

FAT32-IP for NVMe (PCIe Gen4) Demo Instruction

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1 Introduction

This guide provides instructions for running the FAT32-IP for NVMe (PCIe Gen4) demo on an FPGA development board to access an NVMe Gen4 SSD with FAT32 file system functionality. The demo supports for Format, Write file, Read file, and Shutdown, allowing users to control test operations through the FPGA console.

To get started, please follow the instructions outlined in the "dg_nvmeip_fpgasetup" document to set up the FPGA board and the test system. The document is available at the following link. <u>https://dgway.com/products/IP/NVMe-IP/dg_nvmeip_fpgasetup_xilinx_en/</u>

Once the setup process is completed, the SSD initialization is triggered. The default configuration is displayed, giving the option for the user to proceed with the default configuration or change it.

	Iser input
	 User output
+++ FAT32-IP for NVMe Test design [IPVer = 2.1]	***
> NUMeG4IP [IPUer = 2.1] +++	nitialization
Waiting IP initialization n	nessage
IP initialization complete	
	fault value of
TTT WARNING TTT	nfiguration
	nter 'y' to confirm change file size
Enter file size [0] : 32 MB [1] : 64 MB [2] : 128 MB [3] : 256 MB [4] : 512 MB [5] : 1024 MB [6] : 2048 MB => 3	
Current file size : 256 [MB] file configuration	
Press 'y' to confirm Format => y Format operation Format complete	
Message after Format operation is completed[0] : Format[1] : Write File [2] : Read File [3] : Shutdown	
Figure 1-1 The initialization using the modified file of	onfiguration

Figure 1-1 illustrates an example of the test system booting up with the selection to update the file configuration to a new value. If the file size is modified or if the test SSD is a new device that has never been formatted by FAT32-IP, the next step is to enable the Format operation by entering 'y' to confirm the operation. Alternatively, the user can execute the Format operation by selecting option '0' from the main menu.



• : User input Iser output +++ FAT32-IP for NUMe Test design [IPVer = 2.1] +++ > NUMeG4IP [IPUer = 2.1] +++ Waiting IP initialization IP initialization complete >Current file size : 32 [MB] >Maximum file in disk : 29799 files *** WARNING *** To change file size, Format must be run Press 'y' to confirm change file size => n-Enter other key ('n') to use default file configuration >Current file size : 32 [MB] >Maximum file in disk : 29799 files Input other key ('n') to Press 'y' to confirm Format Cancel Format => nskip format operation Main menu ---[0] : Format [1] : Write File [2] : Read File Main menu to select the command [3] : Shutdown

Figure 1-2 The initialization using the default file configuration without Format operation

Figure 1-2 illustrates an example of test system booting up with the default file configuration. In this scenario, it is assumed that the test SSD is a device that has been previously formatted by FAT32-IP using the same file configuration (File size = 32 MB). Consequently, there is no need for the Format command and the user enters any key other than 'y' for both inputs.

2 Test Menu

2.1 Format

Select '0' from the main menu to initiate the Format command of FAT32-IP. The Format command is required under the following conditions.

- 1) The device has never been previously formatted by FAT32-IP.
- 2) The user needs to delete all files stored on the SSD.
- 3) The user needs to modify the file size on the SSD.

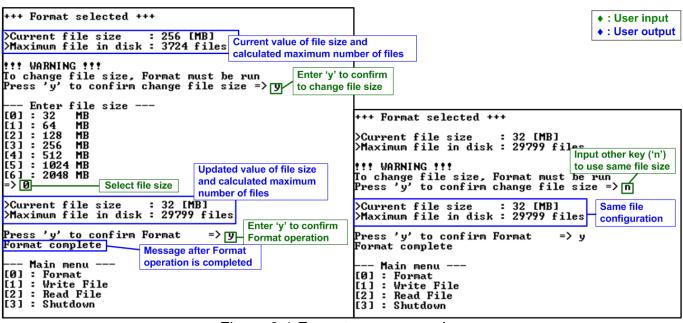


Figure 2-1 Format menu operation

Upon selecting this menu option, the current file configuration, including file size and maximum number of files, will be displayed on the console. The user can enter 'y' to modify the file size, while entering any other key to keep the same file configuration.

If the user proceeds with changing the file size, all seven file sizes, ranging from 32 MB to 2048 MB, can be selected. Once a valid value is entered, the updated file configuration will be displayed to confirm the chosen size.

Next, a menu confirming the Format operation will appear. To execute the Format command, the user enters 'y'. Otherwise, the other key is entered to skip the Format command.

Upon completing all previous steps, the main menu will be displayed on the console.



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dg_fat32ip_nvmeg4_instruction_en.doc

2.2 Write File

Select '1' from the main menu to initiate the Write file command of FAT32-IP. The console will then display the default value of the created time of the file. The user can enter 'y' to change the time or any other key to use the default time.

Note: The default created time after system boot-up is 24 Sep 2018, 17:35:00.

	Write File with new created	d time	 : User input : User output
+++ Write File select	ed +++	Default creat	ed time
Current time created	: 24/09/2018, 17:35:00		change time
Press 'y' to change t Year (1980 - 2107)	ime created $=$ y		
Year (1980 - 2107) Invalid input : Param		s	et time created
Month (1 - 12)	=> 2	Enter	r invalid value
Date (1 - 31)	=> 14 Change		same value)
Hour (0 - 23) Minute (0 - 59)	=> 14 — Month/Dat => 14 Hour/Min/3		
Second 2-Sec unit (0		Jec	
Date and Time Changed		Updated crea	ated time
Current time created	: 14/02/2018, 14:14:28		Input
Input NUM of file Selected Pattern [0]I File size = 32 [MB], 6.932 [GB] 13.894 [GB] 20.819 [GB] 27.780 [GB]	(0x0000000 - 0x0007466) (0x0000001 - 0x0007467) nc32 [1]Dec32 [2]All_0 NUM of file = 2048[File	=> <mark>0x800_</mark> [3]All_1 [4], Total si:	parameters
			<u> </u>
[otal = 68.719 [GB]	, Time = 9899[ms] , Tra	nsfer speed	= 6941[MB/s]
Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown			

Figure 2-2 Result from Write File menu with modified created time

Figure 2-2 provides an example of executing the Write File menu with a new created time of file. All written files in this command will have the same created time as set in this step. The following six values are required for setting the created time.

- a) Date: Enter the created date as a decimal unit. The valid range is 1 31.
- b) Month: Enter the created month as a decimal unit. The valid range is 1 12.
- c) Year: Enter the created year as a decimal unit. The valid range is 1980 2107.
- d) Hour: Enter the created hour as a decimal unit. The valid range is 0 23.
- e) Minute: Enter the created minute as a decimal unit. The valid range is 0 59.
- f) Second: Enter the created x2 seconds as a decimal unit. The valid range is 0 29. The created second is equal to the input value multiplied by 2.

If an input value is invalid, the corresponding parameter value will not change. Parameter is updated when the input is set in valid range. After receiving all the values, the console displays the new created time.



Next, the menu to receive user parameters for Write file commands are displayed. Three parameters are required, as described below.

- 1) Start file No: Input the number of the first file name. The input is a decimal unit when the user enters only a digit number. The user can add "0x" to be prefix for hexadecimal unit.
- 2) NUM of file: Input the total number of written files. The input is a decimal unit when the user enters only a digit number. The user can add "0x" to be prefix for hexadecimal unit.
- 3) Test pattern: Select the test data pattern of the written file. There are five patterns available: 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.

Once all valid inputs are set, the console will display the file size, the number of written files, and the total transfer size. The operation will then start. During the operation, the current amount of write data is displayed on the console every second to indicate that the system is functioning. Finally, total size, total time usage, and transfer performance are displayed on the console upon completion of the operation. As a result of this operation, the SSD will contain the new written files. The first file name will be FILE<Value of Start file No>.BIN and the last file name is FILE<Value of Start file No + NUM of file - 1>.BIN.

	 ◆ : User input ◆ : User output 							
Write File with default created time	• . User output							
+++ Write File selected +++								
Current time created : 14/02/2018, 14:14:28 Press 'y' to change time created => n Enter other k (use same va Input Start file No. (0x0000000 - 0x0007466) => 0x800 Input NUM of file (0x0000001 - 0x0006C67) => 0x800 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4] File size = 32 [MB], NUM of file = 2048[File], Total siz 6.961 [GB] 13.850 [GB] 20.805 [GB] 27.763 [GB] 24.722 [GB] 41.644 [GB] 48.604 [GB] 55.561 [GB] 62.450 [GB]	ILFSR=> 0							
<pre>Iotal = 68.719 [GB] , Time = 9904[ms] , Transfer speed = 6938[MB/s]</pre>								
Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown								

Figure 2-3 Result from Write File menu with default created time

Figure 2-3 provides an example of executing the Write File menu using the default created time of file. In this scenario, to continue the previous Write file command, the "Start file No." is configured to be the next value from the previous command, which creates FILE0000.BIN – FILE07FF.BIN. Therefore, the "Start file No" is set to 0x800 (0x7FF + 1). The new written files after completing the new command will be FILE0800.BIN - FILE0FFF.BIN, all with the same created time (14-Feb-2018, 14:14:28).



Drive name = DG_FA	AT32						
→ This PC → DG_FAT32 (E:)	✓ ♂ Search DG_F	AT32 (E:)	File size = 32 MB				
The 1 st File name = FILE0000.BIN	Date modified	Туре	Size ^				
FILE0000.BIN	2/14/2018 2:14 PM	BIN File	32,768 KB				
FILE000A.BIN	2/14/2018 2:14 PM	BIN File	32,768 KB				
FILE000B.BIN	Modified Date = Created	Time in an	example 32,768 KB				
FILE000C.BIN	2/14/2018 2:14 PM	BIN File	32,768 KB				
FILE000D.BIN	2/14/2018 2:14 PM	BIN File	32,768 KB				
FILE000E.BIN	2/14/2018 2:14 PM	BIN File	32,768 KB				
FILE000F.BIN	2/14/2018 2:14 PM	BIN File	32,768 KB				
FILE00A0.BIN	2/14/2018 2:14 PM	BIN File	32,768 KB				
Figure 2-4 Example test files written by Write File command							

Figure 2-4 illustrates an example result when the test SSD is connected to other host systems running the Windows 10 OS. The drive name is "DG_FAT32", and FILE0000.BIN – FILE0FFF.BIN are stored in the drive. The created time of all files is 14-Feb-2018, 2.14 PM.

<u>Note</u>: When connecting the SSD to other host system, please be caution and ensure that the device is not written or modified. Only read operation is allowed. If any modifications are done by other host systems, the SSD must be reformatted by FAT32-IP when reconnected to the FAT32-IP system.



•	Test o	lata of 3	3 2- bi	t inc	reme	ent p	atte	rn—					•	-				Test	t da1	ta of	f 32-b	oit LF	SR	pati	ern				-
	♣64-bit head	der of ea	nch 5'	12-by	/te-									4-6 4	4-bit	hea	der o	of ead	ch 5'	12-b	yte-								
	t unique value e x File size) +		0x0	0000	000		(data crem	ent)			32-	bit u	nique	e valu	ue O	x 000	0000	00			(st dat it LF			
Offset	0 1 2	3 4	1 5	6	7	8	9	A	в	°c/	D	E	F	0	1	A 2	3	4	5	6	7	8	9	A	в	с	↓ 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	01	00	00	00	02	00	00	00
00000010	04 00 00	00 09	5 00	00	00	06	00	00	00	07	00	00	00				00			00					_		00		
00000020	08 00 00	00 09	9 00	00	00	OA	00	00	00	0B	00	00	00	49	00	00	00	92	00	00	00	24	01	00	00	49	02	00	00
00000030	OC 00 00	00 OI	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		00 11			00					13				24	49	00	00	49	92	00	00	92	24	01	00	24	49	02	00
00000050	14 00 00				00					17							00										92		
00000060		00 19			00					1B		00					00										24		
00000070		00 11			00	1E				1F							04						24				49		
00000080	20 00 00				00 00	22		00		23 27	00						49										9E		
00000090					00	26 2A				27 2B		00					92 24										E7 7A		
000000B0		00 21				2E		00			00						24 49										AE		
000000000					00	32		00			00						93					C1					EB		
000000000	34 00 00				00					37		00					3C										B8		
000000E0	38 00 00	00 39	9 00	00	00	ЗÀ	00	00	00	3B	00	00	00				CF										83		
000000F0	3C 00 00	00 31	00 (00	00	3E	00	00	00	ЗF	00	00	00	70	07	D7	F5	EO	0E	ΑE	EB	C1	1D	5C	D7	83	3B	B8	ΑE
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	00	46	00			47		00	00	73	70	07	D7	E6	E0	0E	ΑE	CD	C1	1D	5C	9A	83	3B	B8
00000120		00 49			00	4A				4B		00				77		68									39		
00000130	4C 00 00									4F							07										9A		
00000140		00 51			00	52				53							77										A3		
00000150	54 00 00				00	56				57		00					70										3A		
00000160 00000170	58 00 00 5C 00 00	00 53 00 51			00	5A 5E		00		5B		00					07										A6		
00000170		00 51			00	5£ 62				5r 63					40 C6		73 34										63 37		
00000190	64 00 00									67							34 47										70		
000001A0		00 69			00					6B							74										0D		
000001B0		00 61			00	6E				6F							4C										DO		
000001C0	70 00 00	00 71	00	00	00	72	00	00	00	73	00	00	00				C6										06		
000001D0	74 00 00	00 79	5 00	00	00	76	00	00	00	77	00	00	00				6E					ЗF	30	68	B8	7F	60	DO	70
000001E0	78 00 00	00 79	9 00	00	00	7A	00	00	00	7B	00	00	00	FF	CO	AO	E1	FF	81	41	C3	FE	03	83	86	FD	07	06	0D
000001F0	7C 00 00	00 71	00 (00	00					7F							1Å					E9	3F	30	68	D3	7F	60	DO
00000200	01 00 00									83							00					02	00	00	00	04	00	00	00
00000210	84 00 00				00					87							00										00		
00000220	88 00 00			00	00	8A	00	00	00	8B	00	00	00	92	00		00			00	00	49	02	00	00	92	04	00	00
	6	4-bit hea	der													6	4-bit	head	der										
	Figure 2)_5 E	von	nnl	<u>م T</u>	act	Чэ	ta	of	the	1	st 🧲	nd	ว ท	d 5	12	-h	/to	da	to	of	-11	FΛ	nn		ЯIN	i i		

Figure 2-5 Example Test data of the 1st and 2nd 512-byte data of FILE0000.BIN using incremental and LFSR pattern

Test data in FILE0000.BIN is divided into 512-byte units. For incremental, decremental, and LFSR patterns, each 512-byte data contains a unique 64-bit header. This header consists of a 32-bit unique value (determined by file name x file size + the 512-byte offset within the file) and a 32-bit zero value. The data following the 64-bit header is the test pattern selected by the user.

The left window of Figure 2-5 provides an example of the 32-bit incremental pattern, while the right window displays an example of the 32-bit LFSR pattern. When running all-0 or all-1 patterns, the unique header is not included in the data.



Figure 2-6 – Figure 2-8 show an example of the inputs that are out of the recommended range for each parameter. The console displays "Invalid input" and then the operation is cancelled.

+++ Write File selected +++ Current time created : 14/02/2018, 14:14:28 Press 'y' to change time created => n Input Start file No. (0x0000000 - 0x0007466) => 0x10000 Invalid input Error message --- Main menu ---



+++ Write File selected +++ Current time created : 14/02/2018, 14:14:28 Press 'y' to change time created => n Input Start file No. (0x0000000 - 0x0007466> => 0x1000 Input NUM of file (0x0000001 - 0x0006467> => 0 Invalid input Error message Out of range NUM of file ---- Main menu ---

Figure 2-7 Invalid Num of file input

+++ Write File selected +++ Current time created : 14/02/2018, 14:14:28 Press 'y' to change time created => n Input Start file No. (0x0000000 - 0x0007466) => 0x1000 Input NUM of file (0x0000001 - 0x0006467) => 0x400 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 5 Invalid input Error message --- Main menu ---

Figure 2-8 Invalid Test pattern input



2.3 Read File

Select '2' from the main menu to initiate the Read file command of FAT32-IP.

Read File	
<pre>+++ Read File selected +++ Input Start file No. (0x000000 - 0x0007466) => Input NUM of file (0x0000001 - 0x0007467) => Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3] File size = 32 [MB], NUM of file = 2048[File], 7.523 [GB] 15.048 [GB] 22.575 [GB] Current transfer size 52.532 [GB] 60.058 [GB] 67.584 [GB]</pre>	0x800 All_1 [4]LFSR=> <u>4</u> Total size = 68.719 [GB]
[] [] [] [] [] [] [] [] [] [] [] [] [] [Output performance er speed = 7509 [MB/s]
Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown	
gure 2-9 Result and input from Read File men	u with successful verification

Similar to the Write File menu, the Read file menu also requires three parameters, as described below.

- 1) Start file No: Input the number of the first file name. The input is a decimal unit when the user enters only a digit number. The user can add "0x" to be prefix for hexadecimal unit.
- 2) NUM of file: Input the total number of read files. The input is a decimal unit when the user enters only a digit number. The user can add "0x" to be prefix for hexadecimal unit.
- 3) Test pattern: Select the test data pattern to verify data of the read file. There are five patterns available: 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.

When all inputs are valid, the operation starts. During the operation, the current amount of read data is displayed on the console every second to indicate that the system is functioning. In the event of invalid input, "Invalid input" will be displayed instead. Once the operation is completed, the console will present the total size, total time usage, and test performance.

Figure 2-10 and Figure 2-11 illustrate examples of error message when the data verification fails. The message "Verify fail" is displayed with the information about the first failure data, including the first file name, the error offset position within a file, the expected value, and the read value.

User can simply press any key to cancel read operation. However, if no cancellation command is initiated, the operation will continue until the Read file command is finished. After completion, the console presents the output performance.

If the operation is cancelled, the Read file command will still run as a background process and may not finish in a good sequence. In such cases, it is recommended to power off the FPGA board and the adapter board (if connected), and then power them on to ensure proper functionality.



Verification error without cancellation +++ Read File selected +++ Input Start file No. (0x0000000 - 0x0007466) => 0 Input NUM of file (0x0000001 - 0x0007467) => 0x1000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4 File size = 32 [MB], NUM of file = 4096[File], Total size = 137.438 [GB] 7.523 [GB] 15.049 [GB] 22.575 [GB] Wrong pattern (In the example, file "0000000.BIN"-"00007FF.BIN" is written by LFSR (In the example, file "0000000.BIN"-"00007FF.BIN" is written by LFSR pattern, but file "0000800.BIN" is written by incremental pattern) 67.730 [GB] Verify fail message Verify fail 1st Error at File name = 0000800.BIN $= 0 \times 00000000$ Byte Address - 0x00000000 = 0xBFF80004_4007FFFF_DFFC0002_2003FFFF = 0xEFFE0001_1001FFFF_00000000_08000000 = 0x00000007_00000006_00000005_00000004 = 0x00000003_00000002_00000000_08000000 Expect Data[255:128] Expect Data[127: 0] Read Data[255:128] Read Data[127: 0] Press any key to cancel operation 75.255 [GB] 82.781 [GB] 90.306 [GB] 135.459 [GB] Output performance Total = 137.438 [GB] , Time = 18263[ms] , Transfer speed = 7525[MB/s] - Main menu ---[0] : Format [1] : Write File [2] : Read File [3] : Shutdown

Figure 2-10 Data verification fails but no cancellation

	Verification error with ca	ncellation							
Input NUM of file Selected Pattern [0]	ed +++ {0x0000000 – 0x000746 {0x0000001 – 0x000746 Inc32 [1]Dec32 [2]A11_ NUM of file = 4096[Fi	7) => 0x100 0 [3]All_1	[4]LFSR=> 4						
67.730 [GB]			Verify fail message						
1st Error at File na Byte Address Expect Data[255:128]	Expect Data[255:128] = 0xBFF80004_4007FFFF_DFFC0002_2003FFFF Expect Data[127: 0] = 0xEFFE0001_1001FFFF_00000000_08000000 Read Data[255:128] = 0x00000007_0000006_00000005_00000004								
Press any key to can 75.256 [GB] - Operation is cancello	cel operation	Enter an cancel t	hy key to he operation						
Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown		Verify fail and operation is c							
Figure 2-11 Data ver	ification fails and pre	ss any key	y to cancel operation						



2.4 Shutdown

Select '3' from the main menu to initiate the Shutdown command of FAT32-IP.

	 ♦ : User input ♦ : User output
+++ Shutdown selected +++ Are you sure you want to shu Press 'y' to confirm : y	Confirmation message utdown the device now ? Enter 'y' to confirm
Shutdown is complete The device has turned off	
Figure 2-12 Shutdown mer	

A confirmation message will be displayed on the console, and the user will need to enter 'y' or 'Y' to proceed with the operation. Press any other key to cancel the operation.

Once the Shutdown operation is complete, "Shutdown is complete" will be displayed as the final message. The console becomes inactive. To begin a new test operation, the user will need to power off and on the test system.



3 Revision History

Revision	Date	Description
1.0	13-Nov-23	Initial version release