FLASH

Firmware Manual

Rev. Date 11/20/92

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1.General Information

1.1.Revision History

Rev	Date	Description	Author
P2	07/13/92	Preliminary Release	Alex Tang
P3	11/20/92	Update	Alex Tang

1.2.Scope

The purpose of this manual is to document the FLASH Series Firmware. This manual documents deviations from the SCSI and AT specifications and describes the superset (diagnostic) commands. In addition to documenting the external interface, certain internal features of the firmware and its architecture are described.

1.3.Applicable Documents

SCSI-II Specification
CAM ATA Specification
Konishiki Specification.

Note: The latest revisions of these manuals should be used.

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2.Superset Commands

2.1.Introduction

The superset or diagnostic commands are accessible as opcode FFH along with a one-byte subcode specifying the particular diagnostic function. Subcodes 00H through 3FH are set aside for the common diagnostic command set. The common commands are co-defined by the Gemini and L-Series projects in an effort to pave the path for common diagnostic software with standard Command Descriptor Blocks. However, the internal implementation of these commands may be product dependent.

The following table shows how the 256 subcodes are being allocated:

Address	Description
00-3F	Common diagnostic command set
40-5F	Reserved for Gemini and Robin
60-7F	Reserved for future FLASH products
80-9F	Lethal Series diagnostic set
A0-BF	Reserved for future products
C0-FF	Reserved for customer specific commands

Note: This manual only describes the commands implemented in the Lethal series products.

The actual superset commands are the same for both SCSI and AT. The method of enabling them and sending the bytes over the interfaces differs between them. The following sections will detail those differences.

2.2.SCSI Superset Commands

The diagnostic mode must be enabled prior to executing any diagnostic command with one exception:

Write Configuration to page 6 (customer name) is allowed at all times.

Executing a diagnostic command in normal mode will result in an ILLEGAL COMMAND condition. The SCSI diagnostic commands are enabled by sending a SEND DIAGNOSTIC command to the drive. The diagnostic mode is always disabled on power-up or after a host Reset. Once enabled, the diagnostic commands are issued by sending a ten byte command with CDB0 (byte 0) set to 0FFh and CDB6 set to the appropriate subcode. Other bytes may be used as necessary and are described in the Command Description section in this chapter.

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2.2.1. SCSI Send Diagnostic Command

	7	6	5	4	3	2	1	0
0	Opcode = 01Dh							
1	LUN = 0			Reserved = 0		SLFTST	DEVOFL	UNTOFL
2	Reserved = 0							
3	Reserved = 0							
4	Parameter List Length = 7							
5	VU = 0		Reserved = 0				F	L

This is the standard SCSI SEND DIAGNOSTIC command. This is used to enable and disable the diagnostic (a.k.a. Super) mode. The diagnostic mode is always disabled on power up or after a host reset.

SLFTST - Self test is supported
DEVOFL - Device off-line is not supported
UNTOFL - Unit off-line is not supported

The parameter list length specifies the length in bytes of the parameter list that shall be transferred during the DATA OUT phase. A value other than 7 will result in an ILLEGAL REQUEST sense error.

2.2.2. SCSI Send Diagnostic Data Format

Byte	Enable Diagnostic Mode	Disable Diagnostic Mode
0	01h	00h
1	C1h	xx
2	F9h	xx
3	37h	xx
4	CFh	xx
5	8Eh	xx
6	59h	xx

A value of 0 in byte 0 of the parameter list will disable Diagnostic Mode. Bytes 1 through 6 are ignored when byte 0 has a value of 0.

A value of 1 in byte 0 of the parameter list will enable Diagnostic Mode, provided that bytes 1 through 6 are as specified. Other values in bytes 1 through 6 will result in an ILLEGAL REQUEST sense error.

A value other than 0 or 1 in byte 0 of the parameter list will result in an ILLEGAL REQUEST sense error.

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2.2.3.Self Test Description

When the selftest bit is set in CDB1, Flash performs the following diagnostic functions:

1. Perform a checksum on the internal and external rom's.
2. Write and read the sector buffer with FF's and 0's.
3. Verify sequencer ram.
4. Test sequencer rollover registers.
5. Perform a butterfly seek test.
6. Verify that KONI's FIFO is functioning correctly (SCSI).

2.3.AT Superset Commands

The diagnostic mode must be enabled prior to executing any diagnostic command. Executing a diagnostic command in normal mode will set the Error and Abort bits. The AT diagnostic commands are enabled by sending an extended command F0H with the Sector Count register set to 9. The 9-byte key information (see Send Diagnostic for AT) are sent to the drive using the special handshake method described below. The diagnostic mode is always disabled on power-up or after a host Reset. The diagnostic commands are sent by setting the Command register to FFH.

After the drive has decoded the command and is ready to accept the command bytes, it resets Busy. The host then puts the first command byte (CDB0) into the Command register causing Busy to be set. After the drive receives this byte, it again resets Busy signalling that it is ready for the another byte. All ten CDB bytes are communicated in this manner. In general, input parameters for the diagnostic commands are sent to the drive using the following handshake: 1. wait for not Busy 2. write to Command register 3. repeat from step 1 for the next byte. Information is returned from the drive with the following handshake: 1. wait for DRQ 2. read data from Error register 3. write a zero to Command register 4. wait for not Busy 5. if DRQ is set, repeat from step 2 for another byte.

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2.3.1. AT Extended Command

	7	6	5	4	3	2	1	0
1F1								
1F2	Sector Count = 9							
1F3	Sector = 0							
1F4	Cylinder Low = 0							
1F5	Cylinder High = 0							
1F6	N/A			Drive	Head = 0			
1F7	Command = 0F0h							

The AT diagnostic commands are enabled or disabled by sending an Extended command to the drive. The Extended command is also used for the Send Configuration, Read Configuration, Read Error Log, and Read Defect Tables commands. These commands are explained later.

The sector count register is used to specify the number of bytes that will be transferred to the drive. A value other than nine will result in the Error and Aborted Command bits being set. The format of the 9 bytes sent to the drive is not the same as in the SCSI Send Diagnostic Command.

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2.4.Superset Command Descriptions

2.4.1.Command Summary

Sub Opcode	Command
00	Read Micro Memory
01	Write Micro Memory
02	Read Configuration
03	Write Configuration
04	Call Subroutine
05	Convert LBA To CHS
06	Compute Starting Sector
07	Read Command History
08	Read Cache Tables
09	Read ECC Results
0A	Seek Physical
0B	Seek Verify
0C	Read Physical
0D	Read Long Physical
0E	Write Physical
0F	Write Long Physical
10	Reassign Physical
11	Read Index Time
12	Read ID
13	Read Peak Amplitude - Not implemented in L Series products.
14	Microstep
15	Recalibrate
16	Erase Track
17	Erase Track Data
18	Format Track
19	Write Immediate
1A	Read Sequencer WCS
1B	Write Sequencer WCS
1C	Peek Buffer
1D	Poke Buffer
1E	Read Variables
1F	Factory Format

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Sub Opcode	Command
20	Start / Stop
21	Convert CHS To LBA
22	AT Mode Select
23	AT Mode Sense
41	Read A B Servo
43	Equalize A B
49	Prediction Control
4A	Read Tracks to Lock
4C	Read Runout Tables
4E	Read Thermistor
4F	Seek and Sample
60	Write Read-Channel
61	Set Write Current
62	Sequencer Trigger
63	Wedge Format
64	Window Margin Test
65	Extended Low Z
81	Servo Verify
82	Read Current Cylinder
85	Self Scan
86	Read Perr

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2.4.2.Read Micro Memory

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Microprocessor Memory Address - msb							
5	Microprocessor Memory Address - lsb							
6	Sub Opcode = 00h							
7	Transfer Length - msb							
8	Transfer Length - lsb							
9	Reserved = 0						F	L

This command is used to read the memory in the microprocessor's memory address space. The starting memory address is specified by the microprocessor memory address and the transfer length specifies the number of bytes to be read.

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2.4.3. Write Micro Memory

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Microprocessor Memory Address - msb							
5	Microprocessor Memory Address - lsb							
6	Sub Opcode = 01h							
7	Transfer Length - msb							
8	Transfer Length - lsb							
9	Reserved = 0						F	L

This command is used to write the memory in the microprocessor's memory address space. The starting memory address is specified by the microprocessor memory address and the transfer length specifies the number of bytes to be written.

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2.4.4.Read Configuration

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Page Number							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 02h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command is used to get drive configuration information, such as the drive model and serial number, from the drive. The information is organized in pages similar in concept to the Mode Select/Sense pages. The page to be returned is specified in page number. The write configuration command may be used to modify these pages.

Upon completion of the command, the number of bytes specified in the requested page is transferred to the host. ASCII fields are left-justified and filled with spaces on the right. Numeric fields are organized with the LSB being sent first.

Configuration data format

Page	Lengh	Contents
0	1	Customer number (binary data) 0 Generic. 1 Apple.
1	2	Jumper settings.
2	16	Vendor = ASCII "QUANTUM ".
3	16	Product identification = ASCII characters.
4	8	Drive revision level = ASCII characters.
5	12	Drive serial number = ASCII characters.
6	32	Customer name = ASCII characters.

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Page	Length	Contents			
7	6	AT configuration flags.			
		Byte	Bit	Description	
		0	0	1 = return page 7 logical CHS always.	
				0 = return current logical CHS	
			2	1 = disable wiggle retry.	
				0 = enable wiggle retry	
			4	save command history.	
		1	5-4	I/O read delay.	
				00	0 ns (default).
				01	10 ns.
				10	20 ns.
				11	30 ns.
		2-3		AT logical cylinders per drive.	
		4		AT logical heads per cylinder.	
		5		AT logical sectors per track.	
8	1	Number of heads.			
9	16	Configuration validation field.			
		0,1,0FF,2,0FE,3,0FD,4,0FC,5,0FB,6,0FA,7,0F9,8			
10	173	Zone table. (see next page)			
11	3	Number of user accessable sectors - lsb first.			
12	1	Trigger mask.		Bit - 0	
				Bit - 1	Seek timeout.
				Bit - 2	Seek fault.
				Bit - 3	
				Bit - 4	ECC error.
				Bit - 5	Sequencer read/write error.
				Bit - 6	Sequencer underrun/overrun.
				Bit - 7	Sequencer timeout.
13	2	Drive family and model.			

All pages can be read by the read configuration command, and all pages except page 1 can be written via the write configuration command. Both the host and the drive are expected to transfer the correct number of bytes for a given page based on the documented page length.

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Page 10 (zone table) is organized as follows:

Offset	Size (bytes)	Description
0	2	Zone 0 - starting cylinder.
2	3	Zone 0 - starting logical sector address.
5	1	Zone 0 - sectors per track.
6	2	Zone 0 - sectors per zone.
8	1	Zone 0 - track skew.
9	1	Zone 0 - cylinder skew.
10	2	Zone 0 - synthesizer frequency.
12	1	Zone 0 - servo filter bandwidth.
13	1	Zone 0 - servo threshold.
14	1	Zone 0 - servo agc.
15	1	Zone 0 - data recovery.
16	1	Zone 0 - threshold time constant.
17	1	Zone 0 - extended low z.
18	1	Zone 0 - head 0 write current.
19	1	Zone 0 - head 0 data threshold.
20	1	Zone 0 - head 0 data filter bandwidth
21	1	Zone 0 - head 0 data filter boost
22	1	Zone 0 - head 0 write precomp
23	1	Zone 0 - head 1 write current
24	1	Zone 0 - head 1 data threshold
25	1	Zone 0 - head 1 data filter bandwidth
26	1	Zone 0 - head 1 data filter boost
27	1	Zone 0 - head 1 write precomp
...		
	Repeat for heads 2 and 3	
...		
	Repeat for zones 1 through 15	
...		
608	2	Maximun cylinder.
610	3	Maximum logical sector address.

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2.4.5. Write Configuration

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				SP
2	Page Number							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 03h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command is used to write drive configuration information, such as the drive model and serial number, to the drive. The information is organized in pages similar in concept to the Mode Select/Sense pages. The page to be sent is specified in CDB2. The read configuration command may be used to read these pages.

The number of bytes implicit for the specified page are transferred from the host. ASCII fields are left justified and filled with spaces on the right. Numeric fields are organized with the least significant byte being sent first.

If the SP bit is set, the saveable configuration pages are written to disk. If it is a 0, the pages are only modified in memory.
Refer to read configuration for a description of the configuration pages.

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2.4.6. Call Subroutine

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Subroutine Address - msb							
3	Subroutine Address - lsb							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 04h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to call the subroutine whose address is specified in subroutine address. There are two purposes for the command. One is to be able to programmatically execute individual subroutines in the firmware to see that they work or to set up certain initial conditions. This command also allows for the implementation of quick and simple commands without the need to modify the command decode tables and the firmware documentation. This will also helps to reduce the proliferation of commands.

The unused bytes may be used freely for whatever purpose, such as transferring parameters to the subroutine.

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2.4.7.Convert LBA to CHS

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0			Phys	Next
2	Logical Block Address - msb							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address - lsb							
6	Sub Opcode = 05h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the physical address of the block specified by the logical block address, and the number of contiguous sectors that can be read starting at that address. The number of contiguous sectors is determined by the lesser of the number of sectors remaining on the track or the number of sectors until a spare or an offline spared sector is encountered.
If the Next bit is 0, the INIT_LBA_TO_CHS routine is invoked. If it is 1, the NEXT_LBA_TO_CHS routine is invoked. If the Phys bit is 0, the formatted sector is returned in all cases.
The returned data format is:

Byte	Contents
0	Cylinder - lsb.
1	Cylinder - msb.
2	Head.
3	Sector.
4	Number of contiguous sectors.

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2.4.8.Compute Starting Sector

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 06h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to calculate and return the sector number of the first physical sector on the track specified by cylinder and head. The appropriate cylinder and head skew values are factored into the calculation. Subsequent sector numbers can be derived by adding one to the starting sector and taking the result mod the number of sectors per track. The returned data format is:

Byte	Contents
0	Starting physical sector number for specified track.

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2.4.9.Read Command History

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 07h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return 512 bytes. The first two bytes returned indicates the length of the data to be returned. The next byte is the number of bytes per entry , and the next two bytes point to the next available entry in the command stack. The rest of the buffer (507 bytes) is the command stack data. (39 entries @ 13 bytes per entry)

In order to ease the host decoding logic, the last command entry in the buffer is not allowed to wrap around. Thus the first byte in the command buffer is always the first byte of a CDB for a command.

The returned data format is:

Byte	Content
0-1	0FBh. (507)
2	Bytes per entry. (13)
3-4	Offset within buffer.
5 - 511	Command history data.
	Data format is as follows per command:

Byte	AT 6 byte	AT 10 byte	SCSI 6 byte	SCSI 10 byte
0	CDB0	CDB0	CDB0	CDB0
1	CDB1	CDB1	CDB1	CDB1
2	CDB2	CDB2	CDB2	CDB2
3	CDB3	CDB3	CDB3	CDB3
4	CDB4	CDB4	CDB4	CDB4
5	CDB5	CDB5	CDB5	CDB5
6	A0	CDB6	S0	CDB6
7	F0	CDB7	F0	CDB7
8	F1	CDB8	F1	CDB8
9	F2	CDB9	F2	CDB9
10	Error code	Error code	Error code	Error code
11	A1	A1	Initiator ID	Initiator ID
12	Cache status	Cache status	Cache status	Cache status

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2.4.10.Read Cache Tables

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 08h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the status of the cache and the cache tables. It returns the segment number of the segment last accessed, the status of the segment (whether it was a hit or a miss) and the cache table entries for all segments.

The number of bytes returned depends on the number of segments in the cache. There are 6 bytes of data for each cache segment. The returned data format is:

Cache Header:	Byte	Content
	0-1	Number of bytes in the cache table (lsb first).
	2	Segment number of last segment accessed.
	3	Cache hit/miss flag: 0 = miss, 1 = hit.
	4-n	Cache tables for all cache segments.

Cache Table:Byte	Content	(one per cache segment)
	0-2	Lower cache LBA (lsb first).
	3	Number of blocks in the entry.
	4	Upper byte of rollover register.
	5	Upper byte of rollunder register.

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2.4.11. Read ECC Results

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 09h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the latest values for ECC variables. Data format is as follows:

Byte	Contents	
0	Number of errors:	Bits 0-1 = Number of errors in interleave 0.
		Bits 2-3 = Number of errors in interleave 1.
		Bits 4-5 = Number of errors in interleave 2.
1-2	Location of the first error in interleave 0 (lsb first).	
3	Value of the first error in interleave 0.	
4-5	Location of the first error in interleave 1 (lsb first).	
6	Value of the first error in interleave 1.	
7-8	Location of the first error in interleave 2 (lsb first).	
9	Value of the first error in interleave 2.	
10-11	Location of the second error in interleave 0 (lsb first).	
12	Value of the second error in interleave 0.	
13-14	Location of the second error in interleave 1 (lsb first).	
15	Value of the second error in interleave 1.	
16-17	Location of the second error in interleave 2 (lsb first).	
18	Value of the second error in interleave 2.	

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2.4.12.Seek Physical

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved		MON	CCD	SD
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Sector							
6	Sub Opcode = 0Ah							
7	Transfer Length - msb							
8	Transfer Length - lsb							
9	Reserved = 0						F	L

This command causes the drive to seek to the physical track specified in cylinder and head.

If ccd (cylinder check disable) is set to 1, This allows single step seeks beyond cylinder -10.

If sd (send data) is set to 1, send the seek time to the host.
If mon (monitor servo) is set to 1, servo variables are recorded after each interrupt and sent back to the host.

Byte	Contents
0	Seek time - lsb.
1	Seek time - msb.

Limitation: the seek timer can only return values up to 65534uS.

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2.4.13. Seek Verify

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 0Bh							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command is similar to the seek physical command except that the seek verify command reads the first header it can find after a seek and verifies that it seeked to the correct target cylinder.

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2.4.14. Read Physical

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Sector							
6	Sub Opcode = 0Ch							
7	Transfer Length - msb							
8	Transfer Length - lsb							
9	Reserved = 0						F	L

This command causes the drive to read the number of sectors specified in transfer length from the physical address specified in cylinder, head and sector. It also dirties all segments of the cache.

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2.4.15. Read Long Physical

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Sector							
6	Sub Opcode = 0Dh							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command is similar to the read physical command except that it returns the ECC field in addition to the data field.

This command causes the drive to read the data and ECC field for the sector specified in cylinder, head and sector. It also dirties the current segment in the cache.

This command returns 526 bytes per sector; the first 512 are the data bytes, followed by 2 crosscheck bytes, the last 12 bytes are ECC bytes.

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2.4.16. Write Physical

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Sector							
6	Sub Opcode = 0Eh							
7	Transfer Length - msb							
8	Transfer Length - lsb							
9	Reserved = 0						F	L

This command causes the drive to write the number of sectors specified in transfer length to the physical address specified in cylinder, head and sector. It also dirties all segments of the cache.

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2.4.17.Write Long Physical

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Sector							
6	Sub Opcode = 0Fh							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command is similar to the write physical command except that it writes the ECC field in addition to the data field. This command causes the drive to write the data and ECC fields for the sector specified in cylinder, head and sector. It also dirties the current segment in the cache.

This command expects 526 bytes per sector; the first 512 are the data bytes, followed by 2 crosscheck bytes, the last 12 bytes are ECC bytes.

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2.4.18. Reassign Physical

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Sector							
6	Sub Opcode = 10h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to reassign the physical sector whose address is specified in cylinder, head and sector.

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2.4.19. Read Index Time

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 11h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to determine the time between index pulses and return the value in microseconds. The returned data format is:

Byte	Contents
0-1	Index time (lsb first).

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2.4.20. Read Id

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				Long
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 12h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to read and return all ID fields on the current cylinder and head, starting at index. If the long bit is set to 1, the ID's and the CRC bytes are sent back to the host. The data format is:

Byte	Content
0	Sector count.
1 - n	ID data.

8 bytes per wedge ID in the following order if Long = 0:

i+0	Count byte 2.
i+1	Count byte 1.
i+2	Count byte 0.
i+3	Flag byte.
i+4	Sector.
i+5	Head.
i+6	Sequencer status.
i+7	Sequencer error status.
Note:	512 bytes is always returned to the host.

12 bytes per wedge ID in the following order if Long = 1:

i+0	Count byte 2.
i+1	Count byte 1.
i+2	Count byte 0.
i+3	Flag byte.
i+4	Sector.
i+5	Head.
i+6	CRC.
i+7	CRC.
i+8	CRC.
i+9	0FFh.
i+10	Sequencer status.
i+11	Sequencer error status.
Note:	1024 bytes is always returned to the host. This data is also used by format track long.

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2.4.21. Read Peak Amplitude

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 13h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to read the peak amplitude of the read signal, the returned data format is:

Byte	Content
0-1	Peak Amplitude

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2.4.22. Microstep

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				Inf
2	Micro Step Count - msb							
3	Micro Step Count - lsb							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 14h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to move the head position by the number of microsteps specified in the parameter micro step count. If inf (In Flag) is 1, then the drive microsteps inwards, otherwise, it microsteps outwards.

1 microstep = 1/2048 of 1 track.

NOTE: Currently, this command has not been implemented.

Use Write Micro Memory (wrmm) to "pos_offs" variable(2's complement) to move offtrack.
Scale = 512 Counts / Track

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2.4.23. Recalibrate

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 15h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to recalibrate to cylinder 0.

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2.4.24. Erase Track

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 16h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to DC erase a track at the specified head of the current cylinder. The servo information is preserved.

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2.4.25. Erase Track Data

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				Inf
2	Reserved = 0							
3	Step Size							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 17h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to DC erase a track data area using the following method:

1. DC erase track data on the current position.
2. Move the number of steps specified by step size.
3. DC erase track data.
4. Move the number of steps specified by step size.
5. DC erase track data.

The move direction is inward if inf (IN Flag) is 1, and outward if inf is 0. The head number of the area to erase is specified by the head parameter.

There are two main differences between this command and the ERASE TRACK command. This command erases at the current head position and two positions offset from the current position, and it preserves the servo bursts which ERASE TRACK command does not.

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2.4.26. Format Track

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			0	Long	Neg	FD	SD
2	Reserved = 0							
3	Data Pattern							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 18h							
7	Parameter List Length - msb							
8	Parameter List Length - lsb							
9	Reserved = 0						F	L

Format the desired cylinder with IDs provided by the HOST. The value provided in CDB3 will be used during the write update portion of the format. This value will be written throughout the data sector. Long is normally set to 0. If Long is set to 1, a format long operation will be performed. Format long writes the id field count bytes, head and sector numbers, AND the CRC bytes using data from the HOST_READ_ID command with the Long bit set. (read id long)

SD bit - If this bit is set to 1, data is sent from the host. If it is set to 0, the system cylinders CANNOT be formatted. The reason for this is due to the fact that the count byte info is stored in this area. If you format this area, you lose the information. If SD is set to 1, the ID field data format for each sector is as follows:

Byte	Content
0	Count byte 2.
1	Count byte 1.
2	Count byte 0.
3	Sector.
4	Head.
5	Flag byte.

Count byte = (number of bytes in data segment / 4) - 1

FD bit - If this bit is set = 1, the whole drive is formatted from cylinder 0 to the last cylinder using the count byte information stored on the system cylinder. The system cylinders are excluded.

Neg bit - If this bit is set, the negative cylinders will be formatted.

Long bit - Format long - Format the track using data fromRead ID long. This data includes the CRC bytes. NOTE: Read Id long must be done before this command is issued. No data is taken from the host at this time.

NOTE: Formatting individual tracks with this command may alter certain tracks on the drive which may have been formatted with inline sparing (factory format). This will confuse defect management. Be careful.

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2.4.27. Write Immediate

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 19h							
7	Reserved = 0							
8	Number of Sectors							
9	Reserved = 0						F	L

This command causes the drive to seek to the specified cylinder and head, read the next available ID and start writing to the next available sector. The number of sectors field specifies the maximum number of sectors the command will write. Data used in writing to the sectors are taken from location 0 (and up) of the buffer RAM. Therefore, the user should use a write buffer command (opcode 3BH) to pre-fill the drive's buffer with the desired data. Head and Cylinder switching is not supported so the number of sectors may not be written.

This command is normally used to test settling.

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2.4.28. Read Sequencer WCS

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 1Ah							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the 124 bytes of microprogram in the sequencer's Writable Control Store. The data is organized as 31 words of 4-byte instructions in the following format:

Byte	Content
0-3	Instruction word at address 0 (MSB first)
...	
92-95	Instruction word at address 31 (MSB first).

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2.4.29. Write Sequencer WCS

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 1Bh							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to accept 124 bytes of microprogram from the host and download it to the sequencer's Writable Control Store. The data is organized as 31 words of 4-byte instruction in the following format:

Byte	Content
0-3	Instruction word at address 0 (MSB first)
. . .	
92-95	Instruction word at address 23 (MSB first).

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2.4.30. Peek Buffer

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Page Number							
4	Buffer Memory Address - msb							
5	Buffer Memory Address - lsb							
6	Sub Opcode = 1Ch							
7	Transfer Length - msb							
8	Transfer Length - lsb							
9	Reserved = 0						F	L

This command is used to read the contents of the cache buffer RAM. The starting buffer location is specified by the buffer memory address. Transfer length specifies the number of bytes to be read.

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2.4.31.Poke Buffer

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Page Number							
4	Buffer Memory Address - msb							
5	Buffer Memory Address - lsb							
6	Sub Opcode = 1Dh							
7	Transfer Length - msb							
8	Transfer Length - lsb							
9	Reserved = 0						F	L

This command is used to write to the cache buffer RAM. The starting buffer location is specified by the buffer memory address. Transfer length specifies the number of bytes to be written.

2.4.32. Read Variables

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 1Eh							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return a table of pointers to a group of internal firmware variables. The host may use this information along with the read/write micro memory, peekbuf, and/or pokebuf commands to gain indirect access to the firmware variables. The list of pointers chosen to be returned from read variables is product specific - catered to product debugging and testing. The returned data format is:

Byte	Content
0	Number of pointers.
1-2	Pointer to first variable - lsb first.
3	Variable location. 0 = microprocessor ram. 1 = buffer ram.
4-6	Next variable pointer and location.
...	

2.4.33. Factory Format

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			1	1	1	0	1
2	Data Pattern							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 1Fh							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to perform a "high level" drive format operation. It is included primarily to allow diagnostic software to factory format the drive. This format command performs the following functions:

1. Create the primary defect list with incoming physical defect descriptors.
2. Store the new P list to the disk, erasing the old P list.
3. Create a new W list from the new P list information.
4. Unformat the old inlines, if any.
5. Create new inlines using the new W list.
6. Store the new W list to the disk, erasing the old W list - Note: Grown defect information is lost.

Header Block

0	00h
1	00h
2	Transfer Length - msb
3	Transfer Length - lsb

Transfer length is = number of

Descriptor block for each defect-Wedge

0	Cylinder - msb
1	Cylinder - lsb
2	Head
3	Wedge
4	Bytes from wedge - msb
5	Bytes from wedge - lsb
6	Defect Length - msb

Descriptor block for each defect - CHS

0	Cylinder - msb
1	cylinder
2	Head
3	0FFh
4	Reserved = 0
5	Reserved = 0
6	Reserved = 0

Physical descriptor data format. (taken from SCSI spec.)

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2.4.34. Start / Stop

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				IMM
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0						M	S/L
5	Reserved = 0							
6	Sub Opcode = 20h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command requests the drive to spin up or spin down.

If S/L flag is 1, the spin up and recalibration procedure is performed and further drive operations are enabled. If S/L is 0, the drive is spun down or parked depending on the M bit. Further operations requiring read/write and mechanical functionalities are disabled.

If M is 0, Start/Stop will be performed. If M is 1, Load/Unload will be performed.

If IMM is 1, the drive will return with completion status as soon as the operation is initiated. If it is 0, the drive will remain busy until the operation is completed.

M	S/L	Operation	Description
0	0	Stop	Park & spin down.
0	1	Start	Unpark and spin up.
1	0	Load	Unpark and spin up.
1	1	Unload	Park and spin up.

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2.4.35.CHS to LBA

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Sector							
6	Sub Opcode = 21h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

Convert the given CHS to an LBA. This command uses defect management to assign a correct LBA to the CHS. An Invalid LBA error is returned if the given CHS is not associated with an LBA. This can occur if the given CHS is an alternate sector with no defect assigned to it. The 3 byte LBA is returned msb first.

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2.4.36.AT Mode Select

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				SP
2	Reserved = 0							
3	Reserved = 0							
4	Parameter List Length (bytes)							
5	Reserved = 0							
6	Sub Opcode = 22h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

The MODE SELECT command allows the initiator to specify device parameters to the drive. A MODE SELECT command will override any previous selection of device parameters. When the drive motor spins up at power on, the drive reads the set of device parameters most recently saved, from a reserved cylinder. See the Saved Mode Table.

- If the drive cannot successfully read the parameter values from the Saved Mode Table, these values will revert to their defaults and the additional sense code will be set to Mode Select Parameter Changed, as though another initiator had altered the parameters.

- If the drive can successfully read the parameter values, it will set the additional sense code to Drive Reset, to indicate a reset condition.

SP - Save Parameters

When SP is set to one, only the pages of the Current Mode Table that can be saved will be copied to the Saved Mode Table.

Parameter List Length

Specifies the length of the MODE SELECT parameter list transferred during the DATA OUT phase, in bytes. A parameter list length of zero indicates that the drive will transfer no data.

2.4.37.MODE SELECT Parameter List

MODE SELECT parameter list shown on the following page, contains a four-byte header, followed by zero or one block descriptors, then zero or more pages.

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Mode Select Header

	7	6	5	4	3	2	1	0
0	Reserved = 0							
1	Medium Type = 0							
2	Reserved = 0							
3	Block Descriptor Length (Bytes)							

Block Descriptor

	7	6	5	4	3	2	1	0
0	Density Code = 0							
1-3	(MSB) Number of Blocks (LSB)							
4	Reserved = 0							
5-7	Block Length							

Page Descriptors

	7	6	5	4	3	2	1	0
0	Reserved=0		Page Code					
1	Page Length							
2-n	Refer to Pages Definition							

Medium Type

Set to zero - the current medium type - by default, because the drive has nonremovable media.

Block Descriptor Length

Specifies the length of all of the block descriptors, in bytes. This value is equal to the number of block descriptors times eight. It does not include the pages, if any. A block descriptor length of zero indicates the drive includes no block descriptors in the parameter list. The Flash hard disk drive uses a single block descriptor.

Block Descriptor

Specifies the media characteristics of the drive, including its logical block length, density code, and number of blocks.

Density Code

Set to zero. This parameter is not used by direct-access devices.

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Number of Blocks

Specifies the number of logical blocks on the media that match the density code and block length in the block descriptor. A value of zero indicates that all remaining logical blocks on the drive have the media characteristics specifies by the block descriptor. Any non zero value within the capacity of the drive can limit access to a specified number of blocks.

Block Length

Specifies the length of each logical block described by the block descriptor, in bytes. For the Flash hard disk drive, only a block length of 512 is allowed.

PAGE DESCRIPTORS:

Page Code

Pages are optional. They can be included in any order, immediately following the block descriptor. To avoid the specification of all mode parameter each time the initiator issues a MODE SELECT command, the mode parameter are divided into pages. A page is the smallest unit that can be specified in a MODE SELECT or MODE SENSE command. Each time an initiator accesses a page, all parameters on that page must be specified. Modifiable parameters can be set to any acceptable value. Unmodifiable parameters must be set to zero. Pages are numbered for reference. Each page contains parameters grouped by functionality. For example, page 1 contains the read/write error, including the retry count parameter, and bits that turn error detection on or off, and determine whether the drive reports soft errors. The drive supports the pages as shown.

Mode Pages Supported by the FLASH Hard Disk Drive

Page	Description
01H	Read/Write Error-Recovery Parameters
02H	Disconnect/Reconnect Control Parameters
03H	Direct-Access Device Format Parameters*
04H	Rigid Disk-Drive Geometry Parameters*
08H	Cache-Control Parameters
0CH	Notch and Partition Parameters
32H	Automatic-Shutdown Control Parameters
37H	Quantum-Unique Control Parameters

Note: *Read only. Can be accessed only via the MODE SENSE command.

Page Length

Indicates the number of bytes for the page that follows, beginning with the first byte of flags or values, then continuing with consecutive bytes. The page length must be set to the value returned by the drvie in the MODE SENSE page length byte.

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2.4.38. Error-Recovery Parameters, Page Code 1H

Error-Recovery Parameters

	7	6	5	4	3	2	1	0
0	Reserved=0		Page Code 01h					
1	Page Length = 06h							
2	AWRE	ARRE	TB	RC	EEC	PER	DTE	DCR
3	Retry Count							
4	Correction Span							
5	Head Offset Count = 10 (0Ah)							
6	Data Strobe Offset Count = 0							
7	Recovery Time Limit = 0							

DCR - Disable Correction

When set to one, DCR indicates that the data will be transferred without double burst error correction, whether or not correction is possible. When set to zero, this bit indicates that the data will be corrected, if possible. Uncorrectable data will be transferred without attempting error-correction; however, retries will be attempted. If RC is set to one, the drive ignores this bit. The default is zero.

DTE - Disable Transfer on Error

When set to one PER is also set to one, DTE indicates that the drive will enter CHECK CONDITION status immediately on detecting an error. The drive will terminate data transfer to the initiator. The block in error may or may not be transferred to the initiator, depending on the setting of the TB bit. ADTE bit set to zero enables data transfer for any data that can be recovered within the limits of the error-recovery flags. Errors are not posted until the transfer length is exhausted. If PER is zero or RC is one, the drive ignores this bit. The default is zero.

PER - Post Error

When set to zero, PER indicates that the drive will not report error on errors recovered within the limits established by the other error-recovery flags. Recovery procedures that exceed the limits established by the other error-recovery flags will be posted. The data transfer may terminate prior to exhausting the transfer length, depending on the error and state of the other error-recovery flags. A PER bit set to one enables error to be reported for detected errors, with the appropriate sense key. If error occur, the sense data will report the logical block address at which the unrecoverable error occurred. If no unrecoverable error occurred, the sense data will report the last block in which a recovered error occurred. The default is zero.

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EEC - Enable Early Correction

When EEC is set to one, the drive will use its ECC algorithm if it detects two consecutive, equal, non zero error syndromes. The drive will not perform read retries before applying correction, unless it determines that the error is uncorrectable. Seek or positioning retries, and the message system's recovery-procedure retries are not affected by the EEC bit's value. When set to zero, the drive will use its normal recovery procedures when an error occurs. If the RC bit is one, the drive ignores this bit. The default is zero.

RC - Read Continuous

When RC is set to one, the drive transfers data of the requested length, with out adding delays that would increase data integrity - that is, delays caused by the drive's error-recovery scheme. To maintain a continuous flow of data and avoid delays, the drive may send data that is erroneous. When set to zero, time-consuming, error-recovery operations are acceptable during data transfer. The default is zero.

ARRE - Automatic Read Reallocation Enabled

When ARRE is set to one, the drive will enable automatic reallocation of the bad blocks. Automatic reallocation functions similarly to the REASSIGN BLOCKS command, but is initiated by the drive when it encounters a hard error - that is, when it encounters the same non zero ECC syndrome on two consecutive retries. When set to zero, the drive will not automatically reallocate bad blocks. When RC is one, the drive ignores this bit. The default is zero.

AWRE - Automatic Write Reallocation Enabled

When AWRE is set to one, the drive enables automatic reallocation of bad blocks. Automatic Write Reallocation is similar in function to Automatic Read Reallocation, but is initiated by the drive when a defective block becomes inaccessible for writes. When set to zero, the drive will not automatically reallocate bad blocks.

Retry Count

The number of times the drive will attempt to recover from a data error by rereading before it applies error correction. The default is eight.

Correction Span

Specifies the size, in bits, of the largest read data error on which correction can be attempted. Values range from eight to sixteen. The default is sixteen.

Head Offset Count

Set to 10, read only, indicates that of all on-track retries have failed, the drive will attempt to recover the data with a series of off-track reads. The reads will be performed 10 microsteps off center (approximately 1/25 of a track), on both sides of the track.

The Table on the following page summarizes the valid modes of operation for the FLASH hard disk drive.

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Modes of Operation

EEC	PER	DTE	DCR	Description
0	0	0	0	Normal error-recovery procedure. The drive attempts read retries until it reads good data, obtains a stable syndrome, or exhausts the retry count. When correction is possible, the drive invokes ECC. Data transfer is complete, unless the drive encounters an uncorrectable error. The drive reports only uncorrectable errors.
0	0	0	1	Same as 0,0,0,0 - except the drive attempts no ECC correction. If read retries are unsuccessful, the drive stops the data transfer and reports an unrecoverable error.
0	0	1	0	Invalid Request
0	0	1	1	Invalid Request
0	1	0	0	Same as 0,0,0,0 - except the drive reports all recoverable and unrecoverable data errors. The drive reports a recoverable error after the data transfer is complete.
0	1	0	1	Same as 0,0,0,0 - except the drive reports all data errors. The drive reports a data error recovered through read retries after the data transfer is complete.
0	1	1	0	The drive attempts read retries until it reads good data, obtains stable syndrome, or exhausts the retry count. If error correction is possible, the drive invokes ECC. The drive stops data transfer on detecting an error and reports all data errors.
0	1	1	1	Same as 0,1,1,0 - except the drive attempts no ECC correction. If read retries are unsuccessful, the drive reports an error as unrecoverable.
1	0	0	0	If error correction is possible, the drive immediately invokes ECC. If an error is uncorrectable, the drive attempts read retries until it reads good data, obtains a stable syndrome, or exhausts the retry count. Data transfer is complete, unless the drive encounters an unrecoverable error. The drive reports only unrecoverable errors.
1	0	0	1	Invalid Request
1	0	1	0	Invalid Request
1	0	1	1	Invalid Request
1	1	0	0	Same as 1,0,0,0 - except the drive reports all data errors. The drive reports a recoverable error after the data transfer is complete.
1	1	0	1	Invalid Request
1	1	1	0	Same as 1,0,0,0 - except the drive stops the data transfer on detecting a recoverable or unrecoverable error, and reports all data errors.
1	1	1	1	Invalid Request

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2.4.39. Disconnect/Reconnect Control Parameters, Page Code 2H

	7	6	5	4	3	2	1	0
0	Reserved = 0		Page Code = 02h					
1	Page Length = 0Ah							
2	Buffer Full Ratio							
3	Buffer Empty Ratio							
4-11	Reserved = 0							

Disconnect/Reconnect Control Parameters

Buffer Full Ratio

On reads, the drive disconnects when the buffer contains no data. For commands that require data transfer to the initiator, the buffer full ratio represents the percentage of the buffer that must become full before the drive will reconnect - unless the buffer can hold all requested data. A buffer full ratio of 128 represents 100% full, 64 represents 50% full, and so on. Each bit represents 1/128 of the maximum buffer size. The default value is 92.

Buffer Empty Ratio

For commands that require data transfer from the initiator, the buffer empty ratio represents the percentage of the buffer that must become empty before the drive will reconnect to fetch more data - unless the buffer can hold all requested data. A buffer empty ratio of 128 represents 100% empty, 64 represents 50% empty, and so on. Each bit represents 1/128 of the maximum buffer size. The default value is 32.

Note: For commands that require a logical block transfer, the drive rounds the buffer full ratio down and the buffer empty ratio up, to the nearest multiple of 512 bytes.

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2.4.40.Direct - Access Device Format, Page Code 03H

Direct - Access Device Format

	7	6	5	4	3	2	1	0
0	Reserved=0		Opcode = 03h					
1	Opcode =16h							
2-3	Track per Zone							
4-5	Alternate Sectors per Zone							
6-7	Alternate Tracks per Zone							
8-9	Alternate Tracks per Logical Unit							
10-11	Sectors per Track							
12-13	Data Bytes per Physical Sector							
14-15	Interleave							
16-17	Track Shew Factor							
18-19	Cylinder Shew Factor							
20	ssec=0	hsec=1	rmb=0	surf=0	Reserved = 0			

Note: The drive uses only the default values for the fields in bytes 2-9 and ignores any other values.

DEFECT - HANDLING FIELDS:

Tracks per Zone (Bytes 2 - 3)

The value in this field indicates the number of tracks per defect zone.

Alternate Sectors per Zone (Bytes 4 - 5)

The value in this field indicates that the drive will deallocate one sector per zone from the initiator-addressable blocks on execution of the FORMAT UNIT command. These sectors are available as replacement sectors for defective sectors.

Alternate Tracks per Zone (Bytes 6 - 7)

Set to zero. The drive does not allocate alternate tracks.

Alternate Tracks per Volume (Bytes 8 - 9)

Set to zero. The drive does not allocate alternate tracks.

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TRACK - FORMAT FIELD:

Sectors per Track (Bytes 10 - 11)

The value in this field indicates the number of physical sectors the drive allocates per track. Set to zero, indicating that the drive has a variable number of sectors per track.

SECTOR - FORMAT FIELDS:

Data Bytes per Physical Sector (Bytes 12 - 13)

This parameter indicates the number of data bytes the drive allocates per physical sector. This value may be different from the block descriptor length specified in the MODE SELECT parameters. Each physical sector on the drive contains 512 data bytes.

Interleave (Bytes 14 - 15)

The drive has an interleave factor of one.

Track Skew Factor (Bytes 16 - 17)

This parameter indicates the number of physical sectors between the last logical block on one cylinder and the first logical block on the next sequential cylinder.

Cylinder Skew Factor (Bytes 18 - 19)

This parameter indicates the number of physical sectors between the last logical block on one cylinder and the first logical block on the next sequential cylinder.

SSEC - Soft Sector

SSEC is always set to one, indicating that the FLASH hard disk drive uses soft sector formatting.

HSEC - Hard Sector

HSEC is always set to zero, indicating that the FLASH hard disk drive does not use hard sector formatting. The HSEC and SSEC bits are mutually exclusive.

RMB - Removable

Set to zero for the FLASH hard disk drive, indicating that the logical unit is not removable.

SURF - Surface

Set to zero, indicating that the drive allocates successive addresses to all sectors within a cylinder, prior to allocating sector addresses to the next cylinder.

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2.4.41.Cache Control, Page Code 08H

Cache Control

	7	6	5	4	3	2	1	0
0	Reserved=0		Page Code = 08h					
1	Page Length = 0Ah							
2	Reserved = 0					WCE	MS=0	RCD
3	Demand Read Retension Priority = 0				Write Retension Priority = 0			
4-5	Disable Fetch				Transfer Length = 0			
6-7	(MSB) Minimum Prefetch (LSB)							
8-9	(MSB) Maximum Prefetch (LSB)							
10-11	Maximum Prefetching Ceiling							

The Cache Control Parameters page specifies the parameters that control the operation of the cache. This page and page 37h should be used to control the caching parameters. Parameters set in either page cause the drive to automatically set the corresponding parameters in the other page.

WCE - Write Cache Enable

Set to one by default, indicating that the drive returns GOOD status for a WRITE command after successfully receiving the data, but before writing it to the disk. A value of zero indicates that the drive returns GOOD status for a WRITE command after successfully receiving the data and writing it to the disk.

MS - Multiple Selection

Not Supported.

RCD - Read Cache Disable

Set to zero by default, indicating that the FLASH hard disk drive can return some or all of the data requested by a READ command by accessing the cache, rather than the disk. When the RCD bit is set to one, the drive must read all requested data from disk and cannot return any data by accessing the cache. Setting the RCD bit to one causes the drive to automatically set the PE and CE bits in page 37h. Setting the CE bit in page 37h causes the drive to turn on the RCD bit in this page.

When prefetching data, the drive reads data not yet specifically requested by an initiator and stores it in the cache - usually in conjunction with reading requested data from disk. Prefetching always begins at the logical block immediately following the last logical block previously read and always stops before the end of the media. The drive reports no errors to the initiator during prefetching, unless it is unable to execute subsequent commands successfully due to the error. Subsequent parameters indicate how much additional data the drive will read and store in the cache following a READ command.

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Minimum Prefetch (Bytes 6 -7)

This parameter specifies the minimum number of blocks the drive will prefetch despite any delay prefetching might cause in the execution of subsequent commands. When set to zero, the drive terminates prefetching whenever another command is ready for execution. The value is set at zero, is read-only, and is not changeable.

Maximum Prefetch (Bytes 8 - 9)

This parameter specifies the maximum number of blocks the drive will prefetch following a READ command - if prefetching would cause no delay in the execution of subsequent commands. The value is set at 128, read-only, and is not changeable.

2.4.42.Notch and Partition, Page Code 0CH

	7	6	5	4	3	2	1	0
0	PS=0	RSVD=0	Page Code = 0Ch					
1	Page Length = 16h							
2	ND=1	PLN	Reserved = 0					
3	Reserved =0							
4-5	Maximum Number of Notches							
6-7	Active Notch							
8-11	Starting Boundary							
12-15	Ending Baundary							
16-23	Page Notched							

Notch and Partitioning

PS - Parameters Savable

The MODE SENSE command reserves this bit for its use. In the FLASH hard disk drive, PS is set to zero, indicating that the drive does not save the page.

ND - Notched Drive

This parameter indicates whether the drive is notched or not. Each notch has a different numbers of blocks per cylinder. When set to zero, ND indicates that the device is not notched. The drive returns all other parameters in the page as zero. When set to one, ND indicates that the device is notched. The FLASH hard disk drive is a notched device - that is, ND is set to one. This is a read-only parameter.

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PLN - Physical or Logical Notch

This parameter indicates whether the notch boundaries are physical or logical locations on the drive. When PLN is set to zero, the drive uses physical notch boundaries. Physical locations are defined by cylinder and head. When PLN is set to one, the drive uses logical notch boundaries. Logical locations are defined by logical block address. The FLASH hard disk drive uses physical notch boundaries - PLN is set to zero. This is a read-only parameter.

Maximum Number of Notches (Bytes 4 - 5)

This parameter defines the maximum number of notches supported by the drive. The FLASH hard disk drive supports a maximum of sixteen notches. This is a read-only parameter.

Active Notch (Bytes 6 - 7)

This parameter indicates the notch to which this and subsequent MODE SELECT and MODE SENSE commands refer - until a later MODE SELECT command changes this parameter. When this parameter is set to zero, this and subsequent MODE SELECT and MODE SENSE commands refer to those parameters that apply across notches. For the FLASH hard disk drive, valid notch numbers range from zero to fifteen. This is the only Notch and Partition Page parameter that can be set by the MODE SELECT command.

Starting Boundary (Bytes 8 - 11)

This parameter defines the starting address of the active notch. When active notch is set to zero, this parameter defines the starting address of the logical unit. For all drives, bytes 8-10 define the cylinder and byte 11 defines the head. This is a read-only parameter.

Ending Boundary (Bytes 12 - 15)

This parameter defines the ending address of the active notch. Only the MODE SENSE command can set this parameter. When active notch is set to zero, this parameter defines the ending address of the logical unit. For all drives, bytes 12-14 define the cylinder and byte 15 defines the head. This is a read-only parameter.

Pages Notched (Bytes 16 - 23)

This parameter consists of a bit map of the mode page codes that indicates pages containing parameters that can be differnt for differnt notches. The most significant bit of this field corresponds to page 3Fh; the least significant bit, to page 00h. When a bit is set to one, the corresponding mode page contains parameters that can be differnt for differnt notches. When a bit is set to zero, the corresponding mode page contains parameters that are constant for all notches. For the FLASH hard disk drive, the bits corresponding to pages 03h and 0Ch are set to one, and are notch dependent. All other bits are set to zero. This is a read-only parameter.

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Starting and Ending Boundaries for Active Notches

Active Notch	Starting Boundary	Ending Boundary
15	2505	2670
14	2339	2504
13	2173	2338
12	2007	2172
11	1841	2006
10	1675	1840
9	1509	1674
8	1343	1508
7	1177	1342
6	1011	1176
5	845	1010
4	679	844
3	513	678
2	347	512
1	181	346
0	0	180

2.4.43.Automatic Shutdown Control, Page Code 32H

	7	6	5	4	3	2	1	0
0	Reserved =0		Page Code = 32h					
1	Page Length = 02h							
2	Auto Standby Time = 0							
3	Auto Shutdown Time (minutes)							

Automatic Shutdown Control

Auto Shutdown Time

The maximum time period, in minutes, the drive can remain deselected before entering power-shutdown mode. On entering this mode, the drive turns off its servo and motor circuitry, the optical encoder's LED, and 12-volt power, then puts the microprocessor in halt mode. When this byte is set to zero, auto shutdown is disabled. The default is zero.

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2.4.44.Quantum-Unique Control Parameters, Page Code 37H

	7	6	5	4	3	2	1	0
0	Reserved = 0		Page Code = 37h					
1	Page Length = 0Eh							
2	Reserved = 0				WIE	PO	PE	CE
3	Number of Cache Segments							
4	Minimum Prefetch							
5	Maximum Prefetch							
6-15	Reserved = 0							

Quantum-Unique Control Parameters

WIE - Write Index Enable

All write data reside in a cache segment that is indexed in the cache table. When WIE is set to one, the drive overwrites this segment for a cache hit on a read. When WIE is set to zero, the drive marks this segment as that least recently used. Thus, this segment is most likely to be overwritten on the next read or write, but can be accessed for a cache hit. This default is zero.

PO - Prefetch Only

When PO is set to one, the drive retains prefetch data only in the cache. The read data originally requested will be overwritten with prefetched data. When PO is set to zero, both the read data originally requested and prefetched data will be retained in the cache segment. The default is zero.

PE - Prefetch Enable

When PE is set to one, the drive prefetches data into the cache. When PE is set to zero, the drive will not prefetch data into the cache. To enable the PE bit, the CE bit must be set to one, the default. The drive automatically sets this bit when the RCD bit in page 8H is set to one.

CE - Cache Enable

When CE is set to one, the drive will activate caching on all reads. When CE is set to zero, the drive will disable caching and use the 256-kilobyte RAM only as a transfer buffer. The default is one. The drive automatically sets this bit when the RCD bit in page 8H is set to one. When the CE bit is set, the drive automatically turns on the RCD bit in page 8H

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Number of Cache Segments

This parameter indicates the number of segments the drive can index in the cache - that is, the number of entries in the cache table. The only valid entry is 4. Any other entry will result in a CHECK CONDITION status, with the sense key ILLEGAL REQUEST. The default is four. This byte is read-only.

Minimum Prefetch

This parameter indicates the minimum number of logical blocks the drive can prefetch on a cache miss for a READ command. The default is one and is not changeable. Setting this byte also sets the MINIMUM PREFETCH bytes in page 8H.

Maximum Prefetch

This parameter indicates the maximum number of logical blocks the drive can prefetch on a cache miss for a READ command. The default is 128 and is not changeable. Setting this byte also sets the MAXIMUM PREFETCH bytes in page 8H.

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2.4.45.AT Mode Sense

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	PCF		Page Code					
3	Reserved = 0							
4	Allocation Length							
5	Reserved = 0							
6	Sub Opcode = 23h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

PCF - Page Control Field

Defines the page parameter values to be returned. There are four options:

Report Current Values (PCF = 00h)
The drive returns the page defines by the page code to the initiator, with fields and bits set to the current values. The current values are either:

- Those set by the last MODE SELECT command successfully completed
- Identical to the values saved - if the initiator has issued no MODE SELECT command since the last power on or reset

Fields and bits not supported by the drive are set to zero.

Report Changeable Values (PCF = 01h)
The drive returns the page defined by the page code to the initiator, with all fields and bits that can be modified by the initiator set to one. Fields and bits that cannot be changed by the initiator are set to zero.

Report Default Values (PCF = 10h)
The drive returns the page defined by the page code to the initiator, with fields and bits set to the drive's default values - that is, as shipped from the factory. Fields and bits not supported by the drive are set to zero. To determine whether a returned value of zero indicates a default parameter or an unsupported parameter, the initiator can examine the modifiable values.

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Report Saved Values (PCF = 11h)
The drive returns the page defined by the page code to the initiator, with fields and bits set to the values saved. The values saved are either:

- Those set in the last MODE SELECT command successfully completed, with the Save Parameters bit (byte 1, bit 0) of the CDB set to one
- Identical to the default values - if no MODE SELECT command completed successfully, with the SP bit set

Fields and bits not supported by the drive are set to zero.

Page Code

For all page-control parameters, the value returned in the page-length byte indicates the number of bytes the drive supports within each page. This value must be specified in the page-length field (byte 1 of each page descriptor) when issuing the MODE SELECT command. The page code specifies the specific page information to be returned to the initiator in the MODE SENSE data. If a page code of zero is specified, no mode page information except the head and block descriptor is returned. The drive supports the pages shown below.

Mode Pages Supported by the FLASH Hard Disk Drive

Page	Description
01H	Read/Write Error-Recovery Parameters
02H	Disconnect/Reconnect Control Parameters
03H	Direct-Access Device Format Parameters (MODE SENSE only)
04H	Rigid Disk-Drive Geometry Parameters (MODE SENSE only)
08H	Cache-Control Parameters
0CH	Notch and Partition Parameters
32H	Automatic-Shutdown Control Parameters
37H	Quantum-Unique Control Parameters
3FH	Return all pages to the initiator (MODE SENSE only)

The MODE SENSE data provides information to the initiator about the drive's format parameter, if page 03h is specified, and its drive-geometry parameters, if page 04h is specified. If page 3Fh is specified, the drive returns information from all pages implemented to the initiator in the MODE SENSE data. This page code is valid only in the MODE SENSE command. Specifying page code 04h in a MODE SELECT command results in a err status.

Allocation Length

This parameter specifies the number of bytes the initiator has allocated for returned MODE SENSE data. An allocation length of zero indicates that the drive will transfer no MODE SENSE data. Any other value indicates the maximum number of bytes that the drive will transfer. The drive will terminate the DATA IN phase when it has transferred either the allocation-length bytes or all available MODE SENSE data to the initiator, whichever is less.

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2.4.46.Mode Sense Data

Header

	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	Medium Type = 0							
2	WP=0	Reserved = 0						
3	Block Descriptor Length = 08h							

Block Descriptor

	7	6	5	4	3	2	1	0
0	Density Code = 0							
1-3	Number of Blocks = 0							
4	Reserved = 0							
5-7	Block Length							

Page Descriptors

	7	6	5	4	3	2	1	0
0	PS	R=0	Page Code					
1	Page Length							
2-n	Refer to Pages Definition							

The MODE SENSE data, contain a four-byte header, followed by an eight-byte block descriptor, then zero or more pages. The meaning and organization of these data are the same as for the corresponding MODE SELECT data which are modified by the option specified in the page-control field of the CDB, byte 2.

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Sense Data Length

This parameter specifies the length, in bytes, of the MODE SENSE data to be transferred during the DATA IN phase. The sense data length does not include its own length.

WP - Write Protected

WP is always set to zero, indicating that the drive is write enabled.

Block Descriptor Length

This parameter specifies the length of all the Block Descriptors, in bytes, and is set to eight for the FLASH hard disk drive.

Block Descriptor

The block descriptor specifies the media characteristics of the drive-in its density code, number of blocks, and block length. These characteristics are the same as those in the corresponding fields in the MODE SELECT parameter list.

PAGE DESCRIPTORS:

PS - Parameters Saveable

When PS is set to zero in each page header, the drive cannot save the supported parameters on that page. When PS is set to one, the drive can save the supported parameters on that page. The drive can save all pages with parameters that can be modified by the initiator.

2.4.47.Direct - Access Device Format Parameters, Page Code 3H

The following are direct-access device format parameters. Notes to keep in mind while looking at the table are:

- The value for alternate tracks per zone is two for the FLASH 262 hard disk drive; four for the FLASH 525 hard disk drive.
- These fields contain parameters that are zone dependent. Their values vay depending on the active zone.

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Handling of Defects Fields

	7	6	5	4	3	2	1	0
2-3	Track per Zone							
4	Alternate Sectors per Zone = 0							
5	Alternate Sectors Per Zone = 1h							
6	Alternate Sectors per Zone = 0							
7	Alternate Tracks per Zone = 0							
8	Alternate Tracks per Volume = 0							
9	Alternate Tracks per Volume = 0							

Track Format Fields

	7	6	5	4	3	2	1	0
10	Sector per Track = 0							
11	Sectors per Track = 0							

Sector Format Fields

	7	6	5	4	3	2	1	0
12	Data Bytes per Physical Sector = 02h							
13	Data Bytes per Physical Sector =0							
14	Interleave = 0							
15	Interleave =01h							
16	Track Skew Factor = 0							
17	Track Skew Factor = 07h							
18	Cylinder Skew Factor = 0							
19	Cylinder Skew Factor = 0Fh							

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2.4.48.Rigid Disk Drive Geometry Parameters, Page Code 4H

Rigid Disk Geometry Parameters

	7	6	5	4	3	2	1	0
0	Reserved=0		Opcode = 04h					
1	Opcode =12h							
2	(MSB) Number of Cylinders = 0 *							
3	Number of Cylinders							
4	Number of Cylinders (LSB)							
5	Number of Heads (02h or 04h)							
6-8	Starting Cylinder-Write Precompensation = 0							
9-11	Starting Cylinder-Reduced Write Current = 0							
12-13	Drive Steps Rate							
14-16	Landing Zone Cylinders = 0							
17-19	Reserved = 0							

* These fields contain parameters that are zone dependent. Their values depend on the active zone.

The embedded SCSI controller on the FLASH hard disk drive handles the write precompensation stating cylinders, reduced write current starting cylinders, and drive step rate fields.

Landing Zone Cylinder (Bytes 14 - 16)

This parameter is set to zero, because the drive automatically parks the heads in the landing zone, using AIRLOCK, at power off. This field applies only to drives that do not automatically seek to the landing zone, before stopping the spindle motor.

2.4.49.Read A B Servos

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0			MBF	0t
2	Reserved = 0							
3	Reserved = 0							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 41h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

NOTE: The following description of the command is from Gemini Firmware Manual. For Flash, it may be different and will be updated for the next revision.

This command causes the drive to read and return the current amplitude of the A and B servos on the specified head in the following format:

Byte	Content
0	A servo (LSB first).
2	encoder error (LSB first).
4	B servo (LSB first).

If MBF (Multiple Burst Flag) is 1, all 55 servo bursts pairs found on the cylinders in the calibration area are returned. A total of 438 bytes are returned, the data format is:

Byte	Content
0	1st A servo (LSB first).
2	encoder err (LSB first).
4	1st B servo (LSB first).
6	encoder error (LSB first).
.	.
.	.
432	55th A servo
434	encoder error
436	55th B servo

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2.4.50. Equalize A B

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0			MBF	0t
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 43h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

NOTE: The following description of the command is from the Gemini Firmware Manual. For Flash, it may be different and will be updated in the next revision.

This command causes the drive to read the A & B servos bursts and perform one correction to the encoder servo reference angle so as to equalize the bursts and center the selected head on the current track. If MBF (Multiple Burst Flag) is 1, equalization is performed based on the multiple AB bursts; it is the responsibility of the host to make sure that the drive is currently at a multi-bursts track. If MBF is 0, equalization is performed using a single pair of AB bursts.

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2.4.51.Prediction Control

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			0	SPE	FREQ	UPD	ENA
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 49h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command serves multiple purposes: it can enable or disable prediction updates via the ENA (enable prediction) bit, and it can trigger a prediction update via the UPD (update prediction) bit. If the UPD bit is set, the drive performs a prediction update and the ENA bit is ignored. If UPD is 0 and ENA is 0, prediction updates are disabled. If UPD is 0 and ENA is 1, prediction updates are enabled.

The FREQ bit set with ENA bit forces a test mode where prediction updates are performed at high frequencty (approx. once every 3 seconds). This mode is used to hasten any problem which are related to the update prediction activity.

The SPE bit is used to enable or disable the servo pause feature in which a fixed number of servo samples may be suspended. This bit should normally be set.

CAUTION: Disabling prediction updates could allow the drive to read and write offtrack. It may require several recalibration attempts to restore the integrity of the servo system. In the worst case, it could cause recalibration failure.

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2.4.52. Read Tracks To Lock

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	RPM (MSB)							
3	RPM (LSB)							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 4Ah							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the number of tracks from the airlock to the inner crash stop. The returned data format is:

Byte	Contents
0-1	Tracks to crash stop (LSB first).

Parameter RPM is passed (for test modes) to set the motor speed at which the servo will begin to search for the airlock. This allows to drive to determine of the speed at which the airlock opens. Default is zero which causes the drive to use a nominal speed (approx. ???RPM) to perform the airlock search.

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2.4.53. Read Runout Tables

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 4Ch							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to read and return the content of the runout prediction table. Format to be determined.

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2.4.54. Read Thermistor

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 4Eh							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the current thermistor value. The returned data format is:

Byte	Contents
0-1	Thermistor value (LSB first).

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2.4.55.Seek and Sample

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder (MSB)							
3	Cylinder (LSB)							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 4Fh							
7	Reserved = 0							
8	Number of Samples							
9	Reserved = 0						F	L

This command causes the drive to seek to the specified cylinder and head. Then samples of the ANGLE_ERROR variable are taken with every A/D result for the number of samples specified in the NUMBER OF SAMPLES field. Each sample is a two-byte value, therefore, the initiator should expect 2 x NUMBER OF SAMPLES of bytes to be returned. The returned data format is:

Byte	Contents
0-1	Angle Error sample (LSB first, 2's complement).
2-3	next sample.
.	
.	

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2.4.56. Write Read-Channel

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Address							
3	Data Value							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 60h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

Used to program the registers of the READ Channel IC.
This command will support:

Register Address	Register Name
20h	power down control
60h	data mode filter bandwidth
64h	servo mode filter bandwidth
68h	data mode filter boost
28h	data mode threshold
24h	servo mode threshold
2Ch	control A
18h	control B
30h	N counter
38h	M counter
10h	data recovery
50h	window shift
58h	write precomp
22h	AGC level
2Ah	hysteresis decay

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2.4.57.Set Write Current

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 61h							
7	Reserved = 0							
8	Write Current Number							
9	Reserved = 0						F	L

This command will select one of four write current setting. Ports P32 and P33 are assigned to signals REDIWR0 and REDIWR1, respectively. If both signals are low, the lowest write current is selected; if both are high, the highest write current is selected.

WC#		P32	P33
0	0	0	(Lowest)
1	0	1	
2	1	0	
3	1	1	(Hightest)

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2.4.58. Sequencer Trigger

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 62h							
7	Reserved = 0							
8	ID/ERROR							
9	Reserved = 0						F	L

This command will support ID Match and Error Pulse.
ID Match is used to have a signal go active when the currently requested sector is located. Error Pulse is used to have a signal go active when an error occurs somewhere in a sector or ID field.

- ID/ERROR byte of 1 means ID Match will be executed.
- ID/ERROR byte of 0 means Error Pulse will be executed.

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2.4.59.Wedge Format

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Wedge Number							
6	Sub Opcode = 63h							
7	Data Pattern							
8	Data Pattern							
9	Reserved = 0						F	L

Format data a single data area between two servo burst.

2.4.60. Window Margin Test

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Cylinder (MSB)							
3	Cylinder (LSB)							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 64h							
7	Reserved = 0							
8	Exp. of Number of Bits to Read							
9	Reserved = 0						F	L

Used to determine the error rate for a given window size by shifting the window in the Read Channel's PPl.

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2.4.61. Extended Low-Z

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 65h							
7	Reserved = 0							
8	Number of Bytes							
9	Reserved = 0						F	L

Allows CLAMP signal from KONI to be extended by a given number of bytes.

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2.4.62. Servo Verify

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							Opt
1	LUN = 0			Reserved = 0				
2	Cylinder - msb							
3	Cylinder - lsb							
4	Head							
5	Reserved = 0							
6	Sub Opcode = 81h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to seek to the physical address specified in cylinder and head. It then performs a servo verify on all 70 of the servo wedges on the track.

If Opt is 0 then it will return two bytes. If there are more than one bad wedge on the track, it will only return the status for the first bad wedge encountered. The returned data format is as follows.

Byte	Contents
0	Sector number (from index) of the first bad servo (if any).
1	Error code.

If Opt is 1 then it will return 70 bytes, one for each wedge where the first byte is the error code for wedge 0 and second for wedge 1 and so on.

The error codes are as follows:

Code	Description
0	No error.
1	Bad servo sync.
2	Bad servo address.
3	Bad track data.
4	Read wrong track ID.
5	Perr out of bump range.
6	Speed out of range.
7	Wedge marked bad at servo verify.

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2.4.63. Read Current Cylinder

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode =82h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the current cylinder over which the actuator is located. The returned data format is:

Byte	Contents
0	Current cylinder - lsb.
1	Current cylinder - msb.

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2.4.64. Self Scan Test

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 85h							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command starts self scan. See chapter 3 on Self Scan for all of the details.

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2.4.65. Read Perr Variables

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Reserved = 0							
5	Reserved = 0							
6	Sub Opcode = 86H							
7	Reserved = 0							
8	Reserved = 0							
9	Reserved = 0						F	L

This command causes the drive to return the prediction error for the current track, cylinder and head, for all 70 servo bursts. If the returned word is negative, the head is inside (towards to I.D.) of track center (i.e. step out is required to return to track center).

Byte	Contents
0	perr - lsb - burst 0.
1	perr - msb - burst 0.
2	perr - msb - burst 1.
3	perr - msb - burst 1.
...	
102	perr - msb - burst 69.
103	perr - msb - burst 69.

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3.Self Scan

3.1.Introduction

Self scan was introduced to reduce production costs by letting the drive test itself without the need for special equipment.

FLASH's self scan was written to replace function test and digital scan. This will eliminate the need for the special hardware required for function test and digital scan, and it also eliminates a handling step in the manufacturing process.

3.2.How It Works

Self scan feeds itself commands stored on the drive's test cylinder. Self scan reads each command and its associated parameter list from the test cylinder, performs the test, and stores the results to the test cylinder. The self scan command and parameter list must be stored on the test cylinder prior to the start of self scan. On FLASH drives, this is done with the servo writer.

Self scan is invoked either by inserting the self scan jumper on the power adapter board or through the selfscan superset command. Note: Since the drive checks the self scan pin during power up only, the test jumper must be installed prior to power on to invoke the test.

If self scan is started with the jumper, the following occurs:

1. The LED on the adapter board is turned on for the duration of the test.
2. The test script password is checked for validity.
3. The test script header is copied to the result data.
4. Perform each test, writing the results at the end of each test.
5. Writes the self scan tail, which contains accumulated test data.
6. Writes the self scan defect list.
7. Sets the LED to blinking when finished if selfscan passed.
   The LED is turned off if self scan failed.

If self scan is started from a diagnostic, the following occurs:

1. The drive disconnects for the duration of the test.
2. The LED on the adapter board is turned on for the duration of the test.
3. The test script password is checked for validity.
4. The test script header is copied to the result data.
5. Perform each test, writing the results at the end of each test.
6. Writes the self scan tail, which contains accumulated test data.
7. Writes the self scan defect list.
8. Turns the LED off and reconnects. Sense information will reflect a failure.

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3.3.Command Data

Command data is stored on the test system cylinder of the drive. Four sectors (2kB) are reserved for the test script. (See chapter5 for more details.)

3.3.1.Test Script Data Structure

The test script data contains a test header, defect scan data patterns, and a command list with associated parameters. The data structure is as follows:

Byte (hex)	Description - Test script header.
0-7	"SELFSCAN" or "LOCKLOCK" (ascii).
8-F	Version number.
10-11	Maximum number of hard errors allowed for this drive.
12-13	Maximum number of hard errors allowed for each head.
14-15	Maximum number of hard errors allowed for each cylinder.
16-17	Maximum number of seek errors allowed for this test.
18-19	Maximum test time allowed for this test.
1A-1F	- unused -
20-2B	Serial Number
2C-3C	- unused -
3D-3F	- Reserved - see the description for the Wait for Power Off command.
40-1FF	Defect scan data patterns 1-14 - see below for description.
200	Beginning of the command list - see command descriptions for more detail.
200+n	FFh - End of command list. (n < 800h)

Note: All unused and reserved bytes should be set to 0 or unpredictable results will occur.

3.3.2.Defect Scan Data Patterns

The user can define data patterns to be used in the defect scans. 32 bytes are set aside for each pattern, and the pattern is repeated throughout the data buffer. (The buffer length is set to 1 sector or 1 wedge size in bytes depending on the type of scan) The patterns must follow the following format:

Byte (hex)	Description.
0	Pattern length - anything from 1 - 31 bytes.
1-1F	Data pattern

If byte 0 = FFh, then a random pattern will be generated. The following format applies:

Byte (hex)	Description.
0	FFh - Generate a random pattern.
1-4	Random number seed. (if = 0, seed is set internally)
5-6	Random pattern length. (if = 0, pattern length is set to the sector or wedge size.)
7-1F	Unused.

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3.4.Result Data

Result data is stored on the test system cylinder of the drive. Four sectors (2kB) are reserved for the data.

3.4.1.Test Result Data Structure

The test result data contains a copy of the test script header, result data, and a "tail". The result data structure is as follows:

Byte (hex)	Description - Result header. (this is a copy of the command header)
0-7	"SELFSCAN" (ascii).
8-F	Version number.
10	Maximum number of hard errors allowed for this drive.
12	Maximum number of hard errors allowed for each head.
14	Maximum number of hard errors allowed for each cylinder.
16	Maximum number of seek errors allowed for this test.
18	Maximum test time allowed for this test.
1A-1F	- unused -
20-2B	Serial Number
2C-38	- unused -
39-3F	- Reserved - see the description for the Wait for Power Off command.
	Result list - see command descriptions for more detail.
40	Command result data - 16 bytes per command.
...	Repeat for each command.
	FFh - End of results.
	Result Data - Tail.
word	Test execution time.
byte	Internal drive error code.
byte	Self scan error flag.
word	Total number of seek errors.
word	Total soft error count for head 0 - zone 0.
word	Total soft error count for head 1 - zone 0.
word	Total soft error count for head 2 - zone 0.
word	Total soft error count for head 3 - zone 0.
...	Repeat the soft error count per head for each zone.

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3.5.Defect list

Selfscan keeps track of defects with it's own defect list. the list is stored on the test system cylinder of the drive. Two sectors (1kB) are reserved for the list.

3.5.1.Defect List Data Structure

Bytes from wedge	CHS
Cylinder - msb	Cylinder - msb
Cylylinder - lsb	Cylinder - lsb
Head	Head
Wedge ID	0FFh - indicates CHS format
Bytes from wedge - msb	-
Bytes from wedge - lsb	-
Defect length - msb	-
Defect length - lsb	Sector

If Cylinder - msb = 0FFh, this indicates the end of the defect list.

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3.6.Command history

Selfscan command history data is stored on the test system cylinder of the drive. One sector (512 bytes) is rserved for the command history data.

The first two bytes returned indicates the length of the data to be returned (507 for FLASH). The next byte is the number of bytes per entry (13 for FLASH), and the next two bytes point to the next available entry in the command stack. The rest of the buffer (507 bytes) is the command stack data. (39 entries @ 13 bytes per entry)

In order to ease the host decoding logic, the last command entry in the buffer is not allowed to wrap around. Thus the first byte in the command buffer is always the first byte of a CDB for a command.

Command history sector data format:

Byte	Content
0-1	0FBh. (507)
2	Bytes per entry. (13)
3-4	Offset within buffer.
5 - 511	Command history data.
	Data format per command:

Byte	Description
0	0FFh.
1	00h.
2	Cylinder - msb.
3	Cylinder - lsb.
4	Head.
5	Sector.
6	9Fh.
7	00h.
8	Number of sectors.
9	Servo status.
10	Firmware error code.
11	Selfscan error flag.
12	Selfscan command code.

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3.7.Self Scan Commands

The commands currently supported are:

Cmd	Description
00h	Invalid Command.
01h	Defect Scan.
02h	Delete Password.
03h	Format Inline - uses defect information.
04h	Format Media - uses no defect information.
05h	Servo Verify.
06h	Wait for Power Off.
07h	Butterfly Seek.
08h	Head Switch.
09h	Full Stroke Seek.
0Ah	Random Seek.
0Bh	Single Track Seek
0Ch	Start Stop.
0Dh	Third Stroke Seek.
0Eh	Weighted Average Seek.
0Fh	RRO / NRRO.
FFh	End of List.

The command descriptions are contained in the following pages.

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3.7.1.Butterfly Seek - Self Scan Command Code - 07h

Do a butterfly seek measuring the seek times. Note that the average seek time is calculated anew each time through the loop.

The test algorithm is as follows:

```
while (loop count > 0)
    {
    C1 = 0;
    C2 = maximum cylinder;
    average seek time = 0;
    Seek to C1;
    while (C1 <= maxc)
        {
        Do a timed seek to C2;
        total seek time = seek time + total seek time;
        C2—;
        C1++;
        If (C1 <= maxc)
            {
            Do a timed seek to C1.
            total seek time = seek time + total seek time;
            }
        }
    loop count—;
    }
calculate the average seek time;
```

Parameter List Description.

Type	Description
byte	07h - command code.
byte	Loop count to average.
word	Pass limit - uS - The average seek time must be less than this limit.

Result sector data format:

Byte	Description
0	07h - command code.
2	Error flag.
3	Error code.
4-5	Test time - S.
6-7	Minimum seek time - uS.
8-9	Average seek time - uS.
10-11	Maximum seek time - uS.
12-13	Seek error count.
14-15	- unused -

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3.7.2.Defect Scan - Self Scan Command Code - 01h

Scan the drive to find defective. Any defects found will be entered into a defect map that is eventually used to create a Primary defect list used during normal drive operation.

Parameter List Description.

Type	Description
byte	01h - command code.
byte	Loop count.
byte	Defect scan option select. (See the description on the next page.)
byte	Retry write/verify loop count.
word	Soft errors allowed per head.
word	Soft errors allowed per drive.
byte	Margin option for test.
byte	Margin option for retry.
byte*8	Data pattern sequence. (See the description on the next page.)
byte	Hard read error threshold.
byte	Hard write/read/verify error threshold.
word	Starting cylinder number.
word	Ending cylinder number.
word	Read offtrack (bit 15 sign bit, offtrack 0fd00H TO 01ffH).
byte*8	Command sequence. (See the description on the next page.)
word*2	Number of sectors transferred by this command if random scan selected.
word*2	Random number seed if random scan selected.

Result sector data format:

Byte	Description Random Scan	Byte	Description Sequential Scan
0	02h - command code.	0	02h - command code.
2	Error flag.	2	Error flag.
3	Error code.	3	Error code.
4-5	Test time - S.	4-5	Test time - S.
6-9	Number of blocks/wedges transferred (lsb first).	6-7	Last error - Cylinder
		8	Last error - Head
		9	Last error - Sector/wedge
10-11	Retry count.	10-11	Retry count.
12-13	Seek error count.	12-13	Seek error count.
14	Scan type.	14	Scan Type
15		15	

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3.7.2.1.Defect Scan Option Select Byte

Bit	If = 0	If = 1	Description
0	Sequential	Random Scan Type.	
1	Wedge	Sector	Scan Format.
2	Track	Wedge / Sector	Scan Length.
3	Scan in	Scan out	Scan Direction. (sequential only)
4	Use	Do not use	Use the W list if inline format has occured.

3.7.2.2.Margin Options

Bit	Description
7	Enable test threshold
3	Strobe bit 2 of bank(1,1) of the 84910
2	Strobe bit 1 of bank(1,1) of the 84910
1	Strobe bit 0 of bank(1,1) of the 84910
0	Strobe sign bit of bank(1,1) of the 84910

3.7.2.3.Data pattern sequence

8 bytes are set aside for a data pattern sequence. The data patterns are the patterns stored in the test script. The scan routine will look at each byte to see which pattern is run. The legal values for these patterns are as follows:

00h	Skip - no pattern specified.
01h-0Eh	Pattern number 1-14 stored in the command test script data.
0Fh-FFh	illegal

3.7.2.4.Command sequence

Cmd #	Command Description
0	NOP(End of command)
1	seek
2	read
3	write

Note: Commands must include at least one read command to end.

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3.7.3. Delete Password - Self Scan Command Code - 02h

Deletes the self scan password from the command data sectors on the drive. This will prevent self scan from running again and is used to protect the drive after shipment.

Parameter List Description.

Type	Description
byte	02h - command code.

Result sector data format:

Byte	Description
0	02h - command code.
2	Error flag.
3	Error code.
4-5	Test time - S.
6-15	- unused -

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3.7.4.End of List - Self Scan Command Code - FFh

This command number signals the end of the selfscan process. There are no more commands in the list.

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3.7.5.Format Inline - Self Scan Command Code - 03h

Append the self scan defect map to the primary defect list (P list) and format the drive with inline spares. The system cylinders are not formatted.

Note: The ID field count byte information must be on the system cylinder.

Parameter List Description.

Type	Description
byte	03h - command code.

Result sector data format:

Byte	Description
0	03h - command code.
2	Error flag.
3	Error code.
4-5	Test time.
6-15	- unused -

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3.7.6.Format Media - Self Scan Command Code - 04h

Formats the drive ignoring defects. Sector data is initialized to 00h. System cylinders are not formatted.

Note: ID field information must be on the system cylinder.

Parameter List Description.

Type	Description
byte	04h - command code.

Result sector data format:

Byte	Description
0	04h - command code.
2	Error flag.
3	Error code.
4-5	Test time - S.
6-7	Last error - cylinder.
8	Last error - head.
9	Last error - sector.
10-15	- unused -

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3.7.7. Full Stroke Seek - Self Scan Command Code - 09h

Measure each full stroke seek time.

Test Algorithm:

```
seek to cylinder 0, head 0;
total seek time = 0;
while (loop count != 0)
    {
    do a timed seek to the maximum cylinder and head;
    total seek time = seek time + total seek time;
    do a timed seek to cylinder 0, head 0;
    total seek time = seek time + total seek time;
    loop count --;
    }
calculate the average seek time;
```

Parameter List Description.

Type	Description
byte	09h - command code.
byte	Loop count to average (byte) if 0 then endless loop.
word	Pass limit - uS - The average seek time must be less than this limit.

Result sector data format:

Byte	Description
0	09h - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-7	Minimum seek time - uS.
8-9	Average seek time - uS.
10-11	Maximum seek time - uS.
12-13	Seek error count.
14-15	- unused -

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3.7.8.Head Switch - Self Scan Command Code - 08h

Measures the head switch time.

Test Algorithm:

```
seek to the specified cylinder and head 0;
while (loop count != 0)
    {
    if (head++ > max head)
        {
        head = 0;
        }
    do a timed seek to the head;
    loop count--;
    }
calculate the average seek time;
```

Parameter List Description.

Type	Description
byte	08h - command code.
byte	Loop count.
word	Pass limit - uS - The average seek time must be less than this limit.
word	Cylinder.

Result sector data format:

Byte	Description
0	08h - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-7	Minimum head switch time - uS.
8-9	Average head switch time - uS.
10-11	Maximum head switch time - uS.
12-15	- unused -

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3.7.9. Invalid Command - Self Scan Command Code - 00h

This is an invalid command code. If this value is read from a list as a command, then an error condition exists and all self scan processing is stopped.

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3.7.10.Random Seek - Self Scan Command Code - 0Ah

Seek to a random head and cylinder and measure the seek times.

Test Algorithm:

```
while (loop count != 0)
    {
    do a timed seek to a random cylinder and head;
    loop count--;
    }
calculate the average seek time;
```

Parameter List Description.

Type	Description
byte	0Ah - command code.
byte	Loop count to average (byte) if 0 then endless loop.
word	Pass limit - uS - The average seek time must be less than this limit.
word	Number of random seeks to perform per loop.

Result sector data format:

Byte	Description
0	0Ah - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-7	Minimum seek time - uS.
8-9	Average seek time - uS.
10-11	Maximum seek time - uS.
12-13	Seek error count.
14-15	- unused -

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3.7.11.RRO / NRRO - Self Scan Command Code - 0Fh

Measure the repeatable and non-repeatable runout on the drive. The self scan result data just contains pass/fail information with no details. The data from the RRO/NRRO measurements will be stored in the test cylinder on two consecutive sectors. The data format is listed below.

The measurements will be taken twice on each platter at the outer and inner cylinders and the results will be stored on the test cylinder.

The equations used to calculate these measurements are located in Figure 3-1, and the test algorithm can be found on the following page.

Parameter List Description.

Type	Description		
byte	0Fh - command code.		
byte	status.		
byte	reserved *see note below		
word	"		
word	"		
word	RRO limit	% of track width*10	i.e. 217(D9h) = 21.7%
word	NRRO limit	% of track width*10	

Result sector data format:

Byte	Description
0	0Fh - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-15	- unused -

3.7.12.RRO/NRRO Data

The following data is stored on the runout result sectors.

RRO/NRRO data format:

Byte	Description
0	Number of wedges.
1	Number of samples per wedge.
2-15	Unused.

Repeat the following data structure for each head on both the inner and outer cylinders.

16	Head.		
17	Unused.		
18-19	Cylinder.		
20-21	RRO	% of track width*10	i.e. 406 (196h) = 40.6%
22-23	NRRO	% of track width*10	
....			

Note: This routine can be called from the servo verify command therefor the input data structure for this routine must match the data structure for servo verify.

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```
RRO / NRRO
for (zone = 0;zone < max zone;zone++)
    {
    ns = 128;                                           // number of samples = 128
    set sum, sum square, and data sample arrays to 0;
    seek to the first cylinder in the zone;
    wait 1 revolution for settling;
    for (data samples = 0;data samples < ns;data samples++)
        {
        starting at index, aquire the PERR data for this track;
        for (wedge = 0;wedge < num of wedges;wedge++)       // get the data for each wedge and keep
            {                                               // a running sum and sum of the squares
            sum[wedge] = sum[wedge] + data sample[wedge];   // for all of the samples.
            sum square[wedge] = sum square[wedge] + (data sample[wedge] * data sample[wedge]);
            }
        }
    std dev sum = 0;                                    // init the sum of the standard deviations
    ave sum = 0;                                        // init the sum of the averages
    ave sum square = 0;                                 // init the sum squared of the averages
    for (wedge = 0;wedge < num of wedges;wedge++)
        {
        average[wedge] = sum[wedge] / ns;               // figure the standard deviation and ave value for each we
        ave sum = ave sum + average[wedge];
        ave sum square = ave sum square + (average[wedge] * average[wedge]);
        std dev[wedge] = sqrt((sum square[wedge] - ((sum[wedge] * sum[wedge]) / ns)) / (ns - 1));
        std dev sum = std dev sum + std dev[wedge];
        }
                                                        // rro = standard deviation of the average wedge values.
    RRO = sqrt((ave sum square[wedge] - ((ave sum[wedge] * ave sum[wedge]) / 64)) / 63;
    RRO = (RRO*3*100)/2048;
    NRRO = std dev sum / 64;                            // nrro = average of the wedges standard deviations.
    NRRO = (NRRO*3*100)/2048;
    if (either RRO or NRRO are out of spec)
        {
        set fatal error flag;
        }
    store the data in the system cylinder.
    }
if (fatal error)
    {
    set error code;
    store RRO and NRRO data;
    exit(error);
    }
else
    {
    exit(ok);
    }
```

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3.7.13.Servo Verify - Self Scan Command Code - 05h

This is the first command to run after a servo write. It will verify the servo wedges across the entire surface of the drive. If two or more servo wedge sets are initially written to the drive, and a good set is found during this scan, then the bad or unused set(s) will be erased. If no good set of servo wedges is found, the drive will fail this test and have to be re-servo written.

Since the system cylinder information is written to the drive during servo write, this command must also take care of preserving the data during the erasing of the unused set of servo wedges. The data will be read from the drive and stored in ram, the unused wedges will be erased, and the system cylinders will be formatted. The data will then be written back to the system cylinders.

If RRO/NRRO measurements are to be made, the data from these measurements will be stored in the RRO/NRRO data sector. (see the description for RRO/NRRO) Also, the defective servo wedge information will be stored on the test cylinder as a servo defect list.

Parameter List Description.

Type	Description		
byte	05h - command code.		
byte	Option select. (see below)		
byte	Number of servo sets.		
word	Minimum burst amplitude.		
word	Maximum burst amplitude.		
word	RRO limit	% of track width*10	i.e. 217 (D9h) = 21.7%
word	NRRO limit	% of track width*10	

Result sector data format:

Byte	Description
0	05h - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-15	- unused -

The Runout result sectors contain the runout data.

3.7.14.Servo Verify Option Select Byte

Bit	If = 0	If = 1	Description
0	off	on	Verify servo bursts.
1	off	on	RRO/NRRO measurement.
2	off	on	Erase unused servo bursts and initialize diskware.

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3.7.15.Servo Defect List

Defective servo information will be stored in a defect list on the test cylinder. This data is made available for anyone to use. (see chapter 5 for the test cylinder layout)

Servo defect list format:

Byte	Description	
0	Status	
	Bit	Description
	0	
	1	
	2	
	3	
	4	
	5	
	6	
	7	
1	Head	
2	Wedge number	
3-4	Cylinder	

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```
Servo Verify
    {
    wedge set = 0;
    bad wedge set count = 0;
    while (wedge set != number of wedge sets)            // check 1 set of servo wedges at a time.
        {
        set all flags = 0;
        syncronize the servo with the current wedge set;
        cylinder = outermost;
        while ((cylinder < maxc) && (fatal error flag = 0))
            {
            head = 0;
            while ((head < maxh) && (fatal error flag = 0))
                {
                seek;
                set the scan data flag;
                while (scan data flag = 1)
                    {
                    wait for 1 revolution for seek settle;
                    starting at index, aquire wedge data for the current track;
                    check the wedge data against the specs.;
                    if (there were no errors that require a re-scan or we're out of retries);
                        {
                        scan data flag = 0;
                        }
                    if (a bad wedge occured in the last data set)
                        {
                        fatal error flag = 1;
                        }
                    }
                head++;
                }
            cylinder++;
            }
        if (fatal error flag = 0)      // if all the wedges were good, no need to check other sets.
            {
            exit wedge set loop;
            }
        else                           // else this is a bad wedge set.
            {
            wedge set++;
            }
        }
    if (wedge set < number of wedge sets)
        {                              // a good wedge set has been found.
        do RRO and NRRO measurements in three areas of the disk;
        if (RRO and NRRO measurements are ok)
            {
            read in all data from the disk and store it in buffer ram;
            dc erase unused set of servo wedges;
            format the system cylinders;
            configure the drive, writing the data to the system cylinders;
            if (write verify of system cylinders failed)
                {
                set a fatal error condition - minimum number of system copies could not be written.
                }
            }
        else
            {
            set a fatal error condition - RRO/NRRO out of spec;
            }
        }
    else
        {                              // no good servo sets were found. set error then exit.
        set a fatal error condition - no good servo set found;
        }
    }
```

3.7.16.Single Track Seek - Self Scan Command Code - 0Bh

Measure each single track seek.

Test Algorithm:

```
seek to the test cylinder and head 0;
while (loop count != 0)
    {
    do a timed seek to test cylinder + 1, max head;
    do a timed seek to test cylinder, head 0;
    loop count--;
    }
calculate the average seek time;
```

Parameter List Description.

Type	Description
byte	0Bh - command code.
byte	Loop count.
word	Pass Limit - uS - The average seek time must be less than this limit.
word	Cylinder.

Result sector data format:

Byte	Description
0	0Bh - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-7	Minimum seek time - uS.
8-9	Average seek time - uS.
10-11	Maximum seek time - uS.
12-13	Seek error count.
14-15	- unused -

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3.7.17.Start Stop - Self Scan Command Code - 0Ch

Measures start and stop times.

Test Algorithm:

```
while (loop count != 0)
    {
    do a timed stop of the drive;
    do a timed start of the drive;
    loop count --;
    }
```

Parameter List Description.

Type	Description
byte	0Ch - command code.
byte	Loop count.
byte	Waiting time after stop - S.
byte	Test limit time between start to drive ready - S.

Result sector data format:

Byte	Description
0	0Ch - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-15	- unused -

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3.7.18.Third Stroke Seek - Self Scan Command Code - 0Dh

Measures third stroke seek times.

Test Algorithm:

```
cylinder = 0;
head = 0;
zone = 0;
seek to the CHS;
while (zone < 3)
    {
    initialize the loop count;
    while (loop count != 0)
        {
        do a timed seek to cylinder = ((maxc/3)*zone) + maxc/3, max head;
        do a timed seek to cylinder = (maxc/3)*zone, head 0;
        }
    zone++;
    }
calculate the average seek time;
```

Parameter List Description.

Type	Description
byte	0Dh - command code.
byte	Loop count.
word	Pass limit - uS - The average seek time must be less than this limit.

Result sector data format:

Byte	Description
0	0Dh - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-7	Minimum seek time - uS.
8-9	Average seek time - uS.
10-11	Maximum seek time - uS.
12-13	Seek error count.
14-15	- unused -

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3.7.19.Wait for Power Off - Self Scan Command Code - 06h

This command suspends selfscan until a power off - power on cycle occurs.

A potential use for this feature is to syncronize the tests during temperature testing. i.e. Run a test at a certain temperature then wait. The temperature is changed then the power is cycled to the drives under test. After power on, a new test is run at the new temperature.

This would get rid of the hassle of trying to run drives in the temperature chamber with computers connected to them.

Parameter List Description.

Type	Description
byte	06h - command code.

This command modifies bytes 39 to 3F in the command data as follows:

Byte	Description
39	Power on restart status.
3A-3B	Power on restart command history pointer.
3C-3D	Power on restart command buffer pointer.
3E-3F	Power on restart result buffer pointer.

After these bytes are modified, the command data is written back out to the drive. When the power cycle occurs, selfscan will check these bytes. If they are not 0, then selfscan will start running at the command pointed to by the command buffer pointer.

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3.7.20. Weighted Average Seek - Self Scan Command Code - 0Eh

Measure the weighted average seek time.

Test Algorithm:

```
weighted cylinder = 0;
while (weighted cylinder < maxc)
    {
    seek 1 - do a timed seek to the weighted cylinder;
    seek 2 - do a timed seek to cylinder 0;
    average = (seek 1 + seek 2)/2;
    weighted average = average * (maxc - weighted cylinder);
    weighted cylinder = weighted cylinder + cylinder increment;
    }
```

Parameter List Description.

Type	Description
byte	0Eh - command code.
byte	Loop count, if 0 then endless loop.
word	Pass limit - uS - The average seek time must be less than this limit.
byte	Cylinder increment.

Result sector data format:

Byte	Description
0	0Eh - command code.
2	Command error code.
3	Firmware error code.
4-5	Test time - S.
6-9	Total seek time - uS.
10-11	- unused -
12-13	Seek error count.
14-15	- unused -

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3.8. Miscellaneous

3.8.1. Error Codes

Continue testing on error codes 01h to 0fh.

00h	Pass Test.
01h	Seek time is out of the limit.
02h	Too many soft sector errors/drive.
03h	Too many soft sector errors/head.
08h	Too many hard sector errors per drive.
09h	Too many hard sector errors per head.
0Ah	Too many hard sector errors per cylinder.

Stop test on error codes 10h to 0ffh

10h	Test time out of the limit.
20h	Invalid/out-of-range test number requested.
30h	Cannot latch the head.
40h	Too many seek errors.
48h	Servo error cannot recovered by retry.
4fh	Cannot seek to location after retry.
50h	Start stop test failed.
C0h	Selfscan defect sectors are full.
D0h	Internal firmware error.
E0h	Sequencer error.
F0h	Selfscan password not found.
F1h	Error reading selfscan test sectors.
F2h	Error writing selfscan test sectors.

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4.Defect Management

4.1.The Defect Lists

Three different lists are stored on system cylinder -2:

1. Primary defect list (P list) - this list contains the defects found in Analog and Digital scans at the factory. Only the factory test software has the capability to define the P list. The P list contains the description for defects only. No information regarding their replacement is included.

2. Working list (W list) - typically, the W list is a union of the P and G lists, plus it contains all information necessary to locate the replacement to all defects.
Grown defect list (G list) - this list contains the defects found in the field during operation of the drive. All user's reassigned defects (i.e. with Reassign Blocks) and auto-reallocated defects are recorded in this list.
Note: In Lethal products, the G list is merged in with the W list, i. e. there is no separate G list.

3. Temporary list - During an update of the W list (a block reallocation for example) the old W list is stored to this area before any modifications are made to it. This allows for the recovery of the old list if an abort happens during the generation of the new list.

The host may access the P and G lists with the Read Defect Data SCSI command. The G list is decoded from information stored in the W list.

The W list is used by defect management whenever a logical-to-physical address conversion is called for. This list is not accessible with standard SCSI commands.

4.1.1.Replacement Strategy

Flash reserves one alternate sector per cylinder for defect sparing, and it utilizes two methods for sector replacement - inline and offline sparings.

4.1.1.1.Inline Sparing

Inline sparing is where a defective sector is replaced by the next immediate sector; all sectors thereafter within the same cylinder is shifted, logically, by one. (see figure 4.1) The access penalty is very small for inline replacement which is one sector time. Whenever possible, defects are spared with inline replacement at the factory. In the unlikely event where there are multiple defects on the same cylinder, additional spare sectors must be allocated from adjacent cylinders. This is defined as offline replacement. Accessing the defective sector requires a short seek and latency. All grown defects are offline spared during drive operation. However, the drive will attempt to inline spare all known defects when a Format Unit command is issued.

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4.1.1.2.Offline Sparing

Off line sparing is where a defective sector is replaced by a spare sector located at the end of a cylinder. Defect management will try to replace the defective sector with a spare on the same cylinder. If this is not possible, as in the case of the spare is already in use, defect management will find a spare sector located on an adjacent cylinder. The disadvantage to this is the performance hit caused by the seek. Figure 4.1 containes an example of an offline spare.

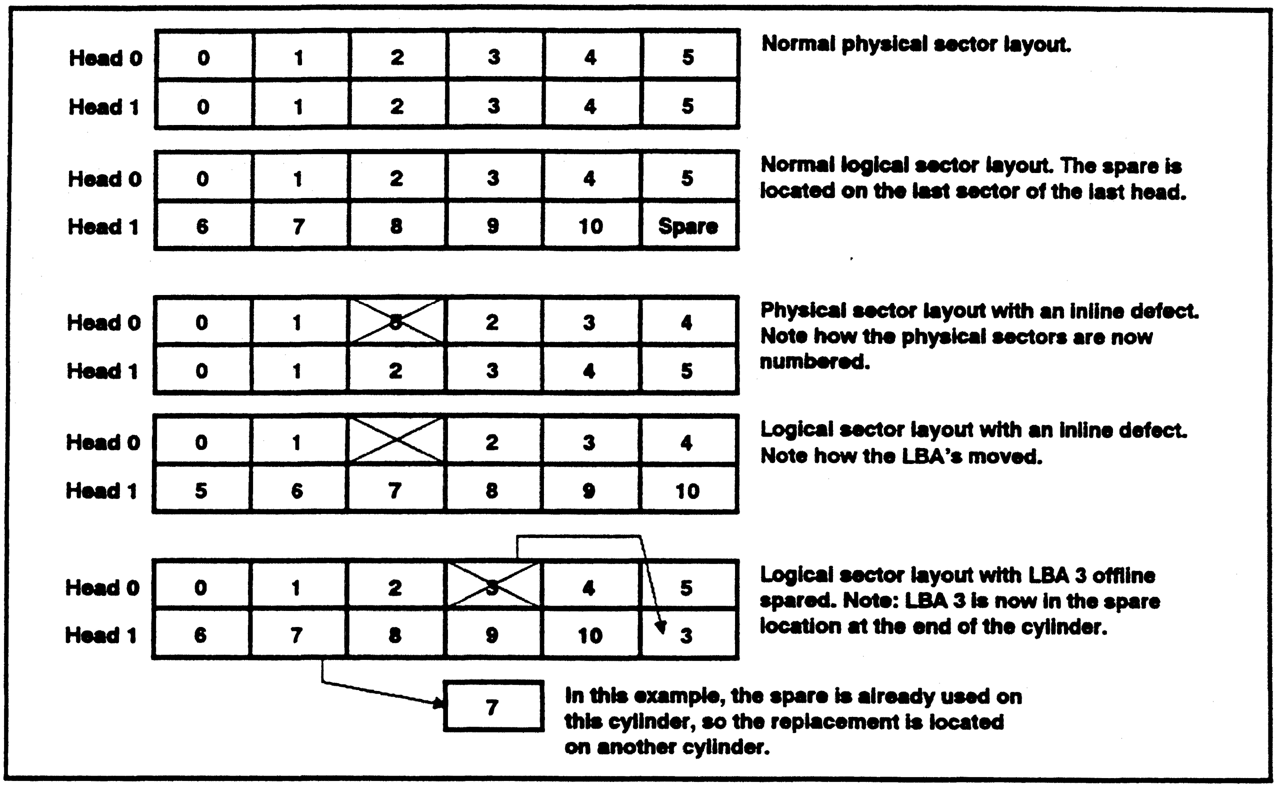

Figure 4.1Inline and Offline Examples.

4.1.1.3.Orphans

An orphan occurs when a replacement sector goes bad. The replacement is assigned a new sector and the original replacement sector is tagged as an orphan in the defect list. It is no longer used. Defect management skips over defect entries that are tagged orphans.

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4.1.2.Defect List Data Structure

The defect lists maintained and accessed by the defect management system consist of 7 byte defect entries. The P list contains only defect entries while the W list contains both defect and replacement cylinder information. The defect list structure is illustrated below.

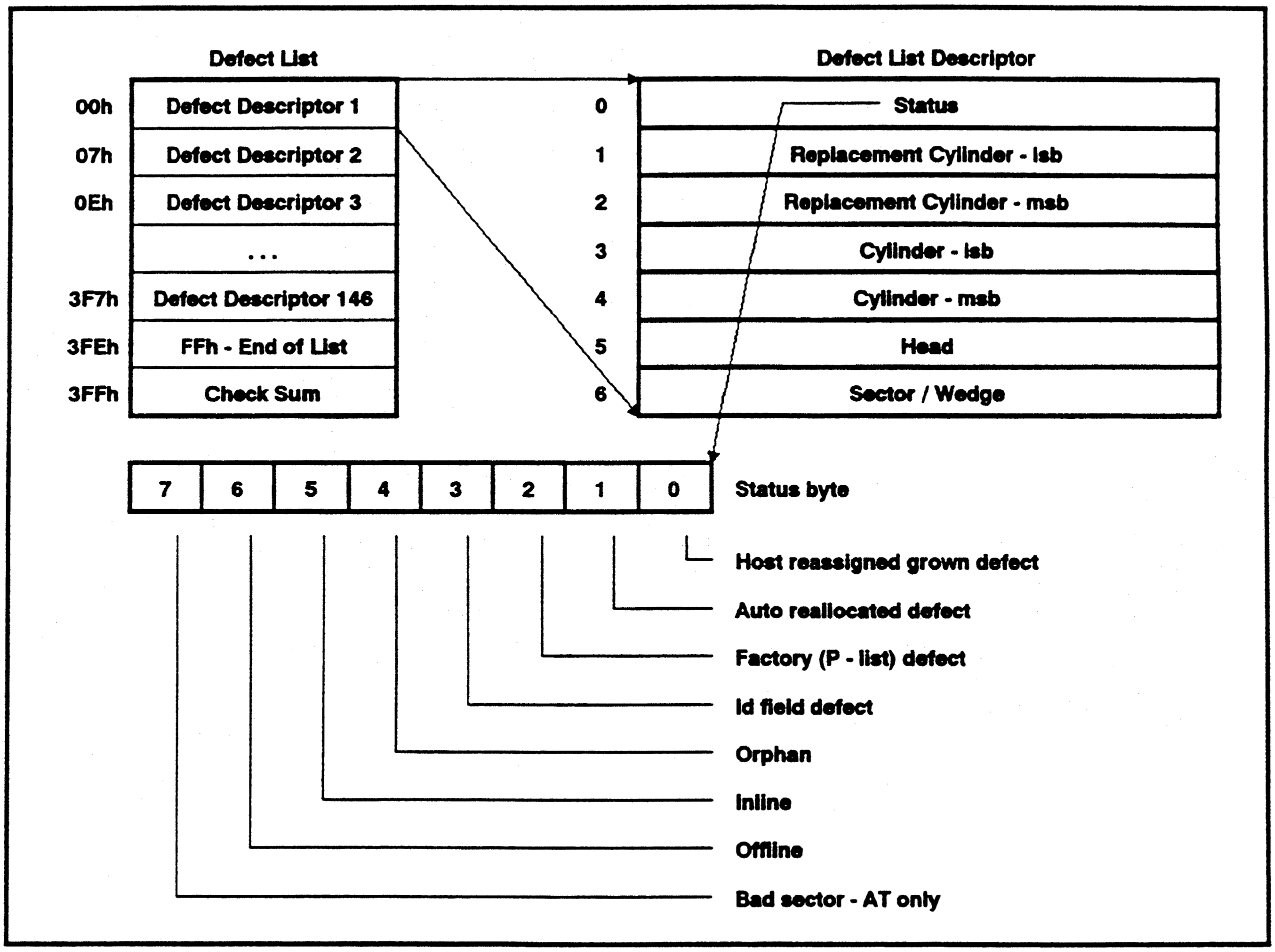

Figure 4.2Defect List Data Structure

The end of list marker is placed after the last entry in the list.

The checksum is placed at the end of the list, and the empty area in the list is filled with zeros. When this byte is added to the rest of the bytes in the list, the lsb of the checksum will equal ascii "L".

Defect type is used to distinguish between P list entries (factory defect) and G list entries (auto reallocated and user reassigned).

Replacement type is used by defect management to find the correct physical sector for a given LBA.

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4.2.Defect List Storage

Up-to-date versions of the P and W lists are saved on the disk, only the W list needs to be resident in RAM during drive operation. Each defect list may require up to 2048 bytes of storage, therefore, a total of 4 sectors per list are reserved to hold the defect lists on a system track. See Paragraph 5.3.2 System Cylinder Layout for the location of the lists. Since the W list is limited to 2048 bytes in size, a maximum of 292 defects may be recorded in a Flash drive.

4.3.LBA to CHS Conversion

There are two entry points for performing the LBA to CHS conversion. Given an LBA, the caller invokes INIT_LBA_TO_CHS to initiate the conversion process.

INIT_LBA_TO_CHS determines the destination cylinder for the logical block and scans for known defects from the beginning of that cylinder. The function returns the CHS of the first valid sector plus a value indicating the number of consecutive data sectors starting from the first accessible sector.

It is left to the caller to decide how many sectors are actually required to complete its operation. If sectors are needed in addition to the first series of consecutive sectors, the caller uses the NEXT_LBA_TO_CHS function to locate the next series of sectors. NEXT_LBA_TO_CHS requires no input parameter and returns the same information as INIT_LBA_TO_CHS. Since media defects are sparse, there should be large number of contiguous cylinders with no defects for a typical drive. Basing on this fact, when a location on the disk is accessed, defect management firmware locates a range of "defect-free" cylinders in both directions of the current position. Once the range is defined, subsequent access made within the range will not require any reference to the defect list.

4.4.Auto Reallocation

Reallocation during read operation is processed on sector-by-sector basis (not necessarily the whole logical block). When a sector is determined to be defective by the read or write firmware, it is then subjected to write/verify test before it will reallocated. Using the data read from the defective sector, the drive writes to and reads the sector for up to ten times. If any of the ten tests fail, the defect is considered repeatable and the sector is reallocated. If all ten tests pass, then the failure is considered non-repeatable and the sector is left as is.

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5.System Cylinders

5.1.General Information

Three tracks on all drives are reserved for system and test usage. These cylinders contain drive configuration information, drive test information, and diskware. Customers cannot access these reserved cylinders. The reserved cylinders are only accessible with physical address commands which are protected diagnostic commands.

Data is read from and written to these areas according to the firmware redundancy algorithm.

The reserved cylinders are assigned as follows:

Cylinder	Description
	Outer System Area.
- 1	Test equipment data.
- 2	System and firmware data and Diskware.
- 3	Copy of cylinder -2.

Note: The data on the system cylinders, unless specified otherwise, will use the following rules:

ASCII fields must be left justified, terminated with binary 0, and padded with binary 0's.
ASCII fields read by the drive firmware, such as the serial number, must be right justified with spaces and terminated with 0.

5.2.Test Equipment Cylinder

5.2.1.Introduction

The test equipment cylinder is reserved for test equipment usage. This cylinder contains test parameters and data collected during production test.

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5.2.2.Description of Sectors (Cylinder -1)

The sector usage is as follows:

Sector	Description
0	Servo Writer test results.
1	Analog Scan test results.
2	Diskware Station Test results.
3	Post Op - Final test results.
4	Digital Scan test results.
5	QA/DA test results.
6 - 13	Self scan test results
14 - 17	Self scan parameters.
18	Error log.
19 - 26	Analog scan defect lists.
27 - 34	Self Scan defect lists.
35 - 42	Digital Scan defect list.
43	Reserved
44 - 49	Self Scan RRO/NRRO Results
50 - 53	Defect Map.
54 - 61	QA/DA defect list.
62	Self Scan command history.
63 - 74	Self Scan overlays (8K + 8K).
75 -	Error Log

5.2.3.Test Data

The test data sectors (0-5) of all stations are written at the beginning of each test in the following format:

Byte	Format	Description
0 - 20	ASCII	Test station name. "LSW" - servo writer. "LAS" - analog scan. "LFT" - functional test. "LSS" - self scan. "LPO" - post op. "LDS" - digital scan.
30 - 109	ASCII	Date.
110 - 111	Binary	Exit code.
112 - 511	Binary	Reserved (filled with 0).

5.2.4.Self Scan Test Parameters

See the chapter on Self Scan for all the information.

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5.2.5.Defect Lists

Each test that scans for defects maintains its own defect list. Note that each defect list is only allocated 1024 bytes or 2 sectors.

5.2.5.1.Analog and Digital Scan Defect List Format

The defect lists for analog scan and digital scan are saved in the following format:

Byte	Format	Description
0 - 13	ASCII	"LAS DEF LST " or "LDS DEF LST".
14 - 15	Binary	Number of defects (lsb, msb).
16 - 47	Binary	Head, cylinder skew, zone 0 to 16.
		Byte — Description
		16 — Head skew for zone 0.
		17 — Cylinder skew for zone 0.
		. . .
		46 — Head skew for zone 15.
		47 — Cylinder skew for zone 15.
48 - 1023	Binary	Defect list - Analog Scan & Digital Scan (4 bytes per defect).
		Byte — Description
		48 — Cylinder - lsb.
		49 — Cylinder - msb.
		50 — Head.
		51 — Sector.
		. . .

The maximum number of defects allowed is 244, calculated as follows:
(1024 bytes - 48 byte header) / 4 bytes per defect entry.

5.2.5.2.Self Scan Defect List Format

Byte	Format	Description
0	Binary	Cylinder - msb.
1		Cylinder - lsb.
2		Head.
3		Wedge ID.
4		Bytes from wedge - msb.
5		Bytes from wedge - lsb.
6		Defect length - msb.
7		Defect length - lsb.
...		Repeat for each defect.
n	FFh	End of list.

The maximum number of defects allowed is 255 plus the end of list flag.

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5.3.System / Firmware Cylinder

5.3.1.Introduction

This cylinder is reserved for system and firmware usage. It contains mode page information, configuration information, defect lists, and format information for the drive.

5.3.2.Description of Sectors (Cylinder -2)

Sector	Description (see detailed descriptions below)
0	Saved mode pages 1, 2, 20h, 37h, 38h, and 39h.
1	Saved mode pages 3 and 4.
2 - 3	Configuration pages.
4 - 8	Working defect list.
8 - 13	Primary defect list.
14 - 18	Temporary defect list.
19 - 34	Format header bytes - zones 0 - 15
35 - 114	Diskware 24K + 8K overlays (48 +16 +16 = 80).
115-119	Not in use.
120-123	Reserved for in-line defect sparing.

5.3.2.1.Saved Mode Select Sectors

The data stored on these sectors is only the changeable part of the mode select pages. See the section on Mode Pages for more details.

5.3.2.2.Configuration Pages

This area contains the drives configuration information such as the revision level, number of heads, etc. See the Read Configuration superset command for a detailed explanation of the data contained in this sector.

5.3.2.3.Defect List Sectors

These sectors contain the defect lists used during the drives normal operation. See the chapter on Defect Management for more information.

5.3.2.4.Format Header Sectors

In order for the firmware to format the drive, it needs to know the count byte information for the split sector data fields. Since there is no simple algorithm to generate this information, the count bytes must be stored in a table. We allocated 16 sectors on the system cylinder to hold this information. Each sector contains the count byte information for a particular zone.

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6. Diskware

6.1. Introduction

The Flash architecture has been designed to support diskware. Part of the Buffer memory may be used to load firmware from disk and the processor is able to execute the firmware directly from the buffer.

6.2. Memory Map

The memory map for FLASH is organized as follows:

Address Range	Length	Description
0000h - 3FFFh	16K	CPU ROM code.
4000h - 7FFFh	16K	CPU ROM / Diskware code.
8000h - DFFFh	24K	Diskware code.
E000h - EFFFh	4K	Buffer access - floating block 1.
F000h - FAFFh	2.8K	Buffer access - floating block 2.
FB00h - FC7Fh	384	Asics.
FC80h - FEFFh	640	Internal ram.
FF00h - FFFFh	256	Internal special function registers.

The firmware is partitioned between the CPU ROM and the Diskware. The CPU ROM code contains all of the routines necessary to power up the drive and read the diskware into the Buffer. It also contains routines that allow the Diskware to be written to the disk via the host interface. All time critical code is located in the CPU ROM because the processor is able to execute CPU ROM code much faster than Diskware code. The Diskware code contains non time critical code that is not required for powering up the drive. The Diskware code also contains provisions to allow firmware bugs in the CPU ROM code to be corrected by mapping erroneous subroutines from CPU ROM into the Diskware.

There are two areas in the processor address space that may be used for diskware. The FLASH firmware uses only the address range 8000-DFFF for diskware, the other address range 4000-7FFF is always mapped to CPU ROM.

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6.3.Diskware Code Organization

The diskware code space is partitioned into two parts, a resident part and an overlay part. The Resident diskware is loaded during the drive power up initialization and remains in memory while the drive is powered on. The Overlay diskware is loaded on an as needed basis, at present there are two overlays defined, one for SelfScan and one for normal operation.

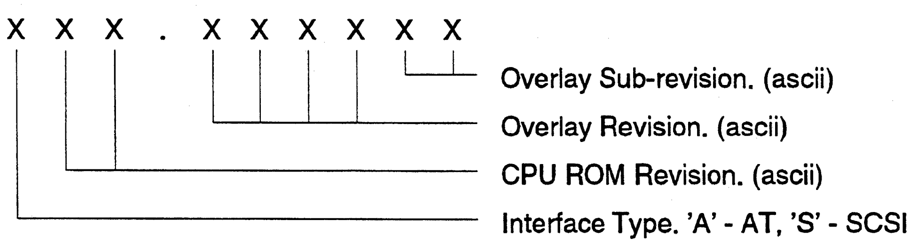
Address Range	Description
8000 - BFFF	Resident Diskware
	Vector Table
	Code
C000 - DFFFOverlay	Diskware
	1 - Normal Operating Code
	Vector table
	Code
	2 - Selfscan Code
	Vector Table
	Code

The Resident Diskware contains a vector table which is used by the CPU ROM code for accessing Diskware subroutines and data, and for mapping erroneous CPU ROM subroutines into Diskware subroutines. During power up initialization a default vector table is copied from CPU ROM, this is replaced by the actual vector table when the Diskware is loaded from disk.

The Flash firmware has only rudimentary overlay management, in general because of speed considerations it is the responsibility of the calling routine to ensure that the required Overlay is loaded.

6.4.Overlay Integrity Verification

The integrity of the Resident and Overlay Diskware is checked by means of a checksum and a revision number. The checksum is the written in the last address of the overlay and is calculated such that the one byte sum of all the bytes in the overlay is zero. The revision number is used check compatibility between the Resident diskware, Overlay diskware and the CPU ROM code, the revision number is stored at the end of the overlay and has the following format.



Compatibility between the CPU ROM code and the Resident Diskware code is determined by comparing the revision number of the Resident Diskware with the revision number of the CPU ROM. The codes are compatible if the Interface Type and CPU ROM Revision are equal. Compatibility between the Resident Diskware code and the Overlay Diskware code is also determined by comparing their revision numbers. The codes are compatible if the Interface Type, CPU ROM Revision and Overlay Revision are equal. The Overlay SubRevision code is not used for checking compatibility, it is used to allow the Overlay Diskware (SelfScan code) to be revised independently of the Resident Diskware.

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6.5.Diskware Storage Requirements

The diskware is stored on reserved system cylinders in memory image format. A new configuration page (15) specifies where the overlays are stored on the system cylinders and where the overlays are loaded into the processor memory. Generally system cylinder information is stored in multiple places for redundancy, the overlay configuration page only specifies where the first copy of the diskware is stored. Redundant copies of the diskware are stored according to the firmware redundancy algorithm for system cylinder information. The Flash firmware stores redundant system cylinder information on all physical heads in system cylinder areas.

Configuration Page 15 - Overlay Page

Field Offset	Description
0	00h - Overlay 0 - Resident diskware.
1	Load address.
3	Number of sectors.
4	Cylinder.
6	Head.
7	Starting sector.
8	01h - Overlay 1 - Normal operating diskware.
9-15	Same fields as above.
16	02h - Overlay 2 - Self scan diskware.
17-23	Same fields as above.
24	FFh - End marker.

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6.6.Diskware Update

The Flash diskware may be updated through the drive interface using LPT or by using the SCSI Write Buffer Download Microcode command. LPT uses a disk file which contains the configuration page information and diskware in a binary format as shown below.

Field	Description
Overlay Number	Overlay number, 0 - Resident Memory address.
Load Address	Memory address of overlay.
Number of Sectors	Number of sectors in overlay.
Cylinder	Cylinder at which to store overlay on disk.
Head	Head at which to store overlay on disk.
Starting Sector	Starting sector at which to store overlay on disk.
	Repeat of above for all overlays.
FFh	End marker for overlays.
Fill	Fill 00 to end of sector (512 byte).
Overlay 0 Code	Code for Overlay 0.
	Code for rest of overlays.

LPT uses the information in the file to update the diskware cylinders directly using write configuration and write physical commands.

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7.Miscellaneous Information

7.1.Programmable Trigger

Firmware allows certain conditions to generate a scope trigger. The conditions under which a trigger pulse is generated is controlled by Configuration Page 12 which consists of one byte. The eight bits are used to control whether a pulse is to be generated on an associated condition. If the bit is set and the condition occurs, a 1 microsecond (approximately) pulse is generated. Multiple trigger conditions may be specified at a time. The supported bits and associated conditions are as follows:

Bit	Description
0	—
1	Seek time-out
2	Seek fault
3	—
4	ECC error
5	Sequencer read/write error
6	Sequencer overrun/underrun
7	Sequencer time-out

As as example, to enable a pulse on either a seek time-out or ECC error, enter the following SCSIdiag command line: DEPB 0 18 WRCONF 12

The programmable scope trigger magically appears on microprocessor port P0.7.

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7.2.Mode Pages

The following is information on the mode pages. Some of the pages contain information that can be configured by the customer, and this information is denoted by a value in the Mask column of the lists. If a bit is set to 1 in the mask, then that bit can be configured by the customer.

Page 1h Error recovery parameters.

Byte	Mask	Default	Description
0		81h	Page code.
1		06h	Page length.
2	FFh	C0h	AWRE, ARRE.
3	FFh	08h	Retry count.
4	FFh	10h	Maximum ecc error burst on which to perform corrections.
5		00h	2's complement value of microsteps offset from track center.
6		00h	Data strobe offset count.
7		00h	Recovery time limit in units of 10 ms.

Page 2h Disconnect/reconnect control parameters.

Byte	Mask	Default	Description
0		82h	Page code.
1		0Ah	Page length.
2	FFh	00h	On reads, how full buffer should be before reconnecting.
3	FFh	FFh	On writes, how empty buffer should be before reconnecting.
4		00h	Bus inactivity limit - msb.
5		00h	Bus inactivity limit - lsb.
6		00h	Disconnect time limit - msb.
7		00h	Disconnect time limit - lsb.
8		00h	Connect time limit - msb.
9		00h	Connect time limit - lsb.
10		00h	Reserved.
11		00h	Reserved.

modeselect \

Page 3h Direct access device format parameters.

Byte	Mask	Default	Description
0		03h	Page code.
1		16h	Page length.
2		00h	Tracks per zone as defined in CCS - msb.
3	00h	02h	Tracks per zone as defined in CCS - lsb.
4		00h	Alternate sectors per zone - msb.
5		01h	Alternate sectors per zone - lsb.
6		00h	Alternate tracks per zone - msb.
7		00h	Alternate tracks per zone - lsb.
8		00h	Alternate tracks per volume - msb.
9		00h	Alternate tracks per volume - lsb.
10	00h	00h	Sectors per track - msb.
11		3Ah	Sectors per track - lsb.
		44h	"
12	00h	02h	Bytes per sector - msb.
13		00h	Bytes per sector - lsb.
14		00h	Interleave - msb.
15		01h	Interleave - lsb.
16		00h	Track skew factor - msb.
17	00h	12h	Track skew factor - lsb.
		0Fh	"
18		00h	Cylinder skew factor - msb.
19	00h	13h	Cylinder skew factor - lsb.
		18h	"
20		40h	Drive type definition bits. (40H = hard sector format).
21		00h	Reserved.
22		00h	Reserved.
23		00h	Reserved.

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Page 4h — Rigid disk drive geometry parameters.

Byte	Mask	Default	Description
0		04h	Page code - 04h.
1		12h	Page length - 18.
2	00h	00h	Number of cylinders - msb.
3		03h	Number of cylinders - middle.
		04h	"
4		66h	Number of cylinders - lsb.
		49h	"
5	00h	02h	Number of heads.
6		00h	Starting cylinder for write precompensation.
7		00h	Starting cylinder for write precompensation.
8		00h	Starting cylinder for write precompensation.
9		00h	Starting cylinder for reduced write current.
10		00h	Starting cylinder for reduced write current.
11		00h	Starting cylinder for reduced write current.
12		00h	Drive step rate.
13		00h	Drive step rate.
14		00h	Landing zone cylinder.
15		00h	Landing zone cylinder.
16		00h	Landing zone cylinder.
17		00h	Reserved.
18		00h	Reserved.
19		00h	Reserved.

Page 8h — Cache page.

Byte	Mask	Default	Description
0		88h	Page code.
1		0Ah	Page length.
2	05H	04h	Write cache enable (bit 4 = 1); Read Cache Disable (bit 0) = 0.
3		00h	None of the features in the Priority byte is supported.
4		00h	Disable Prefetch Transfer Length - msb is not supported.
5		00h	Disable Prefetch Transfer Length - lsb is not supported.
6		00h	Minimum number of blocks to prefetch - msb is not supported.
7		00h	Minimum number of blocks to prefetch - lsb is not supported.
8		00h	Maximum number of blocks to prefetch - msb is not supported.
9		00h	Maximum number of blocks to prefetch - lsb is not supported.
10		00h	Maximum Prefetch Ceiling - msb, not applicable.
11		00h	Maximum Prefetch Ceiling - lsb, not applicable.

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Page Ch Notch page.

Byte	Mask	Default	Description
0		0Ch	Page code.
1		16h	Page length.
2		80h	Device is notched, with physical boundaries.
3		00h	Reserved.
4		00h	Maximum number of notches - middle.
5		08h	Maximum number of notches - lsb.
6	FFh	00h	Active notch high not used.
7	FFh	00h	Active notch low by default is 0 (entire device).
8		00h	Starting cylinder - msb.
9	00h	00h	Starting cylinder - middle.
10		00h	Starting cylinder - lsb.
11		00h	Starting head 0.
12		00h	Ending at cylinder max minus 1.
13	00h	03h	Ending cylinder middle.
		04h	"
14		65h	Ending cylinder lsb.
		48h	"
15	00h	01h	Ending head.
16		00h	Indicate pages 3, 4 and C are notched.
17		00h	Indicate pages 3, 4 and C are notched.
18		00h	Indicate pages 3, 4 and C are notched.
19		00h	Indicate pages 3, 4 and C are notched.
20		00h	Indicate pages 3, 4 and C are notched.
21		00h	Indicate pages 3, 4 and C are notched.
22		10h	Indicate pages 3, 4 and C are notched.
23		18h	Indicate pages 3, 4 and C are notched.

Page 32h Auto power down page.

Byte	Mask	Default	Description
0		B2h	Page code.
1		02h	Page length.
2	FFh	00h	Standby mode disabled with 0.
3	FFh	00h	Shutdown mode disabled with 0.

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Page 37h Tako (Cache) page.

Byte	Mask	Default	Description
0		B7h	Page code.
1		0Eh	Page length.
2	3Fh	03h	Tako configuration bits.
3	FFh	02h	Number of segments in cache.
4	00h	Minimum number of blocks to prefetch is not supported.	
5		00h	Maximum number of blocks to prefetch is not supported.
6-15		00h	Unused.

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7.3.Error/Event Logging

At the present time this feature is only included in AT second release code. Error/event logging is used to save runtime information on a drive. The total time the drive has been powered on, maximum and minimum operating temperatures and varios error/event counts are the saved. On powering up the error/event log is read from disk to RAM. The error log is written to a sector on the system cylinder periodically, this write is done at prediction update time (approximately every 15 minutes). At least 9 minutes must have passed since the last save of the error/event log to disk before the next auto write of the log will occur. If it is very critical not to lose any log information that has not been written to disk yet, issue the Update Error Log super command before powering off the drive. Use the following formula to convert thermistor values into degrees Celsius within approximately 10%: (88 - (thermistor value / 8)) = degrees Celsius. All values are since new or since an Initialize Error Log super command has been issued to the drive. The total time allows for 136+ years of operation. All counts will roll over to zero after 65535 occurrences.

Flash AT has expanded the set of extended commands with op code 0F0H to support error/event logging. This command is used to read the error/event log. The data sent to the host has the same format as maintained on the drive with the exception that the max and min thermistor values are converted to degrees Celsius. This command has the same password protection as other extended commands (read defect list, read/write configuration) but will use a sub-op code of 02 loaded in the sector count register of the task file. This departs from pervious practice for extended commands where the sub-opcode was equal to the required data transfer size (Flash AT error/event logging command will transfer only one sector to the host).

Byte	Definition (As stored on the drive)
0-3	Total Number of seconds the drive has been powered up. (LSB first)
4-5	Maximum operating temperature of the drive in thermistor values. (LSB first)
6-7	Minimum operating temperature of the drive in thermistor values. (LSB first)
8-9	Pointer to the location for the next error log entry in sector. (Always 0 on Flash)
10-11	Pointer to the sector in which the next error log entry goes. (Always 0 on Flash)
12-13	Number of sectors .
14-15	Number of bytes .
16-17	Number of times .
18-19	Number of times.
20-21	Number of times.
22-23	Number of times.
24-25	Number of times.
26-27	Number of times .
28-29	Number of times .
30-31	Number of times.
32-33	Number of times.
34-510	Reserved.
511	Error log checksum.

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7.4.Firmware Error Codes

00	(00)	EC_NO_ERROR	No error.
01	(01)	EC_WRITE_FAULT	Write fault.
02	(02)	EC_RECAL	Recalibrate failure.
04	(04)	EC_DATA_ECC	Data field ECC error.
06	(06)	EC_TARGET_RE_SELECT	A target attempted to re-select.
07	(07)	EC_DATA_SYNC_TMO	Data field sync timeout.
09	(09)	EC_NO_RECORD_FOUND	No record found.
11	(0B)	EC_SEEK_ERROR	Seek error.
13	(0D)	EC_REC_DATA_EQUAL	Data error recovered via ECC w/ 2 consecutive = syndromes.
14	(0E)	EC_REC_DATA_LAST	Data error recovered via ECC on last retry.
15	(0F)	EC_PARAMETER_OVR	Parameter overrun.
16	(10)	EC_INV_COMMAND	Invalid Command.
17	(11)	EC_INV_LBA	Invalid LBA.
18	(12)	EC_INV_CDB	Invalid bits set in CDB.
19	(13)	EC_INV_PARAMETER	Invalid fields in parameters.
20	(14)	EC_RESET_OCCURRED	Reset occurred.
21	(15)	EC_MODE_CHANGED	Mode select parameters were changed.
22	(16)	EC_BUFFER_RAM	Ram error (most likely found in a diagnostic).
23	(17)	EC_ASSERT_ERROR	Logical assertion (firmware consistency check) error.
24	(18)	EC_ROM_CHKSUM	Internal ROM checksum error.
25	(19)	EC_SCSI_PARITY	SCSI bus parity error.
26	(1A)	EC_PROM_CHKSUM	External PROM checksum error.
27	(1B)	EC_WRITE_SYSTEM	Error in writing to system error.
28	(1C)	EC_READ_SYSTEM	Error in reading from a system sector.
29	(1D)	EC_MOTOR_FAULT	Motor drops out of legal speed range.
31	(1F)	EC_SEQ_RAM_FAIL	Failure in writing to sequencer format table.
32	(20)	EC_UNXPCTD_SEQ_ERR	Unexpected sequencer error.
34	(22)	EC_BAD_HEAD_SELECT	Head read from ID not equal to selected head.
35	(23)	EC_INVALID_HEAD	Invalid head specified.
36	(24)	EC_INVALID_CYL	Invalid cylinder specified.
37	(25)	EC_BAD_BPS_BPB	Bytes per block/ bytes per sector gives a remainder.
38	(26)	EC_RECALING	Drive is up to speed and recalibrating.
39	(27)	EC_SPINNING	Drive is spinning up.
40	(28)	EC_STOPPED	Drive has not been told to spin up.
41	(29)	EC_NO_ALT_SECTS	No more alternate sectors available.
42	(2A)	EC_INVALID_SECTOR	Invalid sector specified.
43	(2B)	EC_SEQ_TIMEOUT	Sequencer timeout.
45	(2D)	EC_BUMP_TIMEOUT	Bump timeout.
47	(2F)	EC_MISCOMPARE	Read buffer miscompare.
48	(30)	EC_SEQ_ROLLOVER	Sequencer rollover register failure.
49	(31)	EC_REASSIGN_FAIL	Failure in reading sector in Reassign Blocks command.
50	(32)	EC_BAD_MODE_PAGE	Some parameter(s) in the mode pages found to be bad during init.
51	(33)	EC_FMT_FAILURE	Failure to write fill data pattern in Format Unit command.
52	(34)	EC_ID_ECC	ID ecc error.
54	(36)	EC_ID_SYNC_TMO	AM mark not found for ID field.
56	(38)	EC_INVALID_DATA	Data read was written after reallocation of uncorrectable data.
58	(3A)	EC_BAD_DFCT_LIST	Bad defect list.
59	(3B)	EC_DFCT_LIST_FULL	Defect list is full.

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60 (3C) EC_REC_BAD_FORMAT Requested format in Read Defect Data not available.
61 (3D) EC_UNDERRUN Underrun error.
63 (3F) EC_CS_TIMEOUT Timed out getting burst data (CALC_SLOPE).
64 (40) EC_AEQBM Recal fault - AEQBM <= offset value (CALC_SLP).
65 (41) EC_AEQBH_OVERFLOW Recal fault - AEQBH > 0FFH (CALC_SLP).
66 (42) EC_FCS_TIMEOUT Recal fault - Timed out getting burst date (FINE_CALC_SLP).
67 (43) EC_AEQB_RANGE Recal fault - AEQB burst data not in range (FINE_CALC_SLP).

68 (44) EC_AEQBH_UNDER Recal fault - AEQBH burst data <= mid value (FINE_CALC_SLP).
69 (45) EC_AEQBL_OVER Recal fault - AEQBL burst data >= mid value (FINE_CALC_SLP).
70 (46) EC_AEQB_DELTA Recal fault - AEQBH and low are to close (FINE_CALC_SLP).
71 (47) EC_NO_SAM Recal fault - No SAM UN_PARKING.
72 (48) EC_RCAL_SK_TIMOUT Recal fault - Seek timeout in recal.
73 (49) EC_HO_TIMEOUT Recal fault - Timed out getting head offsets.
74 (4A) EC_FW_AUTOWRERR Autowrite command received while host channel disabled.
75 (4B) EC_ID_NOT_FOUND ID not found. Bad sector number in format track descriptor list.
76 (4C) EC_BAD_DESCRIPTOR Bad descriptor in format track desriptor list.
77 (4D) EC_BAD_BLOCK Bad Block Mark set for ID (AT).

78 (4E) EC_LATCH_OPEN Latch stuck open.
79 (4F) EC_WUS_WRITE_FLT WUS write fault (bump).
81 (51) EC_READ_DISKWARE Error during reading of diskware.
82 (52) EC_BAD_SYNC Bad servo sync.
84 (54) EC_BAD_SAM Bad servo address mark.
86 (56) EC_BAD_DATA Bad track data.
88 (58) EC_SERVO_DEFECT Bad servo sample.
90 (5A) EC_BUMPED PERR out of bump range.
92 (5C) EC_OFF_TRACK Actual track != desired track in ontrack mode.
94 (5E) EC_LOST_LOCK Multiple bad AM/Sync, fatal servo error, need to recal.
96 (60) EC_OUT_SPEED Speed is out of range.
98 (62) EC_LAST_SERVO_STATUS Marker for last servo status defined.
100 (64) EC_CRC_CONT Marker for CRC/Continue
102 (66) EC_RES_OVR_VERSION Marker for resident and overlay are incompatable.
103 (67) EC_ROM_RES_VERSION Marker for ROM and resident code are incompatable.
104 (68) EC_ROM_OVR_VERSION Marker for ROM and overlay are incompatable.
105 (69) EC_OVL_CHKSUM Marker for overlay check sum.
106 (6A) EC_DAC_OFFSET Recal fault - DAC offset calibration failure.
107 (6B) EC_VT_CHKSUM Marker for diskware vector table checksum.

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