SSD 测试技术、工具和服务白皮书 Ver 2.0

该文档介绍了业内主流的针对 SSD 进行测试的各种技术、工具、设备、免费/商业软件、第三方测试服务，业内针对 SSD 的标准组织，主要涉及 PCIe/NVMe SSD 的相关测试，同时这些产品和技术大部分也适用于 12G SAS SSD, 6G SAS/SATA SSD Controller 以及 Drive 盘/卡等相关的开发/测试。

Saniffer Co., Limited
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目录

SSD 测试技术、工具和服务白皮书

本文讨论的 SSD 主要是面向目前业内关注最多的 PCIe NVMe SSD 测试，但是下面的工具集也普遍用于 12G SAS, 6G SAS, 6G SATA SSD 等。

注意：本文档内部有些内容取自 IDC 报告、第三方测试服务实验室官方网站，为了方便全部采用英文原版，未进行翻译。

(一) SSD 协议分析仪

NVMe SSD 在测试过程中遇到任何问题，包括性能，功能，兼容性等，都需要及时抓包分析问题所在，这需要协议分析仪。

常用的协议分析仪分为两类：

- 独立第三方 PCIe/NVMe 协议分析仪
- 测试设备自带的 NVMe 协议分析功能

1.1 SerialTek PCIe/NVMe Gen 3/4 协议分析仪

位于美国硅谷核心区域 San Jose 的 SerialTek 公司研发/设计总线协议分析仪的历史追溯到最早的 Bus Doctor 将近 20 年，其推出的 PCIe/NVMe analyzer 获得超过 100 家美国知名芯片以及 SSD 业界公司的选择。

目前主流 SSD Controller 以及 SSD Drive 模组厂商都在使用 SerialTek PCIe/NVMe Gen 3 或者 Gen 4 analyzer，包括 Intel, WDC, Toshiba, Micron 等。

1.1.1 产品优势

SerialTek 提供 Gen 3 和 Gen 4 PCIe/NVMe analyzer。其中 Gen 4 analyzer 采用全新于 Gen 3 的硬件架构设计，可以提供 20Gbps 的 trace 导出速度，以及内置的 2TB 的 NVMe SSD 用于保存 trace 文件在 analyzer 设备内部。

作为独立第三方 PCIe/NVMe analyzer，SerialTek 提供如下优势：

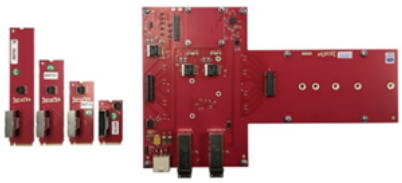
1. NVMe SSD Gen 3 x4 analyzer 非常便携，适合外场调试；
2. 支持 AIC, U.2, M.2 接口 SSD，适合于各种 SSD 问题分析场景；
3. 业内唯一无需对 Interposer 信号进行手工校准(Calibration)的 PCIe 分析仪；
4. 业内唯一支持无需抓取 boot trace 即可随时进行数据捕获的 PCIe 分析仪；
5. 业内唯一允许用户根据 BDF, Control Registers, Queues 进行 trigger 或 filter 的分析仪；
6. 业内唯一与 PCIe Spec 及 NVMe Spec 解码完全一致的界面，非常适合研发人员使用；
7. 业内唯一提供一张 U.2 interposer 同时支持 single port 和 dual port NVMe SSD 分析；
8. 其使用 MINI-SAS-HD cable 连接分析仪和各种 AIC, U.2, M.2 interposer，非常经济；
9. 其 NVMe analyzer 分析仪是 UNH IOL 官方网站推荐使用的分析仪；
10. 产品界面友好，普通工程师使用几乎不需要培训；
11. 其提供针对 NVMe 层的快速/高级过滤/查找/trigger 等功能非常强大；
12. 提供业内最高性价比的 PCIe/NVMe analyzer

1.1.2 产品图片

PCIe Gen 3 x8 和 Gen 3 x4 analyzer 的尺寸对照图

Slot Interposer
Capture and display PCI Express traffic between an adapter card (AIC) and Host system

M.2 Interposer
For M.2 socket 2 or M.2 socket 3 devices between a host system and a M.2/NGFF connector on an SSD



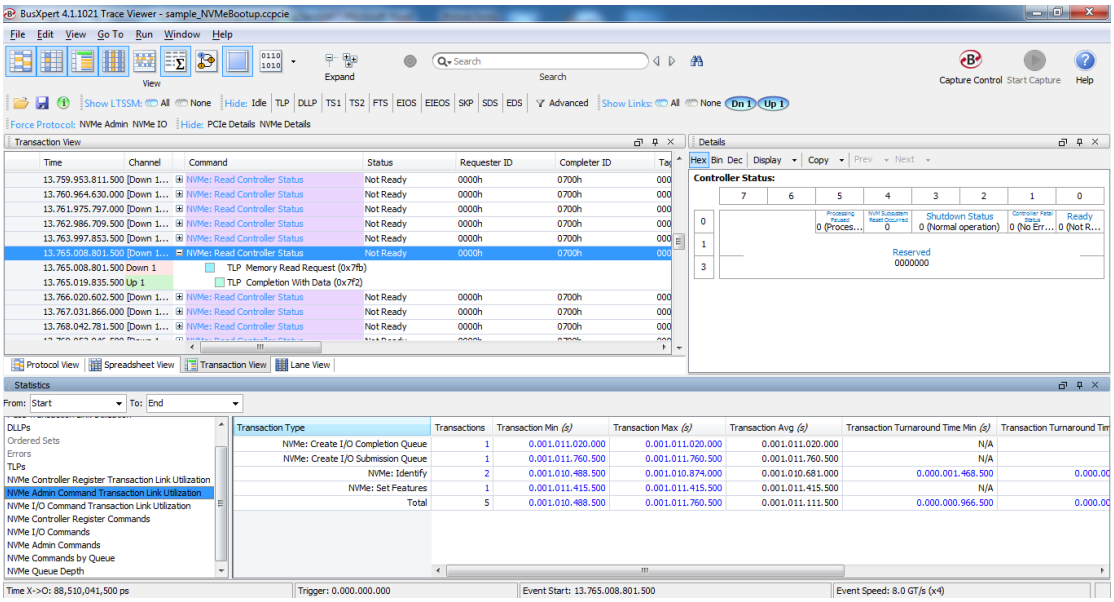
SFF-8639 Interposer
Designed to be used to analyze PCIe traffic between a host backplane and single or dual ported SSDs

PCIe/NVMe analyzer 的三种 interposer: Slot, U.2, M.2

便携式 12G SAS Analyzer 产品图片

便携式 6G SAS/SATA Analyzer 产品图片

1.1.3 产品软件



上图为 SerialTek PCIe/NVMe analyzer 的主界面，从上面可以查看 NVMe SSD CMD，关于 NVMe 层次的汇总统计信息，以及 NVMe Transaction 解码。

上图为 UNH IOL 实验室官方主页推荐的 NVMe SSD 测试使用的工具，从上至下依次为：

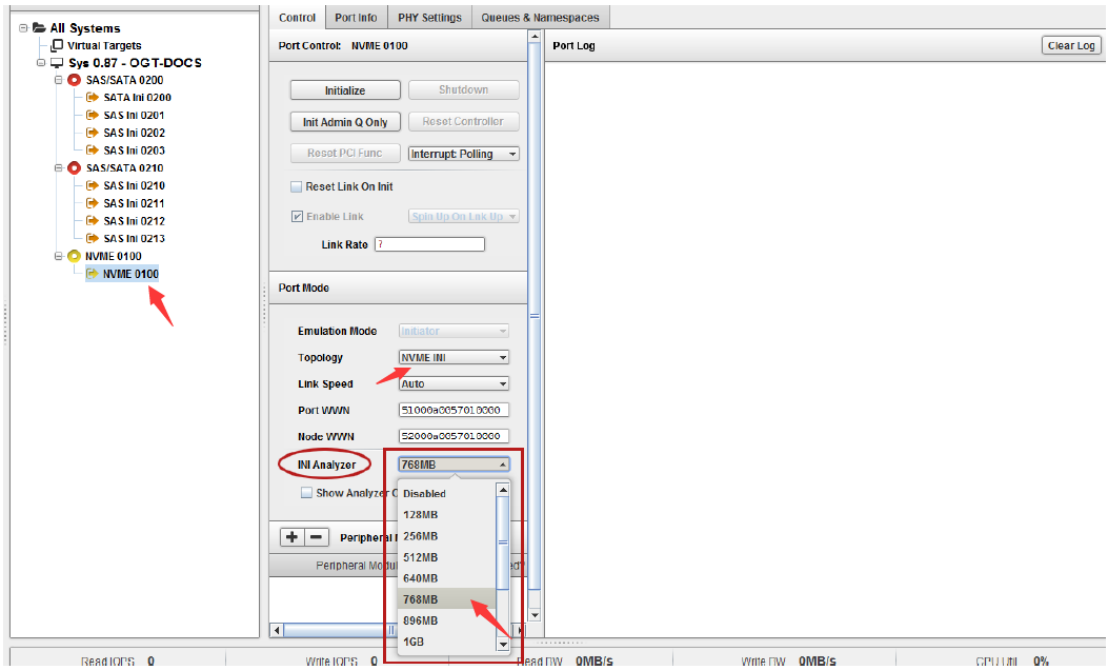
- Oakgate SSD 测试系统
- Quarch 公司针对 NVMe SSD 的热插拔自动化测试套件
- SerialTek 公司的 PCIe/NVMe SSD analyzer

1.2 Oakgate NVMe Analyzer

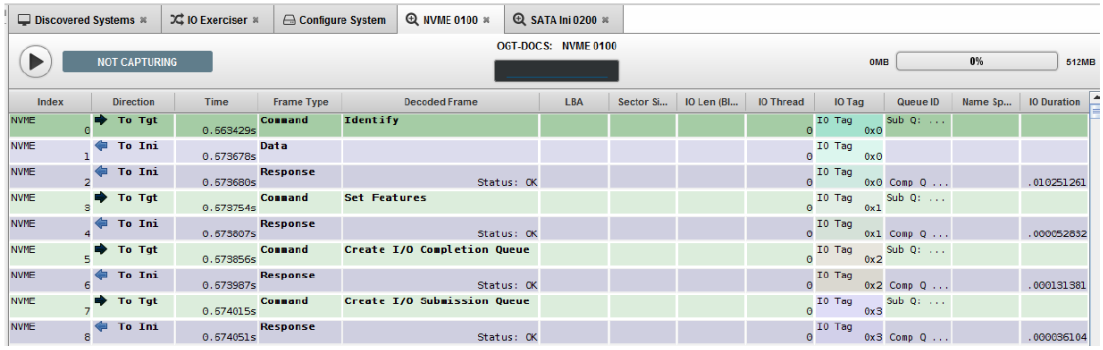
如果用户在使用 Oakgate 测试 SAS/SATA 或者 NVMe SSD 过程中碰到问题，可以立即调用其内嵌的 SAS/SATA/NVMe 协议抓包工具进行抓包解码分析，目前提供两种方式：

a. 使用 Oakgate 内置的 memory 抓包分析
   ** 该模式默认自带，每块 SSD 允许最多抓取 8G buffer，然后环回。
b. 使用 Deep Analyzer 卡进行抓包分析
   ** 该模式需要软件版本 4.1.x 之后版本支持，需要外购 Deep Analyzer 分析卡，默认可以抓取最多 2TB 字节数据，根据测试时候的 I/O 流量，可以抓取从几个小时 ~ 几天的数据进行分析，非常适合于一些不稳定的问题的分析。

其设置和解码界面参见下图。



上图为设置 capture buffer 大小。



上图为停止抓取 trace 后的解码界面。

(二) SSD 测试常用适配器和夹具

在 NVMe SSD 测试过程中由于测试主机和 SSD 接口不匹配，可能经常需要进行转接，所以经常需要各种 NVMe SSD 的适配器和延长线缆。

2.1 M.2 PCIe x4 转 U.2

2.2 M.2 NVMe SSD 转 PCIe 插卡

2.3 U.2 NVMe SSD 转 PCIe 插卡

2.4 M.2 SATA 转 SATA3 接口

2.5 PCIe 延长线

** 注意：常用的 Gen 3 x4 延长线在实际环境中有时可能无法达到 Gen 3。

(三) SSD 性能测试工具

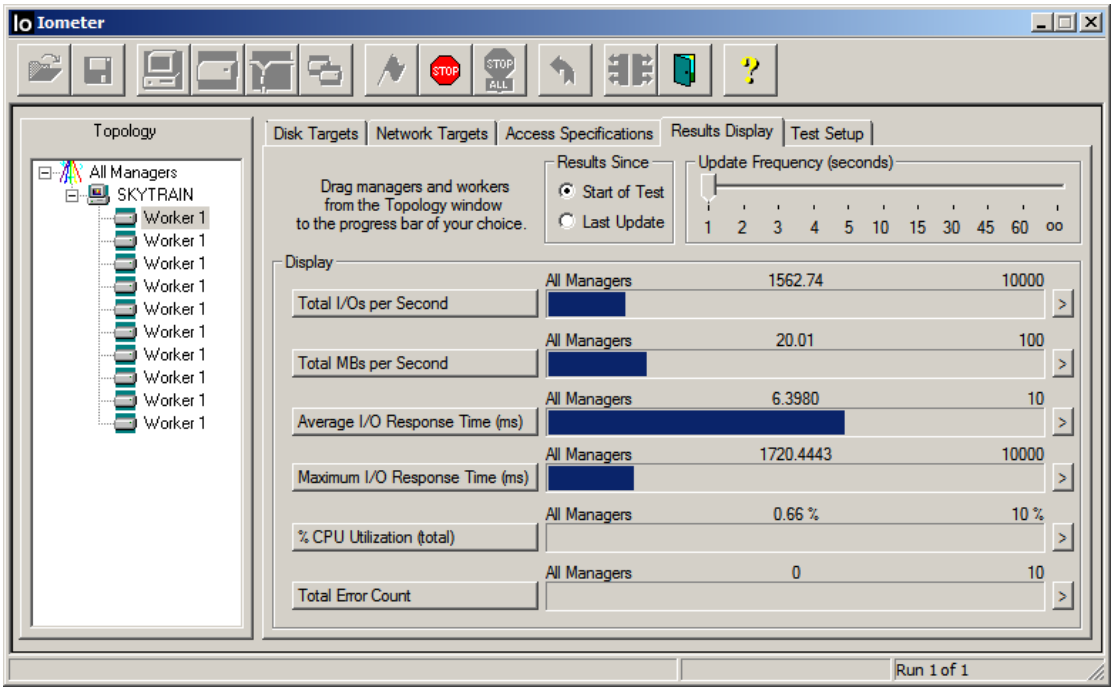
3.1 免费工具

目前业内针对 NVMe SSD 进行测试免费工具主要有下面几个：

3.1.1 IOmeter (Windows & Linux*)

Open sourced by Intel in 2001, there have been a few releases subsequently. More importantly, in the 2010 release there were options for pseudorandom and full random to account for deduplicating target devices.

An ‘old-time’ favorite of Storage Pro’s, originally developed by Intel and and now distributed under GNU Public License. The tool allows you to run stress tests sessions for I/O Performance Analysis.



3.1.1.1 主要优势

- Nice UI that's easy to use, you can learn quickly how to run tests
- It can produce graphs fairly easily

3.1.1.2 产品缺点

- Limited command-line parameters. Advanced CLI fans don't like this.
- Even its full random load generation turns up entirely deduped in Reduxio - makes it hard to simulate real-life data.
- Although pretty stable and we use it continously, development for IOMeter ended long time ago and there are no new builds. As Storage industry keeps advancing, new media and features come out, this can have a toll on how tests come out.

3.1.1.3 注意事项

- Remember to disable OS Cache.

3.1.2 FIO

FIO is a powerful open source Linux/Unix benchmarking tool that is extremely flexible and writes random data (100% non-dedup friendly) by default.

This is originally written by Jens Axboe, current blq-mq developer for Linux kernel. Axboe got tired of writing specific test application and developed FIO which set the world record in 2012 for highest IOPS in a single system. Axboe left Fusion IO and is currently employed by Facebook.

FIO allows you to simulate different types of IO loads and tweak several parameters including the write/read mix, amount of processes, etc.

3.1.2.1 主要优势

- Batch mode & very extensive set of parameters.
- It's still being developed. Our friend Jens keeps fine-tuning it.
- Multiple OS support: Although we mostly run it on Linux, it also supports Windows.

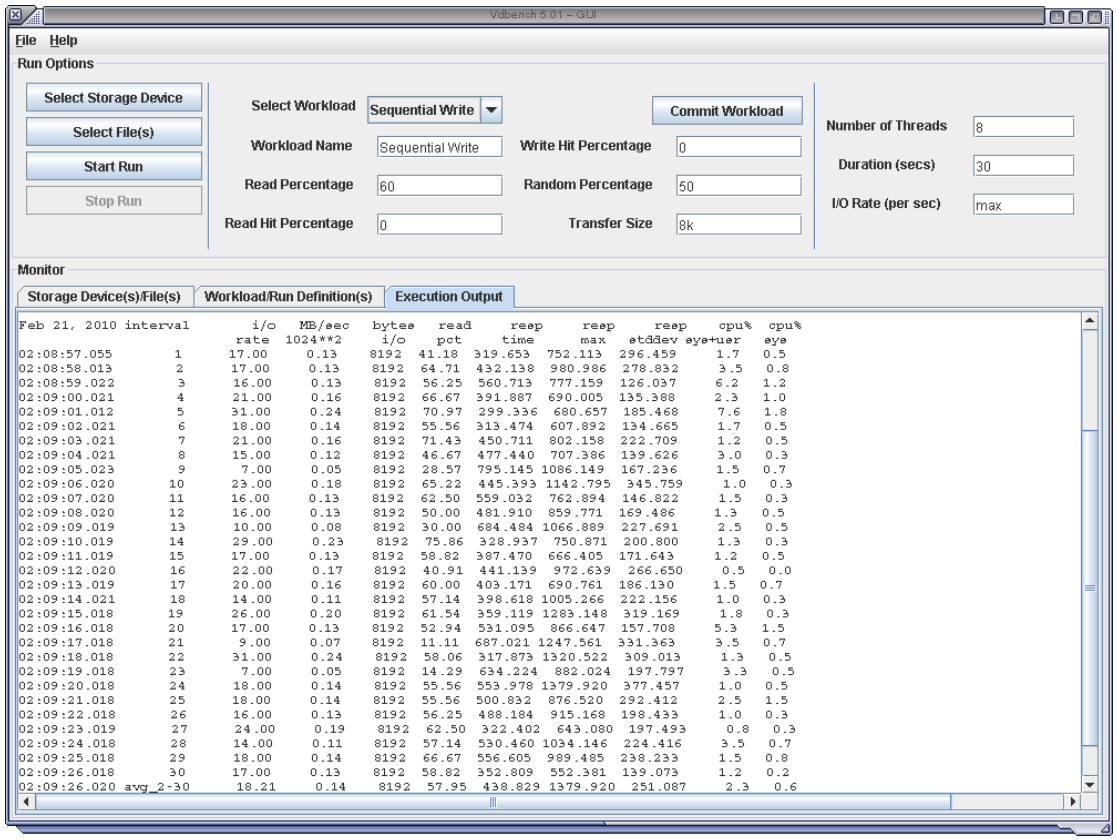
3.1.2.2 产品缺点

- No sophisticated GUI or Graphics features. This is for CLI hardliners only.
- Sophisticated syntax, it'll take some time to get the hang of it. But it definitely worth the effort if you are going to run multiple tests.

3.1.3 VDBench

The latest beta version has support for configurable dedup ratios.

A CLI utility developed by Oracle which lets you generate a wide variety of I/O workloads and has plenty of control over workload parameters, include rate, LUN/file sizes, read/write ratios, which as mentioned before, is important to test different ratios, among other parameters.



3.1.3.1 主要优势

- Lets you analyze response time by buckets (i.e. 0.1-0.2ms, 0.2-0.3ms etc.).
- If you run histograms on the performance results you end up with quite nice looking graphics.Reports are HTML accessible as well.
- Supported & maintained by Oracle: There's an active community that can solve questions you might have.

3.1.3.2 注意事项

Check with us if you want to learn more about how to use VDBench.

3.1.4 Btest

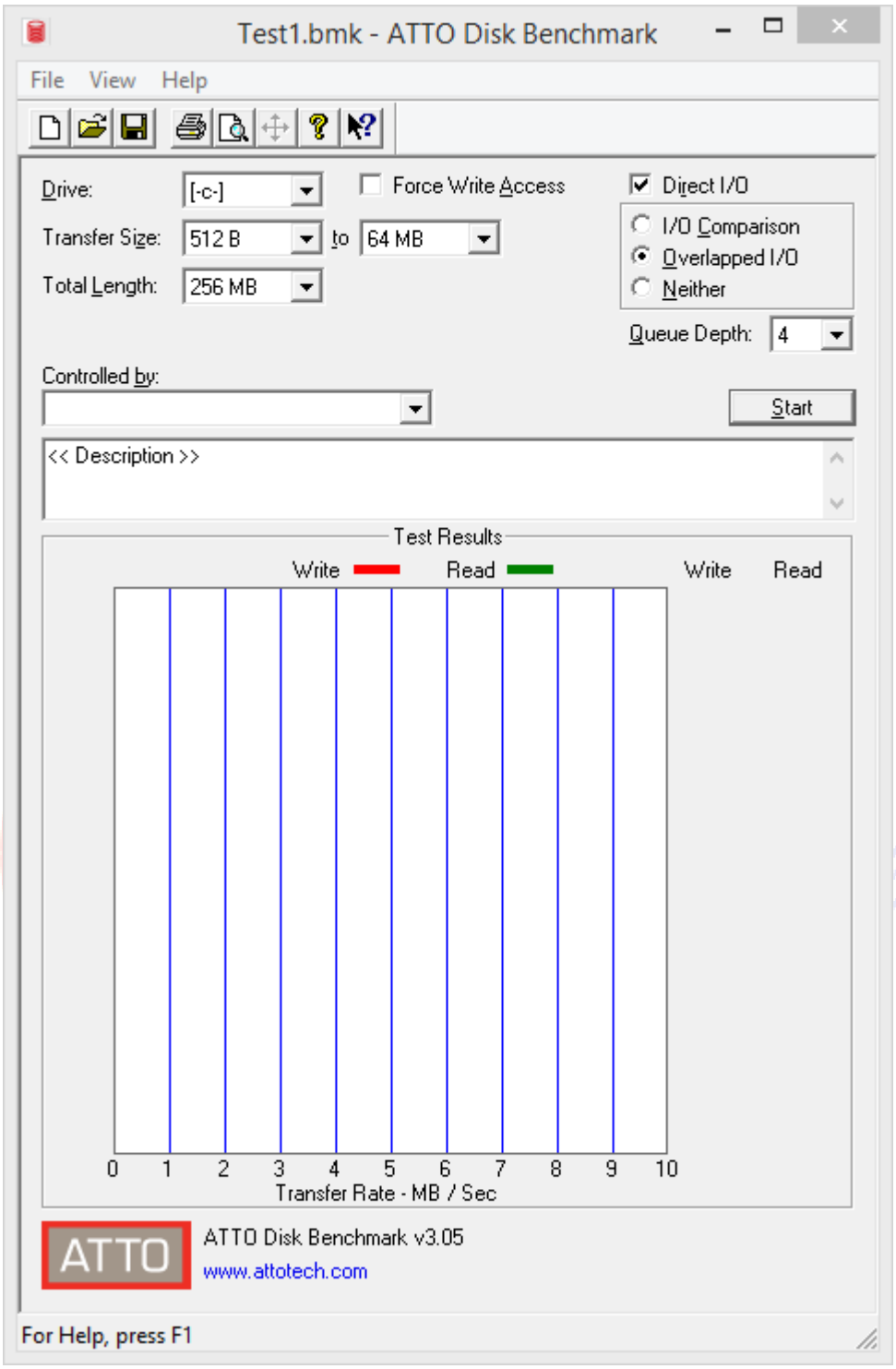
This open source Linux-based tool has controllable levels of block sizes, threads counts, read/write mix, and data de-duplication ratios and is oriented toward generating high levels of I/O load in a repeatable fashion.

3.1.5 ATTO Disk Benchmark

Test Hard Drives, SSD Drives, HBAs, RAID Adapters & Storage Controllers

As the industry's leading provider of high-performance storage & network connectivity products, ATTO has created a widely-accepted Disk Benchmark freeware software to help measure storage system performance. As one of the top tools utilized in the industry, Disk Benchmark identifies performance in hard drives, solid state drives, RAID arrays as well as the host connection to attached storage. Top drive manufacturers, like Hitachi, build and test every drive using the ATTO Disk Benchmark.

The ATTO Disk Benchmark performance measurement tool is compatible with Microsoft Windows. Use ATTO Disk Benchmark to test any manufacturers RAID controllers, storage controllers, host bus adapters (HBAs), hard drives and SSD drives and notice that ATTO products will consistently provide the highest level of performance to your storage.



3.1.5.1 Specifications

- Transfer sizes from 512B to 64MB
- Transfer lengths from 64KB to 32GB
- Support for overlapped I/O
- Supports a variety of queue depths
- I/O comparisons with various test patterns

- Timed mode allows continuous testing
- Non-destructive performance measurement on formatted drives

3.1.5.2 Customer Feedback

*Disk Benchmark is one of the better benchmarking tools for HD's and SSD's. ATTO gives a truer reading for SSD's than HDTune does. —**abxzone.com***

*One of the finest tools available to measure storage performance is ATTO Disk Benchmark...it is so reliable and produces such accurate results. —**Hibert Hagedoorn**, Guru3D.com*

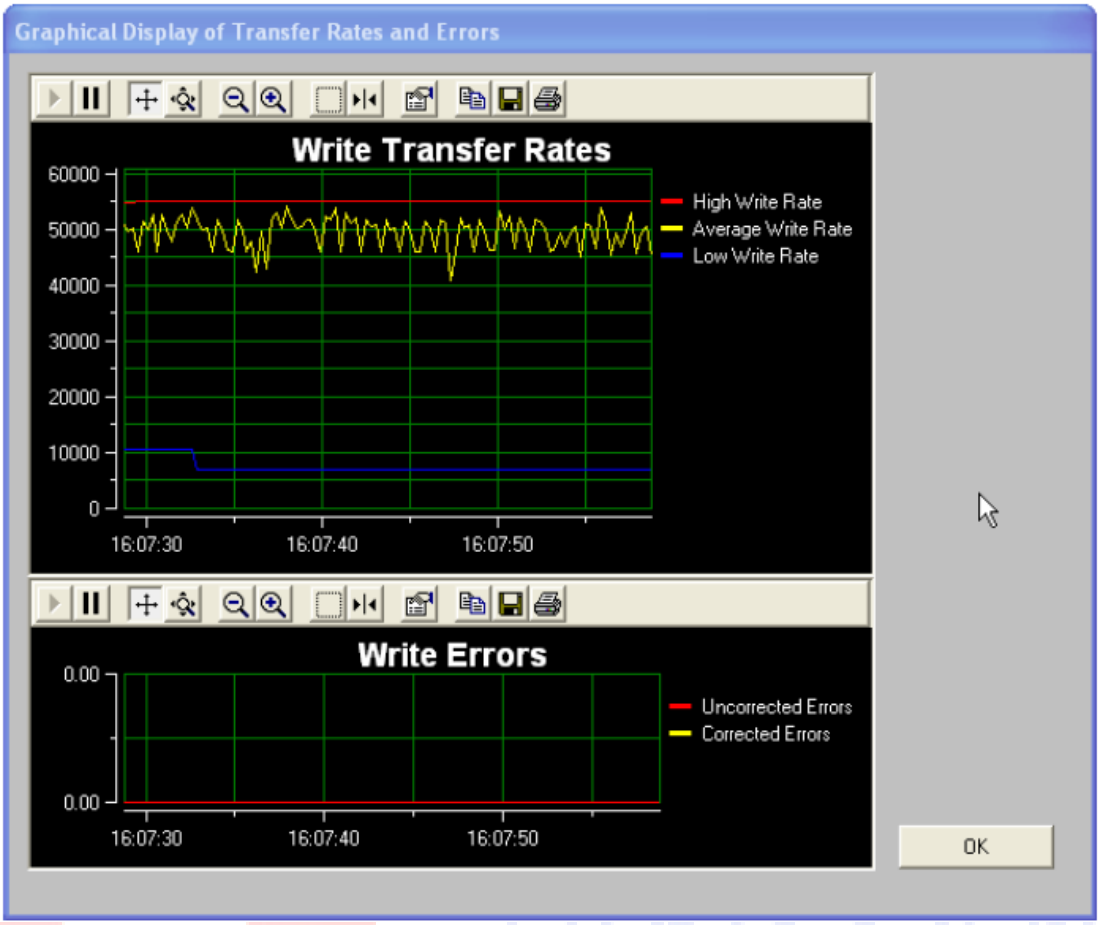
*Disk Benchmark measures raw transfer rates for both reads and writes and places the data into graphs which you can easily interpret. —**Nathan Kirsch**, Legit Reviews*

*Offers nice features to benchmark RAID setups —**techpowerup.com***

3.2 商业软件

3.2.1 STB Suite

The STB Suite is the industry's most advanced and widely used Enterprise level peripheral testing software. In use world-wide since 1992, the STB Suite™ of software encompasses every tool that you need to design, compliance test, manufacture, burn-in, troubleshoot, configure, Sanitize/Purge/DOD/DIST wipe and diagnose any SCSI, Fibre Channel, iSCSI, SATA, ATAPI, SAS or NVMe.



TheSTBSuiteistheindustry'smostadvancedandwidelyusedtestinganddiagnosticsoftwaretool.Inuseworldwidesince1992,theSTBSuiteencompasseseverytestingsoftwaretoolthatyouneedtotest,troubleshoot,configure,anddiagnoseanysingle-ended,differential,SCSI1,2,3,wideornarrowdevices,Ultra|I,Ultra3,FC,iSCSI,SATA,ATAPI,orSASdevice!

TheSTBSuiteistheSCSI,iSCSI,FC,SATA,SAStestingsoftwarethatvirtuallyeveryRepairDepot,OEM,DiskandTapeManufacturer,Integrator,3rdpartysolutionprovider,FieldServiceandA/VsolutionproviderusesattheEnterpriseLevelintheworld.Ifyoudoperipheraltestingfortheprofessionalmarket,youshouldbeusingTheSTBSuite.

If your job is to screen Hard Disk Drives (HDDs), Solid State Drive (SSDs) or Tape Drives (including Libraries or Juke boxes) that could possibly be bad, or are flagged as bad from a customer you want to look at the Disk Manufacturing/Screening Module or Tape Manufacturing/Screening Module included with The STB Suite. The Remote Manufacturing Engine (RME) allows you to run DMM sequences to remote computers with a simple interface for finding attached drives, and launching the tests. If your job is the write a custom SCSI, iSCSI, SATA, SAS, FC testing solution that integrates with your already existing tests, or you need to write the tests yourself from scratch you would use

the Developer Toolbox (API) included with The STB Suite. The Developer Toolbox will allow you to use Visual Basic (VB), Visual C++ (VC++), Visual Basic .NET (VB.NET), or if you're using Linux there is a Shared Object Library (.so file) to access the hundreds of built in functions that include detailed logging, multi-threading and much more. All Protocols and all HBA's are supported!

The STB Suite consists of three main components:

1. **An** interactive GUI **test environment**
2. **A high volume manufacturing environment**
3. **A** Visual Basic and C++ **test** development

The Interactive GUI

An interactive test system with pre-defined commands and tests for detailed testing of disk drives, tape drives, storage libraries, and processor devices. Hundreds of "real-world" tests developed in cooperation with our wide customer base since 1992 makes this the most versatile test system ever. From user defined CDB's through complete suites of compliance, performance, and stress tests for all device types, The STB Suite can be used by SCSI experts and novices alike.

The Manufacturing Modules

The STB Suite comes with a complete high volume manufacturing/reliability test/burn-in test system for both disks and tapes. Each drive on up to 16 host bus adapters has its own independent test thread for the highest data throughput and least interaction with other devices under test. A simple Point and Click interface allows complex sequences of tests to be assembled in minutes, and with many pre-defined test sequences included your test line will be up and running in no time at all. Detailed test reports are generated for each device tested, and an Access data base records all test steps and results, allowing you to build up a historical data base tracking every drive that passes through your facility.

The Development System

The STB Suite also includes the Developers Toolbox, a rich library of over 170 functions allowing you to quickly write your own tests in Visual Basic or C++. From simple commands through completely threaded multi-drive high level tests, the Developers Toolbox supplies every tool you need to write custom tests for any device and any interface. And best of all the Developer Toolbox lets you program in industry standard programming languages and environments, keeping the learning curve to a minimum and letting your device experts work at providing solutions.

Modules and Capabilites

All of the modules that have been developed for The STB Suite over the past decade are still included in the software package, such as:

Fibre Channel Module

The Fibre Channel Upgrade allows your existing SCSI toolbox to perform all of the SCSI toolbox tests and commands on Fibre Channel devices. Direct port driver access and dual port capabilities. Organizes drives into logical addresses and allows for up to 126 devices per host adapter. Supports all Fibre Channel host adapters.

Workstation Prep Module

The Workstation Prep Module guarantees high-level formatting, partitioning, and labeling of drives in seconds. Designed for use on your Windows-based PC or laptop, this module can prep and format for various UNIX operating systems, including SunOS, Solaris, HP/UX, DEC Ultrix and IRIX. In addition, Workstation Prep reads the drive and reports drive geometry and flaw information, making it easy to integrate a drive into the workstation environment.

Media Module

The Media Module allows for complete duplication of disks and tapes. Quickly and effortlessly clones up to 15 targets from one source, regardless of the data or format on the source device. The Media Module allows you to copy form disk-to-tape/tape-to-disk as well.

Jukebox Module

The Jukebox Module exercises and programs robotics for all optical or tape libraries such as HP, STK, Exabyte, ADIC, ATL, Qualstar, Sony, and many others. A simple to use graphical representation of the library gives an instant view of the state of all storage elements, drives, mailboxes, and pickers. Drag and Drop allows you to move media, view VolSer information, or position the picker.

Script Writer Pro Module

ScriptWriter Pro is a full-featured programming language that follows Microsoft Visual Basic syntax and semantics and features full flow of control, subroutines and functions. A full-featured editor is included that allows you to edit and debug existing scripts, create new scripts, and run and test scripts. Integrated into the editor is a debugger that supports stepping into and over functions, watching and evaluating variables, and setting breakpoints. The editor also includes a dialog editor, which permits visual editing of dialog controls. Any command can be included in a script. Full access to all systems resources, including the Windows API DLLs, allows your script to be “network aware”, as well.

TheDeveloperToolboxusesourproveninterfacetoaccessSCSI,FibreChannel,SATA,SAS,iSCSI,orATAPIdevicesfromVisualBasicorC++runningon32bitand64bitversionsofWindowsandLinux.

This library can be integrated into all popular test and process development environments such as Visual Basic or Visual C++. Over 200 functions allow you to easily work with disk drives, tape drives, libraries, processors, and any other SCSI/FC/ATAPI/SATA/SAS peripherals! With more tests and functions being added monthly, the Developer Toolbox is a solid and growing test development tool. In use at major manufacturers and integrators, the Developer Toolbox is the proven way to test peripheral storage devices FAST! The Developer Toolbox also includes its own stand-alone development environment, Scriptwriter Pro. Scriptwriter Pro is a Visual Basic for Applications compatible development environment that includes a debugger/editor, an interpreter/compiler, and a GUI design tool. Complete OLE-aware stand alone applications with graphical user interface can be quickly created with this tool.

TheDiskManufacturingModuleistheeasiesttouse,mostversatile,andfastestdisktestingproductonthemarket.

A true multi-threaded, multiple host bus adapter, multi-drive screening and testing tool, the Disk Manufacturing Module allows you to:

- Confirm that the proper drives are in the subsystem
- Download new drive firmware if needed
- Set all mode pages to your standard
- Set block size and capacity
- Format
- Log and track all error information
- Run any type of test, or sequence of tests at full bus and device speeds
- Log all process activities, drive information, and any errors to an Access database

All processes and test sequences are created from a graphical user interface – no programming or scripting is required! Time from installation to a complete test process can be as little as 5 minutes!

.AUTOMATED MANUFACTURING ENGINE

TheAutomated ManufacturingEngine –GUI-lessDMMtestsequencestoensureconsistentrepeatableresults.

The Automated Manufacturing Engine (AME) is STB's automation tool that allows you to run scripts created in our Disk Manufacturing Module (DMM). AME can be run from a Command Prompt Window or even a batch file. Like other automation tools, once run it requires no user-intervention or "baby sitting". After AME completes, the user can then analyze the extensive logfiles for success and view details on the failures.

In order to run AME, there are five steps that must be done. These steps are:

1. Create, within DMM, one or more testing scripts
2. Decide which devices on your system will be tested
3. Create a configuration file that will test the devices in step 2
4. Launch AME
5. Analyze the logfiles

.TAPE MANUFACTURING MODULE

TheTapeManufacturingModuleistheeasiesttouse,mostversatile,andfastesttapetestingproductonthemarket.

A true multi-threaded, multiple host bus adapter, multi-drive screening and testing tool, the Tape Manufacturing Module allows you to:

- confirm that the proper drives are in the subsystem
- download new drive firmware if needed
- set compression on or off
- log and track all error information
- run any type of test, or sequence of tests at full bus and device speeds
- run ANY external program as a part of the test sequence
- log all process activities, drive information, and any errors to an Access database
- create an individual text log file for each device tested

All processes and test sequences are created from a graphical user interface – no programming or scripting is required! Time from installation to a complete test process can be as little as 5 minutes!

.BUS ANALYZER MODULE

BAMisansoftwarebusanalyzerthatcancapture,display,andanalyzetracedatafromanyperipheralbus,includingSCSI,FibreChannel,IDE,ATA,SATA,andSAS.

BAM offers complete versatility as far as choice of phases that are captured and displayed, capture modes to minimize I/O impact, buffer size and capture size, and device(s) to capture trace data from.

User-Defined Custom Option

If your company requires features not already included in STB Suite, STB can adapt this diagnostic software to meet your custom SCSI manufacturing, production, field service and programming needs. Simply consult a STB sales representative for more information.

Protocol Support

- SCSI (All interfaces – single-ended, differential, SCSI 1, 2, 3, wide or narrow devices, Ultra II, Ultra3)
- Fibre Channel (FCAL)
- Magneto Optical (MO)
- Serial Attached SCSI (SAS)
- iSCSI
- Serial ATA (SATA)
- ATAPI
- NVMe
- PCIe

Operating System Requirements

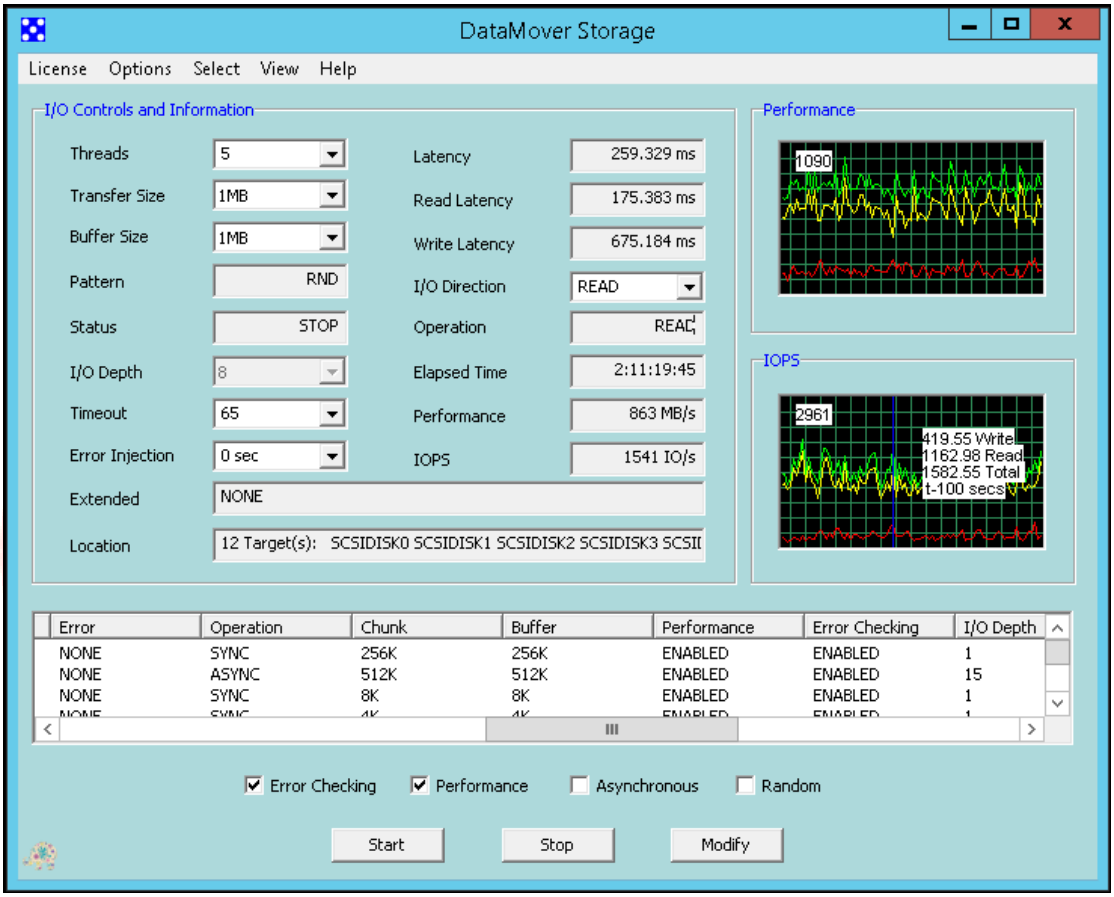
The STB Suite is available for the following platforms:

- Windows XP SP2 or higher (32 and 64bit)
- Windows Server 2008 (32 and 64bit)
- Windows Server 2012 (32 and 64bit)
- Windows Vista (32 and 64bit)
- Windows 7 (32 and 64bit)
- Windows 8
- Redhat Linux Kernel 2.6 or higher (API’s only)

3.2.2 Moojit's DataMover Storage

I/O generation tool with GUIs that validate enterprise storage and networking subsystems

DataMover Storage is an storage i/o stress tool providing basic and advanced feature sets meant to validate and test storage devices ranging from a single drive to a complex external RAID array with hundreds of drives.

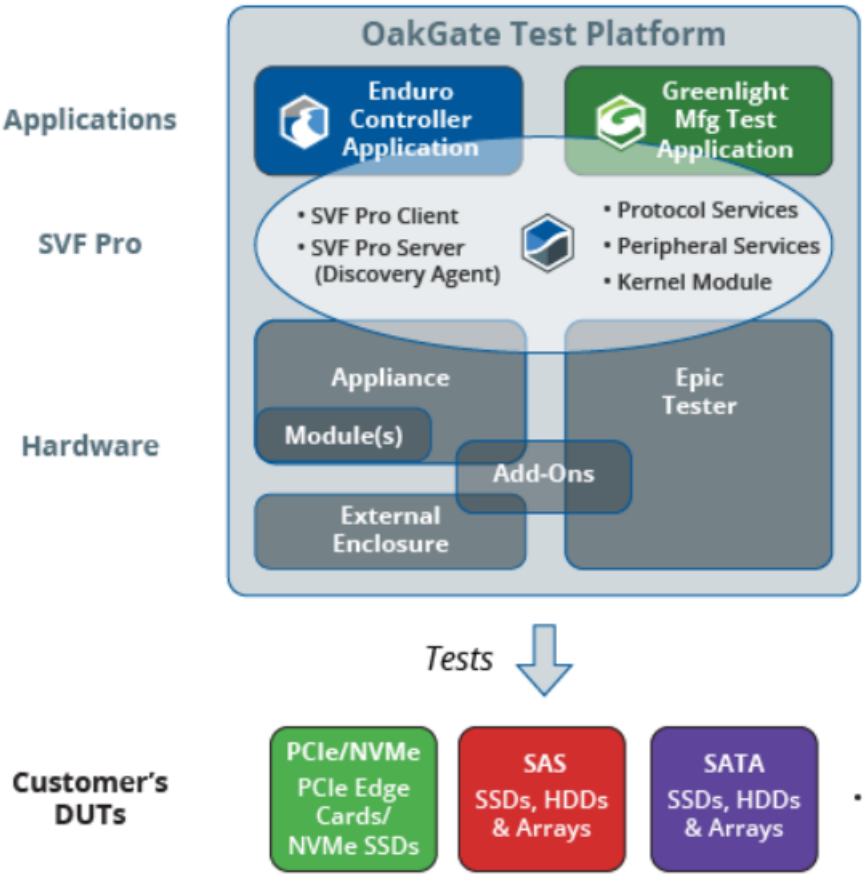


- Wide range of storage protocols supported - SATA, SAS, iSCSI, Fibre Channel, M.2 SATA, NVMe
- Wide range of storage devices supported - HDD, SSD, external RAID array, JBOD
- Both block and filesystem I/O supported
- Automated performance tests suites for standard and mixed workloads
- Multi-threaded asynchronous and synchronous workloads
- Custom workload generation - read/write percentage, sequential/random percentage, wait states and more
- Adjustable I/O timeout settings
- Advanced functional testing with data integrity checks
- Advanced real-time performance metrics including throughput, IOPS and latency
- Advanced data patterns - pre-defined and customizable

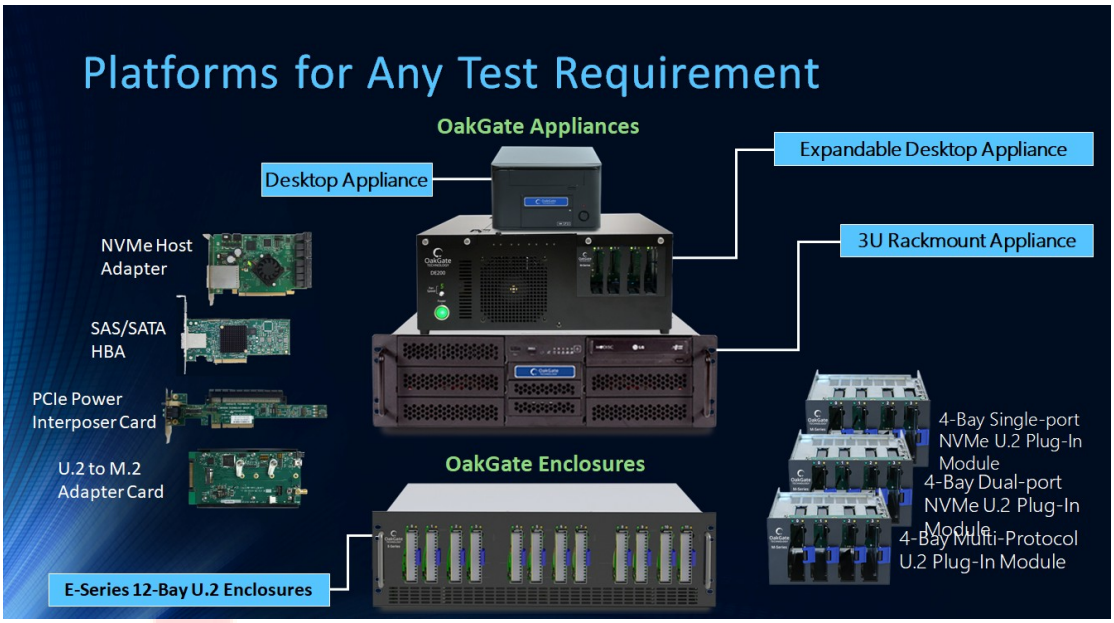
- Advanced SCSI Persistent Reservation and legacy Reserve and Release testing
- Automated bus triggers used for debug
- Automation mode supported for scripting purposes
- Easy to use graphical interface, no complicated command line switches to learn
- Up and running in minutes
- License key required for activation
- Please contact us for an evaluation license

3.3 专业测试设备

3.3.1 Oakgate 测试设备



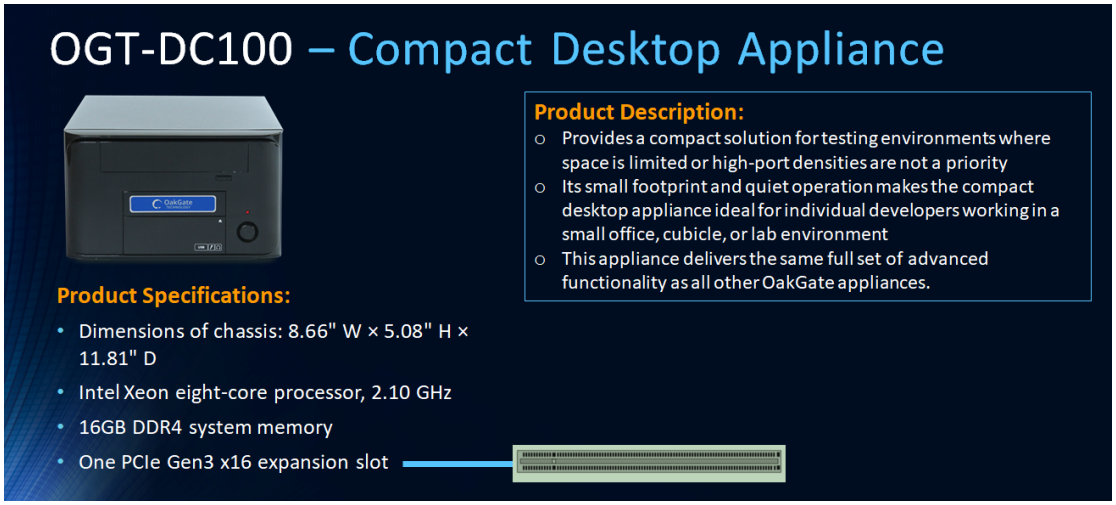
3.3.1.1 Oakgate 产品型号和典型配置



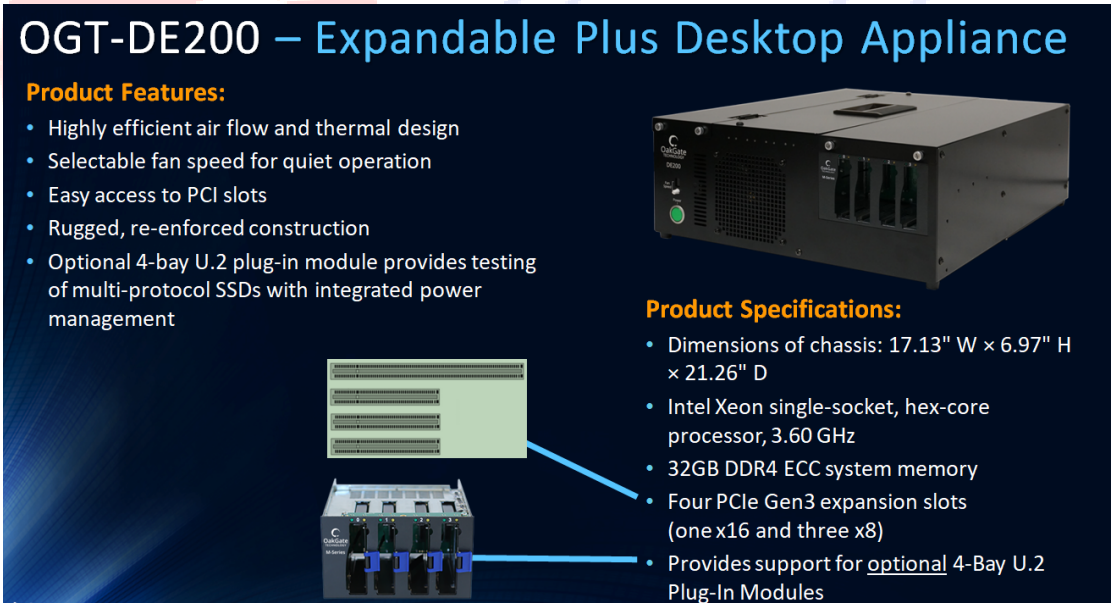
下表是三种型号对比。

Products	Product Features / Specifications	Compact Desktop Appliance	Expanded Desktop Appliance	3U Rackmount Appliance
Appliances	Image			
	Dimensions	8.66" W × 5.08" H × 11.81" D	17.32" W × 6.89" H × 17.13" D	16.9" W × 5.9" H × 26" D
	Processor	Intel Xeon Eight-core processor, 2.10 GHz	Intel Xeon single-socket, Hex-core processor, 3.60 GHz	Intel Xeon dual-socket, Eight-core processor, 3.20 GHz
	Memory	16GB DDR4 system memory	32GB DDR4 ECC system memory	64GB DDR4 ECC system memory
	PCIe expansion slots	One (1) PCIe Gen3 x16	One (1) PCIe Gen3 x16 / Three (3) PCIe Gen3 x 8	Three (3) PCIe Gen3 x16 / Three (3) PCIe Gen3 x 8
	DUT expansion options (w/ 4-bay modules or 12-bay enclosures)		☑	☑
Enduro / SVF Pro Software	Image			
	Single integrated solution	☑	☑	☑
	Windows GUI	☑	☑	☑
	Multi-views	☑	☑	☑
	Multi-instances	☑	☑	☑
	Data validation	☑	☑	☑
	Traffic generation	☑	☑	☑
	Extra traffic generation	☑	☑	☑
	Error injection	☑	☑	☑
	Device-level protocol support	PCIe/NVMe 1.2/1.3, SAS, SATA, AHCI, Fibre Channel	PCIe/NVMe 1.2/1.3, SAS, SATA, AHCI, Fibre Channel	PCIe/NVMe 1.2/1.3, SAS, SATA, AHCI, Fibre Channel
	Block protocol support	☑	☑	☑
	Real-time protocol analysis	☑	☑	☑
	Pass-through commands	☑	☑	☑
	Event logging	☑	☑	☑
	Command line interface	☑	☑	☑
	Integrated peripheral control	☑	☑	☑
	Integrated power management	☑	☑	☑
	Directed Tests	☑	☑	☑
	Manufacturing system support		☑	☑
	Performance graphs / dashboard	☑	☑	☑
	Performance benchmarking	☑	☑	☑
	Integrated Help System	☑	☑	☑
	Customization through APIs and SDKs	☑	☑	☑
	Automation	Python, Java	Python, Java	Python, Java

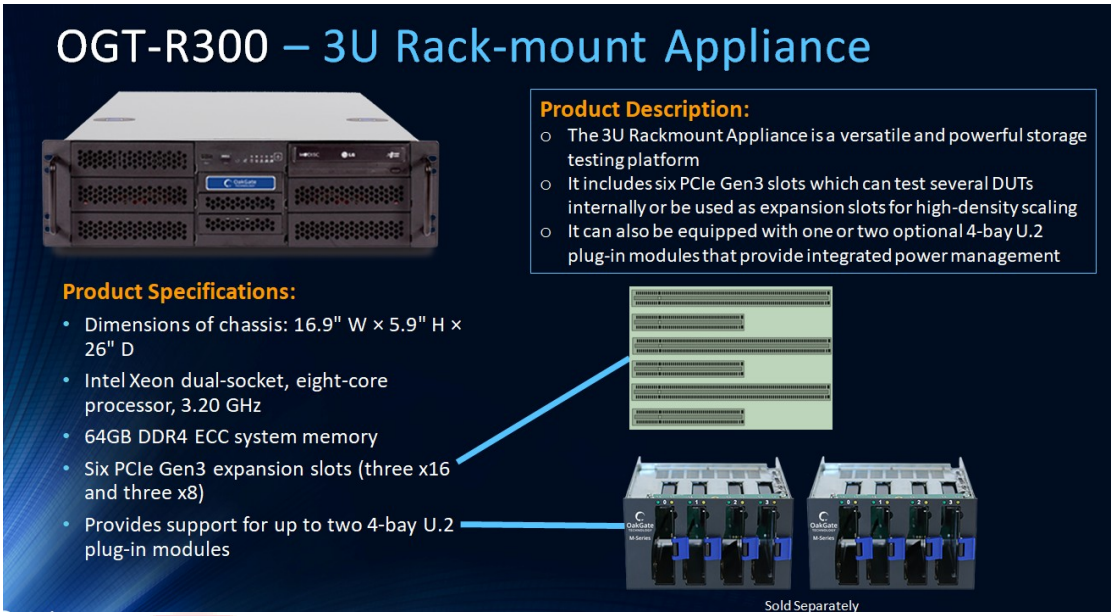
3.3.1.1.1 OGT-DC100 （基础型）



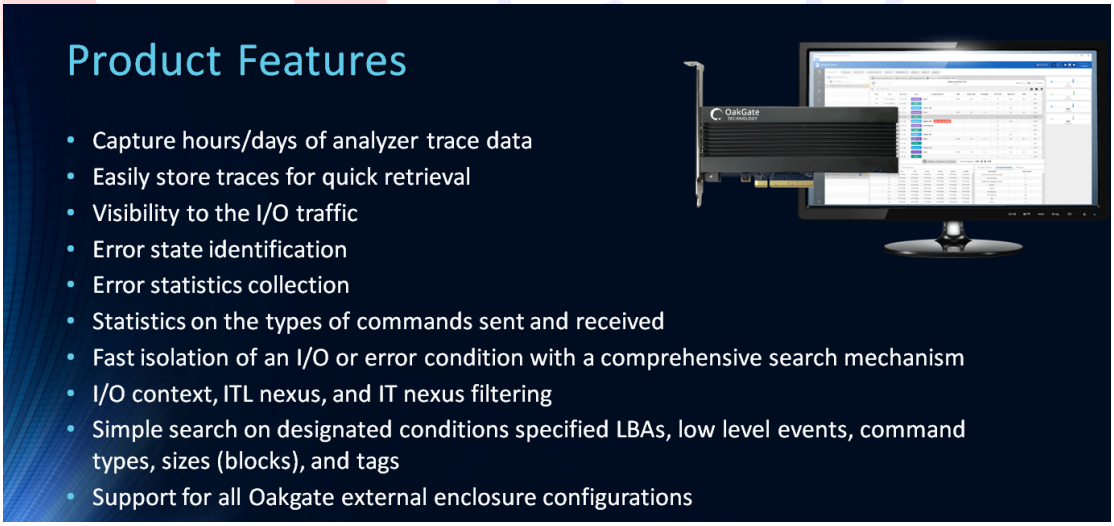
3.3.1.1.2 OGT-DE200 （经济型）



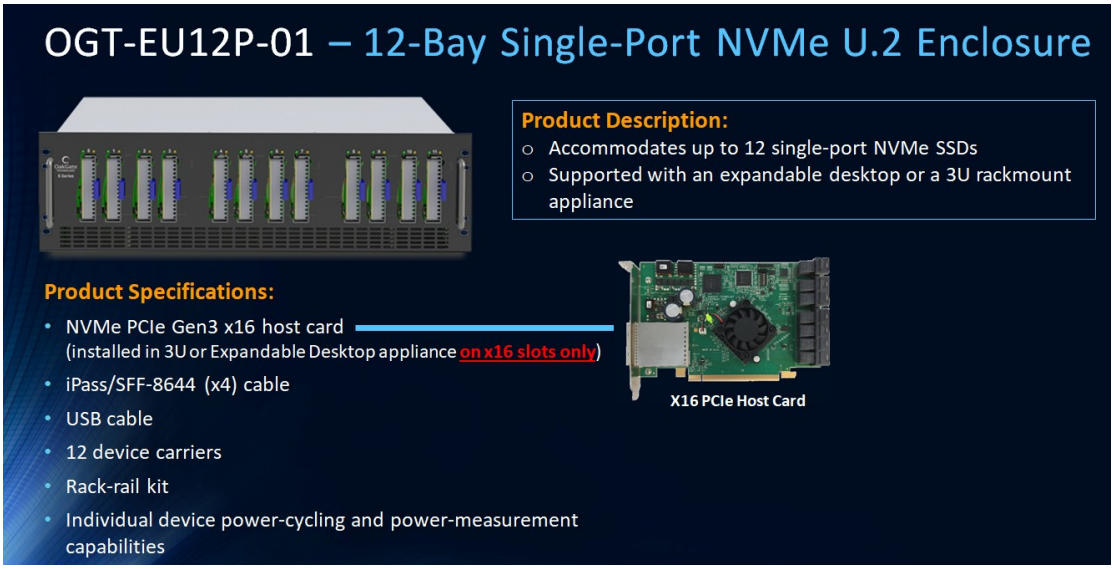
3.3.1.1.3 OGT-R300 （高端配置）



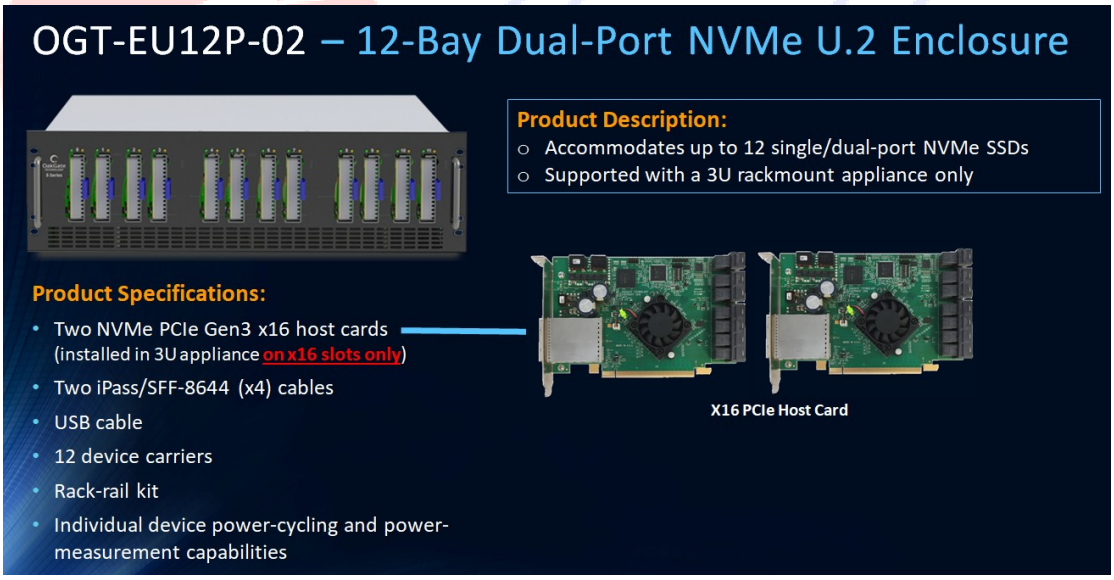
3.3.1.1.4 OGT-AD102 Deep Analyzer 协议分析卡



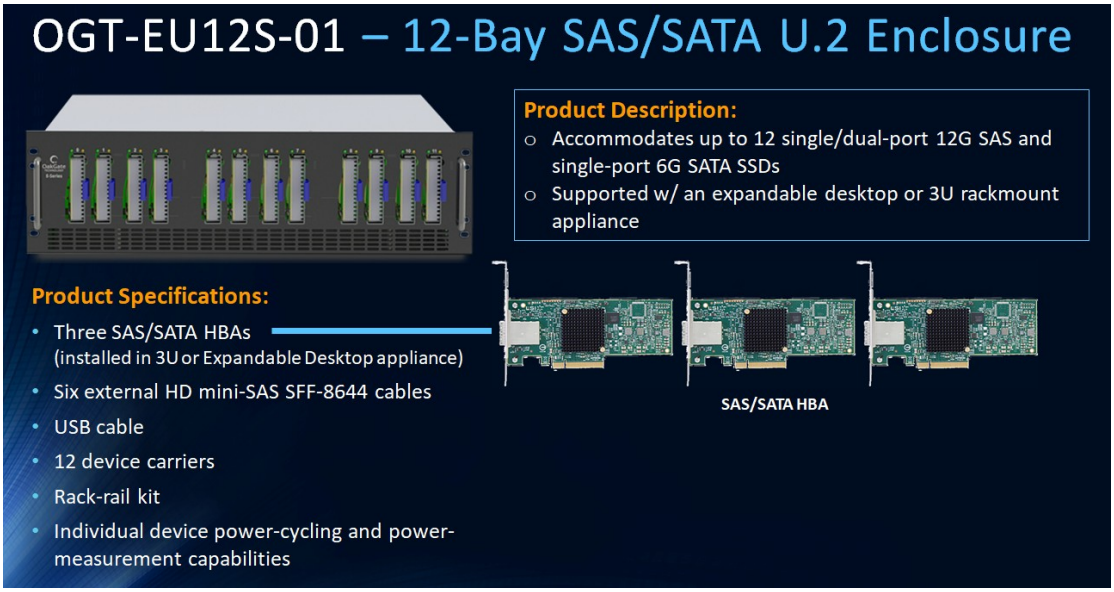
3.3.1.1.5 12 盘位扩展测试机柜 – Single Port NVMe



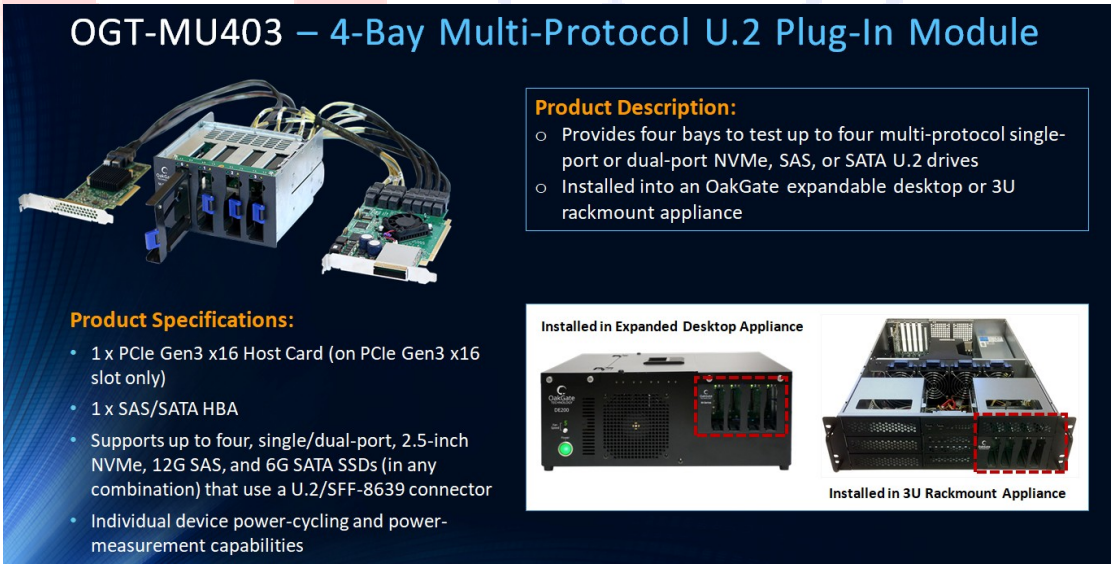
3.3.1.1.6 12 盘位扩展测试机柜 – Dual Port NVMe



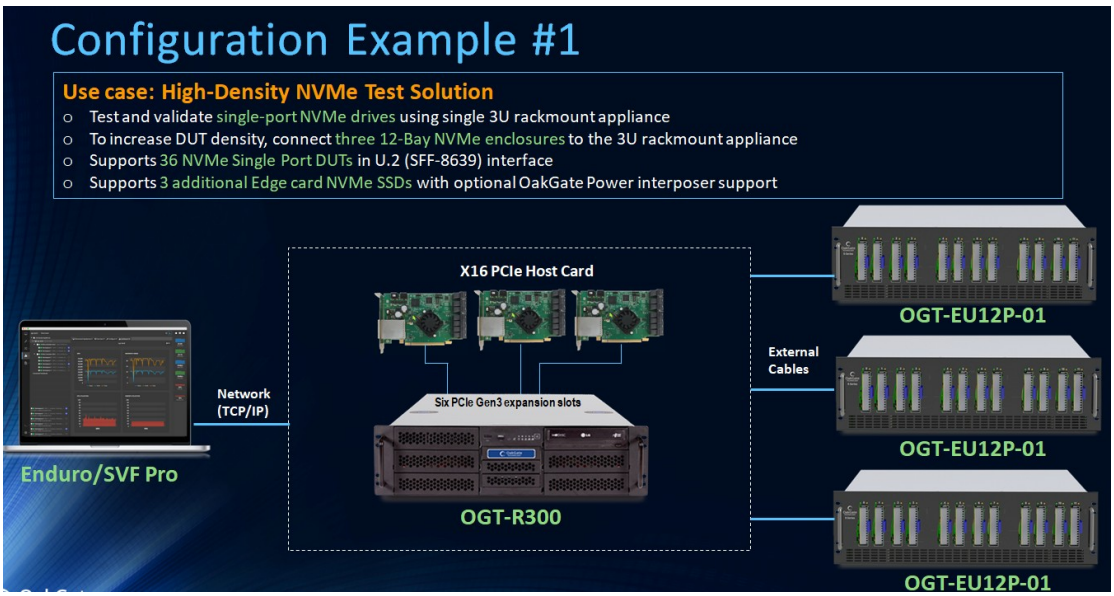
3.3.1.1.7 12 盘位扩展测试机柜 – SAS/SATA



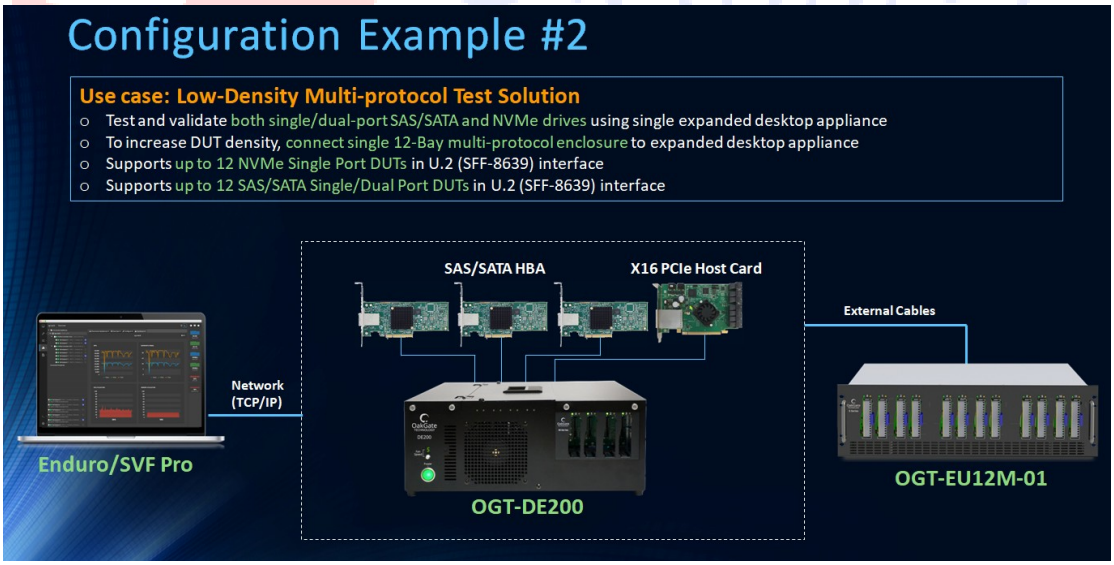
3.3.1.1.8 4 盘位扩展测试机柜 – 多协议 SAS/SATA/NVMe



3.3.1.1.9 典型配置#1



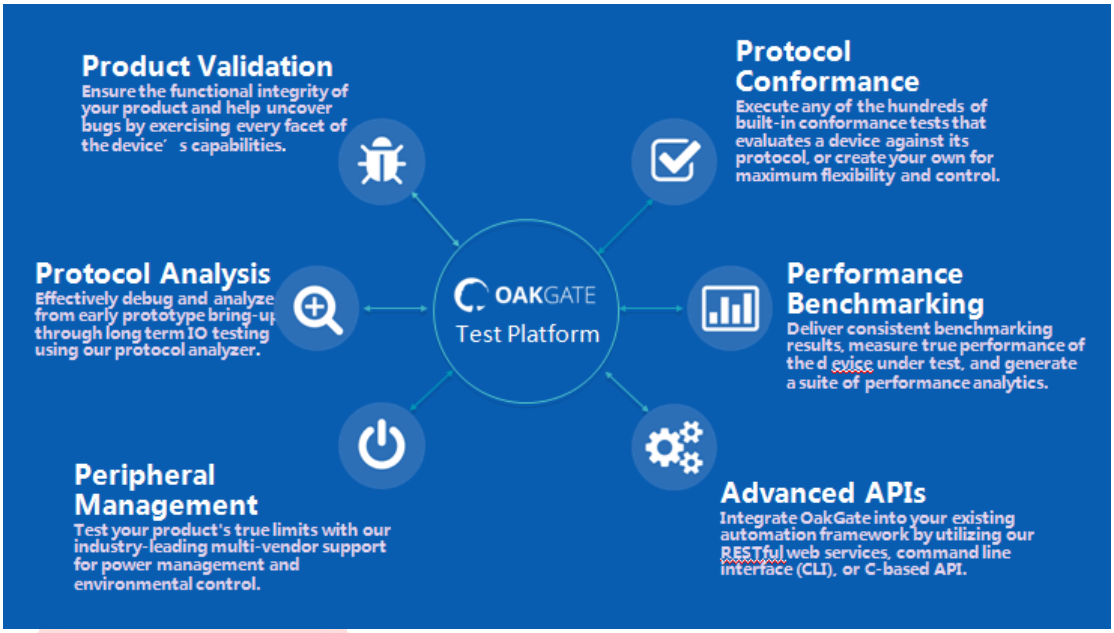
3.3.1.1.10典型配置#2



3.3.1.2 Oakgate 主要功能

- 产品验证测试
- 性能压力测试
- 协议分析

- NVMe 协议兼容性测试
- 外围设备管理，例如电源异常掉电、功耗测试等
- 高级 API 调用以及自动化测试



3.3.1.3 Oakgate 功能列表

OakGate Test, Validation & Benchmarking Systems offer the industry's most comprehensive set of features and capabilities and are designed expressly for the emerging flash based storage, including Solid State Drives (SSDs). These systems support all popular storage interfaces and are available in Desktop and Rack-mount versions. Based on industry standard Linux server platform and OakGate's proprietary software, these systems are available as turnkey, ready-to-use appliances.
OakGate's PCIe Desktop system is designed to work with the customer's existing block level storage driver or drivers based on industry standard protocols such as NVMe and AHCI. OakGate's PCIe Systems leverage the company's proven, second generation software architecture that is common across all OakGate products.

Supports PCIe Gen 1, 2 and 3

High performance, highly flexible traffic generation

Provides maximum control of workloads
Fixed and random IO sizes
Small to large Q-Depths

Performance benchmarking and characterization

Average IOPS, Bandwidth, Latency

Performance versus Time
Entropy Data Patterns

Error injection capabilities
Extensive error injection capabilities
Can be run concurrent with IO traffic at heavy load levels

Built-in protocol Analyzer
Traffic/Error Presentation
Real-time Traffic
Real-time Error statistics

Customer programming via robust API
C/C++ SDK
Rich OakGate Function Library

Test automation
Large test suites
Product validation suites
Full SNIA Benchmarks
SPC-style workloads
Fully customizable for creation of customer specific benchmarks

Summary report generation
Complete HTML reports
Histograms
Error logs
Pass/Fail report

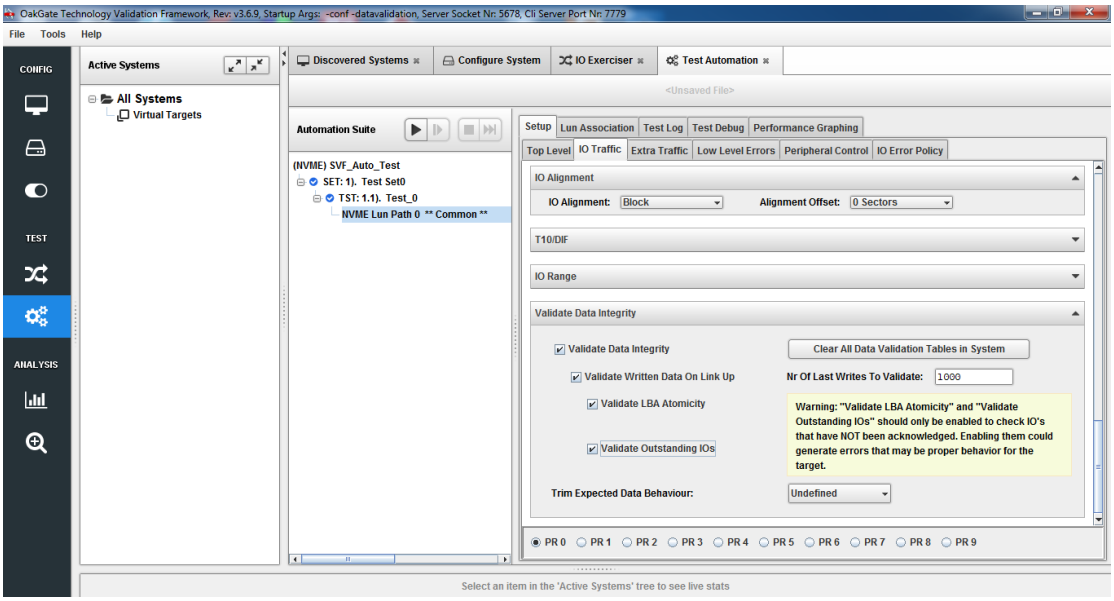
Automated power cycling with data validation
Applicable to externally connected devices

“Canned” test sequences, including JEDEC Endurance

3.3.1.4 产品功能简介

**下面截图以版本 3.8.2 为例，最新版本 4.x.x，GUI 界面显示有差异，但是主要功能一致。

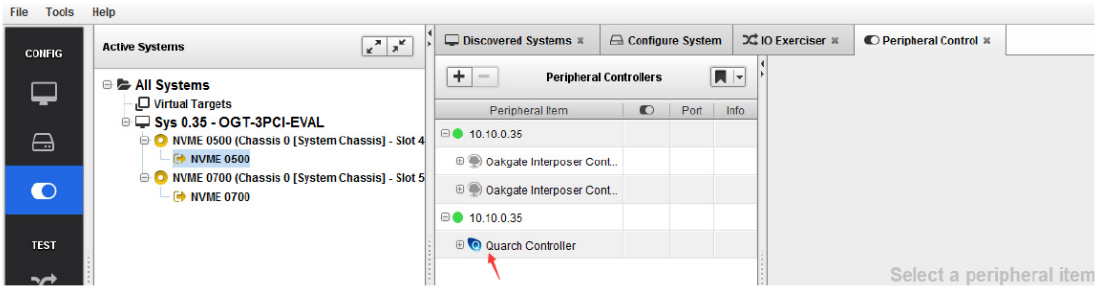
3.3.1.4.1 异常掉电测试数据完整性



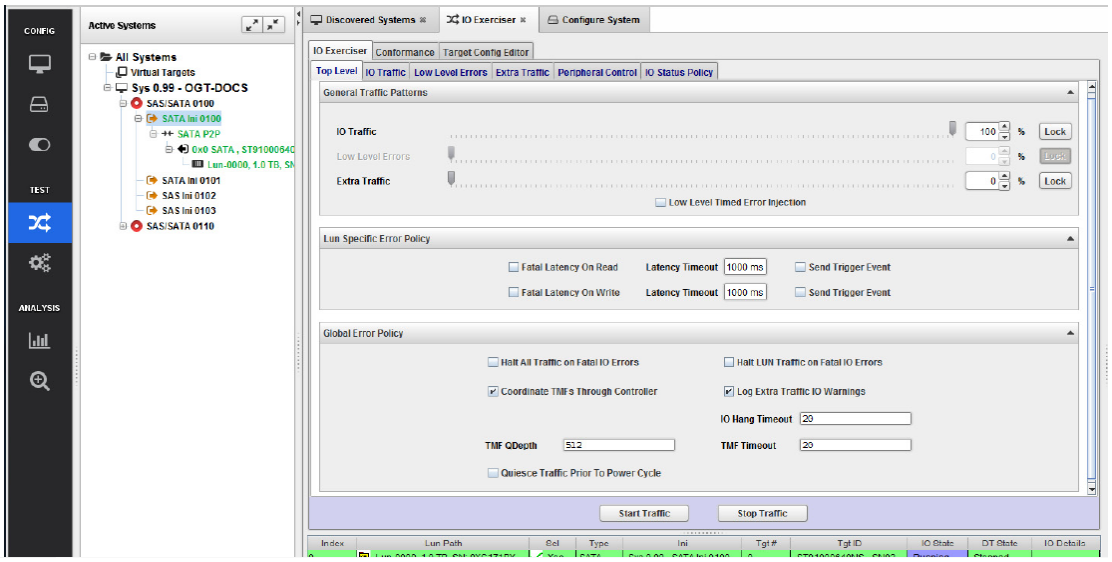
控制周边外围设备，例如 Oakgate 或者第三方公司，例如 Quarch 公司热插拔或者可编程电源模块进行测试。

The following screenshot shows two power controllers (OakGate Interposer Card and Quarch Controller) in the OakGate system with IP address of 10.10.0.35:

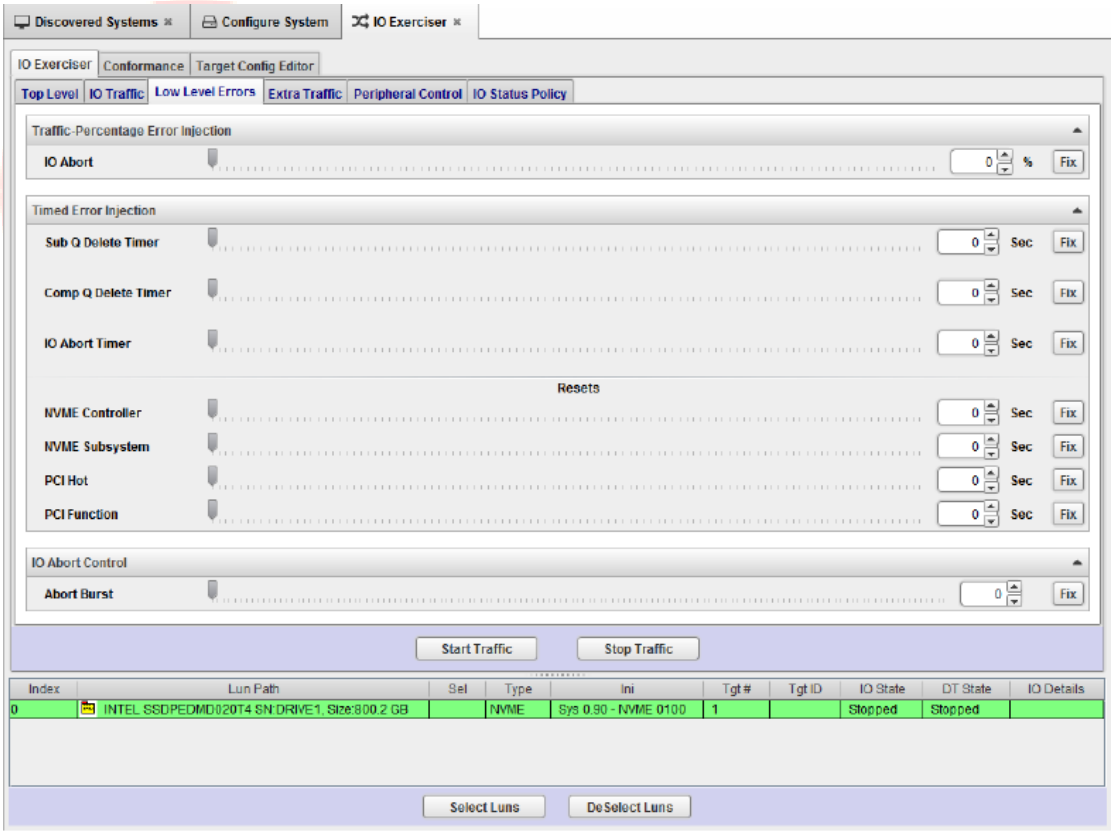
Screenshot 5-5 Connect to a Peripheral Controller



Oakgate 可以在读/写的同时注入底层错误和其它 NVMe 命令

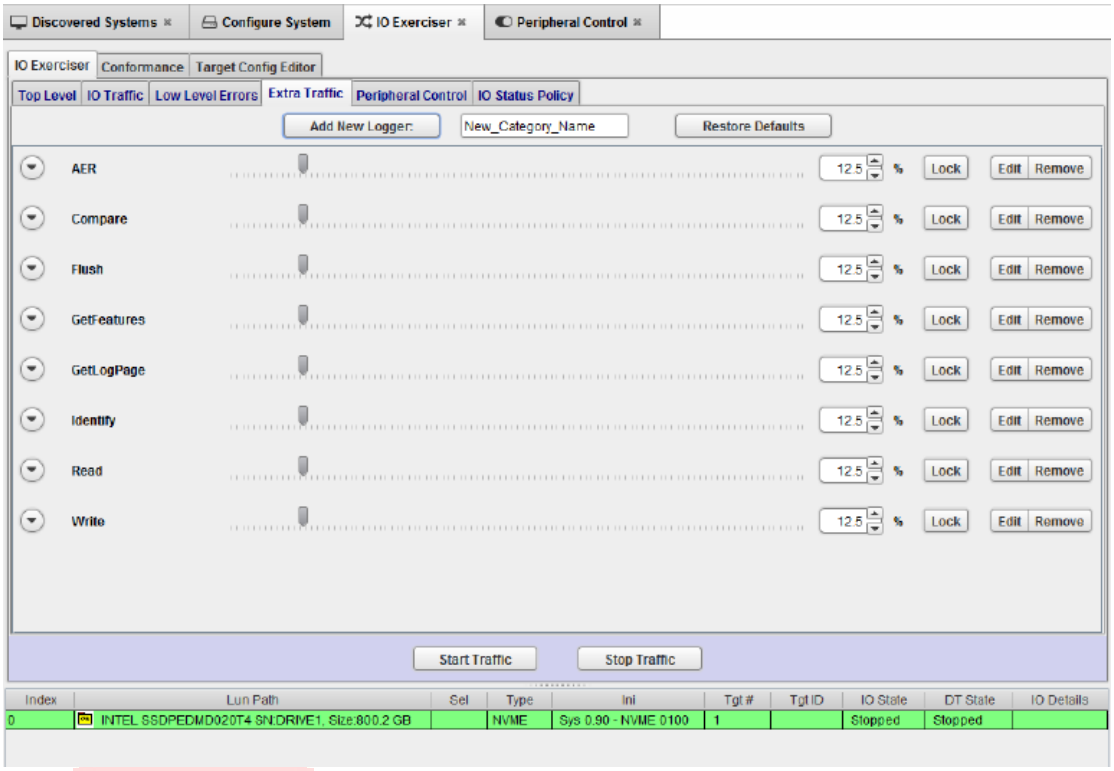


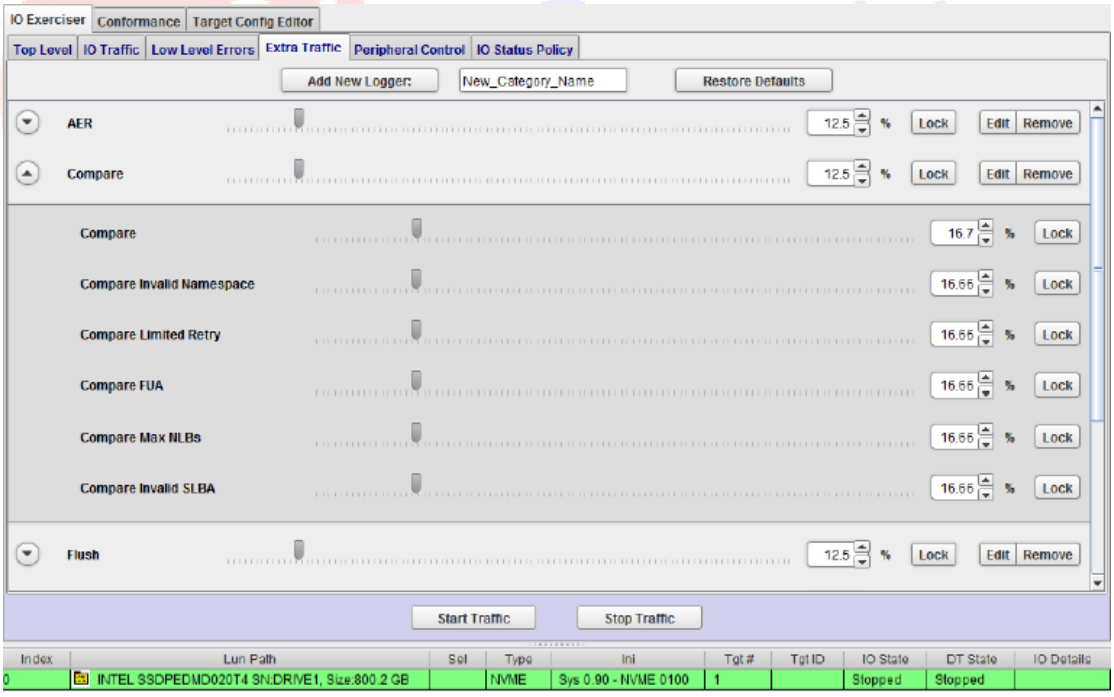
3.3.1.4.2 NVMe 底层错误、异常注入



3.3.1.4.3 NVMe 读/写之外的命令注入

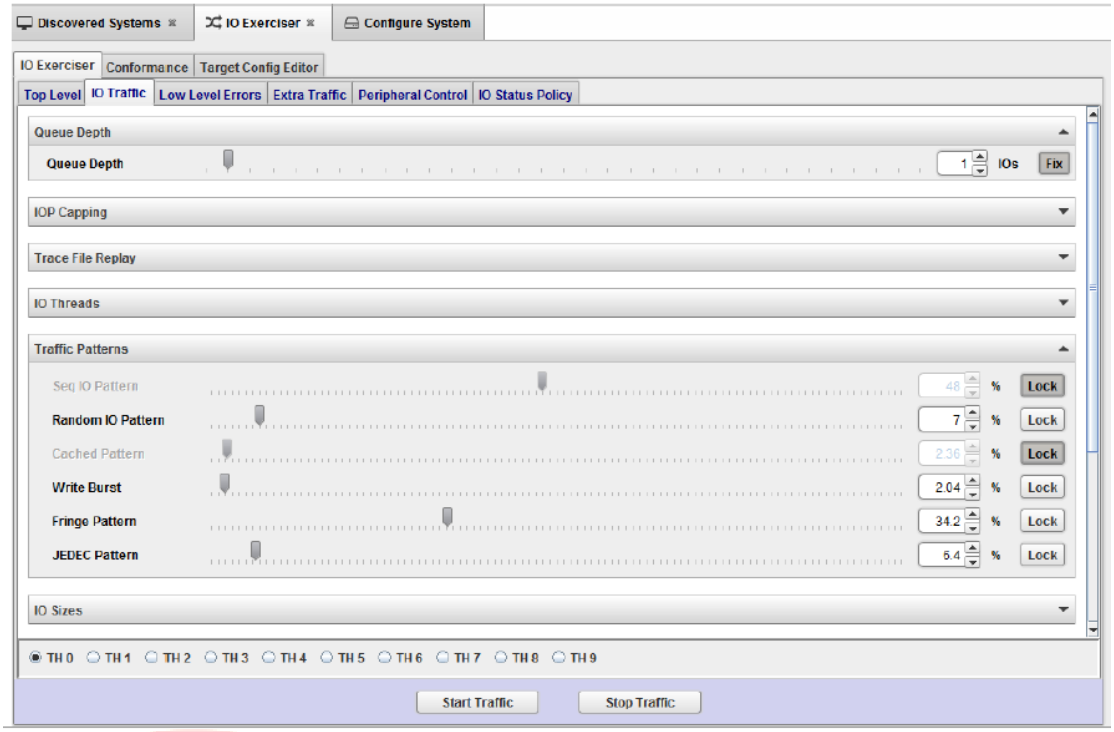
可以在 NVMe 读/写指令之外，随意指定所有 NVMe 命令的每种命令注入的流量百分比。





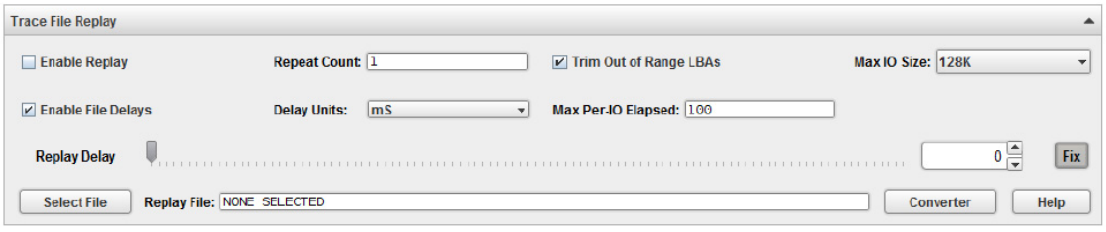
通过上图可以看到每类命令下面的子集命令都可以指定百分比。

3.3.1.4.4 I/O 流量模型定义 – 队列深度



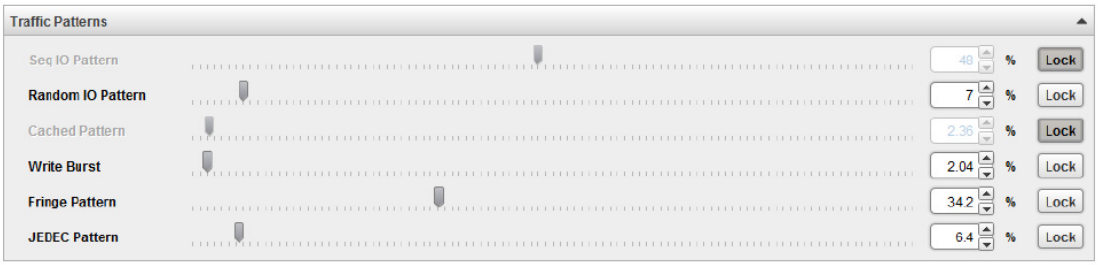
3.3.1.4.5 I/O 流量模型定义 – I/O 上限设置

3.3.1.4.6 I/O 流量模型定义 – JEDEC trace 文件回放

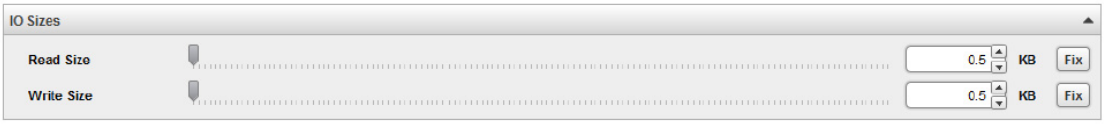


3.3.1.4.7 I/O 流量模型定义 – 10 个线程百分比设置

3.3.1.4.8 I/O 流量模型定义 – 流量模型设置



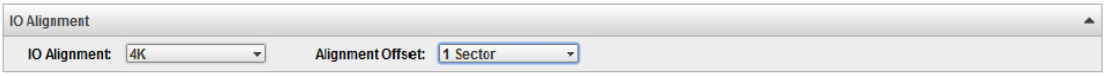
3.3.1.4.9 I/O 流量模型定义 – I/O Block Size 设置



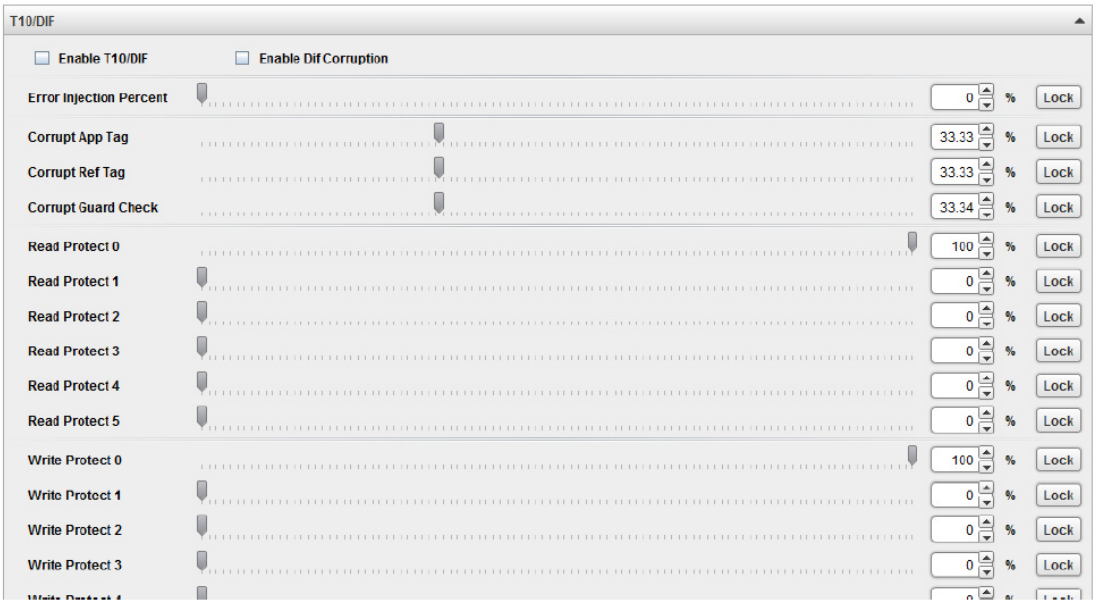
3.3.1.4.10I/O 流量模型定义 – I/O 比例设置

3.3.1.4.11I/O 流量模型定义 – 数据 Payload Pattern 设置

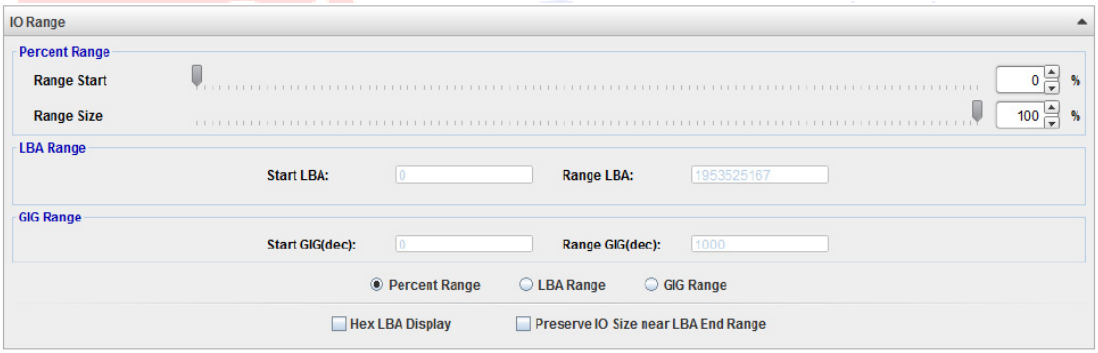
3.3.1.4.12I/O 流量模型定义 – I/O 对齐设置



3.3.1.4.13I/O 流量模型定义 – T10/DIF 设置

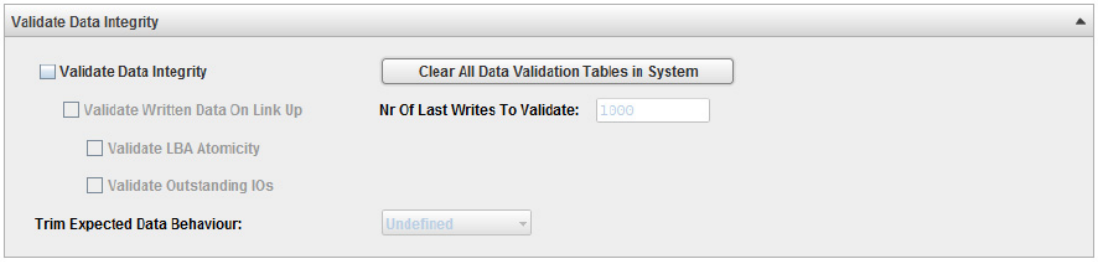


3.3.1.4.14I/O 流量模型定义 – I/O 读写范围设置



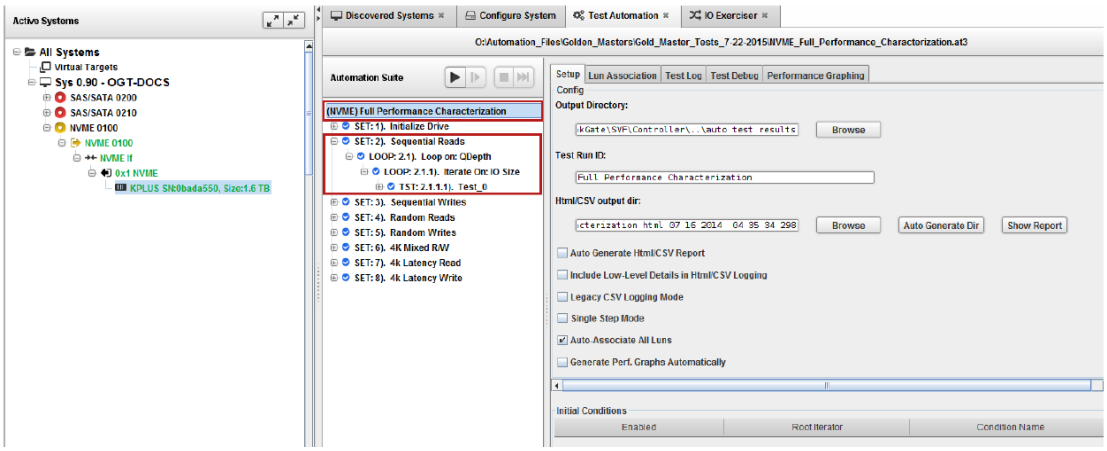
上图设置可以为盘总容量的百分比，LBA 范围，按照字节数。

3.3.1.4.15I/O 流量模型定义 – 数据一致性测试

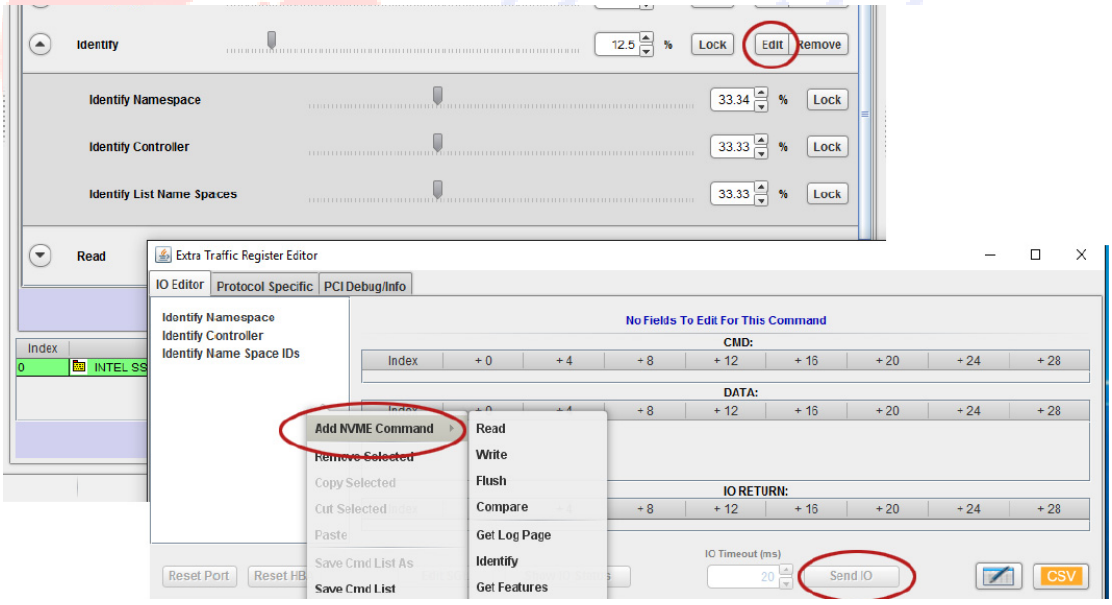


上图为数据读写一致性校验，通过配合 Oakgate 的 power interposer 或者第三方 Quarch 的热插拔自动化测试套件可以实现 SSD 异常掉电起动后针对最后读写的数据进行校验。

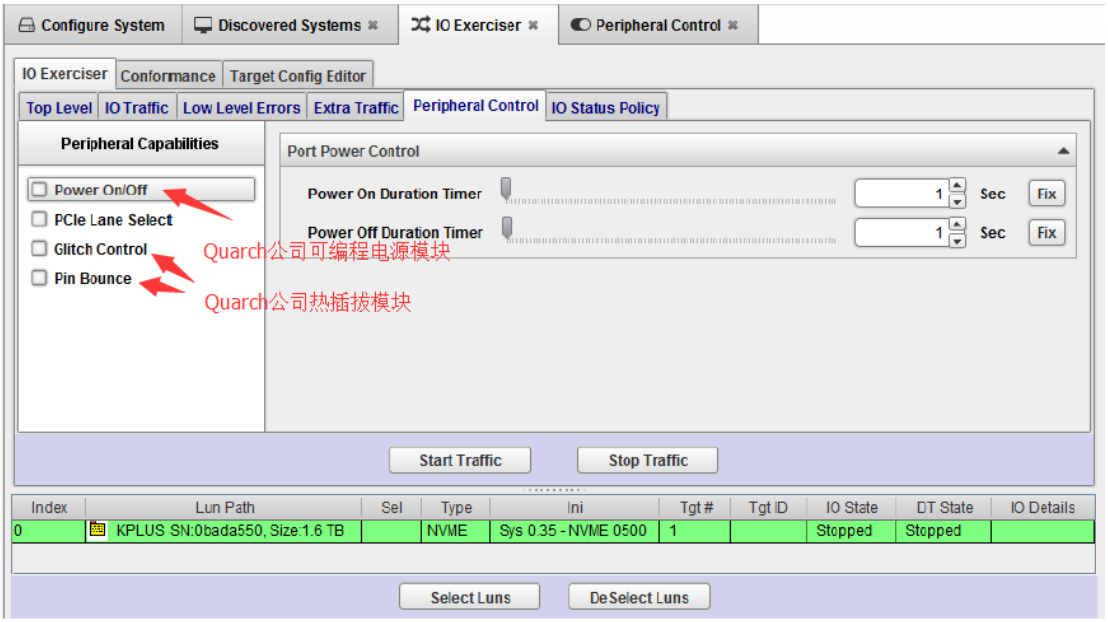
3.3.1.4.16自动化测试框架



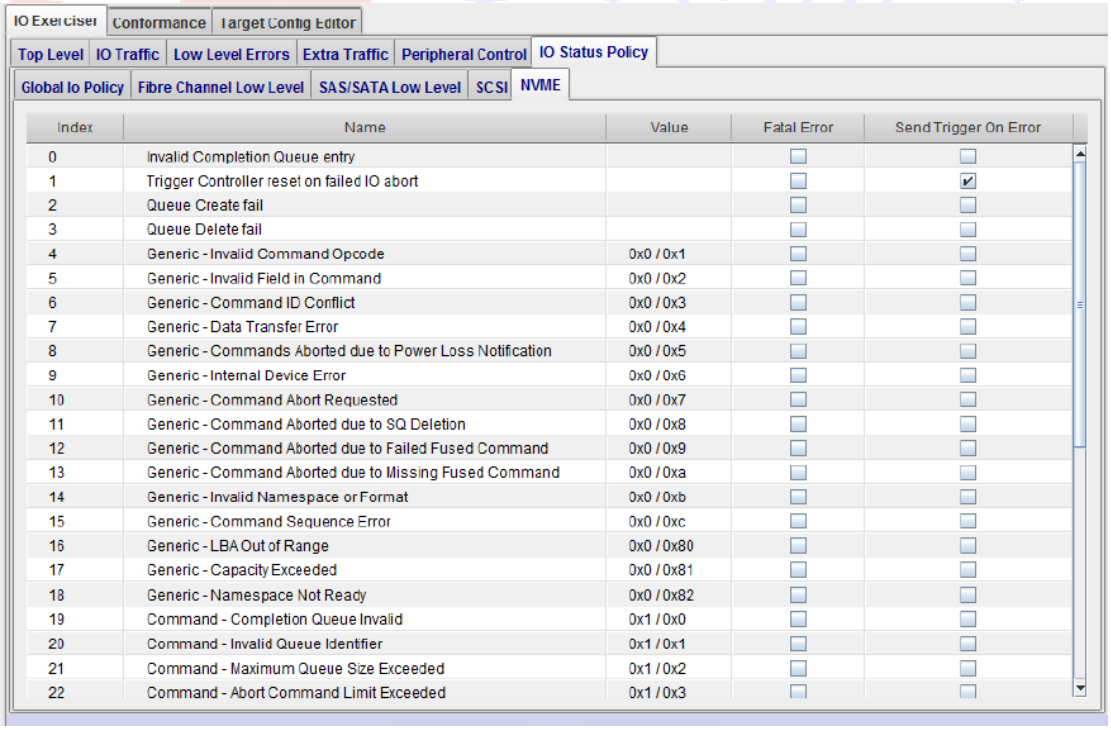
3.3.1.4.17注入客户自定义的任意 NVMe 命令



3.3.1.4.18控制外围热插拔以及电源模块进行测试

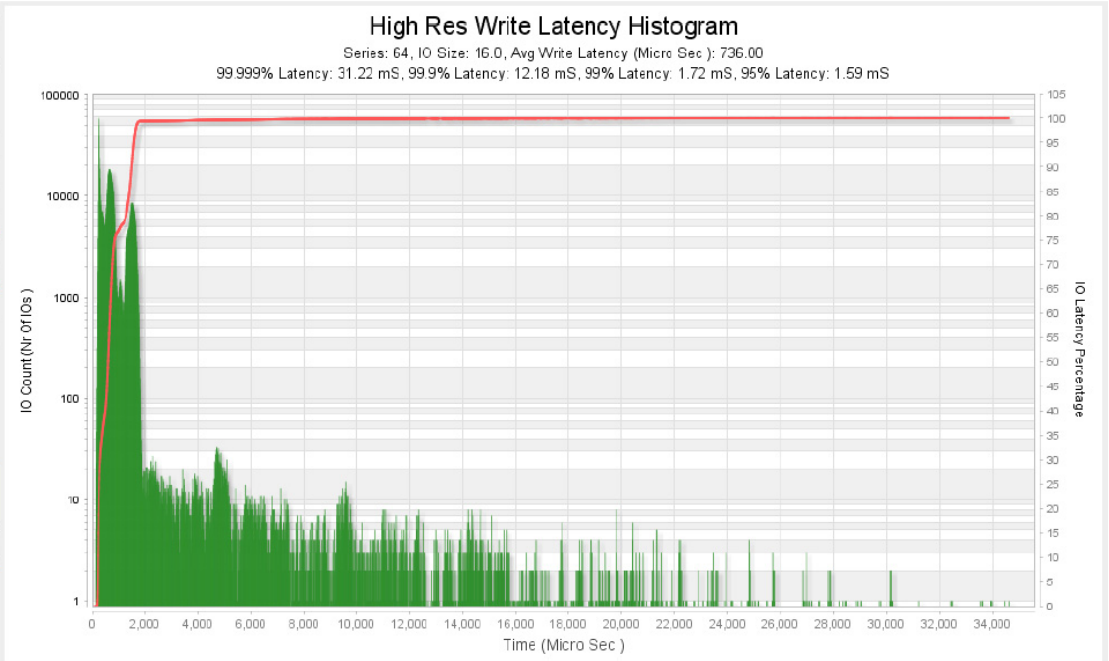


3.3.1.4.19NVMe 严重错误及触发条件设置

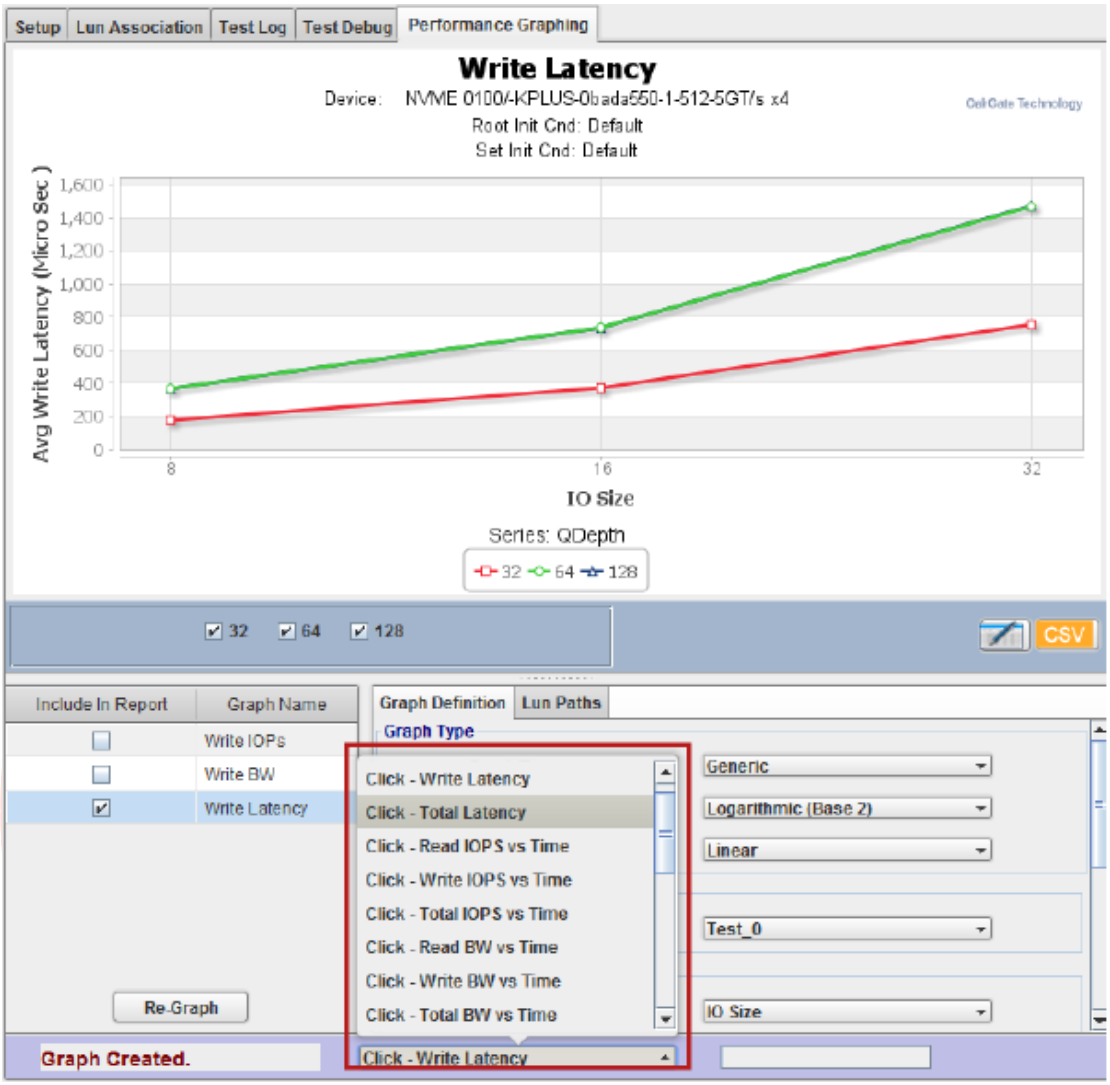


3.3.1.4.20读/写延迟统计图

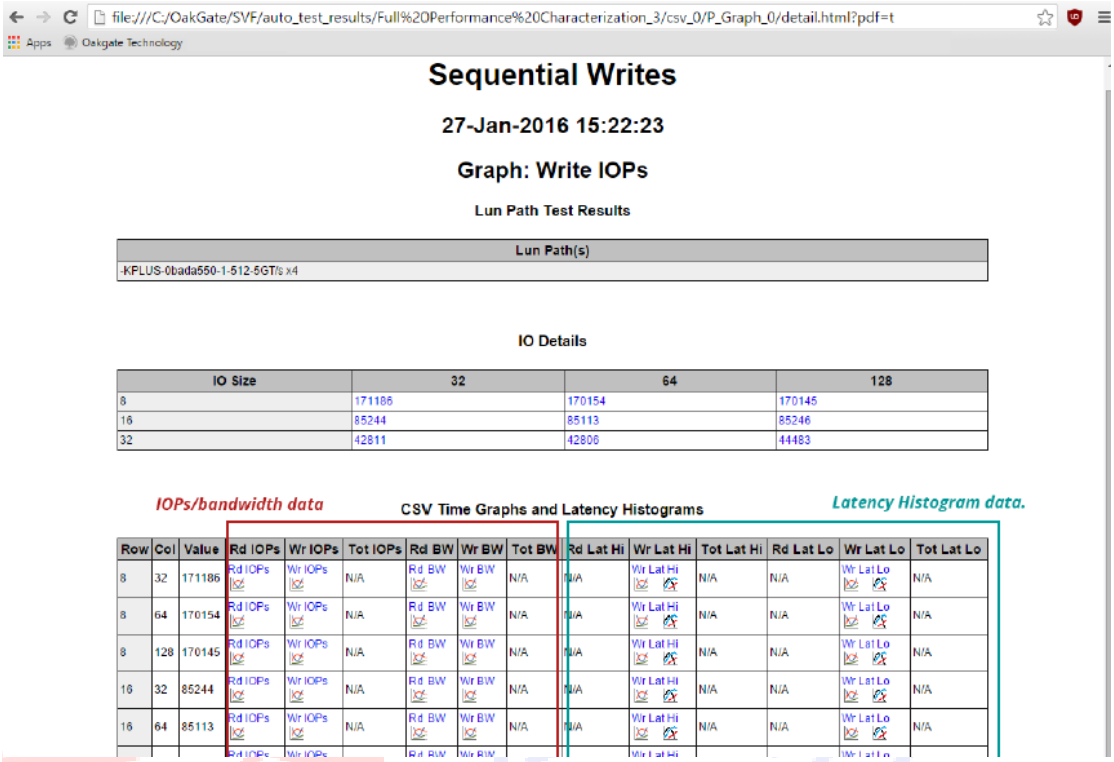
默认提供 99.999%, 99.9%, 99%, 95%等多个读/写的延迟时间的统计，参见下图。



3.3.1.4.21丰富的各种性能展现视图



3.3.1.4.22测试结果 Web 统计



file:///C:/OakGate/SVF/auto_test_results/Full%20Performance%20Characterization_3/csv_0/P_Graph_0/detail.html?pdf=t

Apps Oakgate Technology

Sequential Writes

27-Jan-2016 15:22:23

Graph: Write IOPs

Lun Path Test Results

Lun Path(s)
-KPLUS-0bada550-1-512-5GT/s x4

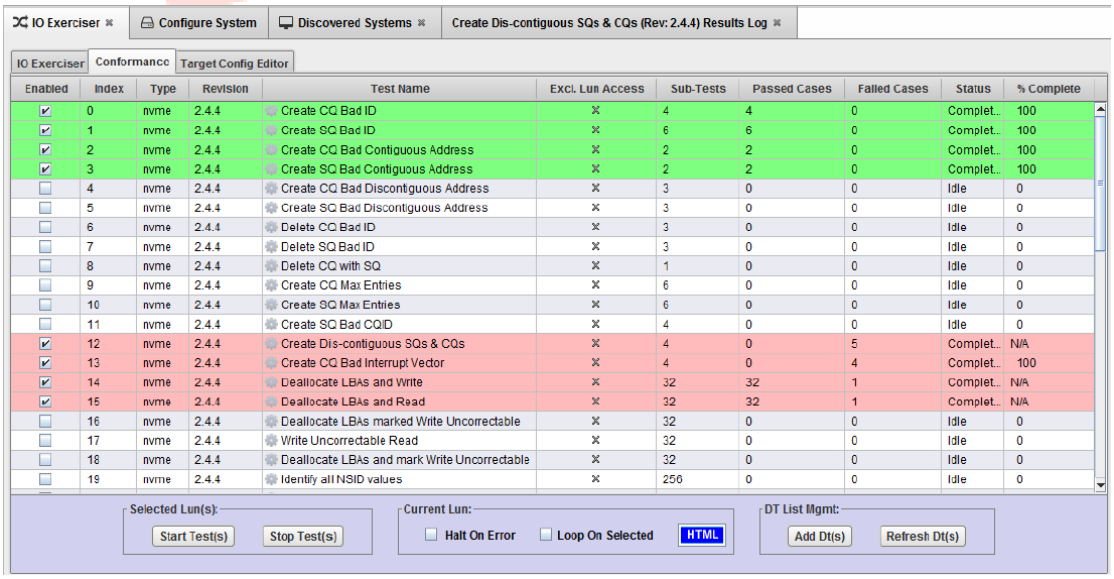
IO Details

IO Size	32	64	128
8	171186	170154	170145
16	85244	85113	85246
32	42811	42806	44483

IOPs/bandwidth data CSV Time Graphs and Latency Histograms *Latency Histogram data.*

Row	Col	Value	Rd IOPs	Wr IOPs	Tot IOPs	Rd BW	Wr BW	Tot BW	Rd Lat Hi	Wr Lat Hi	Tot Lat Hi	Rd Lat Lo	Wr Lat Lo	Tot Lat Lo
8	32	171186	Rd IOPs	Wr IOPs	N/A	Rd BW	Wr BW	N/A	N/A	Wr Lat Hi	N/A	N/A	Wr Lat Lo	N/A
8	64	170154	Rd IOPs	Wr IOPs	N/A	Rd BW	Wr BW	N/A	N/A	Wr Lat Hi	N/A	N/A	Wr Lat Lo	N/A
8	128	170145	Rd IOPs	Wr IOPs	N/A	Rd BW	Wr BW	N/A	N/A	Wr Lat Hi	N/A	N/A	Wr Lat Lo	N/A
16	32	85244	Rd IOPs	Wr IOPs	N/A	Rd BW	Wr BW	N/A	N/A	Wr Lat Hi	N/A	N/A	Wr Lat Lo	N/A
16	64	85113	Rd IOPs	Wr IOPs	N/A	Rd BW	Wr BW	N/A	N/A	Wr Lat Hi	N/A	N/A	Wr Lat Lo	N/A

3.3.1.4.23NVMe 协议兼容性测试



IO Exerciser | Configure System | Discovered Systems | Create Dis-contiguous SQs & CQs (Rev: 2.4.4) Results Log

IO Exerciser | Conformance | Target Config Editor

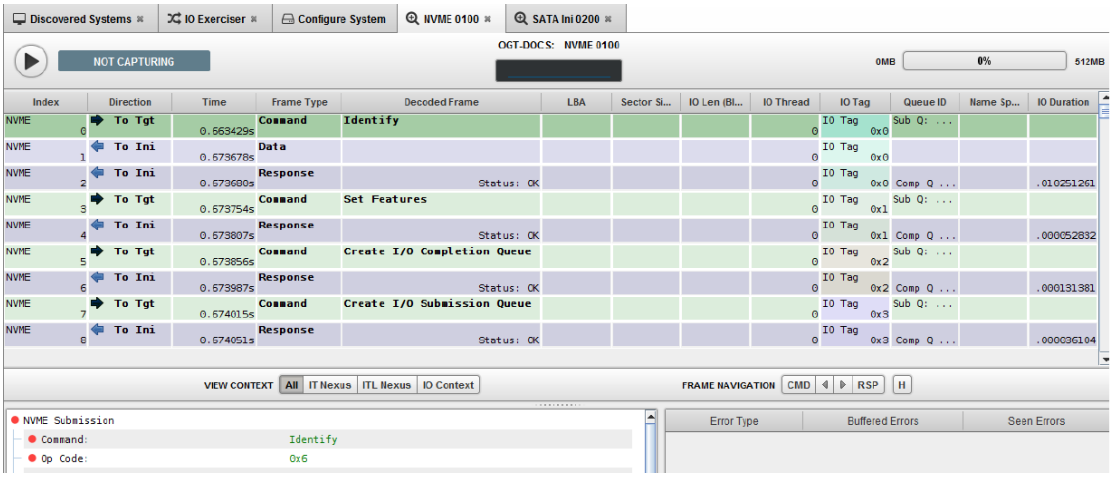
Enabled	Index	Type	Revision	Test Name	Excl. Lun Access	Sub-Tests	Passed Cases	Failed Cases	Status	% Complete
☑	0	nvme	2.4.4	Create CQ Bad ID	✕	4	4	0	Complet...	100
☑	1	nvme	2.4.4	Create SQ Bad ID	✕	6	6	0	Complet...	100
☑	2	nvme	2.4.4	Create CQ Bad Contiguous Address	✕	2	2	0	Complet...	100
☑	3	nvme	2.4.4	Create SQ Bad Contiguous Address	✕	2	2	0	Complet...	100
☐	4	nvme	2.4.4	Create CQ Bad Discontiguous Address	✕	3	0	0	Idle	0
☐	5	nvme	2.4.4	Create SQ Bad Discontiguous Address	✕	3	0	0	Idle	0
☐	6	nvme	2.4.4	Delete CQ Bad ID	✕	3	0	0	Idle	0
☐	7	nvme	2.4.4	Delete SQ Bad ID	✕	3	0	0	Idle	0
☐	8	nvme	2.4.4	Delete CQ with SQ	✕	1	0	0	Idle	0
☐	9	nvme	2.4.4	Create CQ Max Entries	✕	6	0	0	Idle	0
☐	10	nvme	2.4.4	Create SQ Max Entries	✕	6	0	0	Idle	0
☐	11	nvme	2.4.4	Create SQ Bad CQID	✕	4	0	0	Idle	0
☑	12	nvme	2.4.4	Create Dis-contiguous SQs & CQs	✕	4	0	5	Complet...	N/A
☑	13	nvme	2.4.4	Create CQ Bad Interrupt Vector	✕	4	0	4	Complet...	100
☑	14	nvme	2.4.4	Deallocate LBAs and Write	✕	32	32	1	Complet...	N/A
☑	15	nvme	2.4.4	Deallocate LBAs and Read	✕	32	32	1	Complet...	N/A
☐	16	nvme	2.4.4	Deallocate LBAs marked Write Uncorrectable	✕	32	0	0	Idle	0
☐	17	nvme	2.4.4	Write Uncorrectable Read	✕	32	0	0	Idle	0
☐	18	nvme	2.4.4	Deallocate LBAs and mark Write Uncorrectable	✕	32	0	0	Idle	0
☐	19	nvme	2.4.4	Identify all NSID values	✕	256	0	0	Idle	0

Selected Lun(s): Start Test(s) Stop Test(s)

Current Lun: Halt On Error Loop On Selected HTML

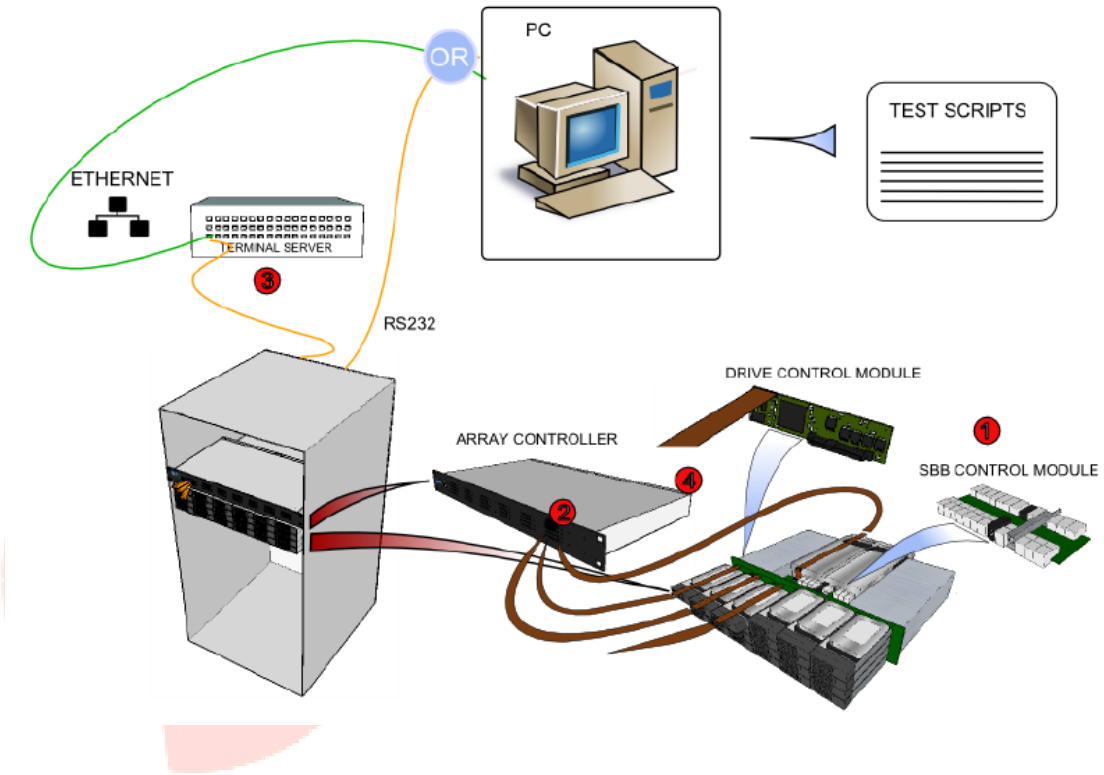
DT List Mgmt: Add Dt(s) Refresh Dt(s)

3.3.1.4.24协议分析功能



(四) SSD 热插拔自动化测试工具

4.1 热插拔自动化测试拓扑图



4.2 热插拔设备实际连接图

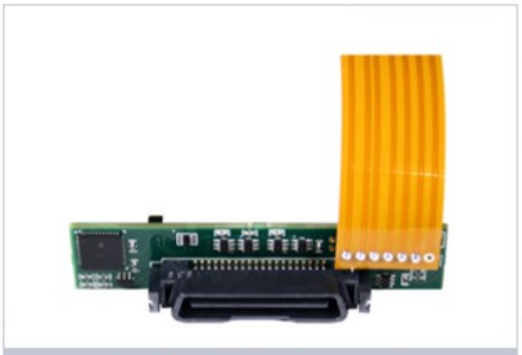
4.3 热插拔模块

目前提供针对 NVMe SSD (U.2, M.2, AIC 插卡)，12G SAS, 6G SAS, 6G SATA 等各种热插拔模块。

SAS/SATA 硬盘热插拔模块

6G SAS HS Drive Module

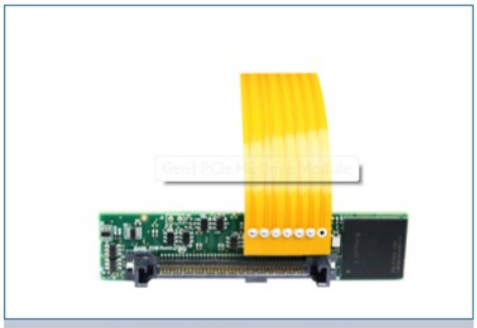
12G SAS HS Drive Module



SCA2-40 HS LITE Drive Module

NVMe SSD 热插拔模块

包括 2.5 NVMe SSD and M.2, Slot HOT PLUG MODULES

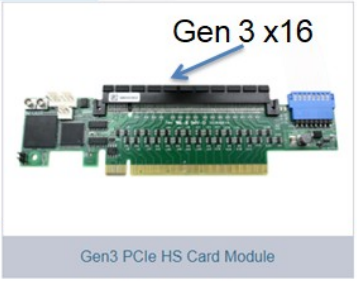


Gen3 PCIe HS Drive Module

M.2 M-Key Vertical Card Module

这些插卡不仅限于测试PCIe SSD卡，实际上可以测试任意的服务器PCIe插卡

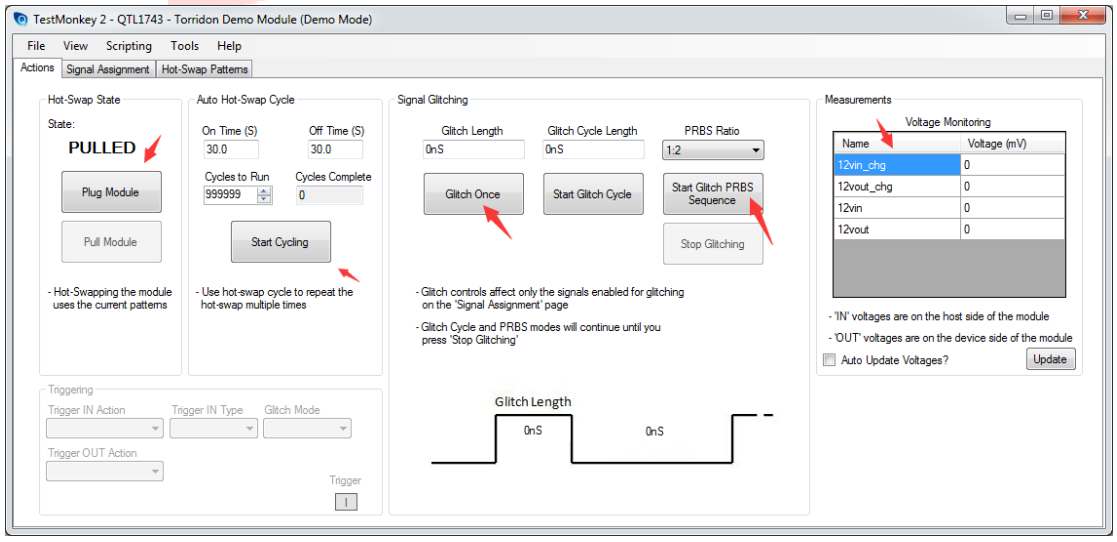
Gen3 x8 PCIe HS Card Module



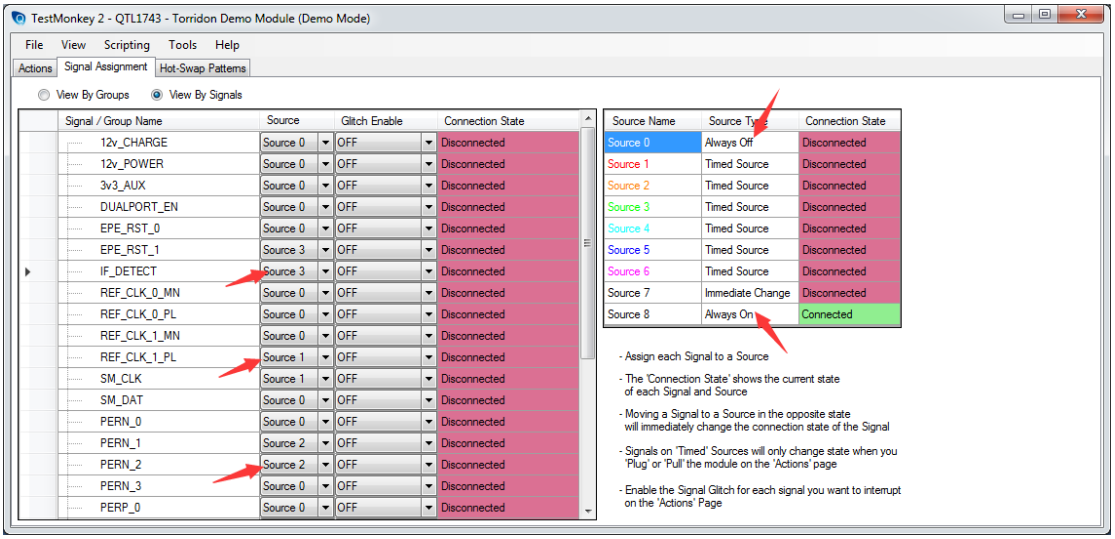
Gen3 PCIe HS Card Module

Gen4 PCIe HS Card Module

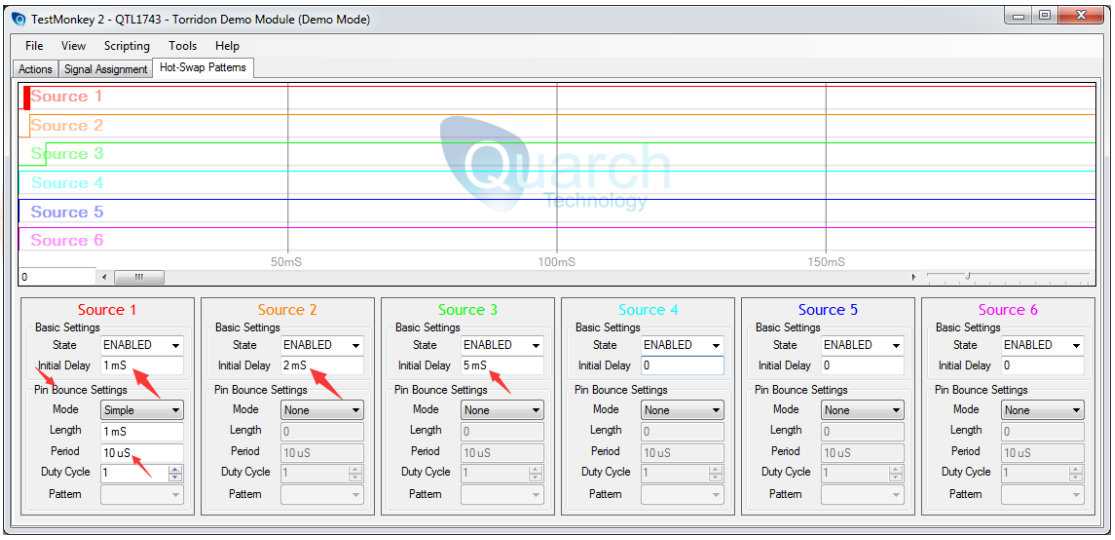
4.4 热插拔配置界面 – Test Monkey



该界面提供注入信号毛刺、测量电压等功能



上面的界面提供针脚分组，模拟某根针脚断了，某根针脚一直接触、以及设置哪些针脚需要导入信号毛刺。



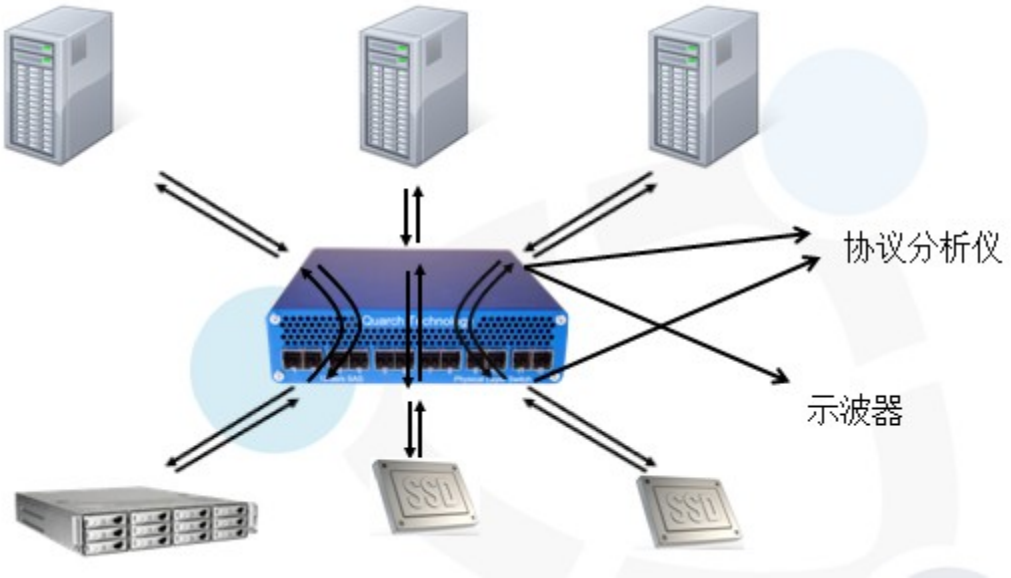
上面结面实现对于模拟针脚接入的顺序，以及针脚接入瞬间信号跳针现象，即时断时续的这种状态。

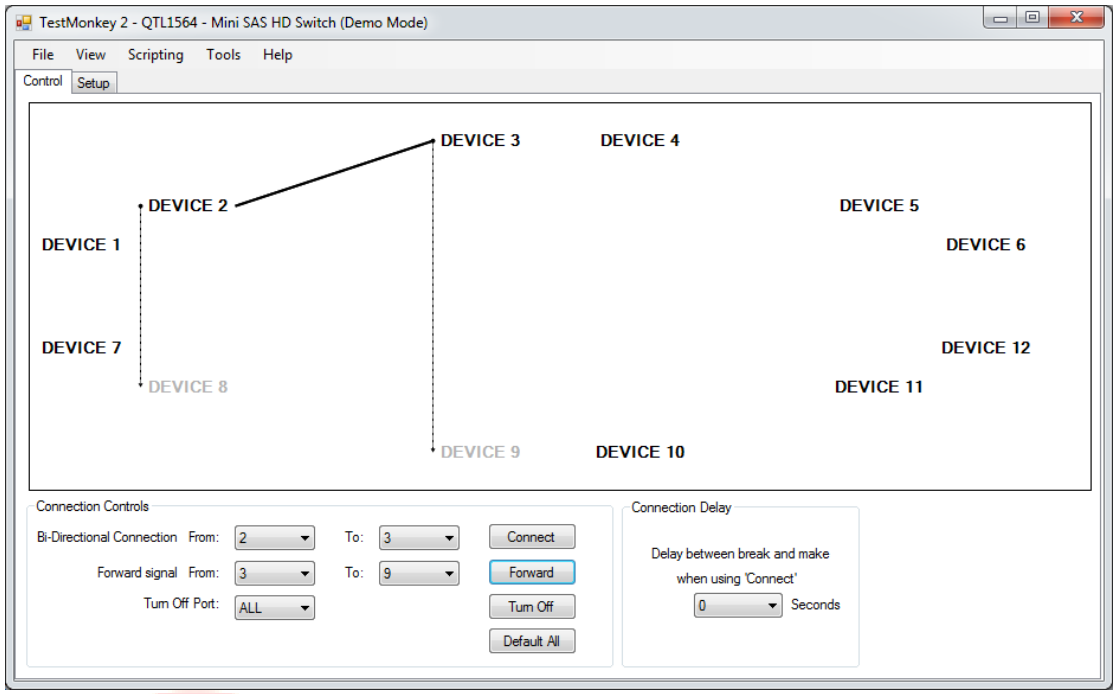
(五) SSD 拓扑切换自动化测试

5.1 SSD 拓扑自动切换设备

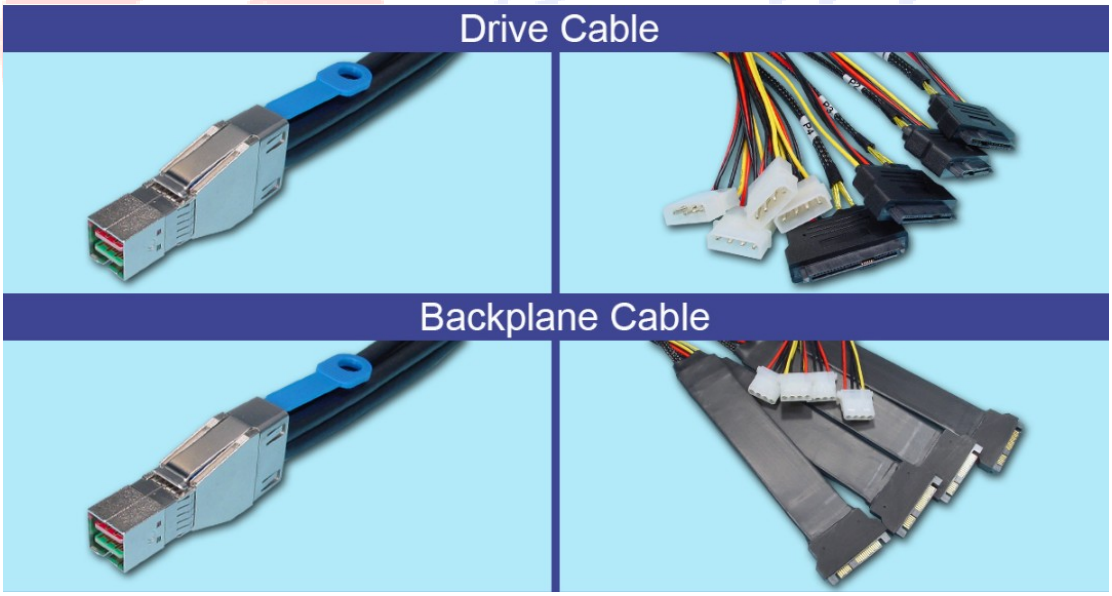
在 SSD 测试过程中，如果需要通过一台主机（或者多台主机）测试很多 SSD，那么经常需要进行手工切换链路，这样就无法通过脚本进行自动化测试。这种场景下面就需要进行主机-SSD 连接拓扑的自动切换。

5.1.1 12G SAS 信号切换交换机（12 口）



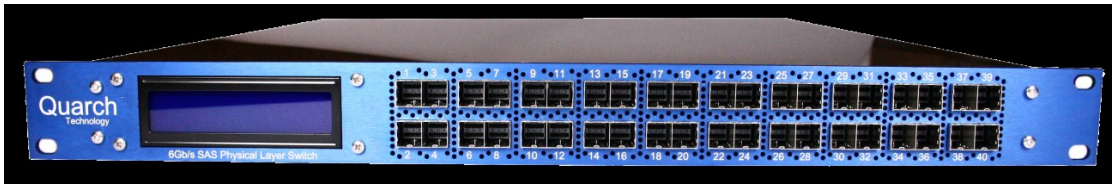


上面的界面可以实现信号切换，另外，也可以将双向信号导入示波器或者协议分析分析分析。



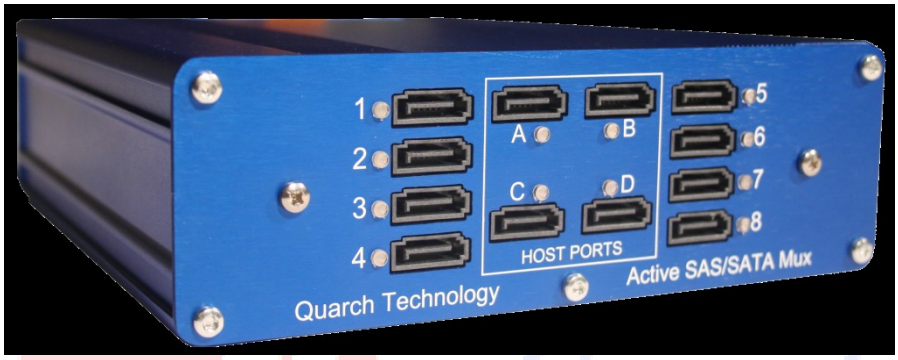
无论 12G，还是 6G SAS，如果面板为 MINI-SAS-HD 接口，那么需要通过上面的线缆实现和 SSD 的连接，这样就可以实现 initiator 和 target SSD 的切换。

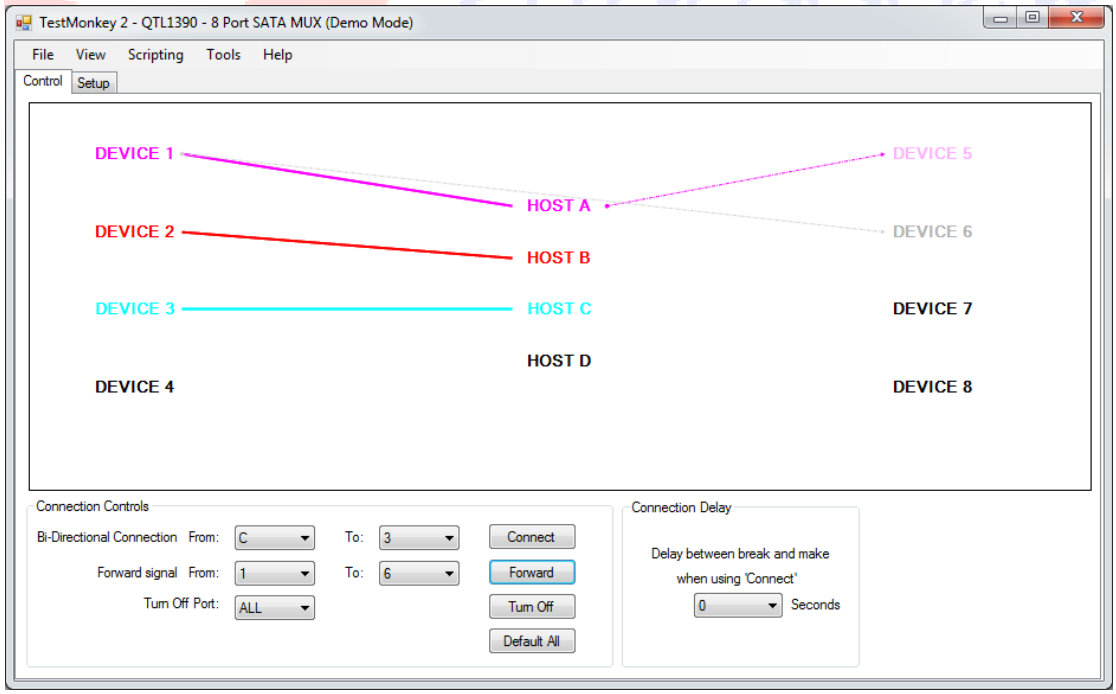
5.1.2 6G SAS/SATA 信号切换交换机（40 口）



需要转接线缆连接 SSD，参见 5.1.1 最后一张图片说明。

5.1.3 6G SAS/SATA 信号切换交换机（8 口）





**目前针对 PCIe NVMe SSD 进行自动拓扑切换的设备很快将发布。

5.2 SSD 链路自动通断测试

有的场景下 12G 或者 6G SAS SSD 是通过线缆连接主板或者背板，这个时候如果需要进行自动通断测试，需要在链路串接一个自动通断测试的工具，参见下面的图片。

说明：如果连接 12G SAS SSD 需要将 MINI-SAS-HD 转换成 2 个或者 4 个 SAS 母接口 Connector。参见 5.1.1 最后一张图片说明。

(六) SSD 电压拉偏和功耗测试工具

6.1 产品功能

Programmable Power Module – 专用于 SAS/SATA/NVMe SSD 测试的高分辨率可编程电源模块

XLC Programmable Power Module

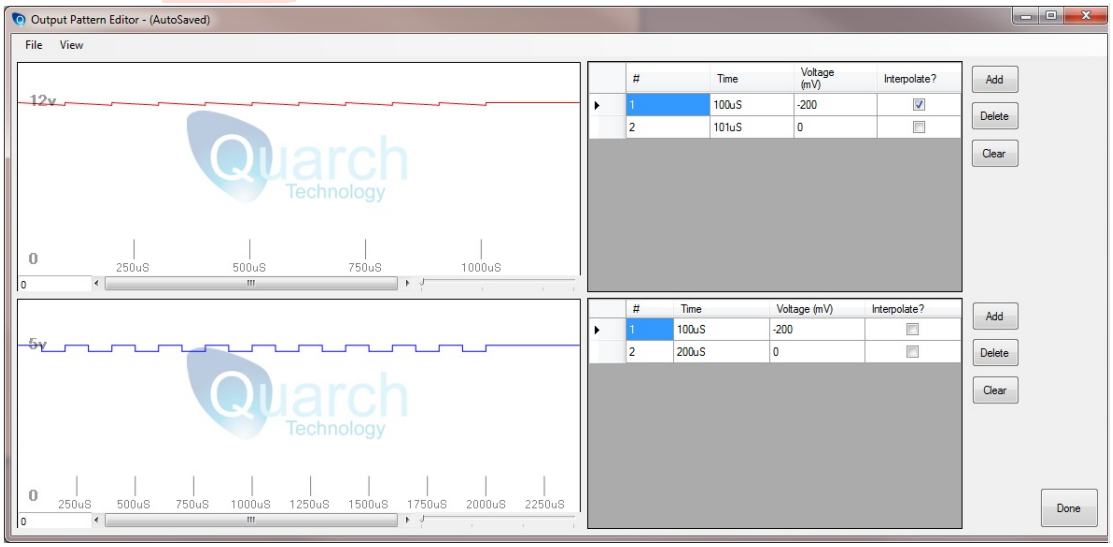
- 12V/5V or 12V/3.3V mode software selectable
- Custom Pattern Generator
- 250 KHz max sample rate
- Output Resolution: 4mV
- Measurement Resolution: 4mV, 25 uA
- Measurement Accuracy: ±(2uA + 2%) @ 100uA-1mA ±(2mA + 1%) @ 1mA-3000mA
- External trigger in/out
- Output Capacitance
- Pull Down

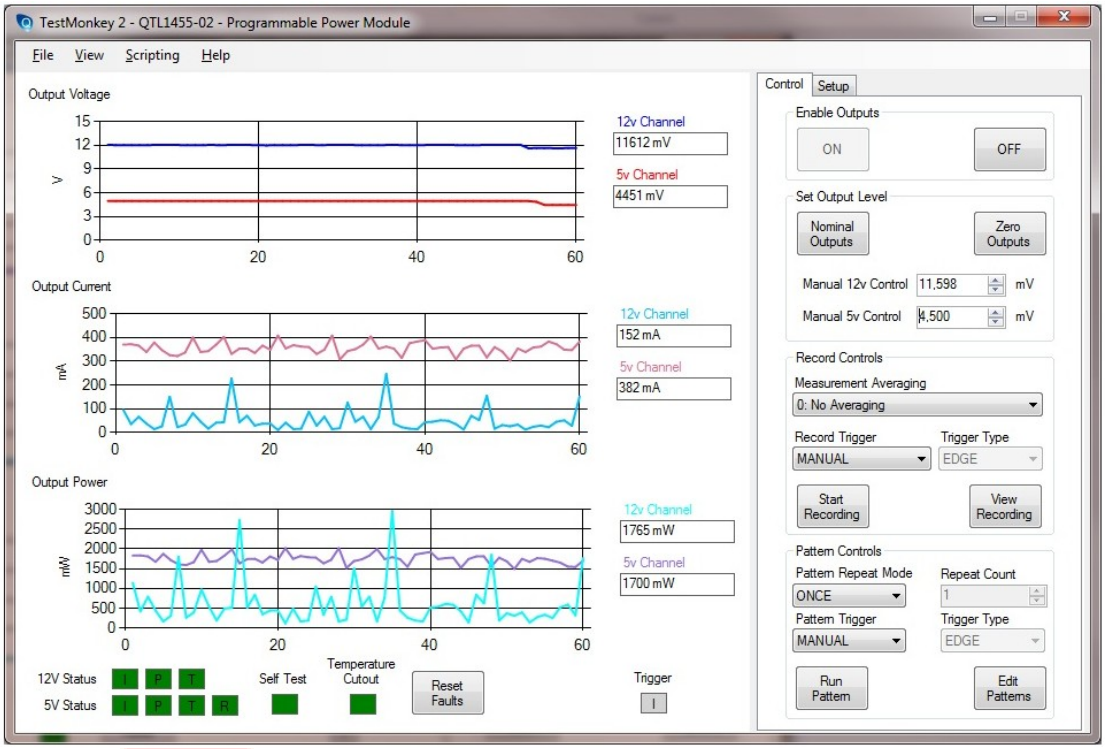
HD x6 Programmable Power Module

+ Support Quarch Power Studio

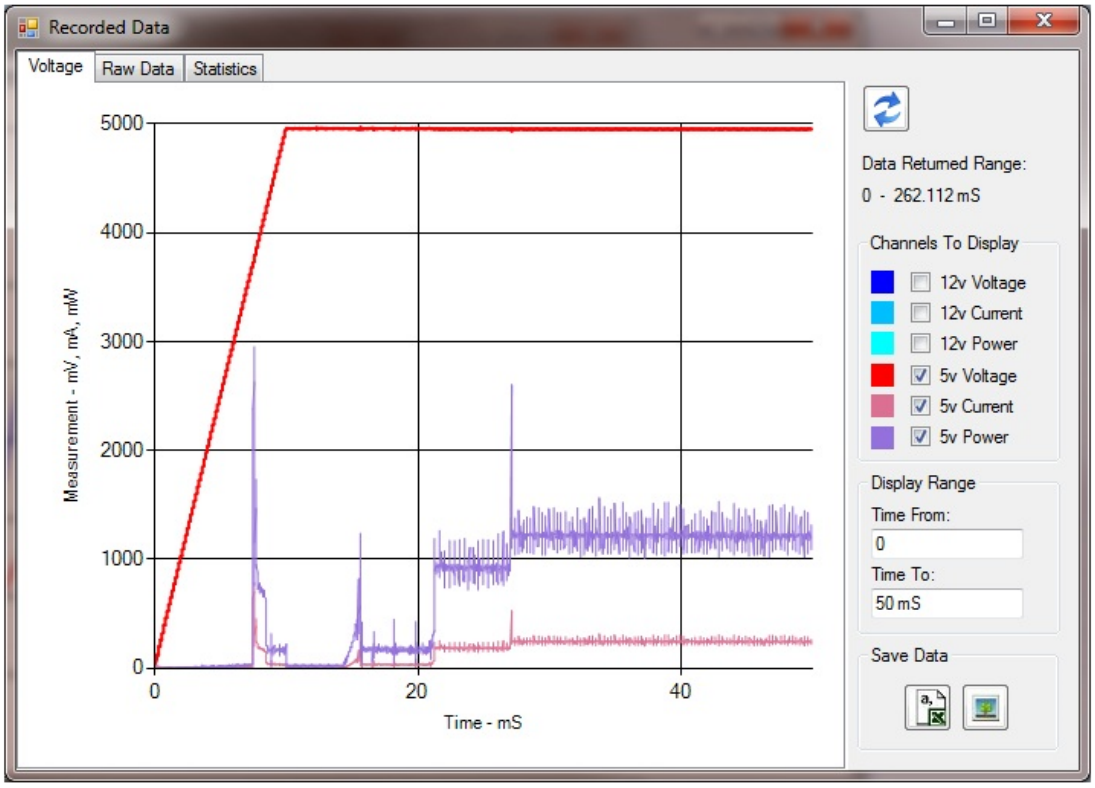
HD Programmable Power Module

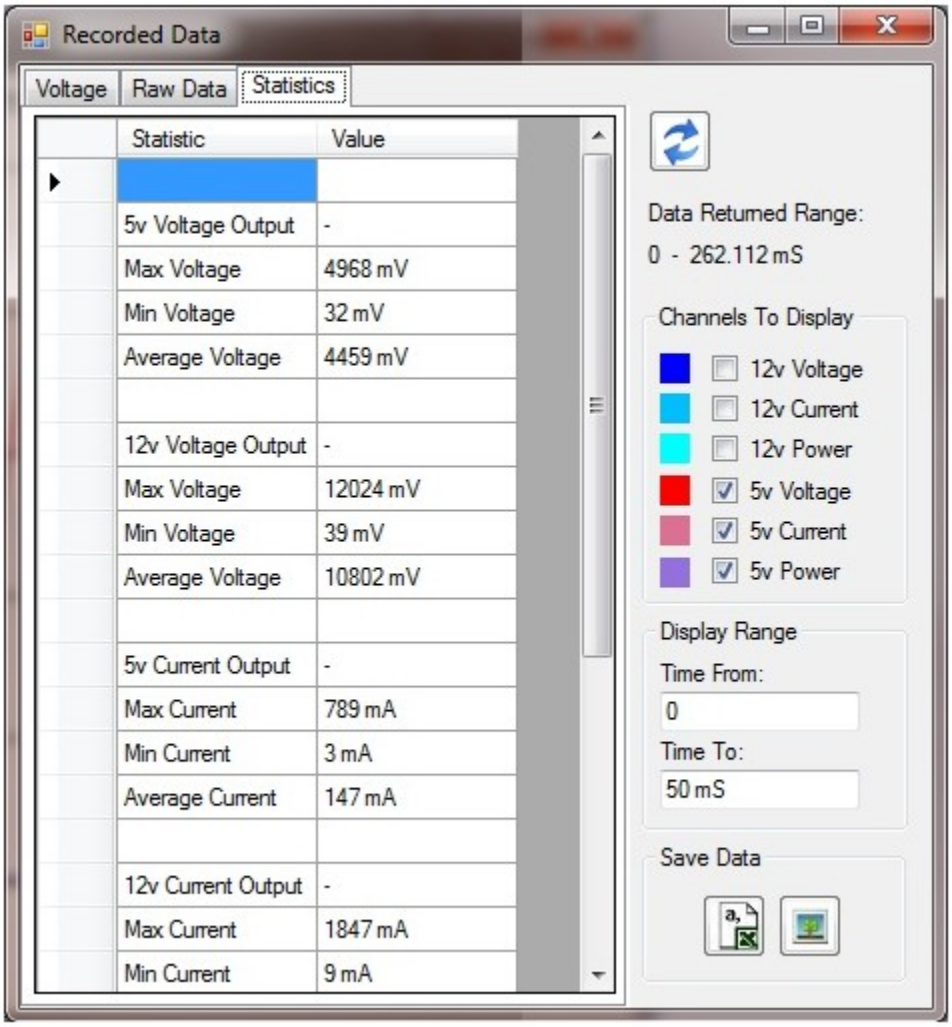
+ Support Quarch Power Studio





- Create programmable ramps, spikes, glitches, interruptions, ripple
- 1024 points per channel, 4mV/1uS resolution
- Step or ramp between points
- Single or Repeated patterns



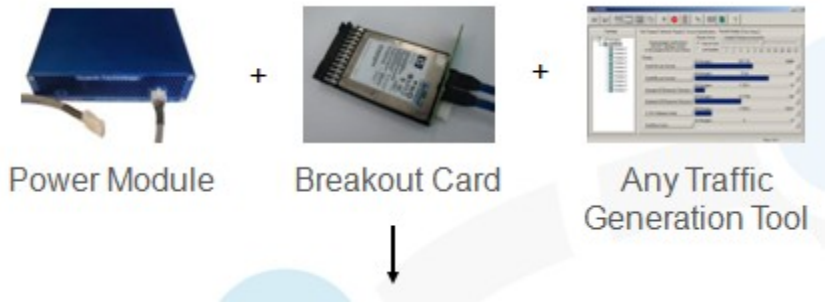


- Ensure your device can cope with voltage dips at any time
- XLC pull down option allows you to test hard shorts and similar failures

- External sense lines for accurate voltage measurement
- Max Sample rate 250KHz, simultaneous measurements of voltage & current
- Average up to 32k samples to filter noise or increase recording time:
    - XLC Modules: 350mS @ 0 Averaging; 190 minutes @ 32K Averaging
- Disable Channels for greater recording times and less data transfer
- Real time streaming modes to output measurements indefinitely

6.2 测试场景

6.2.1 测试场景一 – 线缆连接方式

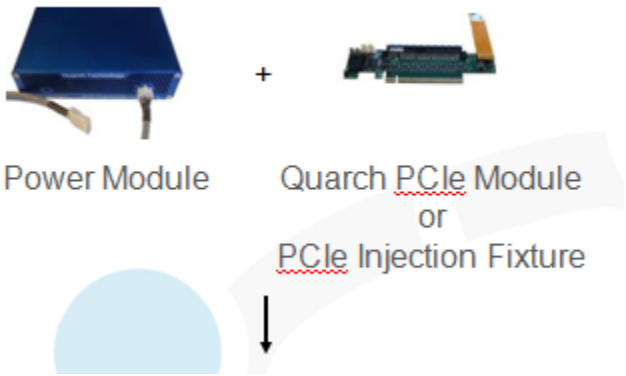


- Profile power consumption under different data loads
- Capture and chart power-on spikes
- Verify drive performance during Power Loss / Low Voltage / Noisy Power situations
- As used by MYCE.COM, the SSD Review and Tom's IT Pro for drive reviews

6.2.2 测试场景二 – 背板插入方式

- Margin or measure drive power in your application with no hardware modification required.
- Power is supplied from the Power Module via a thin flex cable. Host power is not used.
- Drive is offset by ~14mm

6.2.3 测试场景三 – PCIe SSD 卡方式



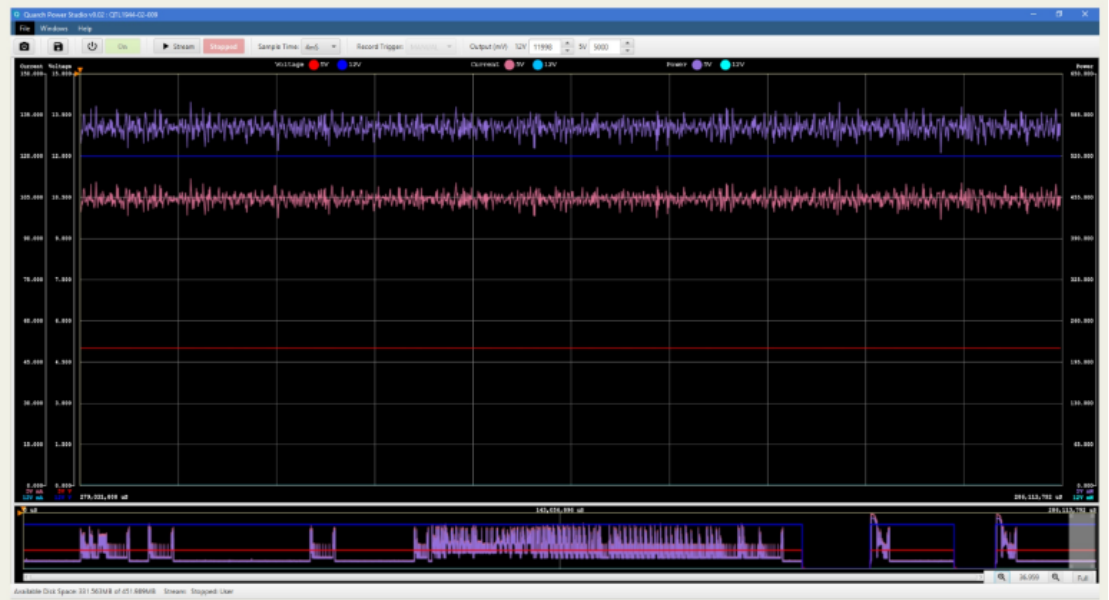
- Syncs with host voltages, to ensure correct power up
- Power margin and measure GEN3 PCIe devices

6.3 Quarch Power Studio 分析软件

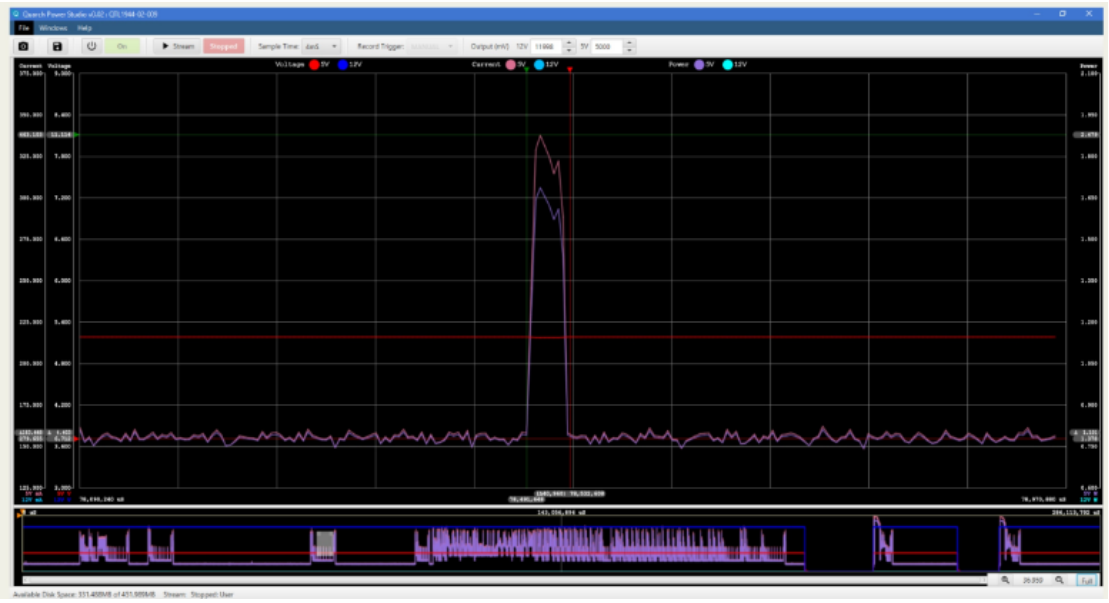
该软件适用于 HDing 型号的 PPM。

Zooming in on a power cycle within a longer trace

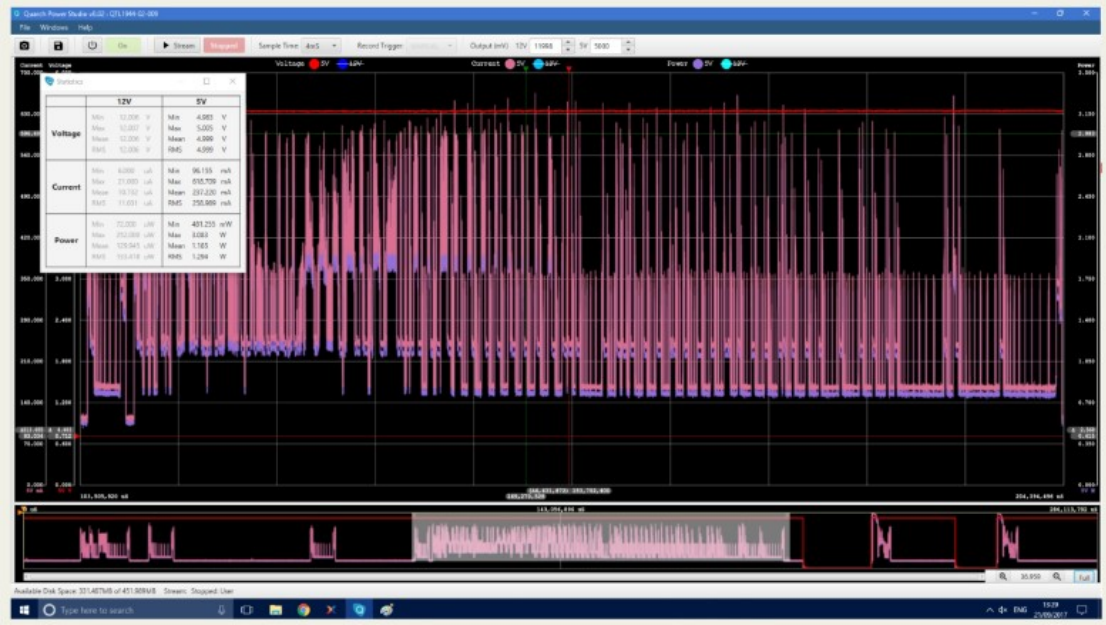
Live scope view of current performance



Extreme zoom in to a small power spike

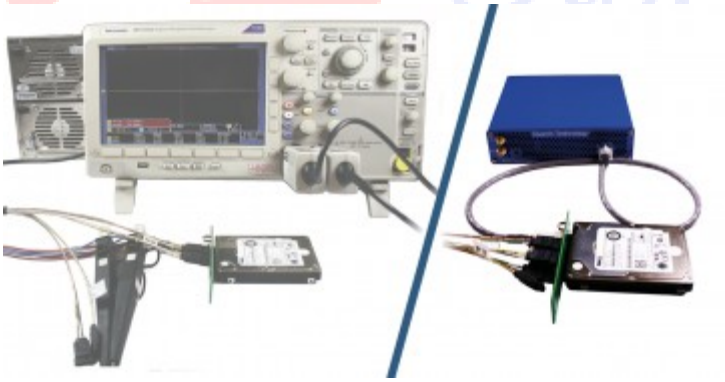


Max/Min/Mean/RMS statistics over a write operation



6.4 为什么不用万用表、示波器来测试 SSD 功耗？

Scope v Quarch PPMs – see the results



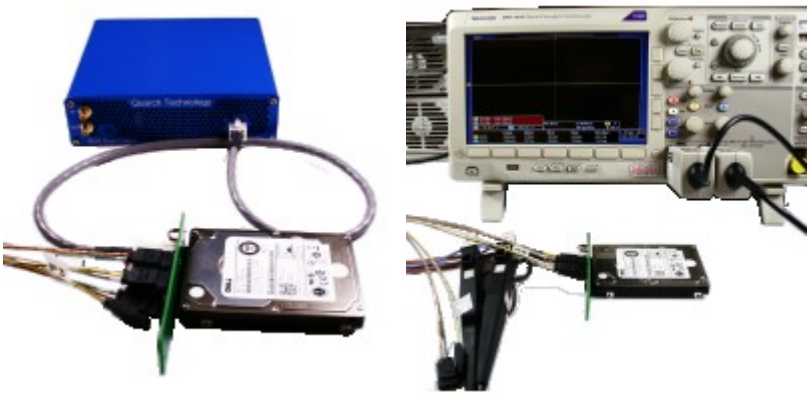
Power consumption is a critical factor in both the design and the purchase of storage devices. Yet it can be hard to measure, especially on an individual device.

Traditional methods using an oscilloscope and current probes can be effective but are expensive and hard to implement. A tool that's specifically designed for drive power testing will give you a much wider range of test options and is much easier to set up. The cost savings of using a purpose-built tool are significant too.

6.4.1 Comparison tests

To quantify the difference between using one popular traditional approach and using a purpose-built tool, Quarch set up two key test scenarios in the lab, using:

- A Quarch XLC Programmable Power Module (PPM), and
- A combination of a Tektronix DPO 3032 Oscilloscope and TCP0030 Current Probes.



Each of the above was used to measure:

- The average power use of an idle drive over 400 seconds
- Start-up current (the mean and RMS current for 20 seconds, beginning 2 seconds before drive start-up).

6.4.2 Comparison results

The results give a clear comparison of the accuracy and usability of each method.

Oscilloscopes excel at measuring fast signals but aren't specifically designed for measuring the currents relevant to storage devices. Set-up is complicated and it's difficult to obtain accurate results or record results for long durations of time.

Quarch power modules solve these problems. In addition, they supply power, allowing you to run a range of extra tests.

The availability of injection fixtures and USB, Serial and Ethernet control, with dedicated software, makes running tests both simple and cost-effective.

- Download the Programmable Power Module Vs Scope application note for the **full technical details** of the comparison tests and results.
- See below for a summary of the advantages of using Quarch power modules.

6.4.3 Why use a purpose-built tool?

One of the main benefits of using Quarch power modules is that they are *specifically designed* for testing storage devices. They are purpose-built to eliminate the problems associated with traditional testing methods – and therefore perform better.

Some of the various traditional multi-unit testing methods may have a few of the following features; the Quarch power module has *all* of these:

- **Quick, easy set-up** – specific power injection fixtures, for 2.5” drives, PCIe cards and M.2 devices, remove the hassle of clamping current probes in awkward places

- The ability to **run tests for long periods of time and continuously record power use** – ideal when running a drive workload simulation which may last for several hours or longer
- **Simple automation** – saving engineer time and making testing reliable, repeatable and fast
- **Low-current accuracy** – Quarch specify measurement down to 100uA, which is accurate at a far lower current than most other devices, and is ideal for measuring standby power
- **Fast sampling** – 250,000 samples per second, faster than a multi-meter or even many expensive Source Measure Units (SMUs)
- Full range, dual rail, power margining – create **fast slew-rate custom patterns**, from 0V to nominal +20%, allowing for ramps, glitches, brown-out and more, at 1uS resolution
- **External triggering** – allowing synchronization with third-party equipment (analyzers and similar).

6.4.4 Cost-saving implications

Two types of cost saving are achievable using the Quarch power module set-up:

1. **Purchase price:** for example, the total cost of the oscilloscope plus probes set-up used in the comparison tests was approximately three times that of a Quarch XLC Programmable Power Module.
2. Significant **time-savings in the testing process**, meaning you get your new storage products to market quicker and save on engineering time, leaving your engineers free to focus on designing the next generation of your company's products.

"Our readers need accurate, comprehensive information about the properties of the drives they buy, so we use Quarch's power modules to test drive power performance for our SSD reviews. Our testing process is much easier – and even more accurate – since we introduced the Quarch modules, making our SSD reviews even more relevant for our readers."

Gustav Gager, Nordic Hardware (the largest test lab in Sweden)

(七) SSD 盘 NAND FLASH 测试工具

7.1 NPLUST - NAND FLASH TEST EXPERT

7.1.1 History

NplusT was created in December 2002 by Tamás Kerekes' 20-years experience in the field of electrical semiconductors and reliability testing.The company started with the sales representation of semiconductor equipment and consumable suppliers. In the meantime, qualified engineering services, linked to the represented products, were provided in Europe.In 2003 NplusT started to market "RIFLE", the non-volatile memory engineering tester, and related services. In a few years, this product has become a reference platform for many memory makers.In 2005 Liliom Laboratories, a Hungarian software development company, merged into NplusT. Thanks to this operation, the company became leader in the test data collection and processing segment.From 2008 a dominant portion of NplusT"s turn-over derived from licensing software products. Today almost every European along with several Far East semicon companies license our software products and make use of qualified engineering services.From 2011, NplusT provides turn-key solutions for device testing and characterization, including hardware, software and support.

7.1.2 Focus

The semiconductor industry has had an aggressive growth in the past dozens of years and this trend is supposed to continue. Due to the increasing competition, semicon companies have to face huge investments. Fast and efficient return can be obtained only by optimal equipment utilization together with fast time-to-market of new products. This is more than ever true in the testing, which has become one of the dominant cost drivers in manufacturing. NplusT supports semicon companies by providing:

- testing tools for speeding up technology and product development;
- data collection and processing tools for the efficient data management, crucial for taking right technical and economic decisions;
- software tools to enhance the test development process;
- consultancy services and dedicated solutions for optimizing the testing process.

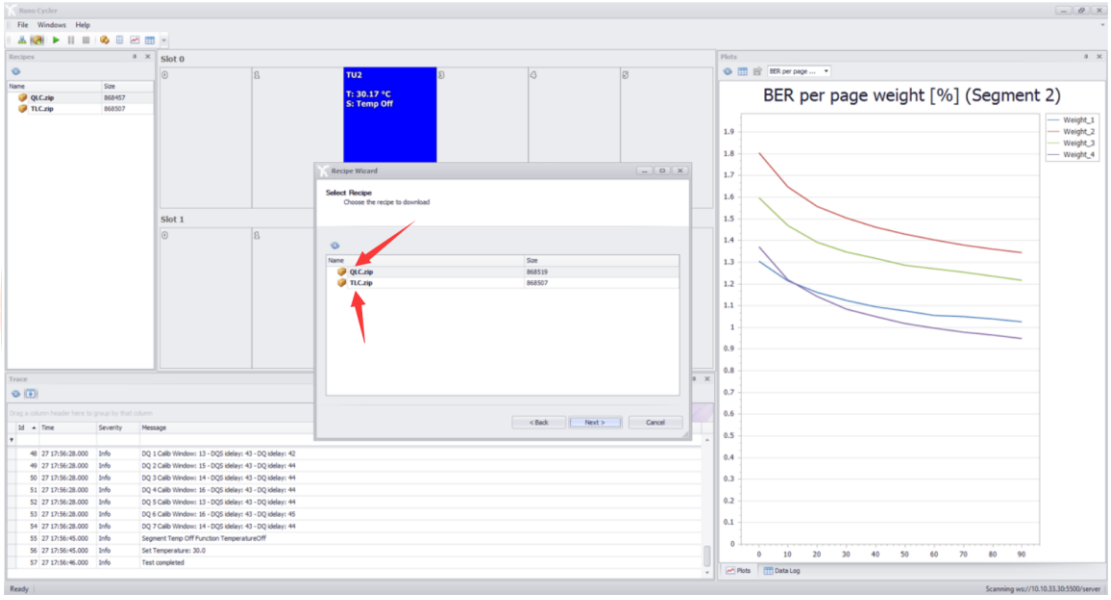
7.1.3 NplusT Testing Services

Its testing services are being used in:

- technology development;
- device characterization;
- product qualification;
- production testing, low cost parallel testing;
- burn-in, test during burn-in.

7.1.4 NanoCycler - NVM Performance and Reliability Analyzer

Understand to Optimize Your Solid State Storage



Features

• Straightforward management
- Easy test setup supported by a large set of built-in experiments
- Integrated data collection
- Desktop installation
• Large number of independent experiments in parallel
- Per package thermal control
- Independent test per package
- Available in 1, 6, 12, 24 and 48 package configurations
• ONFI Compatible

- BGA-152 and BGA-132 packages
- Dual-channel multi-die testing
- Up to 400 MT/sec

7.1.5 RIFLE Tester Platform for Every NVM

RIFLE has been designed for obtaining fast and reliable results in non-volatile memory technology and product development. Created by Active Technologies principally for research activities and supported by NplusT in industrial applications, RIFLE became a world-wide reference for the segment.
The flexible architecture, powerful analog resources and the true-interactive-testing concept make a difference over the competition, which focus on mass production. The best cost-performance ratio and the lack of need of lab facilities allow the “per-engineer” installation.

RIFLE is used today for testing and characterizing almost all NVM technologies and product interfaces:

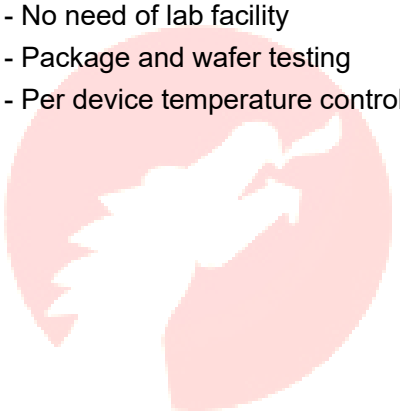
- Single cell, test arrays, products,
- NAND, NOR, NROM, PCM, eFlash, RRAM technologies,
- Single-level and multi-level cells,
- Parallel, multiplexed, serial, JTAG and custom interfaces;

in a wide range of applications:

- Package and wafer level.
- Technology and product development.
- Failure analysis.

Features

• Optimized for NVM Testing
- 100MHz arbitrary waveform generators
- 70Msample/sec accurate cell current measurement
- Full synchronization between digital sequencer, waveform generators and PMU
• Protocol-Based Approach
- Programmable communication protocol
- Increased visibility through algorithmic device management
• Software Environment for Engineering Usage
- True interactive testing
- Easy-to-use IDE for test creation and debug
- Natively integrated on-the-fly data analysis
• Desktop installation
- Small footprint
- No need of lab facility
- Package and wafer testing
- Per device temperature control



(八) SSD Test Chamber 测试温箱

8.1 国外进口 SSD 测试专用温箱

8.1.1 Oakgate 测试温箱 （Daichu）- EPIC Testers

OakGate has partnered with Daichu Technologies to provide a series of versatile and high-performance turnkey testers that enable customers to exercise the power of the OakGate software in reliability and manufacturing environments for NVMe, SAS, and SATA SSDs.

These Epic Testers are powered by OakGate's Greenlight Manufacturing Test Application and Storage Validation Framework (SVF) software, the industry’s most advanced storage testing software. This robust software, now in its third generation, offers a comprehensive set of testing features and capabilities.

8.1.1.1 Epic 10-Slot PCIe/NVMe SSD Tester

-5 to +90°C
(OGT-EPIC-10C0)

Features

- 10 PCIe Gen3 x8 lane slots
- Supports up to 10 PCIe edge cards
  - U.2/SFF-8639 (single or dual-port) and M.2 devices supported with attachments
- Driven by SVF Pro/Greenlight software
- Comprehensive functionality, including long-run testing, aging test, low/high temperature test, and marginal voltage testing.

Specifications

- Temperature Range: -5°C to +90°C
- Airflow: Adjustable 700 to 1500 LFM to each device
- Dimensions of chassis: 600 mm (W) × 700 mm (D) × 1500 mm (H)
- Weight: 250kg (551.1 lbs)

EPIC-10C0 Tester Brochure

8.1.1.2 Epic 10-Slot PCIe/NVMe SSD Tester

Room+10 to +90°C
(OGT-EPIC-10C1)

Features

- 10 PCIe Gen3 x8 lane slots
- Supports up to 10 PCIe edge cards
  - U.2/SFF-8639 (single or dual-port) and M.2 devices supported with attachments
- Driven by SVF Pro/Greenlight software
- Comprehensive functionality, including long-run testing, aging test, low/high temperature test, and marginal voltage testing.

Specifications

- Temperature Range: Room+10°C to +90°C
- Airflow: Adjustable 500 to 1500 LFM to each device
- Dimensions of chassis: 500 mm (W) × 690 mm (D) × 1575 mm (H)
- Weight: 150kg (330.7 lbs)

EPIC-10C1 Tester Brochure

8.1.1.3 Epic 10-Slot PCIe/NVMe SSD Tester

-40°C to +90°C
(OGT-EPIC-10C4)

Features

- 10 PCIe Gen3 x8 lane slots
- Supports up to 10 PCIe edge cards
  - U.2/SFF-8639 (single or dual-port) and M.2 devices supported with attachments
- Driven by SVF Pro/Greenlight software
- Comprehensive functionality, including long-run testing, aging test, low/high temperature test, and marginal voltage testing.

Specifications

- Temperature Range: -40°C to +90°C
- Airflow: Adjustable 500 to 1700 LFM to each device
- Dimensions of chassis: 850mm (W)x 1200mm (D) x 1800mm(H)
- Weight: 300kg (661.39 lbs)

EPIC-10C4 Tester Brochure

8.1.1.4 Epic 60-Slot PCIe/NVMe SSD Tester

-40 to +90°C
(OGT-EPIC-60C4)

Features

- 60 PCIe Gen3 x8 lane slots
- Supports up to 10 PCIe edge cards
  - U.2/SFF-8639 (single or dual-port) and M.2 devices supported with attachments
- Driven by SVF Pro/Greenlight software
- Comprehensive functionality, including long-run testing, aging test, low/high temperature test, and marginal voltage testing.

Specifications

- Temperature Range: -40°C to +90°C
- Airflow: Adjustable 500 to 1500 LFM to each device
- Dimensions of chassis: 1300 mm (W) × 1450 mm (D) × 2050 mm (H)
- Weight: 1100kg (2425.1 lbs)

EPIC-60C4 Tester Brochure

8.1.1.5 Epic 64-Slot SAS/SATA SSD Tester

-40 to +90°C
(OGT-EPIC-64C4S)

Features

- 64 SAS/SATA slots

- Supports up to 64 SAS 12G / SATA 3.0 U.2/SFF-8639 type SSDs
- Comprehensive functionality, including long-run testing, aging test, low/high temperature test, and marginal voltage testing.

Specifications

- Temperature Range: -40°C to +90°C
- Airflow: Adjustable 700 to 1500 LFM to each device
- Dimensions of chassis: 1500 mm (W) × 1480 mm (D) × 2050 mm (H)
- Weight: 1300kg (2866.0 lbs)

EPIC-64C4S Tester Brochure

8.1.1.6 Epic 120-Slot PCIe/NVMe SSD Tester

-5 to +90°C
(OGT-EPIC-120C0)

Features

- 120 PCIe Gen3 x8 lane slots
- Supports up to 120 PCIe edge cards
  - U.2/SFF-8639 (single or dual-port) and M.2 devices supported with attachments
- Driven by SVF Pro/Greenlight software

- Comprehensive functionality, including long-run testing, aging test, low/high temperature test, and marginal voltage testing.

Specifications

- Temperature Range: -5°C to +90°C
- Airflow: Adjustable 700 to 1700 LFM to each device
- Dimensions of chassis: 1500 mm (W) × 1400 mm (D) × 2050 mm (H)
- Weight: 1300kg (2866.0 lbs)

EPIC-120C0 Tester Brochure

8.1.1.7 Epic 128-Slot SAS/SATA SSD Tester

-5 to +90°C
(OGT-EPIC-128C0S)

Features

- 128 SAS/SATA slots
- Supports up to 128 SAS 12G / SATA 3.0 U.2/SFF-8639 type SSDs
- Driven by SVF Pro/Greenlight software
- Comprehensive functionality, including long-run testing, aging test, low/high temperature test, and marginal voltage testing.

Specifications

- Temperature Range: -5°C to +90°C
- Airflow: Adjustable 700 to 1500 LFM to each device
- Dimensions of chassis: 1500 mm (W) × 1480 mm (D) × 2050 mm (H)
- Weight: 1300kg (2866.0 lbs)

EPIC-128C0S Tester Brochure

8.1.2 Ardent Storage 测试温箱

8.1.2.1 环境测试平台 P80000/P40000

P80000 - PCIe/NVMe Burn-In tester

Key Features:

- P80000: 80 port, P40000: 40 port (optional dual port available)
- PCIe-Gen3 4 lanes per port (gen3 2 lanes for dual port tester)
- Support Gen1, Gen2, Gen3 auto select or manual select
- Exchangeable loader adapter technology
  - [default] 2.5" SFF8639 (HDD/SSD form factor) adapter
  - [optional] PCIe-edge card adapter
  - [optional] M.2 card adapter

- PMU (Power Management Unit) – programmable via USB or Ethernet
  - Drive insertion detection circuitry
  - Power on/off control, LED control
- WEB based GUI control SW
- Customized UART connectivity
- Temperature control up to 70C

P40000 - PCIe/NVMe Test Chamber

Key Features:

- P40000: 40 port (optional dual port available)
- PCIe-Gen3 4 lanes per port (gen3 2 lanes for dual port tester)
- Support Gen1, Gen2, Gen3 auto select or manual select
- Exchangeable loader adapter technology
  - [default] 2.5" SFF8639 (HDD/SSD form factor) adapter
  - [optional] PCIe-edge card adapter
  - [optional] M.2 card adapter

- PMU (Power Management Unit) – programmable via USB or Ethernet
  - Drive insertion detection circuitry
  - Power on/off control, LED control
- WEB based GUI control SW
- Customized UART connectivity
- Temperature control up to 70C

8.1.2.2 老化测试平台 BI120A/BI-003

BI-120A

BI-003

8.1.2.3 桌面测试平台 BI-003/P8100/P12000

BI-003

READ MORE

P8100

READ MORE

P12000

8.2 国产智能通用测试温箱 - SSDIST

控制方式与特色

平衡调温调湿BTC控制系统,以PID 方式控制SSR,使系统之加热湿量等于热湿损耗量,故能长期稳定的使用.

A:性能:指气冷式在室温20℃,空载时:
1.温度范围: -70℃~+150℃
2.湿度范围: 20%~98%
3.温度稳定度: ±0.2℃
4.湿度稳定度: ±0.5%
5.温度分布均度: ±2℃
6.湿度分布均度: ±3%
7.温度最低极限: -73℃
8.升温时间: 由-60℃升至100℃约需40 分钟
9.降温时间: 由20℃降至-60约需70 分钟

(九) SSD 业界协会组织

9.1 University of New Hampshire InterOperability Laboratory

The **University of New Hampshire InterOperability Laboratory** (**UNH-IOL**) is an independent test facility that provides interoperability and standards conformance testing for networking, telecommunications, data storage, and consumer technology products.

Founded in 1988, it employs approximately 25 full-time staff members and over 100 part-time undergraduate and graduate students, and counts over 150 companies as members.

9.1.1 Mission

To provide a neutral environment to foster multi-vendor interoperability, conformance to standards, and improvement of data networking while attracting students to, and educating them for, future employment in cutting-edge technologies.

9.1.2 History

The UNH-IOL began as a project of the University's Research Computing Center (RCC). In 1988 the RCC was testing Fiber Distributed Data Interface (FDDI) equipment with the intention of deploying it in its network. The RCC found that equipment from two vendors did not work together and contacted the vendors to find a solution. The two vendors cooperated with the RCC to solve the problem which was caused by differences between the draft and final FDDI specification. During this same time period the RCC was testing 10BASE-T Ethernet interfaces for another project.

The University recognized the need for interoperability testing of networking equipment and also the opportunity to provide students with hands-on experience in emerging technologies. With the idea of providing testing services to companies in a vendor-neutral environment the first UNH-IOL consortium (10BASE-T Ethernet) was founded in 1990.[4]

Over the next decade the UNH-IOL grew to twelve consortia with over 100 member companies. In 2002, having outgrown several smaller locations, the UNH-IOL moved to a 32,000 square foot facility on the outskirts of the UNH campus.

One area in which the UNH-IOL has been influential is IPv6 standardization and deployment. Between 2003 and 2007 the UNH-IOL organized the Moonv6 project, which was a multi-site, IPv6 based network designed to test the interoperability of IPv6 implementations. At the time the Moonv6 project was the largest permanently deployed multi-vendor IPv6 network in the world. The UNH-IOL is also the only North American laboratory offering ISO/IEC 17025 accredited testing designed specifically for the USGv6 Test Program.

The UNH-IOL is also known for organizing and hosting plugfests for a number of industry trade organizations. The lab has hosted plugests for the Broadband Forum NVM Express, SCSI Trade Association, Ethernet Alliance, and the Open Compute Project, among others.

In 2013 the UNH-IOL was awarded the IEEE-SA Corporate Award "for outstanding corporate leadership and contribution to IEEE-SA".

In January 2016 the lab moved to a new 28,000 square foot location adjacent to the main UNH campus in Durham, NH.

9.1.3 Consortia

The UNH-IOL operates testing programs on an annual membership basis called consortia. Each consortium is a collaboration between equipment vendors, test equipment manufacturers, industry forums, and the UNH-IOL in a particular technology. The collaborative testing model is intended to distribute the costs associated with maintaining a high-quality testing program among the consortium members.

The UNH-IOL currently administers consortia in over 20 different technologies, including:

- **Internetworking Protocols**
  - IPv6, Routing and SDN, RTC and VoIP, DLNA, RVU, TR-069
- **Data Center**
  - Open Compute Project testing, iSCSI, Fibre Channel, NVMe, Data center bridging, OpenFabrics Alliance
- **Embedded Systems**
  - AVnu, Precision Time Protocol, BroadR-Reach (Automotive Ethernet)
- **Broadband Systems**
  - DSL, G.fast, Power over Ethernet, Wireless LAN, Open Platform for NFV
- **Baseband Systems**
  - MIPI, Serial ATA, Serial attached SCSI, PCI Express, 40/100 Gigabit Ethernet, 10 Gigabit Ethernet, Backplane Ethernet, Gigabit Ethernet, Fast Ethernet

9.2 SNIA

Storage Networking Industry Association (SNIA) is focused on developing, maintaining, educating, and promoting data storage–related activities and standards.

One of the SNIA technical projects, "Solid State Storage (SSS) Performance Test Specification (PTS) Enterprise" is chartered to create a common methodology for testing and comparison for vendors and end users regarding SSS.

9.3 JEDEC

JEDEC Solid State Technology Association
The JEDEC Solid State Technology Association was formerly known as the Joint Electron Devices Engineering Council and is responsible for fostering and maintaining open standards for the microelectronics industry. Throughout IDC's research for this document two JEDEC documents were consistently referenced with respect to component-level solid state storage testing:

- **JESD218.** Solid State Drive (SSD) Requirements and Endurance Test Method
- **JESD219.** Solid State Drive (SSD) Endurance Workloads

9.4 Storage Performance Council (SPC)

The SPC is a vendor-neutral, industry standards body focused on the storage industry.

The SPC serves as a catalyst for performance improvement in storage products. In support of that goal, the SPC has developed a complete portfolio of industry-standard storage benchmarks. The comprehensive SPC benchmark portfolio utilizes I/O workloads that represent the "real world" storage performance behavior of both OLTP *(online transaction processing)* and sequential applications.

The SPC benchmark portfolio provides a rigorous, audited and reliable means to produce comparative storage performance, price-performance and energy use data, which is used to develop and evaluate storage products, which range from individual components to complex, distributed storage configurations.

Both Storage Performance Council (SPC) and Transaction Performance Council (TPC) provide a variety of benchmarks and testing material; however, none of the testing is focused specifically for solid state or flash storage.

(十) SSD 测试第三方实验室

10.1 Demartek SSD Testing Services

10.1.1 Testing Services and Infrastructure

Demartek provides real-world, hands-on research & analysis by focusing on industry analysis and lab validation testing of data center computer equipment such as servers, networking and storage systems. Demartek has experienced I.T. professionals on staff and has invested in its own lab facilities including servers, networking, storage infrastructure and more. We also work with new technologies just coming to market. We have commented or written about some of these new technologies on our **news page** or in the **Demartek Video Library**. Specific technology test results are available on our **FC Zone**, **FCoE Zone**,**iSCSI Zone** and **SSD Zone** pages.

Due to the variety of interface types used for storage devices, Demartek has compiled its popular**Storage Interface Comparison reference page** that provides technical information for many storage interfaces. This page was updated 7-October-2016.

10.1.2 Demartek Services

Demartek performs both public and private testing of hardware and software solutions. We post results of public projects on our website. Results of private testing are not posted on our website. Demartek's lab testing services include:

- Ease of Use Studies
- Deployment Guides and Solutions Guides
- Lab Validation Testing
- Performance Testing and Reporting
    - Synthetic benchmarks using tools such as IOmeter, VDbench, FIO, SQLIO, etc.
    - Database testing using real databases such as Oracle and Microsoft SQL Server
    - Email testing such as Microsoft Jetstress and ESRP, LoadGen and our own email server message generator
    - File server testing
    - Hadoop, Ceph, OpenStack and other distributed computing and storage environments
    - Virtualization (VMware vSphere, Microsoft Hyper-V, Xen and others)
    - Virtual Desktop Infrastructure (VDI)
    - Web Server testing
- Electrical Power Efficiency Testing

10.1.3 Non-English Translations

Demartek offers translations of our reports into non-English languages. View an example of a **Chinese translation** of one of our reports.

10.1.4 Demartek Infrastructure

10.1.4.1 Servers

Demartek has a collection quad-processor, dual-processor and single-processor rack and blade servers, some having 60 or more cores, and up to 1.5 TB of memory in these servers, making them suitable for a wide variety of **storage stress testing**, **virtualized server environment testing** and for testing **real-world applications** such as Microsoft Exchange Server, SQL Server, SharePoint Server, Oracle database and more. In December 2014, we added an **eight-node cluster of servers** to perform Hadoop and other distributed computing and storage platform testing.

10.1.4.2 Ethernet

The Demartek lab is equipped with Ethernet switches that have many ports of 1Gb Ethernet (1GbE), 10Gb Ethernet (10GbE) and several ports of 40Gb Ethernet (40GbE). We recently added a new 25GbE/100GbE switch that supports the new speeds of Ethernet. For 10GbE, we have both SFP+ and 10GBASE-T ports. The 25GbE ports are SFP+. The 40GbE and 100GbE ports are QSFP+. Demartek has appropriate copper and fiber optic cables for 1GbE, 10GbE, 25GbE, 40GbE and 100GbE. Demartek runs typical TCP/IP network and file server traffic, in addition to FCoE and iSCSI traffic. Demartek has 1GbE, 10GbE, 25GbE, 40GbE and 100GbE NICs, iSCSI offload adapters and FCoE CNAs. Some of the NICs support SR-IOV and RoCE (RDMA over Converged Ethernet).

10.1.4.3 Fibre Channel

Demartek has 32Gb, 16Gb, 8Gb and 4Gb Fibre Channel switches in its lab, along with 32Gb, 16Gb, 8Gb and 4Gb Fibre Channel HBAs and the appropriate fiber optic cables and transceivers (optics).

10.1.4.4 SAS

Demartek has 12Gb, 6Gb and 3Gb SAS HBAs and RAID controllers, including SSD caching versions. Demartek also has a SAS switch in its lab.

10.1.4.5 Storage Systems

Demartek has a variety of direct attached storage (DAS), network attached storage (NAS) and storage area network (SAN) storage systems. DAS includes internal enterprise HDDs (7200, 10K and 15K RPM) and SSDs and various types of RAID controllers and SAS HBAs. The NAS systems connect via 1GbE, 10GbE and 40GbE and include one or more shelves of disk drives. Some NAS systems include flash caching features. The SAN storage systems have Fibre Channel, Ethernet (including iSCSI and FCoE) and InfiniBand host ports. Some of these storage systems use hard disk drives (HDDs) and some are all-flash arrays. Demartek also has some enterprise-grade PCIe SSDs including some NVMe SSDs.

10.1.4.6 Power Meters

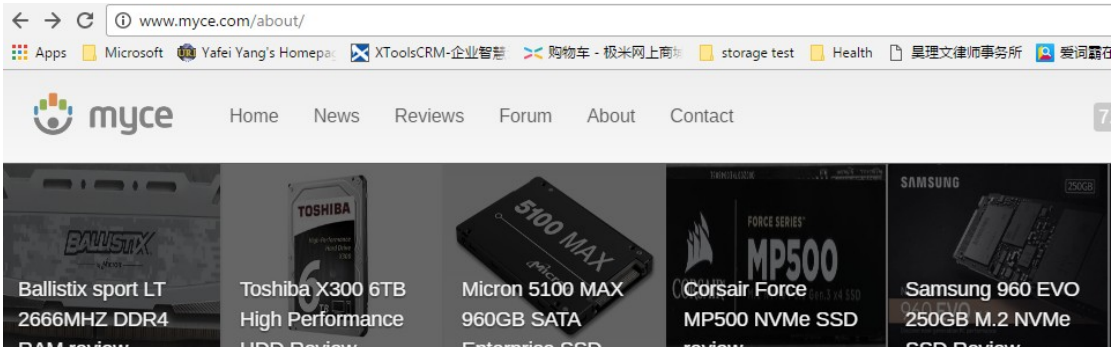
Demartek has a electric power meters to measure electric power consumption of servers, network and storage equipment. For precise electrical power measurement, A/C sources are used to provide power with very tight tolerances for voltage and harmonic distortion.

10.2 CMTL (Computer Memory Test Labs)

Around 35% of our customers are overseas, this is a link for the current customer and old customer that we have tested with on both Memory/flash, and platform/system manufacturers.
CMTL Current & Previous Clients: Memory/Flash Manufacturers & Platform/System Manufacturers
In fact we just started testing for BIWIN and once testing is completed they will have there own web site similar to your company if we to test. Below a list of SSD manufacturers in which we currently test for.

10.3 Myce Labs

Myce 是美国知名的 SSD 评测网站，具体参见下面的截图。



10.4 UNH IOL Labs

Each of the UNH-IOL's testing services represents a collaboration of the industry leaders in network equipment, test equipment, industry forums and service providers to benefit each other. This collaborative testing model distributes the cost of performing trusted, third-party testing and validation through an annual membership in each technology-specific service.

Read about the benefits of membership or find out more about our certification programs that supplement testing services based testing.

10.4.1 Testing Services

We offer collaborative testing services in 40 different data networking and storage technologies, including:

10.4.2 NVM Express® (NVMe) Testing Services

We offer conformance and interop testing for NVMe™ hosts and devices, which help products to qualify for the NVMe™ Integrators List. We also use our NVMe™ interop test bed to enable heterogeneous testing across various OS, drivers, and hardware platforms to prove the viability and robustness of NVMe™.

Test services include:

- Conformance testing using the IOL INTERACT PC Edition software
- Conformance testing using the IOL INTERACT Teledyne-LeCroy Edition software
- Interoperability testing using VDbench software

Like all UNH-IOL Testing Services, NVMe is a collaborative test program that brings together industry leaders to foster quality, interoperable systems.