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SAMSUNG

Rev. 1.0, Aug. 2022

MZILG960HCHQ-00A07
MZILG1T9HCJR-00A07
MZILG3T8HCLS-00A07
MZILG7T6HBLA-00A07
MZILG15THBLA-00A07
MZILG30THBLA-00A07

SAMSUNG SSD PM1653

Specification(SAS 2.5" 24Gb/s)

Datasheet

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Revision History

Revision No	History	Draft Date	Remark	Edited by	Reviewed by
1.0	1. Initial release	Aug. 29, 2022	Final	Semi Lee	Najeong Kim

Part Number	Capacity[1]	LBA Count[2]
MZILG960HCHQ-00A07	960GB	1,875,385,008
MZILG1T9HCJR-00A07	1.92TB	3,750,748,848
MZILG3T8HCLS-00A07	3.84TB	7,501,476,528
MZILG7T6HBLA-00A07	7.68TB	15,002,931,888
MZILG15THBLA-00A07	15.36TB	30,005,842,608
MZILG30THBLA-00A07	30.72TB	60,001,615,872

FEATURES

- SAS 24 Gb/s interface (SAS-4)
- Fully complies Active-active dual port
- Enhanced Power-Loss Data Protection with Aluminum Electrolytic Capacitors
- TCG-compliant Self-Encryption Drive
- Hardware based AES 256-bit Encryption Engine
- End-to-End Data Protection
- Support 32 Initiator with TCQ (Up to 256Q-depth) Command Set
- 8 RRDY provide
- Auto good response
- Supports Tag-overlap check and reserved field check
- Compliant with SCSI Specification (SAS-4 /SPL-4 /SBC-4 /SPC-5 /SAM-6)
- Compliant with TCG Enterprise Specification Rev. 1.01
- Support T10 DIF

DRIVE CONFIGURATION

· Capacity	960GB/ 1.92TB/ 3.84GB/ 7.68TB/ 15.36TB/ 30.72TB
· Form Factor	2.5-inch
· Interface	SAS 24Gbps
· Bytes per Sector	512/520/4096/4160 Bytes

PERFORMANCE SPECIFICATIONS[3),4)]

· Data Transfer Rate (128KB data size)	
- Sequential Read	(12Gb/s): 2,100 MB/s (24Gb/s): 4,200 MB/s
- Sequential Write	(12Gb/s): Up to 2,100 MB/s (24Gb/s): Up to 3,700 MB/s
· Data I/O Speed (4KB data size, Sustained)	
- Random Read	(12Gb/s): 450K IOPS (24Gb/s): Up to 800K IOPS
- Random Write	(12Gb/s): Up to 110K IOPS (24Gb/s): Up to 140K IOPS
· Latency (Sustained random workload)	
- Read/Write (typical)	Up to 120/30 us
· Quality of service	
- Read/Write (99%)	(12Gb/s): 140/35 us (24Gb/s): 110/25 us
- Read/Write (99.9%)	(12Gb/s): 210/40 us (24Gb/s): 170/35 us

PRODUCT ECOLOGICAL COMPLIANCE

· RoHS	meet spec

RELIABILITY SPECIFICATIONS

· Uncorrectable Bit Error Rate	1 sector per 10^{17} bits read
· MTBF	2,500,000 hours
· Component Design Life	5 years
· Endurance	1 DWPD
· Data loss Protection	yes

ENVIRONMENTAL SPECIFICATIONS

· Temperature[5)]	
- Operating	0 ~ 70 °C
- Non-operating[6)]	-40 ~ 85 °C
· Humidity (Non-operating)	5 ~ 95%
· Linear Shock(0.5ms duration with sine wave)	
- Non-operating	1,500 G
· Vibration (20Hz to 2,000Hz, 4min/cycle, 5cycle/axis on 3axis)	
- Non-operating	20 Gpeak
· Altitude (relative to sea level)	
- Operating	0 to 15,000 feet

POWER REQUIREMENTS[7)]

· Read Power (typical)	13.2 W
· Write Power (typical)	18.0 W
· Idle (typical)	5.0 W

PHYSICAL DIMENSION

· Width	69.85 ± 0.25 mm
· Length	100.20 ± 0.25 mm
· Height	15.00 +0.0 -0.5mm
· Weight	Up to 157.5g

NOTE: *Specifications are subject to change without notice.*

1) 1GB =1,000,000,000 Bytes, 1TB = 1,000,000,000,000 Byte, Unformatted Capacity. User accessible capacity may vary depending on operating environment and formatting.
2) 1Sector = 512bytes, LBA Count is based on the IDEMA standard.
3) Performance measured using FIO with queue depth 64.
Actual performance may vary depending on use conditions and environment.
-. OS : CentOS Linux 7.5.1804
-. HW config (CPU/MB/HBA)
(12G) I7-7700K/Z270/LSI 9300-8e
(24G) Ryzen9 3900X/X570/Broadcom 9600-16i
(I9-10900/B460M/Broadcom 9600-16i)
4) Performance is measured at dual port.
5) Case temperature (Tcase(Tc)) based on the hottest point on the external case surface. Highly recommending to provide sufficient airflow or cooling condition for operating properly even with heavier workloads within the operating temperature. Performance throttling will be engaged as touching the over-temperature threshold (see the detail in the contents)
6) Storing (or shipping) temperature without power connection.
7) Typical Power Consumption.
(Maximum average power with a measurement period of 500ms.)

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1.0 INTRODUCTION

1.1 General Description

This document describes the specification of the PM1653 SSD which use SAS 24Gb/s interface. Supporting SAS 24Gb/s interface shows much faster performance than previous SAS 12G SSDs.

PM1653 delivers 4,200GB/s for sequential read and 3,700GB/s for sequential write speed under up to 12W power.

By combining the enhanced reliability Samsung NAND Flash memory silicon with NAND Flash management technologies, PM1653 delivers the extended endurance of up to 1 Drive Writes Per Day (DWPD) for 5 years, which is suitable for enterprise applications, in three 2.5-inch form factor line ups: 960GB, 1.92TB, 3.84TB, 7.68TB, 15.36TB, 30.72TB

Because of SAS 24Gb/s interface has backward compatibility with SAS, you can use PM1653 as 12Gbps speed at old systems for SAS 12G interface. In addition, PM1653 supports Power Loss Protection which can guarantee that data issued by the host system are written to the storage media without any loss in the event of sudden power off or sudden power failure.

1.2 Product List

[Table 1] Product Line-up

Type	Capacity	Part Number
PM1653 2.5"	960GB	MZILG960HCHQ-00A07
	1.92TB	MZILG1T9HCJR-00A07
	3.84TB	MZILG3T8HCLS-00A07
	7.68TB	MZILG7T6HBLA-00A07
	15.36TB	MZILG15THBLA-00A07
	30.72TB	MZILG30THBLA-00A07

NOTE: 1) SFF-8681 standard connector

1.3 Ordering Information

M	Z	X	X	X	X	X	X	X	X	X	X
1	2	3	4	5	6	7	8	9	10	11	12

1. Memory (M)

2. Module Classification
Z: SSD

3. Interface/ Form Factor
I: SAS 2.5 inch

4. Line-Up
L: VT: Client/SV (VNAND 3bit MLC)

5. SSD CTRL
G: Rhino

6~8. NAND Density
960: 960GB
1T9: 1.92TB
3T8: 3.84TB
7T6: 7.68TB
15T: 15.36TB
30T: 30.72TB

9. NAND PKG
H: BGA (LF,HF)

10. Flash Generation
B: 3rd Generation
C: 4th Generation

11~12. NAND Density
HQ: 1T QDP 4CE
JR: 2T ODP 2CE(FBI)
LS: 4T HDP 2CE(FBI)
LA: 8T HDP 2CE(FBI)

2.0 PRODUCT SPECIFICATION

2.1 Capacity

Support the high capacity product compared previous models and help the same system implement higher capacity than previous status.
Samsung SSD fulfills IDEMA (The International Disk Drive Equipment and Materials Association) rule to represent a maximum LBA in SSD.
According to the IDEMA rule (LBA1-03), the maximum LBA numbers can be represented are the following table.

512bytes logical block size:
*Maximum LBA = (97,696,368) + (1,953,504 * (Advertised Capacity in Gigabytes - 50))*
4096bytes logical block size:
*Maximum LBA = (12,212,046) + (244,188 * (Advertised Capacity in Gigabytes - 50))*

[Table 2] User Capacity and Addressable Sectors

Capatity[1)]	LBA Count[2)]			
	512B	520B	4096B	4160B
960GB	1,875,385,008	1,875,385,008	234,423,126	234,423,126
1.92TB	3,750,748,848	3,750,748,848	468,843,606	468,843,606
3.84TB	7,501,476,528	7,501,476,528	937,684,566	937,684,566
7.68TB	15,002,931,888	15,002,931,888	1,875,366,486	1,875,366,486
15.36TB	30,005,842,608	3,005,842,608	3,750,730,326	3,750,730,326
30.72TB	60,001,615,872	58,781,073,408	7,500,201,984	7,347,634,176

NOTE: 1) 1 Gigabyte(GB) = 1,000,000,000 Bytes, 1 Tetrabyte(TB) = 1,000,000,000,000 Bytes
2) Capacity shown in Table 2 represents the total usable capacity of the SSD which may be less than the total physical capacity.
A certain area in physical capacity, not in the area shown to the user, might be used for the purpose of NAND flash management.

2.2 Performance

[Table 3] 12Gb/s Sequential Read/Write Performance

Max. Performance[1)]	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Sequential Read (MB/s)	2,100	2,100	2,100	2,100	2,100	2,100
Sequential Write (MB/s)	1,200	2,100	2,100	2,100	2,100	2,100

[Table 4] 24Gb/s Sequential Read/Write Performance

Max. Performance[1)]	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Sequential Read (MB/s)	4,200	4,200	4,200	4,200	4,200	4,200
Sequential Write (MB/s)	1,200	2,400	3,700	3,700	3,700	3,300

NOTE : 1) Measured performance with FIO on CentOS 7.x, 128KB data size and 64 queue depth on active-active mode based sustained precondition.
Sustained means the test is performed with 2 times full LBA range sequential write operation prior to the test.
The Performance value had gotten by the condition that 1'st port's test LBA start at 0, and 2'nd port's test LBA start at half of the disk's capacity.
Actual performance may vary depending on use conditions and environment.

[Table 5] 12Gb/s Sustained Random Read/Write Performance

Max. Performance[1)]	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Random Read (QD = 64)[2)] (KIOPS)	430	450	450	450	450	450
Random Write (QD = 64)[2)] (KIOPS)	50	75	105	105	110	110

[Table 6] 24Gb/s Sustained Random Read/Write Performance

Max. Performance[1)]	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Random Read (QD = 64)[2)] (KIOPS)	600	720	770	770	800	800
Random Write (QD = 64)[2)] (KIOPS)	55	85	135	135	140	140

NOTE : 1) Measured performance with FIO on CentOS 7.x, 4KB data size and 64 queue depth on active-active mode based sustained precondition.
Sustained means the test is performed with 2 times full LBA range random write operation prior to the test.
Actual performance may vary depending on use conditions and environment.
2) Queue Depth : An initiator is guaranteed at least one command queue slot at any time, regardless of the actions of other initiators.
A single initiator may queue up to 192 commands, but the maximum number may be reduced as other initiators consume queue slots.
The total number of commands in the drive can never exceed 256.

2.3 Latency[1)]

[Table 7] 12Gb/s Latency (sustained state)

Queue Depth = 1	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Random Read/Write[2)] (us)	120/30	120/30	120/30	120/30	120/30	120/30
Sequential Read/Write[3)] (us)	220/160	220/160	220/160	220/160	220/160	220/160

[Table 8] 24Gb/s Latency (sustained state)

Queue Depth = 1	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Random Read/Write[2)] (us)	95/20	95/20	95/20	95/20	95/20	95/20
Sequential Read/Write[3)] (us)	210/120	210/120	210/120	210/120	210/120	210/120

NOTE: 1) Typical values.
2) The random read/write latency is measured by using FIO in CentOS 7.x and 4KB transfer size with queue depth 1 on a random workload of sustained state.
3) The sequential read/write latency is measured by using FIO in CentOS 7.x and 128KB transfer size with queue depth 1 on a sequential workload of sustained state.

2.4 Quality of Service (QoS)[1)]

[Table 9] 12Gb/s Quality of Service (QoS)

Quality of Service (99%)[2)]	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Read(4KB)(QD=1,Job=1) (us)	140	140	140	140	140	140
Write(4KB)(QD=1,Job=1) (us)	35	35	35	35	35	35
Read(4KB)(QD=128) (us)	1300	1300	1300	1300	1300	1300
Write(4KB)(QD=128) (us)	6000	6000	6000	6000	6000	6000
Quality of Service (99.99%)[3)]	**960GB**	**1.92TB**	**3.84TB**	**7.68TB**	**15.36TB**	**30.72TB**
Read(4KB)(QD=1,Job=1) (us)	210	210	210	210	210	210
Write(4KB)(QD=1,Job=1) (us)	40	40	40	40	40	40
Read(4KB)(QD=128) (us)	5700	5700	5700	5700	5700	5700
Write(4KB)(QD=128) (us)	9500	9500	9500	9500	9500	9500

[Table 10] 24Gb/s Quality of Service (QoS)

Quality of Service (99%)[2)]	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Read(4KB)(QD=1,Job=1) (us)	110	110	110	110	110	110
Write(4KB)(QD=1,Job=1) (us)	25	25	25	25	25	25
Read(4KB)(QD=128) (us)	680	680	680	680	680	680
Write(4KB)(QD=128) (us)	4300	4300	4300	4300	4300	4300
Quality of Service (99.99%)[3)]	**960GB**	**1.92TB**	**3.84TB**	**7.68TB**	**15.36TB**	**30.72TB**
Read(4KB)(QD=1,Job=1) (us)	170	170	170	170	170	170
Write(4KB)(QD=1,Job=1) (us)	35	35	35	35	35	35
Read(4KB)(QD=128) (us)	3000	3000	3000	3000	3000	3000
Write(4KB)(QD=128) (us)	6200	6200	6200	6200	6200	6200

NOTE: 1) QoS is measured using FIO (99/99.99 %) with queue depth 1 and 128 on 4 KB random and write.
2) QoS is measured as the maximum round-trip time taken for 99 % of commands to host.
3) QoS is measured as the maximum round-trip time taken for 99.99 % of commands to host.

2.5 Power Consumption

PM1653 is implemented in standardized 2.5-inch form factor and gets 12V power as well as 5V power through the indicated pins (#P13~15 for 12V and #P7~P9 for 5V in SFF-8681 connector plug) from the host system.
For 12V and 5V, the allowable voltage tolerance and noise level in SSD are described in Table 11, the power consumption in Table 12

2.5.1 Operating Voltage (12V and 5V)

[Table 11] Operating Voltage Conditions [1)]

Operating Voltage	960GB / 1.92TB / 3.84TB / 7.68TB / 15.36TB / 30.72TB
12V Supply Voltage Tolerance	12V±10%
12V Allowable Noise Level	DC to 100Khz : 450mVp-p Max 100Khz to 220Mhz : 350mVp-p Max
12V Rise Time (Max/Min)	1s/1ms
12V Fall Time (Max/Min)	1s/1ms
12V Minimum Off Time	10ms
5V Supply Voltage Tolerance	5V±5%
5V Allowable Noise Level	100hz to 20Mhz: 250mVp-p Max
5V Rise Time (Max/Min)	1s/1ms
5V Fall Time (Max/Min)	1s/1ms
5V Minimum Off Time	10ms

NOTE: 1) The components inside SSD were designed to endure the range of voltage fluctuations, which might be induced by the host system, in Table 11.

[Table 12] Power Consumption

Parameter		Interface Speed	Power Consumption
Active[1)]	Read	12 Gbps	9.4 W (12V : 6.9 W, 5V : 2.5 W)
		24 Gbps	13.2 W (12V : 10.1 W, 5V : 3.1 W)
	Write	12 Gbps	12.1 W (12V : 9.0 W, 5V : 3.1 W)
		24 Gbps	18.0 W (12V : 14.0 W, 5V : 4.0 W)
Idle[2)]			5 W

NOTE: 1) Typical Power Consumption : Maximum average power with a current measurement period of 500ms.
2) Power-saving idle mode which is activated in case of no host command for 500ms.

2.6 Reliability

The reliability specification of the PM1653 follows JEDEC standard, which are included in JESD218A and JESD219A documents.

2.6.1 Mean Time Between Failures

MTBF is Mean Time Between Failure, and is the predicted elapsed time between inherent failures of a system during operation.
MTBF can be calculated as the arithmetic average time between failures of a system.

[Table 13] MTBF Specifications

Parameter	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
MTBF	2,500,000 hours[1)]					

NOTE : 1) AFR(annual failure ratio) is 0.35%

2.6.2 Uncorrectable Bit Error Rate

By definition, Uncorrectable Bit Error Rate (UBER) is a metric for the rate of occurrence of data errors, equal to the number of data errors per bits read as specified in the JESD218 document of JEDEC standard.

[Table 14] UBER Specifications

Parameter	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
UBER	1 sector per 10^{17} bits read					

2.6.3 Data Retention

By definition, the endurance of SSD in enterprise application is defined as the maximum number of drive writes per day that can meet the requirements specified in the JESD218 document of JEDEC standard.

[Table 15] Data Retention Specifications

Parameter	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Data Retention[1)]	3 months					

NOTE : 1) Data retention was measured by assuming that SSD reaches the maximum rated endurance at 40°C in power-off state.

2.6.4 Endurance

By definition, the endurance of SSD in enterprise application is defined as the maximum number of drive writes per day that can meet the requirements specified in the JESD218 document of JEDEC standard.

[Table 16] Drive Write Per Day (DWPD) Specifications

Parameter	960GB / 1.92TB / 3.84GB / 7.68TB / 15.36TB / 30.72TB
DWPD	1 DWPD

[Table 17] TBW(TeraBytes Written)

Parameter	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
TBW(TB)	1,752	3,504	7,008	14,016	28,032	56,064

NOTE : TBW = DWPD x 365 x 5 x User capacity

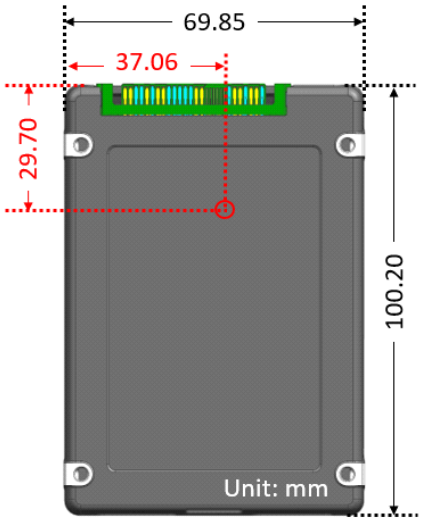
2.7 Environmental Specifications

2.7.1 Temperature

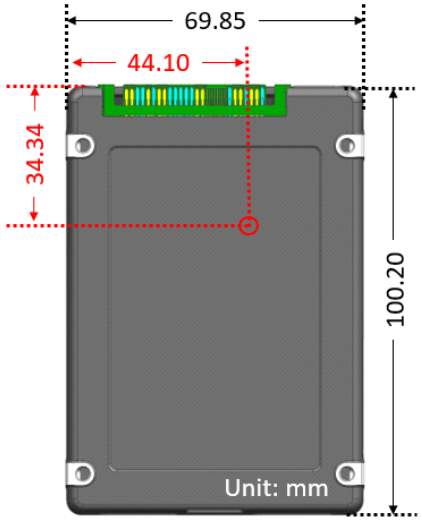
[Table 18] Standard Temperatures

		960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Temperature	Operating[1)]	0 to 70 °C					
	Non-Operating[2)]	-40 to 85 °C					

NOTE: 1) Case temperature (Tcase(Tc)) at the hottest point on the external case surface.
Highly recommending to provide sufficient airflow or cooling condition for operating properly even with heavier workloads within the operating temperature.
Performance throttling will be engaged as touching the over-temperature threshold (See the detail in the follows).
2) Storing (or shipping) without power connection.



[Figure 1] Thermal Probe Location (960GB~7.68TB)



[Figure 2] Thermal Probe Location (15.36TB~ 30.72TB)

2.7.1.1 Dynamic Thermal Throttling

The dynamic thermal throttling (DTT) is implemented to prevent overheating. Table 19 shows the engaging thresholds for DTT.

[Table 19] DTT Table

DTT Step & Threshold[1),2)]	960GB~7.68TB	15.36TB~30.72TB	Throttled Performance[3)]
DTT1	79°C	80°C	<85%
DTT2	83°C	81°C	<45%
DTT3	85°C	82°C	<20%
Critical (DTT4)	86°C	83°C	0%
Shut-down[4)]	94°C	87°C	n/a

NOTE: 1) All temperatures are based on the composite temperature (Tcomp).
2) Recovring to the previous step as the temperature falls by 1°C for its threshold except thermal shut-down.
3) Throttling levels could be varied with workloads and capacities.
4) Blocked all I/O, drive will be hanged/halted. Just Recoverable by NPOR(normal power off recovery).

2.7.1.2 Composite temperature ($T_{composite}$)

Tcomp is defined by the correlation equation as follows:

$$T_{comp} = TS$$

where, TS means the reading temperature of the standard thermal sensor on the drive.

2.7.2 Humidity

[Table 20] Humidity Specifications

Power Mode		960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Humidity[1)]	Non-Operating	5 to 95%					

NOTE: 1) Humidity is measured in non-condensing state

2.7.3 Shock and Vibration

[Table 21] Shock and Vibration Specifications

Parameter		960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Shock	Non-Operating	1500G (0.5ms duration with half sine wave)					
Vibration	Non-Operating	20G (20Hz to 2,000Hz)					

3.0 MECHANICAL SPECIFICATION

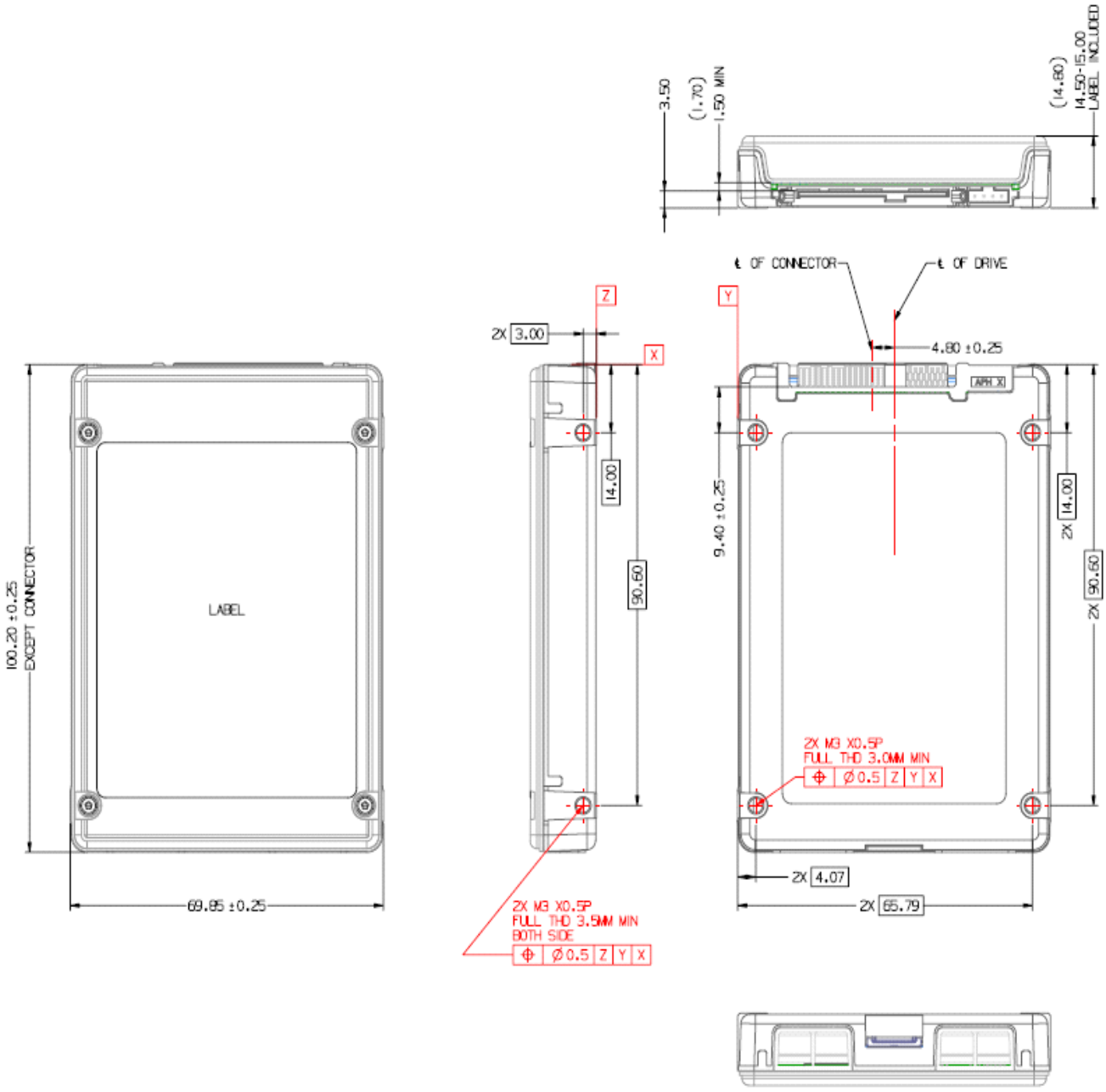
3.1 Physical Information

The physical case of the PM1653 in 2.5-inch form factor follows the standardized dimensions defined by SSD Form Factor Work Group

[Table 22] Physical Dimensions and Weight

Parameter	960GB	1.92TB	3.84TB	7.68TB	15.36TB	30.72TB
Width (mm)	69.85±0.25					
Length (mm)	100.20±0.25					
Height (mm)	15.00 +0.0 -0.5					
Weight (g)	Up to 157.5					

3.2 Form Factor

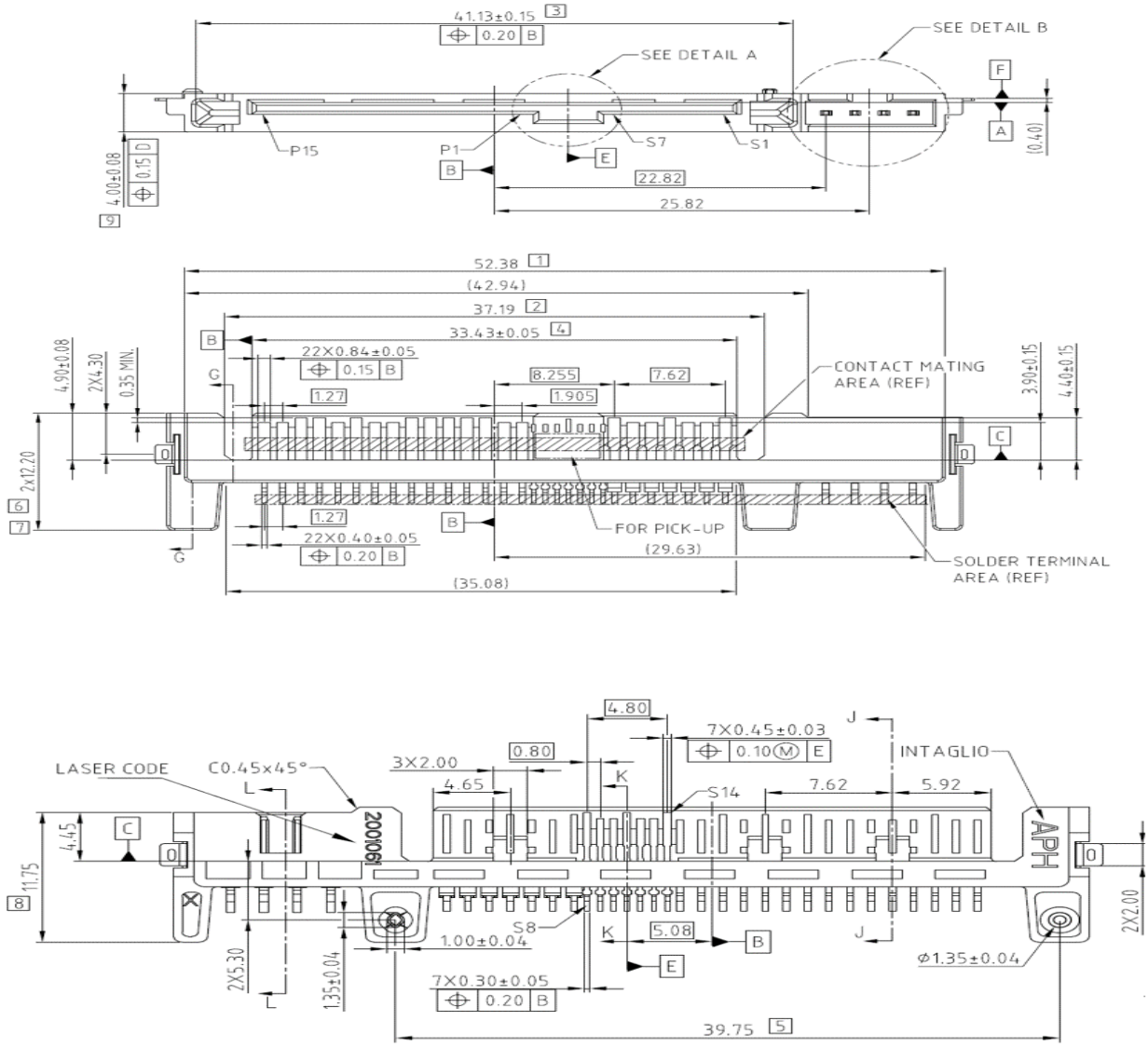


[Figure 3] Mechanical Outline

NOTE: 1) Do not disassemble the SSD, damage the SSD, or remove the sticker or the label affixed on the product.
Any product that has had its case opened or its label damaged or removed shall not be covered by the warranty.

4.0 INTERFACE SPECIFICATION

4.1 Connector Dimension and Pin Location



[Figure 4] Layout of 2.5-inch Form Factor Connector Pins

4.2 Pin Assignments and Definition

[Table 23] Pin Assignments

Pin#	Assignment	Description
S1	GND	Ground
S2	S0T+ (A+)	SAS 0 Transmit +
S3	S0T- (A-)	SAS 0 Transmit -
S4	GND	Ground
S5	S0R- (B-)	SAS 0 Receive -
S6	S0R+ (B+)	SAS 0 Receive +
S7	GND	Ground
S8	GND	Ground
S9	S1T+	SAS 1 Transmit +
S10	S1T-	SAS 1 Transmit -
S11	GND	Ground
S12	S1R-	SAS 1 Receive -
S13	S1R+	SAS 1 Receive +
S14	GND	Ground
...		
P1	Not Used	NC (Not Connected)
P2	Not Used	NC (Not Connected)
P3	3.3V Power disable[1)]	Power Disable
P4	GND	Ground
P5	GND	Ground
P6	GND	Ground
P7	5V Precharge [2)]	5V Precharge power
P8	5V	5V Primary power
P9	5V	5V Primary power
P10	GND	Ground
P11	Activity	Device Activity
P12	GND	Ground
P13	12V Precharge [2)]	12V Precharge power
P14	12V	12V Primary power
P15	12V	12V Primary power

NOTE: 1) Host can power on/off control each SSD using this pin. If Host inserts 3.3V, the SSD is power off.
And If host inserts 0V, the SSD is Power on.It follows SAS4 spec.
2) It recommends the enclosure (Back Plane) has precharge resistor to prevent hot-plug inrush voltage or current. It follows the SATA/SAS spec.

5.0 SUPPORTED COMMAND SET

5.1 Supported SAS/SCSI Commands

This chapter provides the information regarding of the supported commands by the drive as listed below.
For more detailed command description, refer to "Samsung RFX SSD SAS Command Code Specification Rev 16" or SCSI standard command specifications from T10 committee.

[Table 24] Supported SAS/SCSI Commands

Command Name	Command Code(Hex)	Applicable Standard
Format Unit	04h	SBC–4
Get LBA Status (16)	9Eh/12h	SBC–4
Get LBA Status (32)	7Fh/0012h	SBC–4
Get Stream Status	9Eh/16h	SBC–4
Inquiry	12h	SPC–5
Log Select	4Ch	SPC–5
Log Sense	4Dh	SPC–5
Mode Select (6)	15h	SPC–5
Mode Select (10)	55h	SPC–5
Mode Sense (6)	1Ah	SPC–5
Mode Sense (10)	5Ah	SPC–5
Persistent Reserve In	5Eh	SPC–5
Persistent Reserve Out	5Fh	SPC–5
Read (6)	08h	SBC–3
Read (10)	28h	SBC–4
Read (12)	A8h	SBC–4
Read (16)	88h	SBC–4
Read (32)	1Fh/0009h	SBC–4
Read Buffer (10)	3Ch	SPC–5
Read Buffer (16)	9Bh	SPC–5
Read Capacity (10)	25h	SBC–4
Read Capacity (16)	9Eh/10h	SBC–4
Read Defect Data (10)	37h	SBC–4 Actual implementation different from SBC definition
Read Defect Data (12)	B7h	SBC–4 Actual implementation different from SBC definition
Read Long (10)	3Eh	SBC–3
Read Long (16)	9Eh/11h	SBC–3
Reassign Blocks	07h	SBC–4
Receive Diagnostic Results	1Ch	SPC–5
Release (6)	17h	SPC-2 Based implementation supported
Release (10)	57h	SPC-2 Based implementation supported
Report Identifying Information	A3h/05h	SPC–5
Report LUNS	A0h	SPC–5
Report Supported Operation Codes	A3h/0Ch	SPC–5
Report Supported Task Mgt. Functions	A3h/0Dh	SPC–5
Report Timestamp	A3h/0Fh	SPC–5
Request Sense	03h	SPC–5
Reserve (6)	16h	SPC–2
Reserve (10)	56h	SPC–2
Sanitize	48h	SBC–4
Send Diagnostics	1Dh	SPC–5

Start Stop Unit	1Bh	SBC–4
Set Identifying Information	A4h/06h	SPC–5
Set Timestamp	A4h/0Fh	SPC–5
Stream Control	9Eh/14h	SBC–4
Synchronize Cache (10)	35h	SBC–3
Synchronize Cache (16)	91h	SBC–3
Test Unit Ready	00h	SPC–5
Unmap	42h	SBC–4
Verify (10)	2Fh	SBC–4
Verify (12)	AFh	SBC–4
Verify (12)	AFh	SBC–4
Verify (32)	7Fh/000Ah	SBC–4
Write (6)	0Ah	SBC–3
Write (10)	2Ah	SBC–4
Write (12)	AAh	SBC–4
Write (16)	8Ah	SBC–4
Write (32)	7Fh/000Bh	SBC–4
Write and Verify (10)	2Eh	SBC–4
Write and Verify (12)	AEh	SBC–4
Write and Verify (16)	8Eh	SBC–4
Write and Verify (32)	7Fh/000Ch	SBC–4
Write Buffer	3Bh	SPC–5
Write Long (10)	3Fh	SBC–3
Write Long (16)	9Fh/11h	SBC–3
Write Same (10)	41h	SBC–4
Write Same (16)	93h	SBC–4
Write Same (32)	7Fh/000Dh	SBC–4
Write Stream (16)	9Ah	SBC–4
Write Stream (32)	7Fh/0010h	SBC–4

6.0 SPOR SPECIFICATION

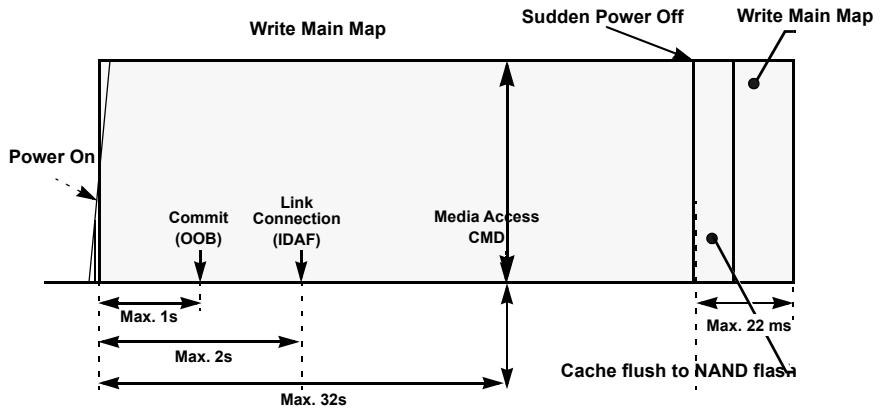
This chapter provides the information regarding of the SPOR (Sudden Power Off and Recovery) feature of the SSD.

6.1 Data Recovery in Sudden Power Off

If power interruption is detected, SSD dumps all cached data and meta data to NAND Flash.
SSD could protect even the user data in DRAM from sudden power off while SSD is used with cache on.
Commonly, data is protected all of operation period.

6.2 Time to Ready Sequence

SSD gives drive ready signal finishing FTL OPEN when is maximum 32 seconds..



[Figure 5] Time to Ready Sequence

7.0 PRODUCT COMPLIANCE

7.1 Product regulatory compliance and Certifications

[Table 25] Standards Reference

Category	Certification
CE	Comunaute Europeenne
BSMI	Bureau of Standards, Metrology and Inspection
KCC	KCC Korea Communications commission
VCCI	Voluntary Control Council for Interference
C-Tick	Radio Telecommunication Labeling
FCC	Federal Communications Commission
IC	Industry Canada
UL	Underwriters Laboratories Inc.
TUV	Technischer Uberwachungs Verine.e.V
CB	Scheme of the IECEE for Mutual Recognition of Test Certificates for Electrical Equipment

Federal Communications Commission

Caution :
Any changes or modifications in construction of this device which are not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE :
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. Modifications not expressly approved by the manufacturer could void the user's authority to operated the equipment under FCC rules.

Modifications not expressly approved by the manufacturer could void the user's authority to operated the equipment under FCC rules.

1. 기자재 명칭 : SSD (Solid State Drive)
2. 모델명(Model): 라벨 별도 표기
3. 제조연월 : 라벨 별도 표기
4. 제조자 : 삼성전자(주)
5. 제조국가 : 대한민국
6. 상호명 : 삼성전자(주)

Industry Canada ICES-0G3 Compliance Label:
CAN ICES-3 (B)/NMB-3(B)

8.0 REFERENCES

[Table 26] References

Item	Website
Serial Attached SCSI (SAS-4)	http://www.t10.org/
SCSI Architecture Model-6 (SAM-6)	http://www.t10.org/
SCSI Primary Commands-5 (SPC-5)	http://www.t10.org/
SCSI Block Commands-4 (SBC-4) Standard	http://www.t10.org/
SFF-8681	https://www.snia.org/
Enterprise SSD Form Factor Version 1.0a	http://www.ssdformfactor.org/
Solid-State Drive Requirements and Endurance Test Method (JESD218A)	http://www.jedec.org/standards-documents/docs/jesd218a