

Demo Instruction for muNVMe -IP

Rev1.0 14-Jun-22

1 Overview

This document describes the instruction to run muNVMe-IP demo on FPGA development board for two users accessing one NVMe SSD. The demo is designed to run Identify, Write/Read, SMART, Flush, and Shutdown command. User controls test operation via FPGA console.

After user finishes FPGA board setup following “dg_nvmeip_fpgasetup” document, main menu is displayed and the user sets the input to the console for selecting test operation.

```
+++ muNVMeIP Test design [IPVer = 1.0] +++
Waiting PCIe Linkup
Waiting IP initialization
PCIe Gen3 x4 Device Detect
--- muNVMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
```

Figure 1-1 muNVMe-IP main menu

On welcome screen, IP name and IP version number are displayed. The PCIe speed and number of PCIe lanes are displayed in the next message. Finally, the test menu is displayed on the console.

2 Test Menu

2.1 Identify Command

Select '0' to send Identify command to NVMe SSD via User#0 I/F.

```

+++ Identify Command selected +++
Model Number      : INTEL SSDPED1D280GA
SSD Capacity      = 280[GB]
Data size per LBA = 512[Byte]

--- muNUMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command

```

Model name, SSD Capacity, and LBA unit
(Output from Identify command)

Figure 2-1 Test result when running Identify command

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

- 1) SSD model number: This value is decoded from Identify controller data.
- 2) SSD capacity: This value is signal output from muNVMe-IP.
- 3) Data size per LBA: This value is signal output from muNVMe-IP. Two values are supported - 512 byte and 4 Kbyte.

2.2 Write/Read Command

Select '1' to send Write/Read command by using 1-2 users to NVMe SSD.

2.2.1 Write command

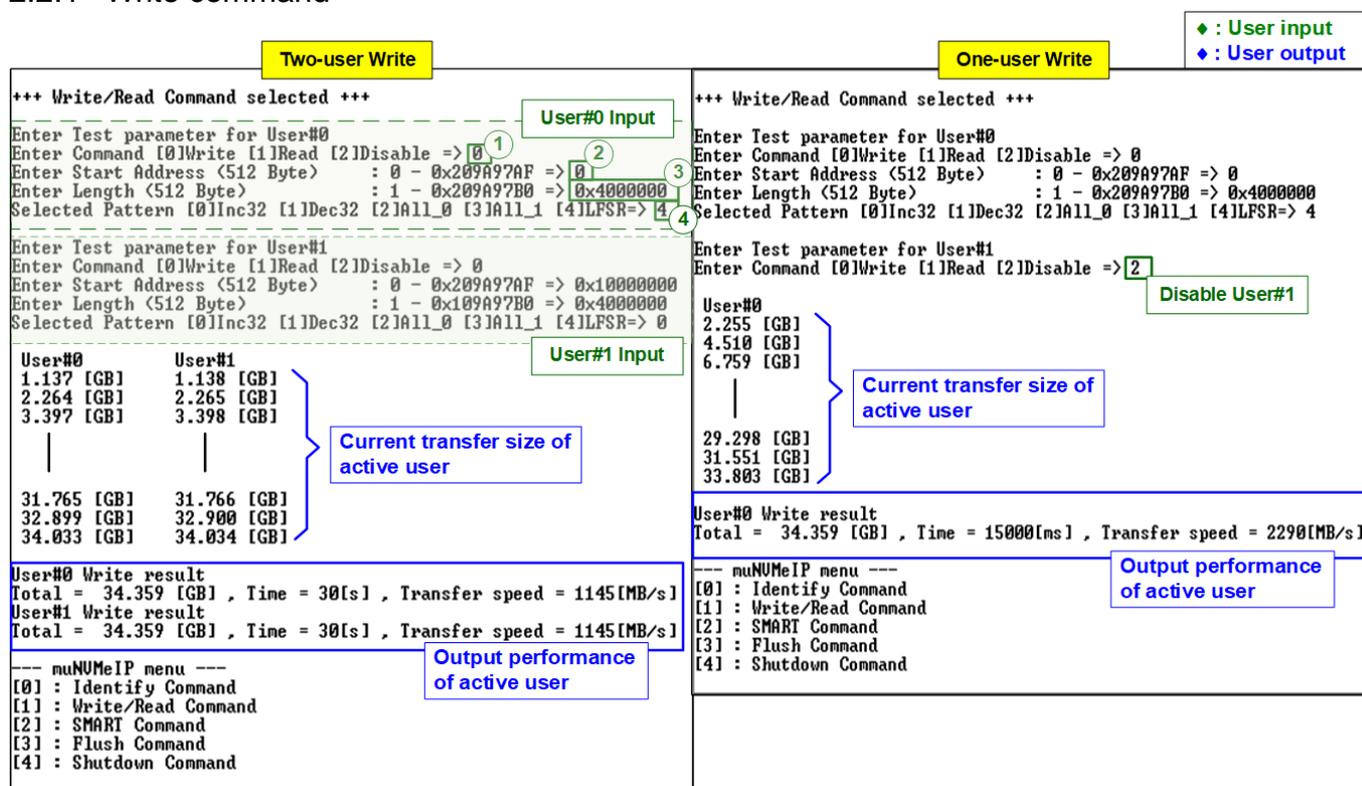


Figure 2-2 Write command by 1-2 users

Input four parameters per user as follows.

- 1) Command: Select command - Write, Read, or Disable (no operation).
- 2) 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. When LBA unit of SSD is 4 Kbyte, this input must be aligned to 8.
- 3) 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. When LBA unit of SSD is 4 Kbyte, this input must be aligned to 8.
- 4) 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.

When all inputs are valid, the operation begins. While the command is operating, current amount of write data in the active user is displayed on the console every second to show that system is still alive. Finally, total size, total time usage, and test speed of the active user are displayed on the console as test result.

As shown in Figure 2-2, total performance when running one-user and two-user are equal (1145+1145 MB/s and 2290 MB/s). The performance per user when running two-user test is equal to a half of the one-user performance.

Note: The performance of each user depends on SSD characteristic.

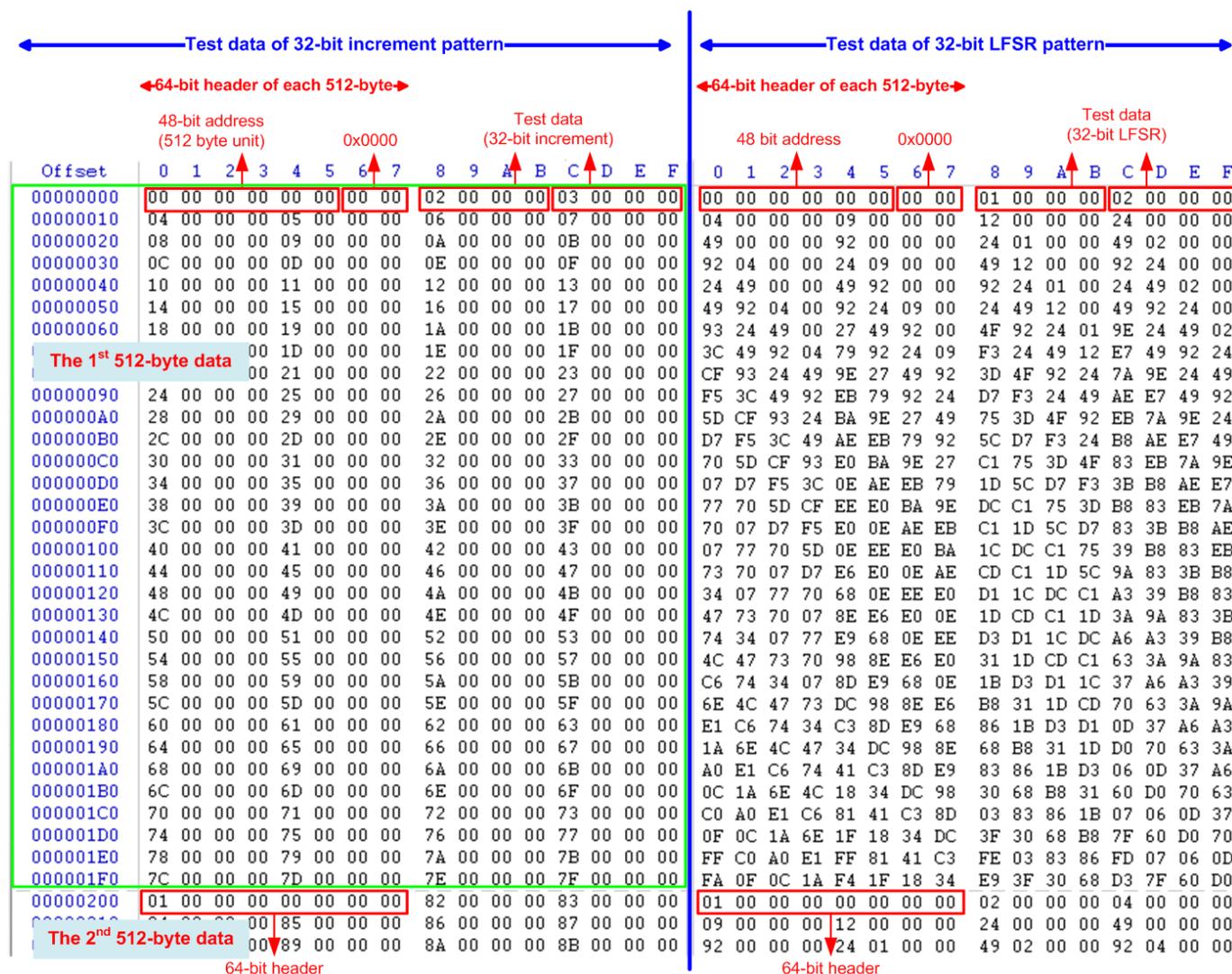


Figure 2-3 Example Test data of the 1st and 2nd 512-byte by using incremental/LFSR pattern

Test data in SSD is split into 512-byte unit. For incremental, decremental, and LFSR pattern, each 512-byte data has unique 64-bit header consisting of 48-bit address (in 512-byte unit) and 16-bit zero value. The data after 64-bit header is the test pattern which is selected by user.

The left window of Figure 2-3 shows the example when using 32-bit incremental pattern while the right window shows the example when using 32-bit LFSR pattern. The unique header is not included when running all-0 or all-1 pattern.

When user runs Write/Read command with 4-Kbyte LBA SSD, there is the message displayed on the console to show the input limitation which must be aligned to 8, as shown in Figure 2-4. When the input does not align to 8, “Invalid input” is displayed and the operation is cancelled.

```

Enter Test parameter for User#0
Please input [Start Address] and [Length] in unit of 8
Enter Command [0]Write [1]Read [2]Disable => 0
Enter Start Address <512 Byte> : 0 - 0x209A97AF => 0x8
Enter Length <512 Byte> : 1 - 0x209A97B0 => 0x7
Invalid input
-- muNUMeIP
[0] : Identif
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
    
```

LBA alignment error

Recommended message when LBA unit = 4 Kbyte

When LBA unit = 4 KB and length is not aligned to 8, error message is displayed.

Figure 2-4 Error message when the input is unaligned for SSD with 4KB LBA unit

Also, Figure 2-5 shows the example when the input is out of the recommended range for each parameter. The console displays “Invalid input” and then the operation is cancelled.

```

Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 3
Invalid input
Invalid command

Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 0
Enter Start Address <512 Byte> : 0 - 0x209A97AF => 0xFFFFFFFF
Invalid input
Out of range address

Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 0
Enter Start Address <512 Byte> : 0 - 0x209A97AF => 0
Enter Length <512 Byte> : 1 - 0x209A97B0 => 0xFFFFFFFF
Invalid input
Out of range length

Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 0
Enter Start Address <512 Byte> : 0 - 0x209A97AF => 0
Enter Length <512 Byte> : 1 - 0x209A97B0 => 0x400000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 5
Invalid input
Invalid pattern
    
```

Error input

Invalid command

Out of range address

Out of range length

Invalid pattern

Figure 2-5 Error message from the invalid input

2.2.2 Read Command

Two-user Read

One-user Read

◆ : User input
◆ : User output

```

+++ Write/Read Command selected +++
Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0
Enter Length (512 Byte) : 1 - 0x209A97B0 => 0x40000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4

Enter Test parameter for User#1
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0x10000000
Enter Length (512 Byte) : 1 - 0x109A97B0 => 0x40000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 0

User#0      User#1
1.374 [GB]  1.376 [GB]
2.743 [GB]  2.744 [GB]
4.115 [GB]  4.116 [GB]

31.548 [GB] 31.549 [GB]
32.920 [GB] 32.921 [GB]
34.290 [GB] 34.292 [GB]

User#0 Read result
Total = 34.359 [GB] , Time = 25000[ms] , Transfer speed = 1374[MB/s]
User#1 Read result
Total = 34.359 [GB] , Time = 25000[ms] , Transfer speed = 1374[MB/s]

--- muNUMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
        
```

```

+++ Write/Read Command selected +++
Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0
Enter Length (512 Byte) : 1 - 0x209A97B0 => 0x40000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4

Enter Test parameter for User#1
Enter Command [0]Write [1]Read [2]Disable => 2

User#0
2.747 [GB]
5.489 [GB]
8.234 [GB]

27.442 [GB]
30.187 [GB]
32.930 [GB]

User#0 Read result
Total = 34.359 [GB] , Time = 12000[ms] , Transfer speed = 2863[MB/s]

--- muNUMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
        
```

Figure 2-6 Read command by 1-2 users

Input four parameters per user as follows.

- 1) Command: Select command - Write, Read, or Disable (no operation).
- 2) Start Address: Input 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. When LBA unit of SSD is 4 Kbyte, this input must be aligned to 8.
- 3) 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. When LBA unit of SSD is 4 Kbyte, this input must be aligned to 8.
- 4) Test pattern: Select test data pattern to verify data from SSD. Test pattern must be matched with the pattern using in Write Command menu. There are five patterns, i.e., 32-bit incremental, 32-bit decremental, all-0, all-1, and 32-bit LFSR counter.

Similar to Write command menu, test system reads data from SSD when all inputs are valid. While running Read command, current amount of read data is displayed on the console every second to show that system is still alive. Finally, total size, total time usage, and test speed of the active user are displayed on the console as test result.

"Invalid input" is displayed when some inputs are invalid or unaligned to 8 (when connecting to 4-KB LBA SSD).

As shown in Figure 2-6, total performance when running one-user (2863 MB/s) is slightly more than two-user (1374 + 1374 MB/s). The performance of each user is similar. However, the performance result depends on SSD characteristic.

Figure 2-7 shows error message when data verification is failed. “Verify fail in User#x” is displayed with the information of the 1st failure data, i.e., the error byte address, the expected value, and the read value.

User can press any key(s) to cancel read operation. Otherwise, the operation is still run until finishing Read command. After that, the output performance is displayed on the console.

When cancelling the operation, the Read command still runs as the background process and may not finish in a good sequence. It is recommended to power-off/on FPGA board and adapter board (if connected).

Verification error without cancellation

```

+++ Write/Read Command selected +++
Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0
Enter Length (512 Byte) : 1 - 0x209A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 0

Enter Test parameter for User#1
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0x10000000
Enter Length (512 Byte) : 1 - 0x109A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4

Verify fail in User#0
1st Error at Byte Addr = 0x00000000
Expect Data[127: 0] = 0x00000003_00000002_00000000_00000000
Read Data[127: 0] = 0x00000002_00000001_00000000_00000000
Press any key to cancel operation

Verify fail in User#1
1st Error at Byte Addr = 0x00000020
Expect Data[127: 0] = 0x40000002_20000001_00000000_10000000
Read Data[127: 0] = 0x00000003_00000002_00000000_10000000
Press any key to cancel operation

User#0 User#1
1.373 [GB] 1.375 [GB]
2.741 [GB] 2.742 [GB]
4.112 [GB] 4.113 [GB]

| |
31.533 [GB] 31.534 [GB]
32.905 [GB] 32.906 [GB]
34.276 [GB] 34.277 [GB]

User#0 Read result
Total = 34.359 [GB] , Time = 25000[ms] , Transfer speed = 1374[MB/s]
User#1 Read result
Total = 34.359 [GB] , Time = 25000[ms] , Transfer speed = 1374[MB/s]

```

Verification error with cancellation

```

+++ Write/Read Command selected +++
Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0
Enter Length (512 Byte) : 1 - 0x209A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 0

Enter Test parameter for User#1
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0x10000000
Enter Length (512 Byte) : 1 - 0x109A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4

Verify fail in User#0
1st Error at Byte Addr = 0x00000000
Expect Data[127: 0] = 0x00000003_00000002_00000000_00000000
Read Data[127: 0] = 0x00000002_00000001_00000000_00000000
Press any key to cancel operation

Verify fail in User#1
1st Error at Byte Addr = 0x00000020
Expect Data[127: 0] = 0x40000002_20000001_00000000_10000000
Read Data[127: 0] = 0x00000003_00000002_00000000_10000000
Press any key to cancel operation

User#0 User#1
1.373 [GB] 1.375 [GB]
2.741 [GB] 2.742 [GB]
4.112 [GB] 4.113 [GB]

Operation is cancelled
Please reset system before starting a new test

--- muNVMIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command

```

Figure 2-7 Data verification is failed

2.2.3 Mixed Write/Read command

◆ : User input
◆ : User output

Write-Read command

```

+++ Write/Read Command selected +++

Enter Test parameter for User#0
Enter Command [0]Write [1]Read [2]Disable => 0
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0
Enter Length (512 Byte) : 1 - 0x209A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4

Enter Test parameter for User#1
Enter Command [0]Write [1]Read [2]Disable => 1
Enter Start Address (512 Byte) : 0 - 0x209A97AF => 0x10000000
Enter Length (512 Byte) : 1 - 0x109A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 0

User#0      User#1
1.207 [GB]  1.208 [GB]
2.410 [GB]  2.411 [GB]
3.618 [GB]  3.619 [GB]

|           |
31.429 [GB] 31.430 [GB]
32.639 [GB] 32.640 [GB]
33.843 [GB] 33.844 [GB]

User#0 Write result
Total = 34.359 [GB] , Time = 28000[ms] , Transfer speed = 1227[MB/s]
User#1 Read result
Total = 34.359 [GB] , Time = 28000[ms] , Transfer speed = 1227[MB/s]

--- muNUMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
    
```

Current transfer size of active user

Output performance of active user

Figure 2-8 Test result when running mixed Write/Read command

Input four parameters for each user as follows.

- 1) Command: Select command - Write, Read, or Disable (no operation).
- 2) Start Address: Input start address to write/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. When LBA unit of SSD is 4 Kbyte, this input must be aligned to 8.
- 3) 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. When LBA unit of SSD is 4 Kbyte, this input must be aligned to 8.
- 4) Test pattern: Select test data pattern for writing/verifying data to/from SSD. There are five patterns, i.e., 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.

When all inputs are valid, the operation begins. While the command is operating, current amount of write/read data in the active user is displayed on the console every second to show that system is still alive. Finally, total size, total time usage, and test speed of the active user are displayed on the console as test result.

The error message is displayed if the input is invalid or data verification is failed.

2.3 SMART Command

Select '2' to send SMART command to NVMe SSD via User#0 I/F.

```

+++ SMART Command selected +++
<< Health Status >>
Remaining Life : 100%

<< SMART Log Information >>
Percentage Used : 0%
Temperature : 36 Degree Celsius
Total Data Read : 68534 GB
Total Data Read (Raw data) : 0x00000000_00000000_00000000_07FA58BE
Total Data Written : 83621 GB
Total Data Written (Raw data) : 0x00000000_00000000_00000000_09BBF801
Power On Cycles : 1383 Times
Power On Hours : 127 Hours
Unsafe Shutdowns : 539 Times

SMART Command Complete

--- muNUMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command

```

Data output decoded from SMART command

Figure 2-9 Test result when running SMART command

After finishing the operation, SMART/Health Information (output from SMART command) is displayed as shown in Figure 2-9. The console shows Health status and SMART log information. Health status shows the remaining life of the SSD in percent unit which is calculated from Percentage Used in the SMART log information.

The SMART log information shows seven parameters as follow.

- 1) Percentage used: Display SSD usage in percent unit.
- 2) Temperature in °C unit.
- 3) Total Data Read decoded as GB/TB unit. Also, raw data without decoding is displayed by 32 digits of hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 4) Total Data Written decoded as GB/TB unit. Also, raw data without decoding is displayed by 32 digits of hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 5) Power On Cycles: Display the number of power cycles.
- 6) Power On Hours: Display the period of time in hours to show how long the SSD has been powered on.
- 7) Unsafe Shutdowns: Display the number of unsafe shutdowns of SSD.

2.4 Flush Command

Select '3' to send Flush command to NVMe SSD via User#0 I/F.

```

+++ Flush Command selected +++
Flush Command Complete
--- muNUMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
  
```

Message after finishing the operation

Figure 2-10 Test result when running Flush command

“Flush Command Complete” is displayed after finishing Flush operation.

2.5 Shutdown Command

Select '4' to send Shutdown command to NVMe SSD via User#0 I/F.

```

--- muNUMeIP menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
+++ Shutdown Command selected +++
Are you sure you want to shutdown the device now ?
Press 'y' to confirm : y
Shutdown command is complete
The device has turned off...
  
```

◆ : User input
◆ : User output

Confirmation message

Press 'y' to confirm

Last message before muNVMe-IP and SSD are inactive status

Figure 2-11 Test result when running Shutdown command

The confirmation message is displayed on the console. User enters 'y' or 'Y' to continue the operation or enters other keys to cancel the operation.

After finishing Shutdown operation, “Shutdown command is complete” is displayed on the console as the last message. Main menu is not displayed anymore. User needs to power off/on test system to start new test operation.

3 Revision History

Revision	Date	Description
1.0	14-Jun-22	Initial version release