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# **PX-xxxG5He-72 Series**

**Half-slim SATA Solid State Drive**

**Engineering Specification**

(for Advantech)

## Document History

Revision	Date	Changes
Rev 0.1	2012/12/28	First draft release
Rev 0.2	2013/1/9	Added PX-xxxG5He-72 series, update Identify Device data
Rev 0.3	2013/2/6	Update Smart attribute Update Current Consumption Sec 5.2 <b>Current Consumption</b>
Rev 0.4	2013/3/15	Update Sec.4.8 Band Performance
Rev 0.5	2013/05/23	Modify Sec 8.3 Identify data Update Sec. 8.1 SMART commands Add Sec 4.19 Compliance
<b>Rev 0.6</b>	<b>2013/07/01</b>	<b>Update Sec. 5.2 Max current consumption</b>

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## 1 Introduction

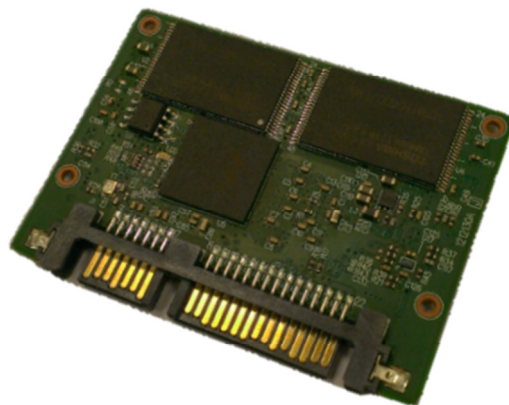
The **PX-xxxG5He-72 series** Half-Slim SATA Solid State Drive (SSD) deliver leading performance in an industry standard Half Slim form factor while simultaneously improving system responsiveness for automotive applications over standard rotating drive media or hard disk drives. By combining leading NAND flash memory technology with our innovative high performance firmware; LITE-ON IT delivers Half Slim SATA SSD drives drop-in replacement with enhanced performance, reliability, ruggedness and power savings. Since there are no rotating platters, moving heads, fragile actuators, or unnecessary delays due to spin-up time or positional seek time that can slow down the storage subsystem, significant I/O and throughput performance improvement is achieved as compared to rotating media or hard disk drives. This document describes the specifications of the **PX-xxxG5He-72 series** Half-Slim SATA Solid State Drive (SSD) form factors.

The **PX-xxxG5He-series-72 Half Slim** SATA SSD key attributes include high performance, low power, increased system responsiveness, high reliability, and enhanced ruggedness as compared to standard automotive SATA hard drives. The **PX-xxxG5He-72 series Half Slim** SATA SSD is available in a Half Slim form factor that is electrically, mechanically, and software compatible with existing Half Slim SATA slots and cables. Our flexible design allows interchangeability with existing mobile hard drives based on the SATA interface standard.

The **PX-xxxG5He-72 series** Half Slim SATA SSD includes the advantage of the **PX-xxxG5He-72 series Half Slim** SATA SSD and comes with standard **MO-297** small form factor. It is suitable for the application with limited space and high performance requirement.

## 2 Features

- **High speed mass storage device**
- **S-ATA III 6.0G interface**
- **No movement parts and noise free**
- **Excellent ability against Shock/Vibration**
- **Fast access performance**
- **Half Slim (MO-297) SSD form factor**



### 3 Block Diagram

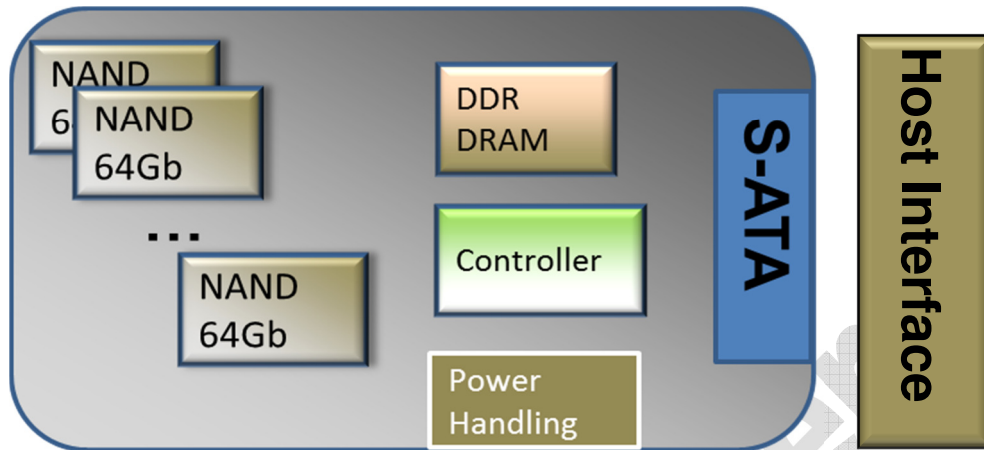


Figure 1 Block Diagram



## 4 Basic Specifications

### 4.0 Key Component and FW Version

**4.0.1 Flash Type:** Toshiba 19nm

**4.0.2 Controller:** Marvell Monet Lite 9188

**4.0.3 FW Version:** 1.00

### 4.1 Capacity

#### 4.1.1 Physical Capacity

32GB, PX-32G5He-72

64GB, PX-64G5He-72

128GB, PX-128G5He-72

#### 4.1.2 User Capacity

Unformatted capacity	Total user addressable sectors in LBA mode
32GB	62,533,296
64GB	125,045,424
128G	250,069,680

**Table 1 User Addressable Sectors**

**Notes:** 1. 1GB=1,000,000,000 bytes and not all of the memory can be used for storage.

2. 1 Sector = 512 bytes

### 4.2 Flash Type

Multi-Level Cell (MLC)

### 4.3 Program/Erase Cycle

3000(global)

### 4.4 ECC Ability

81bits/2KB

#### 4.5 Buffer Memory Size

128-256MB DDR3, consist of FTL Table and write cache data.

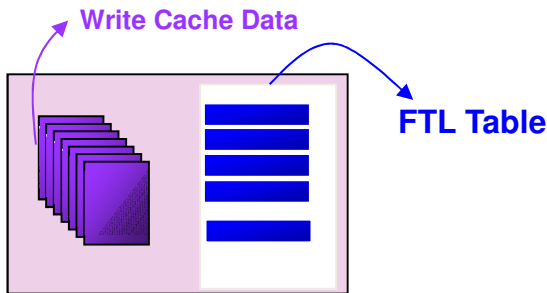


Figure 2 Buffer Memory

#### 4.6 Compatibility

- SATA Revision 3.0 compliant  
Compatible with SATA 1.5Gb/s, 3.0Gb/s & 6.0Gb/s Interface rates
- ATA/ATAPI- 8 compliant
- SSD enhanced SMART ATA feature set
- Native Command Queuing (NCQ) command set
- TRIM supported

#### 4.7 Temperature Sensor (Optional)

The temperature information is available from a built-in temperature sensor between -40 °C to +125 °C with  $\pm 3$  °C accuracy.

#### 4.8 Band Performance

Capacity	Access Type	MB/s
32GB	Sequential Read	Up to 280 MB/s
	Sequential Write	Up to 80 MB/s
64GB	Sequential Read	Up to 280 MB/s
	Sequential Write	Up to 160 MB/s
128G	Sequential Read	TBD
	Sequential Write	TBD

Table 2 Maximum Sustained Read and Write Bandwidth

- Notes:**
- 1). Performance measured using CrystalDiskMark.
  - 2). 1 MB/sec = 1,048,576 bytes/sec is used in measuring sequential performance.  
If 1 MB/sec = 1,000,000 bytes/sec is used, performance values become 4.85% higher.

#### 4.9 Read and Write IOPS (IOMETER)

Capacity	Access Type	IOPS
32 GB	4K Read (IOPS)	40,000
	4K Write (IOPS)	20,000
64 GB	4K Read (IOPS)	50,000
	4K Write (IOPS)	40,000
128 GB	TBD (IOPS)	TBD (IOPS)
	TBD (IOPS)	TBD (IOPS)

**Table 3 Random Read/Write Input/output Operations per Second**

- Notes:** 1. Performance measured using IOMETER with queue depth set to 1.  
 2. Write cache enabled

#### 4.10 Power On to Ready

Operating Mode	Typical (25°C)	Max.(0°C to +70 °C)
Power on to Ready	1s	4s

**Table 4 Latency Specifications**

- Notes:** 1. Write cache enabled  
 2. Device measured using Drive Master  
 3. Power on to ready time assumes proper shutdown  
 (Power removal preceded by Flush Cache or STANDBY command)

#### 4.11 Temperature

Environment	Mode	Min	Max	Unit
Ambient Temperature	Operating	0	70	°C
	Non-operating, Storage	-40	90	°C
Humidity	Operation	5	95	%
	Non-operation, Storage	5	95	%
Thermal Gradient	Operation, Non-operation, Storage	5	-	°C/ min

**Table 5 Temperature Relative Specifications**

No permanent damage will occur on the module when it is powered ON at -40°C and +95°C.

There will be no flame / spark / smoke from the module in any condition of short circuit and/or temperature above +95°C.

#### 4.12 Reliability

Parameter	Value
Mean Time between Failure (MTBF)	> 1,400,000 hours
Power on/off cycles	25,000 cycles
Data Reliability	1 per 10 <sup>13</sup> bits read (max)
Interface	50 cycles of Insert and Removal operation(min)

**Table 6 Reliability specifications**

**Notes:**

1. MTBF is calculated based on a Part Stress Analysis. It assumes nominal voltage. With all other parameters within specified range.
2. Power on/off cycles is defined as power being removed from the drive, and the restored. Application systems remove power with the Flush Cache command or Standby Immediate command in advance before the system shutdown.
- 3.

#### 4.13 Shock and Vibration

Item	Mode	Timing/Frequency	Max
Shock <sup>1</sup>	Operation Non-operating	At 1 msec half-sine	1500G
	Operation Non-operating	At 2 msec half-sine	1000G
Random Vibration <sup>2</sup>	Operation	7~800 Hz	2.17Grms
	Non-operation	7~800 Hz	3.08Grms

**Table 7 Shock and Vibration**

**Notes:**

1. Shock specifications assume that the SSD is mounted securely with the input vibration applied to the drive mounting screws. Stimulus may be applied in the X, Y or Z axis
2. Vibration specifications assume that the SSD is mounted securely with the input vibration applied to the drive mounting screws. Stimulus may be applied in the X, Y or Z axis. The measured specification is in root mean squared form.

**4.14 Altitude**

Operational Altitude: 5,500 meters  
 Altitude Gradient: 300m / min

**4.15 Angle**

The drives will operate at any Angle or/and Orientation.

**4.16 Rattle Noise**

The drives will have no rattle noise during any operation.

Note: There are no movement parts in the SSD drives; the rattle noise will not be tested.

**4.17 Operating noise**

The operating noise of the module will not exceed 35dBA (20Hz to 20kHz)

Note: There are no movement parts in the SSD drive; the operation noise will not be tested.

**4.18 Electromagnetic Compatibility of PX-xxxG5He-72 series**

Electromagnetic compatibility tests assume the SSD is properly installed in the representative host system. The drive operates properly without errors degradation in performance when subjected to radio frequency (RF) environments defined in the following table.

Test	Description	Performance criteria	Reference standard
Electrostatic discharge	Packaging and Handling Contact ±4KV ±8KV	A	IEC 61000-4-2:2008
Electrostatic discharge	Production and Service Contact ±2KV	A	IEC 61000-4-2:2008
Radiated Emission	-	-	CISPER-22 Class B

**Table 8 Radio Frequency Specifications**



**Notes:**

1. Performance criterion A = The device shall continue to operate as intended, i.e., normal unit operation with no degradation of performance.
2. Performance criterion B = The device shall continue to operate as intended after completion of test, however, during the test, some degradation of performance is allowed as long as there is no data loss operator intervention to restore device function.
3. Performance criterion C = Temporary loss of function is allowed. Operator intervention is acceptable to restore device function.
4. Contact electrostatic discharge is applied to drive enclosure during operation.
5. Contact electrostatic discharge is applied to drive enclosure and I/O pins when Non-Operation.

**4.19 Compliance:**

Certification	Description
RoHS compliant	Restriction of Hazardous Substance Directive
CE compliant	Indicates conformity with the essential health and safety requirements set out in European Directives Low voltage Directive and EMC Directive
UL certified	Underwriters Laboratories, Inc. Component Recognition UL60950-1
BSMI	Compliance to the Taiwan EMC standard "Limits and methods of Radio Disturbance Characteristics of Information Technology Equipment, CNS 13438 Class B"

**Table 9 Device Compliance**

## 5 Power Supply

### 5.1 Power Interface

Description	Specifications
Nominal Supply (V1)	+5Vdc +/- 5%
Absolute Voltage	Min. -0.5V Max. +10V
Ripple voltage (0-20MHz)	150mV p-p max
Supply Rise Time	1 – 100ms

Table 10 Operating Voltage

### 5.2 Current Consumption

#### PX-64G5He:

Operation Mode	Typical	Max.	Unit
Read Mode	0.37	-	A
Write Mode	0.42	-	A
Standby	0.025	-	A
Power On Inrush Current	-	1.5 (T<10ms)	A

Table 11 Current Consumption

**Note:** Active power is measured using IOMETER Power Consumption with RMS current 5s.

Active Mode: Measured after power on initiation and without activity.

### 5.3 Power ON Reset

Parameter	Symbol	Min.	Typ.	Max	Unit
Detect voltage Rising	V <sub>DET</sub>	4.0	4.3	4.4	V
Input voltage high	V <sub>IH</sub>	2.0	-	-	V
Delay time	t <sub>delay</sub>	5	-	40	ms

Table 12 Power On Reset Characteristics

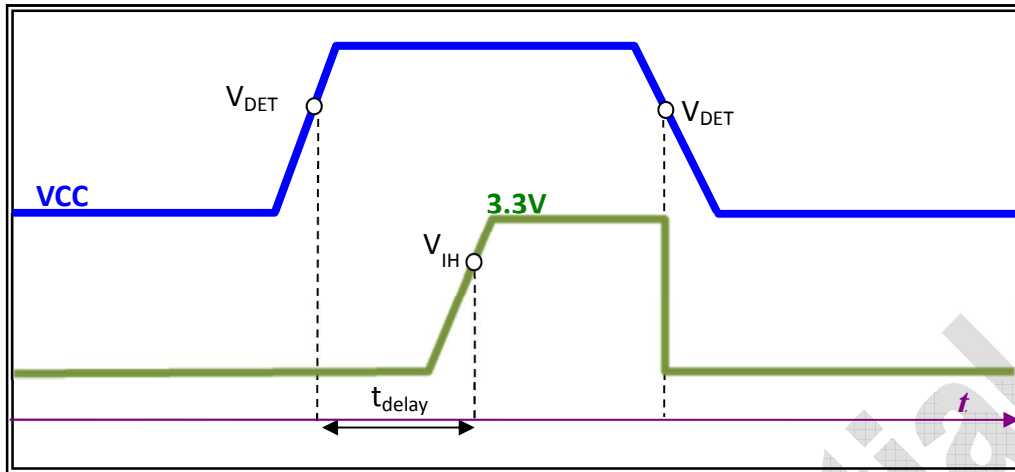


Figure 3 Power On Reset

#### 5.4 Power Off Sequence

**Note:** Power off without Flush Cache command or Standby Immediate Command in advance may cause cache buffer data which received from host and waiting for programming lose. Please implement the power off sequence as the process in the Figure 4 to prevent the data loss

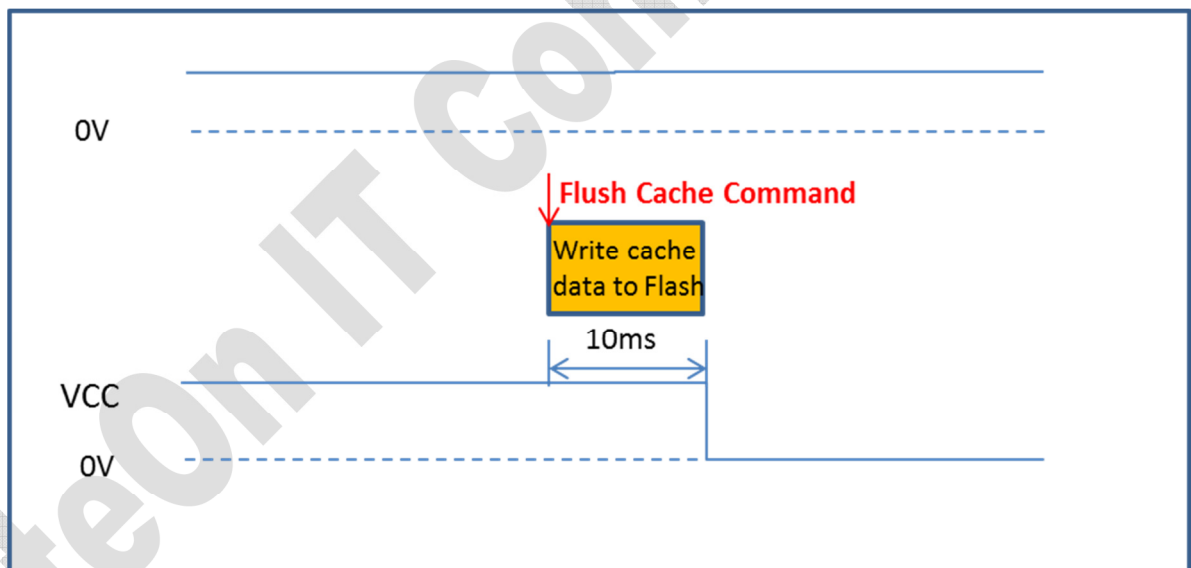


Figure 4 Power off sequence

## 5.5 Power Mode

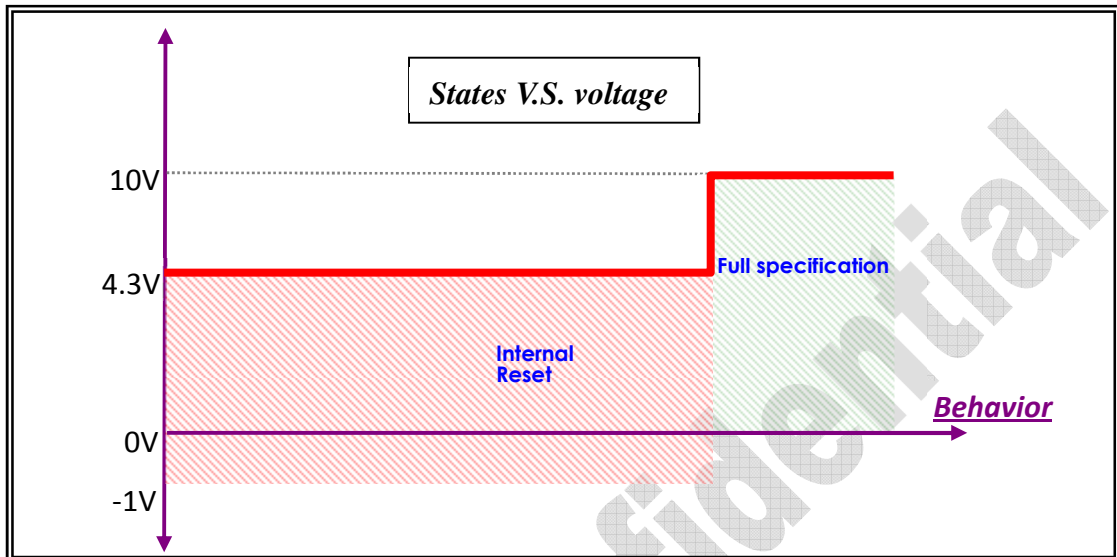


Figure 5 Power Mode

The module has a reset controlled protection implemented.

## 5.6 Temperature Sensor

Parameter	Symbol	Min.	Typ.	Max	Unit
Temperature range	-	-40	-	+125	°C
Resolution	$V_{IL}$	-	-	0.25	°C
Temperature error -40~+125°C	$T_{ERROR1}$	-	-	±3	°C
Temperature error -25~+85°C	$T_{ERROR2}$	-	-	±2	°C

Table 13 DC Characteristics

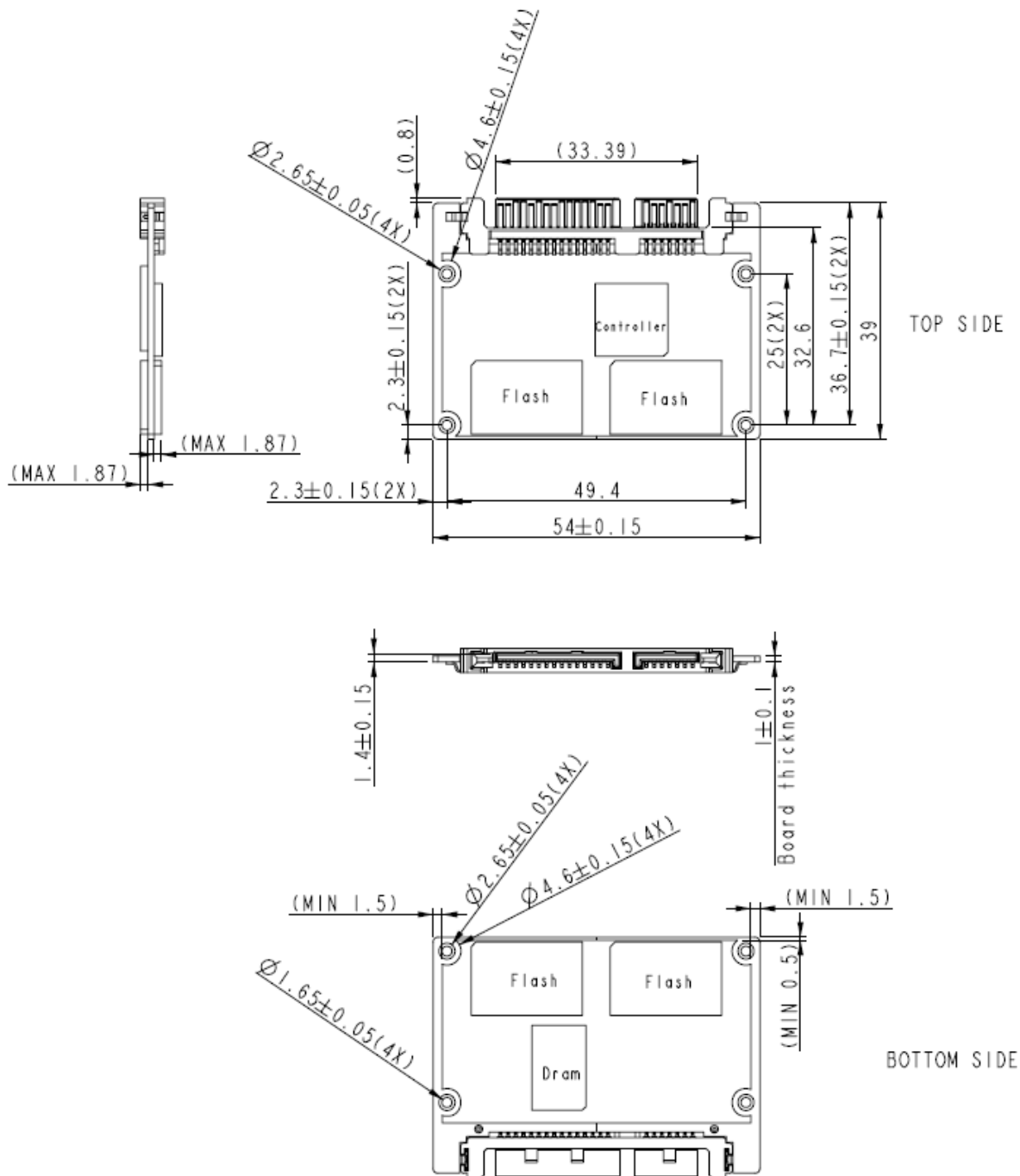
## 6 Outline and Dimension

### 6.1 PX-xxxG5He-72 Half Slim

6.1.1 The module is compliance to Standard MO-297

6.1.2 Dimension: 54.0mm x 39.0mm x 4.5 mm (L x W x H)

6.1.3 Weight: 12 g Max





## 7 Pin Locations and Definition

### 7.1 Pin Location

The data and power connector pin locations of the **PX-xxxG5He-72** series 2.5" SATA 6 Gb/s SSD are as shown below.

### 7.2 Signal Description

**Data Connector:**

1	Type	Description
S1	GND	
S2	A+	Differential Signal Pair A
S3	A-	
S4	GND	
S5	B-	Differential Signal Pair B
S6	B+	
S7	GND	

**Power Connector:**

Name	Type	Description
P1	V <sub>33</sub>	3.3V Power (No Use)
P2	V <sub>33</sub>	3.3V Power (No Use)
P3	V <sub>33</sub>	3.3V Power, Pre-change (No Use)
P4	GND	
P5	GND	
P6	GND	
P7	V <sub>5</sub>	5V Power, Pre-change
P8	V <sub>5</sub>	5V Power
P9	V <sub>5</sub>	5V Power
P10	GND	
P11	DAS	Device Activity Signal
P12	GND	
P13	V <sub>12</sub>	12V Power, Pre-change
P14	V <sub>12</sub>	12V Power
P15	V <sub>12</sub>	12V Power

**Table 14 Pin Name****Note:**

1. All pins are in a single row, with a 1.27mm (0.05") pitch
2. Pins P1, P2 and P3 are connected together, although they are not connected internally to the device. The host may put 3.3v on these pins.
3. The mating sequence is
  - The ground pins P4-P6, P10, P12 and the 5V power pin P7
  - The signal pins and the rest of the 5V power pins P8-P9
4. Ground connectors P4 and P12 may contact before the other 1st mate pins in both the power and signal connectors to discharge ESD in a suitably configured backplane connector.
5. Power pins P7, P8 and P9 are internally connected to one another within the device.
6. The host may ground P11 if it is not used for Device Activity Signal (DAS)
7. Pins P13, P14, P15 are connected together, although they are not connected internally to the device.

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## 8 Command Description

### 8.1 ATA Command

The **PX-xxxG5He-72 series Half Slim** and **PX-xxxG5He-72 series Half Slim** SATA SSD support all the mandatory ATA commands defined in the ATA/ATAPI-8 specification.

#### ATA General Feature Command Set

##### General feature Command set (non-packet)

- EXECUTE DEVICE DIAGNOSTIC
- FLUSH CACHE
- IDENTIFY DEVICE
- READ DMA
- READ SECTOR(S)
- READ VERIFY SECTORS(S)
- SEEK
- SET FEATURES
- TRIM (\*ATA/ATAPI-8 specification)
- WRITE DMA
- WRITE SECTOR(S)
- READ MULTIPLE
- SET MULTIPLE MODE
- WRITE MULTIPLE

##### Optional commands

- READ BUFFER
- WRITE BUFFER
- NOP
- DOWNLOAD MICROCODE

##### Power Management Command Set

- CHECK POWER MODE
- IDLE
- IDLE IMMEDIATE
- SLEEP
- STANDBY
- STANDBY IMMEDIATE

**Security Mode Feature Set**

- SECURITY SET PASSWORD
- SECURITY UNLOCK
- SECURITY ERASE PREPARE
- SECURITY ERASE UNIT
- SECURITY FREEZE LOCK
- SECURITY DISABLE PASSWORD

**Host Protected Area Command Set**

- READ NATIVE MAX ADDRESS
- SET MAX ADDRESS
- READ NATIVE MAX ADDRESS EXT
- SET MAX ADDRESS EXT

**Optional commands.**

- SET MAX SET PASSWORD
- SET MAX LOCK
- SET MAX FREEZE LOCK
- SET MAX UNLOCK

**48-Bit Address Command Set**

- READ NATIVE MAX ADDRESS
- FLUSH CACHE EXT
- READ DMA EXT
- READ NATIVE MAX ADDRESS EXT
- READ SECTOR(S) EXT
- READ VERIFY SECTOR(S) EXT
- SET MAX ADDRESS EXT
- WRITE DMA EXT
- WRITE MULTIPLE EXT
- WRITE SECTOR(S) EXT

**SMART Command Set**

- SMART ENABLE OPERATIONS
- SMART DISABLE OPERATIONS
- SMART ENABLE/DISABLE AUTOSAVE
- SMART RETURN STATUS

**Optional commands.**

- SMART EXECUTE OFF-LINE IMMEDIATE
- SMART READ DATA
- SMART READ LOG
- SMART WRITE LOG

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The table below lists the SMART commands.

Subcommand	Code	LBA Low value
SMART ATTRIBUTE VALUES (READ DATA)	D0h	
READ ATTRIBUTE THRESHOLDS	D1h	
ENABLE/DISABLE ATTRIBUTE AUTOSAVE	D2h	
SAVE ATTRIBUTE VALUES	D3h	
EXECUTE OFF-LINE IMMEDIATE	D4h	
EXECUTE SMART OFF-LINE ROUTINE		00h
EXECUTE SMART SHORT SELF-TEST ROUTINE (OFFLINE)		01h
EXECUTE SMART EXTENDED SELF-TEST ROUTINE (OFFLINE)		02h
ABORT OFF-LINE ROUTINE		7Fh
EXECUTE SMART SHORT SELF-TEST ROUTINE (CAPTIVE)		81h
EXECUTE SMART EXTENDED SELF-TEST ROUTINE ( CAPTIVE )		82h
READ LOG SECTOR	D5h	
WRITE LOG SECTOR	D6h	
ENABLE SMART OPERATIONS	D8h	
DISABLE SMART OPERATIONS	D9h	
RETURN SMART STATUS	DAh	
Enable/Disable Automatic OFFLINE	DBh	

## SMART Attributes

- 01h : Raw Read Error Rate
- 05h : Re-allocated Sector Count
- 09h : Power-On Hours Count
- 0Ch : Power Cycle Count
- **ADh : Average Program/Erase Count**
- B1h : Wear Leveling Count
- B2h : Used Reserved Block Count (Worst Case)
- B5h : Program Fail Count (Total)
- B6h : Erase Fail Count (Total)
- BBh : Uncorrectable Error Count
- C0h : Unsafe Shutdown Count
- C2h : Temperature
- C4h : Reallocate Event Count
- C6h : Offline Uncorrected Error Count
- C7h : CRC Error Count
- E8h : Available reserved space
- **F1h : Total Block Written from Host**
- **F2h : Total Block Read from Host**
- **F4h : Maximum Program/Erase Count**
- **F5h : Minimum Program/Erase Count**

## Temperature (Optional)

The **PX-xxxG5He-72 series Half Slim** and **PX-xxxG5He-72 series Half Slim SATA SSD** provide two kinds of command to access temperature information. One is the temperature value which can be got by OP Code 0xFA. The other is the SMART Attribute ID194.

## 8.2 Vendor Specify Command: Get Temperature Command (Optional)

### 8.2.1 OP Code : 0xFA

See the following table for the byte definitions of Return Data:

Byte	Value	Description
<b>0</b>	Temperature	This byte indicates the current temperature in degrees Celsius. Valid values are D8h to 7Dh (-40 to +125).
<b>1-511</b>	00h	Reserved

### 8.2.2 SMART Attribute C2h

**Attribute ID:** C2h (194 decimal)

**Threshold:** None

**Description:** The Temperature attribute indicates the current drive temperature in degrees Celsius.

See the following table for the byte definitions.

Byte	Value	Description
0	C2h	This is the attribute ID (194 decimal).
1-2	00h	Set to 0200h to indicate the attribute does not trigger an imminent failure (that is, the pre-fail advisory bit is not set).
3	64h	Each of these bytes is set to a constant value, which is always 64h (100 decimal).
4	64h	
5	As description	This byte indicates the current temperature in degrees Celsius. Valid values are D8h to 7Dh (-40 to +125).
6-11	00h	Reserved

### 8.3 Identify Device Data

The following table details the sector data returned after issuing an IDENTIFY DEVICE command.

Word	F=Fixed V=Variable X=Both	Default Value	Description
0	F	0040h	General configuration bit-significant information
1	F	3FFFh	Obsolete-Number of logical cylinders (16,383)
2	F	C837h	Specific configuration
3	F	0010h	Obsolete-Number of logical heads (16)
4-5	F	0000h	Retired
6	F	003Fh	Obsolete-Number of logical sectors per logical track (63)
7-8	F	0000h	Reserved for assignment by the Compact Flash Association
9	F	0000h	Retired
10-19	V	Var.	Serial number (20 ASCII characters)
20-22	F	0000h	Retired / Obsolete