4-Ch RAID0 (NVMeG3-IP) Demo Instruction

Rev1.1   28-Jun-23

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This document describes the instruction to run 4-ch RAID0 demo on FPGA development board by using the AB18-PCIeX16 board and Quad M.2 Card. The demo is designed to write/verify data with four M.2 NVMe SSDs for RAID0 operation. It is recommended to use the same SSD model for every channel. 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: VCU118
2) PC installing Xilinx programmer software (Vivado) and Serial console software such as TeraTerm.
3) AB18-PCIeX16 board
4) ATX power supply for AB18
5) Xilinx power adapter for FPGA board
6) ASROCK Ultra Quad M.2 Card, connecting B side (Device) of AB18.
    https://www.asrock.com/mb/spec/product.asp?Model=ULTRA QUAD M.2 CARD
7) Four M.2 NVMe SSDs.
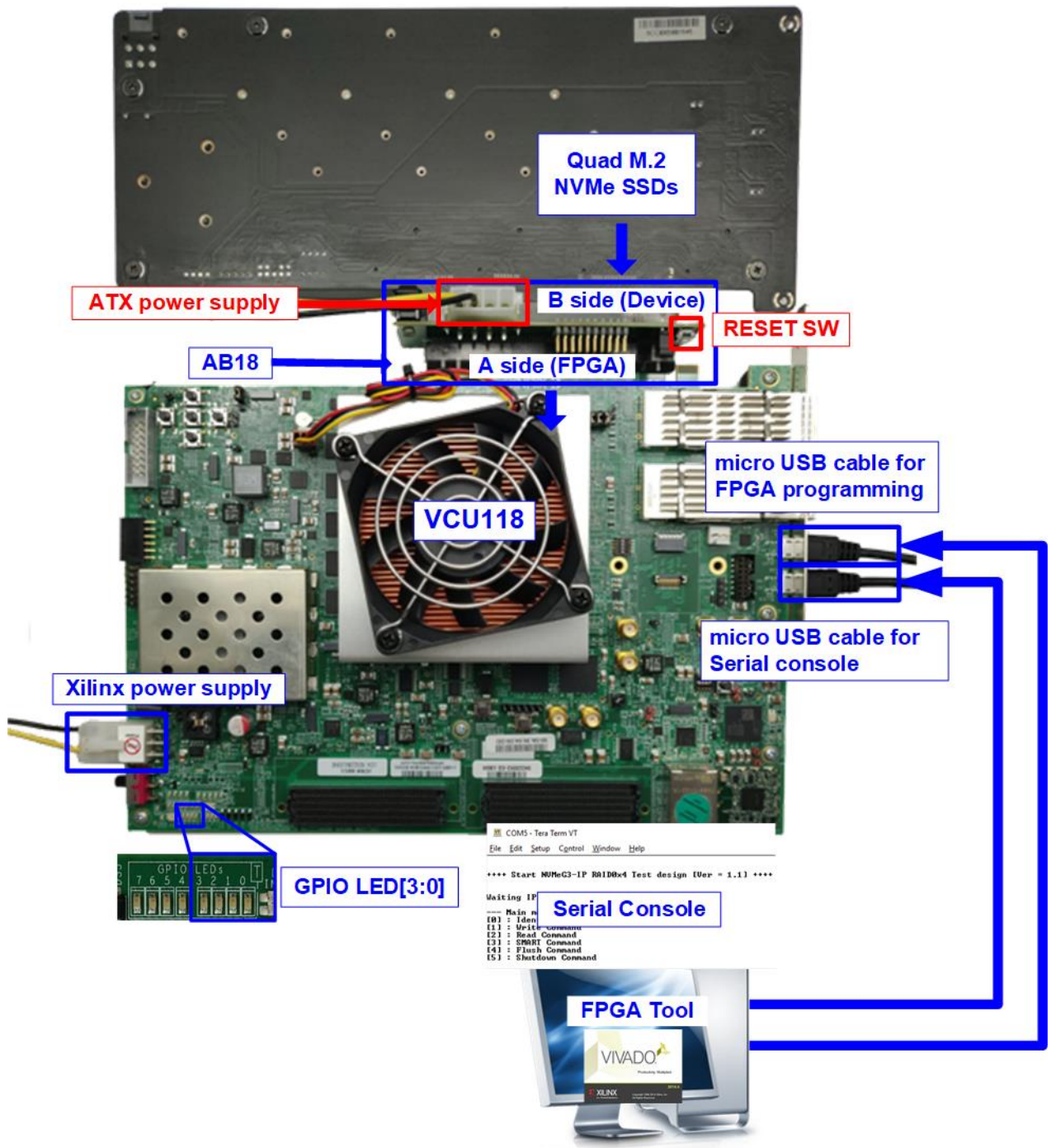8) Two micro USB cables for programming FPGA and Serial console, connecting between FPGA board and PC

Figure 1-1 NVMeG3-IP RAID0 demo setup by AB18 on VCU118

2   Demo setup

1) Power off system. Then, connect ATX power supply to AB18-PCIeX16 board and Xilinx power adapter to FPGA development board.
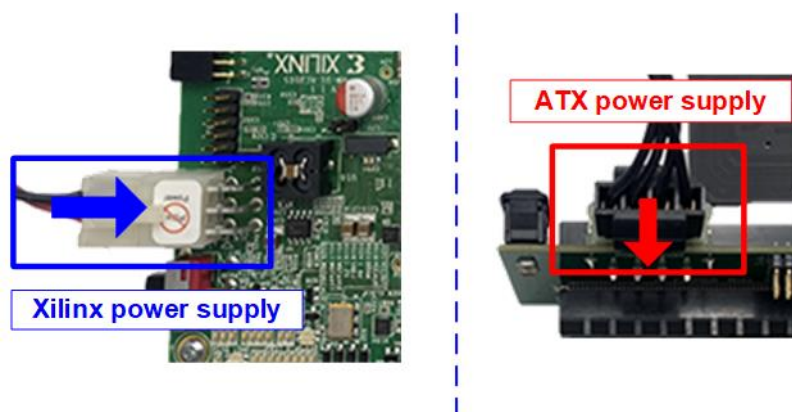

Figure 2-1 Power supply connection

2) Connect four M.2 NVMe SSDs to four connectors on Ultra Quad M.2 Card as shown in Figure 2-2.

Figure 2-2 Four M.2 NVMe SSDs with Ultra Quad M.2 Card

3) Confirm that two mini jumpers are inserted at J5 connector on AB18. After that, connect FPGA Side (A-side) on AB18 to PCIe connector on FPGA board and connect Quad M.2 NVMe SSD Card to device side (B-Side) on AB18, as shown in Figure 2-3.
Warning: Please confirm that the Quad M.2 Card is inserted in the correct side of AB18 (B-side, not A-side) before power on system.
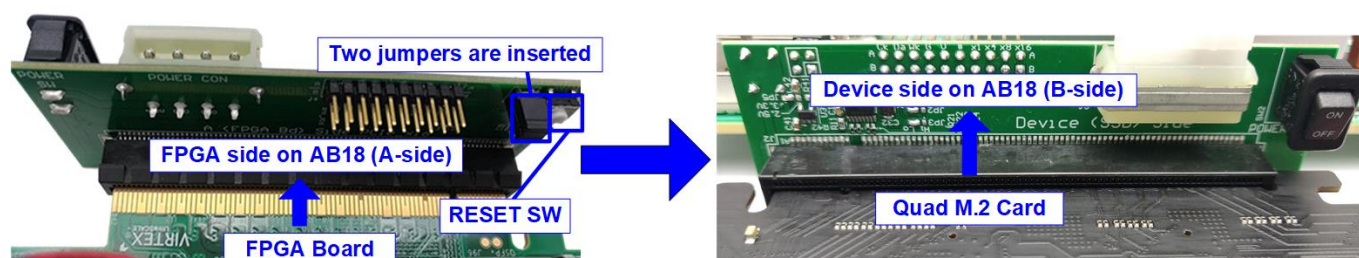

Figure 2-3 Connect Adapter board to Quad M.2 NVMe SSD Card and FPGA board

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

microUSB for FPGA Programming

microUSB for Serial console
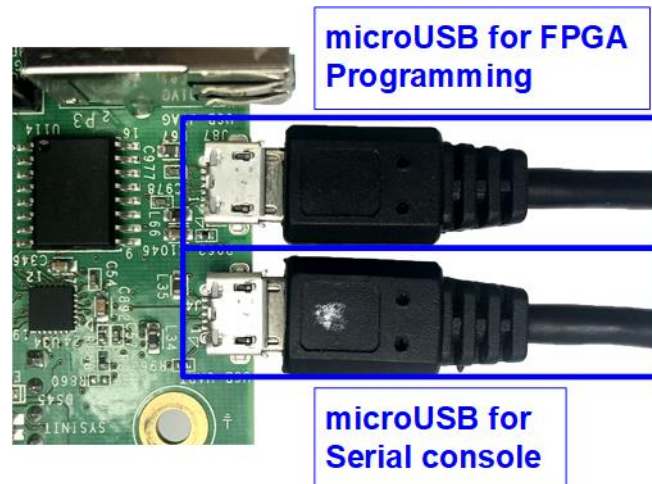
Figure 2-4 USB cable connection

5) Power on FPGA development board, ATX power supply for AB18, and AB18 board, as shown in Figure 2-5.

Power switch on AB18

Power switch on FPGA board

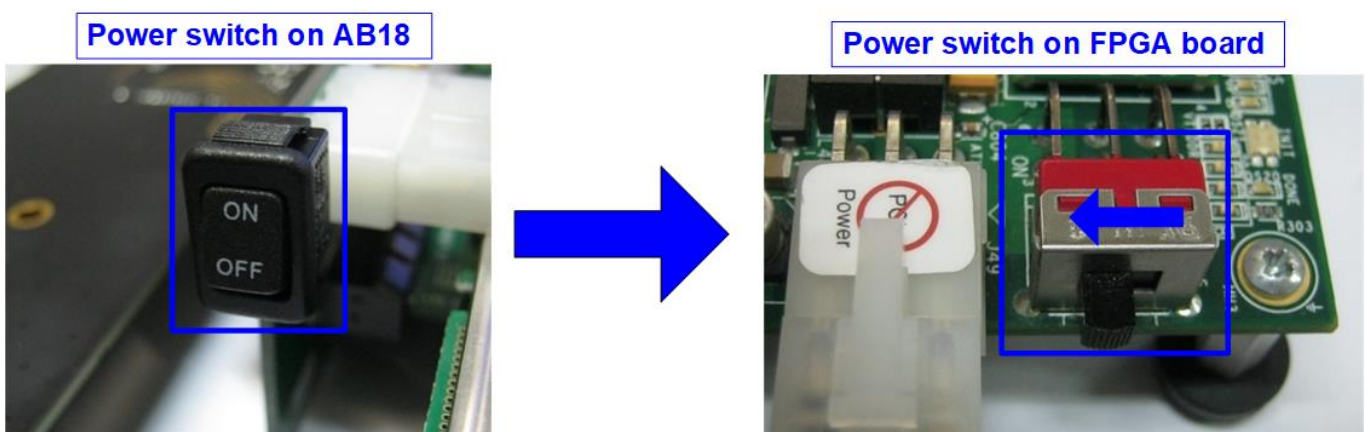Figure 2-5 Turn on power switch on FPGA and adapter board

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 VCU118, select Standard COM port as shown in Figure 2-6.

On Serial console, the setting is as follows.
Baud rate=115,200, Data=8-bit, Non-Parity, and Stop = 1.
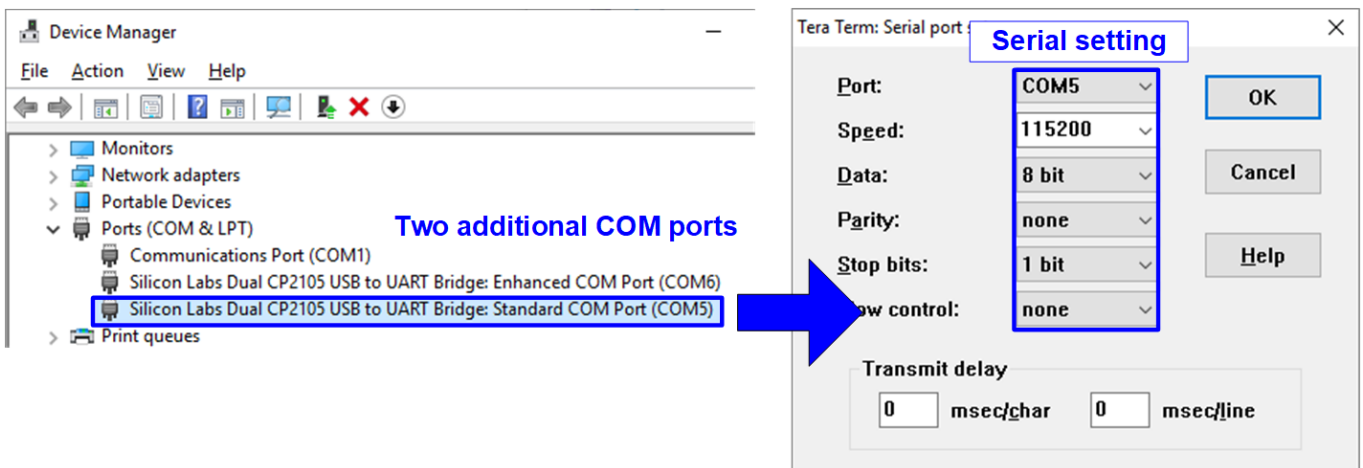
Figure 2-6 Two COM ports from FPGA connection

7) Use Vivado tool to download configuration file, as shown in Figure 2-7.

a. Click Open Hardware Manager

b. Open target -> Auto Connect

c. Select FPGA device to program bit file

d. Click Program device

e. Click "…" to select Programming file (NVMeG3IPRaid0x4Test_xxx.bit)

f. Click Program button to start FPGA programming

Figure 2-7 Programmed by Vivado

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

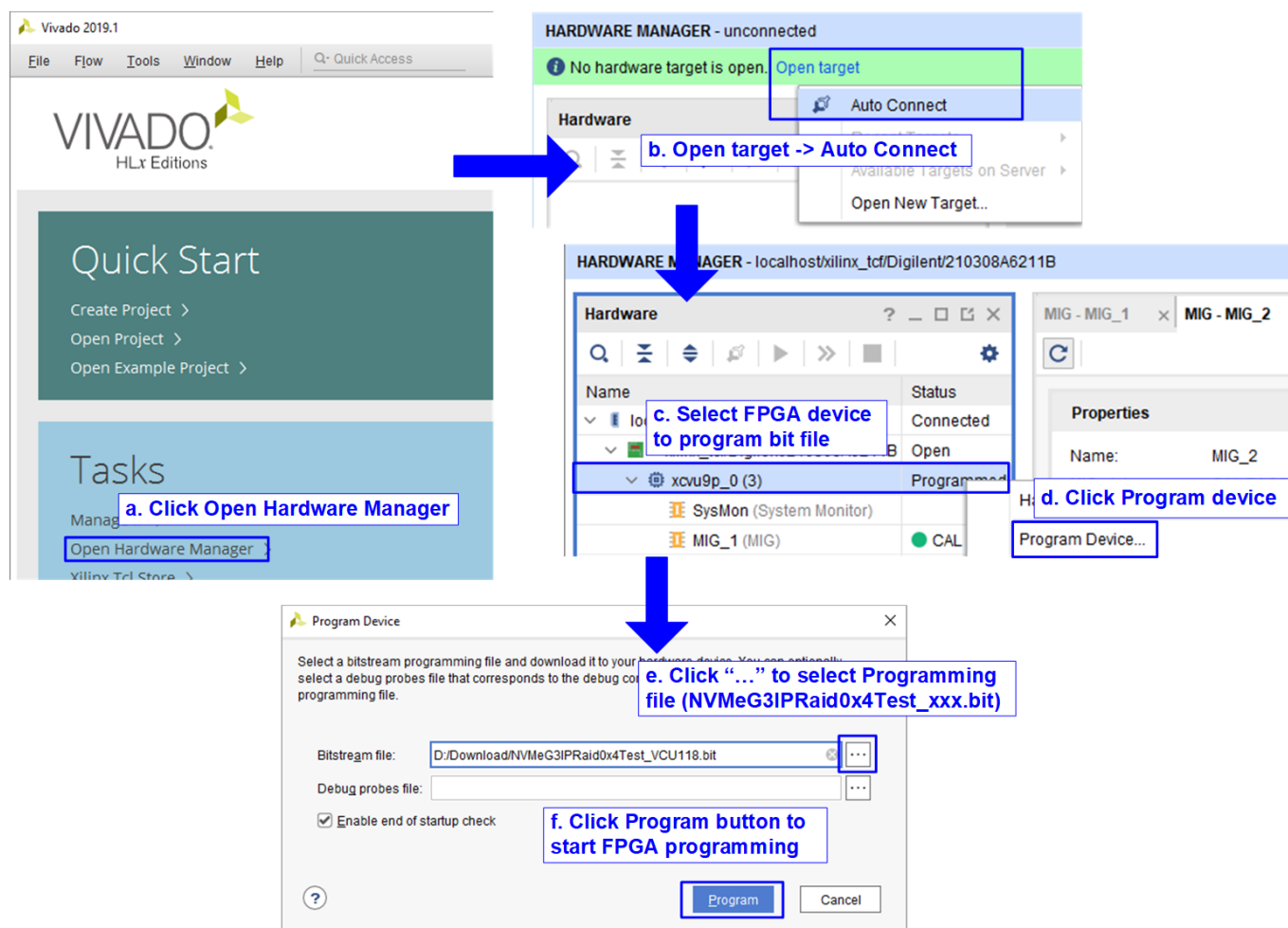9) After programming completely, LED[0] and LED[1] are ON during PCIe initialization process. Then, LED[1] changes to OFF after PCIe completes initialization process.

Figure 2-8 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.
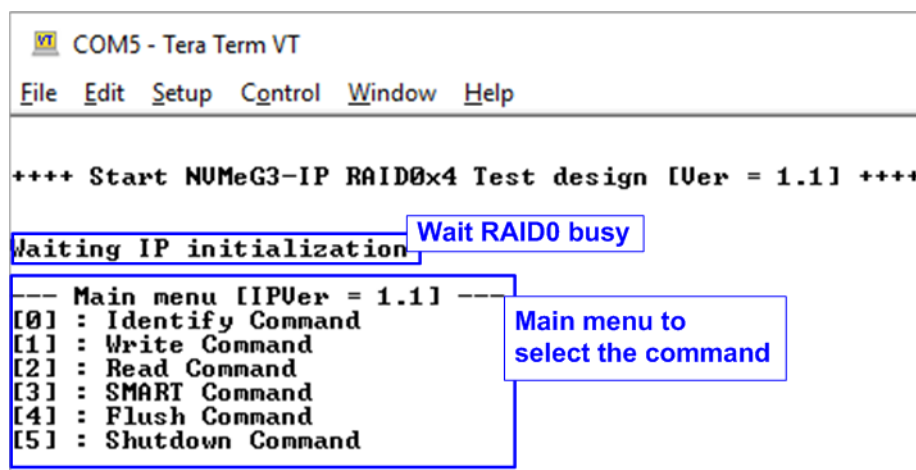
Figure 2-9 Main menu after RAID0 finishes initialization

When LBA size is 4 Kbyte, the error message is displayed on the console as shown in Figure 2-10
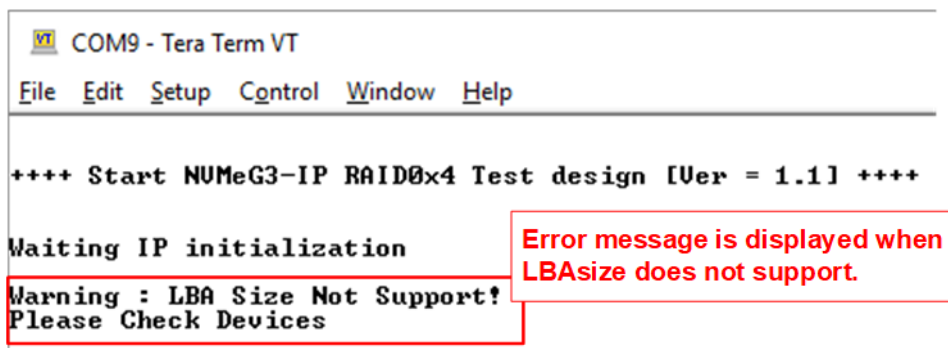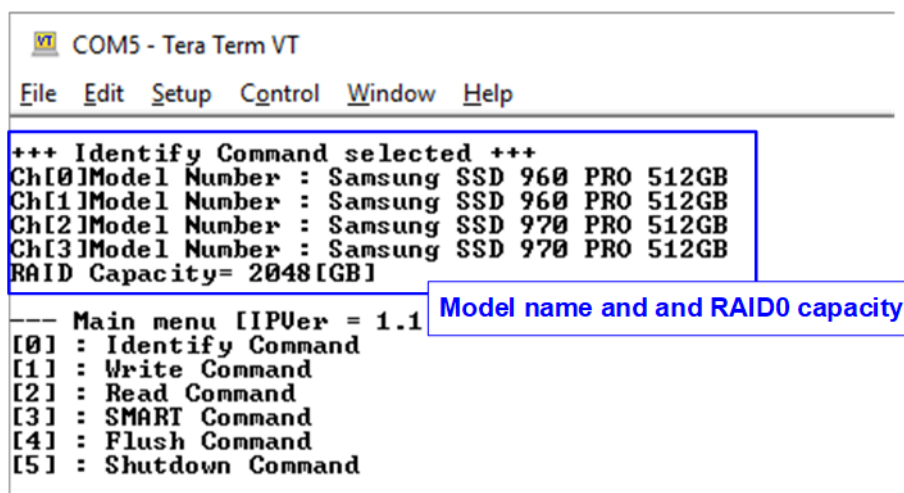
Figure 2-10 Error message when LBA does not support

3   Test Menu

3.1   Identify Command

Select '0' to send Identify command to RAID0.

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.
2) RAID capacity: This value is calculated by multiplying device capacity in channel#0 by 4.

3.2 Write Command

Select '1' to send Write command to RAID0.
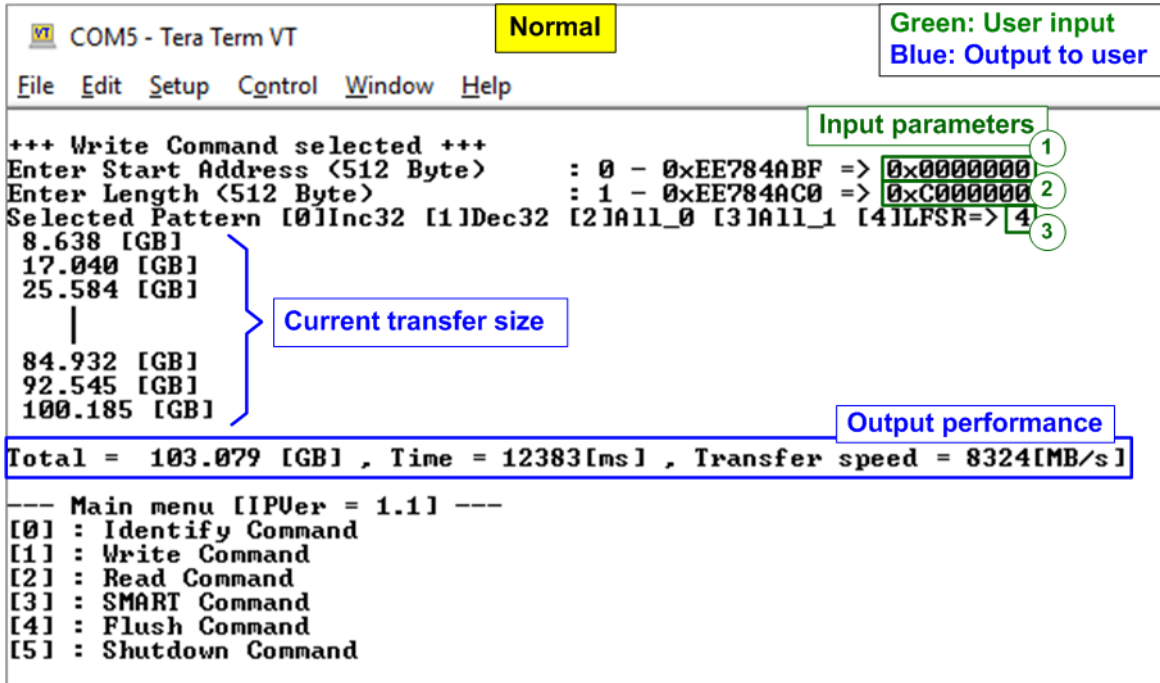
Figure 3-2 Test result when running Write command

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" to be 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" to be a prefix for hexadecimal unit.
3) Test pattern: Select test data pattern for writing RAID0. There are five patterns, i.e. 32-bit increment, 32-bit decrement, 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 to be a test result.

←64-bit header of each sector→

SSD#0

48-bit LBA Address = 0   0x0000   32-bit LFSR pattern

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	FF	FF	00	00	FF	FF	FF	00
0000000010	01	00	00	00	FF	01	00	00	FF	FF	01	00	FE	FF	FF	01
0000000020	02	00	00	00	FF	03	00	00	FF	FF	03	00	FD	FF	FF	03
0000000030	04	00	00	00	FF	07	00	00	FF	FF	07	00	FB	FF	FF	07
0000000040	09	00	00	00	FF	0F	00	00	FF	FF	0F	00	F6	FF	FF	0F
0000000050	12	00	00	00	FF	1F	00	00	FF	FF	1F	00	ED	FF	FF	1F

48-bit LBA Address = 4

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00000001A0	9E	24	49	02	D9	F6	FF	FF	24	D9	F6	FF	45	92	B4	FD
00000001B0	3C	49	92	04	B2	ED	FF	FF	49	B2	ED	FF	8A	24	69	FB
00000001C0	79	92	24	09	64	DB	FF	FF	92	64	DB	FF	14	49	D2	F6
00000001D0	F3	24	49	12	C9	B6	FF	FF	25	C9	B6	FF	28	92	A4	ED
00000001E0	E7	49	92	24	92	6D	FF	FF	4A	92	6D	FF	51	24	49	DB
00000001F0	CF	93	24	49	24	DB	FE	FF	94	24	DB	FE	A3	48	92	B6
0000000200	04	00	00	00	00	00	00	00	FB	FF	00	00	FB	FF	FF	00
0000000210	09	00	00	00	F7	01	00	00	F7	FF	01	00	F6	FF	FF	01

SSD#1

48-bit LBA Address = 1

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000000000	01	00	00	00	00	00	00	00	FE	FF	00	00	FE	FF	FF	00
0000000010	02	00	00	00	FC	01	00	00	FC	FF	01	00	FD	FF	FF	01
0000000020	04	00	00	00	F9	03	00	00	F9	FF	03	00	FB	FF	FF	03
0000000030	09	00	00	00	F2	07	00	00	F2	FF	07	00	F6	FF	FF	07
0000000040	12	00	00	00	E4	0F	00	00	E4	FF	0F	00	ED	FF	FF	0F
0000000050	24	00	00	00	C9	1F	00	00	C9	FF	1F	00	DB	FF	FF	1F

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00000001A0	3C	49	92	04	7B	9B	24	F9	86	B4	2D	F9	E7	FF	6F	FB
00000001B0	79	92	24	09	F7	36	49	F2	0C	69	5B	F2	CF	FF	DF	F6
00000001C0	F3	24	49	12	EE	6D	92	E4	18	D2	B6	E4	9E	FF	BF	ED
00000001D0	E7	49	92	24	DD	DB	24	C9	31	A4	6D	C9	3C	FF	7F	DB
00000001E0	CF	93	24	49	BA	B7	49	92	62	48	DB	92	79	FE	FF	B6
00000001F0	9E	27	49	92	75	6F	93	24	C5	90	B6	25	F2	FC	FF	6D
0000000200	05	00	00	00	00	00	00	00	FA	FF	00	00	FA	FF	FF	00
0000000210	0A	00	00	00	F4	01	00	00	F4	FF	01	00	F5	FF	FF	01

SSD#2

48-bit LBA Address = 2

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000000000	02	00	00	00	00	00	00	00	FD	FF	00	00	FD	FF	FF	00
0000000010	04	00	00	00	FA	01	00	00	FA	FF	01	00	FB	FF	FF	01
0000000020	09	00	00	00	F4	03	00	00	F4	FF	03	00	F6	FF	FF	03
0000000030	12	00	00	00	E9	07	00	00	E9	FF	07	00	ED	FF	FF	07
0000000040	24	00	00	00	D2	0F	00	00	D2	FF	0F	00	DB	FF	FF	0F
0000000050	49	00	00	00	A4	1F	00	00	A4	FF	1F	00	B6	FF	FF	1F

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00000001A0	79	92	24	09	3E	40	92	F4	C3	6F	9B	F4	A2	24	D9	F6
00000001B0	F3	24	49	12	7D	80	24	E9	86	DF	36	E9	45	49	B2	ED
00000001C0	E7	49	92	24	FA	00	49	D2	0C	BF	6D	D2	8A	92	64	DB
00000001D0	CF	93	24	49	F5	01	92	A4	19	7E	DB	A4	14	25	C9	B6
00000001E0	9E	27	49	92	EB	03	24	49	33	FC	B6	49	28	4A	92	6D
00000001F0	3D	4F	92	24	D6	07	48	92	66	F8	6D	93	51	94	24	DB
0000000200	06	00	00	00	00	00	00	00	F9	FF	00	00	F9	FF	FF	00
0000000210	0C	00	00	00	F2	01	00	00	F2	FF	01	00	F3	FF	FF	01

SSD#3

48-bit LBA Address = 3

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000000000	03	00	00	00	00	00	00	00	FC	FF	00	00	FC	FF	FF	00
0000000010	07	00	00	00	F9	01	00	00	F9	FF	01	00	F8	FF	FF	01
0000000020	0F	00	00	00	F2	03	00	00	F2	FF	03	00	F0	FF	FF	03
0000000030	1F	00	00	00	E4	07	00	00	E4	FF	07	00	E0	FF	FF	07
0000000040	3F	00	00	00	C9	0F	00	00	C9	FF	0F	00	C0	FF	FF	0F
0000000050	7F	00	00	00	92	1F	00	00	92	FF	1F	00	80	FF	FF	1F

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00000001A0	DB	FF	FF	0F	9C	2D	49	F2	61	02	40	F2	00	49	02	F0
00000001B0	B6	FF	FF	1F	38	5B	92	E4	C3	04	80	E4	00	92	04	E0
00000001C0	6D	FF	FF	3F	70	B6	24	C9	86	09	00	C9	00	24	09	C0
00000001D0	DB	FE	FF	7F	E1	6C	49	92	0D	13	00	92	00	48	12	80
00000001E0	B6	FD	FF	FF	C3	D9	92	24	1B	26	00	24	00	90	24	00
00000001F0	6C	FB	FF	FF	87	B3	25	49	37	4C	00	48	00	20	49	00
0000000200	07	00	00	00	00	00	00	00	F8	FF	00	00	F8	FF	FF	00
0000000210	0F	00	00	00	F1	01	00	00	F1	FF	01	00	F0	FF	FF	01

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

The stripe size in 4-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 bits header is the test pattern which is selected by user. The 1st stripe is mapped to the first 512-byte of SSD#0. The 2nd - the 4th stripe are mapped to the first 512-byte of SSD#1 - SSD#3 respectively, as shown in Figure 3-3. The unique header is not included when running all-0 or all-1 pattern.

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.

Figure 3-4 Error message from the invalid input

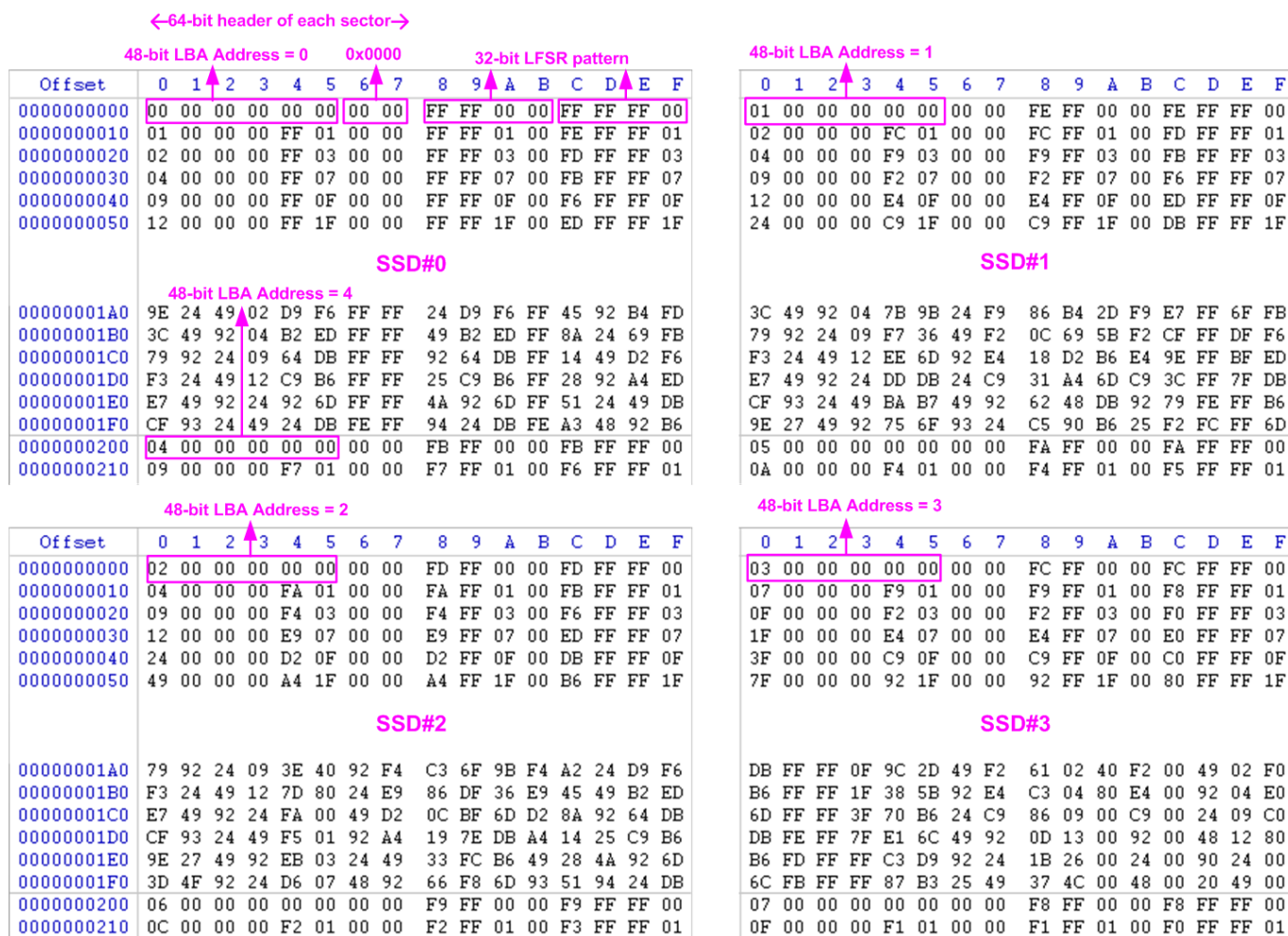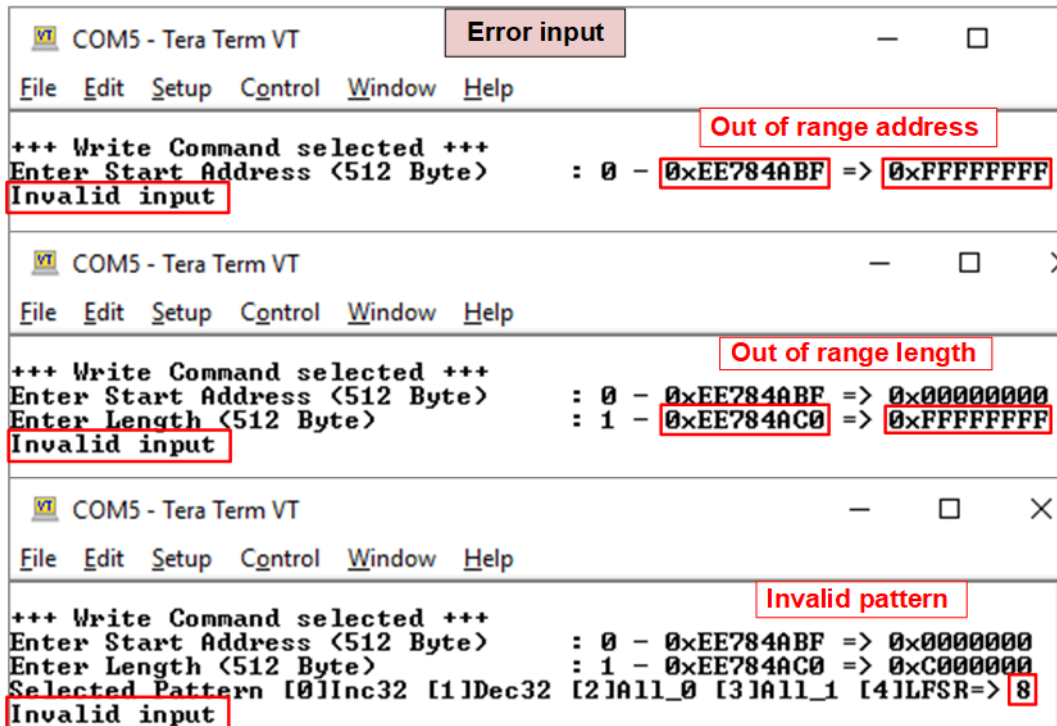## 3.3 Read Command

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" to be 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" to be 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.

Figure 3-6 Data verification is failed

3.4   SMART Command

Select '3' to send SMART command to RAID0.

Figure 3-7 Test result when running SMART command

When the operation is completed, SMART/Health Information (output from SMART command) is displayed as shown in Figure 3-7. The console shows six values from each SSD.
1) Temperature in °C unit.
2) Total Data Read decoded as GB/TB unit. Additionally, raw data without decoding is displayed in 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 in 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.

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.

Figure 3-9 Message after Shutdown command is completed

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
1.1	20-Apr-20	Remove power adapter cable from AB18