

NVMe-IP by AB17 Demo Instruction

Rev1.1 28-Jan-20

This document describes the instruction to run NVMe-IP demo on FPGA development board by using AB17-M2FMC board. The demo is designed to write/verify data with M.2 NVMe SSD. 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: KCU105/ZCU106/VCU118
- 2) PC installing Xilinx programmer software (Vivado) and Serial console software such as HyperTerminal and TeraTerm
- 3) AB17-M2FMC board, provided by Design Gateway
- 4) Xilinx Power adapter for FPGA board
- 5) M.2 NVMe SSD, inserting to Drive#1 M.2 connector on AB17
- 6) Two micro USB cables for programming FPGA and Serial console, connecting between FPGA board and PC

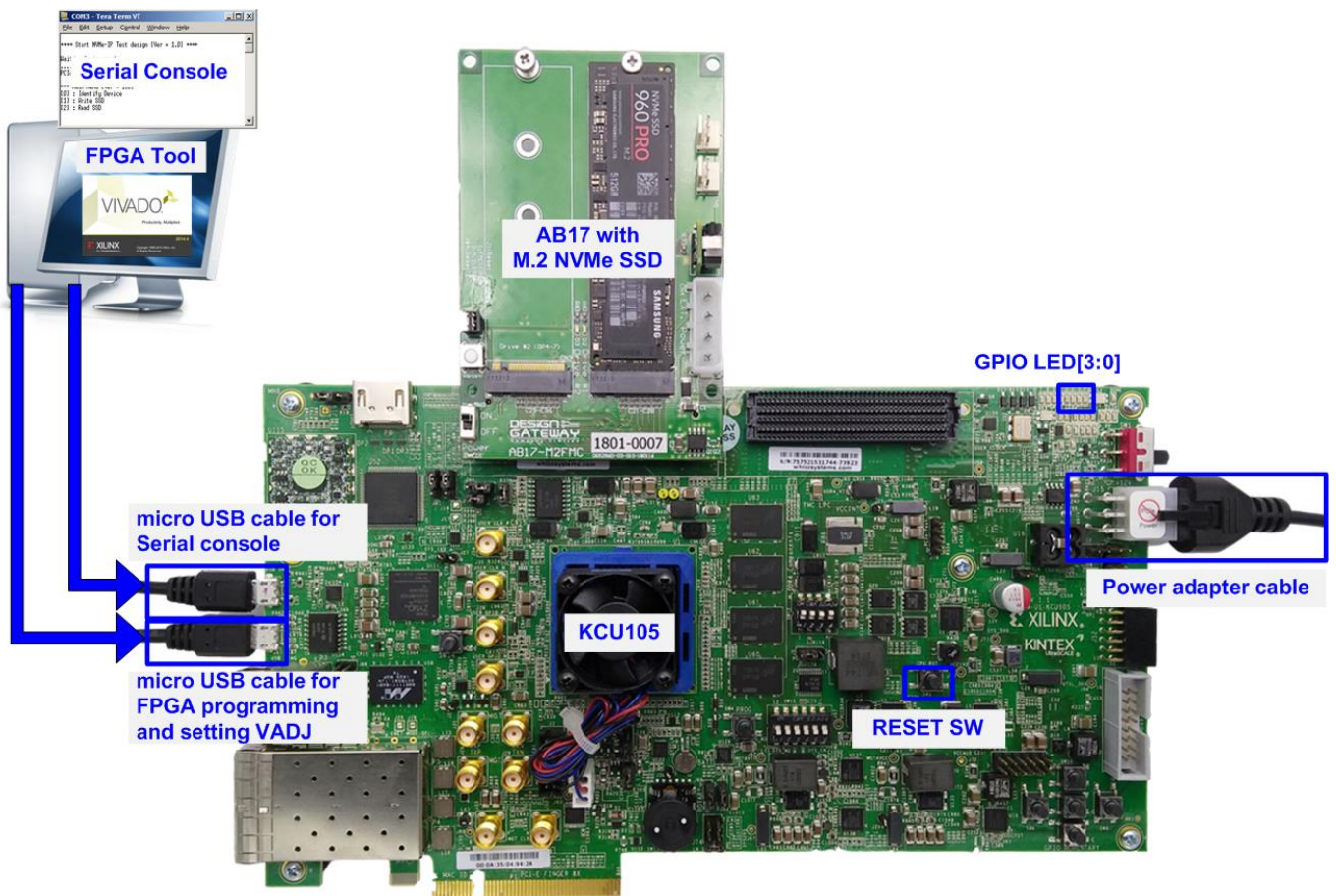


Figure 1-1 NVMe-IP demo by AB17 setup on KCU105

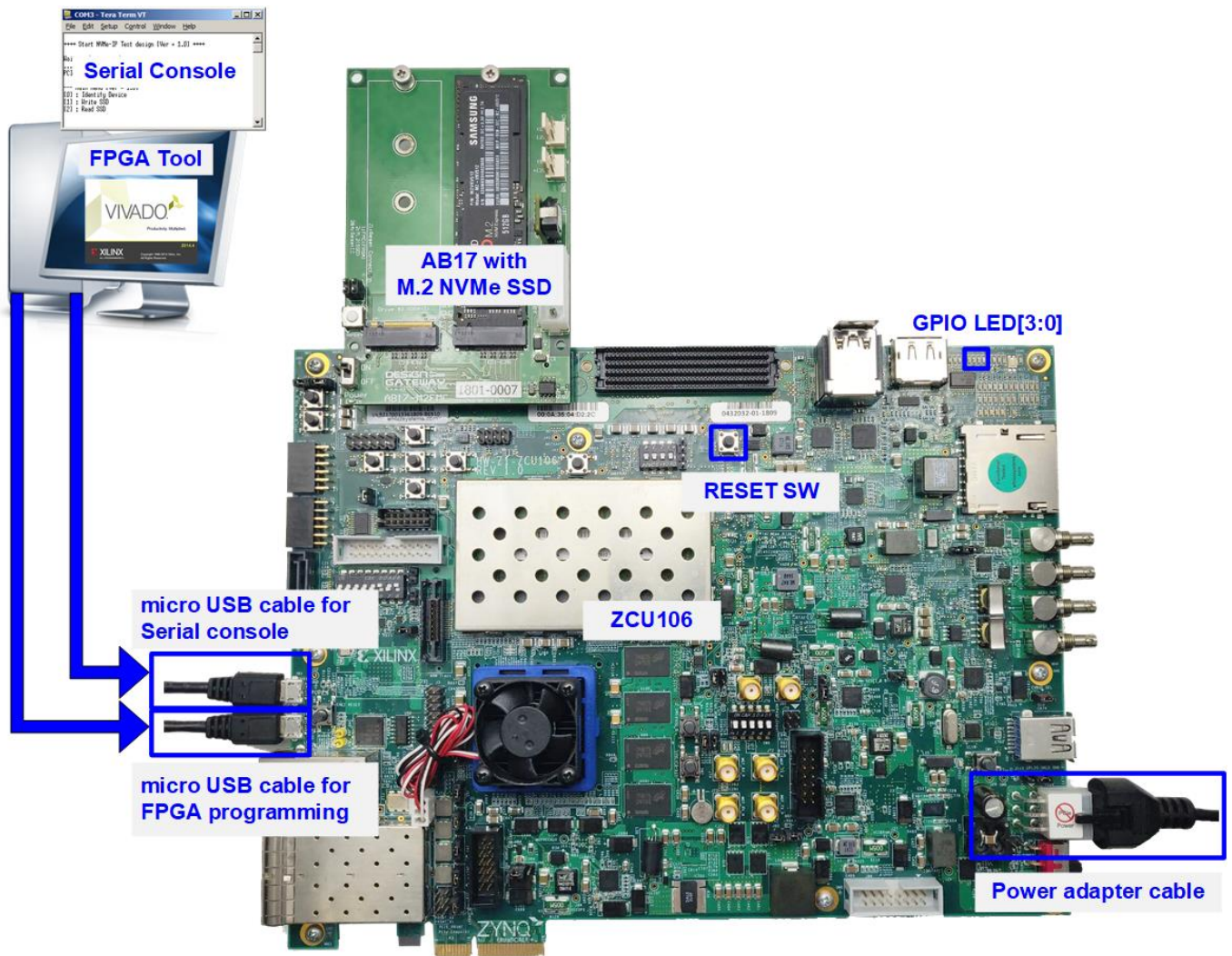


Figure 1-2 NVMe-IP demo by AB17 setup on ZCU106

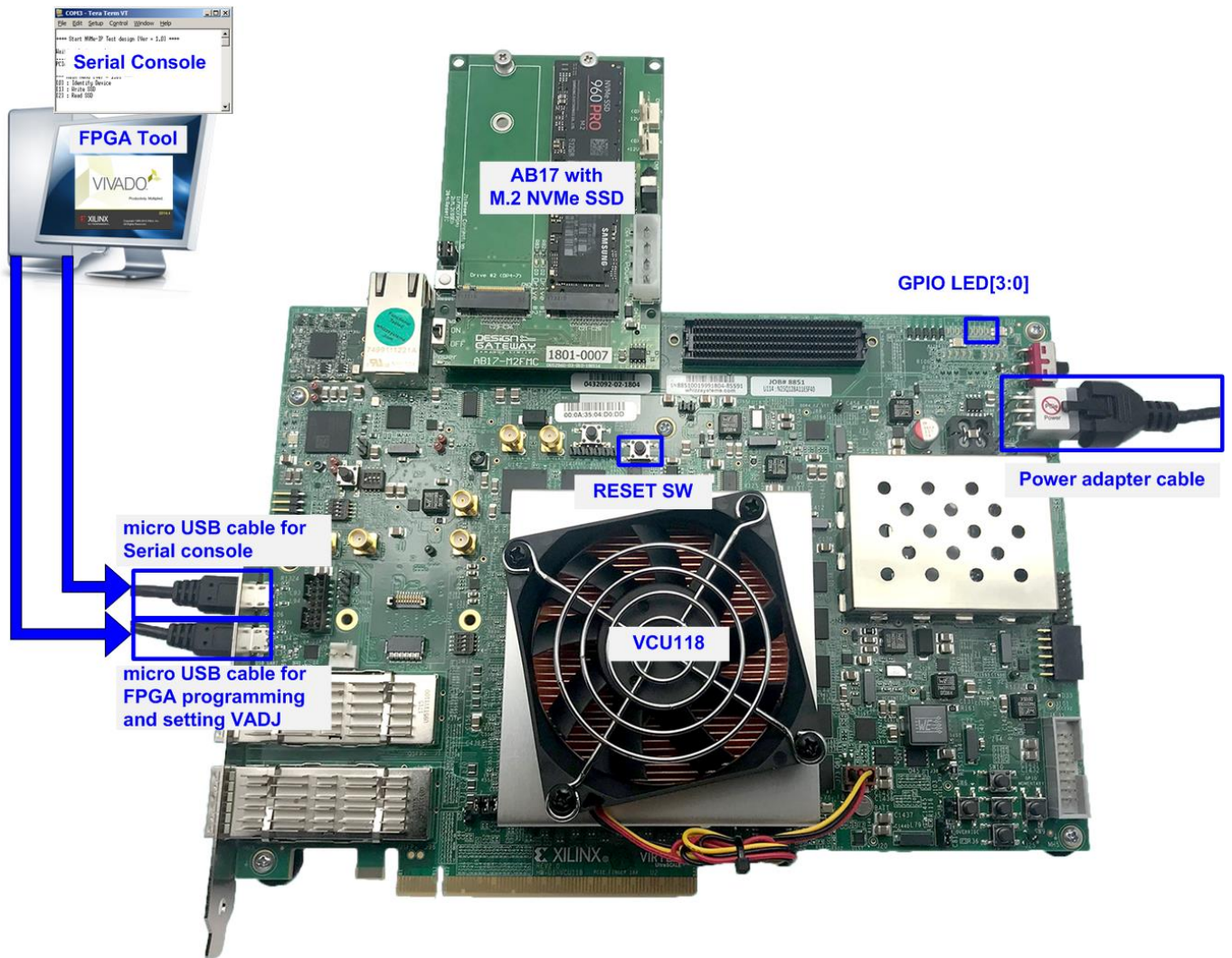


Figure 1-3 NVMe-IP demo by AB17 setup on VCU118

2 Demo setup

- 1) Power off system.
- 2) For ZCU106 board, set SW6=all ON to configure PS from JTAG, as shown in Figure 2-1.

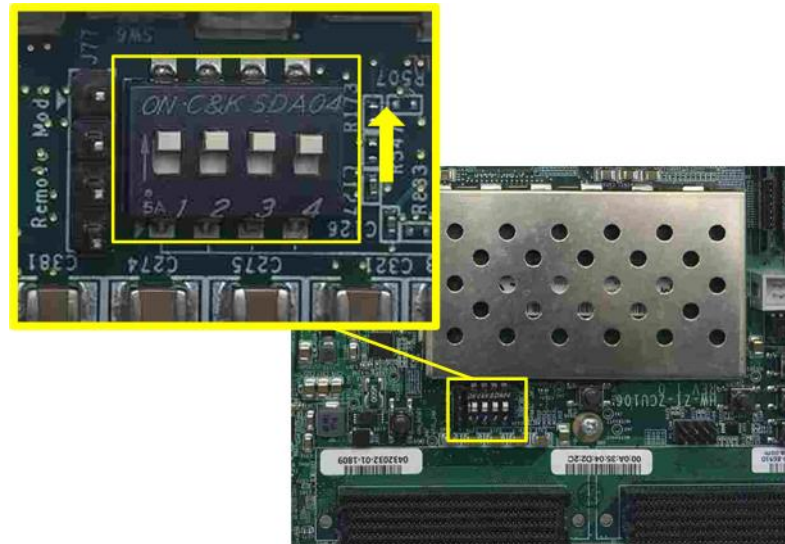


Figure 2-1 SW6 setting to configure PS from JTAG on ZCU106

- 3) Connect M.2 NVMe SSD to Drive#1 M.2 connector on AB17-M2FMC, as shown in Figure 2-2.

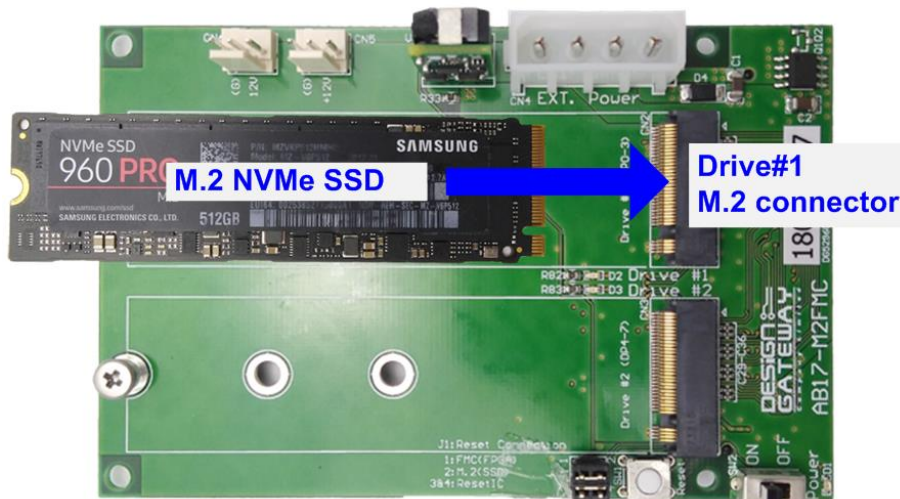


Figure 2-2 Connect M.2 NVMe to AB17

- 4) Connect AB17-M2FMC to HPC connector on KCU105(J22)/ZCU106(J5) or HSPC on VCU118 (J22), as shown in Figure 2-3.

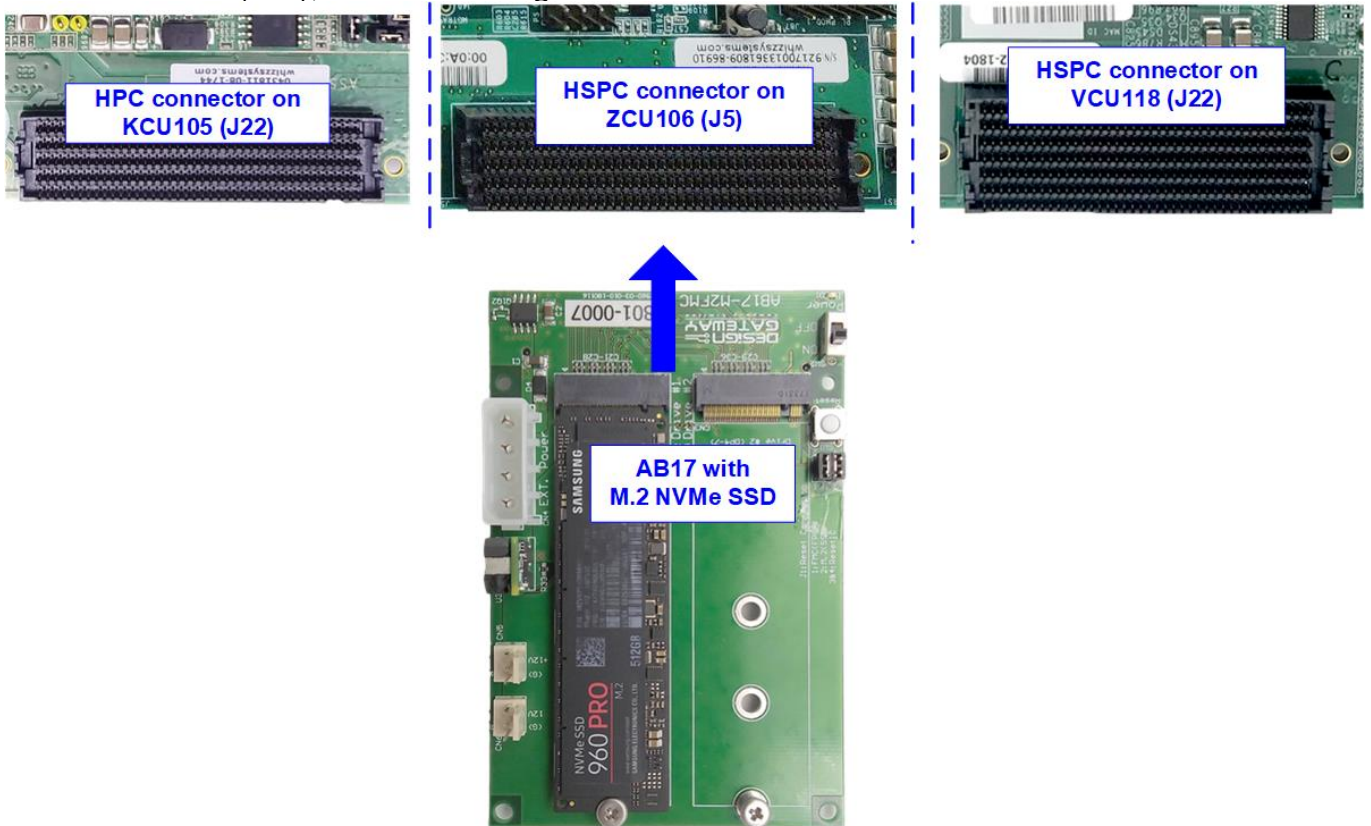


Figure 2-3 Connect AB17 to FPGA board

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

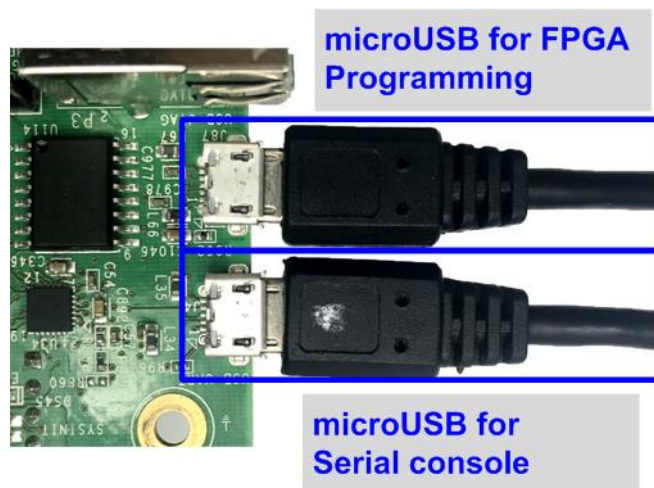


Figure 2-4 USB cable connection

- 6) Turn on power switch on AB17-M2FMC and FPGA development board, as shown in Figure 2-5.

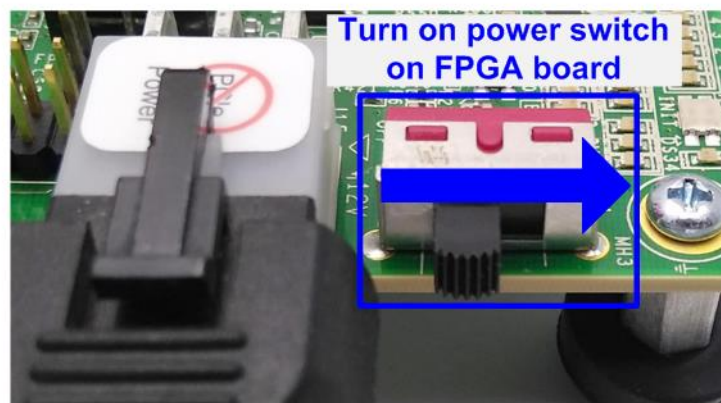
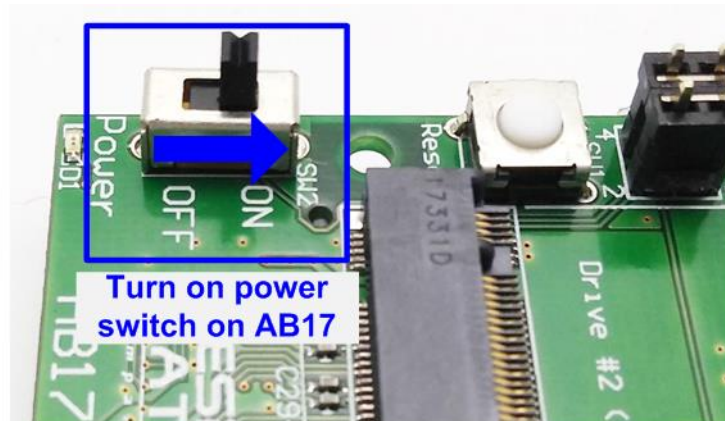


Figure 2-5 Turn on power switch

- 7) On PC, additional COM port is detected after connecting USB cables to FPGA board. On Ultrascale/Ultrascale+ board, there are more than one COM ports detected. In case of KCU105 and VCU118, select Standard COM port. In case of ZCU106, select the lowest number for ZCU106 board, 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.

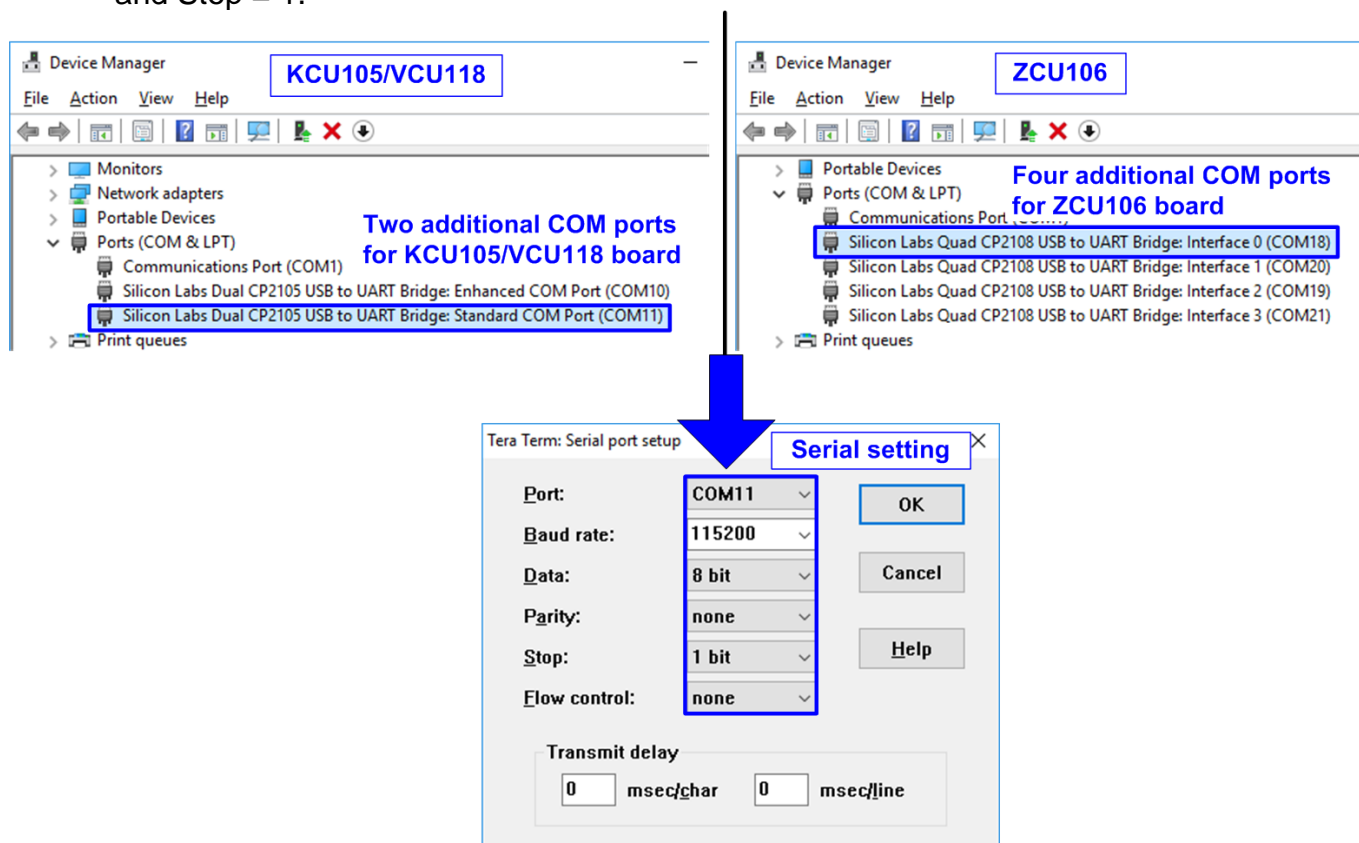


Figure 2-6 Select and set COM port

- 8) Set VADJ of FMC for KCU105 and VCU118 board.
 - a) For KCU105 board, open Serial console to connect with Enhanced COM port (Baud rate=115,200 Data=8 bit Non-Parity Stop=1). The console shows System Controller menu, as shown in Figure 2-7. To set VADJ of FMC to 1.8V, the following step is recommended.
 - (1) Input '4' to select Adjust FMC Settings.
 - (2) Input '4' to set FMC VADJ to 1.8V.
 - (3) Input '0' to return to Main Menu.
 - (4) Input '2' to get PMBUS Voltages.
 - (5) Input '7' to get VADJ1V8 Voltage. The output voltage of this menu must be equal to 1.8V to confirm that VADJ has been set completely.
 For more details of System Controller, please check "UG917 KCU105 Board User Guide" in section "Appendix C: System Controller".
https://www.xilinx.com/support/documentation/boards_and_kits/kcu105/ug917-kcu105-eval-bd.pdf

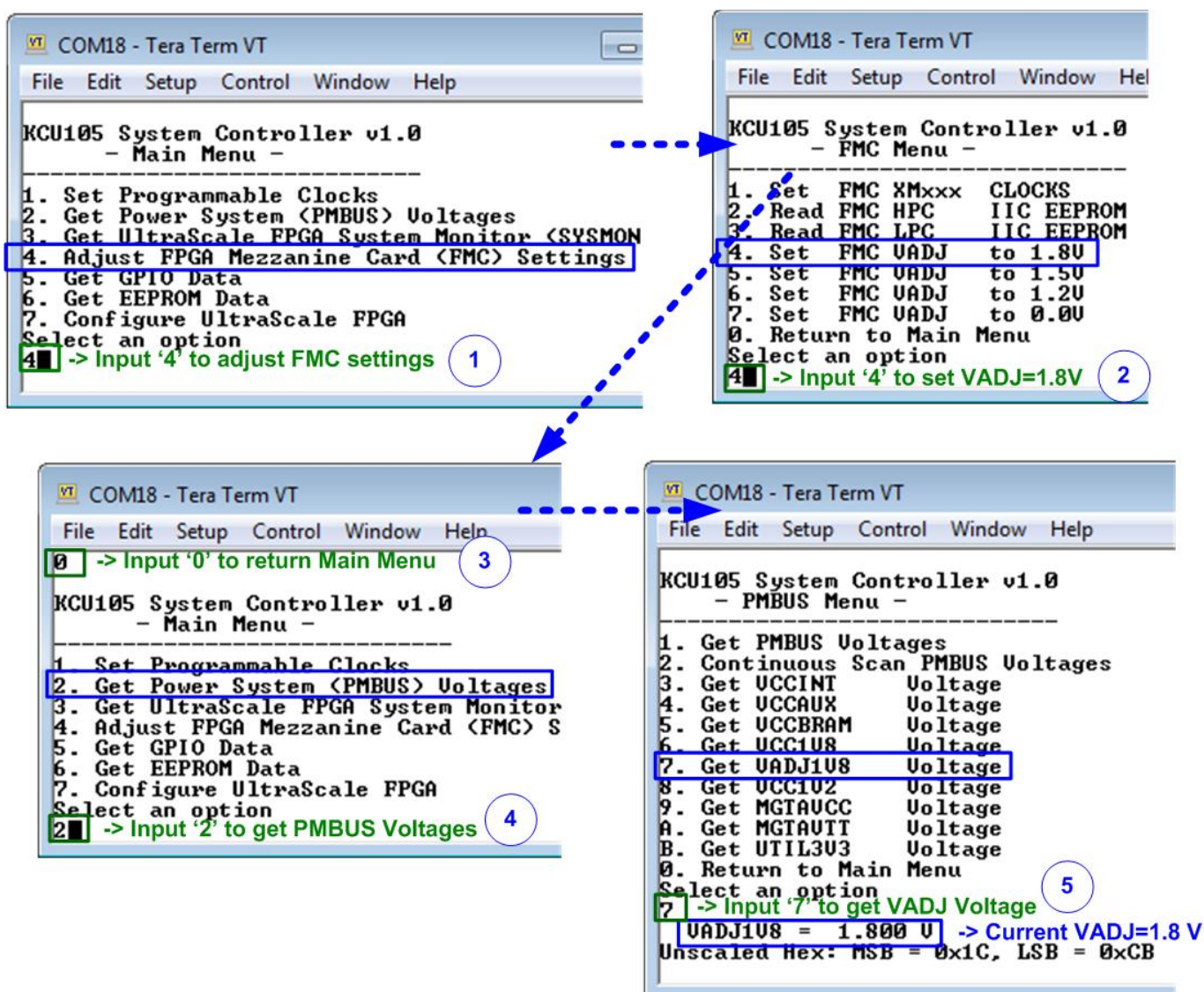


Figure 2-7 Setting VADJ of FMC for KCU105

b) For VCU118 board, it needs to download System controller tool (SCUI.exe) for setting VADJ from Xilinx website.

<https://www.xilinx.com/products/boards-and-kits/vcu118.html#documentation>

Direct link for Vivado2017.4 version to download the tool is as follows.

<https://www.xilinx.com/member/forms/download/design-license.html?cid=07015756-bc89-402c-9308-2be69db6f96c&filename=rd0396-vcu118-system-controller-c-2017-4.zip>

To set VADJ of FMC to 1.8V, open SCUI.exe and run following step.

- (1) Select File->Change the System Controller Port.
- (2) Select COM port number which is Enhanced COM Port.
- (3) Click "OK" button to confirm the port.
- (4) Select FMC tab -> Set VADJ tab -> Current tab. Click "Set VADJ to 1.8V" button.
- (5) Select Voltages tab and click "Get VADJ_1V8 Voltage" button. The output voltage must be equal to 1.8V to confirm that VADJ has been set completely.

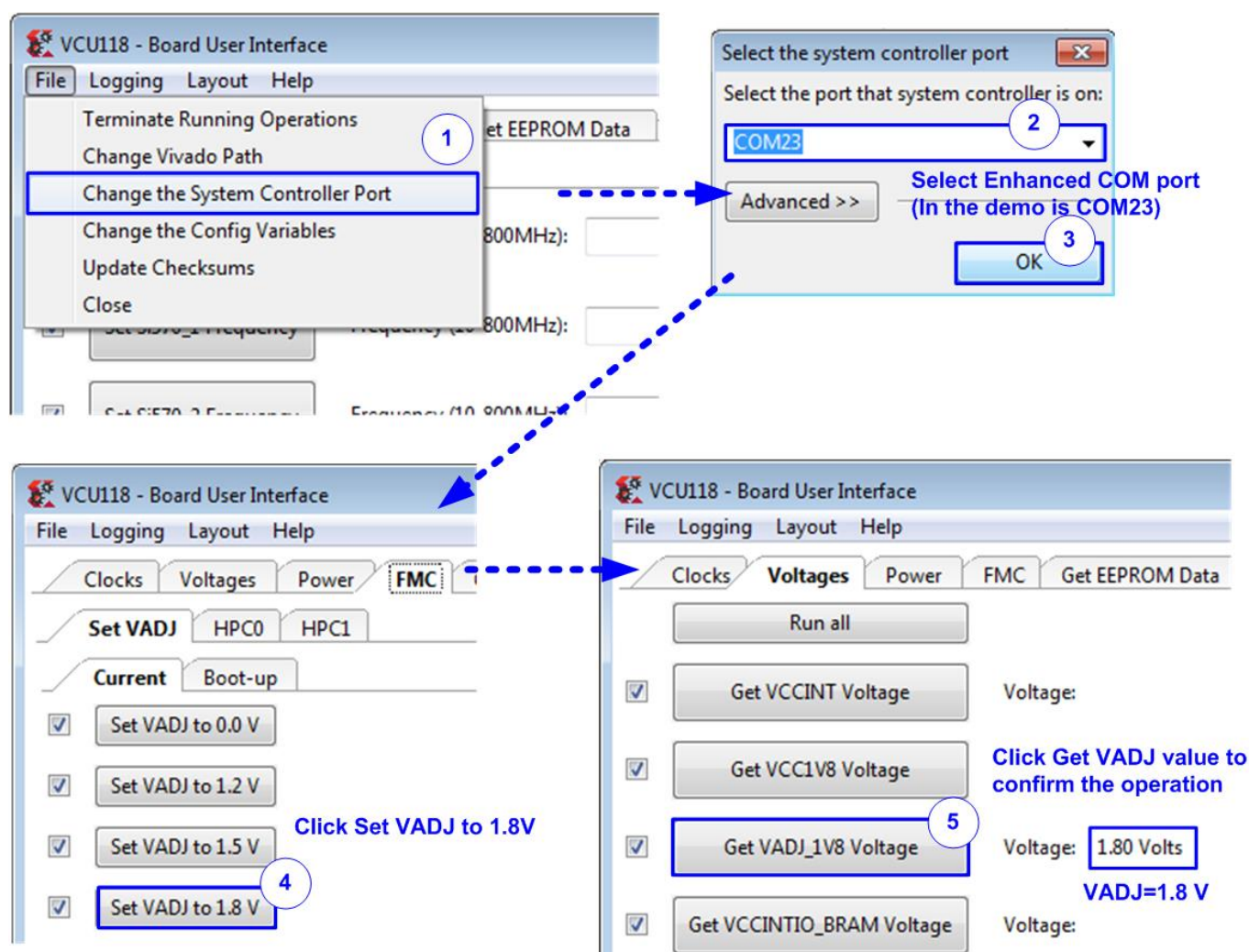


Figure 2-8 Setting VADJ of FMC for VCU118

- 9) Download and program configuration file and firmware to FPGA board.
 a. For KCU105 and VCU118, use Vivado tool to download configuration file, as shown in Figure 2-9.

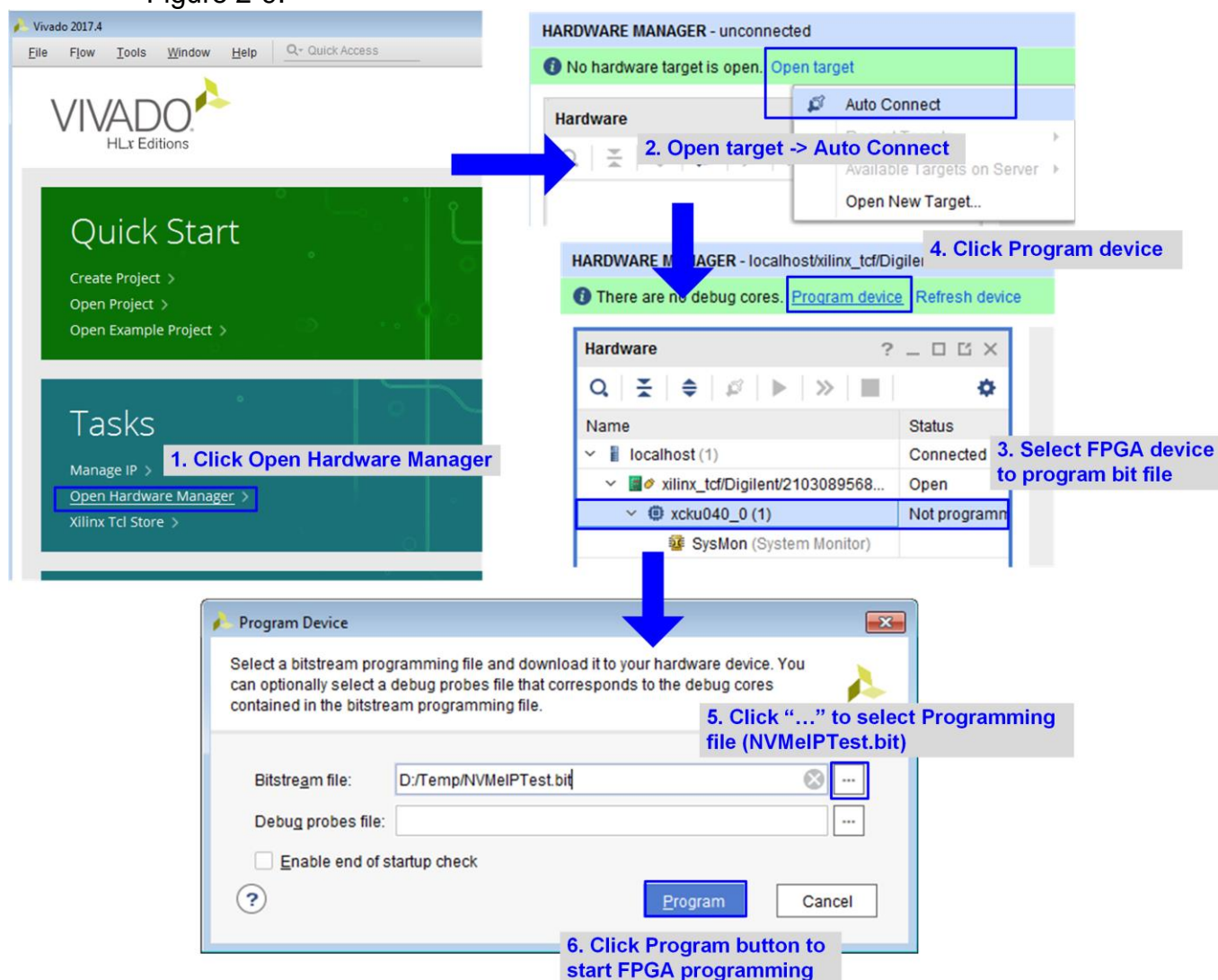


Figure 2-9 Programmed by Vivado

- b. For ZCU106 board, open Vivado TCL shell and change directory to ready_for_download or directory that batch file is located. Next, type zcu106_NVMeIPTest.bat, as shown in Figure 2-10.



Figure 2-10 Command script to download demo file on Vivado TCL shell

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

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

Table 2-1 LED Definition

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.

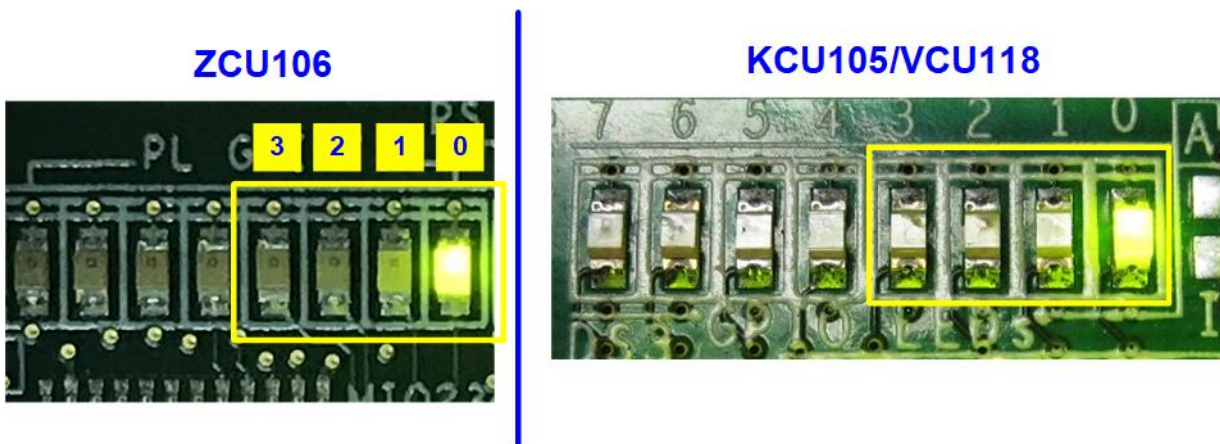


Figure 2-11 LED status after program configuration file and PCIe initialization complete

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

“Waiting PCIe Linkup” is displayed after finishing configuration.

After PCIe is linkup, “Waiting IP initialization” is displayed.

After finishing NVMe IP initialization, PCIe speed and number of PCIe lanes are displayed. Finally, main menu to run six commands is shown on the console.

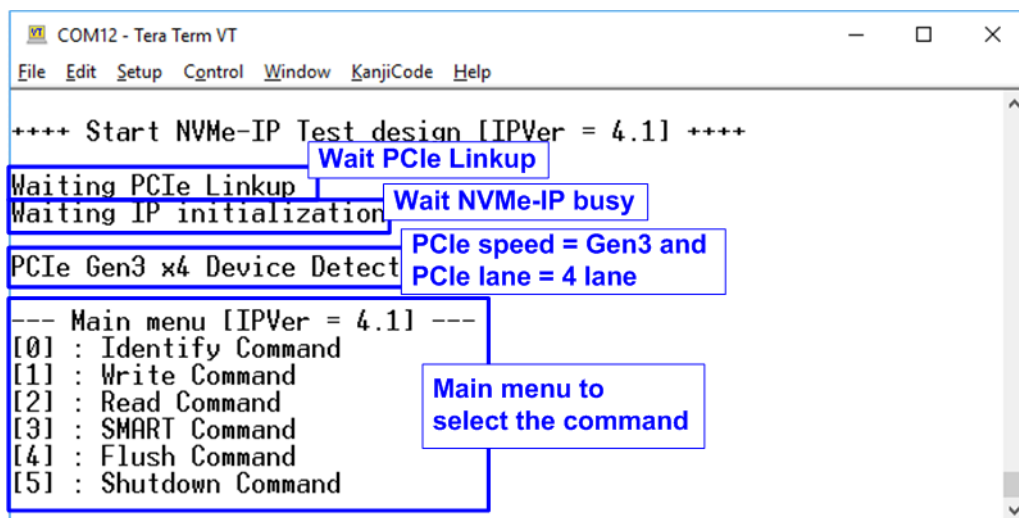


Figure 2-12 Main menu after program configuration file and PCIe initialization complete

3 Test Menu

3.1 Identify Command

Select '0' to send Identify command to NVMe SSD.

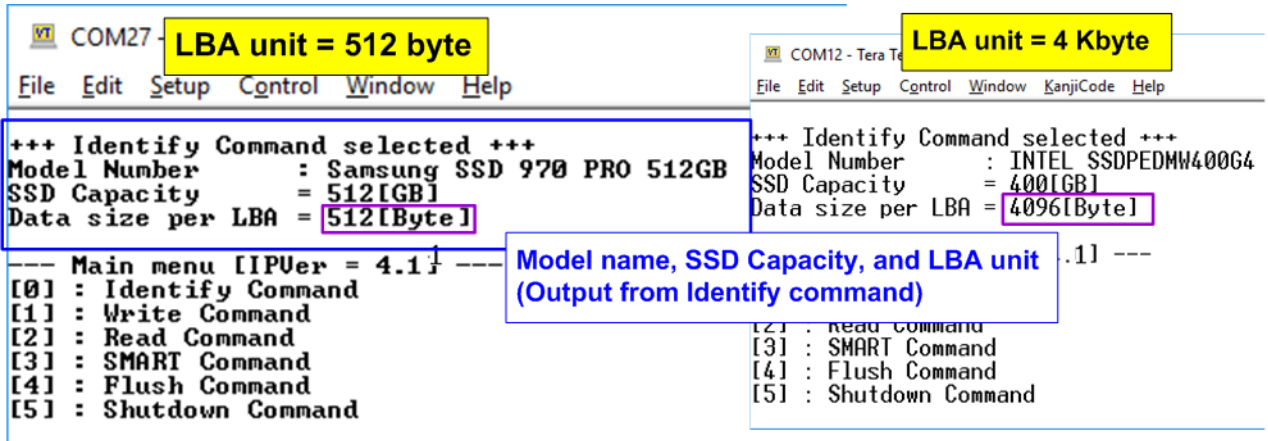


Figure 3-1 Test result when running Identify command

After finishing the operation, the SSD information output from Identify command is displayed. The console shows three values.

- 1) SSD model number: This value is decoded from Identify controller data.
- 2) SSD capacity: This value is signal output from NVMe-IP.
- 3) Data size per LBA: This value is signal output from NVMe-IP. Two values are supported, i.e. 512 byte and 4 Kbyte.

3.2 Write Command

Select '1' to send Write command to NVMe SSD.

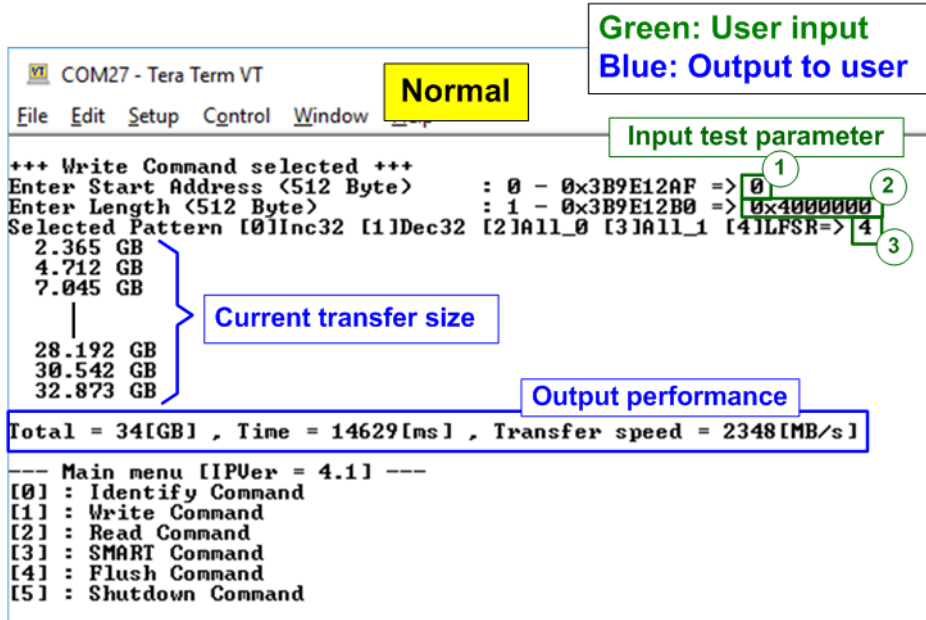


Figure 3-2 Test result when running Write command

User inputs three parameters as follows.

- 1) 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.
- 2) 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.
- 3) 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, 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 displayed on the console as test result.

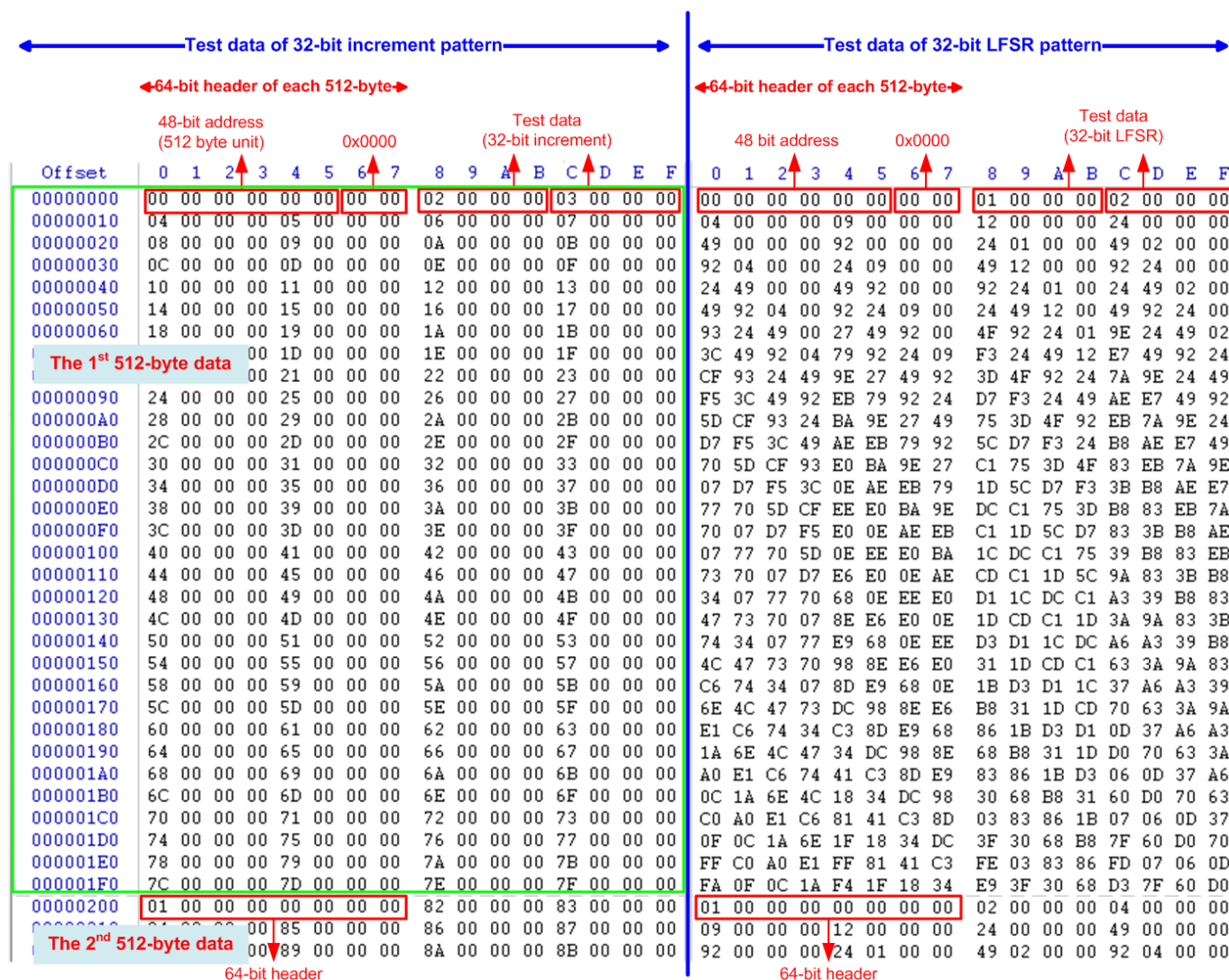


Figure 3-3 Example Test data of the 1st and 2nd 512-byte by using incremental/LFSR pattern

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 3-3 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 or Read command with 4-Kbyte LBA SSD, there is the message displaying on the console to show the input limitation which must be aligned to 8, as shown in Figure 3-4. When the input does not align to 8, “Invalid input” is displayed and the operation is cancelled.

Also, Figure 3-5 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.

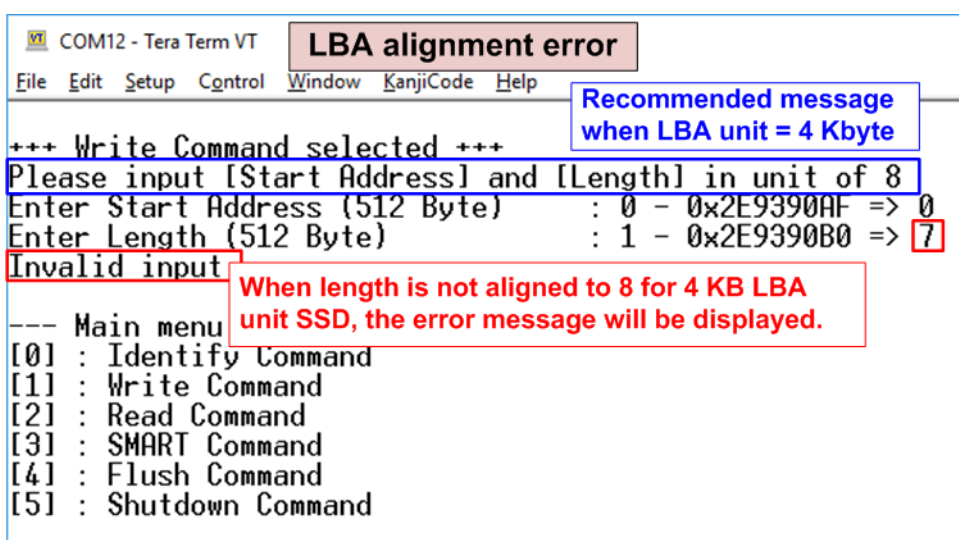


Figure 3-4 Error message when the input is unaligned for SSD with 4KB LBA unit

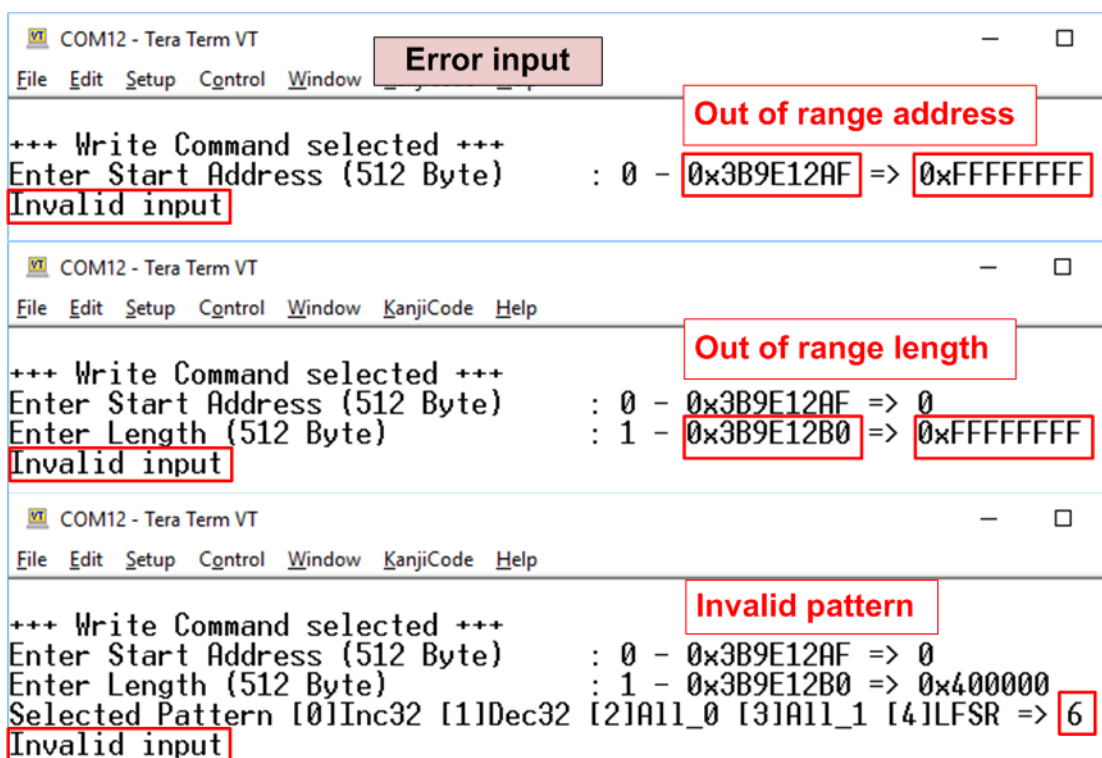
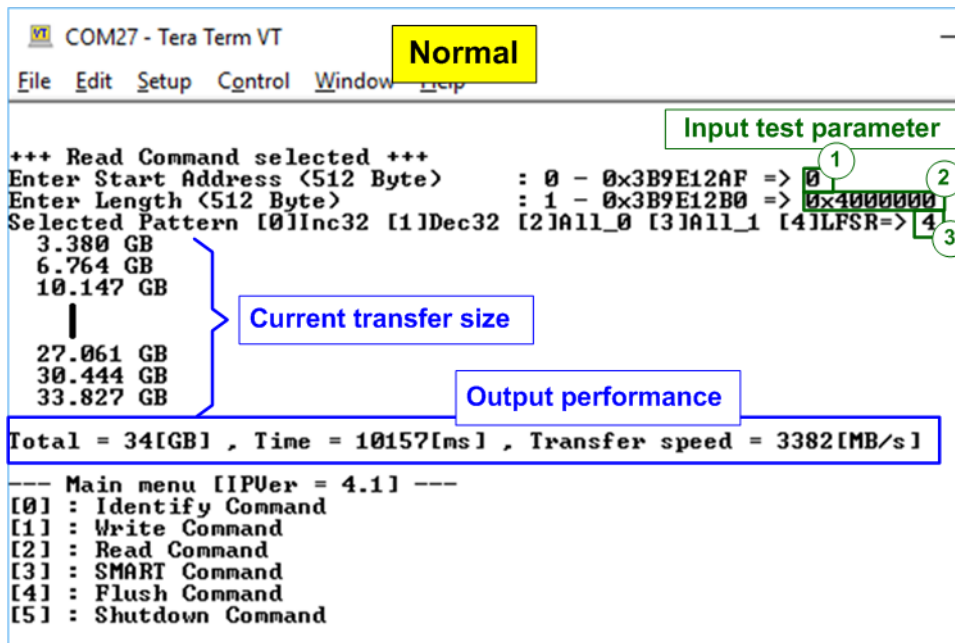


Figure 3-5 Error message from the invalid input

3.3 Read Command

Select '2' to send Read command to NVMe SSD.



```

COM27 - Tera Term VT
File Edit Setup Control Window Help
Normal

+++ Read Command selected +++
Enter Start Address (512 Byte)      : 0 - 0x3B9E12AF => 0
Enter Length (512 Byte)            : 1 - 0x3B9E12B0 => 0x40000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4

3.380 GB
6.764 GB
10.147 GB
|
27.061 GB
30.444 GB
33.827 GB

Total = 34[GB] , Time = 10157[ms] , Transfer speed = 3382[MB/s]

--- Main menu [IPVer = 4.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command
  
```

Figure 3-6 Test result when running Read command

User inputs three parameters as follows.

- 1) 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.
- 2) 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.
- 3) 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. 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 displayed after finishing the operation.

"Invalid input" is displayed when some inputs are invalid or unaligned to 8 (when connecting to 4-KB LBA SSD).

Figure 3-7 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. Similar to the normal condition, the output performance is displayed on the console when the user does not enter any key(s) to stop the operation.

When cancelling the operation, the read command still runs as the background process. It is recommended to power-off/on AB17, and then press “RESET” button to restart system.

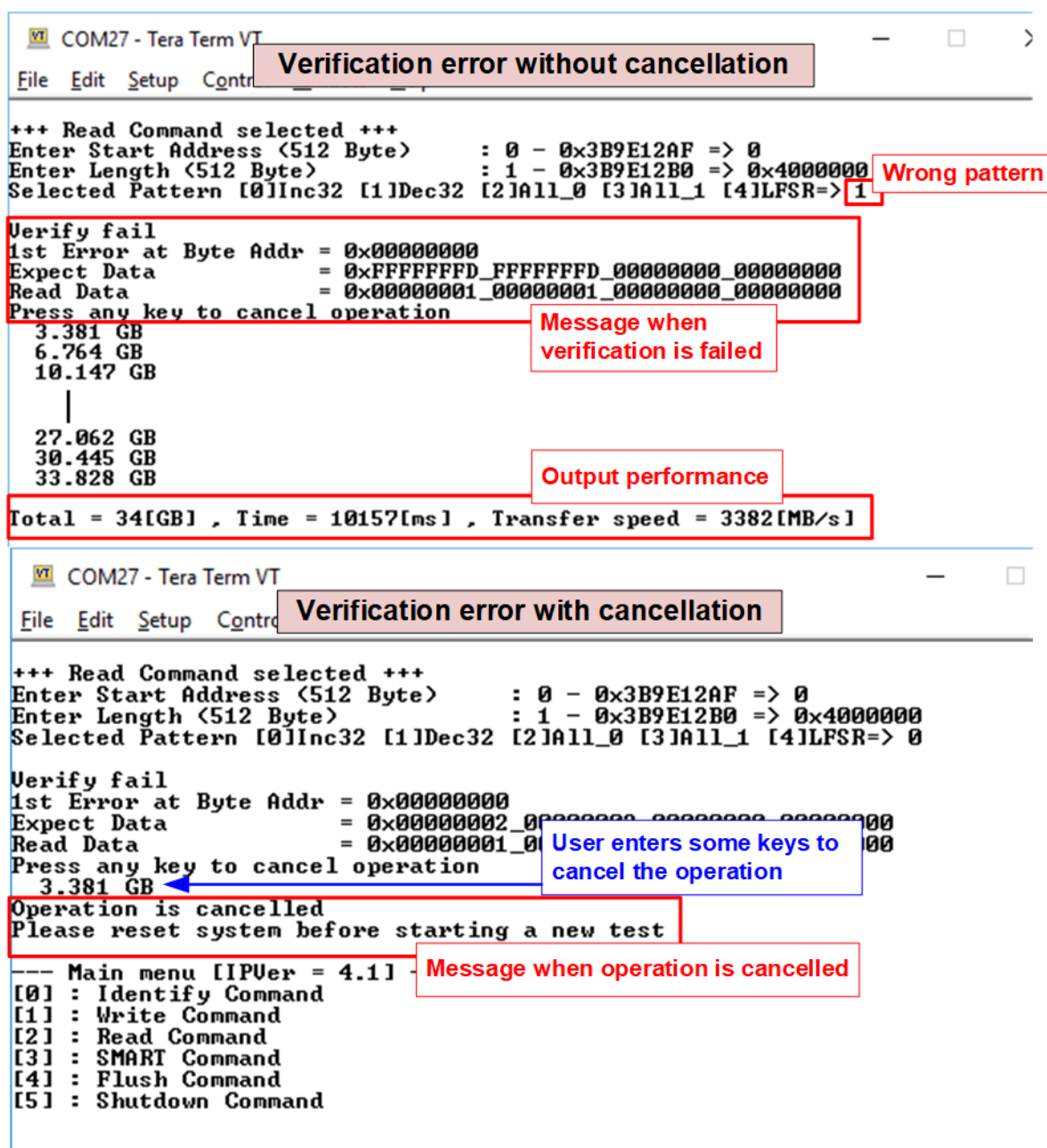


Figure 3-7 Data verification is failed

3.4 SMART Command

Select '3' to send SMART command to NVMe SSD.

```

COM12 - Tera Term VT
File Edit Setup Control Window KanjiCode Help

+++ SMART Command selected +++

Data output decoded
from SMART command

<< SMART Log Information >>
Temperature           : 30 Degree Celsius
Total Data Read       : 51805 GB
Total Data Read (Raw data) : 0x00000000_00000000_00000000_0607D02A
Total Data Written    : 59420 GB
Total Data Written (Raw data) : 0x00000000_00000000_00000000_06EAC2E5
Power On Cycles       : 1570 Times
Power On Hours        : 135 Hours
Unsafe Shutdowns     : 1526 Times

SMART Command Complete...

--- Main menu [IPVer = 4.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command
    
```

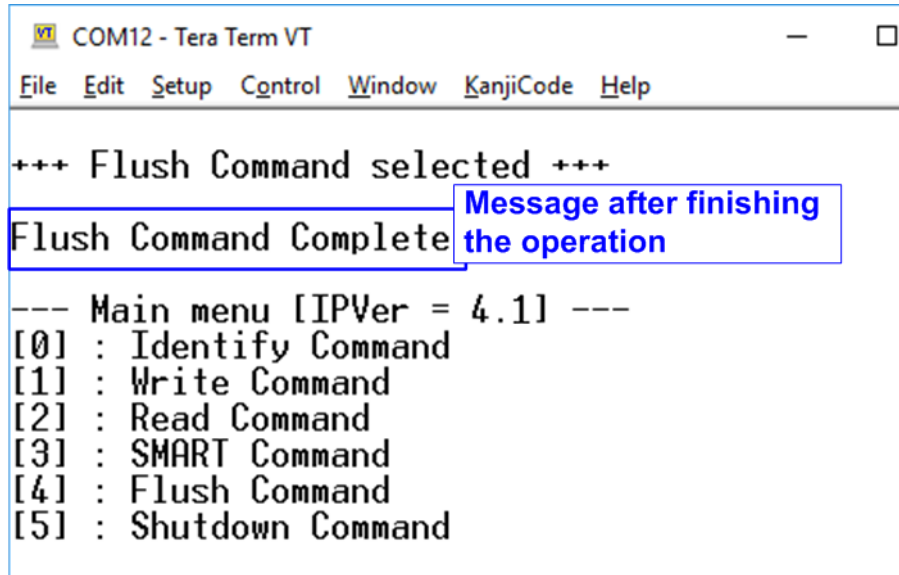
Figure 3-8 Test result when running SMART command

After finishing the operation, SMART/Health Information (output from SMART command) is displayed as shown in Figure 3-8. The console shows six parameters, 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 the 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 NVMe SSD.



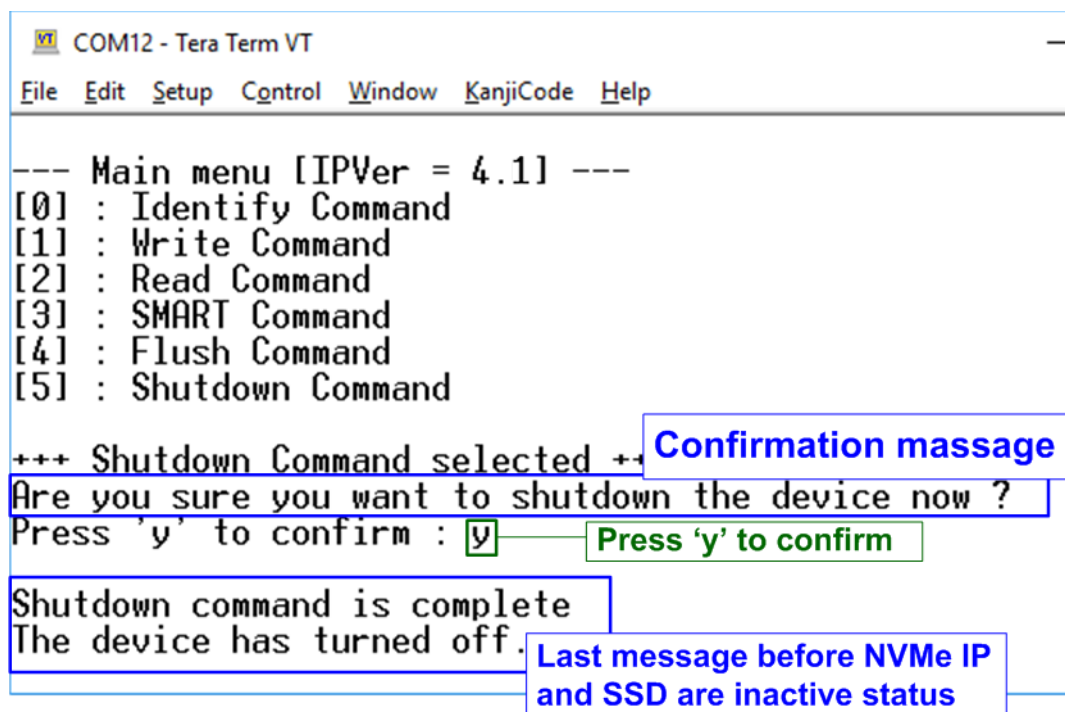
```
COM12 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
+++ Flush Command selected +++
Flush Command Complete
--- Main menu [IPVer = 4.1] ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Shutdown Command
```

Figure 3-9 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 NVMe SSD.



```

COM12 - Tera Term VT
File Edit Setup Control Window KanjiCode Help

--- Main menu [IPVer = 4.1] ---
[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.
  
```

Figure 3-10 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.

4 Revision History

Revision	Date	Description
1.0	4-May-18	Initial version release
1.1	28-Jan-20	Support Shutdown, SMART, and Flush command