



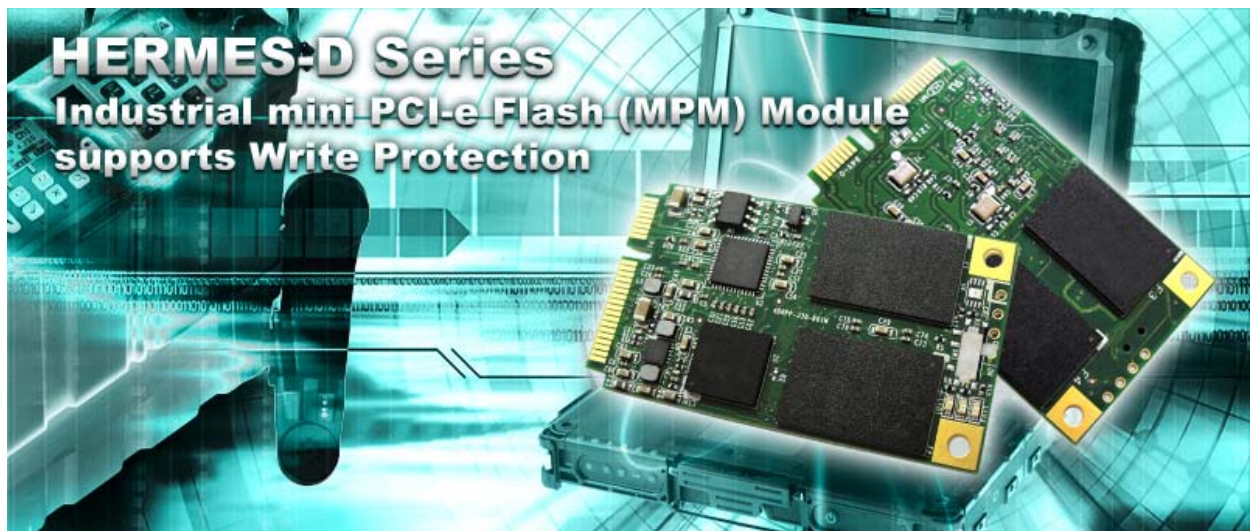
August 2012

Product Specification

Industrial mini PCI-e Module (MPM) supports Write Protect Function

-HERMES-D Series-

Doc-No: 100-xBMPM-JDSL-1V0



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Revision History

Revision	Description	Date
1.0	Initial Release	2012/8/13

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1. Introduction

APRO Industrial mini PCI-e Flash (MPM) Module is a Solid State Disk on Module which works for mini PCI Express host interface. This product is compliant with PCI Express Generation 1.0 Specification; with PCI Express x1 lane bandwidth for high speed data transfer. Compare with conventional compact form factor flash memory drive, APRO mini PCI-e Flash Module adopts 4-channel flash technology to access data to and from flash memory chips simultaneously to perform a very high speed of data transfer rate. Since Data Program/Erase always damage flash memory cells, APRO mini PCI-e Module levels the unavoidable wear of flash memory with Static Wear Leveling to reach a longer drive lifespan. With hardware error collection, APRO mini PCI-e Module can collect 12 random bits for each 512 byte data sector depends on the spare area of flash memory.

The available disk capacities are 2GB, 4GB, 8GB, 16GB, 32GB and 64GB SLC Flash memory. The operating temperature grade is optional for commercial grade 0°C ~ 70°C and Industrial grade -40°C ~ +85°C. The data transfer performance by sequential read is up to 140.0 MB/sec, and sequential write is up to 122.0 MB/sec.

Figure 1 shows a block diagram of the used high tech Industrial mini PCI-e Flash (MPM) Module controller.

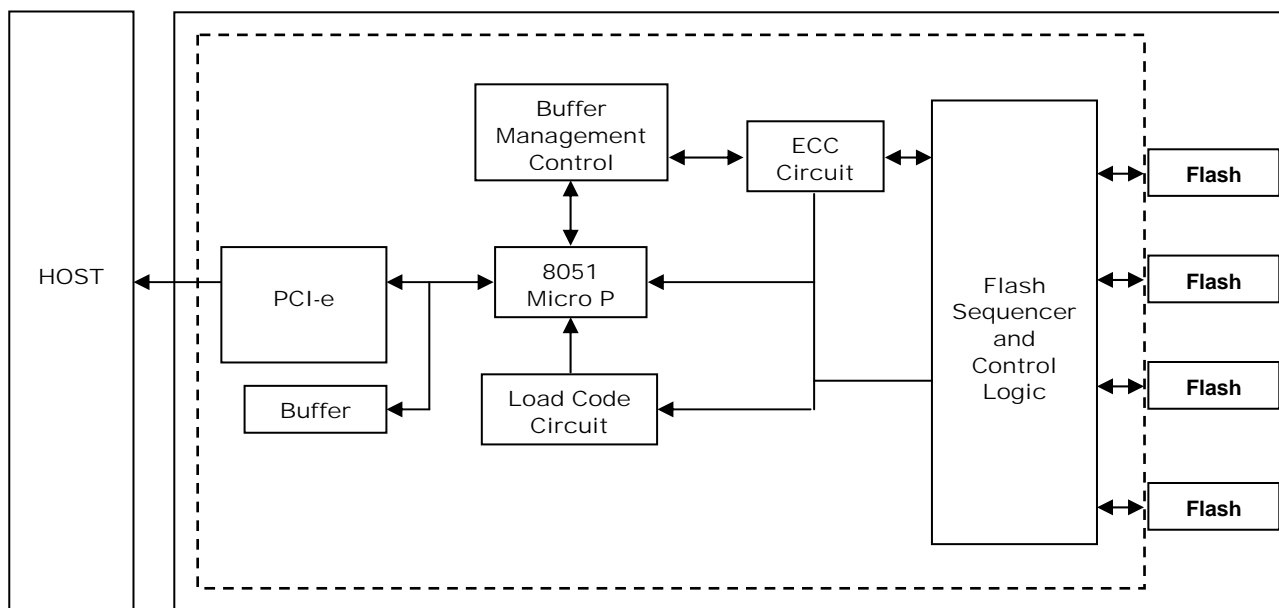


Figure 1: Industrial mini PCI-e Flash Module - HERMES-D Series controller block diagram

1.1. Scope

This document describes the features and specifications and installation guide of APRO's Industrial mini PCI-e Flash (MPM) Module – HERMES-D Series. In the appendix, there provides order information, warranty policy, and RMA procedure for the most convenient reference.

1.2. **System Features**

- SLC-NAND type flash technology
- Compliant with PCI Express generation 1.0
- Compact form factor for highly integrated system
- Supports standard ATA command
- Supports write protect function by switch
- Supports high speed PCI Express host bus to 2.5Gbps
- Bootable for system installation (**BIOS PCI-Express Bootable support needed**)
- Static wear-leveling algorithms
- Large memory capacity for heavy data access and storage
- Standard grade capacity from 2GB up to 64GB
- Industrial grade capacity from 2GB up to 64GB
- Performance up to 140.0 MB/sec
- Automatic 12 bits Error Correcting Code (ECC) error correction and retry capabilities
- +3.3V \pm 5% operation
- MTBF > 4,000,000 hours
- Vibration : 15 G, compliance to MIL-STD 810G
- Shock : 1500 G, compliance to MIL-STD 810G
- Altitude: 70,000 feet
- Working well in critical environment
- Very high performance, very low power consumption
- Low weight, Noiseless

1.3. **Flash Management Technology - Static Wear Leveling**

In order to gain the best management for flash memory, APRO Industrial Mini PIC-e Module – HERMES-D Series supports static wear -leveling technology to manage the Flash system. The life of flash memory is limited; the management is to increase the life of the flash product.

A static wear-leveling algorithm evenly distributes data over an entire Flash cell array and searches for the least used physical blocks. The identified low cycled sectors are used to write the data to those locations. If blocks are empty, the write occurs normally. If blocks contain static data, it moves that data to a more heavily used location before it moves the newly written data. The static wear leveling maximizes effective endurance Flash array compared to no wear leveling or dynamic wear leveling.

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

2.1.1. Temperature

Table 1: Environmental Specification

APRO SLC Mini PCI-e Module supports Write Protect Function HERMES-D Series		Commercial Grade	Industrial Grade
		SBMPM0xxG-JDCSC	WBMPM0xxG-JDISI
Temperature	Operating:	0°C ~ +70°C	-40°C ~ +85°C
	Non-operating:	-20°C ~ +80°C	-50°C ~ +95°C
Humidity	Operating & Non-operating:	10% ~ 95% non-condensing	
Vibration	Operating & Non-operating:	15G, compliance to MIL-STD-810G	
Shock	Operating & Non-operating:	1,500G, compliance to MIL-STD-810G	
Altitude	Operating & Non-operating:	70,000 feet	

2.2. System Power Requirements

Table 2: Power Requirement

APRO SLC Mini PCI-e Module supports Write Protect Function HERMES-D Series		Standard Grade	Industrial Grade
		SBMPM0xxG-JDCSC	WBMPM0xxG-JDISI
DC Input Voltage (VCC)		3.3V ± 5%	
3.3V Current (Maximum average value)	Reading Mode :	226 mA (max.)	
	Writing Mode :	325 mA (max.)	
	Idle Mode :	128 mA (max.)	

2.3. System Performance

Table 3: System Performances

Flash IC		Samsung SLC Flash IC					
Data Transfer Mode supporting		- PIO mode : 0, 1, 2, 3, 4 - MWDMA mode : 0,1 and 2 UDMA mode: 0, 1, 2, 3, 4, 5, 6					
Maximum Performance	Capacity	2GB	4GB	8GB	16GB	32GB	64GB
	Sequential Read (MB/s)	62.8	65.4	128.8	136.7	138.2	140.00
	Sequential Write (MB/s)	34.4	36.3	74.8	118.8	120.2	122.00
Maximum QD 32	4K Random Read (MB/s)	15.7	16.0	16.6	16.4	16.8	17.1
	4K Random Write (MB/s)	0.5	0.7	2.1	1.6	2.2	2.5
Random Access Time		0.2	0.2	0.2	0.2	0.2	0.2
The number of Flash IC		1	2	4	4	4	4

2.4. System Reliability

Table 4: System Reliability

MTBF	>4,000,000 hours
Wear-leveling Algorithms	Static Wear Leveling
Bad Blocks Management	Supportive
ECC Technology	12 bits per 512 bytes Error Connection Code
Endurance	Greater than 2,000,000 cycles Logically contributed by Wear-leveling and advanced bad sector management
Data Retention	10 years

2.5. Physical Specifications

Refer to Table 5 and see Figure 2 for Industrial mini PCI-e Flash (MPM) Module - HERMES-D Series physical specifications and dimensions.

Table 5: Physical Specifications

Length:	51.00 ± 1 mm / 2.00 in
Width:	30.00 ± 1 mm / 1.18 in
Thickness:	3.5 ± 1 mm / 0.13 in
Weight:	8 ± 1 g / 0.3 oz

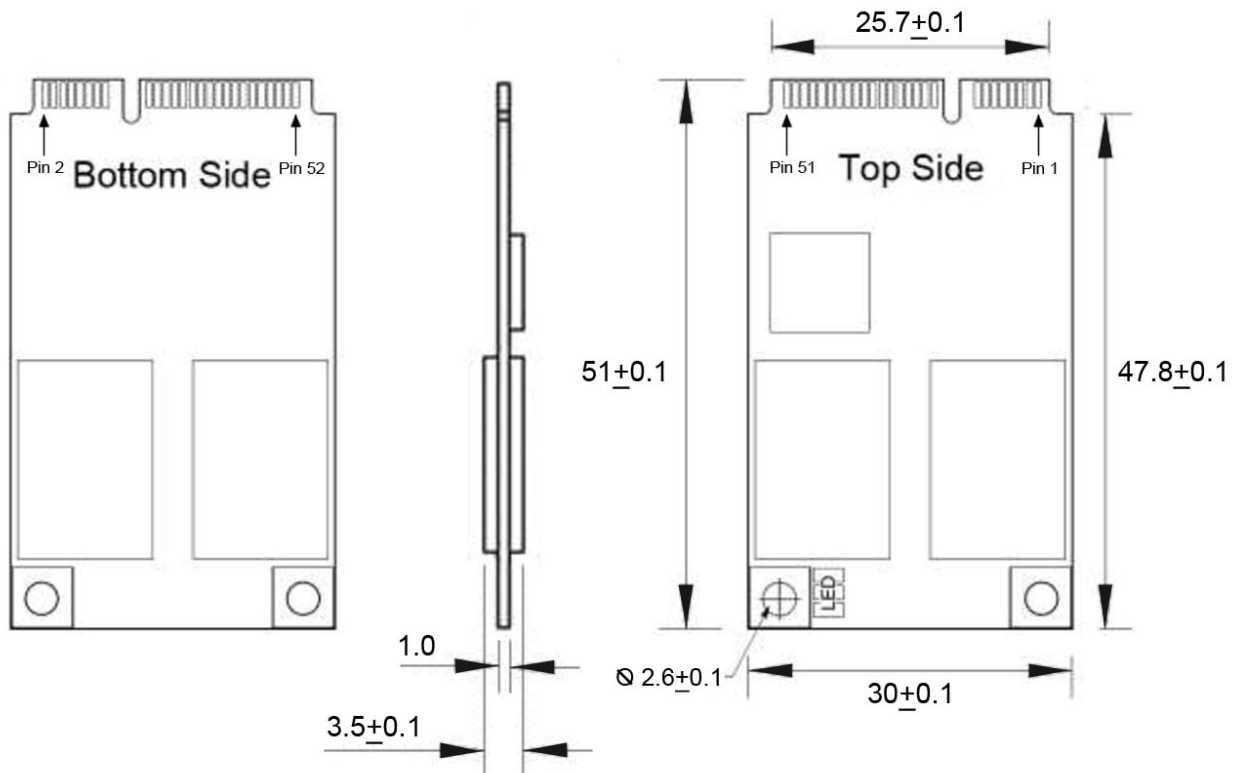


Figure 2: mini PCI-e Flash (MPM) Module Dimension

2.6. Conformal coating

Conformal coating is a protective, dielectric coating designed to conform to the surface of an assembled printed circuit board. Commonly used conformal coatings include silicone, acrylic, urethane and epoxy. APRO applies only silicone on APRO storage products upon request especially by customers. The type of silicone coating features good thermal shock resistance due to flexibility. It is also easy to apply and repair.

Conformal coating offers protection of circuitry from moisture, fungus, dust and corrosion caused by extreme environments. It also prevents damage from those Flash storage products handling during construction, installation and use, and reduces mechanical stress on components and protects from thermal shock. The greatest advantage of conformal coating is to allow greater component density due to increased dielectric strength between conductors.

APRO uses MIL-I-46058C silicon conformal coating.

2.7. Capacity Specifications

APRO Industrial mini PCI-e Flash (MPM) Module has built-in TOSHIBA SLC -NAND Type Flash memory chips. The table 6 shows the specific capacity for the various models and the default number of heads, sectors/track and cylinders.

Table 6: Device Parameters

Unformatted Capacity	Default Cylinder	Default Head	Default Sector	LBA
2GB	3,897	16	63	3,928,176
4GB	7,773	16	63	7,835,184
8GB	15,525	16	63	15,649,200
16GB	16,383	16	63	31,277,232
32GB	16,383	16	63	62,533,296
64GB	16,383	16	63	125,045,424

3. Interface Description

3.1. Pin Assignments

The pin assignments are listed in below table 7.

Table 7: Pin Assignments

Mechanical Key			
Pin #	Name	Type	Description
1	Reserved	-	Reserved - DC power supply.
2	3.3V	P	Power - DC power supply.
3	Reserved	-	Reserved - DC power supply.
4	GND	P	Power - DC power supply.
5	Reserved	-	Reserved - DC power supply.
6	Reserved	-	Power - DC power supply.
7	GND	P	Power - DC power supply.
8	Reserved	-	Reserved - DC power supply.
9	GND	P	Power - DC power supply.
10	Reserved	-	Reserved - DC power supply.
11	REFCLK-	A _{DIFF}	Analog differential - Signal pair for the twisted-pair interface.
12	Reserved	-	Reserved - DC power supply.
13	REFCLK+	A _{DIFF}	Analog differential - Signal pair for the twisted-pair interface.
14	Reserved	-	Reserved - DC power supply.
15	GND	P	Power - DC power supply.
16	Reserved	-	Reserved - DC power supply.
17	Reserved	-	Reserved - DC power supply.
18	GND	P	Power - DC power supply.
19	Reserved	-	Reserved - DC power supply.
20	Reserved	-	Reserved - DC power supply.
21	GND	P	Power - DC power supply.
22	PERST#	I	Input - Standard input-only signal.
23	PERn0	A _{DIFF}	Analog differential - Signal pair for the twisted-pair interface.
24	+3.3Vaux	P	Power - DC power supply.
25	PERp0	A _{DIFF}	Analog differential - Signal pair for the twisted-pair interface.

26	GND	P	Power - DC power supply.
27	GND	P	Power - DC power supply.
28	Reserved	-	Reserved - DC power supply.
29	GND	P	Power - DC power supply.
30	Reserved	-	Reserved - DC power supply.
31	PETn0	A _{DIFF}	Analog differential - Signal pair for the twisted-pair interface.
32	Reserved	-	Reserved - DC power supply.
33	PETp0	A _{DIFF}	Analog differential - Signal pair for the twisted-pair interface.
34	GND	P	Power - DC power supply.
35	GND	P	Power - DC power supply.
36	Reserved	-	Reserved - DC power supply.
37	GND	P	Power - DC power supply.
38	Reserved	-	Reserved - DC power supply.
39	+3.3Vaux	P	Power - DC power supply.
40	GND	P	Power - DC power supply.
41	+3.3Vaux	P	Power - DC power supply.
42	Reserved	-	Reserved - DC power supply.
43	GND	P	Power - DC power supply.
44	Reserved	-	Reserved - DC power supply.
45	Reserved	-	Reserved - DC power supply.
46	Reserved	-	Reserved - DC power supply.
47	Reserved	-	Reserved - DC power supply.
48	Reserved	-	Reserved - DC power supply.
49	Reserved	-	Reserved - DC power supply.
50	GND	P	Power - DC power supply.
51	Reserved	-	Reserved - DC power supply.
52	3.3V	P	Power - DC power supply.

Notes:

PETp0 / PETn0 : PCI Express transmitter differential pair

PERp0 / PERn0 : PCI Express receiver differential pair

REFCLK+ / REFCLK- : PCI Express differential clock

PERST# : PCI Express reset

CLKREQ# : Clock request to host

GND : Ground

4. Functional Description

4.1. ATA Commands

The commands supported ATA/ATAPI-7 commands; certain obsolesced commands are also supported. The supported commands are listed in Table 8.

Table 8: ATA Commands Supported

Command Name	Code	PARAMETERS USED					
		SC	SN	CY	DR	HD	FT
CHECK POWER MODE	E5h	O	X	X	O	X	X
DEVICE CONFIGURATION OVERLAY	B1h	X	X	X	O	X	O
EXECUTE DIAGNOSTICS	90h	X	X	X	O	X	X
FLUSH CACHE	E7h	X	X	X	O	X	X
FLUSH CACHE EXT	EAh	X	X	X	O	X	X
IDENTIFY DEVICE	ECh	X	X	X	O	X	X
IDLE	E3h	O	X	X	O	X	X
IDLE IMMEDIATE	E1h	X	X	X	O	X	X
NOP	00h	F	F	F	O	X	O
INITIALIZE DEVICE PARAMETERS	91h	O	X	X	O	O	X
READ BUFFER	E4h	X	X	X	O	X	X
READ DMA	C8h or C9h	O	O	O	O	O	X
READ DMA EXT	25h	O	O	O	O	O	X
READ FPDMA QUEUED	60h	O	O	O	O	O	O
READ LOG EXT	2Fh	O	O	O	O	O	O
READ MULTIPLE	C4h	O	O	O	O	O	X
READ MULTIPLE EXT	29h	O	O	O	O	O	X
READ NATIVE MAX ADDRESS	F8h	X	X	X	O	X	X
READ NATIVE MAX ADDRESS EXT	27h	X	X	X	O	X	X
READ SECTOR(S)	20h or 21h	O	O	O	O	O	X
READ SECTOR(S) EXT	24h	O	O	O	O	O	X
READ VERIFY SECTOR(S)	40h or 41h	O	O	O	O	O	X
READ VERIFY SECTOR(S) EXT	42h	O	O	O	O	O	X
RECALIBRATE	10h	X	X	X	O	X	X
SECURITY DISABLE PASSWORD	F6h	X	X	X	O	X	X
SECURITY ERASE PREPARE	F3h	X	X	X	O	X	X
SECURITY ERASE UNIT	F4h	X	X	X	O	X	X
SECURITY FREEZE LOCK	F5h	X	X	X	O	X	X
SECURITY SET PASSWORD	F1h	X	X	X	O	X	X
SECURITY UNLOCK	F2h	X	X	X	O	X	X
SEEK	7xh	X	X	O	O	O	X
SET FEATURES	EFh	O	X	X	O	X	O
SET MAX	F9h	O	O	O	O	O	O
SET MAX ADDRESS EXT	37h	O	O	O	O	O	X

SET MULTIPLE MODE	C6h	O	X	X	O	X	X
SLEEP	E6h	X	X	X	O	X	X
SMART	B0h	X	X	O	O	X	O
STANDBY	E2h	X	X	X	O	X	X
STANDBY IMMEDIATE	E0h	X	X	X	O	X	X
WRITE BUFFER	E8h	X	X	X	O	X	X
WRITE DMA	CAh or CBh	O	O	O	O	O	X
WRITE DMA EXT	35h	O	O	O	O	O	X
WRITE DMA FUA EXT	3Dh	O	O	O	O	O	X
WRITE FPDMA QUEUED	61h	O	O	O	O	O	O
WRITE LOG EXT	3Fh	O	O	O	O	O	X
WRITE MULTIPLE	C5h	O	O	O	O	O	X
WRITE MULTIPLE EXT	39h	O	O	O	O	O	X
WRITE MULTIPLE FUA EXT	CEh	O	O	O	O	O	X
WRITE SECTOR(S)	30h or 31h	O	O	O	O	O	X
WRITE SECTOR(S) EXT	34h	O	O	O	O	O	X
WRITE VERIFY	3Ch	O	O	O	O	O	O

Note:

O = Valid, X = Don't care

SC = Sector Count Register

SN = Sector Number Register

CY = Cylinder Low/High Register

DR = DEVICE SELECT Bit (DEVICE/HEAD Register Bit 4)

HD = HEAD SELECT Bit (DEVICE/HEAD Register Bit 3-0)

FT = Features Register

4.1. ATA Command Specification

4.1.1. Check Power Mode (E5h)

Features	- This command is mandatory for devices. - This command is mandatory when the Power Management feature set is implemented.
Protocol	Non-data command

Check power mode command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	Obs	DEV	Na	Na	Na	Na
Command	E5h							

Device register:

DEV shall specify the selected device.

5. Identify Device (ECh)

Features	-Mandatory for all devices. -Devices implementing the PACKET Command feature set
Protocol	PIO data-in

Identify device command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	Obs	DEV	Na	Na	Na	Na
Command	ECh							

Device register:

DEV shall specify the selected device.

Identify device command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description - The IDENTIFY DEVICE command enables the host to receive parameter information from the device. When the command is issued, the device sets the BSY bit to one, prepares to transfer the 256 words of device identification data to the host, sets the DRQ bit to one, clears the BSY bit to zero, and asserts INTRQ if nIEN is cleared to zero. The host may then transfer the data by reading the Data register. In Table of Check power mode command for inputs information, which defines the arrangement and meaning of the parameter words in the buffer. All reserved bits or words shall be zero. Some parameters are defined as a 16-bit value. A word that is defined as a 16-bit value places the most significant bit of the value on signal line DD15 and the least significant bit on signal line DD0.

Some parameters are defined as 32-bit values (e.g. words (61:60)). Such fields are transfer using two successive word transfers. The device will first transfer the least significant bits, bits (15:0) of the value, on signal lines DD(15:0) respectively. After the least significant bits have been transferred, the most significant bits, bits(31:16) of the value, shall be transferred on DD(15:0) respectively. Some parameters are defined as a string of ASCII characters.

Device 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.

5.1. Identify Device Information Default Value

Table 9: Identify Device command parameters

Word	Value	F/V	Description
0	0040h	F	General configuration
		X	15 0 = ATA device
		X	14-8 Retired
		X	7-6 Obsolete
		X	5-3 Retired
		V	2 Response incomplete
		X	1 Retired
			0 Reserved
1	XXXXh	F	Number of logical cylinders
2	C837h	V	Specific configuration
3	0010h	F	Number of logical heads
4-5	0000h	X	Retired
6	003Fh	F	Number of logical sector per logical track
7-8	0000h		Reserved for assignment by the CompactFlash_ Association
9	0000h	X	Retired
10-19	XXXXh	F	Serial number (20 ASCII characters)
20-21	0000h	X	Retired
22	0000h	X	Obsolete
23-26	XXXXh	F	Firmware revision (8 ASCII characters)
27-46	XXXXh	F	Model number (40 ASCII characters)
47	8010h	F	15-8 80h
		F	7-0 00h = Reserved
			01h = Maximum number of 1 sectors on READ/WRITE MULTIPLE commands
48	0000h		Reserved
49	2F00h	F	Capabilities
			15-14 Reserved for the IDENTIFY PACKET DEVICE command.
		F	13 1 = Standby timer values as specified in this standard are supported 0 = Standby timer values shall be managed by the device
		F	12 Reserved for the IDENTIFY PACKET DEVICE command.
		F	11 1 = IORDY supported 0 = IORDY may be supported
		F	10 1 = IORDY may be disabled
		F	9 1 = LBA supported
F	8 1 = DMA supported.		
X	7-0 Retired		
50	4000h	F	Capabilities
		F	15 Shall be cleared to zero.
		F	14 Shall be set to one.
		X	13-2 Reserved. 1 Obsolete

Word	Value	F/V	Description
		F	0 Shall be set to one to indicate a device specific Standby timer value minimum.
51	0000h	F	15-8 PIO data transfer cycle timing mode 7-0 Reserved
52	0000h	X	Obsolete
53	0007h	F	15-3 Reserved
		F	2 1 = the fields reported in word 88 are valid 0 = the fields reported in word 88 are not valid
		F	1 1 = the fields reported in words 70:64 are valid 0 = the fields reported in words 70:64 are not valid
		X	0 1 = the fields reported in words 58:54 are valid 0 = the fields reported in words 58:54 are not valid
54	XXXXh	X	Number of current cylinders
55	0010h	X	Number of current heads
56	003Fh	X	Number of current sector per track
57-58	XXXXh	X	Current capacity in sectors
59	0110h	V	15-9 Reserved
		V	8 1 = Multiple sector setting is valid
		V	7-0 xxh = Setting for number of sectors that shall be transferred per interrupt on R/W Multiple command
60-61	XXXXh	F	Total number of user addressable sectors
62	0000h	X	Obsolete
63	0X07h	V	15-11 Reserved
		V	10 1 = Multiword DMA mode 2 is selected 0 = Multiword DMA mode 2 is not selected
		V	9 1 = Multiword DMA mode 1 is selected 0 = Multiword DMA mode 1 is not selected
		V	8 1 = Multiword DMA mode 0 is selected 0 = Multiword DMA mode 0 is not selected
			7-3 Reserved
		F	2 1 = Multiword DMA mode 2 and below are supported
		F	1 1 = Multiword DMA mode 1 and below are supported
		F	0 1 = Multiword DMA mode 0 is supported
64	0003h	F	15-8 Reserved 7-0 Advanced PIO modes supported
65	0078h	F	Minimum Multiword DMA transfer cycle time per word
66	0078h	F	Manufacturer's recommended Multiword DMA transfer cycle time
67	0078h	F	Minimum PIO transfer cycle time without flow control
68	0078h	F	Minimum PIO transfer cycle time with IORDY flow control
69-70	0000h		Reserved
71-74	0000h		Reserved for the IDENTIFY PACKET DEVICE command
75	001Fh	F	Queue depth 15-5 Reserved 4-0 Maximum queue depth - 1
76	0106h	F	Serial ATA Capabilities 15-11 Reserved for Serial ATA
		F	10 1 = Supports Phy Event Counts
		F	9 1 = Supports receipt of host initiated power management requests

Word	Value	F/V	Description
		F	8 1 = Supports the NCQ feature set 7-3 Reserved for Serial ATA
		F	2 1 = Supports SATA Gen2 Signaling Speed (3.0Gb/s)
		F	1 1 = Supports SATA Gen1 Signaling Speed (1.5Gb/s)
		F	0 Shall be cleared to zero
77	0000h		Reserved for Serial ATA
			Serial ATA feature supported
		F	15-7 Reserved for Serial ATA
		F	6 1 = Device supports Software Settings Preservation
		F	5 Reserved for Serial ATA
		F	4 1 = Device supports in-order data delivery
		F	3 1 = Device supports initiating power management
		F	2 1 = Device supports DMA Setup auto-activation
		F	1 1 = Device supports non-zero buffer offsets
		F	0 Shall be cleared to zero
			Serial ATA feature enabled
		V	15-7 Reserved for Serial ATA
		V	6 1 = Software Settings Preservation enabled
		V	5 Reserved for Serial ATA
		V	4 1 = In-order data delivery enabled
		V	3 1 = Device initiated power management enabled
		V	2 1 = DMA Setup auto-activation enabled
		V	1 1 = Non-zero buffer offsets enabled
		F	0 Shall be cleared to zero
			Major version number 0000h or FFFFh = device does not report version
		F	15 Reserved
		F	14 Reserved for ATA/ATAPI-14
		F	13 Reserved for ATA/ATAPI-13
		F	12 Reserved for ATA/ATAPI-12
		F	11 Reserved for ATA/ATAPI-11
		F	10 Reserved for ATA/ATAPI-10
		F	9 Reserved for ATA/ATAPI-9
		F	8 Reserved for ATA/ATAPI-8
		F	7 1 = supports ATA/ATAPI-7
		F	6 1 = supports ATA/ATAPI-6
		F	5 1 = supports ATA/ATAPI-5
		F	4 1 = supports ATA/ATAPI-4
		F	3 Obsolete
		X	2 Obsolete
		X	1 Obsolete
			0 Reserved
81	0000h	F	Minor version number
			Command and feature sets supported
		X	15 Obsolete
		F	14 1 = NOP command supported
		F	13 1 = READ BUFFER command supported
		F	12 1 = WRITE BUFFER command supported
		X	11 Obsolete
		F	10 1 = Host Protected Area feature set supported
		F	9 1 = DEVICE RESET command supported
		F	8 1 = SERVICE interrupt supported
		F	7 1 = release interrupt supported
		F	6 1 = look-ahead supported

Word	Value	F/V	Description
		F	5 1 = write cache supported
		F	4 Shall be cleared to zero to indicate that the PACKET Command feature set is not supported.
		F	3 1 = mandatory Power Management feature set supported
		F	2 1 = Removable Media feature set supported
		F	1 1 = Security Mode feature set supported
		0	1 = SMART feature set supported
83	7D08h	F	Command and feature sets supported
		F	15 Shall be cleared to zero
		F	14 Shall be set to one
		F	13 1 = The FLUSH CACHE EXT command is supported
		F	12 Shall be set to one to indicate that the mandatory FLUSH CACHE command is supported
		F	11 1 = The DCO feature set is supported
		F	10 1 = The 48-bit Address feature set is supported
		F	9 1 = The AAM feature set is supported
		8	1 = SET MAX security extension supported
		F	7 Reserved
		F	6 1 = SET FEATURES subcommand required to spinup after power-up
		F	5 1 = Power-Up In Standby feature set supported
		F	4 1 = Removable Media Status Notification feature set supported
		F	3 1 = Advanced Power Management feature set supported
		F	2 1 = CFA feature set supported
		F	1 1 = READ/WRITE DMA QUEUED supported
		0	1 = DOWNLOAD MICROCODE command supported
84	4040h	F	15 Shall be cleared to zero
		F	14 Shall be set to one
		F	13 1 = The IDLE IMMEDIATE command with UNLOAD feature is supported
			12-11 Reserved for TLC
		X	10-9 Obsolete
		F	8 1 = The 64-bit World wide name is supported
		F	7 1 = The WRITE DMA QUEUED FUA EXT command is supported
		F	6 1 = The WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands are supported
		F	5 1 = The GPL feature set is supported
		F	4 1 = The Streaming feature set is supported
		F	3 1 = The Media Card Pass Through Command feature set is supported
		F	2 1 = Media serial number is supported
		F	1 1 = SMART self-test supported
		0	1 = SMART error logging supported
85	746Xh		Command and feature sets supported or enable
		X	15 Obsolete
		F	14 1 = The NOP command is supported
		F	13 1 = The READ BUFFER command is supported
		F	12 1 = The WRITE BUFFER command is supported
		X	11 Obsolete
		V	10 1 = HPA feature set is supported
		F	9 Shall be cleared to zero to indicate that the DEVICE RESET command is not supported
		V	8 1 = The SERVICE interrupt is enabled
		V	7 1 = The release interrupt is enabled
		V	6 1 = Read look-ahead is enabled
		F	5 1 = The volatile write cache is enabled
		F	4 Shall be cleared to zero to indicate that the PACKET Command feature set is not supported.
		X	

Word	Value	F/V	Description
		V V 2 1 0	3 Shall be set to one to indicate that the mandatory Power Management feature is supported 2 Obsolete 1 = The Security feature set is enabled 0 = The SMART feature set is enabled
86	BC00h	F F F F F V V 7 F V X V F F F	Command and feature sets supported or enable 15 = Words 119-120 are valid 14 Reserved 13 = FLUSH CACHE EXT command supported 12 = FLUSH CACHE command supported 11 = The DCO feature set is supported 10 = The 48-bit Address feature set is supported 9 = The AAM feature set is enable 8 = The SET MAX security extension is enabled by SET MAX SET PASSWORD 7 Reserved for Address Offset Reserved Area Boot Method 6 = SET FEATURES subcommand required to spin-up after power-up 5 = The PUIS feature set is enabled 4 Obsolete 3 = The APM feature set is enabled 2 = The CFA feature set is supported 1 = The TCQ feature set is supported 0 = The DOWNLOAD MICROCODE command is supported
87	4040h	F F F X F F F F X V V F F	Command and feature sets supported or enabled 15 Shall be cleared to zero 14 Shall be set to one 13 = The IDLE IMMEDIATE command with UNLOAD feature is supported 12-11 Reserved for TLC 10-9 Obsolete 8 = The 64-bit World wide name is supported 7 = The WRITE DMA QUEUED FUA EXT command is supported 6 = The WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands are supported 5 = The GPL feature set is supported 4 Obsolete 3 = The Media Card Pass Through Command feature set is supported 2 = Media serial number is supported 1 = SMART self-test supported 0 = SMART error logging supported
88	XX7Fh	V V V V V V V	Ultra DMA modes 15 Reserved 14 = Ultra DMA mode 6 is selected 0 = Ultra DMA mode 6 is not selected 13 = Ultra DMA mode 5 is selected 0 = Ultra DMA mode 5 is not selected 12 = Ultra DMA mode 4 is selected 0 = Ultra DMA mode 4 is not selected 11 = Ultra DMA mode 3 is selected 0 = Ultra DMA mode 3 is not selected 10 = Ultra DMA mode 2 is selected 0 = Ultra DMA mode 2 is not selected 9 = Ultra DMA mode 1 is selected 0 = Ultra DMA mode 1 is not selected 8 = Ultra DMA mode 0 is selected 0 = Ultra DMA mode 0 is not selected 7 Reserved

Word	Value	F/V	Description
		F	6 1 = Ultra DMA mode 6 and below are supported
		F	5 1 = Ultra DMA mode 5 and below are supported
		F	4 1 = Ultra DMA mode 4 and below are supported
		F	3 1 = Ultra DMA mode 3 and below are supported
		F	2 1 = Ultra DMA mode 2 and below are supported
		F	1 1 = Ultra DMA mode 1 and below are supported
		F	0 1 = Ultra DMA mode 0 is supported
89	001Eh	F	15-8 Reserved 7-0 Time required for Normal Erase mode SECURITY ERASE UNIT command
90	001Eh	F	15-8 Reserved 7-0 Time required for Enhanced Erase mode SECURITY ERASE UNIT command
91	0000h	V	Current APM level value
92	FFFEh	V	Master Password Identifier
93	0000h	X	Hardware reset result
94	0000h	F	Current AAM value 15-8 Vendor's recommended AAM value
		V	7-0 Current AAM value
95-99	0000h		Reserved
100-103	XXXXh	X	Total Number of User Addressable Logical Sectors for 48-bit commands (QWord)
104-105	0000h		Reserved
106	4000h	F	Physical sector size / logical sector size 15 Shall be cleared to zero
		F	14 Shall be set to one
		F	13 1 = Device has multiple logical sectors per physical sector
		F	12 1 = Device Logical Sector longer than 256 Words
			11-4 Reserved
		F	3-0 2x logical sectors per physical sector
107	0000h	F	Inter-seek delay for ISO 7779 standard acoustic testig
108-111	XXXXh	F	Worldwide name
112-115	0000h		Reserved
116	0000h		Reserved for TLC
117-118	0000h	F	Logical sector size (DWord)
119	4000h	F	Commands and feature sets supported (Continued from words 84:82) 15 Shall be cleared to zero
		F	14 Shall be set to one
			13-6 Reserved
		F	5 1= The Free-fall Control feature set is supported
		F	4 1 = The DOWNLOAD MICROCODE command with mode 3 is supported
		F	3 1 = The READ LOG DMA EXT and WRITE LOG DMA EXT commands are supported
		F	2 1 = The WRITE UNCORRECTABLE EXT command is supported
		F	1 1 = The Write-Read-Verify feature set is supported
			0 Reserved for DDT
120	4000h	F	Commands and feature sets supported or enabled (Continued from words 87:85) 15 Shall be cleared to zero
		F	14 Shall be set to one
			13-6 Reserved
		V	5 1= The Free-fall Control feature set is enabled

Word	Value	F/V	Description
		F	4 1 = The DOWNLOAD MICROCODE command with mode 3 is supported
		F	3 1 = The READ LOG DMA EXT and WRITE LOG DMA EXT commands are supported
		F	2 1 = The WRITE UNCORRECTABLE EXT command is supported
		V	1 1 = The Write-Read-Verify feature set is enabled
			0 Reserved for DDT
121-126	0000h		Reserved for expended supported and enabled settings
127	0000h	X	Obsolete
128	0021h		Security status
		V	15-9 Reserved
		V	8 Security level 0 = High, 1 = Maximum
		F	7-6 Reserved
		F	5 1 = Enhanced security erase supported
		V	4 1 = Security count expired
		V	3 1 = Security frozen
		V	2 1 = Security locked
		V	1 1 = Security enabled
		F	0 1 = Security supported
129-159	0000h	X	Vendor specific
160	0000h		CFA power mode
		F	15 Word 160 supported
		F	14 Reserved
		V	13 CFA power mode 1 is required for one or more commands implemented by the device
		F	12 CFA power mode 1 disabled
			11:0 Maximum current in ma
161-167	0000h		Reserved for the Compact Flash Association
168	0003h		15:4 Reserved
		F	3:0 Device Nominal Form Factor
169	0000h		DATA SET MANAGEMENT is supported
		F	15:1 Reserved
		F	0 1 = the Trim bit in the DATA SET MANAGEMENT is supported
170-173	0000h	F	Additional Product Identifier (ATA String)
174-175	0000h		Reserved
176-205	0000h	V	Current media serial number (ATA String)
206	0000h		SCT Command Transport
		X	15:12 Vendor Specific
			11:6 Reserved
		F	5 The SCT Data Tables command is supported
		F	4 The SCT Feature Control command is supported
		F	3 The SCT Error Recovery Control command is supported
		F	2 The SCT Write Same command is supported
		F	1 Obsolete
		F	0 The SCT Command Transport is supported
207-208	0000h		Reserved for CE-ATA
209	4000h		Alignment of logical blocks within a physical block
		F	15 Shall be cleared to zero
		F	14 Shall be set to one
		F	13:0 Logical sector offset within the first physical sector where the first logical sector is placed

Word	Value	F/V	Description
210-211	0000h	V	Write-Read-Verify Sector Count Mode 3 (DWord)
212-213	0000h	F	Write-Read-Verify Sector Count Mode 2 (DWord)
214	0000h	F F V V F	NV Cache Capabilities 15:12 NC+V Cache feature set version 11:8 NV Cache Power Mode feature set version 7:5 Reserved 4 1 = NV Cache feature set enabled 3:2 Reserved 1 1 = NV Cache Power Mode feature set enabled 0 1 = NV Cache Power Mode feature set supported
215-216	0000h	V	NV Cache Size in Logical Blocks (DWord)
217	0001h	F	Nominal media rotation rate
218	0000h		Reserved
219	0000h	F	NV Cache Options 15:8 Reserved 7:0 Device Estimated Time to Spin Up in Seconds
220	0000h	V	15:8 Reserved 7:0 Write-Read-Verify feature set current mode
221	0000h		Reserved
222	101Fh	F F F F F F	Transport major version number 0000h or FFFFh = device does not report version 15:12 Transport Type 0h = Parallel 1h = Serial 2h-Fh = Reserved Parallel Serial 11:5 Reserved Reserved 4 Reserved SATA Rev 2.6 3 Reserved SATA Rev 2.5 2 Reserved SATA II: Extensions 1 ATA/ATAPI-7 SATA 1.0a 0 ATA8-APT ATA8-AST
223	0000h	F	Transport minor version number
224-233	0000h		Reserved for CE-ATA
234	0000h	F	Minimum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 3
235	0000h	F	Maximum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 3
236-254	0000h		Reserved
255	XXXXh	V V	Integrity word 15-8 Checksum 7-0 Checksum Validity Indicator

Key:

F/V – Fixed/variable content

F = the content of the word is fixed and does not change. For removable media devices, these values may change when media is removed or changed.

V = the contents of the word is variable and may change depending on the state of the device or the commands executed by the device.

X = the content of the word may be fixed or variable.

5.1.1. IDLE (E3h)

Features	Power Management Feature Set
Protocol	Non-Data

Values other than zero in the Sector Count register when the IDLE command is issued shall determine the time period programmed into the Standby timer.

Idle command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Timer period value							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	Obs	DEV	Na	Na	Na	Na
Command	E3h							

Device register :

DEV shall specify the selected device.

Idle command sector count register contents information

Sector Count register contents	Corresponding timeout period
0 (00h)	Timeout disabled
1-240 (01h-F0h)	(value*5)s
241-251 (F1h-FBh)	((Value-240)*30)min
252 (FCh)	21min
253 (FDh)	Period between 8 and 12 hrs
254 (FEh)	Reserved
255 (FFh)	21 min 15 s
NOTE – Times are approximate	

Idle command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							

LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device Register -

DEV shall indicate the selected device.

Status register -

BSY will be cleared to zero indicating command completion.

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ shall be cleared to zero.

ERR shall be cleared to zero.

Idle command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The IDLE command allows the host to place the device in the idle mode and also set the Standby timer.

Status register:

DRDY set to one

5.1.2. Idle Immediate (E1h)

Features	Power Management Feature Set
Protocol	Non-Data

Idle immediate command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Command	E1h							

Device register:

DEV shall specify the selected device.

Idle immediate command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The IDLE IMMEDIATE command allows the host to immediately place the device in the idle mode.

Device Register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion.

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ shall be cleared to zero.

ERR shall be cleared to zero.

5.1.3. S.M.A.R.T. Function (Self-Monitoring, Analysis, and Reporting Technology)

To perform different processing requires predicting device failures, according to the subcommand specified in the Features register.

SMART Feature registers values

Value	Command
D0h	SMATR Read Data
D8h	SMART ENABLE OPERATIONS
D9h	SMART DISABLE OPERATIONS

5.1.4. S.M.A.R.T. Read Data (D0h)

Features	Operation when the SMART feature set is implemented.
Protocol	PIO data-in

SMART command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	D0h							
Sector Count	Na							
LBA Low	Na							
LBA Mid	4Fh							
LBA High	C2h							
Device	Obs	Na	obs	DEV	Na	Na	Na	Na

Register	7	6	5	4	3	2	1	0
Command	B0h							

Device register:

DEV shall specify the selected device.

SMART command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall indicate the selected device.

Status registers:

BSY will be cleared to zero indicating command completion.

DRDY will be set to one. SMART enabled.

DF (Device Fault) will be cleared to zero.

DRQ shall be cleared to zero.

ERR shall be cleared to zero.

ID of SMART data structure

	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11
Attribute Name	ID	Flags		Init	Worst	Raw Attribute Value						Rsv
Read Error Rate	01h	0Bh	00h	64h	64h	FFh	FFh	FFh	00h	00h	00h	00h
Throughput Performance	02h	05h	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h
Spin Up Time	03h	07h	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h
Reallocated Sector Count	05h	13h	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h
Seek Error Rate	07h	0Bh	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h
Seek Time performance	08h	05h	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h
Power-On hours Count	09h	12h	00h	64h	64h	(1)		00h	00h	00h	00h	00h
Spin Retry Count	0Ah	13h	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h
Drive Power Cycle Count	0Ch	12h	00h	64h	64h	(2)		00h	00h	00h	00h	00h
SATA PHY Error Count	A8h	12h	00h	64h	64h	(3)		00h	00h	00h	00h	00h
Bad Block Count	AAh	03h	00h	64h	64h	00h	00h	(4)		(5)		00h
Erase Count	ADh	12h	00h	64h	64h	(6)		(7)		(6)	(7)	00h
Bad Cluster Table Count	AFh	03h	00h	64h	64h	(8)		00h	00h	00h	00h	00h
Unexpected Power Loss Count	C0h	12h	00h	64h	64h	(9)		00h	00h	00h	00h	00h
Temperature	C2h	22h	00h	(10)	64h	(10)	00h	(11)	00h	(12)	00h	00h

Current Pending Sector Counter	C5h	12h	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h
Write Head	F0h	13h	00h	64h	64h	00h	00h	00h	00h	00h	00h	00h

Smart command for AVERAGE/MAX ERASE count information

	SMART	DI 101
	F: Fixed V: Variable X: None	
Byte	F/V	Description
0-188	X	
189-190	F	Total Bad Block Number of System(190:MSB 189:LSB)
191-192	F	Later Bad Block Number of System(192:MSB 191:LSB)
193-198	X	
199-200.203	F	Average Erase Count(203:MSB 199:LSB)
201-202.204	V	Maximum Erase Count(204:MSB 201:LSB)
205-510	X	
511	V	Check Sum

When the Maximum erase count is 255 bigger than average erase count, the wear-leveling will be executed.

5.1.5. S.M.A.R.T. ENABLE OPERATIONS (D8h)

Features	Smart Feature Set
Protocol	Non-data

SMART Enable command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	D8h							
Sector Count	Na							
LBA Low	Na							
LBA Mid	4Fh							
LBA High	C2h							
Device	Obs	Na	obs	DEV	Na	Na	Na	Na
Command	B0h							

Device register:

DEV shall specify the selected device.

SMART command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							

LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device Register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion.

DRDY will be set to one. (This command enables access to all SMART capabilities within device.)

DF (Device Fault) will be cleared to zero.

DRQ shall be cleared to zero.

ERR shall be cleared to zero.

5.1.6. SMART DISABLE OPERATIONS (D9h)

Features	Smart Feature Set
Protocol	Non-data

SMART DISABLE Command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	D9h							
Sector Count	Na							
LBA Low	Na							
LBA Mid	4Fh							
LBA High	C2h							
Device	Obs	Na	obs	DEV	Na	Na	Na	Na
Command	B0h							

Device register:

DEV shall specify the selected device.

SMART command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: *This command disables all SMART capabilities within device.*

Device Register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion.

DRDY will be set to one. SMART enabled.

DF (Device Fault) will be cleared to zero.

DRQ shall be cleared to zero.

ERR shall be cleared to zero.

5.1.7. Read Multiple (C4h)

Protocol	PIO data-in
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Read multiple command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector Count							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	Na	obs	DEV	LBA(27:24)			
Command	C4h							

Sector Count:

Number of sectors to be transferred. A value of 00h specifies that 256 sectors are to be transferred.

LBA Low:

Starting LBA bits (7:0).

LBA Mid:

Starting LBA bits (15:8)

LBA High:

Starting LBA bits (23:16)

Device:

DEV shall specify the selected device.

Bit (3:0) starting LBA bits (27:24)

Read multiple command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Read multiple command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	UNC	MC	IDNF	MCR	ABRT	NM	Obs
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command reads the number of sectors specified in the sector Count register. The number of sectors per block is defined by the content of word 59 in the IDENTIFY DEVICE response.

An unrecoverable error encountered during the execution of this command results in the termination of the command. The Command Block registers contain the address of the sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate.

Error register:

UNC shall be set to one if data is uncorrectable.

IDNF shall be set to one if a user-accessible address is requested could not be found.

LBA Low, LBA Mid, and LBA High, Device

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.8. Read Sector(s) (20h)

Protocol	PIO data-in
----------	-------------

Read sector command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector Count							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							

LBA High	LBA(23:16)				
Device	obs	Na	obs	DEV	LBA(27:24)
Command	20h				

Sector Count:

Number of sectors to be transferred. A value of 00h specifies that 256 sectors are to be transferred.

LBA Low:

Starting LBA bits (7:0).

LBA Mid:

Starting LBA bits (15:8)

LBA High:

Starting LBA bits (23:16)

Device:

DEV shall specify the selected device.

Bit (3:0) starting LBA bits (27:24)

Read sector command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Read sector command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	UNC	MC	IDNF	MCR	ABRT	NM	Obs
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command reads from 1 to 256 sectors as specified in the Sector Count register. A sector

count of 0 requests 256 sectors. This transfer shall begin at the sector specified in the LBA Low, LBA Mid, LBA High, and Device registers.

The DRQ bit is always set to one prior to data transfer regardless of the presence or absence of an error condition. The device shall interrupt for each DRQ block transferred.

An unrecoverable error encountered during the execution of this command results in the termination of the command. The Command Block registers contain the address of the sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate.

Error register:

UNC shall be set to one if data is uncorrectable.

IDNF shall be set to one if a user-accessible address is requested could not be found.

LBA Low, LBA Mid, and LBA High, Device

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.9. Read Verify Sector (40h)

Protocol	Non-data
-----------------	----------

Read verify sector command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector Count							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	Na	obs	DEV	LBA(27:24)			
Command	40h							

Sector Count:

Number of sectors to be transferred. A value of 00h specifies that 256 sectors are to be transferred.

LBA Low:

Starting LBA bits (7:0).

LBA Mid:

Starting LBA bits (15:8)

LBA High:

Starting LBA bits (23:16)

Device:

The LBA bit shall be set to one to specify the address is an LBA.

DEV shall specify the selected device.

Bit (3:0) starting LBA bits (27:24)

Read verify sector command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Read verify sector command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	UNC	MC	IDNF	MCR	ABRT	NM	Obs
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command is identical to the READ SECTOR(s) command, except that the device shall have read the data from the SSD, the DRQ bit is never set to one, and no data is transferred to the host.

An unrecoverable error encountered during the execution of this command results in the termination of the command.

The Command Block registers contain the address of the sector where the first unrecoverable error occurred.

Error register:

UNC shall be set to one if data is uncorrectable.

IDNF shall be set to one if a user-accessible address could not be found.

LBA Low, LBA Mid, and LBA High, Device

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.10. Read DMA (C8h)

Protocol	DMA
----------	-----

Read DMA command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector Count							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	Na	obs	DEV	LBA(27:24)			
Command	C4h							

Sector Count:

Number of sectors to be transferred. A value of 00h specifies that 256 sectors are to be transferred.

LBA Low:

Starting LBA bits (7:0).

LBA Mid:

Starting LBA bits (15:8)

LBA High:

Starting LBA bits (23:16)

Device:

DEV shall specify the selected device.

Bit (3:0) starting LBA bits (27:24)

Read DMA command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Read DMA command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	ICRC	UNC	MC	IDNF	MCR	ABRT	NM	Obs
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	Obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The READ DMA command allows the host to read data using the DMA data transfer protocol. An unrecoverable error encountered during the execution of this command results in the termination of the command. The Command Block registers contain the address of the sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate.

Error register:

ICRC shall be set to one if an interface CRC error has occurred during an Ultra DMA data transfer. The content of this bit is not applicable for Multiword DMA transfers.

UNC shall be set to one if data is uncorrectable.

IDNF shall be set to one if a user-accessible address could not be found.

LBA Low, LBA Mid, and LBA High, Device

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one. The host shall initialize the DMA channel.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.11. Set Multiple Mode (C6h)

Protocol	Non-data
-----------------	----------

Set multiple mode command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector per block							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Command	C6h							

Description: If the content of the Sector Count Register is not zero, then the Sector Count register contains the number of sectors per block for the device to be used on all following READ/WRITE

MULTIPLE commands. The content of the Sector Count register shall be less than or equal to the value in bits (7:0) in word 47 in the IDENTIFY DEVICE information. The host should set the content of the Sector Count register to 1.

Set multiple mode command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Set multiple mode command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	obs	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command establishes the block count for READ MULTIPLE, READ MULTI EXT, WRITE MULTIPLE. SSD can only support 1 sector per block.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.12. Set Sleep Mode (E6h)

Protocol	Non-data
-----------------	----------

Set sleep mode for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Command	E6h							

Device register:

DEV shall specify the selected device.

Set sleep mode for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Set sleep mode for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na			

Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR
--------	-----	------	----	----	-----	----	----	-----

Description: This command is the only way to cause the device to enter Sleep mode.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.13. Flush Cache (E7h)

Protocol	Non-data
----------	----------

Flush cache command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Command	E7h							

Device register:

DEV shall specify the selected device.

Flush cache command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Flush cache command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	Obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command is used by the host to request the device to flush the write cache. If there is data in write cache, that data shall be written to the SSD. The BSY bit shall remain set to one until all data has been successfully written or an error occurs.

Error register:

ABRT may be set to one if the device is not able to complete the action requested by the command.

LBA Low, LBA Mid, and LBA High, Device

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.14. Standby (E2h)

Protocol	Non-data
----------	----------

Standby command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Time period value							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Command	E2h							

Description: The value in the Sector Count register when the STANDBY command is issued shall determine the time period programmed into the Standby timer.

Device register:

DEV shall specify the selected device.

Standby command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Standby command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description : This command causes the device to enter the Standby mode. If the Sector Count register is non-zero then Standby timer shall be enabled. The value in the Sector Count register shall be used determine the time programmed into the Standby timer. If the Sector Count register is zero then the Standby timer is disabled.

Error register:

ABRT may be set to one if the device is not able to complete the action requested by the command.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.15. Standby Immediate (E0h)

Protocol	Non-data
-----------------	----------

Standby immediate command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Command	E0h							

Device register:

DEV shall specify the selected device.

Standby immediate command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Standby immediate command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na			

Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR
--------	-----	------	----	----	-----	----	----	-----

Description : This command causes the device to immediately enter the Standby mode.

Error register:

ABRT may be set to one if the device is not able to complete the action requested by the command.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.16. Write Multiple (C5h)

Protocol	PIO data-out
----------	--------------

Write multiple command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector Count							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	Na	obs	DEV	LBA(27:24)			
Command	C5h							

Description : The LBA mid, LBA High, Device, and LBA Low specify the starting sector address to be written. The Sector Count register specifies the number of sectors to be transferred.

Sector Count:

Number of sectors to be transferred. A value of 00h specifies that 256 sectors shall be transferred.

LBA Low:

Starting LBA bits (7:0)

LBA Mid:

Starting LBA bits (15:8)

LBA High:

Starting LBA bits (23:16)

Device:

The LBA bit shall be set to one to specify the address is an LBA.

DEV shall specify the selected device.

Bits(3:0) starting LBA bits (27:24)

Write multiple command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
----------	---	---	---	---	---	---	---	---

Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Write multiple command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	WP	MC	IDNF	MCR	ABRT	NM	Na
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	Obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command writes the number of sectors specified in the Sector Count register. The number of sectors per block is defined by the content of word 59 of the IDENTIFY DEVICE response. When the WRITE MULTIPLE command is issued, the SECTOR Count register contains the number of sectors (not the number of blocks) requested. The device shall interrupt for each DRQ block transferred. IF the number of requested sectors is not evenly divisible by the block count, as many full blocks as possible are transferred, followed by a final, partial block transfer. The partial block transfer is for n sectors, where: $N = \text{Remainder} (\text{sector count} / \text{block count})$.

If the WRITE MULTIPLE command is received when WRITE MULTIPLE commands are disabled, the Write Multiple operation shall be rejected with command aborted.

Device errors encountered during WRITE MULTIPLE commands are posted after the attempted device write of the block or partial block transferred. The command ends with the sector in error, even if the error was in the middle of a block. Subsequent blocks are not transferred in the event of an error.

The contents of the Command Block Registers following the transfer of a data block that had a sector in error are undefined. The host should retry the transfer as individual requests to obtain valid error information. Interrupt pending is set when the DRQ bit is set to one at the beginning of each block or partial block.

An unrecoverable error encountered during the execution of this command results in the termination of the command. The Command Block register contain the address of the sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate.

Error register:

IDNF shall be set to one if a user-accessible address could not be found. IDNF shall be set to one if an address outside of the range user-accessible address is requested if command aborted is not returned.

ABRT shall be set to one if an error, include an ICRC error, has occurred during an Ultra DMA data transfer.
ABRT shall be set to one if an address outside of the range of user-accessible address is requested if IDNF is not set to one.

LBA Low, LBA Mid, and LBA High, Device -

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one. (If bit 8 of IDENTIFY DEVICE word 59 is cleared to zero, a successful SET MULTIPLE MODE command shall proceed a WRITE MULTIPLE command.)

DF (Device Fault) will be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.17. Write Sector (30h)

Protocol	PIO data-out
----------	--------------

Write sector command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector Count							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	LBA	obs	DEV	LBA(27:24)			
Command	30h							

Description: The LBA mid, LBA High, Device, and LBA Low specify the starting sector address to be written. The Sector Count register specifies the number of sectors to be transferred.

Sector Count:

Number of sectors to be transferred. A value of 00h specifies that 256 sectors shall be transferred.

LBA Low:

Starting LBA bits (7:0)

LBA Mid:

Starting LBA bits (15:8)

LBA High:

Starting LBA bits (23:16)

Device:

The LBA bit shall be set to one to specify the address is an LBA.

DEV shall specify the selected device.

Bits(3:0) starting LBA bits (27:24)

Write sector command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							

LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Write sector command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	WP	MC	IDNF	MCR	ABRT	NM	Na
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	Obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command writes from 1 to 256 sectors as specified in the Sector Count register. A sector count of 0 requests 256 sectors. The device shall interrupt for each DRQ block transferred.

An unrecoverable error encountered during the execution if this command results in the termination of the command. The Command Block registers contain the address of the sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate.

Error register:

IDNF shall be set to one if a user-accessible address could not be found. *IDNF* shall be set to one if an address outside of the range of user-accessible addresses is requested if command aborted is not returned.

ABRT shall be set to one if an error, including an ICRC error, has occurred during an Ultra DMA data transfer.

ABRT shall be set to one if the device is not able to complete the action requested by the command. *ABRT* shall be set to one if an address outside of the range of user-accessible addresses is requested if *IDNF* is not set to one.

LBA Low, *LBA Mid*, and *LBA High*, *Device*

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.18. Write DMA (CAh)

Protocol	DMA
-----------------	-----

Write DMA command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Sector Count							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	obs	LBA	obs	DEV	LBA(27:24)			
Command	CAh							

Description: The LBA Mid, LBA High, Device, and LBA Low specify the starting sector address to be written. The Sector Count register specifies the number of sectors to be transferred.

Sector Count:

Number of sectors to be transferred. A value of 00h specifies that 256 sectors shall be transferred.

LBA Low:

Starting LBA bits (7:0)

LBA Mid:

Starting LBA bits (15:8)

LBA High:

Starting LBA bits (23:16)

Device:

The LBA bit shall be set to one to specify the address is an LBA.

DEV shall specify the selected device.

Bits (3:0) starting LBA bits (27:24)

Write DMA command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall specify the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

Write DMA command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	ICRC	WP	MC	IDNF	MCR	ABRT	NM	Obs
Sector Count	Na							
LBA Low	LBA(7:0)							
LBA Mid	LBA(15:8)							
LBA High	LBA(23:16)							
Device	Obs	Na	obs	DEV	LBA(27:24)			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The Write DMA command allows the host to write data using the DMA data transfer protocol.

Error register:

ICRC shall be set to one if an interface CRC error has occurred during an Ultra DMA data transfer.

The content of this bit is not applicable for Multiword DMA transfers.

IDNF shall be set to one if a user-accessible address could not be found. **IDNF** shall be set to one if an address outside of the range of user-accessible address is requested if command aborted is not returned.

ABRT shall be set to one if an error, including an ICRC error, has occurred during an Ultra DMA data transfer. **ABRT** shall be set to one if the device is not able to complete the action requested by the command. **ABRT** shall be set to one if an address outside of the range of user-accessible addresses is requested if **IDNF** is not set to one.

LBA Low, LBA Mid, and LBA High, Device

Shall be written with the address of first unrecoverable error.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one. (The host shall initialize the DMA channel.)

DF (Device Fault) will be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.19. Execute Device Diagnostic (90h)

Feature	General feature set
Protocol	Device diagnostic

Execute device diagnostic command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							

LBA High	Na				
Device	obs	Na	obs	Na	Na
Command	90h				

Description: Only the command code (90h). All other registers shall be ignored.

Device:

DEV shall be ignored.

Execute device diagnostic command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Diagnostic Code							
Sector Count	Signature							
LBA Low	Signature							
LBA Mid	Signature							
LBA High	Signature							
Device	Signature							
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The diagnostic code written into the Error register is an 8-bit code.

Error register:

Diagnostic Code

Sector Count, LBA Low, LBA Mid, LBA High, Device registers

Device signature

Device register:

DEV shall be cleared to zero.

Execute device diagnostic command for status register information

Code	Description
01h	Device passed
Others	Device failed

Execute device diagnostic command for ERROR OUTPUTS information

Description: In Table of Identify device command for normal outputs information shows the error information that is returned as a diagnostic code in the Error register. This command shall cause the devices to perform the internal diagnostic tests. This command shall be accepted regardless of the state of DRDY.

5.1.20. Security Set Password (F1h)

Feature	Security Mode feature set
Protocol	PIO data-out

Security set password command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	Na	Na			
Command	F1h							

Device:

DEV shall specify the selected device.

Security set password command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register

DEV shall indicate the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be set to zero.

DRQ will be cleared to zero

ERR will be set to zero.

Security set password command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							

Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command transfer 512 byte of data from the host. In Table of Identify device command for normal outputs information, it defines the content of this information. The data transferred controls the function of this command. In Table of Identify device command parameters, it defines the interaction of the identifier and security level bits.

The revision code field shall be returned in the IDENTIFY DEVICE word 92. The valid revision codes are 0001h through FFEh. A value of 0000h or FFFFh indicates that the Master Password Revision Code is not supported.

Error Register:

ABRT may be set to one if the device is not able to complete the action requested by the command

Device register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) should be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

Security set password command's data content

Word	Content
0	Control Word Bit 0 Identifier 0=set User password 1=set Master password Bits (7:1) Reserved Bit(8) Security level 0=High 1=Maximum Bits(15:9) Reserved
1-16	Password(32 bytes)
17	Master Password Revision Code()
18-255	Reserved

Security Set password command's identifier and security level bit interaction

Identifier	Level	Command result
User	High	The password supplied with the command shall be saved as the new User password. The Lock mode shall be enabled from the next power-on or hardware reset. The device shall than be unlocked by either the User password it the previously set Master password.
User	Maximum	The password supplied with the command shall be saved as the new User password. The lock mode shall be enabled from the

		next power-on or hardware reset. The device shall then be unlocked by only the User password. The Master password previously set is still stored in the device but shall not be unlock
Master	High or Maximum	This combination shall set a Master password but shall not enable or disable the Lock mode. The security level is not changed. Master password revision code set to the value in Master Password Revision Code field.

5.1.21. Security Unlock (F2h)

Feature	Security Mode feature set
Protocol	PIO data-out

Security unlock command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	Na	Na			
Command	F2h							

Device register:

DEV shall specify the selected device.

Security unlock command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be set to zero.
DRQ will be cleared to zero
ERR will be set to zero.

Security unlock command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The device shall return aborted if the device is in Frozen mode.
 This command transfers 512 bytes of data from the host. In Table of Idle command sector count register contents information, it defines the content of this information. If the Identifier bit is set to Master and the device is in high security level, then the password supplied shall be compared with the stored Master password. If the device is in maximum security level then the unlock shall be rejected.
 If the Identifier bit is set to user then the device shall compare the supplied password with the stored User password. If the password compare fails then the device shall return command aborted to the host and decrements the unlock counter. This counter shall be initially set to five and shall decremented for each password mismatch when SECURITY UNLOCK and SECURITY ERASE UNIT commands shall be command aborted until a power-on reset or a hardware reset. SECURITY UNLOCK commands issued when the device is unlocked have no effect on the unlock counter.

Error Register:
ABRT may be set to one if the device is not able to complete the action requested by the command
Device register:
DEV shall indicate the selected device.
Status register:
BSY will be cleared to zero indicating command completion
DRDY will be set to one.
DF (Device Fault) should be set to one if a device fault has occurred.
DRQ will be cleared to zero
ERR will be set to one if an Error register bit is set to one.

5.1.22. Security Erase Prepare (F3h)

Feature	Security Mode feature set
Protocol	Non-data

Security erase prepare command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							

LBA High	Na				
Device	obs	Na	obs	Na	Na
Command	F3h				

Device register:

DEV shall specify the selected device.

Security erase prepare command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be set to zero.

DRQ will be cleared to zero

ERR will be set to zero.

Security erase prepare command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: *The SECURITY ERASE PREPARE command shall be issued immediately before the SECURITY ERASE UNIT command to enable device erasing and unlocking. This command prevents accidental loss of data on the device. The device shall return aborted if the device is in Frozen mode.*

Error Register:

ABRT shall be set to one if the device is in Frozen mode. ABRT may be set to one if the device is not able to complete the action requested by the command

Device register

DEV shall indicate the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.
DF (Device Fault) should be set to one if a device fault has occurred.
DRQ will be cleared to zero
ERR will be set to one if an Error register bit is set to one.

5.1.23. Security Erase Unit (F4h)

Feature	Security Mode feature set
Protocol	PIO data-out

Security erase unit command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	Na	Na	Na	Na	Na
Command	F4h							

Device register:
DEV shall specify the selected device.

Security erase unit command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device 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) will be set to zero.
DRQ shall be cleared to zero
ERR shall be cleared to zero.

Security erase unit command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: This command transfer 512 bytes of data from the host. In Table of Idle command for inputs information defines the content of this information. If the password does not match the password previously saved by the device, the device shall reject the command with command aborted.

The SECURITY ERASE PREPARE command shall be completed immediately prior to the SECURITY ERASE UNIT command. If the device receives a SECURITY ERASE UNIT command without an immediately prior SECURITY ERASE PREPARE command, the device shall command abort the SECURITY ERASE UNIT command.

When Normal Erase mode is specified, the SECURITY ERASE UNIT command shall write binary zeroes to all user data areas. The Enhanced Erase mode is optional. When Enhanced Erase Mode is specified, the device shall write predetermined data patterns to all user areas. In Enhanced Erase mode, all previously written user data shall be overwritten, including sectors that are no longer in use due to reallocation.

This command shall disable the device Lock mode, however, the Master password shall still be stored internally within the device and may be reactivated later a new User password is set.

The device shall return aborted if the device is in Frozen mode, not preceded by a SECURITY ERASE PREPARE command, if Enhance Erase is specified but not supported, or if the data area is not successfully overwritten.

Error Register

ABRT shall be set to one if the device is in Frozen mode, not preceded by a SECURITY ERASE PREPARE command, or if the data area is not successfully overwritten. ABRT may be set to one if the device is not able to complete the action requested by the command.

Device register

DEV shall indicate the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one. (DRDY set to one. This command shall be immediately preceded by a SECURITY ERASE PREPARE command.)

DF (Device Fault) should be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

Security erase unit password information

Word	Content
0	Control Word Bit 0 Identifier 0=Compare User password 1= Compare Master password

	Bit 1 Erase mode 0=Normal Erase 1=Enhanced Erase Bit(15:2) Reserved
1-16	Password (32 Bytes)
17-255	Reserved

5.1.24. Security Freeze Lock (F5h)

Feature	Security Mode feature set
Protocol	Non-data

Security freeze lock for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	Na	Na	Na	Na	Na
Command	F5h							

Device register:

DEV shall specify the selected device.

Security freeze lock for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device 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) will be set to zero.

DRQ shall be cleared to zero

ERR shall be cleared to zero.

Security freeze lock for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	Obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The SECURITY FREEZE LOCK command shall set the device to Frozen mode. After command completion any other commands that update the device Lock mode shall be command aborted. Frozen mode shall be disabled by power-off or hardware reset. If SECURITY FREEZE LOCK shall be issued when the device in Frozen mode, the command executes and the device shall remain in Frozen mode.

Command disabled by SECURITY FREEZE LOCK are:

SECURITY SET PASSWORD

SECURITY UNLOCK

SECURITY DISABLE PASSWORD

SECURITY ERASE PREPARE

SECURITY ERASE UNIT

The device shall return aborted if the device is in Frozen mode, not preceded by a SECURITY ERASE PREPARE command, if Enhance Erase is specified but not supported, or if the data area is not successfully overwritten.

Error Register:

ABRT shall be set to one if the device is in locked mode. ABRT may be set to one if the device is not able to complete the action requested by the command.

Dvice register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) should be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.

5.1.25. Security Disable Password (F6h)

Feature	Security Mode feature set
Protocol	PIO data-out

Security disable password command for INPUTS information

Register	7	6	5	4	3	2	1	0
Features	Na							
Sector Count	Na							

LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	Na	Na	Na	Na	Na
Command	F6h							

Device register:

DEV shall specify the selected device.

Security disable password command for NORMAL OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device 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) will be set to zero.

DRQ shall be cleared to zero

ERR shall be cleared to zero.

Security disable password command for ERROR OUTPUTS information

Register	7	6	5	4	3	2	1	0
Error	Na	Na	Na	Na	Na	ABRT	Na	Na
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na			
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Description: The SECURITY DISABLE PASSWORD command transfer 512 bytes of data from the host.

In Table of Idle command sector count register contents information defines the content of this information.

If the password selected by word 0 matches the password previously saved by the device, the device shall disable the Lock mode. This command shall not change the Master password. The Master password shall be reactivated when a User password is set. The device shall return aborted if the device is in Locked mode, or device is in Frozen mode.

Error Register:

ABRT may be set to one if the device is not able to complete the action requested by the command.

Device register:

DEV shall indicate the selected device.

Status register:

BSY will be cleared to zero indicating command completion

DRDY will be set to one. (Device shall be in Unlocked mode.)

DF (Device Fault) should be set to one if a device fault has occurred.

DRQ will be cleared to zero

ERR will be set to one if an Error register bit is set to one.


Security disable password command content

Word	Content
0	Control Word Bit 0 Identifier 0=Compare User password 1= Compare Master password Bit(15:1) Reserved
1-16	Password (32 Bytes)
17-255	Reserved

Appendix A. Ordering Information

1. Part Number List:

◆ Industrial mini PCI-e flash module supports write protection – HERMES-D Series

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	2GB	SBMPM002G-JDCSC	WBMPM002G-JDISI
	4GB	SBMPM004G-JDCSC	WBMPM004G-JDISI
	8GB	SBMPM008G-JDCSC	WBMPM008G-JDISI
	16GB	SBMPM016G-JDCSC	WBMPM016G-JDISI
	32GB	SBMPM032G-JDCSC	WBMPM032G-JDISI
	64GB	SBMPM064G-JDCSC	WBMPM064G-JDISI

2. Part Number Decoder:

X1 **X2** **X3** **X4** **X5** **X6** **X7** **X8** **X9** – **X11** **X12** **X13** **X14** **X15** – **C**

X1 : Grade

S: Standard Grade – operating temp. 0° C ~ 70 ° C

W: Industrial Grade – operating temp. -40° C ~ +85 ° C

X2 : The material of case

B : Bare (without casing)

X3 **X4** **X5** : Product category

MPM : mini PCI-e flash module (MPM)

X6 **X7** **X8** **X9** : Capacity

002G: 2GB **016G:** 16GB

004G: 4GB **032G:** 32GB

008G: 8GB **064G:** 64GB

X11 : Controller

J : JMicron (HERMES-D Series)

X12 : Controller version

A,B,C.....D

X13 : Controller Grade

C : Commercial grade

I : Industrial grade

X14 : Flash IC

S : Samsung SLC-NAND Flash IC

X15 : Flash IC grade / Type

C : Commercial grade

I : Industrial grade

C : Reserved for specific requirement

C : Conformal-coating

Appendix B. Limited Warranty

APRO warrants your Industrial mini-PCI-e Flash (MPM) Module against defects in material and workmanship for the life of the drive. The warranty is void in the case of misuse, accident, alteration, improper installation, misapplication or the result of unauthorized service or repair. The implied warranties of merchantability and fitness for a particular purpose, and all other warranties, expressed or implied, except as set forth in this warranty, shall not apply to the products delivered. In no event shall APRO be liable for any lost profits, lost savings or other incidental or consequential damages arising out of the use of or inability to use this product.

BEFORE RETURNING PRODUCT, A RETURN MATERIAL AUTHORIZATION (RMA) MUST BE OBTAINED FROM APRO.

Product shall be returned to APRO with shipping prepaid. If the product fails to conform based on customers' purchasing orders, APRO will reimburse customers for the transportation charges incurred.

Warranty period:

- SBMPM0xxG-JDCSC 3 years
- WBMPM0xxG-JDISI 5 years



The warranty period is able to extend. Please contact APRO and/or Your APRO distributors for more information.