

SATA III 6Gb/s SSD

# SSD422K-ADV

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## Datasheet

### Products

TS1TSSD422K-ADV  
TS512GSSD422K-ADV  
TS256GSSD422K-ADV  
TS128GSSD422K-ADV  
TS64GSSD422K-ADV  
TS32GSSD422K-ADV

### Product Description

2.5" SSD, SATA3, MLC, SEC-14.

### Datasheet version

1.0



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No.70, Xingzhong Rd., Neihu Dist., Taipei City 114, Taiwan, R.O.C.  
Tel:+886-2-2792-8000 Fax:+886-2-2792-1614  
[www.transcend-info.com](http://www.transcend-info.com)

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## Revision History

Revision No.	History	Released Date	Editor by
1.0	Customized Datasheet for 研華	2021/11/29	TSD

# Transcend SSD422K-ADV Features

Part Name	Capacity
TS1TSSD422K-ADV	1TB
TS512GSSD422K-ADV	512GB
TS256GSSD422K-ADV	256GB
TS128GSSD422K-ADV	128GB
TS64GSSD422K-ADV	64GB
TS32GSSD422K-ADV	32GB

## FEATURES

- SATA 6Gbps
- 2D MLC NAND Flash
- Standard-temperature operation
- 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
- Supports DEVSLP mode
- Self-encrypting drives (SED) with AES-256 (Optional)

## PERFORMANCE<sup>1)</sup>

- Data Transfer Rate
  - Sequential Read Up to 550 MB/s
  - Sequential Write Up to 460 MB/s

## RELIABILITY<sup>1)</sup>

- TBW
  - 1TB 2940TB
  - 512GB 1480TB
  - 256GB 740TB
  - 128GB 360TB
  - 64GB 180TB
  - 32GB 90TB

- UBER  $10^{-15}$
- DWPD 2.6 DWPD
- MTBF 2,000,000 hours
- Data Retention 1 year
- Warranty 3 years

## ENVIRONMENTAL SPECIFICATIONS<sup>1)</sup>

- 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<sup>1)</sup>

- Supply voltage / Tolerance 5V±5%
- Active (max) 7.75W
- Idle (max) 1.35W

## PHYSICAL DIMENSION

- Width 69.85±0.25mm
- Length 100.00±0.25mm
- Height 6.8±0.2mm
- Weight Max.63g

### Note:

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

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# 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
- Embedded DDR3 DRAM cache
- Power shield function
- AES-256 function (Optional)
- Hardware-purge function (Optional)

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

## 1.2 Product List

Form Factor	Part Name	Capacity
2.5 inch	TS1TSSD422K-ADV	1TB
	TS512GSSD422K-ADV	512GB
	TS256GSSD422K-ADV	256GB
	TS128GSSD422K-ADV	128GB
	TS64GSSD422K-ADV	64GB
	TS32GSSD422K-ADV	32GB

### 1.3 Ordering Information

**T S X X X G S S D 4 2 2 K - A D V**  
1            2            3            4            5            6            7

- 1 – Transcend
- 2 – SSD Density
- 3 – G: Gigabyte; T: Terabyte
- 4 – SATA device
- 5 – 2.5 inch form factor
- 6 – Standard-temperature operation
- 7 – Customized item

## 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

	32GB	64GB	128GB
User-Addressable Sectors	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	32GB	64GB	128GB
Sequential Read	290MB/s	550MB/s	550MB/s
Sequential Write	60MB/s	140MB/s	260MB/s

Read / Write	256GB	512GB	1TB
Sequential Read	550MB/s	550MB/s	550MB/s
Sequential Write	440MB/s	440MB/s	460MB/s

**Note: Maximum transfer speed recorded**

1) 25°C, test on GIGABYTE GA-Z87X-D3H, 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	32GB	64GB	128GB	256GB	512GB	1TB
Random Read IOPS	24K	60K	67K	68K	68K	68K
Random Write IOPS	16K	33K	58K	68K	68K	68K

**Note: Maximum transfer speed recorded**

1) 25°C, test on GIGABYTE GA-Z87X-D3H, 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	5V±5%
Allowable noise / ripple	100 mV p-p or less

## 2.5 System Power Consumption

[Table 5] Power Consumption

Read / Write	32GB	64GB	128GB	256GB	512GB	1TB
Active Write (Max.) <sup>1)</sup>	1.5W	2.5W	3.2W	4.5W	5W	7.75W
Active Read (Max.) <sup>1)</sup>	1.85W	2W	2.7W	4W	4.15W	7.5W
Idle	0.45W	0.6W	0.6W	1W	1.1W	1.35W
DEVSPL	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 <sup>1)</sup>	Non-Operating <sup>2)</sup>
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 <sup>3)</sup>	
Vibration	20G, 7~2000Hz, 3 axis <sup>4)</sup>	

**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.

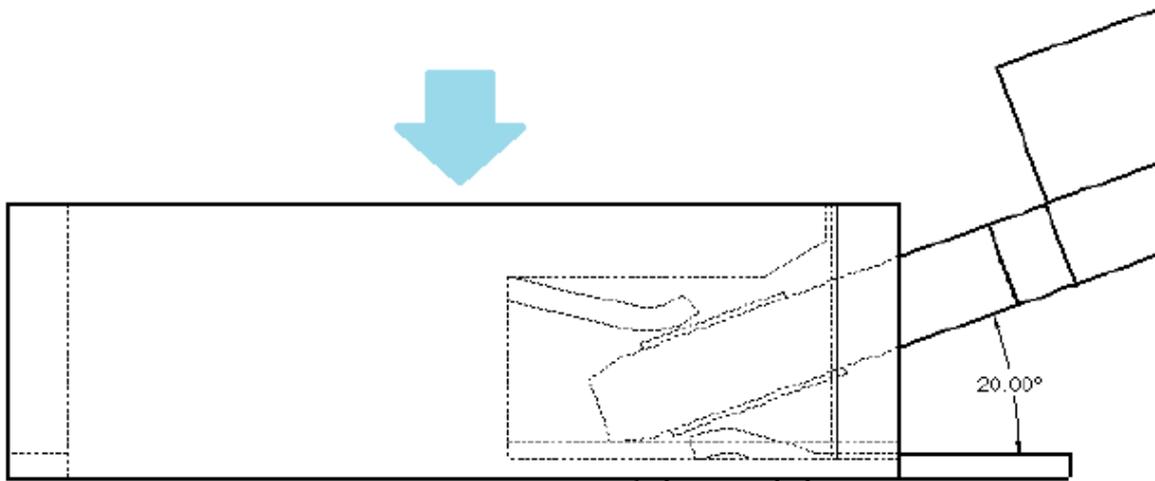
2) The non-operating specification is regarded as storage specification.

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 SATA cable 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	32GB	64GB	128GB	256GB	512GB	1TB
MTBF	2,000,000 hours					

**Note:**

1) The calculation is based on 25°C.

[Table 8] UBER Specifications

Parameter	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	32GB	64GB	128GB	256GB	512GB	1TB
TBW	90TB	180 TB	360 TB	740TB	1480TB	2940TB

**Note:**

1) TBW specification follows JESD219A Client workload.

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

Parameter	32GB	64GB	128GB	256GB	512GB	1TB
DWPD <sup>1)</sup>	2.6 (3 Years)					

**Note:**

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

[Table 11] Data Retention Specifications

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

[Table 13] Warranty

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

[Table 14] Regulations

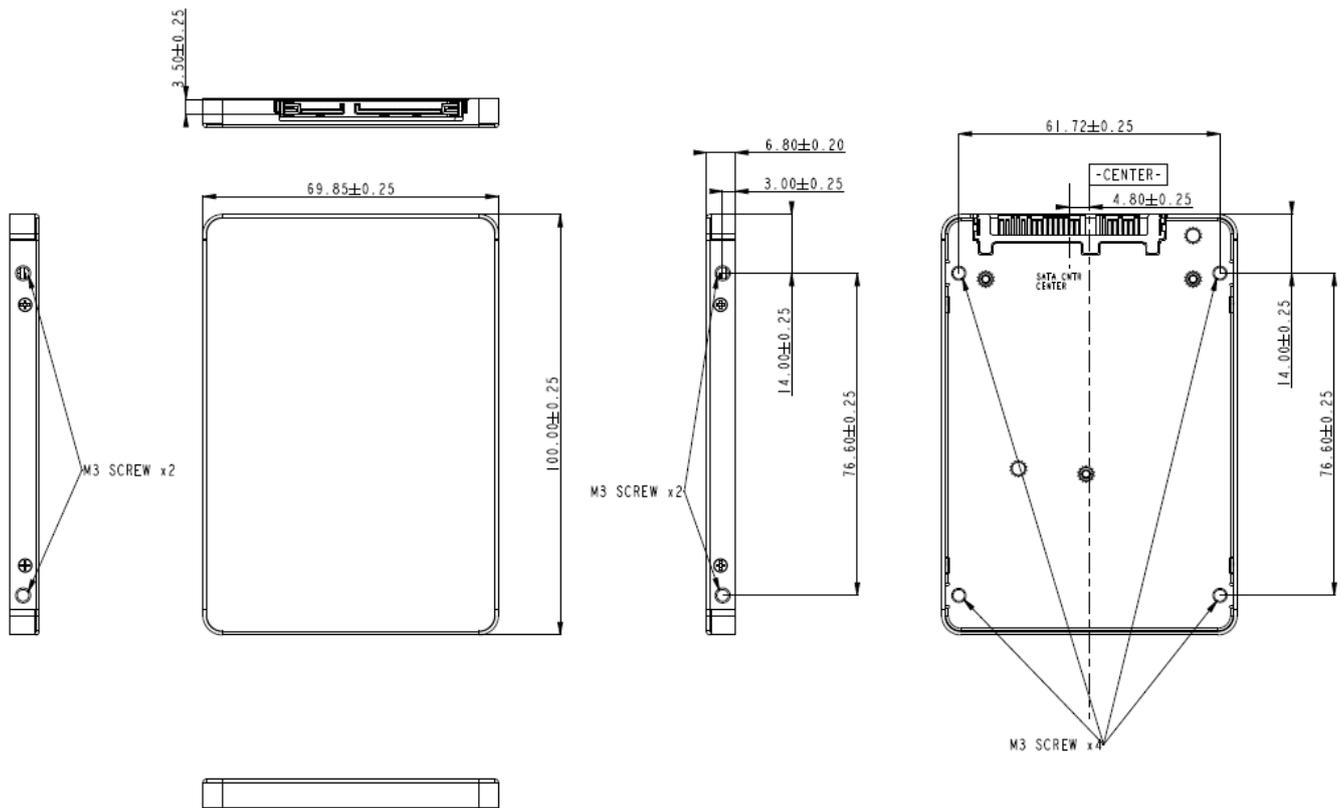
Parameter	32GB	64GB	128GB	256GB	512GB	1TB
Compliance	CE, UKCA, FCC and BSMI					

### 3. Mechanical Specification

The figure below illustrates the Transcend 2.5 inch Solid State Drive.

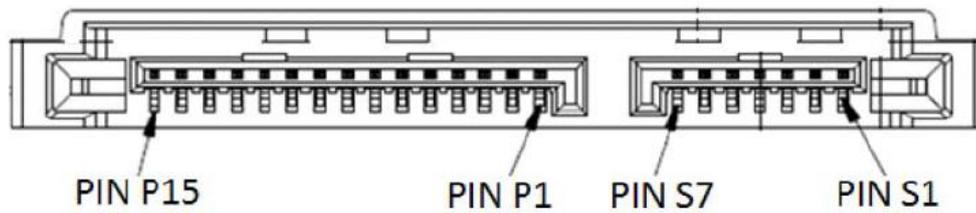
[Table 15] Physical Dimensions and Weight

Model	Height (mm)	Width (mm)	Length (mm)	Weight (gram)
32GB/64GB/128GB/256GB/ 512GB/1TB	6.8±0.2	69.85±0.25	100.00±0.25	Max 63g



## 4. Pin Assignments

### 4.1 Serial ATA Interface Connector



### 4.2 Pin Assignments

[Table 16] Pin Assignments

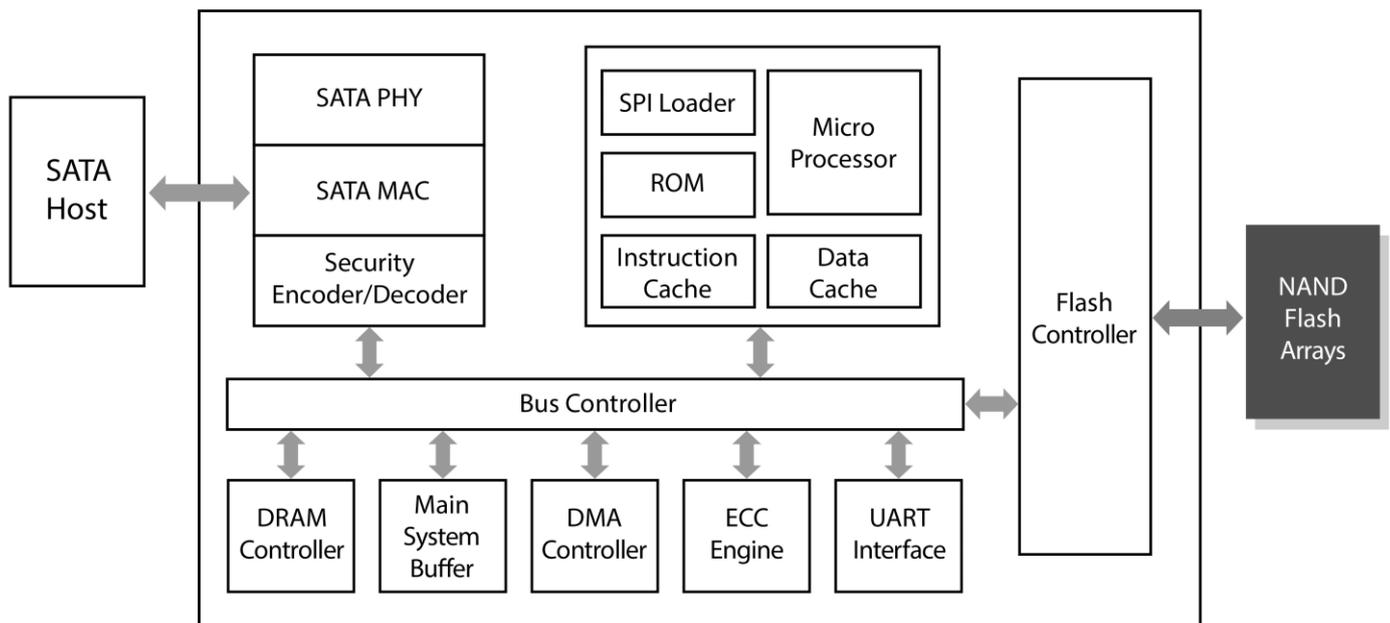
Word.	No.	Plug Connector Pin Definition	
Signal	S1	GND <sup>1)</sup>	2 <sup>nd</sup> mate / Ground
	S2	A +	Differential Signal A from Phy
	S3	A -	
	S4	GND <sup>1)</sup>	2 <sup>nd</sup> mate / Ground
	S5	B -	Differential Signal B from Phy
	S6	B +	
	S7	GND <sup>1)</sup>	2 <sup>nd</sup> mate / Ground
Power	P1	NC <sup>4)</sup>	
	P2	NC <sup>4)</sup>	
	P3	DEVSLP <sup>3)</sup>	Device Activity Signal
	P4	GND <sup>1)</sup>	1 <sup>st</sup> mate / Ground
	P5	GND <sup>1)</sup>	2 <sup>nd</sup> mate / Ground
	P6	GND <sup>1)</sup>	2 <sup>nd</sup> mate / Ground
	P7	5V	5V Power
	P8	5V	5V Power
	P9	5V	5V Power
	P10	GND <sup>1)</sup>	2 <sup>nd</sup> mate / Ground
	P11	DAS <sup>2)</sup>	Device Activity Signal
	P12	GND <sup>1)</sup>	1 <sup>st</sup> mate / Ground
	P13	NC <sup>4)</sup>	
	P14	NC <sup>4)</sup>	
	P15	NC <sup>4)</sup>	

**Note:**

- 1) For SATA 2.5 inch 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 Scope Pro

Transcend's 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 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 SSD Installation**

Regarding the system assembling, the torque force of mounting screws should not exceed more than 2 Kgf-cm of torque. For SATA cable connection, the cable should not longer than 1 meter and well-connected is necessary to avoid signal transmission error. The standard 2.5 inch SATA interface has a separated connector for power connection. For the connection detail, please refer chapter 4.

## 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
<b>General Feature Set</b>		
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
<b>Power Management Feature Set</b>		
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
<b>Security Mode Feature Set</b>		
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
<b>SMART Feature Set</b>		
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
<b>Host Protected Area Feature Set</b>		
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
<b>48-bit Address Feature Set</b>		
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
<b>NCQ Feature Set</b>		
Read FPDMA Queued	60h	DMA Queued
Write FPDMA Queued	61h	DMA Queued
<b>Other</b>		
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
	MSB						LSB	
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 <sup>1)</sup>
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.

## 9. Contact Information

### TAIWAN

No.70, XingZhong Rd., NeiHu Dist., Taipei, Taiwan,  
R.O.C

TEL +886-2-2792-8000

Fax +886-2-2793-2222

E-mail: [sales-tw@transcend-info.com](mailto:sales-tw@transcend-info.com)

### Shanghai

E-mail: [sales-cn@transcendchina.com](mailto:sales-cn@transcendchina.com)

TEL: +86-21-6161-9388

### Beijing

E-mail: [sales-cn@transcendchina.com](mailto:sales-cn@transcendchina.com)

TEL: +86-10-8265-9969

### Shenzhen

E-mail: [sales-cn@transcendchina.com](mailto:sales-cn@transcendchina.com)

TEL: +86-755-2598-7200

### Hong Kong

E-mail: [sales-hk@transcend-info.com](mailto:sales-hk@transcend-info.com)

TEL: +852-2331-8929

### Los Angeles

E-mail: [sales-us@transcend-info.com](mailto:sales-us@transcend-info.com)

TEL: +1-714-921-2000

### Maryland

E-mail: [sales-us@transcend-info.com](mailto:sales-us@transcend-info.com)

TEL: +1-410-689-4900

### Silicon Valley

E-mail: [sales-us@transcend-info.com](mailto:sales-us@transcend-info.com)

TEL: +1-408-785-5990

### JAPAN

E-mail: [sales-jp@transcend-info.com](mailto:sales-jp@transcend-info.com)

TEL: +81-3-5820-6000

### KOREA

E-mail: [sales-kr@transcend-info.com](mailto:sales-kr@transcend-info.com)

TEL: +82-2-782-8088

### GERMANY

E-mail: [sales-de@transcend-info.com](mailto:sales-de@transcend-info.com)

TEL: +49-40-538-907-0

### NETHERLANDS

E-mail: [sales-nl@transcend-info.com](mailto:sales-nl@transcend-info.com)

TEL: +31-10-298-8500

### United Kingdom

E-mail: [sales-uk@transcend-info.com](mailto:sales-uk@transcend-info.com)

TEL: +44-1442-202-880