

# FAT32-IP for NVMe Demo Instruction

### Rev1.2 3-Jul-23

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#### 1 Introduction

This guide provides instructions for running the FAT32-IP for NVMe demo on an FPGA development board to access an NVMe SSD with FAT32 file system functionality. The demo supports for Format, Write file, Read file, and Shutdown commands, 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.

[]	<ul> <li>User input</li> <li>User output</li> </ul>	
+++ FAT32-IP For NUMe Test design [IPVer = 2.0]	***	
> NUMeIP [IPUer = 4.3] +++ II Waiting IP initialization n	nitialization nessage	
IP initialization complete >Current file size : 32 [MB] Maximum file in dick : 15257 files The de	fault value of	
<pre>&gt;Maximum file in disk : 15257 files file configuration ??? WARNING ??? Io change file size, Format must be run Press 'y' to confirm change file size =&gt; y     Enter 'y' to confirm to 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 =&gt; 3     Select file size     The new value of</pre>		
<pre>&gt;Current file size : 256 [MB] file configuration &gt;Maximum file in disk : 1907 files Press 'y' to confirm Format =&gt; y Format open Form</pre>	confirm eration	
Format completeMessage after Format operation is completed[0] : FormatImage: Completed[1] : Write FileMain menu to select the command[2] : Read FileImage: Completed		
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.





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.

+++ Format selected +++ Current file size : 256 [MB] Maximum file in disk : 1907 files calculated maximum num	<ul> <li>♦ : User input</li> <li>♦ : User output</li> <li>♦ : User output</li> </ul>
fit WARNING fit To change file size, Format must be run Press 'y' to confirm change file size => y to change f	confirm ile size
Enter file size [0] : 32 MB [1] : 64 MB [2] : 128 MB [3] : 256 MB [4] : 512 MB [5] : 1024 MB => Ø Select file size : 32 [MB] >Maximum file in disk : 15257 files Press 'y' to confirm Format => y Format complete Main menu Message after Format [1] : Write File [2] : Read File [3] : Shutdown	<pre>+++ Format selected +++ &gt;Current file size : 32 [MB] &gt;Maximum file in disk : 15257 fil input other key ('n') to use same file size Io change file size, Format must be run Press 'y' to confirm change file size =&gt; n &gt;Current file size : 32 [MB] &gt;Maximum file in disk : 15257 files Configuration Press 'y' to confirm Format =&gt; y Format complete Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown</pre>

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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#### 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 tim	e ♦ : User input	
+++ Write File selecte	ed +++	It created time	
Current time created :	24/09/2018, 17:35:00		
Press 'y' to change t	ime created => y == Ent	er 'y' to change time	
Year (1980 - 2107) Invalid input : Papam	= b	Set time created	
Month $(1 - 12)$		Enter invalid value	
Date (1 - 31)	=> 14 Change	(use same value)	
Hour (0 - 23)	=> 14 month/date/		
Minute (0 - 59)	=> 14 hour/min/sec		
Second 2-Sec unit (0 - Date and Time Changed		had anothed firms	
Current time created :	14/02/2018, 14:14:28	ted created time	
Input NUM of file (0x0000001 - 0x0003099) =>[0x400] Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4 File size = 32 [MB], NUM of file = 1024[File], Total size = 34.359 [GB] 2.358 [GB] 4.710 [GB] 7.043 [GB]			
28.180 [GB]			
32.859 [GB]		Output porformance	
[otal = 34.359 [GB] , Time = 14656[ms] , Transfer speed = 2320[MB/s]			
Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown			
nure 2-2 Result fro	m Write File menu with i	modified created ti	

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.

- 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>.BIN.

			♦ : User input	
[	Write File with default created t	ime	• : User output	
+++ Write File selected	+++			
Current time created : $14/02/2018$ , $14:14:28$ Press 'y' to change time created => n (use same value)				
Input Start file No. (0x0000000 - 0x0003B98) => 0x400 Input NUM of file (0x0000001 - 0x0003799) => 0x600 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 0 File size = 32 [MB], NUM of file = 1536[File], Total size = 51.539 [GB] 2.377 [GB] 4.717 [GB]				
44.623 [GB] 46.981 [GB] 49.331 [GB]	ent transfer size	Outpu	It performance	
Total = 51.539 [GB] ,	Time = 21958[ms] , Transfer	speed	= 2323[MB/s]	
Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown				
iqure 2-3 Result fro	m Write File menu with o	defau	ult 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 – FILE03FF.BIN. Therefore, the "Start file No" is set to 0x400 (0x3FF + 1). The new written files after completing the new command will be FILE0400.BIN - FILE09FF.BIN, all with the same created time (14-Feb-2018, 14:14:28).



Drive name = DG_FA	T32		
→ This PC → DG_FAT32 (E:)	✓ ♂ Search DG_F	AT32 (E:) File s	size = 32 MB
The 1 <sup>st</sup> 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 exampl	e 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 – FILE09FF.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 data of 32-bit increme	ent pattern	Test data of 32-bit LFSR pattern	ı <b></b>
♦64-bit header of each 512-byte		←64-bit header of each 512-byte→	
32-bit unique value =	Test data	Те	est data
(File name x File size) + offset 0x0000000	(32-bit increment)	32-bit unique value 0x00000000 (32-b	
Offset 0 1 2 3 4 5 6 7	894 B C D E F	0 1 2 3 4 5 6 7 8 9 A B	CDEF
0000000 00 00 00 00 00 00 00 00	02 00 00 00 03 00 00 00	00 00 00 00 00 00 00 00 00 01 00 00 00	02 00 00 00
00000010 04 00 00 00 05 00 00 00	06 00 00 00 07 00 00 00	04 00 00 00 09 00 00 00 12 00 00 00	24 00 00 00
	UA UU UU UU UB UU UU UU	49 00 00 00 92 00 00 00 24 01 00 00	49 02 00 00
	UE UU UU UU UF UU UU UU		92 24 00 00
			24 49 02 00
	18 00 00 00 17 00 00 00	49 92 04 00 92 24 09 00 24 49 12 00	49 92 24 00
		73 24 47 00 27 47 72 00 4F 72 24 01 20 49 92 04 79 92 24 09 52 24 49 12	7E 24 47 U2
		CE 93 24 49 9E 27 49 92 3D 4E 92 24	71 95 24 49
		F5 3C 49 92 FB 79 92 24 D7 F3 24 49	AF F7 49 92
000000A0 28 00 00 00 29 00 00 00	2A 00 00 00 2B 00 00 00	5D CF 93 24 BA 9E 27 49 75 3D 4F 92	EB 7A 9E 24
000000B0 2C 00 00 00 2D 00 00 00	2E 00 00 00 2F 00 00 00	D7 F5 3C 49 AE EB 79 92 5C D7 F3 24	B8 AE E7 49
000000C0 30 00 00 00 31 00 00 00	32 00 00 00 33 00 00 00	70 5D CF 93 E0 BA 9E 27 C1 75 3D 4F	83 EB 7A 9E
000000D0 34 00 00 00 35 00 00 00	36 00 00 00 37 00 00 00	07 D7 F5 3C 0E AE EB 79 1D 5C D7 F3	3B B8 AE E7
000000E0 38 00 00 00 39 00 00 00	3A 00 00 00 3B 00 00 00	77 70 5D CF EE EO BA 9E DC C1 75 3D	B8 83 EB 7A
000000F0 3C 00 00 00 3D 00 00 00	3E 00 00 00 3F 00 00 00	70 07 D7 F5 E0 0E AE EB C1 1D 5C D7	83 3B B8 AE
00000100 40 00 00 00 41 00 00 00	42 00 00 00 43 00 00 00	07 77 70 5D 0E EE E0 BA 1C DC C1 75	39 B8 83 EB
00000110 44 00 00 00 45 00 00 00	46 00 00 00 47 00 00 00	73 70 07 D7 E6 E0 0E AE CD C1 1D 5C	9A 83 3B B8
00000120 48 00 00 00 49 00 00 00	4A 00 00 00 4B 00 00 00	34 07 77 70 68 0E EE E0 D1 1C DC C1	A3 39 B8 83
00000130 4C 00 00 00 4D 00 00 00	4E 00 00 00 4F 00 00 00	47 73 70 07 8E E6 E0 0E 1D CD C1 1D	3A 9A 83 3B
00000140 50 00 00 00 51 00 00 00	52 00 00 00 53 00 00 00	74 34 07 77 E9 68 0E EE D3 D1 1C DC	A6 A3 39 B8
	56 00 00 00 57 00 00 00	4C 47 73 70 98 8E E6 E0 31 1D CD C1	63 3A 9A 83
	5A UU UU UU 5B UU UU UU	C6 74 34 U7 8D E9 68 UE 1B D3 D1 1C	37 A6 A3 39
	5E 00 00 00 5F 00 00 00	5E 4C 47 73 DC 98 8E E5 B8 31 ID CD	0D 27 36 3A
			DD 37 AD A3
	60 00 00 00 07 00 00 00	10 E1 C4 7/ 34 DC 90 0E 00 D0 31 1D	06 0D 27 X6
000001R0 6C 00 00 00 6D 00 00 00	6E 00 00 00 6E 00 00 00	0C 1A 6F 4C 18 34 DC 98 30 68 B8 31	60 DD 37 A0
	72 00 00 00 73 00 00 00	CO AO F1 C6 81 41 C3 8D 03 83 86 1B	00 D0 70 00
000001D0 74 00 00 00 75 00 00 00	76 00 00 00 77 00 00 00	OF OC 1A 6E 1F 18 34 DC 3F 30 68 B8	7F 60 D0 70
000001E0 78 00 00 00 79 00 00 00	7A 00 00 00 7B 00 00 00	FF CO AO E1 FF 81 41 C3 FE 03 83 86	FD 07 06 0D
000001F0 7C 00 00 00 7D 00 00 00	7E 00 00 00 7F 00 00 00	FA OF OC 1A F4 1F 18 34 E9 3F 30 68	D3 7F 60 D0
00000200 01 00 00 00 00 00 00 00	82 00 00 00 83 00 00 00	01 00 00 00 00 00 00 00 02 00 00 00	04 00 00 00
00000210 84 00 00 00 85 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 88 00 00 00 89 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
64-bit header		64-bit header	

1

Figure 2-5 Example Test data of the 1<sup>st</sup> and 2<sup>nd</sup> 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 - 0x0003B98> => 0x4000 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 - 0x0003B98) => 0x1000
Input NUM of file (0x0000001 - 0x0002B99) => 0
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 - 0x0003B98> => 0x1000 Input NUM of file <0x0000001 - 0x0002B99> => 0x400 Selected Pattern [0]Inc32 [1]Dec32 [2]All\_0 [3]All\_1 [4]LFSR=> 5 Invalid input Error message Invalid pattern

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	<ul> <li>♦ : User input</li> <li>♦ : User output</li> </ul>
+++ Read File selected +++ Input Start file No. (0x0000000 - 0x0003B98) => 0 Input NUM of file (0x0000001 - 0x0003B99) => 0x400 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4] File size = 32 [MB], NUM of file = 1024[File], Total siz 3.380 [GB]	Input parameters LFSR=> $4$ e = 34.359 [GB]
10.146 [GB] 27.062 [GB] 30.445 [GB] 33.828 [GB]	
Total = 34.359 [GB] , Time = 10157[ms] , Transfer speed	= 3349 [MB/s]
Main menu [0] : Format [1] : Write File [2] : Read File [3] : Shutdown	

Figure 2-9 Result and input from Read File menu 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.





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#### 2.4 Shutdown Command

Select '4' from the main menu to initiate the Shutdown command of FAT32-IP.

	<ul><li>♦ : User input</li><li>♦ : User output</li></ul>
+++ Shutdown selected +++	Confirmation message
Are you sure you want to shu	tdown the device now ?
Press 'y' to confirm : y	Enter 'y' to confirm
Shutdown is complete	
The device has turned off	Last massage before the IP
	and SSD become inactive
Figure 2-12 Shutdown Comm	and with confirmation

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 command 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
1.2	3-Jul-23	Remove FPGA setup section and add Shutdown command
1.1	25-May-18	Update firmware version and description
1.0	9-Nov-17	Initial version release