



**-602 Series
Industrial Grade
SATA SSD**

Product Manual

October 17, 2012

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1.Introduction to Cactus Technologies -602 Series Industrial Grade SATA SSD Products

Features:

- Solid state design with no moving parts
- Industry standard 2.5” or 1.8” SATA Drive form factor
- Capacities from 8GB to 128GB
- Compliant with Serial ATA 2.6 specifications
- Supports Serial ATA Generation I/II transfer rate of 1.5/3.0Gbps
- Support for ATA SMART Feature Set
- Support for ATA Security Feature Set
- BCH ECC capable of correcting 8 random single bit errors per sector
- High reliability, MTBF > 4,000,000 hrs.
- Enhanced error correction, < 1 error in 10^{14} bits read
- Intelligent power management to reduce power consumption
- Voltage support: 5.0V±10%

The Cactus Technologies® -602 Series SATA Solid State Drive(SSD) is a high capacity solid-state flash memory product that complies with the Serial ATA 2.6 standard and is functionally compatible with a SATA hard disk drive. Cactus Technologies® -602 Series SATA SSDs provide up to 128GB of formatted storage capacity in 2.5” form factor or up to 64GB in a 1.8” form factor.

The Cactus Technologie®s -602 Series Industrial Grade SATA SSD product uses high quality SLC NAND flash memory from well known vendors, such as Samsung Corporation. In addition, it include an on-drive intelligent controller that manages interface protocols, data storage and retrieval as well as ECC, defect handling and diagnostics, power management, and clock control. The controller’s firmware is upgradeable, thus allowing feature enhancements and firmware updates while keeping the BOM stable.

1.1. Supported Standards

Cactus Technologies® -602 Series SATA SSD is fully electrically compatible with the following specification:

- ATA 7 Specification published by ANSI: X3.221 AT Attachment Interface for Disk Drives
- Serial ATA 2.6 Specification published by the Serial ATA International Organization

1.2. Product Features

Cactus Technologies® -602 Series Industrial SATA SSD contains a high level, intelligent controller. This intelligent controller provides many capabilities including the following:

- Standard ATA register and command set (same as found on most magnetic disk drives).
- Manages details of erasing and programming flash memory independent of the host system
- Sophisticated defect managing capabilities (similar to magnetic disk drives).
- Sophisticated system for error recovery using powerful error correction code (ECC).
- Intelligent power management for low power operation.

1.2.1. Host and Technology Independence

Cactus Technologies® -602 Series Industrial SATA SSD appears as a standard SATA disk drive to the host system. The drive utilizes a 512-byte sector which is the same as that in an IDE magnetic disk drive. To write or read a sector (or multiple sectors), the host computer software simply issues an ATA Read or Write command to the drive as per the SATA protocol. The host software then waits for the command to complete. The host system does not get involved in the details of how the flash memory is erased, programmed or read as this is all managed by the built-in controller in the drive. Also, with the intelligent on-board controller, the host system software will not require changing as new flash memory evolves. Thus, systems that support the Cactus Technologies® -602 Series Industrial SATA SSD products today will continue to work with future Cactus Technologies® -602 Series Industrial SATA SSDs built with new flash technology without having to update or change host software.

1.2.2. Defect and Error Management

Cactus Technologies® -602 Series Industrial SATA SSD contains a sophisticated defect and error management system similar to those found in magnetic disk drives. The defect management is completely transparent to the host and does not consume any user data space.

The soft error rate for Cactus Technologies® -602 Series Industrial SATA SSDs is much lower than that of magnetic disk drives. In the extremely rare case where a read error does occur, the drive has sophisticated ECC to recover the data.

These defect and error management systems, coupled with the solid-state construction, give Cactus Technologies® -602 Series Industrial SATA SSDs unparalleled reliability.

1.2.3. Power Supply Requirements

Cactus Technologies® -602 Series Industrial SATA SSD operates at a voltage range of 5.00 volts \pm 10%.

2. Product Specifications

For all the following specifications, values are defined at ambient temperature and nominal supply voltage unless otherwise stated.

2.1. System Environmental Specifications

Table 2-1. Environmental Specifications

		Cactus Technologies® -602 SATA SSD
Temperature	Operating:	0° C to +70° C (Standard) -45° C to +90° C (Extended)
Humidity	Operating & Non-Operating:	8% to 95%, non-condensing
Vibration	Operating & Non-Operating:	20G, MIL-STD-883G Method 2005.2, Condition A
Shock	Operating & Non-Operating:	3,000 G, MIL-STD-883G Method 2002.4, Condition C
Altitude (relative to sea level)	Operating & Non-Operating:	100,000 feet maximum

2.2. System Power Requirements

Table 2-2. Power Requirements

		Cactus Technologies® -602 SATA SSD
DC Input Voltage (VCC) 100 mV max. ripple (p-p)		5V \pm 10%

(Maximum Average Value) See Notes.	Sleep:	160 mA
	Reading:	350 mA
	Writing:	450 mA

NOTES: All values quoted are typical at ambient temperature and nominal supply voltage unless otherwise stated.

Sleep mode is specified under the condition that all drive inputs are static CMOS levels and in a “Not Busy” operating state.

2.3. System Performance

All performance timings assume the drive controller is in the default (i.e., fastest) mode.

Table 2-3. Performance

Start Up Times	Reset to ready:	35 msec typical
Read Transfer Rate		8-16GB - 110.0 MBytes/sec 32-128GB - 145 Mbytes/sec
Write Transfer Rate		8-16GB - 70 Mbytes/sec 32-128GB - 110MBytes/sec
Controller Overhead	Command to DRQ	2 msec maximum

2.4. System Reliability

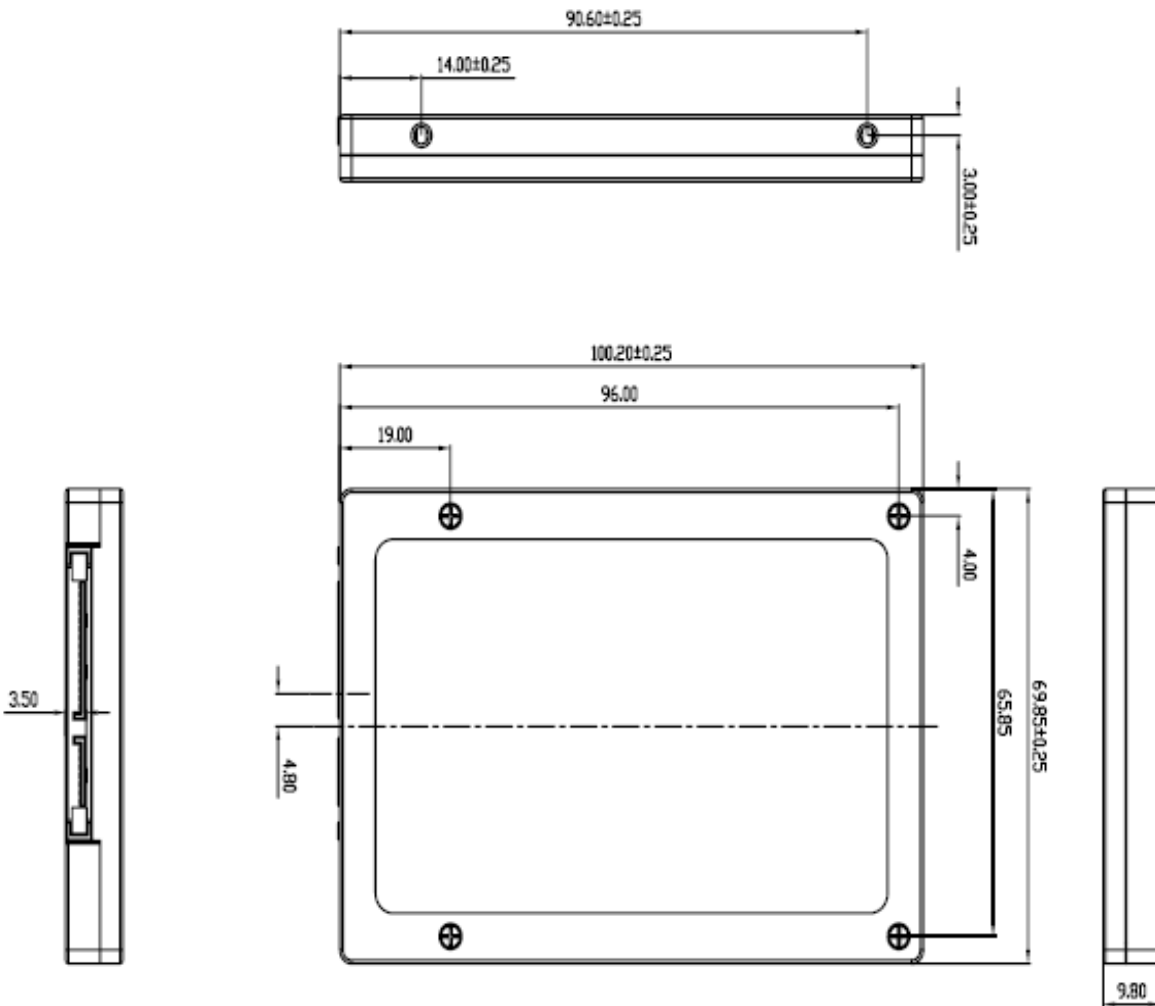
Table 2-4. Reliability

MTBF (@ 25°C)	> 4,000,000 hours
Data Reliability	< 1 non-recoverable error in 10 ¹⁴ bits READ
Endurance:	> 2,000,000 erase/program cycles

2.5. Physical Specifications

The following sections provide the physical specifications for Cactus Technologies® -602 Series Industrial SATA SSD products.

2.5.1. 2.5" SATA SSD Physical Specifications



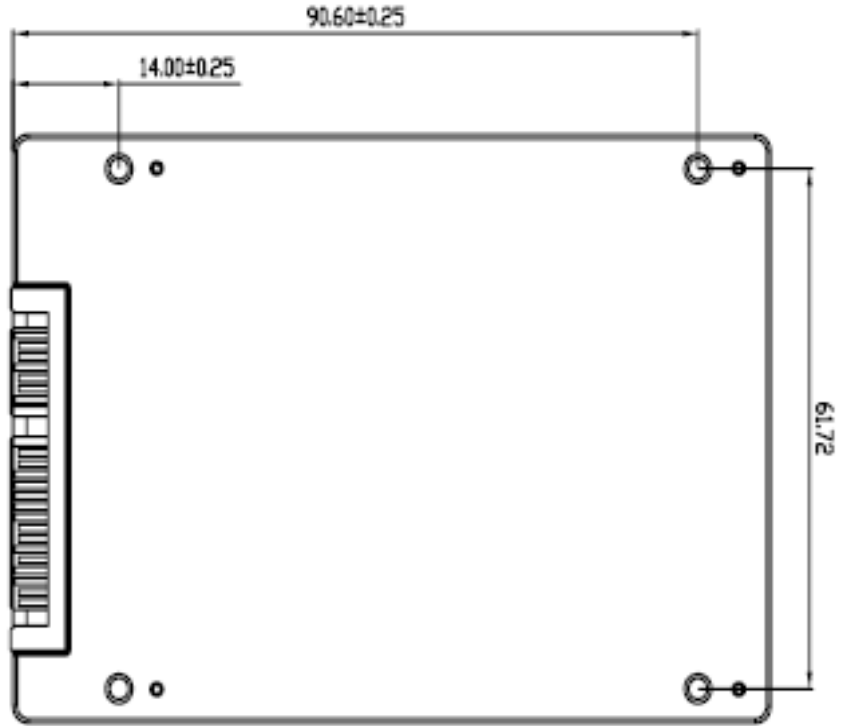
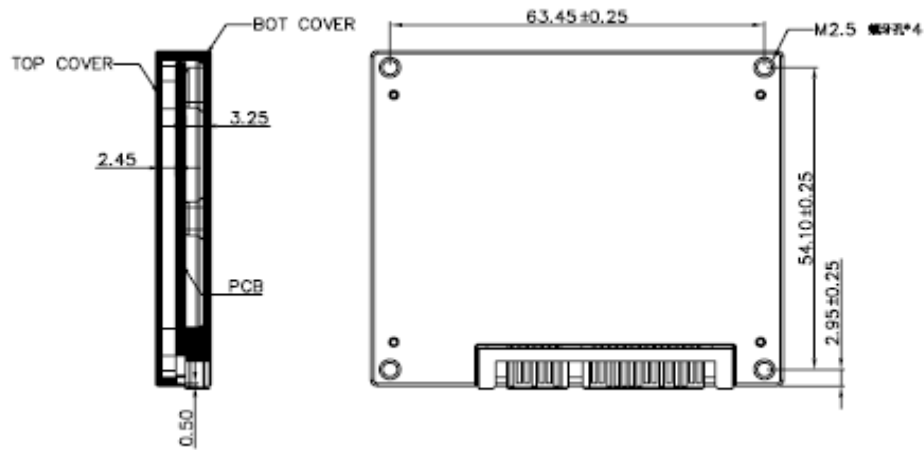
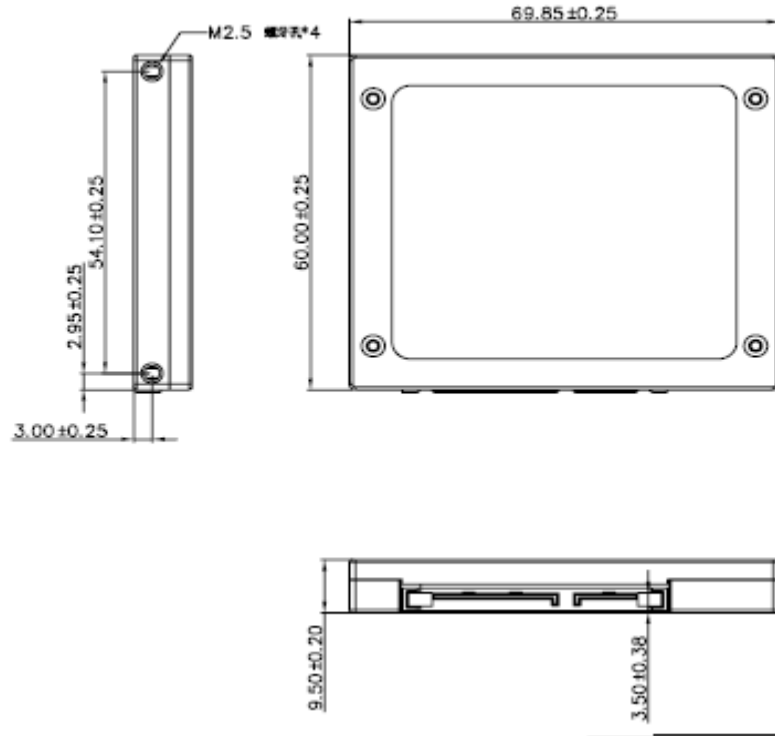


Figure 2-1. 2.5" SATA SSD Dimensions

2.5.2. 1.8" SATA SSD Physical Specifications



3. Interface Description

The following sections provide detailed information on the Cactus Technologies® -602 Series Industrial SATA SSD interface.

3.1. SSD Pin Assignments and Pin Type

Cactus Technologies® -602 Series SATA SSD uses industry standard 7+12 connector. The signal/pin assignments are listed in Table 3-5.

Table 3-5. SSD Pin Assignments and Pin Type

Signal Segment Pin #	Signal Name	Pin Type	Power Segment Pin #	Signal Name	Pin Type
S1	GND		P1	3.3V	
S2	RXP	Analog In	P2	3.3V	
S3	RXN	Analog In	P3	3.3V	
S4	GND		P4	GND	
S5	TXN	Analog Out	P5	GND	
S6	TXP	Analog Out	P6	GND	
S7	GND		P7	5V	
			P8	5V	
			P9	5V	
			P10	GND	
			P11	Reserved	
			P12	GND	
			P13	12V	
			P14	12V	
			P15	12V	

3.2. Signal Description

Table 3-6 describes the I/O signals. Signals whose source is the host are designated as inputs while signals that the SATA SSD sources are outputs. The SATA SSD signal levels conform to those specified in the Serial ATA 2.6 *Specification*.

Table 3-6. Signal Description

Signal Name	Dir.	Description
RXN	AI	Differential receive negative
RXP	AI	Differential receive positive

Signal Name	Dir.	Description
TXN	AO	Differential transmit negative
TXP	AO	Differential transmit positive
3.3V		3.3V power supply; not used
12V		12V power supply; not used
GND	--	Ground.
5V		5V power supply

3.3. Electrical Specification

The following table defines all D.C. Characteristics for the SATA SSD Series. Unless otherwise stated, conditions are:

$$V_{cc} = 5V \pm 10\%$$

$$T_a = -40^{\circ}\text{C to } 90^{\circ}\text{C}$$

3.3.1. Absolute Maximum Ratings

Parameter	Symbol	MIN	MAX	Units
Storage Temperature	T _s	-65	+150	°C
Operating Temperature	T _A	-45	+90	°C
V _{cc} with respect to GND	V _{cc}	-0.3	6.5	V

3.3.2. DC Characteristics

Parameter	Symbol	MIN	MAX	Units
Input Voltage	V _{in}	-0.5	V _{cc} + 0.5	V
Output Voltage	V _{out}	-0.3	V _{cc} + 0.3	V
Input Leakage Current	I _{li}	-10	10	uA
Output Leakage Current	I _{lo}	-10	10	uA
Input/Output Capacitance	C _i /C _o		10	pF
Operating Current	I _{cc}			mA
Sleep Mode			160	
Active			450	

3.3.3. AC Characteristics

Cactus Technologies® -602 Series SATA SSD products conforms to all AC timing requirements as specified in the Serial ATA specifications. Please refer to that document for details of AC timing for all operation modes of the device.

4.ATA Drive Register Set Definition and Protocol

The communication to or from the SATA SSD is done using FIS. Legacy ATA protocol is supported by using the legacy mode defined in the SATA specifications. In this mode, the FIS has defined fields which provide all the necessary ATA task file registers for control and status information. The Serial ATA interface does not support Primary/Secondary or Master/Slave configurations. Each SATA channel supports only one SATA device, with the register selection as defined by the ATA standard.

4.1. ATA Task File Definitions

The following sections describes the usage of the ATA task file registers. Note that the Alternate Status Register of legacy ATA is not defined for SATA drives.

4.1.1. Data Register

The Data Register is a 16-bit register, and it is used to transfer data blocks between the SSD data buffer and the Host.

4.1.2. Error Register

This register contains additional information about the source of an error when an error is indicated in bit 0 of the Status register. The bits are defined as follows:

D7	D6	D5	D4	D3	D2	D1	D0
BBK	UNC	0	IDNF	0	ABRT	0	AMNF

- Bit 7 (BBK)** This bit is set when a Bad Block is detected.
- Bit 6 (UNC)** This bit is set when an Uncorrectable Error is encountered.
- Bit 5** This bit is 0.
- Bit 4 (IDNF)** The requested sector ID is in error or cannot be found.
- Bit 3** This bit is 0.
- Bit 2 (Abort)** This bit is set if the command has been aborted because of a status condition: (Not Ready, Write Fault, etc.) or when an invalid command has been issued.
- Bit 1** This bit is 0.
- Bit 0 (AMNF)** This bit is set in case of a general error.

4.1.3. Feature Register

This register provides information regarding features of the SSD that the host can utilize.

4.1.4. Sector Count Register

This register contains the number of sectors of data requested to be transferred on a read or write operation between the host and the SSD. If the value in this register is zero, a count of 256 sectors is specified. If the command was successful, this register is zero at command completion. If not successfully completed, the register contains the number of sectors that need to be transferred in order to complete the request.

4.1.5. Sector Number (LBA 7-0) Register

This register contains the starting sector number or bits 7-0 of the Logical Block Address (LBA) for any SSD data access for the subsequent command.

4.1.6. Cylinder Low (LBA 15-8) Register

This register contains the low order 8 bits of the starting cylinder address or bits 15-8 of the Logical Block Address.

4.1.7. Cylinder High (LBA 23-16) Register

This register contains the high order bits of the starting cylinder address or bits 23-16 of the Logical Block Address.

4.1.8. Drive/Head (LBA 27-24) Register

The Drive/Head register is used to select the drive and head. It is also used to select LBA addressing instead of cylinder/head/sector addressing. The bits are defined as follows:

D7	D6	D5	D4	D3	D2	D1	D0
1	LBA	1	DRV	HS3	HS2	HS1	HS0

Bit 7 This bit is set to 1.

Bit 6 LBA is a flag to select either Cylinder/Head/Sector (CHS) or Logical Block Address Mode (LBA). When LBA=0, Cylinder/Head/Sector mode is selected. When LBA=1, Logical Block Address is selected. In Logical Block Mode, the Logical Block Address is interpreted as follows:
 LBA07-LBA00: Sector Number Register D7-D0.
 LBA15-LBA08: Cylinder Low Register D7-D0.
 LBA23-LBA16: Cylinder High Register D7-D0.
 LBA27-LBA24: Drive/Head Register bits HS3-HS0.

Bit 5 This bit is set to 1.

Bit 4 (DRV) DRV is the drive number. This should always be set to 0.

Bit 3 (HS3) When operating in the Cylinder, Head, Sector mode, this is bit 3 of the head number. It is Bit 27 in the Logical Block Address mode.

Bit 2 (HS2) When operating in the Cylinder, Head, Sector mode, this is bit 2 of the head number. It is Bit 26 in the Logical Block Address mode.

Bit 1 (HS1) When operating in the Cylinder, Head, Sector mode, this is bit 1 of the head number. It is Bit 25 in the Logical Block Address mode.

Bit 0 (HS0) When operating in the Cylinder, Head, Sector mode, this is bit 0 of the head number. It is Bit 24 in the Logical Block Address mode.

4.1.9. Status Registers

These registers return the status when read by the host. Reading the Status register does clear a pending interrupt while reading the Auxiliary Status register does not. The meaning of the status bits are described as follows:

D7	D6	D5	D4	D3	D2	D1	D0
BUSY	RDY	DWF	DSC	DRQ	CORR	0	ERR

- Bit 7 (BUSY)** The busy bit is set when the device has access to the command buffer and registers and the host is locked out from accessing the command register and buffer. No other bits in this register are valid when this bit is set to a 1.
- Bit 6 (RDY)** RDY indicates whether the device is capable of performing operations requested by the host. This bit is cleared at power up and remains cleared until the device is ready to accept a command.
- Bit 5 (DWF)** This bit, if set, indicates a write fault has occurred.
- Bit 4 (DSC)** This bit is set when the device is ready.
- Bit 3 (DRQ)** The Data Request is set when the device requires that information be transferred either to or from the host through the Data register.
- Bit 2 (CORR)** This bit is set when a Correctable data error has been encountered and the data has been corrected. This condition does not terminate a multi-sector read operation.
- Bit 1 (IDX)** This bit is always set to 0.
- Bit 0 (ERR)** This bit is set when the previous command has ended in some type of error. The bits in the Error register contain additional information describing the error.

4.1.10. Device Control Register

This register is used to control the drive interrupt request and to issue an ATA soft reset to the drive. The bits are defined as follows:

D7	D6	D5	D4	D3	D2	D1	D0
HOB	X	X	X	1	SW Rst	-IEn	0

- Bit 7** This bit is used in 48-bit addressing mode. When cleared, the host can read the most recently written values of the Sector Count, Drive/Head and LBA registers. When set, the host will read the previous written values of these registers. A write to any Command block register will clear this bit.
- Bit 6** This bit is an X (Do not care).
- Bit 5** This bit is an X (Do not care).
- Bit 4** This bit is an X (Do not care).
- Bit 3** This bit is ignored by the drive.
- Bit 2 (SW Rst)** This bit is set to 1 in order to force the drive to perform an AT Disk controller Soft Reset operation. The drive remains in Reset until this bit is reset to '0'.
- Bit 1 (-IEn)** The Interrupt Enable bit enables interrupts when the bit is 0. When the bit is 1, interrupts from the drive are disabled. This bit is set to 0 at power on and Reset.
- Bit 0** This bit is ignored by the drive.

4.1.11. Drive Address Register

This register is provided for compatibility with the AT disk drive interface. It is recommended that this register not be mapped into the host's I/O space because of potential conflicts on Bit 7. The bits are defined as follows:

D7	D6	D5	D4	D3	D2	D1	D0
X	-WTG	-HS3	-HS2	-HS1	-HS0	-nDS1	-nDS0

- Bit 7** This bit is unknown.
Implementation Note:
Conflicts may occur on the host data bus when this bit is provided by a Floppy Disk Controller operating at the same addresses as the SSD. Following are some possible solutions to this problem:
1. Locate the SSD at a non-conflicting address (i.e., Secondary address (377) when a Floppy Disk Controller is located at the Primary addresses).
 2. Do not install a Floppy and a SSD in the system at the same time.
 3. Implement a socket adapter that can be programmed to (conditionally) tri-state D7 of I/O address 3F7/377 when a SSD product is installed and conversely to tri-state D6-D0 of I/O address 3F7/377 when a floppy controller is installed.
 4. Do not use the SSD's Drive Address register. This may be accomplished by either a) If possible, program the host adapter to enable only I/O addresses 1F0-1F7, 3F6 (or 170-177, 176) to the SSD or b) if provided use an additional Primary/Secondary configuration in the SSD that does not respond to accesses to I/O locations 3F7 and 377. With either of these implementations, the host software must not attempt to use information in the Drive Address Register.
- Bit 6 (-WTG)** This bit is 0 when a write operation is in progress, otherwise, it is 1.
Bit 5 (-HS3) This bit is the negation of bit 3 in the Drive/Head register.
Bit 4 (-HS2) This bit is the negation of bit 2 in the Drive/Head register.
Bit 3 (-HS1) This bit is the negation of bit 1 in the Drive/Head register.
Bit 2 (-HS0) This bit is the negation of bit 0 in the Drive/Head register.
Bit 1 (-nDS1) This bit is 0 when drive 1 is active and selected.
Bit 0 (-nDS0) This bit is 0 when the drive 0 is active and selected.

5.ATA Command Description

This section defines the ATA command set supported by the Cactus Technologies® -602 Series SATA SSDs.

5.1. ATA Command Set

Table 5-7 summarizes the supported ATA command set .

Table 5-7. ATA Command Set

COMMAND	Code	FR	SC	SN	CY	DH
Check Power Mode	E5h or 98h	-	-	-	-	D
Execute Drive Diagnostic	90h	-	-	-	-	-
Flush Cache	E7h	-	-	-	-	Y
Flush Cache Ext	EAh	-	-	-	-	Y

COMMAND	Code	FR	SC	SN	CY	DH
Identify Drive	ECh	-	-	-	-	D
Idle	E3h	-	Y	-	-	D
Idle Immediate	E1h	-	-	-	-	D
Initialize Drive Parameters	91h	-	Y	-	-	Y
Read DMA	C8h or C9h	-	Y	Y	Y	Y
Read DMA Ext	25h	-	Y	Y	Y	Y
Read FPDMA Queued	60h	Y	Y	Y	Y	Y
Read Log Ext	2Fh	Y	Y	Y	Y	Y
Read Multiple	C4h	-	Y	Y	Y	Y
Read Multiple Ext	29h	-	Y	Y	Y	Y
Read Sector(s)	20h or 21h	-	Y	Y	Y	Y
Read Sector(s) Ext	24h	-	Y	Y	Y	Y
Read Verify Sector(s)	40h or 41h	-	Y	Y	Y	Y
Read Verify Sector(s) Ext	42h	-	Y	Y	Y	Y
Recalibrate	1Xh	-	-	-	-	D
Security Disable Password	F6h	-	-	-	-	D
Security Erase Prepare	F3h	-	-	-	-	D
Security Erase Unit	F4h	-	-	-	-	D
Security Freeze Lock	F5h	-	-	-	-	D
Security Set Password	F1h	-	-	-	-	D
Security Unlock	F2h	-	-	-	-	D
Seek	7Xh	-	-	Y	Y	Y
Set Features	EFh	Y	-	-	-	D
Set Multiple Mode	C6h	-	Y	-	-	D
Set Sleep Mode	E6h	-	-	-	-	D
SMART	B0h	Y	-	-	Y	D
Stand By	E2h	-	-	-	-	D
Stand By Immediate	E0h	-	-	-	-	D
Write DMA	CAh or CBh	-	Y	Y	Y	Y
Write DMA Ext	35h	-	Y	Y	Y	Y
Write DMA FUA Ext	3Dh	-	Y	Y	Y	Y
Write FPDMA Queued	61h	Y	Y	Y	Y	Y
Write Multiple	C5h	-	Y	Y	Y	Y
Write Multiple Ext	39h	-	Y	Y	Y	Y
Write Multiple FUA Ext	CEh	-	Y	Y	Y	Y
Write Sector(s)	30h or 31h	-	Y	Y	Y	Y
Write Sector(s) Ext	34h	-	Y	Y	Y	Y

Definitions: FR = Features Register, SC = Sector Count Register, SN = Sector Number Register, CY = Cylinder Registers, DH = Drive/Drive/Head Register.

Y—The register contains a valid parameter for this command. For the Drive/Head Register Y means both the drive and head parameters are used; D—only the drive parameter is valid and not the head parameter.

Note: 1. For SATA drives, the drive number is always 0.

5.1.1. Identify Drive—ECH

The Identify Drive command enables the host to receive parameter information from the drive. 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 Table 5-8. All reserved bits or words are zero. Table 5-8 is the definition for each field in the Identify Drive Information.

Table 5-8. Identify Drive Information

Word Address	Default Value	Total Bytes	Data Field Type Information
0	0040H	2	General configuration bit-significant information.
1	XXXXH	2	Default number of cylinders; capacity dependent.
2	C837H	2	Reserved.
3	00XXH	2	Default number of heads; capacity dependent.
4	XXXXH	2	Number of unformatted bytes per track.
5	XXXXH	2	Number of unformatted bytes per sector.
6	XXXXH	2	Default number of sectors per track; capacity dependent.
7-8	XXXXH,XXX XH	4	Number of sectors per drive (Word 7 = MSW, Word 8 = LSW); capacity dependent.
9	000EH	2	Reserved.
10-19	aaaa	20	Serial number in ASCII (Right Justified).
20	XXXXH	2	Retired
21	XXXXH	2	Retired
22	0003FH	2	Obsolete
23-26	aaaa	8	Firmware revision in ASCII . Big Endian Byte Order in Word.
27-46	aaaa	40	Model number in ASCII (Left Justified) Big Endian Byte Order in Word.
47	8001H	2	Maximum number of sectors on Read/Write Multiple command
48	4000H	2	Double Word not supported.
49	2F00H	2	Capabilities: DMA Supported (bit 8), LBA supported (bit 9).
50	4000H	2	Reserved.
51	0280H	2	PIO data transfer cycle timing mode
52	0000H	2	Single Word DMA data transfer cycle timing mode (not supported).
53	0007H	2	Data fields 54-58,64-70 and 88 are valid.
54	XXXX	2	Current numbers of cylinders.
55	00XX	2	Current numbers of heads.
56	XXXX	2	Current sectors per track.
57-58	XXXX	4	Current capacity in sectors (LBAs) (Word 57 = LSW, Word 58 = MSW).
59	0000H	2	Multiple sector setting is valid; low byte is capacity dependent.
60-61	XXXX	4	Total number of sectors addressable in LBA Mode.
62	0000H	2	Reserved
63	0007H	2	Multiword DMA modes 0-2 are supported; upper byte reflects currently selected MWDMA mode.
64	0003H	2	Advanced PIO modes supported (modes 3 and 4)
65	0078H	2	Minimum MWDMA cycle time per word is 120ns.
66	0078H	2	Recommended MWDMA cycle time is 120ns.

Word Address	Default Value	Total Bytes	Data Field Type Information
67	0078H	2	Minimum PIO cycle time without IORDY flow control is 120ns.
68	0078H	2	Minimum PIO cycle time with IORDY flow control is 120ns.
69-74	0000H	10	Reserved
75	0000H	2	Queue depth of 1
76	0106H	2	Supports SATA NCQ, Gen 1, Gen2 signaling rates
77	0000H	2	Reserved
78	0004H	2	Supports DMA Setup Auto-Activate optimization
79	0000H	2	Status of word 78 features
80	01FEH	2	Supports ATA7 standard.
81	0021H	2	No minor revision reported.
82	0069H	2	PACKET Command, Security Mode feature sets not supported; SMART feature supported
83	7400H	2	48-bit mode supported; Flush Cache/Flush Cache Ext supported.
84	4060H	2	WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT supported
85	XXXXH	2	Feature status
86	XXXXH	2	Feature status
87	XXXXH	2	Feature status
88	203FH	2	UDMA Modes 0-5 supported.
89-91	0000H	6	Reserved
92	XXXXH	2	Master password revision code
93	XXXXH	2	COMRESET result
94	80FEH	2	Acoustic management values
95-99	0000H	10	Reserved
100-103	XXXXH	8	Maximum user LBA for 48-bit addressing mode.
104-127	0000H	48	Reserved
128	XXXXH	2	Security status
129-255	-		Reserved

6.S.M.A.R.T. Support

Cactus Technologies -602 Series SATA SSDs support S.M.A.R.T. Status and attribute reporting functions. The S.M.A.R.T. subcommands supported are as follows:

Code	Sub Command
D0	Read Data
D1	Read Attribute Thresholds
D2	Enable/Disable Attribute Autodave
D3	Save Attribute Values
D8	Enable Operations
D9	Disable Operations
DA	Return Status

6.1. S.M.A.R.T. Read Data

This subcommand returns 512 bytes of S.M.A.R.T. data structure. When this subcommand is issued, the Feature Register must contain D0h, the LBA Mid register must contain 4Fh and the LBA high register must contain C2h. The returned data has the following structure:

Byte	Description
0-1	Data structure revision number
2-13	1 st attribute data
14-361	2 nd – 30 th attribute data (12 bytes each)
362	Offline data collection status
363	Reserved
364-365	Total time in seconds to complete offline data collection
366	Reserved
367	Offline data collection capability
368-369	S.M.A.R.T. Capability
370-510	Reserved
511	checksum

ff

6.2. S.M.A.R.T. Attributes

The attributes reported are shown in the following table:

ID	Description
E5	Halt system ID, Flash IDs
E8	Firmware version information
E9	ECC Fail Record
EA	Average Erase Count, Max Erase Count
EB	Good Block Count, System Block Count

For each attribute, the format of the data structure is as follows:

Byte	Description
0	Attribute ID

1-2	Status Flag (0x0002)
3	Attribute Value (0x64)
4-11	Attribute Specific

The following tables lists the returned data for each reported attribute.

Attribute E5	
Byte	Description
0	Halt System ID
1	Flash ID byte 0
2	Flash ID byte 1
3	Flash ID byte 2
4	Flash ID byte 3
5	Flash ID byte 4
6	Flash ID byte 5
7	Flash ID byte 6

Attribute E8	
Byte	Description
0	Year, High Byte (ASCII)
1	Year, Low Byte (ASCII)
2	Month, High Byte (ASCII)
3	Month, Low Byte (ASCII)
4	Day, High Byte (ASCII)
5	Day, Low Byte (ASCII)
6	Channels (binary)
7	Banks (binary)

Attribute E9	
Byte	Description
0	ECC Fail Number
1	Row Address 3
2	Row Address 2
3	Row Address 1
4	Channel number of last ECC fail
5	Bank number of last ECC fail
6-7	Reserved

Attribute EA	
Byte	Description
0	Average Erase Count (Byte 3)
1	Average Erase Count (Byte 2)
2	Average Erase Count (Byte 1)
3	Max Erase Count (Byte 3)
4	Max Erase Count (Byte 2)
5	Max Erase Count (Byte 1)
6-7	Reserved

Attribute EB	
Byte	Description
0	Good Block Count (Byte 3)
1	Good Block Count (Byte 2)
2	Good Block Count (Byte 1)
3	System Free Block Count (High Byte)
4	System Free Block Count (Low Byte)
5-7	Reserved

6.3. S.M.A.R.T. Enable Operations

Enables the SMART function. This setting is maintained when the power is turned off and then back on. Once the SMART function is enabled, subsequent SMART ENABLE OPERATIONS commands do not affect any parameters.

6.4. S.M.A.R.T. Disable Operations

Disables the SMART function. Upon receiving the command, the drive disables all SMART operations. This setting is maintained when the power is turned off and then back on. Once this command has been received, all SMART commands other than SMART ENABLE OPERATIONS are aborted with the Aborted Command error.

This command disables all SMART capabilities including any and all timer and event count functions related exclusively to this feature. After command acceptance, this controller will disable all SMART operations. SMART data is no longer monitored or saved. The state of SMART is preserved across power cycles.

6.5. S.M.A.R.T. Return Status

Reports the drive reliability status. Values reported when a predicted defect has not been detected:

Cylinder Low register: 4Fh
Cylinder High register: C2h

Values reported when a predicted defect has been detected:

Cylinder Low register: F4h
Cylinder High register: 2Ch

Appendix A. Ordering Information

Model KD X F Y T-602 S A

Where: X is drive capacities:

4G ----- 4GB
8G ----- 8GB
16G ----- 16GB
32G ----- 32GB
64G ----- 64GB
128G ----- 128GB

Where Y is temperature:

Blank ----- Standard temperature (0° C to +70° C)
I ----- Extended temperature (-45° C to +90° C)

Where T is memory type:

Blank ----- Samsung
T ----- Toshiba (only for 128GB)

Where A is form factor:

Blank ----- 2.5"
A ----- 1.8"

Example:

- (1) 8GB 2.5" SATA SSD ----- KD8GF-602S
- (2) 8GB 2.5" SATA SSD Extended Temp ----- KD8GFI-602S
- (3) 8GB 1.8" SATA SSD ----- KD8GF-602SA
- (4) 128GB 2.5" SATA SSD ----- KD128GFT-602S

Appendix B. Technical Support Services

B.1. Direct Cactus Technical Support

Cactus Technologies Limited
Suite C, 15/F, Capital Trade Center
62 Tsun Yip Street, Kwun Tong
Kowloon, Hong Kong

Tel: +852-27972261
Fax: +852-27973777
Email: tech@cactus-tech.com

Appendix C.Cactus Worldwide Sales Offices

Cactus Technologies Limited
Suite C, 15/F, Capital Trade Center
62 Tsun Yip Street, Kwun Tong
Kowloon, Hong Kong

Tel: +852-27972277
Fax: +852-27973777
Email: sales@cactus-tech.com

Appendix D.Limited Warranty

I. WARRANTY STATEMENT

Cactus Technologies® warrants its Industrial Grade products only to be free of any defects in materials or workmanship that would prevent them from functioning properly for five years from the date of purchase. This express warranty is extended by Cactus Technologies® Limited to customers of our products.

II. GENERAL PROVISIONS

This warranty sets forth the full extent of Cactus Technologies® responsibilities regarding the Cactus Technologies® Industrial Grade Flash Storage Products. Cactus Technologies®, at its sole option, will repair, replace or refund the purchase price of the defective product. Cactus Technologies® guarantees our products meet all specifications detailed in our product manuals. Although Cactus Technologies® products are designed to withstand harsh environments and have the highest specifications in the industry, they are not warranted to never have failure and Cactus Technologies® does not warranty against incidental or consequential damages. Accordingly, in any use of products in life support systems or other applications where failure could cause injury or loss of life, the products should only be incorporated in systems designed with appropriate redundancy, fault tolerant or backup features.

III. WHAT THIS WARRANTY COVERS

For products found to be defective within five years of purchase, Cactus Technologies® will have the option of repairing, replacing or refunding the purchase price the defective product, if the following conditions are met:

- A. The defective product is returned to Cactus Technologies® for failure analysis as soon as possible after the failure occurs.
- B. An incident card filled out by the user, explaining the conditions of usage and the nature of the failure, accompanies each returned defective product.
- C. No evidence is found of abuse or operation of products not in accordance with the published specifications, or of exceeding maximum ratings or operating conditions.

All failing products returned to Cactus Technologies® under the provisions of this limited warranty shall be tested to the product's functional and performance specifications. Upon confirmation of failure, each product will be analyzed, by whatever means necessary, to determine the root cause of failure. If the root cause of failure is found to be not covered by the above provisions, then the product will be returned to the customer with a report indicating why the failure was not covered under the warranty.

This warranty does not cover defects, malfunctions, performance failures or damages to the unit resulting from use in other than its normal and customary manner, misuse, accident or neglect; or improper alterations or repairs. Cactus Technologies® Limited may repair or replace, at its discretion, any product returned by its customers, even if such product is not covered under warranty, but is under no obligation to do so.

IV. RECEIVING WARRANTY SERVICE

According to Cactus Technologies® warranty procedure, defective product should be returned only with prior authorization from Cactus Technologies® Limited. Please contact Cactus Technologies® Customer Service department (tech@cactus-tech.com) with the following information: product model number and description, nature of defect, conditions of use, proof of purchase and purchase date. If approved, Cactus Technologies® will issue a Return Material Authorization or Product Repair Authorization number. Ship the defective product to:

Cactus Technologies Limited
Suite C, 15/F, Capital Trade Center
62 Tsun Yip Street, Kwun Tong
Kowloon, Hong Kong