
exFAT IP Core for SATA

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Product Specification

Rev1.0



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Features

- Access SATA device as exFAT system without using CPU and external memory
- Simple user interface and operating with DG SATA HCTL IP suite
- Achieve best write/read speed (up to 533 MB/s for write and up to 560 MB/s for read)
- Support disk capacity: 8 Gigabyte* – 64 Petabyte*
*Gigabyte means 1024x1024x1024 byte while Petabyte means 1024x1024x1024x1024x1024 byte
- Three user commands, i.e. Format, Write file, and Read file
- Support eight file sizes, i.e. 32MB, 128MB, 512MB, 2GB, 8GB, 32GB, 128GB, and 512GB (some file sizes are not available, depending on disk capacity)
- Reference design available on ZC706 board with AB09-FMCRAID adapter board

Core Facts

Provided with Core	
Documentation	Reference Design Manual Demo Instruction Manual
Design File Formats	Encrypted HDL
Instantiation Templates	VHDL
Reference Designs & Application Notes	Vivado Project, See Reference Design Manual
Additional Items	Demo on ZC706
Support	
Support Provided by Design Gateway Co., Ltd.	

Table 1: Example Implementation Statistics for Ultrascale device

Family	Example Device	Fmax (MHz)	CLB Regs	CLB LUTs	CLB	IOB	BRAMTile	PLL	Design Tools
Kintex-Ultrascale	XCKU040FFVA1156-2E	400	2017	2150	397	-	3	-	Vivado2017.4

Table 2: Example Implementation Statistics for 7-Series device

Family	Example Device	Fmax (MHz)	Slice Regs	Slice LUTs	Slices	IOB	BRAMTile	PLL	Design Tools
Zynq-7000	XC7Z045FFG900-2	370	2017	2190	777	-	3	-	Vivado2017.4

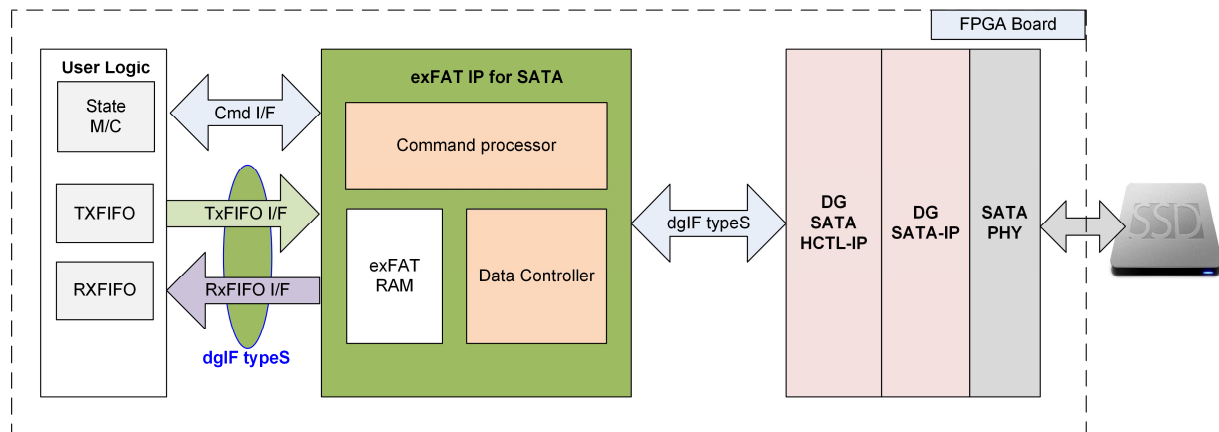


Figure 1: exFAT IP for SATA Block Diagram

Applications

exFAT IP for SATA must operate with SATA HCTL IP suite (DG SATA HCTL IP and DG SATA IP) and SATA PHY. The IP Core is an ideal to access SATA device as exFAT file system with high speed performance, like raw data access. This solution fits the application which needs to record data to SATA device by FPGA, but the data file is read by other system such as PC through file system format.

General Description

In general system, CPU and firmware are required to write/read data with the device as file system. So, system must include CPU and memory to store CPU firmware. Write/Read performance when access the device as file system by using CPU firmware is not good. There is overhead time which reduces the performance. Finally, most users decide to make their own file system, not using standard file system.

To solve above problem, exFAT IP for SATA is designed to meet two requirements, i.e. using less FPGA resource (no CPU and no external memory) and writing/reading data at the highest speed like raw data access. exFAT IP for SATA is top-up module of SATA HCTL IP to allow user write/read data with SATA device as exFAT file system instead of raw data (raw data system could be designed by using only SATA HCTL IP). The interface of exFAT IP for SATA is simple and almost similar to SATA HCTL IP. Two groups of user interface are designed, i.e. control and data.

Control interface is almost similar to SATA HCTL IP, but file parameters are used instead of physical parameters. File name is used to specify starting point to access data, instead of physical address. Numbers of file is used to specify transfer size, instead of physical length. Three commands are designed in exFAT IP to access SATA device, i.e. Format, Write file, and Read file.

Data interface of exFAT IP is designed by using general FIFO interface, same as SATA HCTL IP. Clock domain of exFAT IP must be same as user clock of SATA HCTL IP because there is no asynchronous circuit included to interface between exFAT IP and SATA HCTL IP.

Otherwise, user needs to input file parameters to exFAT IP as input signals such as created date, created time, file size. Created date and created time must be valid during sending command request to exFAT IP. File size must be fixed to one value after Format operation. There are eight file sizes to set, i.e. 32 MB, 128 MB, 512 MB, 2 GB, 8 GB, 32 GB, 128 GB, and 512 GB. More details of supported file size are shown in Table 3.

Table 3: Supported File size following device capacity

Device capacity	32MB ⁽²⁾	128MB ⁽²⁾	512MB ⁽²⁾	2GB ⁽²⁾	8GB ⁽²⁾	32GB ⁽²⁾	128GB ⁽²⁾	512GB ⁽²⁾
8 GB - 16 GB ⁽¹⁾	Yes	Yes	Yes	Yes	No	No	No	No
16 GB - 64 GB ⁽¹⁾	Yes	Yes	Yes	Yes	Yes	No	No	No
64 GB - 256 GB ⁽¹⁾	Yes	Yes	Yes	Yes	Yes	Yes	No	No
256 GB - 1 TB ⁽¹⁾	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
1 TB - 512 TB ⁽¹⁾	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
512 TB - 8 PB ⁽¹⁾	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8 PB - 64 PB ⁽¹⁾	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Note

(1) Upper limit range means less than this size. For example, if device capacity is 512 TB, 32 MB size will not support.

(2) In the table, MB means 1024x1024 byte. GB means 1024x1024x1024 byte.

TB means 1024x1024x1024x1024 byte. PB means 1024x1024x1024x1024x1024 byte.

After Format command, file size input to exFAT IP must be fixed. There are 128 empty directories created in the device after complete Format command. Directory name is DIR00, DIR01, ..., DIR0F, DIR10, ... , DIR7E, and DIR7F. Two hexadecimal digits are used to refer directory number.

In Write file command operation, when FileName is equal to 0, exFAT IP creates the 1st file (FILE0000000.BIN) to DIR00. The next file is stored to DIR00 until total files in DIR00 is equal to maximum limitation, read from DirCap signal as shown in Table 4. After that, the next file is stored to DIR01. The limitation to store file in one directory depends on device capacity.

Table 4: Maximum file in one directory

Device capacity	DirCap[21:0]	Used directory
8 GB - 32 GB ⁽¹⁾	0x000400 (1024)	DIR00
32 GB - 128 GB ⁽¹⁾	0x000800 (2048)	DIR00 - DIR01
128 GB - 512 GB ⁽¹⁾	0x001000 (4096)	DIR00 - DIR03
512 GB - 2 TB ⁽¹⁾	0x002000 (8192)	DIR00 - DIR07
2 TB - 8 TB ⁽¹⁾	0x004000 (16384)	DIR00 - DIR0F
8 TB - 32 TB ⁽¹⁾	0x008000 (32768)	DIR00 - DIR1F
32 TB - 128 TB ⁽¹⁾	0x010000 (65536)	DIR00 - DIR3F
128 TB - 512 TB ⁽¹⁾	0x020000 (131072)	DIR00 - DIR7F
512 TB - 2 PB ⁽¹⁾	0x040000 (262144)	DIR00 - DIR7F
2 PB - 8 PB ⁽¹⁾	0x080000 (524288)	DIR00 - DIR7F
8 PB - 32 PB ⁽¹⁾	0x100000 (1048576)	DIR00 - DIR3F
32 PB - 64 PB ⁽¹⁾	0x200000 (2097152)	DIR00 - DIR3F

Note (1) Upper limit range means less than this size. For example, if device capacity is 32 GB, maximum file in one directory is equal to 2048.

Functional Description

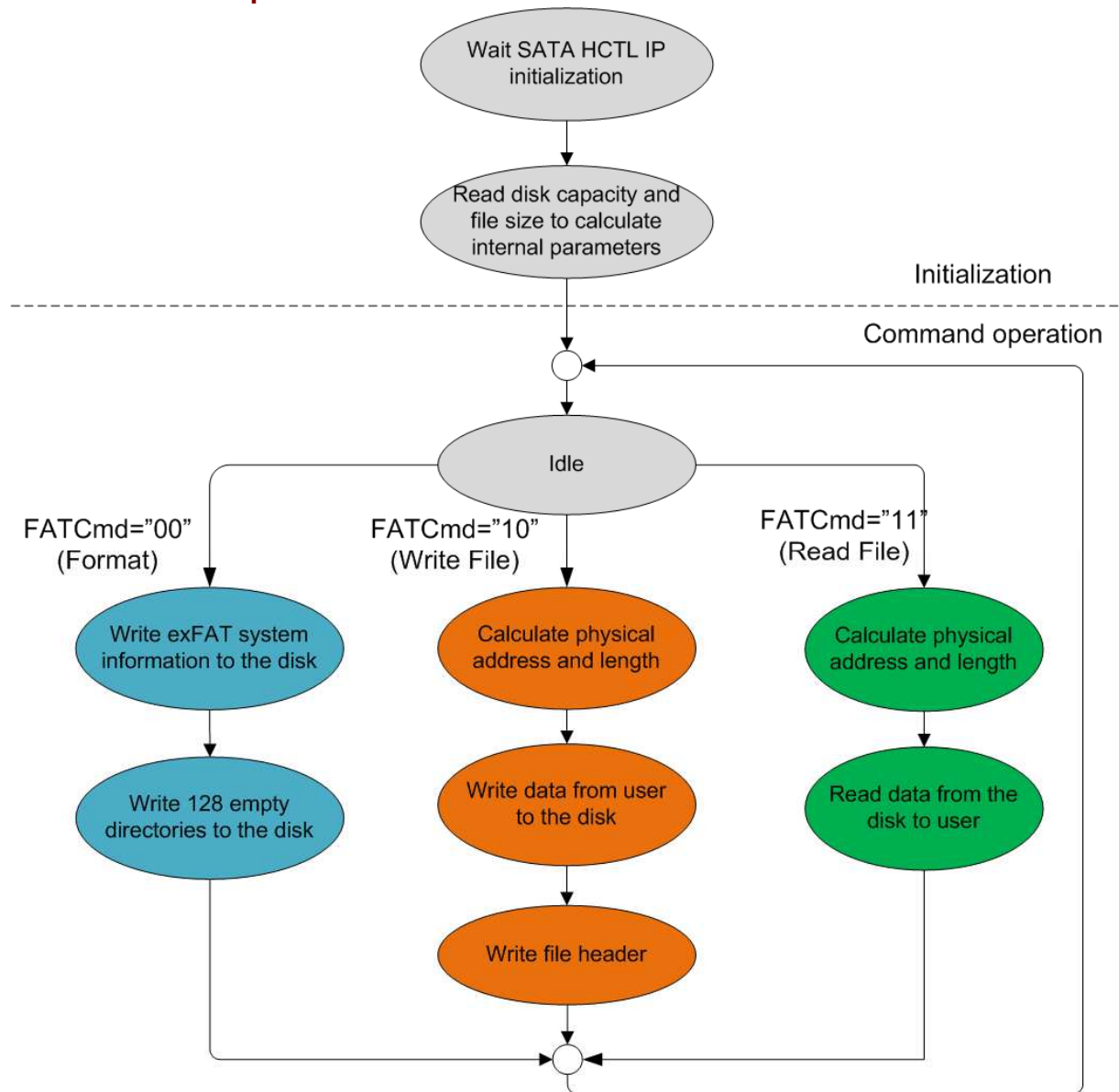


Figure 2: exFAT IP for SATA Operation

The sequence of exFAT IP Core for SATA operation is as follows:

- 1) exFAT IP waits SATA HCTL IP to complete SATA device initialization.
- 2) exFAT IP sends Identify device command to SATA HCTL IP to get disk capacity. File size (input from user) and disk capacity (input from SATA HCTL IP) are applied to calculate system parameters inside exFAT IP. Finally, exFAT IP is ready to receive new command from user. Three commands are supported, i.e. Format, Write file, and Read file. Format command is the first command which must be used when connecting new SATA device to the system.
- 3)
 - a. For the new disk, Format command must be run to clean up the disk, set up file system, and create 128 empty directories. Otherwise, Format command must be applied when file size from user is changed which is effect to other system parameters. So, all files in one disk must have the same size.
 - b. When user selects Write file command, the start file name and numbers of file (inputs from user) are received from user. File name and numbers of file are converted to be physical address and total length which are the input parameters for SATA HCTL IP. After that, exFAT IP sends Write commands to SATA HCTL IP. Next, Data from user is forwarded to SATA HCTL IP until complete to transfer total data. Finally, exFAT-IP writes file header to link user data to each file name.

Note:

- File header is filled to the disk as the final step. If system is powered down during writing file command, the file will be lost or corrupt.
 - There is no protection in the logic when some user inputs are out-of-range. User logic needs to send only valid input to exFAT IP.
- c. Similar to Write file command, the 1st process of Read file command is to calculate start physical address and total length to send to SATA HCTL IP. exFAT IP sends Read commands to SATA HCTL IP. Data is returned from SATA HCTL IP to user until complete to transfer total data.

exFAT IP for SATA

As shown in Figure 1, there are three submodules inside the IP, i.e. Command processor, Data Controller, and exFAT RAM. Command processor controls command interface of user logic and SATA HCTL IP while Data controller controls data interface of user logic and SATA HCTL IP. exFAT RAM stores internal file parameters transferring between Command processor and Data controller. More details of each submodule are described as follows.

- **Command processor**

This module includes state machine to control the sequence to operate user command, following in Figure 2. Otherwise, many calculation units are included to convert file parameters from user to be physical parameters for SATA HCTL IP. Most file parameters depend on File size and disk capacity.

- **exFAT RAM**

This RAM is implemented by BlockRAM to store file system data. RAM size is 3072x32-bit. 3072 depth is designed by using two RAMs (one is 2048 depth and another is 1024 depth).

- **Data Controller**

Data transferring with SATA HCTL IP is split into three types, i.e. raw data, file system data, and file parameters. The source and destination of raw data is FIFO interface of user logic. Most file system data is stored in exFAT RAM. File parameters are calculated and latched within the logic of the IP.

DG SATA HCTL IP and DG SATA IP

exFATIP for SATA is the top-up module of DG SATA HCTL IP. So, the system needs to include DG SATA HCTL IP and DG SATA IP to control SATA device. More details of SATA HCTL IP and SATA IP are described in datasheet which can be download from following link.

https://dgway.com/products/IP/SATA-IP/dg_sata_hctl_ip_data_sheet_en.pdf

https://dgway.com/products/IP/SATA-IP/dg_sata_ip_data_sheet_7series_en.pdf

User Logic

This module could be designed by using small state machine to send command and input parameters to exFAT IP. Two FIFOs are used to store data to write and read with exFAT IP. exFAT IP reference design is designed to receive input parameters from user through Serial console. So, CPU with simple firmware is designed instead of using small state machine to set input parameters as constant value.

Core I/O Signals

Descriptions of all signal I/O are provided in Table 5.

Table 5: Core I/O Signals

Signal	Dir	Description
System signal		
RstB	In	Synchronous reset signal. Active low. Deassert to '1' after Clk signal is stable.
Clk	In	User clock. Must use the same clock as Clk input of SATA HCTL IP. (At least 150 MHz for SATA3 or at least 75 MHz for SATA2)
FSize[2:0]	In	File size: "000": 32MB, "001": 128MB, "010": 512MB, "011": 2GB, "100": 8GB, "101": 32GB, "110": 128GB, "111": 512GB Note: 1) 1 MB is 1024x1024 byte, 1 GB is 1024x1024x1024 byte 2) FSize must be fixed value after Format command. Format command is required when FSize value is changed.
User Interface (Command)		
UserCmd[1:0]	In	User Command. "00": Format command, "01" Reserved, "10": Write file, "11": Read file.
UserFName[26:0]	In	Start file name to write/read file (0="0000000.BIN", 1="0000001.BIN", ...). Valid from 0 to TotalFCap - 1. This input is not used in Format command. In Write file command, this value must be equal 0 for empty disk or equal to the last file name + 1 for non-empty disk (continue to write the next file from previous write).
UserFLen[26:0]	In	Total files transferring in the request. Valid from 1 to (TotalFCap – UserFName). This input is not used in Format command.
UserReq	In	Assert to '1' to send new command request with the valid value on UserCmd, UserFName, UserFLen, FDateYMD, and FTimeHMS. This signal could be asserted to '1' when the IP is Idle only (UserBusy='0').
UserBusy	Out	Assert to '1' when IP is busy.
TotalFCap[26:0]	Out	Maximum files to store in SATA device. This value is valid after exFAT IP completes initialization process (UserBusy='0').
DirCap[21:0]	Out	Maximum files to store in one directory. This value is valid after exFAT IP completes initialization process (UserBusy='0').
FDateY[6:0]	In	Year in created date, count from 1980 (For example, FDateY=39 is year 2019). This input is used to be created time of directory in Format command and created time of file in Write file command.
FDateM[3:0]	In	Month in created date. Valid from 1-12 (1=Jan, 2= Feb, ...). This input is used to be created time of directory in Format command and created time of file in Write file command.
FDateD[4:0]	In	Day in created date. Valid from 1-31. This input is used to be created time of directory in Format command and created time of file in Write file command.
FTimeH[4:0]	In	Hour in created time. Valid from 0-23. This input is used to be created time of directory in Format command and created time of file in Write file command.
FTimeM[5:0]	In	Minute in created time. Valid from 0-59. This input is used to be created time of directory in Format command and created time of file in Write file command.

exFAT IP Core for SATA

Signal	Dir	Description
User Interface (Command)		
FTimeS[4:0]	In	x2 sec in created time. Valid from 0-29 (1=2, 2=4, ...). This input is used to be created time of directory in Format command and created time of file in Write file command.
UserError	Out	Error flag. Assert to '1' when UserErrorType is not equal to 0. The flag is cleared to '0' by asserting RstB signal to SATA HCTL IP and exFAT IP.
UserErrorType[31:0]	Out	[15:0] - Direct mapped to SATAErrorType signal of SATA HCTL IP. Please see more details in SATA HCTL IP datasheet. [24] - Error when disk capacity is more than or equal to 64 PetaByte.
IPVesion[31:0]	Out	IP version number
TesPin[63:0]	Out	Reserved to be IP test point.
User Interface (Data)		
UserFifoWrCnt[15:0]	In	Write data counter of Rx FIFO. Used to check full status. If total FIFO size is less than 16-bit, please fill '1' to upper bit. UserFifoWrEn could be asserted to '1' when UserFifoWrCnt[15:3] is not equal to all 1.
UserFifoWrEn	Out	Asserted to '1' to write data to Rx FIFO when read file command is operated and receive data from SATA HCTL IP.
UserFifoWrData[31:0]	Out	Write data bus of Rx FIFO. Valid when UserFifoWrEn='1'.
UserFifoRdCnt[15:0]	In	This signal is unused for this IP.
UserFifoEmpty	In	FIFO empty flag of Tx FIFO to check data available status. This signal is de-asserted to '0' when Tx FIFO has the data during running write file command.
UserFifoRdEn	Out	Asserted to '1' to read data from Tx FIFO when UserFifoEmpty='0' and SATA HCTL IP sends read enable to exFAT IP.
UserFifoRdData[31:0]	In	Read data returned from Tx FIFO. Valid in the next clock after UserFifoRdEn is asserted to '1'.
SATA HCTL IP User Interface (Connect to dgIF typeS of SATA HCTL IP) (Please see more details from SATA HCTL IP datasheet)		
SATACmd[1:0]	Out	Connect to UserCmd of SATA HCTL IP
SATAAddr[47:0]	Out	Connect to UserAddr of SATA HCTL IP
SATALen[47:0]	Out	Connect to UserLen of SATA HCTL IP
SATAREq	Out	Connect to UserReq of SATA HCTL IP
SATABusy	In	Connect to UserBusy of SATA HCTL IP
SATALBASize[47:0]	In	Connect to LBASize of SATA HCTL IP
SATAError	In	Connect to UserError of SATA HCTL IP
SATAErrorType[31:0]	In	Connect to UserErrorType of SATA HCTL IP
SATAFifoWrCnt[15:0]	Out	Connect to UserFifoWrCnt of SATA HCTL IP
SATAFifoWrEn	In	Connect to UserFifoWrEn of SATA HCTL IP
SATAFifoWrData[31:0]	In	Connect to UserFifoWrData of SATA HCTL IP
SATAFifoRdCnt[15:0]	Out	Connect to UserFifoRdCnt of SATA HCTL IP
SATAFifoEmpty	Out	Connect to UserFifoEmpty of SATA HCTL IP
SATAFifoRdEn	In	Connect to UserFifoRdEn of SATA HCTL IP
SATAFifoRdData[31:0]	Out	Connect to UserFifoRdData of SATA HCTL IP

Timing Diagram

Initialization

The sequence of the initialization process is as follows.

- 1) RstB is released to '1' by user after Clk is stable.
- 2) exFAT IP starts initialization process by sending Identify device command to SATA HCTL IP.
- 3) UserBusy is deasserted to '0' after exFAT IP receives Identify device data from SATA HCTL IP completely. After that, TotalFCap to show maximum files to store in the disk is valid to read.

After complete above sequence, exFAT IP is ready to receive the command from user.

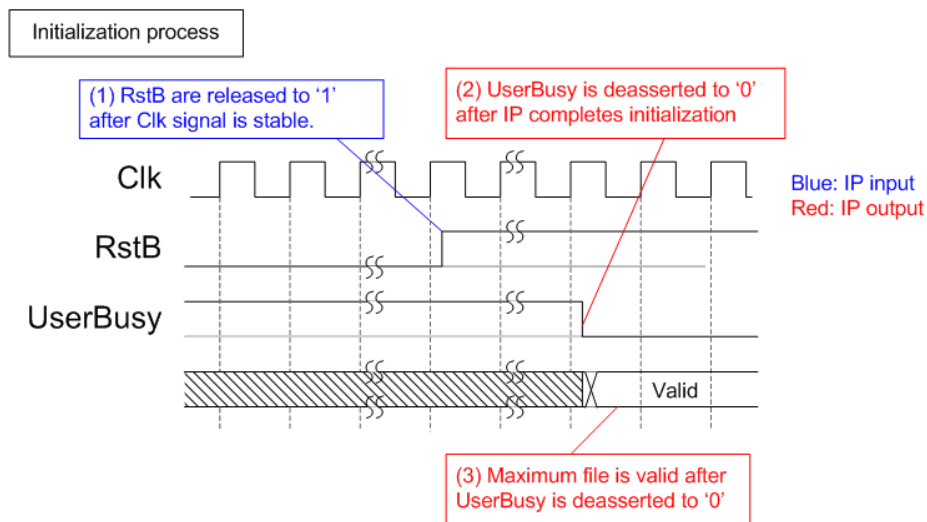


Figure 3: exFAT-IP for SATA Initialization

User Interface

User interface is split into two interfaces, i.e. command interface and data interface. Figure 4 shows timing diagram of command interface as file parameters instead of physical parameters like user interface of SATA HCTL IP. Before sending new command to exFAT IP, UserBusy must be monitored to confirm that IP is Idle. Command parameters (UserCmd, UserFName, UserFLen, FDateYMD, and FTimeHMS) must be valid and stable during asserting UserReq='1'. After receiving new request from user, UserBusy changes status from '0' to '1'. In the next clock, UserReq is de-asserted to '0'. After that, user logic can prepare the parameters for the next command on the bus without asserting UserReq.

Note: 1) UserFName and UserFLen input are ignored in Format command.
2) FDateYMD and FTimeHMS are ignored in Read file command.

For data interface, TxFIFO (Transmit FIFO) is read in Write file command and Rx FIFO (Received FIFO) is written in Read file command. Timing diagram of data interface is same as SATA HCTL IP timing diagram, as shown in Figure 5 and Figure 6.

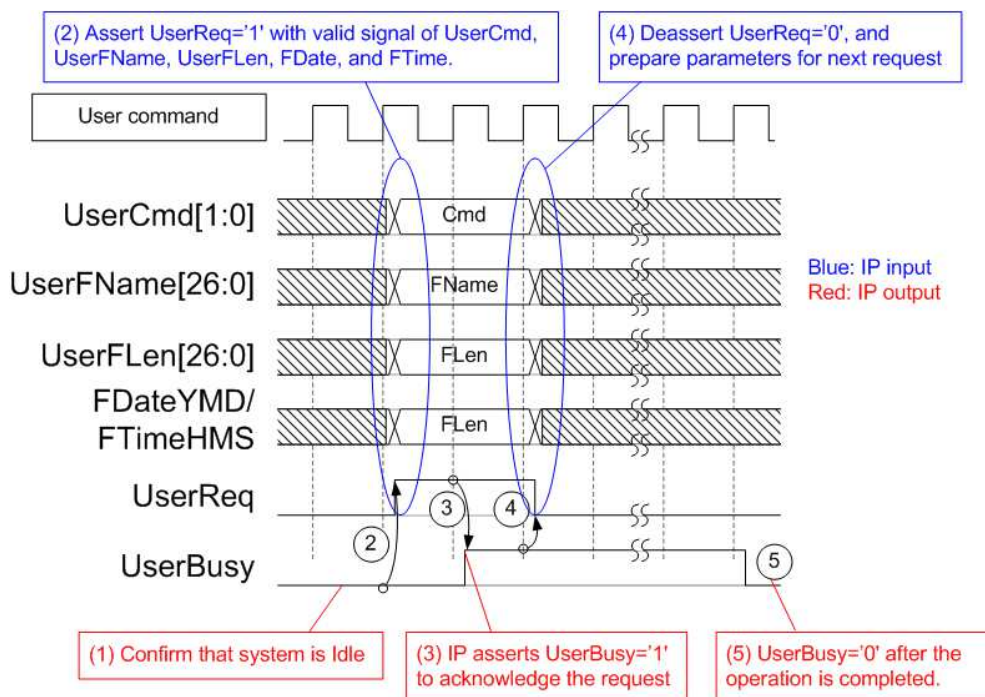


Figure 4: Command User Interface Timing diagram

For Write file command, UserFifoEmpty is monitored to check data available status of Tx FIFO. When data is ready (UserFifoEmpty='0'), UserFifoRdEn could be asserted to '1'. In the next clock, UserFifoRdData output from Tx FIFO is valid for forwarding to SATA HCTL IP. After total data are transferred to SATA HCTL IP, UserFifoRdEn is de-asserted to '0'.

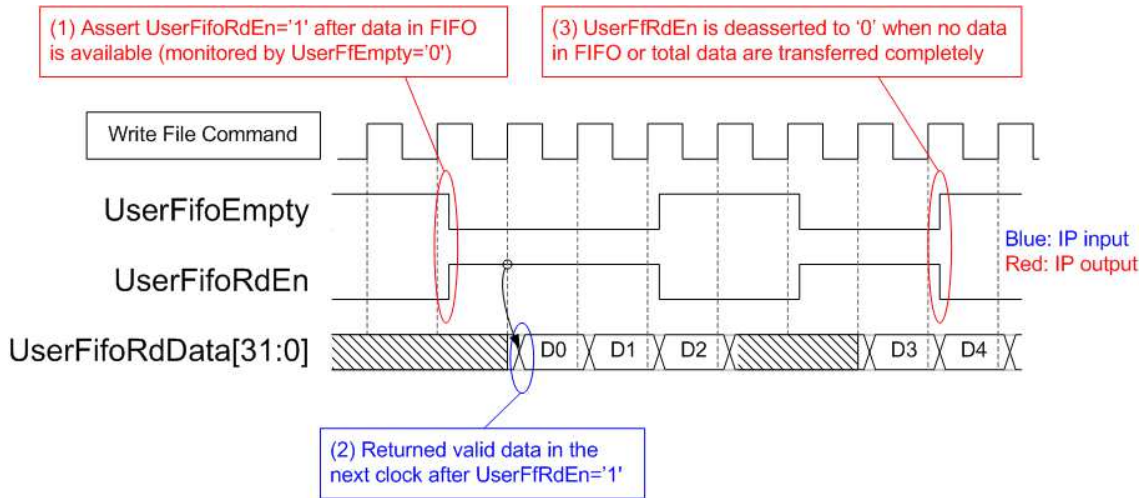


Figure 5: TX FIFO Interface for Write file command

For Read file command, UserFifoWrEn is asserted to '1' with the valid value of UserFifoWrData to send data to Rx FIFO. Before asserting UserFifoWrEn, UserFifoWrCnt is monitored to check free space size of Rx FIFO. Data is transferred when free space in Rx FIFO is more than 7 (UserFfWrCnt is less than 65528). UserFifoWrEn is deasserted to '0' to pause data transferring when free space size is too less or total data are transferred completely, as shown in Figure 6.

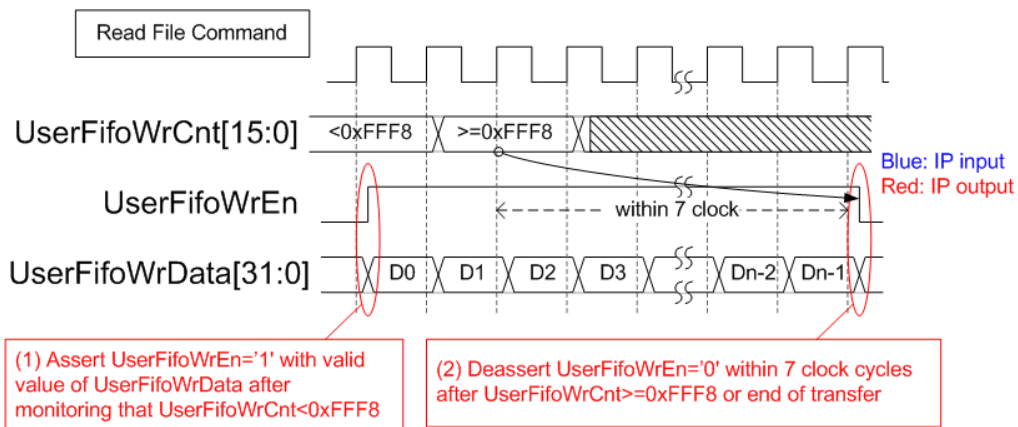


Figure 6: RX FIFO Interface for Read file command

Error

When SATA HCTL IP detects abnormal situation or exFAT IP detects too much disk capacity, UserError is asserted to '1'. The error status is shown in UserErrorType. To clear Error flag, user needs to send reset signal (RstB='0') to exFAT IP and HCTL IP.

After complete above sequence, exFAT IP is ready to receive the command from user.

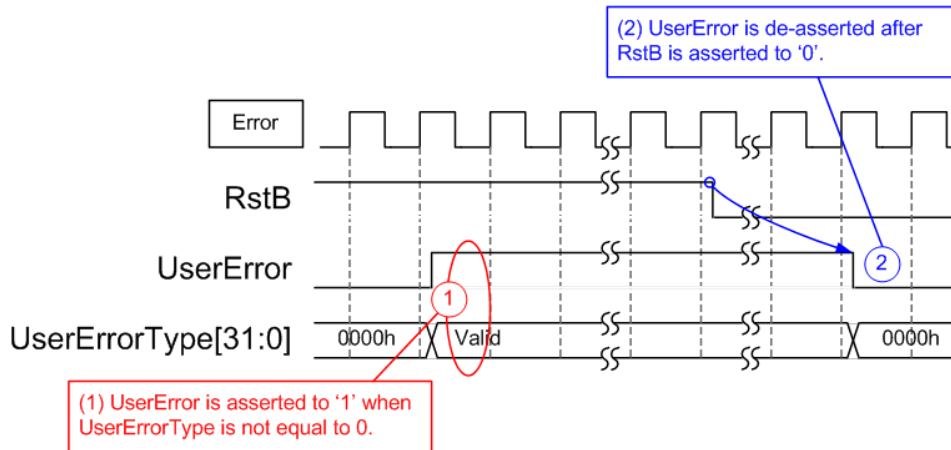


Figure 7: Error flag timing diagram

Example usage

The example sequence to use exFAT IP for SATA to write or read file with SATA device is shown as follows.

- 1) De-assert RstB to '1' to start system initialization. Wait until UserBusy='0'.
- 2) Skip to the next step when the disk does not need to format. Format command must be run when some following conditions are found.
 - a) The disk is new and not formatted by exFAT IP for SATA.
 - b) User needs to delete file in the disk.
 - c) User needs to change FSize (File size) parameter.

Following is the step to operate Format command.

- a) Set value to FDateYMD and FTimeHMS to specify Created date and Created time of 128 empty directories (DIR00 – DIR7F) which are created by Format command operation.
- b) Assert UserReq to '1' and set UserCmd="00". Wait until UserBusy changes from '0' to '1' as acknowledge for Format command. Then, de-assert UserReq to '0' in the next clock.
- c) Wait until exFAT IP operation is completed by monitoring UserBusy='0'.

As a result, DIR00 – DIR7F as empty directory are created in the disk.

- 3) Send Write file command (UserCmd="10") or Read file command (UserCmd="11") to SATA HCTL IP. The sequence of Write file and Read file command are as follows.

In case of Write file command

- a) Set FDateYMD and FTimeHMS to specify Created date and Created time of new file.
- b) Set UserFName to be equal to the next value of the latest write file. For example, if the latest write file in the disk is 0000019.BIN, UserFName will be set to 0x000001A.
- c) Set UserFLen as valid value (less than or equal to <TotalFCap – UserFName>), and then asserts UserReq='1'. Wait until UserBusy='1' and de-asserts UserReq to '0' in the next clock.
- d) Send data to exFAT IP through Tx FIFO interface. Total data size is equal to Total write files (UserFLen) x File size (FSize). UserFifoEmpty must be equal to '0' to allow exFAT IP reading data.
- e) Wait until exFAT IP operation complete by monitoring UserBusy='0'.

In case of Read file command

- a) Set UserFName and UserFLen to read the file from the disk. The sum of UserFname and UserFLen must not be more than TotalFCap.
- b) Asserts UserReq='1' to send Read file command to exFAT IP. Wait until UserBusy='1' and de-asserts UserReq to '0' in the next clock.
- c) Read total data from RxFIFO. When UserFifoWrCnt[15:3] is not equal to '1', write enable of RxFIFO could be asserted to write data by exFAT IP. Total data size is equal to Total read files (UserFLen) x File size (FSize).
- d) Wait until exFAT IP operation complete by monitoring UserBusy='0'.

Limitation

- (1) exFAT IP writes or reads file from the disk when the disk is formatted and the file is written by exFAT IP only. If not, the disk must be formatted by exFAT IP before connecting to exFAT IP. Other host system allows to access the disk as read-only mode.
- (2) File size (FSize) input to exFAT IP must be fixed after Format command. All files in one disk written by exFAT IP have the same size following FSize value. To change FSize value, the disk must be formatted. Also, maximum files stored in one disk (TotalFCap) depends on FSize value.
- (3) As shown in Table 4, one directory has limitation of number of file to store, depending on device capacity. The relation of filename and directory name which stores the file is as follows.
 DIR Name = (<FileName>/DirCap) – 1
 Assumed that device capacity is 200 GB, DirCap (the maximum file in one directory) is equal to 4096.
 0000000.BIN – 00000FFF.BIN are stored to DIR00.
 0001000.BIN – 00001FFF.BIN are stored to DIR01.
 0002000.BIN – 00002FFF.BIN are stored to DIR02.
 0003000.BIN – 00003FFF.BIN are stored to DIR03.
 DIR04 – DIR7F are empty directories.
- (4) In Write file command, UserFName value must be the next value from the latest write file name. The example of correct parameter is shown in Figure 8.
 Assumed that, the 1st write file operation sends command to write 0000000.BIN and 0000001.BIN.
 The next write file to continue filename is 0000002.BIN. So, the next write file command must set UserFName=2.
 The example to set the wrong value of UserFName is shown in Figure 9 - Figure 10.

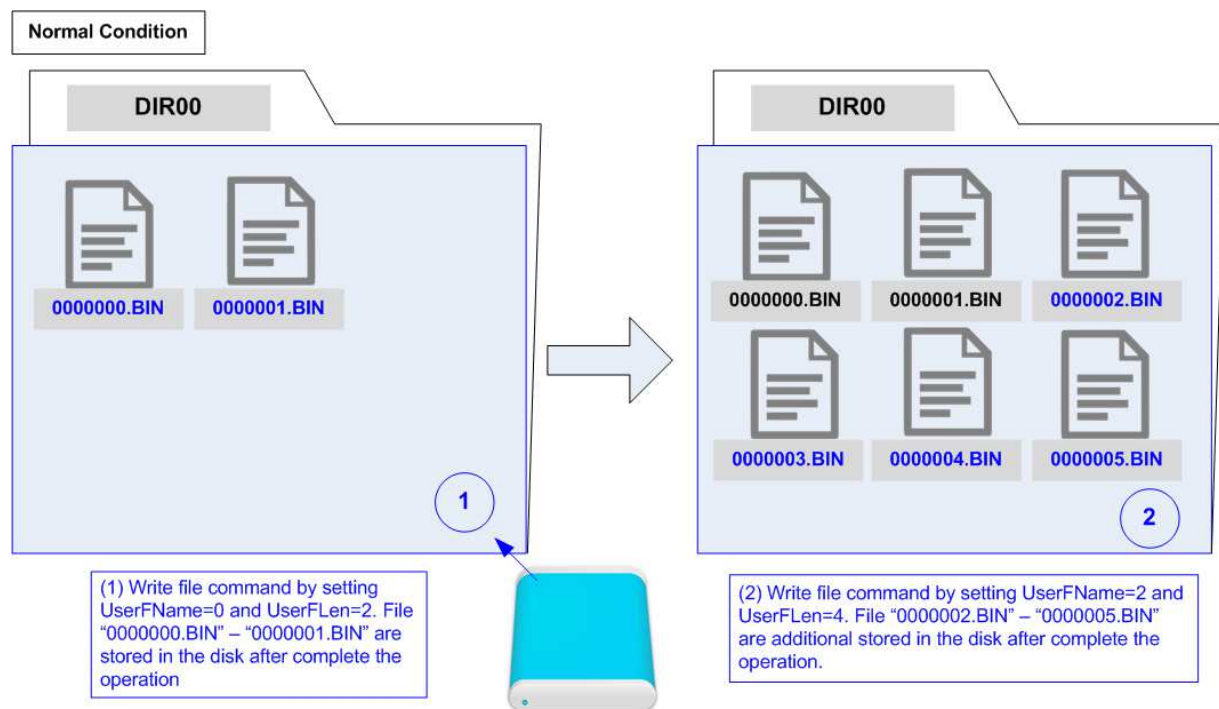


Figure 8: Write file command in normal condition

- a) When UserFName is more than (the latest write file name + 1), there are three results which could be possible, i.e.
- (i) Dummy file is created between the latest write file and the new file, as shown in (2a) of Figure 9. File 0000002.BIN is dummy file which consists of random data is generated when UserFName input is equal to 3 instead of 2 which is correct value.
 - (ii) No file is additional created, as shown in (2b) of Figure 9. If UserFName input is much skipped than correct value, there is no additional file created. For example, UserFName is equal to 8 instead of 2 which is correct value.
 - (iii) No dummy file is created and new file is created correctly. If UserFName is not correct but meet some special conditions, the file in directory will be found as normal operation.

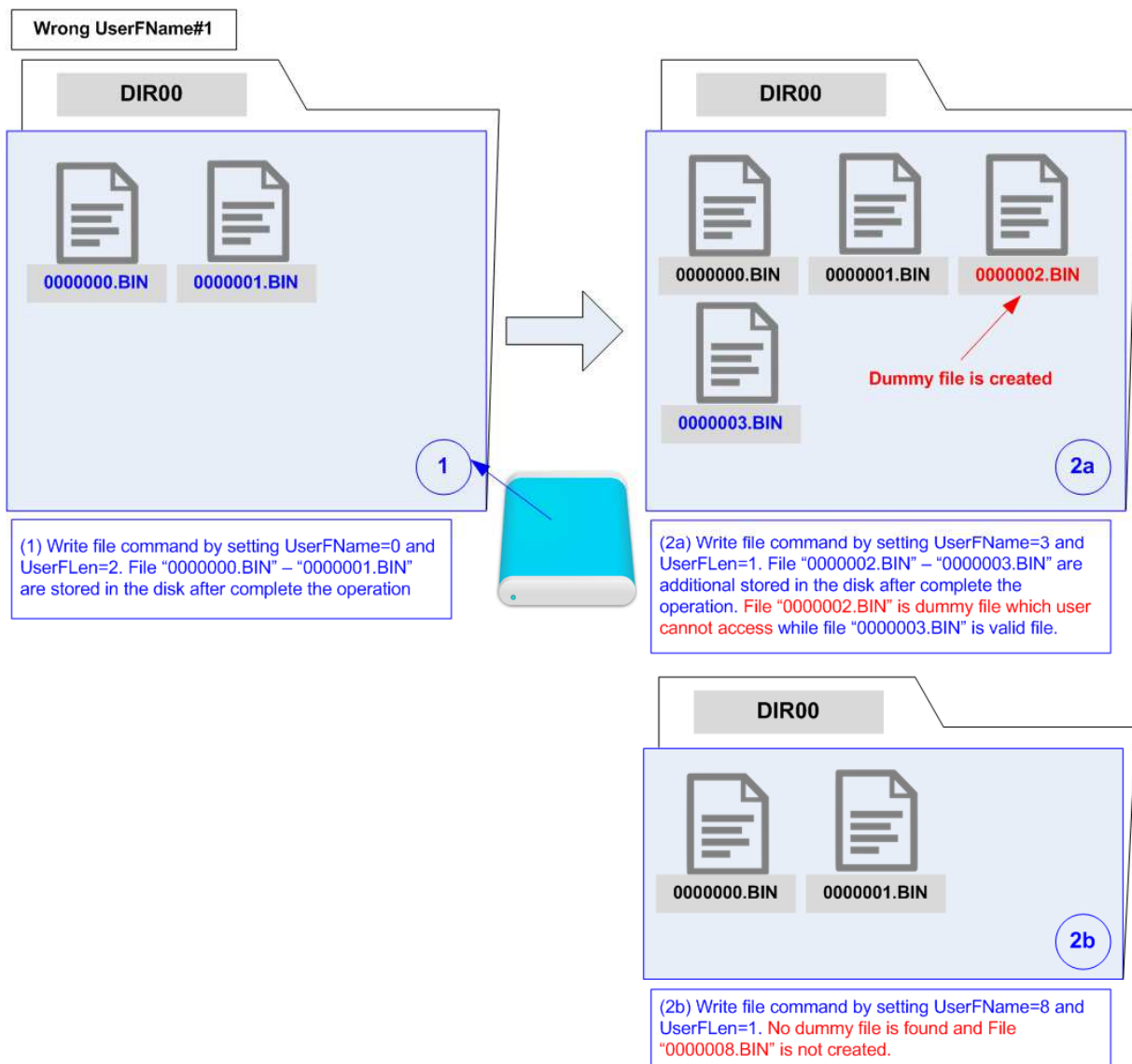


Figure 9: Write file command but UserFName is more than normal value

- b) When UserFName is less than (the latest write file name + 1), some old files which are more than UserFName may be deleted, as shown in Figure 10.
Assumed that, the 1st write file operation sends command to write 0000000.BIN – 0000003.BIN.
UserFName in the next write is equal to 2 and UserFLen is equal to 1. As a result, 0000002.BIN is created by the new data and 0000003.BIN is lost.

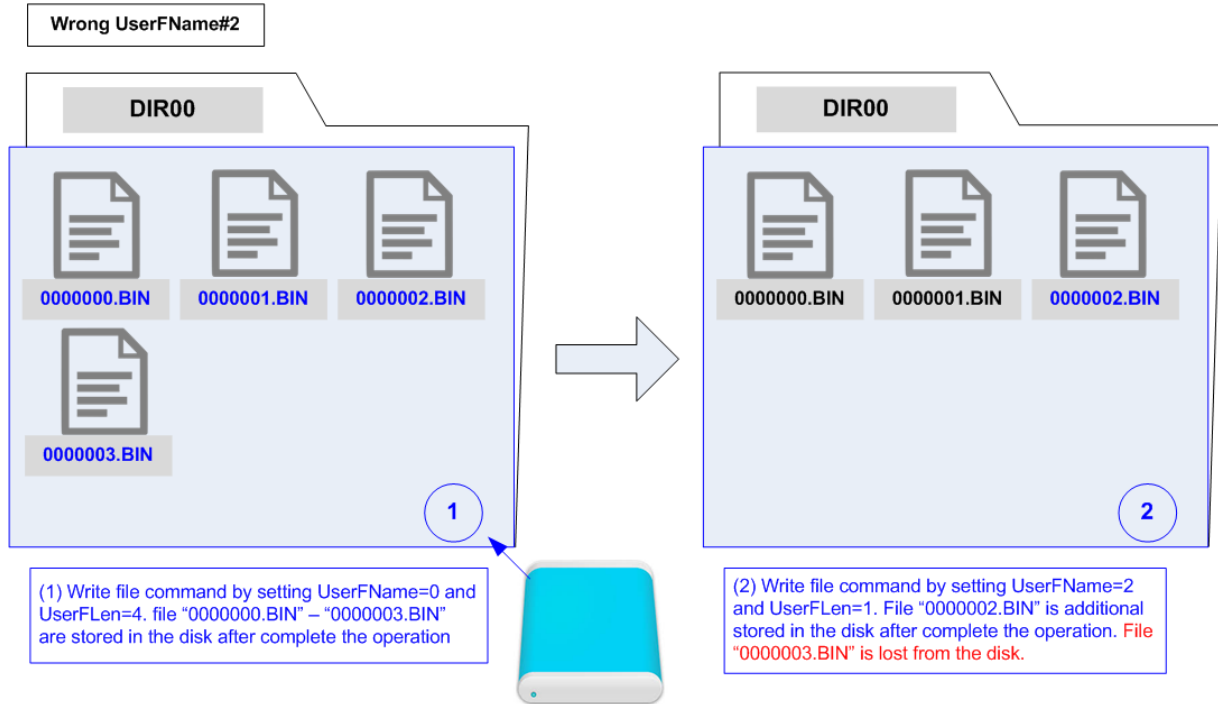


Figure 10: Write file command but UserFName is less than normal value

Verification Methods

The exFAT-IP Core for SATA functionality was verified by simulation and also proved on real board design by using ZC706 board.

Recommended Design Experience

Experience design engineers with a knowledge of Vivado Tools should easily integrate this IP into their design.

Ordering Information

This product is available directly from Design Gateway Co., Ltd. Please contact Design Gateway Co., Ltd. for pricing and additional information about this product using the contact information on the front page of this datasheet.

Revision History

Revision	Date	Description
1.0	Nov-19-2018	Initial Release