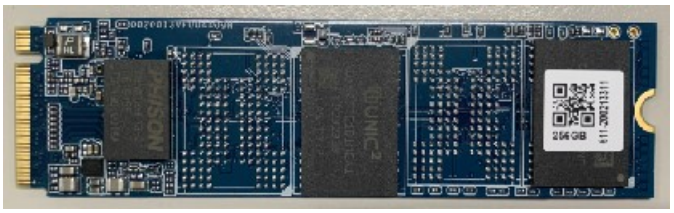
C801 (PCIE) 3D Nand Flash



Product Datasheet

Version 1.3

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Product Overview

- **Capacities**
  - 120, 240, 480, 960, 1920 GB
  - 128, 256, 512, 1024, 2048 GB
- **Form Factor**
  - M.2 2280-S2-M
- **PCIe Interface**
  - PCIe Gen 3 x 4
- **Compliance**
  - NVMe 1.3
  - PCI Express Base 3.1
- **Flash Interface**
  - Transfer rate up to 800MT/s
  - Up to 4pcs of BGA132 flash
- **Performance**[1]
  - Read: up to 2500 MB/s
  - Write: up to 2100 MB/s
- **Reliability**
  - Mean Time Between Failure (MTBF)
    1,500,000 hours
  - Uncorrectable Bit Error Rate (UBER)
    < 1 sector per 10^{16} bits read
- **Advanced Flash Management**
  - Static and Dynamic Wear Leveling
  - Bad Block Management
  - TRIM
  - SMART
  - Over-Provision
  - Firmware Update
- **Power Management**
  - Support APST
  - Support ASPM
  - Support L1.2
- **Power Consumption**[2]
  - Idle < 70 mW
  - L1.2 < 2 mW
- **Temperature Range**[3]
  - Operation: 0°C ~ 70°C
  - Storage: -40°C ~ 85°C
- **RoHS-Compliant**
- **Features Support List:**
  - End to end data path protection
  - Thermal throttling
  - SmartZIP™
  - SmartRefresh™
  - Drive log
  - Support HMB (Host Memory Buffer)
  - Support of TCG OPAL[4]
    Support of TCG Pyrite

NOTES:

1. Refer to Chapter 2 for more details
2. Refer to Chapter 4, Section 4.2 Power Consumption for more details.
3. The operation temperature means the case temperature, in which can be decided via the S.M.A.R.T.
4. Supported by a separate firmware version. Further information available upon request.

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1. INTRODUCTION

1.1. General Description

C801 M.2 2280 with no external DDR solution delivers all the advantages of flash disk technology with PCIe Gen3 x4 interface and is fully compliant with the standard Next Generation Form Factor (NGFF) called M.2 Card Format. C801 M.2 2280 offers a wide range of capacities up to 2048 GB and its performance can reach up to 2500 MB/s[1] (for read) and 2100 MB/s[1] (for write) based on KIOXIA BiCS4 TLC NAND flash. Moreover, the power consumption of C801 M.2 2280 is much lower than traditional hard drives, making it the best embedded solution for new platforms.

NOTES:

1. Achieved by 1920/2048GB SSD at FOB (fresh-out-of-box) state on CrystalDiskMark v6.0.

1.2. Controller Block Diagram

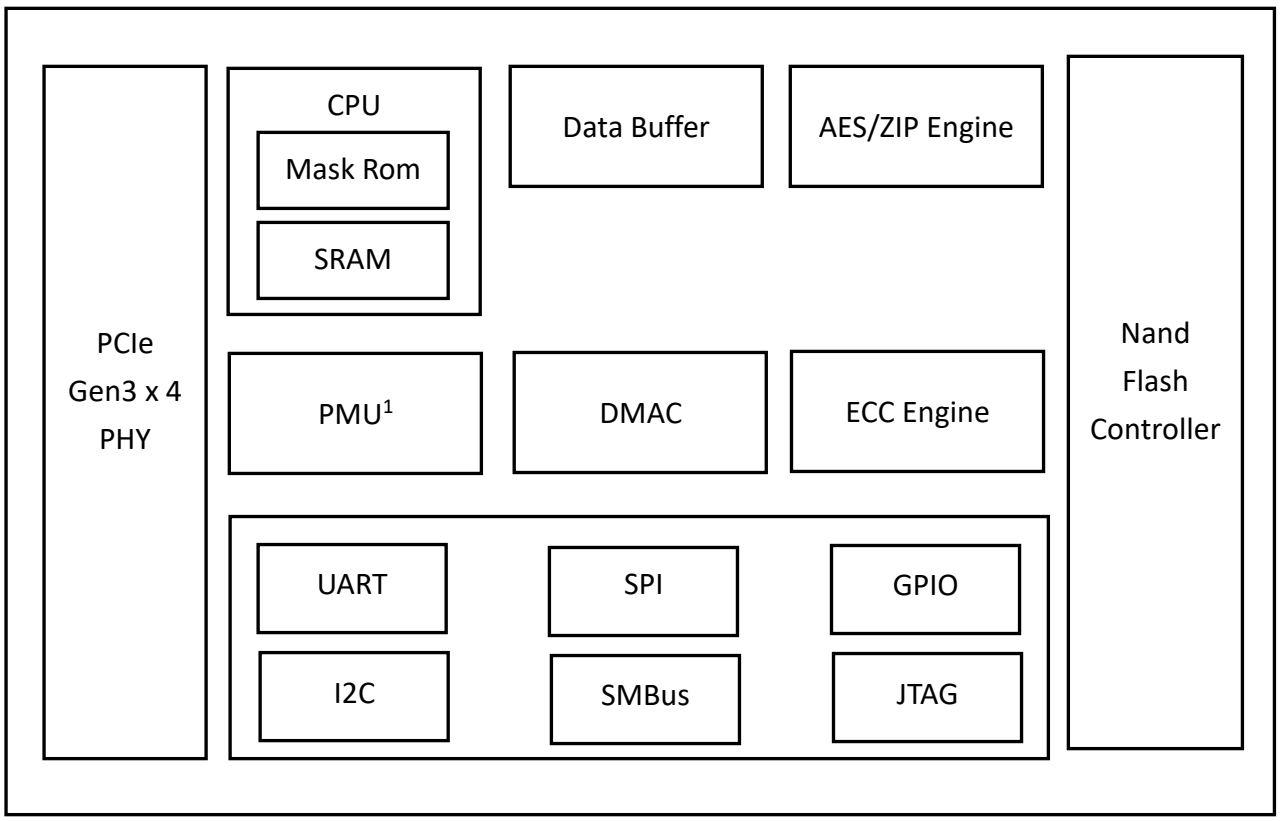


Figure 1-1 C801 Controller Block Diagram

NOTE:

1. PMU = Power Management Unit

1.3. Product Block Diagram

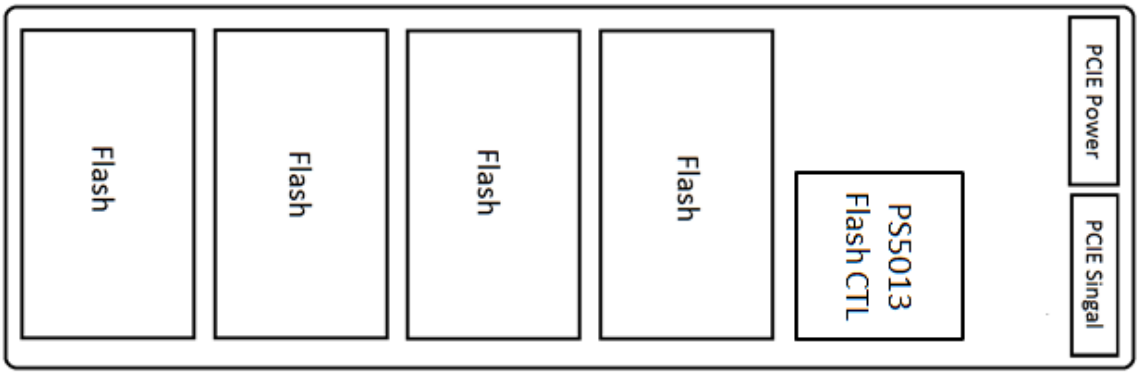


Figure 1-2 C801 M.2 2280 Product Block Diagram

1.4. Flash Management

1.4.1. Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, C801 PCIe SSD applies the LDPC (Low Density Parity Check) of ECC algorithm, which can detect and correct errors occur during read process, ensure data been read correctly, as well as protect data from corruption.

1.4.2. Wear Leveling

NAND flash devices can only undergo a limited number of program/erase cycles, when flash media is not used evenly, some blocks get updated more frequently than others and the lifetime of device would be reduced significantly. Thus, wear leveling is applied to extend the lifespan of NAND flash by evenly distributing write and erase cycles across the media.

C801 provides 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.

1.4.3. Bad Block Management

Bad blocks are blocks that do not function properly or contain more invalid bits causing stored data unstable, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as “Early Bad Blocks”. Bad blocks that are developed during the lifespan of the flash are named “Later Bad Blocks”. C801 implements an efficient bad block management algorithm to detect the factory-produced bad blocks and manages bad blocks that appear with use. This practice prevents data being stored into bad blocks and further improves the data reliability.

1.4.4. TRIM

TRIM is a feature which helps improve the read/write performance and speed of solid state drives (SSD). Unlike hard disk drives (HDD), 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.

1.4.5. SMART

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a solid state drive to automatically detect its health and report potential failures. When a failure is recorded by SMART, users can choose to replace the drive to prevent unexpected outage or data loss. Moreover, SMART can inform users impending failures while there is still time to perform proactive actions, such as save data to another device.

1.4.6. 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.

1.4.7. Firmware Upgrade

Firmware can be considered as a set of instructions on how the device communicates with the host. Firmware will be upgradable when new features are added, compatibility issues are fixed, or read/write performance gets improved.

1.4.8. Thermal Throttling

The purpose of thermal throttling is to prevent any components in a SSD from over-heating during read and write operations. C801 is designed with an on-die thermal sensor and with its accuracy; firmware can apply different levels of throttling to achieve the purpose of protection efficiently and proactively via SMART reading.

1.5. Advanced Device Security Features

1.5.1. Secure Erase

Secure Erase is a standard NVMe format command and will write all “0x00” 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.

1.5.2. Crypto Erase

Crypto Erase is a feature that erases all data of an OPAL-activated SSD or a “SED”(Security-Enabled Disk) drive by resetting the cryptographic key of the disk. Since the key is modified, the previously encrypted data will become useless, achieving the purpose of data security.

1.5.3. Physical Presence SID (PSID)

Physical Presence SID (PSID) is defined by TCG OPAL as a 32-character string and the purpose is to revert SSD back to its manufacturing setting when the drive is still OPAL-activated. PSID code can be printed on a SSD label when an OPAL-activated SSD supports PSID revert feature.

1.6. SSD Lifetime Management

1.6.1. 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 218/219 workload.

1.6.2. Media Wear Indicator

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

1.6.3. 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.

1.7. Adaptive Approach to Performance Tuning

1.7.1. Throughput

Based on the available space of the disk, C801 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, C801 will slow down the read/write processing, and implement garbage collection to release memory. Hence, read/write performance will become slower.

1.7.2. Predict & Fetch

Normally, when the Host tries to read data from the PCIe SSD, the PCIe SSD will only perform one read action after receiving one command. However, C801 applies ***Predict & Fetch*** to improve the read speed. When the host issues sequential read commands to the PCIe SSD, the PCIe SSD will automatically expect that the following will also be read commands. Thus, before receiving the next command, flash has already prepared the data. Accordingly, this accelerates the data processing time, and the host does not need to wait so long to receive data.

1.7.3. SLC Caching

C801's firmware design currently adopts dynamic caching to deliver better performance for better endurance and consumer user experience.

2. PRODUCT SPECIFICATIONS

- **Capacity**
  - 120GB, 240GB, 480GB, 960GB, 128GB, 256GB, 512GB, 1024GB, 1920GB, 2048GB
  - Support 32-bit addressing mode
- **Electrical/Physical Interface**
  - PCIe Interface
  - Compliant with NVMe 1.3
  - PCIe Express Base Ver 3.1
  - PCIe Gen 3 x 4 lane & backward compatible to 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 up to 4pcs of BGA132 flash
  - Support 8-bit I/O NAND Flash
  - Support Toggle2.0, Toggle3.0, ONFI 2.3, ONFI 3.0, ONFI 3.2 and ONFI 4.0 interface
    - KIOXIA BiCS3 / BiCS4 TLC/QLC
    - SanDisk BiCS3 / BiCS4 TLC
    - UNIC 3D NAND
    - Micron 3D NAND
    - Intel 3D NAND
    - SpecTek 3D NAND
    - JGS 3D NAND
- **ECC Scheme**
  - C801 PCIe SSD applies LDPC of ECC algorithm.
- **Sector Size Support**
  - 512B
  - 4KB
- **UART/ GPIO**
- **Support SMART and TRIM commands**
- **LBA Range**
  - IDEMA standard

2.1 Performance

KIOXIA BiCS3 (533Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
120, 128GB	64GB x 2	4	BGA, BiCS3 TLC	1500	500	70K	100K
240, 256GB	128GB x 2	8	BGA, BiCS3 TLC	1730	1000	130K	190K
480, 512GB	128GB x 4	16	BGA, BiCS3 TLC	1730	1560	200K	260K

KIOXIA BiCS4 (533Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
120, 128GB	64GB x 2	4	BGA, BiCS4 TLC	1550	550	70K	120K
240, 256GB	128GB x 2	8	BGA, BiCS4 TLC	1700	1100	130K	230K
480, 512GB	128GB x 4	16	BGA, BiCS4 TLC	1700	1550	210K	295K

KIOXIA BiCS4 (800Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
120, 128GB	64GB x 2	4	BGA, BiCS4 TLC	2200	600	85K	130K
240, 256GB	128GB x 2	8	BGA, BiCS4 TLC	2300	1200	150K	240K
480, 512GB	128GB x 4	16	BGA, BiCS4 TLC	2500	2100	210K	380K
960, 1024GB	256GB x 4	16	BGA, BiCS4 TLC	2500	2100	215K	390K
1920, 2048GB	512GB x 4	16	BGA, BiCS4 TLC	2500	2100	230K	390K

WD BiCS4 (800Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
120, 128GB	64GB x 2	4	BGA, BiCS4 TLC	2250	600	120K	130K
240, 256GB	128GB x 2	8	BGA, BiCS4 TLC	2500	1100	240K	230K
480, 512GB	128GB x 4	16	BGA, BiCS4 TLC	2500	2100	350K	370K
960, 1024GB	256GB x 4	16	BGA, BiCS4 TLC	2500	2100	320K	330K
1920, 2048GB	512GB x 4	16	BGA, BiCS4 TLC	2500	2100	320K	330K

KIOXIA BiCS4 pTLC (667Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
480, 512GB	340GB x 2	4	BGA, BiCS4 QLC	1835	585	50K	125K
960, 1024GB	680GB x 2	8	BGA, BiCS4 QLC	1980	1175	90K	240K
1920, 2048GB	680GB x 4	16	BGA, BiCS4 QLC	2050	1810	140K	320K

UNIC B16A (667Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
240, 256GB	128GB x 2	8	BGA, B16A TLC	2050	1200	190K	260K
480, 512GB	128GB x 4	16	BGA, B16A TLC	2100	1800	290k	390K

SpecTek B16C (533Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
240GB	128GB x 2	8	BGA,B16A TLC	1700	1100	170K	250K
480GB	128GB x 4	16	BGA,B16A TLC	1700	1500	260K	340K

UNIC/ Intel/ SpecTek B16A (667Mbps)

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
120, 128GB	32GB x 4 64GB x 2	4	BGA,B16A TLC	1800	560	120K	130K
240, 256GB	64GB x 4 128GB x 2	8	BGA,B16A TLC	2050	1000	180K	240K
480, 512GB	128GB x 4	16	BGA,B16A TLC	2100	1800	280K	390K

JGS

Capacity	Flash Structure	CE#	Flash Type	Sequential (CDM)		IOMeter	
				Read (MB/s)	Write (MB/s)	Read (IOPS)	Write (IOPS)
120, 128GB	64GB x 2	4	BGA, JGS TLC	2100	600	75 k	130k
240, 256GB	128GB x 2	8	BGA, JGS TLC	2300	1100	135k	240k
480, 512GB	128GB x 4	16	BGA, JGS TLC	2400	1900	220k	420k
960, 1024GB	256GB x 4	16	BGA, JGS TLC	2400	1600	205k	395k

NOTES:

1. Performance was estimated based on KIOXIA BiCS3/BiCS4, WD BiCS4 and UNIC B16A TLC QLC NAND flash.
2. Performance may differ according to flash configuration and platform.
3. The tables are for reference only. Any criteria for accepting goods shall be further discussed based on different flash configurations.
4. Performance is measured with the following conditions
   (a) CrystalDiskMark 6.0, 1GB range, QD=32T1
   (b) IOMeter, 1GB range, 4K data size, QD=32T8
   (c) ATTO, transfer Size 64 MB
   (d) OS Version : Win10 (64bit), version 1709

3. ENVIRONMENTAL SPECIFICATIONS

3.1. Environmental Conditions

3.1.1. Temperature and Humidity

Table 3-1 High Temperature

	Temperature	Humidity
Operation	70°C	90% RH
Storage	85°C	90% RH

Table 3-2 Low Temperature

	Temperature	Humidity
Operation	0°C	90% RH
Storage	-40°C	90% RH

Table 3-3 High Humidity

	Temperature	Humidity
Operation	40°C	90% RH
Storage	40°C	93% RH

Table 3-4 Temperature Cycling

	Temperature
Operation	0°C
	70°C[1]
Storage	-40°C
	85°C

NOTES:

1. The operation temperature is measured by the case temperature, in which can be decided via the S.M.A.R.T. Airflow is suggested and it will allow device to be operated at appropriate temperature for each component during heavy workloads environment.

3.1.2. Shock

Table 3-5 Shock

	Acceleration Force
Non-operational	1500G

3.1.3. Vibration

Table 3-6 Vibration

	Condition	
	Frequency/Displacement	**Frequency/Acceleration**
Non-operational	20Hz~80Hz/1.52mm	80Hz~2000Hz/20G

3.1.4. Drop

Table 3-7 Drop

	Height of Drop	Number of Drop
Non-operational	80cm free fall	6 face of each unit

3.1.5. Bending

Table 3-8 Bending

	Force	Action
Non-operational	≥ 20N	Hold 1min/5times

3.1.6. Torque

Table 3-9 Torque

	Force	Action
Non-operational	0.5N-m or ±2.5 deg	Hold 1min/5times

3.1.7. Electrostatic Discharge (ESD)

Table 3-10 ESD

Specification	+/- 4KV
EN 55024, CISPR 24 EN 61000-4-2 and IEC 61000-4-2	Device functions are affected, but EUT will be back to its normal or operational state automatically.

3.1.8. EMI Compliance

Table 3-11 EMI

Specification
EN 55032, CISPR 32(CE)
AS/NZS CISPR 32(CE)
ANSI C63.4 (FCC)
VCCI-CISPR 32 (VCCI)
CNS 13438 (BSMI)

3.2. MTBF

MTBF, Mean Time Between Failures, is a measure of reliability of a device. Its value represents the average time between a repair and the next failure. The unit of MTBF is in hours. The higher the MTBF value, the higher the reliability of the device.

Our MTBF result is based on Telcorida methodology. Please note that a lower MTBF should be expected for higher capacity drives, and we apply the lowest MTBF for all capacities.

3.3. Certification & Compliance

- RoHS
- WHQL
- PCI Express Base 3.1
- UNH-IOL NVM Express Logo

4. ELECTRICAL SPECIFICATIONS

4.1. Supply Voltage

Table 4-1 Supply Voltage

Parameter	Rating
Operating Voltage	Min = 3.14V Max = 3.47 V
Rise Time (Max/Min)	100 ms / 0.1 ms
Fall Time (Max/Min)	5 s / 1 ms
Min. Off Time[1]	1.5 s

NOTE:

1. Minimum time between power removed from SSD (Vcc < 100 mW) and power re-applied to the drive.

4.2. Power Consumption

Table 4-2 Power Consumption with KIOXIA BiCS3 TLC in mW

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
120, 128GB	64GB x 2	4	2910	1830	2850	1750
240, 256GB	128GB x 2	8	3250	2520	3190	2450
480, 512GB	128GB x 4	16	3450	3100	3390	2980

Table 4-3 Power Consumption with KIOXIA BiCS4 (533) TLC in mW

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
120, 128GB	64GB x 2	4	2310	1800	2220	1750
240, 256GB	128GB x 2	8	2850	2730	2800	2650
480, 512GB	128GB x 4	16	3020	2990	2950	2900

Table 4-4 Power Consumption with KIOXIA BiCS4 (800) TLC in mW

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
120, 128GB	64GB x 2	4	3200	1780	3150	1740
240, 256GB	128GB x 2	8	3510	2580	3450	2500
480, 512GB	128GB x 4	16	3570	3300	3520	3200
960, 1024GB	256GB x 4	16	3750	3600	3680	3500
1920, 2048GB	512GB x 4	16	3820	3740	3750	3620

Table 4-5 Power Consumption with KIOXIA BiCS4 (667) pTLC in mW

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
480, 512GB	340GB x 2	4	TBD	TBD	TBD	TBD
960, 1024GB	680GB x 2	8	TBD	TBD	TBD	TBD
1920, 2048GB	680GB x 4	16	TBD	TBD	TBD	TBD

Table 4-6 Power Consumption with WD BiCS4 (800) TLC in mW

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
120, 128GB	64GB x 2	4	TBD	TBD	3100	1720
240, 256GB	128GB x 2	8	TBD	TBD	3350	2800
480, 512GB	128GB x 4	16	TBD	TBD	3400	3200
960, 1024GB	256GB x 4	16	TBD	TBD	3500	3400
1920, 2048GB	512GB x 4	16	TBD	TBD	3650	3460

Table 4-7 Power Consumption with UNIC B16A (667) TLC in mW

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
240, 256GB	128GB x 2	8	2480	2450	2450	2400
480, 512GB	128GB x 4	16	2610	3150	2570	3090

Table 4-8 Power Consumption with UNIC/ Intel/ SpecTek B16A (667) TLC in mW

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
120, 128GB	32GB x 4 64GB x 2	4	TBD	TBD	TBD	TBD
240, 256GB	64B x 4 128GB x 2	8	2650	2600	2600	2500
480, 512GB	128GB x 4	16	2800	3350	2750	3300

Table 4-9 Power Consumption with SpecTek B16C (533) TLC in Mw

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
240, 256GB	128GB x 2	8	3050	2900	3000	2850
480, 512GB	128GB x 4	16	3250	3500	3200	3400

Table 4-10 Power Consumption with JGS in Mw

Capacity	Flash Structure	CE#	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
120, 128GB	64GB x 2	4	2690	1730	2480	1370
240, 256GB	128GB x 2	8	3010	2670	2940	2530
480, 512GB	128GB x 4	16	TBD	TBD	TBD	TBD
960, 1024GB	256GB x 4	16	TBD	TBD	TBD	TBD

NOTES:

1. Based on EDFM0xxx-series under ambient temperature.
2. Use IO Meter with the setting of 1GB. Sequentially read and write the disk for 5 times, and measure power consumption during sequential Read.
3. Power Consumption may differ according to flash configuration and platform.
4. The measured power voltage is 3.3V.
5. The temperature of a storage device in PS1 should remain constant or should slightly decrease for all workloads so the actual power in PS1 should be lower than PS0.
6. The temperature of a storage device in PS2 should decrease sharply for all workloads so the actual power in PS2 should be lower than PS1.

Table 4-11 Power State Power Consumption with KIOXIA BiCS3 TLC in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
120, 128GB	64GB x 2	4	2850	1550	1200	70	2
240, 256GB	128GB x 2	8	3190	1890	1470	70	2
480, 512GB	128GB x 4	16	3390	1970	1570	70	2

Table 4-12 Power State Power Consumption with KIOXIA BiCS4 (533) TLC in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
120, 128GB	64GB x 2	4	2220	1320	1050	70	2
240, 256GB	128GB x 2	8	2800	1530	1200	70	2
480, 512GB	128GB x 4	16	2950	1650	1300	70	2

Table 4-13 Power State Power Consumption with KIOXIA BiCS4 (800) TLC in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
120, 128GB	64GB x 2	4	3150	1830	1370	70	2
240, 256GB	128GB x 2	8	3450	1960	1550	70	2
480, 512GB	128GB x 4	16	3520	2060	1600	70	2
960, 1024GB	256GB x 4	16	3680	2150	1690	70	2
1920, 2048GB	512GB x 4	16	3750	2190	1740	70	2

Table 4-14 Power State Power Consumption with KIOXIA BiCS4 (667) pTLC in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
480, 512GB	340GB x 2	4	TBD	TBD	TBD	TBD	TBD
960, 1024GB	680GB x 2	8	TBD	TBD	TBD	TBD	TBD
1920, 2048GB	680GB x 4	16	TBD	TBD	TBD	TBD	TBD

Table 4-15 Power State Power Consumption with WD BiCS4 (800) TLC in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
120, 128GB	64GB x 2	4	3100	1830	1370	70	2
240, 256GB	128GB x 2	8	3350	1960	1550	70	2
480, 512GB	128GB x 4	16	3400	2040	1600	70	2
960, 1024GB	256GB x 4	16	3500	2110	1690	70	2
1920, 2048GB	512GB x 4	16	3650	2190	1740	70	2

Table 4-16 Power State Power Consumption with UNIC B16A (667) TLC in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
240, 256GB	128GB x 2	8	2450	1300	1120	70	2
480, 512GB	128GB x 4	16	2570	1440	1270	70	2

Table 4-17 Power State Power Consumption with UNIC/ Intel/ SpecTek B16A (667) TLC in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
120, 128GB	32GB x 4 64GB x 2	4	TBD	TBD	TBD	TBD	TBD
240, 256GB	64GBx 4 128GB x 2	8	2600	1330	1170	25	2
480, 512GB	128GB x 4	16	2750	1500	1330	25	2

Table 4-18 Power State Power Consumption with SpecTek B16C (533)

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
240, 256GB	128GB x 2	8	3000	1820	1600	25	2
480, 512GB	128GB x 4	16	3200	2050	1850	25	2

Table 4-19 Power State Power Consumption with JGS in mW

Capacity	Flash Structure	CE#	Seq. Read			PS3	PS4
			PS0	PS1	PS2		
120, 128GB	64GB x 2	4	2690	1600	1150	20	2
240, 256GB	128GB x 2	8	3010	1740	1320	20	2
480, 512GB	128GB x 4	16	TBD	TBD	TBD	TBD	TBD
960, 1024GB	256GB x 4	16	TBD	TBD	TBD	TBD	TBD

NOTES:

1. Based on EDFM0xxx-series under ambient temperature.
2. The average value of power consumption is achieved based on 100% conversion efficiency.
3. The measured power voltage is 3.3V.

Table 4-20 Mobile Mark 2014 Average Power Consumption with KIOXIA BiCS3 TLC

Capacity	Flash Structure	CE#	Primary
120, 128GB	64GB x 2	4	TBD
240, 256GB	128GB x 2	8	TBD
480, 512GB	128GB x 4	16	TBD
1920, 2048GB	512GB x 4	16	TBD

Table 4-21 Mobile Mark 2014 Average Power Consumption with KIOXIA BiCS4 TLC

Capacity	Flash Structure	CE#	Primary
120, 128GB	64GB x 2	4	(TBD)
240, 256GB	128GB x 2	8	(TBD)
480, 512GB	128GB x 4	16	(TBD)
960, 1024GB	256GB x 4	16	(TBD)
1920, 2048GB	512GB x 4	16	(TBD)

Table 4-22 Mobile Mark 2014 Average Power Consumption with KIOXIA BiCS4 pTLC

Capacity	Flash Structure	CE#	Primary
480, 512GB	340GB x 2	4	(TBD)
960, 1024GB	680GB x 2	8	(TBD)
1920, 2048GB	680GB x 4	16	(TBD)

Table 4-23 Mobile Mark 2014 Average Power Consumption with WD BiCS4 TLC

Capacity	Flash Structure	CE#	Primary
120, 128GB	64GB x 2	4	(TBD)
240, 256GB	128GB x 2	8	(TBD)
480, 512GB	128GB x 4	16	(TBD)
960, 1024GB	256GB x 4	16	(TBD)
1920, 2048GB	512GB x 4	16	(TBD)

Table 4-24 Mobile Mark 2014 Average Power Consumption with UNIC B16A TLC

Capacity	Flash Structure	CE#	Primary
240, 256GB	128GB x 2	8	(TBD)
480, 512GB	128GB x 4	16	(TBD)

Table 4-25 Mobile Mark 2014 Average Power Consumption with UNIC/ Intel/

Capacity	Flash Structure	CE#	Primary
120, 128GB	32GB x 4 64GB x 2	4	(TBD)
240, 256GB	64GBx 4 128GB x 2	8	(TBD)
480,512GB	128GB	16	(TBD)

Table 4-26 Mobile Mark 2014 Average Power Consumption with SpecTek B16C TLC

Capacity	Flash Structure	CE#	Primary
240, 256GB	128GB x 2	8	(TBD)
480, 512GB	128GB x 4	16	(TBD)

NOTES:

1. Based on EDFM0xxx-series under ambient temperature.
2. The average value of power consumption is achieved based on 100% conversion efficiency.
3. The measured power voltage is 3.3V.

5. INTERFACE

5.1. Pin Assignment and Descriptions

Table 5-1 defines the signal assignment of the internal NGFF connector for SSD usage, described in the PCI Express M.2 Specification version 1.0 of the PCI-SIG.

Figure 5-1 Pin Assignment and Description of C801 M.2 2280

Pin No.	PCIe Pin	Description
1	GND	CONFIG_3 = GND
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	N/C	No connect
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

Pin No.	PCIe Pin	Description
29	PETn1	PCIe TX Differential signal defined by the PCI Express M.2 spec
30	N/C	No connect
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

Pin Number	PCIe Pin	Description
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	
61	Module Key M	
62	Module Key M	
63	Module Key M	
64	Module Key M	
65	Module Key M	
66	Module Key M	
67	N/C	No connect
68	SUSCLK(32KHz) (I)(0/3.3V)	32.768 kHz clock supply input that is provided by the platform chipset to reduce power and cost for the module.
69	NC	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

6. SUPPORTED COMMANDS

6.1. NVMe Command List

Table 6-1 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

Table 6-2 Admin Commands – NVM Command Set Specific

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

Table 6-3 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

The following table details the sector data returned by the IDENTIFY DEVICE command.

Table 6-4 Identify Controller Data Structure

Bytes	O/M	Description	Default Value
01:00	M	PCI Vendor ID (VID)	0x1987
03:02	M	PCI Subsystem Vendor ID (SSVID)	0x1987
23:04	M	Serial Number (SN)	SN
63:24	M	Model Number (MN)	Model Number
71:64	M	Firmware Revision (FR)	FW Name
72	M	Recommended Arbitration Burst (RAB)	0x01
75:73	M	IEEE OUI Identifier (IEEE)	Assigned by IEEE/RAC
76	O	Controller Multi-Path I/O and Namespace Sharing Capabilities (CMIC)	0x00
77	M	Maximum Data Transfer Size (MDTS)	0x09
79:78	M	Controller ID (CNTLID)	0x0000
83:80	M	Version (VER)	0x00010300
87:84	M	RTD3 Resume Latency (RTD3R)	0x124F80
91:88	M	RTD3 Entry Latency (RTD3E)	0x2191C0
95:92	M	Optional Asynchronous Events Supported (OAES)	0x00000100
99:96	M	Controller Attributes (CTRATT)	0x00000000
111:100	-	Reserved	0x00
127:112	O	FRU Globally Unique Identifier (FGUID)	0x00
239:128	-	Reserved	0x00
255:240	-	Refer to the NVMe Management Interface Specification for definition	0
257:256	M	Optional Admin Command Support (OACS)	0x001F
258	M	Abort Command Limit (ACL)	0x00
259	M	Asynchronous Event Request Limit (AERL)	0x03
260	M	Firmware Updates (FRMW)	0x12

Bytes	O/M	Description	Default Value
261	M	Log Page Attributes (LPA)	0x0E
262	M	Error Log Page Entries (ELPE)	0x0F
263	M	Number of Power States Support (NPSS)	0x04
264	M	Admin Vendor Specific Command Configuration (AVSCC)	0x01
265	O	Autonomous Power State Transition Attributes (APSTA)	0x01
267:266	M	Warning Composite Temperature Threshold (WCTEMP)	0x155
269:268	M	Critical Composite Temperature Threshold (CCTEMP)	0x157
271:270	O	Maximum Time for Firmware Activation (MTFA)	0x2710
275:272	O	Host Memory Buffer Preferred Size (HMPRE)	0x00000000(HMB off)Depend on Disk Size(HMB on)
279:276	O	Host Memory Buffer Minimum Size (HMMIN)	0x00000000(HMB off)Depend on Disk Size(HMB on)
295:280	O	Total NVM Capacity (TNVMCAP)	non-zero
311:296	O	Unallocated NVM Capacity (UNVMCAP)	0
315:312	O	Replay Protected Memory Block Support (RPMBS)	0x00000000
317:316	O	Extended Device Self-test Time (EDSTT)	0x001E
318	O	Device Self-test Options (DSTO)	0x01
319	M	Firmware Update Granularity (FWUG)	0x4
321:320	M	Keep Alive Support (KAS)	0x0001
323:322	O	Host Controlled Thermal Management Attributes (HCTMA)	1
325:324	O	Minimum Thermal Management Temperature (MNTMT)	0x111

Bytes	O/M	Description	Default Value
327:326	O	Maximum Thermal Management Temperature (MXTMT)	0x157
331:328	O	Sanitize Capabilities (SANICAP)	0x00000006
511:316	-	Reserved	0
NVM Command Set Attributes			
512	M	Submission Queue Entry Size (SQES)	0x66
513	M	Completion Queue Entry Size (CQES)	0x44
515:514	M	Maximum Outstanding Commands (MAXCMD)	0
519:516	M	Number of Namespaces (NN)	0x000000001
521:520	M	Optional NVM Command Support (ONCS)	0x005F
523:522	M	Fused Operation Support (FUSES)	0
524	M	Format NVM Attributes (FNA)	0x01
525	M	Volatile Write Cache (VWC)	0x01
527:526	M	Atomic Write Unit Normal (AWUN)	0x00FF
529:528	M	Atomic Write Unit Power Fail (AWUPF)	0x0000
530	M	NVM Vendor Specific Command Configuration (NVSCC)	0x01
531	M	Reserved	0x00
533:532	O	Atomic Compare & Write Unit (ACWU)	0x0000
535:534	M	Reserved	0x0000
539:536	O	SGL Support (SGLS)	0x0000000000
767:540	M	Reserved	0x00
IO Command Set Attributes			
2047:704	M	Reserved	0
2079:2048	M	Power State 0 Descriptor	0x0081031600401C52000000000000025800000258000003 16
2111:2080	O	Power State 1 Descriptor	0x0081031600401C52010101010000025800000258000003 16
2143:2112	O	Power State 2 Descriptor	0x0081031600401C52020202020000025800000258000003 16
2175:2144	O	Power State 3 Descriptor	0x0081031600401C52030303030000003E8000003E8030003E8

2207:2176	O	Power State 4 Descriptor	0x0081031600401C5224040404000186A00000138803000032
…	-	(N/A)	0
3071:3040	O	Power State 31 Descriptor	0
Vendor Specific			
4095:3072	O	Vendor Specific (VS)	Reserved

Table 6-5 Identify Namespace Data Structure & NVM Command Set Specific

Bytes	Description
7:0	Namespace Size (NSZE)
15:8	Namespace Capacity (NCAP)
23:16	Namespace Utilization (NUSE)
24	Namespace Features (NSFEAT)
25	Number of LBA Formats (NLBAF)
26	Formatted LBA Size (FLBAS)
27	Metadata Capabilities (MC)
28	End-to-end Data Protection Capabilities (DPC)
29	End-to-end Data Protection Type Settings (DPS)
30	Namespace Multi-path I/O and Namespace Sharing Capabilities (NMIC)
31	Reservation Capabilities (RESCAP)
32	Format Progress Indicator (FPI)
33	Deallocate Logical Block Features (DLFEAT)
35:34	Namespace Atomic Write Unit Normal (NAWUN)
37:36	Namespace Atomic Write Unit Power Fail (NAWUPF)
39:38	Namespace Atomic Compare & Write Unit (NAWWU)
41:40	Namespace Atomic Boundary Size Normal (NABSN)
43:42	Namespace Atomic Boundary Offset (NABO)
45:44	Namespace Atomic Boundary Size Power Fail (NABSPF)
47:46	Namespace Atomic Optimal IO Boundary (NOIOB)
63:48	NVM Capacity (NVMCAP)
103:64	Reserved
119:104	Namespace Globally Unique Identifier (NGUID)
127:120	IEEE Extended Unique Identifier (EUI64)
131:128	LBA Format 0 Support (LBAF0)
135:132	LBA Format 1 Support (LBAF1)
139:136	LBA Format 2 Support (LBAF2)
143:140	LBA Format 3 Support (LBAF3)
147:144	LBA Format 4 Support (LBAF4)
151:148	LBA Format 5 Support (LBAF5)
155:152	LBA Format 6 Support (LBAF6)
159:156	LBA Format 7 Support (LBAF7)
163:160	LBA Format 8 Support (LBAF8)
167:164	LBA Format 9 Support (LBAF9)
171:168	LBA Format 10 Support (LBAF10)

175:172	LBA Format 11 Support (LBAF11)
179:176	LBA Format 12 Support (LBAF12)
183:180	LBA Format 13 Support (LBAF13)
187:184	LBA Format 14 Support (LBAF14)
191:188	LBA Format 15 Support (LBAF15)
383:192	Reserved
4095:384	Vendor Specific (VS)

Table 6-6 List of Identify Namespace Data Structure for Each Capacity

Capacity (GB)	Byte[7:0]: Namespace Size (NSZE)
120	DF94BB0h
240	1BF244B0h
480	37E436B0h
960	6FC81AB0h
1920	DF8FE2B0h
128	EE7C2B0h
256	1DCF32B0h
512	3B9E12B0h
1024	773BD2B0h
2048	EE7752B0h

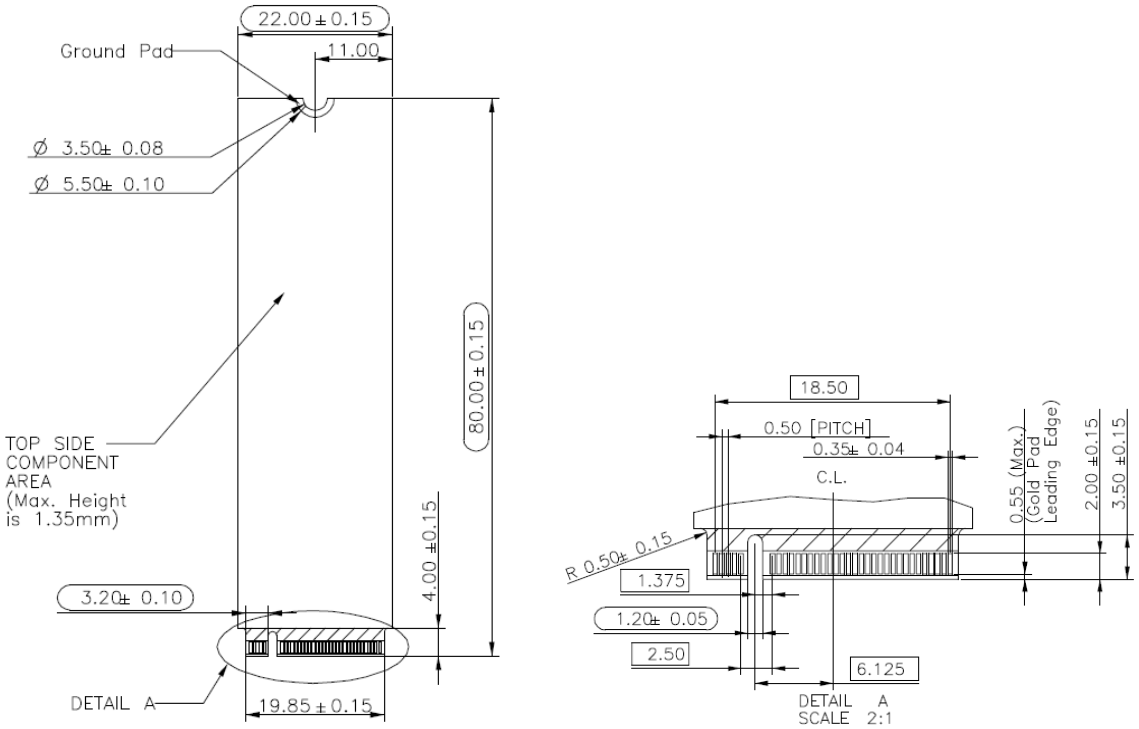
6.3. SMART Attributes

Table 6-7 SMART Attributes (Log Identifier 02h)

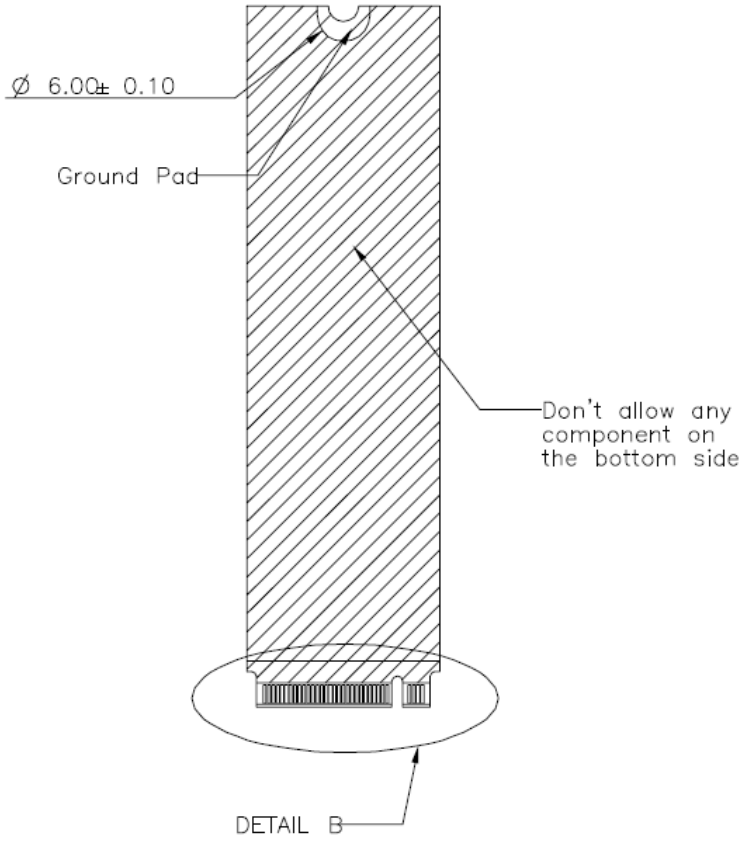
Bytes Index	Bytes	Description
[0]	1	Critical Warning
[2:1]	2	Composite Temperature
[3]	1	Available Spare
[4]	1	Available Spare Threshold
[5]	1	Percentage Used
[31:6]	26	Reserved
[47:32]	16	Data Units Read
[63:48]	16	Data Units Written
[79:64]	16	Host Read Commands
[95:80]	16	Host Write Commands
[111:96]	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

7. PHYSICAL DIMENSION

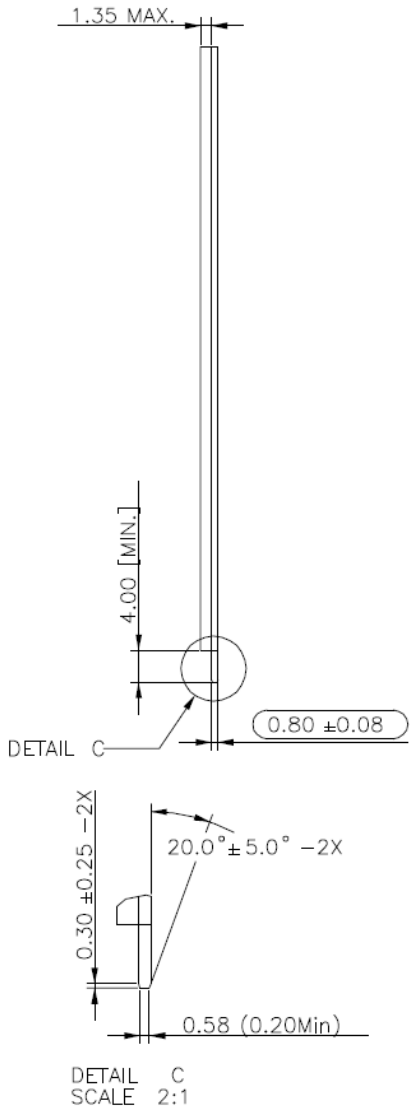
M.2 2280 S2 : 80.00mm (L) x 22.00mm (W) x 2.15mm (H)



Top View



Bottom View



Side View

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

8. TERMINOLOGY

The following table is to list out the acronyms that have been applied throughout the document.

Table 8-1 List of Terminology

Term	Definitions
ATTO	Commercial performance benchmark application
DDR	Double data rate (SDRAM)
ASPM	Active States Power Management
APST	Autonomous Power State Transition
LBA	Logical block addressing
MB	Mega-byte
GB	Giga-byte
TB	Tera-byte
MTBF	Mean time between failures
PCIe	PCI Express / Peripheral Component Interconnect Express
S.M.A.R.T.	Self-monitoring, analysis and reporting technology
SSD	Solid state disk