



exFAT IP for SATA Demo Instruction

Rev1.2 22-Aug-23

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

1 Environment Requirement

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

- 1) IntelFPGA board: Intel Cyclone10 GX development board or Intel Arria10 SoC Development board
- 2) PC installing QuartusII programmer and NiosII command shell software
- 3) AB09-FMCRAID provided by Design Gateway
- 4) SATA-III device connecting to AB09 board
- 5) Intel power adapter for FPGA board
- 6) ATX power supply for SATA device
- 7) micro USB cable for programming FPGA and NiosII command shell, connecting between FPGA board and PC

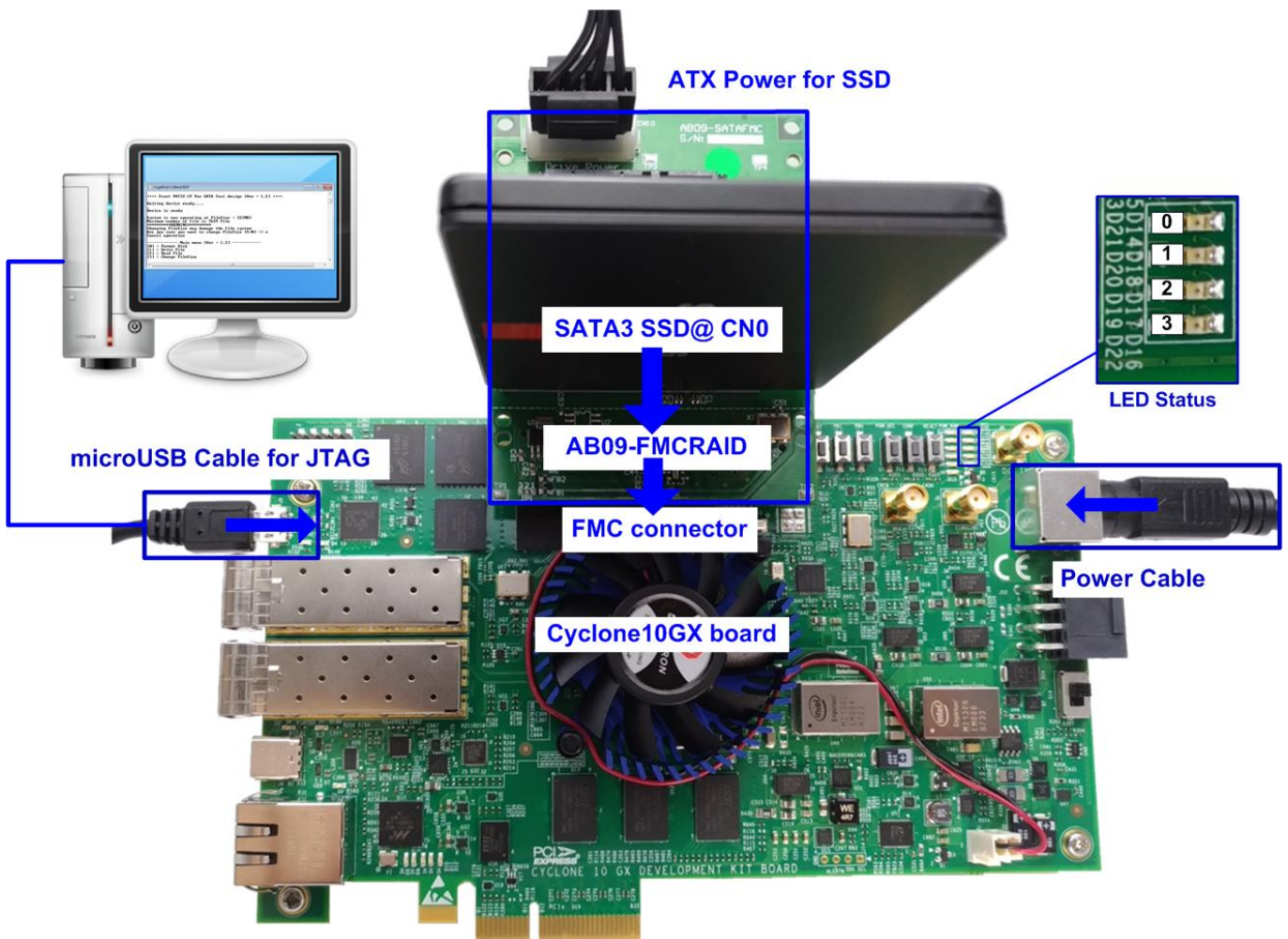


Figure 1-1 exFAT-IP for SATA demo environment setup on Cyclone10 GX board

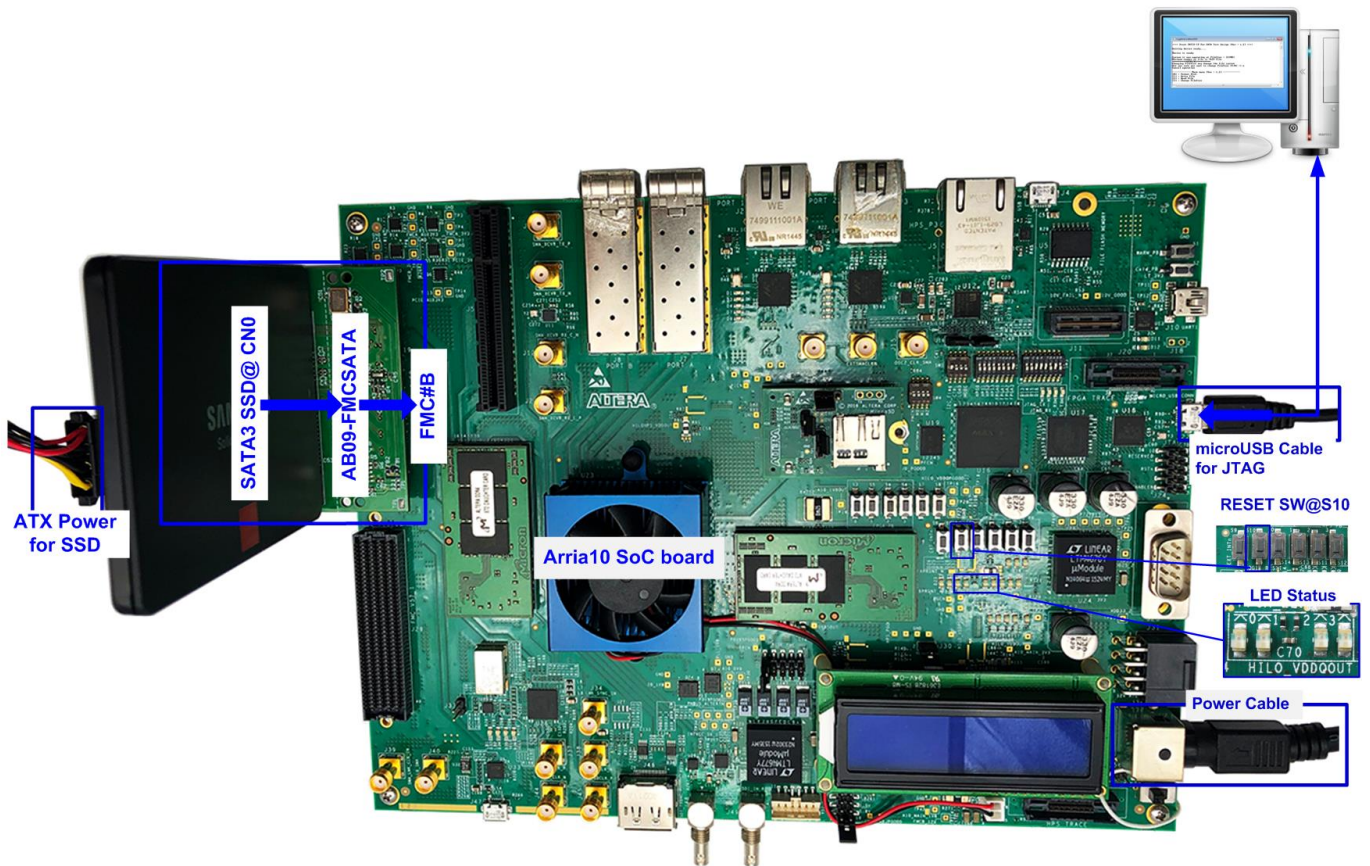


Figure 1-2 exFAT-IP for SATA demo environment setup on Arria10 SoC development board

2 Demo setup

- 1) Power off system.
- 2) Setup AB09 adapter board as shown in Figure 2-1.
 - i. Connect AB09-FMCRAID to FMC#B/FMC connector on FPGA development board.
 - ii. Connect SATA-III device to CN0 on AB09-FMCRAID board.
 - iii. Connect ATX power to power connector on AB09.

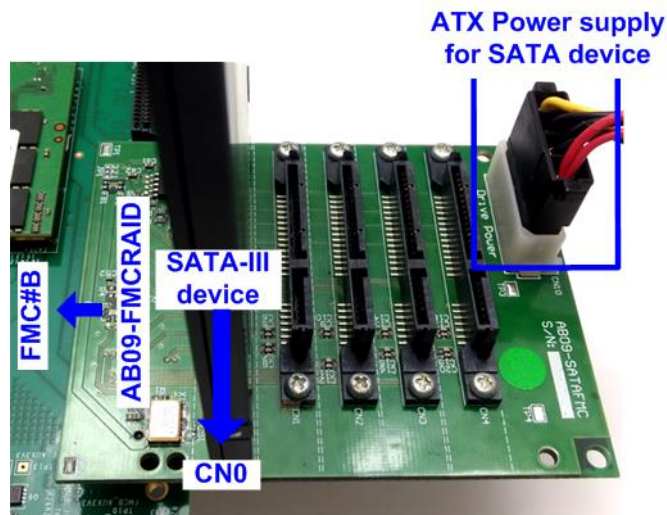


Figure 2-1 AB09 connection to FPGA board

- 3) Connect micro USB cable from FPGA board to PC for JTAG programming and JTAG UART.

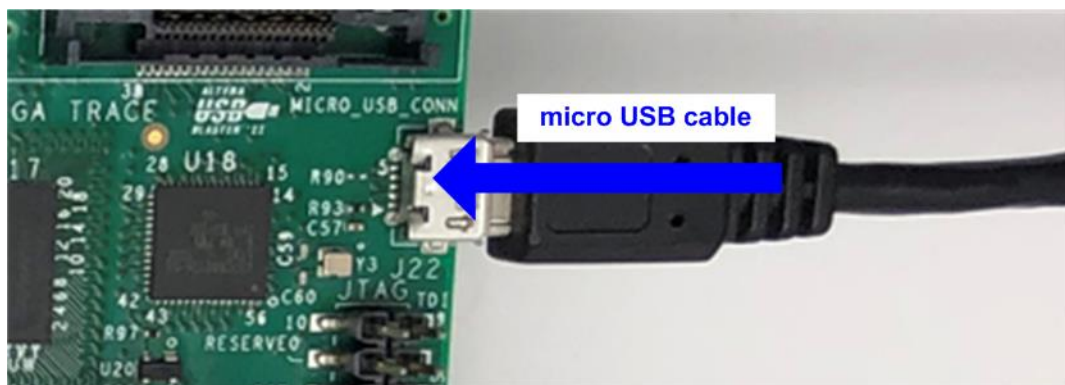


Figure 2-2 micro USB cable for JTAG

- 4) Power on FPGA development board and ATX power supply for SATA device.

5) Use QuartusII Programmer to program “exFATSataTest.sof” file, as shown in Figure 2-3.

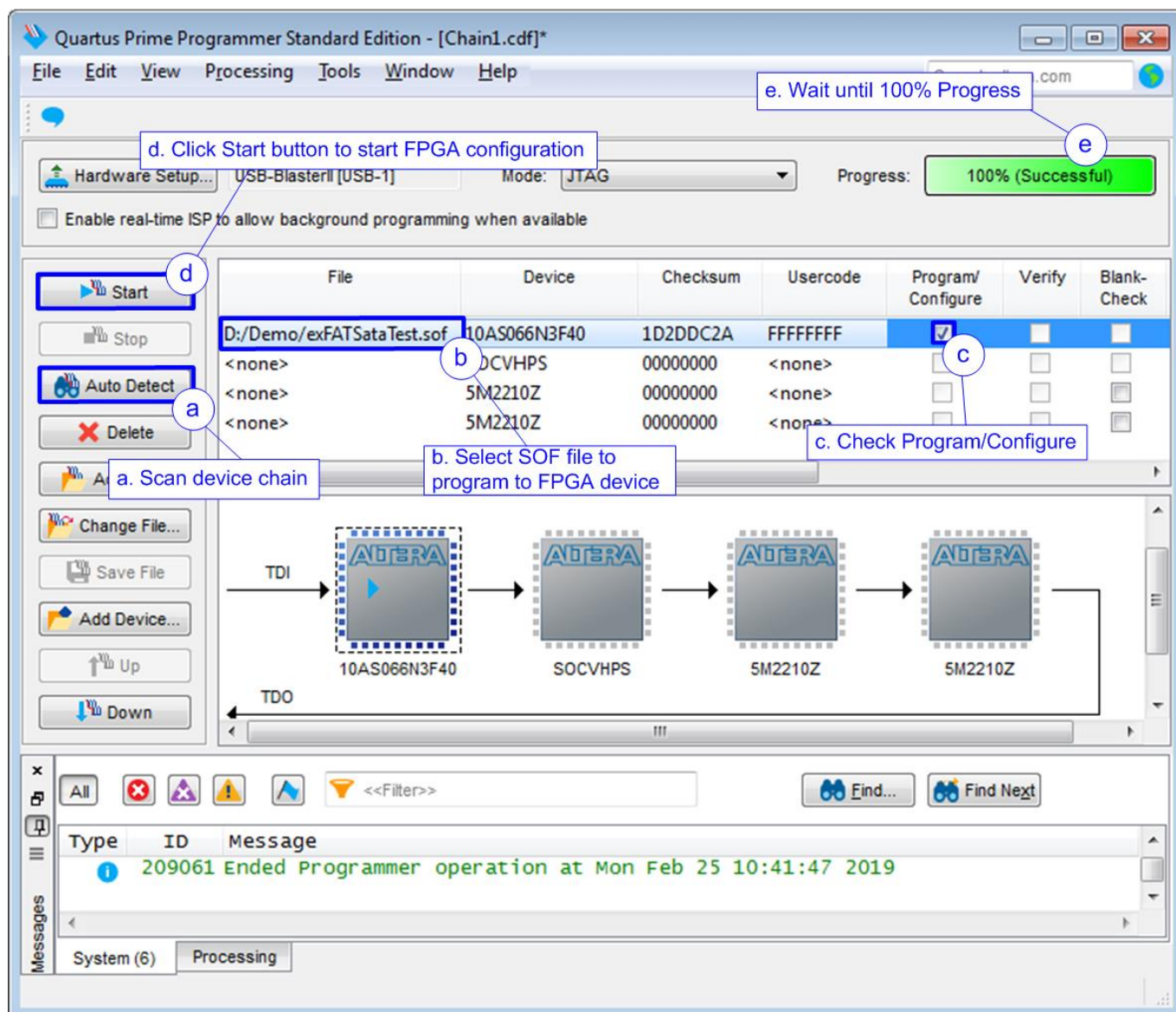


Figure 2-3 Programmed by QuartusII Programmer

- Open NiosII Command Shell and run nios2-terminal command. After that, boot message is displayed as shown in Figure 2-6.

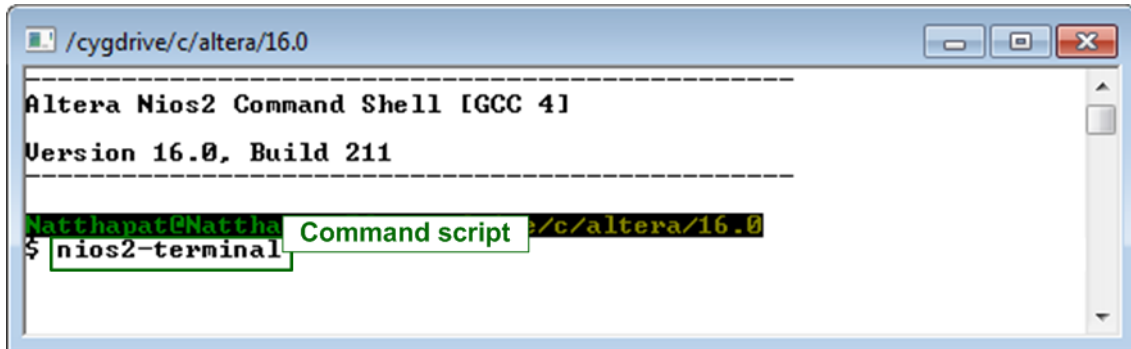


Figure 2-4 NiosII Command Shell

- 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
1	System is busy	Idle status
2	Error detect	Normal operation
3	Data verification fail	Normal operation

- After programming complete, LED[0] and LED[1] are ON during running initialization process. LED[1] changes to OFF after finishing exFAT IP initialization.

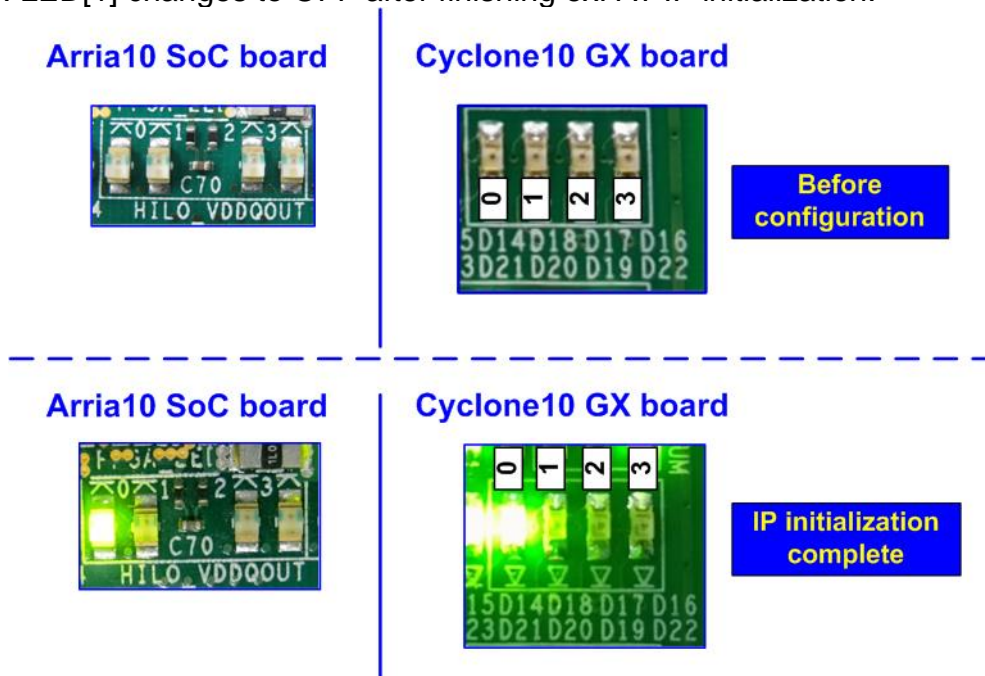


Figure 2-5 LED Status

- 9) On NiosII command shell, 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.

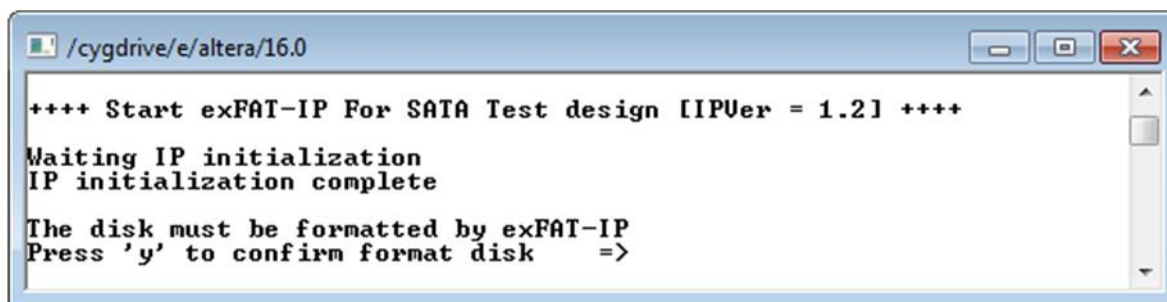


Figure 2-6 Message when IP runs initialization process

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.

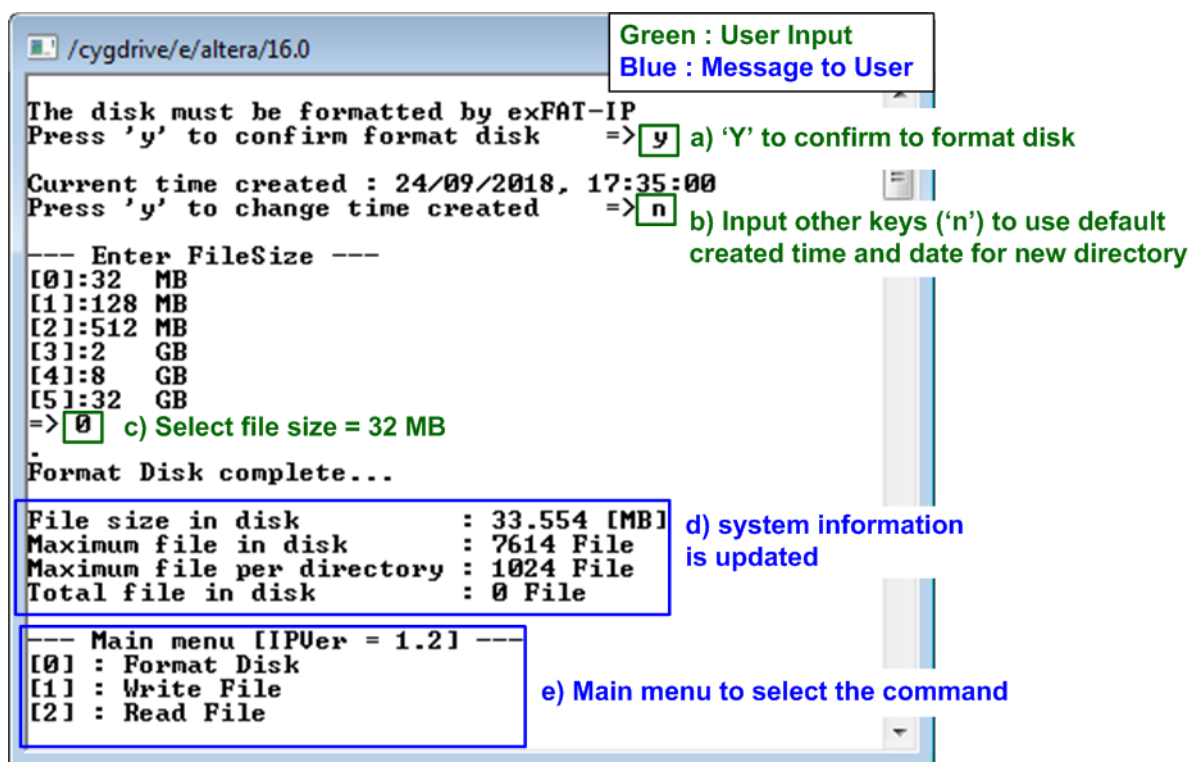


Figure 2-7 Initialization with format operation

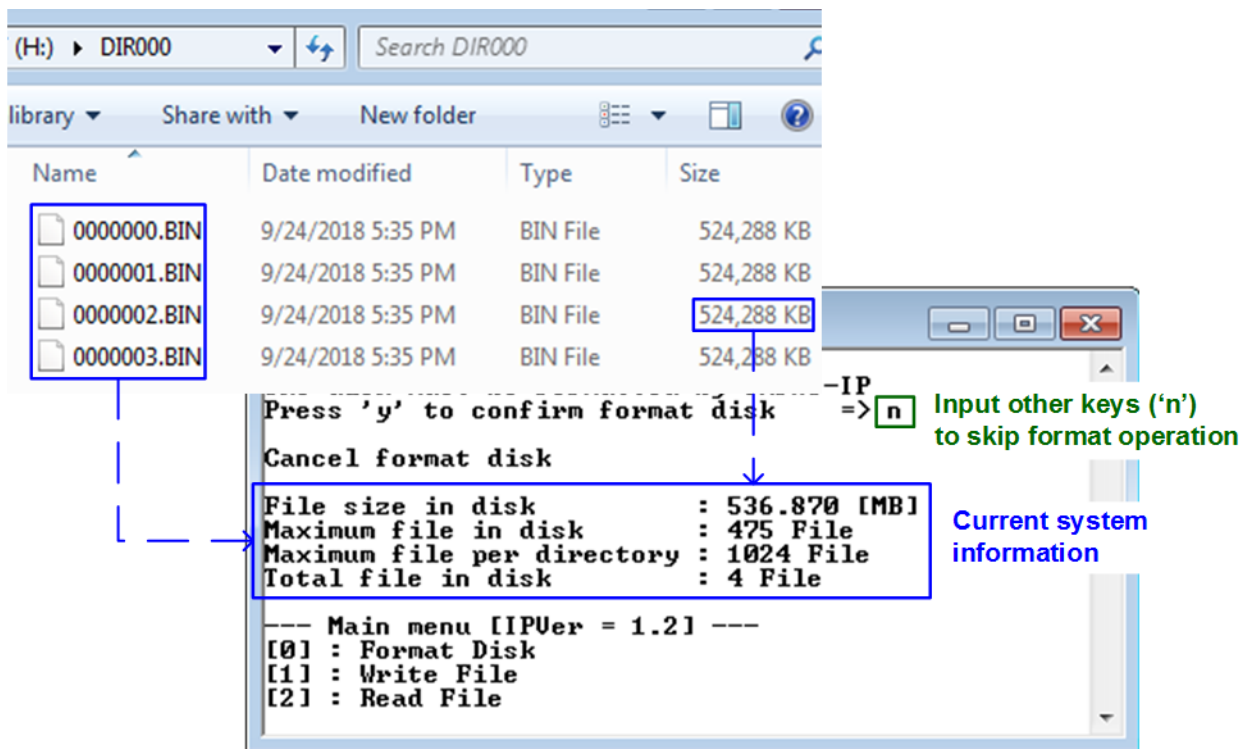


Figure 2-8 Initialization without format operation

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.

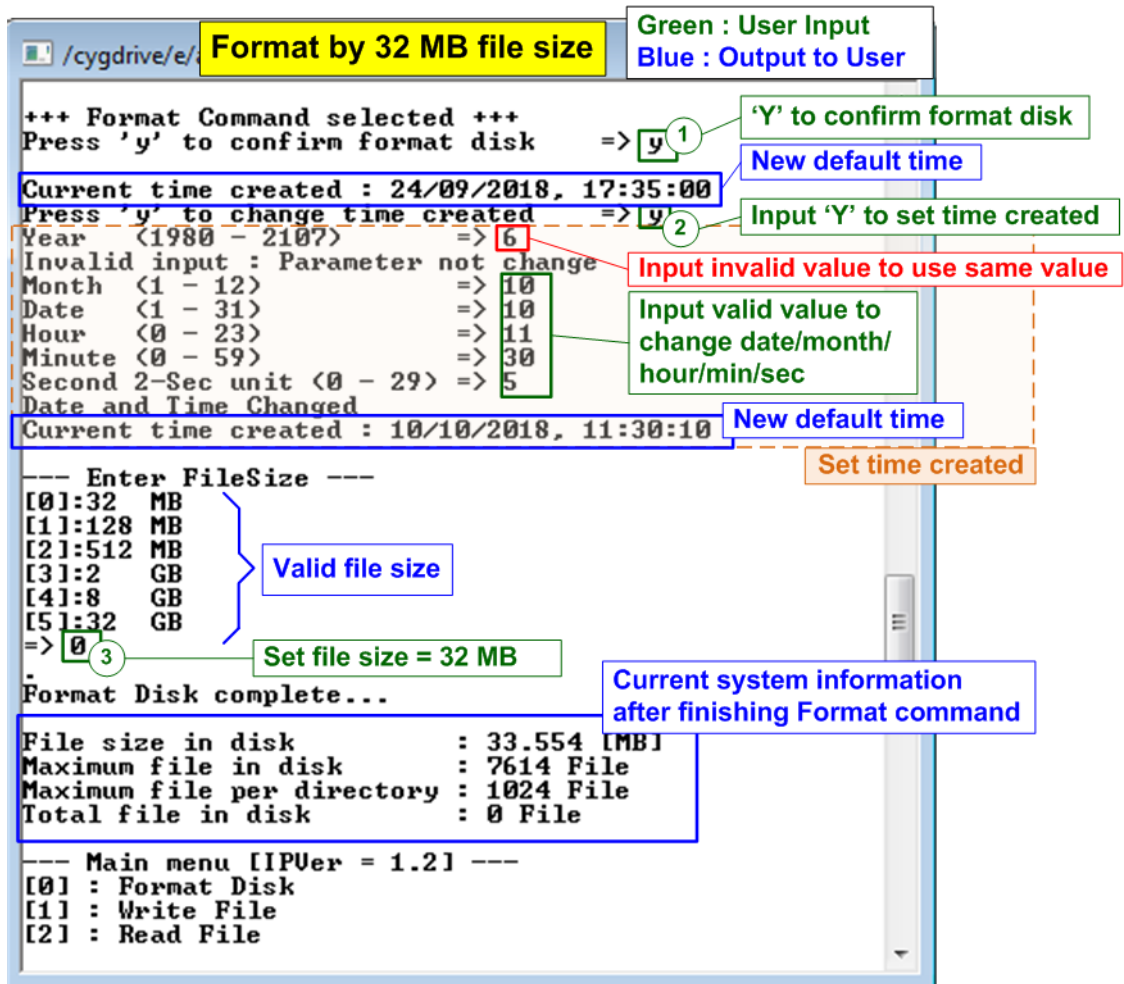


Figure 3-1 Format Disk menu when updating the created time

- 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.

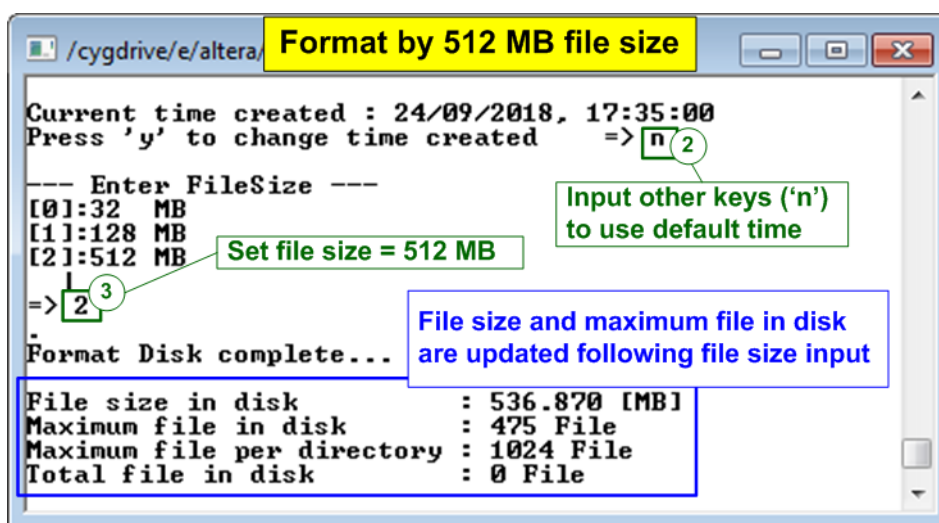


Figure 3-2 Format Disk menu when using the default created time

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.

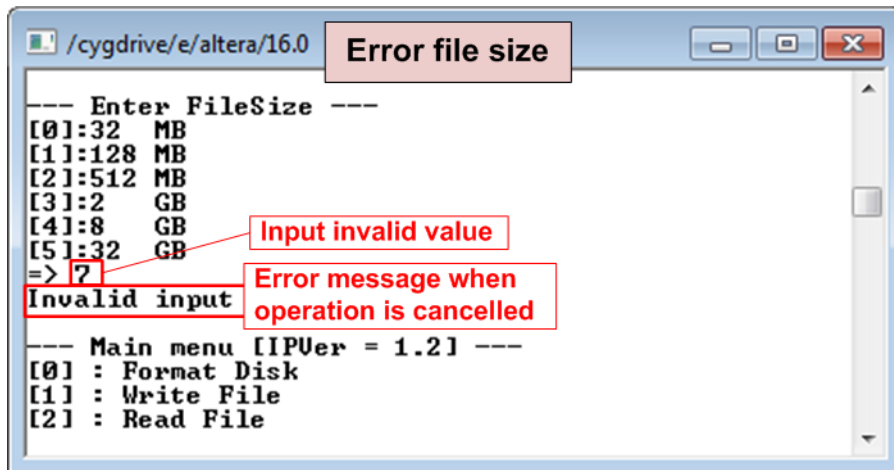


Figure 3-3 Result from Format Disk menu when file size is invalid

When the disk formatted by exFAT IP is connected to PC, DG_exFAT drive is detected with 512 empty directories (DIR000<1st directory> - DIR1FF<512th 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.

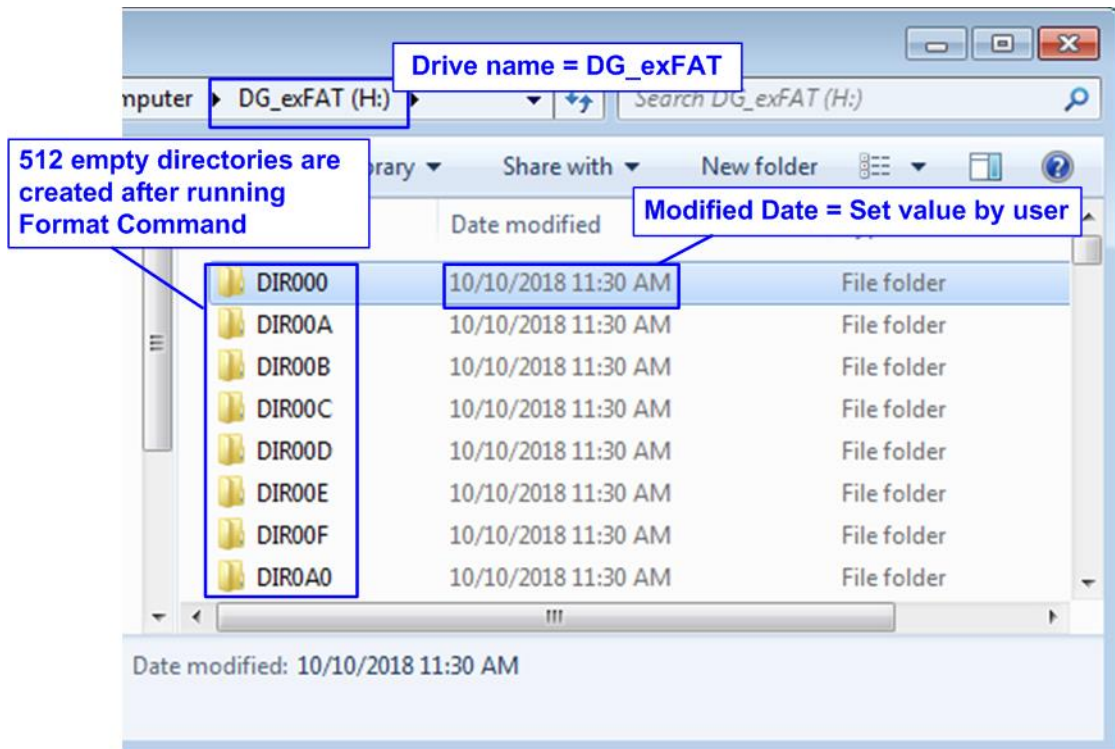


Figure 3-4 512 Empty directories after Format Disk command completes

3.2 Write File

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

The screenshot shows a terminal window with the following content and annotations:

```

+++ 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 (0x00000001 - 0x00001DBE) => 0x0000142
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4
File size = 33.554 [MB] , NUM of file = 322[File] , Total size = 10.804 [GB]
524.666 [MB]
1.050 [GB]
1.575 [GB]
|
9.459 [GB]
9.984 [GB]
10.510 [GB]

Total = 10.804 [GB] , Time = 20560[ms] , Transfer speed = 525[MB/s]
Written file : Dir000/00000000.BIN - Dir000/0000141.BIN
Last file : Dir000/0000141.BIN

--- Main menu [IPVer = 1.2] ---
[0] : Format Disk
[1] : Write File
[2] : Read File
  
```

Annotations in the image include:

- Set time created**: Points to the initial time display.
- Display default time created**: Points to the first 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 the year.
- Input valid value to change month/date/hour/min/sec**: Points to the inputs for month, date, hour, and minute.
- 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 file number and pattern inputs.
- 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' output.
- File list in this command (File name and directory path)**: Points to the 'Written file' output.

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.

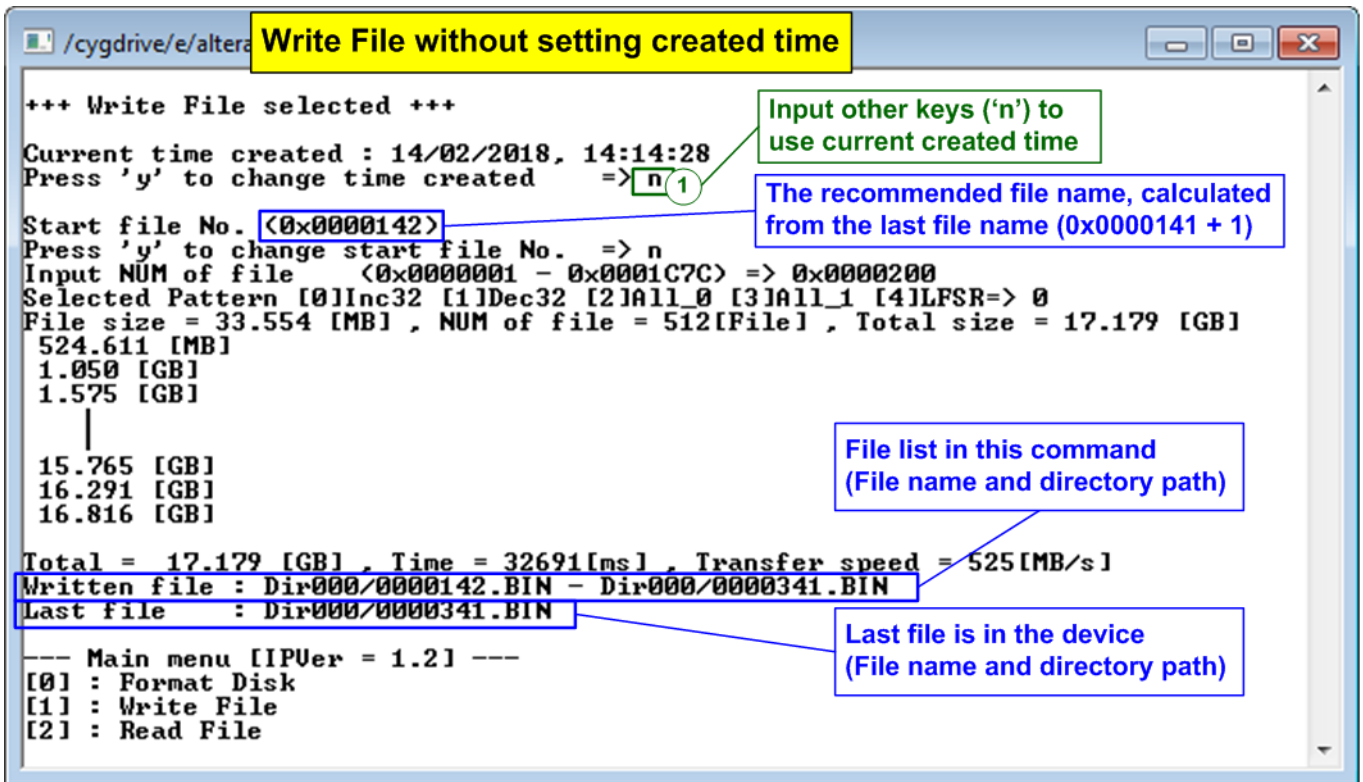


Figure 3-6 Result from Write File by using current created time

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.

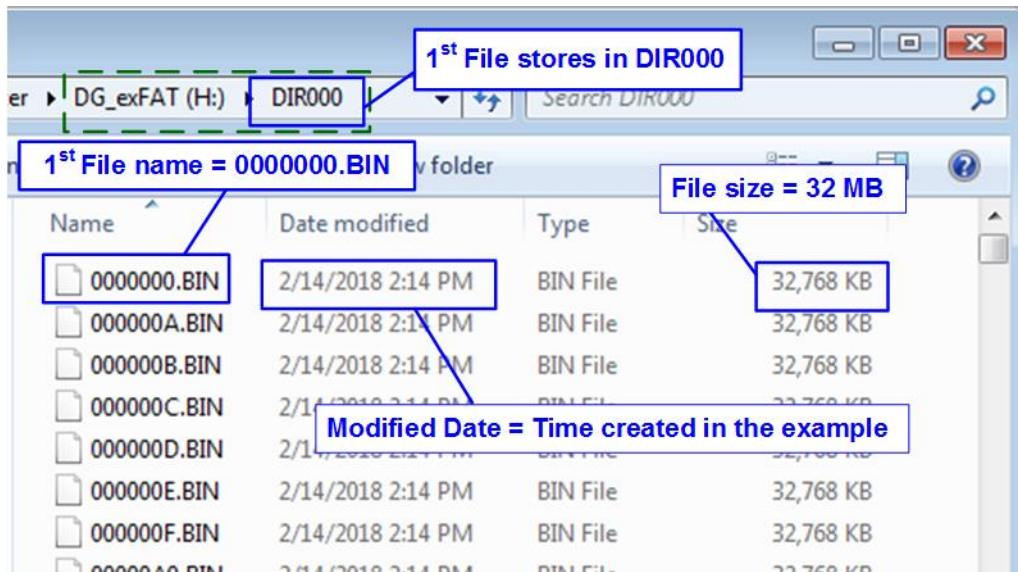


Figure 3-7 Example test files written by Write File command

When plug the device to PC, the new files are found in the directory. The 1st 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.

Offset	Test data of 32-bit increment pattern																Test data of 32-bit LFSR pattern															
	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	48-bit unique value = (File name x File size) + offset 0x0000							Test data (32-bit increment)									48 bit unique value 0x0000							Test data (32-bit LFSR)								
00000000	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	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	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	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	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	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	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 st 512-byte data	64-bit header																64-bit header															
	00	1D	00	00	00	00	00	1E	00	00	00	1F	00	00	00	3C	49	92	04	79	92	24	09	F3	24	49	12	E7	49	92	24	
00000090	24	00	00	00	25	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	2A	00	00	00	2B	00	00	00	F5	3C	49	92	EB	79	92	24	D7	F3	24	49	AE	E7	49	92	
000000B0	2C	00	00	00	2D	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	72	00	00	00	73	00	00	00	0C	A0	E1	C6	81	41	C3	8D	03	83	86	1B	07	06	0D	37	
000001D0	74	00	00	00	75	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	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	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	64-bit header																64-bit header															
00000200	01	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	
00000210	64-bit header																64-bit header															
00000210	00	85	00	00	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	64-bit header																64-bit header															
00000220	00	89	00	00	00	00	00	8A	00	00	00	8B	00	00	00	92	00	00	00	24	01	00	00	49	02	00	00	92	04	00	00	

Figure 3-8 Test data in sector#0 - #1 of file "0000000.BIN" by increment/LFSR pattern

Test data is split into 512 byte unit. Each 512 byte data has the different 64 bit header which consists of 48 bit address (calculated by <file name x file size> + offset in the file) and 16 bit zero value. 48 bit address is the unique value for each 512 byte data. The data after 64 bit header is the test pattern which is selected by user. The example data in file "0000000.BIN" when writing data by increment pattern is in the left window of Figure 3-8. The right window of Figure 3-8 shows the example when test pattern is LFSR pattern. The header is same for every test pattern, but the test data (starting from byte#8) depends on the test pattern.

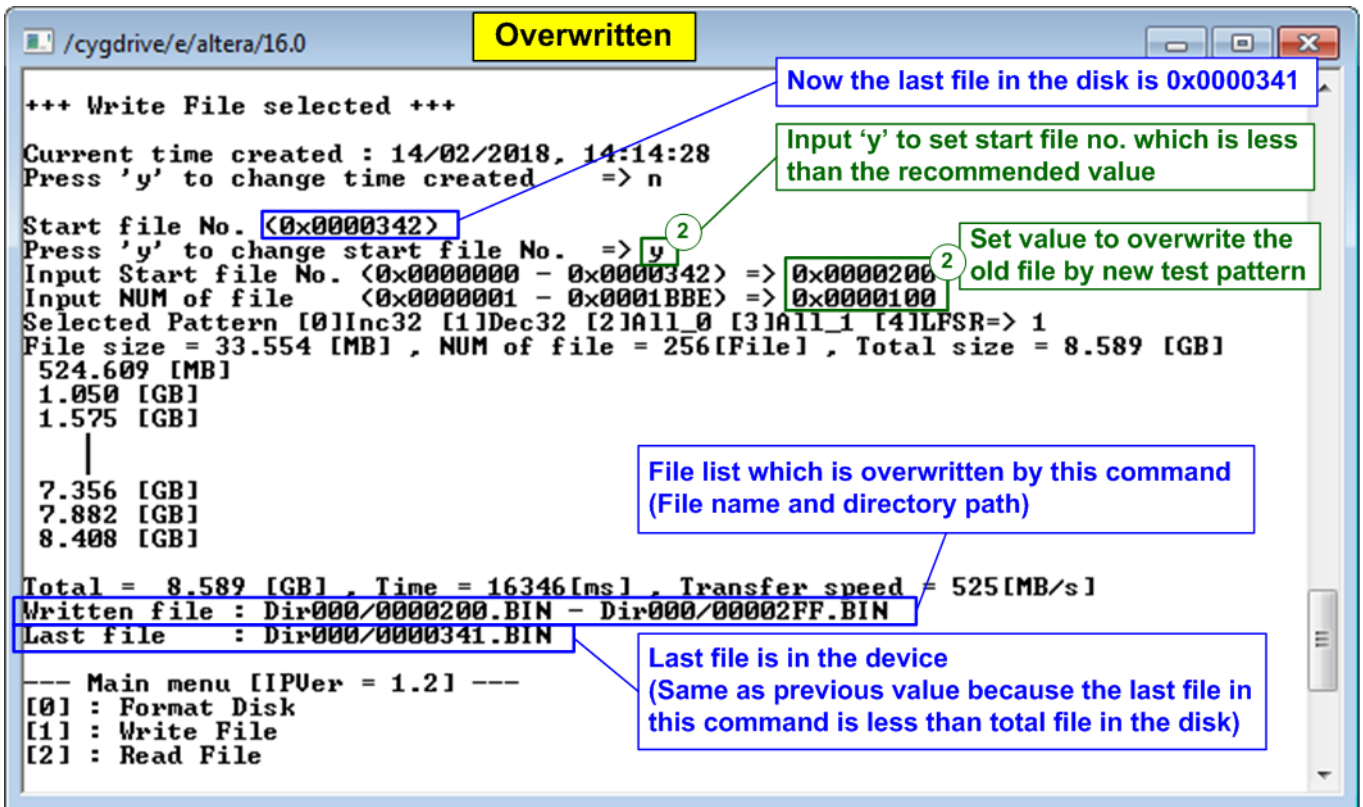


Figure 3-9 Set new start file no.

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.

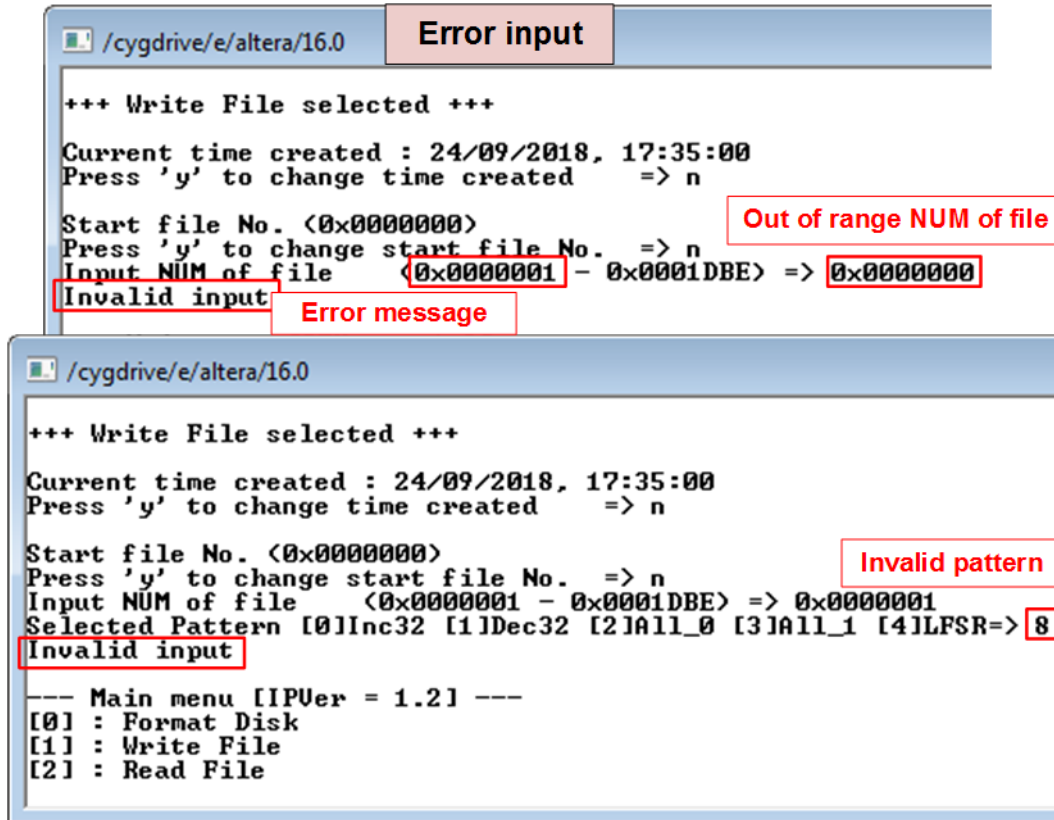


Figure 3-10 Error message from the invalid input

3.3 Read File

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

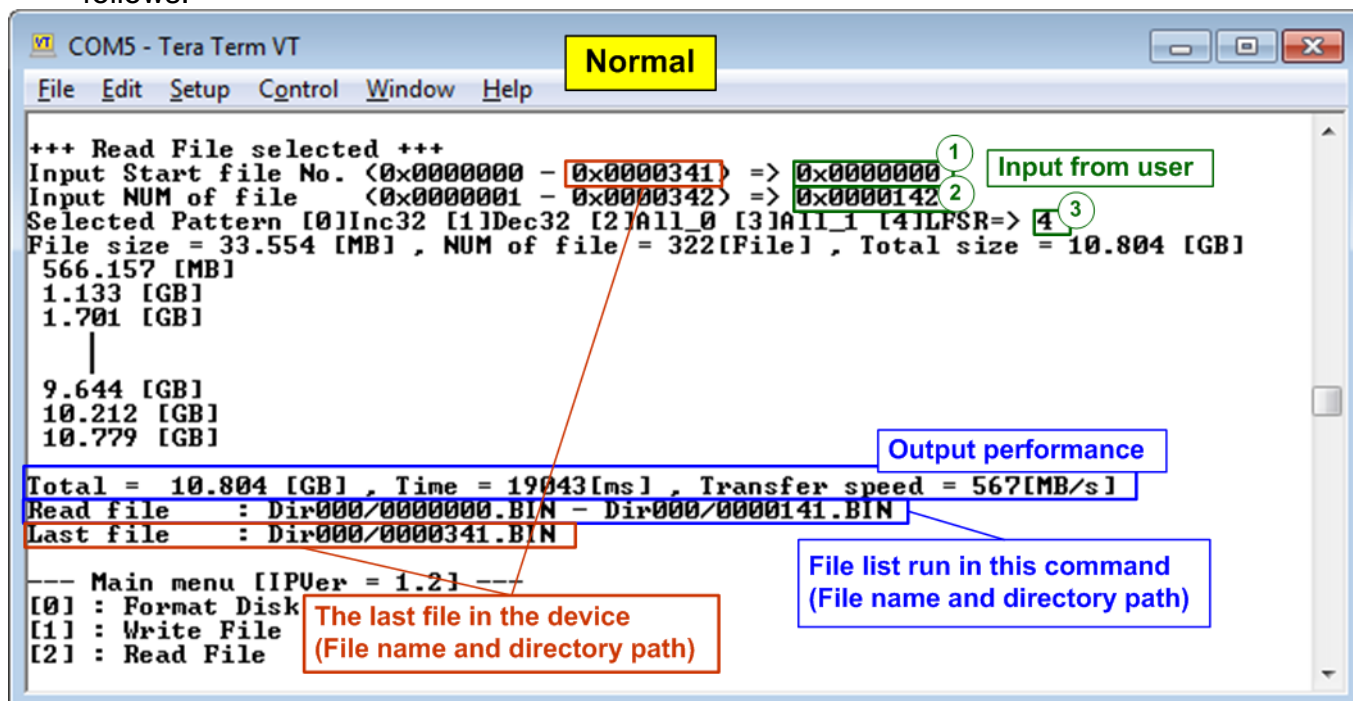


Figure 3-11 Read File menu when verification is successful

- 1) Input Start file No – Input the 1st 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 can add “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.

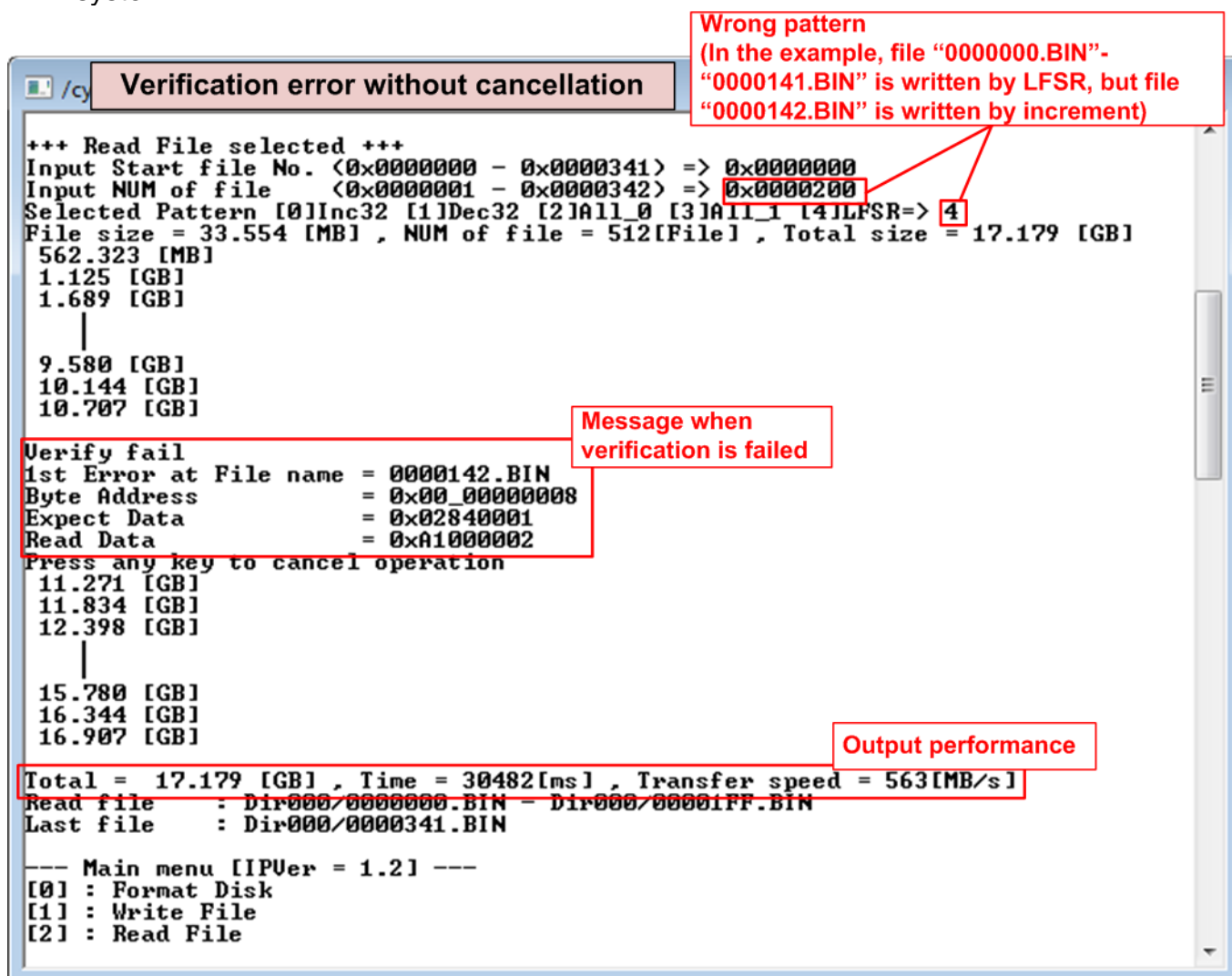


Figure 3-12 Data verification is failed but wait until read complete

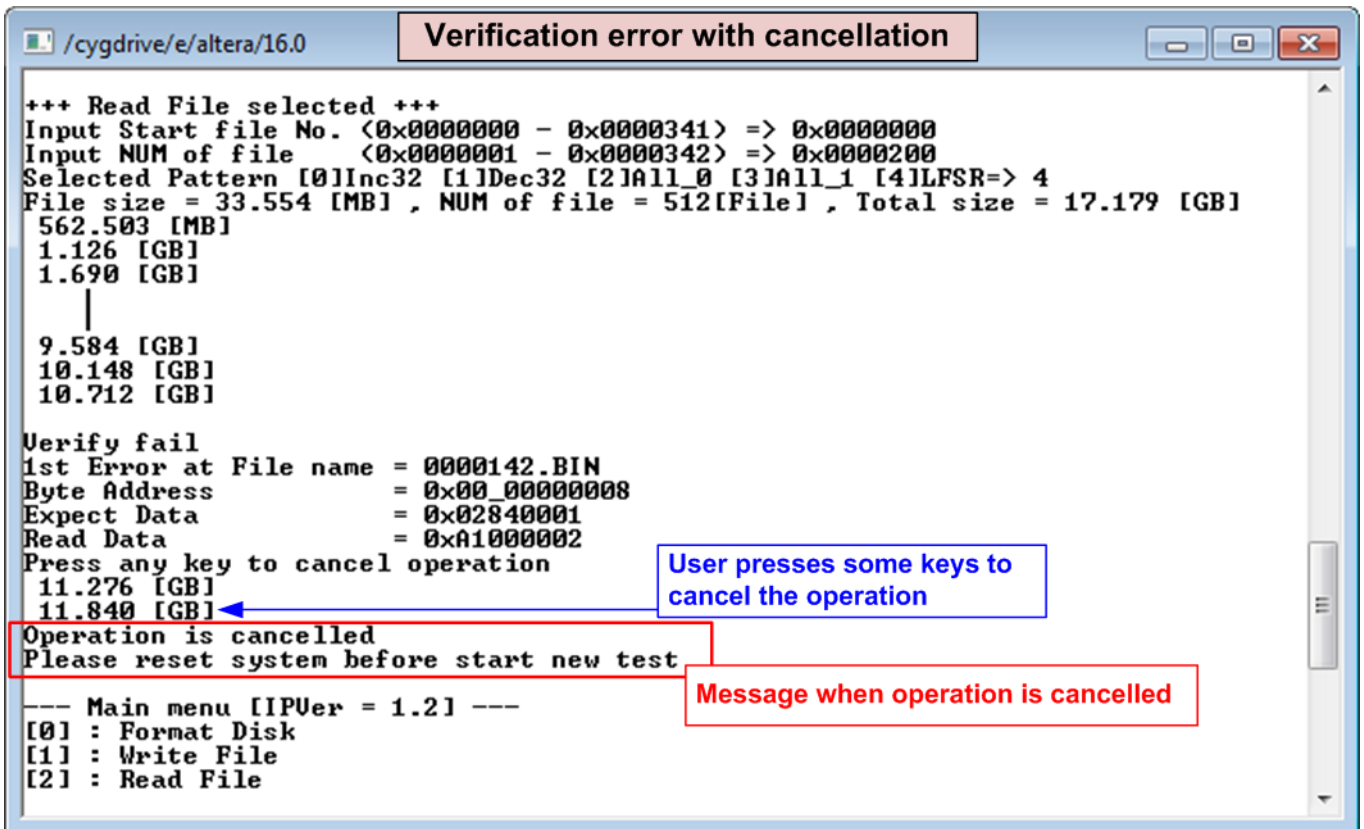


Figure 3-13 Data verification is failed and press any key to cancel operation

4 Revision History

Revision	Date	Description
1.0	29-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