Solid State Storage (SSS) Performance Test Specification (PTS) Enterprise

Version 1.1 Revision h

Abstract: This Working Draft describes a solid state storage device-level test methodology, test suite and reporting format intended to provide an accurate, repeatable and reliable comparison of NAND Flash-based solid state storage products of various form factors and interfaces used in Client and Enterprise applications.

Publication of this Working Draft for review and comment has been approved by the Solid State Storage (SSS) TWG. This draft represents a "best effort" attempt by the SSS TWG to reach preliminary consensus, and it may be updated, replaced, or made obsolete at any time. This document should not be used as reference material or cited as other than a "work in progress." Suggestion for revision should be directed to http://www.snia.org/feedback/.

Working Draft

April 16, 2013

Revision History

Revision	Release Date	Originator	Comments
	May-2009	Jonathan Thatcher	• Initial proposal in SSS TWG • Initial Draft Outline
	Jun-2009	Eden Kim	• Added material re: Definitions, Reference Platform, Test Definitions/Procedures, etc. • Content contributions from Eden Kim, Phil Mills, Easen Ho, Dave Landsman, Steven Johnson
0.0.0	Jul-7-2009	Dave Landsman	• Major restructure to get overall document sections/styles in place for serious editing and 1st full committee review. • Incorporated Calypso material. • Added section on Performance Index • Re-wrote Scope & Introduction
0.0.1	Jul-15-2009	Dave Landsman	• Merged Jonathan Thatcher draft. • Merged Chuck Paridon definitions • Merged Chuck Paridon test flow (Annex) • Further general restructuring/editing.
0.0.2	Aug-4-2009	Dave Landsman	• Updated Preconditioning and Test sections per Jul 20-22 F2F. • Integrated Logical/Physical Address conventions into Definitions. • Other general stylistic and editorial changes.
0.1	Sep-23-2009	Dave Landsman	• Changed versioning to x.y, from x.y.z • Miscellaneous edits in Sections 3 & 4 • Revised Section 5 (Preconditioning) for clarity • Flipped “for loop” in IOPS test (Sec. 6.2) • Added QD=1for IOPS test (Sec. 6) • Edited “Alternative Extended IOPS Test” (Section 6.6) • Added graphic for RPT spec (Annex A) • Added rough latency example to sample report (Annex B)
0.3	Dec-2-2009	Dave Landsman	• Based on slide version of spec (2009-10-23). No revision marks due to major restructure; this is clean version. • Removed previous Preconditioning sections. • Restructured tests with suite of Client (Sections 6-8) and Enterprise (Sections 9-11) tests. • Removed “Idle Test”. • Revised general flow of tests, plus types of reports. • Added new section (Section 5) to provide informative overview of test flow, and other key concepts/definitions.
0.4	Dec-12-2009	Dave Landsman	• Clean version; no change bars • Changed “Active Use State” to “Steady State” • Completely revised Section 5 for better flow. • Added new 6 & 7 as prefaces to actual test sections. • Changed basic test flow to incorporate methodology where convergence to Steady State must be detected AND maintained for duration of test. • Updated Latency test loop parameters and report proposal per discussions w/ Gary Kotzur.
0.5	Feb-27-2010	Dave Landsman	Incorporated TWG changes from V0.4 • Updated section 1.2 for better background • Updated 1.4 with notes on App Testing and Reference Platform • Updated 2.1 with new/modified definitions (steady state, OIO, etc.) • Updated 4, in particular 4.2 with test tools requirements. • Completely rewrote/restructured Informative Section 5, including notes on Data Patterns and IO demand (QD/TC). More complete explanations of Steady State, Detecting Steady State, etc. • Rewrote Section 6 to provide better intro to detailed test flow. • Edited all tests per comments in TWG. • Deleted sample test report in appendix because need to remove company identification from the sample and a Word bug made it impossible to remove just the name/logo. Will add back later.

0.6	Mar-20-2010	Dave Landsman	• Integrated all changes from Mar-8-2010 TWG F2F • Rewrote material on IO Demand • Updated/Deleted/Checked definitions, & validated per SNIA Dictionary • Added “Test Parameters” to required reporting (Sec 3) • Revised Section 4 to better address platform requirements • Created new IOPS and Throughput Plots
0.7	Apr-23-2010	Dave Landsman	• Made all changes per comment resolution of V.06e (commentable) • Tried to make “shall”, “may”, etc. more explicit throughout spec • Re-ordered Reporting and Platform requirements sections for flow • Revised “Reporting Requirements” to be more clear. • Added Informative Annex B – PTS Platform Example • Added Informative Annex C – Synthetic Application Workloads • Restructured sections for flow.
0.7a	May-19-2010	Dave Landsman	• Integrated changes from V0.7 comment resolution, up through, and including Section 8, Client IOPS test.
0.8	June-07-2010	Dave Landsman	• Major update to get to final test structure, report formats, etc. • Integrated changes from V0.7a comment resolution. • Updated all test sections to new uniform structure. • ALL new graphs/charts/tables. • Inserted draft Annex A
0.9	June-22-2010	Dave Landsman	• Continued cleanup. • First real edits of Annex A and B, mostly for formatting.
0.98	Nov-11-2010	Dave Landsman	• Removed Client sections and updated to make it “Enterprise” only. • Added Write Saturation Test • Changed block size to be the outer loop for Throughput test. • Added explanation of pseudo code in “Conventions” • Deleted “Test Overview”, no longer needed since Enterprise only. • Added Client and Enterprise to “Definitions” • Modified reporting requirement for when Steady State not reached. • Updated references.
0.99	Nov-17-2010	Dave Landsman	• Added cache requirements (Sec 3.7 and definitions) • Revised definition of Latency (definitions) • Updated all tables to go from low-to-high block sizes and 100% Writes (R/W Mix % = 0/100) to 100% Reads (R/W Mix = 100/0) • Removed “Workload Independent Preconditioning” step from the Throughput test.
1.0	Nov-19-2010	Dave Landsman	• Updated Annex A
1.1(a)	Nov-21-2011	Eden Kim	• Updated to PTS-E 1.1 from TWG F2F comments 12SEP11 • Consolidate / harmonize introduction w/ PTS-C v 1.1(a) • Consolidate Definitions w/ PTS-C v 1.1(a) • Addition of PTS-E 1.1 Tests for initial review
1.1(b)(2)	Dec-28-2011	Eden Kim	• Updated Normative Annex A PTS Sample Report Format • Updated reference to KiB Base 2 • Test Example Plots replaced with Annex Normative plots • Added Section 10: WSAT Optional Test • Harmonized PTS-C 1.1 with PTS-E 1.1
1.1(c)	Jan-25-2012	Eden Kim	• Harmonize w/ PTS-C 1.1(c)
1.1(d)	Feb 20-2012	Eden Kim	• Harmonize w/ PTS-C 1.1(d) • Update pseudo code HIR, Cross Stim Rec • Addition table of figures & table of plots
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1.1(f)	Jul-09-2012	Eden Kim Easen Ho	• ECW & DIRTH pseudo code & plots update
1.1 (g)	Mar-8-2013	Marilyn Fausset	• Editorial work to publish a Working Draft for ballot
1.1 (h)	Mar-12-21-2013	Marilyn Fausset Eden Kim	• Added new plots to main sections and Annex A, minor revisions

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Intended Audience

This document is intended for use by individuals and companies engaged in the development of this Specification and in validating the tests and procedures incorporated herein. After approvals and release to the public, this Specification is intended for use by individuals and companies engaged in the design, development, qualification, manufacture, test, acceptance and failure analysis of SSS devices and systems and sub systems incorporating SSS devices.

Changes to the Specification

Each publication of this Specification is uniquely identified by a two-level identifier, comprised of a version number and a release number. Future publications of this specification are subject to specific constraints on the scope of change that is permissible from one publication to the next and the degree of interoperability and backward compatibility that should be assumed between products designed to different publications of this standard. The SNIA has defined three levels of change to a specification:

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Contents

List of Figures, Plots, and Tables

1 Introduction

1.1 Preamble

This *Enterprise Performance Test Specification (PTS-E) 1.1 i*s a companion specification to the *SNIA Solid State Storage Client Performance Test Specification (PTS-C) 1.1*. Both Performance Test Specifications (PTS) are intended to be used to obtain reliable and comparative measurement of NAND Flash based solid state storage devices. In both PTS in their present form, the tests and methodologies are designed to use a synthetic, or known and repeatable, test stimulus applied to a solid state storage product at the device level. In these PTS, "device level" refers to measurement of block IO at the physical device level as opposed to file system IO in the host Operating System.

Both of these PTS are based on test and preparation methodologies developed by the SNIA SSS TWG for performance test of NAND based solid state storage. NAND Flash based solid state storage (SSS) performance tends to be highly dependent on the write history of the SSS device, the type of stimulus applied to the SSS device, as well as the test environment (both hardware and software) in which the test stimulus is applied and measurements taken. Much of the preconditioning, test condition set up and parameters take these SSS behaviors into consideration.

These PTS do not require the use a specific test environment, but test tool requirements, capabilities and examples are set forth in the specifications. Care should be taken by the test operator to ensure that the test hardware does not bottleneck the SSS device performance, that the OS or test software tool has minimal contribution to test measurements, and that the same hardware and software test combination is used when comparing performance results of different SSS devices.

This Enterprise PTS-E 1.1 differs from the Client PTS-C 1.1 in the preparation of the Device Under Test (DUT) for steady state performance measurement and in the amount and type of test stimulus applied to the DUT. For example, preconditioning LBA ranges may be limited in the Client PTS-C to less than 100% of the available LBAs while the test stimulus Active Range may be limited to a reduced number of uniquely touched LBAs (see Client PTS-C Specification). The use of limited preconditioning and test active ranges are meant to provide test stimulus that share more characteristics with empirically observed Client workloads.

Readers and industry members are encouraged to participate in the further SNIA SSS TWG works and can contact the TWG at its website portal at http://www.snia.org/feedback/.

1.2 Purpose

Manufacturers need to set, and customers need to compare, the performance of Solid State Storage (SSS) devices. This Specification defines a set of device level tests and methodologies intended to enable comparative testing of SSS devices in Enterprise (see 2.1.5) systems.

Note: While the tests defined in this specification could be applied to SSS devices based on any technology (RAM, NAND, etc.), the emphasis in this specification, in particular regarding Preconditioning and Steady State, is oriented towards NAND.

1.3 Background

A successful device level performance test isolates the device being tested from the underlying test platform (HW, OS, Tools, Applications) so the only limiting variable in the test environment is the device being tested. To achieve this goal with NAND-based SSS devices, in addition to typical system/device isolation issues, the test, and test methodologies, must address attributes unique to NAND-based flash media.

NAND-based SSS device controllers map Logical Addresses (LBA) to Physical Blocks Addresses (LBA) on the NAND media, in order to achieve the best NAND performance and endurance. The SSS device manages this LBA-to-PBA mapping with internal processes that operate independently of the host. The sum of this activity is referred to as “flash management”.

The performance of the flash management during a test, and hence the overall performance of the SSS device during the test, depends critically on:

1) Write History and Preconditioning: The state of the device prior to the test
2) Workload Pattern: Pattern of the I/O (r/w mix, block size, etc.) written to device during test
3) Data Pattern: The actual bits in the data payload written to the device

The methodologies defined in the SSS Performance Test Specification (SSS PTS) attempt to create consistent conditions for items 1-3 so that the only variable is the device under test.

Note: Descriptive notes precede each test section to explain the test rationale and examples of possible interpretations of test results. These notes are **informative only** and are set forth as “Descriptive Note” for the reader’s convenience.

The importance of the SSS PTS methodologies on SSS performance measurement is shown in Figure 1-1. A typical SSS device, taken Fresh Out of the Box (FOB), and exposed to a workload, experiences a brief period of elevated performance, followed by a transition to Steady State performance. The SSS PTS ensures that performance measurements are taken in the Steady State region, representing the device’s performance during its normal working life.

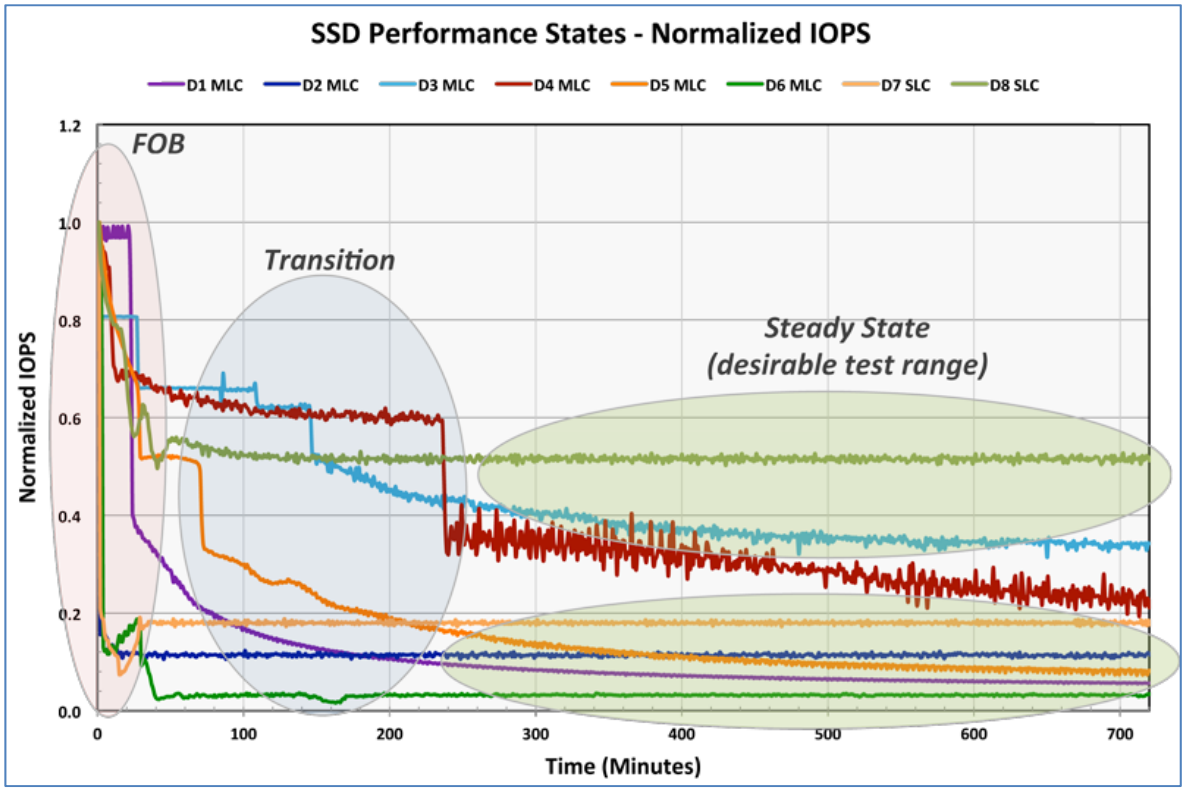


Figure 1-1 – NAND-based SSS Performance States for 8 Devices (RND 4KiB Writes)

1.4 Scope

1) Preconditioning methods
2) Performance tests
3) Test reporting requirements

1.5 Not in Scope

1) Application Workload Tests
2) Test Platform (HW/OS/Tools)
3) Certification/Validation procedures for this specification
4) Device reliability, availability, or data integrity

1.6 Disclaimer

Use or recommended use of any public domain, third party or proprietary software does not imply nor infer SNIA or SSS TWG endorsement of the same. Reference to any such test or measurement software, stimulus tools, or software programs is strictly limited to the specific use and purpose as set forth in this Specification and does not imply any further endorsement or verification on the part of SNIA or the SSS TWG.

1.7 Normative References

1.7.1 Approved references

These are the standards, specifications and other documents that have been finalized and are referenced in this specification.

- IDEMA Document LBA1-02 -- LBA Count for IDE Hard Disk Drives Standard
- JEDEC JESD218 – Solid-State Drive (SSD) Requirements and Endurance Test Method
- JEDEC JESD219 – Solid-State Drive (SSD) Endurance Workloads

1.7.2 References under development

- ATA/ATAPI Command Set - 2 (ACS-2) – INCITS/T13 2015-D

1.7.3 Other references

- None in this version

2 Definitions, symbols, abbreviations, and conventions

2.1 Definitions

2.1.1 **ActiveRange:** Specified as ActiveRange(start:end), where “start” and “end” are percentages. ActiveRange is the range of LBA’s that may be accessed by the preconditioning and/or test code, where the starting LBA# = start%*MaxUserLBA and the ending LBA# = end%*MaxUserLBA.

2.1.2 **Cache:** A volatile or non-volatile data storage area outside the User Capacity that may contain a subset of the data stored within the User Capacity.

2.1.3 **Client:** Single user desktop or laptop system used in home or office.

2.1.4 **CPU Usage:** amount of time for which a central processing unit (CPU) is used for processing instructions. CPU time is also measured as a percentage of the CPU's capacity at any given time.

2.1.5 **Enterprise:** Servers in data centers, storage arrays, and enterprise wide / multiple user environments that employ direct attached storage, storage attached networks and tiered storage architectures.

2.1.6 **Fresh Out of the Box (FOB):** State of SSS prior to being put into service.

2.1.7 **IO Demand:** Measured # of OIOs executing in the host.

2.1.8 **Logical Block Address (LBA):** The address of a logical block, i.e., the offset of the block from the beginning of the logical device that contains it.

2.1.9 **Latency:** The time between when the workload generator makes an IO request and when it receives notification of the request’s completion.

2.1.10 **MaxUserLBA:** The maximum LBA # addressable in the User Capacity.

2.1.11 **Measurement Window:** The interval, measured in Rounds, during which test data is collected, bounded by the Round in which the device has been observed to have maintained Steady State for the specified number of Rounds (Round x), and five Rounds previous (Round x-4).

2.1.12 **Nonvolatile Cache:** A cache that retains data through power cycles.

2.1.13 **Outstanding IO (OIO):** The number of IO operations issued by a host, or hosts, awaiting completion.

2.1.14 **OIO/Thread:** The number of OIO allowed per Thread (Worker, Process)

2.1.15 **Over-Provisioned Capacity:** LBA range provided by the manufacturer for performance and endurance considerations, but not accessible by the host file system, operating system, applications, or user.

2.1.16 **Preconditioning:** The process of writing data to the device to prepare it for Steady State measurement.

(a) Workload Independent Preconditioning (WIPC): The technique of running a prescribed workload, unrelated to the test workload, as a means to facilitate convergence to Steady State.

(b) Workload Dependent Preconditioning (WDPC): The technique of running the test workload itself, typically after Workload Independent Preconditioning, as a means to put the device in a Steady State relative to the dependent variable being tested.

2.1.17 **Preconditioning Code:** Refers to the Preconditioning steps set forth in this Specification.

2.1.18 **Purge:** The process of returning an SSS device to a state in which subsequent writes execute, as closely as possible, as if the device had never been used and does not contain any valid data.

2.1.19 **Round**: A complete pass through all the prescribed test points for any given test.

2.1.20 Queue Depth: Interchangeably refers to the OIO/Thread produced by the Workload Generator.

2.1.21 **Steady State:** A device is said to be in Steady State when, for the dependent variable (y) being tracked:

a) Range(y) is less than 20% of Ave(y): Max(y)-Min(y) within the Measurement Window is no more than 20% of the Ave(y) within the Measurement Window; and

b) Slope(y) is less than 10%: Max(y)-Min(y), where Max(y) and Min(y) are the maximum and minimum values on the best linear curve fit of the y-values within the Measurement Window, is within 10% of Ave(y) value within the Measurement Window.

2.1.22 **Test Code:** Refers to the measurement steps set forth in the test sections contained in this Specification.

2.1.23 **Transition Zone:** A performance state where the device's performance is changing as it goes from one state to another (such as from FOB to Steady State).

2.1.24 **Thread:** Execution context defined by host OS/CPU (also: Process, Worker)

2.1.25 **Thread Count (TC):** Number of Threads (or Workers or Processes) specified by a test.

2.1.26 **Total OIO:** Total outstanding IO Operations specified by a test = (OIO/Thread) * (TC)

2.1.27 **User Capacity:** LBA range directly accessible by the file system, operating system and applications, not including Over-Provisioned Capacity.

2.1.28 **Volatile Cache:** A cache that does not retain data through power cycles.

2.2 Acronyms and Abbreviations

2.2.1 **IOPS:** I/O Operations per Second

2.2.2 **DUT:** Device Under Test

2.2.3 **FOB:** Fresh Out of Box

2.2.4 **OIO:** Outstanding IO

2.2.5 **TOIO:** Total Outstanding IO

2.2.6 **R/W:** Read/Write

2.2.7 **SSSI:** Solid State Storage Initiative

2.2.8 **SSS TWG:** Solid State Storage Technical Working Group

2.2.9 **TC:** Thread Count

2.2.10 **ART:** Average Response Time

2.2.11 **QD:** Queue Depth

2.2.12 **TP:** Throughput

2.2.13 **LAT:** Latency

2.2.14 **WSAT:** Write Saturation

2.2.15 **HIR:** Host Idle Recovery

2.2.16 **XSR:** Cross Stimulus Recovery

2.2.17 **ECW:** Enterprise Composite Workload

2.2.18 **DIRTH:** Demand Intensity / Response Time Histogram

2.3 Keywords

The key words “shall”, “required”, “shall not”, “should”, “recommended”, “should not”, “may”, and “optional” in this document are to be interpreted as:

2.3.1 **Shall:** This word, or the term "required", means that the definition is an absolute requirement of the specification.

2.3.2 **Shall Not:** This phrase means that the definition is an absolute prohibition of the specification.

2.3.3 **Should:** This word, or the adjective "recommended", means that there may be valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and weighed before choosing a different course.

2.3.4 **Should Not:** This phrase, or the phrase "not recommended", means that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.

2.3.5 **May:** This word, or term “optional”, indicates flexibility, with no implied preference.

2.4 Conventions

2.4.1 Number Conventions

Numbers that are not immediately followed by lower-case b or h are decimal values.

Numbers immediately followed by lower-case b (xxb) are binary values.

Numbers immediately followed by lower-case h (xxh) are hexadecimal values.

Hexadecimal digits that are alphabetic characters are upper case (i.e., ABCDEF, not abcdef).

Hexadecimal numbers may be separated into groups of four digits by spaces. If the number is not a multiple of four digits, the first group may have fewer than four digits (e.g., AB CDEF 1234 5678h).

Storage capacities and data transfer rates and amounts shall be reported in Base-10. IO transfer sizes and offsets shall be reported in Base-2. The associated units and abbreviations used in this specification are:

- A kilobyte (KB) is equal to 1,000 (10^3) bytes.
- A megabyte (MB) is equal to 1,000,000 (10^6) bytes.
- A gigabyte (GB) is equal to 1,000,000,000 (10^9) bytes.
- A terabyte (TB) is equal to 1,000,000,000,000 (10^{12}) bytes.
- A petabyte (PB) is equal to 1,000,000,000,000,000 (10^{15}) bytes
- A kibibyte (KiB) is equal to 2^{10} bytes.
- A mebibyte (MiB) is equal to 2^{20} bytes.
- A gibibyte (GiB) is equal to 2^{30} bytes.
- A tebibyte (TiB) is equal to 2^{40} bytes.
- A pebibyte (PiB) is equal to 2^{50} bytes

2.4.2 Pseudo Code Conventions

The specification uses an informal pseudo code to express the test loops. It is important to follow the precedence and ordering information implied by the syntax. In addition to nesting/indentation, the main syntactic construct used is the “For” statement.

A “For” statement typically uses the syntax: For (variable = x, y, z). The interpretation of this construct is that the Test Operator sets the variable to x, then performs all actions specified in

the indented section under the “For” statement, then sets the variable to y, and again performs the actions specified, and so on. Sometimes a “For” statement will have an explicit “End For” clause, but not always; in these cases, the end of the For statement’s scope is contextual.

Take the following loop as an example:

For (R/W Mix % = 100/0, 95/5, 65/35, 50/50, 35/65, 5/95, 0/100)
For (Block Size = 1024KiB, 128KiB, 64KiB, 32KiB, 16KiB, 8KiB, 4KiB, 0.5KiB)
- Execute **random IO**, per (R/W Mix %, Block Size), for 1 minute
- Record Ave IOPS(R/W Mix%, Block Size)

This loop is executed as follows:

- Set R/W Mix% to 100/0 >>>>> Beginning of Loop 1
- Set Block Size to 1024KiB
- Execute random IO…
- Record Ave IOPS…
- Set Block Size to 128KiB
- Execute…
- Record…
- …
- Set Block Size to 0.5KiB
- Execute…
- Record… >>>>> End of Loop 1
- Set R/W Mix% to 95/5 >>>>> Beginning of Loop 2
- Set Block Size to 1024 KiB
- Execute…
- Record…
- …

3 Key Test Process Concepts

The performance of an SSS device is highly dependent on its prior usage, the pre-test state of the device and test parameters. This section describes key SSS test methodology concepts.

3.1 Steady State

SSS devices that are Fresh Out of the Box (FOB), or in an equivalent state, typically exhibit a transient period of elevated performance, which evolves to a stable performance state relative to the workload being applied. This state is referred to as a Steady State (Definition 2.1.21).

It is important that the test data be gathered during a time window when the device is in Steady State, for two primary reasons:

1) To ensure that a device's initial performance (FOB or Purged) will not be reported as "typical", since this is transient behavior and not a meaningful indicator of the drive's performance during the bulk of its operating life.

2) To enable Test Operators and reviewers to observe and understand trends. For example, oscillations around an average are "steady" in a sense, but might be a cause for concern.

Steady State may be verified:

- by inspection, after running a number of Rounds and examining the data;
- programmatically, during execution; or
- by any other method, as long as the attainment of Steady State, per Definition 2.1.21, is demonstrated and documented.

Steady State as defined in Definition 2.1.21 shall meet the Steady State Verification criteria as set forth in each test. Steady State reporting requirements are covered in the respective test sections.

3.2 Purge

The purpose of the Purge process (Definition 2.1.18) is to put the device in a consistent state prior to preconditioning and testing, and to facilitate a clear demonstration of Steady State convergence behavior.

Purge shall be run prior to each preconditioning and testing cycle. If the device under test does not support any kind of Purge method, and the Test Operator chooses to run the PTS, the fact that Purge was not supported/run must be documented in the test report.

The Test Operator may select any valid method of implementing the Purge process, including, but not limited to, the following:

a) ATA: SECURITY ERASE, SANITIZE DEVICE (BLOCK ERASE EXT)
b) SCSI: FORMAT UNIT
c) Vendor specific methods

The Test Operator shall report what method of Purge was used.

3.3 Preconditioning

The goal of preconditioning is to facilitate convergence to Steady State during the test itself.

The SSS PTS defines two types of preconditioning:

- Workload Independent Preconditioning (Definition 2.1.16.1); and
- Workload Dependent Preconditioning (Definition 2.1.16.2)

Note: While Workload Based Preconditioning is not a distinct step in the test scripts (it occurs as part of running the core test loop in each test), it is critically important to achieving valid Steady State results.

3.4 ActiveRange

It is desirable to be able to test the performance characteristics of workloads which issue IO across a wide range of the LBA space vs. those which issue IO across only a narrow range. To enable this, the SSS Performance Specification defines ActiveRange. (Definition 2.1.1)

The test scripts define required and optional settings for ActiveRange.

Figure 3-1 show two examples of ActiveRange.

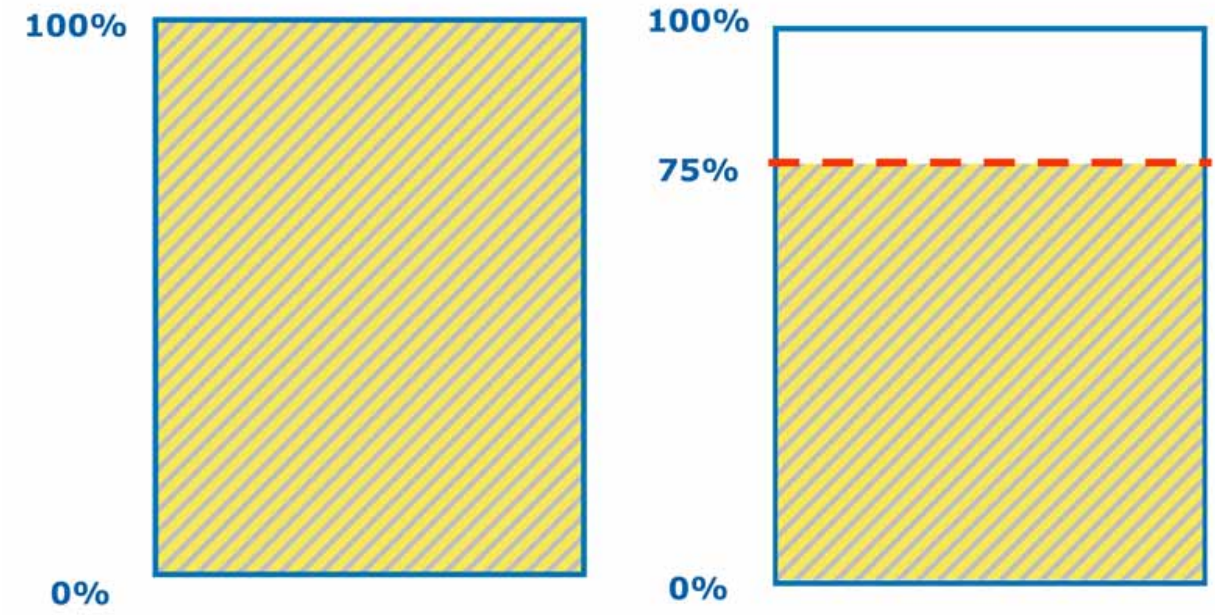


Figure 3-1 – ActiveRange Diagram

3.5 Data Patterns

All tests shall be run with a random data pattern. The Test Operator may execute additional runs with non-random data patterns. If non-random data patterns are used, the Test Operator must report the data pattern.

Note: Some SSS devices look for and optimize certain data patterns in the data written to the device. It is not feasible to test for all possible kinds of optimizations, which are vendor specific and often market segment specific. The SSS TWG is still trying to characterize “how random is random enough” with respect to data patterns.

3.6 Multiple Thread Guideline

If the Test Operator wishes to run a test using multiple Threads, it is recommended that OIO/Thread, or Queue Depth, for all Threads be equal, so Total OIO is equal to (OIO/Thread) * (Thread Count). This will enable more direct comparisons.

While the Test Operator may select a given OIO for a test, the Test Operator shall use the same Thread Count and OIO/Thread for all steps of a given test.

3.7 Caching

All tests should be run with all volatile write caches disabled. The cache state shall be reported for drives that cannot have write cache disabled.

4 Overview of Common Test Flow

The Steady State tests in the SSS PTS (IOPS, Throughput and Latency) use the same general steps and flow, described in Figure 4-1. Test-specific parameter settings, reports, and other requirements are documented in the test sections themselves.

Basic Test Flow:

For (ActiveRange = the specified values)

1) **Purge the device**

   Note: Test Operator may use any values for ActiveRange and Test Parameters for this step; no parameter reporting is required.

2) **Run Workload Independent Preconditioning**

   Note: Test Operator shall use specified ActiveRange ("For ActiveRange ="), but may choose other Test Parameter values to optimize this step, and shall report them.

3) **Run Test (includes Workload Based Preconditioning):**

   a) Set Test Parameters (OIO/Thread, Thread Count, Data Pattern, etc.) as specified in the test script.

   b) Run test loop until Steady State reached, or a maximum of 25 Rounds. Accumulate/Record intermediate data, as specified in test, for each Round.

4) **Post process & plot the Rounds data:**

   a) If Steady State is reached by Round x=25, where the Measurement Window is Round (x-4):x, the Test Operator shall:
      i) Plot Rounds 1:x per "Steady State Convergence Plot";
      ii) Plot Rounds (x-4):x per "Steady State Verification Plot"; and
      iii) Plot Rounds (x-4):x per "Measurement Plot".

   b) If Steady State is not reached by Round x=25, the Test Operator shall either:
      i) Continue at 3b until Steady State reached (x>25), and then report per 4a(i-iii); or
      ii) Stop at Round x and report per 4a(i-iii).

End "For ActiveRange"

The Test Operator may re-run the entire "For ActiveRange" loop with alternate test parameters, which may be optional or required, depending on the test.

End "Basic Test Flow"

Figure 4-1 – Basic Test Flow

Note: Steps (2) and (3) must each be run with no interruptions, and there must be no delay between Step (2) and Step (3), to maintain consistent test conditions for all devices.

Note: With respect to the reports in Step (4):

- The **Steady State Convergence Plot** shows general visual convergence to Steady State by plotting the dependent variable (IOPS, Throughput, etc.) for each Round.
- The **Steady State Verification Plot** shows, via either graph or table, that the device has reached Steady State per definition 2.1.21, by examining dependent variable behavior within the Measurement Window.
- The **Measurement Plot** is not one, but a set of, plots/reports, which summarize the test data in the Measurement Window, for the metric being measured.
- The content of these plots, and other test-specific reporting, is specified in each test.
- Examples of these plots are set forth in Annex A.

5 Common Reporting Requirements

The following items, common to all tests, shall be included in the final test report. These items only need to be reported once in the test report. Test-specific report items are defined in the relevant test sections themselves. A sample test report can be found in Annex A.

5.1 General

1) Test Date
2) Report Date
3) Test Operator name
4) Auditor name, if applicable
5) Test Specification Version

5.2 Test System Hardware

1) Manufacturer/Model #
2) Mother Board/Model #
3) CPU
4) DRAM
5) Host Bus Adapter
6) Primary Storage
7) Peripherals

5.3 Test System Software

1) Operating System Version
2) File System and Version
3) Test Software

5.4 Device Under Test

1) Manufacturer
2) Model Number
3) Serial Number
4) Firmware Revision
5) User Capacity
6) Interface/Speed
7) Form Factor (e.g., 2.5”)
8) Media Type (e.g., MLC NAND Flash)
9) Optional: Other major relevant features (e.g., NCQ, Hot plug, Sanitize support, etc.)

6 Test Tool Guidelines

The SSS PTS is platform (HW/OS/Tool) agnostic. A sample platform is outlined Annex B. SW tools used to test SSS devices pursuant to this PTS shall have the ability to:

1) Act as workload stimulus generator as well as data recorder
2) Issue Random and Sequential block level I/O
3) Restrict LBA accesses to a particular range of available user LBA space
4) Test Active Range – shall be able to limit “total unique LBAs used” to a specific value
5) Ability to randomly distribute a number of equally sized LBA segments across the test active range.
6) Set R/W percentage mix %
7) Set Random/Sequential IO mix %
8) Set IO Transfer Size
9) Generate and maintain multiple outstanding IO requests. Ensure that all steps in the test sequence can be executed immediately one after the other, to ensure that drives are not recovering between processing steps, unless recovery is the explicit goal of the test.
10) Provide output, or output that can be used to derive, IOPS, MB/s, maximum latency and average response time (latency if OIO=1) within some measurement period.

The random function for generating random LBA #’s during random IO tests shall be:

1) seedable;
2) have an output >= 48-bit; and
3) deliver a uniform random distribution independent of capacity.

7 IOPS Test

7.1 IOPS Descriptive Note

General Purpose:

Enterprise IOPS test is intended to measure the test SSD IOPS at a range of Random Block Sizes and Read/Write mixes. This Enterprise IOPS test is intended to emulate characteristics of Enterprise workloads. PTS-E Enterprise workload tests use 100% LBAs.

Test Flow:

The Enterprise IOPS test makes use of:

1) a preconditioning range of 100% LBAs (Section 2.1);
2) a one-step Workload Independent PC (Section 2.1.16 a) consisting of 128KiB SEQ W for 2X (twice) the user capacity; and
3) a one-step Workload Dependent PC (WDPC) (Section 2.1.16 b) consisting of the IOPS loop using the ActiveRange until Steady State, as defined, is achieved.

Test Results:

The test results captured during steady state measurement window shall be tabulated and plotted as specified in section 7 and are intended to present the IOPS performance over the 56 element matrix of Read/Write Mixes (aka the "outer loop") and Block Sizes (aka the "inner loop").

Test Interpretation:

A higher value (more IOPS) is better.

7.2 IOPS Pseudo Code

```
For (ActiveRange(0:100), optional ActiveRange(Test Operator Choice))
```

1 Purge the device. (Note: ActiveRange and other Test Parameters are not applicable to Purge step; any values can be used and none need to be reported.)

2 Run Workload Independent Preconditioning

2.1 Set and record test conditions:
- 2.1.1 Device volatile write cache = disabled
- 2.1.2 OIO/Thread: Test Operator Choice
- 2.1.3 Thread Count: Test Operator Choice
- 2.1.4 Data Pattern: Required = Random, Optional = Test Operator

2.2 Run SEQ Workload Independent Preconditioning - Write 2X User Capacity with 128KiB SEQ writes, writing to the entire ActiveRange without LBA restrictions.

3 Run Workload Dependent Preconditioning and Test stimulus. Set test parameters and record for later reporting

3.1 Set and record test conditions:
- 3.1.1 Device volatile write cache = Disabled
- 3.1.2 OIO/Thread: Same as in step 2.1 above.
- 3.1.3 Thread Count: Same as in step 2.1 above.
- 3.1.4 Data Pattern: Required= Random, Optional = Test Operator Choice.

3.2 Run the following test loop until Steady State is reached, or maximum of 25 Rounds:
- 3.2.1 For (R/W Mix % = 100/0, 95/5, 65/35, 50/50, 35/65, 5/95, 0/100)

```
            3.2.1.1  For (Block Size = 1024KiB, 128KiB, 64KiB, 32KiB, 16KiB,
                     8KiB, 4KiB, 0.5KiB)
            3.2.1.2  Execute RND IO, per (R/W Mix %, Block Size), for 1 minute
              3.2.1.2.1 Record Ave IOPS (R/W Mix%, Block Size)
              3.2.1.2.2 Use IOPS (R/W Mix% = 0/100, Block Size = 4KiB) to
                        detect Steady State.
              3.2.1.2.3 If Steady State is not reached by Round x=25, then the
                        Test Operator may either continue running the test
                        until Steady State is reached, or may stop the test at
                        Round x. The Measurement Window is defined as Round x-4
                        to Round x.
            3.2.1.3  End "For Block Size" Loop
          3.2.2 End "For R/W Mix%" Loop
   4 Process and plot the accumulated Rounds data, per report guidelines in 7.3.
End (For ActiveRange)0 loop
```

Note: It is important to adhere to the nesting of the loops as well as the sequence of R/W Mixes and Block Sizes.

7.3 Test Specific Reporting for IOPS Test

7.3.1 through 7.3.6.3 list the reporting requirements specific to the IOPS test. Reporting requirements common to all tests are documented in Section 5. See also Annex A.

If Steady State was reached at Round x, the Test Operator shall:
Plot Rounds 1:x per "IOPS Steady State Convergence Plot";
Plot Rounds (x-4):x per "IOPS Steady State Verification Plot"; and
Plot Rounds (x-4):x per "IOPS Measurement Plot."

If Steady State was not reached then the Test Operator may report results per above, picking the last Round run as Round x. *In the case where Steady State was not reached, the Test Operator must state this fact in the final report.*

7.3.1 Purge Report

The Test Operator shall report the method used to run the Purge operation.

7.3.2 Preconditioning Report

The Test Operator shall report both Workload Independent and Workload Dependent preconditioning information as shown in the Report Headers that follow.

> Note on Headers: The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

7.3.3 Steady State Convergence Report

The Test Operator shall generate a Steady State Convergence plot as shown in Plot 7-1, including the test set-up and parameters set forth in the Report Header. See Annex A.

Test Run Date:	11/02/2011 02:56 PM	Report Run Date:	3/4/2013 8:43:00 AM

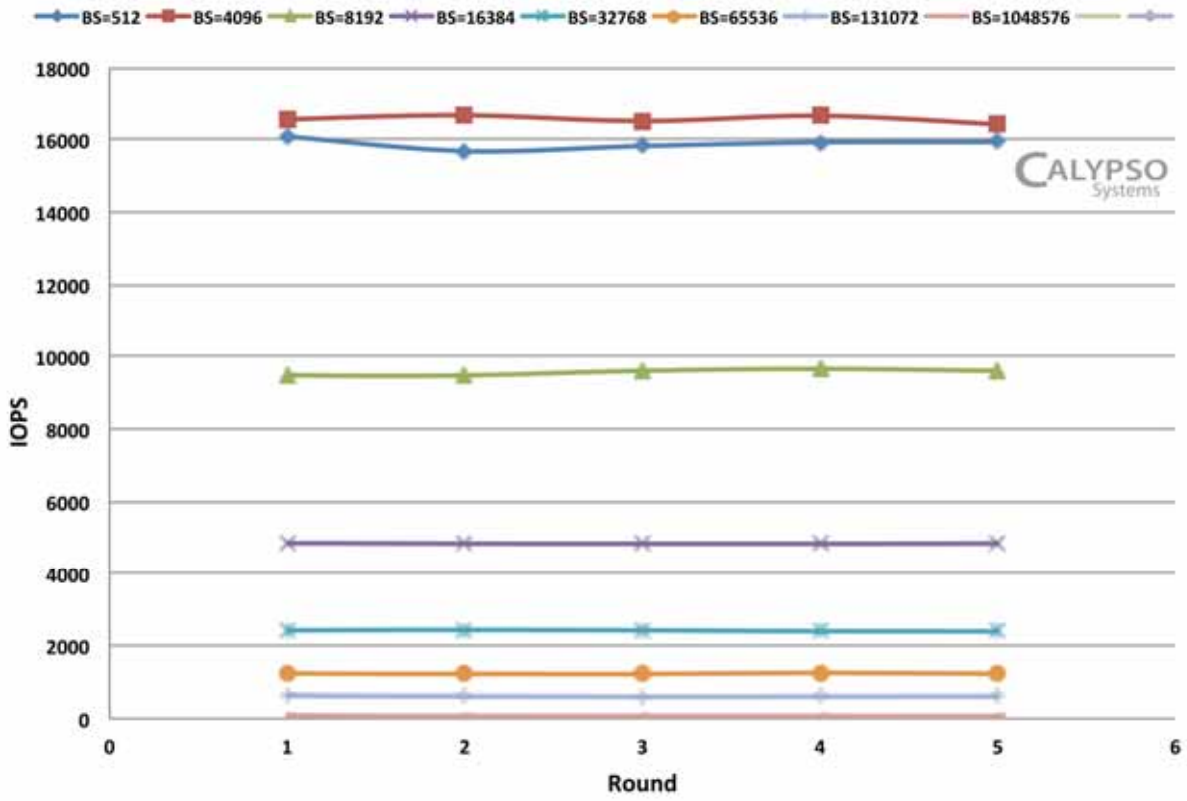
IOPS Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	IOPS - Block Size x RW Mix Matrix	Rev.	PTS-E 1.1
			Page	1 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	IOPS Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 2/ QD 16	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	IOPS Loop	Steady State	1 - 5
Test ID No.	RS-456	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	N/A

IOPS Steady State Convergence Plot – All Block Sizes



Plot 7-1 - IOPS SS Convergence Report

7.3.4 Steady State Verification

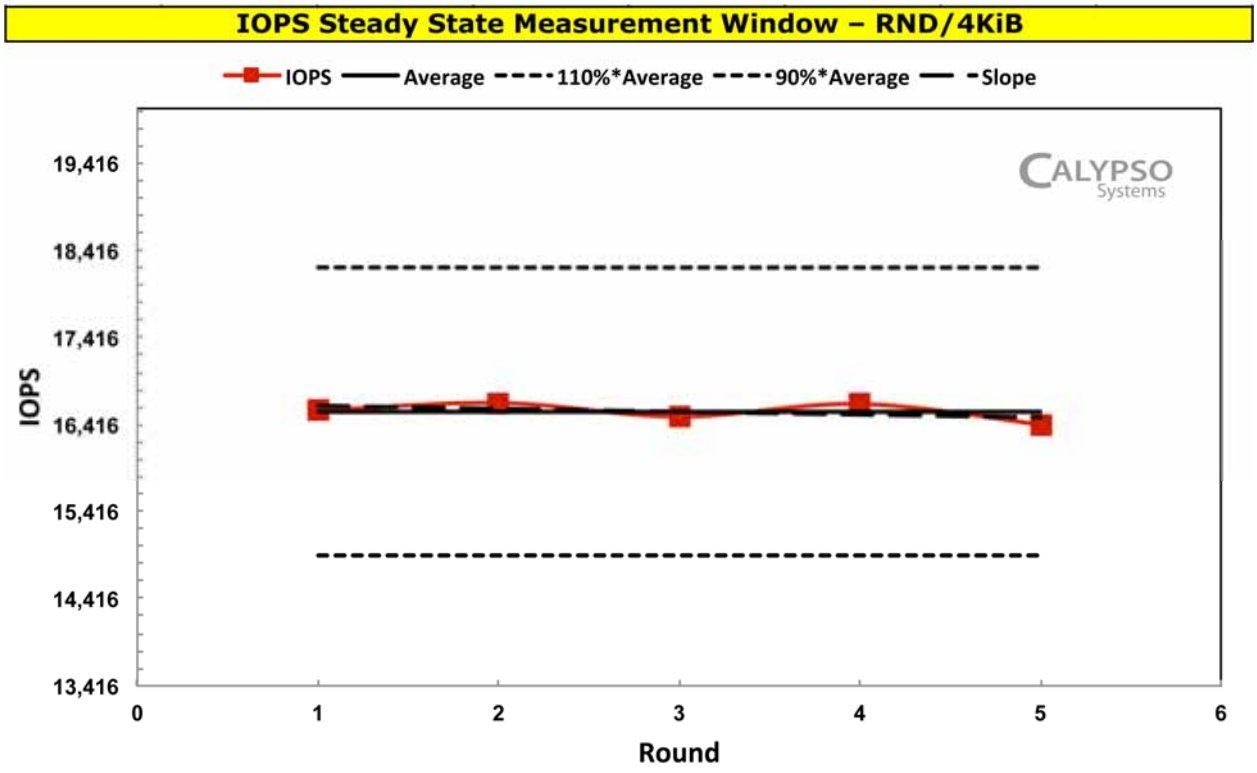
The Test Operator shall document the following for Steady State Verification, using Ave 4KiB Random Write IOPS as the dependent variable:

IOPS Test - Steady State Verification
Dependent Variable = Ave 4KiB Random Write IOPS
ActiveRange = (x,y); OIO/Thread = x; Thread Count = x; Data Pattern = x

- Measurement Window: Start __; End __
- Ave. value in Measurement Window: __
- Calculated allowed range in Measurement Window (+-10% of Ave.): Max__; Min __
- Measured range in Measurement Window: Max __; Min __ (pass/fail)
- Slope of best linear fit in Measurement Window (must be <= 10%): __% (pass/fail)
- Correlation coefficient for best linear fit: __

7.3.5 Steady State Measurement Window

The Test Operator shall include a plot showing the Steady State Measurement Window, as shown in Plot 7-2, including the test set up and parameters set forth in the Report Header (see Annex A to see Report Header).



Steady State Determination Data

Average IOPS:			16563.0
Allowed Maximum Data Excursion:	3312.6	Measured Maximum Data Excursion:	248.3
Allowed Maximum Slope Excursion:	1656.3	Measured Maximum Slope Excursion:	128.6
Least Squares Linear Fit Formula:			-32.143 * R + 16659.425

Plot 7-2 - IOPS SS Measurement Window

7.3.6 Measurement Window Report

The results for the test shall be reported in the following series of tables and graphs (7.3.6.1 - 7.3.6.3) that record and report the data from the Steady State Measurement Window.

7.3.6.1 IOPS Measurement Window Tabular Data

The Test Operator shall include a plot showing an IOPS Tabular Data, as shown in Plot 7-3, including the test set up and parameters set forth in the Report Header. See Annex A.

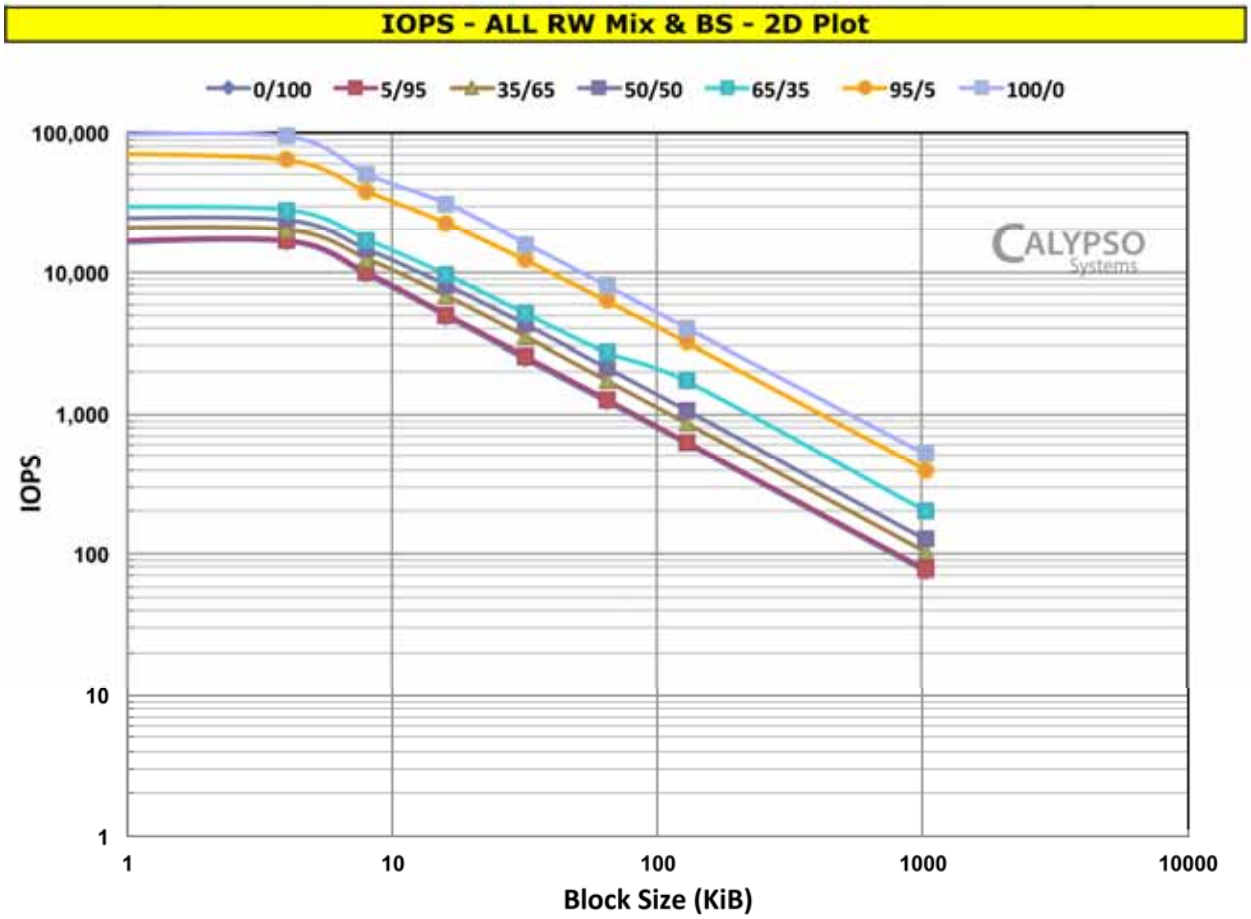
IOPS - ALL RW Mix & BS – Tabular Data							
Block Size (KiB)	Read / Write Mix %						
	0/100	5/95	35/65	50/50	65/35	95/5	100/0
0.5	15,887.4	16,634.7	20,678.6	24,402.8	29,386.2	72,428.4	95,924.3
4	16,563.0	17,032.2	20,234.2	23,705.2	28,018.6	63,447.7	93,707.0
8	9,559.8	9,998.4	12,547.1	14,636.6	17,199.1	37,872.9	50,301.2
16	4,842.2	5,032.3	6,802.5	8,132.1	9,655.8	22,462.2	31,072.8
32	2,413.3	2,535.4	3,478.4	4,241.3	5,061.7	12,174.7	15,994.2
64	1,219.2	1,275.7	1,728.4	2,126.1	2,726.3	6,284.6	8,094.9
128	612.7	632.5	859.1	1,061.4	1,709.4	3,205.7	4,060.8
1024	74.8	78.0	103.6	126.7	202.7	398.8	514.6

Plot 7-3 - IOPS Measurement Window Tabular Data

Each entry in the table is the average of the values in the five Rounds comprising the Steady State Measurement Window, for the selected (R/W Mix%, Block Size) element.

7.3.6.2 IOPS Measurement Plot – 2D

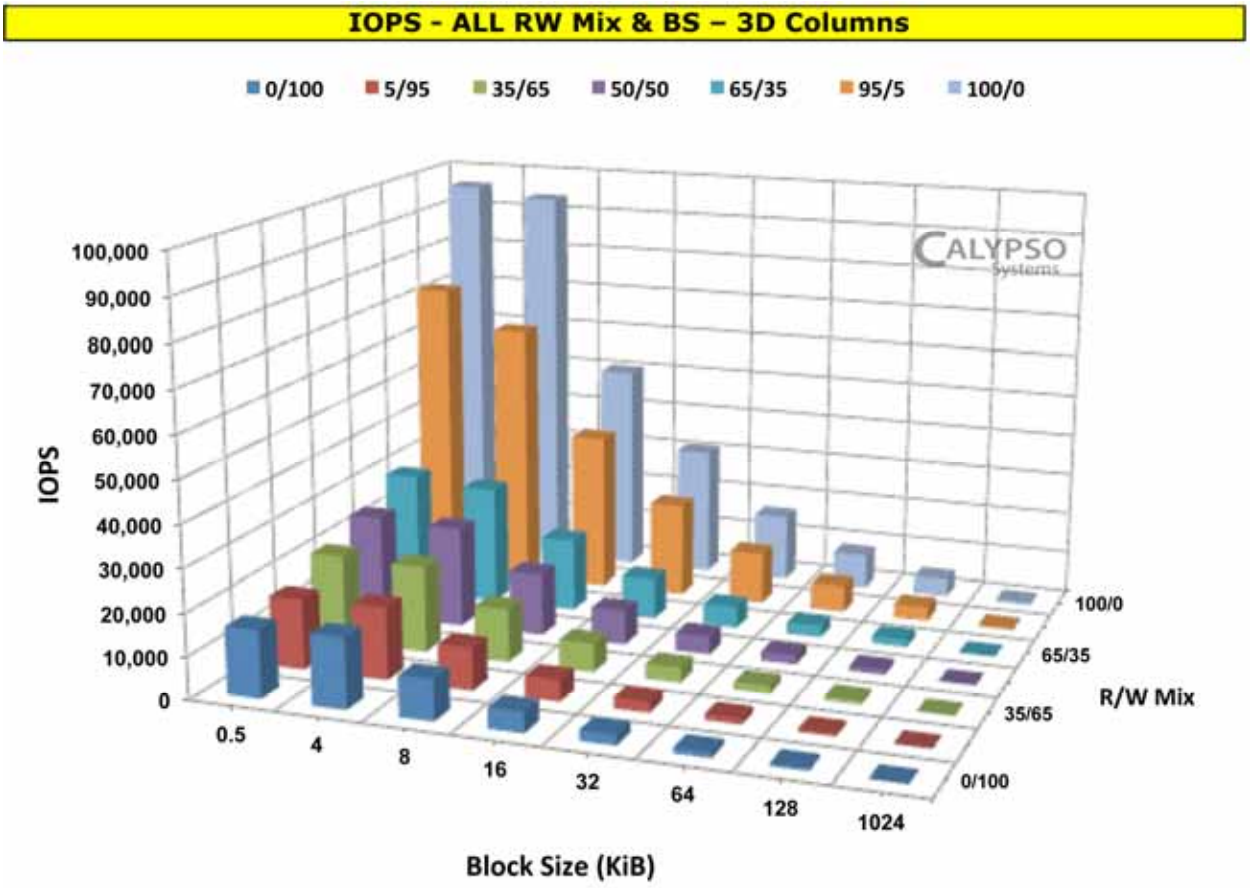
The Test Operator shall include a plot showing an IOPS 2D Plot, as shown in Plot 7-4, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.



Plot 7-4 - IOPS Measurement Plot – 2D

7.3.6.3 IOPS Measurement Plot – 3D

The Test Operator shall include a plot showing an IOPS 3D Plot, as shown in Plot 7-5, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.



Plot 7-5 - IOPS Measurement Plot – 3D

8 Throughput Test

8.1 Throughput (TP) Descriptive Note

General Purpose:

Enterprise Throughput test is intended to measure the test SSD Throughput (TP) at two Block Sizes (128KiB and 1024KiB) at Sequential Read/Write (100/0, 0/100) during Steady State. This Enterprise TP test is intended to present the test SSD data transfer rate in MB/s for the prescribed R/W Mixes and Block Sizes. The intent of the TP test is to determine how fast the test SSD can transfer Sequential data without limitation from the IO Bus.

Test Flow:
The Enterprise TP tests are separate tests for each Block Size and makes use of:

1) a preconditioning LBA ActiveRange of 100% (section 2.1);
2) a one step Workload Independent PC (section2.1.16 a) consisting of 128KiB SEQ W, or optionally 1024KiB for the 1024KiB TP test, for 2X (twice) the user capacity; and
3) a one step Workload Dependent PC (WDPC) (section2.1.16 b) consisting of the test stimulus at each Block Size over the ActiveRange until Steady State, as defined, is achieved.

Test Results:
The test results captured during steady state measurement window shall be tabulated and plotted as specified in Section 8.

Test Interpretation:
A higher value (greater MB/s) is better.

8.2 TP Pseudo Code

```
For (ActiveRange(0:100), optional ActiveRange(Test Operator Choice))

  For (Block Size = 128KiB, 1024KiB)

    1 Purge the device. (Note: ActiveRange Amount and other Test Parameters are
      not applicable to Purge step; any values can be used and none need to be
      reported.)

    2 Workload Independent Preconditioning
        1.1.    Set and record parameters for later reporting.
          2.1.1 Volatile Write cache: disabled
          2.1.2 Thread Count: Test Operator Choice
          2.1.3 OIO/Thread: Test Operator Choice*
          2.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice


      2.2 Run SEQ WIPC - Write 2X User Capacity w/ 128KiB SEQ writes, or
          optionally run 1024KiB writes for the 1024KiB TP test, to the entire
          ActiveRange without any LBA restrictions.

    3 Run Workload Dependent Preconditioning and Test Stimulus

      3.1 Set parameters and record for later reporting
          3.1.1 Volatile Write cache: disabled
          3.1.2 Thread Count: Same as in step 2.1 above.
          3.1.3 OIO/Thread: Same as in step 2.1 above.
          3.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice
```

```
    3.2  Run the following until Steady State is reached, or maximum of 25
         Rounds
         3.2.1 For (R/W Mix % = 100/0, 0/100)

            3.2.1.1  Execute SEQ IO, per (R/W Mix%, Block Size) for 1 minute
            3.2.1.2  Record Ave MB/s (R/W Mix%, Block Size)
            3.2.1.3  Use Ave MB/s (RW Mix%, Block Size) to detect Steady State.
            3.2.1.4  If Steady State is not reached by Round x=25, then the Test
                     Operator may continue running the test until Steady State
                     is reached, or may stop the test at Round x. The
                     Measurement Window is defined as Round x-4 to Round x.
            3.2.1.5  Note that the sequential accesses shall be continuous and
                     use the entire ActiveRange between test steps.
         3.2.2 End (For R/W Mix%) Loop


  4 Process and plot the accumulated Rounds data, per report guidelines in
    Section 8.3, based on current values of ActiveRange, etc.
End (For ActiveRange) loop
```

8.3 Test Specific Reporting for Throughput Test

Sections 8.3.1 through 8.3.7 list the reporting requirements specific to the Throughput test. Reporting requirements common to all tests are documented in Section 5. See also Annex A.

If Steady State was reached at Round x, the Test Operator shall:

- Plot Rounds 1:x per “Throughput Steady State Convergence Plot”;
- Plot Rounds (x-4):x per “Throughput Steady State Verification Plot”; and
- Plot Rounds (x-4):x per “Throughput Measurement Plot.”

If Steady State was not reached then the Test Operator may report results per above, picking the last Round run as Round x. In the case where Steady State was not reached, the Test Operator must state this fact in the final report.

8.3.1 Purge Report

The Test Operator shall report the method used to run the Purge operation.

8.3.2 Preconditioning Report

The Test Operator shall report both Workload Independent and Workload Dependent preconditioning information as shown in the Report Headers that follow.

> **Note on Headers**: The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

8.3.3 Steady State Convergence Report - Write

The Test Operator shall generate a Steady State Convergence Report Write, as shown in Plot 8-1, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

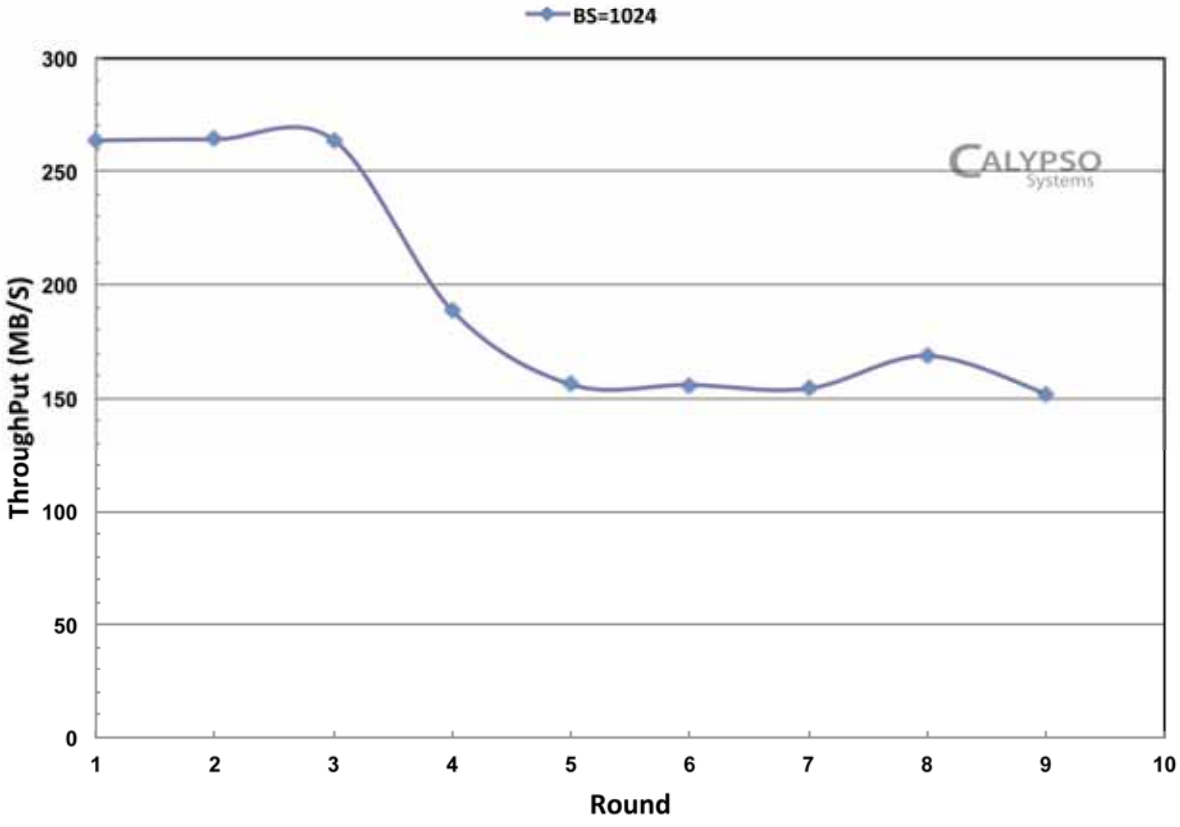
Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB & SEQ 128KiB	Rev.	PTS-E 1.1
			Page	1 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-897	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

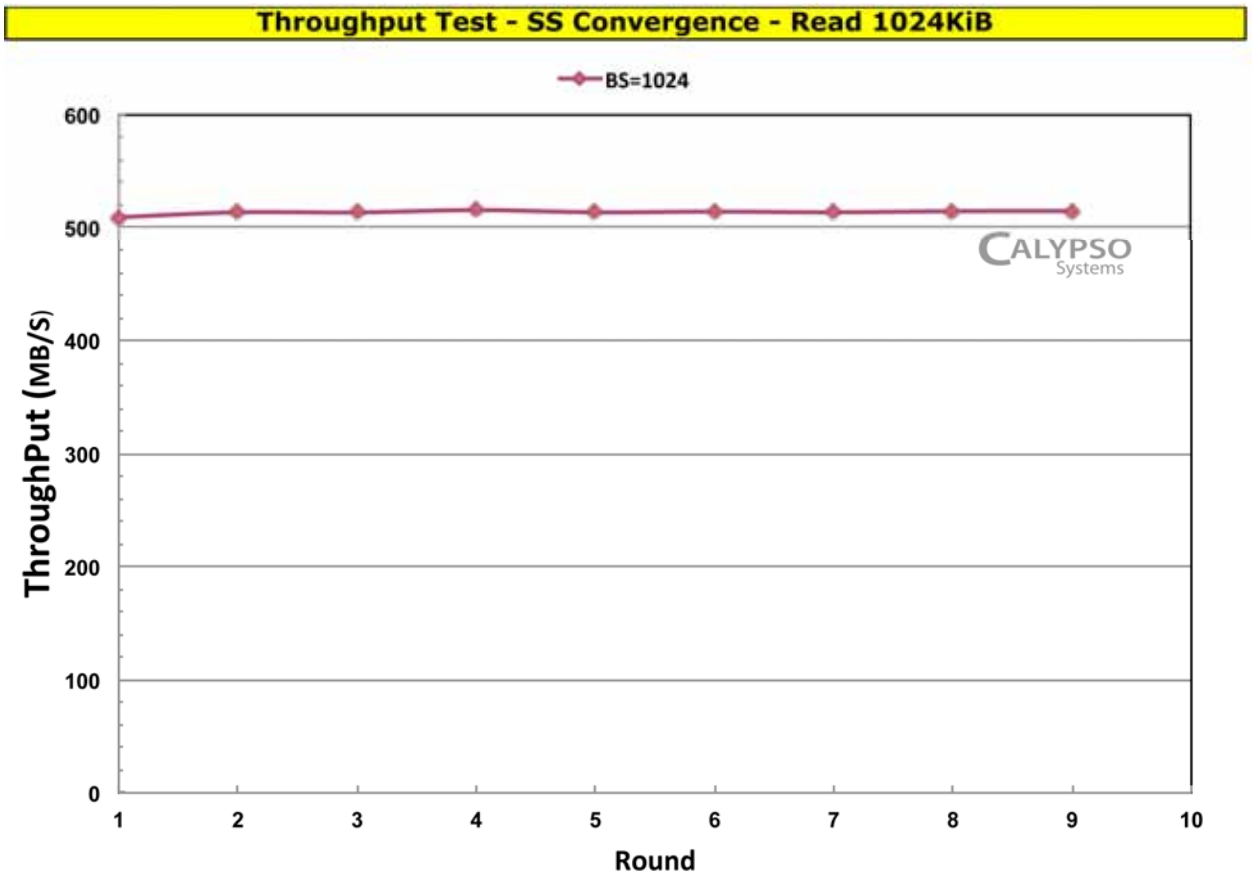
Throughput Test - SS Convergence - Write 1024KiB



Plot 8-1 - TP SS Convergence Report Write

8.3.4 Steady State Convergence Report - Read

The Test Operator shall include a plot showing the Steady State Convergence Report Read, as shown in Plot 8-2, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.



Plot 8-2 - TP SS Convergence Report Read

8.3.5 Steady State Verification Report

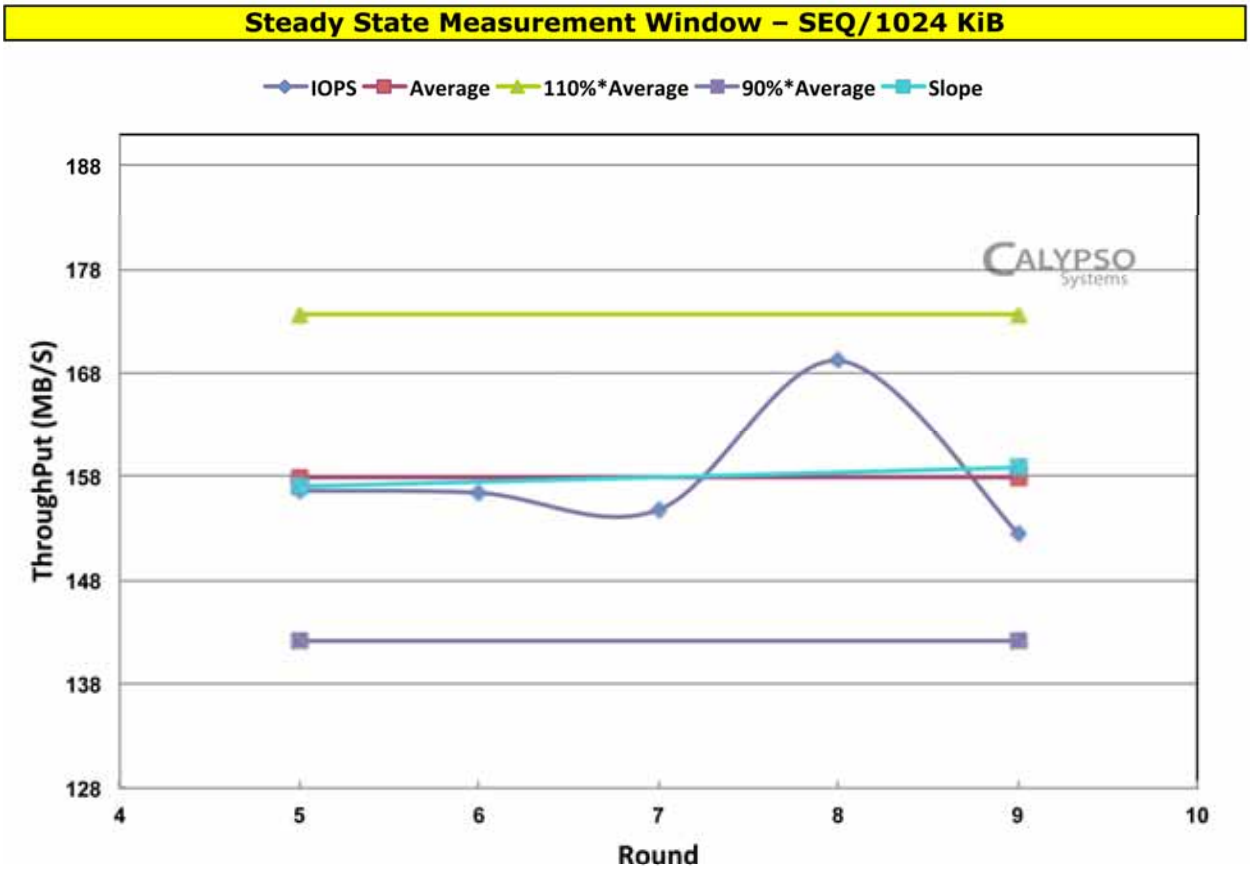
The Test Operator shall document the following for Steady State Verification, using, depending on the test Block Size, *Ave 128KiB or 1024KiB Sequential Write MB/s* as the dependent variable:

- Measurement Window: Start __; End __
- Ave. value in Measurement Window: __
- Calculated allowed range in Measurement Window (+-10% of Ave.): Max__; Min __
- Measured range in Measurement Window: Max __; Min __ (pass/fail)
- Slope of best linear fit in Measurement Window (must be <= 10%): __% (pass/fail)
- Correlation coefficient for best linear fit: __

8.3.6 Steady State Measurement Window

The Test Operator shall include a plot showing the Steady State Measurement Window, as shown in Plot 8-3, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.

.



Steady State Determination Data

Average ThroughPut:			**157.5**
Allowed Maximum Data Excursion:	**31.5**	Measured Maximum Data Excursion:	**16.6**
Allowed Maximum Slope Excursion:	**15.7**	Measured Maximum Slope Excursion:	**1.9**
Least Squares Linear Fit Formula:			**0.470 * R + 154.165**

Plot 8-3 - TP SS Measurement Window

8.3.7 Measurement Window Report

The results for the test must be reported in the following series of tables and graphs (Plot 8-4 through Plot 8-7) that record and report the data from the Steady State Measurement Window.

8.3.7.1 TP Measurement Window Tabular Data - 1024KiB

The Test Operator shall include a plot showing a Throughput Tabular Data, as shown in Plot 8-4, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.

.

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	4 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-897	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput - ALL RW Mix & BS – Tabular Data 1024KiB

Block Size (KiB)	Read / Write Mix %	
	0/100	100/0
1024	157.5	514.3

Plot 8-4: TP Measurement Window Tabular Data – 1024KiB

Each entry in the table is the average of the values in the five Rounds comprising the Steady State Measurement Window, for the selected (R/W Mix%, Block Size) element.

8.3.7.2 Measurement Window Summary Data Table 128KiB

The Test Operator shall include a plot showing a Throughput 2D Plot for Block Size 128KiB, as shown in Plot 8-5, including the test set up and parameters set forth in the Report Header. See Annex A.

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB / SEQ 128KiB	Rev.	PTS-E 1.1
			Page	9 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-891	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput - ALL RW Mix & BS – Tabular Data 128KiB

Block Size (KiB)	Read / Write Mix %	
	0/100	100/0
128	144.5	409.3

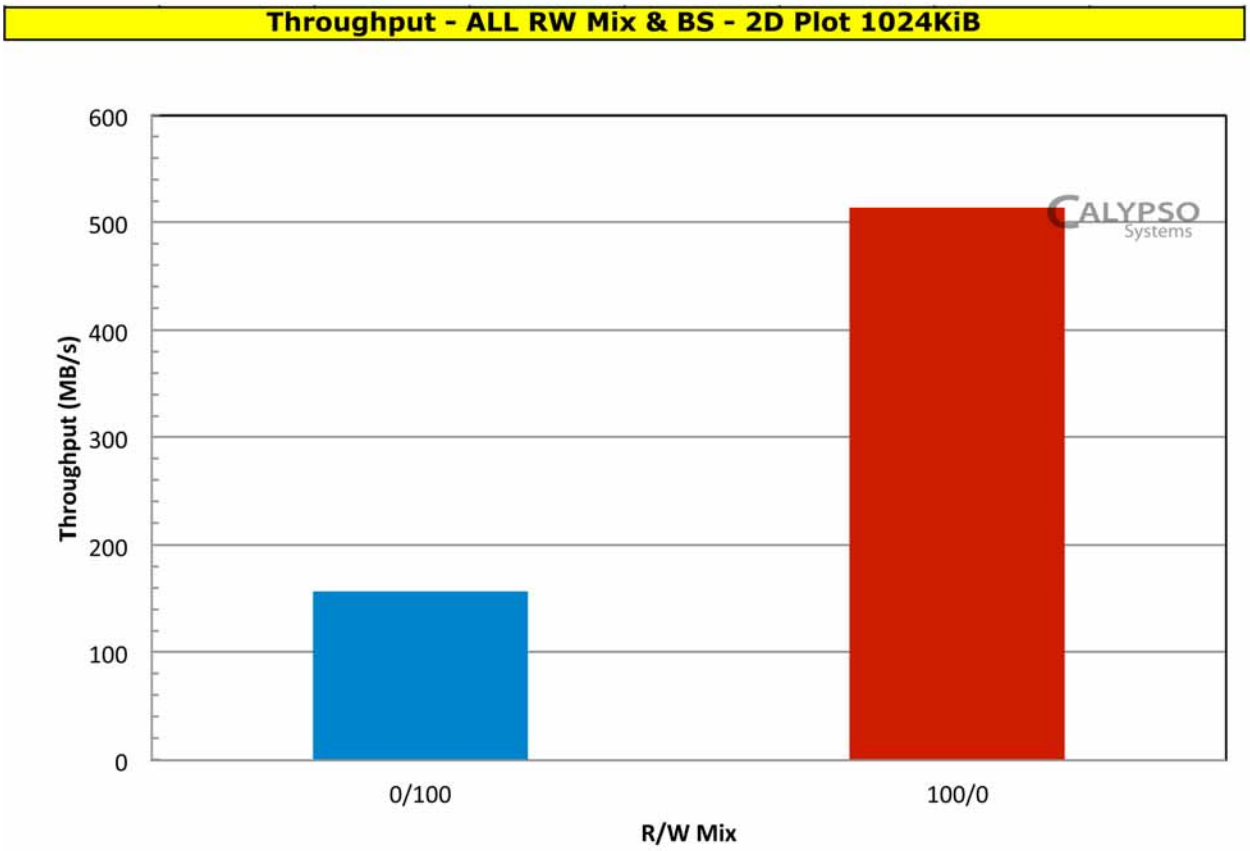
Plot 8-5 - TP Measurement Window Tabular Data – 128KiB

Each entry in the table is the average of the values in the data series *Average_MB/s(x,y)*, recorded in the per-Round MB/s matrices within the Measurement Window, for the selected (R/W Mix%, Block Size) pair.

8.3.7.3 TP Measurement Plot - 2D SEQ 1024KiB

The Test Operator shall include a plot showing a Throughput 2D Plot for Block Size 1024KiB, as shown in Plot 8-6, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.

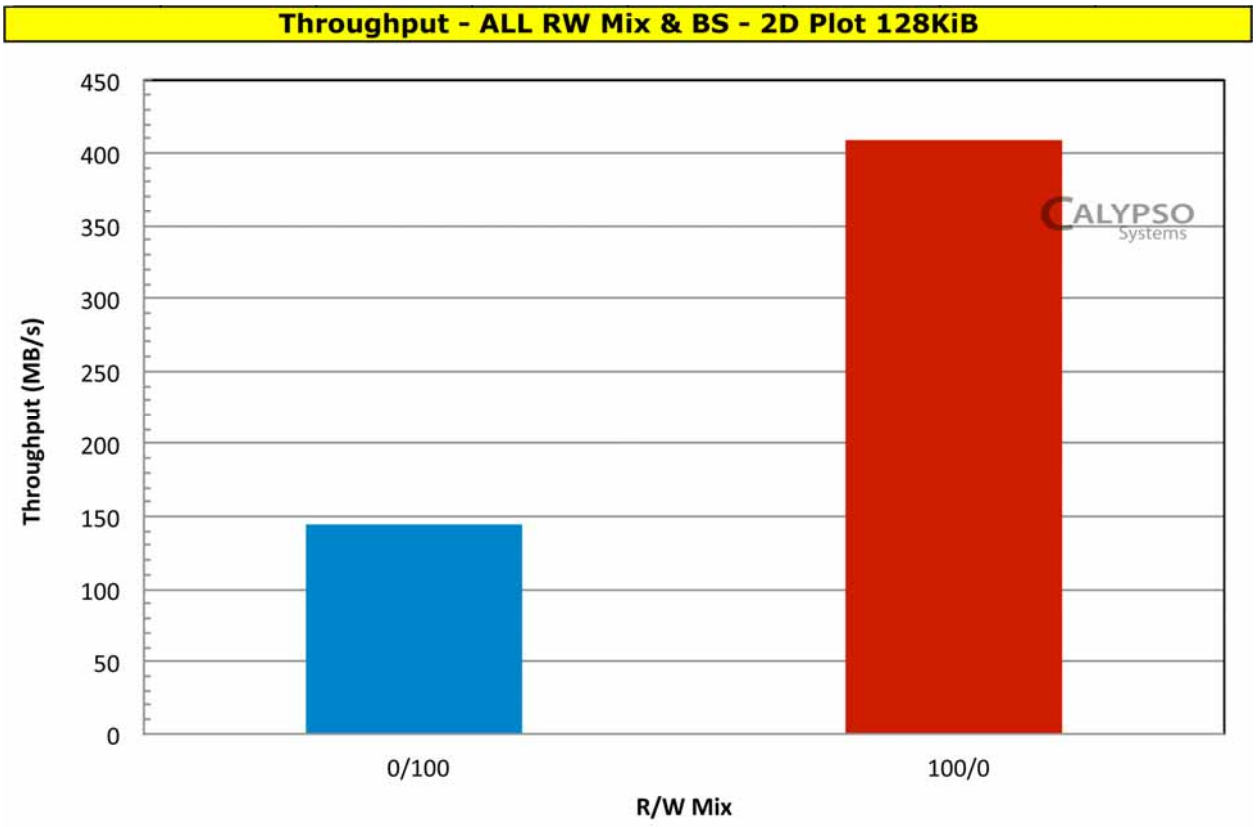
.



Plot 8-6 - TP Measurement Plot – 2D SEQ 1024KiB

8.3.7.4 Measurement Plot SEQ 128KiB– 2D

The Test Operator shall include a plot showing a Throughput 2D Plot for Block Size 128KiB, as shown in Plot 8-7, including the test set up and parameters set forth in the Report Header. See Annex A to view Header.



Plot 8-7 - TP Measurement Plot – 2D SEQ 128KiB

9 Latency Test

9.1 Latency (LAT) Descriptive Note

General Purpose:

Enterprise Latency test is intended to measure the test SSD response time at 3 Block Sizes (8KiB, 4KiB and 0.5KiB) and 3 Read/Write mixes (100/0, 65/35, 0/100) using 100% preconditioning and 100% Test ActiveRange. This Latency test is intended to observe how well the test SSD handles a single OIO without the benefit of queuing.

This Enterprise Latency test is intended to present Average and Maximum Response Times (Latency) at a total outstanding IO of 1 (one Thread and a single OIO/Thread (Queue Depth)). The Latency measurement is inherently dependent on the treatment of the outstanding IOs by the host hardware and software test platform. An OIO of 1 is set to normalize the impact of the test system (as OIO >1 may be treated differently by different test hardware).

Test Flow:

The Enterprise Latency test makes use of:

1) preconditioning to the entire LBA ActiveRange (section 2.1.1);

2) a one step Workload Independent PC (section 2.1.6a) consisting of 128KiB SEQ W for 2X (twice) the user capacity; and

3) a one step Workload Dependent PC (WDPC) (section 2.1.6b) consisting of the Latency loop over the LBA ActiveRange until Steady State, as defined, is achieved.

Test Results:

The test results captured during steady state measurement window shall be tabulated and plotted as specified in section 9.3.

Test Interpretation:

A lower value (lower msec) is better.

9.2 LAT Pseudo Code

```
For (ActiveRange(0:100), optional ActiveRange(Test Operator Choice))
```

1 Purge the device. (Note: Active Range and other Test Parameters are not applicable to Purge step; any values can be used and none need to be reported.)

2 Run Workload Independent Preconditioning

```
2.1  Set test parameters and record for later reporting
     2.1.1 Device volatile write cache = disabled
     2.1.2 OIO/Thread: 1
     2.1.3 Thread Count: 1
     2.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice
2.2  Run SEQ Workload Independent Preconditioning - Write 2X User Capacity
     w/ 128KiB sequential writes, writing to the entire ActiveRange.
```

3 Run the Workload Dependent Preconditioning test loop until Steady State is reached, or maximum of 25 Rounds:

```
3.1  For (R/W% = 100/0, 65/35, 0/100)
     3.1.1 For (Block Size = 8KiB, 4KiB, 0.5KiB)
           3.1.1.1.1 Execute RND IO per (R/W%, Block Size), for 1 minute
        3.1.1.2 Record Max and Ave Latency (R/W%, Block Size)
```

3.1.1.3 Use Ave Latency (R/W Mix%=0/100, Block Size=4KiB) to detect Steady State.

3.1.1.4 If Steady State is not reached by Round x=25, then the Test Operator may either continue running the test until Steady State is reached, or may stop the test at Round x. The Measurement Window is defined as Round x-4 to Round x

3.1.2 End (For Block Size) Loop

3.2 End (For R/W Mix %) Loop

4 Process and plot the accumulated Rounds data, per report guidelines in next section.

End "For ActiveRange" loop

9.3 Test Specific Reporting for Latency Test

Sections 9.3.1 through 9.3.6 list the reporting requirements specific to the Latency test. Reporting requirements common to all tests are documented in Section 5. See also Annex A.

If Steady State was reached at Round x, the Test Operator shall:

- Plot Rounds 1:x per "Latency Test Steady State Convergence Plot";
- Plot Rounds (x-4):x per "Latency Test Throughput Steady State Verification Plot"; and
- Plot Rounds (x-4):x per "Latency Test Measurement Plot."

If Steady State was not reached then the Test Operator may report results per above, picking the last Round run as Round x. **In the case where Steady State was not reached, the Test Operator must state this fact in the final report.**

9.3.1 Purge

The Test Operator shall report the method used to run the Purge operation.

9.3.2 Preconditioning Report

The Test Operator shall report both Workload Independent and Workload Dependent preconditioning information as shown in the Report Headers that follow.

> **Note on Headers:** The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

9.3.3 Steady State Convergence Report

The Test Operator shall generate a Steady State Convergence plot, as shown in Plot 9-1, including the test set up and parameters set forth in the Report Header. See Annex A.

Test Run Date:	06/28/2011 05:07 AM	Report Run Date:	3/04/2013 08:47 AM

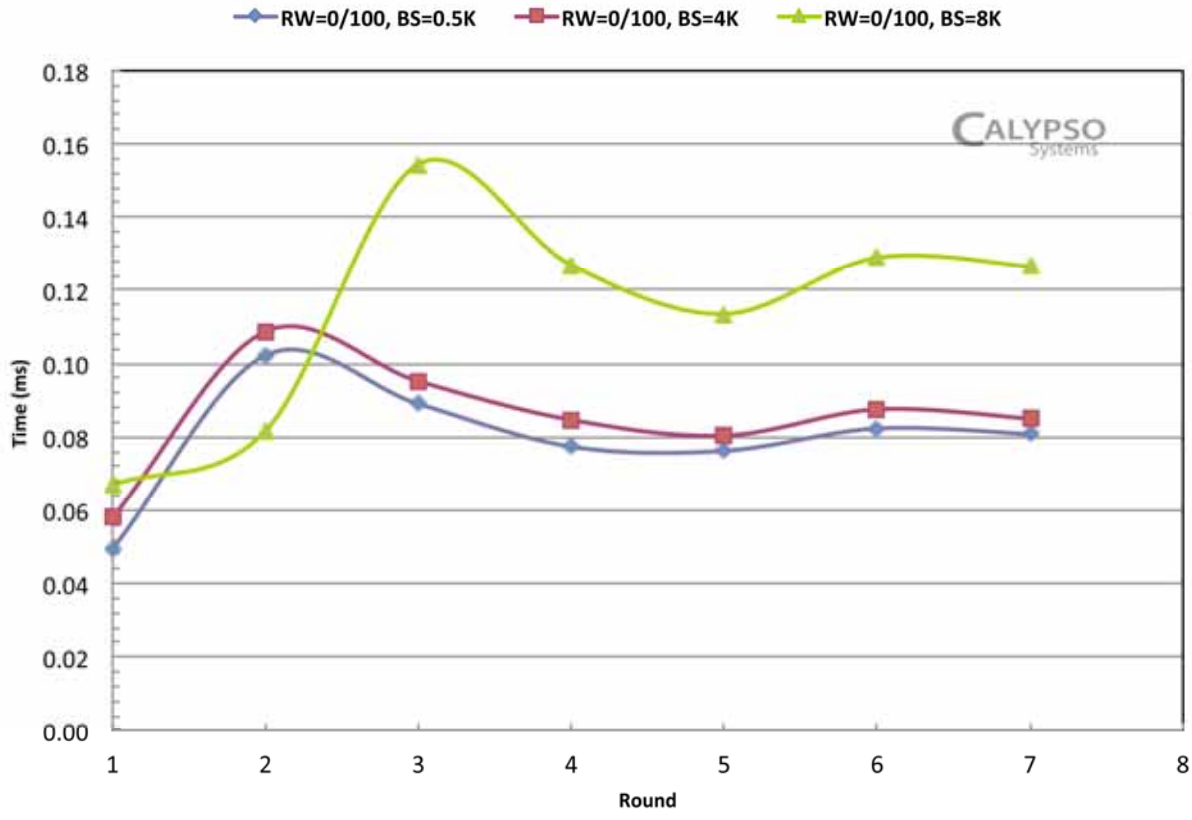
LATENCY Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	LATENCY - Response Time OIO=1	Rev.	PTS-E 1.1
			Page	1 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	LAT Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 1/QD 1
Test SW Info	1.10.9/1.9.16	NAND Type	SLC	Pre Condtion 2	LAT Loop	Steady State	3 - 7
Test ID No.	R5-523	PCIe NVM	N/A	TOIO - TC/QD	TC 1/ QD 1	Histogram	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	3 - 7	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Note	-

Steady State Convergence Plot – Average Latency - 100% Writes



Plot 9-1 - LAT SS Convergence Report

9.3.4 Steady State Verification Report

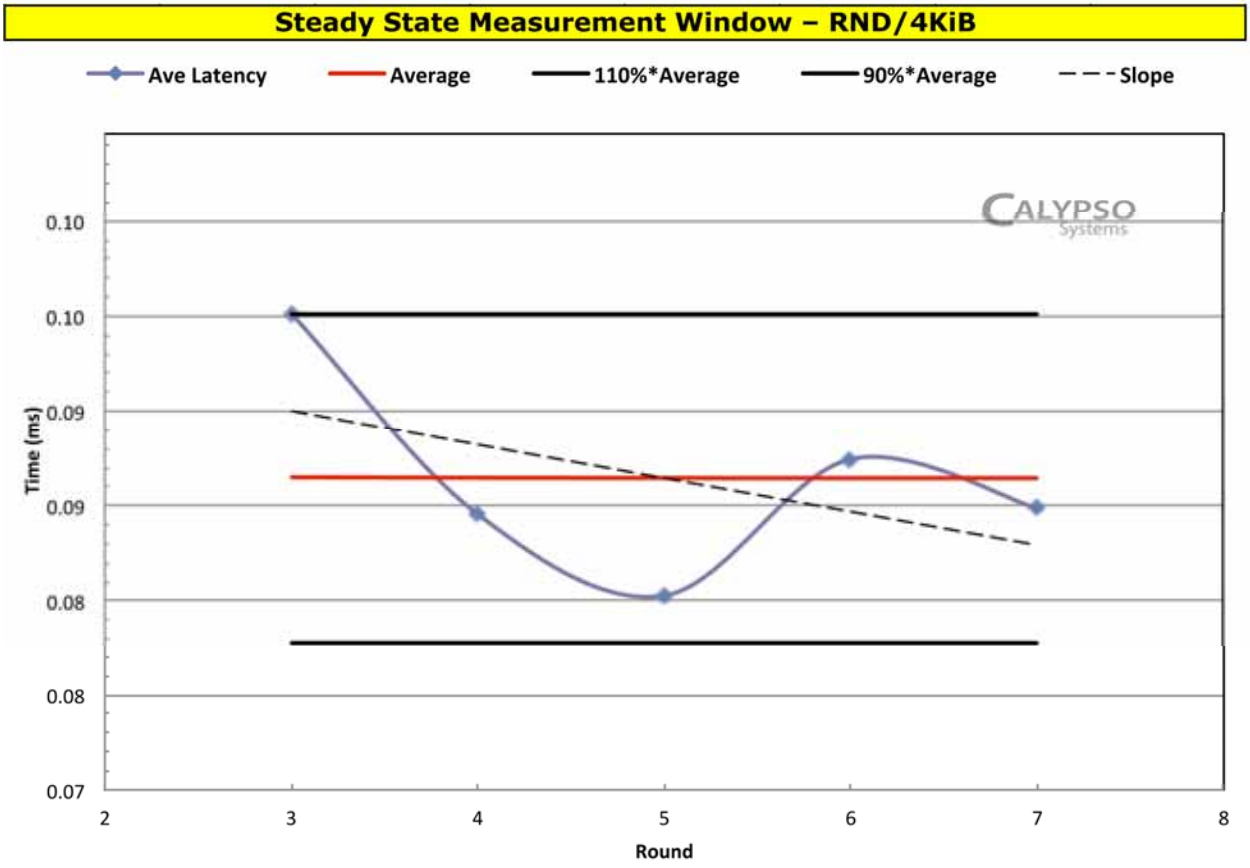
The Test Operator shall document the following for Steady State Verification, using *Ave 4KiB Random Write Latency (ms)* as the dependent variable:

- Measurement Window: Start __; End __
- Ave. value in Measurement Window: __
- Calculated allowed range in Measurement Window (+-10% of Ave.): Max__; Min __
- Measured range in Measurement Window: Max __; Min __ (pass/fail)
- Slope of best linear fit in Measurement Window (must be <= 10%): __% (pass/fail)
- Correlation coefficient for best linear fit: __

9.3.5 Steady State Measurement Window

The Test Operator shall include a plot showing the Steady State Measurement Window, as shown in Plot 9-2, including the test set up and parameters set forth in the Report Header. See Annex A to view Report Header.

.



Steady State Determination Data

Average Latency (ms):			**0.087**
Allowed Maximum Data Excursion:	**0.017**	Measured Maximum Data Excursion:	**0.015**
Allowed Maximum Slope Excursion:	**0.009**	Measured Maximum Slope Excursion:	**0.007**
Least Squares Linear Fit Formula:			**-0.002 * R + 0.095**

Plot 9-2 - LAT SS Measurement Window

9.3.6 Measurement Window Report

The results for the test must be reported in the following series of tables and graphs (Plot 9-3 through Plot 9-5) that record and report the data from the Steady State Measurement Window.

9.3.6.1 LAT Measurement Window Tabular Data

The Test Operator shall include a plot showing a Latency Tabular Data, as shown in Plot 9-3, including the test set up and parameters set forth in the Report Header. See Annex A to view Report Header.

Average and Maximum Response Time - ALL RW Mix & BS – Tabular Data

Average Response Time (ms)			
	Read / Write Mix %		
Block Size (KiB)	0/100	65/35	100/0
0.5	0.0811486	0.1307696	0.1470862
4	0.0865518	0.1386792	0.155532
8	0.1300188	0.1697318	0.171237

Maximum Response Time (ms)			
	Read / Write Mix %		
Block Size (KiB)	0/100	65/35	100/0
0.5	56.8668	39.4566	5.7996
4	32.6272	46.7808	6.2596
8	80.4266	39.3802	12.9866

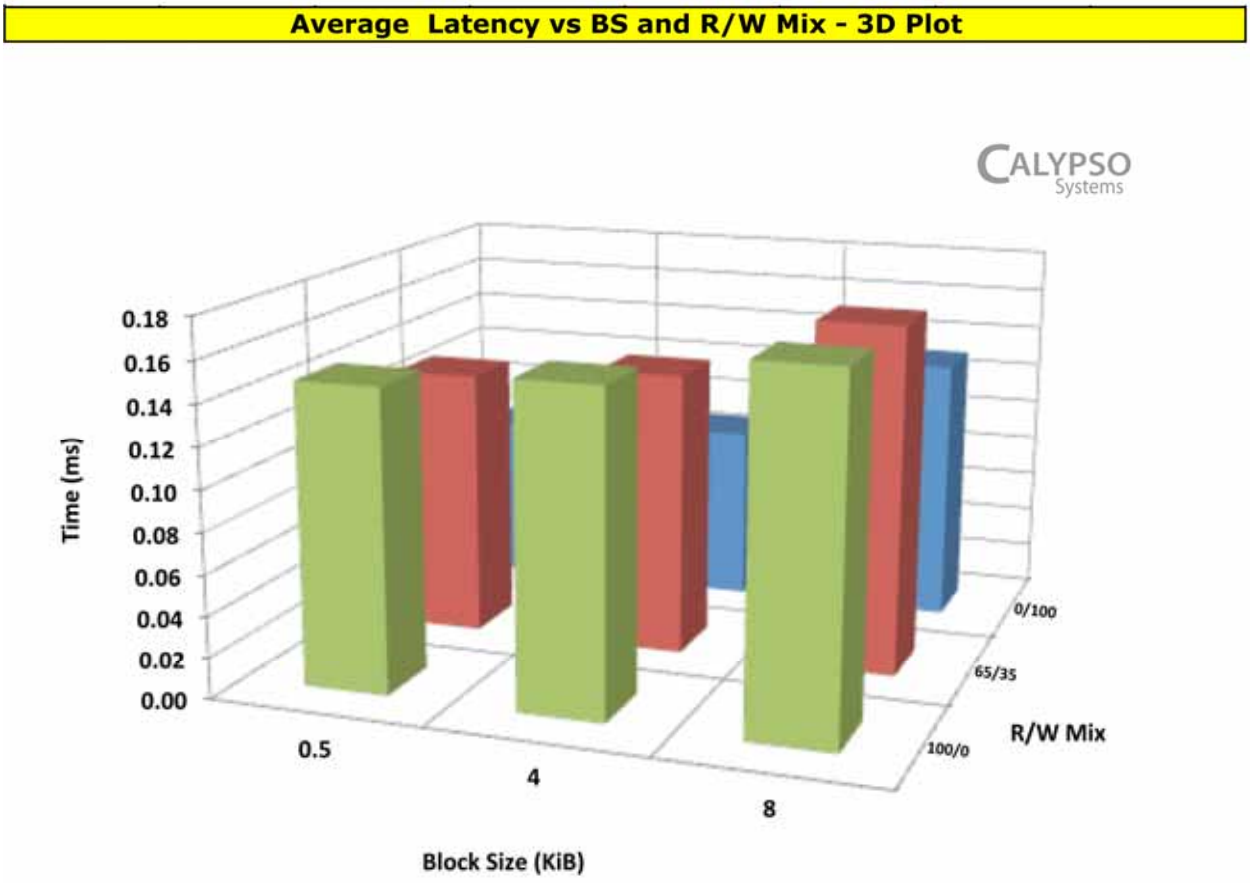
Plot 9-3 - LAT Measurement Window Tabular Data

Each entry in the Average table is the average values in the five Rounds comprising the Average Latency Steady State Measurement Window, for the selected (R/W Mix%, Block Size) element.

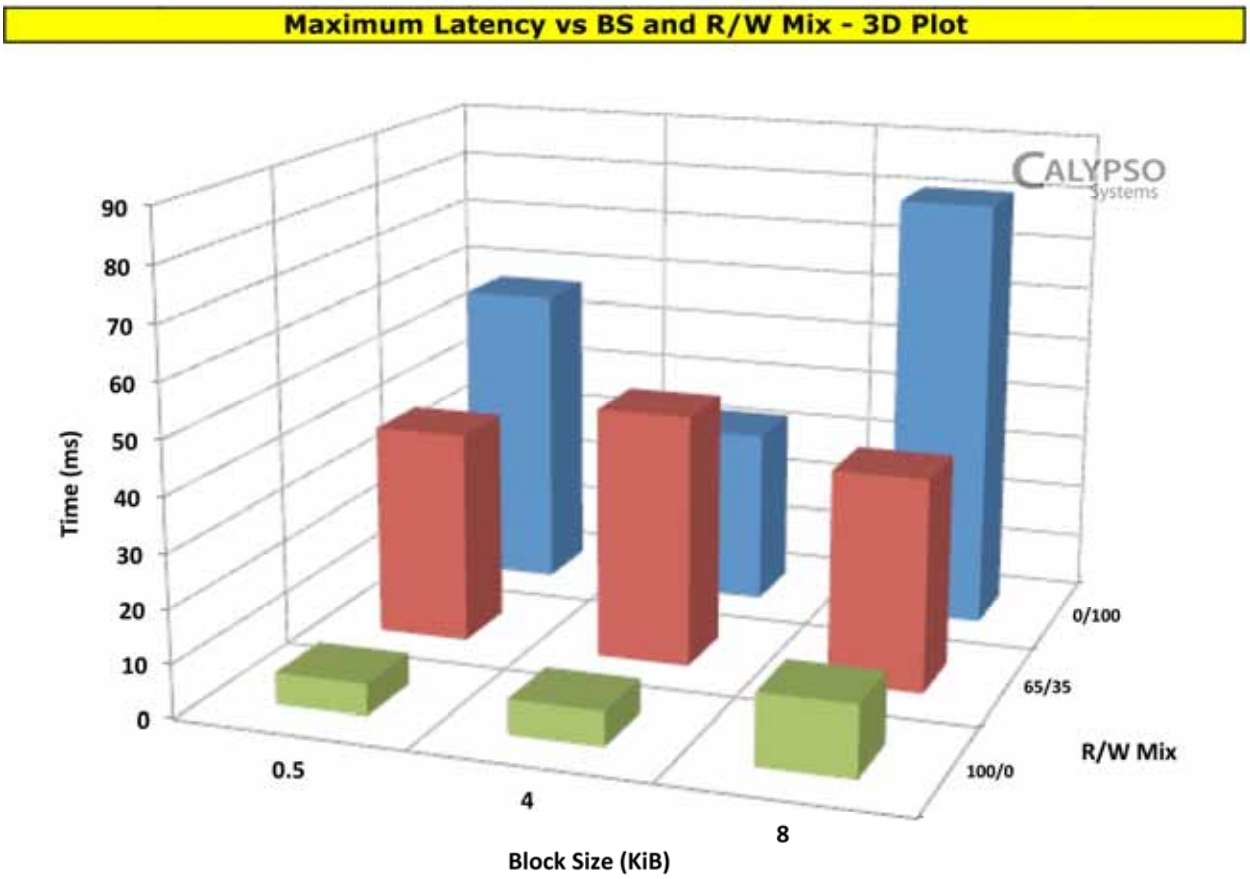
Each entry in the Maximum table is the maximum value in the five Rounds comprising the Maximum Latency Steady State Measurement Window, for the selected (R/W Mix%, Block Size) element.

9.3.6.2 LAT Measurement Window Plots: Average Latency and Maximum Latency 3D Plots

The Test Operator shall include a plot showing a Latency 3D Plot for Average and Maximum Latency, as shown in Plot 9-4 and Plot 9-5, including the test set up and parameters set forth in the Report Header. See Annex A to view Report Header.



Plot 9-4 - AVE LAT – 3D Plot



Plot 9-5 - MAX LAT – 3D Plot

10 Write Saturation Test

10.1 Write Saturation (WSAT) Descriptive Note

General Description:

The Enterprise WSAT test is designed to observe how the test SSD responds to continuous RND 4KiB Writes from a PURGED FOB state. This test is intended to demonstrate how the SSDs performance characteristics evolve over TIME and Total GB Written (TGBW) to WSAT Steady State.

Test Flow:

The Enterprise WSAT test makes use of:

1) a device PURGE, followed by
2) continuous RND 4KiB Writes for 24 hours or 4X the user capacity, whichever occurs first.

Test Results:

The test results captured for the 24 hours or 4X the user capacity shall be tabulated and plotted as specified in section 10.3.

> **Note**: the user may optionally run the WSAT test to Steady State using the average five-round steady state window defined in 2.1.21 using 1-minute test periods separated by 30 minutes of test stimulus.

Test Interpretation:

The test operator is encouraged to observe the initial peak IOPS values, the shape and length of the Transition Zones, and the level of IOPS at the "WSAT Steady State." Less drop off from peak FOB IOPS and a more level settled state with a smaller amplitude variation is better.

10.2 WSAT Pseudo Code

```
For (ActiveRange(0:100), optional ActiveRange(Test Operator Choice))
```

1 Purge the device. (Note: Active Range and other Test Parameters are not applicable to Purge step; any values can be used and none need to be reported.)

2 Run Test stimulus. Set test parameters and record for later reporting

```
  2.1  Set and record test conditions:
       2.1.1 Device volatile write cache = Disabled
       2.1.2 OIO/Thread: Test Operator Choice.
       2.1.3 Thread Count: Test Operator Choice.
       2.1.4 Data Pattern: Required= Random, Optional = Test Operator Choice.
  2.2  Run the following test stimulus until 4X user Capacity is written, 24
       hours, or five round steady state as defined in 10.3.2, whichever
       occurs first.
       2.2.1 Execute RND IO (R/W Mix 100% W, Block Size 4KiB), for 1 minute
       2.2.2 Record Ave IOPS, Max and Ave Latency
  2.3  Process and plot the accumulated Rounds data, per report guidelines in
       next section.
End "For ActiveRange" loop
```

After generating report data for current parameter values, the Test Operator may re-run “For ActiveRange” loop with alternate Test Parameters, if specified in (2), and may also run the entire test again with an optional value (or values) of ActiveRange.

10.3 Test Specific Reporting for Write Saturation Test

Sections 10.3.1 and 10.3.3 list the reporting requirements specific to the Write Saturation test. Reporting requirements common to all tests are documented in Section 5. See also Annex A.

10.3.1 Purge Report

The Test Operator shall report the method used to run the Purge operation.

10.3.2 Steady State Measurement

The test operator shall run the stimulus for the capacity or time set forth in the pseudo code Section 10.2 above OR until Steady State is achieved by calculating a five Round average as defined in 2.1.21 using one-minute test periods separated by 30 minutes of stimulus.

10.3.3 Measurement Report

The Test Operator shall generate Measurement Plots for WSAT plotting IOPS v Time and IOPS v TGBW and should follow the format shown in Plot 10-1 and Plot 10-2.

> Note on Headers: The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

Test Run Date:	11/07/11 08:40 AM	Report Run Date:	3/14/2013 08:45 AM

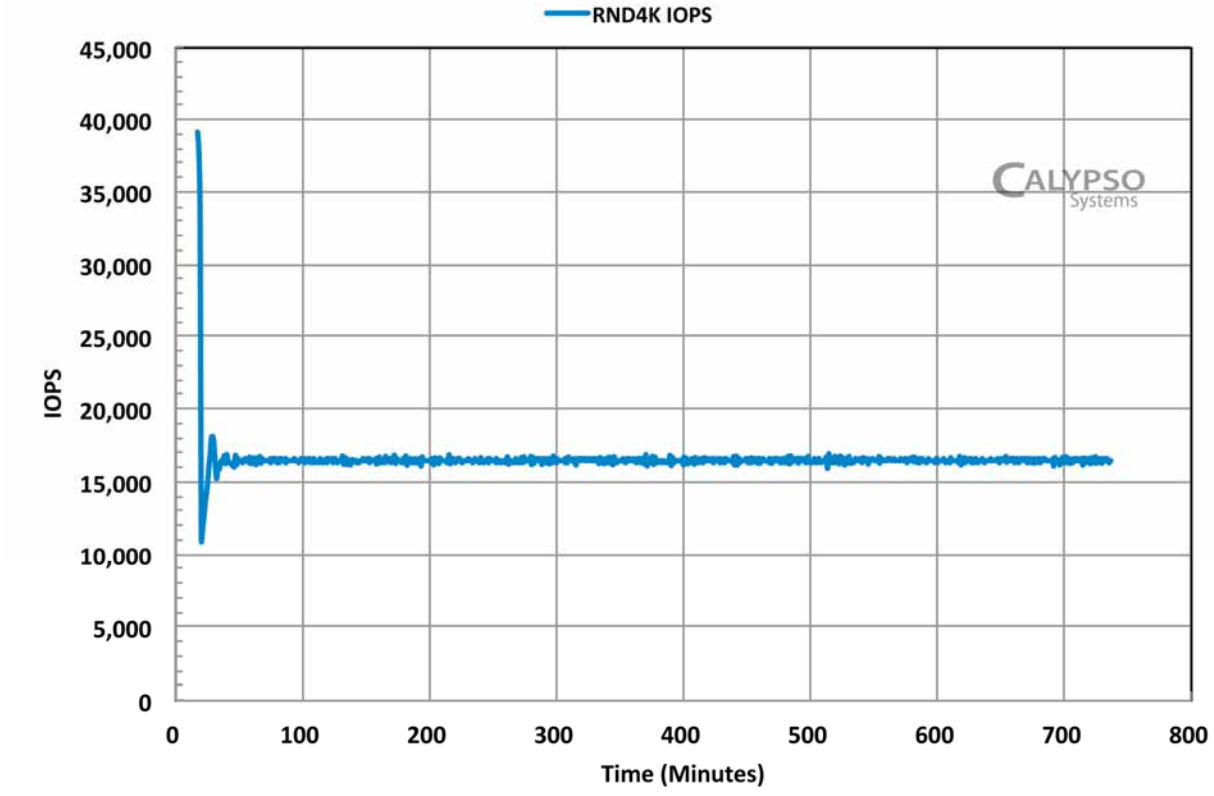
Write Saturation Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	WSAT - RND 4KiB 100% W	Rev.	PTS-E 1.1
			Page	1 of 4

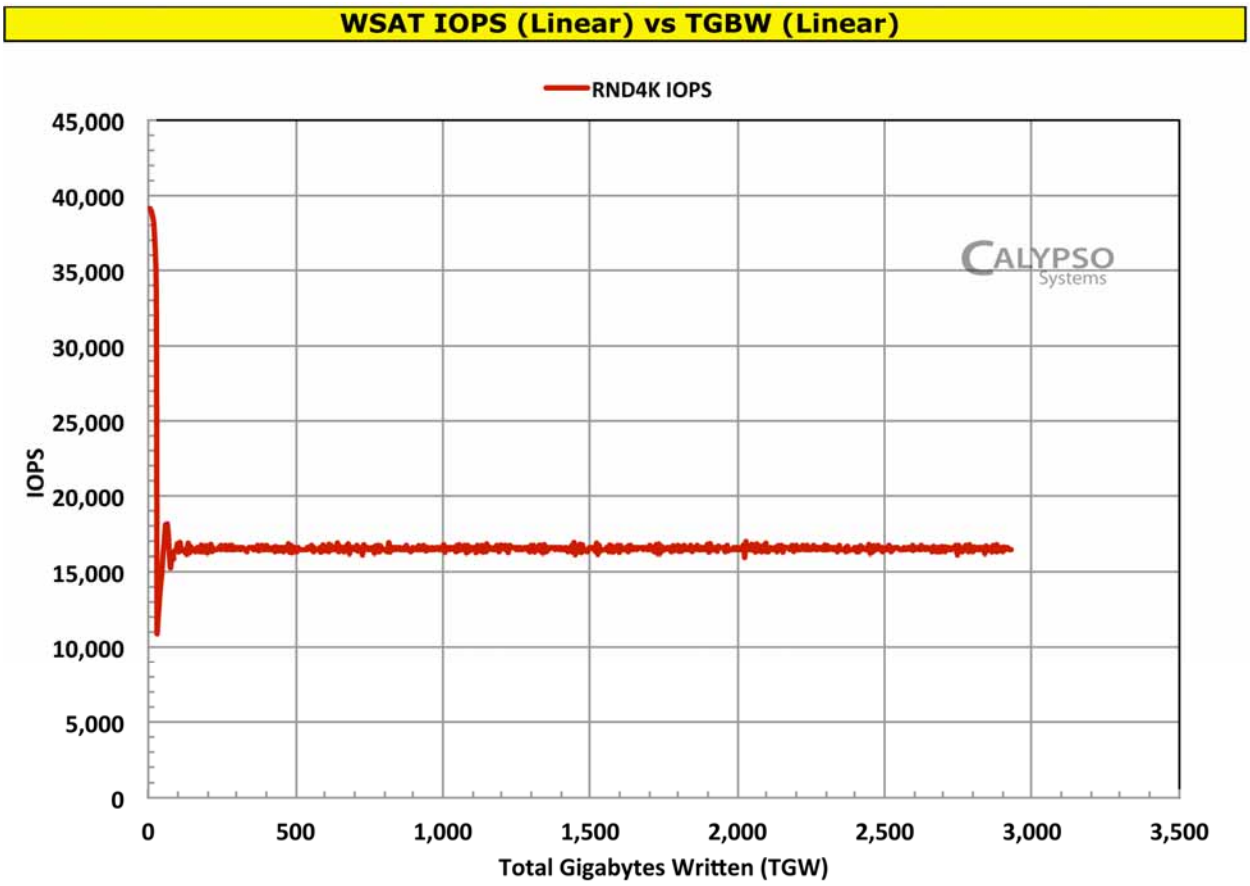
Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	RND 4KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	None	TOIO - TC/QD	TC 2/QD 16
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	-	Steady State	N/A
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	SS Rounds	-	Time	6 Hr
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	None	Test Stimulus 2	N/A
Test ID No.	R5-452	PCIe NVM	N/A	TOIO - TC/QD	-	TOIO - TC/QD	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	-	Steady State	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Time	N/A

WSAT IOPS (Linear) vs Time (Linear)



Plot 10-1 - WSAT IOPS v Time



Plot 10-2 - WSAT IOPS v TGBW

11 Host Idle Recovery

11.1 Host Idle Recovery (HIR) Descriptive Note

General Description:

SSD background processes (such as Garbage Collection) may take advantage of Host Idle times to improve performance. The Host Idle Recovery Test applies a sequence of Host Idle times interspersed between periods of RND 4KiB Writes in order to observe if the introduction of Host Idle time results in an improvement in the test SSD IOPS performance.

Note: “Idle” in “Host Idle Test” refers to a period of no commands generated by the host system (sandwiched between periods of Random 4KiB writes) and is to be distinguished from an OS hibernation or other system software timeout. “Host” refers to the OS, application software and hardware that generate IOs to the test SSD.

Test Flow:

The Enterprise Host idle Recovery test makes use of:

1. An initial PURGE of the device, followed by
2. Application of RND 4KiB until Steady State is achieved, followed by
3. Wait State 1 Segment:
    a. A cycle - consisting of RND 4KiB writes for 5 seconds followed by 5 seconds of no host writes - is repeated 360 times followed by
    b. a Return to baseline by executing 1800 seconds of continuous RND 4KiB writes followed by
4. Wait State 2 Segment:
    a. A cycle - consisting of RND 4KiB writes for 5 seconds followed by 10 seconds of no host writes - is repeated 360 times followed by
    b. a Return to baseline by executing 1800 seconds of continuous RND 4KiB writes followed by
5. Wait State 3 Segment:
    a. A cycle - consisting of RND 4KiB writes for 5 seconds followed by 15 seconds of no host writes - is repeated 360 times followed by
    b. a Return to baseline by executing 1800 seconds of continuous RND 4KiB writes followed by
6. Wait State 5 Segment:
    a. A cycle - consisting of RND 4KiB writes for 5 seconds followed by 25 seconds of no host writes - is repeated 360 times followed by
    b. a Return to baseline by executing 1800 seconds of continuous RND 4KiB writes followed by
7. Wait State 10 Segment:
    a. A cycle - consisting of RND 4KiB writes for 5 seconds followed by 50 seconds of no host writes - is repeated 360 times followed by
    b. a Return to baseline by executing 1800 seconds of continuous RND 4KiB writes followed by
8. Plotting of the results as set forth in section 11.1**.**

Test Results:

The test output graph will present succeeding Host Idle "wait states" and any increase in performance associated therewith. The graph will present as either a relatively straight line or one with stair-step periods of varied IOPS performance.

Test Interpretation:

The test operator should first consider the IOPS measurement of the test SSD. Second, the test operator should examine the plot for any enhancement relative to the "return to baseline" results that would indicate the test SSD is taking advantage of Host Idle Times for performance enhancement. A relatively flat line response graph could be interpreted that there is no impact on the test SSD IOPS performance because:

1) the test SSD is sufficiently limited in performance (low IOPS) that no introduction of Host Idle times will results in meaningful enhancement, or
2) the test SSD has high performance (IOPS) and an advanced Garbage Collection algorithm / SSD design that does not need/use additional wait states to improve performance. However, examination of the y-axis value for IOPS can distinguish between a "low performing" SSD (with low IOPS) vs. an "advanced" SSD (with high IOPS).

An increasing staircase graph (ignoring the "return to baseline" portion) could indicate that the test SSD is using the idle periods to invoke "Garbage Collection" or other background processes that allow for improvement in IOPS performance. The height of the maximum staircase compared to the "return to baseline" portion indicates the amount of enhancement in performance due to the introduction of Host Idle times.

11.2 HIR Pseudo Code

```
For ( ActiveRange=100%, optional ActiveRange=Test Operator Choice )
```

1 Purge the device. (Note: Active Range and other Test Parameters are not applicable to Purge step; any values can be used and none need to be reported.)

2 Set test parameters and record for later reporting

2.1 Volatile device write cache: Required=Disabled, Optional = Enabled

2.2 OIO/Thread: Test Operator Choice

2.3 Thread Count: Test Operator Choice

2.4 Data Pattern: Required = Random, Optional = Test Operator Choice

3 Preconditioning using the BS=4KiB, 100% random, R/W Mix=0%, using the required ActiveRange=100% or the corresponding desired optional ActiveRange.

3.1 Record elapsed time, IOPS, Average Response Time (ART) and Maximum Response Time (MRT) every 1 minute.

3.2 Using the first 1 Minute IOPS, along with subsequent 1 Minute IOPS results that are 30 Minutes apart (these IOPS results are called the Tracking Rounds), run Access Pattern until Steady State (see 2.1.21) is reached, or until the maximum number of Rounds=25 has been reached.

4 Wait State 1 Segment Including Return To Baseline: 100% Write, Random, Block Size of 4KiB

4.1 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds (Access A), followed by 5 seconds without access activity (Access B). Log Elapsed Time, IOPS, Average Response Time and Maximum Response Time at the end of each Access A period. Repeat (Access A + Access B) combination 360 times.

4.2 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds. Repeat 360 times for a total of 5*360=1800 seconds (Access C) to re-establish RND 4KiB baseline.

5 Wait State 2 Segment Including Return To Baseline: 100% Write, Random, Block Size of 4KiB

5.1 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds (Access A), followed by 10 seconds without access activity (Access B). Log Elapsed Time, IOPS, Average Response Time and Maximum Response Time at the end of each Access A period. Repeat (Access A + Access B) combination 360 times.

5.2 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds. Repeat 360 times for a total of 5*360=1800 seconds (Access C) to re-establish RND 4KiB baseline.

6 Wait State 3 Segment Including Return To Baseline: 100% Write, Random, Block Size of 4KiB

6.1 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds (Access A), followed by 15 seconds without access activity (Access B). Log Elapsed Time, IOPS, Average Response Time and Maximum Response Time at the end of each Access A period. Repeat (Access A + Access B) combination 360 times.

6.2 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds. Repeat 360 times for a total of 5*360=1800 seconds (Access C) to re-establish RND 4KiB baseline.

7 Wait State 5 Segment Including Return To Baseline: 100% Write, Random, Block Size of 4KiB

7.1 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds (Access A), followed by 25 seconds without access activity (Access B). Log Elapsed Time, IOPS, Average Response Time and Maximum Response Time at the end of each Access A period. Repeat (Access A + Access B) combination 360 times.

7.2 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds. Repeat 360 times for a total of 5*360=1800 seconds (Access C) to re-establish RND 4KiB baseline.

8 Wait State 10 Segment Including Return To Baseline: 100% Write, Random, Block Size of 4KiB

8.1 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds (Access A), followed by 50 seconds without access activity (Access B). Log Elapsed Time, IOPS, Average Response Time and Maximum Response Time at the end of each Access A period. Repeat (Access A + Access B) combination 360 times.

8.2 Execute R/W Mix=0/100%, Block Size=4KiB for 5 seconds. Repeat 360 times for a total of 5*360=1800 seconds (Access C) to re-establish RND 4KiB baseline.

9 Process and plot the accumulated data, per report guidelines in Section 11.3.

11.3 Test Specific Reporting for Host Idle Recovery Test

Sections 11.3.1 and 11.3.2 list the reporting requirements specific to the Host Idle Recovery test. Reporting requirements common to all tests are documented in Section 5, See also Annex A.

> **Note on Headers:** The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

11.3.1 Purge Report

The Test Operator shall report the method used to run the Purge operation.

11.3.2 Measurement Report

The Test Operator shall generate Preconditioning Plot, Preconditioning Steady State Measurement Plot, and Measurement Plots for IOPS for each Wait State plus their corresponding Return To Baselines**.**

11.3.2.1 Preconditioning IOPS Report

A Preconditioning IOPS Report (HIR IOPS v Time) is shown in Plot 11-1.

Test Run Date:	08/17/2012 04:02 PM	Report Run Date:	03/06/2013 03:01PM

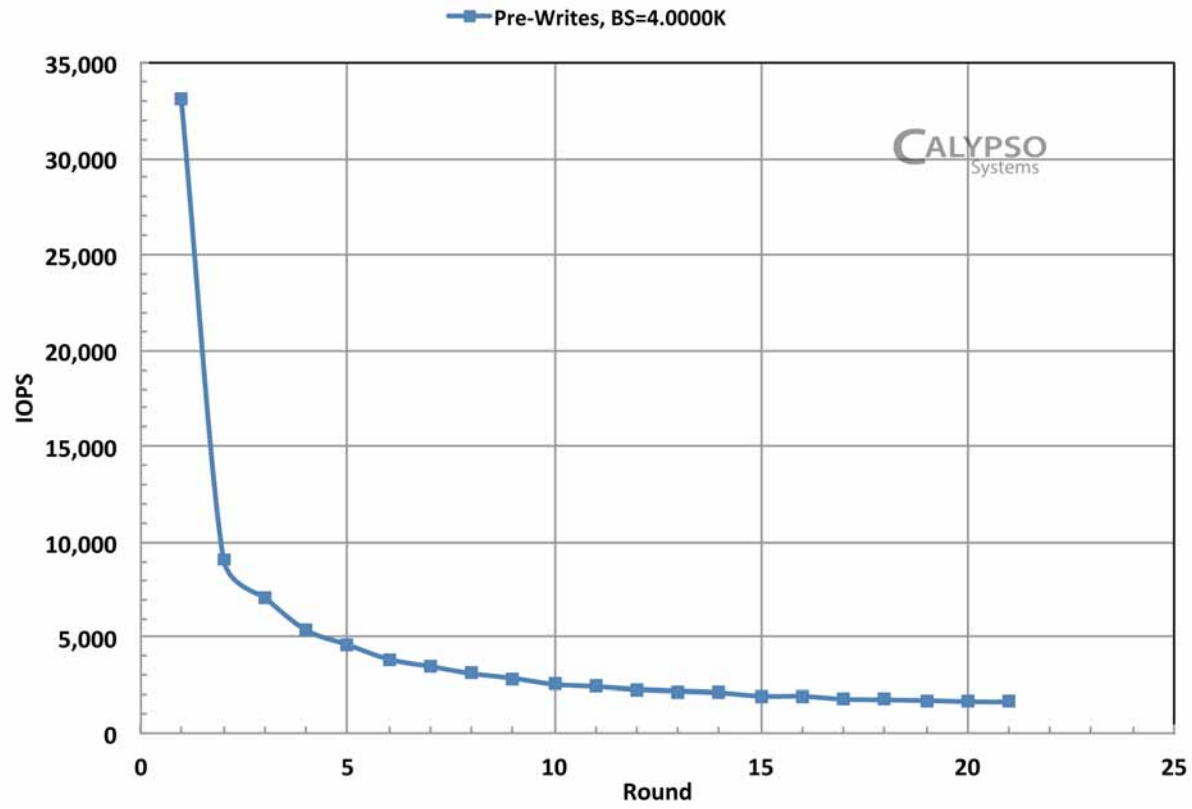
Host Idle Recovery (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	RND 4KiB 5s Ws / Variable Wait States	Rev.	PTS-E 1.1
			Page	1 of 3

Vendor:	ABC Co.	SSD Model:	ABC Co. Super Drive 256	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/4KiB	Write Stimulus	RND/4KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	TC 2 / QD 16	TOIO - TC/QD	TC 2 / QD 16
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	1-5	Duration (S)	5
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Idle State	Host Idle
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	-
Test ID No.	R32-2040	PCIe NVM	N/A	SS Rounds	-	Duration (S)	5,10,15,25,50
HBA	LSI 9212-4e4i	Purge Method	Security Erase			Wait States	1,2,3,5,10
PCIe	Gen 3 x 16	Write Cache	WCD				

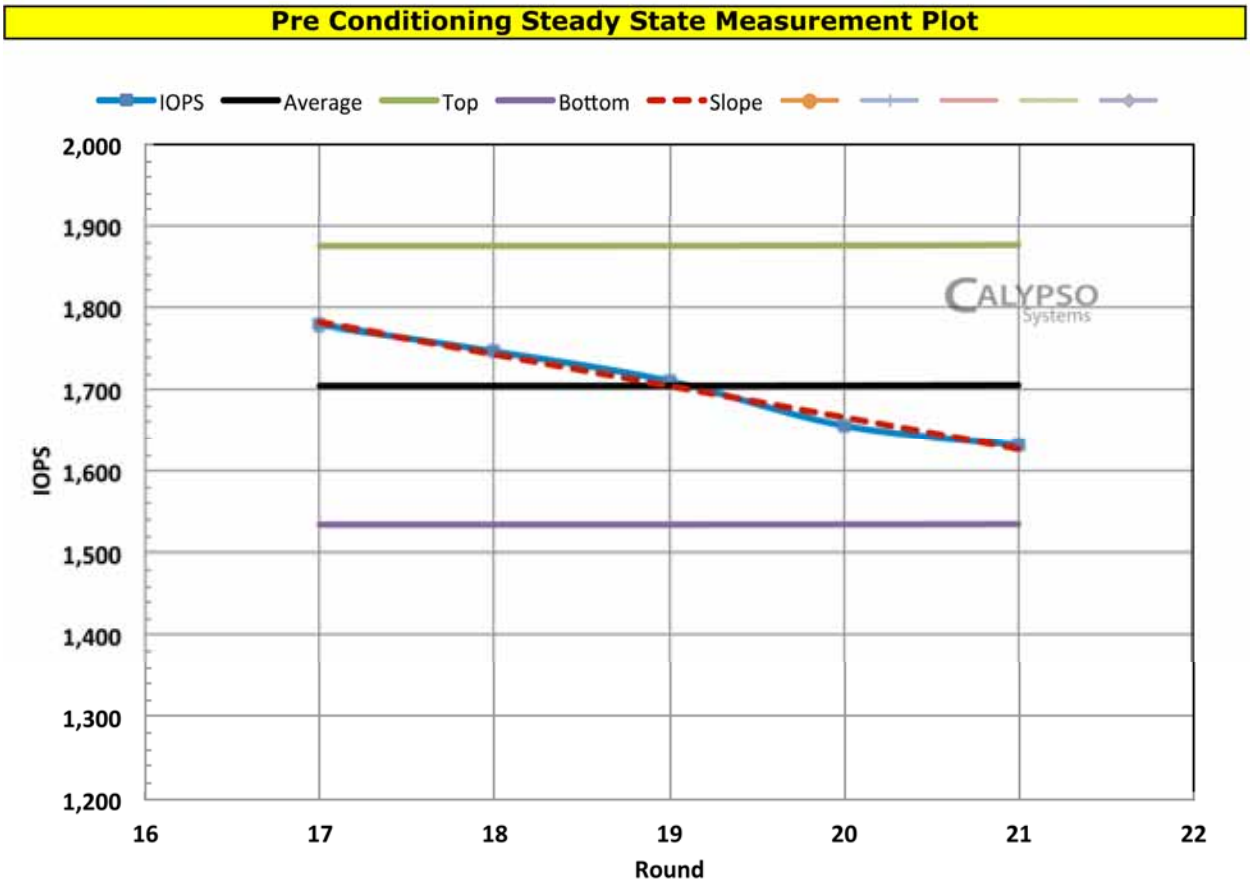
Pre Conditioning IOPS Plot



Plot 11-1 - HIR IOPS v Time

11.3.2.2 Preconditioning Steady State Measurement Plot

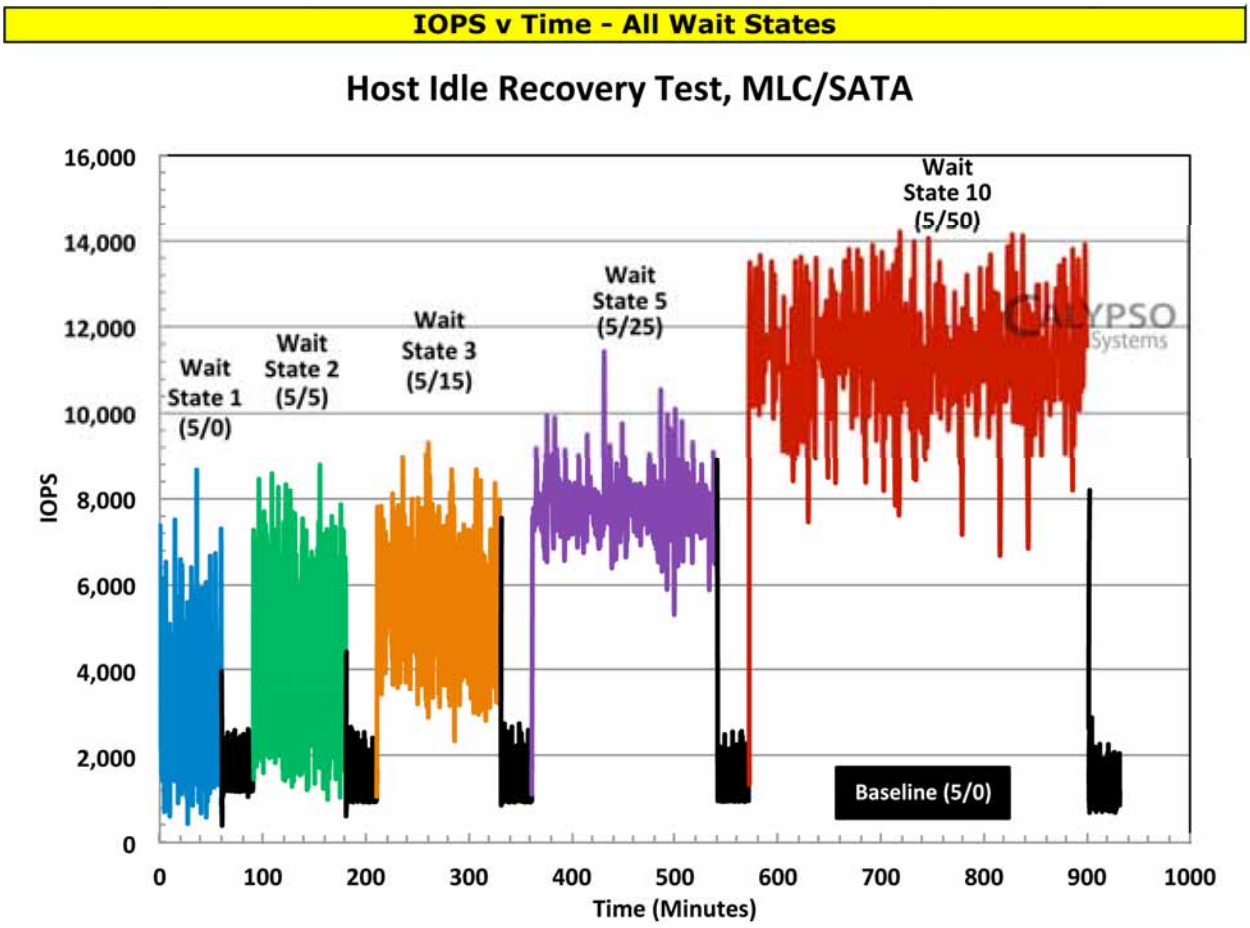
A Preconditioning Steady State Measurement Plot is shown in Plot 11-2.



Plot 11-2 - HIR IOPS v Time

11.3.2.3 IOPS vs. Time for All Wait States

An IOPS vs. Time for All Wait States Plot is shown in Plot 11-3.



Plot 11-3 - IOPS vs. Time for All Wait States

12 Cross Stimulus Recovery

12.1 Cross Stimulus Recovery (XSR) Descriptive Note:

General Description:

Cross Stimulus Recovery is designed to observe how the test SSD handles transitions from large block sequential writes to small block random writes and returning to large block sequential writes. This test is intended to demonstrate the interaction between two close proximity workloads on a device, such as different workload demands in a virtualized environment.

Test Flow:

The Enterprise Cross Recovery test makes use of:

1. An initial PURGE of the device followed by
2. An initial sequence of SEQ 1024 KiB Writes for (8) hours, followed by
3. A sequence of RND 8 KiB Writes for (6) hours, followed by
4. A sequence of SEQ 1024 KiB Writes for (8) hours.
5. Plotting of the results as set forth in Section 11.1

Test Results:

The test output graph will present three sustained stimulus measurement segments and the transition between those stimuli. The OIO setting may be selected and reported by the test operator. However, a larger OIO setting may better emulate an extreme demand environment from which a meaningful transition may be observed. The test operator should choose (and report) a different optimal OIO for each stimulus.

Test Interpretation:

The test operator is encouraged to observe the shape and length of the transition zones (rather than looking for a some type of “steady state” zone). The test operator is further encouraged to vary the length of sustained stimulus to highlight performance zones of interest.

12.2 XSR Pseudo Code

```
For (ActiveRange=100%, optional ActiveRange=Test Operator Choice)
  1 Purge the device. (Note: Active Range and other Test Parameters are not
    applicable to Purge step; any values can be used and none need to be
    reported.)
  2 Access Group 1: 100% Write, Sequential, Block Size of 1024KiB
    2.1 Set test parameters and record for later reporting
        2.1.1 Volatile Device write cache = Disabled
        2.1.2 OIO/Thread: Test Operator Choice
        2.1.3 Thread Count: Test Operator Choice
        2.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice
    2.2 Execute R/W Mix=0/100, Block Size=1024KiB for a minimum of 8 Hours,
        with logging of Elapsed Time, IOPS, Average Response Time and Maximum
        Response Time at 1 minute interval.
  3 Access Group 2: 100% Write, Random, Block Size of 8KiB
    3.1 Set test parameters and record for later reporting
        3.1.1 Volatile Device write cache = Disabled
        3.1.2 OIO/Thread: Test Operator Choice
```

3.1.3 Thread Count: Test Operator Choice

3.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice

3.2 Execute R/W Mix=0/100, Block Size=8KiB for a minimum of 6 Hours, with logging of Elapsed Time, IOPS, Average Response Time and Maximum Response Time at 1 minute interval.

4 Access Group 3: 100% Write, Sequential, Block Size of 1024KiB

4.1 Set test parameters and record for later reporting

4.1.1 Volatile Device write cache = Disabled

4.1.2 OIO/Thread: Same as 2.1.2 above

4.1.3 Thread Count: Same as 2.1.3 above

4.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice

4.2 Execute R/W Mix=0/100, Block Size=1024KiB for a minimum of 8 Hours, with logging of Elapsed Time, IOPS Average Response Time and Maximum Response Time at 1 minute interval.

5 Process and plot the accumulated data, per report guidelines in next section.

12.3 Test Specific Reporting for Cross Stimulus Recovery Test

Sections 12.3.1 and 12.3.2 list the reporting requirements specific to the Cross Stimulus Recovery test. Reporting requirements common to all tests are documented in Section 5: Common Reporting Requirements. See also Annex A.

Note on Headers: The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

12.3.1 Purge Report

The Test Operator shall report the method used to run the Purge operation.

12.3.2 Measurement Report

The Test Operator shall generate Measurement Plots for Cross Stimulus Recovery for each Access Group, along with enlarged plots of the two transitions from SEQ→RND and RND→SEQ.

12.3.2.1 Throughput vs. Time for All Access Groups

Plot 12-1 shows XSR TP vs. Time.

Test Run Date:	10/18/2012 4:02:00 PM	Report Run Date:	03/06/2013 05:01PM

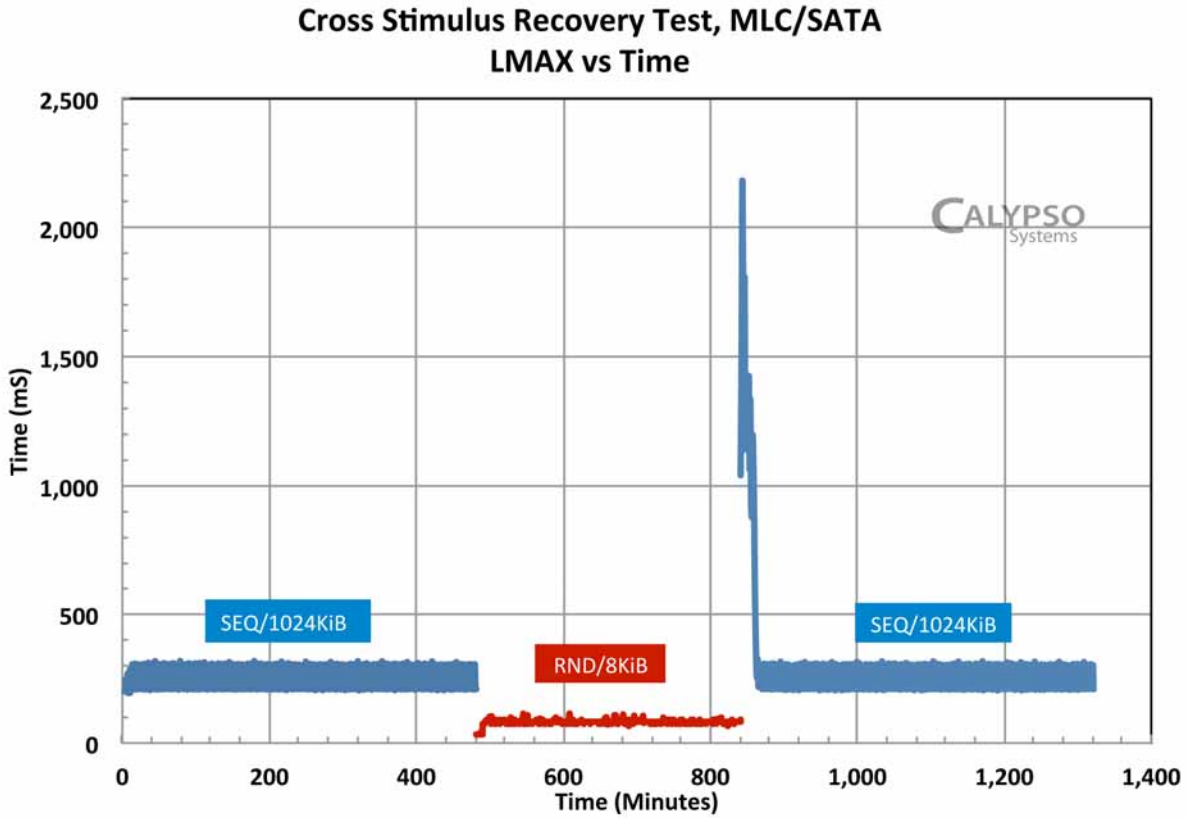
Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	1 of 5

Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

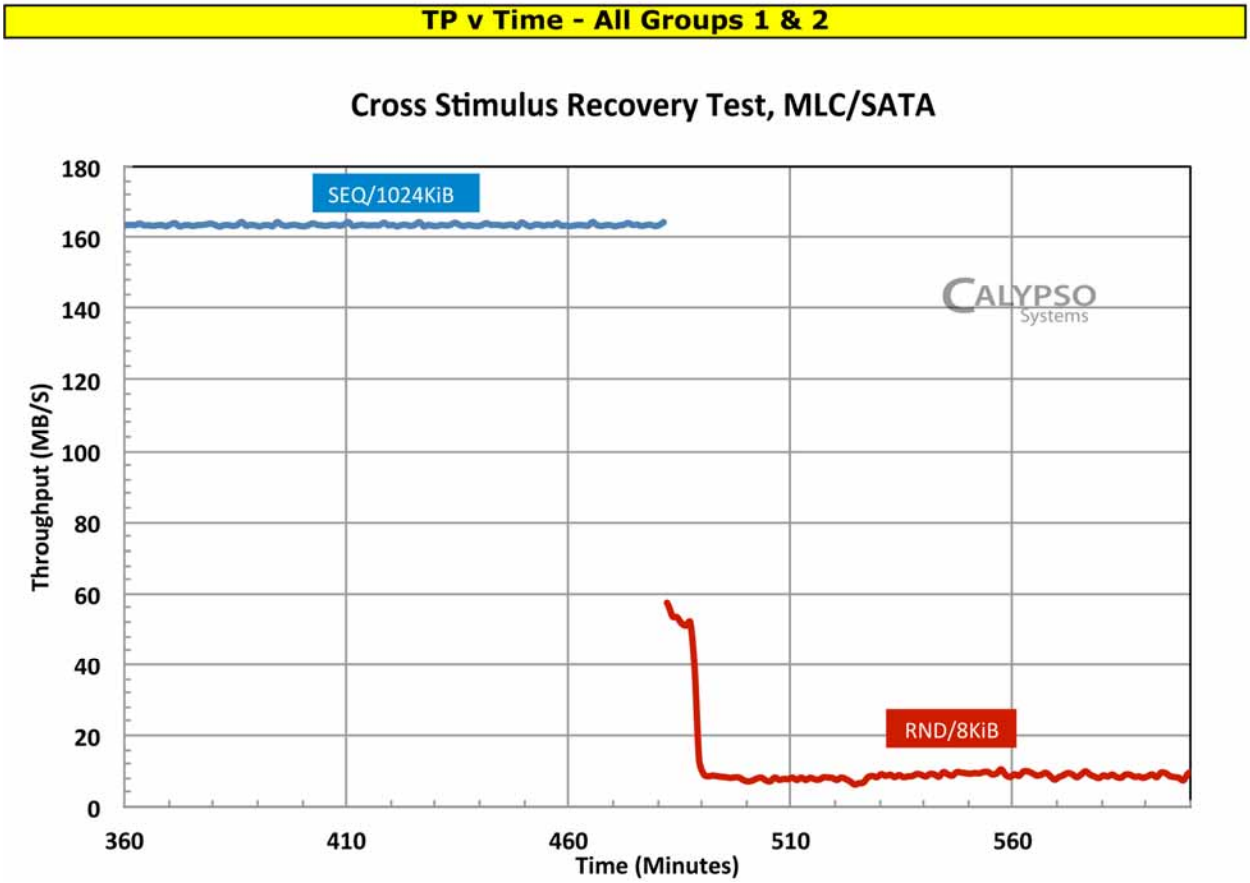
TP v Time - All Access Groups



Plot 12-1 - XSR TP vs. Time

12.3.2.2 Throughput vs. Time, Access Groups 1 and 2

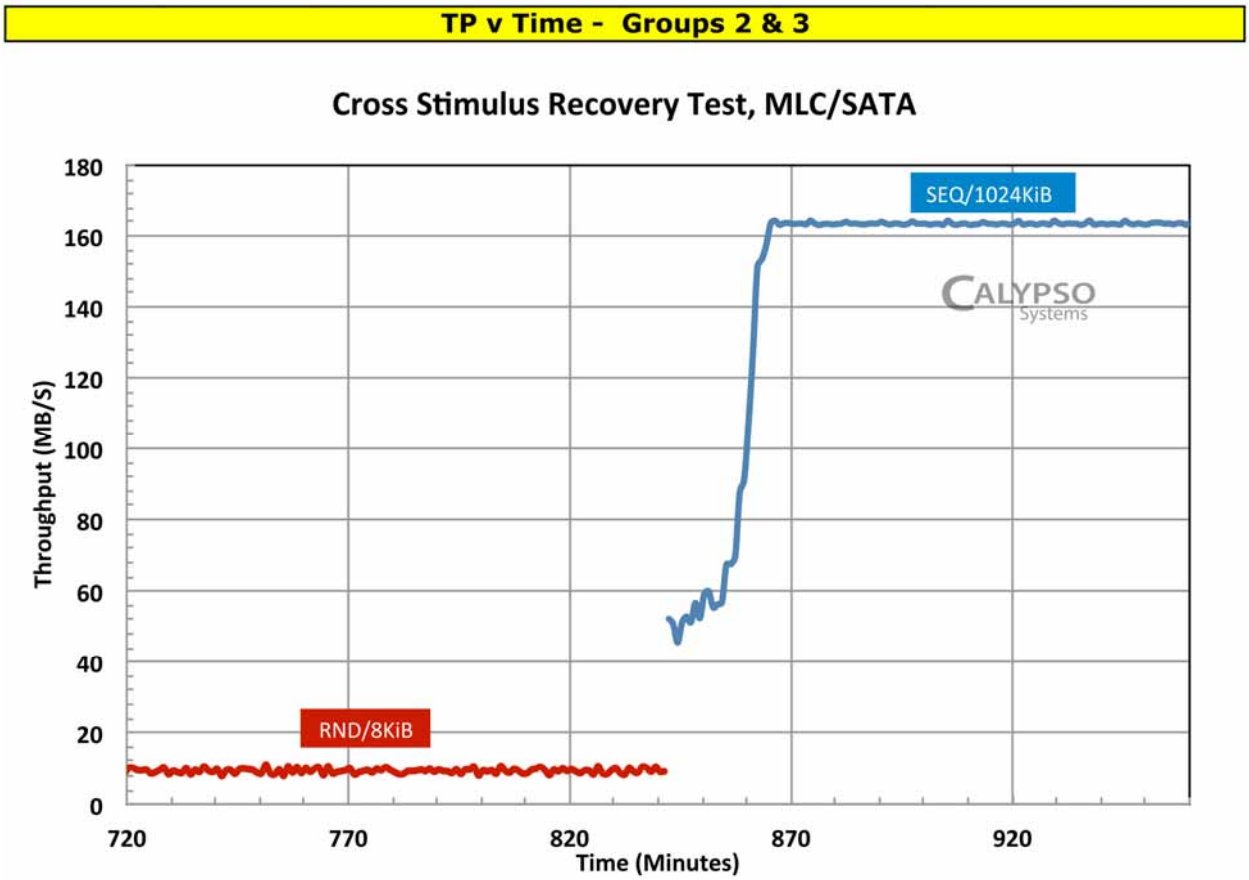
Plot 12-2 shows Throughput vs. Time, Access Groups 1 and 2.



Plot 12-2 - Throughput vs. Time, Access Groups 1 and 2

12.3.2.3 Throughput vs. Time, Access Groups 2 and 3

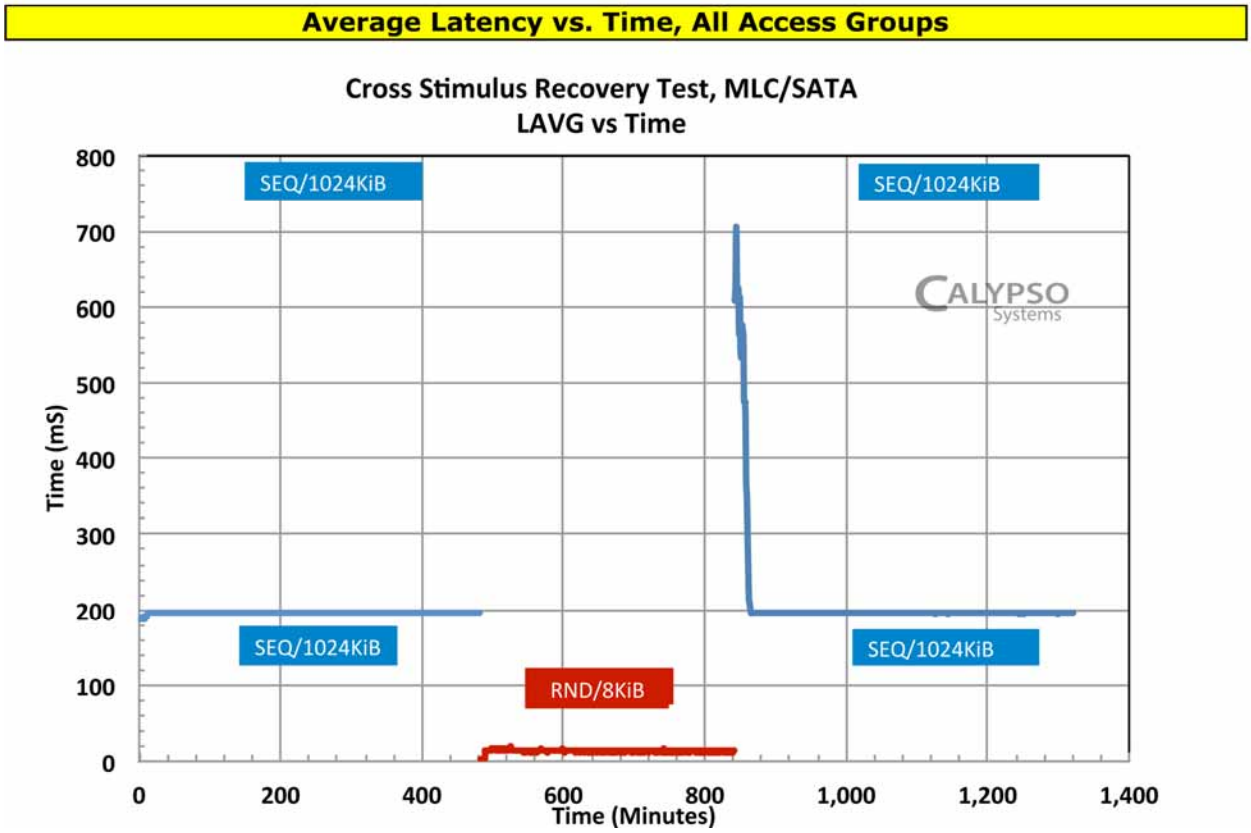
Plot 12-3 shows Throughput vs. Time, Access Groups 2 and 3.



Plot 12-3 - Throughput vs. Time, Access Groups 2 and 3

12.3.2.4 Average Latency vs. Time, All Access Groups

Plot 12-4 and Plot 12-5 show Average Latency vs. Time, All Access Groups.



Plot 12-4 - Average Latency vs. Time, All Access Groups (1)

Test Run Date:	10/18/2012 4:02:00 PM	Report Run Date:	03/06/2013 05:01PM

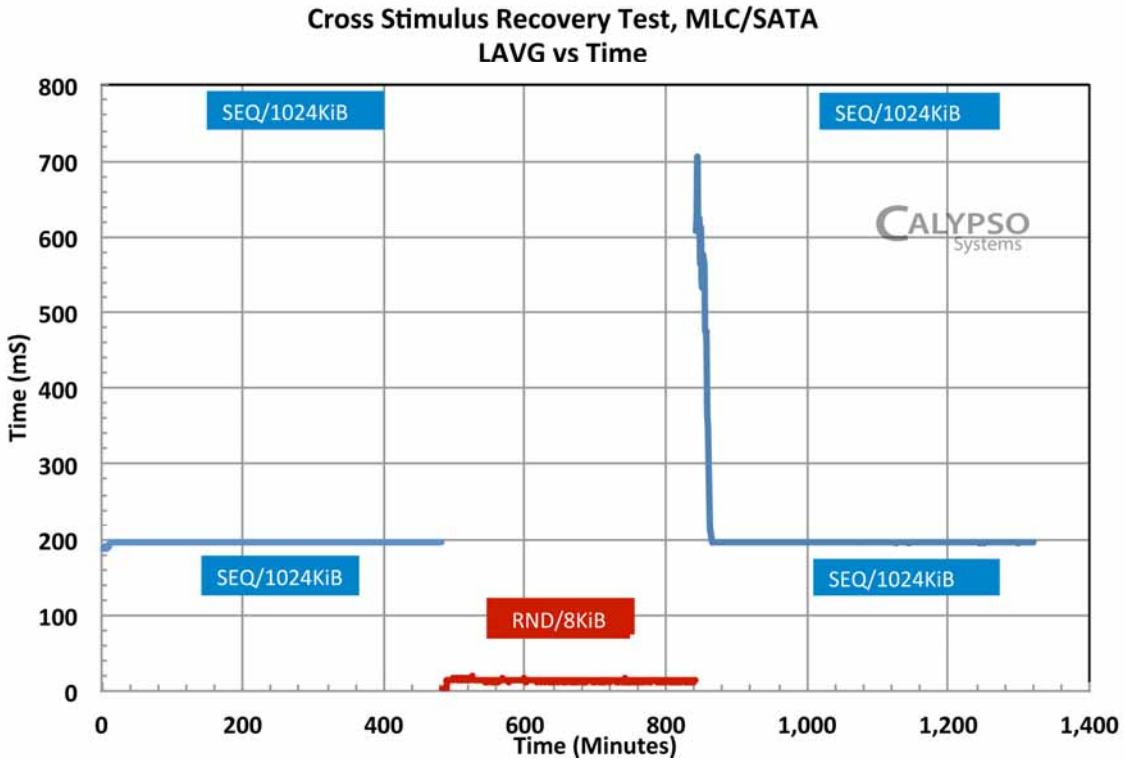
Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	4 of 5

Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

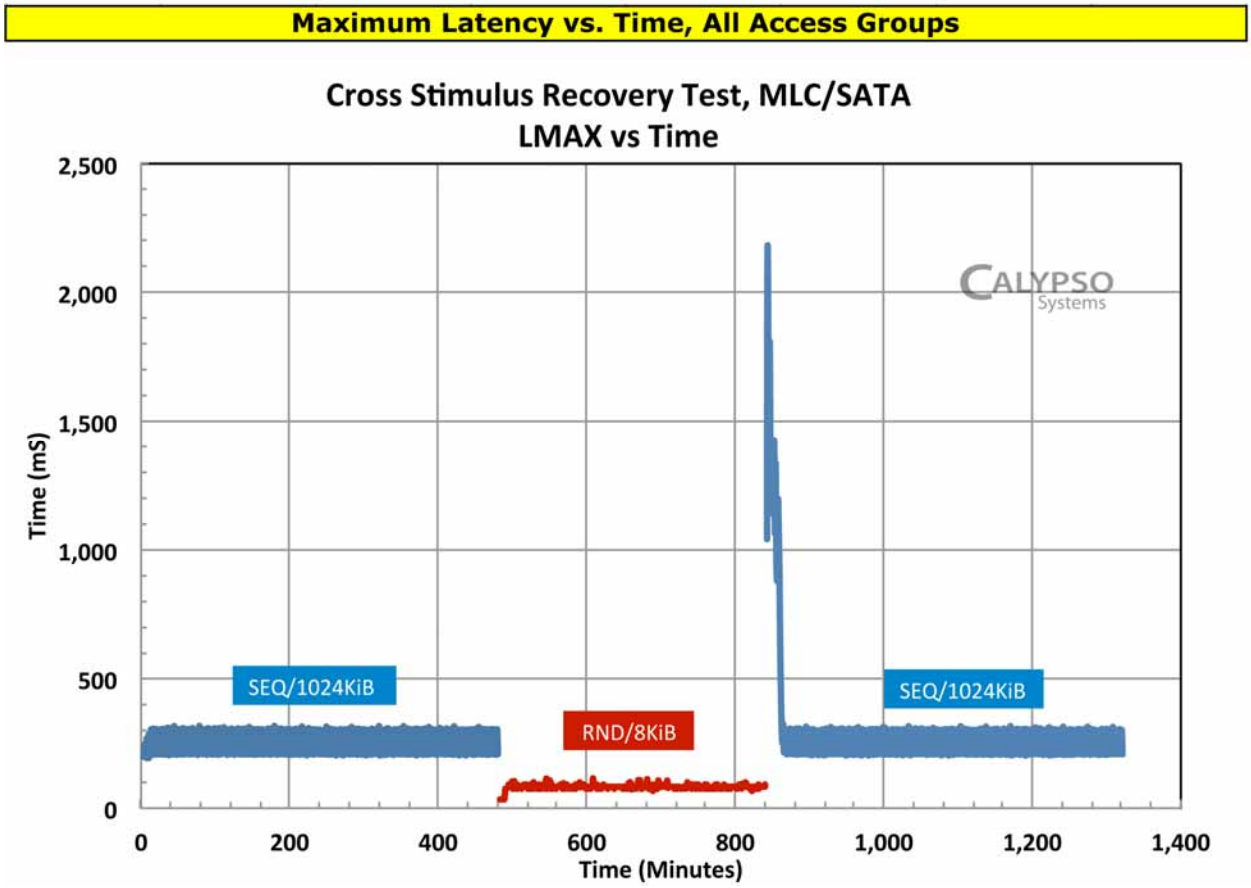
Average Latency vs. Time, All Access Groups



Plot 12-5 - Average Latency vs. Time, All Access Groups (2)

12.3.2.5 Maximum Latency vs. Time, All Access Groups

Plot 12-7 and Plot 12-7 show Maximum Latency vs. Time, All Access Groups.



Plot 12-6 - Maximum Latency vs. Time, All Access Groups (1)

Test Run Date:	10/18/2012 4:02:00 PM	Report Run Date:	03/06/2013 05:01PM

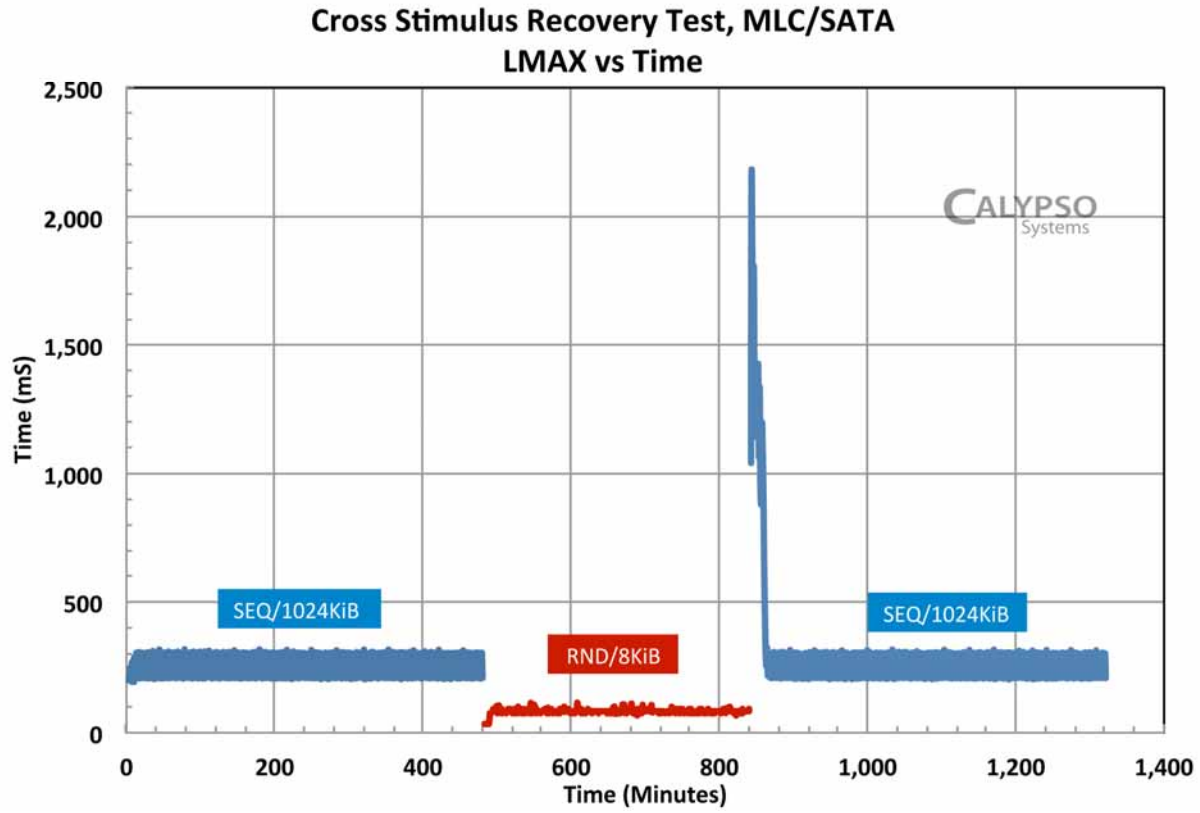
Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	5 of 5

Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

Maximum Latency vs. Time, All Access Groups



Plot 12-7 - Maximum Latency vs. Time, All Access Groups (2)

13 Enterprise Composite Workload

13.1 Enterprise Composite Workload (ECW) Descriptive Note:

General Description:

The workload, transfer size distributions and Random data payload consists of random data distributed across an SSD in a manner similar to enterprise workload traces that are publicly available.

The purpose of this test is to understand Response Times in a mixed IO workload.

Test Flow:

The Enterprise Composite test makes use of:

1. An initial PURGE of the device followed by
2. Preconditioning to the entire LBA ActiveRange (Section2.1);
    1) a one step Workload Independent PC (Section 2.1.16 a) consisting of 128KiB SEQ writes for 2X (twice) the user capacity; and
    2) a one step Workload Dependent PC (WDPC) (Section 2.1.16 b) consisting of the Composite Access Pattern of mixed Block Sizes applied with relative block size probabilities and ActiveRange distribution restrictions at an overall R/W mix of 100% write over the LBA ActiveRange until Steady State, as defined, is achieved.
3. Running the Composite Access Pattern while varying the Total Outstanding IOs by applying an outer loop of High to Low Thread Count by an inner loop of High to Low Queue Depth with the application of an inter loop Pre Write between each TOIO loop until Steady State, as defined, is reached for the TOIO tracking variable. Note that Queue Depth here refers to the application Queue Depth, or sometimes also referred to as Outstanding IOs issued by a particular application process.
4. Using the Steady State data, plot ART v IOPS and CPU Usage v Thread Count for all the Thread Count settings used.
5. Selecting a MAX IOPS point representing an operating point where the IOPS is maximum while achieving a reasonable ART; select a MIN IOPS point where TC=1 and QD=1; and select a minimum of 1 additional MID IOPS point(s), using the (Thread Count, OIO/Thread) operating points obtained during the test run such that their IOPS values lie between and equally divides the IOPS value between MinIOPS and MaxIOPS.
6. Plotting Response Time Histograms for each of the MAX, MIN and MID IOPS points.

Test Results:

The test output graph will present a plot of Response Time v Composite IO Rate and CPU Utilization v Composite IO Rate.

Test Interpretation:

The test operator can observe a typical Response Time at a given IO Rate and to observe the performance curve and the “knee” (saturation point). Some drives may show a linear relationship between Response Time and IO Rate whereas other drives may show cpu saturation if processes are loaded to the host cpu. The test operator can observe the optimal Average Response Time relative to the IO Rate before saturation.

13.2 ECW Pseudo Code

For (ActiveRange=100%, optional ActiveRange=Test Operator Choice, Access Pattern = Enterprise Composite Workload Access Pattern (ECWAP) as prescribed below)

1 Purge the device. (Note: Active Range and other Test Parameters are not applicable to Purge step; any values can be used and none need to be reported.)

2 Access Pattern

2.1 The Enterprise Composite Workload Access Pattern (ECWAP) as prescribed here shall be used as the Workload Dependent Preconditioning and measurement stimulus;

2.1.1 The required Data Pattern shall be random; additional test may be run at the option of the test sponsor using alternate data patterns, such data patterns shall be described such that other test sponsors can exactly repeat the entire sequence of data patterns

2.1.2 Read/Write Ratio shall be 40% Reads and 60% Writes

2.1.3 Block Size Probability Distribution: The Block Sizes issued along with each Block Size's relative access probabilities measured within each of the Measurement Duration of 1 Minute shall be according to the following table. The actual Block Size for each access shall occur randomly according to the assigned access probabilities, as shown in Table 13-1.

Table 13-1 – ECW Block Size Access Probabilities

Block Size in Bytes (KiB)	Access Probability Within Each Measurement Period
512 bytes (0.5 KiB)	**4%**
1024 bytes (1 KiB)	**1%**
1536 bytes (1.5 KiB)	**1%**
2048 bytes (2 KiB)	**1%**
2560 bytes (2.5 KiB)	**1%**
3072 bytes (3 KiB)	**1%**
3584 bytes (3.5 KiB)	**1%**
4096 bytes (4 KiB)	**67%**
8192 bytes (8 KiB)	**10%**
16,384 bytes (16 KiB)	**7%**
32,768 bytes (32 KiB)	**3%**
65,536 bytes (64 KiB)	**3%**
Total	**100%**

2.1.4 Access Range Probability Distribution: The ECWAP shall be issued to the DUT such that the following distribution is achieved with each of the Measurement Periods, as shown in Table 13-2.

Table 13-2 – ECW Access Range Distribution Restrictions

% of Access within 1 Measurement Period	Active Range Restriction	Label
50%	First 5%	LBA Group A
30%	Next 15%	LBA Group B
20%	Remaining 80%	LBA Group C

3 Preconditioning using the Access Pattern, but with R/W Mix=0% (100% Write)

3.1 Set test parameters and record for later reporting

3.1.1 Volatile device write cache = Disabled

3.1.2 QD or OIO/Thread: 32

3.1.3 Thread Count: 32

3.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice

3.2 Run Access Pattern, using the required ActiveRange=100% or the corresponding desired optional ActiveRange.

3.2.1 Record elapsed time, IOPS, Average Response Time (ART) and Maximum Response Time (MRT) every 1 minute. Note that IOPS is the IOPS achieved for the entire Access Pattern.

3.2.2 Run Access Pattern until Steady State (see 2.1.21) is achieved, or until the maximum number of Rounds=25 has been reached, using the following as the tracking variable for Steady State determination:

3.2.2.1 The overall average IOPS for the specified Access Pattern

3.2.2.2 Use the first 1 Minute overall average IOPS, along with subsequent 1 Minute overall average IOPS results that are 30 Minutes apart for Steady State determination.

4 Run the Access Pattern while varying demand settings:

4.1 Set test parameters and record for later reporting

4.1.1 Volatile device write cache = Disabled

4.1.2 Data Pattern: Same as Preconditioning

4.1.3 Vary TC using TC=[32,16,8,6,4,2,1]

4.1.4 Vary QD using QD=[32,16,8,6,4,2,1]

4.2 Apply Inter-Round Pre-Write

4.2.1 Apply Access Pattern, using TC=32 and QD=32 for a minimum of 5 minutes and a maximum of either 30 minutes or 10% of the User Capacity, whichever occurring first.

4.2.2 Record elapsed time, IOPS, ART, MRT and Percentage CPU Utilization by System (SYS_CPU) every 1 Minute.

4.3 Apply One Round of the Access Pattern:

4.3.1 Apply Access Pattern for 1 Minute at each TC and QD combination, in the order of decreasing TOIO from 1024 (32x32) to 1, using all of the TC/QD combinations that can be generated from TC/QD values given in Sections 4.1.3 and 4.1.4. When multiple TC/QD combinations give rise to equal TOIO values, apply TC/QD combination with the higher TC first.

4.3.2 Record elapsed time, IOPS, ART and MRT and Percentage CPU Utilization by System (SYS_CPU).

4.3.3 Repeat 4.2 and 4.3 until Steady State (see 2.1.21) is reached, using the overall average IOPS for the Access Pattern with TC=32 and QD=32 as the tracking variable, or until the maximum number of Rounds=25 has been reached.

5 Using Steady State data (or if Steady State not reached, data from the Measurement Window):

5.1 Plot ART versus IOPS using all of the (Thread Count, OIO/Thread) operating points, plotting 1 serie per Thread Count setting for all Thread Count settings used.

5.2 Plot CPU_SYS versus Thread Count and OIO/Thread for all data.

6 Determine MaxIOPS, MinIOPS and a minimum of 1 MidIOPS operating point:

6.1 A MaxIOPS point shall be chosen from the (Thread Count, OIO/Thread) operating points, such that:

6.1.1 The MaxIOPS point should be chosen to represent the operating point where the IOPS is maximum while achieving a reasonable ART.

6.1.2 The ART for such MaxIOPS point shall be below 5 mS.

6.2 The MinIOPS point is defined to be the operating point where Thread Count=1 and QD=1.

6.3 Choose a minimum of 1 additional MidIOPS point(s), using the (Thread Count, OIO/Thread) operating points obtained during the test run such that their IOPS values lie between and, as much as possible, equally divides the IOPS value between MinIOPS and MaxIOPS.

7 Response Time Histogram at Maximum IOPS:

7.1 Select a (Thread Count, Queue Depth) operating point that yields maximum IOPS using the lowest number of Total Outstanding IO (TOIO=Thread Count x Queue Depth)

7.2 Run Pre-Writes

7.2.1 Execute the Access Pattern as prescribed, but with R/W Mix=0/100 for 60 minutes. Log elapsed time, IOPS, ART and MRT every 1 minute.

7.3 Execute the Access Pattern as prescribed, for 10 minutes. Capture all individual IO command completion times such that a response time histogram showing count versus time can be constructed. The maximum time value used in the capture shall be greater or equal to the MRT encountered during the 10 minute capture.

8 Response Time Histogram at Minimum IOPS:

8.1 Select a (Thread Count=1, Queue Depth=1) operating point

8.2 Run Pre-Writes

8.2.1 Execute the Access Pattern as prescribed, but with R/W Mix=0/100 for 60 minutes. Log elapsed time, IOPS, ART and MRT every 1 minute.

8.3 Execute the Access Pattern as prescribed for 10 minutes. Capture all individual IO command completion times such that a response time histogram showing count versus time can be constructed. The maximum time value used in the capture shall be greater or equal to the MRT encountered during the 10 minute capture.

9 Response Time Histogram at one or more chosen MidIOPS operating points:

9.1 Select a (Thread Count, Queue Depth) operating point that yields an IOPS result that lies approximately halfway between Maximum IOPS in (6) above, and the Minimum IOPS in (7) above.

```
    9.2  Run Pre-Writes:
         9.2.1 Execute the Access Pattern as prescribed, but with R/W Mix=0/100
               for 60 minutes. Log elapsed time, IOPS, ART and MRT every 1
               minute.
    9.3  Execute the Access Pattern as prescribed for 10 minutes. Capture all
         individual IO command completion times such that a response time
         histogram showing count versus time can be constructed. The maximum
         time value used in the capture shall be greater or equal to the MRT
         encountered during the 10 minute capture.
10  Process and plot the accumulated data, per report guidelines in next
    section.
```

13.3 Test Specific Reporting for ECW Test

Sections 13.3.1 and 13.3.2 list the reporting requirements specific to the Enterprise Composite Workload test. Reporting requirements common to all tests are documented in Section 5.

13.3.1 Purge Report

The Test Operator shall report the method used to run the Purge operation.

13.3.2 Measurement Report

The Test Operator shall generate Measurement Plots for ECW for Preconditioning; Steady State Determination; Between Round Pre Writes; Demand Variation IOPS Plots for Thread Count tracking; Steady State for OIO Tracking Variable; Demand Variation Plot; Demand Intensity Plot; CPU Utilization Plot; MAX IOPS Pre Write Plot; MID IOPS Pre Write Plot; MIN IOPS Pre Write Plot; and Response Time Histograms for MAX IOPS, MIN IOPS and MID IOPS using the Ranges, Ordinates and Plot Types are listed in Table 13-3. Plots are shown in Sections 13.3.2.1 through 13.3.2.14.

Table 13-3 – ECW Measurement Plots

Plot	Plot Title	Range	Ordinate	Plot Type	Description
1	PC IOPS Plot	IOPS	Round	2D, x-y-spline	IOPS v Tracking Round for the tracking variable for Preconditioning using Access Pattern
2	PC Steady State Plot	IOPS	Round	2D, x-y-spline	IOPS v Rounds for the tracking variable showing Steady State details
3	Btw-Round Prewrites Plot	IOPS	Time	2D, x-y-scatter	IOPS v Time showing Between Round Pre-Writes
4	DV IOPS Plot, TC=Tracking	IOPS	Round	2D, x-y-spline	IOPS v Round for TC of Tracking Variable, ALL QD as separate Series
5	DV Steady State Plot, Tracking Variable	IOPS	Round	2D, x-y-spline	IOPS v Round for Tracking Variable, showing Steady State details
6	Demand Variation Plot	IOPS	QD	2D, x-y-spline	IOPS v QD for all TCs as separate series for Steady State results
7	Demand Intensity Plot	Time	IOPS	2D, x-y-spline	Time (mS) v IOPS for all TC/QD Combinations, each TC plotted as a Series for Steady State results. MaxIOPS MidIOPS(s) MinIOPS points labeled.
8	System CPU Utilization Plot	%	TC,QD	3D, x-y-z-bar	CPU_SYS (%) v TC & QD for all Steady State results
9	MaxIOPS Prewrites	IOPS	Time	2D, x-y-spline	MaxIOPS Prewrite: IOPS v Time for Prewrite preceding MaxIOPS Histogram Capture
10	Max IOPS Histogram	Count	Time	2D, x-y-bar	MaxIOPS Histogram: Count (A.U.) v Time (ms), Legend should indicate MRT for the Histogram Capture
11	MidIOPS Prewrites	IOPS	Time	2D, x-y-spline	MidIOPS Prewrite: IOPS v Time for Prewrite preceding MidIOPS Histogram Capture
12	Mid IOPS Histogram	Count	Time	2D, x-y-bar	MidIOPS Histogram: Count (A.U.) v Time (ms), Legend should indicate MRT for the Histogram Capture
13	MinIOPS Prewrites	IOPS	Time	2D, x-y-spline	MinIOPS Prewrite: IOPS v Time for Prewrite Preceding MinIOPS Histogram Capture
14	Min IOPS Histogram	Count	Time	2D, x-y-bar	MinIOPS Histogram: Count (A.U.) v Time (ms), Legend should indicate MRT for the Histogram Capture

Note on Headers: The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

13.3.2.1 PC IOPS Plot

Test Run Date:	10/14/2012 12:51 AM	Report Run Date:	03/7/2013 9:26:00 AM

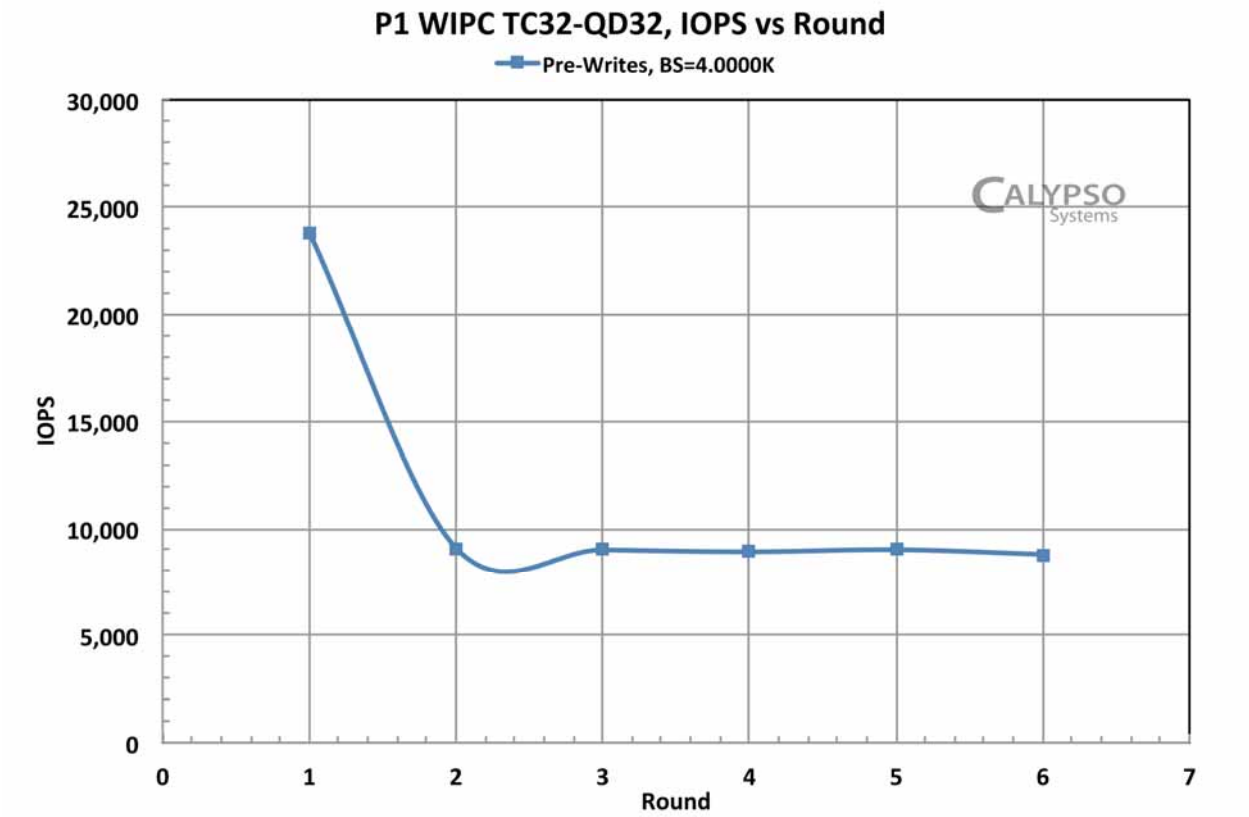
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	2 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-942	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

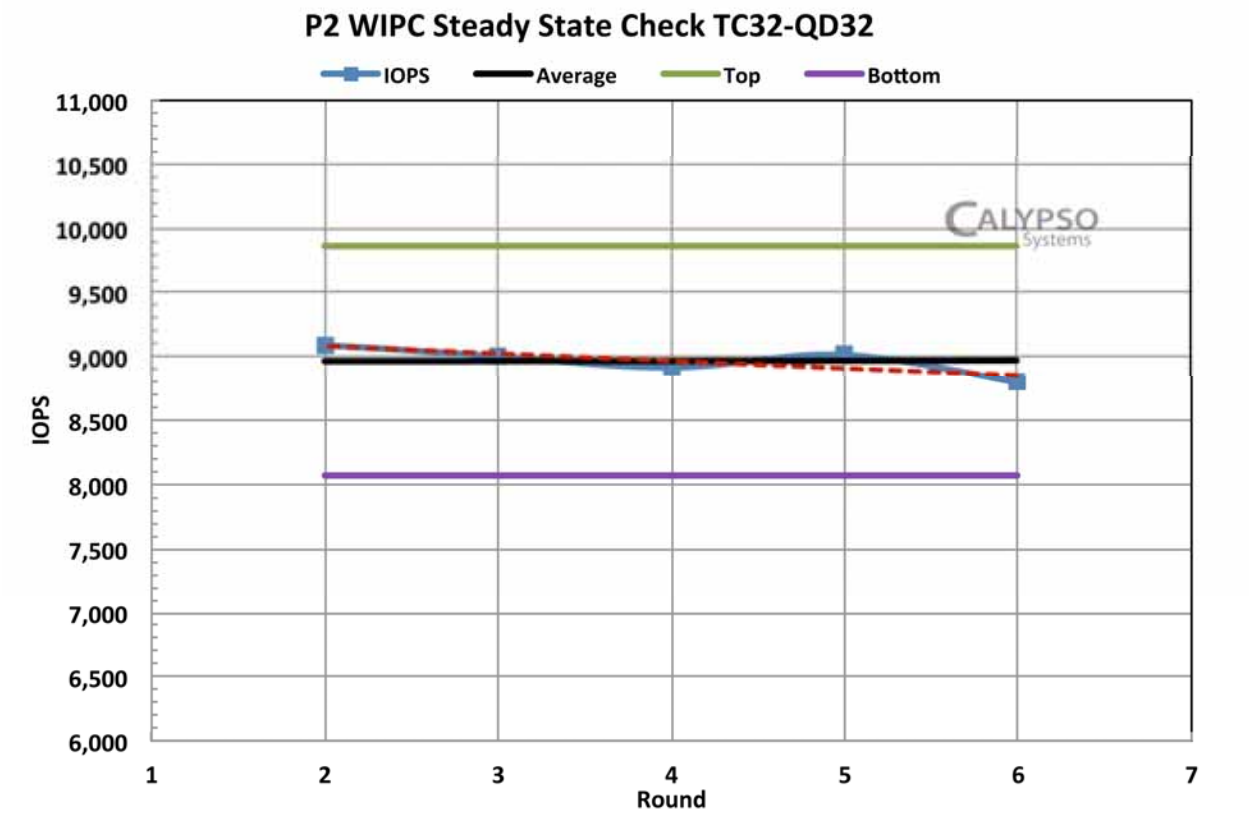
Pre Conditioning IOPS Plot



Plot 13-4 - Pre Conditioning IOPS Plot

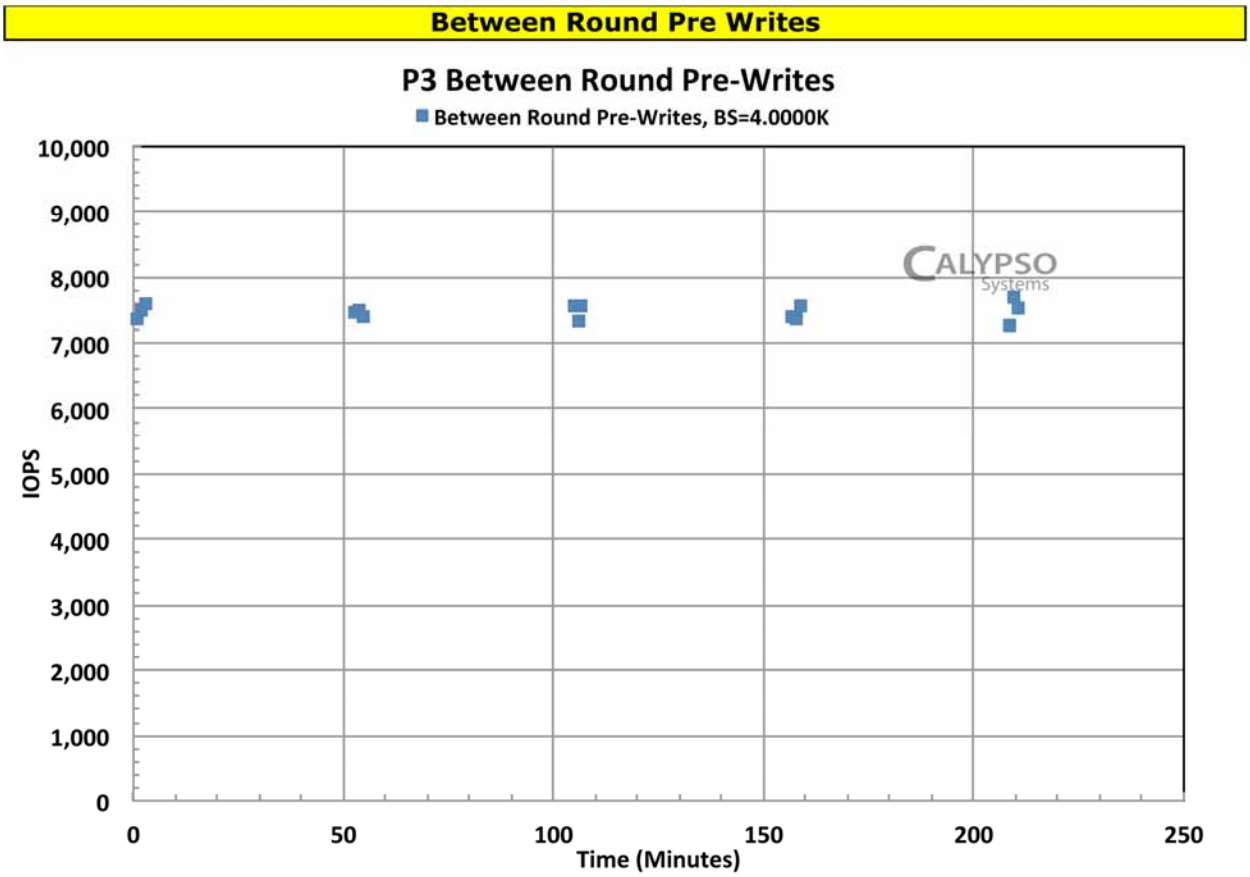
13.3.2.2 PC Steady State Plot

Pre Conditioning Steady State Plot



Plot 13-5 - PC Steady State Plot

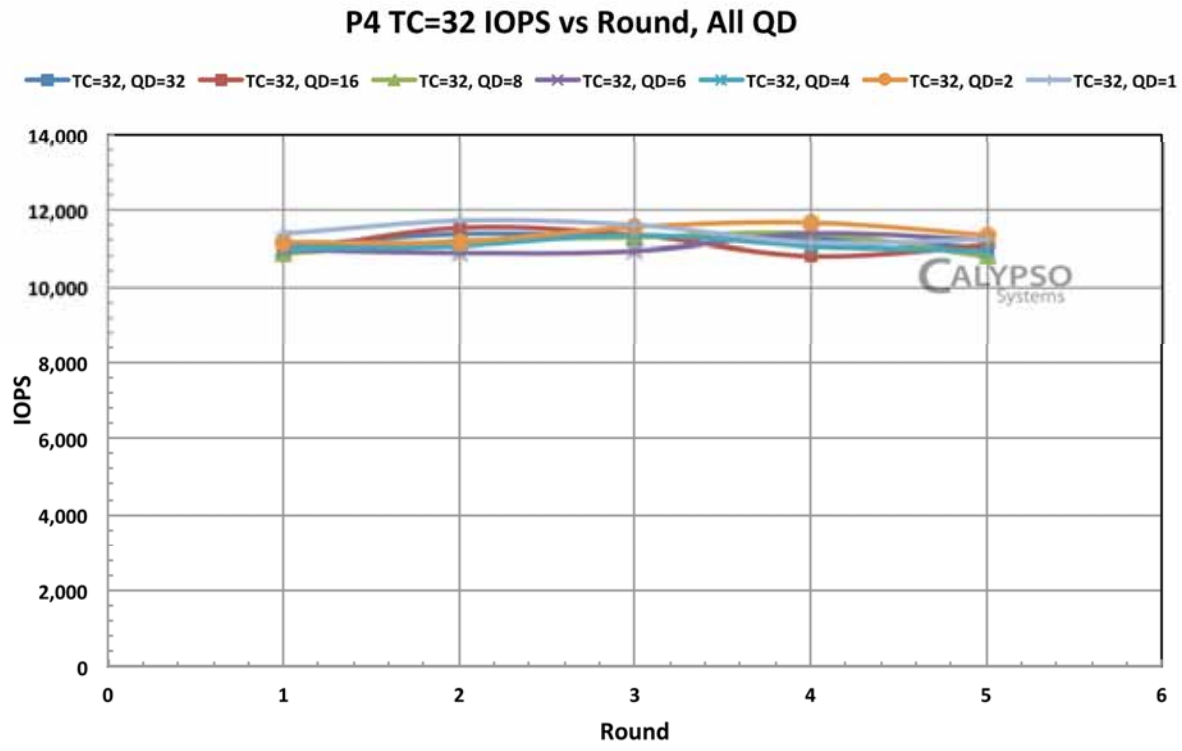
13.3.2.3 Btw-Round Prewrites Plot



Plot 13-6 - Between-Round Prewrites

13.3.2.4 DV IOPS Plot, TC=Tracking

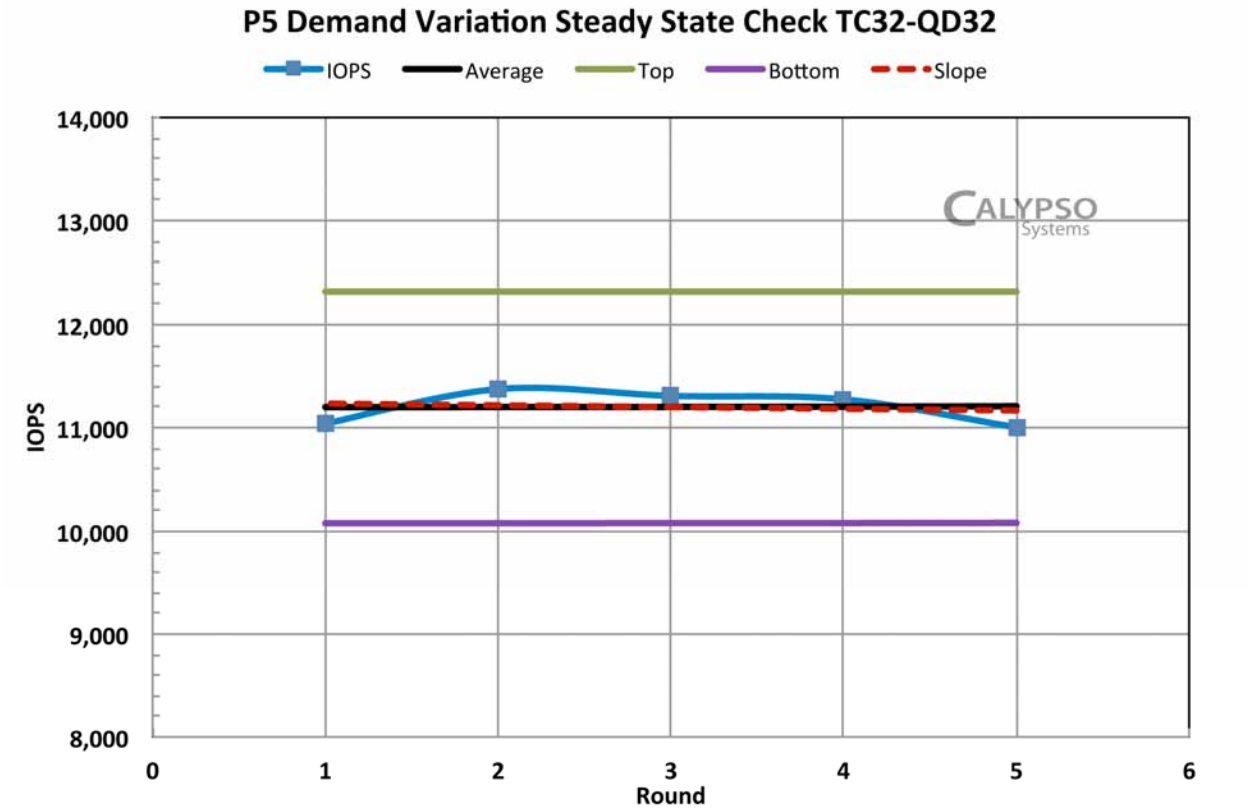
DV IOPS Plot, TC=Tracking



Plot 13-7 - DV IOPS Plot, TC=Tracking

13.3.2.5 DV Steady State Plot, Tracking Variable

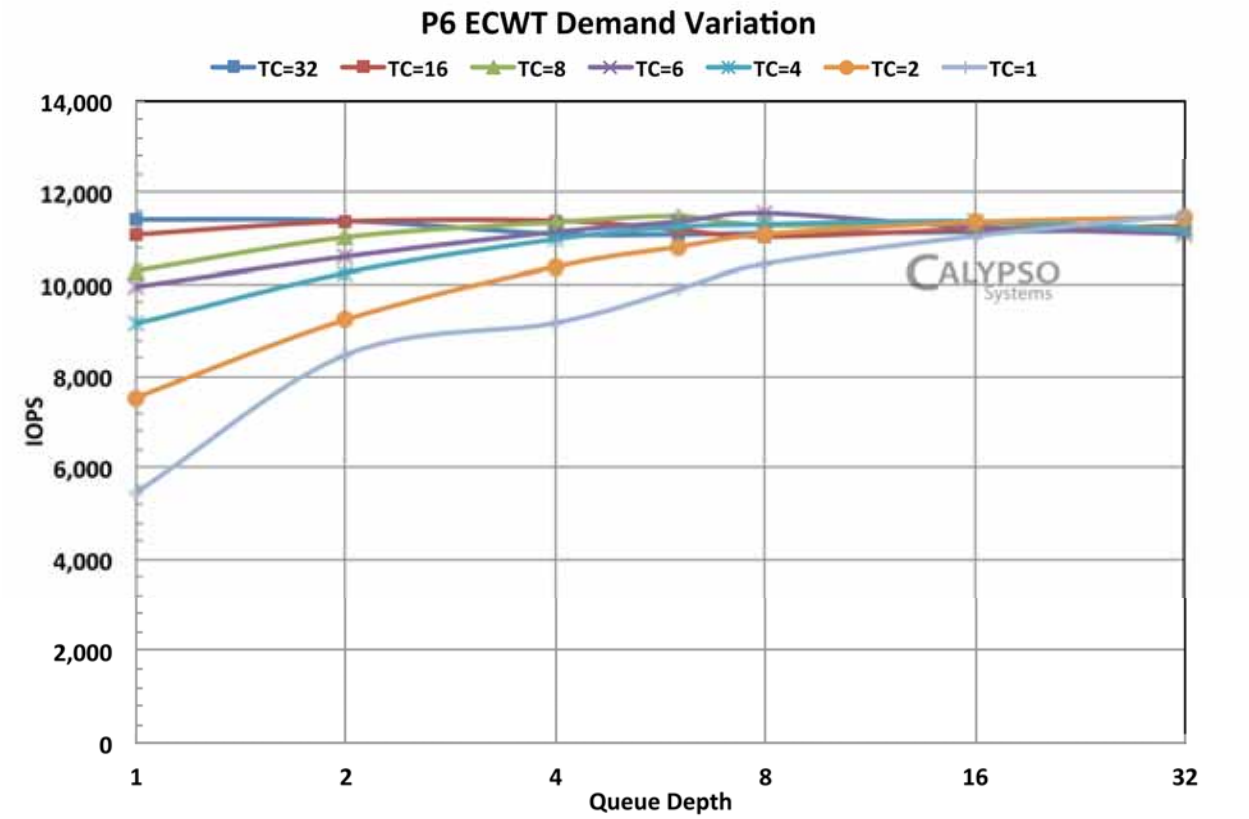
DV Steady State Plot, Tracking Variable



Plot 13-8 - DV Steady State Plot, Tracking Variable

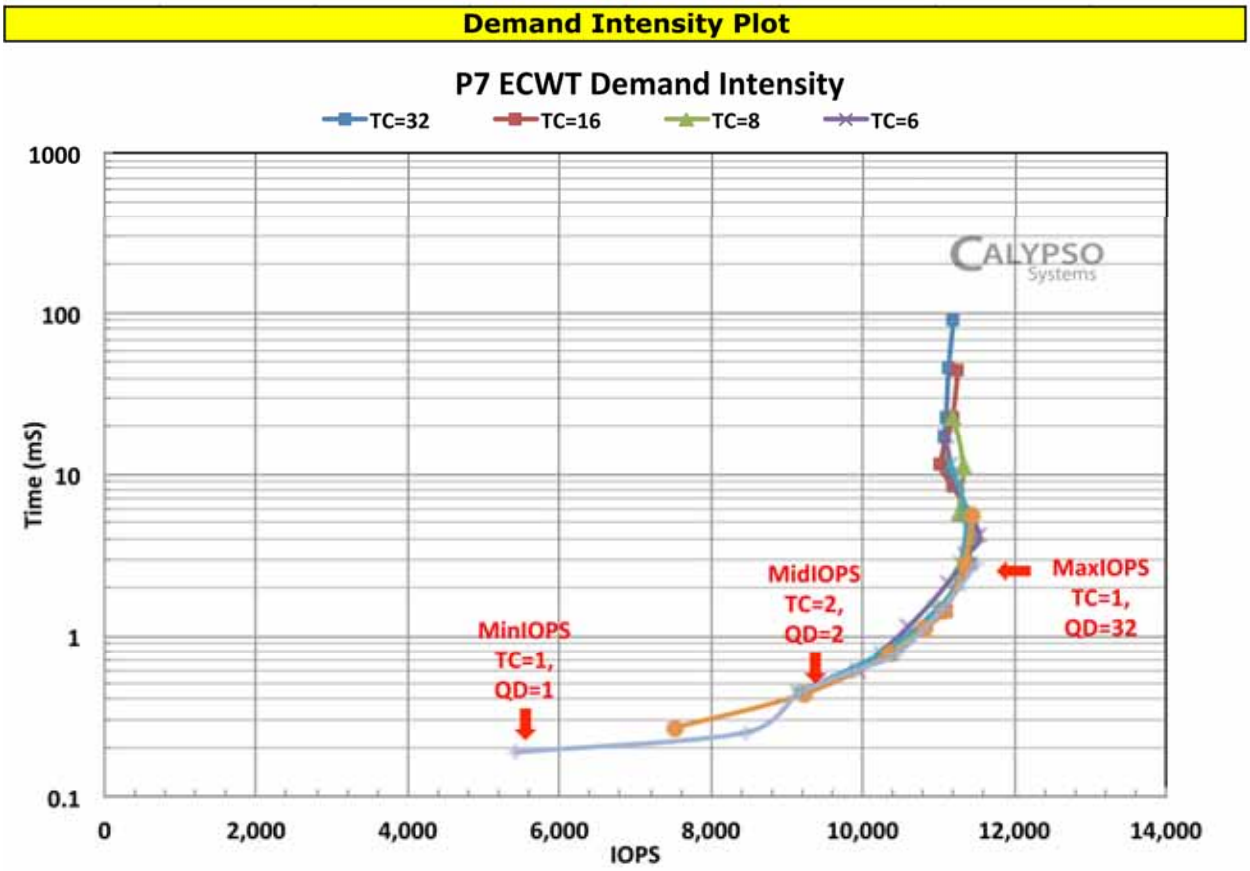
13.3.2.6 Demand Variation Plot

Demand Variation Plot



Plot 13-9 - Demand Variation Plot

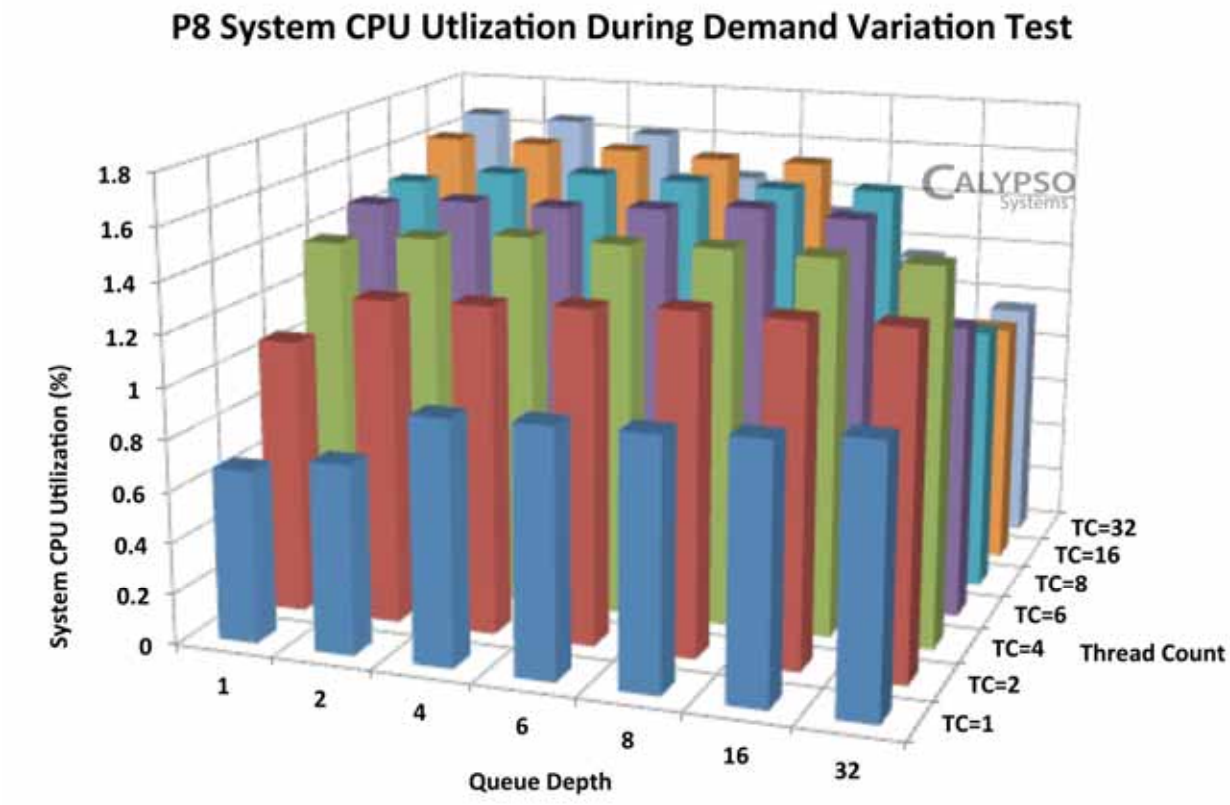
13.3.2.7 Demand Intensity Plot



Plot 13-10 - Demand Intensity Plot

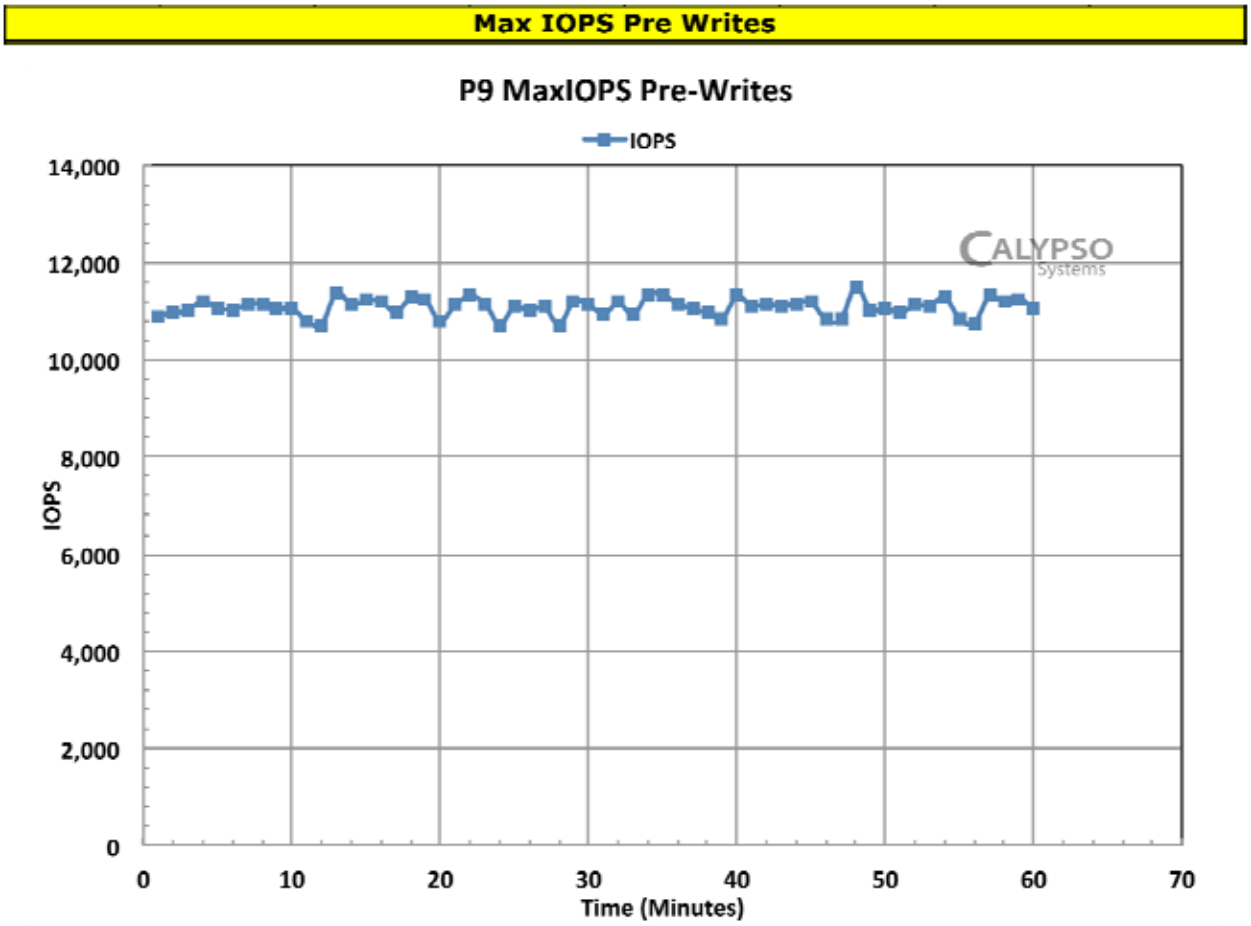
13.3.2.8 CPU Utilization Plot

System CPU Utilization Plot



Plot 13-11 - CPU Utilization Plot

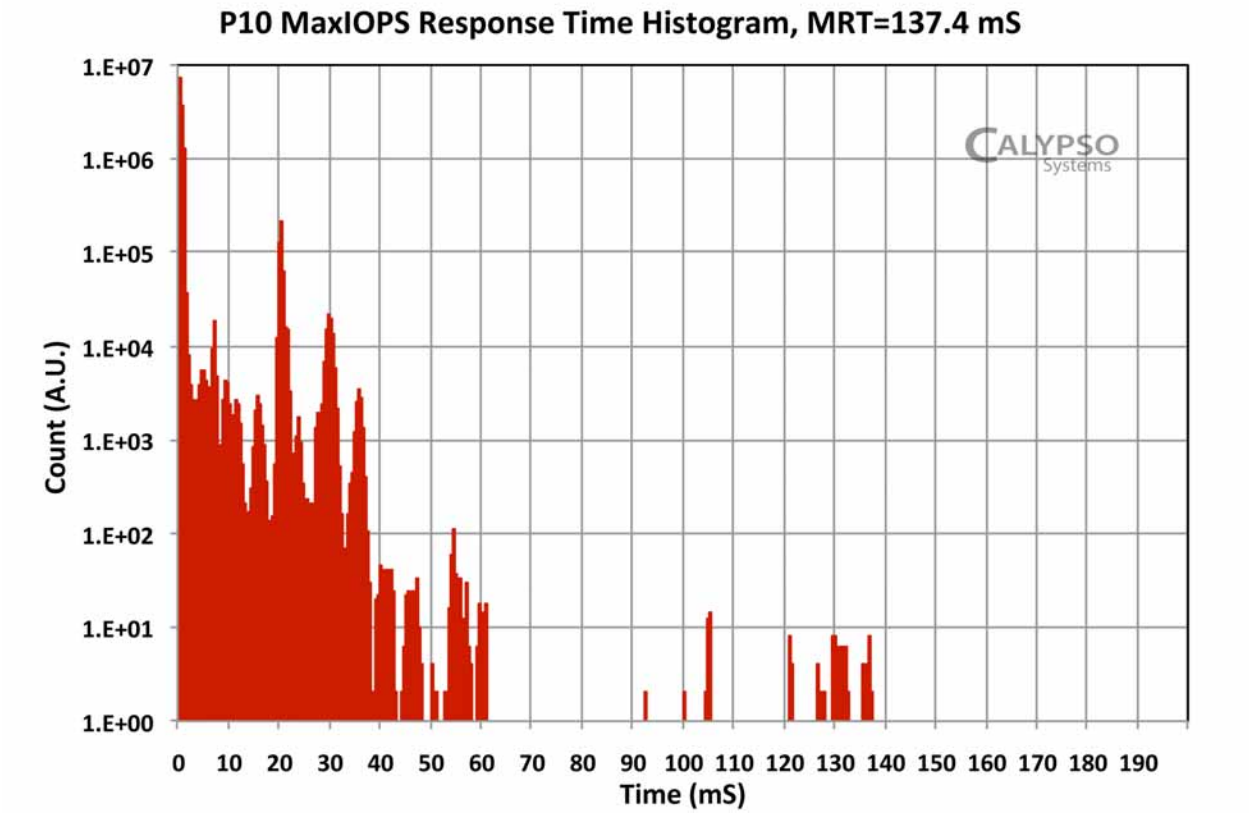
13.3.2.9 MaxIOPS Prewrites



Plot 13-12 - MaxIOPS Prewrites

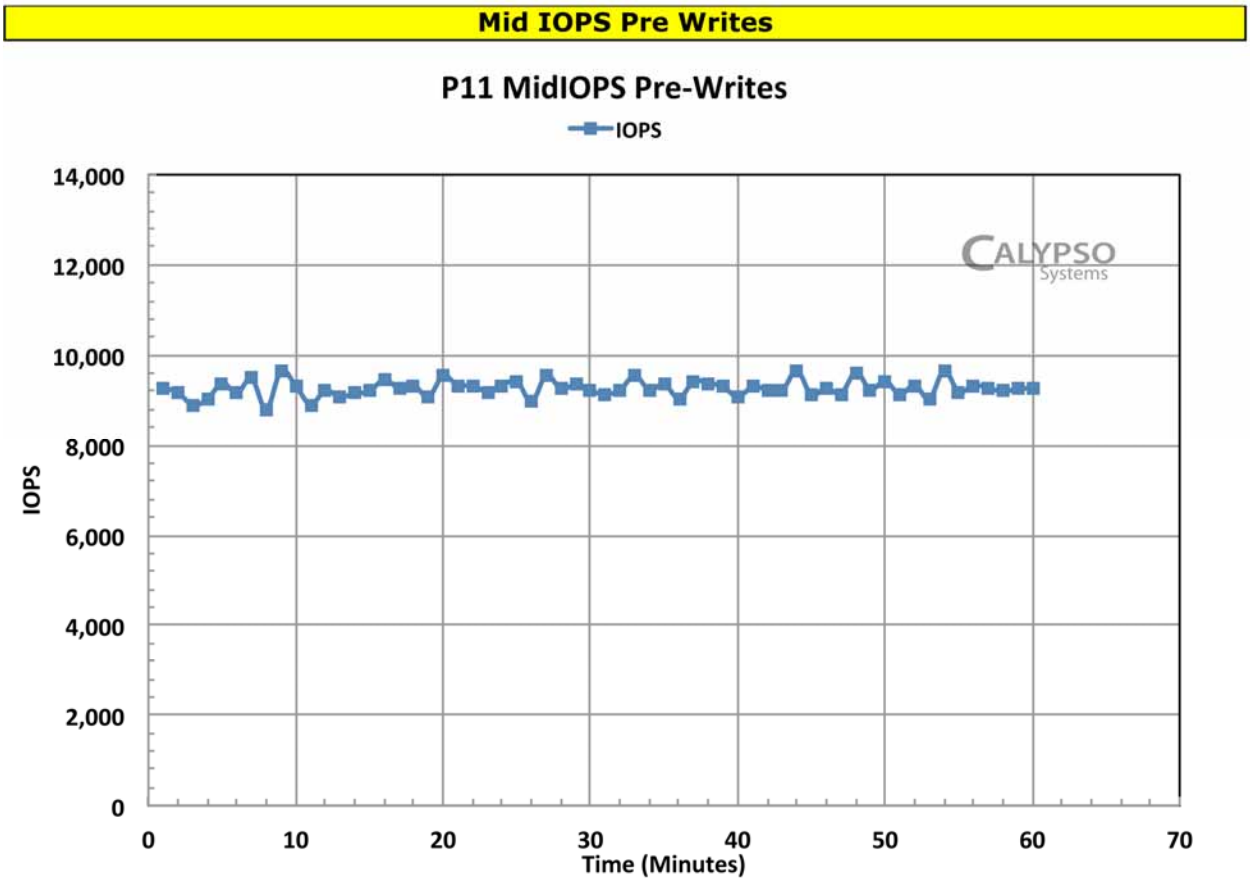
13.3.2.10 Max IOPS Histogram

Max IOPS Histogram



Plot 13-13 - MaxIOPS Histogram

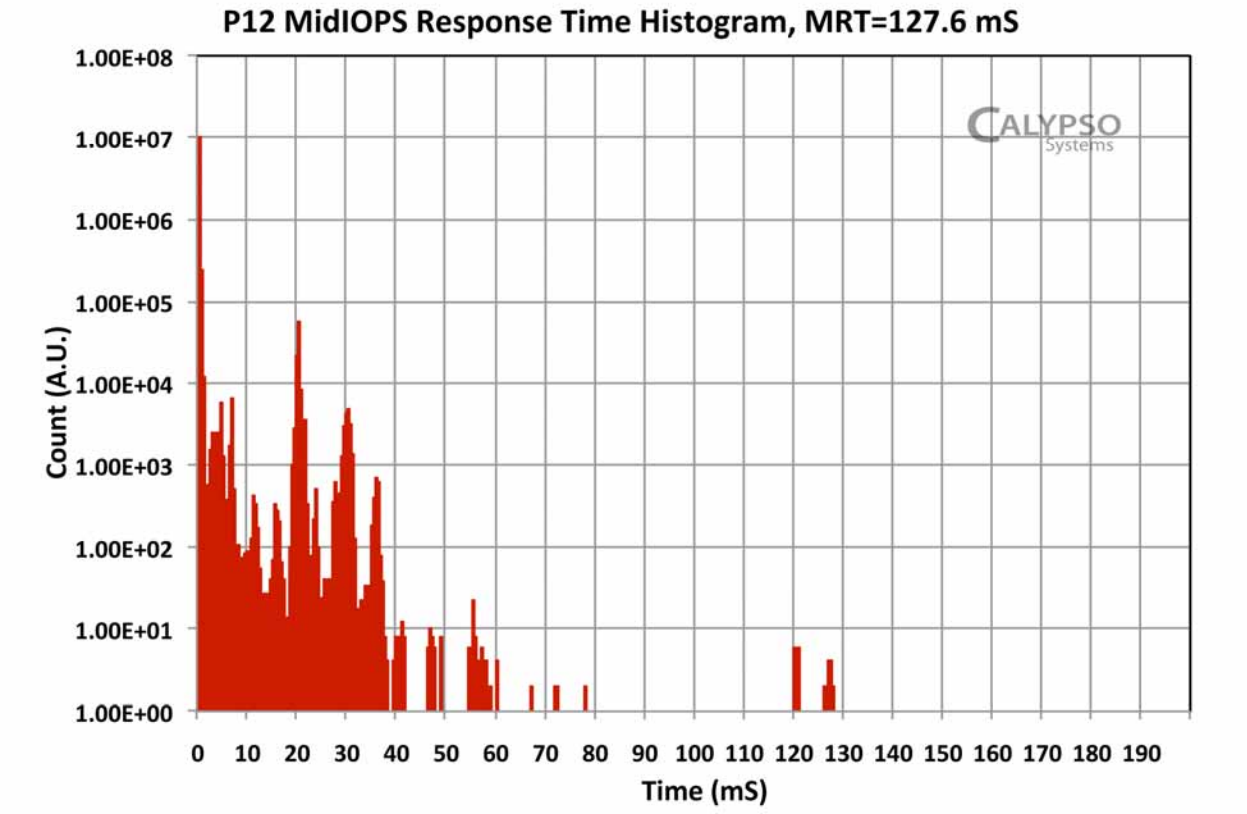
13.3.2.11 MidIOPS Prewrites



Plot 13-14 - MidIOPS Prewrites

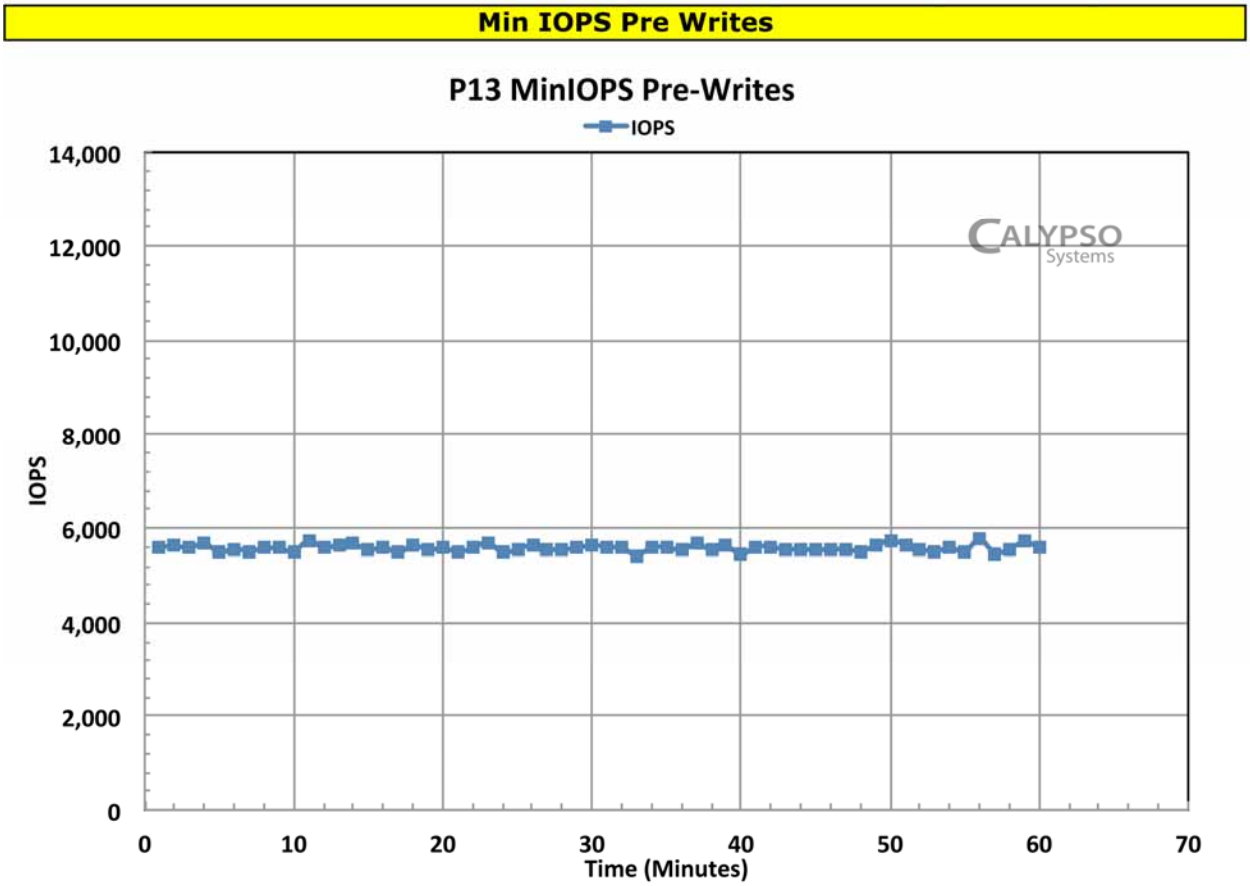
13.3.2.12 Mid IOPS Histogram

Mid IOPS Histogram



Plot 13-15 - MidIOPS Histogram

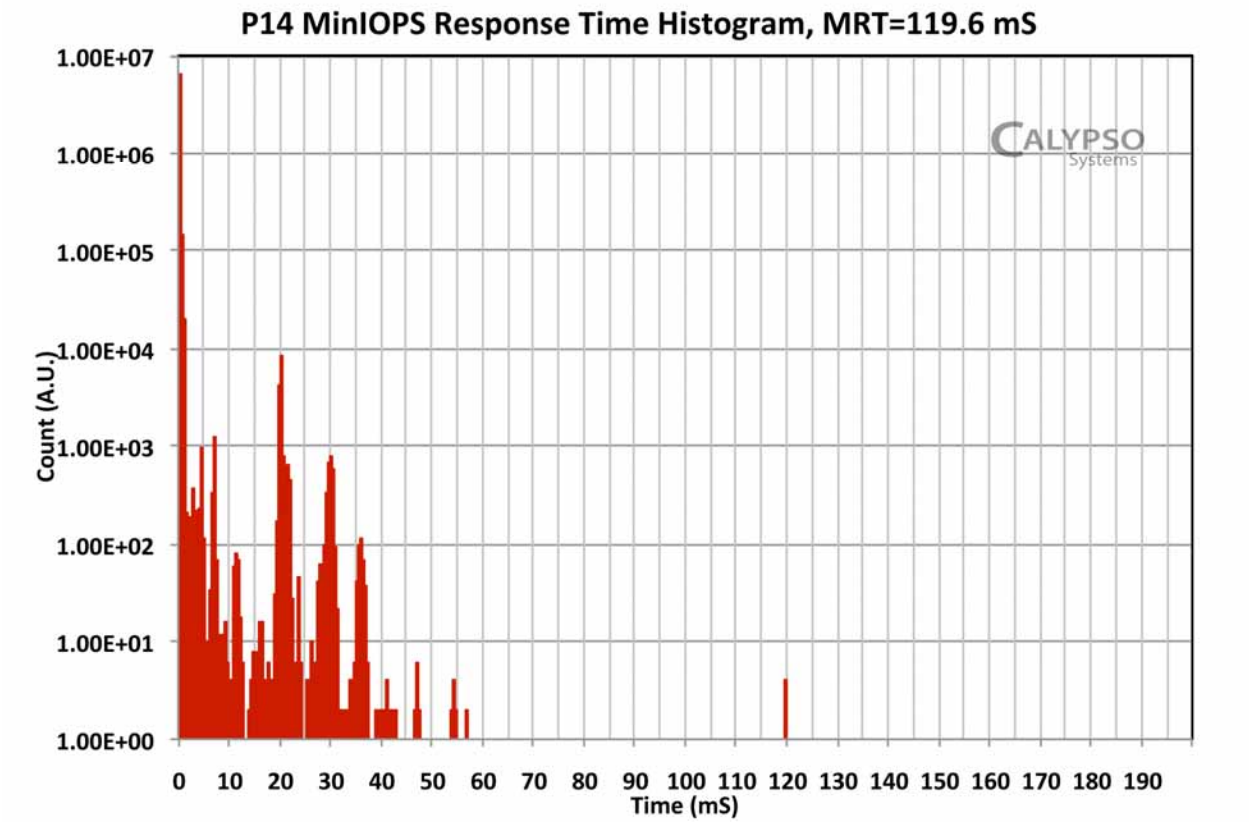
13.3.2.13 MinIOPS Prewrites



Plot 13-16 - MinIOPS Prewrites

13.3.2.14 Min IOPS Histogram

Min IOPS Histogram



Plot 13-17 - MinIOPS Histogram

14 Demand Intensity / Response Time Histogram

14.1 Demand Intensity / Response Time Histogram (DIRTH) Descriptive Note:

General Description:

This test is designed to demonstrate the mode of degradation of an SSD when it is subject to a super saturating IO load. This test will show how well a device handles a workload of increasing demand intensity. This is important to determine where a given OIO combination (in Thread Count and QD) will result in the highest IOPS and / or lowest Response Time. In addition, this test also shows the statistical distribution of response times at a number of operating points below the maximum response time ceiling.

Test Flow:

The Enterprise Demand Intensity / Response Time test makes use of:

1. An initial PURGE of the device followed by
2. Preconditioning to the entire LBA ActiveRange (Section 2.1.1);
    1) a one step Workload Independent PC (Section 2.1.16a) consisting of 128KiB SEQ writes for 2X (twice) the user capacity; and
    2) a one step Workload Dependent PC (WDPC) (Section 2.1.16b) consisting of a single Block Size of test operator choice applied at an overall R/W mix of 100% write over the LBA ActiveRange at a Total OIO TC=32, QD=32 until Steady State, as defined, is achieved. Note that Queue Depth here refers to the application Queue Depth, or sometimes also referred to as Outstanding IOs issued by a particular application process.
3. Running the Access Pattern while varying the Total Outstanding IOs by applying an outer loop of High to Low Thread Count by an inner loop of High to Low Queue Depth with the application of an inter loop Pre Write between each TOIO loop until Steady State, as defined, is reached for the TOIO tracking variable.
4. Using the Steady State data, plot ART v IOPS and CPU Usage v Thread Count for all the Thread Count settings used.
5. Selecting a MAX IOPS point representing an operating point where the IOPS is maximum while achieving a reasonable ART; select a MIN IOPS point where TC=1 and QD=1; and select a minimum of 1 additional MID IOPS point(s), using the (Thread Count, OIO/Thread) operating points obtained during the test run such that their IOPS values lie between and equally divides the IOPS value between MinIOPS and MaxIOPS.
6. Plotting Response Time Histograms for each of the MAX, MIN and MID IOPS points.

Test Results:

The test output graph will present the IO rate and response time of the device given a varying number of OIO (derived by the combination of TC and QD). The secondary plot will present the time statistics (or histogram) for the selected OIO points.

Test Interpretation:

The DI curve shows the Average Response times. To see Maximum Response Times, the histogram will show time statistics (response times and distributions) at the selected OIO maximum IOPS point. In general, the test operator should view the Response Time histogram with regard to the clustering of response times (tighter grouping is better), response times of the measurements (faster is better), the maximum response times and number of slow response time “outliers.”

14.2 DIRTH Pseudo Code

For (ActiveRange=100%, optional ActiveRange=Test Operator Choice, Access Pattern = (R/W Mix=RW1, Block Size=BS1, Random)

1 Purge the device. (Note: Active Range and other Test Parameters are not applicable to Purge step; any values can be used and none need to be reported.)

2 Preconditioning using the Access Pattern, but with R/W Mix=0%

2.1 Set test parameters and record for later reporting

2.1.1 Volatile device write cache = Disabled

2.1.2 QD or OIO/Thread: 32

2.1.3 Thread Count: 32

2.1.4 Data Pattern: Required = Random, Optional = Test Operator Choice

2.2 Run Access Pattern, using the required ActiveRange=100% or the corresponding desired optional ActiveRange.

2.2.1 Record elapsed time, IOPS, Average Response Time (ART) and Maximum Response Time (MRT) every 1 minute.

2.2.2 Using the first 1 Minute IOPS, along with subsequent 1 Minute IOPS results that are 30 Minutes apart, run Access Pattern until Steady State (see 2.1.21) is reached, or until the maximum number of Rounds=25 has been reached.

3 Run the Access Pattern while varying demand settings:

3.1 Set test parameters and record for later reporting

3.1.1 Volatile device write cache = Disabled

3.1.2 Data Pattern: Same as Preconditioning

3.1.3 Vary TC using TC=[32,16,8,6,4,2,1]

3.1.4 Vary QD using QD=[32,16,8,6,4,2,1]

3.2 Apply Inter-Round Pre-Write

3.2.1 Apply Access Pattern, using TC=32 and QD=32 for a minimum of 5 minutes and a maximum of either 30 minutes or 10% of the User Capacity, whichever occurring first.

3.2.2 Record elapsed time, IOPS, ART, MRT and Percentage CPU Utilization by System (SYS_CPU) every 1 Minute.

3.3 Apply One Round of the Access Pattern:

3.3.1 Apply Access Pattern for 1 Minute at each TC/QD combination, in the order of decreasing TOIO from 1024 (32x32) to 1, using all of the TC/QD combinations that can be generated from TC and QD values given in Sections 3.1.3 and 3.1.4. When multiple TC/QD combinations give rise to equal TOIO values, apply TC/QD combination with the higher TC first.

3.3.2 Record elapsed time, IOPS, ART and MRT and Percentage CPU Utilization by System (CPU_SYS).

3.3.3 Repeat 3.2 and 3.3 until Steady State (see 2.1.21) is reached, using IOPS values for TC=32, QD=32 and Block Size and R/W Mix as specified in the Access Pattern as the tracking variable, or until the maximum number of Rounds=25 has been reached.

4 Using Steady State data (or if Steady State not reached, data from the Measurement Window):

4.1 Plot ART versus IOPS using all of the (Thread Count, OIO/Thread) operating points, plotting 1 serie per Thread Count setting for all Thread Count settings used.

4.2 Plot CPU_SYS versus Thread Count and OIO/Thread for all data.

5 Determine MaxIOPS, MinIOPS and a minimum of 1 MidIOPS operating point:

5.1 A MaxIOPS point shall be chosen from the (Thread Count, OIO/Thread) operating points, such that:

5.1.1 The MaxIOPS point should be chosen to represent the operating point where the IOPS is maximum while achieving a reasonable ART.

5.1.2 The ART for such MaxIOPS point shall be below 5 mS.

5.2 The MinIOPS point is defined to be the operating point where Thread Count=1 and OIO/Thread=1.

5.3 Choose a minimum of 1 additional MidIOPS point(s), using the (Thread Count, OIO/Thread) operating points obtained during the test run such that their IOPS values lie between and, as much as possible, equally divides the IOPS value between MinIOPS and MaxIOPS.

6 Response Time Histogram at Maximum IOPS:

6.1 Select a (Thread Count, Queue Depth) operating point that yields maximum IOPS using the lowest number of Total Outstanding IO (TOIO=Thread Count x Queue Depth)

6.2 Run Pre-Writes

6.2.1 Execute R/W Mix=0/100, Random, Block Size=BS1 for 60 minutes. Log elapsed time, IOPS, ART and MRT every 1 minute.

6.3 Execute R/W Mix=RW1, Random IO, Block Size=BS1 KiB for 10 minutes. Capture all individual IO command completion times such that a response time histogram showing count versus time can be constructed. The maximum time value used in the capture shall be greater or equal to the MRT encountered during the 10 minute capture.

7 Response Time Histogram at Minimum IOPS:

7.1 Select a (Thread Count=1, Queue Depth=1) operating point

7.2 Run Pre-Writes

7.2.1 Execute R/W Mix=0/100, Random, Block Size=BS1 for 60 minutes. Log elapsed time, IOPS, ART and MRT every 1 minute.

7.3 Execute R/W Mix=RW1, Random IO, Block Size=BS1 KiB for 10 minutes. Capture all individual IO command completion times such that a response time histogram showing count versus time can be constructed. The maximum time value used in the capture shall be greater or equal to the MRT encountered during the 10 minute capture.

8 Response Time Histogram at one or more chosen MidIOPS operating points:

8.1 Select a (Thread Count, Queue Depth) operating point that yields an IOPS result that lies approximately halfway between Maximum IOPS in (6) above, and the Minimum IOPS in (7) above.

8.2 Run Pre-Writes:

8.2.1 Execute R/W Mix=0/100, Random, Block Size=BS1 KiB for 60 minutes. Log elapsed time, IOPS, ART and MRT every 1 minute.

8.3 Execute R/W Mix=RW1, Random IO, Block Size=BS1 KiB for 10 minutes. Capture all individual IO command completion times such that a response time histogram showing count versus time can be constructed. The maximum time value used in the capture shall be greater or equal to the MRT encountered during the 10 minute capture.

9 Process and plot the accumulated data, per report guidelines in next section.

14.3 Test Specific Reporting for DIRTH Test

The following sub-sections list the reporting requirements specific to the Demand Intensity / Response Time Histogram test. Reporting requirements common to all tests are documented in Section 5.

Note on Headers: The individual Report Headers are the same for all pages of the report, except for reference to a specific test ID number if more than one test is used to generate the SNIA Report Header. The plots in the following sections show the test Report Header for the first plot example only. Test Report Headers are omitted for subsequent report pages for the same test report in order to provide more clarity for the related plot or graph.

14.3.1 Purge Report

The Test Operator shall report the method used to run the Purge operation.

14.3.2 Measurement Report

The Test Operator shall generate Measurement Plots for DIRTH for Preconditioning; Steady State Determination; Between Round Pre Writes; Demand Variation IOPS Plots for Thread Count tracking; Steady State for OIO Tracking Variable; Demand Variation Plot; Demand Intensity Plot; CPU Utilization Plot; MAX IOPS Pre Write Plot; MID IOPS Pre Write Plot; MIN IOPS Pre Write Plot; and Response Time Histograms for MAX IOPS, MIN IOPS and MID IOPS using the Ranges, Ordinates and Plot Types listed in Table 14-1 and shown in plots in Sections 14.3.2.1 through 14.3.2.14.

Table 14-1 – DIRTH Measurement Plots

Plot	Plot Title	Range	Ordinate	Plot Type	Description
1	PC IOPS Plot	IOPS	Time	2D, x-y-spline	IOPS v Time for tracking variable for Preconditioning using Access Pattern
2	PC Steady State Plot	IOPS	Round	2D, x-y-spline	IOPS v Rounds for the tracking variable showing Steady State details
3	Inter-Round Pre Writes Plot	IOPS	Time	2D, x-y-scatter	IOPS v Time showing Between Round Pre-Writes
4	DV IOPS Plot, TC=Tracking	IOPS	Round	2D, x-y-spline	IOPS v Round for TC of Tracking Variable, ALL QD as separate Series
5	DV Steady State Plot, Tracking Variable	IOPS	Round	2D, x-y-spline	IOPS v Round for Tracking Variable, showing Steady State details
6	Demand Variation Plot	IOPS	QD	2D, x-y-spline	IOPS v QD for all TCs as separate series for Steady State results
7	Demand Intensity Plot	Time	IOPS	2D, x-y-spline	Time (mS) v IOPS for all TC/QD Combinations, each TC plotted as a Series for Steady State results. MaxIOPS MidIOPS(s) MinIOPS points labeled.
8	CPU Utilization Plot	%	TC,QD	3D, x-y-z-bar	CPU_SYS (%) v TC & QD for all Steady State results
9	MaxIOPS Prewrites	IOPS	Time	2D, x-y-spline	MaxIOPS Prewrite: IOPS v Time for Prewrite preceding MaxIOPS Histogram Capture
10	Max IOPS Histogram	Count	Time	2D, x-y-bar	MaxIOPS Histogram: Count (A.U.) v Time (ms), Legend should indicate MRT for the Histogram Capture
11	MidIOPS Prewrites	IOPS	Time	2D, x-y-spline	MidIOPS Prewrite: IOPS v Time for Prewrite preceding MidIOPS Histogram Capture
12	Mid IOPS Histogram	Count	Time	2D, x-y-bar	MidIOPS Histogram: Count (A.U.) v Time (ms), Legend should indicate MRT for the Histogram Capture
13	MinIOPS Prewrites	IOPS	Time	2D, x-y-spline	MinIOPS Prewrite: IOPS v Time for Prewrite Preceding MinIOPS Histogram Capture
14	Min IOPS Histogram	Count	Time	2D, x-y-bar	MinIOPS Histogram: Count (A.U.) v Time (ms), Legend should indicate MRT for the Histogram Capture

14.3.2.1 Pre Conditioning Plot

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

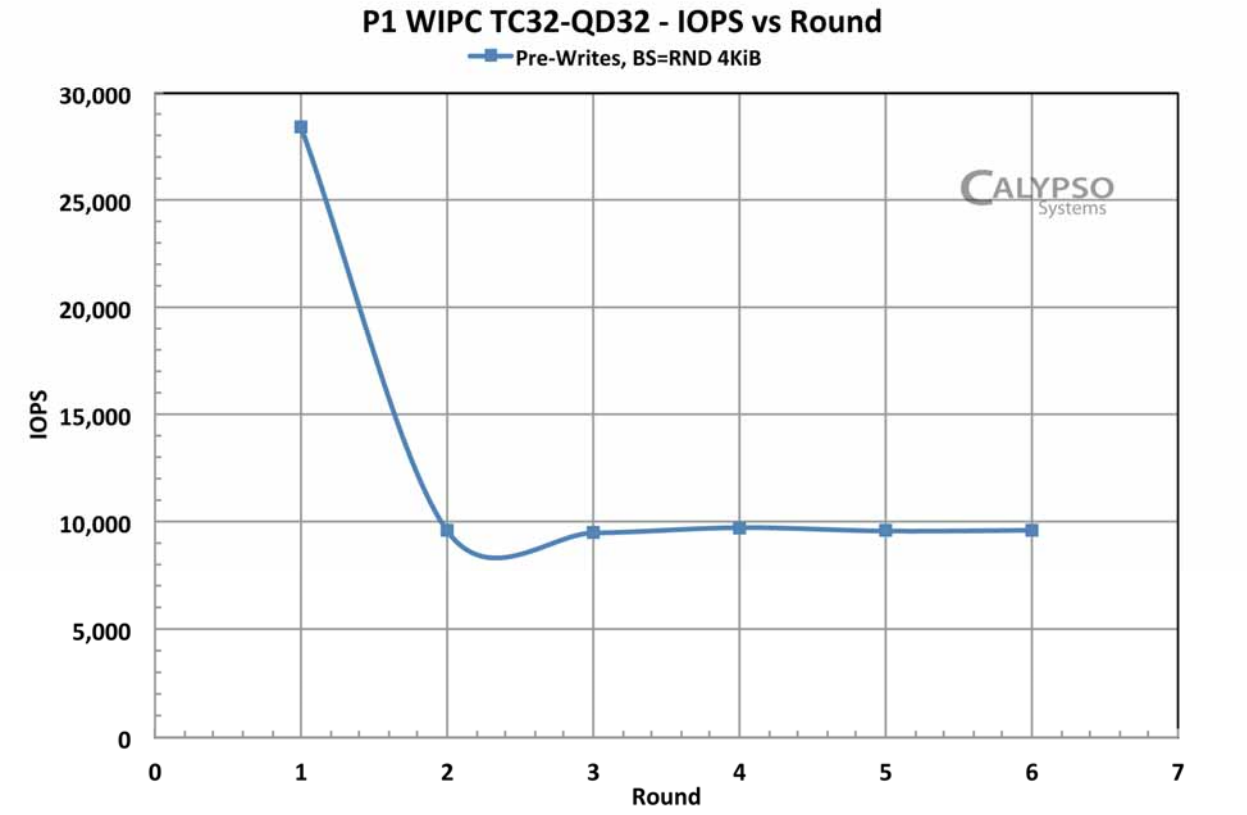
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	1 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

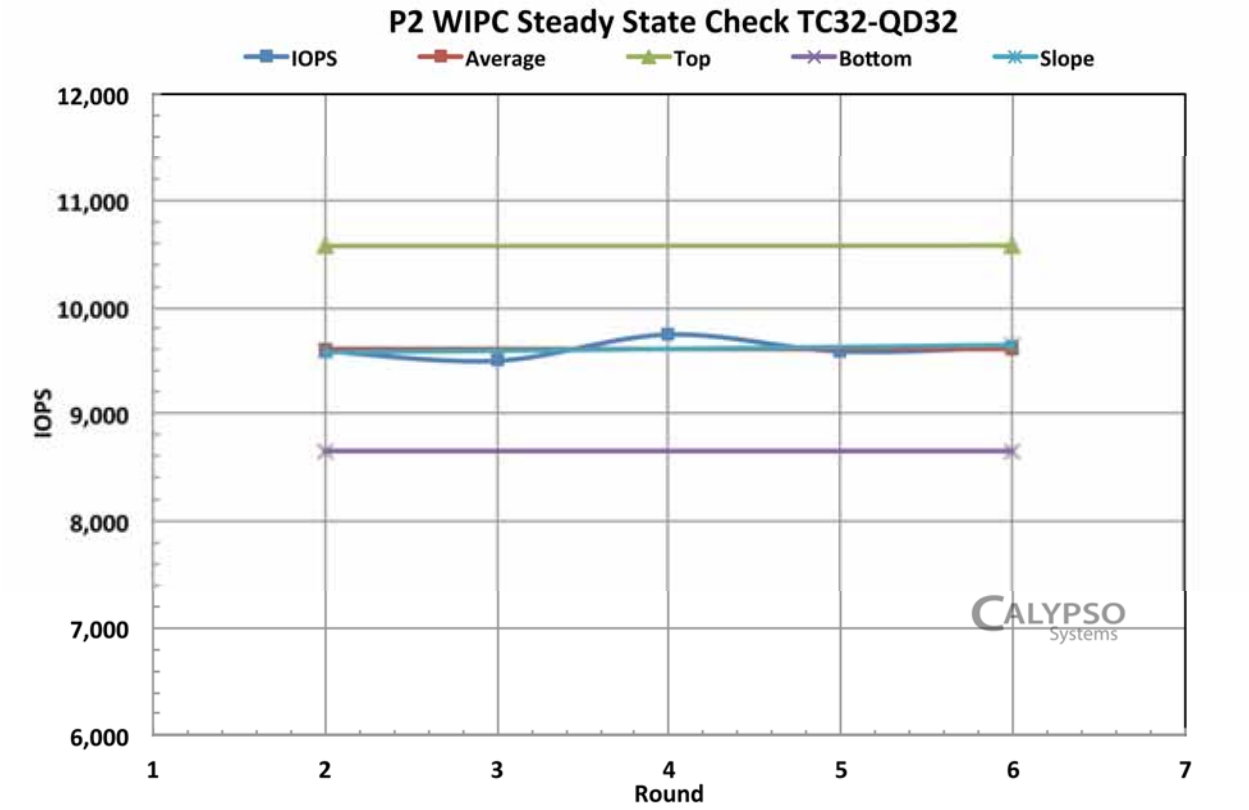
Pre Conditioning IOPS Plot



Plot 14-2 - Pre-Conditioning IOPS Plot

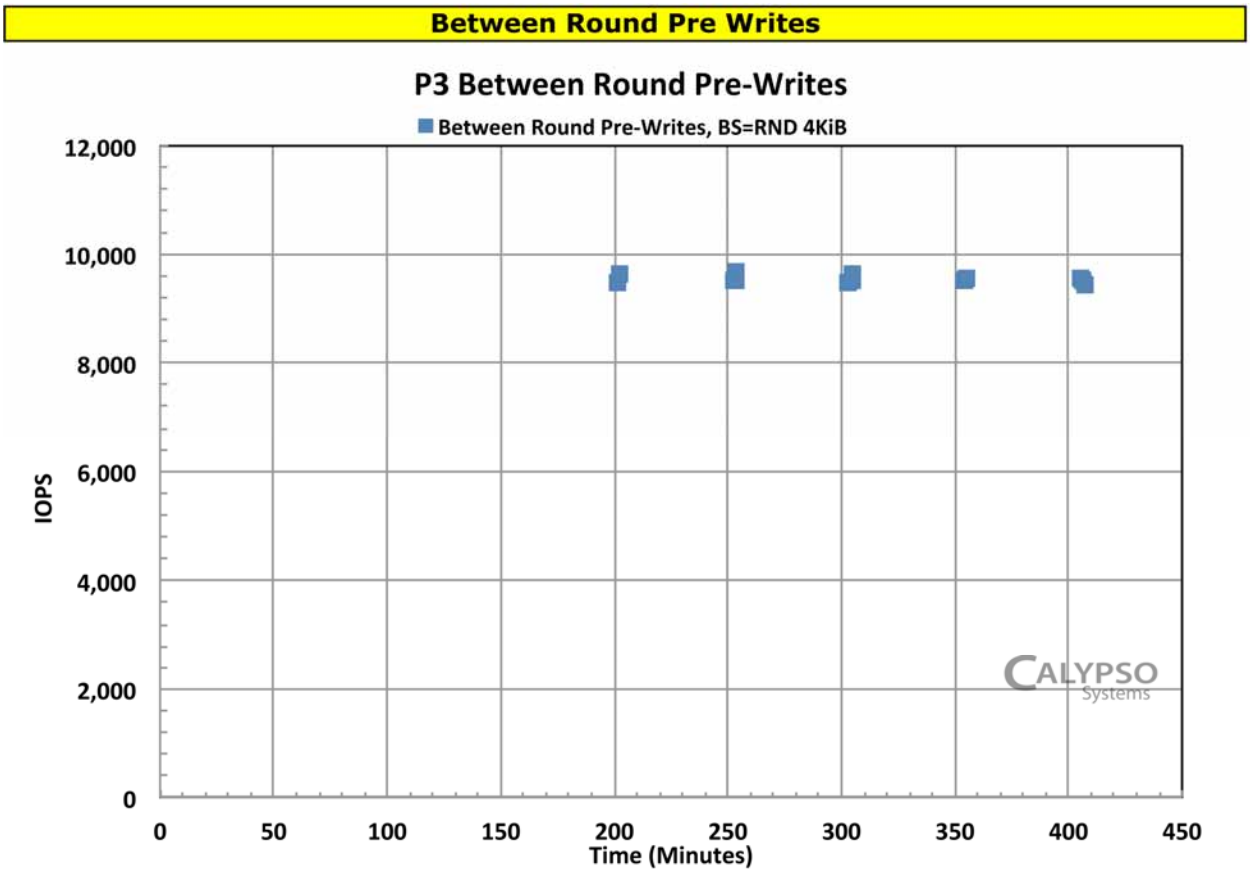
14.3.2.2 Pre Conditioning Steady State

Pre Conditioning Steady State Plot



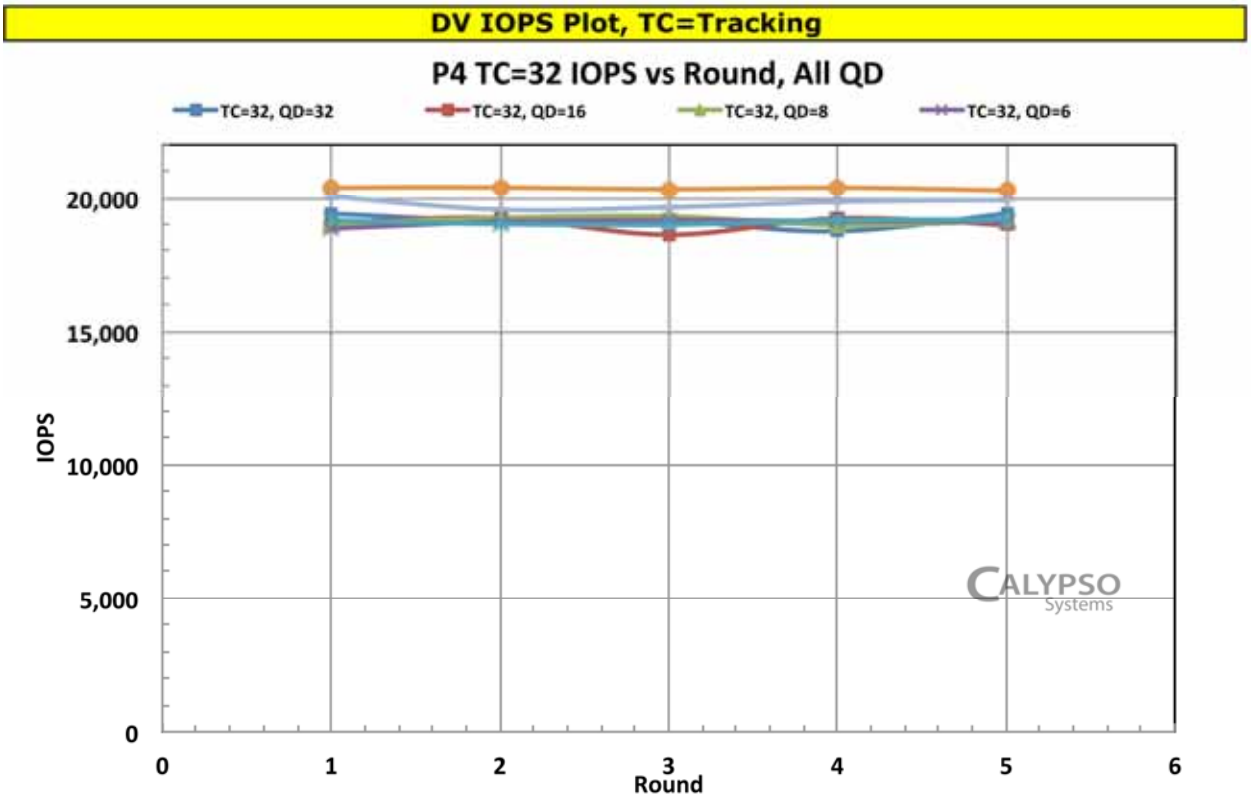
Plot 14-3 - Pre-Conditioning Steady State Plot

14.3.2.3 Inter Round Pre Writes



Plot 14-4 - Between Round Pre Writes

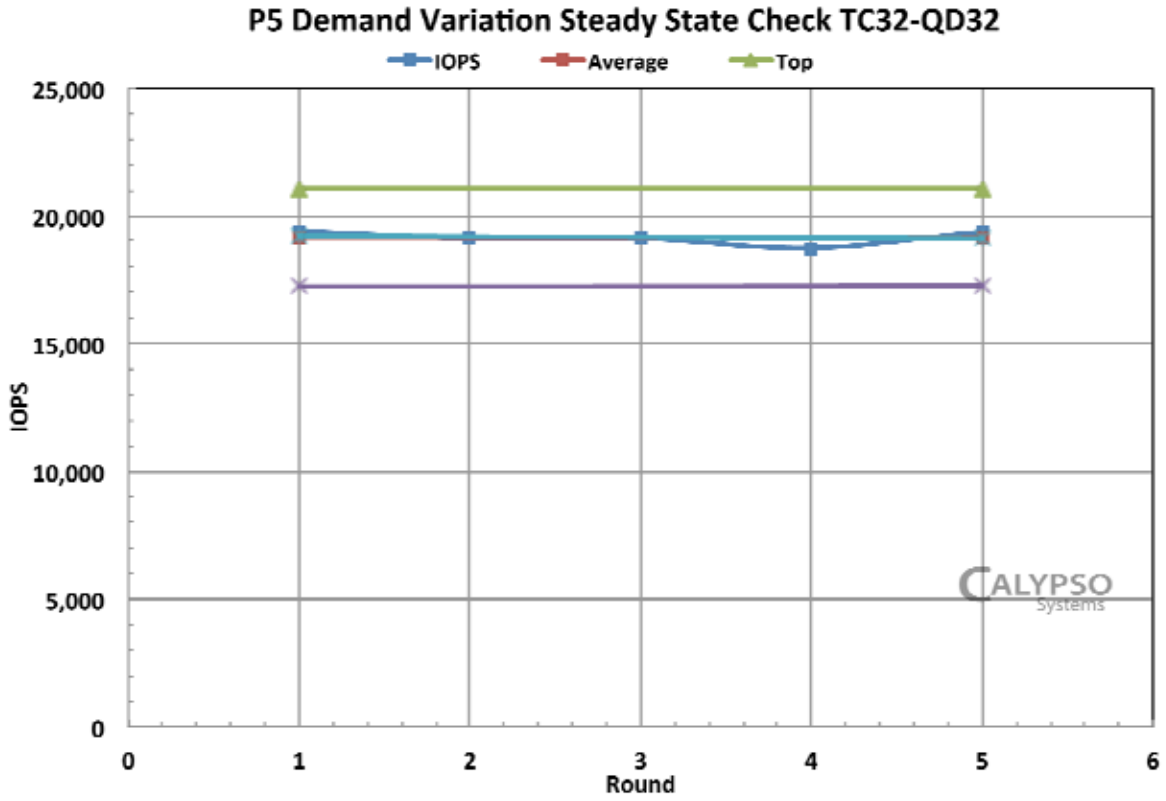
14.3.2.4 Demand Variation IOPS



Plot 14-5 - DV IOPS Plot, TC=Tracking

14.3.2.5 Demand Variation Steady State

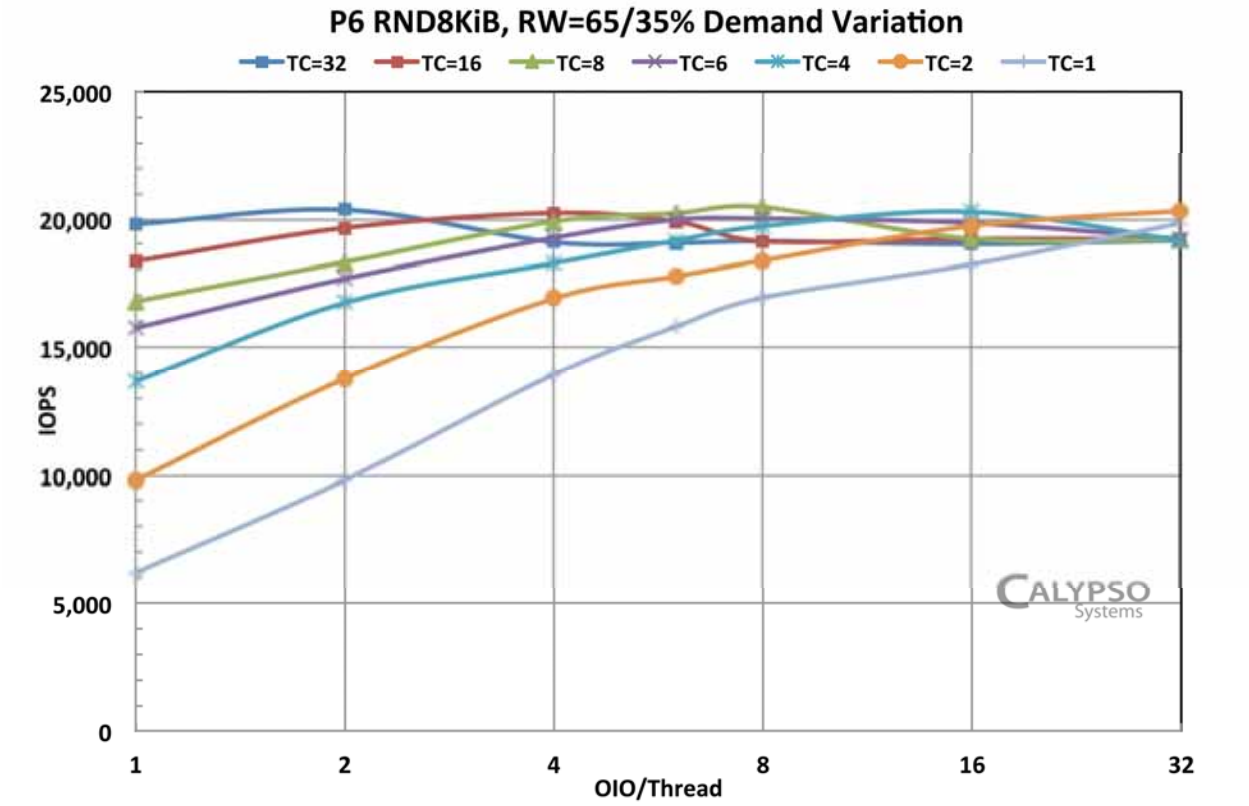
DV Steady State Plot, Tracking Variable



Plot 14-6 - DV Steady State Plot, Tracking Variable

14.3.2.6 Demand Variation IOPS v QD

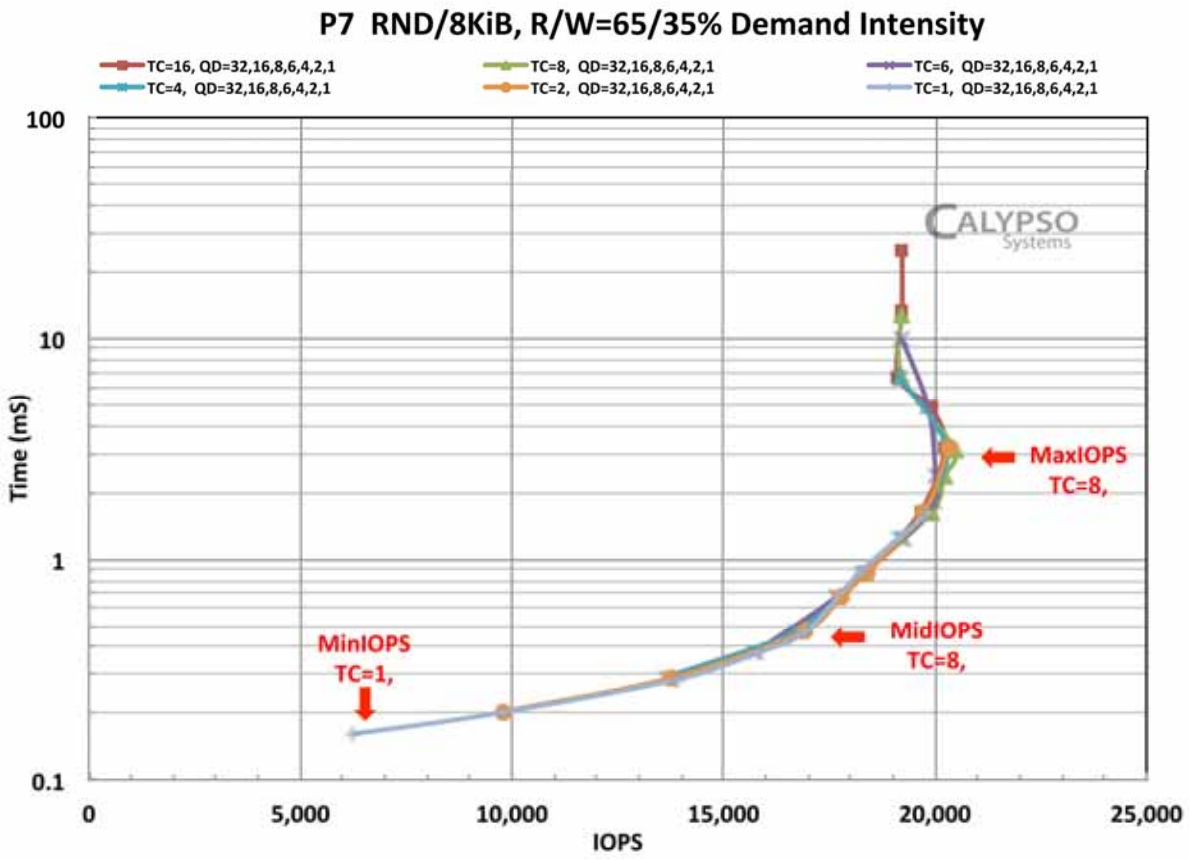
Demand Variation Plot



Plot 14-7 - Demand Variation Plot

14.3.2.7 Demand Intensity

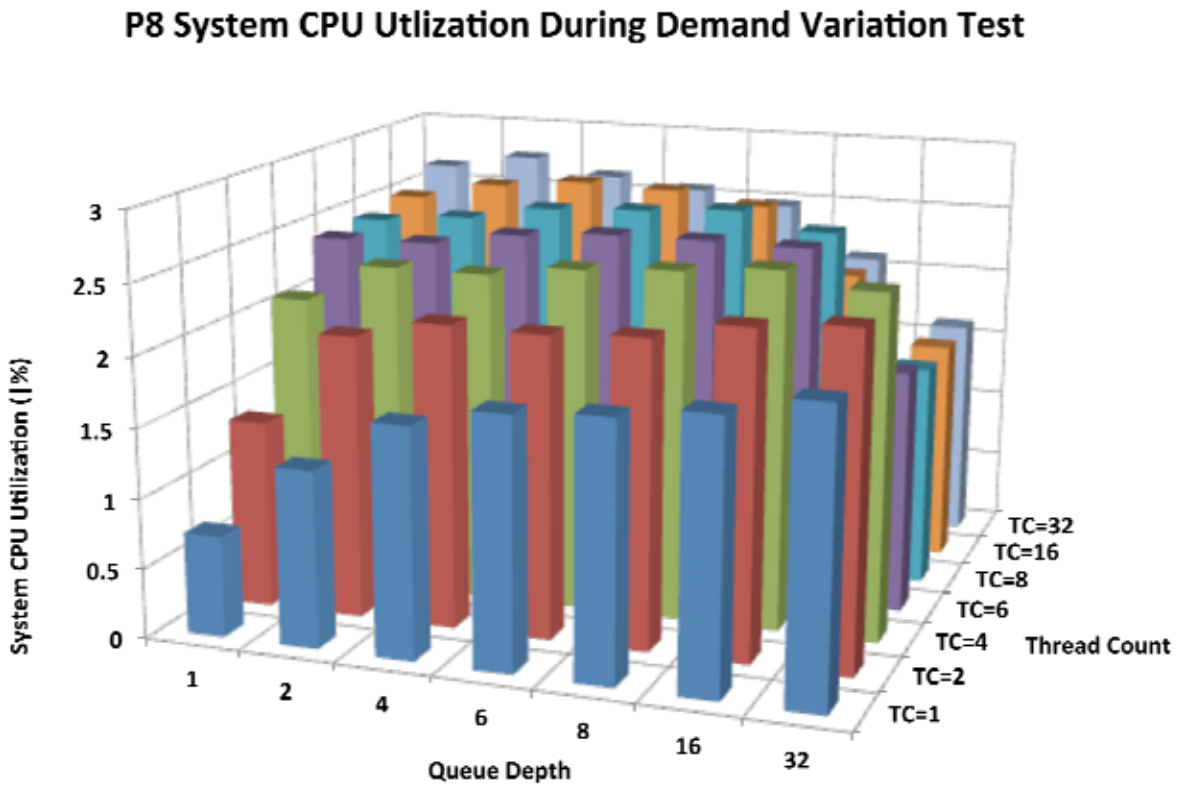
Demand Intensity Plot



Plot 14-8 - Demand Intensity Plot

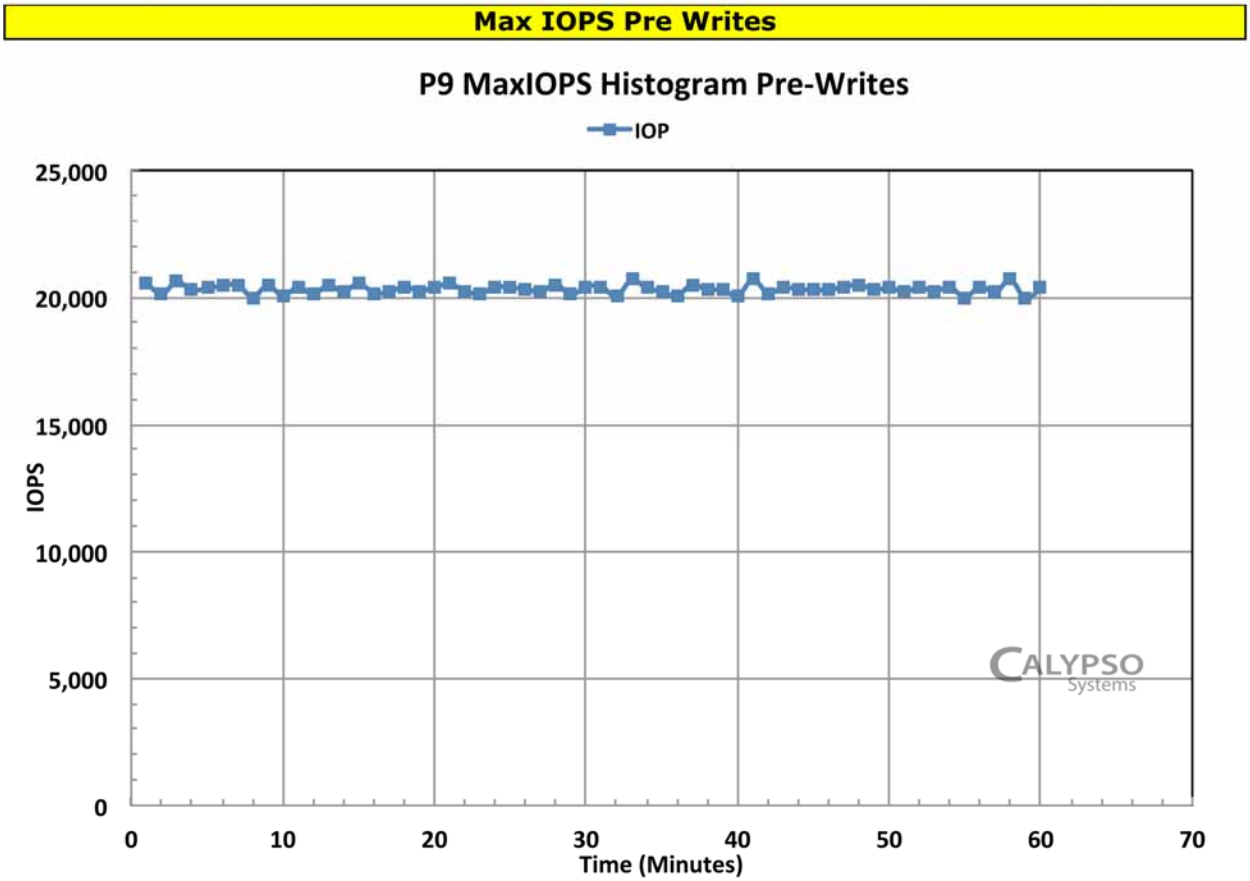
14.3.2.8 CPU Utilization

System CPU Utilization Plot



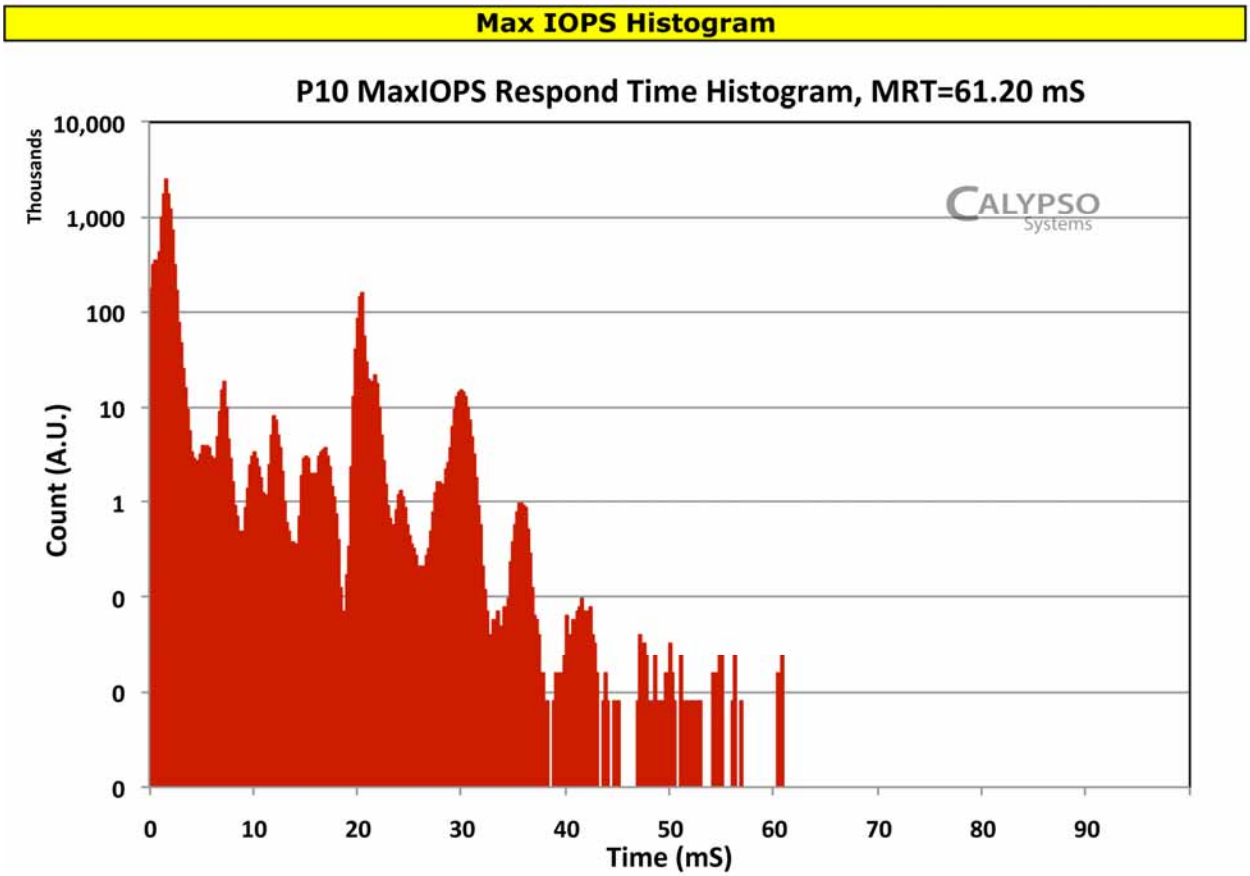
Plot 14-9 - System CPU Utilization Plot

14.3.2.9 Max IOPS Pre Writes



Plot 14-10 - Max IOPS Pre Writes

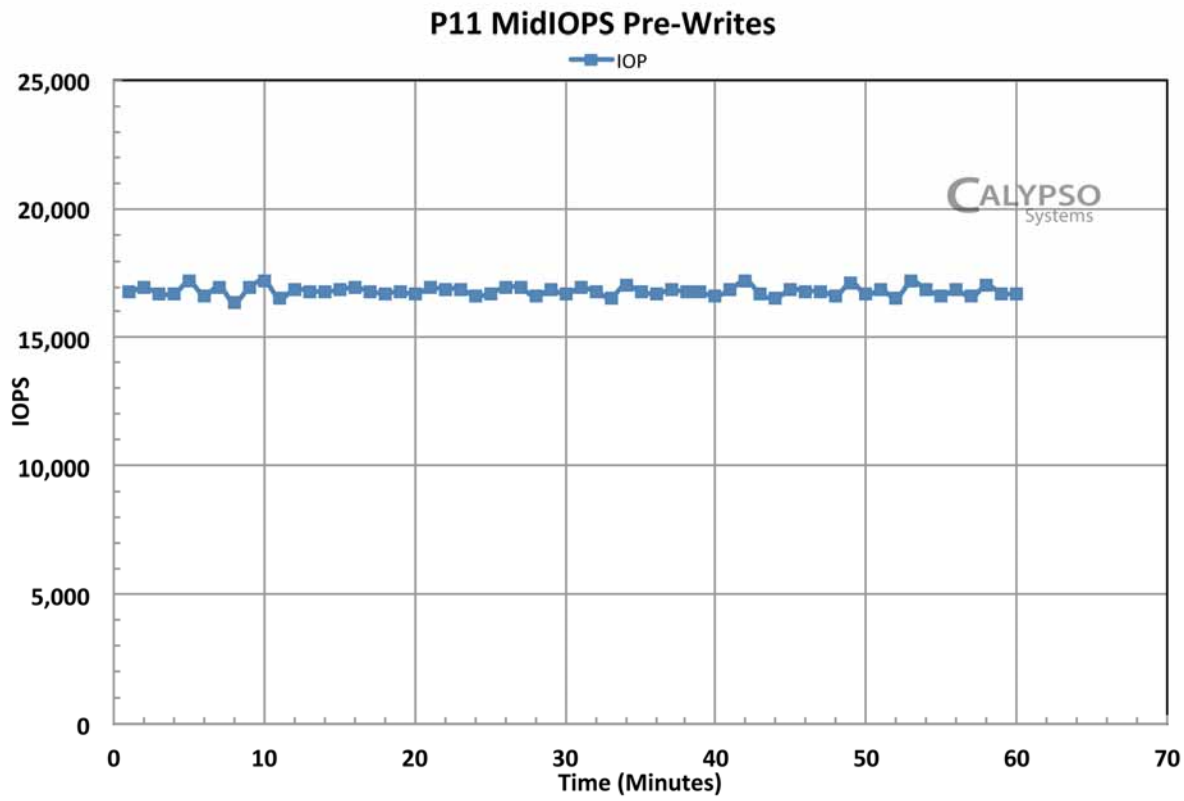
14.3.2.10 Max IOPS Histogram



Plot 14-11 - Max IOPS Histogram

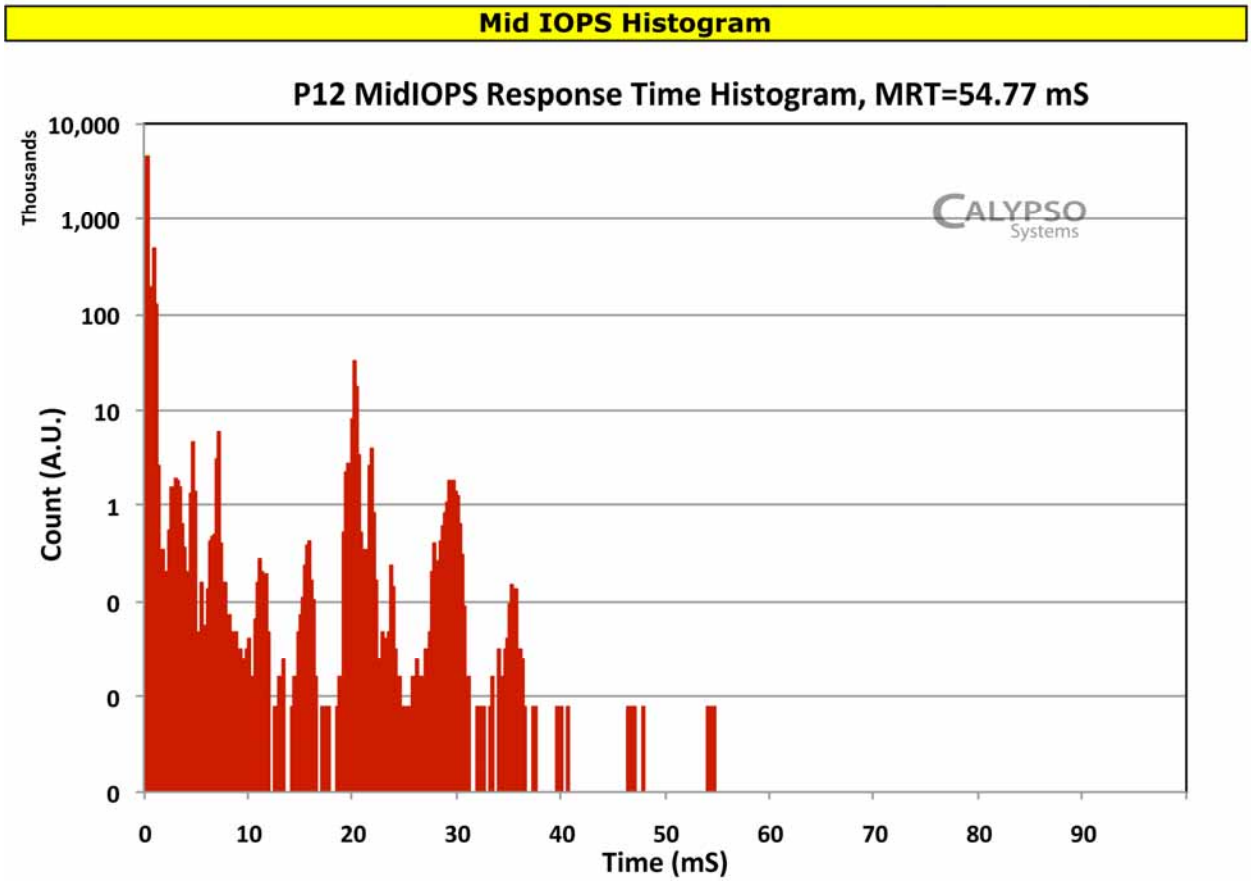
14.3.2.11 Mid IOPS Pre Writes

Mid IOPS Pre Writes



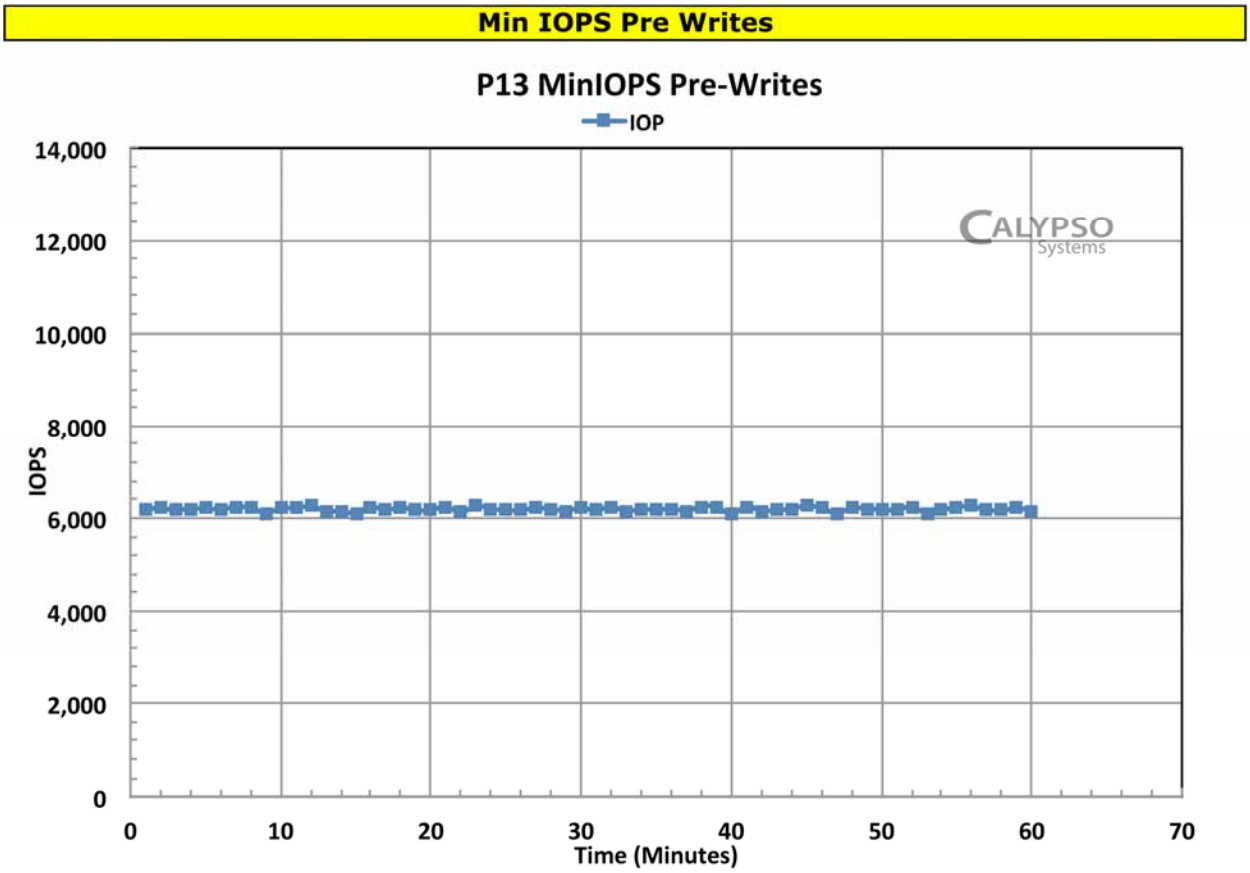
Plot 14-12 - Mid IOPS Pre Writes

14.3.2.12 Mid IOPS Histogram



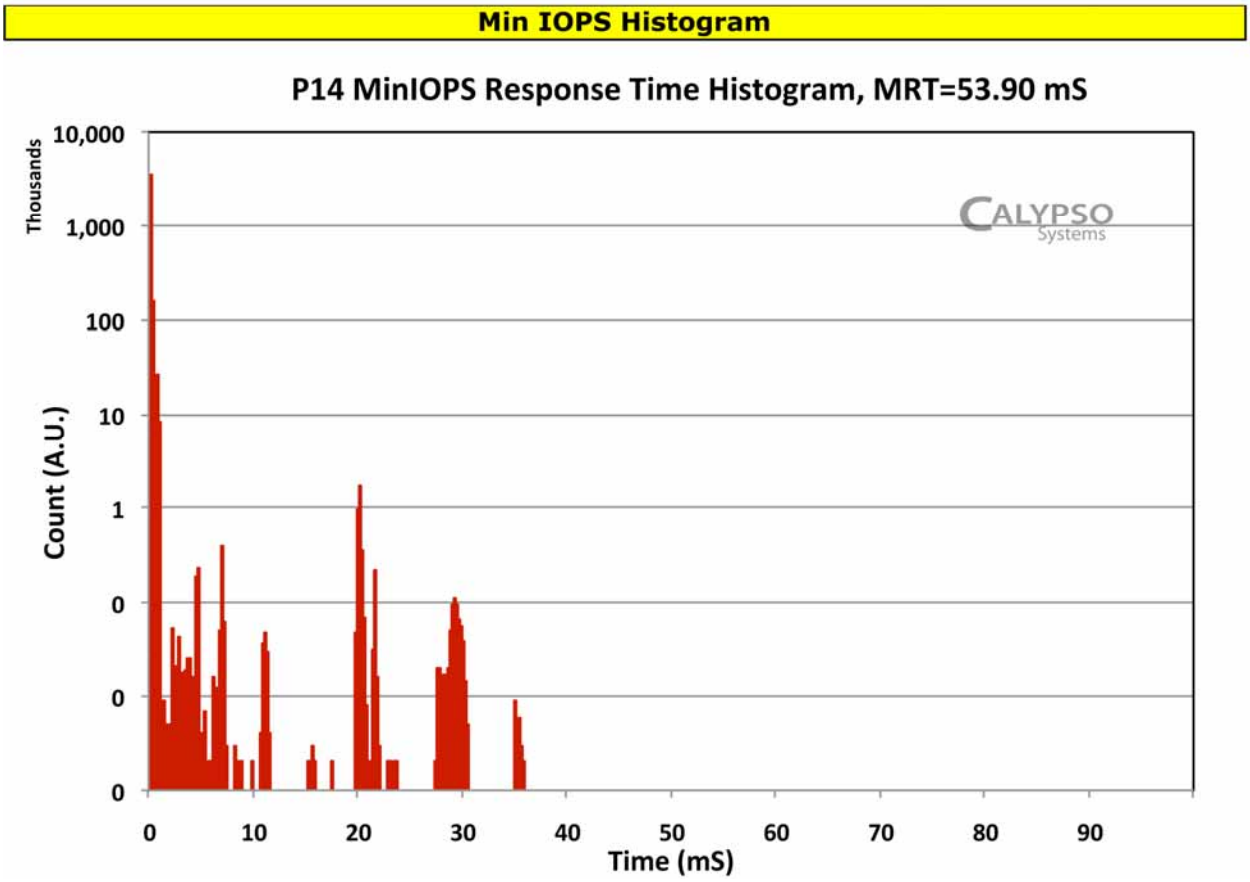
Plot 14-13 - Mid IOPS Histogram

14.3.2.13 Min IOPS Pre Writes



Plot 14-14 - Min IOPS Pre Writes

14.3.2.14 Min IOPS Histogram



Plot 14-15 - Min IOPS Histogram

Annex A (normative) Sample Test Report

This annex displays a sample PTS-E version 1.1 SNIA Test Report (displayed in Plot A.1 through Plot A.63). Normative Individual Report Pages contain mandatory Report Headers on each page that set forth required reporting information pertinent to the tests presented on the particular page(s).

A.1 Sample IOPS Test Report Pages

The sample IOPS Test Report pages are shown in **Plot A.1** through Plot A.6.

Test Run Date:	11/02/2011 02:56 PM	Report Run Date:	3/4/2013 8:43:00 AM

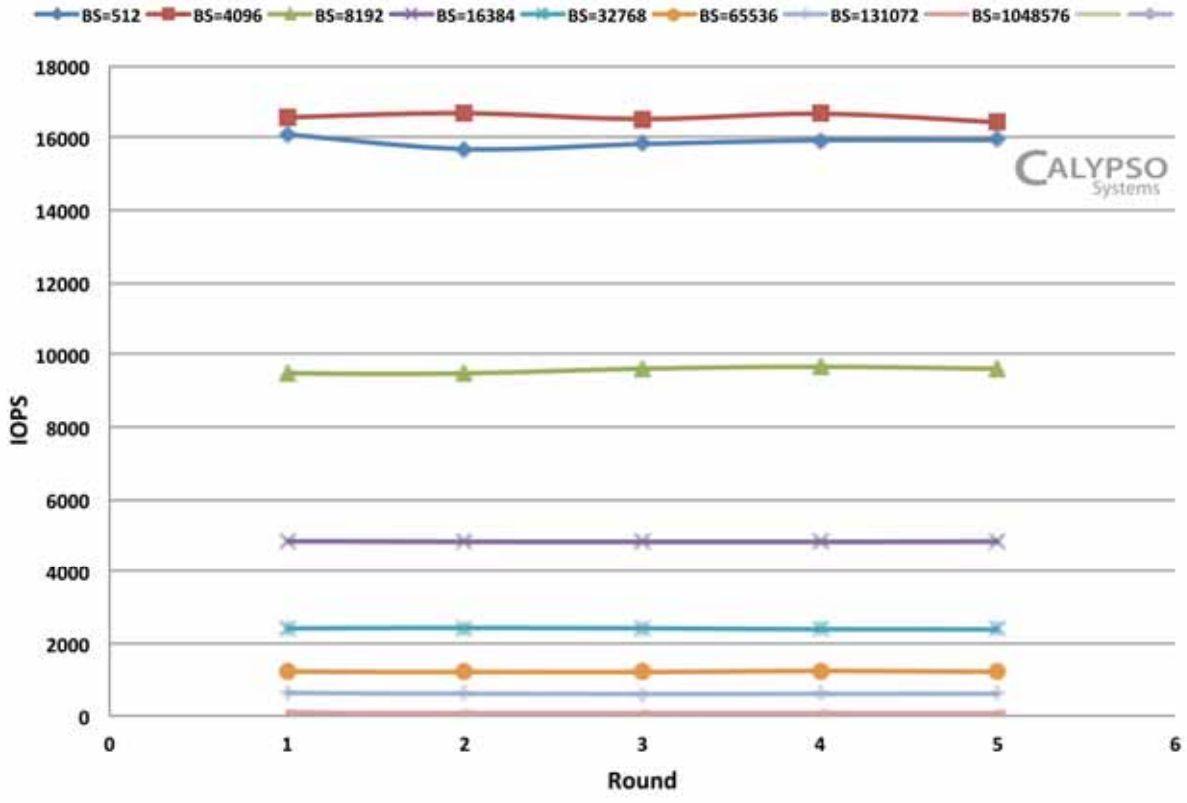
IOPS Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	IOPS - Block Size x RW Mix Matrix	Rev.	PTS-E 1.1
			Page	1 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	IOPS Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 2/ QD 16	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	IOPS Loop	Steady State	1 - 5
Test ID No.	RS-456	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	N/A

IOPS Steady State Convergence Plot – All Block Sizes



Plot A.1 – IOPS Steady State Convergence Plot - All Block Sizes

Test Run Date:	11/02/2011 02:56 PM	Report Run Date:	3/4/2013 8:43:00 AM

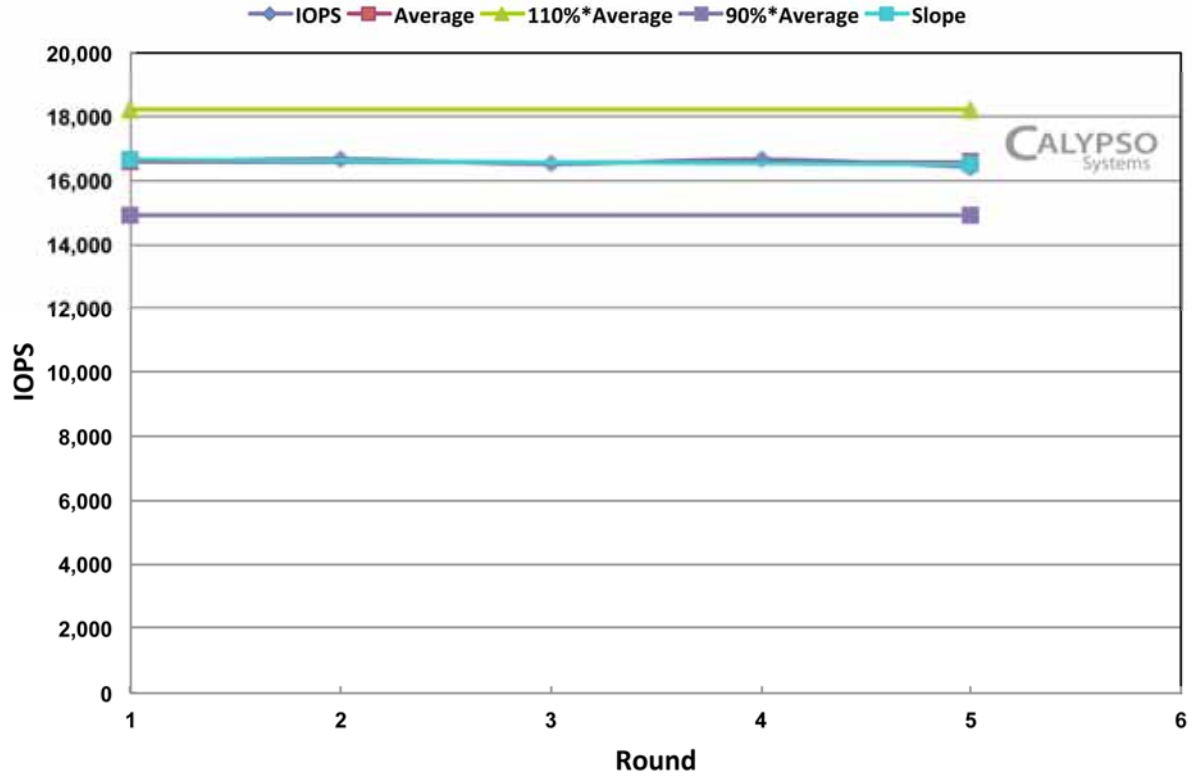
IOPS Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	IOPS - Block Size x RW Mix Matrix	Rev.	PTS-E 1.1
			Page	2 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	IOPS Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 2/ QD 16	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	IOPS Loop	Steady State	1 - 5
Test ID No.	R5-456	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	N/A

IOPS Steady State Measurement Window



Plot A.2 – IOPS Steady State Measurement Window

Test Run Date:	11/02/2011 02:56 PM	Report Run Date:	3/4/2013 8:43:00 AM

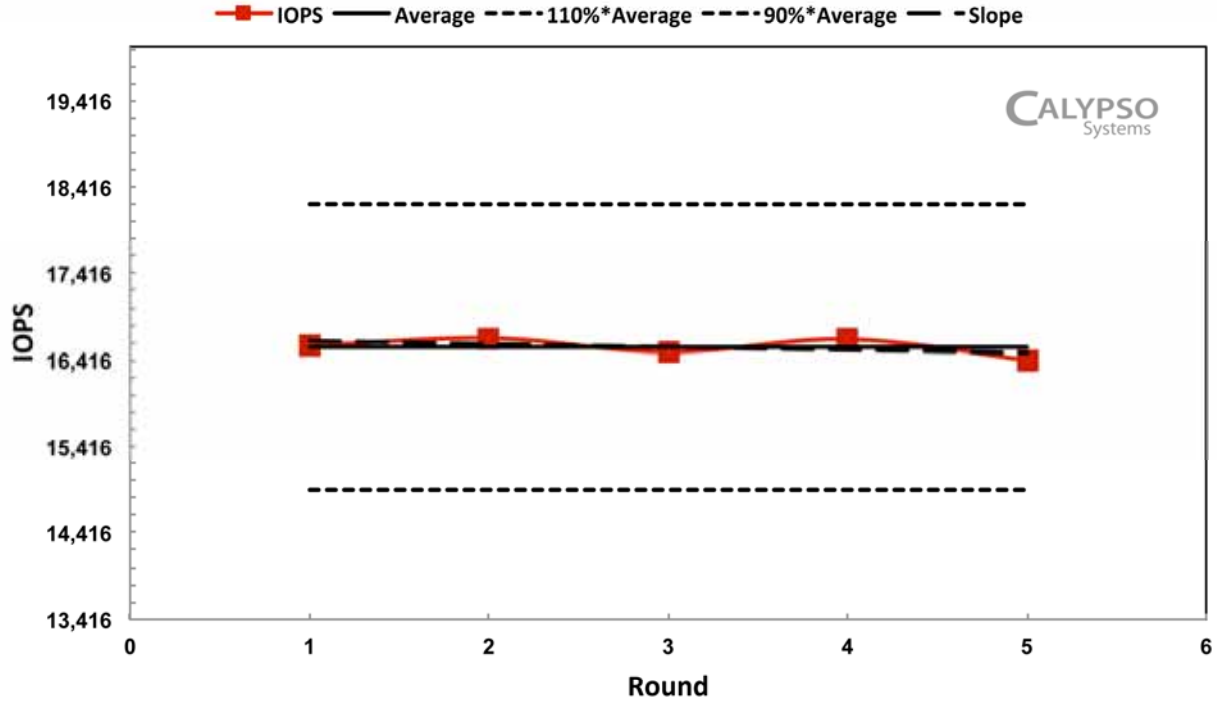
IOPS Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	IOPS - Block Size x RW Mix Matrix	Rev.	PTS-E 1.1
			Page	3 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	IOPS Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 2/ QD 16	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	IOPS Loop	Steady State	1 - 5
Test ID No.	R5-456	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	N/A

IOPS Steady State Measurement Window – RND/4KiB



Steady State Determination Data

Average IOPS:			16563.0
Allowed Maximum Data Excursion:	3312.6	Measured Maximum Data Excursion:	248.3
Allowed Maximum Slope Excursion:	1656.3	Measured Maximum Slope Excursion:	128.6
Least Squares Linear Fit Formula:			-32.143 * R + 16659.425

Plot A.3 – IOPS Steady State Measurement Window - RND/4KiB

Test Run Date:	11/02/2011 02:56 PM	Report Run Date:	3/4/2013 8:43:00 AM

IOPS Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	IOPS - Block Size x RW Mix Matrix	Rev.	PTS-E 1.1
			Page	4 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	IOPS Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 2/ QD 16	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	IOPS Loop	Steady State	1 - 5
Test ID No.	R5-456	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	N/A

IOPS - ALL RW Mix & BS – Tabular Data

Block Size (KiB)	Read / Write Mix %						
	0/100	5/95	35/65	50/50	65/35	95/5	100/0
0.5	15,887.4	16,634.7	20,678.6	24,402.8	29,386.2	72,428.4	95,924.3
4	16,563.0	17,032.2	20,234.2	23,705.2	28,018.6	63,447.7	93,707.0
8	9,559.8	9,998.4	12,547.1	14,636.6	17,199.1	37,872.9	50,301.2
16	4,842.2	5,032.3	6,802.5	8,132.1	9,655.8	22,462.2	31,072.8
32	2,413.3	2,535.4	3,478.4	4,241.3	5,061.7	12,174.7	15,994.2
64	1,219.2	1,275.7	1,728.4	2,126.1	2,726.3	6,284.6	8,094.9
128	612.7	632.5	859.1	1,061.4	1,709.4	3,205.7	4,060.8
1024	74.8	78.0	103.6	126.7	202.7	398.8	514.6

Plot A.4 – IOPS - All RW Mix & BS - Tabular Data

Test Run Date:	11/02/2011 02:56 PM	Report Run Date:	3/4/2013 8:43:00 AM

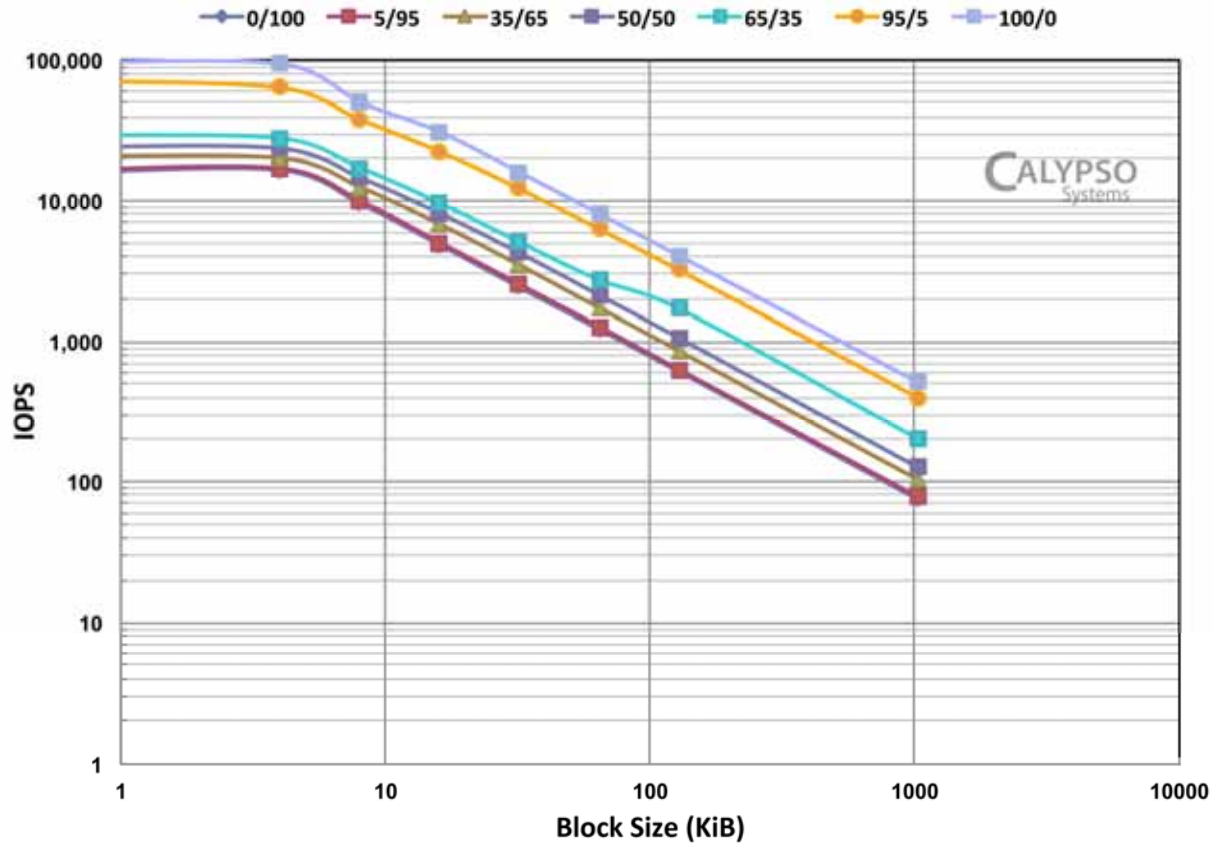
IOPS Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	IOPS - Block Size x RW Mix Matrix	Rev.	PTS-E 1.1
			Page	5 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	IOPS Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 2/ QD 16	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	IOPS Loop	Steady State	1 - 5
Test ID No.	R5-456	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	N/A

IOPS - ALL RW Mix & BS - 2D Plot



Plot A.5 – IOPS - All RW Mix & BS - 2D Plot

Test Run Date:	11/02/2011 02:56 PM	Report Run Date:	3/4/2013 8:43:00 AM

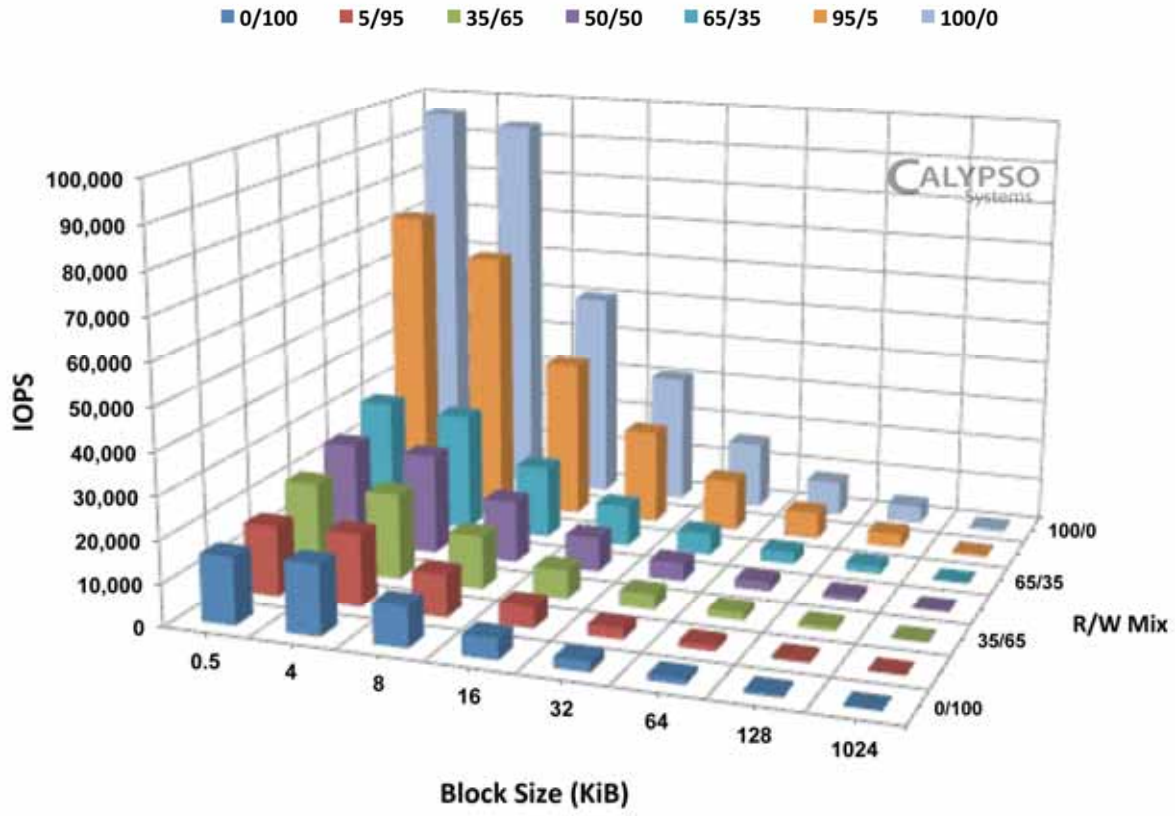
IOPS Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	IOPS - Block Size x RW Mix Matrix	Rev.	PTS-E 1.1
			Page	6 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	IOPS Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 2/ QD 16	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	IOPS Loop	Steady State	1 - 5
Test ID No.	R5-456	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	N/A

IOPS - ALL RW Mix & BS – 3D Columns



Plot A.6 – IOPS -All RW Mix & BS - 3D Columns

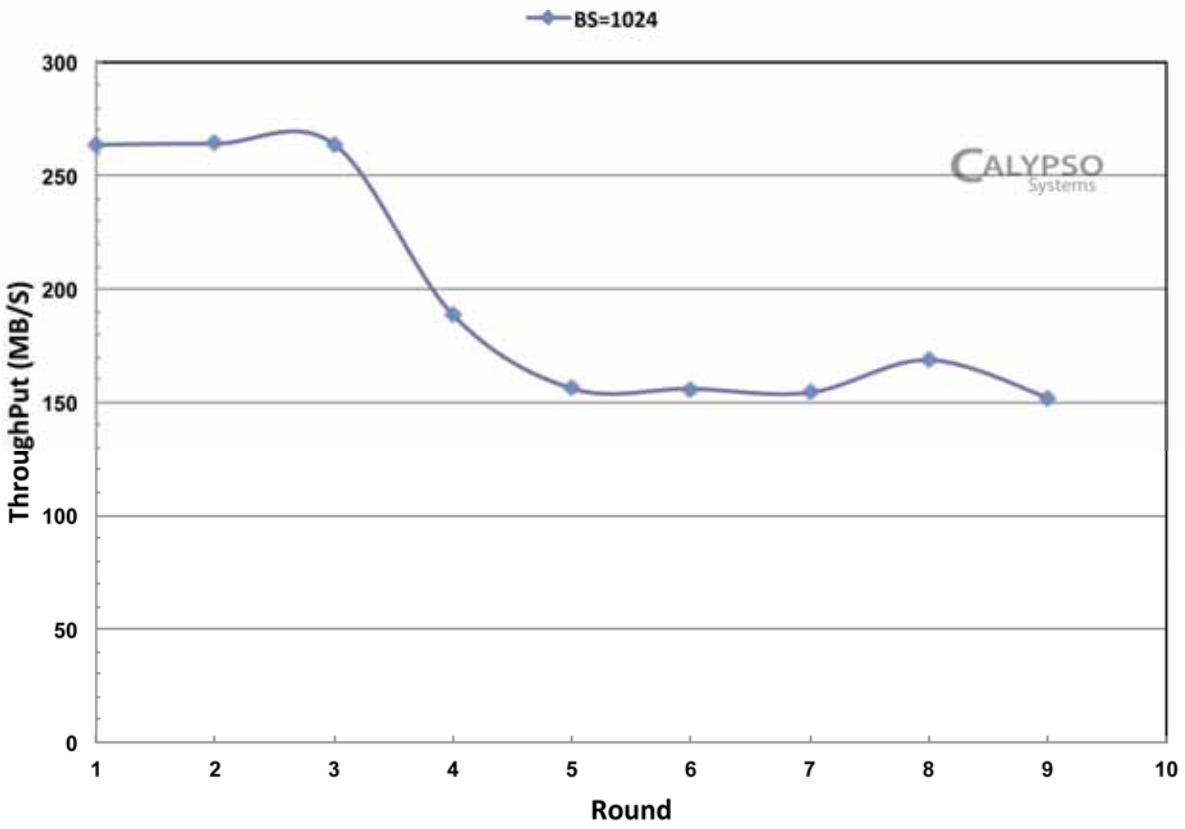
A.2 Sample Throughput Test Report Pages

The sample Throughput Test Report pages are shown in Plot A.7 through Plot A.16.

Test Run Date:	12/04/2011 08:21 AM			Report Run Date:	3/04/2013 10:03 AM		
Throughput Test (REQUIRED) - Report Page							
SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB & SEQ 128KiB				Rev.	PTS-E 1.1
						Page	1 of 10
Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100		TEST SPONSOR	CALYPSO Systems	

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	RS-897	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput Test - SS Convergence - Write 1024KiB



Plot A.7 – Throughput Test - SS Convergence - Write 1024KiB

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

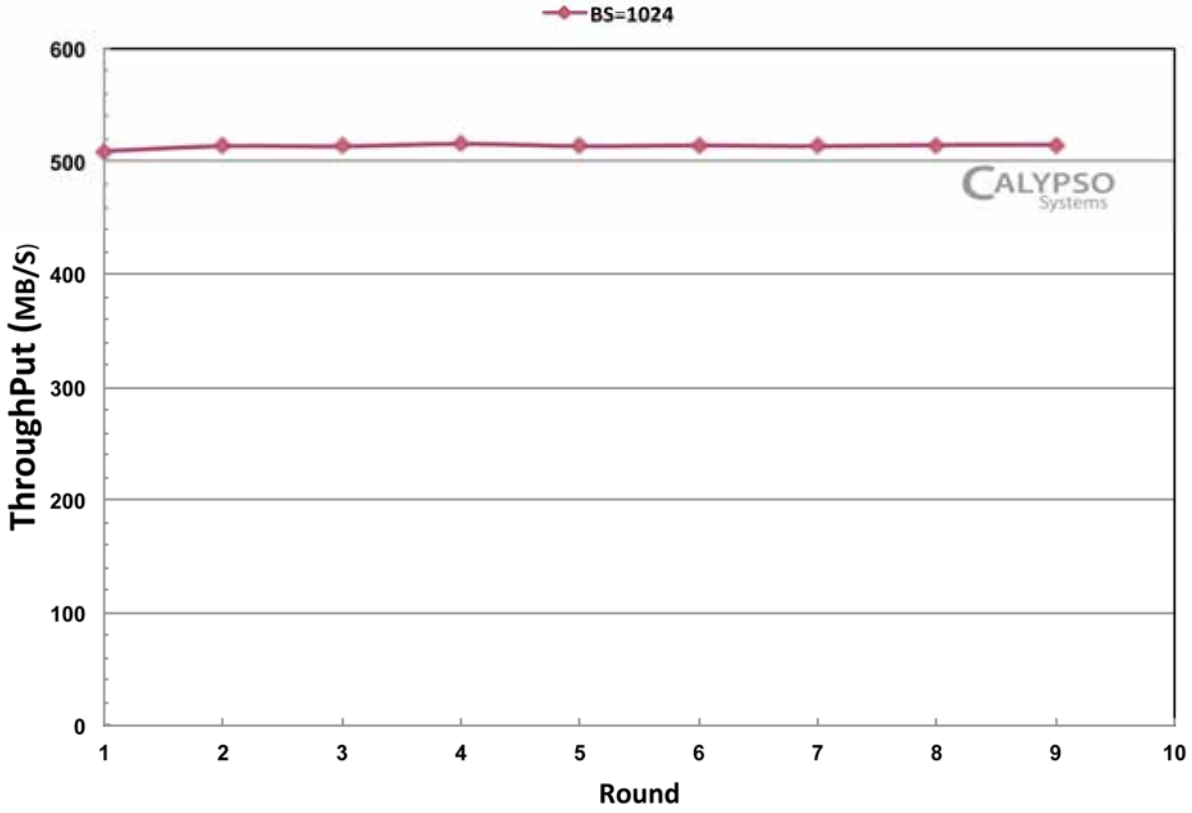
Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	2 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-897	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput Test - SS Convergence - Read 1024KiB



Plot A.8 – Throughput Test - SS Convergence - Read 1024 KiB

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

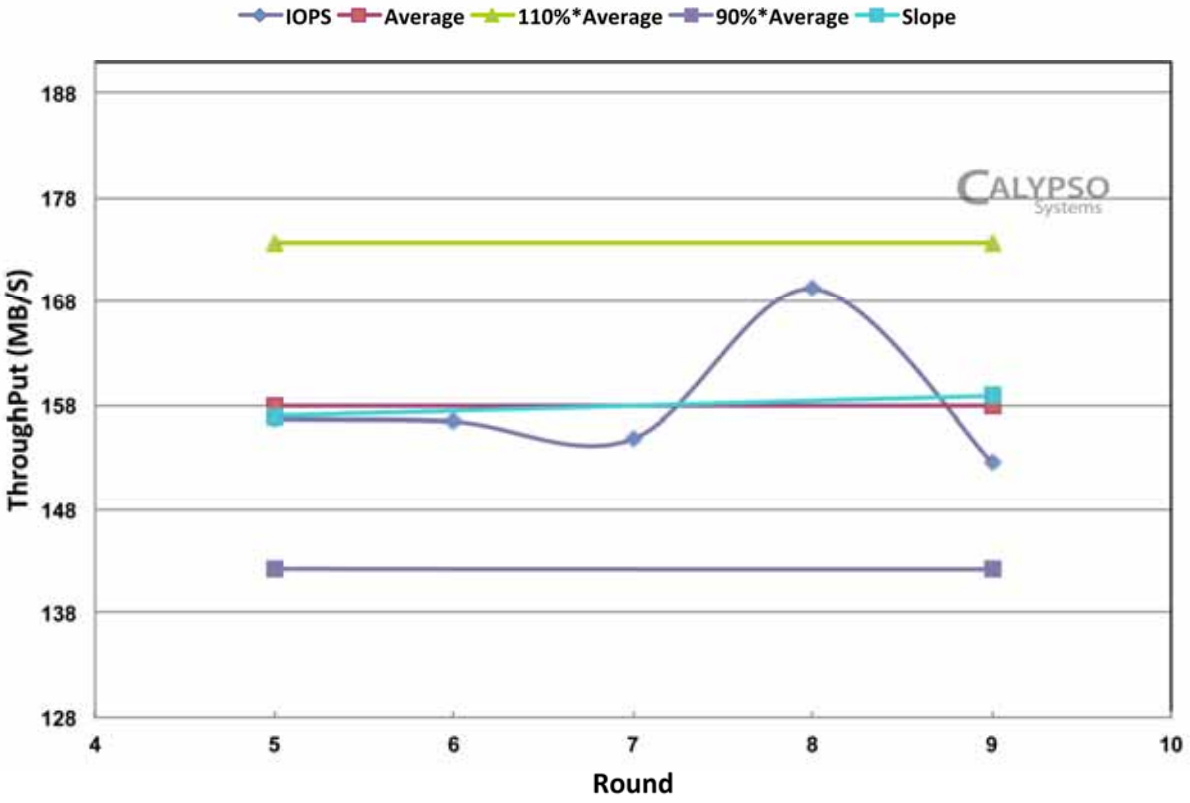
Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	3 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-897	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Steady State Measurement Window – SEQ/1024 KiB



Steady State Determination Data

Average ThroughPut:			157.5
Allowed Maximum Data Excursion:	31.5	Measured Maximum Data Excursion:	16.6
Allowed Maximum Slope Excursion:	15.7	Measured Maximum Slope Excursion:	1.9
Least Squares Linear Fit Formula:			0.470 * R + 154.165

Plot A.9 – Steady State Measurement Window - SEQ/1024 KiB

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	4 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-897	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput - ALL RW Mix & BS – Tabular Data 1024KiB

Block Size (KiB)	Read / Write Mix %	
	0/100	100/0
1024	157.5	514.3

Plot A.10 – Throughput - All RW Mix & BS - Tabular Data 1024KiB

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

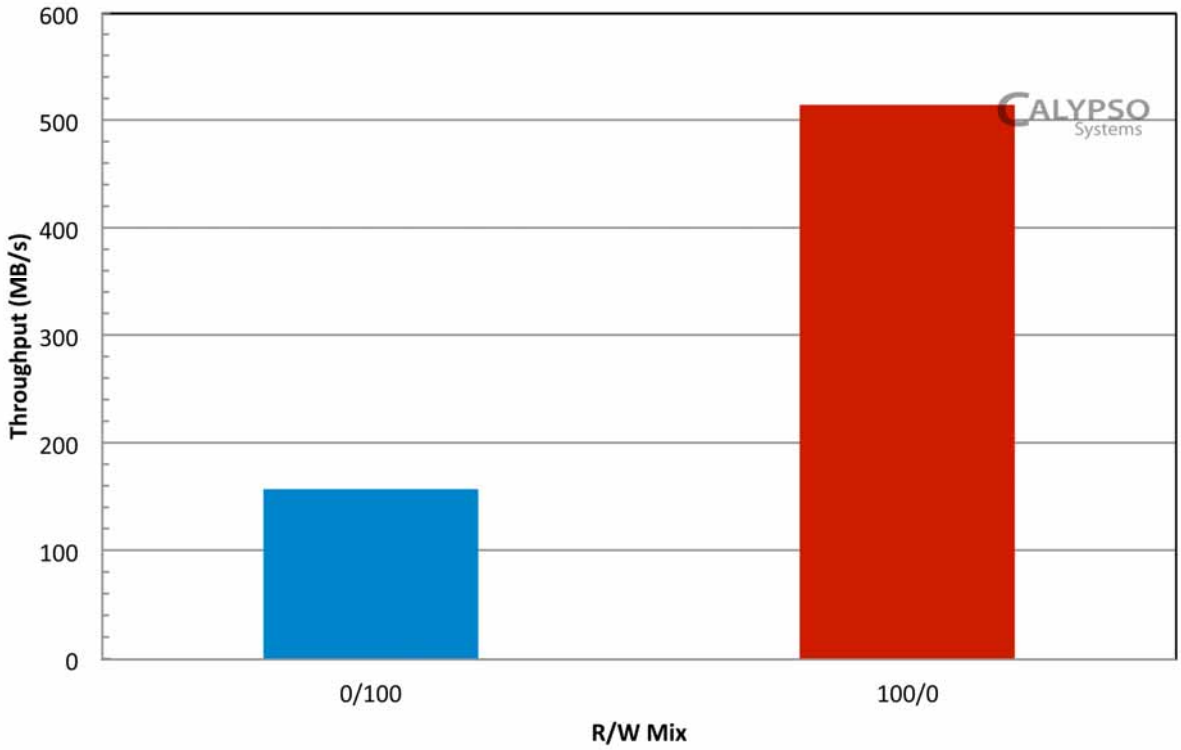
Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	5 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-897	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput - ALL RW Mix & BS - 2D Plot 1024KiB



Plot A.11 – Throughput - All RW Mix & BS - 2D Plot 1024KiB

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

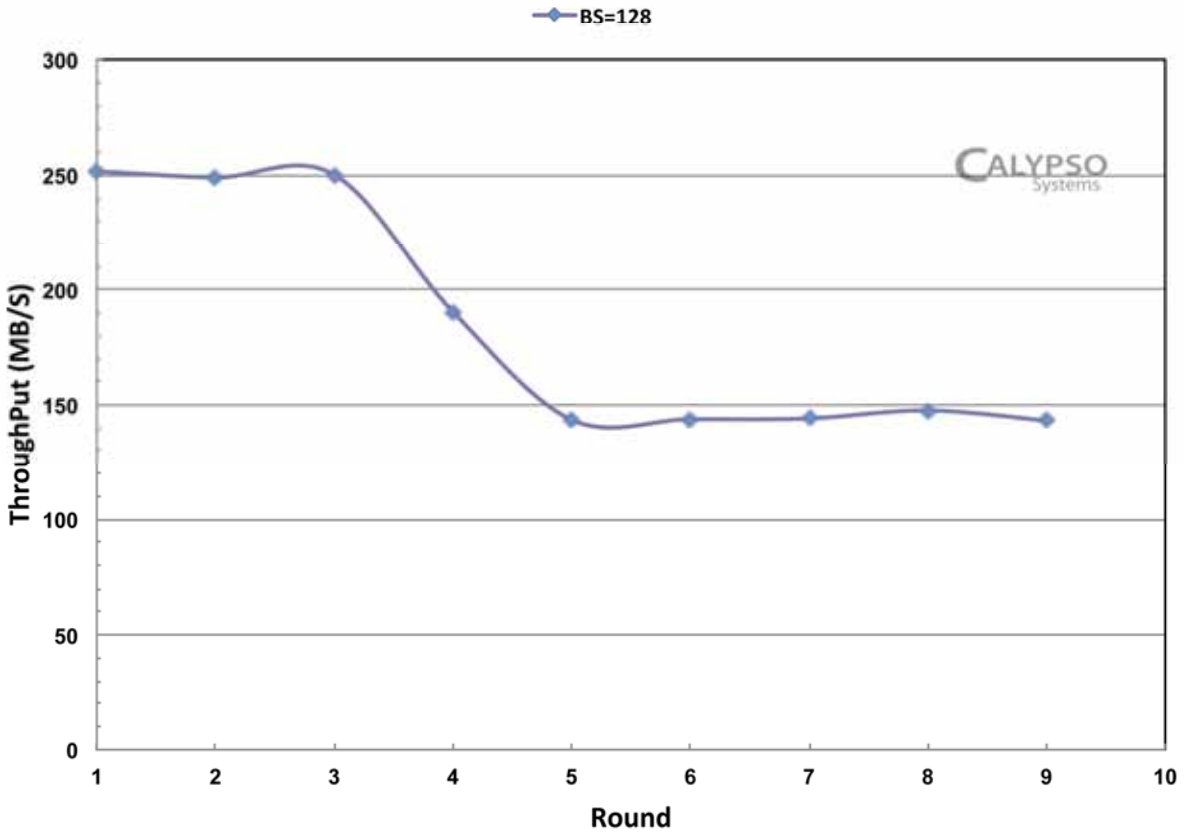
Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 128KiB	Rev.	PTS-E 1.1
			Page	6 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-891	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput Test - SS Convergence - Write 128KiB



Plot A.12 – Throughput Test - SS Convergence - Write 128KiB

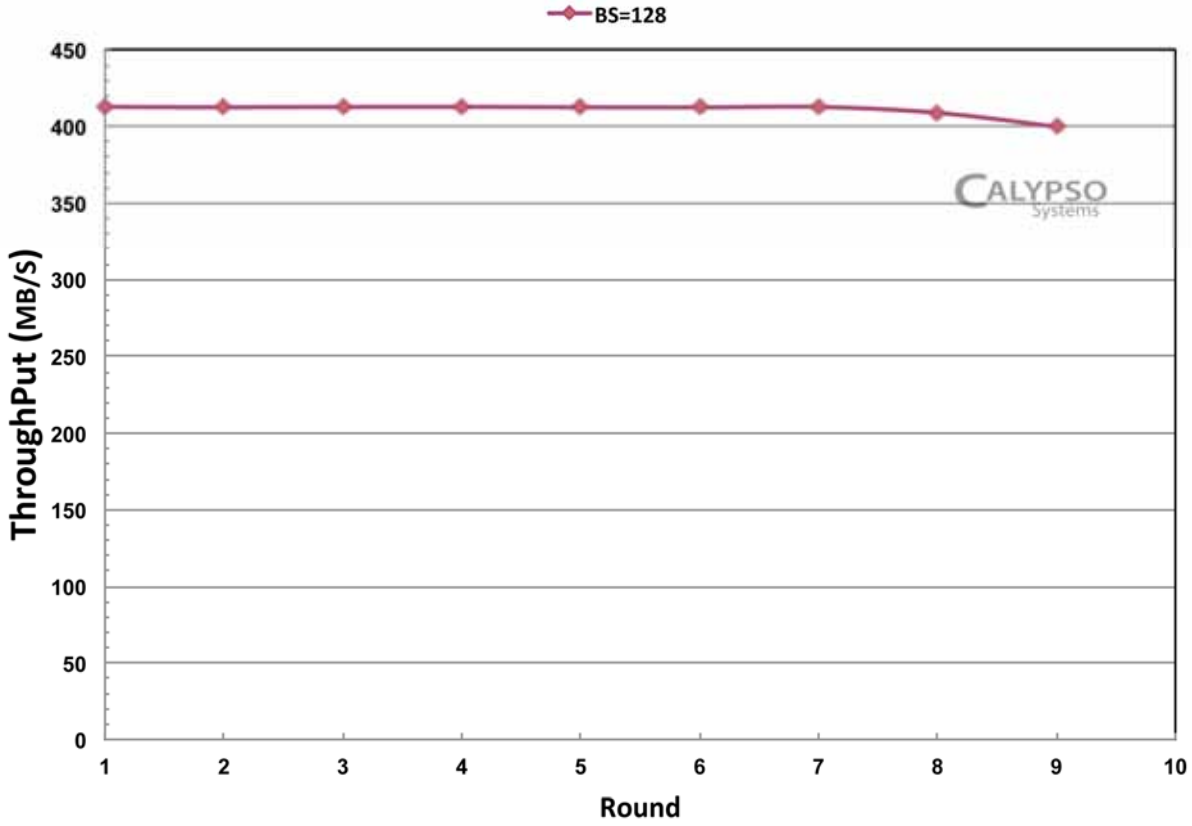
Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB / SEQ 128KiB	Rev.	PTS-E 1.1
			Page	7 of 10
Vendor:	ABC Co.	SSD Model: ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-891	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput Test - SS Convergence - Read 128KiB



Plot A.13 – Throughput Test - SS Convergence - Read 128KiB

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

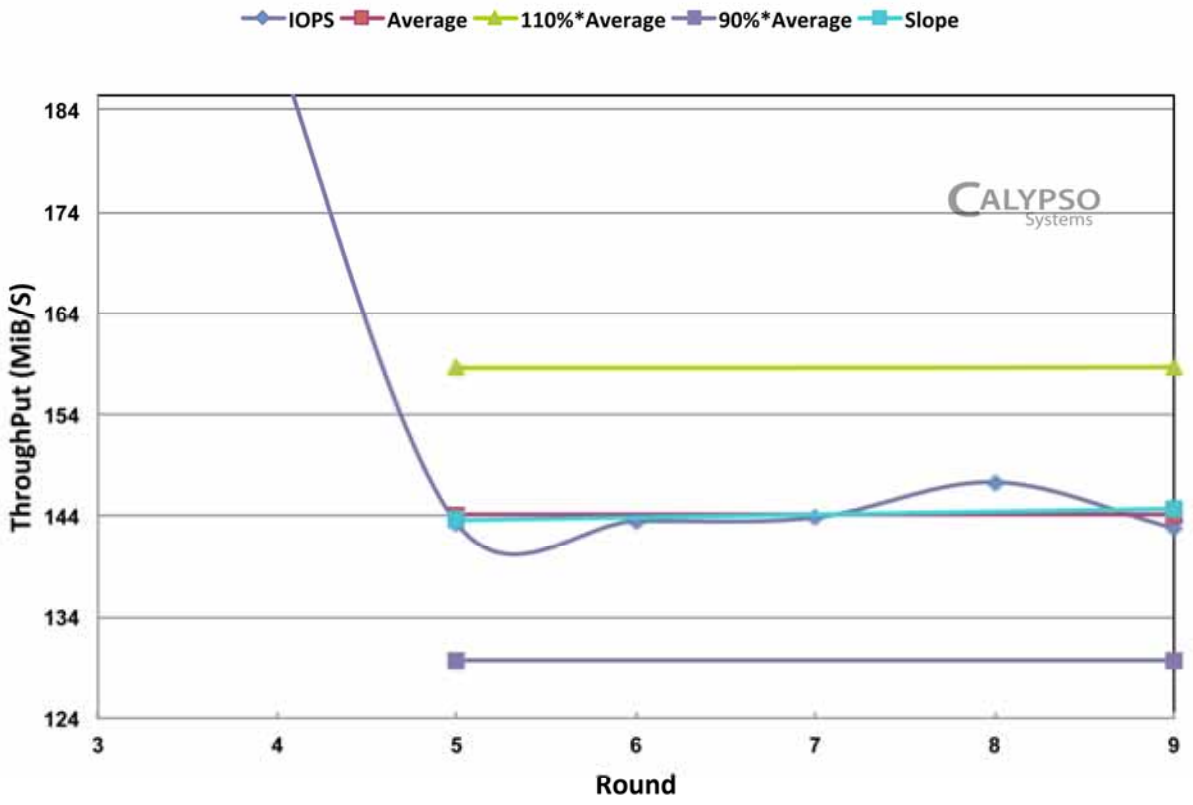
Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB / SEQ 128KiB	Rev.	PTS-E 1.1
			Page	8 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-891	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Steady State Measurement Window – SEQ/128 KiB



Steady State Determination Data

Average ThroughPut:			144.5
Allowed Maximum Data Excursion:	28.9	Measured Maximum Data Excursion:	4.5
Allowed Maximum Slope Excursion:	14.4	Measured Maximum Slope Excursion:	1.2
Least Squares Linear Fit Formula:			0.2931 * R + 142.43

Plot A.14 – Steady State Measurement Window - SEQ/128 KiB

Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB / SEQ 128KiB	Rev.	PTS-E 1.1
			Page	9 of 10

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-891	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput - ALL RW Mix & BS – Tabular Data 128KiB

Block Size (KiB)	Read / Write Mix %	
	0/100	100/0
128	144.5	409.3

Plot A.15 – Throughput -All RW Mix & BS - Tabular Data 128KiB

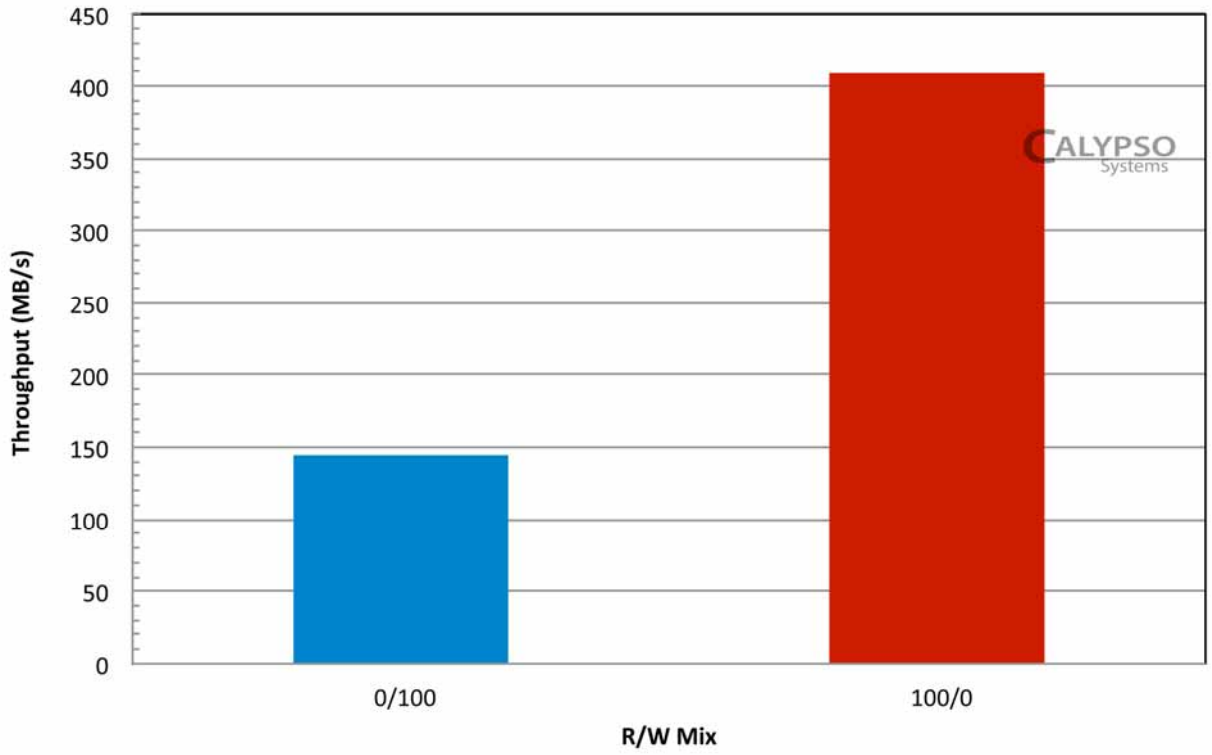
Test Run Date:	12/04/2011 08:21 AM	Report Run Date:	3/04/2013 10:03 AM

Throughput Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	TP - SEQ 1024KiB / SEQ 128KiB	Rev.	PTS-E 1.1
			Page	10 of 10
Vendor:	ABC Co.	SSD Model: ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	SEQ 1024KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128KiB W	RW Mix	100:0 / 0:100
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	SEQ 1024KiB
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 2/QD 16
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	SEQ 128KiB W	Steady State	1 - 5
Test ID No.	R5-891	PCIe NVM	N/A	TOIO - TC/QD	TC 2/ QD 16	Test Stimulus 2	SEQ 128KiB
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	1 - 5	TOIO - TC/QD	TC 2/QD 16
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Steady State	1 - 5

Throughput - ALL RW Mix & BS - 2D Plot 128KiB



Plot A.16 – Throughput -All RW Mix & BS - 2D Plot 128KiB

A.3 Sample Latency Test Report Pages

The sample Latency Test Report pages are shown in Plot A.17 through Plot A.22.

Test Run Date:	06/28/2011 05:07 AM	Report Run Date:	3/04/2013 08:47 AM

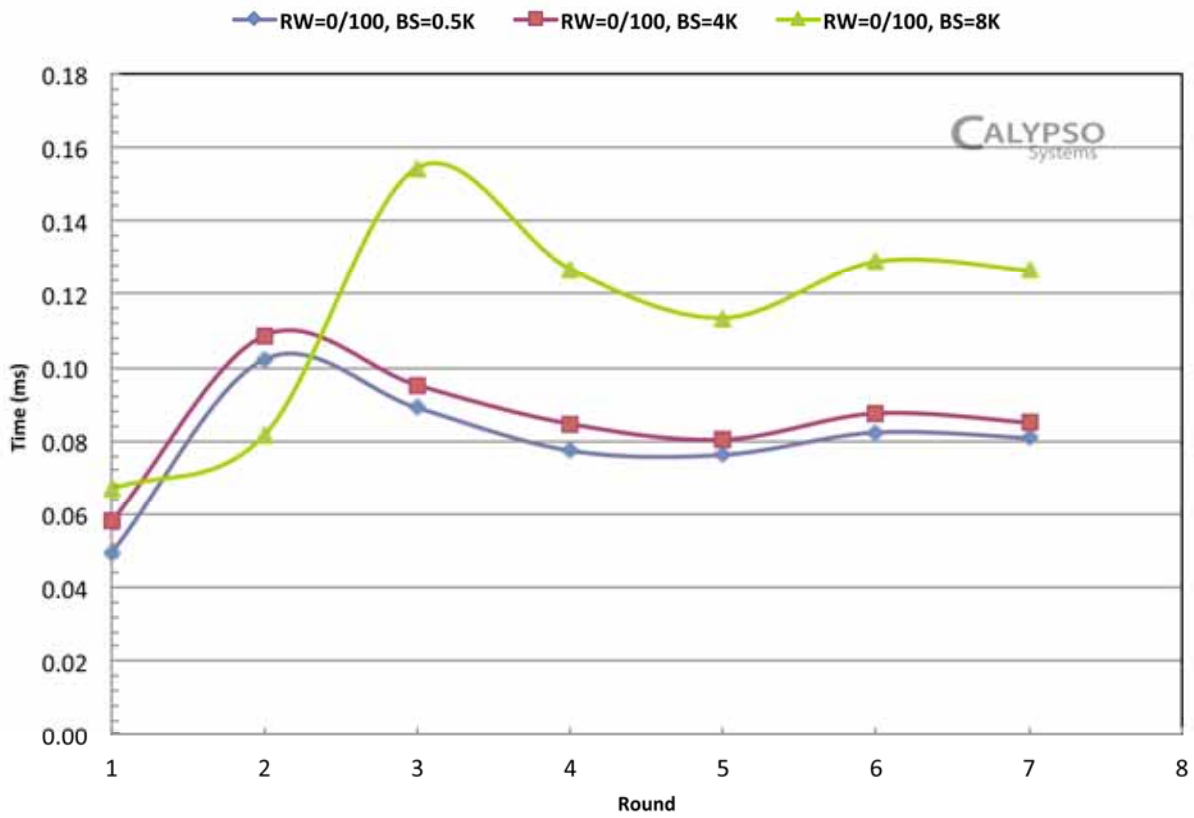
LATENCY Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	LATENCY - Response Time OIO=1	Rev.	PTS-E 1.1
			Page	1 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	LAT Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 1/QD 1
Test SW Info	1.10.9/1.9.16	NAND Type	SLC	Pre Condtion 2	LAT Loop	Steady State	3 - 7
Test ID No.	R5-523	PCIe NVM	N/A	TOIO - TC/QD	TC 1/ QD 1	Histogram	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	3 - 7	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Note	-

Steady State Convergence Plot – Average Latency - 100% Writes



Plot A.17 – Steady State Convergence Plot - Average Latency - 100% Writes

Test Run Date:	06/28/2011 05:07 AM	Report Run Date:	3/04/2013 08:47 AM

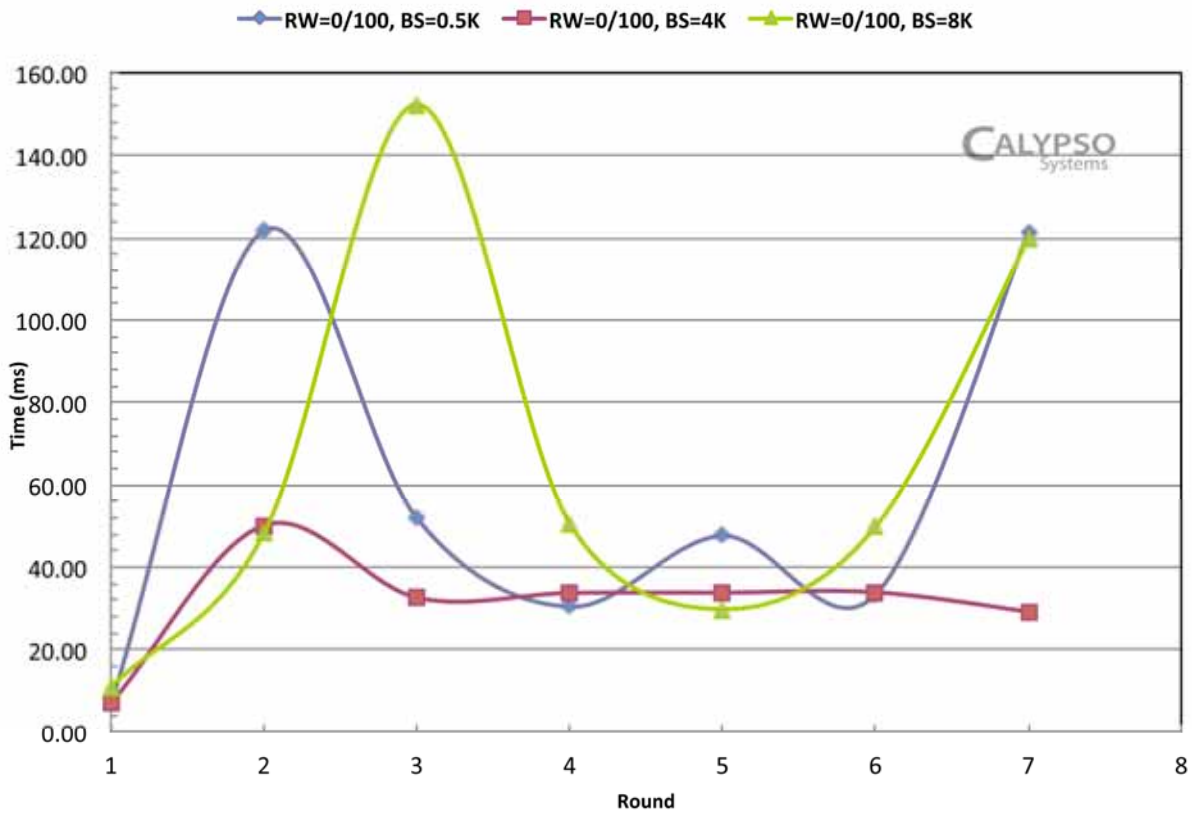
LATENCY Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	LATENCY - Response Time OIO=1	Rev.	PTS-E 1.1
			Page	2 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	LAT Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 1/QD 1
Test SW Info	1.10.9/1.9.16	NAND Type	SLC	Pre Condtion 2	LAT Loop	Steady State	3 - 7
Test ID No.	R5-523	PCIe NVM	N/A	TOIO - TC/QD	TC 1/ QD 1	Histogram	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	3 - 7	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Note	-

Steady State Convergence Plot – Maximum Latency - 100% Writes



Plot A.18 – Steady State Convergence Plot - Maximum Latency - 100% Writes

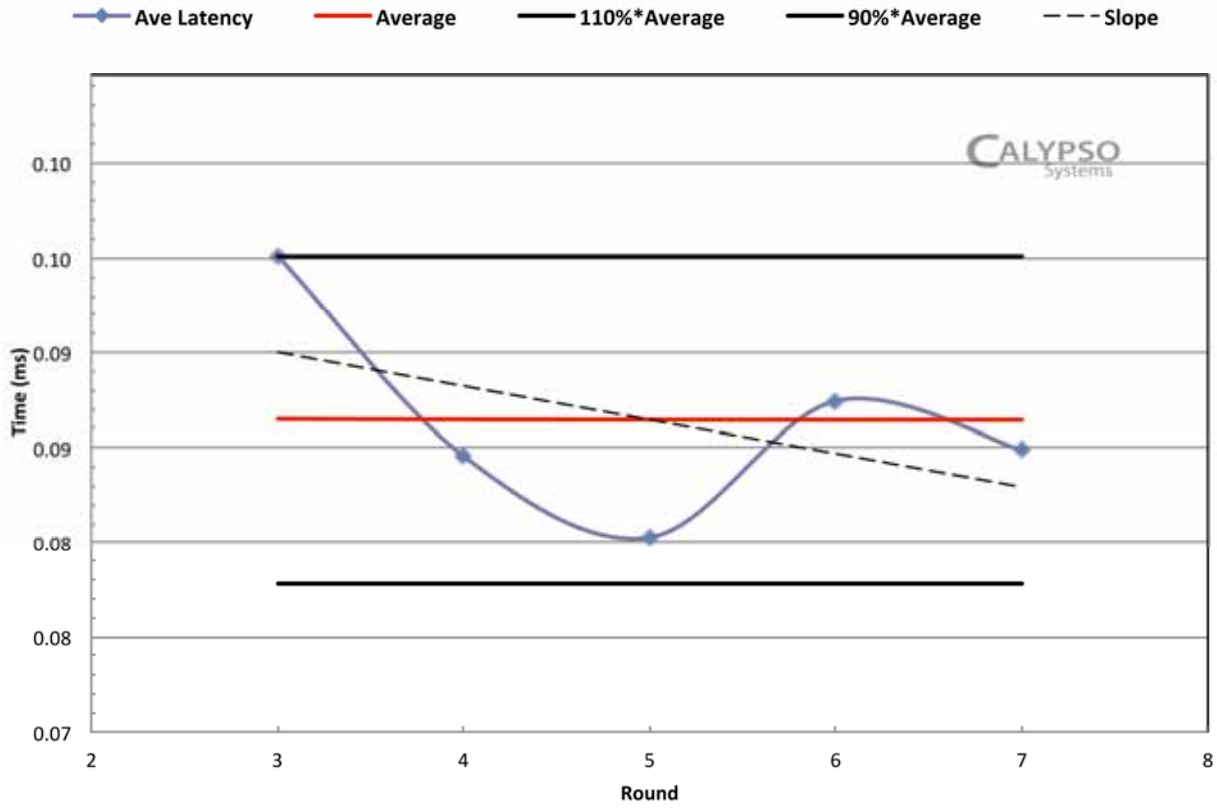
Test Run Date:	06/28/2011 05:07 AM	Report Run Date:	3/04/2013 08:47 AM

LATENCY Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	LATENCY - Response Time OIO=1	Rev.	PTS-E 1.1
			Page	3 of 6
Vendor:	ABC Co.	SSD Model: ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	LAT Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 1/QD 1
Test SW Info	1.10.9/1.9.16	NAND Type	SLC	Pre Condtion 2	LAT Loop	Steady State	3 - 7
Test ID No.	R5-523	PCIe NVM	N/A	TOIO - TC/QD	TC 1/ QD 1	Histogram	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	3 - 7	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Note	-

Steady State Measurement Window – RND/4KiB



Steady State Determination Data

Average Latency (ms):			0.087
Allowed Maximum Data Excursion:	0.017	Measured Maximum Data Excursion:	0.015
Allowed Maximum Slope Excursion:	0.009	Measured Maximum Slope Excursion:	0.007
Least Squares Linear Fit Formula:			-0.002 * R + 0.095

Plot A.19 – Steady State Measurement Window - RND/4KiB

Test Run Date:	06/28/2011 05:07 AM	Report Run Date:	3/04/2013 08:47 AM

LATENCY Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	LATENCY - Response Time OIO=1	Rev.	PTS-E 1.1
			Page	4 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	LAT Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 1/QD 1
Test SW Info	1.10.9/1.9.16	NAND Type	SLC	Pre Condtion 2	LAT Loop	Steady State	3 - 7
Test ID No.	R5-523	PCIe NVM	N/A	TOIO - TC/QD	TC 1/ QD 1	Histogram	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	3 - 7	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Note	-

Average and Maximum Response Time - ALL RW Mix & BS – Tabular Data

Average Response Time (ms)			
	Read / Write Mix %		
Block Size (KiB)	0/100	65/35	100/0
0.5	0.0811486	0.1307696	0.1470862
4	0.0865518	0.1386792	0.155532
8	0.1300188	0.1697318	0.171237

Maximum Response Time (ms)			
	Read / Write Mix %		
Block Size (KiB)	0/100	65/35	100/0
0.5	56.8668	39.4566	5.7996
4	32.6272	46.7808	6.2596
8	80.4266	39.3802	12.9866

Plot A.20 – Average and Maximum Response Time - All RW Mix & BS - Tabular Data

Test Run Date:	06/28/2011 05:07 AM	Report Run Date:	3/04/2013 08:47 AM

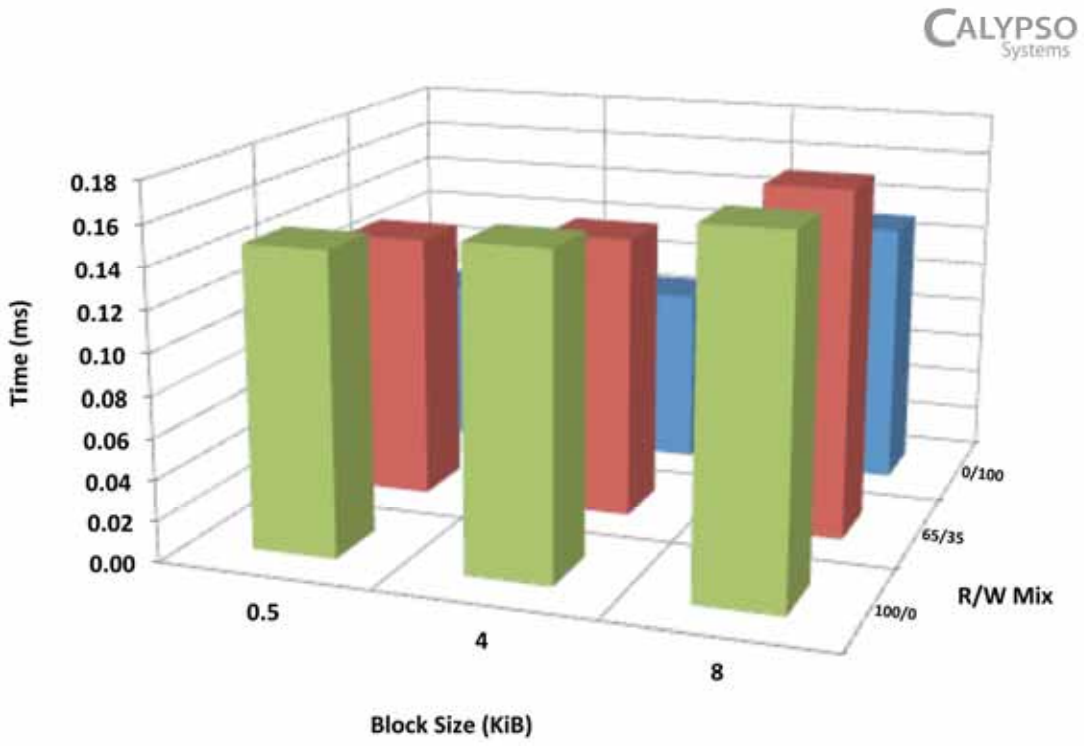
LATENCY Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	LATENCY - Response Time OIO=1	Rev.	PTS-E 1.1
			Page	5 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	LAT Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 1/QD 1
Test SW Info	1.10.9/1.9.16	NAND Type	SLC	Pre Condtion 2	LAT Loop	Steady State	3 - 7
Test ID No.	R5-523	PCIe NVM	N/A	TOIO - TC/QD	TC 1/ QD 1	Histogram	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	3 - 7	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Note	-

Average Latency vs BS and R/W Mix - 3D Plot



Plot A.21 – Average Latency vs. BS and R/W Mix - 3D Plot

Test Run Date:	06/28/2011 05:07 AM	Report Run Date:	11/14/2011 08:47 AM

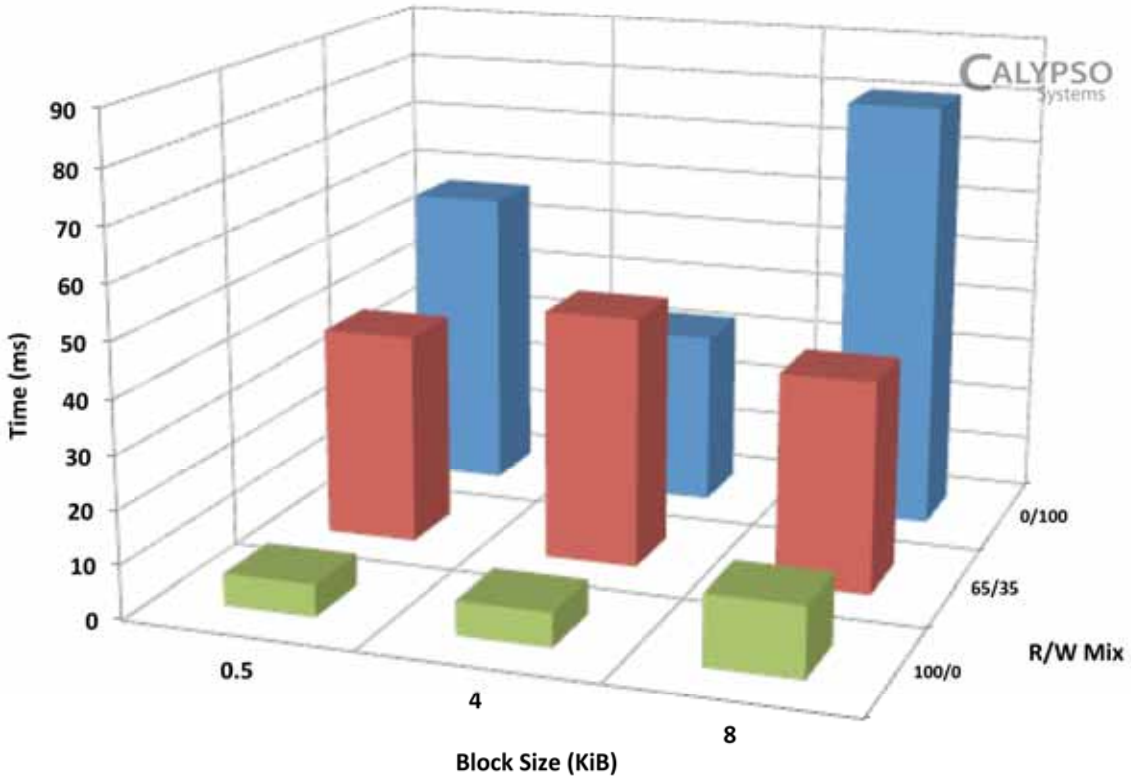
LATENCY Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	LAT - 0.5,4,8KiB x R, 65:35, W	Rev.	PTS-E 1.1
			Page	6 of 6

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	LAT Loop
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	SEQ 128K W	RW Mix	Outer Loop
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 1/ QD 1	Block Sizes	Inner Loop
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Duration	Twice User Capacity	TOIO - TC/QD	TC 1/QD 1
Test SW Info	1.10.9/1.9.16	NAND Type	SLC	Pre Condtion 2	LAT Loop	Steady State	3 - 7
Test ID No.	R5-523	PCIe NVM	N/A	TOIO - TC/QD	TC 1/ QD 1	Histogram	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	3 - 7	TOIO - TC/QD	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Note	-

Maximum Latency vs BS and R/W Mix - 3D Plot



Plot A.22 – Maximum Latency vs. BS and R/W Mix - 3D Plot

A.4 Sample Write Saturation Test Report Pages

The sample Write Saturation Test Report pages are shown in Plot A.23 through Plot A.26.

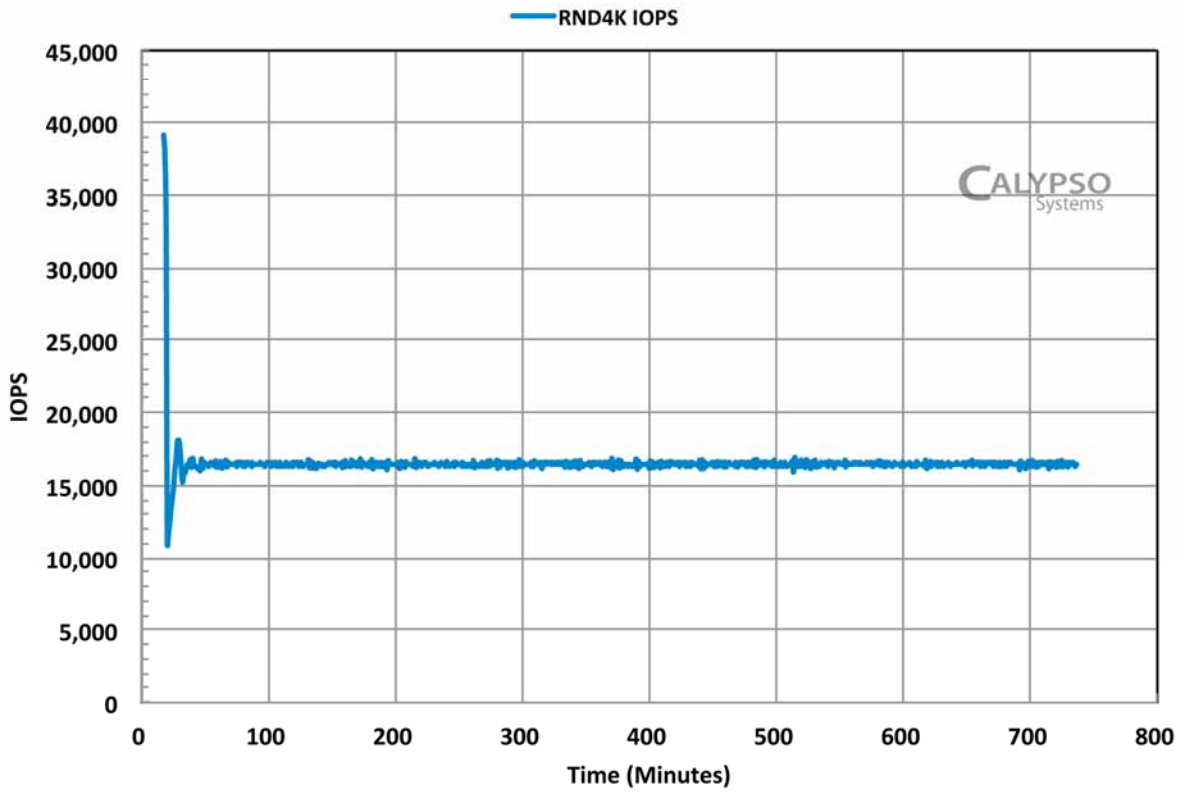
Test Run Date:	11/07/11 08:40 AM	Report Run Date:	3/14/2013 08:45 AM

Write Saturation Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	WSAT - RND 4KiB 100% W	Rev.	PTS-E 1.1
			Page	1 of 4
Vendor:	ABC Co.	SSD Model: ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	RND 4KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	None	TOIO - TC/QD	TC 2/QD 16
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	-	Steady State	N/A
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	SS Rounds	-	Time	6 Hr
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	None	Test Stimulus 2	N/A
Test ID No.	R5-452	PCIe NVM	N/A	TOIO - TC/QD	-	TOIO - TC/QD	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	-	Steady State	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Time	N/A

WSAT IOPS (Linear) vs Time (Linear)



Plot A.23 – WSAT IOPS (Linear) vs. Time (Linear)

Test Run Date:	11/07/11 08:40 AM	Report Run Date:	3/14/2013 08:45 AM

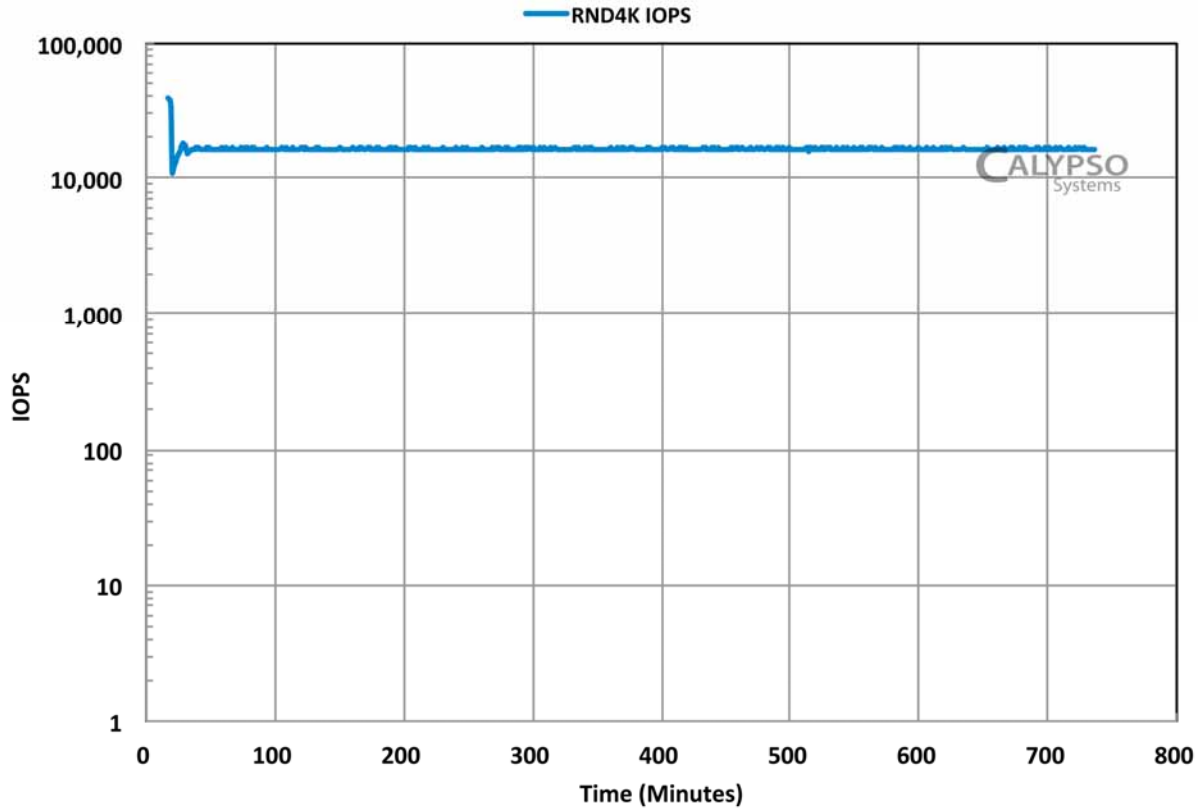
Write Saturation Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	WSAT - RND 4KiB 100% W	Rev.	PTS-E 1.1
			Page	2 of 4

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	RND 4KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	None	TOIO - TC/QD	TC 2/QD 16
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	-	Steady State	N/A
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	SS Rounds	-	Time	6 Hr
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	None	Test Stimulus 2	N/A
Test ID No.	R5-452	PCIe NVM	N/A	TOIO - TC/QD	-	TOIO - TC/QD	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	-	Steady State	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Time	N/A

WSAT IOPS (LOG) vs Time (Linear)



Plot A.24 – WSAT IOPS (Log) vs. Time (Linear)

Test Run Date:	11/07/11 08:40 AM	Report Run Date:	3/14/2013 08:45 AM

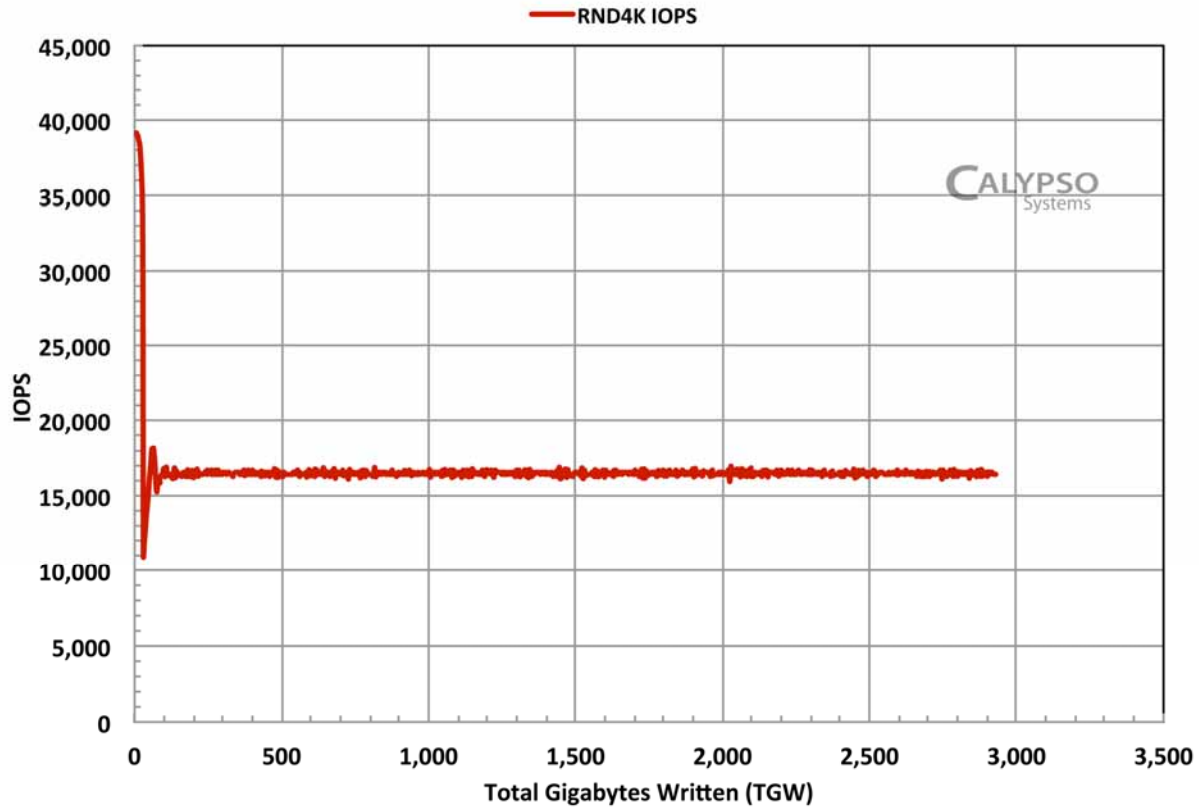
Write Saturation Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	WSAT - RND 4KiB 100% W	Rev.	PTS-E 1.0
			Page	3 of 4

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	RND 4KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	None	TOIO - TC/QD	TC 2/QD 16
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	-	Steady State	N/A
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	SS Rounds	-	Time	6 Hr
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	None	Test Stimulus 2	N/A
Test ID No.	R5-452	PCIe NVM	N/A	TOIO - TC/QD	-	TOIO - TC/QD	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	-	Steady State	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Time	N/A

WSAT IOPS (Linear) vs TGBW (Linear)



Plot A.25 – WSAT IOPS (Linear) vs. TGBW (Linear)

Test Run Date:	11/07/11 08:40 AM	Report Run Date:	3/14/2013 08:45 AM

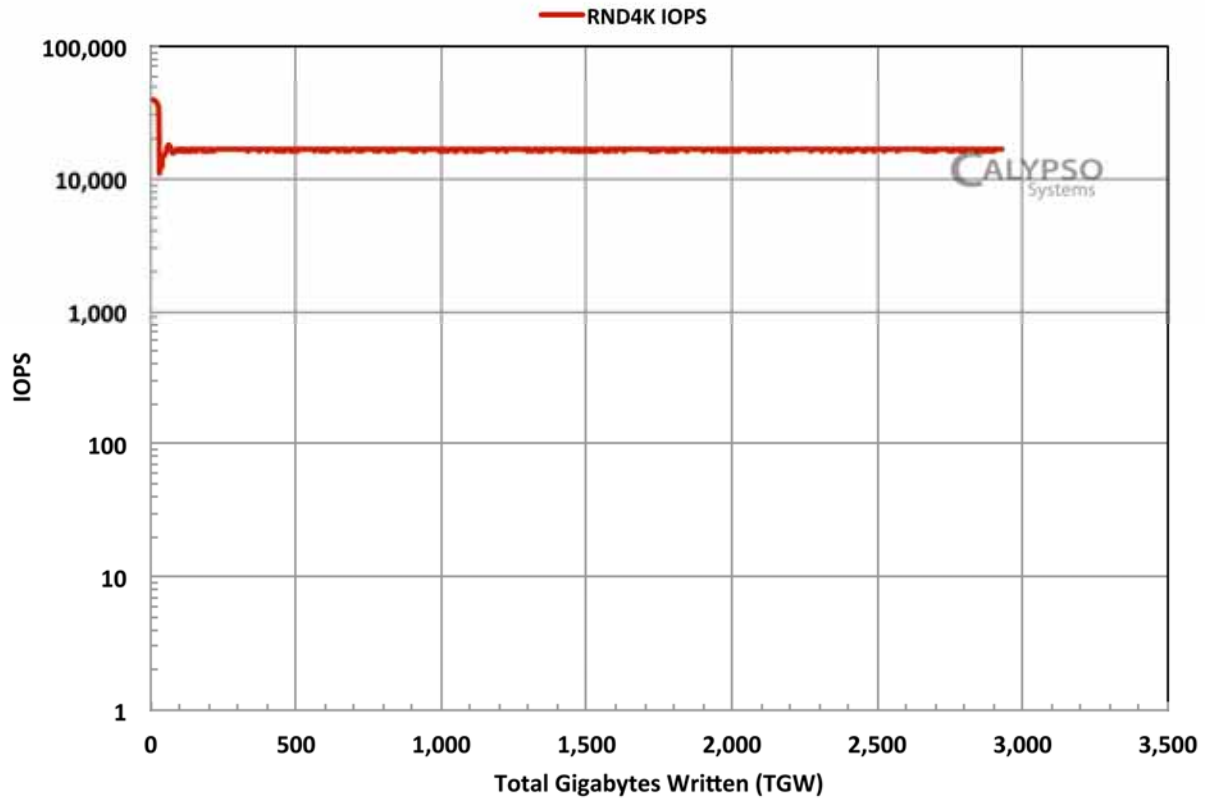
Write Saturation Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	WSAT - RND 4KiB 100% W	Rev.	PTS-E 1.0
			Page	4 of 4

Vendor:	ABC Co.	SSD Model:	ABC Co. SLC-A 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel 5520HC	Model No.	SLC-A	AR	100%	AR & Amount	100%
CPU	Intel XEON 5580W	S/N	123456	AR Segments	N/A	Test Stimulus 1	RND 4KiB
Memory	8 GB PC1600 DDR2	Firmware ver	ABCDEF	Pre Condtion 1	None	TOIO - TC/QD	TC 2/QD 16
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	-	Steady State	N/A
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	SS Rounds	-	Time	6 Hr
Test SW Info	1.10.7/1.9.16	NAND Type	SLC	Pre Condtion 2	None	Test Stimulus 2	N/A
Test ID No.	R5-452	PCIe NVM	N/A	TOIO - TC/QD	-	TOIO - TC/QD	N/A
HBA	LSI 9212-4e4i	Purge Method	Format Unit	SS Rounds	-	Steady State	N/A
PCIe	Gen 2 x 8	Write Cache	WCD	Note	-	Time	N/A

WSAT IOPS (LOG) vs TGBW (Linear)



Plot A.26 – WSAT IOPS (Log) vs. TGBW (Linear)

A.5 Sample Host Idle Recovery Test Report Pages

The sample Host Idle Recovery Test Report pages are shown in Plot A.27 through Plot A.29.

Test Run Date:	08/17/2012 04:02 PM	Report Run Date:	03/06/2013 03:01PM

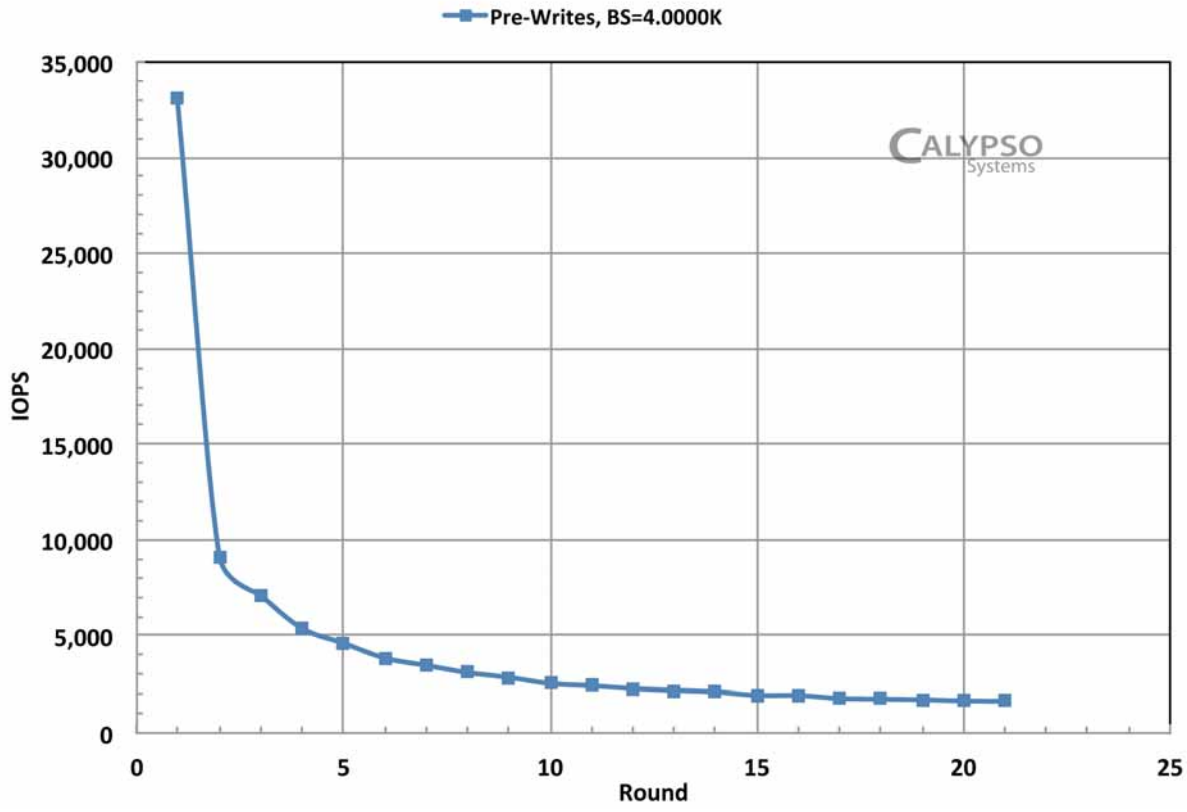
Host Idle Recovery (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	RND 4KiB 5s Ws / Variable Wait States	Rev.	PTS-E 1.1
			Page	1 of 3

Vendor:	ABC Co.	SSD Model:	ABC Co. Super Drive 256	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/4KiB	Write Stimulus	RND/4KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	TC 2 / QD 16	TOIO - TC/QD	TC 2 / QD 16
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	1-5	Duration (S)	5
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Idle State	Host Idle
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	-
Test ID No.	R32-2040	PCIe NVM	N/A	SS Rounds	-	Duration (S)	5,10,15,25,50
HBA	LSI 9212-4e4i	Purge Method	Security Erase			Wait States	1,2,3,5,10
PCIe	Gen 3 x 16	Write Cache	WCD				

Pre Conditioning IOPS Plot



Plot A.27 – Pre Conditioning IOPS Plot

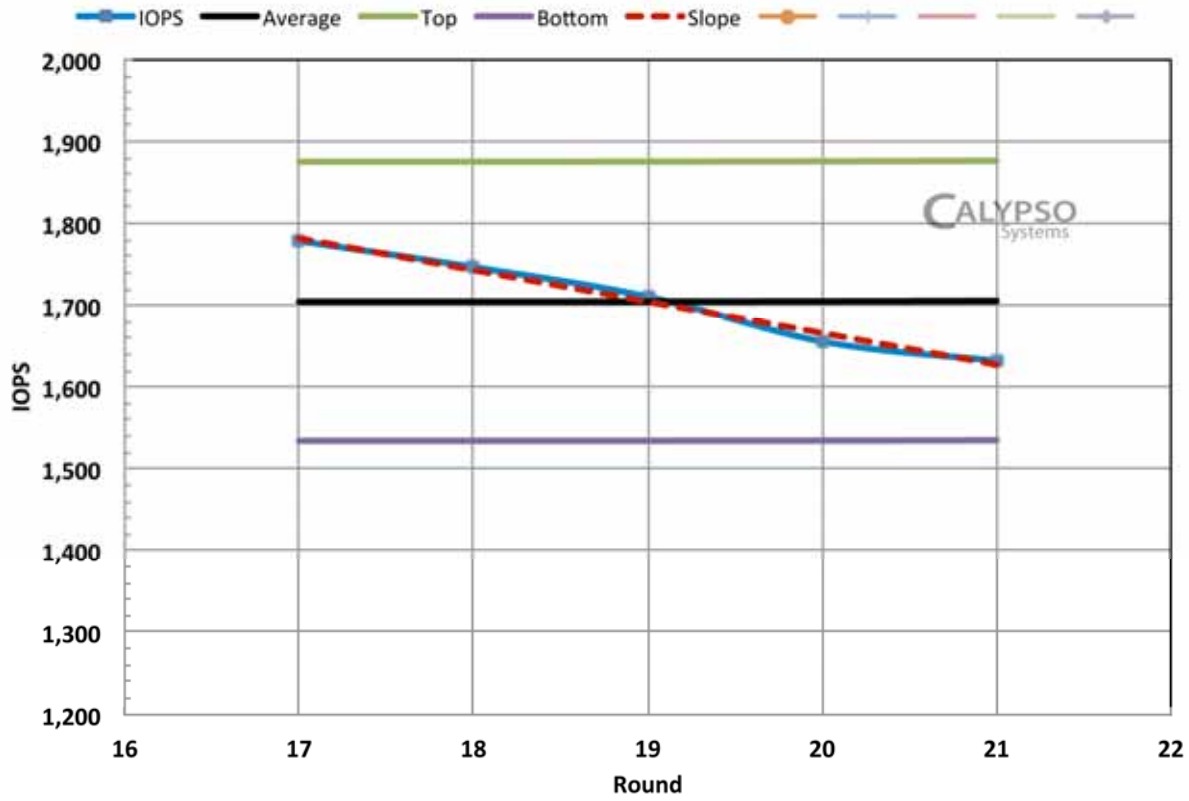
Test Run Date:	08/17/2012 04:02 PM	Report Run Date:	03/06/2013 03:01PM

Host Idle Recovery (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	RND 4KiB 5s Ws / Variable Wait States	Rev.	PTS-E 1.1
			Page	2 of 3
Vendor:	ABC Co.	SSD Model: ABC Co. Super Drive 256	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/4KiB	Write Stimulus	RND/4KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	TC 2 / QD 16	TOIO - TC/QD	TC 2 / QD 16
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	1-5	Duration (S)	5
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Idle State	Host Idle
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	-
Test ID No.	R32-2040	PCIe NVM	N/A	SS Rounds	-	Duration (S)	5,10,15,25,50
HBA	LSI 9212-4e4i	Purge Method	Security Erase			Wait States	1,2,3,5,10
PCIe	Gen 3 x 16	Write Cache	WCD				

Pre Conditioning Steady State Measurement Plot



Plot A.28 – Pre Conditioning Steady State Measurement Plot

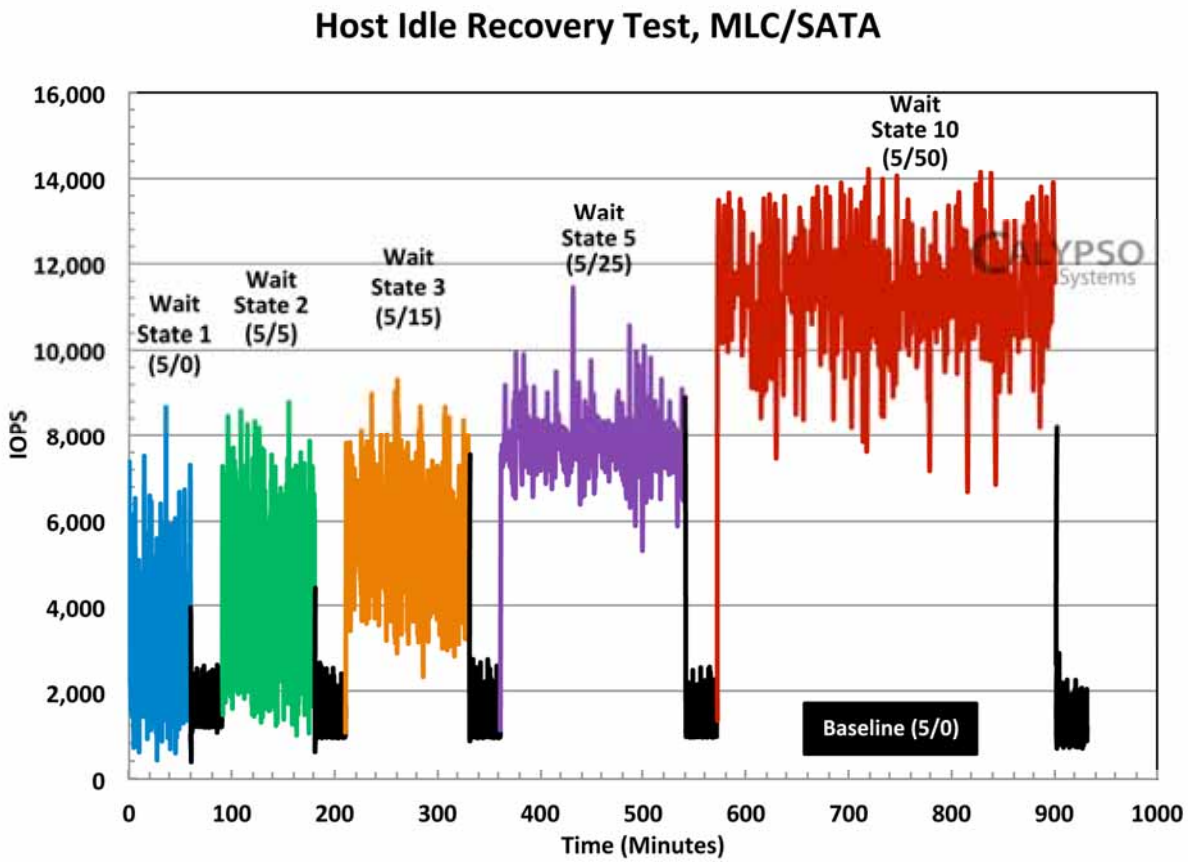
Test Run Date:	08/17/2012 04:02 PM	Report Run Date:	03/06/2013 03:01PM

Host Idle Recovery (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	RND 4KiB 5s Ws / Variable Wait States	Rev.	PTS-E 1.1
			Page	3 of 3
Vendor:	ABC Co.	SSD Model: ABC Co. Super Drive 256	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/4KiB	Write Stimulus	RND/4KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	TC 2 / QD 16	TOIO - TC/QD	TC 2 / QD 16
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	1-5	Duration (S)	5
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Idle State	Host Idle
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	-
Test ID No.	R32-2040	PCIe NVM	N/A	SS Rounds	-	Duration (S)	5,10,15,25,50
HBA	LSI 9212-4e4i	Purge Method	Security Erase			Wait States	1,2,3,5,10
PCIe	Gen 3 x 16	Write Cache	WCD				

IOPS v Time - All Wait States



Plot A.29 – IOPS vs. Time - All Wait States

A.6 Sample Cross Stimulus Recovery Test Report Pages

The sample Cross Stimulus Test Reports pages are shown in Plot A.30 through Plot A.34.

Test Run Date:	10/18/2012 4:02:00 PM	Report Run Date:	03/06/2013 05:01PM

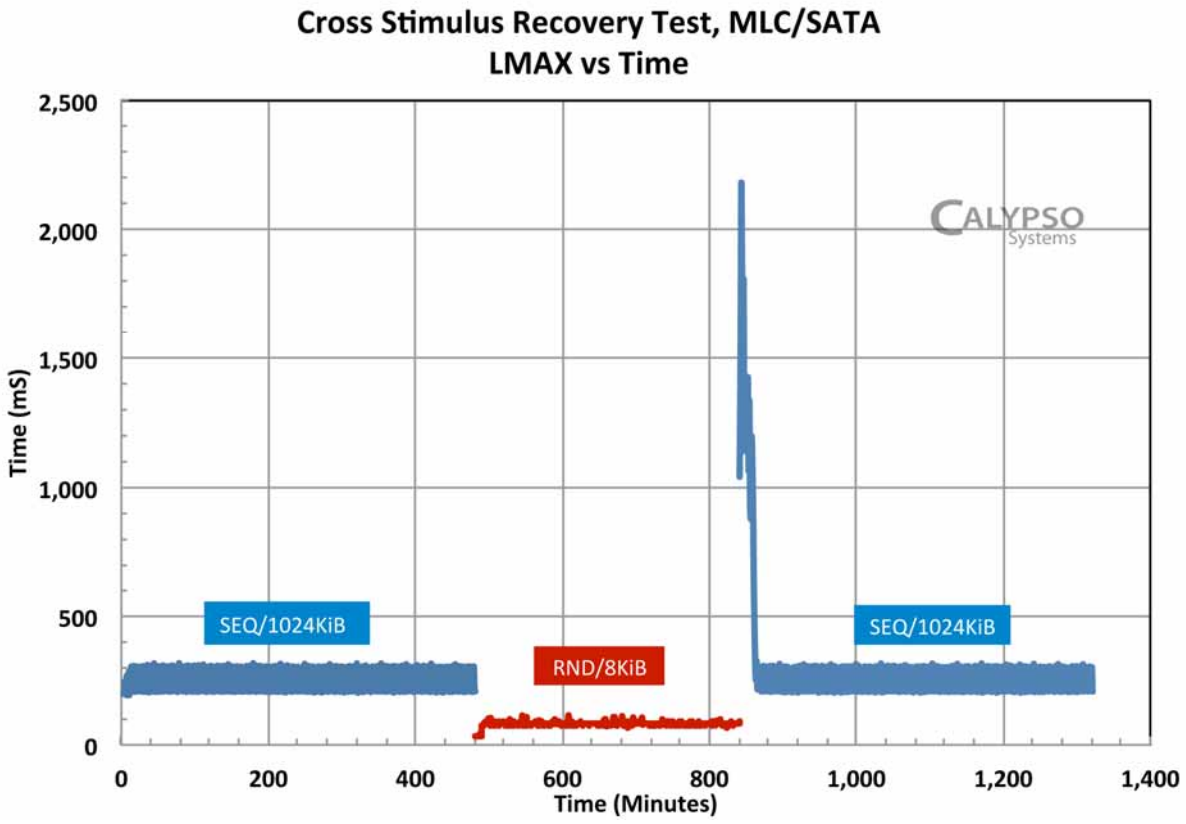
Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	1 of 5

Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

TP v Time - All Access Groups



Plot A.30 – TP vs. Time - All Access Groups

Test Run Date:	10/18/2012 4:02:00 PM	Report Run Date:	03/06/2013 05:01PM

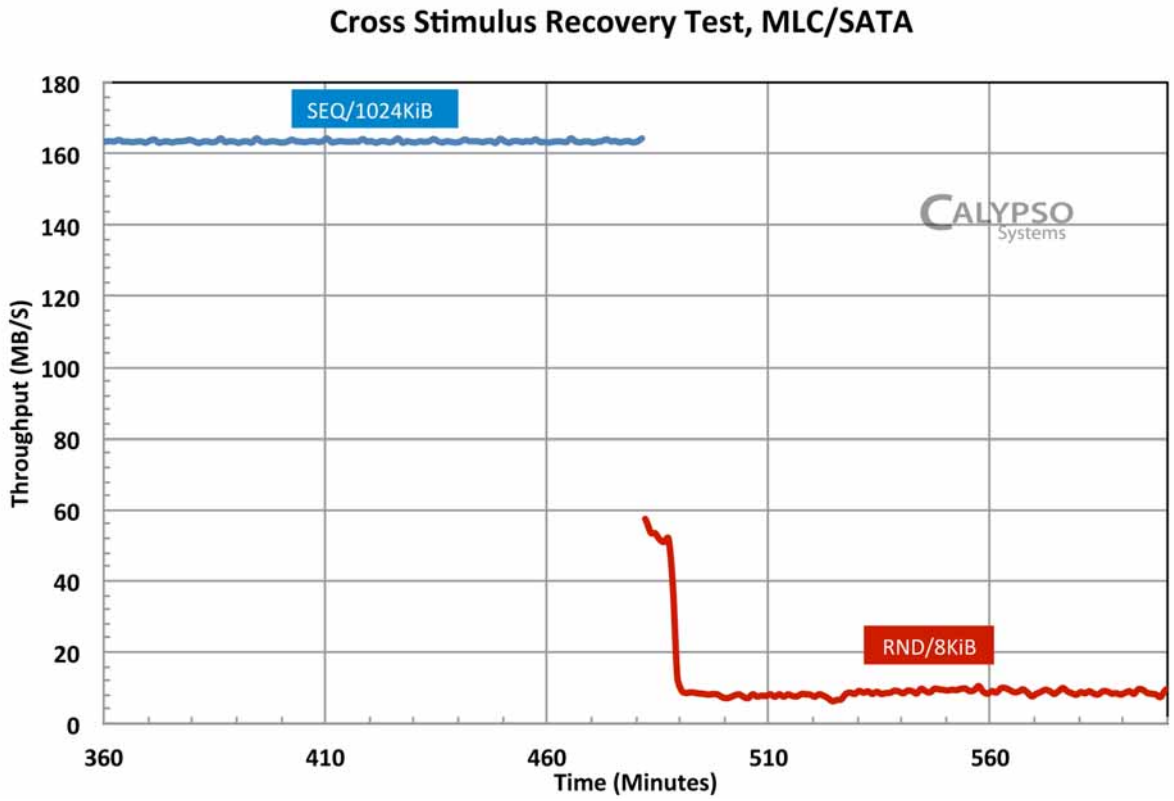
Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	2 of 5

Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

TP v Time - All Groups 1 & 2

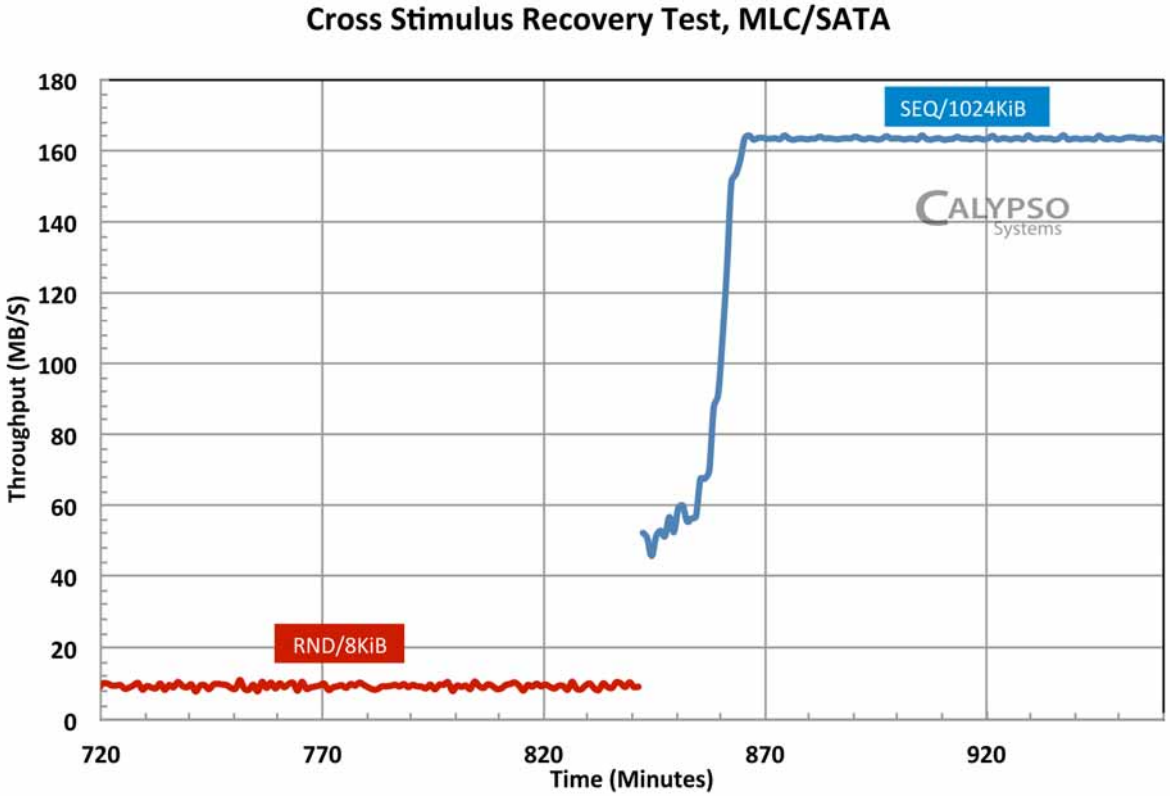


Plot A.31– TP vs. Time - All Groups 1 & 2

Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page							
SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)		XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB			Rev.	PTS-E 1.1
						Page	3 of 5
Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100		TEST SPONSOR	CALYPSO Systems	

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

TP v Time - Groups 2 & 3



Plot A.32 – TP vs. Time - Groups 2 & 3

Test Run Date:	10/18/2012 4:02:00 PM	Report Run Date:	03/06/2013 05:01PM

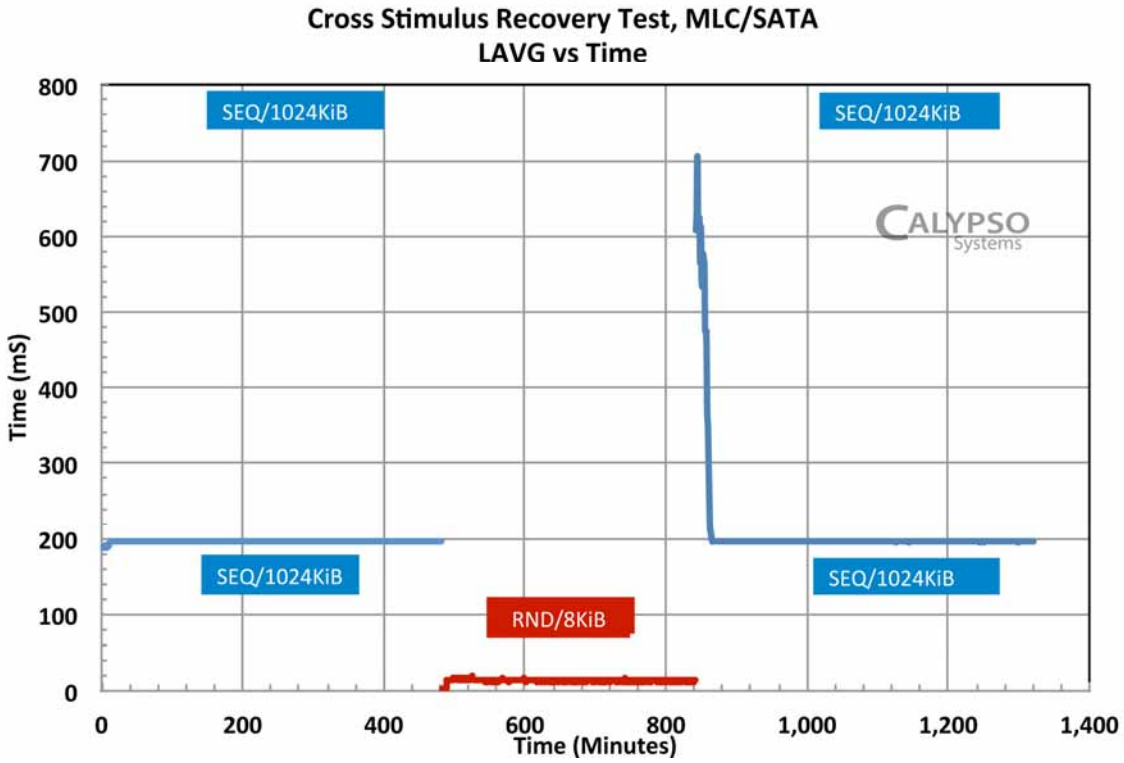
Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	4 of 5

Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

Maximum Latency vs. Time, All Access Groups



Plot A.33 – Maximum Latency vs. Time, All Access Groups

Test Run Date:	10/18/2012 4:02:00 PM	Report Run Date:	03/06/2013 05:01PM

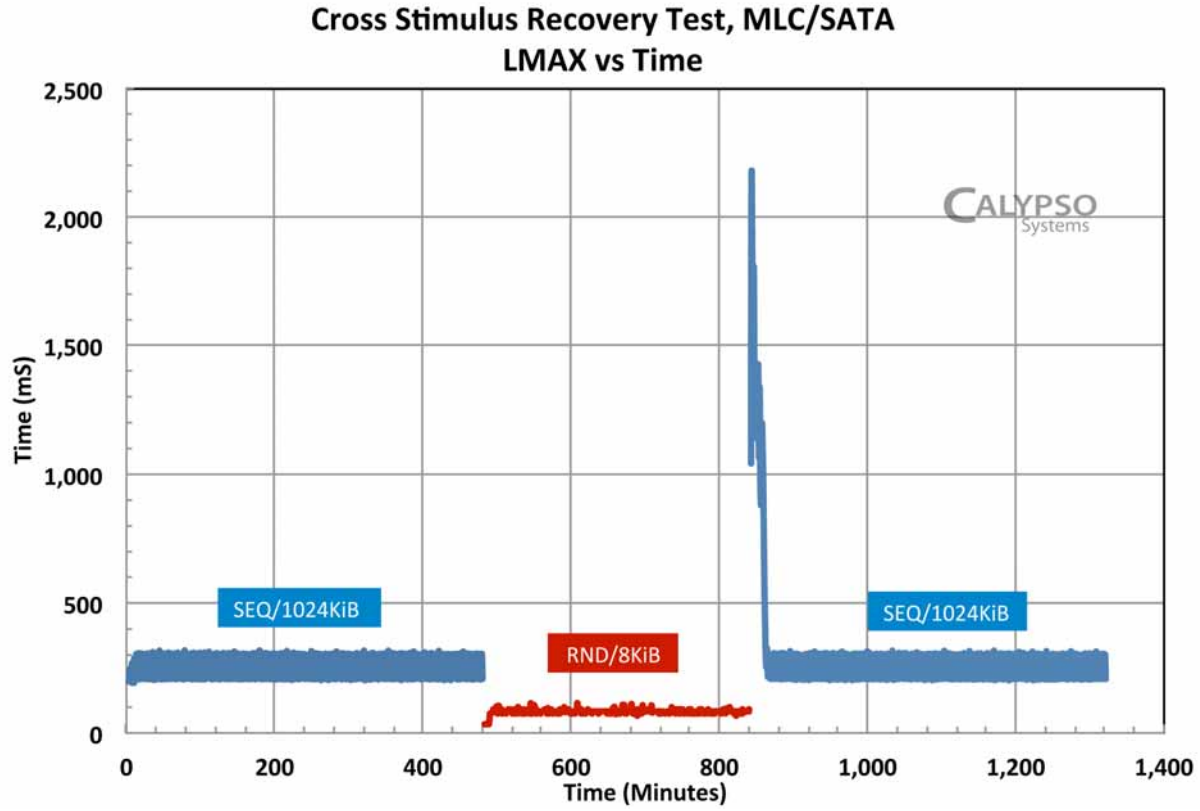
Cross Stimulus Recovery- SEQ-RND-SEQ (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	XSR - SEQ 1024KiB - RND 8KiB - SEQ 1024KiB	Rev.	PTS-E 1.1
			Page	5 of 5

Vendor:	ABC Co.	SSD Model:	XYZ Co. My Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	Calypso RTP 2.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Super Drive 256	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	None	Test Stimulus 1	SEQ/1024KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	TOIO - TC/QD	-	TOIO - TC/QD	TC1 / QD32
Operating System	CentOS 6.3	Capacity	256 GB	SS Rounds	-	Duration (Hr)	8
Test SW	CTS 6.5 1.13.8	Interface	SATA 6Gb/s	Pre Condtion 2	None	Test Stimulus 2	RND/8KiB
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	eMLC	TOIO - TC/QD	-	TOIO - TC/QD	TC2 / QD16
Test ID No.	R29-807	PCIe NVM	N/A	SS Rounds	-	Duration (Hr)	6
HBA	LSI 9212-4e4i	Purge Method	Security Erase				
PCIe	Gen 3 x 16	Write Cache	WCD				

Average Latency vs. Time, All Access Groups



Plot A.34 – Average Latency vs. Time, All Access Groups

A.7 Sample Enterprise Composite Workload Test Report Pages

The sample Enterprise Composite Workload Test Report pages are shown in Plot A.35 through Plot A.49.

Test Run Date:	10/14/2012 12:51 AM	Report Run Date:	03/7/2013 9:26:00 AM

Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	1 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-942	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Access Pattern Block Sizes & Access Probabilities - 40:60 RW

Block Size in Bytes (KiB)	Access Probability Within Each Measurement Period
512 bytes (0.5 KiB)	4%
1024 bytes (1 KiB)	1%
1536 bytes (1.5 KiB)	1%
2048 bytes (2 KiB)	1%
2560 bytes (2.5 KiB)	1%
3072 bytes (3 KiB)	1%
3584 bytes (3.5 KiB)	1%
4096 bytes (4 KiB)	67%
8192 bytes (8 KiB)	10%
16,384 bytes (16 KiB)	7%
32,768 bytes (32 KiB)	3%
65,536 bytes (64 KiB)	3%
Total	100%

% of Access within 1 Measurement Period	Active Range Restriction	Label
50%	First 5%	LBA Group A
30%	Next 15%	LBA Group B
20%	Remaining 80%	LBA Group C

Plot A.35 – Access Pattern Block Sizes & Access Probabilities - 40:60 RW

Test Run Date:	10/14/2012 12:51 AM	Report Run Date:	03/7/2013 9:26:00 AM

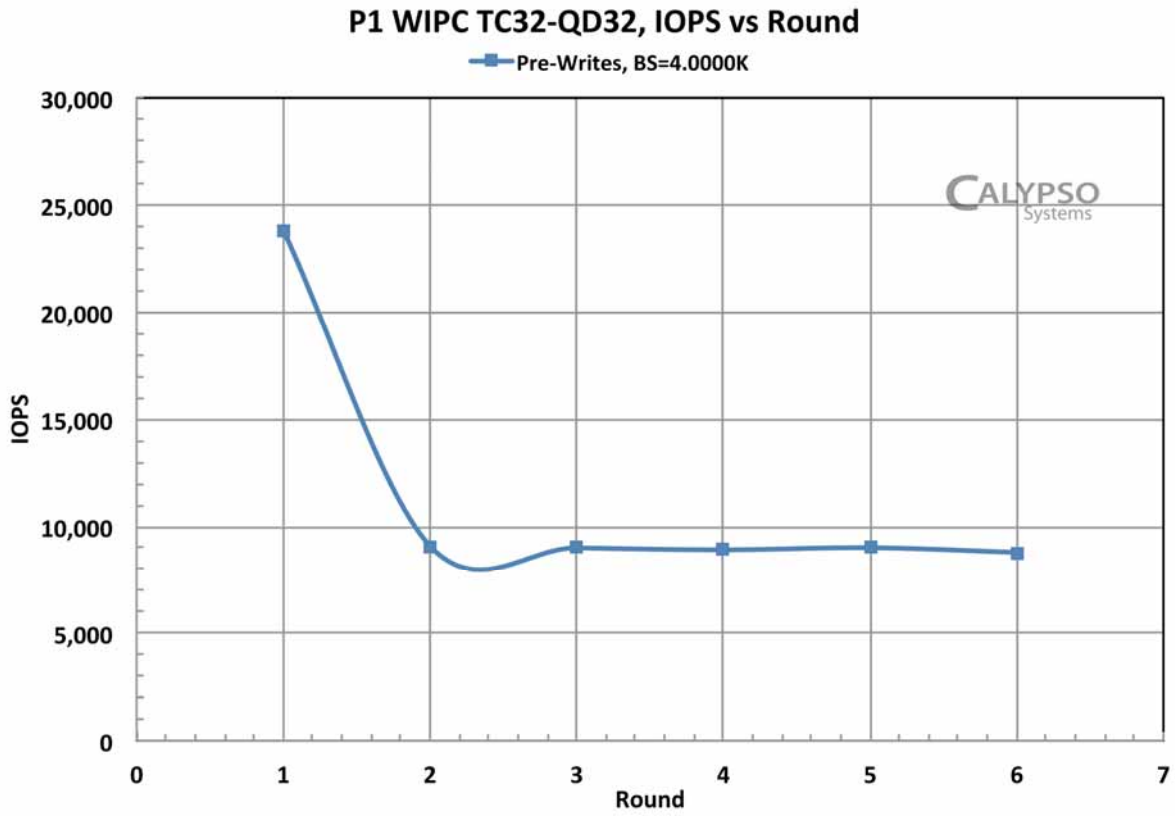
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	2 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-942	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Pre Conditioning IOPS Plot



Plot A.36 – Pre Conditioning IOPS vs. Round Plot

Test Run Date:	10/14/2012 12:51 AM	Report Run Date:	03/7/2013 9:26:00 AM

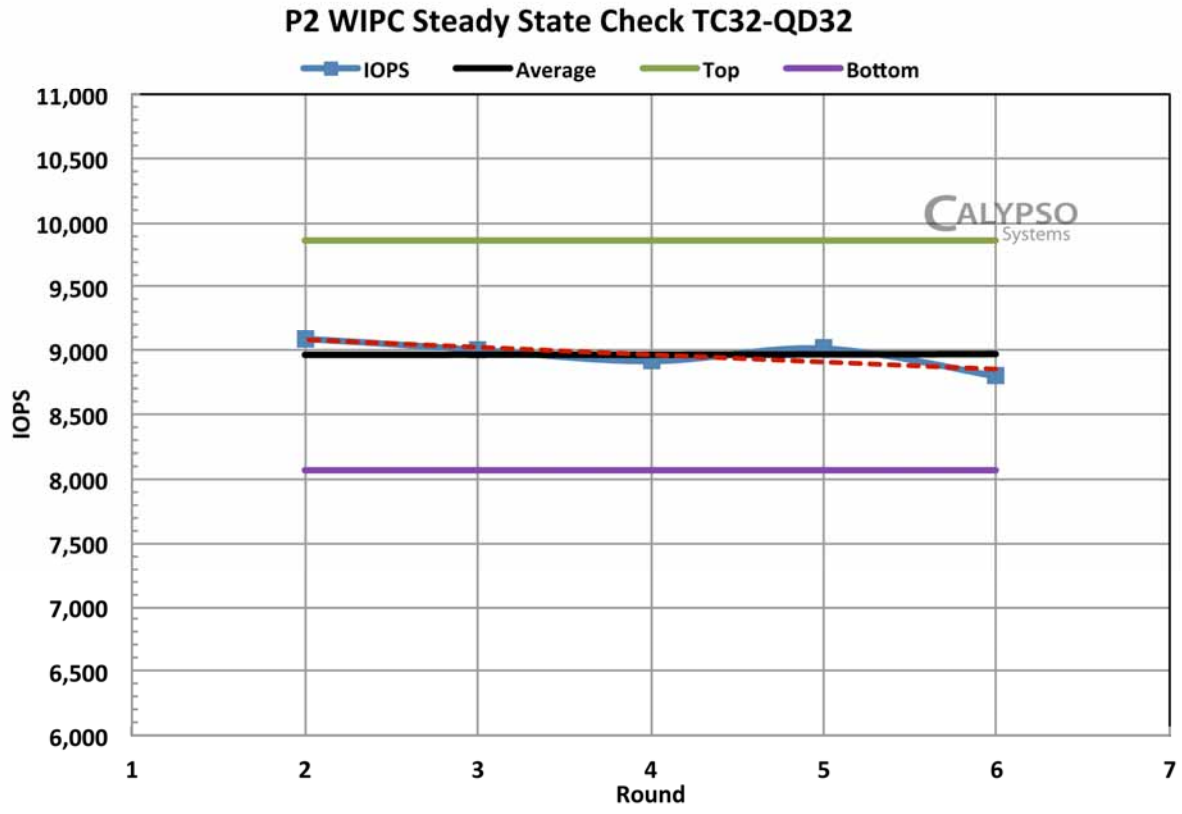
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	3 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-942	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Pre Conditioning Steady State Plot



Plot A.37 – Pre Conditioning Steady State Plot

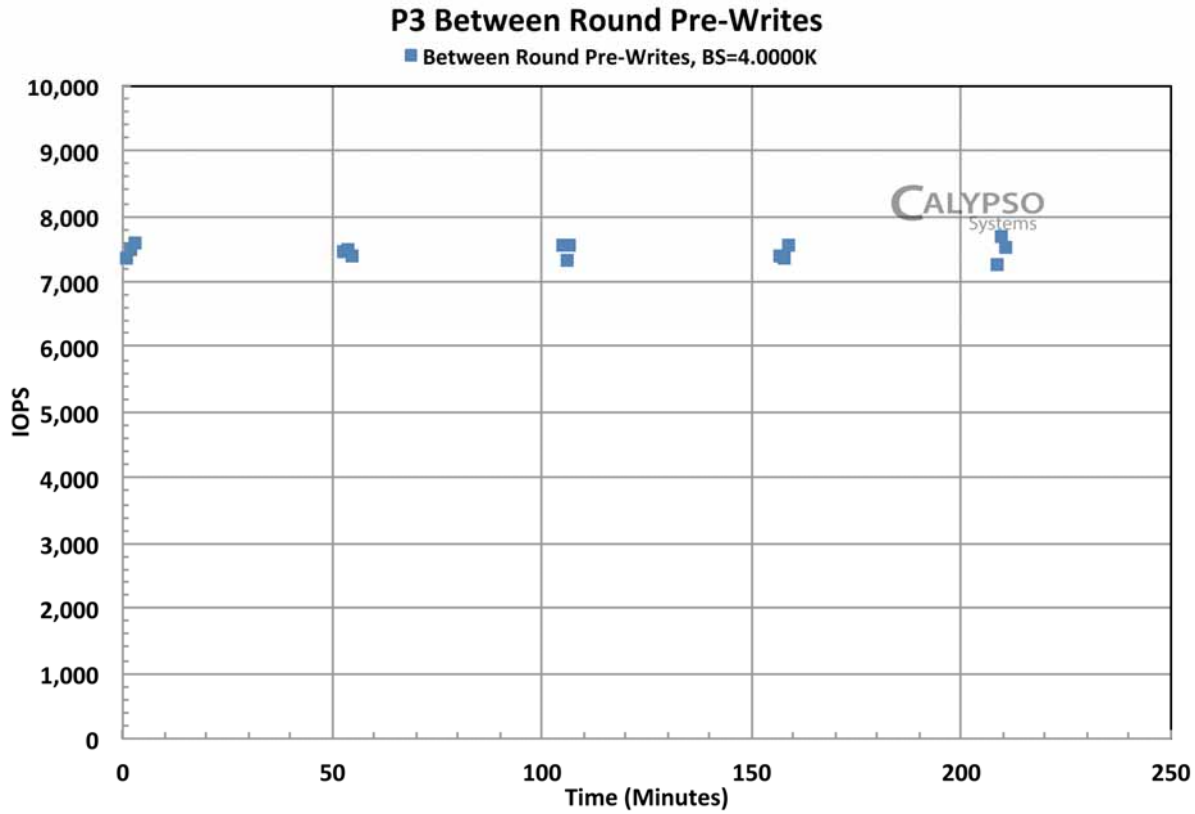
Test Run Date:	10/13/2012 08:27 PM	Report Run Date:	03/7/2013 9:26:00 AM

Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	4 of 15
Vendor:	ABC Co.	SSD Model: ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-940	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Between Round Pre Writes



Plot A.38 – Between Round Pre Writes

Test Run Date:	10/13/2012 08:27 PM	Report Run Date:	03/7/2013 9:26:00 AM

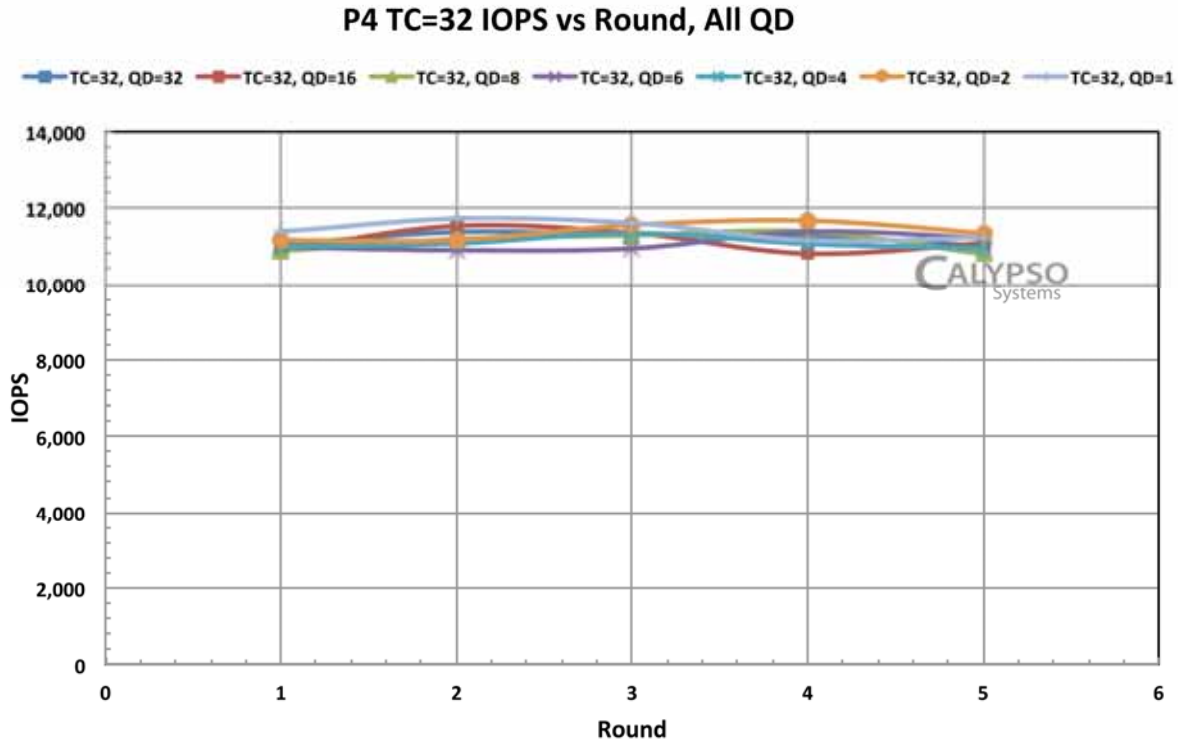
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	5 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-940	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

DV IOPS Plot, TC=Tracking



Plot A.39 – DV IOPS Plot, TC=Tracking

Test Run Date:	10/13/2012 08:27 PM	Report Run Date:	03/7/2013 9:26:00 AM

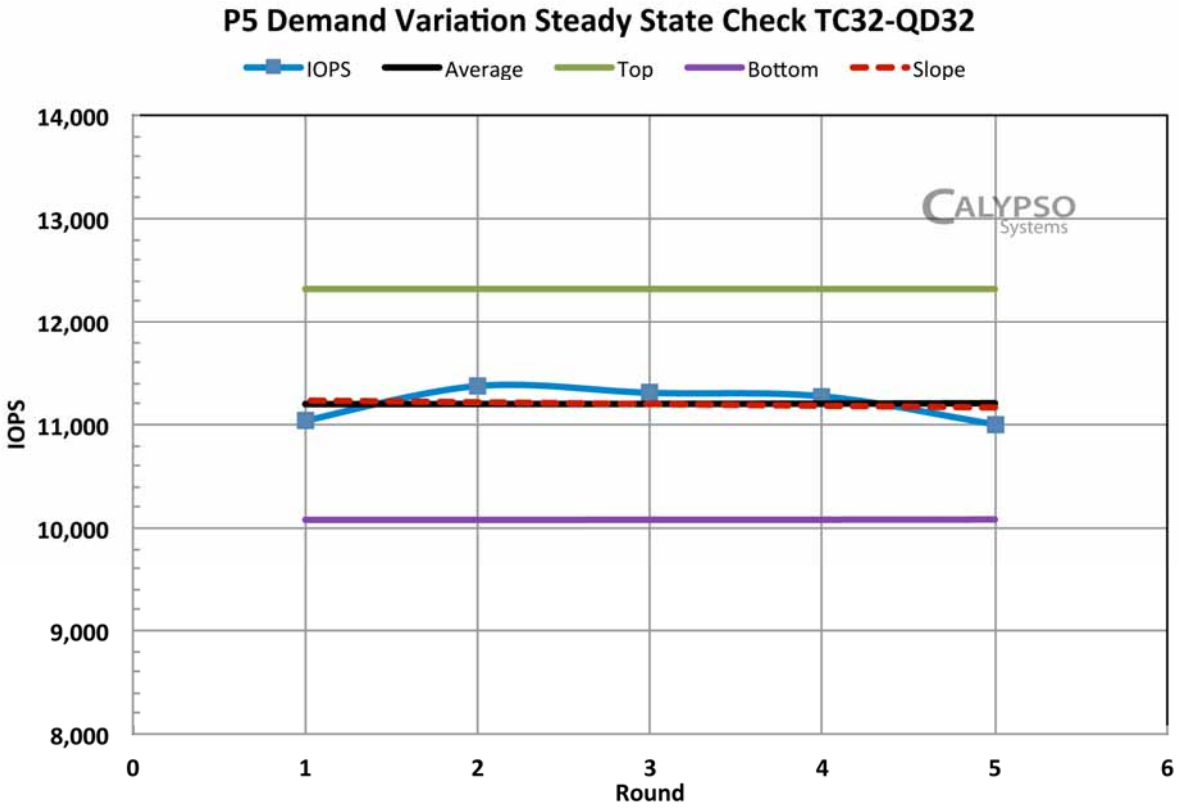
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	6 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-940	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

DV Steady State Plot, Tracking Variable



Plot A.40 – DV Steady State Plot, Tracking Variable

Test Run Date:	10/13/2012 08:27 PM	Report Run Date:	03/7/2013 9:26:00 AM

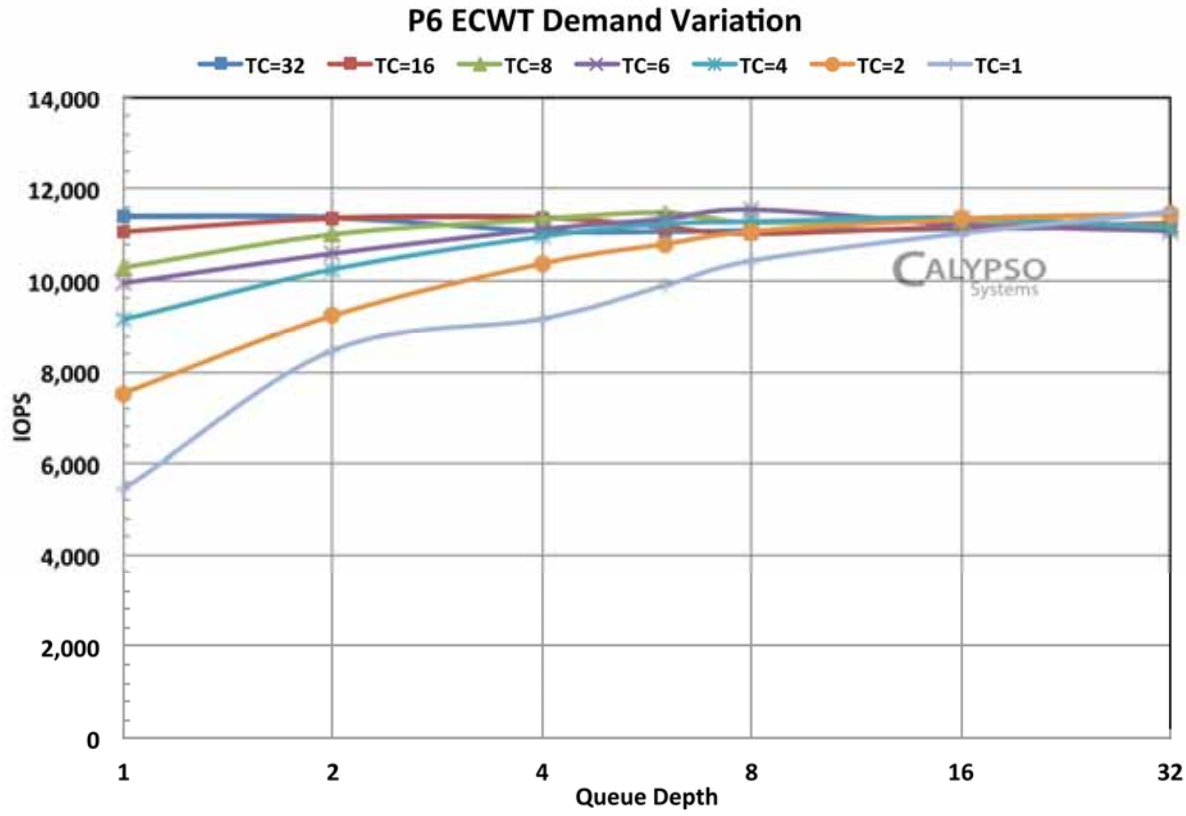
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	7 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-940	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Demand Variation Plot



Plot A.41 – Demand Variation Plot

Test Run Date:	10/13/2012 08:27 PM	Report Run Date:	03/7/2013 9:26:00 AM

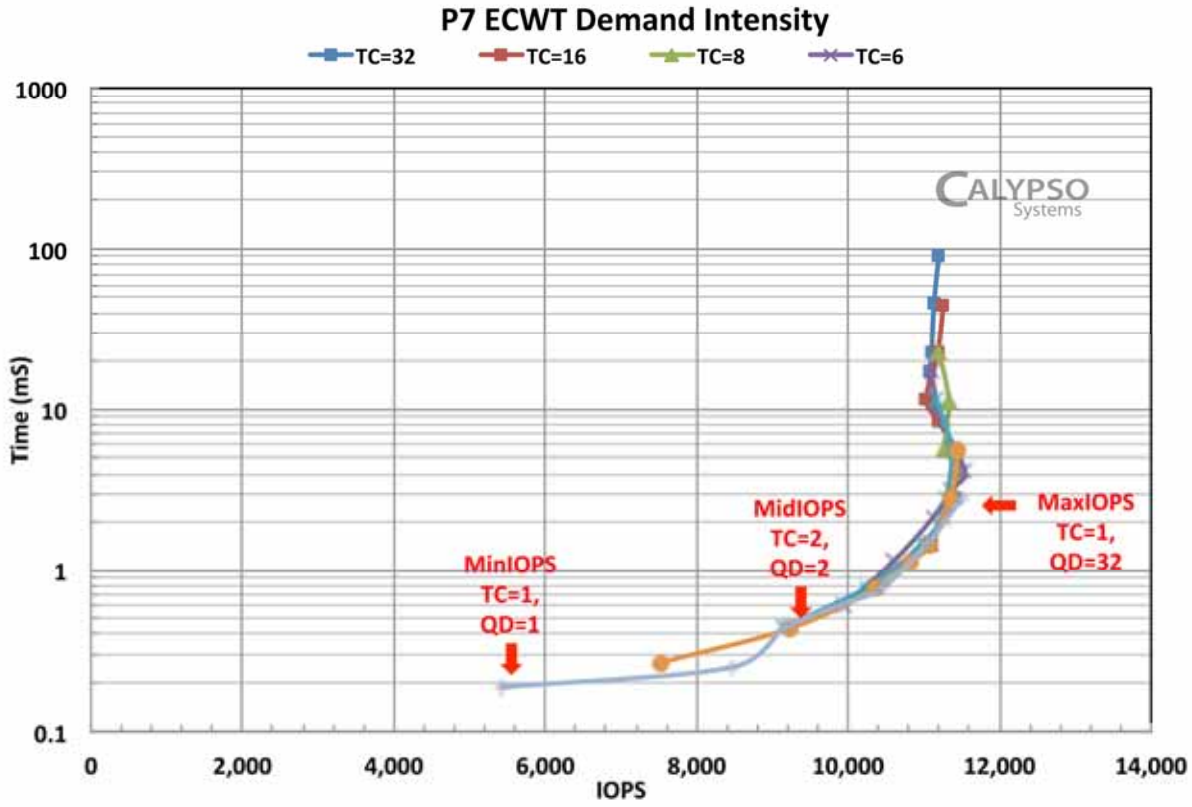
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	8 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-940	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Demand Intensity Plot



Plot A.42 – Demand Intensity Plot

Test Run Date:	10/13/2012 08:27 PM	Report Run Date:	03/7/2013 9:26:00 AM

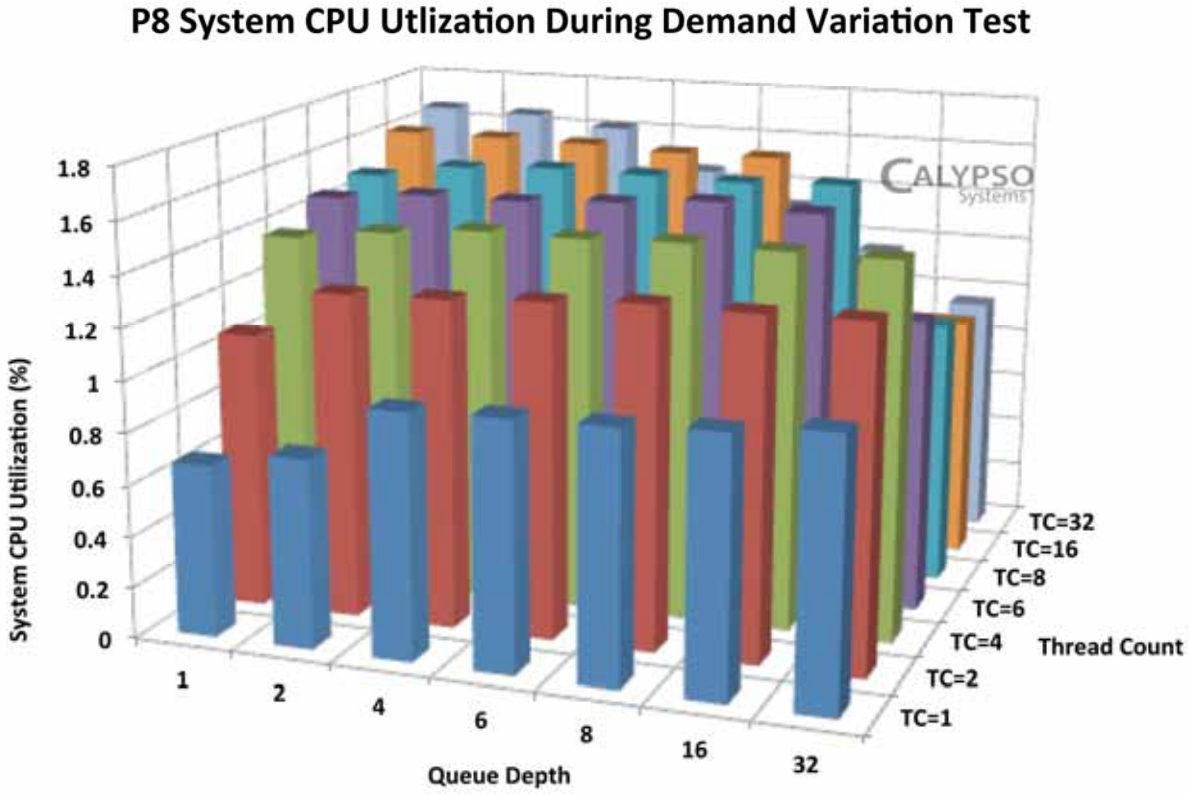
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	9 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-940	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

System CPU Utilization Plot



Plot A.43 – System CPU Utilization Plot

Test Run Date:	10/13/2012 07:11 PM	Report Run Date:	03/7/2013 10:18:00 AM

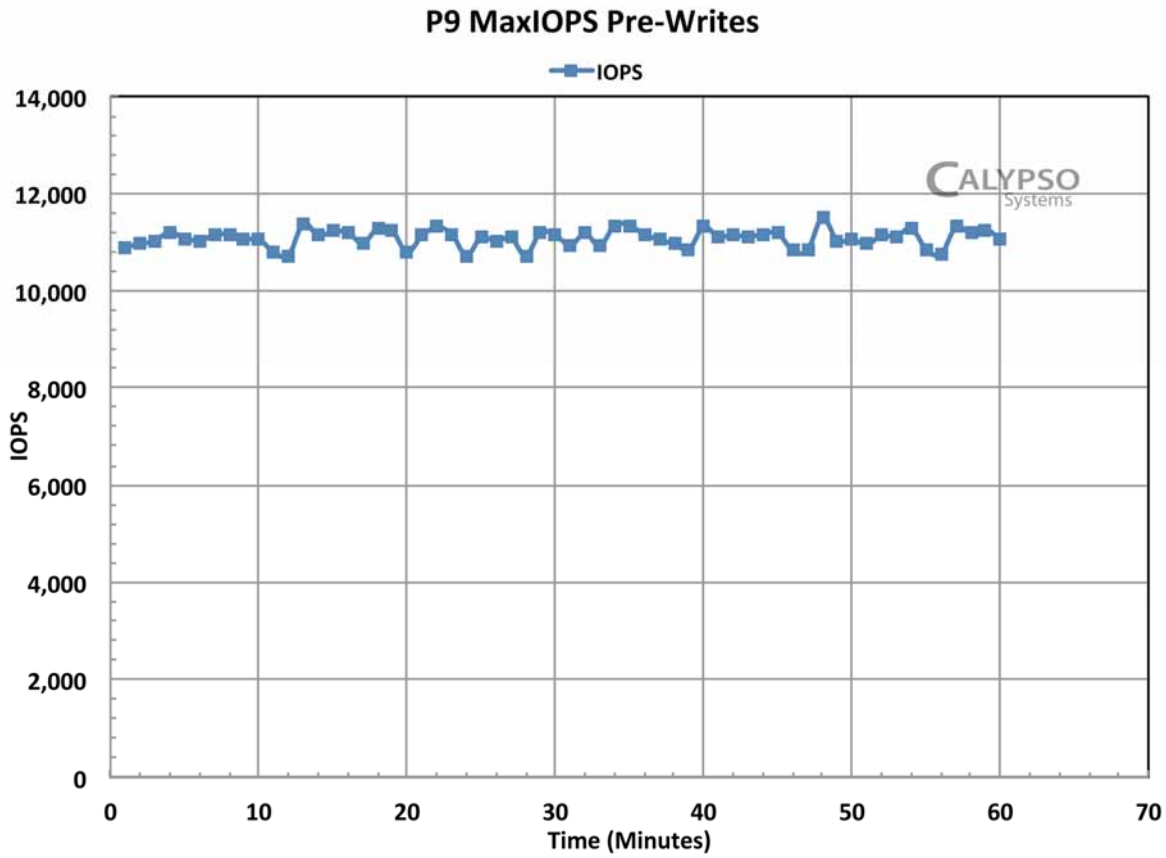
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	10 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-938	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Max IOPS Pre Writes



Plot A.44 – Max IOPS Pre Writes

Test Run Date:	10/13/2012 7:11:00 PM	Report Run Date:	03/7/2013 10:18:00 AM

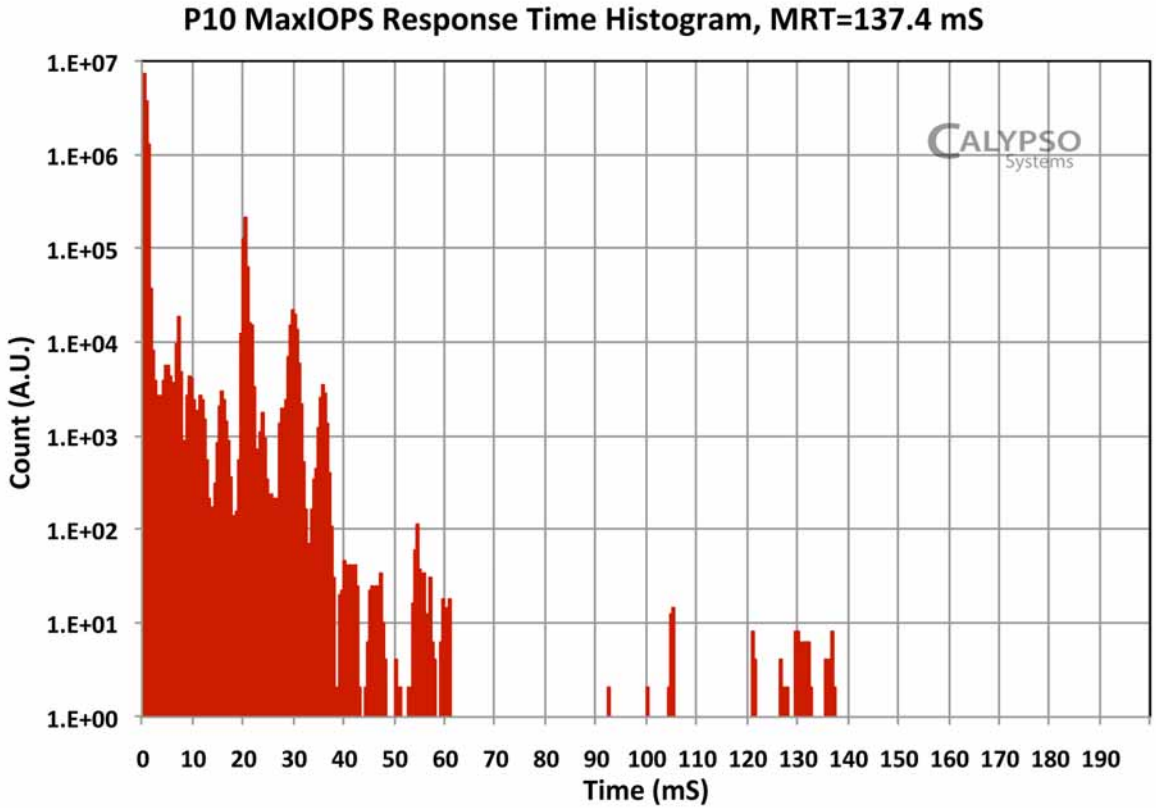
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	11 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-938	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Max IOPS Histogram



Plot A.45 – Max IOPS Histogram

Test Run Date:	10/13/2012 3:26:00 PM	Report Run Date:	03/7/2013 11:02:00 AM

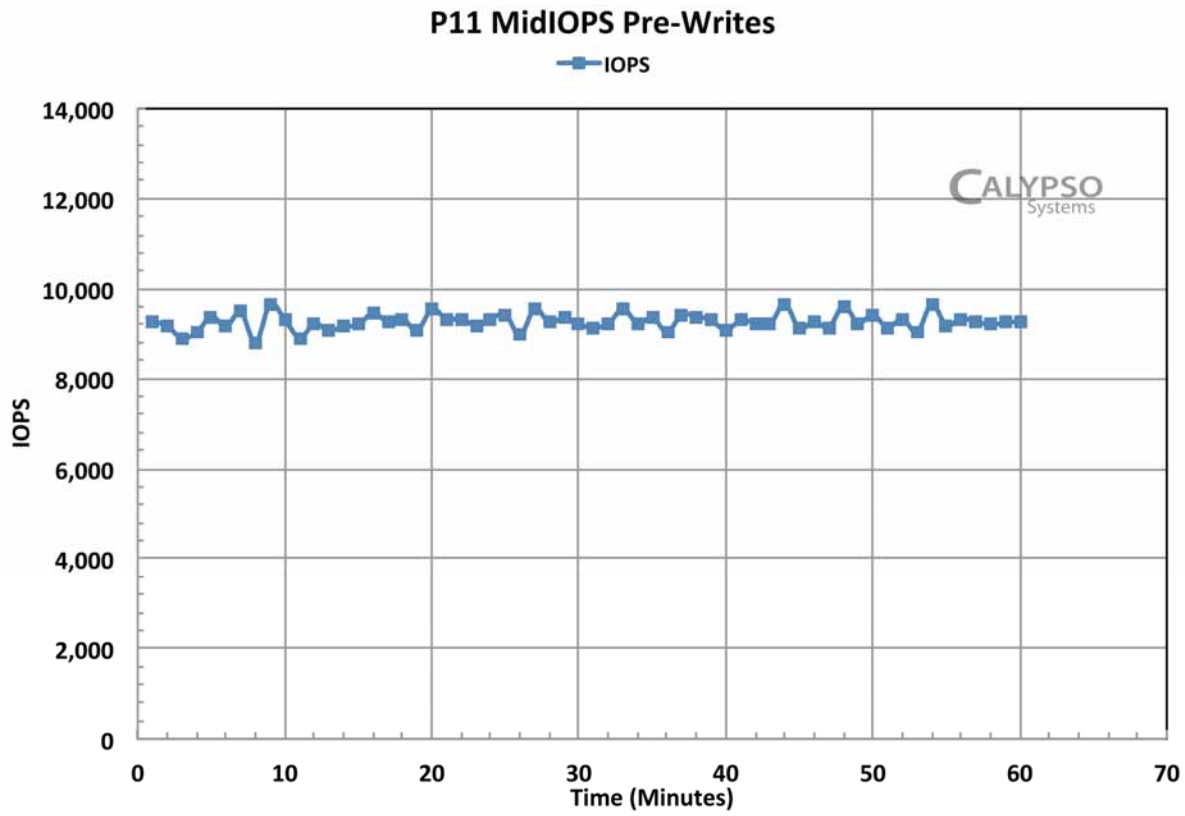
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	12 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-932	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Mid IOPS Pre Writes



Plot A.46 – Mid IOPS Pre Writes

Test Run Date:	10/13/2012 3:26:00 PM	Report Run Date:	03/7/2013 11:02:00 AM

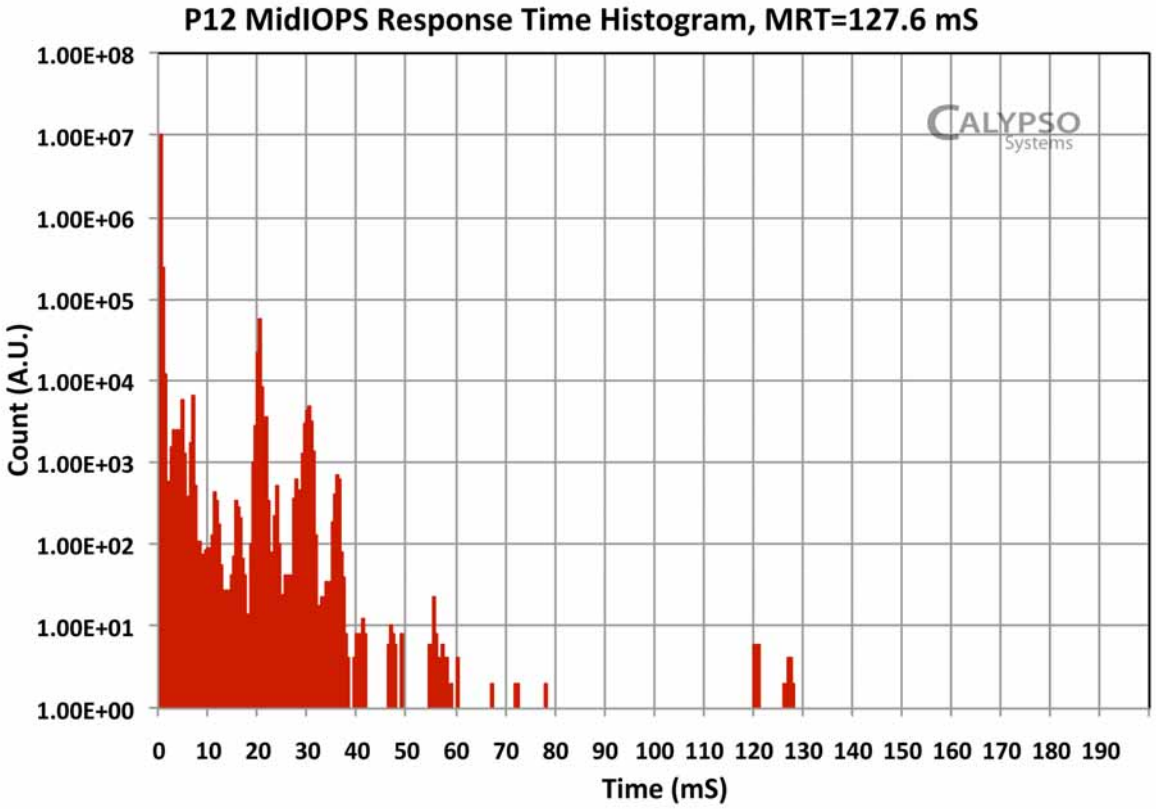
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	13 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-932	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Mid IOPS Histogram



Plot A.47 – Mid IOPS Histogram

Test Run Date:	10/13/2012 1:25:00 PM	Report Run Date:	03/7/2013 11:35:00 AM

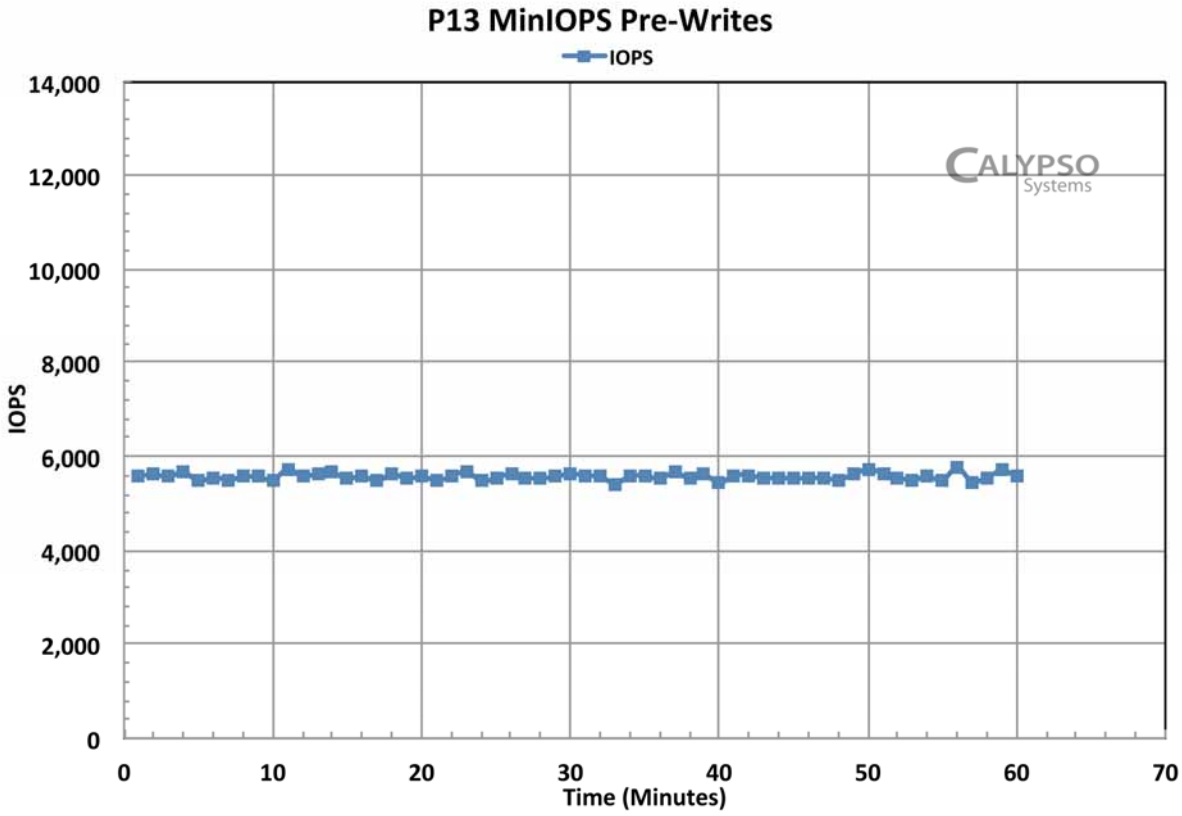
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probablility Workload	Rev.	PTS-E 1.1
			Page	14 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-915	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Min IOPS Pre Writes



Plot A.48 – Min IOPS Pre Writes

Test Run Date:	10/13/2012 1:25:00 PM	Report Run Date:	03/7/2013 11:35:00 AM

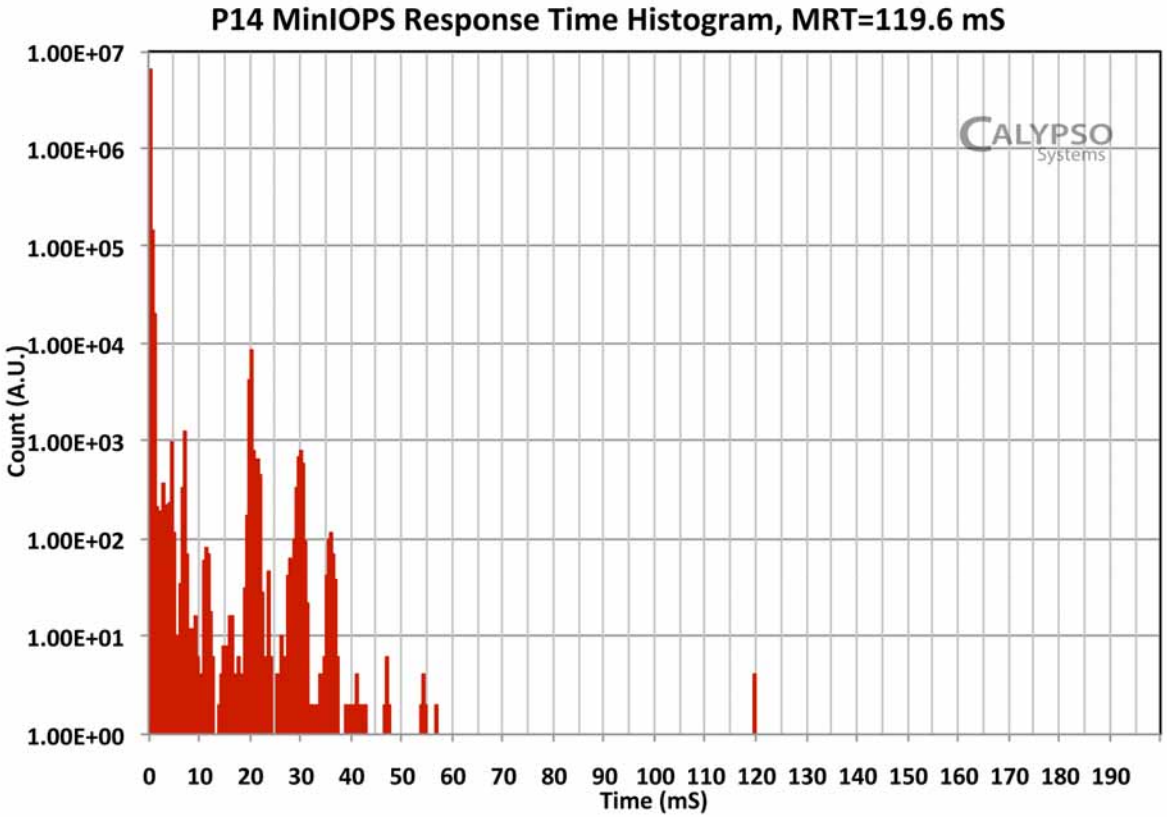
Enterprise Composite Workload Test (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	ECW Block Size / Probability Workload	Rev.	PTS-E 1.1
			Page	15 of 15

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	ECW	Test Stimulus 1	ECW
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100 %	R/W %	-
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Inter-Round Pre W	ECW	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-915	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Min IOPS Histogram



Plot A.49 – Min IOPS Histogram

A.8 Sample DIRTH Test Report Pages

The sample Demand Intensity Response Time Test Report pages are shown in Plot A.50 through Plot A.61.

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

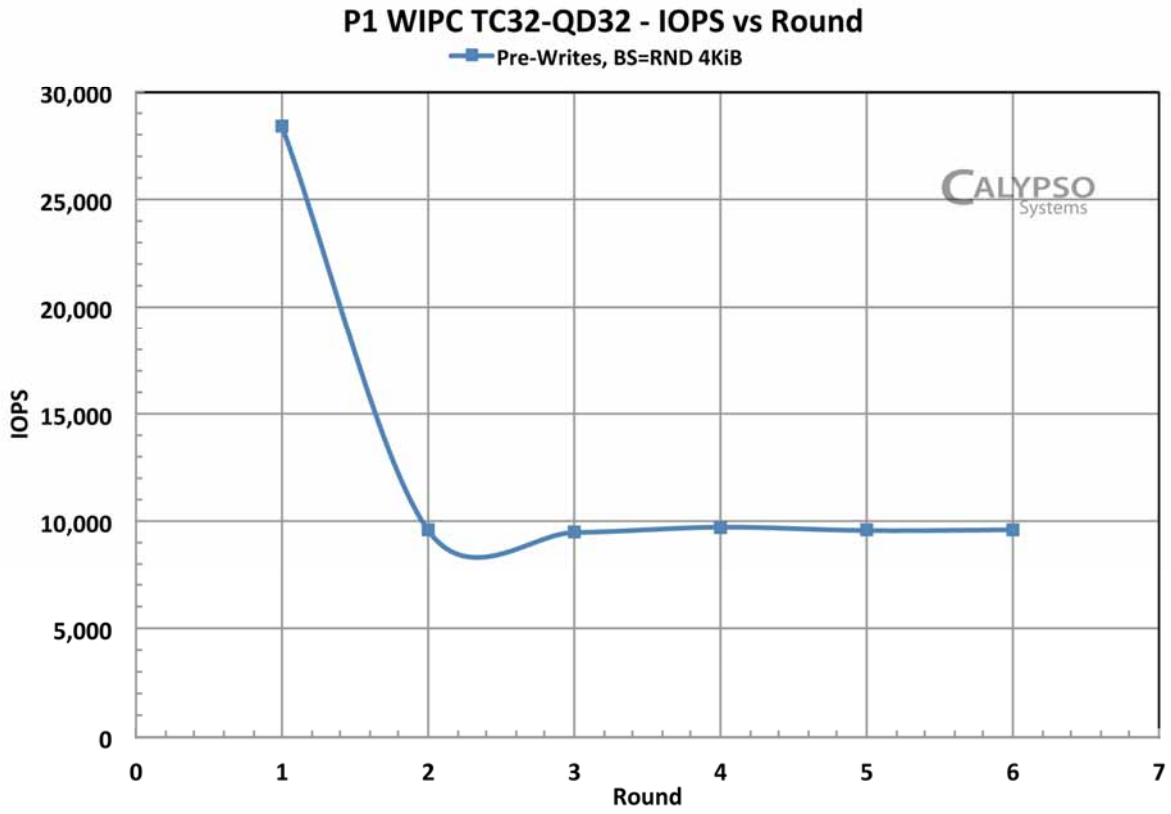
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	1 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Pre Conditioning IOPS Plot



Plot A.50 – DIRTH Pre Conditioning IOPS Plot

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

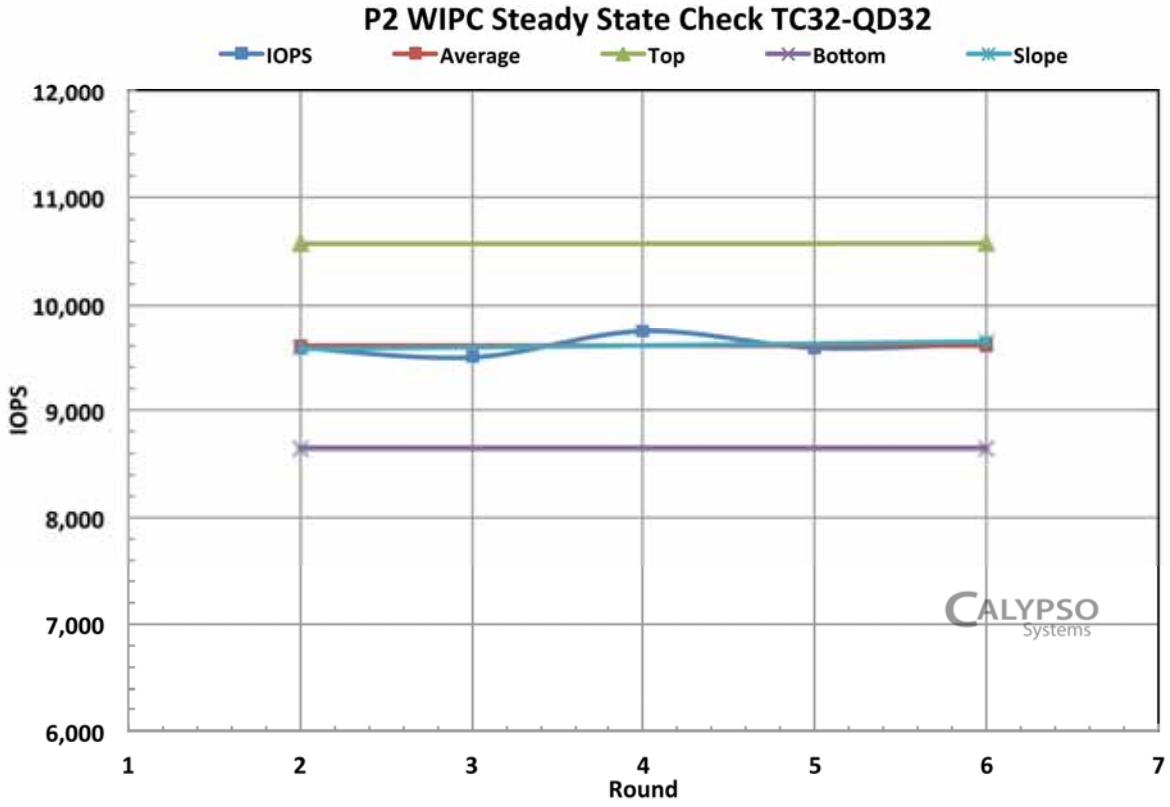
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	2 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Pre Conditioning Steady State Plot



Plot A.51 – DIRTH Pre Conditioning Steady State Plot

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

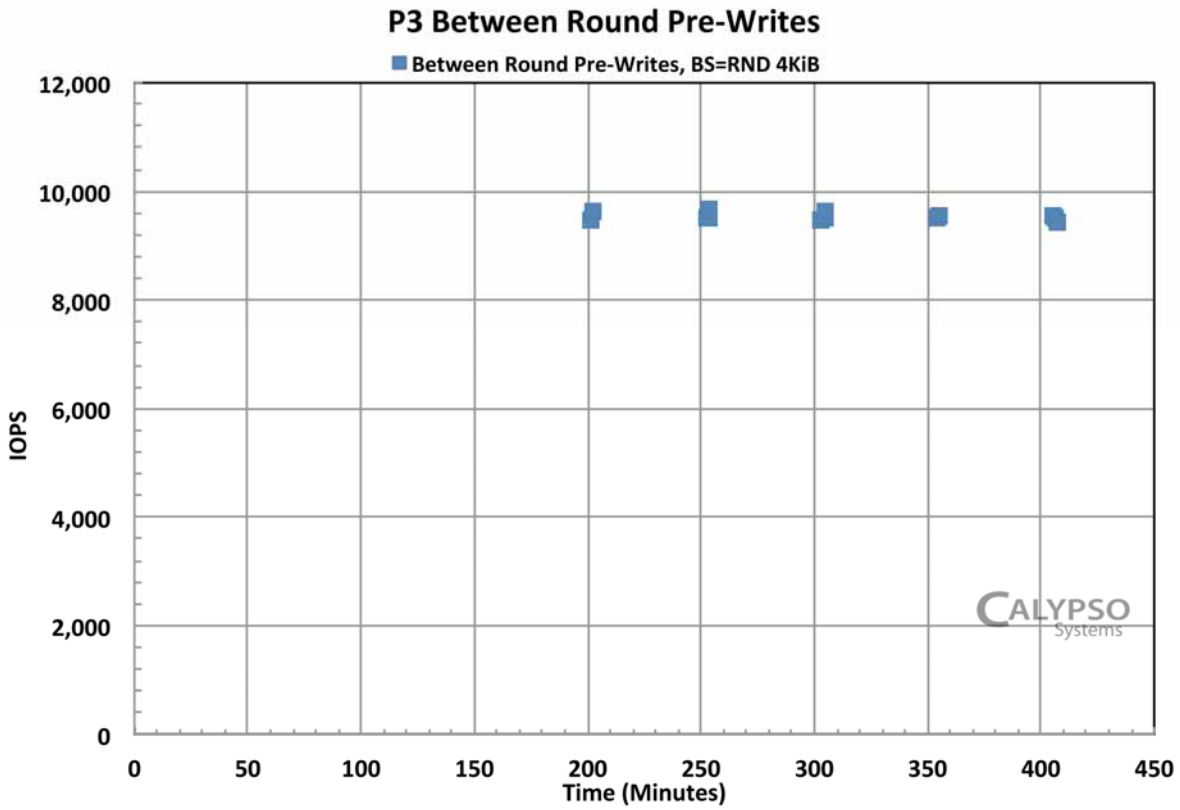
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	3 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Between Round Pre Writes



Plot A.52 – DIRTH Between Round Pre Writes

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

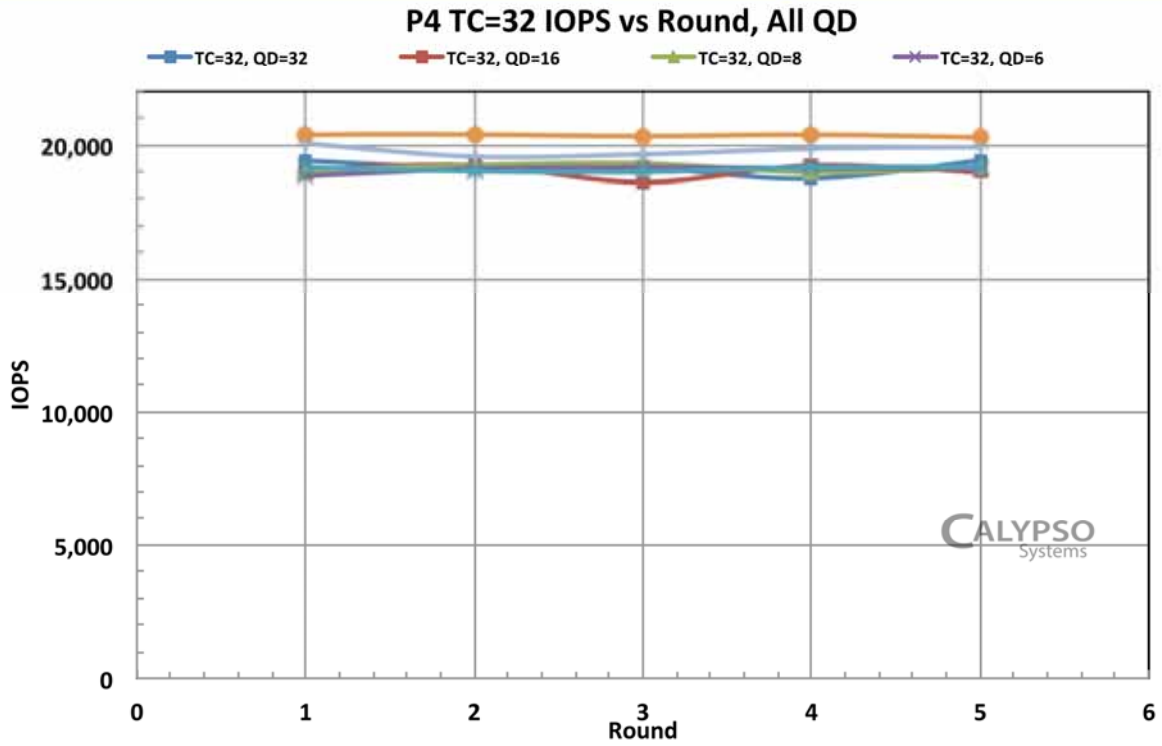
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	4 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

DV IOPS Plot, TC=Tracking



Plot A.53 – DIRTH DV IOPS Plot, TC=Tracking

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

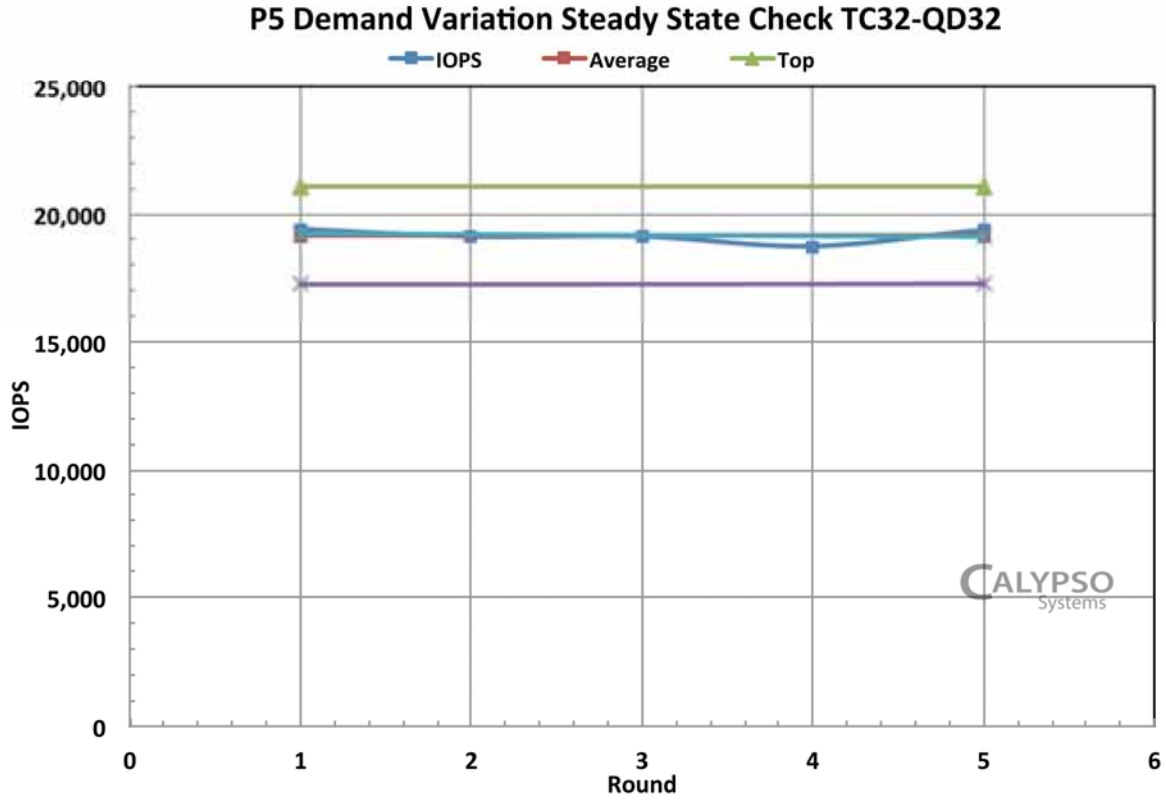
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	5 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

DV Steady State Plot, Tracking Variable



Plot A.54 – DIRTH DV Steady State Plot, Tracking Variable

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

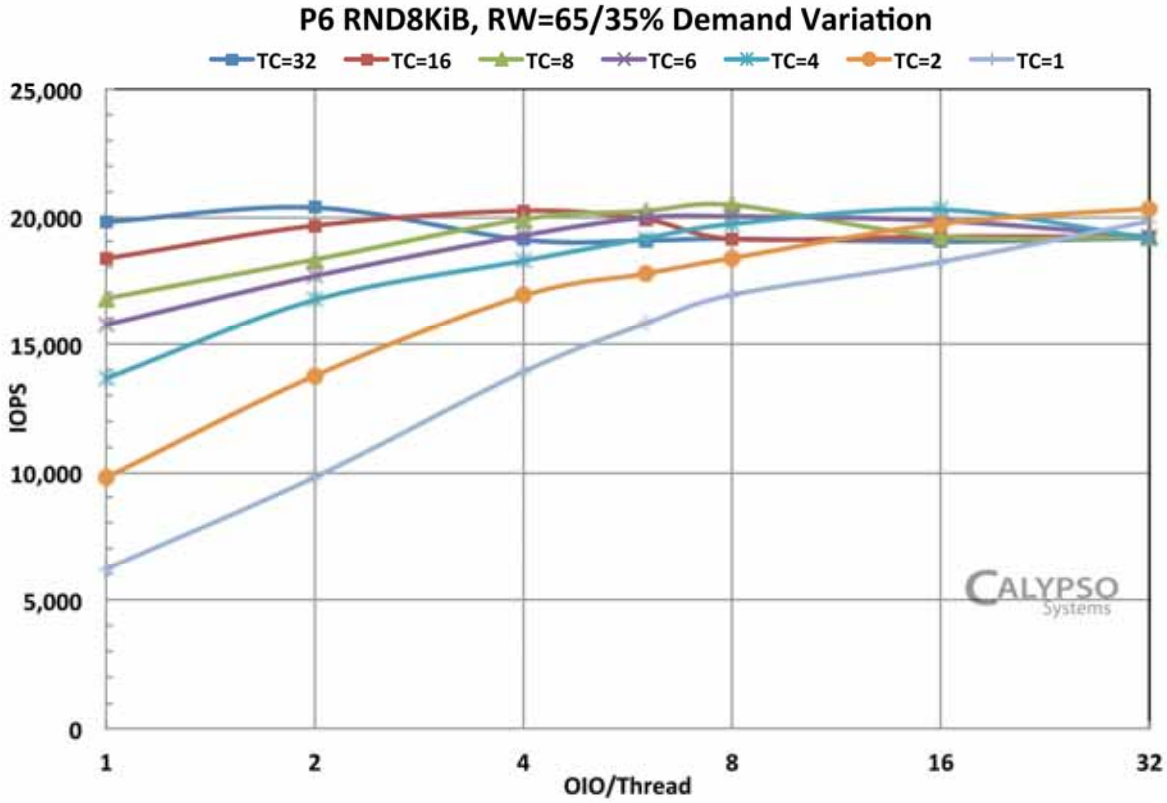
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	6 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Demand Variation Plot



Plot A.55 – DIRTH Demand Variation Plot

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

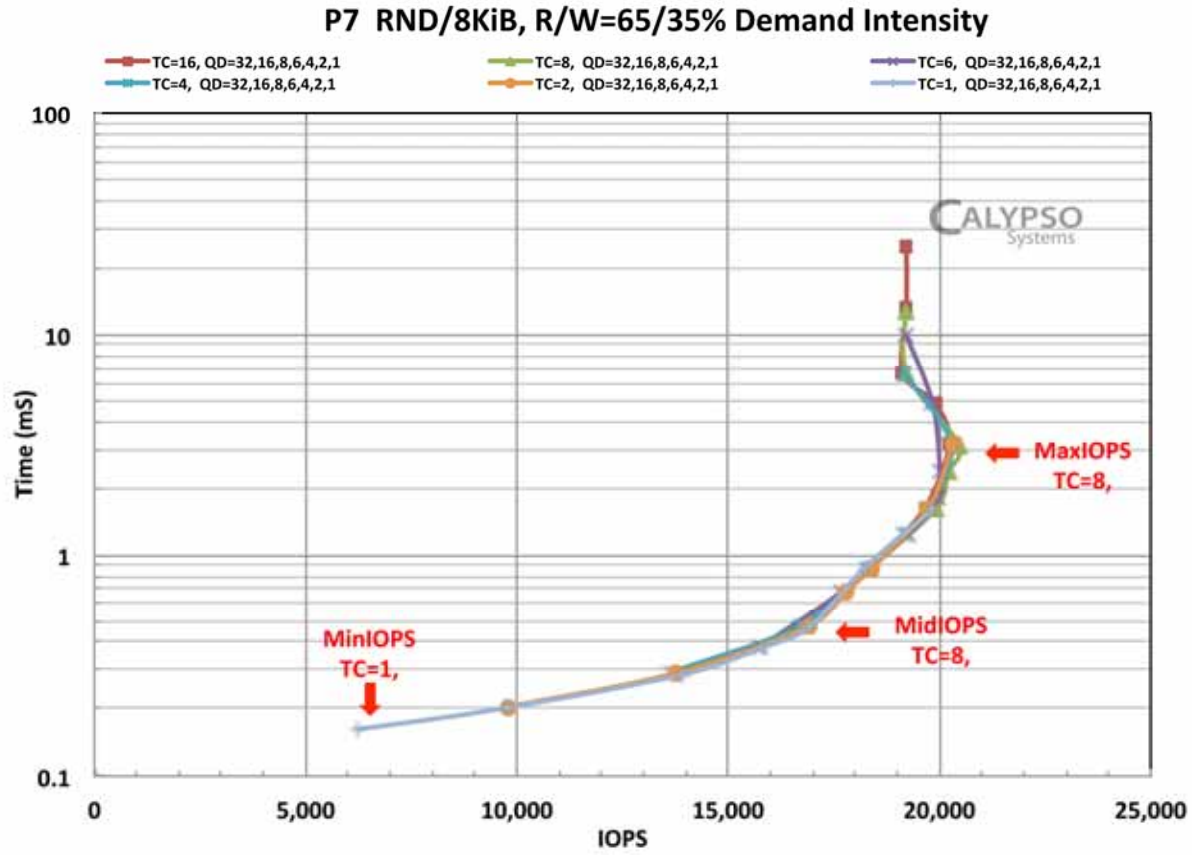
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	7 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Demand Intensity Plot



Plot A.56 – DIRTH Demand Intensity Plot

Test Run Date:	12/26/2012 12:51 AM	Report Run Date:	03/8/2013 7:43:00 AM

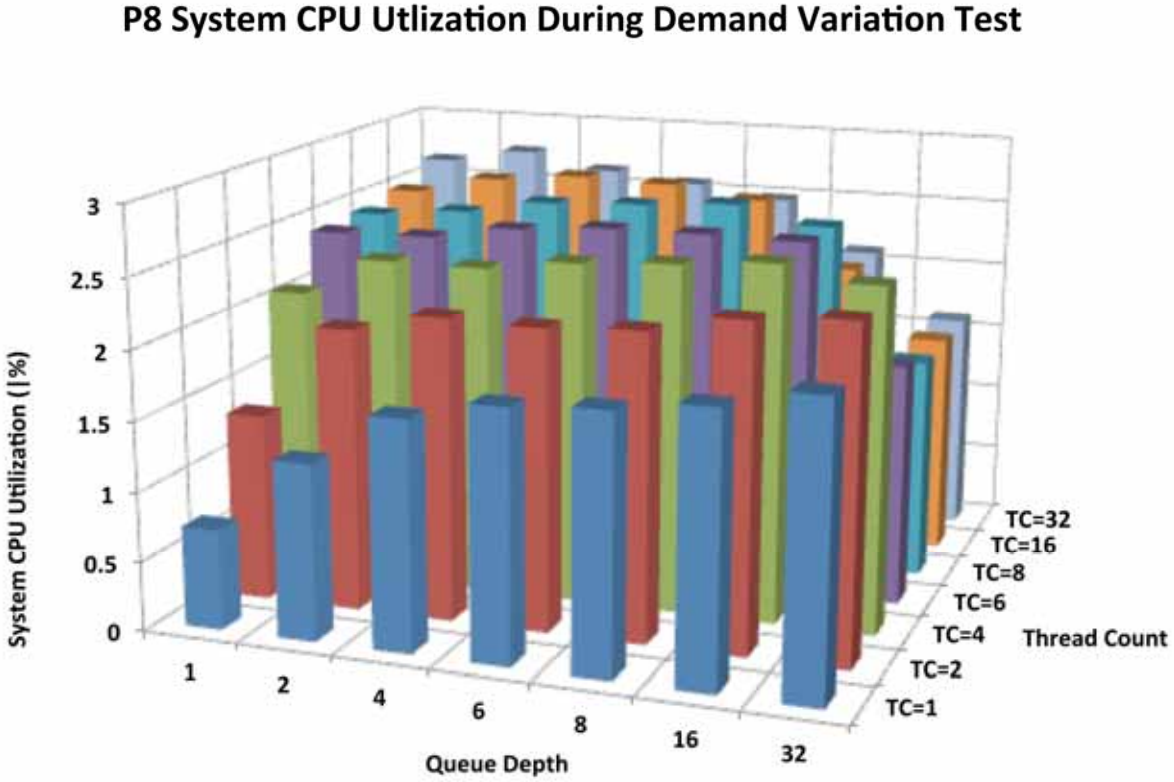
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	8 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1196	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

System CPU Utilization Plot



Plot A.57 – DIRTH System CPU Utilization Plot

Test Run Date:	12/27/2012 04:22 AM	Report Run Date:	03/7/2013 11:07:00 AM

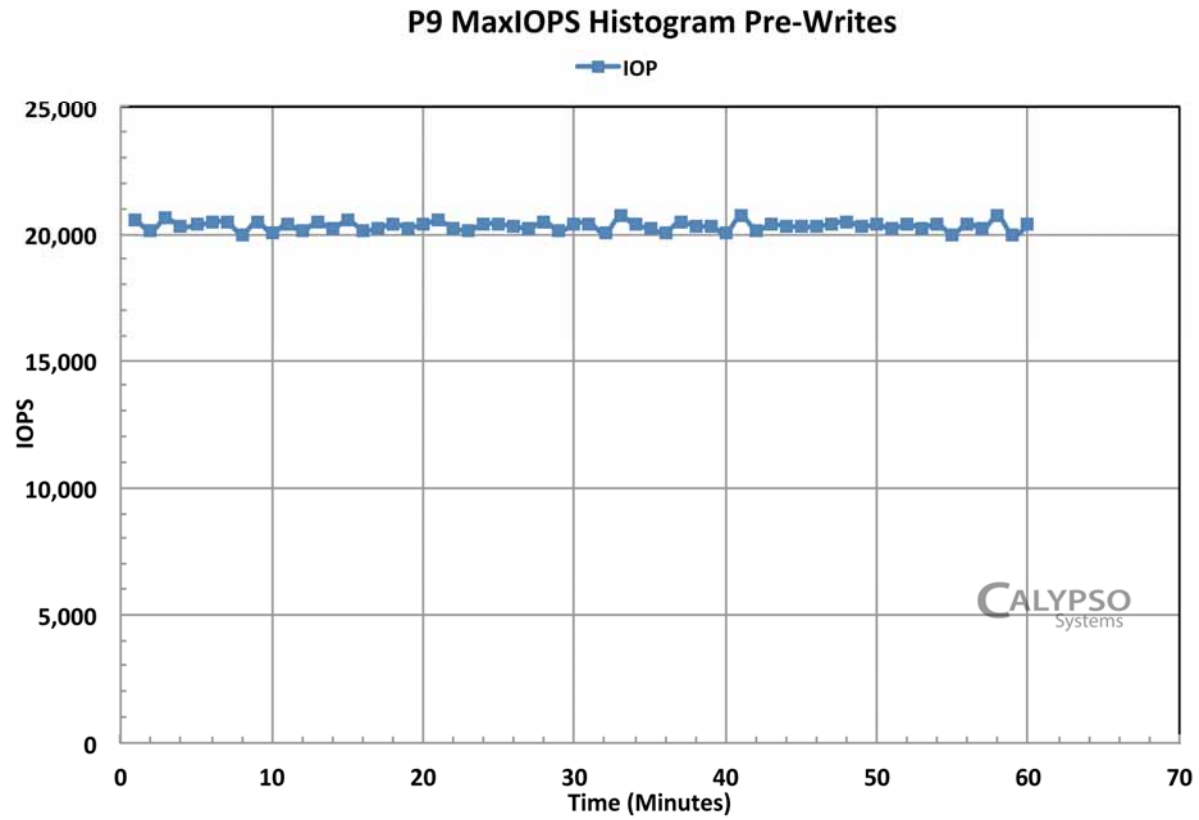
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	9 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1203	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Max IOPS Pre Writes



Plot A.58 – DIRTH Max IOPS Pre Writes

Test Run Date:	12/27/2012 04:22 AM	Report Run Date:	03/7/2013 11:07:00 AM

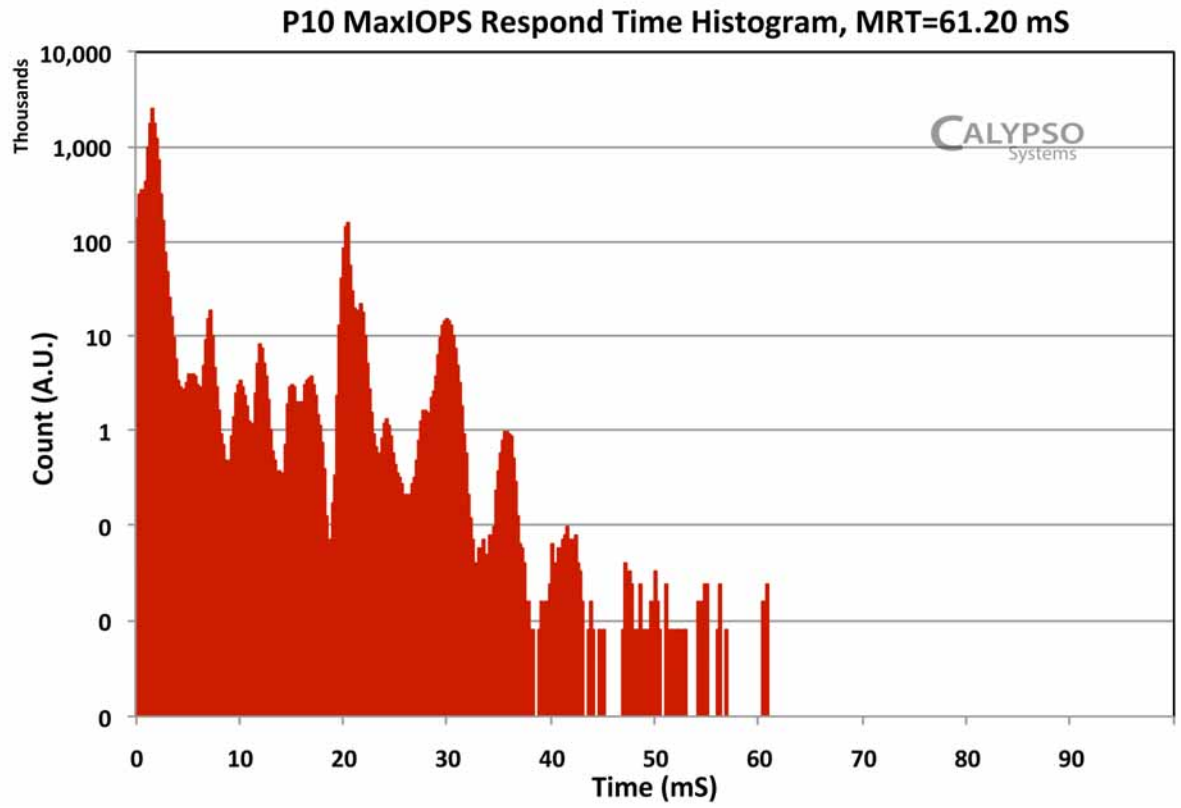
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	10 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1203	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Max IOPS Histogram



Plot A.59 – DIRTH Max IOPS Histogram

Test Run Date:	12/27/2012 3:12:00AM	Report Run Date:	03/7/2013 1:00:00 PM

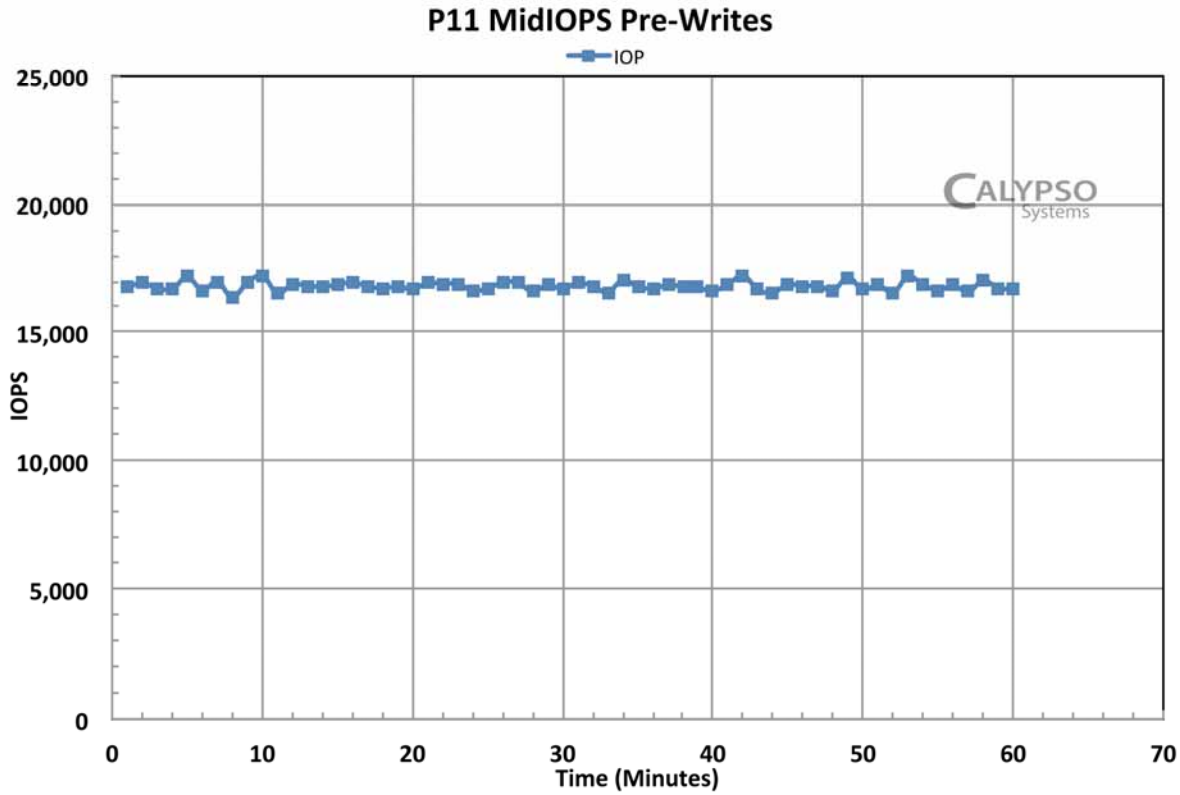
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	11 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1202	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Mid IOPS Pre Writes



Plot A.60 – DIRTH Mid IOPS Pre Writes

Test Run Date:	12/27/2012 3:12:00AM	Report Run Date:	03/7/2013 1:00:00 PM

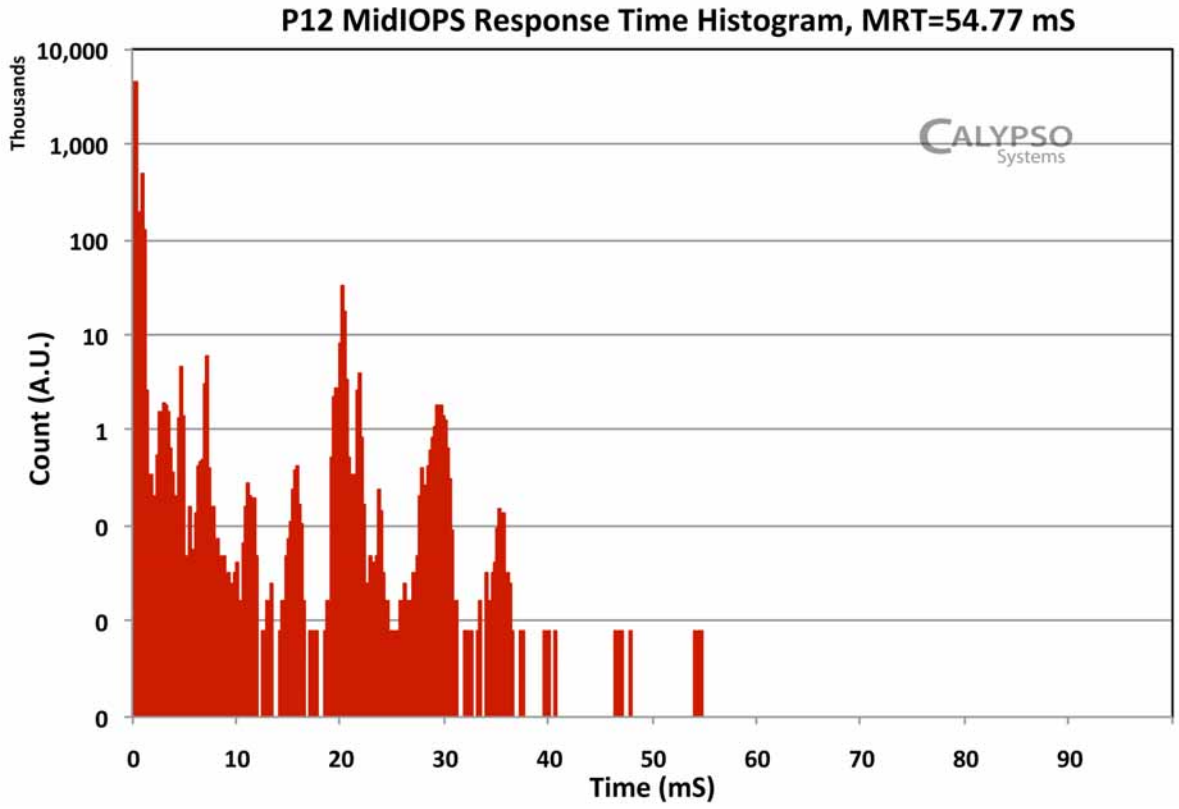
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	12 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1202	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Mid IOPS Histogram



Plot A.61 – DIRTH Mid IOPS Histogram

Test Run Date:	1/19/2013 7:14:00 AM	Report Run Date:	03/7/2013 1:15:00 PM

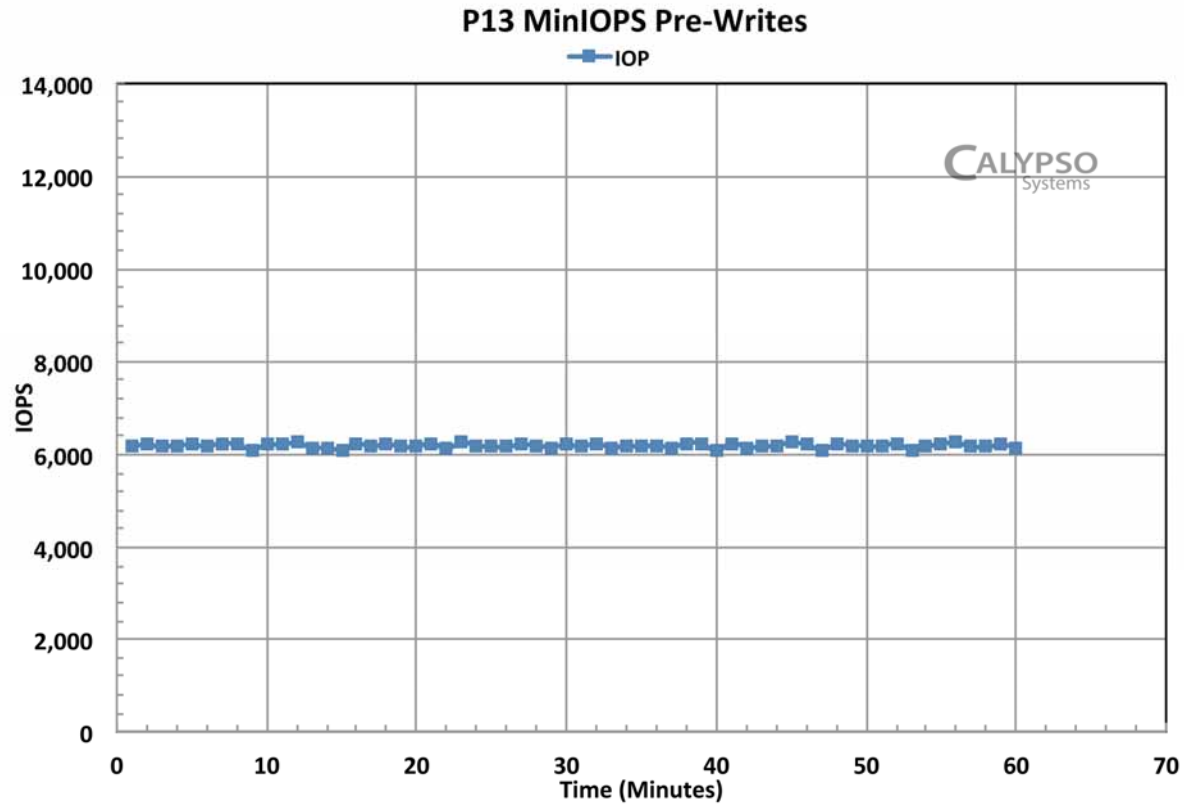
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	13 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1298	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Min IOPS Pre Writes



Plot A.62 – Min IOPS Pre Writes

Test Run Date:	1/19/2013 7:14:00 AM	Report Run Date:	03/7/2013 1:15:00 PM

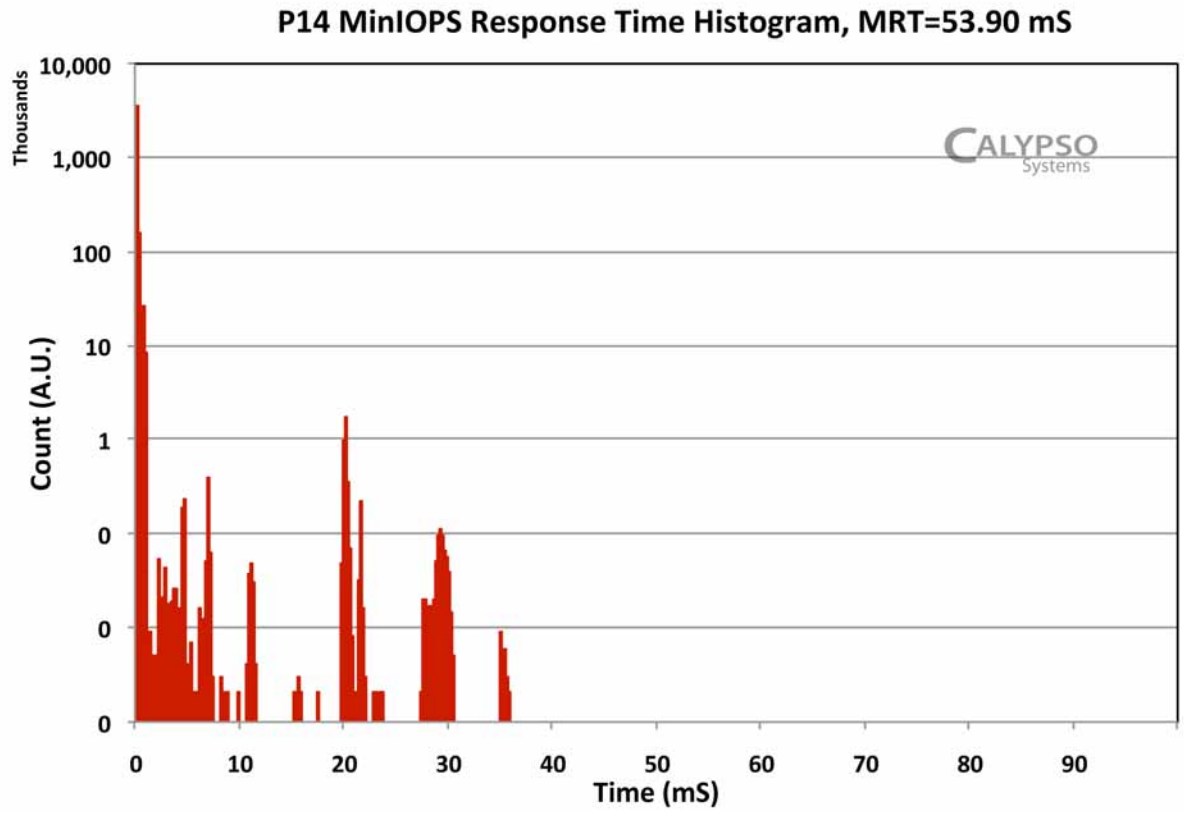
Demand Intensity Response Time Historam (REQUIRED) - Report Page

SNIA SSS TWG	Solid State Storage Performance Test Spec (PTS)	DIRTH - OLTP - RND 8KiB 65:35 RW	Rev.	PTS-E 1.1
			Page	14 of 14

Vendor:	ABC Co.	SSD Model:	ABC Co. Your Drive 100	TEST SPONSOR	CALYPSO Systems

Test Platform		Device Under Test		Set Up Parameters		Test Parameters	
Ref Test Platform	SNIA RTP 1.0	Mfgr	ABC Co.	Data Pattern	RND	Data Pattern	RND
Motherboard	Intel S2600 COE	Model No.	Your Drive 100	AR	100%	AR	100%
CPU	Intel E5 2690	S/N	123456	Pre Condtion 1	RND/8KiB	Test Stimulus 1	RND/8KiB
Memory	16G PC1600 DDR2	Firmware ver	ABCDEF	R/W %	0/100	R/W %	65/35 %
Operating System	CentOS 6.3	Capacity	100 GB	TOIO - TC/QD	TC 32/QD 32	TC / QD	TC/QD from 1-32
Test SW	CTS 6.5 1.13.8	Interface	SAS 6Gb/s	SS Rounds	2 - 6	TC & QD Loops	High to Low TOIO
Test SW Info	1.9.97-el6/R1.13.7	NAND Type	SLC	Pre Condtion 2	Inter Rnd Pre Write	Min IOPS Point	TC 1/QD 1
Test ID No.	R30-1298	PCIe NVM	N/A	R/W %	0/100	Mid IOPS Point	User Select
HBA	LSI 9212-4e4i	Purge Method	Format Unit	TOIO - TC/QD	TC 32/QD 32	Max IOPS Point	User Select
PCIe	Gen 3 x 16	Write Cache	WCD	Duration	30 M or 10% Cap.		

Min IOPS Histogram



Plot A.63 – DIRTH Min IOPS Histogram

Annex B (informative) Reference Test Platform Example

This annex describes the hardware/software Reference Test Platform (RTP) that was used by the SSS TWG to do the bulk of the research and validation of the SSS PTS.

The RTP is not required to run the SSS PTS tests; it is an example of a platform that was used to validate and run the PTS.

In addition to the RTP, other hardware/software platforms and software tools were used in the development and refinement of the PTS, such as Calypso CTS, IOmeter, Vdbench and in-house stimulus generators running on various versions of the Windows and Linux OS.

B.1 RTP Configurations

The RTP is designed to enable the testing of SSS devices. It can be configured for Standard test or extended for the testing of higher performance SSS products.

The table below shows the two currently defined configurations of the RTP. The validation of the PTS was performed using the RTP 2.0 configuration. The RTP 3.0 is recommended for use with enterprise class PCIe and SAS SSDs utilizing Gen 3 motherboards.

Table B.1 - RTP Configurations

Component	RTP 2.0	Notes	RTP 3.0	Notes
Chassis	Intel SC5650DP or similar	5u	Intel P4308XXMHJC	4u
Motherboard	Gen 2 Intel S5520HC	1	Gen 3 Intel S2600	COE or CP2
Processor	Intel 3.2GHz quad core W5580	1 or 2	Intel 3.1GHz 8 core E2687L or E2690W	1 or 2
Main Memory	1333MHz DDR3, ECC	12GB – 96GB	1600Mhz ECC DDR3	32GB to 64GB
Boot Drive(s)	500GB SATA 7200 RPM HDD	1	1.0 TB Dual SATA SSD	RAID1
SAS/SATA HBA	LSI 6Gb/s 9212-4i4e	1	12Gb/s TBD	
Operating System	Linux	CentOS 6.3	Linux	CentOS 6.3
Test Software	Calypso CTS	CTS 6.5	Calypso CTS	CTS 6.5

B.2 RTP Components

This section contains a more detailed description of the components used in the RTP.

Chassis:
The RTP 2.0 chassis is an Intel SC5650DP. The chassis has a limited effect on performance, so a similar chassis could be used, but it should have a 600W or larger power supply.

The RTP 3.0 uses an Intel P4308XXMHJC 4U. The chassis has more impact on the testing of higher performance PCIe and SAS devices due to the use of Gen 3 Motherboards and the increased power and heat dissipation associated with higher performance PCIe and SAS DUTs. The RTP 3.0 chassis has an increased internal airflow specification for higher power and heat.

Motherboard:
The RTP 2.0 motherboard is a Gen 2 Intel S5520HC. A similar motherboard can be used, and if so, must be disclosed. To support the testing of higher performance DUTs, it is recommended to populate two processor sockets for dual CPU usage.

The RTP 3.0 motherboard is a Gen 3 Intel S2600 COE / CP2 with dual CPU sockets. While a similar motherboard can be used, it is recommended to use this specific motherboard for comparative performance test as the motherboard can have significant impact on performance.

CPU:
The processor used in the RTP 2.0 is a quad core Intel S5520HC. The Standard configuration has one CPU, and while the higher performance configuration has two CPUs.

The processors used in the RTP 3.0 are eight core Intel E26876L or E2690W. The Standard configuration has one CPU, and while the higher performance configuration has two CPUs.

Memory:
The RTP 2.0 main memory utilizes 1333MHz DDR3 DIMMs with ECC. The Standard configuration has 12GB of RAM while the higher Performance configuration has 96GB of RAM.

The RTP 3.0 main memory utilizes 1600MHz DDR3 DIMMs with ECC. The Standard configuration has 32GB while and the higher Performance configuration has 64GB of RAM.

It is advisable to install the memory in multiples of three DIMMs, to optimize performance.

Boot Drive(s):
The Boot HDD used in the RTP 2.0 is a 500GB SATA 7200 RPM HDD with a SATA interface. It is not clear what impact the HDD has on performance testing, so it is recommended to use (and disclose) the highest performance SATA drive that is widely available.

The RTP 3.0 uses dual 1.0 TB SSDs in RAID1 with a SAS/SATA connection.

HBA:
The RTP 2.0 uses an LSI 9212-4i4e Host Bus Adaptor containing the IT firmware set. Other sufficiently high performance HBAs are available, but were not tested.

The RTP 3.0 described above will be used to qualify and select 12Gb/s SAS/SATA HBAs and future HBAs for SFF 8639 PCIe SSDs as they become available in the market.

DUT Power Supply:
The RTP hardware platform has a dedicated DUT power supply for all test SAS/SATA DUT bays separate from the main power supply. The DUT power supply shall provide adequate power to simultaneously run all test DUTs with a surplus of 25% of the rated peak voltage draw.

Operating System (OS):
Both RTP 2.0 and 3.0 utilize Linux Community Enterprise OS (CentOS) version 6.3. The OS kernel revision used shall be disclosed.

Test Software:
The test software used to validate the RTP / PTS 1.1 is CTS 6.5 made by Calypso Systems, Inc. (www.calypsotesters.com).

The Calypso test software requires CentOS 6.3 Linux OS.