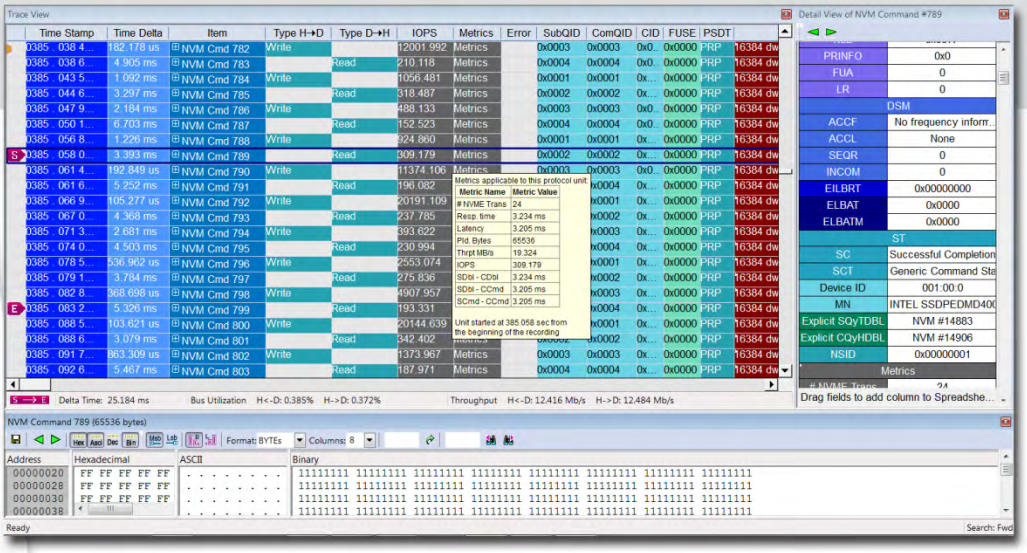
TELEDYNE LECROY
Everywhereyoulook™

Protocol Test Tools for NVM Express™

nvm EXPRESS



Key Features

- **Decodes NVMe Traffic**
  - ✓ CATC View™
  - ✓ Spreadsheet View
  - ✓ 3 Window View
  - ✓ Detail View
  - ✓ TCG Decodes
  - ✓ Queue and Device Tracking
  - ✓ Long Trace Recording
  - ✓ Low Power State Support
  - ✓ Auto NVMe PCIe SSD Base Register Mapping
  - ✓ NVMe XML Schema File Tracking
- **Storage Specific Probing**
  - ✓ U.2 (SFF-8639) Interposer
  - ✓ M.2 B/M Interposer
  - ✓ 90 Degree Interposer
  - ✓ PCIe Slot Interposer
  - ✓ Multi-lead Solder-down
- **Performance and Statistics**
  - ✓ Trace Expert Report
  - ✓ Traffic Summaries
  - ✓ Statistical Graphs
  - ✓ Packet Inline Metrics
  - ✓ Timing Calculator
- **Testing**
  - ✓ NVMe Conformance Tests
  - ✓ NVMe Host and Device Emulation
  - ✓ Error Injection
  - ✓ Corner Case Testing
  - ✓ Scripting
  - ✓ Canned Tests

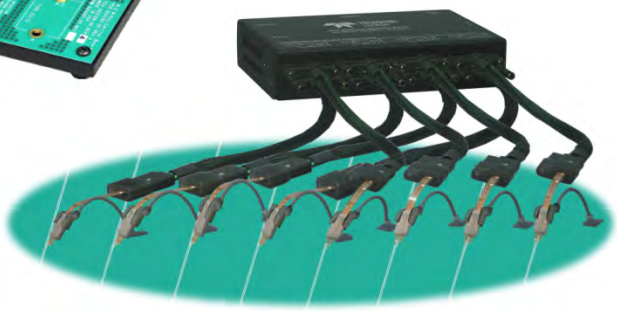
NVM Express is a scalable host controller interface designed to address the needs of Enterprise, Data Center and Client systems for supporting chip-to-chip, board-to-board, adapter and distance solutions. The protocol can efficiently use interconnect and fabric technologies such as PCI Express, Ethernet and Fibre Channel. Teledyne LeCroy provides protocol analysis, emulation, exerciser and other test functions to service all of your NVMe storage application needs.

Teledyne LeCroy's NVM Express protocol analyzers build on the expertise that Teledyne LeCroy has developed over the years with its serial protocol analyzers. NVMe protocol analyzers range from a ultra light portable to rackable size for data center use and are comprehensive analysis tools to capture, decode, display and analyze data traffic for NVM Express. Depending on the protocol analyzer up to sixteen lanes of traffic can be captured and trace memory is fully configurable to meet your needs and can currently be configured with trace memory of up to 64 GB in size.

The application display is highly configurable and can be modified to fit a users' debugging style. A customizable multi-state trigger makes it easy to discover protocol issues on the bus. Features such as capture filters, multiple local/global timers and counters allow the user advanced control to create sophisticated recording sequences. The NVMe protocol analyzer can time-correlate and cross trigger traces to other Teledyne LeCroy supported protocols and buses.

This new multi-storage protocol decoding capability combined with storage triggering, searching, filtering and protocol analysis views are optimized for storage development and are currently supported across the product line and make these tools valuable to under-standing data transmission from the base protocol layer, such as PCI Express, up to the NVMe transport and command layers. In addition, our PCI Express tools fully support other PCIe storage protocols such as SATA Express (AHCI and ATA) as well as SCSI Express (PQI, SOP and SCSI).

▼ OPEN TO SEE PRODUCTS THAT SUPPORT NVM EXPRESS ▼



Innovative Probing Options

Probing options include a slot interposer, custom form-factor interposers such as M.2 and U.2 (SFF-8639), mid-bus probes, and multi-lead solder-down probes, all of which support a wide range of data rates.

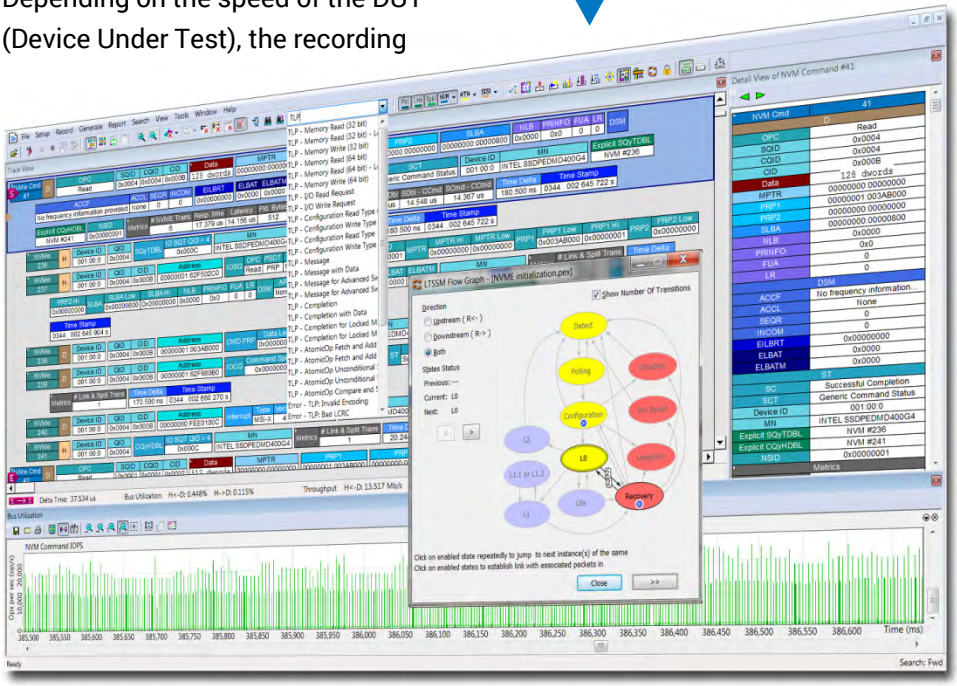
Teledyne LeCroy protocol analysis also fully supports the Trusted Computing Group (TCG) specification. Method calls such as invoking UID and method UID within a trusted command can be decoded both inline and detailed analysis, and examined in context with the NVM Express and transport bus infrastructure, such as PCI Express.

Other features such as hierarchical displays, spreadsheet view, queue graphs, performance and statistic reports, protocol traffic summaries, detailed error reports, powerful test scripting and the ability to create user-defined test reports as well as the "Trace Expert" analysis report allow developers to quickly find and fix bugs, determine performance and complete projects on time.

The challenges of probing have been addressed through a wide variety of options for storage probing connectivity, including adapters, interposers and probes for M.2 and U.2 (SFF-8639) single- and dual-port connectors, multi-lead solder-down. tapping, mid-bus probing and standard PCIe slot interposer, to name a few. All solutions support CLKREQ# low power state recording.

To achieve maximum trace recording times, a new NVMe Enhanced Mode is available (certain models only). Enhanced Mode builds on and optimizes the existing deep buffer memory to allow users long recording time capability. Depending on the speed of the DUT (Device Under Test), the recording time can be maximized to up to several hours for a single trace capture. This feature is useful for tasks such as measuring performance or determining how well the queue handling algorithms are functioning.

Powerful displays allow for easy analysis of protocol traffic.



PRODUCTS TO SUPPORT NVM EXPRESS OVER PCIe

Protocol Analyzers

The best way to choose a NVMe protocol analyzer is to look at your overall requirements. This includes desired maximum link width (x1, x2, x4, x8 or x16), required speed support (2.5GT/s, 5GT/s or 8GT/s), desired memory buffer size (2, 4, 8, 32 or 64 GB) and special features like NVMe Enhanced mode for long trace recording for your test application. Below you will find a list of analyzer platforms that support NVMe along with a short description to help you determine which would be best fit for your requirements. Although all of the analyzers listed below will support NVMe design, debug and validation, we currently recommend use of our Summit T34 analyzer due to its deep recording memory buffers as well as its ability to support our "NVMe Enhanced Mode", which provides additional capabilities normally desired by storage developers.

Summit T3-16 Analyzer

- Captures, decodes and displays all NVMe traffic at up to 8 GT/s data rates
- Supports x1, x2, x4, x8 and x16 link widths
- Provides 8 GB of recording memory depth
- Supports trigging and filtering for NVMe, SATA Express, SCSI Express and PCI Express
- Includes "Trace Expert" analysis report for NVMe and all other supported storage protocols

Summit T3-8 Analyzer

- Captures, decodes and displays all NVMe traffic at up to 8 GT/s data rates
- Supports x1, x2, x4 and x8 link widths
- Provides 8 GB of recording memory depth
- Supports trigging and filtering for NVMe, SATA Express, SCSI Express and PCI Express
- Includes "Trace Expert" analysis report for NVMe and all other supported storage protocols

Summit T34 Analyzer

- Can provide extremely long capture ability through the use of its “NVMe Enhanced Mode” option
- Captures, decodes and displays all NVMe traffic at up to 8 GT/s data rates
- Supports x1, x2 and x4 link widths (can be configured to x8 link widths using “Extended Mode”)
- Provides 8 GB of recording memory depth (can be configured up to 64 GB using “Extended Mode”)
- Supports trigging and filtering for NVMe, SATA Express, SCSI Express and PCI Express
- Includes "Trace Expert" analysis report for NVMe and all other supported storage protocols

Summit T28 Analyzer

- Captures, decodes and displays all NVMe traffic at up to 5 GT/s data rates
- Supports x1, x2, x4 and x8 link widths
- Provides 4 GB of recording memory depth
- Supports trigging and filtering for NVMe, SATA Express, SCSI Express and PCI Express
- Includes "Trace Expert" analysis report for NVMe and all other supported storage protocols

Summit T24 Analyzer

- Captures, decodes and displays all NVMe traffic at up to 5 GT/s data rates
- Supports x1, x2 and x4 link widths
- Provides 2 GB of recording memory depth
- Supports trigging and filtering for NVMe, SATA Express, SCSI Express and PCI Express
- Includes "Trace Expert" analysis report for NVMe and all other supported storage protocols

Protocol Exercisers

Our NVMe exerciser can be programmed to an extremely broad range of capabilities, as well as emulate NVM Express, SATA Express and SCSI Express protocol interfaces as a device or host. Additionally, it is used as part of the test set up required for NVMe compliance testing. When used in a host emulation configuration it should be paired with one of our "test platforms". A test platform provides a backplane structure in which a device under test can be quickly and easily attached though the use of a standard CEM connector. The best way to choose which of our test platforms will meet your needs is to determine if you are looking for a simple backplane-only test setup or if you would also like to have full control over clock inputs and settings, an integrated power supply as well as platform embedded probing capabilities.

Summit Z3-16 Exerciser

The Summit Z3-16 can emulate NVM Express root complexes or device endpoints, allowing storage devices to be tested with working or corrupted Read or Write commands, errors, messaging types of transmissions and various corner case issues. The exerciser can be used to run the UNH Conformance Test from the NVMe Consortium.

PCI Express Test Platform

The Teledyne LeCroy Test Platform is a Gen 3 capable (up to 8GT/s) two-slot advanced test platform that provides an integrated bus probe for up to 16 lanes, selections for various clock configurations, various LED status indicators as well as an integrated power supply that is capable of providing up to 150 watts of power for the device under test (DUT).

PXP-100B Test Platform

The Teledyne LeCroy PXP-100B Test Platform is a Gen 3 capable (up to 8 GT/s) two-slot platform that provides a convenient means for testing PCIe cards with a self-contained portable and powered passive backplane. The PXP-100B provides the power required for both backplane slots.

An example of the performance metrics that are available include the ability to measure the NVMe queue distribution over a sustained period of time. Gathering queue behavior for long periods helps driver and OS developers fine tune their applications and balance queue loads for optimized product performance.

Inline packet metrics and traffic summaries show submission doorbell to completion doorbell times and submission commands to completion commands per queue.

"Trace Expert" supports the industry's requirement for a comprehensive performance and statistic report that documents storage device behavior in real world situations and controlled test environments. Metrics such as NVMe transaction count, throughput, response time, latency time, IOP Speed, NVMe Read/Write command and queue performance are analyzed and displayed in tables and graphs.

In addition to the standard storage protocols, all of our NVMe platforms also fully support Single Root I/O Virtualization (SRIOV), Multi-Root I/O Virtualization (MRIOV) and Address Translation Services (ATS). A full list of capabilities, views and reports can be found on the product pages for each of our analyzers.

The Summit Z3-16 Exerciser, in combination with the Summit T3-8 Analyzer (shown here) or other Summit analyzers, forms the basis of standardized NVMe Conformance Test Suites developed by UNH-IOL.

iol University of New Hampshire InterOperability Laboratory

The NVMe exerciser is a programmable test tool that works with the protocol analyzer to generate traffic for the user's device under test (DUT). Test scripts can be created and run on DUT to meet testing requirements previously achieved by storage jammers in previous protocols. The NVMe exerciser can also provide both host and device emulation capability.

Additionally, the UNH NVMe conformance tests run on the Teledyne LeCroy protocol analyzer and exerciser. These tools support the necessary NVMe emulation capabilities to perform these tests. The required hardware configuration would include a Summit T3 Analyzer, a Summit Z3 Exerciser, a PCIe Test Platform as well as the compliance test scripts provided by UNH-IOL.

Expanding Applications

NVMe is expanding beyond the PCIe back bone and out of the box. The NVMe Over Fabrics initiative provides a server-to-storage array protocol that is transport-agnostic, highly efficient and supported by emerging standards. Whether over Ethernet, Fibre Channel or other fabrics, the NVMe protocol will dramatically improve the migration of data to and through the cloud.

The SierraNet™ Family of Ethernet & Fibre Channel Protocol Analyzers are specifically engineered to support the myriad of fabric storage protocols, evolving in the data storage industry. Used in conjunction with the Summit NVMe tools, Teledyne LeCroy PSG can provide the required end-to-end insight for system-wide performance evaluation of the NVMe traffic under examination.

Whether needed by development teams, system validators or data center managers, Summit and SierraNet product lines will provide the ability to observe the traffic from source to destination and back, and give users immediate and complete access for optimization of transits, root cause determination of issues and bottlenecks and comprehensive analysis of the entire fabric.

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Visit our website to find the most convenient location.