

# FIRMWARE MANUAL FOR



Document	Maverick Firmware Manual
Revision	B
Part Number	
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# 1. General Information

## 1.1. Revision History

<u>REVISION</u>	<u>AUTHOR</u>	<u>DATE</u>	<u>DESCRIPTION</u>
A	Jing B	07/01/94	Release for MASSPRO
B	Don O, Bob C	08/30/94	First mark-up

## 1.2. Scope

The purpose of this manual is to document the *Maverick* firmware commands. 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.

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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. Although the common diagnostic commands used the same command descriptor blocks, the internal implementation of these commands may be product dependent.

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.

### 2.2.1. Enable SCSI Diagnostic Commands

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				
2	Reserved = 0							
3	Reserved = 0							
4	Parameter List Length = 7							
5	UV = 0	Reserved = 0				F	L	

Standard SCSI Send Diagnostic command is used to enable and disable the Quantum diagnostic commands. The diagnostic mode is always disabled on power up or after a host reset.

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 Password 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.

### 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 FOH 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.



### 2.3.1. Enable AT Diagnostic Commands

	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.

### 2.3.2. AT Password Data Format

<u>Byte</u>	<u>Enable Diagnostic Mode</u>	<u>Disable Diagnostic Mode</u>
0	01h	00h
1	"H"	xx
2	"B"	xx
3	"N"	xx
4	"J"	xx
5	"M"	xx
6	"K"	xx
7	"R"	xx
8	"H"	xx

Same as SCSI, a value of 0 in byte 0 in front of the password will disable diagnostic mode and a 1 will enable the diagnostic modes. A bus reset will automatically disabled the diagnostic mode.

## 2.4. Superset Command Descriptions

### 2.4.1. Command Summary

<u>Sub Opcode</u>	<u>Command</u>	
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	•
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 Bufer	
1D	Poke Buffer	
1E	Read Variables	
1F	Factory Format	

- Not implemented in Maverick products.

<u>Sub Opcode</u>	<u>Command</u>	
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	

- Not implemented in Maverick products.

### 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.

### 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.

### 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	Length	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

Page	Length	Contents																																					
7	7	<b>AT configuration flags.</b>																																					
		<table border="1"> <thead> <tr> <th>Byte</th> <th>Bit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td rowspan="8">0</td> <td>0</td> <td>1 = return page 7 logical CHS always. 0 = return current logical CHS</td> </tr> <tr> <td>1</td> <td>1 = Silent servo 0 = Normal servo</td> </tr> <tr> <td>2</td> <td>1 = disable wiggle retry. 0 = enable wiggle retry</td> </tr> <tr> <td>3</td> <td>1 = Cache debug 0 = Normal cache operations</td> </tr> <tr> <td>4</td> <td>save command history.</td> </tr> <tr> <td>5</td> <td>Auto transfer</td> </tr> <tr> <td>6</td> <td>Auto read</td> </tr> <tr> <td>7</td> <td>AT idle spin down enable</td> </tr> <tr> <td rowspan="6">1</td> <td>0</td> <td>0 = Fast seek mode 1 = Slow seek mode</td> </tr> <tr> <td>1</td> <td>1 = Firmware variable POS_OFFS no change throughout all seeks. 0 = Clears POS_OFFS with every seek.</td> </tr> <tr> <td>5-4</td> <td>I/O read delay. 00h 0 ns (default). 01h 10 ns. 10h 20 ns. 11h 30 ns.</td> </tr> <tr> <td>6-7</td> <td>DMA modes</td> </tr> <tr> <td>2-3</td> <td>AT logical cylinders per drive.</td> </tr> <tr> <td>4</td> <td>AT logical heads per cylinder.</td> </tr> <tr> <td>5</td> <td>AT logical sectors per track.</td> </tr> <tr> <td>6</td> <td># minutes to Auto Power Down</td> </tr> </tbody> </table>	Byte	Bit	Description	0	0	1 = return page 7 logical CHS always. 0 = return current logical CHS	1	1 = Silent servo 0 = Normal servo	2	1 = disable wiggle retry. 0 = enable wiggle retry	3	1 = Cache debug 0 = Normal cache operations	4	save command history.	5	Auto transfer	6	Auto read	7	AT idle spin down enable	1	0	0 = Fast seek mode 1 = Slow seek mode	1	1 = Firmware variable POS_OFFS no change throughout all seeks. 0 = Clears POS_OFFS with every seek.	5-4	I/O read delay. 00h 0 ns (default). 01h 10 ns. 10h 20 ns. 11h 30 ns.	6-7	DMA modes	2-3	AT logical cylinders per drive.	4	AT logical heads per cylinder.	5	AT logical sectors per track.	6	# minutes to Auto Power Down
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8	1	<b>Number of heads</b>																																					
9	16	<b>Configuration validation field.</b> 0,1,0FF,2,0FE,3,0FD,4,0FC,5,0FB,6,0FA,7,0F9,8																																					
10	613	<b>Zone table. See next page</b>																																					
11	3	<b>Number of user accessible sectors - lsb first.</b>																																					
12	1	<table border="1"> <thead> <tr> <th>Trigger mask.</th> <th>Bit 0</th> <th>Not defined</th> </tr> </thead> <tbody> <tr> <td></td> <td>Bit 1</td> <td>Seek timeout</td> </tr> <tr> <td></td> <td>Bit 2</td> <td>Seek fault.</td> </tr> <tr> <td></td> <td>Bit 3</td> <td>Not defined</td> </tr> <tr> <td></td> <td>Bit 4</td> <td>ECC error.</td> </tr> <tr> <td></td> <td>Bit 5</td> <td>Sequencer read/write error.</td> </tr> <tr> <td></td> <td>Bit 6</td> <td>Sequencer underrun/overrun.</td> </tr> <tr> <td></td> <td>Bit 7</td> <td>Sequencer timeout.</td> </tr> </tbody> </table>	Trigger mask.	Bit 0	Not defined		Bit 1	Seek timeout		Bit 2	Seek fault.		Bit 3	Not defined		Bit 4	ECC error.		Bit 5	Sequencer read/write error.		Bit 6	Sequencer underrun/overrun.		Bit 7	Sequencer timeout.													
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13	2	<b>Drive family and model identification numbers</b>																																					
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17	1h	MAVERICK 270																																					
17	2h	MAVERICK 405																																					
17	3h	MAVERICK 540																																					

Page	Length	Contents
14	6	<b>Head Mapping</b>
		0 Hardware head map. Bit <b>n</b> is set if head <b>n</b> was found during power up.
		1-2 unused
		3 User head map. Bit <b>n</b> is et if head <b>n</b> is mapped into use.
		4-5 unused.
15	57	<b>Diskware Overlay</b>
		<b>Byte Description</b>
		0 00h - Overlay 0 - Vector table
		1 Load address
		2 Number of sectors
		3 Cylinder
		6 Head
		7 Starting sector
		8 01h - Overlay 1 - Resident overlay segment for firmware
		9-15 Same fields as above.
		16 02h - Overlay 2 - Main overlay segment for firmware
		17-23 Same fields as above
		24 03h - Overlay 3 - Selfscan resident overlay
		25-31 Same fields as above
		32 04h - Overlay 4 - Selfscan first overlay
		33-39 Same fields as above
		40 05h - Overlay 5 - Selfscan second overlay
		41-47 Same fields as above
		48 06h - Overlay 6 - Selfscan third overlay
		49-55 Same fields as above
56 07h - Overlay 7 - Apple diagnostic commands overlay. SCSI only		
57-63 Same fields as above		
64 0FFh - End marker		
16	1	<b>HDA Control Flags</b>
		<b>Bit Description</b>
		0 Do not spin down when recal failed on power up
		1 Allow drive to attempt recal on fatal power up error
		2 Reserved
		3 Disable idle servo mode (Disable power saving mode)
		4 Reserved for servo use only
		5 Trace DAC on
		6 Enable read on arrival
		7 Reserved

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.



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 (M-1,N-1).
12	1	Zone 0 - Odie register
13	1	Zone 0 - servo threshold.
14	1	Zone 0 - servo agc.
15	1	Zone 0 - data recovery.
16	1	Zone 0 - PWM 0
17	1	Reserved = 0
18	1	Reserved = 0
19	1	Reserved = 0
20	1	Reserved = 0
21	1	Reserved = 0
22	1	Reserved = 0
23	1	Reserved = 0
24	1	Reserved = 0
25	1	Reserved = 0
26	1	Reserved = 0
27	1	Reserved = 0

Repeat for heads 2 and 3

Repeat for zones 1 through 15

608	2	Maximum cylinder.
610	3	Maximum logical sector address.

### 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.

### 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 =							
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 help to reduce the proliferation of commands.

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

### 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:

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

### 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:

<u>Byte</u>	<u>Contents</u>
0	Starting physical sector number for specified track.

### 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:

<u>Byte</u>	<u>Content</u>
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:

<u>Byte</u>	<u>AT 6 byte</u>	<u>AT 10 byte</u>	<u>SCSI 6 byte</u>	<u>SCSI 10 byte</u>
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

### 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 14 bytes of data for each cache segment. The returned data format is:

Cache Header:	Byte	Content
	2	Number of bytes in the cache table (lsb first).
	3	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).
	3-5	Number of blocks in the entry.
	6	CACHE_SEG_OFFSET
	7	LRU counter
	8-9	Upper byte of rollover register.
	A-B	Upper byte of rollunder register.
	C	Sectors in cache segment
	D	Cache flag

## 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 =							
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:

<u>Byte</u>	<u>Contents</u>
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.



### 2.4.12. Seek Physical

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0		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.

<u>Byte</u>	<u>Contents</u>
0	Seek time - lsb.
1	Seek time - msb.

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

## 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.

### 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.

### 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.

## 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	Number of Sectors - msb							
8	Number of Sectors - 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.

## 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.

### 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.

## 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:

<u>Byte</u>	<u>Contents</u>
0-1	Index time (lsb first).



## 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:

<u>Byte</u>	<u>Content</u>
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.

**2.4.21. Microstep**

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0			Pct	Inf
2	Microstep Count - msb							
3	Microstep 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. If the **PCT** bit is set, then use CDB3 for the percentage.

$$1 \text{ microstep} = \frac{1}{512 \text{ of 1 track}}$$

$$\text{Scale} = \frac{512 \text{ counts}}{\text{Track}}$$

## 2.4.22. 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.

## 2.4.23. 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.

### 2.4.24. 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.

## 2.4.25. 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:

<u>Byte</u>	<u>Content</u>
0	Count byte 2.
1	Count byte 1.
2	Count byte 0.
3	Sector.
4	Head.
5	Flag byte.

$$\text{Count Byte} = \frac{\text{Number of bytes in data segment}}{4} - 1$$

**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 from Read 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.

## 2.4.26. 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:

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

## 2.4.27. 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.



### 2.4.28. 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.

## 2.4.29. 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:

<u>Byte</u>	<u>Content</u>
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.
...	

### 2.4.30. 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. Grown defect information is lost.

#### Header Block

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

Transfer length = number of defects \* 8

#### Wedge Defect Descriptor Block

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

#### CHS Defect Descriptor block

0	Cylinder - msb
1	Cylinder - lsb
2	Head
3	0FFh
4	Reserved = 0
5	Reserved = 0
6	Reserved = 0
7	Sector

Physical descriptor data format is from SCSI spec.

## 2.4.31. 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.

<u>M</u>	<u>S/L</u>	<u>Operation</u>	<u>Description</u>
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.

## 2.4.32. 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.

### 2.4.33. 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.

### 2.4.33.1. 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.

*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	Number of Blocks - MSB							
2	Number of Blocks							
3	Number of Blocks - LSB							
4	Reserved = 0							
5	Block Length - MSB							
6	Block Length							
7	Block Length - LSB							

*Page Descriptor*

	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 Maverick 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.

**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 specified 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 Maverick 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 Maverick Hard Disk Drive*

<b>Page</b>	<b>Description</b>
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

- **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 drive in the MODE SENSE page length byte.



## 2.4.33.2. Error-Recovery Parameters, Page Code 1H

<i>Error Recovery Parameters</i>									
	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 = 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. A **DTE** 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.

**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 Maverick drives

*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 completed.
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 completed.
0	1	1	0	The drive attempts read retries until it reads good data, obtains stable syndrome, or exhausts the retry counts. 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 counts. 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

## 2.4.33.3. Disconnect/Reconnect Control Parameters, Page Code 2H

<i>Disconnect/Reconnect Control Parameters</i>								
	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	Reserved = 0							

**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.

## 2.4.33.4. Direct - Access Device Format, Page Code 03H

<i>Direct-Access Device Format</i>								
	7	6	5	4	3	2	1	0
0	Reserved = 0		Page Code 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 Skew Factor							
18-19	Cylinder Skew Factor							
20	ssec=0	hsec=1	rmb=0	surf=0	Reserved = 0			
21-23	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.

**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 MAVERICK hard disk drive uses soft sector formatting.

**HSEC - Hard Sector**

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

**RMB - Removable**

Set to zero for the MAVERICK 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.

## 2.4.33.5. Cache Control, Page Code 08H

	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 Retention Priority = 0				Write Retention Priority = 0			
4-5	Disable Prefetch Transfer Length (MSB, LSB)							
6-7	Reserved							
8-9	Reserved							
10-11	Reserved							

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 MAVERICK 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.

## 2.4.33.6. Notch and Partition, Page Code 0CH

	7	6	5	4	3	2	1	0
0	PS=0	RSVD=0	Page Code 02h					
1	Page Length = 0Ah							
2	ND=1	PLN	Reserved = 0					
3 -	Reserved = 0							
4-5	Maximum Number of Notches (MSB,LSB)							
6-7	Active Notch(MSB,LSB)							
8-11	Starting Boundary(MSB to LSB)							
12-15	Ending Boundary (MSB to LSB)							
16-23	Page Notched (MSB to LSB)							

**PS - Parameters Savable**

The MODE SENSE command reserves this bit for its use. In the MAVERICK 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 MAVERICK hard disk drive is a notched device - that is, ND is set to one. This is a read-only parameter.

**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 MAVERICK 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 MAVERICK 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 MAVERICK 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 different for different 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 different for different notches. When a bit is set to zero, the corresponding mode page contains parameters that are constant for all notches. For the MAVERICK 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.

*Starting and Ending Boundaries for Active Notches*

Active Notch	Start Cylinder	Sectors per track
0	0	118
1	200	118
2	359	118
3	597	114
4	745	112
5	873	108
6	1031	104
7	1219	97
8	1397	93
9	1585	88
10	1783	83
11	1941	78
12	2179	74
13	2297	69
14	2435	65
15	2613	58

**2.4.33.7. Automatic Shutdown Control, Page Code 32H**

	7	6	5	4	3	2	1	0
<b>0</b>	Reserved = 0		Page Code = 32h					
<b>1</b>	Page Length = 02h							
<b>2</b>	Auto Standby Time = 0							
<b>3</b>	Auto Shutdown Time in minutes							

**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.

## 2.4.33.8. Quantum-Unique Control Parameters, Page Code 37H

<i>Quantum-Unique Control Parameters</i>								
	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	Reserved = 0							
5	Reserved = 0							
6-15	Reserved = 0							

**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

**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.

### 2.4.34. 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 defined 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.

**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 MAVERICK Hard Disk Drive***

<b>Page</b>	<b>Description</b>
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.

## 2.4.34.1. Mode Sense Data

		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								

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

		7	6	5	4	3	2	1	0
0	PS	R=0	Page Code						
1	Page Length								
3	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.

**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 MAVERICK 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.

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

The following are direct-access device format parameters. These fields contain parameters that are zone dependent. Their values vary depending on the active zone.

*Handling of Defects Fields*

	7	6	5	4	3	2	1	0
2-3	Tracks Per Zone (MSB, LSB)							
4	Alternate Sectors Per Zone = 0							
5	Alternate Sectors Per Zone = 01h							
6	Alternate Sectors Per Zone = 00h							
7	Alternate Tracks Per Zone = 00h							
8	Alternate Tracks Per Volume = 00h							
9	Alternate Tracks Per Volume = 00h							

*Track Format Fields*

	7	6	5	4	3	2	1	0
10	Sectors Per Track = 00h							
11	Sectors Per Track = 00h							

*Sector Format Fields*

	7	6	5	4	3	2	1	0
12	Data Bytes Per Physical Sector = 02h							
13	Data Bytes Per Physical Sector = 00h							
14	Interleave = 00h							
15	Interleave = 01h							
16	Track Skew Factor = 00h							
17	Track Skew Factor = 07h							
18	Cylinder Skew Factor = 00h							
19	Cylinder Skew Factor = 0Fh							



## 2.4.34.3. Rigid Disk Drive Geometry Parameters, Page Code 4H

	7	6	5	4	3	2	1	0
0	Reserved = 0		Opcode = 04h					
1	Opcode = 12h							
2	• Number of Cylinders (MSB) = 0							
3	Number of Cylinders							
4	Number of Cylinders (LSB)							
5	Number of Heads							
6-8	Starting Cylinder for Write Precompensation = 0							
9-11	Starting Cylinder for 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 MAVERICK hard disk drive handles the write precompensation starting 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.

### 2.4.35. 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.

### 2.4.36. Servo Verify

	7	6	5	4	3	2	1	0
0	Opcode = 0FFh							
1	LUN = 0			Reserved = 0				Opt
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 78 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.

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

If **Opt** is 1 then it will return 78 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 code's bit defines are as follows:

<u>Bit</u>	<u>Description</u>
0	Not used.
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.

## 2.4.37. 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:

<u>Byte</u>	<u>Contents</u>
0	Current cylinder - lsb.
1	Current cylinder - msb.

### 2.4.38. Self Scan Test

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

This command execute self scan supported functions. See Self Scan Manual for all of the test details.

The following selfscan functions are supported through selfscan command:

Selfscan Opcode	Description
0	Start selfscan •
1	Start selfscan using IDLE_CALL_VECTOR but does not check for password•
2	Stop selfscan. Selfscan will save all results before terminate
3	Abort selfscan. Selfscan will not do a save all results before terminate
4	Pause selfscan
5	Resume selfscan
6	Status. Non-zero means selfscan is busy
7	Start selfscan using IDLE_CALL_VECTOR; validity of the password is checked •
8	Selfscan control flags: Bit 0 - Power on start immediate; this option will start selfscan immediately. Bit 1 - Power on start wait; drive will wait for 2 minutes before start selfscan; any incoming or reset will terminate selfscan until next power cycle. Bit 2 - Power on restart immediate; this option will continue selfscan from last run. Bit 3 - Power on restart wait; drive will wait for 2 minutes before restart and continue selfscan. Bit 4 - Reserved Bit 5 - Reserved Bit 6 - Reserved Bit 7 - Selfscan is in progress. This bit is set by selfscan. It is used to determine to restart selfscan if either power on restart bit is set.

- These selfscan opcodes for Maverick provide the same function as opcode 7; this is to provide compatibility with Thunderbolt.

## 2.4.39. 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 78 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).

<u>Byte</u>	<u>Contents</u>
0	perr - lsb - burst 0
1	perr - msb - burst 0
2	perr - msb - burst 1
3	perr - msb - burst 1
...	
154	perr - msb - burst 77
155	perr - msb - burst 77

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## 3. Defect Management

### 3.1. The Defect Lists

Three different lists are stored on system cylinder -2 and -3:

1. Primary defect list (P list) - this list contains the defects found in defect scans at the factory. The P list contains the locations of the 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.
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.

#### 3.1.1. Replacement Strategy

Maverick reserves one spare sector per cylinder for 135mb, 270 Mb, 405 Mb drives, and two spare sectors for 540 Mb drives; it utilizes two methods for sector replacement - inline and offline sparing.

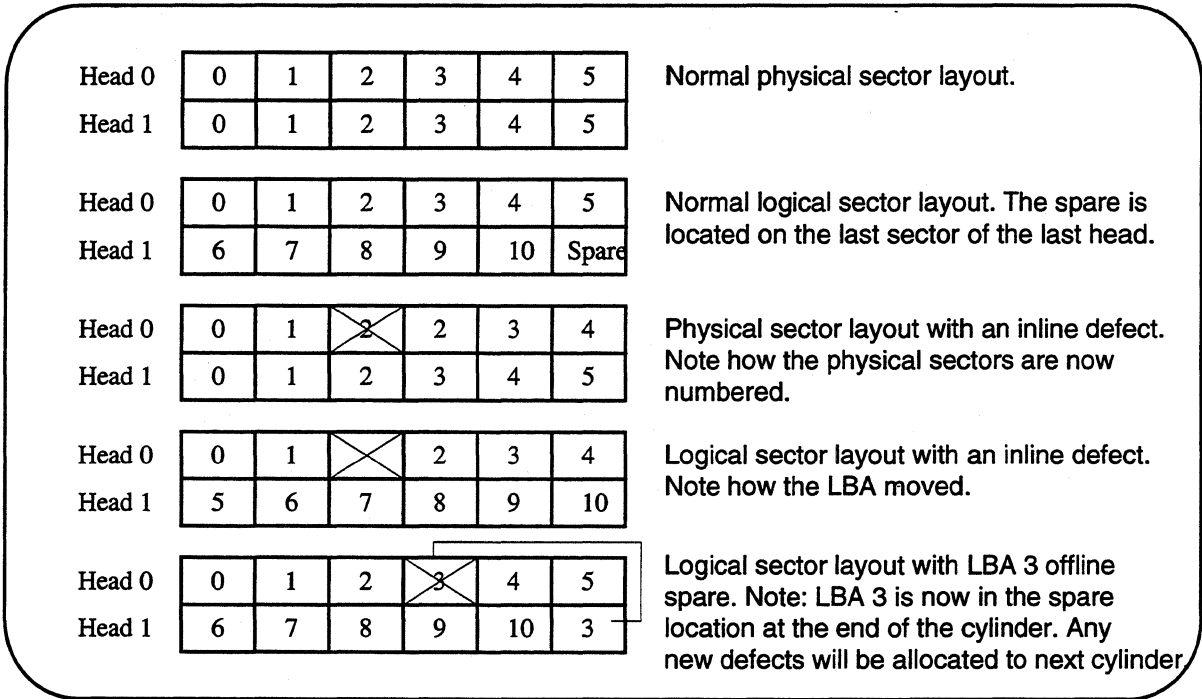
##### 3.1.1.1. Inline Sparing

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.



**3.1.1.2. 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 contains an example of an offline spare.



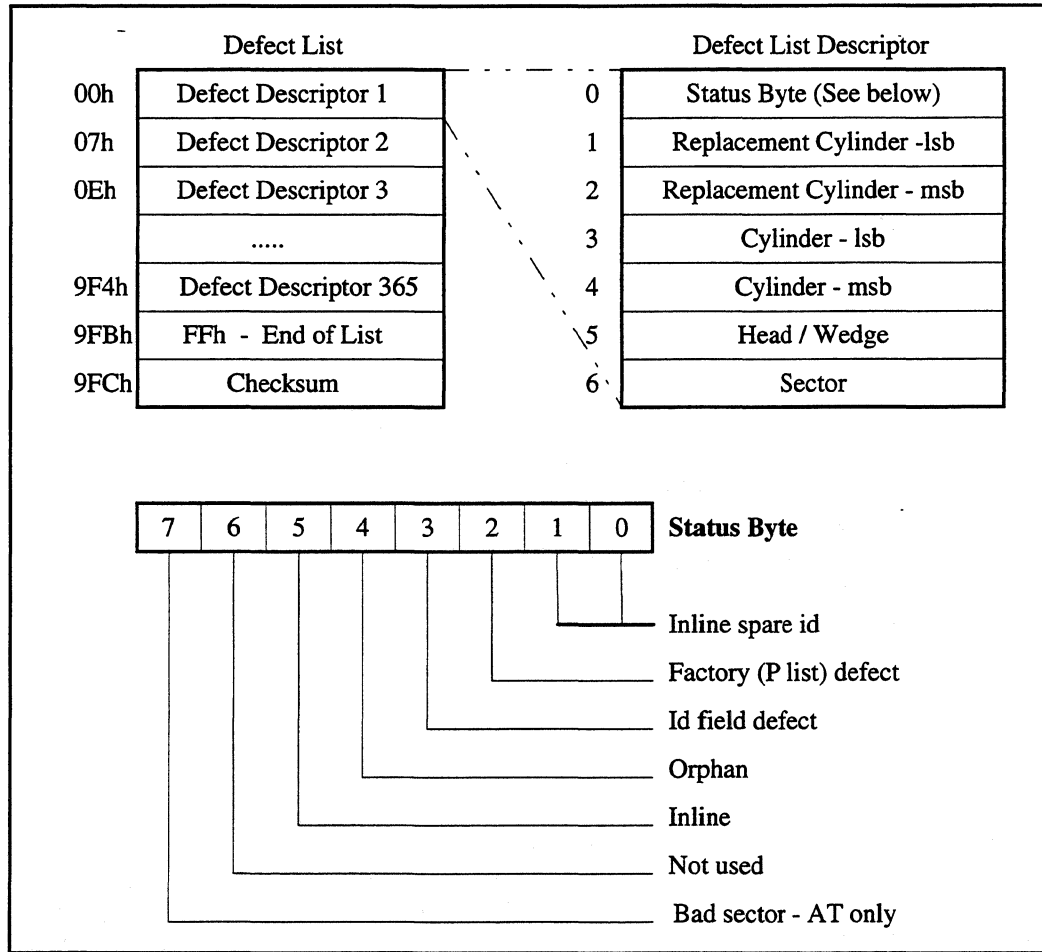
**Example of Inline and Offline Spares**

**3.1.1.3. 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.

### 3.1.2. 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.



**Defect 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 '<'.>

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.

### 3.2. 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 2560 bytes of storage, therefore, a total of 5 sectors per list are reserved to hold the defect lists on a system track. See section 4 for storage layouts of the lists. Since the W list is limited to 2560 bytes in size, a maximum of 365 defects may be recorded in a Maverick drive.

## 4. System Cylinders

### 4.1. General Information

**Three cylinders** 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:

<u>Cylinder</u>	<u>Description Outer System Area</u>
-1	Test data
-2	System and firmware data and Diskware
-3	Copy of cylinder -2
-4	Firmware diskware
-5	Copy of cylinder -4
-6	Reserved for future overlays
-7	Reserved for future overlays

## 4.2. Test Equipment Cylinder

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

The sector usages are as follows:

<b>Sector</b>	<b>Description</b>	<b>Size</b>
0	Servo Writer	1
1	Test interlock	1
2	Reclassification	1
3-12	History queue	10
13-20	DS defect list	8
21-28	AS defect list	8
29-36	SS defect list	8
37-40	Selfscan test script	4
41-48	Selfscan test results	8
49-52	Selfscan runout results	4
53-54	Selfscan wedge defects	2
55	Selfscan command history	1
56-59	Selfscan reserved	4
60-63	Drive parameter analysis	4
64-92	Reserved	29

### 4.3. System / Firmware Cylinder

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

Description of Sectors (Cylinder -2, -3)

<b>Sector</b>	<b>Description</b>	<b>Size</b>
0	Saved mode pages 1, 2, 20h, 37h, 38h, and 39h	1
1	Saved mode pages 3 and 4	1
2-7	Configuration pages	6
8-12	Working defect list	5
13-17	Primary defect list	5
18-22	Temporary defect list	5
23-39	Format header bytes for 17 zones	17
40	Apple system sector for read/write of OS information	1
41-44	Selfscan overlay 1	4
45-56	Selfscan overlay 2	12
57-68	Selfscan overlay 3	12
69-80	Selfscan overlay 4	12
81-92	Reserved	12

Sector usages of cylinder -4 and -5.

<b>Sector</b>	<b>Description</b>	<b>Size</b>
0-47	Diskware overlays	48
48-63	Reserved	16
64-79	Drive parameter analysis overlay	5
85-88	Reserved for inline sparings	4
89-93	Reserved	5

#### **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.

#### **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.

#### **Defect List Sectors**

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

#### **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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## 5. Diskware

### 5.1. Introduction

The Maverick 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.

### 5.2. Memory Map

The memory map for MAVERICK is organized as follows:

<u>Address Range</u>	<u>Length</u>	<u>Description</u>
0000h - 7FFFh	32K	CPU ROM.
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	ASIC's.
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.

The MAVERICK firmware uses only the address range 8000-DFFF for diskware; it is divided into 2 segments. The first segment name is RESIDENT and the second segment is MAIN. The code in segment RESIDENT cannot be swapped during drive operations. But the code in MAIN segment can be swapped in and out of the memory. This is mainly used by selfscan and Drive parameter analysis codes.



### 5.3. 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 three overlays defined, one for SelfScan, one for drive parameter analysis, and one for normal operation.

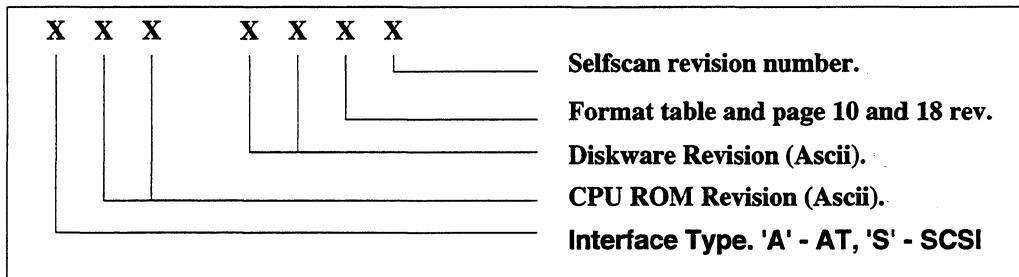
<u>Address Range</u>	<u>Description</u>
8000 - BFFF	Resident Diskware Vector Table Code
C000 - DFFF	Overlay Diskware 1 - Normal Operating Code Code 2 - Selfscan Code Code 3 - Drive parameter analysis (AT only) Code

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 Maverick 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.

### 5.4. 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 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 to 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.

## 5.5. Diskware Storage Requirements

The diskware is stored on reserved system cylinders in memory image format. 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 Maverick firmware stores redundant system cylinder information on all physical heads in system cylinder areas.

### Configuration Page 15 - Overlay Page

<u>Field Offset</u>	<u>Description</u>
0	00h - Overlay 0 - Resident diskware.
1	Load address.
3	Number of sectors.
4	Cylinder.
6	Head.
7	Starting sector.
8	01h - Overlay 1 - Resident diskware.
9-15	Same fields as above.
16	01h - Overlay 2 - Normal operating diskware.
17-23	Same fields as above.
...	03h - 06h Overlays - Self scan diskware.
...	07h - Overlay 7 - Drive parameter analysis
64	FFh - End marker.

## 5.6. Diskware Update

The Maverick diskware may be updated using process software (RRPT) by writing diskware directly rite Buffer Download Microcode command. LPT uses a disk file which contains the configuration page information and diskware in a binary format as shown below.

<u>Field</u>	<u>Description</u>
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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## 6. Miscellaneous Information

### 6.1. 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:

<u>Bit</u>	<u>Description</u>
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 an 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.

## 6.2. 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.

<u>Byte</u>	<u>Mask</u>	<u>Default</u>	<u>Description</u>
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.

<u>Byte</u>	<u>Mask</u>	<u>Default</u>	<u>Description</u>
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.

**Page 3h** Direct access device format parameters.

<u>Byte</u>	<u>Mask</u>	<u>Default</u>	<u>Description</u>
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.



**Page 4h** Rigid disk drive geometry parameters.

<u>Byte</u>	<u>Mask</u>	<u>Default</u>	<u>Description</u>
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.

<u>Byte</u>	<u>Mask</u>	<u>Default</u>	<u>Description</u>
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.

**Page Ch** Notch page.

<u>Byte</u>	<u>Mask</u>	<u>Default</u>	<u>Description</u>
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.

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

**Page 37h** Tako (Cache) page.

<u>Byte</u>	<u>Mask</u>	<u>Default</u>	<u>Description</u>
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

### 6.3. Firmware Error Codes

Internal Error Code	Sense Key	Sense Code	Sense code qualifier	Description
0	0	00	00	No Error detected at Drive level
1	3	03	00	Write fault
2	1	03	00	Recovered Write Fault
4	3	11	00	Uncorrectable data field ECC error
5	1	17	01	Recovered data field ECC error
6	6	9A	00	A target attempted to re-select
7	3	13	00	Data field sync timeout
8	1	13	00	Recovered data field sync timeout
9	3	14	01	No record found
A	1	14	00	Recovered no record found
B	4	15	00	Seek error
C	1	15	00	Recovered seek error
D	1	18	00	Recovered data error via ECC w/2 = syndromes
E	1	18	01	Recovered data error via ECC on last retry
F	5	1A	00	Parameter overrun
10	5	20	00	Invalid command
11	5	21	00	Invalid LBA
12	5	24	00	Invalid bits set in CDB
13	5	26	00	Invalid field in parameters
14	6	29	00	Reset occurred
15	6	2A	00	Mode select parameters were changed
16	4	40	00	RAM error (most likely found in a diagnostic)
17	4	87	00	Logical assertion/firmware consistency check err
18	4	42	00	Internal ROM checksum error
19	B	47	00	SCSI Bus parity error
1A	4	42	01	Marker for resident code checksum
1B	3	80	00	Error in writing to system sector
1C	3	81	00	Error in reading from system sector
1D	4	9E	00	Motor unable to get up to speed
1E	1	9E	00	Recovered motor unable to get up to speed
1F	4	84	00	Failure in writing to sequencer format table
20	4	86	00	Unexpected sequencer error
21	1	86	00	Recovered unexpected sequencer error
22	4	8A	00	Head read from ID not equal to selected head
23	5	8A	00	Invalid head specified
24	5	8B	00	Invalid cylinder specified
25	5	8D	00	Bytes per block/bytes per sector gives a remaindr
26	2	04	00	Drive is up to speed and recalibrating
27	2	04	01	Drive is spinning up
28	2	04	02	Drive has not been told to spin up
29	3	32	01	No more alternate sectors available
2A	5	8F	00	Invalid sector specified
2B	4	95	00	Sequencer timeout
2C	1	95	00	Recovered sequencer timeout
2D	4	09	00	Bump timeout
2E	1	09	00	Recovered bump timeout
2F	E	1D	00	Read buffer miscompare
30	4	A1	00	Sequencer rollover register failure
31	3	A3	00	Failure reading sector in Reassign Blocks command
32	5	AE	00	Bad parameter(s) found in mode pages during init
33	3	31	01	FDPE write failed during format unit command
34	3	10	00	ID ECC error
35	1	10	00	Recovered ID ECC error
36	3	12	00	AM mark not found for ID field
37	1	12	00	Recovered AM mark not found for ID field
38	3	AA	00	Read Data written on realloc of uncorrectbl data
39	1	AA	00	Recovrd Rd data Wr on realloc of uncorrectbl data
3A	3	19	00	Bad defect list
3B	3	32	00	Defect list is full
3C	1	AB	00	Requested format in Read Defect Data not avail
3D	4	97	00	Underrun error

Internal Error Code	Sense Key	Sense Code	Sense code qualifier	Description
3E	1	97	00	Recovered underrun error
3F	4	06	01	RCL FLT- Coarse Slope PES Gain calibration
40	1	06	01	Recovered RCL FLT- Coarse Slope PES calibration
41	4	06	02	RCL FLT- Fine Slope PES Gain calibration at AEQBH
42	1	06	02	Recovered RCL FLT- Fine Slope PES calib at AEQBH
43	4	06	03	RCL FLT- Fine Slope PES Gain calib at AEQBL
44	1	06	03	Recovered RCL FLT- Fine Slope PES calib at AEQBL
45	4	06	04	RCL FLT- Cannot Lock to track
46	1	06	04	Recovered RCL FLT- Cannot Lock to track
47	4	06	05	RCL FLT- Cannot detect SAM during unparking
48	1	06	05	Recovered RCL FLT- Can't detect SAM during unpark
49	4	42	06	Marker for diskware vector table checksum
4A	4	FF	00	Autowr cmd received while host channel disabled
4B	4	FF	01	ID in format track descriptor list not found
4C	4	FF	02	Bad descriptor in format track descriptor list
4D	3	14	01	Bad block mark set for ID (AT)
4E	4	AC	00	Airlock stuck open
4F	4	03	00	WUS Write fault (bump)
50	1	03	00	Recovered WUS Write fault (bump)
51	3	82	00	Error during reading of diskware
52	4	09	04	Unrecoverable Bad servo sync
53	1	09	04	Recovered bad servo sync
54	4	09	05	Unrecoverable Bad servo address mark (SAM)
55	1	09	05	Recovered bad servo address mark (SAM)
56	4	09	06	Unrecoverable Bad track number data
57	1	09	06	Recovered bad track number data
58	4	09	07	Unrecoverable Servo Defect
59	1	09	07	Recovered Servo Defect
5A	4	09	08	Unrecoverable Bump
5B	1	09	08	Recovered Bump
5C	4	15	01	Unrecovrd Gray code != desired track while ontrk
5D	1	15	01	Recovered Gray code != desired track while ontrk
5E	4	15	03	Unrecovrd multi bad Sync/SAM while Settle/Ontrk
5F	1	15	03	Recovered multi bad Sync/SAM while Settle/Ontrk
60	4	9E	01	Unrecoverable Speed out of range
61	1	9E	01	Recovered speed out of range
62	4	15	04	Seek timeout with no servo fault
63	1	15	04	Recovered seek timeout with no servo fault
64	3	11	01	Marker for CRC/Continue
65	1	17	08	Recovered marker for CRC/Continue
66	4	42	02	Marker for resident and overlay are incompatible
67	4	42	03	Marker for ROM and resident are incompatible
68	4	42	04	Marker for ROM and overlay are incompatible
69	4	42	05	Marker for overlay checksum
6A	4	06	06	RCL FLT - DAC offset calibration failure
6B	1	06	06	Recovered RCL FLT - DAC offset calib failure
6C	4	86	01	Unexpected SEQ Err during recovery from SEQ TMO
6D	1	86	01	Recovrd unexpect SEQ err during SEQ TMO recovery
6E	4	86	02	Read/write ID miscompared
6F	1	86	02	Recovered read/write ID miscompared
70	3	12	01	AM not found for ID field with internal continue
71	1	12	01	Recovrd AM not found for ID w/ internal continue
72	3	03	00	Write gate still asserted when wedge detected
73	4	15	05	Unrecovrd multi bad Sync/SAM during Seek ISR
74	1	15	05	Recovered multi bad Sync/SAM during Seek ISR
75	4	06	06	RCL FLT - Cannot detect reliable SAM on any head
76	1	06	06	Recovrd RCL FLT-Can't detect SAM on any head
77	4	06	07	RCL FLT - Can't seek to OD to get near Sys yl
78	1	06	07	Recovrd RCL FLT - Can't seek to OD near Sys Cyl
79	4	06	08	RCL FLT - Can't seek to Fine Slope PES calib trk
7A	1	06	08	Recovrd RCL FLT-Can't seek to Fine SLP calib trk

Internal Error Code	Sense Key	Sense Code	Sense code qualifier	Description
7B	4	06	09	RCL FLT - Seek failure during Nulli calibration
7C	1	06	09	Recoverd RCL FLT - Seek fail during Nulli calib
7D	4	06	0A	RCL FLT - Seek failure during V_SCALE adaptation
7E	1	06	0A	Recovered RCL FLT-Seek fail during V_SCALE adapt
7F	4	06	0B	RCL FLT - Seek failure during KLOOP calibration
80	1	06	0B	Recoverd RCL FLT - Seek fail during KLOOP calib
81	4	06	0C	RCL FLT - Seek failure during RRO calibration
82	1	06	0C	Recoverd RCL FLT - Seek fail during RRO calib
83	4	06	0D	RCL FLT - Seek failure to track 0 during rezero
84	1	06	0D	Recoverd RCL FLT-Seek fail to trk 0 during rezero
85	4	06	0E	RCL FLT - Unable to complete KLOOP calibration
86	1	06	0E	Recoverd RCL FLT - Unable to complete KLOOP calib
87	4	06	0F	RCL FLT - Unable to complete RRO calibration
88	1	06	0F	Recoverd RCL FLT - Unable to complete RRO calib
89	3	01	00	No disk index found on current track
8A	1	17	09	Data corrected by ECC on the fly
8B	4	42	07	Invalid diskware version.
8C	4	42	08	Invalid ROM version
8D	4	1B	00	Synchronous transfer error
8E	5	9B	00	Invalid period or offset in synchronous message
8F	5	9C	00	Active initiator attempted a select while disconnected
90	5	25	00	Invalid LUN specified
91	4	43	00	Invalid message
92	B	45	00	Reselection timeout
93	B	48	00	Initiator detected error
94	4	85	00	Reject of message that should not been sent
95	B	00	00	Response of an Abort message
96	5	8C	00	Attempt by intruding initiator to select drive a second time
97	6	8E	00	Unexpected SIC interrupt occurred
98	4	90	00	Synchronous acknowledge error
99	4	91	00	Synchronous request error
9A	4	94	00	SIC error
9B	4	4A	00	FIFO load error
9C	4	49	00	FIFO unload error
9D	4	4B	00	FIFO predicted full error
9E	B	29	00	RAM parity error
A0	3	31	00	Medium format corrupted
A1	5	C2	00	Command not implemented
A2	2	C0	00	Burn-In test in progress