# UD info Corp.

## Industrial PCIe BGA SSD
## MPC-16DL Series
## Product DataSheet




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# Revision History

| Revision | Draft Date | History | Author |
|---|---|---|---|
| 1.0 | 2024/11/1 | New release | Golden Lee |
| 1.1 | 2025/5/7 | Added pSLC data | Golden Lee |

# Product Overview

- **Capacity**
  - TLC: 64GB up to 1TB
  - pSLC: 40GB up to 320GB
- **Form Factor**
  - BGA SSD 1620, 16mm x 20mm
- **PCIe Express Base Specification**
  - PCIe Gen4 x4
  - NVMe 1.4
  - PCI Express Base 4.0
- **Performance[1]**
  - Read up to 4,900 MB/s
  - Write up to 4,300 MB/s
- **Power Power Saving Modes (Optional)**
  - PS0/ PS1/ PS2/ PS3/ PS4 (<2.5W)
  - Support APST
  - Support ASPM
  - Support L1.2
- **Voltage Supply Rails**
  - P1=2.5V
  - P2=1.2V
  - P3=0.85V
- **Package Compliant**
  - RoHS
  - MSL3
- **Temperature Range[2]**
  - Industrial Grade: -40°C ~ 85°C
  - Automotive Grade 2: -40°C ~ 105°C
- **Reliability**
  - MTBF > 2,000,000 hours
  - UBER < 1 sector per $10^{16}$ bits
- **TeraBytes Written (TBW)**
  - Up to 1,341 TB for 1TB TLC
  - Up to 12,169 TB for 320GB pSLC
- **Features Support List**
  - SMART
  - Host-controlled thermal management
  - Power loss protection
  - End to end data path protection
  - Thermal throttling
  - LDPC + RAID ECC
  - SmartRefresh™
  - Support HMB (Host Memory Buffer)[3] (option support)
  - Support TCG OPAL (option support)
  - RPMB[4]
  - Boot Partition[4]

**Notes:**

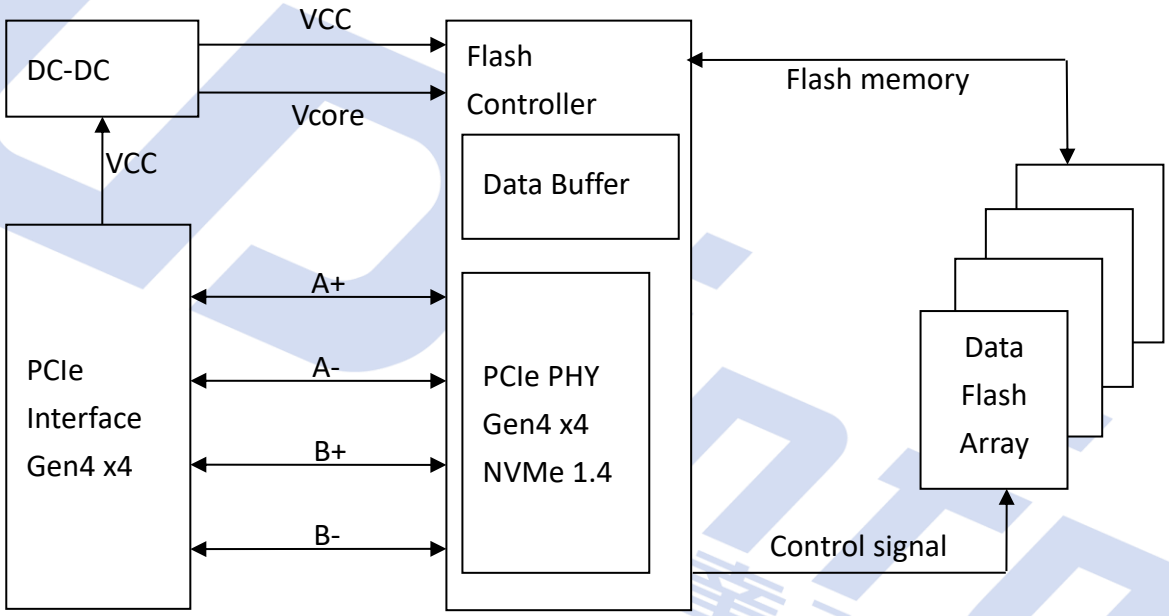
1. Refer to Chapter 2 for more details.
2. The operation temperature means the case temperature, in which can be decided via S.M.A.R.T.
3. Win10 (version 1809) and above supports HMB (Host Memory Buffer) function.
4. Replay Protected Memory Block and Boot Partition currently under development.

# 1. INTRODUCTION

## 1.1. General Description

UDinfo's PCIe BGA SSD delivers all the advantages of flash disk technology with PCIe Gen4 x4 interface. The PCIe BGA SSD could provide the capacity range up to 1TB. Moreover, it can reach up to 4,900 MB/s read as well as 4,300 MB/s write high performance. Its lower power consumption makes it an ideal storage choice for high performance embedded platforms.

## 1.2. Block Diagram




**PCIe BGA SSD Block Diagram**

# 2. PRODUCT SPECIFICATIONS

## 2.1. Product Specifications

- **Capacity**
  - TLC: 64GB up to 1TB
  - pSLC: 40GB up to 320GB
  - Support 32-bit addressing mode
- **Electrical/Physical Interface**
  - PCI Express Base Ver 4.0
  - Compliant with NVMe 1.4
  - 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
- **Sector Size Support**
  - 512Bytes
  - 4KB
- **Voltage Rails**
  - P1=2.5V
  - P2=1.2V
  - P3=0.85V
- **LBA Range**
  - IDEMA standard

| Capacity | IDEMA Standard | | User Data Size |
|---|---|---|---|
| | 512Bytes/Sector | 4KBytes/Sector | |
| | Total Sectors (LBA) | Total Sectors (LBA) | |
| 64GB | 125,045,424 | 15,630,678 | Depended on file management |
| 128GB | 250,069,680 | 31,258,710 | |
| 256GB | 500,118,192 | 62,514,774 | |
| 512GB | 1,000,215,216 | 125,026,902 | |
| 1TB | 2,000,409,264 | 250,051,158 | |
| 40GB | 78,161,328 | 9,770,166 | |
| 80GB | 156,301,488 | 19,537,686 | |

| | | | |
|---|---|---|---|
| 160GB | 312,581,808 | 39,072,726 | |
| 320GB | 625,142,448 | 78,142,806 | |

**Notes:**

1. 1 Gigabyte (GB) is equal to 1,000,000,000 Bytes; 1 sector is equal to 512 Bytes.
2. The calculation is following IDEMA Standard.
3. The total actual user data size of the SSD may be less than device capacity due to SSD format, SSD partition, operating system.

   EX: OS shows 238.47GB (NTFS) with 256GB SSD.

- **Performance**

| Capacity | Flash Configuration | Sequential (CDM) | | Random (IOMeter) | |
|---|---|---|---|---|---|
| | | Read (MB/s) | Write (MB/s) | Read (IOPS) | Write (IOPS) |
| 64GB | Kioxia TLC, 64GB x1 | 660 | 250 | 30K | 53K |
| 128GB | Kioxia TLC, 64GB x2 | 1,400 | 510 | 60K | 120K |
| 256GB | Kioxia TLC, 64GB x4 | 2,950 | 1,000 | 110K | 245K |
| 512GB | Kioxia TLC, 64GB x8 | 3,650 | 1,900 | 220K | 450K |
| 1TB | Kioxia TLC, 64GB x16 | 3,650 | 2,900 | 380K | 500K |
| 40GB | Kioxia pSLC, 64GB x2 | 1,850 | 850 | 110K | 220K |
| 80GB | Kioxia pSLC, 64GB x4 | 3,800 | 1,700 | 200K | 400K |
| 160GB | Kioxia pSLC, 64GB x8 | 4,900 | 3,600 | 450K | 800K |
| 320GB | Kioxia pSLC, 64GB x16 | 4,900 | 4,300 | 700K | 800K |

**Notes:**

1. Performance may differ according to flash configuration, use condition, environment and platform.
2. Performance specification is under that Thermal Throttling has not worked yet.
3. Performance is measured based on the follow conditions:
   (a) OS Version: Win10 (64bit), version 1809
   (b) CPU: AMD Ryzen 7 5800X 8-Core Processor
   (c) CrystalDiskMark 7.0.0 with QD8T1, 1GB range for sequential read/write test
   (d) IOmeter v1.1.0 with QD32T16, 1GB range for 4KB random read/write test.
4. Measurement environment: Room temperature: 20~25℃, humidity: 40~60%RH, DC+3.3V condition.

- **TBW (Terabytes Written)**

| Capacity | TBW | DWPD |
|---|---|---|
| 64GB | 70 | 1 |
| 128GB | 85 | 0.606 |
| 256GB | 248 | 0.885 |
| 512GB | 661 | 1.180 |
| 1TB | 1,341 | 1.196 |
| 40GB | 972 | 27.734 |
| 80GB | 2,492 | 35.556 |
| 160GB | 5,477 | 39.080 |
| 320GB | 12,169 | 43.412 |

**Notes:**

1. TBW is measured by JEDEC Client 219A workload.
   (a.) Calculated with PE count = 3,000 for TLC.
   (b.) Calculated with PE count = 50,000 for pSLC.
2. TBW may differ according to flash configuration and platform.
3. DWPD (Drive Write Per Day) is calculated based on 3-year lifetime.
   DWPD = TBW / (365 days x 3 years x User Capacity)
4. 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)
5. The endurance of SSD could be estimated based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.

## 2.2. Thermal Throttling

The purpose of thermal throttling is to prevent any components in a SSD from over-heating during read and write operations. The controller 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 S.M.A.R.T. reading.

- **Purpose of Thermal Throttling:**
  - In order to keep the optimal performance in the safe range of the temperature.
- **Thermal sensors:**
  - We have on-die thermal sensor (inside the controller and NAND flash) to detect temperature.

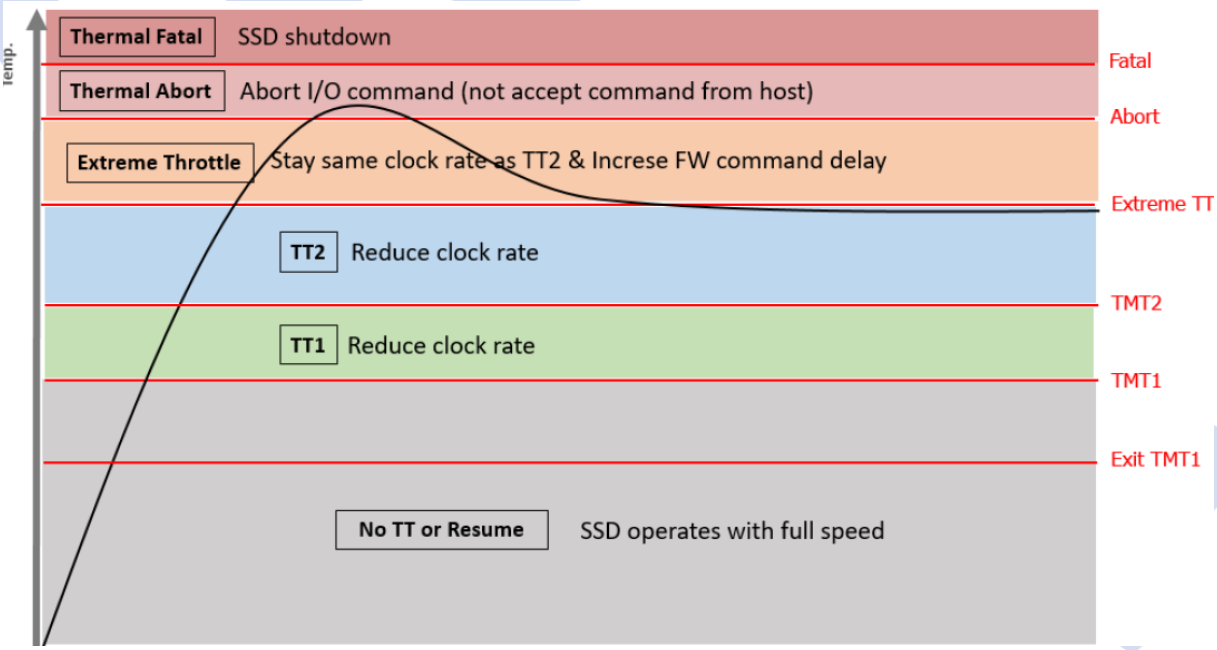



**Figure 2-1 Thermal Throttling by On-die Thermal Sensor**

## 2.3. TCG Opal 2.0 (Option)

The Opal specification is a set of specifications for self-encrypting drives published by the Trusted Computing Group (TCG), a non-profit organization that develops, defines, and promotes standards and specifications for secure computing. The Opal Security Subsystem Class(SSC) 2.0 defines the details of data management in storage devices and the classes authority for data access, and secures data from theft and tampering by unauthorized persons who are able to gain access to the storage device or host system.

**TCG Opal 2.0 Main Features:**

- AES 256-bit Hardware Self Encryption
- Deploy Storage Device & Take Ownership:

  The Storage Device is integrated into its target system and ownership transferred by setting or changing the Storage Device's owner credential.
- Activate or Enroll Storage Device:

  LBA ranges are configured and data encryption and access control credentials (re)generated and/or set on the Storage Device. Access control is configured for LBA range unlocking.
- Lock & Unlock Storage Device:

  Unlocking of one or more LBA ranges by the host and locking of those ranges under host control via either an explicit lock or implicit lock triggered by a reset event. MBR shadowing provides a mechanism to boot into a secure pre-boot authentication environment to handle device unlocking.
- Repurpose & End-of-Life:

  Erasure of data within one or more.

## 2.4. Autonomous Power State Transition (Option)

Device to support multiple power states. APST supports states where there is reduced power equating to slower performance or where the device is temporarily sleeping in a non-operational state and then woken up on activity. APST allows the transition between operational state (PS0/1/2) and non-operational states (PS3/4) automatically. Host can configure power state as below table:

| Initial Power States | ITPS | ITPT (ms) * |
|---|---|---|
| PS0 | PS3 | 100 |
| PS1 | PS3 | 100 |
| PS2 | PS3 | 100 |
| PS3 | PS4 | 9,900 |

**Notes:**

1. Idle Transition Power State (ITPS): Transfer from Initial Power States to other Power States.
2. Idle Time Prior to Transition (ITPT): The waiting time that Initial Power States transfers to other Power States when device is idle.

## 2.5. Active State Power Management (Option)

Active-state power management (ASPM) is a power management mechanism for PCI Express devices. It is an autonomous hardware-based, active state mechanism that enables power savings even when the connected components are in the fully active state. Link Power Management State (L0, L1, L1.1, L1.2) can be controlled by ASPM. PCI Express defines the following Link power management states:

- L0: Active state
- L0s: A low resume latency, energy saving “standby” state.
- L1: Higher latency, lower power “standby” state.
- L1.1: Lite-energy-saving state.
- L1.2: Deep-energy-saving state.

# 3. ENVIRONMENTAL SPECIFICATIONS

## 3.1. UBER

| Capacity | UBER |
|---|---|
| TLC: 64GB ~ 1TB<br>pSLC: 40GB ~ 320GB | < 1 sector per $10^{16}$ bits read |

**Notes:**

1. UBER (Uncorrectable Bit Error Rates) means the uncorrectable error per bits read.
2. UBER = FER (fail rate) / Data Size (user data bit).
3. FER = uncorrectable ECC frame number / total ECC frame number.
4. IDR-300 LDPC for Kioxia 3D NAND TLC ECC capability = 138bit/1KB.

## 3.2. MTBF

MTBF, an acronym for 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 simulation software (Relex 7.3). Please note that a lower MTBF should be expected for higher capacity drives, and we apply the lowest MTBF for all capacities.

| Capacity | MTBF |
|---|---|
| TLC: 64GB ~ 1TB<br>pSLC: 40GB ~ 320GB | 2 million hours |

# 4. ELECTRICAL SPECIFICATIONS

## 4.1. Supply Voltage

| Parameter | Rating | | | |
|---|---|---|---|---|
| Operating Voltage | Specification | Min. | Typ. | Max. |
| | Flash Core | +2.45V | +2.5V | +2.75V |
| | Flash IO supply | +1.16V | +1.2V | +1.26V |
| | Controller Core | +0.80V | +0.85V | +0.88V |
| Rise Time (Max/Min) | 1.2ms / 0.8ms | | | |
| Fall Time (Max/Min) | Note[4] | | | |

Note:

1. Minimum time between power removed from SSD (Vcc < 500 mW) and power re-applied to the drive.
2. It shall be driven down Vcc to below 0.5V and stay low for at least 1ms before Vcc power up.
3. The Min. Off Time may differ according to power solution used.
4. Please follow PCI Express M.2 Specification: BGA SSD Voltage Supply Power-off Sequencing.

## 4.2. Power Consumption

- **Kioxia 112L 3D TLC Power Consumption of each power state**

| Capacity | Flash Configuration | Read (Max.) | | | Write (Max.) | | | PS3 | PS4 |
|---|---|---|---|---|---|---|---|---|---|
| | | PS0 | PS1 | PS2 | PS0 | PS1 | PS2 | | |
| 64GB | TLC, 64GB x1 | 1,750 | 1,465 | 1,250 | 1,550 | 1,250 | 1,200 | 50 | 2.5 |
| 128GB | TLC, 64GB x2 | 2,065 | 1,800 | 1,250 | 1,650 | 1,350 | 1,200 | 50 | 2.5 |
| 256GB | TLC, 64GB x4 | 2,900 | 2,000 | 1,350 | 2,200 | 1,700 | 1,200 | 50 | 2.5 |
| 512GB | TLC, 64GB x8 | 3,200 | 2,200 | 1,300 | 2,650 | 1,700 | 1,200 | 50 | 2.5 |
| 1TB | TLC, 64GB x16 | 3,500 | 2,100 | 1,300 | 3,500 | 1,800 | 1,200 | 50 | 2.5 |
| 40GB | pSLC, 64GB x2 | 2,380 | 2,080 | 1,340 | 1,870 | 1,600 | 1,030 | 50 | 2.5 |
| 80GB | pSLC, 64GB x4 | 3,240 | 2,230 | 1,470 | 2,410 | 1,945 | 1,370 | 50 | 2.5 |
| 160GB | pSLC, 64GB x8 | 3,770 | 2,390 | 1,620 | 3,300 | 2,110 | 1,380 | 50 | 2.5 |
| 320GB | pSLC, 64GB x16 | 4,000 | 2,600 | 1,820 | 3,710 | 2,140 | 1,430 | 50 | 2.5 |

Unit: mW

**Notes**

1. Power consumption is measured with the condition under ambient temperature @25°C.
2. 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.

3. 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.

## ■ Kioxia 112L 3D TLC PS0 (Full Speed Mode) MAX Current

| Capacity | Flash Configuration | PWR1 (Max.) | PWR2 (Max.) | PWR3 (Max.) |
|---|---|---|---|---|
| 64GB | TLC, 64GB x1 | 300 | 430 | 1,500 |
| 128GB | TLC, 64GB x2 | 650 | 650 | 1,500 |
| 256GB | TLC, 64GB x4 | 970 | 1,000 | 1,500 |
| 512GB | TLC, 64GB x8 | 1,000 | 1,130 | 1,500 |
| 1TB | TLC, 64GB x16 | 1,100 | 1,260 | 1,500 |
| 40GB | pSLC, 64GB x2 | 630 | 730 | 1,785 |
| 80GB | pSLC, 64GB x4 | 1,120 | 1,160 | 1,810 |
| 160GB | pSLC, 64GB x8 | 1,280 | 1,280 | 1,890 |
| 320GB | pSLC, 64GB x16 | 1,350 | 1,460 | 1,900 |

Unit: mA

**Notes**

4. Power consumption is measured with the condition under ambient temperature @25°C.
5. The Max value of power consumption is achieved based on 100% conversion efficiency.
6. Max current is estimated under burst performance for TLC.

# 5. INTERFACE

## 5.1. BGA type 1620 Pin Assignment and Descriptions

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | DNU | DNU | | DNU | | DNU | | DNU | | | DNU | | DNU | | DNU | | DNU | DNU | A |
| B | DNU | DNU | | DNU | | DNU | | 1V8_REG | | | DNU | | DNU | | DNU | | DNU | DNU | B |
| C | GND | GND | GND | GND | GND | DNU | DNU | DNU | DNU | FLASH_RZQ | DNU | DNU | DNU | DNU | GND | DNU | DNU | DNU | C |
| D | | | | REFCLKP | REFCLKN | GND | PERSTN | CLKREQB | PWR_1 | PWR_1 | GND | XEXTRSTB | DIAG1 | DNU | DNU | | | | D |
| E | GND | GND | GND | GND | GND | GND | GND | DNU | PWR_1 | PWR_1 | GND | DNU | DIAG0 | GND | GND | DNU | DNU | DNU | E |
| F | | | | PERP0 | PERN0 | GND | | | | | | | | DNU | GND | | | | F |
| G | GND | GND | GND | GND | GND | | PWR_3 | PWR_3 | GND | GND | PWR_3 | PWR_3 | | GND | GND | DNU | DNU | DNU | G |
| H | | | | PETP0 | PETN0 | | PWR_3 | PWR_3 | GND | GND | PWR_3 | PWR_3 | | GND | PLN | | | | H |
| J | GND | GND | GND | GND | GND | | PWR_3 | PWR_3 | GND | GND | PWR_3 | PWR_3 | | GND | GND | DNU | DNU | DNU | J |
| K | | | | PERP1 | PERN1 | | GND | GND | GND | GND | GND | GND | | DNU | PLA | | | | K |
| L | GND | GND | GND | GND | GND | | DNU | DNU | DNU | DNU | DNU | DNU | | GND | GND | DNU | DNU | DNU | L |
| M | | | | PETP1 | PETN1 | | DNU | DNU | GND | GND | DNU | DNU | | DNU | DNU | | | | M |
| N | GND | GND | GND | GND | GND | | DNU | DNU | DNU | DNU | DNU | DNU | | GND | GND | DNU | JTAG_TCK | JTAG_TMS | N |
| P | | | | PERP2 | PERN2 | | GND | GND | GND | GND | GND | GND | | DNU | DNU | | | | P |
| R | GND | GND | GND | GND | GND | | PWR_2 | PWR_2 | GND | GND | PWR_2 | PWR_2 | | GND | GND | DNU | XGPIO0 | DNU | R |
| T | | | | PETP2 | PETN2 | | PWR_2 | PWR_2 | GND | GND | PWR_2 | PWR_2 | | DNU | DNU | | | | T |
| U | GND | GND | GND | GND | GND | | PWR_2 | PWR_2 | GND | GND | PWR_2 | PWR_2 | | GND | GND | DNU | SMB_CLK | SMB_DATA | U |
| V | | | | PERP3 | PERN3 | | | | | | | | | DNU | DNU | | | | V |
| W | GND | GND | GND | GND | GND | GND | LED/DAS | DNU | PWR_1 | PWR_1 | GND | DNU | DNU | GND | GND | DNU | DNU | DNU | W |
| Y | | | | PETP3 | PETN3 | GND | DNU | DNU | PWR_1 | PWR_1 | GND | DNU | GND | DNU | DNU | | | | Y |
| AA | GND | GND | GND | GND | GND | DNU | DNU | DNU | DNU | CTL_RZQ | DNU | DNU | DNU | GND | GND | DNU | DNU | DNU | AA |
| AB | DNU | DNU | | DNU | | DNU | | DNU | | | DNU | | DNU | | DNU | | DNU | DNU | AB |
| AC | DNU | DNU | | DNU | | DNU | | DNU | | | DNU | | DNU | | DNU | | DNU | DNU | AC |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |

- **Pin Assignment and Descriptions**

| Pin Name | BGA 291 | Pin Type | Description | IO Voltage |
|---|---|---|---|---|
| UART/GPIO | | | | |
| XGPIO0 | R17 | I | Debug only | 1.8V |
| DIAG1 | D13 | I | Debug only | 1.8V |
| DIAG0 | E13 | O | Debug only | 1.8V |
| SMB_CLK | U17 | I/O | Debug only | 1.8V |
| SMB_DATA | U18 | I/O | Debug only | 1.8V |
| JTAG_TCK | N17 | I/O | Debug only | 1.8V |
| JTAG_TMS | N18 | I/O | Debug only | 1.8V |
| XEXTRSTB | D12 | - | Debug only | 1.8V |
| 1V8_REG | B8 | - | Debug only | 1.8V |
| PCIe Interface Signals | | | | |
| PERP0 | F4 | I/O | PCIe TX/RX Differential signals defined by the PCI Express Card Electromechanical Specification. | -- |
| PERN0 | F5 | | | |
| PERP1 | K4 | | | |
| PERN1 | K5 | | | |
| PERP2 | P4 | | | |
| PERN2 | P5 | | | |
| PERP3 | V4 | | | |
| PERN3 | V5 | | | |
| PETP0 | H4 | | | |
| PETN0 | H5 | | | |
| PETP1 | M4 | | | |
| PETN1 | M5 | | | |
| PETP2 | T4 | | | |
| PETN2 | T5 | | | |
| PETP3 | Y4 | | | |
| PETN3 | Y5 | | | |
| REFCLKP | D4 | I | PCIe Reference Clock signals (100 MHz) defined by the PCI Express Card Electromechanical Specification. | -- |
| REFCLKN | D5 | I | | -- |
| PERSTN | D7 | I | PCIe Reset is a functional reset to the card as defined by the PCI Express Mini Card Electromechanical Specification. | 1.8V |
| CLKREQB | D8 | I/O | Clock Request is a reference clock request | 1.8V |

| | | | | |
|---|---|---|---|---|
| | | | signal as defined by the PCI Express Mini Card Electromechanical Specification; Also used by L1 PM Substates. | |
| Optional Signals | | | | |
| FLASH_RZQ | C10 | I | Flash Calibration REF RESISTENCE | - |
| CTL_RZQ | AA10 | I | Controller Calibration REF RESISTENCE | - |
| PLA | K15 | O | Power Loss Acknowledge | 1.8V |
| PLN | H15 | I | Power Loss Notification | 1.8V |
| SSD Specific Signals | | | | |
| LED/DAS# | W7 | O | Open drain, active low signal. This signal is used to allow the Adapter to provide status indication via LED device that will be provided by the system. | 3.3V |
| Power Supply Signals | | | | |
| PWR_1 | D9, D10, E9, E10, W9, W10, Y9, Y10 | I | +2.5 V source | 2.5V |
| PWR_2 | R7, R8, R11, R12, T7, T8, T11, T12, U7, U8, U11, U12 | I | +1.2 V source | 1.2V |
| PWR_3 | G7, G8, G11, G12, H7, H8, H11, H12, J7, J8, J11, J12 | I | +0.85 V source | 0.85V |
| Other signals | | | | |
| **Pin Name** | **BGA 291** | | **Description** | **IO Voltage** |
| GND | C1, C2, C3, C4, C5, C15, D6, D11, E1, E2, E3, E4, E5, E6, E7, E11, E14, E15, F6, F15, G1, G2, G3, G4, G5, G9, G10, G14, G15, H9, H10, H14, J1, J2, J3, J4, J5, J9, J10, J14, J15, K7, K8, | | Ground | -- |

| | | | |
|---|---|---|---|
| | K9, K10, K11, K12, L1, L2, L3, L4, L5, L14, L15, M9, M10, N1, N2, N3, N4, N5, N14, N15, P7, P8, P9, P10, P11, P12, R1, R2, R3, R4, R5, R9, R10, R14, R15, T9, T10, U1, U2, U3, U4, U5, U9, U10, U14, U15, W1, W2, W3, W4, W5, W6, W11, W14, W15, Y6, Y11, Y13, AA1, AA2, AA3, AA4, AA5, AA14, AA15 | | |
| DNU | A1, A2, A4, A6, A8, A11, A13, A15, A17, A18, B1, B2, B4, B6, B11, B13, B15, B17, B18, C6, C7, C8, C9, C11, C12, C13, C14, C16, C17, C18, D14, D15, E8, E12, E16, E17, E18, F14, G16, G17, G18, J16, J17, J18, K14, L7, L8, L9, L10, L11, L12, L16, L17, L18, M7, M8, M11, M12, M14, M15, N7, N8, N9, N10, N11, N12, N16, P14, P15, R16, R18, T14, T15, U16, V14, V15, W8, W12, W13, W16, W17, W18, Y7, Y8, Y12, Y14, Y15, AA6, AA7, AA8, AA9, AA11, AA12, AA13, AA16, AA17, AA18, AB1, AB2, AB4, AB6, AB8, AB11, AB13, AB15, AB17, AB18, AC1, AC2, AC4, AC6, AC8, AC11, AC13, AC15, AC17, AC18 | Do not use. Manufacturing purpose only. | -- |

# 6. SUPPORTED COMMANDS

## 6.1. NVMe Command List

**Table 6-1 Admin Commands**

| Op-Code | 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**

| Op-Code | Command Description |
|---|---|
| 80h | Format NVM |
| 81h | Security Send |
| 82h | Security Receive |
| 84h | Sanitize |

**Table 6-3 NVM Commands**

| Op-Code | 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.

■ **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) | Serial Number |
| 63:24 | M | Model Number (MN) | Model Number |
| 71:64 | M | Firmware Revision (FR) | Firmware Name |
| 72 | M | Recommended Arbitration Burst (RAB) | 0x04 |
| 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) | 0x06 |
| 79:78 | M | Controller ID (CNTLID) | 0x0000 |
| 83:80 | M | Version (VER) | 0x00010400 |
| 87:84 | M | RTD3 Resume Latency (RTD3R) | 0x000186A0 |
| 91:88 | M | RTD3 Entry Latency (RTD3E) | 0x004C4B40 |
| 95:92 | M | Optional Asynchronous Events Supported (OAES) | 0x00000000 |
| 99:96 | M | Controller Attributes (CTRATT) | 0x0002 |
| 101:100 | O | Read Recovery Level support bitmap (RRLS) | 0x00 |
| 110:102 | - | Reserved | 0x00 |
| 111 | M | Controller Type, if support NVMe 1.4 shall be set to other than 0 (cntrltype) | 0x01 |
| 127:112 | O | FRU Globally Unique Identifier (FGUID[16]) | 0x00 |
| 129:128 | O | Command Retry Delay Time 1 (CRDT1) | 0x00 |
| 131:130 | O | Command Retry Delay Time 2 (CRDT2) | 0x00 |
| 133:132 | O | Command Retry Delay Time 3 (CRDT3) | 0x00 |
| 255:134 | - | Reserved | 0x00 |
| 257:256 | M | Optional Admin Command Support (OACS) | 0x0017 |
| 258 | M | Abort Command Limit (ACL) | 0x03 |
| 259 | M | Asynchronous Event Request Limit (AERL) | 0x07 |
| 260 | M | Firmware Updates (FRMW) | 0x12 |
| 261 | M | Log Page Attributes (LPA) | 0x1E |
| 262 | M | Error Log Page Entries (ELPE) | 0xFE |

| Bytes | O/M | Description | Default Value |
|---|---|---|---|
| 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) | 0x017D |
| 269:268 | M | Critical Composite Temperature Threshold (CCTEMP) | 0x017F |
| 271:270 | O | Maximum Time for Firmware Activation (MTFA) | 0x0064 |
| 275:272 | O | Host Memory Buffer Preferred Size (HMPRE) | 0x0 |
| 279:276 | O | Host Memory Buffer Minimum Size (HMMIN) | 0x0 |
| 295:280 | O | Total NVM Capacity (TNVMCAP) | By capacity |
| 311:296 | O | Unallocated NVM Capacity (UNVMCAP) | 0x00 |
| 315:312 | O | Replay Protected Memory Block Support (RPMBS) | 0x1F0002 |
| 317:316 | O | Extended Device Self-test Time (EDSTT) | 0x001E |
| 318 | O | Device Self-test Options (DSTO) | 0x00 |
| 319 | M | Firmware Update Granularity (FWUG) | 0x04 |
| 321:320 | M | Keep Alive Support (KAS) | 0x0000 |
| 323:322 | O | Host Controlled Thermal Management Attributes (HCTMA) | 0x0001 |
| 325:324 | O | Minimum Thermal Management Temperature (MNTMT) | 0x0111 |
| 327:326 | O | Maximum Thermal Management Temperature (MXTMT) | 0x0170 |
| 331:328 | O | Sanitize Capabilities (SANICAP) | 0xA0000002 |
| 335:332 | O | Host Memory Buffer Min. Descriptor Entry Size (hmminds) | 0x400 |
| 337:336 | O | Host Memory Maximum Descriptor Entries (hmmaxd) | 0x10 |
| 339:338 | O | NVM Set ID Maximum (nsetidmax) | 0x00 |
| 341:340 | O | Endurance Group ID Maximum (endgidmax) | 0x00 |
| 342 | O | ANA Maximum Transition Time (anatt) | 0x00 |
| 343 | O | Asymmetric Namespace Access Capabilities (ANACAP) | 0x00 |
| 347:344 | O | ANA Group ID Maximum (anagrpmax) | 0x00 |

| Bytes | O/M | Description | Default Value |
|---|---|---|---|
| 351:348 | O | Number of ANA Group IDs (nanagrpid) | 0x00 |
| 355:352 | O | Persistent Event Log Size (PELS) | 0x60 |
| 511:356 | - | Reserved | 0x00 |
| **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) | 0x0100 |
| 519:516 | M | Number of Namespaces (NN) | 0x00000001 |
| 521:520 | M | Optional NVM Command Support (ONCS) | 0x00D7 |
| 523:522 | M | Fused Operation Support (FUSES) | 0x0000 |
| 524 | M | Format NVM Attributes (FNA) | 0x00 |
| 525 | M | Volatile Write Cache (VWC) | 0x07 |
| 527:526 | M | Atomic Write Unit Normal (AWUN) | 0xFF |
| 529:528 | M | Atomic Write Unit Power Fail (AWUPF) | 0x00 |
| 530 | M | NVM Vendor Specific Command Configuration (NVSCC) | 0x01 |
| 531 | M | Namespace Write Protection Capabilities (NWPC) | 0x00 |
| 533:532 | O | Atomic Compare & Write Unit (ACWU) | 0x0000 |
| 535:534 | - | Reserved | 0x0000 |
| 539:536 | O | SGL Support (SGLS) | 0x00000000 |
| 543:540 | O | Maximum Number of Allowed Namespace, if supports ANA Reporting shall not be 0 and less than NN (MNAN) | 0x00 |
| 767:544 | - | Reserved | 0x00 |
| **IO Command Set Attributes** | | | |
| 1023:768 | M | NVM Subsystem NVMe Qualified Name (SUBNQN) | nqn.2020-11.org.nvmexpress:uuid: (SN) |
| 1791:1024 | - | Reserved | 0x00 |
| 2047:1792 | - | Refer to the NVMe over Fabrics specification | 0x00 |
| 2079:2048 | M | Power State 0 Descriptor (PSD0) | 0x00 |
| 2111:2080 | O | Power State 1 Descriptor (PSD1) | 0x00 |
| 2143:2112 | O | Power State 2 Descriptor (PSD2) | 0x00 |
| 2175:2144 | O | Power State 3 Descriptor (PSD3) | 0x00 |
| 2207:2176 | O | Power State 4 Descriptor (PSD4) | 0x00 |
| 2239:2208 | O | Power State 5 Descriptor (PSD5) | 0x00 |
| 2271:2240 | O | Power State 6 Descriptor (PSD6) | 0x00 |

| Bytes | O/M | Description | Default Value |
|---|---|---|---|
| 2303:2272 | O | Power State 7 Descriptor (PSD7) | 0x00 |
| 2335:2304 | O | Power State 8 Descriptor (PSD8) | 0x00 |
| 2367:2336 | O | Power State 9 Descriptor (PSD9) | 0x00 |
| 2399:2368 | O | Power State 10 Descriptor (PSD10) | 0x00 |
| 2431:2400 | O | Power State 11 Descriptor (PSD11) | 0x00 |
| 2463:2432 | O | Power State 12 Descriptor (PSD12) | 0x00 |
| 2495:2464 | O | Power State 13 Descriptor (PSD13) | 0x00 |
| 2527:2496 | O | Power State 14 Descriptor (PSD14) | 0x00 |
| 2559:2528 | O | Power State 15 Descriptor (PSD15) | 0x00 |
| 2591:2560 | O | Power State 16 Descriptor (PSD16) | 0x00 |
| 2623:2592 | O | Power State 17 Descriptor (PSD17) | 0x00 |
| 2655:2624 | O | Power State 18 Descriptor (PSD18) | 0x00 |
| 2687:2656 | O | Power State 19 Descriptor (PSD19) | 0x00 |
| 2719:2688 | O | Power State 20 Descriptor (PSD20) | 0x00 |
| 2751:2720 | O | Power State 21 Descriptor (PSD21) | 0x00 |
| 2783:2752 | O | Power State 22 Descriptor (PSD22) | 0x00 |
| 2815:2784 | O | Power State 23 Descriptor (PSD23) | 0x00 |
| 2847:2816 | O | Power State 24 Descriptor (PSD24) | 0x00 |
| 2879:2848 | O | Power State 25 Descriptor (PSD25) | 0x00 |
| 2911:2880 | O | Power State26 Descriptor (PSD26) | 0x00 |
| 2943:2912 | O | Power State 27 Descriptor (PSD27) | 0x00 |
| 2975:2944 | O | Power State 28 Descriptor (PSD28) | 0x00 |
| 3007:2976 | O | Power State 29 Descriptor (PSD29) | 0x00 |
| 3039:3008 | O | Power State 30 Descriptor (PSD30) | 0x00 |
| 3071:3040 | O | Power State 31 Descriptor (PSD31) | 0x00 |
| 3107:3072 | O | Vendor Specific (VS) | 0x00 |
| 3109:3108 | O | PLP Supported | 0x8001 |
| 4095:3110 | O | Vendor Specific (VS) | 0x00 |

**Notes:**

"O/M": O = Optional, M = Mandatory.

"-" : Not support

## 6.3. 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 (N/A) |
| [203:202] | 2 | Temperature Sensor 2 (N/A) |
| [205:204] | 2 | Temperature Sensor 3 (N/A) |
| [207:206] | 2 | Temperature Sensor 4 (N/A) |
| [209:208] | 2 | Temperature Sensor 5 (N/A) |
| [211:210] | 2 | Temperature Sensor 6 (N/A) |
| [213:212] | 2 | Temperature Sensor 7 (N/A) |
| [215:214] | 2 | Temperature Sensor 8 (N/A) |
| [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 |

# 7. PHYSICAL DIMENSION

**Package: 16mm (x-axis) x 20mm (y-axis) / 0.8mm (Ball Pitch)**

**Table 7-1 BGA SSD Physical Dimensions and Weight**

| Capacity | Height (mm) | Width (mm) | Length (mm) | Weight (gram) |
|---|---|---|---|---|
| 64GB | 1.15 | 16 | 20 | 0.67 |
| 128GB (40GB pSLC) | 1.15 | | | 0.67 |
| 256GB (80GB pSLC) | 1.15 | | | 0.67 |
| 512GB (160GB pSLC) | 1.35 | | | 0.84 |
| 1TB (320GB pSLC) | 1.65 | | | 1 |

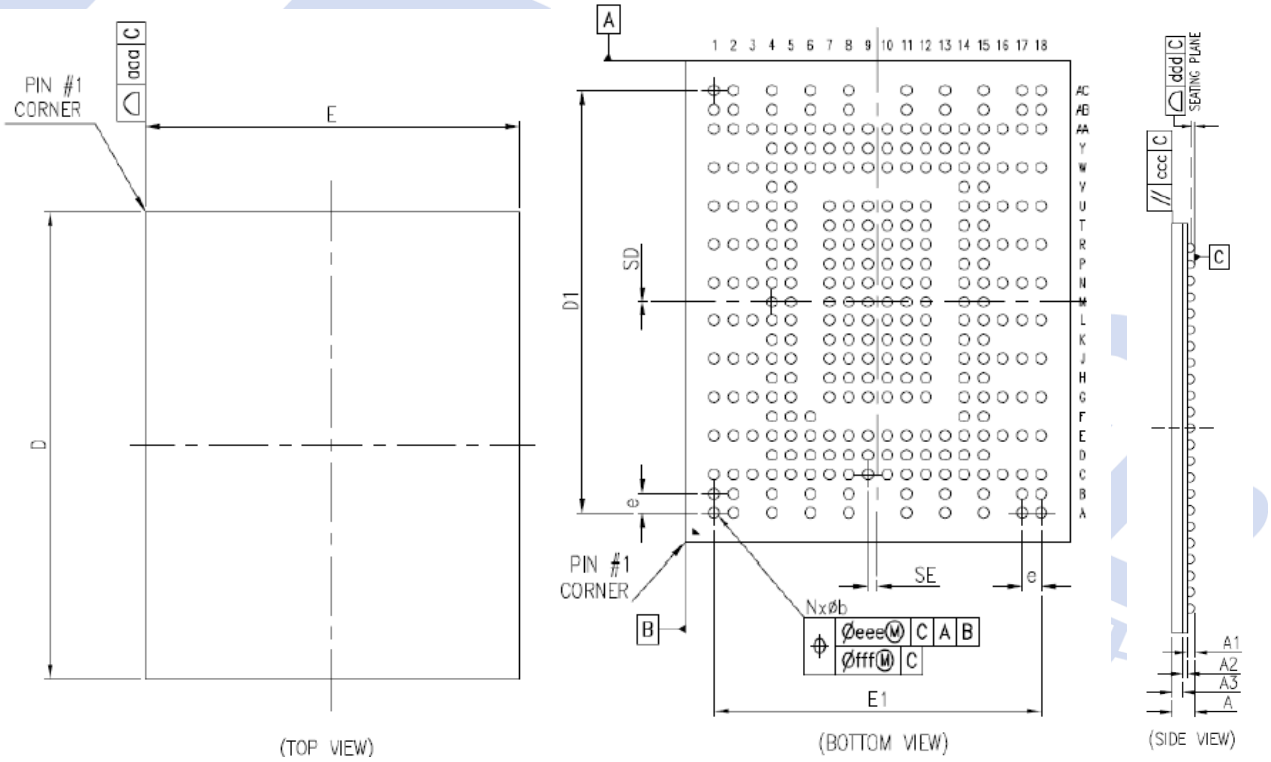


**Table 7-2 Package Specification (Kioxia 112Layers 3D TLC x1 / x2 / x4 solution)**

| LY No.PS-MK-291-56001-** | SYMBOL | DIMENSION IN MM | | |
|---|---|---|---|---|
| | | MIN. | NOM. | MAX. |
| TOTAL THICKNESS | A | 0.95 | 1.07 | 1.15 |
| STAND OFF | A1 | 0.30 | 0.35 | 0.40 |
| SUBSTRATE THICKNESS | A2 | | 0.22 | |
| MOLD THICKNESS | A3 | | 0.50 | |
| BODY SIZE | D | | 20 | |
| | E | | 16 | |
| BALL DIAMETER | | | 0.45 | |
| BALL OPENING | | | 0.40 | |
| BALL WIDTH | b | 0.40 | 0.45 | 0.50 |
| BALL PITCH | e | | 0.80 | |
| BALL COUNT | N | | 291 | |
| EDGE BALL CENTER TO CENTER | D1 | | 17.60 BSC. | |
| | E1 | | 13.60 BSC. | |
| BODY CENTER TO CONTACT BALL | SD | | 0.00 BSC. | |
| | SE | | 0.40 BSC. | |
| JEDEC(REF) | | | MO-216(REF.) | |
| PACKAGE EDGE TOLERANCE | aaa | | 0.15 | |
| MOLD FLATNESS | ccc | | 0.20 | |
| COPLANARITY | ddd | | 0.20 | |
| BALL OFFSET(PACKAGE) | eee | | 0.15 | |
| BALL OFFSET(BALL) | fff | | 0.08 | |

**Table 7-3 Package Specification (Kioxia 112Layers 3D TLC x8 solution)**

| LY No.PS-MK-291-56001-** | SYMBOL | DIMENSION IN MM | | |
|---|---|---|---|---|
| | | MIN. | NOM. | MAX. |
| TOTAL THICKNESS | A | 1.15 | 1.27 | 1.35 |
| STAND OFF | A1 | 0.30 | 0.35 | 0.40 |
| SUBSTRATE THICKNESS | A2 | | 0.22 | |
| MOLD THICKNESS | A3 | | 0.70 | |
| BODY SIZE | D | | 20 | |
| | E | | 16 | |
| BALL DIAMETER | | | 0.45 | |
| BALL OPENING | | | 0.40 | |
| BALL WIDTH | b | 0.40 | 0.45 | 0.50 |
| BALL PITCH | e | | 0.80 | |
| BALL COUNT | N | | 291 | |
| EDGE BALL CENTER TO CENTER | D1 | | 17.60 BSC. | |
| | E1 | | 13.60 BSC. | |
| BODY CENTER TO CONTACT BALL | SD | | 0.00 BSC. | |
| | SE | | 0.40 BSC. | |
| JEDEC(REF) | | | MO-216(REF.) | |
| PACKAGE EDGE TOLERANCE | aaa | | 0.15 | |
| MOLD FLATNESS | ccc | | 0.20 | |
| COPLANARITY | ddd | | 0.20 | |
| BALL OFFSET(PACKAGE) | eee | | 0.15 | |
| BALL OFFSET(BALL) | fff | | 0.08 | |

**Table 7-4 Package Specification (Kioxia 112Layers 3D TLC x16 solution)**

| LY No.PS-MK-291-56001-** | SYMBOL | DIMENSION IN MM | | |
|---|---|---|---|---|
| | | MIN. | NOM. | MAX. |
| TOTAL THICKNESS | A | 1.45 | 1.57 | 1.65 |
| STAND OFF | A1 | 0.30 | 0.35 | 0.40 |
| SUBSTRATE THICKNESS | A2 | | 0.22 | |
| MOLD THICKNESS | A3 | | 1.00 | |
| BODY SIZE | D | | 20 | |
| | E | | 16 | |
| BALL DIAMETER | | | 0.45 | |
| BALL OPENING | | | 0.40 | |
| BALL WIDTH | b | 0.40 | 0.45 | 0.50 |
| BALL PITCH | e | | 0.80 | |
| BALL COUNT | N | | 291 | |
| EDGE BALL CENTER TO CENTER | D1 | | 17.60 BSC. | |
| | E1 | | 13.60 BSC. | |
| BODY CENTER TO CONTACT BALL | SD | | 0.00 BSC. | |
| | SE | | 0.40 BSC. | |
| JEDEC(REF) | | | MO-216(REF.) | |
| PACKAGE EDGE TOLERANCE | aaa | | 0.15 | |
| MOLD FLATNESS | ccc | | 0.20 | |
| COPLANARITY | ddd | | 0.20 | |
| BALL OFFSET(PACKAGE) | eee | | 0.15 | |
| BALL OFFSET(BALL) | fff | | 0.08 | |

**Notes:**

1. All dimensions are in mm.
2. Ball designation is per JEP95, SECTION 3, SPP-010.
3. Fiducial Markings (Missing Fiducial location is A1 Corner Indicator).
4. A1 Triangle (orientation can vary and is non-critical).
5. DIM b is measured at the maximum solder ball diameter, parallel to primary datum Z.

# 8. PART NUMBER DECODER

MPC-16DL$X^8X^9X^{10}X^{11}X^{12}X^{13}X^{14}X^{15}X^{16}X^{17}$

| $X^1X^2X^3$ | $X^4X^5$ | $X^6X^7$ | $X^8$ $X^9$ $X^{10}$ $X^{11}$ $X^{12}$ | $X^{13}$ | $X^{14}$ | $X^{15}$ | $X^{16}X^{17}$ |
|---|---|---|---|---|---|---|---|
| MPC | 16 | DL | 040GB<br>064GB<br>080GB<br>128GB<br>160GB<br>256GB<br>320GB<br>512GB<br>001TB | B: 3D TLC Industrial (-40ºC~+85ºC)<br>D: 3D TLC Automotive Grade2 (-40ºC~+105ºC)<br>W: 3D pSLC Industrial (-40ºC ~ +85ºC) | F | P | blank |