

SATA III MSATA SSD

MSA452T2

Datasheet

Products

TS1TMSA452T2

TS512GMSA452T2

TS256GMSA452T2

TS128GMSA452T2

TS64GMSA452T2

Product Description

mSATA SSD, SATA3, 3D TLC, PE: 3K, 30u"

Datasheet version

1.2



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Revision History

| Revision No. | History | Released Date | Editor by |
|--------------|---|---------------|-----------|
| 1.0 | First version (WD BICS4) | 2020/05/26 | TSD |
| 1.1 | Add Corner Bond process information Supports DEVSLP mode (Default) | 2020/07/01 | TSD |
| 1.2 | Extended the Temperature Storage from -55°C to 85°C Added 5.2.13 Early Move Function Added 5.2.14 Read Retry Function | 2020/08/25 | TSD |

Transcend MSA452T2 Features

| Part Name | Capacity |
|----------------|----------|
| TS1TMSA452T2 | 1TB |
| TS512GMSA452T2 | 512GB |
| TS256GMSA452T2 | 256GB |
| TS128GMSA452T2 | 128GB |
| TS64GMSA452T2 | 64GB |

FEATURES

- SATA 6Gbps
- 3D TLC NAND Flash
- MO-300A form factor
- DDR3 DRAM cache
- Global wear-leveling function
- Enhance Bad block management
- Power shield function
- LDPC ECC (Error correction code) functionality
- TRIM and NCQ command function
- Advanced Garbage Collection
- Internal RAID Engine
- Supports S.M.A.R.T. Function
- PCB Gold Finger 30u"
- Dynamic Thermal Throttling (Default)
- Supports DEVSLP mode (Default)
- Self-encrypting drives (SED) with AES-256 (Optional)
- Corner Bond (Key components)

- UBER 10^{-15}
- DWPD 1.61 DWPD
- MTBF 3,000,000 hours
- Data Retention 1 year
- Warranty 3 years

ENVIRONMENTAL SPECIFICATIONS¹⁾

- Temperature
 - Operating -20°C to 75°C
 - Non-operating -55°C to 85°C
- Humidity(non-condensing) 5%~95%
- Shock 1500G, 0.5ms
- Vibration 20G, 7~2000Hz

POWER REQUIREMENTS¹⁾

- Supply voltage / Tolerance 3.3V±5%
- Active (max) 2.4W
- Idle (max) 0.4W

PERFORMANCE¹⁾

- Data Transfer Rate
 - Sequential Read Up to 560 MB/s
 - Sequential Write Up to 520 MB/s

PHYSICAL DIMENSION

- Width 29.85±0.15 mm
- Length 50.80±0.15 mm
- Height Max 4.85mm
- Weight Max 8g

Note:

1) For detail information, please refer to document content.

RELIABILITY¹⁾

- TBW
 - 1TB 1,760TB
 - 512GB 880TB
 - 256GB 440TB
 - 128GB 220TB
 - 64GB 110TB

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1. Introduction

1.1 General Feature Information

Hardware Feature

- SATA 6Gbps
- Controller SM2258H
- 3D TLC NAND Flash
- Temperature operation from -20°C to 75°C
- MO-300A form factor
- Embedded DDR3 DRAM cache
- Power shield function
- PCB Gold Finger 30u”
- TCG-Opal function (Optional)
- Corner bond in key components

Firmware Feature

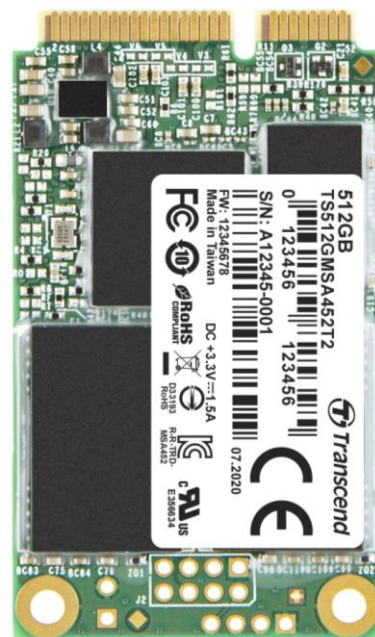
- Global wear-leveling function
- Early Move function
- Read Retry function
- Enhance Bad block management function
- LDPC ECC(Error Correction Code) function
- TRIM Command function
- Advanced Garbage Collection function
- StaticDataRefresh function
- Internal RAID Engine
- S.M.A.R.T. Function
- Dynamic Thermal Throttling (Default)
- DEVSLP mode (Default)
- AES-256 function (Optional)

Software Feature

- Transcend SSD Scope Pro

1.2 Product List

| Form Factor | Part Name | Capacity |
|-------------|----------------|----------|
| MO-300A | TS1TMSA452T2 | 1TB |
| | TS512GMSA452T2 | 512GB |
| | TS256GMSA452T2 | 256GB |
| | TS128GMSA452T2 | 128GB |
| | TS64GMSA452T2 | 64GB |



TS512GMSA452T2

1.3 Ordering Information

T S X X X G M S A 4 5 2 T 2
1 2 3 4 5 6

1 – Transcend

2 – SSD Density

3 – G: Gigabyte; T: Terabyte

4 – mSATA device

5 – 3D TLC NAND flash

6 – PCB Gold Finger 30u”

Temperature operation from -20°C to 75°C

Temperature storage from -55°C to 85°C

Default Dynamic Thermal Throttling

Corner bond in key components

2. Product Specifications

2.1 Interface and Compliance

- SATA3, compatible to SATA2 and SATA1
- Compatible with ATA/ATAPI-7 Standard
- Native Command Queuing(NCQ) Command Set
- RoHS Compliance
- CE, FCC and BSMI Compliance

2.2 Drive Capacity

[Table 1] User Capacity and Addressable Sectors

| | 64GB | 128GB | 256GB | 512GB | 1TB |
|--------------------------|-------------|-------------|-------------|---------------|---------------|
| User-Addressable Sectors | 125,045,424 | 250,069,680 | 500,118,192 | 1,000,215,216 | 2,000,409,264 |
| Byte per Sector | 512 Byte | | | | |

2.3 System Performance

[Table 2] Sequential Read / Write Performance

| Read / Write | 64GB | 128GB | 256GB | 512GB | 1TB |
|------------------|---------|---------|---------|---------|---------|
| Sequential Read | 400MB/s | 560MB/s | 560MB/s | 560MB/s | 560MB/s |
| Sequential Write | 200MB/s | 410MB/s | 410MB/s | 520MB/s | 520MB/s |

Note: Maximum transfer speed recorded

1) 25°C, test on acer X6620G, 4GB, Windows® 7 Professional with AHCI mode, benchmark utility CrystalDiskMark (version 5.1.2), copied file 1000MB.

2) The recorded performance is obtained while the SSD is not operated as an OS disk Physical Specification.

[Table 3] Random Read / Write Performance

| Read / Write | 64GB | 128GB | 256GB | 512GB | 1TB |
|-------------------|------|-------|-------|-------|-----|
| Random Read IOPS | 35K | 64K | 65K | 90K | 95K |
| Random Write IOPS | 60K | 75K | 75K | 85K | 85K |

Note: Maximum transfer speed recorded

1) 25°C, test on acer X6620G, 4GB, Windows® 7 Professional with AHCI mode, benchmark utility IOmeter2008 with 4K file size and queue depth of 32, unit IOPS

2) The recorded performance is obtained while the SSD is not operated as an OS disk Physical Specification.

2.4 Supply Voltage

[Table 4] Supply Voltage

| Item | Requirements |
|--------------------------|--------------------|
| Allowable voltage | 3.3V±5% |
| Allowable noise / ripple | 100 mV p-p or less |

2.5 System Power Consumption

[Table 5] Power Consumption

| Read / Write | 64GB | 128GB | 256GB | 512GB | 1TB |
|-----------------------------------|------|-------|-------|-------|------|
| Active Write (Max.) ¹⁾ | 1.8W | 2.0W | 2.1W | 2.3W | 2.4W |
| Active Read (Max.) ¹⁾ | 1.5W | 1.6W | 1.7W | 1.9W | 2.2W |
| Idle | 0.4W | 0.4W | 0.4W | 0.4W | 0.4W |
| DEVSLP | 5mW | | | | |

Note:

1) The power consumption is measured under SSD operation at maximum performance. The value is affected by system operation performance and workload.

2.6 Environment Specifications

[Table 6] Environment Specification

| Features | Operating ¹⁾ | Non-Operating ²⁾ |
|----------------------|--|-----------------------------|
| Temperature | -20°C to +75°C | -55°C to 85°C |
| Temperature Gradient | 60°C/Hr | 60°C/Hr |
| Humidity | 5% to 95%, non-condensing | |
| Shock | 1500G, duration 0.5 ms, 3 axis ³⁾ | |
| Vibration | 20G, 7~2000Hz, 3 axis ⁴⁾ | |

Note:

1) The operating specification is regarded as Ambient Temperature. Extended grade (-20°C to +75°C) and Industrial grade (-40°C to +85°C) indicate the temperature conditions for testing devices on programmable temperature and humidity chamber room.

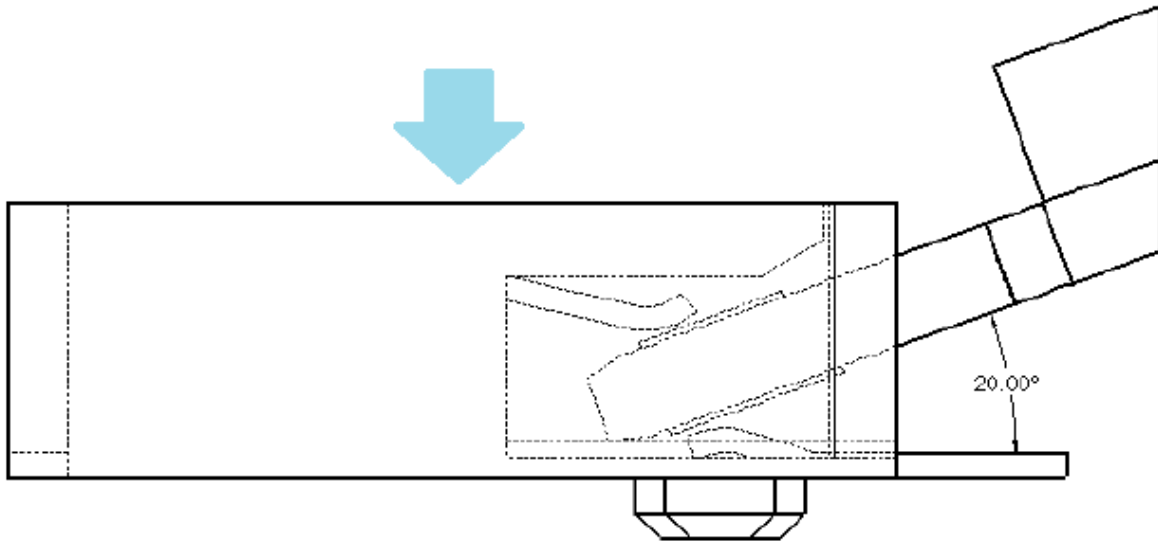
2) The non-operating specification is regarded as storage specification.

3) Refer IEC 68-2-27 standard.

4) Refer IEC 68-2-6 standard.

Recommended Measurement Point

Recommended temperature measurement point is in the center of the connector inserted by the device. Sufficient airflow is recommended for proper operation on heavier workloads within the device operating temperature.



2.7 System Reliability

[Table 7] Telcordia SR332 issue 4 MTBF Specifications

| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|-----------|-----------------|-------|-------|-------|-----|
| MTBF | 3,000,000 hours | | | | |

Note:

1) The calculation is based on 25°C.

[Table 8] UBER Specifications

| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|-----------|------------|-------|-------|-------|-----|
| UBER | 10^{-15} | | | | |

Note:

1) Uncorrectable Bit Error Rate (UBER) is a metric for the rate of occurrence of data errors, equal to the number of data errors per bits read as specified in the JESD218 document of JEDEC standard. For the client application, JEDEC recommends that UBER shall be below 10^{-15} .

[Table 9] TBW (Terabytes Written) Specifications

| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|-----------|--------|--------|--------|--------|----------|
| TBW | 110 TB | 220 TB | 440 TB | 880 TB | 1,760 TB |

Note:

1) TBW specification follows JESD219A Client workload.

[Table 10] Drive Write Per Day (DWPD) Specifications

| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|--------------------|----------------|-------|-------|-------|-----|
| DWPD ¹⁾ | 1.61 (3 years) | | | | |

Note:

1) DWPD is based on [Table 13] Warranty year to calculate.

[Table 11] Data Retention Specifications

| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|----------------|--------|-------|-------|-------|-----|
| Data Retention | 1 year | | | | |

Note:

- 1) Data retention was measured by assuming that SSD reaches the maximum rated endurance at 30°C under power-off state.
- 2) The data retention is defined in JESD218 Requirements for standard classes of SSDs.

[Table 12] Power On to Ready

| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|------------|--------|-------|-------|-------|-----|
| Setup time | 0.22 s | | | | |

[Table 13] Warranty

| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|-----------|-----------------|-------|-------|-------|-----|
| Warranty | 3 years limited | | | | |

[Table 14] Regulations

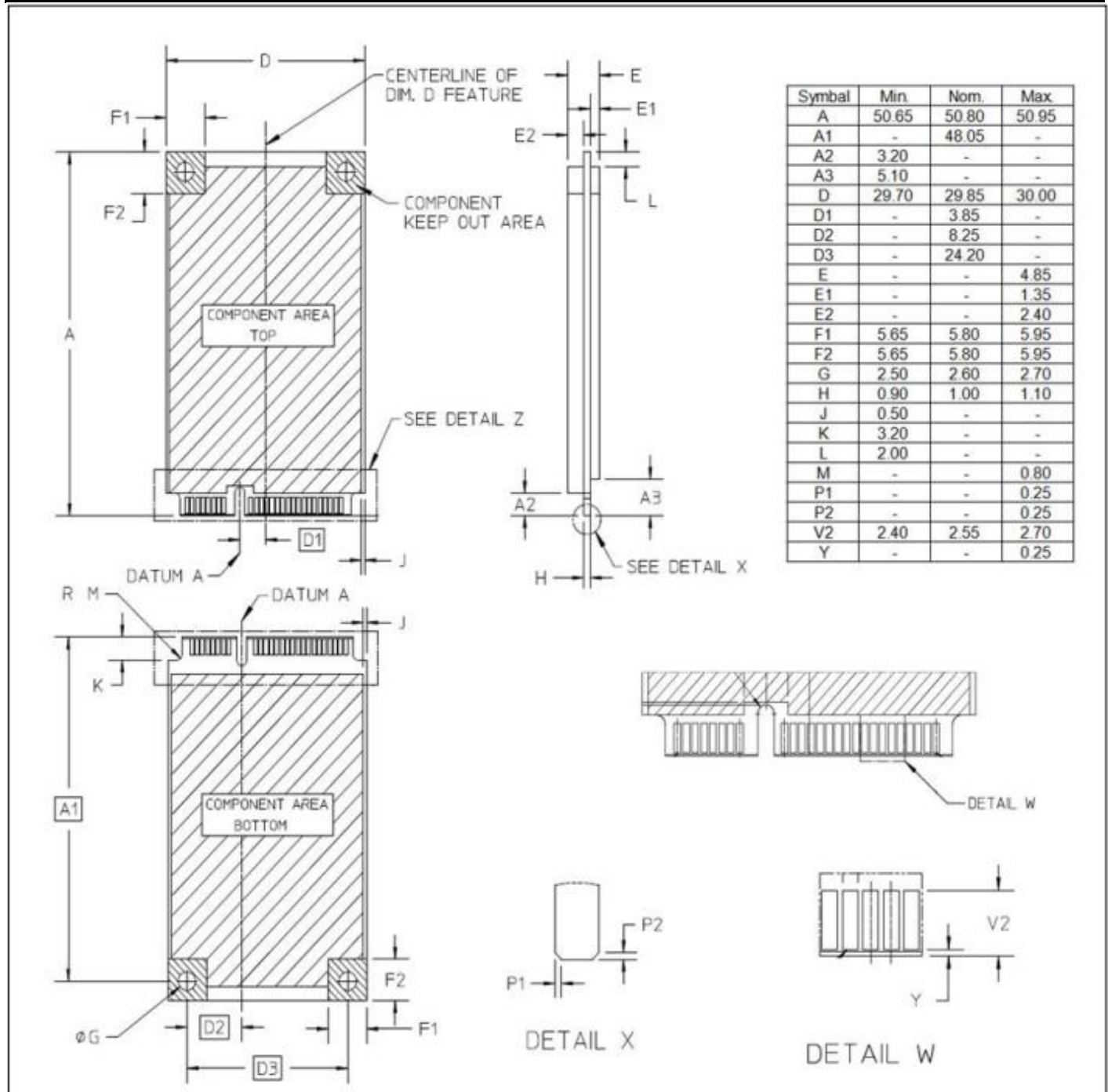
| Parameter | 64GB | 128GB | 256GB | 512GB | 1TB |
|------------|------------------|-------|-------|-------|-----|
| Compliance | CE, FCC and BSMI | | | | |

3. Mechanical Specification

The figure below illustrates the Transcend mSATA Solid State Drive.

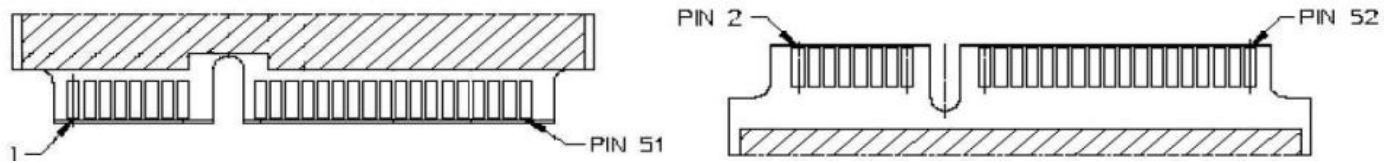
[Table 15] Physical Dimensions and Weight

| Model | Height (mm) | Width (mm) | Length (mm) | Weight (gram) |
|--------------------------------|-------------|------------|-------------|---------------|
| 64GB/128GB/256GB/ 512GB/1TB | Max 4.85 | 29.85±0.15 | 50.80±0.15 | Max 8g |



4. Pin Assignments

4.1 mSATA Serial ATA Interface



4.2 Pin Assignments

[Table 16] Pin Assignments

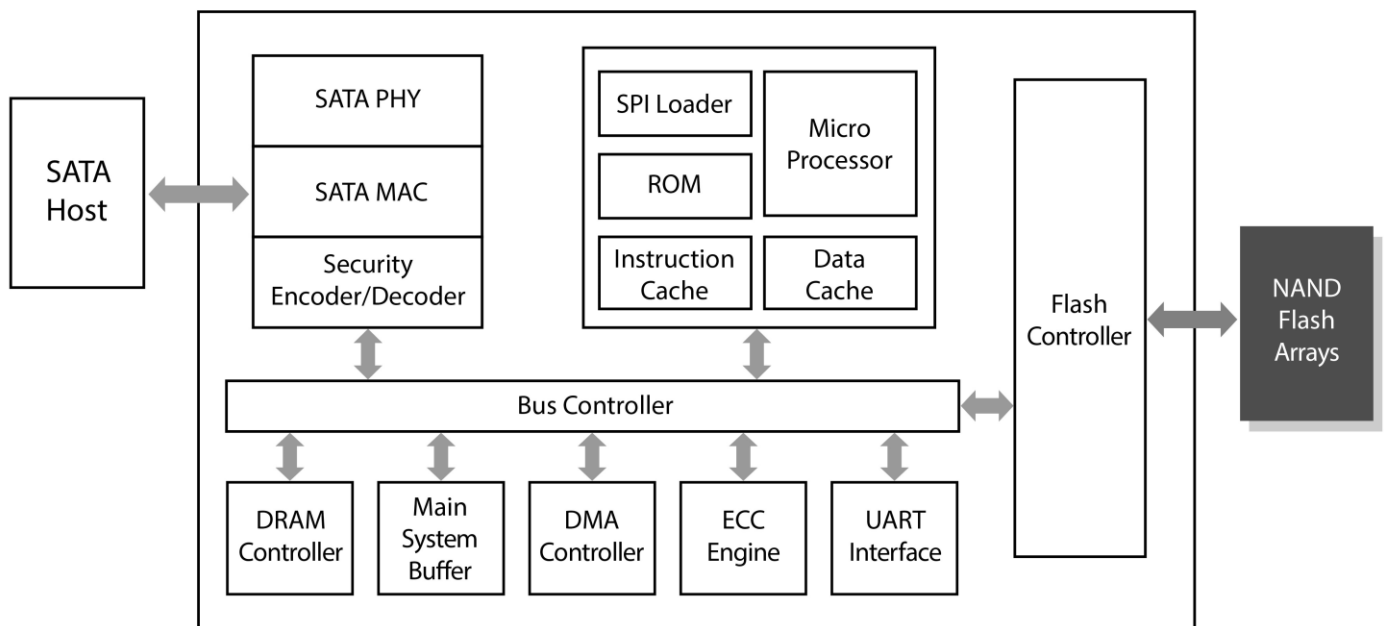
| Pin No. | Pin Name | Pin No. | Pin Name |
|---------|----------------------------------|---------|----------------------|
| 01 | NC | 02 | 3.3V |
| 03 | NC | 04 | GND ¹⁾ |
| 05 | NC | 06 | NC |
| 07 | NC | 08 | NC |
| 09 | GND ¹⁾ | 10 | NC |
| 11 | NC | 12 | NC |
| 13 | NC | 14 | NC |
| 15 | GND ¹⁾ | 16 | NC |
| 17 | NC | 18 | GND ¹⁾ |
| 19 | NC | 20 | NC |
| 21 | GND ¹⁾ | 22 | NC |
| 23 | TX+ | 24 | 3.3V |
| 25 | TX- | 26 | GND ¹⁾ |
| 27 | GND ¹⁾ | 28 | NC |
| 29 | GND ¹⁾ | 30 | NC |
| 31 | RX- | 32 | NC |
| 33 | RX+ | 34 | GND ¹⁾ |
| 35 | GND ¹⁾ | 36 | NC |
| 37 | GND ¹⁾ | 38 | NC |
| 39 | 3.3V | 40 | GND ¹⁾ |
| 41 | 3.3V | 42 | NC |
| 43 | NC | 44 | DEVSLP ³⁾ |
| 45 | NC | 46 | NC |
| 47 | NC | 48 | NC |
| 49 | DAS/DSS ²⁾ | 50 | GND ¹⁾ |
| 51 | Presence Detection ⁵⁾ | 52 | 3.3V |

Note:

- 1) For SATA M.2 SSD, these pins are connected to GND internally.
- 2) Device Activity Signal / Disable Staggered Spin-up
- 3) DEVSLP, Device Sleep is an input pin. If driven high, the host is informing the SSD to enter a low power state. (Optional)
- 4) NC. Do not connect.
- 5) Presence Detection. This pin is connected to GND internally.

5. Block Diagram and Function Explanations

5.1 Block Diagram



5.2 Function Explanations

5.2.1 Global Wear Leveling Function

Global wear leveling ensures that every block has an even erase count. This helps to extend the life expectancy of an SSD.

There are three main processes in global wear leveling:

- (1) Record the block erase count and save this in the wear-leveling table.
- (2) Find the static-block and save this in the wear-leveling pointer.
- (3) Check the erase count when a block is pulled from the pool of spare blocks. If the block erase count is larger than WEARCNT, then swap the static-block and the over-count-block.

5.2.2 Bad Block Management Function

When the flash encounters ECC fail, program fail or erase fail, the controller will mark the block as a bad block. This will prevent the usage of bad blocks which may result in data loss in the future.

5.2.3 Enhanced S.M.A.R.T. function

Transcend SSD supports S.M.A.R.T. command (Self-Monitoring, Analysis, and Reporting Technology) that allows users to read the health information of the SSD. Transcend also define some innovated S.M.A.R.T. features which allows the user to evaluate the status of the SSD in a much more efficient way.

5.2.4 StaticDataRefresh Technology

Normally, ECC engine corrections are taken place without affecting the host normal operations. As time passes by, the number of error bits accumulated in the read transaction exceeds the correcting capability of the ECC engine, resulting in corrupted data being sent to the host. In order to prevent such occurrence,

the controller monitors the error bit levels at each read operation; when it reaches the preset threshold value, the controller automatically performs data refresh to “restore” the correct charge levels in the cell. This implementation practically restores the data to its original, error-free state, and hence lengthening data life.

5.2.5 PS(Power shield) Function

Power Shield (PS) is a basic technology supported by all Transcend's embedded SSDs to prevent internal NAND flash data loss in event of a sudden power outage. The internal voltage detection circuit (VDT) of the controller monitors the external power supply. When the external voltage drops from 5V to 4V or from 3.3V to 2.7V, the VDT activates the PS detection mechanism. When a sudden power outage occurs, the internal power shield circuit would trigger the PS function so that the controller will stop accepting new write commands. The write operation is terminated to ensure that the firmware and the data in the NAND flash are undamaged.

When the external voltage drops to a certain level, the internal voltage detection circuit (VDT) of the controller activates the PS mechanism. The SSD controller then stops accepting new write commands from the host, ensuring the integrity of existing data for the NAND flash.

The PS function ensures the safety of the data which has already been written into the flash before sudden power outage.

5.2.6 DEVSLP Function(Default)

DevSlp or DevSleep (regarded as device sleep or SATA DEVSLP) is a feature in SATA SSD which allows them to go into a low power "device sleep" mode when sent the appropriate signal, which uses one or two orders of magnitude less power than a traditional idle (about 5 mW). This function can help save battery power in platform idle, so that the user can operate the platform for longer time.

5.2.7 AES-256 Function(Optional)

Defined by the National Institute of Standards and Technology (NIST) under the Federal Information Processing Standards Publication 197 (FIPS PUB 197), the Advanced Encryption Standard (AES) specifies a FIPS-approved cryptographic algorithm that can be used to protect electronic data.

Transcend Information's SSDs, equipped with hardware-based AES-256 encryption, offer superior data protection and performance compared to competing offerings that utilize software-based or firmware-based encryption. With hardware-based encryption, all data are encrypted before being stored in NAND Flash. After the encrypted data has been written into the flash, it becomes virtually impossible to decrypt the data without the original key. Performance is also improved as compared to software-based solutions, since hardware-based encryption does not require system resources to perform the encryption/decryption process.

5.2.8 TCG-Opal Function(Optional)

Opal is a comprehensive set of guidelines. The target audience includes manufacturers of storage devices, software vendors, system integrators, and academia. These specifications cover the manufacture of storage devices, system setup, management, and use; they allow for password protection and hierarchical storage management, while preventing data from being stolen or tampered with.

They are self-encrypting devices: Data encryption is performed on the device, without need to pass

through the host. The encryption key is also stored on the device (commonly AES is utilized).

(1) Features boot authentication:

When the user starts the device, the shadow MBR will conduct a pre-boot identification; where the user is cleared, the normal boot process will begin and connections to the devices are to be made.

(2) Sector specific permissions:

The device manager may create a logical block address (LBA) range and assign different permissions for each LBA range. Only users with the correct key for a particular LBA range may perform permitted actions. Where drive locations are password-protected, only users with the correct key will be authorized entry.

5.2.9 Hardware-purge function(Optional)

Hardware purge is the effective, hardware-based erasure of all data blocks in flash memory, which returns the SSD to its original state at the time of manufacture. Compared to software-based methods which utilize the ATA command to erase data, hardware purge uses an external switch to adjust the voltage level from High to Low via the controller's General Purpose Input/Output. By short-circuiting the hardware purge pin, the quick erase function is activated and all data written to the SSD is fully erased. Erased data is non-recoverable, meaning that confidential information is made safe by being destroyed.

In addition to data encryption, Transcend Information offers a variety of SATA III SSD models that can be equipped with a hardware purge function to execute a quick, secure erase. The hardware purge pin is connected to the designated pin of the controller's GPIO¹. With Transcend's hardware purge feature, sensitive data can be securely, permanently erased in an effective way.

Note:

1) Customized firmware settings are required to support the hardware purge pin.

5.2.10 RAID engine

RAID engine technology stores data parity information in a specific area. The parity information can restore damaged data back which can enhance data reliability.

5.2.11 Dynamic Thermal Throttling

For 3D TLC SSD applications, when operation temperature increases, system CLK will decrease to protect the SSD and controller with dynamic thermal throttling algorithm. The read/write speeds of the SSD will change at different temperature levels in order to extend its lifespan.

5.2.12 Transcend SSD Scope Pro

Transcend's SSD Scope Pro is a convenient software package that helps users monitor and manage SSD status via an intuitive interface. It offers various useful features, including drive information and S.M.A.R.T. status monitoring, diagnostic scan, secure erase, health indication, system clone, and monitoring. For more information, please refer the website link. <https://us.transcend-info.com/Embedded/Essay-20>

5.2.13 Early Move Function

Early move detects and corrects potential data errors. If error bits in a block reach upper limit, then the data should be moved to another block and the original block should be erased.

5.2.14 Read Retry Function

Read retry is designed for flash memory to adjust the read reference voltage and eliminate the read error.

5.2.15 Corner Bond (Key Components)

Corner bond is used as a stress relieving agent, evenly distributing the expansion and contraction effects. By spreading stresses throughout the chip and PCB interface with a mechanical bond, less stress is concentrated on the solder joints, increasing device reliability.

5.2.16 Other Functions

Transcend SSD embedded a lot of cutting-edge technology. Should you have any technical request, please contact the local support team or send us an e-mail.

6. Technology Term Explanations

6.1 TBW

Terabytes Written (TBW) directly measures how much you can write cumulatively into the drive over its lifetime. Essentially, it just includes the multiplication conducted above in the measurement itself.

For example, if your drive is rated for 365 TBW, that means you can write 365 TB into it before a replacement is required.

If its warranty period is 5 years, that works out to $365 \text{ TB} \div (5 \text{ years} \times 365 \text{ days/year}) = 200 \text{ GB}$ of writes per day. If your drive was 200 GB in size, that's equivalent to 1 DWPD. Correspondingly, if your drive was rated for 3.65 PBW = 3,650 TBW, that works out to 2 TB of writes per day, or 10 DWPD.

As you can see, if you know the drive's size and warranty period, you can always calculate TBW from DWPD and vice-versa with simple multiplications or divisions. The two measurements are very similar.

6.2 DWPD

Drive Writes Per Day (DWPD) measures how many times you could overwrite the drive's entire size each day of its life. For example, suppose your drive is 200 GB and its warranty period is 5 years. If its DWPD is 1, that means you can write 200 GB (its size, one time) into it every single day for the next five years.

If you multiply that out, that's $200 \text{ GB per day} \times 365 \text{ days/year} \times 5 \text{ years} = 365 \text{ TB}$ of cumulative writes before you may need to replace it.

If the DWPD is 10 instead of 1, that means you can write $10 \times 200 \text{ GB} = 2 \text{ TB}$ (its size, ten times) into it every day. Correspondingly, that's $3,650 \text{ TB} = 3.65 \text{ PB}$ of cumulative writes over 5 years.

6.3 MTBF – Telcordia SR-332

MTBF (mean time between failures) is a measure of how reliable a hardware product or component is. For most components, the measurement is typically in thousands or even tens of thousands of hours between failures. For example, a SSD may have a mean time between failures of 200,000 hours. A desired MTBF can be used as a quantifiable objective when designing a new product. The MTBF figure can be developed as the result of intensive testing, based on actual product experience, or predicted by analyzing known factors. The manufacturer may provide it as an index of a product's or component's reliability and, in some cases, to give customers an idea of how much service to plan for. In Transcend MTBF data, we use Telcordia SR-332 Issue 4 method to do estimated calculation.

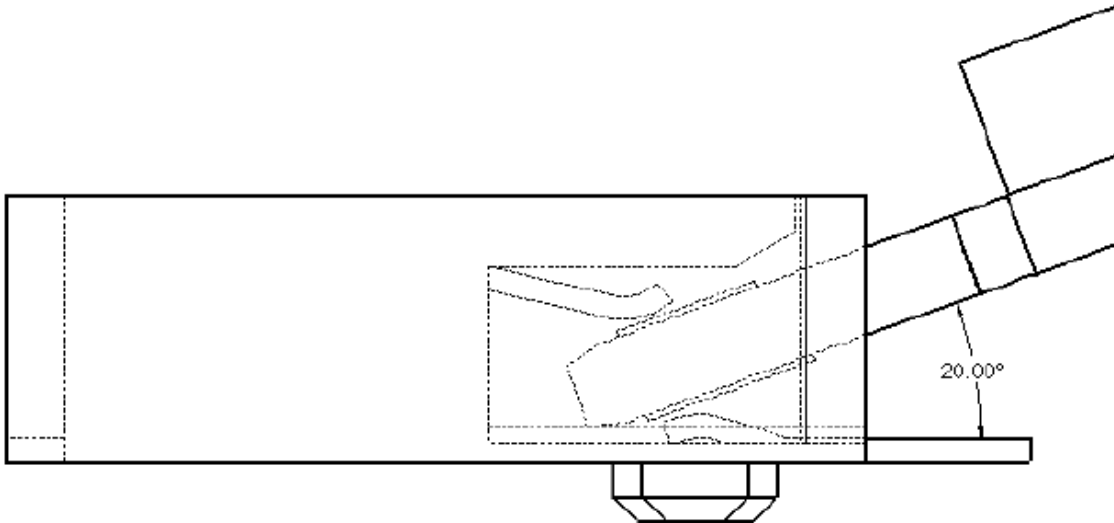
7. Installation Requirements

7.1 Card Insertion

Angles insertion is allowable and preferred; the intention is to minimize the insertion/extraction force.

- Minimum of angle of insertion is 5°

Minimum two step insertion is desirable; the intention is to minimize the insertion/extraction force.



8. Command Descriptions

8.1 Support ATA Commands

This table and the following paragraphs summarize the ATA command set.

[Table 17] ATA Command Table

| Support ATA/ATAPI Command | Code | Subcode / Page |
|--|------|----------------|
| NOP | 00h | |
| Data Set Management | 06h | |
| Trim | | 01h |
| Recalibrate | 1Xh | |
| Read Sectors | 20h | |
| Read Sectors (w/o retry) | 21h | |
| Read Sectors Ext | 24h | |
| Read DMA Ext | 25h | |
| Read Native Max Address Ext | 27h | |
| Read Multiple Ext | 29h | |
| Read Log Ext | 2Fh | |
| Log Directory | | 00h |
| Extended Comprehensive SMART Error Log | | 03h |
| Device Statistics Logs | | 04h |
| <i>List of supported log pages</i> | | 00h |
| <i>General Statistics</i> | | 01h |
| <i>General Errors Statistics</i> | | 04h |
| <i>Transport Statistics</i> | | 06h |
| <i>SSD Statistics</i> | | 07h |
| Extended SMART Self-test Log | | 07h |
| NCQ Error Log | | 10h |
| SATA Phy Event Counters Log | | 11h |
| Identify Device Data Log | | 30h |
| <i>List of Supported Pages</i> | | 00h |
| <i>Copy of IDENTIFY DEVICE Data</i> | | 01h |
| <i>Capacity</i> | | 02h |
| <i>Supported Capabilities</i> | | 03h |
| <i>Current Settings</i> | | 04h |
| <i>ATA Strings</i> | | 05h |
| <i>Security</i> | | 06h |
| <i>Serial ATA</i> | | 08h |
| Write Sectors | 30h | |
| Write Sectors Ext | 34h | |
| Write DMA Ext | 35h | |

| | | |
|---|-----|---------|
| Set Max Address Ext | 37h | |
| Write Multiple Ext | 39h | |
| Write DMA FUA Ext | 3Dh | |
| Write Log Ext | 3Fh | |
| Selective Self-Test log(SMART) | | 09h |
| Host Specific(SMART) | | 80h~9Fh |
| SCT Command/Status(SCT) | | E0h |
| SCT Data Transfer(SCT) | | E1h |
| Read Verify Sectors | 40h | |
| Read Verify Sectors (w/o retry) | 41h | |
| Read Verify Sectors Ext | 42h | |
| Write Uncorrectable Ext | 45h | |
| Pseudo-UECC with logging | | 55h |
| Read FPDMA Queued | 60h | |
| Write FPDMA Queued | 61h | |
| Seek | 7Xh | |
| Execute Device Diagnostic | 90h | |
| Initialize Drive Parameters | 91h | |
| Download Microcode | 92h | |
| Download with offsets and save microcode for immediate and future use. | | 03h |
| Download (without offsets) and save microcode | | 07h |
| Download with offsets and save microcode for future use / Activate downloaded microcode | | 0Eh/0Fh |
| SMART | B0h | |
| Read Data | | D0h |
| Read Thresholds | | D1h |
| Enable/Disable Attr Autosave | | D2h |
| Exec Off-line Immediate | | D4h |
| <i>Execute Off-Line routine</i> | | 00h |
| <i>Execute Short Self-test routine (Off-Line)</i> | | 01h |
| <i>Execute Extended Self-test routine (Off-Line)</i> | | 02h |
| <i>Abort Off-Line Self-test routine</i> | | 7Fh |
| <i>Execute Short Self-test routine (Captive)</i> | | 81h |
| <i>Execute Extended Self-test routine (Captive)</i> | | 82h |
| Read Log Sector | | D5h |
| Write Log Sector | | D6h |
| Enable Operations | | D8h |
| Disable Operations | | D9h |
| Return Status | | Dah |
| Sanitize Device | B4h | |

| | | |
|---------------------------|-----|-----|
| Sanitize Status Ext | | 00h |
| Block Erase Ext | | 12h |
| Sanitize Freeze Lock Ext | | 20h |
| Read Multiple | C4h | |
| Write Multiple | C5h | |
| Set Multiple Mode | C6h | |
| Read DMA | C8h | |
| Read DMA (w/o retry) | C9h | |
| Write DMA | CAh | |
| Write DMA (w/o retry) | CBh | |
| Write Multiple FUA Ext | CEh | |
| Standby Immediate | E0h | |
| Idle Immediate | E1h | |
| Standby | E2h | |
| Idle | E3h | |
| Read Buffer | E4h | |
| Check Power Mode | E5h | |
| Sleep | E6h | |
| Flush Cache | E7h | |
| Write Buffer | E8h | |
| Flush Cache Ext | EAh | |
| Identify Device | ECh | |
| Set Features | EFh | |
| Security Set Password | F1h | |
| Security Unlock | F2h | |
| Security Erase Prepare | F3h | |
| Security Erase Unit | F4h | |
| Security Freeze Lock | F5h | |
| Security Disable Password | F6h | |
| Read Native Max Address | F8h | |
| Set Max Address | F9h | |
| Set Max Set Password | | 01h |
| Set Max Lock | | 02h |
| Set Max Unlock | | 03h |
| Set Max Freeze Lock | | 04h |
| Set Max Set Password DMA | | 05h |
| Set Max Unlock DMA | | 06h |

8.2 SMART Data Structure

[Table 18] SMART Data Structure

| BYTE | F / V | Description |
|---------|-------|--|
| 0-1 | X | Revision code |
| 2-361 | X | Vendor specific |
| 362 | V | Off-line data collection status |
| 363 | X | Self-test execution status byte |
| 364-365 | V | Total time in seconds to complete off-line data collection activity |
| 366 | X | Vendor specific |
| 367 | F | Off-line data collection capability |
| 368-369 | F | SMART capability |
| 370 | F | Error logging capability 7-1 Reserved 0 1=Device error logging supported |
| 371 | X | Vendor specific |
| 372 | F | Short self-test routine recommended polling time (in minutes) |
| 373 | F | Extended self-test routine recommended polling time (in minutes) |
| 374 | F | Conveyance self-test routine recommended polling time (in minutes) |
| 375-385 | R | Reserved |
| 386-395 | F | Firmware Version/Date Code |
| 396-399 | F | Reserved |
| 400-409 | V | SMI2258TLC |
| 410-510 | X | Vendor specific |
| 511 | V | Data structure checksum |

Note:

- 1) F = content (byte) is fixed and does not change.
- 2) V= content (byte) is variable and may change depending on the state of the device or the commands executed by the device.
- 3) X= content (byte) is vendor specific and may be fixed or variable.
- 4) R= content (byte) is reserved and shall be zero.

8.3 SMART Attributes

The following table shows the vendor specific data in byte 2 to 361 of 512-byte SMART data.

[Table 19] SMART Attributes

| Attribute ID (hex) | Raw Attribute Value | | | | | | | Attribute Name |
|--------------------|---------------------|-----|----|-----|----|----|-----|---|
| 01 | MSB | 00 | 00 | 00 | 00 | 00 | 00 | Read Error Rate |
| 05 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Reallocated sectors count |
| 09 | LSB | - | - | MSB | 00 | 00 | 00 | Power-on hours |
| 0C | LSB | - | - | MSB | 00 | 00 | 00 | Power Cycle Count |
| 94 | LSB | - | - | MSB | 00 | 00 | 00 | SLC Total Erase Count |
| 95 | LSB | - | - | MSB | 00 | 00 | 00 | SLC Max Erase Count |
| 96 | LSB | - | - | MSB | 00 | 00 | 00 | SLC Min Erase Count |
| 97 | LSB | - | - | MSB | 00 | 00 | 00 | SLC Average Erase Count |
| 9F | LSB | - | - | MSB | 00 | 00 | 00 | DRAM one bit error count |
| A0 | LSB | - | - | MSB | 00 | 00 | 00 | Uncorrectable sectors count when read/write |
| A1 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Number of valid spare blocks |
| A3 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Number of initial invalid blocks |
| A4 | LSB | - | - | MSB | 00 | 00 | 00 | TLC Total erase count |
| A5 | LSB | - | - | MSB | 00 | 00 | 00 | TLC Maximum erase count |
| A6 | LSB | - | - | MSB | 00 | 00 | 00 | TLC Minimum erase count |
| A7 | LSB | - | - | MSB | 00 | 00 | 00 | TLC Average erase count |
| A8 | LSB | - | - | MSB | 00 | 00 | 00 | Max erase count of spec |
| A9 | LSB | - | - | MSB | 00 | 00 | 00 | Remain Life (percentage) |
| B1 | LSB | - | - | MSB | 00 | 00 | 00 | Total wear level count |
| B5 | LSB | - | - | MSB | 00 | 00 | 00 | Total program fail count |
| B6 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Total erase fail count |
| C0 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Power-off retract Count |
| C2 | MSB | 00 | 00 | 00 | 00 | 00 | 00 | Controller temperature ¹⁾ |
| C3 | LSB | - | - | MSB | 00 | 00 | 00 | Hardware ECC recovered |
| C4 | LSB | - | - | MSB | 00 | 00 | 00 | Reallocation event count |
| C7 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Ultra DMA CRC Error Count |
| E8 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Available reserved space |
| F1 | LSB | - | - | - | - | - | MSB | Total LBA written (each write unit = 32MB) |
| F2 | LSB | - | - | - | - | - | MSB | Total LBA read (each read unit = 32MB) |
| F5 | LSB | - | - | - | - | - | MSB | Flash write sector count |

Note:

1) Controller temperature is only presented as a positive value.

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