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SATA 6Gb/s
Industrial 2.5” SSD
Manual

The SATA SSD is a non-volatile, solid-state storage device. With its Serial ATA interface and industry-standard form factors, it is a drop in replacement for hard disk drives. The SSD delivers extremely high levels of performance, reliability and ruggedness for I/O intensive or environmentally challenging applications.

Revision History

Date	Revision	Description	Checked by
2/28/17	A	New Industrial datasheet modified from PSFS22xxxGxxx_F	
3/9/17	B	Add pSLC	

Legal Information

Legal Information

Ordering Information: Industrial 2.5” SSD Solid-State Drive

Part Numbers	SATA Interface	Application	Useable Capacity (GB)[1]	Temperature Range	NAND
VRFS22060GTIRSTH	SATA 6GB	Industrial	60	(-40 to +85'c)	TSB 15nm SLC
VRFS22060GTIDMTL	SATA 6GB	Industrial	60	(-40 to +85'c)	TSB 15nm MLC
VRFS22120GTIBMTL	SATA 6GB	Industrial	120	(-40 to +85'c)	TSB 15nm MLC
VRFS22240GTIAMTL	SATA 6GB	Industrial	240	(-40 to +85'c)	TSB 15nm MLC
VRFS22480GTIZMTL	SATA 6GB	Industrial	480	(-40 to +85'c)	TSB 15nm MLC
VRFS22960GTICMTL	SATA 6GB	Industrial	960	(-40 to +85'c)	TSB 15nm MLC
VRFS221T92TICMTL	SATA 6GB	Industrial	1920	(-40 to +85'c)	TSB 15nm MLC
VRFS22030GTIDPTL	SATA 6GB	Industrial	30	(-40 to +85'c)	TSB 15nm pSLC
VRFS22060GTIBPTL	SATA 6GB	Industrial	60	(-40 to +85'c)	TSB 15nm pSLC
VRFS22120GTIAPTL	SATA 6GB	Industrial	120	(-40 to +85'c)	TSB 15nm pSLC
VRFS22240GTIZPTL	SATA 6GB	Industrial	240	(-40 to +85'c)	TSB 15nm pSLC
VRFS22480GTICPTL	SATA 6GB	Industrial	480	(-40 to +85'c)	TSB 15nm pSLC
VRFS22960GTICPTL	SATA 6GB	Industrial	960	(-40 to +85'c)	TSB 15nm pSLC

- 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

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, a 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 a 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

Viking SSD's offer the highest flash storage reliability and performance as well as support for many functional features.

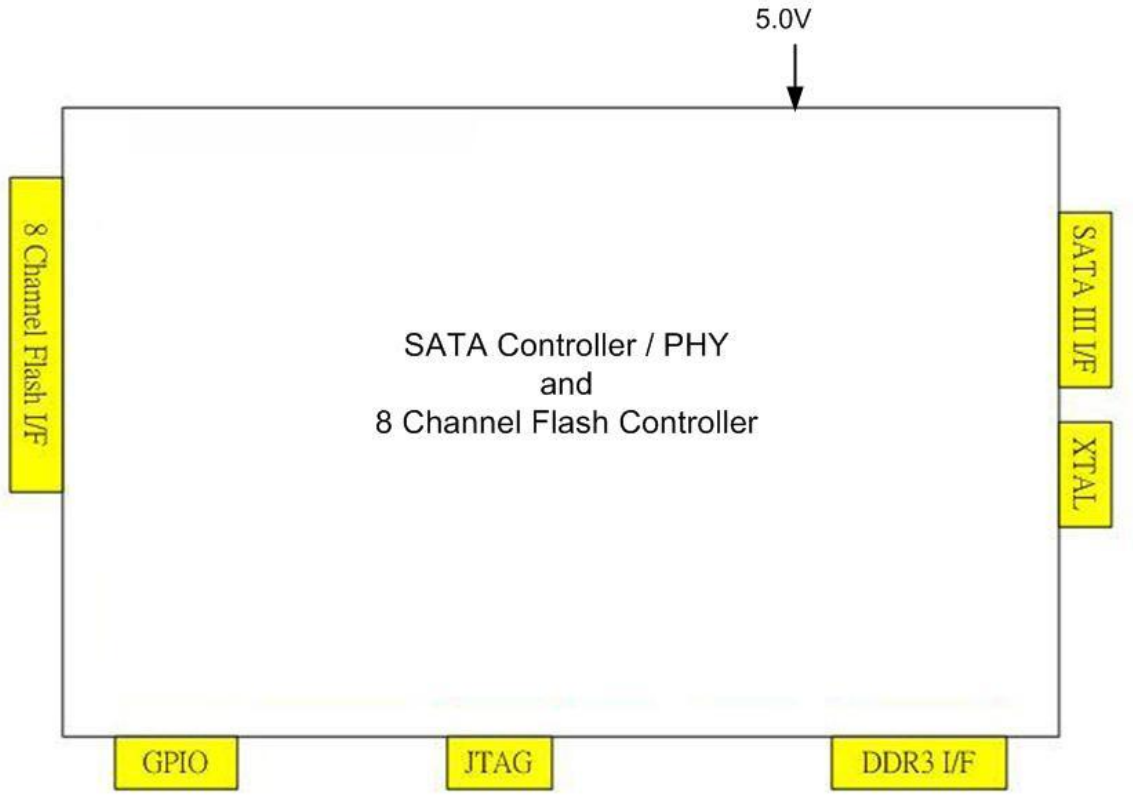
1.1 Features

The SSD delivers the following features:

- Seamless SATA Revision 3.2 interface support for SATA up to 6Gb/s
- Low overall SSD power consumption
- Supports Native Command Queuing (NCQ) to 32 commands
- Compatible with all major SLC and MLC flash technologies
- S.M.A.R.T.
- Power hold-up circuit technology ensures no data loss resulting from an unexpected power loss
- Superior static and dynamic wear-leveling algorithm
- Efficient error recovery
- TRIM Support
- 48-bit LBA Support

1.2 Block Diagram

Figure 1-1: High-Level Block Diagram



Notes: Support for up to 8-channels and 32 CE in the NAND Flash interface

1.3 SATA Interface

- The Serial ATA (SATA) interface is compliant with the SATA IO Serial ATA specification, revision 3.2 that supports SATA up to 6GB/s.
- The SATA interface connects the host computer to the SSD subsystem.
- The SATA interface runs at a maximum speed of 6.0 Gbps (Giga-bits per second). If the host computer is unable to negotiate a speed of 6.0 Gbps, the SATA interface automatically renegotiates to a speed of 3GBPs or 1.5Gbps.

For a list of supported commands and other specifics, please see Chapter 5.

2 Product Specifications

2.1 Capacity and LBA count

Raw Capacity (GB)	User Capacity (GB)	LBA Count
16	14	27,370,224
16	16	31,277,232
32	30	58,626,288
32	32	62,533,296
64	60	117,231,408
64	64	125,045,424
128	120	234,441,648
128	128	250,069,680
256	240	468,862,128
256	256	500,118,192
512	480	937,703,088
512	512	1,000,215,216
1024	960	1,875,385,008
1024	1024	2,000,409,264
2048	1920	3,750,748,848
2048	2048	4,000,797,360

Notes:

1. Per LBA1-03 spec, LBA counts = (97,696,368) + (1,953,504 * (Advertised Capacity in GBytes – 50))

2.2 Performance

Table 2-1: Maximum Sustained Read and Write Bandwidth

Access Type	MB/s
Sequential Read, 256K	Up to 550
Sequential Write, 256K	Up to 448

Notes:
1. Performance measured using IOMeter and Anvils Storage Utility with queue depth set to 32.
2. Write Cache enabled with DDR3 cache.
3. Refer to Application Note AN0006 for Viking SSD Benchmarking Methodology.
4. Data is based on SSD's capacities > 250GB, using Synchronous NAND devices (ONFI or toggle mode)

Table 2-2: Random Read and Write Input/Output Operations per Second (IOPS)

Access Type	IOPS
Read, 4K	Up to 126,000
Write, 4K	Up to 90,000

Notes:
2. Performance measured using IOMeter and Anvils Storage Utility with queue depth set to 32.
3. Write Cache enabled.
4. Random IOPS cover the entire range of legal logical block addresses (LBA's). Measurements are performed on a full drive (all LBA's have valid content).
5. Performance may vary by NAND type and host.
6. Refer to Application Note AN0006 for Viking SSD Benchmarking Methodology.
7. Data is based on SSD's capacities > 250GB, using Synchronous NAND devices (ONFI or toggle mode)

2.3 Timing

Table 2-3: Timing Specifications

Type	Average Latency
Read (at 64KB)	0.14mS
Write (at 64KB)	2.12mS
Power On Ready (POR)	536mS

Notes:
1. Device measured using Drivemaster.
2. DRQ (Data Transfer Requested) bit being asserted

2.4 Electrical Characteristics

2.4.1 Absolute Maximum Ratings

Values shown are stress ratings only. Functional operation outside normal operating values is not implied. Extended exposure to absolute maximum ratings may affect reliability.

Table 2-4: Absolute Maximum Ratings

Description	Min	Max	Unit
Maximum Voltage Range for Vin	-0.2	6	V
Maximum Temperature Range	-40	85	c

2.4.2 Supply Voltage

The operating voltage is 5V.

Table 2-5: Operating Voltage

Description	Min	Max	Unit
Operating Voltage for 5.0 V (+/- 5%)	4.75	5.25	V
Ripple (0-30MHz)		100	mV

2.4.3 Power Consumption

All onboard power requirements of the SSD are derived from the SATA 5.0V input rail.

Table 2-6: Typical Power Consumption

Capacity	Flash: TSBA19	Read()	Write	Idle	Partial	Slumber
128GB	8GBx1Diex16CE	2.224	3.446	0.505	0.0911	0.0911
256GB	8GBx1Diex32CE	2.21	4.31	0.566	0.0695	0.068
512GB	8GBx2Diex32CE	2.335	4.431	0.632	0.0824	0.0798
1TB	16GBx2Diex32CE	2.481	4.234	0.651	0.1014	0.1009

Capacity	Flash: M L95B	Read()	Write	Idle	Partial	Slumber
128GB	16GBx1Diex8CE	2.193	2.524	0.625	0.1158	0.0716
256GB	16GBx1Diex16CE	2.161	3,624	0,571	0.0675	0,0659
512GB	16GBx2Diex16CE	2.39	3.971	0.567	0.1199	0.0968

Notes:

1. The average value of power consumption is achieved based on 100% conversion efficiency.
2. The measured power voltage is 5V.
3. Samples were built of Toshiba A19nm Toggle MLC NAND flash and measured under ambient temperature.
4. Sequential R/W is measured while testing 400MB sequential R/W 5 times by CrystalDiskMark(CDM).
5. Power Consumption may differ according to flash configuration and platform.

2.5 Environmental Conditions

2.5.1 Temperature and Altitude

Table 2-7: Temperature and Altitude Related Specifications

Conditions	Operating	Shipping	Storage
Industrial Temperature - Ambient	-40 to 85°C (-40 to 185° F)	-40 to 85°C (-40 to 185° F)	-40 to 85°C (-40 to 185° F)
Humidity (noncondensing)	90% under 40C	93% under 40C	93% under 40C

Notes:

1. SLC flash based products may be available in the following temperature ranges:
   a) Commercial temperature range of 0 to 70°C (32 to 158° F)
   b) Industrial temperature range -40 to 85°C (-40 to 185° F)

2.5.2 Shock and Vibration

SSD products are tested in accordance with environmental specification for shock and vibration

Table 2-8: Shock and Vibration Specifications

Stimulus	Description		
Shock	500G (2ms)		
Vibration	Condition		Vibration Orientation
	Frequency/Displacement	Frequency/Acceleration	
Non-operational	20Hz~80Hz/1.52mm	80Hz~2000Hz/20G	X, Y, Z axis/30 min for each

2.5.3 Electromagnetic Immunity

This SSD is an embedded product for host systems and is designed not to impair with system functionality or hinder system EMI/FCC compliance.

2.6 Reliability

Table 2-9: Reliability Specifications

Parameter	Value
ECC	up to 120bit/2KB ECC circuit (BCH)
MTBF	~ 2,000,000 hours
Read Endurance	Unlimited
Write Endurance	(Refer to Endurance table)
Data retention	SLC and MLC is 1 year at NAND expiration eMLC is 90 days at NAND expiration

Table 2-10: Endurance Specifications

Capacity	Flash Structure	Terabytes Written (TBW)
60GB	8GB x 8	32
120GB	16GB x 8	60
240GB	32GB x 8	107
480GB	64GB x 8	240
960GB	128GB x 8	465

Notes:

1. Samples were built using Toshiba A19nm Toggle MLC NAND flash.
2. TBW may differ according to flash 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.

2.7 Data Security

2.7.1 Encryption

The SSD drive is a self-encrypting drive (SED), with a bulk data encryption feature that provides automatic hardware-based data security and enhanced secure erase capability.

A self-encrypting drives, scrambles data using a data encryption key as it is written to the drive and then descrambles it with the key as it is retrieved. This gives the user the highest level of data protection available and provides a fast erase simply by deleting the encryption key, eliminating the need for time consuming data-overwrite. Data on the drive is instantly rendered unreadable.

The SSD supports AES-256 encryption and ATA Secure Erase features to protect sensitive data.

The SSD drives support the following security features:

- AES 256 on the fly support.
- RSA 512/1024/2048
- SHA 160/256/512
- TCG OPAL SSC V1.0

2.7.2 Write Protect

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

2.7.3 Quick Erase

Quick Erase has been designed to remove data under prompt and urgent situation and is triggered by sending an ATA Command.

Input Info of Executing Quick Erase Command

Register	7	6	5	4	3	2	1	0
Features	01h							
Sector Count	2Fh							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	A0h							
Command	6Fh							

Normal Output Info of Executing Quick Erase Command

Register	7	6	5	4	3	2	1	0
Features	na							
Sector Count	na							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	obs	na	obs	DEV	na	na	na	na
Command	BSY	DRDY	DF	na	DRQ	na	na	ERR

Device/Head Register:
DEV shall indicate the selected device.
Status Register:
BSY shall be cleared to zero indicating command completion.
DRDY shall be set to one.
DF (Device Fault) shall be cleared to zero.
DRQ shall be cleared to zero.
ERR shall be cleared to zero.

2.7.4 Military Secure Erase / Sanitization/ Purge Routines

Many government and military organizations such as NIST/NSA define their own standard and procedures for performing a Military Secure Erase which overwrite different patterns to sanitize the flash media. Some of the more common military or government purge routines are defined in the following table and the data security features of the drive comply with Department of Defense (DoD) and US military data security standards.

Table 2-11: Military Secure Erase / Sanitize Routines

Standard	Action	SSD Code[1]
NSA/CSS 9-12	Erase and overwrite all locations with a known unclassified pattern. Verify the overwrite procedure by randomly rereading the overwritten information to confirm that only the known pattern can be recovered.	Note 1
NSA/CSS 130-2	Erase the media and overwrite with random data 2 times, then erase and overwrite with a character	Note 1
DoD5220.22-M	Erase the media and overwrite with single character, then erase again	Note 1
NISPOMSUP	Erase the media and overwrite with single character, then	Note 1

Standard	Action	SSD Code[1]
Chap 8, Sect.8-501	erase again and overwrite with single character, then erase again and overwrite with random character then erase again	
USA Army 380-19	Erase the media and overwrite with random data, erase and overwrite with a character, then erase and overwrite with complement of the character	Note 1
Navy NAVSO P-5239-26	Erase the media and overwrite with random data, then erase again	Note 1
Air Force AFSSI 5020	Erase the media and overwrite with pattern, repeat 3 times	Note 1
Air Force AFSSI 8580	TBD	Note 1

Notes:

1. Enabled using ATA commands

2.7.4.1 AFSSI 5020

Pattern:
1) To erase the whole disk.
2) To fill the whole disk with random data.

Input Info of Executing AFSSI 5020 Command

Register	7	6	5	4	3	2	1	0
Features	02h							
Sector Count	2Fh							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	A0h							
Command	6Fh							

Normal Output Info of Executing AFSSI 5020 Command

Register	7	6	5	4	3	2	1	0
Features	na							
Sector Count	na							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	obs	na	obs	DEV	na	na	na	na
Command	BSY	DRDY	DF	na	DRQ	na	na	ERR

Device/Head Register:
DEV shall indicate the selected device.
Status Register:
BSY shall be cleared to zero indicating command completion.
DRDY shall be set to one.
DF (Device Fault) shall be cleared to zero.
DRQ shall be cleared to zero.
ERR shall be cleared to zero.

2.7.4.2 DOD 5220.22-M

Pattern:
1) To fill the whole disk with fixed character pattern of 0x55.
2) To erase the whole disk.

Input Info of Executing DoD 5220.22-M Command

Register	7	6	5	4	3	2	1	0
Features	03h							
Sector Count	2Fh							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	A0h							
Command	6Fh							

Normal Output Info of Executing DoD 5220.22-M Command

Register	7	6	5	4	3	2	1	0
Features	na							
Sector Count	na							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	obs	na	obs	DEV	na	na	na	na
Command	BSY	DRDY	DF	na	DRQ	na	na	ERR

Device/Head Register:
DEV shall indicate the selected device.
Status Register:
BSY shall be cleared to zero indicating command completion.
DRDY shall be set to one.
DF (Device Fault) shall be cleared to zero.
DRQ shall be cleared to zero.
ERR shall be cleared to zero.

2.7.4.3 USA NAVY NAVSO P-5239-26

Pattern:
1) To erase the whole disk.
2) To fill the whole disk with random data.
3) To erase the whole disk again.

Input Info of Executing USA Navy NAVSO P-5239-26 Command

Register	7	6	5	4	3	2	1	0
Features	04h							
Sector Count	2Fh							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	A0h							
Command	6Fh							

Normal Output Info of Executing USA Navy NAVSO P-5239-26 Command

Register	7	6	5	4	3	2	1	0
Features	na							
Sector Count	na							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	obs	na	obs	DEV	na	na	na	na
Command	BSY	DRDY	DF	na	DRQ	na	na	ERR

Device/Head Register:
DEV shall indicate the selected device.
Status Register:
BSY shall be cleared to zero indicating command completion.
DRDY shall be set to one.
DF (Device Fault) shall be cleared to zero.
DRQ shall be cleared to zero.
ERR shall be cleared to zero.

2.7.4.4 NSAMANUAL 130-2

Pattern:
1) To erase the whole disk.
2) To fill the whole disk with random data.
3) To fill the whole disk with random data one more time.
4) To erase the whole disk again.
5) To fill the whole disk with fixed character pattern of 0x55.

Input Info of Executing NSA Manual 130-2 Command

Register	7	6	5	4	3	2	1	0
Features	05h							
Sector Count	2Fh							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	A0h							
Command	6Fh							

Normal Output Info of Executing NSA Manual 130-2 Command

Register	7	6	5	4	3	2	1	0
Features	na							
Sector Count	na							
Sector Number	na							
Cylinder High	na							
Cylinder Low	na							
Device/Head	obs	na	obs	DEV	na	na	na	na
Command	BSY	DRDY	DF	na	DRQ	na	na	ERR

Device/Head Register:
DEV shall indicate the selected device.
Status Register:
BSY shall be cleared to zero indicating command completion.
DRDY shall be set to one.
DF (Device Fault) shall be cleared to zero.
DRQ shall be cleared to zero.
ERR shall be cleared to zero.