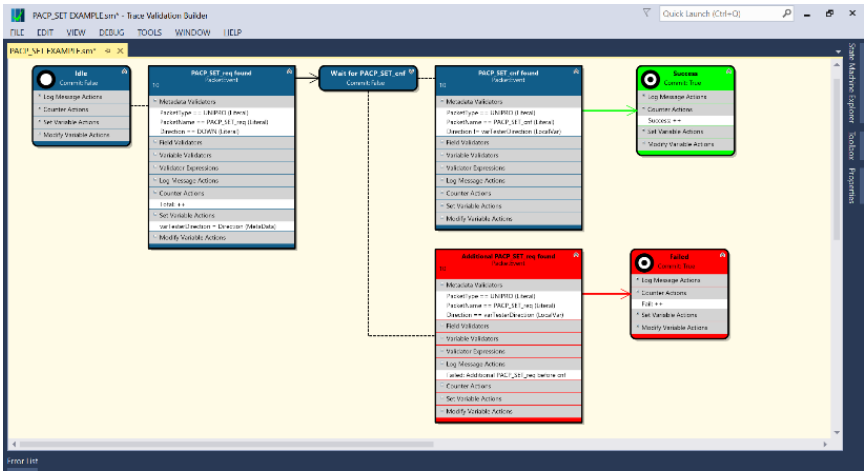
Eye Monitor is used to assess the quality of the eye and can constructed with the offline viewer. Eye Monitor constructs an eye diagram of the link to determine link quality. Quantitative measurements can be peformed on the eye diagram for jitter, noise, and eye opening.



Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Trace Validation

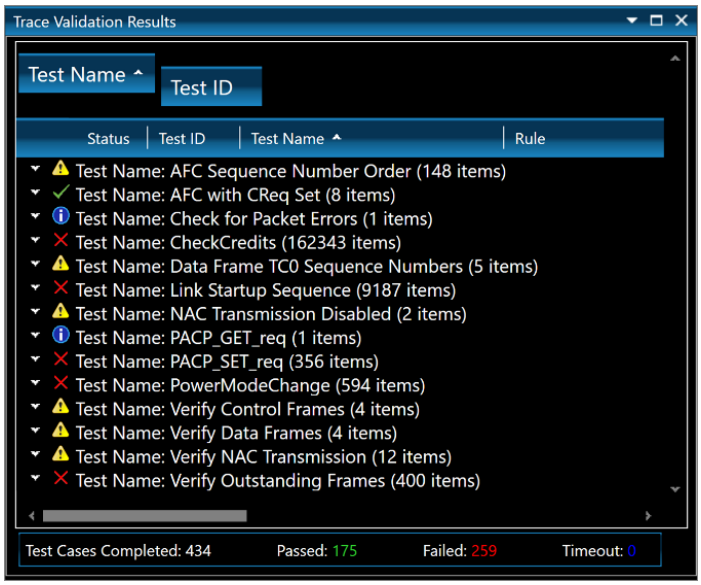
Trace Validation identifies transactions on the link by analyzing millions of packets in a trace capture, then evaluates the complete protocol sequences and individual packets for conformance to the specification.



With Trace Validation, complex transactions such as power mode changes, Link Startup Sequence and NAC/Replay events can be automatically analyzed and easily debugged. Complex measurements such as UFS packet latency can also be performed and evaluated against pass/fail metrics.

Trace Validation results are flagged as follows:

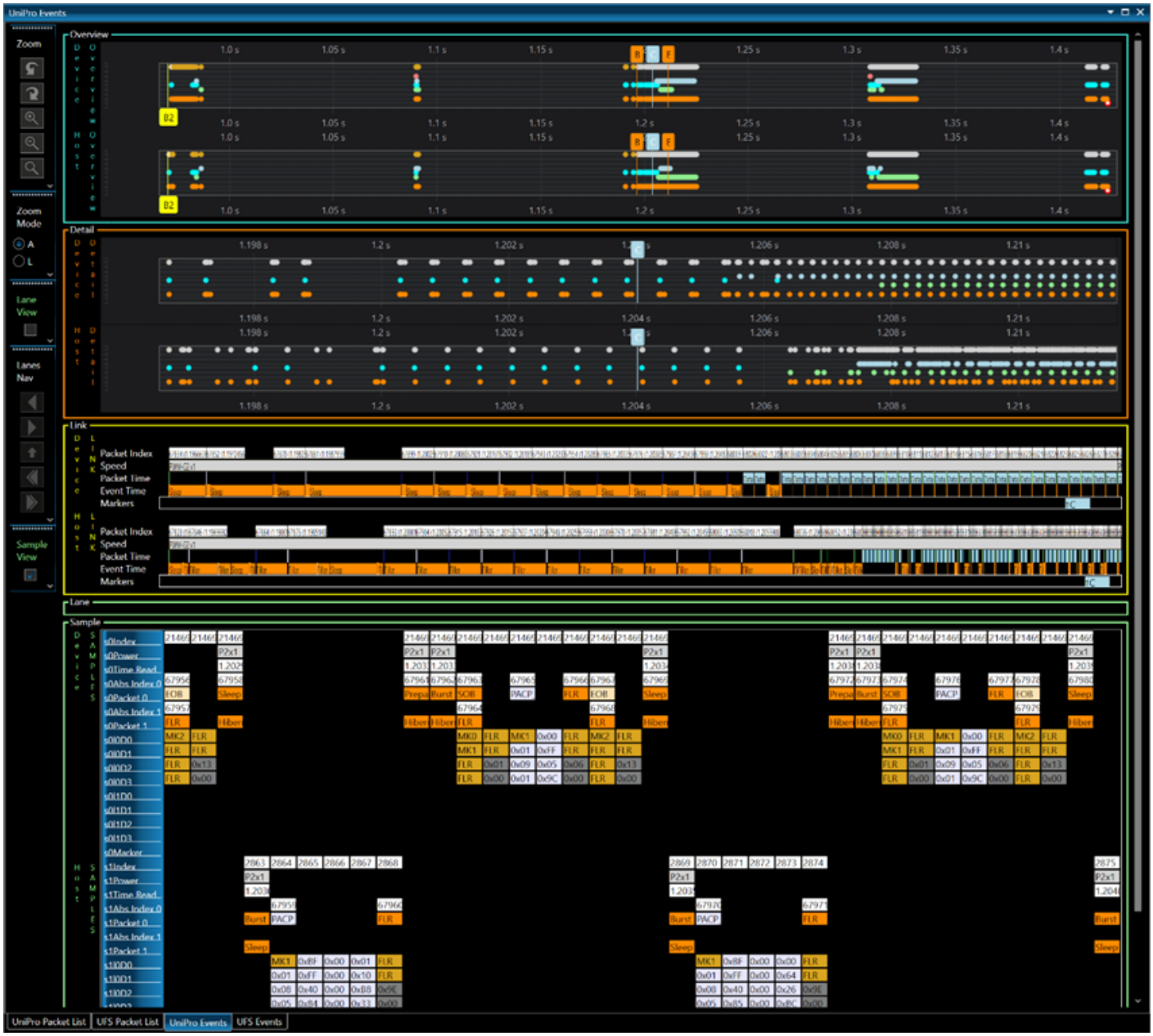
- Failure ✕ and Warning ⚠ status flags
  - A Failure is a transaction or packet that does not meet a defined primary rule. This rule may be defined by the JEDEC JESD224x CTS, UniPro CTS or by the user.
  - A Warning is a transaction or packet that does not meet a defined secondary rule. This rule may be defined by the JEDEC JESD220x spec, UniPro spec or by the user.
- Pass ✓ and Info ⓘ and Debug 🔍 status flags
  - Any transaction or packet that conforms the rule set is marked as Pass
  - Any packets not inspected due to run conditions are highlighted and explained with the Info flag
  - Information on state machine execution of an inspection rule can be provided with Debug messages



Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Events views

UniPro and UFS Events views complement the Packet List windows, showing all events on the bus in both directions in one single snapshot linked to the selected packet and bookmarks. Zooming in on any event or series of events will show the time-aligned packet data and expanded packet information in detail down to raw trace K-Code information, including the One Hot and Hex values.



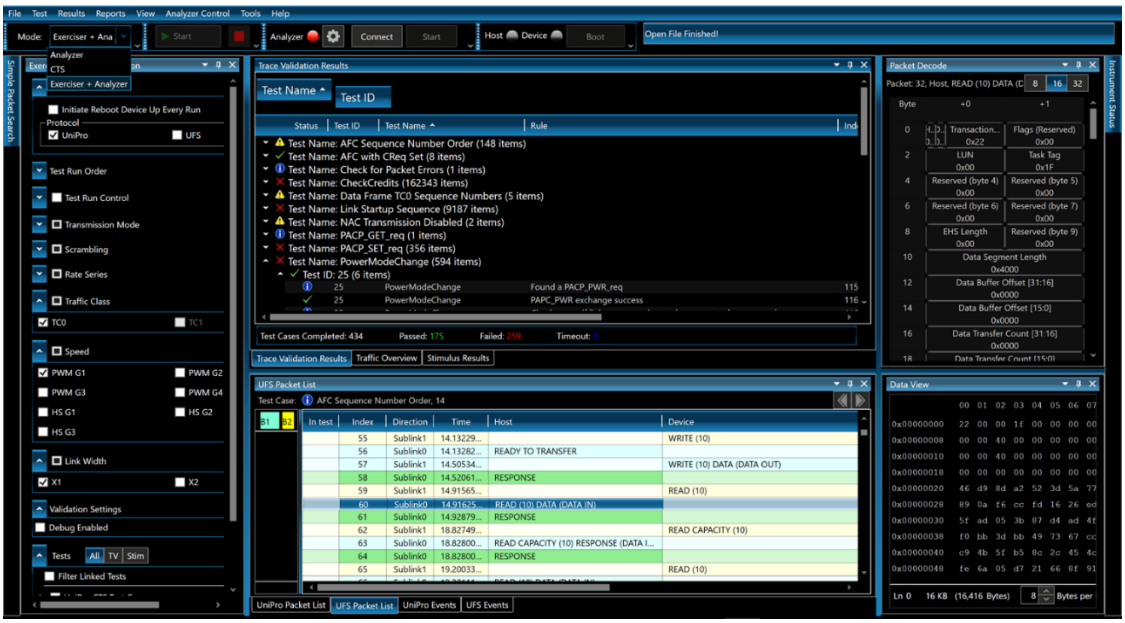
UniPro Events view

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Compliance/Conformance Verification

The Falcon G650 and G650R can execute UFS and UniPro compliance test spec (CTS) tests, using Trace Validation to verify that the resulting protocol sequences and packets conform to the CTS. These exercisers will support the forthcoming MIPI UniPro 3.0 CTS. The Falcon exerciser instrument supports device verification with the UFSA Compliance Test Matrix, including preliminary test cases for UFS 3.1 JESD220D, JESD220E, JESD220-2A and planned support for UFS 5.0 test cases.

Extensive reporting and analysis tools include reports by test parameters – status, individual tests, or test rules, and within tests by packet characteristics such as packet number, byte, speed, link, etc. Summary and full reports and pass/fail reports are also provided.



Pass/fail analysis using Trace Validation Results

Stimulus with full UniPro stack in HW

The Falcon G650 and G650R utilize a full UniPro stack embedded in hardware so the user can:

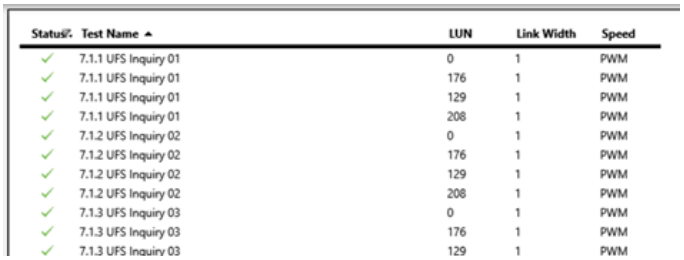
- Emulate a host
- Create specific traffic on the link
- Put the DUT into known states
- Insert errors into the UniPro or UFS traffic stream
- Create custom stimulus sequences to execute complex events, such as NAC Conditions or Power Mode Changes
- Automate with Run Control for stress testing

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Run Time Control

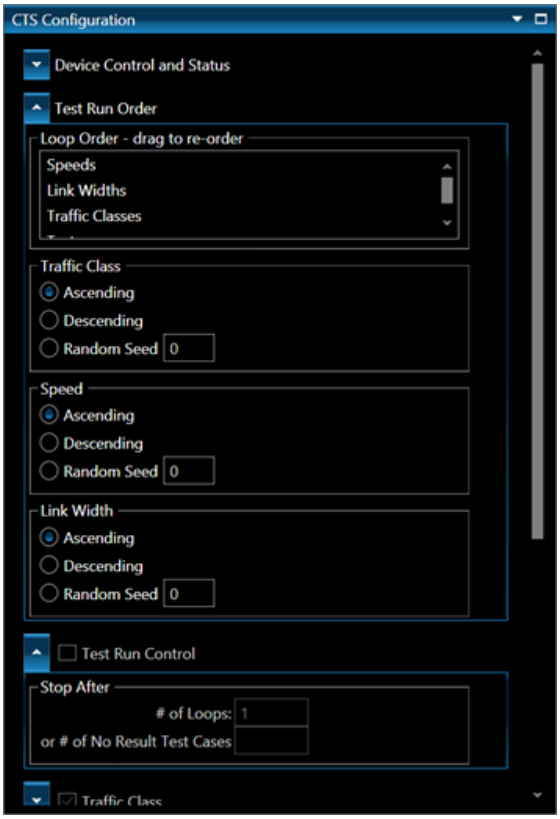
The run time control capability included with the G550C and G450C Exerciser/Analyzer can be used for compliance and conformance testing and for stress, margin and corner case automated testing:

- UFS device CTS compliance
  - Verifies test cases defined in JESD224 for JESD220B.
  - Verifies test cases defined in JESD224A for JESD220B, JESD220C and JESD220-2.
  - Preliminary test cases for UFS 3.1 JESD220D, JESD220E and JESD220-2A and UFS 4.0 JESD220F have been added.
  - Planned support for UFS 5.0 test cases.



Status	Test Name	LUN	Link Width	Speed
✓	7.1.1 UFS Inquiry 01	0	1	PWM
✓	7.1.1 UFS Inquiry 01	176	1	PWM
✓	7.1.1 UFS Inquiry 01	129	1	PWM
✓	7.1.1 UFS Inquiry 01	208	1	PWM
✓	7.1.2 UFS Inquiry 02	0	1	PWM
✓	7.1.2 UFS Inquiry 02	176	1	PWM
✓	7.1.2 UFS Inquiry 02	129	1	PWM
✓	7.1.2 UFS Inquiry 02	208	1	PWM
✓	7.1.3 UFS Inquiry 03	0	1	PWM
✓	7.1.3 UFS Inquiry 03	176	1	PWM
✓	7.1.3 UFS Inquiry 03	129	1	PWM

- UniPro CTS conformance
  - Verifies test cases as defined in the UniPro 2.0 CTS.
  - Planned support for UniPro 3.0 CTS.



- UniPro and UFS device spec conformance
  - Trace Validation engine evaluates UniPro and UFS protocol sequences, “shall” statements and logical requirements.

- Custom test cases
  - Create stimulus and Trace Validation analysis test cases
  - Executable with Run Control
  - Build tests from scratch, or use existing CTS and debug tests cases as a starting point

- Stress Testing
  - Execute any loop order by Speed, Link widths, LUNs or individual test cases
  - Each category can be run ascending, descending, or random seed order
  - Stop after a specified number of test case configuration loops or No Result Test Cases have occurred

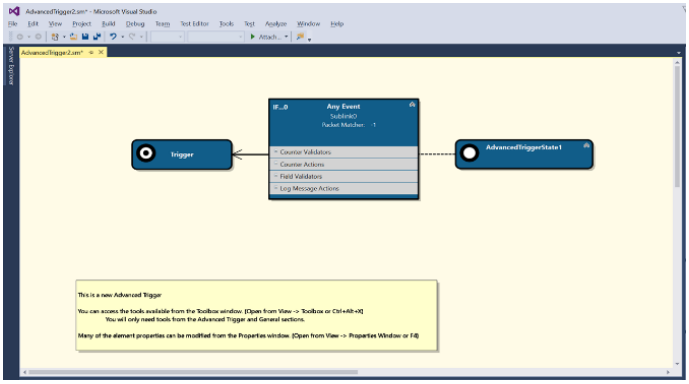
- Group, filter and summarize test results by test parameters – status, individual tests, or test rules

- Summary reports and full file export

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Custom Test Editors

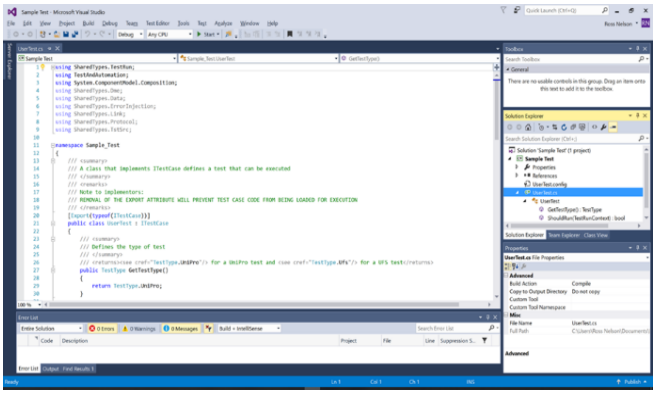
The Falcon series include Test Editors for creating advanced triggers and Trace Validation tests, and the G550C and G450C include custom stimulus Test Editors that can be used to create unique stimulus tests. Tests created with Stimulus Test Editor can be executed with Run Time Control for automated margin, corner case and stress testing.



Custom tests can be created from scratch, or they can be based on the pre-defined tests provided in the software library.

Stimulus capabilities available with custom Stimulus Editors include:

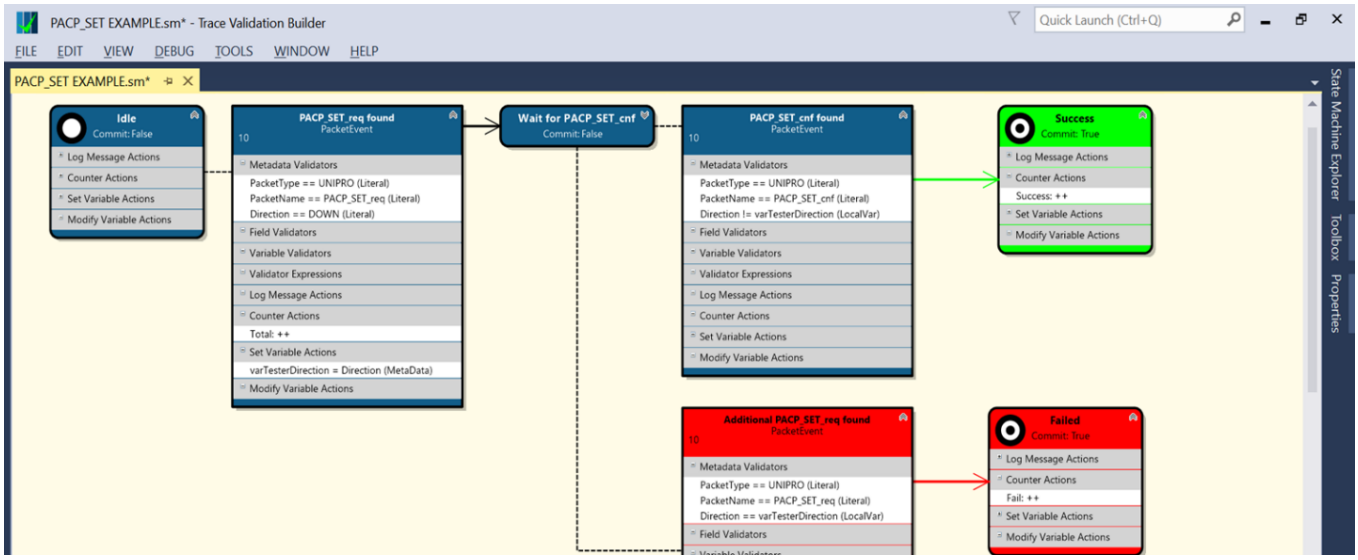
- Host emulation
- Put DUT into known states
- Create specific link traffic
- Insert errors into the traffic stream
- Create stimulus sequences to execute complex events, e.g. NAC Conditions or Power Mode Changes
- Automate with Run Control for stress testing



Analysis capabilities available with the Trace Validation Editor include:

- Analyze traffic on any trace file captured “sniffer” style from any bi-directional link
- Use complex state machine logic to verify all trace attributes
- Log messages and attributes with Failure, Warning, Pass, Info and Debug flags
- Easy-to-use graphical user interface:

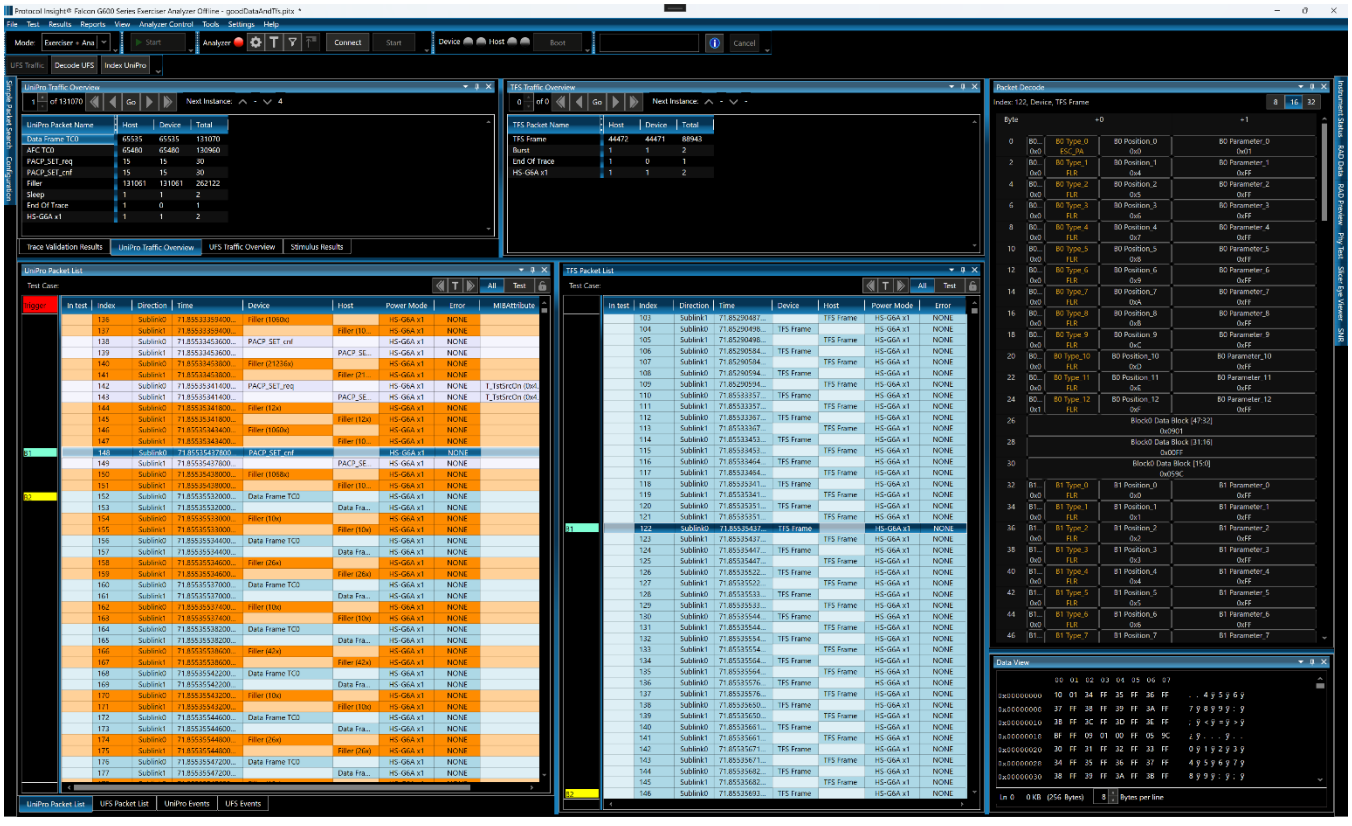
Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025



Powerful Debug Capabilities

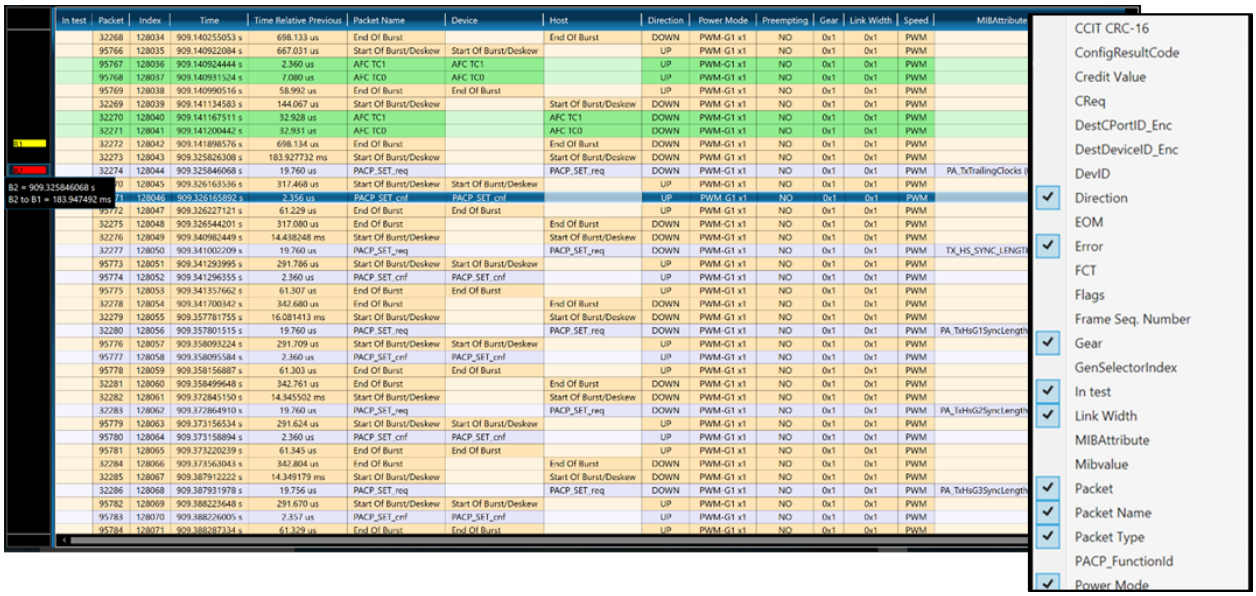
The Falcon application software includes extensive general protocol analysis capabilities, including Packet List, Packet Decode and Data windows, bookmarks and navigation, triggers and pre and post capture filters.

New TFS Packet List view, time correlated with the UFS 5.0 and UniPro 3.0 Packet Lists and the RAD Data.



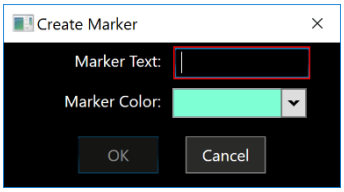
Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Packet List windows display all packets in a trace. 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.

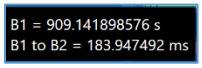


The **Packet Decode** window displays the packet header information and the **Data View** window displays the entire packet, including header and payload for a selected packet.

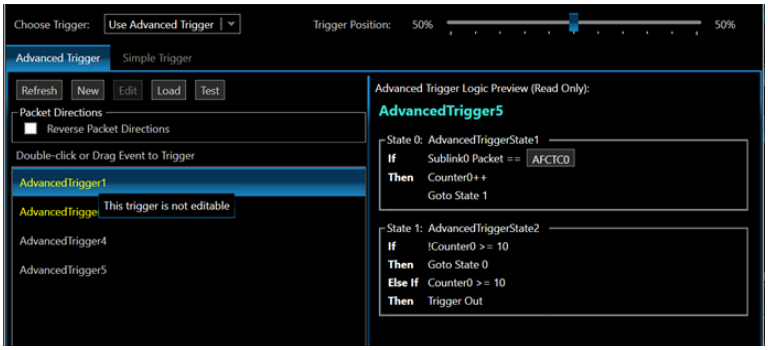
Navigation within the windows can be accomplished with **Bookmarks**. Bookmarks can be added to any packet in a Packet List window by right-clicking and selecting Add Bookmark. By right-clicking and selecting Edit Bookmark an existing bookmark can be renamed or given a different color.



Hovering over a bookmark will display a tooltip indicating timestamp and delta time to other bookmarks.



Simple and **Advanced Triggers** 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.

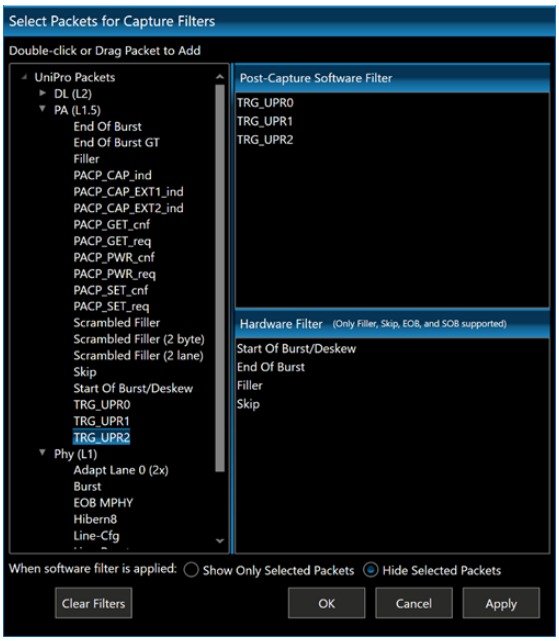


Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Filters permit 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 UFS payload can also be filtered out. Since these are filtered out prior to trace capture they are not stored or saved with the pitx trace.

Post-Capture Software Filter captures and stores all packets, but suppresses the selected UniPro packet types from the UniPro List window. The Traffic Summary window will still display all packets but it highlights and deactivates those that have been filtered.



Specifications

Product specifications are subject to change without notice.

Falcon G600, G600R, G650 and G650R
Supports up to UFS 5.x, UniPro 3.x and M-PHY 6.0 HS-G6.
Available Upgrade:

- Trace capture memory depth: 8 GB (default), upgrade to 15 GB.
- Real-time Analog Display memory depth: 1 Gpt per channel (4 channels, 2 channels per sublink, two sublinks)

G600R Analyzer
M-PHY 6.0, speeds:

- High-Speed (HS) Gear1, Gear2, Gear3, Gear4, and Gear5, Gear 6 Rate Series A/B
- Low-speed Pulse-width Modulation (PWM) Gear1 in Type-I LS implementation
- Support for LS LSS and HS LSS.

- Link Width: x1 and x2
- Trace capture memory depth: 8 GB, upgradeable to 16GB.
- Probing options: SMP and solder-down available.

G650R Exerciser

- Includes all features of the G600R Analyzer
- Compliance support: UFS 5.x (preliminary)
- Conformance support: UniPro 3.x (preliminary)

© Protocol Insight 2025, Revision 1.0.1, October 2025

Orderable Accessories

- HS-G6 Solder-down probe x2 bundle (FG6PSD2)
- HS-G6 High Speed Break-out board (FG6HSBO)
- HS-G6 Interposer (FG6AMPGR)
- Enhanced connectivity option – includes Thunderbolt 4 6ft/2m 40Gbps active cable and cable retention device
- Offline Viewer software with Trace Validation and TV Editor
- Offline Viewer software with Trace Validation and all Editors (TV, advanced trigger and UniPro and UFS stimulus)

DUT Requirements to sync analyzer to a UniPro link:

Attribute	Spec	Typical
TxHsG1SyncLength (0x1552)	256 Symbols, 0x48 Capability value	64 Symbols, 0x46 Capability value
TxHsG2SyncLength (0x1555)	256 Symbols, 0x48 Capability value	64 Symbols, 0x46 Capability value
TxHsG3SyncLength (0x1556)	256 Symbols, 0x48 Capability value	64 Symbols, 0x46 Capability value
TxHsG4SyncLength (0x15D0)	256 Symbols, 0x48 Capability value	64 Symbols, 0x46 Capability value
TxHsG5SyncLength (0x15D6)	256 Symbols, 0x48 Capability value	64 Symbols, 0x46 Capability value
TxHsG6SyncLength (0x15DA)	256 Symbols, 0x48 Capability value	64 Symbols, 0x46 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
TxHsG6PrepareLength(0x15DC)	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 supported accessories 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 3.0 compliant Link Startup Sequence.

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

General Characteristics

System requirements:

Basic PC 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 4 enabled type-c connector required.

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

- 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.

For streaming capture with existing PCs you can verify if your SSD has acceptable Sustained Write Bandwidth at https://ssd.userbenchmark.com, which provides a good tool for SSD Sustained Write Bandwidth benchmarking.

Software requirements

- Windows 11 64-bit operating system
- Microsoft Visual Studio 2022 Community or Professional editions
- Protocol Insight application software and firmware version 6.0 or later

Physical Characteristics

Dimensions	15” x 15” x 7”, 38.1cm x 38.1cm x 17.8cm
Weight	22 lbs, 10kg

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

Export Control Classification Number (ECCN): 3A992.a, No License Required

US Export Schedule-B harmonization code: 9030.89.0100

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025

Safety, Compliance and Environmental Information

Falcon 600R and 650R Series
Conforms to UL STD 62368-1
Certified to CSA STD C22.2 No. 62368-1
ETL Control Number: xxxxxxxxx

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

Contact Information

For additional information, to request a demonstration or quote, or place an order, please contact your local Protocol Insight representative or sales@protocolinsight.com

Support materials, application notes and examples files are available at https://www.protocolinsight.com/support-materials/

For technical support please contact your local Protocol Insight representative or support@protocolinsight.com

Product specifications and descriptions in this document are subject to change without notice.
© Protocol Insight 2025, Revision 1.0.1, October 2025