SATA III MSATA SSD

MSA372M

Datasheet

Products

TS1TMSA372M

TS512GMSA372M

TS256GMSA372M

TS128GMSA372M

TS64GMSA372M

TS32GMSA372M

TS16GMSA372M

Product Description

mSATA SSD, SATA3, MLC, 30u”

Datasheet version

1.1

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Revision History

Revision No.	History	Released Date	Editor by
1.0	First version (WD-15nm)	2021/10/05	TSD
1.1	Add Corner Bond process information Add PCB Gold Finger 30u" information	2021/12/01	TSD

Transcend MSA372M Features

Part Name	Capacity
TS1TMSA372M	1TB
TS512GMSA372M	512GB
TS256GMSA372M	256GB
TS128GMSA372M	128GB
TS64GMSA372M	64GB
TS32GMSA372M	32GB
TS16GMSA372M	16GB

FEATURES

- SATA 6Gbps
- 2D MLC NAND Flash
- MO-300A form factor
- DDR3 DRAM cache
- Global wear-leveling function
- Enhance Bad block management
- Power shield function
- BCH ECC function
- TRIM Command function
- Advanced Garbage Collection
- Supports S.M.A.R.T. function
- PCB Gold Finger 30u”
- Supports DEVSLP mode
- Self-encrypting drives(SED) with AES-256 (Optional)
- Corner Bond (Key components)

PERFORMANCE[1)]

- Data Transfer Rate
  - Sequential Read Up to 550 MB/s
  - Sequential Write Up to 450 MB/s

RELIABILITY[1)]

- TBW
  - 1TB 2360TB
  - 512GB 1480TB
  - 256GB 740TB
  - 128GB 360TB
  - 64GB 180TB
  - 32GB 90TB
  - 16GB 45TB
- UBER 10^{-15}
- DWPD 2.6 DWPD
- MTBF 2,500,000 hours
- Data Retention 1 year
- Warranty 3 years

ENVIRONMENTAL SPECIFICATIONS[1)]

- Temperature
  - Operating 0°C to 70°C
  - Non-operating -40°C to 85°C
- Humidity(non-condensing) 5%~95%
- Shock 1500G, 0.5ms
- Vibration 20G, 7~2000Hz

POWER REQUIREMENTS[1)]

- Supply voltage / Tolerance 3.3V±5%
- Active (max) 2.64W
- Idle (max) 0.40W

PHYSICAL DIMENSION

- Width 29.85±0.15mm
- Length 50.8±0.15mm
- Height Max 4.85mm
- Weight 8g

Note:

1) For detail information, please refer to document content

Table of Content

1. Introduction

1.1 General Feature Information

Hardware Feature

- SATA 6Gbps
- Transcend Controller TS6500
- 2D MLC NAND Flash
- Temperature operation from 0°C to 70°C
- MO-300A form factor
- Embedded DDR3 DRAM cache
- Power shield function
- PCB Gold Finger 30u”
- AES-256 function (Optional)
- Hardware-purge function (Optional)
- Corner bond in key components

Firmware Feature

- Global wear-leveling function
- Enhance Bad block management function
- BCH ECC(Error Correction Code) function
- TRIM Command function
- Advanced Garbage Collection function
- StaticDataRefresh function
- S.M.A.R.T. function
- DEVSLP mode
- TCG-Opal function (Optional)

Software Feature

- Transcend SSD Scope Pro
- Transcend Control Center
- Transcend One Touch Recovery

1.2 Product List

Form Factor	Part Name	Capacity
MO-300A	TS1TMSA372M	1TB
	TS512GMSA372M	512GB
	TS256GMSA372M	256GB
	TS128GMSA372M	128GB
	TS64GMSA372M	64GB
	TS32GMSA372M	32GB
	TS16GMSA372M	16GB

1.3 Ordering Information

T S X X X G M S A 3 7 2M

1 2 3 4 5

1 – Transcend

2 – SSD Density

3 – G: Gigabyte; T: Terabyte

4 – SATA device with mSATA form factor

5 – Model name with 2D MLC NAND Flash
PCB Gold Finger 30u”
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, UKCA, FCC and BSMI Compliance

2.2 Drive Capacity

[Table 1] User Capacity and Addressable Sectors

	16GB	32GB	64GB	128GB
User-Addressable Sectors	31,277,232	62,533,296	125,045,424	250,069,680
Byte per Sector	512 Byte			

	256GB	512GB	1TB
User-Addressable Sectors	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	16GB	32GB	64GB	128GB
Sequential Read	140MB/S	280MB/s	520MB/s	520MB/s
Sequential Write	25MB/s	50MB/s	100MB/s	200MB/s

Read / Write	256GB	512GB	1TB
Sequential Read	520MB/s	520MB/s	550MB/s
Sequential Write	400MB/s	470MB/s	450MB/s

Note: Maximum transfer speed recorded

1) 25°C, test on Asus P8Z68-M PRO, 4GB, Windows® 7 Professional with AHCI mode, benchmark utility CrystalDiskMark (version 3.0.1), 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	16GB	32GB	64GB	128GB
Random Read IOPS	13K	26K	50K	70K
Random Write IOPS	6K	13K	25K	50K

Read / Write	256GB	512GB	1TB
Random Read IOPS	70K	70K	70K
Random Write IOPS	75K	75K	70K

Note: Maximum transfer speed recorded

1) 25°C, test on Asus P8Z68-M PRO, 4GB, Windows® 7 Professional with AHCI mode, benchmark utility IOmeter2006 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	16GB	32GB	64GB	128GB
Active Write (Max.)[1)]	0.59W	0.66W	0.81W	1.22W
Active Read (Max.)[1)]	0.58W	0.63W	0.74W	0.81W
Idle	0.26W	0.28W	0.28W	0.28W
DEVSLP	5mW			

Read / Write	256GB	512GB	1TB
Active Write (Max.)[1)]	1.82W	2.38W	2.64W
Active Read (Max.)[1)]	0.84W	0.89W	1.88W
Idle	0.28W	0.30W	0.40W
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	0°C to +70°C	-40°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. Standard grade (0°C to +70°C) and Industrial grade (-40°C to +85°C) indicate the temperature conditions for testing devices on programmable temperature and humidity chamber room.

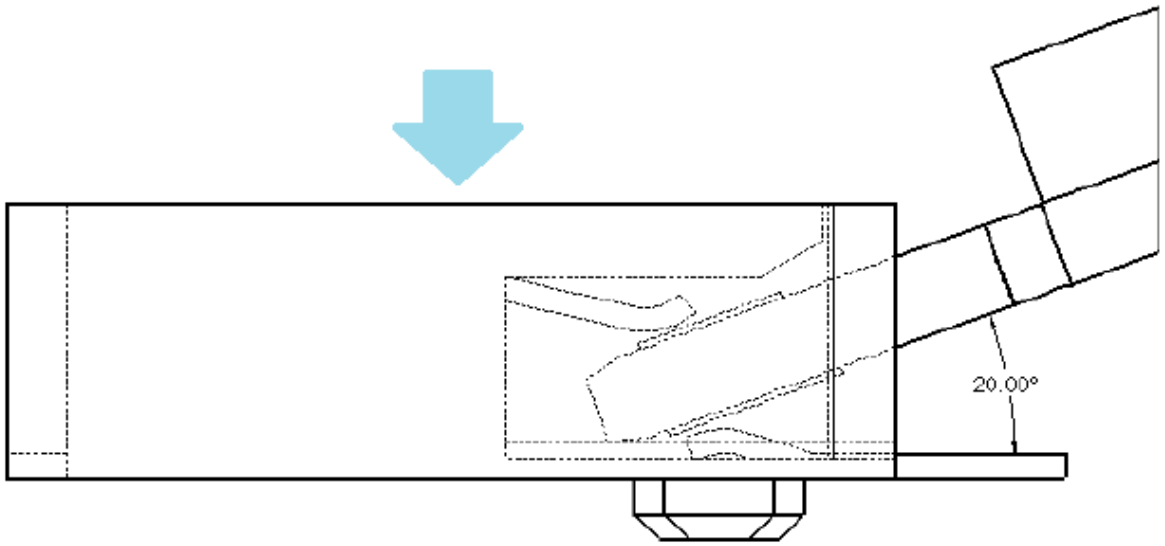
2) The non-operating specification is regarded as storage specification.

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 SR-332 issue 4 MTBF Specifications

Parameter	16GB	32GB	64GB	128GB	256GB	512GB	1TB
MTBF	2,500,000 hours						

Note:

1) The calculation is based on 25°C.

[Table 8] UBER Specifications

Parameter	16GB	32GB	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	16GB	32GB	64GB	128GB	256GB	512GB	1TB
TBW	45TB	90TB	180TB	360TB	740TB	1480TB	2360TB

Note:

1) TBW specification follows JESD219A Client workload.

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

Parameter	16GB	32GB	64GB	128GB	256GB	512GB	1TB
DWPD[1)]	2.6 (3 years)						

Note:

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

[Table 11] Data Retention Specifications

Parameter	16GB	32GB	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	16GB	32GB	64GB	128GB	256GB	512GB	1TB
Setup time	0.4 s						

[Table 13] Warranty

Parameter	16GB	32GB	64GB	128GB	256GB	512GB	1TB
Warranty	3 years limited						

[Table 14] Regulations

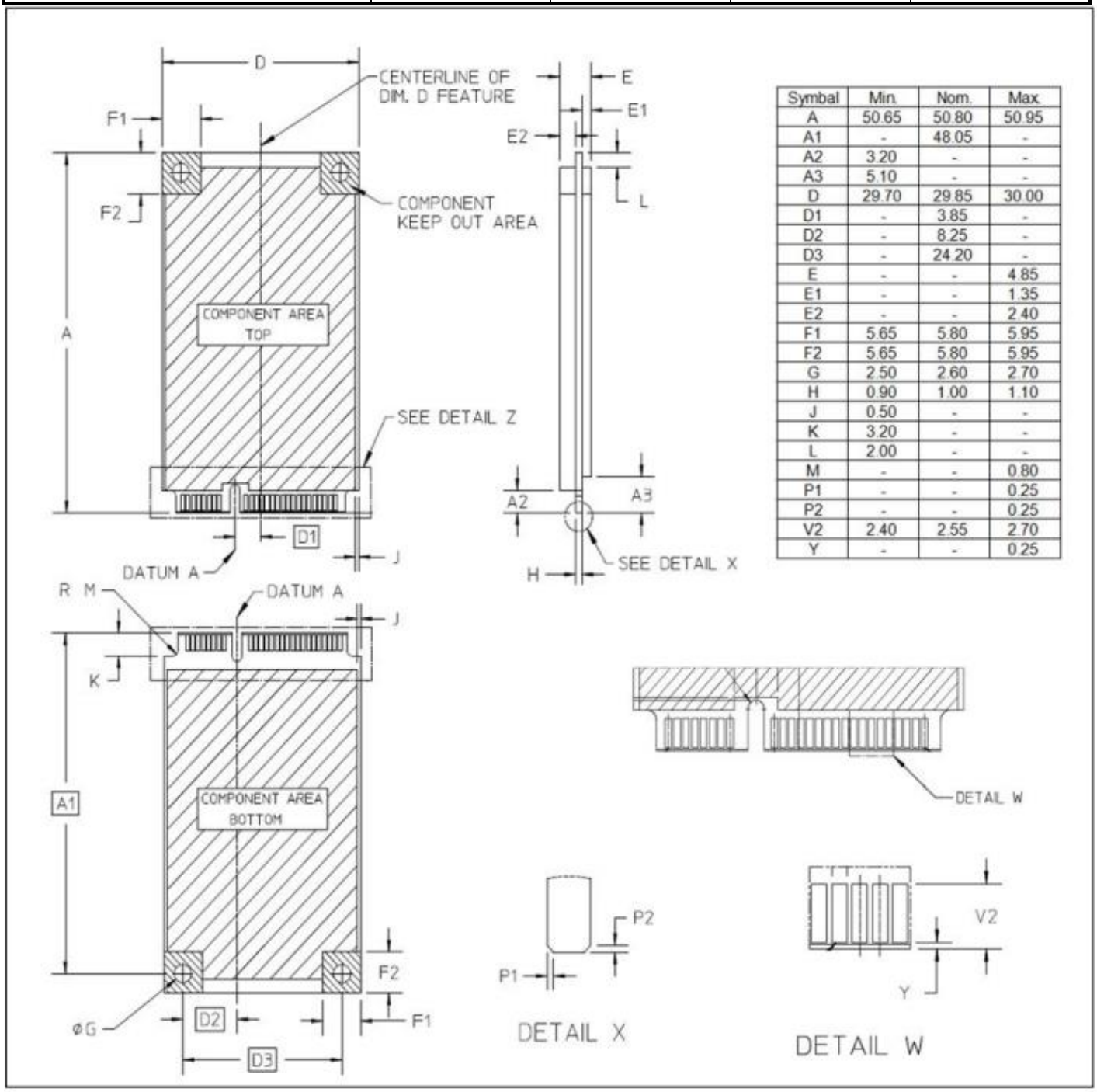
Parameter	16GB	32GB	64GB	128GB	256GB	512GB	1TB
Compliance	CE, UKCA, FCC and BSMI						

3. Mechanical Specification

The figure below illustrates the Transcend mSATA Solid State Drive.

[Table 15] Physical Dimensions and Weight

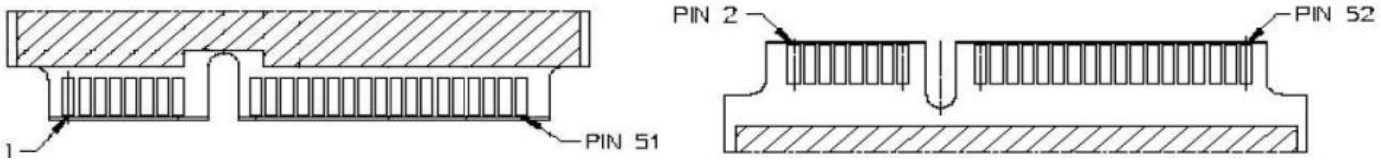
Model	Height (mm)	Width (mm)	Length (mm)	Weight (gram)
16GB/32GB/64GB/128GB/256GB /512GB/1TB	Max 4.85	29.85±0.15	50.8.±0.15	8g



Symbol	Min.	Nom.	Max.
A	50.65	50.80	50.95
A1	-	48.05	-
A2	3.20	-	-
A3	5.10	-	-
D	29.70	29.85	30.00
D1	-	3.85	-
D2	-	8.25	-
D3	-	24.20	-
E	-	-	4.85
E1	-	-	1.35
E2	-	-	2.40
F1	5.65	5.80	5.95
F2	5.65	5.80	5.95
G	2.50	2.60	2.70
H	0.90	1.00	1.10
J	0.50	-	-
K	3.20	-	-
L	2.00	-	-
M	-	-	0.80
P1	-	-	0.25
P2	-	-	0.25
V2	2.40	2.55	2.70
Y	-	-	0.25

4. Pin Assignments

4.1 mSATA Serial ATA Interface



4.2 Pin Assignments

[Table 16] Pin Assignments

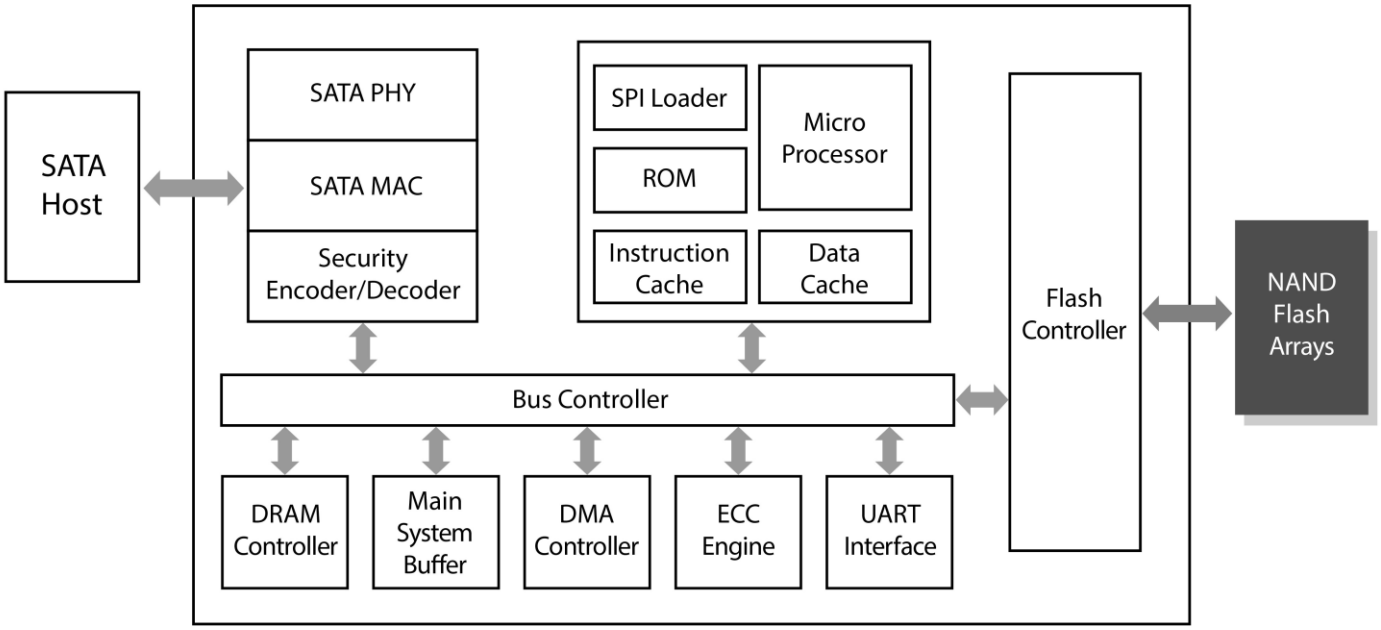
Pin No.	Pin Name	Pin No.	Pin Name
01	NC	02	3.3V
03	NC	04	GND[1)]
05	NC	06	NC
07	NC	08	NC
09	GND[1)]	10	NC
11	NC	12	NC
13	NC	14	NC
15	GND[1)]	16	NC
17	NC	18	GND[1)]
19	NC	20	NC
21	GND[1)]	22	NC
23	TX+	24	3.3V
25	TX-	26	GND[1)]
27	GND[1)]	28	NC
29	GND[1)]	30	NC
31	RX-	32	NC
33	RX+	34	GND[1)]
35	GND[1)]	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 mSATA SSD, these pins are connected to GND internally.
2) Device Activity Signal / Disable Staggered Spin-up
3) Device Sleep is an input pin. If driven high, the host is informing the SSD to enter a low power state.
4) NC means the SSD does not connect to these pins 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 take place without affecting the normal operations of the host. As time passes by, the number of error bits, accumulated in the read transaction, exceeds the correcting capability of the ECC engine and causes corrupted data to be 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

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 more 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 an 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 manufacturing of storage devices, system setup, management, and use; they allow 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 the 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 and permanently erased in an effective way.

Note:

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

5.2.10 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**

5.2.11 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.

5.2.12 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 TB ÷ (5 years × 365 days/year) = 200 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 GB per day × 365 days/year × 5 years = 365 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 × 200 GB = 2 TB (its size, ten times) into it every day. Correspondingly, that's 3,650 TB = 3.65 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.

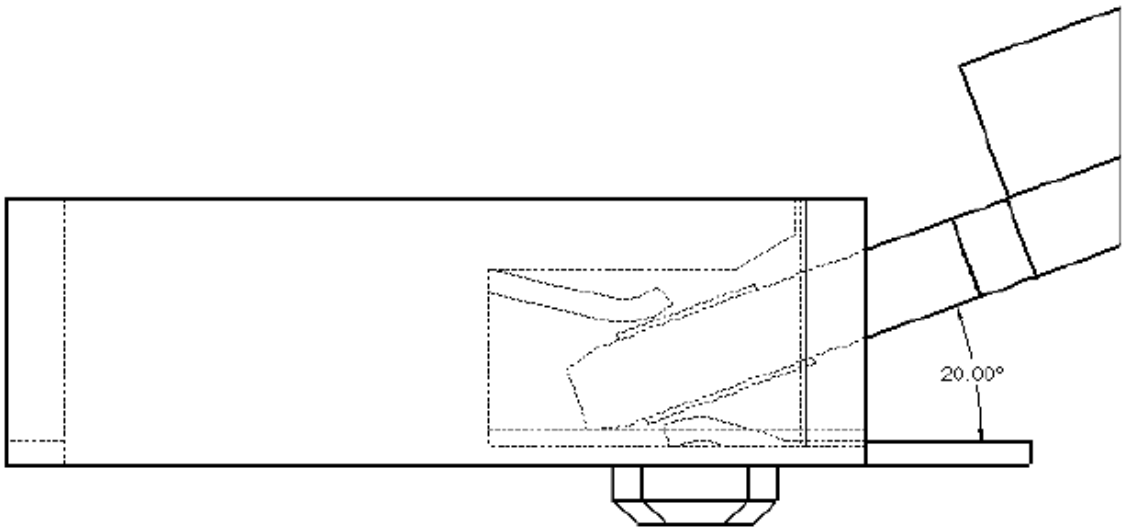
7. Installation Requirements

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	Protocol
General Feature Set		
EXECUTE DIAGNOSTICS	90h	Device diagnostic
FLUSH CACHE	E7h	Non-data
IDENTIFY DEVICE	ECh	PIO data-In
Initialize Drive Parameters	91h	Non-data
READ DMA	C8h	DMA
READ LOG Ext	2Fh	PIO data-In
READ MULTIPLE	C4h	PIO data-In
READ SECTOR(S)	20h	PIO data-In
READ VERIFY SECTOR(S)	40h or 41h	Non-data
SET FEATURES	EFh	Non-data
SET MULTIPLE MODE	C6h	Non-data
WRITE DMA	CAh	DMA
WRITE MULTIPLE	C5h	PIO data-out
WRITE SECTOR(S)	30h	PIO data-out
NOP	00h	Non-data
READ BUFFER	E4h	PIO data-out
WRITE BUFFER	E8h	PIO data-out
Power Management Feature Set		
CHECK POWER MODE	E5h or 98h	Non-data
IDLE	E3h or 97h	Non-data
IDLE IMMEDIATE	E1h or 95h	Non-data
SLEEP	E6h or 99h	Non-data
STANDBY	E2h or 96h	Non-data
STANDBY IMMEDIATE	E0h or 94h	Non-data
Security Mode Feature Set		
SECURITY SET PASSWORD	F1h	PIO data-out
SECURITY UNLOCK	F2h	PIO data-out
SECURITY ERASE PREPARE	F3h	Non-data
SECURITY ERASE UNIT	F4h	PIO data-out
SECURITY FREEZE LOCK	F5h	Non-data
SECURITY DISABLE PASSWORD	F6h	PIO data-out
SMART Feature Set		
SMART Disable Operations	B0h	Non-data

SMART Enable/Disable Autosave	B0h	Non-data
SMART Enable Operations	B0h	Non-data
SMART Execute Off-Line Immediate	B0h	Non-data
SMART Read LOG	B0h	PIO data-In
SMART Read Data	B0h	PIO data-In
SMART Read THRESHOLD	B0h	PIO data-In
SMART Return Status	B0h	Non-data
SMART SAVE ATTRIBUTE VALUES	B0h	Non-data
SMART WRITE LOG	B0h	PIO data-out
Host Protected Area Feature Set		
Read Native Max Address	F8h	Non-data
Set Max Address	F9h	Non-data
Set Max Set Password	F9h	PIO data-out
Set Max Lock	F9h	Non-data
Set Max Freeze Lock	F9h	Non-data
Set Max Unlock	F9h	PIO data-out
48-bit Address Feature Set		
Flush Cache Ext	Eah	Non-data
Read Sector(s) Ext	24h	PIO data-in
Read DMA Ext	25h	DMA
Read Multiple Ext	29h	PIO data-in
Read Native Max Address Ext	27h	Non-data
Read Verify Sector(s) Ext	42h	Non-data
Set Max Address Ext	37h	Non-data
Write DMA Ext	35h	DMA
Write Multiple Ext	39h	PIO data-out
Write Sector(s) Ext	34h	PIO data-out
NCQ Feature Set		
Read FPDMA Queued	60h	DMA Queued
Write FPDMA Queued	61h	DMA Queued
Other		
Data Set Management	06h	DMA
SEEK	70h	Non-data

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
396-397	F	Reserved
398-399	V	Reserved
400-406	V	TS6500
407-415	X	Vendor specific
416	F	Reserved
417	F	Program/write the strong page only
418-419	V	Number of spare block
420-423	V	Average Erase Count
424-510	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
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	Total erase count
A5	LSB	-	-	MSB	00	00	00	Maximum erase count
A6	LSB	-	-	MSB	00	00	00	Minimum erase count
A7	LSB	-	-	MSB	00	00	00	Average erase count
A8	LSB	-	-	MSB	00	00	00	Max erase count of spec
A9	LSB	-	-	MSB	00	00	00	Remain Life (percentage)
AF	LSB	-	-	MSB	00	00	00	Program fail count in worst die
B0	LSB	MSB	00	00	00	00	00	Erase fail count in worst die
B1	LSB	-	-	MSB	00	00	00	Total wear level count
B2	LSB	MSB	00	00	00	00	00	Runtime invalid block 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
C5	LSB	MSB	00	00	00	00	00	Current Pending Sector Count
C6	LSB	-	-	MSB	00	00	00	Uncorrectable error count off-line
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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