DELKIN DEVICES®

Automotive Grade 2

INDUSTRIAL M.2 2230 BGA SSD

Engineering Specification

Document Number: 401-0609-00

Revision: A

Overview

- **Capacity**
  - 1TB
- **Form Factor**
  - M.2 2230, 22mm x 30mm
- **PCIe Express Base Specification**
  - Gen 4 x 4 lanes
  - NVMe 1.4
  - PCI Express Base 4.0
- **Performance**
  - Read: 3650 MB/s
  - Write: 2900 MB/s
- **Reliability**
  - MTBF >1.5 million hours
  - UBER < 1 sector per10^{16} bits read
- **Voltage Supply Rails**
  - P1 = 2.5V
  - P2= 1.2V
  - P3= 0.85V
- **Power Saving Modes (Optional)**
  - PS0/PS1/PS2/PS3/PS4 (<3.5W)
  - Support APST
  - Support ASPM
  - Support L1.2
- **Endurance: TBW**
  - 1341TB
- **Operation Temperature Range**
  - -40°C ~ 105°C
- **Feature Support List**
  - SMART
  - Host controlled thermal management
  - Power loss protection
  - End to end data path protection
  - Thermal throttling
  - LDPC + RAID ECC
  - Support HMB[1]
  - RPMB
  - Boot Partition
- **RoHS compliant**

Notes:

1. Win10 (version 1809) and above supports HMB (Host Memory Buffer) function.

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1. INTRODUCTION

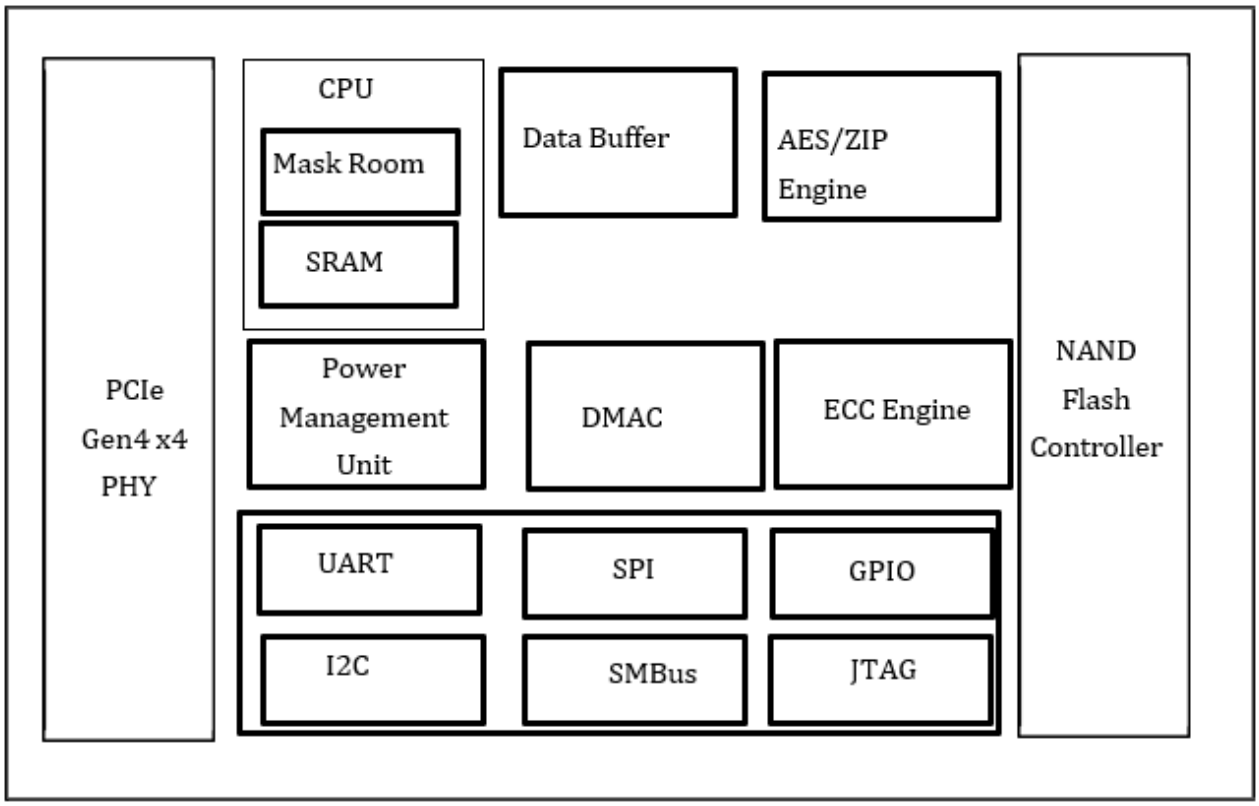
1.1. General Description

Delkin Devices M.2 2230 SSD delivers all the advantages of flash drive technology with PCIe Gen 4x4 interface in an embedded BGA form factor. It is estimated to reach up to 3700 MB/s read as well as 3000 MB/s write sequential performance. The Delkin Devices BGA SSD throughput is capable of saturating Gen 4x4 host interface. The power consumption of our M.2 2230 SSD is much lower than traditional hard drives, making it the best embedded solution for new platforms.

Table 1 – Device Summary

Part Number	Available Capacities	BGA	Size
M51TFSTNV-30000-2	1TB	291 Ball	22 x 30 x 2.15mm

1.2 CONTROLLER BLOCK DIAGRAM



1.3 Flash Management

1.3.1 Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, Delkin's BGA SSD controller applies the LDPC (Low Density Parity Check) ECC algorithm, which can detect and correct errors that occur during the Read process, ensuring data has been read correctly, as well as protect data from corruption.

1.3.2 Wear Leveling

NAND Flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some areas are updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling techniques are applied to extend the lifespan of NAND Flash by evenly distributing write and erase cycles across the media. Delkin's controller utilizes an advanced Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing both dynamic and static Wear Leveling algorithms, the life expectancy of the NAND Flash is greatly improved.

1.3.3 Bad Block Management

Bad blocks are blocks that include one or more invalid bits, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as "Initial Bad Blocks". Bad blocks that are developed during the lifespan of the flash are named "Later Bad Blocks". Delkin implements an efficient bad block management algorithm to detect the factory-produced bad blocks and manages any bad blocks that develop with use. This practice further prevents data being stored into bad blocks and improves the data reliability.

1.3.4 TRIM

TRIM is a feature which helps improve the read/write performance and speed of solid state drives (SSD). SSDs are not able to overwrite existing data, so the available space gradually becomes smaller with each use. With the TRIM command, the operating system can inform the SSD so that blocks of data that are no longer in use can be removed permanently. Thus, the SSD will perform the erase action, which prevents unused data from occupying blocks at all time.

1.3.5 Smart Function

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is a special function that allows a memory device to automatically monitor its health. When a failure is recorded by S.M.A.R.T., users can choose to replace the drive to prevent unexpected outage or data loss. S.M.A.R.T. can inform users impending failures while there is still time to perform proactive actions, such as save data to another device.

1.3.6 Over-Provision

Over Provisioning refers to the preserving additional area beyond user capacity in a SSD, which is not visible to users and cannot be used by them. However, it allows a SSD controller to utilize additional space for better performance and WAF. With Over Provisioning, the performance and IOPS (Input/ Output Operations per Second) are improved by providing the controller additional space to manage P/E cycles, which enhances the reliability and endurance as well. Moreover, the write amplification of the SSD becomes lower when the controller writes data to the flash.

1.4 Advanced Device Security Features

1.4.1 Secure Erase

Secure Erase is a standard NVMe format command and will make all “0xFF” to fully wipe all the data on hard drives and SSDs. When this command is issued, SSD controller will erase its storage blocks and return to its factory default settings

1.5 SSD Lifetime Management

Terabytes Written (TBW)

TBW (Terabytes Written) is a measurement of SSDs’ expected lifespan, which represents the amount of data written to the device. To calculate the TBW of a SSD, the following equation is applied:

TBW = [(NAND Endurance) x (SSD Capacity)] / [WAF]

NAND Endurance: NAND endurance refers to the P/E (Program/Erase) cycle of a NAND flash.

SSD Capacity: The SSD capacity is the specific capacity in total of a SSD.

WAF: Write Amplification Factor (WAF) is a numerical value representing the ratio between the amount of data that a SSD controller needs to write and the amount of data that the host’s flash controller writes. A better WAF, which is near 1, guarantees better endurance and lower frequency of data written to flash memory.

TBW in this document is based on JEDEC 219 workload.

Media Wear Indicator

Actual life indicator reported by SMART Attribute byte index [5], Percentage Used, recommends User to replace drive when reaching to 100%.

Read Only Mode (End of Life)

When drive is aged by cumulated program/erase cycles, media worn-out may cause increasing numbers of later bad block. When the number of usable good blocks falls outside a defined usable range, the drive will notify Host through AER event and Critical Warning to enter Read Only Mode to prevent further data corruption. User should start to replace the drive with another one immediately.

1.4 An Adaptive Approach to Performance Tuning

1.4.1 Throughput

Based on the available space of the disk, the Delkin Device BGA SSD will regulate the read/write speed and manage the performance of throughput. When there still remains a lot of space, the firmware will continuously perform read/write action. There is still no need to implement garbage collection to allocate and release memory, which will accelerate the read/write processing to improve the performance. Contrarily, when the space is going to be used up, the BGA SSD will slow down the read/write processing, and implement garbage collection to release memory. Hence, read/write performance will become slower.

2 PRODUCT SPECIFICATION OVERVIEW

- **Capacity**
  - 1TB
- **Operation Temp. Range**
  - -40~105°C

Electrical/Physical Interface

- PCIe Interface
- Compliant with NVMe 1.4
- PCIe Express Base ver. 4.0
- PCIe Gen 4 x 4 lane & backward compatible to PCIe Gen 3, PCIe Gen 2, and Gen 1
- Support up to QD 128 with queue depth of up to 64K
- Support power management

Supported NAND Flash

- Support up to 16 Flash Chip Enables (CE) within a single design
- Support 8-bit I/O NAND Flash
- Support Toggle 2.0, Toggle 3.0 and Toggle 4.0 interface

ECC Scheme

- BGA SSD applies the LDPC + RAID ECC algorithm.

Sector Size Support

- 512byte
- 4KB

UART/GPIO

Voltage Rails

2230-BGA SSD

- P1=2.5V
- P2=1.2V
- P3=0.85V

Support SMART and TRIM commands

LBA Range

- **IDEMA Standard**

Capacity	512 Bytes/Sector		Sequential	
	Number of Total LBA	User Available Bytes	Number of Total LBA	User Available Bytes
1TB	2,000,409,264	1,024,209,543,168	250,051,158	1,024,209,543,168

2.4 Performance

- **PS0 (Full Speed Mode)**

Capacity	Sequential		Random	
	Read (MB/s)	Write (MB/s)	Read (MB/s)	Write (MB/s)
1TB	3650	2900	380K	500K

NOTES:

Performance is estimated with the following conditions

- Sequential: CrystalDiskMark 7.0, 1GB range, QD=8T1
- Random: IOMeter, 1GB range, 4K data size, QD=32T16

TBW (Terabytes Written)

Capacity	TBW
1TB	1341

NOTES:

- TBW is measured by JEDEC Client 219A workload and calculated with PE count = 3000.
- TBW may differ according to flash configuration and platform configuration.
- The SSD supports trim function. If Operation System does not support trim command, performance and TBW will be affected. (Like certain Windows OS, Linux kernel version before 2.6.33, other OS please reference each own user manual)
- The endurance of SSD could be estimated based on user behavior, NAND endurance cycles, and write amplification factor.

3 ENVIRONMENTAL SPECIFICATIONS

3.1 MTBF

MTBF, an acronym for Mean Time Between Failures, is a measure of a device's reliability. Its value represents the average time between a repair and the next failure. The measure is typically in units of hours. The higher the MTBF value, the higher the reliability of the device.

The predicted result of Delkin's BGA SSD is more than 1,500,000 hours.

3.2 Certifications and Compliances

- RoHS
- WHQL
- PCI Express Base 4.0
- UNH-IOL NVM Express Logo

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4 ELECTRICAL SPECIFICATIONS

4.1 Supply Voltage

Parameter	Rating		
Operating Voltage	Min.	Nom.	Max.
	+3.135V	+3.3V DC	+3.465V
Rise Time (Max/Min)	100ms/0.1ms		
Fall Time (Max/Min)	5s/1ms		
Min. Off Time[1 2]	1s		

NOTES:

1. Minimum time between power removed from SSD (VCC < 500 mW) and power re-applied to the drive.
2. The Min. Off Time may differ according to power solution used.

4.2 Power Consumption

Power Consumption in mW

Capacity	Read	Write
1TB	4000	3700

NOTES:

1. The measured power voltage of M.2 SSD is 3.3V.
2. Measurement environment: Room temperature: 20~25℃, humidity: 40~60%RH, DC+3.3V condition.
3. Power consumption may differ according to flash configuration, use condition, environment and platform configuration.

3.1 Idle Power Consumption

Idle Power Consumption in mW

Capacity	Idle
1TB	1500

NOTES:

1. Idle power consumption is measured at idle state with no write/read operation.
2. The measured power voltage of M.2 SSD is 3.3V.
3. Measurement environment: Room temperature: 20~25℃, humidity: 40~60%RH, DC+3.3V condition.
4. Power consumption may differ according to flash configuration, use condition, environment and platform configuration.

4 M.2 2230 PIN ASSIGNMNET/DESCRIPTION

4.1 Pin Assignment and Descriptions

Pin #	PCIe Pin	Description
1	CONFIG_3 = GND	Ground
2	3.3V	3.3V source
3	GND	Ground
4	3.3V	3.3V source
5	PETn3	PCIe TX Differential signal defined by the PCI Express M.2 spec
6	N/C	No Connect
7	PETp3	PCIe TX Differential signal defined by the PCI Express M.2 spec
8	TBD	TBD
9	GND	Ground
10	LED1#	Open drain, active low signal. These signals are used to allow the add-in card to provide status indicators via LED devices that will be provided by the system.
11	PERn3	PCIe RX Differential signal defined by the PCI Express M.2 spec
12	3.3V	3.3V source
13	PERp3	PCIe RX Differential signal defined by the PCI Express M.2 spec
14	3.3V	3.3V source
15	GND	Ground
16	3.3V	3.3V source
17	PETn2	PCIe TX Differential signal defined by the PCI Express M.2 spec
18	3.3V	3.3V source
19	PETp2	PCIe TX Differential signal defined by the PCI Express M.2 spec
20	N/C	No connect
21	GND	Ground
22	N/C	No connect
23	PERn2	PCIe RX Differential signal defined by the PCI Express M.2 spec
24	N/C	No connect
25	PERp2	PCIe RX Differential signal defined by the PCI Express M.2 spec

26	N/C	No connect
27	GND	Ground
28	N/C	No connect
29	PETn1	PCIe TX Differential signal defined by the PCI Express M.2 spec
30	TBD	TBD
31	PETp1	PCIe TX Differential signal defined by the PCI Express M.2 spec
32	N/C	No connect
33	GND	Ground
34	N/C	No connect
35	PERn1	PCIe RX Differential signal defined by the PCI Express M.2 spec
36	N/C	No connect
37	PERp1	PCIe RX Differential signal defined by the PCI Express M.2 spec
38	N/C	No connect
39	GND	Ground
40	SMB_CLK (I/O)(0/1.8V)	SMBus Clock; Open Drain with pull-up on platform
41	PETn0	PCIe TX Differential signal defined by the PCI Express M.2 spec
42	SMB_DATA (I/O)(0/1.8V)	SMBus Data; Open Drain with pull-up on platform.
43	PETp0	PCIe TX Differential signal defined by the PCI Express M.2 spec
44	ALERT#(O) (0/1.8V)	Alert notification to master; Open Drain with pull-up on platform; Active low.
45	GND	Ground
46	N/C	No connect
47	PERn0	PCIe RX Differential signal defined by the PCI Express M.2 spec
48	N/C	No connect
49	PERp0	PCIe RX Differential signal defined by the PCI Express M.2 spec

50	PERST#(I)(0/3.3V)	PE-Reset is a functional reset to the card as defined by the PCIe Mini CEM specification.
51	GND	Ground
52	CLKREQ#(I/O)(0/3.3V)	Clock Request is a reference clock request signal as defined by the PCIe Mini CEM specification; Also used by L1 PM Sub-states.
53	REFCLKn	PCIe Reference Clock signals (100 MHz) defined by the PCI Express M.2 spec.
54	PEWAKE#(I/O)(0/3.3V)	PCIe PME Wake Open Drain with pull up on platform; Active Low.
55	REFCLKp	PCIe Reference Clock signals (100 MHz) defined by the PCI Express M.2 spec.
56	Reserved for MFG DATA	Manufacturing Data line. Used for SSD manufacturing only. Not used in normal operation. Pins should be left N/C in platform Socket.
57	GND	Ground
58	Reserved for MFG CLOCK	Manufacturing Clock line. Used for SSD manufacturing only. Not used in normal operation. Pins should be left N/C in platform Socket.
59	Module Key M	Module Key
60	Module Key M	Module Key
61	Module Key M	Module Key
62	Module Key M	Module Key
63	Module Key M	Module Key
64	Module Key M	Module Key
65	Module Key M	Module Key
66	Module Key M	Module Key
67	N/C	No Connect
68	SUSCLK(32KHz)(I)(0/3.3V)	No connect
69	N/C	CONFIG_1 = No connect
70	3.3V	3.3V source
71	GND	Ground
72	3.3V	3.3V source

73	GND	Ground
74	3.3V	3.3V source
75	GND	CONFIG_2 = Ground

5 SUPPORTED COMMANDS

6.1. NVME COMMAND LIST

Admin Commands

Opcode	Command Description
00h	Delete I/O Submission Queue
01h	Create I/O Submission Queue
02h	Get Log Page
04h	Delete I/O Completion Queue
05h	Create I/O Completion Queue
06h	Identify
08h	Abort
09h	Set Features
0Ah	Get Features
0Ch	Asynchronous Event Request
0Dh	Namespace Management
10h	Firmware Activate
11h	Firmware Image Download
14h	Device Self-test
15h	Namespace Attachment
18h	Keep Alive

Admin Commands – NVM Command Set Specific

Opcode	Command Description
80h	Format NVM
81h	Security Send
82h	Security Receive
84h	Sanitize

NVM Commands

Opcode	Command Description
00h	Flush
01h	Write
02h	Read
04h	Write Uncorrectable
05h	Compare
08h	Write Zeroes
09h	Dataset Management

6.2 IDENTIFY DEVICE DATA

Identify Controller Data Structure

Bytes	Description	Default Value
01:00	PCI Vendor ID (VID)	0x1987
03:02	PCI Subsystem Vendor ID (SSVID)	0x1987
23:04	Serial Number (SN)	SN
63:24	Model Number (MN)	Model Number
71:64	Firmware Revision (FR)	FW Name
72	Recommended Arbitration Burst (RAB)	0x4
75:73	IEEE OUI Identifier (IEEE)	Assigned by IEEE/RAC
76	Controller Multi-Path I/O and Namespace Sharing Capabilities (CMIC)	0x0
77	Maximum Data Transfer Size (MDTS)	0x6
79:78	Controller ID (CNTLID)	0x0000
83:80	Version (VER)	0x10400
87:84	RTD3 Resume Latency (RTD3R)	0x186A0
91:88	RTD3 Entry Latency (RTD3E)	0x4C4B40
95:92	Optional Asynchronous Events Supported (OAES)	0x0
99:96	Controller Attributes (CTRATT)	0x2
101:100	Read Recovery Levels Supported (RRLS)	0x0
110:102	Reserved	0x00
111	Controller Type (CNTRLTYPE)	0x01

127:112	FRU Globally Unique Identifier (FGUID)	0x00
129:128	Command Retry Delay Time 1 (CRDT1)	0x0
131:130	Command Retry Delay Time 2 (CRDT2)	0x0
133:132	Command Retry Delay Time 3 (CRDT3)	0x0
239:134	Reserved	0x00
255:240	Refer to the NVMe Management Interface Specification for Definition	0x00
257:256	Optional Admin Command Support (OACS)	0x17
258	Abort Command Limit (ACL)	0x3
259	Asynchronous Event Request Limit (AERL)	0x3
260	Firmware Updates (FRMW)	0x12
261	Log Page Attributes (LPA)	0x1E
262	Error Log Page Entries (ELPE)	0x3E
263	Number of Power States Support (NPSS)	0x4
264	Admin Vendor Specific Command Configuration (AVSCC)	0x1
265	Autonomous Power State Transition Attributes (APSTA)	0x1
267:266	Warning Composite Temperature Threshold (WCTEMP)	0x16B
269:268	Critical Composite Temperature Threshold (CCTEMP)	0x170
271:270	Maximum Time for Firmware Activation (MTFA)	0x64
275:272	Host Memory Buffer Preferred Size (HMPRE)	0x00000000(HMB off)Depend on Disk Size(HMB on)
279:276	Host Memory Buffer Minimum Size (HMMIN)	0x00000000(HMB off)Depend on Disk Size(HMB on)
295:280	Total NVM Capacity (TNVMCAP)	non-zero
311:296	Unallocated NVM Capacity (UNVMCAP)	0x00
315:312	Replay Protected Memory Block Support (RPMBS)	0x1F1F0002
317:316	Extended Device Self-test Time (EDSTT)	0x1E
318	Device Self-test Options (DSTO)	0x0
319	Firmware Update Granularity (FWUG)	0x4
321:320	Keep Alive Support (KAS)	0x0
323:322	Host Controlled Thermal Management Attributes (HCTMA)	0x1

325:324	Minimum Thermal Management Temperature (MNTMT)	0x111
327:326	Maximum Thermal Management Temperature (MXTMT)	0x170
331:328	Sanitize Capabilities (SANICAP)	0xA0000006
335:332	Host Memory Buffer Minimum Descriptor Entry Size (HMMINDS)	0x0
337:336	Host Memory Maximum Descriptors Entries (HMMAXD)	0x0
339:338	NVM Set Identifier Maximum (NSETIDMAX)	0x0
341:340	Endurance Group Identifier Maximum (ENDGIDMAX)	0x0
342	ANA Transition Time (ANATT)	0x0
343	Asymmetric Namespace Access Capabilities (ANACAP)	0x0
347:344	ANA Group Identifier Maximum (ANAGRPMAX)	0x0
351:348	Number of ANA Group Identifiers (NANAGRPID)	
355:352	Persistent Event Log Size (PELS)	0x60
511:356	Reserved	0x00
512	Submission Queue Entry Size (SQES)	0x66
513	Completion Queue Entry Size (CQES)	0x44
515:514	Maximum Outstanding Commands (MAXCMD)	0x100
519:516	Number of Namespaces (NN)	0x1
521:520	Optional NVM Command Support (ONCS)	0xDF
523:522	Fused Operation Support (FUSES)	0x0
524	Format NVM Attributes (FNA)	0x0
525	Volatile Write Cache (VWC)	0x7
527:526	Atomic Write Unit Normal (AWUN)	0xFF
529:528	Atomic Write Unit Power Fail (AWUPF)	0x0
530	NVM Vendor Specific Command Configuration (NVSCC)	0x1
531	Reserved	0x0
533:532	Atomic Compare & Write Unit (ACWU)	0x0
535:534	Reserved	0x00
539:536	SGL Support (SGLS)	0x0
543:540	Maximum Number of Allowed Namespaces (MNAN)	0x0
767:544	Reserved	0x00
1023:768	NVM Subsystem NVMe Qualified Name (SUBNQN)	nqn.2020-11.com.delkin:nvme:PS5021:

1791:1024	Reserved	0x00
2047:1792	Refer to the NVMe over Fabrics specification	0x00
2079:2048	Power State 0 Descriptor (PSD0)	
Bit[255:184]	Reserved	0x00
Bit[183:182]	Active Power Scale (APS)	0x0
Bit[181:179]	Reserved	0x0
Bit[178:176]	Active Power Workload (APW)	0x0
Bit[175:160]	Active Power (ACTP)	0x0
Bit[159:152]	Reserved	0x0
Bit[151:150]	Idle Power Scale (IPS)	0x0
Bit[149:144]	Reserved	0x0
Bit[143:128]	Idle Power (IDLP)	0x0
Bit[127:125]	Reserved	0x0
Bit[124:120]	Relative Write Latency (RWL)	0x0
Bit[119:117]	Reserved	0x0
Bit[116:112]	Relative Write Throughput (RWT)	0x0
Bit[111:109]	Reserved	0x0
Bit[108:104]	Relative Read Latency (RRL)	0x0
Bit[103:101]	Reserved	0x0
Bit[100:96]	Relative Read Throughput (RRT)	0x0
Bit[95:64]	Exit Latency (EXLAT)	0x0
Bit[63:32]	Entry Latency (ENLAT)	0x0
Bit[31:26]	Reserved	0x0
Bytes	Description	Default Value
Bit[25]	Non-Operational State (NOPS)	0x0
Bit[24]	Max Power Scale (MPS)	0x0
Bit[23:16]	Reserved	0x0
Bit[15:0]	Maximum Power (MP)	0x1F4
2111:2080	Power State 1 Descriptor (PSD1)	
Bit[255:184]	Reserved	0x00
Bit[183:182]	Active Power Scale (APS)	0x0
Bit[181:179]	Reserved	0x0

Bit[178:176]	Active Power Workload (APW)	0x0
Bit[175:160]	Active Power (ACTP)	0x0
Bit[159:152]	Reserved	0x0
Bit[151:150]	Idle Power Scale (IPS)	0x0
Bit[149:144]	Reserved	0x0
Bit[143:128]	Idle Power (IDLP)	0x0
Bit[127:125]	Reserved	0x0
Bit[124:120]	Relative Write Latency (RWL)	0x1
Bit[119:117]	Reserved	0x0
Bit[116:112]	Relative Write Throughput (RWT)	0x1
Bit[111:109]	Reserved	0x0
Bit[108:104]	Relative Read Latency (RRL)	0x1
Bit[103:101]	Reserved	0x0
Bit[100:96]	Relative Read Throughput (RRT)	0x1
Bit[95:64]	Exit Latency (EXLAT)	0x0
Bit[63:32]	Entry Latency (ENLAT)	0x0
Bit[31:26]	Reserved	0x0
Bit[25]	Non-Operational State (NOPS)	0x0
Bit[24]	Max Power Scale (MPS)	0x0
Bit[23:16]	Reserved	0x0
Bit[15:0]	Maximum Power (MP)	0x1F4
2143:2112	Power State 2 Descriptor (PSD2)	
Bit[255:184]	Reserved	0x00
Bit[183:182]	Active Power Scale (APS)	0x0
Bit[181:179]	Reserved	0x0
Bit[178:176]	Active Power Workload (APW)	0x0
Bit[175:160]	Active Power (ACTP)	0x0
Bit[159:152]	Reserved	0x0
Bit[151:150]	Idle Power Scale (IPS)	0x0
Bit[149:144]	Reserved	0x0
Bytes	Description	Default Value
Bit[143:128]	Idle Power (IDLP)	0x0
Bit[127:125]	Reserved	0x0

Bit[124:120]	Relative Write Latency (RWL)	0x2
Bit[119:117]	Reserved	0x0
Bit[116:112]	Relative Write Throughput (RWT)	0x2
Bit[111:109]	Reserved	0x0
Bit[108:104]	Relative Read Latency (RRL)	0x2
Bit[103:101]	Reserved	0x0
Bit[100:96]	Relative Read Throughput (RRT)	0x2
Bit[95:64]	Exit Latency (EXLAT)	0x0
Bit[63:32]	Entry Latency (ENLAT)	0x0
Bit[31:26]	Reserved	0x0
Bit[25]	Non-Operational State (NOPS)	0x0
Bit[24]	Max Power Scale (MPS)	0x0
Bit[23:16]	Reserved	0x0
Bit[15:0]	Maximum Power (MP)	0x1F4
2175:2144	Power State 3 Descriptor (PSD3)	
Bit[255:184]	Reserved	0x00
Bit[183:182]	Active Power Scale (APS)	0x0
Bit[181:179]	Reserved	0x0
Bit[178:176]	Active Power Workload (APW)	0x0
Bit[175:160]	Active Power (ACTP)	0x0
Bit[159:152]	Reserved	0x0
Bit[151:150]	Idle Power Scale (IPS)	0x0
Bit[149:144]	Reserved	0x0
Bit[143:128]	Idle Power (IDLP)	0x0
Bit[127:125]	Reserved	0x0
Bit[124:120]	Relative Write Latency (RWL)	0x3
Bit[119:117]	Reserved	0x0
Bit[116:112]	Relative Write Throughput (RWT)	0x3
Bit[111:109]	Reserved	0x0
Bit[108:104]	Relative Read Latency (RRL)	0x3
Bit[103:101]	Reserved	0x0
Bit[100:96]	Relative Read Throughput (RRT)	0x3
Bit[95:64]	Exit Latency (EXLAT)	0x7D0

Bit[63:32]	Entry Latency (ENLAT)	0xBB8
Bit[31:26]	Reserved	0x0
Bit[25]	Non-Operational State (NOPS)	0x1
Bytes	Description	Default Value
Bit[24]	Max Power Scale (MPS)	0x0
Bit[23:16]	Reserved	0x0
Bit[15:0]	Maximum Power (MP)	0x1F4
2207:2176	Power State 4 Descriptor (PSD4)	
Bit[255:184]	Reserved	0x00
Bit[183:182]	Active Power Scale (APS)	0x0
Bit[181:179]	Reserved	0x0
Bit[178:176]	Active Power Workload (APW)	0x0
Bit[175:160]	Active Power (ACTP)	0x0
Bit[159:152]	Reserved	0x0
Bit[151:150]	Idle Power Scale (IPS)	0x0
Bit[149:144]	Reserved	0x0
Bit[143:128]	Idle Power (IDLP)	0x0
Bit[127:125]	Reserved	0x0
Bit[124:120]	Relative Write Latency (RWL)	0x4
Bit[119:117]	Reserved	0x0
Bit[116:112]	Relative Write Throughput (RWT)	0x4
Bit[111:109]	Reserved	0x0
Bit[108:104]	Relative Read Latency (RRL)	0x4
Bit[103:101]	Reserved	0x0
Bit[100:96]	Relative Read Throughput (RRT)	0x4
Bit[95:64]	Exit Latency (EXLAT)	0x9C40
Bit[63:32]	Entry Latency (ENLAT)	0x2710
Bit[31:26]	Reserved	0x0
Bit[25]	Non-Operational State (NOPS)	0x1
Bit[24]	Max Power Scale (MPS)	0x0
Bit[23:16]	Reserved	0x0
Bit[15:0]	Maximum Power (MP)	0x1F4
…	(N/A)	0

3071:3040	Power State 31 Descriptor (PSD31)	0
3107:3072	Vendor Specific (VS)	0x00
3109:3108	PLP Supported	0x8001
4095:3110	Vendor Specific (VS)	0x00

7 SMART ATTRIBUTES

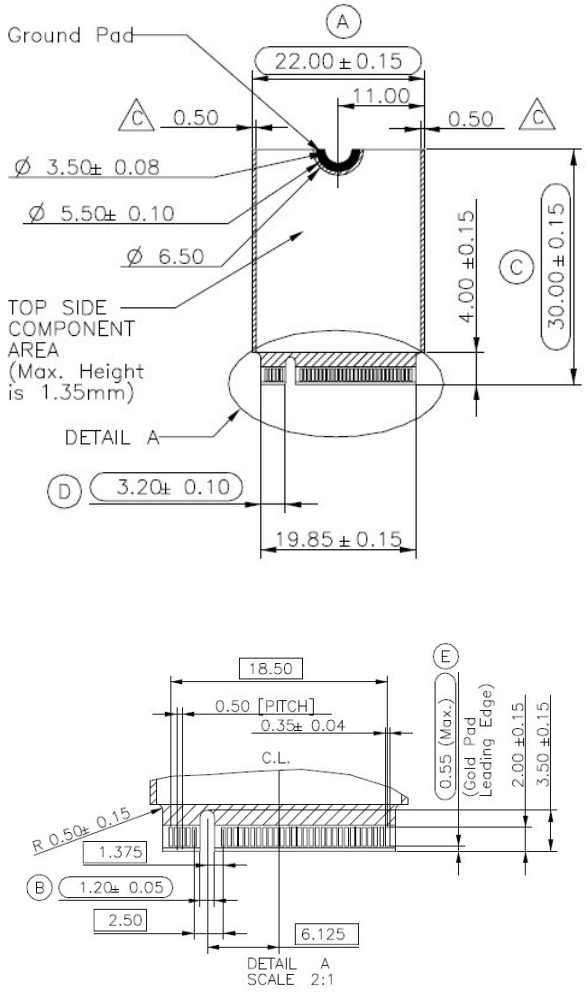
SMART Attributes (Log Identifier 02h)

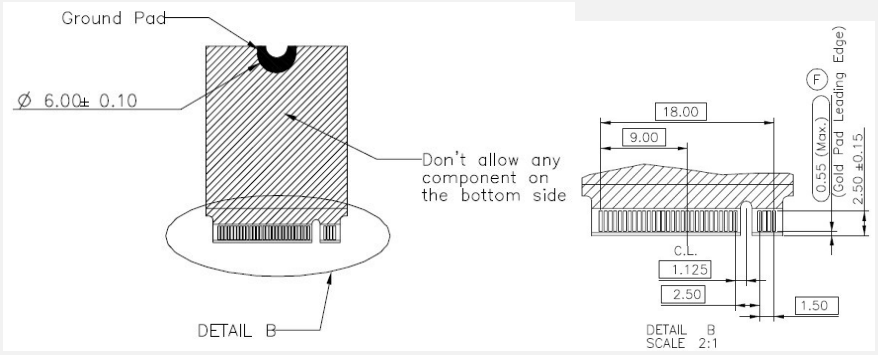
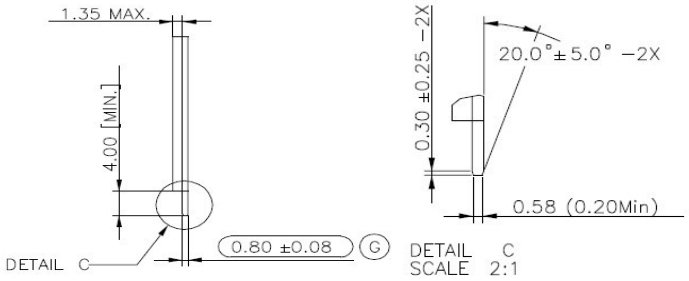
Bytes Index	Bytes	Description
[0]	1	Critical Warning
[2:1]	2	Composite Temperature
[3]	1	Available Spare
[4]	1	Available Spare Threshold
[5]	1	Percentage Used
[31:6]	26	Reserved
[47:32]	16	Data Units Read
[63:48]	16	Data Units Written
[79:64]	16	Host Read Commands
[95:80]	16	Host Write Commands
[111:96]	16	Controller Busy Time
[127:112]	16	Power Cycles
[143:128]	16	Power On Hours
[159:144]	16	Unsafe Shutdowns
[175:160]	16	Media and Data Integrity Errors
[191:176]	16	Number of Error Information Log Entries
[195:192]	4	Warning Composite Temperature Time
[199:196]	4	Critical Composite Temperature Time
[201:200]	2	Temperature Sensor 1
[203:202]	2	Temperature Sensor 2
[205:204]	2	Temperature Sensor 3
[207:206]	2	Temperature Sensor 4
[209:208]	2	Temperature Sensor 5

[211:210]	2	Temperature Sensor 6
[213:212]	2	Temperature Sensor 7
[215:214]	2	Temperature Sensor 8
[219:216]	4	Thermal Management Temperature 1 Transition Count
[223:220]	4	Thermal Management Temperature 2 Transition Count
[227:224]	4	Total Time For Thermal Management Temperature 1
[231:228]	4	Total Time For Thermal Management Temperature 2
[511:232]	280	Reserved

8 PHYSICAL DIMENSIONS

Capacity	Height (mm)	Width (mm)	length (mm)
1TB	2.15±0.08	22±0.15	30±0.15

View Direction	Diagram
Top	

Bottom	
Side	
Notes : 1. = Max Component Height 2. = No Component 3. = No Component / Signal Vias / Signal Copper / Printing 4.General Tolerance ±0.15mm 5. are critical dimensions	

WARNING: This product may contain chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.p65warnings.ca.gov.