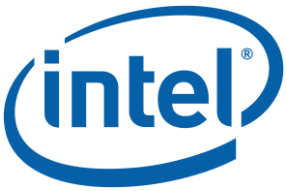


Intel® Optane™ Persistent Memory Module

300 Series DSM Interface

Revision V3.0

October, 2022

The following changes will make up the publicly released DSM V3.0 specification available on http://pmem.io/documents/
These changes are specific to the FIS 3.2 specification for the PMem Module 300 series product.

- *PCD Error Inject*
  - *New DSM to allow injecting errors in to PCD region 2, Label Storage Area*
- *Master Passphrase*
  - *Clarify when Master Passphrase Enabled in Get Security State will be set to 1*
  - *Clarify when commands will be rejected if Master Passphrase is still set to default*

Notices

Contents

Contents

1 Introduction

1.1 Document Scope

This document is targeted to writers of BIOS and OS drivers for NVDIMMs whose design adheres to the NFIT Tables in the ACPI V6.2 specification. This document specifically discusses the NVDIMM Device Specific Method (_DSM).

1.2 Related Documents

The related documents are:

- ACPI Specification Version 6.0, 6.1 & 6.2, 6.2 Errata A (http://www.uefi.org/specifications)
- UEFI 2.7, 2.7 Errata A - NVDIMM Label Protocol, UEFI 2.7 NVDIMM BTT Layout (http://www.uefi.org/specifications)
- This DSM Specification (http://pmem.io/documents)

1.3 Terminology

Refer to Table 1-1 for definitions of terms used in this document.

Table 1-1 – Terminology

Term	Description
Intel® Optane™ Persistent Memory Module or PMem Module or NVDIMM	The non-volatile DDR DIMM form factor byte addressable PMEM. Also referred to throughout this specification as the NVDIMM or PMem Module.
NFIT	The NVDIMM Firmware Interface Table defines the ACPI 6.2 specified information created by the BIOS to inform the OS about NVDIMMs in the system.
NVDIMM	Non-volatile memory in a DIMM form factor. See PMem Module above.
NVDIMM Namespace Label	Labels, stored at a known location on NVDIMMs, which define the DIMM's contribution to NVDIMM Namespaces. This is a software mechanism; the DIMM itself just sees the labels as part of the overall data stored on the DIMM. See the ACPI 6.2 NVDIMM Label additions and the UEFI 2.7 NVDIMM Label Protocol additions to describe this in more detail.
NVDIMM Namespace	Similar to an NVMe Namespace or a Logical Unit (LUN) on a SCSI disk, this is a software mechanism for managing ranges of persistence on NVDIMMs. See the ACPI 6.2 NVDIMM Label additions, and the UEFI 2.7 NVDIMM Label Protocol additions to describe this in more detail.

Term	**Description**
Persistent Memory	Byte-addressable memory that retains its contents after power loss.
SPA	System Physical Address. A physical address on the host operating system.

2 _DSM Interface for NVDIMM ACPI0012 Root Device

This root _DSMs defined in this chapter enables interfacing on group of NVDIMMs under the root device whereas the _DSMs defined in chapter 3 enables interfacing with specific NVDIMM.

2.1 ACPI0012 NVDIMM Root Device _DSM

This section defines a NVDIMM Root Device _DSM associated with _HID of ACPI0012 in ACPI name space hierarchy.

The following tables outlines the required Arg1, Arg2 parameters that are to be utilized for this version of the specification. The platform shall support the Arg1 - Revision Id = 1 as outlined below. No other Arg1 - Revision Id values are supported at this time.

Arg0 – UUID - *c7d8acd4-2df8-4b82-9f65-a325335af149*

Table 2-A Supported Function Index for Arg1 - Revision Id = 1

Arg1 - Revision Id	Arg2 – Function Index	_DSM Function Name
1	0	*Query implemented commands per ACPI Specification (returns the list below based on Arg1 - Revision Id = 1).*
	1	*Get Devices Runtime FW Activation Info*
	2	*Activate Firmware*

Arg3 – A package containing parameters for the function specified by the UUID, Revision ID, and Function Index. Refer to chapter 3 for detailed description.

Table 2-1 NVDIMM Root Device DSM Return Codes

Return Status Value - Bytes[1-0]	Return Status Value - Description
0	*Success*
1	*Failure - Function Not Supported*

2	*Failure - Invalid Input Parameters*
3	*Failure – HW Error*
4	*Failure – Retry Suggested*
5	*Failure – Unknown Reason*
6	*Function Specific Error (details in Extended Status Field)*

2.2 Runtime FW Activation for NVDIMM ACPI0012 Root Device

2.2.1 Runtime FW Activation – Theory of Operation

NVDIMM devices utilizes firmware to carryout various initialization and runtime operation. After product qualification and deployment, often security and bug fixes are addressed through firmware change. To upgrade NVDIMM firmware, a system or NVDIMM reset may be required, which could result in long service down time. In order to reduce the downtime, runtime (without system reboot) activation of firmware is introduced.

Child device _DSM function index 12-16 provides a mechanism to download new firmware to the NVDIMM. If activating new firmware at runtime requires pausing host memory access, the OS needs to understand the timing information and should prepare itself before host memory access is paused and new NVDIMM firmware is activated. If the platform firmware is not capable of pausing memory traffic for estimated amount of time, OS may need to prepare itself to pause I/O memory traffic and give control to the platform firmware to active new NVDIMM firmware. If NVDIMM firmware is activated one at a time, then total estimated time to activate new firmware on system would be total number of NVDIMM in the system times the estimated activation time per NVDIMM. This may not be tolerable for some OS services, hence activating NVDIMM firmware in parallel may be preferred to reduce service interruption time. The NVDIMM root level _DSMs help in activating the NVDIMM firmware in parallel if possible.

If I/O devices need to be quiesced during firmware activation, the following options could be considered:

- Live activation if platform firmware is capable of performing pausing I/O and processor access to host memory and activating new NVDIMM firmware.
- Live activation if OS can disable device bus mastering capability to host memory, and if platform firmware can pause processor access to host memory and activate new NVDIMM firmware
- Warm reset based activation - if platform can support NVDIMM firmware activation during warm reset and OS can tolerate warm reset. In this case, I/O devices are going through reset resulting in naturally stopping the I/O device access to host memory.
- System reset based activation – System reset causes activation of NVDIMM firmware.

The first three options require platform firmware assistance in addition to OS assistance and the NVDIMMs need to be armed in order to activate the firmware. The platform firmware activation capability available through root "Get Devices Runtime FW Activation Info" DSM call.

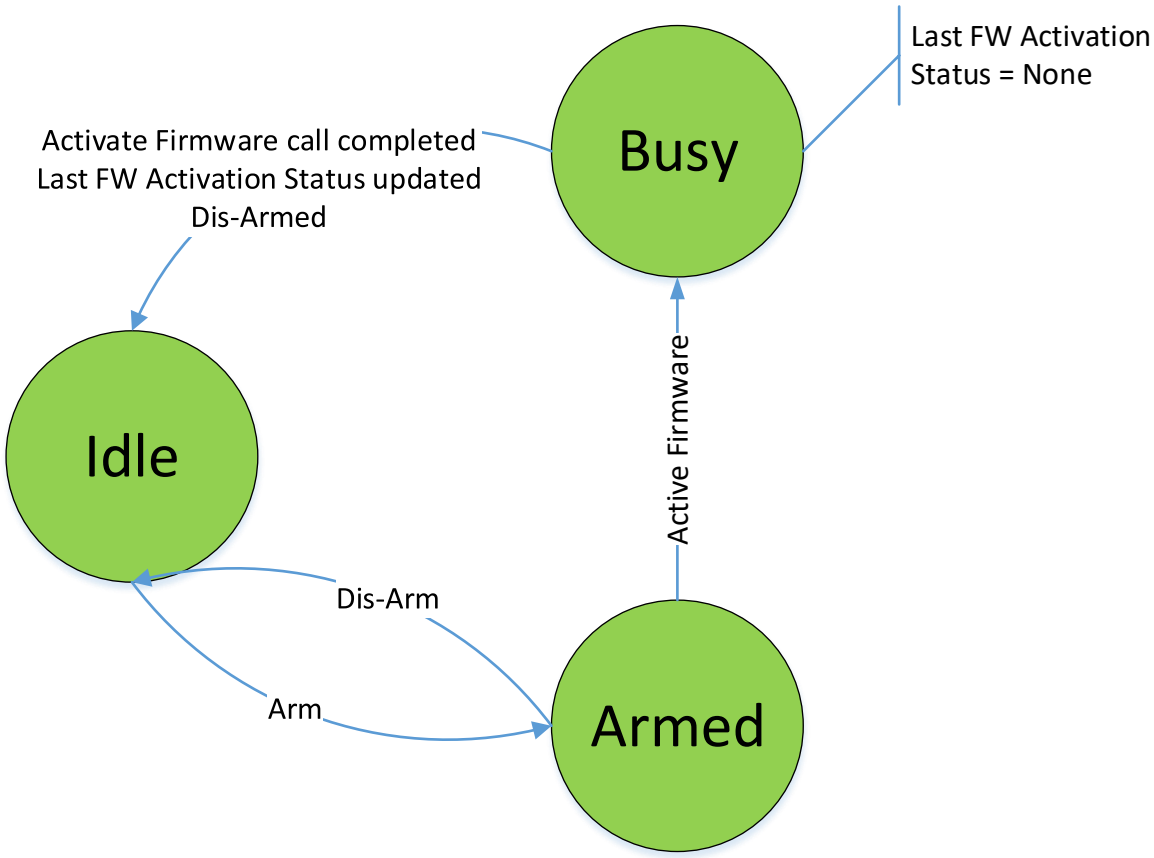
The following sequence provides example steps to activate a new firmware:

- Download new firmware to NVDIMMs using child device _DSM function index 12-16
- Check if platform supports runtime firmware activation by calling "Get Devices Runtime FW Activation Info" and checking FW Activation Capability field. If individual DIMMs support runtime FW activation or shutdown required to activation the firmware can be retrieved through "Get FW Info" FW Update Capability field.
- Arm NVDIMMs using child "Set Device Runtime FW Activation Arm State" function (optionally arming and getting estimated time could be done before downloading the firmware).
- Get estimated times using root "Get Devices Runtime FW Activation Info"
    - Estimated time may vary depending on which NVDIMMs are Armed.
    - The estimated timing provides estimated firmware activation time, estimated processor quiesce time during firmware activation and estimated I/O quiesce time during firmware activation. Note that the estimated activation time includes the processor and I/O quiesce time, the processor quiesce time includes the I/O quiesce time. Note that if a DIMM requires I/O or processor quiesce during FW activation can be retrieved through "Get FW Info" FW Update Capability field.
    - If the Estimated I/O quiesce time is more than Platform supported Max I/O quiesce time, dis-arm some DIMMs and re-evaluate. If none are below Platform Max I/O quiesce time, Live activation is not possible.
- Get FW Activation Capability using root "Get Devices Runtime FW Activation Info".
- Prepare OS to invoke platform firmware to activate new NVDIMM firmware.
    - If FW Activation Capability indicates "live activation supported with platform firmware managed processor and I/O quiesce" and if OS can tolerate estimated timing
        - OS to complete any pending PMem module mailbox accesses
        - Call root "Activate Firmware" to activate firmware on the Armed NVDIMMs
        - Wait for "FW Activation State" become Idle by polling root "Get Devices Runtime FW Activation Info" method

        - Determine firmware activation by calling “Get Devices Runtime FW Activation Info” on each Armed NVDIMM child method and checking “Last FW Activation Status”
    - If FW Activation Capability indicates “live activation supported with OS managed I/O quiesce (device idle) and platform managed processor quiesce” and OS can bring I/O devices to idle
        - OS to complete any pending PMem module mailbox accesses
        - Place I/O devices in idle state (complete all existing bus mastering/DMA cycles and stop initiating new bus mastering/DMA cycles by I/O devices)
        - Call root “Activate Firmware” to activate firmware on the Armed NVDIMMs
        - Wait for “FW Activation State” become Idle by polling root “Get Devices Runtime FW Activation Info” method
        - Determine firmware activation by calling “Get Devices Runtime FW Activation Info” on each Armed NVDIMM child method and checking “Last FW Activation Status”
        - Once the firmware activation is completed, OS to bring back I/O devices to normal operational state
    - If FW Activation Capability indicates “warm reset-based activation supported” and OS can tolerate warm reset
        - OS to prepare for warm reset
        - Invoke warm reset
        - Platform firmware activates the NVDIMM during warm reset flow
        - When OS is reloaded, the new NVDIMM firmware is in use
    - If none of the above conditions are possible, system reset is required to activate the firmware
    - On system reset, staged firmware is activated regardless of Arm state.

The Figure 1 shows the firmware activation state transitions.

Figure 1 FW Activation State transitions



Runtime firmware activation is an optional feature. If supported, the platform shall implement:

- Root _DSM functions:
  - Get Devices Runtime FW Activation Info
  - Activate Firmware
- Child _DSM functions:
  - Get Device Runtime FW Activation Status
  - Set Device Runtime FW Activation Arm State

2.2.2 Get Devices Runtime FW Activation Info (Function Index 1)

If the platform provides runtime firmware activation support for NVDIMMs, this function provides related information that is aggregate of all the armed NVDIMM devices. The software shall meet the requirements provided in this function before activating new firmware during runtime. If multiple NVDIMMs are armed, this function provides aggregate (not addition of individual NVDIMMs estimated times) at the platform firmware level. For individual NVDIMM firmware activation success/failure info, the software shall query each NVDIMM through child NVDIMM _DSM.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 2-2 Get Devices Runtime FW Activation Info – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined in above Table 2-1
Extended Status	2	2	Extended Status Field Undefined
Reserved	2	4	Shall return 0
FW Activation State	1	6	0 – Idle 1 – Armed 2 – Busy Note: If any one of the NVDIMM is Armed, the state before Armed. The state become Busy when “Activate Firmware” is called. Once the “Activate Firmware” completes the state become Idle.
FW Activation Capability	1	7	Bit[0] – 1 indicates, live activation supported with platform firmware managed processor and I/O quiesce

			Bit[1] – 1 indicates, live activation supported with OS managed I/O quiesce (device idle) and platform managed processor quiesce Bit[2] – 1 indicates, warm reset-based activation supported Bits[7:3] – Reserved – shall be 0 Note: Cold reset activates new firmware if not activated before
Following fields are valid only if the FW Activation State is Armed			
Estimated FW Activation Time	8	8	Estimated FW activation time in micro seconds
Estimated Processor Quiesce Time for FW Activation	8	16	Estimated processor quiesce time during FW activation in micro seconds. 0 – no processor quiesce required Note: Estimated FW Activation Time includes the Estimated Processor Quiesce Time.
Estimated I/O Access to Memory Quiesce Time for FW Activation	8	24	Estimated I/O access to host memory quiesce time during FW activation in micro seconds. 0 – no I/O quiesce required Note: Estimated Processor Quiesce Time includes Estimated I/O Access to Memory Quiesce Time. This implies when I/O is quiesced, processor is also quiesced.
Platform FW Supported Max I/O Access to Memory Quiesce Time	8	32	Platform FW Supported Max I/O Access to Memory Quiesce Time during FW activation in micro seconds 0 – information not available Note: If Platform FW Supported Max I/O Access to Memory Quiesce Time is less than Estimated I/O Access to Memory Quiesce Time, then dis-arm some DIMMs

			and re-evaluate to check if the platform can meet timing requirement for live activation.

2.2.3 Activate Firmware (Function Index 2)

This function initiates activation of new firmware on armed NVDIMM devices. Once this function completes successfully, “FW Activation State” in “Get Devices Runtime FW Activation Info” provides the aggregate of NVDIMMs firmware activation state. For understanding individual NVDIMMs firmware activation success/failure info, refer to “Last FW Activation Status” in “Get Device Runtime FW Activation Status” of NVDIMM.

Before calling the Activate Firmware call, the OSPM shall check the “Get Devices Runtime FW Activation Info” and determine the estimated times and platform firmware support for firmware activation. Based on the information, OSPM shall determine the OS preparation requirement and prepare OS and “Activate Firmware” with indication of I/O Device State.

Once this call completes, all NVDIMM devices are dis-armed and the “FW Activation State” are set Idle.

Function Input

The following tables outline the expected input payload for this command.

Table 2-3 Activate Firmware – Input Format

Field	Byte Length	Byte Offset	Description
I/O Device State	1	0	0 – Platform firmware managed I/O and processor quiesce 1 – OS managed I/O quiesce and platform firmware managed processor quiesce

Function Output

The following tables outline the expected output payload for this command.

Table 2-4 Activate Firmware – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined in above Table 2-1
Extended Status	2	2	Extended Status Field 01 – No armed devices are available to activate firmware 02 – One or more armed devices failed to activate firmware (query armed devices' Get Device Runtime FW Activation Status for more information) 03 – No new firmware found to activate on any of the armed NVDIMM 04 – Unable to meet memory quiesce timing requirements, firmware activation is not submitted to the NVDIMMs 05 – Unable to verify I/O devices are in idle state, firmware activation is not submitted to the NVDIMMs

3 _DSM Interface for the NVDIMM Device

Platforms that have the _DSM interface implemented, as outlined in this section, can support a NVDIMM region with Region Format Interface Code (RFIC) of 0x0201 or 0x0301.

Note that the _DSM methods defined in this section are required to be implemented under NVDIMM devices that are child devices of the NVDIMM Root Device associated with _HID of ACPI0012 in ACPI name space hierarchy.

The following tables outlines the required Arg1, Arg2 parameters that are to be utilized for this version of the specification. The platform shall support the Arg1 - Revision Id = 1 and Arg1 - Revision Id = 2 Function Indexes simultaneously as outlined below. No other Arg1 - Revision Id values are supported at this time.

Arg0 – UUID - *4309AC30-0D11-11E4-9191-0800200C9A66*

Table 3-A Supported Function Index for Arg1 - Revision Id = 1

Arg1 - Revision Id	Arg2 – Function Index	_DSM Function Name
1	0	*Query implemented commands per ACPI Specification (returns the list below based on Arg1 - Revision Id = 1).*
	1	*Get SMART and Health Info*
	2	*Get SMART Threshold*
	3	*Get Block NVDIMM Flags*
	4	*Deprecated - Get Namespace Label Data Size*
	5	*Deprecated - Get Namespace Label Data*
	6	*Deprecated - Set Namespace Label Data*
	7	*Get Command Effect Log Info*
	8	*Get Command Effect Log*
	9	*Pass-Through Command*
	10	*Enable Latch System Shutdown Status*

Table 3-B Supported Function Index for Arg1 - Revision Id = 2

Arg1 - Revision Id	Arg2 – Function Index	_DSM Function Name
2	*0*	*Query implemented commands per ACPI Specification (returns the list below based on Arg1 - Revision Id = 2).*
	1	*Get SMART and Health Info*
	2	*Get SMART Threshold*
	3	*Deprecated - Get Block NVDIMM Flags*
	4	*Deprecated - Get Namespace Label Data Size*
	5	*Deprecated - Get Namespace Label Data*
	6	*Deprecated - Set Namespace Label Data*
	7	*Get Command Effect Log Info*
	8	*Get Command Effect Log*
	9	*Pass-Through Command*
	10	*Enable Latch System Shutdown Status*
	11	*Get Supported Modes*
	12	*Get FW Info*
	13	*Start FW Update*
	14	*Send FW Update Data*
	15	*Finish FW Update*
	16	*Query Finish FW Update Status*
	17	*Set SMART Threshold*
	18	*Inject Error*
	19	*Get Security State*
	20	*Set Passphrase*
	21	*Disable Passphrase*

	22	*Unlock Unit*
	23	*Freeze Lock*
	24	*Secure Erase NVDIMM w User Passphrase*
	25	*Overwrite NVDIMM*
	26	*Query Overwrite NVDIMM Status*
	27	*Set Master Passphrase*
	28	*Secure Erase NVDIMM w Master Passphrase*
	29	*Get Device Runtime FW Activation Status*
	30	*Set Device Runtime FW Activation Arm State*
	31	*LSA Error Inject*

Arg3 – A package containing parameters for the function specified by the *UUID, Revision ID, and Function Index.* The layout of the package for each command along with the corresponding output are illustrated in the respective *Function Index* description sections. For DSM functions that take an input argument, Arg3 is a package containing a Buffer, list of bytes, values. For DSM functions that do not take an input parameter, Arg3 is an empty package. The output of all functions in the DSM is a Buffer with a list of bytes. The first four bytes provide Status and Extended Status for the DSM function. Depending on the status code, additional bytes may follow the status bytes. If status bytes signal an error condition, the additional bytes are not present, unless some additional information is explicitly defined for the particular error code. If status bytes signal success, all output bytes defined for the function are present.

The following table outlines the returned Status field common to all of the DSMs defined in this specification. The status adopts the following conventions for the _DSM function return status codes. This status can always be utilized for the status of each _DSM function, whether the specific status value is defined in the output buffer or not.

Table 3-C Supported _DSM Return Status Values

Return Status Value - Bytes[1-0]	Return Status Value - Description
0	*Success*
1	*Failure - Function Not Supported*
2	*Failure - Non-Existing Memory Device*
3	*Failure - Invalid Input Parameters*
4	*Failure – HW Error*
5	*Failure – Retry Suggested - Command Timed Out, Other Command In Progress, Mailbox not Ready* *Typically an operation is executing and cannot be interrupted. Operations most likely to be executing are: ARS, Overwrite NVDIMM, and Finish FW Update. Software shall wait for those operations to complete utilizing Get ARS Status, Query Overwrite NVDIMM Status, or Query Finish FW Update Status before restarting an ARS, Overwrite NVDIMM, or FW Update sequence respectively.*
6	*Failure – Unknown Reason*
7	*Function Specific Error (details in Extended Status Field)*
8	*Failure – Retry Suggested - Out of Resources*
9	*Failure – HW Not Ready*
10	*Failure – Invalid Security State*

11	*Failure – Invalid Current Passphrase Supplied - Returned by the NVDIMM when the Current Passphrase does not match the saved passphrase. If the NVDIMM is also in the wrong security state, the Invalid Security State status is reported instead of this status.*

3.1 SMART Health Monitoring & Alarms

3.1.1 Get SMART and Health Info (Function Index 1)

This command requests the device to return Smart and Health information for the requested device.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-1 Get SMART and Health Info – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
Smart and Health Data	128	4	Output formatted as shown in Table 3-2.

Table 3-2 SMART and Health Data – Output Format

Field	Byte Length	Byte Offset	Description
Validity Flags	4	0	Validity Flags – if the corresponding validation flag is not set in this field, it is indication to software that the corresponding field is not valid and must not be interpreted. Bit[0] – if set to 1, indicates that Health Status field is valid Bit[1] – if set to 1, indicates that Percentage Remaining field is valid Bit[2] – Reserved, shall return 0. Bit[3] – if set to 1, indicates that Current NVDIMM Media Temperature field is valid Bit[4] – if set to 1, indicates that Current NVDIMM Controller Temperature field is valid Bit[5] – If set to 1, indicates that Latched Dirty Shutdown Count field is valid

			Bit[6] – If set to 1, indicates that the AIT DRAM Status field is valid Bit[7] – If set to 1, indicates that the Health Status Reason field is valid Bit[8] – Reserved, shall return 0. Bit[9] – if set to 1, indicates that Alarm Trips field is valid Bit[10] – if set to 1, indicates that Latched Last Shutdown Status field is valid Bit[11] – if set to 1, indicates that Size of Vendor-specific SMART Data field is valid. If this field is not valid, the software will ignore the vendor-specific data fields. Bits[31:12] – Reserved, shall return 0.
Reserved	4	4	Shall return 0.
Health Status	1	8	Health Status (HS): Overall health summary. Normal health is indicated by all HS bits being clear. Only one bit will be set at a time. Bit[0] – if set to 1, indicates Non-Critical condition, maintenance required but no data loss detected Bit[1] – if set to 1, indicates Critical condition, features or performance degraded due to failures but no data loss detected Bit[2] – if set to 1, indicates Fatal condition, data loss is detected or is imminent. Bit[7:3] - Reserved, shall return 0.
Percentage Remaining	1	9	Percentage Remaining: Remaining modules life as a percentage value of factory expected life span. The value of 0 means that the warranted life span of the device has been reached.
Reserved	1	10	Reserved, shall return 0.
Alarm Trips	1	11	Alarm Trips: Bits to signify if values have tripped their respective alarm thresholds Bit[0] - Percentage Remaining Trip - If set then the Percentage Remaining value has gone below the pre-programmed threshold limit Bit[1] – NVDIMM Media Temperature Trip - If set then the NVDIMM Media temperature value has gone above the pre-programmed threshold limit

			Bit[2] – NVDIMM Controller Temperature Trip - If set then the NVDIMM Controller temperature value has gone above the pre-programmed threshold limit Bits[7:3] - Reserved, shall return 0.
Current NVDIMM Media Temperature	2	12	Current Media Temperature: Current temperature of the NVDIMM Media Bits[14:0] - Temperature in 0.0625 degree Celsius resolution. Bit[15] – Sign bit for temperature (1 = negative, 0 = positive)
Current NVDIMM Controller Temperature	2	14	Current Controller Temperature: Current temperature of the NVDIMM Controller Bits[14:0] - Temperature in 0.0625 degree Celsius resolution. Bit[15] – Sign bit for temperature (1 = negative, 0 = positive)
Dirty Shutdown Count	4	16	Latched Dirty Shutdown Count (LDSC) – Number of times the NVDIMM Last Shutdown Status (LSS) was non-zero, indicating a dirty shutdown. Incremented anytime Last Shutdown Status (LSS) != 0 & Latch System Shutdown Status is set by host SW (via Enable Latch System Shutdown Status _DSM) . Count wraps back to 0 at overflow. Only updated and valid when Latch System Shutdown Status is enabled on the NVDIMM via Enable Latch System Shutdown Status.
AIT DRAM Status	1	20	AIT DRAM Status 00 – AIT DRAM is disabled 01 – AIT DRAM is enabled If the AIT DRAM is disabled, it will cause a performance degradation and will trigger a SMART Health Status change to critical state
Health Status Reason	2	21	Health Status Reason: Provides an additional reason why the current Health Status is Non-Critical, Critical, or Fatal. Bit[0] – 0% < Percentage Remaining <= 1% Bit[1] – Reserved Bit[2] – CAP Self-Test returns a Warning Bit[3] – Percentage Remaining equals 0 Bit[4] - Die Failure Bit[5] – AIT DRAM state is disabled

			Bit[6] – CAP Self-Test Failed Bit[7] – Critical internal state failure Bit[8] – Performance Degraded Bit[9] – CAP Self-test communications failure Bit[15:10] - Reserved
Reserved	8	23	Shall return 0.
Last Shutdown Status	1	31	Latched Last Shutdown Status (LLSS): status of last shutdown 00 – Clean shutdown All other Values – Not Clean Shutdown, indicates that there was either a platform or memory device-related failure occurred when saving data targeted for this memory device. Dirty Shutdown Count (DSC) above maintains a count of the number of times a non-clean shutdown occurs. Only updated and valid when Latch System Shutdown Status is enabled on the NVDIMM via Enable Latch System Shutdown Status.
Size of Vendor-specific SMART Data	4	32	Size of Vendor-specific SMART Data in bytes. If set to 0, indicates that there is no Vendor-specific SMART Data that follows. Otherwise, indicates size of the Vendor-specific SMART Data that follows.
Vendor-specific SMART Data	92	127-36	Vendor-specific SMART Data. The contents of this byte array are vendor specific based on the hardware installed. See **Table 3-3 PMem Module Specific SMART Data**, below, for the Intel® Optane™ Persistent Memory Module specific field definitions

The following table outlines the Intel® Optane™ PMem Module specific fields that are utilized with SMART Latched Last Shutdown Status and Latched Dirty Shutdown Count to provide specific details as to the clean or dirty determination. Please see the PMem Module specific FIS specification for details on the other vendor specific fields not outlined here.

Note: These vendor specific fields apply to the Intel® Optane™ Persistent Memory Module based products ONLY.

Table 3-3 PMem Module Specific SMART Data – Output Format

Field	Byte Length	Overall SMART payload Byte Offset	Intel® Optane™ PMem Module Specific SMART Byte Offset	Description
Reserved	28	36	0	See FIS for specific values. May not read as 0.
Latched Last Shutdown Status Details	1	64	28	Latched Last Shutdown Status Details shows the additional signals and state utilized by the NVDIMM when determining the final latched Last Shutdown Status and latched Dirty Shutdown Count. Multiple bits can be set. Bit[0] – When set to 1, PM ADR Command Received Bit[1] – When set to 1, PM S3 Received Bit[2] - When set to 1, PM S5 Received Bit[3] - When set to 1, DDRT Power Fail Command Received Bit[4] - When set to 1, PMIC 12V/DDRT 1.2V Power Loss Occurred Bit[5] - When set to 1, PM Warm Reset Received Bit[6] - When set to 1, Thermal Shutdown Received Bit[7] - When set to 1, Controller FW State Flush Completed
Reserved	8	65	29	See FIS for specific values. May not read as 0.
Latched Last Shutdown Status Extended Details	3	73	37	Latched Last Shutdown Status Extended Details shows additional signals and state utilized by the NVDIMM when determining the final Latched Last Shutdown Status (LLSS) and Latched Dirty Shutdown Count (LDSC). Multiple bits can be set. Bit[0] - When set to 1, Viral Interrupt Received Bit[1] - When set to 1, Surprise Clock Stop Received Bit[2] - When set to 1, Write Data Flush Complete Bit[3] - When set to 1, PM S4 Received Bit[4] - When set to 1, PM Idle Received Bit[5] - When set to 1, DDRT Surprise Reset Received Bit[9:6] – Extended Flush Status 1111b – Extended Flush completed successfully All other values – Extended Flush did not complete successfully Bit[13:10] – Sx Extended Flush Status 1111b – Sx Extended Flush completed successfully All other values – Sx Extended Flush did not complete successfully Bit[23:14] - Reserved
Reserved	10	76	40	See FIS for specific values. May not read as 0.

Thermal Throttle Performance Loss Percentage	1	86	50	The average percentage loss due to thermal throttling since last read in current boot. Valid range is 0..100
Reserved	52	87	51	See FIS for specific values. May not read as 0.

3.1.2 Get SMART Threshold (Function Index 2)

This command requests the device to return Smart Threshold values that have been programmed by the platform for the requested device.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-4 Get SMART Threshold – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
Smart Threshold Data	8	4	Output formatted as shown in Table 3-4.

Table 3-5 SMART Threshold Data – Output Format

Field	Byte Length	Byte Offset	Description
Threshold Alarm Enable	2	0	Threshold Alarm Control – If a bit is set to 1, the specific alarm is enabled and the corresponding Alarm Trip bit in the SMART Health Status output payload will be set when a specific threshold outlined below has been reached. Bit[0] - Percentage Remaining Threshold Alarm Enable Bit[1] – NVDIMM Media Temperature Threshold Alarm Enable Bit[2] – NVDIMM Controller Temperature Threshold Alarm Enable Bit[15:3] - Reserved, shall return 0
Percentage Remaining Threshold	1	2	Percentage Remaining Threshold: Remaining Spare Capacity as % of factory configured space. Valid range 0 to 100. If the *Percentage Remaining Threshold Alarm Enable* bit is set and when the remaining spare block capacity goes below this threshold, the *Percentage Remaining Trip* bit will be set in the SMART and Health Data structure defined in Table 3-2.
NVDIMM Media Temperature Threshold	2	3	Media Temperature Threshold Bit[14:0] – Temperature in 0.0625 degree Celsius resolution. Bit[15] – Sign bit for temperature (1 = negative, 0 = positive) If the *NVDIMM Media Temperature Threshold Alarm Valid* bit is enabled and when the *NVDIMM Media* temperature goes above this value, the *NVDIMM Media Temperature Trip* bit will be set in the SMART and Health Data structure defined in Table 3-2.
NVDIMM Controller Temperature Threshold	2	5	Controller Temperature Threshold Bit[14:0] - Temperature in 0.0625 degree Celsius resolution. Bit[15] - Sign bit for temperature (1 = negative, 0 = positive) If the *NVDIMM Controller Temperature Threshold Alarm Valid* bit is enabled and when the NVDIMM Controller temperature goes above this value, the *NVDIMM Controller Temperature Trip* bit will be set in the SMART and Health Data structure defined in Table 3-2.
Reserved	1	7	Shall return 0.

3.1.3 Set SMART Threshold (Function Index 17)

This command requests the device to simultaneously enable specific SMART Threshold Alarm Triggers and set the SMART Threshold Alarm Trigger values for the device. Parameter values are verified first before any enable/disable state or threshold values are updated.

Function Input
The following tables outline the expected input payload for this command.

Table 3-6 Set SMART Threshold – Input Format

Field	Byte Length	Byte Offset	Description
Threshold Alarm Enable	2	0	Threshold Alarm Control - If a bit is set to 1, the specific alarm is enabled and the corresponding Alarm Trip bit in the SMART Health Status output payload will be set when a specific threshold outlined below has been reached. Bit[0] - Percentage Remaining Threshold Alarm Enable Bit[1] – NVDIMM Media Temperature Threshold Alarm Enable Bit[2] – NVDIMM Controller Temperature Threshold Alarm Enable Bit[15:3] - Reserved, shall be 0
Percentage Remaining Threshold	1	2	Percentage Remaining Alarm - A % of factory configured spare blocks. Values 0 & 100 are not valid and will result in an error. If the *Percentage Remaining Threshold Alarm Enable* bit is set and when the spare block capacity goes below this threshold, the *Percentage Remaining Trip* bit will be set in the SMART and Health Data structure defined in Table 3-2. This field is ignored if the *Percentage Remaining Threshold Alarm Enable* bit above is cleared to 0.
NVDIMM Media Temperature Threshold	2	3	Media Temperature Alarm Bit[14:0] – Temperature in 0.0625 degree Celsius resolution. Bit[15] – Sign bit for temperature (1 = negative, 0 = positive) If the *NVDIMM Media Temperature Threshold Alarm Enable* bit is enabled and when the *NVDIMM Media* temperature goes above this value, the *NVDIMM Media Temperature Trip* bit will be set in the SMART and Health Data structure defined in Table 3-2.

			This field is ignored if the *NVDIMM Media Temperature Threshold Alarm Enable* bit above is cleared to 0.
NVDIMM Controller Temperature Threshold	2	5	Control Temperature Alarm Bit[14:0] - Temperature in 0.0625 degree Celsius resolution. Bit[15] - Sign bit for temperature (1 = negative, 0 = positive) If the *NVDIMM Controller Temperature Threshold Alarm Enable* bit is enabled and when the NVDIMM Controller temperature goes above this value, the *NVDIMM Controller Temperature Trip* bit will be set in the SMART and Health Data structure defined in Table 3-2. This field is ignored if the *NVDIMM Controller Temperature Threshold Alarm Enable* bit above is cleared to 0.

Function Output

The following tables outline the expected output payload for this command.

Table 3-7 Set SMART Threshold – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 03 – Invalid Input Parameters Returned If any threshold value requested to be enabled is invalid. No changes are made to any previously set threshold enable/disable state and no changes are made to any previously set threshold values.
Extended Status	2	2	Extended Status Field Undefined

3.2 Command Effect Log

3.2.1 Get Command Effect Log Info (Function Index 7)

This command requests the device to return the Command Effect Log Information for the requested device.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-8 Get Command Effect Log Info – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
Max Command Effect Log Data Length	4	4	In bytes, Maximum size of the command effect log data buffer supported by the device

3.2.2 Get Command Effect Log (Function Index 8)

This command requests the device to return the Command Effect Log associated with the requested device. If the OpCode is not in the Command Effect log, OSPM may block the Pass-Through Command calls for that OpCode.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-9 Get Command Effect Log – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
OpCode Count	2	4	Number of OpCode command effect logs returned
Reserved	2	6	Shall return 0.
Command Effect Data	Max Command Effect Log Data Length from Get Command Effect Log Info	8	The command effect data for each OpCode. The Fields in Table 3-8 are repeated *OpCode Count* times.

Table 3-10 Command Effect Data – Output Format

Field	Byte Length	Byte Offset	Description
OpCode	4	0	OpCode representing a Vendor-specific command
OpCode Command Effect	4	4	Bit[0] – No Effects (NE) If set to 1, execution of this OpCode does not change DIMM state. If this bit is set, all the following bits must be clear. Bit[1] – Security State Change (SSC) If set to 1, execution of this Opcode results in immediate security state change of the NVDIMM.

			Bit[2] – DIMM Configuration Change after Reboot (DCC) If set to 1, execution of this Opcode results in change to the configuration of the NVDIMM or data contained within persistent memory regions of the NVDIMM. The change does not take effect until the system re-boots. Bit[3] – Immediate DIMM Configuration Change (IDCC) If set to 1, execution of this Opcode results in immediate change to the configuration of the NVDIMM or data contained within persistent memory regions of the NVDIMM. Bit[4] – Quiesce All IO (QIO) If set to 1, execution of this Opcode may disrupt on-going operations of the memory region covered by this NVDIMM. The outstanding IO operations corresponding to this NVDIMM must be quiesced before executing this command; otherwise, undefined system behavior will result. Operations that must be quiesced include CPU load/store/move/flush memory operations, writes to NFIT Flush Hint Addresses, HW Block aperture programming sequences, in progress sequences including ARSs, and NVDIMM controller mailbox commands. Bit[5] - Immediate DIMM Data Change (IDDC) If set to 1, execution of this Opcode results in immediate change to the data written to the NVDIMM. Bit[6] – Test Mode (TM) If set to 1, execution of this Opcode activates a test feature that may disrupt on-going operations. This may result in errors or error recovery operations. Bit[7] – Debug Mode (DM) If set to 1, execution of this Opcode activates a debug feature that is non-disruptive, but may alter performance characteristics of the NVDIMM. Bit[8] – Immediate DIMM Policy Change (IPDC) If set to 1, then this Opcode makes an immediate change to the policies utilized by the DIMM, without a reboot.

			Bit[31:9] – Reserved, shall return 0.

3.3 Pass-Through Command (Function Index 9)

This command requests the device to execute the vendor specific command contained in the input payload for the requested device.

Function Input

The following tables outline the expected input payload for this command.

Table 3-11 Pass-Through Command – Input Format

Field	Byte Length	Byte Offset	Description
OpCode	4	0	Vendor-specific command OpCode
OpCode Parameters Data Length	4	4	In bytes Length of OpCode parameters data
OpCode Parameters Data	OpCode Parameters Data Length	8	Vendor-specific command input data

Function Output

The following tables outline the expected output payload for this command.

Table 3-12 Pass-Through Command – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
Output Data Length	4	4	In bytes. If *Status* is not *Success,* output data length returned is 0.
Output Data	Output Data Length	8	The *Output Data* is valid only when the *Output Data Length* is non-zero.

3.4 Enable Latch System Shutdown Status (Function Index 10)

DSM command to allow a SW agent enable the latching of SMART LSS & SMART Dirty Shutdown Count state of each NVDIMM. By default the NVDIMM powers up assuming that this latch is disabled. When the latch is disabled the NVDIMM will report the previously saved value for the SMART LSS and SMART DSC values. Those values will not change again until the next power down sequence following the enable of the latch utilizing this DSM.

Function Input

The following tables outline the expected input payload for this command.

Table 3-13 Enable Latch System Shutdown Status – Input Format

Field	Byte Length	Byte Offset	Description
Latch System Shutdown Status	1	0	Enable System Shutdown Status –Enables latching of SMART Last Shutdown Status (LSS) & SMART Dirty Shutdown Count in NVDIMM on the next power down event. 01 – Enable the latch. Update SMART LSS & SMART Dirty Shutdown Count on next power-down, power-up sequence All other values are reserved.

Function Output

The following tables outline the expected output payload for this command.

Table 3-14 Enable Latch System Shutdown Status – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined

3.5 Get Supported Modes (Function Index 11)

This command requests the platform to return details about the supported Modes of the NVDIMM Interface implementation.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-15 Get Supported Modes – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
Supported Modes	2	4	The list of the DIMMs capabilities: Bit[0] – Memory Mode supported Bit[1] – PMEM Mode supported Bit[2] – Block Aperture Mode supported Bit[15:3] – Reserved, shall return 0.

3.6 NVDIMM FW Download

3.6.1 Get FW Info (Function Index 12)

This command returns information for the limits utilized for Send FW Update Data function, the running FW image revision, the running FW image Firmware Interface Specification (FIS) version, and the Updated FW Image, if one exists.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-16 Get FW Info – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
Size of FW Update Image Storage Area	4	4	In bytes, Total size of the FW Update Image Storage Area supported by the platform.
Max Send FW Update Data Length	4	8	In bytes, Maximum Length value that can be utilized with each Send FW Update Data command.
Query Finish FW Update Status Polling Interval	4	12	Polling interval in uSecs describing how often software should issue a Query Finish FW Update Status polling command to check for Finish FW Update completion.
Max Time to Query Finish FW Update Status	4	16	Maximum time in uSec software should have to poll for Query Finish FW Update Status on a single NVDIMM.
FW Update Capabilities	1	20	Flags further defining the FW Update capabilities or features of the NVDIMM Bit[0] – FW Update Requires System Cold Re-Boot – If set the NVDIMM requires a system cold-boot for the new FW image

			to become the new executing FW image. This assumes that the FW update sequence has completed successfully. Bit[1] – If set, runtime FW activation requires I/O and processor quiesce to host memory access. Platform firmware support capability and estimated time information for NVDIMM firmware activation is available through “Get Devices Runtime FW Activation Info” function. Bit[7:2] - Reserved Returned as 0.
Reserved	3	21	Read as 0
Running FW Interface Version	4	24	The current running FW Interface Specification (FIS) revision using the product specific format. -Implementations that do not report a full 4 bytes of Running FW Interface Version information shall fill unused MSB bytes with 0’s. Note: This is for informational purposes only and shall not be utilized to determine the command set that is supported by the NVDIMM.
Running FW Revision	8	28	Contains the revision information of the currently running NVDIMM firmware using the product specific format. -Implementations that do not report a full 8 bytes of Running FW Revision information shall fill unused MSB bytes with 0’s. -Larger version value indicate newer FW revision.
Updated FW Revision	8	36	Upon successful completion of the Finish FW Update command this field contains the revision information of the updated NVDIMM firmware using the product specific format. -This revision becomes valid after successful completion of a Send FW Update Data & Finish FW Update sequence. This field then becomes invalid after a cold system boot and this revision shall be reported as all 0’s at that time. -If no FW image has been sent or an image has been sent but the update has not been finished, or the Finish FW Update fails, then this revision shall be reported as all 0’s. -Implementations that do not report a full 8 bytes of Updated FW Revision information shall fill unused MSB bytes with 0’s. -Larger version value indicate newer FW revision.

3.6.2 Start FW Update (Function Index 13)

This command requests the NVDIMM device to start a FW download sequence. The FW download sequence consists of a single Start FW Update, followed by one or more Send FW Update Data commands and completes with a single Finish FW Update command followed by one or more Query Finish FW Update Status to poll for Finish FW Update completion.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-17 Start FW Update – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. FW Update Context field is valid. 07 – Function Specific Status (see Extended Status below) 08 - Failure – Retry Suggested - Out of Resources. Software may need to complete other outstanding FW update sequences, potentially for other NVDIMM devices before retrying the Start FW Update command. It is also possible to abort other FW update sequences in progress to recover internal platform resources, using the Control Flags in the Finish FW Update input payload.
Extended Status	2	2	Extended Status Field 01 – FW Update already in progress for this NVDIMM device. The FW Update Context field returned is valid and indicates the context for the currently executing FW Update on the NVDIMM device. Software must complete the current FW update sequence with one of the two methods: -Sending a Finish FW Update command and possibly a system cold re-boot before another FW update sequence can be started on the same NVDIMM -Using the returned FW Update Context to abort the existing FW Update that is in progress by calling Finish FW Update with the Control Flag set to Abort Existing FW Update Sequence 02 – FW Update already occurred – A successful FW update sequence has already occurred and another Start FW Update command is being attempted without a system cold-boot.

FW Update Context	4	4	Upon successful completion of the Start FW Update command this field contains a platform implementation specific value that must be passed as an input parameter to Send FW Update Data and Finish FW Update commands.

3.6.3 Send FW Update Data (Function Index 14)

This command requests the device to update the FW image in the NVDIMMs FW Update Image Storage Area as part of a FW download sequence. The FW download sequence consists of a single Start FW Update, followed by one or more Send FW Update Data commands and completes with a single Finish FW Update command followed by one or more Query Finish FW Update Status to poll for Finish FW Update completion.

The Offset and Length fields allow software to divide the FW image in to pieces based on the Max Send FW Update Data Length reported in the Get FW Info output payload. There is no ordering restriction regarding how the pieces of the FW image are sent to the NVDIMMs FW Update Image Storage Area.

No validation of the FW image occurs until the FW download sequence is complete. The FW image is considered complete and its validity is verified only after the Finish FW Update command has completed.

If software is aborting a FW Update sequence that is already in progress it can call Finish FW Update directly without issuing any Send FW Update Data commands. See the Control Flags in the Finish FW Update command for details on aborting an outstanding FW Update sequence.

Function Input

The following tables outline the expected input payload for this command.

Table 3-18 Send FW Update Data – Input Format

Field	Byte Length	Byte Offset	Description
FW Update Context	4	0	Platform specific FW update sequence context provided by the platform as part of the Start FW Update output payload.
Offset	4	4	In bytes Indicates the byte offset in the NVDIMMs FW Update Image Storage Area where this portion of the FW Image data will be written
Length	4	8	In bytes Indicates the number of bytes to be written starting at the Offset specified above
FW Image Data	Length	12	FW Image data to be written at the starting Offset for Length bytes

Function Output

The following tables outline the expected output payload for this command.

Table 3-19 Send FW Update Data – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 03 – Invalid Input Parameters - Offset + Length is > Size of FW Update Image Storage Area reported in the Get FW Info command - Length is > Max Send FW Update Data Length reported in the Get FW Info command - Length does not match the size of the ACPI input package contained in Arg3 07 – Function Specific Status (see Extended Status below) 08 - Failure – Out of Resources. Software may need to complete other outstanding FW update sequences, potentially for other NVDIMM devices before retrying the Start FW Update command. It is also possible to abort other FW update sequences in progress to recover internal platform resources, using the Control Flags in the Finish FW Update input payload.
Extended Status	2	2	Extended Status Field 01 – FW Update Context invalid

3.6.4 Finish FW Update (Function Index 15)

This command requests the NVDIMM device to begin the process of finishing a FW download sequence. The FW download sequence consists of a single Start FW Update, followed by one or more Send FW Update Data commands and completes with a single Finish FW Update command followed by one or more Query Finish FW Update Status to poll for Finish FW Update completion.

Upon successful completion of this command, the NVDIMM has begun the process of finishing the FW update process. This consists of decrypting the FW image header, verifying header information including checksum, and saving the FW image in the internal NVDIMM FW Image Storage Area. This can take seconds to complete, requiring the use of the Query Finish FW Update Status so that applications can poll for Update FW completion without waiting for the update to be completed by the NVDIMM.

Software must issue the Query Update FW Status command to poll for Update FW completion. The Update FW image sequence is not complete until the query command returns proper status indicating the Update FW process is complete.

The Control Flags allow software to abort an existing FW Download instead of completing the sequence. Aborting a FW download sequence results in no change to the NVDIMM FW image. If aborting a FW Update sequence, software does not send the Query Finish FW Update command.

Function Input

The following tables outline the expected input payload for this command.

Table 3-20 Finish FW Update – Input Format

Field	Byte Length	Byte Offset	Description
Control Flags	1	0	Finish FW Update Control Flags 00 – Finish the FW Update sequence. Once software instructs the platform to finish the FW Update, it is not possible to abort the Finish FW Update sequence at a later date. Software needs to wait for the FW Update to complete using the Query Finish FW Update Status. 01 – Abort Existing FW Update Sequence. The FW Update Context describes an existing FW Download sequence that shall be aborted without updating the FW image on the NVDIMM. When aborting an active FW Update sequence, software does not call Query Finish FW Update Status. All other values are reserved.
Reserved	3	1	Must be 0

FW Update Context	4	4	Platform specific FW update sequence context provided by the platform as part of the Start FW Update output payload.

Function Output

The following tables outline the expected output payload for this command.

Table 3-21 Finish FW Update – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success – The Finish FW Update sequence has started. Software shall call Query Finish FW Update Status command to poll for FW Update sequence completion 05 - Failure – Retry Suggested - Command Timed Out, Other Command In Progress, Mailbox not Ready 07 – Function Specific Status (see Extended Status below) 08 - Failure – Out of Resources. Software may need to complete other outstanding FW update sequences, potentially for other NVDIMM devices before retrying the Start FW Update command. It is also possible to abort other FW update sequences in progress to recover internal platform resources, using the Control Flags in the Finish FW Update input payload. 09 - Failure – HW Not Ready
Extended Status	2	2	Extended Status Field - Any non-zero value returned here means the FW Update sequence is not active. Software does not need to call Query Finish FW Update Status for any of these cases. 01 – FW Update Context invalid 02 – FW Update already occurred – A successful FW update sequence has already occurred and another Finish FW Update command is being attempted without a system cold-boot. 03 – Current updated FW Image failed authentication checks – fallback to prior FW image

			04 – FW update sequence successfully aborted. Only returned if the caller requested a FW Update sequence to be aborted by setting Control Flags to Abort Existing FW Update Sequence.

3.6.5 Query Finish FW Update Status (Function Index 16)

This command allows software to poll for completion of the FW download sequence. The FW download sequence consists of a single Start FW Update, followed by one or more Send FW Update Data commands and completes with a single Finish FW Update command followed by one or more Query Finish FW Update Status to poll for Finish FW Update completion.

Finish FW Update consists of decrypting the FW image header, verifying header information including checksum, and saving the FW image in the internal FW Image Storage Area. This can take seconds to complete requiring the use of the Query Finish FW Update Status so that applications can poll for completion without the BIOS blocking in SMM waiting for the update to be completed by the NVDIMM. The Query Finish FW Update Status Polling Interval returned in the Get FW Info command specifies what frequency software should utilize when polling for Finish FW Update completion using the Query Finish FW Update Status command.

Upon successful completion of this command, the updated FW image will become the new executing FW image on the next system cold re-boot, replacing the currently executing FW image.

Sending a Finish FW Update followed by one or more Query Finish FW Update Status commands completes the FW download sequence and requests the NVDIMM to verify the Updated FW Image and report the revision information for the Updated FW Image. If no updated FW image is sent or the updated FW image is incomplete, Query Finish FW Update Status command will return an appropriate error and the Updated FW Image Revision will be reported as all 0's.

Only a single FW Update sequence can be handled per NVDIMM per system cold-boot sequence. Once successful status is returned for Query Finish FW Update Status, the system must be go through a cold-boot cycle before another FW Update sequence can be executed on that same NVDIMM. Multiple NVDIMMs can have FW images updated and utilize a single system cold-boot to activate the new FW image on all NVDIMMs.

Function Input

The following tables outline the expected input payload for this command.

Table 3-22 Query Finish FW Update Status – Input Format

Field	Byte Length	Byte Offset	Description
FW Update Context	4	0	Platform specific FW update sequence context provided by the platform as part of the Start FW Update output payload.

Function Output

The following tables outline the expected output payload for this command.

Table 3-23 Query Finish FW Update Status – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success – The Update FW sequence has completed successfully. Authentication checks passed. Updated FW Revision field is valid. The Updated FW Image will be loaded on the next system cold-boot. 07 – Function Specific Status (see Extended Status below) 08 - The Finish FW Update sequence timed out
Extended Status	2	2	Extended Status Field 01 – FW Update Context invalid 02 – FW Update in progress 03 – Current updated FW Image failed authentication checks – fallback to prior FW image 04 – Sequencing Error – Query Finish FW Update Status called without first calling Finish FW Update
Updated FW Revision	8	4	Upon successful completion of the Finish FW Update command this field contains the revision information of the updated NVDIMM firmware using the product specific format. -This becomes valid after successful completion of a Send FW Update Data & Finish FW Update sequence. This field then becomes invalid after a cold system re-boot. -If no FW image has been updated or the updated FW image is invalid, or the Finish FW Update fails, then this revision shall be reported as all 0's. -Implementations that do not report a full 8 bytes of Updated -FW Revision information shall fill unused MSB bytes with 0's. -Larger version value indicates newer FW revision.

3.7 Inject Error (Function Index 18)

Inject NVDIMM specific errors not covered by the ACPI ARS Error Inject function. None of the injected errors are persistent across power cycles or re-boots unless otherwise stated below. An error will stay injected until disabled using this command or the system is restarted, unless otherwise stated below.

Function Input

The following tables outline the expected input payload for this command.

Table 3-24 Inject Error - Input Format

Field	Byte Length	Byte Offset	Description
Error Inject Validity Flags	8	0	Valid Fields – if the corresponding validation flag is not set in this field, it is indication to software that the corresponding field is not valid and must not be interpreted. Bit[0] – if set to 1, indicates that all Media Temperature Error Inject fields are valid Bit[1] – if set to 1, indicates that all Percentage Remaining Trigger fields are valid Bit[2] – if set to 1, indicates that all Fatal Error Trigger fields are valid Bit[3] – if set to 1, indicates that all Dirty Shutdown Error Trigger fields are valid Bit[63:4] – Reserved, shall be 0
Media Temperature Error Inject	3	8	Media Temperature Error Inject fields - This will override the NVDIMM from reading the actual temperature of the media device and spoof a media temperature reading of the injected value instead. Byte[0] Bit[0] – Enable If 0, injecting Media Temperature Errors is disabled. If 1, the Media Temperature specified will be injected. Bit[7:1] - Reserved, shall be 0. Byte[2:1] - Media Temperature to Inject Bit[14:0] – Temperature in Celsius with 0.0625 resolution Bit[15] – Sign Bit, if 1 the Temperature is negative, if 0 the temperature is positive Note: Although actions taken due to the Media Temperature

			injected may cause adverse effects on the NVDIMM, including IO throttling, the media temperature injected is an artificial temperature and will not cause harm to the NVDIMM. If the critical shutdown temperature, or higher, is injected, the NVDIMM may shutdown in order to preserve the part and data.
Percentage Remaining Inject	2	11	Percentage Remaining Trigger - This will spoof the NVDIMM to trigger either: -User Configured Percentage Remaining Alarm for a previously set value using the Set SMART Threshold function -SMART Health Change Notification for Health Status Non-Critical or Critical Byte[0] Bit[0] – Enable If 0, injecting Percentage Remaining is disabled If 1, the Percentage Remaining will be injected Bit[7:1] – Reserved, shall be 0. Byte[1] – Percentage Remaining to inject. Valid values are 0-99. All other values are reserved and will result in returned Status of Invalid Input Parameters. Note: For this trigger to inject a User Configured Spare Block Alarm Threshold Trigger requires the Spare Block Alarm Threshold to be previously enabled using the Set SMART Threshold function. If the Spare Block Alarm Threshold has not been enabled, this function will inject SMART Health Change notification ACPI Notification 0x81 as follows: Percentage Remaining of 1% - Causes Health Status to change to Non-Critical Percentage Remaining of 0% - Causes Health Status to change to Critical
Fatal Error Inject	1	13	Fatal Error Trigger – This trigger will spoof the NVDIMM to trigger a fatal NVDIMM error. Injecting this error will result in a change to the SMART Health Info – Health Status of fatal. Bit[0] – Enable If 0, injecting Fatal Error Trigger is disabled If 1, a Fatal Error Trigger will be injected Bit[7:1] – Reserved, shall be 0

Dirty Shutdown Error Inject	1	14	Dirty Shutdown Error Trigger – This trigger will spoof an ADR or system shutdown failure on the next power down as follows: -Enable SMART Last Shutdown Status (LSS) and Dirty Shutdown Count (DSC) increment via the Enable Latch System Shutdown Status DSM with Bit[0] - Enable System Shutdown Status set -Power down the system – The device spoofs a failure and latches SMART LSS, increments SMART DSC -Power the system up – SMART Health Change is reported with non-zero LSS ad incremented DSC Bit[0] – Enable If 0, injecting ADR Failure is disabled If 1, an ADR Failure will be injected Bit[7:1] – Reserved, shall be 0

Function Output

The following tables outline the expected output payload for this command.

Table 3-25 Inject Error Data – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 03 – Invalid Input Parameters Returned If any Error Inject parameter value requested is invalid. No changes are made to any previous enable/disable Error Injection state and no changes are made to any previously set Error Inject values.
Extended Status	2	2	Extended Status Field 01 – Platform not enabled for error injection. Error Injection must be enabled on the platform before attempting to inject NVDIMM specific errors.

3.8 NVDIMM Security Management

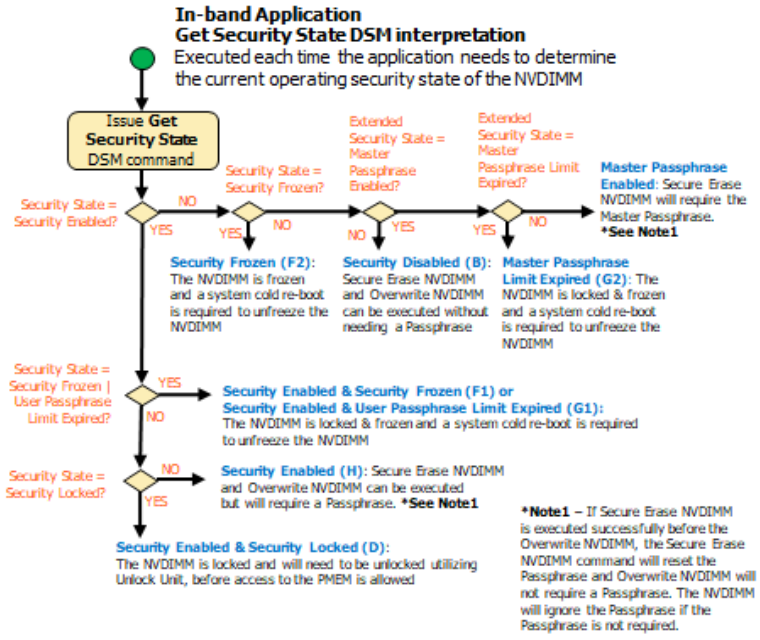
3.8.1 Theory of Operation

The following section outlines some of the security features of the implementation required to make use of the security DSMs and basic sequences that can be utilized with the Secure Erase NVDIMM and Overwrite NVDIMM DSMs for an in-band application. Note the following notes regarding the in-band DSM based security implementation:

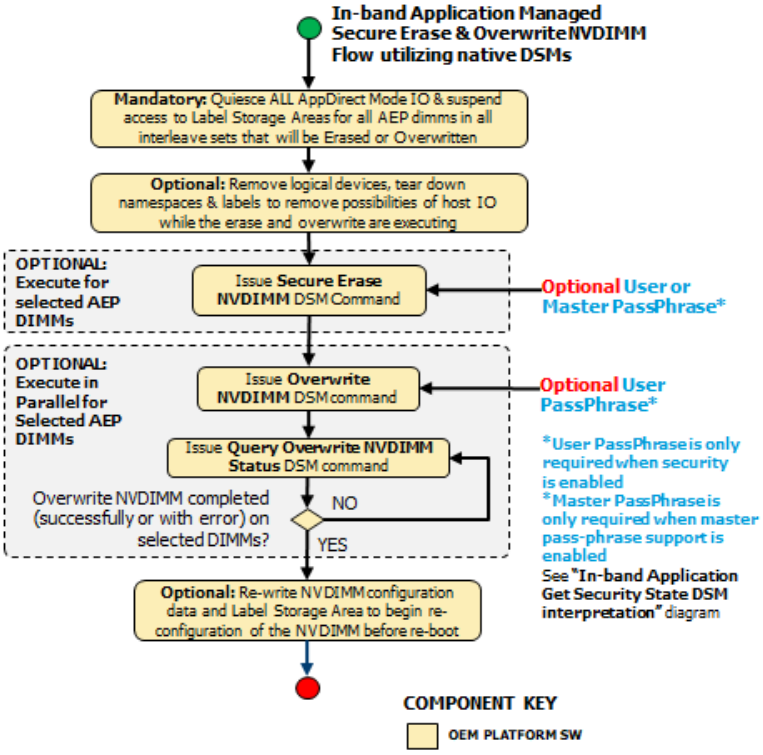
- The NVDIMM supports running without security enabled, in which case, the data can be accessed without unlocking the NVDIMM. With security disabled, Secure Erase and Overwrite NVDIMM command can be executed without the need for a passphrase. The GetSecurityState DSM will return **Security Disabled** when the NVDIMM security is disabled. See the GetSecurityState DSM diagram below.
- The NVDIMM also supports enabling a security model similar to the legacy SATA/SCSI ATA security model utilized with HDDs and SSDs. To support this, the NVDIMM requires a pass phrase to enable security on the NVDIMM. Once enabled, a Passphrase will be required to access the PMEM data, or to execute a Secure Erase NVDIMM or Overwrite NVDIMM request. The GetSecurityState DSM will return **Security Enabled** when the NVDIMM security is enabled. See the GetSecurityState DSM diagram below.
- If security is enabled on the NVDIMM and the NVDIMM is currently locked, speculative reads from the mapped in PMEM will pollute cpu caches with all 1's data for a locked NVDIMM. It is imperative that the system either prevent speculative reads from occurring while the NVDIMM is locked, OR cpu caches are invalidated before the first read access is allowed, after unlocking the NVDIMM. The GetSecurityState DSM will return **Security Locked** when the NVDIMM is locked. See the GetSecurityState DSM diagram below.
- Removing the logical devices from access by the running OS before the Secure Erase and Overwrite NVDIMM operations are executed is recommended to remove any interactions with host IO while the erase or overwrite are executing.
- The DSM commands do NOT invalidate cpu caches.
- The NVDIMM allows access to the Label Storage Area and PMEM after the Overwrite NVDIMM completes and before the system has been restarted with a cold system re-boot. This allows optional re-configuration of the NVDIMM, including the initial re-write of the Label Storage Area to occur before the first reboot in the configuration process.
- In-Band Managed Overwrite NVDIMM Operation utilizing native DSMs:
    - This is an OEM implementation specific function required when overwriting PMem modules without BIOS intervention or system reboots
    - Requires that all IO be quiesced for PMEM Mode and Memory Mode regions before execution. See the **Get Supported Modes** DSM.
    - May require passphrase knowledge to be available to ring3/0 application if security is enabled on the NVDIMM
- Requires no system re-boots until after Overwrite NVDIMM is complete
- In-band Applications utilizes the following mechanisms to handle the Secure Erase and Overwrite NVDIMM implementation:

- **DSM V1.7 Spec -** Native DSMs are added for the following security commands to match FIS V1.12:
  - GetSecurityState
  - SetPassphrase
  - DisablePassphrase
  - UnlockUnit
  - FreezeLock
  - SecureEraseNVDIMM
  - OverwriteNVDIMM
  - QueryOverwriteNVDIMMStatus
- **DSM V1.8 Spec** - Native DSMs are added for the following security commands to match FIS V1.13:
  - SetMasterPassphrase
- Secure Erase NVDIMM DSM broken in to Secure Erase NVDIMM w User Passphrase and Secure Erase NVDIMM w Master Passphrase DSMs. This allowed preserving backwards compatibility with the V1.7 DSM spec and released OS support code while adding the Master Passphrase support. This requires some BIOS translation to complete the payload mapping.

The following figures shows the basic handling of the Get Security State DSM each time the application is executed or requires the current security state of the NVDIMM, and the Passphrase requirements when executing a Secure Erase NVDIMM or Overwrite NVDIMM command.



Application In-band Get Security State Sequence



Application In-band Secure Erase & Overwrite NVDIMM Sequence

3.8.2 Get Security State (Function Index 19)

Retrieve the current security state of the NVDIMM.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-26 Get Security State – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully and the returned Security State is valid.

			05 - Failure – Retry Suggested - Command Timed Out, Other Command In Progress, Mailbox not Ready 09 – Failure – HW Not Ready
Extended Status	2	2	Extended Status Field Undefined
Extended Security State	1	4	Extended Security State Bit[0] – **Master Passphrase Enabled –** When set to 1, the Master Passphrase feature has been enabled. The Master Passphrase Enabled will not be set to 1 until master passphrase has been changed to a non-default value. Bit[1] – **Master Passphrase Limit Expired** - - When set to 1, the NVDIMM is frozen due to the Master Passphrase limit reached. While this is reported as a different state than the frozen state (Bit[3]), the NVDIMM will freeze its internal security state when the passphrase limit has been reached, to protect itself from a denial-of-service attack. Once frozen, all security DSMs, except Get Security State and Query Overwrite NVDIMM Status, will be rejected. Other management interfaces and DSMs are not affected. If this occurs, a cold system re-boot, that includes power cycling of the NVDIMM, is required before the security state of the NVDIMM can be changed utilizing these DSMs. Bit[7:2] – Reserved, read as 0
Reserved	3	5	Returned as 0
Security State	1	8	Current NVDIMM Security State NO BITS SET: Security Supported, Security Disabled Bit[0] – Reserved - Returned as 0 Bit[1] – **Security Enabled** - When Set to 1, security is enabled on the NVDIMM. Security Disabled - When Clear to 0, the PMEM can be accessed without unlocking the NVDIMM. Overwrite NVDIMM and Secure Erase NVDIMM security commands that normally require a Passphrase, can be executed without a Passphrase. Bit[2] – **Security Locked** - When set to 1, the NVDIMM is locked. Access to the Label Storage Area and the PMEM is only allowed by supplying the correct Passphrase. Changing the configuration is

			not allowed. To enable media access the NVDIMM media is unlocked by executing a Unlock Unit command and supplying the required Passphrase Bit[3] – **Security Frozen** - When set to 1, the current Security State is frozen. The NVDIMM may freeze its internal security state to protect itself from a denial-of-service attack. Once frozen, all security DSMs, except Get Security State and Query Overwrite NVDIMM Status, will be rejected, while other management interfaces and DSMs are not affected. If this occurs, a cold system re-boot, that includes power cycling of the NVDIMM, is required before the security state of the NVDIMM can be changed utilizing these DSMs. The NVDIMM is not Freeze Locked by default. Bit[4] – **User Passphrase Limit Expired** - When set to 1, the NVDIMM is frozen due to the User Passphrase limit reached. While this is reported as a different state than the frozen state (Bit[3]), the NVDIMM will freeze its internal security state when the passphrase limit has been reached, to protect itself from a denial-of-service attack. Once frozen, all security DSMs, except Get Security State and Query Overwrite NVDIMM Status, will be rejected. Other management interfaces and DSMs are not affected. If this occurs, a cold system re-boot, that includes power cycling of the NVDIMM, is required before the security state of the NVDIMM can be changed utilizing these DSMs. Bit[5] – Security Not Supported - When set to 1, the NVDIMM security feature is not supported by this HW Bit[6] – BIOS Security Nonce has been set Bit[7] – Reserved - Returned as 0

3.8.3 Set Passphrase (Function Index 20)

Allows the caller to set the User Passphrase and enable security on the NVDIMM.

Function Input

The following tables outline the expected input payload for this command.

Table 3-27 Set Passphrase – Input Format

Field	Byte Length	Byte Offset	Description
Current Passphrase	32	0	The User Passphrase supplied when the user enables security on the NVDIMM using this command. -If the NVDIMM is in the **Security Enabled** state, this must match the passphrase that was supplied in the **New Passphrase** field on last successful invocation of the Set Passphrase command. -If the NVDIMM is in the Security Disabled state this field is ignored
New Passphrase	32	32	The new User Passphrase. Required field utilized as part of setting a new user passphrase on the NVDIMM.

Function Output

The following tables outline the expected output payload for this command.

Table 3-28 Set Passphrase – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. 01 - Failure - Function Not Supported - This is reported if the NVDIMM **Security Enabled** state for Get Security State command is not set 07 – Function Specific Status (see Extended Status below) 10 - Failure – Invalid Security State 11 - Failure – Invalid Current Passphrase Supplied
Extended Status	2	2	Extended Status Field Undefined

3.8.4 Disable Passphrase (Function Index 21)

Disable security on the NVDIMM. If security is not enabled via Set Passphrase, it is not required to disable security.

Function Input

The following tables outline the expected input payload for this command.

Table 3-31 Disable Passphrase – Input Format

Field	Byte Length	Byte Offset	Description
Current Passphrase	32	0	The User Passphrase supplied when the user disables security on the NVDIMM using this command. -This field is required if the NVDIMM returns **Security Enabled** state for Get Security State command. See **Theory Of Operation, Application In-band Get Security State Sequence** for this logic.

Function Output

The following tables outline the expected output payload for this command.

Table 3-32 Disable Passphrase – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. 01 - Failure - Function Not Supported - This is reported if the NVDIMM **Security Enabled** state for Get Security State command is not set 10 - Failure – Invalid Security State 11 - Failure – Invalid Current Passphrase Supplied
Extended Status	2	2	Extended Status Field Undefined

3.8.5 Unlock Unit (Function Index 22)

Unlock the NVDIMM and allow configuration changes. To make changes to the configuration of the NVDIMM, it is required to unlock the NVDIMM using this command. While the unit is locked, host IO to PMEM regions will return all 1's data for reads and drop writes completely. Unless speculative CPU reads are actively prevented (removing virtual memory mapping may not be enough), CPU caches must be invalidated after the Unlock Unit command completes and before the NVDIMM is returned to normal operation.

NOTE: NVDIMM users wishing to utilize the Clear Uncorrectable Error DSM found in the ACPI specification must unlock the NVDIMM first utilizing this command.

Function Input

The following tables outline the expected input payload for this command.

Table 3-33 Unlock Unit – Input Format

Field	Byte Length	Byte Offset	Description
Current Passphrase	32	0	The User Passphrase supplied when the user unlocks the NVDIMM using this command. -This field is required if the NVDIMM returns **Security Locked** state for Get Security State command. See **Theory Of Operation, Application In-band Get Security State Sequence** for this logic.

Function Output

The following tables outline the expected output payload for this command.

Table 3-34 Unlock Unit – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. 01 - Failure - Function Not Supported - This is reported if the NVDIMM **Security Enabled** state for Get Security State command is not set 10 - Failure – Invalid Security State 11 - Failure – Invalid Current Passphrase Supplied
Extended Status	2	2	Extended Status Field Undefined

3.8.6 Freeze Lock (Function Index 23)

Lock the current security state of the NVDIMM, requiring a cold system re-boot before further attempts to change the state of the NVDIMM. After successful execution of this command, Get Security State shall report **Security Frozen** state.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-35 Freeze Lock – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. 01 - Failure - Function Not Supported - This is reported if the NVDIMM **Security Enabled** state for Get Security State command is not set 10 - Failure – Invalid Security State
Extended Status	2	2	Extended Status Field Undefined

3.8.7 Secure Erase NVDIMM w User Passphrase (Function Index 24)

Instruct the NVDIMM to generate a new encryption key for the PMEM which crypto-scrambles/randomizes all existing user data in the PMEM using the User Passphrase. The Label Storage Area is unaffected and the existing configuration is preserved. The erase typically takes seconds or less to complete. For details on affected data and metadata regions on the NVDIMM when executing this action, see the product specific FIS.

NOTE: There are significant responsibilities placed on the caller utilizing Secure Erase. See the additional notes at the end of this section.

Function Input

The following tables outline the expected input payload for this command.

Table 3-36 Secure Erase NVDIMM w User Passphrase – Input Format

Field	Byte Length	Byte Offset	Description
User Passphrase	32	0	The User Passphrase supplied when the user secure erases the NVDIMM using this command. -This field is required if the NVDIMM returns **Security Enabled** state for Get Security State command. -This field is ignore by the NVDIMM if it returns **Security Disabled** state for Get Security State command See **Theory Of Operation, Application In-band Get Security State Sequence** for this logic.

Function Output

The following tables outline the expected output payload for this command.

Table 3-37 Secure Erase NVDIMM w User Passphrase – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. 10 - Failure – Invalid Security State 11 - Failure – Invalid Current Passphrase Supplied
Extended Status	2	2	Extended Status Field Undefined

Further application responsibilities when utilizing Secure Erase NVDIMM:

- Host IO to the PMEM shall be quiesced and new IO blocked while this security command is executing for the NVDIMM
- If the application will also execute an Overwrite NVDIMM command, the Secure Erase NVDIMM shall be executed before the Overwrite NVDIMM
- Any IO to the PMEM region while the Secure Erase NVDIMM is executing will cause encrypted random data to be read. While tearing down the logical device stack can be helpful in removing host IO, unless speculative cpu reads are actively prevented (removing virtual memory mapping may not be enough), , cpu caches must be invalidated, after the Secure Erase NVDIMM command completes and before the NVDIMM is returned to operation.
- While the Label Storage Area is preserved, any address abstraction info blocks in PMEM are destroyed.

3.8.8 Overwrite NVDIMM (Function Index 25)

The Overwrite NVDIMM operation overwrites the entire PMEM of the NVDIMM with encrypted 0's including retired ECC blocks, NVM die that were previous swapped out as part of a die sparing operation, and all user addressable PMEM locations. After the overwrite process has completed, the Label Storage Area is overwritten with 0's and all configuration data is lost.

This operation can take a significant amount of time requiring the use of the Query Overwrite NVDIMM Status to poll for the completion of the Overwrite operation. SW shall call Query Overwrite NVDIMM Status at least once to verify completion of the operation. These interfaces allow parallel Overwrite NVDIMM operations to be started on all NVDIMMs and parallel polling for completions. Since this operation takes a long amount of time to complete, it is recommended to overwrite all of the NVDIMMs in the same session.

The Overwrite NVDIMM operation may not be supported for all NVDIMM configurations. If an overwrite operation is requested for an unsupported overwrite configuration, the Overwrite NVDIMM request shall be failed with an explicit extended status, Failure – Unsupported Overwrite Configuration.

NOTE: If Secure Erase NVDIMM is executed successfully before the Overwrite NVDIMM, the Secure Erase NVDIMM command will reset the passphrase and Overwrite NVDIMM will not require a Passphrase. The NVDIMM will ignore the Passphrase argument in the input payload if the Passphrase is not required.

NOTE: There are responsibilities placed on the caller utilizing Overwrite NVDIMM. See the additional notes at the end of this section.

Function Input

The following tables outline the expected input payload for this command.

Table 3-38 Overwrite NVDIMM – Input Format

Field	Byte Length	Byte Offset	Description
Current Passphrase	32	0	The User Passphrase supplied when the user overwrites the NVDIMM using this command. -This field is required if the NVDIMM returns **Security Enabled** state for Get Security State command. -This field is ignored by the NVDIMM if it returns **Security Disabled** state for Get Security State command See **Theory Of Operation, Application In-band Get Security State Sequence** for this logic.

Function Output

The following tables outline the expected output payload for this command.

Table 3-39 Overwrite NVDIMM – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. This status indicates that the overwrite operation was started. Utilize Query Overwrite NVDIMM Status security command to periodically poll for command completion. 07 – Function Specific Status (see Extended Status below) 10 - Failure – Invalid Security State 11 - Failure – Invalid Current Passphrase Supplied
Extended Status	2	2	Extended Status Field 01 – Failure – Unsupported Overwrite Configuration

Further application responsibilities when utilizing Overwrite NVDIMM:

- At a minimum, host IO to PMEM Mode and Memory Mode regions of the NVDIMM shall be quiesced and new IO blocked while this security command is executing for the NVDIMM
- If the application will also execute a Secure Erase NVDIMM command, the Overwrite NVDIMM SHALL be executed AFTER the Secure Erase NVDIMM
- After SW has issued the Overwrite NVDIMM DSM request and it has returned successful status, SW is required to poll for Overwrite operation completion by calling Query Overwrite NVDIMM Status command periodically until the command completes
- The NVDIMM's internal configuration information is overwritten and all partition info & interleave set configuration info is lost. The NVDIMM may lose its relationship to its current interleave set after the completion of the Overwrite NVDIMM command.
- The Label Storage Area is overwritten and all label info blocks and labels are destroyed.

3.8.9 Query Overwrite NVDIMM Status (Function Index 26)

After SW has issued the Overwrite NVDIMM DSM request and it has returned successful status, SW is required to poll for Overwrite operation completion by calling this command periodically until successful status or failed status is reported. As long as "Overwrite NVDIMM In Progress" is reported for extended status, SW shall continue to poll for completion. Once the Query Overwrite NVDIMM Status operation completes with success status, optionally, it is possible to begin a new configuration sequence to write new NVDIMM configuration information, including the Label Storage Area data, before the first re-boot in the configuration process.

NOTE: There are responsibilities placed on the caller utilizing Query Overwrite NVDIMM Status. See the additional notes at the end of this section.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-40 Query Overwrite NVDIMM Status – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. This status indicates the Overwrite NVDIMM operation completed successfully. 07 – Function Specific Status (see Extended Status below)
Extended Status	2	2	Extended Status Field 01 – Overwrite NVDIMM in Progress. Software should continue to poll for overwrite completion until a success or failure status is returned 02 – Sequencing Error – Query Overwrite NVDIMM Status called without first calling Overwrite NVDIMM

Further application responsibilities when utilizing Query Overwrite NVDIMM Status:

- Host IO to the PMEM of the NVDIMM shall be quiesced and new IO blocked while this security command continues to report “Overwrite NVDIMM In Progress”.
- If the Overwrite NVDIMM fails to complete with success the state of the NVDIMM is indeterminate and it is recommended that the Overwrite be executed again.
- The Overwrite NVDIMM operation takes a significant amount of time to complete: 15min - 128GB, 30min - 256GB, 60min – 512GB, etc. There for, it is recommended that SW poll for completion with an interval of 10-60 seconds.. These values can also be used as a guide as to when SW may want to give up on polling for successful completion. Implementations may wish to issue the first query with a small timeout to make sure the Overwrite NVDIMM is still executing before moving to a longer polling frequencies for the rest of the query calls.

Note: It is possible to issue other DSMs while the Overwrite is executing so SW can monitor the DIMM health and temperature (for example) while the Overwrite DIMM executes. Other operations (ARS, FW Update) are not allowed and those DSMs will be rejected.

3.8.10 Set Master Passphrase (Function Index 27)

Allows the caller to set the Master Passphrase on the NVDIMM. The Master Passphrase is a passphrase that can be used to perform a Secure Erase operation. This command is only available if security is not enabled. Setting a Master Passphrase does not enable security. Once the Master Passphrase is enabled, it is always in affect, and is reflected in Set Security State function. You can change from the default to another value but you can't turn it off. If security is enabled after enabling the master passphrase, either passphrase can be utilized when calling Secure Erase NVDIMM.

Function Input

The following tables outline the expected input payload for this command.

Table 3-29 Set Master Passphrase – Input Format

Field	Byte Length	Byte Offset	Description
Current Passphrase	32	0	The Master Passphrase supplied when the user previously set a master passphrase on the NVDIMM using this command. -If the NVDIMM is in the **Master Passphrase Enabled** state, this must match the passphrase that was supplied in the **New Passphrase** field on last successful invocation of the Set Master Passphrase command. -The first time this is invoked, the default master passphrase must be utilized as the Current Passphrase. The default master passphrase is 32 bytes of zero's.
New Passphrase	32	32	The new Master Passphrase. Required field utilized as part of setting a new master passphrase on the NVDIMM. The Master Passphrase cannot be set to the default passphrase.

Function Output

The following tables outline the expected output payload for this command.

Table 3-30 Set Master Passphrase – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. 01 - Failure - Function Not Supported - This is reported if the NVDIMM Master Passphrase is not supported OR if **Master Passphrase Limit Expired** in **Get Security State** has been reached. 07 – Function Specific Status (see Extended Status below)

			10 - Failure – Invalid Security State 11 - Failure – Invalid Current Passphrase Supplied
Extended Status	2	2	Extended Status Field Undefined

3.8.11 Secure Erase NVDIMM w Master Passphrase (Function Index 28)

Instruct the NVDIMM to generate a new encryption key for the PMEM which crypto-scrambles/randomizes all existing user data in the PMEM, using the Master Passphrase. The Label Storage Area is unaffected and the existing configuration is preserved. The erase typically takes seconds or less to complete. For details on affected data and metadata regions on the NVDIMM when executing this action, see the product specific FIS.

NOTE: There are significant responsibilities placed on the caller utilizing Secure Erase. See the additional notes at the end of this section.

Function Input

The following tables outline the expected input payload for this command.

Table 3-36 Secure Erase NVDIMM w Master Passphrase – Input Format

Field	Byte Length	Byte Offset	Description
Master Passphrase	32	0	The Master Passphrase supplied when the user secure erases the NVDIMM using this command. See **Theory Of Operation, Application In-band Get Security State Sequence** for this logic. -This protocol will only successfully erase the NVDIMM If the **Master Passphrase Enabled** state is reported for Get Security State command and the correct Master Passphrase is provided when erasing the NVDIMM.

Function Output

The following tables outline the expected output payload for this command.

Table 3-37 Secure Erase NVDIMM w Master Passphrase – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 00 – Success. The security command executed successfully. 01 - Failure - Function Not Supported - If the NVDIMM **Master Passphrase Enabled** state for Get Security State command is NOT set, this error will result. If Master Passphrase is set to default passphrase Secure Erase will be rejected until it is changed. 10 - Failure – Invalid Security State 11 - Failure – Invalid Master Passphrase Supplied
Extended Status	2	2	Extended Status Field Undefined

Further application responsibilities when utilizing Secure Erase NVDIMM:

- Host IO to the PMEM shall be quiesced and new IO blocked while this security command is executing for the NVDIMM
- If the application will also execute an Overwrite NVDIMM command, the Secure Erase NVDIMM shall be executed before the Overwrite NVDIMM
- Any IO to the PMEM region while the Secure Erase NVDIMM is executing will cause encrypted random data to be read. While tearing down the logical device stack can be helpful in removing host IO, unless speculative cpu reads are actively prevented (removing virtual memory mapping may not be enough), cpu caches must be invalidated, after the Secure Erase NVDIMM command completes and before the NVDIMM is returned to operation.
- While the Label Storage Area is preserved, any address abstraction info blocks in PMEM are destroyed.

3.9 NVDIMM Runtime FW Activation

3.9.1 Get Device Runtime FW Activation Status (Function Index 29)

If NVDIMM supports runtime firmware activation, this function provides runtime firmware activation related information.

Function Input

None

Function Output

The following tables outline the expected output payload for this command.

Table 3-38 Get Device Runtime FW Activation Status – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined
Last FW Activation Status	2	4	Previous FW Activation Status. Valid if FW Activation State is not Busy. 0 – None 1 – Success 2 – No new staged firmware to activate 3 – NVDIMM Reset required to activate staged firmware 4 – Media disabled during firmware activation 5 – Activation aborted due to throttling or device busy, recommended software to retry firmware activation 6 – Staged firmware does not meet activation requirements 7 – Unclassified firmware activation error

			This field gets reset to None on boot. Arm or dis-Arm will not clear the field. This field gets updated on FW activation.
FW Activation State	1	6	0 – Idle 1 – Armed 2 – Busy
Reserved	1	7	Shall return 0

3.9.2 Set Device Runtime FW Activation Arm State (Function Index 30)

If NVDIMM supports runtime firmware activation, this function is used to select or unselect NVDIMM to participate in runtime firmware activation. The arm state selection can be made regardless of new firmware downloaded to the NVDIMM or not. The arm state is not consulted when system is going through reset system reset.

Function Input

The following tables outline the expected input payload for this command.

Table 3-39 Set Device Runtime FW Activation Arm State – Input Format

Field	Byte Length	Byte Offset	Description
Arm State	1	0	0 – Not Armed (Dis-Armed) 1 – Armed Default at boot is Not Armed

Function Output

The following tables outline the expected output payload for this command.

Table 3-40 Set Device Runtime FW Activation Arm State – Output Format

Field	Byte Length	Byte Offset	Description

Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field Undefined

Implantation Note: Do not allow changing Arm State while firmware activation is in progress.

3.10 LSA Error Inject (Function Index 31)

Allows the injection of a poison error into the Label Storage Area of the NVDIMM. The size of the LSA is obtained from the ACPI NVDIMM Label method _LSI (Label Storage Information).

An error will persist and stay injected until cleared. It is up to the error injection test program to keep track of the injected poison and clear the poison using this command when the test is complete. If error tracking is unavailable, then the entire LSA can be cleared of all poison & data using this command.

Error Injection must be enabled on the platform before attempting to inject NVDIMM specific errors. Clearing injected poison errors and data does not require error injection to be enabled.

Function Input

The following tables outline the expected input payload for this command.

Table 3-41 LSA Error Inject - Input Format

Field	Byte Length	Byte Offset	Description
Enable	1	0	0 – Clear, Clear poison errors and data in each cache line in LSA specified by the offset and length. 1 – Set, Inject poison errors in each cache line in LSA specified by the offset and length.
Reserved	3	1	Reserved
Offset	4	4	Offset in bytes of the LSA to inject memory error. Offset shall be aligned to the Clear Uncorrectable Error Range Length Unit Size reported in ACPI NVDIMM Root Device _DSM Query ARS Capabilities.
Error Inject Range Length	4	8	Error injection length, In bytes.

			Length shall be an integer multiple of the Clear Uncorrectable Error Range Length Unit Size reported in ACPI NVDIMM Root Device _DSM Query ARS Capabilities. Offset + Length shall not exceed the size of the partition as reported by the field SizeOfLabelStoreageArea in the NVDIMM Label method _LSI (Label Storage Information).

Function Output
The following tables outline the expected output payload for this command.

Table 3-42 LSA Error Inject Data – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 03 – Invalid Input Parameters Returned If any LSA Error inject parameter value requested is invalid. No changes are made to any previous enable/disable Error Injection state and no changes are made to any previously set Error Inject values.
Extended Status	2	2	Extended Status Field 01 – Platform not enabled for error injection. Error Injection must be enabled on the platform before attempting to inject NVDIMM specific errors.

Note: LSA Error injection injects errors into the LSA using an injection unit size that is equal to Clear Uncorrectable Error Range Length Unit Size reported in ACPI NVDIMM Root Device _DSM Query ARS Capabilities. LSA Error Inject is not an atomic operation, as such if the Error Inject Range Length is an integer multiple larger than the injection unit size and an error ([4]Failure - HW Error, [5]Failure - Retry Suggested – Command Timed Out, [6]Unknown Reason) occurs the state of the range defined by Error Inject Range Length may be undefined. _LSW may be used to return LSA to a known good state.

3.11 Deprecated Functions

3.11.1 Get Block NVDIMM Flags (Function Index 3)

This function that is only applicable if block mode is enabled in the NVDIMM (i.e., the Number of Block Control Windows field set is set to a non-zero value in the NVDIMM Control Region Structure). Used by

the NVDIMM to report specific features or alternative sequences that need to be implemented by SW drivers.

Warning: This function has been deprecated. It is included here for backwards compatibility with existing Arg1 - Revision Id = 1 implementations.

Function Input
None

Function Output
The following tables outline the expected output payload for this command.

Table 3-41 Get Block NVDIMM Flags - Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	Extended Status Field
NVDIMM Flags	4	4	Byte[0] Bit[0] – Block Data Window Invalidation Required – If this bit is set to 1, indicates that the NVDIMM requires the driver to flush previous data from cache lines that will be moved through the Block Data Window, before re-using the Block Data Window for read. If set to '0', flushing of previous data from cache lines that will be moved through the Block Data Window are handled by the platform or VMM. Typical usage of this flag is in a virtualized environment. Bit[1] – Command Register in Block Control Window Latch – If this bit is set to 1, indicates that after a write to the Command Register in Block Control Windows, the NVDIMM requires the software to read the same Command Register to ensure that the command is latched before reading contents from Block Data Window. If this bit is set to 0, software is allowed to read the contents of the Block Data Window immediately after writing to the Command Register of Block Control Window. Bits[7:2] – Reserved, shall return 0 Byte[3:1] – Reserved, shall return 0

3.11.2 Get Namespace Label Size (Function Index 4)

This command requests the device to return the size of the Namespace Label storage area for the requested device.

Warning: This function has been deprecated in preference to the ACPI 6.2 _LSI (Label Storage Information) NVDIMM Device Interface and is only supported with Arg1 – Revision Id = 1. It is included here for backwards compatibility with existing Arg1 - Revision Id = 1 implementations.

Function Input

None

Function Output

The following tables outline the expected output payload for this command. See **updated/new additions & clarifications** below for this existing LSM.

Table 3-42 Get Namespace Label Size – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C
Extended Status	2	2	01 – Extended Success Status - Locked Persistent Memory Region – The PMEM is currently in a locked state. This DSM is expected to continue to report a valid namespace label size, returns status success (0) and reports this extended status if the persistent memory region of the NVDIMMs are in a state that requires one or more security keys to be applied before the region is accessible.
Size of Namespace Label Area	4	4	Size returned in bytes
Max Namespace Label Data Length	4	8	In bytes, Maximum size of the namespace label data length supported by the platform in *Get/Set Namespace Label Data* functions

3.11.3 Get Namespace Label Data (Function Index 5)

This command requests the device to return Namespace Label storage area data based on the requested buffer offset and length for the requested device.

Warning: This function has been deprecated in preference to the ACPI 6.2 _LSR (Label Storage Read) NVDIMM Device Interface and is only supported with Arg1 – Revision Id = 1. It is included here for backwards compatibility with existing Arg1 - Revision Id = 1 implementations.

Function Input

The following tables outline the expected input payload for this command.

Table 3-43 Get Namespace Label Data – Input Format

Field	Byte Length	Byte Offset	Description
Offset	4	0	In bytes Indicates the offset in the namespace label data area, to which the namespace label data is to be read from the target NVDIMM
Length	4	4	In bytes

Function Output

The following tables outline the expected output payload for this command.

Table 3-44 Get Namespace Label Data – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 03 – Invalid Input Parameters - Offset + Length is > size of Namespace Label Data Area (Max Namespace Label Data Length from GetNamespaceLabelDataSize LSM) - Length is > maximum amount of data the OSPM can transfer in a single request
Extended Status	2	2	Extended Status Field

Namespace Label Data	Varies	4	The size of the output is equal to input's *Length* if *Status* is Success; otherwise, the contents of rest of the output buffer are not valid.

3.11.4 Set Namespace Label Data (Function Index 6)

This command requests the device to update Namespace Label Data area data based on the requested buffer offset and length for the requested device.

Warning: This function has been deprecated in preference to the ACPI 6.2 _LSW (Label Storage Write) NVDIMM Device Interface and is only supported with Arg1 – Revision Id = 1. It is included here for backwards compatibility with existing Arg1 - Revision Id = 1 implementations.

Function Input

The following tables outline the expected input payload for this command.

Table 3-45 Set Namespace Label Data – Input Format

Field	Byte Length	Byte Offset	Description
Offset	4	0	In bytes Indicates the offset in the namespace label data area, to which the *Namespace Label Data* is to be written to the target NVDIMM
Length	4	4	In bytes
Namespace Label Data	Varies	8	Namespace label data. Size of the namespace label data is as indicated by *Length* field above.

Function Output

The following tables outline the expected output payload for this command.

Table 3-46 Set Namespace Label Data – Output Format

Field	Byte Length	Byte Offset	Description
Status	2	0	Defined above in Table 3-C 03 – Invalid Input Parameters - Offset + Length is > size of Namespace Label Data Area (Max Namespace Label Data Length from GetNamespaceLabelDataSize LSM)

			- Length is > maximum amount of data the OSPM can transfer in a single request
Extended Status	2	2	Extended Status Field