exFAT2-IP for NVMe Gen5 Demo Instruction

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exFAT2-IP for NVMe Gen5 Demo Instruction

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1 Overview

This document details the procedures for operating the exFAT2-IP for NVMe Gen5 demo on an FPGA development board, facilitating access to an NVMe Gen5 SSD with exFAT file system capabilities.

Users can test the functionality of the following six commands through the test menu: Format, Secure Format, Write File, Read File, Read File Info, and Shutdown. Users interact with the demo via the FPGA console, which provides input prompts for command selection and displays the corresponding status and test results.

Before running the demo, set up the FPGA board and test system according to the instructions in the “FPGA Set up for NVMe-IP for Gen5 Demo” document, available at the following link:

https://dgway.com/products/IP/NVMe-IP/dg_nvmeip_fpgasetup_g5_amd/

After the FPGA configuration file has been successfully downloaded, the IP initialization process starts. When initialization is complete, the welcome screen appears, as shown in Figure 1.

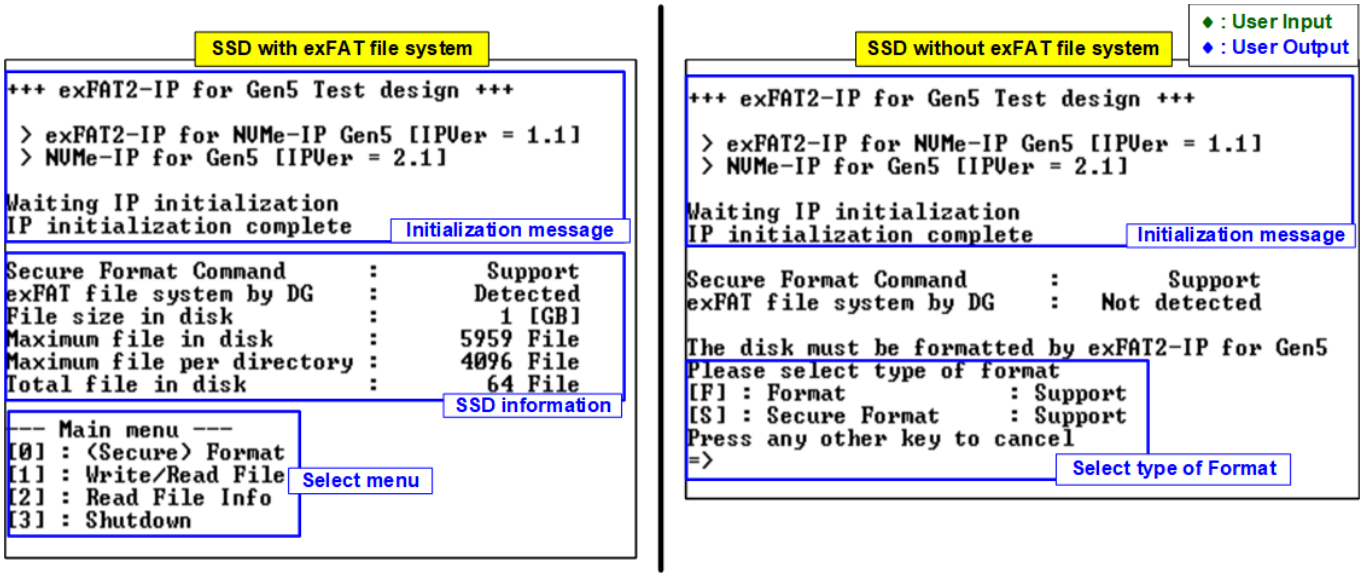

Figure 1 Welcome Screens After Finishing Initialization

This welcome screen displays the IP name and version number and confirms that IP initialization is complete. It also provides SSD information, including Secure Format command support and whether the SSD has been formatted with the exFAT file system by DG’s exFAT-IPs.

If the SSD is formatted with exFAT, the disk information is displayed and the main menu becomes available, as shown on the left side of Figure 1. If the SSD is not formatted with exFAT, the user is prompted to execute the (Secure) Format command before proceeding, as shown on the right side of Figure 1.

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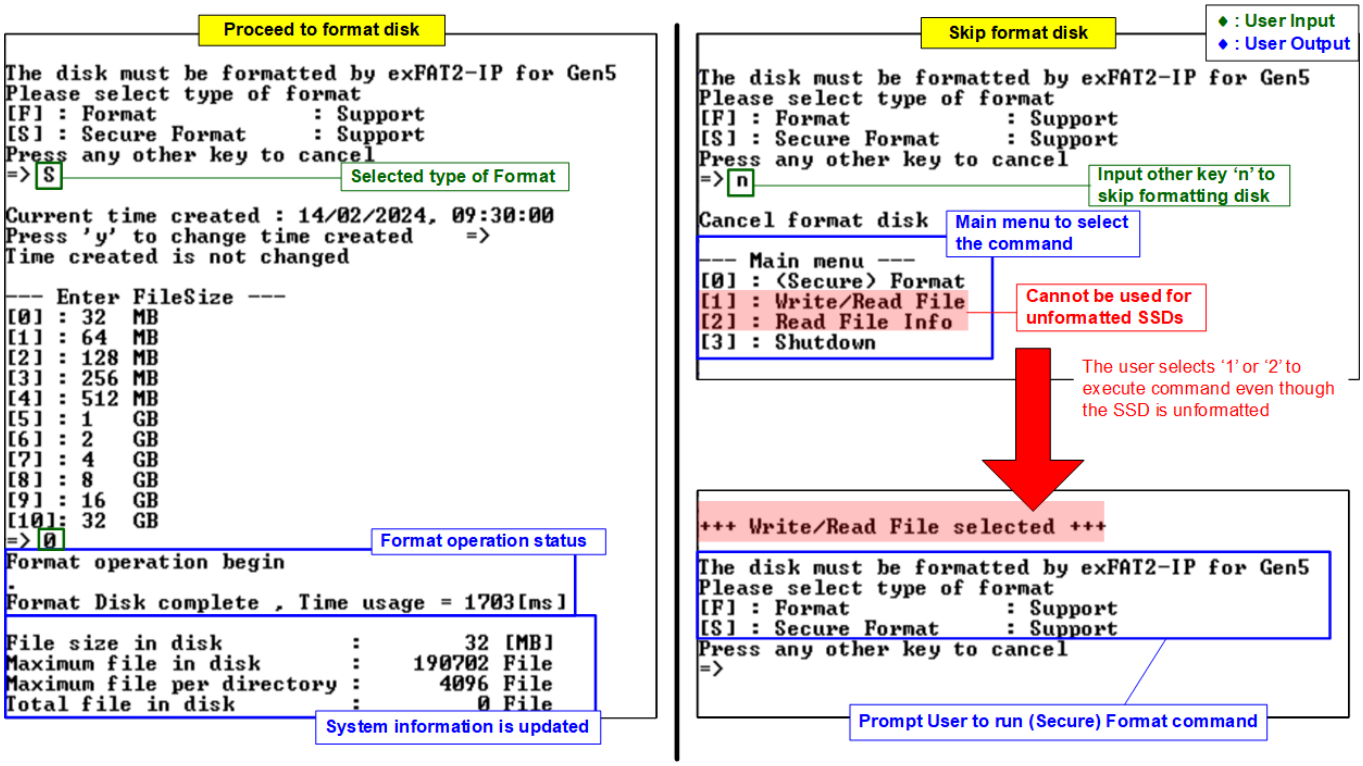

Figure 2 Initialization Complete With and Without Disk Formatting

If an exFAT file system created by Design Gateway's exFAT-IP is not detected on the SSD, the user must execute the (Secure) Format command before performing write/read file operations. After the format operation is complete, the system displays the updated disk information, including the configured file size, maximum number of files in the disk, maximum number of files per directory, and current total number of files in the disk, as shown on the left side of Figure 2. The system then becomes ready to accept commands from the main menu.

As shown on the right side of Figure 2, if the SSD is not formatted with the exFAT file system by DG's exFAT-IPs, the Write File, Read File, and Read File Info commands cannot be executed. If any of these commands is selected, the console prompts the user to execute the (Secure) Format command before proceeding.

The Shutdown command can still be executed without formatting the SSD. Detailed explanations of all four main menu options are provided in the following sections.

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2 Test Menu

2.1 Format/Secure Format Command

Select '0' from the main menu to initiate the (Secure) Format operation of exFAT2-IP. The console displays two formatting options: Format and Secure Format, and indicates whether each operation is supported by the connected SSD.

- Format Command: Executes standard formatting.
- Secure Format Command: Includes an erase operation ensuring all deleted data is irrecoverable, addressing security concerns. On certain SSDs, this function can also restore write performance that has degraded after extensive use.

Execution steps for Format and Secure Format are as follows.

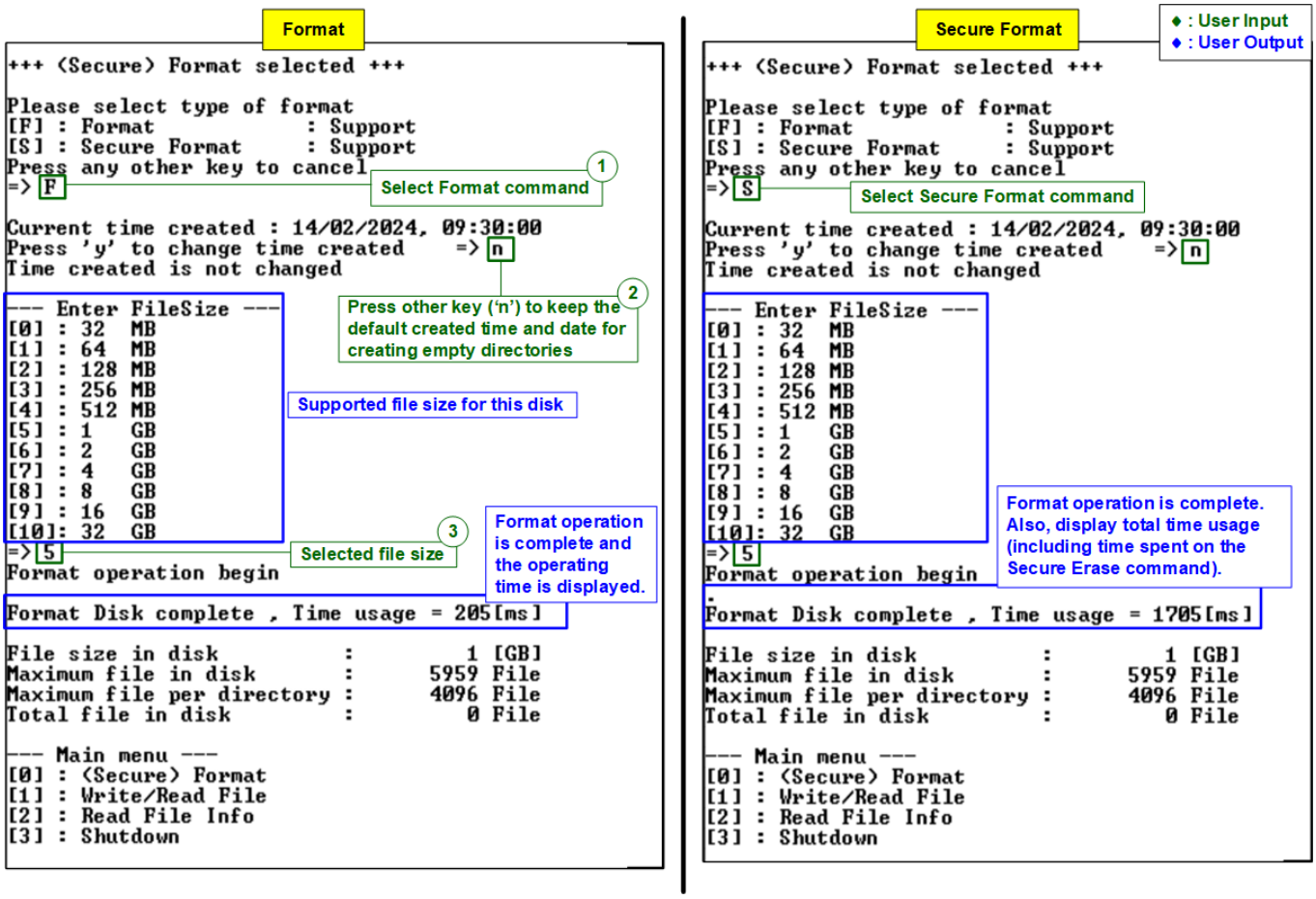

Figure 3 (Secure) Format Menu

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1) Select Format Type.
   - Press ‘F’ to execute the Format command.
   - Press ‘S’ to execute the Secure Format command.
   - Press any other key to cancel the operation. This action cancels the “(Secure) Format” submenu and returns to the main menu.

   If a Format option is selected, the system displays the default created date and time to be assigned to the empty directories created during the format operation.
2) Set Created Date and Time:
   - Press ‘y’ to input a new created date and time.
   - Press any other key (e.g., ‘n’) to retain the default values.

   After setting the date and time, the console will list all supported file sizes for the disk.
3) Select the disk’s file size from the provided options. After a valid selection, the Format or Secure Format process begins.

During the (Secure) Format operation, the message “Format operation begin” will appear. The operation’s progress is indicated by dots (.) displayed on the console. Upon completion, “Format disk complete” will be displayed, along with the total duration of the format process.

Note: As illustrated in Figure 3*, the Secure Format typically takes longer than the standard Format due to the additional erase operation*.

Upon successfully formatting a disk with exFAT2-IP and connecting it to a PC, the system recognizes the DG_exFAT drive, displaying 512 empty directories ranging from DIR000 (the first directory) to DIR1FF (the 512th directory). The modified date and time of these directories correspond to the values specified during the format operation, as shown in Figure 4.

Note: When the formatted disk is connected to a PC, avoid creating, writing to, or modifying data on the disk. Any such modifications necessitate reformatting the disk with exFAT2-IP.

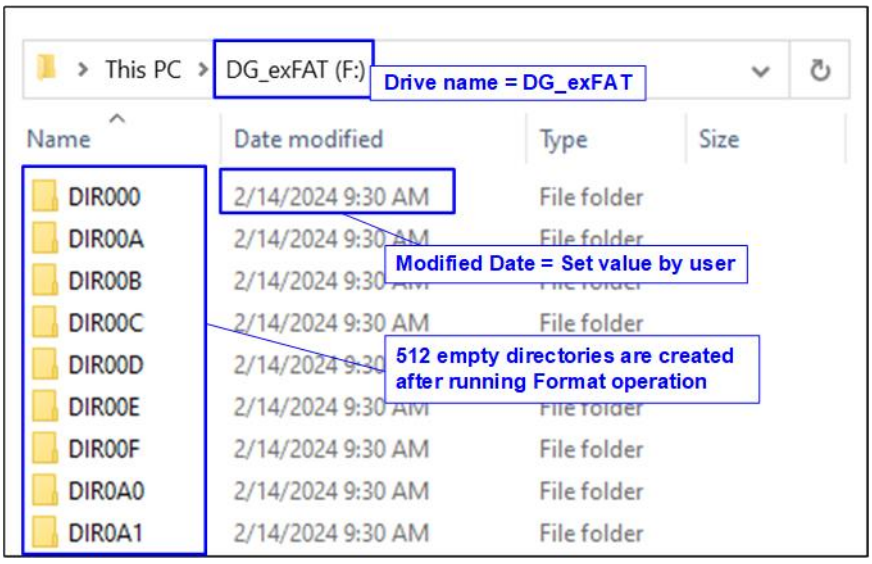

Figure 4 Empty Directories after the Format Completion

If an incorrect file size is entered during the formatting process, an error message is displayed. The format operation is not started, and the system returns to the main menu, as illustrated in Figure 5.

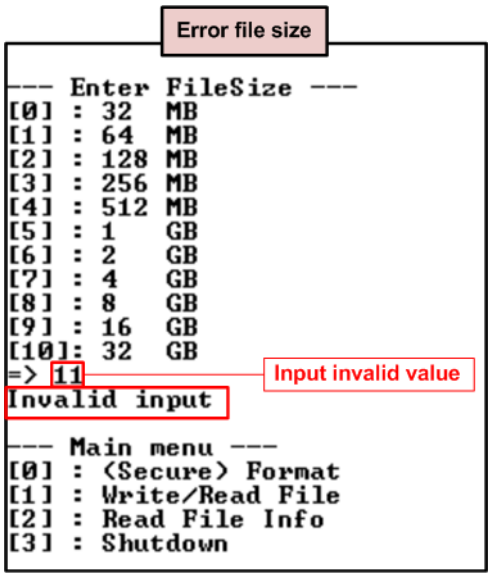

Figure 5 Invalid File-Size Selection

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2.2 Write / Read File Command

Select option '1' to initiate the Write/Read File operation. This function is supported only when the SSD is formatted with the exFAT file system by DG's exFAT-IPs. If the SSD is not formatted with exFAT, the user will be prompted to execute the (Secure) Format command before proceeding.

2.2.1 Write File Command

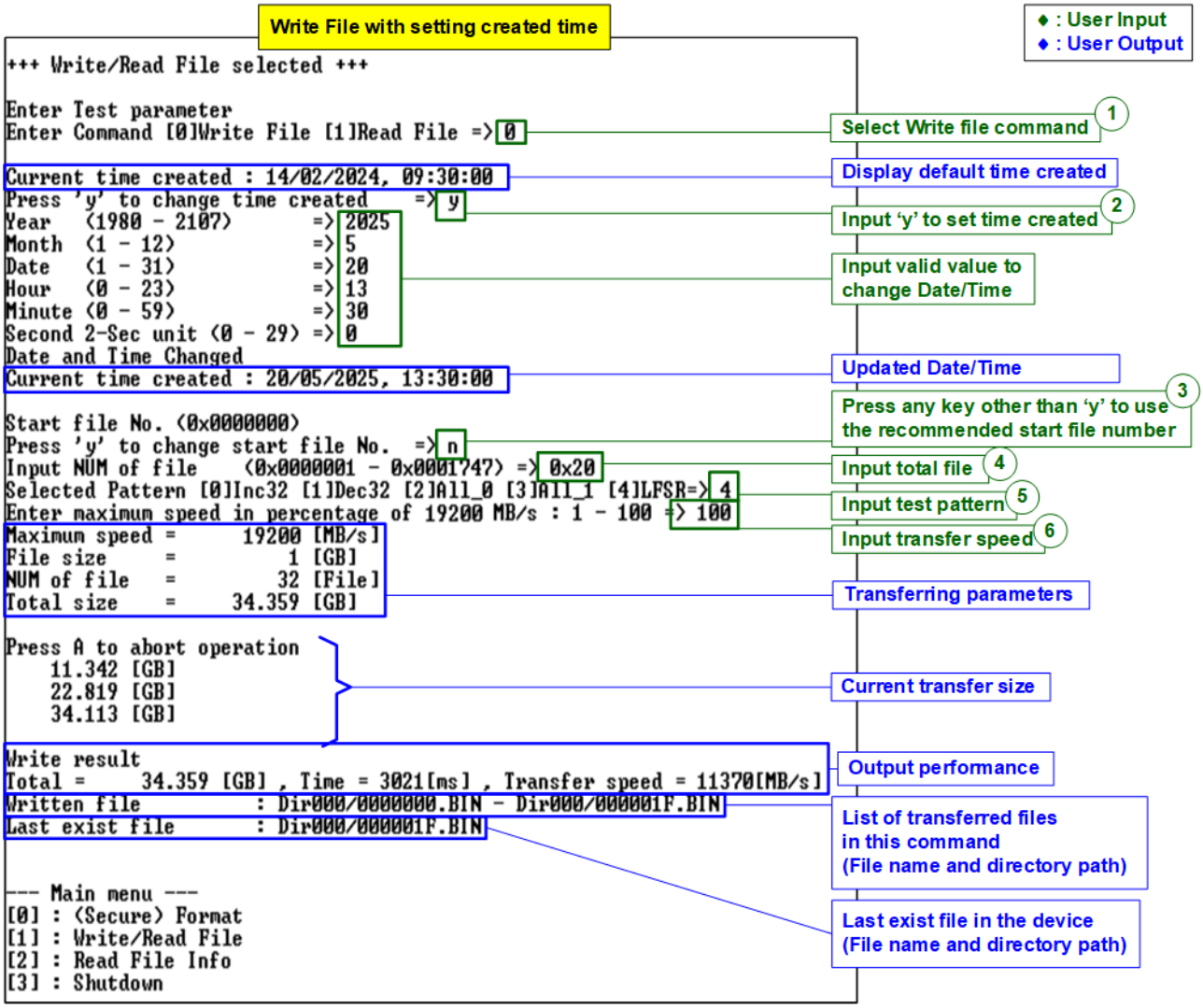

Figure 6 Write File with Setting Created Time

Refer to Figure 6 for a step-by-step guide on executing the Write File command, which requires six input parameters.

1) Command Selection: [0]-Write File or [1]-Read File. Select '0' to initiate the Write File command. After that, the console will display the most recent created date and time.
2) Setting the Created Date and Time: Press 'y' to modify the created date and time for new files or press any other key for the default value. If updating, specify the following parameters:
   - Year : Range 1980 – 2107
   - Month : Range 1 – 12
   - Date : Range 1 – 31
   - Hour : Range 0 – 23
   - Minute : Range 0 – 59
   - Second : Value in steps of 2 seconds (0, 2, …, 58); valid range 0 – 29 (representing 0 – 58 seconds).

   Decimal input is used by default. Prefix the value with '0x' to enter a hexadecimal value. If an invalid value is entered, the previous value is retained. After all values have been entered successfully, the message "Date and Time Changed" is displayed together with the updated creation date and time.

   The console then displays the recommended start file number based on the files currently stored on the SSD.
3) Setting Start file number: Press any key other than 'y' to use the recommended number. To overwrite existing files, press 'y' and input a new number, less than the recommended value. Existing files within the selected range are overwritten by the new data.
4) Number of files: Specify the total number of files to be written. Input decimal value or prefix "0x" for hexadecimal.
5) Test pattern: Choose from 32-bit incremental, 32-bit decremental, all-0, all-1, and 32-bit LFSR pattern.
6) Maximum speed: Set the transfer-rate limit as a percentage of 19,200 MB/s, with a valid input range of 1-100. The value of 19,200 MB/s is calculated from the 300-MHz user clock and 512-bit data width.

Once all inputs are confirmed, the console previews the transfer parameters. During execution, the written data amount is shown every second. When the operation is completed, the console displays the total size, total time usage, and test speed.

After the Write File command concludes, the data is stored on the SSD in file format, with names spanning from the first file number (set in step 3) to the last file number (Start file number + Number of files – 1). The file name is defined by seven hexadecimal digits. Since the number of files per directory is limited, new files might be distributed across directories. The console will display the names and directory paths of the new files as a concluding message.

Figure 7 presents an example of executing a subsequent Write File command where the created date and time are not modified. After the operation concludes, the new file names sequentially follow those from the previous command (with the last file named '000001F.BIN'), starting with '0000020.BIN' and ending with '000003F.BIN'.

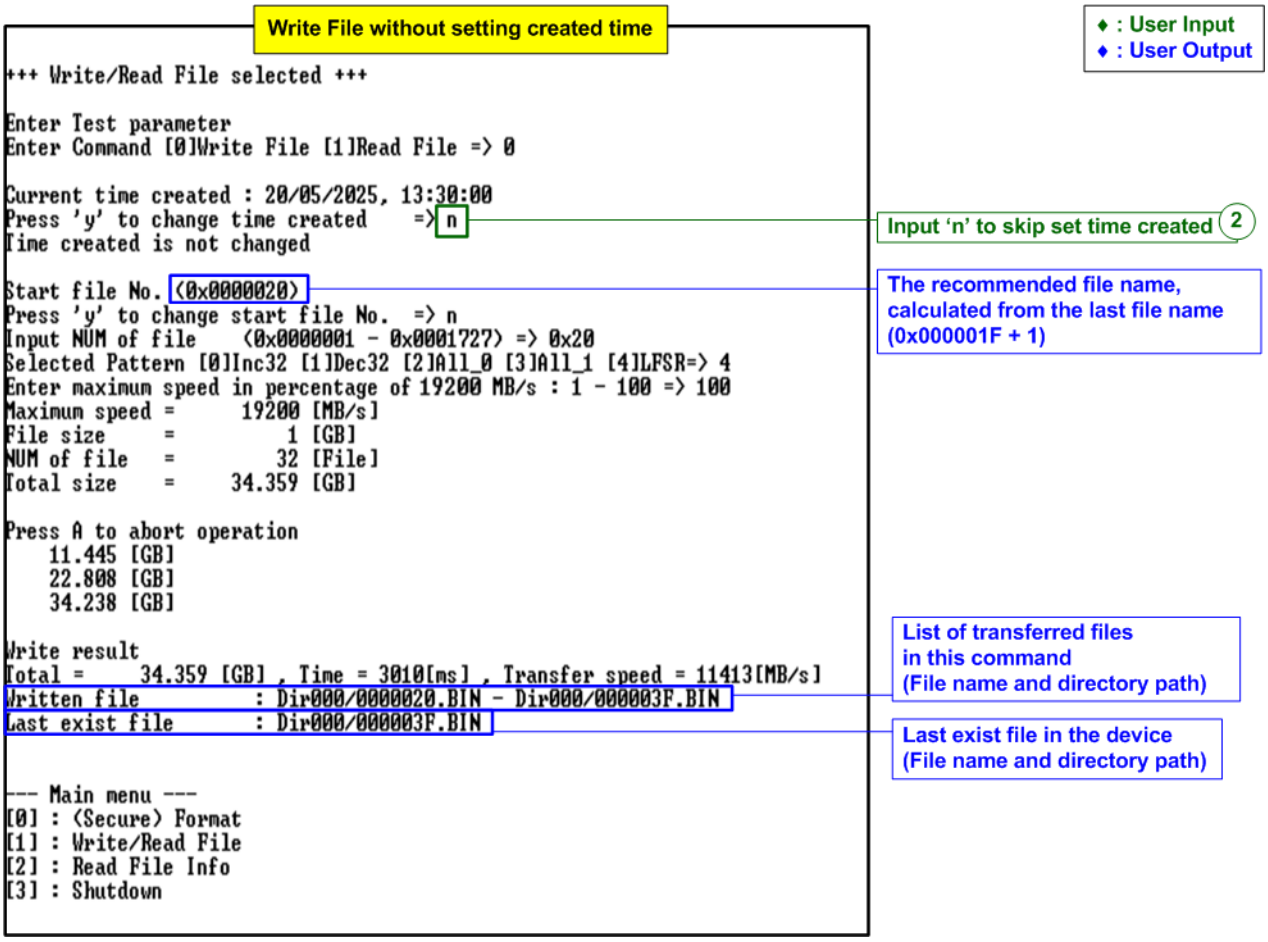

Figure 7 Write File Command without Changing the Creation Date and Time

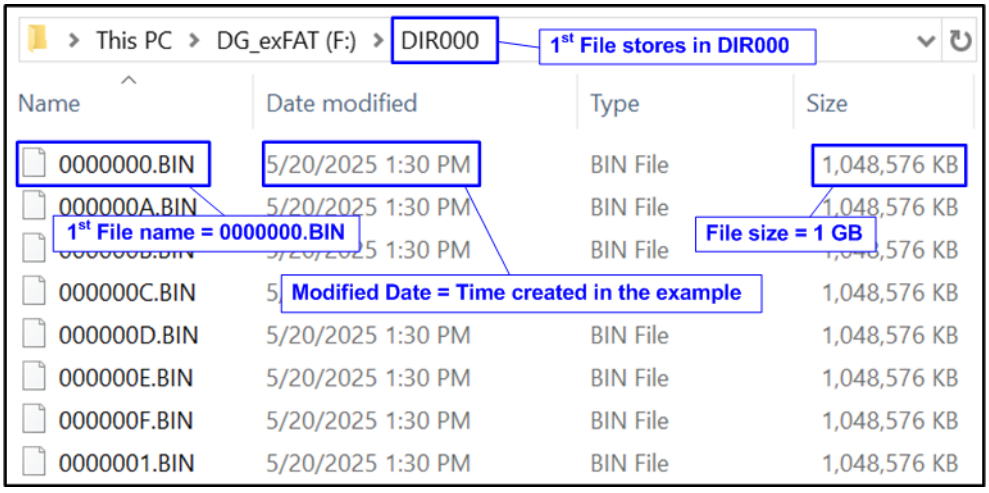

Figure 8 Example Test File Written by Write File Command

When the SSD is connected to a PC, the files are accessible within the subdirectories of the DG_exFAT drive. The first file, 0000000.BIN, is located in DIR000. The file size corresponds to the value configured during the Format command, and the modified date of each file matches the creation date and time configured during the Write File command.

Note: Please refrain from creating, writing, or modifying data on the SSD when it is connected to a PC. If any modifications occur, the SSD will require reformatting with exFAT2-IP to maintain integrity.

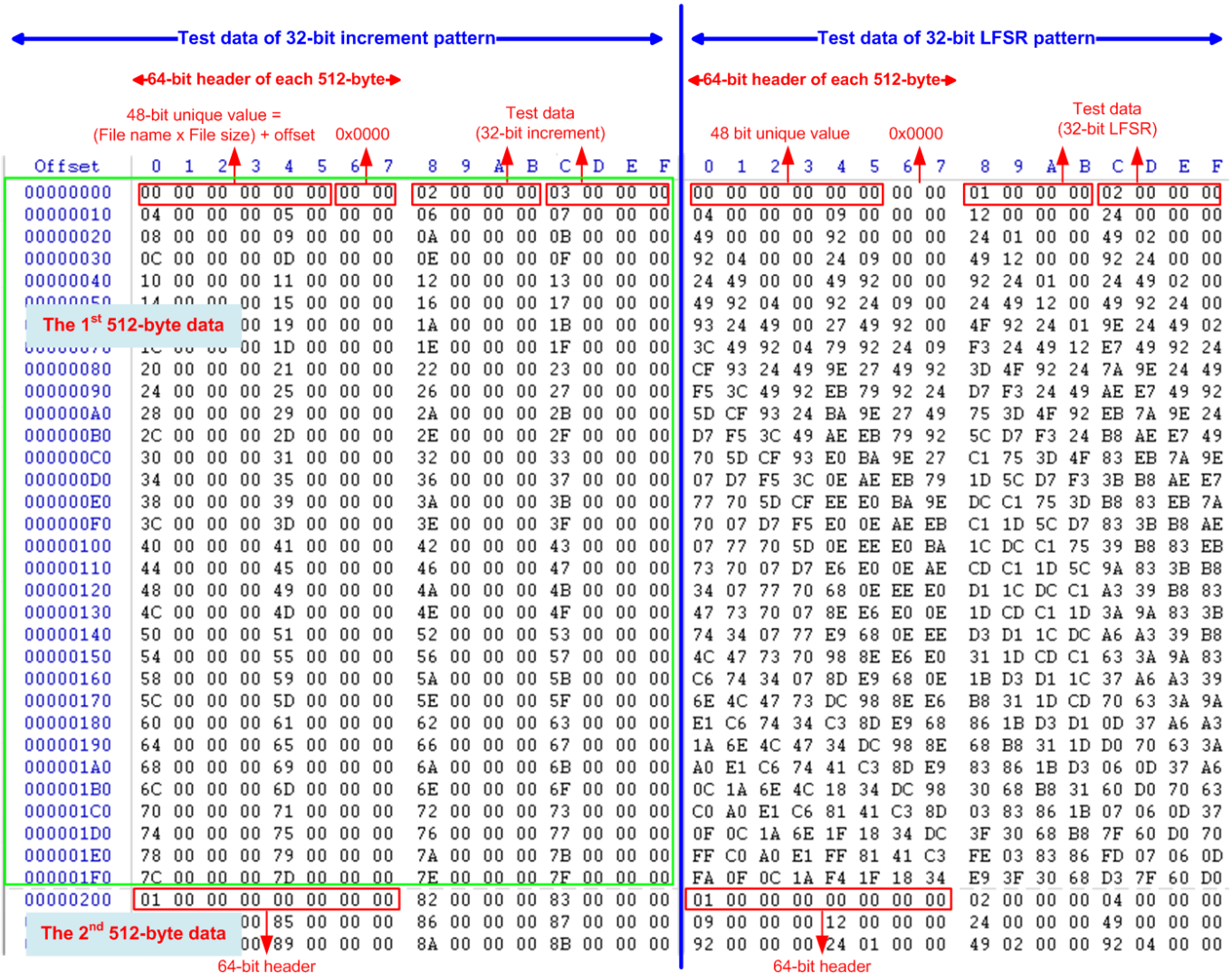

Figure 9 Test Data in Sector#0 - #1 of File "0000000.BIN" by Increment/LFSR Pattern

Test data is split into 512-byte segments. For incremental, decremental, or LFSR pattern, each segment includes a unique 64-bit header consisting of a 48-bit address (derived from <file number x file size> + file offset) and 16-bit zero value, ensuring a distinct address for every 512-byte segment. The unique header is not included in the all-0 or all-1 patterns.

The data following the 64-bit header will display the selected test pattern. For instance, in Figure 9, the left window illustrates data in file '0000000.BIN' with an incremental pattern, while the right window depicts the LFSR pattern. The header (byte#0-byte#7) remains consistent across test patterns, followed by the specific test data (incremental, decremental, and LFSR).

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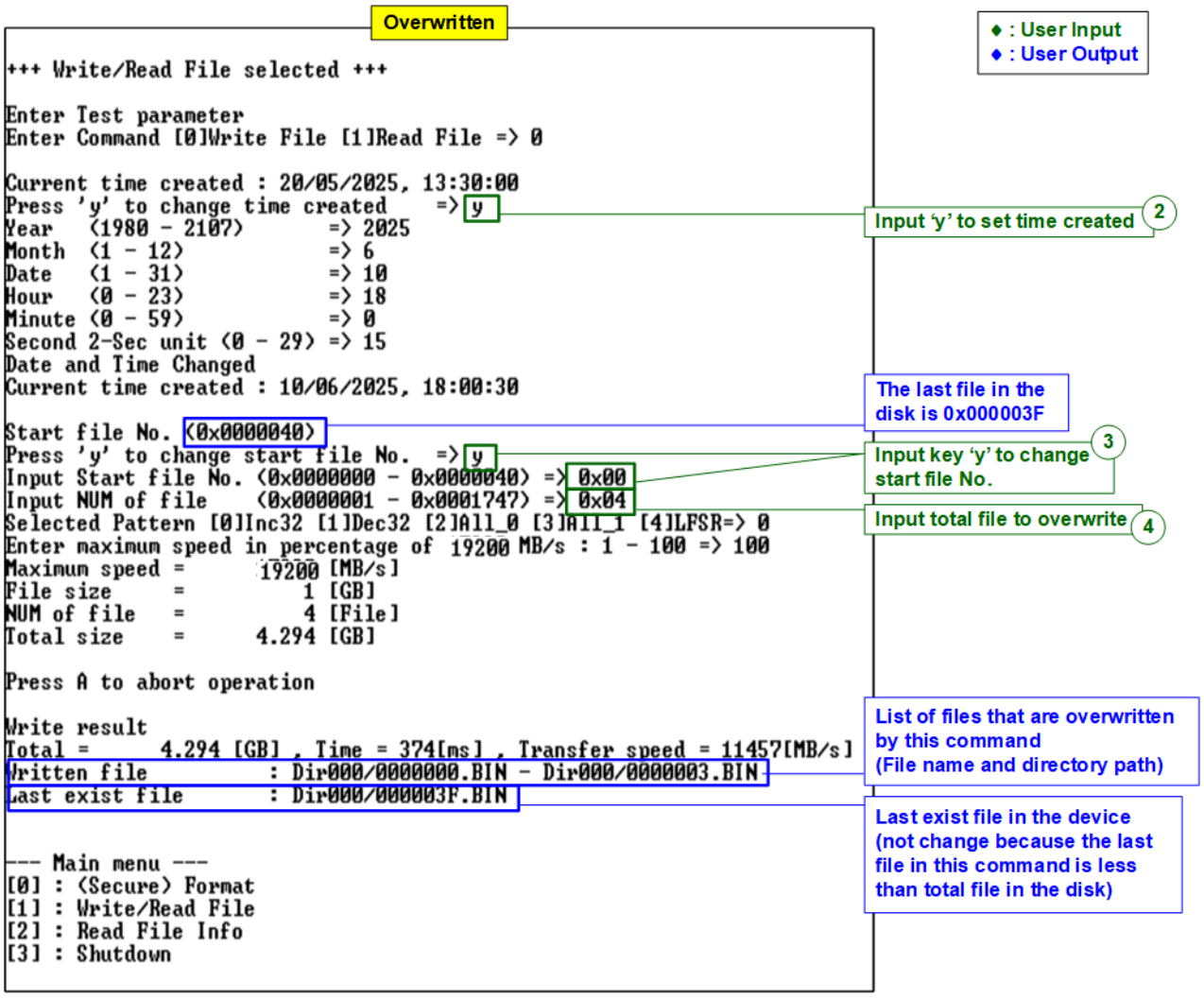

Figure 10 Overwriting Files with a New Creation Date and Time

Figure 10 illustrates an example of overwriting files by setting the Start file number to a value lower than the default settings. Initially, the last file on the SSD is '000003F.BIN'. However, the overwrite operation writes files '0000000.BIN' through '0000003.BIN'. During this operation, the created date and time is set to a new value (10 Jun 2025, 18:00:30), which differs from the default created date. Since the last file number in this overwrite command (0000003.BIN) is lower than the last file on the SSD (000003F.BIN), the display of the last file on the console remains unchanged, as detailed in Figure 10.

Upon completing the operation, the modified date for files ‘0000000.BIN’ to ‘0000003.BIN’ is updated to reflect the newly set date of 10 Jun 2025, 18:00:30, as shown in Figure 11.

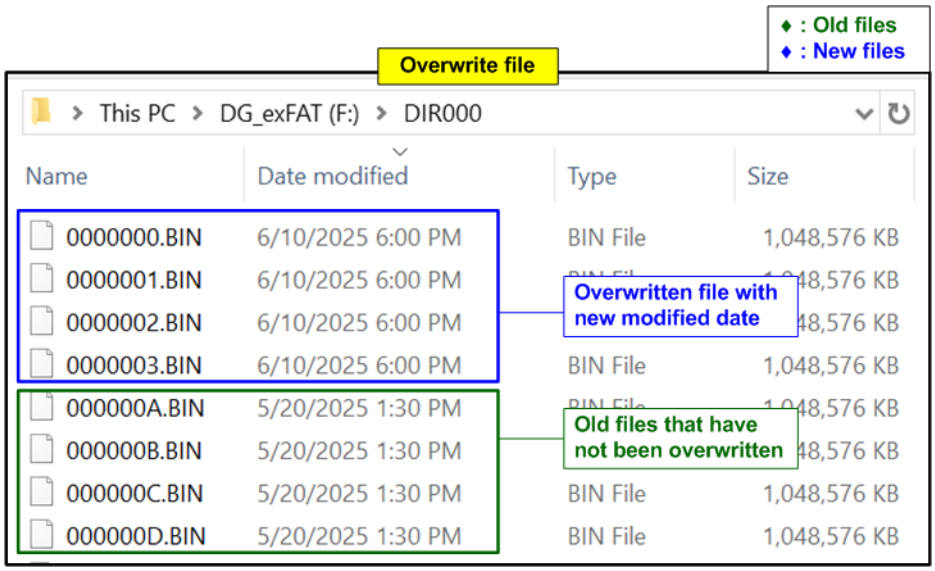

Figure 11 Overwritten Files with a New Modified Date and Time

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The Write File command supports an abort function. Before the operation begins, the console displays “Press A to abort operation”. Press ‘A’ during the operation to request an abort. The console displays “Abort request from User”, indicating the interruption of the operation. The system then processes the request and terminates the Write File operation.

After the abort request is successfully processed, the console presents the Write File command results, including the total size, total time usage, and test speed.

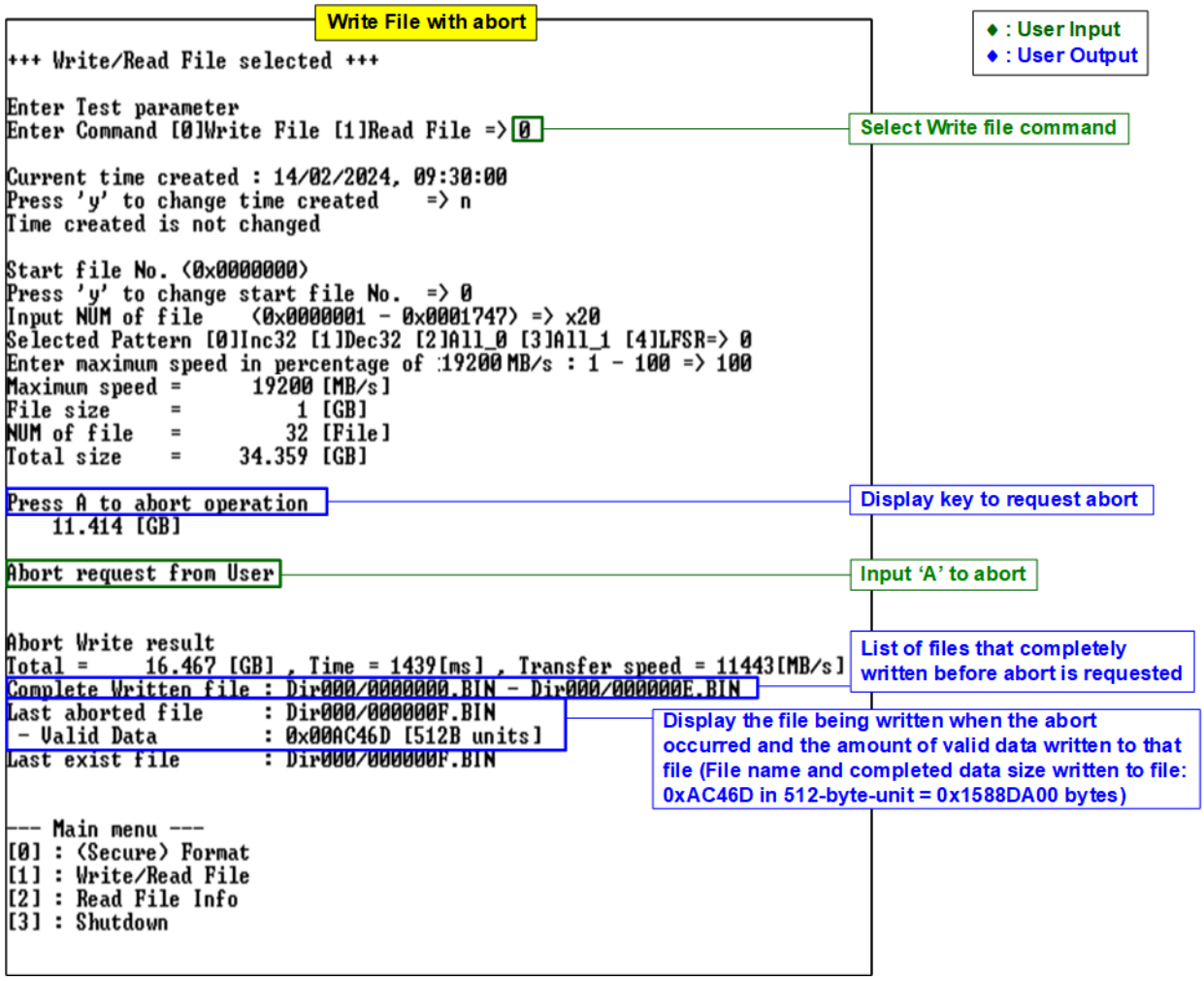

Figure 12 Write File Command with Abort

If an abort request occurs while a file is being written, the last file may contain only partially valid data. After the abort operation is complete, the console displays the last file being processed and the amount of valid data written to that file in 512-byte units. For example, if the Valid Data value is 0xAC46D, the corresponding valid data size is 0x1588DA00 bytes (0xAC46D × 512 bytes).

Figure 13 illustrates the last file, ‘000000F.BIN’, which contains 0x1588DA00 bytes of valid data, showcasing the state post-abort.

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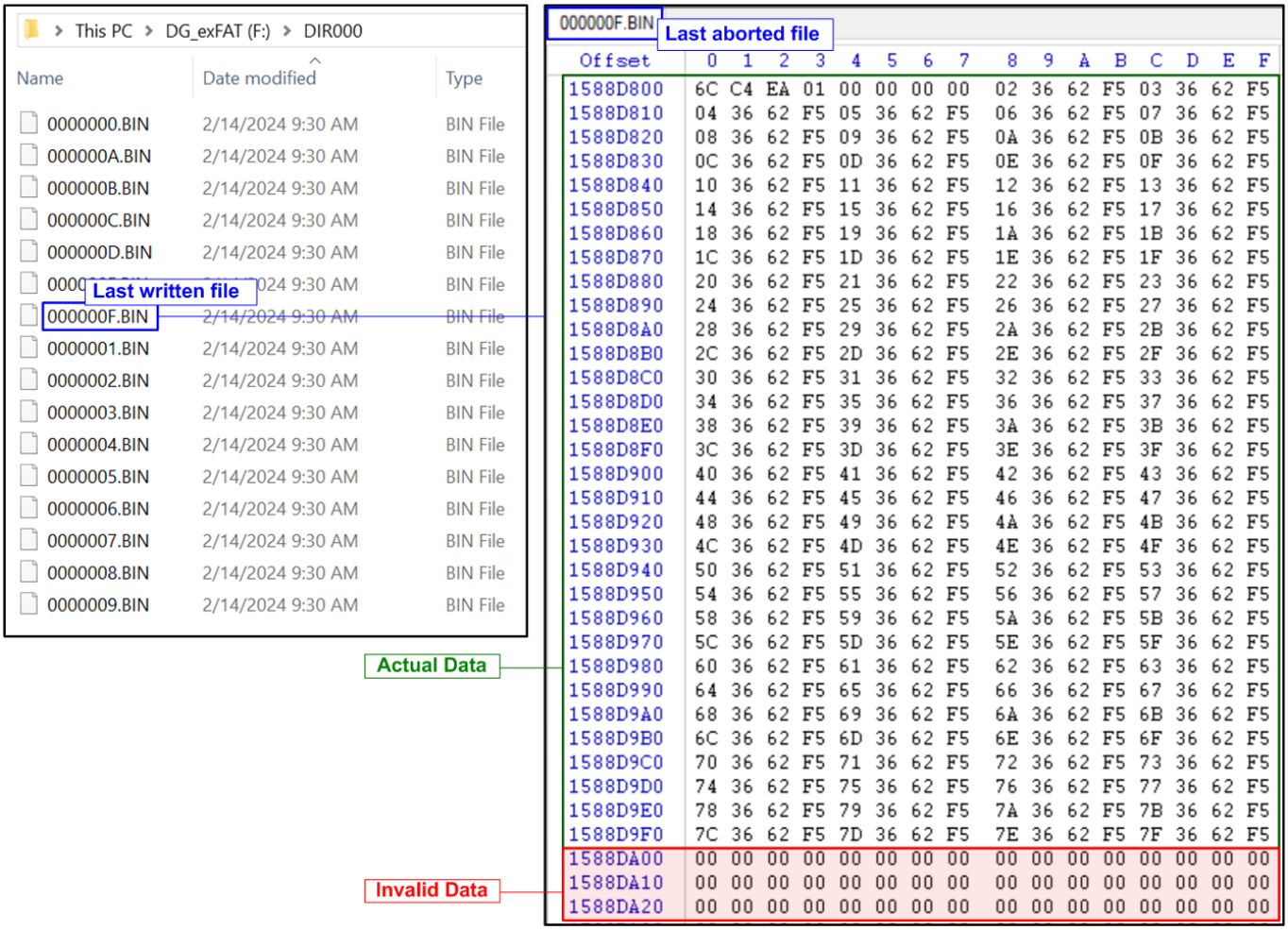

Figure 13 Last Written File after Aborting Write File Command

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Figure 14 shows examples of invalid command, start file number, number of files, test pattern, and maximum-speed inputs. If any of these inputs is invalid or outside the permitted range, the console displays “Invalid input”, cancels the command, and returns to the main menu.

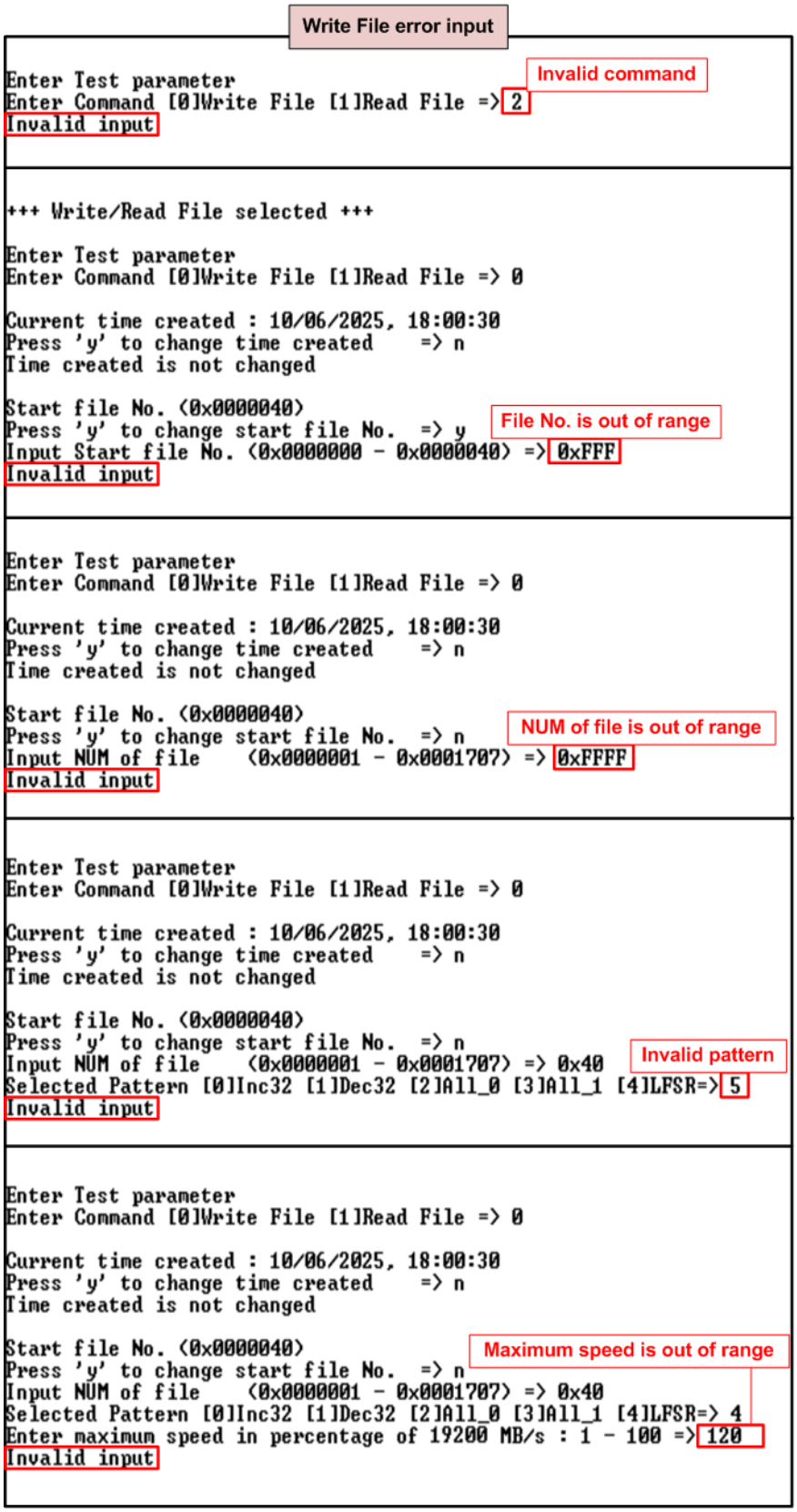

Figure 14 Invalid Input for the Write File Command

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2.2.2 Read File Command

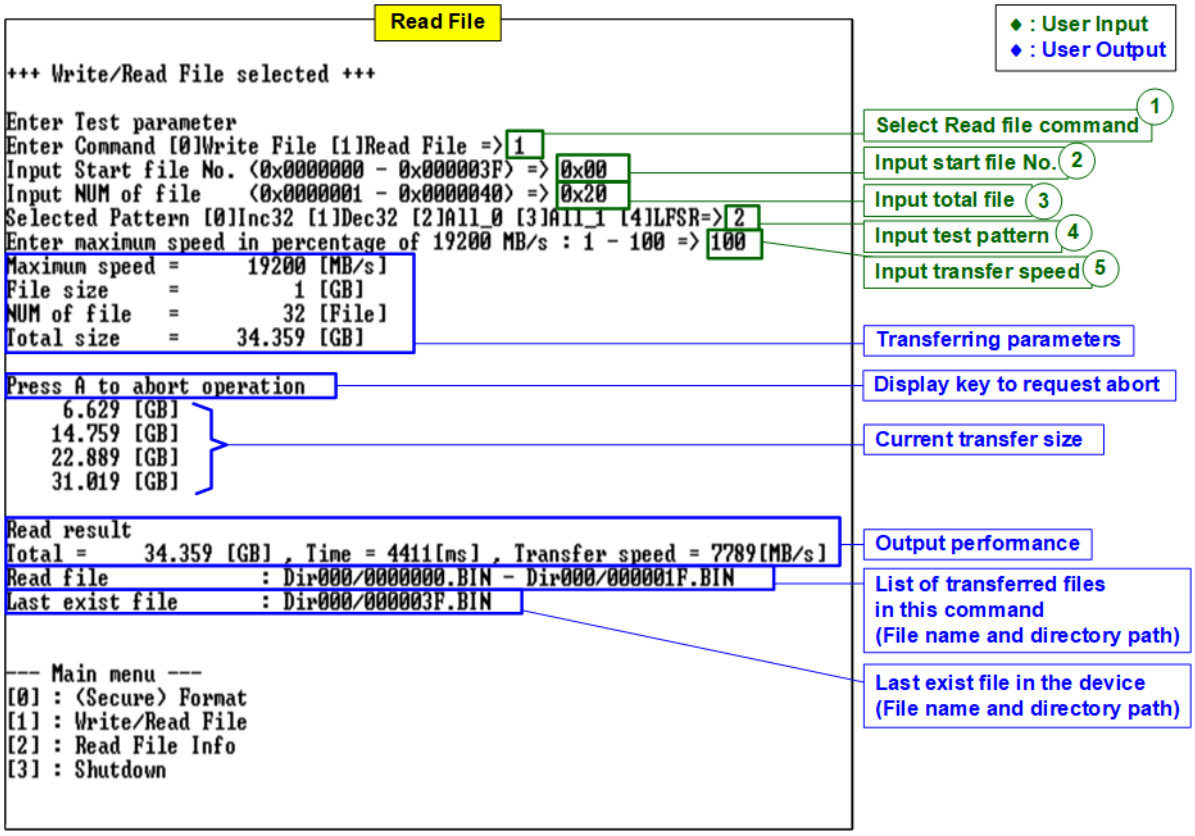

Figure 15 Read File Command

To execute the Read File command, the user needs to input the following five parameters.

1) Command Selection: There are two options: [0]-Write File or [1]-Read File. Choose '1' to initiate the Read File command.
2) Start file number: Set the starting file number for the read operation, within the range of 0 to (total number of files on the disk – 1). Default input is decimal; use prefix "0x" for hexadecimal.
3) Number of files: Specify the total number of files to read. Enter a decimal value or prefix with "0x" for hexadecimal input.
4) Test pattern: Select a verification pattern that corresponds with the one used in the Write File command. Five options include 32-bit incremental, 32-bit decremental, all-0, all-1, and 32-bit LFSR pattern.
5) Maximum speed: Define the speed as a percentage of 19,200 MB/s, with valid inputs ranging from 1 to 100.

After the inputs are confirmed, the console previews the transfer parameters. During execution, the amount of data read is shown every second. Upon completion, the console displays the total size, total time usage, and test speed of the operation. The final step includes displaying the names and directory paths of the files involved in the transfer before returning to the main menu.

If invalid inputs are entered, an "Invalid input" message is displayed, and the command is cancelled, similar to the Write File command's behavior.

When the user presses ‘A’, the console displays “Abort request from User”. The system then processes the abort request and terminates the Read File operation. After the abort request is successfully processed, the console provides a test summary including the total size, total time usage, and test speed.

The console also lists the files that were completely read and identifies the last file processed, including the amount of data read from that file in 512-byte units.

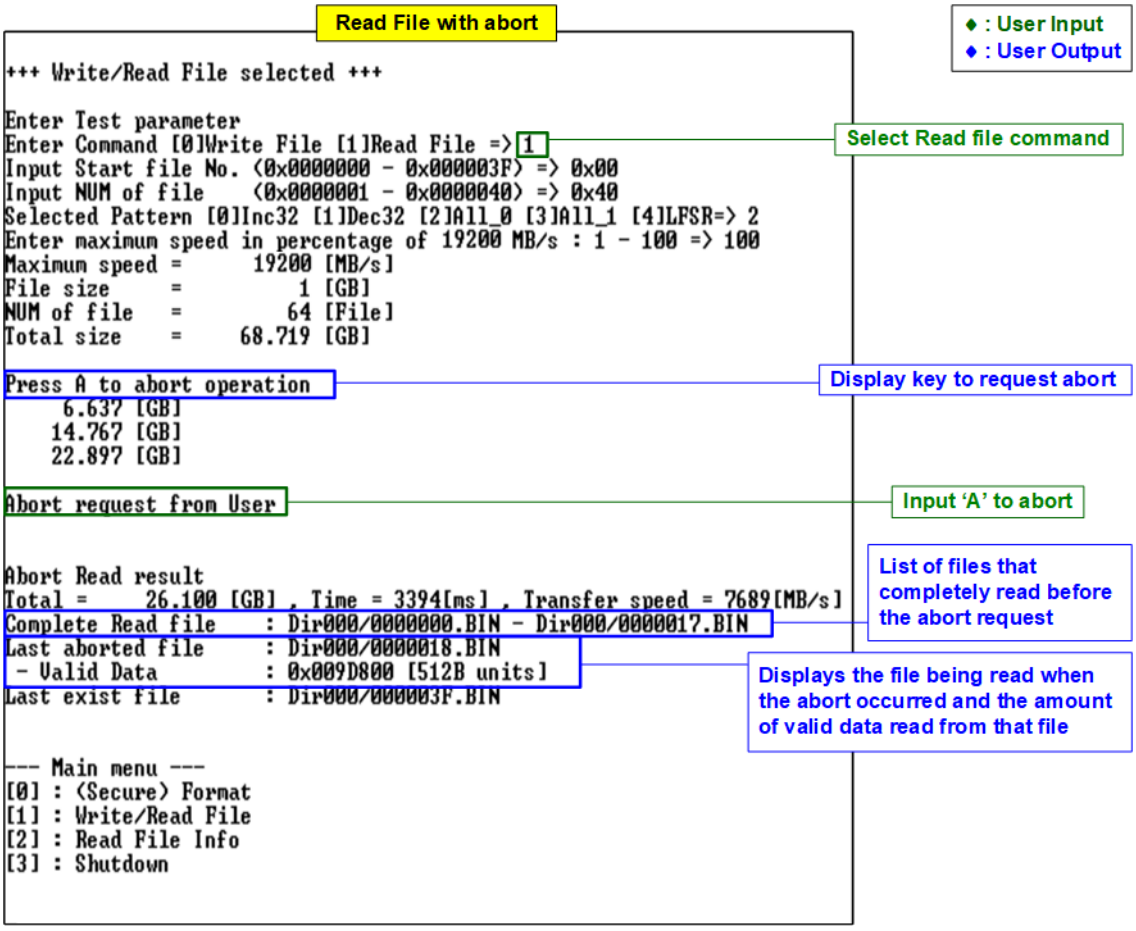

Figure 16 Read File Command with Abort

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If the Read File command encounters a data verification failure, the read transfer continues after the verification failure is reported. The console will display an error message, as depicted in Figure 17. The error message “Verify fail” will be shown, along with the name of the first file where the error occurred, the byte address of the first verification error, the expected data, and the data that was actually read.

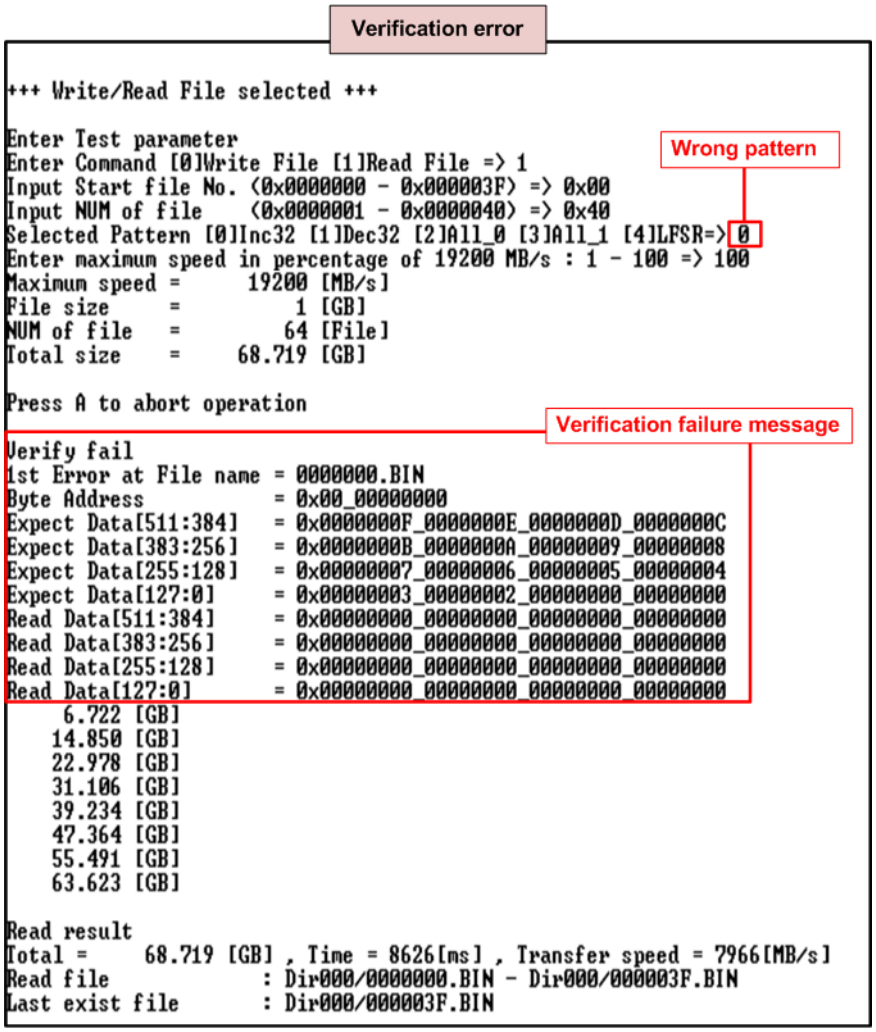

Figure 17 Data Verification Failure

2.3 Read File Info Command

Select option '2' to initiate the Read File Info command. This function is supported only when the SSD is formatted with the exFAT file system by DG's exFAT-IPs. If the SSD is not formatted with exFAT, the user will be prompted to execute the (Secure) Format command before proceeding.

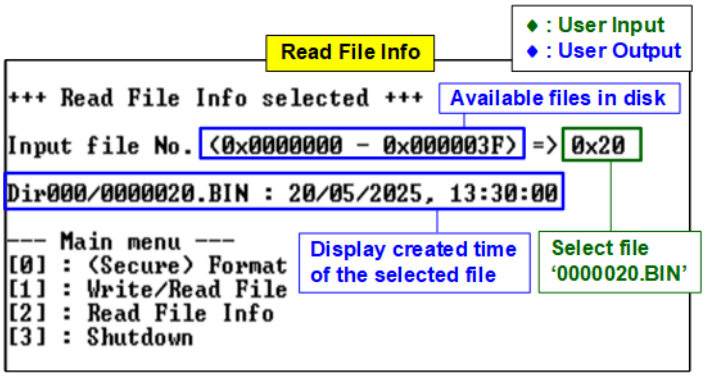

Figure 18 Read File Info Command

To operate the Read File Info command, enter the file number to obtain its information. Input can be a decimal value or prefixed with "0x" for hexadecimal, ranging from 0 to (total number of files on the disk – 1).

Once the inputs are verified, the command executes. Upon completion, the console displays the created/modified date and time for the specified file.

If the input is invalid, an "Invalid input" message will appear on the console, the operation will be cancelled, and the system will revert to the main menu.

2.4 Shutdown Command

Select option '3' to initiate the Shutdown command. This command forces the exFAT2-IP and the connected SSD to become inactive.

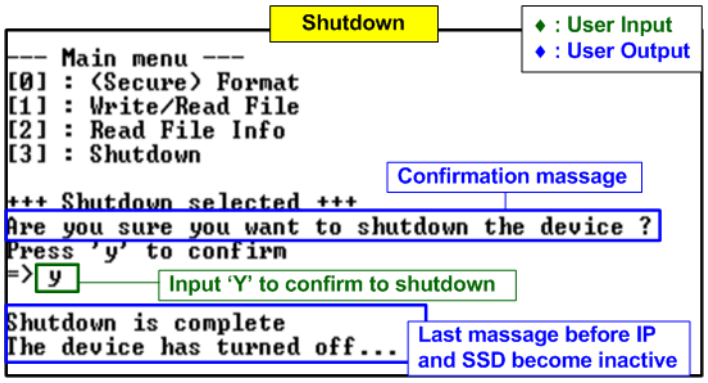

Figure 19 Shutdown Command with Confirmation

When initiating the Shutdown operation, a confirmation message will appear on the console. To proceed with the shutdown, the user inputs 'y' or 'Y'. Any other key will cancel the operation. After the command executes successfully, the console will display the message "Shutdown command is complete", indicating the system has been properly shut down.

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3 Revision History

Revision	Date (D-M-Y)	Description
1.00	6-Oct-26	Initial version release

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