

PA4 series

Automotive-grade PCIe SSD

Specifications

Capacity

- U.2: 960 GB~7680 GB
- E1.S: 960 GB~7680 GB
- M.2 2280: 960 GB~7680 GB
- M.2 2242: 960 GB~1920 GB
- M.2 2230: 240 GB~960 GB

Components

- Controller: Marvell 88SS1321
- Flash: 1.2GHz 3D TLC
- DRAM: LPDDR3/DDR4

Compliance

- PCIe Gen4x4/ Gen4x2/ Gen3x4
- Surprise insertion / surprise removal (SISR) and hot-plug capable (U.2/E1.S support)

Performance (up to)¹

- Sequential read: 3,500 MB/s
- Sequential write: 3,000 MB/s
- Random 4K read: 500,000 IOPS
- Random 4K write: 55,000 IOPS

Power management

- Auto idle
- PCIe link power management
- Temperature monitoring and throttling

Storage technology (Optional)

- Underfill
- Conformal coating

Security (Optional)

- TCG-OPAL 2.0
- NVM Format
- Support SED (TCG/AES)

Reliability

- Advanced LDPC error correction
- Global static and dynamic wear leveling
- Hardware Power Loss Protection (PLP) (For U.2 & E1.S form factor)
- UBER: <1 sector per 10¹⁷ bits read
- MTBF: 2.0 million hours

Endurance ²

- 480GB : 300TB
- 960GB : 600TB
- 1920GB : 1200TB
- 3840GB : 2400TB
- 7680GB : 4800TB

Data retention

- JESD218A-compliant

Compatibility

- Windows 10/8.1/7
- Windows Server 2016/2012 R2/2012
- CentOS, Fedora, FreeBSD, openSUSE, Red Hat, Ubuntu, VMware ESXi, Citrix, KVM

Mechanical form factor

- U.2: 100.5 mm x 69.85 mm x 7 mm
- M.2 2280: 80 mm x 22 mm x 3.5 mm
- M.2 2242: 42 mm x 22 mm x 3.5 mm
- M.2 2230: 30 mm x 22 mm x 3.5 mm
- E1.S: 111.49 mm x 31.5 mm x 5.9 mm

Power consumption (TYP)

- Active: <7.0 W
- Idle: <1.0 W

Environment

- Operating temperature: -40–85 °C
- Storage temperature: -50–95 °C

Shock & vibration

- Operating: 50 G (11 ms duration, half sine wave)
- Non-operating: 1500 G (0.5 ms duration, half sine wave)
- Vibration: 10 G (peak, 10–2000 Hz)

Warranty

- 3-year limited warranty³

Specification notes:

1. Performance claims
 - a. Actual performance may vary based on the hardware, software, and overall system configuration.
 - b. Sequential performance is measured with 128 KB transfer size, QD 32 and 4 KB alignment with Iometer.
 - c. Random performance is sustained performance measured with 4K/8K transfer size, QD 32 and 4 KB alignment with Iometer.
 - d. Performance test platform: CPU: Intel Core i7 4770K; motherboard: ASUS Z87-DELUXE; chipset: Intel Z87 Express; OS: Windows 8.1 Pro x64.
2. Endurance claims
 - a. DWPD stands for Drive Writes Per Day. $TBW = DWPD * capacity * warranty * 365 / 1000$.
 - b. Access patterns used for random workload during endurance testing is compliant with the JESD219 standard.
3. Limited warranty details: please refer to limited warranty policy and warranty terms.

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Product datasheet

1. Order information

The following table lists the standard part numbers for Exascend PA4 series SSDs. For customization and design service inquiries, including – but not limited to – custom operating temperature, capacity, over-provisioning, endurance, performance, and power, please contact your Exascend account manager or send us an email at sales@exascend.com.

Table 1: PA4 series SSD product list

| PART NUMBER | CAPACITY* | FLASH TYPE | FORM FACTOR |
|--------------|-----------|------------|-------------|
| EXPA4R240GB | 240GB * | 3D TLC | M.2 2230 |
| EXPA4R480GB | 480GB * | 3D TLC | M.2 2230 |
| EXPA4R960GB | 960GB * | 3D TLC | M.2 2230 |
| EXPA4Q960GB | 960GB * | 3D TLC | M.2 2242 |
| EXPA4Q1920GB | 1920GB * | 3D TLC | M.2 2242 |
| EXPA4M960GB | 960GB * | 3D TLC | M.2 2280 |
| EXPA4M1920GB | 1920GB * | 3D TLC | M.2 2280 |
| EXPA4M3840GB | 3840GB * | 3D TLC | M.2 2280 |
| EXPA4M7680GB | 7680GB * | 3D TLC | M.2 2280 |
| EXPA4U960GB | 960GB * | 3D TLC | U.2 |
| EXPA4U1920GB | 1920GB * | 3D TLC | U.2 |
| EXPA4U3840GB | 3840GB * | 3D TLC | U.2 |
| EXPA4U7680GB | 7680GB * | 3D TLC | U.2 |
| EXPA4E960GB | 960GB * | 3D TLC | E1.S |
| EXPA4E1920GB | 1920GB * | 3D TLC | E1.S |
| EXPA4E3840GB | 3840GB * | 3D TLC | E1.S |
| EXPA4E7680GB | 7680GB * | 3D TLC | E1.S |

2. Part number decoder

| | | | | |
|----|------|---|--------|----|
| EX | PfA4 | M | 1920GB | -X |
|----|------|---|--------|----|

1. Exascend
2. Product series (SC1/SC3/PC3/PC4/SE1/SE3/PE3/PE4/SI2/SI3/PI3/PE4/PI4/PA3/PA4)
3. Form factor
(A=2.5"; B=mSATA; M=M.2 2280; P=M.2 2260; Q=M.2 2242; R=M.2 2230; U=U.2; E=E1.S)
4. Capacity
5. Identifier (H= extended temp)

3. Product overview

3.1 PA4 series

Exascend provides customizable hardware and firmware design, manufacturing, and service of cutting-edge SSD products and advanced storage systems. Our products are designed specifically for high reliability commercial, enterprise data center, and cloud computing applications. By combining world class design R&D, and superior execution in delivery and support capabilities, Exascend strives to provide customers with the best in class product and service, enabling enhanced boot times, faster application load times, reduced power consumption and extended reliability.

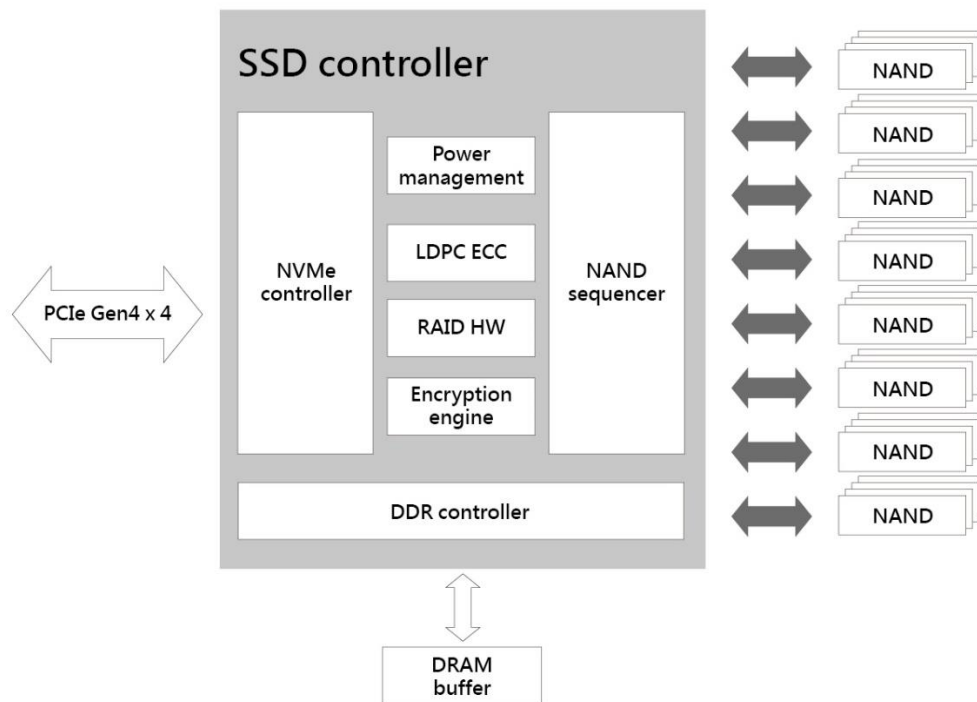
PA4 series product supports U.2, E1.S, and M.2 form factors, integrating high speed PCIe Gen 4 x 4 interface with third generation 3D TLC NAND flash memory technology, delivering capacities up to 8TB.

PA4 series products are offered in two product categories with different over-provisioning.

Key product highlights include:

- High I/O and throughput performance
- Next generation LDPC technology secures NAND endurance
- Advanced Flash management and global wear leveling algorithm extending drive life
- High stability and reliability
- Temperature monitoring and intelligent management

Figure 1: SSD functional logic diagram



3.2 Customization and tuning services

Exascend provides customized hardware and firmware design services, tailoring cutting-edge SSD products for advanced storage systems. Combining world-class R&D and engineering support capabilities, Exascend provides customers with best-in-class products and services, enabling enhanced boot times, faster-loading applications, reduced power consumption, and extended reliability. To learn more about our extended engineering support services, e.g., tailored capacity, over-provisioning, extended operating temperature range, endurance, performance, power, and longevity, please contact your Exascend account manager or send us an email at sales@exascend.com.

4. Detailed specifications

Exascend PA4 series SSD provides you the ultimate performance and ultra-high reliability over traditional hard disk drive by achieving up to 3,500MB/s for sequential read, 2,600MB/s for sequential write, 600,000 IOPS for random read, 450,000 IOPS for steady state random write.

Exascend PA4 series SSD consists solely of semiconductor devices, it does not contain any mechanical part such as platter (disk), motor and suspension as traditional hard disk drive. Thus, it exhibits superior performance, capacity, reliability, ruggedness, low power, and small form factor profiles that qualified to be the best storage solution for enterprise application with extreme workloads and increased MTBF requirements.

Exascend PA4 SSD uses a single-chip Flash controller to manage multiple NAND Flash memory modules. The controller works with a host system to allow data to be written to and read from the Flash memory modules through a PCIe interface.

4.1 Capacity

Table 2: PA4 logical block address configuration

| PA4 SERIES | UNFORMATTED CAPACITY (TOTAL USER ADDRESSABLE SECTORS IN LBA MODE) |
|------------|--|
| 240 GB | 468,851,544 |
| 480 GB | 937,703,088 |
| 960 GB | 1,875,385,008 |
| 1,920 GB | 3,750,748,848 |
| 3,840 GB | 7,501,476,528 |
| 7,680 GB | 15,002,931,888 |

Notes:

- The LBA count shown represents total user-accessible storage capacity and will remain the same throughout the drive's lifetime.
- The total usable capacity of the SSD may be less than the total physical capacity because a small portion of the capacity is used for NAND flash management and maintenance purposes.

4.2 Performance

Table 3: Drive performance – PA4 series

| | UNIT | PA4 SERIES | | | | | |
|--------------------|------|---------------------------------------|--------|--------|--------|------------|--------|
| | | 960GB | 1920GB | 3840GB | 7680GB | 3840GB | 7680GB |
| Capacity | GB | | | | | | |
| Sequential read | MB/s | 3,200 | 3,200 | 2,800 | 2,200 | 3,500 | 3,500 |
| Sequential write | MB/s | 1,800 | 3,000 | 2,800 | 2,200 | 3,000 | 3,000 |
| Random read (4KB) | IOPS | 240K | 400K | 400K | 400K | 500K | 500K |
| Random write (4KB) | IOPS | 30K | 48K | 50K | 50K | 55K | 55K |
| DWPD (3 years) | | 0.6 @ JESD218 2 @ Sequential Write | | | | | |
| Form factor | | M.2, E1.S & U.2 | | M.2 | | E1.S & U.2 | |

Notes:

- Measured with device connected as secondary drive.
- Actual performance may vary based on the hardware, software, and overall system configuration.
- Sequential performance is measured with 128 KB transfer size, QD 32 and 4 KB alignment with Iometer.
- Random performance is sustained performance measured with 4K/8K transfer size, QD 32 and 4 KB alignment with Iometer.
- Performance test platform: CPU: Intel Core i7 4770K; motherboard: ASUS Z87-DELUXE; chipset: Intel Z87 Express; OS: Windows 8.1 Pro x64.

4.3 Environment specification

Table 5: Environmental specification table

| PARAMETER | VALUE |
|----------------------------|--|
| Operating temperature | -40–85 °C |
| Storage temperature | -50–95 °C |
| Power supply voltage range | U.2 / E1.S: 12.0 V ±10% M.2: 3.3 V ± 5% |
| Humidity (non-condensing) | 5–95% (Operating) |
| Vibration | 10 G (peak, 10–2000 Hz) |
| Shock (operating) | 50 G, (11 ms duration, half sine wave) |
| Shock (non-operating) | 1500 G, (0.5 ms duration, half sine wave) |

4.5 Power consumption

Table 6: PA4 series power consumption table

| PARAMETER | VALUE | UNIT |
|---------------------------|-------|------|
| Active power (average) | <7 | W |
| Idle mode power (average) | <1.0 | W |

4.6 Reliability

Products in the Exascend PA4 series meet or exceed SSD endurance and data retention requirements as specified in the JESD218 standard. Reliability specifications are listed in the following table.

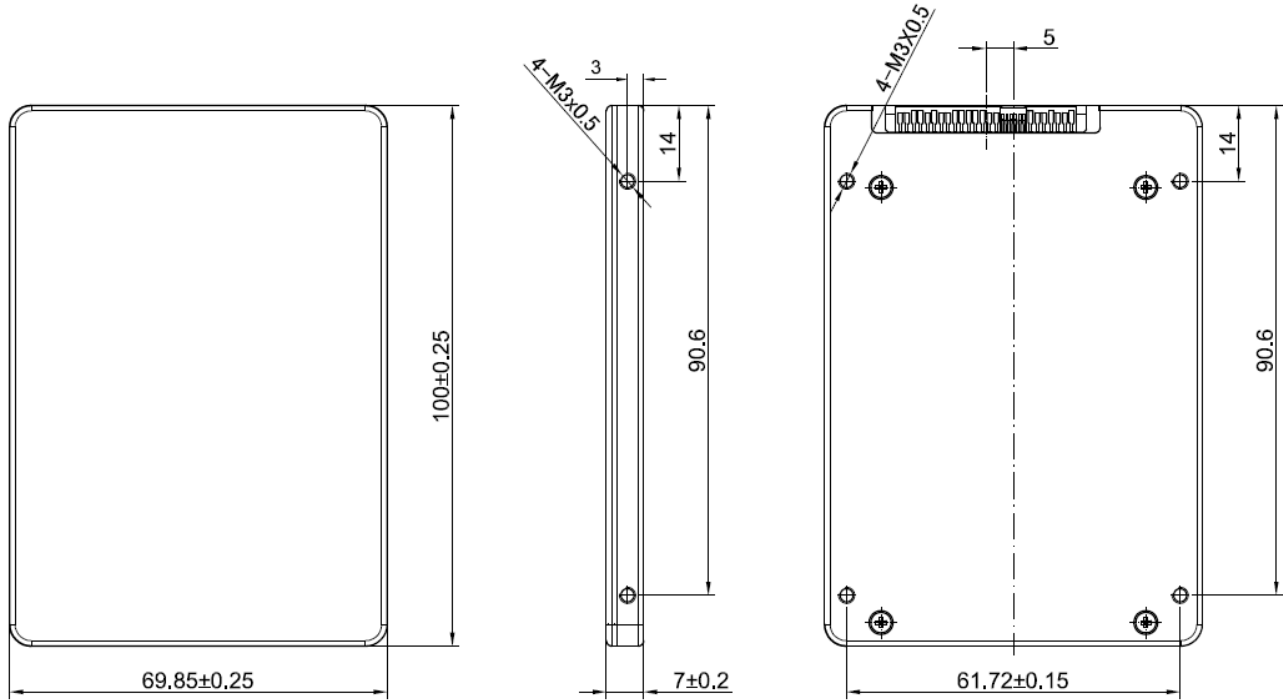
Table 7: Reliability table

| PARAMETER | VALUE |
|---|---|
| Mean Time Between Failures (MTBF) Mean Time Between Failures is a measure of how reliable a hardware product or a component is. The value describes the expected time between two failures. | 2,000,000 hours |
| Uncorrectable Bit Error Rate (UBER) A metric for the rate of occurrence of data errors, equal to the number of data errors per bits read. | <1 sector per 10 ¹⁷ |
| Endurance Rating (TBW) TBW stands for total bytes written whose access pattern is compliant with JESD218 standard. | 480GB : 300TB 960GB : 600TB 1920GB : 1200TB 3840GB : 2400TB 7680GB : 4800TB |

5. Physical dimension diagram

5.1 U.2 board

Figure 2: U.2 physical dimension diagram



GENERAL TOLERANCE IS ± 0.15 mm
DIMENSION UNIT: mm

Table 8: Physical dimensions for U.2

| PHYSICAL DIMENSIONS | VALUE | UNIT |
|---------------------|-------|------|
| Length | 100 | mm |
| Width | 69.85 | mm |
| Thickness | 7 | mm |

5.2 PCIe M.2 2280

Figure 3: M.2 2280 physical dimension diagram

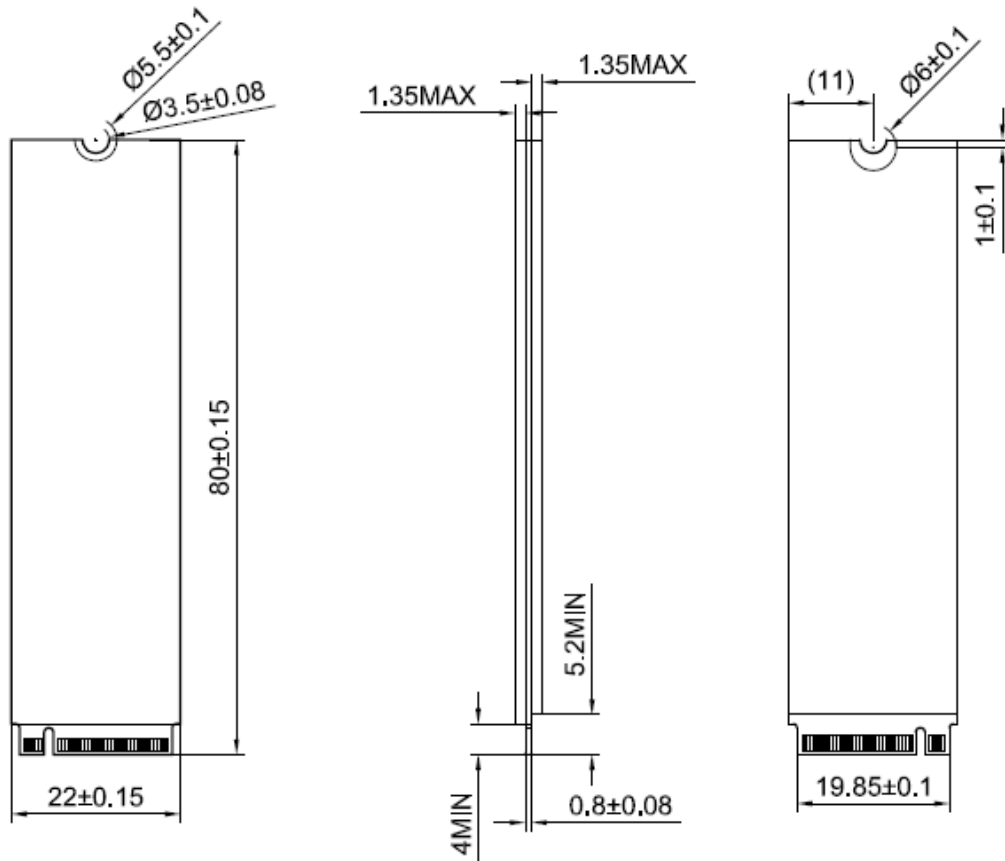


Table 9: Physical dimensions for M.2 2280

| PHYSICAL DIMENSIONS | VALUE | UNIT |
|---------------------|-------|------|
| Length | 80 | mm |
| Width | 22 | mm |
| Thickness | 3.5 | mm |

5.3 PCIe M.2 2242

Figure 4: M.2 2242 physical dimension diagram

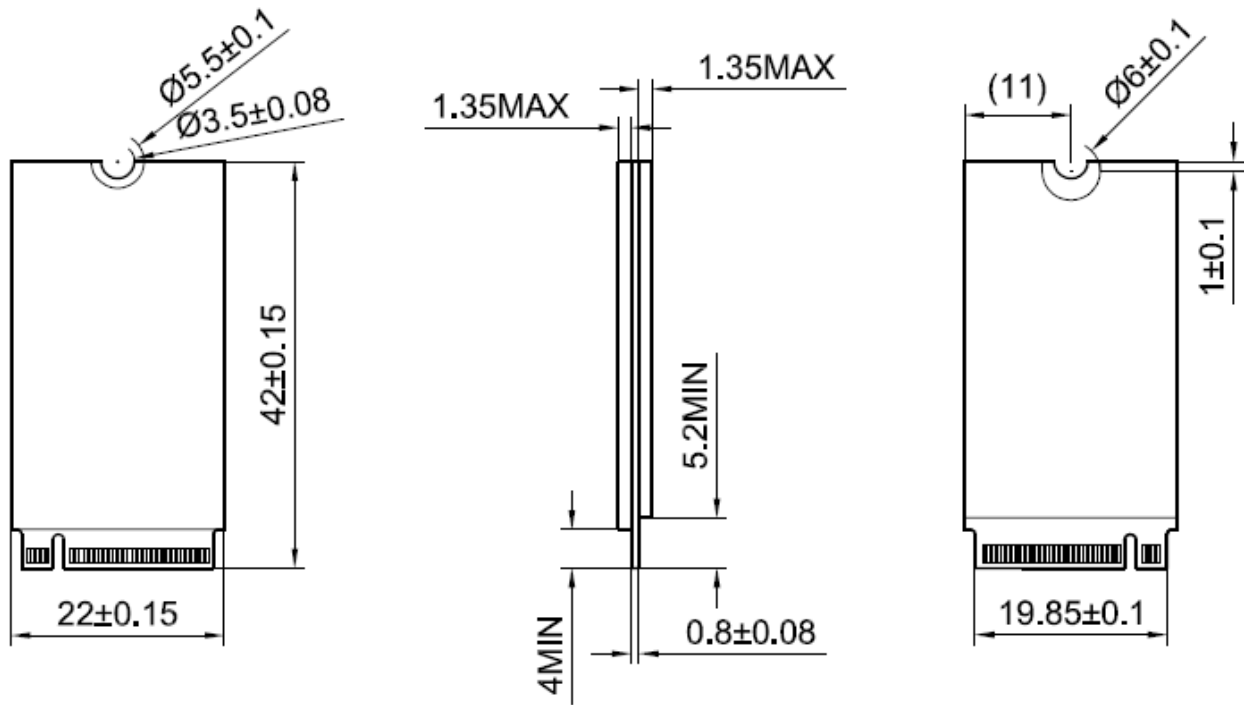


Table 10: Physical dimensions for M.2 2242

| PHYSICAL DIMENSIONS | VALUE | UNIT |
|---------------------|-------|------|
| Length | 42 | mm |
| Width | 22 | mm |
| Thickness | 3.5 | mm |

5.4 PCIe M.2 2230

Figure 5: M.2 2230 physical dimension diagram

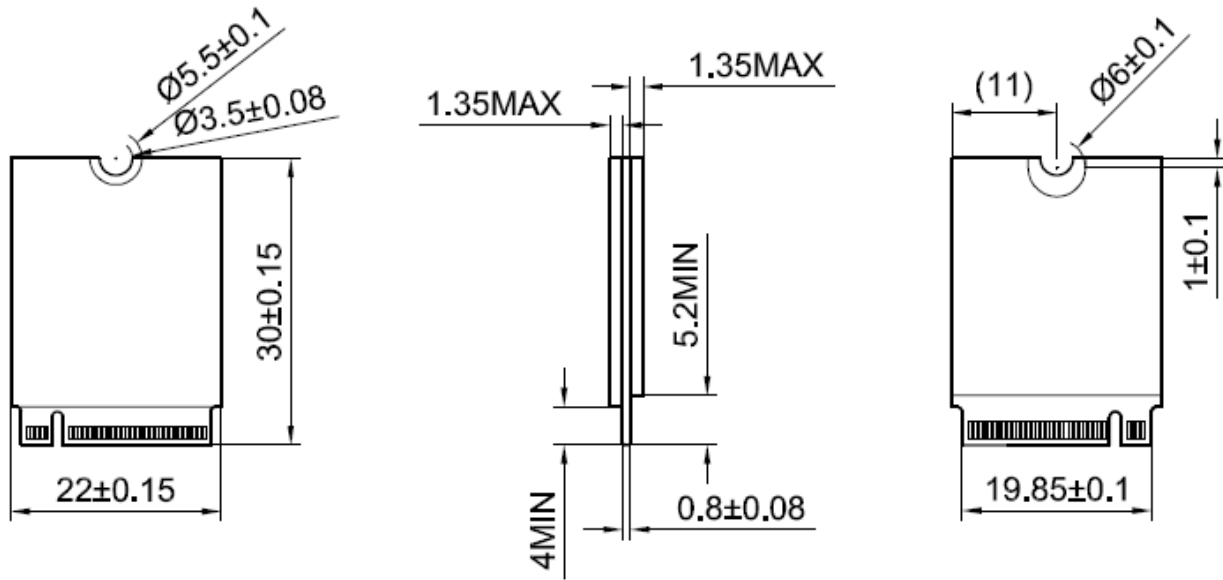


Table 11: Physical dimensions for M.2 2242

| PHYSICAL DIMENSIONS | VALUE | UNIT |
|---------------------|-------|------|
| Length | 30 | mm |
| Width | 22 | mm |
| Thickness | 3.5 | mm |

5.3 PCIe E1.S

Figure 6: E1.S physical dimension diagram

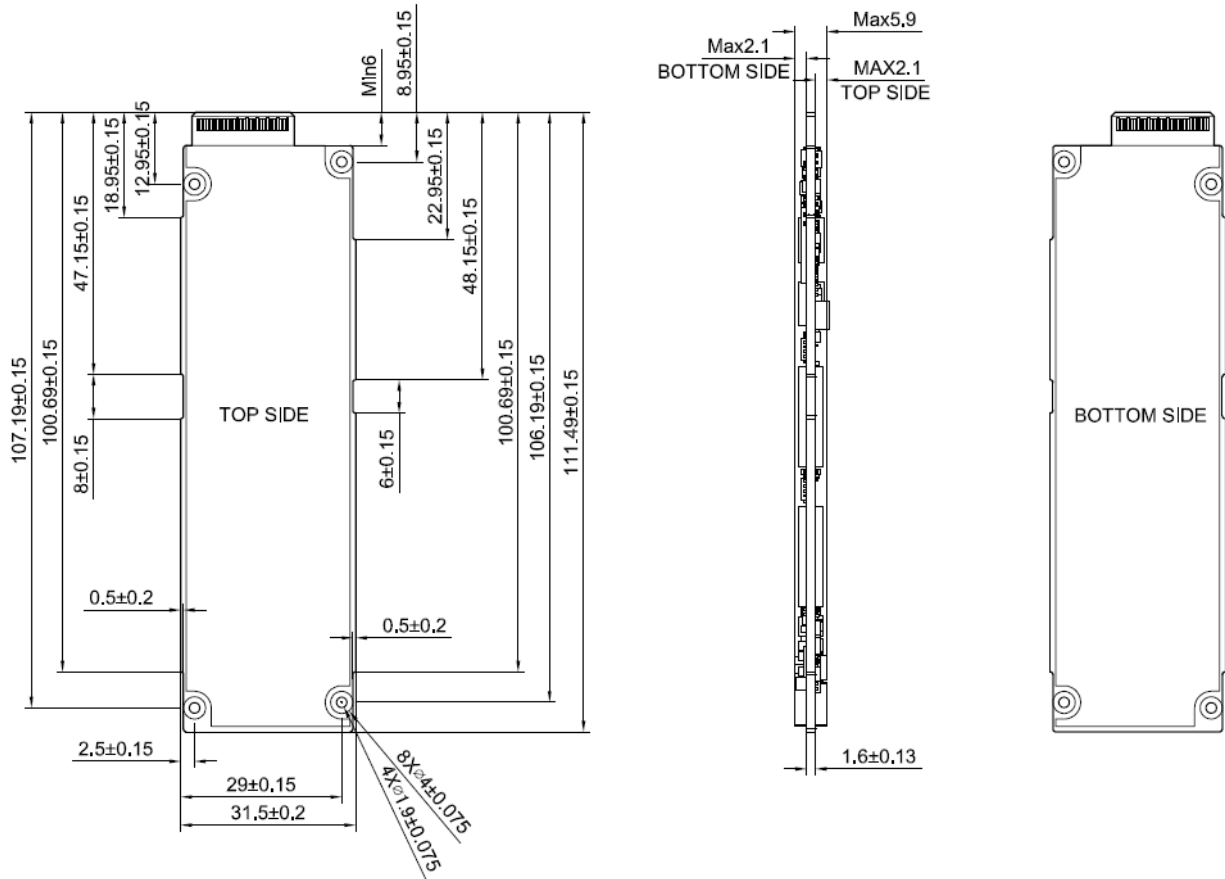


Table 12: Physical dimensions for E1.S

| PHYSICAL DIMENSIONS | VALUE | UNIT |
|---------------------|--------|------|
| Length | 111.49 | mm |
| Width | 31.5 | mm |
| Thickness | 5.9 | mm |

6. Pin Assignment

6.1 U.2 connector

Table 13: U.2 connector signal name, power pin assignment, and description

| PIN NAME | SIGNAL NAME | DESCRIPTION |
|----------|-------------|---|
| S1 | GND | Ground |
| S2 | | Not used |
| S3 | | Not used |
| S4 | GND | Ground |
| S5 | | Not used |
| S6 | | Not used |
| S7 | GND | Ground |
| E1 | | |
| E2 | | |
| E3 | 3.3Vaux | 3.3 V Power |
| E4 | | |
| E5 | PERST0# | Fundamental reset port 0 |
| E6 | Reserved | Reserved |
| P1 | | Not used (SATA/SAS) |
| P2 | | Not used (SATA/SAS) |
| P3 | CLKREQ | CLKREQ |
| P4 | IfDet_N | Interface detection (drive type) |
| P5 | GND | Ground |
| P6 | GND | Ground |
| P7 | | Not used (SATA/SAS) |
| P8 | | Not used (SATA/SAS) |
| P9 | | Not used (SATA/SAS) |
| P10 | PRSNT_N | Presence detection (also used for drive type) |
| P11 | Activity | Activity signal from the drive |
| P12 | Hot-Plug | Ground |
| P13 | +12V_pre | 12V Power |
| P14 | +12V | 12 V Power |
| P15 | +12V | 12 V Power |
| E7 | REFCLK0+ | Reference clock port 0 + |
| E8 | REFCLK0- | Reference clock port 0 - |
| E9 | GND | Ground |
| E10 | PERp0 | + Receive differential pair, channel 0 |
| E11 | PERn0 | - Receive differential pair, channel 0 |
| E12 | GND | Ground |
| E13 | PETn0 | - Transmit differential pair, channel 0 |

| | | |
|-----|--------------|---|
| E14 | PETp0 | + Transmit differential pair, channel 0 |
| E15 | GND | Ground |
| E16 | Reserved | Reserved |
| S8 | GND | Ground |
| S9 | | Not used (SATA/SAS) |
| S10 | | Not used (SATA/SAS) |
| S11 | GND | Ground |
| S12 | | Not used (SATA/SAS) |
| S13 | | Not used (SATA/SAS) |
| S14 | GND | Ground |
| S15 | Reserved | Reserved |
| S16 | GND | Ground |
| S17 | PERp1 | + Receive differential pair, channel 1 |
| S18 | PERn1 | - Receive differential pair, channel 1 |
| S19 | GND | Ground |
| S20 | PETn1 | - Transmit differential pair, channel 1 |
| S21 | PETp1 | + Transmit differential pair, channel 1 |
| S22 | GND | Ground |
| S23 | PERp2 | + Receive differential pair, channel 2 |
| S24 | PERn2 | - Receive differential pair, channel 2 |
| S25 | GND | Ground |
| S26 | PETn2 | - Transmit differential pair, channel 1 |
| S27 | PETp2 | + Transmit differential pair, channel 1 |
| S28 | GND | Ground |
| E17 | PERp3 | + Receive differential pair, channel 3 |
| E18 | PERn3 | - Receive differential pair, channel 3 |
| E19 | GND | Ground |
| E20 | PETn3 | - Transmit differential pair, channel 3 |
| E21 | PETp3 | + Transmit differential pair, channel 3 |
| E22 | GND | Ground |
| E23 | SMCLK | SMBus clock |
| E24 | SMDAT | SMBus data |
| E25 | DualPortEn N | Dual port enable |

6.2 PCIe M.2 connector

Table 14: M.2 connector signal name, power pin assignment, and description

| PIN NAME | SIGNAL NAME | DESCRIPTION |
|----------|-------------|------------------------|
| 1 | GND | Ground |
| 2 | 3.3V | 3.3V Power |
| 3 | GND | Ground |
| 4 | 3.3V | 3.3V Power |
| 5 | PCIe 3 TXn | PCIe Lane 3 TX- |
| 6 | Reserved | Reserved |
| 7 | PCIe 3 TXp | PCIe Lane 3 TX+ |
| 8 | Reserved | Reserved |
| 9 | GND | Ground |
| 10 | DAS | Device Activity Signal |
| 11 | PCIe 3 RXn | PCIe Lane 3 RX- |
| 12 | 3.3V | 3.3V Power |
| 13 | PCIe 3 RXp | PCIe Lane 3 RX+ |
| 14 | 3.3V | 3.3V Power |
| 15 | GND | Ground |
| 16 | 3.3V | 3.3V Power |
| 17 | PCIe 2 TXn | PCIe Lane 2 TX- |
| 18 | 3.3V | 3.3V Power |
| 19 | PCIe 2 TXp | PCIe Lane 2 TX+ |
| 20 | NC | No Connection |
| 21 | GND | Ground |
| 22 | UART RX | Manufacturing Use |
| 23 | PCIe 2 RXn | PCIe Lane 2 RX- |
| 24 | NC | No Connection |
| 25 | PCIe 2 RXp | PCIe Lane 2 RX+ |
| 26 | Reserved | Reserved |
| 27 | GND | Ground |
| 28 | Reserved | Reserved |
| 29 | PCIe 1 TXn | PCIe Lane 1 TX- |
| 30 | Reserved | Reserved |
| 31 | PCIe 1 TXp | PCIe Lane 1 TX+ |
| 32 | UART TX | Manufacturing Use |
| 33 | GND | Ground |
| 34 | Reserved | Reserved |
| 35 | PCIe 1 RXn | PCIe Lane 1 RX- |
| 36 | Reserved | Reserved |
| 37 | PCIe 1 RXp | PCIe Lane 1 RX+ |

| | | |
|----|-----------------|---------------------|
| 38 | Reserved | Reserved |
| 39 | GND | Ground |
| 40 | SCL | SMBus_SCL |
| 41 | PCIe 0 TXn | PCIe Lane 0 TX- |
| 42 | SDA | SMBus_SDA |
| 43 | PCIe 0 TXp | PCIe Lane 0 TX+ |
| 44 | NC | No Connection |
| 45 | GND | Ground |
| 46 | NC | No Connection |
| 47 | PCIe 0 RXn | PCIe Lane 0 RX- |
| 48 | NC | No Connection |
| 49 | PCIe 0 RXp | PCIe Lane 0 RX+ |
| 50 | PERST | PCIe Reset |
| 51 | GND | Ground |
| 52 | CLKREQ | PCIe Clock Request |
| 53 | Ref CLKN | PCIe Reference clk- |
| 54 | NC | No Connection |
| 55 | Ref CLKP | PCIe Reference clk+ |
| 56 | NC | No Connection |
| 57 | GND | Ground |
| 58 | NC | No Connection |
| 59 | PCIe Module Key | |
| 60 | PCIe Module Key | |
| 61 | PCIe Module Key | |
| 62 | PCIe Module Key | |
| 63 | PCIe Module Key | |
| 64 | PCIe Module Key | |
| 65 | PCIe Module Key | |
| 66 | PCIe Module Key | |
| 67 | NC | No Connection |
| 68 | NC | No Connection |
| 69 | NC | No Connection |
| 70 | 3.3V | 3.3V Power |
| 71 | GND | Ground |
| 72 | 3.3V | 3.3V Power |
| 73 | GND | Ground |
| 74 | 3.3V | 3.3V Power |
| 75 | GND | Ground |

6.3 E1.S connector

Table 15: E1.S connector signal name, power pin assignment, and description

| PIN NAME | 1st mate | SIGNAL NAME |
|----------|----------|-----------------|
| A1 | 1st mate | GND |
| A2 | 1st mate | GND |
| A3 | 1st mate | GND |
| A4 | 1st mate | GND |
| A5 | 1st mate | GND |
| A6 | 2nd mate | GND |
| A7 | 2nd mate | SMBCLK |
| A8 | 2nd mate | SMBDAT |
| A9 | 2nd mate | SMBRST# |
| A10 | 2nd mate | LED#/ACTIVITY |
| A11 | 2nd mate | PERST1#/CLKREQ# |
| A12 | 1st mate | PRSNT0# |
| A13 | 2nd mate | GND |
| A14 | 2nd mate | REFCLKn1 |
| A15 | 1st mate | REFCLKp1 |
| A16 | 2nd mate | GND |
| A17 | 2nd mate | PERn0 |
| A18 | 1st mate | PERp0 |
| A19 | 2nd mate | GND |
| A20 | 2nd mate | PERn1 |
| A21 | 1st mate | PERp1 |
| A22 | 2nd mate | GND |
| A23 | 2nd mate | PERn2 |
| A24 | 1st mate | PERp2 |
| A25 | 2nd mate | GND |
| A26 | 2nd mate | PERn3 |
| A27 | 1st mate | PERp3 |
| A28 | 1st mate | GND |
| B1 | 2nd mate | 12V |
| B2 | 2nd mate | 12V |
| B3 | 2nd mate | 12V |
| B4 | 2nd mate | 12V |
| B5 | 2nd mate | 12V |
| B6 | 2nd mate | 12V |
| B7 | 2nd mate | MFG |
| B8 | 2nd mate | RFU |

| B9 | 2nd mate | DUALPORTEN# |
|-----|----------|-------------|
| B10 | 2nd mate | PERST0# |
| B11 | 2nd mate | 3.3 VAux |
| B12 | 2nd mate | PWRDIS |
| B13 | 1st mate | GND |
| B14 | 2nd mate | REFCLKn0 |
| B15 | 2nd mate | REFCLKp0 |
| B16 | 1st mate | GND |
| B17 | 2nd mate | PETn0 |
| B18 | 2nd mate | PETp1 |
| B19 | 1st mate | GND |
| B20 | 2nd mate | PETn1 |
| B21 | 2nd mate | PETp1 |
| B22 | 1st mate | GND |
| B23 | 2nd mate | PETn2 |
| B24 | 2nd mate | PETp2 |
| B25 | 1st mate | GND |
| B26 | 2nd mate | PETn3 |
| B27 | 2nd mate | PETp3 |
| B28 | 1st mate | GND |

7. Compliance

Exascend PA4 series SSD complies with the following specifications:

- FCC
- CE
- RoHS

8. Supported NVMe commands

Exascend PA4 series SSDs support the NVMe commands that are shown in the following table. For details about the NVMe commands, please refer to the NVMe 1.4 command set specifications.

Table 16: Admin commands

| COMMAND NAME | CODE (HEX) | COMMAND NAME | CODE (HEX) |
|-----------------------------|------------|----------------------------|------------|
| Delete I/O submission queue | 00h | Abort | 08h |
| Create I/O completion queue | 01h | Set features | 09h |
| Get log page | 02h | Get features | 0Ah |
| Delete I/O submission queue | 04h | Asynchronous event request | 0Ch |
| Create I/O completion queue | 05h | Firmware commit | 10h |
| Identify | 06h | Firmware image download | 11h |

Table 17: I/O commands

| COMMAND NAME | CODE (HEX) | COMMAND NAME | CODE (HEX) |
|---------------------------|------------|--------------------|------------|
| Flush | 00h | Compare | 05h |
| Write | 01h | Dataset management | 09h |
| Read | 02h | Write zeroes | 08h |
| Write uncorrectable error | 04h | | |

Table 18: Get log commands

| COMMAND NAME | CODE (HEX) | COMMAND NAME | CODE (HEX) |
|-------------------|------------|---------------------------------|------------|
| Reserved | 00h | S.M.A.R.T. / health information | 02h |
| Error information | 01h | Firmware information | 03h |

9. S.M.A.R.T. support

9.1 Overview of S.M.A.R.T. support

Data storage drives capture a variety of information during operation that may be used to analyze drive “health.” Drive manufacturers have adopted S.M.A.R.T. (Self-Monitoring, Analysis, and Reporting Technology) to help warn system software, a system administrator, or a user of impending drive failure, when time still remains to take preventive action. The S.M.A.R.T. standard defines the protocols for reporting errors and for invoking self-tests to collect and analyze data on demand. The specification is flexible and provides for individual manufacturers to define their own unique vendor-specific information. This section describes the baseline S.M.A.R.T. commands and attributes supported by products in the Exascend PA4 series. Further, it is recommended to consult the list of public S.M.A.R.T. attributes.

9.2 S.M.A.R.T. health information

Table 19: S.M.A.R.T. health information

| BYTE | DESCRIPTION |
|--------|---|
| 00 | Critical warning: This field indicates critical warnings for the state of the controller. Each bit corresponds to a critical warning type; multiple bits may be set. If a bit is cleared to ‘0’, then that critical warning does not apply. Critical warnings may result in an asynchronous event notification to the host. Bits in this field represent the current associated state and are not persistent. |
| 2:1 | Composite temperature: Contains a value corresponding to a temperature in degrees Kelvin that represents the current composite temperature of the controller and namespace(s) associated with that controller. The manner this value is computed is implementation-specific and may not represent the actual temperature of any physical point in the NVM subsystem. The value of this field may be used to trigger an asynchronous event. Warning and critical overheating composite temperature threshold values are reported by the WCTEMP and CCTEMP fields in the Identify Controller data structure. |
| 3 | Available spare: Contains a normalized percentage (0 to 100%) of the remaining spare capacity available. |
| 4 | Available spare threshold: When the <i>available spare</i> falls below the threshold indicated in this field, an asynchronous event completion may occur. The value is indicated as a normalized percentage (0 to 100%). |
| 5 | Percentage used: Contains a vendor-specific estimate of the percentage of NVM subsystem life used based on the actual usage and the manufacturer’s prediction of NVM life. A value of 100 indicates that the estimated endurance of the NVM in the NVM subsystem has been consumed but may not indicate an NVM subsystem failure. The value allowed to exceed 100. Percentages greater than 254 shall be represented as 255. This value shall be updated once per power-on hour (when the controller is not in a sleep state). |
| 47:32 | Sectors read: Contains the number of 512-byte user data units read from the controller; This value is reported in thousands (i.e., a value of 1 corresponds to 1000 units of 512 bytes read) and is rounded up. When the LBA size is a value other than 512 bytes, the controller shall convert the amount of data read to 512-byte units. |
| 63:48 | Sectors written: Contains the number of 512-byte user data units written to the controller. This value is reported in thousands (i.e., a value of 1 corresponds to 1000 units of 512 bytes written) and is rounded up. When the LBA size is a value other than 512 bytes, the controller shall convert the amount of data written to 512-byte units. For the NVM* command set, logical blocks written as part of write operations shall be included in this value. |
| 79:64 | Host read commands: Indicates the number of read commands completed by the controller. For the NVM command set, this is the number of <i>compare</i> and <i>read</i> commands |
| 95:80 | Host write commands: Indicates the number of write commands completed by the controller. For the NVM command set, this is the number of <i>write</i> commands. |
| 111:96 | Controller busy time: Contains the amount of time the controller is busy with I/O commands. The controller is busy when there is a command outstanding to an I/O queue (specifically, a command was issued via an I/O submission queue tail doorbell write and the corresponding completion queue entry has not been posted yet to the associated I/O completion queue). This value is reported in minutes. |

| | |
|---------|--|
| 127:112 | Power cycles: Contains the number of power cycles. |
| 143:128 | Power-on hours: Indicates the number of actively power-on hours. This does not include time the controller was powered and in a lower state condition. |
| 159:144 | Number of unsafe shutdowns: Indicates the number of unsafe shutdowns. This count is incremented when a shutdown notification (CC.SHN) is not received prior to loss of power |
| 175:160 | Number of media errors: Indicates the number of occurrences where the controller detected an unrecovered data integrity error. Errors such as uncorrectable ECC, CRC checksum failure, or LBA tag mismatch are included in this field. |
| 195:192 | Warning composite temperature time: Indicates the amount of time in minutes that the controller is operational and the Composite Temperature is greater than or equal to the Warning Composite Temperature Threshold (WCTEMP) field and less than the Critical Composite Temperature Threshold (CCTEMP) field in the Identify Controller data structure. If the value of the WCTEMP or CCTEMP field is 0h, then this field is always cleared to 0h regardless of the Composite Temperature value. |
| 199:196 | Critical composite temperature time: Contains the amount of time in minutes that the controller is operational, and the Composite Temperature is greater the Critical Composite Temperature Threshold (CCTEMP) field in the Identify Controller data structure. If the value of the CCTEMP field is 0h, then this field is always cleared to 0h regardless of the Composite Temperature value. |
| 201:200 | Temperature sensor 1: Contains the current temperature reported by temperature sensor 1 in degrees Kelvin. |

Legal information

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Exascend, Inc. ("Exascend") warrants that Exascend's product, in its original sealed packaging, will be free from defects in materials and workmanship. Subject to the conditions and limitations set forth below, Exascend will either repair or replace any part of its products that prove defective by reason of improper workmanship or materials. This warranty is non-transferable and valid only for the original purchaser of the Exascend products, except where prohibited by law. The original sales receipt or invoice, or a copy thereof, is required to establish the purchase date and original purchaser.

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We offer three (3) years limited warranty for our automotive products.

The warranty period is the SHORTER OF:

- a period of three (3) years beginning from the date of purchase; or
- the period ending when the drive reached advertised DWPD or TBW rating; or
- the period ending when the device's Lifespan indicator has reached 0% or below.

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- Control devices for trains, ships, mass transportation systems or automotive vehicles, etc.

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