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Information technology - AT Attachment 8 - ATA/ATAPI Command Set (ATA8-ACS)

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T13 Technical Editor: Curtis E. Stevens
Western Digital Technologies, Inc.
20511 Lake Forest Dr.
Lake Forest, Ca. 9230
USA

Telephone:949-672-7933
Email: Curtis.Stevens@wdc.com

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Points of Contact

T13 Chair
Dan Colgrove
Hitachi Global Storage Technologies
2903 Carmelo Dr
Henderson, NV 89502
Tel: 702-614-6119
Fax: 702-614-7955

T13 Vice chair
Jim Hatfield
Seagate Technology
389 Disc Drive
Longmont CO 80503
Tel: 720-684-2120
Fax: 720-684-2722

INCITS Secretariat
NCITS Secretariat
1250 Eye Street, NW Suite 200
Washington, DC 20005
Email: INCITS@ITIC.ORG
Tel: 202-737-8888
Fax: 202-638-4922

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Englewood, CO 80112-5704
http://global.ihs.com/H
Telephone: 1-303-792-2181
or 1-800-854-7179
Facsimile: 1-303-792-2192

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ABSTRACT

This standard specifies the AT Attachment command set between host systems and storage devices. It provides a common command set for systems manufacturers, system integrators, software suppliers, and suppliers of intelligent storage devices. It includes the PACKET feature set implemented by devices commonly known as ATAPI devices. This standard maintains a high degree of compatibility with the AT Attachment Interface with Packet Interface - 7 (ATA/ATAPI-7) volume 1, INCITS 397-2004, and while providing additional functions, is not intended to require changes to devices or software that comply with previous T13 standards.

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If no patents have been disclosed place the statement in 5.5.2 shall be used.

If any patents have been disclosed place the statement in 5.5.3 shall be used.

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Document e06122 is the issues list for this draft. e06122 contains a list of the issues associated with the document, an issue number that remains assigned to the issue for the life of document development, a resolution to the issue, an owner for the issue, and a disposition for the issue. All major changes associated with this draft starting with Rev 3b are first documented in e06122 and given a number. This includes proposals which are targeted for inclusion into this draft.

Revision History (part 1 of 18)

Rev	Date	Description
0	August 17, 2004	1) Initial revision created from ATA/ATAPI-7 Volume 1 (1532D Rev 4b). 2) Removed 3 volume structure and changed abstract to reflect a command set document 3) Removed sections on signal, bit, and timing conventions 4) Removed clause 5, I/O register descriptions 5) Kept informative annex's A-C
1	September 7, 2004	1) Restructured all commands to conform to format agreed to in e04139r4. 2) Added a section defining status bits 3) Added a section defining error bits 4) Added a section describing protocols 5) Added a section describing interrupt reason 6) Incorporated single log table e04143r0 table. Did not add wording to status that host VS pages are common between SMART and GPL. 7) Removed prohibited statements from command definitions. These reside in the feature set definitions.
1a	October 6, 2004	1) Replaced duplicate Normal Outputs tables with a see clause to the first usage. 2) Replaced many Error Outputs with a see clause.
1b	February 17, 2005	1) Stripped unused informative references 2) Changed the definition of ordered and unordered lists to make the numeric form ordered. 3) Changed all the lists to conform to the changes in #2 4) Reserved 5Ch-5Fh for TCG. This was done by added command headers and a reserved statement in the command section. Also marked the commands with T in the command matrix table. 5) Moved Normal and Error Outputs to their own section. Commands now have a hotlink to the tables. 6) Moved IDENTIFY (PACKET) DATA to its own section (Input Data) 7) Changed more of the titles to be consistent with the front cover. 8) Deleted unused definitions 9) Changed the General feature set to only apply to non-packet devices 10) Changed the packet feature set to include all the commands in the packet feature set. 11) The command prohibitions are now found in the feature set description and not with each command. 12) Integrated e04127r0 – This makes SATA signatures reserved with no description.

Revision History (part 2 of 18)

Rev	Date	Description
1c	April 15, 2005	1) Added proposal e04143r1 – Notes that the Host Vendor Specific pages are common to both SMART READ LOG and READ LOG EXTENDED 2) Added e04130r2 – Tightens the definition of SMART first polling time. Also adds a field that enables longer times. 3) Added proposal e05103r0 – Changes the features register to log page specific for read and write log commands 4) Added e04153r1 – Historical annex of command documentation to Annex B 5) Added e05102r1 as amended – Reserves some set features and DCO fields as vendor specific 6) Added back in FEATURE SET Clause in front of the description
1d	June 20, 2005	1) Added code 1Dh to IDENTFY DEVICE for ATA/ATAPI-7 Table 14. 2) Added placeholder for reporting alignment. 3) Updated SET FEATURES table 41 to include reserved entries instead of just saying all other entries are reserved. 4) Partially Incorporated e04129r5. Assigned Set Features 0Bh and 8Bh for the enable and disable capability. Had to make several modifications to the proposal to fill in missing pieces. Unable to fill in IDENTIFY DEVICE info, data is incomplete. Stopped incorporation
1e	June 21, 2005	1) Modified Selective self-test description last sentence to be more clear. 2) Updated definition based on WG review. 3) Integrated e05133r3. This conflicts with the definition of IDENTIFY DEVICE which is defined to not return an error. 4) Incorporated e04129r6. Assigned IDENTIFY DEVICE words 210-213 and DCO word 7 bit 14.

Revision History (part 3 of 18)		
Rev	**Date**	**Description**
1f	July 5, 2005	1) Added several technical reports to the approved references. They need to be there since they are mentioned in the body of the document. 2) Updated DCO to refer to TR37 (TLC) for word 7 bit 10. 3) Updated the Scope to match ATA8-AAM 4) Replaced sector with logical sector in many places 5) Replaced all references to the Features register with features field. 6) Replaced all references to the Sector Count register with Count field. There are some places that use the count field in calculations. These places refer to the register. I have chosen to keep the word field although I think it may read better just saying count. 7) Replaced archaic references to sector number register with references to the LBA field. 8) Replaced references to LBA Low, LBA Mid, and LBA high to LBA field. 9) Replaced all references to device/head or device register 10) Deleted references to the device control register. 11) Updated overview in clause 7. 12) Updated security commands to have an output data structure where appropriate 13) Updated SETMAX commands to have an output data structure where appropriate. 14) Removed remaining hardware references from commands. Transport documents will have to reference 1e for notes on information that needs to move. This includes most references to BSY, RDY, DRQ, and bus. 15) Implemented e04161r0 (obsoleted ATAPI overlap and queue) 16) Moved host vendor specific log description into its own clause. 17) Integrated e05130r0 18) Integrated e05131r1 19) Integrated e05120r2 – Needed to add text to 4.21 to support the examples.

Revision History (part 4 of 18)

Rev	Date	Description
2	August 22, 2005	1) Updated SET MAX ADDRESS to indicate that on drives with a capacity that is greater than 28 bits, that issues SET MAX ADDRESS to the NATIVE MAX address clears the HPA and returns the full capacity of the drive, not just 137GB. 2) Added e04132r1 – Defines sub-command 03 for download microcode 3) Incorporated e04162r0 – Obsolete Download Microcode 4) Incorporated e05151r1 – Reserve opcodes for e05106. The following resources were assigned: 1) CHECK POWER MODE normal returns 40h and 41h 2) IDENTIFY DEVICE data words 214-221 3) New opcode B6h – NV CACHE (Sorry, B8h is reserved for CFA) 4) DCO data structure Word 21 bits 14 and 15 5) Incorporated e02126r6 – WRITE UNCORRECTABLE. The following resources were assigned: 1) Opcode 45h 2) IDENTIFY DEVICE data words 119/120 bit 2 3) DCO Data word 21 bit 13 6) Modified DCO to indicate that the data is not an overly, it is just data that can be used to enable or disable reporting of features as well as responding to features. 7) Incorporated e05127r2 – Updated the definition of the DF bit. 8) Incorporated e05129r1 – READ/WRITE LOG DMA EXT. The following resources were assigned: 1) Opcodes 47h and 57h 2) IDENTIFY DEVICE data words 119/120 bit 2 9) Incorporated e05132r1 – Report transport standard. IDENTIFY DEVICE words 222 and 223 were assigned for this purpose. 10) Incorporated e05140r0 – Media Serial Number Endianess 11) Performed a major re-work of the IDENTIFY DEVICE table data. Added a column to indicate applicable transport. 12) Received side-band E-Mail comments from yamini@medusalabs.com resulting in the following changes: 1) CFA Translate Sector Features and Count fields S/B N/A as in ATA7 2) Page number was deleted from the clause reference in 4.4.1 13) Marked bits 15:13 obsolete. This was accidently left out when e04161 was incorporated. 14) Reformatted Table 117, Table 118, Table 119, Table 120. The command code table serves as the master. All of the command codes are now listed. I believe this will cause the table to be maintained better. I also discovered some inconsistencies in the table during the reformat. 15) Performed consistency pass on command tables, several links have been corrupted.

Revision History (part 5 of 18)		
Rev	**Date**	**Description**
2a	December 10, 2005	1) Added cross reference to tables. This is required since several commands point to the same tables. 2) Fixed command tables to match ATA7. 3) e05141r2 was voted in however, no document has been posted. 4) Incorporated e05162r0 5) Incorporated e05161r0 6) Incorporated e05167r0. 7) Incorporated e05109r3 as modified by Mark Evans 8) Addressed ATA/ATAPI-7 public review comment by inserting the statement "If write cache is enabled unrecoverable errors may not be reliably reported as they may occur after the completion of the command. "after the statement that says the first error block is returned in the response fields. 9) Replaced Master password with Master password as per E-Mail review comment. 10) Replaced is specified with is specified as per E-Mail review comment
2b	January 10, 2006	1) Made READ and WRITE LOG EXT optional for ATAPI devices 2) Reincorporated SCT using e05109r4 3) Changed Long Segment Access to Write Same 4) Incorporated e05170r1 5) Incorporated e05154r4 6) Incorporated e05150r2

Revision History (part 6 of 18)		
Rev	**Date**	**Description**
2c	February 7, 2006	1) Changed IDENTIFY DEVICE description that involve different behavior for serial and parallel to have separate paragraphs. 2) Added change to support e04132r1. This proposal uses word 86 bit 15 to indicate support. Word 86 bit 15 has been used to indicate that words 119/120 have valid data. Support for segmented download microcode shall be indicated by words 119/120 bit 4. 3) Removed unreferenced references. I checked AAM and the referenced were duplicated there… 4) Made editorial changes based on working group review 5) Reworded all statements that included the word “will”. 6) Reworded all statements that included the word “can” 7) Was asked to reword statements with the word presently. I found none of these in the document. 8) Removed the word clause from references that were actually subclauses. Fixed the case of the word clause, there were random Clause/clause in the text. 9) Replaced all occurrences of space space with space. Then replaced all occurrences of period space with period space space. This will have the effect of making the document use the same convention for sentence completion. This was done with change bars off. 10) Removed inappropriate references to LBA Low, Mid, and High in annex D. 11) Scrubbed the word register… Most of this was just changing the word register to field. There were some usages where more extensive wording changes were required. 12) Fixed cut and paste error in WRITE STREAM DMA EXT during the incorporation of e05154. Added the description of WC and removed the description of CCTL in favor of a reference to the same description in the READ STREAM DMA EXT command. 13) Normalized Not Applicable to N/A. Replaced all na with N/A. 14) Changed “Host Shall” statements to “Host Should”. The device can not enforce a requirement on the host. The device can only respond to what it receives.

Revision History (part 7 of 18)		
Rev	Date	Description
2d	February 9, 2006	1) Changed “Hosts” the “A Host”. A drive only converses with a single host. 2) Reformatted the IDENTIFY PACKET DEVICE table and added notes regarding some of the inconsistencies. 3) Added an overview subclause to clause 4. The overview includes a table which lists all the feature sets and if each feature set is option mandatory or not a part of this standard. 4) Changed the name of clause 4 to Feature set definitions 5) Merged 4.1 command delivery with the overview 6) Removed the see 4.2 in ID words 60,61 because 4.2 has been removed from the document. 7) Updated Table 6 to include READ/WRITE LOG DMA EXT. Also reformatted table to match other table formatting 8) Added MMCA and CE-ATA references 9) Reformatted approved references and references under development to use tables instead of text and tabs 10) Updated Figure 3 to include Qword. 11) Replaced occurrences of logical sector and sector with 512-byte block of data. This introduces the concept of data block which is a 512 byte fixed unit. There was a previous pass through the document that replaced sector with logical sector. However, new proposals reintroduced the ambiguity. At this point, the doc should have consistent usage of Logical sector for a unit of measure that is reflected in IDENTIFY DEVICE words (118:117). 512-byte block of data refers to transfer units that are fixed at 512 bytes regardless of logical sector size. The phrase data blocks refers to 512 byte units. Modified Table 25 - Extended Self-test log data structure. The byte numbering indicates that there can be 19 log entries, but the description indicates 18 entries 12) Modified Table 26 - Extended Self-test log descriptor entry. The vendors specific values were obviously mis numbered. The Extended Self-test log data structure indicates that there should be 26 bytes. However, the descriptor entry is only 24 bytes long. It looks like the VS bytes were added later and the ending value was not properly updated. 13) Modified the text description of ID words 83 & 86 to read Removable Media Status Notification feature set. Previously they read Removable Media Feature Set. The correct entry was in the table. Words 82 and 85 bit 2 document the removable media feature set. 14) Made minor corrections to Annex C as requested in E-Mail by Rob Elliott 1) Modified C.1 to reference ATA standards prior to ATA/ATAPI-7. The previous statement was a bit strong 2) Softened C.2 to reference Logical Sectors instead of 512-byte sectors. 3) Changed C.3 to reference the logical sector size instead of 512-byte sectors 4) Corrected an inaccuracy in C.3 figure which skipped LBA7… 15) Implemented responses to Rob Elliot comments for e06105. 16) Changed IDENTIFY DEIVCE words 85-87 to read supported instead of enabled for features that can not be disabled 17) Updated the definition of N/A
2d	February 9, 2006	18) In 7.17.6 removed the statement that an ICRC error can occur in IDENTIFY DEVICE. ICRC for SATA has no provision to report a CRC error on one block commands or the last block of the command. 19) Made changes requested at meeting held 21-24 Feb. 20) Added minor revision for ATA8-ACSr2d.

Revision History (part 8 of 18)		
Rev	Date	Description
3a	March 20, 2006	1) Converted document from Word to Frame
3b	March 21, 2006	1) Restored N/A designations to the Normal and Error Outputs. This had the effect of changing WRITE UNCORRECTABLE Sector and LBA field return values from Reserved to N/A 2) Added a table with a list of all the documents incorporated into ATA8-ACS. The purpose of this is to provide a summary of changes and to provide an easy way for the reader to identify new features. 3) Obsoleted DMA Ready as an addition to e04161. This bit is only used for ATAPI overlap and queueing 4) Moved most of the editors notes into e06122 (ATA8-ACS open issues list) 5) Merged the Overlap and Queue feature sets to be the Tagged Command Queuing feature set. This now means that a drive can not implement just overlap 6) Changed Feature Set to feature set everywhere accept in table headings and in the command headings 7) Updated 7.1.1 (Introduction to command structure) to indicate that a mapping shall be supplied by transport documents that reference ATA8-ACS 8) Marked the Tag field obsolete to support e04161 in 7.26.3 PACKET command inputs 9) Added the Device field to all the commands and their associated outputs 10) Modified clause 8 so that all the READ/WRITE LOG EXT command reference also include READ/WRITE LOG DMA EXT 11) Changed log pages E0 and E1 to indicate SCT in table 30 Log address definition 12) Modified 7.56.6 Off-line data collection capabilities to have the bit definitions in a table instead of a list. 13) Modified 7.70.3 WRITE LOG EXT Inputs so the Log Address definition is in a subclause. 14) Modified 7.17.7 IDENTIFY DEVICE data word descriptions to have the form For PATA devices... followed by For SATA devices... for fields that are set differently between PATA and SATA 15) Modified Table 82 Absolute HDA Temperature to reference a circular buffer instead of a queue 16) Incorporated e05178r0. This makes WWN Mandatory 17) Incorporated e05160r0. This clarifies that a flush cache is always successful when write cache is disabled. 18) Incorporated e05162r2. This enhanced DM Mode 3 by allowing the drive to report minimum and maximum transfer sizes. Assigned IDENTIFY DEVICE data words 234 & 235 to this capability 19) Incorporated e05139r7. This adds 4 commands to be used by the Trusted Computing Group. Assigned ID Device word 48 and DCO word 21 bit 12. Added entries to table 6 block size by command and table and table 4 security protocol command actions. The proposal did not provide guidance on these tables. Also updated tables in Annex A Command Set History 20) Incorporated e05109r7. This adds the ability to manipulate non-volatile cache. Assigned IDENTIFY DEVICE data words 214-219, DCO IDENTIFY word 21 bits 15:14, DCO SET word 21 bits 15:14, and opcode B6h. 21) Spell checked the document. Found sooo many spelling errors going back all the way to ATA4.

Revision History (part 9 of 18)		
Rev	**Date**	**Description**
3c	June 14, 2006	1) In Rev 3b most of the editors notes were removed from the doc and placed in the ATA8-ACS Open Issues List, doc #e06122. This document will be used from now on to track the work items remaining on ATA8-ACS. From this point forward, the revision history will reference a work item # when ever possible. 1) Fixed a variety of line issues with the tables. 2) Closed open issue #62 by deleting the sentences that contained the TBDs in TRUSTED RECEIVE 3) Closed open issue #63, the entry for ISO/IEC FDIS 9594-8 in references under development is correct. 4) Marked TRUSTED SEND PROTOCOL EFh as reserved for T10. This is required to keep the assignment values synchronized. 5) Did a substitute to replace Times New Roman font with Arial font. There were over 180 replacements. 6) Did a replacement to remove “body” paragraph type. This may have some formatting effects on the doc, but I did not see any on my first glance. I believe that this change removed all of the strange formatting that was brought across as a result of the import from word. 7) Changed several references to overlap to be TCQ. This also caused a slight rework of the Tag field definition. 8) Deleted the definition of overlap since overlap is not used. 9) Fixed opcode for WRITE LOG DMA EXT. It was listed in 7.71 as 47h when it should have been 57h 10) Implemented open issue #1 to make HPA prohibited for PACKET devices. The prohibition was inserted into clause 4.11.1. Also modified table 26 (IPD Data) to indicate that word 82 bit 10 shall be cleared to zero. 11) Implemented open issue #3 to clarify resets. e06133r0.pdf contains the comments that are the basis for changes. e06133r1 marks comments as completed if the suggested change was made. 12) Implemented issue #8: what constitutes all error logs in 4.21.8. Removed last paragraph which required firmware to clear all error logs. 13) Implemented issue #18: the diagnostics results field should be reserved for DEVICE RESET. see table 92 for changes. 14) Implemented issue #20. In 7.12.2 changed “and all previously downloaded microcode is discarded” to “and all previously downloaded microcode may be discarded” 15) Implemented issue #23. In IPD (table 26) word 2 (table only), the word is titled unique configuration. This was changed to specific configuration to match the ATA version. 16) Implemented issue #24. In IPD (table 26) words 83 & 86 bit 0, the device was allowed to report support for DOWNLOAD MICROCODE. This has been change to “Shall be cleared to zero to indicate ...” 17) Implemented issue #26. In 7.22.5 and 7.22.6.2, changed the lists from ordered to unordered. 18) Implemented issue #27. In 7.23.2 removed the host requirement to send WRITE BUFFER before READ BUFFER. Replaced the requirements with the consequences of such an action. 19) Implemented issue #30. In table 39 SET FEATUREs subcommands 09 and 89 were only listed for TR37. CFA also uses this capability. Changed the definition to allow for the CFA usage as well.

Revision History (part 10 of 18)		
Rev	**Date**	**Description**
3c	June 14, 2006	20) Implemented issue #31. In table 39 SET FEATUREs subcommands 69 was marked reserved. This has a definition in CFA that has not been ported to ATA8 21) Implemented issue #32. In 7.48.20 there is a statement that says see subcommands for normal outputs. Since there are no normal outputs in the subcommands, this statement was deleted. 22) Implemented issue #33. Added subclause 4.11.4 to explain how IDENTIFY DEVICE data words are set after SETMAX is issued. Updated 7.49.2.2 and 7.49.5.2 to reference the new text. 23) Implemented issue #39. Removed the title from word 0 in 7.77.3. 24) Implemented issue #42. The CHK bit was removed from normal and error outputs in Rev 3b when the tables were reorganized. This issue was created after the fact. As a result of this activity, the CHK bit is no longer used. The definition of CHK was deleted from clause 6. 25) Implemented issue #45. This issue was created because a fix was implemented in table B.2 where opcodes 87 and C0 were missing, the opcodes were in the VS area. 26) Implemented issue #46. Each SMART operation is listed in table B.2 although they have the same opcode. SMART now has a single entry. This change will be spawned in table B.3 before publication. 27) Implemented issue #47. Each DCO operation is listed in table B.2 although they have the same opcode. DCO now has a single entry. This change will be spawned in table B.3 before publication. 28) Implemented issue #74. In subclause 8.1 paragraphs 4 and 5 created host requirements. Since the relevant material is already covered in clause 7, paragraphs 4 and 5 were deleted. 29) Implemented issue #73. Deleted the definition of LBA Range Entry since this is only used in one place. Modified 7.20.3.1 where the only reference to LBA Range Entry exists to have a see 7.20.3.5 where the LBA Range Entry is defined. 30) Implemented issue #71. Deleted the list of devices from 7.17.6.2. but kept the reference to SPC. The list of devices changes with time and should be maintained in SPC. 31) Implemented issue #68. Added kept the abort bit added to table 135. 32) Implemented issue #78. There was an error made when implementing e05170r1, in subclause 8.3.3 function codes 0003h and 0004h were used when 0101h and 0102h should have been used... 33) Implemented issue #79. In table 62 the definition of error code 13h was unclear. Changed the definition to reference SCT data. 34) Implemented issue #67. Change title of table 135 to Generic NV Cache Abort. This reflects the fact that several of the NV Cache Commands use this error output. Retained the changes made to e05106r7 during its incorporation. 35) Implemented issue #65. Added abort bit to table 133. This keeps the NV Cache add lba(s) command consistent with other commands.

Revision History (part 11 of 18)		
Rev	**Date**	**Description**
3c	June 14, 2006	36) Implemented issue #66. Added abort bit to table 134. This keeping the NC Cache remove lba(s) command consistent with other commands. Also clarified bit 0 by referencing the pinned set. During the implementation of this issue, in 7.20.9.4 a cut and paste error was corrected. The statement "added to pinned set" was changed to removed from pinned set. 37) Implemented issue #77. Modified 4.8 paragraph #5 to more clearly state the operation of DCO Freeze Lock. 38) Implemented issue #89. This incorporates e06127r0 which assigns a security protocol to IEEE P1667. 39) Implemented issue #81. This incorporates e06125r0 which updates IDENTIFY PACKET DEVICE (IPD). 40) Marked IPD word 82 bits 7 and 8 obsolete. These should have been marked obsolete when ATAPI overlap and queue (e04161) were obsoleted. 41) Implemented issue #80. This incorporates e06116r0 which obsoleted both the removable media and media status notification feature sets. This had the effect of obsoleting 3 status bits (MC,MCR,and NM) in all of the read/write commands. 42) Implemented issue #90. This incorporates e06128r1 which deals with issues surrounding resets. 43) Implemented issue #91. This incorporates e06121r1 which clarifies operation of Write-Read-Verify. Although there is 1 mention of IPD in the Write-Read-Verify feature set description, there are no ATAPI commands listed in the affected commands. Assigned word 200 bits 7:0 to the current mode. 44) Implemented issue #86. This incorporates e06123r0 which allows READ LOG EXT to succeed when the device is security locked. 45) Implemented issue #82. Alphabetized the feature sets in clause 4. This will have the effect of causing all current proposals that reference 4.xx to need an update. 46) Implemented issue #83. Added description of how SETMAX affects IDENTIFY DEVICE data to the description of the HPA feature set in 4.11.4 47) Changed "Note: "paragraphs to conform with the rest of the document and say "Note ## - "with indented text. Also changed punctuation on ICRC notes for better english grammar. 48) Updated Trusted Send/Receive Security Protocol assignments to show that T10 has assigned protocol 20h 49) Assigned minor revision code 0027h to rev 3c. This code was assigned due to the number of new proposals integrated in this rev.
3d	July 10, 2006	1) Alphabetized DCO, NV-Cache, SETMAX subcommands in clause 7 2) Moved log pages into a normative annex and added a reference in the description of READ LOG EXT and SMART READ LOG to table A.1 and Annex A. 3) Previous Annex A, B, and C have been bumped to B, C, and D

Revision History (part 12 of 18)		
Rev	**Date**	**Description**
3e	July 10, 2006	1) Implemented issue #19, Added the e.g. statement to paragraph 6 of 7.12.2 2) Implemented issue #22. Modified 7.16.7.38 word 85 bit 10 to have a more clear definition of how the HPA bit works. 3) The text in IDENTIFY PACKET DEVICE did not show words 71-72 which should have been marked obsolete in e05161. 4) Implemented issue #70. Modified text in IDENTIFY DEVICE and IDENTIFY PACKET DEVICE to use x-y instead of (x:y) for word offset ranges. 5) Implemented issue #75. Added a definition of BIOS to the definition of terms. 6) Implemented issue #87. Inserted text into 4.1 and 7.16.2 to require that commands reported as not supported be aborted. 7) Implemented issue #94. Added note back in from ATA/ATAPI-7 in table A.8 and table A.9 8) The footnote in table A.9 is only relevant to the parallel transport, so it was deleted. The same is true of table A.8. This was caught during a pass to remove the word register. This is why the footnotes were originally removed from the tables. 9) Added the Device field back into table A.23, table A.8, table A.9, and table A.24. This was overlooked when the device field was reintroduced. 10) Implemented issue #86. Once again scrubbed the word register. 11) Implemented issue #100. Modified 7.10.3 and 7.10.5 to redefine the term is allowed. 12) Implemented issue #101. Modified trusted send/receive commands (7.56.3, 7.57.3, 7.58.3, and 7.59.3) to properly use LBA (7:0) as transfer length (15:8). 13) Implemented issue #102. In A.7.3 the number of pages was listed instead of the last page number. 14) Implemented issue #104. In 6.1.8 changed lba (7:0) to properly read (47:0) 15) Implemented issue #105. Added a description of SCT extended status code 0015h to table 62 and 8.3.4. 16) Implemented issue #106. Added WRITE LOG DMA EXT to table 8. 17) Implemented issue #108. Marked NV Cache commands in table 3 prohibited. Also marked Media Card pass-through as prohibited. 18) Implemented issue #115. Updated the definition of command released in 3.1.19. 19) Implemented issue #112. Removed other reference in 2.3 to PC-Card. 20) Implemented issue #117. Modified A.11 (Read Stream Error Log) and A.16 (Write Stream Error Log) to use value range notation (x through y) instead of bit field notation (y:x). Also fixed the range in A.16 to properly be 1 though 31 instead of 0 through 31. 21) Implemented issue #121. Made a global change on the word offset range 101-103 to 100-103. This is the 48 bit device capacity range. Only the significant 48 bits were included when the range was inserted. 22) Implemented issue #114. Added a definition of TCQ to 3.1. Globally changed all references from “command queuing” to “the TCQ feature set”.

Revision History (part 13 of 18)		
Rev	**Date**	**Description**
3e	July 10, 2006	23) Implemented issue #109. Globally changes references from packet devices to ATAPI devices. 24) Implemented issue #113. Globally changed PACKET Command feature set to PACKET feature set. This removed an inconsistency in referencing the feature set. 25) Implemented issue #118. Globally removed the phased "Changed to:". This was found in only one place, A.11. It looks like the change to was left over from a cut and paste error. 26) Implemented issue #123. Globally changed Volatile Value to Volatile_Value and globally changed the abbreviation VV to V_V. 27) Implemented issue #111. Provided hotlink to subclauses referenced by table 39. 28) Implemented issue #124. Globally changed comply with subclause x.y.z to comply with x.y.z. 29) Implemented issue #126. Fixed a typo in 7.77.3. In the Features field change 5:8 to 15:8. 30) Implemented issue #129. Modified the description column of table 73 (write same command description) to only capitalize the first word of each sentence. 31) Implemented issue #130. In 8.3.4 changed "LBA might" to "LBA may". 32) Implemented issue #135. Added an editors note before table B.3 to warn people that the table is not being maintained. This table is a duplicate of table B.2 with the exception that it is sorted in alphabetical order. 33) Implemented issue #133. Modified the Error field in table 92 to be more clear in stating that DEVICE RESET does not provide diagnostic results and all other commands do. 34) Implemented issue #107. It turns out that e05162r0 was already implemented in a previous revision, but a not was not made in the revision history. This proposal added wording to 7.43.2 (SECURITY ERASE UNIT) to explicitly state that a password could be set prior to issuing the command if a password had not been previously set. 35) Implemented issue #119. Created a definition of log address for read log and placed it in READ LOG EXT. Modified READ LOG EXT and SMART READ LOG to point to this definition. Created a subclause definition of Host Vendor Specific logs in READ LOG EXT and referenced this from the READ LOG EXT/SMART READ LOG address definition and WRITE LOG EXT/SMART WRITE LOG address definition. Placed a definition of write log address is SMART WRITE LOG and referenced this from SMART WRITE LOG and WRITE LOG EXT. 36) Implemented issue #132. Added the bit positions to the bit descriptions in clause 6. 37) Implemented issue #131. Normal output tables generic normal outputs w/LBA and Normal output tables generic normal outputs wo/LBA were identical. Changed clause 7 to reference only 1 normal outputs table. Deleted the redundant table from clause 9. 38) The error outputs for SMART WRITE LOG and WRITE LOG EXT were listed incorrectly. Split SET MAX and write log error outputs so they use different tables. Everything now reads the same as ATA/ATAPI-7 for these commands **39) After this revision was archived, clause 7 was split into 2 files. This was kept locally as rev 3e so change bars could be more easily generated**

Revision History (part 14 of 18)		
Rev	**Date**	**Description**
3f	December 11, 2006	1) Assigned minor revision 0033h to ATA8-ACS rev 3e 2) Implemented issue #9. Removed Allocation Unit from the glossary, changed the field in configure stream to reference a subclause that describes allocation unit. Change the description of the flush cache bit to reference the new Allocation Unit subclause. 3) Implemented issue #28. Modified 7.26.5 and 7.27.5, the error outputs for the read DMA queued commands to remove the reference to Overlapped interrupt. The overlapped interrupt is not defined anywhere. Also remove the redundant statement about the command being aborted if it is not support. This material is contained in the definition of the abort bit. 4) Implemented issue #43. The definitions of DF and DRQ should be N/A for normal outputs (table 96 and table 100) and defined for error outputs (table 117 and table 130). 5) Implemented issue #44. Updated the definition of the DCO SET Error, table 122, to be more clear. 6) Implemented issue #95. Changed the definition of words 100-103 in the IDENTIFY DEVICE table (table 22) to read “Total Number of User Addressable Sectors for the 48-bit Address feature set”. Also changed to heading in the text to match. 7) Implemented issue #97. Changed TF Data in 8.3.3 paragraph 6 to input data structure. 8) Implemented issue #98. Inserted a statement requiring the device to abort commands which are reported as not supported by IDENTIFY PACKET DEVICE. Also removed “(See 0)” statement that were left over from a conversion from word. 9) Implemented issue #103. Added verbiage to indicate that a block count of zero is illegal to the Inputs and Error Outputs for WRITE LOG EXT (DMA), READ LOG EXT (DMA), SMART READ LOG and SMART WRITE LOG. 10) Implemented issue #120. Modified the unordered list in 4.11.4 to make it more clear. 11) Implemented issue #128. Changed SCT Long Sector Access to SCT Read/Write Long. 12) Revisited issue #22. Word 85 bit 10 in the IDENTIFY DEVICE data table had not been updated as described in the issue. 13) Implemented issue #127. Inserted the fact that SMART DISABLE OPERATIONS does not disable SCT. 14) Implemented issue #138. The definition of ASCII string from ATA/ATAPI-7 did not seem appropriate for inclusion into IDENTIFY DEVICE. Reworked the definition of ASCII string and included it into 7.16.2. Also move the field data type descriptions from 7.17.2 to 7.16.2 and added a reference in 7.17.2 to 7.16.2. 15) Implemented issue #139. Clarified the definition of uncorrectable options. 16) Implemented issue #140. Changed IDENTIFY DEVICE data word 86 bit 8 from fixed to variable. 17) Implemented issue #141. Clarified SET MAX ADDRESS (7.49.2.2) to remove the requirement on the host that READ NATIVE MAX shall precede SET MAX ADDRESS. Instead the consequences of not issuing the READ NATIVE MAX are listed. 18) Implemented issue #142. Documented Optional/Mandatory, Fixed/Variable, and Serial/Parallel for IDENTIFY DEVICE data words 219 and 220.

Revision History (part 15 of 18)		
Rev	**Date**	**Description**
3f	December 11, 2006	19) Implemented issue #143. Globally changed ID Field was not found to sector was not found. This only affected the error outputs of several SMART commands. 20) Implemented issue #144. Changed maximum values in A.7.1, A.7.3 and A.8.1. 21) Implemented issue #145. Globally changed vendor unique to vendor specific. Several of these had crept in during proposal integration to the Annexes. 22) Implemented issue #149. Fixed DOWNLOAD MICROCODE Normal Outputs (7.12.4)to reference the correct IDENTIFY DEVICE data words. 23) Implemented issue #150. In DOWNLOAD MICROCODE Inputs, labelled mode 3 as optional. 24) Implemented issue #152. Wordsmithed the option byte in DOWNLOAD MICROCODE inputs. 25) Implemented issue #153. Fixed a typo in HPA Security Extensions (4.11.2). 26) Implemented issue #163. The Count Field in IDLE IMMEDIATE UNLOAD (7.19.4) was incorrectly documented as 44h when it should have been reserved. 27) Implemented issue #159. Added WWN to IDENITFY PACKET DEVICE and made it mandatory. Also ported the reserved words for the extension to 128 bits. 28) Implemented issue #136. Moved Host and Device vendor specific log page descriptions along with table A.1 to Annex A 29) Implemented issue #134. Changed table 97 (Normal Output for SMART Offline Immediate), table 98 (Normal Output for SMART Return Status), and table 119 (Error Output for SMART Execute Offline Immediate) to remove the N/A's that were indistinguishable from the key values supplied 30) Integrated e06153r1. This reserves SCT Action Code 0007h, Extended Status Codes BF00h-BFFFh, SCT Feature Control feature codes 0004h-0005h, and SCT Data Table ID's 0003h-0004h for use by SATA-IO. 31) Integrated e06152r3. This adds session and lifetime temperature reporting to SCT status in table 67. Also adds interval count since last over and under temperature conditions 32) Changed byte offsets throughout clause 8 from ":" notation to "-" notation. This brings the clause in line with the rest of the document. Unfortunately, some of the tables have formulas in the offset column. It my be difficult to tell the range from the formula. 33) Integrated e06102r2. Added a new log page at the end of Annex A called device statistics. Modified the proposal during incorporation to allow for definitions by page. 34) Bit 4 of words 119 and 120 (Segmented feature of download Microcode) was documented in the table, but not in the text. Added the description to the text. 35) Implement issue #146. Marked SET Features subcommands 41h, 83h, and C1h, DCO SET/IDNETIFY Word 21 bit 11, IDENITFY DEVICE data words 119/120 bit 5, and IDENTIFY DEVICE data word 53 bits 8-15 as reserved for e06144. 36) Integrated e05179r8. This removes some of the vagueness from the Security feature set. One Editors Note needs resolution in 4.20.10.

Revision History (part 16 of 18)		
Rev	Date	Description
3f	December 11, 2006	37) Added a paragraph at the beginning of this subclause to describe the issues list. (added based on line-by-line review) 38) Changed formatting of IDENTIFY DEVICE data word 222. (added based on line-byline review) 39) Added (i.e., HPA enabled/disabled) to IDENTIFY DEVICE data word 85 bit 10. (added based on line-by-line review) 40) Assigned minor revision code 0042h to this rev (3f)
3g	April 17, 2007	1) Changed SET FEATURES subcommand 83 to be reserved for e06162 instead of e06144. e06162 is for simulating a free fall event. 2) Fixed the byte count at offset 214 in table 67 to properly read 265 instead of 275. 3) Fixed documentation error in revision history. The TCG proposal was e05139r7 but was documented as e05137r7. 4) Fixed integration error for IDENTIFY DEVICE data word 48 bit 14 which should be 1 instead of 0. 5) Implemented issue #165. Integrated e06150r5 NCQ commands from SATA IO. 6) Implemented issue #166. Integrated e06144r6 (Free Fall feature set). Although this proposal was integrated, several modifications were required to make the information fit the form and style of ATA8. The feature set description needs work, I have opened issue #177 to address this issue 7) Added missing entries to historical SET FEATURES table 8) Implemented issue #158, Integrated e06126r3 (NOP Clarifications) 9) Implemented issue #155. Added definition of read and write command. 10) Implemented issue #156. Defined standardized error logs for WRITE UNCORRECTABLE. The term standardized error logs was defined or removed in previous revisions for other feature sets and commands. 11) Implemented issue #64 & 161. Added the output data description to 7.20.3 (ADD LBA(S) TO NV CACHE PINNED SET) and called the data Pin Request Data. Changed the text in PI to refer to this data. 12) Implemented issue #164. Removed the host requirement from the SET MAX EXT description. 13) Implemented issue #171. Changed Data Block Offset to Page #. 14) Implemented issue #172. Changed IDENTIFY DEVICE to refer to the Security feature set instead of Security Mode feature set. Also changed other instances in the text that refer to Security Mode feature set. 15) Implemented issue #175. Added READ LOG DMA EXT to table 8 (Security Command Actions) 16) Implemented issue #172. Removed the host requirement to issue SET MULTIPLE prior to CFA WRITE MULTIPLE WITHOUT ERASE, READ MULTIPLE, READ MULTIPLE EXT, WRITE MULTIPLE and WRITE MULTIPLE EXT. 17) Implemented issue #170. Alphabetized the log addresses in Annex A. Also normalized capitalization and names between the Log Address table and the subclause headers. Placed the log directory definitions at the beginning. Also added cross-links to the log addresses defined in the table. 18) Corrected WRITE UNCORRECTABLE to WRITE UNCORRECTABLE EXT in IDENTIFY DEVICE words 119 and 120 19) Removed several erroneous references to bits 15:8 in the status field.

Revision History (part 17 of 18)

Rev	Date	Description
3g	April 17, 2007	20) Fixed transition in the Power Management State transition diagram (figure 11). The arrow from PM1 to PM3 had the arrowhead on the wrong side. 21) Implemented issue #154. This adds a statement to WRITE UNCORRECTABLE which states that the effect on SMART tests is vendor specific. 22) Implemented issue #167. Integrated e06190r3 to clarify the interaction of NV Cache with media. This proposal attempts to modify the wording in the TCQ feature set regarding the operation of NOP Poll. The text mentioned in e06190r3 was turned into a note and changed. The note was changed to match the intention of e06190r3. Editors note 3 was intended to add word 21 bits 14 & 15 to DCO Set, but the description was incomplete. Additional words were taken from the same definition in DCO Identify. 23) Integrated e05122r6. This is an annex that provides some guidelines for implementing 1K/4K sectors. The February 2007 minutes listed this a e05122r6 as revised. It really meant e05122r5 as revised. 24) Integrated e07122r0. This changes the reference for IEEE P1667 to IEEE 1667 in TRUSTED SEND and TRUSTED RECEIVE. 25) Integrated e07112r1. This removed some of the WRITE UNCORRECTABLE options. 26) Implemented issue #180. Added SATA 2.6 to the IDENTIFY DEVICE data transport standard reporting mechanism. 27) Incorporated e07130r1. This added documentation on the various bit/field interactions to IDENTIFY DEVICE data. 28) Main system was upgraded to Vista Ultimate and Office 2007. as a result, frame maker 7.2 would not allow Visio 2007 drawing to be inserted directly, they now need to be inserted as Windows Meta Files. All figures were reinserted using this format. Some figures had not been converted to Visio, these figures were also converted and then reinserted. The Long logical long physical example figure was changed to use 1K physical sectors instead of 2K. The original drawing was inconsistent in the size of its boxes and the 2K example did not look good in the conversion.

Revision History (part 18 of 18)		
Rev	**Date**	**Description**
4	May 15, 2007	1) Implemented issue #183. Changed both the word 85 bit 3 of both IDENTIFY DEVICE data table and the description. 2) Implemented issue #185. Broke the error outputs paragraph for READ FPDMA and WRITE FPDMA into 2 pieces. 3) Implemented issue #186. If the host attempts to change the Master Password Identifier to an invalid value, the drive was required to report command aborted. This issue changes the text to allow the drive to successfully complete the command without changing the Identifier. 4) Implemented issue #187. Added WRITE UNCORRECTABLE to table 8 which describes the interaction of the Security feature set with all ATA commands. 5) Implemented issue #184. The statement that was voted in needed some wordsmithing to make sense in the command description of NV CACHE DISABLE. 6) Incorporated e07131r3. This incorporates the remainder of the material from SATA 2.5. This complements e06150. 7) Incorporated e07155r1. Assigned IDENTIFY DEVICE data word 217 to report the RPM of the media. This is a mandatory field. However, the device may return 0000h to indicate that it is not telling. 8) Incorporated e07139r3. This was a line-by-line review performed by Seagate and ten reviewed by T13. The changes that were accepted by the group are marked accepted. The changes were marked Migration Complete as they were incorporated. 9) Scrubbed the doc for can, cannot, will, could, would and won’t. 10) scanned the document for all references to “remov”, found several references to removable media capability that should have been taken out earlier. This included the footnote in the IDENTIFY (PACKET) DEVICE data table for the definition of “F”. Also found several references to media status notification. The WP bit was removed and the references were marked obsolete as a result of e07139. 11) Updated the command codes sorted by command name table (table B.3). This table should remain correct since no new commands are expected to be added beyond this point. 12) Scanned the entire document for usage for the word “log”. Changed usages of log, log address, log page, and 512-byte data block to be self consisted. Added definitions of log, log address, log page, and log command to the definition of terms. Also added an explanation of the terms to annex A (second paragraph). 13) Changed references in SCT (Clause 8 and Annex D) from key sector to key page. This matches the changes made in #12 above. 14) Implemented issue #53. This incorporates e03124r12. This proposal has been under development for almost 4 years. I integrated all the state transition diagrams and associated text. I only integrated the blue text into the feature set description. I was concerned that wordings have been updated over the course of the years and did not want to break things again. 15) performed a full spell-check. Found and normalized inconsistent usage of the terms “read lookahead”, “read ahead”, “look ahead”, etc. 16) Wordsmithed out the word comprise.
4a	May 22, 2007	1) Inserted re-worked HPA state transition diagrams. 2) Implemented issue #177. Added text which better describes the Free-fall Control feature set.

New Capabilities added to ATA8-ACS

Integrated Proposal List		
#	Doc	Description
1	e04139r4	Restructured all commands to conform to this format
2	e04143r0	Incorporated single log table
3	e04127r0	Makes SATA signatures reserved with no description.
4	e04143r1	Changes text to clarify that the Host Vendor Specific pages are common to both SMART READ LOG and READ LOG EXTENDED
5	e04130r2	Clarifies the definition of SMART first polling time. Also adds a field that enables longer times.
6	e05103r0	Changes the features register to log page specific for read and write log commands
7	e04153r1	Historical annex of command documentation
8	e05102r1	Reserves some set features and DCO fields as vendor specific
9	e04129r6	***New Feature: Write-Read-Verify***
10	e04161r0	obsoleted ATAPI overlap and queue
11	e05130r0	Extended support and enabled bits to IDENTIFY DEVICE data words 119 & 120
12	e05131r1	Clarifies that drive behavior is indeterminate if IDENTIFY DEVICE data indicates that the feature is not supported
13	e05120r2	***New Feature: Allows the drive to report a logical sector alignment requirements within a physical sector***
14	e04132r1	***New Feature: Defines subcommand 03 (segmented download) for download microcode***
15	e04162r0	Obsoleted DOWNLOAD MICROCODE subcommand 01- temporary use
16	e05151r1	Reserved opcodes for e05106
17	e02126r6	***New Feature: WRITE UNCORRECTABLE***
18	e05127r2	Updated the definition of the DF bit
19	e05129r1	***New Feature: READ/WRITE LOG DMA EXT***
20	e05132r1	***New Feature: Report transport standard***
21	e05140r0	Clarifies Media Serial Number Endianess
22	e05162r0	Clarifies SECURITY ERASE UNIT to require an abort if no passwords have been set in the drive
23	e05161r0	***New Feature: Adds GPL support and reporting in ATAPI PACKET IDENTIFY DEVICE***
24	e05167r0	Updated the block size by command table to include missing elements
25	e05109r4	***New Feature: SCT***
26	e05170r1	***New Feature: Add capability to SCT so write same can be performed as a foreground process***
27	e05154r4	Update streaming
28	e05150r2	Reserve resources for CE-ATA
29	e05178r0	New Feature: WWN is Mandatory
30	e05160r0	Clarifies flush cache operation when write cache is disabled
31	***e05162r2***	***New Feature: Adds to the Download Microcode Mode 3 capability by allowing the drive to report minimum and maximum transfer sizes. Also provides a mechanism for the drive to indicate when the microcode has been applied.***
32	***e05139r7***	***New Feature: Adds commands to support the Trusted Computing Group***
33	***e05106r7***	***New Feature: Adds commands to manipulate NV cache in hybrid devices***
34	***e06127r0***	***New Feature: Assigns a Security Protocol to IEEE P1667***
35	e06125r0	Updates IDENTIFY PACKET DEVICE to better match ATAPI operation
36	e06116r0	Obsoleted the Removable Media and Media Status Notification feature sets
37	e06128r1	Clarifies a variety of issues surrounding resets
38	***e06121r1***	***New Feature: Adds an IDENTIFY DEVICE data field to report the current Write-Read-Verify mode.***

Integrated Proposal List		
#	Doc	Description
39	***e06123r0***	***New Feature: Allows READ LOG EXT to succeed even when the drive is locked.***
40	e05162r0	Clarifies SECURITY ERASE UNIT to add the explicit statement that a password can be set prior to issuing SECURITY ERASE UNIT if a password had not been previously set
41	e06153r1	Reserves SCT resources for use by SATA-IO
42	***e06152r3***	***New Feature: Adds session and lifetime min and max temperature reporting to SCT Status. Also provides some concept of time since last temperature beyond operating limits.***
43	***e06102r2***	***New Feature: Creates a Device Statistics Log for documenting counters. The first counter defined documents lifetime power-on resets.***
44	e05179r8	Clarifies the operation of the Security feature set without changing operation relative to ATA/ATAPI-7. There is a second proposal that will be integrated into ACS-2 to close some of the security holes.
45	e06150r5	Adds the definition of FPDMA Read and Write commands as defined in Serial ATA Rev 2.5
46	e06144r6	***New Feature: Adds the ability to control a Free Fall sensor in the device.***
47	e06126r3	Clarifies the operation of NOP and makes a variety of unrelated small changes.
48	e06190r3	Clarifies the interaction of Cache, NV Cache, and Media.
49	e05122r6	Adds annex E which contains guidelines for implementing 1K and 4K physical sector drives
50	e07122r0	Changed reference from IEEE P1667 to IEEE 1667
51	e07112r1	Reduces the number of options available in WRITE UNCORRECTABLE
52	e07130r1	Adds documentation to IDENTIFY DEVICE data which shows the interaction of the various bits and fields.
53	e07131r3	Adds SATA 2.5 material which was not addressed by e06150. This includes SSP, Phy Counter log pages, and SET FEATUREs.
54	e07155r1	New Feature: Requires a device with rotating media to populate IDENTIFY DEVICE word 217.
55	e03124r12	Updates the HPA feature set to better clarify the interaction of the 28-bit and 48-bit versions on the HPA commands.
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Foreword

(This foreword is not part of this standard.)

Requests for interpretation, suggestions for improvement and addenda, or defect reports are welcome. They should be sent to the INCITS Secretariat, ITI, 1250 Eye Street, NW, Suite 200, Washington, DC 20005-3922.

This standard was processed and approved for submittal to ANSI by InterNational Committee for Information Technology Standards (INCITS). Committee approval of this standard does not necessarily imply that all committee members voted for approval. At the time it approved this standard, INCITS had the following members:

Karen Higginbottom, Chair

David Michael, Vice-chair

Monica Vago, Secretary

Technical Committee T13 on ATA Interfaces, that reviewed this standard, had the following members and additional participants:

Dan Colegrove, Chairman

Jim Hatfield, Vice-Chairman

Mark Overby, Secretary

[Editors Note: Insert T13 Membership List Here]

Introduction

This standard encompasses the following:
Clause 1 describes the scope.
Clause 2 provides normative references for the entire standard.
Clause 3 provides definitions, abbreviations, and conventions used within the entire standard.
Clause 4 describes the general operating requirements of the command layer.
Clause 5 describes the ATA protocols used by the commands in this standard
Clause 6 describes status and error bits
Clause 7 describes commands
Clause 8 describes the SCT Command Transport
Clause 9 describes command normal and error outputs
Annex A disrobes log pages
Annex B provides command summaries
Annex C describes considerations for using devices with non-512 byte sectors
Annex D provides a tutorial on how to use SCT
Annex E provides implementation guidelines for 1K/4K sectors

American National Standard
for Information Technology –

AT Attachment 8 - ATA/ATAPI Command Set (ATA8-ACS)

1 Scope

The set of AT Attachment standards consists of this standard and the ATA implementation standards described in AT Attachment - 8 ATA/ATAPI Architecture Model ATA8-AAM. The AT Attachment ATA Command Set (ATA8-ACS) specifies the command set host systems use to access storage devices. It provides a common command set for systems manufacturers, system integrators, software suppliers, and suppliers of intelligent storage devices. Figure 1 shows the relationship of this standard to the other standards and related projects in the ATA and SCSI families of standards and specifications.

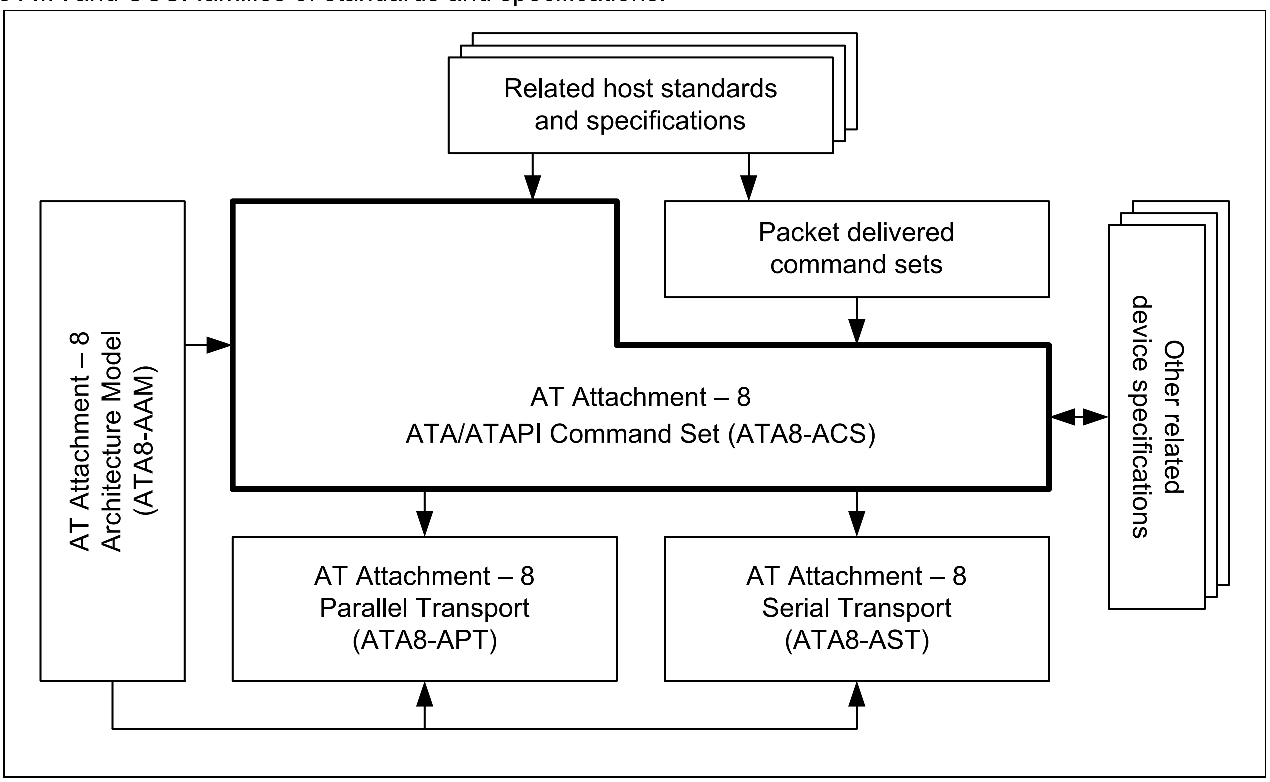

Figure 1 — ATA document relationships

ATA8-ACS maintains compatibility with the AT Attachment with Packet Interface - 7 standard (ATA/ATAPI-7), INCITS 397-2005 volume 1, and while providing additional functions. ATA8-ACS is not intended to require changes to devices or software that comply with previous ATA standards.

2 Normative references

The following standards contain provisions that, through reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

Copies of the following documents may be obtained from ANSI: Approved ANSI standards, approved and draft international and regional standards (ISO, IEC, CEN/CENELEC, ITUT), and approved and draft foreign standards (including BSI, JIS, and DIN). For further information, contact ANSI Customer Service Department at 212-642-4900 (phone), 212-302-1286 (fax), or via the World Wide Web at http://www.ansi.org.

Additional availability contact information is provided below as needed.

2.1 Approved references

Table 1 lists approved ANSI standards, approved international and regional standards (ISO, IEC, CEN/CENELEC, ITUT), may be obtained from the international and regional organizations who control them. To obtain copies of these documents, contact Global Engineering or INCITS. Additional information may be available at http://www.t10.org and http://www.t13.org

Table 1 — Approved ANSI References

Name	Reference
Protected Area Run Time Interface Extensions (PARTIES)	ANSI INCITS 346-2001
AT Attachment with Packet Interface Extension (ATA/ATAPI-4)	ANSI INCITS 317-1998
AT Attachment with Packet Interface Extension (ATA/ATAPI-5)	ANSI INCITS 340-2000
AT Attachment with Packet Interface Extension (ATA/ATAPI-6)	ANSI INCITS 361-2002
AT Attachment with Packet Interface Extension (ATA/ATAPI-7)	ANSI INCITS 397-2005 ISO/IEC 14776-971
Time Limited Commands (TLC)	ANSI INCITS TR37-2004
SMART Command Transport (SCT)	ANSI INCITS TR38-2005
Address Offset Alternate Boot Feature	ANSI INCITS TR27-2001
Acoustics – Measurement of airborne noise emitted by information technology and telecommunications equipment	ISO/IEC 7779:1999(E)
SCSI Primary Commands - 3 (SPC-3)	ANSI INCITS 408-2005 ISO/IEC 14776-453

2.2 References under development

At the time of publication, the following referenced standards were still under development. For information on the current status of the document, or regarding availability, contact the relevant standards body or other organization as indicated.

Table 2 — References Under Development

Name	Project Number
AT Attachment-8 - Parallel Transport (ATA8-APT)	INCITS 1698D ISO/IEC 14776-881
AT Attachment-8 – ATA/ATAPI Architecture Model (ATA8-AAM)	INCITS 1700D ISO/IEC 14776-861
Method to Disable Data Transfer after Error Technical Report	INCITS 1825DT
AT Attachment-8 – ATA Serial Transport (ATA8-AST)	INCITS 1697D ISO/IEC 14776-860
ATA/ATAPI-7 Amendment 1	ANSI INCITS.397-2005/AM 1-2006 ISO/IEC 14776-971? INCITS T13/e05108
Host Bus Adapter – 2 (HBA-2)	INCITS 2014D
Information Technology - Open Systems Interconnection - The Directory: Public-key and attribute certificate frameworks, ITU, 2000	ISO/IEC FDIS 9594-8

Editor's Note 1: Do we still need to list the doc number for ATA/ATAPI-7 Amendment 1? Also, need to remove the ? from ISO/IEC 14776-860

For more information on the current status of the T10 documents, contact INCITS. To obtain copies of T10 or SFF documents, contact Global Engineering.

2.3 Other references

The following standards and specifications are also referenced.

The CE-ATA Digital Protocol Specification.
For the CE-ATA Storage Interface Specification published by CE-ATA, contact them at http://www.ce-ata.org

CompactFlash™ Association Specification, Revision 4.0
For the CompactFlash™ Association Specification published by the CompactFlash™ Association, contact the CompactFlash™ Association at http://www.compactflash.org.

The MultiMedia Card System Specification
For the MultiMedia Card System Specification published by the MultiMedia Card Association, Inc, contact them at 925-417-0127 or http://www.mmca.org

RFC 3280, Internet X.509 Public Key Infrastructure: Certificate and Certificate Revocation List (CRL) Profile, IETF, 2002.
For RFC 3280 contact the Internet Engineering Task Force at http://www.ietf.org.

RFC 3281, An Internet Attribute Certificate: Profile for Authorization, IETF, 2002
For RFC 3280 contact the Internet Engineering Task Force at http://www.ietf.org

SD Card ATA Command Extension (SDA 3C)
For SDA 3C published by the SD Card Association, contact them at http://www.sdcard.org

Serial ATA revision 2.5 (SATA 2.5)
For the SATA 2.5 specification published by SATA-IO, contact them at http://www.sata-io.org

Smart Media ATA Command Extension
For the Smart Media ATA Command Extension, contact the Solid State Floppy Disk Forum at http://www.ssfdc.or.jp

Editor's Note 2: I have contacted the ssfdc to determine if this specification is still available and find out information on how to obtain the latest version.

3 Definitions, abbreviations, and conventions

3.1 Definitions and abbreviations

3.1.1 **ASCII Character:** Designates 8-bit value that is encoded using the ASCII Character set.

3.1.2 **acoustics:** Measurement of airborne noise emitted by information technology and telecommunications equipment [ISO 7779:1999(E)]

3.1.3 **ATA device:** A device implementing the General feature set.

3.1.4 **ATA8-ACS device:** A device that complies with this standard.

3.1.5 **ATAPI (AT Attachment Packet Interface) device:** A device implementing the PACKET feature set.

3.1.6 **AV (Audio-Video):** Audio-Video applications use data that is related to video images and/or audio. The distinguishing characteristic of this type of data is that accuracy is of lower priority than timely transfer of the data.

3.1.7 **Background Activities:** Activities initiated by a command that occur after command completion has been reported.

3.1.8 **BIOS (Basic Input/Output System)**: An initial application client run by a computer when power is applied. The primary function of BIOS is initialize various components of the system, including storage devices.

3.1.9 **Block Data:** Block Data is the data transferred to or from the device using SCT read/write log capabilities.

3.1.10 **Cache:** A data storage area outside the area accessible by application clients that may contain a subset of the data stored in the non-volatile data storage area.

3.1.11 **CFA (CompactFlash™ Association):** The CompactFlash™ Association which created the specification for compact flash memory that uses the ATA interface.

3.1.12 **check condition:** For ATAPI devices, this indicates an error or exception condition has occurred.

3.1.13 **CHS (cylinder-head-sector):** An obsolete method of addressing the data on the device by cylinder number, head number, and sector number.

3.1.14 **command aborted:** Command completion with ERR set to one in the Status field and ABRT set to one in the Error field.

3.1.15 **command acceptance:** Positive acknowledgement of a command being received by a device. See the appropriate transport standard for a definition of positive acknowledgement.

3.1.16 **Command Block:** In a parallel implementation this is the set of interface registers used for delivering commands to the device or posting status from the device. In a serial implementation, the command block fields are FIS payload fields.

3.1.17 **command completion:** The completion by the device of the action requested by the command or the termination of the command with an error, the setting of the appropriate bits in the Error field, and the setting of the appropriate bits in the Status field.

3.1.18 **command packet:** A data structure transmitted to the device during the execution of a PACKET command that includes the command and command parameters.

3.1.19 **command released:** When a device supports the TCQ feature set, a command is considered released when a release occurs before command completion.

3.1.20 **device:** A storage-related peripheral. Traditionally, a device on the interface has been a hard disk drive, but any form of storage device may be placed on the interface provided the device adheres to this standard.

3.1.21 **DMA (direct memory access) data transfer:** A means of data transfer between device and host memory without host processor intervention.

3.1.22 **DRQ data block:** A unit of data words associated with available status when using either the PIO data-in command protocol or the PIO data-out command protocol.

3.1.23 **FIS:** The Frame Information Structure for the serial interface.

3.1.24 **hardware reset:** the routine performed by a device after a hardware reset event as defined in ATA8-AAM. The hardware reset routine performed by the device includes the actions performed by the device for a software reset, and the actions defined in ATA8-AAM, this standard, and the applicable transport standards.

3.1.25 **host:** The computer system executing the application client (e.g., BIOS, operating system, or device driver) controlling the device and the adapter hardware for the ATA interface to the device.

3.1.26 **host adapter:** The implementation of the host transport, link, and physical layers.

3.1.27 **LBA (logical block address):** The value used to reference a logical sector.

3.1.28 **logical sector:** A set of logical words accessed and referenced as a unit (see IDENTIFY DEVICE data words 118:117). These units are referenced by Logical Block Addresses.

3.1.29 **log:** A collection of data accessed using log commands.

3.1.30 **log address:** A numeric value that a log command uses to identify a specific log.

3.1.31 **log command:** A SMART READ LOG command, SMART WRITE LOG command, or GPL feature set command.

3.1.32 **log page:** A unit of measure for determining the size of a log. Each log page is a 512-byte block of data. A log consists of one or more pages.

3.1.33 **Master Password Capability:** The Master Password Capability indicates whether or not the Master password may be used to unlock the device. This was formerly know as “Security Level”.

3.1.34 **Media:** The material on which data is stored.

3.1.35 **Media Access Command:** Any command which causes the device to access non-volatile media.

3.1.36 **native max address:** The highest address a device accepts in the factory default condition, that is, the highest address that is accepted by the SET MAX ADDRESS command.

3.1.37 **Non-Volatile cache:** Cache that retains data through all power and reset events. Non-volatile cache shall be a subset of the non-volatile media.

3.1.38 **Non-Volatile Media:** Physical storage media that retains data written to it for subsequent read operations through all power and reset events (e.g. magnetic media, optical media, flash media).

3.1.39 **NV Cache Pinned Set:** The set of logical blocks that have been made un-removable from the NV Cache by the host. Writes to logical blocks represented in the NV Cache Pinned Set always results in valid data in the NV Cache Set.

3.1.40 **NV Cache Set:** The set of logical blocks currently represented in the device's entire NV Cache.

3.1.41 **NV Cache Set Data:** A data structure representing the standard format of transmitting logical blocks in the form of a list of LBA Range Entries.

3.1.42 **NV Cache Unpinned Set:** The set of logical blocks that are represented in the NV Cache Set but not represented in the NV Cache Pinned Set. The NV Cache Pinned Set and the NV Cache Unpinned Set are mutually exclusive. NV Cache Unpinned Set is completely managed by the device and logical blocks represented in the NV Cache Unpinned Set may be added or removed from the NV Cache Set at any time.

3.1.43 **Password Attempt Counter Exceeded:** There were too many attempts to unlock the device with an incorrect password. This is a name associated with IDENTIFY DEVICE, word 128, bit 4.

3.1.44 **PATA:** A device implementing the parallel transport, see ATA8-APT

3.1.45 **physical sector:** One or more contiguous logical sectors that are read from or written to the device media in a single operation.

3.1.46 **PIO (programmed input/output) data transfer:** PIO data transfers are performed using PIO commands and protocol.

3.1.47 **power cycle:** the period from when power is removed from a host or device until the subsequent power-on event (see ATA8-AAM).

3.1.48 **power-on reset:** the host specific routine performed by the host or the routine performed by a device after detecting a power-on event. The power-on reset routine performed by a device includes the actions performed by the device for a hardware reset and a software reset, and the actions defined in ATA8-AAM, this standard, and the applicable transport standards.

3.1.49 **queued:** Command queuing allows the host to issue concurrent commands to the same device. Only commands included in the Tagged Command Queuing (TCQ) feature set may be queued. In this standard, the queue contains all commands for which command acceptance has occurred but command completion has not occurred.

3.1.50 **Queued Command:** A NCQ command that has reported command acceptance but not command completion.

3.1.51 **read command:** A command that causes the device to transfer data from the device to the host. The following commands are read commands: READ DMA, READ DMA EXT, READ DMA QUEUED, READ DMA QUEUED EXT, READ FPDMA QUEUED, READ MULTIPLE, READ MULTIPLE EXT, READ SECTOR(S), READ SECTOR(S) EXT, READ STREAM DMA, READ STREAM DMA EXT, READ VERIFY SECTOR(S), or READ VERIFY SECTOR(S) EXT.

3.1.52 **release:** The action by a device implementing the TCQ feature set that allows a host to select an alternate device or deliver another queued command.

3.1.53 **SATA:** A device implementing the serial transport, see ATA8-AST

3.1.54 **sector:** See logical sector.

3.1.55 **Security Is Disabled:** The Security feature set is supported, but there is no valid User password. There is a Master password. Access to user data is not restricted by the Security feature set. The terms 'Security Is Locked' and 'Security Is Unlocked' are not applicable. (e.g., Security states SEC0, SEC1, SEC2).

3.1.56 **Security Is Enabled:** The Security feature set is supported, and a valid User password has been set. (e.g., Security states SEC3, SEC4, SEC5, SEC6).

3.1.57 **Security Is Frozen:** Security may be either enabled or disabled. Changes to Security states are not allowed until after the next power-on or hardware reset. (e.g., Security states SEC2, SEC6).

3.1.58 **Security Is Locked:** Security is enabled. In addition, access to the device is restricted. (e.g., Security state SEC4).

3.1.59 **Security Is Not Frozen:** Security may be either enabled or disabled. Changes to Security states are allowed (e.g., Security states SEC1, SEC4, SEC5).

3.1.60 **Security Is Not Supported:** The Security feature set is not supported. The SECURITY commands (see 4.20.5) are not supported and shall be command aborted. IDENTIFY DEVICE reports that the Security feature set is 'not supported'.

3.1.61 **Security Is Unlocked:** Security is enabled. A SECURITY UNLOCK command was successful, allowing access to the device. (e.g., Security state SEC5, SEC6).

3.1.62 **Security Level:** See Master Password Capability.

3.1.63 **signature:** A unique set of values placed in the return parameters used to distinguish command sets (e.g. General, ATAPI device, Port Multiplier). See table 92 for more information.

3.1.64 **software reset:** the routine performed by a device after a software reset event as defined in ATA8-AAM. The software reset routine includes the actions defined in ATA8-AAM, this standard, and the applicable transport standards.

3.1.65 **spin-down:** the process of bringing a rotating media device's media to a stop.

3.1.66 **spin-up:** the process of bringing a rotating media device's media to operational speed.

3.1.67 **Spindle State:** The current state of the device's rotational media. There are two possible states: spun up/spinning up and spun down/spinning down.

3.1.68 **Stream:** a set of operating parameters specified by a host using the CONFIGURE STREAM command (see 7.9) to be used for subsequent READ STREAM commands and WRITE STREAM commands.

3.1.69 **TCG:** Trusted Computing Group: An organization that develops and promotes open standards for hardware-enabled trusted computing and security technologies. See https://www.trustedcomputinggroup.org for more information.

3.1.70 **TCQ (Tagged Command Queuing):** TCQ feature set (see 4.24).

3.1.71 **transport:** The mechanism used to communicate with a device. See ATA8-APT and ATA8-AST.

3.1.72 **unaligned write:** A write command that does not start at the first logical sector of a physical sector or does not end at the last logical sector of a physical sector.

3.1.73 **unrecoverable error:** When the device sets either the ERR bit or the DF bit to one in the Status field at command completion.

3.1.74 **Volatile Cache:** Cache that does not retain data through power cycles.

3.1.75 **VS (vendor specific):** Bits, bytes, fields, and code values that are reserved for vendor specific purposes. These bits, bytes, fields, and code values are not described in this standard, and implementations may vary among vendors. This term is also applied to levels of functionality whose definition is left to the vendor.

3.1.76 **write command:** A command that causes the device to transfer data from the host to the device. The following commands are write commands: WRITE DMA, WRITE DMA EXT, WRITE DMA FUA EXT, WRITE DMA QUEUED, WRITE DMA QUEUED EXT, WRITE DMA QUEUED FUA EXT, WRITE FPDMA QUEUED, WRITE MULTIPLE, WRITE MULTIPLE EXT, WRITE MULTIPLE FUA EXT, WRITE SECTOR(S), WRITE SECTOR(S) EXT, WRITE STREAM DMA EXT, or WRITE STREAM EXT.

3.1.77 **WWN (world wide name):** A 64-bit worldwide unique name based upon a company's IEEE identifier. (See IDENTIFY DEVICE data words (111:108), 7.16.7).

3.2 Conventions

3.2.1 Overview

Lowercase is used for words having the normal English language meaning. Certain words and terms used in this standard have a specific meaning beyond the normal English language meaning. These words and terms are defined either in clause 3 or in the text where they first appear.

The names of abbreviations, commands, fields, and acronyms used as signal names are in all uppercase (e.g., IDENTIFY DEVICE). Fields containing only one bit are usually referred to as the "name" bit instead of the "name" field. (See 3.2.6 for the naming convention used for naming bits.)

Names of device fields begin with a capital letter (e.g., Count).

The expression "word n" or "bit n" shall be interpreted as indicating the content of word n or bit n.

3.2.2 Precedence

If there is a conflict between text, figures, and tables, the precedence shall be tables, figures, then text.

3.2.3 Lists

Unordered lists, those lists describing a sequence, are of the form:

a)
b)
c)

Ordered list are of the form:

1)
2)
3)

3.2.4 Keywords

Several keywords are used to differentiate between different levels of requirements and options.

3.2.4.1 expected: A keyword used to describe the behavior of the hardware or software in the design models assumed by this standard. Other hardware and software design models may also be implemented.

3.2.4.2 mandatory: A keyword indicating items to be implemented as defined by this standard.

3.2.4.3 may: A keyword that indicates flexibility of choice with no implied preference.

3.2.4.4 N/A: A keyword that indicates a field is not applicable and has no defined value and should not be checked by the host or device.

3.2.4.5 obsolete: A keyword indicating that the designated bits, bytes, words, fields, and code values that may have been defined in previous standards are not defined in this standard and shall not be reclaimed for other uses in future standards. However, some degree of functionality may be required for items designated as "obsolete" to provide for backward compatibility.

Obsolete commands should not be used by the host. Commands defined as obsolete may be command aborted by devices conforming to this standard. However, if a device does not command abort an obsolete command, the minimum that is required by the device in response to the command is command completion.

3.2.4.6 optional: A keyword that describes features that are not required by this standard. However, if any optional feature defined by the standard is implemented, the feature shall be implemented in the way defined by the standard.

3.2.4.7 prohibited: A keyword indicating that an item shall not be implemented by an implementation.

3.2.4.8 reserved: A keyword indicating reserved bits, bytes, words, fields, and code values that are set aside for future standardization. Their use and interpretation may be specified by future extensions to this or other standards. A reserved bit, byte, word, or field shall be cleared to zero, or in accordance with a future extension to this standard. The recipient shall not check reserved bits, bytes, words, or fields. Receipt of reserved code values in defined fields shall be treated as a command parameter error and reported by returning command aborted.

3.2.4.9 retired: A keyword indicating that the designated bits, bytes, words, fields, and code values that had been defined in previous standards are not defined in this standard and may be reclaimed for other uses in future standards. If retired bits, bytes, words, fields, or code values are used before they are reclaimed, they shall have the meaning or functionality as described in previous standards.

3.2.4.10 shall: A keyword indicating a mandatory requirement. Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this standard.

3.2.4.11 should: A keyword indicating flexibility of choice with a strongly preferred alternative. Equivalent to the phrase "it is recommended".

3.2.5 Numbering

Numbers that are not immediately followed by a lowercase "b" or "h" are decimal values. Numbers that are immediately followed by a lowercase "b" (e.g., 01b) are binary values. Numbers that are immediately followed by a lowercase "h" (e.g., 3Ah) are hexadecimal values.

3.2.6 Bit conventions

Bit (n:m) denotes a set of bits, for example, bits (7:0).

3.2.7 State diagram conventions

State diagrams shall be as shown in Figure 2.

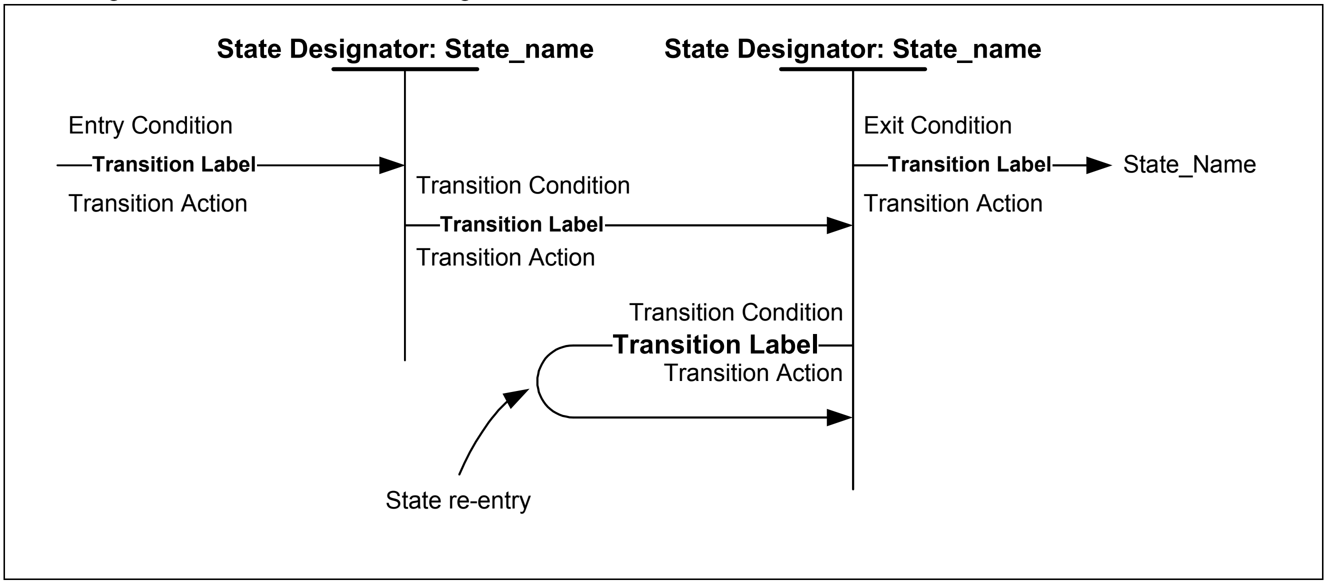

Figure 2 — State diagram convention

Each state is identified by a state designator and a state name. The state designator is unique among all states in all state diagrams in this document. The state designator consists of a set of letters that are capitalized in the title of the figure containing the state diagram followed by a unique number. The state name is a brief description of the primary action taken during the state, and the same state name may appear in other state diagrams. If the same primary function occurs in other states in the same state diagram, they are designated with a unique letter at the end of the name. Additional actions may be taken while in a state and these actions are described in the state description text.

Each transition is identified by a transition label and a transition condition. The transition label consists of the state designator of the state from which the transition is being made followed by the state designator of the state to which the transition is being made. In some cases, the transition to enter or exit a state diagram may come from or go to a number of state diagrams, depending on the command being executed. In this case, the state designator is labeled State_name. The transition condition is a brief description of the event or condition that causes the transition to occur and may include a transition action, indicated in italics, that is taken when the transition occurs. This action is described fully in the transition description text.

Upon entry to a state, all actions to be executed in that state are executed. If a state is re-entered from itself, all actions to be executed in the state are executed again.

Transitions from state to state shall be instantaneous.

3.2.8 Byte, word, DWord, and QWord Relationships

Figure 3 illustrates the relationship between bytes, words DWords, and QWords.

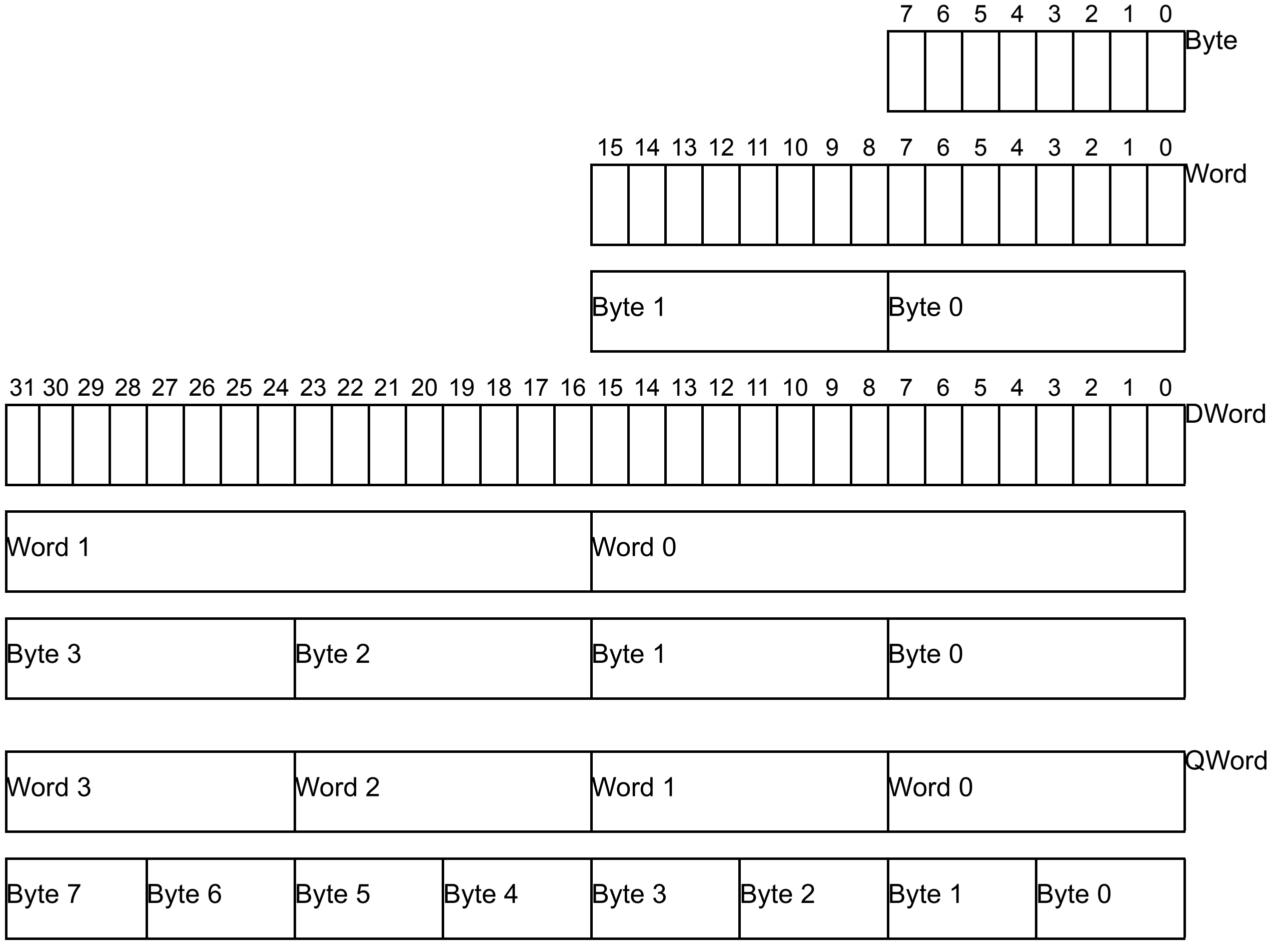

Figure 3 — Byte, word, DWord and QWord relationships

4 Feature set definitions

4.1 Overview

Table 3 lists the feature sets in alphabetical order and provides an indication of support for devices that support the General and Packet feature sets.

Table 3 — Feature Set Summary

Feature set	General Devices	Packet Devices
48-Bit Address feature set (see 4.4)	O	P
Advanced Power Management feature set (see 4.5)	O	O
Automatic Acoustic Management feature set (see 4.6)	O	O
Compact Flash feature set(see 4.7)	N	N
Device Configuration Overlay feature set (see 4.8)	O	O
Free-fall Control feature set (see 4.9)	O	P
General feature set (see 4.2)	M	P
General Purpose Logging feature set (see 4.10)	O	O
Host Protected Area feature set (see 4.11)	O	O
Long Logical Sector feature set (see 4.12)	O	N
Long Physical Sector feature set(see 4.13)	O	N
Media Card Pass Through Command feature set (see 4.14)	N	P
Native Command Queuing (NCQ) feature set (see 4.15)	O	P
NV Cache feature set (see 4.16)	O	P
NV Cache Power Management feature set (see 4.17)	O	P
PACKET feature set (see 4.3)	P	M
Power management feature set (see 4.18)	M	O
Power-Up In Standby feature set (see 4.19)	O	O
Security feature set (see 4.20)	O	O
SMART feature set (see 4.21)	O	P
Software Settings Preservation (see 4.22)	O	P
Streaming feature set (see 4.23)	O	P
Tagged Command Queuing feature set (see 4.24)	O	P
Trusted Computing feature set (see 4.25)	O	P
Write-Read-Verify feature set (see 4.26)	O	O
Key: M – Mandatory, O – Optional, P – Prohibited, N – Not defined		

Commands may be delivered in two forms. For devices that implement the General feature set, all commands and command parameters are delivered by transmitting a Command Block to the device.

Devices that implement the PACKET feature set use DEVICE RESET and PACKET commands as well as a subset of the General feature set to control the device.

The content of command packets delivered during execution of the PACKET command are not described in this standard.

If the host issues a command that is indicated as not supported in the IDENTIFY DEVICE data, the device shall abort the command.

4.2 General feature set

The following General feature set commands are mandatory for all devices that are capable of both reading and writing their media and do not implement the PACKET feature set:

a) EXECUTE DEVICE DIAGNOSTIC

b) FLUSH CACHE
c) IDENTIFY DEVICE
d) READ DMA
e) READ MULTIPLE
f) READ SECTOR(S)
g) READ VERIFY SECTOR(S)
h) SET FEATURES
i) SET MULTIPLE MODE
j) WRITE DMA
k) WRITE MULTIPLE
l) WRITE SECTOR(S)

The following General feature set commands are mandatory for all devices that are capable of only reading their media and do not implement the PACKET feature set:

a) EXECUTE DEVICE DIAGNOSTIC
b) IDENTIFY DEVICE
c) READ DMA
d) READ MULTIPLE
e) READ SECTOR(S)
f) READ VERIFY SECTOR(S)
g) SET FEATURES
h) SET MULTIPLE MODE

The following General feature set commands are optional for devices not implementing the PACKET feature set:

a) DOWNLOAD MICROCODE
b) NOP
c) READ BUFFER
d) WRITE BUFFER
e) WRITE UNCORRECTABLE

The following Packet feature set command is prohibited for use by devices not implementing the PACKET feature set:

a) DEVICE RESET

4.3 The PACKET feature set

4.3.1 Overview

The optional PACKET feature set provides for ATAPI devices that require command parameters that are too extensive to be expressed in the return data structure. Devices implementing the PACKET feature set exhibit responses different from those exhibited by devices not implementing this feature set.

The following commands are mandatory for all devices implementing the PACKET feature set:

a) PACKET
b) DEVICE RESET
c) EXECUTE DEVICE DIAGNOSTIC
d) IDENTIFY DEVICE
e) IDENTIFY PACKET DEVICE
f) NOP
g) READ SECTOR(S)
h) SET FEATURES

The following General feature set commands are optional for all devices implementing the PACKET feature set:

a) FLUSH CACHE
b) READ LOG EXT
c) WRITE LOG EXT
d) READ LOG DMA EXT
e) WRITE LOG DMA EXT

The following General feature set commands are prohibited for use by devices implementing the PACKET feature set.

a) DOWNLOAD MICROCODE
b) READ BUFFER
c) READ DMA
d) READ MULTIPLE
e) READ VERIFY
f) SET MULTIPLE MODE
g) WRITE BUFFER
h) WRITE DMA
i) WRITE MULTIPLE
j) WRITE SECTOR(S)
k) WRITE UNCORRECTABLE

4.3.2 Identification of PACKET feature set devices

The IDENTIFY DEVICE command shall be command aborted and shall return the signature unique to devices implementing the PACKET feature set. The IDENTIFY PACKET DEVICE command is used by the host to get identifying parameter information for a device implementing the PACKET feature set (See 7.16.5 and 7.17).

4.3.3 Processing resets for the PACKET feature set

ATAPI devices process power-on resets, hardware resets, and software resets as described in this standard for ATA devices, except ATAPI devices return a unique signature when the reset is complete (see the appropriate transport standard for details). In addition, ATAPI devices implement the DEVICE RESET command (see 7.11)

4.3.4 The PACKET command

The PACKET command allows a host to send a command to the device via a command packet. The command packet contains the command and command parameters that the device is to execute (See clause 1).

The protocol for handling the transmission of the PACKET command and associated data is transport specific.

4.4 48-bit Address feature set

The optional 48-bit Address feature set allows devices with capacities up to 281,474,976,710,655 logical sectors. This allows device capacity up to 144,115,188,075,855,360 bytes for a 512 byte logical block device. In addition, the number of logical sectors that may be transferred by a single command are increased to 65,536.

The commands in the 48-bit Address feature set are prohibited for use by for devices implementing the PACKET feature set.

Commands unique to the 48-bit Address feature set are:

a) FLUSH CACHE EXT
b) READ DMA EXT
c) READ DMA QUEUED EXT
d) READ MULTIPLE EXT
e) READ NATIVE MAX ADDRESS EXT
f) READ SECTOR(S) EXT
g) READ VERIFY SECTOR(S) EXT
h) SET MAX ADDRESS EXT
i) WRITE DMA EXT
j) WRITE DMA FUA EXT
k) WRITE DMA QUEUED EXT
l) WRITE DMA QUEUED FUA EXT
m) WRITE MULTIPLE EXT
n) WRITE MULTIPLE FUA EXT
o) WRITE SECTOR(S) EXT

The 48-bit Address feature set operates in LBA only. Devices implementing the 48-bit Address feature set shall also implement commands that use 28-bit addressing. 28-bit and 48-bit commands may be intermixed. Support for the 48-bit Address feature set is indicated in the IDENTIFY DEVICE data.

In a device implementing the 48-bit Address feature set, the Feature field and the Count field are 16 bits long, but the LBA field is 48-bits long.

The device shall indicate support of the 48-bit Address feature set in the IDENTIFY DEVICE data. In addition, IDENTIFY DEVICE data words (103:100) contain the maximum user LBA + 1 that is accessible by 48-bit addressable commands.

See 4.11.4 for a description of how to set IDENTIFY DEVICE data words 60-61 and 100-103.

When the 48-bit Address feature set is implemented, the native maximum address is the highest address accepted by the device in the factory default condition using a 48-bit Address feature set command. The native maximum address is the value returned by a READ NATIVE MAX ADDRESS EXT command. If the native maximum address of a device is equal to or less than 268,435,454, a READ NATIVE MAX ADDRESS shall return the native maximum address. If the native maximum address is greater than 268,435,454, a READ NATIVE MAX ADDRESS command shall cause the device to return a maximum value of 268,435,454.

When the 48-bit Address feature set is implemented, the SET MAX ADDRESS command shall execute as described in 7.49.2. However, in addition to modifying the content of words (61:60), the new content of (61:60) shall also be placed in words (103:100). When a SET MAX ADDRESS EXT command is issued and the address requested is greater than 268,435,455, words (103:100) shall be modified to reflect the requested value but words 60, and 61 shall not be modified. When a SET MAX ADDRESS EXT command is issued and the address requested is equal to or less than 268,435,455, words (103:100) shall be modified to reflect the requested value and words 60, and 61 shall be modified as described in 7.49.2.1.

If a Host Protected Area has been created using the SET MAX ADDRESS command, all SET MAX ADDRESS EXT commands shall result in command aborted until the Host Protected Area is eliminated by use of the SET MAX ADDRESS command with the address value returned by the READ NATIVE MAX ADDRESS command. If a Host Protected Area has been created using the SET MAX ADDRESS EXT command, all SET MAX ADDRESS commands shall result in command aborted until the Host Protected Area is eliminated by use of the SET MAX ADDRESS EXT command with the address value returned by the READ NATIVE MAX ADDRESS EXT command.

4.5 Advanced Power Management feature set

The Advanced Power Management feature set is an optional feature set that allows the host to select a power management level. The power management level is specified using a scale from the lowest power consumption setting of 01h to the maximum performance level of FEh, see table 41 in 7.48.6. Device performance may increase with increasing power management levels. Device power consumption may increase as the power management setting numerically increases. A device may implement one power management method for two or more contiguous power management levels. For example, a device may implement one power management method from level 80h to A0h and a higher performance, higher power consumption method from level A1h to FEh. Advanced power management levels 80h and higher do not permit the device to spin down to save power.

The Advanced Power Management feature set uses the following functions:

a) A SET FEATURES subcommand to enable Advanced Power Management
b) A SET FEATURES subcommand to disable Advanced Power Management

Advanced Power Management is independent of the Standby timer setting. If both Advanced Power Management and the Standby timer are set, the device shall go to the Standby state when the timer times out or the device’s Advanced Power Management algorithm indicates that the Standby state should be entered.

The IDENTIFY DEVICE command indicates that Advanced Power Management is supported, whether Advanced Power Management is enabled, and the current advanced power management level if Advanced Power Management is enabled.

4.6 Automatic Acoustic Management feature set

The Automatic Acoustic Management feature set is an optional feature set that allows the host to select an acoustic management level. The acoustic management level ranges from the setting of 00h to FFh, although many levels are currently retired (see table 43). Device performance and acoustic emanation may increase with increasing acoustic management levels. The acoustic management levels may contain discrete bands. For example, a device may implement one acoustic management method from level 80h to A0h, and a higher performance, higher acoustic emanation method from level A1h to FEh.

The Automatic Acoustic Management feature set uses the following functions:

a) A SET FEATURES subcommand to enable the Automatic Acoustic Management feature set
b) A SET FEATURES subcommand to disable the Automatic Acoustic Management feature set

The IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data indicates if the Automatic Acoustic Management feature set is supported, if the Automatic Acoustic Management feature set is enabled, and the current automatic acoustic management level if the Automatic Acoustic Management feature set is enabled.

4.7 CompactFlash™ Association (CFA) feature set

The optional CompactFlash™ Association (CFA) feature set provides support for devices that implement the CFA specifications. A device that implements the CFA feature set shall implement the following minimum set of commands:

a) CFA REQUEST EXTENDED ERROR CODE
b) CFA WRITE SECTORS WITHOUT ERASE
c) CFA ERASE SECTORS
d) CFA WRITE MULTIPLE WITHOUT ERASE
e) CFA TRANSLATE SECTOR
f) SET FEATURES Enable/Disable 8-bit transfer

Devices reporting the value 848Ah in IDENTIFY DEVICE data word 0 or devices having bit 2 of IDENTIFY DEVICE data word 83 set to one shall support the CFA feature Set. If the CFA feature set is implemented, all the CFA commands and the Enable/Disable 8-Bit transfers shall be implemented.

Support of DMA commands is optional for devices that support the CFA feature set.

The CFA ERASE SECTORS command preconditions the logical sector for a subsequent CFA WRITE SECTORS WITHOUT ERASE or CFA WRITE MULTIPLE WITHOUT ERASE command to achieve higher performance during the write operation. The CFA TRANSLATE SECTOR command provides information about a logical sector such as the number of write cycles performed on that sector and an indication of the logical sector's erased precondition. The CFA REQUEST EXTENDED ERROR CODE command provides more detailed error information.

4.8 Device Configuration Overlay (DCO) feature set

The optional Device Configuration Overlay feature set allows a utility program to modify some of the optional commands, modes, and feature sets that a device reports as supported in the IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data as well as the capacity reported.

Commands unique to the Device Configuration Overlay feature set use a single command code and are differentiated from one another by the value placed in the Feature field. These commands are:

a) DEVICE CONFIGURATION FREEZE LOCK
b) DEVICE CONFIGURATION IDENTIFY
c) DEVICE CONFIGURATION RESTORE
d) DEVICE CONFIGURATION SET

The Device Configuration Overlay feature set may affect words in IDENTIFY DEVICE data, IDENTIFY PACKET DEVICE data, and other commands. Certain bits in these words that indicate that a command, mode, capacity, or feature set is supported and enabled may be cleared by a DEVICE CONFIGURATION SET command. For a particular command, mode, capacity, or feature set, when a bit is cleared indicating that the device does not support the feature, the device shall not provide the feature.

The maximum capacity of the device may be reduced. Since a Host Protected Area may be lost if the capacity of the device is reduced, when a Host Protected Area is set the DEVICE CONFIGURATION SET command shall cause the device to return command aborted. The address value returned by a READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command is modified by the DEVICE CONFIGURATION SET command modifying the maximum capacity of the device.

If a DEVICE CONFIGURATION FREEZE LOCK command has been completed by a device since the last power-on reset processed by the device, then the device shall return command aborted for any subsequent DEVICE CONFIGURATION SET command. During processing of a power-on reset or hardware reset, a device shall not change the settings made by a DEVICE CONFIGURATION SET command.

A DEVICE CONFIGURATION IDENTIFY command specifies the selectable commands, modes, capacity, and feature sets that the device is capable of supporting. After the execution of a DEVICE CONFIGURATION SET command this information is no longer available from an IDENTIFY DEVICE or IDENTIFY PACKET DEVICE command but the data that DCO IDENTIFY returns is not changed by DCO SET or DCO RESTORE.

A DEVICE CONFIGURATION RESTORE command enables all capabilities that have been disabled by DEVICE CONFIGURATION SET command and returns the IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data to that indicated by the DEVICE CONFIGURATION IDENTIFY command. If the value returned in IDENTIFY DEVICE data words (103:100) is less than the native max address for a device (i.e., a host protected area has been established), then the device shall command abort a DEVICE CONFIGURATION RESTORE command. If a DEVICE CONFIGURATION FREEZE LOCK command has been completed by a device since the device processed a power-on reset, then the device shall abort any DEVICE CONFIGURATION RESTORE commands.

A DEVICE CONFIGURATION FREEZE LOCK command prevents accidental modification of the state of the Device Configuration Overlay feature set.

If a device has not completed a DEVICE CONFIGURATION SET command without error, then a device shall be in the DCO Factory_config state after processing a power-on reset. If a device has completed a DEVICE CONFIGURATION SET command without error, then a device shall be in the DCO Reduced_config state after processing a power-on reset.

After completing a DEVICE CONFIGURATION FREEZE LOCK command without error, a device aborts all DEVICE CONFIGURATION SET, DEVICE CONFIGURATION IDENTIFY, and DEVICE CONFIGURATION RESTORE commands until after completing the subsequent power-on reset. If a device is in the DCO_locked state, then processing a hardware reset or software reset does not cause the device to change state.

Figure 4 and the text following the figure describe the operation of the Device Configuration Overlay feature set.

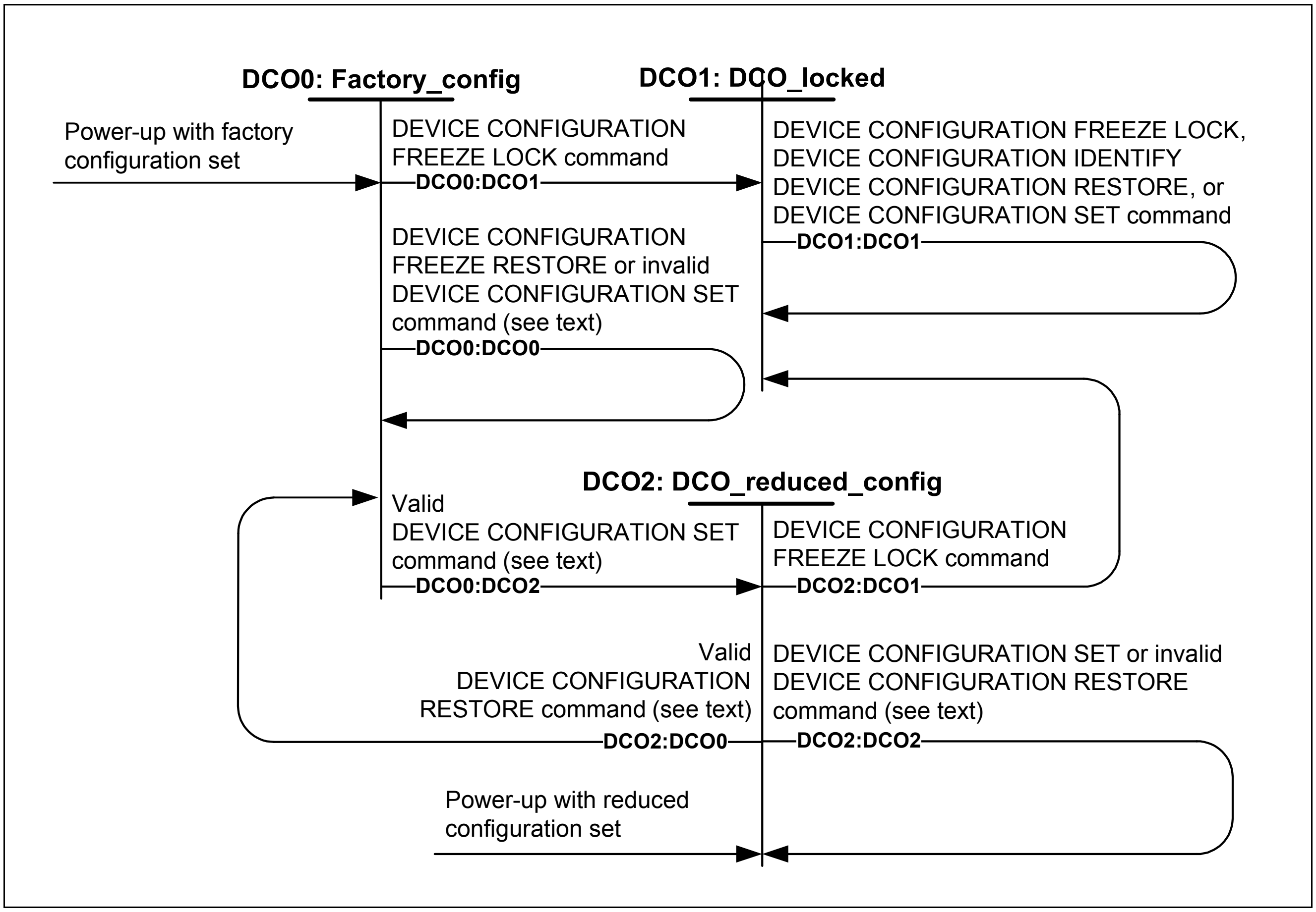

Figure 4 — Device Configuration Overlay state diagram

DCO0: Factory_config State: This state is entered when the device powers-up with the factory configuration set or a valid DEVICE CONFIGURATION RESTORE command is received.

When in this state, the device shall support all commands, modes, features sets, and the capacity indicated by the response to a DEVICE CONFIGURATION IDENTIFY command.

Transition DCO0:DCO1: When a DEVICE CONFIGURATION FREEZE LOCK command is received, the device shall return successful command completion and make a transition to the DCO1: DCO_locked state.

Transition DCO0:DCO2: When a valid DEVICE CONFIGURATION SET command is received, the device shall return successful command completion and make a transition to the DCO2: Reduced_config state. See Transition DCO0:DCO0 for the definition of conditions that make a DEVICE CONFIGURATION SET command invalid. This transition is made even if the configuration described by the DEVICE SET CONFIGURATION SET command is the same as the factory configuration.

Transition DCO0:DCO0: When a DEVICE CONFIGURATION RESTORE command is received, the device shall return command aborted and make a transition to the DCO0: Factory_config state. When an invalid DEVICE CONFIGURATION SET command is received, the device shall return command aborted and make a transition to the DCO0: Factory_config state. A DEVICE CONFIGURATION SET command is invalid if the DEVICE CONFIGURATION SET command requests:

a) the elimination of support of the Host Protected Area feature set if a Host Protected Area has been established.
b) the elimination of support of a Multiword or Ultra DMA mode if that mode is currently selected or a higher numbered mode is currently selected.
c) the elimination of support of the Power-up in Standby feature set if the feature set has been enabled by a jumper.

d) the elimination of support of the Security feature set if the feature set has been enabled.
e) the elimination of support of the SMART feature set if bits (2:1) of word 7 are not cleared to zero or if the SMART feature set has been enabled by use of the SMART ENABLE OPERATIONS command.

DCO1: DCO_locked State: This state is entered when a DEVICE CONFIGURATION RESTORE command is received.

When in this state, all DEVICE CONFIGURATION FREEZE LOCK, DEVICE CONFIGURATION IDENTIFY, DEVICE CONFIGURATION SET, or DEVICE CONFIGURATION RESTORE commands shall return command abort and shall remain in the locked state.

Transition DCO1:DCO1: When a DEVICE CONFIGURATION FREEZE LOCK, DEVICE CONFIGURATION IDENTIFY, DEVICE CONFIGURATION SET, or DEVICE CONFIGURATION RESTORE command is received, the device shall return command aborted and make a transition to the DCO1: DCO_locked state.

DCO2: Reduced_config State: This state is entered when the device powers-up with a reduced configuration set or a valid DEVICE CONFIGURATION SET command is received.

When in this state, the device shall support all commands, modes, features sets, and the capacity specified by the DEVICE CONFIGURATION SET command that caused this state to be entered.

Transition DCO2:DCO1: When a DEVICE CONFIGURATION FREEZE LOCK command is received, the device shall return successful command completion and make a transition to the DCO1: DCO_locked state.

Transition DCO2:DCO0: When a valid DEVICE CONFIGURATION RESTORE command is received, the device shall return successful command completion and make a transition to the DCO0: Factory_config state. See Transition DCO2:DCO2 for the definition of conditions that make a DEVICE CONFIGURATION RESTORE command invalid.

Transition DCO2:DCO2: When a DEVICE CONFIGURATION SET command is received, the device shall return command aborted and make a transition to the DCO2: Reduced_config state. When an invalid DEVICE CONFIGURATION RESTORE command is received, the device shall return command aborted and make a transition to the DCO2: Reduced_config state. A DEVICE CONFIGURATION RESTORE command is invalid if a Host Protected Area has been established using the SET MAX ADDRESS command.

4.9 Free-fall Control feature set

The Freefall Control feature allows the device to protect its data in the event of free-fall detection. When this feature is enabled, upon detecting a free-fall event the device should protect its data from the mechanical contact that could damage data on the device. The implementation of the Freefall Control feature is vendor specific.

The Free-fall Control feature set is enabled and disabled using the following SET FEATUREs subcommands:

a) SET FEATURES subcommand 41h - enable the Freefall Control feature set
b) SET FEATURES subcommand C1h - disable the Freefall Control feature set

The Free-fall control enable and disable subcommands shall be non-volatile. After the feature is enabled, the device shall keep this feature enable until changed by the SET FEATURE enable/disable Freefall Control subcommand.

IDENTIFY DEVICE data word 120 bit 5 or IDENTIFY PACKET DEVICE data word 120 bit 5 indicates when the Free-fall Control feature set is enabled.

4.10 General Purpose Logging feature set

The General Purpose Logging feature set provides a mechanism for accessing logs in a device. These logs are associated with specific feature sets such as SMART. Support of the individual logs (see table A.1) is determined by support of the associated feature set. If the device supports a particular feature set, support for any associated log(s) is mandatory.

Support for the General Purpose Logging feature set shall not be disabled by disabling SMART. If the feature set associated with a requested log is disabled, the device shall return command aborted.

If the General Purpose Logging feature set is implemented, the following commands shall be supported:

a) READ LOG EXT
b) WRITE LOG EXT

The following commands are optional:

a) READ LOG DMA EXT
b) WRITE LOG DMA EXT

If the General Purpose Logging feature set is supported, all Host Vendor Specific logs shall be supported (see A.9).

4.11 Host Protected Area (HPA) feature set

4.11.1 HPA overview

A reserved area for data storage outside the normal operating system file system is required for several specialized applications. Systems may wish to store configuration data or save memory to the device in a location that the operating systems are unable change. The optional Host Protected Area feature set allows a portion of the device to be reserved for such an area when the device is initially configured. Commands in the HPA feature set are prohibited from use in devices that implement the PACKET feature set. A device that implements the Host Protected Area feature set shall implement the following minimum set of commands:

a) READ NATIVE MAX ADDRESS
b) SET MAX ADDRESS

A device that implements the Host Protected Area feature set and supports the 48-bit Address feature set shall implement the following additional set of commands:

a) READ NATIVE MAX ADDRESS EXT
b) SET MAX ADDRESS EXT

Devices supporting this feature set shall set IDENTIFY DEVICE data word 82 bit 10 to one.

4.11.2 HPA security extensions

A device supporting the Host Protected Area feature set may optionally include the HPA security extensions. The Host Protected Area security commands use a single command code and are differentiated from one another by the value placed in the Feature field:

a) SET MAX SET PASSWORD
b) SET MAX LOCK
c) SET MAX FREEZE LOCK
d) SET MAX UNLOCK

Devices supporting these extensions shall set IDENTIFY DEVICE data word 82 bit 10 or IDENTIFY PACKET DEVICE data word 82 bit 10 to one, and shall set IDENTIFY DEVICE data word 83 bit 8 or IDENTIFY PACKET DEVICE data word 83 bit 8 to one.

Upon successfully execution of the power-on reset, the HPA security extensions are disabled and IDENTIFY DEVICE data word 86 bit 8 or IDENTIFY PACKET DEVICE data word 86 bit 8 is cleared to zero. There is no valid HPA password after the device processes a power-on reset and IDENTIFY DEVICE data word 86 bit 8 or IDENTIFY PACKET DEVICE data word 86 bit 8 is cleared to zero.

When a SET MAX SET PASSWORD command is executed successfully the HPA security extensions are enabled. In addition IDENTIFY DEVICE data word 86 bit 8 or IDENTIFY PACKET DEVICE data word 86 bit 8 shall be set to one.

4.11.3 28-bit and 48-bit HPA commands interactions

The READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command allows the host to determine the maximum native address space of the device even when a protected area has been allocated.

The SET MAX ADDRESS or SET MAX ADDRESS EXT command allows the host to redefine the maximum LBA of the user accessible address space. That is, when the SET MAX ADDRESS or SET MAX ADDRESS EXT command is issued with a maximum address less than the native maximum address, the device reduces the user accessible address space to the maximum specified by the command, providing a protected area above that maximum address. See 4.11.4 for a description of how to set IDENTIFY DEVICE data after issuing a SET MAX ADDRESS or SET MAX ADDRESS EXT command.

Any read or write command to an address above the maximum address specified by the SET MAX ADDRESS or SET MAX ADDRESS EXT command shall cause command completion with the IDNF bit set to one and ERR set to one, or command aborted.

A Volatility bit in the Count field allows the host to specify if the maximum address set is preserved after a power-on reset or a hardware reset. During processing a power-on reset or hardware reset, the device sets the maximum address to the last non-volatile address setting regardless of subsequent volatile SET MAX ADDRESS or SET MAX ADDRESS EXT commands. If the SET MAX ADDRESS or SET MAX ADDRESS EXT command is issued with a value that exceeds the native maximum address command aborted shall be returned.

Software reset does not affect the HPA feature set. Software reset does not change the maximum LBA address or the HPA state.

When the device is in unlocked or unfrozen states multiple SET MAX SET PASSWORD commands may be processed. The device only keeps the password set by the last SET MAX SET PASSWORD command; previously received passwords are overwritten by the new password. There is no limit to the number of times the password may be set.

Typical use of these commands is:

After a power-on reset or a hardware reset is processed:

1) BIOS receives control after the reset;
2) BIOS issues a READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command to find the max capacity of the device;
3) BIOS issues a SET MAX ADDRESS or SET MAX ADDRESS EXT command to the values returned by READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT;
4) BIOS reads configuration data from the highest area on the disk;
5) BIOS issues a READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command followed by a SET MAX ADDRESS or SET MAX ADDRESS EXT command to reset the device to the size of the file system.

On save to disk

1) BIOS receives control prior to shut down;
2) BIOS issues a READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command to find the max capacity of the device;
3) BIOS issues a volatile SET MAX ADDRESS or SET MAX ADDRESS EXT command to the values returned by READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT;
4) Memory is copied to the reserved area;
5) Shut down completes;
6) During processing a power-on reset or hardware reset, the device sets the maximum address to the last non-volatile address setting regardless of subsequent volatile SET MAX ADDRESS or SET MAX ADDRESS EXT commands.

These commands are intended for use only by system BIOS or other low-level boot time process. Using these commands outside BIOS controlled boot or shutdown may result in damage to file systems on the device. Devices shall return command aborted if a subsequent non-volatile SET MAX ADDRESS or SET MAX ADDRESS EXT command is received after a power-on or hardware reset.

The SET MAX SET PASSWORD command allows the host to define the password to be used during the current power cycle. The password does not persist after a power-on reset has been processed but does persist after a hardware reset or a software reset has been processed. This password is not related to the password used for the Security feature set. When the password is set the device is in the Set_Max_Unlocked mode.

The SET MAX LOCK command provides a method for the host to disable the SET MAX commands (except SET MAX UNLOCK) until after the device has processed the next power-on reset or command completion of a SET MAX UNLOCK command. When the SET MAX LOCK command is completed the device is in the Set_Max_Locked mode.

The SET MAX UNLOCK command changes the device from the Set_Max_Locked mode to the Set_Max_Unlocked mode.

The SET MAX FREEZE LOCK command provides a method for the host to disable the SET MAX commands (including SET MAX UNLOCK) until after the device has processed the next power-on reset. When the SET MAX FREEZE LOCK command is completed the device is in the Set_Max_Frozen mode.

4.11.4 IDENTIFY DEVICE data

When the host issues a SETMAX ADDRESS or SETMAX ADDRESS EXT, several IDENTIFY DEVICE data words may be affected. The following guidelines are used for setting IDENTIFY DEVICE data:

a) if the 48 bit address feature set is not supported then words 61:60 shall contain the total number of user addressable sectors and words 103:100 shall be reserved;
b) if the 48 bit address feature set is supported and the total number of user addressable sectors is less than or equal to 0FFF_FFFFh then Words 61:60 and 103:100 shall contain the total number of user addressable sectors;
c) if the 48 bit address feature set is supported and the total number of user addressable sectors is greater than 0FFF_FFFFh then words 61:60 shall contain 0FFF_FFFFh and words 103:100 shall contain the total number of user addressable sectors.

Editor’s Note 3: Removed the word BIOS from the following 2 headers. I think that Locking SET MAX is problematic in the way it is currently worded.

4.11.5 Determination of SET MAX security extension status

When the device is locked IDENTIFY DEVICE data word 86 bit 8 or IDENTIFY PACKET DEVICE data word 86 bit 8 shall be set to one.

4.11.6 Locking SET MAX

To allow for multiple BIOSs to gain access to the protected area the host BIOS should only lock the protected area immediately prior to booting the operating system.

4.11.7 HPA State Transition Diagrams

4.11.7.1 State Transition Figures

The HPA state transition diagrams are in five parts: figure 5, figure 6, figure 7, figure 8, and figure 9.

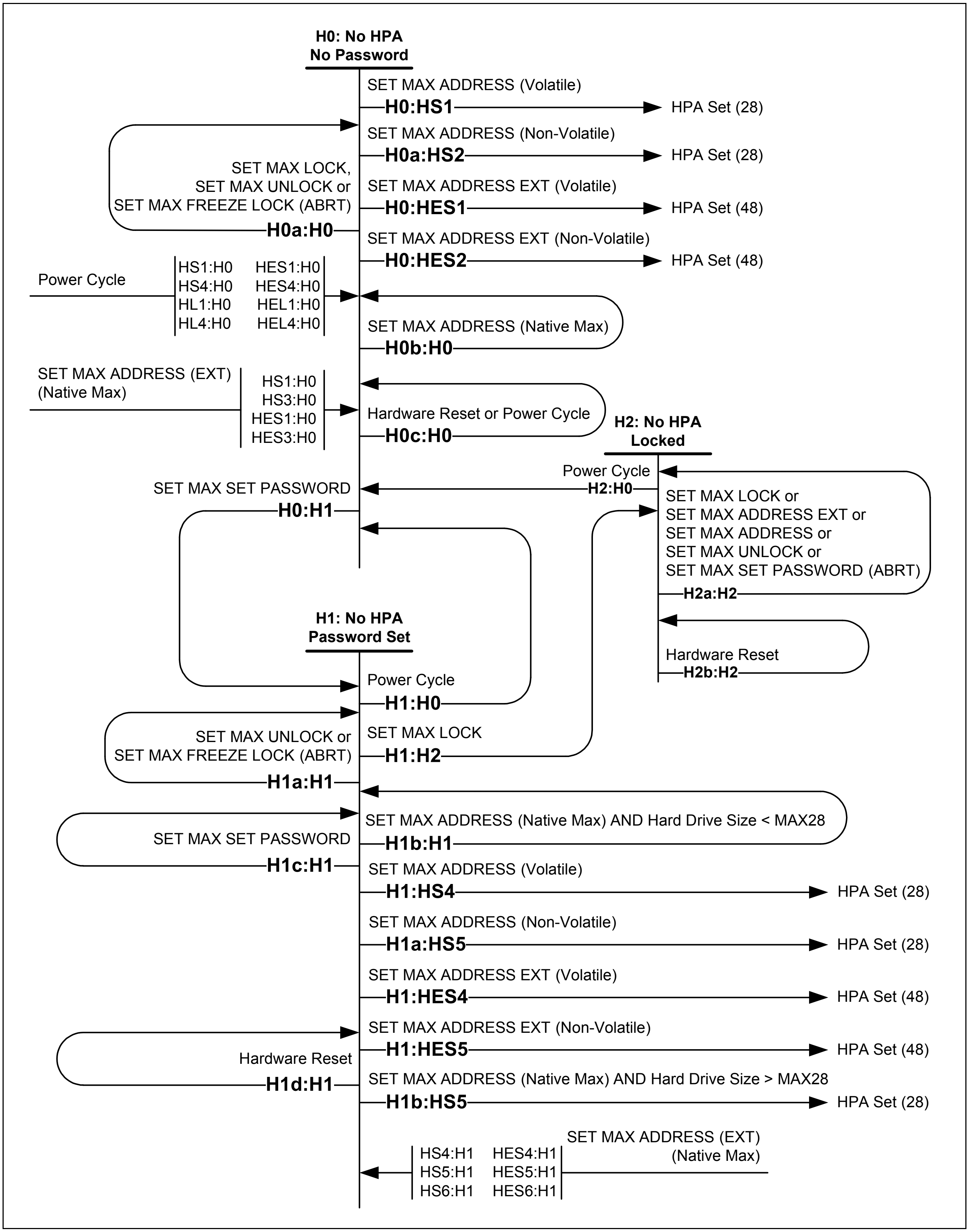

Figure 5 — HPA Not Set

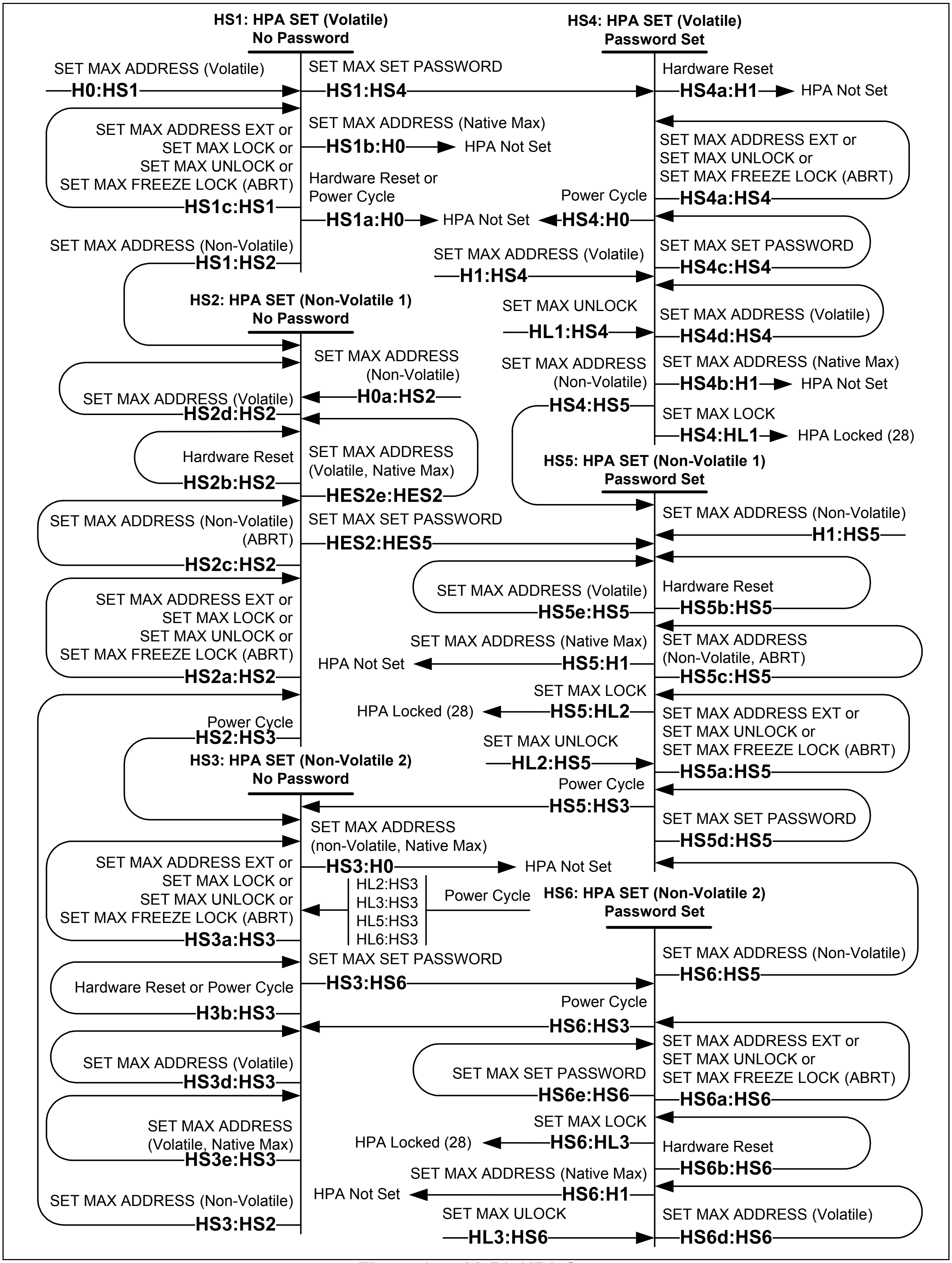

Figure 6 — 28-Bit HPA Set

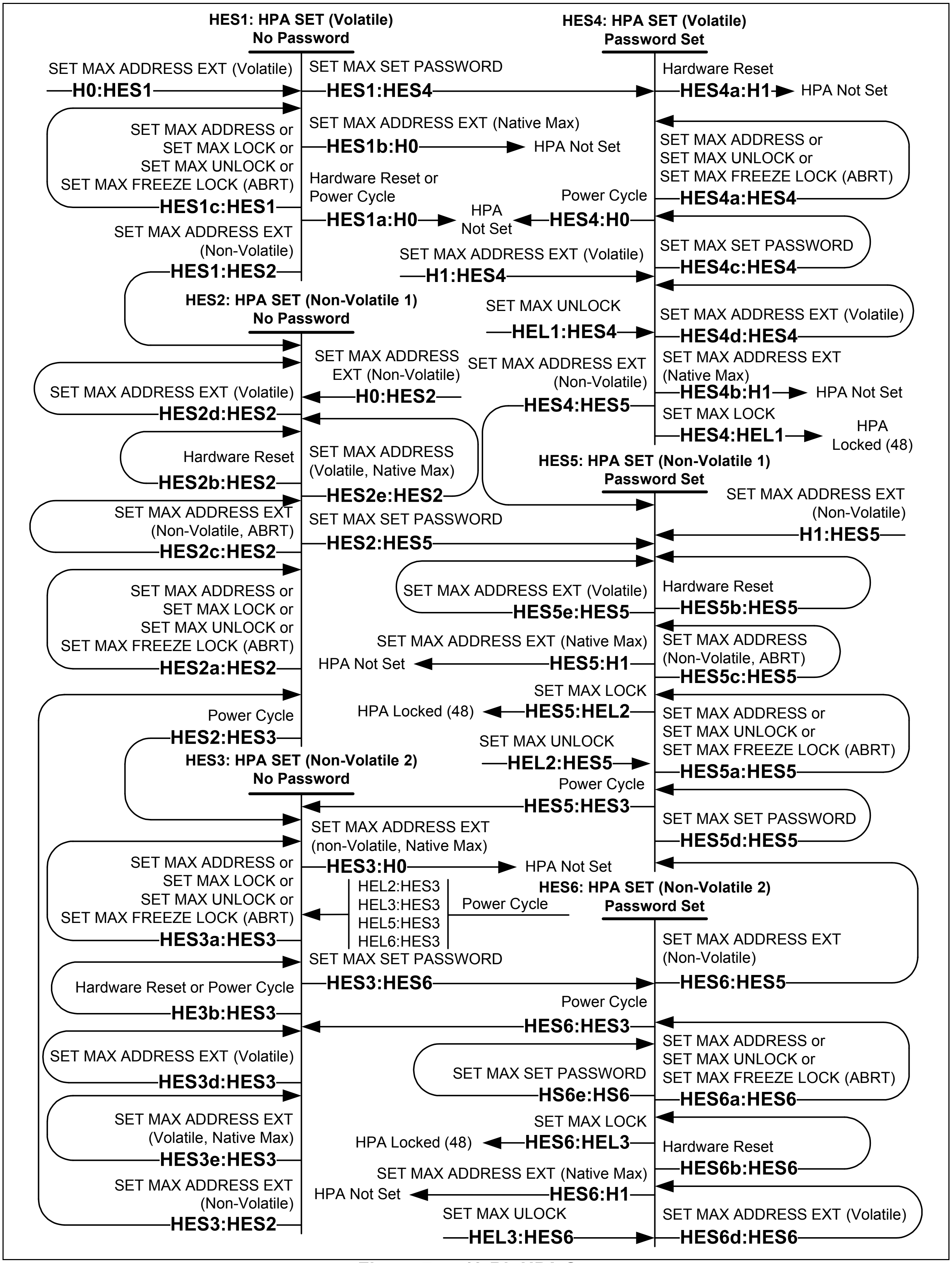

Figure 7 — 48-Bit HPA Set

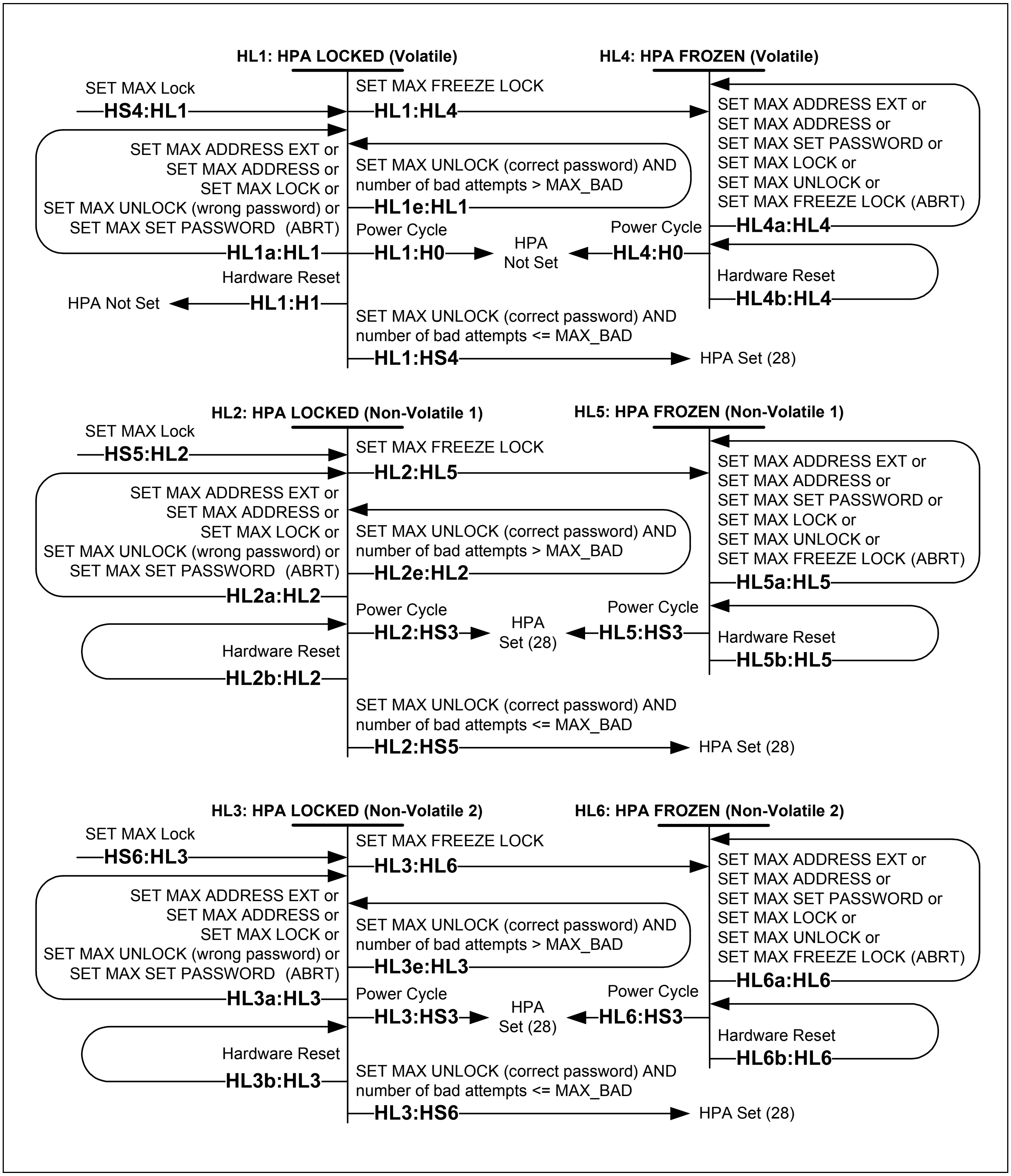

Figure 8 — 28-Bit HPA Locked

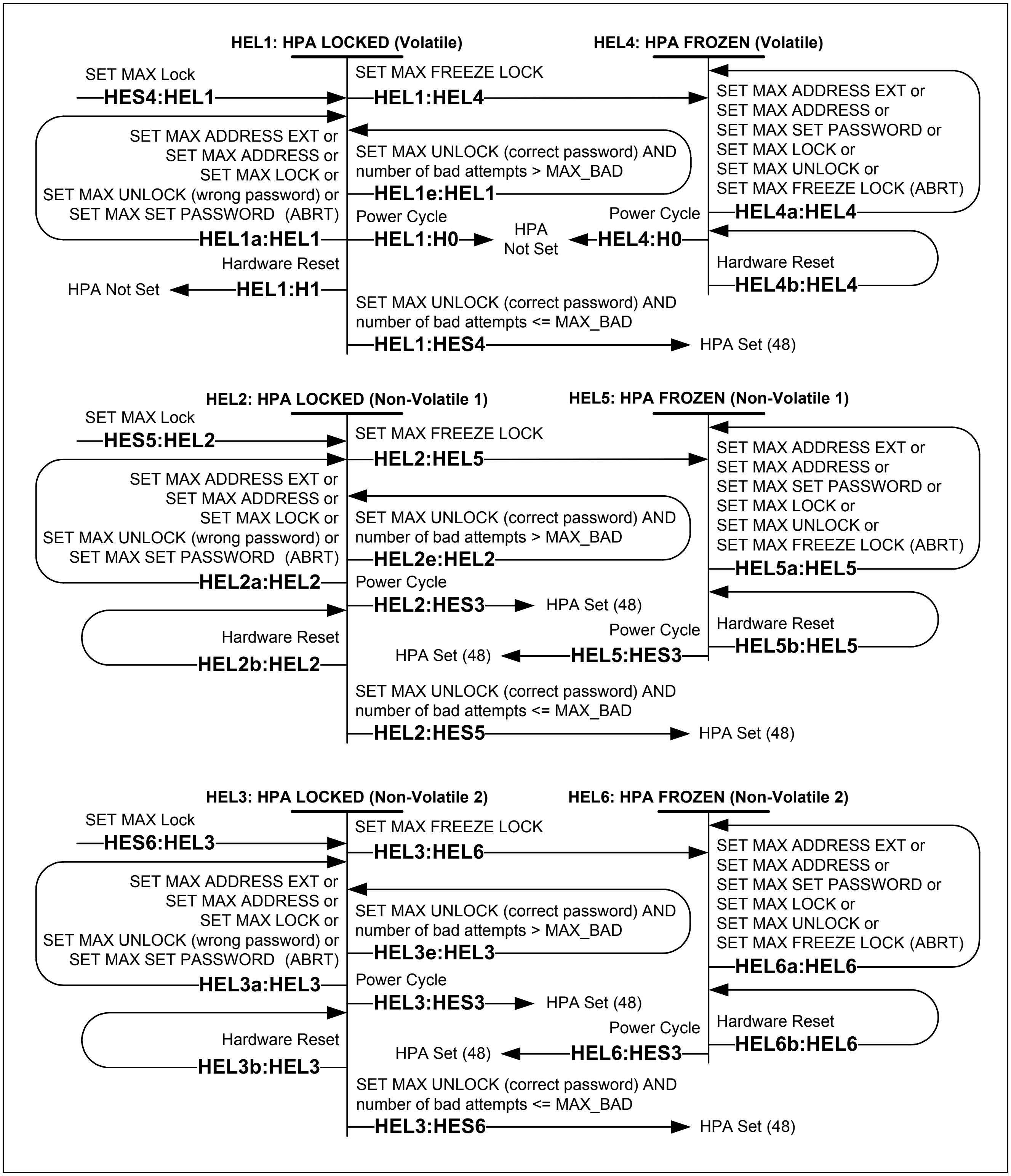

Figure 9 — 48-Bit HPA Locked

4.11.7.2 HPA Not Set

State H0: No HPA/No Password: This state shall be entered when the device is powered on. In this state the device has not established the HPA and the password has not been set.

Transition H0:H1: When the device has completed a SET MAX SET PASSWORD command without error, the device shall make a transition to H1 state.

Transition H0:HS1: When the device has completed a SET MAX ADDRESS command without error in a volatile state (non-volatile bit set to 0), this command shall be executed and the device shall make a transition to the HS1 state.

Transition H0:HES1: When the device has completed a SET MAX ADDRESS EXT command without error in a volatile state (non-volatile bit set to 0), this command shall be executed and the device shall make a transition to the HES1 state.

Transition H0:HES2: When the device has completed a SET MAX ADDRESS EXT command without error in a non-volatile state (non-volatile bit set to 1), this command shall be executed and the device shall make a transition to the HES2 state.

Transition H0a:HS2: When the device has completed a SET MAX ADDRESS command without error in a non-volatile state (non-volatile bit set to 1), this command shall be executed and the device shall make a transition to the HS2 state.

Transition H0a:H0: When the device has completed a SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition H0b:H0: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall remain in the same state.

Transition H0c:H0: When the device processes a hardware reset or a power-on reset, the device shall remain in the same state.

State H1: No HPA/Password Set: When the device has completed a SET MAX SET PASSWORD is received in the H0 state, the device transitions to the H1 state. In this state the device has not established the HPA and the password has been set.

Transition H1:H0: When device processes a power-on reset, the device shall make a transition to the H0 state.

Transition H1:HS4: When the device has completed a SET MAX ADDRESS command without error in a volatile state, the device shall make a transition to the HS4 state.

Transition H1:HES4: When the device has completed a SET MAX ADDRESS EXT command without error in the volatile state, the device shall make a transition to the HES4 state.

Transition H1:HES5: When the SET MAX ADDRESS EXT command without error in the non-volatile state, the device shall make a transition to the HES5 state.

Transition H1a:H1: When the device has completed a SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition H1a:HS5: When the device has completed a SET MAX ADDRESS command without error in a non-volatile state, the device shall make a transition to the HS5: HPA SET (Non-Volatile 1) Password Set state.

Transition H1b:H1: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall remain in the same state.

Transition H1c:H1: When the device has completed a SET MAX PASSWORD command without error, the device shall remain in the same state.

Transition H1d:H1: If the hardware is reset, the device shall remain in the same state.

State H2: No HPA/Locked: When the device has completed a SET MAX LOCK command without error in the H1 state, the device transitions to the H2 state. In this state the device is locked and only the power cycle transits the state to H0.

Transition H2:H0: When device processes a power-on reset, the device shall make a transition to the H0 state.

Transition H2a:H2: When the SET MAX ADDRESS EXT, SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition H2b:H2: If the hardware is reset, the device shall remain in the same state.

4.11.7.3 28-bit HPA Set

State HS1: HPA SET (Volatile)/No Password: This state shall be entered when the device completes SET MAX ADDRESS (Volatile) command. In this state the volatile HPA address is established and the password is not set.

Transition HS1:HS2: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device shall make a transition to HS2 state.

Transition HS1:HS4: When the device has completed a SET MAX SET PASSWORD command without error, the device transitions to the HS4 state.

Transition HS1a:H0: When the device processes a hardware reset or if device processes a power-on reset, the device shall make a transition to the H0 state.

Transition HS1b:H0: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall make a transition to H0 state.

Transition HS1c:HS1: When the device has completed a SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the command and the device shall remain in the same state.

State HS2: HPA SET (Non-Volatile 1)/No Password: This state shall be entered when the device completes SET MAX ADDRESS (Non-Volatile) command. In this state the non-volatile HPA address is established and the password is not set.

Transition H0:HS2: When the device has completed a SET MAX ADDRESS command without error in the non-volatile state, the device shall make a transition to HS2 state.

Transition HS2:H0: When SET MAX ADDRESS (Volatile, Native Max) command without error, the device shall make a transition to H0 state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

Transition HS2:HS5: When the device has completed a SET MAX PASSWORD command without error, the device shall make a transition to HS5 state.

Transition HS2a:HS2: When the device has completed a SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HS2b:HS2: If the hardware is reset, the device shall remain in the same state.

Transition HS2c:HS2: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device shall abort the commands and the device shall remain in the same state.

Transition HS2d:HS2: When the device has completed a SET MAX ADDRESS command without error in volatile state, the device shall make a transition to HS2 state.

Transition HS2e:HS2: When the device has completed a SET MAX ADDRESS command without error in non-volatile state with the address equals to the Native Max address, the device shall make a transition to HS2 state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

Transition HS2:HS3: When device processes a power-on reset, the device shall make transition to HS3 state.

State HS3: HPA SET (Non-Volatile 2)/No Password: Device shall enter this state when the device processes a power-on reset from HS2, HS5 or HS6 states. In this state the non-volatile HPA address is established and the password is not set.

Transition HS3:H0: When the device has completed a SET MAX ADDRESS (Volatile, Native Max) command without error, the device shall transition to H0 state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

Transition HS3:HS2: When the device has completed a SET MAX ADDRESS command without error in a non-volatile state, the device shall transition to HS2 state.

Transition HS3:HS6: When the device has completed a SET MAX SET PASSWORD command without error, the device shall make a transition to HS6 state.

Transition HS3a:HS3: When the device has completed a SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HS3b:HS3: When the device processes a hardware reset or when device processes a power-on reset, the device shall transition to HS3 state.

Transition HS3d:HS3: When the device has completed a SET MAX ADDRESS command without error in a volatile state, the device shall transition to HS3 state.

Transition HS3e:HS3: When the device has completed a SET MAX ADDRESS (Non-Volatile, Native Max) command without error, the device shall transition to HS3 state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

State HS4: HPA SET (Volatile)/Password Set: When the device has completed a SET MAX ADDRESS (Volatile), SET MAX UNLOCK, or SET MAX SET PASSWORD command without error, the device shall enter this state. In this state the volatile HPA address is established and the password is set.

Transition H1:HS4: When the device has completed a SET MAX ADDRESS command without error, the device shall transition to HS4 state.

Transition HL1:HS4: When the device has completed a SET MAX UNLOCK command without error, the device shall transition to HS4 state.

Transition HS4:HL1: When the device has completed a SET MAX LOCK command without error, the device shall transition to HL1 state.

Transition HS4:H0: When device processes a power-on reset, the device shall transition to H0 state.

Transition HS4:HS5: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device shall transition to HS5 state.

Transition HS4a:H1: When the hardware is reset, the device shall transition to H1 state.

Transition HS4a:HS4: When the device has completed a SET MAX ADDRESS EXT, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HS4b:H1: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall transition to H1 state.

Transition HS4c:HS4: When the device has completed a SET MAX SET PASSWORD command without error, the device shall transition to HS4 state.

Transition HS4d:HS4: When the device has completed a SET MAX ADDRESS command without error in volatile state, the device shall transition to HS4 state.

State HS5: HPA SET (Non-Volatile 1)/Password Set: This state shall be entered when the device completes SET MAX ADDRESS (Volatile) command. In this state the non-volatile HPA address is established and the password is set.

Transition H1:HS5: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device shall transition to HS5 state.

Transition HL2:HS5: When the device has completed a SET MAX UNLOCK command without error, the device shall transition to HS5 state.

Transition HS5:H1: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall transition to H1 state.

Transition HS5:HL2: When the device has completed a SET MAX LOCK command without error, the device shall transition to HL2 state.

Transition HS5:HS3: When device processes a power-on reset, the device shall transition to HS3 state.

Transition HS5d:HS5: When the device has completed a SET MAX PASSWORD command without error, the device shall remain in the same state.

Transition HS5e:HS5: When the device has completed a SET MAX ADDRESS command without error in volatile state, the device shall remain in the same state.

Transition HS5a:HS5: When the device has completed a SET MAX ADDRESS EXT, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HS5b:H5: When the hardware is reset, the device shall transition to the HS5 state.

Transition HS5c:H5: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device aborts the command and the device shall remain in the same state.

State HS6: HPA SET (Non-Volatile 2)/Password Set: When the device has completed a SET MAX UNLOCK command without error in the HL3 state or when the device has completed a SET MAX SET PASSWORD is received in HS3 state, the device enters this state. In this state the non-volatile HPA address is established and the password is set.

Transition HL3:HS6: When the device has completed a SET MAX UNLOCK command without error, the device transitions to HS6 state.

Transition HS6:H5: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device transitions to HS5 state.

Transition HS6:H1: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall transition to H1 state.

Transition HS6:HL3: When the device has completed a SET MAX LOCK command without error, the device shall transition to HL3 state.

Transition HS6a:HS6: When the device has completed a SET MAX ADDRESS EXT, SET MAX UNLOCK, or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HS6:HS3: When device processes a power-on reset, the device shall transition to HS3 state.

Transition HS6b:HS6: When the device completes a hardware reset, the device shall remain in the same state.

Transition HS6d:HS6: When the device has completed a SET MAX ADDRESS command without error in the volatile state, the device shall remain in the same state.

Transition HS6e:HS6: When the device has completed a SET MAX SET PASSWORD command without error, the device shall remain in the same state.

4.11.7.4 48-Bit HPA Set

State HES1: HPA SET (Volatile)/No Password: This state shall be entered when the device completes SET MAX ADDRESS EXT (Volatile) command. In this state the volatile HPA address is established and the password is not set.

Transition HES1:HES2: When the device has completed a SET MAX ADDRESS EXT command without error in non-volatile state, the device shall make a transition to HES2 state.

Transition HES1:HES4: When the device has completed a SET MAX SET PASSWORD command without error, the device transitions to the HES4 state.

Transition HES1a:H0: When the device processes a hardware reset or if device processes a power-on reset, the device shall make a transition to the H0 state.

Transition HES1b:H0: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall make a transition to H0 state.

Transition HES1c:HES1: When the device has completed a SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the command and the device shall remain in the same state.

State HES2: HPA SET (Non-Volatile 1)/No Password: This state shall be entered when the device completes SET MAX ADDRESS EXT (Non-Volatile) command. In this state the non-volatile HPA address is established and the password is not set.

Transition HES2:H0: When SET MAX ADDRESS (Non-Volatile, Native Max) command without error, the device shall make a transition to H0 state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

Editor's Note 4: Removed **"State HES3:** When device processes a power-on reset, the device shall make transition to HES3 state." which appeared in the proposal at this location. I believe that this is a cut and paste error in the proposal.

Transition HES2:HES5: When the device has completed a SET MAX PASSWORD command without error, the device shall make a transition to HES5 state.

Transition HES2a:HES2: When the device has completed a SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HES2b:HES2: If the hardware is reset, the device shall remain in the same state.

Transition HES2c:HES2: When the device has completed a SET MAX ADDRESS EXT command without error in non-volatile state, the device shall abort the commands and the device shall remain in the same state.

Transition HES2d:HES2: When the device has completed a SET MAX ADDRESS command without error in volatile state, the device shall remain in the same state.

Transition HES2e:HES2: When the device has completed a SET MAX ADDRESS EXT command without error in volatile state with the address equals to the Native Max address, the device shall make a transition to HES2: HPA SET (Non-Volatile 1) No Password state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

State HES3: HPA SET (Non-Volatile 2)/No Password: Device shall enter this state when the device processes a power-on reset from HES2, HES5 or HES6 states. In this state the non-volatile HPA address is established and the password is not set.

Transition HES3:H0: When the device has completed a SET MAX ADDRESS (Volatile, Native Max) command without error, the device shall transition to H0 state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

Transition HES3:HES2: When the device has completed a SET MAX ADDRESS EXT (Non-Volatile) command without error in a non-volatile state, the device shall transition to HES2 state.

Transition HES3:HES6: When the device has completed a SET MAX SET PASSWORD command without error, the device shall make a transition to HES6 state.

Transition HES3a:HES3: When the device has completed a SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HES3b:HES3: When the device processes a hardware reset or when device processes a power-on reset, the device shall remain in the same state.

Transition HES3d:HES3: When the device has completed a SET MAX ADDRESS EXT (Volatile) command without error in a volatile state, the device shall remain in the same state.

Transition HES3e:HES3: When the device has completed a SET MAX ADDRESS EXT (Non-Volatile, Native Max) command without error, the device shall transition to HS3 state. The Host Protected Area has been established bit in IDENTIFY command word 85 bit 10 is cleared at this state transition.

State HES4: HPA SET (Volatile)/Password Set: When the device has completed a SET MAX ADDRESS EXT (Volatile), SET MAX UNLOCK, or SET MAX SET PASSWORD command without error, the device shall enter this state. In this state the volatile HPA address is established and the password is set.

Transition HES4:H0: When device processes a power-on reset, the device shall transition to H0: No HPA No Password state.

Transition HES4:HES5: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device shall transition to HES5 state.

Transition HEL1:HES4: When the device has completed a SET MAX UNLOCK command without error, the device shall transition to HES4 state.

Transition HES4:HEL1: When the device has completed a SET MAX LOCK command without error, the device shall transition to HEL1 state.

Transition HES4a:H1: When the hardware is reset, the device shall transition to H1 state.

Transition HES4a:HES4: When the device has completed a SET MAX ADDRESS, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HES4b:H1: When the device has completed a SET MAX ADDRESS (Native Max) command without error, the device shall transition to H1 state.

Transition HES4c:HES4: When the device has completed a SET MAX SET PASSWORD command without error, the device shall remain in the same state.

Transition HES4d:HES4: When the device has completed a SET MAX ADDRESS command without error in volatile state, the device shall remain in the same state.

State HES5: HPA SET (Non-Volatile 1)/Password Set: When the device has completed a SET MAX ADDRESS EXT (Non-Volatile) or SET PASSWORD command without error, the device shall enter this state. In this state the non-volatile HPA address is established and the password is set.

Transition H1:HES5: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device shall transition to HS5 state.

Transition HES5:H1: When the device has completed a SET MAX ADDRESS EXT (Native Max) command without error, the device shall transition to H1 state.

Transition HES5:HEL2: When the device has completed a SET MAX LOCK command without error, the device shall transition to HEL2 state.

Transition HES5:HES3: When device processes a power-on reset, the device shall transition to HES3 state.

Transition HES5a:HES5: When the device has completed a SET MAX ADDRESS EXT, SET MAX UNLOCK or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HES5b:HES5: When the hardware is reset, the device shall remain in the same state.

Transition HES5c:HES5: When the device has completed a SET MAX ADDRESS command without error in non-volatile state, the device aborts the command and the device shall remain in the same state.

Transition HES5d:HES5: When the device has completed a SET MAX PASSWORD command without error, the device shall remain in the same state.

Transition HES5e:HES5: When the device has completed a SET MAX ADDRESS command without error in volatile state, the device shall remain in the same state.

State HES6: HPA SET (Non-Volatile 2)/Password Set: When the device has completed a SET MAX UNLOCK command without error in the HEL3 state or when the device has completed a SET MAX SET PASSWORD is received in HES3 state, the device enters this state. In this state the non-volatile HPA address is established and the password is set.

Transition HES6:HES5: When the device has completed a SET MAX ADDRESS EXT command without error in non-volatile state, the device transitions to HES5 state.

Transition HES6:H1: When the device has completed a SET MAX ADDRESS EXT (Native Max) command without error, the device shall transition to H1 state.

Transition HES6:HEL3: When the device has completed a SET MAX LOCK command without error, the device shall transition to HEL3 state.

Transition HES6:HES3: When device processes a power-on reset, the device shall transition to HES3 state.

Transition HES6a:HES6: When the device has completed a SET MAX ADDRESS EXT, SET MAX UNLOCK, or SET MAX FREEZE LOCK command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HES6b:HES6: When the hardware is reset, the device shall remain in the same state.

Transition HES6d:HES6: When the device has completed a SET MAX ADDRESS EXT command without error in the volatile state, the device shall remain in the same state.

Transition HES6e:HES6: When the device has completed a SET MAX SET PASSWORD command without error, the device shall remain in the same state.

4.11.7.5 28-Bit HPA Locked

State HL1: HPA LOCKED (Volatile): This state shall be entered when the device completes SET MAX LOCK (Volatile) command in HS4 state. In this state the volatile HPA address is established, the drive is locked from HPA commands except the SET MAX UNLOCK command with a proper password or the SET MAX FREEZE LOCK command.

Transition HL1:H0: When device processes a power-on reset, the device shall transition to H0 state.

Transition HL1:HL4: When the device has completed a SET MAX FREEZE LOCK command without error, the device shall transition to HL4 state.

Transition HL1:HS4: When the SET MAX UNLOCK (correct password) command without error and the number of bad attempts is less or equal than MAX_BAD, the device shall transition to HS4 state.

Transition HL1a:HL1: When the SET MAX ADDRESS EXT, SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK (wrong password) or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HL1b:HL1: When the hardware is reset, the device shall remain in the same state.

Transition HL1e:HL1: When the device has completed a SET MAX UNLOCK (correct password) and the number of bad attempts is greater than MAX_BAD, the device shall abort the command and remain in the same state.

State HL2: HPA LOCKED (Non-volatile 1): This state shall be entered when the device completes SET MAX LOCK (Non-Volatile) command in HS5 state. In this state the non-volatile HPA address is established, the drive is locked from HPA commands except the SET MAX UNLOCK command with a proper password or the SET MAX FREEZE LOCK command.

Transition HL2:HL5: When the device has completed a SET MAX FREEZE LOCK command without error, the device shall transition to HL5 state.

Transition HL2:HS3: When device processes a power-on reset, the device shall transition to HS3 state.

Transition HL2:HS5: When the device has completed a SET MAX UNLOCK (correct password) command without error and the number of bad attempts is less or equal than MAX_BAD, the device shall transition to HS5 state.

Transition HL2a:HL2: When the device has completed a SET MAX ADDRESS EXT, SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK (wrong password) or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HL2b:HL2: When the hardware is reset, the device shall transition to HL2 state.

Transition HL2e:HL2: When the device has completed a SET MAX UNLOCK (correct password) command without error and the number of bad attempts is greater than MAX_BAD, the device shall remain in the same state.

State HL3: HPA LOCKED (Non-volatile 2): This state shall be entered when the device completes SET MAX LOCK (Non-Volatile) command in HS6 state. In this state the non-volatile HPA address is established, the drive is locked from HPA commands except the SET MAX UNLOCK command with a proper password or the SET MAX FREEZE LOCK command.

Transition HL3:HL6: When the device has completed a SET MAX FREEZE LOCK command without error, the device shall transition to HL6 state.

Transition HL3:HS3: When the device processes a power-on reset, the device shall transition to HS3 state.

Transition HL3:HS6: When the device has completed a SET MAX UNLOCK command without error with the correct password and the number of bad attempts is less or equal than MAX_BAD, the device shall transition to HS6 state.

Transition HL3a:HL3: When the device has completed a SET MAX ADDRESS EXT, SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK (wrong password) or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HL3b:HL3: When the device completes a hardware reset, the device shall remain in the same state.

Transition HL3e:HL3: When the device has completed a SET MAX UNLOCK (correct password) command is given and the number of bad attempts is greater than MAX_BAD, the device shall remain in the same state.

State HL4: HPA FROZEN (Volatile): This state shall be entered when the device completes SET MAX FREEZE LOCK command in HL1 state. In this state the volatile HPA address is established, the drive is locked from all HPA commands. Only a power-cycle shall cause the device to change to other state.

Transition HL4:H0: When device processes a power-on reset, the device shall transition to H0 state.

Transition HL4a:HL4: When the device has completed a SET MAX ADDRESS EXT, SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK, SET MAX FREEZE LOCK or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HL4b:HL4: When the hardware is reset, the device shall remain in the same state.

State HL5: HPA FROZEN (Non-Volatile 1): This state shall be entered when the device completes SET MAX FREEZE LOCK command in HL2 state. In this state the non-volatile HPA address is established, the drive is locked from all HPA commands. Only a power-cycle shall cause the device to change to other state.

Transition HL5a:HL5: When the device has completed a SET MAX ADDRESS EXT, SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK, SET MAX FREEZE LOCK or SET MAX SET PASSWORD command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HL5b:HL5: When the device completes a hardware reset, the device shall remain in the same state.

Transition HL5:HS3: When device processes a power-on reset, the device shall transition to HS3 state.

State HL6: HPA FROZEN (Non-Volatile 2): This state shall be entered when the device completes SET MAX FREEZE LOCK command in HL3 state. In this state the non-volatile HPA address is established, the drive is locked from all HPA commands. Only a power-cycle shall cause the device to change to other state.

Transition HL6:HS3: When device processes a power-on reset, the device shall transition to HS3 state.

Transition HL6a:HL6: When the device has completed a SET MAX ADDRESS EXT, SET MAX ADDRESS, SET MAX LOCK, SET MAX UNLOCK, SET MAX FREEZE LOCK or SET MAX SET PASSWORD command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HL6b:HL6: When the hardware is reset, the device shall remain in the same state.

4.11.7.6 48-Bit HPA Locked

State HEL1: HPA LOCKED (Volatile): This state shall be entered when the device completes SET MAX LOCK command in HES4 state. In this state the volatile HPA address is established, the drive is locked from HPA commands except the SET MAX UNLOCK command with a proper password or the SET MAX FREEZE LOCK command.

Transition HEL1:H0: When device processes a power-on reset, the device shall transition to H0 state.

Transition HEL1:HEL4: When the device has completed a SET MAX FREEZE LOCK command without error, the device shall transition to HEL4 state.

Transition HEL1:HES4: When the SET MAX UNLOCK (correct password) command without error and the number of bad attempts is less or equal than MAX_BAD; the device shall transition to HES4 state.

Transition HEL1a:HEL1: When the SET MAX ADDRESS, SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK (wrong password) or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HEL1b:HEL1: When the hardware is reset, the device shall remain in the same state.

Transition HEL1e:HEL1: When the device has completed a SET MAX UNLOCK (correct password) and the number of bad attempts is greater than MAX_BAD, the device shall remain in the same state.

State HEL2: HPA LOCKED (Non-volatile 1): This state shall be entered when the device completes SET MAX LOCK (Non-Volatile) command in HES5 state. In this state the non-volatile HPA address is established, the drive is locked from HPA commands except the SET MAX UNLOCK command with a proper password or the SET MAX FREEZE LOCK command.

Transition HES5:HEL2: When the device has completed a SET MAX LOCK command without error, the device shall transition to HEL2 state.

Transition HEL2:HEL5: When the device has completed a SET MAX FREEZE LOCK command without error, the device shall transition to HEL5 state.

Transition HEL2:HES3: When device processes a power-on reset, the device shall transition to HES3 state.

Transition HEL2:HES5: When the device has completed a SET MAX UNLOCK (correct password) command without error and the number of bad attempts is less or equal than MAX_BAD, the device shall transition to HES5 state.

Transition HEL2a:HEL2: When the device has completed a SET MAX ADDRESS, SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK (wrong password) or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HEL2b:HEL2: When the hardware is reset, the device shall transition to HEL2 state.

Transition HEL2e:HEL2: When the device has completed a SET MAX UNLOCK (correct password) command without error and the number of bad attempts is greater than MAX_BAD, the device shall remain in the same state.

State HEL3: HPA LOCKED (Non-volatile 2): This state shall be entered when the device completes SET MAX LOCK (Non-Volatile) command in HES6 state. In this state the non-volatile HPA address is established, the drive is locked from HPA commands except the SET MAX UNLOCK command with a proper password or the SET MAX FREEZE LOCK command.

Transition HEL3:HEL6: When the device has completed a SET MAX FREEZE LOCK command without error, the device shall transition to HEL6 state.

Transition HEL3:HES3: When device processes a power-on reset, the device shall transition to HES3 state.

Transition HEL3:HES6: When the device has completed a SET MAX UNLOCK command without error with the correct password and the number of bad attempts is less or equal than MAX_BAD, the device shall transition to HES6 state.

Transition HEL3a:HEL3: When the device has completed a SET MAX ADDRESS, SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK (wrong password) or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HEL3b:HEL3: When the device completes a Hardware reset, the device shall remain in the same state.

Transition HEL3e:HEL3: When the device has completed a SET MAX UNLOCK (correct password) command is given and the number of bad attempts is greater than MAX_BAD, the device shall remain in the same state.

State HEL4: HPA FROZEN (Volatile): This state shall be entered when the device completes SET MAX FREEZE LOCK command in HEL1 state. In this state the volatile HPA address is established, the drive is locked from all HPA commands. Only a power-cycle shall cause the device to change to other state.

Transition HEL4:H0: When device processes a power-on reset, the device shall transition to H0 state.

Transition HEL4a:HEL4: When the device has completed a SET MAX ADDRESS, SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK, SET MAX FREEZE LOCK or SET MAX SET PASSWORD command without error, the device shall abort the command and the device shall remain in the same state.

Transition HEL4b:HEL4: When the hardware is reset, the device shall remain in the same state.

HEL5: HPA FROZEN (Non-Volatile 1): This state shall be entered when the device completes SET MAX FREEZE LOCK command in HEL2 state. In this state the non-volatile HPA address is established, the drive is locked from all HPA commands. Only a power-cycle shall cause the device to change to other state.

Transition HEL5a:HEL5: When the device has completed a SET MAX ADDRESS, SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK, SET MAX FREEZE LOCK or SET MAX SET PASSWORD command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HEL5b:HEL5: When the hardware is reset, the device shall remain in the same state.

Transition HEL5:HES3: When device processes a power-on reset, the device shall transition to HES3 state.

Transition HES6:HEL3: When the device has completed a SET MAX LOCK command without error, the device shall transition to HEL3 state.

State HEL6: HPA FROZEN (Non-Volatile 2): This state shall be entered when the device completes SET MAX FREEZE LOCK command in HEL3 state. In this state the non-volatile HPA address is established, the drive is locked from all HPA commands. Only a power-cycle shall cause the device to change to other state.

Transition HEL6:HES3: When device processes a power-on reset, the device shall transition to HES3 state.

Transition HEL6a:HEL6: When the device has completed a SET MAX ADDRESS, SET MAX ADDRESS EXT, SET MAX LOCK, SET MAX UNLOCK, SET MAX FREEZE LOCK or SET MAX SET PASSWORD command without error, the device shall abort the commands and the device shall remain in the same state.

Transition HEL6b:HEL6: When the hardware is reset, the device shall remain in the same state.

4.12 Long Logical Sector feature set

4.12.1 Overview

The purpose of the long logical sector feature set is to specify additional data words per sector. Sectors with 520 or 528 bytes are typical. Devices with long logical sectors set IDENTIFY DEVICE data word 106 bit 13 to 1. The Long Logical Sector length is described by IDENTIFY DEVICE data words (118:117).

Use of the Long Logical Sector feature set is prohibited for ATAPI devices.

Devices that implement the Long Logical Sector feature set are not backward compatible with applications that use 256 word logical sectors (e.g., desktop and laptop systems). Table 4 lists commands and their block sizes.

Table 4 describes the command behavior of drives that have been manufactured with the Long Logical Sector feature set. Data transfer commands transfer either the long logical sector length or 256 words depending on the command. For example, Read and Write Extended commands transfer data in long logical sectors while READ LOG EXT and WRITE LOG EXT commands transfer 256 word blocks of data, regardless of the logical sector length. Figure 10 example 2 shows a diagram of a device formatted with long logical sectors.

4.12.2 Devices Implementing the Long Physical Sector feature set and the Long Logical Feature Sector Set

The long physical sector feature set and the long logical sector feature set are not exclusive. Figure 10 example 4 illustrates a device implementing both the Long Physical Sector and Long Logical Sector feature sets.

Table 4 — Block Size By Command (part 1 of 3)

Command	Words Transferred
ADD LBA(S) TO NV CACHE PINNED SET	256
CFA ERASE SECTORS	-
CFA REQUEST EXTENDED ERROR CODE	-
CFA TRANSLATE SECTOR	IDENTIFY DEVICE data words (118:117)
CFA WRITE MULTIPLE WITHOUT ERASE	IDENTIFY DEVICE data words (118:117)
CFA WRITE SECTORS WITHOUT ERASE	IDENTIFY DEVICE data words (118:117)
CHECK MEDIA CARD TYPE	-
CHECK POWER MODE	-
CONFIGURE STREAM	-
DEVICE CONFIGURATION FREEZE LOCK	-
DEVICE CONFIGURATION IDENTIFY	256
DEVICE CONFIGURATION RESTORE	-
DEVICE CONFIGURATION SET	256
DEVICE RESET	-
DOWNLOAD MICROCODE	256
EXECUTE DEVICE DIAGNOSTIC	-
FLUSH CACHE	-
FLUSH CACHE EXT	-
FLUSH NV CACHE	-
IDENTIFY DEVICE	256
IDENTIFY PACKET DEVICE	256
IDLE	-
IDLE IMMEDIATE	-
NOP	-
PACKET	-
QUERY NV CACHE MISSES	256
QUERY NV CACHE PINNED SET	256
REMOVE LBA(S) FROM NV CACHE PINNED SET	256
READ BUFFER	256
READ DMA	IDENTIFY DEVICE data words (118:117)
READ DMA EXT	IDENTIFY DEVICE data words (118:117)
READ DMA QUEUED	IDENTIFY DEVICE data words (118:117)
READ DMA QUEUED EXT	IDENTIFY DEVICE data words (118:117)
READ FPDMA QUEUED	IDENTIFY DEVICE data words (118:117)
READ LOG EXT	256
READ LOG DMA EXT	256
READ MULTIPLE	IDENTIFY DEVICE data words (118:117)
READ MULTIPLE EXT	IDENTIFY DEVICE data words (118:117)

Table 4 — Block Size By Command (part 2 of 3)

Command	Words Transferred
READ NATIVE MAX ADDRESS	-
READ NATIVE MAX ADDRESS EXT	-
READ SECTOR(S)	IDENTIFY DEVICE data words (118:117)
READ SECTOR(S) EXT	IDENTIFY DEVICE data words (118:117)
READ STREAM DMA EXT	IDENTIFY DEVICE data words (118:117)
READ STREAM EXT	IDENTIFY DEVICE data words (118:117)
READ VERIFY SECTOR(S)	IDENTIFY DEVICE data words (118:117)
RETURN FROM NV CACHE POWER MODE	-
READ VERIFY SECTOR(S) EXT	-
SECURITY DISABLE PASSWORD	256
SECURITY ERASE PREPARE	-
SECURITY ERASE UNIT	256
SECURITY FREEZE LOCK	-
SECURITY SET PASSWORD	256
SECURITY UNLOCK	256
SERVICE	-
SET FEATURES	-
SET MAX ADDRESS	-
SET MAX ADDRESS EXT	-
SET MAX FREEZE LOCK	-
SET MAX LOCK	-
SET MAX SET PASSWORD	256
SET MAX UNLOCK	256
SET MULTIPLE MODE	-
SET NV CACHE POWER MODE	-
SLEEP	-
SMART DISABLE OPERATIONS	-
SMART ENABLE/DISABLE AUTOSAVE	-
SMART ENABLE OPERATIONS	-
SMART EXECUTE OFF-LINE IMMEDIATE	-
SMART READ DATA	256
SMART READ LOG	256
SMART RETURN STATUS	-
SMART WRITE LOG	256
STANDBY	-
STANDBY IMMEDIATE	-
TRUSTED RECEIVE	256
TRUSTED RECEIVE DMA	256
TRUSTED SEND	256
TRUSTED SEND DMA	256
WRITE BUFFER	256
WRITE DMA	IDENTIFY DEVICE data words (118:117)
WRITE DMA EXT	IDENTIFY DEVICE data words (118:117)

Table 4 — Block Size By Command (part 3 of 3)

Command	Words Transferred
WRITE DMA FUA EXT	IDENTIFY DEVICE data words (118:117)
WRITE DMA QUEUED	IDENTIFY DEVICE data words (118:117)
WRITE DMA QUEUED EXT	IDENTIFY DEVICE data words (118:117)
WRITE DMA QUEUED FUA EXT	IDENTIFY DEVICE data words (118:117)
WRITE FPDMA QUEUED	IDENTIFY DEVICE data words (118:117)
WRITE LOG EXT	256
WRITE LOG DMA EXT	256
WRITE MULTIPLE	IDENTIFY DEVICE data words (118:117)
WRITE MULTIPLE EXT	IDENTIFY DEVICE data words (118:117)
WRITE MULTIPLE FUA EXT	IDENTIFY DEVICE data words (118:117)
WRITE SECTOR(S)	IDENTIFY DEVICE data words (118:117)
WRITE SECTOR(S) EXT	IDENTIFY DEVICE data words (118:117)
WRITE STREAM DMA EXT	IDENTIFY DEVICE data words (118:117)
WRITE STREAM EXT	IDENTIFY DEVICE data words (118:117)
WRITE UNCORRECTABLE EXT	-

Table 4 describes the command behavior of drives that have been manufactured with the Long Logical Sector feature set. Data transfer commands transfer either the long logical sector length or 256 words depending on the command. For example, Read and Write Extended commands transfer data in long logical sectors while READ LOG EXT and WRITE LOG EXT commands transfer 256 word blocks of data, regardless of the logical sector length. Figure 10 example 2 shows a diagram of a device formatted with long logical sectors.

4.12.2.1 Devices Implementing the Long Physical Sector feature set and the Long Logical Feature Sector Set

The long physical sector feature set and the long logical sector feature set are not exclusive. Figure 10 example 4 illustrates a device implementing both the Long Physical Sector and Long Logical Sector feature sets.

4.13 Long Physical Sector feature set

The purpose of the long physical sector feature set is to allow increased media format efficiency. During write operations devices calculate and error correction code, ECC, and write the ECC on the media following the data. ECC encoding is more efficient when used over a larger amount of data.

Use of the Long Physical Sector feature set is prohibited for ATAPI devices.

The long physical sector feature set allows a device to be formatted so that there are multiple logical sectors per physical sector on the media. Each physical sector has an ECC field. This allows, for example, a device to have 2048 word physical sectors each containing 8 logical sectors, or one ECC field per 8 256 word logical sectors, See figure 10 example 3.

A performance penalty may be incurred when writing to devices that implement long physical sector feature set. A physical sector is read or written in a single operation. If a host system does not write all of the logical sectors in a physical sector during a single command the device may need to read the logical sectors that are not to be changed into memory and then write the entire physical sector, see Annex C.

If the device reports a long physical sector and a smaller logical sector, the device may report the alignment of the first logical sector (LBA 0) within the first physical sector. The following paragraphs give examples of logical/physical sector alignments.

Example 1:

There are 2 logical sectors within one physical sector, and the first logical sector is in the first half.

The proposed offset is: 0, and the value in word 209 is 4000h.

Example 1:

physical sector 0		**physical sector 1**	
logical sector 0	logical sector 1	logical sector 2	logical sector 3

Example 2:

There are 2 logical sectors within one physical sector, and the first logical sector is in the second half. The proposed offset is: 1, and the value in word 209 is 4001h.

physical sector 0		**physical sector 1**	
(inaccessible)	logical sector 0	logical sector 1	logical sector 2

Example 3:

There are 4 logical sectors within one physical sector, and the first logical sector is in the second half. The proposed offset is: 3, and the value in word 209 is 4003h.

physical sector 0				**physical sector 1**			
(inaccessible)	(inaccessible)	(inaccessible)	logical 0	logical 1	logical 2	logical 3	logical 4

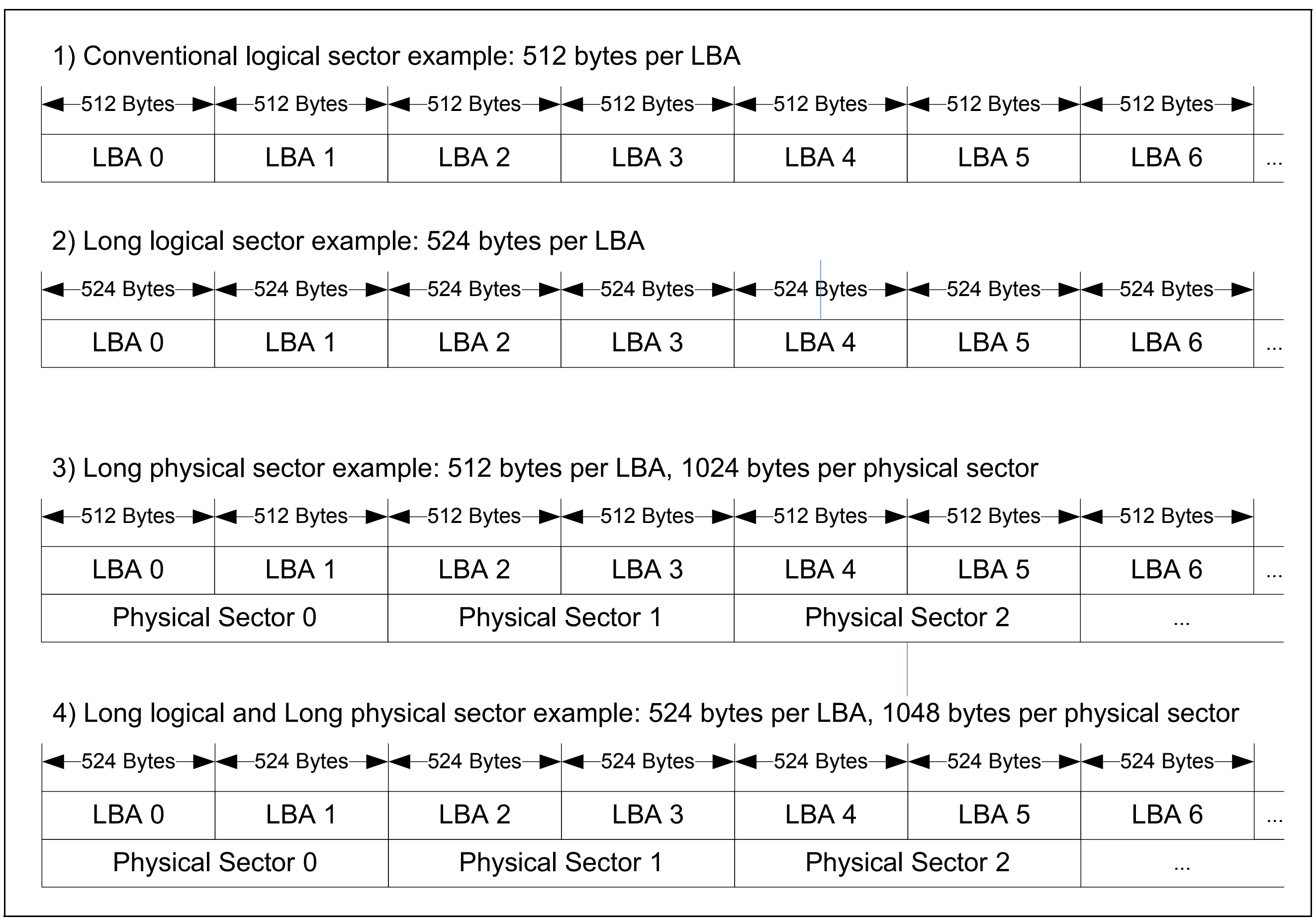

Figure 10 — Long Logical and long Physical Sector Example

4.14 Media Card Pass Through Command feature set

The Media Card Pass Through commands are implemented by a Media Pass Through device. A device implementing the Media Card Pass Through Command feature set is a bridge to one or more types of media card storage devices. The bridge device responds to the same command set as described in 4.2 and to the commands included in this feature set.

Use of the Media Card Pass Through Command feature set is prohibited for PACKET devices.

The Media Card Pass Through Command feature set uses the command codes D1h, D2h, D3h, and D4h and bits in IDENTIFY DEVICE data word 84 and IDENTIFY DEVICE data word 87. The command codes D2h through D4h are reserved for the Media Card Pass Through Command feature set if this feature set is enabled by the CHECK MEDIA CARD TYPE command (D1h). This feature set embeds small-format flash memory card commands inside the ATA commands. The adapter's firmware passes the embedded memory card's command to the memory card as is from the ATA command. The Media Card Pass Through Command feature set reduces the number of commands required for this feature set regardless of the number or type of memory card commands. It also reduces the adapter's firmware overhead in processing them. As new memory cards types are defined in the market, they may all be supported within this one feature.

The commands unique to the Media Card Pass Through Command feature set are:

a) CHECK MEDIA CARD TYPE
b) Command codes D2h through D4h

The CHECK MEDIA CARD TYPE command returns the supporting status of the device to this feature set. It also enables and disables the device from running the Media Card Pass Through Command feature set. When the Media Card Pass Through Command feature set is disabled, the command codes D2h through D4h shall not be interpreted as Media Card Pass Through Command feature set commands and the device shall return command aborted. A device shall disable the Media Card Pass Through Command feature set during the processing of a power-on reset, a hardware reset, or a software reset.

The definitions of the commands D2h-D4h are media card type dependent. Table 5 lists the Media card types and their associated reference document.

Table 5 — Media Card type references

Media Card Type	Reference Document
SD Card	SD Card ATA Command Extension (SDA 3C)
Smart Media	Smart Media ATA Command Extension (SSFDC Forum)

4.15 Native Command Queuing (NCQ) feature set

4.15.1 Overview

The optional NCQ feature set provides support for devices that implement the Serial Transport, see ATA8-AST. The NCQ feature set allows commands within the feature set to be accepted even though one or more previously accepted NCQ commands have not reported command completion. NCQ commands indicate command completion by returning a transport dependent indicator, see ATA8-AST for more information. The following commands are mandatory for devices implementing the NCQ feature set:

a) READ FPDMA QUEUED
b) WRITE FPDMA QUEUED

Devices which report support for the NCQ feature set shall also report support for the General Purpose Logging feature set, the General Purpose Log Directory log and the NCQ Command Error log.

If the device receives a command that is not included in the NCQ feature set while the device is processing queued commands, then the device shall return command aborted for the new command and shall return command aborted for all the queued commands.

All the commands in the NCQ feature set shall include a NCQ Tag. If the value of the NCQ Tag exceeds the value returned in IDENTIFY DEVICE data word 75 (see 7.16.7.30), then the device shall return command aborted for the new command and shall return command aborted for all the queued commands. If a NCQ command is issued with a NCQ Tag value that is identical to the NCQ Tag value for a queued command, then the device shall return command aborted for the new command and shall return command aborted for all the queued commands.

NOTE 1 — The NCQ Tag is used to identify return information (i.e., error status, data transfer and command completion).

If an error occurs while there are queued commands, the device shall abort all queued commands and shall complete any new commands (with the exception of READ LOG EXT requesting log address 10h) it receives with an error, until the device completes a READ LOG EXT command requesting log address 10h (NCQ Command Error log).

Editor’s Note 5: A proposal for READ LOG DMA EXT needs to be a taken to SATA IO

4.15.2 Command Phases

4.15.2.1 Command Acceptance

The device receives a NCQ command and returns command acceptance. Once the device reports command acceptance, it may then accept additional NCQ commands.

4.15.2.2 Data transmission

Data transfer should occur after acceptance of the command.

4.15.2.3 Command completion

When the transfer of all requested data by one or more queued commands has occurred without error, the device returns a transport dependent indicator (see ATA8-AST) that informs the host of completion for one or more queued commands.

If an error occurs then the device shall return command aborted for the command in error and shall return command aborted for all other queued commands. The condition of the data for any queued command that reports command aborted is indeterminate.

4.16 NV Cache feature set

4.16.1 Overview

The NV Cache is managed as two distinct areas, the NV Cache Pinned Set and the NV Cache Unpinned Set. It is not likely that these areas of the NV Cache are contiguous. Each LBA stored in the NV Cache Set has an attribute which determines if the device may remove the sector from the NV Cache. This 'pinned' attribute represents whether the LBA belongs to the NV Cache Pinned Set or the NV Cache Unpinned Set.

The host manages the NV Cache Pinned Set, which is the set of logical blocks that the host requires the device to keep in the NV Cache. The remaining NV Cache Set is the NV Cache Unpinned Set.

4.16.2 Pinning

4.16.2.1 Overview

Adding or Removing an LBA from the NV Cache Pinned Set is accomplished by setting or clearing the 'pinned' attribute on a mapped sector. If a device's NV Cache Unpinned Set is too full to satisfy an Add request, then the device must remove some or all of the NV Cache Unpinned Set in order to complete the Add request.

When an LBA is pinned, the sector data that is placed into the NV Cache may come from one of two sources: the device's media or the host in the form of a write. The source is determined by the Add command's Populate Immediately (PI) bit.

a) If PI is set, the command is not complete until the disk has transferred all of the logical blocks from the device's media into the NV Cache.

b) If PI is not set, the logical blocks are added to the NV Cache Pinned Set but are marked as containing invalid (stale) data. No sector data is transferred to the NV Cache before the Add command completes.

4.16.2.2 Scenarios (Informative)

There are two common scenarios where a host may pin an LBA: it wants to pin an LBA for subsequent read operations, or it wants to pin an LBA which is about to be written to.

a) When the host knows that logical blocks are going to be accessed frequently, the host may add them to the pinned set with the ADD LBA(S) TO NV CACHE PINNED SET command.

   Example:

   A) Preloading frequent randomly accessed OS files.
   B) Preloading boot files in preparation for a system reboot.

b) When the host knows that logical blocks are about to be written, the host may add the logical blocks to the pinned set first with the PI bit cleared to zero. This causes the device to store the data in its non-volatile cache.

   Example: The writing of the hibernate file in preparation for system hibernation.

4.16.3 NV Cache Management

4.16.3.1 Overview

The NV Cache management refers to the use of ATA commands to query or take action on the contents of the NV Cache Pinned Set. It involves transmitting lists of logical blocks that need to be used in an NV Cache management action. Some NV Cache management actions take lists of logical blocks as inputs and some NV Cache management actions give lists of logical blocks as outputs.

When sending lists of logical blocks between the host and the device, the logical blocks are grouped into ranges. LBA ranges consist of an initial LBA and a number which indicates the sequential logical blocks after the initial LBA in the range. More than one LBA range may be sent in a single Add or Remove command. A list of LBA ranges sent in a single Add or Remove command is referred to as the command's NV Cache Set Data.

4.16.3.2 LBA Range Entry

An individual LBA range is called an LBA Range Entry and is represented by 8 bytes. The LBA is expressed by the LBA Range Entry's first 6 bytes and the range length is a zero based number (i.e. 0=0 , 1=1, etc.) represented by the remaining 2 bytes. If the 2 byte range length is 0 then the LBA Range Entry is not valid and should be discarded as padding.

Examples:

a) If logical blocks 11, 12, 13, 14, 15, 16, 17, and 18 were in the NV Cache Pinned Set and logical blocks 10 and 19 were not, logical blocks 11 through 18 make one LBA Range Entry which have the LBA 11 as its first 48 bits and the value of 8 as its next 16 bits. (0000_0000_000B_0008h).
b) If only the single LBA 20 was represented in an LBA Range Entry the range value is 1. (0000_0000_0014_0001h)

The largest range that may be specified in a LBA Range Entry is 65535. Multiple LBA Range Entries shall be used to specify larger range values.

4.16.3.3 NV Cache Remaining for Pinned logical blocks

The NV Cache may run out of space to hold any more pinned logical block data. The number of the remaining available spaces shall be returned to the host during the completion of NV Cache Commands. This is referred to as Logical Blocks Remaining (see 7.20.3.2 and 7.20.3.3 for a description of the return data structure.)

Logical Blocks Remaining is a 6 byte number that always represents the number of logical blocks in the total NV Cache size minus the number of logical blocks currently in the Pinned Cache Set.

4.16.4 NV Cache behavior after a power-on event

4.16.4.1 Query NV Cache Misses

In order to gather information about the system's BIOS read and write behavior, a query of NV Cache misses is necessary (see 7.20.7).

4.16.4.2 Rotating media state after power-on event

If the NV Cache Power Mode is set in a device, then the device should not spin up its rotating media after a power-on event until the device receives a read or write command that requires media access.

4.16.5 Preparing to Pin a Large NV Cache Set Data

Before the pinning of a large number of logical blocks in the NV Cache Pinned Set it is desirable for the host to instigate a flush of some or all of the NV Cache Unpinned Set. This ensures that the potentially lengthy flushing operation in a large NV Cache is completed as quickly and early as possible. This is accomplished using the Flush NV Cache command described in section 7.1.5.

4.17 NV Cache Power Management feature set

4.17.1 Overview

The optional NV Cache Power Management feature set permits a host to modify the behavior of a device in a manner that allows the device to improve response times to read and write commands while reducing the device's power consumption.

Commands unique to the NV Cache Power Management feature set use a single command code and are differentiated from one another by the value placed in the Features field. A device that implements the NV Cache Power Management feature set shall implement the following commands:

a) SET NV CACHE POWER MODE
b) RETURN FROM NV CACHE POWER MODE

When the NV Cache Power Mode is set, the device implements an aggressive policy to remove power from its rotational media and satisfy all reads and writes from the device's NV Cache. If a device is not capable of satisfying a read or write from its NV Cache it shall service the read or write request through other means.

Since all IO operations happen in PM0:Active mode, it is the only state that requires attention. The only aspect of the NV Cache feature that affects the Power Management feature is the NV Cache Power Mode input. The purpose of the NV Cache Power Mode input is to enable and disable the aggressive spinning down of the device while it is in the PM0:Active mode. However, the Power Management state diagram does not reflect spindle state and the NV Cache Power Mode input does not affect any Power Management state transitions. The effects are as follows:

a) When the device is Powered Up, it should satisfy requests from NV Cache independently from the NV Cache Power Mode. This prevents BIOSes from having to be NV Cache sensitive.
b) When NV Cache Power Mode is cleared and the device is in PM0:Active it shall spin up.
c) When NV Cache Power Mode is set and the device is in PM0:Active the device shall enact its aggressive policy to remove power from its rotational media. The only requirement of a device's aggressive policy is that when the device is spun up, it remains spun up for at least the amount of time specified in the SET NV CACHE POWER MODE command.
d) A Device Configuration Overlay command that disables the NV Cache Power Mode support in the device causes the NV Cache Power Mode to be cleared.

4.18 Power Management feature set

A General feature set device shall implement power management. A device implementing the PACKET feature set may implement the power management as defined by the PACKET command set implemented by the device. Otherwise, the device shall implement the Power Management feature set as described in this standard.

The Power Management feature set permits a host to modify the behavior of a device in a manner that reduces the power required to operate. The Power Management feature set provides a set of commands and a timer that enable a device to implement low power consumption modes. A device that implements the General feature set and the Power Management feature set shall implement the following minimum set of functions (see also 4.5 and 4.19):

a) A Standby timer
b) CHECK POWER MODE command
c) IDLE command
d) IDLE IMMEDIATE command
e) SLEEP command
f) STANDBY command
g) STANDBY IMMEDIATE command

A device that implements the PACKET feature set and implements the Power Management feature set shall implement the following minimum set of functions:

a) CHECK POWER MODE command
b) IDLE IMMEDIATE command
c) SLEEP command
d) STANDBY IMMEDIATE command

4.18.1 Power management commands

The CHECK POWER MODE command allows a host to determine if a device is currently in, going to or leaving Standby or Idle mode. The CHECK POWER MODE command shall not change the power mode or affect the operation of the Standby timer.

The IDLE and IDLE IMMEDIATE commands move a device to Idle mode immediately from the Active or Standby modes. The IDLE command also sets the Standby timer count and enables or disables the Standby timer.

The STANDBY and STANDBY IMMEDIATE commands move a device to Standby mode immediately from the Active or Idle modes. The STANDBY command also sets the Standby timer count and enables or disables the Standby timer.

The SLEEP command moves a device to Sleep mode. The device's interface becomes inactive at command completion of the SLEEP command. A device only transitions from Sleep mode after processing a hardware reset, a software reset, or a DEVICE RESET command.

4.18.2 Standby timer

The Standby timer provides a method for the device to automatically enter Standby mode from either Active or Idle mode following a host programmed period of inactivity. If the Standby timer is enabled and if the device is in the Active or Idle mode, the device waits for the specified time period and if no command is received, the device automatically enters the Standby mode.

If the Standby timer is disabled, the device may automatically enter Standby mode.

4.18.3 Power modes

Figure 11 shows the set of mode transitions that shall be implemented.

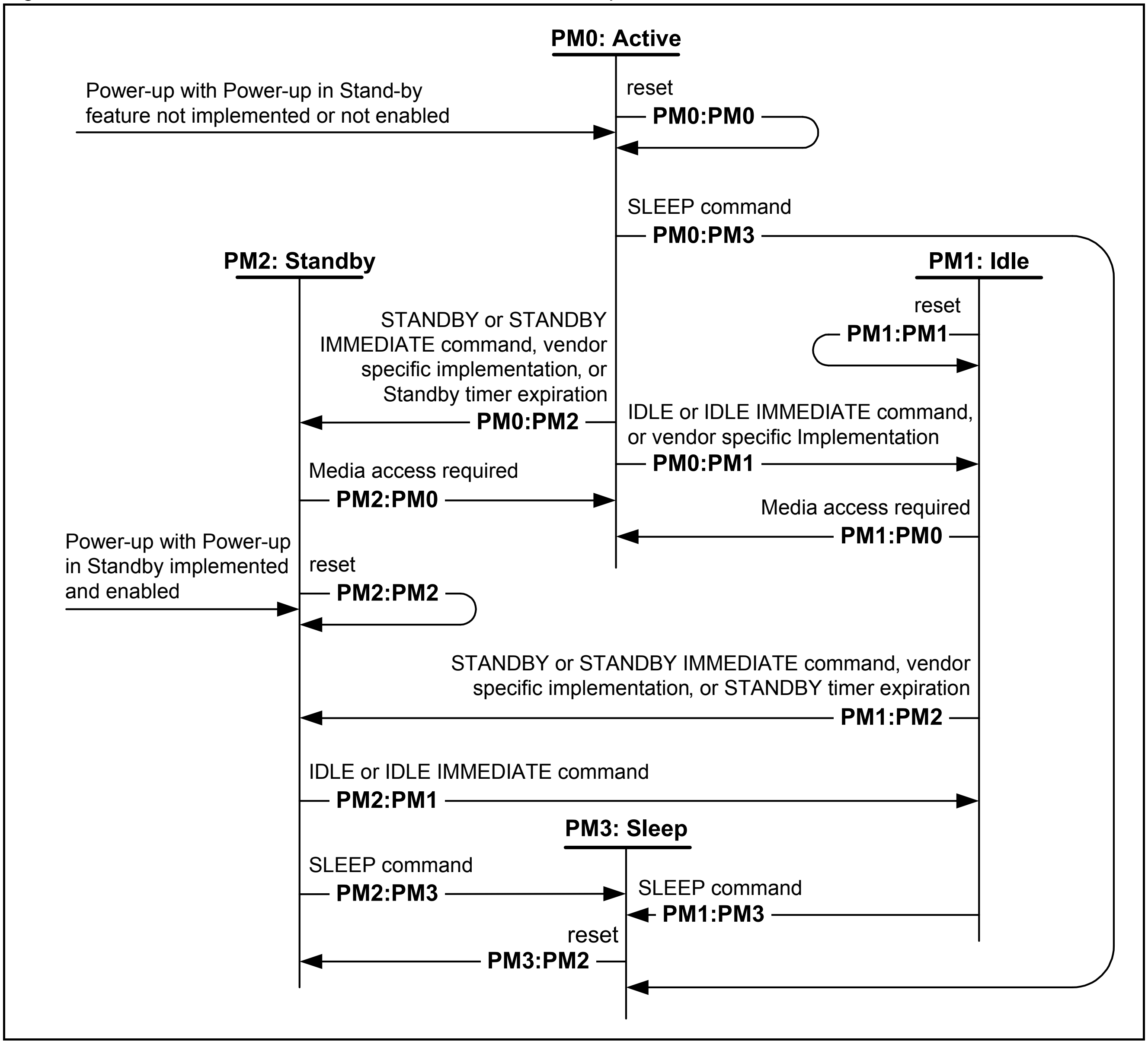

Figure 11 — Power management state diagram

PM0: Active: This mode shall be entered when the device receives a media access command while in Idle or Standby mode. This mode shall also be entered when the device is powered-up with the Power-Up In Standby feature not implemented or not enabled (see 4.19).

In Active mode the device is capable of responding to commands. During the execution of a media access command a device shall be in Active mode. Power consumption is greatest in this mode.

Transition PM0:PM0: The device shall transition to the PM0:Active mode after processing a hardware reset, software reset, or DEVICE RESET command.

Transition PM0:PM1: When an IDLE or IDLE IMMEDIATE command is received or when a vendor specific implementation determines a transition is required, then the device shall make a transition to the PM1:Idle mode.

Transition PM0:PM2: When a STANDBY or STANDBY IMMEDIATE command is received, the Standby timer expires, or a vendor specific implementation determines a transition is required, then the device shall make a transition to the PM2:Standby mode.

Transition PM0:PM3: When a SLEEP command is received, the device shall make a transition to the PM3:Sleep mode.

PM1: Idle: This mode shall be entered when the device receives an IDLE or IDLE IMMEDIATE command. Some devices may perform vendor specific internal power management and make a transition to the Idle mode without host intervention.

In Idle mode the device is capable of responding to commands but the device may take longer to complete commands than when in the Active mode. Power consumption may be reduced from that of Active mode.

Transition PM1:PM0: When a media access is required, the device shall make a transition to the PM0:Active mode.

Transition PM1:PM1: The device shall transition to the PM1:Idle mode after processing a hardware reset, software reset, or DEVICE RESET command.

Transition PM1:PM2: When a STANDBY or STANDBY IMMEDIATE command is received, the Standby timer expires, or a vendor specific implementation determines a transition is required, then the device shall make a transition to the PM2:Standby mode.

Transition PM1:PM3: When a SLEEP command is received, the device shall make a transition to the PM3:Sleep mode.

PM2: Standby: This mode shall be entered when the device receives a STANDBY command, the device receives a STANDBY IMMEDIATE command, the Standby timer expires, or the NV Cache Power mode timer expires. Some devices may perform vendor specific internal power management and make a transition to the Standby mode without host intervention. This mode shall also be entered when the device is powered-up with the Power-Up In Standby feature implemented and enabled.

In Standby mode the device is capable of responding to commands but the device may take longer to complete commands than in the Idle mode. The time to respond may be as long as 30 s. Power consumption may be reduced from that of Idle mode.

Transition PM2:PM0: When a media access is required, the device shall make a transition to the PM0:Active mode.

Transition PM2:PM1: When an IDLE or IDLE IMMEDIATE command is received, or a vendor specific implementation determines a transition is required, then the device shall make a transition to the PM1:Idle mode.

Transition PM2:PM2: The device shall transition to the PM2:Standby mode after processing a hardware reset, software reset, or DEVICE RESET command.

Transition PM2:PM3: When a SLEEP command is received, the device shall make a transition to the PM3:Sleep mode.

PM3: Sleep: This mode shall be entered when the device receives a SLEEP command.

A device transitions from Sleep mode only after processing a hardware reset, a software reset, or a DEVICE RESET command. The time to respond may be as long as 30 s. Sleep mode provides the lowest power consumption of any mode.

In Sleep mode, see the applicable transport standard for a description of the device's interface behavior.

Transition PM3:PM2:, A device shall transition to the PM2:Standby mode after processing a hardware reset, software reset, or DEVICE RESET command.

4.19 Power-Up In Standby feature set

The optional Power-Up In Standby feature set allows devices to be powered-up into the Standby power management state to minimize inrush current at power-up and to allow the host to sequence the spin-up of devices. This optional feature set may be enabled or disabled via the SET FEATURES command or may be enabled by use of a jumper or similar means, or both. When enabled by a jumper, the feature set shall not be disabled via the SET FEATURES command. The IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data indicates whether this feature set is implemented and/or enabled.

Once this feature is enabled in a device, the device shall not disable the feature as a result of processing a power-on reset, a hardware reset, or a software reset.

A device may implement a SET FEATURES subcommand (see 7.48.8) that notifies the device to spin-up to the Active state when the device has powered-up into Standby. If the device implements this SET FEATURES subcommand and power-up into Standby is enabled, the device shall remain in Standby until the SET FEATURES subcommand is received. If the device implements this SET FEATURES subcommand, the fact that the feature is implemented is reported in the IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data.

If the device:

a) implements the Enable/disable Power-up in Standby subcommand,
b) power-up into Standby is enabled, and
c) an IDENTIFY DEVICE or IDENTIFY PACKET DEVICE is received while the device is in Standby as a result of powering up into Standby,

the device shall respond to the command and remain in Standby without spinning-up.

If the device has IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data that requires access to the media, the device shall set word 0 bit 2 to one to indicate that the response is incomplete. At a minimum, word 0 and word 2 shall be correctly reported. Those fields that are not be provided shall be filled with zeros. Once a device is able to return all data for an IDENTIFY DEVICE command or IDENTIFY PACKET DEVICE command, the device shall return all data for those commands until after processing the next power-on reset.

If the device does not implement the SET FEATURES subcommand to spin-up the device after power-up and power-up into Standby is enabled, the device shall spin-up upon receipt of the first command that requires the device to access the media.

4.20 Security feature set

4.20.1 Overview

The optional Security feature set is a password system that restricts access to user data stored on a device. In addition, access to some configuration capabilities is restricted.

See also the Master Password Identifier feature (4.20.12) which is an optional enhancement to the Security feature set.

4.20.2 Passwords

4.20.2.1 Overview

The system has two types of passwords: User and Master.

4.20.2.2 User Password

The User password is used to create a lock to block execution of some commands, including preventing access to all user data on the device. The User password may be used to unlock the device to allow access.

Security is enabled by setting a User password with the SECURITY SET PASSWORD command. When Security is Enabled, the device is automatically Locked (i.e., access to user data on the device is denied) after a power-on reset is processed until a SECURITY UNLOCK command completes successfully.

4.20.2.3 Master Password

The Master password is a password that may be used to unlock the device if the User password is lost or if an administrator requires access (e.g. to re-propose a device).

A factory-installed Master password may be valid before an initial SECURITY SET (master) PASSWORD command has been successfully executed. A device may contain both a valid Master and a valid User password. Setting the Master password does not enable Security (i.e., does not Lock the device after the next power-on reset has been processed).

4.20.3 Master Password Capability

A device with Security enabled has two ways of using the Master password. This capability has values of 'High' or 'Maximum'.

When the Master Password Capability is set to High, either the User or Master password may be used interchangeably. See table 6.

When the Master Password Capability is set to Maximum, the Master password is not used with the SECURITY DISABLE PASSWORD and SECURITY UNLOCK commands. The SECURITY ERASE UNIT command, however, does accept either a valid User or Master password.

Table 6 — Interaction of Master Password Capability and Passwords (when Security is not frozen)

				Actions Taken by Security Commands		
Security Enabled	**Master Password Capability**	**Passwords Defined**	**Password Supplied**	**SECURITY ENABLE PASSWORD**	**SECURITY UNLOCK**	**SECURITY ERASE UNIT**
No	N/A	Master Only	Correct Master	N	N	P
No	N/A	Master Only	Not Valid	A	A	A
Yes	High	Master and User	Correct Master	P	P	P
Yes	High	Master and User	Correct User	P	P	P
Yes	Maximum	Master and User	Correct Master	A	A	P
Yes	Maximum	Master and User	Correct User	P	P	P
Key: N - NOP, do nothing and return normal completion A - Return command aborted P - Process the command (if all validations pass) or return command aborted						

4.20.4 Frozen Mode

The SECURITY FREEZE LOCK command prevents changes to all Security states until a following power-on reset or hardware reset. The purpose of the SECURITY FREEZE LOCK command is to prevent password setting attacks on the security system.

4.20.5 Commands

A device that implements the Security feature set shall implement the following set of commands:

a) SECURITY SET PASSWORD
b) SECURITY UNLOCK (requires a password)
c) SECURITY ERASE PREPARE
d) SECURITY ERASE UNIT (requires a password)
e) SECURITY FREEZE LOCK
f) SECURITY DISABLE PASSWORD (requires a password)

4.20.6 IDENTIFY DEVICE data

Support of the Security feature set is indicated in IDENTIFY DEVICE and IDENTIFY PACKET DEVICE data word 82 and data word 128.

Security information in words 82, 89 and 90 is fixed until the next power-on reset and shall not change unless DEVICE CONFIGURATION OVERLAY removes support for the Security feature set.

Security information in words 85, 92 and 128 are variable and may change.

If the Security feature set is not supported, then words 89, 90, 92 and 128 are N/A.

4.20.7 Security initial setting

When the device is shipped by the manufacturer, Security shall be disabled (e.g. is not Locked). The initial Master password value is not defined by this standard.

4.20.8 Password Rules

This section applies to any Security command that accepts a password, and for which there exists a valid password. This section does not apply while Security is Frozen.

The SECURITY ERASE UNIT command ignores the Master Password Capability value when comparing passwords, and shall accept either a valid Master or User password.

If the User password sent to the device does not match the user password previously set with the SECURITY SET PASSWORD command, the device shall return command aborted.

If the Master Password Capability was set to High during the last SECURITY SET (user) PASSWORD command, the device shall accept the Master password and complete normally.

If the Master Password Capability was set to Maximum during the last SECURITY SET (user) PASSWORD command, the device shall return command aborted for SECURITY UNLOCK or SECURITY DISABLE PASSWORD if the Master password is supplied. .

4.20.9 Password Attempt Counter

The device shall have an password attempt counter. The purpose of this counter is to defeat repeated trial attacks. The counter shall be decremented while in state SEC4, whenever the SECURITY UNLOCK command fails because of an invalid User or Master password.

Once the counter reaches zero, it shall not be decremented, and the PasswordAttemptCounterExceeded bit (IDENTIFY DEVICE (data word 128, bit 4) shall be set to one, and the SECURITY UNLOCK and SECURITY ERASE UNIT commands shall be command aborted until after processing the next power-on or hardware reset.

The PasswordAttemptCounterExceeded bit shall be cleared to zero by processing a power-on or a hardware reset.

The counter shall be set to five (5) after a power-on or hardware reset.

4.20.10 Security states

See figure 12 and table 7. When the power is off, the Security characteristics are as in table 7, but are not reportable.

Table 7 — Summary of Security States and Characteristics

Security State	Security Characteristics				
	Power	**Enabled[a]**	**Locked[b]**	**Frozen[c]**	**Password Attempts Exceeded[d]**
SEC0	off	0	N/A	N/A	N/A
SEC1	on	0	0	0	0
SEC2	on	0	0	1	Varies
SEC3	off	1	N/A	N/A	N/A
SEC4	on	1	1	0	Varies
SEC5	on	1	0	0	Varies
SEC6	on	1	0	1	Varies

[a] IDENTIFY DEVICE data word 85 bit 1
[b] IDENTIFY DEVICE data word 128 bit 2
[c] IDENITFY DEVICE data word 128 bit 3
[d] IDENTIFY DEVICE data word 128 bit 4

Editor's Note 6: The proposal calls for an Unlocked/disabled column as previously documented, but asks for a normative statement regarding download microcode being different. The original proposal does not list any differences for download microcode.

Table 8 — Security Command Actions (part 1 of 3)

Command	Locked[a]	Unlocked or Disabled[b]	Frozen[c]
ADD LBA(S) TO NV CACHE PINNED SET	Command aborted	Executable	Executable
CFA ERASE SECTORS	Command aborted	Executable	Executable
CFA REQUEST EXTENDED ERROR CODE	Executable	Executable	Executable
CFA TRANSLATE SECTOR	Executable	Executable	Executable
CFA WRITE MULTIPLE WITHOUT ERASE	Command aborted	Executable	Executable
CFA WRITE SECTORS WITHOUT ERASE	Command aborted	Executable	Executable
CHECK MEDIA CARD TYPE	Command aborted	Executable	Executable
CHECK POWER MODE	Executable	Executable	Executable
CONFIGURE STREAM	Command aborted	Executable	Executable
DEVICE CONFIGURATION	Command aborted	Executable	Executable
DEVICE RESET	Executable	Executable	Executable
DOWNLOAD MICROCODE	Vendor Specific	Vendor Specific	Vendor Specific
EXECUTE DEVICE DIAGNOSTIC	Executable	Executable	Executable
FLUSH CACHE	Command aborted	Executable	Executable
FLUSH CACHE EXT	Command aborted	Executable	Executable
FLUSH NV CACHE	Command aborted	Executable	Executable
GET MEDIA STATUS	Command aborted	Executable	Executable
IDENTIFY DEVICE	Executable	Executable	Executable
IDENTIFY PACKET DEVICE	Executable	Executable	Executable
IDLE	Executable	Executable	Executable
IDLE IMMEDIATE	Executable	Executable	Executable
MEDIA EJECT	Command aborted	Executable	Executable
MEDIA LOCK	Command aborted	Executable	Executable
MEDIA UNLOCK	Command aborted	Executable	Executable
NOP	Executable	Executable	Executable
PACKET	Command aborted	Executable	Executable
QUERY NV CACHE MISSES	Command aborted	Executable	Executable
QUERY NV CACHE PINNED SET	Command aborted	Executable	Executable
READ BUFFER	Executable	Executable	Executable
READ DMA	Command aborted	Executable	Executable
READ DMA EXT	Command aborted	Executable	Executable

[a] State SEC4
[b] States SEC1 or SEC5
[c] States SEC2 or SEC6

Table 8 — Security Command Actions (part 2 of 3)

Command	Locked[a]	Unlocked or Disabled[b]	Frozen[c]
READ FPDMA QUEUED	Command aborted	Executable	Executable
READ DMA QUEUED	Command aborted	Executable	Executable
READ DMA QUEUED EXT	Command aborted	Executable	Executable
READ LOG DMA EXT	Executable	Executable	Executable
READ LOG EXT	Executable	Executable	Executable
READ MULTIPLE	Command aborted	Executable	Executable
READ MULTIPLE EXT	Command aborted	Executable	Executable
READ NATIVE MAX ADDRESS	Executable	Executable	Executable
READ NATIVE MAX ADDRESS EXT	Executable	Executable	Executable
READ SECTOR(S)	Command aborted	Executable	Executable
READ SECTOR(S) EXT	Command aborted	Executable	Executable
READ STREAM DMA EXT	Command aborted	Executable	Executable
READ STREAM EXT	Command aborted	Executable	Executable
READ VERIFY SECTOR(S)	Command aborted	Executable	Executable
READ VERIFY SECTOR(S) EXT	Command aborted	Executable	Executable
REMOVE LBA(S) FROM NV CACHE PINNED SET	Command aborted	Executable	Executable
RETURN FROM NV CACHE POWER MODE	Command aborted	Executable	Executable
SCT READ/WRITE LONG	Command aborted	Executable	Executable
SCT WRITE SAME	Command aborted	Executable	Executable
SCT ERROR RECOVERY CONTROL	Command aborted	Executable	Executable
SCT FEATURE CONTROL	Command aborted	Executable	Executable
SCT DATA TABLES	Command aborted	Executable	Executable
SCT READ STATUS	Executable	Executable	Executable
SECURITY DISABLE PASSWORD	Command aborted	Executable	Command aborted
SECURITY ERASE PREPARE	Executable	Executable	Command aborted
SECURITY ERASE UNIT	Executable	Executable	Command aborted
SECURITY FREEZE LOCK	Command aborted	Executable	Executable
SECURITY SET PASSWORD	Command aborted	Executable	Command aborted
SECURITY UNLOCK	Executable	Executable	Command aborted
SERVICE	Command aborted	Executable	Executable
SET FEATURES	Executable	Executable	Executable
SET MAX ADDRESS	Command aborted	Executable	Executable
SET MAX ADDRESS EXT	Command aborted	Executable	Executable
SET MAX SET PASSWORD	Command aborted	Executable	Executable
SET MAX LOCK	Command aborted	Executable	Executable
SET MAX FREEZE LOCK	Command aborted	Executable	Executable
SET MAX UNLOCK	Command aborted	Executable	Executable
SET MULTIPLE MODE	Executable	Executable	Executable
SET NV CACHE POWER MODE	Command aborted	Executable	Executable
SLEEP	Executable	Executable	Executable

[a] State SEC4
[b] States SEC1 or SEC5
[c] States SEC2 or SEC6

Table 8 — Security Command Actions (part 3 of 3)

Command	Locked[a]	Unlocked or Disabled[b]	Frozen[c]
SMART DISABLE OPERATIONS	Executable	Executable	Executable
SMART ENABLE/DISABLE AUTOSAVE	Executable	Executable	Executable
SMART ENABLE OPERATIONS	Executable	Executable	Executable
SMART EXECUTE OFF-LINE IMMEDIATE	Executable	Executable	Executable
SMART READ DATA	Executable	Executable	Executable
SMART READ LOG	Executable	Executable	Executable
SMART RETURN STATUS	Executable	Executable	Executable
SMART WRITE LOG	Executable	Executable	Executable
STANDBY	Executable	Executable	Executable
STANDBY IMMEDIATE	Executable	Executable	Executable
TRUSTED RECEIVE	Command aborted	Executable	Executable
TRUSTED RECEIVE DMA	Command aborted	Executable	Executable
TRUSTED SEND	Command aborted	Executable	Executable
TRUSTED SEND DMA	Command aborted	Executable	Executable
WRITE BUFFER	Executable	Executable	Executable
WRITE DMA	Command aborted	Executable	Executable
WRITE DMA EXT	Command aborted	Executable	Executable
WRITE DMA FUA EXT	Command aborted	Executable	Executable
WRITE DMA QUEUED	Command aborted	Executable	Executable
WRITE DMA QUEUED EXT	Command aborted	Executable	Executable
WRITE DMA QUEUED FUA EXT	Command aborted	Executable	Executable
WRITE FPDMA QUEUED	Command aborted	Executable	Executable
WRITE LOG DMA EXT	Command aborted	Executable	Executable
WRITE LOG EXT	Command aborted	Executable	Executable
WRITE MULTIPLE	Command aborted	Executable	Executable
WRITE MULTIPLE EXT	Command aborted	Executable	Executable
WRITE MULTIPLE FUA EXT	Command aborted	Executable	Executable
WRITE SECTOR(S)	Command aborted	Executable	Executable
WRITE SECTOR(S) EXT	Command aborted	Executable	Executable
WRITE STREAM DMA EXT	Command aborted	Executable	Executable
WRITE STREAM EXT	Command aborted	Executable	Executable
WRITE UNCORRECTABLE	Command aborted	Executable	Executable

[a] State SEC4
[b] States SEC1 or SEC5
[c] States SEC2 or SEC6

4.20.11 Security states

Figure 12 describes security states and state transitions.

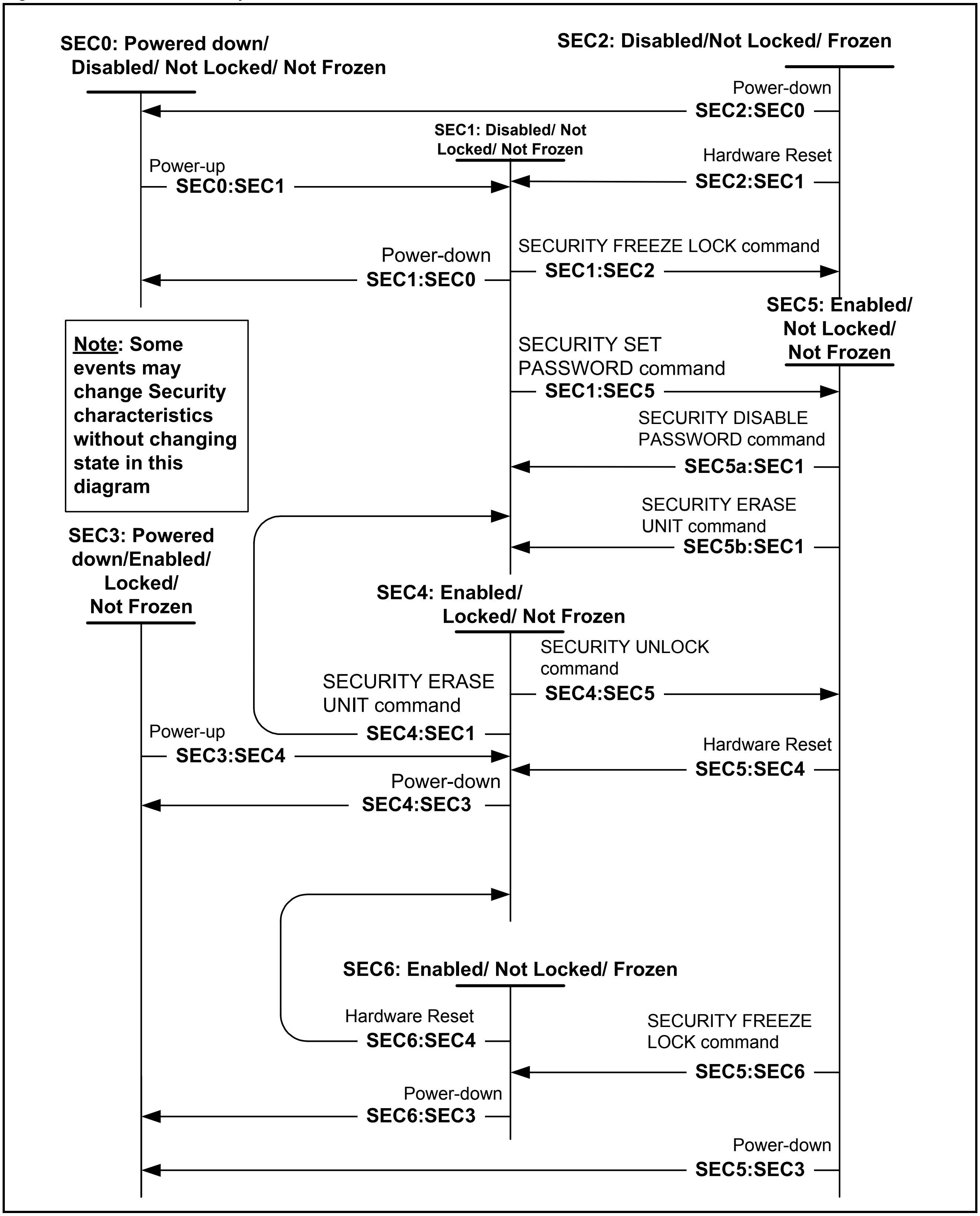

Figure 12 — Security state diagram

State SEC0: Powered down/Security Disabled/Not Locked/ Not Frozen: This state shall be entered when the device is powered-down with the Security feature set disabled.

Transition SEC0:SEC1: When the device is powered-up, the device shall make a transition to state SEC1.

State SEC1: Security Disabled/Not Locked/ Not Frozen: This state shall be entered when the device is powered-up or a hardware reset is received with the Security feature set disabled or when the Security feature set is disabled by a SECURITY DISABLE PASSWORD or SECURITY ERASE UNIT command.

When entering this state after processing a power-on or hardware reset, the device shall initialize the password attempt counter and clear the PasswordAttemptCounterExceeded flag

In this state, the device shall respond to all commands as specified in the “Disabled” column of Table 4. With the exception of the SECURITY commands, execution of these commands shall not cause a transition from state SEC1.

In this state, IDENTIFY DEVICE and IDENTIFY PACKET DEVICE shall report values as described in table 9.

Table 9 — IDENTIFY settings for Security state SEC1

Word	Bit Position	Value	Description
82	1	1	Security feature set is supported
85	1	0	There is no active User password
128	0	copy of word 82 bit 1	Security feature set is supported
128	1	copy of word 85 bit 1	Security feature set is disabled
128	2	0	device is not locked
128	3	0	device is not frozen
128	4	Varies	Password Attempt Counter Exceeded 1= counter exceeded 0= counter not exceeded
128	8	0	Master Password Capability is not maximum

Transition SEC1:SEC0: When the device is powered-down, the device shall make a transition to state SEC0.

Transition SEC1:SEC1: When a SECURITY SET (master) PASSWORD command completes successfully, the Master password and the optional Master Password Identifier shall be saved, and the device shall remain in state SEC1. The Master Password Capability shall remain unchanged.Transition SEC1:SEC2: When a SECURITY FREEZE LOCK command completes successfully, the device shall make a transition to state SEC2.

Transition SEC1:SEC5: When a SECURITY SET (user) PASSWORD command completes successfully, the device shall save the User password, update the Master Password Capability and make a transition to state SEC5.

State SEC2: Security Disabled/ Not Locked/ Frozen: This state shall be entered when the device receives a SECURITY FREEZE LOCK command while in state SEC1.

In this state, the device shall respond to all commands as specified in the “Frozen” column of table 8. Execution of any of these commands shall not cause a transition from state SEC2.

The device shall report IDENTIFY DEVICE or IDENTIFY PACKET DEVICE field values in accordance with table 10.

Table 10 — IDENTIFY settings for Security state SEC2

Word	Bit Position	Value	Description
82	1	1	Security feature set is supported
85	1	0	There is no active User password
128	0	copy of word 82 bit 1	Security feature set is supported
128	1	copy of word 85 bit 1	Security feature set is disabled
128	2	0	device is not locked
128	3	1	device is frozen
128	4	Varies	Password Attempt Counter Exceeded 1= counter exceeded 0= counter not exceeded
128	8	Varies	Master Password Capability 0=high/User password disabled 1=Maximum/User password disabled

Transition SEC2:SEC0: When the device is powered-down, the device shall make a transition to state SEC0.

Transition SEC2:SEC1: When the device receives a hardware reset, the device shall make a transition to state SEC1.

State SEC3: Powered down/Security Enabled/ Locked/ Not Frozen: This state shall be entered when the device is powered-down with the Security feature set enabled.

Transition SEC3:SEC4: When the device is powered-up, the device shall make a transition to state SEC4.

State SEC4: Security Enabled/ Locked/ Not Frozen: This state shall be entered when the device is powered-up or a hardware reset is received with the Security feature set enabled.

In this state, the device shall respond to all commands as specified in the “Locked” column of table 8. With the exception of the SECURITY commands, execution of these commands shall not cause a transition from state SEC4.

When entering this state from power-on or hardware reset, the device shall initialize the password attempt counter and clear the PasswordAttemptCounterExceeded flag

The device shall report IDENTIFY DEVICE or IDENTIFY PACKET DEVICE field values in accordance with table 11.

Table 11 — IDENTIFY settings for Security state SEC4

Word	Bit Position	Value	Description
82	1	1	Security feature set is supported
85	1	1	There is an active User password
128	0	copy of word 82 bit 1	Security feature set is supported
128	1	copy of word 85 bit 1	Security feature set is enabled
128	2	1	device is locked
128	3	0	device is not frozen
128	4	Varies	Password Attempt Counter Exceeded 1= counter exceeded 0= counter not exceeded
128	8	Varies	Master Password Capability 0=high 1=Maximum

Transition SEC4:SEC1: When a SECURITY ERASE UNIT command completed successfully, the device shall make a transition to state SEC1.

Transition SEC4:SEC3: When the device is powered-down, the device shall make a transition to state SEC3.

Transition SEC4:SEC4: When a SECURITY UNLOCK command is received with an incorrect password, the password attempt counter shall be decremented by 1, and remain in state SEC4.

If password attempt counter reaches 0, the PasswordAttemptCounterExceeded bit (IDENTIFY DEVICE word 128, bit 4) shall be set to 1.

After execution of the SECURITY ERASE PREPARE command, the device remains in state SEC4.

Transition SEC4:SEC5: When a SECURITY UNLOCK command is successful, the device shall make a transition to state SEC5.

State SEC5: Security Enabled/ Not Locked/ Not Frozen: This state shall be entered when either a SECURITY SET (user) PASSWORD command or a SECURITY UNLOCK command is successful.

In this state, the device shall respond to all commands as specified in the “Unlocked” column of table 8. With the exception of the SECURITY commands, execution of these commands shall not cause a transition from state SEC5.

The device shall report IDENTIFY DEVICE or IDENTIFY PACKET DEVICE field values in accordance with table 12.

Table 12 — IDENTIFY settings for Security state SEC5

Word	Bit Position	Value	Description
82	1	1	Security feature set is supported
85	1	1	There is an active User password
128	0	copy of word 82 bit 1	Security feature set is supported
128	1	copy of word 85 bit 1	Security feature set is enabled
128	2	0	device is not locked
128	3	0	device is not frozen
128	4	Varies	Password Attempt Counter Exceeded 1= counter exceeded 0= counter not exceeded
128	8	Varies	Master Password Capability 0=high 1=Maximum

Transition SEC5:SEC1: When a SECURITY DISABLE PASSWORD or a SECURITY ERASE UNIT command is successful, the device shall make a transition to the SEC1 state.

Transition SEC5:SEC3: When the device is powered-down, the device shall make a transition to state SEC3.

Transition SEC5:SEC4: When the device receives a hardware reset, the device shall make a transition to state SEC4.

Transition SEC5:SEC5: When a successful SECURITY SET (master) PASSWORD command is received, the Master password and the optional Master Password Identifier shall be saved, the Master Password Capability shall remain unchanged, and the device shall remain in state SEC5.

When a SECURITY SET (user) PASSWORD command is successful, the device shall save the User password, update the Master Password Capability and shall remain in state SEC5.

After execution of the SECURITY ERASE PREPARE command, the device remains in state SEC4.

Transition SEC5:SEC6: When a SECURITY FREEZE LOCK command is successful, the device shall make a transition to state SEC6.

State SEC6: Security Enabled/ Not Locked/ Frozen: This state shall be entered when the device receives a SECURITY FREEZE LOCK command while SEC5 state.

In this state, the device shall respond to all commands as specified in the “Frozen” column of Table 4. With the exception of the SECURITY commands, execution of these commands shall not cause a transition from state SEC6.

The device shall report IDENTIFY DEVICE or IDENTIFY PACKET DEVICE field values in accordance with table 12.

Table 13 — IDENTIFY settings for Security state SEC6

Word	Bit Position	Value	Description
82	1	1	Security feature set is supported
85	1	1	There is an active User password
128	0	copy of word 82 bit 1	Security feature set is supported
128	1	copy of word 85 bit 1	Security feature set is enabled
128	2	0	device is not locked
128	3	1	device is frozen
128	4	Varies	Password Attempt Counter Exceeded 1= counter exceeded 0= counter not exceeded
128	8	Varies	Master Password Capability 0=high 1=Maximum

Transition SEC6:SEC4: When the device receives a hardware reset, the device shall make a transition to state SEC4.

Transition SEC6:SEC3: When the device is powered-down, the device shall make a transition to state SEC3.

4.20.12 Master Password Identifier feature

4.20.12.1 Overview

This is an optional enhancement to the Security feature set, which is a prerequisite.

4.20.12.2 Use Case (Informative)

The intended purpose of this feature is to assist an administrator that uses several sets of Master passwords (for use in different deployments of devices). The administrator may maintain a mapping of actual Master passwords and a corresponding Identifier. When an administrator sets a Master password, the corresponding Master Password Identifier may be also set.

When the time comes to redeploy a device for which a User password had been set (and subsequently lost), the administrator needs to know which Master password is actually valid for this individual device. Since the device never reveals the Master password but does reveal the Identifier, the administrator may obtain a hint as to which Master password was previously set.

4.20.12.3 Requirements

The device shall maintain a 2-byte host vendor-specific data value associated with the Master Password.

The Master Password Identifier does not indicate whether a Master Password exists or is valid.

Support for this feature is reported in the IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data in word 92. Valid identifiers are 0001h through FFFEh. A value of 0000h or FFFFh indicates that this feature is not supported.

If the device supports this feature,

a) The device shall store a non-volatile identifier field with the stored Master password. The identifier is maintained for the benefit of the host. The value is not modified by the device.
b) Prior to first use, the initial Master Password Identifier shall be set to FFFEh by the manufacturer.

4.21 SMART (Self-monitoring, analysis, and reporting technology) feature set

4.21.1 Overview

The intent of self-monitoring, analysis, and reporting technology (the SMART feature set) is to protect user data and minimize the likelihood of unscheduled system downtime that may be caused by predictable degradation and/or fault of the device. By monitoring and storing critical performance and calibration parameters, SMART feature set devices attempt to predict the likelihood of near-term degradation or fault condition. Providing the host system the knowledge of a negative reliability condition allows the host system to warn the user of the impending risk of a data loss and advise the user of appropriate action. Support of this feature set is indicated in the IDENTIFY DEVICE data.

Devices that implement the PACKET feature set shall not implement the SMART feature set.

4.21.2 Device SMART data structure

SMART feature set capability and status information for the device are stored in the device SMART data structure. The off-line data collection capability and status data stored herein may be useful to the host if the SMART EXECUTE OFF-LINE IMMEDIATE command is implemented (see 7.53.5).

4.21.3 Background data collection

Collection of SMART data in the background shall have no impact on device performance. The SMART data that is collected or the methods by which data is collected in this mode may be different than those in the off-line data collection mode for any particular device and may vary from one device to another.

4.21.4 Off-line/Captive mode data collection

The device shall use the off-line or captive mode for data collection and self-test routines that have an impact on performance if the device is required to respond to commands from the host while performing that data collection. This impact on performance may vary from device to device. The data that is collected or the methods by which the data is collected in this mode may be different than those in the background data collection mode for any particular device and may vary from one device to another.

4.21.5 Threshold exceeded condition

This condition occurs when the device’s SMART reliability status indicates an impending degrading or fault condition.

4.21.6 SMART feature set commands

These commands use a single command code and are differentiated from one another by the value placed in the Feature field (see 7.53).

If the SMART feature set is implemented, the following commands shall be implemented:

a) SMART DISABLE OPERATIONS
b) SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE
c) SMART ENABLE OPERATIONS
d) SMART RETURN STATUS

If the SMART feature set is implemented, the following commands are optional:

a) SMART EXECUTE OFF-LINE IMMEDIATE
b) SMART READ DATA
c) SMART READ LOG
d) SMART WRITE LOG

4.21.7 SMART operation with power management modes

When used with a host that has implemented the Power Management feature set, a SMART enabled device should automatically save the device accumulated SMART data upon receipt of an IDLE IMMEDIATE, STANDBY IMMEDIATE, or SLEEP command or upon return to an Active or Idle mode from a Standby mode (see 7.53.6).

If a SMART feature set enabled device has been set to use the Standby timer, the device should automatically save the device accumulated SMART data prior to going from an Idle mode to the Standby mode or upon return to an Active or Idle mode from a Standby mode.

A device shall not execute any routine to automatically save the device accumulated SMART data while the device is in a Standby or Sleep mode.

4.21.8 SMART device error log reporting

Logging of reported errors is an optional SMART feature. If error logging is supported by a device, it is indicated in byte 370 of the SMART READ DATA command response and IDENTIFY DEVICE DATA word 84 bit 0. If error logging is supported, the device shall provide information on the last five errors that the device reported as described in the SMART READ LOG command (see 7.53.7). The device may also provide additional vendor specific information on these reported errors.

If error logging is supported, it shall not be disabled when SMART is disabled. Error log information shall be gathered when the device is powered-on except that logging of errors when in a reduced power mode is optional. If errors are logged when in a reduced power mode, the reduced power mode shall not change. Disabling SMART shall disable the delivering of error log information via the SMART READ LOG command.

The SMART error logs are: the Summary Error Log, the Comprehensive Error Log and the Extended Comprehensive Error Log.

4.22 Software Settings Preservation (SSP)

When a device is enumerated, software configures the device using SET FEATURES and other commands. These software settings are often preserved across software reset but not necessarily across hardware reset. In Parallel ATA, only commanded hardware resets occur, thus legacy software only reprograms settings that are cleared for the particular type of reset it has issued. In Serial ATA, COMRESET is equivalent to hard reset and a non-commanded COMRESET may occur if there is an asynchronous loss of signal. Since COMRESET is equivalent to hardware reset, in the case of an asynchronous loss of signal some software settings may be lost without legacy software knowledge. In order to avoid losing important software settings without legacy driver knowledge, the software settings preservation ensures that the value of important software settings is maintained across a COMRESET. Software settings preservation may be enabled or disabled using SET FEATURES with a Count field of 06h. If a device supports software settings preservation, the feature shall be enabled by default. See SATA 2.6 for more information.

The software settings that shall be preserved across COMRESET are listed below. The device is only required to preserve the indicated software setting if it supports the particular feature/command the setting is associated with.

Table 14 — Preserved Feature Sets and Settings

Capability	Preserved Setting
INITIALIZE DEVICE PARAMETERS	- Obsolete Command -
Security Mode	Preserved the Current Security State as defined in the security state transition diagram
Standby Timer	Preserved the setting for the standby timer
Read/Write Stream Error Logs	Preserve the contents of these logs
Security Unlock Counter	Preserve the contents of the failed attempts counter
SET MAX ADDRESS (EXT)	Current maximum address
Write Cache enable/disable	Enabled or DIsabled
Transfer Mode	Preserved the PIO, DMA and UDMA transfer mode settings
Advanced Power Mode	Enabled or Disabled
Read look-ahead	Enabled or Disable
Release Interrupt	Enabled or Disabled
Service Interrupt	Enabled or DIsabled
Reverting to Power-On Defaults	Enabled or Disabled
Multiple Mode	Preserve the block size from the last set multiple mode

4.23 Streaming feature set

4.23.1 Streaming feature set overview

The Streaming feature set is an optional feature set that allows a host to request delivery of data within an allotted time, placing a priority on the time to transfer the data rather than the integrity of the data. This feature set is defined to satisfy the requirements for AV type applications. While processing commands in the Streaming feature set, devices may execute background tasks so long as the specified command processing time limits for the commands are met. The Streaming feature set only defines commands that use 48-bit addressing.

Commands in the Streaming feature set are prohibited from use in devices that implement the PACKET feature set.

a) CONFIGURE STREAM
b) READ STREAM EXT
c) WRITE STREAM EXT
d) READ STREAM DMA EXT
e) WRITE STREAM DMA EXT
f) READ LOG EXT
g) WRITE LOG EXT
h) READ LOG DMA EXT
i) WRITE LOG DMA EXT

Editor’s Note 7: The introductory sentence for this list was removed by comment review in e07139. It said “A device that implements the streaming feature set shall implement these commands:” I am not sure why we removed this...

Support of the Streaming feature set is indicated in IDENTIFY DEVICE data word 84 bit 4.

4.23.2 Streaming commands

4.23.2.1 Streaming command overview

The CONFIGURE STREAM command is used by a host to define the properties of a stream to assist the device in configuring its caching for best performance. The Stream Identifier (Stream ID) in the CONFIGURE STREAM command is used by the host to specify the number of the stream to which the operating parameters in the command apply. Up to a total of eight streams may be configured. The Stream ID may be used by the device to configure its resources to support the streaming requirements of the AV content.

A host may use both READ STREAM and WRITE STREAM commands to access any stream.

The Default Command Completion Time Limit (Default CCTL) provides a method for a host to set the time limit for a device to process READ STREAM and WRITE STREAM commands (see 7.9.3.4). If the host does not use a CONFIGURE STREAM command to set Default CCTL, the host may specify the time limit for command processing by using the Command Completion Time Limit (CCTL) in each READ STREAM or WRITE STREAM command, where the time limit is effective for that command only (see 7.37.3.2). Each stream may be configured for with different command completion time limits by each CONFIGURE STREAM command.

The READ STREAM and WRITE STREAM commands may access any user LBA on a device. These commands may be interspersed with commands not in the Streaming feature set, but, if commands not in the Streaming feature set are interspersed with READ STREAM or WRITE STREAM commands, there may be an impact on performance due to the unknown time required to complete the commands not in the Streaming feature set.

READ STREAM or WRITE STREAM commands should be issued using a specified minimum number of logical sectors to be transferred per command. This number is the Stream Minimum Request Size indicated in IDENTIFY DEVICE data word 95. The transfer length of a request should be a multiple of the minimum number of logical sectors per transfer.

4.23.2.2 Flush bit

The Flush bit (Flush) in the WRITE STREAM commands (see 7.75.3.3) specifies that the device flushes all volatile cache data for the specified stream to the media before command completion. If a host requests flushes at times other than the end of each Allocation Unit ((see 7.9.3.5), streaming performance may be degraded. The SET FEATURES command to enable and disable caching (see 7.48.4) may affect caching for commands in the Streaming feature set.

4.23.2.3 Not Sequential bit

The Not Sequential bit (NS) in the READ STREAM commands (see 7.37.3.4) specifies that the next READ STREAM command with the same Stream ID may not be sequential in LBA space. This information helps the device with pre-fetching decisions.

4.23.2.4 Read Continuous bit

The Read Continuous bit (RC) in the READ STREAM commands (see 7.37.3.3) specifies that the device shall transfer the requested amount of data to the host within the time specified by Default CCTL or CCTL even if an error occurs. The data sent to the host by the device in an error condition is vendor specific.

4.23.2.5 Write Continuous bit

The Write Continuous bit (WC) in the WRITE STREAM commands (see 7.75.3.2) specifies that the device shall transfer the requested amount of data to the host within the time specified by Default CCTL or CCTL even if an error occurs. If the device is unable to resolve an error within the time specified by Default CCTL or CCTL, the erroneous section on the media may be unchanged or may contain undefined data. A future read of this area may not report as an error, even though the data is erroneous.

4.23.2.6 Handle Streaming Error

The Handle Streaming Error feature allows a device to continue its error recovery sequence for a stream from where it left off earlier. The Handle Streaming Error feature is vendor-specific and may be always enabled in devices conforming to this standard.

4.23.2.7 Streaming Logs

A device implementing the Streaming feature set shall implement a Read Stream Error Log (see A.11) and a Write Stream Error Log (see A.16). These logs are accessed by a host via the READ LOG EXT command (see 7.29).

The Read Stream and Write Stream Error logs are 512 bytes in length. The Read Stream Error log retains the last 31 errors that occurred during any READ STREAM command. The Write Stream Error log retains the last 31 errors that occurred during any WRITE STREAM command. The information included in the error logs is volatile and is not maintained by a device after the device processes a power-on reset or a hard reset, or after the device enters the Sleep mode.

4.24 Tagged Command Queuing (TCQ) feature set

4.24.1 Overview

The optional TCQ feature set allows devices that require extended command time to perform a release so that the other device on the bus may be used. See the appropriate transport standard for the transport specific elements of service and release.

When the TCQ feature set is supported, the following commands shall be implemented:

a) NOP
b) READ DMA QUEUED
c) SERVICE
d) WRITE DMA QUEUED

When the TCQ feature set and the 48-bit feature set are both supported, the following commands shall be implemented:

a) READ DMA QUEUED EXT
b) WRITE DMA QUEUED EXT
c) WRITE DMA QUEUED FUA EXT

For the READ DMA QUEUED, READ DMA QUEUED EXT, WRITE DMA QUEUED, WRITE DMA QUEUED EXT, and WRITE DMA QUEUED FUA EXT commands, the device may perform a release. If the device is ready to complete execution of one of these commands, the device may complete the command without performing a release. If the device is not ready to complete execution of the command, the device may perform a release and complete the command via a service request.

If a device has an outstanding command and has performed a release, the device indicates that service is required only when the device is selected. If there is more than one device in a domain that has an outstanding command and has performed a release, then the host polls each device to determine if it is requesting service. To minimize host processor overhead, an application client may initiate hardware polling in a host adapter that supports it by issuing the NOP command with the NOP Auto Poll subcommand (see 7.21).

An application client may test whether or not the host adapter supports hardware polling by issuing the NOP command with the NOP Auto Poll subcommand and checking the response as follows:

a) If the host adapter does not support hardware polling, it transmits the NOP command with the NOP Auto Poll subcommand to the device and returns the response from the device. The device terminates the command with the ABRT bit set to one and the ERR bit set to one. (see 7.21); and

NOTE 2 — This flushes the volatile write cache to the non-volatile media, but does not abort any TCG queued commands (see 7.21).

b) If the host adapter does support hardware polling, the host adapter does not transmit the command to the device. Instead, it initiates hardware polling and generates a response with the ABRT bit set to one and the ERR bit cleared to zero (see 7.21).

4.24.2 Queueing

The queueing allows the host to issue concurrent commands to the same device. The queue contains all commands for which command acceptance has occurred but command completion has not occurred. If a queue exists when a non-queued command is received (except NOP Auto Poll), the non-queued command shall be command aborted and the commands in the queue shall be discarded. The ending status shall be command aborted and the results are indeterminate.

The maximum queue depth supported by a device shall be indicated in IDENTIFY DEVICE data word 75 or IDENTIFY PACKET DEVICE data word 75.

A queued command shall have a Tag provided by the host in the Count field to uniquely identify the command. When the device restores command parameters during the execution of the SERVICE command, this Tag shall be restored so that the host may identify the command for which status is being presented. A Tag value may be any value between 0 and 31, regardless of the queue depth supported. If a queued command is issued with a Tag value that is identical to the Tag value for a command already in the queue, the device shall stop processing commands in the queue and remove them from the queue. The ending status shall be command aborted and the results are indeterminate. If any error occurs, the device shall stop processing commands in the queue and remove them from the queue.

When the device is ready to continue the processing of a released command, the device requests service by setting SERV to one. SERV shall remain set until all commands ready for service have been serviced. When the device is ready to continue the processing of a released command the device requests service by setting SERV to one. SERV shall remain set until all commands ready for service have been serviced.

When the device receives a new command while queued commands are ready for service, the device shall execute the new command per the protocol for the new command. If the queued commands ready for service still exist at command completion of this command, SERV remains set to one.

When reading status at command completion of a command, the host should check the SERV bit since the SERV bit may be set because the device is ready for service associated with another command.

4.25 Trusted Computing feature set

The Trusted Computing feature set provides a interface between a horizontal security product embedded in devices whose behavior may be authorized via interaction with a trusted host system.

These commands are prohibited for use by devices that implement the PACKET feature set.

This feature set defines two data-in commands (TRUSTED RECEIVE and TRUSTED RECEIVE DMA) and two data-out commands (TRUSTED SEND and TRUSTED SEND DMA). These commands provide for variable length data transfers.

TRUSTED SEND and TRUSTED SEND DMA may be used interchangeably. They only differ by the type of data transport protocol used (PIO vs. DMA). Similarly, TRUSTED RECEIVE and TRUSTED RECEIVE DMA are interchangeable.

The IDENTIFY DEVICE command indicates whether or not this feature set is supported.

The DEVICE CONFIGURATION OVERLAY (SET) command offers a mechanism to remove support for the feature set.

The data streams and subsequent actions resulting from these commands are defined by the security protocol identified in the command parameters. These protocols may be defined by groups outside of T10 and T13. The intent is to standardize the data content so it is identical across both ATA and SCSI interfaces.

4.26 Write-Read-Verify feature set

The optional Write-Read-Verify feature set allows a host to control Read After Write behavior in a device.

This feature set is available for all devices.

To enable or disable the feature of Write/Read/Verify, the host may execute a SET FEATURES command with one of two subcommand codes.

It is possible that the device may experience a performance degradation when the Write-Read-Verify feature is enabled.

These commands are affected by this feature:

a) WRITE DMA
b) WRITE DMA EXT
c) WRITE DMA FUA EXT
d) WRITE DMA QUEUED
e) WRITE DMA QUEUED EXT
f) WRITE DMA QUEUED FUA EXT
g) WRITE MULTIPLE
h) WRITE MULITIPLE EXT
i) WRITE MULTIPLE FUA EXT
j) WRITE SECTOR(S)
k) WRITE SECTOR(S) EXT

See 7.48.10 for a description of device behavior when this feature set is supported and enabled.

The IDENTIFY DEVICE or IDENTIFY PACKET DEVICE command shall reflect the supported and enabled or disabled state of the feature set.

If the volatile write cache is enabled, the device may report status to the Host before writing the data to the non-volatile media. When the device's volatile write cache is enabled, the device may report "good" status to the host even if the data is in the device volatile write cache and not written and verified to the non-volatile media. This is important to reduce the performance degradation when the Write-Read-Verify function is enabled.

If the Write-Read-Verify feature is disabled, or if the device has already verified the maximum number of logical sectors configured for this feature set, then no further action shall be taken.

After the device has written the sectors to the non-volatile media, it shall attempt to read (Verify) those same sectors. A read from the non-volatile media shall be performed before verification. The verification of sectors is defined as vendor specific.

If an unrecoverable error condition is encountered by the device during the write, read, or verify operation, the device shall set the DF bit. See 6.1.3 for details on the DF bit operation.

5 ATA Protocols

ATA Protocols are fully described in the transport documents. The protocols listed here shall be implemented by all transports that use ATA8-ACS commands. The following list of protocols are described in ATA8-AAM and the implementation is described in the applicable transport standard.

a) Non-data Command Protocol
b) PIO data-in Command Protocol
c) PIO data-out Command Protocol
d) DMA Command Protocol
e) Packet Command Protocol
f) DMA Queued Command Protocol
g) Execute Device Diagnostic Command Protocol
h) Device Reset Command Protocol

6 Status and Error fields

6.1 Status field

6.1.1 Busy (BSY) bit

Status bit 7. The BSY bit is transport dependent. Refer to the applicable transport standard for the usage of the BSY bit.

6.1.2 Error (ERR) bit

Status bit 0. The ERR bit shall be set to one if any bit in the Error field (see 6.2) is set to one.

6.1.3 Device Fault (DF) bit

Status bit 5. If the device enters a condition where continued operation may affect user data integrity (e.g., failure to spin-up properly, or no spares remaining for reallocation.), the device shall set the DF bit to one and no longer accept commands. This condition is only cleared by power cycling the drive. Once the DF bit has been cleared it may remain clear until a command that affects user data integrity is received by the device.

6.1.4 Device Ready (DRDY) bit

Status bit 6. The DRDY bit is transport dependent. Refer to the applicable transport standard for the usage of the DRDY bit.

6.1.5 Data Request (DRQ) bit

Status bit 4. The DRQ bit is transport dependent. Refer to the appropriate transport standard for the usage of the DRQ bit.

6.1.6 Deferred Write Error (DWE) bit

Status bit 4. The DWE bit shall be set to one if an error was detected in a deferred write to the media for a previous WRITE STREAM DMA EXT or WRITE STREAM EXT command. This error is from a previously issued command. If the DWE bit is set to one, the location of the deferred error is only reported in the Write Stream error log.

6.1.7 Service (SERV) bit

Status bit 4. The SERV bit shall be cleared to zero when no other queued command is ready for service. the SERV bit shall be set to one when another queued command is ready for service. The SERV bit shall be set to one when the device has prepared this command for service. If TCQ is not supported, the SERV bit is command specific.

6.1.8 Stream Error (SE) bit

Status bit 5. The SE bit is set to one if an error occurred during the processing of a command in the Streaming feature set and either the Read Continuous (RC) bit is set to one in a READ STREAM command (see 7.37.3.3) or the Write Continuous (WC) bit is set to one in a WRITE STREAM command (see 7.75.3.2). When the SE bit is set to one, the value returned in the LBA bits (47:0) contains the address of the first logical sector in error, and the Count field contains the number of consecutive logical sectors that may contain errors. If the RC bit is set to one in a READ STREAM command or the WC bit is set to one a WRITE STREAM command, and ICRC, UNC, IDNF, ABRT, or CCTO is set to one (see 6.3), then the SE bit is set to one, the ERR bit is cleared to zero, and the error information (e.g., bits set in the Error field) is saved in the appropriate Read Stream or Write Stream Error log.

6.1.9 Transport Dependent (TD)

All bits and fields that are labelled transport dependent are defined in the transport standards. For example, ATA/ATAPI-7 defines the status bits BSY, DRDY, and DRQ. These bits are documented in the transport standards. Although all of the commands in this standard use BSY=0, DRDY=1 and DRQ=0 to specify that the device is ready to accept a command and to specify that a command is complete, they are processed differently in the various transport standards.

6.2 Error field

6.2.1 Abort (ABRT) bit

Error bit 2. An ABRT bit set to one indicates the command was aborted. An ABRT bit cleared to zero indicates the command was not aborted.

Each command description indicates the conditions under which the command is terminated with the ABRT bit set to one (e.g., the device is not able to complete the action requested by the command). ABRT is set to one when the device chooses not to return IDNF (see 4.10.3 and 6.2.4). ABRT is set to one if an unsupported command is received (see 7.new).

6.2.2 Command Completion Time Out (CCTO) bit

Error bit 0. The CCTO bit shall be set to one if a Command Completion Time Limit Out error has occurred.

6.2.3 End of Media (EOM) bit

Error bit 1. The operation of the EOM bit is specific to the SCSI command set implemented by ATAPI devices.

6.2.4 ID Not Found (IDNF) bit

Error bit 4. The IDNF bit shall be set to one if a user-accessible address was not found. The IDNF bit shall be set to one if an address outside of the range of user-accessible addresses is requested when command aborted is not returned (see 4.11.3 and 6.2.1).

6.2.5 Illegal Length Indicator (ILI) bit

Error bit 0. The operation of the ILI bit is specific to the SCSI command set implemented by ATAPI devices.

6.2.6 Interface CRC (ICRC) bit

Error bit 7. The ICRC bit shall be set to one if an interface CRC error has occurred during an Ultra DMA data transfer. The content of the ICRC bit may be applicable to Multiword DMA and PIO data transfers.

6.2.7 Media Error (MED) bit

Error bit 0. The MED bit shall be set to one if a media error is detected.

6.2.8 Sense Key field

Error bits (7:4) The operation of this four bit field is specific to the SCSI command set implemented by ATAPI devices.

6.2.9 Uncorrectable Error (UNC) bit

Error bit 6. The UNC bit shall be set to one if data is uncorrectable.

6.2.10 Attempted Partial Range Removal (APRRR) bit

Error bit 0. The APRRR bit shall be set to one if the REMOVE LBA(S) FROM NV CACHE PINNED SET command (see 7.20.9) attempted to unpin part of a previously defined NV Cache command range.

6.2.11 Insufficient NV Cache space (INCS) bit

Error bit 0. The INCS bit shall be set to one of there is not enough NV Cache to satisfy the ADD LBA(S) TO NV CACHE PINNED SET command (see 7.20.3)

6.2.12 Insufficient LBA Range Entries Remaining (ILRER) bit

Error bit 1. The device has run out of space to store LBA ranges for ADD LBA(S) TO NV CACHE PINNED SET command (see 7.20.3).

6.3 Interrupt Reason field

6.3.1 Command/Data (C/D) bit

Count bit 0. The C/D bit shall be cleared to zero if the transfer is data, otherwise the C/D bit shall be set to one.

6.3.2 Input/Output (I/O) bit

Count bit 1. The I/O bit shall be cleared to zero if the transfer is to the device (O). Shall be set to one if the transfer is to the host (I).

6.3.3 NCQ Tag field

Count bits (7:3). If the device supports NCQ, the NCQ Tag field shall contain the NCQ Tag value for the NCQ command. A NCQ Tag value may be any value that does not exceed IDENTIFY DEVICE data word 75 (see 7.16.7.30).

6.3.4 Release (REL) bit

Count bit 2. The REL bit shall be set to one if a command has been accepted but not completed and the device is ready to accept another command.

6.3.5 Tag field

Count bits (7:3). If the TCQ feature set is enabled then this field contains the Tag value for the command. A Tag value may be any value between 0 and 31 regardless of the queue depth supported.

7 Command Descriptions

7.1 Overview

7.1.1 Introduction

In ATA/ATAPI-7, commands were described by indicating how Features, Sector Count, LBA Low, LBA Mid, LBA High, Device, and Command registers are initialized. The ATA command sets have become popular on many transports in addition to the APT (Parallel) transport. ATA8-ACS has abstracted the parameter and return values into a data structure for each command. This allows any transport that uses ATA8-ACS to provide a mapping of the values in the abstracted data structure to the elements of the transport that accept command parameters and return command completion values.

The basic structure of an ATA8 command has Feature, Count, LBA, Device and Command fields. These fields all reside in the Command Structure. Fields length are fixed at either 8, 16, or 48 bits. When a command only uses 8 bits of a 16 bit field, or 28 bits of a 48 bit field, the unused bits are marked “shall be cleared to zero”.

ATA8-ACS describes the ATA command set in a transport independent fashion. Each command is defined by a series of subclauses as described in 7.1.2 through 7.1.9.

7.1.2 Command Name - Command Code [/Feature Code], Command Protocol

The heading for each command starts with the name of the command. The name is followed by “-” and then the command code and protocol used to execute the command.

An example heading reads:

READ SECTOR(S) - 20h, PIO data-in

The name of the command is “READ SECTOR(S)”. The command code is 20h. The protocol used to transfer the data is PIO data-out.

Protocols are generically defined in ATA8-AAM. The transport protocol standards define how they support each of the protocols.

7.1.3 Feature Set

The feature set subclause for each command lists the feature sets (see clause 4) which list this command as optional or mandatory.

A sample feature set section reads:

Feature Set

This command is mandatory for all devices implementing the General feature set.

7.1.4 Description

Each command starts with a description. This description contains information regarding the feature set, if the command is optional or mandatory, and any prerequisites that may be required before the command is executed. A sample description reads:

Description

This command reads from 1 to 256 logical sectors as specified in the Count field. A count of 0 requests 256 logical sectors. The transfer shall begin at the logical sector specified in the LBA field.

7.1.5 Inputs

7.1.5.1 Inputs for 28-bit Read/Write Commands

All commands require inputs. Inputs are specified in the Command Structure. A generic command structure for 28-bit commands is listed below. The description field shows how the fields mapped to ATA/ATAPI-7 registers.

Word	Name	Description
00h	Feature	In ATA/ATAPI-7 this was the Feature register. Each transport standard shows how the Feature field is mapped for proper functionality. The transport documents also show how 28-bit commands are mapped differently from 48-bit commands.
01h	Count	In ATA/ATAPI-7 this was the Sector Count register. Each transport standard shows how the Count field is mapped for proper functionality. The transport documents also show how 28-bit commands are mapped differently from 48-bit commands.
02h	LBA	(MSB) In ATA/ATAPI-7 this was the LBA Low, LBA Mid, LBA High, and Device (3:0) Registers. For many commands this is the address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero for 28 bit commands. Each transport defines how these 48-bits are mapped to the appropriate fields or registers.
03h		
04h		(LSB)
05	Device	In ATA/ATAPI-7 this was the Device register. This standard includes bits 3:0 of the ATA/ATAPI-7 Device register as a part of the LBA field. Each transport standard shows how the Device field bits 7:4 are mapped for proper functionality
	Command	Bit 7:0 - The command number goes here.

The Feature, Count, and Command fields are 16 bit fields where bits 15:8 shall be cleared to zero. The LBA field is 48 bits where bits 47:28 shall be cleared to zero. The command field shall always be represented as an 8-bit value.

7.1.5.2 Inputs for 48-bit Read/Write Commands

All commands require inputs. Inputs are specified in the Command Structure. A generic command structure for 48-bit commands is listed below. The description field shows how the fields mapped to ATA/ATAPI-7 registers.

Word	Name	Description
00h	Feature	In ATA/ATAPI-7 this was the Feature Current and Previous registers. Each transport standard shows how the Feature field is mapped for proper functionality.
01h	Count	In ATA/ATAPI-7 this was the Count Current and Previous registers. Each transport standard shows how the Count field is mapped for proper functionality.
02h	LBA	(MSB) In ATA/ATAPI-7, this are the LBA Low, LBA Mid, LBA High both Current and Previous registers. For many commands this is the address of first logical sector to be transferred. Each transport defines how these 48-bits are mapped to the appropriate fields or registers.
03h		
04h		(LSB)
05h	Device	In ATA/ATAPI-7 this was the Device register. Each transport standard shows how the Device field is mapped for proper functionality.
	Command	The command number goes here.

The Feature, and Count, fields shall be 16 bit values; the LBA field shall be a 48-bit value. The command field shall always be represented as an 8-bit value.

7.1.6 Normal Outputs

Many of the commands have a Normal Outputs description that looks exactly like the one shown below. A command with Normal Outputs has no error, this field is reserved in every command. Count and LBA may be reserved. In some commands these fields have return parameters on successful command completion. The status field shows the Device Fault bit and the Error bit. Bits 7,6, and 3 are marked Transport Dependent in many of the Normal Outputs. These bits correspond to Busy, Device Ready, and Device Request in ATA/ATAPI-7 and are transport specific in their operation.

Word	Name	Description
00h	Error	Reserved
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Status	Bit Description 15:8 Reserved 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2 N/A 1 N/A 0 Error - See 6.1.2

7.1.7 Error Outputs

The Error Outputs subclause shows the Error, Count, LBA and Status fields. An Error Output occurs when a bit in the Status field indicates that an error has occurred. Examples of status bits that indicate and error has occurred include Error, Device Fault, Stream Error, etc. If the Error bit is set to one, the Error field shall indicate the type of Error that occurred.

Word	Name	Description
00h	Error	Bit / Description 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9 5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1 Obsolete 0 Obsolete
01h	Count	Reserved
02h	LBA	(MSB) Address of first unrecoverable error.
03h		Bits 47:28 shall be cleared to zero.
04h		(LSB)
05h	Status	Bit / Description 15:8 Reserved 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

7.1.8 Input Data Structure

Some commands, such as IDENTIFY DEVICE or DEVICE CONFIGURATION SET, return a data structure to the host. This data structure is referred to as an input data structure and is documented following the Error Outputs subclause.

7.1.9 Output Data Structure

Some commands, such as DEVICE CONFIGURATION SET or SECURITY SET PASSWORD, accept a data structure from the host. This data structure is referred to as an Output Data Structure and is documented following the Error Outputs subclause.

7.1.10 Unsupported commands

The host should not issue commands that are indicated as not supported. If the device receives an unsupported command, it shall respond with command aborted as described in table 139.

7.2 CFA ERASE SECTORS - C0h, non-data

7.2.1 Feature Set

This command is mandatory for devices implementing the CFA feature set. This command code is Vendor Specific for devices not implementing the CFA feature Set.

7.2.2 Description

This command pre-erases and conditions from 1 to 256 logical sectors as specified in the Count field. This command should be issued in advance of a CFA WRITE SECTORS WITHOUT ERASE or a CFA WRITE MULTIPLE WITHOUT ERASE command to increase the execution speed of the write operation.

7.2.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	Number of logical sectors to be erased. A value of 00h specifies that 256 logical sectors are to be erased.
02h	LBA	(MSB) Address of first logical sector to be erased. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 24h

7.2.4 Normal Outputs

See table 85.

7.2.5 Error Outputs

See table 106.

7.3 CFA REQUEST EXTENDED ERROR CODE - 03h, non-data

7.3.1 Feature Set

This command is mandatory for devices implementing the CFA feature set.

7.3.2 Description

This command provides an extended error code which identifies the cause of an error condition in more detail than is available with Status and Error field values. The CFA REQUEST EXTENDED ERROR CODE command shall return an extended error code (see table 15) if the previous command completed with an error or a no error detected extended error code if the previous command completed without error.

7.3.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 03h

7.3.4 Normal Outputs

See table 84.

Table 15 — Extended error codes

Extended error code	Description
00h	No error detected / no additional information
01h	Self-test passed
03h	Write / Erase failed
05h	Self-test or diagnostic failed
09h	Miscellaneous error
0Bh	Vendor specific
0Ch	Corrupted media format
0D-0Fh	Vendor specific
10h	ID Not Found / ID Error
11h	Uncorrectable ECC error
14h	ID Not Found
18h	Corrected ECC error
1Dh, 1Eh	Vendor specific
1Fh	Data transfer error / command aborted
20h	Invalid command
21h	Invalid address
22-23h	Vendor specific
27h	Write protect violation
2Fh	Address overflow (address too large)

Table 15 — Extended error codes

Extended error code	Description (Continued)
30-34h	Self-test or diagnostic failed
35h, 36h	Supply or generated voltage out of tolerance
37h, 3Eh	Self-test or diagnostic failed
38h	Corrupted media format
39h	Vendor specific
3Ah	Spare sectors exhausted
3Bh 3Ch, 3Fh	Corrupted media format
3Dh	Vendor specific
All other values	Reserved

7.3.5 Error Outputs

See table 108.

7.4 CFA TRANSLATE SECTOR - 87h, PIO data-in

7.4.1 Feature Set

This command is mandatory for devices implementing the CFA feature set. This command code is Vendor Specific for devices not implementing the CFA feature Set.

7.4.2 Description

This command provides information related to a specific logical sector. The data indicates the erased or not erased status of the logical sector, and the number of erase and write cycles performed on that sector. Devices may return zero in fields that do not apply or that are not supported by the device.

7.4.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h	LBA	(MSB) Logical sector Address.
03h		Bits 47:28 shall be cleared to zero.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 87h

7.4.4 Normal Outputs

See table 87.

7.4.5 Output Data Structure

512 bytes of data are transferred to the host (see table 16).

Table 16 — CFA TRANSLATE SECTOR data

Bytes	Description
00h-03h	Obsolete
04h	LBA bits (23:16)
05h	LBA bits (15:8)
06h	LBA bits (7:0)
07h-12h	Reserved
13h	Logical sector erased flag (FFh = erased; 00h = not erased)
14h-17h	Reserved
18h	Logical sector write cycles count bits (23:16)
19h	Logical sector write cycles count bits (15:8)
1Ah	Logical sector write cycles count bits (7:0)
1Bh-1FFh	Reserved

7.4.6 Error Outputs

See table 108.

7.5 CFA WRITE MULTIPLE WITHOUT ERASE - CDh, PIO data-out

7.5.1 Feature Set

This command is mandatory for devices implementing the CFA feature set.

7.5.2 Description

This command is similar to the WRITE MULTIPLE command. Interrupts are not generated on every logical sector, but on the transfer of a block that contains the number of logical sectors defined by the SET MULTIPLE MODE.

Command execution is identical to the WRITE MULTIPLE operation except that the logical sectors are written without an implied erase operation. The logical sectors should be pre-erased by a preceding CFA ERASE SECTORS command.

If bit 8 of IDENTIFY DEVICE data word 59 is cleared to zero, and a CFA WRITE MULTIPLE WITHOUT ERASE command is received by the device, and no successful SET MULTIPLE MODE command has been processed by the device, the device shall return command aborted. A successful SET MULTIPLE MODE command should precede a CFA WRITE MULTIPLE WITHOUT ERASE command.

7.5.3 Inputs

Word	Name	Description	
00h	Feature	N/A	
01h	Count	Number of logical sectors to be transferred. A value of 00h specifies that 256 logical sectors are to be transferred.	
02h	LBA	(MSB) Starting logical sector address to be written. Bits 47:28 shall be cleared to zero.	
03h			
04h		(LSB)	
05h	Device	**Bit**	**Description**
		15	Obsolete
		14	Shall be set to one
		13	Obsolete
		12	Transport Dependent - See 6.1.9
		11:8	Reserved
	Command	7:0	CDh

7.5.4 Normal Outputs

See table 87.

7.5.5 Error Outputs

An unrecoverable error encountered during execution of this command results in the termination of the command. The command returns the address of the logical sector where the first unrecovered error occurred. The amount of data transferred is indeterminate. See table 107.

7.6 CFA WRITE SECTORS WITHOUT ERASE - 38h, PIO data-out

7.6.1 Feature Set

This command is mandatory for device implementing the CFA feature set.

7.6.2 Description

This command is similar to the WRITE SECTORS command. Command execution is identical to the WRITE SECTORS operation except that the logical sectors are written without an implied erase operation. The logical sectors should be pre-erased by a preceding CFA ERASE SECTORS command.

7.6.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	Number of logical sectors to be transferred. A value of 00h specifies that 256 logical sectors are to be transferred.
02h	LBA	(MSB) Starting logical sector address to be written. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	Bit Description 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 38h

7.6.4 Normal Outputs

See table 87.

7.6.5 Error Outputs

An unrecoverable error encountered during execution of this command results in the termination of the command. The command returns the address of the logical sector where the first unrecovered error occurred. The amount of data transferred is indeterminate. See table 107.

7.7 CHECK MEDIA CARD TYPE - D1h, Non-data

7.7.1 Feature Set

This command is mandatory for devices implementing the Media Card Pass Through Command feature set.

7.7.2 Description

The CHECK MEDIA CARD TYPE command allows the host to determine if the device supports the Media Card Pass Through Command feature set. If the Enable bit in the Feature field is set to one, IDENTIFY DEVICE data word 87 bit 3 shall be set to one upon successful command completion.

If the adapter supports the Media Card Pass Through Command feature set and the Enable bit of the Feature field is set to one, the adapter shall process any further Media Card Pass Through Command feature set commands. If the Enable bit is cleared to zero, the adapter shall not interpret the command codes D2 through D4 as the Media Card Pass Through Command feature set commands.

If the adapter does not support the Media Card Pass Through Command feature set, or the host has disabled the Media Card Pass Through Command feature set mode by clearing the Enable bit to zero, the host should not send any further Media Card Pass Through Command feature set commands to the adapter.

7.7.3 Inputs

Word	Name	Description
00h	Feature	**Bit Description** 15:1 N/A 0 Enable - Shall be set to one to enable the Media Card Pass Through Command feature set. Enable shall be cleared to zero to disable the Media Card Pass Through Command feature set.
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 D1h

7.7.4 Normal Outputs

See table 88.

7.7.5 Error Outputs

See table 109.

7.8 CHECK POWER MODE - E5h, Non-data

7.8.1 Feature Set

This command is mandatory for devices implementing the General feature set. This command is mandatory for devices implementing the PACKET feature set when power management is not implemented in the command set transmitted via the PACKET command.

7.8.2 Description

The CHECK POWER MODE command allows the host to determine the current power mode of the device. The CHECK POWER MODE command shall not cause the device to change power or affect the operation of the Standby timer.

NOTE 3 — Elements of the device may be in transition to the reported state.

7.8.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	Bit **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E5h

7.8.4 Normal Outputs

See table 89.

7.8.5 Error Outputs

See table 108.

7.9 CONFIGURE STREAM - 51h, Non-data

7.9.1 Feature Set

This command is Mandatory for devices that implement the Streaming feature set.

7.9.2 Description

The CONFIGURE STREAM command specifies the operating parameters for a stream. A CONFIGURE STREAM command may be issued for each stream that is to be added or removed from the current operating configuration.

7.9.3 Inputs

7.9.3.1 Overview

Word	Name	Description
00h	Feature	**Bit Description** 15 Add/Remove Stream (A/R) – See 7.9.3.2. 14 Obsolete 13:11 Reserved 10:8 Stream ID - See 7.9.3.3. 7:0 Default Command Completion Time Limit (Default CCTL) - See 7.9.3.4.
01h	Count	Allocation Unit – See 7.9.3.5
02h-04h	LBA	Reserved
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 51h

7.9.3.2 Add/Remove Stream (A/R)

If A/R is set to one, then the device shall set the operating parameters for the stream as specified by this command. If A/R is cleared to zero, then the device shall clear the operating characteristics for the Stream ID specified by this command. If A/R is cleared to zero, then the other bits in Features are N/A.

If A/R is set to one, the Stream ID was specified by a previous CONFIGURE STREAM command, and the current CONFIGURE STREAM command completes without error, then the operating parameters specified by the current CONFIGURE STREAM command shall replace the operating parameters specified by the previous CONFIGURE STREAM command for the stream.

7.9.3.3 Stream Identifier (Stream ID)

Stream ID specifies the stream to which the operating parameters in the command apply. There are eight possible streams total. A host may use both READ STREAM and WRITE STREAM commands to access any stream.

7.9.3.4 Default Command Completion Time Limit (Default CCTL)

If CCTL is cleared to zero for a READ STREAM or WRITE STREAM command (see 7.37.3.2) with the Stream ID specified in this command, then the device shall report command completion within

(Default CCTL * (IDENTIFY DEVICE data words (99:98)) microseconds

The device shall measure the time before reporting command completion from command acceptance.

7.9.3.5 Allocation Unit

The Allocation Unit Size specifies the number of logical blocks a device should use for read look-ahead and write cache operations for the stream being configured.

NOTE 4 — Setting the AU Size does not restrict or change command behavior.

7.9.4 Normal Outputs

See table 90.

7.9.5 Error Outputs

ABRT shall be set to one if any of the following are true:

a) The device does not support the requested stream configuration;
b) A/R is cleared to zero and the Feature field contains a Stream ID that has not been sent in a previous CONFIGURE STREAM command;
c) The device does not support the requested Default CCTL; or
d) The device does not support the Streaming feature set.

See table 111 for the definition of other Error Outputs.

7.10 Device Configuration Overlay (DCO)

7.10.1 DCO Overview

Individual Device Configuration Overlay (DCO) feature set commands are identified by the value placed in the Feature field. Table 17 shows these Feature field values.

Table 17 — Device Configuration Overlay Feature field values

Value	Commands
C0h	DEVICE CONFIGURATION RESTORE
C1h	DEVICE CONFIGURATION FREEZE LOCK
C2h	DEVICE CONFIGURATION IDENTIFY
C3h	DEVICE CONFIGURATION SET
00h-BFh, C4h-FFh	Reserved

7.10.2 DEVICE CONFIGURATION FREEZE LOCK - B1h/C1h, Non-data

7.10.2.1 Feature Set

This command is mandatory for devices implementing the Device Configuration Overlay feature set.

7.10.2.2 Description

The DEVICE CONFIGURATION FREEZE LOCK command prevents accidental modification of the Device Configuration Overlay settings. After successful execution of a DEVICE CONFIGURATION FREEZE LOCK command, all DEVICE CONFIGURATION SET, DEVICE CONFIGURATION FREEZE LOCK, DEVICE CONFIGURATION IDENTIFY, and DEVICE CONFIGURATION RESTORE commands shall be aborted by the device. A device shall be in the DCO factory_config state (see 4.14) after processing a power-on reset. A device shall not change Device Configuration Overlay states as the result of processing a hardware reset or a software reset.

7.10.2.3 Inputs

Word	Name	Description
00h	Feature	C1h
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
05h	Command	7:0 B1h

7.10.2.4 Normal Outputs

See table 86.

7.10.2.5 Error Outputs

Abort shall be set to one if the device has completed a previous DEVICE CONFIGURATION FREEZE LOCK command without error since processing the most recent power-on reset. See table 109.

7.10.3 DEVICE CONFIGURATION IDENTIFY - B1h/C2h, PIO Data-in

7.10.3.1 Feature Set

This command is mandatory for devices implementing the Device Configuration Overlay feature set.

7.10.3.2 Description

The DEVICE CONFIGURATION IDENTIFY command returns a 512 byte data structure. The content of this data structure indicates the selectable commands, modes, and feature sets that the device is capable of supporting. If a DEVICE CONFIGURATION SET command has been issued reducing the capabilities, the response to an IDENTIFY DEVICE, IDENTIFY PACKET DEVICE, and other commands shall reflect the reduced set of capabilities, while the DEVICE CONFIGURATION IDENTIFY command shall reflect the entire set of selectable capabilities.

The term ‘is allowed’ indicates that the device may report that a feature is supported.

If the device is not ‘allowed’ to report support, then the device shall not support and shall report that the selected feature is both ‘not supported’ and if appropriate ‘not enabled.’

The format of the Device Configuration Overlay data structure is shown in table 18.

7.10.3.3 Inputs

Word	Name	Description
00h	Feature	C2h
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
05h	Command	7:0 B1h

7.10.3.4 Normal Outputs

See table 86.

7.10.3.5 Error Outputs

Abort shall be set to one if the device has completed a previous DEVICE CONFIGURATION FREEZE LOCK command without error since processing the most recent power-on reset. The device may return error status if an Interface CRC error has occurred. See table 109.

NOTE 5 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer, there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.10.3.6 Input Data

Table 18 — Device Configuration Identify data structure (part 1 of 2)

Word	Content
0	Data structure revision
1	Multiword DMA modes supported 15:3 Reserved 2 1 = Reporting support for Multiword DMA mode 2 and below is allowed 1 1 = Reporting support for Multiword DMA mode 1 and below is allowed 0 1 = Reporting support for Multiword DMA mode 0 is allowed
2	Ultra DMA modes supported 15:7 Reserved 6 1 = Reporting support for Ultra DMA mode 6 and below is allowed 5 1 = Reporting support for Ultra DMA mode 5 and below is allowed 4 1 = Reporting support for Ultra DMA mode 4 and below is allowed 3 1 = Reporting support for Ultra DMA mode 3 and below is allowed 2 1 = Reporting support for Ultra DMA mode 2 and below is allowed 1 1 = Reporting support for Ultra DMA mode 1 and below is allowed 0 1 = Reporting support for Ultra DMA mode 0 is allowed
3-6	Maximum LBA
7	Command set/feature set supported part 1 15 Reserved 14 1 = Reporting support for Write-Read-Verify feature set is allowed 13 1 = Reporting support for SMART Conveyance self-test is allowed 12 1 = Reporting support for SMART Selective self-test is allowed 11 1 = Reporting support for Forced Unit Access is allowed 10 Reserved for ANSI/INCITS TR37-2004 9 1 = Reporting support for Streaming feature set is allowed 8 1 = Reporting support for 48-bit Addressing feature set is allowed 7 1 = Reporting support for Host Protected Area feature set is allowed 6 1 = Reporting support for Automatic acoustic management is allowed 5 1 = Reporting support for READ/WRITE DMA QUEUED commands is allowed 4 1 = Reporting support for Power-up in Standby feature set is allowed 3 1 = Reporting support for Security feature set is allowed 2 1 = Reporting support for SMART error log is allowed 1 1 = Reporting support for SMART self-test is allowed 0 1 = Reporting support for SMART feature set is allowed
8	Serial ATA Command set/feature set supported part 2 15:5 Reserved 4 1 = Reporting support for software settings preservation is allowed 3 1 = Reporting support for asynchronous notification is allowed 2 1 = Reporting support for interface power management is allowed 1 1 = Reporting support for non-zero buffer offsets is allowed 0 1 = Reporting support for the NCQ feature set is allowed
9	Reserved for serial ATA
10-20	Reserved

Table 18 — Device Configuration Identify data structure (part 2 of 2)

Word	Content
21	Command set/feature set supported part 3
	15 1 = Reporting support for NV Cache feature set is allowed
	14 1 = Reporting support for NV Cache Power Management feature set is allowed
	13 1= Reporting support for WRITE UNCORRECTABLE is allowed
	12 1= Reporting of support for the Trusted Computing feature set is allowed
	11 1 = Reporting support for the Free-fall Control feature set is allowed
	10:0 Reserved
22	Command set/feature set supported part 3
	15:0 Reserved
23-207	Reserved
208-254	Vendor Specific
255	Integrity word
	15:8 Checksum
	7:0 Signature

7.10.3.6.1 Word 0: Data structure revision

Word 0 shall contain the value 0002h.

7.10.3.6.2 Word 1: Multiword DMA modes supported

Word 1 bits (2:0) contain the same information as contained in IDENTIFY DEVICE data word 63 or IDENTIFY PACKET DEVICE data word 63 (see 7.16.7.23). Bits (15:3) of word 1 are reserved.

7.10.3.6.3 Word 2: Ultra DMA modes supported

Word 2 bits (6:0) contain the same information as contained in IDENTIFY DEVICE data word 88 or IDENTIFY PACKET DEVICE data word 88 (see 7.16.7.39). Bits (15:7) of word 2 are reserved.

7.10.3.6.4 Words (6:3): Maximum LBA

Words (6:3) define the maximum LBA. This is the highest address accepted by the device in the factory default condition. If no DEVICE CONFIGURATION SET command has been executed modifying the factory default condition, this is the same value as that returned by a READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command.

7.10.3.6.5 Word 7: Command/features set supported part 1

Word 7 bit 0 if set to one indicates that the device is allowed to report support for the SMART feature set.

Word 7 bit 1 if set to one indicates that the device allowed to report support for SMART self-test including the self-test log.

Word 7 bit 2 if set to one indicates that the device is allowed to report support for SMART error logging.

Word 7 bit 3 if set to one indicates that the device is allowed to report support for the Security feature set.

Word 7 bit 4 if set to one indicates that the device is allowed to report support for the Power-up in Standby feature set.

Word 7 bit 5 if set to one indicates that the device is allowed to report support for the READ DMA QUEUED and WRITE DMA QUEUED commands.

Word 7 bit 6 if set to one indicates that the device is allowed to report support for the Automatic Acoustic Management feature set.

Word 7 bit 7 if set to one indicates that the device is allowed to report support for the Host Protected Area feature set.

Word 7 bit 8 if set to one indicates that the device is allowed to report support for the 48-bit Addressing feature set.

Word 7 bit 9 if set to one indicates that the device is allowed to report support for Streaming feature set.

Word 7 bit 10 is reserved for technical report ANSI/INCITS TR37-2004.

Word 7 bit 11if set to one indicates that the device is allowed to report support for Force Unit Access commands.

Word 7 bit 12 if set to one indicates that the device is allowed to report support for SMART Selective self-test, see 7.53.6.6

Word 7 bit 13 if set to one indicates that the device is allowed to report support for SMART Conveyance self-test, see 7.53.6.6.

Word 7 bit 14 if set to one indicates that the device is allowed to report support for the Write-Read-Verify feature set.

7.10.3.6.6 Word 8: Serial ATA Command set/feature set supported part 2

Bits 15:5 Reserved for Serial ATA

Bit 4 if set to one indicates that the device is allowed to report support for software settings preservation.

Bit 3 if set to one indicates that the ATAPI device is allowed to report support for asynchronous notification. See SATA 2.6 for more information.

Bit 2 if set to one indicates that the device is allowed to report support for interface power management requests. See SATA 2.6 for more information.

Bit 1 if set to one indicates that the device is allowed to report support for non-zero buffer offsets for commands in the NCQ feature set.

Bit 0 if set to one indicates that the device is allowed to report support for the NCQ feature set.

7.10.3.6.7 Word 9: Reserved for serial ATA

This word is reserved for Serial ATA.

7.10.3.6.8 Words (20:10) Reserved

7.10.3.6.9 Word 21: Command/features set supported part 3

Word 21 bit 15 if set to one indicates that the device is allowed to support the NV Cache feature set

Word 21 bit 14 if set to one indicates that the device is allowed to support the NV Cache Power Management feature set

Word 21 bit 13 if set to one indicates that the device is allowed to support the WRITE UNCORRECTABLE command.

Word 21, bit 12 if set to one indicates that the device is allowed to report support for the Trusted Computing feature set.

Word 21, bit 11 if set to one indicates that the device is allowed to support the Free-fall Control feature set.

Word 21 bits 10:0 are reserved.

7.10.3.6.10 Word 22: Command/features set supported part 3

Bits 15:0 are reserved.

7.10.3.6.11 Words (207:23): Reserved

7.10.3.6.12 Words (254:208): Vendor Specific

7.10.3.6.13 Word 255: Integrity word

Bits (7:0) of this word shall contain the value A5h. Bits (15:8) of this word shall contain the data structure checksum. The data structure checksum shall be the two’s complement of the sum of all byte in words (154:0) and the byte consisting of bits (7:0) of word 255. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all bytes is zero when the checksum is correct.

7.10.4 DEVICE CONFIGURATION RESTORE - B1h/C0h, Non-data

7.10.4.1 Feature Set

This command is mandatory for devices implementing the Device Configuration Overlay feature set.

7.10.4.2 Description

The DEVICE CONFIGURATION RESTORE command disables any setting previously made by a DEVICE CONFIGURATION SET command and restores the content of the IDENTIFY DEVICE data, IDENTIFY PACKET DEVICE data, and other feature settings to their factory default settings. The results of this action are indicated by the data returned from the Input Data of an DEVICE CONFIGURATION IDENTIFY command.

If DCO RESTORE changes reporting of support for the Security feature set from 'not allowed' to 'allowed', and if DCO IDENTIFY indicates that reporting of that support is 'allowed', then the device shall set the Security state to SEC1, setting IDENTIFY DEVICE data to the values described in table 9, and shall restore the saved Master password and Master Password Identifier; otherwise, the Security state shall not change.

7.10.4.3 Inputs

Word	Name	Description
00h	Feature	C0h
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B1h

7.10.4.4 Normal Outputs

See table 86.

7.10.4.5 Error Outputs

Abort shall be set to one if a Host Protected Area has been set by a SET MAX ADDRESS or SET MAX ADDRESS EXT command, or if DEVICE CONFIGURATION FREEZE LOCK command has been successfully executed since a power-on reset has been processed. See table 109.

7.10.5 DEVICE CONFIGURATION SET - B1h/C3h, PIO Data Out

7.10.5.1 Feature Set

This command is mandatory for devices implementing the Device Configuration Overlay feature set.

7.10.5.2 Description

The DEVICE CONFIGURATION SET command allows a device manufacturer or a personal computer system manufacturer to reduce the set of optional commands, modes, or feature sets supported by a device as indicated by a DEVICE CONFIGURATION IDENTIFY command. The DEVICE CONFIGURATION SET command may modify the data returned by IDENTIFY DEVICE or IDENTIFY PACKET DEVICE. When the IDENTIFY DEVICE data or IDENTIFY PACKET DEVICE data is changed, the device shall respond in a manner consistent with the new data.

If a bit is set in the DCO data transmitted to the device that is not set in the DCO data received from a DEVICE CONFIGURATION IDENTIFY command, no action is taken for that bit.

Modifying the maximum LBA of the device also modifies the address value returned by a READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command.

The format of the DCO data transmitted by the device is described in table 19. The restrictions on changing these bits are also described in 7.10.5.6. If any of the bit modification restrictions described are violated, the device shall return command aborted.

The term ‘is allowed’ indicates that the device may report that a feature is supported.

If the device is not ‘allowed’ to report support, then the device shall not support and shall report that the selected feature is both ‘not supported’ and if appropriate ‘not enabled’.

7.10.5.3 Inputs

Word	Name	Description
00h	Feature	C3h
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
05h	Command	7:0 B1h

7.10.5.4 Normal Outputs

See table 86.

7.10.5.5 Error Outputs

See table 122

7.10.5.6 Output Data Structure

Table 19 — Device Configuration Overlay (DCO) data structure (part 1 of 2)

Word	Content	
0	Data structure revision	
1	Multiword DMA modes supported	
	15:3	Reserved
	2	1 = Reporting support for Multiword DMA mode 2 and below is allowed
	1	1 = Reporting support for Multiword DMA mode 1 and below is allowed
	0	1 = Reporting support for Multiword DMA mode 0 is allowed
2	Ultra DMA modes supported	
	15:7	Reserved
	6	1 = Reporting support for Ultra DMA mode 6 and below is allowed
	5	1 = Reporting support for Ultra DMA mode 5 and below is allowed
	4	1 = Reporting support for Ultra DMA mode 4 and below is allowed
	3	1 = Reporting support for Ultra DMA mode 3 and below is allowed
	2	1 = Reporting support for Ultra DMA mode 2 and below is allowed
	1	1 = Reporting support for Ultra DMA mode 1 and below is allowed
	0	1 = Reporting support for Ultra DMA mode 0 is allowed
3-6	Maximum LBA	
7	Command set/feature set supported part 1	
	15	Reserved
	14	1 = Reporting support for Write-Read-Verify feature set is allowed
	13	1 = Reporting support for SMART Conveyance self-test is allowed
	12	1 = Reporting support for SMART Selective self-test is allowed
	11	1 = Reporting support for Forced Unit Access is allowed
	10	Reserved for ANSI/INCITS TR37-2004
	9	1 = Reporting support for Streaming feature set is allowed
	8	1 = Reporting support for 48-bit Addressing feature set is allowed
	7	1 = Reporting support for Host Protected Area feature set is allowed
	6	1 = Reporting support for Automatic acoustic management is allowed
	5	1 = Reporting support for READ/WRITE DMA QUEUED commands is allowed
	4	1 = Reporting support for Power-up in Standby feature set is allowed
	3	1 = Reporting support for Security feature set is allowed
	2	1 = Reporting support for SMART error log is allowed
	1	1 = Reporting support for SMART self-test is allowed
	0	1 = Reporting support for SMART feature set is allowed
8	Serial ATA Command set/feature set supported part 2	
	15:5	Reserved
	4	1 = Reporting support for software settings preservation is allowed
	3	1 = Reporting support for asynchronous notification is allowed
	2	1 = Reporting support for interface power management is allowed
	1	1 = Reporting support for non-zero buffer offsets is allowed
	0	1 = Reporting support for the NCQ feature set is allowed
9	Reserved for Serial ATA	
10-20	Reserved	

Table 19 — Device Configuration Overlay (DCO) data structure (part 2 of 2)

Word	Content
21	Command set/feature set supported part 3
	15 Reporting support for the NV-Cache feature set is allowed
	14 Reporting support for the NV-Cache Power Management feature set is allowed
	13 1= Reporting support for the WRITE UNCORRECTABLE command is allowed
	12 1= reporting of support for the Trusted Computing feature set is allowed
	11 1 = Reporting support for the Free-fall Control feature set is allows
	10:0 Reserved
22	Command set/feature set supported part 3
	15:0 Reserved
23-207	Reserved
208-254	Vendor Specific
255	Integrity word
	15:8 Checksum
	7:0 Signature

7.10.5.6.1 Word 0: Data structure revision

Word 0 shall contain the value 0002h.

7.10.5.6.2 Word 1: Multiword DMA modes supported

Word 1 bits (15:3) are reserved.

Word 1 bit 2 is cleared to disable support for Multiword DMA mode 2 and has the effect of clearing IDENTIFY DEVICE data word 63 bit 2 or IDENTIFY PACKET DEVICE data word 63 bit 2. This bit shall not be cleared to zero if Multiword DMA mode 2 is currently selected.

Word 1 bit 1 is cleared to disable support for Multiword DMA mode 1 and has the effect of clearing bit 1 to zero in word 63 of the IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data. This bit shall not be cleared to zero if Multiword DMA mode 2 is supported or Multiword DMA mode 1 or 2 is selected.

Word 1 bit 0 shall not be cleared to zero.

7.10.5.6.3 Word 2: Ultra DMA modes supported

Word 2 bits (15:7) are reserved.

Word 2 bit 6 is cleared to zero to disable support for Ultra DMA mode 6 and has the effect of clearing IDENTIFY DEVICE data word 88 bit 6 or IDENTIFY PACKET DEVICE data word 88 bit 6. This bit shall not be cleared to zero if Ultra DMA mode 6 is currently selected.

Word 2 bit 5 is cleared to zero to disable support for Ultra DMA mode 5 and has the effect of clearing IDENTIFY DEVICE data word 88 bit 5 or IDENTIFY PACKET DEVICE data word 88 bit 5. This bit shall not be cleared to zero if Ultra DMA mode 5 is currently selected.

Word 2 bit 4 is cleared to zero to disable support for Ultra DMA mode 4 and has the effect of clearing IDENTIFY DEVICE data word 88 bit 4 or IDENTIFY PACKET DEVICE data word 88 bit 4. This bit shall not be cleared to zero if Ultra DMA mode 5 is supported or if Ultra DMA mode 5 or 4 is selected.

Word 2 bit 3 is cleared to zero to disable support for Ultra DMA mode 3 and has the effect of clearing IDENTIFY DEVICE data word 88 bit 3 or IDENTIFY PACKET DEVICE data word 88 bit3. This bit shall not be cleared to zero if Ultra DMA mode 5 or 4 is supported or if Ultra DMA mode 5, 4, or 3 is selected.

Word 2 bit 2 is cleared to zero to disable support for Ultra DMA mode 2 and has the effect of clearing IDENTIFY DEVICE data word 88 bit 2 or IDENTIFY PACKET DEVICE data word 88 bit 2. This bit shall not be cleared to zero if Ultra DMA mode 5, 4, or 3 is supported or if Ultra DMA mode 5, 4, 3, or 2 is selected.

Word 2 bit 1 is cleared to zero to disable support for Ultra DMA mode 1 and has the effect of clearing IDENTIFY DEVICE data word 88 bit 1 or IDENTIFY PACKET DEVICE data word 88 bit 1. This bit shall not be cleared to zero if Ultra DMA mode 5, 4, 3, or 2 is supported or if Ultra DMA mode 5, 4, 3, 2, or 1 is selected.

Word 2 bit 0 is cleared to zero to disable support for Ultra DMA mode 0 and has the effect of clearing IDENTIFY DEVICE data word 88 bit 0 or IDENTIFY PACKET DEVICE data word 88 bit 0 This bit shall not be cleared to zero if Ultra DMA mode 5, 4, 3, 2, or 1 is supported or if Ultra DMA mode 5, 4, 3, 2, 1, or 0 is selected.

7.10.5.6.4 Words (6:3): Maximum LBA

Words (6:3) define the maximum LBA. This shall be the highest address accepted by the device after execution of the command. When this value is changed, the content of IDENTIFY DEVICE data words (61:60) and (103:100) shall be changed as described in the SET MAX ADDRESS and SET MAX ADDRESS EXT command descriptions to reflect the maximum address set with this command. This value shall not be changed and command aborted shall be returned if a Host Protected Area has been established by the execution of a SET MAX ADDRESS or SET MAX ADDRESS EXT command with an address value less than that returned by a READ NATIVE MAX ADDRESS or READ NATIVE MAX ADDRESS EXT command. Any data contained in the Host Protected Area is not affected.

7.10.5.6.5 Word 7: Command/features set supported part 1

Word 7 bits (15:14) are reserved.

Word 7 bit 14 is cleared to zero to disable support for the Write-Read-Verify feature set and has the effect of clearing word 119 bit 1 and word 120 bit 1.

Word 7 bit 13 is cleared to zero to disable support for the SMART Conveyance self-test. Subsequent attempts to start this test via the SMART EXECUTE OFF-LINE IMMEDIATE command shall cause that command to abort. In addition, the SMART READ DATA command shall clear bit 5 to zero in the “Off-line data collection capabilities” field. If this bit is supported by DEVICE CONFIGURATION SET, then this feature shall not be disabled by bit 1 of word 7.

Word 7 bit 12 is cleared to zero to disable support for the SMART Selective self-test. Subsequent attempts to start this test via the SMART EXECUTE OFF-LINE IMMEDIATE command shall cause that command to abort. In addition, the SMART READ DATA command shall clear bit 6 to zero in the “Off-line data collection capabilities” field. If this bit is supported by DEVICE CONFIGURATION SET, then this feature shall not be disabled by bit 1 of word 7.

Word 7 bit 11 is cleared to zero to disable support for the Force Unit Access commands and has the effect of clearing IDENTIFY DEVICE data word 84 bits (7:6) or IDENTIFY PACKET DEVICE data word 84 bits (7:6).

Word 7 bit 10 is –Reserved for ANSI/INCITS TR37-2004

Word 7 bit 9 is cleared to zero to disable support for the Streaming feature set and has the effect of clearing IDENTIFY DEVICE data or IDENTIFY PACKET DEVICE data word 84 bits 4, 9 and 10 and IDENTIFY DEVICE data or IDENTIFY PACKET DEVICE data word 87 bits 4, 9 and 10 to zero and clearing IDENTIFY DEVICE data or IDENTIFY PACKET DEVICE data words (99:95) and IDENTIFY DEVICE data word 104.

Word 7 bit 8 is cleared to zero to disable support for the 48-bit Addressing feature set and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 83 bit 10, word 86 bit 10, and words (103:100) to zero.

Word 7 bit 7 is cleared to zero to disable support for the Host Protected Area feature set and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 82 bit 10, word 85 bit 10, word 83 bit 8, and word 86 bit 8 to zero. If a Host Protected Area has been established by use of the SET MAX ADDRESS or SET MAX ADDRESS EXT command, these bits shall not be cleared to zero and the device shall return command aborted.

Word 7 bit 6 is cleared to zero to disable for the Automatic Acoustic Management feature set and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 83 bit 9 and word 94 to zero.

Word 7 bit 5 is cleared to zero to disable support for the READ DMA QUEUED and WRITE DMA QUEUED commands and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 83 bit 1and word 86 bit 1 to zero.

Word 7 bit 4 is cleared to zero to disable support for the Power-up in Standby feature set and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 83 bits (6:5) and word 86 bits (6:5) to zero. If Power-up in Standby has been enabled by a jumper, these bits shall not be cleared.

When word 7 bit 3 is cleared to zero, if Security is Enabled, then the device shall return command aborted. When word 7 bit 3 is cleared to zero, if Security is Disabled then any stored Master Password and Master Password Identifier shall be preserved and IDENTIFY DEVICE or IDENTIFY PACKET DEVICE commands shall respond as follows: clear word 82 bit 1 to zero, clear word 85 bit 1 to zero, clear words 89, 90, 92 and 128 to zero. When word 7 bit 3 is set to one, the Security state shall not change.

Word 7 bit 2 is cleared to zero to disable support for the SMART error logging and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 84 bit 0 and 87bit 0 to zero.

Word 7 bit 1 is cleared to zero to disable support for the SMART self-test and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 84 bit 1 and word 87 bit 1to zero. Word 7 bit 1 disables support for the offline, short, extended self-tests (off-line and captive modes). For backward compatibility, if word 7 bits 12 or 13 of are not supported, Word 7 bit 1 may also disable support for conveyance self-test and selective self-test, see 7.53.6.6.

Word 7 bit 0 is cleared to zero to disable support for the SMART feature set and has the effect of clearing IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 82 bit 0 and word 85 bit 0 to zero. If bits (2:1) of word 7 are not cleared to zero or if the SMART feature set has been enabled by use of the SMART ENABLE OPERATIONS command, these bits shall not be cleared and the device shall return command aborted.

7.10.5.6.6 Word 8: Serial ATA Command set/feature set supported part 2

This word enables configuration of command sets and feature sets.

Bits 15:5 Reserved for Serial ATA

Bit 4 is cleared to zero to disable support for software settings preservation and has the effect of clearing word 78 bit 6 and word 79 bit 6 of IDENTIFY DEVICE data or IDENTIFY PACKET DEVICE data to zero. When software settings preservation is disabled, the device shall not preserve any software settings that are normally cleared when the device processes a hardware reset.

Bit 3 is cleared to zero to disable support for asynchronous notification and has the effect of clearing word 78 bit 5 and word 79 bit 5 of IDENTIFY PACKET DEVICE to zero. See SATA 2.6 for more information.

Bit 2 is cleared to zero to disable support for interface power management requests and has the effect of clearing word 76 bit 9, word 78 bit 3, and word 79 bit 3 of IDENTIFY DEVICE or IDENTIFY PACKET DEVICE to zero. See SATA 2.6 for more information.

Bit 1 is cleared to zero to disable support for non-zero buffer offsets for commands in the NCQ feature set and has the effect of clearing word 78 bit 1, word 78 bit 4, word 79 bit 1, and word 79 bit 4 of IDENTIFY DEVICE to zero. See SATA 2.6 for more information.

Bit 0 is cleared to zero to disable support for the NCQ feature set and has the effect of clearing word 76 bit 8, word 78 bit 1, word 78 bit 2, word 78 bit 4, word 79 bit 1, word 79 bit 2, and word 79 bit 4 of IDENTIFY DEVICE data to zero.

7.10.5.6.7 Words 9: Reserved for serial ATA

This word is reserved for Serial ATA use.

7.10.5.6.8 Words (20:10) Reserved

7.10.5.6.9 Word 21: Command/features set supported part 2

Word 21 bit 15 if set to one indicates that the device is allowed to support the NV Cache feature set. If bit 15 is cleared to 0 the device shall report command aborted if bit 14 is set to one. If bit 15 is cleared to 0 and there is pinned data or the nv-cache has not been flushed, then the device shall report command aborted.

Word 21 bit 14 if set to one indicates that the device is allowed to support the NV Cache Power Management feature set.

Word 21 bit 13 if set to one indicates that the device is allowed to support the WRITE UNCORRECTABLE command.

Word 21 bit 12 shall be cleared to zero to disable support for the Trusted Computing feature set and has the effect of clearing IDENTIFY DEVICE data word 48 bit 0 to zero. This value shall not be changed and command aborted shall be returned if the Security feature set is enabled.

Word 21 bit 11 if set to one indicates that the device is allowed to support the Free-fall Control feature set.

Word 21 bits 10:0 are reserved.

7.10.5.6.10 Word 22: Command/features set supported part 3

Bits 15:0 are reserved.

7.10.5.6.11 Words (207:23): Reserved

7.10.5.6.12 Words (254:208): Vendor Specific

7.10.5.6.13 Word 255: Integrity word

Bits (7:0) of this word shall contain the value A5h. Bits (15:8) of this word shall contain the data structure checksum. The data structure checksum shall be the two's complement of the sum of all byte in words (254:0) and the byte consisting of bits (7:0) of word 255. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all bytes is zero when the checksum is correct.

7.11 DEVICE RESET - 08h, Device reset

7.11.1 Feature Set

This command is mandatory for devices implementing the PACKET feature set.

7.11.2 Description

The DEVICE RESET command enables the host to reset the targeted device.

7.11.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
05h	Command	7:0 08h

7.11.4 Normal Outputs

See table 92.

7.11.5 Error Outputs

If DEVICE RESET is supported, it should not complete with an error. If the device is able to complete the DEVICE RESET and maintain the device setting then DEVICE RESET shall complete with Check Condition cleared to zero. If the device reverts to its default state, the device shall report an exception by setting the Check Condition bit in the Status field.

7.12 DOWNLOAD MICROCODE - 92h, PIO Data-out

7.12.1 Feature Set

This command is optional for devices implementing the General feature set.

7.12.2 Description

This command enables the host to alter the device's microcode. The data transferred using the DOWNLOAD MICROCODE command is vendor specific.

All transfers shall be an integer multiple of 512 byte data blocks. The size of the data transfer is determined by the contents of the LBA and Count fields. The LBA field shall be used to extend the Count field to create a 16-bit logical sector count value. The low order 8 bits of the LBA field shall be the most significant eight bits and the Count field shall be the least significant eight bits. A value of zero in both field shall specify no data is to be transferred. This allows transfer sizes from 0 bytes to 33,553,920 bytes, in 512 byte increments.

The Feature field shall be used to determine the effect of the DOWNLOAD MICROCODE command as described in 7.12.3.

A Features field value of 03h indicates that the microcode shall be transferred in two or more DOWNLOAD MICROCODE commands using the offset transfer method.

The download block count value in the Count and LBA fields shall indicate how many 512 byte blocks of the data are being transferred in one command.

The Buffer Offset value is defined by the value in the LBA (23:8). The buffer offset value is the starting location in the data relative to the last successful DOWNLOAD MICROCODE command received by the device with a Buffer Offset of zero. The Buffer Offset value shall be between 0 and 65,535. The buffer offset value is the byte count divided by 512 (e.g., if a microcode file is to be transferred to the device in 32KB segments the first command should be issued with 0 buffer offset value, the second command should be issued with 64 buffer offset value, the third command should be issued with 128 buffer offset value and so on until the complete microcode is transferred.)

All microcode segments shall be sent to the device in sequence.

The device may abort the DOWNLOAD MICROCODE command and discard all previously downloaded microcode if the current buffer offset is not equal to the sum of the previous DOWNLOAD MICROCODE command buffer offset and the previous sector count. The first DOWNLOAD MICROCODE command shall have a buffer offset of zero.

The new microcode should become effective immediately after the transfer of the last data segment has completed.

When the device detects the last download microcode command for the firmware download the device shall perform any device required verification and save the complete set of downloaded microcode. Device feature configuration (e.g. SET FEATURES settings) may be affected by the download microcode command.

If the device receives a command other than DOWNLOAD MICROCODE prior to the receipt of the last segment, then the new command is executed and all previously downloaded microcode may be discarded.

During the processing of a power-on reset, a hardware reset, or a software reset a device shall discard any received microcode segments.

7.12.3 Inputs

Word	Name	Description
00h	Feature	**Sub command** **Description** 00h Reserved 01h Obsolete 02h Reserved 03h Optional Download with offsets and save microcode for immediate and future use. 04h-06h Reserved 07h Download and save microcode for immediate and future use. 08-FFh Reserved
01h	Count	**Bit** Description 15:8 Reserved 7:0 Block count (7:0)
02h-04h	LBA	**Bit** **Description** 47:24 Reserved 23:8 Buffer offset (only used for Feature = 03h, otherwise this field shall be reserved) 7:0 Block count (15:8)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 92h

7.12.4 Normal Outputs

If IDENTIFY DEVICE data word 234 or IDENTIFY DEVICE data word 235 have a value other than 0000h or FFFFh then table 20 describes the indicator returned in the count field.

Table 20 — DOWNLOAD MICROCODE Mode 3 return options

Value	Description
00h	No indication of download microcode status.
01h	Indicates the device is expecting more download microcode commands to follow.
02h	Indicates that the drive has applied the new microcode.
03h-FFh	Reserved

For additional returns see table 86.

7.12.5 Error Outputs

The device shall return command aborted if the device did not accept the microcode data. The device shall return command aborted if subcommand code is not a supported value. See table 109.

7.13 EXECUTE DEVICE DIAGNOSTIC - 90h, Execute Device Diagnostic

7.13.1 Feature Set

This command is mandatory for all devices.

7.13.2 Description

This command shall cause the devices to perform internal diagnostic tests.

NOTE 6 — There are transport and Host Bus Adapter implications for this command (i.e., see ATA8-APT and HBA2)

If the host issues an EXECUTE DEVICE DIAGNOSTIC command while a device is in or going to a power management mode except Sleep, then the device shall execute the diagnostic sequence.

7.13.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 90h

7.13.4 Normal Outputs

See table 92. The diagnostic code written into the Error field is an 8-bit code. Table 21 defines these values.

Table 21 — Diagnostic codes

Code[a]	Description
When this code is in the Device 0[c] Error field	
01h	Device 0[c] passed, Device 1[c] passed or not present
00h, 02h-7Fh	Device 0[c] failed, Device 1[c] passed or not present
81h	Device 0[c] passed, Device 1[c] failed
80h, 82h-FFh	Device 0[c] failed, Device 1[c] failed
When this code is in the Device 1[c] Error field	
01h	Device 1[c] passed[b]
00h, 02h-7Fh	Device 1[c] failed[b]

[a] Codes other than 01h and 81h may indicate additional information about the failure(s).
[b] If Device 1 is not present, the host may see the information from Device 0 even though Device 1 is selected.
[c] See the appropriate transport standard for the definition of device 0 and device 1

7.13.5 Error Outputs

This command shall complete without setting the Error bit in the Status field, see 7.13.4.

7.14 FLUSH CACHE - E7h, Non-data

7.14.1 Feature Set

This command is mandatory for devices not implementing the PACKET feature set. This command is optional for devices implementing the PACKET feature set.

7.14.2 Description

This command is used by the host to request the device to flush the volatile write cache. If there is data in the volatile write cache, that data shall be written to the non-volatile media. This command shall not indicate completion until the data is flushed to the non-volatile media or an error occurs. If the device supports more than 28 bits of addressing this command shall attempt to flush all the data in the volatile cache. If the volatile write cache is disabled or no volatile write cache is present, the device shall indicate command completion without error.

NOTE 7 — This command may take longer than 30 seconds to complete.

7.14.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E7h

7.14.4 Normal Outputs

See table 86.

7.14.5 Error Outputs

An unrecoverable error encountered during execution of writing data results in the termination of the command. The logical sector address of the sector where the first unrecoverable error occurred. Subsequent FLUSH CACHE commands continue the process of flushing the cache starting with the first logical sector after the sector in error is returned. LBA bits 47:28 shall be cleared to zero. See table 112.

If an error occurs during the flush process and the LBA of the data in error is outside the 28 bit address range then the LBA of the logical sector in error shall be incorrectly reported. For correct error reporting in a device that has more than a 28 bit address range, use FLUSH CACHE EXT (see 7.15).

7.15 FLUSH CACHE EXT - EAh, Non-data

7.15.1 Feature Set

This command is mandatory for devices implementing the 48-bit Address feature set

7.15.2 Description

This command is used by the host to request the device to flush the volatile write cache. If there is data in the volatile write cache, that data shall be written to the non-volatile media. This command shall not indicate completion until the data is flushed to the non-volatile media or an error occurs. If the volatile write cache is disabled or no volatile write cache is present, the device shall indicate command completion without error.

NOTE 8 — This command may take longer than 30 seconds to complete.

7.15.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 EAh

7.15.4 Normal Outputs

See table 99.

7.15.5 Error Outputs

An unrecoverable error encountered while writing data results in the termination of the command and the logical sector address of the logical sector where the first unrecoverable error occurred is returned. Subsequent FLUSH CACHE EXT commands continue the process of flushing the cache starting with the first sector after the sector in error. See table 112.

7.16 IDENTIFY DEVICE - ECh, PIO Data-in

7.16.1 Feature Set

This command is mandatory for all devices.

7.16.2 Description

The IDENTIFY DEVICE command enables the host to receive a 512-byte block of data from the device. See 7.16.7 for a description of the return data.

Some devices may have to read the media in order for all applicable IDENTIFY DEVICE data fields to be valid.

The IDENTIFY DEVICE data contains information regarding optional feature or command support. If the host issues a command that is indicated as not supported in the IDENTIFY DEVICE data, the device shall abort the command.

Some parameters are defined as a 16-bit value. A word that is defined as a 16-bit value transmits the most significant byte of the value the first and the least significant byte second.

Some parameters are defined as 32-bit values (e.g., words 60-61). Such values are transferred using two word transfers. The device shall first transfer the least significant word followed by the most significant value.

Some parameters are defined as ASCII strings. ASCII strings are a list of values that range from 20h to 7Eh which the host should interpret ASCII Characters. Values 00h-1Fh and values 7Fh-FFh shall not appear in ASCII strings.

7.16.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 ECh

7.16.4 Normal Outputs for devices that do not implement the PACKET feature set

See table 86.

7.16.5 Normal Outputs for PACKET feature set devices

In response to this command, devices that implement the PACKET feature set shall return command aborted and place the PACKET feature set signature in the appropriate fields (see 7.11.4).

7.16.6 Error Outputs

Devices implementing the General feature set shall not report an error.

7.16.7 Input Data

Table 22 — IDENTIFY DEVICE data (part 1 of 11)

Word	OM	SP	FV	Description
0	M	B		General configuration bit-significant information:
			F	15 0 = ATA device
			X	14:8 Retired
			X	7:6 Obsolete
			X	5:3 Retired
			V	2 Response incomplete
			X	1 Retired
			F	0 Reserved
1			X	Obsolete
2	O	B	V	Specific configuration
3			X	Obsolete
4-5			X	Retired
6			X	Obsolete
7-8				Reserved for assignment by the CompactFlash™ Association
9			X	Retired
10-19	M	B	F	Serial number (ASCII String)
20-21			X	Retired
22			X	Obsolete
23-26	M	B	F	Firmware revision (ASCII String)
27-46	M	B	F	Model number (ASCII String)
47	M		F	15:8 80h
			F	7:0 00h = Reserved
		P	F	01h-FFh = Maximum number of logical sectors that shall be transferred per DRQ data block on READ/WRITE MULTIPLE commands
48	O	B		Trusted Computing feature set options
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
				13:1 Reserved for the Trusted Computing Group
			F	0 1=Trusted Computing feature set is supported
49	M			Capabilities
				15:14 Reserved for the IDENTIFY PACKET DEVICE command.
		B	F	13 1 = Standby timer values as specified in this standard are supported
				0 = Standby timer values shall be managed by the device
				12 Reserved for the IDENTIFY PACKET DEVICE command.
		P	F	11 1 = IORDY supported
				0 = IORDY may be supported
		P	F	10 1 = IORDY may be disabled
		B	F	9 1 = LBA supported
		P	F	8 1 = DMA supported.
			X	7:0 Retired

Table 22 — IDENTIFY DEVICE data (part 2 of 11)

Word	O M	S P	FV	Description
50	M			Capabilities
			F	15 Shall be cleared to zero.
			F	14 Shall be set to one.
			F	13:2 Reserved.
			X	1 Obsolete
		B	F	0 Shall be set to one to indicate a vendor specific Standby timer value minimum.
51-52			X	Obsolete
53	M		F	15:8 Free-fall Control Sensitivity
				00h = Vendor's recommended setting
				01h-FFh = Sensitivity level. A larger number is a more sensitive setting.
			F	7:3 Reserved
		B	F	2 1 = the fields reported in word 88 are valid
		B		0 = the fields reported in word 88 are not valid
		B	F	1 1 = the fields reported in words (70:64) are valid
		P		0 = the fields reported in words (70:64) are not valid
			X	0 Obsolete
54-58			X	Obsolete
59	M		F	15:9 Reserved
		B	V	8 1 = Multiple sector setting is valid
		B	V	7:0 Current setting for number of logical sectors that shall be transferred per DRQ data block on READ/WRITE Multiple commands
60-61	M	B	F	Total number of user addressable logical sectors
62			X	Obsolete
63	M		F	15:11 Reserved
		P	V	10 1 = Multiword DMA mode 2 is selected
		P		0 = Multiword DMA mode 2 is not selected
		P	V	9 1 = Multiword DMA mode 1 is selected
		P		0 = Multiword DMA mode 1 is not selected
		P	V	8 1 = Multiword DMA mode 0 is selected
		P		0 = Multiword DMA mode 0 is not selected
			F	7:3 Reserved
		P	F	2 1 = Multiword DMA mode 2 and below are supported
		P	F	1 1 = Multiword DMA mode 1 and below are supported
		P	F	0 1 = Multiword DMA mode 0 is supported
64	M		F	15:8 Reserved
		P	F	7:0 PIO modes supported
65	M			Minimum Multiword DMA transfer cycle time per word
		P	F	15:0 Cycle time in nanoseconds
66	M			Manufacturer's recommended Multiword DMA transfer cycle time
		P	F	15:0 Cycle time in nanoseconds
67	M			Minimum PIO transfer cycle time without flow control
		P	F	15:0 Cycle time in nanoseconds
68	M			Minimum PIO transfer cycle time with IORDY flow control
		P	F	15:0 Cycle time in nanoseconds
69-70			F	Reserved

Table 22 — IDENTIFY DEVICE data (part 3 of 11)

Word	O M	S P	FV	Description
71-74				Reserved for the IDENTIFY PACKET DEVICE command.
75	O			Queue depth
			F	15:5 Reserved
		B	F	4:0 Maximum queue depth - 1
76	O	S	F	Serial ATA Capabilities
				15:11 Reserved for Serial ATA
				10 1 = Supports Phy Event Counters
				9 1 = Supports receipt of host initiated power management requests
				8 1 = Supports native Command Queuing
				7:3 Reserved for future SATA signaling speed grades
				2 1 = Supports SATA Gen2 Signaling Speed (3.0Gb/s)
				1 1 = Supports SATA Gen1 Signaling Speed (1.5Gb/s)
				0 Shall be cleared to zero
77				Reserved for Serial ATA
78	O	S	F	SATA Features Supported
				15:7 Reserved for Serial ATA
				6 1 = Device supports Software Settings Preservation
				5 Reserved for Serial ATA
				4 1 = Device supports in-order data delivery
				3 1 = Device supports initiating power management
				2 1 = Device supports DMA Setup auto-activation
				1 1 = Device supports non-zero buffer offsets
				0 Shall be cleared to zero
79	O	S		SATA Features Enabled
				15:7 Reserved for Serial ATA
			V	6 1 = Software Settings Preservation enabled
				5 Reserved for Serial ATA
			V	4 1 = In-order data delivery enabled
			V	3 1 = Device initiated power management enabled
			V	2 1 = DMA Setup auto-activation enabled
			V	1 1 = Non-zero buffer offsets enabled
			F	0 Shall be cleared to zero
80	M	B		Major revision number 0000h or FFFFh = device does not report version
			F	15:9 Reserved
		B	F	8 1 = supports ATA8-ACS
		B	F	7 1 = supports ATA/ATAPI-7
		B	F	6 1 = supports ATA/ATAPI-6
		B	F	5 1 = supports ATA/ATAPI-5
		B	F	4 1 = supports ATA/ATAPI-4
			X	3 Obsolete
			X	2 Obsolete
			X	1 Obsolete
			F	0 Reserved
81	M	B	F	Minor revision number

Table 22 — **IDENTIFY DEVICE data** (part 4 of 11)

Word	O M	S P	FV	Description
82	M			Command set supported.
			X	15 Obsolete
		B	F	14 1 = NOP command supported
		B	F	13 1 = READ BUFFER command supported
		B	F	12 1 = WRITE BUFFER command supported
			X	11 Obsolete
		B	F	10 1 = Host Protected Area feature set supported
		N	F	9 1 = DEVICE RESET command supported
		B	F	8 1 = SERVICE interrupt supported
		B	F	7 1 = release interrupt supported
		B	F	6 1 = read look-ahead supported
		B	F	5 1 = volatile write cache supported
		B	F	4 Shall be cleared to zero to indicate that the PACKET feature set is not supported.
		B	F	3 1 = mandatory Power Management feature set supported
			X	2 Obsolete
		B	F	1 1 = Security feature set supported
		B	F	0 1 = SMART feature set supported
83	M			Command sets supported.
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
		B	F	13 1 = FLUSH CACHE EXT command supported
		B	F	12 1 = mandatory FLUSH CACHE command supported
		B	F	11 1 = Device Configuration Overlay feature set supported
		B	F	10 1 = 48-bit Address feature set supported
		B	F	9 1 = Automatic Acoustic Management feature set supported
		B	F	8 1 = SET MAX security extension supported
				7 Reserved for technical report INCITS TR27-2001
		B	F	6 1 = SET FEATURES subcommand required to spin-up after power-up
		B	F	5 1 = Power-Up In Standby feature set supported
			X	4 Obsolete
		B	F	3 1 = Advanced Power Management feature set supported
		N	F	2 1 = CFA feature set supported
		B	F	1 1 = READ/WRITE DMA QUEUED supported
		B	F	0 1 = DOWNLOAD MICROCODE command supported

Table 22 — IDENTIFY DEVICE data (part 5 of 11)

Word	O M	S P	FV	Description
84	M			Command set/feature supported
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
		B	F	13 1 = IDLE IMMEDIATE with UNLOAD FEATURE supported
				12 Reserved for technical report INCITS TR37-2004
				11 Reserved for technical report INCITS TR37-2004
			X	10:9 1 = Obsolete
		B	F	8 1 = 64-bit World wide name supported
		B	F	7 1 = WRITE DMA QUEUED FUA EXT command supported
		B	F	6 1 = WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands supported
		B	F	5 1 = General Purpose Logging feature set supported
		B	F	4 1 = Streaming feature set supported
		N	F	3 1 = Media Card Pass Through Command feature set supported
		B	F	2 1 = Media serial number supported
		B	F	1 1 = SMART self-test supported
		B	F	0 1 = SMART error logging supported
85	M			Command set/feature enabled/supported.
			X	15 Obsolete
		B	F	14 1 = NOP command supported
		B	F	13 1 = READ BUFFER command supported
		B	F	12 1 = WRITE BUFFER command supported
			X	11 Obsolete
		B	V	10 1 = Host Protected Area has been established (i.e., the maximum LBA is less than the maximum native LBA)
		N	F	9 1 = DEVICE RESET command supported
		B	V	8 1 = SERVICE interrupt enabled
		B	V	7 1 = release interrupt enabled
		B	V	6 1 = read look-ahead enabled
		B	V	5 1 = volatile write cache enabled
			F	4 Shall be cleared to zero to indicate that the PACKET feature set is not supported.
		B	F	3 Shall be set to one to indicate that the Mandatory Power Management feature set is supported.
			X	2 Obsolete
		B	V	1 1 = Security feature set enabled
		B	V	0 1 = SMART feature set enabled

Table 22 — IDENTIFY DEVICE data (part 6 of 11)

Word	O M	S P	FV		Description
86	M				Command set/feature enabled/supported.
		B	F	15	1 = Words 120:119 are valid
			F	14	Reserved
		B	F	13	1 = FLUSH CACHE EXT command supported
		B	F	12	1 = FLUSH CACHE command supported
		B	F	11	1 = Device Configuration Overlay supported
		B	F	10	1 = 48-bit Address features set supported
		B	V	9	1 = Automatic Acoustic Management feature set enabled
		B	V	8	1 = SET MAX security extension enabled by SET MAX SET PASSWORD
				7	Reserved for technical report INCITS TR27-2001
		B	F	6	1 = SET FEATURES subcommand required to spin-up after power-up
		B	V	5	1 = Power-Up In Standby feature set enabled
			X	4	Obsolete
		B	V	3	1 = Advanced Power Management feature set enabled
		N	F	2	1 = CFA feature set supported
		B	F	1	1 = READ/WRITE DMA QUEUED command supported
		B	F	0	1 = DOWNLOAD MICROCODE command supported
87	M				Command set/feature enabled/supported.
			F	15	Shall be cleared to zero
			F	14	Shall be set to one
		B	F	13	1 = IDLE IMMEDIATE with UNLOAD FEATURE supported
				12	Reserved for technical report INCITS TR37-2004
				11	Reserved for technical report INCITS TR37-2004
			X	10:9	Obsolete
		B	F	8	1 = 64 bit World wide name supported
		B	F	7	1 = WRITE DMA QUEUED FUA EXT command supported
		B	F	6	1 = WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands supported
		B	F	5	1 = General Purpose Logging feature set supported
			X	4	Obsolete
		N	V	3	1 = Media Card Pass Through Command feature set supported
		B	V	2	1 = Media serial number is valid
		B	F	1	1 = SMART self-test supported
		B	F	0	1 = SMART error logging supported

Table 22 — IDENTIFY DEVICE data (part 7 of 11)

Word	OM	SP	FV	Description
88	O			Ultra DMA modes
			F	15 Reserved
		P	V	14 1 = Ultra DMA mode 6 is selected
		P		0 = Ultra DMA mode 6 is not selected
		P	V	13 1 = Ultra DMA mode 5 is selected
		P		0 = Ultra DMA mode 5 is not selected
		P	V	12 1 = Ultra DMA mode 4 is selected
		P		0 = Ultra DMA mode 4 is not selected
		P	V	11 1 = Ultra DMA mode 3 is selected
		P		0 = Ultra DMA mode 3 is not selected
		P	V	10 1 = Ultra DMA mode 2 is selected
		P		0 = Ultra DMA mode 2 is not selected
		P	V	9 1 = Ultra DMA mode 1 is selected
		P		0 = Ultra DMA mode 1 is not selected
		P	V	8 1 = Ultra DMA mode 0 is selected
		P		0 = Ultra DMA mode 0 is not selected
			F	7 Reserved
		P	F	6 1 = Ultra DMA mode 6 and below are supported
		P	F	5 1 = Ultra DMA mode 5 and below are supported
		P	F	4 1 = Ultra DMA mode 4 and below are supported
		P	F	3 1 = Ultra DMA mode 3 and below are supported
		P	F	2 1 = Ultra DMA mode 2 and below are supported
		P	F	1 1 = Ultra DMA mode 1 and below are supported
		P	F	0 1 = Ultra DMA mode 0 is supported
89	O	B	F	Time required for security erase unit completion
90	O	B	F	Time required for Enhanced security erase completion
91	O	B	V	Current advanced power management value
92	O	B	V	Master Password Identifier

Table 22 — IDENTIFY DEVICE data (part 8 of 11)

Word	O M	S P	FV	Description
93	M			Hardware reset result. The contents of bits (12:0) of this word shall change only during the execution of a hardware reset. See 7.16.7.44 for more information.
			F	15 Shall be cleared to zero.
			F	14 Shall be set to one.
		P	V	13 1 = device detected CBLID- above V_{iH} 0 = device detected CBLID- below V_{iL}
		P		12:8 Device 1 hardware reset result. Device 0 shall clear these bits to zero. Device 1 shall set these bits as follows:
			F	12 Reserved.
		P	V	11 0 = Device 1 did not assert PDIAG-. 1 = Device 1 asserted PDIAG-.
		P	V	10:9 These bits indicate how Device 1 determined the device number: 00 = Reserved. 01 = a jumper was used. 10 = the CSEL signal was used. 11 = some other method was used or the method is unknown.
				8 Shall be set to one.
		P		7:0 Device 0 hardware reset result. Device 1 shall clear these bits to zero. Device 0 shall set these bits as follows:
			F	7 Reserved.
		P	F	6 0 = Device 0 does not respond when Device 1 is selected. 1 = Device 0 responds when Device 1 is selected.
		P	V	5 0 = Device 0 did not detect the assertion of DASP-. 1 = Device 0 detected the assertion of DASP-.
		P	V	4 0 = Device 0 did not detect the assertion of PDIAG-. 1 = Device 0 detected the assertion of PDIAG-.
		P	V	3 0 = Device 0 failed diagnostics. 1 = Device 0 passed diagnostics.
		P	V	2:1 These bits indicate how Device 0 determined the device number: 00 = Reserved. 01 = a jumper was used. 10 = the CSEL signal was used. 11 = some other method was used or the method is unknown.
			F	0 Shall be set to one.
94	O	B	F	15:8 Vendor's recommended acoustic management value.
		B	V	7:0 Current automatic acoustic management value.
95	O	B	F	Stream Minimum Request Size
96	O	B	V	Streaming Transfer Time - DMA
97	O	B	V	Streaming Access Latency - DMA and PIO
98-99	O	B	F	Streaming Performance Granularity
100-103	O	B	V	Total Number of User Addressable Sectors for the 48-bit Address feature set.
104	O	B	V	Streaming Transfer Time - PIO
105			F	Reserved

Table 22 — IDENTIFY DEVICE data (part 9 of 11)

Word	O M	S P	FV	Description
106	O			Physical sector size / Logical Sector Size
		B	F	15 Shall be cleared to zero
		B	F	14 Shall be set to one
		B	F	13 1 = Device has multiple logical sectors per physical sector.
		B		12 1= Device Logical Sector Longer than 256 Words
			F	11:4 Reserved
		B	F	3:0 2^X logical sectors per physical sector
107	O	B	F	Inter-seek delay for ISO-7779 acoustic testing in microseconds
108	M	B	F	15:12 NAA (3:0) 11:0 IEEE OUI (23:12)
109	M	B	F	15:4 IEEE OUI (11:0) 3:0 Unique ID (35:32)
110	M	B	F	15:0 Unique ID (31:16)
111	M	B	F	15:0 Unique ID (15:0)
112-115			F	Reserved for world wide name extension to 128 bits
116				Reserved for INCITS TR37-2004
117-118	O	B	F	Words per Logical Sector
119	M			Supported Settings (Continued from words 84:82)
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
			F	13:6 Reserved
				5 1 = Free-fall Control feature set is supported
		B	F	4 1 = The Segmented feature for DOWNLOAD MICROCODE is supported
		B	F	3 1 = READ and WRITE DMA EXT GPL optional commands are supported
		B	F	2 1 = WRITE UNCORRECTABLE EXT is supported
		B	F	1 1 = Write-Read-Verify feature set is supported
				0 Reserved for technical report DT1825
120	M			Command set/feature enabled/supported. (Continued from words 87:85)
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
			F	13:6 Reserved
				5 1 = Free-fall Control feature set is enabled
		B	F	4 1 = The Segmented feature for DOWNLOAD MICROCODE is supported
		B	F	3 1 = READ and WRITE DMA EXT GPL optional commands are supported
		B	F	2 1 = WRITE UNCORRECTABLE EXT is supported
		B	F	1 1 = Write-Read-Verify feature set is enabled
				0 Reserved for technical report DT1825
121-126			F	Reserved for expanded supported and enabled settings
127			X	Obsolete

Table 22 — IDENTIFY DEVICE data (part 10 of 11)

Word	O M	S P	FV	Description
128	O			Security status
			F	15:9 Reserved
		B	V	8 Security level 0 = High, 1 = Maximum
			F	7:6 Reserved
		B	F	5 1 = Enhanced security erase supported
		B	V	4 1 = Security count expired
		B	V	3 1 = Security frozen
		B	V	2 1 = Security locked
		B	V	1 1 = Security enabled
		B	F	0 1 = Security supported
129-159			X	Vendor specific
160	O			CFA power mode 1
			F	15 Word 160 supported
			F	14 Reserved
		N	F	13 CFA power mode 1 is required for one or more commands implemented by the device
		N	V	12 CFA power mode 1 disabled
		N	F	11:0 Maximum current in ma
161-175				Reserved for assignment by the CompactFlash™ Association
176-205	O	B	V	Current media serial number (ASCII String)
206	O	B		SCT Command Transport
			X	15:12 Vendor Specific
			F	11:6 Reserved
			F	5 SCT Command Transport Data Tables supported
			F	4 SCT Command Transport Features Control supported
			F	3 SCT Command Transport Error Recovery Control supported
			F	2 SCT Command Transport Write Same supported
			F	1 SCT Command Transport Long Sector Access supported
			F	0 SCT Command Transport supported
207-208				Reserved for CE-ATA.
209	O		F	Alignment of logical blocks within a larger physical block
				15 Shall be cleared to zero
				14 Shall be set to one
		B		13:0 ‘Logical sector’ offset within the first physical sector where the first logical sector is placed.
210-211	O	B	V	Write-Read-Verify Sector Count Mode 3 Only
212-213	O	B	F	Verify Sector Count Mode 2 Only
214	O	B		NV Cache Capabilities
			F	15:12 NV Cache feature set version
			F	11:8 NV Cache Power Mode feature set version
			F	7:5 Reserved
			V	4 1 = NV Cache feature set enabled
			F	3:2 Reserved
				1 1 = NV Cache Power Mode feature set enabled
			V	0 1 = NV Cache Power Mode feature set supported
215	O	B	V	NV Cache Size in Logical Blocks (15:0)

Table 22 — IDENTIFY DEVICE data (part 11 of 11)

Word	O M	S P	FV	Description
216	O	B	V	NV Cache Size in Logical Blocks (31:16)
217	M	B	F	Nominal media rotation rate
218			F	Reserved
219	O	B		NV Cache Options
			F	15:8 Reserved
			F	7:0 Device Estimated Time to Spin Up in Seconds
220	O	B	F	15:8 Reserved
			V	7:0 Write-Read-Verify feature set current mode
221			F	Reserved
222	M	B	F	Transport Major revision number. 0000h or FFFFh = device does not report version
				15:12 Transport Type – 0 = Parallel, 1 = Serial, 2-15 = Reserved
				Parallel **Serial**
				11:5 Reserved Reserved
				4 Reserved SATA Rev 2.6
				3 Reserved SATA Rev 2.5
				2 Reserved SATA II: Extensions
				1 Reserved SATA 1.0a
				0 ATA8-APT ATA8-AST
223	M	B	F	Transport Minor revision number
224-233				Reserved for CE-ATA
234	O	B	F	Minimum number of 512 byte units per DOWNLOAD MICROCODE command for mode 03h
235	O	B	F	Maximum number of 512 byte units per DOWNLOAD MICROCODE command for mode 03h
236-254			F	Reserved
255	M		V	Integrity word
		B		15:8 Checksum
		B		7:0 Signature

Key:
F/V – Fixed/variable content
F – The content of the field is fixed and does not change. The DCO command may change the value of a fixed field.
V – The contents of the field is variable and may change depending on the state of the device or the commands executed by the device.
X – The fixed or variable type of this field is not defined in this standard.

O/M – Mandatory/optional requirement.
M – Support of the word is mandatory.
O – Support of the word is optional.
S/P – Content applies to Serial or Parallel transport
S – Serial Transport
P – Parallel Transport
B – Both Serial and Parallel Transports
N – Belongs to a transport other than Serial or Parallel

7.16.7.1 Word 0: General configuration

Devices that conform to this standard shall clear bit 15 to zero.

Bits 7:6 are obsolete.

If bit 2 is set to one it indicates that the content of the IDENTIFY DEVICE data is incomplete. This may occur if the device supports the Power-up in Standby feature set and required data is contained on the device media. In this case the content of at least word 0 and word 2 shall be valid.

Devices supporting the CFA feature set shall place the value 848Ah in word 0. In this case, the above definitions for the bits in word 0 are not valid.

7.16.7.2 Word 1: Obsolete

7.16.7.3 Word 2: Specific configuration

Word 2 shall be set as follows:

Value	Description
37C8h	Device requires SET FEATURES subcommand to spin-up after power-up and IDENTIFY DEVICE data is incomplete (see 4.19).
738Ch	Device requires SET FEATURES subcommand to spin-up after power-up and IDENTIFY DEVICE data is complete (see 4.19).
8C73h	Device does not require SET FEATURES subcommand to spin-up after power-up and IDENTIFY DEVICE data is incomplete (see 4.19).
C837h	Device does not require SET FEATURES subcommand to spin-up after power-up and IDENTIFY DEVICE data is complete (see 4.19).
All other values	Reserved.

7.16.7.4 Word 3: Obsolete

7.16.7.5 Words 4-5: Retired

7.16.7.6 Word 6: Obsolete

7.16.7.7 Words 7-8: Reserved for assignment by the CompactFlash™ Association

7.16.7.8 Word 9: Retired

7.16.7.9 Words 10-19: Serial number

This field contains the serial number of the device. The contents of this field is an ASCII string of twenty bytes. The device shall pad the character string with spaces (20h), if necessary, to ensure that the string is the proper length. The combination of Serial number (words 10-19) and Model number (words 27-46) shall be unique for a given manufacturer (See 0).

7.16.7.10 Words 20-21: Retired

7.16.7.11 Word 22: Obsolete

7.16.7.12 Words 23-26: Firmware revision

This field contains the firmware revision number of the device. The contents of this field is an ASCII string of eight bytes. The device shall pad the character string with spaces (20h), if necessary, to ensure that the string is the proper length (See 0).

7.16.7.13 Words 27-46: Model number

This field contains the model number of the device. The contents of this field is an ASCII string of forty bytes. The device shall pad the character string with spaces (20h), if necessary, to ensure that the string is the proper length. The combination of Serial number (words 10-19) and Model number (words 27-46) shall be unique for a given manufacturer.

7.16.7.14 Word 47: READ/WRITE MULTIPLE support

For PATA devices Bits (7:0) of this word define the maximum number of logical sectors per DRQ data block that the device supports for READ/WRITE MULTIPLE commands.

For SATA devices this field shall be set to 16 or less.

7.16.7.15 Word 48: Trusted Computing feature set options

Bit 0 of word 48 when set to one, indicates that the Trusted Computing feature set is supported.

7.16.7.16 Words 49-50: Capabilities

Bits (15:14) of word 49 are reserved for use in the IDENTIFY PACKET DEVICE data.

Bit 13 of word 49 is used to determine whether a device uses the Standby timer values as defined in this standard. Table 27 specifies the Standby timer values used by the device if bit 13 is set to one. If bit 13 is cleared to zero, the timer values shall be vendor specific.

Bit 12 of word 49 is reserved for use in the IDENTIFY PACKET DEVICE data.

For PATA devices bit 11 of word 49 indicates whether a device supports IORDY. If this bit is set to one, then the device supports IORDY operation. All devices except CFA and PCMCIA devices shall support PIO mode 3 or higher, shall support IORDY, and shall set this bit to one.

For SATA devices bit 11 of word 49 shall be set to one.

For PATA devices bit 10 of word 49 is used to indicate a device's ability to enable or disable the use of IORDY. If this bit is set to one, then the device supports the disabling of IORDY. Disabling and enabling of IORDY is accomplished using the SET FEATURES command.

For SATA devices bit 10 of word 49 shall be set to one.

Bit 9 of word 49 shall be set to one to indicate that an LBA transition is supported.

Bits 8 of word 49 Shall be set to one to indicate that DMA is supported. For devices not implementing the CompactFlash feature set this bit shall be set to one.

Bits (7:0) of word 49 are retired.

Bit 15 of word 50 shall be cleared to zero to indicate that the contents of word 50 are valid.

Bit 14 of word 50 shall be set to one to indicate that the contents of word 50 are valid.

Bits (13:2) of word 50 are reserved.

Bit 1 of word 50 is obsolete.

Bit 0 of word 50 set to one indicates that the device has a minimum Standby timer value that is vendor specific.

7.16.7.17 Words 51-52: Obsolete

7.16.7.18 Word 53: Field validity

Bit 0 of word 53 is obsolete.

For PATA devices when bit 1 of word 53 is set to one, the values reported in words 64-70 are valid. If this bit is cleared to zero, the values reported in words 64-70 are not valid. All devices except CFA and PCMCIA devices shall support PIO mode 3 or above and shall set bit 1 of word 53 to one and support the fields contained in words 64-70.

For SATA devices, bit 1 of word 53 shall be set to one.

For PATA devices, if the device supports Ultra DMA and the values reported in word 88 are valid, then bit 2 of word 53 shall be set to one. If the device does not support Ultra DMA and the values reported in word 88 are not valid, then this bit is cleared to zero.

For SATA devices, bit 2 of word 53 shall be set to one.

7.16.7.19 Words 54-58: Obsolete

7.16.7.20 Word 59: Multiple sector setting

If bit 8 is set to one, bits (7:0) reflect the number of logical sectors currently set to transfer on a READ/WRITE MULTIPLE command. This field may default to the preferred value for the device (see 7.51).

7.16.7.21 Words 60-61: Total number of user addressable sectors

This field contains a value that is one greater than the maximum user accessible logical block address. The maximum value that shall be placed in this field is 0FFF_FFFFh. See 4.11.4 for more information.

7.16.7.22 Word 62: Obsolete

7.16.7.23 Word 63: Multiword DMA transfer

Word 63 identifies the Multiword DMA transfer modes supported by the device and indicates the mode that is currently selected. Only one DMA mode shall be selected at any given time. If an Ultra DMA mode is enabled, then no Multiword DMA mode shall be enabled. If a Multiword DMA mode is enabled then no Ultra DMA mode shall be enabled.

Bits (15:11) of word 63 are reserved.

If bit 10 of word 63 is set to one, then Multiword DMA mode 2 is selected. If this bit is cleared to zero, then Multiword DMA mode 2 is not selected. If bit 9 is set to one or if bit 8 is set to one, then this bit shall be cleared to zero.

If bit 9 of word 63 is set to one, then Multiword DMA mode 1 is selected. If this bit is cleared to zero then Multiword DMA mode 1 is not selected. If bit 10 is set to one or if bit 8 is set to one, then this bit shall be cleared to zero.

If bit 8 of word 63 is set to one, then Multiword DMA mode 0 is selected. If this bit is cleared to zero then Multiword DMA mode 0 is not selected. If bit 10 is set to one or if bit 9 is set to one, then this bit shall be cleared to zero.

Bits (7:3) of word 63 are reserved.

For PATA devices, when bit 2 of word 63 is set to one, Multiword DMA modes 2 and below are supported. If this bit is cleared to zero, then Multiword DMA mode 2 is not supported. If Multiword DMA mode 2 is supported, then Multiword DMA modes 1 and 0 shall also be supported. If this bit is set to one, bit 0 and bit 1 shall also be set to one.

For SATA devices, bit 2 of word 63 shall be set to one.

For PATA devices, when bit 1 of word 63 is set to one Multiword DMA modes 1 and below are supported. If this bit is cleared to zero, then Multiword DMA mode 1 is not supported. If Multiword DMA mode 1 is supported, then Multiword DMA mode 0 shall also be supported. If this bit is set to one, bit 0 shall be set to one.

For SATA devices, bit 1 of word 63 shall be set to one.

For PATA devices, when bit 0 of word 63 is set to one Multiword DMA mode 0 is supported.

For SATA devices, bit 0 of word 63 shall be set to one.

7.16.7.24 Word 64: PIO transfer modes supported

For PATA devices bits (7:0) of word 64 is defined as the PIO data and register transfer supported field. If this field is supported, bit 1 of word 53 shall be set to one. This field is bit significant. Any number of bits may be set to one in this field by the device to indicate the PIO modes the device is capable of supporting.

Of these bits, bits (7:2) are Reserved for future PIO modes. Bit 0, if set to one, indicates that the device supports PIO mode 3. All devices except CFA and PCMCIA devices shall support PIO mode 3 and shall set bit 0 to one. Bit 1, if set to one, indicates that the device supports PIO mode 4. See ATA8-APT for more information.

For SATA devices bits (1:0) shall be set to one.

7.16.7.25 Word 65: Minimum Multiword DMA transfer cycle time per word

For PATA devices word 65 is defined as the minimum Multiword DMA transfer cycle time per word. This field defines, in nanoseconds, the minimum cycle time that the device supports when performing Multiword DMA transfers on a per word basis.

For SATA devices word 65 shall be set to indicate 120ns.

If this field is supported, bit 1 of word 53 shall be set to one. Any device that supports Multiword DMA mode 1 or above shall support this field, and the value in word 65 shall not be less than the minimum cycle time for the fastest DMA mode supported by the device.

If bit 1 of word 53 is set to one because a device supports a field in words 64-70 other than this field and the device does not support this field, the device shall return a value of zero in this field.

7.16.7.26 Word 66: Device recommended Multiword DMA cycle time

For PATA devices word 66 is defined as the device recommended Multiword DMA transfer cycle time. This field defines, in nanoseconds, the minimum cycle time per word during a single logical sector host transfer while performing a multiple logical sector READ DMA or WRITE DMA command for any location on the media under nominal conditions. If a host runs at a faster cycle rate by operating at a cycle time of less than this value, the device may negate DMARQ for flow control. The rate at which DMARQ is negated may result in reduced throughput despite the faster cycle rate. Transfer at this rate does not ensure that flow control is not be used, but implies that higher performance may result. See ATA8-APT for more information.

If this field is supported, bit 1 of word 53 shall be set to one. Any device that supports Multiword DMA mode 1 or above shall support this field, and the value in word 66 shall not be less than the value in word 65.

If bit 1 of word 53 is set to one because a device supports a field in words 64-70 other than this field and the device does not support this field, the device shall return a value of zero in this field.

For SATA devices word 66 shall be set to indicate 120ns.

7.16.7.27 Word 67: Minimum PIO transfer cycle time without IORDY flow control

For PATA devices word 67 is defined as the minimum PIO transfer without IORDY flow control cycle time. This field defines, in nanoseconds, the minimum cycle time that, if used by the host, the device guarantees data integrity during the transfer without utilization of IORDY flow control.

For SATA devices word 67 shall be set to indicate 120ns.

If this field is supported, Bit 1 of word 53 shall be set to one.

Any device that supports PIO mode 3 or above shall support this field, and the value in word 67 shall not be less than the value reported in word 68.

If bit 1 of word 53 is set to one because a device supports a field in words 64-70 other than this field and the device does not support this field, the device shall return a value of zero in this field.

7.16.7.28 Word 68: Minimum PIO transfer cycle time with IORDY flow control

For PATA devices word 68 is defined as the minimum PIO transfer with IORDY flow control cycle time. This field defines, in nanoseconds, the minimum cycle time that the device supports while performing data transfers while utilizing IORDY flow control.

For SATA devices word 68 shall be set to indicate 120ns.

If this field is supported, Bit 1 of word 53 shall be set to one.

All devices except CFA and PCMCIA devices shall support PIO mode 3 and shall support this field, and the value in word 68 shall be the fastest defined PIO mode supported by the device. The maximum value reported in this field shall be 180 to indicate support for PIO mode 3 or above.

If bit 1 of word 53 is set to one because a device supports a field in words 64-70 other than this field and the device does not support this field, the device shall return a value of zero in this field.

7.16.7.29 Words 69-74: Reserved

7.16.7.30 Word 75: Queue depth

Bits (4:0) of word 75 indicate the maximum queue depth supported by the device. The queue depth includes all commands for which command acceptance has occurred and command completion has not occurred. The value in this field equals (maximum queue depth - 1), e.g., a value of zero indicates a queue depth of one, a value of 31 indicates a queue depth of 32. If bit 1 of word 83 is cleared to zero indicating that the device does not support READ/WRITE DMA QUEUED commands, or if bit 6 of word 76 is cleared to zero indicating that the device does not support READ/WRITE FPDMA commands, the value in this field shall be zero. Support of this word is mandatory if the TCQ feature set is supported.

7.16.7.31 Word 76: Serial ATA Capabilities

If not 0000h or FFFFh, the device claims compliance with the Serial ATA specification. If this field is not 0000h or FFFFh, words 77 through 79 shall be valid. If this field is 0000h or FFFFh the device does not claim compliance with the Serial ATA specification and Words 76 through 79 are not valid and shall be ignored.

Bits 15:11 Reserved for Serial ATA

If bit 10 is set to one the device supports Phy event counters. If the device supports Phy event counters, it shall support the Phy event counter READ LOG EXT address 11h. See SATA 2.6 for more information.

If bit 9 is set to one the device supports Partial and Slumber interface power management states when initiated by the host. See SATA 2.6 for more information.

If bit 8 is set to one the device supports the Native Command Queuing feature set.

Bits 7:3 Reserved for Serial ATA.

If bit 2 is set to one the device supports the Gen2 signaling rate of 3.0 Gb/s. See SATA 2.6 for more information.

If bit 1 is set to one the device supports the Gen1 signaling rate of 1.5 Gb/s. See SATA 2.6 for more information.

Bit 0 shall be cleared to zero.

7.16.7.32 Words 77: Reserved for Serial ATA

Word 77 is reserved for future Serial ATA definition and shall be cleared to zero.

7.16.7.33 Word 78: Serial ATA Features/command sets supported

If Word 76 is not 0000h or FFFFh, Word 78 reports the optional features supported by the device. Support for this word is optional and if not supported the word shall be zero indicating the device has no support for new Serial ATA capabilities.

Bits 15:7 Reserved for Serial ATA

If bit 6 is set to one the device supports software settings preservation across COMRESET. See 4.22 for more information.

> Editor's Note 8: "When bit 6 is cleared to zero the device clears all software settings when a COMRESET occurs." was in the original. This is a concern because it could be specifying more functionality.

Bit 5 Reserved

If bit 4 is set to one the device supports guaranteed in-order data delivery when non-zero buffer offsets are used for commands in the NCQ feature set. See SATA 2.6 for more information.

If bit 3 is set to one the device supports initiating power management requests to the host. If bit 3 is cleared to zero the device does not support initiating power management requests. A device may support reception of power management requests initiated by the host as described in the definition of bit 9 of Word 76 without supporting initiating such power management requests as indicated by this bit. (bit 3)

If bit 2 is set to one the device supports the use of the DMA Setup FIS Auto-Activate optimization. See SATA 2.6 for more information.

If bit 1 is set to one the device supports the use of non-zero buffer offsets for commands in the NCQ feature set. See SATA 2.6 for more information.

Bit 0 shall be cleared to zero.

7.16.7.34 Word 79: Serial ATA Features/command sets supported

If Word 76 is not 0000h or FFFFh, Word 79 reports which optional features supported by the device are enabled. This word shall be supported if optional Word 78 is supported and shall not be supported if optional Word 78 is not supported.

Bits 15:7 Reserved for Serial ATA.

If bit 6 is set to one then software settings preservation is enabled. If the device supports software settings preservation this field shall be one by default. If the device does not support software settings preservation this field shall be zero by default.

Bit 5 Reserved.

If bit 4 is set to one then device support for guaranteed in-order data delivery when non-zero buffer offsets are used for commands in the NCQ feature set is enabled. See SATA 2.6 for more information.

If bit 3 is set to one then device support for initiating power management requests to the host is enabled. When set to one the device may initiate power management transition requests. When cleared to zero the device shall not initiate interface power management requests to the host. This field shall be zero by default.

If bit 2 is set to one then the device support for use of the DMA Setup FIS Auto-Activate optimization is enabled. See SATA 2.6 for more information.

If bit 1 is set to one then device support the use of non-zero buffer offsets for commands in the NCQ feature set is enabled. See SATA 2.6 for more information.

Bit 0 shall be cleared to zero.

7.16.7.35 Word 80: Major revision number

If not 0000h or FFFFh, the device claims compliance with the major version(s) as indicated by bits (6:3) being set to one. Values other than 0000h and FFFFh are bit significant. Since ATA standards maintain downward compatibility, a device may set more than one bit.

7.16.7.36 Word 81: Minor revision number

Table 23 defines the value that shall be reported in word 81 to indicate the revision of the standard that guided the implementation.

Table 23 — Minor revision number (part 1 of 2)

Value	Minor Revision
0000h	Minor revision is not reported
0001h	Obsolete
0002h	Obsolete
0003h	Obsolete
0004h	Obsolete
0005h	Obsolete
0006h	Obsolete
0007h	Obsolete
0008h	Obsolete
0009h	Obsolete
000Ah	Obsolete
000Bh	Obsolete
000Ch	Obsolete
000Dh	ATA/ATAPI-4 X3T13 1153D revision 6
000Eh	ATA/ATAPI-4 T13 1153D revision 13
000Fh	ATA/ATAPI-4 X3T13 1153D revision 7
0010h	ATA/ATAPI-4 T13 1153D revision 18
0011h	ATA/ATAPI-4 T13 1153D revision 15
0012h	ATA/ATAPI-4 published, ANSI INCITS 317-1998
0013h	ATA/ATAPI-5 T13 1321D revision 3
0014h	ATA/ATAPI-4 T13 1153D revision 14
0015h	ATA/ATAPI-5 T13 1321D revision 1
0016h	ATA/ATAPI-5 published, ANSI INCITS 340-2000
0017h	ATA/ATAPI-4 T13 1153D revision 17
0018h	ATA/ATAPI-6 T13 1410D revision 0
0019h	ATA/ATAPI-6 T13 1410D revision 3a
001Ah	ATA/ATAPI-7 T13 1532D revision 1
001Bh	ATA/ATAPI-6 T13 1410D revision 2
001Ch	ATA/ATAPI-6 T13 1410D revision 1

Table 23 — Minor revision number (part 2 of 2)

Value	Minor Revision
001Dh	ATA/ATAPI-7 published ANSI INCITS 397-2005.
001Eh	ATA/ATAPI-7 T13 1532D revision 0
001Fh	Reserved
0020h	Reserved
0021h	ATA/ATAPI-7 T13 1532D revision 4a
0022h	ATA/ATAPI-6 published, ANSI INCITS 361-2002
0023h-0026h	Reserved
0027h	ATA8-ACS revision 3c
0028h	Reserved
0029h	ATA8-ACS revision 4
30h-32h	Reserved
0033h	ATA8-ACS Revision 3e
0034h-0041h	Reserved
0042h	ATA8-ACS Revision 3f
0043h-0051h	Reserved
0052h	ATA8-ACS revision 3b
0053h-0106h	Reserved
0107h	ATA8-ACS revision 2d
0108h-FFFEh	Reserved
FFFFh	Minor revision is not reported

7.16.7.37 Words 82-84, 119: Features/command sets supported

Words 82-84 and 119 shall indicate features/command sets supported. If a defined bit is cleared to zero, the indicated features/command set is not supported. If bit 14 of word 83 is set to one and bit 15 of word 83 is cleared to zero, the contents of words 82-83 contain valid support information. If not, support information is not valid in these words. If bit 14 of word 84 is set to one and bit 15 of word 84 is cleared to zero, the contents of word 84 contains valid support information. If not, support information is not valid in this word. If bit 14 of word 119 is set to one and bit 15 of word 119 is cleared to zero, the contents of word 119 contains valid support information. If not, support information is not valid in word 119.

Editor’s Note 9: instead of “is supported”, should these all read “shall be supported”?

If bit 0 of word 82 is set to one, the SMART feature set is supported.

If bit 1 of word 82 is set to one, then the Security feature set is supported.

bit 2 of word 82 is obsolete.

If bit 3 of word 82 is set to one, then the Power Management feature set is supported.

If bit 4 of word 82 is set to one, then the PACKET feature set is supported.

If bit 5 of word 82 is set to one, then volatile write cache is supported.

If bit 6 of word 82 is set to one, then read look-ahead is supported.

If bit 7 of word 82 is set to one, then the release interrupt is supported.

If bit 8 of word 82 is set to one, then the SERVICE interrupt is supported. See 7.48.15 for more information regarding the SERVICE interrupt.

If bit 9 of word 82 is set to one, then the DEVICE RESET command is supported.

If bit 10 of word 82 is set to one, then the Host Protected Area feature set is supported.

Bit 11 of word 82 is obsolete.

If bit 12 of word 82 is set to one, then the WRITE BUFFER command is supported.

If bit 13 of word 82 is set to one, then the READ BUFFER command is supported.

If bit 14 of word 82 is set to one, then the NOP command (see 7.21) is supported.

Bit 15 of word 82 is obsolete.

If bit 0 of word 83 is set to one, then the DOWNLOAD MICROCODE command is supported.

If bit 1 of word 83 is set to one, then the TCQ feature set is supported.

If bit 2 of word 83 is set to one, then the CFA feature set is supported.

If bit 3 of word 83 is set to one, then the Advanced Power Management feature set is supported.

bit 4 of word 83 is obsolete.

If bit 5 of word 83 is set to one, then the Power-Up In Standby feature set is supported.

If bit 6 of word 83 is set to one, then the device requires the SET FEATURES subcommand to spin-up after power-up if the Power-Up In Standby feature set is enabled (see 7.48.8). This bit is valid when the bit 5 of word 83 and bit 5 of word 86 are one, indicating the Power-Up in Standby feature set is supported.

Bit 7 is defined in Address Offset Reserved Area Boot, INCITS TR27-2001.

If bit 8 of word 83 is set to one, then the HPA Security Extensions (see 4.11.2) are supported.

If bit 9 of word 83 is set to one, then the Automatic Acoustic Management feature set is supported.

If bit 10 of word 83 is set to one, then the 48-bit Address feature set is supported.

If bit 11 of word 83 is set to one, then the DCO feature set is supported.

Bit 12 of word 83 shall be set to one indicating the device supports the mandatory FLUSH CACHE command.

If bit 13 of word 83 is set to one, then the FLUSH CACHE EXT command is supported.

If bit 0 of word 84 is set to one, SMART error logging is supported. This bit is valid if the bit 0 of word 82 is set to 1 indicating SMART feature set is supported.

If bit 1 of word 84 is set to one, SMART self-test is supported. This bit is valid if the bit 0 of word 82 is set to 1 indicating SMART feature set is supported.

If bit 2 of word 84 is set to one, then media serial number field words 176-205 are supported.

If bit 3 of word 84 is set to one, then the Media Card Pass Through Command feature set is supported.

If bit 4 of word 84 is set to one, then the Streaming feature set is supported.

If bit 5 of word 84 is set to one, then the General Purpose Logging feature set is supported.

If bit 6 of word 84 is set to one, then the WRITE DMA FUA EXT command and WRITE MULTIPLE FUA EXT command is supported.

If bit 7 of word 84 is set to one, then the WRITE DMA QUEUED FUA EXT command is supported.

Bit 8 of word 84 shall be set to one indicating the mandatory World Wide Name in words 108-111 is supported.

Bit 11 of word 84 is reserved for INCITS TR37-2004.

Bit 12 of word 84 is reserved for INCITS TR37-2004.

If bit 13 of word 84 is set to one, then the IDLE IMMEDIATE with UNLOAD FEATURE is supported.

Bit 0 of word 119 is reserved for technical report DT1825.

Editor's Note 10: is it still DT1825? Also need to make an entry in the references subclause.

If bit 1 of word 119 is set to one, then the Write-Read-Verify feature set is supported.

If bit 2 of word 119 is set to one, then the WRITE UNCORRECTAB LE EXT command is supported.

If bit 3 of word 119 is set to one, then the optional READ DMA EXT command and the optional WRITE DMA EXT command commands are supported. This bit shall only be set to one if word 84 bit 5 is set to one.

if bit 4 of word 119 is set to one, then DOWNLOAD MICROCODE mode 03h is supported

if bit 5 of word 119 is set to one, then the Free-fall Control feature set is supported

7.16.7.38 Words 85-87, 120: Features/command sets enabled

Words 85-87 and 120 shall indicate features/command sets enabled. If a defined bit is cleared to zero, the indicated features/command set is not enabled. If a supported feature or feature set is supported and there is no defined method to disable the feature or feature set, it is defined as supported and the bit shall be set to one. If bit 14 of word 87 is set to one and bit 15 of word 87 is cleared to zero, the contents of words 85-87 contain valid information. If bit 14 of word 120 is set to one and bit 15 of word 120 is cleared to zero, the contents of word 120 contain valid information. If not, information is not valid in these words.

> NOTE 9 — Some features do not have a method to be disabled. These features are marked as supported in this subclause for symmetry.

If bit 0 of word 85 is set to one, then the SMART feature set is enabled (see 7.53.4). If bit 0 of word 85 is cleared to zero, then the SMART feature set is disabled (see 7.53.2). This bit is valid if the bit 0 of word 82 is set to 1 indicating SMART feature set is supported.

If bit 1 of word 85 is set to one, then Security has been enabled by setting a User password via the SECURITY SET PASSWORD command. If bit 1 of word 85 is cleared to zero, then there is no valid User password. If the Security feature set is not supported, this bit shall be cleared to zero. This bit is valid if the bit 1 of word 82 is set to 1 indicating Security Mode feature set is supported. See 7.53.2 and See 7.53.4 for more information.

Bit 2 of word 85 is obsolete.

Bit 3 of word 85 shall be set to one to indicate that the Mandatory Power Management feature set is supported. This bit is a copy of bit 3 of word 82.

Bit 4 of word 85 shall be cleared to zero to indicate that the PACKET feature set is not supported.

If bit 5 of word 85 is set to one, then volatile write cache is enabled (see 7.48.4). If bit 5 of word 85 is cleared to zero, then volatile write cache is disabled. This bit is valid if the bit 5 of word 82 is set to 1 indicating write cache is supported.

If bit 6 of word 85 is set to one, then read look-ahead is enabled (see 7.48.13). If bit 6 of word 85 is cleared to zero, then read look-ahead is disabled. This bit is valid if the bit 6 of word 82 is set to 1 indicating read look-ahead is supported.

If bit 7 of word 85 is set to one, then the release interrupt is enabled (see 7.48.14). If bit 7 of word 85 is cleared to zero, then the release interrupt is disabled.

If bit 8 of word 85 is set to one, then the SERVICE interrupt is enabled (see 7.48.15). If bit 8 of word 85 is cleared to zero, then the SERVICE interrupt is disabled.

Bit 9 of word 85 shall be cleared to zero to indicate that the DEVICE RESET command is not supported.

If the device is not indicating its full size as defined by READ NATIVE MAX or READ NATIVE MAX EXT command because a SET MAX ADDESS or SET MAX ADDRESS EXT command has been issued to resize the device, then bit 10 of word 85 shall be set to one indicating that a Host Protected Area has been established (i.e., HPA enabled). If the device is indicating its full size as defined by READ NATIVE MAX or READ NATIVE MAX EXT command then bit 10 of word 85 shall be cleared to zero indicating that a Host Protected Area has not been established (i.e., HPA disabled). This bit is valid if the bit 10 of word 82 is set to 1 indicating Host Protected Area feature set is supported.

Bit 11 of word 85 is obsolete.

If bit 12 of word 85 is set to one, then the WRITE BUFFER command is supported.

If bit 13 of word 85 is set to one, then the READ BUFFER command is supported.

If bit 14 of word 85 is set to one, then the NOP command is supported.

Bit 15 of word 85 is obsolete.

If bit 0 of word 86 is set to one, then the DOWNLOAD MICROCODE command is supported.

If bit 1 of word 86 is set to one, then the TCQ feature set is supported.

If bit 2 of word 86 is set to one, then the CFA feature set is supported.

If bit 3 of word 86 is set to one, then the Advanced Power Management feature set is enabled (see 7.48.6). If bit 3 of word 86 is cleared to zero, the Advanced Power Management feature set is disabled.

Bit 4 of word 86 is obsolete.

If bit 5 of word 86 is set to one, then the Power-Up In Standby feature set is enabled (see 7.48.7). If bit 5 of word 86 is cleared to zero, then the Power-Up In Standby feature set is disabled. This bit is valid if the bit 3 of word 83 is set to 1 indicating Advanced Power Management feature set is supported.

If bit 6 of word 86 is set to one, then the device requires the SET FEATURES subcommand to spin-up after power-up (see 7.48.8). This bit is valid if the bit 5 of word 83 and bit 5 of word 86 are set to 1 indicating Power-Up In Standby feature set is supported.

Bit 7 of word 86 is defined in Address Offset Reserved Area Boot, INCITS TR27-2001.

If bit 8 of word 86 is set to one, then the HPA Security Extensions are enabled (see 7.49.5). This bit is valid if the bit 8 of word 83 is set to 1 indicating the HPA Security Extensions are supported.

If bit 9 of word 86 is set to one, then the Automatic Acoustic Management feature set is enabled (see 7.48.11) and the value in word 94 is valid. This bit is valid if the bit 9 of word 83 is set to 1 indicating that the Automatic Acoustic Management feature set is supported.

If bit 10 of word 86 is set to one, then the 48-bit Address feature set is supported.

If bit 11 of word 86 is set to one, then the DCO feature set is supported.

Bit 12 of word 86 shall be set to one indicating the mandatory FLUSH CACHE command is supported.

If bit 13 of word 86 is set to one, then the FLUSH CACHE EXT command is supported.

If bit 0 of word 87 is set to one, then the device supports SMART error logging. This bit is valid if the bit 0 of word 82 is set to 1 indicating SMART feature set is supported.

Editor's Note 11: I think this bit is a copy of word 82 bit 0.

If bit 1 of word 87 is set to one, the device supports SMART self-test. This bit is valid if the bit 0 of word 82 is set to 1 indicating SMART feature set is supported.

Editor's Note 12: I think this bit is a copy of word 82 bit 1.

If bit 2 of word 87 is set to one, then the media serial number field in words 176-205 is valid. This bit shall be cleared to zero if the media does not contain a valid serial number or if no media is present. This bit is valid if the bit 2 of word 84 is set to 1 indicating Media serial number is supported.

If bit 3 of word 87 is set to one, then the Media Card Pass Through feature set is enabled.

If bit 5 of word 87 is set to one, then the General Purpose Logging feature se is supported.

If bit 6 of word 87 is set to one, then the WRITE DMA FUA EXT command and WRITE MULTIPLE FUA EXT command is supported.

If bit 7 of word 87 is set to one, then the WRITE DMA QUEUED FUA EXT command is supported.

bit 8 of word 84 shall be set to one indicating the mandatory World Wide Name in words 108-111 is supported.

Bit 11 of word 87 is reserved for NCITS TR37-2004.

Bit 12 of word 87 is reserved for NCITS TR37-2004.

If bit 13 of word 87 is set to one, then the IDLE IMMEDIATE with UNLOAD FEATURE is supported.

Bit 0 of word 120 is reserved for technical report DT1825.

Editor’s Note 13: Need to fill in real name.

If bit 1 of word 120 is set to one then the Write-Read-Verify feature set is enabled.

If bit 2 of word 120 is set to one then the WRITE UNCORRECTABLE EXT command is supported.

If bit 3 of word 120 is set to one, then the READ LOG DMA EXT and WRITE LOG DMA EXT commands are supported. This bit is valid if the bit 4 of word 85 is set to 1 indicating General Purpose Logging feature set is supported.

if bit 4 of word 120 is set to one, then DOWNLOAD MICROCODE mode 03h is supported. This bit is valid if the bit 0 of word 83 and bit 0 of word 86 are set to 1 indicating DOWNLOAD MICROCODE command is supported.

If bit 5 of word 120 is set to one, then the Free-fall Control feature set is enabled.

7.16.7.39 Word 88: Ultra DMA modes

Word 88 identifies the Ultra DMA transfer modes supported by the device and indicates the mode that is currently selected. Only one DMA mode shall be selected at any given time. If an Ultra DMA mode is selected, then no Multiword DMA mode shall be selected. If a Multiword DMA mode is selected, then no Ultra DMA mode shall be selected. Support of this word is mandatory if any Ultra DMA mode is supported.

Bit 15 of word 88 is reserved.

If bit 14 of word 88 is set to one, then Ultra DMA mode 6 is selected. If this bit is cleared to zero, then Ultra DMA mode 6 is not selected. If bit 13 or bit 12 or bit 11 or bit 10 or bit 9 or bit 8 is set to one, then this bit shall be cleared to zero.

If bit 13 of word 88 is set to one, then Ultra DMA mode 5 is selected. If this bit is cleared to zero, then Ultra DMA mode 5 is not selected. If bit 12 or bit 11 or bit 10 or bit 9 or bit 8 is set to one, then this bit shall be cleared to zero.

If bit 12 of word 88 is set to one, then Ultra DMA mode 4 is selected. If this bit is cleared to zero, then Ultra DMA mode 4 is not selected. If bit 13 or 11 or bit 10 or bit 9 or bit 8 is set to one, then this bit shall be cleared to zero.

If bit 11 of word 88 is set to one, then Ultra DMA mode 3 is selected. If this bit is cleared to zero, then Ultra DMA mode 3 is not selected. If bit 13 or 12 or bit 10 or bit 9 or bit 8 is set to one, then this bit shall be cleared to zero.

If bit 10 of word 88 is set to one, then Ultra DMA mode 2 is selected. If this bit is cleared to zero, then Ultra DMA mode 2 is not selected. If bit 13 or 12 or bit 11 or bit 9 or bit 8 is set to one, then this bit shall be cleared to zero.

If bit 9 of word 88 is set to one, then Ultra DMA mode 1 is selected. If this bit is cleared to zero then Ultra DMA mode 1 is not selected. If bit 13 or 12 or bit 11 or bit 10 or bit 8 is set to one, then this bit shall be cleared to zero.

If bit 8 of word 88 is set to one, then Ultra DMA mode 0 is selected. If this bit is cleared to zero then Ultra DMA mode 0 is not selected. If bit 13 or 12 or bit 11 or bit 10 or bit 9 is set to one, then this bit shall be cleared to zero.

Bit (7) of word 88 are reserved.

For PATA devices when bit 6 of word 88 is set to one Ultra DMA modes 6 and below are supported. If this bit is cleared to zero, then Ultra DMA mode 6 is not supported. If Ultra DMA mode 6 is supported, then Ultra DMA modes 5, 4, 3, 2, 1 and 0 shall also be supported. If this bit is set to one, then bits (5:0) shall be set to one.

For SATA devices bit 6 of word 88 shall be set to one.

For PATA devices when bit 5 of word 88 is set to one Ultra DMA modes 5 and below are supported. If this bit is cleared to zero, then Ultra DMA mode 5 is not supported. If Ultra DMA mode 5 is supported, then Ultra DMA modes 4, 3, 2, 1 and 0 shall also be supported. If this bit is set to one, then bits (4:0) shall be set to one.

For SATA devices bit 5 of word 88 shall be set to one.

For PATA devices when bit 4 of word 88 is set to one Ultra DMA modes 4 and below are supported. If this bit is cleared to zero, then Ultra DMA mode 4 is not supported. If Ultra DMA mode 4 is supported, then Ultra DMA modes 3, 2, 1 and 0 shall also be supported. If this bit is set to one, then bits (3:0) shall be set to one.

For SATA devices bit 4 of word 88 shall be set to one.

For PATA devices when bit 3 of word 88 is set to one Ultra DMA modes 3 and below are supported. If this bit is cleared to zero, then Ultra DMA mode 3 is not supported. If Ultra DMA mode 3 is supported, then Ultra DMA modes 2, 1 and 0 shall also be supported. If this bit is set to one, then bits (2:0) shall be set to one.

For SATA devices bit 3 of word 88 shall be set to one.

For PATA devices when bit 2 of word 88 is set to one Ultra DMA modes 2 and below are supported. If this bit is cleared to zero, then Ultra DMA mode 2 is not supported. If Ultra DMA mode 2 is supported, then Ultra DMA modes 1 and 0 shall also be supported. If this bit is set to one, bits (1:0) shall be set to one.

For SATA devices bit 2 of word 88 shall be set to one.

For PATA devices when bit 1 of word 88 is set to one Ultra DMA modes 1 and below are supported. If this bit is cleared to zero, then Ultra DMA mode 1 is not supported. If Ultra DMA mode 1 is supported, then Ultra DMA mode 0 shall also be supported. If this bit is set to one, bit 0 shall be set to one.

For SATA devices bit 1 of word 88 shall be set to one.

For PATA devices when bit 0 of word 88 is set to one Ultra DMA mode 0 is supported. If this bit is cleared to zero, then Ultra DMA is not supported.

For SATA devices bit 0 of word 88 shall be set to one.

7.16.7.40 Word 89: Time required for Security erase unit completion

Word 89 specifies the estimated time required for the SECURITY ERASE UNIT command to complete its normal mode erasure. Support of this word is mandatory if the Security feature set is supported. If the Security feature set is not supported, this word shall be cleared to zero.

Value	Time
0	Value not specified
1-254	(Value*2) minutes
255	>508 minutes

7.16.7.41 Word 90: Time required for Enhanced security erase unit completion

Word 90 specifies the estimated time required for the SECURITY ERASE UNIT command to complete its enhanced mode erasure. Support of this word is mandatory if support of the Security feature set is supported. If the Security feature set is not supported, this word shall be cleared to zero.

Value	Time
0	Value not specified
1-254	(Value*2) minutes
255	>508 minutes

7.16.7.42 Word 91: Advanced power management level value

Bits (7:0) of word 91 contain the current Advanced Power Management level setting. Support of this word is mandatory if the Advanced Power Management feature set is supported. This word is valid if the bit 3 of word 83 and bit 3 of word 86 are set to 1 indicating the Advanced Power Management feature set is supported.

7.16.7.43 Word 92: Master Password Identifier

If the Security feature set is not supported (bit 1 of word 82) or the Master Password Identifier feature is not supported, word 92 shall contain the value 0000h or FFFFh.

If the Security feature set and the Master Password Identifier feature are supported, word 92 contains the value of the Master Password Identifier set when the Master Password was last changed.

7.16.7.44 Word 93: Hardware configuration test results

For PATA devices when bit 14 of word 93 is set to one and bit 15 of word 93 is cleared to zero the content of word 93 contains valid information. During processing of a hardware reset, Device 0 shall set bits (12:8) of this word to zero and shall set bits (7:0) of this word as indicated to show the result of the hardware reset. During processing of a hardware reset, Device 1 shall clear bits (7:0) of this word to zero and shall set bits (12:8) of the word as indicated to show the result of the hardware reset. Support of bits (15:13) is mandatory. Support of bits (12:0) is optional.

Bit 13 shall be set or cleared by the selected device to indicate whether the device detected CBLID- above V_{IH} or below V_{IL} at any time during execution of each IDENTIFY DEVICE command after receiving the command from the host but before returning data to the host. This test may be repeated as desired by the device during command execution (See ATA8-APT).

For SATA devices word 93 shall be set to the value 0000h.

7.16.7.45 Word 94: Current automatic acoustic management value

Bits (15:8) contain the device vendor's recommended acoustic management level (see table 43 for an enumeration of all of the possible acoustic management levels). If the host desires the drive to perform with highest performance, it should set the automatic acoustic management level to FEh. If the OEM host desires the vendor's recommended acoustic management level as defined by the device's vendor, the host should set the automatic acoustic management level to the value returned to the host in these 8 bits. The use of this setting may not provide the lowest acoustics, or the best trade-off of acoustics and performance, in all configurations. Support of this word is mandatory if the Acoustic Management feature set is supported.

Bits (7:0) contain the current automatic acoustic management level. If the Automatic Acoustic Management feature set is supported by the device, but the level has not been set by the host, this byte shall contain the drive's default setting. If the Automatic Acoustic Management feature set is not supported by the device, the value of this byte shall be zero.

This word is valid if the bit 9 of word 83 is set to 1 indicating that the Automatic Acoustic Management feature set is supported.

7.16.7.46 Word 95: Stream Minimum Request Size

Number of logical sectors that provides optimum performance in a streaming environment. This number shall be a power of two, with a minimum of eight logical sectors (4096 bytes). The starting LBA value for each streaming command should be evenly divisible by this request size. This word is valid if the bit 4 of word 84 is set to 1 indicating Streaming feature set is supported.

7.16.7.47 Word 96: Streaming Transfer Time - DMA

Word 96 defines the Streaming Transfer Time for DMA mode. The worst-case sustainable transfer time per logical sector for the device is calculated as follows:

Streaming Transfer Time = (word 96) * (Streaming Performance Granularity / 65536)

The content of word 96 may be affected by the host issuing a SET FEATURES subcommand 43h (Typical Host Interface Sector Time for DMA mode). Because of this effect, an IDENTIFY DEVICE command shall be issued after a SET FEATURES command that may affect these words. If the Streaming feature set is not supported by the device, the content of word 96 shall be zero.

This bit is valid if the bit 4 of word 84 is set to 1 indicating Streaming feature set is supported.

7.16.7.48 Word 97: Streaming Access Latency - DMA and PIO

Word 97 defines the Streaming Access Latency for DMA and PIO mode. The worst-case access latency of the device for a streaming command is calculated as follows:

Access Latency = (word 97) * (Streaming Performance Granularity / 256)

The content of word 97 may be affected by the host issuing a SET FEATURES subcommand 42h or C2h (Automatic Acoustic Management). Because of this effect, an IDENTIFY DEVICE command shall be issued after a SET FEATURES command that may affect these words. If the Streaming feature set is not supported by the device, the content of word 97 shall be zero.

This bit is valid if the bit 4 of word 84 is set to 1 indicating Streaming feature set is supported.

7.16.7.49 Words 98-99: Streaming Performance Granularity

These words define the fixed unit of time that is used in IDENTIFY DEVICE data words 96-97 and 104, SET FEATURES subcommand Set Maximum Host Interface Sector Times (see 7.48.12), and in the Command Completion Time Limit that is passed in streaming commands. The unit of time for this parameter shall be in microseconds, e.g., a value of 10000 indicates 10 milliseconds. If yy was returned by the drive for this parameter, then

a) the Command Completion Time Limit in the Feature field for a streaming command shall be yy microseconds.
b) the Streaming Transfer Time shall be ((word 96) * (yy/65536)) microseconds, ((word 104) * (yy / 5536)) microseconds.
c) The Streaming Access Latency shall be ((word 97) * (yy/256)) microseconds.
d) taking these units into account, the host may calculate the estimated time for a streaming command of size S logical sectors as ((word 96 * S / 65536) + (word 97 / 256)) * yy microseconds for DMA mode.
e) taking these units into account, the host may calculate the estimated time for a streaming command of size S logical sectors as ((word 104 * S / 65536) + (word 97 / 256)) * yy microseconds for PIO mode.

The value of the Streaming Performance Granularity is vendor specific and fixed for a device.

This bit is valid if the bit 4 of word 84 is set to 1 indicating Streaming feature set is supported.

7.16.7.50 Words 100-103: Total Number of User Addressable Sectors for the 48-bit Address feature set

Words 100-103 contain a value that is one greater than the maximum LBA in user accessible space when the 48-bit Addressing feature set is supported. The maximum value that shall be placed in this field is 0000_FFFF_FFFF_FFFFh. Support of these words is mandatory if the 48-bit Address feature set is supported.

7.16.7.51 Word 104: Streaming Transfer Time - PIO

Word 104 defines the Streaming Transfer Time for PIO mode. The worst-case sustainable transfer time per logical sector for the device is calculated as follows:

Streaming Transfer Time = (word 104) * (Streaming Performance Granularity / 65536)

The content of word 104 may be affected by the host issuing a SET FEATURES subcommand 43h (Typical Host Interface Sector Time for PIO mode). Because of this effect, an IDENTIFY DEVICE command shall be issued after a SET FEATURES command that may affect these words. If the Streaming feature set is not supported by the device, the content of word 104 shall be zero.

This bit is valid if the bit 4 of word 84 is set to 1 indicating Streaming feature set is supported.

7.16.7.52 Word 106: Physical sector size / Logical Sector Size

If bit 14 of word 106 is set to one and bit 15 of word 106 is cleared to zero, the contents of word 106 contain valid information. If not, information is not valid in this word.

Bit 13 of word 106 shall be set to one to indicate that the device has more than one logical sector per physical sector.

Bit 12 of word 106 shall be set to 1 to indicate that the device has been formatted with a logical sector size larger than 256 words. Bit 12 of word 106 shall be cleared to 0 to indicate that words 117-118 are invalid and that the logical sector size is 256 words.

Bits (11:4) of word 106 are reserved.

Bits (3:0) of word 106 indicate the size of the device physical sectors in power of two logical sectors.

Examples:

Bits (3:0): 0 = 2^0 = 1 logical sector per physical sector
Bits (3:0): 1 = 2^1 = 2 logical sector per physical sector
Bits (3:0): 2 = 2^2 = 4 logical sector per physical sector
Bits (3:0): 3 = 2^3 = 8 logical sector per physical sector

7.16.7.53 Word 107: Inter-seek delay for ISO 7779 standard acoustic testing

Word 107 is defined as the manufacturer's recommended time delay between seeks during ISO-7779 standard acoustic testing in microseconds (ISO 7779 value t_D. See ISO 7779:1999 (E), subclause C.9 Equipment Category: Disk units and storage subsystems).

7.16.7.54 Words 108-111: World wide name

Words 111-108 shall contain the mandatory value of the world wide name (WWN) for the device.

Word 108 bits 15-12 shall contain 5h, indicating that the naming authority is IEEE. All other values are reserved.

Words 108 bits 11-0 and word 109 bits (15:4) shall contain the Organization Unique Identifier (OUI) for the device manufacturer. The OUI shall be assigned by the IEEE/RAC as specified by ISO/IEC 13213:1994.

The identifier may be obtained from:

Institute of Electrical and Electronic Engineers, Inc.
Registration Authority Committee
445 Hoes Lane
Piscataway, NJ 08855-1331

Word 109 bits (3:0), word 110, and word 111 shall contain a value assigned by the vendor that is unique for the device in the OUI domain.

This field is valid if the bit 8 of word 84 is set to 1 indicating 64-bit World wide name is supported.

7.16.7.55 Words 112-115: Reserved for a 128-bit world wide name

7.16.7.56 Word 116: Reserved for TLC technical report

This field is described in Time-Limited Commands (TLC) INCITS TR37-2004

7.16.7.57 Words 117-118: Logical Sector Size

Words 117-118 indicate the size of device logical sectors in words. The value of words (117-118) shall be equal to or greater than 256. The value in words (117-118) shall be valid when word 106 bit 12 is set to 1. All logical sectors on a device shall be this length. When word 106, bit 12 is cleared to zero this field shall be cleared to zero.

7.16.7.58 Words 121-126: Reserved

7.16.7.59 Word 127: Obsolete

7.16.7.60 Word 128: Security status

Support of this word is mandatory if the Security feature set is supported. If the Security feature set is not supported, this word shall be cleared to zero.

Bit 8 of word 128 indicates the Master Password Capability. If security is enabled and the Master Password Capability is high, bit 8 shall be cleared to zero. If security is enabled and the Master Password Capability is maximum, bit 8 shall be set to one. When security is disabled, bit 8 shall be cleared to zero.

Bit 5 of word 128 set to one indicates that the enhanced mode of the SECURITY ERASE UNIT command is supported.

Bit 4 of word 128 set to one indicates that the password attempt counter has decremented to zero. This is also known as the “Password Attempt Counter Exceeded” bit.

Bit 3 of word 128 set to one indicates that security is frozen.

Bit 2 of word 128 set to one indicates that security is locked.

Bit 1 of word 128 set to one indicates that security is enabled. This is a copy of word 85, bit 1.

Bit 0 of word 128 set to one indicates that the Security feature set is supported. This is a copy of word 82, bit 1.

7.16.7.61 Words 129-159: Vendor specific

7.16.7.62 Word 160: CFA power mode

Word 160 indicates the presence and status of a CFA feature set device that supports CFA Power Mode 1. Support of this word is mandatory if CFA Power Mode 1 is supported.

If bit 13 of word 160 is set to one then the device shall be in CFA Power Mode 1 to perform one or more commands implemented by the device.

If bit 12 of word 160 is set to one the device is in CFA Power Mode 0 (see 7.48.9).

Bits (11:0) indicate the maximum average RMS current in Milliamperes required during 3.3V or 5V device operation in CFA Power Mode 1.

7.16.7.63 Words 161-175: Reserved for assignment by the CompactFlash™ Association

7.16.7.64 Words 176-205: Current media serial number

Words (205:176) contain the current media serial number. Serial numbers shall consist of 60 bytes. The first 40 bytes shall indicate the media serial number and the remaining 20 bytes shall indicate the media manufacturer.

7.16.7.65 Word 206: SCT Command Transport

Bits 15:12 indicate support for vendor specific action codes.

Bits 11:6 of word 206 are reserved

If bit 5 of word 206 is set to one, then SCT Data Tables (see 8.3.6) are supported.

If bit 4 of word 206 is set to one the device supports SCT Features Control (see 8.3.5).

If bit 3 of word 206 is set to one the device supports SCT Error Recovery Control (see 8.3.4).

If bit 2 of word 206 is set to one the device supports SCT Write Same (see 8.3.3).

If bit 1 of word 206 is set to one the device supports SCT Long Sector Access (see 8.3.2).

If bit 0 of word 206 is set to one the device supports the SCT Command Transport including SCT Read Status (see clause 8).

7.16.7.66 Word 209: Alignment of logical blocks within a physical block

Word 209 shall report the location of LBA0 within the first physical sector of the media. See Annex C for more information. This bit is valid if the bit 13 of word 106 is set to 1 indicating Device has multiple sector per physical sector.

7.16.7.67 Words 210-211: Write-Read-Verify Sector Count Mode 3

Words 210-211 shall indicate the number of logical sectors to be verified after every spin-up, as set by the SET FEATURES command for the Enable Write-Read-Verify subcommand. This count only applies to mode 3.

7.16.7.68 Words 212-213:Write-Read-Verify Sector Count Mode 2

Words 212-213 shall indicate the number of logical sectors to be verified after every spin-up, as set by the SET FEATURES command for the Enable Write-Read-Verify subcommand. This count only applies to mode 2.

7.16.7.69 Word 214: NV Cache Capabilities

Both the NV Cache Power Mode feature set version (word 214 bits 8-11) and the NV Cache feature set version (word 214 bits 12-15) shall be set to 0.

If bit 4 of word 214 is set to 1, the NV Cache feature set is both supported and enabled.

if bit 1 of word 214 is set to 1, the NV Cache Power Management feature is enabled. This capability is enabled by issuing a SET NV CACHE POWER MODE and disabled by issuing a RETURN FROM NV CACHE POWER MODE.

if bit 0 of word 214 is set to 1, the NV Cache Power Management feature set is supported.

7.16.7.70 Words 215-216: NV Cache Size in Logical Blocks (MSW)

Words 215 and 216 specify the maximum number of logical sectors that the device's NV Cache Set contains for the host to pin. This field is valid if the bit 5 of word 214 is set to 1 indicating NV Cache feature set is supported.

7.16.7.71 Word 217: Nominal Media Rotation Rate

Word 217 indicates the nominal media rotation rate of the device and is defined in table 24.

Table 24 — Nominal Media Rotation Rate

Value	Description
0000h	Rate not reported
0001h	Non-rotating media (e.g., solid state device)
0002h-0400h	Reserved
0401h-FFFEh	Nominal media rotation rate in rotations per minute (rpm) (e.g., 7200 rpm = 1C20h)
FFFFh	Reserved

7.16.7.72 Word 218: Reserved

7.16.7.73 Word 219: NV Cache Options

Word 219 bits 0-7 specify a value which is the device's estimate of the amount of time it takes to be able to satisfy a read or write request from its rotational media when the read or write request is received while the rotational media is not spinning. This field is valid if the bit 5 of word 214 is set to 1 indicating NV Cache feature set is supported.

7.16.7.74 Word 220: Write-Read-Verify Mode

Word 220 contains the current mode of the Write-Read-Verify feature set, as set by the SET FEATURES Enable/Disable Write-Read-Verify subcommand. See 7.48.10 for more information on setting Write-Read-Verify mode.

Bits 15:8 reserved

Bits 7:0 current mode of the Write-Read-Verify feature set

7.16.7.75 Word 221: Reserved

7.16.7.76 Word 222: Transport major revision number

If not FFFFh, the device claims compliance with the Transport Standard major version(s) as indicated by bits (6:3) being set to one. Values other than 0000h and FFFFh are bit significant. Since ATA standards maintain downward compatibility, a device may set more than one bit.

7.16.7.77 Word 223: Transport minor revision number

Table 25 defines the value that shall be reported in word 223 to indicate the revision of the standard that guided the implementation.

Table 25 — Transport minor version number

Value	Minor Revision
0000h	Minor revision not reported
0001h-0020h	Reserved
0021h	ATA8-AST T13 Project D1697 Revision 0b
0022h-FFFEh	Reserved
FFFFh	Minor version not reported

7.16.7.78 Words 224-233: Reserved for CE-ATA

7.16.7.79 Word 234: Minimum number of 512 byte data blocks per DOWNLOAD MICROCODE command mode 3

This is the minimum number of 512 byte data blocks per DOWNLOAD MICROCODE command mode 3 the device shall accept. This bit is valid if the bit 0 of word 83, bit 0 of word 86, and bit 4 of word 120 are set to one indicating DOWNLOAD MICROCODE Mode 3 command is supported.

7.16.7.80 Word 235: Maximum number of 512 byte data blocks per DOWNLOAD MICROCODE command mode 3

This is the maximum number of 512 byte data blocks per DOWNLOAD MICROCODE command mode 3 the drive shall accept. This bit is valid if the bit 0 of word 83, bit 0 of word 86, and bit 4 of word 120 are set to one indicating DOWNLOAD MICROCODE Mode 3 command is supported.

7.16.7.81 Words 236-254: Reserved

7.16.7.82 Word 255: Integrity word

The use of this word is optional. If bits (7:0) of this word contain the signature A5h, bits (15:8) contain the data structure checksum. The data structure checksum is the two's complement of the sum of all bytes in words 0-254 and the byte consisting of bits (7:0) in word 255. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all 512 bytes is zero when the checksum is correct.

7.17 IDENTIFY PACKET DEVICE - A1h, PIO Data-in

7.17.1 Feature Set

This command is mandatory for devices implementing the PACKET feature set.

7.17.2 Description

The IDENTIFY PACKET DEVICE command enables the host to receive parameter information from a device that implements the PACKET feature set. Table 26 for a description of the return data.

Some devices may have to read the media in order to complete this command.

The IDENTIFY PACKET DEVICE data contains information regarding optional feature or command support. If the host issues a command that is indicated as not supported in the IDENTIFY PACKET DEVICE data, the device shall abort the command

See 7.16.2 for the description of the data types found in Table 26.

7.17.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 A1h

7.17.4 Normal Outputs

See table 86.

7.17.5 Error Outputs

The device shall return command aborted if the device does not implement this command, otherwise, the device shall not report an error. See table 109. The device may return error status if an Interface CRC error has occurred.

NOTE 10 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer; there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.17.6 Input Data

7.17.6.1 Overview

Table 26 — IDENTIFY PACKET DEVICE data (part 1 of 7)

Word	O M	S P	F V	Description
0	M	B		General configuration bit-significant information:
			F	15:14 10 = ATAPI device
			F	11 = Reserved
			F	13 Reserved
			F	12:8 Field indicates command packet set used by device
			F	7 Obsolete
			F	6:5 00 = Device shall set DRQ to one within 3 ms of receiving PACKET command.
				01 = Obsolete.
				10 = Device shall set DRQ to one within 50 µs of receiving PACKET command.
			F	11 = Reserved
			F	4:3 Reserved
			V	2 Incomplete response
			F	1:0 00 = 12 byte command packet
				01 = 16 byte command packet
				1x = Reserved
1			F	Reserved
2		B	V	Specific configuration
3-9			F	Reserved
10-19	M	B	F	Serial number (ASCII String)
20-22			F	Reserved
23-26	M	B	F	Firmware revision (ASCII String)
27-46	M	B	F	Model number (ASCII String)
47-48			F	Reserved
49	M			Capabilities
			X	15:12 Obsolete
		P	F	11 1 = IORDY supported
		P	F	10 1 = IORDY may be disabled
			F	9 Shall be set to one.
		P	F	8 1 = DMA supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0
			X	7:0 Vendor specific
50	O			Capabilities
			F	15 Shall be cleared to zero.
			F	14 Shall be set to one.
			F	13:2 Reserved
			X	1 Obsolete
		B	F	0 Shall be set to one to indicate a device specific Standby timer value minimum.
51-52			X	Obsolete

Table 26 — IDENTIFY PACKET DEVICE data (part 2 of 7)

Word	O M	S P	F V	Description
53	M		F	15:3 Reserved
		B	F	2 1 = the fields reported in word 88 are valid
		B	F	1 1 = the fields reported in words (70:64) are valid
			X	0 Obsolete
54-61			F	Reserved
62	M	S	F	15 1 = DMADIR bit in the Packet command is required for DMA transfers 0 = DMADIR bit in Packet command is not required for DMA transfers.
			F	14:11 Reserved
		P	F	10 1 = DMA is supported
		P	F	9 1 = Multiword DMA mode 2 is supported
		P	F	8 1 = Multiword DMA mode 1 is supported
		P	F	7 1 = Multiword DMA mode 0 is supported
		P	F	6 1 = Ultra DMA mode 6 and below are supported
		P	F	5 1 = Ultra DMA mode 5 and below are supported
		P	F	4 1 = Ultra DMA mode 4 and below are supported
		P	F	3 1 = Ultra DMA mode 3 and below are supported
		P	F	2 1 = Ultra DMA mode 2 and below are supported
		P	F	1 1 = Ultra DMA mode 1 and below are supported
		P	F	0 1 = Ultra DMA mode 0 is supported
63	M		F	15:11 Reserved
		P	V	10 1 = Multiword DMA mode 2 is selected
		P	V	9 1 = Multiword DMA mode 1 is selected
		P	V	8 1 = Multiword DMA mode 0 is selected
			F	7:3 Reserved
		P	F	2 1 = Multiword DMA mode 2 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
		P	F	1 1 = Multiword DMA mode 1 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
		P	F	0 1 = Multiword DMA mode 0 is supported Multiword DMA mode selected Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
64	M		F	15:8 Reserved
		P	F	7:0 PIO transfer modes supported
65	M			Minimum Multiword DMA transfer cycle time per word
		P	F	15:0 Cycle time in nanoseconds
66	M			Manufacturer's recommended Multiword DMA transfer cycle time
		P	F	15:0 Cycle time in nanoseconds
67	M			Minimum PIO transfer cycle time without flow control
68		P	F	15:0 Cycle time in nanoseconds
	M			Minimum PIO transfer cycle time with IORDY flow control
		P	F	15:0 Cycle time in nanoseconds
69-70			F	Reserved
71-72			X	Obsolete
73-74			F	Reserved
75			X	Obsolete
76-79				Reserved for Serial ATA

Table 26 — IDENTIFY PACKET DEVICE data (part 3 of 7)

Word	O M	S P	F V	Description
80	M	B		Major version number 0000h or FFFFh = device does not report version
			F	15:9 Reserved
			F	8 1 = supports ATA8-ACS
			F	7 1 = Supports ATA/ATAPI-7
			F	6 1 = supports ATA/ATAPI-6
			F	5 1 = supports ATA/ATAPI-5
			F	4 1 = supports ATA/ATAPI-4
			X	3 Obsolete
			X	2 Obsolete
			X	1 Obsolete
			F	0 Reserved
81	M	B		Minor version number 0000h or FFFFh = device does not report version 0001h-FFFEh=See 7.16.7.36
82	M			Feature sets/commands supported. If words (83:82) = 0000h or FFFFh feature set/command support notification not supported.
			X	15 Obsolete
			F	14 Shall be set to one to indicate that the NOP command is supported
			F	13 Shall be cleared to zero to indicate that the READ BUFFER command is not supported
			F	12 Shall be cleared to zero to indicate that the WRITE BUFFER command is not supported
			X	11 Obsolete
			F	10 Shall be cleared to zero to indicate that the Host Protected Area feature set is not supported
			F	9 Shall be set to one to indicate that the DEVICE RESET command is supported
			X	8 Obsolete
			X	7 Obsolete
			F	6 1 = read look-ahead supported
			F	5 1 = volatile write cache supported
			F	4 Shall be set to one indicating the PACKET feature set is supported.
			F	3 1 = Power Management feature set supported
			X	2 Obsolete
			F	1 1 = Security feature set supported
			F	0 Shall be cleared to zero to indicate that the SMART feature set is not supported

Table 26 — IDENTIFY PACKET DEVICE data (part 4 of 7)

Word	O M	S P	F V	Description
83	M			Feature sets/commands supported.
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
			F	13 Reserved
			F	12 1 = FLUSH CACHE command supported
			F	11 1 = Device Configuration Overlay feature set supported
			F	10 Reserved
			F	9 1 = AUTOMATIC Acoustic Management feature set supported
			F	8 1 = SET MAX security extension supported
				7 Reserved for INCITS TR27-2001
			F	6 1 = SET FEATURES subcommand required to spin-up after power-up
			F	5 1 = Power-Up In Standby feature set supported
			X	4 Obsolete
			F	3:1 Reserved
			F	0 Shall be cleared to zero to indicate that the DOWNLOAD MICROCODE command is not supported
84	M			Feature set/commands supported extension.
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
			F	13:6 Reserved
				5 General Purpose Logging feature set
			F	4:0 Reserved
85	M			Feature sets/commands enabled.
			X	15 Obsolete
			F	14 Shall be set to one to indicate that the NOP command is supported
			F	13 Shall be cleared to zero to indicate that the READ BUFFER command is not supported
			F	12 Shall be cleared to zero to indicate that the WRITE BUFFER command is not supported
			X	11 Obsolete
			V	10 Shall be cleared to zero to indicate that the Host Protected Area feature set is not supported
			F	9 Shall be set to one to indicate that the DEVICE RESET command is supported
			X	8 Obsolete
			X	7 Obsolete
			V	6 1 = read look-ahead enabled
			V	5 1 = volatile write cache enabled
			F	4 Shall be set to one indicating the PACKET feature set is supported.
			F	3 1 = Power Management feature set enabled
			X	2 Obsolete
			V	1 1 = Security feature set enabled
			V	0 Shall be cleared to zero to indicate that the SMART feature set is not supported

Table 26 — IDENTIFY PACKET DEVICE data (part 5 of 7)

Word	O M	S P	F V	Description
86	M			Feature sets/commands enabled.
			F	15:13 Reserved
			V	12 1 = FLUSH CACHE command supported
			F	11 1 = Device Configuration Overlay feature set supported
			F	10 Reserved
			V	9 1 = Automatic Acoustic Management feature set enabled
			V	8 1 = SET MAX security extension enabled by a SET MAX SET PASSWORD
			V	7 Reserved for INCITS TR27-2001
			F	6 1 = SET FEATURES subcommand required to spin-up after power-up
			V	5 1 = Power-Up In Standby feature set enabled
			X	4 Obsolete
			F	3:1 Reserved
			F	0 Shall be cleared to zero to indicate that the DOWNLOAD MICROCODE command is not supported
87	M			Feature sets/commands enabled.
			F	15 Shall be cleared to zero
			F	14 Shall be set to one
			F	13:6 Reserved
			F	5 General Purpose Logging feature set
			F	4:0 Reserved
88	M		F	15 Reserved
				14 1 = Ultra DMA mode 6 is selected
			V	13 1 = Ultra DMA mode 5 is selected
			V	12 1 = Ultra DMA mode 4 is selected
			V	11 1 = Ultra DMA mode 3 is selected
			V	10 1 = Ultra DMA mode 2 is selected 0 = Ultra DMA mode 2 is not selected
			V	9 1 = Ultra DMA mode 1 is selected 0 = Ultra DMA mode 1 is not selected
			V	8 1 = Ultra DMA mode 0 is selected 0 = Ultra DMA mode 0 is not selected
			F	7 Reserved
			F	6 1 = Ultra DMA mode 6 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
			F	5 1 = Ultra DMA mode 5 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
			F	4 1 = Ultra DMA mode 4 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
			F	3 1 = Ultra DMA mode 3 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
			F	2 1 = Ultra DMA mode 2 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
			F	1 1 = Ultra DMA mode 1 and below are supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
			F	0 1 = Ultra DMA mode 0 is supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0.
89	O	B	F	Time required for security erase unit completion

Table 26 — IDENTIFY PACKET DEVICE data (part 6 of 7)

Word	O M	S P	F V	Description
90	O	B	F	Time required for Enhanced security erase completion
91			F	Reserved
92	O	B	V	Master Password Identifier
93	M			Hardware reset result. The contents of bits (12:0) of this word shall change only during the execution of a hardware reset.
			F	15 Shall be cleared to zero.
			F	14 Shall be set to one.
			V	13 1 = device detected CBLID- above V_{iH}
				0 = device detected CBLID- below V_{iL}
				12:8 Device 1 hardware reset result. Device 0 shall clear these bits to zero. Device 1 shall set these bits as follows:
			F	12 Reserved.
			V	11 0 = Device 1 did not assert PDIAG-.
				1 = Device 1 asserted PDIAG-.
			V	10:9 These bits indicate how Device 1 determined the device number:
				00 = Reserved.
				01 = a jumper was used.
				10 = the CSEL signal was used.
				11 = some other method was used or the method is unknown.
			F	8 Shall be set to one.
				7:0 Device 0 hardware reset result. Device 1 shall clear these bits to zero. Device 0 shall set these bits as follows:
			F	7 Reserved.
			F	6 0 = Device 0 does not respond when Device 1 is selected.
				1 = Device 0 responds when Device 1 is selected.
			V	5 0 = Device 0 did not detect the assertion of DASP-.
				1 = Device 0 detected the assertion of DASP-.
			V	4 0 = Device 0 did not detect the assertion of PDIAG-.
				1 = Device 0 detected the assertion of PDIAG-.
			V	3 0 = Device 0 failed diagnostics.
				1 = Device 0 passed diagnostics.
			V	2:1 These bits indicate how Device 0 determined the device number:
				00 = Reserved.
				01 = a jumper was used.
				10 = the CSEL signal was used.
				11 = some other method was used or the method is unknown.
			F	0 Shall be set to one.
94	O	B	V	15:8 Vendor's recommended acoustic management value.
		B	V	7:0 Current automatic acoustic management value.
95-107			F	Reserved
108	M	B	F	15:12 NAA (3:0)
				11:0 IEEE OUI (23:12)
109	M	B	F	15:4 IEEE OUI (11:0)
				3:0 Unique ID (35:32)
110	M	B	F	15:0 Unique ID (31:16)
111	M	B	F	15:0 Unique ID (15:0)

Table 26 — IDENTIFY PACKET DEVICE data (part 7 of 7)

Word	O M	S P	F V	Description
112-115			F	Reserved for world wide name extension to 128 bits
116-124			F	Reserved
125	M	B	F	ATAPI byte count = 0 behavior
126-127			X	Obsolete
128	O			Security status
			F	15:9 Reserved
			V	8 Security level 0 = High, 1 = Maximum
			F	7:6 Reserved
			F	5 1 = Enhanced security erase supported
			V	4 1 = Security count expired
			V	3 1 = Security frozen
			V	2 1 = Security locked
			V	1 1 = Security enabled
			F	0 1 = Security supported
129-159			X	Vendor specific
160-175		N		Reserved for assignment by the CompactFlash™ Association
176-254			F	Reserved
255	O		V	Integrity word
		B		15:8 Checksum
		B		7:0 Signature

Key:
F/V – Fixed/variable content
F – The content of the field is fixed and does not change. The DCO command may change the value of a fixed field.
V – The contents of the field is variable and may change depending on the state of the device or the commands executed by the device.
X – The fixed or variable type of this field is not defined in this standard.

O/M – Mandatory/optional requirement.
M – Support of the word is mandatory.
O – Support of the word is optional.
S/P – Content applies to Serial or Parallel transport
S – Serial Transport
P – Parallel Transport
B – Both Serial and Parallel Transports
N – Belongs to a transport other than Serial or Parallel

7.17.6.2 Word 0: General configuration

Bits (15:14) of word 0 indicate the type of device. Bit 15 shall be set to one and bit 14 shall be cleared to zero to indicate the device implements the PACKET feature set.

Bits (12:8) of word 0 indicate the command packet set implemented by the device. This value follows the peripheral device type value as defined in SPC-3.

Bit 7 of word 0 is Obsolete.

If the Parallel interface is implemented, bits (6:5) of word 0 indicate the DRQ response time when a PACKET command is received. A value of 00b indicates a maximum time of 3 ms from receipt of PACKET to the setting of DRQ to one. A value of 10b indicates a maximum time of 50 μs from the receipt of PACKET to the setting of DRQ to one. The value 11b is reserved.

If bit 2 is set to one it indicates that the content of the IDENTIFY PACKET DEVICE data is incomplete. This may occur if the device supports the Power-up in Standby feature set and required data is contained on the device media. In this case the content of at least word 0 and word 2 shall be valid.

Bits (1:0) of word 0 indicate the packet size the device supports. A value of 00b indicates that a 12-byte packet is supported; a value of 01b indicates a 16 byte packet. The values 10b and 11b are reserved.

7.17.6.3 Word 1: Reserved

7.17.6.4 Word 2: Specific configuration

Word 2 shall have the same content described for IDENTIFY DEVICE data word 2.

7.17.6.5 Words 3-9: Reserved

7.17.6.6 Words 10-19: Serial number

The use of these words is optional. If not implemented, the content shall be zeros. If implemented, the content shall be as described in IDENTIFY DEVICE data words 10-19. See 7.16.7.

7.17.6.7 Words 20-22: Reserved

7.17.6.8 Words 23-26: Firmware revision

Words 23-26 shall have the content described for IDENTIFY DEVICE data words 23-26.

7.17.6.9 Words 27-46: Model number

Words 27-46 shall have the content described for IDENTIFY DEVICE data words 27-46.

7.17.6.10 Words 47-48: Reserved

7.17.6.11 Word 49: Capabilities

Bit 15:12 of word 49 are obsolete.

Bit 11 of word 49 is used to determine whether a device supports IORDY. If this bit is set to one, then the device supports IORDY operation. If this bit is zero, the device may support IORDY. This ensures backward compatibility. If a device supports PIO mode 3 or higher, then this bit shall be set to one. If the serial interface is implemented, this bit shall be set to one.

Bit 10 of word 49 is used to indicate a device’s ability to enable or disable the use of IORDY. If this bit is set to one, then the device supports the disabling of IORDY. Disabling and enabling of IORDY is accomplished using the SET FEATURES command. If the serial interface is implemented, this bit shall be set to one.

Bit 9 of word 49 shall be set to one.

Bit 8 of word 49 indicates that DMA is supported. Devices which require the DMADIR bit in the Packet command shall clear this bit to 0

7.17.6.12 Word 50: Capabilities

Word 50 shall have the content described for IDENTIFY DEVICE data word 50. Support of this word is mandatory if the STANDBY command is supported.

7.17.6.13 Word 51: Obsolete

7.17.6.14 Word 52: Reserved

7.17.6.15 Word 53: Field validity

Word 53 shall have the content described for IDENTIFY DEVICE data word 53.

7.17.6.16 Words 54-61: Reserved

7.17.6.17 Word 62: DMADIR

ATAPI devices that use a serial ATA bridge chip for connection to a serial ATA host may require use of the DMADIR bit to indicate transfer direction for Packet DMA commands. Word 62 is used to indicate if such support is required.

If bit 15 of word 62 is set to one, then DMADIR bit in the Packet Command is required by the device for Packet DMA and Bits 2:0 of word 63, bits 15 and 8 in word 49, and bits 6:0 of word 88 shall be cleared to 0,.

If bit 15 of word 62 is cleared to 0, DMADIR bit in the PACKET command is not required. If bit 15 of word 62 is cleared to zero, then all bits of word 62 shall be cleared to zero.

Bits (14:11)of word 62 are reserved.

Bits (10:1)of word 62 indicate DMA mode support. Since the DMADIR bit is only used for a Serial ATAPI device, all of these bits are set to 1.

7.17.6.18 Word 63: Multiword DMA transfer

Word 63 identifies the Multiword DMA transfer modes supported by the device and indicates the mode that is currently selected. Only one DMA mode shall be selected at any given time. If an Ultra DMA mode is enabled, then no Multiword DMA mode shall be enabled. If a Multiword DMA mode is enabled then no Ultra DMA mode shall be enabled.

Bits (15:11) of word 63are reserved.

Bits (10:8) of word 63 shall have the content described for IDENTIFY DEVICE data word 63.

Bits (7:3) of word 63 are reserved

If bit 2 of Word 63 is set to one, then Multiword DMA modes 2 and below are supported. If this bit is cleared to zero, then Multiword DMA mode 2 is not supported. If Multiword DMA mode 2 is supported, then Multiword DMA modes 1 and 0 shall also be supported.

If bit 2 of Word 63 is set to one, bits (1:0) shall be set to one. If the serial interface is implemented, this bit shall be set to one except this bit shall be cleared 0 for Serial ATAPI devices requiring the DMADIR bit in the PACKET command.

If bit 1 of Word 63 is set to one, then Multiword DMA modes 1 and below are supported. If this bit is cleared to zero, then Multiword DMA mode 1 is not supported. If Multiword DMA mode 1 is supported, then Multiword DMA mode 0 shall also be supported.

If bit 1 of Word 63 is set to one, bit 0 shall be set to one. If the serial interface is implemented, this bit shall be set to one except this bit shall be cleared to 0 for Serial ATAPI devices which require the DMADIR bit in the PACKET command.

If bit 0 of word 63 is set to one, then Multiword DMA mode 0 is supported. If the serial interface is implemented, this bit shall be set to one except this bit shall be cleared to 0 for Serial ATAPI devices which require the DMADIR bit in the PACKET command.

7.17.6.19 Word 64: PIO transfer mode supported

Word 64 shall have the content described for IDENTIFY DEVICE data word 64.

7.17.6.20 Word 65: Minimum multiword DMA transfer cycle time per word

Word 65 shall have the content described for IDENTIFY DEVICE data word 65.

7.17.6.21 Word 66: Device recommended multiword DMA cycle time

Word 66 shall have the content described for IDENTIFY DEVICE data word 66.

7.17.6.22 Word 67: Minimum PIO transfer cycle time without flow control

Word 67 shall have the content described for IDENTIFY DEVICE data word 67.

7.17.6.23 Word 68: Minimum PIO transfer cycle time with IORDY

Word 68 shall have the content described for IDENTIFY DEVICE data word 68.

7.17.6.24 Words 69-70: Reserved

7.17.6.25 Words 71-72: Obsolete

7.17.6.26 Words 73-74: Reserved

7.17.6.27 Word 75: Obsolete

7.17.6.28 Words 76-79: Reserved for Serial ATA

7.17.6.29 Word 80: Major revision number

Word 80 shall have the content described for IDENTIFY DEVICE data word 80.

7.17.6.30 Word 81: Minor revision number

Word 81 shall have the content described for IDENTIFY DEVICE data word 81.

7.17.6.31 Words 82-84: Feature sets/commands supported

Words 82-84 shall have the content described for words IDENTIFY DEVICE data words 82-84 except that bit 4 of word 82 shall be set to one to indicate that the PACKET feature set is supported.

7.17.6.32 Words 85-87: Feature sets/commands enabled

Words 85-87 shall have the content described for words IDENTIFY DEVICE data words 85-87 except that bit 4 of word 85 shall be set to one to indicate that the PACKET feature set is supported.

7.17.6.33 Word 88:Ultra DMA modes

Word 88 shall have the content described for IDENTIFY DEVICE data words 88, except bits 6:0 shall be cleared to 0 for Serial ATAPI devices which require the DMADIR bit in the Packet command.

7.17.6.34 Word 89: Time required for Security erase unit completion

Word 89 shall have the content described for IDENTIFY DEVICE data words 89.

7.17.6.35 Word 90: Time required for Enhanced security erase unit completion

Word 90 shall have the content described for IDENTIFY DEVICE data words 90.

7.17.6.36 Word 91: Reserved

7.17.6.37 Word 92

Word 92 shall have the content described for IDENTIFY DEVICE data words 92.

7.17.6.38 Word 93: Hardware reset results

Word 93 shall have the content described for IDENTIFY DEVICE data words 93. Support of bits (15:13) is mandatory. Support of bits (12:0) is optional.

7.17.6.39 Word 94: Current automatic acoustic management value

Word 94 shall have the content described for IDENTIFY DEVICE data words 94.

7.17.6.40 Word 95-107: Reserved

7.17.6.41 Words 108-111: World wide name

Words 111-108 shall contain the mandatory value of the world wide name (WWN) for the device.

Word 108 bits 15-12 shall contain 5h, indicating that the naming authority is IEEE. All other values are reserved.

Words 108 bits 11-0 and word 109 bits (15:4) shall contain the Organization Unique Identifier (OUI) for the device manufacturer. The OUI shall be assigned by the IEEE/RAC as specified by ISO/IEC 13213:1994.

The identifier may be obtained from:

> Institute of Electrical and Electronic Engineers, Inc.
> Registration Authority Committee
> 445 Hoes Lane
> Piscataway, NJ 08855-1331

Word 109 bits (3:0), word 110, and word 111 shall contain a value assigned by the vendor that is unique for the device in the OUI domain.

7.17.6.42 Words 112-115: Reserved for a 128-bit world wide name

7.17.6.43 Words 116-124: Reserved

7.17.6.44 Word 125 ATAPI byte count=0 behavior

If the contents of word 125 are 0000h and the value of the byte count limit is zero, the device shall return command aborted.

If the contents of word 125 are non-zero and the value of the byte count limit is zero, the device shall use the contents of word 125 as the actual byte count limit for the current command and shall not abort.

The device may be reconfigured to report a new value. However, after the device is reconfigured, the content of word 125 reported shall not change until after the next power-on reset or hardware reset.

7.17.6.45 Word 126-127: Obsolete

7.17.6.46 Word 128: Security status

Word 128 shall have the content described for IDENTIFY DEVICE data word 128. Support of this word is mandatory if the Security feature set is supported.

7.17.6.47 Words 129-160: Reserved

7.17.6.48 Words 161-175: Reserved for assignment by the CompactFlash™ Association

7.17.6.49 Words 176-254: Reserved

7.17.6.50 Word 255: Integrity Word

Word 255 shall have the content described for IDENTIFY DEVICE data words 255. Word 255 should be implemented.

7.18 IDLE - E3h, Non-data

7.18.1 Feature Set

This command is mandatory for devices implementing the Power Management feature set.

7.18.2 Description

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

If the Count field is non-zero then the Standby timer shall be enabled. The value in the Count field shall be used to determine the time programmed into the Standby timer (see 4.18). If the Count field is zero then the Standby timer is disabled.

7.18.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	Timer period value (TPV) -The TPV shall determine the time period programmed into the Standby timer. Table 27 defines these values.
02h-04h	LBA	Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E3h

Table 27 — Automatic Standby timer periods

Count field contents		Corresponding time-out period
0	(00h)	Time-out disabled
1-240	(01h-F0h)	(value * 5) seconds
241-251	(F1h-FBh)	((value - 240) *30) minutes
252	(FCh)	21 minutes
253	(FDh)	Period between 8 hours and 12 hours
254	(FEh)	Reserved
255	(FFh)	21 min. 15 seconds
Note 1 - Times are approximate.		

7.18.4 Normal Outputs

See table 86.

7.18.5 Error Outputs

See table 109.

7.19 IDLE IMMEDIATE - E1h, Non-data

7.19.1 Feature Set

This command is mandatory for devices implementing the Power Management feature set.

7.19.2 Description

7.19.2.1 Default Function

The IDLE IMMEDIATE command allows the host to immediately place the device in the Idle mode. Command completion may occur even though the device has not fully transitioned into the Idle mode.

7.19.2.2 Unload feature

The optional UNLOAD feature of the IDLE IMMEDIATE command provides a method for the host to cause a device that is a hard disk drive to move its read/write heads to a safe position as soon as possible.

Upon receiving an IDLE IMMEDIATE command with the UNLOAD feature, a device shall:

a) stop read look-ahead if that operation is in process;
b) stop writing cached data to the media if that operation is in process;
c) if a device implements unloading its head(s) onto a ramp, then the device shall retract the head(s) onto the ramp;
d) if a device implements parking its head(s) in a landing zone on the media, then the device shall park its head(s) in the landing zone; and
e) transition to the Idle mode.

The device shall retain data in the write cache and resume writing the cached data onto the media after receiving a Software Reset, a Hardware Reset, or any new command except IDLE IMMEDIATE with UNLOAD feature.

A device shall report command completion after the head(s) have been unloaded or parked.

NOTE 11 — The time required by a device to complete an unload or park operation is vendor specific. However, a typical time for a drive to unload heads on to a ramp is 500 ms, and a typical time for a drive to park heads in a landing zone is 300 ms.

7.19.3 Inputs (Default Function)

Word	Name	Description
00h	Feature	N/A except when the unload feature is requested, see 7.19.4
01h	Count	N/A except when the unload feature is requested, see 7.19.4
02h-04h	LBA	N/A except when the unload feature is requested, see 7.19.4
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E1h

7.19.4 Inputs (Unload Feature)

Word	Name	Description
00h	Feature	0044h
01h	Count	Reserved
02h-04h	LBA	000000554E4Ch
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E1h

7.19.5 Normal Outputs (Default Function)

See table 86.

7.19.6 Normal Outputs (Unload Feature)

See table 93.

7.19.7 Error Outputs

See table 109.

7.20 Non-Volatile Cache

7.20.1 NV Cache Overview

The optional NV Cache Commands feature set permits a host to modify the NV Cache Pinned Set of a device in a manner that allows the device to improve response times to read and write commands while reducing the device's power consumption.

The NV Cache Commands feature set provides a set of commands that guide a device's management of the contents of its NV Cache.

Commands unique to the NV Cache Commands feature set use a single command code and are differentiated from one another by the value placed in the Features field. A device that implements the NV Cache Commands feature set shall implement the following commands:

A) ADD LBA(S) TO NV CACHE PINNED SET
B) REMOVE LBA(S) FROM NV CACHE PINNED SET
C) QUERY NV CACHE PINNED SET
D) QUERY NV CACHE MISSES
E) FLUSH NV CACHE
F) NV CACHE ENABLE/DISABLE

Individual NV Cache Commands are identified by the value placed in the Feature field as shown in table 28.

Table 28 — NV Cache Commands

Value	Command Name
00h-0Fh	Reserved for the NV Cache Power Management feature set
10h	ADD LBA(S) TO NV CACHE PINNED SET
11h	REMOVE LBA(S) FROM NV CACHE PINNED SET
12h	QUERY NV CACHE PINNED SET
13h	QUERY NV CACHE MISSES
14h	FLUSH NV CACHE
15h	NV CACHE ENABLE
16h	NV CACHE DISABLE
17h-2Fh	Reserved for the NV Cache feature set
30h-CFh	Reserved
D0h-EFh	Vendor Specific
F0-FFh	Reserved

7.20.2 NV Cache Power Management Overview

The optional NV Cache Power Management feature set permits a host to modify the behavior of a device in a manner that allows the device to improve response times to read and write commands while reducing the device's power consumption.

Commands unique to the NV Cache Power Management feature set use a single command code and are differentiated from one another by the value placed in the Features field. A device that implements the NV Cache Power Management feature set shall implement the following commands:

A) SET NV CACHE POWER MODE
B) RETURN FROM NV CACHE POWER MODE

Individual NV Cache Power Management commands are identified by the value placed in the Feature field as shown in table 29.

Table 29 — NV Cache Power Managements Commands

Value	Command Name
00h	SET NV CACHE POWER MODE
01h	RETURN FROM NV CACHE POWER MODE
02h-0Fh	Reserved for the NV Cache Power Management feature set
10h-2Fh	Reserved for the NV Cache feature set
30h-CFh	Reserved
D0h-EFh	Vendor Specific
F0-FFh	Reserved

7.20.3 ADD LBA(S) TO NV CACHE PINNED SET - B6h/10h, DMA

7.20.3.1 Description

This command adds the logical blocks specified in the NV Cache Set Data to the NV Cache Pinned Set if they are not already so.

If the PI bit is set to one the command shall not complete until the NV Cache population is complete. If the PI bit is set to zero, the command shall complete immediately and the population of the sector data shall be completed on subsequent Write operations to that LBA. If a Read operation occurs to this LBA before the sector data is populated in the NV Cache then this data should be sourced from the valid data located on the magnetic media and may require a disk spin up.

If an LBA Range Entry (see 7.20.3.5) specified in the NV Cache Set Data does exist but is beyond the range of user-accessible logical blocks, the device shall add the logical blocks to the NV Cache Pinned Set, but continue to fail all reads and writes to the LBA as before.

The response to this command shall be the number of sectors that may be added to the NV Cache's pinned set.

7.20.3.2 Inputs

7.20.3.2.1 Overview

Word	Name	Description
00h	Feature	0010h
01h	Count	Number of 256 word data blocks to be transferred. 0000h specifies that 65,536 blocks shall be transferred.
02h-04h	LBA	**Bit** **Description** 47:1 Reserved 0 Populate Immediately (PI) - See 7.20.3.2.2
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B6h

7.20.3.2.2 Populate Immediately

PI (Populate Immediately) shall be set to one to specify that the logical blocks specified in the Pin Request Data (see table 30) are to be added to the device's NV Pinned Cache Set and populated immediately from the disk before the command completion. PI shall be set to zero to specify that the logical blocks specified in the Pin Request Data are to be added to the device's NV Pinned Cache Set and populated upon subsequent Write operation to that LBA.

7.20.3.3 Normal Outputs

See table 102.

7.20.3.4 Error Outputs

If this command fails, none of the requested logical blocks are added to the Pinned Set. See table 133 for more information.

7.20.3.5 Output Data

Pin Request Data is a list of individual LBA ranges. Each entry in Pin Request Data is called a LBA Range Entry and is represented by 8 bytes. The LBA is expressed by the LBA Range Entry's first 6 bytes and the range length is a zero based number (i.e. 0=0, 1=1, etc.) represented by the remaining 2 bytes. If the 2 byte range length is 0 then the LBA Range Entry is not valid. The range entries shall be non-overlapping and sorted with the LBA Values in ascending order.

Table 30 — Request Pin Data

Word	Description	
0-7	Entry #0	
	63:16	LBA Value
	15:0	Range Length
8-15	Entry #1	
	63:16	LBA Value
	15:0	Range Length
...	...	...
496-511	Entry #63	
	63:16	LBA Value
	15:0	Range Length

7.20.4 FLUSH NV CACHE - B6h/14h, Non-data

7.20.4.1 Description

The device ensures that it has at least as many logical blocks as specified in the 'Minimum Number of logical blocks to Flush Make Available' available to be pinned without requiring a future spin up. If the device must spin up in order to make the required number of logical blocks available it must do so. The command completes immediately and if necessary the device performs the task of removing logical blocks from the NV Cache Unpinned Set to provide the capacity requested in a prudent fashion. If the device determines it is unable to complete the operation, it shall report an error.

The output of this command is the number of logical blocks which have yet to be removed from the NV Cache Unpinned Set to satisfy the 'Minimum Number of logical blocks to Make Available ' or completely empty the NV Cache Unpinned Set, whichever is lesser.

7.20.4.2 Inputs

Word	Name	Description
00h	Feature	0014h
01h	Count	Reserved
02h-04h	LBA	Bit Description 47:32 Reserved 31:0 Minimum number of logical blocks to flush
05h	Device	**Bit Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B6h

7.20.4.3 Normal Outputs

The number of unflushed logical blocks is the number of logical blocks which have not yet to be flushed from the NV Cache Unpinned Set to satisfy the Minimum Number of logical blocks to flush or to completely empty the NV Cache Unpinned Set, whichever is lesser. See table 103.

7.20.4.4 Error Outputs

See table 135.

7.20.5 NV CACHE DISABLE- B6h/16h, Non-data

7.20.5.1 Description

In response to receiving an NV Cache disable, the device shall perform the following actions:

a) flush all non-volatile cached data (both pinned and unpinned data) to other non-volatile media,
b) erase the pinned sectors list,
c) disable the NV Cache Power Mode feature set and
d) no longer read from or write user data to the non-volatile cache.

Once the device has reported successful command completion, the device shall abort all commands in the NV Cache feature set except for NV Cache enable.

This setting is non-volatile.

7.20.5.2 Inputs

Word	Name	Description
00h	Feature	0016h
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B6h

7.20.5.3 Normal Outputs

See table 99.

7.20.5.4 Error Outputs

See table 135.

7.20.6 NV CACHE ENABLE - B6h/15h, Non-data

7.20.6.1 Description

In response to receiving an NV Cache enable, the device may read or write data to the non-volatile cache.

This setting is non-volatile.

7.20.6.2 Inputs

Word	Name	Description
00h	Feature	0015h
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B6h

7.20.6.3 Normal Outputs

See table 99.

7.20.6.4 Error Outputs

See table 135.

7.20.7 QUERY NV CACHE MISSES - B6h/13h, DMA

7.20.7.1 Description

This command requests the device to report NV Cache Misses in LBA Ranges in a single 512 byte block. The first 64 cache misses are returned as LBA Ranges and shall be listed in accessed order. If the device does not have as many LBA ranges as are requested in the transfer, the unused LBA ranges shall be filled with zero.

Any of the following conditions shall cause the NV-CACHE misses table to be cleared:

a) the device processes a power-on reset
b) completion of the QUERY NV CACHE MISSES command
c) completion of a STANDBY IMMEDIATE command

7.20.7.2 Inputs

Word	Name	Description	
00h	Feature	0013h	
01h	Count	0001h	
02h-04h	LBA	Reserved	
05h	Device	**Bit**	**Description**
		15:13	N/A
		12	Transport Dependent - See 6.1.9
		11:8	Reserved
	Command	7:0	B6h

7.20.7.3 Normal Outputs

See table 102.

7.20.7.4 Error Outputs

See table 135.

7.20.7.5 Input Data

Cache Miss Data is a list of individual LBA ranges. Each entry in Cache Miss Data is called a LBA Range Entry and is represented by 8 bytes. The LBA is expressed by the LBA Range Entry's first 6 bytes and the range length is a zero based number (i.e. 0=0, 1=1, etc.) represented by the remaining 2 bytes. If the 2 byte range length is 0 then the LBA Range Entry is not valid.

Table 31 — Cache Miss Data

Word	**Description**	
0-7	Entry #0	
	63:16	LBA Value
	15:0	Range Length
8-15	Entry #1	
	63:16	LBA Value
	15:0	Range Length
...	...	...
496-511	Entry #63	
	63:16	LBA Value
	15:0	Range Length

7.20.8 QUERY NV CACHE PINNED SET - B6h/12h, DMA

7.20.8.1 Description

This command requests the device to send the LBA Ranges currently in the NV Cache pinned set in 512 bytes block equal to the number in Block Count. The LBA Ranges sent must be in numerical order. If a device does not have as many LBA Ranges as are requested in the transfer, the unused LBA Ranges shall be filled with zero.

7.20.8.2 Inputs

Word	Name	Description
00h	Feature	0012h
01h	Count	Number of 256 word data blocks to be transferred. 0000h specifies that 65,536 blocks shall be transferred.
02h-04h	LBA	Starting LBA - The first LBA to be Queried
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B6h

7.20.8.3 Normal Outputs

See table 102.

7.20.8.4 Error Outputs

See table 135.

7.20.8.5 Input Data

Pin Set Data is a list of individual LBA ranges. Each entry in Pin Set Data is called a LBA Range Entry and is represented by 8 bytes. The LBA is expressed by the LBA Range Entry's first 6 bytes and the range length is a zero based number (i.e. 0=0, 1=1, etc.) represented by the remaining 2 bytes. If the 2 byte range length is 0 then the LBA Range Entry is not valid. The range entries shall be non-overlapping and sorted with the LBA Values in access order.

Table 32 — Pin Set Data

Word	**Description**	
0-7	Entry #0	
	63:16	LBA Value
	15:0	Range Length
8-15	Entry #1	
	63:16	LBA Value
	15:0	Range Length
...	...	...
496-511	Entry #63	
	63:16	LBA Value
	15:0	Range Length

7.20.9 REMOVE LBA(S) FROM NV CACHE PINNED SET - B6h/11h, DMA

7.20.9.1 Description

This command removes the logical blocks specified in the NV Cache Set Data from the NV Cache's pinned set, no longer including them in the set of logical blocks that must always be mapped in the NV Cache.

If the NV Cache Set Data specifies an LBA not in the NV Cache Pinned Set, the LBA shall be ignored without causing an error.

The response to this command shall be the number of additional logical blocks that the host may add to the NV Cache's pinned working set as specified in the Count and LBA fields.

7.20.9.2 Inputs

7.20.9.2.1 Overview

Word	Name	Description
00h	Feature	0011h
01h	Count	Number of 256 word data blocks to be transferred. 0000h specifies that 65,536 blocks shall be transferred.
02h-04h	LBA	**Bit** **Description** 47:1 Reserved 0 Unpin All (UA) - See 7.20.9.2.2
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B6h

7.20.9.2.2 Unpin All

UA (Unpin All) indicates that the Value in the Count field should be ignored, and the NV Cache Pinned Set shall have no logical blocks mapped

7.20.9.3 Normal Outputs

See table 102.

7.20.9.4 Error Outputs

If this command fails, none of the requested logical blocks are removed from the Pinned Set. See table 134 for more information.

7.20.9.5 Output Data

Remove Pin Data is a list of individual LBA ranges. Each entry in Remove Pin Data is called a LBA Range Entry and is represented by 8 bytes. The LBA is expressed by the LBA Range Entry's first 6 bytes and the range length is a zero based number (i.e. 0=0, 1=1, etc.) represented by the remaining 2 bytes. If the 2 byte range length is 0 then the LBA Range Entry is not valid. The range entries shall be non-overlapping and sorted with the LBA Values in ascending order

Table 33 — Remove Pin Data

Word	**Description**	
0-7	Entry #0	
	63:16	LBA Value
	15:0	Range Length
8-15	Entry #1	
	63:16	LBA Value
	15:0	Range Length
...	...	...
496-511	Entry #63	
	63:16	LBA Value
	15:0	Range Length

7.20.10 RETURN FROM NV CACHE POWER MODE - B6h/01h, Non-data

7.20.10.1 Description

This command shall cause the device to disable the NV Cache Power Mode and clear IDENTIFY DEVICE word 214 bit 1. Upon completion of this command the device shall disable the NV Cache Power Mode timer.

This command shall not enable or disable the non-volatile cache or the NV Cache feature set.

7.20.10.2 Inputs

Word	Name	Description
00h	Feature	0001h
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15:13 N/A 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B6h

7.20.10.3 Normal Outputs

See table 86.

7.20.10.4 Error Outputs

See table 110

7.20.11 SET NV CACHE POWER MODE - B6h/00h, Non-data

7.20.11.1 Description

This command shall cause the device to set the NV Cache Power Mode timer and set IDENTIFY DEVICE data word 214 bit 1 to one. The device should minimize power consumption and use the NV Cache to satisfy read and write requests whenever possible.

If the device is unable to satisfy a read or write request from its NV Cache it shall access the media and the media shall remain available for at least as many seconds as the value in the Count field.

If the standby timer expires before the NV Cache Power Mode timer, the device shall not transition to standby mode until the NV Cache Power Mode timer expires. Advanced Power Management shall not cause the device to transition to a lower power state until the NV Cache Power Mode timer expires.

7.20.11.2 Inputs

7.20.11.2.1 Overview

Word	Name	Bit	Description
00h	Feature		0000h
01h	Count		Minimum High-Power Time - See 7.20.11.2.2
02h-04h	LBA		Reserved
05h	Device	**Bit**	**Description**
		15:13	N/A
		12	Transport Dependent - See 6.1.9
		11:8	Reserved
	Command	7:0	B6h

7.20.11.2.2 Minimum High-Power Time

Contains minimum value, in seconds, that the device shall stay in a high power state in the case that the device needs to enter the high power state to access it's media while NV CACHE Power Mode is set. The high power state may include any PM Power Management state in which the media is spun up and readily available.

The maximum amount of time the device shall keep the media spun up is vendor specific.

7.20.11.3 Normal Outputs

See table 86.

7.20.11.4 Error Outputs

See table 110

7.21 NOP - 00h, Non-data

7.21.1 Feature Set

This command is mandatory for devices implementing the PACKET feature set. This command is mandatory for devices implementing the TCQ feature set.

7.21.2 Description

The subcommand determines the effect on TCQ queued commands (see table 34 in 7.21.3).

7.21.3 Inputs

Word	Name	Description
00h	Feature	Subcommand Code (see table 34)
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 00h

Table 34 — NOP Subcommand Code

Subcommand Code	Description	Action
00h	NOP	Return command aborted and abort any outstanding queued commands.
01h	NOP Auto Poll	When processed by a device, write all data in the write cache to the media, return command aborted and do not abort any outstanding TCQ queued commands (see 4.24.2). When processed by a host adapter that supports hardware polling, initiate hardware polling, do not transmit the command to the device, and return ABRT set to one and ERR set to zero (see 4.24.1).
02h-FFh	Reserved	Return command aborted and do not abort any outstanding TCQ queued commands.

7.21.4 Normal Outputs

This command always fails with an error (see 7.21.5) for:

a) subcommand code 00h;
b) subcommand 01h when processed by a device;
c) and subcommands 02h-FFh.

When subcommand code 01h is processed by a host adapter as a host adapter function (see 4.24), see table 86.

The Count and LBA fields retain the values that were present when the NOP command was accepted.

7.21.5 Error Outputs

See table 123

7.22 PACKET - A0h, Packet

7.22.1 Feature Set

This command is mandatory for devices implementing the PACKET feature set.

7.22.2 Description

The PACKET command is used to transfer a SCSI Command Descriptor Block (CDB) via a command packet. If the native form of the encapsulated command is shorter than the packet size reported in bits (1:0) of word 0 of the IDENTIFY PACKET DEVICE data, the encapsulated command shall begin at byte 0 of the packet. Packet bytes beyond the end of the encapsulated command are reserved.

7.22.3 Inputs

Word	Name	Description
00h	Feature	**Bit Description** 7:3 Reserved 2 DMADIR - See 7.22.4 1 Obsolete. 0 DMA - This bit is set to one to inform the device that the data transfer (not the command packet transfer) associated with this command is via Multiword DMA or Ultra DMA mode.
01h	Count	Bit Description 7:3 Obsolete 2:0 N/A
02h-04h	LBA	**Bit Description** 47:24 Reserved 23:8 Byte Count - See 7.22.5 7:0 Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 A0h

7.22.4 DMADIR

This bit indicates Packet DMA direction and is used only for devices that implement the Packet feature set with a Serial ATA bridge that require direction indication from the host. Support for this bit is determined by reading bit 15 of word 62 in the IDENTIFY PACKET DEVICE data. If bit 15 of word 62 is set to 1, the device requires the use of the DMADIR bit for Packet DMA commands.

If the device requires the DMADIR bit to be set for Packet DMA operations and the current operations is DMA (i.e. bit 0, the DMA bit, is set), this bit indicates the direction of data transfer (0 = transfer to the device; 1 =

transfer to the host). If the device requires the DMADIR bit to be set for Packet DMA operations but the current operations is PIO (i.e. bit 0, the DMA bit, is cleared), this bit is ignored.

Since the data transfer direction is set by the host as the command is constructed, the DMADIR bit should not conflict with the data transfer direction of the command. If a conflict between the command transfer direction and the DMADIR bit occurs, the device should return with an ABORTED command, and the sense key set to ILLEGAL REQUEST.

If the device does not require the DMADIR bit for Packet DMA operations, this bit should be cleared to 0.

A device that does not support the DMADIR feature may abort a command if the DMADIR bit is set to 1.

7.22.5 Byte Count Limit

This is the maximum byte count that is to be transferred in any single DRQ data block for PIO transfers. The Byte Count Limit does not apply to the command packet transfer. If the PACKET command does not transfer data, the Byte Count Limit is ignored.

NOTE 12 — The amount of data transferred by this command is specified in the CDB.

If the PACKET command results in a data transfer:

a) the host should not set the byte count limit to zero. If the host sets the byte count limit to zero, the contents of IDENTIFY PACKET DEVICE data word 125 determines the expected behavior;
b) the value set into the byte count limit shall be even if the total requested data transfer length is greater than the byte count limit;
c) the value set into the byte count limit may be odd if the total requested data transfer length is equal to or less than the byte count limit;

The value FFFFh is interpreted by the device as though the value were FFFEh.

7.22.6 Normal Outputs

7.22.6.1 Awaiting command

When the device is ready to accept the command packet from the host the return structure shall be set according to table 94. Input/Output shall be cleared to zero, and Command/Data shall be set to one. The Byte Count Limit shall reflect the value set by the host when the command was issued.

7.22.6.2 Data transmission

Data transfer shall occur after the receipt of the command packet. See table 94 for the return structure when the device is ready to transfer data requested by a data transfer command. Input/Output is ignored, and Command/Data shall be set to zero.

If the transfer is to be in PIO mode, the byte count of the data to be transferred for this DRQ data block shall be presented.

Valid byte count values are as follows:

a) the byte count shall be less than or equal to the byte count limit value from the host;
b) the byte count shall not be zero;
c) the byte count shall be less than or equal to FFFEh;
d) the byte count shall be even except for the last transfer of a command;
e) if the byte count is odd, the last valid byte transferred is on DD(7:0) and the data on DD(15:8) is a pad byte of undefined value;

If the last transfer of a command has a pad byte, the byte count shall be odd.

7.22.6.3 Successful command completion

When the device has command completion without error, the device returns the data structure found in table 94. Input/Output shall be set to one, Command/Data shall be set to one. Byte Count is reserved at command completion.

7.22.7 Error Outputs

The device shall not terminate the PACKET command with an error before the last byte of the command packet has been written. See table 124

7.23 READ BUFFER - E4, PIO data-in

7.23.1 Feature Set

This command is optional for devices not implementing the PACKET feature set.

7.23.2 Description

The READ BUFFER command enables the host to read a 512-byte block of data.

The READ BUFFER and WRITE BUFFER commands shall be synchronized such that sequential WRITE BUFFER and READ BUFFER commands access the same data.

The command prior to a READ BUFFER command should be a WRITE BUFFER command. If the READ BUFFER command is not preceded by a WRITE BUFFER command, the data returned by READ BUFFER may be indeterminate.

7.23.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E4h

7.23.4 Normal Outputs

See table 86.

7.23.5 Error Outputs

The device may return error status if an Interface CRC error has occurred. See table 109.

NOTE 13 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer, there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.24 READ DMA - C8h, DMA

7.24.1 Feature Set

This command is mandatory for devices not implementing the PACKET feature set.

7.24.2 Description

The READ DMA command allows the host to read data using the DMA data transfer protocol.

7.24.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero.
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 C8h

7.24.4 Normal Outputs

See table 86.

7.24.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The LBA field contains the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. LBA bits 47:28 shall be cleared to zero. See table 113.

7.25 READ DMA EXT - 25h, DMA

7.25.1 Feature Set

This command is mandatory for devices implementing the 48-bit Address feature set.

7.25.2 Description

The READ DMA EXT command allows the host to read data using the DMA data transfer protocol.

7.25.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 25h

7.25.4 Normal Outputs

See table 99.

7.25.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The address of the logical sector where the first unrecoverable error occurred is returned. The amount of data transferred is indeterminate. See table 113.

7.26 READ DMA QUEUED - C7h, DMA Queued

7.26.1 Feature Set

This command is mandatory for devices implementing the TCQ feature set

7.26.2 Description

This command executes in a similar manner to a READ DMA command. The device may perform a release or may execute the data transfer without performing a release if the data is ready to transfer.

7.26.3 Inputs

Word	Name	Description
00h	Feature	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero
01h	Count	**Bit Description** 15:8 Reserved 7:3 Tag - See 6.3.5 2:0 N/A
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 C7h

7.26.4 Normal Outputs

7.26.4.1 Data transmission

Data transfer may occur after receipt of the command or may occur after the receipt of a SERVICE command. When the device is ready to transfer data requested by a data transfer command, the device returns the data structure described in table 95. Release shall be cleared to zero, Input/Output shall be set to one, and Command/Data shall be cleared to zero.

7.26.4.2 Release

If the device performs a release before transferring data for this command, the device returns the data structure described in table 95. Release shall be set to one, Input/Output shall be cleared to zero, and Command/Data shall be cleared to zero.

7.26.4.3 Service request

When the device is ready to transfer data or complete a command after the command has performed a release, the device shall set the SERV bit and not change the state of any other status bit. When the SERVICE command is received, the device shall set outputs as described in data transfer, command completion, or Error Outputs depending on the service the device requires.

7.26.4.4 Command completion

When the transfer of all requested data has occurred without error, the device returns the data structure described in table 95. Release shall be cleared to zero, Input/Output shall be set to one, and Command/Data shall be set to one.

7.26.5 Error Outputs

The Count field contains the Tag for this command if the device supports the TCQ feature set. The device shall return command aborted if the device supports the TCQ feature set and the Tag is invalid. An unrecoverable error encountered during the execution of this command results in the termination of the command and the logical sector where the first unrecoverable error occurred is returned. If write cache is enabled, unrecoverable errors may not be reliably reported because they may occur after the completion of the command. If a queue existed, the unrecoverable error shall cause the queue to abort. See table 125 for more information.

7.27 READ DMA QUEUED EXT- 26h, DMA Queued

7.27.1 Feature Set

This command is mandatory for devices implementing both the TCQ and 48-bit feature sets

7.27.2 Description

This command executes in a similar manner to a READ DMA command. The device may perform a release or may execute the data transfer without performing a release if the data is ready to transfer.

7.27.3 Inputs

Word	Name	Description
00h	Feature	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
01h	Count	**Bit Description** 15:8 Reserved 7:3 Tag - See 6.3.5 2:0 Reserved
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 26h

7.27.4 Normal Outputs

7.27.4.1 Data transmission

Data transfer may occur after receipt of the command or may occur after the receipt of a SERVICE command. When the device is ready to transfer data requested by a data transfer command, the device returns the data structure described in table 101. Release shall be cleared to zero, Input/Output shall be set to one, and Command/Data shall be cleared to zero.

7.27.4.2 Release

If the device performs a release before transferring data for this command, the device returns the data structure described in table 101. Release shall be set to one, Input/Output shall be cleared to zero, and Command/Data shall be cleared to zero.

7.27.4.3 Service request

When the device is ready to transfer data or complete a command after the command has performed a release, the device shall set the SERV bit and not change the state of any other status bit. When the SERVICE command is received, the device shall set outputs as described in data transfer, command completion, or Error Outputs depending on the service the device requires.

7.27.4.4 Command completion

When the transfer of all requested data has occurred without error, the device returns the data structure described in table 101. Release shall be cleared to zero, Input/Output shall be set to one, and Command/Data shall be set to one.

7.27.5 Error Outputs

The Count field contains the Tag for this command if the device supports the TCQ feature set. The device shall return command aborted if the device supports the TCQ feature set and the Tag is invalid. An unrecoverable error encountered during the execution of this command results in the termination of the command and the logical sector where the first unrecoverable error occurred is returned. If write cache is enabled, unrecoverable errors may not be reliably reported as they may occur after the completion of the command. If a queue existed, the unrecoverable error shall cause the queue to abort. See table 126.

7.28 READ FPDMA QUEUED - 60h, DMA Queued

7.28.1 Feature Set

This command is mandatory for devices implementing the NCQ feature set (see feature set reference).

7.28.2 Description

This command requests that data to be transferred from the device to the host.

7.28.3 Inputs

7.28.3.1 Overview

Word	Name	Description
00h	Feature	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
01h	Count	**Bit** **Description** 15:8 Reserved 7:3 NCQ Tag - See 6.3.3 2:0 Reserved
02h	LBA	(MSB)
03h		Address of the first logical sector to be transferred.
04h		(LSB)
05h	Device	Bit **Description** 15 FUA - See 7.28.3.2 14 Shall be set to one 13 Reserved 12 Shall be set to zero 11:8 Reserved
	Command	7:0 60h

7.28.3.2 Forced Unit Access (FUA)

When the FUA bit is set to one the device shall retrieve the data from the non-volatile media regardless of whether the device holds the requested information in its volatile cache. If the device holds a modified copy of the requested data as a result of having volatile cached writes, the modified data shall be written to the non-volatile media before being retrieved from the non-volatile media as part of this operation. When the FUA bit is cleared to zero the data shall be retrieved either from the device's non-volatile media or cache.

7.28.4 Command Acceptance Outputs

See table 104

7.28.5 Normal Outputs

See table 105.

7.28.6 Error Outputs

This return indicates that the command was aborted due to LBA out of range, a duplicate tag number, an invalid tag number, or an ICRC error, see table 136 for more information.

Errors which occur during the processing of this command are reported by returning a transport dependent indicator with additional information available in the NCQ Command Error log, see table 138 for more information.

7.29 READ LOG EXT - 2Fh, PIO data-in

7.29.1 Feature Set

This command is mandatory for devices implementing the General Purpose Logging feature set

7.29.2 Description

7.29.2.1 Overview

This command returns the specified log to the host. See table A.1 for the list of logs.

7.29.3 Inputs

7.29.3.1 Overview

All the logs in this standard reserve the Feature field unless otherwise specified.

Word	Name	Description
00h	Feature	Log Specific
01h	Count	Block Count - See 7.29.3.2 for the definition of Block Count
02h-04h	LBA	**Bit** **Description** 47:32 Reserved 31:16 Page # - Specifies the first 512-byte block of data of the log to be read. 15:8 Reserved 7:0 Log Address - Specifies the log to be read as described in table A.1. See 7.29.3.3 for more information.
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 2Fh

7.29.3.2 Block Count

Specifies the number of 512-byte blocks of data to be read from the specified log. The log transferred by the drive shall start at the block of data in the specified log at the specified offset, regardless of the block count requested. A value of zero is illegal and shall result in command aborted.

7.29.3.3 Log Address

A device may support a subset of the available logs. Support for individual logs is determined by support for the associated feature set. Support of the associated log(s) is mandatory for devices implementing the associated feature.

7.29.4 Normal Outputs

See table 99.

7.29.5 Error Outputs

If the feature set associated with the log specified in the LBA field (7:0) is not supported or enabled, or if the values in the Features, Count, or LBA (47:8) fields are invalid, the device shall return command aborted. Abort shall be set to one if the feature associated with the log specified in the LBA bits 7:0 is not supported, if the count field is cleared to zero, or if other field values are invalid. Abort may be set to one if the device is not able to complete the action requested by the command. Abort shall be set to one if the Page # plus the Count is larger than the log size reported in the General Purpose Log Directory. The device may return error status if an Interface CRC error has occurred. See table 114.

Editor’s Note 14: Why do we say Abort may be set to one if the device is not able to complete the action by the command? This should either be a shall or deleted.

NOTE 14 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer; there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.30 READ LOG DMA EXT - 47h, DMA

7.30.1 Feature Set

This command is optional for devices implementing the General Purpose Logging feature set

7.30.2 Description

See 7.29.2.

7.30.3 Inputs

See 7.29.3.

7.30.4 Normal Outputs

See 7.29.4.

7.30.5 Error Outputs

See 7.29.5.

7.31 READ MULTIPLE - C4h, PIO data-in

7.31.1 Feature Set

This command is mandatory for devices implementing the General feature set.

7.31.2 Description

This command reads the number of logical sectors specified in the Count field.

The number of logical sectors per DRQ data block is defined by the content of IDENTIFY DEVICE data word 59. The device shall interrupt for each DRQ data block transferred.

When the READ MULTIPLE command is issued, the Count field contains the number of logical sectors (not the number of blocks) requested.

If the number of requested logical sectors is not evenly divisible by the DRQ data block count, as many full DRQ data blocks as possible are transferred, followed by a final, partial DRQ data block transfer. The partial DRQ data block transfer shall be for n logical sectors, where n = remainder (Count / DRQ data block count).

Device errors encountered during READ MULTIPLE commands are posted at the beginning of the block or partial block transfer The contents of the Command Structure following the transfer of a data block that had a logical sector in error are undefined.

Subsequent DRQ data blocks or partial DRQ data blocks are transferred only if the error was a correctable data error. All other errors cause the command to stop after transfer of the DRQ data block that contained the error.

If bit 8 of IDENTIFY DEVICE data word 59 is cleared to zero, and a READ MULTIPLE command is received by the device, and no successful SET MULTIPLE MODE command has been processed by the device, the device shall return command aborted. A successful SET MULTIPLE MODE command should precede a READ MULTIPLE command.

7.31.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero.
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 C4h

7.31.4 Normal Outputs

See table 86.

7.31.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The LBA field contains the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. LBA bits 47:28 shall be cleared to zero. The device may return error status if an Interface CRC error has occurred. See table 115.

NOTE 15 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer; there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.32 READ MULTIPLE EXT - 29h, PIO data-in

7.32.1 Feature Set

This command is mandatory for all devices implementing the 48-bit Address feature set.

7.32.2 Description

This command reads the number of logical sectors specified in the Count field.

The number of logical sectors per DRQ data block is defined by the content of word 59 in the IDENTIFY DEVICE data. The device shall interrupt for each DRQ data block transferred.

When the READ MULTIPLE EXT command is issued, the Count field contains the number of logical sectors (not the number of blocks) requested.

If the number of requested logical sectors is not evenly divisible by the DRQ data block count, as many full DRQ data blocks as possible are transferred, followed by a final, partial DRQ data block transfer. The partial DRQ data block transfer shall be for n logical sectors, where n = remainder (Count/ DRQ data block count).

Device errors encountered during READ MULTIPLE EXT commands are posted at the beginning of the block or partial block transfer The contents of the Command Structure following the transfer of a data block that had a logical sector in error are undefined.

Subsequent DRQ data blocks or partial DRQ data blocks are transferred only if the error was a correctable data error. All other errors cause the command to stop after transfer of the DRQ data block that contained the error.

If bit 8 of IDENTIFY DEVICE data word 59 is cleared to zero, and a READ MULTIPLE EXT command is received by the device, and no successful SET MULTIPLE MODE command has been processed by the device, the device shall return command aborted. A successful SET MULTIPLE MODE command should precede a READ MULTIPLE EXT command.

7.32.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65.536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 29h

7.32.4 Normal Outputs

See table 99.

7.32.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The LBA field contains the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. The device may return error status if an Interface CRC error has occurred. See table 128.

NOTE 16 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer; there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.33 READ NATIVE MAX ADDRESS - F8h, Non-data

7.33.1 Feature Set

This command is mandatory for devices implementing the HPA feature set.

7.33.2 Description

This command returns the native maximum address. The native maximum address is the highest address accepted by the device in the factory default condition. The native maximum address is the maximum address that is valid when using the SET MAX ADDRESS command.

If the 48-bit Address feature set is supported and the 48-bit native max address is greater than 268,435,455, the READ NATIVE MAX ADDRESS command shall return a maximum value of 268,435,454.

7.33.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F8h

7.33.4 Normal Outputs

See table 96. LBA contains the Native Max Address. Bits 47:28 of LBA shall be cleared to zero.

7.33.5 Error Outputs

See table 110.

7.34 READ NATIVE MAX ADDRESS EXT - 27h, Non-data

7.34.1 Feature Set

This command is mandatory for devices implementing both the HPA feature set and the 48-bit Address feature set.

7.34.2 Description

This command returns the native maximum address. The native maximum address is the highest address accepted by the device in the factory default condition (see 7.33). The native maximum address is the maximum address that is valid when using the SET MAX ADDRESS EXT command.

7.34.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description**
		15 Obsolete
		14 Shall be set to one
		13 Obsolete
		12 Transport Dependent - See 6.1.9
		11:8 Reserved
	Command	7:0 27h

7.34.4 Normal Outputs

See table 100. LBA contains the Native Max Address.

7.34.5 Error Outputs

See table 129.

7.35 READ SECTOR(S) - 20h, PIO data-in

7.35.1 Feature Set

This command is mandatory for all devices implementing the General and PACKET feature sets.

7.35.2 Description

This command reads from 1 to 256 logical sectors as specified in the Count field. The transfer shall begin at the logical sector specified in the LBA field.

7.35.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero.
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 20h

7.35.4 Outputs

7.35.5 Normal Outputs

See table 86.

7.35.6 Outputs for PACKET feature set devices

In response to this command, devices that implement the PACKET feature set shall post command aborted and place the PACKET feature set signature in the LBA field (23:8), see table 92 for a list of the possible signatures.

7.35.7 Error Outputs

LBA bits 47:28 shall be cleared to zero. The device may return error status if an Interface CRC error has occurred. See table 115.

NOTE 17 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer; there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.36 READ SECTOR(S) EXT - 24h, PIO data-in

7.36.1 Feature Set

This command is mandatory for devices implementing the 48-bit Address feature set

7.36.2 Description

This command reads from 1 to 65,536 logical sectors as specified in the Count field. The transfer shall begin at the logical sector specified in the LBA field.

7.36.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 24h

7.36.4 Normal Outputs

See table 99.

7.36.5 Error Outputs

The device may return error status if an Interface CRC error has occurred. See table 128.

NOTE 18 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer, there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.37 READ STREAM DMA EXT - 2Ah, DMA

7.37.1 Feature Set

This command is mandatory for devices that implement the Streaming feature set.

7.37.2 Description

The READ STREAM DMA EXT command provides a method for a host to read data within an allotted time using the DMA data transfer protocol. This command allows the host to specify that additional actions are to be performed by the device prior to the completion of the command.

7.37.3 Inputs

7.37.3.1 Inputs Overview

Word	Name	Description
00h	Feature	**Bit Description** 15:8 Command Completion Time Limit (CCTL) - See 7.37.3.2 7 Obsolete 6 Read Continuous (RC) - See 7.37.3.3 5 Not Sequential (NS) – See 7.37.3.4 4 Obsolete 3 Reserved 2:0 Stream ID – See 7.37.3.5
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 2Ah

7.37.3.2 Command Completion Time Limit (CCTL)

CCTL specifies the time allowed for the device to process the command before reporting command completion.

If CCTL is not cleared to zero, then the device shall report command completion within (CCTL * (IDENTIFY DEVICE data words (99:98)) microseconds. The device shall measure the time before reporting command completion from command acceptance.

If CCTL is cleared to zero, and Default CCTL was not cleared to zero in the most recent CONFIGURE STREAM command (see 7.9) for the Stream ID, then the device shall report command completion within the time specified by Default CCTL (see 7.9.3.4).

If CCTL is cleared to zero, and Default CCTL was cleared to zero in the most recent CONFIGURE STREAM command (see 7.9) for the Stream ID, or CCTL is cleared to zero and no previous CONFIGURE STREAM command was used to specify a Default CCTL for this Stream ID, then the result is vendor specific.

After reporting command completion, a device may continue to write data for the command from device cache to the media.

7.37.3.3 Read Continuous

If RC is set to one, then:

a) the device shall not stop processing the command due to errors;
b) if an error occurs during data transfer or while reading data from the media before command completion or before the amount of time allowed for command completion based on the setting of CCTL (see 7.37.3.2) or Default CCTL (see 7.9.3) is reached, then the device:
    1) shall continue to transfer the amount of data requested;
    2) may continue reading data from the media;
    3) shall report command completion after all data for the command has been transferred; and
    4) shall save the error information in the Read Streaming Error log;

    or
c) if the amount of time allowed for command completion based on the setting of CCTL (see 7.37.3.2) or Default CCTL (see 7.9.3) is reached, then the device:
    1) shall stop processing the command;
    2) shall report command completion; and
    3) shall set CCTO in the Read Streaming Error log to one.

If RC is cleared to zero and an error occurs, then the device:

a) may continue transferring data; and
b) shall report command completion after the data transfer has been completed.

7.37.3.4 Not Sequential (NS)

If NS is set to one, then the next READ STREAM command with the same Stream ID may not be sequential in the LBA space. Any read of the device media or internal device buffer management as a result of the state of the NS bit is vendor specific.

7.37.3.5 Stream ID

Stream ID specifies the stream to be read. The device shall operate according to the parameters specified by the most recent successful CONFIGURE STREAM command specifying this Stream ID.

7.37.4 Normal Outputs

See table 91 for the definition of Normal Outputs.

7.37.5 Error Outputs

If:

a) RC was set to one in the command, and
b) the device is able to return the amount of data requested for the command (e.g., an error occurred while reading from the media);

then the device shall set SE to one and clear ERR to zero.

If:

a) RC was set to one in the command, and
b) the device is not able to return the amount of data requested for the command (e.g., an ICRC error is reported at command completion);

then the device shall clear SE to zero and set ERR to one.

If:

a) RC was cleared to zero in the command;
b) CCTL was not cleared to zero in the command, or CCTL was cleared to zero in the command and Default CCTL specified in the most recent CONFIGURE STREAM command for the Stream ID (see 7.9) was not cleared to zero; and

c) the time specified for command completion by CCTL (see 7.37.3.2) or Default CCTL (see 7.9.3) has been reached;

then the device shall clear SE to zero, set ERR to one, and set ABRT to one.

If:

a) RC was cleared to zero in the command;
b) CCTL was cleared to zero in the command; and
c) Default CCTL was cleared to zero in the most recent CONFIGURE STREAM command for the Stream ID (see 7.9);

then the device shall clear SE to zero, set ERR to one, and set ICRC, IDNF, and/or ABRT to one (i.e., indicating the error type).

See table 116 for the definition of other Error Outputs.

7.38 READ STREAM EXT - 2Bh, PIO data-in

7.38.1 Feature Set

This command is mandatory for devices that implement the Streaming feature set.

7.38.2 Description

See 7.37.2 for the description of this command.

7.38.3 Inputs

See 7.37.3 for a description of the inputs for this command.

7.38.4 Normal Outputs

See 7.37.4 for a description of the Normal Outputs.

7.38.5 Error Outputs

See 7.37.5 for the description of Error Outputs.

7.39 READ VERIFY SECTOR(S) - 40h, Non-data

7.39.1 Feature Set

This command is mandatory for all devices that implement the General feature set

7.39.2 Description

This command is identical to READ SECTOR(S) command, except that data in the volatile cache is flushed to the non-volatile media. No data is transferred from the device to the host. The device shall read the data from the non-volatile media and verify that there are no errors.

7.39.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero.
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 40h

7.39.4 Normal Outputs

See table 86.

7.39.5 Error Outputs

LBA bits 47:28 shall be cleared to zero. See table 115.

7.40 READ VERIFY SECTOR(S) EXT - 42h, Non-data

7.40.1 Feature Set

This command is mandatory for devices implementing the 48-bit Address feature set

7.40.2 Description

This command is identical to READ SECTOR(S) EXT command, except that data in the volatile cache is flushed to the non-volatile media. No data is transferred from the device to the host. The device shall read the data from the non-volatile media and verify that there are no errors.

7.40.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 42h

7.40.4 Normal Outputs

See table 99.

7.40.5 Error Outputs

See table 128.

7.41 SECURITY DISABLE PASSWORD - F6h, PIO data-out

7.41.1 Feature Set

This command is mandatory for devices that implement the Security feature set.

7.41.2 Description

The SECURITY DISABLE PASSWORD command transfers 512 bytes of data from the host. Table 35 defines the content of this information.

If the password selected by word 0 matches the password previously saved by the device, the device shall disable the User password, and return the drive to the SEC1 state.

This command shall not change the Master password or the Master Password Identifier.

This command shall return command aborted if the Security feature set is not supported, if Security is Locked (SEC4) or is Frozen (states SEC2 or SEC6).

When Security is Disabled and the Identifier bit is set to User, then the device shall return command aborted.

When Security is Enabled, and the Master Password Capability is 'High':

a) If the Identifier bit is set to Master, then the password supplied shall be compared with the stored Master password.
b) If the Identifier bit is set to User, then the password supplied shall be compared with the stored User password.

When Security is Enabled, and the Master Password Capability is 'Maximum'

a) If the Identifier bit is set to Master, then the device shall return command aborted, even if the supplied Master password is valid.
b) If the Identifier bit is set to User, then the password supplied shall be compared with the stored User password.

Upon successful completion, these fields of IDENTIFY DEVICE or IDENTIFY PACKET DEVICE shall be updated:

a) word 85, bit 1 shall be cleared to zero (no active User password)
b) word 128, bit 1 is a copy of word 85, bit 1
c) word 128, bit 8 shall be cleared to zero (Master Password Capability is not Maximum)

7.41.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F6h

7.41.4 Normal Outputs

See table 86.

7.41.5 Error Outputs

The device shall return command aborted if the device is in Locked mode or the device is in Frozen mode. The device may return error status if an Interface CRC error has occurred. See table 109.

7.41.6 Output Data Structure

Table 35 — SECURITY DISABLE PASSWORD data content

Word	Content		
0	Control word		
	Bit	**Field Name**	**Description**
	0	Identifier	0=compare User password 1=compare Master password
	15:1	Reserved	
1-16	Password (32 bytes)		
17-255	Reserved		

7.42 SECURITY ERASE PREPARE - F3h, Non-data

7.42.1 Feature Set

This command is mandatory for devices that implement the Security feature set.

7.42.2 Description

The SECURITY ERASE PREPARE command shall be issued immediately before the SECURITY ERASE UNIT command.

7.42.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F3h

7.42.4 Normal Outputs

See table 86.

7.42.5 Error Outputs

Abort shall be set to one if the device is in Frozen mode. See table 109.

7.43 SECURITY ERASE UNIT - F4h, PIO data-out

7.43.1 Feature Set

This command is mandatory for devices that implement the Security feature set.

7.43.2 Description

This command transfers 512 bytes of data from the host. Table 11 defines the content of this information.

If the password does not match the password previously saved by the device, the device shall return command aborted.

The SECURITY ERASE PREPARE command shall be completed immediately prior to the SECURITY ERASE UNIT command. If the device receives a SECURITY ERASE UNIT command and the previous command was not a successful SECURITY ERASE PREPARE command, the device shall return command aborted for the SECURITY ERASE UNIT command.

When Security is Disabled and the Identifier bit is set to User, then the device shall return command aborted.

When Security is Enabled, and the Master Password Capability is 'High':

a) If the Identifier bit is set to Master, then the password supplied shall be compared with the stored Master password.
b) If the Identifier bit is set to User, then the password supplied shall be compared with the stored User password.

When Security is Enabled, and the Master Password Capability is 'Maximum':

a) If the Identifier bit is set to Master, then the password supplied shall be compared with the stored Master password.
b) If the Identifier bit is set to User, then the password supplied shall be compared with the stored User password.

When Normal Erase mode is specified, the SECURITY ERASE UNIT command shall write binary zeroes to all user data areas (as determined by READ NATIVE MAX or READ NATIVE MAX EXT). IDENTIFY DEVICE or IDENTIFY PACKET DEVICE word 89 gives an estimate of the time required to complete the erasure.

The Enhanced Erase mode is optional. IDENTIFY DEVICE or IDENTIFY PACKET DEVICE word 128, bit 5 indicates whether it is supported. When Enhanced Erase mode is specified, the device shall write predetermined data patterns to all user data areas. In Enhanced Erase mode, all previously written user data shall be overwritten, including sectors that are no longer in use due to reallocation. IDENTIFY DEVICE or IDENTIFY PACKET DEVICE word 90 gives an estimate of the time required to complete the erasure.

On successful completion, this command shall disable Security (e.g. returns the device to Security state SEC1), and invalidate any existing User password. Any previously valid Master password and Master Password Identifier remains valid.

Upon successful completion, these fields of IDENTIFY DEVICE or IDENTIFY PACKET DEVICE shall be updated:

a) word 85, bit 1shall be cleared to zero (no active user password)
b) word 128, bit 1shall be cleared to zero (no active user password)
c) word 128, bit 8shall be cleared to zero (Master Password Capability is not Maximum)

7.43.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F4h

7.43.4 Normal Outputs

See table 86.

7.43.5 Error Outputs

The device shall return command aborted if the not immediately preceded by a SECURITY ERASE PREPARE command, or if Enhanced mode was requested but the device does not support it, or of an invalid password was specified, or if the data area is not successfully overwritten. The device may return error status if an Interface CRC error has occurred. See table 109.

7.43.6 Output Data Structure

Table 36 — SECURITY ERASE UNIT data content

Word	Content
0	Control word **Bit** **Field Name** **Description** 0 Identifier 0=Compare User password 1=Compare Master password 1 Erase mode 0=Normal Erase 1=Enhanced Erase 15:2 Reserved
1-16	Password (32 bytes)
17-255	Reserved

7.44 SECURITY FREEZE LOCK - F5h, Non-data

7.44.1 Feature Set

This command is mandatory for devices that implement Security feature set.

7.44.2 Description

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

See table 8 for a list of commands disabled by SECURITY FREEZE LOCK.

Upon successful completion, IDENTIFY DEVICE data or IDENTIFY PACKET DEVICE data word 128, bit 3 shall be set to one.

7.44.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F5h

7.44.4 Normal Outputs

See table 86.

7.44.5 Error Outputs

Abort shall be set to one if the device is in Frozen mode. See table 109.

7.45 SECURITY SET PASSWORD - F1h, PIO data-out

7.45.1 Feature Set

This command is mandatory for devices that implement the Security feature set.

7.45.2 Description

7.45.2.1 Overview

This command transfers 512 bytes of data from the host. Table 37 defines the content of this information. The command sets only one password at a time.

7.45.2.2 Setting the Master Password

If a Master password is specified, the device shall save the supplied Master password in a non-volatile location. The Master Password Capability shall remain unchanged. This does not cause any changes to IDENTIFY DEVICE or IDENTIFY PACKET DEVICE words 85 or 128.

If the device supports the Master Password Identifier feature and a valid identifier is supplied (see 4.20.12), the device shall save the identifier in a non-volatile location. This new value shall be returned in word 92 of IDENTIFY DEVICE or IDENTIFY PACKET DEVICE result data. If the host attempts to set the Master Password Identifier to 0000h or FFFFh, the device shall preserve the existing Master Password Identifier and return successful command completion.

If the device does not support the Master Password Identifier feature, the device shall not validate the identifier field, and shall not change word 92 of IDENTIFY DEVICE or IDENTIFY PACKET DEVICE. This shall not be cause to return command aborted.

7.45.2.3 Setting the User Password

If a User password is specified, the device shall save the User password in a non-volatile location and update the Master Password Capability. The Master Password Identifier shall not be changed. These fields of IDENTIFY DEVICE or IDENTIFY PACKET DEVICE shall be updated:

a) word 85, bit 1 shall be set to one (Security enabled)
b) word 128, bit 1 shall be set to one (Security enabled)
c) word 128, bit 8 shall indicate the Master Password Capability

7.45.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F1h

7.45.4 Normal Outputs

See table 86.

7.45.5 Error Outputs

Abort shall be set to one if the device is in Frozen mode. The device may return error status if an Interface CRC error has occurred. See table 109.

7.45.6 Output Data Structure

Table 37 — SECURITY SET PASSWORD data content

Word	Content		
0	Control word		
	Bit	**Field Name**	**Description**
	0	Identifier	0=set User password 1=set Master password
	7:1	Reserved	
	8	Security level	0=High 1=Maximum
	15:9	Reserved	
1-16	Password (32 bytes)		
17	Master Password Identifier (valid if word 0 bit 0 = 1)		
18-255	Reserved		

7.46 SECURITY UNLOCK - F2h, PIO data-out

7.46.1 Feature Set

This command is mandatory for devices that implement the Security feature set.

7.46.2 Description

This command transfers 512 bytes of data from the host. Table 38 defines the content of this information.

When Security is Disabled and the Identifier bit is set to User, then the device shall return command aborted.

When Security is Enabled, and the Master Password Capability is 'High':

a) If the Identifier bit is set to Master, then the password supplied shall be compared with the stored Master password.
b) If the Identifier bit is set to User, then the password supplied shall be compared with the stored User password.

When Security is Enabled, and the Master Password Capability is 'Maximum'

a) If the Identifier bit is set to Master, then the device shall return command aborted.
b) If the Identifier bit is set to User, then the password supplied shall be compared with the stored User password.

If the password compare fails then the device shall return command aborted to the host and decrements the password attempt counter. When this counter reaches zero, IDENTIFY DEVICE or IDENTIFY PACKET DEVICE word 128 bit 4 shall be set to one, and SECURITY UNLOCK and SECURITY ERASE UNIT commands shall return command aborted until a power-on reset or a hardware reset. SECURITY UNLOCK commands issued when the device is unlocked have no effect on the unlock counter.

Upon successful completion of this command, IDENTIFY DEVICE data or IDENTIFY PACKET DEVICE data word 128, bit 2 shall be set to cleared to zero (not locked).

7.46.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
05h	Command	7:0 F2h

7.46.4 Normal Outputs

See table 86.

7.46.5 Error Outputs

If the device is in Frozen mode or an invalid password is supplied or the password attempt counter has decremented to zero, the device shall return command aborted.

The device may return error status if an Interface CRC error has occurred. See table 109.

7.46.6 Output Data Structure

Table 38 — SECURITY UNLOCK data content

<table>
<tr><th>Word</th><th>Content</th></tr>
<tr><td>0</td><td>Control word
<table><tr><th>Bit</th><th>Field Name</th><th>Description</th></tr><tr><td>0</td><td>Identifier</td><td>0=compare User password
1=compare Master password</td></tr><tr><td>15:1</td><td>Reserved</td><td></td></tr></table></td></tr>
<tr><td>1-16</td><td>Password (32 bytes)</td></tr>
<tr><td>17-255</td><td>Reserved</td></tr>
</table>

7.47 SERVICE - A2h, Packet or DMA Queued

7.47.1 Feature Set

This command is mandatory for devices that implement the TCQ Feature set.

7.47.2 Description

The SERVICE command is used to provide data transfer and/or status of a command that was previously released.

The device shall have performed a release for a previous READ DMA QUEUED, READ DMA QUEUED EXT, WRITE DMA QUEUED, WRITE DMA QUEUED EXT. or WRITE DMA QUEUED FUA EXT command and shall have set the SERV (see 6.1.7) bit to one to request the SERVICE command be issued to continue data transfer and/or provide command status (see 7.48.15).

7.47.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 A2h

7.47.4 Outputs

Outputs as a result of a SERVICE command are described in the command description for the command for which SERVICE is being requested.

7.48 SET FEATURES - EFh, Non-data

7.48.1 Feature Set

This command is mandatory for all devices.

7.48.2 Description

The set transfer mode subcommand is mandatory. Enable/disable write cache subcommands are mandatory when a write cache is implemented.

This command is used by the host to establish parameters that affect the execution of certain device features. Table 39 defines these features.

After a power-on reset or a hardware reset, the settings of the functions specified by the subcommands are vendor specific unless otherwise specified in this standard.

Table 39 — SET FEATURES Feature field definitions (part 1 of 2)

Value	Description
00h	Reserved
01h	Enable 8-bit PIO transfer mode (CFA feature set only) (see 7.48.3)
02h	Enable write cache (see 7.48.4)
03h	Set transfer mode based on value in Count field (see 7.48.5)
04h	Obsolete
05h	Enable advanced power management (see 7.48.6)
06h	Enable Power-Up In Standby feature set (see 7.48.7)
07h	Power-Up In Standby feature set device spin-up (see 7.48.8)
08h	Reserved
09h	If the device implements the CFA feature set, then this subcommand is reserved for CFA. Otherwise, this subcommand is reserved for ANSI INCITS TR27-2001.
0Ah	Enable CFA power mode 1 (see 7.48.9)
0Bh	Enable Write-Read-Verify feature set (see 7.48.10)
0Ch-0Fh	Reserved
10h	Enable use of SATA feature (see 7.48.18)
11h-1Fh	Reserved
20h	Reserved for technical report INCITS TR37-2004
21h	Reserved for technical report INCITS TR37-2004
22h-30h	Reserved
31h	Obsolete
32h	Reserved
33h	Obsolete
34h-40h	Reserved
41h	Enable Free-fall Control
42h	Enable Automatic Acoustic Management feature set (see 7.48.11)
43h	Set Maximum Host Interface Sector Times (see 7.48.12)
44h	Obsolete
45h-53h	Reserved
54h	Obsolete
55h	Disable read look-ahead feature (see 7.48.13)
56h-5Ch	Vendor Specific
5Dh	Enable release interrupt (see 7.48.14)
5Eh	Enable service interrupt (see 7.48.15)
5Fh	Reserved for DT1825

Table 39 — SET FEATURES Feature field definitions (part 2 of 2)

Value	Description
60h-65h	Reserved
66h	Disable reverting to power-on defaults (see 7.48.16)
67h-68h	Reserved
69h	If the device implements the CFA feature set, then this subcommand is reserved for CFA.
6Ah-76h	Reserved
77h	Obsolete
78h-80h	Reserved
81h	Disable 8-bit PIO transfer mode (CFA feature set only) (see 7.48.3)
82h	Disable write cache (see 7.48.4)
83h	Reserved for e06162
84h	Obsolete
85h	Disable advanced power management (see 7.48.6)
86h	Disable Power-Up In Standby feature set (see 7.48.7)
87h	Reserved
88h	Obsolete
89h	If the device implements the CFA feature set, then this subcommand is reserved for CFA. Otherwise, this subcommand is reserved for ANSI INCITS TR27-2001.
8Ah	Disable CFA power mode 1 (see 7.48.9)
8Bh	Disable Write-Read-Verify feature set (see 7.48.10)
8Ch-8Fh	Reserved
90h	Disable use of SATA feature (see 7.48.18)
91h-94h	Reserved
95h	Obsolete
96h-99h	Reserved
99h	Obsolete
9Ah	Obsolete
9Bh-A9h	Reserved
AAh	Enable read look-ahead feature (see 7.48.13)
ABh	Obsolete
ACh-BAh	Reserved
BBh	Obsolete
BCh-C0h	Reserved
C1h	Disable Free-fall Control
C2h	Disable Automatic Acoustic Management feature set (see 7.48.11)
C3h-CBh	Reserved
CCh	Enable reverting to power-on defaults
CDh-D5h	Reserved
D6h-DCh	Vendor Specific
DDh	Disable release interrupt (see 7.48.14)
DEh	Disable SERVICE interrupt (see 7.48.15)
DFh	Reserved for DT1825
E0h	Vendor Specific
E1h-EFh	Reserved
F0h-FFh	Reserved for assignment by the CompactFlash™ Association

7.48.3 Enable/disable 8-bit PIO data transfer

Devices implementing the CFA feature set shall support 8-bit PIO data transfers. Devices not implementing the CFA feature set shall not support 8-bit PIO data transfers. See the CFA specification for more information.

7.48.4 Enable/disable write cache

Subcommand codes 02h and 82h allow the host to enable or disable volatile write cache in devices that implement volatile write cache. When the subcommand disable volatile write cache is issued, the device shall initiate the sequence to flush volatile cache to non-volatile media before command completion (see 7.14). These subcommands may affect caching for commands in the Streaming feature set.

7.48.5 Set transfer mode

A host selects the transfer mechanism by Set Transfer Mode, subcommand code 03h, and specifying a value in the Count field. The upper 5 bits define the type of transfer and the low order 3 bits encode the mode value. The host may change the selected modes by the SET FEATURES command.

Table 40 — Transfer mode values

Mode	Bits (7:3)	Bits (2:0)
PIO default mode	00000b	000b
PIO default mode, disable IORDY	00000b	001b
PIO flow control transfer mode	00001b	mode
Retired	00010b	N/A
Multiword DMA mode	00100b	mode
Ultra DMA mode	01000b	mode
Reserved	10000b	N/A
Mode = transfer mode number		

If a device supports this standard, and receives a SET FEATURES command with a Set Transfer Mode parameter and a Count field value of “00000000b”, the device shall set the default PIO mode. If the value is “00000001b” and the device supports disabling of IORDY, then the device shall set the default PIO mode and disable IORDY. A device shall support all PIO modes below the highest mode supported, e.g., if PIO mode 1 is supported PIO mode 0 shall be supported.

Support of IORDY is mandatory when PIO mode 3 or above is the current mode of operation.

A device shall support all Multiword DMA modes below the highest mode supported, e.g., if Multiword DMA mode 1 is supported Multiword DMA mode 0 shall be supported.

A device shall support all Ultra DMA modes below the highest mode supported, e.g., if Ultra DMA mode 1 is supported Ultra DMA mode 0 shall be supported.

If an Ultra DMA mode is enabled any previously enabled Multiword DMA mode shall be disabled by the device. If a Multiword DMA mode is enabled any previously enabled Ultra DMA mode shall be disabled by the device.

For PATA systems using a cable assembly, the host should determine that an 80-conductor cable assembly is connecting the host with the device(s) before enabling any Ultra DMA mode greater than 2 in the device(s).

7.48.6 Enable/disable advanced power management

Subcommand code 05h allows the host to enable Advanced Power Management. To enable Advanced Power Management, the host writes the Count field with the desired advanced power management level and then executes a SET FEATURES command with subcommand code 05h. The power management level is a scale from the lowest power consumption setting of 01h to the maximum performance level of FEh. Table 41 shows these values.

Table 41 — Advanced power management levels

Count Field	Level
FEh	Maximum performance
81h-FDh	Intermediate power management levels without Standby
80h	Minimum power consumption without Standby
02h-7Fh	Intermediate power management levels with Standby
01h	Minimum power consumption with Standby
FFh	Reserved
00h	Reserved

Device performance may increase with increasing power management levels. Device power consumption may increase with increasing power management levels. The power management levels may contain discrete bands. For example, a device may implement one power management method from 80h to A0h and a higher performance, higher power consumption method from level A1h to FEh. Advanced power management levels 80h and higher do not permit the device to spin down to save power.

Subcommand code 85h disables Advanced Power Management. Subcommand 85h may not be implemented on all devices that implement SET FEATURES subcommand 05h.

7.48.7 Enable/disable Power-Up In Standby feature set

Subcommand code 06h enables the Power-Up In Standby feature set. When this feature set is enabled, the device shall power-up into Standby mode, i.e., the device shall be ready to receive commands but shall not spin-up (see 4.19). Once this feature set is enabled, it shall only be disabled by a subsequent SET FEATURES command disabling the feature set (i.e., the feature set shall not be disabled after a power-on reset, a hardware reset, or a software reset).

Subcommand code 86h disables the Power-Up In Standby feature set. When this feature set is disabled, the device shall power-up into Active mode. The factory default for this feature set shall be disabled.

7.48.8 Power-Up In Standby feature set device spin-up

Subcommand code 07h shall cause a device that has powered-up into Standby to go to the Active state (see 4.19 and figure 11).

7.48.9 Enable/disable CFA power mode 1

Subcommand code 0Ah causes a CFA device to transition to CFA Power Mode 1. CFA devices may consume up to 500 mA maximum average RMS current for either 3.3 V or 5 V operation in Power Mode 1.

Subcommand 8Ah causes a CFA device to transition to CFA Power Mode 0. CFA devices may consume up to 75 mA maximum average RMS current for 3.3 V or 100 mA maximum average RMS current for 5 V operation in Power Mode 0.

If a CFA device is in CFA Power Mode 0, then the device shall transition to CFA Power Mode 1 during processing of a power-on reset or a hardware reset.

If a CFA device is in CFA Power Mode 0 and in the Reverting to defaults enabled mode (see 7.51.17), then the device shall transition to CFA Power Mode 1 during processing of a software reset.

If a CFA device is in CFA Power Mode 0 and in the Reverting to defaults disabled mode (see 7.51.17), then the device shall not transition to CFA Power Mode 1 during processing of a software reset.

Enabling CFA Power Mode 1 does not cause a spin-up.

A device in Power Mode 0 the device shall accept the following commands:

a) IDENTIFY DEVICE
b) SET FEATURES (function codes 0Ah and 8Ah)
c) STANDBY
d) STANDBY IMMEDIATE

e) SLEEP
f) CHECK POWER MODE
g) EXECUTE DEVICE DIAGNOSTICS
h) CFA REQUEST EXTENDED ERROR

A device in Power Mode 0 may accept any command that the device is capable of executing within the Power Mode 0 current restrictions. Commands that require more current than specified for Power Mode 0 shall be rejected with an abort error.

7.48.10 Enable/Disable Write-Read-Verify feature set

Subcommand code 0Bh enables the Write-Read-Verify feature set.

Bits (7:0) of the LBA field in the SET FEATURES command specify the Write-Read-Verify mode. Table 42 defines the Write-Read-Verify modes.

Table 42 — Write-Read-Verify Sector Counts

Mode	Description
00h	Always enabled (i.e., the device shall perform a Write-Read-Verify for all sectors for all write commands).
01h	The device shall perform a Write-Read-Verify on the first 65,536 logical sectors written by the host after: a) spin-up; or b) the device completes a SET FEATURES command setting the Write-Read-Verify mode without error.
02h	The number of logical sectors on which a device performs a Write-Read-Verify is vendor specific.
03h	The device shall perform a Write-Read-Verify on the first (number specified by the Count field in the SET FEATURES command x 1024) logical sectors written by the host after: a) spin-up; or b) the device completes a SET FEATURES command setting the Write-Read-Verify mode without error.
04h-FFh	Reserved
Note 1 - When Mode 03h is not selected, the Count field is ignored	

Subcommand code 8Bh disables the Write-Read-Verify feature set.

A device shall set the Write-Read-Verify feature set to its factory default setting during processing of a power-on reset or a hardware reset.

If a device is in the reverting to defaults enabled mode (see 7.48.16), then the device shall set the Write-Read-Verify feature set to its factory default setting during processing of a software reset.

If a device is in the reverting to defaults disabled mode (see 7.48.16), then the device shall not change the settings of the Write-Read-Verify feature set during processing of a software reset.

7.48.11 Enable/disable Automatic Acoustic Management

Subcommand code 42h allows the host to enable the Automatic Acoustic Management feature set. To enable the Automatic Acoustic Management feature set, the host writes the Count field with the requested automatic acoustic management level and executes a SET FEATURES command with subcommand code 42h. The acoustic management level is selected on a scale from 01h to FEh. Table 43 shows the acoustic management level values.

Enabling or disabling of the Automatic Acoustic Management feature set, and the current automatic acoustic management level setting shall be preserved by the device across all forms of reset, i.e. power-on, hardware, and software resets.

Table 43 — Automatic acoustic management levels

Count Field	Level
FFh	Reserved
FEh	Maximum performance
81h-FDh	Intermediate acoustic management levels
80h	Minimum acoustic emanation level
01h-7Fh	Retired
00h	Vendor Specific

Device performance may increase with increasing acoustic management levels. Device power consumption may decrease with decreasing acoustic management levels. The acoustic management levels may contain discrete bands. For example, a device may implement one acoustic management method from 80h to BFh and a higher performance, higher acoustic management method from level C0h to FEh.

Upon successful completion of this SET FEATURES subcommand, IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data word 94, bits (7:0) shall be updated by the device. If the command is aborted by the device, the previous automatic acoustic management state shall be retained.

Subcommand code C2h disables the Automatic Acoustic Management feature set. Devices that implement SET FEATURES subcommand 42h are not required to implement subcommand C2h. If device successfully completes execution of this subcommand, then the acoustic behavior of the device shall be vendor-specific, and the device shall return zeros in bits (7:0) of word 94 and bit 9 of word 86 of the IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data.

Upon completion of SET FEATURES subcommands 42h and C2h, the device may update words (97:96) and word 104 in IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data.

7.48.12 Set Maximum Host Interface Sector Times

Subcommand code 43h allows the host to inform the device of a host interface rate limitation. This information shall be used by the device to meet the Command Completion Time Limits of the commands of the streaming feature set. To inform the device of a host interface rate limitation, the host writes the value of its Typical PIO Host Interface Sector Time to the Count field (7:0) and LBA (7:0) field and writes the value of its Typical DMA Host Interface Sector Time to the LBA (23:8) field. The Typical Host Interface Sector Times have the same units as IDENTITY DEVICE data word 96 for DMA and word 104 for PIO. A value of zero indicates that the host interface shall be capable of transferring data at the maximum rate allowed by the selected transfer mode. The Typical PIO Mode Host Interface Sector Time includes the host's interrupt service time.

Upon completion of SET FEATURES subcommand 43h, the device may adjust IDENTIFY DEVICE data words (97:96) to allow for the specified host interface sector time.

Field	Bits	Description
Count	15:8	Reserved
	7:0	Typical PIO Mode Host Interface Sector Time (7:0)
LBA	47:24	Reserved
	23:8	Typical DMA Mode Host Interface Sector Time
	7:0	Typical PIO Mode Host Interface Sector Time (15:8)

7.48.13 Enable/disable read look-ahead

Subcommand codes AAh and 55h allow the host to request the device to enable or disable read look-ahead. Error recovery performed by the device is vendor specific.

7.48.14 Enable/disable release interrupt

Subcommand codes 5Dh and DDh allow a host to enable or disable the asserting of Interrupt Pending when a device releases the bus for a TCQ command.

7.48.15 Enable/disable SERVICE interrupt

Subcommand codes 5Eh and DEh allow a host to enable or disable the asserting of an Interrupt Pending when DRQ is set to one in response to a SERVICE command.

7.48.16 Enable/disable reverting to defaults

Subcommand codes CCh and 66h allow the host to enable or disable the reverting to defaults mode.

A device is in the reverting to defaults disabled mode after completing a SET FEATURES command with subcommand code 66h without error. In this mode a device shall not reset parameters to their default power-on values during the processing of a software reset.

A device is in the Reverting to defaults enabled mode after the device:

a) processes a power-on reset or hardware reset; or
b) completes a SET FEATURES command with subcommand CCh without error.

A device in the reverting to defaults enabled mode may reset parameters to their default power-on values during the processing of a software reset

7.48.17 Enable/Disable Free-fall Control

Subcommand code 41h allows the host to enable the Free-fall Control feature set. To enable the Free-fall Control feature set, the host writes the Count field with the requested free-fall control sensitivity setting and executes a SET FEATURES command with subcommand code 41h.

The sensitivity is selected on a scale from 00h to FFh. A value of zero selects the device vendor's recommended setting. Other values set the sensitivity from host and the meanings are vendor specific. The higher the sensitivity value, the more sensitive the device is to changes in acceleration.

Enabling or disabling of the Free-fall Control feature set, and the current free-fall sensitivity setting shall be preserved by the device across all forms of reset, i.e. power-on, hardware, and software resets.

7.48.18 Enable/Disable SATA feature

7.48.18.1 Overview

The Count field contains the specific Serial ATA feature to enable or disable. The specific Serial ATA features are defined as defined in table 44.

Table 44 — SATA Features

Count	Description
00h	Reserved
01h	Non-zero Buffer Offsets
02h	DMA Setup FIS Auto-Activate optimization
03h	Device-initiated interface power state transitions
04h	Guaranteed In-Order Data Delivery
05h	Asynchronous Notification
06h	Software Settings Preservation
07h-FFh	Reserved

7.48.18.2 Enable/Disable Non-Zero Buffer Offsets

A Count field value of 01h is used to enable or disable non-zero buffer offsets for commands in the NCQ feature set. By default, non-zero buffer offsets are disabled. The enable/disable state for non-zero offsets shall be preserved across software reset. The enable/disable state for non-zero offsets shall be reset to its default state upon COMRESET. See SATA 2.6 for more information.

7.48.18.3 Enable/Disable DMA Setup FIS Auto-Activate Optimization

A Count field value of 02h is used to enable or disable DMA Setup FIS Auto-Activate optimization. See SATA 2.6 details. The enable/disable state for the auto-activate optimization shall be preserved across software reset. The enable/disable state for the auto-activate optimization shall be reset to its default state upon COMRESET.

7.48.18.4 Enable/Disable Device-Initiated Interface Power State Transitions

A Count field value of 03h is used to enable or disable device initiation of interface power state transitions. By default, the device is not permitted to initiate interface power state transitions. See SATA 2.6 for more information. The enable/disable state for device initiated power management shall persist across software reset. The enable/disable state shall be reset to its default disabled state upon COMRESET.

If device initiated interface power management is enabled, the device shall not attempt to initiate an interface power state transition between reset and the delivery of the device reset signature.

7.48.18.5 Enable/Disable Guaranteed in-Order Data Delivery

A Count field value of 04h is used to enable or disable guaranteed in-order data delivery for commands in the NCQ feature set. This setting is only valid when non-zero buffer offsets are enabled. By default, guaranteed in-order data delivery is disabled. See SATA 2.6 for more information. The enable/disable state for guaranteed in-order data delivery shall be preserved across software reset. The enable/disable state for guaranteed in-order data delivery shall be reset to its default state upon COMRESET.

7.48.18.6 Enable/Disable Asynchronous Notification

For devices implementing the PACKET feature set, a Count field value of 05h is used to enable or disable asynchronous notification. By default, asynchronous notification is disabled. See SATA 2.6 for more information. The enable/disable state for asynchronous notification shall be preserved across software reset. The enable/disable state for asynchronous notification shall be reset to its default state upon COMRESET.

7.48.18.7 Enable/Disable Software Settings Preservation

A Count field value of 06h is used to enable or disable software settings preservation. By default, if the device supports software settings preservation the feature is enabled when it processes a power-on reset. The enable/disable state for software settings preservation shall persist across software reset. The enable/disable state for software settings preservation shall be reset to its default state upon COMRESET. The host may disable software settings preservation in order to not preserve software settings across COMRESET.

Editor's Note 15: Need to remove the double negative.

7.48.19 Inputs

Word	Name	Description
00h	Feature	Subcommand Code - Table 39 defines the value of the subcommand.
01h	Count	Subcommand specific
02h-04h	LBA	Subcommand specific
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 EFh

7.48.20 Normal Outputs

See table 86.

7.48.21 Error Outputs

Abort shall be set to one if any subcommand input value is not supported or is invalid. See table 109.

7.49 SET MAX

7.49.1 SET MAX Overview

Individual SET MAX commands are identified by the value placed in the Feature field. Table 45 shows these Feature field values.

Table 45 — SET MAX Feature field values

Value	Command
00h	SET MAX ADDRESS
01h	SET MAX SET PASSWORD
02h	SET MAX LOCK
03h	SET MAX UNLOCK
04h	SET MAX FREEZE LOCK
05h-FFh	Reserved

7.49.2 SET MAX ADDRESS - F9h

7.49.2.1 Feature Set

This command is mandatory for devices that implement the Host Protected Area feature set.

7.49.2.2 Description

After successful command completion, all read and write access attempts to addresses greater than specified by the successful SET MAX ADDRESS command shall be rejected with an ID Not Found error (see 6.2.4). IDENTIFY DEVICE data words (61:60) shall reflect the maximum address set with this command.

If the 48-bit Address feature set is supported, the value placed in IDENTIFY DEVICE data words (103:100) shall be the same as the value placed in IDENTIFY DEVICE data words (61:60).

A host should not issue more than one non-volatile SET MAX ADDRESS or SET MAX ADDRESS EXT command after a power-on or hardware reset. Devices should report an IDNF error upon receiving a second non-volatile SET MAX ADDRESS command after a power-on or hardware reset.

The contents of IDENTIFY DEVICE data words and the max address shall not be changed if a SET MAX ADDRESS command fails.

After a successful SET MAX ADDRESS command using a new maximum LBA the content of all IDENTIFY DEVICE data words shall comply with 4.11.4 and the content of IDENTIFY DEVICE data words (61:60) shall be equal to the new Maximum LBA + 1.

A successful READ NATIVE MAX ADDRESS command should immediately precede a SET MAX ADDRESS command. If the SET MAX ADDRESS command is not preceded by a successful READ NATIVE MAX ADDRESS command, the device may abort the SET MAX ADDRESS command or execute one of the following commands: SET MAX SET PASSWORD, SET MAX LOCK, SET MAX UNLOCK, SET MAX FREEZE LOCK. The result depends on the value of the Feature field.

Issuing a SET MAX ADDRESS to the value returned by READ NATIVE MAX ADDRESS shall clear the HPA regardless of the maximum logical block address.

7.49.2.3 Inputs

7.49.2.3.1 Overview

Word	Name	Description
00h	Feature	N/A
01h	Count	**Bit** **Description** 16:1 N/A 0 Volatile_Value (V_V) - See 7.49.2.3.2.
02h	LBA	(MSB) SET MAX LBA Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F9h

7.49.2.3.2 Volatile_Value (V_V)

If V_V is set to one, then, during processing of a power-on reset or a hardware reset, a device shall not change the content in words 60-61 (see 7.16.7.21) or 100-103 (see 7.16.7.50) in the IDENTIFY DEVICE data.

If V_V is cleared to zero, then, during processing of a power-on reset or a hardware reset, a device shall change the content in words 60-61 and words 100-103 in the IDENTIFY DEVICE data to be a value one greater than the value of either:

a) the value in the SET MAX LBA field in the most recent SET MAX ADDRESS or SET MAX ADDRESS EXT command that completed without error in which V_V was set to one; or
b) if no SET MAX ADDRESS or SET MAX ADDRESS EXT command has completed without error, then the native max address.

Regardless of the setting of V_V, a device shall not change the content in words 60-61 or 100-103 in IDENTIFY DEVICE data during processing of a software reset.

7.49.2.4 Normal Outputs

See Table 96. LBA bits 47:28 shall be cleared to zero.

7.49.2.5 Error Outputs

If the maximum value to be set exceeds the capacity of the device, a host protected area has been established by a SET MAX ADDRESS EXT command, or the device is in the Set_Max_Locked or Set_Max_Frozen state, then the device shall return command aborted. ID Not Found shall be set to one if the command was the second non-volatile SET MAX ADDRESS command after power-on or hardware reset. Abort shall be set to one if the maximum value requested exceeds the device capacity, a host protected area has been established by a SET MAX ADDRESS EXT command, the device is in the Set_Max_Locked or Set_Max_Frozen state, or the command is not immediately preceded by a READ NATIVE MAX ADDRESS command. See table 117.

7.49.3 SET MAX FREEZE LOCK – F9h/04h, Non-data

7.49.3.1 Feature Set

This command is mandatory for devices that implement the HPA Security Extensions.

7.49.3.2 Description

The SET MAX FREEZE LOCK command sets the device to Set_Max_Frozen state. After successful command completion, any subsequent SET MAX commands shall be command aborted until a power-on reset has been processed by the device.

Commands disabled by SET MAX FREEZE LOCK are:

a) SET MAX ADDRESS
b) SET MAX SET PASSWORD
c) SET MAX LOCK
d) SET MAX UNLOCK

This command should not be immediately preceded by a READ NATIVE MAX ADDRESS command. If this command is immediately preceded by a READ NATIVE MAX ADDRESS command, it shall be interpreted as a SET MAX ADDRESS command.

7.49.3.3 Inputs

Word	Name	Description
00h	Feature	04h - SET MAX FREEZE LOCK
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F9h

7.49.3.4 Normal Outputs

See table 86.

7.49.3.5 Error Outputs

Abort shall be set to one if the device is not in the Set_Max_Unlocked state. Seetable 110.

7.49.4 SET MAX LOCK - F9h/02h, Non-data

7.49.4.1 Feature Set

This command is mandatory for devices that implement the HPA Security Extensions.

7.49.4.2 Description

The SET MAX LOCK command sets the device into Set_Max_Locked state. After this command is completed any other SET MAX commands except SET MAX UNLOCK and SET MAX FREEZE LOCK shall be command aborted. The device shall remain in this state until a power-on reset has been processed or command completion without error of a SET MAX UNLOCK or SET MAX FREEZE LOCK command.

This command should not be immediately preceded by a READ NATIVE MAX ADDRESS command. If this command is immediately preceded by a READ NATIVE MAX ADDRESS command, it shall be interpreted as a SET MAX ADDRESS command.

7.49.4.3 Inputs

Word	Name	Description
00h	Feature	02h - SET MAX LOCK
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F9h

7.49.4.4 Normal Outputs

See table 86.

7.49.4.5 Error Outputs

Abort shall be set to one if the device is in the Set_Max_Locked or Set_Max_Frozen state. See table 110.

7.49.5 SET MAX SET PASSWORD - F9h/01h, PIO data-out

7.49.5.1 Feature Set

This command is mandatory for devices that implement the HPA Security Extensions.

7.49.5.2 Description

This command requests a transfer of a single 512-byte block of data from the host. Table 46 defines the content of this 512-byte block of data. The password is not retained by the device after the device has processed a power-on reset. When the device accepts this command the device is in Set_Max_Unlocked state.

> NOTE 19 — This password is not related to the passwords that are part of the Security feature set (see 4.20).

This command should not be immediately preceded by a READ NATIVE MAX ADDRESS command. If this command is immediately preceded by a READ NATIVE MAX ADDRESS command, it shall be interpreted as a SET MAX ADDRESS command.

7.49.5.3 Inputs

Word	Name	Description
00h	Feature	01h - SET MAX PASSWORD
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F9h

7.49.5.4 Normal Outputs

See table 86.

7.49.5.5 Error Outputs

Abort shall be set to one if the device is in the Set_Max_Locked or Set_Max_Frozen state. The device may return error status if an Interface CRC error has occurred. See table 117.

7.49.5.6 Output Data Structure

Table 46 — SET MAX SET PASSWORD data content

Word	Content
0	Reserved
1-16	Password (32 bytes)
17-255	Reserved

7.49.6 SET MAX UNLOCK - F9h/03h, PIO data-out

7.49.6.1 Feature Set

This command is mandatory for devices that implement the HPA Security Extensions.

7.49.6.2 Description

This command requests a transfer of a single 512-byte block of data from the host. Table 46 defines the content of this data.

The password supplied in the data transferred shall be compared with the password set by the SET MAX SET PASSWORD command.

If the password compare fails, then the device shall return command aborted and decrement the unlock counter. On the acceptance of the SET MAX LOCK command, this counter is set to a value of five and shall be decremented for each password mismatch when SET MAX UNLOCK is issued and the device is locked. When this counter reaches zero in a device, then the device shall return command aborted for all subsequent SET MAX UNLOCK commands until after the device has processed a power-on reset.

If the password compare matches, then the device shall make a transition to the Set_Max_Unlocked state and all SET MAX commands shall be accepted.

This command should not be immediately preceded by a READ NATIVE MAX ADDRESS command. If this command is immediately preceded by a READ NATIVE MAX ADDRESS command, it shall be interpreted as a SET MAX ADDRESS command.

7.49.6.3 Inputs

Word	Name	Description
00h	Feature	03h - SET MAX UNLOCK
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 F9h

7.49.6.4 Normal Outputs

See table 86.

7.49.6.5 Error Outputs

Abort shall be set to one if the device is not in the Set_Max_Locked state. The device may return error status if an Interface CRC error has occurred. See table 110.

7.50 SET MAX ADDRESS EXT - 37h, Non-data

7.50.1 Feature Set

This command is mandatory for devices that implement both the HPA feature set and the 48-bit Address feature set.

7.50.2 Description

After successful command completion, all read and write access attempts to addresses greater than specified by the successful SET MAX ADDRESS EXT command shall be rejected with an IDNF error.

A hosts should not issue more than one non-volatile SET MAX ADDRESS or SET MAX ADDRESS EXT command after a power-on or hardware reset. Devices shall report an IDNF error upon receiving a second non-volatile SET MAX ADDRESS EXT command after a power-on or hardware reset.

The contents of IDENTIFY DEVICE data words and the max address shall not be changed if a SET MAX ADDRESS EXT command fails.

After a successful SET MAX ADDRESS EXT command using a new maximum LBA the content of all IDENTIFY DEVICE data words shall comply with 4.11.4.

A successful READ NATIVE MAX EXT command should immediately precede SETMAX ADDRESS EXT. If the device receives a SET MAX ADDRESS EXT that is not immediately preceded by READ NATIVE MAX EXT, the device shall report command aborted.

7.50.3 Inputs

7.50.3.1 Overview

Word	Name	Description
00h	Feature	Reserved
01h	Count	**Bit Description** 16:1 Reserved 0 Volatile_Value (V_V) - See 7.50.3.2
02h	LBA	(MSB)
03h		SET MAX LBA
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 37h

7.50.3.2 Volatile_Value (V_V)

If V_V is set to one, then, during processing of a power-on reset or a hardware reset, a device shall not change the content in words 60-61 (see 7.17.7.22) or 100-103 (see 7.17.7.22) in the IDENTIFY DEVICE data.

If V_V is cleared to zero, then, during processing of a power-on or hardware reset, a device shall:

a) change the content in words 100-103 in the IDENTIFY DEVICE data to be a value one greater than the value of either:
   A) the value in the SET MAX LBA field in the most recent SET MAX ADDRESS or SET MAX ADDRESS EXT command that completed without error in which V_V was set to one; or

B) if no SET MAX ADDRESS or SET MAX ADDRESS EXT command has completed without error, then the native max address;
and

b) change the content in words 60-61 in the IDENTIFY DEVICE data to be the value in words 100-103 in IDENTIFY DEVICE data or 0FFF_FFFFh, whichever is less.

Regardless of the setting of V_V, a device shall not change the content in words 60-61 or 100-103 in the IDENTIFY DEVICE data during processing of a software reset.

7.50.4 Normal Outputs

See table 100.

7.50.5 Error Outputs

If the maximum value to be set exceeds the capacity of the device, a host protected area has been established by a SET MAX ADDRESS command, the command is not immediately preceded by a READ NATIVE MAX ADDRESS EXT command, or the device is in the Set_Max_Locked or Set_Max_Frozen state, then the device shall return command aborted. ID Not Found shall be set to one if the command was the second non-volatile SET MAX ADDRESS EXT command after power-on or hardware reset. See table 130.

7.51 SET MULTIPLE MODE - C6h, Non-data

7.51.1 Feature Set

This command is mandatory for devices implementing the General feature set

7.51.2 Description

This command establishes the number of logical sectors in the DRQ data block count for READ MULTIPLE, READ MULTIPLE EXT, WRITE MULTIPLE, and WRITE MULTIPLE EXT commands.

Devices shall support the DRQ data block size specified in the IDENTIFY DEVICE data word 47, bits (7:0), and may also support smaller values.

Upon receipt of the command, the device checks the Count field. If the content of the Count field is not zero, the Count field contains a valid value, and the DRQ data block count is supported, then the value in the Count field is used for all subsequent READ MULTIPLE, READ MULTIPLE EXT, WRITE MULTIPLE, and WRITE MULTIPLE EXT commands and their execution is enabled. If the content of the Count field is zero, the device may:

a) disable multiple mode and respond with command aborted to all subsequent READ MULTIPLE, READ MULTIPLE EXT, WRITE MULTIPLE, and WRITE MULTIPLE EXT commands;
b) respond with command aborted to the SET MULTIPLE MODE command;
c) retain the previous multiple mode settings.

After a successful SET MULTIPLE command the device shall report the valid value set by that command in IDENTIFY DEVICE data word 59.

After a power-on or hardware reset, if bit 8 is set to one and bits (7:0) are cleared to zero in IDENTIFY DEVICE data word 59, a SET MULTIPLE command is required before issuing a READ MULTIPLE, READ MULTIPLE EXT, WRITE MULTIPLE, or WRITE MULTIPLE EXT command. If bit 8 is set to one and bits (7:0) are not cleared to zero, a SET MULTIPLE command may be issue to change the multiple value required before issuing a READ MULTIPLE, READ MULTIPLE EXT, WRITE MULTIPLE, or WRITE MULTIPLE EXT command.

7.51.3 Inputs

The content of the Count field shall be less than or equal to the value in IDENTIFY DEVICE data word 47 bits (7:0). The host should set the content of the Count field to 1, 2, 4, 8, 16, 32, 64 or 128.

If the content of the Count field is zero and the SET MULTIPLE command completes without error, then the device shall respond to any subsequent read multiple or write multiple command with command aborted until a subsequent successful SET MULTIPLE command completion where the Count field is not set to zero.

Word	Name	Description
00h	Feature	N/A
01h	Count	Number of logical sectors per DRQ Block
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 C6h

7.51.4 Normal Outputs

See table 86.

7.51.5 Error Outputs

Abort shall be set to one if the block count is not supported. See table 109.

7.52 SLEEP - E6h, Non-data

7.52.1 Feature Set

This command is mandatory for devices implementing the Power Management feature set.

7.52.2 Description

This command is the only way to cause the device to enter Sleep mode. The device shall exit the Sleep state (PM3) only after processing a hardware reset, a software reset, or a DEVICE RESET command.

A device shall not power-on in Sleep state.

7.52.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E6h

7.52.4 Normal Outputs

See table 86.

7.52.5 Error Outputs

See table 109.

7.53 SMART

7.53.1 Overview

Individual SMART commands are identified by the value placed in the Feature field. Table 47 shows these values.

Table 47 — SMART Feature field values

Value	Command
00h-CFh	Reserved
D0h	SMART READ DATA
D1h	Obsolete
D2h	SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE
D3h	Obsolete
D4h	SMART EXECUTE OFF-LINE IMMEDIATE
D5h	SMART READ LOG
D6h	SMART WRITE LOG
D7h	Obsolete
D8h	SMART ENABLE OPERATIONS
D9h	SMART DISABLE OPERATIONS
DAh	SMART RETURN STATUS
DBh	Obsolete
DCh-DFh	Reserved
E0h-FFh	vendor specific

7.53.2 SMART DISABLE OPERATIONS - B0h/D9h, Non-data

7.53.2.1 Feature Set

This command is mandatory for devices that implement the SMART feature set.

7.53.2.2 Description

This command disables all SMART capabilities within the device including any and all timer and event count functions related exclusively to this feature. After command acceptance the device shall disable all SMART operations. SMART data shall no longer be monitored or saved by the device. The state of SMART, either enabled or disabled, shall be preserved by the device during all power reset events.

After receipt of this command by the device, with the exception of SMART ENABLE OPERATIONS and the SCT Command Transport commands, all other SMART commands including SMART DISABLE OPERATIONS commands are disabled and shall be command aborted by the device.

7.53.2.3 Inputs

Word	Name	Description
00h	Feature	D9h - SMART DISABLE OPERATIONS
01h	Count	N/A
02h-04h	LBA	**Bit Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 N/A
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.2.4 Normal Outputs

See table 86.

7.53.2.5 Error Outputs

Abort shall be set to one if SMART is not enabled, or if an input value is invalid. See table 109.

7.53.3 SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE - B0h/D2h, Non-data

7.53.3.1 Feature Set

This command is mandatory for devices that implement the SMART feature set.

7.53.3.2 Description

This command enables and disables the optional attribute autosave feature of the device. This command may either allow the device, after some vendor specified event, to save the device updated attributes to non-volatile memory; or this command may cause the autosave feature to be disabled. The state of the attribute autosave feature (either enabled or disabled) shall be preserved by the device during all power and reset events.

A value of zero written by the host into the device's Count field before issuing this command shall cause this feature to be disabled. Disabling this feature does not preclude the device from saving SMART data to non-volatile memory during some other normal operation such as during a power-on or power-off sequence or during an error recovery sequence.

A value of F1h written by the host into the device's Count field before issuing this command shall cause this feature to be enabled. Any other meaning of this value or any other non-zero value written by the host into this field before issuing this command is vendor specific. The meaning of any non-zero value written to this field at this time shall be preserved by the device during all power and reset events.

If the device receives a command from the host while executing the autosave routine the device shall begin processing the command within two seconds.

7.53.3.3 Inputs

Word	Name	Description
00h	Feature	D2h - SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE
01h	Count	**Value** **Description** 00h Disable attribute autosave 01h-F0h Vendor specific F1h Enable attribute autosave F2h-FFh Vendor specific
02h-04h	LBA	**Bit** **Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.3.4 Normal Outputs

See table 86.

7.53.3.5 Error Outputs

Abort shall be set to one if SMART is not enabled, or if an input value is invalid. See table 109.

7.53.4 SMART ENABLE OPERATIONS - B0h/D8h, Non-data

7.53.4.1 Feature Set

This command is mandatory for devices that implement the SMART feature set.

7.53.4.2 Description

This command enables access to all available SMART capabilities within the device. Prior to receipt of this command SMART data are neither monitored nor saved by the device. The state of SMART (either enabled or disabled) shall be preserved by the device during all power and reset events. Once enabled, the receipt of subsequent SMART ENABLE OPERATIONS commands shall not affect any SMART data or functions.

7.53.4.3 Inputs

Word	Name	Description
00h	Feature	D8h - SMART ENABLE OPERATIONS
01h	Count	N/A
02h-04h	LBA	**Bit** **Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.4.4 Normal Outputs

See table 86.

7.53.4.5 Error Outputs

See table 109.

7.53.5 SMART EXECUTE OFF-LINE IMMEDIATE - B0h/D4h, Non-data

7.53.5.1 Feature Set

This command is optional for devices that implement the SMART feature set.

7.53.5.2 Description

This command causes the device to immediately initiate the optional set of activities that collect SMART data in an off-line mode and then preserve this data across power and reset events, or execute a vendor specific self-diagnostic test routine in either captive or off-line mode.

Table 48 — SMART EXECUTE OFF-LINE IMMEDIATE Subcommands

Value	Description of subcommand to be executed
0	Execute SMART off-line routine immediately in off-line mode
1	Execute SMART Short self-test routine immediately in off-line mode
2	Execute SMART Extended self-test routine immediately in off-line mode
3	Execute SMART Conveyance self-test routine immediately in off-line mode
4	Execute SMART Selective self-test routine immediately in off-line mode
5-63	Reserved
64-126	Vendor specific
127	Abort off-line mode self-test routine
128	Reserved
129	Execute SMART Short self-test routine immediately in captive mode
130	Execute SMART Extended self-test routine immediately in captive mode
131	Execute SMART Conveyance self-test routine immediately in captive mode
132	Execute SMART Selective self-test routine immediately in captive mode
133-191	Reserved
192-255	Vendor specific

7.53.5.3 Off-line mode

The following describes the protocol for executing a SMART EXECUTE OFF-LINE IMMEDIATE subcommand routine (including a self-test routine) in the off-line mode.

1) The device shall execute command completion before executing the subcommand routine.
2) The device shall remain ready to receive a new command during execution of the subcommand routine.
3) If the device is in the process of performing the subcommand routine and is interrupted by any new command from the host except a SLEEP, SMART DISABLE OPERATIONS, SMART EXECUTE OFF-LINE IMMEDIATE, or STANDBY IMMEDIATE command, the device shall suspend or abort the subcommand routine and begin processing the new command within two seconds after receipt of the new command. After servicing the interrupting command from the host the device may immediately re-initiate or resume the subcommand routine without any additional commands from the host (see 7.53.6.6).
4) If the device is in the process of performing a subcommand routine and is interrupted by a SLEEP command from the host, the device may abort the subcommand routine and execute the SLEEP command. If the device is in the process of performing any self-test routine and is interrupted by a SLEEP command from the host, the device shall abort the subcommand routine and execute the SLEEP command.
5) If the device is in the process of performing the subcommand routine and is interrupted by a SMART DISABLE OPERATIONS command from the host, the device shall suspend or abort the subcommand routine and begin processing the new command within two seconds after receipt of the command. Upon receipt of the next SMART ENABLE OPERATIONS command the device may, either re-initiate the subcommand routine or resume the subcommand routine from where it had been previously suspended.
6) If the device is in the process of performing the subcommand routine and is interrupted by a SMART EXECUTE OFF-LINE IMMEDIATE command from the host, the device shall abort the subcommand

routine and begin processing the new command within two seconds after receipt of the command. The device shall then service the new SMART EXECUTE OFF-LINE IMMEDIATE subcommand.

7) If the device is in the process of performing the subcommand routine and is interrupted by a STANDBY IMMEDIATE or IDLE IMMEDIATE command from the host, the device shall suspend or abort the subcommand routine, and begin processing the new command within two seconds after receipt of the command. After receiving a new command that causes the device to exit a power saving mode, the device shall initiate or resume the subcommand routine without any additional commands from the host unless these activities were aborted by the host (see 7.53.6.2).
8) While the device is performing the subcommand routine it shall not automatically change power states (e.g., as a result of its Standby timer expiring).
9) If a test failure occurs while a device is performing a self-test routine the device may discontinue the testing and place the test results in the Self-test execution status byte (see table 49).

7.53.5.4 Captive mode

When executing a self-test in captive mode, the device executes the self-test routine after receipt of the command. At the end of the routine the device places the results of this routine in the Self-test execution status byte (See table 49) and reports command completion. If an error occurs while a device is performing the routine the device may discontinue its testing, place the results of this routine in the Self-test execution status byte, and complete the command.

7.53.5.5 SMART off-line routine

This routine shall only be performed in the off-line mode. The results of this routine are placed in the Off-line data collection status byte (see table 50).

7.53.5.6 SMART Short self-test routine

Depending on the value in the LBA field (7:0), this self-test routine may be performed in either the captive or the off-line mode. This self-test routine should take on the order of ones of minutes to complete (see 7.53.6.2).

7.53.5.7 SMART Extended self-test routine

Depending on the value in the LBA field (7:0), this self-test routine may be performed in either the captive or the off-line mode. This self-test routine should take on the order of tens of minutes to complete (see 7.53.6.2).

7.53.5.8 SMART Conveyance self-test routine

Depending on the value in the LBA field (7:0), this self-test routine may be performed in either the captive or the off-line mode. This self-test routine is intended to identify damage incurred during transporting of the device. This self-test routine should take on the order of minutes to complete (see 7.53.6.2).

7.53.5.9 SMART Selective self-test routine

The SMART Selective self-test routine is an optional self-test routine. If the routine is implemented, all features of the routine shall be implemented. Support for the routine is indicated in off-line data collection capabilities (see 7.53.6.6). When the value in the LBA field (7:0) is 4 or 132, the Selective self-test routine shall be performed. This self-test routine shall include the initial tests performed by the Extended self-test routine plus a selectable read scan. The host should not write the Selective self-test log while the execution of a Selective self-test command is in progress.

The user may choose to do read scan only on specific areas of the media. To do this, user shall set the test spans desired in the Selective self-test log and set the flags in the Feature flags field of the Selective self-test log to indicate do not perform off-line scan. In this case, the test spans defined shall be read scanned in their entirety. The Selective self-test log is updated as the self-test proceeds indicating test progress. When all specified test spans have been completed, the test is terminated and the appropriate self-test execution status is reported in the SMART READ DATA response depending on the occurrence of errors. Figure 13 shows an example of a Selective self-test definition with three test spans defined. In this example, the test terminates when all three test spans have been scanned.

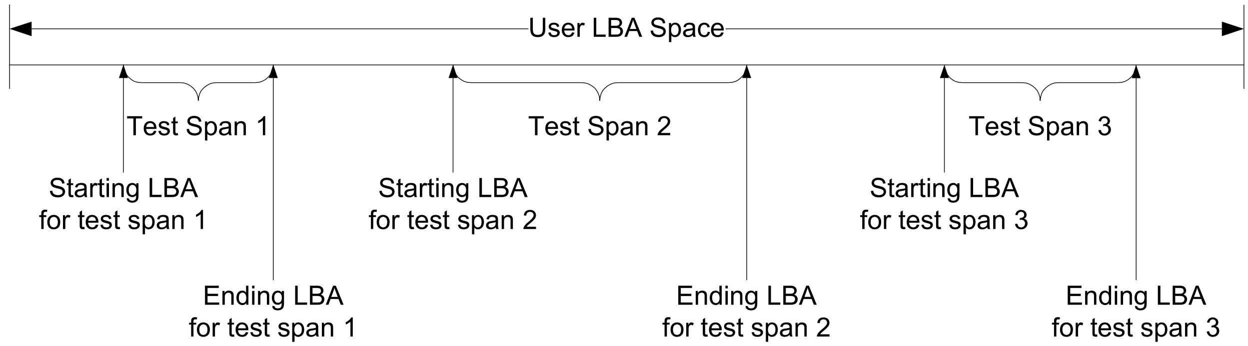

Figure 13 — Selective self-test span example

After the scan of the selected spans described above, a user may wish to have the rest of media read scanned as an off-line scan. In this case, the user shall set the flag to enable off-line scan in addition to the other settings. If an error occurs during the scanning of the test spans, the error is reported in the self-test execution status in the SMART READ DATA response and the off-line scan is not executed. When the test spans defined have been scanned, the device shall then set the off-line scan pending and active flags in the Selective self-test log to one, the span under test to a value greater than five, the self-test execution status in the SMART READ DATA response to 00h, set a value of 03h in the off-line data collection status in the SMART READ DATA response and shall proceed to do an off-line read scan through all areas not included in the test spans. This off-line read scan shall completed as rapidly as possible, no pauses between block reads, and any errors encountered shall not be reported to the host. Instead error locations may be logged for future reallocation. If the device is powered-down before the off-line scan is completed, the off-line scan shall resume when the device is again powered up. From power-up, the resumption of the scan shall be delayed the time indicated in the Selective self-test pending time field in the Selective self-test log. During this delay time the pending flag shall be set to one and the active flag shall be set to zero in the Selective self-test log. Once the time expires, the active flag shall be set to one, and the off-line scan shall resume. When the entire media has been scanned, the off-line scan shall terminate, both the pending and active flags shall be cleared to zero, and the off-line data collection status in the SMART READ DATA response shall be set to 02h indicating completion.

During execution of the Selective self-test, the self-test executions time byte in the Device SMART Data Structure may be updated but the accuracy may not be exact because of the nature of the test span segments. For this reason, the time to complete off-line testing and the self-test polling times are not valid. Progress through the test spans is indicated in the selective self-test log.

When bit 3 in the Selective self-test feature flags field is set to one (see A.13), a device shall continue processing the Selective self-test after processing a hardware reset or a software reset. When bit 3 in the Selective self-test feature flags field is cleared to zero, a device shall abort the Selective self-test during processing a hardware reset or a software reset.

If a device receives a SMART EXECUTE OFF-LINE IMMEDIATE command with the Abort off-line test routine subcommand, then the device shall abort the Selective self-test.

If a device receives a SMART EXECUTE OFF-LINE IMMEDIATE command specifying that the device perform a self-test while a selective self-test is in progress, the device shall abort the selective self-test and process the specified self-test.

7.53.5.10 Inputs

Word	Name	Description
00h	Feature	D4h - SMART EXECUTE OFF-LINE IMMEDIATE
01h	Count	N/A
02h-04h	LBA	**Bit Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 Table 48 defines the subcommand that shall be executed
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.5.11 Normal Outputs

See table 97.

7.53.5.12 Error Outputs

ID Not Found shall be set to one if the SMART data is not available. Abort shall be set to one if SMART is not enabled or if a self-test fails while executing a sequence in captive mode. See table 119.

7.53.6 SMART READ DATA - B0h/D0h, PIO data-in

7.53.6.1 Feature Set

This command is optional for devices that implement the SMART feature set.

7.53.6.2 Description

This command returns the Device SMART data structure to the host.

Table 49 defines the 512 bytes that make up the Device SMART data structure. All multi-byte fields shown in this structure follow the byte ordering described in 3.2.8.

Table 49 — Device SMART data structure

Byte	F/V	Description
0-361	X	Vendor specific
362	V	Off-line data collection status
363	X	Self-test execution status byte
364-365	V	Total time in seconds to complete off-line data collection activity
366	X	Vendor specific
367	F	Off-line data collection capability
368-369	F	SMART capability
370	F	Error logging capability
		7-1 Reserved
		0 1=Device error logging supported
371	X	Vendor specific
372	F	Short self-test routine recommended polling time (in minutes)
373	F	Extended self-test routine recommended polling time (7:0) in minutes. If FFh, use bytes 375 and 376 for the polling time.
374	F	Conveyance self-test routine recommended polling time (in minutes)
375	F	Extended self-test routine recommended polling time (7:0) in minutes
376	F	Extended self-test routine recommended polling time (15:8) in minutes
377-385	R	Reserved
386-510	X	Vendor specific
511	V	Data structure checksum
Key: F = the content of the byte is fixed and does not change. V = the content of the byte is variable and may change depending on the state of the device or the commands executed by the device. X = the content of the byte is vendor specific and may be fixed or variable. R = the content of the byte is reserved and shall be zero.		

7.53.6.3 Off-line collection status byte

The value of the off-line data collection status byte defines the current status of the off-line activities of the device. Table 50 lists the values and their respective definitions.

Table 50 — Off-line data collection status byte values

Value	Definition
00h or 80h	Off-line data collection activity was never started.
01h	Reserved
02h or 82h	Off-line data collection activity was completed without error.
03h	Off-line activity in progress.
04h or 84h	Off-line data collection activity was suspended by an interrupting command from host.
05h or 85h	Off-line data collection activity was aborted by an interrupting command from host.
06h or 86h	Off-line data collection activity was aborted by the device with a fatal error.
07h-3Fh	Reserved
40h-7Fh	Vendor specific
81h	Reserved
83h	Reserved
87h-BFh	Reserved
C0h-FFh	Vendor specific

7.53.6.4 Self-test execution status byte

The self-test execution status byte reports the execution status of the self-test routine.

a) Bits (3:0) (Percent Self-Test Remaining) The value in these bits indicates an approximation of the percent of the self-test routine remaining until completion in ten percent increments. Valid values are 9 through 0. A value of 0 indicates the self-test routine is complete. A value of 9 indicates 90% of total test time remaining.
b) Bits (7:4) (Self-test Execution Status) The value in these bits indicates the current Self-test Execution Status (see table 51).

Table 51 — Self-test execution status values

Value	Description
0	The previous self-test routine completed without error or no self-test has ever been run
1	The self-test routine was aborted by the host
2	The self-test routine was interrupted by the host with a hardware or software reset
3	A fatal error or unknown test error occurred while the device was executing its self-test routine and the device was unable to complete the self-test routine.
4	The previous self-test completed having a test element that failed and the test element that failed is not known.
5	The previous self-test completed having the electrical element of the test failed.
6	The previous self-test completed having the servo (and/or seek) test element of the test failed.
7	The previous self-test completed having the read element of the test failed.
8	The previous self-test completed having a test element that failed and the device is suspected of having handling damage.
9-14	Reserved.
15	Self-test routine in progress.

7.53.6.5 Total time to complete off-line data collection

The total time in seconds to complete off-line data collection activity word specifies how many seconds the device requires to complete the sequence of off-line data collection activity. Valid values for this word are from 0001h to FFFFh.

7.53.6.6 Off-line data collection capabilities

The following describes the definition for the off-line data collection capability bits. If the value of all of these bits is cleared to zero, then no off-line data collection is implemented by this device.

Table 52 — Offline Data Collection Capabilities

Bit	Description
7	Reserved
6	Selective self-test implemented - If this bit is cleared to zero, the device does not implement the Selective self-test routine. If this bit is set to one, the device implements the Selective self-test routine.
5	Conveyance self-test implemented - If this bit is cleared to zero, the device does not implement the Conveyance self-test routines. If this bit is set to one, the device implements the Conveyance self-test routines.
4	Self-test implemented - If this bit is cleared to zero, the device does not implement the Short and Extended self-test routines. If this bit is set to one, the device implements the Short and Extended self-test routines.
3	Off-line read scanning implemented - If this bit is cleared to zero, the device does not support off-line read scanning. If this bit is set to one, the device supports off-line read scanning.
2	Abort/restart off-line by host - If this bit is set to one, then the device shall abort all off-line data collection activity initiated by an SMART EXECUTE OFF-LINE IMMEDIATE command upon receipt of a new command within 2 seconds of receiving the new command. If this bit is cleared to zero, the device shall suspend off-line data collection activity after an interrupting command and resume off-line data collection activity after some vendor-specified event.
1	Vendor specific.
0	EXECUTE OFF-LINE IMMEDIATE implemented - If this bit is set to one, then the SMART EXECUTE OFF-LINE IMMEDIATE command is implemented by this device. If this bit is cleared to zero, then the SMART EXECUTE OFF-LINE IMMEDIATE command is not implemented by this device.

7.53.6.7 SMART capabilities

The following describes the definition for the SMART capabilities bits.

a) Bit 0 - If this bit is set to one, the device saves SMART data prior to going into a power saving mode (Idle, Standby, or Sleep) or immediately upon return to Active or Idle mode from a Standby mode. If this bit is cleared to zero, the device does not save SMART data prior to going into a power saving mode (Idle, Standby, or Sleep) or immediately upon return to Active or Idle mode from a Standby mode.
b) Bit 1 - This bit shall be set to one to indicate that the device supports the SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE command.
c) Bits (15:2) (Reserved).

7.53.6.8 Self-test routine recommended polling time

The self-test routine recommended polling time shall be equal to the estimated number of minutes that is the minimum recommended time before which the host should first poll check for test completion status. Actual test time may be several times this value. The host should wait at least this long before sending the first SMART READ DATA command to check for test completion status. Polling Checking before this time may extend the self-test execution time or abort the test depending on the state of bit 2 of the offline data capability bits. Subsequent checking by the host should be at a vendor specific interval.

7.53.6.9 Data structure checksum

The data structure checksum is the two's complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all 512 bytes shall be zero when the checksum is correct. The checksum is placed in byte 511.

7.53.6.10 Inputs

Word	Name	Description
00h	Feature	D0h - SMART READ DATA
01h	Count	N/A
02h-04h	LBA	**Bit** **Description** 47:28 Reserved 47:24 N/A 23:8 C24Fh 7:0 N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.6.11 Normal Outputs

See table 86.

7.53.6.12 Error Outputs

Uncorrectable Error shall be set to one if SMART data is uncorrectable. ID Not Found shall be set to one if the SMART data is not available or the data structure checksum is invalid. Abort shall be set to one if SMART is not enabled, or if field values are invalid. The device may return error status if an Interface CRC error has occurred. See table 127.

NOTE 20 — There is no defined mechanism for a device to return an ICRC error status that may have occurred during the last data block of a PIO-in data transfer; there may be other mechanisms in which a host may verify that an Interface CRC error occurred in these cases.

7.53.7 SMART READ LOG - B0h/D5h

7.53.7.1 Feature Set

This command is optional for devices that implement the SMART feature set.

7.53.7.2 Description

This command returns the specified log to the host. See table A.1 for the list of logs.

7.53.7.3 Inputs

Word	Name	Description
00h	Feature	D5h - SMART READ LOG
01h	Count	Specifies the number of 512-byte blocks of data to be read from the specified log. The log transferred by the drive shall start at the first block in the specified log, regardless of the Count requested. Bits 15:8 shall be cleared to zero.
02h-04h	LBA	Bit **Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 Log Address - Specifies the log to be read as described in table A.1. See 7.29.3.3 for more information.
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.7.4 Normal Outputs

See table 86.

7.53.7.5 Error Outputs

Uncorrectable Error shall be set to one if SMART data is uncorrectable. ID Not Found shall be set to one if the data is not available or the data structure checksum is invalid. Abort shall be set to one if SMART is not enabled, if the Count field is cleared to zero, or if field values are invalid. Abort shall be set to one if the Count is larger than the log size reported in the Log Directory. See table 127.

7.53.8 SMART RETURN STATUS - B0h/DAh, Non-data

7.53.8.1 Feature Set

This command is mandatory for devices that implement the SMART feature set.

7.53.8.2 Description

This command causes the device to communicate the reliability status of the device to the host. If a threshold exceeded condition is not detected by the device, the device shall set the LBA field (15:8) to 4Fh and the LBA field (23:16) to C2h. If a threshold exceeded condition is detected by the device, the device shall set the LBA field (15:8) to F4h and the LBA field (23:16) to 2Ch.

7.53.8.3 Inputs

Word	Name	Description
00h	Feature	DAh - SMART RETURN STATUS
01h	Count	N/A
02h-04h	LBA	**Bit** **Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.8.4 Normal Outputs

See table 98.

7.53.8.5 Error Outputs

Abort shall be set to one if SMART is not enabled. See table 109.

7.53.9 SMART WRITE LOG - D6h, PIO data-out

7.53.9.1 Feature Set

This command is optional for devices that implement the SMART feature set.

7.53.9.2 Description

This command writes the specified number of 512-byte block of data to the specified log. See table A.1 for the list of logs.

7.53.9.3 Inputs

7.53.9.3.1 Overview.

Word	Name	Description
00h	Feature	D6h - SMART WRITE LOG
01h	Count	Specifies the number of 512-byte blocks of data that shall be written to the specified log. The log transferred to the drive shall be stored by the drive starting at the first block in the specified log. A value of zero is illegal and shall result in command aborted. Bits 15:8 shall be cleared to zero
02h-04h	LBA	**Bit** **Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 Log Address - Specifies the log to be written as described in table A.1. See 7.53.9.3.2 for more information.
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h

7.53.9.3.2 Log Address

A device may support a subset of the available logs. Support for individual logs is determined by support for the associated feature set. Support of the associated log(s) is mandatory for devices implementing the associated feature set. If this command is implemented, all address values defined as host vendor specific shall be implemented, see A.9 for more information on Host Vendor Specific logs. See A.6 for information regarding Device Vendor Specific logs. If the host attempts to write to a read only (RO) log address, the device shall return command aborted.

7.53.9.4 Normal Outputs

See table 86.

7.53.9.5 Error Outputs

ID Not Found shall be set to one if the SMART data is not available. Abort shall be set to one if SMART is not enabled, if the log is not implemented, or if the count field is cleared to zero. The device may return error status if an Interface CRC error has occurred. See table 118.

7.54 STANDBY - E2h, Non-data

7.54.1 Feature Set

This commands is mandatory for devices that implement the Power Management feature set

7.54.2 Description

This command causes the device to enter the Standby mode.

If the Count field is non-zero then the Standby timer shall be enabled. The value in the Count field shall be used to determine the time programmed into the Standby timer (see table 27).

If the Count field is zero then the Standby timer is disabled.

7.54.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	This value shall determine the time period programmed into the Standby timer. Table 27 defines these values.
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E2h

7.54.4 Normal Outputs

See table 86.

7.54.5 Error Outputs

See table 109.

7.55 STANDBY IMMEDIATE - E0h, Non-data

7.55.1 Feature Set

This commands is mandatory for devices that implement the Power Management feature set

7.55.2 Description

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

7.55.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E0h

7.55.4 Normal Outputs

See table 86.

7.55.5 Error Outputs

See table 109.

7.56 TRUSTED RECEIVE – 5Ch

7.56.1 Feature Set

This command is mandatory for devices implementing the Trusted Computing feature set.

7.56.2 Description

The TRUSTED RECEIVE command is used to retrieve security protocol information (see 7.56.6) or the results from one or more TRUSTED SEND commands.

Any association between a previous TRUSTED SEND command and the data transferred by a TRUSTED RECEIVE command depends on the protocol specified by the Security_Protocol field (see table 53). If the device has no data to transfer (e.g., the results for any previous TRUSTED SEND commands are not yet available), the device may transfer data indicating it has no other data to transfer.

Indications of data overrun or underrun and the mechanism, if any, for processing retries depend on the protocol specified by the Security_Protocol field (see table 53).

For Security_Protocol field set to 00h, the format of the data is described in 7.56.6.2. The format of the data for other Security_Protocol values is documented by the group that owns the associated Security_Protocol value.

The device shall retain data resulting from a TRUSTED SEND command awaiting retrieval by a TRUSTED RECEIVE command until one of the following events is processed:

a) the data is delivered according to the Security_Protocol field (see table 53) specific rules for the TRUSTED RECEIVE command;
b) any reset; or
c) loss of communication with the host that sent the TRUSTED SEND command.

7.56.3 Inputs

7.56.3.1 Overview

Word	Name	Description
00h	Feature	**Bit** **Description** 15:8 Reserved 7:0 Security_Protocol (see 7.56.3.2)
01h	Count	**Bit** **Description** 15:8 Reserved 7:0 Transfer_Length (7:0)
02h-04h	LBA	**Bit** **Description** 47:24 Reserved 23:8 Sp_Specific - Security Protocol Specific (see 7.56.6) 7:0 Transfer_Length (15:8)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 5Ch

7.56.3.2 Security_Protocol

The Security_Protocol field identifies which security protocol is being used. This determines the format of the command block parameters and of the data that is transferred (see table 53). If the Security_Protocol field is set to a reserved value, the device shall return command aborted.

Table 53 — TRUSTED RECEIVE Security_Protocol field description

Value	Description
00h	Return security protocol information (see 7.56.6)
01h – 06h	Defined by TCG, see 7.56.6
07h – 1Fh	Reserved.
20h	Reserved for T10
21h-EDh	Reserved
EEh	Defined by IEEE 1667
EFh	Reserved for T10
F0h – FFh	Vendor Specific.

The meaning of the security protocol-specific fields are defined by each security protocol.

7.56.4 Normal outputs

See table 86

7.56.5 Error outputs

The device shall return command aborted if an unrecoverable error occurred during the execution of the command. The amount of data transferred is indeterminate. See table 109.

7.56.6 Command Block Parameters for Security_Protocol 00h - 06h

7.56.6.1 Overview

The SP_Specific field provides Security_Protocol field specific information. The meaning of these fields are defined by each security protocol. For Security_Protocol field set to 00h, see 7.56.6.2.

The Transfer_Length field contains the number of 512-byte blocks of data to be transferred. (One means 512 bytes, two means 1024 bytes, etc.) A Transfer_Length value of zero specifies that no data shall be transferred. This condition shall not be considered an error.

The total data length shall conform to the Transfer_Length field requirements (e.g. the total data length shall be a multiple of 512). Pad bytes shall be added as needed to meet this requirement. Pad bytes shall have a value of 00h.

If the length of the TRUSTED RECEIVE parameter data is greater than the Transfer_Length, then the device shall return the TRUSTED RECEIVE parameter data truncated to the requested Transfer_Length.

7.56.6.2 Security_Protocol 00h Description

The purpose of Security_Protocol 00h is to return basic information about the device. A TRUSTED RECEIVE using Security_Protocol field set to 00h is not linked to an earlier TRUSTED SEND command.

When the Security_Protocol field is set to 00h, the SP_Specific field is shown in table 54.

Table 54 — Security_Protocol 00h - SP_Specific field descriptions for Protocol 00h

SP_Specific	Description	Reference	Support
0000h	Return supported security protocol list		Mandatory
0001h	Return a certificate		Mandatory
0002h-FFFFh	Reserved		

If the SP_Specific field is set to a reserved value, the command shall be aborted.

Each time a TRUSTED RECEIVE command with Security_Protocol field set to 00h is received, the device shall transfer the data starting with byte 0.

7.56.6.3 Supported security protocols list description

When the Security_Protocol field is set to 00h, and SP_Specific is set to 0000h in a TRUSTED RECEIVE command, the parameter data shall have the format shown in table 55.

Table 55 — TRUSTED RECEIVE parameter data for SP_Specific=0000h

Byte \ Bit	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	(MSB	List Length						
7								(LSB
8	Supported Security_Protocol List							
M								
M+1	Pad bytes (if any)							
511								

The List Length field indicates the total length, in bytes, of the supported security protocol list.

The Supported Security_Protocol List field shall contain a list of all supported Security_Protocol field values. Each byte indicates a supported Security_Protocol field value. The values shall be in ascending order starting with 00h.

The total data length shall be 512 bytes. Pad bytes are appended as needed to meet this requirement. Pad bytes shall have a value of 00h.

7.56.6.4 Certificate data description

7.56.6.4.1 Certificate overview

A certificate is either an X.509 Attribute Certificate or an X.509 Public Key Certificate depending on the capabilities of the device.

When the Security_Protocol field of the TRUSTED RECEIVE command is set to 00h, and SP_Specific is 0001h, the parameter data shall have the format shown in table 56.

Table 56 — TRUSTED RECEIVE parameter data for SP_Specific=0001h

Byte \ Bit	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	(MSB)	CERTIFICATE LENGTH (M - 3)						
3	(MSB)							(LSB)
4	X.509 certificate bytes							
M								
M+1	Pad bytes (if any)							
511								

The CERTIFICATE LENGTH indicates the total length, in bytes, of the certificate(s). This length includes one or more certificates. If the device doesn't have a certificate to return, the certificate length is set to 0000h and only the 4 byte header and 508 pad bytes are returned.

The contents of the certificate fields are defined in table 7.56.6.4.2 and table 7.56.6.4.3.

The total data length shall conform to the Transfer_Length field requirements.

7.56.6.4.2 Public Key certificate description

RFC 3280 defines the certificate syntax for certificates consistent with X.509v3 Public Key Certificate Specification.

7.56.6.4.3 Attribute certificate description

RFC 3281 defines the certificate syntax for certificates consistent with X.509v2 Attribute Certificate Specification.

7.57 TRUSTED RECEIVE DMA – 5Dh

7.57.1 Feature Set

This command is mandatory for devices implementing the Trusted Computing feature set.

7.57.2 Description

See 7.56.2 for the description of TRUSTED RECEIVE DMA

7.57.3 Inputs

Word	Name	Description
00h	Feature	**Bit** **Description** 15:8 Reserved 7:0 Security_Protocol (see 7.56.3.2)
01h	Count	**Bit** **Description** 15:8 Reserved 7:0 Transfer_Length (7:0)
02h-04h	LBA	**Bit** **Description** 47:24 Reserved 23:8 Sp_Specific - Security Protocol Specific (see 7.56.6) 7:0 Transfer_Length (15:8)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 5Dh

See 7.56.3 for a description of the inputs to this command

7.57.4 Normal Outputs

See 7.56.4 for the normal outputs of this command

7.57.5 Error Outputs

See 7.56.5 for the error outputs of this command.

7.58 TRUSTED SEND – 5Eh

7.58.1 Feature Set

This command is mandatory for devices implementing the Trusted Computing feature set.

7.58.2 Description

The TRUSTED SEND command is used to send data to the device. The data sent contains one or more Security_Protocol specific instructions to be performed by the device. The host uses TRUSTED RECEIVE commands to retrieve any data resulting from these instructions.

Any association between a TRUSTED SEND command and a subsequent TRUSTED RECEIVE command depends on the protocol specified by the Security_Protocol field (see table 57). Each protocol shall specify whether:

a) the device shall complete the command with normal status as soon as it determines the data has been correctly received. An indication that the data has been processed is obtained by sending a TRUSTED RECEIVE command and receiving the results in the associated data transfer; or
b) the device shall complete the command with normal status only after the data has been successfully processed and an associated TRUSTED RECEIVE command is not required.

There may be intentional side effects, depending on the trusted operation requested. Most trusted operations have no side effects, but there may be some allowable exceptions. For example, a request to lock the device is expected to cause subsequent reads or writes to fail.

The completion of background activity resulting from a trusted command shall not abort any outstanding queued commands.

The format of the data and some of the command block parameters depends on the protocol specified by the Security_Protocol field (see table 57).

7.58.3 Inputs

7.58.3.1 Overview

Word	Name	Description
00h	Feature	**Bit** **Description** 15:8 Reserved 7:0 Security_Protocol (see 7.58.3.2)
01h	Count	**Bit** **Description** 15:8 Reserved 7:0 Transfer_Length (7:0)
02h-04h	LBA	**Bit** **Description** 47:24 Reserved 23:8 Sp_Specific - Security Protocol Specific (see 7.58.6) 7:0 Transfer_Length (15:8)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 5Eh

7.58.3.2 Security_Protocol

The Security_Protocol field identifies which security protocol is being used. This determines the format of the command block parameters and of the data that is transferred. (see table 57). If the Security_Protocol field is set to a reserved value, the device shall return command aborted.

Table 57 — TRUSTED SEND - Security_Protocol field description

Value	Description
00h	Reserved
01h – 06h	Defined by TCG
07h-1Fh	Reserved
20h	Reserved for T10
21h – EDh	Reserved
EEh	Defined by IEEE 1667
EFh	Reserved for T10
F0h – FFh	Vendor Specific

The meaning of the security protocol-specific fields are defined by each security protocol.

For Security_Protocol values 01h-06h, see 7.58.6.

7.58.4 Normal outputs

See table 86

7.58.5 Error outputs

The device shall return command aborted if an unrecoverable error occurred during the execution of the command. The amount of data transferred is indeterminate. See table 109.

7.58.6 Command Block Parameters for Security_Protocol 01h - 06h

7.58.6.1 Overview

The Transfer_Length Field contains the number of 512-byte blocks of data to be transferred. (One means 512 bytes, two means 1024 bytes, etc.). Pad bytes are appended to the valid data as needed to meet this requirement. Pad bytes shall have a value of 00h. A value of zero specifies that no data transfer shall take place, and shall not be considered to be an error.

The SP_Specific field provides Security_Protocol field specific information. The meaning of this field is defined by each security protocol.

7.59 TRUSTED SEND DMA – 5Fh

7.59.1 Feature Set

This command is mandatory for devices implementing the Trusted Computing feature set.

7.59.2 Description

See 7.58.2 for the description of TRUSTED SEND DMA

7.59.3 Inputs

Word	Name	Description
00h	Feature	**Bit** **Description** 15:8 Reserved 7:0 Security_Protocol (see 7.58.3.2)
01h	Count	**Bit** **Description** 15:8 Reserved 7:0 Transfer_Length (7:0)
02h-04h	LBA	**Bit** **Description** 47:24 Reserved 23:8 Sp_Specific - Security Protocol Specific (see 7.58.6) 7:0 Transfer_Length (15:8)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 5Fh

See 7.58.3 for a description of the inputs to this command

7.59.4 Normal Outputs

See 7.58.4 for the normal outputs of this command

7.59.5 Error Outputs

See 7.58.5 for the error outputs of this command.

7.60 WRITE BUFFER - E8h, PIO data-out

7.60.1 Feature Set

This command is optional for devices that implement the General feature set

7.60.2 Description

This command enables the host to write the contents of one 512-byte block of data in the device's buffer.

The READ BUFFER and WRITE BUFFER commands shall be synchronized within the device such that sequential WRITE BUFFER and READ BUFFER commands access the same bytes within the buffer.

7.60.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 E8h

7.60.4 Normal Outputs

See table 86.

7.60.5 Error Outputs

The device may return error status if an Interface CRC error has occurred. See table 109.

7.61 WRITE DMA - CAh, DMA

7.61.1 Feature Set

This command is mandatory for devices that implement the General feature set

7.61.2 Description

The WRITE DMA command allows the host to write data using the DMA data transfer protocol.

7.61.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero.
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 CAh

7.61.4 Normal Outputs

See table 86.

7.61.5 Error Outputs

LBA bits 47:28 shall be cleared to zero. See table 131.

7.62 WRITE DMA EXT - 35h, DMA

7.62.1 Feature Set

This command is mandatory for devices that implement the 48-bit Address feature set

7.62.2 Description

The WRITE DMA EXT command allows the host to write data using the DMA data transfer protocol.

7.62.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65.536 logical sectors are to be transferred.
02h	LBA	(MSB) Address of first logical sector to be transferred.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 35h

7.62.4 Normal Outputs

See table 99.

7.62.5 Error Outputs

See table 120.

7.63 WRITE DMA FUA EXT - 3Dh, DMA

7.63.1 Feature Set

This command is mandatory for devices that implement the 48-bit Address feature set

7.63.2 Description

The WRITE DMA FUA EXT command provides the same function as the WRITE DMA EXT command except that regardless of whether volatile and/or non-volatile write caching in the device is enabled or not, the user data shall be written to non-volatile media before command completion is reported.

7.63.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65.536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 3Dh

7.63.4 Normal Outputs

See table 99.

7.63.5 Error Outputs

See table 120.

7.64 WRITE DMA QUEUED - CCh, DMA Queued

7.64.1 Feature Set

This command is mandatory for devices that implement the TCQ feature set

7.64.2 Description

This command executes in a similar manner to a WRITE DMA command. The device may perform a release or may execute the data transfer without performing a release if the data is ready to transfer.

If the device performs a release, the host should reselect the device using the SERVICE command.

Once the data transfer is begun, the device shall not perform a release until the entire data transfer has been completed.

7.64.3 Inputs

Word	Name	Description
00h	Feature	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero
01h	Count	**Bit** **Description** 15:8 Reserved 7:3 Tag - See 6.3.5 2:0 N/A
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 CCh

7.64.4 Normal Outputs

7.64.4.1 Data transmission

Data transfer may occur after receipt of the command or may occur after the receipt of a SERVICE command. When the device is ready to transfer data requested by a data transfer command, the device sets the following field content to initiate the data transfer. See table 95 for the layout of the Normal Outputs data structure. Release shall be cleared to zero, Input/Output Shall be cleared to zero, Command/Data shall be cleared to zero.

7.64.4.2 Release

If the device performs a release before transferring data for this command, the field content upon performing a release shall be as shown in table 95. Release shall be set to one, Input/Output Shall be cleared to zero, Command/Data shall be cleared to zero.

7.64.4.3 Service request

When the device is ready to transfer data or complete a command after the command has performed a release, the device shall set the SERV bit and not change the state of any other status field bit. When the SERVICE command is received, the device shall set outputs as described in data transfer, command completion, or Error Outputs depending on the service the device requires.

7.64.4.4 Command completion

When the transfer of all requested data has occurred without error, the field content shall be as shown below. See table 95 for the layout of the Normal Outputs data structure. Release shall be cleared to zero, Input/Output Shall be set to one, Command/Data shall be set to one.

7.64.5 Error Outputs

The Count field contains the Tag for this command if the device supports the TCQ feature set. The device shall return command aborted if the device supports the TCQ feature set and the Tag is invalid. An unrecoverable error encountered during the execution of this command results in the termination of the command and the logical sector where the first unrecoverable error occurred is returned. Bits 47:48 of logical sector where the first unrecoverable error occurred shall be cleared to zero. If write cache is enabled unrecoverable errors may not be reliably reported as they may occur after the completion of the command. If a queue existed, the unrecoverable error shall cause the queue to abort. See table 132.

7.65 WRITE DMA QUEUED EXT - 36h, DMA Queued

7.65.1 Feature Set

This command is mandatory for devices that implement both the TCQ feature set and 48-bit Address feature set

7.65.2 Description

This command executes in a similar manner to a WRITE DMA EXT command. The device may perform a release the bus or may execute the data transfer without performing a release if the data is ready to transfer.

If the device performs a release, the host should reselect the device using the SERVICE command.

Once the data transfer is begun, the device shall not perform a release until the entire data transfer has been completed.

7.65.3 Inputs

Word	Name	Description
00h	Feature	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
01h	Count	**Bit** **Description** 15:8 Reserved 7:3 Tag - See 6.3.5 2:0 Reserved
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 36h

7.65.4 Normal Outputs

7.65.4.1 Data transmission

Data transfer may occur after receipt of the command or may occur after the receipt of a SERVICE command. When the device is ready to transfer data requested by a data transfer command, the device sets the following field content to initiate the data transfer. See table 101 for the layout of the Normal Outputs data structure. Release shall be cleared to zero, Input/Output Shall be cleared to zero, Command/Data shall be cleared to zero.

7.65.4.2 Release

If the device performs a release before transferring data for this command, the field content upon performing a release shall be as shown in table 101. Release shall be set to one, Input/Output Shall be cleared to zero, Command/Data shall be cleared to zero.

7.65.4.3 Service request

When the device is ready to transfer data or complete a command after the command has performed a release, the device shall set the SERV bit and not change the state of any other status field bit. When the SERVICE command is received, the device shall set outputs as described in data transfer, command completion, or Error Outputs depending on the service the device requires.

7.65.4.4 Command completion

When the transfer of all requested data has occurred without error, the field content shall be as shown below. See table 101 for the layout of the Normal Outputs data structure. Release shall be cleared to zero, Input/Output Shall be set to one, Command/Data shall be set to one.

7.65.5 Error Outputs

The Interrupt Reason field contains the Tag for this command if the device supports the TCQ feature set. The device shall return command aborted if the device supports the TCQ feature set and the Tag is invalid. An unrecoverable error encountered during the execution of this command results in the termination of the command and the logical sector where the first unrecoverable error occurred is returned. If write cache is enabled unrecoverable errors may not be reliably reported as they may occur after the completion of the command. If a queue existed, the unrecoverable error shall cause the queue to abort. Abort shall be set to one if the LBA plus Count is larger than the value reported in IDENTIFY DEVICE data words 100-103. See table 132.

7.66 WRITE DMA QUEUED FUA EXT - 3Eh, DMA Queued

7.66.1 Feature Set

This command is mandatory for devices that implement both the TCQ feature set and 48-bit Address feature set.

7.66.2 Description

This command executes in a similar manner to a WRITE DMA EXT command. The device may perform a release or may execute the data transfer without performing a release if the data is ready to transfer.

If the device performs a release, the host should reselect the device using the SERVICE command.

Once the data transfer is begun, the device shall not perform a release until the entire data transfer has been completed.

The WRITE DMA QUEUED FUA EXT command provides the same function as the WRITE DMA EXT command. It is a TCQ feature set command and when issued it shall not cause an existing queue to be aborted. However, regardless of whether volatile and/or non-volatile write caching in the device is enabled or not, the user data shall be written to non-volatile media before command completion is reported.

7.66.3 Inputs

Word	Name	Description
00h	Feature	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
01h	Count	**Bit** **Description** 15:8 Reserved 7:3 Tag - See 6.3.5 2:0 Reserved
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 3Eh

7.66.4 Normal Outputs

See 7.65.4.

7.66.5 Error Outputs

See 7.65.5.

7.67 WRITE FPDMA QUEUED - 61h, DMA Queued

7.67.1 Feature Set

This command is mandatory for devices implementing the NCQ feature set

7.67.2 Description

This command causes data to be transferred from the host to the device.

7.67.3 Inputs

7.67.3.1 Overview

Word	Name	Description
00h	Feature	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred.
01h	Count	**Bit** **Description** 15:8 Reserved 7:3 NCQ Tag - See 6.3.3 2:0 Reserved
02h	LBA	(MSB)
03h		Address of the first logical sector to be transferred.
04h		(LSB)
05h	Device	Bit **Description** 15 FUA - See 7.67.3.2 14 Shall be set to one 13 Reserved 12 Shall be set to zero 11:8 Reserved
	Command	7:0 61h

7.67.3.2 Forced Unit Access (FUA)

When the FUA bit is set to one regardless of whether volatile and/or non-volatile write caching in the device is enabled or not, the user data shall be written to non-volatile media before command completion is reported. When the FUA bit is cleared to zero the device may return command completion before the data is written to the media.

7.67.4 Command Acceptance Outputs

See table 104.

7.67.5 Normal Outputs

See table 105.

7.67.6 Error Outputs

This return indicates that the command was aborted due to LBA out of range, a duplicate tag number, an invalid tag number, or an ICRC error, see table 136 for more information.

Errors which occur during the processing of this command are reported by returning a transport dependent indicator with additional information available in the NCQ Command Error log, see table 137 for more information.

7.68 WRITE LOG EXT - 3Fh, PIO data-out

7.68.1 Feature Set

This command is mandatory for devices that implement the General Purpose Logging feature set.

7.68.2 Description

This command writes a specified number of 512 byte blocks of data to the specified log. See table A.1 for the list of logs.

7.68.3 Inputs

7.68.3.1 Overview

Word	Name	Description
00h	Feature	Reserved
01h	Count	Data Block Count - See 7.68.3.2 for the definition of Data Block Count
02h-04h	LBA	**Bit Description** 47:32 Reserved 31:16 Page # - Specifies the first 512-byte block of data of the log to be written. 15:8 Reserved 7:0 Log Address - Specifies the log to be written as described in table A.1. See 7.53.9.3.2 for more information.
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 3Fh

7.68.3.2 Data Block Count

Specifies the number of 512-byte blocks of data that shall be written to the specified log. If the number zero, or the number is greater than the number indicated in the General Purpose Log Directory (see table A.2), the device shall return command aborted.

7.68.4 Normal Outputs

See table 99.

7.68.5 Error Outputs

If the count field is cleared to zero, if the feature set associated with the log specified in the LBA field (7:0) is not supported or enabled, or if the values in the Features, Count, or LBA (47:8) are invalid, the device shall return command aborted. If the host attempts to write to a read only (RO) log address, the device shall return command aborted. ID Not Found shall be set to one if the log data is not available or a data structure checksum error occurred. Abort shall be set to one if the feature associated with the log specified in bit 7:0 of the LBA field is not supported or not enabled. Abort shall be set to one if the Page # plus the Data Block Count is larger than the log size reported in the General Purpose Log Directory. The device may return error status if an Interface CRC error has occurred. See table 118.

7.69 WRITE LOG DMA EXT - 57h, DMA

7.69.1 Feature Set

This command is optional for devices implementing the General Purpose Logging feature set

7.69.2 Description

See 7.68.2.

7.69.3 Inputs

See 7.68.3.

7.69.4 Normal Outputs

See 7.68.4.

7.69.5 Error Outputs

See 7.68.5.

7.70 WRITE MULTIPLE - C3h, PIO data-out

7.70.1 Feature Set

This command is mandatory for devices that implement the General feature set

7.70.2 Description

This command writes the number of logical sectors specified in the Count field.

The number of logical sectors per DRQ data block is defined by the content of IDENTIFY DEVICE data word 59.

When the WRITE MULTIPLE command is issued, the Count field contains the number of logical sectors (not the number of DRQ data blocks) requested.

If the number of requested logical sectors is not evenly divisible by the DRQ data block count, as many full blocks as possible are transferred, followed by a final, partial block transfer. The partial block transfer is for n logical sectors, where:

n = Remainder (Count / DRQ data block count).

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

The contents of the Command Structure following the transfer of a DRQ data block that had a logical sector in error are undefined. The host should retry the transfer as individual requests to obtain valid error information.

If bit 8 of IDENTIFY DEVICE data word 59 is cleared to zero, and a WRITE MULTIPLE command is received by the device, and no successful SET MULTIPLE MODE command has been processed by the device, the device shall return command aborted. A successful SET MULTIPLE MODE command should precede a WRITE MULTIPLE command.

7.70.3 Inputs

<table>
<tr><th>Word</th><th>Name</th><th>Description</th></tr>
<tr><td>00h</td><td>Feature</td><td>N/A</td></tr>
<tr><td>01h</td><td>Count</td><td>The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero.</td></tr>
<tr><td>02h</td><td>LBA</td><td rowspan="3">(MSB)
Address of first logical sector to be transferred.
Bits 47:28 shall be cleared to zero.
(LSB)</td></tr>
<tr><td>03h</td><td></td></tr>
<tr><td>04h</td><td></td></tr>
<tr><td rowspan="2">05h</td><td>Device</td><td>Bit Description
15 Obsolete
14 Shall be set to one
13 Obsolete
12 Transport Dependent - See 6.1.9
11:8 Reserved</td></tr>
<tr><td>Command</td><td>7:0 C3h</td></tr>
</table>

7.70.4 Normal Outputs

See table 86.

7.70.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The return fields contain the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. LBA field Bits 47:28 shall be cleared to zero. The device may return error status if an Interface CRC error has occurred. See table 131.

7.71 WRITE MULTIPLE EXT - 39h, PIO data-out

7.71.1 Feature Set

This command is mandatory for devices that implement the 48-bit Address feature set

7.71.2 Description

This command writes the number of logical sectors specified in the Count field.

The number of logical sectors per DRQ data block is defined by the content of IDENTIFY DEVICE data word 59.

When the WRITE MULTIPLE EXT command is issued, the Count field contains the number of logical sectors (not the number of DRQ data blocks) requested.

If the number of requested logical sectors is not evenly divisible by the DRQ data block count, as many full blocks as possible are transferred, followed by a final, partial block transfer. The partial block transfer is for n logical sectors, where:

n = Remainder (Count / DRQ data block count).

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

The contents of the Command Structure following the transfer of a data block that had a logical sector in error are undefined. The host should retry the transfer as individual requests to obtain valid error information.

If bit 8 of IDENTIFY DEVICE data word 59 is cleared to zero, and a WRITE MULTIPLE EXT command is received by the device, and no successful SET MULTIPLE MODE command has been processed by the device, the device shall return command aborted. A successful SET MULTIPLE MODE command should precede a WRITE MULTIPLE EXT command.

7.71.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65.536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 39h

7.71.4 Normal Outputs

See table 99.

7.71.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The return fields contain the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. The device may return error status if an Interface CRC error has occurred. See table 120.

7.72 WRITE MULTIPLE FUA EXT - CEh, PIO data-out

7.72.1 Feature Set

This command is mandatory for devices that implement the 48-bit Address feature set

7.72.2 Description

The WRITE MULTIPLE FUA EXT command provides the same functionality as the WRITE MULTIPLE EXT command except that regardless of whether volatile and/or non-volatile write caching in the device is enabled or not, the user data shall be written to non-volatile media before command completion is reported.

If bit 8 of IDENTIFY DEVICE data word 59 is cleared to zero, and a WRITE MULTIPLE FUA EXT command is received by the device, and no successful SET MULTIPLE MODE command has been processed by the device, the device shall return command aborted. A successful SET MULTIPLE MODE command should precede a WRITE MULTIPLE FUA EXT command.

7.72.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65.536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 CEh

7.72.4 Normal Outputs

See table 99.

7.72.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The return fields contain the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. The device may return error status if an Interface CRC error has occurred. See table 120.

7.73 WRITE SECTOR(S) - 30h, PIO data-out

7.73.1 Feature Set

This command is mandatory for devices that implement the General feature set

7.73.2 Description

This command writes from 1 to 256 logical sectors as specified in the Count field.

7.73.3 Inputs

Word	Name	Description
00h	Feature	N/A
01h	Count	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred. Bits 15:8 shall be cleared to zero.
02h	LBA	(MSB) Address of first logical sector to be transferred. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 30h

7.73.4 Normal Outputs

See table 86.

7.73.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The return fields contain the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. LBA field Bits 47:28 shall be cleared to zero. The device may return error status if an Interface CRC error has occurred. See table 131.

7.74 WRITE SECTOR(S) EXT - 34h, PIO data-out

7.74.1 Feature Set

This command is mandatory for devices that implement the 48-bit Address feature set

7.74.2 Description

This command writes from 1 to 65,536 logical sectors as specified in the Count field.

7.74.3 Inputs

Word	Name	Description
00h	Feature	Reserved
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65.536 logical sectors are to be transferred.
02h	LBA	(MSB) Address of first logical sector to be transferred.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 34h

7.74.4 Normal Outputs

See table 99.

7.74.5 Error Outputs

An unrecoverable error encountered during the execution of this command results in the termination of the command. The return fields contain the address of the logical sector where the first unrecoverable error occurred. The amount of data transferred is indeterminate. The device may return error status if an Interface CRC error has occurred. See table 120.

7.75 WRITE STREAM DMA EXT - 3Ah, DMA

7.75.1 Feature Set

This command is mandatory for devices that implement the Streaming feature set.

7.75.2 Description

The WRITE STREAM DMA EXT command provides a method for a host to write data within an allotted time using the DMA data transfer protocol. This command allows for the host to specify that additional actions are to be performed by the device prior to the completion of the command.

7.75.3 Inputs

7.75.3.1 Inputs overview

Word	Name	Description
00h	Feature	**Bit Description** 15:8 Command Completion Time Limit (CCTL) - See 7.37.3.2. 7 Obsolete 6 Write Continuous - See 7.75.3.2 5 Flush - See 7.75.3.3 4 Obsolete 3 Reserved 2:0 Stream ID – See 7.75.3.4
01h	Count	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred.
02h	LBA	(MSB)
03h		Address of first logical sector to be transferred.
04h		(LSB)
05h	Device	Bit Description 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 3Ah

7.75.3.2 Write Continuous (WC)

WC specifies whether the Write Continuous mode is enabled or disabled.

If WC is set to one, then:

a) the device shall not stop processing the command due to errors;
b) if an error occurs during data transfer or while writing data to media before command completion or before the amount of time allowed for command completion based on the setting of CCTL (see 7.37.3.2) or Default CCTL (see 7.9.3) is reached, then the device:
   1) shall continue to transfer the amount of data requested;
   2) may continue writing data to the media;
   3) shall report command completion after all data for the command has been transferred; and
   4) shall save the error information in the Write Streaming Error log; or
c) if the amount of time allowed for command completion based on the setting of CCTL (see 7.37.3.2) or Default CCTL (see 7.9.3) is reached, then the device:

1) shall stop processing the command;
2) shall report command completion;
3) shall set CCTO in the Write Streaming Error log to one; and
4) may continue writing data to the media.

If WC is cleared to zero and an error occurs, then the device:

a) shall stop processing the command and report command completion; and
b) may continue writing data to the media.

7.75.3.3 Flush

If Flush is set to one, Default CCTL is cleared to zero, and CCTL is cleared to zero, then the device shall write all data for the specified stream to the media before command completion is reported.

If Flush is set to one and Default CCTL was not cleared to zero in the most recent CONFIGURE STREAM command (see 7.9) for the Stream ID, then the device shall report command completion within the time specified by Default CCTL (see 7.9.3.4).

If Flush is set to one and CCTL is not cleared to zero, then the device shall report command completion within (CCTL * (IDENTIFY DEVICE data words (99:98)) microseconds.

If Flush is set to one and either Default CCTL was not cleared to zero in the most recent CONFIGURE STREAM command (see 7.9) for the Stream ID, or CCTL is not cleared to zero, then device:

a) shall measure the time before reporting command completion from command acceptance;
b) shall set CCTO to one if all of the data for the command has been received by the device, but the device has not yet written all of the data to its media; and
c) should continue writing data to its media after reporting command completion.

7.75.3.4 Stream ID

Stream ID specifies the stream to be written. The device shall operate according to the parameters specified by the most recent successful CONFIGURE STREAM command specifying this Stream ID. Any write to the device media or internal device buffer management as a result of the Stream ID is vendor specific.

7.75.4 Normal Outputs

See table 90 for the definition of Normal Outputs.

7.75.5 Error Outputs

If

a) WC was set to one in the command, and
b) the device is able to accept the amount of data requested for the command (e.g., an error occurred while writing to the media);

then the device shall set SE to one and clear ERR to zero.

If:

a) WC was set to one in the command, and
b) the device is not able to return the amount of data requested for the command (e.g., an ICRC error shall be reported at command completion);

then the device shall clear SE to zero and set ERR to one;

If:

a) WC was cleared to zero in the command;
b) CCTL was not cleared to zero in the command, or CCTL was cleared to zero in the command and Default CCTL specified in the most recent CONFIGURE STREAM command (see 7.9) for the Stream ID was not cleared to zero; and
c) the time specified for command completion by CCTL (see 7.37.3.2) or Default CCTL (see 7.9.3) has been reached;

then the device shall clear SE to zero, set ERR to one, and set ABRT to one whether or not all data has been flushed to media.

If:

a) WC was cleared to zero in the command;
b) CCTL was cleared to zero in the command; and
c) Default CCTL specified in the most recent CONFIGURE STREAM command (see 7.9) for the Stream ID was cleared to zero;

then the device shall clear SE to zero, set ERR to one, and set ICRC, IDNF, and/or ABRT to one (i.e., indicating the error type).

See table 121 for the definition of other Error Outputs.

7.76 WRITE STREAM EXT - 3Bh, PIO data-out

7.76.1 Feature Set

This command is mandatory for devices that implement the Streaming feature set.

7.76.2 Description

See 7.75.2 for the description of this command.

7.76.3 Inputs

See 7.75.3 for the inputs to this command

7.76.4 Normal Outputs

See 7.75.4 for Normal Outputs.

7.76.5 Error Outputs

See 7.75.5 for Error Outputs.

7.77 WRITE UNCORRECTABLE EXT - 45h, Non-data

7.77.1 Feature Set

This command is optional for devices implementing the General feature set.

7.77.2 Description

The Write Uncorrectable EXT command is used to cause the device to report an uncorrectable error when the target sector is subsequently read.

When the Feature field contains a value of 55h the Write Uncorrectable EXT command shall cause the device to indicate a failure when reads to any of the sectors that are contained in physical block of the specified sector are performed. These sectors are referred to as 'pseudo uncorrectable' sectors. In this case whenever a pseudo uncorrectable sector is accessed via a read command the drive shall perform normal error recovery to the fullest extent and then set the UNC and ERR bits to indicate the sector is bad. Sectors that have been made pseudo uncorrectable when read back shall be treated in the same manner as an UNC, including error logging and SMART

When the Features field (7:0) contains a value of AAh the Write Uncorrectable EXT command shall cause the device to flag the specified sector as 'flagged uncorrectable'. Flagging a logical sector as uncorrectable shall cause the device to indicate a failure when reads to the specified sector are performed. These sectors are referred to as 'flagged uncorrectable' sectors. In this case whenever a 'flagged uncorrectable' sector is accessed via a read command the drive shall set the UNC and ERR bits to indicate the sector is bad If this command is sent to the device with the content of the Features field (7:0) set to anything other than what is defined above the device shall abort the command. Reading of flagged sectors should not be logged as an error or by SMART.

Commands that return UNC and ERR when a pseudo uncorrectable or flagged uncorrectable sector is read include: READ DMA, READ DMA EXT, READ DMA QUEUED, READ DMA QUEUED EXT, READ MULTIPLE, READ MULTIPLE EXT, READ SECTOR(S), READ SECTOR(S) EXT, READ VERIFY SECTOR(S), READ VERIFY SECTOR(S) EXT, READ STREAM EXT, READ STREAM DMA EXT. If the host writes to a 'pseudo uncorrectable' or 'flagged uncorrectable' sector, the drive shall attempt to write the data to the sector. The write shall clear the uncorrectable status of the sector and make the sector good if possible and the device shall verify that the sector may now be read without error. It is possible that an 'uncorrectable' sector location has actual physical errors. In this case read commands and/or write commands shall return ERR status information that is consistent with the error.

The pseudo uncorrectable or flagged uncorrectable status of a sector shall remain set during the processing of all power and reset events. If the drive is unable to process a WRITE UNCORRECTABLE EXT command for any reason the device shall abort the command.

7.77.3 Inputs

Word	Name	Description
00h	Feature	**Bit Description** 15:8 Reserved 7:0 Uncorrectable options Value Description 00h-54h Reserved 55h Create a pseudo-uncorrectable error with logging 56h-A9h Reserved AAh Create a flagged error without logging ABh-FFh Reserved
01h	Count	The number of sectors to be marked. A value of 0000h indicates that 65,536 sectors are to be marked.
02h	LBA	(MSB)
03h		Address of first sector to be marked.
04h		(LSB)
05h	Device	**Bit Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 45h

7.77.4 Normal Outputs

See table 86.

7.77.5 Error Outputs

See table 109.

8 SCT Command Transport

8.1 Introduction

8.1.1 Overview

The SCT Command Transport feature set provides a method for a host to send commands and data to a device and for a device to send data and status to a host using logs. Log Address E0h (SCT Command/Status) is used to issue commands and return status. Log Address E1h (SCT Data Transfer) is used to transport data.

There are two methods to access the logs defined for the SCT Command Transport feature set:

a) using SMART READ LOG and SMART WRITE LOG commands; and
b) using READ LOG (DMA) EXT and WRITE LOG (DMA) EXT commands.

Both sets of commands access the same logs and provide the same capabilities. The two methods are also used in the same way: a command is issued, data is transferred (if necessary), and status may be retrieved multiple times if desired.

If the SMART feature set is supported but not enabled, then a device that implements this feature set shall support SMART READ LOG and SMART WRITE LOG commands to the SCT Command/Status log and the SCT Data Transfer log.

Sending a key 512-byte block of data (key data block) to the SCT Command/Status log starts the command process. The key data block specifies Action and Function Codes along with the parameters that are required to perform the action. The SCT command response (either error or command) is the same for both methods of issuing commands.

SCT commands are executed like other ATA commands, therefore they take precedence over any background function the device may be performing when the SCT command is issued (i.e., a function initiated by a SMART EXECUTE OFFLINE IMMEDIATE command). Some SCT commands indicate command completion and return status while the SCT command is still executing.

The commands that are defined in the SCT Command Transport feature set are subject to all other feature set requirements (i.e., if the Security feature set is enabled and a password has not been issued to unlock the device, then all SCT commands shall be aborted by the device).

A device supporting the SCT Command Transport feature set should report a length of one in the General Purpose Log Directory and the SMART Log Directory for the SCT Command/Status log and the SCT Data Transfer log. The length of the SCT Data Transfer log does not indicate the length of an SCT Command Transport feature set data transfer. This differs from the requirement in this standard that the General Purpose Log Directory and the SMART Log Directory report the actual length of the specified log pages.

8.1.2 Device addressing methods

Standard ATA commands employ either LBA or Logical CHS addressing using both 28-bit and 48-bit capability. SCT commands only support 48-bit addressing.

For LBA access all logical user sectors on the device are numbered in a one-dimensional sequence from 0 to the maximum number of logical user sectors minus one. ATA Commands support 28-bits of LBA addressing and ATA Extended commands support 48-bits of LBA addressing. All SCT commands support 48-bits of LBA address. In this method, all defective cylinders, heads and sectors are mapped out by defect management, rendering them inaccessible.

8.1.3 SCT command nesting and interspersing with standard commands

Standard ATA commands may be interspersed with SCT commands, but SCT commands shall not be nested. SCT commands that do not require a subsequent data transfer operation are not interspersed with any ATA commands or each other. SCT commands that do require data transfer, on the other hand, shall not be nested; that is, if an SCT command that requires a data transfer is issued, all data transfer - to or from the host - shall complete before another SCT command is issued. In most cases, however, ATA read/write commands may be inserted in between data transfers for SCT commands, that is, between complete log commands. Furthermore, any reset (power-on, software or hardware) shall cause the SCT command to be aborted.

8.1.4 Resets

A device shall terminate the processing an SCT command during the processing of a software reset, hardware reset, or power-on reset. This may result in partial command execution or data loss. There is no indication once the device becomes ready that the previous command was terminated.

A device shall clear the SCT Status Response fields (i.e., Extended Status Code, Action Code, and Function Code) during the processing of a power-on reset and a hardware reset. A device shall only clear the Extended status code during processing of a hardware reset or a software reset (i.e., the other content of the SCT Status Response fields shall not be affected by the device processing the reset).

8.2 Processing SCT commands

8.2.1 Processing SCT commands overview

There are four phases involved in processing of SCT commands. These phases are:

1) Capability identification (see 8.2.2);
2) Command transfer (see 8.2.3);
3) Data transfer (see 8.2.4); and
4) Status (see 8.2.5).

8.2.2 SCT capability identification

Capability Identification is performed by the host issuing an IDENTIFY DEVICE command to determine if the SCT Command Transport feature set is enabled and which Action Codes are supported (see 7.16.7.65).

8.2.3 SCT command transfer

Transfer of an SCT command occurs when a 512-byte data packet is created by the host and written to the SCT Command/Status log. The 512-byte data packet contains a single command as defined in the SCT Command Transport feature set.

Table 58 shows how a host should set the fields to issue a SMART WRITE LOG command to send an SCT command.

Table 58 — Fields to issue an SCT command using SMART WRITE LOG

Word	Name	Description
00h	Feature	D6h - SMART WRITE LOG
01h	Count	**Bit Description** 15:8 Reserved 7:0 01h
02h-04h	LBA	**Bit Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 E0h - Log Address
05h	Device	Bit Description 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h - SMART

Table 59 shows how a host should set the fields to issue a WRITE LOG EXT command to send an SCT command.

Table 59 — Fields to issue an SCT command using WRITE LOG (DMA) EXT

Word	Name	Description
00h	Feature	Reserved
01h	Count	0001h
02h-04h	LBA	**Bit Description** 47:32 Reserved 31:16 0000h 15:8 Reserved 7:0 E0 - Log Address
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 3F - WRITE LOG EXT/57h - WRITE LOG DMA EXT

Table 60 defines how a device shall set the fields after successful completion of an SCT command.

Table 60 — Successful SCT command response

Word	Name	Description
00h	Error	**Bit Description** 15:8 Reserved 7:0 00h
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Table 61 defines how a device shall set the fields after an error occurred during processing of an SCT command.

Table 61 — SCT command error response

Word	Name	Description
00h	Error	**Bit Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	**Bit Description** 15:8 Reserved 7:0 Extended Status Code (7:0) (see table 62)
02h-04h	LBA	**Bit Description** 47:24 Reserved 23:8 SCT Command dependent. 7:0 Extended Status Code (15:8) (see table 62)
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 1b (Error - See 6.1.2)

Table 62 — Extended Status codes

Extended Status Code	Description
0000h	Command complete without error
0001h	Invalid Function Code
0002h	Input LBA out of range
0003h	Request 512-byte data block count overflow. The number of data blocks requested to transfer (Count field) in the log command is larger than specified by the SCT command
0004h	Invalid Function code in Error Recovery command
0005h	Invalid Selection code in Error Recovery command
0006h	Host read command timer is less than minimum value
0007h	Host write command timer is less than minimum value
0008h	Background SCT command was aborted because of an interrupting host command
0009h	Background SCT command was terminated because of unrecoverable error
000Ah	Invalid Function code in SCT Read/Write Long command
000Bh	SCT data transfer command was issued without first issuing an SCT command
000Ch	Invalid Function code in Feature Control command
000Dh	Invalid Feature code in Feature Control command
000Eh	Invalid New State value in Feature Control command
000Fh	Invalid Option Flags value in Feature Control command
0010h	Invalid SCT Action code
0011h	Invalid Table ID (table not supported)
0012h	Command was aborted due to device security being locked
0013h	Invalid revision code in SCT data
0014h	Foreground SCT operation was terminated because of unrecoverable error
0015h	The most recent non-SCT command was completed with an error due to the SCT Read Command Timer or Write Command Timer timing out.
0016h-BEFFh	Reserved
BF00h-BFFFh	Reserved for Serial ATA
C000h-FFEFh	Vendor specific
FFF0h-FFFEh	Reserved
FFFFh	SCT command executing in background

8.2.4 SCT data transfer

Once an SCT command for a data transfer has been issued, status is checked and data is transferred using the SCT Data Transfer log. Up to 255 512-byte blocks of data of data may be transferred at a time. If the SCT command requires more than 255 blocks of data transfer and SMART READ LOG or SMART WRITE LOG commands are used to transfer the data, the data may be written or read in up to 255 data block increments. If GPL feature set commands are used to transfer data, up to 65,535 512-byte data blocks may be transferred by a single command. If more than 65,535 data blocks are required, then multiple GPL feature set commands may be issued. Table 63 shows how to perform an SCT data transfer using a SMART READ LOG or SMART WRITE LOG command.

Table 63 — SCT data transfer using SMART READ LOG or SMART WRITE LOG

Word	Name	Description
00h	Feature	D5h/D6h (SMART READ LOG/SMART WRITE LOG subcommand code)
01h	Count	**Bit Description** 15:8 Reserved 7:0 Number of 512-byte data blocks to transfer
02h-04h	LBA	**Bit Description** 47:28 Reserved 27:24 N/A 23:8 C24Fh 7:0 E1h - Log Address
05h	Device	Bit Description 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h - SMART

Table 64 defines the fields for data transfer using a READ LOG EXT or WRITE LOG EXT command.

Table 64 — SCT data transfer using READ LOG (DMA) EXT or WRITE LOG (DMA) EXT

Word	Name	Description
00h	Feature	Reserved
01h	Count	Number of 512-byte data blocks to transfer
02h-04h	LBA	**Bit Description** 47:32 Reserved 31:16 0000h 15:8 Reserved 7:0 E1 - Log Address
05h	Device	Bit Description 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 2Fh - READ LOG EXT/47h - READ LOG DMA EXT/3Fh - WRITE LOG EXT/57h - WRITE LOG DMA EXT

8.2.5 SCT status

Status for an SCT command may be read at any time by reading the SCT Command/Status log. If the command involves data transfer, the host should check status before data is transferred to ensure that the device is ready. The host should also check status when the command is complete to confirm that the data was transferred successfully. When the command is complete, the host may check status a third time to determine if the command succeeded, failed, or partially succeeded.

Once an SCT command has been issued, status is reported in the ATA fields. This status indicates that the command was accepted or that an error occurred. This ATA status return does not indicate successful completion of the SCT actions, except Foreground LBA Segment Access commands that require the completion of the SCT action (e.g., LBA Segment Access with function code 0101h and 0102h). Some commands may take several minutes or even hours to execute. In this case, the host determines execution progress by requesting SCT status. Some commands may require setup time before they a device is ready to receive data. SCT status is used to determine when the device is read to receive data.

Reading the SCT Command/Status log retrieves the status information. The SCT status may be acquired any time that the host is allowed to send a command to the device. This command shall not change the power state of the device, nor terminate any background activity, including any SCT command in progress. This means if the device is in the Standby or Idle state, then the log request shall succeed.

Table 65 defines shows how to get the SCT status using a SMART READ LOG command.

Table 65 — SCT status request using SMART READ LOG

Word	Name	Description
00h	Feature	D5h (SMART READ LOG subcommand code)
01h	Count	**Bit Description** 15:8 Reserved 7:0 01h
02h-04h	LBA	**Bit Description** 47:24 Reserved 23:8 C24Fh 7:0 E0h (Log Address)
05h	Device	Bit Description 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 B0h - SMART

Table 66 defines the fields for retrieving status using a READ LOG EXT command.

Table 66 — SCT status request using READ LOG (DMA) EXT

Word	Name	Description
00h	Feature	Reserved
01h	Count	0001h
02h-04h	LBA	**Bit Description** 47:32 Reserved 31:16 0001h 15:8 Reserved 7:0 E0 (Log Address)
05h	Device	Bit Description 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Command	7:0 2Fh - READ LOG EXT/47h - READ LOG DMA EXT

Table 67 defines the format of the status response information that shall be set by the device in the SCT Command/Status log.

Table 67 — Format of SCT status response

Byte	Type	Field Name	Description
0-1	Word	Format Version	0002h - Status Response format version number.
2-3	Word	SCT Version	Manufacturer’s vendor specific implementation version number
4-5	Word	SCT Spec.	0001h - Highest level of ATA8-ACS supported.
6-9	DWord	Status Flags	Bit 0: Segment Initialized Flag. If this bit is set to 1, a Write Same command to all logical blocks has completed without error. This bit shall be cleared to 0 when any user LBA is written, even if write cache is enabled. This bit is also cleared if the capacity of the device is changed via SET MAX, SET MAX EXT or DCO. This bit is preserved during the processing of all power and reset events. Bits 1-31: Reserved
10	Byte	Device State	0 = Active waiting for a command 1 = Stand-by 2 = Sleep 3 = DST executing in background 4 = SMART Off-line Data Collection executing in background 5 = SCT command executing in background
11-13	Byte [3]	reserved	
14-15	Word	Extended Status Code	Status of last SCT command issued. FFFFh if SCT command executing in background (see table 62).
16-17	Word	Action Code	Action code of last SCT command issued. If the Extended Status Code is FFFFh this is the Action Code of the command that is currently executing
18-19	Word	Function Code	Function code of last SCT command issued. If the Extended Status Code is FFFFh this is the Function Code of the command that is currently executing
20-39	Byte [20]	reserved	
40-47	QWord	LBA	Current LBA of SCT command executing in background. If there is no command currently executing in the background, this field is undefined.
48-199	Byte [152]	reserved	
200	Byte	HDA Temp	Current device HDA temperature in degrees Celsius. This is a 2’s complement integer. 80h indicates that this value is invalid.
201	Byte	Min Temp	Minimum HDA temperature in degrees Celsius seen this power cycle. This is a 2’s complement integer. 80h indicates that this value is invalid.
202	Byte	Max Temp	Maximum HDA temperature in degrees Celsius seen this power cycle. This is a 2’s complement integer. 80h indicates that this value is invalid.
203	Byte	Life Min Temp	Minimum HDA temperature in degrees Celsius seen for the life of the device. This is a 2’s complement integer. 80h indicates that this value is invalid.
204	Byte	Life Max Temp	Maximum HDA temperature in degrees Celsius seen for the life of the device. This is a 2’s complement integer. 80h indicates that this value is invalid.

Table 67 — Format of SCT status response

Byte	Type	Field Name	Description
205	Byte	reserved	
206-209	DWord	Over Limit Count	Number of temperature recording Intervals since the last power-on reset where the recorded temperature was greater than Max Op Limit. See table 82 for information about this Interval.
210-213	DWord	Under Limit Count	Number of temperature recording Intervals since the last power-on reset where the recorded temperature was less than Min Op Limit. See table 82 for information about this Interval.
214-479	Byte [265]	reserved	
480-511	Byte [32]	Vendor Specific	

8.3 SCT Command Set

8.3.1 Overview

An SCT command shall be 512 bytes long. While an SCT command is in progress a host may use an SCT status request to retrieve status information (e.g., to determine if a command active or complete, the current LBA, or error information) about the current SCT command.

Table 68 defines the generic format of an SCT command written to the SCT Command/Status log.

Table 68 — SCT command format

Byte	Field	Words	Description
0-1	Action Code	1	This field specifies the command type and the type of data being accessed (e.g., sector or long sector), or the action being performed (e.g., a seek on the device). (See table 69 for definition of the Action Code field contents.)
2-3	Function Code	1	This field specifies the type of access and varies by command (e.g., this field specifies read, write, or verify).
4-x	Parameter1	Depends on command	Depends on command
x+1 - y	Parameter2	Depends on command	Depends on command
…	...	...	...
	Total Words	256	

Table 69 — SCT Action Codes

Action Code	Description
0000h	Reserved
0001h	SCT Read/Write Long
0002h	Write Same
0003h	Error Recovery Control
0004h	Features Control
0005h	SCT Data Tables
0006h	Vendor specific
0007h	Reserved for Serial ATA
0007h-BFFFh	Reserved
C000h-FFFFh	Vendor specific

8.3.2 SCT Read/Write Long

The function performed by the SCT Read/Write Long command is based on the obsolete ATA READ LONG/WRITE LONG capability, and has been extended beyond 28-bit addressing.

The SCT Read/Write Long data format for both reads and writes is two blocks long (i.e., each block is 512 bytes long). The first block contains the user data. The second data block contains the error correction and detection bytes. The remainder of the second block should contain zeros. Once the SCT command has been issued and the status response indicates that the device is ready to transfer data, the SCT Data Transfer log should be read or written to transfer the data. SCT Read/Write Long commands cause a forced unit access to occur.

Table 70 defines the format of an SCT Read/Write Long command written to the SCT Command/Status log.

Table 70 — SCT Read/Write Long command

Word	Name	Value	Description
0	Action Code	0001h	Read or Write a sector with full ECC or CRC data
1	Function Code	0001h	Read Long function
		0002h	Write Long function
2	LBA	QWord	Logical sector to be read or written

Table 71 defines the format of the status response for an SCT Read/Write Long command.

Table 71 — SCT Read/Write Long command status response

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	Bit Description 15:8 Reserved 7:0 Number of ECC/CRC bytes, (7:0)
02h-04h	LBA	**Bit** **Description** 47:24 Reserved 23:8 0002h – Number of 512-byte data blocks requested 7:0 Number of ECC/RCR bytes, (15:8)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Table 72 defines the format of the data to be written to the SCT Data Transfer log for an SCT Read/Write Long command.

Table 72 — SCT Read/Write Long Format

Field	Size	Description
First Block		
User Data	512	This is the data normally sent or returned by a read or write command. This data may be encoded.
Second Block		
ECC/CRC Data	Vendor Specific	Error correction and detection bytes in vendor-specific format. The number of bytes is returned as status response data on both read and write operations.
Reserved	Remainder of block	All zeros

8.3.3 Write Same

The Write Same command provides the ability for the host to specify that the device shall write a specific pattern to its media.

The Write Same command shall cause the device to begin writing logical sectors from the first logical sector specified by the command in the Start field (see table 73) in incrementing order until the number of logical sectors specified by the command in the Count field (see table 73) have been written. If the Count field contains all zeros, then the device shall write all logical sectors beginning with the logical sector specified by the Start field through the last user LBA on the device. If the Host Protected Area feature set is implemented by and enabled on the device, then this feature set shall determine the last user LBA. This command shall not write over a hidden partition when hidden partitions are enabled using the Host Protected Area feature set. Automatic sector reassignment is permitted during the operation of this function.

If the Start field or the Start field plus the Count field specify an LBA greater than the last user LBA, then the device shall report an error and abort the command. If the Start field and the Count field contain zero, then the device shall write the specified pattern to all user logical blocks on the device.

Any new command other than an SCT status request, including IDENTIFY DEVICE, received by the device while this command is in progress shall terminate the Write Same command. The device shall process the new command.

While a background Write Same command is in progress, the SCT status error code shall be set to FFFFh. If the command completes without error, then the SCT status error code shall be set to 0000h. The SCT status error code shall be set to a value less than FFFFh and greater than 0000h if the command is terminated prematurely for any reason.

Once the key data block has been issued, if the Function Code was 0002h and the input data structure indicates that the drive is ready to receive data, the SCT Data Transfer log should be written to transfer the data.

For the Foreground SCT LBA Segment Access command with function code 0101h the Command Completion Status of the write to the SCT Command/Status log shall indicate the success or failure of the LBA Segment Access command. For the Foreground SCT LBA Segment Access command with function Code 0102h the Command Completion Status of the write to the SCT Data Transfer log shall indicate the success or failure of the LBA Segment Access command. The Status and Error fields indicate the relevant status/error values as defined in ATA/ATAPI-7 specification. In the case of an error an SCT Status Request may be made by reading the SCT Command/Status log to obtain a more detailed analysis of the error.

This command may change the Segment Initialized Flag. If the command writes all the user addressable sectors and completes without encountering an error or being aborted, then the Segment Initialized Flag (i.e., bit 0 of the Status Flags in the SCT status) shall be set to one. A write to any user addressable sector on the device, except one caused by another Write Same command with the Start field and the Count field set to zero (i.e., an Write Same command causing the device to write to all user logical blocks), shall cause the Segment Initialized Flag to be cleared. Reallocations as a result of reading data (foreground or background) shall not clear the Device Zeroed flag.

Table 73 defines the format of a Write Same command written to the SCT Command/Status log.

Table 73 — Write Same command

Word	Name	Value	Description
0	Action Code	0002h	This action writes a pattern or 512-byte data block repeatedly to the media.
1	Function Code	0001h	Repeat write pattern
		0002h	Repeat write data block
		0003h-0100h	Reserved
		0101h	Repeat write pattern foreground
		0102h	Repeat write data block foreground
		0103h-FFFFh	Reserved
2-5	Start	QWord	First LBA
6-9	Count	QWord	Number of logical sectors to fill
10-11	Pattern	DWord	If the Function Code is 0001h or 0003h, this field contains a 32-bit pattern that is written on the media starting at the location specified in words two through five.

Table 74 defines the format of the status response for a Write Same command.

Table 74 — Write Same command status response

Word	Name	Description
00h	Error	**Bit Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	Reserved
02h-04h	LBA	**Bit Description** 47:24 Reserved 23:8 0001h – Number of data blocks requested 7:0 Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9 5:1 N/A 0 Error - See 6.1.2

8.3.4 Error Recovery Control command

The Error Recovery Control command is used to set time limits for read and write error recovery. For non-queued commands, these timers apply to command completion at the host interface. For queued commands where in-order data delivery is enabled, these timers begin counting when the device begins to execute the command, not when the command is sent to the device. These timers do not apply to streaming commands or to queued commands when out-of-order data delivery is enabled. Time limits for error recovery may be used in a data redundant RAID environment where it is more desirable to have the device report a data error rather than risk having it being dropped from the RAID.

The typical usage for this command is when a device has its write cache function enabled. With write cache enabled, the device may not be able to report an error on a write command. This is because the write command with which a device is experiencing difficulty is one for which the device has reported status (i.e., considered by the host to be complete). This leaves no recourse for the device other than to reallocate any sectors with which it is experiencing difficulty.

Table 75 defines the format of an Error Recovery Control command written to the SCT Command/Status log.

Table 75 — Error Recovery Control command

Word	Name	Value	Description
0	Action Code	0003h	Set the read and write error recovery time
1	Function Code	0001h	Set New Value
		0002h	Return Current Value
2	Selection Code	0001h	Read Command Timer
		0002h	Write Command Timer
3	Recovery Time Limit		If the function code is 0001h then this field contains the recovery time limit in 100 ms units (i.e., a value of 1 = 100 ms, 2 = 200 ms, etc.). The tolerance is vendor specific.

The Read Command Timer sets an upper limit for the amount of time a device processes a read command. This limit is the amount of time the device shall process a read command in total but, in some cases, a read command requires more than one access to the media. The minimum value for the Read Command Timer is one. Setting this value to zero shall disable Read Command time-out, allowing the device to perform all available error recovery procedures without time limit.

If the Read Command Timer is going to expire while the device is performing error recovery, the device shall stop processing the command and report an uncorrectable ECC error for the LBA that was causing error recovery to be invoked prior to timer expiration. Extended status code 0015h shall be returned if the read command timer expires. The LBA may be recoverable given more time for error recovery. At this point the host may reconstruct the data for the failing LBA from the other devices in a RAID and issue a write command to the target LBA, allowing the device to attempt vendor specific error recovery on the suspect LBA.

The Write Command Timer sets the upper limit for the amount of time a device processes a write command. The minimum value for this command is one. Setting this value to zero shall disable Write Command time-out, allowing the device to perform all available error recovery procedures without a time limit.

The Write Command Timer has the effect of controlling how aggressively the device reallocates write data when encountering write errors. A large Write Command Timer value allows the device to use more available error recovery procedures for dealing with write errors. A small Write Command Timer value forces the device to attempt to reallocate sectors that may have otherwise been written without error. If the timer is about to expire, then the device should attempt to reallocate the data before the timer expires. Extended status code 0015h shall be returned if the write command timer expires. If the device is unable to complete data reallocation before the timer expires then the devices fails the command when the timer expires. When write cache is enabled the operation of the timer is vendor specific.

A host implementor should use the Write Command Timer with great caution as a very small timer value may cause a device to permanently reallocate good sectors as the result of temporary, external conditions (e.g., induced vibration).

Read and Write Command Timer values are set to default values at power-on but may be altered by an SCT command at any time. A device shall not change these settings while processing a hardware reset or a software reset.

Table 76 defines the format of the status response for a Error Recovery Control command.

Table 76 — Error Recovery Control command status response

Word	Name	Description
00h	Error	**Bit Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	If Function Code was 0002h, then this is the requested recovery limit (7:0). Otherwise, this field is Reserved.
02h-04h	LBA	**Bit Description** 47:8 Reserved 7:0 If the Function Code was 0002h, then this is the requested recovery limit (15:8). Otherwise, this field is Reserved.
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9 5:1 N/A 0 Error - See 6.1.2

8.3.5 Feature Control command

The Feature Control command is used to determine and set the state (i.e., enabled or disabled) of the features specified by the command.

Table 77 defines the format of a Feature Control command written to the SCT Command/Status log.

Table 77 — Feature Control command

Word	Name	Value	Description
0	Action Code	0004h	Set or return the state of device features defined in table 78
1	Function Code	0001h	Set state for a feature
		0002h	Return the current state of a feature
		0003h	Return feature option flags
2	Feature Code		See table 78 for definition of the Feature Code
3	State		Feature Code dependent value **Bit Description** 15:1 Reserved 0 If the function code is 0001h, setting bit 0 to one shall cause the requested feature state change to be preserved during all power and reset events. If the function code is 0001h, setting bit 0 to zero shall cause the requested feature state change to be volatile. A hard reset causes the device to revert to default, or last non-volatile setting.

Table 78 — Feature Code List

Feature Code	State Definition
0001h	If State is set to 0001h, then the SET FEATURES command shall determine the state of the write cache (see 7.48.4). If State is set to 0002h, then write cache shall be enabled. If State is set to 0003h, then write cache shall be disabled. If State is set to 0002h or 0003h, then write cache shall be set to the specified state, and any attempt to change the write cache settings using a SET FEATURES command shall not result in an error but shall not change the operational state of the write cache. In all cases, IDENTIFY DEVICE data word 85 bit 5 shall reflect the current operational state of write cache (i.e., if set to one, then volatile write cache is enabled, and if set to zero, then write cache is disabled. The default is State set to 0001h.
0002h	If State is set to 0001h, then volatile Write Cache Reordering shall be enabled (i.e., disk write scheduling may be reordered by the device). If State is set to 0002h, then volatile Write Cache Reordering shall be disabled, and disk write scheduling is executed on a first-in-first-out (FIFO) basis. If volatile write cache is disabled, then the current volatile Write Cache Reordering state is remembered but has no effect on non-cached writes, which are always written in the order received. The state of volatile Write Cache Reordering has no effect on queued commands. The default is State set to 0001h.
0003h	The value in State sets the time interval for temperature logging. State set to 0000h is invalid. State may be set to 0001h to FFFFh to specify the temperature logging interval in minutes This value applies to the Absolute HDA Temperature History queue. Issuing this command shall cause the queue to be reset and any prior values in the queues shall be lost. Queue Index shall be set to zero and the first queue location for shall be set to the current value. All remaining queue locations are set to 80h. The Sample Period, Max Op Limit, Over Limit, Min Op Limit and Under Limit values are preserved. The default is State set to 0001h.
0004h-0005h	Reserved for Serial ATA
0006h-CFFFh	Reserved
D000h-FFFFh	Vendor Specific

Table 79 defines the format of the status response for a Feature Control command.

Table 79 — Feature Control command status response

Word	Name	Description
00h	Error	**Bit Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	If the Function Code was set to 0002h this is the Feature State (7:0) If the Function Code was set to 0003h this is the Option Flags (7:0) Otherwise this field is reserved
02h-04h	LBA	**Bit Description** 47:8 Reserved 7:0 If the Function Code was set to 0002h this is the Feature State (15:8) If the Function Code was set to 0003h this is the Option Flags (15:8) Otherwise this field is Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9 5:1 N/A 0 Error - See 6.1.2

8.3.6 SCT Data Table command

The SCT Data Table command is used to read the specified data table.

Table 80 defines the format of an SCT Data Table command written to the SCT Command/Status log.

Table 80 — SCT Data Table command

Word	Name	Value	Description
0	Action Code	0005h	Read a data table
1	Function Code	0001h	Read Table
2	Table ID	Word	See Table 81 for a list of data tables

Table 81 — SCT Data Tables (by Table Identifier)

Table Id	Description
0000h	Invalid
0001h	Reserved
0002h	HDA Temperature History Table (in absolute degrees C). (See Table 82)
0003h-0004h	Reserved for Serial ATA
0003h-CFFFh	Reserved
D000h-FFFFh	Vendor Specific

Table 82 — Absolute HDA Temperature

Byte	Size	Field Name	Description
0-1	Word	Format Version	0002h - Data table format version
2-3	Word	Sampling Period	Absolute HDA Temperature sampling period in minutes. This is how often the device samples its temperature sensor. This period takes precedence over new read or write operations, but does not interrupt operations in process. The Sampling Period may be smaller that the timer interval between entries in the history queue. A value of 0000h in this field indicates that sampling is disabled.
4-5	Word	Interval	The timer interval between entries in the history queue. The default value of this field is vendor specific. This value should not be less than the Sampling Period.
6	Byte	Max Op Limit	Maximum recommended continuous operating temperature (see Note 3). This is a one byte two's complement number that allows a range from -127 °C to +127 °C to be indicated. 80h is an invalid value. This is a fixed value.
7	Byte	Over Limit	Maximum temperature limit. Operating the device above this temperature may cause physical damage to the device (see Note 3). This is a one-byte two's complement number that allows a range from -127 °C to +127 °C to be indicated. 80h is an invalid value. This is a fixed value.
8	Byte	Min Op Limit	Minimum recommended continuous operating limit (see Note 3). This is a one byte 2's complement number that allows a range from -127 °C to +127 °C to be indicated. 80h is an invalid value. This is a fixed value.

Table 82 — Absolute HDA Temperature

Byte	Size	Field Name	Description
9	Byte	Under Limit	Minimum temperature limit. Operating the device below this temperature may cause physical damage to the device (see Note 3). This is a one-byte two's complement number that allows a range from -127 °C to +127 °C to be indicated. 80h is an invalid value. This is a fixed value.
10-29	Byte [20]	reserved	
30-31	Word	CB Size	Number of entry locations in history buffer. This number shall be in the range of 128 to 478.
32-33	Word	CB Index	Last updated entry in buffer. CB Index is zero-based, so CB Index 0000h is the first location in the buffer (i.e., at offset 34). The most recent temperature entered in the buffer is at CB Index + 34 (see Note 1 and Note 2).
34 - (CB Size + 33)	Byte [CB Size]	CB	This is a circular buffer of absolute HDA Temperature values. Other device activities, such as data transfer, take priority over writing this data to non-volatile storage. These are one-byte two's complement numbers that allow a range from -127 °C to +127 °C to be indicated. A value of 80h indicates an initial value or a discontinuity in temperature recording. The time between samples may vary because commands shall not be interrupted. The sampling period is the minimum time between samples (see Note 1). If the host changes the logging interval using the volatile option, then the interval between entries in the queue may change between power cycles with no indication to the host.
(CB Size + 34) - 511	Byte [512 - CB Size - 34]	reserved	Shall be zero.

Note 1 - The Absolute HDA Temperature History is preserved during the processing of all power and reset events with the requirement that when the device powers up, a new entry is made in the history queue with a value of 80h (i.e., an invalid absolute temperature value). This allows an application viewing the history to see the discontinuity in temperature resulting from the device being turned off. If the device does not sample temperatures during a certain power state (e.g., Sleep or Standby), then a value of 80h is entered into the history queue to indicate that temperature sensing has resumed.

Note 2 - When the Absolute HDA Temperature history is cleared (e.g., for new devices or after changing the Logging Interval) the Queue Index shall be set to zero and the first queue location shall be set to the current Absolute HDA Temperature value. All remaining queue locations shall be set to 80h.

Note 3 - These values should take into account the accuracy of the temperature sensor. The placement, accuracy, and granularity of temperature sensors to support table 82 are vendor specific.

Table 83 defines the format of the status response for an SCT Data Table command.

Table 83 — Feature Control command status response

Word	Name	Description
00h	Error	**Bit Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	Reserved
02h-04h	LBA	**Bit Description** 47:24 Reserved 23:8 0001h – Number of data blocks requested 7:0 Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9 5:1 N/A 0 Error - See 6.1.2

9 Normal and Error Outputs

9.1 Overview

The commands listed in clause 7 each have sections labeled “Normal Outputs” and “Error Outputs”. Subclauses 9.2 and 9.3 document the return data format for all the commands described in clause 7. Each command in clause 7 may provide additional information about a normal or error output, but all the information that is referenced in clause 9 applies to the command as well.

9.2 Normal Outputs

The following tables document all the possible Normal Outputs a command returns.

Reference: 7.3

Table 84 — Extended Error Code

Word	Name	Description
00h	Error	Extended error code (see table 15)
01h	Count	Vendor Specific
02h	LBA	(MSB) Bits 27:0 are Vendor Specific. Bits 47:28 shall be cleared to zero. (LSB)
03h		
04h		
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Reference: 7.2

Table 85 — Error Bit Defined For Normal Output

Word	Name	Description
00h	Error	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.10.4, 7.10.2, 7.10.3, 7.10.5, 7.12, 7.14, 7.16, 7.17, 7.18, 7.19, 7.21.4, 7.20.11, 7.23, 7.24, 7.31, 7.35, 7.39, 7.41, 7.42, 7.43, 7.44, 7.45, 7.46, 7.48, 7.49.5, 7.49.4, 7.49.6, 7.49.3, 7.51, 7.52, 7.53.2, 7.53.3, 7.53.4, 7.53.6, 7.53.7, 7.53.9, 7.54, 7.55, 7.56, 7.58, 7.60, 7.61, 7.70, 7.73, 7.77

Table 86 — Generic Normal Output (No LBA Return Value)

Word	Name	Description
00h	Error	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.4, 7.5, 7.6

Table 87 — CFA Normal Output

Word	Name	Description
00h	Error	N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Reference: 7.7

Table 88 — Media Card Type Normal Output

Word	Name	Description
00h	Error	N/A
01h	Count	0055h
02h-04h	LBA	**Bit Description** 47:28 Reserved 27 Write Protect - shall be set to one if the device is write protected, Write Protect shall be cleared to zero if the device is not write protected. 26:24 **Media Type** **Value Description** 000b Reserved 001b SD Memory Card 010b MMC Card 011b SD-IO Card 100b Smart Media Card 101b-111b Reserved 23:8 Card specific Data 7:0 Shall be set to AAh
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9 5 Device Fault - See 6.1.3 4:1 N/A 0 Error - See 6.1.2

Reference: 7.8

Table 89 — Check Power Mode Normal Output

<table>
<tr><th>Word</th><th>Name</th><th>Description</th></tr>
<tr><td>00h</td><td>Error</td><td>N/A</td></tr>
<tr><td>01h</td><td>Count</td><td>Value Description
00h Device is in Standby mode.
40h Device is in NV Cache Power Mode and the spindle is spun down or spinning down.
41h device is in NV Cache Power Mode and the spindle is spun up or spinning up.
80h Device is in Idle mode.
FFh Device is in Active mode or Idle mode.</td></tr>
<tr><td>02h-04h</td><td>LBA</td><td>N/A</td></tr>
<tr><td rowspan="2">05h</td><td>Device</td><td>Bit Description
15 Obsolete
14 N/A
13 Obsolete
12 Transport Dependent - See 6.1.9
11:8 Reserved</td></tr>
<tr><td>Status</td><td>7:6 Transport Dependent - See 6.1.9.
5 Device Fault - See 6.1.3
4 N/A
3 Transport Dependent - See 6.1.9.
2:1 N/A
0 Error - See 6.1.2</td></tr>
</table>

Reference: 7.9

Table 90 — Configure Stream Normal

Word	Name	Description
00h	Error	Reserved
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Stream Error - See 6.1.8 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.37, 7.75

Table 91 — Stream Normal

Word	Name	Description
00h	Error	Reserved
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Stream Error - See 6.1.8 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.11, 7.13

Table 92 — Power-on, Device Reset and Execute Diagnostics

<table>
<tr><th>Word</th><th>Name</th><th>Description</th></tr>
<tr><td>00h</td><td>Error</td><td>Diagnostic Results - The diagnostic code as described in table 21 is returned.
This field shall be reserved for the DEVICE RESET command.</td></tr>
<tr><td>01h</td><td>Count</td><td rowspan="2"><table>
<tr><td>Bit</td><td>General</td><td>Packet</td><td>Reserved for SATA</td><td>Reserved for SATA</td><td>Reserved for CE-ATA</td><td rowspan="2">All other signatures reserved</td></tr>
<tr><td>7:0</td><td>01h</td><td>01h</td><td>01h</td><td>01h</td><td>Reserved for CE-ATA</td></tr>
<tr><td>47:24</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td></td></tr>
<tr><td>23:16</td><td>00h</td><td>14h</td><td>C3h</td><td>96h</td><td>AAh</td><td></td></tr>
<tr><td>15:8</td><td>00h</td><td>EBh</td><td>3Ch</td><td>69h</td><td>CEh</td><td></td></tr>
<tr><td>7:0</td><td>01h</td><td>01h</td><td>01h</td><td>01h</td><td>Reserved for CE-ATA</td><td></td></tr>
</table></td></tr>
<tr><td>02h-04h</td><td>LBA</td></tr>
<tr><td rowspan="2">05h</td><td>Device</td><td><table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>15</td><td>Obsolete</td></tr>
<tr><td>14</td><td>N/A</td></tr>
<tr><td>13</td><td>Obsolete</td></tr>
<tr><td>12</td><td>Transport Dependent - See 6.1.9</td></tr>
<tr><td>11:8</td><td>Reserved</td></tr>
</table></td></tr>
<tr><td>Status</td><td><table>
<tr><td>7:6</td><td>Transport Dependent - See 6.1.9.</td></tr>
<tr><td>5</td><td>Device Fault - See 6.1.3</td></tr>
<tr><td>4</td><td>N/A</td></tr>
<tr><td>3</td><td>Transport Dependent - See 6.1.9.</td></tr>
<tr><td>2:1</td><td>N/A</td></tr>
<tr><td>0</td><td>Error - See 6.1.2</td></tr>
</table></td></tr>
</table>

Reference: 7.19

Table 93 — IDLE Unload

Word	Name	Description
00h	Error	N/A
01h	Count	N/A
02h-04h	LBA	**Bit Description** 47:28 Reserved 27:8 N/A 7:0 C4h
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.22.6

Table 94 — ATAPI Normal Output

Word	Name	Description
00h	Error	N/A
01h	Interrupt Reason	**Bit** **Description** 7:3 Tag - See 6.3.5 2 Obsolete 1 Input/Output - See 6.3.2. 0 Command/Data - See 6.3.1. Shall be set to zero
02h-04h	LBA	**Bit** **Description** 47:28 Reserved 27:24 N/A 23:8 Byte Count 7:0 N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7 Transport Dependent - See 6.1.9. 6 N/A 5 Obsolete 4 Service - See 6.1.7. 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2. Shall be cleared to zero

Reference: 7.26.4, 7.64.4

Table 95 — Queued Normal Output

Word	Name	Description
00h	Error	N/A
01h	Interrupt Reason	**Bit** **Description** 7:3 Tag - See 6.3.5. 2 Release - See 6.3.4. 1 Input/Output - See 6.3.2. 0 Command/Data - See 6.3.1.
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7 Transport Dependent - See 6.1.9. 6 N/A 5 Device Fault - See 6.1.3 4 Service - See 6.1.7. 3 Transport Dependent - See 6.1.9 2:1 N/A 0 Error - See 6.1.2. Shall be cleared to zero

Reference: 7.33, 7.49.2

Table 96 — HPA Normal Output

Word	Name	Description
00h	Error	N/A
01h	Count	N/A
02h	LBA	(MSB)
03h		Max address
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Reference: 7.53.5

Table 97 — SMART Off-Line Immediate Normal Output

<table>
<tr><td>Word</td><td>Name</td><td>Description</td></tr>
<tr><td>00h</td><td>Error</td><td>N/A</td></tr>
<tr><td>01h</td><td>Count</td><td>N/A</td></tr>
<tr><td>02h-04h</td><td>LBA</td><td>Bit Description
47:24 Reserved
23:8
Value Description
C24Fh Subcommand specified a captive self-test that has executed without failure.
All Other Values the subcommand specified an off-line routine including an off-line self-test routine.
7:0 N/A</td></tr>
<tr><td>05h</td><td>Device</td><td>Bit Description
15 Obsolete
14 N/A
13 Obsolete
12 Transport Dependent - See 6.1.9
11:8 Reserved</td></tr>
<tr><td></td><td>Status</td><td>7:6 Transport Dependent - See 6.1.9.
5 Device Fault - See 6.1.3
4 N/A
3 Transport Dependent - See 6.1.9.
2 N/A
1 N/A
0 Error - See 6.1.2</td></tr>
</table>

Reference: 7.53.8

Table 98 — SMART Return Status Normal Output

Word	Name	Description
00h	Error	N/A
01h	Count	N/A
02h-04h	LBA	**Bit** **Description** 47:28 Reserved 27:24 N/A 23:8 **Value** **Description** C24Fh The device has not detected a threshold exceeded condition 2CF4h The device has detected a threshold exceeded condition 7:0 N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2 N/A 1 N/A 0 Error - See 6.1.2

Reference: 7.15, 7.20.5, 7.25, 7.29, 7.32, 7.36, 7.40, 7.62, 7.63, 7.68, 7.71, 7.72, 7.74

Table 99 — Generic Extended Normal Output

Word	Name	Description
00h	Error	Reserved
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.34, 7.50

Table 100 — SETMAX Extended Normal Output

Word	Name	Description
00h	Error	Reserved
01h	Count	Reserved
02h	LBA	(MSB)
03h		Max address
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Reference: 7.27.4, 7.65.4

Table 101 — Queued Extended Normal Output

Word	Name	Description
00h	Error	N/A
01h	Interrupt Reason	**Bit** **Description** 7:3 Tag - See 6.3.5. 2 Release - See 6.3.4. 1 Input/Output - See 6.3.2. 0 Command/Data - See 6.3.1.
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7 Transport Dependent - See 6.1.9. 6 N/A 5 Device Fault - See 6.1.3 4 Service - See 6.1.7. 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2. Shall be cleared to zero

Reference: 7.20.3, 7.20.9, 7.20.8, 7.20.7

Table 102 — NV Cache Normal Output

Word	Name	Description
00h	Error	Reserved
01h	Count	Reserved
02h-04h	LBA	Unpinned logical blocks remaining
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.20.4

Table 103 — NV Cache Flush Normal Output

Word	Name	Description
00h	Error	Reserved
01h	Count	Reserved
02h-04h	LBA	Number of unflushed logical blocks remaining
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.28.4, 7.67.4

Table 104 — NCQ Command Acceptance

Word	Name	Description
00h	Error	Shall be cleared to zero
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15:8 N/A
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.28.5, 7.67.5

Table 105 — NCQ Normal Outputs

Word	Name	Description
00h		Transport Dependent
01h	Error	**Bit** **Description** 15:8 Shall be cleared to zero
	Status	7 Shall be cleared to zero 6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Shall be cleared to zero. 2:1 N/A 0 Error - See 6.1.2
02h-03h	SActive	31:0 Transport dependent completion indicator
04h-05h		Reserved

9.3 Error Outputs

The following tables document all the possible Error Outputs a command returns. References to these tables are found in clause 7.

Reference: 7.2

Table 106 — CFA Erase Error Status

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4 3 N/A 2 Abort - See 6.2.1 1 N/A 0 Media Error - See 6.2.7
01h	Count	N/A
02h	LBA	(MSB) Address of first unrecoverable error Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4:1 N/A 0 Error - See 6.1.2

Reference: 7.5, 7.6

Table 107 — CFA Write Error Status

Word	Name	Description
00h	Error	Bit Description 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4 3 N/A 2 Abort - See 6.2.1 1 N/A 0 Media Error - See 6.2.7
01h	Count	N/A
02h	LBA	(MSB) Address of first unrecoverable error Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	Bit Description 7:6 Transport Dependent - See 6.1.9 5 Device Fault - See 6.1.3 4 Transport Dependent - See 6.1.9 3:1 N/A 0 Error - See 6.1.2

Reference: 7.3, 7.4, 7.8

Table 108 — CFA & Check Power Mode Abort Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:3 N/A 2 Abort - See 6.2.1 1:0 N/A
01h	Count	N/A
02h-4h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4:1 N/A 0 Error - See 6.1.2

Reference: 7.7, 7.10.4, 7.10.2, 7.10.3, 7.12, 7.17, 7.18, 7.19, 7.23, 7.41, 7.42, 7.43, 7.44, 7.45, 7.46, 7.48, 7.51, 7.52, 7.53.2, 7.53.3, 7.53.4, 7.53.8, 7.54, 7.55, 7.56, 7.58, 7.60, 7.77

Table 109 — Generic Abort

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6. 6:3 N/A 2 Abort - See 6.2.1. 1:0 N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.33, 7.49.4, 7.49.6, 7.49.3

Table 110 — Generic Abort w/o Device Fault

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6:3 N/A 2 Abort - See 6.2.1 1:0 N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Reference: 7.9

Table 111 — Configure Stream Error

Word	Name	Description
00h	Error	Bit Description 15:8 Reserved 7:3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	Bit Description 7:6 Transport Dependent - See 6.1.9. 5 Stream Error - See 6.1.8 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.14, 7.15

Table 112 — Flush Cache Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:3 N/A 2 Abort - See 6.2.1 1:0 N/A
01h	Count	Flush Cache - N/A Flush Cache Ext - Reserved.
02h-04h	LBA	(MSB) Address of first unrecoverable error (LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.24, 7.25

Table 113 — Read DMA Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9. 5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1:0 Obsolete
01h	Count	READ DMA - N/A READ DMA EXT - Reserved
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.29

Table 114 — Read Log Ext Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9. 5 N/A 4 ID Not Found - See 6.2.4 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.31, 7.35, 7.39

Table 115 — Read PIO Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9 5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1:0 Obsolete
01h	Count	N/A
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.37

Table 116 — Read Stream Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9. 5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1 Obsolete 0 Command Completion Time Limit Out - See 6.2.2
01h	Count	Length of Stream Error - number of contiguous logical sectors containing potentially bad data, beginning with the LBA of the first logical sector with an uncorrectable error.
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Stream Error - See 6.1.8. 4 Deferred Write Error - See 6.1.6. 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2.

Reference: 7.49.2, 7.49.5

Table 117 — HPA Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.53.9, 7.68

Table 118 — Write Log Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	SMART WRITE LOG - N/A WRITE LOG EXT - Reserved
02h-04h	LBA	SMART WRITE LOG - N/A WRITE LOG EXT - Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9 2:1 N/A 0 Error - See 6.1.2

Reference: 7.53.5

Table 119 — SMART Error

<table>
<tr><th>Word</th><th>Name</th><th>Description</th></tr>
<tr><td>00h</td><td>Error</td><td>Bit Description
15:8 Reserved
7:5 N/A
4 ID Not Found - See 6.2.4.
3 N/A
2 Abort - See 6.2.1.
1 N/A
0 Obsolete</td></tr>
<tr><td>01h</td><td>Count</td><td>Reserved</td></tr>
<tr><td>02h-04h</td><td>LBA</td><td>Bit Description
47:24 Reserved
23:8
Value Description
C24Fh Subcommand specified a captive self-test and some error other than a self-test routine failure occurred (i.e., if the sub-command is not supported or field values are invalid)
2CF4h the subcommand specified a captive self-test routine which has failed during execution.
All Other Values the subcommand specified an off-line routine including an off-line self-test routine.
7:0 N/A</td></tr>
<tr><td rowspan="2">05h</td><td>Device</td><td>Bit Description
15 Obsolete
14 N/A
13 Obsolete
12 Transport Dependent - See 6.1.9
11:8 Reserved</td></tr>
<tr><td>Status</td><td>Bit Description
7:6 Transport Dependent - See 6.1.9.
5 Device Fault - See 6.1.3
4 N/A
3 Transport Dependent - See 6.1.9.
2:1 N/A
0 Error - See 6.1.2</td></tr>
</table>

Reference: 7.62, 7.63, 7.71, 7.72, 7.74

Table 120 — Write Extended Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6:5 Obsolete. 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1. 1 Obsolete 0 N/A
01h	Count	Reserved
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.75

Table 121 — Write Stream Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6:5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1 Obsolete 0 Command Completion Time Limit Out - See 6.2.2
01h	Count	Length of Stream Error - number of contiguous logical sectors containing potentially bad data, beginning with the LBA of the first logical sector with an uncorrectable error.
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Stream Error - See 6.1.8. 4 Deferred Write Error - See 6.1.6. 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2.

Reference: 7.10.5

Table 122 — DCO Set Error (part 1 of 2)

Word	Name	Description
00h	Error	**Bit Description** 15:8 Reserved 7:3 N/A 2 Abort - See 6.2.1. Abort shall be set to one if a DEVICE CONFIGURATION SET command has already modified the original settings as reported by a DEVICE CONFIGURATION IDENTIFY command, if DEVICE CONFIGURATION FREEZE LOCK is set, if any of the bit modification restrictions described in 7.10.5.2 are violated, or if a Host Protected Area has been established by the execution of a SET MAX ADDRESS or SET MAX ADDRESS EXT command, or if an attempt was made to modify a mode or feature that shall not be modified with the device in its current state. 1:0 N/A
01h	Count	Vendor Specific
02h-04h	LBA	**Bit Description** 47:28 Reserved 27:24 N/A 23:16 Word location - If the command was aborted because an attempt was made to modify a bit that shall not be modified with the device in its current state, this field shall contain the offset of the first word encountered that the device shall not change. If an illegal maximum LBA is encountered, the offset of word 3 shall be entered. If a checksum error occurred, the value FFh shall be entered. A value of 00h indicates that the Data Structure Revision was invalid. 15:0 15:0 Bit Location - If the command was aborted because an attempt was made to disable a mode or feature that shall not be disabled with the device in its current state, this field shall contain an array of bits that correspond to the device configuration overlay data structure listed in Table 11 relative to the word indicated in Word Location (23:16). A one in this array indicates that the requested mode or feature shall not be disabled by the device. If not, the value shall be 0000h.

Table 122 — DCO Set Error (part 2 of 2)

Word	Name	Description
05h	Device	**Bit Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.21

Table 123 — NOP Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:3 N/A 2 Abort - See 6.2.1. 1:0 Obsolete
01h	Count	Initial Value
02h-04h	LBA	Initial Value
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.22

Table 124 — PACKET Command Error

Word	Name	Description
00h	Error	**Bit** **Description** 7:4 Sense Key - See 6.2.8 3 N/A 2 Abort - See 6.2.1 1 End of Media - See 6.2.3 0 Illegal Length Indicator - See 6.2.5
01h	Interrupt Reason	**Bit** **Description** 7:3 Tag - See 6.3.5 2 Release - See 6.3.4. Shall be cleared to zero 1 Input/Output - See 6.3.2. Shall be set to one 0 Command/Data - See 6.3.1. Shall be set to one
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 N/A 4 Service - See 6.1.7. 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2.

Reference: 7.26.5

Table 125 — Read DMA Queued Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9 5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1:0 Obsolete
01h	Interrupt Reason	**Bit** **Description** 7:3 Tag - See 6.3.5. If the device supports the TCQ feature set, this field shall contain the Tag of the command being released. 2 Release - See 6.3.4. Shall be cleared to zero 1 Input/Output - See 6.3.2. Shall be set to one 0 Command/Data - See 6.3.1. Shall be set to one
02h	LBA	(MSB) Address of first unrecoverable error. Bits 47:28 shall be cleared to zero.
03h		
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 Service - See 6.1.7 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.27

Table 126 — Read DMA Queued Extended Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9 5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1:0 Obsolete
01h	Interrupt Reason	**Bit** **Description** 15:8 Reserved 7:3 Tag - See 6.3.5. If the device supports the TCQ feature set, this field shall contain the Tag of the command being released. 2 Release - See 6.3.4. Shall be cleared to zero 1 Input/Output - See 6.3.2. Shall be set to one 0 Command/Data - See 6.3.1. Shall be set to one
02h	LBA	(MSB)
03h		Address of first unrecoverable error
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 Service - See 6.1.7 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference:, 7.53.6, 7.53.7

Table 127 — SMART Read Log/SMART Read Data Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9. 5 N/A 4 ID Not Found - See 6.2.4 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.32, 7.36, 7.40

Table 128 — Read PIO Extended Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6 Uncorrectable Error - See 6.2.9 5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1:0 Obsolete
01h	Count	Reserved
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.34

Table 129 — Read Native Max Extended Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6:3 N/A 2 Abort - See 6.2.1 1:0 N/A
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 Shall be set to one 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Reference: 7.50

Table 130 — SETMAX Extended Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:5 N/A 4 ID Not Found - See 6.2.4. 3 N/A 2 Abort - See 6.2.1. 1 N/A 0 Obsolete
01h	Count	Reserved
02h-04h	LBA	Reserved
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.61, 7.70, 7.73

Table 131 — Write Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6:5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1. 1 Obsolete 0 N/A
01h	Count	N/A
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.64, 7.65

Table 132 — Write DMA Queued Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6 6:5 Obsolete 4 ID Not Found - See 6.2.4 3 Obsolete 2 Abort - See 6.2.1 1:0 Obsolete
01h	Interrupt Reason	**Bit** **Description** 7:3 Tag - See 6.3.5. If the device supports the TCQ feature set, this field shall contain the Tag of the command being released. 2 Release - See 6.3.4. Shall be cleared to zero 1 Input/Output - See 6.3.2. Shall be set to one 0 Command/Data - See 6.3.1. Shall be set to one
02h	LBA	(MSB)
03h		Address of first unrecoverable error.
04h		(LSB)
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 Service - See 6.1.7 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.20.3

Table 133 — NV Cache Add Abort

Word	Name	Description
00h	Error	**Bit** **Description** 15:3 Reserved 2 Abort - See 6.2.1 1 Insufficient LBA Range Entries - See 6.2.12 0 Insufficient NV Cache space - See 6.2.11
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.20.9

Table 134 — NV Cache Remove Abort

Word	Name	Description
00h	Error	**Bit** **Description** 15:3 Reserved 2 Abort - See 6.2.1 1 Reserved 0 Attempted partial range removal from pinned set- See See 6.2.10
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.20.8, 7.20.7, 7.20.4, 7.20.5

Table 135 — Generic NV Cache Abort

Word	Name	Description
00h	Error	**Bit** **Description** 15:3 Reserved 2 Abort - See 6.2.1 1:0 Reserved
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15 Obsolete 14 N/A 13 Obsolete 12 Transport Dependent - See 6.1.9 11:8 Reserved
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5 Device Fault - See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.28.6, 7.67.6

Table 136 — NCQ Command Acceptance Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7 Interface CRC - See 6.2.6. 6:3 N/A 2 Abort - See 6.2.1. 1:0 N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15:8 N/A
	Status	7:6 Transport Dependent - See 6.1.9. 5 Device Fault – See 6.1.3 4 N/A 3 Transport Dependent - See 6.1.9. 2:1 N/A 0 Error - See 6.1.2

Reference: 7.67.6

Table 137 — NCQ Write Command Aborted Error

Word	Name	Bit	Description
00h			Transport Dependent
01h	Error	**Bit**	**Description**
		15	Interface CRC - See 6.2.6
		14:13	Obsolete
		12	ID Not Found - See 6.2.4
		11	Obsolete
		10	Abort - See 6.2.1
		9:8	Obsolete
	Status		
		7	Shall be cleared to zero
		6	Transport Dependent - See 6.1.9
		5	Device Fault – See 6.1.3
		4	N/A
		3	Shall be cleared to zero.
		2:1	N/A
		0	Error - See 6.1.2
02h-03h	SActive	31:0	Transport dependent completion indicator
04h-05h			Reserved

Reference: 7.28.6

Table 138 — NCQ Read Command Aborted Error

Word	Name	Description
00h		Transport Dependent
01h	Error	**Bit** **Description** 15 Interface CRC - See 6.2.6 14 Uncorrectable Error - See 6.2.9 13 Obsolete 12 ID Not Found - See 6.2.4 11 Obsolete 10 Abort - See 6.2.1 9:8 Obsolete
	Status	7 Shall be cleared to zero 6 Transport Dependent - See 6.1.9 5 Device Fault – See 6.1.3 4 N/A 3 Shall be cleared to zero. 2:1 N/A 0 Error - See 6.1.2
02h-03h	SActive	31:0 Transport dependent completion indicator
04h-05h		Reserved

Reference: 7.1.10

Table 139 — Unsupported Command Error

Word	Name	Description
00h	Error	**Bit** **Description** 15:8 Reserved 7:3 N/A 2 Abort - See 6.2.1 1:0 N/A
01h	Count	N/A
02h-04h	LBA	N/A
05h	Device	**Bit** **Description** 15:8 N/A
	Status	**Bit** **Description** 7:6 Transport Dependent - See 6.1.9. 5:1 N/A 0 Error - See 6.1.2

Annex A
(Normative)

Log Definitions

A.1 Overview

This Annex provides a comprehensive description of all standardized logs. Table A.1 is a summary of these logs.

There are 3 terms associated with logs: names, addresses and pages. The log name is a term that describes the data in the associated log. Each log name has an associated numeric value which is the log address. The log address is used by read and write log commands to access a specific log. Each log is composed of one or more pages. Log pages shall be 512 bytes of data. The SMART READ LOG command and the SMART WRITE LOG command always start sending their data from the first page and allow the host to specify the number of log pages to be returned. The GPL commands allow the host to specify the starting log page number as well as the number of log pages to be returned.

Table A.1 — Log address definition

Log Address	Log Name	Feature Set	R/W	Access
00h	Log directory, see A.2 and A.3	N/A	RO	GPL,SL
01h	Summary SMART Error Log, see A.15	SMART	RO	SL
02h	Comprehensive SMART Error Log, see A.4	SMART error logging	RO	SL
03h	Extended Comprehensive SMART Error Log, see A.7	SMART error logging	RO	GPL
04h	Device Statistics, see A.5	N/A	RO	GPL/SL
05h	Reserved			
06h	SMART Self-Test Log, see A.14	SMART self-test	RO	SL
07h	Extended SMART Self-Test Log, see A.8	SMART self-test	RO	GPL
08h	Reserved	N/A	Reserved	
09h	Selective Self-Test Log, see A.13	SMART Self-test	R/W	SL
0Ah-0Fh	Reserved	N/A	Reserved	
10h	NCQ Command Error, see A.10	NCQ	RO	GPL
11h	SATA Phy Event Counters, see A.12	N/A	RO	GPL
12h-17h	Reserved for Serial ATA	N/A	Reserved	
18h-1Fh	Reserved	N/A	Reserved	
20h	Obsolete			
21h	Write Stream Error Log, see A.16	Streaming	RO	GPL
22h	Read Stream Error Log, see A.11	Streaming	RO	GPL
23h	Obsolete			
24h-7Fh	Reserved	N/A	Reserved	
80h-9Fh	Host Vendor Specific, see A.9	SMART	R/W	GPL,SL
A0h-BFh	Device Vendor Specific, see A.6	SMART	VS	GPL,SL
C0h-EFh	Reserved	N/A	Reserved	
E0	SCT Command/Status, see 8.1	N/A	R/W	GPL,SL
E1h	SCT Data Transfer, see 8.1	N/A	R/W	GPL,SL
E2h-FFh	Reserved	N/A		

Key -

RO - Log is only read by the host.
R/W - Log is read or written by the host.
VS - Log is vendor specific thus read/write ability is vendor specific.
GPL - General Purpose Logging
SL - SMART Logging

Command Abort shall be returned if a GPL command is used to access a log that is marked only with SL.
Command Abort shall be returned if an SL command is used to access a log that is marked only with GPL.

A.2 General Purpose Log Directory (GPL Log Address 00h)

Table A.2 defines the 512 bytes that make up the General Purpose Log Directory.

Table A.2 — General Purpose Log Directory

Byte	Description
0-1	General Purpose Logging Version
2	Number of 512-byte blocks of data in the log at log address 01h (7:0)
3	Number of 512-byte blocks of data in the log at log address 01h (15:8)
4	Number of 512-byte blocks of data in the log at log address 02h (7:0)
5	Number of 512-byte blocks of data in the log at log address 02h (15:8)
…	
256	10h 512-byte blocks of data in the log at log address 80h
257	00h 512-byte blocks of data in the log at log address 80h
…	
510-511	Number of 512-byte blocks of data in the log at log address FFh

The value of the General Purpose Logging Version word shall be 0001h. A value of 0000h indicates that no General Purpose Log Directory exists.

A.3 SMART Log Directory (SMART Logging Log Address 00h)

Table A.3 defines the 512 bytes that make up the optional SMART Log Directory. The SMART Log Directory is defined as one log page.

Table A.3 — SMART Log Directory

Byte	Description
0-1	SMART Logging Version
2	Number of 512-byte blocks of data in the log at log address 1
3	Reserved
4	Number of 512-byte blocks of data in the log at log address 2
5	Reserved
…	…
510	Number of 512-byte blocks of data in the log at log address 255
511	Reserved

The value of the SMART Logging Version word shall be 01h if the drive supports multi-block SMART logs.

If the drive does not support multi-block SMART logs, then log address zero is defined as reserved.

A.4 Comprehensive SMART Error Log (Log Address 02h)

A.4.1 Overview

Table A.4 defines the format of each of the log pages that are part of the SMART comprehensive error log. The SMART Comprehensive error log provides logging for 28-bit addressing only. For 48-bit addressing, see A.7. The maximum size of the SMART comprehensive error log shall be 51 log pages. Devices may support fewer than 51 log pages. All multi-byte fields shown in this structure follow the byte ordering described in 3.2.8. The comprehensive error log data structures shall include UNC errors, IDNF errors for which the address requested was valid, servo errors, write fault errors, etc. Comprehensive SMART Error Log data structures shall not include errors attributed to the receipt of faulty commands such as command codes not supported by the device or requests with invalid parameters or invalid addresses.

Table A.4 — Comprehensive error log

Byte	First Log Page	Subsequent Log Pages
0	SMART error log version	Reserved
1	Error log index	Reserved
2-91	First error log data structure	Data structure 5n+1
92-181	Second error log data structure	Data structure 5n+2
182-271	Third error log data structure	Data structure 5n+3
272-361	Fourth error log data structure	Data structure 5n+4
362-451	Fifth error log data structure	Data structure 5n+5
452-453	Device error count	Reserved
454-510	Reserved	Reserved
511	Data structure checksum	Data structure checksum
n is the n^{th} log page within the log. The first log page is numbered zero.		

A.4.2 Error log version

The value of the error log version byte shall be set to 01h.

A.4.3 Error log index

The error log index indicates the error log data structure representing the most recent error. If there have been no error log entries, the error log index is set to zero. Valid values for the error log index are zero to 255.

A.4.4 Error log data structure

The error log is viewed as a circular buffer. The device may support from two to 51 error log blocks. When the last supported error log block has been filled, the next error shall create an error log data structure that replaces the first error log data structure in logical block zero. The next error after that shall create an error log data structure that replaces the second error log data structure in block zero. The sixth error after the log has filled shall replace the first error log data structure in block one, and so on.

The error log index indicates the most recent error log data structure. Unused error log data structures shall be filled with zeros.

The content of the error log data structure entries is defined in A.15.4.

A.4.5 Device error count

The device error count field is defined in A.15.5.

A.4.6 Data structure checksum

The data structure checksum is defined in A.4.6.

A.5 Device Statistics (Log Address 04h)

A.5.1 Overview

The optional Device Statistics log contains selected statistics about the device. This log shall be read-only, and shall only be accessed via the GPL feature set. This log is supported if there is a non-zero length for log address

04h in the General Purpose Log Directory. The format of the data is defined in table A.5. If the Device Statistics log is supported, only the 'Structure Version' field is required. Each statistic is composed of a 1-byte flag field and a value field. If the most significant bit of the flag field is set to one then the value field of that statistic is valid. Each statistic shall be a multiple of 8 bytes long. The number of log pages may be greater than one.

A.5.2 General Statistics (Page 0)

A.5.2.1 Overview

Device Statistics log page 0 contains general information about the drive as described in table A.5.

Table A.5 — General Statistics

Offset	Type	Content		
0-1	Word	Structure Version - Value = 0001h		
2-7	Byte			
8-15	Qword	Lifetime Power-On Resets		
			Bit	**Meaning**
			63	1 = Counter Supported, 0 = Counter not supported
			62:32	Reserved
			31:0	Number of times that the device has processed a Power-On Reset event
16-511	Byte	Reserved		

A.5.2.2 Lifetime Power-On Resets

A.5.2.2.1 Description

Lifetime Power-On Resets is a counter which records the number of times that the drive has processed a power-on reset.

A.5.2.2.2 Update Interval

Lifetime Power-On Resets is incremented by one after processing each Power-On Reset and the device is capable of recording this statistic.

A.5.2.2.3 Measurement Units

Lifetime Power-On Resets is incremented by one for each Power-On Reset event.

A.5.2.2.4 Initialization

Lifetime Power-On Resets shall be initialized to zero at the factory.

A.6 Device Vendor Specific Logs (Log Addresses A0h-BFh)

Support for device vendor specific logs is optional. Device vendor specific logs may be used by the device vendor to store any data and need only be implemented if used.

A.7 Extended Comprehensive SMART Error log (Log Address 03h)

A.7.1 Overview

Table A.6 defines the format of each of the log pages that define the Extended Comprehensive SMART error log. The maximum size of the Extended Comprehensive SMART error log is 16,383 log pages. Devices may support fewer than 16,383 log pages. All multi-byte fields shown in this structure follow the byte ordering described in 3.2.8. Error log data structures shall include Uncorrectable errors (See 6.2.9), ID Not Found errors (See 6.2.4) for which the address requested was valid, servo errors, write fault errors, etc. Error log data structures shall not include errors attributed to the receipt of faulty commands such as command codes not implemented by the device or requests with invalid parameters or invalid addresses.

All 28-bit entries contained in the Comprehensive SMART log, defined under section A.4, shall also be included in the Extended Comprehensive SMART error log with the 48-bit entries.

Table A.6 — Extended Comprehensive SMART error log

Byte	First Log Page	Subsequent Log Pages
0	SMART error log version	Reserved
1	Reserved	Reserved
2	Error log index (7:0)	Reserved
3	Error log index (15:8)	Reserved
4-127	First error log data structure	Data structure 4n+1
128-251	Second error log data structure	Data structure 4n+2
252-375	Third error log data structure	Data structure 4n+3
376-499	Fourth error log data structure	Data structure 4n+4
500-501	Device error count	Reserved
502-510	Reserved	Reserved
511	Data structure checksum	Data structure checksum
n is the logical log page number within the log. The first log page is numbered zero		

A.7.2 Error log version

The value of the SMART error log version byte shall be 01h.

A.7.3 Error log index

The error log index is the error log data structure number representing the most recent error. If there have been no error log entries, the error log index is cleared to zero. Valid values for the error log index are zero to 65,535.

A.7.4 Extended Error log data structure

A.7.4.1 Overview

The Extended Comprehensive SMART error log is viewed as a circular buffer. When the last supported error log has been filled, the next error shall create an error log data structure that replaces the first error log data structure in log page zero. The next error after that shall create an error log data structure that replaces the second error log data structure in log page zero. The fifth error after the log has filled shall replace the first error log data structure in log page one, and so on.

The error log index indicates the most recent error log data structure. Unused error log data structures shall be filled with zeros.

The content of the error log data structure entries is defined in Table A.7.

Table A.7 — Extended Error log data structure

Byte	Description
n - n+17	First command data structure
n+18 - n+35	Second command data structure
n+36 - n+53	Third command data structure
n+54 - n+71	Fourth command data structure
n+72 - n+89	Fifth command data structure
n+90 - n+123	Error data structure

A.7.4.2 Command data structure

The fifth command data structure shall contain the command or reset for which the error is being reported. The fourth command data structure should contain the command or reset that preceded the command or reset for which the error is being reported, the third command data structure should contain the command or reset preceding the one in the fourth command data structure, etc. If fewer than four commands and resets preceded the command or reset for which the error is being reported, the unused command data structures shall be zero filled, for example, if only three commands and resets preceded the command or reset for which the error is being reported, the first command data structure shall be zero filled. In some devices, the hardware implementation may preclude the device from reporting the commands that preceded the command for which the error is being reported or that preceded a reset. In this case, the command data structures are zero filled.

If the command data structure represents a command or software reset, the content of the command data structure shall be as shown in Table A.8. If the command data structure represents a hardware reset, the content of byte n shall be FFh, the content of bytes n+1 through n+13 are vendor specific, and the content of bytes n+14 through n+17 shall contain the timestamp.

Table A.8 — Command data structure

Byte	Description
n	Content of the Device Control field when the Command was initiated.
n+1	Content of the Feature field (7:0) when the Command was initiated.
n+2	Content of the Feature field (15:8) when the Command was initiated.
n+3	Content of the Count field (7:0) when the Command was initiated.
n+4	Content of the Count field (15:8) when the Command was initiated.
n+5	Content of the LBA field (31:24) when the Command was initiated.
n+6	Content of the LBA field (15:8) when the Command was initiated.
n+7	Content of the LBA field (39:32) when the Command was initiated.
n+8	Content of the LBA field (31:24) when the Command was initiated.
n+9	Content of the LBA field (23:16) when the Command was initiated.
n+10	Content of the LBA field (47:40) when the Command was initiated.
n+11	Content of the Device field when the Command was initiated.
n+12	Content written to the Command field when the command was initiated
n+13	Reserved
n+14	Timestamp (least significant byte)
n+15	Timestamp (next least significant byte)
n+16	Timestamp (next most significant byte)
n+17	Timestamp (most significant byte)

Timestamp shall be the time since power-on in milliseconds when command acceptance occurred. This timestamp may wrap around.

A.7.4.3 Error data structure

The error data structure shall contain the error description of the command for which an error was reported as described in Table A.9. If the error was logged for a hardware reset, the content of bytes n+1 through n+11 shall be vendor specific and the remaining bytes shall be as defined in Table A.9.

Table A.9 — Error data structure

Byte	Description
n	Transport specific value when the Command was initiated. See the appropriate transport standard, reference Device Control register.
n+1	Content of the Error field (7:0) after command completion occurred.
n+2	Content of the Count field (7:0) after command completion occurred.
n+3	Content of the Count field (15:8) after command completion occurred.
n+4	Content of the LBA field (7:0) after command completion occurred.
n+5	Content of the LBA field (15:8) after command completion occurred.
n+6	Content of the LBA field (23:16) after command completion occurred.
n+7	Content of the LBA field (31:24) after command completion occurred.
n+8	Content of the LBA field (39:32) after command completion occurred.
n+9	Content of the LBA field (47:40) after command completion occurred.
n+10	Content of the Device field after command completion occurred.
n+11	Content written to the Status field after command completion occurred.
n+12 through n+30	Extended error information
n+31	State
n+32	Life timestamp (least significant byte)
n+33	Life timestamp (most significant byte)

Extended error information shall be vendor specific.

State shall contain a value indicating the state of the device when the command was initiated or the reset occurred as described in Table A.10.

Table A.10 — State field values

Value	State
x0h	Unknown
x1h	Sleep
x2h	Standby
x3h	Active/Idle
x4h	Executing SMART off-line or self-test
x5h-xAh	Reserved
xBh-xFh	Vendor specific
The value of x is vendor specific and may be different for each state.	

Sleep indicates the reset for which the error is being reported was received when the device was in the Sleep mode.

Standby indicates the command or reset for which the error is being reported was received when the device was in the Standby mode.

Active/Idle indicates the command or reset for which the error is being reported was received when the device was in the Active or Idle mode.

Executing SMART off-line or self-test indicates the command or reset for which the error is being reported was received when the device was in the process of executing a SMART off-line or self-test.

Life timestamp shall contain the power-on lifetime of the device in hours when command completion occurred.

A.7.5 Device error count

The device error count field shall contain the total number of errors attributable to the device that have been reported by the device during the life of the device. These errors shall include Uncorrectable errors (See 6.2.9), ID Not Found errors (See 6.2.4) for which the address requested was valid, servo errors, write fault errors, etc. This count shall not include errors attributed to the receipt of faulty commands such as commands codes not implemented by the device or requests with invalid parameters or invalid addresses. If the maximum value for this field is reached, the count shall remain at the maximum value when additional errors are encountered and logged.

A.7.6 Data structure checksum

The data structure checksum is the two’s complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all 512 bytes shall be zero when the checksum is correct. The checksum is placed in byte 511.

A.8 Extended SMART Self-Test Log (Log Address 07h)

A.8.1 Overview

Table A.11 defines the format of each of the log pages that define the Extended SMART Self-test log. The maximum size of the self-test log is 3,449 log pages. Devices may support fewer than 3,449 log pages. All multi-byte fields shown in this structure follow the byte ordering described in 3.2.8.

The Extended SMART self-test log shall support 48-bit and 28-bit addressing. All 28-bit entries contained in the SMART self-test log, defined in A.14 shall also be included in the Extended SMART self-test log with all 48-bit entries.

Table A.11 — Extended Self-test log data structure

Byte	First Log Page	Subsequent Log Pages
0	Self-test log data structure revision number	Reserved
1	Reserved	Reserved
2	Self-test descriptor index (7:0)	Reserved
3	Self-test descriptor index (15:8)	Reserved
4-29	Descriptor entry 1	Descriptor entry 19n+1
30-55	Descriptor entry 2	Descriptor entry 19n+2
….	....	....
472-497	Descriptor entry 19	Descriptor entry 19n+19
498-499	Vendor specific	Vendor specific
500-510	Reserved	Reserved
511	Data structure checksum	Data structure checksum
n is the n^{th} log page within the log. The first log page is number zero		

This log is viewed as a circular buffer. When the last supported Self-test log has been filled, the next self-test shall create a descriptor that replaces descriptor entry 1 in log page 0. The next self-test after that shall create a descriptor that replaces descriptor entry 2 in log page 0, and so on. All unused self-test descriptors shall be filled with zeros.

A.8.2 Self-test descriptor index

The Self-test descriptor index indicates the most recent self-test descriptor. If there have been no self-tests, the Self-test descriptor index is set to zero. Valid values for the Self-test descriptor index are zero to 65,535.

A.8.3 Self-test log data structure revision number

The value of the self-test log data structure revision number shall be 01h.

A.8.4 Extended Self-test log descriptor entry

The content of the self-test descriptor entry is shown in Table A.12.

Table A.12 — Extended Self-test log descriptor entry

Byte	Description
n	Content of the LBA field (7:0)
n+1	Content of the self-test execution status byte.
n+2	Life timestamp (least significant byte).
n+3	Life timestamp (most significant byte).
n+4	Content of the self-test failure checkpoint byte.
n+5	Failing LBA (7:0).
n+6	Failing LBA (15:8).
n+7	Failing LBA (23:16).
n+8	Failing LBA (31:24).
n+9	Failing LBA (39:32).
n+10	Failing LBA (47:40).
n+11 - n+25	Vendor specific.

Content of the LBA field (7:0) shall be the content of the LBA field (7:0) when the nth self-test subcommand was issued (see 7.53.5.2).

Content of the self-test execution status byte shall be the content of the self-test execution status byte when the nth self-test was completed (see 7.53.6.4).

Life timestamp shall contain the power-on lifetime of the device in hours when the nth self-test subcommand was completed.

Content of the self-test failure checkpoint byte may contain additional information about the self-test that failed.

The failing LBA shall be the LBA of the logical sector that caused the test to fail. If the device encountered more than one failed logical sector during the test, this field shall indicate the LBA of the first failed logical sector encountered. If the test passed or the test failed for some reason other than a failed logical sector, the value of this field is undefined.

A.8.5 Data structure checksum

The data structure checksum is the two's complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all 512 bytes is zero when the checksum is correct. The checksum is placed in byte 511.

A.9 Host Vendor Specific Logs (Log Addresses 80h-9Fh)

The mandatory Host Vendor Specific logs shall each be defined as sixteen log pages. The content of the Host Vendor Specific logs shall be common to all log commands. This means that if the host places data in a Host

Vendor Specific page using SMART WRITE LOG, and then issues a READ LOG EXT to the same page, that the host receives the same data that was originally stored by SMART WRITE LOG.

These host vendor specific logs may be used by the host to store any data desired. If a host vendor specific log has never been written by the host, when read the content of the log shall be zeros.

A.10 NCQ Command Error (Log Address 10h)

A.10.1 Overview

Devices supporting the native queued capability shall support READ LOG EXT log address 10h (NCQ Command Error). the NCQ Command Error log is one page in length and is defined in table A.13.

Table A.13 — NCQ Command Error Log

Byte	7	6	5	4	3	2	1	0
0	NQ	Reserved		NCQ Tag				
1	Reserved							
2	Status							
3	Error							
4	LBA (7:0)							
5	LBA (15:8)							
6	LBA (23:16)							
7	Device							
8	LBA (31:24)							
9	LBA (39:32)							
10	LBA (47:40)							
11	Reserved							
12	Count (7:0)							
13	Count (15:8)							
14-255	Reserved							
256-510	Vendor Specific							
511	Checksum							

A.10.2 NCQ Tag

If the NQ bit is cleared, the NCQ Tag field contains the NCQ Tag corresponding to the NCQ command that failed.

A.10.3 NQ

If set indicates that the error condition was a result of a non-NCQ command having been issued and that the NCQ Tag field is therefore not valid. If cleared indicates that the NCQ Tag field is valid and that the error condition applies to a NCQ command.

A.10.4 Return Fields

The Status, Error, LBA and Count fields indicate the error that caused the device to stop processing NCQ commands.

> NOTE 21 — The value returned in the Error field of the NCQ Command Error log may be different than the value returned in the Error field of table nn when the initial error condition is signaled. The Error field in table nn is used for the purpose of signaling a queued command error, while the value in the Error field of the NCQ Command Error log provides specific information about the error condition.

A.10.5 Checksum

The data structure checksum is the 2's complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with 8-bit unsigned arithmetic and overflow shall be ignored. The sum of all 512 bytes of the data structure shall be zero.

A.11 Read Stream Error Log (Log Address 22h)

Table A.14 defines the format of the Read Stream Error log. Entries are placed into the Read Stream Error log only when the SE bit is set to one in the Status field. The 512 bytes returned shall contain a maximum of 31 error entries. The Read Stream Error Count shall contain the total number of Read Stream Errors detected since the last successful completion of the READ LOG EXT command with LBA field (7:0) set to 22h. This error count may be greater than 31, but only the most recent 31 errors are represented by entries in the log. If the Read Stream Error Count reaches its maximum value, after the next error is detected the Read Stream Error Count shall remain at the maximum value. During processing of a READ LOG EXT command with the LBA field (7:0) set to 22h, a device shall clear the Read Stream Error Log and clear the Error Log Index and Read Stream Error Count to zero. A device shall clear the content of the Read Stream Error Log during processing of a power-on reset or a hardware reset.

Table A.14 — Read Stream Error Log

Byte	Content
0	Structure Version
1	Error Log Index
2-3	Read Stream Error Log Count
4-15	Reserved
16-31	Read Stream Error Log Entry #1
32-47	Read Stream Error Log Entry #2
48-63	Read Stream Error Log Entry #3
64-511	Read Stream Error Log Entries #4 through #31

The Data Structure Version field shall contain a value of 02h indicating the second revision of the structure format.

The Read Stream Error Log Count field shall contain the number of uncorrected logical sector entries currently reportable to the host. This value may exceed 31.

The Error Log Index indicates the error log data structure representing the most recent error. Only values 1 through 31 are valid.

Table A.15 defines the format of each entry in the Read Stream Error Log.

Table A.15 — Error Log Entry

Byte	Value
0	Feature (7:0)
1	Feature (15:8)
2	Status
3	Error
4	LBA (7:0)
5	LBA (15:8)
6	LBA (23:16)
7	LBA (31:24)
8	LBA (39:32)
9	LBA (47:40)
10-11	Reserved
12	Count (7:0)
13	Count (15:8)
14	Reserved
15	Reserved

Byte (1:0) (Feature field) contains the contents of the Feature field when the error occurred. This value shall be set to 0FFFFh for a deferred write error.

Byte 2 (Status field) contains the contents of the Status field when the error occurred.

Byte 3 (Error field) contains the contents of the Error field when the error occurred.

Bytes (9:4) (LBA field) indicate the starting LBA of the error.

Bytes (13:12) (Count field) indicate the length of the error. Each entry may describe a range of logical sectors starting at the given address and spanning the specified number of logical sectors.

A.12 SATA Phy Event Counters

A.12.1 Overview

The SATA Phy Event Counters log is one log page (in length. The first Dword of the log page contains information that applies to the rest of the log page. Software should continue to process counters until a counter identifier with value 0h is found or the entire page has been read. A counter identifier with value 0h indicates that the log page contains no more counter values past that point. The SATA Phy Event Counters log is defined in table A.16.

Table A.16 — SATA Phy Event Counters Format

Byte	7	6	5	4	3	2	1	0
0-3	Reserved							
4 - 5	Counter 0 Identifier							
6 - (Counter 0 Length+5)	Counter 0 Value							
...	....							
n - (n+1)	Counter x Identifier							
(n+2) - (Counter x Length+n+1)	Counter x Value							
...	...							
508-510	Reserved							
511	Checksum							

There are two mechanisms by which the host explicitly causes the Phy counters to be reset. The first mechanism is to issue a BIST Activate FIS to the device. Upon reception of a BIST Activate FIS the device shall reset all Phy event counters to their reset value.

The second mechanism uses the READ LOG EXT command. When the device receives a command to read The SATA Phy Event Counters log and bit 0 in the Features register is set to one, the device shall return the current counter values for the command and then reset all Phy event counter values.

See ATA 2.6 for more information.

A.12.2 Counter x Identifier

Phy event counter identifier that corresponds to Counter n Value. Specifies the particular event counter that is being reported. The Identifier is 16 bits in length. Valid identifiers are listed in SATA 2.6.

A.12.3 Counter x Value

Value of the Phy event counter that corresponds to Counter x Identifier. The number of significant bits is determined by Counter n Identifier bits 14:12, see SATA 2.6 for more information. The length of Counter x Value shall always be a multiple of 16-bits. All counters are one-extended. For example, if a counter is only physically implemented as 8-bits when it reaches the maximum value of FFh, it shall be one-extended to FFFFh. The counter shall stop (and not wrap to zero) after reaching its maximum value.

A.12.4 Counter x Length

Size of the SATA Phy event counter as defined by bits 14:12 of Counter n Identifier. The size of the Phy event counter shall be a multiple of 16-bits.

A.12.5 Checksum

The data structure checksum is the 2’s complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic and overflow shall be ignored. The sum of all 512 bytes of the data structure is zero when the checksum is correct.

A.13 Selective Self-Test Log (Log Address 09h)

A.13.1 Overview

The Selective self-test log is a log that may be both written and read by the host. This log allows the host to select the parameters for the self-test and to monitor the progress of the self-test. Table A.17 defines the content of the Selective self-test log.

Table A.17 — Selective self-test log

Byte	Description	Read/Write
0-1	Data structure revision number	R/W
2-9	Starting LBA for test span 1	R/W
10-17	Ending LBA for test span 1	R/W
18-25	Starting LBA for test span 2	R/W
26-33	Ending LBA for test span 2	R/W
34-41	Starting LBA for test span 3	R/W
42-49	Ending LBA for test span 3	R/W
50-57	Starting LBA for test span 4	R/W
58-65	Ending LBA for test span 4	R/W
66-73	Starting LBA for test span 5	R/W
74-81	Ending LBA for test span 5	R/W
82-337	Reserved	Reserved
338-491	Vendor specific	Vendor specific
492-499	Current LBA under test	Read
500-501	Current span under test	Read
502-503	Feature flags	R/W
504-507	Vendor specific	Vendor specific
508-509	Selective self-test pending time	R/W
510	Reserved	Reserved
511	Data structure checksum	R/W

A.13.2 Data structure revision number

The value of the data structure revision number filed shall be 01h. This value shall be written by the host and returned unmodified by the device.

A.13.3 Test span definition

The Selective self-test log provides for the definition of up to five test spans. The starting LBA for each test span is the LBA of the first logical sector tested in the test span and the ending LBA for each test span is the last LBA tested in the test span. If the starting and ending LBA values for a test span are both zero, a test span is not defined and not tested. These values shall be written by the host and returned unmodified by the device.

A.13.4 Current LBA under test

The Current LBA under test field shall be written with a value of zero by the host. As the self-test progresses, the device shall modify this value to contain the beginning LBA of the 65,536 logical sector block currently being tested. When the self-test including the off-line scan between test spans has been completed, a zero value is placed in this field.

A.13.5 Current span under test

The Current span under test field shall be written with a value of zero by the host. As the self-test progresses, the device shall modify this value to contain the test span number of the current span being tested. If an off-line scan between test spans is selected, a value greater then five is placed in this field during the off-line scan. When the self-test including the off-line scan between test spans has been completed, a zero value is placed in this field.

A.13.6 Feature flags

The Feature flags define the features of Selective self-test to be executed (see table A.18).

Table A.18 — Selective self-test feature flags

Bit	Description
0	Vendor specific
1	When set to one, perform off-line scan after selective test.
2	Vendor specific
3	When set to one, off-line scan after selective test is pending.
4	When set to one, off-line scan after selective test is active.
5-15	Reserved.

Bit (1) shall be written by the host and returned unmodified by the device. Bits (4:3) shall be written as zeros by the host and the device shall modify them as the test progresses.

A.13.7 Selective self-test pending time

The selective self-test pending time is the time in minutes from power-on to the resumption of the off-line testing if the pending bit is set. At the expiration of this time, sets the active bit to one, and resumes the off-line scan that had begun before power-down.

A.13.8 Data structure checksum

The data structure checksum is defined in A.15.6.

A.14 SMART Self-Test Log (Log Address 06h)

A.14.1 Overview

Table A.19 defines the log page that make up the SMART self-test log. All multi-byte fields shown in this structure follow the byte ordering described in 3.2.8. The SMART Self-Test log supports 28-bit addressing only.

Table A.19 — Self-test log data structure

Byte	Description
0-1	Self-test log data structure revision number
2-25	First descriptor entry
26-49	Second descriptor entry
.....	....
482-505	Twenty-first descriptor entry
506-507	Vendor specific
508	Self-test index
509-510	Reserved
511	Data structure checksum

This log is viewed as a circular buffer. The first entry shall begin at byte 2, the second entry shall begin at byte 26, and so on until the twenty-second entry, that shall replace the first entry. Then, the twenty-third entry shall replace the second entry, and so on. If fewer than 21 self-tests have been performed by the device, the unused descriptor entries shall be filled with zeroes.

A.14.2 Self-test log data structure revision number

The value of the self-test log data structure revision number shall be 0001h.

A.14.3 Self-test log descriptor entry

The content of the self-test descriptor entry is shown in table A.20.

Table A.20 — Self-test log descriptor entry

Byte	Description
n	Content of the LBA field (7:0).
n+1	Content of the self-test execution status byte.
n+2	Life timestamp (least significant byte).
n+3	Life timestamp (most significant byte).
n+4	Content of the self-test failure checkpoint byte.
n+5	Failing LBA (7:0).
n+6	Failing LBA (15:8).
n+7	Failing LBA (23:16).
n+8	Failing LBA (27:24).
n+9 to n+23	Vendor specific.

Content of the LBA field (7:0) shall be the content of the LBA field (7:0) when the nth self-test subcommand was issued (see 7.53.5.2).

Content of the self-test execution status byte shall be the content of the self-test execution status byte when the nth self-test was completed (see 7.53.6.4).

Life timestamp shall contain the power-on lifetime of the device in hours when the nth self-test subcommand was completed.

Content of the self-test failure checkpoint byte may contain additional information about the self-test that failed.

The failing LBA shall be the LBA of the uncorrectable logical sector that caused the test to fail. If the device encountered more than one uncorrectable logical sector during the test, this field shall indicate the LBA of the first uncorrectable logical sector encountered. If the test passed or the test failed for some reason other than an uncorrectable logical sector, the value of this field is undefined.

A.14.4 Self-test index

The self-test index shall point to the most recent entry. Initially, when the log is empty, the index shall be set to zero. It shall be set to one when the first entry is made, two for the second entry, etc., until the 22nd entry, when the index shall be reset to one.

A.14.5 Data structure checksum

The data structure checksum is the two's complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all 512 bytes is zero when the checksum is correct. The checksum is placed in byte 511.

A.15 Summary SMART Error Log (Log Address 01h)

A.15.1 Overview

Table A.21 defines the log page that make up the SMART summary error log. All multi-byte fields shown in this structure follow the byte ordering described in 3.2.8. Summary SMART Error log data structures shall include UNC errors, IDNF errors for which the address requested was valid, servo errors, write fault errors, etc. Summary error log data structures shall not include errors attributed to the receipt of faulty commands such as command codes not implemented by the device or requests with invalid parameters or invalid addresses. If the device supports the Comprehensive SMART Error log, then the Summary SMART Error log duplicates the last five error entries in the Comprehensive SMART Error log. The Summary SMART Error log supports 28-bit addressing only.

Table A.21 — Summary SMART Error log

Byte	Description
0	SMART error log version
1	Error log index
2-91	First error log data structure
92-181	Second error log data structure
182-271	Third error log data structure
272-361	Fourth error log data structure
362-451	Fifth error log data structure
452-453	Device error count
454-510	Reserved
511	Data structure checksum

A.15.2 Error log version

The value of the Summary SMART Error log version byte shall be 01h.

A.15.3 Error log index

The error log index indicates the error log data structure representing the most recent error. Only values zero through five are valid. If there are no error log entries, the value of the error log index shall be zero.

A.15.4 Error log data structure

A.15.4.1 Overview

An error log data structure shall be presented for each of the last five errors reported by the device. These error log data structure entries are viewed as a circular buffer. That is, the first error shall create the first error log data structure; the second error, the second error log structure; etc. The sixth error shall create an error log data structure that replaces the first error log data structure; the seventh error replaces the second error log structure, etc. The error log pointer indicates the most recent error log structure. If fewer than five errors have occurred, the unused error log structure entries shall be zero filled. Table A.22 describes the content of a valid error log data structure.

Table A.22 — Error log data structure

Byte	Description
n - n+11	First command data structure
n+12 - n+23	Second command data structure
n+24 - n+35	Third command data structure
n+36 - n+47	Fourth command data structure
n+48 - n+59	Fifth command data structure
n+60 - n+89	Error data structure

A.15.4.2 Command data structure

The fifth command data structure shall contain the command or reset for which the error is being reported. The fourth command data structure should contain the command or reset that preceded the command or reset for which the error is being reported, the third command data structure should contain the command or reset preceding the one in the fourth command data structure, etc. If fewer than four commands and resets preceded the command or reset for which the error is being reported, the unused command data structures shall be zero filled, for example, if only three commands and resets preceded the command or reset for which the error is being reported, the first command data structure shall be zero filled. In some devices, the hardware implementation may preclude the device from reporting the commands that preceded the command for which the error is being reported or that preceded a reset. In this case, the command data structures are zero filled.

If the command data structure represents a command or software reset, the content of the command data structure shall be as shown in table A.23. If the command data structure represents a hardware reset, the content of byte n shall be FFh, the content of bytes n+1 through n+7 are vendor specific, and the content of bytes n+8 through n+11 shall contain the timestamp.

Table A.23 — Command data structure

Byte	Description
n	Transport specific value when the Command was initiated. See the appropriate transport standard, reference Device Control register.
n+1	Content of the Feature field when the Command was initiated.
n+2	Content of the Count field when the Command was initiated.
n+3	Content of the LBA field (7:0) when the Command was initiated.
n+4	Content of the LBA field (15:8) when the Command was initiated.
n+5	Content of the LBA field (23:16) when the Command was initiated.
n+6	Content of the Device field when the Command was initiated.
n+7	Content written when the Command was initiated
n+8	Timestamp (least significant byte)
n+9	Timestamp (next least significant byte)
n+10	Timestamp (next most significant byte)
n+11	Timestamp (most significant byte)

Timestamp shall be the time since power-on in milliseconds when command acceptance occurred. This timestamp may wrap around.

A.15.4.3 Error data structure

The error data structure shall contain the error description of the command for which an error was reported as described in Table A.23. If the error was logged for a hardware reset, the content of bytes n+1 through n+7 shall be vendor specific and the remaining bytes shall be as defined in table A.23.

Table A.24 — Error data structure

Byte	Description
n	Reserved
n+1	Content of the Error field after command completion occurred.
n+2	Content of the Count field after command completion occurred.
n+3	Content of the LBA field (7:0) after command completion occurred.
n+4	Content of the LBA field (15:8) after command completion occurred.
n+5	Content of the LBA field (23:16) after command completion occurred.
n+6	Content of the Device field after command completion occurred.
n+7	Content written to the Status field after command completion occurred.
n+8 - n+26	Extended error information
n+27	State
n+28	Life timestamp (least significant byte)
n+29	Life timestamp (most significant byte)

Extended error information shall be vendor specific.

State shall contain a value indicating the state of the device when command was initiated or the reset occurred as described in table A.25.

Table A.25 — State field values

Value	State
x0h	Unknown
x1h	Sleep
x2h	Standby
x3h	Active/Idle
x4h	Executing SMART off-line or self-test
x5h-xAh	Reserved
xBh-xFh	Vendor specific
The value of x is vendor specific and may be different for each state.	

Sleep indicates the reset for which the error is being reported was received when the device was in the Sleep mode.

Standby indicates the command or reset for which the error is being reported was received when the device was in the Standby mode.

Active/Idle indicates the command or reset for which the error is being reported was received when the device was in the Active or Idle mode.

Executing SMART off-line or self-test indicates the command or reset for which the error is being reported was received when the device was in the process of executing a SMART off-line or self-test.

Life timestamp shall contain the power-on lifetime of the device in hours when command completion occurred.

A.15.5 Device error count

The device error count field shall contain the total number of errors attributable to the device that have been reported by the device during the life of the device. These errors shall include UNC errors, IDNF errors for which the address requested was valid, servo errors, write fault errors, etc. This count shall not include errors attributed to the receipt of faulty commands such as commands codes not implemented by the device or requests with invalid parameters or invalid addresses. If the maximum value for this field is reached, the count shall remain at the maximum value when additional errors are encountered and logged.

A.15.6 Data structure checksum

The data structure checksum is the two's complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all 512 bytes shall be zero when the checksum is correct. The checksum is placed in byte 511.

A.16 Write Stream Error Log (Log Address 21h)

Table A.26 defines the format of the Write Stream Error log. Entries are placed into the Write Stream Error log only when the SE bit is set to one in the Status field. The log page shall contain a maximum of 31 error entries. The Write Stream Error Count shall contain the total number of Write Stream Errors detected since the last successful reading of the Write Stream Error log. This error count may be greater than 31, but only the most recent 31 errors are represented by entries in the log. If the Write Stream Error Count reaches its maximum value, after the next error is detected, the Write Stream Error Count shall remain at the maximum value. When the Write Stream Error log has been read by the host, the device shall clear the Write Stream Error Log and clear the Error Log Index and Write Stream Error Count to zero. A device shall clear the content of the Write Stream Error Log during processing of a power-on reset or a hardware reset.

Table A.26 — Write Stream Error Log

Byte	Content
0	Structure Version
1	Error Log Index
2-3	Write Stream Error Log Count
4-15	Reserved
5-7	Reserved
16-31	Write Stream Error Log Entry #1
32-47	Write Stream Error Log Entry #2
48-63	Write Stream Error Log Entry #3
64-511	Write Stream Error Log Entries #4 through #31

The Data Structure Version field shall contain a value of 02h indicating the second revision of the structure format.

The Write Stream Error Log Count field shall contain the number of WRITE STREAM command entries since the last power-on reset or hardware reset, or since this log was last read.

The Error Log Index indicates the error log data structure representing the most recent error. Only values 1 through 31 are valid.

Annex B

(Informative)

Command Set summary

The following four tables are provided to facilitate the understanding of the command set. Table B.1 provides information on which command codes are currently defined. Table B.2 provides a list of all of the commands in order of command code with the required use for each. Table B.3 provides a summary of all commands in alphabetical order with the required use for each. Table B.4 documents the assignment history of each opcode by ATA standard. Table B.5 documents the assignment history of each SET FEATURES code by ATA standard.

Table B.1 — Command Matrix

	x0	x1	x2	x3	x4	x5	x6	x7	x8	x9	xA	xB	xC	xD	xE	xF
0x	C	R	R	C	R	R	R	R	C	R	R	R	R	R	R	R
1x	O	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
2x	C	O	O	O	C	C	C	C	R	C	C	C	R	R	R	C
3x	C	O	O	O	C	C	C	C	C	C	C	C	O	C	C	C
4x	C	O	C	R	R	C*	R	C*	R	R	R	R	R	R	R	R
5x	O	C*	R	R	R	R	R	C*	R	R	R	R	C*	C*	C*	C*
6x	C*	C*	S	S	S	S	S	S	R	R	R	R	R	R	R	R
7x	O	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
8x	V	V	V	V	V	V	V	F	V	V	V	V	V	V	V	V
9x	C	O	C	R	E	E	E	E	E	E	V	R	R	R	R	R
Ax	C	C	C	R	R	R	R	R	R	R	R	R	R	R	R	R
Bx	C	C	R	R	R	R	C*	R	A	A	A	A	A	A	A	A
Cx	F	V	V	V	C	C	C	C	C	O	C	O	C	C	C	R
Dx	R	C	M	M	M	R	R	R	R	R	O*	E	E	E	O*	O*
Ex	C	C	C	C	C	C	C	C	C	E	C	R	C	O	O	C
Fx	V	C	C	C	C	C	C	V	C	C	V	V	V	V	V	V

Key:

C = defined command.
R = Reserved, undefined in current specifications.
V = Vendor specific commands.
O = Obsolete.
E = retired command.
F= If the device does not implement the CFA feature set, this command code is Vendor specific.
A= Reserved for assignment by the CompactFlash™ Association
M = Reserved for the Media Card Pass Through Command feature set.
S = Reserved for Serial ATA
* indicates that the entry in this table has changed from ATA/ATAPI-7, INCITS xxx-xxxx.

Table B.2 — Command codes (sorted by command code) (part 1 of 4)

Protocol	Command	General Feature Set	Packet Feature Set	Command Code
ND	NOP	O	M	00h
	Reserved			01h-02h
ND	CFA REQUEST EXTENDED ERROR	O	N	03h
	Reserved			04h-07h
DR	DEVICE RESET	N	M	08h
	Reserved			09h-0Fh
	Obsolete			10h
	Retired			11h-1Fh
PI	READ SECTOR(S)	M	M	20h
	Obsolete			21h-23h
PI	READ SECTOR(S) EXT	O	N	24h
DM	READ DMA EXT	O	N	25h
DMQ	READ DMA QUEUED EXT	O	N	26h
ND	READ NATIVE MAX ADDRESS EXT	O	N	27h
	Reserved			28h
PI	READ MULTIPLE EXT	O	N	29h
DM	READ STREAM DMA EXT	O	N	2Ah
PI	READ STREAM EXT	O	N	2Bh
	Reserved			2Ch-2Fh
PI	READ LOG EXT	O	O	2Fh
PO	WRITE SECTOR(S)	M	N	30h
	Obsolete			31h-33h
PO	WRITE SECTOR(S) EXT	O	N	34h
DM	WRITE DMA EXT	O	N	35h
DMQ	WRITE DMA QUEUED EXT	O	N	36h
ND	SET MAX ADDRESS EXT	O	N	37h
PO	CFA WRITE SECTORS WITHOUT ERASE	O	N	38h
PO	WRITE MULTIPLE EXT	O	N	39h
DM	WRITE STREAM DMA EXT	O	N	3Ah
PO	WRITE STREAM EXT	O	N	3Bh
	Obsolete			3Ch
DM	WRITE DMA FUA EXT	O	N	3Dh
DMQ	WRITE DMA QUEUED FUA EXT	O	N	3Eh
PO	WRITE LOG EXT	O	O	3Fh
ND	READ VERIFY SECTOR(S)	M	N	40h
	Obsolete			41h
ND	READ VERIFY SECTOR(S) EXT	O	N	42h
	Reserved			43h-44h
ND	WRITE UNCORRECTABLE EXT	O	N	45h
	Reserved			46h
DM	READ LOG DMA EXT	O	O	47h
	Reserved			48h-4Fh
	Obsolete			50h
ND	CONFIGURE STREAM	O	O	51H

Table B.2 — Command codes (sorted by command code) (part 2 of 4)

Protocol	Command	General Feature Set	Packet Feature Set	Command Code
	Reserved			52h-56h
DM	WRITE LOG DMA EXT	O	O	57h
	Reserved			58h-5Bh
	TRUSTED RECEIVE	O	P	5Ch
	TRUSTED RECEIVE DMA	O	P	5Dh
	TRUSTED SEND	O	P	5Eh
	TRUSTED SEND DMA	O	P	5Fh
DMQ	READ FPDMA QUEUED	O	N	60
DMQ	WRITE FPDMA QUEUED	O	N	61
	Reserved			62h-6Fh
	Obsolete			70h
	Retired			71h-7Fh
VS	Vendor Specific			80h-86h
PI	CFA TRANSLATE SECTOR	O	N	87h
VS	Vendor Specific			88h-8Fh
DD	EXECUTE DEVICE DIAGNOSTIC	M	M	90h
	Reserved			91h
PO	DOWNLOAD MICROCODE	O	N	92h
	Reserved			93h
	Retired			94h-99h
	Vendor Specific			9Ah
	Reserved			9Bh-9Fh
P	PACKET	N	M	A0h
PI	IDENTIFY PACKET DEVICE	N	M	A1h
P/DMQ	SERVICE	O	O	A2h
	Reserved			A3h-AFH
ND	SMART	O	N	B0h
ND	DEVICE CONFIGURATION OVERLAY	O	O	B1h
	Reserved			B2h-B5h
	NV Cache	O	N	B6h
	Reserved			B7h-BFh
ND	CFA ERASE SECTORS	F	N	C0h
VS	Vendor Specific			C1h-C3h
PI	READ MULTIPLE	M	N	C4h
PO	WRITE MULTIPLE	M	N	C5h
ND	SET MULTIPLE MODE	M	N	C6h
DMQ	READ DMA QUEUED	O	N	C7h
DM	READ DMA	M	N	C8h
	Obsolete			C9h
DM	WRITE DMA	M	N	CAh
	Obsolete			CBh
DMQ	WRITE DMA QUEUED	O	N	CCh
PO	CFA WRITE MULTIPLE WITHOUT ERASE	O	N	CDh
PO	WRITE MULTIPLE FUA EXT	O	N	CEh
	Reserved			CFh

Table B.2 — Command codes (sorted by command code) (part 3 of 4)

Protocol	Command	General Feature Set	Packet Feature Set	Command Code
	Reserved			D0h
ND	CHECK MEDIA CARD TYPE	O	N	D1h
	Reserved for the Media Card Pass through Command feature set			D2h
	Reserved for the Media Card Pass through Command feature set			D3h
	Reserved for the Media Card Pass through Command feature set			D4h
	Reserved			D5h-D9h
	Obsolete	O	O	DAh
	Retired			DBh-DDh
	Obsolete	O	N	DEh
	Obsolete	O	N	DFh
ND	STANDBY IMMEDIATE	M	M	E0h
ND	IDLE IMMEDIATE	M	M	E1h
ND	STANDBY	M	O	E2h
ND	IDLE	M	O	E3h
PI	READ BUFFER	O	N	E4h
ND	CHECK POWER MODE	M	M	E5h
ND	SLEEP	M	M	E6h
ND	FLUSH CACHE	M	O	E7h
PO	WRITE BUFFER	O	N	E8h
	Retired			E9h
ND	FLUSH CACHE EXT	O	N	EAh
	Reserved			EBh
PI	IDENTIFY DEVICE	M	M	ECh
	Obsolete	O	N	EDh
	Obsolete			EEh
ND	SET FEATURES	M	M	EFh
VS	Vendor Specific			F0h

Table B.2 — Command codes (sorted by command code) (part 4 of 4)

Protocol	Command	General Feature Set	Packet Feature Set	Command Code
PO	SECURITY SET PASSWORD	O	O	F1h
PO	SECURITY UNLOCK	O	O	F2h
ND	SECURITY ERASE PREPARE	O	O	F3h
PO	SECURITY ERASE UNIT	O	O	F4h
ND	SECURITY FREEZE LOCK	O	O	F5h
PO	SECURITY DISABLE PASSWORD	O	O	F6h
	Vendor Specific			F7h
ND	READ NATIVE MAX ADDRESS	O	O	F8h
ND	SET MAX ADDRESS	O	O	F9h
VS	Vendor Specific			FAh-FFh

Key:

ND = Non-data command
PI = PIO data-in command
PO = PIO data-out command
DM = DMA command
DMQ = DMA QUEUED command
DR = DEVICE RESET command
DD = EXECUTE DEVICE DIAGNOSTIC command
P = PACKET command
VS = Vendor specific

M = Mandatory
O = Optional
N = Use prohibited
V = Vendor specific implementation
E = Retired
B = Obsolete
R = Reserved
F = If the device does not implement the CFA feature set, this command code is Vendor specific.

Table B.3 — Command codes (sorted by command Name) (part 1 of 3)

Protocol	Command	General Feature Set	Packet Feature Set	Command Code
ND	CFA ERASE SECTORS	F	N	C0h
ND	CFA REQUEST EXTENDED ERROR	O	N	03h
PI	CFA TRANSLATE SECTOR	O	N	87h
PO	CFA WRITE MULTIPLE WITHOUT ERASE	O	N	CDh
PO	CFA WRITE SECTORS WITHOUT ERASE	O	N	38h
ND	CHECK MEDIA CARD TYPE	O	N	D1h
ND	CHECK POWER MODE	M	M	E5h
ND	CONFIGURE STREAM	O	O	51H
ND	DEVICE CONFIGURATION OVERLAY	O	O	B1h
DR	DEVICE RESET	N	M	08h
PO	DOWNLOAD MICROCODE	O	N	92h
DD	EXECUTE DEVICE DIAGNOSTIC	M	M	90h
ND	FLUSH CACHE	M	O	E7h
ND	FLUSH CACHE EXT	O	N	EAh
PI	IDENTIFY DEVICE	M	M	ECh
PI	IDENTIFY PACKET DEVICE	N	M	A1h
ND	IDLE	M	O	E3h
ND	IDLE IMMEDIATE	M	M	E1h
ND	NOP	O	M	00h
	NV Cache	O	N	B6h
	Obsolete	10h, 21h-23h, 31h-33h, 3C, 41h,50h, 70h, C9h, CBh, DAh, DEh-DFh, ED-EEh		
P	PACKET	N	M	A0h
PI	READ BUFFER	O	N	E4h
DM	READ DMA	M	N	C8h
DM	READ DMA EXT	O	N	25h
DMQ	READ DMA QUEUED	O	N	C7h
DMQ	READ DMA QUEUED EXT	O	N	26h
DMQ	READ FPDMA QUEUED	O	N	60
DM	READ LOG DMA EXT	O	O	47h
PI	READ LOG EXT	O	O	2Fh
PI	READ MULTIPLE	M	N	C4h
PI	READ MULTIPLE EXT	O	N	29h
ND	READ NATIVE MAX ADDRESS	O	O	F8h
ND	READ NATIVE MAX ADDRESS EXT	O	N	27h
PI	READ SECTOR(S)	M	M	20h
PI	READ SECTOR(S) EXT	O	N	24h
DM	READ STREAM DMA EXT	O	N	2Ah
PI	READ STREAM EXT	O	N	2Bh
ND	READ VERIFY SECTOR(S)	M	N	40h
ND	READ VERIFY SECTOR(S) EXT	O	N	42h

Table B.3 — Command codes (sorted by command Name) (part 2 of 3)

Protocol	Command	General Feature Set	Packet Feature Set	Command Code
	Reserved	01h-02h, 04h-07h, 09-0Fh, 28h, 2Ch-2Fh, 43h-44h, 46h, 48h-4Fh, 52h-56h, 58h-5Bh, 62h-6Fh, 91h, 93h, 9Bh-9Fh, A3h-AFh, B2h-B5h, B7h-BFh, CFh, D0h, D5h-D9h, EBh		
	Reserved for the Media Card Pass Through Command feature set	O	N	D2h-D4h
	Retired	11h-1Fh, 71F-7Fh, 94h-99h, DBh-DDh, E9h		
PO	SECURITY DISABLE PASSWORD	O	O	F6h
ND	SECURITY ERASE PREPARE	O	O	F3h
PO	SECURITY ERASE UNIT	O	O	F4h
ND	SECURITY FREEZE LOCK	O	O	F5h
PO	SECURITY SET PASSWORD	O	O	F1h
PO	SECURITY UNLOCK	O	O	F2h
P/DMQ	SERVICE	O	O	A2h
ND	SET FEATURES	M	M	EFh
ND	SET MAX ADDRESS	O	O	F9h
ND	SET MAX ADDRESS EXT	O	N	37h
ND	SET MULTIPLE MODE	M	N	C6h
ND	SLEEP	M	M	E6h
ND	SMART	O	N	B0h
ND	STANDBY	M	O	E2h
ND	STANDBY IMMEDIATE	M	M	E0h
	TRUSTED RECEIVE	O	P	5Ch
	TRUSTED RECEIVE DMA	O	P	5Dh
	TRUSTED SEND	O	P	5Eh
	TRUSTED SEND DMA	O	P	5Fh
VS	Vendor Specific	80h-86h, 88h-8Fh, 9Ah, C1h-C3h, F0h, F7h, FAh-FFh		
PO	WRITE BUFFER	O	N	E8h
DM	WRITE DMA	M	N	CAh
DM	WRITE DMA EXT	O	N	35h
DM	WRITE DMA FUA EXT	O	N	3Dh
DMQ	WRITE DMA QUEUED	O	N	CCh
DMQ	WRITE DMA QUEUED EXT	O	N	36h
DMQ	WRITE DMA QUEUED FUA EXT	O	N	3Eh
DMQ	WRITE FPDMA QUEUED	O	N	61
DM	WRITE LOG DMA EXT	O	O	57h
PO	WRITE LOG EXT	O	O	3Fh
PO	WRITE MULTIPLE	M	N	C5h
PO	WRITE MULTIPLE EXT	O	N	39h
PO	WRITE MULTIPLE FUA EXT	O	N	CEh
PO	WRITE SECTOR(S)	M	N	30h
PO	WRITE SECTOR(S) EXT	O	N	34h
DM	WRITE STREAM DMA EXT	O	N	3Ah

Table B.3 — Command codes (sorted by command Name) (part 3 of 3)

Protocol	Command	General Feature Set	Packet Feature Set	Command Code
PO	WRITE STREAM EXT	O	N	3Bh
ND	WRITE UNCORRECTABLE EXT	O	N	45h

Key:

ND = Non-data command
PI = PIO data-in command
PO = PIO data-out command
DM = DMA command
DMQ = DMA QUEUED command
DR = DEVICE RESET command
DD = EXECUTE DEVICE DIAGNOSTIC command
P = PACKET command
VS = Vendor specific

M = Mandatory
O = Optional
N = Use prohibited
V = Vendor specific implementation
E = Retired
B = Obsolete
R = Reserved
F = If the device does not implement the CFA feature set, this command code is Vendor specific.

Table B.4 — Historical Command Assignments (part 1 of 7)

Opcode	Command Name	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
00h	NO-OP	C	C	C	C	C	C	C	C
01h		R	R	R	R	R	R	R	R
02h		R	R	R	R	R	R	R	R
03h	CFA REQUEST EXTENDED ERROR	R	R	R	C	C	C	C	C
04h		R	R	R	R	R	R	R	R
05h		R	R	R	R	R	R	R	R
06h		R	R	R	R	R	R	R	R
07h		R	R	R	R	R	R	R	R
08h	ATAPI Soft Reset / DEVICE RESET	R	R	C	C	C	C	C	C
09h		R	R	R	R	R	R	R	R
0Ah		R	R	R	R	R	R	R	R
0Bh		R	R	R	R	R	R	R	R
0Ch		R	R	R	R	R	R	R	R
0Dh		R	R	R	R	R	R	R	R
0Eh		R	R	R	R	R	R	R	R
0Fh		R	R	R	R	R	R	R	R
10h	RECALIBRATE	C	C	C	O	O	O	O	O
11h	RECALIBRATE	C	C	O	E	E	E	E	E
12h	RECALIBRATE	C	C	O	E	E	E	E	E
13h	RECALIBRATE	C	C	O	E	E	E	E	E
14h	RECALIBRATE	C	C	O	E	E	E	E	E
15h	RECALIBRATE	C	C	O	E	E	E	E	E
16h	RECALIBRATE	C	C	O	E	E	E	E	E
17h	RECALIBRATE	C	C	O	E	E	E	E	E
18h	RECALIBRATE	C	C	O	E	E	E	E	E
19h	RECALIBRATE	C	C	O	E	E	E	E	E
1Ah	RECALIBRATE	C	C	O	E	E	E	E	E
1Bh	RECALIBRATE	C	C	O	E	E	E	E	E
1Ch	RECALIBRATE	C	C	O	E	E	E	E	E
1Dh	RECALIBRATE	C	C	O	E	E	E	E	E
1Eh	RECALIBRATE	C	C	O	E	E	E	E	E
1Fh	RECALIBRATE	C	C	O	E	E	E	E	E
20h	READ SECTORS	C	C	C	C	C	C	C	C
21h	READ SECTORS WITHOUT RETRY	C	C	C	C	O	O	O	O
22h	READ LONG	C	C	C	O	O	O	O	O
23h	READ LONG WITHOUT RETRY	C	C	C	O	O	O	O	O
24h	READ SECTORS EXT	R	R	R	R	R	C	C	C
25h	READ DMA EXT	R	R	R	R	R	C	C	C
26h	READ DMA QUEUED EXT	R	R	R	R	R	C	C	C
27h	READ NATIVE MAX ADDRESS EXT	R	R	R	R	R	C	C	C
28h		R	R	R	R	R	R	R	R

Table B.4 — Historical Command Assignments (part 2 of 7)

Opcode	Command Name	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
29h	READ MULTIPLE EXT	R	R	R	R	R	C	C	C
2Ah	READ STREAM DMA	R	R	R	R	R	R	C	C
2Bh	READ STREAM	R	R	R	R	R	R	C	C
2Ch		R	R	R	R	R	R	R	R
2Dh		R	R	R	R	R	R	R	R
2Eh		R	R	R	R	R	R	R	R
2Fh	READ LOG EXT	R	R	R	R	R	C	C	C
30h	WRITE SECTORS	C	C	C	C	C	C	C	C
31h	WRITE SECTORS WITHOUT RETRY	C	C	C	C	O	O	O	O
32h	WRITE LONG	C	C	C	O	O	O	O	O
33h	WRITE LONG WITHOUT RETRY	C	C	C	O	O	O	O	O
34h	WRITE SECTORS EXT	R	R	R	R	O	C	C	C
35h	WRITE DMA EXT	R	R	R	R	R	C	C	C
36h	WRITE DMA QUEUED EXT	R	R	R	R	R	C	C	C
37h	SET NATIVE MAX ADDRESS EXT	R	R	R	R	R	C	C	C
38h	CFA WRITE SECTORS WITHOUT ERASE	R	R	R	C	C	C	C	C
39h	WRITE MULTIPLE EXT	R	R	R	R	R	C	C	C
3Ah	WRITE STREAM DMA	R	R	R	R	R	R	C	C
3Bh	WRITE STREAM	R	R	R	R	R	R	C	C
3Ch	WRITE VERIFY	C	C	C	O	O	O	O	O
3Dh	WRITE DMA FUA EXT	R	R	R	R	R	R	C	C
3Eh	WRITE DMA QUEUED FUA EXT	R	R	R	R	R	R	C	C
3Fh	WRITE LOG EXT	R	R	R	R	R	C	C	C
40h	READ VERIFY SECTORS	C	C	C	C	C	C	C	C
41h	READ VERIFY SECTORS WITHOUT RETRY	C	C	C	C	O	O	O	O
42h	READ VERIFY SECTORS EXT	R	R	R	R	R	C	C	C
43h		R	R	R	R	R	R	R	R
44h		R	R	R	R	R	R	R	R
45h	WRITE UNCORRECTABLE EXT	R	R	R	R	R	R	R	C*
46h		R	R	R	R	R	R	R	R
47h	READ LOG DMA EXT	R	R	R	R	R	R	R	C*
48h		R	R	R	R	R	R	R	R
49h		R	R	R	R	R	R	R	R
4Ah		R	R	R	R	R	R	R	R
4Bh		R	R	R	R	R	R	R	R
4Ch		R	R	R	R	R	R	R	R
4Dh		R	R	R	R	R	R	R	R
4Eh		R	R	R	R	R	R	R	R
4Fh		R	R	R	R	R	R	R	R
50h	FORMAT TRACK	C	C	C	O	O	O	O	O
51h	CONFIGURE STREAM	R	R	R	R	R	R	C	C
52h		R	R	R	R	R	R	R	R
53h		R	R	R	R	R	R	R	R

Table B.4 — Historical Command Assignments (part 3 of 7)

Opcode	Command Name	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
54h		R	R	R	R	R	R	R	R
55h		R	R	R	R	R	R	R	R
56h		R	R	R	R	R	R	R	R
57h	WRITE LOG DMA EXT	R	R	R	R	R	R	R	C*
58h		R	R	R	R	R	R	R	R
59h		R	R	R	R	R	R	R	R
5Ah		R	R	R	R	R	R	R	R
5Bh		R	R	R	R	R	R	R	R
5Ch	TRUSTED RECEIVE	R	R	R	R	R	R	R	C*
5Dh	TRUSTED RECEIVE DMA	R	R	R	R	R	R	R	C*
5Eh	TRUSTED SEND	R	R	R	R	R	R	R	C*
5Fh	TRUSTED SEND DMA	R	R	R	R	R	R	R	C*
60h	READ FPDMA QUEUED	R	R	R	R	R	R	S	C*
61h	WRITE FPDMA QUEUED	R	R	R	R	R	R	S	C*
62h	SATA (reserved)	R	R	R	R	R	R	S	S
63h	SATA (reserved)	R	R	R	R	R	R	S	S
64h	SATA (reserved)	R	R	R	R	R	R	S	S
65h	SATA (reserved)	R	R	R	R	R	R	S	S
66h	SATA (reserved)	R	R	R	R	R	R	S	S
67h	SATA (reserved)	R	R	R	R	R	R	S	S
68h		R	R	R	R	R	R	S	S
69h		R	R	R	R	R	R	S	S
6Ah		R	R	R	R	R	R	S	S
6Bh		R	R	R	R	R	R	S	S
6Ch		R	R	R	R	R	R	S	S
6Dh		R	R	R	R	R	R	S	S
6Eh		R	R	R	R	R	R	S	S
6Fh		R	R	R	R	R	R	S	S
70h	SEEK	C	C	C	C	C	C	O	O
71h	SEEK	C	C	O	E	E	E	E	E
72h	SEEK	C	C	O	E	E	E	E	E
73h	SEEK	C	C	O	E	E	E	E	E
74h	SEEK	C	C	O	E	E	E	E	E
75h	SEEK	C	C	O	E	E	E	E	E
76h	SEEK	C	C	O	E	E	E	E	E
77h	SEEK	C	C	O	E	E	E	E	E
78h	SEEK	C	C	O	E	E	E	E	E
79h	SEEK	C	C	O	E	E	E	E	E
7Ah	SEEK	C	C	O	E	E	E	E	E
7Bh	SEEK	C	C	O	E	E	E	E	E
7Ch	SEEK	C	C	O	E	E	E	E	E
7Dh	SEEK	C	C	O	E	E	E	E	E
7Eh	SEEK	C	C	O	E	E	E	E	E
7Fh	SEEK	C	C	O	E	E	E	E	E
80h	(vendor specific)	V	V	V	V	V	V	V	V
81h	(vendor specific)	V	V	V	V	V	V	V	V

Table B.4 — Historical Command Assignments (part 4 of 7)

Opcode	Command Name	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
82h	(vendor specific)	V	V	V	V	V	V	V	V
83h	(vendor specific)	V	V	V	V	V	V	V	V
84h	(vendor specific)	V	V	V	V	V	V	V	V
85h	(vendor specific)	V	V	V	V	V	V	V	V
86h	(vendor specific)	V	V	V	V	V	V	V	V
87h	(vendor specific) / CFA TRANSLATE SECTOR	V	V	V	F	F	F	F	F
88h	(vendor specific)	V	V	V	V	V	V	V	V
89h	(vendor specific)	V	V	V	V	V	V	V	V
8Ah	(vendor specific)	V	V	V	V	V	V	V	V
8Bh	(vendor specific)	V	V	V	V	V	V	V	V
8Ch	(vendor specific)	V	V	V	V	V	V	V	V
8Dh	(vendor specific)	V	V	V	V	V	V	V	V
8Eh	(vendor specific)	V	V	V	V	V	V	V	V
8Fh	(vendor specific)	V	V	V	V	V	V	V	V
90h	EXECUTE DEVICE DIAGNOSTICS	C	C	C	C	C	C	C	C
91h	INITIALIZE DEVICE PARAMETERS	C	C	C	C	C	O	O	O
92h	DOWNLOAD MICROCODE	R	C	C	C	C	C	C	C
93h		R	R	R	R	R	R	R	R
94h	STANDBY IMMEDIATE	C	C	C	E	E	E	E	E
95h	IDLE IMMEDIATE	C	C	C	E	E	E	E	E
96h	STANDBY	C	C	C	E	E	E	E	E
97h	IDLE	C	C	C	E	E	E	E	E
98h	CHECK POWER MODE	C	C	C	E	E	E	E	E
99h	SLEEP	C	C	C	E	E	E	E	E
9Ah	(vendor specific)	V	V	V	V	V	V	V	V
9Bh		R	R	R	R	R	R	R	R
9Ch		R	R	R	R	R	R	R	R
9Dh		R	R	R	R	R	R	R	R
9Eh		R	R	R	R	R	R	R	R
9Fh		R	R	R	R	R	R	R	R
A0h	PACKET	R	R	C	C	C	C	C	C
A1h	IDENTIFY PACKET DEVICE	R	R	C	C	C	C	C	C
A2h	SERVICE	R	R	C	C	C	C	C	C
A3h		R	R	R	R	R	R	R	R
A4h		R	R	R	R	R	R	R	R
A5h		R	R	R	R	R	R	R	R
A6h		R	R	R	R	R	R	R	R
A7h		R	R	R	R	R	R	R	R
A8h		R	R	R	R	R	R	R	R
A9h		R	R	R	R	R	R	R	R
AAh		R	R	R	R	R	R	R	R
ABh		R	R	R	R	R	R	R	R
ACh		R	R	R	R	R	R	R	R
ADh		R	R	R	R	R	R	R	R

Table B.4 — Historical Command Assignments (part 5 of 7)

Opcode	Command Name	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
AEh		R	R	R	R	R	R	R	R
AFh		R	R	R	R	R	R	R	R
B0h	SMART	R	R	C	C	C	C	C	C
B1h	CFA DEVICE CONFIGURATION	R	R	R	R	R	C	C	C
B2h		R	R	R	R	R	R	R	R
B3h		R	R	R	R	R	R	R	R
B4h		R	R	R	R	R	R	R	R
B5h		R	R	R	R	R	R	R	R
B6h	NV CACHE	R	R	R	R	R	R	R	C*
B7h		R	R	R	R	R	R	R	R
B8h	CFA (reserved)	R	R	R	R	A	A	A	A
B9h	CFA (reserved)	R	R	R	R	A	A	A	A
BAh	CFA (reserved)	R	R	R	R	A	A	A	A
BBh	CFA (reserved)	R	R	R	R	A	A	A	A
BCh	CFA (reserved)	R	R	R	R	A	A	A	A
BDh	CFA (reserved)	R	R	R	R	A	A	A	A
BEh	CFA (reserved)	R	R	R	R	A	A	A	A
BFh	CFA (reserved)	R	R	R	R	A	A	A	A
C0h	(vendor specific) / CFA ERASE SECTORS	V	V	V	F	F	F	F	F
C1h	(vendor specific)	V	V	V	V	V	V	V	V
C2h	(vendor specific)	V	V	V	V	V	V	V	V
C3h	(vendor specific)	V	V	V	V	V	V	V	V
C4h	READ MULTIPLE	C	C	C	C	C	C	C	C
C5h	WRITE MULTIPLE	C	C	C	C	C	C	C	C
C6h	SET MULTIPLE MODE	C	C	C	C	C	C	C	C
C7h	READ DMA QUEUED	R	R	R	C	C	C	C	C
C8h	READ DMA	C	C	C	C	C	C	C	C
C9h	READ DMA WITHOUT RETRIES	C	C	C	C	O	O	O	O
CAh	WRITE DMA	C	C	C	C	C	C	C	C
CBh	WRITE DMA WITHOUT RETRIES	C	C	C	C	O	O	O	O
CCh	WRITE DMA QUEUED	R	R	R	C	C	C	C	C
CDh	CFA WRITE MULTIPLE WITHOUT ERASE	R	R	R	C	C	C	C	C
CEh	WRITE MULTIPLE FUA EXT	R	R	R	R	R	R	C	C
CFh		R	R	R	R	R	R	R	R
D0h		R	R	R	R	R	R	R	R
D1h	CHECK MEDIA CARD TYPE	R	R	R	R	R	C	C	C
D2h	Reserved for the Media Card Pass through Command feature set	R	R	R	R	R	M	M	M
D3h	Reserved for the Media Card Pass through Command feature set	R	R	R	R	R	M	M	M
D4h	Reserved for the Media Card Pass through Command feature set	R	R	R	R	R	M	M	M
D5h		R	R	R	R	R	R	R	R
D6h		R	R	R	R	R	R	R	R
D7h		R	R	R	R	R	R	R	R

Table B.4 — Historical Command Assignments (part 6 of 7)

Opcode	Command Name	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
D8h		R	R	R	R	R	R	R	R
D9h		R	R	R	R	R	R	R	R
DAh	GET MEDIA STATUS	R	R	R	C	C	C	C	O*
DBh	ACKNOWLEDGE MEDIA CHANGE	C	C	O	E	E	E	E	E
DCh	BOOT POST BOOT	C	C	O	E	E	E	E	E
DDh	BOOT PRE BOOT	C	C	O	E	E	E	E	E
DEh	MEDIA LOCK	C	C	C	C	C	C	C	O*
DFh	MEDIA UNLOCK	C	C	C	C	C	C	C	O*
E0h	STANDBY IMMEDIATE	C	C	C	C	C	C	C	C
E1h	IDLE IMMEDIATE	C	C	C	C	C	C	C	C
E2h	STANDBY	C	C	C	C	C	C	C	C
E3h	IDLE	C	C	C	C	C	C	C	C
E4h	READ BUFFER	C	C	C	C	C	C	C	C
E5h	CHECK POWER MODE	C	C	C	C	C	C	C	C
E6h	SLEEP	C	C	C	C	C	C	C	C
E7h	FLUSH CACHE	R	R	R	C	C	C	C	C
E8h	WRITE BUFFER	C	C	C	C	C	C	C	C
E9h	WRITE SAME	C	C	O	E	E	E	E	E
EAh	FLUSH CACHE EXT	R	R	R	R	R	C	C	C
EBh		R	R	R	R	R	R	R	R
ECh	IDENTIFY DEVICE	C	C	C	C	C	C	C	C
EDh	MEDIA EJECT	R	C	C	C	C	C	C	O
EEh	IDENTIFY DEVICE DMA	R	R	C	O	O	O	O	O
EFh	SET FEATURES	C	C	C	C	C	C	C	C
F0h	(vendor specific)	V	V	V	V	V	V	V	V
F1h	SECURITY SET PASSWORD	V	V	C	C	C	C	C	C
F2h	SECURITY UNLOCK	V	V	C	C	C	C	C	C
F3h	SECURITY ERASE PREPARE	V	V	C	C	C	C	C	C
F4h	SECURITY ERASE UNIT	V	V	C	C	C	C	C	C
F5h	SECURITY FREEZE LOCK	V	V	C	C	C	C	C	C
F6h	SECURITY DISABLE PASSWORD	V	V	C	C	C	C	C	C
F7h	(vendor specific)	V	V	V	V	V	V	V	V
F8h	READ NATIVE MAX ADDRESS	V	V	V	C	C	C	C	C
F9h	SET MAX ADDRESS	V	V	V	C	C	C	C	C
FAh	(vendor specific)	V	V	V	V	V	V	V	V
FBh	(vendor specific)	V	V	V	V	V	V	V	V

Table B.4 — Historical Command Assignments (part 7 of 7)

Opcode	Command Name	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
FCh	(vendor specific)	V	V	V	V	V	V	V	V
FDh	(vendor specific)	V	V	V	V	V	V	V	V
FEh	(vendor specific)	V	V	V	V	V	V	V	V
FFh	(vendor specific)	V	V	V	V	V	V	V	V

Key:
C = a defined command.
E = a retired command.
O = Obsolete.
R = Reserved, undefined in current specifications.
V = Vendor specific commands.
A = Reserved for assignment by the CompactFlash Association
F = If the device does not implement the CFA feature set, this command code is Vendor specific.
M = Reserved for the Media Card Pass Through Command feature set.
S = Reserved for Serial ATA
*Indicates this definition is new to ATA8

Table B.5 — Historical SET FEATURE Code Assignments (part 1 of 7)

Feature Code	Description	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
01h	Enable 8-bit data transfers	C	C	O	E	F	F	F	F
02h	Enable write cache	V	V	C	C	C	C	C	C
03h	Set transfer mode based on value in the count field	C	C	C	C	C	C	C	C
04h	Enable all automatic defect reassignment	R	R	C	O	O	O	O	O
05h	Enable advanced power management	R	R	R	C	C	C	C	C
06h	Enable Power-Up in Standby feature set	R	R	R	R	C	C	C	C
07h	Power-up in Standby feature set device spin-up	R	R	R	R	C	C	C	C
09h	Reserved for Address offset reserved boot area method technical report	R	R	R	R	C	C	C	C
0Ah	Enable CFA power mode 1	R	R	R	R	C	C	C	C
0Bh	Reserved	R	R	R	R	R	R	R	R
0Ch	Reserved	R	R	R	R	R	R	R	R
0Dh	Reserved	R	R	R	R	R	R	R	R
0Eh	Reserved	R	R	R	R	R	R	R	R
0Fh	Reserved	R	R	R	R	R	R	R	R
10h	Enable use of SATA feature	R	R	R	R	R	R	S	C
11h	Reserved	R	R	R	R	R	R	R	R
12h	Reserved	R	R	R	R	R	R	R	R
13h	Reserved	R	R	R	R	R	R	R	R
14h	Reserved	R	R	R	R	R	R	R	R
15h	Reserved	R	R	R	R	R	R	R	R
16h	Reserved	R	R	R	R	R	R	R	R
17h	Reserved	R	R	R	R	R	R	R	R
18h	Reserved	R	R	R	R	R	R	R	R
19h	Reserved	R	R	R	R	R	R	R	R
1Ah	Reserved	R	R	R	R	R	R	R	R

Table B.5 — Historical SET FEATURE Code Assignments (part 2 of 7)

Feature Code	Description	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
1Bh	Reserved	R	R	R	R	R	R	R	R
1Ch	Reserved	R	R	R	R	R	R	R	R
1Dh	Reserved	R	R	R	R	R	R	R	R
1Eh	Reserved	R	R	R	R	R	R	R	R
1Fh	Reserved	R	R	R	R	R	R	R	R
20h	Reserved for Technical Report (T13/DT1696)	R	R	R	R	R	R	T	T
21h	Reserved for Technical Report (T13/DT1696)	R	R	R	R	R	R	T	T
22h	Reserved	R	R	R	R	R	R	R	R
23h	Reserved	R	R	R	R	R	R	R	R
24h	Reserved	R	R	R	R	R	R	R	R
25h	Reserved	R	R	R	R	R	R	R	R
26h	Reserved	R	R	R	R	R	R	R	R
27h	Reserved	R	R	R	R	R	R	R	R
28h	Reserved	R	R	R	R	R	R	R	R
29h	Reserved	R	R	R	R	R	R	R	R
2Ah	Reserved	R	R	R	R	R	R	R	R
2Bh	Reserved	R	R	R	R	R	R	R	R
2Ch	Reserved	R	R	R	R	R	R	R	R
2Dh	Reserved	R	R	R	R	R	R	R	R
2Eh	Reserved	R	R	R	R	R	R	R	R
2Fh	Reserved	R	R	R	R	R	R	R	R
30h	Reserved	R	R	R	R	R	R	R	R
31h	Disable Media Status Notification	R	R	R	C	C	C	C	O
32h	Reserved	R	R	R	R	R	R	R	R
33h	Disable retry	V	V	C	C	O	O	O	O
34h	Reserved	R	R	R	R	R	R	R	R
35h	Reserved	R	R	R	R	R	R	R	R
36h	Reserved	R	R	R	R	R	R	R	R
37h	Reserved	R	R	R	R	R	R	R	R
38h	Reserved	R	R	R	R	R	R	R	R
39h	Reserved	R	R	R	R	R	R	R	R
3Ah	Reserved	R	R	R	R	R	R	R	R
3Bh	Reserved	R	R	R	R	R	R	R	R
3Ch	Reserved	R	R	R	R	R	R	R	R
3Dh	Reserved	R	R	R	R	R	R	R	R
3Eh	Reserved	R	R	R	R	R	R	R	R
3Fh	Reserved	R	R	R	R	R	R	R	R
40h	Reserved	R	R	R	R	R	R	R	R
41h	Enabled Free-fall Control feature set	R*	R*	R*	R*	R*	R*	R*	C*
42h	Enable Automatic Acoustic Management feature set	R	R	R	R	R	R	C	C

Table B.5 — Historical SET FEATURE Code Assignments (part 3 of 7)

Feature Code	Description	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
43h	Set Maximum Host Interface Sector Times	R	R	R	R	R	R	C	C
44h	Vendor specific length of ECC on read long/write long commands	C	C	C	O	O	O	O	O
45h	Reserved	R	R	R	R	R	R	R	R
46h	Reserved	R	R	R	R	R	R	R	R
47h	Reserved	R	R	R	R	R	R	R	R
48h	Reserved	R	R	R	R	R	R	R	R
49h	Reserved	R	R	R	R	R	R	R	R
4Ah	Reserved	R	R	R	R	R	R	R	R
4Bh	Reserved	R	R	R	R	R	R	R	R
4Ch	Reserved	R	R	R	R	R	R	R	R
4Dh	Reserved	R	R	R	R	R	R	R	R
4Eh	Reserved	R	R	R	R	R	R	R	R
4Fh	Reserved	R	R	R	R	R	R	R	R
50h	Reserved	R	R	R	R	R	R	R	R
51h	Reserved	R	R	R	R	R	R	R	R
52h	Reserved	R	R	R	R	R	R	R	R
53h	Reserved	R	R	R	R	R	R	R	R
54h	Set cache segments to the count field value	V	V	C	O	O	O	O	O
55h	Disable read look-ahead feature	C	C	C	C	C	C	C	C
56h	Reserved	R	R	R	R	R	R	R	R
57h	Reserved	R	R	R	R	R	R	R	R
58h	Reserved	R	R	R	R	R	R	R	R
59h	Reserved	R	R	R	R	R	R	R	R
5Ah	Reserved	R	R	R	R	R	R	R	R
5Bh	Reserved	R	R	R	R	R	R	R	R
5Ch	Reserved	R	R	R	R	R	R	R	R
5Dh	Enable release interrupt	R	R	R	C	C	C	C	C
5Eh	Enable SERVICE interrupt	R	R	R	C	C	C	C	C
5Fh	Reserved	R	R	R	R	R	R	R	R
60h	Reserved	R	R	R	R	R	R	R	R
61h	Reserved	R	R	R	R	R	R	R	R
62h	Reserved	R	R	R	R	R	R	R	R
63h	Reserved	R	R	R	R	R	R	R	R
64h	Reserved	R	R	R	R	R	R	R	R
65h	Reserved	R	R	R	R	R	R	R	R
66h	Disable reverting to power on defaults	C	C	C	C	C	C	C	C
67h	Reserved	R	R	R	R	R	R	R	R
68h	Reserved	R	R	R	R	R	R	R	R
69h	Reserved	R	R	R	R	R	R	R	R
6Ah	Reserved	R	R	R	R	R	R	R	R

Table B.5 — Historical SET FEATURE Code Assignments (part 4 of 7)

Feature Code	Description	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
6Bh	Reserved	R	R	R	R	R	R	R	R
6Ch	Reserved	R	R	R	R	R	R	R	R
6Dh	Reserved	R	R	R	R	R	R	R	R
6Eh	Reserved	R	R	R	R	R	R	R	R
6Fh	Reserved	R	R	R	R	R	R	R	R
70h	Reserved	R	R	R	R	R	R	R	R
71h	Reserved	R	R	R	R	R	R	R	R
72h	Reserved	R	R	R	R	R	R	R	R
73h	Reserved	R	R	R	R	R	R	R	R
74h	Reserved	R	R	R	R	R	R	R	R
75h	Reserved	R	R	R	R	R	R	R	R
76h	Reserved	R	R	R	R	R	R	R	R
77h	Disable ECC	V	V	C	O	O	O	O	O
78h	Reserved	R	R	R	R	R	R	R	R
79h	Reserved	R	R	R	R	R	R	R	R
7Ah	Reserved	R	R	R	R	R	R	R	R
7Bh	Reserved	R	R	R	R	R	R	R	R
7Ch	Reserved	R	R	R	R	R	R	R	R
7Dh	Reserved	R	R	R	R	R	R	R	R
7Eh	Reserved	R	R	R	R	R	R	R	R
7Fh	Reserved	R	R	R	R	R	R	R	R
80h	Reserved	R	R	R	R	R	R	R	R
81h	Disable 8-bit data transfers	C	C	O	E	F	F	F	F
82h	Disable write cache	V	V	C	C	C	C	C	C
83h	Reserved	R	R	R	R	R	R	R	R
84h	Disable all automatic defect reassignment	R	R	C	O	O	O	O	O
85h	Disable advanced power management	R	R	R	C	C	C	C	C
86h	Disable Power-Up in Standby feature set	R	R	R	R	C	C	C	C
87h	Reserved	R	R	R	R	R	R	R	R
88h	Enable ECC	V	V	C	C	C	O	O	O
89h	Reserved for Address offset reserved boot area method technical report	R	R	R	R	C	C	C	C
8Ah	Disable CFA power mode 1	R	R	R	R	C	C	F	F
8Bh	Reserved	R	R	R	R	R	R	R	R
8Ch	Reserved	R	R	R	R	R	R	R	R
8Dh	Reserved	R	R	R	R	R	R	R	R
8Eh	Reserved	R	R	R	R	R	R	R	R
8Fh	Reserved	R	R	R	R	R	R	R	R
90h	Disable use of SATA feature	R	R	R	R	R	R	S	C
91h	Reserved	R	R	R	R	R	R	R	R
92h	Reserved	R	R	R	R	R	R	R	R
93h	Reserved	R	R	R	R	R	R	R	R

Table B.5 — Historical SET FEATURE Code Assignments (part 5 of 7)

Feature Code	Description	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
94h	Reserved	R	R	R	R	R	R	R	R
95h	Enable Media Status Notification	R	R	R	C	C	C	C	O
96h	Reserved	R	R	R	R	R	R	R	R
97h	Reserved	R	R	R	R	R	R	R	R
98h	Reserved	R	R	R	R	R	R	R	R
99h	Enable retries	V	V	C	O	O	O	O	O
9Ah	Set device maximum average current	R	R	C	O	O	O	O	O
9Bh	Reserved	R	R	R	R	R	R	R	R
9Ch	Reserved	R	R	R	R	R	R	R	R
9Dh	Reserved	R	R	R	R	R	R	R	R
9Eh	Reserved	R	R	R	R	R	R	R	R
9Fh	Reserved	R	R	R	R	R	R	R	R
A0h	Reserved	R	R	R	R	R	R	R	R
A1h	Reserved	R	R	R	R	R	R	R	R
A2h	Reserved	R	R	R	R	R	R	R	R
A3h	Reserved	R	R	R	R	R	R	R	R
A4h	Reserved	R	R	R	R	R	R	R	R
A5h	Reserved	R	R	R	R	R	R	R	R
A6h	Reserved	R	R	R	R	R	R	R	R
A7h	Reserved	R	R	R	R	R	R	R	R
A8h	Reserved	R	R	R	R	R	R	R	R
A9h	Reserved	R	R	R	R	R	R	R	R
AAh	Enable read look-ahead features	C	C	C	C	C	C	C	C
ABh	Set maximum prefetch using the count field value	V	V	C	O	O	O	O	O
ACh	Reserved	R	R	R	R	R	R	R	R
ADh	Reserved	R	R	R	R	R	R	R	R
AEh	Reserved	R	R	R	R	R	R	R	R
AFh	Reserved	R	R	R	R	R	R	R	R
B0h	Reserved	R	R	R	R	R	R	R	R
B1h	Reserved	R	R	R	R	R	R	R	R
B2h	Reserved	R	R	R	R	R	R	R	R
B3h	Reserved	R	R	R	R	R	R	R	R
B4h	Reserved	R	R	R	R	R	R	R	R
B5h	Reserved	R	R	R	R	R	R	R	R
B6h	Reserved	R	R	R	R	R	R	R	R
B7h	Reserved	R	R	R	R	R	R	R	R
B8h	Reserved	R	R	R	R	R	R	R	R
B9h	Reserved	R	R	R	R	R	R	R	R
BAh	Reserved	R	R	R	R	R	R	R	R
BBh	4 bytes of ECC apply on read long/write long commands	C	C	C	O	O	O	O	O
BCh	Reserved	R	R	R	R	R	R	R	R

Table B.5 — Historical SET FEATURE Code Assignments (part 6 of 7)

Feature Code	Description	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
BDh	Reserved	R	R	R	R	R	R	R	R
BEh	Reserved	R	R	R	R	R	R	R	R
BFh	Reserved	R	R	R	R	R	R	R	R
C0h	Reserved	R	R	R	R	R	R	R	R
C1h	Disable Free-fall Control feature set	R*	R*	R*	R*	R*	R*	R*	C*
C2h	Disable Automatic Acoustic Management feature set	R	R	R	R	R	R	C	C
C3h	Reserved	R	R	R	R	R	R	R	R
C4h	Reserved	R	R	R	R	R	R	R	R
C5h	Reserved	R	R	R	R	R	R	R	R
C6h	Reserved	R	R	R	R	R	R	R	R
C7h	Reserved	R	R	R	R	R	R	R	R
C8h	Reserved	R	R	R	R	R	R	R	R
C9h	Reserved	R	R	R	R	R	R	R	R
CAh	Reserved	R	R	R	R	R	R	R	R
CBh	Reserved	R	R	R	R	R	R	R	R
CCh	Enable reverting to power on defaults	C	C	C	C	C	C	C	C
CDh	Reserved	R	R	R	R	R	R	R	R
CEh	Reserved	R	R	R	R	R	R	R	R
CFh	Reserved	R	R	R	R	R	R	R	R
D0h	Reserved	R	R	R	R	R	R	R	R
D1h	Reserved	R	R	R	R	R	R	R	R
D2h	Reserved	R	R	R	R	R	R	R	R
D3h	Reserved	R	R	R	R	R	R	R	R
D4h	Reserved	R	R	R	R	R	R	R	R
D5h	Reserved	R	R	R	R	R	R	R	R
D6h	Reserved	R	R	R	R	R	R	R	R
D7h	Reserved	R	R	R	R	R	R	R	R
D8h	Reserved	R	R	R	R	R	R	R	R
D9h	Reserved	R	R	R	R	R	R	R	R
DAh	Reserved	R	R	R	R	R	R	R	R
DBh	Reserved	R	R	R	R	R	R	R	R
DCh	Reserved	R	R	R	R	R	R	R	R
DDh	Disable release interrupt	R	R	R	C	C	C	C	C
DEh	Disable SERVICE interrupt	R	R	R	C	C	C	C	C
DFh	Reserved	R	R	R	R	R	R	R	R
E0h	Vendor specific	R	R	R	R	R	R	O	O
E1h	Vendor specific	R	R	R	R	R	R	O	O
E2h	Vendor specific	R	R	R	R	R	R	O	O
E3h	Reserved	R	R	R	R	R	R	R	R
E4h	Reserved	R	R	R	R	R	R	R	R
E5h	Reserved	R	R	R	R	R	R	R	R
E6h	Reserved	R	R	R	R	R	R	R	R
E7h	Reserved	R	R	R	R	R	R	R	R

Table B.5 — Historical SET FEATURE Code Assignments (part 7 of 7)

Feature Code	Description	ATA1	ATA2	ATA3	ATA4	ATA5	ATA6	ATA7	ATA8
E8h	Reserved	R	R	R	R	R	R	R	R
E9h	Reserved	R	R	R	R	R	R	R	R
EAh	Reserved	R	R	R	R	R	R	R	R
EBh	Reserved	R	R	R	R	R	R	R	R
ECh	Reserved	R	R	R	R	R	R	R	R
EDh	Reserved	R	R	R	R	R	R	R	R
EEh	Reserved	R	R	R	R	R	R	R	R
EFh	Reserved	R	R	R	R	R	R	R	R
F0h		R	R	R	R	A	A	A	A
F1h		R	R	R	R	A	A	A	A
F2h		R	R	R	R	A	A	A	A
F3h		R	R	R	R	A	A	A	A
F4h		R	R	R	R	A	A	A	A
F5h		R	R	R	R	A	A	A	A
F6h		R	R	R	R	A	A	A	A
F7h		R	R	R	R	A	A	A	A
F8h		R	R	R	R	A	A	A	A
F9h		R	R	R	R	A	A	A	A
FAh		R	R	R	R	A	A	A	A
FBh		R	R	R	R	A	A	A	A
FCh		R	R	R	R	A	A	A	A
FDh		R	R	R	R	A	A	A	A
FEh		R	R	R	R	A	A	A	A
FFh		R	R	R	R	A	A	A	A

Key:

C = a defined command.
E = a retired command.
O = Obsolete.
R = Reserved, undefined in current specifications.
V = Vendor specific commands.

A = Reserved for assignment by the CompactFlash? Association.
F = If the device does not implement the CFA feature set, this command code is Vendor specific.
M = Reserved for the Media Card Pass Through Command feature set.
S = Reserved for Serial ATA.
T = Reserved for Technical Report T13/DT1696 (Time-Limited Commands).

Annex C
(Informative)

Design and programming considerations for large physical sector devices

C.1 Introduction

In ATA standards preceding ATA/ATAPI-7, the smallest host addressable unit of data has been the 512 byte sector. In hard disk drives each physical sector has an associated error correcting code field to allow detection and correction of read errors. Over time, error correcting code fields have been lengthened to provide greater detection and correction capability. As a result, the proportion of device media devoted to ECC fields has risen. Increasing the length of data sectors on the media increases the efficiency of ECC by enabling better error detection and correction using a smaller proportion of media.

C.2 Physical sectors

Because the 512 byte sector has been a constant since the beginning of ATA many software changes are required if device logical sectors were made larger. To preserve the legacy software that assumes a 512 byte logical sector, logical addressing based on 512 byte sectors has been retained. Larger physical sectors are implemented as power of two multiples of the logical sector size, 1,2,4,8,16, etc. For example, devices may have physical sectors that are 8 logical sectors long or 4096 bytes total. It is not possible to report a logical sector that spans two physical sectors.

C.3 Unaligned write

While allowing a logical sector to be smaller than a physical sector maintains software compatibility it introduces a potential performance issue, unaligned write, which must be avoided. A physical sector must be written to the media in a single operation. To complete a write command that writes a fraction of a physical sector the device must read the entire physical sector into buffer memory update the buffer memory with the write data and then write the entire physical sector to the media. This may incur a performance penalty of one media revolution or more.

Write commands may begin mid physical sector and end mid physical sector resulting in two unaligned writes. In this case the device has to read both the beginning and ending physical sector of the write into the buffer.

To avoid the performance penalty from an unaligned write all write operations must begin with the first sector of a physical sector and end with the last sector of a physical sector.

Figure 10 illustrates an unaligned write on a device with 2048 byte physical sectors. The first four logical sectors, LBA0 - LBA3, reside on physical sector 0. To write only LBA3 the host sends a conventional write command and the data for LBA3. On receipt of the write command the device seeks to the physical sector that contains LBA3, which is physical sector 0. Physical sector 0 is read into the device buffer. Then the new write data for LBA3 is placed in the buffer, overwriting a segment of the buffer. The buffer data is then written to the media, physical sector 0.

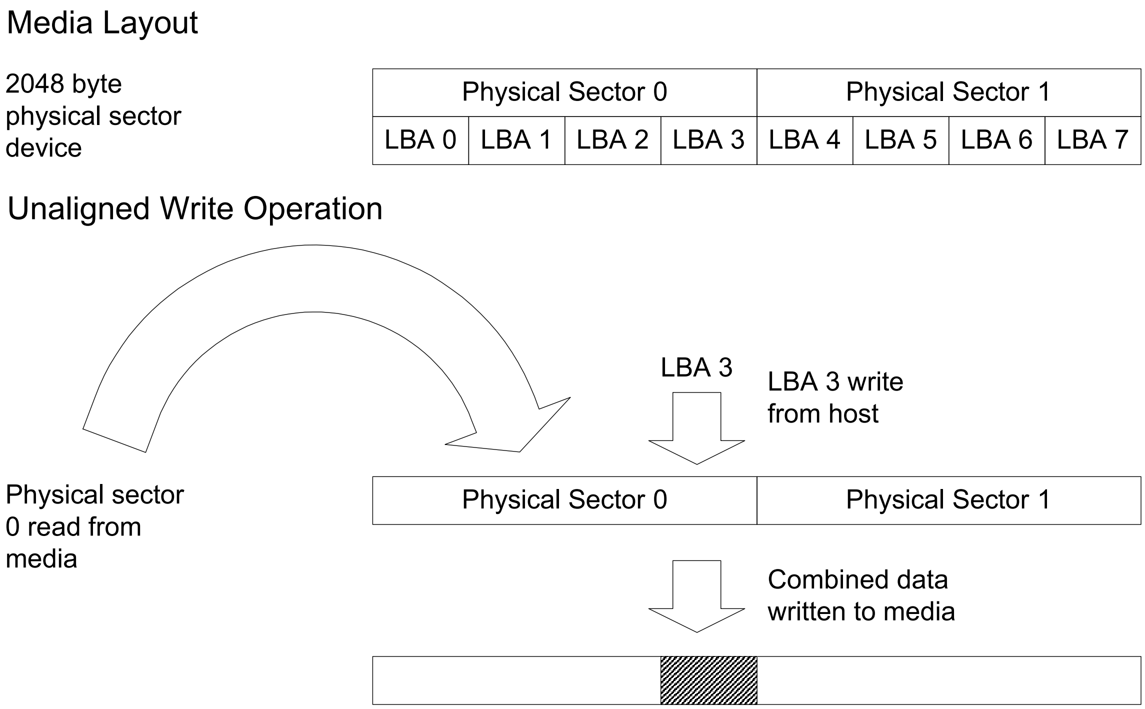

Figure C.1 — Unaligned Write Example

C.4 SET MAX

A Host which uses the SET MAX command should set a value to the last logical sector of a physical sector to allow writes to the end of the user area without requiring an unaligned write. Devices should accommodate a SET MAX setting to any LBA address to maintain compatibility.

C.5 Software compatibility

While the current specification allows devices to report up to 2^{15} or 32,768 logical sectors per physical sector there are file system limitations in existing systems that restrict practical device implementations to 4096 bytes per physical sector.

Annex D
(Informative)

How to use SCT commands

D.1 How to use SCT commands overview

SCT commands piggy-back on the standard ATA commands: SMART READ LOG and SMART WRITE LOG, or READ LOG EXT and WRITE LOG EXT. As viewed through an ATA protocol analyzer, an SCT command is seen as data being transferred by these commands; whereas from the perspective of a device that implements this feature set, this “data” is interpreted as an SCT command request, an SCT command response, SCT command status, or SCT command data.

Figure D.1 is an example flowchart that shows how to process SCT commands using SMART READ LOG and SMART WRITE LOG commands:

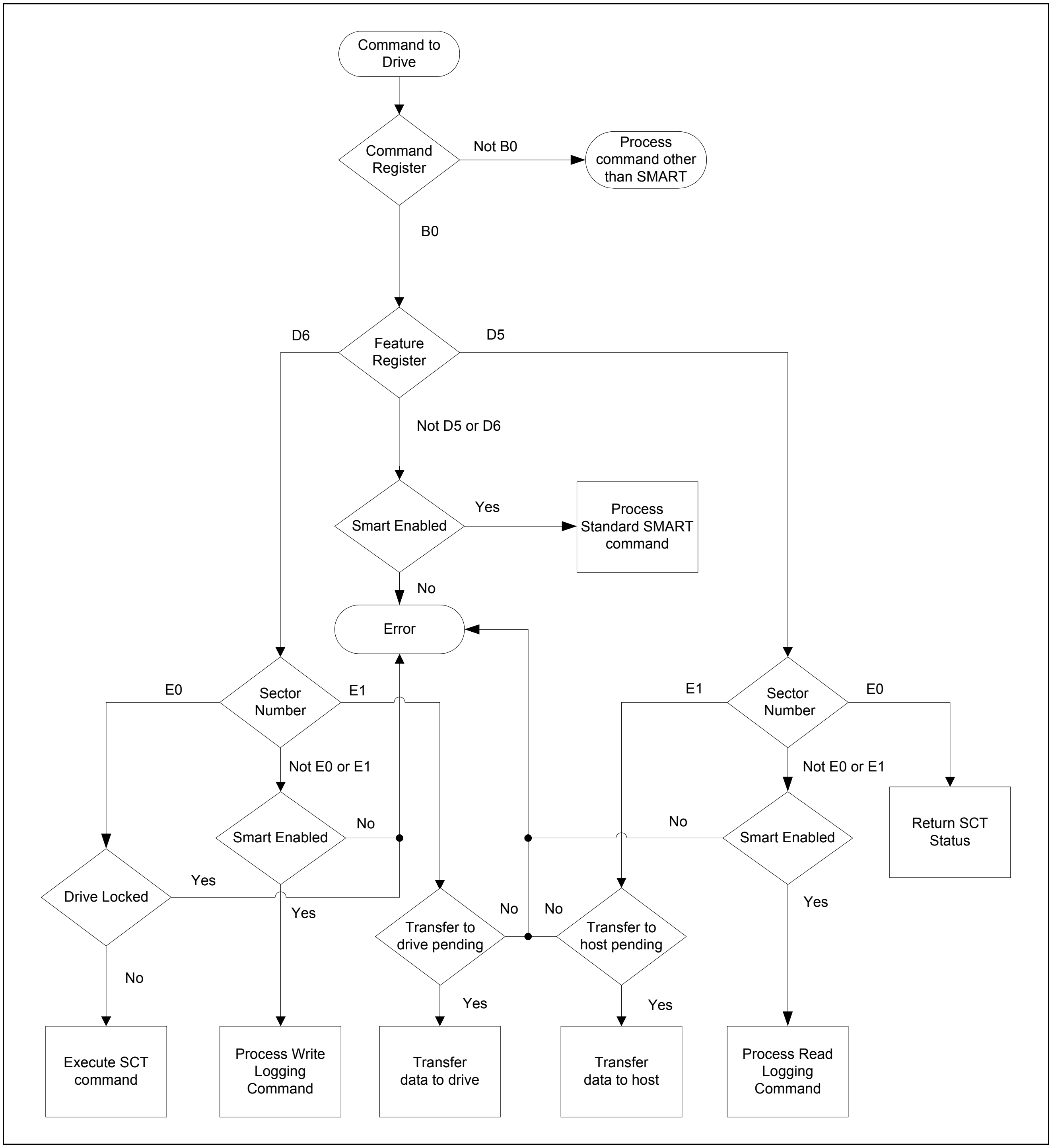

Figure D.1 — Example flowchart for SCT commands

D.2 Examples of Log page command sequences

Figure D.2 shows an example of a foreground write same with a repeating write pattern.

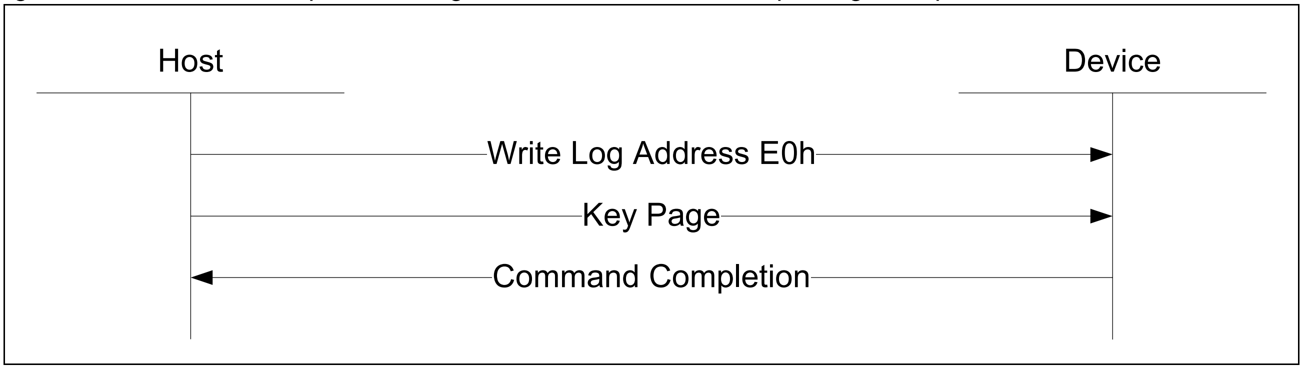

Figure D.2 — Example sequence for foreground write same with a repeating pattern

Figure D.3 shows an example of a foreground write same with a repeating sector.

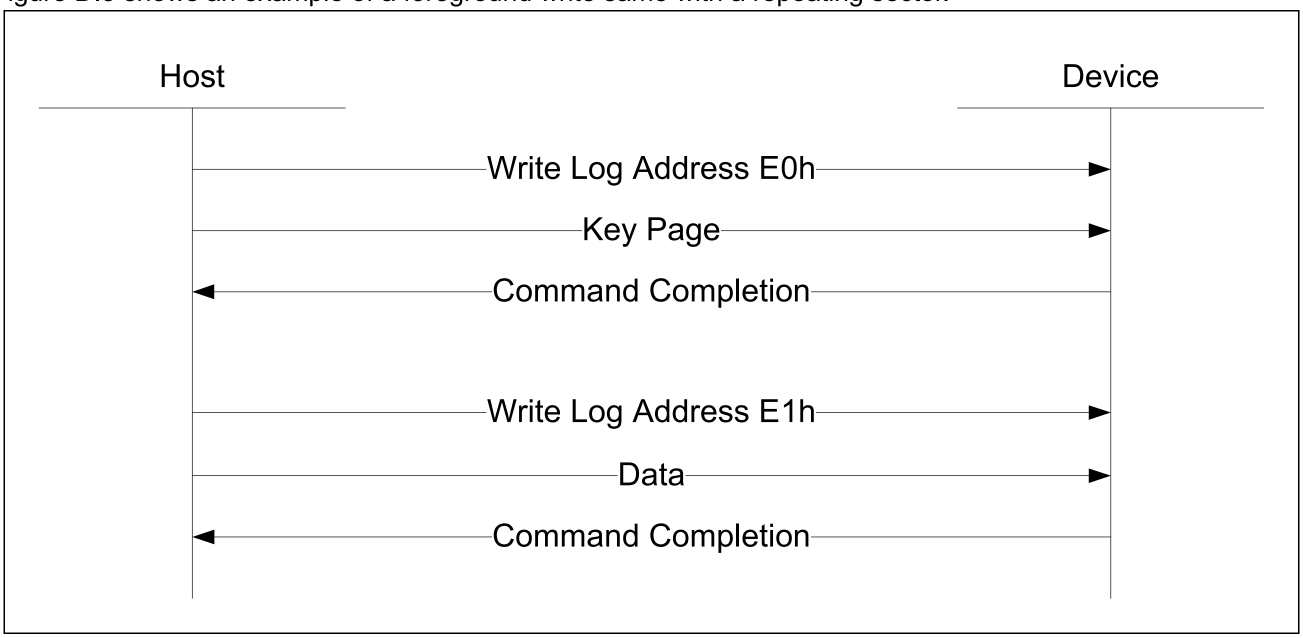

Figure D.3 — Example sequence for foreground write same with a repeating sector

Figure D.4 shows an example command sequence for writing data to a device using an SCT command with no background activity.

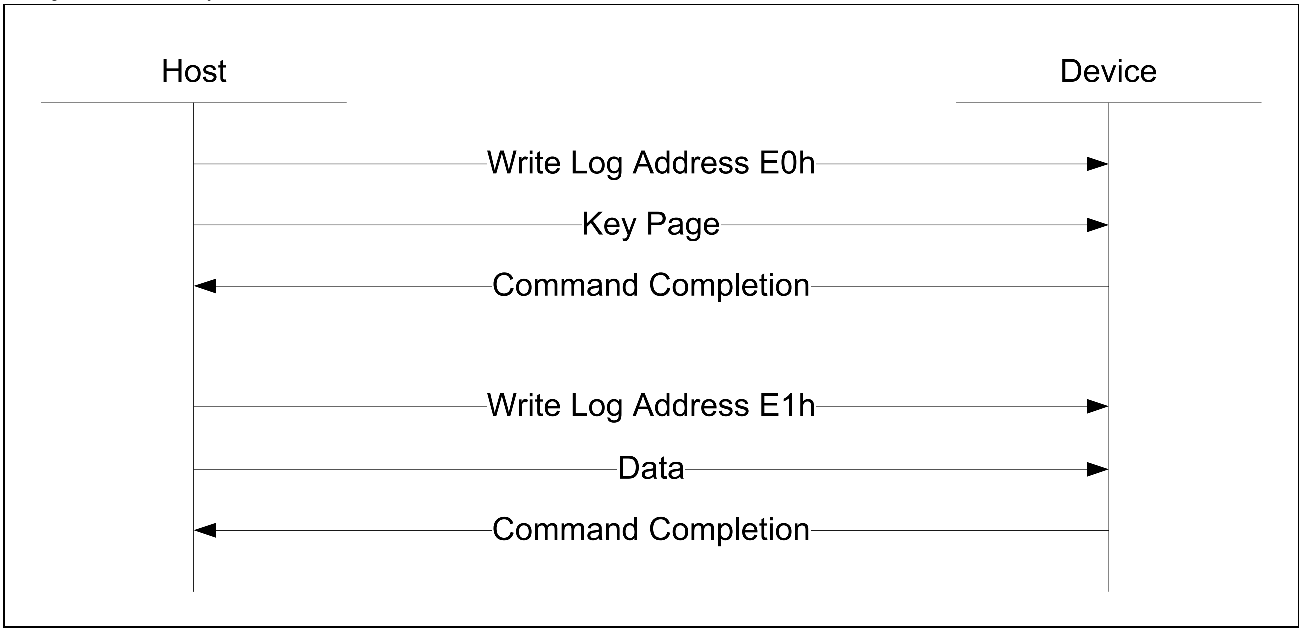

Figure D.4 — Example sequence for writing data using an SCT command with no background activity

Figure D.5 shows an example command sequence for reading data from a device using an SCT command with no background activity.

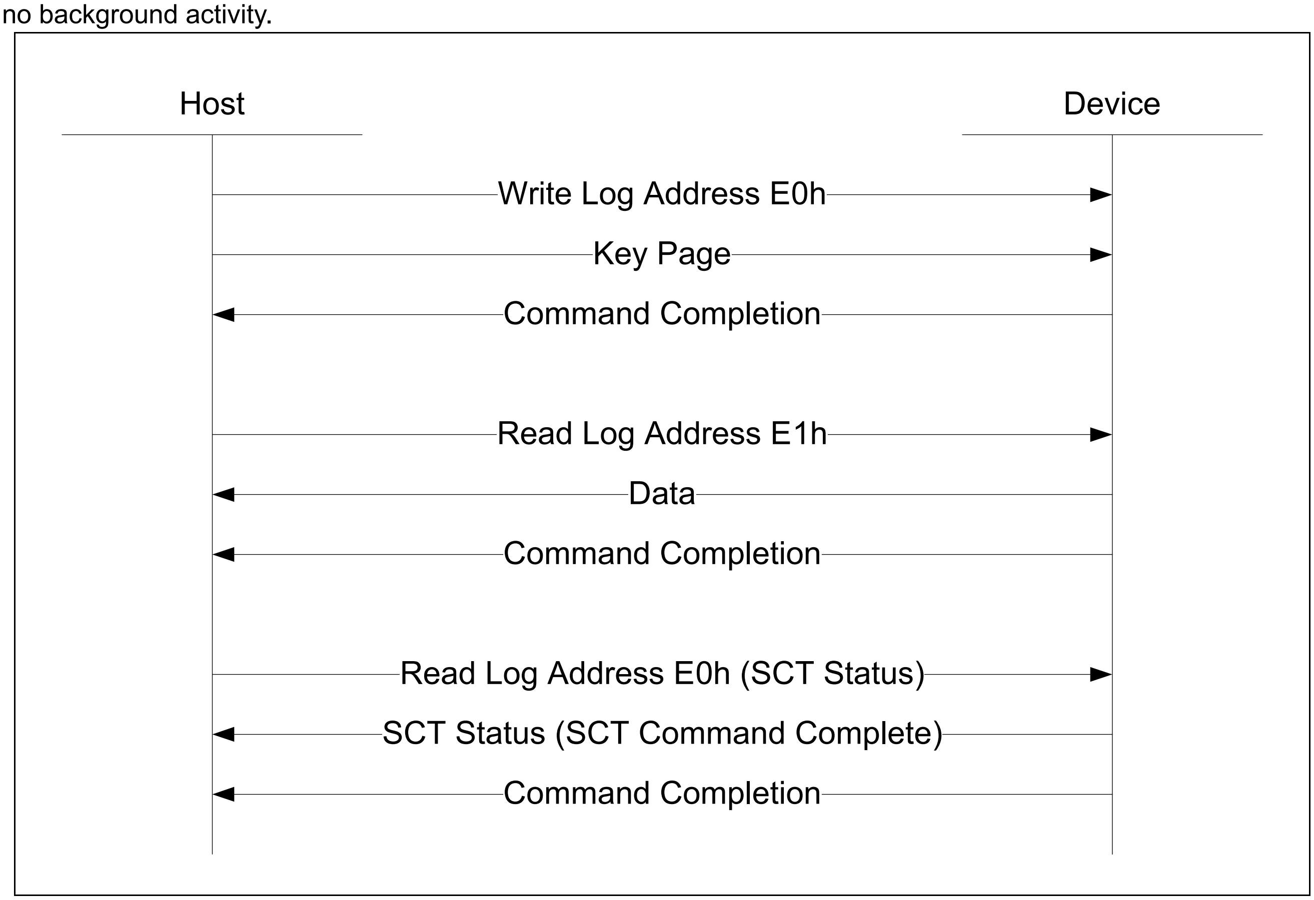

Figure D.5 — Example sequence for reading data using an SCT command with no background activity

Figure D.6 shows an example command sequence for issuing a Log page command that does not transfer data and has no background activity.

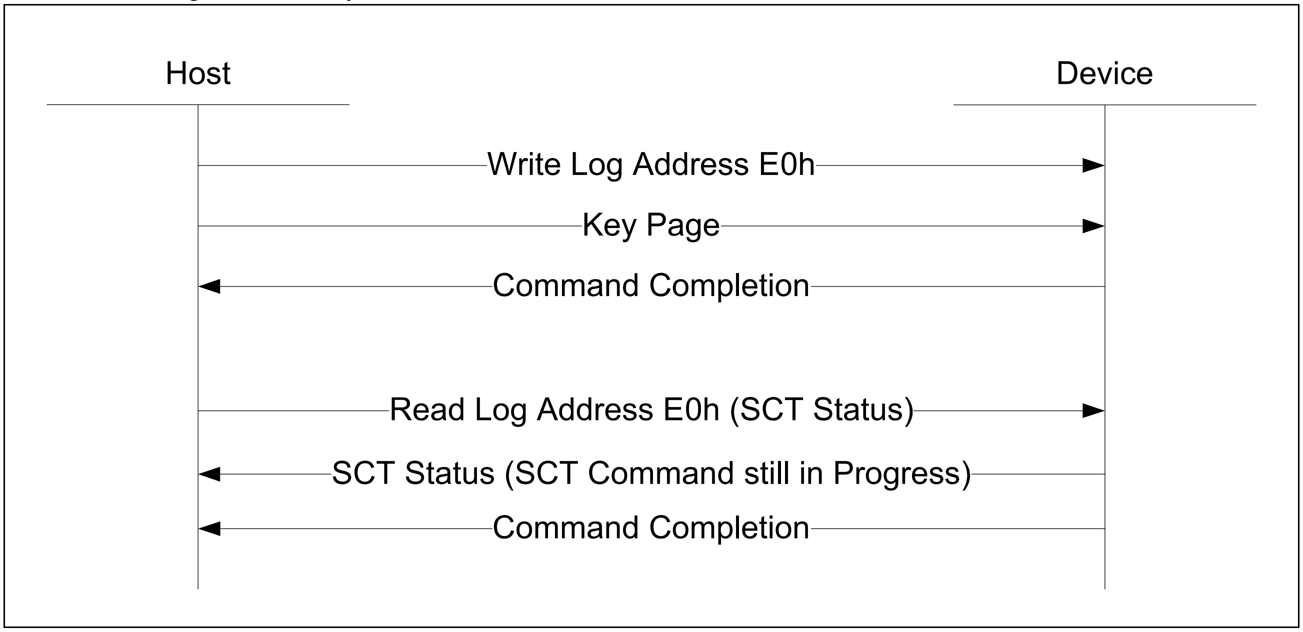

Figure D.6 — Example Sequence for a non-data SCT command with no background activity

Figure D.7 shows an example command sequence for issuing an SCT command that writes data in the background.

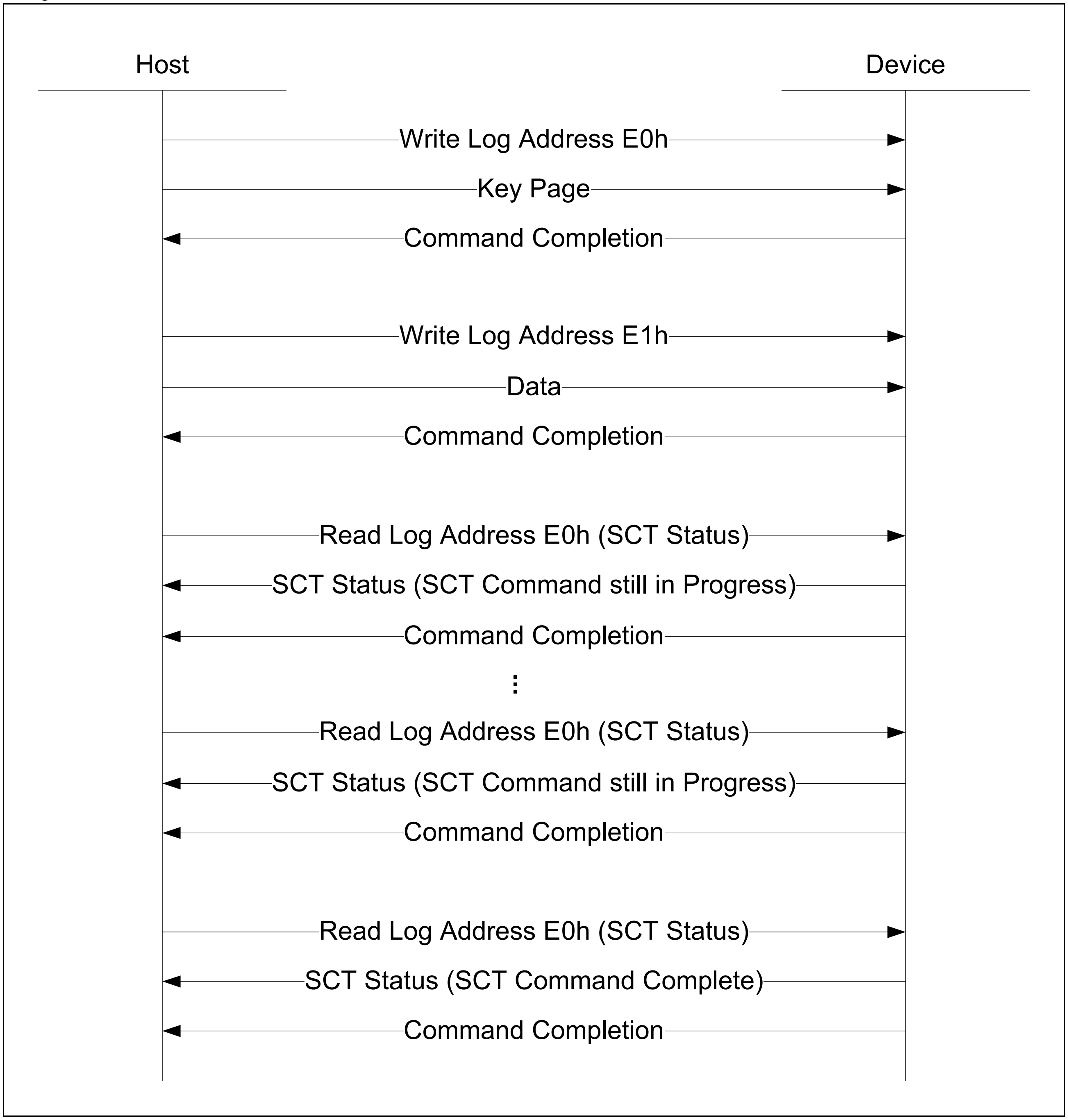

Figure D.7 — Example sequence for writing data using an SCT command with background activity

Figure D.8 shows an example command sequence for issuing an SCT command that executes in the background but does not require the transfer of data to or from the host.

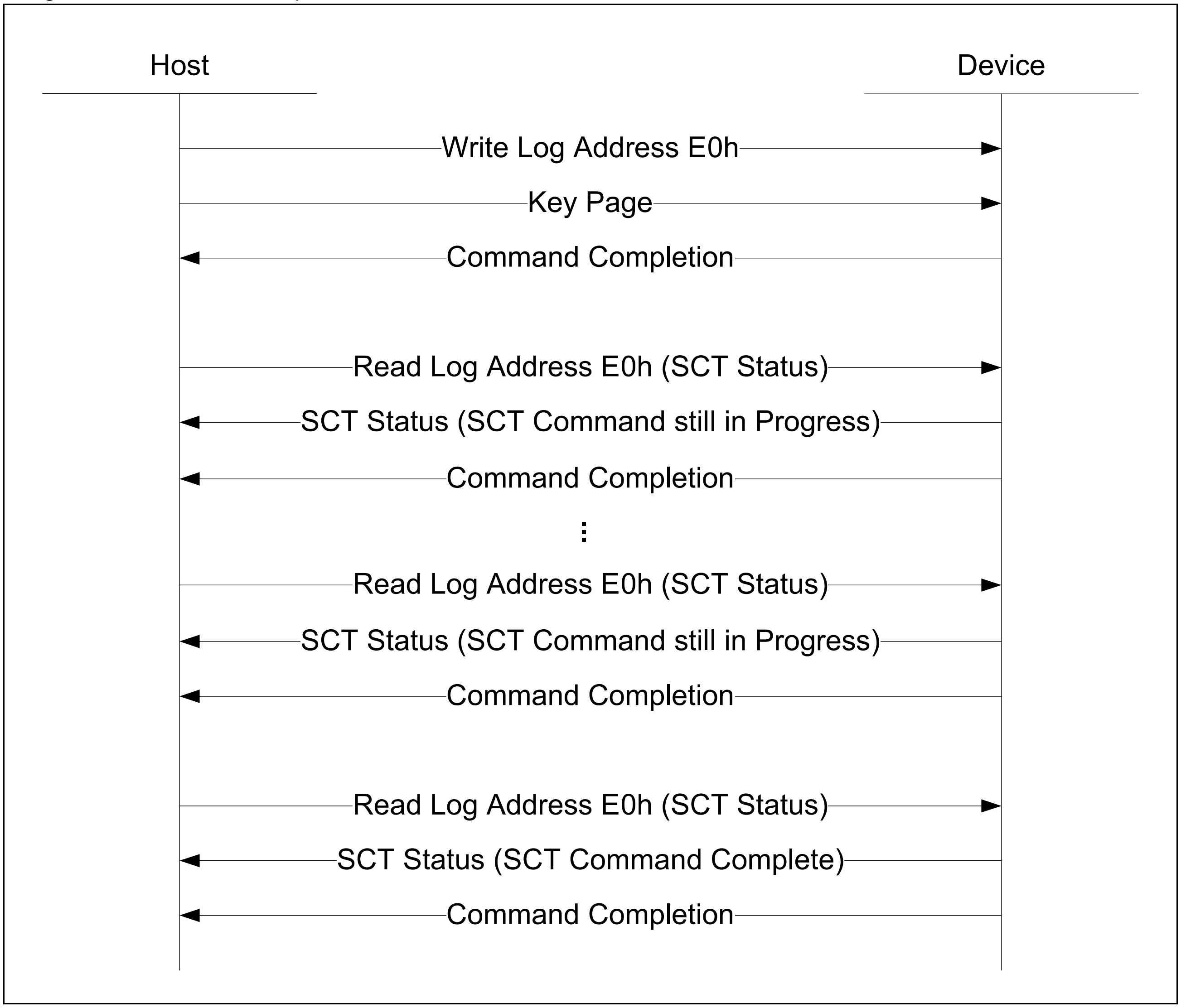

Figure D.8 — Example sequence for a non-data SCT command with background activity

D.3 Issuing an SCT command to a device

D.3.1 Step 1 - Build a Key Page

The host builds the key page in a host buffer for the appropriate action and parameters.

D.3.2 Step 2 - Issue the SCT command

The host issues the SCT command (see table D.1 or table D.2), and sends the key page to the device.

Table D.1 — SCT command using SMART WRITE LOG command

Word	Name	Description
00h	Feature	D6h - SMART WRITE LOG
01h	Count	01h (Shall always be 01h
02h-04h	LBA	Bit Description 47:24 Reserved 23:8 C24Fh 7:0 E0h (Command port)
05h	Command	B0h

Table D.2 — SCT command using WRITE LOG EXT command

Word	Name	Description
00h	Feature	Reserved
01h	Count	01h 1 sector for SCT commands
02h-04h	LBA	**Bit Description** 47:32 Reserved 31:16 00h There is no offset when commands are issued 15:8 Reserved 7:0 E0h
05h	Command	3Fh

The device responds with successful status (see table 60). If the command is aborted (i.e., Status = 51h and Error = 04h), then either the key page format is invalid, the task file contains an invalid value or the command encountered an execution error. The host checks the Count and LBA (7:0) fields for the error code (see table 61 and table 62). If the command was a “write” command, the command is terminated, there is no data transfer, and the host skips Step 3. However, if the command was a “read” command, there maybe partial output available. For example, on a sector read command, the data up to and including the sector in error is available. In this case, the host may proceed to Step 3 to get the partial data. In certain cases the error is not fatal and serves only as a warning.

If the status is 50h, then the host checks the LBA Mid and LBA High fields. If the values are 0, then the command is complete, terminated without error, and the host proceeds to Step 4. If the values are greater than 0, then the host proceeds to Step 3.

D.3.3 Step 3 - Transfer Data if Required

To transfer data from the device to the host, the host issues a SMART READ LOG, READ LOG DMA EXT or READ LOG EXT command to the SCT Data Transfer log (see table 63 and table 64). To transfer data from the host to the device, the host issues a SMART WRITE LOG, WRITE LOG DMA EXT or WRITE LOG EXT command to the SCT Data Transfer log (see table 63 and table 64). The transfer request is in the range of 1 sector up to the total number of sectors not yet transferred. The number of sectors remaining was posted in the LBA (23:8) field in the previous step. If the requested number of sectors is larger than the number of the sectors remaining, the device reports an error. If the value is less then the number of sectors remaining, the host may repeat Step 3 until all sectors have been transferred.

For SCT commands that access the media, the device advances the sector pointer by the number of sectors transferred, and reports in the LBA (23:8) field the number of sectors remaining to be transferred. If both fields contain zero, then the command is complete, and the host proceeds to Step 4. The host has complete control over the number of sectors to transfer at a time. Note, if the number of sectors to be transferred is greater or equal to FFFFh, the device sets the LBA Mid and High fields to FFFFh. The value remains FFFFh until the number of sectors remaining drops below FFFFh. The exact number to be transferred is reported by the SCT Status command. Upon receiving the last block of data, the device performs the specified operation. In the case of very large amounts of data, such as Write Same, some data may be processed (e.g., written to the disk) prior to receiving all of the data from the host.

D.3.4 Step 4 - Final Status/SCT Command Completion

The host reads the SCT status response (see table 65, table 66, and table 67) to determine how the command completed. If the command has not completed (i.e., by reporting FFFFh in table 67 byte 14) then the host waits for some period of time and repeats Step 4 until the command is complete. For SCT commands that require transfer of data to the device (e.g., a write command), the command is not complete until the last block of data has been transferred to the device.

Annex E
(Informative)

Implementation Guidelines For 1K/4K Sector Sizes

E.1 Introduction

The disk drive industry has been standardized on a 512 byte sector size for over 25 years. In the continual pursuit for size and performance, larger sector sizes are being considered.

E.2 Scope

This annex provides guidelines for implementing a media format that incorporates sector sizes greater than 512 bytes. The target sector sizes are 1k followed by 4k. This annex does not make a case for using larger sector sizes. Instead, this annex assumes that the move to larger sector sizes is going to happen and addresses both system and industry implications.

The information provided in this paper enables sector sizes that are a binary multiple greater than 512 bytes. This standard also specifies methods to report sector sizes that are not a binary multiple. Common sector sizes that are not binary multiples include 520, 524, 528 and 532 byte sectors. Non-binary multiples are beyond the scope of this annex.

E.3 Overview

The disk drive industry is considering implementing drives with a media sector size larger than 512 bytes. The purpose of this change is to allow for greater format efficiency, greater error recovery capability, or both. Figure E.1 shows major system components that are affected by a change in sector size.

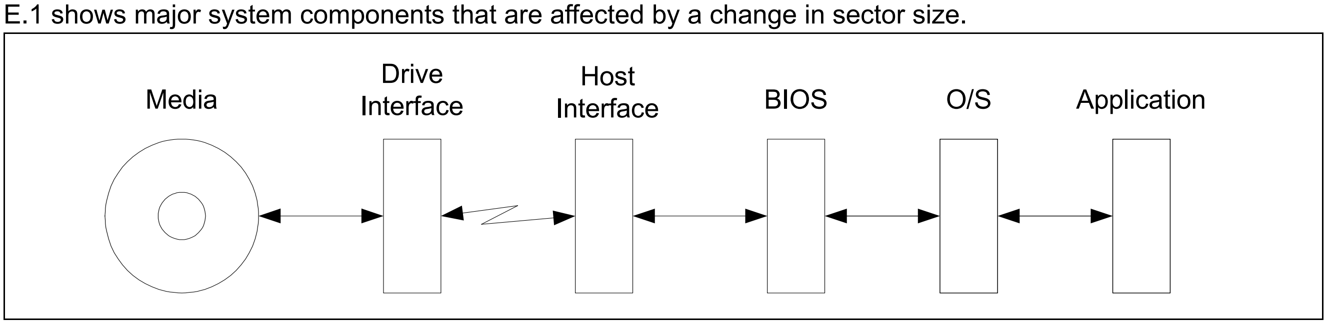

Figure E.1 — System Dependency Chain

There are two competing possibilities for expanding the sector size on the media. One proposal expands the sector size seen at the drive interface; the other keeps the 512 byte sector size at the drive interface. Both possibilities have drawbacks. Figure E.2 illustrates the possibilities.

	Today	512 Byte LBA	Physical Sector Size LBA	512 Byte LBA	Physical Sector Size LBA
Interface Sector Size	512 Bytes	512 Bytes	1K Bytes	512 Bytes	4K Bytes
		Requires RMW, is compatible with system food chain	Incompatible with food chain, does not require RMW	Requires RMW, is compatible with system food chain	Incompatible with food chain, does not require RMW
Media Sector Size	512 Bytes	1K Bytes	1K Bytes	4K Bytes	4K Bytes

Figure E.2 — Mapping Proposals

Using the 512 byte LBA mechanism, the Drive Interface, Host Interface, BIOS, OS, and Applications still function. Optimal performance is achieved if the OS were modified to properly align the disk accesses. The 512 byte LBA mechanism also allows a drive manufacturer to ship a utility with the unit that optimizes performance. If the Physical Sector Size LBA mechanism is employed, the existing Drive Interface, Host Interface, BIOS, OS, and Applications may not function. The reason they may not function is that many components in the System Dependency Chain are hardwired to 512 bytes. These hardwired elements include hardware, firmware and software. If you attach a drive with 1K interface sectors to a system today it should not be able to boot using Windows 2000/XP. If the host interface is able to transfer the data, it is highly likely that the system BIOS is hardwired to 512 bytes. If the BIOS were able to launch Windows, the user should find that Windows is hardwired to 512 bytes and the system may hang. In the case where the BIOS or host interface is hardwired to 512 bytes, no utility may reasonably be used to fix the problem.

This standard provides a mechanism for describing media format and host LBA alignment requirements in the IDENTIFY DEVICE command and as a part of the Long Logical and Long Physical feature sets. Figure E.3 illustrates an example of the capability documented in this standard.

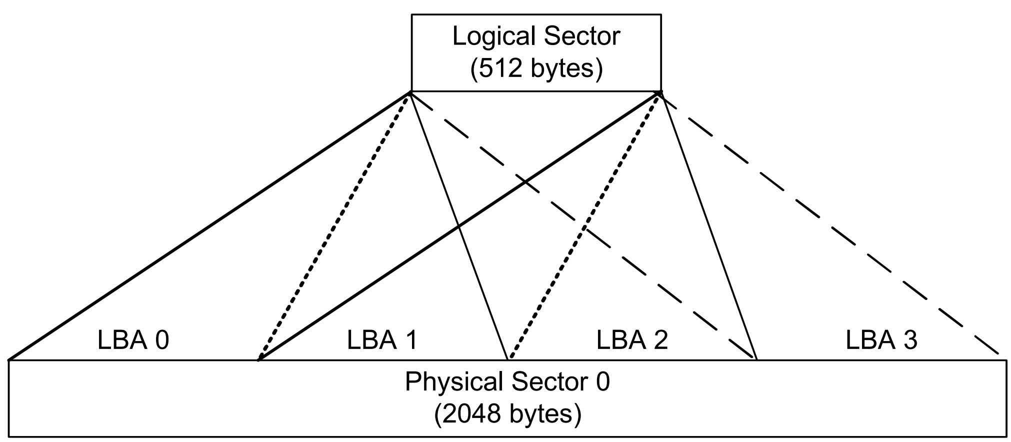

Figure E.3 — Logical to Physical Mapping

In this example, the interface (logical) sector size is 512 bytes, and the media (physical) sector size is 2048 bytes. This mechanism allows an ATA device to both implement a larger physical sector and maintain compatibility with existing systems, interfaces, and software. One of the drawbacks of this method is that drive performance may suffer if the host writes data starting or ending on an LBA that is misaligned with respect to the physical sector boundaries. When misalignment occurs, the drive is be forced to perform a Read-Modify-Write (RMW) operation in order to satisfy the host request.

ATA also allows the Logical Sector size to be changed. This allows a device to implement a 4KB sector on the media and require that the host transfer 4KB of data for each LBA requested. This type of implementation avoids the RMW issue noted above. The main drawback of this implementation is that existing systems, interfaces, BIOS and system software (OS and otherwise) have to change in order to accommodate the device.

E.4 Implementation

E.4.1 1KB Sector Size Implementation

The 1KB sector size allows for greater format efficiency, and a slight increase in performance. The change to 1KB sectors may cause some issues regarding access alignment. These issues should not be seen in an environment that has been optimized for 4KB accessing.

The device indicates the 1KB sector size to the host by returning 6001h in word 106 of IDENTIFY DEVICE. This indicates that the device has 2 512 byte logical sectors to compose a 1KB physical sector. The host may use this information to know that transfers should start on even LBAs and end on odd LBAs for best performance.

Or

The device indicates the 1KB sector size to the host by returning 6000h in word 106 and 400h in words 117-118 of IDENTIFY DEVICE. This indicates that the device has 1 1024 byte logical sector per 1KB physical sector. The host may use this information to know that transfers require 1K bytes per logical block requested.

E.4.2 4KB Sector Size Implementation

The 4KB sector size allows for greater format efficiency than the 1KB sector size; as well as a slight increase in performance. The change to 4KB sectors causes additional issues regarding access alignment.

The device indicates the 4KB sector size to the host by returning 6003h in word 106 of IDENTIFY DEVICE. This indicates that the device has 8 512 byte logical sectors to compose a 4KB physical sector. The host may use this information to know that transfers should start with an LBA where the low order 3 bits are zero and the transfer ends on an LBA where the low order 3 bits are 1.

Or

The device indicates the 4KB sector size to the host by returning 6000h in word 106 and 1000h in words 117-118 of IDENTIFY DEVICE. This indicates that the device has 1 4096 byte logical sector per 4KB physical sector. The host may use this information to know that transfers require 4K bytes per logical block requested.

E.4.3 Reporting Alignment (512 Byte LBA Only)

ATA/ATAPI-7 provides a mechanism for reporting both logical and physical sector sizes, but it does not currently provide a mechanism for reporting the alignment of LBA 0 within the first logical sector. ATA8-ACS has added the ability to report alignment by placing the sector number of the first alignment point in IDENTIFY DEVICE word 209.

If the drive reports a 4K physical sector and a 512 byte logical sector, the following word 209 values report the alignment:

1) Logical LBA0 is aligned to the beginning for the first physical sector - word 209 = 4000h
2) Logical LBA0 is offset from the start of the first physical sector by 512 bytes (1 sector) - word 209 = 4001h
3) Logical LBA0 is offset from the start of the first physical sector by 1024 bytes (1 sector) - word 209 = 4002h
4) Logical LBA0 is offset from the start of the first physical sector by 1536 bytes (1 sector) - word 209 = 4003h
5) Logical LBA0 is offset from the start of the first physical sector by 2048 bytes (1 sector) - word 209 = 4004h
6) Logical LBA0 is offset from the start of the first physical sector by 2560 bytes (1 sector) - word 209 = 4005h

7) Logical LBA0 is offset from the start of the first physical sector by 3072 bytes (1 sector) - word 209 = 4006h

For systems that use Windows XP and earlier, and have drives formatted with a single partition, the optimal value is 4006h.

Windows 3.1, 95, 98, me, NT, 2000, 2003 and XP do not check the logical and physical sector size fields reported in IDENTIFY device. Therefore, it is recommended to optimize alignment to support the target applications required by the host system. It is believed that future operating systems which comply to ATA/ATAPI-7 and above need the new alignment information in order to gain optimal performance from the drive.

E.4.4 Read-Modify-Write (RMW) (512 Byte LBA Only)

For devices with a logical sector size of 512 bytes, the drive may be forced to perform RMW when it receives an unaligned transfer. The ATA/ATAPI-7 WRITE commands do not provide a way to return an error other than an ABORT or a DEVICE FAULT. If there is an uncorrectable error encountered during the initial read operation, the WRITE command has no way to report the issue. Further, this error may affect sectors not accessed by the WRITE command. There are several possible solutions for drive vendors to choose from in providing the information to the host. Figure E.4 illustrates the issue.

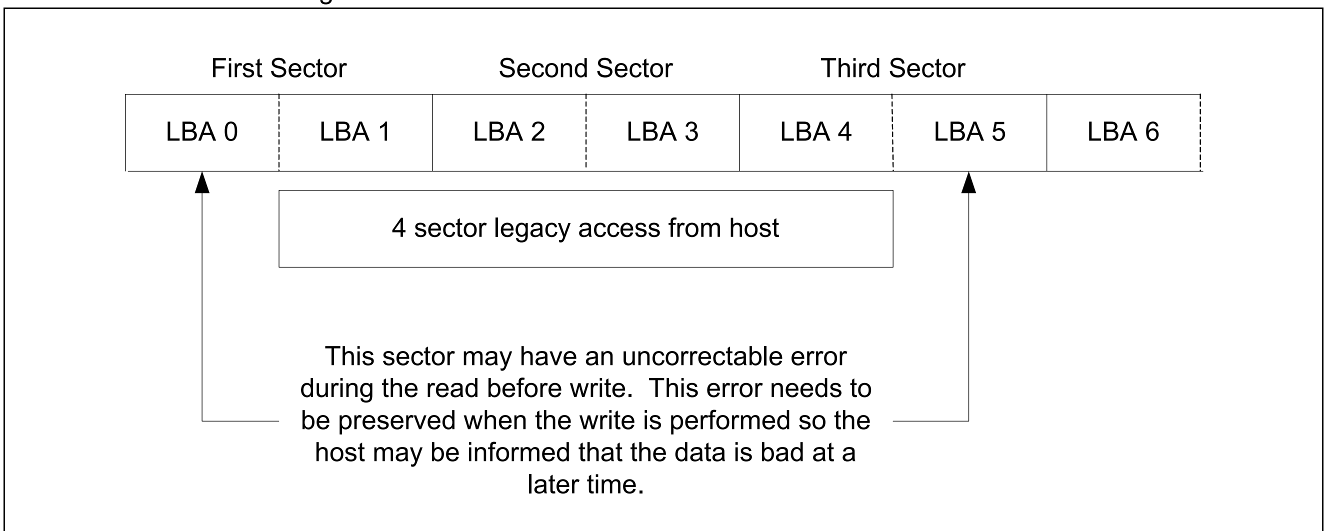

Figure E.4 — Uncorrectable Error Handling

E.5 Implementation Issues (512 Byte LBA Only)

E.5.1 Overview

Although the implementation described here allows a drive to function in a legacy system without modification, there are some issues that are critical in allowing the drive to perform at peak efficiency. Figure E.5 describes a typical device media layout showing the positions of the Master Boot Record (MBR), BIOS Parameter Block (BPB), and the remainder of a FAT based file system. This layout varies based on the type of FAT file system used, but all the elements described here are generally present. The sector numbers on the left hand side of the figures show typical and/or legacy locations for the various data structures on the media. The following sections describe alignment issues associated with current media layout.

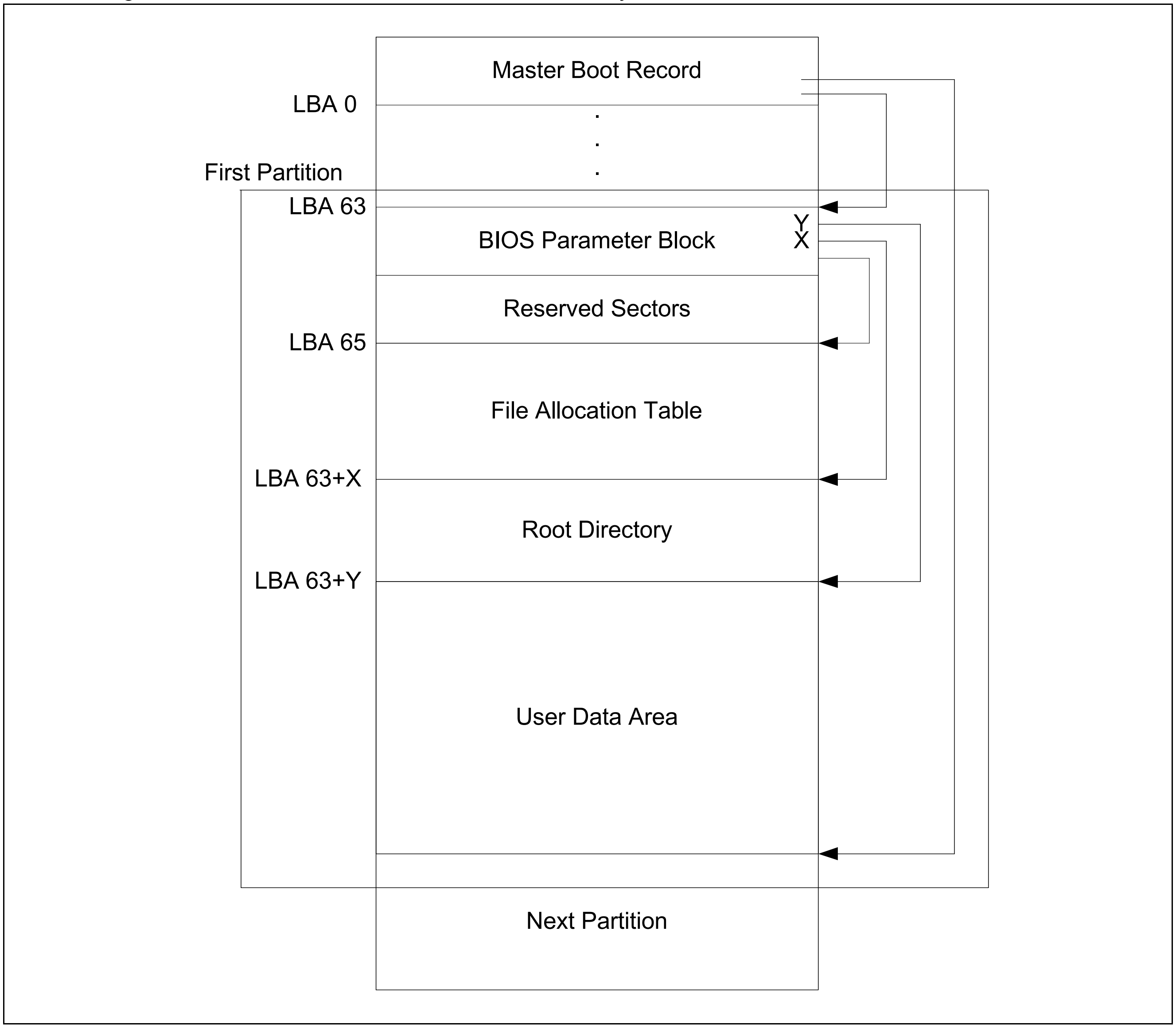

Figure E.5 — Typical HDD Layout

E.5.2 Drive Partitioning

In 1993 when the HDD industry was still dealing in cylinders heads and sectors, an important milestone was reached which caused drive manufacturers to standardize on 63 sectors per track. The norm for disk partitioning software was to place the Master Boot Record (MBR) at Cylinder 0, Head 0, sector 1 (or LBA 0). The MBR contains a pointer to the first partition. The common practice was to place the first partition at Cylinder 0 Head 1, sector 1. This meant that the LBA value of the first sector in the first partition may vary. Once the sectors per track standardized on 63, the LBA value of the first sector in the first partition standardized on LBA 63. Today, there are some applications that check to make sure that partitions start on a track boundary, even though there is no meaning for cylinders heads and sectors.

As we move forward and create larger sectors, partition alignment becomes an important issue. In the case of a 1KB sector device, the partitions should start on an even numbered sector and end on an odd numbered sector. If the drive implements a 4KB sector on the media, then the partition should start on an LBA where the low order 3 bits are zero.

For drives that use 512 byte LBA, all partitions should start on a LBA that is aligned with the start of a physical sector on the media. This effects some applications that check to make sure the first partition starts on sector 63, but a change is required to implement larger sectors on the media.

E.5.3 File System Formatting

There are many file systems that cluster sectors together to create an allocation unit larger than a single 512 byte sector. These file systems generally implement a table to associate clusters with files, commonly called a File Allocation Table (FAT). A typical cluster size is 4KB or 8 512 byte sectors. Even if the Partition is properly aligned, there is an issue where the size of the FAT may cause the individual clusters in the user data area to be unaligned relative to the physical sectors on the media. This also results in performance degradation.

If the clusters in the file system are properly aligned, file accesses is naturally aligned in many cases and performance is not degraded.

E.5.4 Virtual Memory accessing

Once the clusters in the file system are aligned, the OS memory manager needs to be modified to prevent unaligned accesses. When a drive has alignment requirements, disk performance tests may show acceptable performance, but if the virtual memory activity is not aligned, CPU performance tests may provide unacceptable results.

E.5.5 Booting

The drives with alignment requirements should not show significant performance degradation on unaligned reads. Since booting is mainly a reading process, an impact on system boot times in an unaligned environment is not expected.