



2-Ch RAID0 (muNVMe-IP) Demo Instruction

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2-Ch RAID0 (muNVMe-IP) Demo Instruction

Rev1.0 28-Jun-23

1 Overview

This document describes the instruction to run 2-ch RAID0 by muNVMe-IP demo on FPGA development board for two users accessing two NVMe SSD as RAID0 operation. 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_raid0x2_fpgasetup” document, main menu is displayed and the user sets the input to the console for selecting test operation.

```

+++ muNUMeIP RAID0x2 Test design [IPVer = 1.0] +++
Waiting PCIe Linkup

Waiting IP initialization
Ch[0]PCIe Gen3 x4 Device Detect
Ch[1]PCIe Gen3 x4 Device Detect

--- muNUMeIP RAID0x2 menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
    
```

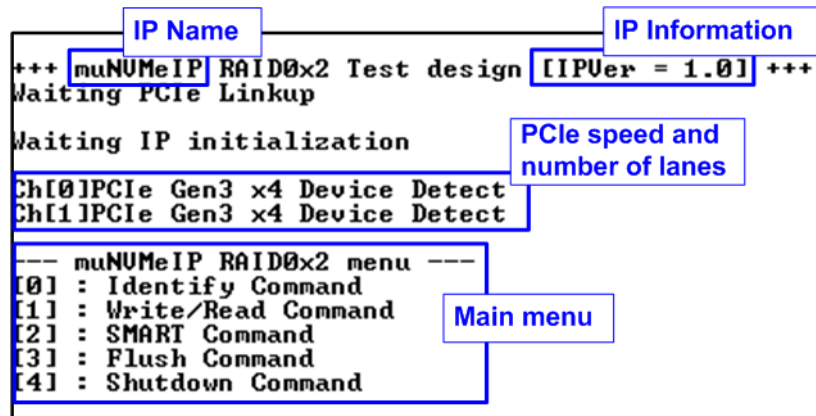


Figure 1-1 2-ch RAID0 by muNVMe-IP main menu

On welcome screen, IP name and IP version number are displayed. The PCIe speed and number of PCIe lanes of each channel 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 RAID0 via User#0 I/F.

```

+++ Identify Command selected +++
Ch[0]Model Number : INTEL SSDPE21D280GA
Ch[1]Model Number : INTEL SSDPED1D280GA
RAID Capacity= 560[GB]

--- muNUMeIP RAID0x2 menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
  
```

Model name and RAID0 capacity

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 two values.

- 1) SSD model number : This value is decoded from Identify controller data of each SSD.
- 2) RAID capacity : This value is calculated by multiplying device capacity in channel#0 by 2. Therefore, it is recommended to connect two SSDs which have the same size.

Note: If two SSDs are different model which has different capacity, please connect the smallest capacity SSD to CH#0.

When unsupported LBA size SSD is detected, the error message is displayed on the console as shown in Figure 2-2

Note: In RAID0 design, LBA size of SSD must be equal to 512-byte. Other size can be supported by modifying RAID0 controller hardware.

```

Warning : LBA Size Not Support!
Please Check Devices
  
```

Figure 2-2 Error message when LBA does not support

2.2 Write/Read Command

Select '1' to send Write/Read command by using 1-2 users to RAID0 system.

2.2.1 Write command

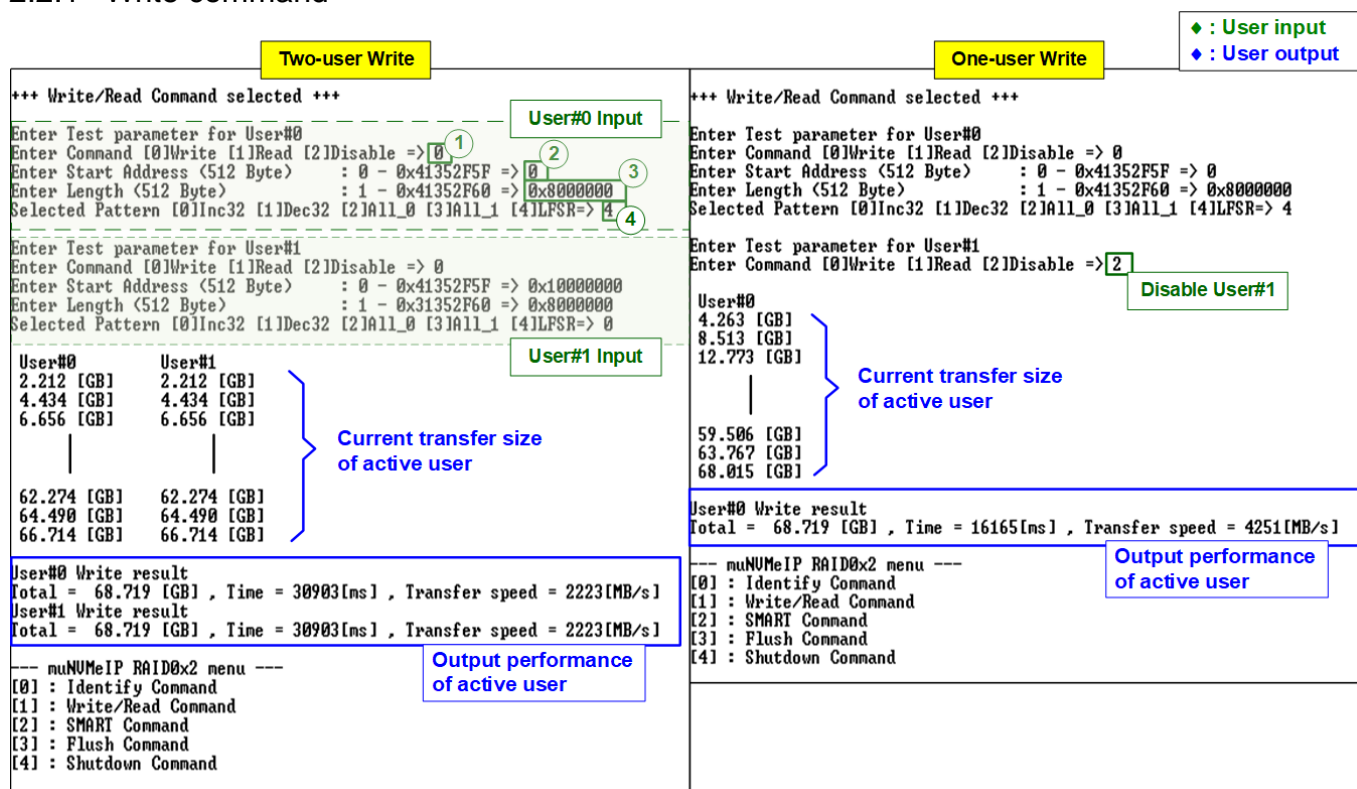


Figure 2-3 Write command by 1-2 users

Input four parameters per user as follows.

- 1) Command: Select command - Write, Read, or Disable (no operation).
- 2) Start Address: Start address to write RAID0 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.
- 3) Transfer Length: 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.
- 4) Test pattern: Select test data pattern for writing to RAID0. 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 2-3, total performance when running one-user and two-user are equal (2223+2223 MB/s and 4251 MB/s). The performance per user when running two-user test is about a half of the one-user performance.

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

←64-bit header of 512-byte data→

Offset	48-bit LBA Address = 0 0x0000								32-bit LFSR pattern								48-bit LBA Address = 1																																																																																																																																														
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F																																																																																																																															
0000000000	00	00	00	00	00	00	00	01	00	00	00	02	00	00	00	01	00	00	00	00	00	00	00	02	00	00	00	00	00	00	00	02	00	00	00	00	00	00	00	04	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	24	00	00	00	49	00	00	00	49	00	00	00	92	00	00	00	24	01	00	00	49	02	00	00	92	00	00	00	24	01	00	00	49	02	00	00	92	04	00	00	24	09	00	00	49	12	00	00	92	24	00	00	24	49	00	00	49	92	00	00	49	92	00	00	92	24	01	00	24	49	02	00	49	92	00	00	92	24	01	00	24	49	02	00	49	92	04	00	49	92	04	00	92	24	09	00	24	49	12	00	49	92	24	00
00000001A0	A0	E1	C6	74	41	C3	8D	E9	83	86	1B	D3	06	0D	37	A6	41	C3	8D	E9	83	86	1B	D3	06	0D	37	A6	0C	1A	6E	4C	18	34	DC	98	30	68	B8	31	60	D0	70	63	C0	A0	E1	C6	81	41	C3	8D	03	83	86	1B	07	06	0D	37	0F	0C	1A	6E	1F	18	34	DC	3F	30	68	B8	7F	60	D0	70	FF	C0	A0	E1	FF	81	41	C3	FE	03	83	86	FD	07	06	0D	FA	0F	0C	1A	F4	1F	18	34	E9	3F	30	68	D3	7F	60	D0	A7	FF	C0	A0	03	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	07	00	00	00	00	0F	00	00	1F	00	00	00	3F	00	00	00	7F	00	00	00	FF	00	00	00							
	SSD#0																SSD#1																																																																																																																																														

Figure 2-4 Example Test data of the 1st and 2nd 512-byte of each SSD by using LFSR pattern

The stripe size in 2-ch RAID0 demo is 512-byte. For incremental, decremental, or LFSR pattern, each 512-byte data has unique 64-bit header which consists 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 1st stripe of RAID0 is mapped to the first 512-byte of SSD#0. The 2nd stripe, the 3rd stripe, and the 4th stripe are mapped to the first 512-byte of SSD#1, the second 512-byte of SSD#0, and the second 512-byte of SSD#1, respectively. The unique header is not included when running all-0 or all-1 pattern.

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.

```

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

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

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

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
    
```

Figure 2-5 Error message from the invalid input

2.2.2 Read Command

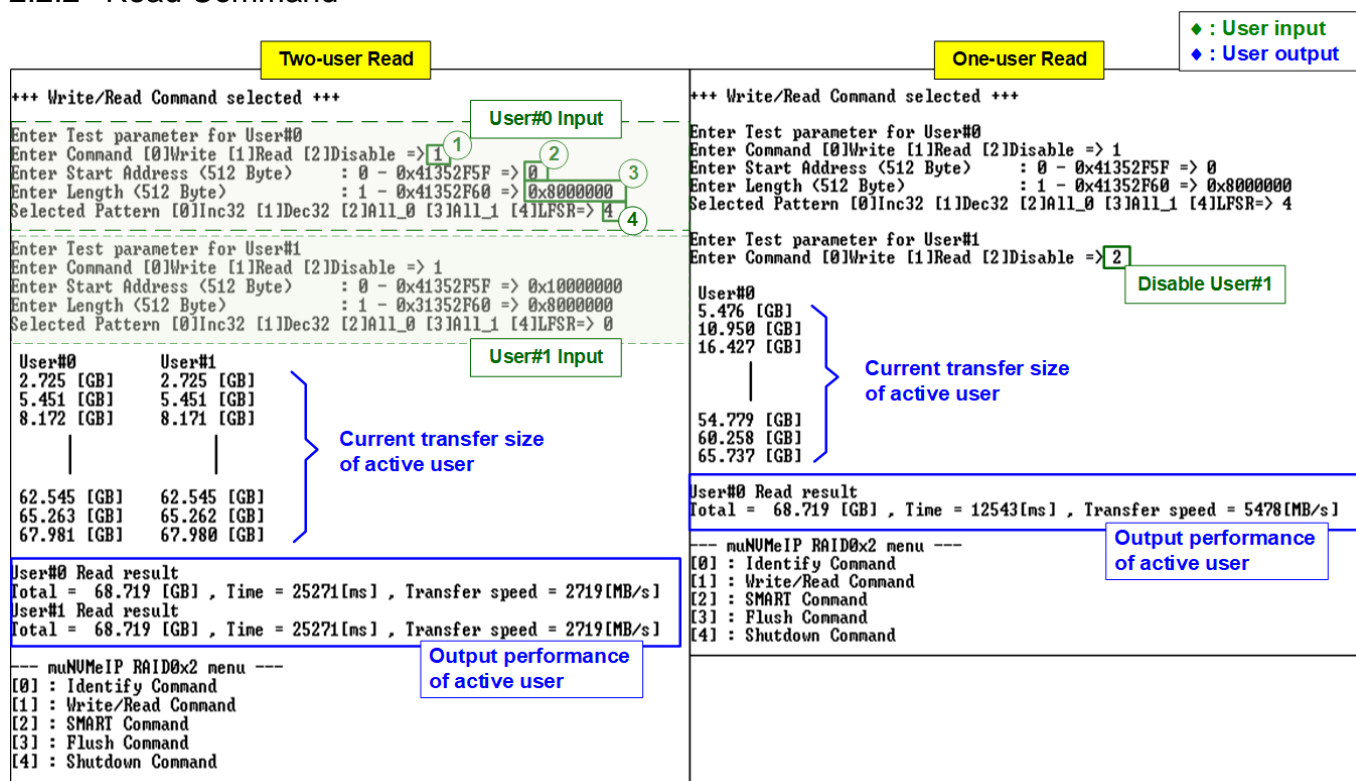


Figure 2-6 Read command by 1-2 users

Input four parameters per user as follows.

- 1) Command: Select command - Write, Read, or Disable (no operation).
- 2) Start Address: Start address to read RAID0 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.
- 3) Transfer Length: 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.
- 4) Test pattern: Select test data pattern to verify data from RAID0. 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 RAID0 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.

As shown in Figure 2-6, total performance when running one-user (5478 MB/s) is slightly more than two-user (2719 + 2719 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. “User#x Verify fail” 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

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 - 0x41352F5F => 0
Enter Length (512 Byte) : 1 - 0x41352F60 => 0x80000000
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 - 0x41352F5F => 0x10000000
Enter Length (512 Byte) : 1 - 0x31352F60 => 0x80000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4

User#0 Verify fail
1st Error at Byte Addr = 0x00000000
Expect Data[255:128] = 0x00000007_00000006_00000005_00000004
Expect Data[127:0] = 0x00000003_00000002_00000001_00000000
Read Data[255:128] = 0x0007FFFF_FFF80004_0003FFFF_FFFC0002
Read Data[127:0] = 0x0001FFFF_FFFE0001_00000000_00000000
Press any key to cancel operation

User#1 Verify fail
1st Error at Byte Addr = 0x0000002000000000
Expect Data[255:128] = 0x8007FFFF_7FF80004_4003FFFF_BFFC0002
Expect Data[127:0] = 0x2001FFFF_DFFE0001_00000000_10000000
Read Data[255:128] = 0x00000007_00000006_00000005_00000004
Read Data[127:0] = 0x00000003_00000002_00000001_00000000
Press any key to cancel operation

User#0      User#1
2.725 [GB]  2.725 [GB]
5.450 [GB]  5.450 [GB]

|           |
65.248 [GB] 65.248 [GB]
67.966 [GB] 67.966 [GB]

User#0 Read result
Total = 68.719 [GB] , Time = 25276[ms] , Transfer speed = 2718[MB/s]
User#1 Read result
Total = 68.719 [GB] , Time = 25277[ms] , Transfer speed = 2718[MB/s]

--- muNUMeIP RAID0x2 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 - 0x41352F5F => 0
Enter Length (512 Byte) : 1 - 0x41352F60 => 0x80000000
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 - 0x41352F5F => 0x10000000
Enter Length (512 Byte) : 1 - 0x31352F60 => 0x80000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4

User#0 Verify fail
Byte Addr = 0x00000000
255:128] = 0x00000007_00000006_00000005_00000004
127:0] = 0x00000003_00000002_00000001_00000000
5:128] = 0x0007FFFF_FFF80004_0003FFFF_FFFC0002
Read Data[127:0] = 0x0001FFFF_FFFE0001_00000000_00000000
Press any key to cancel operation

User#1 Verify fail
Byte Addr = 0x0000002000000000
255:128] = 0x8007FFFF_7FF80004_4003FFFF_BFFC0002
127:0] = 0x2001FFFF_DFFE0001_00000000_10000000
5:128] = 0x00000007_00000006_00000005_00000004
Read Data[127:0] = 0x00000003_00000002_00000001_00000000
Press any key to cancel operation

User#0      User#1
2.725 [GB]  2.725 [GB]
5.450 [GB]  5.450 [GB]
8.169 [GB]  8.169 [GB]

Operation is cancelled
Please reset system before starting a new test

--- muNUMeIP RAID0x2 menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
        
```


Wrong pattern

Message when verification is failed in User#0

Message when verification is failed in User#1

User enters some keys to cancel the operation

Output performance of active user

Message when operation is cancelled

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 - 0x41352F5F => 0
Enter Length (512 Byte) : 1 - 0x41352F60 => 0x80000000
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 - 0x41352F5F => 0x10000000
Enter Length (512 Byte) : 1 - 0x31352F60 => 0x80000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 0

User#0      User#1
2.397 [GB]  2.397 [GB]
4.793 [GB]  4.793 [GB]
7.190 [GB]  7.189 [GB]

62.337 [GB] 62.337 [GB]
64.737 [GB] 64.737 [GB]
67.141 [GB] 67.141 [GB]

User#0 Write result
Total = 68.719 [GB] , Time = 28657[ms] , Transfer speed = 2397[MB/s]
User#1 Read result
Total = 68.719 [GB] , Time = 28657[ms] , Transfer speed = 2397[MB/s]

--- muNUMeIP RAID0x2 menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command
        
```

User#0 Input

User#1 Input

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 RAID0 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.
- 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.
- 4) Test pattern: Select test data pattern for writing/verifying data to/from RAID0. 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 RAID0 via User#0 I/F.

```

+++ SMART Command selected +++
++ ch[0]
<< Health Status >>
Remaining Life : 100%
<< SMART Log Information >>
Percentage Used : 0%
Temperature : 30 Degree Celsius
Total Data Read : 3259 GB
Total Data Read <Raw data> : 0x00000000_00000000_00000000_00612437
Total Data Written : 4243 GB
Total Data Written <Raw data> : 0x00000000_00000000_00000000_007E720C
Power On Cycles : 51 Times
Power On Hours : 6 Hours
Unsafe Shutdowns : 33 Times
Data output decoded from SMART
command (SSD Channel#0)

++ ch[1]
<< Health Status >>
Remaining Life : 100%
<< SMART Log Information >>
Percentage Used : 0%
Temperature : 31 Degree Celsius
Total Data Read : 74194 GB
Total Data Read <Raw data> : 0x00000000_00000000_00000000_08A30AAE
Total Data Written : 91406 GB
Total Data Written <Raw data> : 0x00000000_00000000_00000000_0AA3F5A6
Power On Cycles : 1467 Times
Power On Hours : 134 Hours
Unsafe Shutdowns : 578 Times
Data output decoded from SMART
command (SSD Channel#1)

SMART Command Complete

--- muNUMeIP RAID0x2 menu ---
[0] : Identify Command
[1] : Write/Read Command
[2] : SMART Command
[3] : Flush Command
[4] : Shutdown Command

```

Figure 2-9 Test result when running SMART command

After finishing the operation, SMART/Health Information (output from SMART command) of two SSDs are 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 RAID0 via User#0 I/F.

```

+++ Flush Command selected +++
Flush Command Complete
--- muNUMeIP RAID0x2 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 RAID0 via User#0 I/F.

```

--- muNUMeIP RAID0x2 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-IPs and SSDs 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	11-Aug-22	Initial version release