

## exFAT IP for SATA Demo Instruction

Rev1.2 15-May-19

This document describes the instruction to run exFAT IP for SATA demo on FPGA development board by using AB09-FMCRAID board. The demo is designed to write and verify data with SATA-II or SATA-III device. User controls the test operation through Serial console.

### 1 Environment Setup

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

- 1) FPGA Development board: ZC706
- 2) PC installing Xilinx programmer software (Vivado) and Serial console software such as HyperTerminal and TeraTerm
- 3) AB09-FMCRAID board provided by Design Gateway
- 4) SATA-II or SATA-III device connecting to AB09 board
- 5) Xilinx Power adapter for FPGA board
- 6) ATX power supply for SATA device
- 7) micro USB cable for programming FPGA, connecting between FPGA board and PC
- 8) mini USB cable for Serial console, connecting between FPGA board and PC

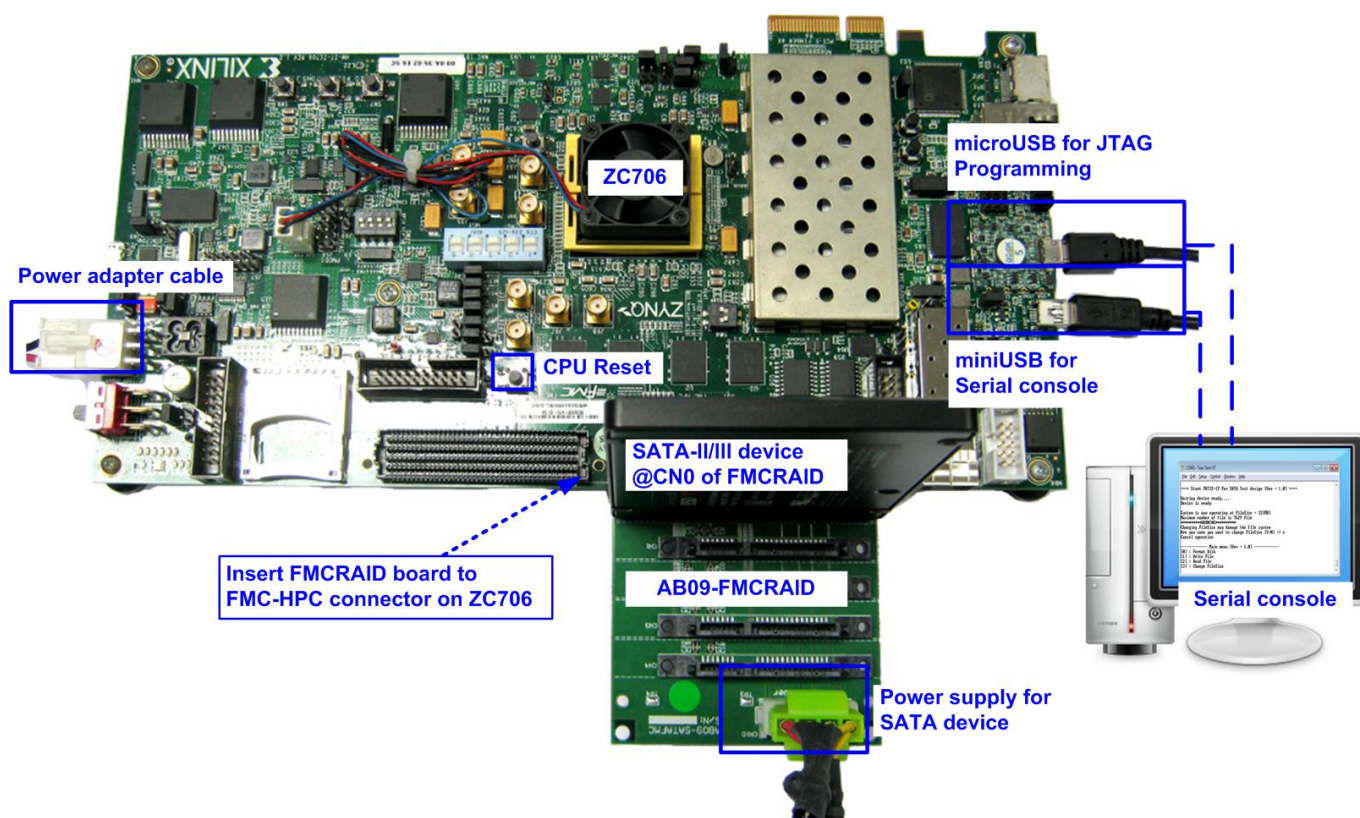


Figure 1-1 exFAT IP for SATA demo environment setup on ZC706

## 2 Demo setup

- 1) Power off system.
- 2) Set up board option for ZC706 board as shown in Figure 2-1.
  - i. Set SW11 = "00000" to configure PS from JTAG
  - ii. Set SW4 = "01" to connect JTAG with USB-to-JTAG interface

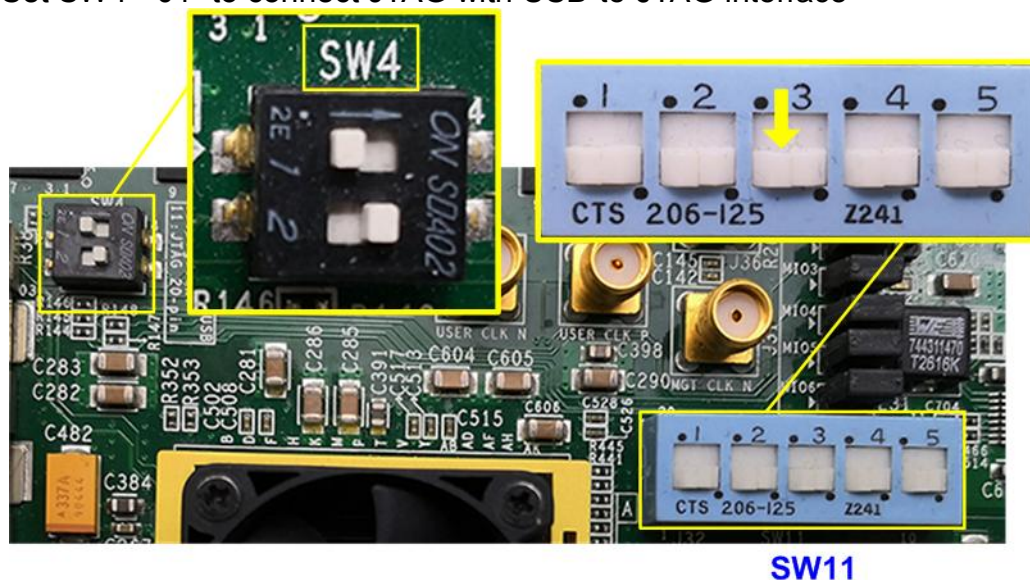


Figure 2-1 SW setting on ZC706 board

- 3) Connect the SATA-II/III device on AB09 and then connect AB09 to FPGA board as shown in Figure 2-2.
  - i. Connect AB09-FMCRAID board to FMC-HPC connector on FPGA board.
  - ii. Connect SATA-II/III device to CN0 on FMCRAID board.
  - iii. Connect ATX power to power connector on FMCRAID board.

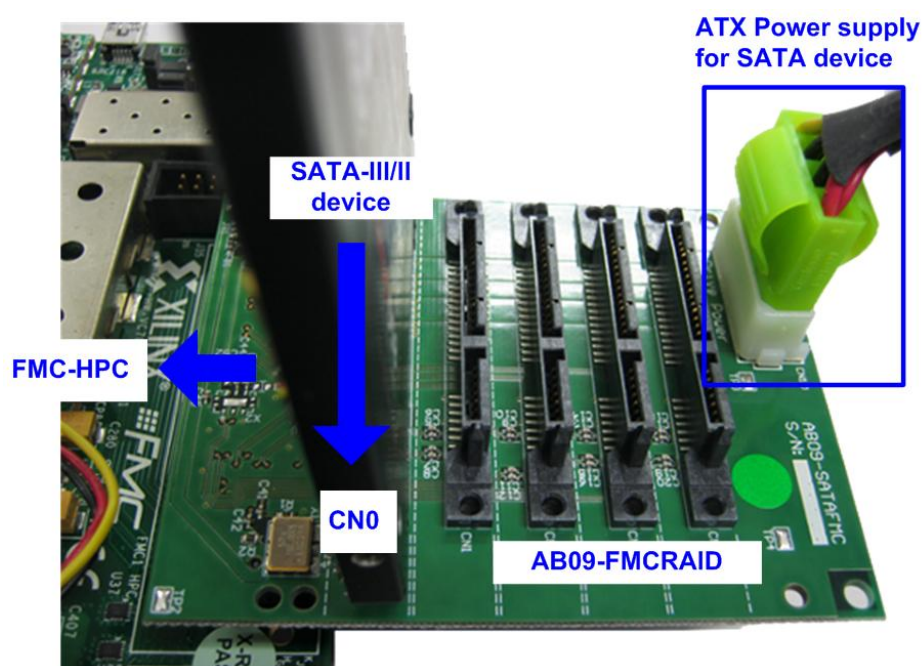


Figure 2-2 AB09-FMCRAID connection

- 4) Connect micro USB cable between FPGA board and PC for JTAG programming and connect mini USB cable between FPGA board and PC for Serial console.



Figure 2-3 USB cable connection

- 5) Power on FPGA board and power supply for SATA device.
- 6) Open Serial console such as TeraTerm and HyperTerminal. Set Baud rate=115,200 Data=8 bit Non-Parity Stop=1.
- 7) Open Vivado TCL shell and change directory to download or directory that batch file is located. Next, type exFATSataTest\_ZC706.bat, as shown in Figure 2-4.

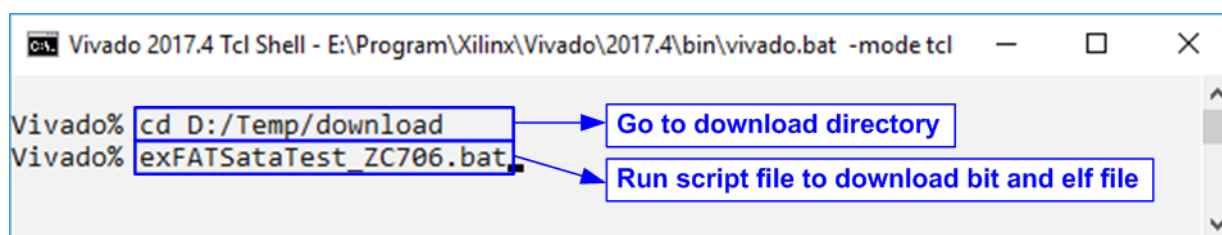


Figure 2-4 Command script for download demo file to ZC706 on Vivado TCL Shell



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

Table 1 LED Definition

GPIO LED	ON	OFF
0	Normal operation	System is in reset condition
R	System is busy	Idle status
C	IP Error is detected	Normal operation
L	Data verification fail	Normal operation

9) After programming completely, LED[0] and LED[R] are ON during running initialization process. LED[R] changes to OFF after finishing initialization.

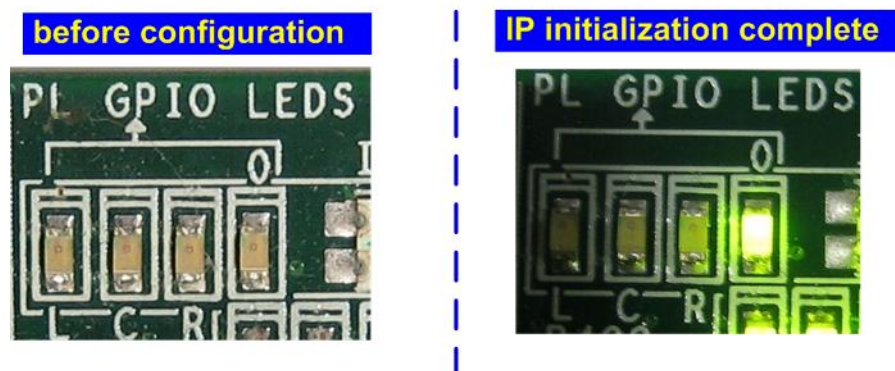


Figure 2-5 LED status

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

- "Waiting IP initialization" is displayed during initialization sequence.
- "IP initialization complete" is displayed when IP is idle.
- Before running the test, "The disk must be formatted by exFAT-IP" is displayed. User input 'y' to format the disk when the disk is the new disk which has never been formatted by exFAT-IP. After running Format command, all data in the disk are deleted. The example to run Format command is shown in Figure 2-7 while the example to skip Format command is shown in Figure 2-8.

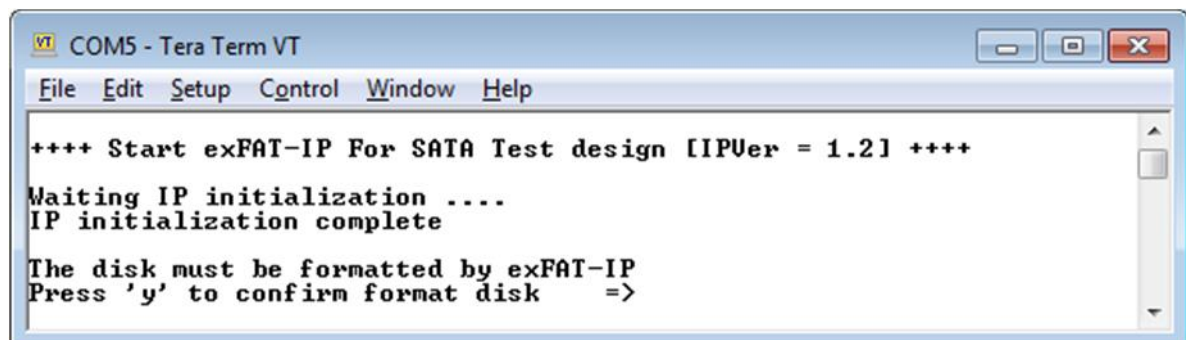


Figure 2-6 Message when IP runs initialization process

The operation after selecting format disk is same as topic 3.1. Please see more details in that topic. After finishing Format operation or Format is skipped, 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. If the disk is not empty, total file in the disk will not be equal to 0. User can continue to write new file by using same file size. Also, Read file command could be used to verify the data in the disk.

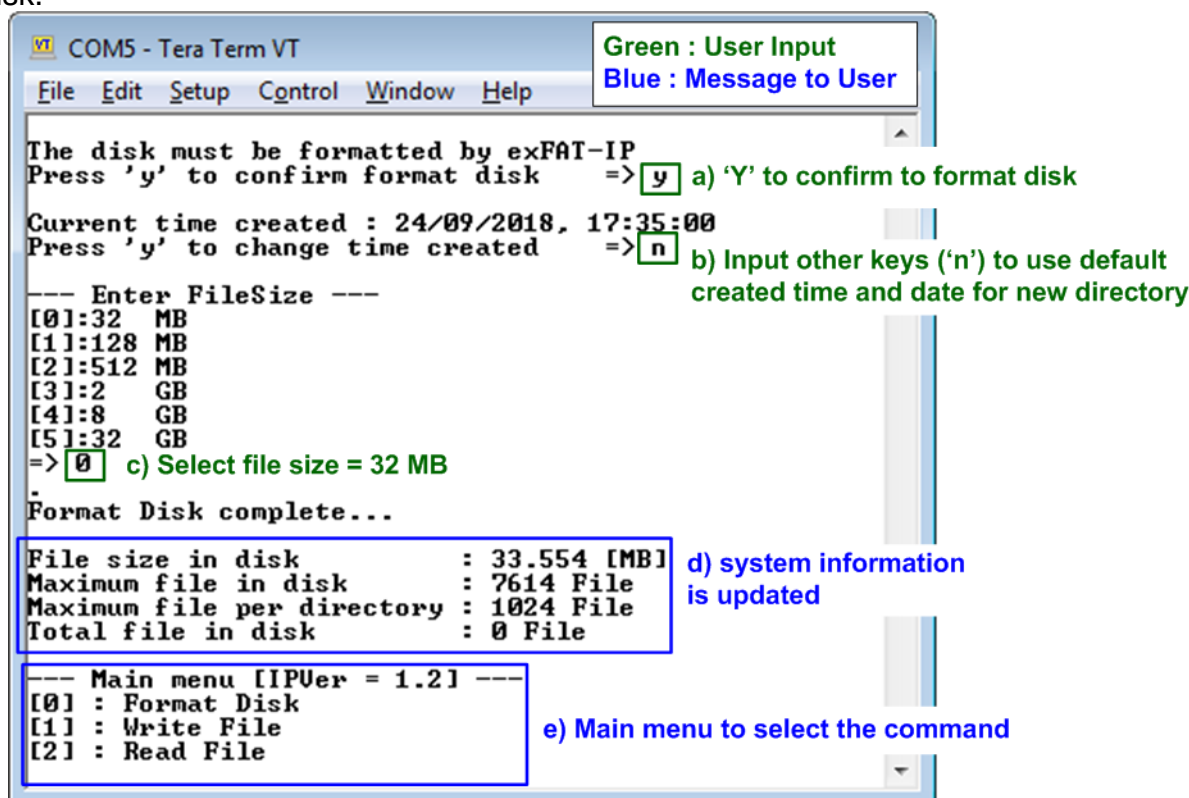


Figure 2-7 Initialization with format operation

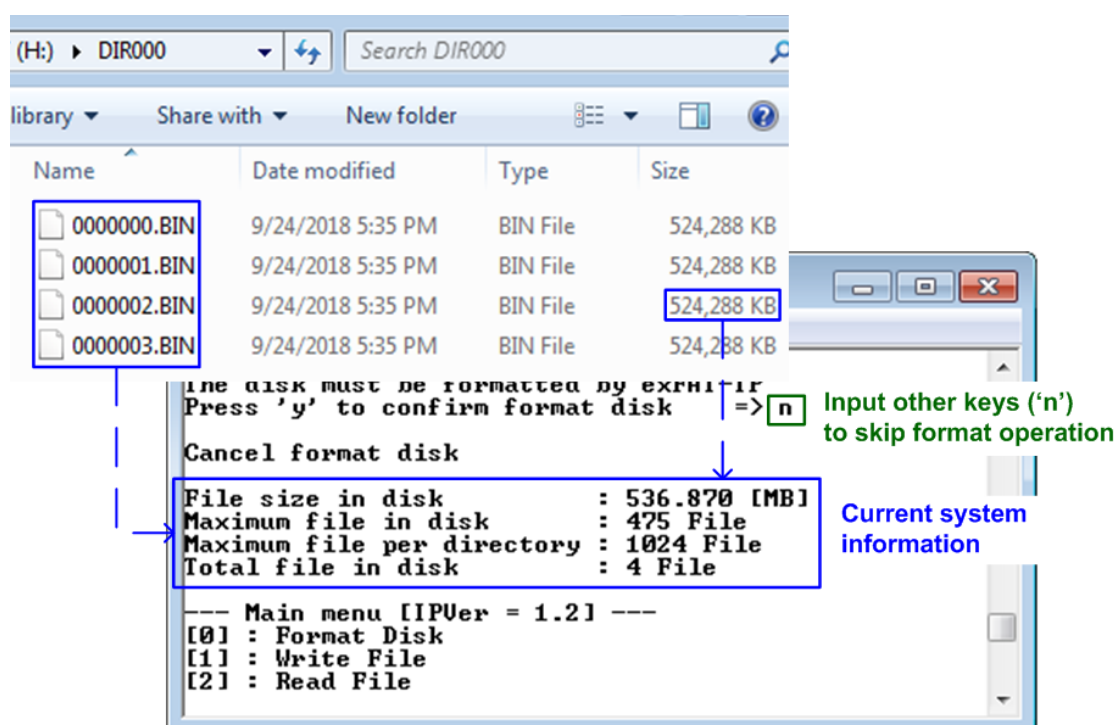


Figure 2-8 Initialization without format operation

## 3 Test Menu

### 3.1 Format Disk

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

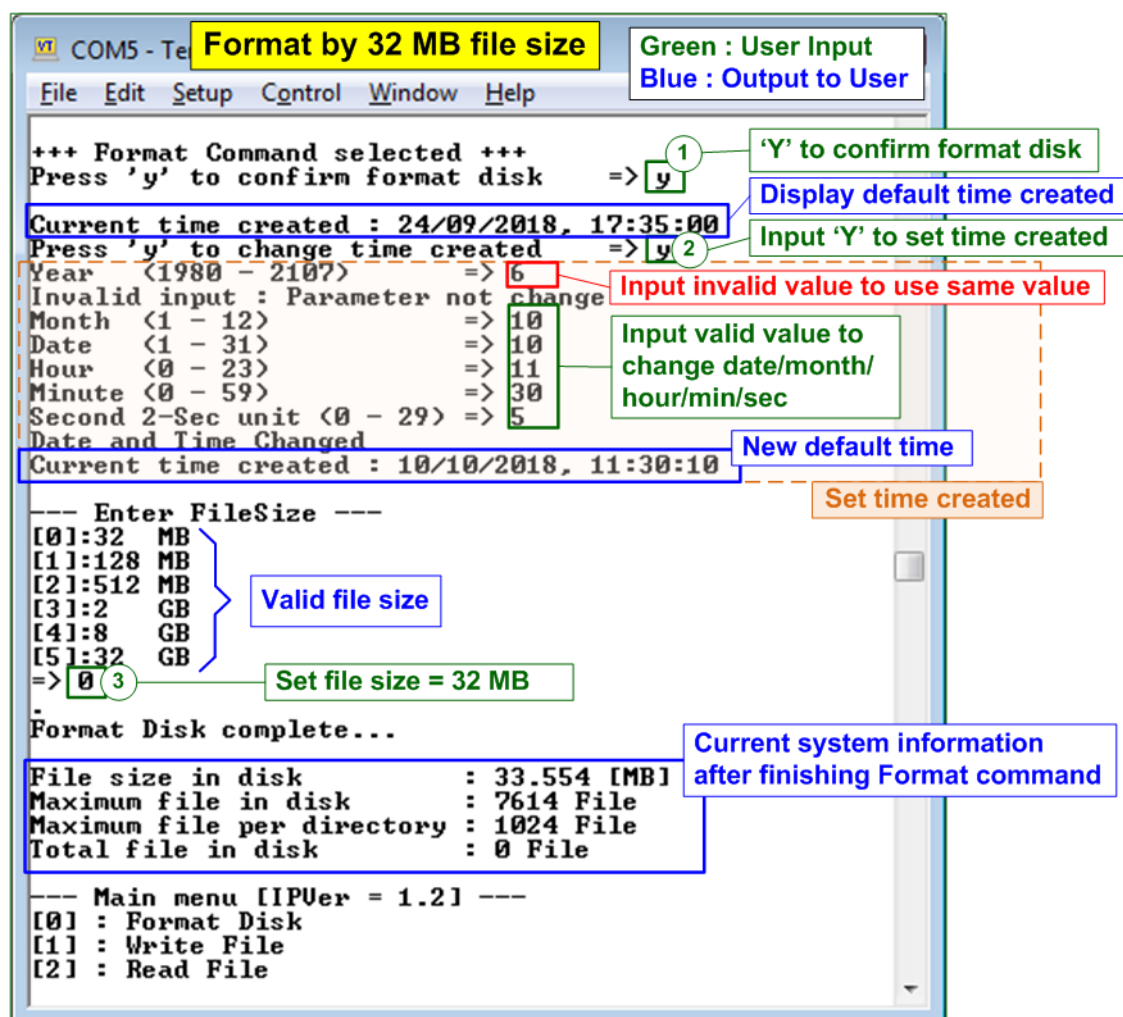


Figure 3-1 Format Disk menu when updating the created time

- 1) Input 'y' to confirm Format operation or input other keys to cancel the operation. When Format is run, the default value of created date and time will be displayed. This value is applied to be created date and time of empty directories.
- 2) Input 'y' to change created date and time or input 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 when the input is hexadecimal unit. If the input is invalid, the parameter will not change by using old value. Only the parameter which is in the valid range is updated. Otherwise, the old value is applied.

As shown in Figure 3-1, year parameter is invalid, so the old value (2018) is applied. Month, date, hour, minute, and second are valid, so these parameters are applied to be the new default value. After that, “Date and Time changed” and the new created time and date are displayed on the console.

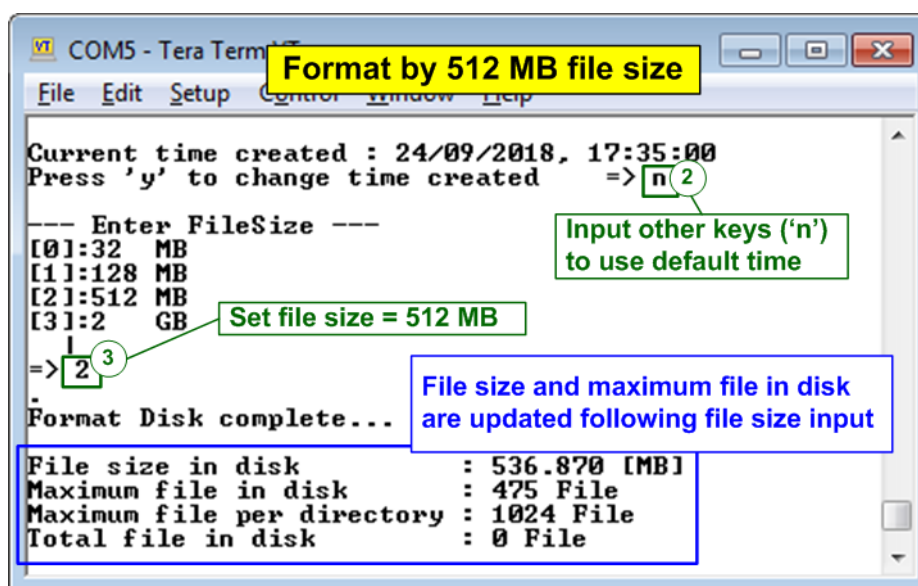


Figure 3-2 Format Disk menu when using the default created time

Figure 3-2 shows the example when running Format command without updating created time.

- 3) Input file size of the disk. The console lists the valid file size of the disk. 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 3-1 and Figure 3-2 sets the different file size based on the same disk capacity. Maximum file in the disk is reduced when file size is increased.

If file size is invalid, the operation will be cancelled, as shown in Figure 3-3.

**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 applied to be the new default value.

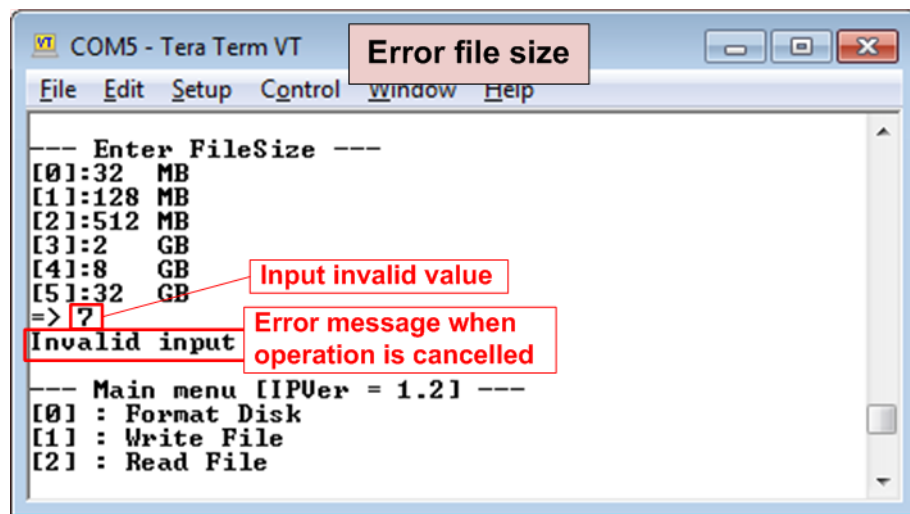


Figure 3-3 Result from Format Disk menu when file size is invalid

When the disk formatted by exFAT IP is connected to PC, DG\_exFAT drive is detected with 512 empty directories (DIR000<1<sup>st</sup> directory> - DIR1FF<512<sup>th</sup> directory>). Modified date of the empty directories is equal to the created date setting 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 formatted by exFAT IP.*

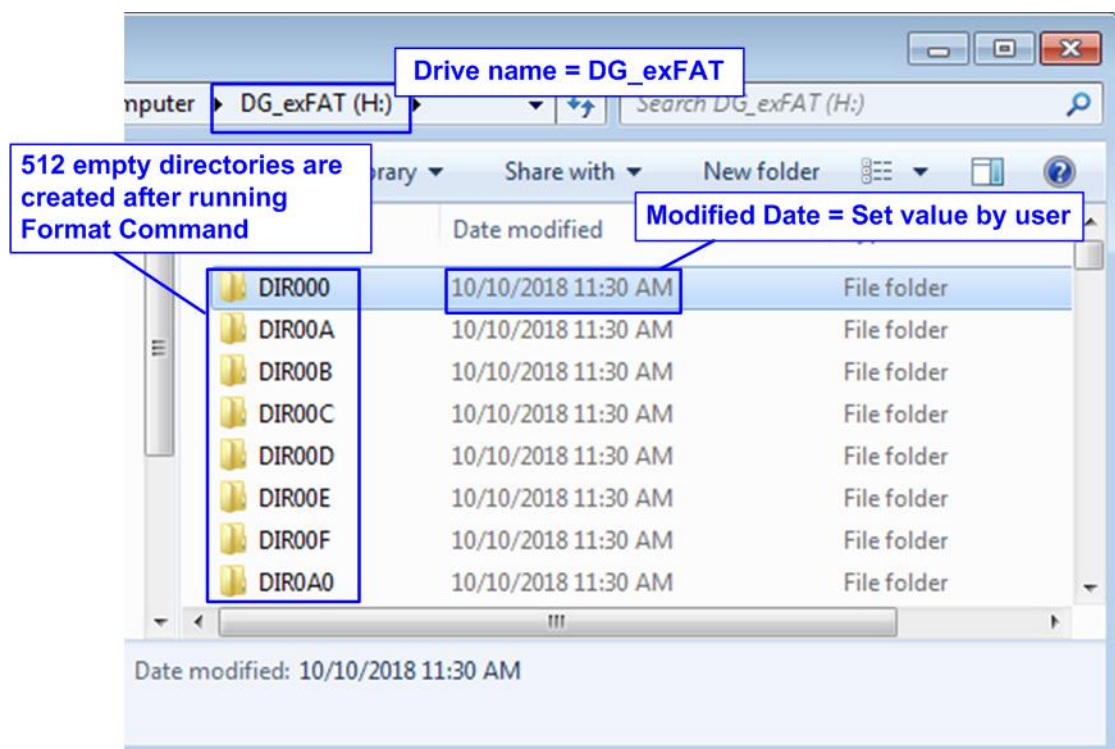


Figure 3-4 512 Empty directories after Format Disk command completes



### 3.2 Write File

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

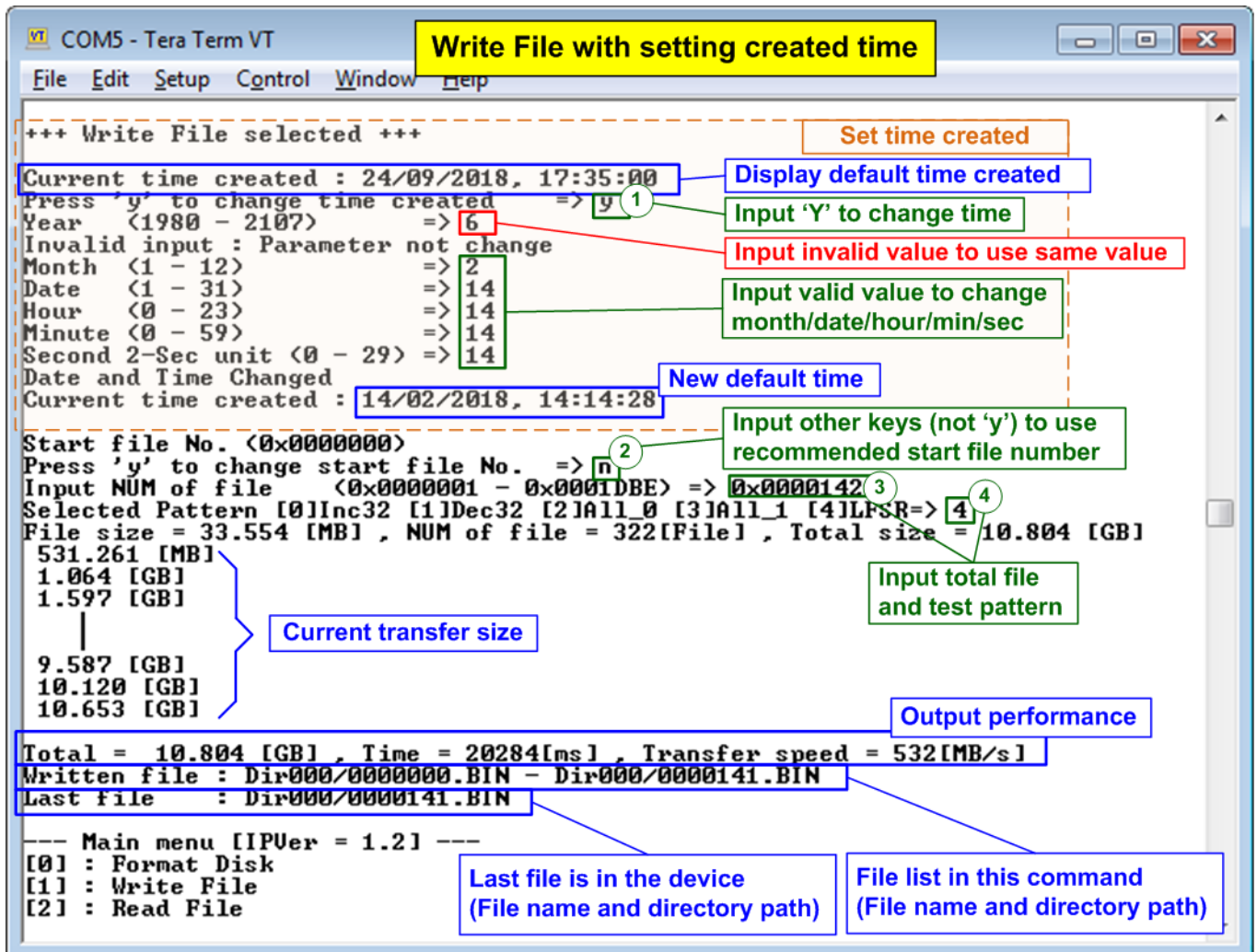


Figure 3-5 Result from Write File menu with setting time created

- 1) Similar to Format command, input 'y' to change created date and time or input other keys to use the default value. There are six parameters to set created date and time for the new file, 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 when the input is hexadecimal unit. If the input is invalid, the parameter will not change by using old value. Only the parameter which is in the valid range is updated. Otherwise, the old value is applied.

As shown in Figure 3-5, year parameter is invalid, so the old value (2018) is applied. Month, date, hour, minute, and second are valid, so these parameters are applied to be 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 applied to replace the old file. After running, the data in the old file is replaced by the new write file command.
- 3) Input NUM of file – Input total files to transfer in this command. After complete 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 when the input is hexadecimal unit.
- 4) Input test pattern – Select pattern of test data in the file. Five patterns can be set, i.e. 32 bit increment, 32 bit decrement, all 0, all 1, and 32 bit LFSR counter.

If all inputs are valid, total data size (calculated by file size x Num of file) will be 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 test result.

One directory limits the number of files to store, so the new files may store in the different directory. After finishing Write file command, the console lists the file which has just written on the console with the directory path (calculated by <file name>/<maximum files per directory>). Finally, the console displays the last available file in the disk.

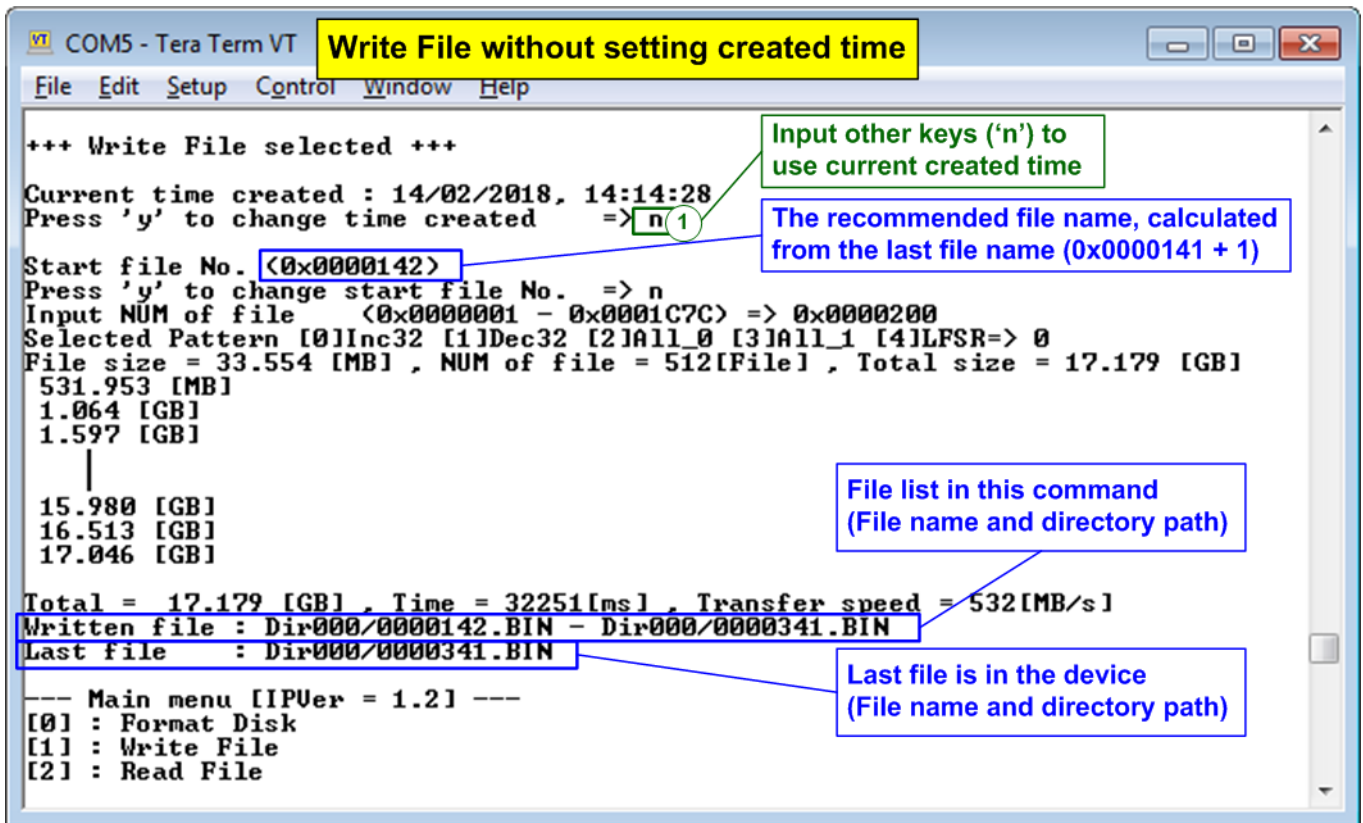


Figure 3-6 Result from Write File by using current created time

Figure 3-6 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 3-5 writes file “0000000.BIN” – “0000141.BIN”, so the recommended “Start file No” is 0x0000142 (0x0000141 + 1). After finishing the operation, 512 new files (0x0000142.BIN – 0x0000341.BIN) are created. Now the last file in the disk is updated to be 0x0000341.BIN.

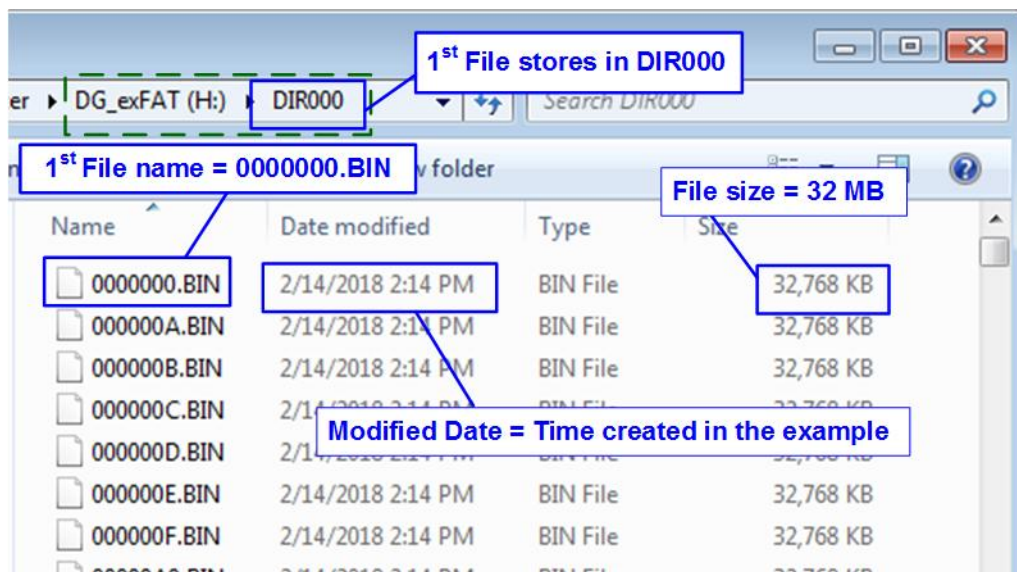


Figure 3-7 Example test files written by Write File command

When plug the device to PC, the new files are found in the directory. The 1<sup>st</sup> file in the disk is 0000000.BIN (stored in DIR000). File size and modified date of the new file are equal to the created date and created time setting 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 formatted by exFAT IP.*



Test data of 32-bit increment pattern																Test data of 32-bit LFSR pattern																
←64-bit header of each 512-byte→																←64-bit header of each 512-byte→																
48-bit unique value = (File name x File size) + offset 0x0000																48 bit unique value 0x0000																
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
00000000	00	00	00	00	00	00	00	00	02	00	00	00	03	00	00	00	00	00	00	00	00	00	00	00	01	00	00	00	02	00	00	00
00000010	04	00	00	00	05	00	00	00	06	00	00	00	07	00	00	00	04	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00
00000020	08	00	00	00	09	00	00	00	0A	00	00	00	0B	00	00	00	49	00	00	00	92	00	00	00	24	01	00	00	49	02	00	00
00000030	0C	00	00	00	0D	00	00	00	0E	00	00	00	0F	00	00	00	92	04	00	00	24	09	00	00	49	12	00	00	92	24	00	00
00000040	10	00	00	00	11	00	00	00	12	00	00	00	13	00	00	00	24	49	00	00	49	92	00	00	92	24	01	00	24	49	02	00
00000050	14	00	00	00	15	00	00	00	16	00	00	00	17	00	00	00	49	92	04	00	92	24	09	00	24	49	12	00	49	92	24	00
00000060	18	00	00	00	19	00	00	00	1A	00	00	00	1B	00	00	00	93	24	49	00	27	49	92	00	4F	92	24	01	9E	24	49	02
The 1 <sup>st</sup> 512-byte data																																
00000090	24	00	00	00	25	00	00	00	26	00	00	00	27	00	00	00	CF	93	24	49	9E	27	49	92	3D	4F	92	24	7A	9E	24	49
000000A0	28	00	00	00	29	00	00	00	2A	00	00	00	2B	00	00	00	5D	CF	93	24	BA	9E	27	49	75	3D	4F	92	EB	7A	9E	24
000000B0	2C	00	00	00	2D	00	00	00	2E	00	00	00	2F	00	00	00	D7	F5	3C	49	AE	EB	79	92	5C	D7	F3	24	B8	AE	E7	49
000000C0	30	00	00	00	31	00	00	00	32	00	00	00	33	00	00	00	70	5D	CF	93	E0	BA	9E	27	C1	75	3D	4F	83	EB	7A	9E
000000D0	34	00	00	00	35	00	00	00	36	00	00	00	37	00	00	00	07	D7	F5	3C	0E	AE	EB	79	1D	5C	D7	F3	3B	B8	AE	E7
000000E0	38	00	00	00	39	00	00	00	3A	00	00	00	3B	00	00	00	77	70	5D	CF	EE	E0	BA	9E	DC	C1	75	3D	B8	83	EB	7A
000000F0	3C	00	00	00	3D	00	00	00	3E	00	00	00	3F	00	00	00	70	07	D7	F5	E0	0E	AE	EB	C1	1D	5C	D7	83	3B	B8	AE
00000100	40	00	00	00	41	00	00	00	42	00	00	00	43	00	00	00	07	77	70	5D	0E	EE	E0	BA	1C	DC	C1	75	39	B8	83	EB
00000110	44	00	00	00	45	00	00	00	46	00	00	00	47	00	00	00	73	70	07	D7	E6	E0	0E	AE	CD	C1	1D	5C	9A	83	3B	B8
00000120	48	00	00	00	49	00	00	00	4A	00	00	00	4B	00	00	00	34	07	77	70	68	0E	EE	E0	D1	1C	DC	C1	A3	39	B8	83
00000130	4C	00	00	00	4D	00	00	00	4E	00	00	00	4F	00	00	00	47	73	70	07	8E	E6	E0	0E	1D	CD	C1	1D	3A	9A	83	3B
00000140	50	00	00	00	51	00	00	00	52	00	00	00	53	00	00	00	74	34	07	77	E9	68	0E	EE	D3	D1	1C	DC	A6	A3	39	B8
00000150	54	00	00	00	55	00	00	00	56	00	00	00	57	00	00	00	4C	47	73	70	98	8E	E6	E0	31	1D	CD	C1	63	3A	9A	83
00000160	58	00	00	00	59	00	00	00	5A	00	00	00	5B	00	00	00	C6	74	34	07	8D	E9	68	0E	1B	D3	D1	1C	37	A6	A3	39
00000170	5C	00	00	00	5D	00	00	00	5E	00	00	00	5F	00	00	00	6E	4C	47	73	DC	98	8E	E6	B8	31	1D	CD	70	63	3A	9A
00000180	60	00	00	00	61	00	00	00	62	00	00	00	63	00	00	00	E1	C6	74	34	C3	8D	E9	68	86	1B	D3	D1	0D	37	A6	A3
00000190	64	00	00	00	65	00	00	00	66	00	00	00	67	00	00	00	1A	6E	4C	47	34	DC	98	8E	68	B8	31	1D	D0	70	63	3A
000001A0	68	00	00	00	69	00	00	00	6A	00	00	00	6B	00	00	00	A0	E1	C6	74	41	C3	8D	E9	83	86	1B	D3	06	0D	37	A6
000001B0	6C	00	00	00	6D	00	00	00	6E	00	00	00	6F	00	00	00	0C	1A	6E	4C	18	34	DC	98	30	68	B8	31	60	D0	70	63
000001C0	70	00	00	00	71	00	00	00	72	00	00	00	73	00	00	00	C0	A0	E1	C6	81	41	C3	8D	03	83	86	1B	07	06	0D	37
000001D0	74	00	00	00	75	00	00	00	76	00	00	00	77	00	00	00	0F	0C	1A	6E	1F	18	34	DC	3F	30	68	B8	7F	60	D0	70
000001E0	78	00	00	00	79	00	00	00	7A	00	00	00	7B	00	00	00	FF	C0	A0	E1	FF	81	41	C3	FE	03	83	86	FD	07	06	0D
000001F0	7C	00	00	00	7D	00	00	00	7E	00	00	00	7F	00	00	00	FA	0F	0C	1A	F4	1F	18	34	E9	3F	30	68	D3	7F	60	D0
00000200	01	00	00	00	00	00	00	00	82	00	00	00	83	00	00	00	01	00	00	00	00	00	00	00	02	00	00	00	04	00	00	00
The 2 <sup>nd</sup> 512-byte data																																
00000210	05	00	00	00	06	00	00	00	86	00	00	00	87	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000220	09	00	00	00	0A	00	00	00	8A	00	00	00	8B	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000230	0D	00	00	00	0E	00	00	00	8E	00	00	00	8F	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000240	11	00	00	00	12	00	00	00	92	00	00	00	93	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000250	15	00	00	00	16	00	00	00	96	00	00	00	97	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000260	19	00	00	00	1A	00	00	00	9A	00	00	00	9B	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000270	1D	00	00	00	1E	00	00	00	9E	00	00	00	9F	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000280	21	00	00	00	22	00	00	00	A2	00	00	00	A3	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000290	25	00	00	00	26	00	00	00	A6	00	00	00	A7	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
000002A0	29	00	00	00	2A	00	00	00	AA	00	00	00	AB	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
000002B0	2D	00	00	00	2E	00	00	00	AE	00	00	00	AF	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
000002C0	31	00	00	00	32	00	00	00	B2	00	00	00	B3	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
000002D0	35	00	00	00	36	00	00	00	B6	00	00	00	B7	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
000002E0	39	00	00	00	3A	00	00	00	BA	00	00	00	BB	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
000002F0	3D	00	00	00	3E	00	00	00	BE	00	00	00	BF	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000300	41	00	00	00	42	00	00	00	C2	00	00	00	C3	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000310	45	00	00	00	46	00	00	00	C6	00	00	00	C7	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
00000320	49	00	00	00	4A	00	00	00	CA	00	00	00	CB	00	00	00	09	00	00													

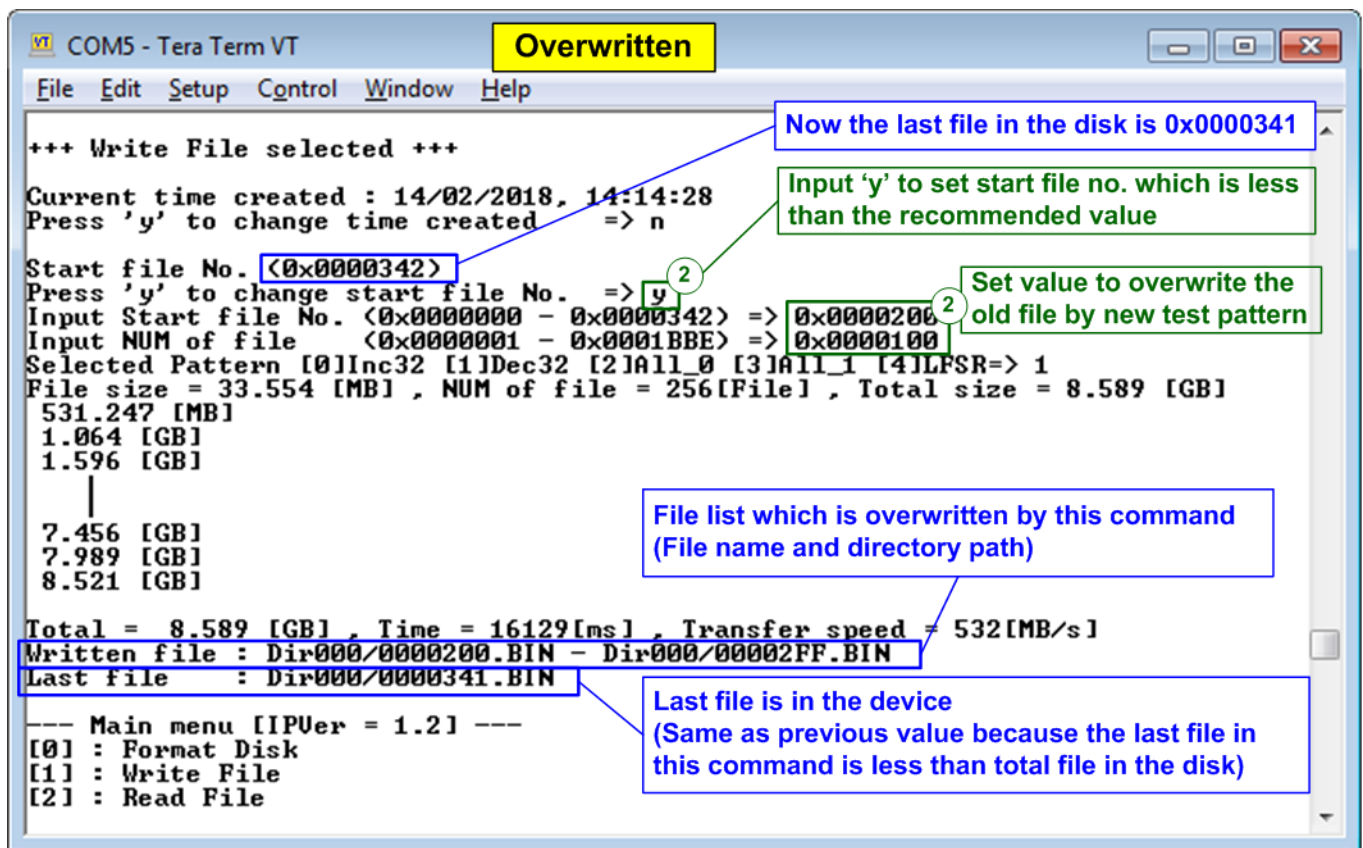


Figure 3-9 Set new start file no.

Figure 3-9 shows the example of the overwritten case by setting Start file No. to be less than the default value. The last file in the disk is 0x0000341, but the new command is sent to write 0x0000200.BIN – 0x00002FF.BIN by using decrement pattern (In Figure 3-6, 0x0000142.BIN – 0x0000341.BIN are created by using increment pattern).

After finishing the operation, the data in 0x0000200.BIN – 0x00002FF.BIN is replaced by the decrement pattern. Because the last file in the new command (0x00002FF.BIN) is less than the last file which is available in the device (0x0000341.BIN), the last file is not updated.

When the last file in the new write file command is more than the previous value, the last file will be updated by the new value.

Figure 3-10 shows the example of error messages when the input is less than or more than the recommended range for each parameter. "Invalid input" message is displayed on the console and then returns to main menu.

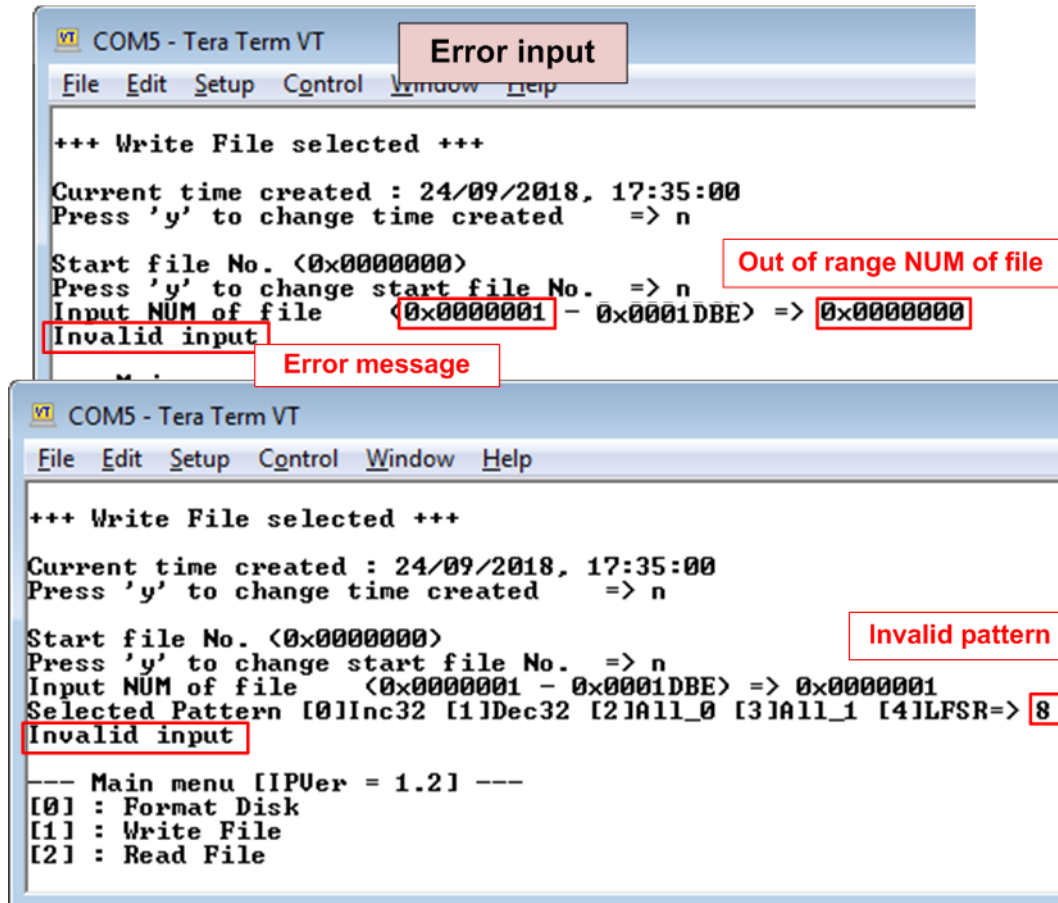


Figure 3-10 Error message from the invalid input

### 3.3 Read File

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

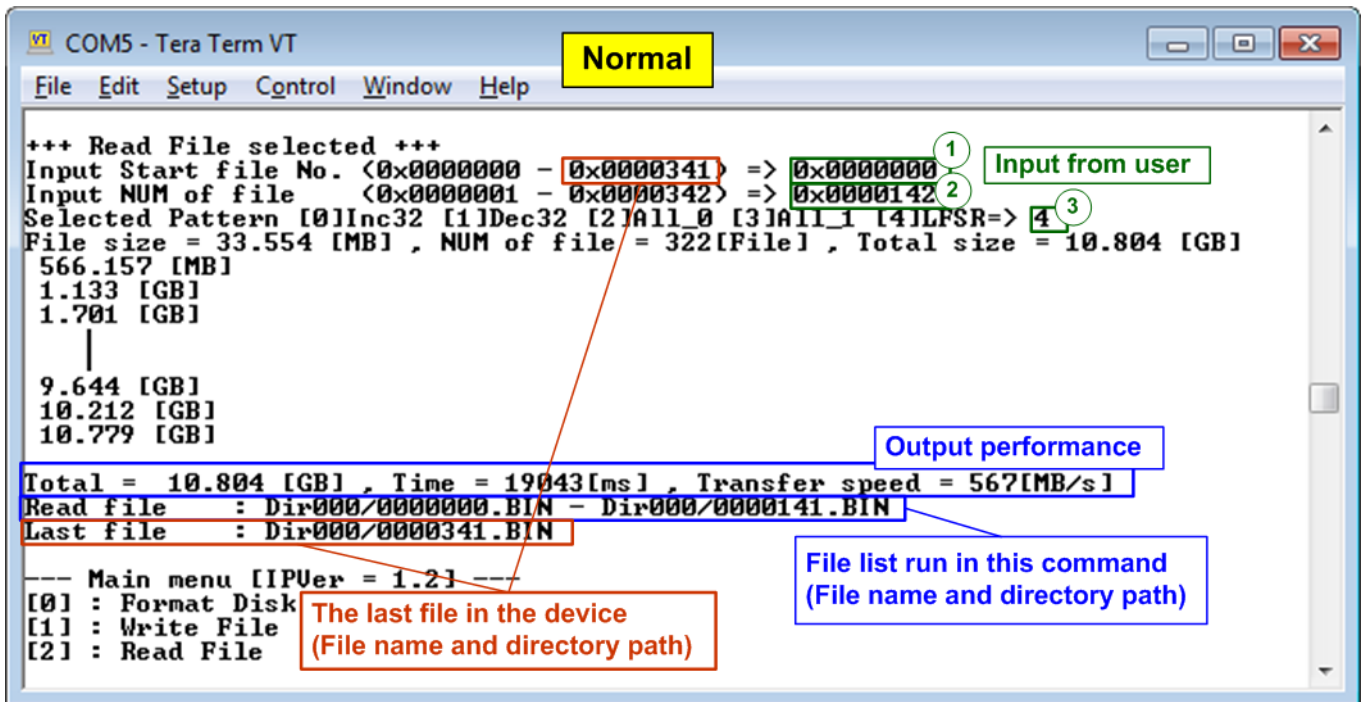


Figure 3-11 Read File menu when verification is successful

- 1) Input Start file No – Input the 1<sup>st</sup> file name to read. The input is decimal unit when input only digit number. User can add “0x” to be prefix when the input is hexadecimal unit. 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 adds “0x” to be prefix when the input is hexadecimal unit. 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 increment, 32 bit decrement, all 0, all 1, and 32 bit LFSR counter.

If “Start file No.”, “NUM of file”, and “Select pattern” are valid, total data size (calculated by File size x NUM of file) will be displayed on the console. 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 test result.

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

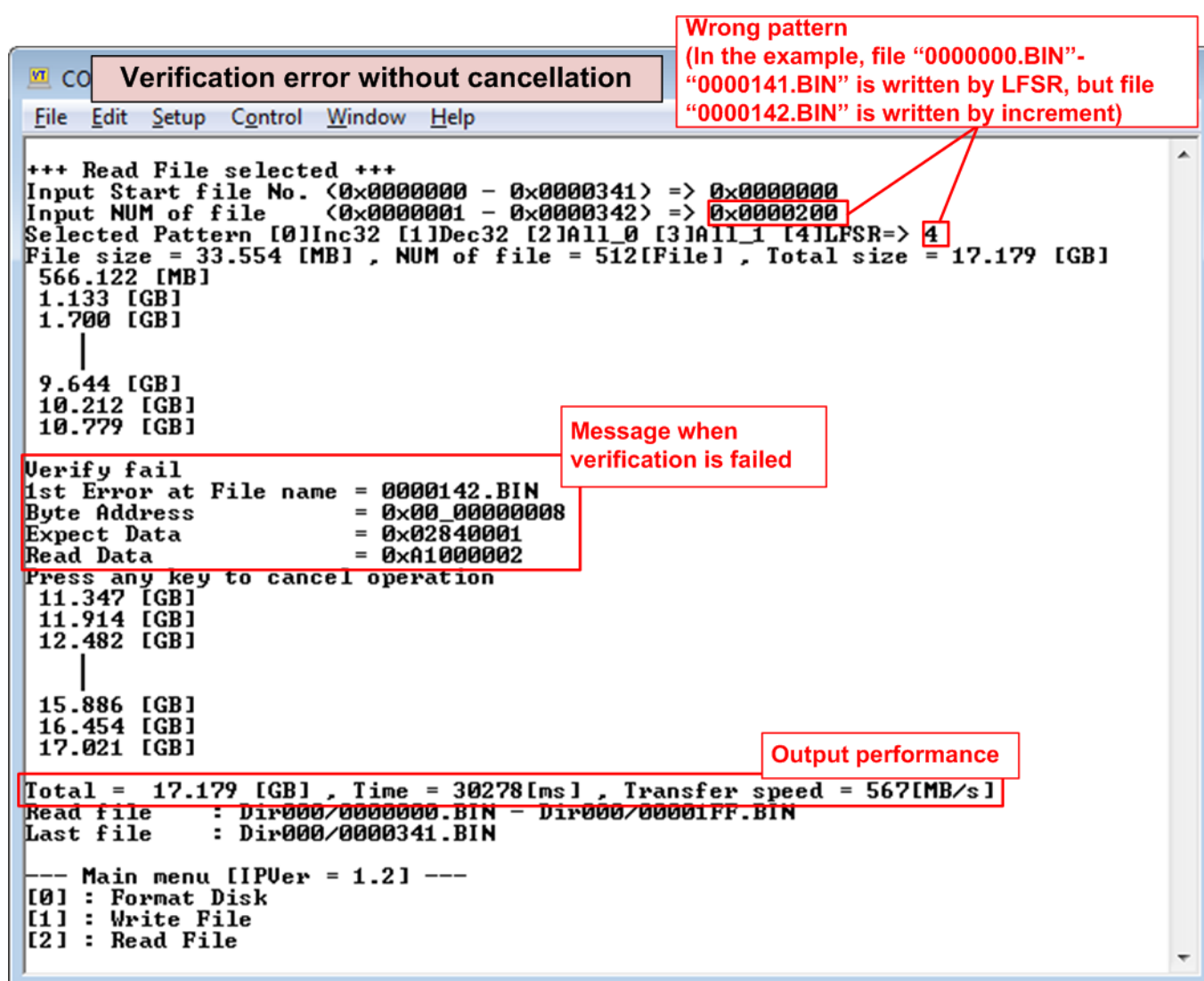
Similar to write file menu, the console lists all read files of the latest command and shows the last available file in the disk. The last file in the disk is not updated by Read file menu. The value is still same as the upper range to input Start File No. of Read file command.



Figure 3-12 and Figure 3-13 show the example of error message when data verification is failed. “Verify fail” is displayed with the first file name which has error, the error address of a file, the expected data, and the read data. User presses any key to cancel read operation or waits until the read process is completed.

If the user waits until read command completing, the output performance from the read process will be displayed. The user can continue to run the system test if the error is caused from wrong test pattern input.

If the user cancels the read operation, the command will not complete in the good sequence. It is recommended to power-off/on SATA device and press “RESET” button to restart system.



```

*** Read File selected ***
Input Start file No. (0x0000000 - 0x0000341) => 0x0000000
Input NUM of file (0x0000001 - 0x0000342) => 0x0000200
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4
File size = 33.554 [MB] , NUM of file = 512[File] , Total size = 17.179 [GB]
566.122 [MB]
1.133 [GB]
1.700 [GB]
|
9.644 [GB]
10.212 [GB]
10.779 [GB]
Verify fail
1st Error at File name = 0000142.BIN
Byte Address = 0x00_00000008
Expect Data = 0x02840001
Read Data = 0xA1000002
Press any key to cancel operation
11.347 [GB]
11.914 [GB]
12.482 [GB]
|
15.886 [GB]
16.454 [GB]
17.021 [GB]
Total = 17.179 [GB] , Time = 30278[ms] , Transfer speed = 567[MB/s]
Read file : Dir000/0000000.BIN - Dir000/00001FF.BIN
Last file : Dir000/0000341.BIN
--- Main menu [IPVer = 1.2] ---
[0] : Format Disk
[1] : Write File
[2] : Read File
  
```

Figure 3-12 Data verification is failed but wait until read complete

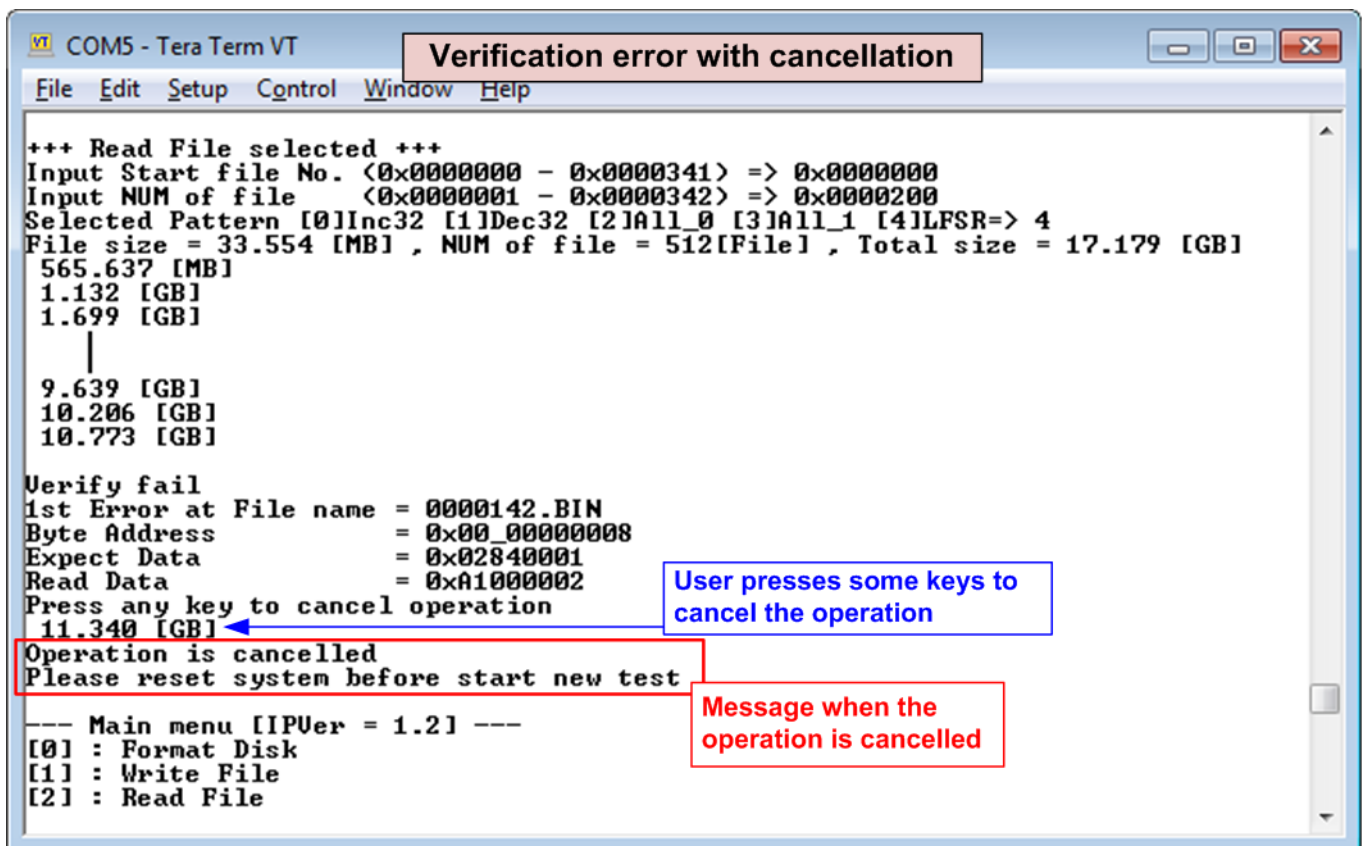


Figure 3-13 Data verification is failed and press any key to cancel operation

## 4 Revision History

Revision	Date	Description
1.0	22-Nov-18	Initial version release
1.1	20-Mar-19	Add file size and total file information
1.2	15-May-19	Correct directory name and update overwritten feature