



**S.M.A.R.T. Features for Cactus
Technologies Industrial-Grade
Flash-Storage Products**

White paper CTWP015

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Introduction

S.M.A.R.T. (Self Monitoring, Analysis and Reporting Technology, a.k.a. SMART) is a feature set defined by the ANSI ATA Specifications. The feature set consists of a set of commands which allow the host to retrieve information about the storage device's health status. This allows the user to know in advance impending device failures and act accordingly before the device actually fails. S.M.A.R.T. was originally introduced for use in hard disk drives but is now being adopted for use in flash based ATA storage devices. S.M.A.R.T is an optional feature per ATA specifications but is offered as a standard feature in Cactus Technologies® 303, 503 and 900S series products.

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S.M.A.R.T Usage

S.M.A.R.T. is an ATA command with a command code of B0h. Within this command, there are further subcommands defined, not all of which are mandatory. The subcommand is selected by the value programmed into the Feature Register.

Cactus Technologies 303 series products support the following set of subcommands:

Value	Command
D0h	SMART Read Data
D2h	SMART Enable/Disable Attribute
D8h	SMART Enable Operations
D9h	SMART Disable Operations
DAh	SMART Return Status

Cactus Technologies 503 series products support the following set of subcommands:

Value	Command
D0h	SMART read data
D1h	SMART read attribute thresholds
D2h	SMART enable/disable attribute autosave
D5h	SMART read log
D6h	SMART write log
D8h	SMART enable operations
D9h	SMART disable operations
DAh	SMART return status

Cactus Technologies 900S series products support the following set of subcommands:

Value	Command
D0	Read Data
D1	Read Attribute Thresholds
D2	Enable/Disable Attribute Autodave
D5	Read Log
D6	Write Log
D8	Enable Operations
D9	Disable Operations
DA	Return Status
E0	Read Remap Data
E1	Read Wear Level Data

The most common usage of S.M.A.R.T is to just check the device's status with subcommand DAh. This will return a pass/fail status to the host. This information, however, is not particularly useful because by the time the fail status is returned, the device has already gone bad.

The more useful way of using S.M.A.R.T is to read the device's attributes using the Read Data (D0h) command. This returns a list of attributes, one or more of which contains information that the user can use to predict the remaining life of the device.

03 S.M.A.R.T Attributes

The S.M.A.R.T. Read Data command retrieves a list of device attributes. While the ANSI ATA specification defines the S.M.A.R.T command and subcommand codes and the data format, it does not specify what attributes the device should return. Therefore, the list of attributes varies from vendor to vendor. Since S.M.A.R.T. was introduced in the mid 1990's, the hard disk drive manufactures have more or less adopted a few attributes which are common to all the drives. These attributes are being adopted by some flash storage vendors as well. However, this is merely a de facto industry standard; it is not an ANSI ATA standard. There is no guarantee that the same attribute ID will return the same attribute from one vendor to another. Furthermore, vendors often have additional attributes that are unique to their products.

There are some public domain S.M.A.R.T utilities available that will read and parse the attribute information. However, these utilities are relying on the de facto standard list of attributes and/or often done with some reverse engineering effort. Cactus Technologies® does not recommend using these utilities to read the S.M.A.R.T attributes from our products as it cannot be guaranteed that the data returned by these utilities is correct or accurate.

Cactus Technologies® S.M.A.R.T. attributes vary slightly from product to product. The details of the S.M.A.R.T. attributes are documented in the respective product manuals.

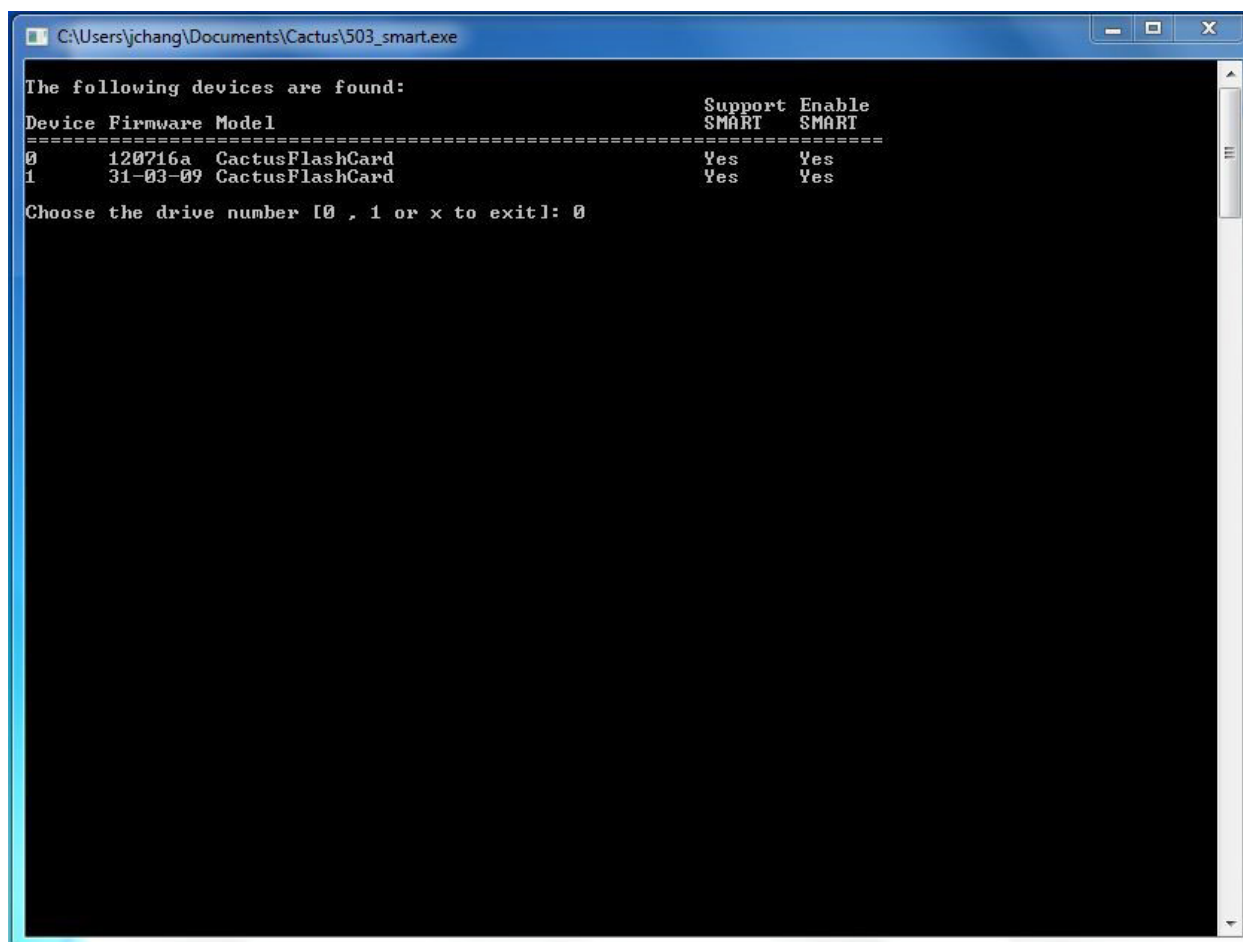
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Cactus Technologies® S.M.A.R.T utility

As there is no standard on S.M.A.R.T. attributes, there are only two ways to accurately retrieve and parse S.M.A.R.T. attributes from Cactus Technologies® products. The first method is for the user to write their own S.M.A.R.T. utility based on information provided in our product manuals. This method is required when the application OS is not Windows or Linux or when the application requires live monitoring. The second method is to use S.M.A.R.T. utility provided by Cactus Technologies®. Currently, this utility is available only as a Win32 application and runs in a Windows Command Prompt environment. A Linux version is in the works and will be available in the near future. Please contact Cactus Technologies® sales to obtain copies for either version. The Cactus Technologies® S.M.A.R.T. utility is a standalone, offline program and is, therefore, not suitable for those applications which requires live monitoring of the S.M.A.R.T. attributes.

This screen shows two Cactus Technologies® products mounted but typically, the user's system will have only one Cactus Technologies® product mounted, which the user can easily identify from the Model information.

When the user runs our S.M.A.R.T. utility, it will automatically detect any supported Cactus Technologies products that are mounted in the system, as shown in the following screen capture:



The user then selects the appropriate device and the utility will proceed to retrieve the S.M.A.R.T. attributes which will be displayed as shown in the following screens:

```

C:\Users\jchang\Documents\Cactus\503_smart.exe
The following devices are found:
Device Firmware Model          Support SMART  Enable SMART
-----
0      120716a  CactusFlashCard             Yes         Yes
1      31-03-09  CactusFlashCard             Yes         Yes

Choose the drive number [0 , 1 or x to exit]: 0
SMART Structure Version: 16
SMART Hyperstone Structure Version: 4
A1 Firmware Commit counter: 0x000030F4
A1 Firmware Wear Level Threshold: 0x00000FFF
Global Wear Leveling Active: 0
Global Bad Block Management Active: 0
Average Flash Block Erase Count: 574
Number of Flash Blocks involved into the Wear Leveling: 3931
Spare Block Count Attribute
- attribute ID                196
- flags                       0x0003
- attribute value             100
- attribute value (worst value) 100
- sum of initial number of spare block of all chip 160
- sum of current number of all spare block of all chip 160
Spare Block Count Worst Chip Attribute
- attribute ID                213
- flags                       0x0002
- attribute value             100
- attribute value (worst value) 100
- Initial number of spare block of chip with least spare 78
- Current number of spare block of chip with least spare 78
Erase Count Attribute
- attribute ID                229
- flags                       0x0002
- attribute value             100
- attribute value (worst value) 100
- estimated total number of block erases 0x00000023D842
Total ECC Errors Attribute
- attribute ID                203
- flags                       0x0002
- attribute value             100
- attribute value (worst value) 100
- total number of ECC errors 0x000014D1
Correctable ECC Errors Attribute
- attribute ID                204
- flags                       0x0002
- attribute value             100
- attribute value (worst value) 100
- total number of correctable ECC errors 0x000014D1

```

```

C:\Users\jchang\Documents\Cactus\503_smart.exe
UDMA CRC Errors Attribute
- attribute ID          199
- flags                0x0002
- attribute value      100
- attribute value (worst value) 100
- total number of UDMA CRC errors 0x00000000
Total Number of Reads Attribute
- attribute ID          232
- flags                0x0002
- attribute value      100
- attribute value (worst value) 100
- total number of flash read commands 0x000114A0FCE2
Power On Count Attribute
- attribute ID          12
- flags                0x0002
- attribute value      100
- attribute value (worst value) 100
- Number of Power On cycle 0x00000020
Total LBAs Written Attribute
- attribute ID          241
- flags                0x0002
- attribute value      100
- attribute value (worst value) 100
- Total number of sectors written to the disk 0x00000001101F0000
Total LBAs Read Attribute
- attribute ID          242
- flags                0x0002
- attribute value      100
- attribute value (worst value) 100
- Total number of sectors read from the disk 0x0000000112470000
Anchor Block Status Attribute
- attribute ID          214
- flags                0x0002
- attribute value      100
- attribute value (worst value) 100
- Anchor Block Write Count 0x00000000
Trim Status Attribute
- attribute ID          215
- flags                0x0002
- attribute value      3
- attribute value (worst value) 1
SMART A1 Read Remap Data
=====
- Chip 0:  initial 78 spare block  current 78 spare block
- Chip 1:  initial 82 spare block  current 82 spare block
Press 'X' to exit ...

```

The user can then exit the utility by pressing “X”.

The most useful attributes are the Spare Block Count and Erase Count attributes. Either one can be used as a predictor of the remaining life left on the storage device.

05 S.M.A.R.T for -203 Series Products

Cactus Technologies® -203 series products were first introduced in 2005 and are still in production today. This product series does not support the ATA S.M.A.R.T Feature Set. However, we can still provide users with information that can allow them to predict end of life of the product. This information is retrieved from the drive using Vendor Specific commands. Cactus Technologies® has written an utility for this purpose. This is an older utility which runs only in a pure DOS environment (not a Windows DOS prompt). If any of our customer is interested in this utility, please contact Cactus Technologies® sales for more information.

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S.M.A.R.T for SD Card Products

SD Cards were originally targeted for consumer markets, where long product life and early failure prediction are not essential features. However, as SD Cards begin to be more widely adopted for use in industrial applications, the need for a S.M.A.R.T like capability becomes apparent. Unfortunately, the SD Association has yet to define a S.M.A.R.T like command in the SD command set.

In light of this shortcoming of SD card products, Cactus Technologies® has worked with our supplier to implement a S.M.A.R.T like feature in our -806 series SD Card products. This feature works by returning S.M.A.R.T like information in the 'Reserved for Vendor' section of the status register, which is retrieved using ACMD13. Essentially, this feature returns information similar to the Spare Block Count attribute in ATA S.M.A.R.T feature. This spare block count information will allow the user to calculate percentage remaining life of the product. Details of the data returned via this status command are documented in the -806 SD Card product manual.

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Summary

In summary, S.M.A.R.T. attributes contain useful information about the health status of the storage device. Cactus Technologies® -303, -503 and -900S series products fully supports the ATA S.M.A.R.T. Feature Set. However, due to the lack of standardization of the S.M.A.R.T. attributes, the only accurate way of retrieving S.M.A.R.T. attributes from our products is to either write your own utility or use the one provided by Cactus Technologies®. In addition, Cactus Technologies® has implemented similar S.M.A.R.T capabilities in our -806 series SD card and -203 series ATA products.

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