KIOXIA

2.5 inch Solid State Drives

KPM61xUG Series
KPM6VxUG Series
KPM6XxUG Series
KPM6WxUG Series

Product Specification
for SAS3 products

KIOXIA Corporation

No.
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TOTAL 78 CONT.ON 2 PAGE No. 1

Revision History

KIOXIA

TITLE: 2.5 inch Solid State Drives KPM61 / KPM6V / KPM6X / KPM6W Series Product Specification

REV No.	DATE	CONTENTS	DEP.	REVISED	APP'D	STGE.PER.
00	2021-01-28	Initial issue for SAS3 products	ES 1	Y. Motegi	K. Tsuji	

Preface

This document describes the KPM61/KPM6V/KPM6X/KPM6W series 2.5 inch solid state drives (After that we write it down with the KPM6 series) with an embedded Serial Attached SCSI (up to SAS3).

This document details the specifications and functions of the above solid state drives, and gives the requirements and procedures for installing it into a host computer system.

This document is written for users who have a basic understanding of the solid state drives and their use in computer systems. The DOCUMENT ORGANIZATION section describes organization and scope of this document. If the need arises, use the other manuals.

The organization of this document, related reference document and conventions for alert messages are as follows.

Overview of Document

This document consists of the following seven chapters:

Chapter 1 General Description

This chapter introduces the solid state drives standard features, hardware and system configuration.

Chapter 2 Specifications

This chapter gives detailed specifications of the solid state drives and the installation environment.

Chapter 3 Data Format

This chapter describes the data structure, the addressing method and the defect management.

Chapter 4 Installation Requirements

This chapter describes the basic physical and electrical requirements for installing the solid state drives.

Chapter 5 Installation

This chapter explains how to install the solid state drives. It includes the notice and procedures for setting device number and operation modes, mounting the solid state drives, and confirming drive operation.

Chapter 6 Diagnostics and Maintenance

This chapter describes the automatic diagnosis, and maintenance of the solid state drives. It also describes diagnostic methods for operation check and the basics of troubleshooting the solid state drives.

Chapter 7 Error Analysis

This chapter describes in detail the information collection for error analysis and analysis of collected error information.

Conventions Used in This Document

The KPM6 series are described as "the SSD" in this document.

Decimal number is represented normally.

Hexadecimal number is represented as X'17B9', 17B9h or 17B9H.

Binary number is represented as "010".

The KPM6 series discussed in this document are the following.

KPM61MUG3T20	KPM6VMUG3T20	KPM6XMUG3T20	KPM6WMUG3T20
KPM61MUG1T60	KPM6VMUG1T60	KPM6XMUG1T60	KPM6WMUG1T60
KPM61MUG800G	KPM6VMUG800G	KPM6XMUG800G	KPM6WMUG800G
KPM61MUG400G	KPM6VMUG400G	KPM6XMUG400G	KPM6WMUG400G
KPM61VUG12T8	KPM6VVUG12T8	KPM6XVUG12T8	KPM6WVUG12T8
KPM61VUG6T40	KPM6VVUG6T40	KPM6XVUG6T40	KPM6WVUG6T40
KPM61VUG3T20	KPM6VVUG3T20	KPM6XVUG3T20	KPM6WVUG3T20
KPM61VUG1T60	KPM6VVUG1T60	KPM6XVUG1T60	KPM6WVUG1T60
KPM61VUG800G	KPM6VVUG800G	KPM6XVUG800G	KPM6WVUG800G
KPM61RUG30T7	KPM6VRUG30T7	KPM6XRUG30T7	KPM6WRUG30T7
KPM61RUG15T3	KPM6VRUG15T3	KPM6XRUG15T3	KPM6WRUG15T3
KPM61RUG7T68	KPM6VRUG7T68	KPM6XRUG7T68	KPM6WRUG7T68
KPM61RUG3T84	KPM6VRUG3T84	KPM6XRUG3T84	KPM6WRUG3T84
KPM61RUG1T92	KPM6VRUG1T92	KPM6XRUG1T92	KPM6WRUG1T92
KPM61RUG960G	KPM6VRUG960G	KPM6XRUG960G	KPM6WRUG960G

Safety Precautions

This section lists important precautions which users of this product(s) (and anyone else) should observe in order to avoid injury and damage to property, and to ensure safe and correct use of the products. Be sure to understand the meanings of the labels and graphic symbols described below before moving to the detailed descriptions of the precautions, and complying with the precautions stated.

Explanation of Labels

⚠DANGER	⚠WARNING	⚠CAUTION	*NOTICE*
Indicates a hazardous situation which, if not avoided, will result in death or serious injury[1].	Indicates a hazardous situation which, if not avoided, could result in death or serious injury[1].	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury[2].	Indicates practices that may cause property damage[3] and other problems, but not personal injury

1. Serious injury includes blindness, wounds, burns (low and high temperature), electric shock, fractures, and poisoning, etc. with long-lasting effects or requiring hospitalization and/or long-term hospital visits for treatment.
2. Minor or moderate injury includes wounds, burns, electric shock, etc. not requiring hospitalization and/or long-term hospital visits for treatment.
3. Property damage means damage to customer or third party machines and equipment.

Explanation of Graphic Symbols

Prohibited	**Instructions**
Indicates prohibited actions.	Indicates actions that must be undertaken for safety purposes.

⚠CAUTION	
Prohibited	Electrical shock Do not touch the SSDs while power-feeding.
Prohibited	Damage Do not use a conductive cleaner to clean the SSDs. Do not remove any labels from the SSD or deface them in any way. Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy SSDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.
Prohibited	High temperature To prevent injury such as burns, do not touch the SSD while it is hot. The DE and LSI become hot during operation and remain hot after turning off the power. 

⚠CAUTION	
 **Instructions**	Data loss Save data stored in the SSD to other media before requesting repair. KIOXIA assumes no liability if data is corrupted during service or repair.
 **Instructions**	Damage To prevent ESD (Electrostatics Discharge) that may cause damage to the device, always ground yourself before handling. Use of wrist strap connected to ground is advisable.
 **Instructions**	Damage When dismounting the SSD mounted on the system while power is supplied; 1) Stop the function by a START STOP UNIT command. It takes about 5 seconds to stop completely. 2) Dismount the SSD using the mounting/dismounting mechanism of the system. Avoid exposure to shock or vibration. If removal will result in shock or vibration, stop dismounting and wait until the SSD stops (about 5 seconds) when SAS connector breaks off contact.
 **Instructions**	Damage When dismounting the SSD mounted on the system while power is not supplied; Dismount the SSD using the mounting/dismounting mechanism of the system. Avoid exposure to shock or vibration.
 **Instructions**	Damage When storing or transporting the SSD, put it in the antistatic bag.

Related Standards

Product specifications and functions described in this document comply with the following ANSI (*1) standards and SFF Committee specifications.

Specification (document) number	Name	Concerned organization
T10/BSR INCITS 417 Revision 10	Serial Attached SCSI-1.1（SAS-1.1）	American National Standards Institute（ANSI）
T10/BSR INCITS 457 Revision 16	Information technology Serial Attached SCSI-2（SAS-2）	American National Standards Institute（ANSI）
T10/BSR INCITS 519 Revision 06	Information technology Serial Attached SCSI-3（SAS-3）	American National Standards Institute（ANSI）
T10/BSR INCITS 505 Revision 05	Information technology SAS Protocol Layer-2（SPL-2)	American National Standards Institute（ANSI）
T10/BSR INCITS 492 Revision 07	Information technology SAS Protocol Layer-3（SPL-3)	American National Standards Institute（ANSI）
T10/BSR INCITS 538 Revision 13	Information technology SAS Protocol Layer-4（SPL-4)	American National Standards Institute（ANSI）
T10/BSR INCITS 513 Revision 37	Information technology SCSI Primary Commands-4 (SPC-4)	American National Standards Institute（ANSI）
T10/BSR INCITS 502 Revision 20a	Information technology SCSI Primary Commands-5 (SPC-5)	American National Standards Institute（ANSI）
T10/BSR INCITS 514 Revision 36	Information Technology SCSI Block Commands-3 (SBC-3)	American National Standards Institute（ANSI）
T10/BSR INCITS 506 Revision 16	Information Technology SCSI Block Commands-4 (SBC-4)	American National Standards Institute（ANSI）
T10/BSR INCITS 515 Revision 21	Information technology SCSI Architecture Model-5 (SAM-5)	American National Standards Institute（ANSI）
SFF-8201 Rev. 3.4	SFF-8201E 2.5 inch Form Factor Drive Dimensions	SNIA SFF Committee
SFF-8639 Rev. 2.1	SFF-8639 Specification for Multifunction 6X Unshielded Connector Rev 2.1	SNIA SFF Committee

* ANSI = American National Standards Institute

In case of conflict between this document and any referenced document, this document takes precedence.

Marking

1) WEEE

Following information is only for EU/UK states:

The use of the symbol indicates that this product may not be treated as household waste. Proper disposal of this product can help prevent negative consequences on the environment and human health, which could be caused by inappropriate waste handling. For more detailed information about recycling of this product, please contact the local city office, the household waste disposal service or the shop where the product was purchased.

2) Names and Contents of Hazardous Substances or Elements in the Products

产品中有害物质的名称及含量

部件名称	有害物质					
	铅（Pb）	汞（Hg）	镉（Cd）	六价铬（Cr(VI)）	多溴联苯（PBB）	多溴二苯醚（PBDE）
SSD(固态硬盘)	×	○	○	○	○	○

本表格依据 SJ/T 11364 的规定编制。
○：表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。
×：表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。

中华人民共和国环保使用期限

Safety/EMC Standards

The drive satisfies the following standards.

	Applied standard
Underwriters Laboratories (UL)	UL60950-1, UL62368-1
Technischer Uberwachungs-Verein (TUV)	EN 60950-1, EN 62368-1
Bureau of Standards, Metrology and Inspection (BSMI)	CNS 13438 (CISPR Pub. 22 Class B):D3B817
Ministry of Science and ICT	電磁波障害防止基準 KN32, KN35 (CISPR Pub. 32 Class B) (Note 1) (CISPR Pub. 35) (Note 1)
Australian Communications and Media Authority (ACMA)	AS/NZS CISPR32
Conformity mark (Morocco Mark)	EN55032 NM EN55035

(Note 1) Marks of KC

	KPM61MUG3T20, KPM6VMUG3T20, KPM6XMUG3T20, KPM6WMUG3T20, KPM61MUG1T60, KPM6VMUG1T60, KPM6XMUG1T60, KPM6WMUG1T60, KPM61MUG800G, KPM6VMUG800G, KPM6XMUG800G, KPM6WMUG800G, KPM61MUG400G, KPM6VMUG400G, KPM6XMUG400G, KPM6WMUG400G, KPM61VUG6T40, KPM6VVUG6T40, KPM6XVUG6T40, KPM6WVUG6T40, KPM61VUG3T20, KPM6VVUG3T20, KPM6XVUG3T20, KPM6WVUG3T20, KPM61VUG1T60, KPM6VVUG1T60, KPM6XVUG1T60, KPM6WVUG1T60, KPM61VUG800G, KPM6VVUG800G, KPM6XVUG800G, KPM6WVUG800G, KPM61RUG7T68, KPM6VRUG7T68, KPM6XRUG7T68, KPM6WRUG7T68, KPM61RUG3T84, KPM6VRUG3T84, KPM6XRUG3T84, KPM6WRUG3T84, KPM61RUG1T92, KPM6VRUG1T92, KPM6XRUG1T92, KPM6WRUG1T92, KPM61RUG960G, KPM6VRUG960G, KPM6XRUG960G, KPM6WRUG960G
Made in Philippines	1. 기기의 명칭(모델명) : KPM61VUG7T68 2. 인증번호 : R-R-TMZ-KPM61VUG7T68 3. 인증받은 자의 상호 : KIOXIA Corporation 4. 제조년월일 : 2019 - XX 5. 제조자 / 제조국가 : KIOXIA Corporation / 필리핀

B급 기기 (가정용 방송통신기자재)	이 기기는 가정용(B급) 전자파적합기기로서 주로 가정에서 사용하는 것을 목적으로 하며, 모든 지역에서 사용할 수 있습니다.

	KPM61RUG15T3, KPM6VRUG15T3, KPM6XRUG15T3, KPM6WRUG15T3, KPM61VUG12T8, KPM6VVUG12T8, KPM6XVUG12T8, KPM6WVUG12T8
Made in Philippines	1. 기기의 명칭(모델명) : KPM61RUG15T3 2. 인증번호 : R-R-TMZ-KPM61RUG15T3 3. 인증받은 자의 상호 : KIOXIA Corporation 4. 제조년월일 : 2019 - XX 5. 제조자 / 제조국가 : KIOXIA Corporation / 필리핀

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	KPM61RUG30T7, KPM6VRUG30T7, KPM6XRUG30T7, KPM6WRUG30T7
Made in Philippines	1. 기기의 명칭(모델명) : KPM61RUG30T7 2. 인증번호 : R-R-TMZ-KPM61RUG30T7 3. 인증받은 자의 상호 : KIOXIA Corporation 4. 제조년월일 : 2019 - XX 5. 제조자 / 제조국가 : KIOXIA Corporation / 필리핀

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1) FCC information is as below.

FCC Information

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

−Reorient or relocate the receiving antenna.

−Increase the separation between the equipment and receiver.

−Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

−Consult the dealer or an experienced radio/TV technician for help.

Caution

Changes or modifications made to this equipment, not expressly approved by KIOXIA Corporation or parties authorized by KIOXIA Corporation could void the user's authority to operate the equipment.

FCC conditions

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

US Contact

Name: KIOXIA America, Inc.
Address: 2610 Orchard Parkway, San Jose, CA 95134, USA
Phone: +1-408-526-2700

CE Marking

The drive satisfies the following standards.

Category	Applied standard	Issued year	Comment
EMC 2014/30/EU	Emission: EN55032	2015	Class B (including domestic environment)
	Immunity: EN55035	2017	Product immunity standard for multimedia equipment
RoHS 2011/65/EU	EN IEC63000	2018	Category 3

*CE-European Union & United Kingdom (Northern Ireland)

UKCA Marking

The drive satisfies the following standards.

Category	Applied standard	Issued year	Comment
EMC	Emission: EN55032	2015	Class B (including domestic environment)
	Immunity: EN55035	2017	Product immunity standard for multimedia equipment
RoHS	EN IEC63000	2018	

*UKCA－United Kingdom (Great Britain)

DOCUMENT ORGANIZATION

PRODUCT SPECIFICATION (This document)	1. General Description 2. Specifications 3. Data Format 4. Installation Requirements 5. Installation 6. Diagnostics and Maintenance 7. Error Analysis
INTERFACE SPECIFICATION	1. Command Processing 2. Data Buffer Management 3. Command Specifications 4. Parameter Data Format 5. Sense Data and Error Recovery Methods 6. Media Management
TCG ENTERPRISE SPECIFICATION	Refer to KPM5 series TCG Enterprise Specification (No.440081894).

Contents

Illustrations

Figures

Tables

CHAPTER 1 General Description

This chapter describes the feature and configuration of the solid state drives (SSDs).

The SSD is a high performance, large capacity 2.5 inch solid state drives with an embedded Serial Attached SCSI (SAS) controller.

The interface use to connect the SSDs to the host system complies with ANSI T10/1601D Serial Attached SCSI-1.1 (SAS-1.1), ANSI T10/1760D Serial Attached SCSI-2 (SAS-2). T10/2212-D Serial Attached SCSI-3 (SAS-3) which covers items ranging from SAS physical layers to SCSI command protocols.

The high-speed data transfer and long-distance transmission capabilities of SAS technology and the powerful command set the SSDs facilitate creation of high-performance and highly reliable storage subsystems with large storage capacities.

1.1 Standard Features

(1) Compactness

The SSD is a compact enclosure which complies with the 2.5 inch drive form factor.

(2) Environmental Protection

The SSDs comply with the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS) directive issued by European Union (EU).

(3) SAS Standard

The SSDs are equipped with a serial attached SCSI (SAS) as a host interface.

- Transfer rate: 12.0Gbit/s, 6.0Gbit/s, 3.0Gbit/s, 1.5Gbit/s
- Number of SAS ports: One or two
- Full-duplex (simultaneous bidirectional data transfer) is supported at two port type.

(4) Dual SAS port support

The SSDs have two pairs of driver and receiver set (PHY) for the SAS to support dual SAS port connection.

On SSDs, Primary and Secondary Ports on SAS plug connector (4 physical links plus power connections) are used for SAS port connection.

(5) High-speed data transfer

The maximum data-transfer speed is SAS3: 1,100 MB/s per SAS port. The data buffer of the SSDs enables the effective use of high-speed data transfers available on the SAS connection.

(6) Multi-segment data buffer

The SSD has a data buffer. Data is transferred between SAS port and media through this data buffer. This feature provides a suitable usage environment for users.

(7) Cache feature

The SSD supports the Read Look-Ahead cache function. As a data reading command practice, the SSD always performs reading of data from the Flash memory logical block.

In addition, this SSD always works with the write cache function enabled. Therefore, high-speed write processing is attained, since the SSD reports good status for WRITE commands without waiting for the completion of write processing to Flash memory.

IMPORTANT

When power shutdown of SSD occurs, the writing to the Flash memory media of the write cache data where WRITE commands are completed is guaranteed by the data protection mechanism inside the SSD. Moreover, by executing a SYNCHRONIZE CACHE command with Immed bit set to 1 or a START STOP UNIT command with Immed bit set to 1 and checking GOOD status, the user data in the write cache can be written to the Flash memory media.

(8) Command queuing feature

The SSDs can queue a maximum SAS3:128 commands per port.

(9) Reserve and release functions

The SSDs can be accessed exclusively in the multi-host or multi-initiator environment by using the reserve and release functions.

(10) Error recovery

The SSDs can try to recover from errors using its powerful retry processing. If a recoverable data check occurs, error-free data can be transferred to the initiator after being corrected in the data buffer. The initiator software is released from the complicated error recover processing by these error recovery functions of the SSDs.

(11) Automatic alternate block reassignment

SSD has more Flash memory physical blocks than the quantity required to store user data. SSD has the function that automatically reallocate the defective block detected during read or write to the other Flash memory physical block and to save data.

(12) Programmable data block length

Data can be accessed in fixed-block length units. The data block length is programmable, and can be specified at initialization with a multiple of 8 within the range of 512 to 520 bytes, or with a multiple of 64 within the range of 4,096 to 4,160 bytes

IMPORTANT

The SSD format at factory shipment is generally 512 bytes/sector.

(13) Start/Stop function of the SSD

Using the SCSI command, the host system can start and stop the function. SSD starts automatically when the drive receives NOTIFY primitive after power on.

(14) Diagnosis

The SSDs have a diagnostic capability which checks internal controller functions and SSD operations.

(15) Low power consumption

By using highly integrated LSI components, the power consumption of the SSDs is very low. This enables the unit to be used in a wide range of environmental conditions.

(16) Microcode downloading

The SSDs implement the microcode download feature. This makes it easier to achieve maintenance and function enhancement of the SSDs.

(17) Self Encryption drive (SED)

SED model is available in this SSD series. SED model is TCG (Trusted Computing Group) protocol. This function prevents information leakage if the SSDs are stolen or missing. Therefore, it is a good data security protocol, providing protection from accident.
Refer to TCG ENTERPRISE SPECIFICATION for more detail.

(18) Sanitize Instant Erase (SIE) functions

SIE model is available in this SSD series. SIE model is supported by sanitize device feature set. TCG is not supported. When the deletion of data is executed by using this function, the SSDs cannot restore all this recorded data.
Refer to INTERFACE SPECIFICATION for more detail.

(19) Digital Signature

Firmware is protected by digital signature.

1.2 Hardware Structure

The SSDs have a drive enclosure (DE) and printed circuit board assemblies (PCBA).

(1) Drive enclosure (DE)

The aluminum case is used.

(2) Printed circuit board assemblies (PCBA)

PCBA consists of controller circuits, the TLC Flash memory which is the media, an interface and Flash memory controller circuit. The controller circuit supports the SAS interface and has realized high speed and high performance by integration.

1.3 System Configuration

For the Serial Attached SCSI, the ANSI standard defines Point-to-Point technology. Figure 1.1, Figure 1.2 and Figure 1.3 show the SAS configuration for Narrow Single, Narrow Dual and Wide Single for internal cabled.

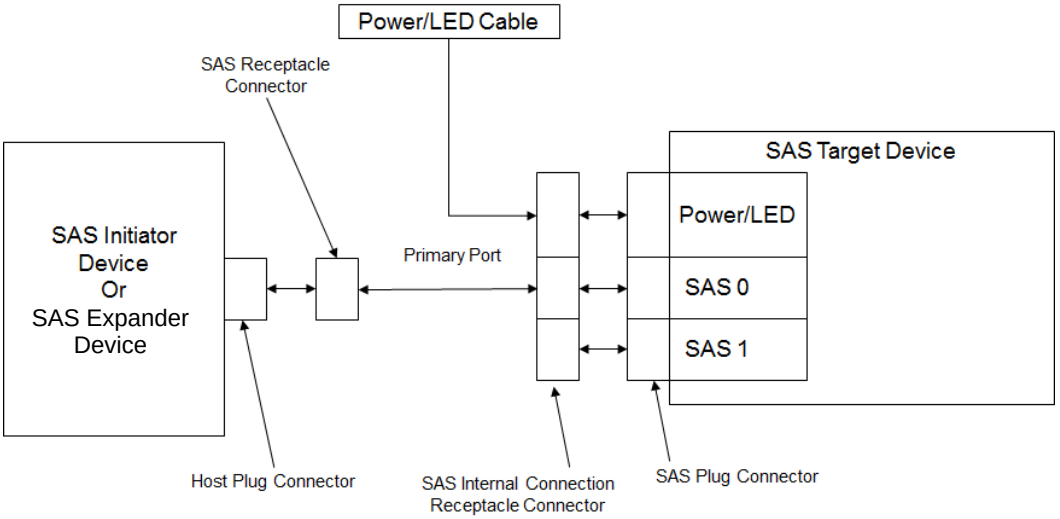


Figure 1.1 SAS System Configuration (1/3)
(Narrow Single port internal cabled environment)

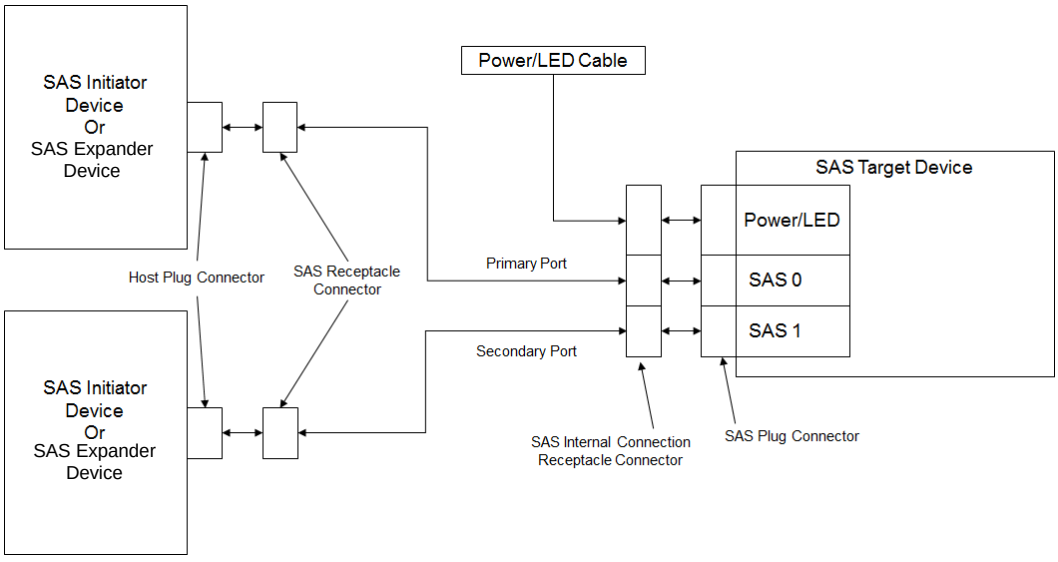


Figure 1.2 SAS System Configuration (2/3)
(Narrow Dual port internal cabled environment)

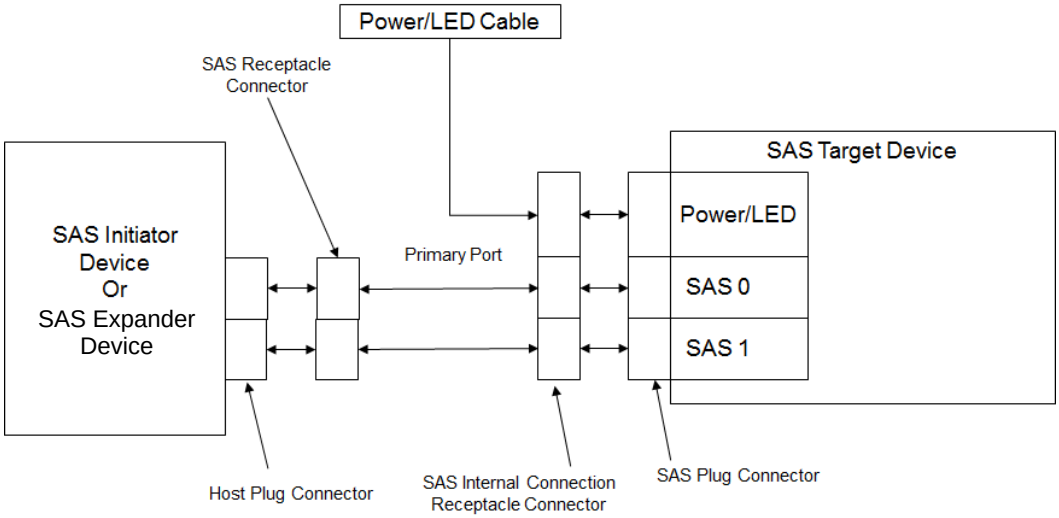


Figure 1.3 SAS System Configuration (3/3)
(Wide Single port internal cabled environment)

(1) Port addressing

Every device connected with the SAS protocol has a unique address (SAS address). SAS addresses are in the Name Address Authority (NAA) IEEE Registered format defined by SCSI Primary Command-4 (SPC-4).

A SAS address consists of 8 bytes which is a unique value set for each device.

The initiator can implement an I/O operation on an SSD by using the corresponding SAS address stored by the SSDs.

CHAPTER 2 Specifications

This chapter describes specifications of the SSDs.

2.1 Hardware Specifications

2.1.1 Model Name

Table 2.1 shows the model name, drive capacities, and encryption option.

The data format can be changed by reinitializing with the user's system.

Table 2.1 Model Name and Encryption Option (1/3)

Model name	DWPD (*1)	TBW (*2)	Capacity (user area) (*3)	Model type (*4)	Function		
					SCEF (*8)	TCG (*9)	FIPS140 (*10)
KPM61MUG3T20	10	58,400 TB	3,200 GB	Base	No	No	No
KPM61MUG1T60	10	29,200 TB	1,600 GB	Base	No	No	No
KPM61MUG800G	10	14,600 TB	800 GB	Base	No	No	No
KPM61MUG400G	10	7,300 TB	400 GB	Base	No	No	No
KPM6XMUG3T20	10	58,400 TB	3,200 GB	SIE (*5)	Yes	No	No
KPM6XMUG1T60	10	29,200 TB	1,600 GB	SIE (*5)	Yes	No	No
KPM6XMUG800G	10	14,600 TB	800 GB	SIE (*5)	Yes	No	No
KPM6XMUG400G	10	7,300 TB	400 GB	SIE (*5)	Yes	No	No
KPM6VMUG3T20	10	58,400 TB	3,200 GB	SED (*6)	Yes	Yes	No
KPM6VMUG1T60	10	29,200 TB	1,600 GB	SED (*6)	Yes	Yes	No
KPM6VMUG800G	10	14,600 TB	800 GB	SED (*6)	Yes	Yes	No
KPM6VMUG400G	10	7,300 TB	400 GB	SED (*6)	Yes	Yes	No
KPM6WMUG3T20	10	58,400 TB	3,200 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WMUG1T60	10	29,200 TB	1,600 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WMUG800G	10	14,600 TB	800 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WMUG400G	10	7,300 TB	400 GB	FIPS (*7)	Yes	Yes	Yes

Table 2.1 Model Name and Encryption Option (2/3)

Model name	DWPD (*1)	TBW (*2)	Capacity (user area) (*3)	Model type (*4)	Function		
					SCEF (*8)	TCG (*9)	FIPS140 (*10)
KPM61VUG12T8	3	70,080 TB	12,800 GB	Base	No	No	No
KPM61VUG6T40	3	35,040 TB	6,400 GB	Base	No	No	No
KPM61VUG3T20	3	17,520 TB	3,200 GB	Base	No	No	No
KPM61VUG1T60	3	8,760 TB	1,600 GB	Base	No	No	No
KPM61VUG800G	3	4,380 TB	800 GB	Base	No	No	No
KPM6XVUG12T8	3	70,080 TB	12,800 GB	SIE (*5)	Yes	No	No
KPM6XVUG6T40	3	35,040 TB	6,400 GB	SIE (*5)	Yes	No	No
KPM6XVUG3T20	3	17,520 TB	3,200 GB	SIE (*5)	Yes	No	No
KPM6XVUG1T60	3	8,760 TB	1,600 GB	SIE (*5)	Yes	No	No
KPM6XVUG800G	3	4,380 TB	800 GB	SIE (*5)	Yes	No	No
KPM6VVUG12T8	3	70,080 TB	12,800 GB	SED (*6)	Yes	Yes	No
KPM6VVUG6T40	3	35,040 TB	6,400 GB	SED (*6)	Yes	Yes	No
KPM6VVUG3T20	3	17,520 TB	3,200 GB	SED (*6)	Yes	Yes	No
KPM6VVUG1T60	3	8,760 TB	1,600 GB	SED (*6)	Yes	Yes	No
KPM6VVUG800G	3	4,380 TB	800 GB	SED (*6)	Yes	Yes	No
KPM6WVUG12T8	3	70,080 TB	12,800 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WVUG6T40	3	35,040 TB	6,400 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WVUG3T20	3	17,520 TB	3,200 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WVUG1T60	3	8,760 TB	1,600 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WVUG800G	3	4,380 TB	800 GB	FIPS (*7)	Yes	Yes	Yes

Table 2.1 Model Name and Encryption Option (3/3)

Model name	DWPD (*1)	TBW (*2)	Capacity (user area) (*3)	Model type (*4)	Function		
					SCEF (*8)	TCG (*9)	FIPS140 (*10)
KPM61RUG30T7	1	56,064 TB	30,720 GB	Base	No	No	No
KPM61RUG15T3	1	28,032 TB	15,360 GB	Base	No	No	No
KPM61RUG7T68	1	14,016 TB	7,680 GB	Base	No	No	No
KPM61RUG3T84	1	7,008 TB	3,840 GB	Base	No	No	No
KPM61RUG1T92	1	3,504 TB	1,920 GB	Base	No	No	No
KPM61RUG960G	1	1,752 TB	960 GB	Base	No	No	No
KPM6XRUG30T7	1	56,064 TB	30,720 GB	SIE (*5)	Yes	No	No
KPM6XRUG15T3	1	28,032 TB	15,360 GB	SIE (*5)	Yes	No	No
KPM6XRUG7T68	1	14,016 TB	7,680 GB	SIE (*5)	Yes	No	No
KPM6XRUG3T84	1	7,008 TB	3,840 GB	SIE (*5)	Yes	No	No
KPM6XRUG1T92	1	3,504 TB	1,920 GB	SIE (*5)	Yes	No	No
KPM6XRUG960G	1	1,752 TB	960 GB	SIE (*5)	Yes	No	No
KPM6VRUG30T7	1	56,064 TB	30,720 GB	SED (*6)	Yes	Yes	No
KPM6VRUG15T3	1	28,032 TB	15,360 GB	SED (*6)	Yes	Yes	No
KPM6VRUG7T68	1	14,016 TB	7,680 GB	SED (*6)	Yes	Yes	No
KPM6VRUG3T84	1	7,008 TB	3,840 GB	SED (*6)	Yes	Yes	No
KPM6VRUG1T92	1	3,504 TB	1,920 GB	SED (*6)	Yes	Yes	No
KPM6VRUG960G	1	1,752 TB	960 GB	SED (*6)	Yes	Yes	No
KPM6WRUG30T7	1	56,064 TB	30,720 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WRUG15T3	1	28,032 TB	15,360 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WRUG7T68	1	14,016 TB	7,680 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WRUG3T84	1	7,008 TB	3,840 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WRUG1T92	1	3,504 TB	1,920 GB	FIPS (*7)	Yes	Yes	Yes
KPM6WRUG960G	1	1,752 TB	960 GB	FIPS (*7)	Yes	Yes	Yes

(*1) DWPD: Drive Writes per Day

(*2) TBW: Terabytes Written

1) Definition and conditions of TBW (Terabytes Written) are based on JEDEC standard; JESD218A, February 2011, and defined for the service life.
2) TBW is defined under the workload of 4K Random Write operation covering full drive capacity. The valid operating conditions are applied.

(*3) One gigabyte (GB) = one billion bytes; accessible capacity will be less. Actual capacity depends on the operating environment and formatting.

(*4) Model type is displayed as Base, SIE, SED and FIPS.

(*5) SIE: Sanitize Instant Erase drive

(*6) SED: Self Encryption drive
(*7) FIPS: Federal Information Processing Standardization
(*8) SCEF: Sanitize Cryptographic Erase Function
(*9) TCG: Trusted Computing Group Enterprise SSC (Security Subsystem Class)
(*10) FIPS140: FIPS 140 complete

2.1.2 Function Specifications

Table 2.2 and Table 2.3 show the function specifications of the SSDs.

Table 2.2 Function Specifications 1 (1/3) (SAS3)

Item	SAS3 Specification			
	KPM61MUG3T20 KPM6VMUG3T20 KPM6XMUG3T20 KPM6WMUG3T20	KPM61MUG1T60 KPM6VMUG1T60 KPM6XMUG1T60 KPM6WMUG1T60	KPM61MUG800G KPM6VMUG800G KPM6XMUG800G KPM6WMUG800G	KPM61MUG400G KPM6VMUG400G KPM6XMUG400G KPM6WMUG400G
Formatted Capacity (*1)	3,200 GB (*2)	1,600 GB (*2)	800 GB (*2)	400 GB (*2)
Time to ready (Typ. / Max.) (*4)	9 sec / 13.5 sec	6.5 sec / 10 sec	5.5 sec / 9 sec	5.5 sec / 9 sec
Stop Time (Typ.)	4 sec	4 sec	4 sec	4 sec
Sustained Performance (*3)				
12.0 Gbit/s interface speed by single port				
4KiB, QD=32, Random Read	210 KIOPS			
4KiB, QD=16, Random Write (9W/12W)	170 KIOPS	180 KIOPS		
4KiB, QD=16, Random Write (14W)	180 KIOPS			
128KiB, QD=16, Sequential Read	1,100 MB/s			
128KiB, QD=16, Sequential Write	1,100 MB/s			
4KiB, QD=32, Random Combined (70%/30% Read/Write, 14W Mode)	220 KIOPS			215 KIOPS
Latency (QD=1, Aligned, Random 4KiB) Read	100 us			
Latency (QD=1, Aligned, Random 4KiB) Write	30 us			
12.0 Gbit/s interface speed by dual port				
4KiB, QD=64, Random Read (9W)	390 KIOPS	415 KIOPS		
4KiB, QD=64, Random Read (12W/14W)	415 KIOPS			
4KiB, QD=32, Random Write (9W)	185 KIOPS	290 KIOPS		300 KIOPS
4KiB, QD=32, Random Write (12W)	290 KIOPS	300 KIOPS		
4KiB, QD=32, Random Write (14W)	300 KIOPS			
128KiB, QD=32, Sequential Read	2,200 MB/s			
128KiB, QD=32, Sequential Write (9W)	1,150 MB/s	1,450 MB/s	1,750 MB/s	1,450 MB/s
128KiB, QD=32, Sequential Write (12W)	1,650 MB/s	2,050 MB/s	2,150 MB/s	1,450 MB/s
128KiB, QD=32, Sequential Write (14W)	2,150 MB/s			1,450 MB/s
4KiB, QD=32, Random Combined (70%/30% Read/Write, 14W Mode)	430 KIOPS	405 KIOPS	420 KIOPS	310 KIOPS
Latency (QD=1, Aligned, Random 4KiB) Read	100 us			
Latency (QD=1, Aligned, Random 4KiB) Write	30 us			

Table 2.2 Function Specifications 1 (2/3) (SAS3)

Item	SAS3 Specification				
	KPM61VUG12T8 KPM6VVUG12T8 KPM6XVUG12T8 KPM6WVUG12T8	KPM61VUG6T40 KPM6VVUG6T40 KPM6XVUG6T40 KPM6WVUG6T40	KPM61VUG3T20 KPM6VVUG3T20 KPM6XVUG3T20 KPM6WVUG3T20	KPM61VUG1T60 KPM6VVUG1T60 KPM6XVUG1T60 KPM6WVUG1T60	KPM61VUG800G KPM6VVUG800G KPM6XVUG800G KPM6WVUG800G
Formatted Capacity (*1)	12,800 GB (*2)	6,400 GB (*2)	3,200 GB (*2)	1,600 GB (*2)	800 GB (*2)
Time to ready (Typ. / Max.) (*4)	16 sec / 19 sec	12.5 sec / 18.5 sec	9 sec / 13.5 sec	6.5 sec / 10 sec	5.5 sec / 9 sec
Stop Time (Typ.)	4 sec	4 sec	4 sec	4 sec	4 sec
Sustained Performance(*3)					
12.0 Gbit/s interface speed by single port					
4KiB, QD=32, Random Read	210 KIOPS				
4KiB, QD=16, Random Write (9W)	55 KIOPS	85 KIOPS	125 KIOPS	150 KIOPS	135 KIOPS
4KiB, QD=16, Random Write (12W)	130 KIOPS		150 KIOPS	180 KIOPS	135 KIOPS
4KiB, QD=16, Random Write (14W)	150 KIOPS		180 KIOPS		135 KIOPS
128KiB, QD=16, Sequential Read	1,100 MB/s				
128KiB, QD=16, Sequential Write (9W/12W/14W)	1,100 MB/s				
4KiB, QD=32, Random Combined (70%/30% Read/Write, 14W Mode)	215 KIOPS				200 KIOPS
Latency (QD=1, Aligned, Random 4KiB) Read	125 us	100 us			
Latency (QD=1, Aligned, Random 4KiB) Write	30 us				
12.0 Gbit/s interface speed by dual port					
4KiB, QD=64, Random Read (9W)	375 KIOPS	390 KIOPS	415 KIOPS		
4KiB, QD=64, Random Read (12W/14W)	415 KIOPS				
4KiB, QD=32, Random Write (9W)	55 KIOPS	85 KIOPS	125 KIOPS	150 KIOPS	135 KIOPS
4KiB, QD=32, Random Write (12W)	130 KIOPS		150 KIOPS	200 KIOPS	135 KIOPS
4KiB, QD=32, Random Write (14W)	150 KIOPS		240 KIOPS	200 KIOPS	135 KIOPS
128KiB, QD=32, Sequential Read	2,200 MB/s				
128KiB, QD=32, Sequential Write (9W)	1,100 MB/s	1,150 MB/s	1,450 MB/s	1,750 MB/s	1,450 MB/s
128KiB, QD=32, Sequential Write (12W)	1,650 MB/s		2,050 MB/s	2,150 MB/s	1,450 MB/s
128KiB, QD=32, Sequential Write (14W)	2,150 MB/s				1,450 MB/s
4KiB, QD=32, Random Combined (70%/30% Read/Write, 14W Mode)	390 KIOPS	380 KIOPS	350 KIOPS	370 KIOPS	270 KIOPS
Latency (QD=1, Aligned, Random 4KiB) Read	125 us	100 us			
Latency (QD=1, Aligned, Random 4KiB) Write	30 us				

Table 2.2 Function Specifications 1 (3/3) (SAS3)

Item	SAS3 Specification					
	KPM61RUG30T7 KPM6VRUG30T7 KPM6XRUG30T7 KPM6WRUG30T7	KPM61RUG15T3 KPM6VRUG15T3 KPM6XRUG15T3 KPM6WRUG15T3	KPM61RUG7T68 KPM6VRUG7T68 KPM6XRUG7T68 KPM6WRUG7T68	KPM61RUG3T84 KPM6VRUG3T84 KPM6XRUG3T84 KPM6WRUG3T84	KPM61RUG1T92 KPM6VRUG1T92 KPM6XRUG1T92 KPM6WRUG1T92	KPM61RUG960G KPM6VRUG960G KPM6XRUG960G KPM6WRUG960G
Formatted capacity (*1)	30,720 GB (*2)	15,360 GB (*2)	7,680 GB (*2)	3,840 GB (*2)	1,920 GB (*2)	960 GB (*2)
Time to ready (Typ. / Max.) (*4)	23 sec / 28 sec	16 sec / 19 sec	12.5 sec / 18.5 sec	9 sec / 13.5 sec	6.5 sec / 10 sec	5.5 sec / 9 sec
Stop Time (Typ.)	4 sec	4 sec	4 sec	4 sec	4 sec	4 sec
Sustained Performance(*3)						
12.0 Gbit/s interface speed by single port						
4KiB, QD=32, Random Read (9W)	185 KIOPS	210 KIOPS				
4KiB, QD=32, Random Read (12W/14W)	210 KIOPS					
4KiB, QD=16, Random Write (9W)	30 KIOPS	45 KIOPS		60 KIOPS	75 KIOPS	
4KiB, QD=16, Random Write (12W)	47 KIOPS	70 KIOPS		75 KIOPS	90 KIOPS	75 KIOPS
4KiB, QD=16, Random Write (14W)	65 KIOPS	84 KIOPS	80 KIOPS	105 KIOPS	90 KIOPS	75 KIOPS
128KiB, QD=16, Sequential Read	1,100 MB/s					
128KiB, QD=16, Sequential Write (9W)	700 MB/s	1,100 MB/s				
128KiB, QD=16, Sequential Write (12W/14W)	1,100 MB/s					
4KiB, QD=32, Random Combined (70%/30% Read/Write, 14W Mode)	155 KIOPS	185 KIOPS	195 KIOPS	185 KIOPS	190 KIOPS	160 KIOPS
Latency (QD=1, Aligned, Random 4KiB) Read	155 us	125 us	100 us			
Latency (QD=1, Aligned, Random 4KiB) Write	30 us					
12.0 Gbit/s interface speed by dual port						
4KiB, QD=64, Random Read (9W)	190 KIOPS	375 KIOPS	390 KIOPS	415 KIOPS		
4KiB, QD=64, Random Read (12W)	360 KIOPS	415 KIOPS				
4KiB, QD=64, Random Read (14W)	400 KIOPS	415 KIOPS				
4KiB, QD=32, Random Write (9W)	30 KIOPS	45 KIOPS		60 KIOPS	75 KIOPS	
4KiB, QD=32, Random Write (12W)	47 KIOPS	70 KIOPS		75 KIOPS	90 KIOPS	75 KIOPS
4KiB, QD=32, Random Write (14W)	65 KIOPS	84 KIOPS	80 KIOPS	105 KIOPS	90 KIOPS	75 KIOPS
128KiB, QD=32, Sequential Read	2,200 MB/s					
128KiB, QD=32, Sequential Write (9W)	700 MB/s	1,100 MB/s	1,150 MB/s	1,450 MB/s	1,750 MB/s	1,450 MB/s
128KiB, QD=32, Sequential Write (12W)	1,370 MB/s	1,650 MB/s		2,050 MB/s	2,150 MB/s	1,450 MB/s
128KiB, QD=32, Sequential Write (14W)	1,900 MB/s	2,150 MB/s				1,450 MB/s
4KiB, QD=32, Random Combined (70%/30% Read/Write, 14W Mode)	160 KIOPS	240 KIOPS	230 KIOPS	250 KIOPS	255 KIOPS	180 KIOPS
Latency (QD=1, Aligned, Random 4KiB) Read	155 us	125 us	100 us			
Latency (QD=1, Aligned, Random 4KiB) Write	30 us					

Table 2.3 Function Specifications 2

Item		Specification
External Dimensions	Height	15.0 mm +0/-0.5mm
	Width	69.85 ± 0.25 mm
	Length	100.45 mm Max.
Weight		150 g Max.
Power Consumption (*5)	Ready(Idle A)	5.0 W Typ.
Power Consumption Efficiency (Random read / W) (*9)	12Gbit/s Single Port	15 KIOPS/W
	12Gbit/s Dual Port	29.6 KIOPS/W
Data Transfer Speed		12.0 Gbit/s, 6.0 Gbit/s, 3.0 Gbit/s, 1.5 Gbit/s
Logical Data Block Length		512, 520, 4096, 4104, 4160 Bytes (*6)
Related Standards		SAS-1.1 (T10/BSR INCITS 417 Rev. 10), SAS-2 (T10/BSR INCITS 457 Rev. 16), SAS-3（T10/BSR INCITS 519 Rev. 06） SPL-2 (T10/BSR INCITS 505 Rev. 05) SPL-3 (T10/BSR INCITS 492 Rev. 07) SPL-4 (T10/BSR INCITS 538 Rev. 13) SPC-4 (T10/BSR INCITS 513 Rev. 37), SPC-5 (T10/BSR INCITS 502 Rev. 20a) SBC-3 (T10/BSR INCITS 514 Rev. 36), SBC-4 (T10/BSR INCITS 506 Rev. 16) SAM-5 (T10/BSR INCITS 515 Rev. 21) SFF-8201E 2.5 inch Form Factor Drive Dimensions (SFF-8201 Rev. 3.4) SFF-8639 Specification for Multifunction 6X Unshielded Connector Rev 2.1 (SFF-8639 Rev. 2.1)
Data Buffer		FIFO ring buffer

These are typical values obtained in a specific test environment at KIOXIA and are provided for reference purposes only.

(*1) The number of the maximum blocks is decided by the model. The formatted capacity can be modified by changing the logical block length. See CHAPTER 3 for the further information.

(*2) One gigabyte (GB) = one billion bytes; accessible capacity will be less. Actual capacity depends on the operating environment and formatting.

(*3) Testing conditions for these performance numbers stated in the table are as follows:

SAS3

Random Read	Drive at steady state (preconditioned with 4kiB Random Writes), Queue depth=32/port, 4kiB-aligned LBA.
Random Write	Drive at steady state (preconditioned with 4kiB Random Writes), Queue depth=16/port, 4kiB-aligned LBA
Sequential Read	Drive at steady state (preconditioned with 128kiB Sequential Writes), Queue depth=16/port, 4kiB-aligned LBA.
Sequential Write	Drive at steady state (preconditioned with 128kiB Sequential Writes), Queue depth=16/port, 4kiB-aligned LBA.
Random combined	Drive at steady state (preconditioned with 4kiB random Writes), Queue depth=32/port, 4kiB-aligned LBA

The process of preconditioning a drive to steady state refers to applying a specific workload for a duration of time that is long enough to allow the drive to converge from an initial period of elevated performance (Fresh Out of the Box[*7]) to a stable state. When the drive has maintained this stable performance for an adequate period of time, it has achieved steady state. Collection of performance numbers can begin.

Typically, the drive is preconditioned by writing data with alignment and block length identical to the test conditions. For example, when measuring the performance of a 4kiB random write workload, the test writes random data to random addresses in 4kiB blocks to 100% of the drive's active range[*8]. It will write random data to sequential addresses when measuring the sequential write performance. The writes will continue until the measured KIOPS or throughput (MB/s) is stable for a long enough test time to ensure that the drive has been appropriately preconditioned and has achieved steady state.

The performance numbers in the Table 2.2 are for a typical case and may vary, depending on the host environment in which the drive is employed. Some factors may cause performance differences, but are not limited to host configuration, operating system, and target application.

(*4) The start time is defined as the time from power on until the SSDs are ready. The stop time is the time for SSDs to completely stop its functions from power off or stop command.

(*5) Power supply is at ±1% of nominal voltage. 25°C ambient. Refer to Subsection 1.5 "Power Conditions" of the INTERFACE SPECIFICATION for details of idle and ready states. "Ready state" corresponds to 1.5.2 "Active state" of the INTERFACE SPECIFICATION.

(*6) Refer to item (12) in Subsection 1.1.

(*7) Fresh Out of the Box refers to the state of a drive when it is brand new, prior to being put into service.

(*8) Active Range is the ratio of the number of LBA in use over the total number of LBA available in percentage form.

(*9) Power Consumption Efficiency is defined by using an SSD with a formatted capacity of 7680GB (Single/Dual: 14W).

2.1.3 Environmental Specifications

Table 2.4 lists environmental and power requirements.

Table 2.4 Environmental and Power Requirements

Item			Specification	
			Normal mode (9W)	Performance mode (*9)
Temperature (*1)	Non-operating (Transporting)		–40 to 80 °C	
	DE surface temperature at operating		0 to 70 °C	
	Gradient		20 °C/h or less	
Relative humidity	Operating		5 to 95 %RH	
	Non-operating (Transporting)		5 to 95 %RH	
	Maximum wet bulb temperature		32.5 °C (no condensation)	
Vibration (*2)	Operating (*3)		21.27 m/s^2 {2.17Grms} (5 to 800Hz)	
	Non-operating (Transporting) (*4)		159.74 m/s^2 {16.3Grms} (20 to 2000Hz)	
Shock (*2)	Operating		9,800 m/s^2 {1000G} / 0.5 ms duration	
	Non-operating (Transporting)		9,800 m/s^2 {1000G} / 0.5 ms duration	
Altitude	Operating		–305 to +5,486 m {–1,000 to +18,000 feet}	
	Non-operating		–305 to +12,192 m {–1,000 to +40,000 feet}	
Power requirement (*5)	+12V DC	Regulation	±10% (*7)	
		Ready	400 mA	400 mA
		At the time of starting	1.5A Max	
		Operating average current DC (reference) (*6)	810 mA	710 mA
	+5V DC	Regulation	+10%/-7% (*7)	
		Ready	50 mA	50 mA
		At the time of starting	1.7A Max	
		Operating average current DC (reference) (*6)	25 mA	1,400 mA
	Ripple (+5V, +12V)		250 mVp-p or less (*8)	
	Power consumption (Max)		14 W	
	Total number of Power Cycles		50,000	

These are typical values obtained in a specific test environment at KIOXIA and are provided for reference purposes only.

(*1) For detail condition, see Section 4.1.

(*2) Vibration applied to the SSD is measured near the mounting screw hole on the frame.

(*3) At write/read and default on retry setting with log sweep vibration.

(*4) At power-off state after installation

(*5) Input voltages are specified at the SSD connector side, during SSD ready state.

(*6) Operating currents are values at the time of the maximum transmission under Sequential Write operation.

(*7) Make sure the value is not less than −0.3V DC (less than –0.6V, 0.1ms) when the power is turned on or off.

(*8) High frequency noise (over 20MHz) is less than 100 mVp-p.

(*9) High performance mode that may exceed the normal mode (9W) performance and normal mode power consumption.

2.1.4 Error Rate

Errors detected during initialization and replaced by alternate block assignments are not included in the error rate.

(1) Unrecoverable error rate

An unrecoverable error (URE) is a read error which cannot be recovered, after error recovery processing. For this SSD, the rate is 1 URE for every 10^{17} bit read.

2.1.5 Reliability

(1) Mean Time to Failures (MTTF)

MTTF of the SSDs during its life time is 2,500,000 hours (operating: 24 hours/day, 7 days/week)

Note:

The MTTF is defined as:

$$\text{MTTF} = \frac{\text{Operating time (hours) at all field sites}}{\text{The number of equipment failures from all field sites}}$$

Note: Equipment Failure is defined as failure that requires repair, adjustment, or replacement. Mishandling by the operator, failures due to bad environmental conditions, power trouble, host system trouble, cable failures, or other failures not caused by the equipment are not considered.

(2) Service life

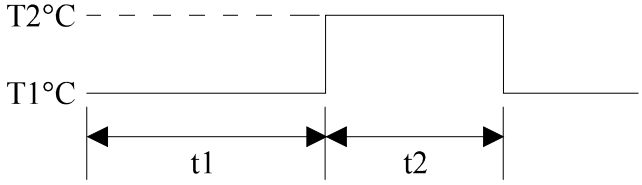
The service life is dependent on the environmental temperature. Therefore, the user must design the system cabinet so that the average DE surface temperature is as low as possible. When average DE surface temperature exceeds 70°C or lower than 0°C, it is not guaranteed for an MTTF 2,500,000 hours.

Even if the SSDs are used intermittently, the longest service life is 5 years.

The maximum storage period without turning the power on, during which the drive gets available, is 5 years at 40°C in the state at the time of shipment. During product-warranties expiration (period of 5 years), the maximum storage period is reduced to three months at the environmental temperature of 40°C or less.

Note:

The "average DE surface temperature" means the average temperature at the DE surface throughout the year when the SSDs are operating.



$$\text{Average DE surface temperature} = \frac{T1 \times t1 + T2 \times t2}{t1 + t2}$$

(3) Data security at power failure

The user data blocks in the cache, which have not yet been written to the Flash memory, and the write command status, which has been reported to an initiator are also guaranteed to be written to the Flash memory against the DC voltage drop or the DC power shutdown.

(4) Data retention

Data retention with power removed (typical): 3 months max at 40 ℃ (*1)

(*1) Definition and conditions are based on JEDEC standard; JESD218A, February 2011.

2.1.6 Thermal Throttling

The drive manages its operating temperature within a range that keeps its healthy condition, by enabling the thermal throttling function. It can be enabled/disabled via MODE SELECT command.

When the function is enabled, the drive dynamically adjusts Read and Write performance to avoid extremely high operating temperature.

The following items can be adjusted by the user.

A) Performance Throttling Level

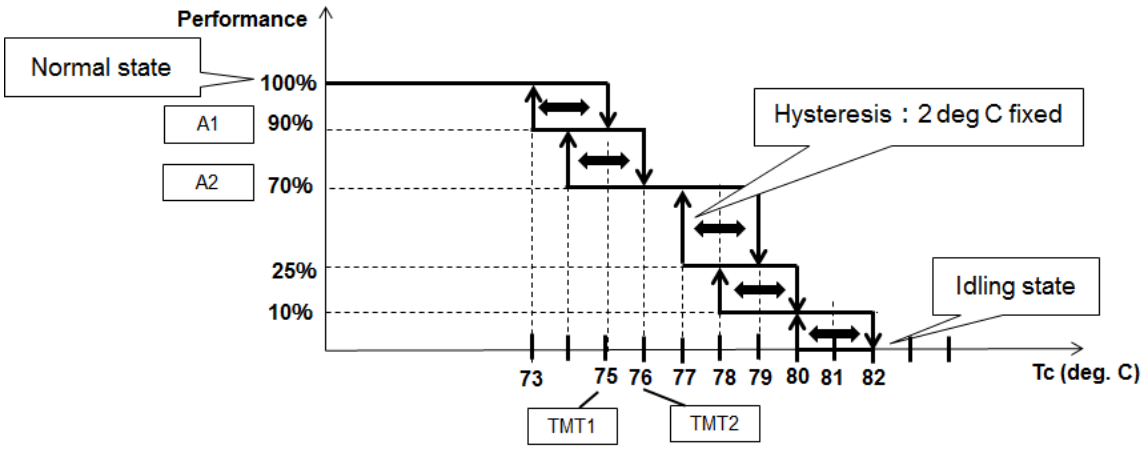
B) TMT1: from Normal State to the Lighter Thermal Throttling State (A1)

C) TMT2: from Lighter Thermal Throttling State (A1) to Light Thermal Throttling State (A2)

D) Transition Temperature: from the Thermal Throttling States to Normal State.

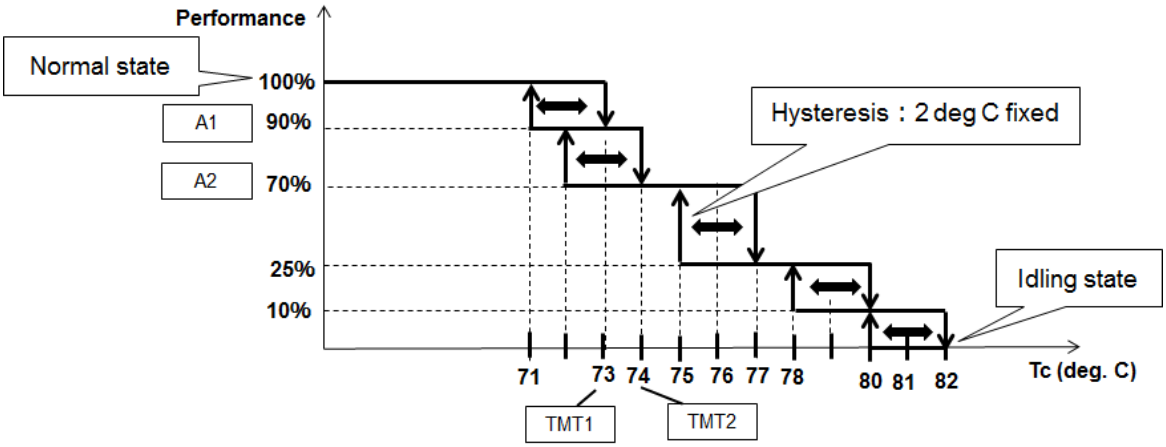
The drive goes into idling state when T_C exceeds 82 deg C. It stays in idling state until T_C is below 80 deg C. During this state, CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid Field Parameter [=26-00]) is returned for all I/O commands received.

400 GB – 7,680 GB



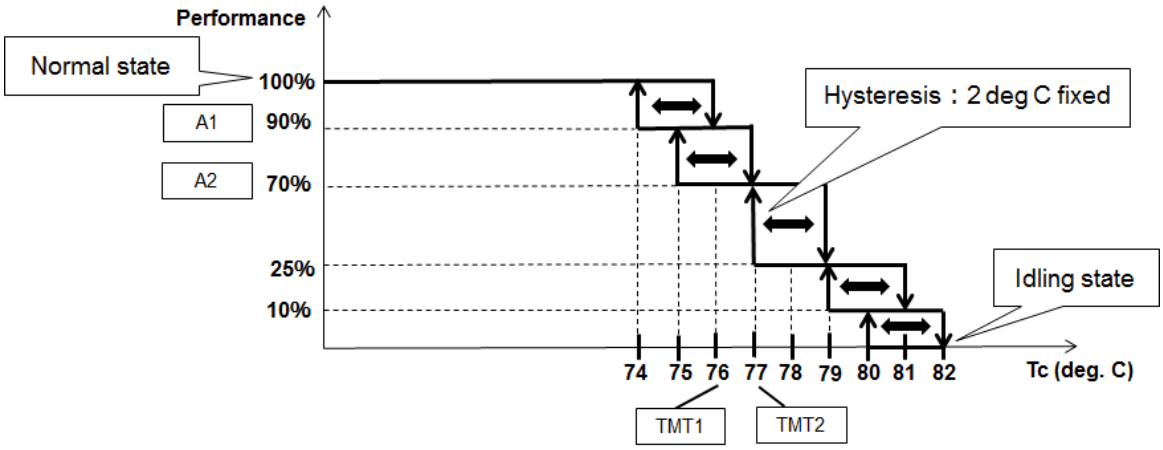
A1：Customer Changeable (5% resolution, 35 - 95%, A1 > A2)
A2：Customer Changeable (5% resolution, 30 - 90%, A1 > A2)
TMT1/TMT2：Customer Changeable (1 deg C resolution, 62 – 78 deg C)
Note1：Performance thresholds 25% and 10% are not changeable.
Note2：Temperature thresholds 78, 80 deg C are not changeable.

12,800 GB – 15,360GB



A1：Customer Changeable (5% resolution, 35 - 95%, A1 > A2)
A2：Customer Changeable (5% resolution, 30 - 90%, A1 > A2)
TMT1/TMT2：Customer Changeable (1 deg C resolution, 62 – 76 deg C)
Note1：Performance thresholds 25% and 10% are not changeable.
Note2：Temperature thresholds 78, 80 deg C are not changeable.

30,720GB



A1：Customer Changeable (5% resolution, 35 - 95%, A1 > A2)
A2：Customer Changeable (5% resolution, 30 - 90%, A1 > A2)
TMT1/TMT2：Customer Changeable (1 deg C resolution, 62 – 77 deg C)
Note1：Performance thresholds 25% and 10% are not changeable.
Note2：Temperature thresholds 78, 80 degC are not changeable.

CHAPTER 3 Data Format

This chapter explains data space definition, logical data block addressing and defect management on the SSD.

3.1 Data Space

The SSDs manage the entire data storage area. It is divided into the following two data spaces.

- User space: Storage area for user data
- System space: Area for exclusive use of the SSD

The user space allows a user access by specifying data. It can be accessed with the logical data block addressing method described in Section 3.2.

The system space is accessed inside the SSDs at power-on or during the execution of a specific command, but the user cannot directly access the system space.

3.1.1 Format Capacity

Table 3.1 shows the maximum user blocks. For the SSD, the number of maximum user blocks is dependent on the model and not affected by data block length.

The following formula must be used when the number of logical data blocks is specified with the parameter in the MODE SELECT (6) or MODE SELECT (10) command.

[Format capacity] = [logical data block length] × [number of logical data blocks]

The logical data block length, the maximum logical block address and the number of the logical data blocks can be read out by a READ CAPACITY, MODE SENSE (6) or MODE SENSE (10) command after initializing the media.

Table 3.1 Format Capacity (1/2)

Model	Data block length (byte)	User blocks	Format capacity
KPM61MUG400G, KPM6XMUG400G, KPM6VMUG400G, KPM6WMUG400G	512 / 520	781,422,768	400 GB
KPM61MUG800G, KPM6XMUG800G, KPM6VMUG800G, KPM6WMUG800G, KPM61VUG800G, KPM6XVUG800G, KPM6VVUG800G, KPM6WVUG800G	512 / 520	1,562,824,368	800 GB
KPM61RUG960G, KPM6XRUG960G, KPM6VRUG960G, KPM6WRUG960G	512 / 520	1,875,385,008	960 GB
KPM61MUG1T60, KPM6XMUG1T60, KPM6VMUG1T60, KPM6WMUG1T60, KPM61VUG1T60, KPM6XVUG1T60, KPM6VVUG1T60, KPM6WVUG1T60	512 / 520	3,125,627,568	1,600 GB
KPM61RUG1T92, KPM6XRUG1T92, KPM6VRUG1T92, KPM6WRUG1T92	512 / 520	3,750,748,848	1,920 GB
KPM61MUG3T20, KPM6XMUG3T20, KPM6VMUG3T20, KPM6WMUG3T20, KPM61VUG3T20, KPM6XVUG3T20, KPM6VVUG3T20, KPM6WVUG3T20	512 / 520	6,251,233,968	3,200 GB
KPM61RUG3T84, KPM6XRUG3T84, KPM6VRUG3T84, KPM6WRUG3T84	512 / 520	7,501,476,528	3,840 GB
KPM61VUG6T40, KPM6XVUG6T40, KPM6VVUG6T40, KPM6WVUG6T40	512 / 520	12,502,446,768	6,400 GB
KPM61RUG7T68, KPM6XRUG7T68, KPM6VRUG7T68, KPM6WRUG7T68	512 / 520	15,002,931,888	7,680 GB
KPM61VUG12T8, KPM6XVUG12T8, KPM6VVUG12T8, KPM6WVUG12T8	512	25,000,148,992	12,800 GB
	520	24,490,541,056	
KPM61RUG15T3, KPM6XRUG15T3, KPM6VRUG15T3, KPM6WRUG15T3	512	30,001,856,512	15,360 GB
	520	29,391,585,280	
KPM61RUG30T7, KPM6XRUG30T7, KPM6VRUG30T7, KPM6WRUG30T7	512	60,001,615,872	30,720 GB
	520	58,781,073,408	

Table 3.1 Format Capacity (2/2)

Model	Data block length (byte)	User blocks	Format capacity
KPM61MUG400G, KPM6XMUG400G, KPM6VMUG400G, KPM6WMUG400G	4,096 / 4,104 / 4,160	97,677,846	400 GB
KPM61MUG800G, KPM6XMUG800G, KPM6VMUG800G, KPM6WMUG800G, KPM61VUG800G, KPM6XVUG800G, KPM6VVUG800G, KPM6WVUG800G	4,096 / 4,104 / 4,160	195,353,046	800 GB
KPM61RUG960G, KPM6XRUG960G, KPM6VRUG960G, KPM6WRUG960G	4,096 / 4,104 / 4,160	234,423,126	960 GB
KPM61MUG1T60, KPM6XMUG1T60, KPM6VMUG1T60, KPM6WMUG1T60, KPM61VUG1T60, KPM6XVUG1T60, KPM6VVUG1T60, KPM6WVUG1T60	4,096 / 4,104 / 4,160	390,703,446	1,600 GB
KPM61RUG1T92, KPM6XRUG1T92, KPM6VRUG1T92, KPM6WRUG1T92	4,096 / 4,104 / 4,160	468,843,606	1,920 GB
KPM61MUG3T20, KPM6XMUG3T20, KPM6VMUG3T20, KPM6WMUG3T20, KPM61VUG3T20, KPM6XVUG3T20, KPM6VVUG3T20, KPM6WVUG3T20	4,096 / 4,104 / 4,160	781,404,246	3,200 GB
KPM61RUG3T84, KPM6XRUG3T84, KPM6VRUG3T84, KPM6WRUG3T84	4,096 / 4,104 / 4,160	937,684,566	3,840 GB
KPM61VUG6T40, KPM6XVUG6T40, KPM6VVUG6T40, KPM6WVUG6T40	4,096 / 4,104 / 4,160	1,562,805,846	6,400 GB
KPM61RUG7T68, KPM6XRUG7T68, KPM6VRUG7T68, KPM6WRUG7T68	4,096 / 4,104 / 4,160	1,875,366,486	7,680 GB
KPM61VUG12T8, KPM6XVUG12T8, KPM6VVUG12T8, KPM6WVUG12T8	4,096	3,125,018,624	12,800 GB
	4,104	3,103,260,672	
	4,160	3,061,317,632	
KPM61RUG15T3, KPM6XRUG15T3, KPM6VRUG15T3, KPM6WRUG15T3	4,096	3,750,232,064	15,360 GB
	4,104	3,724,017,664	
	4,160	3,673,948,160	
KPM61RUG30T7, KPM6XRUG30T7, KPM6VRUG30T7, KPM6WRUG30T7	4,096	7,500,201,984	30,720 GB
	4,104	7,448,035,328	
	4,160	7,347,634,176	

3.2 Logical Data Block Addressing

Logical Data Block Addressing, which is independent of the Flash memory physical address layout of a drive, is used as a data access method on the media.

SSD performs matching with the data position on the media and logical data block address (LBA) when writing data. Write access to the data position on the media is performed by considering a Flash memory as a unit. In case of an initiator access, it is specified using a logical data block address.

Refer to Subsection 1.9.2 "Logical block addressing" of the INTERFACE SPECIFICATION for further details.

3.3 Defect Management

3.3.1 Defect List

Information on the defect location on the media is managed by the defect list. The following are the defect lists.

P list: The defective Flash memory physical block information on the SSD shipment is registered into this list.

G list: The defective Flash memory physical block information detected after the SSD shipment is registered into this list.

P List and G List are registered on the system area of the media.

Flash memory physical blocks, which are registered into the list, are not used as a recording media. In addition, SSD does not have the means to erase the defect list. Therefore, registered Flash memory physical blocks are not used eternally.

The initiator can read the contents of the P and G lists by the READ DEFECT DATA command.

3.3.2 Alternate block allocation

SSD has more Flash memory physical blocks than user data capacity. When a defective Flash memory physical block is detected, SSD chooses an alternative Flash memory physical block automatically, and stores the data.

Automatic Flash memory physical block reallocation processing reassigns only the defective Flash memory physical blocks, unrelated to the LBA. For this reason, initiators do not need to manage the defective LBA. When the number of defective Flash memory physical block is below the guaranteed operation, the initiator can use the SSD capacity as consecutive LBA space.

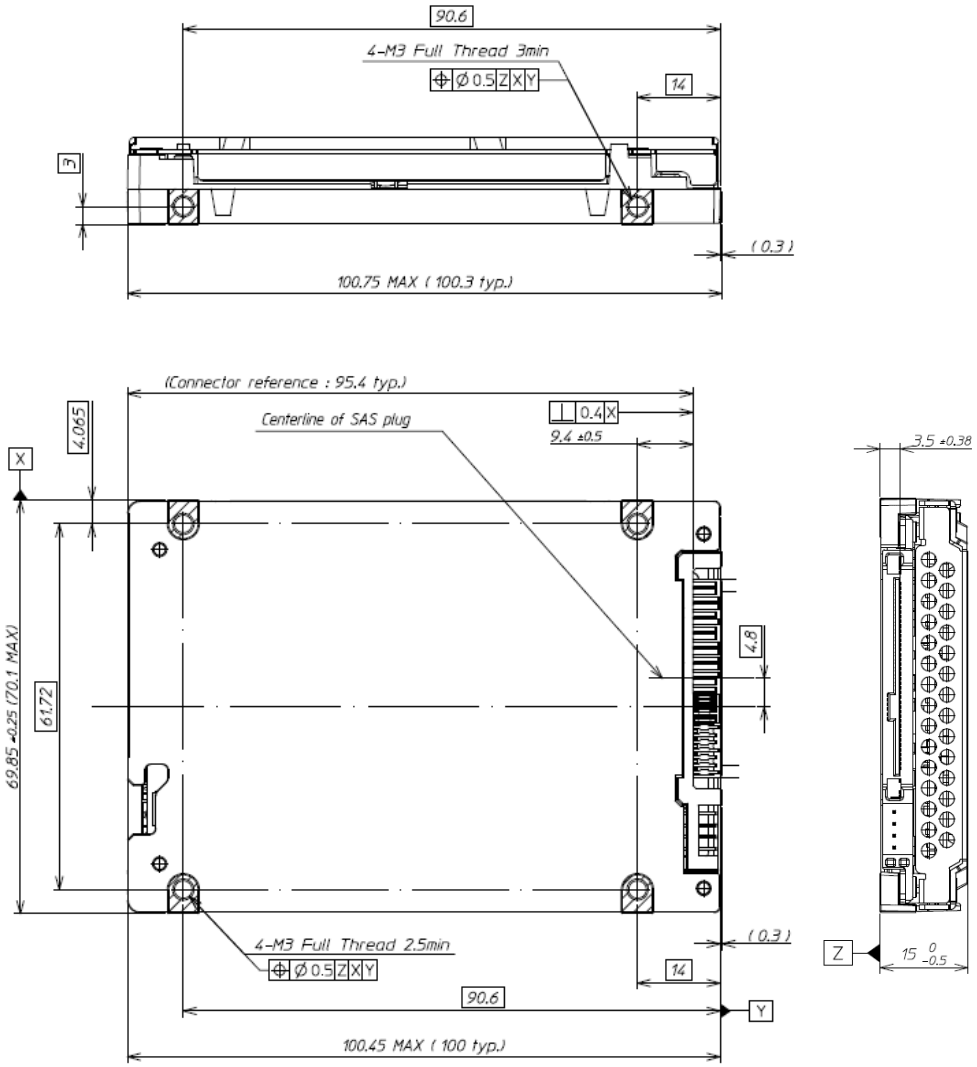
CHAPTER 4 Installation Requirements

This chapter describes the mounting, power supply and connection.

4.1 Mounting Requirements

4.1.1 Dimensions

Figure 4.1 shows the dimensions of the KPM6 series and the location of the mounting screw holes.



[Unit: mm]

Figure 4.1 KPM6 Series Dimensions

4.1.2 Mounting Orientations

As shown in Figure 4.2, the KPM6 series can be installed flat on any of their six sides.

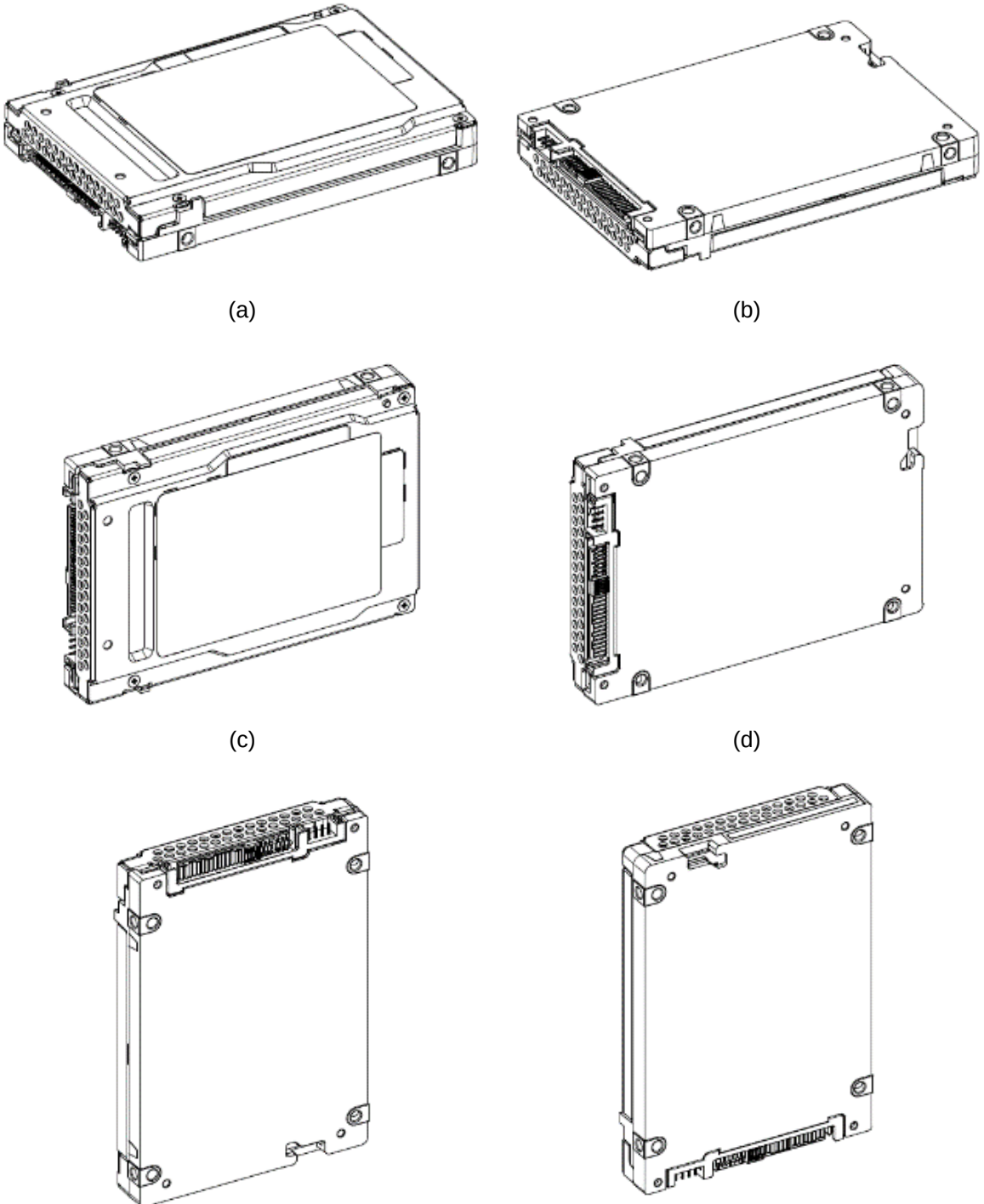


Figure 4.2 KPM6 Series Orientations

4.1.3 Notes on Mounting

⚠CAUTION	
Prohibited	Damage Do not use a conductive cleaner to clean the SSDs. Do not remove any labels from the SSD or deface them in any way. Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy SSDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.

(1) Mounting screw

The mounting screws must use M3 × 0.5 metric.

(2) Mounting frame structure

As for the system frame structure mounting of the SSDs, the following criteria are required.

a) The frame shall not touch the PCBA of the SSDs. It must be mounted with a gap of 2.5 mm or more from the frame.

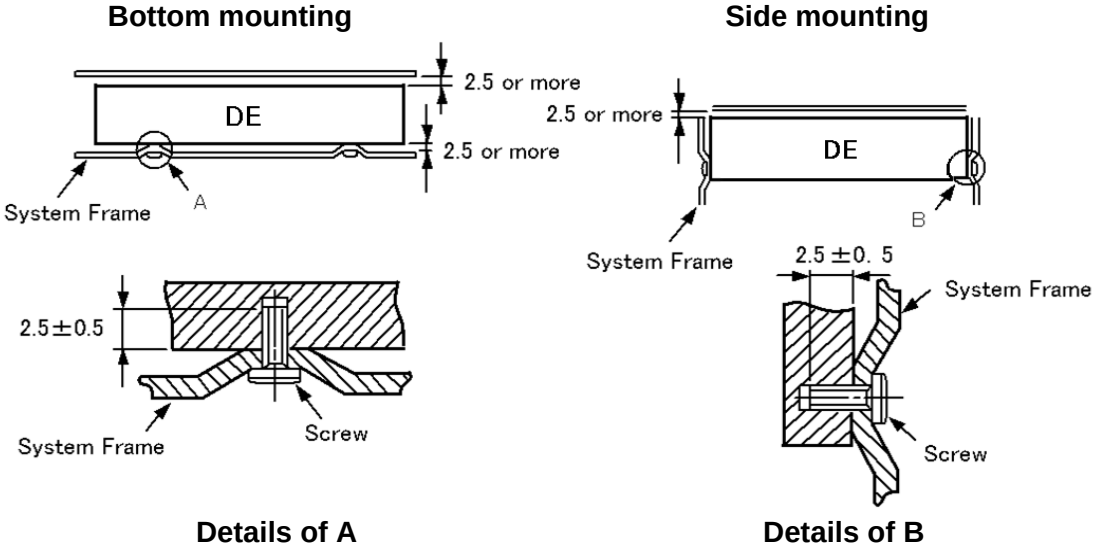
b) The inward projection of the screw from the SSD frame wall at the corner must be 2.5 mm ±0.5 mm.

c) When securing the SSD, the tightening torque of the screws must be secured with 0.49 N·m (5 kgf·cm) ±12%.

d) The frame must not distort the SSDs.

e) The impact of an electric screwdriver must not exceed the SSD specifications.

Refer to Figure 4.3, as an example.



[Unit: mm]

Figure 4.3 Example of a Mounting Frame Structure

(3) Limitation of side-mounting

Use all 4 mounting holes on both sides.

(4) Limitation of bottom-mounting

Use all 4 mounting holes on bottom face.

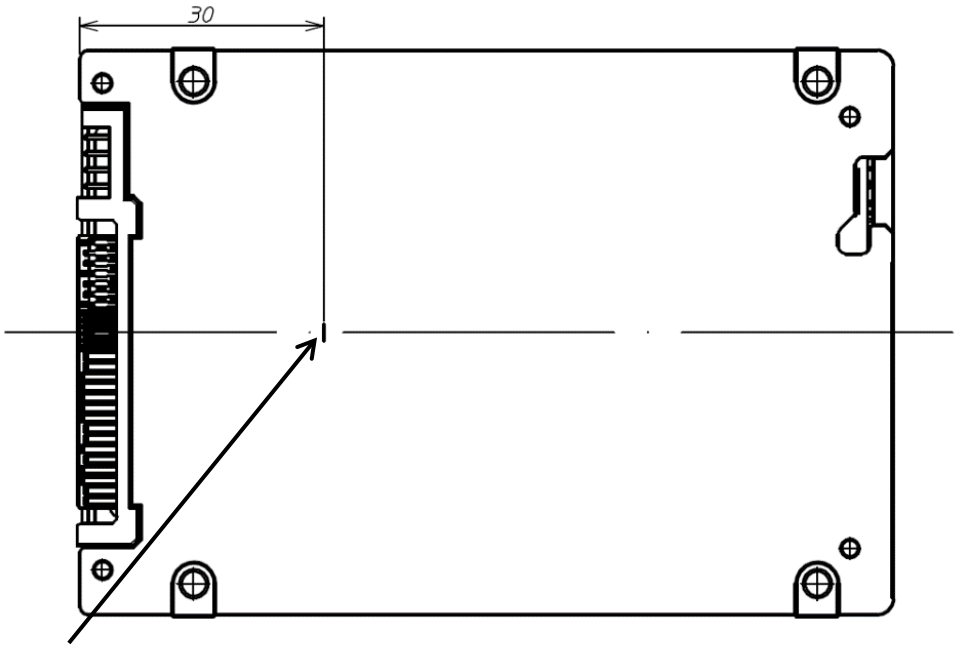
(5) Environmental temperature

The temperature condition inside the system cabinet is defined by the ambient temperature measured 30 mm from the SSD. When designing the system cabinet, the following points should be considered.

- There should be suitable air flow. The DE surface temperature should not exceed the maximum allowable temperature in Table 4.1.
- Measure the surface temperature of DE with air circulation inside the cabinet, and confirm the cooling effect. These measurement results must satisfy the temperature condition listed in Table 4.1.
- Keep the DE surface temperature at 70°C or below to meet the condition for assuring an MTTF of 2,500,000 hours.

Table 4.1 Surface Temperature Check Point and Maximum Allowable Temperature

Measurement point	Maximum allowable temperature
DE surface	70°C



DE surface temperature measurement point [Unit: mm]

Figure 4.4 KPM6 Series Surface Temperature Measurement Point

4.2 Power Supply Requirements

(1) Allowable input voltage and current

The power supply input voltage measured at the power supply connector pin of the SSDs (receiving end) must satisfy the requirement given in Subsection 2.1.3. (For other requirements, see Items (4) below.)

(2) Current waveform (reference)

Figure 4.5 and show the startup current waveform of +5V DC and +12V DC.

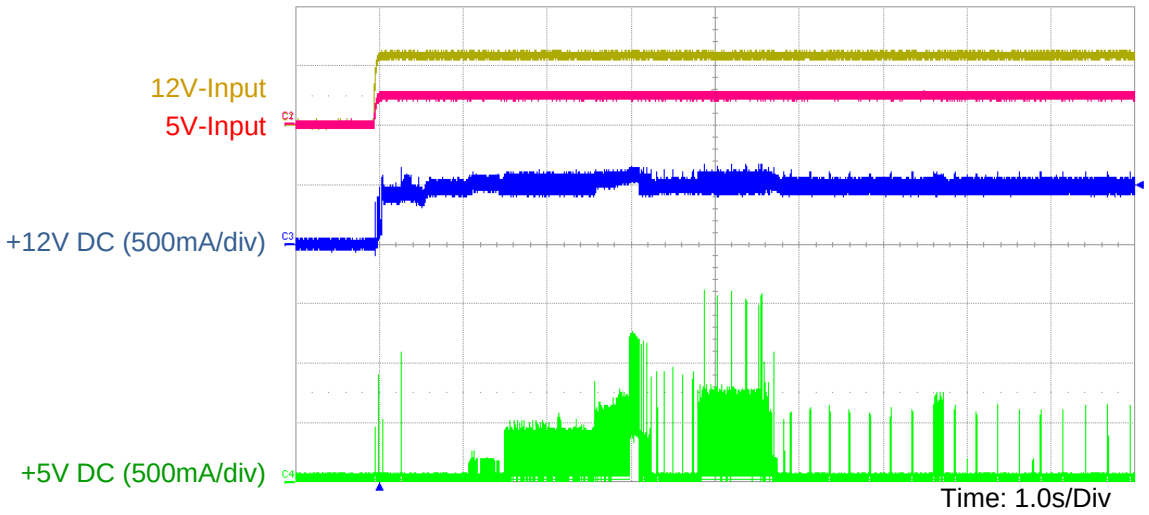


Figure 4.5 KPM61VUG12T8 current waveform

(3) Power on/off sequence

The order of the power on/off sequence of +5V DC and +12V DC, supplied to the SSDs, does not matter.

(4) Sequential starting

When power to the SSDs is turned on, high current flows in the +5V / +12V DC line. Therefore, if more than one SSD are in a system, the SSD should be started sequentially. A time difference of 12s or more should be applied when turning on the +5V / +12V DC line, to prevent overloading of the power supply unit.

(5) Noise filter

To reduce AC line noise, a noise filter should be installed at the AC input terminal on the SSD power supply unit. The specification of this noise filter is as follows:

- Attenuation: 40 dB or more at 10 MHz
- Circuit construction: T-configuration, as shown in Figure 4.6 is recommended.

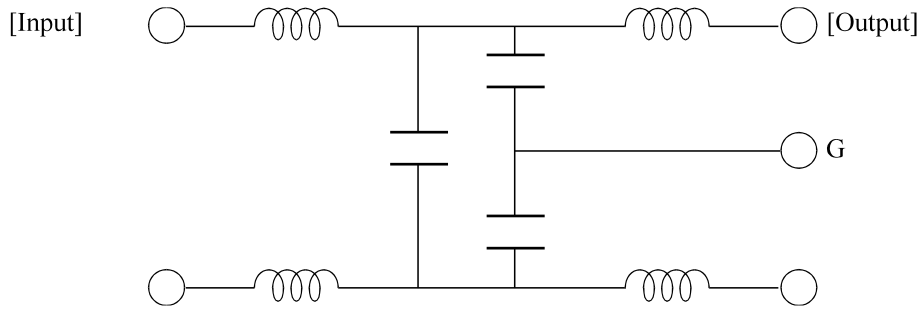


Figure 4.6 AC Noise Filter (recommended)

4.3 Connection Requirements

4.3.1 Connector Location

Figure 4.7 shows the location of the KPM6 series interface connector.

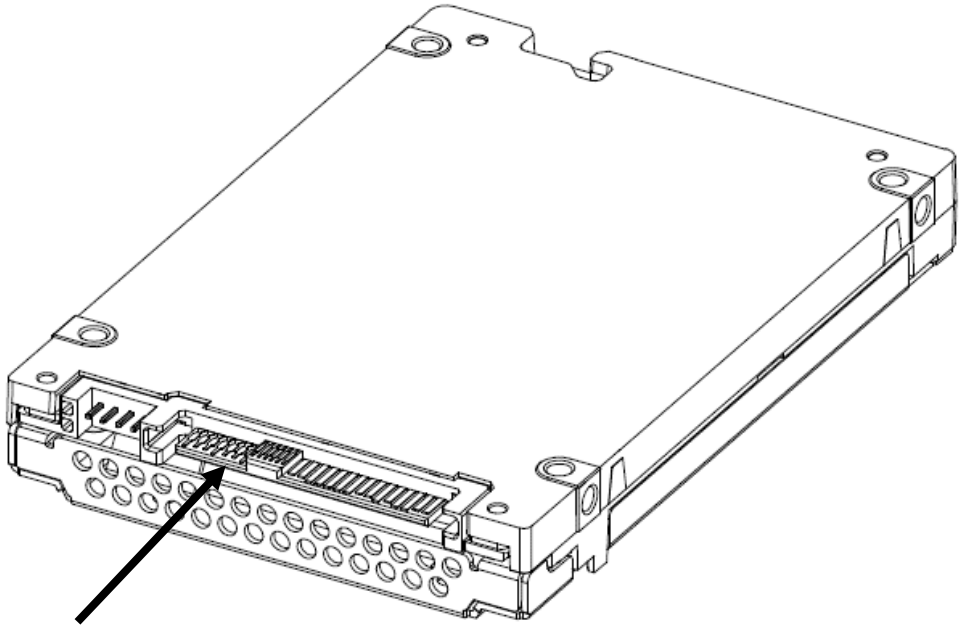


Figure 4.7 Connector Location of KPM6

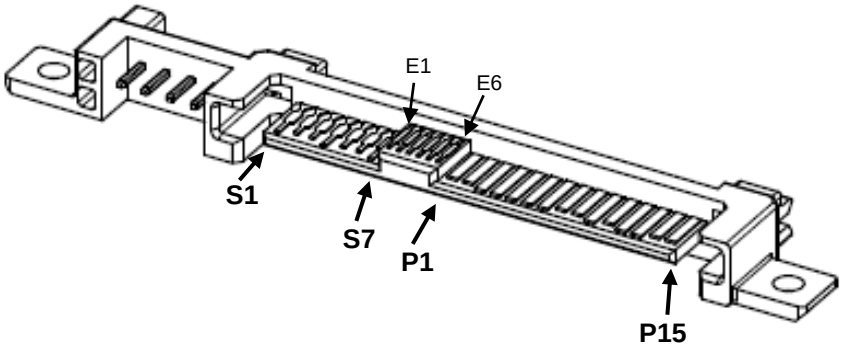
4.3.2 Interface Connector

Figure 4.8 shows the SFF-8639 interface connector (SFF-8639 plug) overview.

SFF-8639 plug is a common connector supporting SAS (SFF-8680, 8482, 8630) and PCIe.

Table 4.2 lists the signal allocation of the SFF-8639 plug on the SSDs.

Primary port side (E1 to E6 are not used in this product)



Secondary port side (S15 to S28, E7 to E25 are not used in this product)

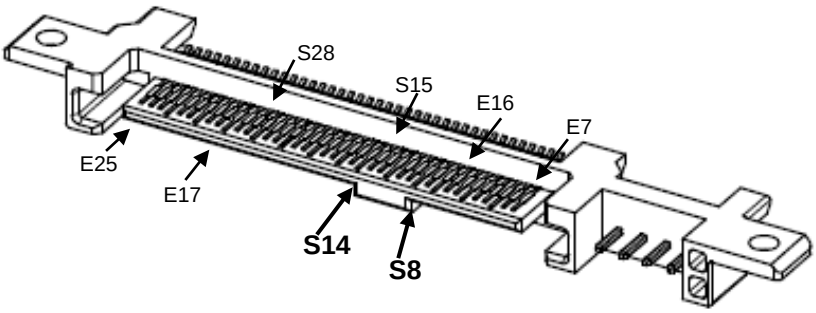


Figure 4.8 SFF-8639 Plug Connector Overview

Table 4.2 Interface Connector (SFF-8639 plug) Signal Allocation: CN1 (1/2)

Pin No.	Signal	Description
S1	GND	GROUND
S2	S0T+	SAS 0 Transmit (positive) signal
S3	S0T-	SAS 0 Transmit (negative) signal
S4	GND	GROUND
S5	S0R-	SAS 0 Receive (negative) signal
S6	S0R+	SAS 0 Receive (positive) signal
S7	GND	GROUND
S8	GND	GROUND
S9	S1T+	SAS 1 Transmit (positive) signal
S10	S1T-	SAS 1 Transmit (negative) signal
S11	GND	GROUND
S12	S1R-	SAS 1 Receive (negative) signal
S13	S1R+	SAS 1 Receive (positive) signal
S14	GND	GROUND
S15	Reserved	Not used for this product
S16	GND	GROUND
S17	Reserved	Not used for this product
S18	Reserved	Not used for this product
S19	GND	GROUND
S20	Reserved	Not used for this product
S21	Reserved	Not used for this product
S22	GND	GROUND
S23	Reserved	Not used for this product
S24	Reserved	Not used for this product
S25	GND	GROUND
S26	Reserved	Not used for this product
S27	Reserved	Not used for this product
S28	GND	GROUND
P1 (*1)	Reserved	Do not supply 3.3V power if POWER DISABLE Function is used.
P2 (*1)	Reserved	
P3 (*2)	POWER DISABLE	Power Disable Control input signal
P4	GND	GROUND
P5	GND	GROUND
P6	GND	GROUND
P7	+5V-Charge	Pre-charge pin for +5V
P8	+5V	+5V power supply input
P9	+5V	+5V power supply input
P10	GND	GROUND
P11	READY LED	READY LED output
P12	GND	GROUND
P13	+12V-Charge	Pre-charge pin for +12V
P14	+12V	+12V power supply input
P15	+12V	+12V power supply input

Table 4.2 Interface Connector (SFF-8639 plug) Signal Allocation: CN1 (2/2)

Pin No.	Signal	Description
E1	Reserved	Not used for this product
E2	Reserved	
E3	Reserved	
E4	Reserved	
E5	Reserved	
E6	Reserved	
E7	Reserved	
E8	Reserved	
E9	GND	GROUND
E10	Reserved	Not used for this product
E11	Reserved	
E12	GND	GROUND
E13	Reserved	Not used for this product
E14	Reserved	
E15	GND	GROUND
E16	Reserved	Not used for this product
E17	Reserved	
E18	Reserved	
E19	GND	GROUND
E20	Reserved	Not used for this product
E21	Reserved	
E22	GND	GROUND
E23	Reserved	Not used for this product
E24	Reserved	
E25	Reserved	

(* 1) Do not supply 3.3V power if POWER DISABLE feature is used.

(* 2) The terminal P3 is used as POWER DISABLE control signal in SAS-3. This terminal is connected to GROUND or OPEN, on the host side, when the POWER DISABLE function is not used.

4.3.3 Ready LED Output Signal

Figure 4.9 shows a recommended circuit for external LED connection to Ready LED Output signal.

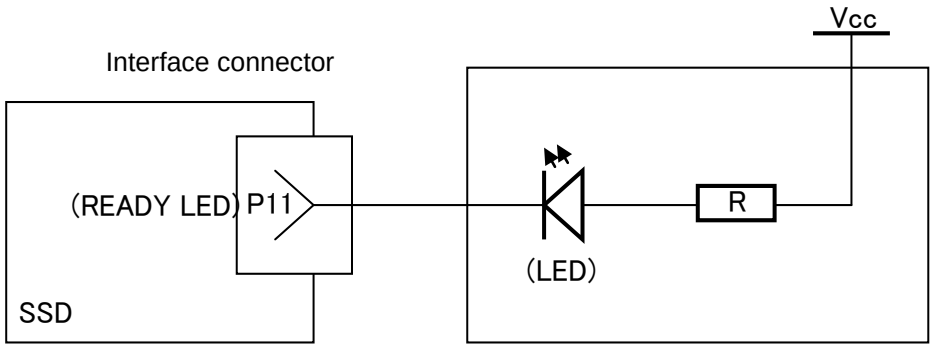


Figure 4.9 Recommended External Circuit for Ready LED Output

Either +3.3 V or +5 V can be used for external power supply for LED (V_{CC}). Current limiting resister (R) value needs to be adjusted depending on the V_{CC} voltage. For +3.3 V V_{CC} voltage, recommended resistance is 220Ω. For +5 V V_{CC} voltage, recommended resistance is 330Ω.

4.3.4 POWER DISABLE Control Input Signal

When this signal is asserted at the High level, +5V/+12V power supply to the inside of the drive is cut with the switch in the SSDs. +5V/+12V power supply to the inside of the SSDs restarts when this signal is asserted at the Low level, and the drive begins processing according to the same procedure as turning on the power supply.

	Minimum	Maximum
Absolute maximum input voltage range	-0.5 V	3.6 V
Negated voltage (power on)	-0.5 V	0.7 V
Asserted voltage (power disabled)	2.1 V	3.6 V

4.3.5 Connector Requirements

Table 4.3 lists the recommended connectors for the host system.

Table 4.3 Recommended connectors (SAS3)

Manufacturer	Part Number	Remarks
Amphenol	PSASF313021-XXX	Vertical SMT
	PSASF213021-XXX	R/A SMT
	SAS3F313009XXX	V/T SMT Socket
	SAS3F313010XXX	V/T SMT Socket
Molex	78719	SAS3 Through Hole
	78716	SAS3 Hybrid
	78720	SAS3 Press Fit Type
	78715	SAS3 Receptacle Vertical SMT
	78728	
	78795	
	151039	
	78718	SAS3 Receptacles R/A SMT
	151002	
	78847	
	78861	
	78794	
	78757	SFF-8639 (SAS3) Receptacle Vertical SMT
	78777	
	78784	
	78798	SFF-8639 (SAS3) Receptacle R/A SMT
	78776	
	78844	
	78809	

CHAPTER 5 Installation

This chapter describes the notes on handling SSDs, setting, mounting SSDs, confirming SSD operations after installation and preparation for use and dismounting SSDs.

5.1 Notes on Handling SSDs

The specifications listed in Table 2.2 must be strictly observed.

(1) General notes

a) Avoid shocks or vibrations exceeding the value defined in the specification because it may cause critical damage to the SSD. Be careful when unpacking.

b) Do not leave the SSD in a dirty or contaminated environment.

c) Since Electrostatic Discharge (ESD) may destroy the CMOS semiconductors in the SSD, note the following after unpacking:

- Use an antistatic mat and body grounding when handling the SSD.
- Hold the DE when handling the SSD. Do not touch PCBAs except during setting.

d) Many semiconductor products are used for SSD.

Semiconductor products may experience corroded lead or degraded characteristics when used under corrosive gases such as SOX, NOX or H2S.

Especially when corrosive gas and a high humidity environment overlap, the speed of degradation increases to a rapid pace and a chemical reaction may cause an electrical leakage between leads.

For example, sulfidizing gas may be generated from rubber products, when corrosion of device leads of semiconductor products and leakage between leads may occur. Therefore, the use of rubber products around semiconductor products requires consideration.

⚠CAUTION		
 **Prohibited**	High temperature To prevent injury such as burns, do not touch the SSD while it is hot. The DE and LSI become hot during operation and remain hot after turning off the power.	

(2) Unpacking

a) Use a flat work area. Check that the "This Side Up" sign side is up. Handle the package on soft material such as a rubber mat, not on hard material such as a desk.

b) Be careful not to give excess pressure to the internal unit when removing cushions.

c) Be careful not to give excess pressure to the PCBA and interface connector when removing the SSD from the antistatic bag.

d) Do not remove any labels from the SSD. Never open the DE for any reason.

(3) Installation/Removal/Replacement

a) Do not move the SSD when power is turned on. Wait until the SSD completely stops after power is turned off (about 5 seconds).

b) Keep removed screws and other parts to avoid loss or damage.

c) Keep a record of all maintenance work for replacement.

(4) Packing

a) Store the SSD in the antistatic bag.

b) It is recommended to use the same cushions and packaging as those at the time of delivery. (For details, see Section 6.4.) If unavailable, use a package with shock absorption, so that the SSD is free from direct shocks. Fully protect the PCBA and interface connector to prevent damage.

(5) Delivery

a) When delivering the SSD, provide packaging. Do not turn it over.

b) Minimize the delivery distance after unpacking. Avoid shocks and vibrations by using cushions. For the mounting orientation during delivery, use one of the allowable mounting orientations in Subsection 4.1.2.

(6) Storage

a) Provide moisture proof packaging for storage.

b) The storage environment must satisfy the requirements specified in Subsection 2.1.3 when the SSD is not operating.

c) To prevent condensation, avoid sudden changes in temperature.

5.2 Setting

5.2.1 Port Address

Every device that uses the SAS interface has unique SAS addresses and commands. A SAS address is used to identify each device for I/O operations. Every SSD is assigned unique SAS addresses before shipment from the factory, so setting of addresses is not required before the SSDs are used.

5.3 Mounting SSDs

5.3.1 Mounting procedures

Since mounting the SSD depends on the system cabinet structure, determine the work procedures considering the requirements specific to each system. The general mounting method and items to be checked are shown below.

1) Fix the SSD in the system cabinet with four mounting screws as follows:
   - The SSD has 8 mounting holes (both sides: 2 × 2, bottom: 4). Fix the SSD by using four mounting holes on both sides of the SSD or the bottom.
   - Use mounting screws of length 2.5 mm ±0.5 mm when tightened inside the SSD mounting frame (see Figure 4.3).
   - When mounting the SSD, be careful not to damage the PCBA.
2) Confirm the DE is not touching the frame on the system side excluding the screw installing part after tightening the screws. At least 2.5mm of clearance is required between the DE and the frame (see Figure 4.3).
3) When using an electric screwdriver, the applied force on the SSD should not exceed the SSD specifications.

See Section 4.1 for the details on the requirements for installing the SSDs.

5.4 Checking Operation after Installation and Preparing the SSDs for Use

5.4.1 Checking Initial Operation

The procedure for verifying operation after power-on is explained below.

(1) Initial diagnosis at power-on:

a) When the SSDs are turned on, the SSDs perform the initial self-diagnosis (controller hardware diagnosis). If external LED is connected, it blinks.
b) When the SAS protocol controller diagnosis is completed normally, the SSDs start the LINK RESET sequence defined by the SAS protocol to establish synchronization with the connected SAS devices.
c) When the initial diagnosis is completed normally, the SSDs can respond to commands from the host, however SSDs cannot operate write / read until SSDs receive NOTIFY (Enable Spinup) primitive (not ready state).

(2) Verifying interface connection:

When verification of initial operation after power-on is completed normally, the Initiator checks whether the SSD connection to the interface is normal. The procedure for this check depends on the Initiator configuration. The following are the general check procedure:

a) Confirm that the transfer rate and SSD SAS addresses can be recognized during the LINK RESET sequence.
b) Issue the INQUIRY, WRITE BUFFER and READ BUFFER commands to verify that data is received and transmitted normally in the interface.

(3) Verifying SSD operation:

After power on, SSD performs power on initialization automatically. After the connection check of an interface connector, the initiator checks that SSD transfers to the ready state, and checks whether the drive can operate.

a) After power on, SSD transfers to the not ready state in about 1 second.
b) SSD goes into the ready state in about 30 seconds, when SSD receives NOTIFY (Enable Spinup) primitive.
c) If the external LED is connected, it blinks (flashes on and off every 0.5 seconds) during the drive setup processing. An initiator checks that the SSD is in ready state by issuing TEST UNIT READY command periodically.
d) After the SSDs enter the ready state, the TEST UNIT READY command finishes normally. If the external LED is connected, the LED is on or off (depending on the READY LED MEANING setting of Mode Page 19).

(4) Responses to operation errors:

a) Confirm again that connectors are securely attached to cables.
b) Check whether the supply voltage is supplied normally. (Measure the voltage at the power connectors of the SSDs.)
c) Issue the REQUEST SENSE command to collect sense data. When sense data has been collected successfully, perform an analysis to check for recoverable errors, and retry operations for recovery from any such errors.

(5) Checking at abnormal end

When sense data can be obtained, analyze the sense data and retry recovery for a recoverable error. Refer to CHAPTER 7 "Error Analysis" for further details.

5.4.2 Formatting

Since the SSD is formatted with a specific (default) data format for each model (part number) when shipped from the factory, the media need not be formatted (initialized) when it is installed in the system.

However, when the system needs data attributes different from the default format, all sides of the media must be formatted (initialized) according to the procedures below.

The user can change the following data attributes at initialization:

- Logical data block length
- Number of logical data blocks in the user space

This section outlines the formatting at installation. Refer to Subsection 1.9 “Data Block Addressing”, 1.10 “Protection Information”, 3.8 "MODE SELECT (6)", 3.9 "MODE SELECT (10)", 3.2 "FORMAT UNIT and Chapter 6 "Media Management" of the INTERFACE SPECIFICATION for further details.

(1) MODE SELECT command

Specify the format attributes on the media with the MODE SELECT (6) or MODE SELECT (10) command. The parameters are as follows.

a. Block descriptor
Specify the size (byte length) of the logical data block in the "data block length" field. To explicitly specify the number of logical data blocks, specify the number in the "number of data blocks" field. Otherwise, specify 0 in "number of data blocks" field. In this case, the currently set value is used.

(2) FORMAT UNIT command

Initialize the entire recording surface of the media with the FORMAT UNIT command. The FORMAT UNIT command initializes the entire surface the P-Lists. As for SSD, the format settings related to defect list are ignored. Therefore, if the initializing data pattern is the default (“00”), the parameter is not necessary.

a. The command issue method when default data pattern "00"
Set "0" in FmtData bit in CDB, “0” in CmpLst bit and “000” in Defect List Format field, not to transfer the format parameter.
b. The command issue method when specified data pattern
Set “1” in FmtData bit and proper value in LONGLIST.
Set "1" in IP bit of the header of a format parameter, and the initialization data pattern.

Refer to Subsection 3.2 "FORMAT UNIT" of the INTERFACE SPECIFICATION for further details of initialize data pattern.

5.4.3 Setting Parameters

The user can specify the optimal operation mode for the user system environments by setting the following parameters with the MODE SELECT (6) or MODE SELECT (10) command:

- Error recovery parameter
- Port control parameter

With the MODE SELECT (6) or MODE SELECT (10) command, specify 1 for the "SP" bit on CDB to save the specified parameter value on the media. This enables the SSDs to operate by using the parameter value set by the user when the power is turned on again.

When the parameters are not set or saved with the MODE SELECT (6) or MODE SELECT (10) command, the SSDs set the default values for the parameters and operates when power is turned on or after reset. Although the SSD operations are assured with the default values, the operations are not always optimal for the system. To obtain the best performance, set the parameters in consideration of the system requirements specific to the user.

This section outlines the parameter setting procedures. Refer to Subsection 3.8 "MODE SELECT (6)", 3.9 "MODE SELECT (10)" of the INTERFACE SPECIFICATION for further details of the MODE SELECT (6) and MODE SELECT (10) commands and specifying the parameters.

IMPORTANT

1. At factory shipment of the SSDs, the saving operation for the MODE SELECT parameter is not executed. So, if the user does not set parameters, the SSDs operate according to the default value of each parameter.
2. The MODE SELECT parameter is not saved for each initiator but as the common parameter for all initiator. In the multi-initiator system, the parameter setting cannot be changed for each initiator.
3. Once parameters are saved, the saved value is effective as long as next saving operation is executed from the initiator. For example, even if the initialization of the media is performed by the FORMAT UNIT command, the saved value of parameters described in this section is not affected.
4. When the SSDs, to which the saving operation has been executed on a system, are connected to another system, the user must pay attention to the SSDs. Operation should be according to the saved parameter value if the saving operation is not executed at installation.
5. The saved value of the MODE SELECT parameter is assumed as the initial value of each parameter after the power-on, the HARD RESET sequence or the LOGICAL UNIT RESET frame. The initiator can change the parameter value temporary (actively) at any timing by issuing the MODE SELECT (6) or MODE SELECT (10) command by specifying "0" to the SP bit in the CDB.

(1) Error recovery parameters

The following parameters are used to control operations such as SSD internal error recovery:

a. Read/write error recovery parameters (page code = 1)

Parameter	Default value
• TB (Uncorrectable data transfer to the initiator)	0 (disabled)
• PER (Report of recovered error)	0 (disabled)
• Recovery Time Limit	5 seconds

b. Verify error recovery parameters (page code = 7)

Parameter	Default value
• PER (Report of recovered error)	0 (disabled)

Notes:

1. The user can arbitrarily specify the following parameters according to the system requirements:
   - TB
   - PER

2. The user can also arbitrarily specify parameters other than the ones mentioned above. However, it is recommended to use the default setting in normal operations.

(2) Port control parameters (when the external LED is connected)

The following parameters are used to control the ready LED signal behavior.

Parameter	Default value
• Ready LED Meaning	0 (External LED is on when SSD is ready)

5.5 Dismounting SSDs

Since the method and procedure for dismounting the SSD for replacement of the SSD, etc. depends on the locker structure of the system, etc., the work procedure must be determined in consideration of the requirements specific to the system. This section describes the general procedure and notes on dismounting the SSD.

⚠CAUTION	
Prohibited	High temperature To prevent injury such as burns, do not touch the SSD while it is hot. The DE and LSI become hot during operation and remain hot after turning off the power. 
Instructions	Damage When dismounting the SSD mounted on the system while power is supplied; 1) Stop the function by a START STOP UNIT command. It takes about 5 seconds to stop completely. 2) Dismount the SSD using the mounting/dismounting mechanism of the system. Avoid exposure to shock or vibration. If removal will result in shock or vibration, stop dismounting and wait until the SSD stops (about 5 seconds) when SAS connector breaks off contact.
Instructions	Damage When dismounting the SSD mounted on the system while power is not supplied; Dismount the SSD using the mounting/dismounting mechanism of the system. Avoid exposure to shock or vibration.
Instructions	Damage When storing or transporting the SSD, put it in the antistatic bag.

CHAPTER 6 Diagnostics and Maintenance

This chapter describes diagnostics and maintenance.

6.1 Diagnostics

6.1.1 Self-diagnostics

The SSDs have the following self-diagnostic function. This function checks the basic operations of the SSDs.

- Initial self-diagnostics
- Online self-diagnostics (SEND DIAGNOSTIC command)

Table 6.1 lists the contents of the tests performed with the self-diagnostics. For a general check of the SSDs including the operations of the initiator and interface, use a test program that runs on the initiator (see Subsection 6.1.2).

Table 6.1 Self-diagnostic functions

Test contents	Initial self-diagnostics	SEND DIAGNOSTIC command	
		Self Test = 1 Unit Offline = 0	Self Test = 1 Unit Offline = 1
Hardware function test	○	○	○
Write/read test			○

Note:
○ indicates the tests to be executed and arrows (↓) show the sequence of execution.

Brief test contents of self-diagnostics are as follows.

a. Hardware function test

This test checks the basic operation of the controller section, and contains following test.

- RAM (microcode is stored)
- Peripheral circuits of microprocessor (MPU)
- Data buffer

b. Write/read test

This test checks the write/read function by using the Internal test space of the SSD.

(1) Initial self-diagnostics

When the SSDs are turned on, they run the initial self-diagnostics. The initial self-diagnostics test the basic operations of hardware functions.

If the initial self-diagnostics detects an error, the SSDs in this state post the CHECK CONDITION status to all I/O operation requests except the REQUEST SENSE command. The initiator can collect sense data when the CHECK CONDITION status is posted.

Sense data contains detailed information on the error detected by the initial self-diagnostics.

When sense data has been collected after the CHECK CONDITION status has been posted, the CHECK CONDITION status continues. This status can be cleared only when the SSDs are turned off and turned on again. When the status is cleared, the SSDs run the initial self-diagnostics again.

The SSDs do not reply to requests from the host system for a maximum of 2 seconds after the start of the initial self-diagnostics. Thereafter, the SSDs can accept I/O operation requests normally, but any received command, except commands that are executable even in the not ready state, is terminated with the CHECK CONDITION status until the SSDs become ready. The commands that are executable even in the not ready state are executed in parallel with the initial self-diagnostics, or they are queued by the command queuing feature and executed when the initial self-diagnostics is completed.

(2) Online self-diagnostics (SEND DIAGNOSTIC command)

The initiator can make the SSDs execute self-diagnostics by issuing the SEND DIAGNOSTIC command.

The initiator specifies the execution of self-diagnostics by setting 1 for the SelfTest bit on the CDB in the SEND DIAGNOSTIC command and specifies the test contents with the UnitOfl bit.

When the UnitOfl bit on the CDB is set to 0, the SSDs execute the hardware function test only once. When UnitOfl bit is set to 1, the SSDs execute the hardware function test and data write/read test for the internal test space only once.

a. Error recovery during self-diagnostics

During the self-diagnostics specified by the SEND DIAGNOSTIC command, when the recoverable error is detected during the write/read test, the SSDs perform the error recovery according to the MODE SELECT parameter value (read/write error recovery parameter, additional error recovery parameter) which the initiator specifies at the time of issuing the SEND DIAGNOSTIC command.

PER	Operation of self-diagnostics
0	The self-diagnostics continues when the error is recovered. The self-diagnostics terminates normally so long as the unrecoverable error is not detected.
1	The self-diagnostics continues when the error is recovered. If the unrecoverable error is not detected, consecutive tests are executed until the last test but the self-diagnostics terminates with error. The error information indicates that of the last recovered error.

b. Reporting result of self-diagnostics and error indication
When all specified self-diagnostics terminate normally, the SSDs post the GOOD status for the SEND DIAGNOSTIC command.

When an error is detected in the self-diagnostics, the SSDs terminate the SEND DIAGNOSTIC command with the CHECK CONDITION status.

The SSD status, after the CHECK CONDITION status is posted differs according to the type of the detected error.

a) When an error is detected in write/read test, the subsequent command can be accepted correctly.
b) When an error is detected in the hardware function test, the SSD goes to the failure state. And post the CHECK CONDITION status except some commands.

Refer to section 3.42 "SEND DIAGNOSTIC " of the INTERFACE SPECIFICATION for further details of the command specifications.

6.1.2 Test programs

The basic operations of the SSD itself can be checked with the self-diagnostic function. However, to check general operations such as the host system and interface operations in a status similar to the normal operation status, a test program that runs on the host system must be used.

The structure and functions of the test program depend on the user system requirements. Generally, it is recommended to provide a general input/output test program that includes devices connected to the input/output devices on other I/O ports.

Including the following test items in the test program is recommended to test the SSD functions generally.

(1) Interface test

The operations of the data buffer on the SSDs are checked with the WRITE BUFFER and READ BUFFER commands.

(2) Basic operation test

The basic operations of the SSDs are checked by executing self-diagnosis with the SEND DIAGNOSTIC command (see Subsection 6.1.1).

(3) Random/sequential read test

The positioning operation and read operation are tested in random access and sequential access modes with the READ (6), READ (10) or VERIFY command.

6.2 Operation Check

6.2.1 Initial Operation Check

If an error is detected during initialization by the initial operation check routine at power-on, the function of the SSD stops, and then the SSD becomes unusable.

For an explanation of the operation check before the initial operation, refer to the Section 5.4.

6.2.2 Operation Test

While the host computer is processing data, the SSDs monitor SSD operation including data processing and command processing. If the SSDs detect an error, the SSDs post the error to the initiator. The initiator then posts the error to the user.

The user may detect an intermittent or nonfatal error such as abnormal noise, abnormal odor or very slow operation.

An error posted in an operation test must be investigated. The user can replace the SSD to see whether the error was caused by the SSD.

Often, errors posted in an operation test may be caused by the host system. Possible causes include insufficient power capacity, loose cable connection, insufficient timing or insufficient mechanical margin, and other problems related to the systems.

If an operation error is detected by the error detection circuit of the SSD, an interrupt occurs. The interrupt is posted to the MPU on the PCBA. The MPU stops the currently processed command, and causes the CHECK CONDITION status to post the error to the initiator.

When receiving the CHECK CONDITION status, the initiator collects detailed information via SENSE data. In the normal operating state, the SSD or an initiator opts for processing (a retry or discontinuation of processing) of the detected failure state.

To analyze the error posted in the operation test, reconstruct the conditions in which the error occurred. Then, start troubleshooting the whole host system by replacing the SSD.

6.2.3 Diagnostic Test

The diagnostic test is executed to find a faulty subassembly in a faulty SSD or to check SSD performance. This test is usually a combination of specific SSD functions or group of functions. This test may be executed using a different host computers or test equipment and away from the environment where the error first occurred.

To analyze the error posted in the diagnostic test, reconstruct the conditions in which the error occurred. Then, look for a possibly faulty subassembly or part of the SSD.

The procedures to be used in this test depend largely on the type of test equipment used, and are not covered by this document.

6.3 Troubleshooting

See Section 5.1 and 6.4 for notes on packaging and handling when returning the SSD.

⚠CAUTION	
Instructions	Data loss Save data stored on the SSD to other media before troubleshooting. KIOXIA assumes no liability if data is corrupted during service or troubleshooting.

6.3.1 Precautions

Take the following precautions to prevent injury during troubleshooting:

⚠CAUTION	
Prohibited	High temperature To prevent injury such as burns, do not touch the SSD while it is hot. The DE and LSI become hot during operation and remain hot after turning off the power. 
Prohibited	Electrical shock Do not touch the SSDs while power-feeding.

Take the following precautions to prevent SSD damage during troubleshooting:

⚠CAUTION	
Prohibited	Damage Do not use a conductive cleaner to clean the SSDs. Do not remove any labels from the SSD or deface them in any way. Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy SSDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.
Instructions	Damage To prevent ESD (Electrostatics Discharge) that may cause damage to the device, always ground yourself before handling. Use of wrist strap connected to ground is advisable.

6.3.2 Outline of Troubleshooting Procedures

This section explains the troubleshooting procedures for SSD errors.

Depending on the maintenance level, analyze the error to detect a possibly faulty part (SSD or SSD part).

Full-scale troubleshooting is usually required if the error cause is unknown. If the error cause is clear (e.g., abnormal noise in DE or burning of the PCBA), troubleshooting is straightforward.

6.3.3 Troubleshooting with SSD Replacement in the Field

At this level of maintenance, replacing the SSD as a unit is recommended. If replacing the SSD rectifies the fault, return the removed SSD to KIOXIA, for test. If the newly installed SSD does not rectify the fault, another part of the system is faulty. Table 6.2 summarizes system-level field troubleshooting. Troubleshooting must be done in the field, to find faulty part (SSD or system).

Table 6.2 System-level Field Troubleshooting

Item	Recommended work
DC power level	Check that the DC voltage is within the specified range (±7%).
	For +5V DC, measure the voltage between pin P8 (+5V) and pin P4 to P6 (GND) of the interface connector, and confirm the value is between 4.65 and 5.35 VDC.
	For +12V DC, measure the voltage between pin P14 (+12V) and pin P4 to P6 (GND) of the interface connector, and confirm the value is between 11.16 and 12.84 VDC.
Electrical noise	Make sure the maximum ripple peak-to-peak value of +5V DC is within 250 mV and +12V DC is within 250 mV.
	Make sure the high frequency noise (over 20 MHz) is less than 100mVp-p.
System cables	Check that all system cables are connected correctly.
System diagnostic test	If possible, execute the system level diagnostic routine as explained in the host system manual. This gives a detailed report of a possible fault.
Intermittent or nonfatal errors	Check the AC voltage from the power supply. Check the DC voltage level at the power connector for the SSD.
	If the AC voltage level is abnormal or there is a lot of electrical noise, notify the user of the error.
	If the DC voltage level is unstable, replace the power supply unit.
	If possible, replace the SSD. If replacing the SSD does not eliminate the error, the removed SSD is probably not faulty. To continue error analysis, refer to the hardware and software manuals supplied with the system.

6.3.4 Troubleshooting in more detail

For troubleshooting at this level, additional testing of the SSD and signal checking is recommended.

The sense data posted from the SSDs help with troubleshooting. This sense data make the error type clear (functional, mechanical or electrical error). CHAPTER 7 discusses error analysis by sense data, and gives supplementary information on finding the error cause (faulty part).

Table 6.3 lists the ways to detect a faulty SSD subassembly. This fault finding requires a working host computer or SSD test equipment to recreate the error conditions.

If the detected error cannot be recreated in an ordinary test, SSD conditions can be changed to force the error to recur. This is done by changing the DC voltage or the ambient temperature of the SSD.

If the error does not recur with changed conditions, the SSD is not faulty. If no error occurs in the SSD test, notify the user of the test results, and find out from the user the environmental conditions where the SSD is used.

Table 6.3 SSD troubleshooting

Item	Recommended action
Frequent or repeated errors	Collect sense data, and see CHAPTER 7.
	Replace the SSD, and check that the test method is correct. If the error recurs, it is likely that the SSD is normal but the test method is incorrect.
Intermittent or nonfatal errors	Replace the SSD, and check that the test method is correct. If the error recurs, it is likely that the SSD is normal but the test method is incorrect.
	To check performance, change the SSD conditions by changing the voltage or temperature.

If the SSD error recurs or a possibly faulty SSD is found by troubleshooting, return the complete SSD to KIOXIA.

⚠CAUTION	
 **Prohibited**	Damage Do not use a conductive cleaner to clean the SSDs. Do not remove any labels from the SSD or deface them in any way. Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy SSDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.

6.4 Packaging

When the SSD is to be returned, the following packaging methods are recommended.

6.4.1 Bag Packaging

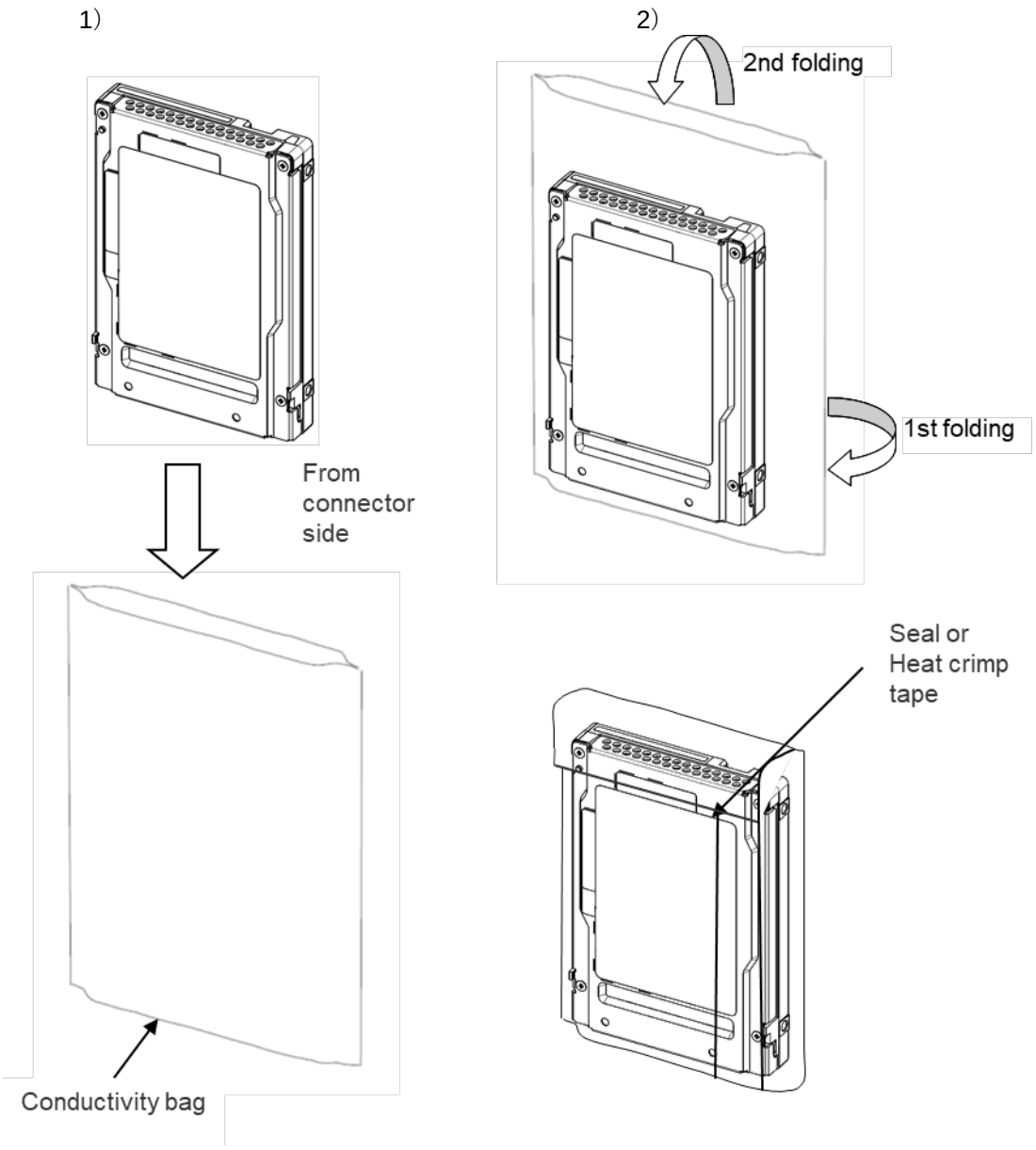


Figure 6.1 Bag Packaging

(1) Put the SSD in the conductivity bag.
The SSD shall be put in the bag from the connector side.

(2) Fold the bag, and then seal the bag.

6.4.2 Box Packaging

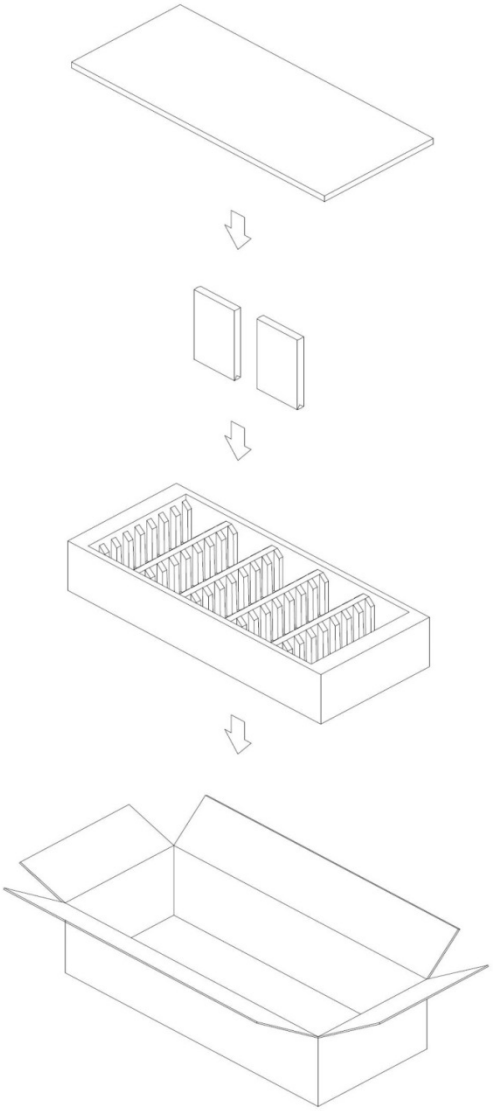


Figure 6.2 Box Packaging

(1) Put the conductivity bag (large) into the multi-box, in addition, put the cushion (lower) into the bag.

(2) Put the bag packed SSDs into the cushion (lower).
- Insert the seal side upward.

(3) Put the cushion (upper) into the box.

(4) Seal the conductivity bag (large) with the packaging tape.

(5) Close the box with the packaging tape. (Attach the tape in 'H' figure at the top.)

CHAPTER 7 Error Analysis

This chapter explains in detail how sense data collected from a SSD is used for troubleshooting. Sense data reflects an error in the SSD, and helps with troubleshooting.

7.1 Sense Data Collection

When SSDs post a CHECK CONDITION status, it indicates that the command execution was terminated due to an error. The sense data sent with status has to be analyzed and recovery processing which had responded to the error has to be performed.

This SSD is equipped with sense data with a byte length of 48. Accordingly, KIOXIA recommends collecting all 48-byte sense data when the initiator collects sense data.

A set of sense key, additional sense code and additional sense code qualifier are often used for failure investigation. This section describes troubleshooting based on the set of sense key, additional sense code and additional sense code qualifier. Unless otherwise specified, "sense data" means the above three codes. When sense data is represented as (x-xx-xx), the leftmost x is a sense key, the middle xx is an additional sense code, and the rightmost xx is an additional sense code qualifier.

7.2 Sense Data Analysis

7.2.1 Error Information Indicated with Sense Data

Table 7.1 lists the definition of sense data. For details of the following sense data, refer to Chapter 5 "Sense Data and Error Recovery Methods" of the INTERFACE SPECIFICATION.

Subsection 7.2.2 onwards explains troubleshooting using sense data.

Table 7.1 Definition of Sense Data

Sense data			Definition
Sense key	Additional sense code	Additional sense code qualifier	
1	1x	xx	A media read error occurred, but terminated normally with error recovery functions.
3	1x	xx	A media read error occurred.
E	1D	00	Data discrepancy found by VERIFY command byte check.
7	27	xx	The SSD became read only mode
5	2x	xx	An illegal request error, such as an invalid operation code, occurred.
4	40	xx	An error occurred during self diagnosis at the power on.
4	44	xx	A hardware error occurred in the SSD inside.
B	4B	xx	An interface error was issued.
	4E	00	An overlap command was issued.

7.2.2 Sense Data (4-40-xx) and (4-44-xx): Hardware error

Sense data (4-40-xx) and (4-44-xx) indicate one of the following:

- Write or erase to the Flash memory terminated unsuccessfully.
- An error occurred in power-on self-diagnosis.
- A SSD error occurred.
- A hardware error occurred in the SSD inside.

The symptoms above are generally caused by an error in a PCBA or DE.

7.2.3 Sense Data (1-1x-xx), (3-1x-xx) and (E-1D-00): Media Read Error

When sense data (1-1x-xx) and (3-1x-xx) occurred, it indicates that the media read error occurred in the Flash memory block and automatic reassign is executed. Sense data(0E-1D-00) is the sense data reported by factors other than the medium read error at the time of Byte Check execution of the VERIFY command, automatic reassign processing of Flash memory block is not executed. (If a media read error occurred during VERIFY command with Byte Check, sense data (1-1x-xx) or (3-1x-xx) is reported.

7.2.4 Sense Data (5-2x-xx), (B-4B-xx) and (B-4E-00): Interface Error

Sense data (5-2x-xx), (B-4B-xx) and (B-4E-00) indicate one of the following symptoms:

- An invalid or unsupported command was issued, or invalid or unsupported parameters were specified.
- An interface error occurred.

If this error occurs, the PCBA or the interface may be faulty.

7.2.5 Sense data (7-27-xx): Read Only Mode

Sense data (7-27-xx) indicate one of the following symptoms:

- Write/Erase count exceeded a threshold.
- Over provisioning was less than a threshold.
- The lack of backup power capacitance was detected.

If this error occurs, it may be due to the end of SSD service life or any hardware failure.

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KIOXIA Corporation

CONDITIONS THAT VOID THE PRODUCT WARRANTY

Conditions that Void the Warranty on KIOXIA SSDs include, but are not limited to:

- Subjecting the SSD to conditions that are outside the limits described in the Environmental Specifications section of this User's Guide
- Exceeding the total number of rated power cycles, as specified in this Product Specification
- When the remaining endurance attribute, as reported by the drive, indicates that the drive's endurance has been fully consumed
- Physical damage to the drive, including, but not limited to, the following:
  - Exposure to liquids and/or exposure to corrosive atmospheric conditions
  - Signs of physical mistreatment including but not limited to stripped screw holes, scratches to or deformations of the drive housing if the drive is so equipped
  - Tampering (such as label modifications or defacing especially including anti-tamper labels, opening the case if the drive is so equipped, making modifications to the drive printed circuit board assembly, etc.)
  - Damage or wear to the connector housing or fingers

  (Note: This does NOT cover damage during shipment. These are operating and storage conditions for individual, single SSDs.)