SPC Benchmark 1™

Full Disclosure Report

Telecommunications Technology Association

Gluesys AnyStor-700EK

SPC-1™ v3.10.0

Submission Identifier: A32024

Submitted for Review: November 29, 2021
First Edition – November 2021

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Benchmark Specification and Glossary

The official SPC Benchmark 1™ (SPC-1™) specification is available on the website of the Storage Performance Council (SPC) at www.spcresults.org.

The SPC-1™ specification contains a glossary of the SPC-1™ terms used in this publication.
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AUDIT CERTIFICATION

Hyo-Sil Kim
Telecommunications Technology Association
47, Bundang-ro, Bundang-gu, Seongnam-city
Gyeonggi-do, 13591
Republic of Korea

November 24, 2021

I verified the SPC Benchmark 1™ (SPC-1™ v3.10.0) test execution and performance results of the following Tested Storage Product:

**Gluesys AnyStor-700EK**

The results were:

| SPC-1 IOPS™ | 310,022 |
| SPC-1 Price-Performance | $99.71/SPC-1 KIOPS™ |
| SPC-1 Total System Price | 30,910.00 |
| SPC-1 IOPS Response Time | 0.229 ms |
| SPC-1 Overall Response Time | 0.193 ms |
| SPC-1 ASU Capacity | 4,799 GB |
| SPC-1 ASU Price | $6.45/GB |

In my opinion, these performance results were produced in compliance with the SPC requirements for the benchmark.

The testing was executed using the SPC-1 Toolkit Version v3.0.2. The audit process was conducted in accordance with the SPC Policies and met the requirements for the benchmark.

A Letter of Good Faith was issued by Telecommunications Technology Association, stating the accuracy and completeness of the documentation and testing data provided in support of the audit of this result.
A Full Disclosure Report for this result was prepared by InfoSizing, reviewed and approved by Telecommunications Technology Association, and can be found at www.spcresults.org under the Submission Identifier A32024.

The independent audit process conducted by InfoSizing included the verifications of the following items:

- The physical capacity of the data repository (12,802 GB).
- The total capacity of the Application Storage Unit (4,799 GB).
- The accuracy of the Benchmark Configuration diagram.
- The tuning parameters used to configure the Benchmark Configuration.
- The Workload Generator commands used to execute the testing.
- The validity and integrity of the test result files.
- The compliance of the results from each performance test.
- The compliance of the results from each persistence test.
- The compliance of the submitted pricing model.
- The differences between the tested and the priced configuration, if any.

The Full Disclosure Report for this result was prepared in accordance with the disclosure requirements set forth in the specification for the benchmark.

The following benchmark requirements, if any, were waived in accordance with the SPC Policies:

None.

Respectfully Yours,

[Signature]

Doug Johnson, Certified SPC Auditor

63 Lourdes Dr. | Leominster, MA 01453 | 978-348-6582 | www.sizing.com
LETTER OF GOOD FAITH

47, Bundang-ro, Bundang-gu, Seongnam-city,
Gyeonggi-do, 13591, Republic of Korea
TEL: 82-31-724-0114

November 8, 2021

From: Telecommunications Technology Association

To: Mr. Doug Johnson, Certified SPC Auditor
   InfoSizing
   63 Lourdes Drive
   Leominster, MA 01453

Subject: SPC-1 Letter of Good Faith for GLUESYS AnyStor-700EK

Telecommunications Technology Association is the SPC-1 Test Sponsor for the above listed project. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V3.10 of the SPC-1 benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Signed: Cheol-Soon Park
Date: November 9, 2021

Cheol-Soon Park
Vice President,
Telecommunications Technology Association
Gluesys AnyStor-700EK

SPC-1 IOPS™: 310,022
SPC-1 IOPS Response Time: 0.229 ms
SPC-1 Overall Response Time: 0.193 ms

SPC-1 Price Performance: $99.71/SPC-1 KIOPS™
SPC-1 Total System Price: $30,910.00
SPC-1 Overall Discount: 46.94%

Currency / Target Country: USD / Korea
Availability Date: November 29, 2021

Storage Metrics:
- SPC-1 Data Protection Level: Protected 1
- SPC-1 Physical Storage Capacity: 12,802 GB
- SPC-1 ASU Capacity: 4,799 GB
- SPC-1 ASU Price: $6.45/GB

Extensions:
- SPC-1 Data Reduction: NA
- SPC-1 Encryption: NA
- SPC-1 NDU: NA
- SPC-1 Synchronous Replication: NA
- SPC-1 Snapshot: NA

Priced Storage Configuration Summary:
1. Mellanox 100 Gbps IB HCA (dual port)
2. Gluesys AnyStor-700EK Controller
64 GB Total Cache
2. Total Front-End Ports (100 Gbps IB)
8. 1.6 TB Intel 2.5” NVMe SSDs
2. Total RUs

Related graphs showing RAMPD Average Response Time (ms) vs. IOPS, SUSTAIN Response Time (ms), and RAMPD_100 Response Time (ms).
## Pricing Details

Discount Details: The discounts shown are based on the storage capacity purchased and are generally available.

Warranty: The 3-year maintenance and support included in the above pricing meets or exceeds a 24x7 coverage with a 4-hour response time.

### Differences Between Tested and Priced Storage Configurations

There were no differences between the TSC and the Priced Storage Configuration.

### Table

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
<th>Source</th>
<th>Qty</th>
<th>Unit Price</th>
<th>Ext. Price</th>
<th>Disc.</th>
<th>Disc. Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASE-4024</td>
<td>1x Ampere Altra CPU, up to 80 Arm v8.2+64-bit CPU cores at up to 3.30 GHz with Sustained Turbo 64GB Memory(Max. 2TB) NAS O/S(860GB M.2 NVMe Disk) 10/100/1000 Gigabit Ethernet 2Port (UTP) Hot-Swappable 24 NVMe Disk Bay AnyStor Enterprise O/S - Raid: 0, 1, 10, 5, 6 Support Supported Protocol - NFS, CIFS, FTP, iSCSI/iSER AnyManager - Web-Based NAS Management Tool - Cluster Management - Volume Management &amp; Monitoring - Auto / Manual recovery - Parallel &amp; distributed recovery - Data Replication Management - Online Scale-Out Support - POSIX FS API Support - Monitoring Tool on WEB (WMS) - Data Distributed I/O - Data Replication &amp; NetworkRAID</td>
<td>1</td>
<td>1</td>
<td>40,000.00</td>
<td>40,000.00</td>
<td>50%</td>
<td>20,000.00</td>
</tr>
<tr>
<td>HD-SD01600T</td>
<td>INTEL SSDPE2KE016TB</td>
<td>1</td>
<td>8</td>
<td>1,250.00</td>
<td>10,000.00</td>
<td>45%</td>
<td>5,500.00</td>
</tr>
<tr>
<td>NC-IB Cable</td>
<td>MCP1600-ED02 IB EDR Cable</td>
<td>1</td>
<td>2</td>
<td>180.00</td>
<td>360.00</td>
<td>0%</td>
<td>360.00</td>
</tr>
<tr>
<td>NC-IB0002 Card</td>
<td>MCX556A-ECAT ConnectX®-5 VPI adapter card, EDR IB (100Gb/s) and 100GbE, dual-port QSFP28, PCIe3.0 x16, tall bracket, ROHS R6</td>
<td>1</td>
<td>2</td>
<td>1,100.00</td>
<td>2,200.00</td>
<td>0%</td>
<td>2,200.00</td>
</tr>
<tr>
<td>SV-WTE724-3Y</td>
<td>Premium Package 3-Year Support &amp; Maintenance</td>
<td>1</td>
<td>1</td>
<td>5,700.00</td>
<td>5,700.00</td>
<td>50%</td>
<td>2,850.00</td>
</tr>
</tbody>
</table>

**Hardware & Software Subtotal**: 28,060.00

**Support & Maintenance**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
<th>Qty</th>
<th>Unit Price</th>
<th>Ext. Price</th>
<th>Disc.</th>
<th>Disc. Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV-WTE724-3Y</td>
<td>Premium Package 3-Year Support &amp; Maintenance</td>
<td>1</td>
<td>5,700.00</td>
<td>5,700.00</td>
<td>50%</td>
<td>2,850.00</td>
</tr>
</tbody>
</table>

**Support & Maintenance Subtotal**: 2,850.00

**SPC-1 Total System Price**: 30,910.00

**SPC-1 Price-Performance™ ($/SPC-1 KIOPS™)**: 99.71

**SPC-1 ASU Capacity (GB)**: 4,799

**SPC-1 ASU Price ($/GB)**: 6.45

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Full Disclosure Report: Gluesys AnyStor-700EK

SPC Benchmark 1™ v3.10.0 Telecommunications Technology Association

Submission ID: A32024

Submitted: November 29, 2021
**Publication Details**

This section provides contact information for the test sponsor and auditor, a revision history of this document, and a description of any exceptions or waivers associated with this publication.

**Contact Information**

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Sponsor</td>
<td>Telecommunications Technology Association</td>
<td><a href="http://tta.or.kr/eng/index.jsp">http://tta.or.kr/eng/index.jsp</a> <a href="mailto:hyosil.kim@tta.or.kr">hyosil.kim@tta.or.kr</a></td>
</tr>
<tr>
<td>Primary Contact</td>
<td>Hyo-Sil Kim</td>
<td></td>
</tr>
<tr>
<td>SPC Auditor</td>
<td>InfoSizing</td>
<td><a href="http://www.sizing.com">www.sizing.com</a> <a href="mailto:doug@sizing.com">doug@sizing.com</a></td>
</tr>
<tr>
<td></td>
<td>Doug Johnson</td>
<td></td>
</tr>
</tbody>
</table>

**Revision Information**

<table>
<thead>
<tr>
<th>Date</th>
<th>FDR Revision</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 29, 2021</td>
<td>First Edition</td>
<td>Initial Publication</td>
</tr>
</tbody>
</table>

**Anomalies, Exceptions, Waivers**

There were no anomalies, exceptions or waivers associated with the audit of the Gluesys AnyStor-700EK.
CONFIGURATION INFORMATION

Tested Storage Product Description

Gluesys AnyStor-700EK (AS700EK) is an all-flash storage system that is designed and optimized to deliver outstanding response speed and performance for a wide range of enterprise environments. Due to its flexibility, AS700EK has the storage gateway capability depending on the backbone infrastructure of the business, as well as the storage expansion and data tiering in heterogeneous storage devices. Furthermore, as the AS700EK block storage is derived from its previous scale-out NAS products, it supports NVMeoF protocol for InfiniBand and Ethernet, and also with iSCSI, iSER and file-based protocols.

Host System and Tested Storage Configuration Components

The following table lists the components of the Host System(s) and the TSC.

<table>
<thead>
<tr>
<th>Host Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x KTNF KRS580S1</td>
</tr>
<tr>
<td>2 x Intel® Xeon® Gold 6140 (2.30 GHz, 18-Core, 24 MB L3)</td>
</tr>
<tr>
<td>768 GB Main Memory</td>
</tr>
<tr>
<td>Red Hat Enterprise Linux 8.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tested Storage Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x Mellanox 100 Gbps IB HCA (dual port)</td>
</tr>
<tr>
<td>1 x Gluesys AnyStor-700EK with:</td>
</tr>
<tr>
<td>1 x Storage Controller</td>
</tr>
<tr>
<td>1 x Ampere™ Altra™ ARMv8 (2.80 GHz, 32MB)</td>
</tr>
<tr>
<td>64 GB cache</td>
</tr>
<tr>
<td>2 x 100 Gbps IB Front End Ports</td>
</tr>
<tr>
<td>8 x 1.6 TB Intel 2.5” NVMe SSD</td>
</tr>
</tbody>
</table>

Component Changes in Revised Full Disclosure Report

The following table outlines component changes that were made in revisions to this Full Disclosure Report.

<table>
<thead>
<tr>
<th>Original Component</th>
<th>Revised Component</th>
<th>Description of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>n/a</td>
<td>Initial submission</td>
</tr>
</tbody>
</table>
Configuration Diagrams

BC/TSC Configuration Diagram

The following diagram illustrates the Benchmark Configuration (BC), including the Tested Storage Configuration (TSC) and the Host System(s).

**Host System**

1 x KTNF KRS580S1 Server

100Gbps IB HCA (dual-port)

2 x 100Gbps Infiniband

**Gluesys AnyStor-700EK**

AnyStor-700EK, with:

1 x Controller, with:

1 x Ampere™ Altra™ ARMv8 (2.80GHz, 32MB)

64 GB main memory

1 x 100Gbps IB HCA (dual-port)

8 x 1.6TB Intel 2.5” NVMe SSD

**Tested Storage Configuration (TSC)**

Storage Network Configuration

The Tested Storage Configuration (TSC) consisted of a single storage subsystem (Gluesys AnyStor-700EK), driven by a single KTNF KRS580S1 host system. The host had two InfiniBand (IB) connections to the storage subsystem. The connections operated at 100 Gbps.
Benchmark Configuration Creation Process

Customer Tuning Parameters and Options

All the customer tuning parameters and options that have been altered from their default values for this benchmark are included in Appendix C and in the Supporting Files (see Appendix A).

Tested Storage Configuration Creation

A detailed description of how the logical representation of the TSC was created is included in Appendix D and in the Supporting Files (see Appendix A).

Tested Storage Configuration Inventory

An inventory of the components in the TSC, as seen by the Benchmark Configuration, is included in Appendix E and in the Supporting Files (see Appendix A).

Workload Generator Storage Configuration

The SPC-1 Workload Generator storage configuration commands and parameters used to invoke the execution of the tests are included in Appendix F and in the Supporting Files (see Appendix A).

Logical Volume Capacity and Application Storage Unit Mapping

The following table details the capacity of the Application Storage Units (ASUs) and how they are mapped to logical volumes (LVs). All capacities are reported in GB.

<table>
<thead>
<tr>
<th>LV per ASU</th>
<th>LV Capacity</th>
<th>Used per LV</th>
<th>Total per ASU</th>
<th>% ASU Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASU-1</td>
<td>9</td>
<td>239.9</td>
<td>239.9</td>
<td>2,159.6</td>
</tr>
<tr>
<td>ASU-2</td>
<td>9</td>
<td>239.9</td>
<td>239.9</td>
<td>2,159.6</td>
</tr>
<tr>
<td>ASU-3</td>
<td>2</td>
<td>239.9</td>
<td>239.9</td>
<td>479.9</td>
</tr>
</tbody>
</table>

**SPC-1 ASU Capacity**: 4,799

*See Space Optimization Techniques

Physical Storage Capacity and Utilization

The following table details the Physical Capacity of the storage devices and the Physical Capacity Utilization (percentage of Total Physical Capacity used) in support of hosting the ASUs. All capacities are reported in GB.

<table>
<thead>
<tr>
<th>Devices</th>
<th>Count</th>
<th>Physical Capacity</th>
<th>Total Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVMe</td>
<td>8</td>
<td>1,600.3</td>
<td>12,802.6</td>
</tr>
</tbody>
</table>

**Total Physical Capacity**: 12,802

**Physical Capacity Utilization**: 37.49%

Data Protection

The data protection level used for all LVs was Protected 1 (RAID 1+0).
Space Optimization Information

Description of Utilized Techniques

The TSC did not use any space optimization techniques.

Physical Free Space Metrics

The following table lists the Physical Free Space as measured at each of the required points during test execution. If space optimization techniques were not used, “NA” is reported.

<table>
<thead>
<tr>
<th>Physical Free Space Measurement</th>
<th>Free Space (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>After Logical Volume Creation</td>
<td>NA</td>
</tr>
<tr>
<td>After ASU Pre-Fill</td>
<td>NA</td>
</tr>
<tr>
<td>After Repeatability Test Phase</td>
<td>NA</td>
</tr>
</tbody>
</table>

Space Optimization Metrics

The following table lists the required space optimization metrics. If space optimization techniques were not used, “NA” is reported.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Space Optimization Ratio</td>
<td>NA</td>
</tr>
<tr>
<td>SPC-1 Space Effectiveness Ratio</td>
<td>NA</td>
</tr>
</tbody>
</table>
**BENCHMARK EXECUTION RESULTS**

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs.

**Benchmark Execution Overview**

**Workload Generator Input Parameters**

The SPC-1 Workload Generator commands and input parameters for the Test Phases are presented in the Supporting Files (see Appendix A).

**Measurement Intervals by Test Phase Graph**

The following graph presents the average IOPS and the average Response Times measured over the MI of each Test Phase.
**Response Time vs. Throughput Graph**

The following graph presents the average Response Times versus the average IOPS for RAMPD_100 to RAMPD_10.

![Graph showing average response time vs. IOPS](image)

**ASU Pre-Fill**

The following table provides a summary of the Pre-Fill performed on the ASU prior to testing.

<table>
<thead>
<tr>
<th>ASU Pre-Fill Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start Time</strong></td>
</tr>
<tr>
<td><strong>Requested IOP Level</strong></td>
</tr>
<tr>
<td><strong>End Time</strong></td>
</tr>
<tr>
<td><strong>Observed IOP Level</strong></td>
</tr>
<tr>
<td><strong>Duration</strong></td>
</tr>
</tbody>
</table>

For additional details see the Supporting Files.
SUSTAIN Test Phase

SUSTAIN – Results File

The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

SUSTAIN – Execution Times

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date &amp; Time</th>
<th>End Date &amp; Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Period</td>
<td>31-Oct-21 14:14:09</td>
<td>31-Oct-21 14:44:09</td>
<td>0:30:00</td>
</tr>
<tr>
<td>Measurement Interval</td>
<td>31-Oct-21 14:44:09</td>
<td>31-Oct-21 22:44:10</td>
<td>8:00:01</td>
</tr>
</tbody>
</table>

SUSTAIN – Throughput Graph

Throughput Graph (SUSTAIN @ 310,000 IOPS)

Request Throughput (IOPS) vs. Relative Run Time (minutes)
SUSTAIN – Response Time Graph

Response Time Graph (SUSTAIN @ 310,000 IOPS)

SUSTAIN – Data Rate Graph

Data Rate Graph (SUSTAIN @ 310,000 IOPS)
SUSTAIN – Response Time Frequency Graph

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O stream, its coefficient of variation (Variation), and the percentage of difference (Difference) between Defined and Measured.

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0011</td>
<td>0.0004</td>
<td>0.0008</td>
<td>0.0004</td>
<td>0.0017</td>
<td>0.0008</td>
<td>0.0012</td>
<td>0.0004</td>
</tr>
<tr>
<td>Difference</td>
<td>0.014%</td>
<td>0.002%</td>
<td>0.001%</td>
<td>0.002%</td>
<td>0.004%</td>
<td>0.001%</td>
<td>0.001%</td>
<td>0.002%</td>
</tr>
</tbody>
</table>
RAMPD_100 Test Phase

RAMPD_100 – Results File

The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

RAMPD_100 – Execution Times

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date &amp; Time</th>
<th>End Date &amp; Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Period</td>
<td>31-Oct-21 22:45:09</td>
<td>31-Oct-21 22:50:09</td>
<td>0:05:00</td>
</tr>
<tr>
<td>Measurement Interval</td>
<td>31-Oct-21 22:50:09</td>
<td>31-Oct-21 23:00:10</td>
<td>0:10:01</td>
</tr>
</tbody>
</table>

RAMPD_100 – Throughput Graph
RAMPD_100 – Response Time Graph

Response Time Graph (RampD_100 @ 310,000 IOPS)

RAMPD_100 – Data Rate Graph

Data Rate Graph (RampD_100 @ 310,000 IOPS)
RAMPD_100 – Response Time Frequency Graph

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O stream, its coefficient of variation (Variation), and the percentage of difference (Difference) between Defined and Measured.

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0009</td>
<td>0.0004</td>
<td>0.0008</td>
<td>0.0004</td>
<td>0.0021</td>
<td>0.0010</td>
<td>0.0009</td>
<td>0.0003</td>
</tr>
<tr>
<td>Difference</td>
<td>0.003%</td>
<td>0.013%</td>
<td>0.001%</td>
<td>0.010%</td>
<td>0.031%</td>
<td>0.046%</td>
<td>0.033%</td>
<td>0.012%</td>
</tr>
</tbody>
</table>

RAMPD_100 – I/O Request Summary

| I/O Requests Completed in the Measurement Interval | 186,015,688 |
| I/O Requests Completed with Response Time <= 30 ms | 186,015,688 |
| I/O Requests Completed with Response Time > 30 ms | 0 |
Response Time Ramp Test

Response Time Ramp Test – Results File

The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

Response Time Ramp Test – Phases

The Response Time Ramp Test is comprised of 11 Test Phases, including six Ramp-Down Phases (executed at 100%, 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit) and five Ramp-Up Phases (executed at 50%, 80%, 90%, 95%, and 100% of the Business Scaling Unit).

Response Time Ramp Test – Average Throughput Graph

![Average Throughput Graph (Response Time Ramp Test)](image)
Response Time Ramp Test – Average Response Time Graph

Response Time Ramp Test – RAMPD_10 Response Time Graph
Repeatability Test

Repeatability Test Results File

The results file generated during the execution of the Repeatability Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

Repeatability Test Results

The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the table below.

<table>
<thead>
<tr>
<th>Test Phase</th>
<th>100% IOPS</th>
<th>10% IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAMPD</td>
<td>310,022.3</td>
<td>31,009.2</td>
</tr>
<tr>
<td>REPEAT_1</td>
<td>310,021.0</td>
<td>31,012.0</td>
</tr>
<tr>
<td>REPEAT_2</td>
<td>310,011.4</td>
<td>31,002.1</td>
</tr>
</tbody>
</table>

REPEAT_1_100 – Throughput Graph

![Throughput Graph (Repeat_1_100 @ 310,000 IOPS)](image-url)
REPEAT_1_100 – Response Time Graph

REPEAT_2_100 – Throughput Graph
REPEAT_2_100 – Response Time Graph

Response Time Graph (Repeat_2_100 @ 310,000 IOPS)

Repeatability Test – Intensity Multiplier

The following tables list the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O stream, its coefficient of variation (Variation), and the percent of difference (Difference) between Defined and Measured.

REPEAT_1_100 Test Phase

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0010</td>
<td>0.0003</td>
<td>0.0005</td>
<td>0.0006</td>
<td>0.0021</td>
<td>0.0009</td>
<td>0.0014</td>
<td>0.0003</td>
</tr>
<tr>
<td>Difference</td>
<td>0.048%</td>
<td>0.005%</td>
<td>0.009%</td>
<td>0.014%</td>
<td>0.001%</td>
<td>0.006%</td>
<td>0.062%</td>
<td>0.004%</td>
</tr>
</tbody>
</table>

REPEAT_2_100 Test Phase

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0012</td>
<td>0.0002</td>
<td>0.0010</td>
<td>0.0002</td>
<td>0.0010</td>
<td>0.0005</td>
<td>0.0012</td>
<td>0.0003</td>
</tr>
<tr>
<td>Difference</td>
<td>0.012%</td>
<td>0.011%</td>
<td>0.007%</td>
<td>0.014%</td>
<td>0.032%</td>
<td>0.018%</td>
<td>0.073%</td>
<td>0.011%</td>
</tr>
</tbody>
</table>
Data Persistence Test

Data Persistence Test Results File
The results files generated during the execution of the Data Persistence Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_PERSIST_1_0_Raw_Results.xlsx
- SPC1_PERSIST_2_0_Raw_Results.xlsx

Data Persistence Test Execution
The Data Persistence Test was executed using the following sequence of steps:

- The PERSIST_1_0 Test Phase was executed to completion.
- The Benchmark Configuration was taken through an orderly shutdown process and powered off.
- The Benchmark Configuration was powered on and taken through an orderly startup process.
- The PERSIST_2_0 Test Phase was executed to completion.

Data Persistence Test Results

<table>
<thead>
<tr>
<th>Data Persistence Test Phase: Persist1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Logical Blocks Written</td>
<td>63,708,869</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Verified</td>
<td>33,584,616</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Overwritten</td>
<td>30,124,253</td>
</tr>
<tr>
<td>Total Number of Logical Blocks that Failed Verification</td>
<td>0</td>
</tr>
<tr>
<td>Time Duration for Writing Test Logical Blocks (sec.)</td>
<td>600</td>
</tr>
<tr>
<td>Size in bytes of each Logical Block</td>
<td>8,192</td>
</tr>
<tr>
<td>Number of Failed I/O Requests in the process of the Test</td>
<td>0</td>
</tr>
</tbody>
</table>

Committed Data Persistence Implementation
The persistence of committed data is implemented at the disk level. Data loss is prevented by using RAID1 arrays. At the controller level, the cache is set to write-through mode.
## APPENDIX A: SUPPORTING FILES

The following table details the content of the Supporting Files provided as part of this Full Disclosure Report.

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>/SPC1_RESULTS</td>
<td>Data reduction worksheets</td>
<td>root</td>
</tr>
<tr>
<td>SPC1_INIT_0_Raw_Results.xlsx</td>
<td>Raw results for INIT Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Quick_Look.xlsx</td>
<td>Quick Look Test Run Overview</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Raw_Results.xlsx</td>
<td>Raw results for Primary Metrics Test</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Summary_Results.xlsx</td>
<td>Primary Metrics Summary</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_1_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST1 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_2_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST2 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_Run_Set_Overview.xlsx</td>
<td>Run Set Overview Worksheet</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_0_Raw_Results.xlsx</td>
<td>Raw results for first VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_1_Raw_Results.xlsx</td>
<td>Raw results for second VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>set_host_kernel_parameters.sh</td>
<td>Set host tuning parameters</td>
<td>/C_Tuning</td>
</tr>
<tr>
<td>connect_nvme.sh</td>
<td>Storage configuration creation</td>
<td>root</td>
</tr>
<tr>
<td>mkraid.sh</td>
<td>Connects NVMe; creates LVs</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>nvme-binding.sh</td>
<td>Overprovision NVMe; create RAID volumes</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>get_tsc_config.sh</td>
<td>Creates NVMe/TCP targets</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>inventory_start.out</td>
<td>Configuration inventory</td>
<td>root</td>
</tr>
<tr>
<td>inventory_end.out</td>
<td>Collect configuration inventory</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>spc1_run.sh</td>
<td>Storage inventory before INIT</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>spc1_run_persist2.sh</td>
<td>Storage inventory restart</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>1host.HST</td>
<td>Workload generator</td>
<td>root</td>
</tr>
<tr>
<td>SPC1.asu</td>
<td>Host configuration file</td>
<td>/F_generator</td>
</tr>
<tr>
<td>spc1_run.sh</td>
<td>Define the LUNs hosting the ASUs</td>
<td>/F_generator</td>
</tr>
<tr>
<td>spc1_run_persist2.sh</td>
<td>Execute test phases up through PERSIST1</td>
<td>/F_generator</td>
</tr>
<tr>
<td>spc1_run_persist2.sh</td>
<td>Execute PERSIST2</td>
<td>/F_generator</td>
</tr>
</tbody>
</table>
APPENDIX B: THIRD PARTY QUOTATION

<table>
<thead>
<tr>
<th>모델</th>
<th>상세내역</th>
<th>수량</th>
<th>소비자단가</th>
<th>공급단가</th>
<th>공급금액</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS700EK</td>
<td>1x Ampere Altra CPU, up to 80 Arm v8.2+ 64-bit CPU cores at up to 3.30 GHz with Sustained Turbo 64GB Memory(Max. 2TB)</td>
<td>1</td>
<td>40,000.00</td>
<td>20,000.00</td>
<td>20,000.00</td>
</tr>
<tr>
<td></td>
<td>NAS (5160GB M.2 NVMe Disk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10/100/1000 Gigabit Ethernet 2Port (UTP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot-Swappable 24 NVMe Disk Bay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AnyStor Enterprise OS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Raid undergraduate: 0, 1, 5, 6 Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- NFS, CIFS, FTP, iSCSI/ISER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AnyManager</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 월 기반의 NAS 관리 툴기</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cluster Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Volume Management &amp; Monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Auto/Manual recovery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Parallel &amp; distributed recovery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Data Replication Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Online Scale-Out Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- POSIX F5 API Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Monitoring Tool on WEB (WMS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Data Distributed (ID)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Data Replication &amp; NetworkRAID</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Premium Package 3-Year Support &amp; Maintenance</td>
<td>1</td>
<td>5,700.00</td>
<td>2,850.00</td>
<td>2,850.00</td>
</tr>
<tr>
<td></td>
<td>DATA Disk</td>
<td>8</td>
<td>10,000.00</td>
<td>5,500.00</td>
<td>5,500.00</td>
</tr>
<tr>
<td></td>
<td>INTEL S3012EXD16TB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I/B Cable</td>
<td>2</td>
<td>180.00</td>
<td>360.00</td>
<td>360.00</td>
</tr>
<tr>
<td></td>
<td>MCP1600-0002 I/B EDR Cable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCK555A-ECAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ConnectX® 5 VPI adapter card, EDR IB (1000Gb/s) and 1000Gb, dual-port QSF</td>
<td>2</td>
<td>1,100.00</td>
<td>2,200.00</td>
<td>2,200.00</td>
</tr>
<tr>
<td></td>
<td>P28, PCIe3.0 x16, tall bracket, ROHS R6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

금액:
- 공급가: 30,910.00
- 부가가치세: 30,910.00
- 총합계: 30,910.00

비고:
1. 무상유지보수 기간은 납품 설치 후 H/W 3년(48개월)입니다.
2. 결제조건 별도 협의.
3. 위 견적은 건에 한하여 적용 됩니다.
APPENDIX C: TUNING PARAMETERS AND OPTIONS

The script set_host_kernel_parameters.sh was used to configure the operating system parameters on the host system. This script is included below as well as in the Supporting Files (see Appendix A).

```bash
#!/bin/sh

# OS configuration setup (SPC-1 Users' Guide)
cat /proc/sys/fs/epoll/max_user_watches >> /proc/sys/fs/aio-max-nr
source ulimit -n 1000
source ulimit -s unlimited

echo 3 > /proc/sys/vm/drop_caches

# systemctl stop irqbalance
# systemctl disable irqbalance

# CPU Governor setup
for i in `seq 0 35`
do
    echo performance > /sys/devices/system/cpu/cpu$i/cpufreq/scaling_governor
done

# Queue setup
devs=$(ls /sys/block/nvme*n1/device/model | awk -F '/' '{print $4}')
for dev in $devs;
do
    # devices configuration setup
    echo 128 > /sys/block/$dev/queue.nr_requests #128 is the max size
    echo 'none' > /sys/block/$dev/queue/scheduler
    echo 2 > /sys/block/$dev/queue/nomerges
    echo 0 > /sys/block/$dev/queue/add_random
    echo 1 > /sys/block/$dev/queue/rq_affinity

cat /sys/block/$dev/queue.nr_requests
cat /sys/block/$dev/queue/scheduler
cat /sys/block/$dev/queue/nomerges
cat /sys/block/$dev/queue/add_random
cat /sys/block/$dev/queue/rq_affinity
done
```
## APPENDIX D: STORAGE CONFIGURATION CREATION

### Storage Configuration Creation

**Step 1 – Create RAID volumes**

The `mkraid.sh` script performs over-provisioning on each NVMe device and creates software RAID volumes (RAID 10).

```bash
#!/bin/sh

# NVMe NameSpace Overprovisioning Function
nvme_over_provision () {
    for num in $(seq 0 7)
    do
        echo OverProvision 30% /dev/nvme${num}n1
        nvme detach-ns /dev/nvme${num} -namespace-id=1 -controllers=0
        nvme delete-ns /dev/nvme${num} -namespace-id=1
        nvme create-ns /dev/nvme${num} -nsze 0x8bc00000 -ncap 0x8bc00000 -flbas 0 -dps 0 -nmic 0
        nvme attach-ns /dev/nvme${num} -namespace-id=1 -controllers=0
        nvme reset /dev/nvme${num}
    done
}

# Linux RAID 1 Create Function
mkraid () {
    yes | mdadm --create --verbose /dev/md0 --level=1 --raid-devices 2 /dev/nvme0n1 /dev/nvme1n1
    yes | mdadm --create --verbose /dev/md1 --level=1 --raid-devices 2 /dev/nvme2n1 /dev/nvme3n1
    yes | mdadm --create --verbose /dev/md2 --level=1 --raid-devices 2 /dev/nvme4n1 /dev/nvme5n1
    yes | mdadm --create --verbose /dev/md3 --level=1 --raid-devices 2 /dev/nvme6n1 /dev/nvme7n1
}

# Main Start
nvme_over_provision
mkraid
```
### Step 2 – Set-Up NVMeoF/TCP Target on the Storage Subsystem

The `nvme-binding.sh` script creates NVMe/TCP targets (using nvmet kernel driver).

```bash
#!/bin/bash

# Load nvmet kernel driver Function
load_nvmet () {
    modprobe nvme
    modprobe nvme-tcp
    modprobe nvmet
}

# Bind nvmet target Function
bind_md_nvmet () {
    mkdir -p /sys/kernel/config/nvmet/ports/1
    echo "ipv4" > /sys/kernel/config/nvmet/ports/1/addr_adrfam
    echo "tcp" > /sys/kernel/config/nvmet/ports/1/addr_trtype
    echo 12.12.12.11 > /sys/kernel/config/nvmet/ports/1/addr_traddr
    echo 4220 > /sys/kernel/config/nvmet/ports/1/addr_trsvcid

    for vol in `seq 124 127`
    do
        echo add /dev/md${vol} to nvmetcp
        mkdir -p /sys/kernel/config/nvmet/subsystems/spc-${vol}
        echo 1 > /sys/kernel/config/nvmet/subsystems/spc-${vol}/attr_allow_any_host
        mkdir -p /sys/kernel/config/nvmet/subsystems/spc-${vol}/namespaces/1
        echo -n /dev/md${vol} > /
        /sys/kernel/config/nvmet/subsystems/spc-${vol}/namespaces/1/device_path
        echo 1 >
        /sys/kernel/config/nvmet/subsystems/spc-${vol}/namespaces/1/enable
        ln -s /sys/kernel/config/nvmet/subsystems/spc-${vol} /sys/kernel/config/nvmet/subsystems/spc-${vol}/namespaces/1
    done
}

# Main Start
load_nvmet
bind_md_nvmet
```
Step 3 — Connect to NVMe/TCP Target on the Host system.

The `connect_nvme.sh` script on the host system discovers and connects NVMe/TCP targets, and create 20 Logical Volumes for ASUs.

```bash
#!/bin/sh

# nvme discover & connect & volume info update
nvme_connect () {
    for subnqn in `nvme discover -t tcp -a 12.12.12.11 -s 4220 | \
                    grep subnqn | cut -d";" -f2 | cut -d "-" -f2 | sort -h`
    do
        nvme connect -t tcp -n spc-${subnqn} -a 12.12.12.11 -s 4220
        sleep 1 && nvme list
        vgscan && vgchange -ay
    done
}

# Test Volume Create Function
make_vol () {
    pvcreate /dev/nvme0n1 /dev/nvme1n1 /dev/nvme2n1 /dev/nvme3n1
    vgcreate LD /dev/nvme0n1 /dev/nvme1n1 /dev/nvme2n1 /dev/nvme3n1
    for vol in `seq 0 19`
    do
        lvcreate -l57212 -i4 -I512 -nvol$vol LD
    done
}

# Main Start
nvme_connect
#make_vol
```
APPENDIX E: CONFIGURATION INVENTORY

The script get_tsc_config.sh was used to collect an inventory of the TSC during the execution of spc1_run.sh and spc1_runPersist2.sh. The following log files were generated:

- inventory_start.out
- inventory_end.out

These files are included in the Support Files (see Appendix A).
APPENDIX F: WORKLOAD GENERATOR

The ASUs accessed by the SPC-1 workload generator are defined in SPC1.asu. The test phases up through PERSIST1 are executed by spc1_run.sh. PERSIST2 is executed by spc1_run_persist2.sh.

These files are included in the Support Files (see Appendix A).