



exFAT IP for NVMe Demo Instruction

Rev2.1 9-Aug-23

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1 Overview

This document describes the instruction to run exFAT-IP for NVMe demo on FPGA development board for accessing one NVMe SSD. The demo is designed to run Format disk, Write file, Read file or Shutdown command. User controls test operation via FPGA console.

FPGA board setup for exFAT-IP demo is the same as in NVMe-IP demo. So, the user can setup the FPGA by following “dg_nvmeip_fpgasetup” document.

https://dgway.com/products/IP/NVMe-IP/dg_nvmeip_fpgasetup_xilinx_en.pdf

After finishing the FPGA configuration, the initialization message is displayed. The user can choose to format the disk or not.

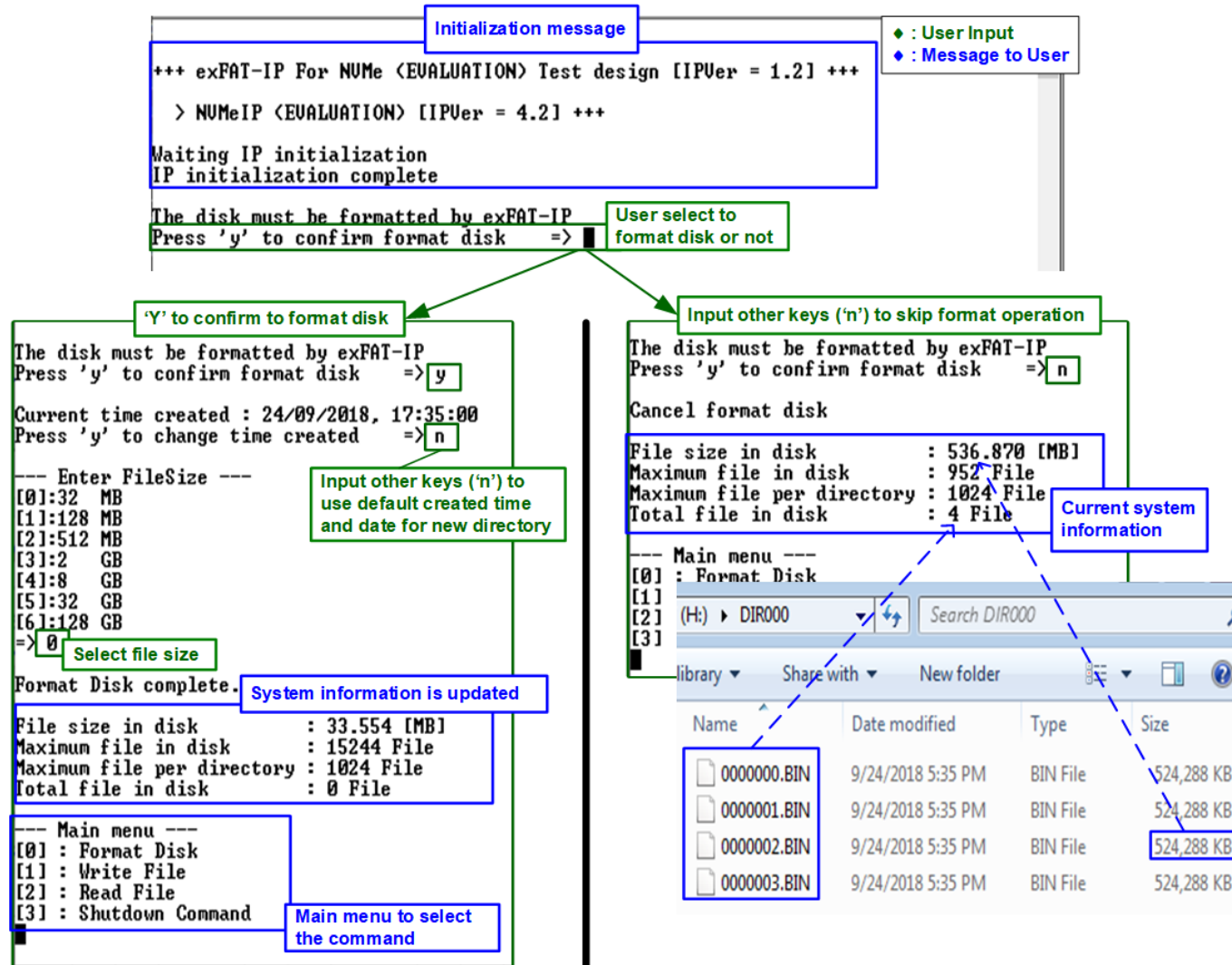


Figure 1-1 exFAT-IP initialization message

For the new disk which has never been formatted by exFAT-IP, user must enter 'y' to format the disk. Otherwise, user enters other keys to skip format process. After that, the system information in the disk are displayed, i.e. current file size, maximum file in the disk, maximum file per directory, and total file in the disk. Finally, the IP is ready to receive command from the user.

2 Test Menu

2.1 Format Disk

Select '0' to send Format disk command to exFAT-IP. The step to run Format command is as follows.

Format by 32 MB file size

```

+++ Format Command selected +++
Press 'y' to confirm format disk => y
Current time created : 24/09/2018, 17:35:00
Press 'y' to change time created => y
Year (1980 - 2107) => 6
Invalid input : Parameter not change
Month (1 - 12) => 10
Date (1 - 31) => 10
Hour (0 - 23) => 11
Minute (0 - 59) => 30
Second 2-Sec unit (0 - 29) => 5
Date and Time Changed
Current time created : 10/10/2018, 11:30:10

--- Enter FileSize ---
[0]:32 MB
[1]:128 MB
[2]:512 MB
[3]:2 GB
[4]:8 GB
[5]:32 GB
[6]:128 GB
=> 0

Format Disk complete.

File size in disk : 33.554 [MB]
Maximum file in disk : 15244 File
Maximum file per directory : 1024 File
Total file in disk : 0 File

--- Main menu ---
[0] : Format Disk
[1] : Write File
[2] : Read File
[3] : Shutdown Command
    
```

◆ : User Input
◆ : Output to User

1) 'Y' to confirm format disk

2) Display default time created

3) Input 'Y' to set time created

Input invalid value to use same value

Input valid value to change date/month/hour/min/sec

New default time

Set time created

Valid file size

Set file size = 32 MB

Current system information after finishing Format command

Figure 2-1 Format Disk menu when updating the created time

- 1) Enter 'y' to confirm Format operation or other keys to cancel the operation. When Format is run, the default value of created date and time is displayed. This value is applied to be created date and time of empty directories, created by Format command.
- 2) Enter 'y' to change created date and time or other keys to use the default value. There are six parameters to set created date and time for empty directories, i.e.
 - a) Year – Year of created date. Valid range is 1980 – 2107.
 - b) Month – Month of created date. Valid range is 1 – 12.
 - c) Date – Date of created date. Valid range is 1 – 31.
 - d) Hour – Hour of created time. Valid range is 0 – 23.
 - e) Minute – Minute of created time. Valid range is 0 – 59.
 - f) Second – x2 Second of created time. Valid range is 0 – 29.

The input is received as decimal unit. User adds “0x” to be a prefix for hexadecimal input. If the input is invalid, the parameter does not change (the same value is used). Only the input in the valid range is applied to update the parameter.

As shown in Figure 2-1, year parameter is invalid, so the value does not change (2018 is applied). Month, date, hour, minute, and second are valid, so these parameters are updated to the new default value. After that, “Date and Time changed” and the new created time and date are displayed on the console.

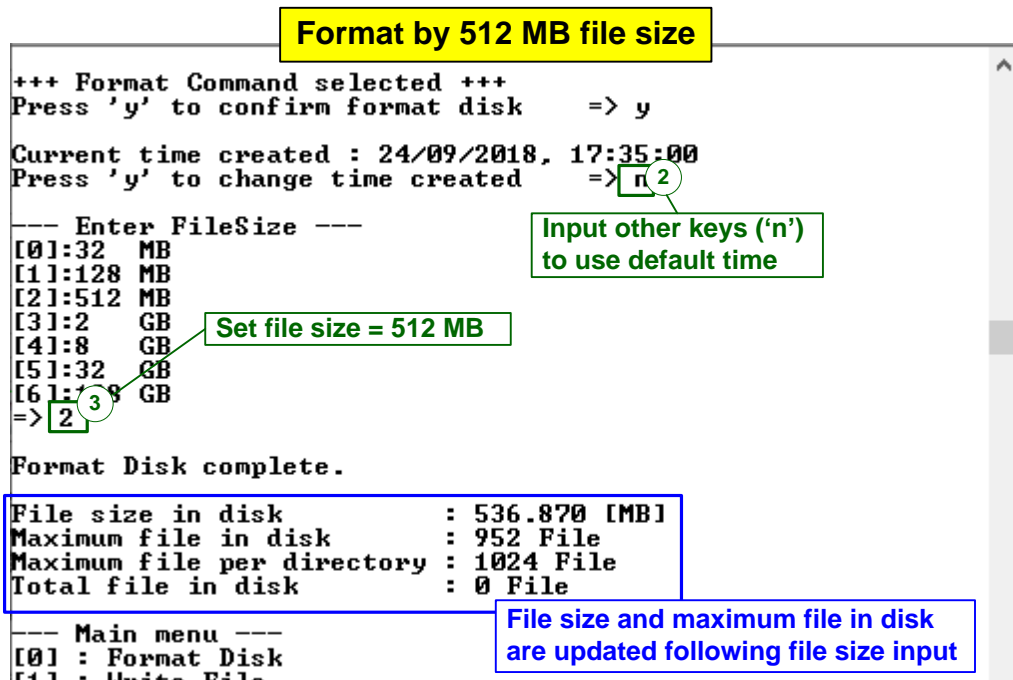


Figure 2-2 Format Disk menu when using the default created time

Figure 2-2 shows the example when running Format command without updating created time.

- 3) Select file size of the disk which is listed on the console. After receiving file size from user, the IP starts Format operation.

“Format Disk complete” and the updated system information are displayed after finishing Format command.

Figure 2-1 and Figure 2-2 show the different file size but the same disk capacity. As a result, maximum file in the disk is reduced when file size is increased.

When file size is invalid, the operation is cancelled, as shown in Figure 2-3.

Note: Default created time after system boot up is 24 Sep 2018, 17:35:00. When user sets the new created time in Format menu or Write file menu, the new value is updated to the new default value

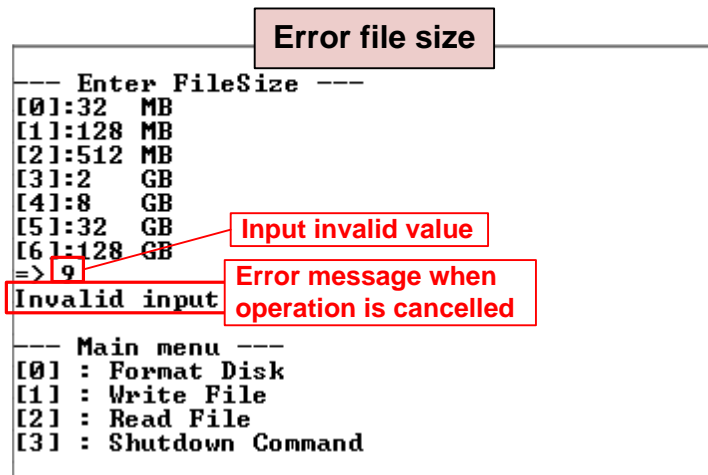


Figure 2-3 Result from Format Disk menu when select invalid file size

When the disk formatted by exFAT-IP is connected to PC, DG_exFAT drive is detected with 512 empty directories (DIR000<1st directory> - DIR1FF<512th directory>). Modified date of the empty directories is equal to the created date, set in the test.

Note: When connecting disk to PC, please do not create, write, or modify data in the disk. If the disk has some modification, the disk must be re-formatted by exFAT-IP.

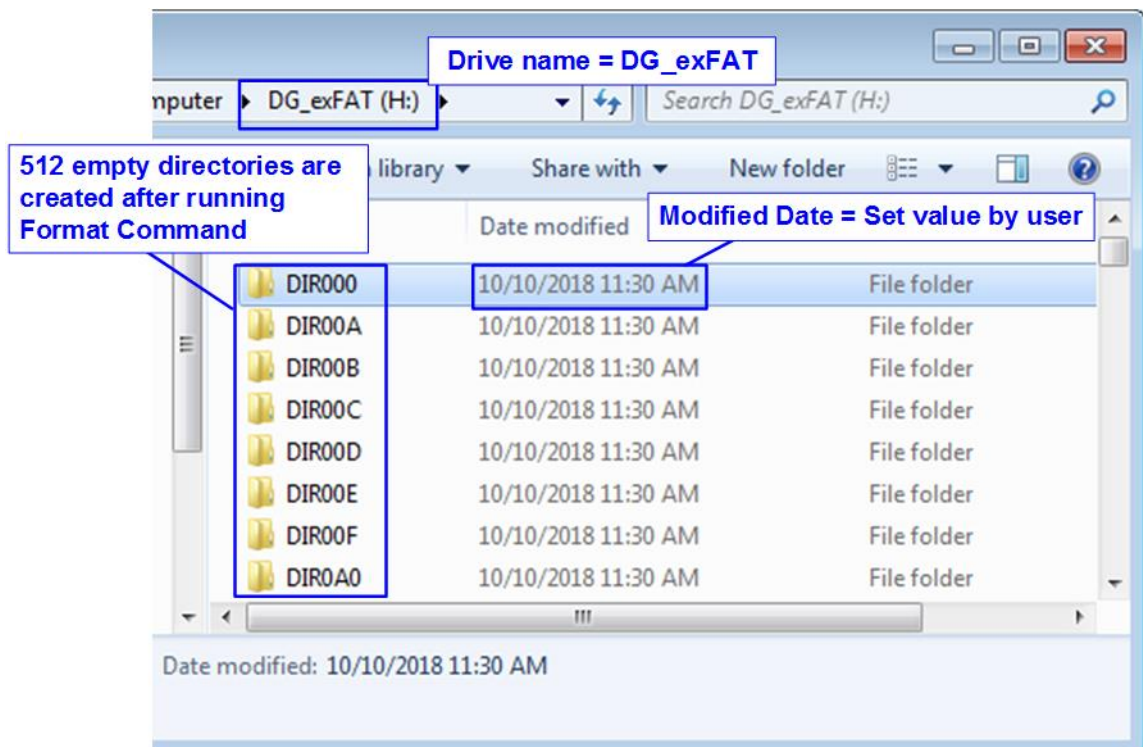


Figure 2-4 512 Empty directories after finishing Format Disk command

2.2 Write File

Select '1' to send Write file command to exFAT-IP. The step to run Write file command is as follows.

Write File with setting created time

```

+++ Write File selected +++
Current time created : 24/09/2018, 17:35:00
Press 'y' to change time created => y
Year (1980 - 2107) => 6
Invalid input : Parameter not change
Month (1 - 12) => 2
Date (1 - 31) => 14
Hour (0 - 23) => 14
Minute (0 - 59) => 14
Second 2-Sec unit (0 - 29) => 14
Date and Time Changed
Current time created : 14/02/2018, 14:14:28

Start file No. (0x0000000)
Press 'y' to change start file No. => n
Input NUM of file (0x0000001 - 0x0003B8C) => 0x0000400
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4
File size = 33.554 [MB] , NUM of file = 1024[File] , Total size = 34.359 [GB]
2.370 [GB]
4.701 [GB]
7.036 [GB]
|
30.488 [GB]
32.831 [GB]

Total = 34.359 [GB] , Time = 14669[ms] , Transfer speed = 2318[MB/s]
Written file : Dir000/0000000.BIN - Dir000/00003FF.BIN
Last file : Dir000/00003FF.BIN

--- Main menu ---
[0] : Format Disk
[1] : Write File
[2] : Read File
[3] : Shutdown Command
  
```

Annotations:

- Set time created:** Points to the initial time display and the 'y' input.
- Display default time created:** Points to the initial time display.
- Input 'Y' to change time:** Points to the 'y' input.
- Input invalid value to use same value:** Points to the '6' input for Year.
- Input valid value to change month/date/hour/min/sec:** Points to inputs '2', '14', '14', and '14'.
- New default time:** Points to the updated time display.
- Input other keys (not 'y') to use recommended start file number:** Points to the 'n' input.
- Input total file and test pattern:** Points to the '4' input for the pattern.
- Current transfer size:** Points to the list of file sizes.
- Output performance:** Points to the total size, time, and transfer speed.
- Last file is in the device (File name and directory path):** Points to the 'Last file' line.
- File list in this command (File name and directory path):** Points to the 'Written file' line.

Figure 2-5 Result from Write File menu with setting time created

- 1) Similar to Format command, enter 'y' to change created date and time or other keys to use the default value. There are six parameters to set created date and time for the new file.
 - a) Year – Year of created date. Valid range is 1980 – 2107.
 - b) Month – Month of created date. Valid range is 1 – 12.
 - c) Date – Date of created date. Valid range is 1 – 31.
 - d) Hour – Hour of created time. Valid range is 0 – 23.
 - e) Minute – Minute of created time. Valid range is 0 – 59.
 - f) Second – x2 Second of created time. Valid range is 0 – 29.

The input is received as decimal unit. User adds "0x" to be a prefix for hexadecimal input. If the input is invalid, the parameter does not change (the same value is used). Only the input in the valid range is applied to update the parameter.

As shown in Figure 2-5, year parameter is invalid, so the value does not change (2018 is applied). Month, date, hour, minute, and second are valid, so these parameters are updated to the new default value. After that, "Date and Time changed" and the new created time and date are displayed on the console.

- 2) Input other keys (not 'y') to use the recommended start file no. The console displays the recommended value which is the next value from the latest write file.
Note: Input 'y' to change start file no. is allowed for replacing the old file. After running, the data in the old file is replaced by the new one.
- 3) Input NUM of file – Input total files to transfer in this command. After finishing write file operation, Filename <Start file No>.BIN - Filename <Start file No + NUM of file - 1>.BIN are stored in the device. The input is decimal unit when input only digit number. User can add "0x" to be prefix for hexadecimal input.
- 4) Input test pattern – Select pattern of test data in the file. Five patterns can be set, i.e. 32-bit incremental, 32-bit decremental, all-0, all-1, and 32-bit LFSR counter.

After all inputs are valid, total data size (calculated by file size x Num of file) is displayed on the console. Next, Write file command is operated. During writing file, 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 the test result.

The number of files per directory is limited, so the new files may store in the different directory. After finishing Write file command, the console displays the 1st file and the last file which has just written with the directory path (calculated by <file name>/<maximum files per directory>). Finally, the console displays the last available file in the disk which may not be equal to the last file in the latest write test when the user runs the write file test for replacing the files.

Write File without setting created time

```

+++ Write File selected +++
Current time created : 14/02/2018, 14:14:28
Press 'y' to change time created => n
Start file No. <0x0000400>
Press 'y' to change start file No. => n
Input NUM of file <0x0000001 - 0x000378C> => 0x0000600
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 0
File size = 33.554 [MB] , NUM of file = 1536[File] , Total size = 51.539 [GB]
2.368 [GB]
4.718 [GB]

|
44.606 [GB]
46.958 [GB]
49.300 [GB]

Total = 51.539 [GB] , Time = 21965[ms] , Transfer speed = 2322[MB/s]
Written file : Dir001/0000400.BIN - Dir002/00009FF.BIN
Last file : Dir002/00009FF.BIN

--- Main menu ---
[0] : Format Disk
[1] : Write File
[2] : Read File
[3] : Shutdown Command
    
```

Annotations:

- Input other keys ('n') to use current created time
- The recommended file name, calculated from the last file name (0x00003FF + 1)
- File list in this command (File name and directory path)
- Last file is in the device (File name and directory path)

Figure 2-6 Result from Write File by using current created time

Figure 2-6 shows the example to Write File by using current created time. “Start file No” of this test is updated from the previous write test. The previous write test in Figure 2-5 writes file “0000000.BIN” – “00003FF.BIN”, so the recommended “Start file No” is 0x0000400 (0x00003FF + 1). After finishing creating 1536 (0x600) file, 0x0000400.BIN – 0x00009FF.BIN are available and the last file in the disk is updated to be 0x00009FF.BIN.

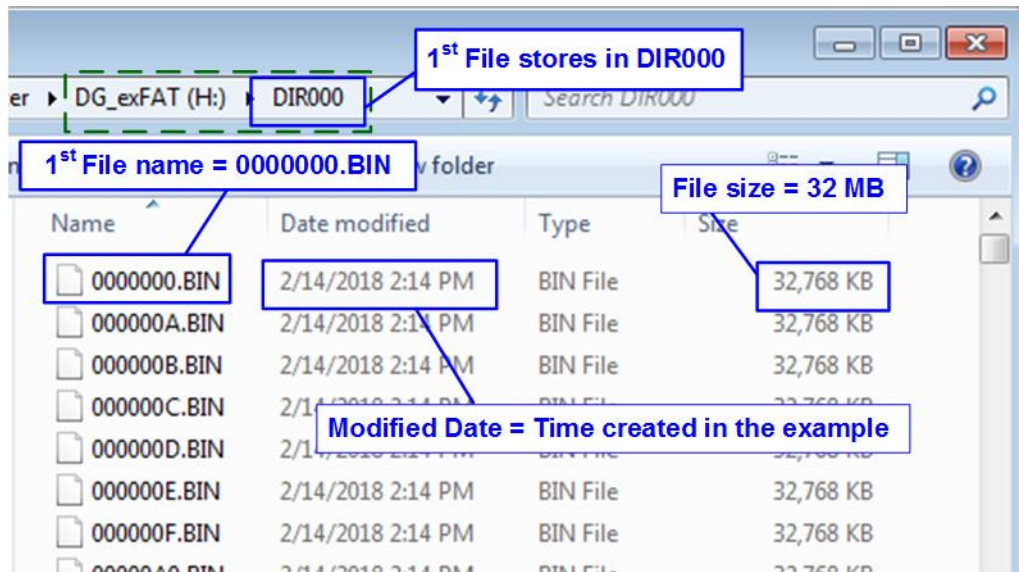


Figure 2-7 Example test files written by Write File command

When plugging the device to PC, PC detects the files in subdirectory of DG_exFAT drive. The 1st file in the disk is 0000000.BIN (stored in DIR000). File size and modified date of each file are equal to the created date and created time, set in Write File test.

Note: When connecting disk to PC, please do not create, write, or modify data in the disk. If the disk has some modification, the disk must be re-formatted by exFAT-IP.

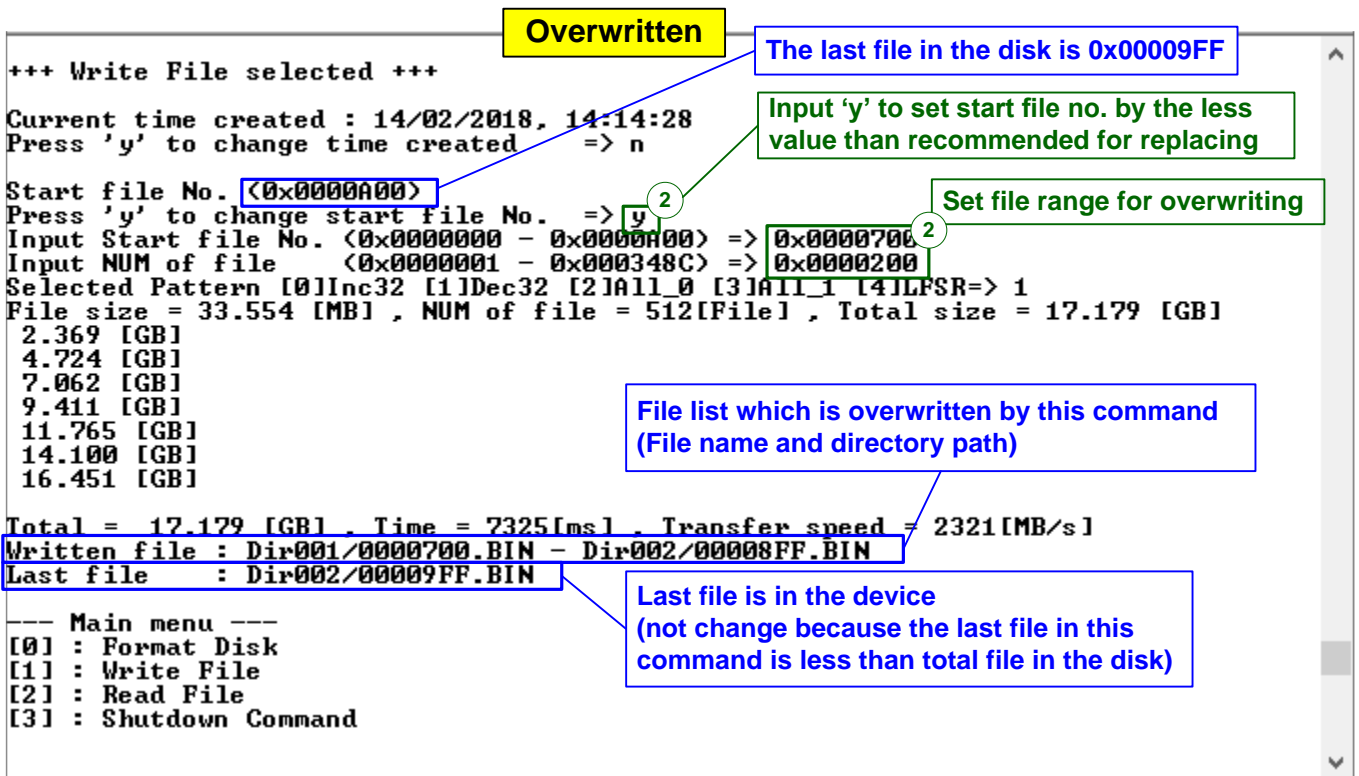


Figure 2-9 Set new start file no.

Figure 2-9 shows the example of the overwritten case by setting Start file No. and NUM of file to be less than the default value. The last file in the disk is 0x00009FF, but the new command writes 0x0000700.BIN – 0x00008FF.BIN by using decremental pattern which is different from Figure 2-6 (0x0000400.BIN – 0x00009FF.BIN are created by using incremental pattern).

After finishing the operation, the data in 0x0000700.BIN – 0x00008FF.BIN is decremental pattern. Because the last file in the new command (0x00008FF.BIN) is less than the last file in the device (0x00009FF.BIN), the last file on the console is not updated. Otherwise, the last file is updated by the last file in this write test.

Figure 2-10 shows the example of error messages when the input is out of the recommended range for each parameter. “Invalid input” message is displayed on the console and then returns to main menu.

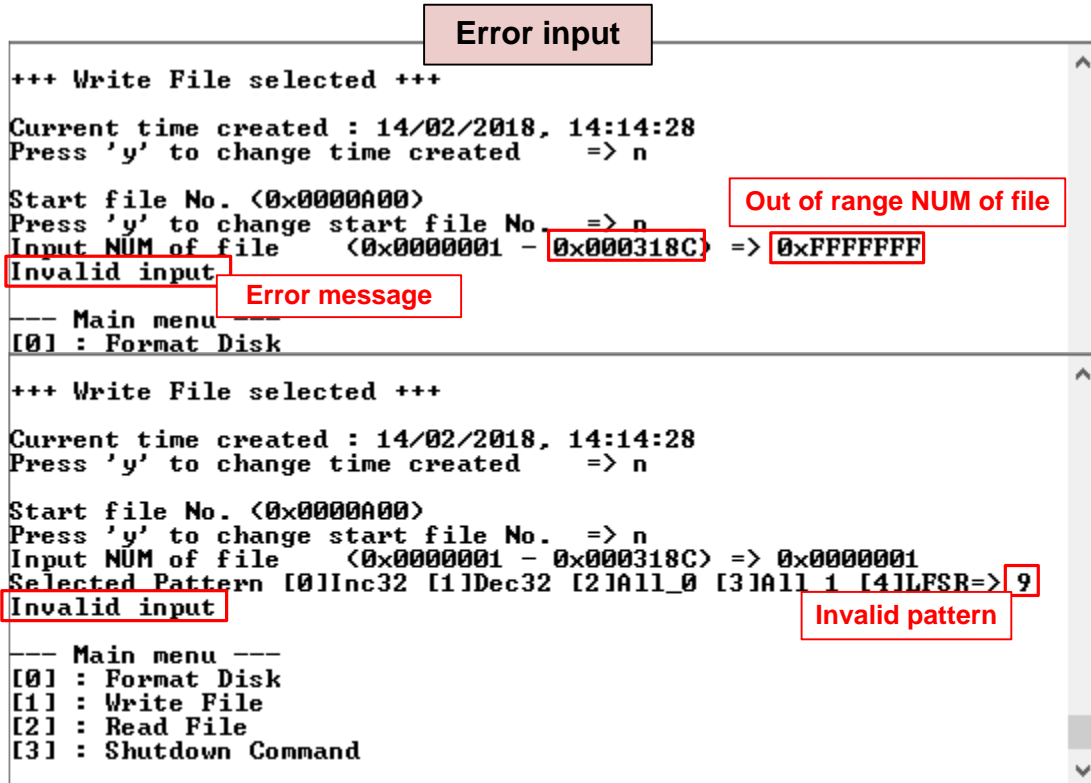


Figure 2-10 Error message from the invalid input

2.3 Read File

Select '2' to send Read file command to exFAT-IP. The step to run Read File command is as follows.

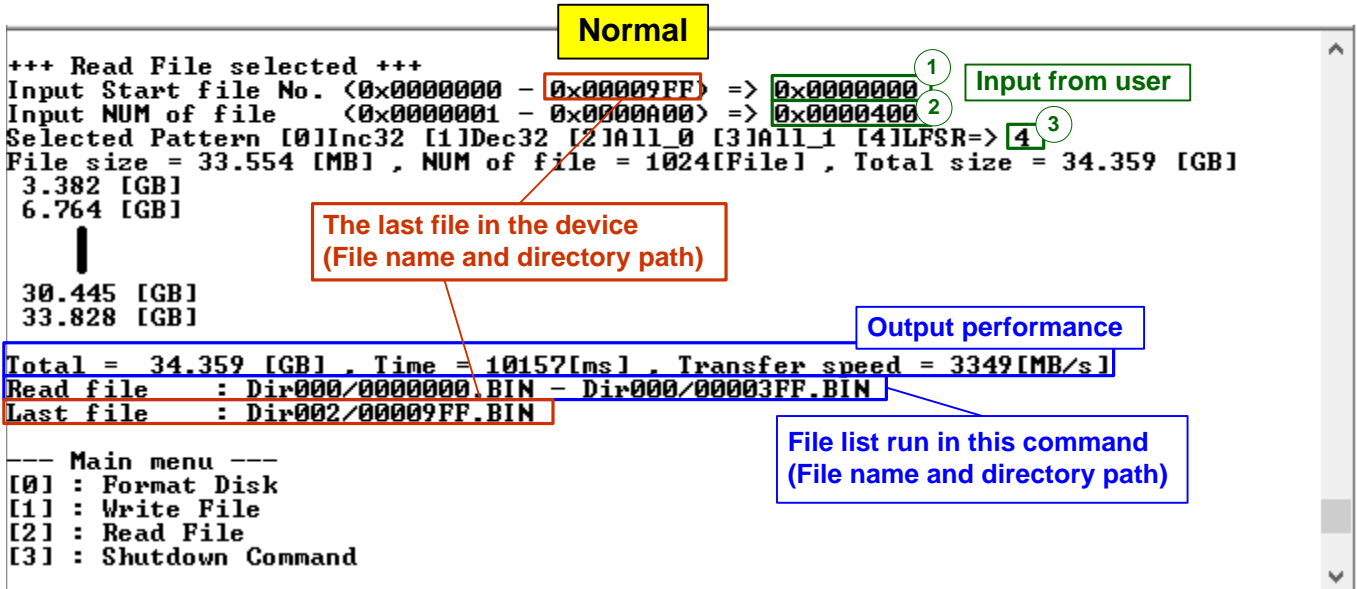


Figure 2-11 Read File menu when verification is successful

- 1) Input Start file No – Input the 1st file name to read. The input is decimal unit when input only digit number. User can add “0x” to be prefix for hexadecimal input. The maximum value is equal to <total file in the disk – 1>.
- 2) Input NUM of file – Input total files to transfer in this command. The input is decimal unit when input only digit number. User can add “0x” to be prefix for hexadecimal input. The maximum value is equal to <total file in the disk – Start file No. input>.
- 3) Input test pattern – Select pattern to verify data in the file. Test pattern must be matched with the test pattern using in Write File menu. Five patterns can be set, i.e. 32-bit incremental, 32-bit decremental, all-0, all-1, and 32-bit LFSR counter.

When “Start file No.”, “NUM of file”, and “Select pattern” are valid, total data size (calculated by file size x NUM of file) are displayed on the console and Read file command is run.

During reading file, 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 the test result.

When input is out-of-range, “Invalid input” is displayed with operation cancelled.

Similar to write file menu, the console shows the 1st and the last file of the latest command. Finally, the last available file in the disk is displayed. This value is not updated by Read menu and always equal to the upper range of Start File No. input.

Figure 2-12 shows the example of error message when data verification is failed. “Verify fail” is displayed with the first error file name, the error address of a file, the expected data, and the read data. User can press any key(s) to cancel read operation or wait until the read process is completed.

After the user waits until read command completing, the output performance is displayed as a test result. The user can continue to run the system test if the error is caused from wrong test pattern input. Otherwise, the command may not complete in a good sequence. It is recommended to reset the system to start the new test operation.

Verification error without cancellation

```
+++ Read File selected +++
Input Start file No. (0x0000000 - 0x00009FF) => 0x0000000
Input NUM of file (0x0000001 - 0x0000A00) => 0x0000600
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4
File size = 33.554 [MB] , NUM of file = 1536[File] , Total size = 51.539 [GB]
3.382 [GB]
6.765 [GB]
|
33.828 [GB]

Verify fail
1st Error at File name = 0000400.BIN
Byte Address = 0x00_00000000
Expect Data = 0x10000002_08000001_00000000_04000000
Read Data = 0x00000003_00000002_00000000_04000000
Press any key to cancel operation
37.211 [GB]
40.594 [GB]
43.976 [GB]
47.359 [GB]
50.742 [GB]

Total = 51.539 [GB] , Time = 15235[ms] , Transfer speed = 3349[MB/s]
Read file : Dir000/00000000.BIN - Dir001/00005FF.BIN
Last file : Dir002/00009FF.BIN

--- Main menu ---
[0] : Format Disk
```

Wrong pattern
(In the example, file “0000000.BIN”-“00003FF.BIN” is written by LFSR, but file “0000400.BIN” is written by increment)

Message when verification is failed

Output performance

Verification error with cancellation

```
+++ Read File selected +++
Input Start file No. (0x0000000 - 0x00009FF) => 0x0000000
Input NUM of file (0x0000001 - 0x0000A00) => 0x0000600
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4
File size = 33.554 [MB] , NUM of file = 1536[File] , Total size = 51.539 [GB]
3.381 [GB]
6.764 [GB]
|
30.445 [GB]
33.827 [GB]

Verify fail
1st Error at File name = 0000400.BIN
Byte Address = 0x00_00000000
Expect Data = 0x10000002_08000001_00000000_04000000
Read Data = 0x00000003_00000002_00000000_04000000
Press any key to cancel operation
37.210 [GB]
Operation is cancelled
Please reset system before start new test

--- Main menu ---
[0] : Format Disk
```

User presses any keys to cancel the operation

Message when the operation is cancelled

Figure 2-12 Data verification is failed

2.4 Shutdown Command

Select '3' to send Shutdown command to NVMe device.

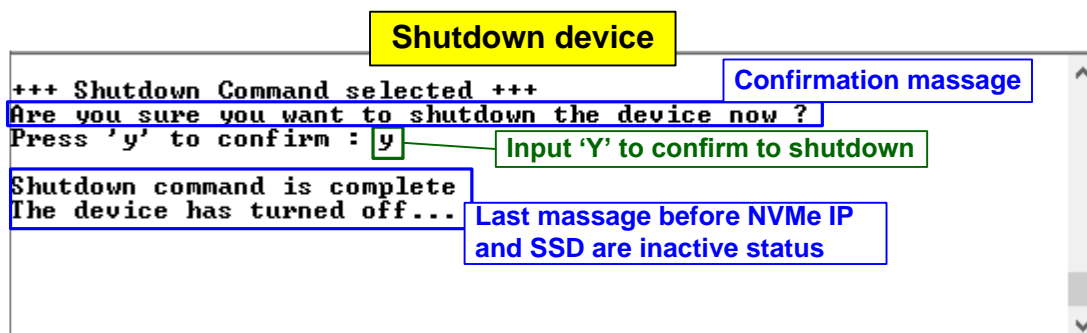


Figure 2-13 Shutdown Command with confirmation

The confirmation message is displayed on the console. User inputs 'y' or 'Y' to confirm the operation or other keys for cancellation.

After finishing the operation, the console cannot receive user input. User needs to power off/on test system to start the new test operation.

3 Revision History

Revision	Date	Description
1.0	16-Jan-19	Initial version release
1.1	22-Mar-19	Add file size and total file information
1.2	16-May-19	Correct directory name and update overwritten feature
1.3	20-Feb-20	Support VCU118 board
1.4	20-Apr-20	Remove power adapter cable from AB18
2.0	23-Jul-20	Remove FPGA setup from the document
2.1	14-Mar-22	Correct Figure index