



2-Ch RAID0 (NVMeG3-IP) Demo Instruction

Rev1.0 28-Jun-23

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2-Ch RAID0 (NVMeG3-IP) Demo Instruction

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This document describes the instruction to run 2-ch RAID0 demo on FPGA development board by using the AB17-M2FMC board. The demo is designed to write/verify data with two M.2 NVMe SSDs as RAID0 operation. It is recommended to use the same SSD model for all SSDs. User controls test operation through Serial console.

1 Environment Requirement

To run the demo on FPGA development board, please prepare following environment.

- 1) FPGA Development board: ZCU106, ZCU102
- 2) PC installing Xilinx programmer software (Vivado) and Serial console software such as TeraTerm.
- 3) AB17-M2FMC board, provided by Design Gateway.
- 4) Xilinx power adapter for FPGA board
- 5) Two M.2 NVMe SSDs, inserting to M.2 connector on AB17.
- 6) Two micro USB cables for programming FPGA and Serial console, connecting between FPGA board and PC

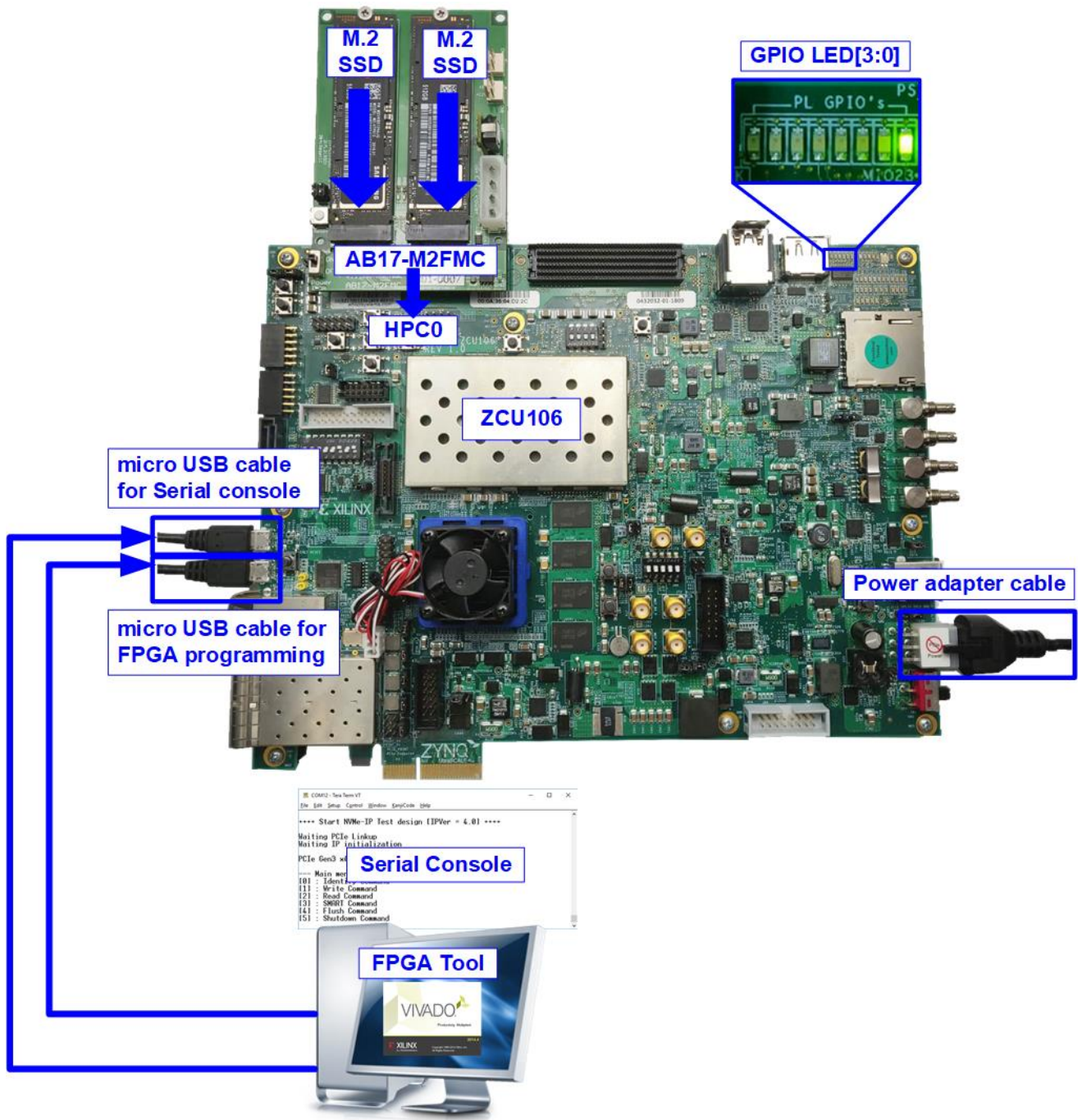


Figure 1-1 NVMeG3-IP RAID0 demo setup by AB17 on ZCU106

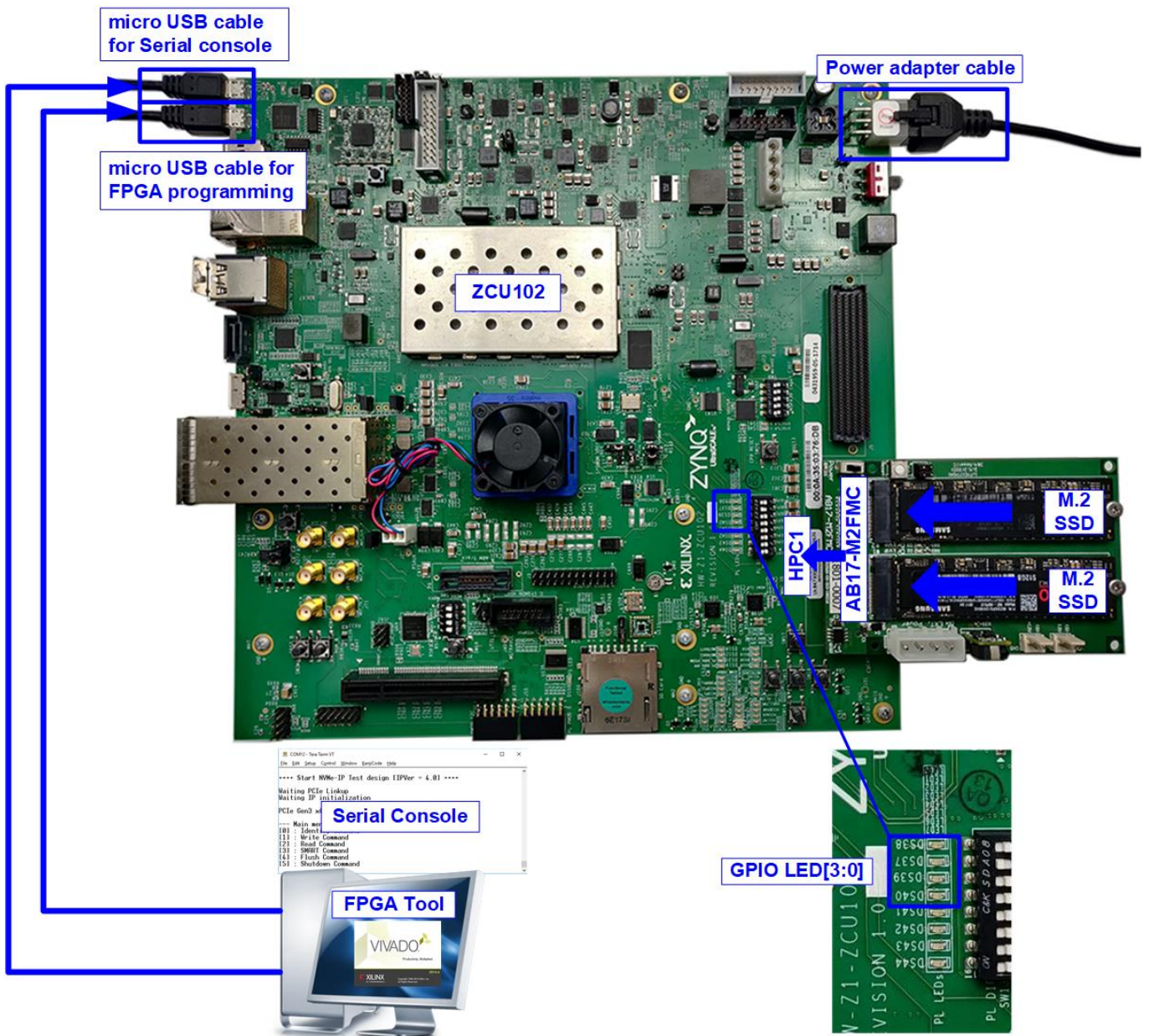


Figure 1-2 NVMeG3-IP RAID0 demo setup by AB17 on ZCU102

2 Demo setup

- 1) Power off system.
- 2) Connect two M.2 NVMe SSDs to Drive#1 and #2 connector on AB17-M2FMC
- 3) Connect AB17-M2FMC to HPC0 (J5) for ZCU106 or HCP1 (J4) for ZCU102 (J4), as shown in Figure 2-1.

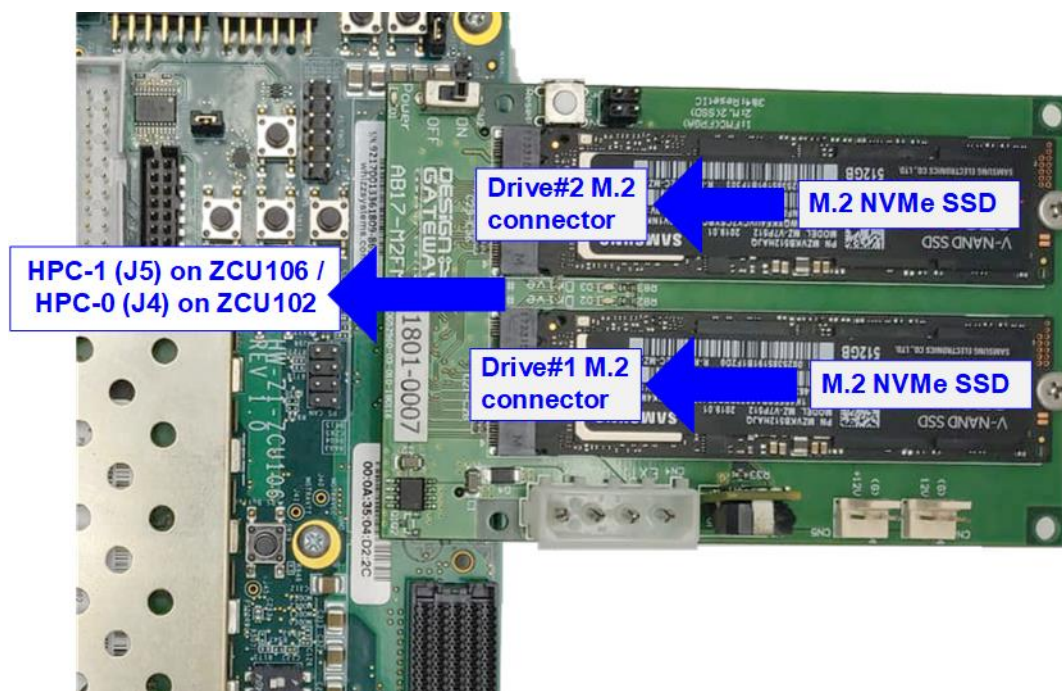


Figure 2-1 Connect AB17 to FPGA board

- 4) Connect two micro USB cables between FPGA board and PC for FPGA programming and Serial console.

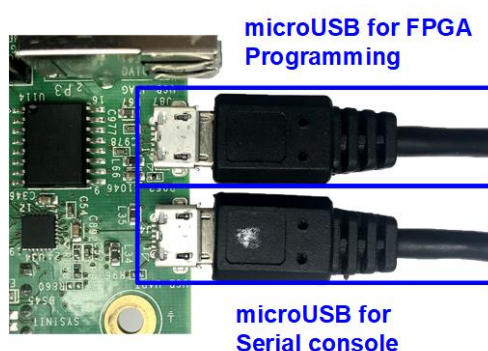


Figure 2-2 USB cable connection

- 5) Power on FPGA development board.

- 6) On PC, additional COM port is detected after connecting USB cables to FPGA board. More than one COM ports are detected. In case of ZCU106/ZCU102, select Interface 0 COM port as shown in Figure 2-3. On Serial console, the setting is as follows. Baud rate=115,200, Data=8-bit, Non-Parity, and Stop = 1.

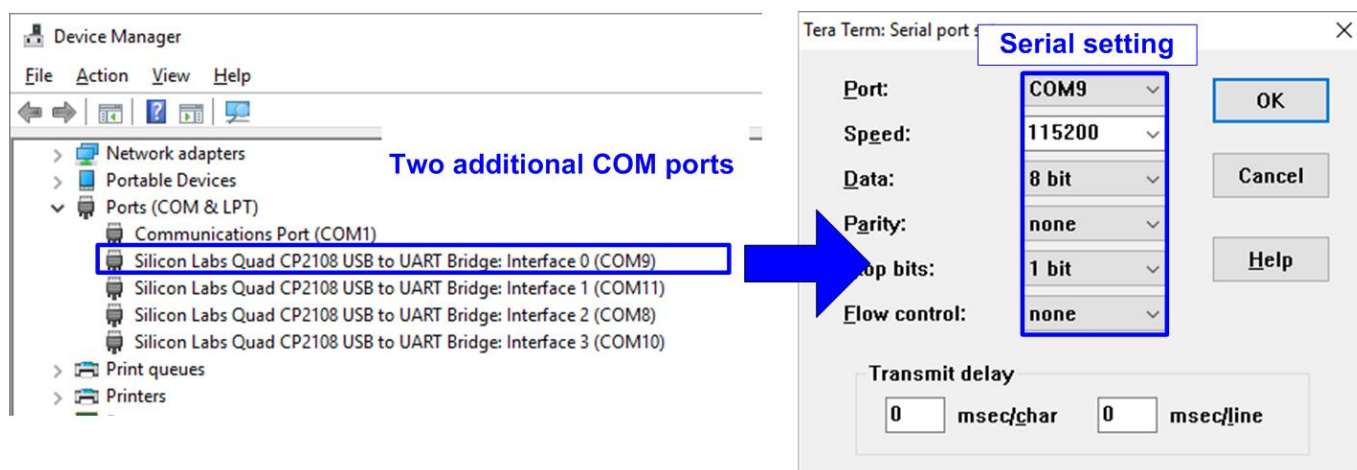


Figure 2-3 Two COM ports from FPGA connection

- 7) Open Vivado TCL shell and change directory to download or directory that batch file is located. Next, type NVMeG3IPRaid0x2Test.bat_ZCU106/ZCU102.bat, as shown in Figure 2-4.

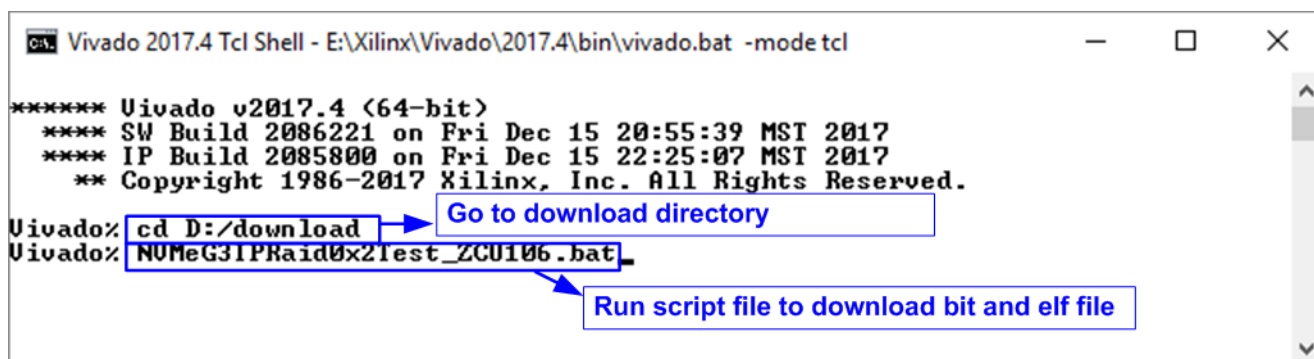


Figure 2-4 Command script to download demo file on Vivado TCL shell

- 8) Check LED status on FPGA board. The description of LED is as follows.

Table 2-1 LED Definition

GPIO LED	ON	OFF
0	Normal operation	SSD is not good status
1	System is busy	Idle status
2	IP Error detect	Normal operation
3	Data verification fail	Normal operation

- 9) After programming completely, LED[0] and LED[1] are ON during PCIe initialization process. Then, LED[1] changes to OFF after PCIe completes initialization process.



Figure 2-5 LED status after programming configuration file and finishing PCIe initialization

- 10) On the console, the message is displayed to show current status as follows.
- “Waiting IP initialization” is displayed after PCIe is linked up.
 - After RAID0 finishes initialization, main menu to run six commands is shown on the console.

```

VT COM9 - Tera Term VT
File Edit Setup Control Window Help

++++ Start NUMeG3-IP RAID0x2 Test design [Uer = 1.1] ++++

Waiting IP initialization
Wait RAID0 busy

--- Main menu [IPUer = 1.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command
    
```

Figure 2-6 Main menu after RAID0 finishes initialization

When LBA size is 4 Kbyte, the error message is displayed on the console as shown in Figure 2-7

```

VT COM9 - Tera Term VT
File Edit Setup Control Window Help

++++ Start NUMeG3-IP RAID0x2 Test design [Uer = 1.1] ++++

Waiting IP initialization
Warning : LBA Size Not Support!
Please Check Devices
    
```

Figure 2-7 Error message when LBA does not support

3 Test Menu

3.1 Identify Command

Select '0' to send Identify command to RAID0.

```

COM9 - Tera Term VT
File Edit Setup Control Window Help
+++ Identify Command selected +++
Ch[0]Model Number : Samsung SSD 970 PRO 512GB
Ch[1]Model Number : Samsung SSD 970 PRO 512GB
RAID Capacity= 1024[GB]
--- Main menu [IPVer = 1.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command
  
```

Model name, SSD capacity, and RAID0 capacity

Figure 3-1 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.

3.2 Write Command

Select '1' to send Write command to RAID0.

```

COM9 - Tera Term VT
Normal
Green: User input
Blue: Output to user
File Edit Setup Control Window Help

+++ Write Command selected +++
Enter Start Address (512 Byte) : 0 - 0x773C255F => 0x00000000
Enter Length (512 Byte) : 1 - 0x773C2560 => 0x80000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4

4.725 [GB]
9.419 [GB]
14.081 [GB]
|
56.292 [GB]
60.951 [GB]
65.642 [GB]

Total = 68.719 [GB] , Time = 14651[ms] , Transfer speed = 4643[MB/s]

--- Main menu [IPVer = 1.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command

```

Figure 3-2 Test result when running Write command

User sets three parameters as follows.

- 1) Start Address: Start address to write RAID0 as 512-byte unit. The input is decimal unit when the input is only digit number. User can add "0x" as a prefix for hexadecimal unit.
- 2) Transfer Length: Total transfer size as 512-byte unit. The input is decimal unit when the input is only digit number. User can add "0x" as a prefix for hexadecimal unit.
- 3) Test pattern: Select test data pattern for writing 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. During writing data, current transfer size is displayed on the console every second to show that system is still alive. Finally, total size, total time usage, and test speed are calculated and displayed on the console as a test result.

← 64-bit header of each sector →

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	00	00	02	00	00	00	04	00	00	00
0000000010	04	00	00	00	09	00	00	12	00	00	00	24	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00	00	00
0000000020	49	00	00	00	92	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	00	00
0000000030	92	04	00	00	24	09	00	49	12	00	00	92	24	00	00	24	09	00	00	49	12	00	00	92	24	00	00	24	49	00	00	00	00
0000000040	24	49	00	00	49	92	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	00	00
0000000050	49	92	04	00	92	24	09	24	49	12	00	49	92	24	00	92	24	09	00	24	49	12	00	49	92	24	00	93	24	49	00	00	00
SSD#0																SSD#1																	
00000001A0	A0	E1	C6	74	41	C3	8D	E9	83	86	1B	D3	06	0D	37	A6	41	C0	8D	E9	83	86	1B	D3	06	0D	37	A6	0C	1A	6E	4C	
00000001B0	0C	1A	6E	4C	18	34	DC	98	30	68	B8	31	60	D0	70	63	18	34	DC	98	30	68	B8	31	60	D0	70	63	C0	A0	E1	C6	
00000001C0	C0	A0	E1	C6	81	41	C3	8D	03	83	86	1B	07	06	0D	37	81	41	C3	8D	03	83	86	1B	07	06	0D	37	0F	0C	1A	6E	
00000001D0	0F	0C	1A	6E	1F	18	34	DC	3F	30	68	B8	7F	60	D0	70	1F	18	34	DC	3F	30	68	B8	7F	60	D0	70	FF	C0	A0	E1	
00000001E0	FF	C0	A0	E1	FF	81	41	C3	FE	03	83	86	FD	07	06	0D	FF	81	41	C3	FE	03	83	86	FD	07	06	0D	FA	0F	0C	1A	
00000001F0	FA	0F	0C	1A	F4	1F	18	34	E9	3F	30	68	D3	7F	60	D0	F4	1F	18	34	E9	3F	30	68	D3	7F	60	D0	A7	FF	C0	A0	
0000000200	02	00	00	00	00	00	00	00	04	00	00	00	09	00	00	00	03	00	00	00	00	00	00	00	00	07	00	00	00	0F	00	00	00
0000000210	12	00	00	00	24	00	00	00	49	00	00	00	92	00	00	00	1F	00	00	00	3F	00	00	00	00	7F	00	00	00	FF	00	00	00

Figure 3-3 Example Test data of the 1st 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 is mapped to the first 512-byte of SSD#0 while the 2nd stripe is mapped to the first 512-byte of SSD#1, as shown in Figure 3-3. The unique header is not included when running all-0 or all-1 pattern.

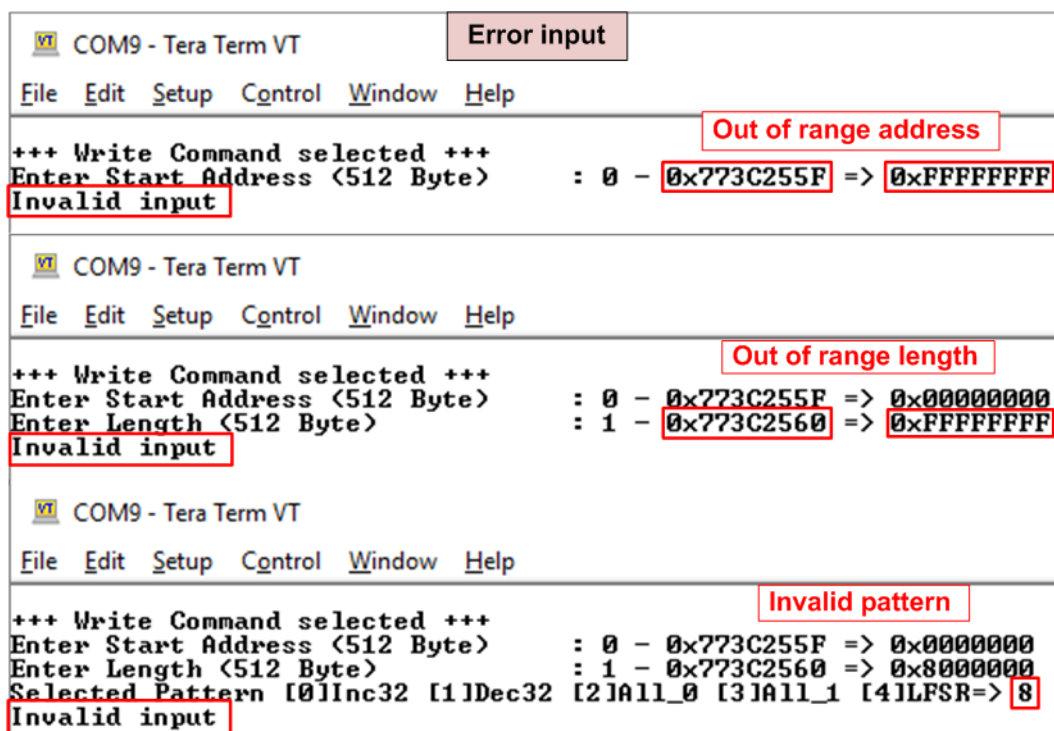


Figure 3-4 Error message from the invalid input

Figure 3-4 shows the example when the input is not in the recommended range for each parameter. The console displays “Invalid input” and then the operation is cancelled.

3.3 Read Command

Select '2' to send Read command to RAID0.

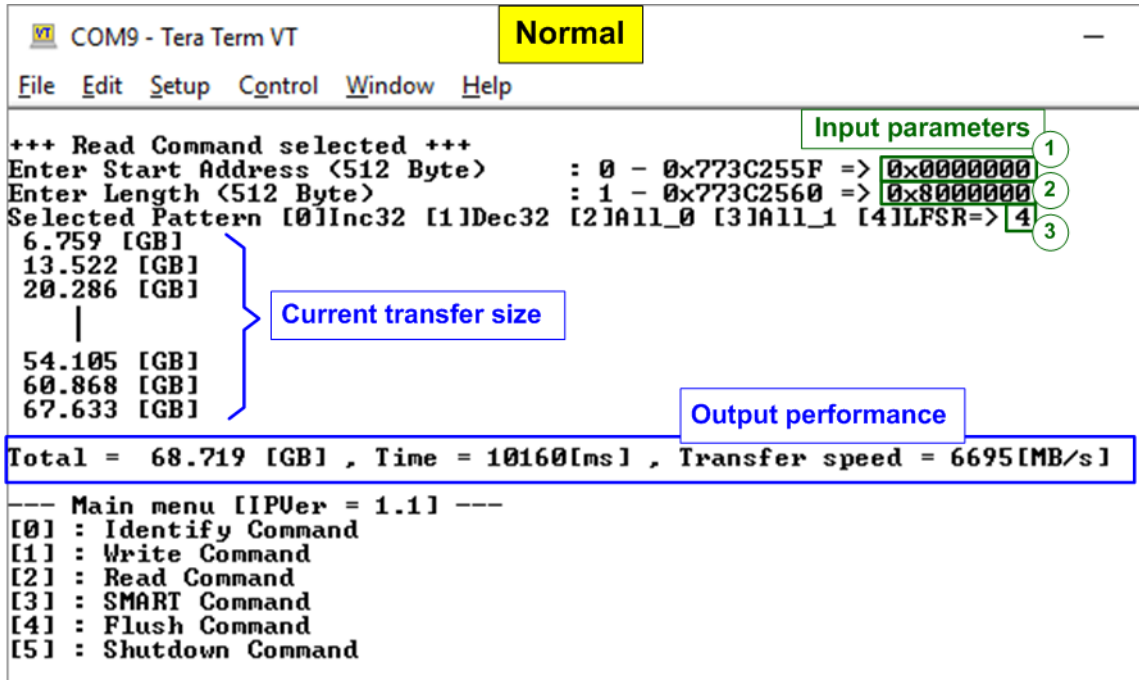


Figure 3-5 Input and result of Read Command menu

User inputs three parameters as follows.

- 1) Start Address: Start address to read SSD as 512-byte unit. The input is decimal unit when the input is only digit number. User can add "0x" as a prefix for hexadecimal unit.
- 2) Transfer Length: Total transfer size as 512-byte unit. The input is decimal unit when the input is only digit number. User can add "0x" as a prefix for hexadecimal unit
- 3) 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 starts reading data from RAID0 when all inputs are valid. During reading data, current transfer size is displayed on the console every second to show that system is still alive. Total size, total time usage, and test speed are calculated and displayed after finishing data transferring.

Figure 3-6 shows error message when data verification is failed. “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 or wait until finishing Read command. Without cancelling the operation, the read operation runs until finish and displays the performance on the console as a test result.

When cancelling the operation, the read command still runs as the background process. So, the operation does not complete in the good sequence. It is recommended to power-off/on AB18/AB16 and then presses “RESET” button to restart system.

```

COM9 - Tera Term VT Verification error without cancellation
File Edit Setup Control Window Help

+++ Read Command selected +++
Enter Start Address (512 Byte) : 0 - 0x773C255F => 0x00000000
Enter Length (512 Byte) : 1 - 0x773C2560 => 0x80000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 1 Wrong pattern

Verify fail Message when verification is failed
1st Error at Byte Addr = 0x00000000
Expect Data[255:128] = 0xFFFFFFFF8_FFFFFFFF9_FFFFFFFFA_FFFFFFFFB
Expect Data[127:0] = 0xFFFFFFFFC_FFFFFFFFD_00000000_00000000
Read Data[255:128] = 0x0007FFFF_FFF80004_0003FFFF_FFFC0002
Read Data[127:0] = 0x0001FFFF_FFFE0001_00000000_00000000

Press any key to cancel operation
6.762 [GB]
13.527 [GB]
20.291 [GB]
27.055 [GB]
33.820 [GB]
40.584 [GB]
47.350 [GB]
54.114 [GB]
60.878 [GB]
67.642 [GB] Output performance

Total = 68.719 [GB] , Time = 10159[ms] , Transfer speed = 6696[MB/s]

COM9 - Tera Term Verification error with cancellation
File Edit Setup Control Window Help

+++ Read Command selected +++
Enter Start Address (512 Byte) : 0 - 0x773C255F => 0x00000000
Enter Length (512 Byte) : 1 - 0x773C2560 => 0x80000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 1 Wrong pattern

Verify fail Message when verification is failed
1st Error at Byte Addr = 0x00000000
Expect Data[255:128] = 0xFFFFFFFF8_FFFFFFFF9_FFFFFFFFA_FFFFFFFFB
Expect Data[127:0] = 0xFFFFFFFFC_FFFFFFFFD_00000000_00000000
Read Data[255:128] = 0x0007FFFF_FFF80004_0003FFFF_FFFC0002
Read Data[127:0] = 0x0001FFFF_FFFE0001_00000000_00000000

Press any key to cancel operation User presses any keys to cancel the operation
6.762 [GB]
Operation is cancelled Message when operation is cancelled
Please reset system before starting a new test

--- Main menu [IPVer = 1.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command

```

Figure 3-6 Data verification is failed

3.4 SMART Command

Select '3' to send SMART command to RAID0.

```

COM9 - Tera Term VT
File Edit Setup Control Window Help
+++ SMART Command selected +++
<< SMART Log Information Ch[0] >>
Temperature : 42 Degree Celsius
Total Data Read : 10204 GB
Total Data Read <Raw data> : 0x00000000_00000000_00000000_01301849
Total Data Written : 13104 GB
Total Data Written <Raw data> : 0x00000000_00000000_00000000_018683C7
Power On Cycles : 335 Times
Power On Hours : 24 Hours
Unsafe Shutdowns : 213 Times

<< SMART Log Information Ch[1] >>
Temperature : 41 Degree Celsius
Total Data Read : 8127 GB
Total Data Read <Raw data> : 0x00000000_00000000_00000000_00F23024
Total Data Written : 11821 GB
Total Data Written <Raw data> : 0x00000000_00000000_00000000_0160491A
Power On Cycles : 273 Times
Power On Hours : 33 Hours
Unsafe Shutdowns : 143 Times

SMART Command Complete

--- Main menu [IPVer = 1.1] ---
[0] : Identify Command
[1] : Write Command
    
```

Data output decoded from SMART command

Figure 3-7 Test result when running SMART command

When finishing the operation, SMART/Health Information (output from SMART command) is displayed as shown in Figure 3-7. The console shows six values from each SSD, described as follows.

- 1) Temperature in °C unit.
- 2) Total Data Read decoded as GB/TB unit. Additionally, raw data without decoding is displayed as 128-bit hexadecimal unit. The unit size of raw data is 512,000 byte.
- 3) Total Data Written decoded as GB/TB unit. Additionally, raw data without decoding is displayed as 128-bit hexadecimal unit. The unit size of raw data is 512,000 byte.
- 4) Power On Cycles: Display the number of power cycles.
- 5) Power On Hours: Display period of time in hours to show how long the SSD has been powered on.
- 6) Unsafe Shutdowns: Display the number of unsafe shutdowns of SSD

3.5 Flush Command

Select '4' to send Flush command to RAID0.

```

COM9 - Tera Term VT
File Edit Setup Control Window Help
+++ Flush Command selected
Flush Command Complete
--- Main menu [IPVer = 1.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command
  
```

Figure 3-8 Test result when running Flush command

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

3.6 Shutdown Command

Select '5' to send Shutdown command to RAID0.

```

COM9 - Tera Term VT
File Edit Setup Control Window Help
--- Main menu [IPVer = 1.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : 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.
  
```

The confirmation message is displayed on the console. User enters 'y' or 'Y' to confirm 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 and user needs to power off/on the test system to start new test operation.



4 Revision History

Revision	Date	Description
1.0	17-Feb-20	Initial version release