

Demo Instruction for muNVMe-IP Rev2.0 16-Nov-23

1	Overview	2
2	Test Menu	3
	2.1 Identify Command	3
	2.2 Write/Read Command	4
	2.2.1 Write command	4
	2.2.2 Read Command	8
	2.2.3 Mixed Write/Read command	10
	2.3 SMART Command	12
	2.4 Flush Command	13
	2.5 Shutdown Command	13
3	Revision History	14



1 Overview

This document provides instructions for running the muNVMe-IP demo on an FPGA development board. Prior to executing the test, please refer to the "dg_nvmeip_fpgasetup" document for setting the test environment. Once the demo configuration file has been downloaded to the FPGA, a welcome message will be displayed, as shown in Figure 1-1.



The welcome screen presents the default message, which includes the IP name and version number, confirming the successful completion of FPGA configuration. Subsequently, when a PCIe connection is established, the screen will show the PCIe speed and the number of PCIe lanes. Finally, the console will display the test menu. The menu offers five options for sending various commands to the muNVMe-IP.

The Write/Read command menu allows two users to simultaneously send Write/Read commands to an NVMe SSD. The other commands (Identify, SMART, Flush, and Shutdown) can be requested by as single user (User#0) without sending Write/Read command requests to the other user (User#1). Further details about each test menu will be covered in the following topic.



2 Test Menu

2.1 Identify Command

To send the Identify command to NVMe SSD via User#0 I/F, select option '0'.

+++ Identify Command sele Model Number : INTEL SSD Capacity = 800[C Data size per LBA = 512[E		
muNUMeIP menu [0] : Identify Command [1] : Write/Read Command	Model name, SSD C (Output from Identit	apacity, and LBA unit fy command)
[2] : SMART Command [3] : Flush Command [4] : Shutdown Command		
Figure 2-1 Test result	when running Ider	ntify command

Once the operation is completed, the console will display the output of the Identify command, which includes three values.

- 1) SSD model number : This value is obtained by decoding the Identify controller data.
- 2) SSD capacity : This value is the signal output from the muNVMe-IP.
- 3) Data size per LBA : This value is the signal output from the muNVMe-IP. It can have two values 512 bytes and 4 KB.



2.2 Write/Read Command

To initiate the Write/Read command, select option '1'. Each user's parameters can be configured independently in the submenu. The console displays the submenu of User#0 and User#1, respectively. Within this submenu, users can select the command as Write, Read, or no operation. Additionally, users can set the maximum data rate for executing Write/Read commands. Consequently, the test system facilitates real-world scenario testing by enabling multiple commands while limiting the maximum speeds for specific users.

2.2.1 Write command



Figure 2-2 Write command by 1-2 users at maximum speed

As shown in Figure 2-2, the user must specify the five inputs for operating the Write command, which are described in detail as follows.

- 1) Command: Select the command type Write, Read, or Disable (no operation).
- 2) Start Address: Specify the start address to write the SSD as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units. When the LBA unit of SSD is 4 KB, this input must be aligned to 8.
- 3) Transfer Length: Specify the total transfer size as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units. When the LBA unit of SSD is 4 KB, this input must be aligned to 8.
- 4) Test pattern: Used to select the test data pattern for writing to the SSD. The user can choose from five patterns, including 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.
- 5) Maximum Speed: Set the maximum speed as a percentage of 4,400 MB/s. Valid values range from 1 to 100. It is noted that 4400 MB/s is derived from multiplying the user clock frequency (275 MHz) by the data width (128-bit), exceeding the maximum throughput of 4-lane PCIe Gen3 speed.

Once all the inputs are valid, the operation begins. During the command execution, the console will display the current amount of write data for each active user every second to indicate that the system is still running. Upon completion of the operation, the console will display the total size, total time usage, and test speed of each active user.



Figure 2-2 demonstrates the results obtained when running the Write command with two-user and a single user. The total performance achieved by the two users (1563 x 2 = 3126 MB/s) and the single user (3014 MB/s) are nearly identical.

Figure 2-3 illustrates an example where the maximum speed is limited for User#1. While User#0 is set to 100% to assess the best Write performance, User#1 have their maximum speed set to 7% or 308 MB/s.

	Two-user Write Limited maximum speed		 User input User output
+++ Write/Read Command s	elected +++		
Enter Test parameter for Enter Command [0]Write [Enter Start Address (512 Enter Length (512 Byte) Selected Pattern [0]Inc3 Enter maximum speed in p Maximum speed = 4400 MB/	User#0 1]Read [2]Disable => 0 Byte) : 0 - 0x5D26CEAF : 1 - 0x5D26CEB0 2 [1]Dec32 [2]A11_0 [3]A11_ ercentage of 4400 MB/s : 1 s	' => 0 => 0x40 1 [4]LFS - 100 =>	00000 B=> 4 100
Enter Test parameter for Enter Command [0]Write [Aximum speed of User#0 User#1 1]Read [2]Disable => 0	Input of Use	maximum speed er#0 and User#1
Enter Start Address (512 Enter Length (512 Byte) Selected Pattern [0]Inc3 Enter maximum speed in p Maximum speed = 308 MB/s	Byte) : 0 - 0x5D26CEAF : 1 - 0x4D26CEB0 2 [1]Dec32 [2]All_0 [3]All_ ercentage of 4400 MB/s : 1	=> 0x10 => 0x78 1 [4]LFS - 100 =>	000000 0000 R=> 4 7
User#0 U 2.747 [GB] 3 5.485 [GB] 6 8.228 [GB] 9 27.427 [GB] 30.170 [GB] 32.913 [GB]	Ser#1 08.725 [MB] 16.295 [MB] 24.299 [MB] 3.080 [GB] 3.388 [GB] 3.696 [GB]	fer size Iser	
User#0 Write result Total = 34.359 [GB] User#1 Write result Total = 4.026 [GB]	, Time = 12527[ms] , Trans , Time = 13073[ms] , Trans	fer spee fer spee	d = 2742[MB/s] d = 307[MB/s]
muNUMeIP menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command		Outp o	out performance f active user
iqure 2-3 Write comma	and by 2-user with limited	d maxin	num sneed

The result in Figure 2-3 shows the higher performance of User#0 compared to User#1. Considering the previous result indicating a maximum Write performance of approximately 3126 MB/s for the SSD, it is expected that User#0's performance should be limited to 3126 – 308 = 2818 MB/s, which closely matches the actual result.

Since User#0's expected write performance (2818 MB/s) is around nine times the write speed of User#1 (308 MB/s), the transfer size of User#0 is set to be eight times that of User1. This ensures that the write operation of two channels is completed simultaneously. As a result, the speed of each user remains relatively constant throughout the entire duration of the operation.



•		-Te	st d	ata	of 3	2-bi	t inc	rem	ent p	atte	rn–					•	-			_	Test	dat	a of	32-l	oit LF	SR	pat	ern				-
♦64-bit header of each 512-byte							4 64	-bit	head	der o	fead	ch 51	12-b	yte-																		
	48 (5	3-bit 12 b	addr yte u	ess ınit)			0x0	000			۔ (32-t	Test bit in	data crem	ent)				48	bit a	ddres	ss		0x0(000			(Tes 32-b	st da it LF	ta SR)		
Offset	0	1	2	3	4	5	6	7	8	9	A	в	Ċ	D	E	F	0	1	2	3	4	5	6	7	8	9	A	в	с	↓ _D	Е	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	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
00000020	08	00	00	00	09	00	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	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	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	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	00	14	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 51	2-by	to d	ata	00	1D	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
The F ST	2-0y	ie u	ata	00	21	00	00	00	22	00	00	00	23	00	00	00	CF	93	24	49	9E	27	49	92	3D	4F	92	24	7A	9E	24	49
00000090	24	00	00	00	25	00	00	00	26	00	00	00	27	00	00	00	F5	3C	49	92	EB	79	92	24	D7	F3	24	49	ΑE	E7	49	92
000000A0	28	00	00	00	29	00	00	00	2Å	00	00	00	2B	00	00	00	5D	CF	93	24	BA	9E	27	49	75	ЗD	4F	92	EΒ	7A	9E	24
000000B0	2C	00	00	00	2D	00	00	00	2E	00	00	00	2F	00	00	00	D7	F5	3C	49	ΑE	EΒ	79	92	5C	D7	F3	24	B8	ΑE	E7	49
000000000	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	ЗD	4F	83	EΒ	7A	9E
000000D0	34	00	00	00	35	00	00	00	36	00	00	00	37	00	00	00	07	D7	F5	3C	0E	ΑE	EΒ	79	1D	5C	D7	F3	3B	B8	ΑE	E7
000000E0	38	00	00	00	39	00	00	00	ЗA	00	00	00	ЗB	00	00	00	77	70	5D	CF	EE	E0	BA	9E	DC	C1	75	ЗD	B8	83	EΒ	7A
000000F0	3C	00	00	00	ЗD	00	00	00	3E	00	00	00	ЗF	00	00	00	70	07	D7	F5	E0	0E	ΑE	EΒ	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	EΒ
00000110	44	00	00	00	45	00	00	00	46	00	00	00	47	00	00	00	73	70	07	D7	E6	E0	0E	ÀΕ	CD	C1	1D	5C	9A	83	ЗB	B8
00000120	48	00	00	00	49	00	00	00	4 A	00	00	00	4B	00	00	00	34	07	77	70	68	0E	EE	E0	D1	1C	DC	C1	АЗ	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	ΕO	0E	1D	CD	C1	1D	ЗÀ	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	Α6	АЗ	39	B8
00000150	54	00	00	00	55	00	00	00	56	00	00	00	57	00	00	00	4C	47	73	70	98	8E	E6	E0	31	1D	CD	C1	63	ЗA	9A	83
00000160	58	00	00	00	59	00	00	00	5A	00	00	00	5B	00	00	00	C6	74	34	07	8D	E9	68	0E	1B	D3	D1	1C	37	A6	АЗ	39
00000170	5C	00	00	00	5D	00	00	00	5E	00	00	00	5F	00	00	00	6E	4C	47	73	DC	98	8E	E6	B8	31	1D	CD	70	63	ЗA	9A
00000180	60	00	00	00	61	00	00	00	62	00	00	00	63	00	00	00	E1	C6	74	34	C3	8D	E9	68	86	1B	D3	D1	OD	37	Α6	ÀЗ
00000190	64	00	00	00	65	00	00	00	66	00	00	00	67	00	00	00	14	6E	4C	47	34	DC	98	8E	68	B8	31	1D	DO	70	63	ЗA
000001A0	68	00	00	00	69	00	00	00	6A	00	00	00	6B	00	00	00	AO	E1	C6	74	41	C3	8D	E9	83	86	1B	D3	06	OD	37	A 6
000001B0	6C	00	00	00	6D	00	00	00	6E	00	00	00	6F	00	00	00	0C	14	6E	4C	18	34	DC	98	30	68	B8	31	60	DO	70	63
00000100	70	00	00	00	71	00	00	00	72	00	00	00	73	00	00	00	CO	AO	E1	C6	81	41	C3	8D	03	83	86	18	07	06	OD	37
000001D0	74	00	00	00	75	00	00	00	76	00	00	00	77	00	00	00	OF	0C	14	6E	1F	18	34	DC	3F	30	68	B8	7F	60	DO	70
000001E0	78	00	00	00	79	00	00	00	74	00	00	00	78	00	00	00	FF	CÜ	AU	E1	FF	81	41	C3	FE	03	83	86	FD	07	06	UD
000001F0	70	00	00	00	70	00	00	00	78	00	00	00	71	00	00	00	FA	OF	UC	14	F4	1F	18	34	_E9	3F	30	68	D3	7F	60	D0_
00000200	101	00	00	00	00	00	00	00	82	00	00	00	03	00	00	00	01	00	00	00	12	00	00	00	02	00	00	00	40	00	00	00
The 2 nd 51	2-bv	te d	ata	00	00	00	00	00	00	00	00	00	07 010	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
	,		6.		89	00	00	00	ŏΑ	00	00	00	8B	00	00	00	92	00	UU	00' 4 bit	24	01	00	00	49	02	00	00	92	04	00	00
- ·	~ .	_	04	+-DIC	neac	ier						a t				- 4 0			. 04	4-DI	neac	ier					. –	~ -				

I.

Figure 2-4 Example Test data of the 1st and 2nd 512-byte by using incremental/LFSR pattern

Test data in the SSD is divided into 512-byte units. For incremental, decremental, and LFSR patterns, each 512-byte data has a unique 64-bit header that consists of a 48-bit address (in 512-byte units) and a 16-bit zero value. The data following the 64-bit header is the test pattern selected by the user.

The left window of Figure 2-4 shows an example when using a 32-bit incremental pattern while the right window shows an example when using a 32-bit LFSR pattern. The unique header is not included when running an all-0 or all-1 pattern.



When a user runs the Write/Read command with a 4KB LBA SSD, a message is displayed on the console to show the input limitation, which must be aligned to 8, as shown in Figure 2-5. If the input is not aligned to 8, the console displays "Invalid input", and the operation is cancelled.

	LBA alignment error		Recommend	ed message
Enter Test parameter f	or User#0		when LBA ur	nit = 4 Kbyte
<u>Please input [Start Ad</u> Enter Command [Ø]Write Enter Start Address (5 Enter Length (512 Byte Invalid input)	dress] and [Length] [1]Read [2]Disable 12 Byte〉 : Ø - 〉 : 1 -	in uni => 0 0x209A9 0x209A9	<u>t of 8</u> 7AF => Ø <u>×</u> 8 7BØ => Ø×7	
When LBA [0] : Identif [1] : Write/Read Comman [2] : SMART Command [3] : Flush Command [4] : Shutdown Command	a unit = 4 KB and length 8, error message is disp πα	is not blayed.		

Figure 2-5 Error message when the input is unaligned for SSD with 4KB LBA unit

Figure 2-6 shows an example when the input is out of the recommended range for each parameter. The console displays "Invalid input", and then the operation is cancelled.





2.2.2 Read Command

Two-user Read	Single-user Read + : User input
+++ Write/Read Command selected +++	+++ Write/Read Command selected +++
Enter Test parameter for User#0 User#0 User#0 User#0 Input Enter Command [0]Write [1]Read [2]Disable => 11 2 User#0 Input Enter Start Address (512 Byte> : 0 - 0x5D26CEAF => 01 3 Enter Length (512 Byte> : 1 - 0x5D26CEB0 => $0x4000000$ Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=3 4 (4 Enter maximum speed in percentage of 4400 MB/s : 1 - 100 => 100 5	Enter Test parameter for User#0 Enter Command [0]Write [1]Read [2]Disable => 1 Enter Start Address (512 Byte) : 0 - 0x5D26CEAF => 0 Enter Length (512 Byte) : 1 - 0x5D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4 Enter maximum speed in percentage of 4400 MB/s : 1 - 100 => 100 Maximum speed = 4400 MB/s
	Enter Test parameter for User#1 Enter Command [0]Write [1]Read [2]Disable =>2 User#0 2.980 [GB] 5.955 [GB] 8.933 [GB] Current transfer size
User#0 User#1 1.651 [GB] 1.652 [GB] 3.297 [GB] 3.298 [GB] 4.946 [GB] 4.947 [GB] Current transfer size of active user	of active user 26.800 [GB] 29.778 [GB] 32.756 [GB] Jser#0 Read result Iotal = 34.359 [GB], Time = 11538[ms], Transfer speed = 2977[MB/s]
31.326 [GB] 31.328 [GB] 32.975 [GB] 32.977 [GB]	nuNVMeIP menu Output performance [0]: Identify Command of active user
User#0 Read result Total = 34.359 [GB] , Time = 20839[ms] , Transfer speed = 1648[MB/s] User#1 Read result Total = 34.359 [GB] , Time = 20839[ms] , Transfer speed = 1648[MB/s]	[1] : Write/read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command
muNUMEIP menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command	

Figure 2-7 Read command by 1-2 users

For operating the Read command, the user must specify the five inputs, which are described in detail as follows.

- 1) Command: Select the command type Write, Read, or Disable (no operation).
- 2) Start Address: Specify the start address to read the SSD as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units. When the LBA unit of SSD is 4 KB, this input must be aligned to 8.
- 3) Transfer Length: Specify the total transfer size as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units. When the LBA unit of SSD is 4 KB, this input must be aligned to 8.
- 4) Test pattern: Used to select the test data pattern for reading and verifying data from the SSD. The test pattern must match the one used in the Write command menu. There are five available patterns: 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.
- 5) Maximum Speed: Set the maximum speed as a percentage of 4,400 MB/s. Valid values range from 1 to 100.

When valid inputs are provided, the test system reads data from the SSD. During the execution of the Read command, the console displays the current amount of read data every second to indicate that the system is still running. Upon completion of the operation, the console will display the total size, total time usage, and test speed of each active user.

Figure 2-7 shows the comparable total read performance between two-user (1648 x 2 = 3296 MB/s) and a single user (2977 MB/s). However, in cases where inputs are invalid or not aligned to 8 (in relation to 4-KB LBA SSD connection), an "Invalid input" message is displayed.



<u>Note:</u> The read performance of most SSDs is enhanced when using larger buffer sizes. When executing a Read Command with two users, the total buffer size is twice that of a single user. Therefore, the read performance of two users might surpass that of a single user.

Verification error wi	thout cancellation			Verification error with c	ancellation	
+++ Write/Read Command selected +++			+++ Write/Read Co	nmand selected +++		
Enter Test parameter for User#0 Enter Command (0)Write [1]Read [2]Di Enter Start Address (512 Byte) : Enter Length (512 Byte) : Selected Pattern [0]Inc32 [1]Dec32 [Enter maximum speed in percentage of Maximum speed = 4400 MB/s Enter Test parameter for User#1	sable => 1 0 - 0x5D26CEAF => 0 1 - 0x5D26CEB0 => 0x4000000 2)All_0 [3]All_1 [4]LFSR=> 0 4400 MB/s : 1 - 100 => 100 Wrong	pattern	Enter Test paramet Enter Command [0] Enter Start Addres Enter Length (512 Selected Pattern Enter maximum speed = 4 Foter Test paramet	ter for User#0 Arite [1]Read [2]Disablass (512 Byte) : 0 - Byte) : 1 - [0]Inc32 [1]Dec32 [2]A] ad in percentage of 440 400 MB/s	e => 1 Øx5D26CEAF Øx5D26CEBØ L_Ø [3]A11_1 ð MB/s : 1 -	=> 0 => 0×4000000 [4]LFSR=> 0 100 => 100
Enter Command [0]Write [1]Read [2]Di Enter Start Address (512 Byte) : Enter Length (512 Byte) : Selected Pattern [0]Inc32 [1]Dec32 [Enter maximum speed in percentage of Maximum speed = 4400 MB/s	sable => 1 0 - 0x5D26CEAF => 0x10000000 1 - 0x4D26CEB0 => 0x40000000 21All_0 [3]All_1 [4]LFSR=> 0 4400 MB/s : 1 - 100 => 100		Enter Command 101 Enter Start Addre: Enter Length (512 Selected Pattern Enter maximum spee Maximum speed = 4	Write [1]Read [2]Disablu ss (512 Byte) : 0 - Byte) : 1 - (0]Inc32 [1]Dec32 [2]A1 ed in percentage of 4400 400 MB/s	e => 1 0x5D26CEAF 0x4D26CEB0 L_0 [3]All_1 0 MB/s : 1 -	=> 0x1000000 => 0x4000000 [4]LFSR=> 0 100 => 100
Verify fail in User#0 Ist Error at Byte Addr = 0x00000000 Expect Data[127:0] = 0x00000003_ Read Data[127:0] = 0x0000002_ Press any key to cancel operation	0000002_00000000_000000000 0000001_00000000_00000000	essage werification User#0	Nerifu fail in Us when at Byte n is failed ta[127:0] [127:0] whey to a	er#0 Addr = 0x00000000] = 0x0000003_0000 = 0x00000002_0000 cancel operation	0002_0000000 0001_00000000	0_00000000 0_00000000
Verify fail in User#1 1st Error at Byte Addr = 0x00000020 Expect Data[127:0] = 0x00000003_ Read Data[127:0] = 0x40000002_ Press any key to cancel operation	0000002_0000000_10000000 2000001_00000000_10000000 In	lessage w erificatior User#1	vhen is failed fress any key to	er#1 Addr = 0x00000020] = 0x00000003_0000 = 0x40000002_20000 cancel operation	0002_0000000 0001_0000000	3_10000000 3_10000000
User#0 User#1 1.651 [GB] 1.652 [GB] 3.297 [GB] 3.298 [GB] 4.946 [GB] 4.947 [GB]			User#0 1.651 [GB] 3.297 [GB] Operation is cance Please reset syste	User#1 1.652 [GB] 3.298 [GB] elled in before starting a new	User enters to cancel the	some keys e operation
29.678 [GB] 29.679 [GB] 31.326 [GB] 31.328 [GB] 32.975 [GB] 32.977 [GP] User#0 Read result Total = 34.359 [GB], Time = 20 User#1 Read result	utput performance of active us 339[ms] , Transfer speed = 164	ser 8[MB/s]	muNUMeIP menu [0] : Identify Con [1] : Write/Read ([2] : SMARI Comman [3] : Flush Comman [4] : Shutdown Con	Message when opera mand Command nd nd mand	tion is cancell	ed
Total = 34.359 [GB], Time = 20 muNUMeIP menu [0] : Identify Command [1] : Write/Read Command [2] : SMARI Command [3] : Flush Command [4] : Shutdown Command	339[ms] , Transfer speed = 164	8 [MB/s]				

Figure 2-8 Data verification has failed

In case of a failed data verification during Read command, an error message is displayed on the console, as shown in Figure 2-8. The message "Verify fail in User#<i>" (where 'i' is the user index ranging from 0 to 1) is displayed with information about the first failure data, such as the error byte address, the expected value, and the read value.

To cancel the Read operation, the user can press any key(s). However, if the operation is not cancelled, it will continue running until it finishes. Once it has finished, the output performance is displayed on the console.

Though the operation is cancelled, the Read command continues running as a background process and may not finish in a proper sequence. Therefore, it is recommended to power off and then power on both the FPGA board and adapter board (if connected) after cancelling the operation.



2.2.3 Mixed Write/Read command

Mixed Write-Read by Intel P5800X SSD	Mixed Write-Read by WD Black SN850 ◆ : User output
+++ Write/Read Command selected +++	+++ Write/Read Command selected +++
Enter Test parameter for User#0 Enter Command [0]Write [1]Read [2]Disable \Rightarrow 0 Enter Start Address (512 Byte) : 0 - 0x5D26CEAF \Rightarrow 0 Enter Length (512 Byte) : 1 - 0x5D26CEB0 \Rightarrow 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4 Enter maximum speed in percentage of 4400 MB/s : 1 - 100 \Rightarrow 100 Maximum speed = 4400 MB/s	Enter Test parameter for User#0 Enter Command [0]Write [1]Read [2]Disable => 0 Enter Start Address (512 Byte) : 0 - $0x74706DAF$ => 0 Enter Length (512 Byte) : 1 - $0x74706DB0$ => $0x4000000$ Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4 Enter maximum speed in percentage of 4400 MB/s : 1 - 100 => 100 Maximum speed = 4400 MB/s
Enter Test parameter for User#1 User#1 Input Enter Command [0]Write [1]Read [2]Disable =>1 1 Enter Start Address (512 Byte) : 0 - 0x5D26CEAF => 0x10000000 Enter Length (512 Byte) : 1 - 0x4D26CEB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]Pall_0 [3]Pall_1 [4]LFSR=> 4 Enter maximum speed in percentage of 4400 MB/s : 1 - 100 => 100 Maximum speed = 4400 MB/s	Enter Test parameter for User#1 Enter Command [0]Write [1]Read [2]Disable => 1 Enter Start Address (512 Byte) : 0 - 0x74706DAF => 0x10000000 Enter Length (512 Byte) : 1 - 0x64706DB0 => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 4 Enter maximum speed in percentage of 4400 MB/s : 1 - 100 => 100 Maximum speed = 4400 MB/s
User#0 User#1 2.565 [GB] 2.567 [GB] 5.123 [GB] 5.125 [GB] 7.684 [GB] 7.687 [GB] 28.169 [GB] 28.171 [GB] 30.730 [GB] 30.732 [GB] 33.290 [GB] 33.293 [GB] User#0 User User#0 User#0 User#1 User#0 User#0 User#1 User#0 User#0 User#1 User#0 User#1 User#1 User#1 User#1 Current transfer size of active user Output performance of active user	User#0 User#1 2.776 [GB] 1.563 [GB] 5.553 [GB] 3.124 [GB] 8.334 [GB] 4.683 [GB] 11.116 [GB] 6.248 [GB] 27.811 [GB] 15.637 [GB] 30.589 [GB] 17.199 [GB] 33.372 [GB] 18.764 [GB]
Jser#4 Write result Total = 34.359 [GB] , Time = 13417[ms] , Transfer speed = 2560[MB/s] Jser#1 Read result Total = 34.359 [GB] , Time = 13417[ms] , Transfer speed = 2560[MB/s]	Complete 22.031 [UB] Complete 24.741 [GB] Complete 27.451 [GB] Complete 30.162 [GB] Complete 32.872 [GB]
	User#0 Write result Total = 34.359 [GB], Time = 12353[ms], Transfer speed = 2781[MB/s] User#1 Read result Total = 34.359 [GB], Time = 17902[ms], Transfer speed = 1919[MB/s]
Figure 2-9 Test result when runn	ning mixed Write/Read command

As shown in Figure 2-9, the user must specify the five inputs for operating the Write and Read commands, which are described in detail as follows.

- 1) Command: Select the command type Write, Read, or Disable (no operation).
- 2) Start Address: Specify the start address to write/read the SSD as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units. When the LBA unit of SSD is 4 KB, this input must be aligned to 8.
- 3) Transfer Length: Specify the total transfer size as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units. When the LBA unit of SSD is 4 KB, this input must be aligned to 8.
- 4) Test pattern: Used to select the test data pattern for writing to the SSD or verifying from the SSD. The user can choose from five patterns, including 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.
- 5) Maximum Speed: Set the maximum speed as a percentage of 4,400 MB/s. Valid values range from 1 to 100.

Once all the inputs are valid, the operation begins. During the command execution, the console will display the current amount of write data or read data for each active user every second to indicate that the system is still running. Upon completion of the operation, the console will display the total size, total time usage, and test speed of each active user. If an error is found from invalid input or failed data verification, an error message is displayed on the console.



Figure 2-9 illustrates how SSDs respond to mixed Write-Read commands. On the left side, the write performance of User#0 matches the read performance, allowing simultaneous completion for both User#0 and User#1. In contrast, on the right side, the Write command shows better performance compared to the Read command, resulting in the completion of the Write command before the Read command finishes.

	Full speed by Intel P5800X SSD		1	Limited Read s by Intel P5800	speed X SSD	 ♦ : User input ♦ : User output
+++ Write/Read Command se	elected +++		+++ Write∕Read Comman	d selected +++		
Enter Test parameter for Enter Command [0]Write [1] Enter Start Address (512 Enter Length (512 Byte) Selected Pattern [0]Inc32 Enter maximum speed in pe Maximum speed = 4400 MB/s	User#0]Read [2]Disable =>0 Byte> : 0 - 0x5D26CE : 1 - 0x5D26CE ! [1]Dec32 [2]A11_0 [3]A1 prentage of 4400 MB/s : 1	AF => 0 B0 => 0x4000000 1_1 [4]LFSR=> 4 1 - 100 => <u>[100]</u>	Enter Test parameter Enter Command [0]Writ Enter Start Address (Enter Length (512 Byt Selected Pattern [0]I Enter maximum speed i Maximum speed = 4400	for User#0 e [1]Read [2]Disable 512 Byte) : 0 - e) : 1 - nc32 [1]Dec32 [2]All n percentage of 4400 MB/s	: => 0 0x5D26CEAF => 0 0x5D26CEB0 => 0 0 [3]All_1 [4] 0 MB/s : 1 - 100	0 3×4000000 1LFSR=> 4 0 => 100
Enter Test parameter for Enter Command [0]Write [1 Enter Start Address (512 Enter Length (512 Byte) Selected Pattern [0]Inc32 Enter maximum speed in pp Maximum speed = 4400 MB/s	User#1 JRead [2]Disable =>1 Byte> : 0 - 0x5D26CE : 1 - 0x4D26CE [1]Dec32 [2]A11_0 [3]A1 preentage of 4400 MB/s : ;;	Full speed AF => 0x10000000 B0 => 0x4000000 1_1 [4]LFSR=> 4 1 - 100 => 100	Enter Test parameter Enter Command [0]Writ Enter Start Address (Enter Length (512 Byt Selected Pattern [0]I Enter maximum speed i Maximum speed = 440 M	for User#1 e [1]Read [2]Disable 512 Byte) : 0 - e) : 1 - nc32 [1]Dec32 [2]All n percentage of 4400 B/s	= > 1 0x5D26CEAF => (0x4D26CEB0 => (_0 [3]All_1 [4]) MB/s : 1 - 100	0x10000000 0x1000000 0LFSR⇒ 4 0 =>10 0 =>10
User#0 Us 2.565 [GB] 5.123 [GB] 7.684 [GB] 28.169 [GB] 2 30.730 [GB] 3 33.290 [GB] 3	Ser#1 2.567 [GB] 5.125 [GB] 7.687 [GB] 18.171 [GB] 10.732 [GB] 13.293 [GB]		User#0 2.934 [GB] 5.860 [GB] 8.790 [GB] 29.299 [GB] 32.229 [GB] Complete	User#1 440,992 [MB] 880.381 [MB] 1.320 [GB] 4.400 [GB] 4.840 [GB] 5.600 [GB]		ea Keaa speea
User#0 Write result Iotal = 34.359 [GB] User#1 Read result Iotal = 34.359 [GB]	, Time = 13417[ms] , Tra , Time = 13417[ms] , Tra	nsfer speed = 2560[MB/s] nsfer speed = 2560[MB/s]	Complete Complete Jser#0 Write result Iotal = 34.359 [User#1 Read result Iotal = 8.589 [7.800 [GB] 8.240 [GB] GB] , Time = 11727[m GB] , Time = 19522[m	Write sp when Read (s], Iransfer s (s], Iransfer s	eed increases speed is limited speed = 2929[MB/s] speed = 439[MB/s]
Figure	e 2-10 Mixed Wr	rite-Read comma	and with limite	d maximum F	Read spee	ed

Figure 2-10 showcases an example result involving two users: one for the Write command and the other for Read command, operating at both maximum and limited speeds. When operating at maximum speed, as shown on the left side, the performance of both Write and Read commands equal 2560 MB/s. In various applications, the Read command is commonly utilized for system monitoring at lower speeds, while the Write command is utilized at the highest speed to log data. Therefore, the example on the right side of Figure 2-10 aims to evaluate the maximum achievable Write speed while simultaneously operating the Read command at a slower speed.

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2.3 SMART Command

To send a SMART command to the NVMe SSD via User#0 I/F, select option '2'. Once the operation is completed, the console will display the SMART/Health Information output, as shown in Figure 2-11. This information includes both the Health status and SMART log information.

+++ SMART Command selected +++ << Health Status >> Remaining Life : 100%		Data output decoded from SMART command
<pre><< SMART Log Information >> Percentage Used Temperature Total Data Read Total Data Read (Raw data) Total Data Written Total Data Written (Raw data) Power On Cycles Power On Hours Unsafe Shutdowns</pre>	: 0% : 26 Degree Celsius : 35717 GB : 0x0000000_00000 : 45178 GB : 0x00000000_000000 : 222 Times : 31 Hours : 45 Times	s 000_00000000_04286647 000_00000000_05425472
SMART Command Complete muNUMeIP menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command		

The Health status displays the remaining life of the SSD as a percentage, which is calculated from the Percentage Used value in the SMART log information. The SMART log information displays the following seven parameters.

- 1) Percentage used: The percentage of the SSD's lifespan that has been consumed.
- 2) Temperature: The temperature of the SSD in degree Celsius.
- 3) Total Data Read: The total amount of data that has been read from the SSD, displayed in GB/TB units. Additionally, the raw data without decoding is displayed as a 32-digit hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 4) Total Data Written: The total amount of data that has been written to the SSD, displayed in GB/TB units. Additionally, the raw data without decoding is displayed as a 32-digit hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 5) Power On Cycles: The number of times the SSD has been powered on.
- 6) Power On Hours: The total amount of time in hours that the SSD has been powered on.
- 7) Unsafe Shutdowns: The number of times the SSD has experienced an unsafe shutdown.



2.4 Flush Command

To initiate a Flush command on the NVMe SSD, select option '3' from the menu. The Flush command ensures that all modified data in the cache memory is written to Flash memory in the SSD.

Flush Command Complete	Message after
muNUMeIP menu [0] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command	đ

Once the Flush operation is completed, the consoled will display the message "Flush Command Complete".

2.5 Shutdown Command

To send a Shutdown command to the NVMe SSD via User#0 I/F, select option '4'.

	♦ : User input♦ : User output
muNUMeIP menu [Ø] : Identify Command [1] : Write/Read Command [2] : SMART Command [3] : Flush Command [4] : Shutdown Command +++ Shutdown Command select	Confirmation massage
Are you sure you want to sl Press 'y' to confirm : y	hutdown the device now ? Press 'y' to confirm
Shutdown command is complet The device has turned off.	te
	Last message before muNVMe-IP and SSD are inactive status
Figure 2.12 Test result when	rupping Shutdown command

Figure 2-13 Test result when running Shutdown command

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
2.0	16-Nov-23	Add maximum speed limitation feature
1.0	14-Jun-22	Initial version release