

rmNVMe-IP for Gen4 Demo Instruction

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| 1 | Overview | 2 |
|---|--------------------------------|------|
| 2 | Test Menu | 3 |
| | 2.1 Identify Command | 3 |
| | 2.2 Write/Read Command | 4 |
| | 2.2.1 Write command | 4 |
| | 2.2.2 Read Command | 8 |
| | 2.2.3 Mixed Write/Read Command | . 10 |
| | 2.3 SMART Command | . 12 |
| | 2.4 Flush Command | . 13 |
| | 2.5 Shutdown Command | . 13 |
| 3 | Revision History | . 14 |
| | • | |



1 Overview

This guide provides instructions on how to use the rmNVMe-IP for Gen4 demo on an FPGA development board to access an NVMe Gen4 SSD. The demo supports performing Identify, Write, Read, SMART, Flush, and Shutdown commands. It allows the user to control test operation through FPGA console.

To get started, follow the instructions in the "dg_nvmeip_fpgasetup" document to set up the FPGA board and the test system. Once setup is complete, the rmNVMeIP for Gen4 menu will be displayed and the user can select the desired test operation through the FPGA console.

| IP Name +++ rmNUMeIP for Gen4 Test Waiting PCIe Linkup Waiting IP initialization PCIe Gen4 x4 Device Detect | IP Information design [IPUer = 1.1] +++ PCle speed and number of lanes |
|--|---|
| rmNUMeIP for Gen4 menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command | Main menu |
| Figure 1-1 rmNVM | e-IP for Gen4 menu |

As shown in Figure 1-1, the welcome screen shows IP name and IP version number. After that, The PCIe speed, the number of PCIe lanes, and the test menu are displayed on the console.



2 Test Menu

2.1 Identify Command

Select '0' to send Identify command to NVMe SSD.



After finishing the operation, the SSD information output from Identify command is displayed. The console shows two values.

1) SSD model number: This value is decoded from Identify controller data.

2) SSD capacity: This value is signal output from rmNVMe-IP.

| +++ Identify Command select | ted +++ | 1 | | |
|--|---------------------------------|-----------|--|--|
| User#0 Error Detect ErrorType = 0x0000040 ErrorType = 0x0000040 | | | | |
| ErrorType[6]: LBA does not PCIe Status = 0x0F2D User#0 TestPin[47:0] = 0x00 User#1 TestPin[15:0] = 0x00 | support 100_0000_001F 100 | | | |
| Figure 2-2 Error when LE | 3A unit does no | t support | | |

When the SSD operates in LBA unit which is not equal to 512 bytes, the error message is displayed on the console, as shown in Figure 2-2. After that, the system enters to the inactive status and user needs to reset the system to restart the demo.



2.2 Write/Read Command

Select '1' to send Write and Read command request to rmNVMe-IP via Write interface and Read interface, respectively. The parameters of Write command and Read command can be configured individually. Additionally, there is the feature to limit the maximum data rate for Write/Read command, expressed as a percentage. This allows the user to evaluate the performance balance and relationship between the Write and Read commands of each SSD. Furthermore, the menu also provides the option to disable either the Write or Read, enabling the user to test the peak performance of the system when running only the Write or Read command.

2.2.1 Write command

This topic shows an example when operating only Write command.

| Sequential Write | Random Write st User input |
|---|---|
| +++ Write/Read Command selected +++ Write command parameters | +++ Write/Read Command selected +++ |
| <pre>### Set Write command parameters ### 1 Send Write Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 0 Enter Start Address (512 Byte> : $0 \times 0 - 0 \times 5D26CEA8 => 0$ Enter Length (512 Byte> : $0 \times 0 - 0 \times 5D26CEB0 => 0 \times 4000000 (5)$ Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 6 Taximum speed = 8800 MB/s</pre> | ### Set Write command parameters ### Send Write Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 1 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s |
| ### Set Read command parameters ### Send Read Command [1]Yes [0]No =>[0] | ### Set Read command parameters ### Send Read Command [1]Yes [0]No => 0 |
| Write 6.371 [GB] 12.739 [GB] 19.113 [GB] 25.479 [GB] 31.849 [GB]Not send Read commandCurrent transfer size of Write command | Write 5.928 [GB] 11.847 [GB] 17.776 [GB] 23.701 [GB] 29.631 [GB] |
| drite result Total = 34.359 [GB] , Time = 5394[ms] Transfer speed = 6369 [MB/s], 1555K [IOPS] | Mrite result Iotal = 34.359 [GB] , Time = 5798[ms] Iransfer speed = 5925 [MB/s], 1446K [IOPS] |
| rmNUMeIP for Gen4 menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command | rmNUMeIP for Gen4 menu [0] : Identify Command [1] : Write/Read Command [2] : SMARI Command [3] : Flush Command [4] : Shutdown Command |

Figure 2-3 Test result of Write command using two Address modes

There are six input parameters for the Write menu, described as follows.

- 1) Send Write Command: Yes or No. If 'No' is selected, the write operation is disabled.
- 2) Address Mode: Sequential or Random mode. The initial address is assigned by Start Address input while the next addresses are calculated based on the selected mode. In sequential mode, the addresses are increased in a continuous sequence. In Random mode, addresses are generated using LFSR equation.
- 3) Start Address: Input start address to write SSD as 512-byte unit. The input is decimal unit when user enters only digit number. User can add "0x" to be prefix for hexadecimal unit. This input must be aligned to 8 for 4-Kbyte alignment.
- 4) Transfer Length: Input total transfer size as 512-byte unit. The input is decimal unit when user enters only digit number. User can add "0x" to be prefix for hexadecimal unit. This input must be aligned to 8 for 4-Kbyte alignment.



- 5) Test pattern: Select test data pattern for writing to SSD. There are five patterns, i.e., 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.
- Maximum Speed: Setting maximum speed in percentage unit of 8,800 MB/s. Valid from 1 to 100.

<u>Note</u>: 8,800 MB/s is calculated by user clock frequency (275 MHz) x data width (256-bit). This resulting value exceeds the maximum throughput of 4-lane PCIe Gen4 speed.

When all inputs are valid, the operation starts. During the operation, the current amount of write data is displayed on the console every second to indicate that the system is functioning. Finally, total size, total time usage, test speed, and IOPS of the Write command are displayed on the console after the operation is done.

Figure 2-3 shows the results of the Write command when executing sequential and random access. The write performance of the sequential access, at 6369 MB/s, is slightly higher than that of the random access, at 5925 MB/s. However, the performance of random access in most SSDs is typically much less than that of the sequential access. The user can investigate each SSD characteristics by using this menu.

| Large-size Write by 1 TB Samsung 990 Pro SSD | Large-size Write by 800GB Intel P5800X SSD | | |
|---|---|--|--|
| +++ Write/Read Command selected +++ | +++ Write/Read Command selected +++ | | |
| <pre>### Set Write command parameters ### Send Write Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 0 Enter Start Address (512 Byte) : 0x0 - 0x74706DB8 => 0 Enter Length (512 Byte) : 0x8 - 0x74706DB0 => 0x10000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s</pre> | ### Set Write command parameters ### Send Write Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 0 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB0 => 0x10000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s | | |
| ### Set Read command parameters ### Send Read Command [1]Yes [0]No => 0 | ### Set Read command parameters ### Send Read Command [1]Yes [0]No => 0 | | |
| Write 6.861 [GB] 13.732 [GB] 20.636 [GB] -6880 MB/s per user | Write 6.381 [GB] 12.749 [GB] 19.120 [GB] 25.488 [GB] | | |
| 123.138 [GB] 124.790 [GB] 126.190 [GB] Speed dropped | Steady speed (~6370 MB/s) | | |
| 134.560 [GB] 135.960 [GB] 137.354 [GB] | 121.061 [GB] 127.430 [GB] 133.799 [GB] Write result Total = 137.438 [GB]. Time = 21571[ms] | | |
| Write result Total = 137.438 [<u>GB] . Time = 28062[ms]</u> Transfer speed = <mark>4897 [MB/s], 1195K [IOPS]</mark> | Iransfer speed = 6371 [MB/s], 1555K [IOPS] Steady average speed | | |
| Average speed dropped | | | |

Figure 2-4 Write performance when using large transfer size

Most SSDs incorporate a cache to showcase impressive Write command performance. However, when transferring large amount of data that fill up the cache, performance tends to decrease. In Figure 2-4, the Write performance results of two different SSDs are illustrated. The SSD on the left initially exhibits higher performance, reaching 6880 MB/s per user. However, as data is continuously written to the SSD, the performance drops to 1400 MB/s. On the other hand, the right-side SSD starts with slightly lower performance but maintains a stable transfer rate of 6370 MB/s throughout the test. It is recommended for users to verify the SSD characteristics to ensure they align with the system requirements.

<u>Note</u>: Some SSDs may show slower write performance after large size data is written. To address this issue, running commands such as Write zero, Format, or Sanitized may help recover performance. Please contact our sales team for this customized feature.



| Test data of 32-bit increment pattern | | Test data of 32-bit | LFSR pattern | | |
|---|---------------------------------|---|----------------------------|--|--|
| ←64-bit header of each 4Kbyte→ | | ←64-bit header of each 4Kbyte→ | | | |
| 48-bit address (512 byte unit) 0x0000 | Test data (32-bit increment) | 64-bit header (Same value for every pattern) | Test data (32-bit LFSR) | | |
| 0ffeet 0 1 2 3 4 5 6 7 | 8 9 A B C D F F | 0 1 2 3 4 5 6 7 | | | |
| | | | 1 00 FE FF FF FF 01 00 | | |
| 000000010 04 00 00 00 05 00 00 00 | 06 00 00 00 07 00 00 00 | 02 00 FC FF FF FF 03 00 0 | 4 00 F8 FF FF FF 07 00 | | |
| 000000020 08 00 00 00 09 00 00 00 | OA 00 00 00 OB 00 00 00 | 09 00 F0 FF FF FF 0F 00 1 | 2 00 E0 FF FF FF 1F 00 | | |
| 000000030 OC 00 00 00 0D 00 00 00 | OE 00 00 00 OF 00 00 00 | 24 00 CO FF FF FF 3F 00 4 | 8 00 80 FF FE FF 7F 00 | | |
| 000000040 10 00 00 00 11 00 00 00 | 12 00 00 00 13 00 00 00 | 90 00 00 FF FD FF FF 00 2 | 0 01 00 FE FB FF FF 01 | | |
| 000000050 14 00 00 00 15 00 00 00 | 16 00 00 00 17 00 00 00 | 40 02 00 FC F6 FF FF 03 8 | 0 04 00 F8 ED FF FF 07 | | |
| 000000060 18 00 00 00 19 00 00 00 | 1A 00 00 00 1B 00 00 00 | 00 09 00 F0 DB FF FF OF 0 | 0 12 00 E0 B6 FF FF 1F | | |
| 0000000070 1C 00 00 00 1D 00 00 00 | 1E 00 00 00 1F 00 00 00 | 00 24 00 C0 6D FF FF 3F 0 | 0 48 00 80 DB FE FF 7F | | |
| 000000080 20 00 00 00 21 00 00 00 | 22 00 00 00 23 00 00 00 | 00 90 00 00 B6 FD FF FF 0 | 1 20 01 00 6C FB FF FF | | |
| 000000090 24 00 00 00 25 00 00 00 | 26 00 00 00 27 00 00 00 | 02 40 02 00 D9 F6 FF FF 0 | 04 80 04 00 B2 ED FF FF | | |
| 0000000A0 28 00 00 00 29 00 00 00 | 2A 00 00 00 2B 00 00 00 | 09 00 09 00 64 DB FF FF 1 | 2 00 12 00 C9 B6 FF FF | | |
| 0x0000 – 0x0FFF : The 1 st 4Kbyte data | | | | | |
| | | | | | |
| | | | | | |
| | F2 02 00 00 F2 02 00 00 | NO 03 E7 E7 04 01 CO CE 4 | 7 15 FF FF 00 33 GF 0F | | |
| 0000000FC0 F0 03 00 00 F1 03 00 00 | | AS UA F/ F/ U4 91 62 CF 4 | F 55 00 0F 27 00 14 70 | | |
| 0000000FF0 F8 03 00 00 F9 03 00 00 | F& 03 00 00 F7 03 00 00 | 30 AA 70 7F 4F 10 29 F6 7 | 28 54 F1 FF 9F 20 52 FC | | |
| 000000FE0 FC 03 00 00 FD 03 00 00 | FF 03 00 00 FF 03 00 00 | F1 A8 C2 FD 3F 41 A4 D8 F | 3 51 85 FB 7C 82 48 B1 | | |
| | | | 1 00 FE FF EF FF 01 00 | | |
| 000001010 04 04 00 00 05 04 00 00 | 06 04 00 00 07 04 00 00 | 22 00 FC FF DF FF 03 00 4 | 4 00 F8 FF BF FF 07 00 | | |
| 0000001020 08 04 00 00 09 04 00 00 | OA 04 00 00 OB 04 00 00 | 89 00 F0 FF 7F FF 0F 00 1 | 2 01 E0 FF FF FE 1F 00 | | |
| 0000001030 OC 04 00 00000 04 00 00 | OE 04 00 00 OF 04 00 00 | 24 02 CO FF FF FD 3F 00 4 | 8 04 80 FF FE FB 7F 00 | | |
| 64-bit header | | | | | |
| 0x1000 – 0x1FFF : The 2 nd 4Kbyte data | | I | | | |
| Figure 2-5 Example Test data of the 1 st and 2 nd 4Kbyte data by using incremental/LFSR pattern | | | | | |

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Test data in SSD is split into 4096-byte (4K-byte) units. For incremental, decremental, and LFSR patterns, each 4K-byte data has a unique 64-bit header that consists of a 48-bit address in 512-byte units and a 16-bit zero value. The data following the 64-bit header is the test pattern selected by the user.

The left window of Figure 2-5 shows an example of the 32-bit incremental pattern, while the right window displays an example of the 32-bit LFSR pattern. When running all-0 or all-1 patterns, the unique header is not included.



Figure 2-6 shows an example of the inputs that are out of the recommended range for each parameter. The console displays "Invalid input" and then the operation is cancelled.





2.2.2 Read Command

This topic shows an example when operating only Read command.



Figure 2-7 Test result of Read command by using two Address modes

The Read command operation requires six or seven parameters, described as follows.

- 1) Send Read Command: Yes or No. If 'No' is selected, the read operation is disabled.
- 2) Address Mode: Sequential or Random mode. The initial address is assigned by Start Address input while the next addresses are calculated based on the selected mode. In sequential mode, the addresses are increased in a continuous sequence. In Random mode, addresses are generated using LFSR equation. Both modes generate the same test data for each memory address, but the order of addresses is different. If the user does not write data to the SSD by full-disk size, the unwritten space will be different for each mode. To verify the written data inside the SSD in such cases, the address mode used in Both the Write menu and Read menu must be the same.
- 3) Enable Verification: Enable or disable data verification for the received data.
- 4) Start Address: Input the start address to read SSD as 512-byte unit. The input is decimal unit when user enters only digit number. User can add "0x" to be prefix for hexadecimal unit. This input must be aligned to 8 for 4-Kbyte alignment.
- 5) Transfer Length: Input total transfer size as 512-byte unit. The input is decimal unit when user enters only digit number. User can add "0x" to be prefix for hexadecimal unit. This input must be aligned to 8 for 4-Kbyte alignment.
- 6) Test pattern (Available when Verification is enabled): Select the test data pattern to verify the received data from the SSD. There are five patterns: 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.
- 7) Maximum Speed: Setting maximum speed in percentage unit of 8,800 MB/s. Valid from 1 to 100.

Note: 8,800 MB/s is calculated by user clock frequency (275 MHz) x data width (256-bit).



When all inputs are valid, the operation starts. During the operation, the current amount of received data is displayed on the console every second to indicate that the system is functioning. In the event of invalid input of failed data verification, an error message will be displayed instead. Once the operation is complete, the console will present the total size, total time usage, test speed, and IOPS of the Read command.

Figure 2-8 shows an example of error message when data verification fails. The message "Verify fail" is displayed with the information of the 1st failure data including the error byte address, the expected value, and the read value.

User can simply press any key(s) to cancel read operation. However, if no cancellation command is initiated, the operation will continue until the Read command is finished. After completion, the console presents the output performance.

If the operation is cancelled, the Read command will still run as a background process and may not finish in a good sequence. In such cases, it is recommended to power off and then power on both the FPGA board and the adapter board (if connected) to ensure proper functionality.

| | Verification error without cancella | tion | | Verification error w | ith cancellation | |
|---|---|--|---|---|---|---------------------|
| +++ Write/Read Command selected +++ | | | +++ Write/Read Command selected +++ | | | |
| ### Set Write Send Write Com | command parameters ### mand [1]Yes [0]No => 0 | | ### Set Write command parameters ### Send Write Command [1]Yes [0]No => 0 | | | |
| <pre>### Set Read command parameters ### Set Read Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 0 Enable verification (0]Diable [1]Enable => 1 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEB8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB8 => 0 Enter Maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum spei Message when data verification is failed Verify fail in User#0 Expect Data[255:128] = 0x00000007_00000006_00000000000000000 Expect Data[127: 0] = 0x0000007_00000006_000000000000000000000</pre> | | <pre>### Set Read command parameters ### Send Read Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 0 Enable verification [0]Diable [1]Enable => 1 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 0 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s Verify fail in User#0 Ist Error at Byte Addr = 0x00000000 Expect Data[255:128] = 0x00000007_00000006_00000000_00000000 Read Data[255:128] = 0x0007FFF_FFF80004_0003FFFF_FFFC0002 Read Data[127: 0] = 0x0001FFFF_FFF80004_0003FFFF_FFFC0002 Read Data[127: 0] = 0x0001FFFF_FFFE0001_0000000_00000000000000</pre> | | 8 3×4000000 (41LFSR => 0 (00 => 100 _00000004 _00000000 _FFFC0002 _00000000 | | |
| Read 6.398 [GB] 12.795 [GB] 19.193 [GB] 19.193 [GB] 25.591 [GB] 31.989 [GB] 31.989 [GB] Read result [otal = 34.3] Iransfer speed | Current transfer size of Read command Output Rea (59 [GB] , Time = 5370[ms] = 6397 [MB/s], 1562K [IOPS] | ld performance | Read 6.398 [GB] 12.796 [GB] Operation is car Please reset sys rmNUMeIP for [0] : Identify ([1] : Write/Read [2] : SMART Comm [3] : Flush Comm [4] : Shutdown (| ncelled stem before starting a r Gen4 me Message w Command d Command nand nand Command | User enters son to cancel the op a new test hen operation is | ne keys leration |

Figure 2-8 Data verification is failed



2.2.3 Mixed Write/Read Command

This section shows an example of operating both Write and Read commands.

| Sequential | Random + : User input | t |
|--|--|----|
| +++ Write/Read Command selected +++ Write command parameters | +++ Write/Read Command selected +++ + User outp | ut |
| <pre>### Set Write command parameters ### Send Write Command [1]Yes [0]No => 1 Select Address Mode [D]Sequential [1]Random => [0] Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEA0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s</pre> | ### Set Write command parameters ### Send Write Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 1 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s | ł |
| ### Set Read command parameters ### Read command parameters Send Read Command [1]Ves [0]No => 1 1 Select Address Mode [0]Diable [1]Enable => 1 1 Enable verification [0]Diable [1]Enable => 1 1 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0x10000000 Enter Length (512 Byte) : 0x8 - 0x4D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 | ### Set Read command parameters ### Send Read Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 1 Enable verification [0]Diahle [1]Enable => 1 Enter Start Address (512 Byte> : 0x0 - 0x5D26CEA8 => 0x10000000 Enter Length (512 Byte> : 0x8 - 0x5D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s | ł |
| Write Read 3.335 IGB1 3.337 IGB1 6.670 IGB1 6.670 IGB1 10.001 IGB1 10.001 IGB1 13.334 IGB1 13.334 IGB1 16.666 IGB1 16.666 IGB1 20.001 IGB1 20.001 IGB1 23.334 IGB1 20.334 IGB1 25.667 IGB1 26.667 IGB1 29.998 IGB1 29.997 IGB1 33.329 IGB1 33.328 IGB1 | Write Read 3.038 [GB] 3.040 [GB] 6.077 [GB] 6.076 [GB] 9.116 [GB] 9.115 [GB] 12.153 [GB] 12.152 [GB] 15.188 [GB] 15.187 [GB] 18.223 [GB] 15.187 [GB] 21.262 [GB] 24.301 [GB] 24.301 [GB] 24.301 [GB] 27.340 [GB] 27.340 [GB] 33.409 [GB] 33.408 [GB] | |
| Write result Total = 34.359 [GB], Time = 10309[ms] Transfer speed = 3332 [MB/s], 813K [I0PS] Read result Total = 34.359 [GB], Time = 10309[ms] Transfer speed = 3332 [MB/s], 813K [I0PS] Output Write/Read performance | Write result Total = 34.359 [GB] , Time = 11314[ms] Transfer speed = 3036 [MB/s], 741K [IOPS] Read result Total = 34.359 [GB] , Time = 11314[ms] Transfer speed = 3036 [MB/s], 741K [IOPS] | 1 |
| | Output Write/Read performance | |

Figure 2-9 Test result of mixed Write-Read command by using two Address modes

The inputs required for the Write command are described in topic 2.2.1, while the inputs for the Read command are described in topic 2.2.2. Note that the Write and Read commands utilize the same SSD resources, which means that increasing the maximum Write speed will result in reduced Read performance, and vice versa.

Figure 2-9 illustrates an SSD that achieves a well-balanced loading for both Write and Read commands. By setting the maximum speed of both Write and Read commands to 100, the resulting Write performance and the Read performance are equal after the operations are completed. In this scenario, the Sequential access performance reaches 3332 MB/s, which is higher than the Random access performance of 3036 MB/s.

Next, the limitations of the maximum speed for both Write command and Read command are demonstrated.



| | Write=100%, Read=20% | | | Write=20%, | , Read=100% | | User input |
|--|---|----------------|--|--|--|--|---|
| +++ Write/Read Comma | nd selected +++ | 1 | +++ Write/Read Co | mmand selecte | d +++ | ' [| • : User output |
| <pre>#### Set Write command parameters ### Send Write Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 1 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB0 => 0xA000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 100 Maximum speed = 8800 MB/s</pre> | | | ### Set Write com Send Write Comman Select Address Mo Enter Start Addre Enter Length (S12 Selected Pattern Enter maximum spe Maximum speed = 1 | mand paramete d [1]Yes [0]N de [0]Sequent ss (512 Byte) Byte) [0]Inc32 [1]D ed in percent 760 MB/s | rs ### lo => 1 ial [1]Random : 0x0 - 0x5D; : 0x8 - 0x5D; ec32 [2]A11_0 age of 8800 M] | => 1 26CEA8 26CEB0 [3]A1] B/s : 1 | => 0 => 0x4000000 L_1 [4]LFSR => 4 L_ 100 =>[20] |
| <pre>### Set Read command parameters ### Send Read Command [1]Yes [0]No => 1 Select Address Mode [0]Sequential [1]Random => 1 Enable verification [0]Diable [1]Enable => 1 Enter Start Address (512 Byte) : 0x0 - 0x5D26CEA8 => 0x41BA1AA0 Enter Length (512 Byte) : 0x8 - 0x5D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4 Enter maximum speed in percentage of 8800 MB/s : 1 - 100 => 20 Maximum speed = 1760 MB/s</pre> | | | ### Set Read comm Send Read Command Select Address Mo Enable verificati Enter Start Addre Enter Length (512 Selected Pattern Enter maximum spe Maximum speed = 8 | and parameter [1]Yes [0]No de [0]Sequent on [0]Diable ss (512 Byte) Byte) [0]Inc32 [1]D ed in percent 800 MB/s | s ### ial [1]Random [1]Enable => : : 0x0 - 0x5D : 0x8 - 0x5D ec32 [2]All_0 age of 8800 M | => 1 L 26CEA8 26CEB0 [3]A1] B/s : 1 | => 0x41BA1AA0 => 0x8000000 _1 [41]LFSR => 4 100 => 100 |
| Write Re 4.139 [GB] 1. 8.277 [GB] 3. 12.414 [GB] 5. | ad 749 [GB] 495 [GB] 243 [GB] | | Write 1.733 [GB] 3.466 [GB] 5.199 [GB] | Read 4.839 [GB] 9.669 [GB] 14.506 [GB] | | | |
| 70.333 [GB] 29. 74.468 [GB] 31. 78.598 [GB] 33. | 713 [GB] 461 [GB] 209 [GB] | | 29.460 [GB] 31.193 [GB] 32.926 [GB] | 82.150 [GB] 86.983 [GB] 91.816 [GB] | | | |
| Write result Total = 85.899 [GB Transfer speed = 420 Read result Total = 34.359 [GB Transfer speed = 174 |], Time = 20430[ms] 4 [MB/s], 1026K [IOPS]], Time = 19658[ms] 7 [MB/s], 426K [IOPS] | | Write result Total = 34.359 Transfer speed = Read result Total = 94.489 Transfer speed = | [GB] , Time = 1732 [MB/s], [GB] , Time = 4832 [MB/s], | 19827[ms] 423K [IOPS] 19552[ms] 1179K [IOPS] | | |
| L | Output Write/Rea | ad performance | | | Output Write | e/Read | performance |
| Figure 2-1 | Figure 2-10 Test result when mixed Write-Read command with limited maximum speed | | | | | | |

As shown in Figure 2-10, if the maximum speed is set to 20%, it will limit the speed to 20% of 8800 MB/s or 1760 MB/s. However, the actual performance achieved with the limited speed may be slightly lower than the set value. When using random access, the total performance, which includes both write and read operations, is approximately in the range of 6000 to 6500 MB/s.



2.3 SMART Command

To send a SMART command to the NVMe SSD, select option '2'. Once the operation is complete, the console will display the SMART/Health Information output, as shown in Figures 2-11. This information includes both the Health status and SMART log information.

| +++ SMART Command selected +++ | Data output decoded |
|---|---|
| << Health Status >> Remaining Life : 100% | from SMART command |
| < <pre><< SMART Log Information >> Percentage Used Iemperature Iotal Data Read Iotal Data Read (Raw data) Iotal Data Written Iotal Data Written Iotal Data Written (Raw data) Power On Cycles Power On Hours Unsafe Shutdowns</pre> | : 0% : 32 Degree Celsius : 18206 GB : 0x00000000_0000000_0000000_021E8FAD : 22410 GB : 0x00000000_0000000_00000000_029BD9F1 : 125 Times : 12 Hours : 17 Times |
| SMART Command Complete rmNUMeIP for Gen4 menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command | |

Figures 2-11 Test result when running SMART command

The Health status displays the remaining life of the SSD as a percentage, which is calculated from the Percentage Used value in the SMART log information. The SMART log information displays the following seven parameters.

- 1) Percentage used: The percentage of the SSD's lifespan that has been consumed.
- 2) Temperature: The temperature of the SSD in degree Celsius.
- 3) Total Data Read: The total amount of data that has been read from the SSD, displayed in GB/TB units. Additionally, the raw data without decoding is displayed as a 32-digit hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 4) Total Data Written: The total amount of data that has been written to the SSD, displayed in GB/TB units. Additionally, the raw data without decoding is displayed as a 32-digit hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 5) Power On Cycles: The number of times the SSD has been powered on.
- 6) Power On Hours: The total amount of time in hours that the SSD has been powered on.
- 7) Unsafe Shutdowns: The number of times the SSD has experienced an unsafe shutdown.



2.4 Flush Command

To initiate a Flush command on the NVMe SSD, select option '3' from the menu. The Flush command ensures that all modified data in the cache memory is written to Flash memory in the SSD.

| +++ Flush Command selected +++ | |
|--|------|
| Flush Command Complete | Ļ |
| rmNUMeIP for Gen4 ([0] : Identify Command | iing |
| [1] : Write/Read Command [2] : SMART Command [3] : Flush Command | |
| [4] : Shutdown Command | |
| Figure 2-12 Test result when running Flush comm | and |

Once the Flush operation is completed, the consoled will display the message "Flush Command Complete".

2.5 Shutdown Command

To send a Shutdown command to the NVMe SSD, select option '4'.

| | User input User output |
|--|---|
| rmNVMeIP for Gen4 menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command | |
| +++ Shutdown Command selected +++ Confirm | mation massage |
| Press 'y' to confirm : y Press 'y' to confirm : y Press 'y' to | confirm |
| Shutdown command is complete The device has turned off. <u>.</u> | |
| Last message be IP and SSD are in | fore the |
| Figure 2-13 Test result when running Shutde | own command |

A confirmation message will be displayed on the console, and the user will need to enter 'y' or 'Y' to proceed with the operation. Press any other key to cancel the operation.

Once the Shutdown operation is complete, "Shutdown command is complete" will be displayed as the final message. The console becomes inactive. To begin a new test operation, the user will need to power off and on the test system.



3 Revision History

| Revision | Date | Description |
|----------|-----------|--------------------------|
| 1.1 | 16-Jun-23 | Update write performance |
| 1.0 | 12-May-23 | Initial version release |