NVMeCraft gui User Guide

NVMeCraft gui

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Getting Started

Welcome to **NVMeCraft gui**.

We hope that using NVMeCraft gui will increase your productivity and enjoyment of NVMe device testing. It was created out of a need to navigate NVMe specification, and to help understand NVMe specification while working and planning.

Key Benefits

NVMeCraft gui's important benefits are:

- It helps to understand the behavior of an existing NVMe windows driver.
- You can quickly navigate NVMe specification and NVMe Device behavior.
- You can find a violation of the NVMe specification.
- You can navigate and edit the admin queue, io queue and data.
- You can submit all commands including VU commands.
- It shows live windows inbox driver behavior.
- It has powerful command and data editing features.
- Dynamic information panels work together to create a productive workflow.
- It is used as part of the test set up required for NVMe compliance testing.

User Interface

This chapter describes the main NVMeCraft gui program window and general information about using different windows available in NVMeCraft gui.

In the screenshot below, the main NVMeCraft gui application window contains the NVMe device explorer at the left, an admin/io queue navigator in the middle, and log output window docked to the bottom side.

☑ NVMeCraft				– Ø ×
NVMeCraft gui 1000	Selected device 4:0.0	Controller Status Admin Queue Data Buffer Pool Ready Ready Ready		
NVMe Devices	a x 4:0.0 A	Admin Queue 4:0.0 I/O SQ #1 ×		
	nd history 🗹 Logging 🔤 📊	I/O Queue #1 🔯 🔯	Follow Doorbell V Auto Command Completion	
Iten Value	A Repair	I/O SQ 1 I Auto Pai	ng I/OCQ 1 Dat	ita 🔚 🚮 Data Patlom User data 🧹 🗖 Intert ed
[SUN] . 19:0.0 V/War				
■ ■ 12/0.5 units ■ ■ Drive 16/0.5 State ■ ■ Drive 16/0.5 State ■ ● Controller legistres 70/0.5 ■ ■ Dorreller 9 ■ ■ 0.6 Wate ■ ■ 0.6 0.6 ■ 10.5 0.6 0.6 ■ 10.5 0.6 0.6 ■ 10.5 0.6 0.6 ■ 10.5 0.6 0.6	And IVVI Express Col dand IVVI Express Col 00000 WRITE OIL READ DOM READ DO	In -0 1 0	A Slot CD SQD SQP PHSE Status □ 1 0	
		Namespace 00000001	SQ Identifier 1 Unit	Data
¢	,	Hetadata Pointer 000000000000000 Right-c PAP Entry 1 00000001FF040000 Right-c Command Duord 10 00000000 C		
Command History		\$ x	Dutput	ů ×
Command History		CLEAR	Output Show output from: Al Devices 🗸 🗸	Auto Scrol CLEAR
Q1D Command 1 Read 00 COW0 NSD Deta Size COW1 1 2 J.2 J.2 J.2 Deta Size COW1000000 D0000000 D000000 D0		⊖ CDAR — CDD — PSDT — FUSE — oper	41.0. PC CQMDDL = 6, 514tus : Successful Completion 41.0. PC (71.100K = 00000001 41.0. PC (71.100K = 0000001 41.0. PC (71.100K = 0000001 41.0. PC (700K = 0.514tus : Successful Completion 41.0. PC (700K = 0.514tus : Successful Completion 41.0. PC (700K = 0.514tus : Successful Completion 41.0. PC (700K = 1, 100K = 1, 100K = 0.514K =	

Selected device	Controller Status	Admin Queue	Data Buffer Pool
27:0.0	Ready	Ready	Ready

The top status bar shows the current status of NVMeCraft's resources.

[Selected device] is the current device.

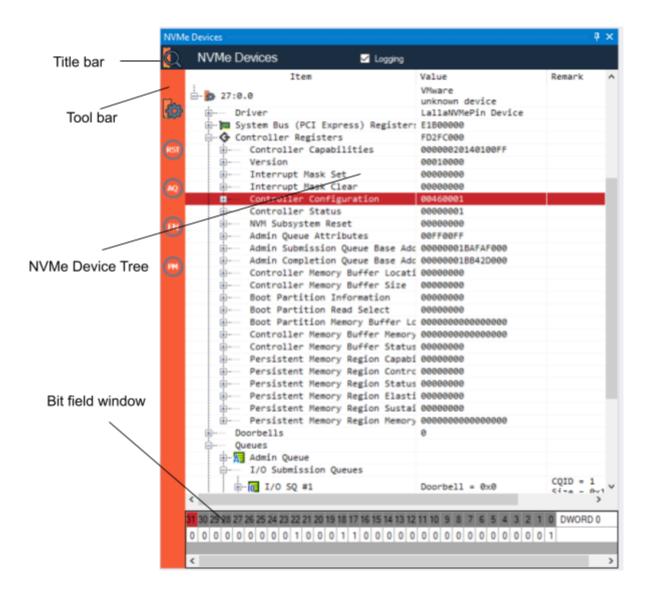
[Controller Status] indicates the value of the Ctrl.CSTS.RDY bit.

[Admin Queue] indicates the status of the admin queue pair. It just checks the AQA, ACQ, ASQ register of the controller, and does not guarantee the integrity of the admin queue pair.

[Data Buffer Pool] indicates the status of internal buffer. NVMeCraft gui prepares 32 X 2M bytes memory buffer for internal data operations.

If you want to quickly check the functions, please go to the link.

NVMe Device Explorer



NVMe Device Explorer appears at the left side of NVMeCraft gui. The NVMe Device Explorer lists all the NVMe devices installed in the system to allow easy navigation within each NVMe device, and to provide a quick access of the NVMe device. It can list the NVMe device with its own driver but also Windows inbox driver. The NVMe Device Explorer displays PCI Header, Controller Registers, Doorbells, Admin/IO Queues, and persistent memory that the user grabs. The items with an icon are interactive by double click.

Title bar

The Title bar has the title and logging checkbox. The logging checkbox can allow logging the output message from the user select device. The logging file is named with the following format. [guiLogyyyymmdd.txt] And, saved in the [LogOutput] folder.

Tool bar

The Toolbar contains the basic functions to operate NVMe Device. If the NVMe Device is grabbed by the inbox driver, Toolbar is not available.



NVMe Device Setup - Initialization to admin queue and io queue.



Reset - Reset NVMe Controller internally CC.EN to 0.

Create Admin Queue Pair - Setup the Admin Queue pair. It is activated when the NVMe Device is not ready.



Enable Controller - Enable the NVMe Controller internally CC.EN to 1.

Allocate a persistent memory - Allocate a persistent memory. It can be used in the admin queue, io queue, the Controller Memory Buffer and where the user wants to use.

NVMe Device Tree

The NVMe Device Tree displays all NVMe device resources. And, If the device is grabbed by its own driver, the user can access the resources by editing value. The node with an icon is interactive with double click.

📜 System Bus (PCI Express) Registers

- It displays the hex data of the PCI header.
- Controller Registers
 - It displays the hex data of the NVMe controller registers.
- 🚰 Admin Queue
 - It displays the details of admin queue
- 🚺 I/O SQ #1
 - It displays the details of the io queue.

·📟 PM#1

- It displays the hex data of the user allocated memory.

Bit field window

It parses the PCI Header and controller registers and displays the bit-fields.

Admin Queue Explorer

	Submit or	ne Command	Title ba	ar			
27:00 Admin 0	344						
Adm	iin Quese	🔳 🏩 🖬 🖩	Auto Command Completi				
	ASQ, DB: A		S Ado Paining AD	Q. D6: A		Data 📄 🔛	
2007 0000020h 000002h 000002h 000002h 000002h 000000h 000000h 000000h 000001h 00000000	Nation Control 20- Maria 0	Set Perfarms Creats 1/0 Completion Que Creats 1/0 Completion Que Creats 1/0 Completion Que Creats 1/0 Completion Que Creats 1/0 Subdistion Que Creat		nda	screwing Competing Secrewing Competing		
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Admin Commands bar

Admin Queue Explorer appears in the middle of NVMeCraft gui. It can be docked to any edge of the main application window. Admin command bar and Data Hex Editor are available with its own driver. It is activated by a double click R Admin Queue node.

Title bar

The Title bar has the title and some functional buttons.



Goto current doorbell - Move the cursor to the current doorbell slot.

Open/Hide Data Hex Editor - Open and hide the data hex editor that can edit the data of admin commands.

Create IO Queues - It can submit the commands set to create IO Queue pairs.

Scan Admin Queue - It scans the admin submission queue to enumerate the IO Queues it has already submitted. It scans the admin queue from slot 0 to the current doorbell.

Auto Command Completion Auto Command Completion - NVMeCraft gui can atomically control the NVMe device. It is a complex job and it makes it a little easier.

Admin Command Bar

The Admin Command Bar has the Submit One Command button and several admin command configuration buttons.



Submit a command - It can submit an admin command of the current doorbell.

ID 06h Several admin command configuration buttons - Users can configure the current admin command following NVMe specification.

Admin Submission Queue and Completion Queue

It displays the admin submission/completion queue in live.

Auto Pairing Auto Pairing - According to the CID of the admin command, pairing the completion entry.

ASQ Entry Details

It displays and edits the selected admin command. Users can access all the fields of the entry.

Data Hex Editor

It displays and edits the data of the admin submission entry. It supports only prp data.

Open binary data - Open a binary data and update the prp data of ASQE.

Save binary data - Save the binary data of ASQE to a binary data file.

IO Queue Explorer

	bar										
/050#1 UO Queue #1	a 🗯	5 A & Com	mand Completion								
1050 1	<u> </u>		10 CQ				Data				_
Slot CID	Command Startin		Slat CI		P PakSI	Status Code		50 01 07 01			
G- 1/0 SQ	Command Startin		- 1/0 CQ	9 SQ10 SQ14	P PRAL	Statut Code A	00000000	33 CO BE DO		CD BE DB BI	
- 0 0	Read 000000000	000 000	- 1 1	1 1	1 500	esoful Complet	00000010	06 89 00 02 BD BE D7 80	FC F3 A4 50 7E 00 00 70	68 1C 06 C	
x6 - 🗘 1 🛛 0			-41				00000030	E2 F1 CD 18	88 56 00 55	C6 46 11 05	5 C8 46 10
uh - 3 0				: :			00000040	F7 C1 01 00	74 03 FE 44	10 66 60 80	7E 10 00
- 4 0			- 4 9				00000000	26 66 68 00 70 68 01 00	60 00 00 64 68 10 00 84		
			- 5 0				00000000	9F 83 C4 10	9E EB 14 BI	01 02 88 00	7C 8A 56
en #							00000000	4E 11 75 00	4E 02 8A 68 80 7E 00 80	03 CD 13 66 0F 84 8A 00	
A - 8 0							0000000	55 32 84 84 AA 76 6E FE	56 00 CD 13 76 00 E8 81	5D EB 5E 81 00 76 17 F/	
			- 1 - 1				00000000	E 11 10 10	DF E6 60 E1	70 00 00 01	E6 64 E
	mission Queu	16	10	Complet	ion Que	eue	00000E0 00000FD	:: IO E	Data He	x Edito	66 81 Fi
- C 8			C 0				00000100	00 66 68 00 53 66 55 66	02 00 00 64 68 00 00 00	68 08 00 00 00 66 60 00	0 00 66 53
D 0			- 0 0				00000120		07 CD 1A 54	32 F6 EA 00	70 00 00
5 - E 0				: :			00000130	18 A0 87 07	EB 08 A0 B4	07 EB 03 A0	
10 0			20 0				00000150	10 EB F2 F4	EB FD 28 C	E4 64 E8 D0	3 24 02 E
11 0			- 13 4				00000160	24 02 C3 45 74 69 65 65		65 64 20 70 6C 65 00 41	
- 12 0			12 0	: :			00000180	20 60 67 61 61	64 69 62 67 79 73 74 65	20 67 70 65	
14 0			14 0				00000190	67 20 6# 70	65 72 61 74	65 68 67 20	
15 0			- 15 0				00000100	65 60 00 00 21 00 07 Pt			C 00 00 0
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		~	17 4	: :			00000100	00 00 00 00	00 00 00 00		
(> 4									
I/O SQ Entry			UO CQ Entry								
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Command Deord		· ·	- Phase To								

IO Commands Bar

IO Queue Explorer appears in the middle of NVMeCraft gui. It can be docked to any edge of the main application window. The IO command bar and Data Hex Editor are available with its own driver. It is activated by a double click is I/O SQ #1 node.

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It displays and edits the data of the IO submission entry. It supports only prp data.

We open binary data - Open a binary data and update the prp data of IO SQE.

Save binary data - Save the binary data of IO SQE to a binary data file.

Log Output

	Title	Bar	Output ma	in window		
Outpu	4	/	/			×
	Output	Show output from:	Al Devices	~	🗹 Auto Scroll	CLEAR
	27:0.0 Write, 27:0.0 Write,	CQ0HDBL, Value : 0 SQ0TDBL, Value : 0 Ctrl - INTMC, Valu SQ0TDBL, Value : 0	00050000 00460000 00FF00FF 00FF00FF Value - 0000001 Value - 0000001 Value - 0000001 00460001 0000001, Opcode 00000001, Status 00000001, Status 00000001, Status 00000001, Status)ueue	<

Title bar

The Title bar has the title and some functional buttons.

Show output from: All Devices

Show output from - User can select the NVMe

device which outputs the message.

Auto Scroll - Follow the tail message.

(CLEAR) Clear - Clear all messages from the window. But, The messages are saved in a log file.

Output main windows

It is limited to 100 lines. You can confirm the full output message with the log file in LogOutput directory.

Command History

		y Window	Run Commar	nd Comm	and Detail	
mand History						····· Ø
Command	History					CLEAR
Q1D	Command	Oata Size	Status code	Item B- SQE	Value	
1	Read	512	Successful Completion Successful Completion	©- CDMB	0000002	
1	Read	512	Successful Completion	- CID - PSDT		
1	Read	512	Successful Completion	- FUSE	0	
1	Read	512	Successful Completion	- OPC	2 00000001	
1	Read	512	Successful Completion	- Data Pointer		
1	Read	512	Successful Completion	- Data Size	200	
1	Read	512	Successful Completion	- CDN11	00000000	
1	Read	517	Successful Completion	- CDN12	0000000	
1	Read	1/2	Successful Completion	CDN13 CDN14	0000000	
QID CDW0	NSID Data Size CDW1	10 COW1 COW1	2 CDW13 CDW14 CDW15	CDV15	0000000	
1, 2, 1, 20	0, 0, 0, 0, 0, 0, 0	· · · ·				

Command History Windows

Shows the most recently executed READ/WRITE IO commands.(The record depth is 10.) The upper item was most recently run. You can select an item to execute a command.

Run Command

Type [ENTER] key in this edit box to submit a command.

Usage Example

NVMe Device Configuration

There are three NVMe devices in the PC.

					Х
Ν	1VI	Ne C	raft gui1	v1.0.00	
N	VMe	Device	es	You can select 1 LallaNVMe device and 1 device of inbox driver.	
		4:0.0	NVMe SSD Controller	LallaNVMePin Device	
\checkmark	OS	19:0.0	NVMe SSD Controller	Standard NVM Express Controller	
\checkmark		27:0.0	NVMe SSD Controller	LallaNVMePin Device	
				OK Cancel	

2 LallaNVMePin device - 4:0.0, 27:0.0

1 Inbox driver device including OS - 19:0.0

*** You can get the LallaNVMePin device by updating the driver to LallaNVMePin driver. Refer to the <u>"Update driver to LallaNVMePin"</u>.

Select the target device you want to test.

I selected two devices, one is an inbox driver device(19:0.0) and the other is LallaNVMe driver device(27:0.0).

Item	Value	Remark
⊟ 19:0.0	NVMe SSD Controller	System Disk
🛓 Driver	Standard NVM Express Co	
🖭 🏣 System Bus (PCI Expres	E1300000	
🗄 🗘 🗘 Controller Registers	FDA00000	
Doorbells	0	
🗄 Queues		
⊟… 🌆 27:0.0	NVMe SSD Controller	
🗄 Driver	LallaNVMePin Device	
🛓 🏣 System Bus (PCI Expres	E1B00000	
🗄 🔆 Controller Registers	FD2FC000	
Doorbells	0	
Queues		
Permanent Memories		

Select the LallaNVMePin device(27:0.0). and check the status of the selected NVMe device.

Selected device	Controller Status	Admin Queue	Data Buffer Pool
27:0.0	Not Ready	Not Ready	Ready

If [Data Buffer Pool] is not ready, you will need to reboot your PC.

_	
Controller Status	00000000
Processing Paused	0
NVM Subsystem Reset Occur	0
Shutdown Status	0
Controller Fatal Status	0
Ready	0

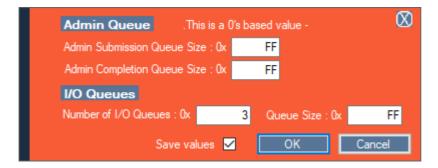
[Controller Status] is not ready because Ctrl.CSTS.RDY is zero.

	-	
÷	Admin Queue Attributes	00000000
÷	Admin Submission Queue Base .	0000000000000000
÷	Admin Completion Queue Base .	0000000000000000

The registers related to the admin queue are zero. And you can see the status of [Admin Queue].

Setup the admin and io Queues

Click the 🔯 [Setup NVMe Device] button or double click b the root node of NVMe device tree to initialize the NVMe device.



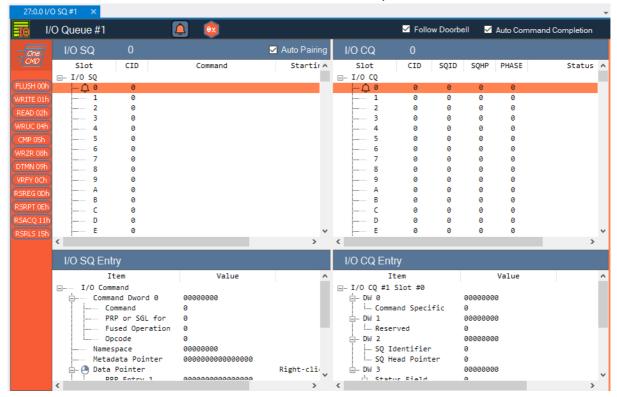
Fill the proper values of the dialog box. refer to the NVMe specification sheet. And, click [OK] button.

Queues	
🚊 📈 🚰 Admin Queue	
Submission Queue	Doorbell = 0x9
Completion Queue	Doorbell = 0x9
I/O Submission Queues	
	Doorbell = 0x0
i I/O Completion Queues	
	Doorbell = 0x0

You can confirm the IO Queues you created.

Read data LBA 0, Sector count 1.

Double click an IO Node to open the IO Queue explorer.



If you Click the READ 02h button, you can see the [Read command] dialog as below.

Read command							\otimes
Metadata Pointer (MPTR) :	0x	0					
Data Pointer (DPTR) 🗹	Size in Byte : 0x	2	200				
Starting LBA (SLBA) : 0x		0					
Limited Retry (LR) 📃 F	orce Unit Access (FL	A) 📃 Protectio	on Information Field (PF	RINFO) : 0x 0	Number of L	ogical Blocks (NLB) : 0x	0
Dataset Management (DSI	M) : 0x 0 Inc	ompressible	Sequential Request	Access Latency	~	Access Frequency	0
Expected Initial Logical Blo	ock Reference Tag (B	ILBRT) : Ox	0				
Expected Logical Block Ap	oplication Tag Mask (ELBATM) : 0x	0 Exp	ected Logical Block	Application Ta	ig (ELBAT) : Ox	0
						ОК	Cancel

Fill the proper values, refer to the NVMe specification. In this case, [Starting LBA] is 0, and the [NLB] is 0. NLB = 0 means sector count is 1, data byte size is 512(0x200). Click the [OK] button.

□ I/O Command □ Command Dword 0 □ PRP or SGL for □ Fused Operation 0 Opcode Namespace □ Metadata Pointer □ Data Pointer □ PRP Entry 1 PRP Entry 2	00000002 0 0 2 00000000 00000000000000	You can confirm the values are filled.
Command Dword 10 Command Dword 11 Command Dword 12 Command Dword 13 Command Dword 14 Command Dword 15	0000000 0000000 0000000 0000000 0000000	Typically, NVMe SSD has only one namespace. You need to indicate proper namespace you will use.

On the value field of [Namespace] node Namespace If you select the value field of [Namespace] and click again, you can update the value. Type in "1" to use namespace 1.



Confirm the complete queue. and the data from the target SSD.

Click 🔯 button to check the data.

Update driver to LallaNVMePin

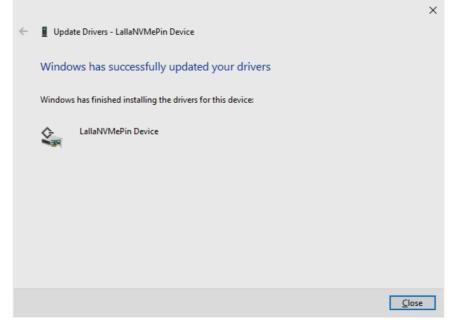
You need to update the NVMe device driver to LallaNVMePin on Windows Device Manager. You have to make sure the target NVMe device is not a primary disk, it includes an OS.

1. Select target NVMe device.

[Device Manager]

- 🗸 🍇 Storage controllers
 - Standard NVM Express Controller
 - landard NVM Express Controller
- 2. Right click and click [Update driver].
- Click → Browse my computer for drivers , on popup dialog. Locate and install a driver manually.
- Click → Let me pick from a list of available drivers on my computer This list will show available drivers compatible with the device, and all drivers in the same category as the device.
- 5. Click Have Disk... button, and Browse... button.

- 6. Select [LallaNVMePin.inf] in LallaNVMePin folder, and click [OK].
- 7. Click Next button.
- 8. Wait for a second.
- 9. You can see the shown below dialog, and clic [Close] button.



10. Reboot.

Examples of Operations

Setup the admin and io Queues

Select the NVMe device which is grabbed by the Lallasoft own driver

- 1. Click the souther the NVMe Device explorer.
- 2. Fill the values below the dialog. And click [OK].

Admin Queue .This is a 0	's based value - 🛛 🖸
Admin Submission Queue Size : 0x	FF
Admin Completion Queue Size : 0x	FF
I/O Queues	
Number of I/O Queues : 0x	3 Queue Size : 0x FF
Save values 🔽	OK Cancel

If the [Save values] is checked, the values are permanently saved as system parameters.

- 3. Users can confirm the created admin/io queue in the NVMe device tree and the log output.
- 4. Log output

```
27:0.0> SQOTDBL = 1, Opcode: Set Features
27:0.0> CQ0HDBL = 1, Status : Successful Completion
27:0.0> SQ0TDBL = 2, Opcode: Create IO Completion Queue
27:0.0> SQOTDBL = 3, Opcode: Create IO Completion Queue
27:0.0> SQ0TDBL = 4, Opcode: Create_IO_Completion_Queue
27:0.0> SQ0TDBL = 5, Opcode: Create_IO_Completion_Queue
27:0.0> SQ0TDBL = 6, Opcode: Create_IO_Submission_Queue
27:0.0> SQ0TDBL = 7, Opcode: Create_IO_Submission_Queue
27:0.0> SQ0TDBL = 8, Opcode: Create_IO_Submission_Queue
27:0.0> SQ0TDBL = 9, Opcode: Create IO Submission Queue
27:0.0> CQ0HDBL = 2, Status : Successful Completion
27:0.0> CQ0HDBL = 3, Status : Successful Completion
27:0.0> CQ0HDBL = 4, Status : Successful Completion
27:0.0> CQ0HDBL = 5, Status : Successful Completion
27:0.0> CQ0HDBL = 6, Status : Successful Completion
27:0.0> CQ0HDBL = 7, Status : Successful Completion
27:0.0> CQ0HDBL = 8, Status : Successful Completion
27:0.0> CQ0HDBL = 9, Status : Successful Completion
```

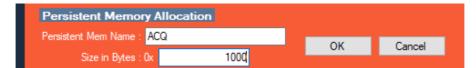
5.		0	0	Set Features			
		1	1	Create	I/0	Completion	Queue
		2	2	Create	I/0	Completion	Queue
		3	3	Create	I/0	Completion	Queue
		4	4	Create	I/0	Completion	Queue
		5	5	Create	I/0	Submission	Queue
		6	6	Create	I/0	Submission	Queue
		7	7	Create	I/0	Submission	Queue
		8	8	Create	I/0	Submission	Queue
	· 🋕	9	0	empty			

Manually setup the admin queue

- 1. Select the NVMe device which is grabbed by the Lallasoft own driver.
- 2. Reset the NVMe device with writing 0 to Ctrl.CC.EN. And wait until Ctrl.CSTA.RDY to 0.
- Allocate a persistent memory for ASQ. The size is 0x4000 = 0x100(ASQ size) X 0x40(ASQE size)

Persistent Memory Alloca	ation		
Persistent Mem Name : ASQ		OK	Cancel
Size in Bytes : 0x	4000	OK	Cancer

 Allocate a persistent memory for ACQ. The size of 0x1000 = 0x100(ACQ size) X 0x10(ACQE size)



- 5. Copy the addresses of ASQ and ACQ to Ctrl.ASQ and Ctrl.ACQ registers.
- 6. Write the Ctrl.CC.IOCQES to 4. And the Ctrl.CC.IOSQES to 6.
- 7. Write the Ctrl.AQA.ACQS to 0xFF. And the Ctrl.AQA.ASQS to 0xFF.
- 8. Finally, Set the Ctrl.CC.EN to 1. And Wait until Ctrl.CSTS.RDY to 1.

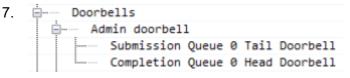
Please pay the careful to allocate the memories, It would be the cause of system crash.

Manually submit an admin command (Identify 06h)

- 1. Uncheck the [Auto Command Completion] on the title bar of Admin Queue Window.
- 2. Select the admin submission queue entry of the current doorbell.
- 3. Write the opcode and CID with correct value in the ASQE panel. (OPC 0x06)
- 4. Allocate the prp data for the command with right click on the PRP node of ASQE panel..

Data Memory A	llocation		
Size in bytes : 0x	1000 📃 Persistent	OK	Cancel

- 5. Ring ASQ doorbell with writing the proper value.
- 6. Check the completion queue entry from the device. And, write ACQ doorbell with the correct value.



8. Write Ctrl.IVMC to 1 to clear the interrupt.(right click on the IVMC node, and click [Write])