

4-Ch RAID0 (NVMeG3-IP) Demo Instruction

<u>Rev1.1 28-Jun-23</u>

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4-Ch RAID0 (NVMeG3-IP) Demo Instruction

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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. <u>https://www.asrock.com/mb/spec/product.asp?Model=ULTRA QUAD M.2 CARD</u>
- 7) Four M.2 NVMe SSDs.
- 8) Two micro USB cables for programming FPGA and Serial console, connecting between FPGA board and PC



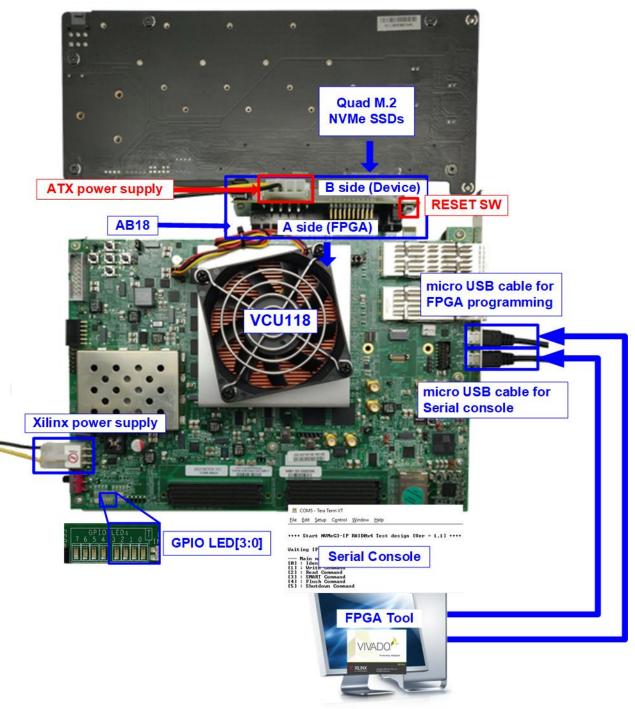


Figure 1-1 NVMeG3-IP RAID0 demo setup by AB18 on VCU118



2 **Demo setup**

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

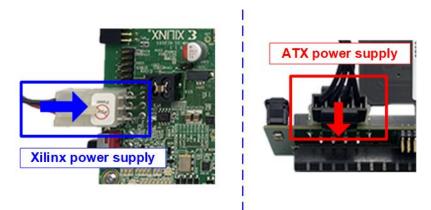


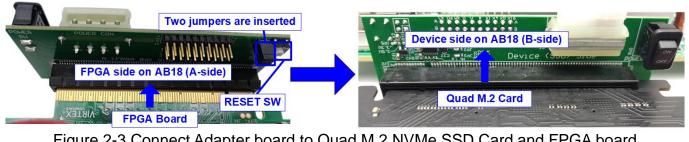
Figure 2-1 Power supply connection

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



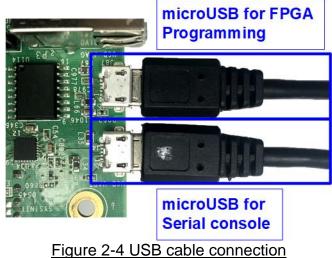
Figure 2-2 Four M.2 NVMe SSDs with Ultra Quad M.2 Card

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.





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



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

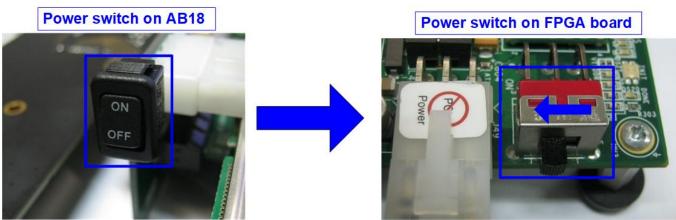


Figure 2-5 Turn on power switch on FPGA and adapter board



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.

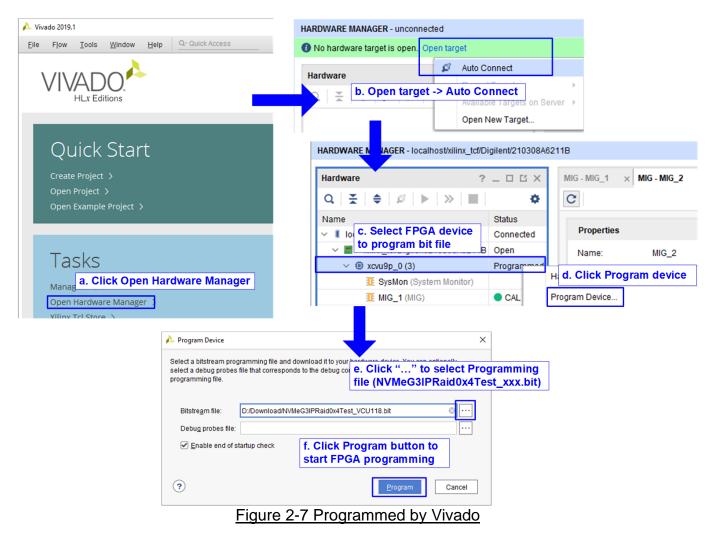
On Serial console, the setting is as follows. Baud rate=115,200, Data=8-bit, Non-Parity, and Stop = 1.

🗄 Device Manager —	Tera Term: Serial port	erial setting	×
Eile Action View Help ← ← ← ← ← → ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← ← <	Port: Sp <u>e</u> ed: Data: P <u>a</u> rity: Stop bits: ow control: Transmit delay 0 msec/	COM5 ~ 115200 ~ 8 bit ~ none ~ 1 bit ~ none ~	OK Cancel Help sec <u>/l</u> ine

Figure 2-6 Two COM ports from FPGA connection



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



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

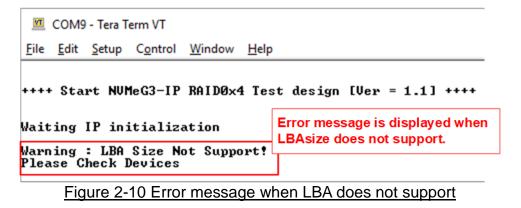
10)On the console, the message is displayed to show current status as follows.

- "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.

💆 COM5 - Tera Term VT	
<u>File Edit Setup Control Window H</u> e	p
++++ Start NUMeG3-IP RAID0x4 Te Waiting IP initialization Waiting IP initialization Wait R Main menu [IPVer = 1.1] [0] : Identify Command [1] : Write Command [2] : Read Command [2] : Read Command [3] : SMART Command [4] : Flush Command [5] : Shutdown Command	est design [Ver = 1.1] ++++ AID0 busy Main menu to select the command

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





3 Test Menu

3.1 Identify Command

Select '0' to send Identify command to RAID0.

COM5 - Tera Term VT

 File
 Edit
 Setup
 Control
 Window
 Help

 *++
 Identify
 Command
 selected
 +++

 Ch[0]Model
 Number
 :
 Samsung
 SSD
 960
 PRO
 512GB

 Ch[1]Model
 Number
 :
 Samsung
 SSD
 970
 PRO
 512GB

 Ch[2]Model
 Number
 :
 Samsung
 SSD
 970
 PRO
 512GB

 Ch[2]Model
 Number
 :
 Samsung
 SSD
 970
 PRO
 512GB

 Ch[3]Model
 Number
 :
 Samsung
 SSD
 970
 PRO
 512GB

 Ch[3]Model
 Number
 :
 Samsung
 SSD
 970
 PRO
 512GB

 Ch[3]Model
 Number
 :
 Samsung
 SSD
 970
 PRO
 512GB

 --- Main
 menu
 [IPUer = 1.1]
 Model
 name and and RAIDO capacity

 [0] :
 Identify
 Command
 [1] :
 Write
 Command

 [1] :
 Write
 Command
 [3] :
 Shutdown</

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.

COM5 - Tera Term VT	Normal	Green: User input Blue: Output to user				
<u>File Edit Setup Control Window</u>	Help					
Input parameters Input parameters						
		Output performance				
Total = 103.079 [GB] , Time	= 12383[ms] , Iransfer s	peed = 8324LMB/sJ				
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 r	esult when running Write con	nmand				

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.
- 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.



<u> </u>	hoodor	of	oach	sector-	
C-04-DI	neauer	0	each	300101-7	

48	B-bit LBA Address = 0 0x0	000 32-bit LFSR pattern	48-bit LBA Address = 1
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
0000000000	00 00 00 00 00 00 00	00 FF FF 00 00 FF FF FF 00	01 00 00 00 00 00 00 00 FE FF 00 00 FE FF FF 00
0000000010	01 00 00 00 FF 01 00		02 00 00 00 FC 01 00 00 FC FF 01 00 FD FF FF 01
0000000020	02 00 00 00 FF 03 00	00 FF FF 03 00 FD FF FF 03	04 00 00 00 F9 03 00 00 F9 FF 03 00 FB FF FF 03
000000030	04 00 00 00 FF 07 00	00 FF FF 07 00 FB FF FF 07	09 00 00 00 F2 07 00 00 F2 FF 07 00 F6 FF FF 07
0000000040	09 00 00 00 FF 0F 00		12 00 00 00 E4 0F 00 00 E4 FF 0F 00 ED FF FF 0F
0000000050	12 00 00 00 FF 1F 00	00 FF FF 1F 00 ED FF FF 1F	24 00 00 00 C9 1F 00 00 C9 FF 1F 00 DB FF FF 1F
		SSD#0	SSD#1
	48-bit LBA Address = 4		
00000001A0	9E 24 49 02 D9 F6 FF		3C 49 92 04 7B 9B 24 F9 86 B4 2D F9 E7 FF 6F FB
00000001B0	3C 49 92 04 B2 ED FF		79 92 24 09 F7 36 49 F2 0C 69 5B F2 CF FF DF F6
00000001C0	79 92 24 09 64 DB FF		F3 24 49 12 EE 6D 92 E4 18 D2 B6 E4 9E FF BF ED
00000001D0 00000001E0	F3 24 49 12 C9 B6 FF E7 49 92 24 92 6D FF		E7 49 92 24 DD DB 24 C9 31 A4 6D C9 3C FF 7F DB CF 93 24 49 BA B7 49 92 62 48 DB 92 79 FE FF B6
	CF 93 24 49 24 DB FE		9E 27 49 92 75 6F 93 24 C5 90 B6 25 F2 FC FF 6D
	04 00 00 00 00 00 00		05 00 00 00 00 00 00 00 FA FF 00 00 FA FF FF 00
	09 00 00 00 F7 01 00		0A 00 00 00 F4 01 00 00 F4 FF 01 00 F5 FF FF 01
	48-bit LBA Address = 2		48-bit LBA Address = 3
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
0000000000	02 00 00 00 00 00 00		03 00 00 00 00 00 00 00 FC FF 00 00 FC FF FF 00
0000000010	04 00 00 00 FA 01 00		07 00 00 00 F9 01 00 00 F9 FF 01 00 F8 FF FF 01
0000000020	09 00 00 00 F4 03 00		OF 00 00 00 F2 03 00 00 F2 FF 03 00 F0 FF FF 03
000000030	12 00 00 00 E9 07 00		1F 00 00 00 E4 07 00 00 E4 FF 07 00 E0 FF FF 07
0000000040	24 00 00 00 D2 OF 00 49 00 00 00 A4 1F 00		3F 00 00 00 C9 0F 00 00 C9 FF 0F 00 C0 FF FF 0F 7F 00 00 00 92 1F 00 00 92 FF 1F 00 80 FF FF 1F
000000000000000000000000000000000000000	49 00 00 00 A4 IF 00	00 A4 FF IF 00 B6 FF FF IF	7F 00 00 00 92 1F 00 00 92 FF 1F 00 80 FF FF 1F
		SSD#2	SSD#3
00000001A0	79 92 24 09 3E 40 92	F4 C3 6F 9B F4 A2 24 D9 F6	DB FF FF 0F 9C 2D 49 F2 61 02 40 F2 00 49 02 F0
	F3 24 49 12 7D 80 24		B6 FF FF 1F 38 5B 92 E4 C3 04 80 E4 00 92 04 E0
00000001C0	E7 49 92 24 FA 00 49	D2 OC BF 6D D2 8A 92 64 DB	6D FF FF 3F 70 B6 24 C9 86 09 00 C9 00 24 09 C0
00000001D0	CF 93 24 49 F5 01 92		DB FE FF 7F E1 6C 49 92 0D 13 00 92 00 48 12 80
00000001E0	9E 27 49 92 EB 03 24		B6 FD FF FF C3 D9 92 24 1B 26 00 24 00 90 24 00
00000001F0	3D 4F 92 24 D6 07 48		6C FB FF FF 87 B3 25 49 37 4C 00 48 00 20 49 00
0000000200	06 00 00 00 00 00 00		07 00 00 00 00 00 00 00 F8 FF 00 00 F8 FF FF 00
0000000210	OC 00 00 00 F2 01 00	00 F2 FF 01 00 F3 FF FF 01	OF 00 00 00 F1 01 00 00 F1 FF 01 00 F0 FF FF 01
Figure 3	3-3 Example Test of	data of the 1 st and 2 nd 5	12 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.

🔟 COM5 - Tera Term VT	Error inpu	ıt		_	
<u>File Edit Setup Control Window</u>	<u>H</u> elp				
+++ Write Command selected +	• • •	Ou	t of range a	addres	S
Enter Start Address (512 Byt Invalid input		0 – 0×EE7	84ABF =>	Ø×FFF	FFFFF
🔟 COM5 - Tera Term VT			-	- C	C
<u>File Edit Setup Control W</u> indow	<u>H</u> elp				
+++ Write Command selected + Enter Start Address (512 Byt Enter Length (512 Byte) Invalid input	:e)	0 - Øxee7 1 - Øxee7		0×000	00000
🔟 COM5 - Tera Term VT			_		×
<u>File Edit Setup Control W</u> indow	<u>H</u> elp				
+++ Write Command selected + Enter Start Address (512 Byt Enter Length (512 Byte) Selected Pattern [0]Inc32 [1 Invalid input	te) : : 1Dec32 [84ACØ =>]All_1 [4	0×000 0×C00	0000
<u>Figure 3-4 Error n</u>	nessage f	rom the inva	alia input		



3.3 Read Command

Select '2' to send Read command to RAID0.

💆 COM5 - Tera Term VT	Normal –
<u>File Edit Setup Control Window Hel</u>	p
+++ Read Command selected +++ Enter Start Address (512 Byte) Enter Length (512 Byte) Selected Pattern [Ø]Inc32 [1]De 12.803 [GB] 38.431 [GB] 51.249 [GB] 64.065 [GB] 76.879 [GB] 89.659 [GB] 102.409 [GB]	: 1 - 0xEE784AC0 => <u>0xC000000</u> ² c32 [2]All_0 [3]All_1 [4]LFSR=> 4 3
Total = 103.079 [GB] , Time =	8052[ms] , Transfer speed = 12801[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 3-5 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
- 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.

```
Verification error without cancellation
  🔟 COM5 - Tera Term VT
 File Edit Setup Control Window Help
+++ Read Command selected +++
                                               : 0 - 0xEE784ABF => 0x0000000
Enter Start Address (512 Byte)
Enter Length (512 Byte)
                                               : 1 - 0xEE784AC0 => 0xC000000 Wrong pattern
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 1
                                     Message when verification is failed
Verify fail
1st Error at Byte Addr = 0x00000000
                              Expect Data[511:384]
Expect Data[383:256]
Expect Data[255:128]
Expect Data[127:0]
Read Data[511:384]
Read Data[383:256]
                               = 0x03FFFFFD_0003FFFF_000003FF_00000002
                               = 0x01FFFFFE_0001FFFF_000001FF_00000001
= 0x00FFFFFF_0000FFFF_0000000_00000000
Read Data[255:128]
Read Data[127:0]
Press any key to cancel operation
12.785 [GB]
  25.593 [GB]
  38.406 [GB]
 51.214 [GB]
 64.053 [GB]
  76.866 [GB]
 89.646 [GB]
 102.392 [GB]
                                                                    Output performance
Total = 103.079 [GB] , Time = 8053[ms] , Transfer speed = 12799[MB/s]
                         Verification error with cancellation
  🔟 COM5 - Tera Term
 File
      Edit Setup Control Window Help
+++ Read Command selected +++
                                                    : 0 - 0xEE784ABF => 0x0000000
: 1 - 0xEE784AC0 => 0xC000000 Wrong pattern
Enter Start Address (512 Byte) : 0 - 0xEE784ABF => 0x0000000
Enter Length (512 Byte) : 1 - 0xEE784ACO => 0xC000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 1
                                               Message when verification is failed
Verify fail
1st Error at Byte Addr = 0x00000000
                                    0×67FFFFF6_FFFFF1_FFFFFF2_FFFFFF5
0×FFFFFF4_FFFFF5_FFFFF6_FFFFFF5
0×FFFFFFF8_FFFFF5_FFFFF6_FFFFFF
0×FFFFFFF8_FFFF9_FFFF6_6000000_0000000
0×07FFFFFF8_0007FFF_000007FF_0000000
0×03FFFFFB_0003FFFF_000003FF_00000000
0×03FFFFFB_0001FFF_000001FF_00000000
0×00FFFFFF_0000FFFF_00000000_00000000
Expect Data[511:384]
Expect Data[383:256]
Expect Data[255:128]
Expect Data[127:0]
                                  =
                                  =
                                  =
                                  =
Read Data[511:384]
Read Data[383:256]
                                  =
                                  =
Read Data[255:128]
                                  =
Read Data[127:0]
                                  =
Press any key to cancel operation
12.816 [GB]
25.638 [GB]
                                          User presses any keys to cancel the operation
Operation is cancelled
Please reset system before st<u>arting a new test</u>
                                            Message when operation is cancelled
  -- Main menu [IPVer = 1.1] -
[0] : Identify Command
[1] : Write Command
[2] : Read Command
                            Figure 3-6 Data verification is failed
```

Dec

dg_nvmeg3ip_raid0x4_instruction_xilinx_en

3.4 SMART Command

Select '3' to send SMART command to RAID0.

🔟 COM5 - Tera Term VT File Edit Setup Control Window Help +++ SMART Command selected +++ Data output decoded from SMART command << SMART Log Information Ch[0] >> Temperature : 32 Degree Celsius 58341 GB Total Data Read Total Data Read (Raw data) 0x0000000_0000000_00000000_06CA9C39 Total Data Written 61699 GB Total Data Written (Raw data) : 0x0000000_0000000_0000000_072EAC8A Power On Cycles Power On Hours : 1813 Times : 122 Hours Unsafe Shutdowns : 1598 Times << SMART Log Information Ch[1] >> Temperature : 32 Degree Celsius 102749 GB Total Data Read Total Data Read (Raw data) Total Data Written 0x0000000_0000000_0000000_0BF5F920 109708 GB : 0x0000000_0000000_0000000_0CC55E34 Total Data Written (Raw data) Power On Cycles Power On Hours : 2675 Times : 216 Hours Unsafe Shutdowns : 2119 Times << SMART Log Information Ch[2] >> 32 Degree Celsius Temperature Total Data Read : 4709 GB Total Data Read (Raw data) Total Data Written 0x0000000 0000000 0000000 008C559F 5603 GB : 0×00000000_00000000_0000000_00A6F917 Total Data Written (Raw data) Power On Cycles Power On Hours : 204 Times : 15 Hours : 135 Times Unsafe Shutdowns << SMART Log Information Ch[3] >> 30 Degree Celsius Temperature Total Data Read 6012 ĞB Total Data Read (Raw data) Total Data Written 0x0000000_0000000_0000000_00B32A18 7210 GB : 0x0000000_0000000_0000000_00D6E352 Total Data Written (Raw data) Power On Cycles Power On Hours : 155 Times : 17 Hours Unsafe Shutdowns : 75 Times SMART Command Complete

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.

<u>vr</u>	COMS	- Tera T	erm VT		
<u>F</u> ile	<u>E</u> dit	<u>S</u> etup	C <u>o</u> ntrol	<u>W</u> indow	<u>H</u> elp
+++	Flus	h Comr	nand se	lected ·	
Flus	h Co	mmand	Complet		essage after ishing the operation
Main menu [IPVer = 1.1]					
101					
[1]	: Wr	entify ite Co	/ Commai mmand		
[1] [2] [3]	: Wr : Re : SM	entify	y Commai ommand omand ommand		

"Flush Command Complete" is displayed after finishing Flush operation.

3.6 Shutdown Command

Select '5' to send Shutdown command to RAID0.

	5 - Tera Term	VT		
<u>F</u> ile <u>E</u> dit	<u>S</u> etup C <u>o</u>	ntrol <u>W</u> indo	w <u>H</u> el	p
[0] : Id [1] : Wr [2] : Re [3] : SM [4] : F1	menu []] entify Co ite Comma ad Comma ART Comma ush Comma utdown Co	and nd and and	.]	
		mand seled want to s	LEU	Confirmation massage
	' to con		Г	Press 'y' to confirm
Shutdown The devi	command ce has ti	is comple urned off	Lastm	nessage before NVMeG3-IP SD are inactive status
—	- · ·			

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