

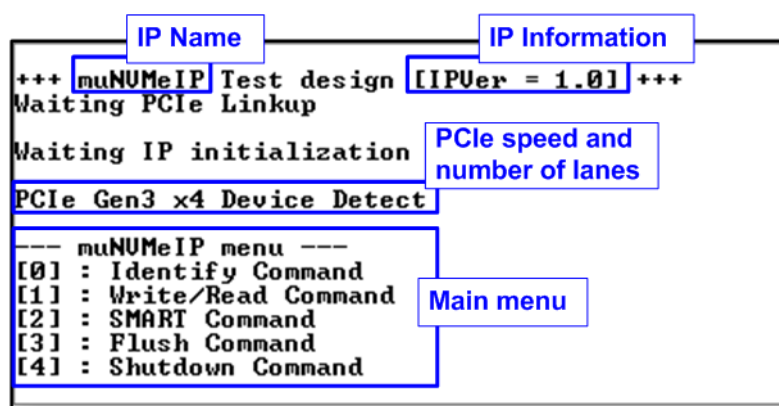
# Demo Instruction for muNVMe -IP

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]

--- muNVMeIP 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

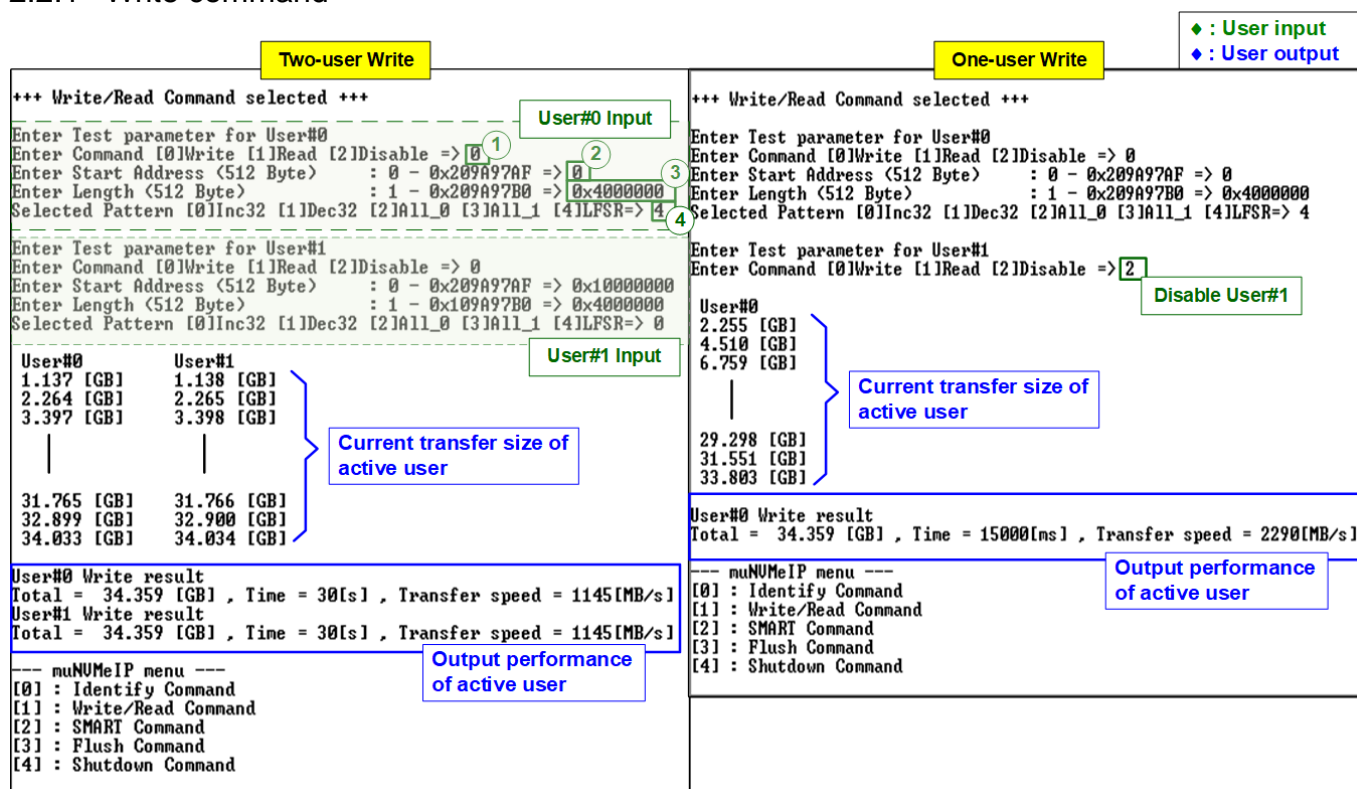


Figure 2-2 Write command by 1-2 users

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.*

Test data of 32-bit increment pattern																Test data of 32-bit LFSR pattern																
←64-bit header of each 512-byte→																←64-bit header of each 512-byte→																
48-bit address (512 byte unit)																48 bit address																
0x0000																0x0000																
Test data (32-bit increment)																Test data (32-bit LFSR)																
Offset	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
00000000	00	00	00	00	00	00	00	00	02	00	00	00	03	00	00	00	00	00	00	00	00	00	00	00	01	00	00	00	02	00	00	00
00000010	04	00	00	00	05	00	00	00	06	00	00	00	07	00	00	00	04	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00
00000020	08	00	00	00	09	00	00	00	0A	00	00	00	0B	00	00	00	49	00	00	00	92	00	00	00	24	01	00	00	49	02	00	00
00000030	0C	00	00	00	0D	00	00	00	0E	00	00	00	0F	00	00	00	92	04	00	00	24	09	00	00	49	12	00	00	92	24	00	00
00000040	10	00	00	00	11	00	00	00	12	00	00	00	13	00	00	00	24	49	00	00	49	92	00	00	92	24	01	00	24	49	02	00
00000050	14	00	00	00	15	00	00	00	16	00	00	00	17	00	00	00	49	92	04	00	92	24	09	00	24	49	12	00	49	92	24	00
00000060	18	00	00	00	19	00	00	00	1A	00	00	00	1B	00	00	00	93	24	49	00	27	49	92	00	4F	92	24	01	9E	24	49	02
The 1 <sup>st</sup> 512-byte data																																
00000090	24	00	00	00	25	00	00	00	26	00	00	00	27	00	00	00	CF	93	24	49	9E	27	49	92	3D	4F	92	24	7A	9E	24	49
000000A0	28	00	00	00	29	00	00	00	2A	00	00	00	2B	00	00	00	5D	CF	93	24	BA	9E	27	49	75	3D	4F	92	EB	7A	9E	24
000000B0	2C	00	00	00	2D	00	00	00	2E	00	00	00	2F	00	00	00	D7	F5	3C	49	AE	EB	79	92	5C	D7	F3	24	B8	AE	E7	49
000000C0	30	00	00	00	31	00	00	00	32	00	00	00	33	00	00	00	70	5D	CF	93	E0	BA	9E	27	C1	75	3D	4F	83	EB	7A	9E
000000D0	34	00	00	00	35	00	00	00	36	00	00	00	37	00	00	00	07	D7	F5	3C	0E	AE	EB	79	1D	5C	D7	F3	3B	B8	AE	E7
000000E0	38	00	00	00	39	00	00	00	3A	00	00	00	3B	00	00	00	77	70	5D	CF	EE	E0	BA	9E	DC	C1	75	3D	B8	83	EB	7A
000000F0	3C	00	00	00	3D	00	00	00	3E	00	00	00	3F	00	00	00	70	07	D7	F5	E0	0E	AE	EB	C1	1D	5C	D7	83	3B	B8	AE
00000100	40	00	00	00	41	00	00	00	42	00	00	00	43	00	00	00	07	77	70	5D	0E	EE	E0	BA	1C	DC	C1	75	39	B8	83	EB
00000110	44	00	00	00	45	00	00	00	46	00	00	00	47	00	00	00	73	70	07	D7	E6	E0	0E	AE	CD	C1	1D	5C	9A	83	3B	B8
00000120	48	00	00	00	49	00	00	00	4A	00	00	00	4B	00	00	00	34	07	77	70	68	0E	EE	E0	D1	1C	DC	C1	A3	39	B8	83
00000130	4C	00	00	00	4D	00	00	00	4E	00	00	00	4F	00	00	00	47	73	70	07	8E	E6	E0	0E	1D	CD	C1	1D	3A	9A	83	3B
00000140	50	00	00	00	51	00	00	00	52	00	00	00	53	00	00	00	74	34	07	77	E9	68	0E	EE	D3	D1	1C	DC	A6	A3	39	B8
00000150	54	00	00	00	55	00	00	00	56	00	00	00	57	00	00	00	4C	47	73	70	98	8E	E6	E0	31	1D	CD	C1	63	3A	9A	83
00000160	58	00	00	00	59	00	00	00	5A	00	00	00	5B	00	00	00	C6	74	34	07	8D	E9	68	0E	1B	D3	D1	1C	37	A6	A3	39
00000170	5C	00	00	00	5D	00	00	00	5E	00	00	00	5F	00	00	00	6E	4C	47	73	DC	98	8E	E6	B8	31	1D	CD	70	63	3A	9A
00000180	60	00	00	00	61	00	00	00	62	00	00	00	63	00	00	00	E1	C6	74	34	C3	8D	E9	68	86	1B	D3	D1	0D	37	A6	A3
00000190	64	00	00	00	65	00	00	00	66	00	00	00	67	00	00	00	1A	6E	4C	47	34	DC	98	8E	68	B8	31	1D	D0	70	63	3A
000001A0	68	00	00	00	69	00	00	00	6A	00	00	00	6B	00	00	00	A0	E1	C6	74	41	C3	8D	E9	83	86	1B	D3	06	0D	37	A6
000001B0	6C	00	00	00	6D	00	00	00	6E	00	00	00	6F	00	00	00	0C	1A	6E	4C	18	34	DC	98	30	68	B8	31	60	D0	70	63
000001C0	70	00	00	00	71	00	00	00	72	00	00	00	73	00	00	00	C0	A0	E1	C6	81	41	C3	8D	03	83	86	1B	07	06	0D	37
000001D0	74	00	00	00	75	00	00	00	76	00	00	00	77	00	00	00	0F	0C	1A	6E	1F	18	34	DC	3F	30	68	B8	7F	60	D0	70
000001E0	78	00	00	00	79	00	00	00	7A	00	00	00	7B	00	00	00	FF	C0	A0	E1	FF	81	41	C3	FE	03	83	86	FD	07	06	0D
000001F0	7C	00	00	00	7D	00	00	00	7E	00	00	00	7F	00	00	00	FA	0F	0C	1A	F4	1F	18	34	E9	3F	30	68	D3	7F	60	D0
The 2 <sup>nd</sup> 512-byte data																																
00000200	01	00	00	00	00	00	00	00	82	00	00	00	83	00	00	00	01	00	00	00	00	00	00	00	02	00	00	00	04	00	00	00
00000210	04	00	00	00	05	00	00	00	86	00	00	00	87	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000220	08	00	00	00	09	00	00	00	8A	00	00	00	8B	00	00	00	92	00	00	00	24	01	00	00	49	02	00	00	92	04	00	00

Figure 2-3 Example Test data of the 1<sup>st</sup> and 2<sup>nd</sup> 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.

LBA alignment error

Recommended message  
when LBA unit = 4 Kbyte

```

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

```

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.

Error input

Invalid command

```

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

```

Out of range address

Out of range length

Invalid pattern

Figure 2-5 Error message from the invalid input

## 2.2.2 Read Command

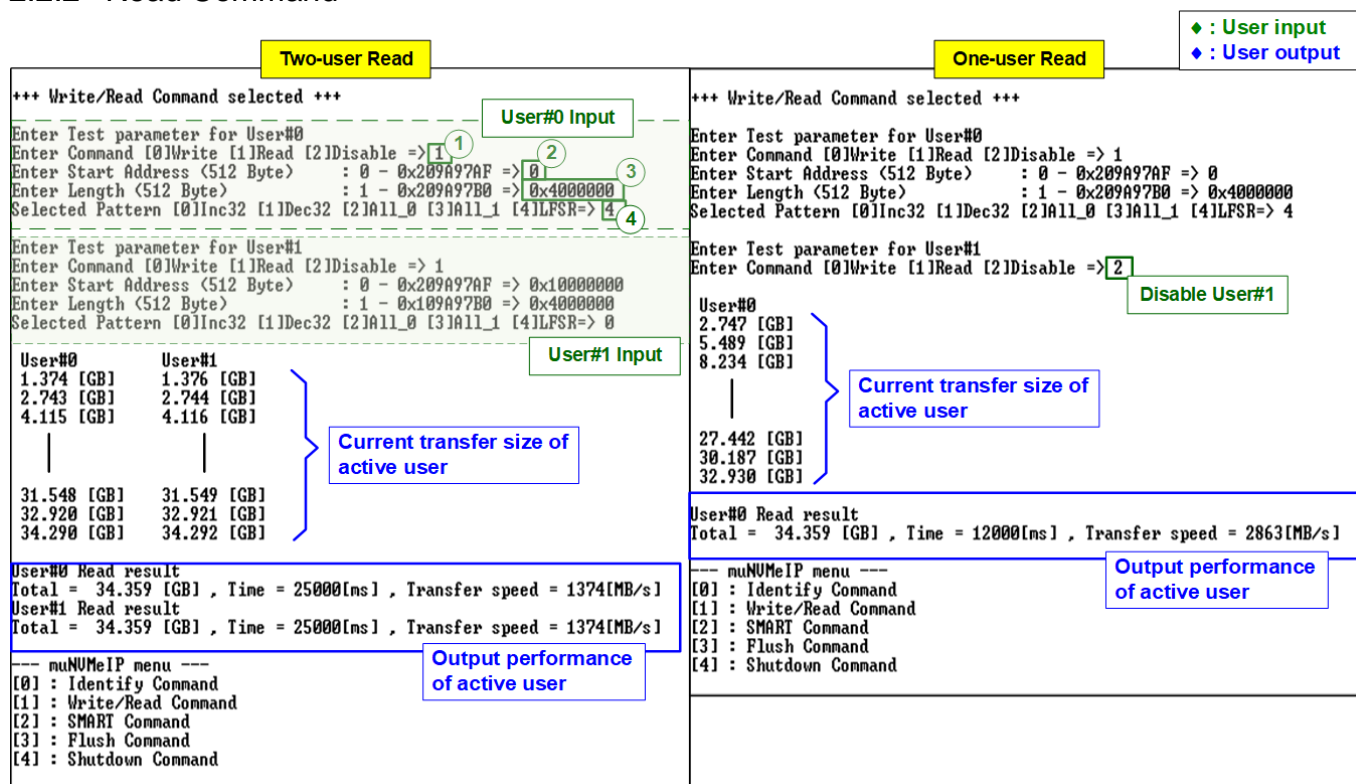


Figure 2-6 Read command by 1-2 users

Input four parameters per user as follows.

- 1) Command: Select command - Write, Read, or Disable (no operation).
- 2) Start Address: 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 1<sup>st</sup> 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).

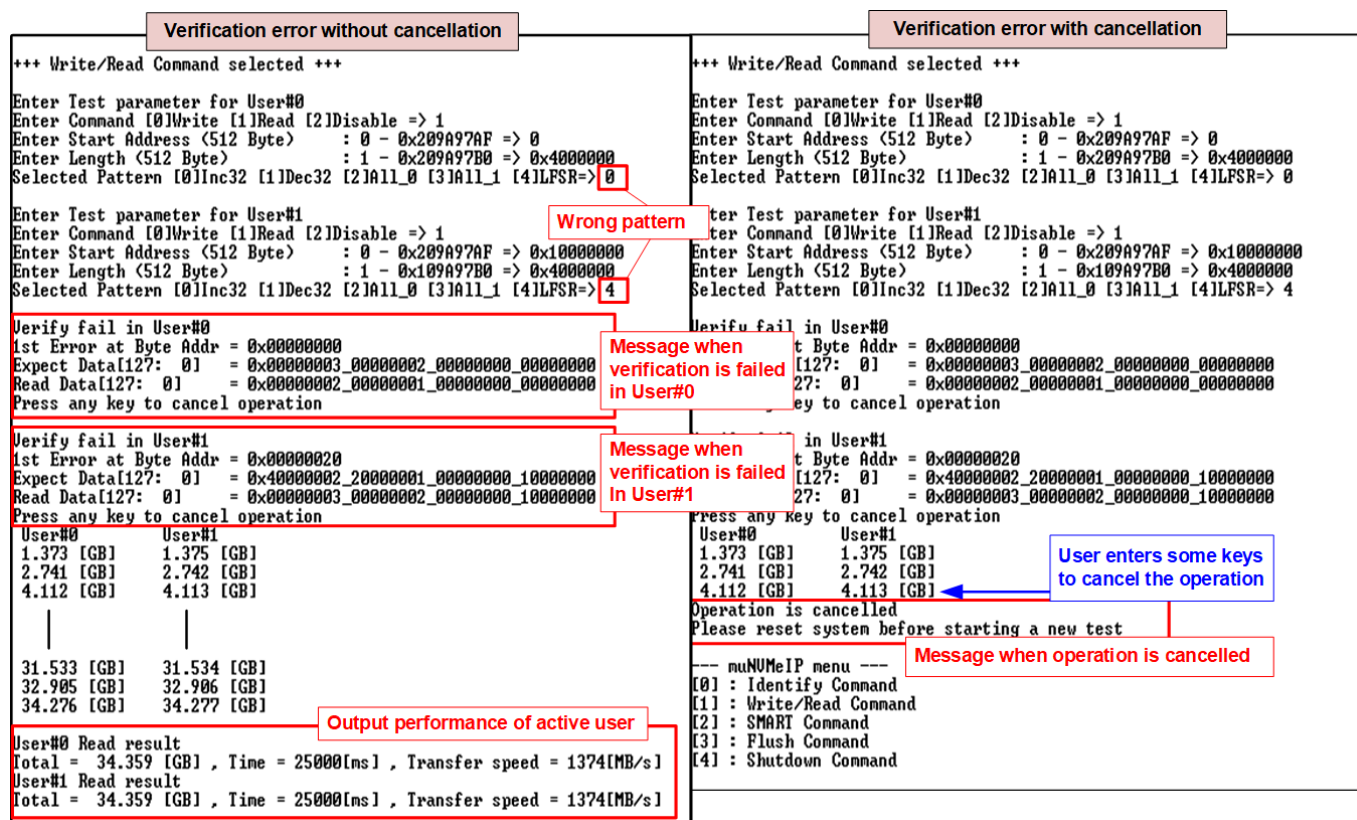


Figure 2-7 Data verification is failed

## 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 => 0x40000000
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 => 0x40000000
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

```

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 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