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SATA 6Gb/s
Industrial
mSATA
Manual

mSATA (mini-SATA, MO-300) is a non-volatile, solid-state storage device delivering Serial ATA performance, reliability and ruggedness for industrial and environmentally challenging applications.

Revision History

Date	Revision	Description	Checked by
7/21/14	X1	Preliminary release based on modified PSFS22xxxGTxxx_A. Add note that industrial MLC SSD's have no PFAIL support. Revise Table 4-1 (Mini PCIe Connector Pin Signal Definitions (add Pin 30, Pin 32 and Pin 48)	
4/27/15	A	Initial release. Add Photo. Update per PSG	
5/26/15	B	Revise power consumption table. IOPS per IOmeter8. Remove PFAIL/DATA Hardening signaling. Changed Absolute max Vin 3.6V. Reliability table changed from 72 bit per 1KB to 120 bit per 2KB page . 5/08/15. Add VPFEM2240GTCVMTK and POR timing (5/12/15 B) change the description of the Pin 43 to NC from GND	
8/8/15	C	Add 15nm PN's	
2/1/16	D	Add VPFEM2032GTCDMTL	
5/31/16	E	Add TBW for 15nm (4/4/16) Add 32GB and 64GB PN's, power and performance. (5/31/16)	
6/1/16	F	Remove I2C support at pin 30 and pin 32 and note 3	
10/17/2016	H	Change VRxxx to VPxxx. Add VPFEM2960GTCZMTL. Revise logo and color scheme. Change company address. Update per vendor spec V1 9 (9/21/16) Revise format. Remove PFAIL notes	
1/30/2017	I	Remove VPFEM2128GTCDMTL	
3/9/2017	J	Add 32G SLC and 128G MLC PN's	

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Ordering Information: mSATA SSD Solid-State Drive

Part Numbers	SATA Interface	Application	Useable Capacity (GB)	NAND Technology	Temperature Range	NAND
VPFEM2001TTCCMTL	SATA 6GB	Client	960	MLC	(0 to +70'c)	TSB 15nm L-die
VPFEM2480GTCZMTL	SATA 6GB	Client	480	MLC	(0 to +70'c)	TSB 15nm L-die
VPFEM2240GTCAMTL	SATA 6GB	Client	240	MLC	(0 to +70'c)	TSB 15nm L-die
VPFEM2120GTCBMTL	SATA 6GB	Client	120	MLC	(0 to +70'c)	TSB 15nm L-die
VPFEM2128GTCBMTL	SATA 6GB	Client	128	MLC	(0 to +70'c)	TSB 15nm L-die
VPFEM2064GTCYMTL	SATA 6GB	Client	64	MLC	(0 to +70'c)	TSB 15nm L-die
VPFEM2032GTCDMTL	SATA 6GB	Client	32	MLC	(0 to +70'c)	TSB 15nm L-die
VPFEM2032GTCDSTL	SATA 6GB	Client	32	SLC	(0 to +70'c)	TSB 15nm L-die

Notes:

- Usable capacity based on specification LBA1-03a and level of over-provisioning applied to wear leveling, bad sectors, index tables etc.
- Higher capacity points may be available based on customer application. Consult your local Viking Field Application Engineer.
- SSD’s ship unformatted from the factory unless otherwise requested.
- 1 GB = 1,000,000,000 Byte
- One Sector = 512 Byte.
- “y’ specifies flash capacity code
- xx is a wild card to indicate customer specific BOM and/or manufacturing location

Viking's solid state drives are available in Enterprise and Client versions:

Enterprise SSD – An Enterprise SSD contains hardware and firmware that detect and manage power failures. This allows the drive to flush the controller cache and harden data to NAND flash. No data is lost or corrupted.

Industrial SSD – An industrial SSD does not include power failure detection or management features. MLC NAND, as opposed to SLC NAND, can become corrupted if power is removed during a write, also known as lower page corruption. Therefore, an industrial SSD using MLC NAND is well-suited in a system that already manages power fail events, allowing for graceful SSD shutdown. Accordingly, system support should include issuing a Standby Immediate command to the SSD while maintaining power for at least 50ms.

If an industrial drive with MLC NAND is used in a system that does not manage power failures and shutdowns, there is a small chance of data corruption. Viking Industrial SSD's take sophisticated hardware and firmware measures to prevent or mitigate such issues making the chance of corruption very small.

If the SSD controller detects data corruption, the drive will be locked. The only way to recover the drive is to return it to the factory for reprogramming; all data will be lost.

Product Picture(s)

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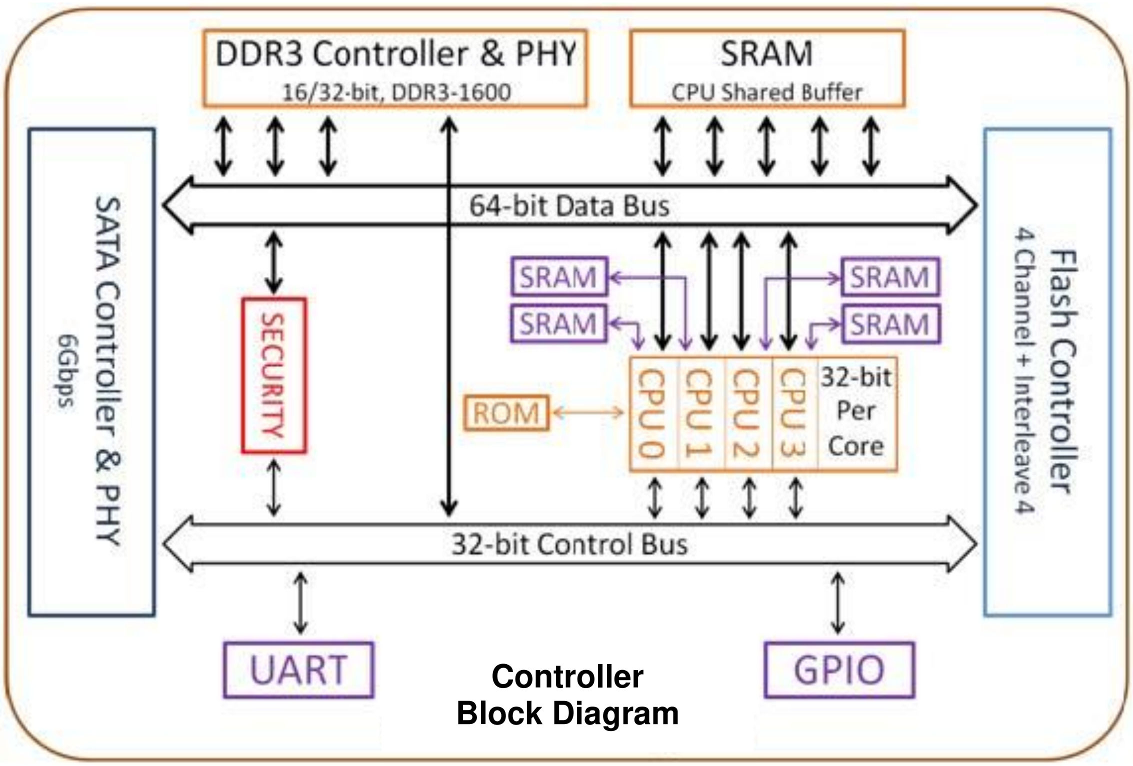
1 INTRODUCTION

1.1 General Description

The Viking mSATA delivers all the advantages of flash disk technology with the Serial ATA I/II/III interface and is fully compliant with the standard mSATA form factor, known as JEDEC MO-300 standard. The module is designed to operate at a maximum operating frequency of 300MHz with 30MHz external crystal. Its capacity could provide a wide range up to 480GB(512GB). Moreover, it can reach up to 530MB/s read as well as 500MB/s write high performance based on Toggle 2.0 MLC flash (with 256MB/512MB DDR enabled and measured by CrystalDiskMark v3.0). Meanwhile, the power consumption of the mSATA module is much lower than traditional hard drives.

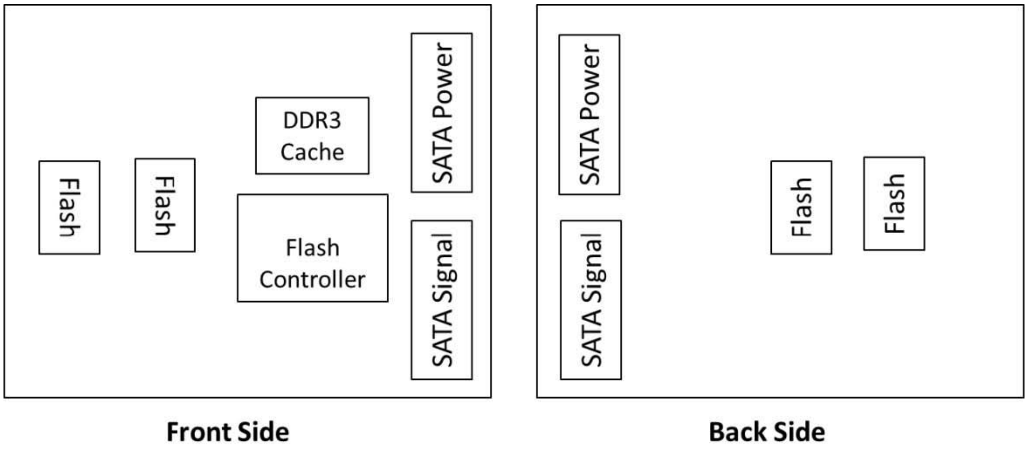
1.2 Controller Block Diagram

Figure 1-1: Viking mSATA Controller Block Diagram



1.3 Product Block Diagram

Figure 1-2: Viking mSATA Product Block Diagram



1.4 Flash Management

1.4.1 Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. The Viking mSATA applies the BCH ECC algorithm, which can detect and correct errors occur during read process, ensure data been read correctly, as well as protect data from corruption.

1.4.2 Wear Leveling

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

1.4.3 Bad Block Management

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

1.4.4 TRIM

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

1.4.5 SMART

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

1.4.6 Over-Provision

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

1.4.7 Firmware Upgrade

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

1.5 Low Power Management

1.5.1 DEVSLP Mode (Optional)

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

1.5.2 DIPM/HIPM Mode

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

1.6 Power Loss Protection: Flushing Mechanism

Power Loss Protection is a mechanism to prevent data loss during unexpected power failure. DRAM is a volatile memory and frequently used as temporary cache or buffer between the controller and the NAND flash to improve the SSD performance. However, one major concern of the DRAM is that it is not able to keep data during power failure. Accordingly, the Viking applies the GuaranteedFlush technology, which requests the controller to transfer data to the cache. For PS3110-S10C, DDR performs as a cache, and its sizes include 256MB or 512MB. Only when the data is fully committed to the NAND flash will the controller send acknowledgement (ACK) to the host. Such implementation can prevent false-positive performance and the risk of power cycling issues.

Additionally, it is critical for a controller to shorten the time the in-flight data stays in the cache. Viking applies an algorithm to reduce the amount of data resides in the cache to provide a better performance. This SmartCacheFlush technology allows incoming data to only have a “pit stop” in the cache and then move to the NAND flash at once. If the flash is jammed due to particular file sizes (such as random 4KB data), the cache will be treated as an “organizer”, consolidating incoming data into groups before written into the flash to improve write amplification.

In sum, with Flush Mechanism, Viking proves to provide the reliability required by consumer, industrial, and enterprise-level applications.

1.7 Advanced Device Security Features

1.7.1 Secure Erase

Secure Erase is a standard ATA command and will write all “0x00” to fully wipe all the data on hard drives and SSDs. When this command is issued, the SSD controller will erase its storage blocks and return to its factory default settings.

1.7.2 Write Protect

When a SSD contains too many bad blocks and data are continuously written in, then the SSD might not be usable anymore. Write Protect is a mechanism to prevent data from being written in and protect the accuracy of data that are already stored in the SSD.

1.8 SSD Lifetime Management

1.8.1 Terabytes Written (TBW)

TBW (Terabytes Written) is a measurement of SSDs' expected lifespan, which represents the amount of data written to the device. To calculate the TBW of a SSD, the following equation is applied:

TBW = [(NAND Endurance) x (SSD Capacity)] / WAF

NAND Endurance:

NAND endurance refers to the P/E (Program/Erase) cycle of the NAND

SSD Capacity:

The SSD capacity is the specific capacity in total of a SSD.

WAF: Write Amplification Factor (WAF) is a numerical value representing the ratio between the amount of data that a SSD controller needs to write and the amount of data that the host's flash controller writes. A better WAF, which is near 1, guarantees better endurance and lower frequency of data written to flash memory.

1.8.2 Thermal Monitor (Optional)

Thermal monitors are devices for measuring temperature, and can be found in SSDs in order to issue warnings when SSDs go beyond a certain temperature. The higher temperature the thermal monitor detects, the more power the SSD consumes, causing the SSD to get aging quickly. Hence, the processing speed of a SSD should be under control to prevent temperature from exceeding a certain range. Meanwhile, the SSD can achieve power savings.

1.9 An Adaptive Approach to Performance Tuning

1.9.1 Throughput

Based on the available space of the disk, Viking will regulate the read/write speed and manage the performance of throughput. When there still remains a lot of space, the firmware will continuously perform read/write action. There is still no need to implement garbage collection to allocate and release memory, which will accelerate the read/write processing to improve the performance. Contrarily, when the space is going to be used up, Viking will slow down the read/write processing, and implement garbage collection to release memory. Hence, read/write performance will become slower.

1.9.2 Predict & Fetch

Normally, when the host tries to read data from the SSD, the SSD will only perform one read action after receiving one command. However, Viking applies Predict & Fetch to improve the read speed. When the host issues sequential read commands to the SSD, the SSD will automatically expect that the following will also be read commands. Before receiving the next command, flash has already prepared the data. Accordingly, this accelerates the data processing time, and the host does not need to wait so long to receive data.

2 PRODUCT SPECIFICATIONS

■ **Capacity**

- From 60GB(64GB) up to 960GB(1TB) (support 48-bit addressing mode)

■ **Electrical/Physical Interface**

- SATA Interface
- Compliant with SATA Revision 3.2
- Compatible with SATA 1.5Gbps, 3Gbps and 6Gbps interface
- Support power management
- Support expanded register for SATA protocol 48 bits addressing mode

■ **Supported NAND Flash**

- Toshiba 24nm, A19nm, 15nm SLC, MLC, Toggle 1.0 and Toggle 2.0
- Intel/Micron 16nm MLC, ONFI 2.3 and ONFI 3.0
- Hynix 20nm(TBD)
- Support all types of SLC/MLC large block: 16K/page NAND flash
- Support ONFI 3.2 interface:
  SDR and NV-DDR up to mode 5, NV-DDR2 up to mode 7
- Contain 2pcs to 4pcs of BGA flash

■ **ECC Scheme**

- Viking mSATA can correct up to 120 bits error in 2KByte data.

■ **UART function**

■ **GPIO**

■ **Support SMART and TRIM commands**

■ **Performance**

Capacity	Flash Structure	Flash Type	Sequential	
			Read (MB/s)	Write (MB/s)
60GB (64GB)	32GB x 2	BGA132, TSB A19nm	530	190
60GB (64GB)	16GB x 4	TSOP, TSB A19nm	530	190
120GB (128GB)	32GB x 4	BGA132, TSB A19nm	530	380
120GB (128GB)	32GB x 4	BGA132, TSB 15nm	540	200
240GB (256GB)	64GB x 4	BGA132, TSB A19nm	520	365
240GB (256GB)	64GB x 4	BGA132, TSB 15nm	540	400
480GB (512GB)	128GB x 4	BGA152, TSB A19nm	520	500
480GB (512GB)	128GB x 4	BGA152, TSB 15nm	540	520
960GB (1TB)	256GB x 4	BGA132, TSB 15nm	540	510
120GB (128GB)	32GB x 4	BGA132, Micron L95B	500	160
240GB (256GB)	64GB x 4	BGA132, Micron L95B	520	320
480GB (512GB)	128GBx4	BGA152, Micron L95B	520	320

Notes:
1. The performance was measured using CrystalDiskMark with SATA 6Gbps host.
2. Samples were built using Toshiba A19nm/15nm Toggle and Micron L95B ONFI MLC NAND.
3. Performance may differ according to flash configuration, DDR configuration, and platform.
4. The table above is for reference only. The criteria for MP (mass production) and for accepting goods shall be discussed based on different flash configuration.

■ **TBW (Terabytes Written)**

Capacity	Flash Structure	TBW
60GB (64GB)	32GB x 2 16GB x 4	128
120GB (128GB)	32GB x 4	257
240GB (256GB)	64GB x 4	514
480GB (512GB)	128GB x 4	1028
960GB (1TB)	256GB x 4	2057

Notes:
1. Samples were built using Toshiba A19nm Toggle MLC, Micron L95B ONFI MLC NAND.
2. TBW may differ according to flash configuration, DDR configuration, and platform.
3. The endurance of SSD could be estimated based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.

3 ENVIRONMENTAL SPECIFICATIONS

3.1 Environmental Conditions

3.1.1 Temperature and Humidity

- **Temperature:**
  - Storage: -40°C to 85°C
  - Operational: 0°C to 70°C
- **Humidity: RH 90% under 40°C (operational)**

Table 3-1: **High Temperature Test Condition**

	Temperature	Humidity	Test Time
Operation	70°C	0% RH	72 hours
Storage	85°C	0% RH	72 hours

Result: No any abnormality is detected.

Table 3-2: **Low Temperature Test Condition**

	Temperature	Humidity	Test Time
Operation	0°C	0% RH	72 hours
Storage	-40°C	0% RH	72 hours

Result: No any abnormality is detected.

Table 3-3: **High Humidity Test Condition**

	Temperature	Humidity	Test Time
Operation	40°C	90% RH	4 hours
Storage	40°C	93% RH	72 hours

Result: No any abnormality is detected.

Table 3-4: **Temperature Cycle Test**

	Temperature	Test Time	Cycle
Operation	0°C	30 min	10 Cycles
	70°C	30 min	
Storage	-40°C	30 min	10 Cycles
	85°C	30 min	

Result: No any abnormality is detected.

3.1.2 Shock

Table 3-5: **Viking mSATA Shock Specification**

	Acceleration Force	Half Sin Pulse Duratio
Non-operational	1500G	0.5ms

Result: No any abnormality is detected when power on.

3.1.3 Vibration

Table 3-6: **Viking mSATA Vibration Specification**

	Condition		Vibration Orientation
	Frequency/Displacement	**Frequency/Acceleration**	
Non-operational	20Hz~80Hz/1.52mm	80Hz~2000Hz/20G	X, Y, Z axis/60 min for each

Result: No any abnormality is detected when power on.

3.1.4 Drop

Table 3-7: **Viking mSATA Drop Specification**

	Height of Drop	Number of Drop
Non-operational	80cm free fall	6 face of each unit

Result: No any abnormality is detected when power on.

3.1.5 Bending

Table 3-8: **Viking mSATA Bending Specification**

	Force	Action
Non-operational	≥ 20N	Hold 1min/5times

Result: No any abnormality is detected when power on.

3.1.6 Torque

Table 3-9: **Viking mSATA Torque Specification**

	Force	Action
Non-operational	0.5N-m or 2.5 deg	Hold 1min/5times

Result: No any abnormality is detected when power on.

3.1.7 Electrostatic Discharge (ESD)

Table 3-10: **Viking mSATA Contact ESD Specification**

Device	Capacity	Temperature	Relative Humidity	+/- 4KV	Result
mSATA	240GB (256GB)	24.0°C	49% (RH)	Device functions are affected, but EUT will be back to its normal or operational state automatically.	PASS
480GB (512GB)					

3.1.8 EMI Compliance

■ **TBD**

3.2 MTBF

MTBF, an acronym for Mean Time Between Failures, is a measure of a device's reliability. Its value represents the average time between a repair and the next failure. The measure is typically in units of hours. The higher the MTBF value, the higher the reliability of the device. The predicted result of Viking mSATA is more than 2,000,000 hours.

3.3 Certification & Compliance

- **RoHS**
- **SATA III (SATA Rev. 3.2)**
- **Up to ATA/ATAPI-8 (Including S.M.A.R.T)**

4 ELECTRICAL SPECIFICATIONS

4.1 Supply Voltage

Table 4-1: **Supply Voltage of Viking mSATA**

Parameter	Rating
Operating Voltage	3.3V

4.2 Power Consumption

Table 4-2: **Power Consumption of Viking mSATA**

Capacity	Flash Structure	Flash Type	Read	Write	Partial	Idle
60GB (64GB)	32GB x 2	BGA, TSB A19nm	TBD	TBD	TBD	TBD
60GB (64GB)	16GB x 4	TSOP, TSB A19nm	2,080	2,295	300	430
120GB (128GB)	32GB x 4	BGA, TSB A19nm	1,990	2,975	300	405
120GB (128GB)	32GB x 4	BGA, TSB 15nm	2060	2350	260	365
240GB (256GB)	64GB x 4	BGA, TSB A19nm	1,965	2,925	260	370
240GB (256GB)	64GB x 4	BGA, TSB 15nm	2080	3560	260	365
480GB (512GB)	128GB x 4	BGA, TSB A19nm	2,025	3,360	280	390
480GB (512GB)	128GB x 4	BGA, TSB 15nm	2380	3620	270	370
960GB (1TB)	256GB x 4	BGA, TSB 15nm	TBD	TBD	TBD	TBD
120GB (128GB)	32GB x 4	BGA132, Micron L95B	2195	2370	305	430
240GB (256GB)	64GB x 4	BGA132, Micron L95B	2240	3535	300	420
480GB (512GB)	128GB x 4	BGA152, Micron L95B	TBD	TBD	TBD	TBD

Notes:
1. Unit: mW
2. The average value of power consumption is achieved based on 100% conversion efficiency.
3. The measured power voltage is 3.3V.
4. Samples are Toshiba A19nm Toggle MLC NAND and measured under ambient temperature.
5. Sequential R/W measured while testing 4000MB sequential R/W 5 times by CyrstalDiskMark.
6. Power Consumption varies on flash configuration, DDR configuration, and platform

5 INTERFACE

5.1 Pin Assignment and Descriptions

Table 5-1: **Pin Assignment and Description of Viking mSATA**

Pin #	mSATA	Description	Pin #	mSATA	Description
1	NC	No Connect	27	SATA GND	SATA Ground Return Pin
2	+3.3V	3.3V Source	28	NC	No Connect
3	NC	No Connect	29	SATA GND	SATA Ground Return Pin
4	DGND	Digital GND	30	NC	No Connect
5	NC	No Connect	31	RXN (in)	Host Transmitter Differential Signal Pair
6	NC	No Connect	32	NC	No Connect
7	NC	No Connect	33	RXP (in)	Host Transmitter Differential Signal Pair
8	NC	No Connect	34	DGND	Digital GND
9	DGND	Digital GND	35	SATA GND	SATA Ground Return Pin
10	NC	No Connect	36	NC	No Connect
11	NC	No Connect	37	SATA GND	SATA Ground Return Pin
12	NC	No Connect	38	NC	No Connect
13	NC	No Connect	39	+3.3V	3.3V Source
14	NC	No Connect	40	DGND	Digital GND
15	DGND	Digital GND	41	+3.3V	3.3V Source
16	NC	No Connect	42	NC	No Connect
17	NC	No Connect	43	NC	No Connect
18	DGND	Digital GND	44	DEVSLP	Enter/Exit DevSleep
19	NC	No Connect	45	NC	Reserved pin
20	NC	No Connect	46	NC	No Connect
21	SATA GND	SATA Ground Return Pin	47	NC	Reserved pin
22	NC	No Connect	48	NC	No Connect
23	TXP (out)	Host Receiver Differential Signal Pair	49	DAS	Device Activity Signal
24	+3.3V	3.3V Source	50	DGND	Digital GND
25	TXN (out)	Host Receiver Differential Signal Pair	51	GND	Default connect to GND
26	SATA GND	SATA Ground Return Pin	52	+3.3V	3.3V Source