

NVMeTCP25G-IP Demo Instruction

1	Overview	2
2	NVMe/TCP Target Setup on Linux PC	2
	2.1 Application Installation	2
	2.2 Ethernet Interface Setting on Linux PC	2
	2.3 NVMe/TCP Target Setting on Linux PC	4
	2.4 Removing NVMe/TCP Target Configuration on Linux PC	6
3	Test operation	7
	3.1 Set Network Parameter	8
	3.2 Connect	11
	3.3 Write Command	13
	3.4 Read Command	16
	3.5 Disconnect Command	18
4	Revision History	19



NVMeTCP25G-IP Demo Instruction

Rev2.00 19-Sep-2024

1 Overview

This document provides instructions for running the NVMeTCP25G-IP demo, which demonstrates the use of an NVMe/TCP Host (Initiator) to access an NVMe SSD installed in an NVMe/TCP Target. The Target system for this demo uses a PC running Ubuntu 20.04.1 OS. The demo involves writing to and reading from the NVMe SSD over a 25G Ethernet connection, following the standard of NVMe/TCP protocol. These operations are managed via the FPGA console interface.

This guide is divided into two sections. Section 2 outlines how to set up the NVMe SSD in the Target PC for accessing by the NVMe/TCP and the process for safely removing the NVMe SSD from the NVMe/TCP target configuration on Ubuntu OS. Section 3 details the operations performed through the FPGA console, with step-by-step instructions for testing and explanations of the test results.

2 NVMe/TCP Target Setup on Linux PC

2.1 Application Installation

Prior to running the NVMeTCP25G-IP demo, certain applications must be installed on Linux PC. These applications only need to be installed once and do not require reinstallation for subsequent uses.

• Ethtool: This utility is used to optimize the performance of the network card. To install Ethtool, open a terminal and execute the following command:

sudo apt install ethtool

 NVMe Command Line Interface (NVMe-CLI): This tool is used to manage NVMe SSDs on a Linux OS. To install NVMe-CLI, run the following command in the terminal:

sudo apt install nvme-cli

2.2 Ethernet Interface Setting on Linux PC

To achieve optimal performance of the 25G Ethernet network card before running the demo, follow these steps below. Open a terminal to begin configuring the Ethernet interface.

1) Use the following command to list the logical name of the 25G Ethernet port on the Linux system:

sudo Ishw -C network

Figure 1 displays the command output, where the 25G Ethernet interface connected to the NVMe/TCP host is identified as "enp1s0f0".



Linux Terminal	 Input by user Output to user
dg_ipdev@dgipdev:~\$ sudo lshw -C network *-network:0 description: Ethernet interface product: MT2894 Family [ConnectX-6 L vendor: Mellanox Technologies physical id: 0 bus info: pci@0000:01:00.0	Display a list of network connection x]
logical name: enpls0f0 Logical name of 25G	b Ethernet connection
serial: 08:c0:eb:1e:73:3e capacity: 25Gbit/s width: 64 bits clock: 33MHz capabilities: pciexpress vpd msix pm	bus_master cap

Figure 1 Display Logical Name of 25G Ethernet Port

Linux Terminal	_
dg_ipdev@dgipdev:~\$ sudo ifconfig enp1s0f0 192.168.25.100 netmask 255.255.255.0	L
dg_ipdev@dgipdev:~\$ sudo ifconfig enp1s0f0 mtu 9000(3)	Į
dg_ipdev@dgipdev:~\$ sudo ethtool -C enpls0f0 adaptive-rx off adaptive-tx off	
dg_ipdev@dgipdev:~\$ sudo ethtool -C enpls0f0 rx-usecs 0 rx-frames 1	
dg_ipdev@dgipdev:~\$	

Figure 2 IP Address and Ethernet Interface Setting

2) Set the IP address and subnet mask for the desired Ethernet port by using the command: "ifconfig <interface> <ipaddr_value> netmask <netmask_value>".

a) Interface	= enp1s0f0
~		

- b) IP address = 192.168.25.100
- c) Subnet mask = 255.255.255.0

sudo ifconfig enp1s0f0 192.168.25.100 netmask 255.255.255.0

3) Enable jumbo frames by setting the Maximum Transfer Unit (MTU) to 9000 using the following command: "ifconfig <interface > mtu <mtu_value>".

sudo ifconfig enp1s0f0 mtu 9000

4) Disable the Rx-Tx latency improvement algorithm to stabilize performance by running: "sudo ethtool -C <interface> adaptive-rx off adaptive-tx off".

sudo ethtool -C enp1s0f0 adaptive-rx off adaptive-tx off

5) Set the highest rate of Rx interrupt to ensure the PC processes each received packet immediately by executing: "sudo ethtool -C <interface> rx-usecs 0 rx-frames 1".

sudo ethtool -C enp1s0f0 rx-usecs 0 rx-frames 1



2.3 NVMe/TCP Target Setting on Linux PC

This section outlines the steps required to configure the Linux PC to function as an NVMe/TCP target after setting up the 25G Ethernet network, as shown in Figure 3.

Linux Terminal	• : Input by user
dg_ipdev@dgipdev:~\$ sudo modprobe nvmet 🔱	+: Output to user
dg_ipdev@dgipdev:~\$ sudo modprobe nvmet-tcp	L
dg_ipdev@dgipdev:~\$ sudo /bin/mount -t configfs none /sys/kernel/config/	
mount: /sys/kernel/config: none already mounted on /sys/fs/bpf.	
dg_ipdev@dgipdev:~\$ sudo mkdir /sys/kernel/config/nvmet/subsystems/dgnvmettest	
dg_ipdev@dgipdev:~\$ cd /sys/kernel/config/nvmet/subsystems/dgnvmettest	4
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/subsystems/dgnvmettest\$ echo 1 sudo tee -a attr_allow_any_host > /dev/null	Ŷ
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/subsystems/dgnvmettest\$ sudo mkdir namespaces/1	—
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/subsystems/dgnvmettest\$ cd namespaces/1/	
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/subsystems/dgnvmettest/namespaces/1\$ echo -n /dev/nvmeln1 sudo tee -a devic	e_path > /dev/null
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/subsystems/dgnvmettest/namespaces/1\$ echo 1 sudo tee -a enable > /dev/null	-
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/subsystems/dgnvmettest/namespaces/1\$ sudo mkdir /sys/kernel/config/nvmet/por	ts/1 7
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/subsystems/dgnvmettest/namespaces/1\$ cd /sys/kernel/config/nvmet/ports/1	
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/ports/1\$ echo 192.168.25.100 sudo tee -a addr_traddr > /dev/null	
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/ports/1\$ echo tcp sudo tee -a addr_trtype > /dev/null	
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/ports/1\$ echo 4420 sudo tee -a addr_trsvcid > /dev/null	
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/ports/1\$ echo ipv4 sudo tee -a addr_adrfam > /dev/null	
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/ports/1\$ sudo ln -s /sys/kernel/config/nvmet/subsystems/dgnvmettest/ /sys/ke	rnel/config/nvmet/p
orts/1/subsystems/dgnvmettest	9
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/ports/1\$ dmesg grep "nvmet_tcp"	\bigcirc
[176.342608] nvmet_tcp: enabling port 1 (192.168.25.100:4420)	
dg_ipdev@dgipdev:/sys/kernel/config/nvmet/ports/1\$	

Figure 3 Target Setting

1) Load the NVMe/TCP target module by running the following command.

sudo modprobe nvmet sudo modprobe nvmet-tcp

2) Mount the kernel user configuration filesystem to manage NVMe/TCP target settings.

sudo /bin/mount -t configfs none /sys/kernel/config/

3) Create an NVMe target subsystem and define the NVMe Qualified Name (NQN). The NQN must match the 'TrgNQN' setting in the NVMeTCP25G-IP demo. Assumed that the NQN is configured by "dgnvmettest", use the following commands to navigate to the subsystem directory.

sudo mkdir /sys/kernel/config/nvmet/subsystems/dgnvmettest

cd /sys/kernel/config/nvmet/subsystems/dgnvmettest

<u>Note</u>: While the 'TrgNQN' on the NVMeTCP25G-IP supports up to 256 characters, the demo system allows input up to 16 characters. Ensure the NQN length does not exceed this limit.

 Set the attribute to allow any host to connect using the following command. This setting is suitable for testing but should be restricted in production environments. The NVMeTCP25G-IP allows configuration of the 'Host NQN' value.

echo 1 |sudo tee -a attr_allow_any_host > /dev/null



NVMeTCP25G IP Core

5) Create a namespace for the subsystem and navigate to the new directory using following command.

sudo mkdir namespaces/1 cd namespaces/1/

6) Assign a local NVMe SSD to the system and enable it using the following command.

echo -n /dev/nvme1n1 |sudo tee -a device_path > /dev/null

echo 1|sudo tee -a enable > /dev/null

Note: Replace 'nvme1n1' with the correct device identifier for your SSD.

7) Create an NVMe target port to export the created subsystem and navigate to the appropriate directory using the following command.

sudo mkdir /sys/kernel/config/nvmet/ports/1

cd /sys/kernel/config/nvmet/ports/1

- 8) Configure Ethernet parameters for the NVMe target port, including the following:
 - a) IP address = 192.168.25.100
 - b) Transport type = tcp
 - c) Port number = 4420
 - d) Address family = ipv4

echo 192.168.25.100 |sudo tee -a addr_traddr > /dev/null

echo tcp | sudo tee -a addr_trtype > /dev/null

echo 4420 | sudo tee -a addr_trsvcid > /dev/null

echo ipv4 | sudo tee -a addr_adrfam > /dev/null

<u>Note</u>: Ensure the IP address corresponds to the Ethernet port configured in Section 2.2 (Ethernet Interface Setting on Linux PC).

9) Create a symbolic link between the target port and the subsystem using the following command.

sudo In -s /sys/kernel/config/nvmet/subsystems/dgnvmettest/ /sys/kernel/config/nvmet/ports/1/subsystems/dgnvmettest

<u>Note</u>: The Target NQN (dgnvmettest) must match the value configured in step 3).

10) Verify that the target is correctly configured by inspecting the system messages using the following command.

dmesg |grep "nvmet_tcp"

11) If the configuration is successful, the system messages will display the target IP address and port number, as shown in Figure 4.

nvmet_tcp: enabling port 1 (192.168.25.100:4420)

Figure 4 NVMe/TCP Target Setup Success Message



2.4 Removing NVMe/TCP Target Configuration on Linux PC

This section provides step-by-step instructions for removing the NVMe/TCP target configuration on Linux PC after completing the tests, as shown in Figure 5.

Linux Terminal			1		
dg_ipdev@dgip	<pre>dev:/\$ cd /sys/kernel/config/</pre>	nvmet			(2)
dg_ipdev@dgip	dev:/sys/kernel/config/nvmet\$	sudo	rm -f	ports/1/subs	systems/dgnvmettest
dg_ipdev@dgip	dev:/sys/kernel/config/nvmet\$	sudo	rmdir	ports/1	3
dg_ipdev@dgip	dev:/sys/kernel/config/nvmet\$	sudo	rmdir	subsystems/d	<pre>ignvmettest/namespaces/1</pre>
dg_ipdev@dgip	dev:/sys/kernel/config/nvmet\$	sudo	rmdir	subsystems/d	ignvmettest/
dg_ipdev@dgip	dev:/sys/kernel/config/nvmet\$				5

Figure 5 Remove NVMe/TCP Target

1) Navigate to the directory where the NVMe/TCP configurations are stored.

cd sys/kernel/config/nvmet/

2) Delete the directory corresponding to the target port to remove its connections.

sudo rm -f ports/1/subsystems/<mark>dgnvmettest</mark> sudo rmdir ports/1

3) Remove subsystems linked to the NVMe SSD.

sudo rmdir subsystems/dgnvmettest/namespace/1

sudo rmdir subsystems/dgnvmettest/

Once the target subsystem is successfully removed, the NVMe SSD should be accessible by the stanadard NVMe device driver on the PC. Use tools such as "hexdump" or other to inspect the SSD and verify the written data.

By following these steps, you can ensure the NVMe/TCP target configuration is properly removed, and the NVMe SSD is returned to its standard operational state for regular PC usage.



3 Test operation

Upon the completion of both the Linux PC and FPGA setups, the FPGA console displays a welcome screen, indicating readiness for operations. This is confirmed by the display of the IP name, IP version number, and the status of the Ethernet connection.

FPGA Console	
IP information +++ NUMeTCP25G-IP Test design [IPUer = 2.1] +++ > XXUGMACRSFECIP [IPUer = 1.0] Waiting Ethernet linkup Main menu [0] : Set Network Parameter	IP information 25G-IP Test design [IPVer = 2.1] +++ CRSFECIP [IPVer = 1.0] Vait Ethernet connection Nernet linkup Annu Network Parameter

Figure 6 Message after System Boot-up

- IP Details: The console displays the name and version of the NVMeTCP25G-IP. If the Ethernet MAC IP Core from Design Gateway is used, its version will also be shown.
- Ethernet Status: The status of the Ethernet connection on the FPGA is displayed. If the Ethernet link fails to establish, an error message prompting a check of the Ethernet cable appears.

FPGA Conso	le					
+++ NUMeT(> XXUGM Waiting Et Link Down	CP25G-IF ACRSFECI thernet Please	P Test d P [IPVe linkup check	esign r = 1. cable	[IPVer = 2. .0] connection	.1] +++ Error when link is down	Ethernet 1
Link Down Link Down Link Down Link Down	Please Please Please Please	check check check check	cable cable cable cable	connection connection connection		

Figure 7 Error Message when Ethernet Connection Down

Once the Ethernet link is successfully established, the main menu will appear. This menu provides several options, each corresponding to different stages of the test process. Initially, only the relevant menu items are available, ensuring that the correct sequence of operations is followed. The first action after boot-up is selecting Menu [0] to configure the network parameters.

3.1 Set Network Parameter

Select option '0' from the main menu to configure the IP parameters. This step is required to set up or update the network settings for communication between the host and target. Initially, the current parameters are shown on the console. The user can either enter 'x' to keep the existing setting or enter any other key to modify the parameters. If an invalid value is entered while setting a parameter, the existing value of that parameter remains unchanged. Below is a list of input parameters.

- 1) Target NVMe Qualified Name (NQN): Identifies the target SSD. Accepts up to 16 characters and the default is "dgnvmettest".
- 2) Host MAC Address: Requires a 12-digit hexadecimal value for the host with the prefix "0x". The default value is 0x000102030405.
- 3) Host IP Address: Input as four decimal numbers separated by dots. Each segment ranges from 0-255. The value is assigned to be the IP address of the host. The default is 192.168.25.44.
- 4) Host Port Number: Inputs the Admin and IO port numbers for the host, with valid inputs ranging from 0 to 65535. The defaults are 40000 (Admin) and 40001 (IO).
- 5) Target MAC Address Mode: Press 'y' to switch to Fixed-MAC mode instead of using ARP mode (which retrieves the MAC address via ARP). The default mode is ARP.
- 6) Target MAC Address: Requires a 12-digit hexadecimal value prefixed with "0x" for the target. The default is 0x101112131415.

<u>Note</u>: This parameter is available only if the Target MAC Address mode is set to Fixed-MAC, as shown in Figure 9.

7) Target IP Address: Follows the same format as the Host IP address. This value is assigned to be the IP address of the target. The default value is 192.168.25.100.

Once all parameters are set, they are displayed for user confirmation. If the user confirms the settings by entering 'y', the parameters are configured on the NVMeTCP25G-IP. A confirmation message, "IP parameters are set", is shown upon successful configuration

The main menu reappears with offering the 'Connect' command as the next step, as detailed in Figure 8.



NVMeTCP25G IP Core

FPGA Console	Target MAC by			♦ : User Input
	ARP mode			Invalid Input
		-		• : User Output
+++ Set Network H	arameter sele	cted +++		
+++ Current IP Pa	rameter +++	•	- I	Current value
Host NQN (Fixed))y f∕w) = dgnv	mehtest		of nameters
Target NQN	= dgnv	mettest		of parameters
Host MAC address	= 0×04	0102030405		
Host IP	= 192.	168.25.44		
Host Admin Port	= 4000	10		
Host IV Port	= 4000	11		
Target MAC Mode	= MAC	by AKP		
larget IP	= 192.	168.25.100	J	Input other key (not 'x')
				to change parameter
Press 'x' to skip) parameter se	tting : n		to change parameter
	D			Maximum chars of
Setting NUMeICP-I	P parameter			Target NQN is 16
Input larget NYN		agnvmett	est	
Input Host MHC ad	laress			Input invalid value
Invalid input : F	arameter not	change		to use same value
Input Host IP add	iress	; <u>n</u>		
Invalid input : F	arameter not	cha <u>nge</u>		Input valid value to
Input Host port n				change parameter
Input Host port n	Tanger LIUJ	TOODE		
rress y to fix	larget nuc	: <u>n</u>		Input other keys (not 'v')
Input larget if a	luuress	ab a construction		to get target MAC address
invalla input - r	arameter not	change		from ARP
+++ Current IP Pa	arameter +++			
Host NQN (Fixed h	oy f∕w) = dgnv	mehtest		
Target NQN	= dgnv	mettest		
Host MAC address	= 0×00	0102030405		
Host IP	= 192.	168.25.44		
Host Admin Port	= 5000	0		New parameters
Host IO Port	= 5000	11		
Target MAC Mode	= MAC	by ARP		
Target IP	_= 192.	168.25.100		Confirmation if all
Press 'y' to conf	irm : y			parameters are correct
IP parameters are	set 🗖			All parameters are undated
				to NVMe TCP25CIP
——— Main menu ——-	-			
[0] : Set Networl	Arameter			Connect menu is allowed after
[1] : Connect				the parameters have been set
			1	

Figure 8 Set Network Parameter Result (ARP Mode)



NVMeTCP25G IP Core

```
Target MAC by
                                                                                        • : User Input
  FPGA Console
                                Fixed-MAC Mode
                                                                                        Invalid Input
                                                                                        • : User Output
+++ Set Network Parameter selected +++
+++ Current IP Parameter +++
Host NQN (Fixed by f/w) = dgnumehtest
Target NQN = dgnumettest
Host MAC address
                                         = 0 \times 000102030405
Host IP
                                         =
                                            192.168.25.44
Host Admin Port
                                         = 50000
Host IO Port
Target MAC Mode
                                         = 50001
                                        = MAC by ARP
= 192.168.25.100
Target IP
Press 'x' to skip parameter setting : n
Setting NUMeTCP-IP parameter
Input Target NQN : dgn
Input Host MAC address : n
Invalid input : Parameter not change
                                                    : dgnvmettest
Input Host IP address : n
Invalid input : Parameter not change
Invalid input : Parameter not change
Input Host port number [ADMIN] : 50000
Input Host port number [IO] : 50001
Press 'y' to fix Target MAC : y
Input Target MAC address : Øx08CI
Input Target IP address : n
Invalid input : Parameter not change
                                                                                        Press 'y' to fix Target
                                                                                        MAC address
                                                       У
Ø×Ø8CØEB1E733E
                                                                                        Input Target
                                                                                        MAC address
+++ Current IP Parameter +++
Host NQN (Fixed by f/w) = dgnumehtest
Target NQN = dgnumettest
Host MAC address = 0x000102030
                                         = 0 \times 000102030405
Host IP
                                         =
                                            192.168.25.44
Host Admin Port
Host IO Port
Target MAC Mode
                                         = 50000
                                         = 50001
                                                                                        Target MAC address
                                        = Fixed MAC
                                                                                        is displayed in
                                        = 0×08C0EB1E733E
Target MAC address
                                                                                        Fixed-MAC mode
Target IP
Press 'y' to confirm : y
                                         = 192.168.25.100
IP parameters are set
```





3.2 Connect

Select option '1' from the main menu to establish a connection between the host and the target.

FPGA Console		
Main menu [0] : Set Networ [1] : Connect	- k Parameter	
+++ Connect sele	cted +++	Connection status
Connect target s SSD Capacity = 1	UCCESSFULLY	et SSD capacity
Main menu [2] : Write Comm [3] : Read Comma [4] : Disconnect	and nd Write/Read	/Disconnect allowed

Figure 10 Console Result when Connect Succeeded

The NVMeTCP25G-IP (host) established a TCP/IP connection using the network parameters configured in Section 3.1 (Set Network Parameter). Following successful TCP/IP setup, the NVMe/TCP connection is established using the specified Target NQN, ensuring that the host is correctly linked to the designated target NVMe SSD. Upon successfully connection, the console displays "Connect target successfully", along with the capacity of the target NVMe SSD. The menu then updates to include options for Write, Read, and Disconnect commands, as illustrated in Figure 10.



If the connection process takes longer than expected, the waiting time will be updated and displayed every second. In cases where TCP/IP initialization fails or the host cannot connect to the target, the console displays error status and detailed error information. Additionally, the TestPin (Internal Test Pin of the IP) is displayed.

If an error occurs, the system must be reset before attempting a new test. This requirement is shown in both Figure 11 and Figure 12.

FPGA Console	
+++ Connect selected +++ Waiting time (sec) while connecting 012 while connecting Error Detect Error status	
ErrorType = 0x0000100 FyyoyTupe[8]: Admin yoyt fails to establish	Error information when TCP/IP connection failed
> Please check Network parameter or Network	connection
IestPin[31:0] = 0×0010017F IestPin[63:32] = 0×00020004 IestPin[95:64] = 0×00000011 IestPin[127:96] = 0×0000004 Internal TestPin value Please reset system before starting a new to	est

Figure 11 Console Result when TCP/IP Initialization Failed

FPGA Console	
+++ Connect selected +++ Error Detect	
ErrorType = 0x00000401	Error information after failure of connecting with target
ErrorType[0]: Target not found > Please check Target NQN ErrorType[10]: Admin response incorrect s > Completion entry status = 0x8304	status
TestPin[31:0] = 0x0000043F TestPin[63:32] = 0x00000500 TestPin[95:64] = 0x00000011 TestPin[127:96] = 0x00000004	
Please reset system before starting a new	v test

Figure 12 Console Result when Target Connection Failed



3.3 Write Command

Select option '2' from the main menu to perform a write operation to the target NVMe SSD. This command tests the data transfer from host's ability to send Write commands and pattern data over Ethernet, allowing data to be written to the target NVMe SSD.



Figure 13 Test Result of Write Command

User inputs three parameters as follows.

- 1) Start Address: Input the start address where the write operation begins on the target NVMe SSD, specified in 512-byte units. Enter the address in decimal form or use the "0x" prefix for hexadecimal values. Ensure the address aligns to 4 KB (8 x 512 bytes), the fixed data length for each Write command.
- 2) Transfer Length: Input the total size to be written in 512-byte units. Like the start address, this can be entered in decimal or hexadecimal (with "0x" prefix) and must align to 4 KB.
- 3) Test pattern: Choose a data pattern for writing. Available options include 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.

<u>Note</u>: SSDs may exhibit optimal performance with the all-zeros pattern due to data compression algorithms inside the SSD controller.

Upon validating all inputs, the write process commences. The console displays the amount of data transferred every second to indicate the operation's progress. Upon completion, the console displays the total size transferred, total time used, and test speed.



For the incremental, decremental, and LFSR patterns, each 4 KB data block starts with a unique 64-bit header. This header consists of a 48-bit address (in 512-byte units), followed by 16 bits set to zero. The remainder of the data block is filled with the chosen test pattern. Figure 14 and Figure 15 illustrate examples using the 32-bit incremental and LFSR patterns, respectively. The unique header is omitted when using all-zero or all-one patterns.

← 64-bit pattern header of each 4096-byte										
Г	48-1	bit addres	SS	Zero	1	(00 b)	est data	-1-15	٦	
da inda	(512	2-byte un	IT)	value	-	(32-DIT	Increme		01	0.0
ag_1pae	veser	verað	:~\$ S1	100 4	exaum		/nvme	∋ni −n	81	92
0000000	0000	0000	0000	0000	0002	0000	0003	0000		
0000010	0004	0000	0005	0000	0006	0000	0007	0000		
0000020	0008	0000	0009	0000	000a	0000	000b	0000		
0000030	000c	0000	000d	0000	000e	0000	000f	0000		
0000040	0010	0000	0011	0000	0012	0000	0013	0000		
0000050	0014	0000	0015	0000	0016	0000	0017	0000		
0000060	0018	0000	0019	0000	001a	0000	001b	0000		
0000070	001c	0000	001d	0000	001e	0000	001f	0000		
0000080	0020	0000	0021	0000	0022	0000	0023	0000		
The 1st	4006 but	o data								
The T	4090-byt	euala								
0000fc0	03f0	0000	03f1	0000	03f2	0000	03f3	0000		
0000fd0	03f4	0000	03f5	0000	03f6	0000	03f7	0000		
0000fe0	03f8	0000	03f9	0000	03fa	0000	03fb	0000		
0000ff0	03fc	0000	03fd	0000	03fe	0000	03ff	0000		
0001000	0008	0000	0000	0000	0402	0000	0403	0000		1

64-bit header



← 64-bit pattern header of each 4096-byte									
1	48	-bit addre	SS	Zero		T	est data		
	(5)	2-byte u	nit)	value		(32-	DIT LFSR)	1
dg_ipde	v@ser	ver . 8	:~\$ sı	ido 🗛	exdum	p # der	v/nvme	enl −n	8192
0000000	0000	0000	0000	0000	0001	0000	0002	0000	
0000010	0004	0000	0009	0000	0012	0000	0024	0000	
0000020	0049	0000	0092	0000	0124	0000	0249	0000	
0000030	0492	0000	0924	0000	1249	0000	2492	0000	
0000040	4924	0000	9249	0000	2492	0001	4924	0002	
0000050	9249	0004	2492	0009	4924	0012	9249	0024	
0000060	2493	0049	4927	0092	924f	0124	249e	0249	
0000070	493c	0492	9279	0924	24f3	1249	49e7	2492	
0000080	93cf	4924	279e	9249	4f3d	2492	9e7a	4924	
The 1st	4006-buto	data		:					
The T	4030-Dyte	uata		•					
0000fc0	1576	90f4	2aec	21e8	55d8	43d0	abb1	87a0	
0000fd0	5762	0f41	aec4	1e82	5d89	3d05	bb12	7a0a	
0000fe0	7624	f415	ec48	e82a	d891	d055	b123	a0ab	
0000ff0	6247	4157	c48f	82ae	891f	055d	123f	Oabb	
0001000	0008	0000	0000	0000	0011	0000	0022	0000	-
The 2 nd 4096-byte data									

64-bit header

Figure 15 Example Test Data using LFSR Pattern



If any invalid inputs are detected, the console displays an "Invalid input" message, and the operation is cancelled, as depicted in Figure 16.

Recommend message +++ Write Command selected +++ Please input [Start Address] and [Length] in unit of 8 Enter Start Address (512 Byte) : 0 - 0x74706DA8 => 0x4 Invalid input **Unaligned address value** +++ Write Command selected +++ Please input [Start Address] and [Length] in unit of 8 Enter Start Address (512 Byte) : 0 - 0x74706DA8 => 0 : 8 - 0x74706DB0 => 0x14 Enter Length (512 Byte) Invalid input **Unaligned length value** +++ Write Command selected +++ Please input [Start Address] and [Length] in unit of 8 Enter Start Address (512 Byte) : 0 - 0x74706DA8 => 0xFFFFFFFF Invalid input Out-of-range input +++ Write Command selected +++ Please input [Start Address] and [Length] in unit of 8 Invalid input Enter Start Address (512 Byte) : 0 - 0x74706DA8 = nInvalid input +++ Write Command selected +++ Please input [Start Address] and [Length] in unit of 8 : 0 - 0x74706DA8 => 0 : 8 - 0x74706DB0 => 0x4000000 Enter Start Address (512 Byte) Enter Length (512 Byte) Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR=> 5 Invalid input **Out-of-range input**

Figure 16 Error Message from Invalid Input

3.4 Read Command

Select option '3' to initiate a Read operation from the target NVMe SSD. This menu facilitates the testing of read operations by sending a Read command over Ethernet. Following the command, the host awaits the data read from the target NVMe SSD.



Figure 17 Test Result of Read Command using 1-MB Read Buffer Size

FPGA Console	Buffer size = 64 KB	◆ : User Inp◆ : User Out	out Itput
+++ Read Command selected + Please input [Start Address Enter Start Address (512 By Enter Length (512 Byte) Selected Pattern [Ø]Inc32 [443.043 [MB] 906.249 [MB] 1.369 [GB] 33.006 [GB]	++] and [Length] in unit te) : 0 - 0x74706 : 8 - 0x74706 1]Dec32 [2]All_0 [3]A]	of 8 DA8 => 0 DB0 => 0×4000000 1_1 [4]LFSR=> 4	
33.469 [GB] 33.922 [GB]		[Output performance
[otal = 34.359 [GB] ,	Time = 74[s] , Transfe	r speed = 458[MB/s]	Д́ I
Main menu [2] : Write Command [3] : Read Command [4] : Disconnect			

Figure 18 Test Result of Read Command using 64-KB Read Buffer Size

The user inputs three parameters as follows.

- Start Address: Input the start address where the read operation begins on the target NVMe SSD, specified in 512-byte units. Enter the address in decimal form or use the "0x" prefix for hexadecimal values. Ensure the address aligns to 4 KB (8 x 512 bytes), the fixed data length for each Read command.
- 2) Transfer Length: Input the total size to be read in 512-byte units. Like the start address, this can be entered in decimal or hexadecimal (with "0x" prefix) and must align to 4 KB.
- 3) Test pattern: Choose a data pattern to verify the data received from the target. Ensure the test pattern matches the one used during the Write command. Options include 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.

Once all inputs are validated, the read process begins. The console displays the amount of data transferred every second to indicate the operation's progress. Upon completion, the console displays the total size transferred, total time used, and test speed.

According to the NVMeTCP25G-IP specification, read performance may vary depending on the read buffer size. Larger read buffer sizes may enhance read performance, as shown in Figure 17 and Figure 18.

If data verification fails, the console will display an error message, showing the first mismatch in the data, including the error byte address, the expected value, and the actual value received (as shown in Figure 19).

F	PGA Cons	ole		Verification fa	iled	
+++ Ple Ent Ent Sei	+ Read Com ease input ter Start ter Length lected Pat	mand s [Star Addres (512 tern	selected +++ rt Address] ss (512 Byte Byte) [0]Inc32 [1]	+ and [Length] ir 2) : 0 - 0; : 8 - 0; 1Dec32 [2]All_0	unit (74706) (74706) [3]Al:	of 8 0A8 => 0 0B0 => 0x4000000 L_1 [4]LFSR=> 3
Jei 1st Exj Rea	rify fail t Error at pect Data[ad Data[12	Byte 127:0] 7:0]	Addr = 0×00] = 0×FI = 0×00	0000000 FFFFFF_FFFFFF 0000002_00000001	Verifi F_FFFFI L_0000(cation failure message FFFF_FFFFFFF 0000_0000000
	1.382 3.212 5.044	[GB] [GB] [GB]				
	28.542 30.613 32.584	[GB] [GB] [GB]				Output performance
[o1	tal =	34.35	59 [GB] , Ti	ime = 17968[ms]	, Tra	nsfer speed = 1912[MB/s]
[2 [3 [4	- Main men] : Write] : Read C] : Discon	u Commar ommand nect	nd d			

Figure 19 Test Result when Data Verification Failed



3.5 Disconnect Command

Select option '4' to disconnect the host from the target. This menu terminates the connection between the NVMeTCP25G-IP (host) and the target, previously established in Section 3.2 (Connect Command). Upon selecting Disconnect, a confirmation prompt appears on the console. Press 'y' to proceed with the disconnection or any other key to cancel the operation.

[1] : Connect						
Main menu [0] : Set Network Parameter						
Disconnect target successfu	11y					
Press 'y' to confirm : y Press 'y' to confirm						
Are you sure to disconnect the target ?						
LJ] : Kead Command [4] : Disconnect						
[2] : Write Command						
Main menu						
FPGA Console	♦ : User Output					
	I ♦ : User Input					

Figure 20 Result of Disconnect Command

Following a successful disconnection, the message "Disconnect target successful" will be displayed on the console. This indicates that both the TCP/IP and NVMe/TCP connections have been properly terminated.

After disconnecting, the user has the following options:

- Reset network parameters: Use the 'Set Network Parameter' menu to adjust settings or configure a new target.
- Re-establish the connection: Use the 'Connect' command to reconnect with the same target.

<u>Note</u>: When re-connecting the host to the target, be aware of potential limitations on the target system, such as the duration of the TCP/IP "Time-Wait State" and whether "TCP Port Reuse" is enabled on the target side, which may affect re-establishment of the connection.

4 Revision History

Revision	Date (D-M-Y)	Description
2.00	19-Sep-24	Update performance result using 4KB data block
1.00	25-Mar-22	Initial version release