raNVMe-IP with multiple-user Demo Instruction

Rev1.1 31-May-22

1 Overview

This document describes the instruction to run raNVMe-IP with multiple-user demo on FPGA development board for accessing one NVMe SSD. Up to 4 users are supported in the reference design. There are six commands in the main menu, controlled via FPGA console, as shown in Figure 1-1.

To setup FPGA test environment, user can follow the instruction in “dg_nvmeip_fpgasetup” document which is the setup document for the standard NVMe-IP.

After finishing the board setup, the main menu is displayed and the user inputs to the console for selecting test operation.

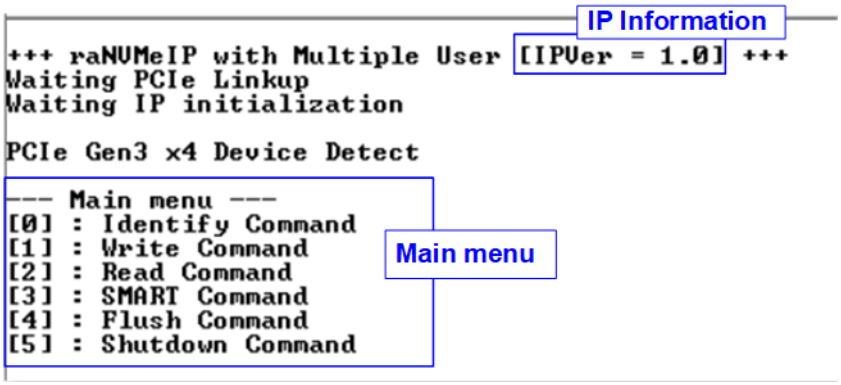

Figure 1-1 Main menu of raNVMe-IP with multiple user demo

2 Test Menu

2.1 Identify Command

Select ‘0’ to send Identify command to NVMe SSD.

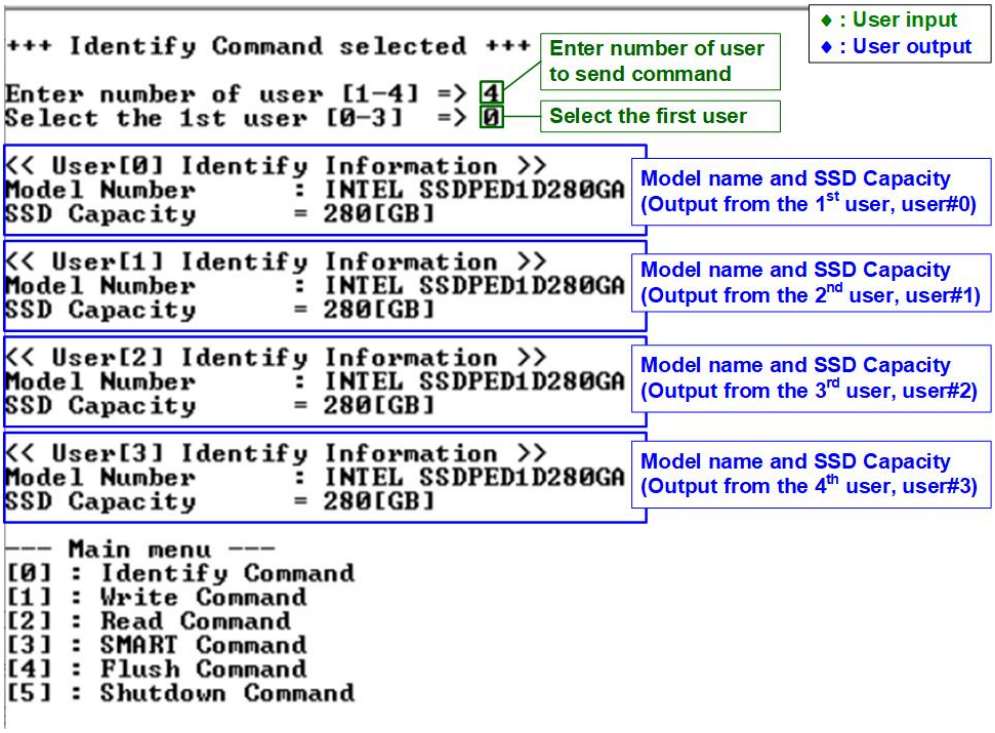

Figure 2-1 Test result when running Identify command

There are two inputs for running Identify command, described as follows.
1) Number of users: Enter number of users to send command. Valid from 1 to 4 users.
2) The first user: Select the first user to operate the command. Valid from 0 to 3.

If all inputs are valid, the operation is started. Identify command of the first user is sent to the SSD and the SSD information output from Identify command is displayed on the console, i.e., SSD model number and SSD capacity.
1) SSD model number: This value is decoded from Identify controller data.
2) SSD capacity: This value is signal output from raNVMe-IP.

If the current user is not the last user, repeat to send Identify command for the next user and display the result on the console.

Note: All users access the same NVMe SSD, so the information that is returned to all users are similar.

If the user input is out-of-range, error message is displayed on the console, as shown in Figure 2-2.

```
+++ Identify Command selected +++

Enter number of user [1-4] => 0
Invalid number
```

Invalid number of user

```
+++ Identify Command selected +++

Enter number of user [1-4] => 4
Select the 1st user [0-3]  => 4
Invalid user
```

Invalid the first user

Figure 2-2 Error message from the invalid user

When the SSD operates in LBA unit which is not equal to 512 bytes, the error message is shown in the console and the system stays inactive status, as shown in Figure 2-3. User needs to reset the system to restart the demo.

```
+++ Identify Command selected +++

Enter number of user [1-4] => 1
Select the 1st user [0-3]  => 0

Error Detect

ErrorType  = 0x00010000

ErrorType[16]: LBA does not support
PCIe Status  = 0x0B4D
TestPin      = 0x0000001F
```

Error message when LBA unit detected does not support

Figure 2-3 Error when LBA unit does not support

2.2 Write Command

Select ‘1’ to send Write command to NVMe SSD.

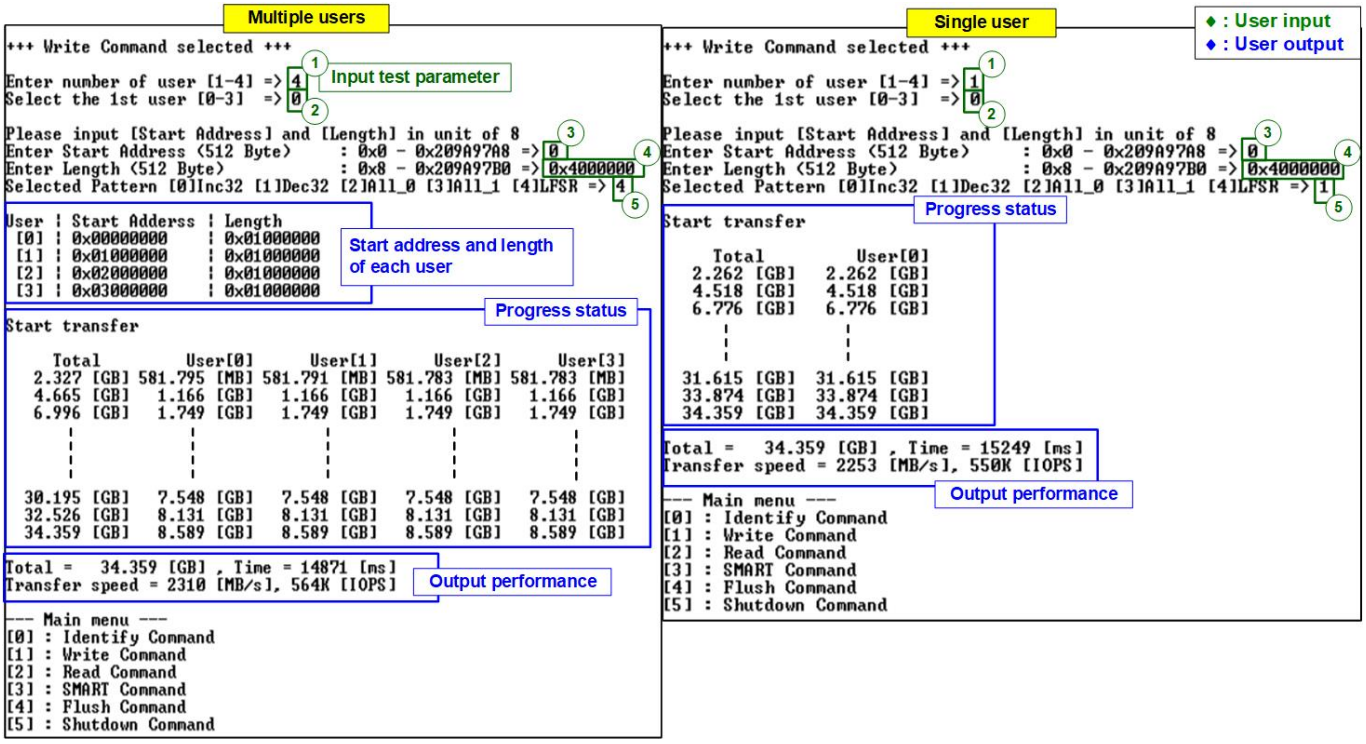

Figure 2-4 Test result when running Write command

There are five input parameters for running Write command, described as follows.

1) Number of users: Enter the number of users to write data. Valid from 1 to 4 users.
2) The first user: Select the first user to operate the command. Valid from 0 to 3.
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.

When all inputs are valid, the operation begins. During writing data, the current amount of transferred data of each user and the sum of transfer data size of all users are displayed on the console every second. Finally, total size, total time usage, and test speed are displayed on the console as a test result.

Note: If Number of users more than 1, the firmware will calculate start address and length for each user. The result of the calculation is displayed on console.

Test data of 32-bit increment pattern

64-bit header of each 4Kbyte

48-bit address (512 byte unit) — 0x0000 — Test data (32-bit increment)

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000000000	00	00	00	00	00	00	00	00	02	00	00	00	03	00	00	00
0000000010	04	00	00	00	05	00	00	00	06	00	00	00	07	00	00	00
0000000020	08	00	00	00	09	00	00	00	0A	00	00	00	0B	00	00	00
0000000030	0C	00	00	00	0D	00	00	00	0E	00	00	00	0F	00	00	00
0000000040	10	00	00	00	11	00	00	00	12	00	00	00	13	00	00	00
0000000050	14	00	00	00	15	00	00	00	16	00	00	00	17	00	00	00
0000000060	18	00	00	00	19	00	00	00	1A	00	00	00	1B	00	00	00
0000000070	1C	00	00	00	1D	00	00	00	1E	00	00	00	1F	00	00	00
0000000080	20	00	00	00	21	00	00	00	22	00	00	00	23	00	00	00
0000000090	24	00	00	00	25	00	00	00	26	00	00	00	27	00	00	00
00000000A0	28	00	00	00	29	00	00	00	2A	00	00	00	2B	00	00	00
0000000FC0	F0	03	00	00	F1	03	00	00	F2	03	00	00	F3	03	00	00
0000000FD0	F4	03	00	00	F5	03	00	00	F6	03	00	00	F7	03	00	00
0000000FE0	F8	03	00	00	F9	03	00	00	FA	03	00	00	FB	03	00	00
0000000FF0	FC	03	00	00	FD	03	00	00	FE	03	00	00	FF	03	00	00
0000001000	08	00	00	00	00	00	00	00	02	04	00	00	03	04	00	00
0000001010	04	04	00	00	05	04	00	00	06	04	00	00	07	04	00	00
0000001020	08	04	00	00	09	04	00	00	0A	04	00	00	0B	04	00	00

0x0000 – 0x0FFF : The 1st 4Kbyte data

64-bit header

0x1000 – 0x1FFF : The 2nd 4Kbyte data

Test data of 32-bit LFSR pattern

64-bit header of each 4Kbyte

64-bit header (Same value for every pattern) — Test data (32-bit LFSR)

0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00	00	00	00	00	00	00	00	01	00	00	00	02	00	00	00
04	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00
49	00	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	92	24	01	00	24	49	02	00
49	92	04	00	92	24	09	00	24	49	12	00	49	92	24	00
93	24	49	00	27	49	92	00	4F	92	24	01	9E	24	49	02
3C	49	92	04	79	92	24	09	F3	24	49	12	E7	49	92	24
CF	93	24	49	9E	27	49	92	3D	4F	92	24	7A	9E	24	49
F5	3C	49	92	EB	79	92	24	D7	F3	24	49	AE	E7	49	92
5D	CF	93	24	BA	9E	27	49	75	3D	4F	92	EB	7A	9E	24
76	15	F4	90	EC	2A	E8	21	D8	55	D0	43	B1	AB	A0	87
62	57	41	0F	C4	AE	82	1E	89	5D	05	3D	12	BB	0A	7A
24	76	15	F4	48	EC	2A	E8	91	D8	55	D0	23	B1	AB	A0
47	62	57	41	8F	C4	AE	82	1F	89	5D	05	3F	12	BB	0A
08	00	00	00	00	00	00	00	11	00	00	00	22	00	00	00
44	00	00	00	89	00	00	00	12	01	00	00	24	02	00	00
49	04	00	00	92	08	00	00	24	11	00	00	49	22	00	00

Figure 2-5 Example Test data of the 1st and 2nd 4Kbyte data by using incremental/LFSR pattern

Test data in SSD is split into 4096-byte (4K) unit. For incremental, decremental, and LFSR pattern, each 4K-byte data has a unique 64-bit header consisting of 48-bit address in 512-byte unit and 16-bit zero value. The header is the same value for every test pattern. The data after 64-bit header is the test pattern which is selected by user.

The left window of Figure 2-5 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.

Figure 2-6 shows the example error message when the input from the user is invalid. For example, the input is out-of-range or not aligned to 8 for some parameters. “Invalid input” is displayed as the error message and the operation is cancelled. After that, it returns to the main menu.

Error input

```
+++ Write Command selected +++

Enter number of user [1-4] => 5
Invalid number
```

Invalid input

```
+++ Write Command selected +++

Enter number of user [1-4] => 4
Select the 1st user [0-3]  => 4
Invalid user
```

Invalid input

```
+++ Write Command selected +++

Enter number of user [1-4] => 4
Select the 1st user [0-3]  => 0

Please input [Start Address] and [Length] in unit of 8
Enter Start Address (512 Byte)      : 0x0 - 0x209A97A8 => 0xFFFFFFFF
Invalid input
```

Out of range

```
+++ Write Command selected +++

Enter number of user [1-4] => 4
Select the 1st user [0-3]  => 0

Please input [Start Address] and [Length] in unit of 8
Enter Start Address (512 Byte)      : 0x0 - 0x209A97A8 => 0
Enter Length (512 Byte)             : 0x8 - 0x209A97B0 => 7
Invalid input
```

Address or length alignment error

```
+++ Write Command selected +++

Enter number of user [1-4] => 4
Select the 1st user [0-3]  => 0

Please input [Start Address] and [Length] in unit of 8
Enter Start Address (512 Byte)      : 0x0 - 0x209A97A8 => 0
Enter Length (512 Byte)             : 0x8 - 0x209A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 6
Invalid input
```

Invalid input

Figure 2-6 Error message from the invalid input

2.3 Read Command

Select ‘2’ to send Read command to NVMe SSD.

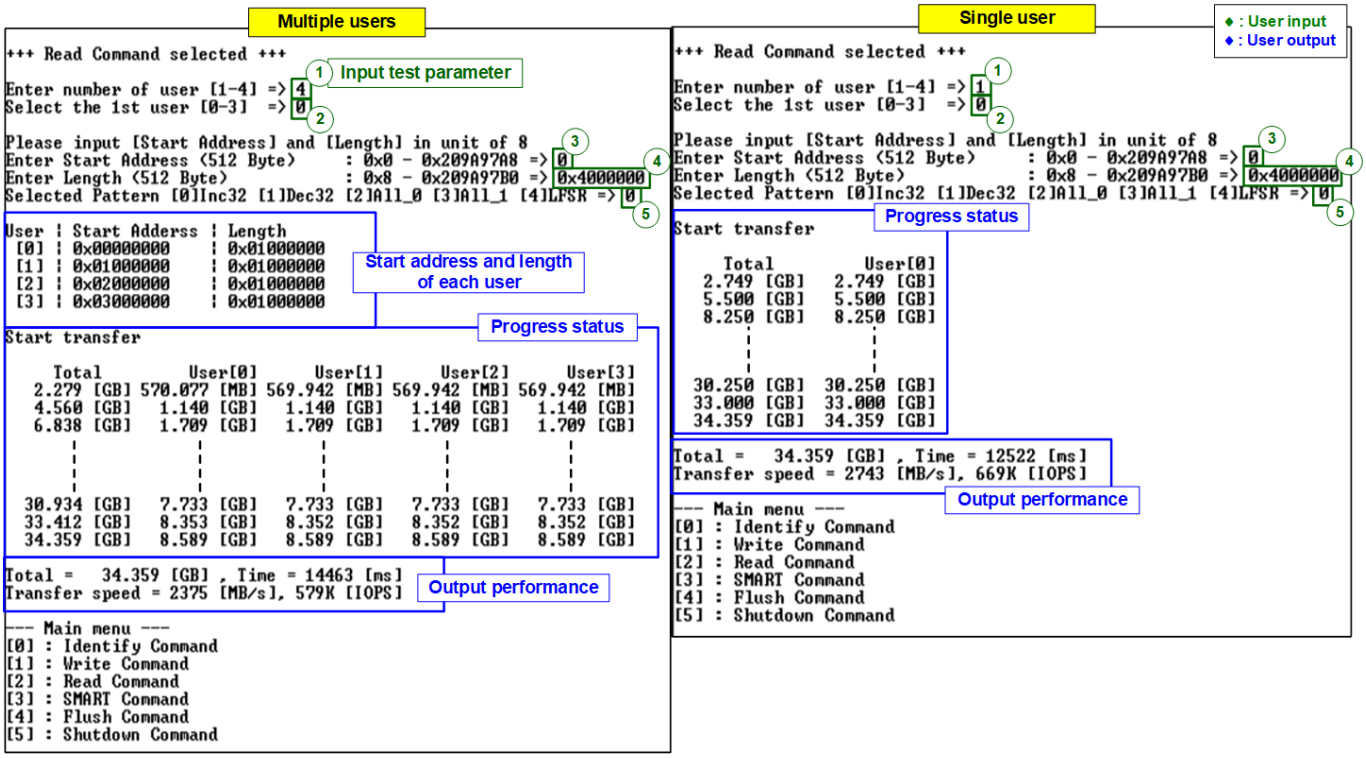

Figure 2-7 Test result when running Read command

There are five inputs parameters for running Read command, described as follows.

1) Number of users: Enter the number of users to write data. Valid from 1 to 4 users.
2) The first user: Select the first user to operate the command. Valid from 0 to 3.
3) 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, 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 verifying to SSD. 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 operation, the progress of the test such as the amount of transferred data is displayed on the console every second. Finally, total size, total time usage, and test speed are displayed on the console as a test result.

Note: If Number of users more than 1, the firmware will calculate start address and length for each user. The result of the calculation is displayed on console.

Figure 2-8 shows the error message when data verification is failed. “Verify fail” is displayed with the information of the 1st failure data of each user, 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.

After cancelling the operation, the read command still runs as the background process and may not finish in a good sequence. It is recommended to restart system before starting a new test

Verification error without cancellation

```
+++ Read Command selected +++

Enter number of user [1-4] => 4
Select the 1st user [0-3]  => 0

Please input [Start Address] and [Length] in unit of 8
Enter Start Address (512 Byte)      : 0x0 - 0x209A97A8 => 0
Enter Length (512 Byte)             : 0x8 - 0x209A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 1

User | Start Adderss | Length
 [0] | 0x00000000    | 0x01000000
 [1] | 0x01000000    | 0x01000000
 [2] | 0x02000000    | 0x01000000
 [3] | 0x03000000    | 0x01000000

Start transfer

Verify fail in user 0
1st Error at Byte Addr = 0x00000000
Expect Data            = 0xFFFFFFFC_FFFFFFFD_00000000_00000000
Read Data              = 0x00000003_00000002_00000000_00000000

Verify fail in user 1
1st Error at Byte Addr = 0x0000000200000000
Expect Data            = 0x7FFFFFFC_7FFFFFFD_00000000_01000000
Read Data              = 0x80000003_80000002_00000000_01000000

Verify fail in user 2
1st Error at Byte Addr = 0x0000000400000000
Expect Data            = 0xFFFFFFFC_FFFFFFFD_00000000_02000000
Read Data              = 0x00000003_00000002_00000000_02000000

Verify fail in user 3
1st Error at Byte Addr = 0x0000000600000000
Expect Data            = 0x7FFFFFFC_7FFFFFFD_00000000_03000000
Read Data              = 0x80000003_80000002_00000000_03000000
Press any key to cancel operation

    Total          User[0]       User[1]       User[2]       User[3]
  2.286 [GB] 571.748 [MB] 571.617 [MB] 571.613 [MB] 571.613 [MB]
  4.566 [GB]   1.141 [GB]   1.141 [GB]   1.141 [GB]   1.141 [GB]
        :             :             :             :             :
 33.337 [GB]   8.334 [GB]   8.334 [GB]   8.334 [GB]   8.334 [GB]
 34.359 [GB]   8.589 [GB]   8.589 [GB]   8.589 [GB]   8.589 [GB]

Total =   34.359 [GB] , Time = 14496 [ms]
Transfer speed = 2370 [MB/s], 578K [IOPS]

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

Wrong pattern

Message when data verification is failed

Progress status

Output performance

Verification error with cancellation

```
+++ Read Command selected +++

Enter number of user [1-4] => 4
Select the 1st user [0-3]  => 0

Please input [Start Address] and [Length] in unit of 8
Enter Start Address (512 Byte)      : 0x0 - 0x209A97A8 => 0
Enter Length (512 Byte)             : 0x8 - 0x209A97B0 => 0x4000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 1

User | Start Adderss | Length
 [0] | 0x00000000    | 0x01000000
 [1] | 0x01000000    | 0x01000000
 [2] | 0x02000000    | 0x01000000
 [3] | 0x03000000    | 0x01000000

Start transfer

Verify fail in user 0
1st Error at Byte Addr = 0x00000000
Expect Data            = 0xFFFFFFFC_FFFFFFFD_00000000_00000000
Read Data              = 0x00000003_00000002_00000000_00000000

Verify fail in user 1
1st Error at Byte Addr = 0x0000000200000000
Expect Data            = 0x7FFFFFFC_7FFFFFFD_00000000_01000000
Read Data              = 0x80000003_80000002_00000000_01000000

Verify fail in user 2
1st Error at Byte Addr = 0x0000000400000000
Expect Data            = 0xFFFFFFFC_FFFFFFFD_00000000_02000000
Read Data              = 0x00000003_00000002_00000000_02000000

Verify fail in user 3
1st Error at Byte Addr = 0x0000000600000000
Expect Data            = 0x7FFFFFFC_7FFFFFFD_00000000_03000000
Read Data              = 0x80000003_80000002_00000000_03000000
Press any key to cancel operation

    Total          User[0]       User[1]       User[2]       User[3]
  2.287 [GB] 571.928 [MB] 571.797 [MB] 571.797 [MB] 571.797 [MB]
  4.566 [GB]   1.141 [GB]   1.141 [GB]   1.141 [GB]   1.141 [GB]

Operation is cancelled
Please reset system before starting new test

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

Wrong pattern

User enters some keys to cancel the operation

Message when operation is cancelled

Figure 2-8 Data verification is failed

2.4 SMART Command

Select ‘3’ to send SMART command to NVMe SSD.

```
+++ SMART Command selected +++

Enter number of user [1-4] => 1
Select the 1st user [0-3]  => 0

<< User[0] SMART Log Information >>

<< Health Status >>
Remaining Life   : 100%

<< SMART Log Information >>
Percentage Used                  : 0%
Temperature                      : 31 Degree Celsius
Total Data Read                  : 69803 GB
Total Data Read (Raw data)       : 0x00000000_00000000_00000000_08202C32
Total Data Written               : 84858 GB
Total Data Written (Raw data)    : 0x00000000_00000000_00000000_09E0CF04
Power On Cycles                  : 1398 Times
Power On Hours                   : 128 Hours
Unsafe Shutdowns                 : 539 Times

SMART Command Complete

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

Enter number of user to send command

Select the first user

♦ : User input
♦ : User output

Data output decoded from SMART command (Output from 1st user)

Figure 2-9 Test result when running SMART command

There are two inputs for running SMART command, described as follows.
1) Number of users: Enter number of users to send command. Valid from 1 to 4 users.
2) The first user: Select the first user to operate the command. Valid from 0 to 3.

If all inputs are valid, the operation is started. SMART command of the first user is sent to the SSD. After the operation is done, 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 as 128-bit hexadecimal unit. 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 as 128-bit hexadecimal unit. 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

If the current user is not the last user, repeat to send SMART command for the next user and display the result on the console.

2.5 Flush Command

Select ‘4’ to send Flush command to NVMe SSD.

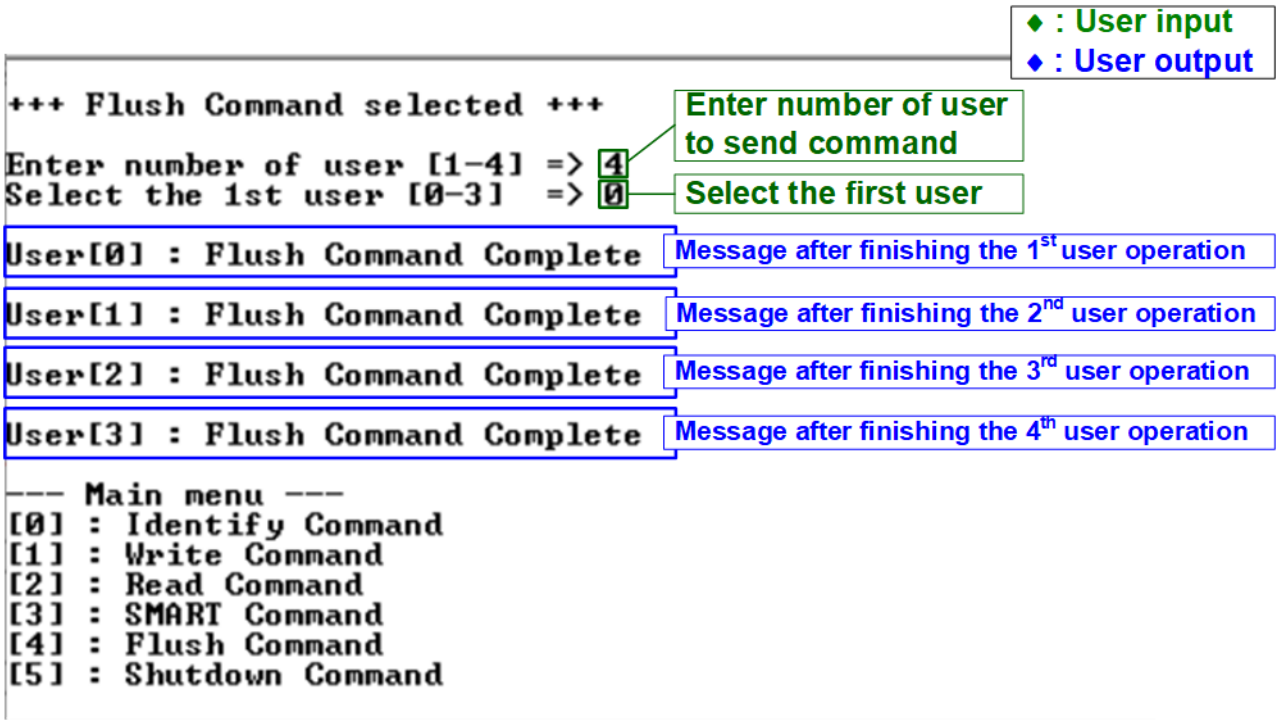

Figure 2-10 Test result when running Flush command

There are two inputs for running Flush command, described as follows.
1) Number of users: Enter number of users to send command. Valid from 1 to 4 users.
2) The first user: Select the first user to operate the command. Valid from 0 to 3.

If all inputs are valid, the operation is started. After finishing Flush operation, the massage “Flush Command Complete” is displayed. If the current user is not the last user, repeat to send Flush command for the next user. The complete message is displayed on the console after the operation of each user is done.

2.6 Shutdown Command

Select ‘5’ to send Shutdown command to NVMe SSD.

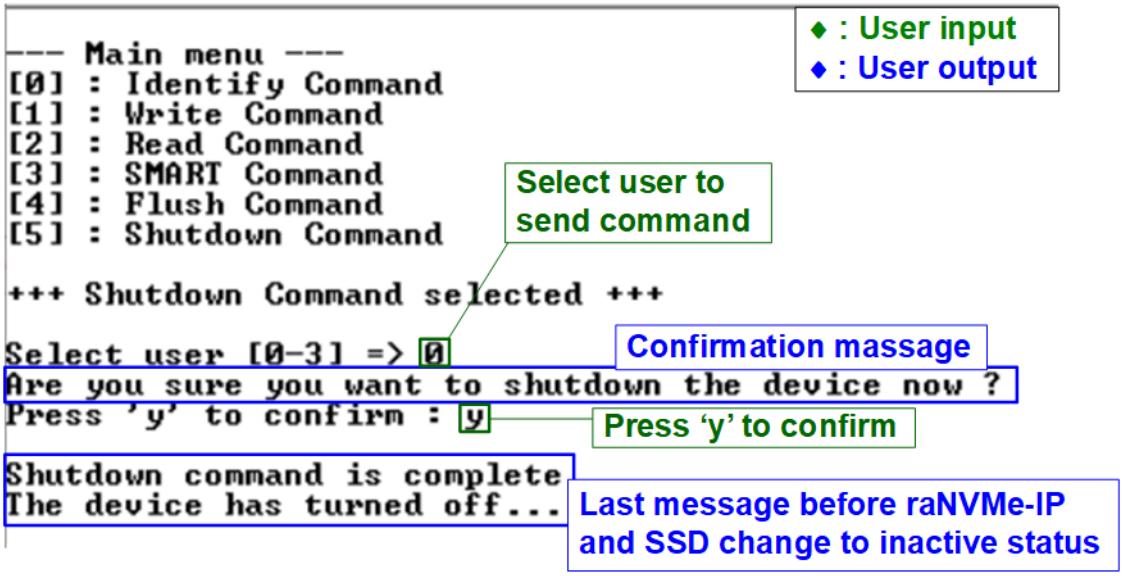

Figure 2-11 Test result when running Shutdown command

The shutdown command can run once in a system.

- User selects the user for sending the command which is valid from 0 to 3. If the input is valid, the confirmation message is displayed on the console.
- User enters ‘y’ or ‘Y’ to continue the operation or 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
1.1	31-May-22	Update SMART log information
1.0	12-Jan-21	Initial version release