



# SMART Storage Products

## **S.M.A.R.T. Attributes**

Technical Reference for  
XceedSecure2, XceedUltraX,  
XceedUltraX2, XceedSecureSB,  
and XceedUltraXSB Drives

Reference Guide

**P/N: 810800015**

**Rev. C**  
[www.smartm.com](http://www.smartm.com)



### **ESD Caution – Handling**

Static electricity may be discharged through this disk subsystem. In extreme cases, this may temporarily interrupt the operation or damage components. To prevent this, make sure you are working in an ESD-safe environment. For example, before handling the disk subsystem, touch a grounded device, such as a computer case, prior to handling.

#### Notice

This manual describes the self-monitoring and reporting technology (S.M.A.R.T.) attributes the specified SMART Modular drives support. SMART Modular Technologies reserves the right to modify, amend or in any way change the contents and/or products described herein, at any time, without notification.

The information contained in this document is provided for reference only. SMART Modular Technologies does not assume any liability arising out of the application or use of the products or features described herein. This document may contain or reference information or products protected by copyrights or patents and does not convey any license under the patent rights of SMART Modular Technologies, nor the rights of others. Errors in this document may be reported in writing to the following address:

### **SMART Modular Technologies (AZ)**

Phoenix Design Center  
4415 E. Cotton Center Blvd.  
Phoenix, AZ 85040  
602-735-0300 voice  
602-735-0349 fax  
fre-sales-phx@smartm.com  
An ISO 9001 certified company.

EraSure® is a registered trademark of SMART Modular Technologies (AZ).

All trademarks are the property of their respective owners.

© 2009 SMART Modular Technologies. All rights reserved.



---

# TABLE OF CONTENTS

<i>CONTENTS</i>	<i>PAGE</i>
<b>1.0 Introduction</b> .....	<b>2</b>
<b>2.0 S.M.A.R.T. Subcommands</b> .....	<b>3</b>
2.1 S.M.A.R.T. Subcommand Registers .....	3
2.2 Output Registers .....	4
<b>3.0 S.M.A.R.T. Attribute Commands</b> .....	<b>4</b>
3.1 Enable/Disable S.M.A.R.T. Operations .....	4
3.2 Return Status .....	5
3.3 Read Data .....	6
3.4 Read Attribute Thresholds .....	8
<b>4.0 Supported Attributes</b> .....	<b>10</b>
4.1 Power-On Time .....	10
4.2 Secure Erase Progress .....	11
4.3 Minimum Spares .....	12
4.4 Temperature .....	13
<b>5.0 Example Using ATADEMO</b> .....	<b>14</b>
<b>6.0 Sales and Technical Support</b> .....	<b>15</b>
6.1 SMART Modular Technologies Headquarters .....	15
6.2 Phoenix Design Center – Sales .....	15
6.3 International .....	15
6.4 United States – Technical Support .....	15

## 1.0 INTRODUCTION

SMART Modular Technologies drives support several self-monitoring analysis and reporting technology (S.M.A.R.T.) subcommands designed to alert you of possible drive problems. With these subcommands, you can retrieve information regarding S.M.A.R.T. attributes, such as the current drive temperature. While SMART Modular Technologies adheres to the ATA Specification for S.M.A.R.T. commands, the attributes are vendor-specific and include the following:

- Power-On Time
- Temperature
- Minimum Spares
- Secure Erase Progress

This document describes how to use S.M.A.R.T. attributes to determine the “health” of the following drives:

- XceedUltraX
- XceedUltraX2
- XceedSecure2
- XceedSecureSB
- XceedUltraXSB

---

**NOTE:** Future firmware versions may support different or additional attributes.

---

To obtain a technical reference for other drives, contact your SMART Modular Technologies sales representative.

## 2.0 S.M.A.R.T. SUBCOMMANDS

As indicated in the ATA Specification, the S.M.A.R.T. Operations command supports several subcommands, including Return Status and Read Data. For the purposes of monitoring drive health, the subcommands described in the following table are used.

**Table 1: S.M.A.R.T. Commands**

Command Name	Function	Page
Enable Operations	Enables S.M.A.R.T. functions on the drive. All other S.M.A.R.T. commands return an ABORT if this command is not issued first.	4
Return Status	Indicates whether or not an attribute value has exceeded the defined threshold. This command simply specifies a threshold was exceeded; it does not identify the specific attribute.	5
Read Data	Returns the current value for each supported attribute.	6
Read Attribute Threshold	Returns the defined threshold value for each supported attribute.	8

The following sections define the command and output registers.

### 2.1 S.M.A.R.T. Subcommand Registers

All S.M.A.R.T. subcommands are issued with the S.M.A.R.T. Operations command (code B0h). The Features register of the S.M.A.R.T. Operations command defines the subcommand, with all other registers set to the values indicated in the following table.

**Table 2: S.M.A.R.T. Command Input Registers**

Register	Bit							
	7	6	5	4	3	2	1	0
Features	Subcommand Code							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	0h			Dev	0h			
Command	B0h							

The drive returns an error if the any of the registers are not set properly (for example, LBA Mid is set to 00h).

## 2.2 Output Registers

When the command succeeds, the drive returns the values indicated in the following table.

**Table 3: Output Register**

Register	Bit							
	7	6	5	4	3	2	1	0
Features	00h							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	0h			Dev	0h			
Status	50h							

If an error occurs, the Status register is set to 51h, and the Error register (the first register) identifies the error that occurred. See the ATA specification for a description of the possible Error bytes.

**NOTE:**

The drive returns an error with the ABRT bit set if the drive receives a S.M.A.R.T. subcommand and S.M.A.R.T. operations are not enabled. See the following section for more information.

If successful, the Read Data and Read Attribute Thresholds subcommands return 512 bytes of data containing the S.M.A.R.T. attribute information. See [page 6](#) and [8](#) for more information.

## 3.0 S.M.A.R.T. ATTRIBUTE COMMANDS

This section describes the S.M.A.R.T. subcommands used to retrieve S.M.A.R.T. attribute data.

### 3.1 Enable/Disable S.M.A.R.T. Operations

**Features:** D8h (Enable); D9h (Disable)

**Use:** Enables S.M.A.R.T. on the drive. Before you can retrieve S.M.A.R.T. data, you must first enable S.M.A.R.T. operations. S.M.A.R.T. operations remain enabled across power cycles. To disable S.M.A.R.T. operations, issue the Disable S.M.A.R.T. Operations subcommand (D9h in the Features register).

**Transfer:** None

**Input:** See the following table for the input registers.

**Table 4: S.M.A.R.T. Enable Operations Registers**

Register	Bit							
	7	6	5	4	3	2	1	0
Features	D8h (Enable) or D9h (Disable)							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	0h			Dev	0h			
Command	B0h							

## 3.2 Return Status

**Features:** DAh

**Use:** Indicates the current status of the supported S.M.A.R.T. attributes. If the drive returns 4Fh in the LBA Mid and C2h in the LBA High registers, the attribute values are below the specified threshold. If the LBA Mid and LBA High registers contain F4h and 2Ch (that is, the nibbles are reversed), one or more of the attributes exceeded the defined threshold level.

**Transfer:** None

**Input:** See the following table for the input registers.

**Table 5: S.M.A.R.T. Return Status Registers**

Register	Bit							
	7	6	5	4	3	2	1	0
Features	DAh							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	0h			Dev	0h			
Command	B0h							

**NOTE:**

If the Return Status subcommand indicates one of the attribute thresholds was exceeded, SMART strongly recommends issuing the Read Data subcommand to identify the attribute. Because the drives support several attributes, it is important to identify the specific attribute that exceeded the threshold.

### 3.3 Read Data

**Features:** D0h

**Use:** Returns 512 bytes of information specific to each supported S.M.A.R.T. attribute.

**Transfer:** PIO Data-In

**Input:** See the following table for the input registers.

**Table 6: S.M.A.R.T. Read Data Registers**

Register	Bit							
	7	6	5	4	3	2	1	0
Features	D0h							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	0h			Dev	0h			
Command	B0h							

**Output:** Each offset defines the specific attribute and the associated raw data. See the following table for the byte values (in hexadecimal format) and [Figure 1](#) for an example of the data.

**Table 7: Read Data Bytes**

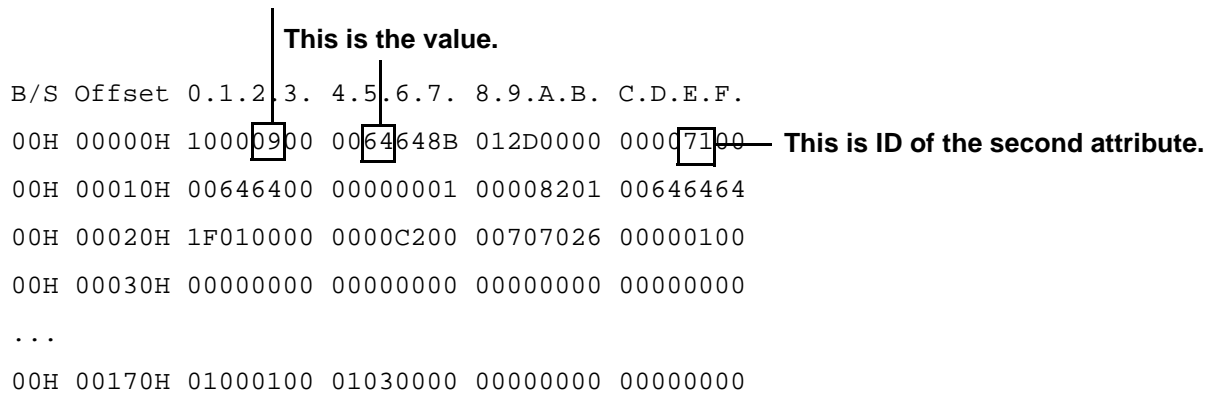
Byte(s)	Data		Comments
	Field Size	Content	
000...001	1 Word	Revision	Vendor-specific
002...013	12 Bytes Each	1 <sup>st</sup> Attribute	Attribute Layout (Each) Byte 0 = ID Number Byte 1 = Status Byte 2 = Reserved Byte 3 = Value Bytes 4-11 = Raw Data
014...025	12 Bytes Each	2 <sup>nd</sup> Attribute	
026...037	12 Bytes Each	3 <sup>rd</sup> Attribute	
...	...	...	
350...361	12 Bytes Each	30 <sup>th</sup> Attribute	
362	Byte	Offline Collection Status	
363	Byte	Self-Test Execution Status	
364...365	Word	Offline Time Remaining	
366	Byte	Reserved	
367	Byte	Offline Collection Capability	
368...369	Word	SMART Capability	
370	Byte	Error Logging Capability	
371	Byte	Reserved	
372	Byte	Short Test Polling Time	

Table 7: Read Data Bytes (Continued)

Byte(s)	Data		Comments
	Field Size	Content	
373	Byte	Extended Test Polling Time	
374...385	12 Bytes	Reserved	Zero
386...509	124 Bytes	Vendor-Specific Reserved	Zero
510	1 Byte	Reserved	Zero
511	1 Byte	Checksum	Total of Previous 511 Bytes

FIGURE 1: Read Data Bytes

This is ID of the first attribute.



The drive returns 12 bytes of data for each attribute, as indicated in Table 6: S.M.A.R.T. Read Data Registers. For attribute details, see page 10.

### 3.4 Read Attribute Thresholds

**Features:** D1h

**Use:** Returns 512 bytes of information specific to each supported S.M.A.R.T. attribute.

**Transfer:** PIO Data-In

**Input:** See the following table for the input registers.

**Table 8: S.M.A.R.T. Read Attribute Thresholds Registers**

Register	Bit							
	7	6	5	4	3	2	1	0
Features	D1h							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	0h			Dev	0h			
Command	B0h							

**Output:** Like the Read Data subcommand, the Read Attribute Thresholds subcommand returns 512 bytes of data. However, the data specifies only the attribute ID and threshold value for each attribute. All other attribute-specific bytes are set to 00h (see the following table).

**Table 9: Read Data Attribute Thresholds Bytes**

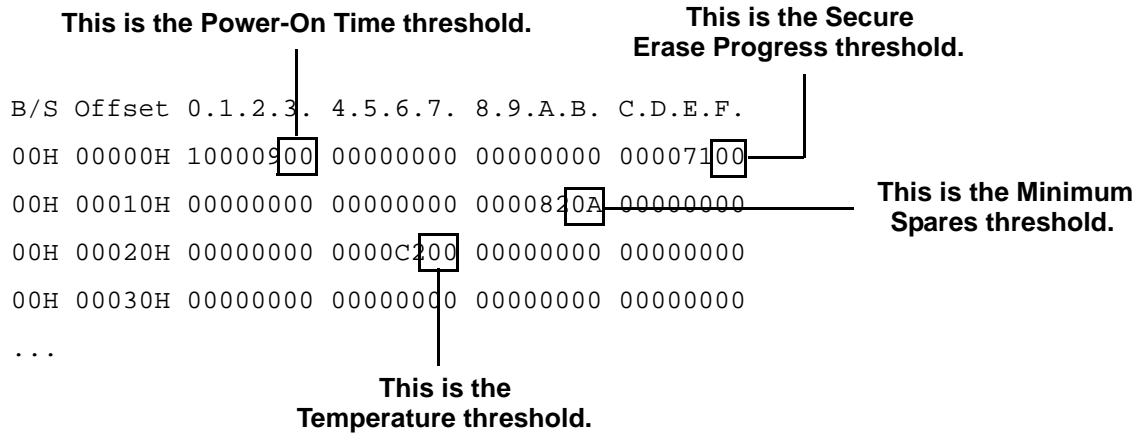
Byte(s)	Data		Comments
	Field Size	Content	
000...001	1 Word	Revision	Vendor-specific
002...013	12 Bytes Each	1 <sup>st</sup> Attribute	Attribute Layout (Each) Byte 0 = Attribute ID Byte 1 = Threshold Bytes 2-11 = 00h
014...025	12 Bytes Each	2 <sup>nd</sup> Attribute	
026...037	12 Bytes Each	3 <sup>rd</sup> Attribute	
...	...	...	
350...361	12 Bytes Each	30 <sup>th</sup> Attribute	
362	Byte	Offline Collection Status	
363	Byte	Self-Test Execution Status	
364...365	Word	Offline Time Remaining	
366	Byte	Reserved	
367	Byte	Offline Collection Capability	
368...369	Word	SMART Capability	
370	Byte	Error Logging Capability	
371	Byte	Reserved	
372	Byte	Short Test Polling Time	

**Table 9: Read Data Attribute Thresholds Bytes (Continued)**

Byte(s)	Data		Comments
	Field Size	Content	
373	Byte	Extended Test Polling Time	
374...385	12 Bytes	Reserved	Zero
386...509	124 Bytes	Vendor-Specific Reserved	Zero
510	1 Byte	Reserved	Zero
511	1 Byte	Checksum	Total of Previous 511 Bytes

If the threshold value for an attribute is 00h, the drive does not examine the attribute value when determining whether or not a threshold was exceeded for the Return Status subcommand. For example, based on the bytes in the following figure, the drive indicates a threshold was exceeded for the Return Status command only if the Secure Erase Progress and/or Minimum Spares attribute value exceeds the indicated threshold (C0h and 0Ah, respectively). The drive does not report an exceeded threshold based on the Power-On Time or Temperature attribute.

**FIGURE 2: Read Attribute Thresholds Bytes**



## 4.0 SUPPORTED ATTRIBUTES

### 4.1 Power-On Time

**Attribute ID:** 09h (09 decimal)

**Threshold:** None

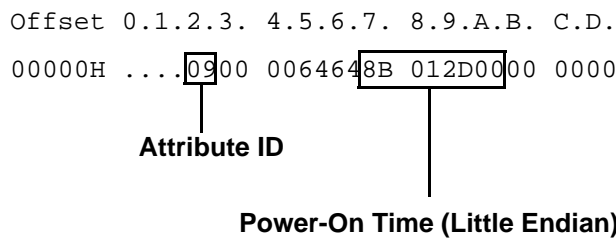
**Description:** The Power-On Time attribute indicates the total number of seconds the drive has been operational. This timer starts when the drive is manufactured in production and continues whenever the drive is powered on. See the following table for the byte definitions.

**Table 10: Powered-On Time**

Byte(s)	Value	Indication
0	09h	This is the attribute ID (9 decimal).
1-2	00h	These two bytes are always 00h.
3	64h	Each of these bytes is set to a constant value, which is always 64h (100 decimal).
4	64h	
5-8	Variable	These bytes are little endian and indicate the total number of seconds the drive has been operational.
9-11	00h	These bytes are set to a constant value, which is always 00h.

**Example:** Using the data in [Figure 1](#), attribute 9 is the first attribute (offsets 2h through Dh). The bytes indicating the power-on time are 0x8B012D00, as shown in the following figure. Because the bytes are little endian, the value is 0x002D018B, which equates to 2,949,515 seconds, or 819 hours.

**FIGURE 3:** Power-On Time Example



**NOTE:**

“Little endian” means the least-significant byte is the first byte, and the most-significant byte is the last byte. For example, in [Figure 3](#), the most-significant byte value is 00h, and the least-significant byte value is 8Bh.

## 4.2 Secure Erase Progress

**Attribute ID:** 71h (113 decimal)

**Threshold:** C0h (192 decimal)

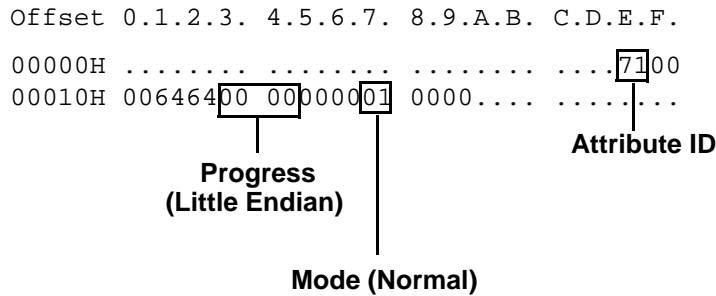
**Description:** The Secure Erase Progress attribute displays the progress of a secure erase operation, if the drive supports EraSure and is currently executing a secure erase sequence. For drives that do not support EraSure or that are not in the process of erasing the drive, this attribute returns zeros as the progress indicator. See the following table for the byte definitions.

**Table 11: Secure Erase Progress**

Byte(s)	Value	Indication
0	71h	This is the attribute ID (113 decimal).
1-2	00h	These two bytes are always 00h for this attribute.
3	64h	Each of these bytes is set to a constant value, which is always 64h (100 decimal).
4	64h	
5-6	Variable	These bytes indicate the progress of the operation and are little endian. The values also differ depending on the mode. For Normal, Checking, and Initializing modes, these bytes are set to zero. For Erasing mode, the bytes increase from 0000h (the operation just started) to FFFFh (the operation is finished).
7	Variable	This byte indicates the index number of the current secure erase function.
8	Variable	This byte identifies the secure erase sequence currently running. Possible values include: 00h = Clear 01h = DoD NISPOM 5220.22-M 02h = DoD NISPOM 5220.22-M Sup 1 03h = NSA/CSS 130-2 04h = Army AR 380-19 05h = Navy NAVSO P-5239-26 06h = Air Force AFSSI-5020 07h = RCC-TG IRIG 106-07 08h = Fast Clear and Initialize Drive 09h = NSA/CSS 9-12 80h = Preselect 81h = Custom
9	Variable	This byte indicates the current secure erase mode. Possible values include: 01h = Normal 02h = Erasing 03h = Checking
10-11	00h	These two bytes are currently reserved and are set to 00h.

**Example:** Using the data in Figure 1, attribute 71h is the second attribute (offsets Eh through 19h). The bytes indicate the drive is in Normal mode and is not executing a sequence, as shown in the following figure.

**FIGURE 4:** Secure Erase Progress Example



**NOTE:** It is important to understand that the progress bytes are little endian. If the drive returns FF00 as the progress indicator, the operation is less than 1% complete (00FF/FFFF); not 99% complete (FF00/FFFF).

### 4.3 Minimum Spares

**Attribute ID:** 82h (130 decimal)

**Threshold:** 0A (10 decimal)

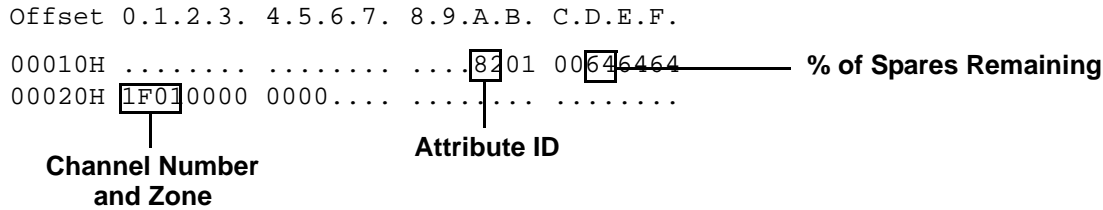
**Description:** The Minimum Spares attribute reports the number of spare blocks remaining as a percentage of the total spare blocks in the worst wear-leveling zone. See the following table for the byte definitions.

**Table 12: Minimum Spares**

Byte(s)	Value	Indication
0	82h	This is the attribute ID (130 decimal).
1-2	0100h	These bytes are always set to 0100h for this attribute.
3	Variable	Each of these bytes is set to the current attribute value, which is the number of spare blocks remaining as a percentage of the total spare blocks in the worst wear-leveling zone. Valid values are 01h to 64h (1-100 decimal).
4		
5	Variable	This byte is also set to the value, but the range is 00h to 64h (0-100 decimal).
6	Variable	This byte specifies the channel number containing the worst leveling zone. The valid range is 00h to 1Fh (0 to 31 decimal).
7	Variable	This byte returns the number of the wear-leveling zone with the fewest spares remaining. The valid range is 0 to N-1, where N is the number of wear-leveling zones for the channel.
8-11	00h	These bytes are set to a constant value, which is always 00h.

**Example:** Using the data in Figure 1, attribute 82 is the third attribute (offsets 1Ah through 25h). Based on the returned data, the drive has 100% of its spares remaining (64h = 100) in the worst wear-leveling zone, which is zone 01 on channel 31 (1Fh = 31), as shown in the following figure.

**FIGURE 5:** Minimum Spares Example



### 4.4 Temperature

**Attribute ID:** C2h (194 decimal)

**Threshold:** None

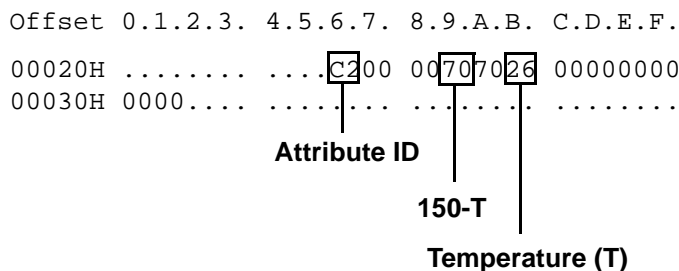
**Description:** The Temperature attribute indicates the current drive temperature in degrees Celsius. See the following table for the byte definitions.

**Table 13: Temperature**

Byte(s)	Value	Indication
0	C2h	This is the attribute ID (194 decimal).
1-2	00h	These bytes are always set to 0h for this attribute.
3	Variable	Each of these bytes is set to the current attribute value, which is 150-T where T is the current temperature in degrees Celsius. Valid values are 19h to CDh (25 to 205 decimal).
4		
5	Variable	This byte indicates the current temperature in degrees Celsius. Valid values are C9h to 7Dh (-55 to 125).
6-11	00h	These bytes are set to a constant value, which is always 00h.

**Example:** Based on the data in Figure 1, attribute C2 is the fourth attribute (offsets 26h through 31h). The bytes indicate the drive temperature is 26h, or 38°C, as shown in the following figure.

**FIGURE 6:** Temperature Example



## 5.0 EXAMPLE USING ATADEMO

This section provides an example of issuing the S.M.A.R.T. subcommands and attributes using ATADEMO. ATADEMO sends vendor-specific ATA commands to the drive to enable S.M.A.R.T. operations. For a copy of the ATADEMO test program, visit <http://www.ata-atapi.com/atademo.html>. Before using the ATADEMO program, SMART Modular Technologies recommends you download and review the User Guide.

### To issue S.M.A.R.T. subcommands in ATADEMO:

1. Start ATADEMO, entering the correct bus, device, drive, and host adapter information to communicate with the drive.
2. Type `ndx 0xD8 0x00 0x00 0x4F 0xC2 0x01 0xB0` and press **ENTER** to enable S.M.A.R.T. operations.
3. Type `ndx 0xDA 0x00 0x00 0x4F 0xC2 0x01 0xB0` and press **ENTER** to view the current status of the S.M.A.R.T. attributes.
4. Type `showcb` and press **ENTER** to view the command block and verify the LBA Mid and LBA High registers contain 0x4F and 0xC2, respectively. If the nibbles are reversed, one or more of the S.M.A.R.T. attributes exceeded the threshold.
5. Type `fillz` and press **ENTER** to fill the buffer with zeroes.

**NOTE:**

Although filling the buffer with zeroes is not required, it is recommended that you first fill the buffer to ensure you are receiving updated data.

6. Type `pdix 0xD1 0x00 0x00 0x4F 0xC2 0x01 0xB0 1` and press **ENTER** to retrieve the S.M.A.R.T. attribute threshold values.
7. Type `dump` and press **ENTER** to view all 512 bytes.
8. Type `fillz` and press **ENTER** to fill the buffer with zeroes.
9. Type `pdix 0xD0 0x00 0x00 0x4F 0xC2 0x01 0xB0 1` and press **ENTER** to retrieve the S.M.A.R.T. data.
10. Type `dump` and press **ENTER** to view all 512 bytes.

## 6.0 SALES AND TECHNICAL SUPPORT

Contact SMART Modular Technologies for technical support, application questions, data sheets, and documentation. Normal business hours are Monday through Friday, 8am to 5pm, MST. Please note that Arizona does not observe Daylight Savings Time.

### 6.1 SMART Modular Technologies Headquarters

SMART Modular Technologies  
P. O. Box 1757  
Fremont, CA 94538  
Tel: (510) 623-1231  
Fax: (510) 623-1434  
E-mail: [fre-info-phx@smartm.com](mailto:fre-info-phx@smartm.com)  
Web: <http://www.smartm.com>

### 6.2 Phoenix Design Center – Sales

SMART Modular Technologies (AZ)  
4415 E. Cotton Center Blvd.  
Phoenix, AZ 85040  
Tel: 602-735-0300  
Fax: 602-735-0349  
E-mail: [fre-sales-phx@smartm.com](mailto:fre-sales-phx@smartm.com)

### 6.3 International

Phoenix, AZ  
Tel: 602-735-0300  
Fax: 602-735-0349  
E-mail: [fre-international-phx@smartm.com](mailto:fre-international-phx@smartm.com)

### 6.4 United States – Technical Support

Tel: 602-735-0300  
Fax: 602-735-0349  
E-mail: [fre-techsupport-phx@smartm.com](mailto:fre-techsupport-phx@smartm.com)  
Web: <http://www.adtron.com/support>

