X3T9.2/90-103
Rev 3

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Subject : **Proposed Extensions for SCSI-3, Standard Physical Layer Access**
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Note: Additions from revision 1 of this document are indicated in ***bold italics and are underlined.*** Minor editorial changes have been made without any identifying markings. A text only version of this file (unformatted) is available on the ANSI Bulletin Board.

The exception to the above is the Direct Access Devices, Physical Layer Model, which essentially has been rewritten and should be considered as new in its entirety.

8.14 Direct Access Devices, Physical Layer Model

The Logical level interface provided by SCSI was not intended to deal directly with the physical characteristics of Direct Access Devices which are comprised of multiple elements e.g., mechanical components, Analog Circuitry and Digital Circuitry.

Disk drives operating as SCSI targets present consistent data to initiators, despite the wide variations in technology and differences in algorithms used for data recording and recovery e.g., Offsetting the Read/Write Head, Shifting the Data Window, Controlling Read Channel Hysteresis, Application of an ECC and/or Use of Retries.

The purpose of the Diagnostic Command Set (DCS) extensions is to control these algorithms. The results may be applicable to an evaluation of the design and the manufacturing process for the physical device. However interpretation of the results requires substantial insight into technology which is undergoing continuous evolution and in some cases revolution.

The descriptive material on the characteristics of disk devices is not inclusive of all the technology used. It is intended to provide a perspective on the kinds of capabilities which the Diagnostic Extensions can impact.

8.14.1 Physical Geometry

The physical device consists of some number of recording disks which are used to store information. The information includes, but is not limited to, user data, sector identification, system operation parameters and actuator positioning data.

The smallest addressable entity by the normal I/O are called logical blocks. The smallest addressable entity by diagnostics are called sectors, which are sequentially organized in concentric circles called tracks. A sector may contain multiple logical blocks and/or a logical block may require multiple sectors. The beginning of a track is indicated by a signal traditionally called INDEX. The DCS extensions refer to the track start marker as INDEX. A collection of tracks which are accessible on all disks without substantial actuator arm movement is called a cylinder.

Some devices read and write sectors by means of magnetic heads attached to a linear or rotary actuator. The motor driven (stepper or voice coil) actuator is positioned over the correct cylinder and a head (located over one track) is selected. If the servo information is on a track basis such as embedded the selection must be completed before positioning is completed. The requested sector(s), and other sectors, as they come under the Read/Write head are passed through the read channel to the controller for processing.

The recording surfaces are not required to be perfect in order to make use of the media. A limited number of sector locations may be identified as containing a defect during the production process, or during actual usage of a drive. SCSI drives use a variety of Defect Management algorithms to mask the presence of the sectors with defects from the user.

SCSI transfers involve only the User Area of disk cylinders. There are more cylinders over the entire stroke (length the actuator can travel between the physical ends of its range of movement). The ends of the stroke are protected by some means referred to as crash stops to catch "runaway" actuators.

The non-User data cylinders may play a large role in the management of the disk device and may provide additional elements to evaluate the drive characteristics.

The time it takes to complete a rotation is dependent on the rpm (revolutions per minute), which can vary e.g., the rotation time for 3600 rpm is 16.67 milliseconds and for 5400 rpm it is 11.11 milliseconds. Latency is the time it takes between the time a head settles and the drive is ready to transfer the requested data. The average latency is half the rotation time.

The MODE SENSE/MODE SELECT commands provide a means for the user to be aware of, and to some degree, control the personality of the physical device e.g., the Cylinder and Track/Sector Map Mode pages provide a means for a disk device to report the detailed physical characteristics of drive geometry,

8.14.2 Servo System for Motion Control

The actuator is controlled via a motor to position the head over the correct data track. Positioning information recorded on the drive is a means to inform the servo system of the current location. Should this information become corrupted, positioning to specific tracks may become degraded.

Different types of servo systems include:

* Open Loop systems: Controlled by only a Stepper Motor with no feed back information during a seek operation.

* Closed Loop systems: Controlled by either a Stepper Motor or a Voice Coil Motor with positioning information located on a dedicated surface or embedded within the data surface. Different types of embedded servo include:

  - sector servo systems, whereby the positioning information is located in fixed locations relative to the sector data,

  - wedge servo systems, whereby the positioning information is located in fixed locations relative to a consistent position such as INDEX, and may cause additional gaps in the data fields.

There are many elements involved in a servo system:

- Seeking: Moving a single and/or multiple cylinders,

- Switching: The changing of Read/Write heads without changing cylinders,

- Settling: The time it takes after physical motion for the head to be declared "on track" after seek completion,

- Algorithms: Various means to optimize seek motion or track following.

Possible candidates to evaluate seek motion include:

* Random Seek tests: This type of test stresses seeking over complex cylinder patterns and its impact on the servo system. This can require extensive run time to achieve a representative sample.

* Sequential Seek tests: This type of test stresses the single cylinder seek portion of the servo system.

* Write/Read tests: This type of test stresses the settling times of the servo system by using the above seek tests in combination with reading and writing of data. Checking the validity of recorded data during such a test may be a means to evaluate Read Channel performance, in addition to the Servo system.

8.14.3 Data Recording and Recovery

The recording and recovering of magnetic disk information is done via a magnetic head which can either induce a magnetic field (writing), or detect a magnetic field (reading). While the Host System, Initiator and Target Controller view data in terms of bytes (00h through FFh), the Read/Write Channel sees magnetic field changes and/or magnetic field strength.

Data encoding schemes are employed to optimize the efficiency of the read/write channel. Amongst the schemes used are methods generally known by the name of Run Length Limited (RLL) encoding, of which there are numerous types referred to by some of their code parameters such as 1:7 and 2:7. It is possible to use the DCS to infer some of the Head-Media characteristics by the Diagnostic Erase Track and Diagnostic Read Track operators of the SEND DIAGNOSTIC commands.

Both reading and writing are affected by the Motion Control System's ability to maintain adequate centering of the head over the requested track.

The process of writing is not usually checked at the instant of recording. It may be accomplished via a subsequent read, usually a Verify in SCSI, at the same location. The ability to reliably recover information on the data disks is influenced by many factors, such as media defects, read channel quality, system resonances; characteristic frequencies of the system, and noise.

The Read process is also affected by the data window, which is the time slot when the Read Channel is expecting to find magnetic information to be interpreted as data. If the Read Channel attempts to read too early or too late, data integrity may be compromised. The window "moves" if the writing process is also influenced by window shifts intentional or otherwise). Window shifts may optionally be controlled by the R/W Error Recovery Mode (Select) Page.

8.14.4 Data Integrity

The most important factor in any data storage and retrieval device is the ability to accurately maintain data. Several means have been developed by drive manufacturers to compensate for less than perfect heads, media and positioning systems. Some of the tools that can be controlled by the device as well as accessed via the DCS command set include:

* Data Strobe Offsets (Window Shifts)
* Head Offsets
* Error Correction Algorithms
* Retries
* Detection Parameters
* Adaptive Algorithms

During the certification pass of a Format Unit command, a disk drive may employ several or all of the above to ensure the media can be written and read under all conditions.

8.14.5 Drive Qualification

Some purchasers of disk drives conduct a lengthy and thorough investigation of devices which they are considering for purchase, in a process generally referred to as qualification. Other purchasers shorten this process by sharing in the qualification conducted by the drive manufacturer. This enables them to reach the market sooner. During qualification, the device is scrutinized in many ways.

A variety of tools such as those defined by DCS provide a means to assess:

* Probability of Errors
* Quality of the Servo System
* Flexibility of the Read Channel
* Design Margin of the Product
* Conformance to the Specifications
* Adequacy of the Defect Management

One method used during qualification relies on reading and writing of data in a controlled environment.

The Diagnostic Read Track Interleave - SEND DIAGNOSTIC and Diagnostic Write Track - SEND DIAGNOSTIC commands permit limited area media formats at specific locations on the media e.g. Outer Diameter and Inner Diameter. The purchaser may wish to erase all information from a limited area of the disk and determine the noise level or control parameters such as Window Shift, Peak detection thresholds and Head offsets to confirm the blocks resident in the P-list.

The Translate Address Page - SEND DIAGNOSTIC command can be used to convert newly assigned physical addresses created with Diagnostic Write Track - SEND DIAGNOSTIC to Logical Block Addresses.

The Diagnostic Erase Track - SEND DIAGNOSTIC and Diagnostic Read Track - SEND DIAGNOSTIC commands permit a unique assessment of the raw head-media-read channel combination.

To control some of the device algorithms, Mode parameters are provided to manipulate:

- Head Offsets (R/W Error Recovery),
- Data Strobe Offsets, also referred to as Window Shift (R/W Error Recovery)
- Data Detection Thresholds (R/W Control)
- Read and Write Retries (R/W Error Recovery)
- the use and extent of ECC (R/W Error Recovery)

The following diagram demonstrates the symmetry of the Diagnostic Extensions for SCSI-3:

DIAGNOSTICS EXTENSIONS
to SCSI-3

The INVESTIGATIVE Process

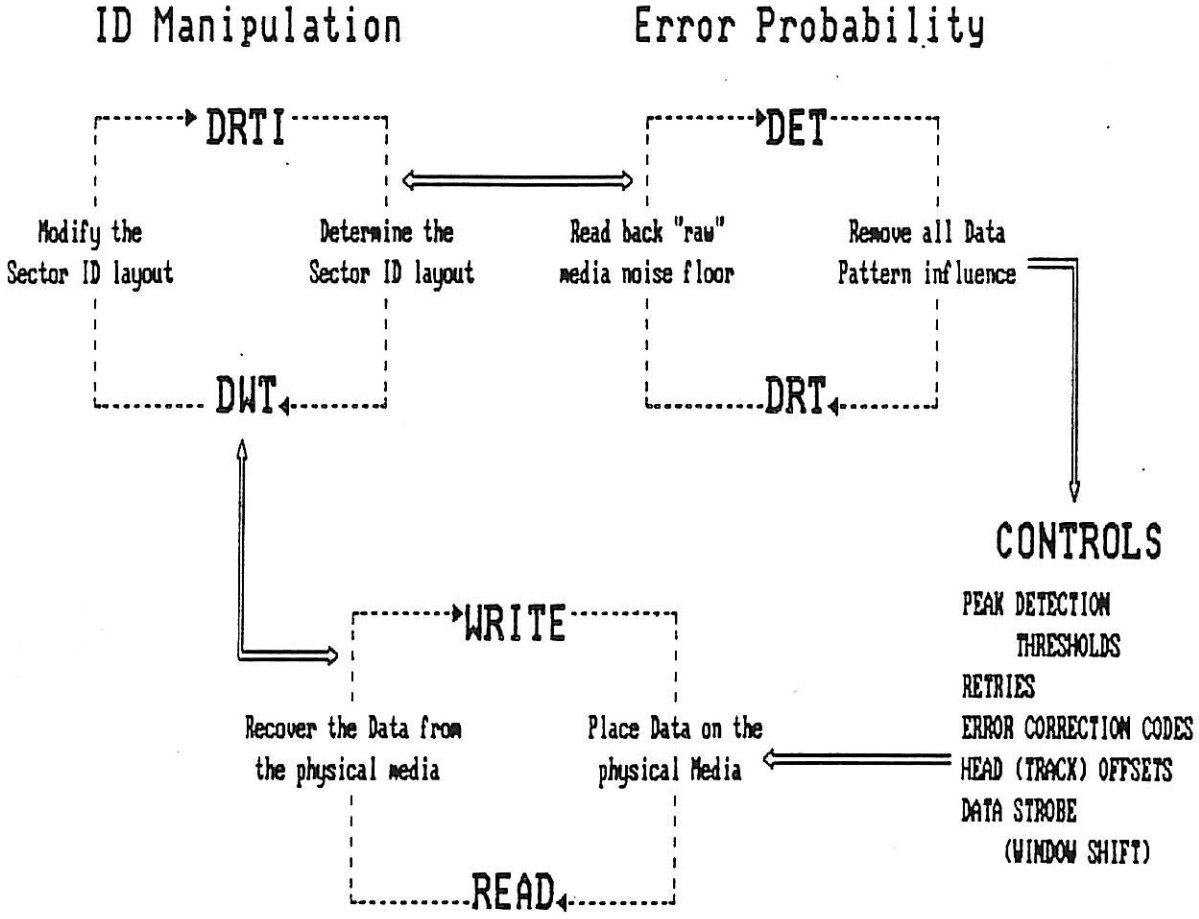
MODE SENSE/SELECT

Track/Sector Map
Cylinder Map

→ Indicates size/length of sector components for the DWT and DRTI commands.

Grading MOTION CONTROL

Diagnostic SEEK - Control Track Centerline



DET-Diagnostic Erase Track DRTI-Diag Read Track Interleave
DRT-Diagnostic Read Track DWT -Diagnostic Write Track

Diagnostic Extensions to SCSI-3

Cylinder Map MODE page

The Cylinder Map page is provided to indicate the layout of cylinders on the physical drive.

Table 1
Cylinder Map Mode Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	RSVD			*Page Code (10h)*			
1								
				Page Length (xxh)				
2								
3	CRASH		LATCH		DIRECTION		Reserved	
4								
- - - - - -				Cylinder Section Descriptor #1				
15								
.....								
m								
- - - - - -				Cylinder Section Descriptor #n				
m+11								

where m = 4+12n, n being the number of Cylinder Section Descriptors.

CRASH: This field is used to indicate the location of the Crash Stop, should one be present.

00b: Does not Apply
01b: Crash Stop is at the Inner Diameter (ID)
10b: Crash Stop is at the Outer Diameter (OD)
11b: Crash Stops exist at both Inner and Outer Diameters

LATCH: This field is used to indicate the location of the Latch (location for locked actuator), should one be present.

00b: Does not Apply
01b: Actuator Latch is at the Inner Diameter (ID)
10b: Actuator Latch is at the Outer Diameter (OD)
11b: Reserved

DIRECTION: This field is provided to communicate the direction of actuator motion when the Logical Block Address is incremented (discounting Defect Management).

00b: Does Not Apply
01b: Logical Block Address increases as the actuator travels from OD to ID
10b: Logical Block Address decreases as the actuator travels from OD to ID
11b: Reserved

Implementor's Note: The above three fields are only reportable during MODE SENSE. Attempts to change these fields in a MODE SELECT shall cause the command to terminate in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Table 2
Cylinder Section Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
m	TYPE							
m+1	Reserved							
m+2	(MSB)							
m+3	Extent Start Cylinder							
m+4								
m+5								(LSB)
m+6	Extent Start Track							
m+7	(MSB)							
m+8	Extent End Cylinder							
m+9								
m+10								(LSB)
m+11	Extent End Track							

The Cylinder Section Descriptor is provided to describe the purpose of an extent of media tracks as described by TYPE.

TYPE: Section Type Descriptor. This field describes the type of cylinders described for this Cylinder Section Descriptor.

Bit	7	6	5	4	3	2	1	0
	VU	ACCESS			DESCRIPTION			

VU: Vendor Unique. This Cylinder Section type is reserved for Vendor Unique purposes. If this bit is set to 1b, the remainder of the TYPE field is undefined by this document. If this bit is reset to 0b, the ACCESS and DESCRIPTION fields are as described below.

ACCESS: Cylinder Access Availability. This field indicates the allowable method of access the Initiator has to this Cylinder Section.

Table 3a
Cylinder TYPE Access

ACCESS	*Meaning*
000b	**No Access.** These cylinders cannot be accessed by the Initiator under any conditions.
001b	**Seek only.** The Read/Write heads cannot be engaged for anything other than positioning purposes while in this Cylinder/Track area. This might only be applicable for dedicated servo type systems.
010b	**Read Only.** These cylinders can be read by the Initiator, but attempts to write these cylinders will terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Write Protected.
011b	**Read/Write.** These cylinders' data fields can be modified by the Write process and recovered by the Read process.
100-111b	Reserved for expansion.

DESCRIPTION: Cylinder Section Description. This field provides general usage information about the specific Cylinder section.

The following table is a breakdown of existing Cylinder Section Descriptions.

Table 3b
Cylinder TYPE Descriptions

DESCRIPTION	*Meaning*
0000b	Logical Block Address Space. These cylinders can be addressed as part of the SCSI Logical Block Address space.
0001b	Protection Area. This a safety region of cylinders used to insure drive margins are available.
0010b	Calibration Area. These cylinders are used by the Device to determine optimal operating parameters. Such parameters might include certain compensation factors to overcome mechanical and thermal variances.
0011b	Diagnostic Area. These cylinders are only used for Diagnostic purposes, such as Power On Self Test and the SEND DIAGNOSTIC command.
0100b	System Cylinders. These cylinders are used for the general operation of the device. These might include system parameter information, bad block reallocation information, etc.
0101b	Unused Cylinder Area. These cylinders are part of the entire stroke (Crash stop to Crash stop, for instance), but are not used for any purpose.
0110b - 1111b	Reserved for expansion.

Extent Start Cylinder: The beginning cylinder number of the Cylinder Section.

Extent Start Track: The beginning track (head) number of the Cylinder Section. This field provides better resolution so that partial cylinder usage can be described. For purposes of consistency, Track Numbers start at 0 and increase monotonically up to the Number of Heads minus 1.

Extent End Cylinder: The ending cylinder number of the Cylinder Section.

Extent End Track: The ending track (head) number of the Cylinder Section. This field provides better resolution so that partial cylinder usage can be described. For purposes of consistency, Track Numbers start at 0 and increase monotonically up to the Number of Heads minus 1.

Implementor's Note #1: All of the above Extent fields (4) are two's compliment numbers which monotonically increase with the first User Cylinder being assigned the number 0. This permits negative cylinder notation.

Implementor's Note #2: The Cylinder sections shall be returned in ascending order, with the most negative (or zero, if not applicable) being returned first. Further, cylinder sections are not permitted to overlap each other, although gaps between sections is permissable. These gaps should be interpreted as TYPE 05h (No Access, Unused). Failure to comply with these rules should negate the validity of the Cylinder Map.

Track/Sector Map Mode Page

This Mode Page is used to control/report the repeatable contents from sector pulse to sector pulse as well as those components which are not repeatable within a sector, i.e., track components.

Table 4
Track/Sector Map Mode Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	RSVD	*Page Code (11h)*					
1	Page Length (4n+1)							
2	(MSB)							
3	Total Physical Sector Length							(LSB)
4	(MSB)							
7	Track/Sector Component Descriptor #1							(LSB)
.....								
4n	(MSB)							
4n+3	Track/Sector Component Descriptor #n							(LSB)

Total Physical Sector Length: This is a count in bytes from a fixed relative point within a sector time to the next same point in the adjacent sector (e.g., sector pulse to sector pulse). This count field should be the sum of the Component Lengths of the subsequent Sector Component Descriptors.

Implementor's Note/WARNING: It is highly probable that the target device can support the changing, i.e., MODE SELECT, of the individual component lengths as long as the sum (Total Physical Sector Length) remains intact. This has highly destructive capacity and should only be used under controlled conditions.

Track/Sector Component Descriptor: The pieces which make up a disk track and/or sector. The ordering of the components shall be as follows:

(1) All repeatable sector components which are also used in the Diagnostic Read Track Interleave - SEND DIAGNOSTIC command. The ordering of these such components shall be identical to that of the Diagnostic Read Track Interleave - SEND DIAGNOSTIC command.

(2) All (non-) repeatable sector components which are not part of the Diagnostic Read Track Interleave - SEND DIAGNOSTIC command.

(3) All track components. Ordering here is not implied.

Table 5
Track/Sector Component Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
m	RTI	TRK	DER	Component Type Code				
m+1	Frequency Count							
m+2	(MSB) Component Length							
m+3	Component Length (LSB)							

RTI: Read Track Interleave component. This bit has meaning only for the MODE SENSE command. If this bit is set to 1b, this *component* will be returned as part of the Read Track Interleave command. If this bit is reset to 0b, this field will not be included in the Read Track Interleave command. Attempts to alter this bit from its MODE SENSE state for the purposes of MODE SELECT shall cause the MODE SELECT to terminate in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

TRK: Track Component. If this bit is set to 1b, the component returned is part of the Track's *component makeup but is not a repeated entity on a sector basis*. If this bit is reset to 0b, the component returned is part of the repeatable portion of a sector. *This bit helps distinguish between those parts of track which do not always appear as part of a sector and those which do.*

Implementor's Note: The setting of the both the RTI and TRK bits to 1b is considered an illegal state *and shall cause the command to terminate in CHECK CONDITION status. In this case, the Sense data should be returned as ILLEGAL REQUEST, Invalid Field in Parameter List.*

DER: DIAGNOSTIC ERASE/READ. If this bit is set to 1b, the track/sector component will be affected by the Diagnostic Erase Track - SEND DIAGNOSTIC and Diagnostic Read Track - SEND DIAGNOSTIC commands. *If this bit is reset to 0b, this component will not be affected when either the Diagnostic Erase Track - SEND DIAGNOSTIC and Diagnostic Read Track - SEND DIAGNOSTIC is executed.*

Component Type Code: This field defines the basic category into which this sector or track component falls:

00h	Post Index
01h	Pre Index
02h	Pre ID
03h	Sector ID (Cylinder Number)
04h	Sector ID (Head Number)
05h	Sector ID (Sector Number)
06h	Sector ID (Flag byte)
07h	Sector ID (CRC)
08h	Sector ID (ECC)
09h	Sector ID (Other)
0Ah	Post ID
0Bh	User Data Field
0Ch	User Data ECC
0Dh	User Data CRC
0Eh	Post Data
0Fh	Absolute Block Address (relative to Disk Start)
10h	ServoBurst
11 - 1Fh	*Other, Vendor Unique*

Frequency Count: This field gives a number of occurences count for this component on a track in this zone. If this field is not meaningful or is variable in nature, this field will be retruend as 00h.

Implementor's Note #1: The intended purpose of this Mode Page is to assist in the usage of the Diagnostic Erase Track - SEND DIAGNOSTIC, Diagnostic Read Track - SEND DIAGNOSTIC and Diagnostic Read Track Interleave - SEND DIAGNOSTIC commands. For the DET and DRT commands, this page gives an approximation of which track fields comprise which bits. Thus, when a Diagnostic Read Track - SEND DIAGNOSTIC indicates a high probability of error exists at bit n, the initiator can determine which track field is most likely affected. For the RTI command, the initiator can be sure of what fields are being controlled.

Implementor's Note #2: To address shifting technologies, the **Other, Vendor Unique** category should be used in a non-repetitive manner. For example, if the target supports three fields which are not listed in the table above, then three sector component descriptors with codes between 11h and 1Fh should be used, but they should be unique (e.g., 11h, 12h and 13h).

Implementor's Note #3: There may be a need to incorporate this in the Notch Page (Mode Page 0Ch) to cover that class of device.

Component Length: This field describes the byte length of the track/sector component. If this field does not apply to this component, the Component Length shall be returned as 0000h.

R/W Control Mode Page

Table 6
Read-Write Control Mode Page

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			*Page Code (12h)*				
1	*Page Length (18h)*							
2	*(MSB)*							
	Reserved							
9								*(LSB)*
10	TA	TV	*(MSB)*					
	Threshold #1							
11								*(LSB)*
12	TA	TV	*(MSB)*					
	Threshold #2							
13								*(LSB)*
14	TA	TV	*(MSB)*					
	Threshold #3							
15								*(LSB)*
16	TA	TV	*(MSB)*					
	Threshold #4							
17								*(LSB)*
18	TA	TV	*(MSB)*					
	Threshold #5							
19								*(LSB)*
20	TA	TV	*(MSB)*					
	Threshold #6							
21								*(LSB)*
22	TA	TV	*(MSB)*					
	Threshold #7							
23								*(LSB)*
24	TA	TV	*(MSB)*					
	Threshold #8							
25								*(LSB)*

TA: **Threshold Active.** This bit indicates whether this is the Peak Detection Threshold currently being used by the Read Channel. If this bit is set to 1b, this threshold was used on the most recent disk access. If this bit is reset to 0b, this threshold was not used on the most recent disk access.

TV: Threshold Valid. This bit indicates whether the Peak DetectionThreshold level in bits *13-0* is valid. If this field is set to 1b, bits *13-0* are a valid threshold value supported by the target. If this bit is reset to 0b, bits *13-0* are Reserved and should be set to zero.

Threshold #n: This field indicates a threshold percentage supported by the device. This value has been divided by 2. Thus if a 14h is written into this field, a 40% Peak Threshold Detection is available on this device.

Implementor's Note #1: This MODE Page is meaningful for both MODE SELECT and MODE SENSE. But, if the Initiator should attempt to set the threshold values (in MODE SELECT) to something not supportable, the command shall terminate in CHECK CONDITION status. The Sense_Key shall be ILLEGAL REQUEST, Invalid Field in Parameter List.

The suggested use of this page is as follows:

(1) Issue a MODE SENSE for this page to determine the current and supportable Peak Detection Thresholds.

(2) Issue a MODE SELECT for this page to change the active threshold. If the selected threshold is not supported (as described by the MODE SENSE) or more than a single TA bit is set to1b, the target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Implementor's Note #2: If the concept of Peak Detection Threshold is not meaningful to the Target, bytes 2 through 9 of the above MODE page should be considered Reserved and set to 00h.

Format Status LOG Page

This LOG page captures the state of the most recent successful FORMAT UNIT and/or Diagnostic Write Track - SEND DIAGNOSTIC command(s) performed.

Table 7
Format Status LOG Page

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Page Code (08h)				
1				Reserved				
2	(MSB)							
				Page Length (xxxxh)				
3								(LSB)
4	(MSB)			Format Options				
5				Parameter Code (0000h)				(LSB)
6	DU	DS	TSD	ETC	TMC		RSVD	LP
7				Parameter Length (04h)				
8				Byte 1 of Format Unit CDB				
9				Byte 1 of Defect List Header				
10				Byte 2 of Defect List Header				
11				Byte 3 of Defect List Header				
12	(MSB)			Grown Defects during Certification				
13				Parameter Code (0001h)				(LSB)
14	DU	DS	TSD	ETC	TMC		RSVD	LP
15				Parameter Length (04h)				
16	(MSB)							
				Event Count (xxxxxxxxh)				
19								(LSB)
20	(MSB)			Total Blocks Reallocated				
21				Parameter Code (0002h)				(LSB)

(continued next page)

Bit / Byte	7	6	5	4	3	2	1	0
22	DU	DS	TSD	ETC	TMC		RSVD	LP
23	Parameter Length (04h)							
24 - 27	(MSB) Event Count (xxxxxxxxh) (LSB)							
28 - 29	(MSB) Spare Blocks Left Unallocated Parameter Code (0003h) (LSB)							
30	DU	DS	TSD	ETC	TMC		RSVD	LP
31	Parameter Length (04h)							
32 - 35	(MSB) Event Count (xxxxxxxxh) (LSB)							
36 - 37	(MSB) Elapsed Time Since Successful Format Unit Parameter Code (0004h) (LSB)							
38	DU	DS	TSD	ETC	TMC		RSVD	LP
39	Parameter Length (08h)							
40 - 47	(MSB) Event Count (in minutes) (LSB)							
48 - 49	(MSB) Diagnostic Write Track Indicator Parameter Code (0005h) (LSB)							
50	DU	DS	TSD	ETC	TMC		RSVD	LP
51	Parameter Length (04h * n)							
52	Valid	(MSB)						
53 - 54	Diag Write Track Cylinder Number (LSB)							
55	Diag Write Track Number							

Allocation Length: This is a variable count field set to 2Ch + (4n + 4) where n is the number of Diagnostic Write Tracks captured in this Log Page. In the above LOG page, bytes 52 through 55 get repeated for each Diagnostic Write Track command performed.

Format Options: This field contains four bytes which capture the set up options employed for the most recent, successful Format Unit operation performed.

Byte 1 of Format Unit CDB: This byte includes the FmtData bit (List passed by Initiator during DATA OUT), CmpLst (List passed by Initiator is complete) and Defect List Format bits.

Byte 1 of Defect List Header: This byte defines the Defect List options.

Bytes 2,3 of Defect List Header: These bytes define the Defect List Length (number of defects in the list).

Grown Defects During Certification Event Counter: This is a counter of the number of defects detected as a result of performing Certification which were not already part of the Plist. If a Certification pass was not performed this field shall be returned as 0000h.

Blocks Reallocated Event Counter: This is a counter of the total blocks reallocated as a result of the FORMAT UNIT operation and any subsequent operation, (includes Grown defects after FORMAT UNIT).

Spares Unallocated Event Counter: This is a counter of the total spare blocks which have yet to be allocated.

Elapsed Operating Time Since Successful FORMAT UNIT Event Count: This field represents the number of usage minutes which have elapsed since the most recently successful FORMAT UNIT command. This field provides for approximately 500 years of counting capability.

Implementor's Note: The fields which are affected by the FORMAT UNIT command should not be updated until its successful completion.

Diagnostic Write Track Indicator: This field exists under the condition a Diagnostic Write Track - SEND DIAGNOSTIC command completes successfully. Note this Event Count may be repeated in the LOG page a number of times. Exhaustion of LOG space is defined within the sections describing LOG SENSE and LOG SELECT. This field is removed from the LOG PAGE upon successful completion of any subsequent FORMAT UNIT command.

Parameter Length: This count divided by four is the number of Tracks which have been affected by the Diagnostic Write Track - SEND DIAGNOSTIC command.

Valid: This bit indicates whether the specific Diagnostic Write Track - SEND DIAGNOSTIC completed successfully. If this bit is set to 1b, the DWT command completed without error. If this bit is reset to 0b, the Track specified in the Diagnostic Write Track Cylinder and Track numbers completed with error. The state of this track is unknown.

Diagnostic Write Track Cylinder Number: This field captures the cylinder number (two's compliment) used in the Diagnostic Write Track - SEND DIAGNOSTIC Page.

Diagnostic Write Track Number: This field captures the track number (two's **compliment) used in the Diagnostic Write Track - SEND DIAGNOSTIC Page.**

Implementor's Note: Tracks should be reported in ascending order without repetition. Thus, if a specific track is called out in multiple Diagnostic Write Track - SEND DIAGNOSTIC commands, only the most recent command specifics will be retained (whether the DWT command completed succesful or not.)

Diagnostic Erase Track - SEND/RECEIVE DIAGNOSTIC

This command is provided for noise measurement and signal distortion detection purposes. This command does not actually imply either DC or AC erase or even the placement of a specific frequency pattern, but must prepare the selected LBA range for relative error probability measurements.

If the Target device supports the Diagnostic Erase Track - SEND DIAGNOSTIC command, then the Diagnostic Read Track - SEND DIAGNOSTIC command must also be supported.

The Diagnostic Erase Track - SEND DIAGNOSTIC command is an INDEX to INDEX write operation where all fields on the specified tracks (minus the exception of the actuator positioning information which may be embedded on the data tracks) are "erased". A successful erase operation leaves the track(s) in a state of a constant frequency pattern. The reading back of this information will yield a pattern representative of the encoding scheme employed by the Read Channel.

Refer to the TRACK/SECTOR Map Mode Page for details about track fields affected by this diagnostic command. Refer to the Diagnostic Read Track - SEND DIAGNOSTIC command for details on the reading back the erased tracks.

Table 8
Diagnostic Erase Track - SEND DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (41h)							
1	Reserved							
2	(MSB)							
3	Page Length (0008h)							(LSB)
4	(MSB)							
5	Starting Cylinder							
6								(LSB)
7	Starting Head							
8	(MSB)							
9	Number of Tracks							
10								
11								(LSB)

Starting Cylinder: This is the first physical cylinder, using the two's compliment notation (refer to CYLINDER MAP Mode Page for determining cylinder layout) to be affected by this command. If this field is set to a value outside the addressable range of the device, the Target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Starting Head: This is the first physical head, (refer to CYLINDER MAP Mode Page for determining cylinder layout) to be affected by this command. If this field is set to a value outside the addressable range of the device, the Target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Implementor's Note: Should the Starting Cylinder/Starting Head combination fall into a cylinder section not accessible for this purpose (refer the CYLINDER MAP Mode Page), this command shall terminate in CHECK CONDITION status. the Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Number of Tracks: This is the count of tracks that shall be affected by this command. The counting of tracks is dictated by the SURF bit in the FORMAT DEVICE Mode Page. If the Starting Track (determined by the Starting Cylinder/Starting Head combination) plus the Number of Tracks should extent into a cylinder region not accessible for this purpose or should extend outside the physical limits of the device, this command shall be terminated in CHECK CONDITION status. The Sense Key will be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

If the Starting Logical Block plus the Transfer Length should equal a value outside the addressable range of the device, the Target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Should the target experience a write error and be unable to "erase" all the tracks requested, the operation will abort on the first failed track.

Table 9
Diagnostic Erase Track - RECEIVE DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (41h)							
1	Reserved							
2	(MSB)							
3	Page Length (0004h)							(LSB)
4	(MSB)							
5								
6	Number of Tracks							
7								(LSB)

Number of Tracks: This is the count of tracks that were successfully "erased". If this count is the same as the Number of Tracks field in the Diagnostic Erase Track - SEND DIAGNOSTIC command, the entire operation can be assumed successful.

Implementor's Note: *It is recommended that the tracks be erased in sequential order so that the NUMBER OF TRACKS field is meaningful in the case of an error.*

Diagnostic Seek - SEND/RECEIVE DIAGNOSTIC

This command is provided to permit the Initiator to determine both servo margins and Read Channel - Servo System interactions. The Diagnostic Seek permits the Initiator to request that the Target use an offset from the physical track centerline when attempting to settle. Both seek tests and Read/Write after seek tests are viable using this command.

Table 10
Diagnostic Seek - SEND DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (42h)							
1	Reserved							
2	(MSB)							
3	Page Length (0006h)							(LSB)
4	(MSB)							
5	Seek Cylinder							
6								(LSB)
7	Seek Head							
8	(MSB)							
9	Head Offset							(LSB)

Seek Cylinder: The Initiator is requesting that the actuator being positioned over this physical cylinder. For the purposes of consistency, physical cylinder numbers are determined using the CYLINDER MAP Mode Page. If the Seek Cylinder provided is outside the range of cylinders available for seek type access, the command terminates in CHECK CONDITION status. The Sense Key is set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Seek Head: The Initiator is requesting that the Target select this physical head. If this field is set to a value outside the addressable range of the device, the Target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Implementor's Note: Should the Seek Cylinder/Seek Head combination fall into a cylinder section not accessible for this purpose (refer the CYLINDER MAP Mode Page), this command shall terminate in CHECK CONDITION status. the Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Head Offset: This field is the signed numerator of a 16 bit fraction. This fraction is the percentage offset from the currently used Track Centerline requested for positioning. Essentially, the Initiator is requesting that the Target use a Logical Track Centerline relative to the current Track Centerline. *The target may round this value by a vendor-defined algorithm.*

If this value is set to FFFFh, the Initiator is requesting that Physical Track Centerline be used, i.e., this is a Head Offset Reset.

For the purposes of consistency, a negative Head Offset requests positioning on the Inner Diameter side of the track, while a positive Head Offset requests positioning on the Outer Diameter side of the track.

Table 11
Diagnostic Seek - RECEIVE DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (42h)							
1	Reserved							
2	(MSB)							
3	Page Length (0002h)							(LSB)
4	(MSB)							
5	Head Offset							(LSB)

Head Offset: This field is the signed numerator of a 16 bit fraction. This fraction is the percentage offset from previous Track Centerline that is currently being used by the Target. This value is the actual value used and may differ from the requested Head Offset value.

If this value is returned as FFFFh, the Target is not currently using Head Offsets, i.e., the Physical Track Centerline is being used for positioning purposes.

For the purposes of consistency, a negative Head Offset requests positioning on the Inner Diameter side of the track, while a positive Head Offset requests positioning on the Outer Diameter side of the track.

Diagnostic Read Track - SEND/RECEIVE DIAGNOSTIC

This command is the counterpart to the Diagnostic Erase Track - SEND DIAGNOSTIC. If this Diagnostic Page is supported it is suggested (but not mandatory) that the Diagnostic Erase Track - SEND DIAGNOSTIC Page also be supported.

The Diagnostic Read Track - SEND DIAGNOSTIC requests the target to return raw track data, i.e., to bypass the decoding process.

Table 12
Diagnostic Read Track - SEND DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (43h)							
1	Reserved							
2	(MSB)							
3	Page Length (0008h)							(LSB)
4	(MSB)							
5	Starting Cylinder							
6								(LSB)
7	Starting Head							
8	(MSB)							
9								
10	Number of Tracks							
11								(LSB)

Starting Cylinder: This is the first physical cylinder, using the two's compliment notation (refer to CYLINDER MAP Mode Page for determining cylinder layout) from which the target shall read. If this field is set to a value outside the addressable range of the device, the Target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Starting Head: This is the first physical head, (refer to CYLINDER MAP Mode Page for determining cylinder layout) from which the target shall read. If this field is set to a value outside the addressable range of the device, the Target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Implementor's Note: Should the Starting Cylinder/Starting Head combination fall into a cylinder section not accessible for this purpose (refer the CYLINDER MAP Mode Page), this command shall terminate in CHECK CONDITION status. the Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Number of Tracks: This is the count of tracks the target shall attemp to read. The counting of tracks is dictated by the SURF bit in the FORMAT DEVICE Mode Page. If the Starting Track (determined by the Starting Cylinder/Starting Head combination) plus the Number of Tracks should extent into a cylinder region not accessible for this purpose or should extend outside the physical limits of the device, this command shall be terminated in CHECK CONDITION status. The Sense Key will be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

If the Starting Logical Block plus the Transfer Length should equal a value outside the addressable range of the device, the Target shall terminate the command in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Should the target experience a read error and be unable to return all the tracks requested, the operation will abort on the first failed track.

Table 13
Diagnostic Read Track - RECEIVE DIAGNOSTIC

Byte \ Bit	7	6	5	4	3	2	1	0
0	Page Code (43h)							
1	Reserved							
2	(MSB)							
	Page Length (xxxxh)							
3								(LSB)
4	(MSB)							
	Number of Tracks							
7								(LSB)
8	(MSB)							
	First Track Segment							
x								(LSB)
x+1	(MSB)							
	Second Track Segment							
y								(LSB)
...								
w+1	(MSB)							
	Last Track Segment							
z								(LSB)

Number of Tracks: This is the count of tracks that were successfully returned. If this count is the same as the Number of Tracks field in the Diagnostic Read Track - SEND DIAGNOSTIC command, the entire operation can be assumed successful.

Track Segment: This is the raw un-decoded track data. The following is a breakdown of a track segment:

Table 14
Diagnostic Read Track - Track Segment

Bit / Byte	7	6	5	4	3	2	1	0
0	Encode Length							
1 - x	Encode Pattern							
x+1 - y	(MSB) Track Length							(LSB)
y+1 - z	Track Data							

Encode Length: This field provides the bit count of the encoded pattern in the absence of data. This should be used as the "check" pattern for the rest of the track.

Encode Pattern: This is the actual encode pattern utilized by the Read Channel in the absence of data. The number of bytes used for this field will be the next highest multiple of four above the Encode Length (converted to bytes). The bit pattern in the bytes used to make the Encode Pattern field a multiple of four bytes is not meaningful to this command.

Track Length: This field provides the bit count of the track data being returned for this track.

Track Data: This is the actual track data as seen by the Read Channel. The number of bytes used for this field will be the next highest multiple of four above the Track Length (converted to bytes). The bit pattern in the bytes used to make the Track Data field a multiple of four bytes is not meaningful to this command.

Each bit of the Track Data represents one data decode window; a bit is set to one if a transition occurs in that data window and is set to zero if no transition occurs in that data window.

Diagnostic Read Track Interleave - SEND/RECEIVE DIAGNOSTIC

This command is for use in conjunction with the Diagnostic Write Track - SEND DIAGNOSTIC command. This command returns an entire track's worth of Sector IDs in the order they come under the Read/Write heads starting from Index.

Table 15
Diagnostic Read Track Interleave - SEND DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (44h)							
1	Reserved							
2	Page Length (06h)							
3								
4	(MSB) Cylinder							
5								
6								(LSB)
7	Head							
8	(MSB) Allocation Length							
9								(LSB)

Cylinder: This field defines the Physical Cylinder to which the actuator shall seek prior to reading the Sector IDs. Should this field be set a value outside the limits of the device (as defined by the Rigid Disk Drive Geometry MODE Page), the command shall be terminated in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Head: This field defines the Physical Head to which the device shall switch prior to reading the Sector IDs. Should this field be set a value outside the limits of the device (as defined by the Rigid Disk Drive Geometry MODE Page), the command shall be terminated in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Allocation Length: This field describes the amount of data the Initiator can receive for the Diagnostic Read Track Interleave - RECEIVE DIAGNOSTIC. This field should be set to a minimum of 4+(m*n), where m is the Sector ID length as defined in the Track/Sector Map Mode Page and n is the number of Sectors per Track on this device. If this field is set to value less than this, the Target may either terminate the command in CHECK CONDITION status, setting the Sense Key to ILLEGAL REQUEST, Invalid Field in Parameter List, or may simply truncate the returned data in the subsequent Diagnostic Read Track Interleave - RECEIVE DIAGNOSTIC.

Table 16
Diagnostic Read Track Interleave - RECEIVE DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (44h)							
1	Reserved							
2	Page Length (xxh)							
3								
4	(MSB)							
5	Cylinder							
6								(LSB)
7	Head							
8	(MSB)							
8+(m-1)	ID Table Entry #1							(LSB)
.....								
y	(MSB)							
y+(m-1)	ID Table Entry #n							(LSB)

where m is the Sector ID Length and n is the number of Sectors per Track this device supports given the Allocation Length in the corresponding SEND DIAGNOSTIC command was large enough to service all of the return data.

Implementor's Note: Should anything about this command be technically unsupportable, the device may reject this diagnostic request. In this case, Page 43h should not be reported via the Supported Pages Diagnostic Page.

Cylinder: This field defines the Physical Cylinder to which the actuator was positioned prior to reading the Sector IDs.

Head: This field defines the Physical Head which was selected prior to reading the Sector IDs.

ID Table Entry: This field describes the contents of the Sector ID components of each sector on the specified track. The specific contents are defined by the returned information in the Track/Sector Map Mode Page.

Diagnostic Write Track - SEND/RECEIVE DIAGNOSTIC

This command permits the Initiator to selectively format (modification of the Sector ID fields) individual tracks on the drive.

Implementor's Note: The suggested use of this command is to precede it with a Diagnostic Read Track Interleave - SEND DIAGNOSTIC and then modify the Sector ID fields as appropriate. This method permits the changing of any number of sectors up to the entire track.

Table 17
Diagnostic Write Track - SEND DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (45h)							
1	Reserved							
2	Page Length (xxh)							
3								
4	(MSB)							
5	Cylinder							
6								(LSB)
7	Head							
8	(MSB)							
...	ID Table Entry #1							
11								(LSB)
.....								
m	(MSB)							
...	ID Table Entry #n							
m+3								(LSB)

where m is the Sector ID Length and n is the number of Sectors per Track this device supports given the Allocation Length in the corresponding SEND DIAGNOSTIC command was large enough to service all of the return data.

The Data fields of the track in question are not controlled by this command. The state of the data after the successful completion of this command is *vendor specific*.

Implementor's Note: Should anything about this command be technically unsupportable, the device may reject this diagnostic request. In this case, Page 44h should not be reported via the Supported Pages Diagnostic Page.

Cylinder: This field defines the Physical Cylinder to which the actuator shall seek prior to the format operation occuring. Should this field be set a value outside the limits of the device (as defined by the Rigid Disk Drive Geometry MODE Page), the command shall be terminated in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

Head: This field defines the Physical Head to which the device shall switch prior to the format operation occuring. Should this field be set a value outside the limits of the device (as defined by the Rigid Disk Drive Geometry MODE Page), the command shall be terminated in CHECK CONDITION status. The Sense Key shall be set to ILLEGAL REQUEST, Invalid Field in Parameter List.

ID Table Entry: This field describes the contents of the Sector ID components of each sector on the specified track. The specific contents are defined by the returned information in the Track/Sector Map Mode Page.

Table 18
Diagnostic Write Track - RECEIVE DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (45h)							
1	Reserved							
2	Page Length (02h)							
3								
4	(MSB) Sector ID Count							
5								(LSB)

Sector ID Count: This field represents the number of successfully written ID fields on the Initiator specified track (in the SEND DIAGNOSTIC counterpart). Should this count field be less than the Sectors per Track for the specified Track, the ID fields of the remaining sectors on the track (absolute sectors beyond the Sector ID Count) are indeterminate.