GOODRAM M.2 2280 SSD
S11 MLC
DATASHEET

Version: 1.0
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REVISION HISTORY

VERSION	CHANGES	DATE
1.0	Initial release	07.12.2020

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PRODUCT OVERVIEW

- **Capacity**
  - 4GB up to 512GB
- **SATA Interface**
  - SATA Revision 3.2
  - SATA 1.5Gbs, 3Gbps and 6Gbps interface
- **Flash Memory**
  - Flash Type: Kioxia 15nm MLC
  - 1-4 pcs of TSOP/BGA flash
- **Performance** Note1
  - Read: up to 550 MB/s
  - Write: up to 490 MB/s
- **Power Consumption** Note2
  - Active mode: < 2,650mW
  - Idle mode: < 280mW
  - DEVSLP mode: < 5mW
- **TBW (terabytes written)** Note3
  - 540 TBW for 512GB
- **RoHS compliant**
- **Controller**
  - Phison S11
- **MTBF**
  - More than 2,000,000 hours
- **Advanced Flash Management**
  - Static and Dynamic Wear Leveling
  - Bad Block Management
  - TRIM
  - SMART
  - NQC
  - Over-provisioning
  - Firmware update
  - SmartZIP™
- **Low Power Management**
  - DEVSLP Mode (Optional)
  - DIPM/HIPM Mode
- **Temperature Range** Note4
  - Operational (Silver): 0 ~ +70°C
  - Operational (Gold): -25° ~ +85°C
  - Operational (Diamond): -40° ~ +85°C
  - Storage: -40°C ~ +85°C

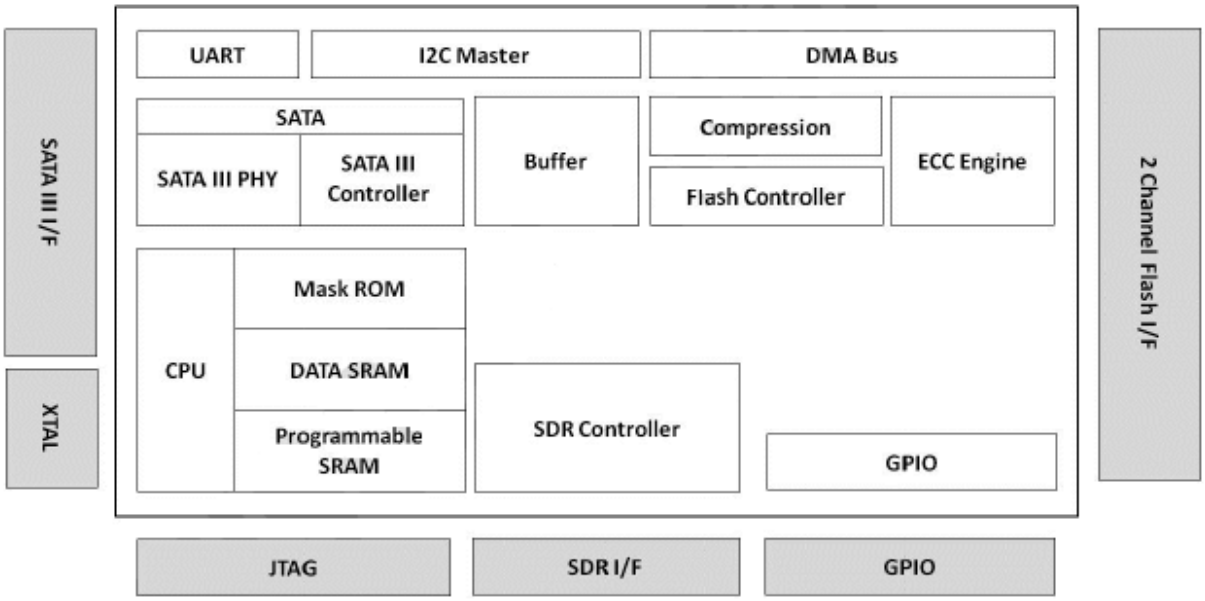
Notes:
1. Measured by CrystalDiskMark v3.0
2. Please see "Power Consumption" for details.
3. Please see "TBW (Terabyte Written)" for details.
4. According to standards IEC-60068-2-1/2/14/38

PRODUCT DETAILS

GENERAL DESCRIPTION

GOODRAM M.2 2280 delivers all the advantages of Flash Drive technology with Serial ATA I/II/III interface and is fully compliant with the standard Next Generation Form Factor (NGFF) called M.2 Card Format. The module is designed to operate at a maximum operating frequency of 200MHz with 30MHz external crystal. The capacity could provide a wide range up to 512GB and the performance reach up to 550MB/s read as well as 490MB/s write based on Toggle 2.0 MLC flash. Meanwhile, the power consumption is much lower than traditional Hard Drives.

CONTROLLER BLOCK DIAGRAM



M.2 2280 Controller Bloc Diagram

FLASH MANAGEMENT

GOODRAM M.2 2280 modules utilizes all the state of art technologies to ensure full reliability until the TBW parameter is reached. These technologies include:

Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data, therefore M.2 2280 applies the Low Density Parity Check (LDPC) of ECC Algorithm, which can detect and correct errors occur during Read process, ensure data been read correctly, as well as protect data from corruption.

Wear Leveling

NAND Flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some area get updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling technique is applied to extend the lifespan of NAND Flash by evenly distributing write and erase cycles across the media. Product has advanced Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing both dynamic and static Wear Leveling algorithms, the life expectancy of the NAND Flash is greatly improved.

Bad Block Management

Bad blocks are blocks that include one or more invalid bits, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as “Initial Bad Blocks”. Bad blocks that are developed during the lifespan of the flash are named “Later Bad Blocks”. We implement an efficient bad block management algorithm to detect the factory-produced bad blocks and manages any bad blocks that appear with use. This practice further prevents data being stored into bad blocks and improves the data reliability.

TRIM

TRIM is a feature which helps improve the read/write performance and speed of solid-state drives (SSD). Unlike hard disk drives (HDD), SSDs are not able to overwrite existing data, so the available space gradually becomes smaller with each use. With the TRIM command, the operating system can inform the SSD which blocks of data are no longer in use and can be removed permanently. Thus, the SSD will perform the erase action, which prevents unused data from occupying blocks all the time.

SMART

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a hard disk drive to automatically detect its health and report potential failures. When a failure is recorded by SMART, users can choose to replace the drive to prevent unexpected outage or data loss. Moreover, SMART can inform users of impending failures while there is still time to perform proactive actions, such as copy data to another device.

Over-Provision

Over Provisioning refers to the inclusion of extra NAND capacity in a SSD, which is not visible and cannot be used by users. With Over Provisioning, the performance and IOPS (Input/Output Operations per Second) is improved by providing the controller additional space to manage P/E cycles, which enhances the reliability and endurance as well. Moreover, the write amplification of the SSD becomes lower when the controller writes data to the flash.

Firmware Upgrade

Firmware can be considered as a set of instructions on how the device communicates with the host. Firmware will be upgraded when new features are added, compatibility issues are fixed or read/write performance gets improved.

SmartZIP™

Write data to the NAND Flash costs time. To improve the write speed performance, controller launches with compression technique – SmartZIP™. Whether a file could be compressed or not depending on the file type, for file types have redundancy data pattern, through our embedded encode engine, we could reduce the amount of data that is actually written to the Flash. Comparing to the SSD without compression, write efficiency is raised and the SSD endurance is also improved since Flash could be benefit from less data written for longer SSD lifetime.

ADDITIONAL FEATURES

Low Power Management: DEVSLP Mode (Optional)

With the increasing need of aggressive power/battery life, SATA interfaces include a new feature – Device Sleep mode (DEVSLP) – which helps reduce the power consumption of the device. It enables the device to completely power down the device PHY and other subsystems, making the device reach a new level of lower power operation. The feature does not specify the exact power level a device can reach in DEVSLP mode but the power usage can be dropped down to 5mW or less.

Low Power Management: DIPM/HIPM Mode

SATA interfaces contain two low power management states for power saving: Partial and Slumber modes. For Partial mode, the device has to resume to full operation within 10 microseconds, whereas the device will spend 10 milliseconds to become fully operational in the Slumber mode. SATA interfaces allow low power modes to be initiated by Host (HIPM, Host Initiated Power Management) or Device (DIPM, Device Initiated Power Management). As for HIPM, Partial or Slumber mode can be invoked directly by the software. For DIPM, the device will send requests to enter Partial or Slumber mode.

Power Loss Protection: Flushing Mechanism

Power Loss Protection is a mechanism to prevent data loss during unexpected power failure. DRAM is a volatile memory and frequently used as temporary cache or buffer between the controller and the NAND flash to improve the SSD performance. However, one major concern of the DRAM is that it is not able to keep data during power failure. Accordingly, the controller applies the GuaranteedFlush Technology, which requests the controller to transfer data to the cache. For the used controller, SDR performs as a cache, and its size include 32MB. Only when the data is fully committed to the NAND flash will the controller send acknowledgement (ACK) to the host. Such implementation can prevent false-positive performance and the risk of power cycling issues.
Additionally, it is critical for a controller to shorten the time the in-flight data stays in the cache. Thus, the controller applies an algorithm to reduce the amount of data resides in the cache to provide a better performance. This SmartCacheFlush technology allows incoming data to only have a "pit stop" in the cache and then move to the NAND flash at once. If the flash is jammed due to particular file sizes (random 4K), the cache will be treated as an "organizer", consolidating incoming data into groups before written into the flash to improve write amplification. In sum, with this Flush Management, the controller proves to provide the reliability required by consumer, industrial, and enterprise-level application.

Advanced Device Security Features (Secure Erase, Write Protect)

Secure Erase is a standard ATA command and will write all "0x00" to fully wipe all the data on hard drives and SSDs. When this command is issued, the SSD controller will empty its storage blocks and return to its factory default settings. When a SSD contains too many bad blocks and data are continuously written in, then the SSD might not be used anymore. Thus, Write Protect is a mechanism to prevent data from being written in and protect the accuracy of data that are already stored in the SSD.

PERFORMANCE AND POWER CONSUMPTION

Capacity	Flash Structure	Performance		Power Consumption			
		CrystalDiskMark		Read (mW)	Write (mW)	DEVSLP (mW)	Idle (mW)
		Read (MB/s)	Write (MB/s)				
4GB	4GB x 1 (TSOP)	160	50	1,120	1,150	4.9	265
	4GB x 1 (TSOP)	300	50	870	800	4.9	263
8GB	8GB x 1 (TSOP)	165	90	1,150	1,180	4.9	265
	8GB x 1 (TSOP)	320	105	900	800	4.9	265
16GB	16GB x 1 (TSOP)	320	84	1,180	1,200	4.9	265
30GB (32GB)	16GB x 2 (TSOP)	550	160	1,200	1,280	4.9	265
60GB (64GB)	16GB x 4 (TSOP)	550	310	1,200	1,320	4.9	265
120GB (128GB)	32GB x 4 (TSOP)	550	465	1,200	1,550	4.9	270
	32GB x 4 (BGA)	550	465	1,280	1,700	4.9	280
	64GB x 2 (BGA)	550	465	1,250	1,600	4.9	275
240GB (256GB)	64GB x 4 (TSOP)	550	465	1,300	1,600	4.9	275
	64GB x 4 (BGA)	550	490	1,350	2,600	4.9	280
480GB (512GB)	128GB x 4 (TSOP)	550	465	1,500	1,700	4.9	270
	128GB x 4 (BGA)	550	490	1,500	2,650	4.9	280

NOTES:

1. The performance was measured using CrystalDiskMark with SATA 6Gbps host.
2. Samples were built using Kioxia 15mn Toggle MLC NAND flash.
3. Performance and power consumption may differ according to flash configuration, SDR configuration, and platform.
4. The table above is for reference only. The criteria for MP (mass production) and for accepting goods shall be discussed based on different flash configuration.

SUPPLY VOLTAGE

PARAMETER	RATING
Operating voltage	3.3V +/- 5%

TBW

Terabytes Written (TBW) is a measurement of SSDs' expected lifespan, which represents the amount of data written to the device.

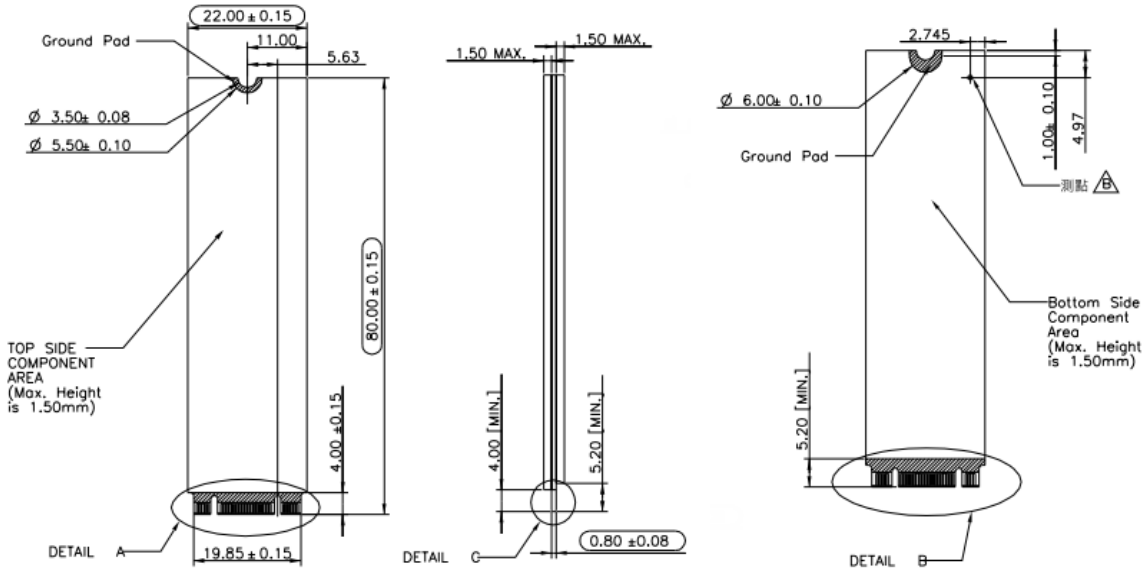
Capacity	Flash Structure	TBW
4GB	4GB x 1	1
8GB	8GB x 1	3
16GB	16GB x 1	6
30GB (32GB)	16GB x 2	13
60GB (64GB)	16GB x 4	30
120GB (128GB)	64GB x 2 32GB x 4	87
240GB (256GB)	64GB x 4	198
480GB (512GB)	128GB x 4	540

NOTES:

1. Samples were built using Kioxia 15nm MLC NAND flash.
2. The test followed JEDEC219A client endurance workload.
3. TBW may differ according to flash configuration, SDR configuration and platform.
4. The endurance of SSD could be estimated based on user behavior, NAND endurance cycles and write amplification factor. It is not guaranteed by flash vendor.

PHYSICAL DIMENSION

Dimension: 80mm(L) x 22mm(W) x 3.75mm(H)



PIN ASSIGNMENT AND DESCRIPTIONS

Pin #	SATA Pin	Description
1	CONFIG_3	Ground
2	3.3V	Supply pin
3	GND	Ground
4	3.3V	Supply pin
5	N/C	No Connect
6	N/C	No Connect
7	N/C	No Connect
8	N/C	No Connect
9	N/C or GND[Note]	No Connect or Ground
10	DAS/DSS# (O) (OD)	Status indicators via LED devices that will be provided by the system Active Low. A pulled-up LED with series current limiting resistor should allow for 9mA when On.
11	N/C	No Connect
12	Module Key	
13	Module Key	
14	Module Key	
15	Module Key	
16	Module Key	
17	Module Key	
18	Module Key	
19	Module Key	
20	N/C	No Connect
21	CONFIG_0	Ground
22	N/C	No Connect
23	N/C	No Connect
24	N/C	No Connect
25	N/C	No Connect
26	N/C	No Connect
27	GND	Ground
28	N/C	No Connect
29	N/C	No Connect
30	N/C	No Connect
31	N/C	No Connect
32	N/C	No Connect
33	GND	Ground

34	N/C	No Connect
35	N/C	No Connect
36	N/C	No Connect
37	N/C	No Connect
38	DEVSLP (I) (0/3.3V)	Device Sleep, Input. When driven high the host is informing the SSD to enter a low power state.
39	GND	Ground
40	N/C	No Connect
41	SATA-B+	SATA differential signals in the SATA specification
42	N/C	No Connect
43	SATA-B-	SATA differential signals in the SATA specification
44	N/C	No Connect
45	GND	Ground
46	N/C	No Connect
47	SATA-A-	SATA differential signals in the SATA specification
48	N/C	No Connect
49	SATA-A+	SATA differential signals in the SATA specification
50	N/C	No Connect
51	GND	Ground
52	N/C	No Connect
53	N/C	No Connect
54	N/C	No Connect
55	N/C	No Connect
56	Reserved for MFG Data	No Connect
57	GND	Ground
58	Reserved for MFG Clock	No Connect
59	Module Key	
60	Module Key	
61	Module Key	
62	Module Key	
63	Module Key	
64	Module Key	
65	Module Key	
66	Module Key	
67	N/C	No Connect
68	SUSCLK (I) (0/3.3V)	No Connect
69	CONFIG_1	Ground

70	3.3V	Supply pin
71	GND	Ground
72	3.3V	Supply pin
73	GND	Ground
74	3.3V	Supply pin
75	CONFIG_2	Ground

NOTE: N/C for Socket 2, and GND for Socket 3.

SUPPORTED ATA COMMAND LIST

Op Code	Description	Op Code			Description
00h	NOP	C9h			Read DMA without Retry
06h	Data Set Management	CAh			Write DMA
10h-1Fh	Recalibrate	CBh			Write DMA without Retry
20h	Read Sectors	CEh			Write Multiple FUA EXT
21h	Read Sectors without Retry	E0h			Standby Immediate
24h	Read Sectors EXT	E1h			Idle Immediate
25h	Read DMA EXT	E2h			Standby
27h	Read Native Max Address EXT	E3h			Idle
29h	Read Multiple EXT	E4h			Read Buffer
2Fh	Read Log EXT	E5h			Check Power Mode
30h	Write Sectors	E6h			Sleep
31h	Write Sectors without Retry	E7h			Flush Cache
34h	Write Sectors EXT	E8h			Write Buffer
35h	Write DMA EXT	E9h			READ BUFFER DMA
37h	Set Native Max Address EXT	EAh			Flush Cache EXT
38h	CFA Write Sectors Without Erase	EBh			Write Buffer DMA
39h	Write Multiple EXT	ECh			Identify Device
3Dh	Write DMA FUA EXT	EFh			Set Features
3Fh	Write Long EXT	EFh	02h		Enable volatile write cache
40h	Read Verify Sectors	EFh	03h		Set transfer mode
41h	Read Verify Sectors without Retry	EFh	05h		Enable the APM feature set
42h	Read Verify Sectors EXT	EFh	10h		Enable use of SATA feature set
44h	Zero EXT	Efh	10h	02h	Enable DMA Setup FIS Auto-Activate optimization
45h	Write Uncorrectable EXT	EFh	10h	03h	Enable Device-initiated interface power state (DIPM) transitions
47h	Read Log DMA EXT	EFh	10h	06h	Enable Software Settings Preservation (SSP)

57h		Write Log DMA EXT	EFh	10h	07h	Enable Device Automatic Partial to Slumber Transitions
60h		Read FPDMA Queued	EFh	10h	09h	Enable Device Sleep
61h		Write FPDMA Queued	EFh	55h		Disable read look-ahead
70h-7Fh		Seek	EFh	66h		Disable reverting to power-on deafaults
90h		Execute Device Diagnostic	EFh	82h		Disable volatile write cache
91h		Initialize Device Parameters	EFh	85h		Disable the APM feature set
92h		Download Microcode	EFh	90h		Disable use of SATA feature set
93h		Download Microcode DMA	EFh	90h	02h	Disable DMA Setup FIS Auto-Activate optimization
B0h		SMART	EFh	90h	03h	Disable Device-initiated interface power state (DIPM) transitions
B0h	D0h	SMART READ DATA	EFh	90h	06h	Disable Software Settings Preservation (SSP)
B0h	D1h	SMART READ ATTRIBUTE THRESHOLDS	EFh	90h	07h	Disable Device Automatic Partial to Slumber transitions
B0h	D2h	SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE	EFh	90h	09h	Disable Device Sleep
B0h	D3h	SMART SAVE ATTRIBUTE VALUES	EFh	AAh		Enable read look-ahead
B0h	D4h	SMART EXECUTE OFF-LINE IMMEDIATE	EFh	CCh		Enable reverting to power-on defaults
B0h	D5h	SMART READ LOG	F1h			Security Set Password
B0h	D6h	SMART WRITE LOG	F2h			Security Unlock
B0h	D8h	SMART ENABLE OPERATIONS	F3h			Security Erase Prepare
B0h	D9h	SMART DISABLE OPERATIONS	F4h			Security Erase Unit
B0h	DAh	SMART RETURN STATUS	F5h			Security Freeze Lock
B0h	DBh	SMART ENABLE/DISABLE AUTOMATIC OFF-LINE	F6h			Security Disable Password
B1h		Device Configuration	F8h			Read Native Max Address
B4h		Sanitize	F9h			Set Max Address
C4h		Read Multiple	F9h	01h		SET MAX SET PASSWORD
C5h		Write Multiple	F9h	02h		SET MAX LOCK
C6h		Set Multiple Mode	F9h	03h		SET MAX UNLOCK
C8h		Read DMA	F9h	04h		SET MAX FREEZE LOCK

PRODUCT ORDERING INFORMATION

PN	Type	Capacity	Technology	Temp range	Grade
RUSM8M004S3SB-P11KI5	M.2	4GB	MLC	0~70°C	silver
RUSM8M008S3SB-P11KI5	M.2	8GB	MLC	0~70°C	silver
RUSM8M016S3SB-P11KI5	M.2	16GB	MLC	0~70°C	silver
RUSM8M030S3SB-P11KI5	M.2	30GB	MLC	0~70°C	silver
RUSM8M032S3SB-P11KI5	M.2	32GB	MLC	0~70°C	silver
RUSM8M060S3SB-P11KI5	M.2	60GB	MLC	0~70°C	silver
RUSM8M064S3SB-P11KI5	M.2	64GB	MLC	0~70°C	silver
RUSM8M120S3SB-P11KI5	M.2	120GB	MLC	0~70°C	silver
RUSM8M128S3SB-P11KI5	M.2	128GB	MLC	0~70°C	silver
RUSM8M240S3SB-P11KI5	M.2	240GB	MLC	0~70°C	silver
RUSM8M256S3SB-P11KI5	M.2	256GB	MLC	0~70°C	silver
RUSM8M480S3SB-P11KI5	M.2	480GB	MLC	0~70°C	silver
RUSM8M512S3SB-P11KI5	M.2	512GB	MLC	0~70°C	silver
RUSM8M004S3GB-P11KI5	M.2	4GB	MLC	-25°C ~85°C	gold
RUSM8M008S3GB-P11KI5	M.2	8GB	MLC	-25°C ~85°C	gold
RUSM8M016S3GB-P11KI5	M.2	16GB	MLC	-25°C ~85°C	gold
RUSM8M030S3GB-P11KI5	M.2	30GB	MLC	-25°C ~85°C	gold
RUSM8M032S3GB-P11KI5	M.2	32GB	MLC	-25°C ~85°C	gold
RUSM8M060S3GB-P11KI5	M.2	60GB	MLC	-25°C ~85°C	gold
RUSM8M064S3GB-P11KI5	M.2	64GB	MLC	-25°C ~85°C	gold
RUSM8M120S3GB-P11KI5	M.2	120GB	MLC	-25°C ~85°C	gold
RUSM8M128S3GB-P11KI5	M.2	128GB	MLC	-25°C ~85°C	gold
RUSM8M240S3GB-P11KI5	M.2	240GB	MLC	-25°C ~85°C	gold
RUSM8M256S3GB-P11KI5	M.2	256GB	MLC	-25°C ~85°C	gold
RUSM8M480S3GB-P11KI5	M.2	480GB	MLC	-25°C ~85°C	gold
RUSM8M512S3GB-P11KI5	M.2	512GB	MLC	-25°C ~85°C	gold
RUSM8M004S3DB-P11KI5	M.2	4GB	MLC	-40°C ~85°C	diamond
RUSM8M008S3DB-P11KI5	M.2	8GB	MLC	-40°C ~85°C	diamond
RUSM8M016S3DB-P11KI5	M.2	16GB	MLC	-40°C ~85°C	diamond
RUSM8M030S3DB-P11KI5	M.2	30GB	MLC	-40°C ~85°C	diamond
RUSM8M032S3DB-P11KI5	M.2	32GB	MLC	-40°C ~85°C	diamond
RUSM8M060S3DB-P11KI5	M.2	60GB	MLC	-40°C ~85°C	diamond
RUSM8M064S3DB-P11KI5	M.2	64GB	MLC	-40°C ~85°C	diamond
RUSM8M120S3DB-P11KI5	M.2	120GB	MLC	-40°C ~85°C	diamond
RUSM8M128S3DB-P11KI5	M.2	128GB	MLC	-40°C ~85°C	diamond
RUSM8M240S3DB-P11KI5	M.2	240GB	MLC	-40°C ~85°C	diamond
RUSM8M256S3DB-P11KI5	M.2	256GB	MLC	-40°C ~85°C	diamond
RUSM8M480S3DB-P11KI5	M.2	480GB	MLC	-40°C ~85°C	diamond
RUSM8M512S3DB-P11KI5	M.2	512GB	MLC	-40°C ~85°C	diamond

STANDARDS & REFERENCES

The following table is to list out the standards that have been adopted for designing the product.

STANDARD USED	ACRONYM/SOURCE
RoHS	Restriction of Hazardous Substances Directive; please contact us for further information.
Serial ATA Revision 3.1	http://www.sata-io.org
ATA-8 spec	http://www.t13.org
CE	Consumer electronics certification; please contact us for further information.

SAFETY PRECAUTIONS

Do not bend, crush, drop, or place heavy objects on top of the Product. Do not use tweezers, pliers or similar items that could damage the Product. Take particular care when inserting or removing the Product. Stop using the Product when the Product does not work properly. Failure to follow these instructions could result in fire, damage to the Product and/or other property, and/or personal injury including burns and electric shock.

Keep out of reach of small children. Accidental swallowing may cause suffocation or injury. Contact a doctor immediately if you suspect a child has swallowed the Product.

Do not directly touch the interface pins, put them in contact with metal, strike them with hard objects or cause them to short. Do not expose to static electricity.

Do not disassemble or modify the Product. This may cause electric shock, damage to the Product or fire.

NOTES ON USAGE

The Product contains nonvolatile semiconductor memory. Do not use the Product in accordance with a method of usage other than that written in the manual. This may cause the destruction or loss of data.

To protect against accidental data loss, you should back up your data frequently on more than one type of storage media. Wilk Elektronik S.A. assumes no liability for destruction or loss of data recorded on the Card for any reason.

When used over a long period of time or repeatedly, the reading, writing and deleting capabilities of the Product will eventually fail, and the performance speed of the Product may decrease below the original speed specific to the Product's applicable class.

If the Product is to be transferred or destroyed, note that the data it contained may still be recoverable unless it is permanently deleted by third-party deletion software or similar means beforehand.

Product is intended for use in general electronics applications and selected industrial applications and any other specific applications as expressly stated in this document. Product is neither intended nor warranted for use in equipment or systems where failure may cause loss of human life, bodily injury, serious property damage or serious public impact (“Unintended Use”). Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment or equipment used to control combustions or explosions. Do not use Product for Unintended Use unless specifically permitted in this document.

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