

# 1100 2.5-Inch and M.2 SATA NAND Flash SSD

**MTFDDAK256TBN, MTFDDAK512TBN, MTFDDAK1T0TBN,  
MTFDDAK2T0TBN, MTFDDAV256TBN, MTFDDAV512TBN,  
MTFDDAV1T0TBN**

## Features

- Micron® 3D TLC NAND Flash
- RoHS-compliant package
- SATA 6 Gb/s interface
- TCG/Opal 2.0-compliant self-encrypting drive (SED)
- Compatible with Microsoft eDrive®
- Hardware-based AES-256 encryption engine
- ATA modes supported
  - PIO mode 3, 4
  - Multiword DMA mode 0, 1, 2
  - Ultra DMA mode 0, 1, 2, 3, 4, 5, 6
- Industry-standard, 512-byte sector size support
- Hot-plug/hot-remove capable (2.5")
- Device sleep (DEVSLP), extreme low-power mode
- Native command queuing support with 32-command slot support
- ATA-8 ACS3 command set compliant
- ATA security feature command set and password login support
- Secure erase (data page) command set: fast and secure erase
- Sanitize device feature set support
- Self-monitoring, analysis, and reporting technology (SMART) command set
- Dynamic write acceleration
- Adaptive thermal monitoring
- Power loss protection for data-at-rest
- Performance<sup>1, 2</sup>
  - PCMark® Vantage (HDD test suite score): Up to 84,000
  - Sequential 128KB READ: Up to 530 MB/s
  - Sequential 128KB WRITE: Up to 500 MB/s
  - Random 4KB READ: Up to 55,000 IOPS
  - Random 4KB WRITE: Up to 83,000 IOPS
  - READ/WRITE latency: 85µs/40µs (TYP)
- Reliability
  - MTTF: 1.5 million device hours<sup>3</sup>
  - Static and dynamic wear leveling
  - Uncorrectable bit error rate (UBER): <1 sector per 10<sup>15</sup> bits read
- Low power consumption
  - Device Sleep numbers: <4mW
  - DIPM numbers: 110mW TYP<sup>4</sup>
- Endurance: Total bytes written (TBW)
  - 120TB
- Capacity (unformatted): 128GB
- 2.5-inch × 7mm form factor
- Secure firmware update with digitally signed firmware image
- Operating temperature
  - Commercial (0°C to +70°C)<sup>5</sup>

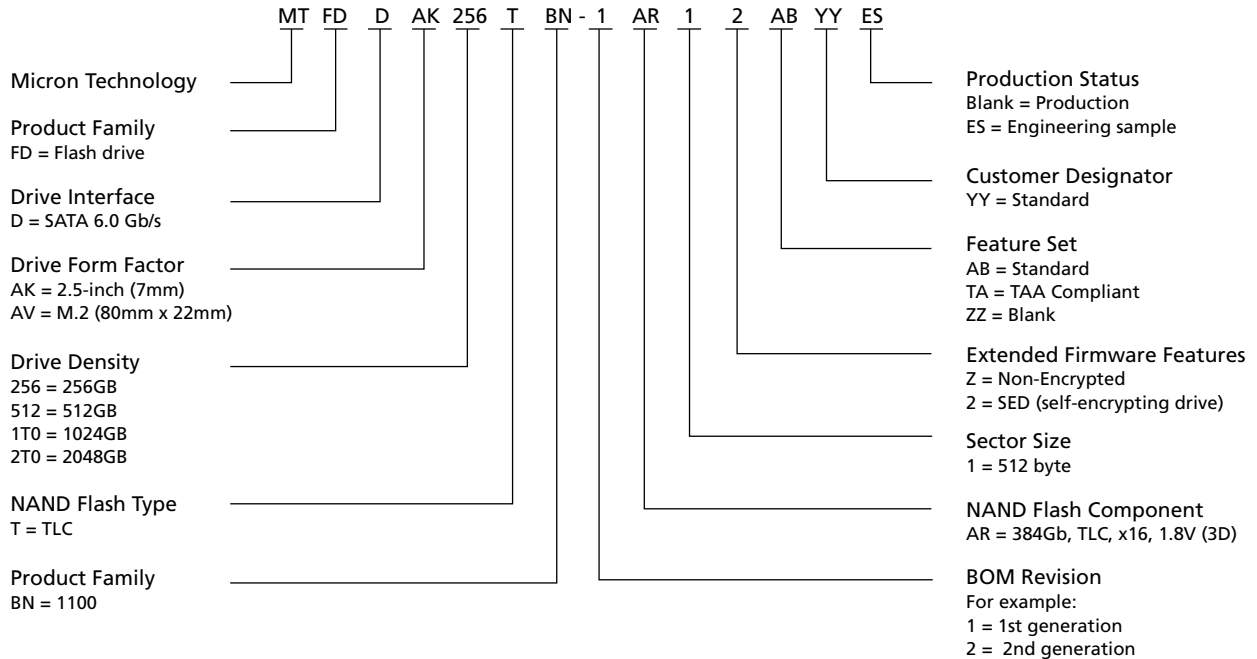
- Notes:
1. Typical I/O performance numbers as measured fresh-out-of-the-box (FOB) using lometer with a queue depth of 32 and write cache enabled.
  2. 4 KB transfers used for READ/WRITE latency values.
  3. The product achieves a mean time to failure (MTTF) based on population statistics not relevant to individual units.
  4. Active average power measured during execution of MobileMark® with DIPM (device-initiated power management) enabled.
  5. Temperature measured by SMART attribute 194.

**Warranty:** Contact your Micron sales representative for further information regarding the product, including product warranties.

## Part Numbering Information

Micron’s 1100 SSD is available in different configurations and densities. The chart below is a comprehensive list of options for the 1100 series devices; not all options listed can be combined to define an offered product. Visit [www.micron.com](http://www.micron.com) for a list of valid part numbers.

**Figure 1: Part Number Chart**



## General Description

Micron’s solid state drive (SSD) uses a single-chip controller with a SATA interface on the system side and up to four channels of Micron NAND Flash internally. Available in both M.2 and 2.5-inch form factors, the SSD integrates easily in existing storage infrastructures.

The SSD is designed to use the SATA interface efficiently during both READs and WRITEs while delivering bandwidth-focused performance. SSD technology enables enhanced boot times, faster application load times, reduced power consumption and extended reliability.

The self-encrypting drive (SED) features a FIPS-compliant, AES-256 encryption engine, providing hardware-based, secure data encryption, with no loss of SSD performance. This SED follows the TCG/Opal specification for trusted peripherals.

When TCG/Opal features are not enabled, the device can perform alternate data encryption by invoking the ATA security command set encryption features, to provide full-disk encryption (FDE) managed in the host system BIOS. TCG/Opal and ATA security feature sets cannot be enabled simultaneously.

The data encryption is always running; however, encryption keys are not managed and the data is not secure until either TCG/Opal or ATA security feature sets are enabled.

**Figure 2: Functional Block Diagram**



## Performance

Measured performance can vary for a number of reasons. The major factors affecting drive performance are the capacity of the drive and the interface of the host. Additionally, overall system performance can affect the measured drive performance. When comparing drives, it is recommended that all system variables are the same, and only the drive being tested varies.

Performance numbers will vary depending on the host system configuration.

For SSDs designed for the client computing market, Micron specifies performance in fresh-out-of-box (FOB) state. Data throughput measured in steady state may be lower than FOB state, depending on the nature of the data workload.

For a description of these performance states and of Micron's best practices for performance measurement, refer to Micron's technical marketing brief, Best Practices for SSD Performance Measurement.

**Table 1: Drive Performance**

| Capacity                          | 256GB  | 512GB  | 1024GB | 2048GB | Unit      |
|-----------------------------------|--------|--------|--------|--------|-----------|
| Interface Speed                   | 6 Gb/s |        |        |        |           |
| PCMark vantage                    | 84,000 | 84,000 | 84,000 | 84,000 | HDD score |
| Sequential read (128KB transfer)  | 530    | 530    | 530    | 530    | MB/s      |
| Sequential write (128KB transfer) | 500    | 500    | 500    | 500    | MB/s      |
| Random read (4KB transfer)        | 55,000 | 92,000 | 92,000 | 92,000 | IOPS      |
| Random write (4KB transfer)       | 83,000 | 83,000 | 83,000 | 83,000 | IOPS      |
| READ latency (TYP)                | 85     | 85     | 85     | 85     | µs        |
| WRITE latency (TYP)               | 40     | 40     | 40     | 40     | µs        |

- Notes:
1. Performance numbers are maximum values, except as noted.
  2. Typical I/O performance numbers as measured using Iometer with a queue depth of 32 and write cache enabled. Fresh-out-of-box (FOB) state is assumed. For performance measurement purposes, the SSD may be restored to FOB state using the SECURE ERASE command.
  3. Iometer measurements are performed on an 20GB span of logical block addresses (LBAs).
  4. 4KB transfers with a queue depth of 1 are used to measure READ/WRITE latency values with write cache enabled.
  5. System variations will affect measured results. For comparison, PCMark scores are measured with the SSD as a secondary drive in a two-drive system. When measured as an OS drive, system overhead can cause lower scores.



## Logical Block Address Configuration

The drive is set to report the number of logical block addresses (LBA) that will ensure sufficient storage space for the specified capacity. Standard LBA settings, based on the IDEMA standard (LBA1-03), are shown below.

**Table 2: Standard LBA Settings**

| Capacity | Total LBA     |             | Max LBA       |             | User Available Bytes |
|----------|---------------|-------------|---------------|-------------|----------------------|
|          | Decimal       | Hexadecimal | Decimal       | Hexadecimal | (Unformatted)        |
| 256GB    | 500,118,192   | 1DCF32B0    | 500,118,191   | 1DCF32AF    | 256,060,514,304      |
| 512GB    | 1,000,215,216 | 3B9E12B0    | 1,000,215,215 | 3B9E12AF    | 512,110,190,592      |
| 1024GB   | 2,000,409,264 | 773BD2B0    | 2,000,409,263 | 773BD2AF    | 1,024,209,543,168    |
| 2048GB   | 4,000,797,360 | EE7752B0    | 4,000,797,359 | EE7752AF    | 2,048,408,248,320    |

## Reliability

Micron’s SSDs incorporate advanced technology for defect and error management. They use various combinations of hardware-based error correction algorithms and firmware-based static and dynamic wear-leveling algorithms.

Over the life of the SSD, uncorrectable errors may occur. An uncorrectable error is defined as data that is reported as successfully programmed to the SSD but when it is read out of the SSD, the data differs from what was programmed.

**Table 3: Uncorrectable Bit Error Rate**

| Uncorrectable Bit Error Rate             | Operation |
|--|-----------|
| <1 sector per 10 <sup>15</sup> bits read | READ      |

## Mean Time To Failure

Mean time to failure (MTTF) for the SSD can be predicted based on the component reliability data using the methods referenced in the Telcordia SR-332 reliability prediction procedures for electronic equipment.

**Table 4: MTTF**

| Capacity | MTTF (Operating Hours) <sup>1</sup> |
|----------|-------------------------------------|
| 256GB    | 1.5 million                         |
| 512GB    |                                     |
| 1024GB   |                                     |
| 2048GB   |                                     |

Note: 1. The product achieves a mean time to failure (MTTF) of 1.5 million hours, based on population statistics not relevant to individual units.

## Endurance

Endurance for the SSD can be predicted based on the usage conditions applied to the device, the internal NAND component cycles, the write amplification factor, and the wear-leveling efficiency of the drive. The table below shows the drive lifetime for each SSD capacity by client computing and sequential input and based on predefined usage conditions.

**Table 5: Drive Lifetime – Client Computing**

| Capacity | Drive Lifetime (Total Bytes Written) |
|----------|--------------------------------------|
| 256GB    | 120TB                                |
| 512GB    | 240TB                                |
| 1024GB   | 400TB                                |
| 2048GB   |                                      |

- Notes:
1. Total bytes written validated with the drive 90% full.
  2. SSD volatile write cache is enabled.
  3. Access patterns used during reliability testing are 25% sequential and 75% random and consist of the following: 1% are 512B; 44% are 4 KiB; 35% are 64 KiB; and 20% are 128 KiB.
  4. Host workload parameters, including write cache settings, I/O alignment, transfer sizes, randomness, and percent full, that are substantially different than the described notes may result in varied endurance results.
  5. GB/day can be calculated by dividing the total bytes written value by the number of days in the interval of interest (365 days × number of years). For example: 100 TB/3 years/365 days = 91 GB/day for 3 years.

## Electrical Characteristics

Environmental conditions beyond those listed may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

**Table 6: SATA Power Consumption**

| Capacity | Device Sleep Typical | Idle Average | Active Average | Active Maximum (128KB transfer) | Unit |
|----------|----------------------|--------------|----------------|---------------------------------|------|
| 256GB    | 2                    | 55           | 70             | 3000                            | mW   |
| 512GB    |                      |              |                | 4000                            |      |
| 1024GB   | 4                    | 65           | 75             | 5000                            | mW   |
| 2048GB   | 25                   | 110          | 150            | 6000                            |      |

- Notes:
1. Data taken at 25°C using a 6 Gb/s SATA interface.
  2. Active average power measured while running MobileMark productivity suite.
  3. Device-initiated power management (DIPM) enabled. DIPM slumber and DEVSLP enabled.
  4. Active maximum power is an average power measurement performed using Iometer with 128KB sequential write transfers.

**Table 7: Maximum Ratings**

| Parameter/Condition                | Symbol         | Min  | Max  | Unit    | Notes |
|------------------------------------|----------------|------|------|---------|-------|
| Voltage input, 2.5-inch            | V5             | 4.5  | 5.5  | V       | –     |
| Voltage input, M.2                 | 3V3            | 3.14 | 3.46 | V       | –     |
| Operating temperature              | T <sub>C</sub> | 0    | 70   | °C      | 1     |
| Non-operating temperature          | –              | –40  | 85   | °C      | –     |
| Rate of temperature change         | –              | –    | 20   | °C/hour | –     |
| Relative humidity (non-condensing) | –              | 5    | 95   | %       | –     |

- Note:
1. Operating temperature is best measured by reading the SSD's on-board temperature sensor, which is recorded in SMART attribute 194 (0xC2).

**Table 8: Shock and Vibration**

| Parameter/Condition     | Specification   |
|-------------------------|-----------------|
| Non-operating shock     | 1500G/0.5ms     |
| Non-operating vibration | 5–800Hz @ 3.10G |



## Dynamic Write Acceleration

Dynamic write acceleration optimizes SSD performance for typical client-computing environments, where WRITE operations tend to occur in bursts of commands with idle time between these bursts.

Capacity for accelerated performance is derived from the adaptive usage of the SSD's native NAND array, without sacrificing user-addressable storage. Recent advances in Micron NAND technology enable the SSD firmware to achieve acceleration through on-the-fly mode switching between SLC and TLC modes to create a high-speed SLC pool that changes in size and location with usage conditions.

During periods of idle time between write bursts, the drive may free additional capacity for accelerated write performance. The amount of accelerated capacity recovered during idle time depends on the portion of logical addresses that contain user data and other runtime parameters. In applications that do not provide sufficient idle time, the device may need to perform SLC-to-TLC data migration during host activity.

Under accelerated operation, write performance may be significantly higher than non-accelerated operations. Power consumption per-byte written is lower during accelerated operation, which may reduce overall power consumption and heat production.

## Adaptive Thermal Monitoring

The device features adaptive thermal monitoring. While most host computers exhibit operating environments that keep an SSD running in the range of 40°C to 45°C, adaptive thermal monitoring enables the SSD to operate in a wide variety of environments by helping to prevent the host computer from running at excessive temperatures.

Adaptive thermal monitoring reduces total SSD power consumption by the device controller, as well as the NAND media, by injecting time-based delays between internal processing of media commands when the device temperature reaches 75°C. The delay times used are bound to the microsecond range and are based on a proportional and differential control equation of the general form shown here:

$$u(t) = K_p \times T_p(t) + K_d \times \frac{dT_d}{dt}$$

The delay-control equation is tuned for a steady-state temperature target, which has been designed as an optimum balance of hardware temperature tolerances and drive performance. Steady-state temperature targets are hardware-configuration dependent and may range around 80°C. Temperatures below the intended steady-state target will not produce a proportional component delay, but may produce a differential component based on the current rate of temperature change according to the control equation. When the feature is active, DRAM refresh rates are also adjusted to improve data integrity and stability while operating outside of temperature specifications.

When the device temperature falls below 73°C, normal operation will continue without induced delays. If the temperature continues to rise above the temperature target and exceeds a hardware-dependent critical threshold, the device will abort host commands to prevent component damage. The critical threshold values have a 5°C margin on top of the target threshold of 85°C.

Device temperature values used by the adaptive thermal monitoring feature are based on an internal temperature sensor located on the device PCB and may differ from case or package temperatures as measured by a thermocouple. Device temperature is accessible through SMART attribute 194, though usage of the SMART feature is not necessary for adaptive thermal monitoring functionality.

Adaptive thermal monitoring does not change the current negotiated speed of the SATA bus, nor require or cause any new commands to be issued on the SATA bus. Rated throughput performance is not guaranteed at any point above the maximum specified operating temperature.

## TCG/Opal Support

**Table 9: TCG/Opal Support Parameters**

| Property   | Supported?                  | Comments   |
|--|-----------------------------|--|
| <b>TCG Storage Specifications</b>                    |                             |  |
| OPAL: TCG Storage Security SubSystem Class           | Specification 2.00          | Revision 1.00, Feb 24, 2012  |
| TCG Core Specification                               | Specification 2.00          | Revision 2.00, Nov 4, 2011   |
| TCG Storage Interface Interactions Specification     | TCG Reference Specification | Specification Version 1.02 Revision 1.00 30 December, 2011   |
| OPAL SSC 1.00 (backward compatibility)               | Not supported               | –  |
| <b>OPAL SSC Additional Feature Set Specification</b> |                             |  |
| Additional DataStore Table                           | Supported                   | Specification 1.00 Revision 1.00, Feb 24, 2012   |
| Single User Mode                                     | Supported                   | Specification 1.00 Revision 1.00, Feb 24, 2012   |
| TCG Storage Protection Mechanisms for Secrets        | Supported                   | Specification Version 1.00 Revision 1.07 17 August, 2011   |
| PSID – Physical Presence SID                         | Supported                   | Specification Version 1.00 Committee Draft Revision 1.05 February 9, 2011  |
| GUDID (Globally Unique Serial Number)                | Supported                   | Mandatory GUDID Proposal 11/03/2011 (Microsoft)  |
| SID Authority Disable                                | Supported                   | SID Authority Disable Proposal 9/26/2011 (Microsoft)   |
| Modifiable CommonName Columns                        | Supported                   | Modifiable CommonName Columns Proposal 7/22/2010 (Microsoft)   |
| <b>OPAL SSC Feature Set – Specific List</b>          |                             |  |
| ALL OPAL Mandatory Features                          | Supported                   | –  |
| Close Session (optional)                             | Supported                   | Allows TPer to notify the host it has aborted a session  |
| Restricted Command & Table (optional)                | Not Supported               | The interface control template enables TPer control over selected interface commands; the benefit is the reduction of undesired side effects |
| Type Table (not required)                            | Not Supported               | –  |
| Activate Method                                      | Supported                   | –  |
| Revert Method  | Supported                   | –  |
| Revert SP Method                                     | Supported                   | –  |
| Activate Method Within Transactions                  | Not Supported               | As per OPAL, this behavior is out of the scope   |
| Revert Method within Transactions                    | Not Supported               | As per OPAL, this behavior is out of the scope   |
| Revert SP Method within Transactions                 | Not Supported               | As per OPAL, this behavior is out of the scope   |
| Creation/Deletion of Tables/Rows after Manufacturing | Not Supported               | As per OPAL, this behavior is out of the scope   |
| <b>TPer Feature</b>                                  |                             |  |
| COM ID Management Support                            | Not Supported               | Dynamic COM ID allocation & management not supported   |
| Buffer Management Support                            | Not Supported               | Flow control   |



**Table 9: TCG/Opal Support Parameters (Continued)**

| Property   | Supported?    | Comments  |
|--|---------------|---|
| ACK/NACK Support                                 | Not Supported | Session reliability   |
| Async Support                                    | Not Supported | Asynchronous protocol support with multiple commands per session  |
| <b>Geometry Reporting Feature</b>                |               |   |
| ALIGN  | Supported     | Alignment is not required   |
| Logical Block Size                               | 512 bytes     | Logical block size = 512 bytes  |
| Alignment Granularity                            | 512 bytes     | Logical block size = 512 bytes  |
| Lowest Aligned LBA                               | 0             | –   |
| <b>OPAL SSC V2.00 Feature Descriptor</b>         |               |   |
| Base COM ID                                      | 0x1000        | 0x1000-0xFFFF defined for COM ID management   |
| Number of COM IDs                                | 1             | –   |
| Range Crossing Behavior                          | 0             | If drive receives a READ or WRITE command that spans multiple LBA ranges and the LBA ranges are not locked, then:<br>1. Process the data transfer, if Range Crossing = 0<br>2. Terminate the command with “Other Invalid Command Parameter” if Range Crossing = 1   |
| Number of Locking SP Admin Authorities Supported | 4             | As per OPAL 2.0, drive should support at least 4 admin  |
| Number of Locking SP User Authorities Supported  | 16            | As per OPAL 2.0, drive should support at least 8 users  |
| Initial C_PIN_SID PIN Indicator                  | 0x00          | 0x00 = The initial C_PIN_SID PIN value is equal to the C_PIN_MSID PIN value<br>0xFF = The initial C_PIN_SID PIN value is VU, and MAY not be equal to the C_PIN_MSID PIN value<br>OPAL 2.0 (only)<br>Customer-specific SID – Configurable  |
| Behavior of C_PIN_SID PIN upon Ter Revert        | 0x00          | 0x00 = The C_PIN_SID PIN value becomes the value of the C_PIN_MSID PIN column after successful invocation of revert on the admin SP’s object in the SP table<br>0xFF = The C_PIN_SID PIN value changes to a VU value after successful invocation of revert on the admin SP’s object in the SP table and MAY not be equal to the C_PIN_MSID PIN value<br>OPAL 2.0 (only) |
| <b>DataStore Table Feature</b>                   |               |   |
| Maximum number of DataStore Tables               | 16            | The maximum number of the DataStore tables that the TPer supports, including the DataStore table defined in OPAL SSC 2.0  |
| Maximum total size of DataStore Tables           | 12MB          | Specifies the maximum total size in bytes of all of the DataStore tables that TPer supports, including the DataStore table defined in OPAL SSC 2.0  |
| MBR Table  | 128MB         | –   |

**Table 9: TCG/Opal Support Parameters (Continued)**

| Property   | Supported?    | Comments   |
|--|---------------|--|
| <b>Byte Table Access Granularity</b>               |               |  |
| Mandatory Write Granularity                        | 1             | TPer enforces when the host invokes the set method on byte tables; it should be less than or equal to 8192; it should be less than or equal to Recommended Access Granularity, OPAL 2.0 (only) |
| Recommended Access Granularity                     | 8192          | TPer recommends when the host invokes the set or get method on byte tables; it should be less than or equal to 8192  |
| <b>Cryptographic Features</b>                      |               |  |
| AES Key Size                                       | 256 Bits      | AES key is generated by using CTR DRBG algorithm (FIPS Compliant)  |
| AES Mode   | XTS           | IV swapped   |
| Number of Ranges/Band Supported                    | 16            | Unique AES key per range/band; range crossing is allowed if the range is unlocked  |
| Re-Encryption                                      | Not Supported | –  |
| Key Management                                     |               | Cryptographic  |
| Crypto Erase Completion Time <1s                   | Yes           | –  |
| Cryptographic Algorithms are Certified by FIPS-197 | No            | Designed to meet, no plans for certification   |
| AES 256-Bit CBC/ECB Mode                           | Supported     | ECB mode used only for generating the random key by CTR DRBG   |
| CTR DRBG   | Supported     | –  |
| SHA 256  | Supported     | –  |
| RSA 2048 Signature Verification                    | Supported     | –  |
| <b>TPer Communication Properties</b>               |               |  |
| Max ComPacket Size                                 | 131072        | 256 sectors (128K)   |
| Max Response ComPacket Size                        | 131072        | 256 sectors (128K)   |
| Max Packet Size                                    | 128512        | –  |
| Max Individual Token Size                          | 123904        | –  |
| Max Packets  | 1             | –  |
| Max SubPackets                                     | 1             | –  |
| Max Sessions                                       | 1             | Each session requires a set of buffers and variables   |
| Max Transaction Limit                              | 1             | Transaction are inside sessions  |
| Max Methods  | 1             | Methods are contained in a transaction   |
| Max Authentications                                | 21            | 21 = 16 users + 4 admins + 1 anybody   |
| Def Session Timeout                                | Yes           | The session timeout length (in milliseconds) used by the TPer by default   |
| <b>IEEE1667</b>                                    |               |  |
| Probe Silo   | Supported     | –  |
| TCG Storage Silo                                   | Supported     | –  |

**Table 9: TCG/Opal Support Parameters (Continued)**

| Property                               | Supported?    | Comments  |
|--|---------------|---|
| Other than Probe and TCG Storage Silo  | Not Supported | –   |
| IEEE1667 Major Version                 | 2             | –   |
| IEEE1667 Minor Version                 | 0             | –   |
| Maximum P_OUT Transfer Size            | 131072        | 256 sectors (128K)  |
| <b>Others</b>                          |               |   |
| FDE (ATA Security with Key Management) | Yes           | –   |
| Secure Firmware Download               | Supported     | Firmware image is validated by using SHA256 and RSA2048 algorithm |

## Device ID

**Table 10: Identify Device**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value        | Description   |
|------|--------|---------|----------------------|---|
| 0    |        |         |                      | General configuration bit-significant information   |
|      | 15     | F       | 0b                   | 0 = ATA device  |
|      | 14–8   | X       | 0000100b             | Retired   |
|      | 7      | F       | 0b                   | Obsolete  |
|      | 6      | F       | 1b                   | Obsolete  |
|      | 5–3    | X       | 000b                 | Retired   |
|      | 2      | V       | 0b                   | Response incomplete   |
|      | 1      | X       | 0b                   | Retired   |
|      | 0      | F       | 0b                   | Reserved  |
| 1    |        |         | 3FFFh                | Obsolete  |
| 2    |        | F       | C837h                | Specific configuration  |
| 3    |        | F       | 0010h                | Obsolete  |
| 4    |        | F       | 0000h 0000h          | Retired   |
| 6    |        | F       | 003Fh                | Obsolete  |
| 7    |        | (O)V    | 0000h 0000h          | Reserved for assignment by the CompactFlash™ Association  |
| 9    |        | X       | 0000h                | Retired   |
| 10   |        | (M)F    | varies               | Serial number (20 ASCII characters)   |
| 20   |        | X       | 0000h 0000h<br>0000h | Retired/Obsolete  |
| 23   |        | (M)F    | varies               | Firmware revision (8 ASCII characters)  |
| 27   |        | (M)F    | varies               | Model number (40 ASCII characters)  |
| 47   | 15–8   | F       | 80h                  | 80h   |
|      | 7–0    | F       | 10h                  | 00h = Reserved<br>01h–FFh = Maximum number of logical sectors that shall be transferred per DRQ data block on READ/WRITE MULTIPLE commands. |
| 48   |        |         |                      | Trusted Computing feature set options   |
|      | 15     | F       | 0b                   | Shall be cleared to zero  |
|      | 14     | F       | 1b                   | Shall be set to one   |
|      | 13–1   | F       | 000000000000b        | Reserved for the Trusted Computing Group  |
|      | 0      | F       | varies               | 1 = Trusted Computing feature set is supported<br>This bit will be 1 for TCG drives, otherwise 0  |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value                      | Description   |
|------|--------|---------|------------------------------------|---|
| 49   |        |         |                                    | Capabilities  |
|      | 15–14  | F       | 00b                                | Reserved for the IDENTIFY PACKET DEVICE command   |
|      | 13     | F       | 1b                                 | 1 = Standby timer values as specified in this standard are supported<br>0 = Standby timer values shall be managed by the device |
|      | 12     | F       | 0b                                 | Reserved for the IDENTIFY PACKET DEVICE command   |
|      | 11     | F       | 1b                                 | 1 = IORDY supported<br>0 = IORDY may be supported   |
|      | 10     | F       | 1b                                 | 1 = IORDY may be disabled.  |
|      | 9      | F       | 1b                                 | 1 = LBA supported   |
|      | 8      | F       | 1b                                 | 1 = DMA supported   |
|      | 7–2    | F       | 000000b                            | Retired   |
|      | 1–0    | F       | 00b                                | Long physical sector alignment error reporting  |
| 50   |        |         |                                    | Capabilities  |
|      | 15     | F       | 0b                                 | Shall be cleared to zero  |
|      | 14     | F       | 1b                                 | Shall be set to one   |
|      | 13–2   | F       | 000000000000b                      | Reserved  |
|      | 1      | X       | 0b                                 | Obsolete  |
|      | 0      | F       | 1b                                 | Shall be set to one to indicate a vendor specific standby timer value minimum   |
| 51   |        | X       | 0000h 0000h                        | Obsolete  |
| 53   | 15–8   | F       | 00000000b                          | Free-fall control sensitivity   |
|      | 7–3    | F       | 00000b                             | Reserved  |
|      | 2      | F       | 1b                                 | 1 = The fields reported in word 88 are valid.<br>0 = The fields reported in word 88 are not valid.                              |
|      | 1      | F       | 1b                                 | 1 = The fields reported in words (70:64) are valid.<br>0 = The fields reported in words (70:64) are not valid.                  |
|      | 0      | X       | 1b                                 | Obsolete  |
| 54   |        | X       | 3FFh 0010h<br>003Fh FC10h<br>00FBh | Obsolete  |



**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word  | Bit(s) | Setting | Default Value      | Description  |
|-------|--------|---------|--------------------|--|
| 59    | 15     | F       | 1b                 | 1 = The BLOCK ERASE EXT command is supported.  |
|       | 14     | F       | 0b                 | 1 = The OVERWRITE EXT command is supported.  |
|       | 13     | F       | varies             | 1 = The CRYPTO SCRAMBLE EXT command is supported. This bit will be 1 for TCG drives, otherwise 0                                 |
|       | 12     | F       | 1b                 | 1 = The Sanitize feature set is supported.   |
|       | 11     | F       | 0b                 | Commands allowed during a sanitize operation are as specified by ACS-2   |
|       | 10     | F       | 0b                 | SANITIZE ANTIFREEZE LOCK EXT command is supported  |
|       | 9      | F       | 0b                 | Reserved   |
|       | 8      | V       | 1b                 | 1 = Multiple sector setting is valid.  |
|       | 7-0    | V       | 00010000b          | xxh = Current setting for number of logical sectors that shall be transferred per DRQ data block on READ/WRITE MULTIPLE commands |
| 60-61 |        | M(F)    | Varies by capacity | Total number of user addressable logical sectors   |
| 62    |        | X       | 0000h              | Obsolete   |
| 63    | 15-11  | F       | 00000b             | Reserved   |
|       | 10     | V       | 0b                 | 1 = Multiword DMA mode 2 is selected.<br>0 = Multiword DMA mode 2 is not selected.   |
|       | 9      | V       | 0b                 | 1 = Multiword DMA mode 1 is selected.<br>0 = Multiword DMA mode 1 is not selected.   |
|       | 8      | V       | 0b                 | 1 = Multiword DMA mode 0 is selected.<br>0 = Multiword DMA mode 0 is not selected.   |
|       | 7-3    | F       | 0000b              | Reserved   |
|       | 2      | F       | 1b                 | 1 = Multiword DMA mode 2 and below are supported.  |
|       | 1      | F       | 1b                 | 1 = Multiword DMA mode 1 and below are supported.  |
|       | 0      | F       | 1b                 | 1 = Multiword DMA mode 0 is supported.   |
| 64    | 15-2   | F       | 00000000000000b    | Reserved   |
|       | 1-0    | F       | 11b                | PIO modes supported  |
| 65    |        | F       | 0078h              | Minimum Multiword DMA transfer cycle time per word<br>Cycle time in nanoseconds  |
| 66    |        | F       | 0078h              | Manufacturer's recommended Multiword DMA transfer cycle time<br>Cycle time in nanoseconds  |
| 67    |        | F       | 0078h              | Minimum PIO transfer cycle time without flow control<br>Cycle time in nanoseconds  |
| 68    |        | F       | 0078h              | Minimum PIO transfer cycle time with IORDY flow control<br>Cycle time in nanoseconds   |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value                      | Description  |
|------|--------|---------|------------------------------------|--|
| 69   |        |         |                                    | Additional Supported   |
|      | 15     | F       | 0b                                 | 1 = CFast Specification Support  |
|      | 14     | F       | 1b                                 | 1 = Deterministic read after Trim is supported.                          |
|      | 13     | F       | 0b                                 | 1 = Long Physical Sector Alignment Error Reporting Control is supported. |
|      | 12     | F       | 0b                                 | Obsolete   |
|      | 11     | F       | 1b                                 | 1 = READ BUFFER DMA is supported.  |
|      | 10     | F       | 1b                                 | 1 = WRITE BUFFER DMA is supported.                                       |
|      | 9      | F       | 0b                                 | Obsolete   |
|      | 8      | F       | 1b                                 | 1 = DOWNLOAD MICROCODE DMA is supported.                                 |
|      | 7      | F       | varies                             | 1 = IEEE-1667 supported  |
|      | 6      | F       | 0b                                 | 1 = Optional ATA device 28-bit commands supported                        |
|      | 5      | F       | 1b                                 | 1 = Read zero after Trim is supported                                    |
|      | 4      | F       | Varies                             | 1 = Device encrypts all user data  |
|      | 3      | F       | 1b                                 | 1 = Extended number of user addressable sectors is supported.            |
| 2    | F      | 0b      | 1 = All write cache is nonvolatile |  |
| 1-0  | F      | 00b     | Reserved                           |  |
| 70   |        | F       | 0000h                              | Reserved   |
| 71   |        | F       | 0000h 0000h<br>0000h 0000h         | Reserved for the IDENTIFY PACKET DEVICE command                          |
| 75   |        |         |                                    | Queue depth  |
|      | 15-5   | F       | 00000000000b                       | Reserved   |
|      | 4-0    | F       | 11111b                             | Maximum queue depth - 1  |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value | Description  |
|------|--------|---------|---------------|--|
| 76   |        |         |               | Serial ATA capabilities  |
|      | 15     | F       | 1b            | 1 = Supports READ LOG DMA EXT as equivalent to READ LOG EXT            |
|      | 14     | F       | 0b            | 1 = Supports device automatic partial to slumber transitions           |
|      | 13     | F       | 0b            | 1 = Supports host automatic partial to slumber transitions             |
|      | 12     | F       | 1b            | Supports Native Command Queuing priority information                   |
|      | 11     | F       | 0b            | Supports Unload while NCQ commands outstanding                         |
|      | 10     | F       | 1b            | Supports Phy event counters  |
|      | 9      | F       | 0b            | Supports receipt of host initiated interface power management requests |
|      | 8      | F       | 1b            | Supports Native Command Queueing                                       |
|      | 7-4    | F       | 0000b         | Reserved for Serial ATA  |
|      | 3      | F       | 1b            | 1 = Supports Serial ATA Gen-3 speed (6.0 Gb/s)                         |
|      | 2      | F       | 1b            | 1 = Supports Serial ATA Gen-2 speed (3.0 Gb/s)                         |
|      | 1      | F       | 1b            | 1 = Supports Serial ATA Gen-1 speed (1.5 Gb/s)                         |
|      | 0      | F       | 0b            | Reserved (set to 0)  |
| 77   |        |         |               | Serial ATA additional capabilities                                     |
|      | 15-8   | F       | 00000000b     | Reserved for future Serial ATA definition                              |
|      | 7      | F       | 1b            | 1 = Supports DEVSLP_to_ReducedPwrState                                 |
|      | 6      | F       | 1b            | Supports RECEIVE FPDMA QUEUED and SEND FPDMA QUEUED commands           |
|      | 5      | F       | 0b            | Supports NCQ Queue Management Command                                  |
|      | 4      | F       | 0b            | Supports NCQ Streaming   |
|      | 3-1    | V       | Varies        | Coded value indicating current negotiated Serial ATA signal speed      |
|      | 0      | F       | 0b            | Shall be cleared to zero   |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value | Description   |
|------|--------|---------|---------------|---|
| 78   |        |         |               | Serial ATA features supported   |
|      | 15–12  | F       | 0000b         | Reserved  |
|      | 11     | F       | 0b            | 1 = Supports Rebuild Assist   |
|      | 10     | F       | 0b            | 1 = Supports Device Initiated Interface Power Management Software Settings Preservation |
|      | 9      | F       | 0b            | 1 = Supports Hybrid Information   |
|      | 8      | F       | 1b            | 1 = Device sleep supported  |
|      | 7      | F       | 0b            | 1 = Supports NCQ Autosense  |
|      | 6      | F       | 1b            | 1 = Supports software settings preservation   |
|      | 5      | F       | 0b            | 1 = HARDWARE FEATURE CONTROL SUPPORTED bit  |
|      | 4      | F       | 0b            | 1 = Supports in-order data delivery   |
|      | 3      | F       | 1b            | 1 = Supports device initiate interface power management                                 |
|      | 2      | F       | 1b            | 1 = Supports DMA Setup Auto-Activate optimization                                       |
|      | 1      | F       | 0b            | 1 = Supports non-zero buffer offsets in DMA Setup FIS                                   |
|      | 0      | F       | 0b            | Reserved (set to 0)   |
| 79   |        |         |               | Serial ATA features enabled   |
|      | 15–12  | V       | 0000b         | Reserved  |
|      | 11     | V       | 0b            | 1 = Rebuild Assist enabled  |
|      | 10     | V       | 0b            | Reserved  |
|      | 9      | V       | 0b            | 1 = Hybrid Information feature is enabled   |
|      | 8      | V       | 0b            | 1 = Device sleep enabled  |
|      | 7      | V       | 0b            | 1 = Device automatic partial to slumber transitions enabled                             |
|      | 6      | V       | 1b            | 1 = Software settings preservation enabled  |
|      | 5      | V       | 0b            | 1 = Hardware feature control is enabled   |
|      | 4      | V       | 0b            | 1 = In-order data delivery enabled  |
|      | 3      | V       | 0b            | 1 = Device initiating interface power management enabled                                |
|      | 2      | V       | 0b            | 1 = DMA Setup Auto-Activate optimization enabled  |
|      | 1      | V       | 0b            | 1 = Non-zero buffer offsets in DMA Setup FIS enabled                                    |
|      | 0      | V       | 0b            | Reserved (set to 0)   |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value                      | Description  |
|------|--------|---------|------------------------------------|--|
| 80   |        |         |                                    | Major revision number  |
|      | 15–11  | F       | 00000b                             | Reserved   |
|      | 10     | F       | 1b                                 | 1 = Supports ACS-3   |
|      | 9      | F       | 1b                                 | 1 = Supports ATA8-ACS2   |
|      | 8      | F       | 1b                                 | 1 = Supports ATA8-ACS  |
|      | 7      | F       | 1b                                 | 1 = Supports ATA/ATAPI-7   |
|      | 6      | F       | 1b                                 | 1 = Supports ATA/ATAPI-6   |
|      | 5      | F       | 1b                                 | 1 = Supports ATA/ATAPI-5   |
|      | 4      | F       | 1b                                 | Obsolete   |
|      | 3      | F       | 1b                                 | Obsolete   |
|      | 2      | S       | 0b                                 | Obsolete   |
|      | 1      | S       | 0b                                 | Obsolete   |
| 0    | F      | 0b      | Reserved                           |  |
| 81   |        | F       | 006Dh                              | Minor revision number  |
|      |        |         |                                    | 006Dh = ACS-3 version 5  |
| 82   |        |         |                                    | Command set supported  |
|      | 15     | X       | 0b                                 | Obsolete   |
|      | 14     | F       | 1b                                 | 1 = NOP command supported  |
|      | 13     | F       | 1b                                 | 1 = READ BUFFER command supported  |
|      | 12     | F       | 1b                                 | 1 = WRITE BUFFER command supported   |
|      | 11     | X       | 0b                                 | Obsolete   |
|      | 10     | X       | 0b                                 | Obsolete   |
|      | 9      | F       | 0b                                 | 1 = DEVICE RESET command supported   |
|      | 8      | F       | 0b                                 | Obsolete   |
|      | 7      | F       | 0b                                 | Obsolete   |
|      | 6      | F       | 1b                                 | 1 = Read look-ahead supported  |
|      | 5      | F       | 1b                                 | 1 = Write cache supported  |
|      | 4      | F       | 0b                                 | Shall be cleared to zero to indicate that the PACKET feature set is not supported. |
|      | 3      | F       | 1b                                 | 1 = Mandatory Power Management feature set supported                               |
|      | 2      | F       | 0b                                 | Obsolete   |
| 1    | F      | 1b      | 1 = Security feature set supported |  |
| 0    | F      | 1b      | 1 = SMART feature set supported    |  |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value                            | Description   |
|------|--------|---------|--|---|
| 83   |        |         |  | Command set supported   |
|      | 15     | F       | 0b                                       | Shall be cleared to zero  |
|      | 14     | F       | 1b                                       | Shall be set to one   |
|      | 13     | F       | 1b                                       | 1 = FLUSH CACHE EXT command supported                               |
|      | 12     | F       | 1b                                       | 1 = Mandatory FLUSH CACHE command supported                         |
|      | 11     | X       | 0b                                       | Obsolete  |
|      | 10     | F       | 1b                                       | 1 = 48-bit address feature set supported                            |
|      | 9      | F       | 0b                                       | Obsolete  |
|      | 8      | X       | 0b                                       | Obsolete  |
|      | 7      | F       | 0b                                       | Obsolete  |
|      | 6      | F       | 0b                                       | 1 = SET FEATURES subcommand required to spin-up after power-up      |
|      | 5      | F       | 0b                                       | 1 = Power-Up In Standby feature set supported                       |
|      | 4      | F       | 0b                                       | Obsolete  |
|      | 3      | F       | varies                                   | 1 = Advanced Power Management feature set supported                 |
|      | 2      | F       | 0b                                       | 1 = CFA feature set supported                                       |
| 1    | F      | 0b      | Obsolete                                 |   |
| 0    | F      | 1b      | 1 = DOWNLOAD MICROCODE command supported |   |
| 84   |        |         |  | Command set/feature supported extension                             |
|      | 15     | F       | 0b                                       | Shall be cleared to zero  |
|      | 14     | F       | 1b                                       | Shall be set to one   |
|      | 13     | F       | 1b                                       | 1 = IDLE IMMEDIATE with UNLOAD FEATURE supported                    |
|      | 12     | F       | 0b                                       | Obsolete  |
|      | 11     | F       | 0b                                       | Obsolete  |
|      | 10–9   | F       | 00b                                      | Obsolete  |
|      | 8      | F       | 1b                                       | 1 = 64-bit word wide name supported                                 |
|      | 7      | F       | 0b                                       | Obsolete  |
|      | 6      | F       | 1b                                       | 1 = WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands supported |
|      | 5      | F       | 1b                                       | 1 = General Purpose Logging feature set supported                   |
|      | 4      | F       | 0b                                       | 1 = Streaming feature set supported                                 |
|      | 3      | F       | 0b                                       | Obsolete  |
|      | 2      | F       | 0b                                       | Reserved  |
|      | 1      | F       | 1b                                       | 1 = SMART self-test supported                                       |
| 0    | F      | 1b      | 1 = SMART error logging supported        |   |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value                            | Description  |
|------|--------|---------|--|--|
| 85   |        |         |  | Command set/feature enabled.   |
|      | 15     | X       | 0b                                       | Obsolete   |
|      | 14     | F       | 1b                                       | 1 = NOP command supported  |
|      | 13     | F       | 1b                                       | 1 = READ BUFFER command supported  |
|      | 12     | F       | 1b                                       | 1 = WRITE BUFFER command supported   |
|      | 11     | X       | 0b                                       | Obsolete   |
|      | 10     | X       | 0b                                       | Obsolete   |
|      | 9      | F       | 0b                                       | 1 = DEVICE RESET command supported   |
|      | 8      | V       | 0b                                       | Obsolete   |
|      | 7      | V       | 0b                                       | Obsolete   |
|      | 6      | V       | 1b                                       | 1 = Read look-ahead enabled  |
|      | 5      | V       | 1b                                       | 1 = Write cache enabled  |
|      | 4      | F       | 0b                                       | Shall be cleared to zero to indicate that the PACKET feature set is not supported. |
|      | 3      | F       | 1b                                       | Power Management feature set is supported  |
|      | 2      | F       | 0b                                       | Obsolete   |
| 1    | V      | 0b      | 1 = Security Mode feature set enabled    |  |
| 0    | V      | 1b      | 1 = SMART feature set enabled            |  |
| 86   |        |         |  | Command set/feature enabled.   |
|      | 15     | F       | 1b                                       | 1 = Words 120-119 are valid  |
|      | 14     | F       | 0b                                       | 1 = Reserved   |
|      | 13     | F       | 1b                                       | 1 = FLUSH CACHE EXT command supported  |
|      | 12     | F       | 1b                                       | 1 = FLUSH CACHE command supported  |
|      | 11     | X       | 0b                                       | Obsolete   |
|      | 10     | F       | 1b                                       | 1 = 48-bit Address features set supported  |
|      | 9      | V       | 0b                                       | Obsolete   |
|      | 8      | F       | 0b                                       | Obsolete   |
|      | 7      | F       | 0b                                       | Obsolete   |
|      | 6      | F       | 0b                                       | 1 = SET FEATURES subcommand required to spin-up after power-up                     |
|      | 5      | V       | 0b                                       | 1 = Power-Up In Standby feature set enabled  |
|      | 4      | V       | 0b                                       | Obsolete   |
|      | 3      | V       | 1b                                       | 1 = Advanced Power Management feature set enabled                                  |
|      | 2      | F       | 0b                                       | 1 = CFA feature set supported  |
| 1    | F      | 0b      | Obsolete                                 |  |
| 0    | F      | 1b      | 1 = DOWNLOAD MICROCODE command supported |  |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value                     | Description   |
|------|--------|---------|-----------------------------------|---|
| 87   |        |         |                                   | Command set/feature enabled/supported                               |
|      | 15     | F       | 0b                                | Shall be cleared to zero  |
|      | 14     | F       | 1b                                | Shall be set to one   |
|      | 13     | F       | 1b                                | 1 = IDLE IMMEDIATE with UNLOAD FEATURE supported                    |
|      | 12     | V       | 0b                                | Obsolete  |
|      | 11     | V       | 0b                                | Obsolete  |
|      | 10–9   | F       | 00b                               | Obsolete  |
|      | 8      | F       | 1b                                | 1 = 64-bit word wide name supported                                 |
|      | 7      | F       | 0b                                | Obsolete  |
|      | 6      | F       | 1b                                | 1 = WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands supported |
|      | 5      | F       | 1b                                | 1 = General Purpose Logging feature set supported                   |
|      | 4      | V       | 0b                                | Obsolete  |
|      | 3      | V       | 0b                                | Obsolete  |
|      | 2      | V       | 0b                                | 1 = Media serial number is valid                                    |
|      | 1      | F       | 1b                                | 1 = SMART self-test supported                                       |
| 0    | F      | 1b      | 1 = SMART error logging supported |   |



**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value                     | Description  |
|------|--------|---------|-----------------------------------|--|
| 88   |        |         |                                   | Ultra DMA modes  |
|      | 15     |         | 0b                                | Reserved   |
|      | 14     |         | 0b                                | 1 = Ultra DMA mode 6 is selected<br>0 = Ultra DMA mode 6 is not selected               |
|      | 13     |         | 0b                                | 1 = Ultra DMA mode 5 is selected<br>0 = Ultra DMA mode 5 is not selected               |
|      | 12     |         | 0b                                | 1 = Ultra DMA mode 4 is selected<br>0 = Ultra DMA mode 4 is not selected               |
|      | 11     |         | 0b                                | 1 = Ultra DMA mode 3 is selected<br>0 = Ultra DMA mode 3 is not selected               |
|      | 10     |         | 0b                                | 1 = Ultra DMA mode 2 is selected<br>0 = Ultra DMA mode 2 is not selected               |
|      | 9      |         | 0b                                | 1 = Ultra DMA mode 1 is selected<br>0 = Ultra DMA mode 1 is not selected               |
|      | 8      |         | 0b                                | 1 = Ultra DMA mode 0 is selected<br>0 = Ultra DMA mode 0 is not selected               |
|      | 7      |         | 0b                                | Reserved   |
|      | 6      |         | 1b                                | 1 = Ultra DMA mode 6 and below are supported   |
|      | 5      |         | 1b                                | 1 = Ultra DMA mode 5 and below are supported   |
|      | 4      |         | 1b                                | 1 = Ultra DMA mode 4 and below are supported   |
|      | 3      |         | 1b                                | 1 = Ultra DMA mode 3 and below are supported   |
|      | 2      |         | 1b                                | 1 = Ultra DMA mode 2 and below are supported   |
|      | 1      |         | 1b                                | 1 = Ultra DMA mode 1 and below are supported   |
| 0    |        | 1b      | 1 = Ultra DMA mode 0 IS supported |  |
| 89   |        | (O)F    | 0001h                             | Time required for security erase unit completion                                       |
| 90   |        | (O)F    | 0001h                             | Time required for enhanced security erase completion                                   |
| 91   |        | (O)V    | 00FEh                             | Current advanced power management value  |
| 92   |        | (O)V    | FFFEh                             | Master Password Identifier   |
| 93   |        | F       | 0000h                             | Shall be 0000h for SATA devices  |
| 94   |        | F       | 0000h                             | Obsolete   |
| 95   |        | (O)V    | 0000h                             | Stream Minimum Request Size  |
| 96   |        | (O)V    | 0000h                             | Streaming Transfer Time – DMA  |
| 97   |        | (O)V    | 0000h                             | Streaming Access Latency – DMA and PIO   |
| 98   |        | (O)F    | 0000h 0000h                       | Streaming Performance Granularity (98-99)  |
| 100  |        | V       | Varies by capacity                | Maximum user LBA for 48-bit Address feature set  |
| 104  |        | (O)V    | 0000h                             | Streaming Transfer Time – PIO  |
| 105  |        | F       | 0008h                             | Maximum number of 512-byte blocks of LBA Range Entries per DATA SET MANAGEMENT command |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value              | Description   |
|------|--------|---------|----------------------------|---|
| 106  |        |         |                            | Physical sector size/logical sector size                          |
|      | 15     | F       | 0b                         | Shall be cleared to zero  |
|      | 14     | F       | 1b                         | Shall be set to one   |
|      | 13     | F       | 0b                         | 1 = Device has multiple logical sectors per physical sector       |
|      | 12     | F       | 0b                         | 1 = Device logical sector longer than 256 words                   |
|      | 11-4   | F       | 00000000b                  | Reserved  |
|      | 3-0    | F       | 0000b                      | 2 <sup>x</sup> logical sectors per physical sector                |
| 107  |        | (O)F    | 0000h                      | Inter-seek delay for ISO-7779 acoustic testing in microseconds    |
| 108  | 15-12  | F       | 0101b                      | NAA (3-0)   |
|      | 11-0   |         | 000000001010b              | IEEE OUI (23-12)  |
| 109  | 15-4   | F       | 000001110101b              | IEEE OUI (11-0)   |
|      | 3-0    |         | Varies                     | Unique ID (35-32)   |
| 110  |        | (M)F    | Varies                     | 5-0 Unique ID (31-16)   |
| 111  |        | (M)F    | Varies                     | Unique ID (15-0)  |
| 112  |        | (O)F    | 0000h 0000h<br>0000h 0000h | Reserved for 12-bit word-wide name extension to 128 bits          |
| 116  |        | (O)     | 0000h                      | Obsolete  |
| 117  |        | (O)F    | 0000h 0000h                | Words per Logical Sector  |
| 119  |        |         |                            | Commands and feature sets supported (continued from words 84-82)  |
|      | 15     | F       | 0b                         | Shall be cleared to zero  |
|      | 14     | F       | 1b                         | Shall be set to one   |
|      | 13-10  | F       | 0000b                      | Reserved  |
|      | 9      | F       | 0b                         | 1 = DSN feature set is supported                                  |
|      | 8      | F       | 1b                         | 1 = Accessible Max address configuration feature set is supported |
|      | 7      | F       | 0b                         | 1 = Extended Power Conditions feature set is supported            |
|      | 6      | F       | 0b                         | 1 = Sense Data Reporting feature set is supported                 |
|      | 5      | F       | 0b                         | 1 = Free-fall control feature set is supported                    |
|      | 4      | F       | 1b                         | 1 = The DOWNLOAD MICROCODE command with mode 3 is supported       |
|      | 3      | F       | 1b                         | 1 = READ LOG DMA EXT and WRITE LOG DMA EXT commands are supported |
|      | 2      | F       | 1b                         | 1 = The WRITE UNCORRECTABLE EXT command is supported              |
|      | 1      | F       | 1b                         | 1 = The Write-Read-Verify feature set is supported                |
| 0    | F      | 0b      | Obsolete                   |   |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word    | Bit(s) | Setting | Default Value  | Description   |
|---------|--------|---------|--|---|
| 120     |        |         |  | Commands and feature sets supported or enabled (continued from words 87–85) |
|         | 15     |         | 0b   | Shall be cleared to zero  |
|         | 14     |         | 1b   | Shall be set to one   |
|         | 13–10  |         | 0000b  | Reserved  |
|         | 9      |         | 0b   | 1 = DSN feature set is enabled  |
|         | 8      |         | 0b   | Reserved  |
|         | 7      |         | 0b   | 1 = EPC feature set is enabled  |
|         | 6      |         | 0b   | 1 = Sense Data Reporting feature set is enabled                             |
|         | 5      |         | 0b   | 1 = Free-fall control feature set is enabled                                |
|         | 4      |         | 1b   | 1 = The DOWNLOAD MICROCODE command with mode 3 is supported                 |
|         | 3      |         | 1b   | 1 = The READ LOG DMA EXT and WRITE LOG DMA EXT commands are supported       |
|         | 2      |         | 1b   | 1 = The WRITE UNCORRECTABLE EXT command is supported                        |
|         | 1      |         | 0b   | 1 = The Write-Read-Verify feature set is enabled                            |
|         | 0      |         | 0b   | Obsolete  |
| 121     |        | F       | 0000h 0000h<br>0000h 0000h<br>0000h 0000h                | Reserved for expanded supported and enabled settings                        |
| 127     |        | (O)     | 0000h  | Obsolete  |
| 128     |        |         |  | Security status   |
|         | 15–9   | F       | 0000000b   | Reserved  |
|         | 8      | V       | 0b   | Security level 0 = High, 1 = Maximum  |
|         | 7–6    | F       | 00b  | Reserved  |
|         | 5      | F       | 1b   | 1 = Enhanced security erase supported                                       |
|         | 4      | V       | 0b   | 1 = Security count expired  |
|         | 3      | V       | 0b   | 1 = Security frozen   |
|         | 2      | V       | 0b   | 1 = Security locked   |
|         | 1      | V       | 0b   | 1 = Security enabled  |
|         | 0      | F       | 1b   | 1 = Security supported  |
| 129–159 |        | X       | Vendor specific data                                     | Vendor specific   |
| 160     |        | X       | 0000h 0000h<br>0000h 0000h<br>0000h 0000h<br>0000h 0000h | Reserved for assignment by the CompactFlash Association                     |
| 168     | 15–4   | F       | 000h   | Reserved  |
|         | 3–0    | F       | Varies   | Device Nominal Form Factor  |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value              | Description   |
|------|--------|---------|----------------------------|---|
| 169  |        |         |                            | DATA SET MANAGEMENT command support   |
|      | 15–1   | F       | 0000000000000000<br>b      | Reserved  |
|      | 0      | F       | 1b                         | 1 = The Trim bit in the DATA SET MANAGEMENT command is supported                                |
| 170  |        | F       | 0000h 0000h<br>0000h 0000h | Additional product identifier   |
| 174  |        | F       | 0000h 0000h                | Reserved  |
| 176  |        | (O)V    | Varies                     | Current media serial number (60 ASCII characters)   |
| 206  |        |         |                            | SCT Command Transport   |
|      | 15–12  | X       | 0000b                      | Vendor-specific   |
|      | 11–6   | F       | 000000b                    | Reserved  |
|      | 5      | F       | 1b                         | SCT Command Transport Data Tables supported   |
|      | 4      | F       | 1b                         | SCT Command Transport Features Control supported  |
|      | 3      | F       | 0b                         | SCT Command Transport Error Recovery Control supported  |
|      | 2      | F       | 1b                         | SCT Command Transport Write Same supported  |
|      | 1      | F       | 0b                         | Obsolete  |
|      | 0      | F       | 1b                         | SCT Command Transport supported   |
| 207  |        | F       | 0000h 0000h                | Reserved for CE-ATA   |
| 209  |        | (O)     |                            | Alignment of logical blocks within a larger physical block                                      |
|      | 15     | F       | 0b                         | Shall be cleared to zero  |
|      | 14     | F       | 1b                         | Shall be set to one   |
|      | 13–0   | F       | 000000000000000b           | Logical sector offset within the first physical sector where the first logical sector is placed |
| 210  |        | (O)V    | 0000h 0000h                | Write-Read-Verify Sector Count Mode 3 Only  |
| 212  |        | (O)F    | 0000h 0001h                | Verify Sector Count Mode 2 Only   |
| 214  |        | (O)     | 0000h                      | Obsolete  |
| 215  |        | (O)V    | 0000h                      | Obsolete  |
| 216  |        | (O)V    | 0000h                      | Obsolete  |
| 217  |        | (M)F    | 0001h                      | Nominal media rotation rate (ATA8-ACS 1699-D Revision 6)  |
| 218  |        | (O)V    | 0000h                      | Reserved  |
| 219  |        |         |                            | Obsolete  |
| 220  | 15–8   | F       | 00h                        | Reserved  |
|      | 7–0    | V       | 00h                        | Write-Read-Verify feature set current mode  |
| 221  |        |         | 0000h                      | Reserved  |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word    | Bit(s) | Setting | Default Value  | Description   |
|---------|--------|---------|--|---|
| 222     |        |         |  | Transport Major revision number. 0000h or FFFFh = device does not report version                    |
|         | 15-12  |         | 0001b  | Transport Type - 0 = Parallel, 1 = Serial, 2-15 = Reserved<br>Parallel (Type = 0) Serial (Type = 1) |
|         | 11-8   |         | 0000b  | Reserved  |
|         | 7      |         | 1b   | Supports SATA Rev 3.2   |
|         | 6      |         | 1b   | Supports SATA Rev 3.1   |
|         | 5      |         | 1b   | Supports SATA Rev 3.0   |
|         | 4      |         | 1b   | Supports SATA Rev 2.6   |
|         | 3      |         | 1b   | Supports SATA Rev 2.5   |
|         | 2      |         | 1b   | Supports SATA II: Extensions  |
|         | 1      |         | 1b   | Supports SATA 1.0a  |
| 0       |        | 1b      | Supports ATA8-APT ATA8-AST   |   |
| 223     |        | (M)F    | 0000h  | Transport Minor revision number   |
| 224     |        | F       | 0000h 0000h<br>0000h 0000h<br>0000h 0000h<br>0000h 0000h<br>0000h 0000h          | Reserved for CE-ATA   |
| 230-233 |        |         | Varies   | Extended number of user addressable sectors   |
| 234     |        | (O)F    | 0001h  | Minimum number of 512 byte units per DOWNLOAD MICRO-CODE command for mode 3                         |
| 235     |        |         | 00FFh  | Maximum number of 512 byte units per DOWNLOAD MICRO-CODE command for mode 3                         |
| 236     |        |         | 0000h 0000h<br>0000h 0000h<br>0000h 0000h<br>0000h                               | Reserved  |
| 243     | 15     |         | 0b   | Reserved  |
|         | 14     |         | varies   | Bit 14 = 1 Supports FDE security features   |
|         | 13-0   |         | 00000000000000b  | Reserved  |
| 244     |        |         | 0000h 0000h<br>0000h 0000h<br>0000h 0000h<br>0000h 0000h<br>0000h 0000h<br>0000h | Reserved  |

**Table 10: Identify Device (Continued)**

See Note 1 for setting definitions

| Word | Bit(s) | Setting | Default Value | Description    |
|------|--------|---------|---------------|----------------|
| 255  |        | (M)F    |               | Integrity word |
|      | 15–8   |         | Varies        | Checksum       |
|      | 7–0    |         | A5h           | Signature      |

- Note: 1. F = The content of the word is fixed and does not change.  
 V = The content of the word is variable and may change depending on the state of the device or the commands executed by the device.  
 X = The content of the word may be fixed or variable.  
 R = The content of the word is reserved and will be zero.  
 M = Support of the word is mandatory.  
 O = Support of the word is optional.

## Commands

**Table 11: Supported ATA Command Set**

See ACS-3 standard for command details

| Command Name                           | Command Code (hex)                               |
|--|--|
| AMAC-GET NATIVE MAX ADDRESS EXT        | 78h/0000h  |
| AMAC-SET ACCESSIBLE MAX ADDRESS EXT    | 78h/0001h  |
| AMAC-FREEZE ACCESSIBLE MAX ADDRESS EXT | 78h/0002h  |
| CHECK POWER MODE                       | 98h or E5h                                       |
| DATA SET MANAGEMENT – TRIM             | 06h/0001h  |
| DOWNLOAD MICROCODE                     | 92h  |
| DOWNLOAD MICROCODE DMA                 | 93h  |
| EXECUTE DEVICE DIAGNOSTIC              | 90h  |
| FLUSH CACHE                            | E7h  |
| FLUSH CACHE EXT                        | EAh  |
| IDENTIFY DEVICE                        | ECh  |
| IDLE                                   | E3h or 97h                                       |
| IDLE IMMEDIATE                         | E1h or 95h                                       |
| INITIALIZE DEVICE PARAMETERS           | 91h  |
| READ BUFFER                            | E4h  |
| READ DMA (with retry)                  | C8h  |
| READ DMA (without retry)               | C9h  |
| READ DMA EXT                           | 25h  |
| READ FPDMA QUEUED                      | 60h  |
| READ LOG EXT                           | 2Fh  |
| READ MULTIPLE                          | C4h  |
| READ MULTIPLE EXT                      | 29h  |
| READ SECTOR(S) EXT                     | 24h  |
| READ SECTOR(S) (with retry)            | 20h  |
| READ SECTOR(S) (without retry)         | 21h  |
| READ VERIFY SECTOR(S) EXT              | 42h  |
| READ VERIFY SECTOR(S) (with retry)     | 40h  |
| READ VERIFY SECTOR(S) (without retry)  | 41h  |
| RECEIVE FPDMA QUEUED                   | 65h  |
| SANITIZE DEVICE                        | B4h  |
| SCT WRITE SAME                         | 02h/0001h<br>02h/0002h<br>02h/0101h<br>02h/0102h |
| SCT SET FEATURE CONTROL                | 04h/01h  |
| SCT RETURN FEATURE CONTROL             | 04h/02h  |
| SCT RETURN FEATURE OPTION FLAG         | 04h/03h  |

**Table 11: Supported ATA Command Set (Continued)**

See ACS-3 standard for command details

| Command Name                     | Command Code (hex) |
|----------------------------------|--------------------|
| SCT RETURN SCT DATA TABLE        | 05h/01h            |
| SECURITY DISABLE PASSWORD        | F6h                |
| SECURITY ERASE PREPARE           | F3h                |
| SECURITY ERASE UNIT              | F4h                |
| SECURITY FREEZE LOCK             | F5h                |
| SECURITY SET PASSWORD            | F1h                |
| SECURITY UNLOCK                  | F2h                |
| SEND FPDMA QUEUED                | 64h                |
| SET FEATURES                     | EFh                |
| SET MULTIPLE MODE                | C6h                |
| SLEEP                            | E6h or 99h         |
| SMART DISABLE OPERATIONS         | B0h/D9h            |
| SMART ENABLE OPERATIONS          | B0h/D8h            |
| SMART ENABLE/DISABLE AUTOSAVE    | B0h/D2h            |
| SMART EXECUTE OFF-LINE IMMEDIATE | B0h/D4h            |
| SMART READ DATA                  | B0h/D0h            |
| SMART READ LOG                   | B0h/D5h            |
| SMART RETURN STATUS              | B0h/DAh            |
| SMART WRITE LOG                  | B0h/D6h            |
| STANDBY                          | E2h or 96h         |
| STANDBY IMMEDIATE                | E0h or 94h         |
| TRUSTED NON-DATA                 | 5Bh                |
| TRUSTED RECEIVE                  | 5Ch                |
| TRUSTED RECEIVE DMA              | 5Dh                |
| TRUSTED SEND                     | 5Eh                |
| TRUSTED SEND DMA                 | 5Fh                |
| WRITE BUFFER                     | E8h                |
| WRITE DMA (with retry)           | CAh                |
| WRITE DMA (without retry)        | CBh                |
| WRITE DMA EXT                    | 35h                |
| WRITE DMA FUA EXT                | 3Dh                |
| WRITE FPDMA QUEUED               | 61h                |
| WRITE LOG EXT                    | 3Fh                |
| WRITE MULTIPLE                   | C5h                |
| WRITE MULTIPLE EXT               | 39h                |
| WRITE MULTIPLE FUA EXT           | CEh                |
| WRITE SECTOR(S) (with retry)     | 30h                |



**Table 11: Supported ATA Command Set (Continued)**

See ACS-3 standard for command details

| Command Name            | Command Code (hex) |
|-------------------------|--------------------|
| WRITE SECTOR(S) EXT     | 34h                |
| WRITE UNCORRECTABLE EXT | 45h                |

## Interface Connectors

### 2.5" 7 mm

**Figure 3: 2.5" 7 mm SSD Interface Connections**



**Table 12: SATA Signal Segment Pin Assignments**

| Signal Name | Type | Description                       |
|-------------|------|-----------------------------------|
| S1          | GND  | Ground                            |
| S2          | A    | Differential signal pair A and A# |
| S3          | A#   |                                   |
| S4          | GND  | Ground                            |
| S5          | B#   | Differential signal pair B and B# |
| S6          | B    |                                   |
| S7          | GND  | Ground                            |

**Table 13: 2.5-Inch SATA Power Segment Pin Assignments**

| Pin# | Signal Name | Description            |
|------|-------------|------------------------|
| P1   | RETIRED     | No connect             |
| P2   | RETIRED     | No connect             |
| P3   | DEVSLP      | Device sleep           |
| P4   | GND         | Ground                 |
| P5   | GND         | Ground                 |
| P6   | GND         | Ground                 |
| P7   | V5          | 5V power, precharge    |
| P8   | V5          | 5V power               |
| P9   | V5          | 5V power               |
| P10  | GND         | Ground                 |
| P11  | DAS         | Device activity signal |
| P12  | GND         | Ground                 |
| P13  | V12         | No connect             |
| P14  | V12         | No connect             |
| P15  | V12         | No connect             |

## M.2 2280

**Figure 4: M.2 2280 SSD Interface Connections**



**Table 14: M.2 2280 Signal Assignments**

| Primary Side |             |                          | Secondary Side |             |                           |
|--------------|-------------|--------------------------|----------------|-------------|---------------------------|
| Pin #        | Signal Name | Description              | Pin #          | Signal Name | Description               |
| 1            | CONFIG_3    | Ground                   | 2              | 3V3         | 3.3V                      |
| 3            | GND         | Ground                   | 4              | 3V3         | 3.3V                      |
| 5            | NC          | No connect               | 6              | NC          | No connect                |
| 7            | NC          | No connect               | 8              | NC          | No connect                |
| 9            | NC          | No connect               | 10             | DAS/DSS     | Drive activity (host LED) |
| 11           | NC          | No connect               | Key            |             |                           |
| Key          |             |                          | 20             | NC          | No connect                |
| 21           | CONFIG_0    | Ground                   | 22             | NC          | No connect                |
| 23           | NC          | No connect               | 24             | NC          | No connect                |
| 25           | NC          | No connect               | 26             | NC          | No connect                |
| 27           | GND         | Ground                   | 28             | NC          | No connect                |
| 29           | NC          | No connect               | 30             | NC          | No connect                |
| 31           | NC          | No connect               | 32             | NC          | No connect                |
| 33           | GND         | Ground                   | 34             | NC          | No connect                |
| 35           | NC          | No connect               | 36             | NC          | No connect                |
| 37           | NC          | No connect               | 38             | DEVSLP      | Device sleep              |
| 39           | GND         | Ground                   | 40             | NC          | No connect                |
| 41           | SATA +B     | SATA B differential pair | 42             | NC          | No connect                |
| 43           | SATA -B     |                          | 44             | NC          | No connect                |
| 45           | GND         | Ground                   | 46             | NC          | No connect                |
| 47           | SATA -A     | SATA A differential pair | 48             | NC          | No connect                |
| 49           | SATA +A     |                          | 50             | NC          | No connect                |
| 51           | GND         | Ground                   | 52             | NC          | No connect                |
| 53           | NC          | No connect               | 54             | NC          | No connect                |
| 55           | NC          | No connect               | 56             | Reserved    | Vendor use                |
| 57           | GND         | Ground                   | 58             | Reserved    | Vendor use                |
| Key          |             |                          | Key            |             |                           |



**Table 14: M.2 2280 Signal Assignments (Continued)**

| Primary Side |             |             | Secondary Side |             |             |
|--------------|-------------|-------------|----------------|-------------|-------------|
| Pin #        | Signal Name | Description | Pin #          | Signal Name | Description |
| 67           | NC          | No connect  | 68             | Reserved    | No connect  |
| 69           | CONFIG_1    | Ground      | 70             | 3V3         | 3.3V        |
| 71           | GND         | Ground      | 72             | 3V3         | 3.3V        |
| 73           | GND         | Ground      | 74             | 3V3         | 3.3V        |
| 75           | CONFIG_2    | Ground      |                |             |             |

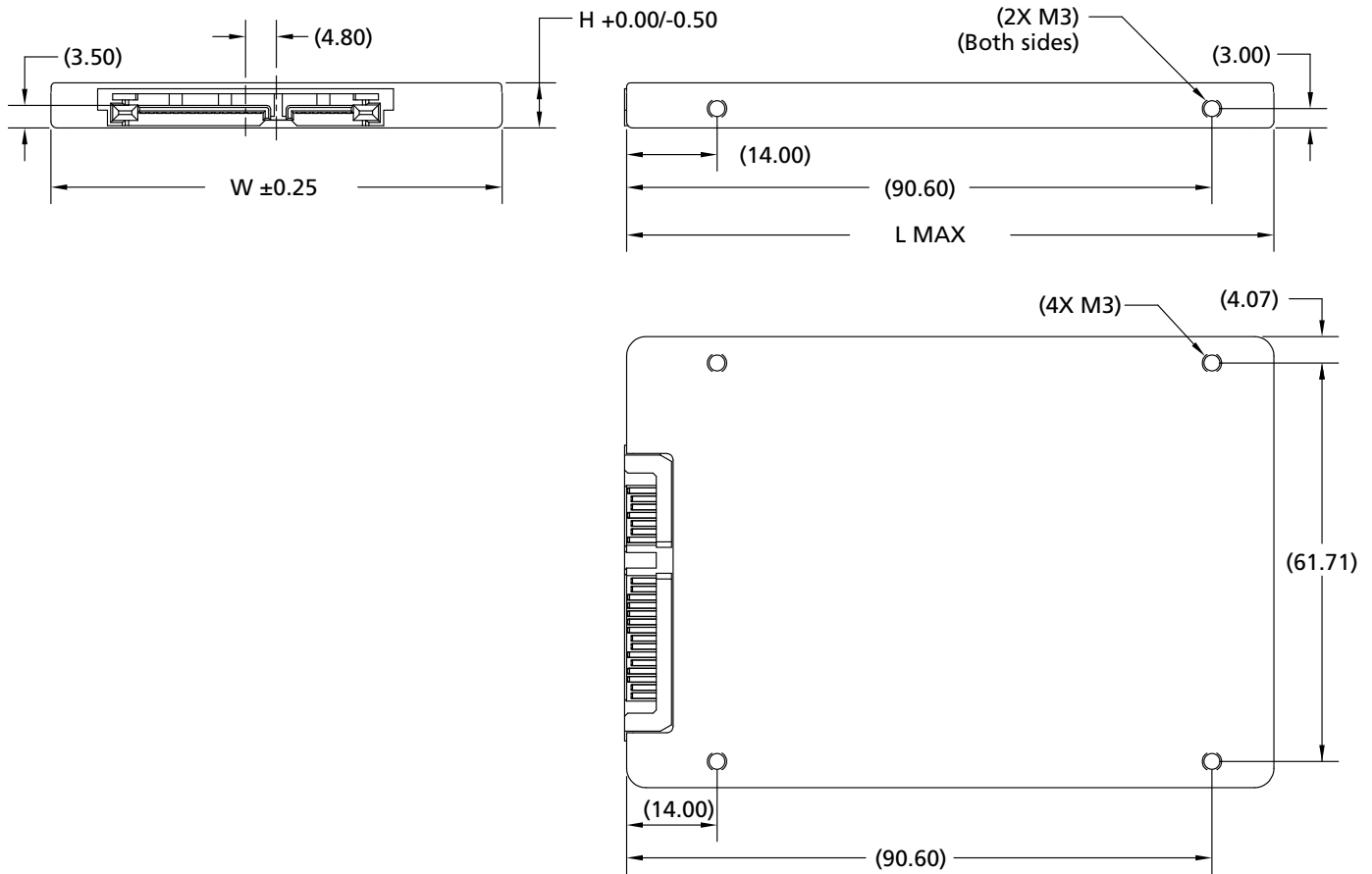
## Physical Configuration

### 2.5" 7 mm

Product mass: 56 grams MAX

Physical dimensions conform to the applicable form factor specifications as listed in the figure below.

**Figure 5: 2.5-Inch Package – 7mm**



Note: 1. All dimensions are in millimeters.

**Table 15: 2.5-Inch Package Dimensions**

| Density (GB) | W     | L      | H    | Unit |
|--------------|-------|--------|------|------|
| 256          | 69.85 | 100.45 | 7.00 | mm   |
| 512          |       |        |      |      |
| 1024         |       |        |      |      |
| 2048         |       |        |      |      |

Note: 1. Dimension values in millimeter per SFF 8201 Rev. 2.7.

## M.2 2280

Product mass: 10 grams MAX

Physical dimensions conform to the applicable form factor specifications as listed in the figure below.

**Figure 6: M.2 Type 2280 Package**



Note: 1. All dimensions are in millimeters.

**Table 16: M.2 Type 2280 Package Dimensions**

| Density (GB) | Specification | W     | L     | A    | B    | Unit |
|--------------|---------------|-------|-------|------|------|------|
| 256          | S2            | 22.00 | 80.00 | 1.35 | 0.80 | mm   |
| 512          |               |       |       | 1.50 |      |      |
| 1024         | S3            |       |       |      |      |      |

Note: 1. M.2 2280 dimension values in millimeter per PCI Express M.2 Specification Rev. 1.0.

## Compliance

Micron SSDs comply with the following:

- Micron Green Standard
- Built with sulfur resistant resistors
- CE (Europe): EN 55032 Class B, RoHS
- FCC: CFR Title 47, Part 15 Class B
- UL/cUL: approval to UL-60950-1, 2nd Edition, IEC 60950-1:2005 (2nd Edition); EN 60950-1 (2006) + A11:2009+ A1:2010 + A12:2011 + A2:2013
- BSMI (Taiwan): approval to CNS 13438 Class B and CNS 15663
- RCM (Australia, New Zealand): AS/NZS CISPR32 Class B
- KC RRL (Korea): approval to KN32 Class B, KN 35 Class B

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- W.E.E.E.: compliance with EU WEEE directive 2012/19/EC. Additional obligations may apply to customers who place these products in the markets where WEEE is enforced.
- TUV (Germany): approval to IEC60950/EN60950
- VCCI (Japan): 2015-04 Class B

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取扱説明書に従って正しい取り扱いをして下さい。

VCCI-B

- IC (Canada): ICES-003 Class B
  - This Class B digital apparatus complies with Canadian ICES-003.
  - Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

## FCC Rules

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

## References

- Serial ATA: High-speed serialized AT attachment, Serial ATA working group, available at [www.sata-io.org](http://www.sata-io.org)
- SATA 3.2 GOLD
- ATA-8 ACS3 (T13/2161-D, Revision 5)
- TCG Storage Security Subsystem Class Opal; Specification 2.00 Revision 1.00, Feb 24, 2012
- TCG Core Specification; Specification 2.00 Revision 2.00, Nov 4, 2011
- TCG Storage Interface Interactions: Specification Version 1.02 Revision 1.00 30 December, 2011
- IEEE-1667: "Standard Protocol for Authentication in Host Attachments of Transient Storage Devices"
- SFF 8201 Rev 2.7: For form factor
- PCI Express M.2 Specification rev 1.0: For form factor
- Trade Agreements Act of 1979 (19 U.S.C. 2501)



## Revision History

### Rev. D – 10/17

- Updated the certifications list
- Updated Table 10, Word 83 to reflect both APM ON & OFF available options

### Rev. C – 12/16

- Added TAA Compliant option
- Updated pin names for M.2 in Table 14

### Rev. B – 5/16

- Updated random 4KB read IOPS
- Updated Adaptive Thermal Monitoring, TCG/Opal Support and Device ID sections
- Updated doc ID number
- Misc. documentation edits

### Rev. A – 12/15

- Initial release

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[MTFDDAK2T0TBN-1AR12ABDB](#) [MTFDDAK512TBN-1AR12ABDB](#) [MTFDDAK256TBN-1AR12ABDA](#)