StorFly® 2.5-Inch SATA Solid-State Drive

Series 6 (Gen2), SATA-III (6Gb/s), 3D TLC

VSFF25CI960G-V11

Datasheet - Rev. 1.3

1. Description

Virtium's StorFly Series 6 2.5" is high-performance SATA-III 6Gb/s embedded solid-state drive (SSD) technology designed for the unique capacity and workload requirements of a broad range of embedded systems, including telco and networking, industrial PC and automation, test and measurement, medical diagnostics and imaging, transportation, defense command and control, self-serve kiosk and POS, security and surveillance, and data recorders.

Features

Capacity
- 960 GB

3D TLC NAND

Sequential Performance
- 128kB Sequential Read: 550 MB/s (QD: 32)
- 128kB Sequential Write: 490 MB/s (QD: 32)

Random Performance
- 4kB IOPS Read: up to 77,000 (QD: 32)
- 4kB IOPS Write: up to 66,000 (QD: 32)

Power: 5.0V±10%
- 128kB Sequential Read: 2.80 W
- 128kB Sequential Write: 3.33 W
- 4kB Random Read: 3.00 W
- 4kB Random Write: 3.30 W
- Idle: 0.56 W

Temperature Ranges
- Industrial: -40ºC to 85ºC
- Non-Operating: -40ºC to 85ºC

Reliability
- Advanced LDPC ECC
- MTBF: >2M hours

Endurance
- JESD219A: 801 TBW
- Sequential: 2,972 TBW

vtGuard® Power Fail Protection
- Integrated power fail protection
- Preserves static data in the event of power failure
- Cache/buffer contents restored at power-on

SMART Attribute Reporting
- Monitors device health
- Anticipates and predicts failures

Mechanical Dimensions
- 2.5-Inch Form Factor
- Length x Width x Height mm (inches)
  100.5 (3.96) x 69.85 (2.75) x 7.0 (0.275)

Compliance
- SATA Revision 3.1 (SATA-III 6Gb/s)
- ATA/ATAPI-8 (ACS-3)
- FCC, CE, UL, RoHS, WEEE

Environmental (Non-operating)
- Humidity (non-condensing): 5% to 95%
- Shock: 1500G, half-sine wave, 0.5ms duration
- Vibration: 20G, 20 Hz to 2000 Hz

Data Security
- Integrated AES-256 encryption (data-at-rest)
- Crypto Erase
- TCG/ Opal 2.0-compliant SED[1]

StorKit® Software - visit virtium.com to learn more.
- vtView®, vtSecure™, vtTools™

Note: (1) Available in parts with -T part number extension

Electrostatic Discharge (ESD) can damage this device. When handling the device, always wear a grounded wrist strap and use a static dissipative surface.

Any damage to the unit that occurs after its removal from the shipping package and ESD protective bag is the responsibility of the user.

Part Numbering System

V SF F25 C I 960G - V11

Where:	
V	= Virtium
SF	= StorFly
F25	= Form Factor / Interface: F25 = 2.5-Inch, SATA-III 6Gb/s
C	= Product Class: C = CE
I	= Operating Temperature: I = Industrial (-40ºC to 85ºC)
960G	= 960GB (1GB = 1,000,000,000 bytes)
V11	= Virtium Proprietary

2. Specifications

Capacity

Unformatted Capacity (GB)[1]	User-Addressable LBA[2]	User-Addressable Capacity Bytes
960	1,875,385,008	960,197,124,096

(1) 1GB = 1,000,000,000 bytes. LBA: Logical Block Address; Logical Block Size = 512 Bytes/1 Sector.
(2) LBA: Logical Block Address; Logical Block Size = 512 Bytes/1 Sector.

Performance

Capacity GB	Performance Throughput[1] 128kB File, Queue Depth (QD) = 32		IOPS[1] 4kB File, Queue Depth (QD) = 32	
	Sequential Read MB/s	Sequential Write MB/s	100% Random Read	100% Random Write
960	550	490	77,000	66,000

(1) Performance is based on fresh out-of-box condition formatted with NTFS filesystem and running CrystalDiskMark 7.0.0 with file size 1024MB. Actual results may vary depending on file system, workload, and SSD condition.

Power Consumption - 5V Supply

Sequential Read[1] 128kB, QD = 32	Sequential Write[1] 128kB, QD = 32	Random Read[1] 4kB, QD = 32	Random Write[1] 4kB, QD = 32	Idle
2.80 W	3.33 W	3.00 W	3.30 W	0.56 W

(1) Power consumption tests were done using Oakgate test system at 25ºC

Temperature and Humidity

Part Number	Operating Temperature	Non-Operating [1] Temperature	Humidity (Non-Condensing)
VSFF25CI960G-V11	-40ºC to 85ºC	-40ºC to 85ºC	5% to 95%

(1) Maximum non-operating temperature assumes data is stored on the SSD. Temperatures above 85ºC are beyond NAND specification for data retention. Please see *Temperature Considerations for Industrial Embedded SSDs* whitepaper under the industrial SSD section of Virtium website (Virtium.com)

Shock and Vibration

Reliability	Test Conditions	Reference Standards
Shock	1500G, half-sine wave, 0.5ms duration	JESD22-B110B.01
Vibration	20G, 20 Hz to 2000 Hz	JESD22-B103B.01

3. Reliability

Endurance

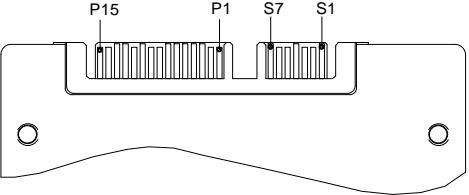| Capacity (GB)	JESD218A[1] & JESD219 Enterprise Workloads		100% Sequential Workloads	
	Total Bytes Written TBW (TB)	Drive Writes per day (3 years)	Total Bytes Written TBW (TB)	Drive Writes per day (3 years)
960	801	0.76	2,972	2.83
(1) JESD218A assumes an active temperature at 55ºC and a retention temperature at 40ºC				

Mean Time Between Failures (MTBF)

The SSD achieves a MTBF of greater than 2,000,000 hours predicted and is derived from the component reliability data using Telcordia SR-332 methods at 40ºC and tested under standard environmental operating conditions.

vtGuard® Power-Fail Protection

vtGuard is an integrated power failure protection technology that will preserve data on the SSD if a sudden power failure should occur. It will also transfer the write cache (metadata, mapping tables) contents to the non-volatile flash and restore the contents upon power restoration. This data will be preserved regardless of the duration of the power failure event. This technology also ensures that the SSD will be recoverable after sudden power failure events although a rebuild of the mapping tables may delay readiness of the SSD on the ensuing power cycle on larger capacities.

4. Physical Specifications

Pin Layout / Assignments

Pin Layout

	Power Pin Assignments		
P1	V33	No Connect
P2	V33	No Connect
P3	DEVSLP	Enter/Exit Device Sleep
P4	GND	Ground
P5	GND	Ground
P6	GND	Ground
P7	V5	5V Power
P8	V5	5V Power
P9	V5	5V Power
P10	GND	Ground
P11	DAS/DSS	Device Activity Signal
P12	GND	Ground
P13	V12	No Connect
P14	V12	No Connect
P15	V12	No Connect

	Signal Pin Assignments	
S1	GND	Ground
S2	A	Differential signal pair A and A#
S3	A#	Differential signal pair A and A#
S4	GND	Ground
S5	B#	Differential signal pair B and B#
S6	B	Differential signal pair B and B#
S7	GND	Ground

Mechanical Dimensions
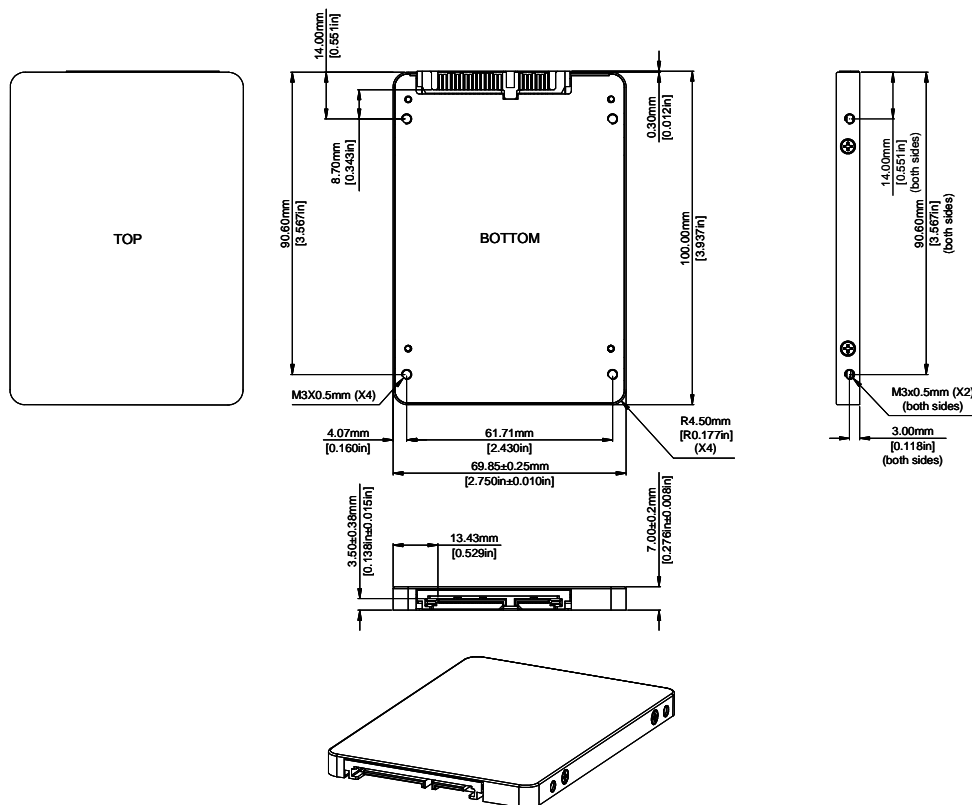
5. ATA Commands

The SSDs support all mandatory ATA commands as defined in the ATA/ATAPI-8 (ACS-3) specification.

General Feature Set

Command	Code	Protocol
Execute Device Diagnostic	90h	Execute Device Diagnostic
Flush Cache	E7h	Non-data
Identify Device	ECh	PIO data-in
Read DMA	C8h	DMA
Read Multiple	C4h	PIO data-in
Read Sector(s)	20h	PIO data-in
Read Verify Sector(s)	40h or 41h	Non-data
Set Feature	EFh	Non-data
Set Multiple Mode	C6h	Non-data
Write DMA	CAh	DMA
Write Multiple	C5h	PIO data-out
Write Sector(s)	30h	PIO data-out
NOP	00h	Non-data
Read Buffer	E4h	PIO data-in
Write Buffer	E8h	PIO data-out
Write Buffer DMA	E9h	DMA
Download Microcode	92h	PIO data-out
Download Microcode DMA	93h	DMA

Power Management

Command	Code	Protocol
Check Power Mode	E5h	Non-data
Idle	E3h	Non-data
Idle Immediate	E1h	Non-data
Sleep	E6h	Non-data
Standby	E2h	Non-data
Standby Immediate	E0h	Non-data

Sanitize

Command	Code	Protocol
Sanitize	B4h	Non-data

Security Mode

Command	Code	Protocol
Security Set Password	F1h	PIO data-out
Security Unlock	F2h	PIO data-out
Security Erase Prepare	F3h	Non-data
Security Erase Unit	F4h	PIO data-out
Security Freeze Lock	F5h	Non-data
Security Disable Password	F6h	PIO data-out

SMART Commands

Command	Code	Protocol
SMART Disable Operations	B0h	Non-data
SMART Enable/Disable Autosave	B0h	Non-data
SMART Enable Operations	B0h	Non-data
SMART Execute OFF-LINE Immediate	B0h	Non-data
SMART Read Log	B0h	PIO data-in
SMART Read Data	B0h	PIO data-in
SMART Read Threshold	B0h	PIO data-in
SMART Return Status	B0h	Non-data
SMART Save Attribute Values	B0h	Non-data
SMART Write Log	B0h	PIO data-out
SMART Write Thresholds	B0h	PIO data-out

Host Protected Area

Command	Code	Protocol
Read Native Max Address	F8h	Non-data
Set Max Address	F9h	Non-data
Set Max Set Password	F9h	PIO data-out
Set Max Lock	F9h	Non-data
Set Max Freeze Lock	F9h	Non-data
Set Max Unlock	F9h	PIO data-out

48-bit Address Feature Set

Command	Code	Protocol
Flush Cache Ext	EAh	Non-data
Read Sector(s) Ext	24h	PIO data-in
Read DMA Ext	25h	DMA
Read Log Ext	2Fh	PIO data-in
Read Log DMA Ext	47h	DMA
Read Multiple Ext	29h	PIO data-in
Read Native Max Address Ext	27h	Non-data
Read Verify Sector(s) Ext	42h	Non-data
Set Max Address Ext	37h	Non-data
Write DMA Ext	35h	DMA
Write DMA FUA Ext	3Dh	DMA
Write Multiple Ext	39h	PIO data-out
Write Multiple FUA Ext	CEh	PIO data-out
Write Sector(s) Ext	34h	PIO data-out

Native Command Queuing (NCQ)

Command	Code	Protocol
Read FPDMA Queued	60h	DMA Queued
Write FPDMA Queued	61h	DMA Queued

Trusted

Command	Code	Protocol
Trusted Send	5Eh	PIO data-out
Trusted Send DMA	5Fh	DMA
Trusted Receive	5Ch	PIO data-in
Trusted Receive DMA	5Dh	DMA
Trusted (Non-Data)	5Bh	Non-data
Trusted Send	5Eh	PIO data-out

Data Set Management and Seek

Command	Code	Protocol
Data Set Management	06h	DMA
Seek	70h	Non-data

Identify Device (ECh) Data

The Identify Device (ECh) command enables the host to receive parameter information from the controller. This command has the same protocol as the Read Sector(s) command. The parameter words in the buffer have the arrangement and meanings defined in the following table.

Word	F/V/X	Value	Description
0	F	0040h	General Configuration
1	X	3FFFh	Default Number of Cylinders
2	V	C837h	Reserved
3	X	0010h	Default Number of Heads
4	X	0000h	Obsolete
5	X	0000h	Obsolete
6	X	003Fh	Default Number of Sectors per Track
7-8	V	0000h	Reserved
9	X	0000h	Obsolete
10-19	F	XXXXh	Serial Number in ASCII (Right justified)
20	X	0000h	Obsolete
21	X	0000h	Obsolete
22	X	0000h	Obsolete
23-26	F	XXXXh	Firmware Revision in ASCII; Big Endian Byte Order in Word
27-46	F	XXXXh	Model Number in ASCII (Left justified); Big Endian Byte Order in Word
47	F	0000h	Maximum Number of Sectors on Read/Write Multiple Command
48	F	4001h	Trusted computing feature set options
49	F	2F00h	Capabilities
50	F	XXXXh	Capabilities
51	X	0000h	Obsolete
52	X	0000h	Obsolete
53	F	0007h	Words 88 and 70 :64 valid
54	X	3FFFh	Current number of cylinders
55	X	0010h	Current number of heads
56	X	003Fh	Current sectors per track
57-58	X	XXXXh	Current capacity in LBAs
59	V	B000h	Multiple Sector Setting
60-61	F	XXXXh	Total number of user addresable logica sectors

Word	F/V/X	Value	Description
62	X	0000h	Obsolete
63	F	0007h	Multiple DMA transfer
64	F	0003h	Advanced PIO transfer mode supported
65	F	0078h	Minimum Multiword DMA Transfer Cycle Time per Word
66	F	0078h	Recommended Multiword DMA Transfer Cycle Time
67	F	0078h	Minimum PIO Transfer Cycle Time without Flow Control
68	F	0078h	Minimum PIO Transfer Cycle Time with IORDY Flow Control
69	F	4D30h	CFast suport
70-74	F	0000h	Reserved
75	F	001Fh	Queue Depth
76	F	870Eh	Serial ATA Capabilities • Supports Serial ATA Gen3 • Supports Serial ATA Gen2 • Supports Serial ATA Gen1 • Supports receipt of Host Initiated Power Management requests • Supports Native Command Queuing
77	F	0086h	Serial ATA Additional Capability; DevSleep_to_ReducedPwerState
78	F	016Ch	Serial ATA Features Supported • Supports Software Settings Preservation • Supports Initiating Power Management
79	V	0040h	Serial ATA features enabled
80	F	07FCh	Major Version Number (ACS-3)
81	F	FFFFh	Minor Version Number
82	F	746Bh	Command Sets Supported 0
83	F	7401h	Command Sets Supported 1
84	F	4063h	Command Sets Supported 2
85	V	7469h	Command Set/Feature Enabled
86	V	B401h	Command Set/Feature Enabled
87	V	4063h	Command Set/Feature Enabled
88	V	047Fh	Ultra DMA Mode Supported and Selected
89	F	0002h	Time required for a Normal Erase Mode Security Erase Unit Command
90	F	0002h	Time required for an Enhanced Erase Mode Security Erase Unit Command
91	V	00FEh	Current Advanced Power Management Value
92	V	FFFEh	Master Password revision code
93-99	V	0000h	Reserved
100-103	V	XXXXh	Maximum User LBA for 48-bit Address Feature Set
104-105	V	0000h	Reserved
106	F	4000h	Sector size
107-127	V	0000h	Reserved
128	V	0021h	Security Status
129-159	X	XXXXh	Virtium Specific
160	X	0000h	Power Requirement Description
161-167	X	0000h	Reserved
168	F	0000h	Reserved
169	X	0001h	Data Set Management supported
170-208	F	0000h	Reserved
209	X	4000h	Reserved
210-216	X	0000h	Reserved
217	X	0001h	Non-rotating Media (SSD)
218-221	X	0000h	Reserved
222	X	10FFh	Transport Major Revision (SATA Revision 3.1)

Word	F/V/X	Value	Description
223-233	X	0000h	Reserved
234	X	0002h	Minimum number of 512 byte units per segmented download
235	X	0200h	Maximum number of 512 byte units per segmented download
236-254	X	0000h	Reserved
255	X	XXXXh	Integrity Word - Checksum

Notes:

1. F = content (byte) is fixed and does not change.
2. V = content (byte) is variable and may change depending on the state of the device or the commands executed by the device.
3. X = content (byte) is specific to manufacturer and may be fixed or variable.

6. SMART Attributes

Introduction

Self-Monitoring, Analysis, and Reporting Technology (SMART) is a system that monitors the device condition according to indicators reported by the device itself. This system is designed to anticipate and predict any failures that might occur, thereby allowing the user to prevent data loss or corruption.

This section is for informational purposes only and about the SMART commands and attributes implemented by Virtium LLC., including the data structures returned by those commands.

Note: Please refer to ACS-3 Specification for information on how to invoke the SMART command.

SMART Subcommands

The following table defines the SMART command set that is supported by the SSDs.

Value	Command
D0h	SMART Read Data
D1h	SMART Read Attribute Threshold
D2h	SMART Enable/Disable Auto-save
D3h	SMART Save Attribute Values
D4h	SMART Execute Off-Line immediate
D5h	SMART Read Log
D6h	SMART Write Log
D8h	SMART Enable Operations
D9h	SMART Disable Operations
DAh	SMART Return Status

SMART Attribute Definitions

The following table defines the SMART data attributes that are currently supported. These SMART attributes are located at Offset 2 of the SMART Data Structure.

ID (Hex)	ID (Decimal)	Description	Type
01	1	Raw Error Rate: Rate of CRC errors over the total number of LBA's read.	Reset on Power On
05	5	Reallocated Block Count: Total number of block failures during operation.	Life Cumulative
09	9	Power On Hours: Cumulative number of power-on hours while drive is in active mode over the life of the device. Partial/slumber/DEVSLP will not be counted as power on hours. FW won't increase the POH if the power on time is less than 60min.	Life Cumulative
0C	12	Power Cycle Count: Cumulative number of drive power cycles. This attribute includes both graceful and ungraceful power-downs.	Life Cumulative
0E	14	Device Capacity : Raw capacity (512B sectors) per IDEMA standard	Fixed Value
0F	15	User Capacity : Addressable user capacity (512B sectors)	Fixed Value
10	16	Spare Block Count: The initial lowest TLC physical spare block count across all NAND die planes	Fixed Value
64	100	Total Erase Count: The total TLC physical block Program/Erase cycle count over the entire drive.	Life Cumulative
A8	168	SATA PHY Error Count: Number of SATA PHY errors that have occurred.	Life Cumulative
AA	170	Total Bad Block Count: Total physical bad blocks on the drive. Attribute includes both factory and grown bad blocks.	Life Cumulative
AC	172	Total Block Erase Failures: Total NAND erase failure count	Life Cumulative
AD	173	Maximum TLC P/E Cycle Count: The count of the worst case TLC P/E cycle count on any superblock across the entire drive	Life Cumulative
AE	174	Unexpected Power Loss Count: Cululative Number of ungraceful power losses. Ungraceful power loss is defined as a shut down that has not been initiated by a Standby Immediate command from the host. It also includes standby, idle, idle immediate, sleep.	Life Cumulative
AF	175	Average TLC Erase Count	Life Cumulative
B5	181	Total Block Program Fail: Cumulative number of physical block program failures.	Life Cumulative
BB	187	Uncorrectable ECC Count: Total Number of Uncorrectable ECC Errors	Life Cumulative
C2	194	SDD Temperature : Indicates the surface temperature of drive in degrees centigrade. The raw values (2 bytes each) represent the Max, Min, and Current temperature. The "Current" Byte represents 100 – Current temperature and the "Worst" Byte represents 100 – Max temperature	Reset at power on
C5	197	Reserved	Static
C6	198	RAID Recovery Count: Number of (internal) RAID recoveries	Life Cumulative
C7	199	SATA FIS CRC Errors: Count of CRC errors occurring between the host and drive during data transfers.	Life Cumulative

ID (Hex)	ID (Decimal)	Description	Type
CA	202	Drive Life Used: Reported as a percentage, starting at 0% and increasing to 100%.	Life Cumulative
E7	231	Drive Life Remaining: Reported as a percentage, starting at 100% and decreasing to 0%.	Life Cumulative
E8	232	RAID Trigger count: Number of RAID triggers (internal), including recoverable and non-recoverable events.	Life Cumulative
EA	234	Total Flash Sectors read (512 Bytes) from the NAND TLC Region	Life Cumulative
EB	235	Total Flash Sectors written (512 Bytes) to the NAND TLC Region	Life Cumulative
F1	241	Total Host Sectors written (512 Bytes)	Life Cumulative
F2	242	Total Host Sectors read (512 Bytes)	Life Cumulative
F7	247	Reserved	Static
F8	248	Reserved	Static

7. Industry Standards

Reference Title	Date / Revision	Location
ATA/ATAPI-8	September 2008	http://www.t13.org
ACS-3 - ATA/ATAPI Command Set-3	October 2013	http://www.t13.org
SATA 3.1	July 2011	http://www.sata-io.org
JEDEC	JESD22-B110B.01	Mechanical Shock – Device and Subassembly, Revision of JESD22-B110B, June 2019, http://www.jedec.org
JEDEC	JESD22-B103B.01	Vibration, Variable Frequency, Minor revision to JESD22-B103-B, September 2016, http://www.jedec.org
JEDEC	JESD218A	Solid-State Drive (SSD) Requirements and Endurance Test Method, February 2011, http://www.jedec.org
JEDEC	JESD219	Solid-State Drive (SSD) Endurance Workloads, September 2010, http://www.jedec.org

8. Certifications and Compliance

Compliance / Certification	Description
CE and FCC Compliant	Class: FCC Part 15 Subpart B Class B:2011 Declaration of Conformity registration No. STE120607699
RoHS Compliant	Restriction of Hazardous Substance Directive
UL Certified	Underwriters Laboratories, Inc. 94V-0
WEEE Certified	Waste, Electrical and Electronic Equipment Directive
ISO-9001 AS9001 Rev. C Certificate	Quality Management
ISO-14001 Certificate	Environmental Management

9. Contact Information

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10. Revision History

Date	Revision	Page(s)	Description
10/30/2020	1.0	All	Initial release
12/01/2020	1.1	1-3	Update datasheet for Performance and Endurance
03/15/2021	1.2	1	Correction typo
12/22/2021	1.3	1, 3	Update endurance sepecifications

10. Revision History

Virtium manufactures storage and memory and solutions for the world's foremost industrial embedded OEMs. For over two decades, we have designed, manufactured and supported our products in the USA – fortified by a network of global locations. Our world-class technology and unsurpassed support provide a superior customer experience that continuously results in better industrial embedded products for an increasingly interconnected world.

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