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Information technology — AT Attachment

Part 105: ATA Command Set — 5 (ACS-5)

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Foreword (This foreword is not part of American National Standard INCITS 558-2021.)

This standard is designed to maintain a high degree of compatibility with the ACS-4 standard.

Requests for interpretation, suggestions for improvement and addenda, or defect reports are welcome. They should be sent to the INCITS Secretariat, ITI, 700 K Street NW, Suite 600, Washington, DC 20001.

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

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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 feature set definitions.
Clause 5 describes the ATA protocols used by the commands in this standard.
Clause 6 describes Normal and Error Output fields.
Clause 7 describes commands.
Clause 8 describes the SCT Command Transport.
Clause 9 describes logs.
Clause 10 describes command normal and error outputs.

Annex A provides command summaries.
Annex B provides a tutorial on how to use SCT.
Annex C provides implementation guidelines for 1 024/4 096 byte sectors.
Annex D provides a tutorial on how to use the DATA SET MANAGEMENT command with Trim.
Annex E provides a tutorial on how to use repurposing depopulation.
Annex F, Bibliography, is the bibliography for this standard.

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AMERICAN NATIONAL STANDARD **INCITS 558-2021**

American National Standard
for Information Technology –

ATA Command Set - 5 (ACS-5)

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). This standard specifies the command set that host systems use to access storage devices. This standard 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 other ATA standards as well as related device and host standards and specifications (e.g., SCSI standards and SATA-IO specifications).

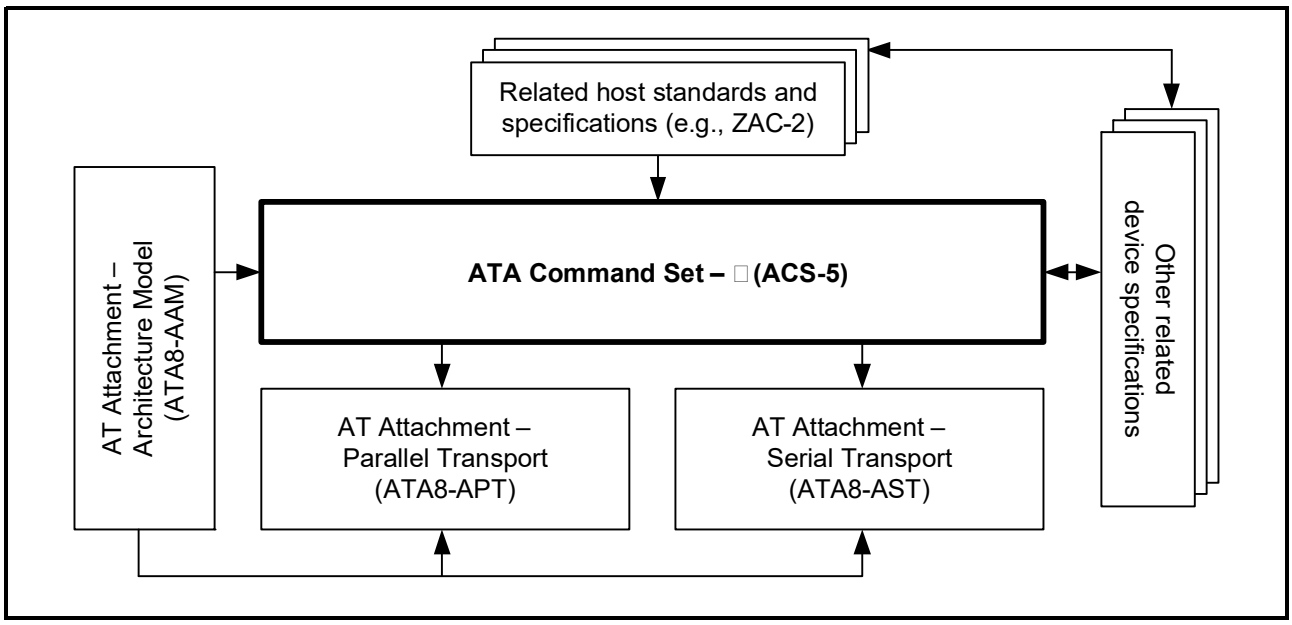

Figure 1 — ATA document relationships

This standard maintains compatibility with the ACS-4 standard, INCITS 529-2018, while providing additional functions.

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INCITS 558-2021

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

INCITS 4-1986 (R2012), *Information Systems – Coded Character Sets – 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII)*

ISO 7779:1999, *Acoustics – Measurement of airborne noise emitted by information technology and telecommunications equipment*

INCITS 451-2008, *AT Attachment-8 – ATA/ATAPI Architecture Model (ATA8-AAM)*

INCITS 493-2012, *AT Attachment-8 – Serial Transport (ATA8-AST)*

INCITS 502-2019, SCSI Primary Commands – 5 (SPC-5)

T10/INCITS BSR 506, *SCSI Block Commands – 4 (SBC-4)* (under consideration)

INCITS 524-2016, *AT Attachment-8 – Parallel Transport (ATA8-APT)*

T13/INCITS BSR 549, *Zoned-device ATA Command Set - 2 (ZAC-2)* (under consideration)

Serial ATA revision 3.5 (SATA 3.5) [1]

RFC 3280, *Internet X.509 Public Key Infrastructure: Certificate and Certificate Revocation List (CRL) Profile, IETF, 2002* [2]

RFC 3281, *An Internet Attribute Certificate: Profile for Authorization, IETF, 2002* [2]

FIPS PUB 140-2, *Security Requirements For Cryptographic Modules, May 25, 2001* [3]

FIPS PUB 140-3, *Security Requirements for Cryptographic Modules, March 23, 2019* [3]

SFF-8447 LBA Count for Disk Drives [4]

SFF-8609 Specification for Management Interface for Drive Conditions, Rev 1.0, July 07, 2017 [4]

1. For more information on Serial ATA international Organization, see http://www.sata-io.org/.
2. For more information on IETF publications, see http://www.ietf.org/.
3. For more information on National Institute of Standards and Technology publications, see http://www.nist.gov/.
4. For more information on SFF specifications contact the SFF committee at http://www.snia.org/sff/specifications.

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3 Definitions, abbreviations, and conventions

3.1 Definitions

3.1.1 28-bit command
command that uses the FEATURE field (7:0), COUNT field (7:0), LBA field (27:0), ICC field (7:0), AUXILIARY field (31:0), DEVICE field (15:8), and COMMAND field (7:0) to specify its arguments

3.1.2 48-bit command
command that uses the FEATURE field (15:0), COUNT field (15:0), LBA field (47:0), ICC field (7:0), AUXILIARY field (31:0), DEVICE field (15:8), and COMMAND field (7:0) to specify its arguments

3.1.3 accessible max address
maximum LBA that is accessible by read commands and write commands that return command completion without error

3.1.4 Active mode
power condition specified by the PM0: Active state

Note 1 to entry: See 4.17.4.

3.1.5 additional sense code
combination of the ADDITIONAL SENSE CODE field and the ADDITIONAL SENSE CODE QUALIFIER field

Note 1 to entry: See 7.34 and 9.14.

3.1.6 administrator
person who is responsible for the administration of one or more devices

Note 1 to entry: For example, the person who establishes passwords in the Security feature set (see 4.22).

3.1.7 advanced background operations
background processing that may impact device response time to affected LBAs and may include garbage collection operations

3.1.8 AOI (Administered Organizational Identifier)
24-bit organizational identifier that is administered by the IEEE

Note 1 to entry: The IEEE Administered Organizational Identifier is described in https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/tutorials/eui.pdf.

Note 2 to entry: The IEEE defines multiple formats of AOI values, including 24-bit AOI values. Only 24-bit AOI values are used by this standard (i.e., the MA-L values and CID values described by the document referenced in note 1 to entry).

Note 3 to entry: The IEEE administration of the MA-L and CID values is defined such that values in each group are mutually unique with respect to each other as described by the document referenced in note 1 to entry.

Note 4 to entry: AOI values are available from the IEEE-SA Registration Authority (see https://standards.ieee.org/products-services/regauth/index.html).

3.1.9 ASCII character
byte containing a 7-bit ASCII pattern in bits 6:0 with bit 7 cleared to zero

Note 1 to entry: See INCITS 4-1986.

3.1.10 ATA device
device that supports the General feature set

Note 1 to entry: See 4.2.

3.1.11 ATA string
set of ASCII characters in the format specified in 3.4.9

3.1.12 background activity
activity initiated by a command that occurs after command completion has been reported

3.1.13 BIOS (Basic Input/Output System)
application client that is run when power is applied whose primary function is to initialize various components (e.g., storage devices)

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3.1.14 byte
sequence of eight contiguous bits considered as a unit

Note 1 to entry: See 3.4.8.

3.1.15 cache
data storage area outside the area accessible by hosts

Note 1 to entry: The cache may contain a subset of the data stored in the non-volatile media.

3.1.16 caching priority level
a measure of the relative importance of keeping a copy of user data in non-volatile cache

3.1.17 CFA-APT device
device that supports the CFA feature set (see ACS-3), the ATA8-APT transport, and not the ATA8-AST transport

3.1.18 circular buffer
buffer that is filled starting at the first byte continuing to the last byte and then wrapping to store data in the first byte of the buffer again

3.1.19 command aborted
command completion with the ERROR bit set to one in the STATUS field and the ABORT bit set to one in the ERROR field

3.1.20 command acceptance
positive acknowledgement of a command being received by a device

3.1.21 command completion
completion by the device of processing the command

Note 1 to entry: As part of command completion the device:

a) completes the action requested by the command or terminates the command with an error; and
b) sets the appropriate bits in the ERROR field and the STATUS field.

3.1.22 COMRESET
commanded hardware reset in the Serial ATA transport

Note 1 to entry: See ATA8-AST.

3.1.23 depopulate
process by which a device removes the capability of a storage element to store logical block data

3.1.24 depopulated
property associated with a physical element that results in the element being unable to store logical block data

3.1.25 depopulation operation
process by which a device removes the capability of a storage element to store user data

3.1.26 device
data storage peripheral

Note 1 to entry: An example of a device is a disk drive.

Note 2 to entry: see 3.1.10.

3.1.27 device configuration changing command
command that is able to change the configuration of the logical sector to physical sector mapping

Note 1 to entry: The following commands are the device configuration changing commands: MUTATE EXT (see 7.16), SET SECTOR CONFIGURATION EXT (see 7.46), REMOVE ELEMENT AND TRUNCATE (see 7.33), and RESTORE ELEMENTS AND REBUILD (see 7.35).

3.1.28 dirty data
user data in a non-volatile cache that is newer than the corresponding data in the primary medium

3.1.29 DMA data transfer
means of data transfer between device and host memory without application client intervention

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3.1.30 DRQ data block
number of logical sectors with available status when using either the PIO Data-In command protocol or the PIO Data-Out command protocol

3.1.31 DQWord
sequence of 16 contiguous bytes considered as a unit

Note 1 to entry: See 3.4.8

3.1.32 DWord
sequence of four contiguous bytes considered as a unit

Note 1 to entry: See 3.4.8

3.1.33 evict
a process within the device to remove user data from the non-volatile cache

3.1.34 FIS
frame structure used by the Serial ATA transport

Note 1 to entry: See ATA8-AST.

3.1.35 flush command
command that flushes the volatile write cache

Note 1 to entry: The following commands are the flush commands: the FLUSH CACHE (see 7.10) command and the FLUSH CACHE EXT (see 7.11) command.

3.1.36 free-fall
vendor specific condition of acceleration

3.1.37 garbage collection operation
process that prepares resources for future allocation

3.1.38 GPL command
command that is associate with the General Purpose Logging feature set

Note 1 to entry: The following commands are the GPL commands: READ LOG EXT, READ LOG DMA EXT, WRITE LOG EXT, and WRITE LOG DMA EXT.

3.1.39 hardware reset
routine performed by a device after a hardware reset event

Note 1 to entry: See the Device Management protocol in ATA8-AAM.

3.1.40 host
object that originates commands and device management functions

Note 1 to entry: See ATA8-AAM.

3.1.41 host interface
service delivery subsystem

Note 1 to entry: See ATA8-AAM.

3.1.42 hybrid device
a device that contains a primary medium and a non-volatile cache

3.1.43 ID Not Found error
command completion with the ID NOT FOUND bit set to one (see 6.3.4)

3.1.44 Idle mode
one or all of the power conditions associated with the PM1: Idle state (see 4.17.4)

3.1.45 LBA
value used to reference a logical sector

3.1.46 LBA mapping resource
resource (e.g., a physical block or a data structure associated with tracking resource usage) that enables storage upon media

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3.1.47 LBA resource
resource (e.g., a physical block) used for storing user data

3.1.48 log
named sequence of one or more log pages

Note 1 to entry: See clause 9.

3.1.49 log address
numeric value that a log command uses to identify a specific log

3.1.50 log command
SMART READ LOG command (see 7.48.2), SMART WRITE LOG command (see 7.48.4), or GPL feature set (see 4.11) command

3.1.51 log page
512-byte block of data associated with a log

Note 1 to entry: See clause 9.

3.1.52 logical block
synonym for logical sector

Note 1 to entry: See 3.1.53.

3.1.53 logical sector
set of words accessed and referenced as a unit (see 9.10.4.4) that contain user data and are referenced by LBA (see 3.1.45)

3.1.54 logical sector size
size in words of logical sectors on the device

Note 1 to entry: If the LOGICAL SECTOR SIZE SUPPORTED bit (see 9.10.4.3.2) is cleared to zero, the device logical sector size is 256 words. If the LOGICAL SECTOR SIZE SUPPORTED bit is set to one, the device logical sector size is indicated by the contents of the LOGICAL SECTOR SIZE field (see 9.10.4.4).

3.1.55 mapping resource
a vendor specific mechanism that may be used by the device internally to describe the physical location and attributes of user data

3.1.56 media
material on which user data is stored

3.1.57 media access command
command that causes the device to access non-volatile media

3.1.58 native max address
LBA that a device reports by GET NATIVE MAX ADDRESS EXT command (see 7.2.2) and the maximum LBA accepted by a device using the SET ACCESSIBLE MAX ADDRESS EXT command (see 7.2.3)

3.1.59 NCQ command
command in the NCQ feature set

Note 1 to entry: See 4.15.

3.1.60 non-volatile media
physical storage media that retains user data written to it through all reset events (e.g., power-on reset)

3.1.61 partition
range of LBAs specified by an application client

3.1.62 PATA device
device that implements the parallel ATA transport

Note 1 to entry: See ATA8-APT.

3.1.63 physical element
subcomponent of an ATA device

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3.1.64 physical sector
one or more contiguous logical sectors that are read from or written to the device media in a single operation

3.1.65 PIO
data transfers performed using PIO commands and protocol

3.1.66 power condition
one of the following power management substates: Idle_a, Idle_b, Idle_c, Standby_y or Standby_z

Note 1 to entry: See 4.9.

3.1.67 power cycle
when power is removed from a host or device until the subsequent power-on event

Note 1 to entry: See the Device Power-on protocol in ATA8-AAM.

3.1.68 power-on reset
routine performed by a device after detecting a power-on event

Note 1 to entry: See ATA8-AAM.

3.1.69 primary medium
the medium to which all user data is synchronized

3.1.70 queued command
NCQ command that has reported command acceptance but not command completion

3.1.71 QWord
sequence of eight contiguous bytes considered as a unit

Note 1 to entry: See 3.4.8.

3.1.72 read command
command that causes the device to retrieve user data

Note 1 to entry: The following commands are the read commands: the READ DMA command, READ DMA EXT command, READ FPDMA QUEUED command, READ SECTOR(S) command, READ SECTOR(S) EXT command, READ STREAM EXT command, READ STREAM DMA EXT command, READ VERIFY SECTOR(S) command, and READ VERIFY SECTOR(S) EXT command.

3.1.73 read stream command
command that causes the device to transfer user data from the device to the host

Note 1 to entry: The following commands are the read stream commands: the READ STREAM EXT command and READ STREAM DMA EXT command.

3.1.74 SATA device
device implementing the serial ATA transport

Note 1 to entry: See ATA8-AST.

3.1.75 SCT Command
command that writes to the SCT command/status log

Note 1 to entry: See clause 8.

3.1.76 SCT Status
command that reads from the SCT command/status log

Note 1 to entry: See clause 8.

3.1.77 Secure Content Storage Association
organization that develops specifications for protecting digital media content

Note 1 to entry: See https://www.vidity.com/ for information on the Secure Content Storage Association.

3.1.78 sense data
combination of the DEFERRED ERROR bit (see 4.24.2), sense key (see 3.1.79), and additional sense code (see 3.1.5)

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3.1.79 sense key
contents of the SENSE KEY field in the sense data

Note 1 to entry: See SPC-5.

3.1.80 signature
unique set of values placed in the return parameters used to distinguish device types (e.g., ATA device)

Note 1 to entry: See table 349.

3.1.81 signed
value that is encoded using two's complement

3.1.82 Sleep mode
power condition specified by the PM3: Sleep state

Note 1 to entry: See 4.17.4.

3.1.83 software reset
routine performed by a device after a software reset event

Note 1 to entry: See the Device Management protocol in ATA8-AAM.

3.1.84 solid state device
a device which uses non-volatile memory to store user data

3.1.85 spin-down
process of bringing a rotating media device's media to a stop

3.1.86 spin-up
process of bringing a rotating media device's media to operational speed

3.1.87 Standby mode
one or all of the power conditions associated with the PM2: Standby state

Note 1 to entry: See 4.17.4.

3.1.88 storage depopulation command
command associated with the storage element depopulation feature set (see 4.26)

Note 1 to entry: The following commands are the storage depopulation commands: the REMOVE ELEMENT AND TRUNCATE command and the RESTORE ELEMENTS AND REBUILD command.

3.1.89 storage element
physical element that provides non-volatile storage for an associated group of logical blocks (see 4.19)

3.1.90 stream
set of operating parameters specified by a host using the CONFIGURE STREAM command (see 7.4) to be used for subsequent read stream commands and write stream commands

3.1.91 sync
a process within the device where dirty data in the non-volatile cache is written to the primary medium

3.1.92 transport
mechanism used to communicate with a device

Note 1 to entry: See ATA8-APT and ATA8-AST.

3.1.93 trim command
DATA SET MANAGEMENT command with the TRIM bit set to one or DATA SET MANAGEMENT XL command with the TRIM bit set to one

3.1.94 trimmed
property associated with a logical sector that affects the data returned by read commands

3.1.95 trimmed logical sector
logical sector that has been affected by a command that has the TRIM bit set to one

Note 1 to entry: Commands that request logical sectors to be trimmed may not affect all specified logical sectors.

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3.1.96 truncate operation
process by which a device reduces its native capacity

3.1.97 unaligned write
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

3.1.98 unrecoverable error
error for which a device is unable to read a logical block or write a logical block

3.1.99 user data
data that is transferred between the host and the device using read commands and write commands

3.1.100 user data area
area of the media that is addressable from LBA 0 to the native max address if the Accessible Max Address Configuration feature set is supported, or LBA 0 to the maximum value defined in table 5 if the Accessible Max Address Configuration feature set is not supported

3.1.101 volatile cache
cache that does not retain data through power cycles

3.1.102 word
sequence of two contiguous bytes considered as a unit

Note 1 to entry: See 3.4.8.

3.1.103 write FUA command
write command that specifies that the device store user data to non-volatile media before reporting command completion

Note 1 to entry: The WRITE FPDMA QUEUED command with the FUA bit set to one, and the WRITE DMA FUA EXT command are the write FUA commands.

3.1.104 write command
command that causes the device to store user data

Note 1 to entry: The following commands are the write commands: the SCT Write Same command, WRITE DMA command, WRITE DMA EXT command, WRITE DMA FUA EXT command, WRITE FPDMA QUEUED command, WRITE SECTOR(S) command, WRITE SECTOR(S) EXT command, WRITE STREAM DMA EXT command, WRITE STREAM EXT command, and ZERO EXT command.

3.1.105 write stream command
command that causes the device to transfer user data from the host to the device

Note 1 to entry: The following commands are the write stream commands: the WRITE STREAM DMA EXT command and WRITE STREAM EXT command.

3.1.106 WWN (World Wide Name)
64 bit worldwide unique name based upon a company's IEEE AOI

Note 1 to entry: See 9.10.5.8.

Note 2 to entry: The WWNs defined by this standard are based on the Name_Identifiers defined in FC-FS-6 (see Bibliography).

3.2 Symbols and abbreviations

3.2.1 Abbreviations

Abbreviations used in this standard:

Abbreviation	Meaning
ABO	Advanced Background Operation
ACS	ATA Command Set
AOI	Administered Organizational Identifier
APM	Advanced Power Management
ASC	Additional Sense Code

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Abbreviation	Meaning
ASCII	American Standard Code for Information Interchange
ASCQ	Additional Sense Code Qualifier
ASR	Asynchronous Signal Recovery (see SATA 3.5)
ATA	AT Attachment
ATA8-AAM	AT Attachment-8 - ATA/ATAPI Architecture Model (see clause 2)
ATA8-ACS	AT Attachment-8 - ATA/ATAPI Command Set (see Bibliography)
ATA8-APT	AT Attachment-8 - Parallel Transport (see clause 2)
ATA8-AST	AT Attachment-8 - Serial Transport (see clause 2)
BIOS	Basic Input/Output System
CCTL	Command Completion Time Limit (see 7.4.3.4 and 7.28.3.2)
CFA	CompactFlash Association (see www.compactflash.org)
CFast	CompactFlash ATA Serial Transport (see clause 2)
CRC	Cyclic Redundancy Check
DAS	Device Activity Signal (see SATA 3.5)
DMA	Direct Memory Access
DRQ	Data ReQuest (see ATA8-APT)
DSN	Device Statistics Notification
DSS	Disable Staggered Spinup (see SATA 3.5)
EPC	Extended Power Conditions
EXT	Command that uses the extended (48-bit LBA) format parameters
FC-FS-6	Fibre Channel Framing and Signaling - 6 (see Bibliography)
FIS	Frame Information Structure
FUA	Forced Unit Access
GPL	General Purpose Logging
ISO	Organization for International Standards
LBA	Logical Block Address
LLS	Long Logical Sector
LPS	Long Physical Sector
LSB	Least Significant Bit
MSB	Most Significant Bit
NVM	Non-Volatile Memory
NCQ	Native Command Queueing
PATA	Parallel ATA
PCIe	PCI Express®
PIO	Programmed Input/Output
PUIS	Power-Up In Standby
RMW	Read-Modify-Write
SATA	Serial ATA
SATA-IO	Serial ATA International Organization (see www.sata-io.org)
SBC-4	SCSI Block Commands - 4
SCSA	Secure Content Storage Association
SMART	Self-Monitoring Analysis and Reporting Technology
SPC-5	SCSI Primary Commands - 5 (see clause 2)
SSP	Software Settings Preservation
T10	INCITS Technical Committee T10
TCG	Trusted Computing Group (see www.trustedcomputinggroup.org)
VS	Vendor Specific
WWN	World Wide Name
ZAC-2	Zoned Device ATA Command Set - 2 (see clause 2)

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3.2.2 Units

Units used in this standard:

Unit	Meaning
h	hour (unit of time)
min	minute (unit of time)
ma	milliampere
ms	millisecond (i.e., 10^{-3} seconds)
ns	nanosecond (i.e., 10^{-9} seconds)
s	second (unit of time)
µs	microsecond (i.e., 10^{-6} seconds)
V	volt

3.2.3 Symbols

Symbols used in this standard:

Symbol	Meaning
©	copyright
®	registered trademark
™	unregistered trademark

3.2.4 Mathematical operators

Mathematical operators used in this standard:

Mathematical Operator	Meaning
+	added to
×	multiplied by
/	divided by
^	power of
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to

3.3 Keywords

3.3.1 expected
keyword used to describe the behavior of the hardware or software in the design models assumed by this standard

Note 1 to entry: Other hardware and software design models may also be implemented.

3.3.2 mandatory
keyword indicating items to be implemented as defined by this standard

3.3.3 may
keyword that indicates flexibility of choice with no implied preference

3.3.4 N/A
keyword that indicates a field is not applicable and has no defined value

Note 1 to entry: A field defined as N/A should not be checked by the host or device.

3.3.5 obsolete
keyword indicating that the designated bits, bytes, words, fields, and code values that may have been defined in

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previous standards are not defined in this standard and shall not be reclaimed for other uses in future standards

Note 1 to entry: Some degree of functionality may be required for items designated as “obsolete” to provide for backward compatibility.

Note 2 to entry: Obsolete commands should not be used by the host.

Note 3 to entry: Commands defined as obsolete may return command aborted by devices conforming to this standard. However, if a device does not return command aborted for an obsolete command, the device shall return command completion for the command.

3.3.6 optional
keyword that describes features that are not required by this standard

Note 1 to entry: If any optional feature defined by the standard is implemented, the feature shall be implemented in the way defined by the standard.

3.3.7 prohibited
keyword indicating that an item shall not be supported by an implementation

3.3.8 reserved
keyword indicating reserved bits, bytes, words, fields, and code values that are set aside for future standardization

Note 1 to entry: The use and interpretation of reserved bits, bytes, words, fields, and code values may be specified by future extensions to this or other standards.

Note 2 to entry: A reserved bit, byte, word, or field shall be cleared to zero, or set in accordance with a future extension to this standard.

Note 3 to entry: The recipient shall not check reserved bits, bytes, words, or fields.

Note 4 to entry: Receipt of reserved code values in defined fields shall be considered a command parameter error and reported by returning command aborted.

3.3.9 retired
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

Note 1 to entry: 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.

3.3.10 shall
keyword indicating a mandatory requirement

Note 1 to entry: Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this standard.

3.3.11 should
keyword indicating flexibility of choice with a strongly preferred alternative

Note 1 to entry: This keyword is equivalent to the phrase “it is recommended”.

3.3.12 vendor specific
something (e.g., a bit, field, code value) that is not defined by this standard

Note 1 to entry: Specification of the referenced item is determined by the device vendor and may be used differently in various implementations.

3.4 Conventions

3.4.1 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 3.4.5 for the naming convention used for naming bits.)

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Names of fields are in small uppercase (e.g., DRAT SUPPORTED). Normal case is used when the contents of a field are being discussed. Fields containing only one bit are usually referred to as the NAME bit instead of the NAME field.

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

3.4.2 Precedence

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

3.4.3 Lists

3.4.3.1 Lists overview

Lists are associated with an introductory paragraph or phrase, and are numbered relative to that paragraph or phrase (i.e., all lists begin with an a) or 1) entry).

Each item in a list is preceded by an identification with the style of the identification being determined by whether the list is intended to be an ordered list or an unordered list.

If the item in a list is not a complete sentence, the first word in the item is not capitalized. If the item in a list is a complete sentence, the first word in the item is capitalized.

Each item in a list ends with a semicolon, except the last item, which ends in a period. The next to the last entry in the list ends with a semicolon followed by an “and” or an “or” (i.e., “…; and”, or “…; or”). The “and” is used if all the items in the list are required. The “or” is used if only one or more items in the list are required.

3.4.3.2 Unordered lists

An unordered list is one in which the order of the listed items is unimportant (i.e., it does not matter where in the list an item occurs as all items have equal importance). Each list item shall start with a lower case letter followed by a close parenthesis. If it is necessary to subdivide a list item further with an additional unordered list (i.e., have a nested unordered list), then the nested unordered list shall be indented and each item in the nested unordered list shall start with an upper case letter followed by a close parenthesis.

The following is an example of an unordered list with a nested unordered list:

EXAMPLE - The following are the items for the assembly:

a) a box containing:
   A) a bolt;
   B) a nut; and
   C) a washer;
b) a screwdriver; and
c) a wrench.

3.4.3.3 Ordered lists

An ordered list is one in which the order of the listed items is important (i.e., item n is required before item n+1). Each listed item starts with a Western-Arabic numeral followed by a close parenthesis. If it is necessary to subdivide a list item further with an additional unordered list (i.e., have a nested unordered list), then the nested unordered list shall be indented and each item in the nested unordered list shall start with an upper case letter followed by a close parenthesis.

The following is an example of an ordered list with a nested unordered list:

EXAMPLE - The following are the instructions for the assembly:

1) remove the contents from the box;
2) assemble the item;
   A) use a screwdriver to tighten the screws; and
   B) use a wrench to tighten the bolts;
   and
3) take a break.

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3.4.4 Numbering

A binary number is represented in this standard by any sequence of digits consisting of only the Western-Arabic numerals 0 and 1 immediately followed by a lower-case b (e.g., 0101b). Underscores or spaces may be included between characters in binary number representations to increase readability or delineate field boundaries (e.g., 0 0101 1010b or 0_0101_1010b).

A hexadecimal number is represented in this standard by any sequence of digits consisting of only the Western-Arabic numerals 0 through 9 and/or the upper-case English letters A through F immediately followed by a lower-case h (e.g., FA23h). Underscores or spaces may be included between characters in hexadecimal number representations to increase readability or delineate field boundaries (e.g., B FD8C FA23h or B_FD8C_FA23h).

A decimal number is represented in this standard by any sequence of digits consisting of only the Arabic numerals 0 through 9 not immediately followed by a lower-case b or lower-case h (e.g., 25). This standard uses the following conventions for representing decimal numbers:

a) the decimal separator (i.e., separating the integer and fractional portions of the number) is a period;
b) the thousands separator (i.e., separating groups of three digits in a portion of the number) is a space; and
c) the thousands separator is used in both the integer portion and the fraction portion of a number.

Table 1 shows some examples of decimal numbers using various numbering conventions.

Table 1 — Numbering conventions

French	English	This standard
0,6	0.6	0.6
3,141 592 65	3.14159265	3.141 592 65
1 000	1,000	1 000
1 323 462,95	1,323,462.95	1 323 462.95

A decimal number represented in this standard with an overline over one or more digits following the decimal point is a number where the overlined digits are infinitely repeating (e.g., $666.\overline{6}$ means 666.666 666… or 666 2/3, and $12.\overline{142\ 857}$ means 12.142 857 142 857… or 12 1/7).

3.4.5 Bit conventions

Name (n:m), where n is greater than m, denotes a set of bits (e.g., Feature (7:0)). n:m where n is greater than m denotes a bit range in a table.

3.4.6 Number range convention

p..q, where p is less than q, represents a range of numbers (e.g., words 100..103 represents words 100, 101, 102, and 103).

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3.4.7 State diagram conventions

All state diagrams use the notation shown in Figure 2.

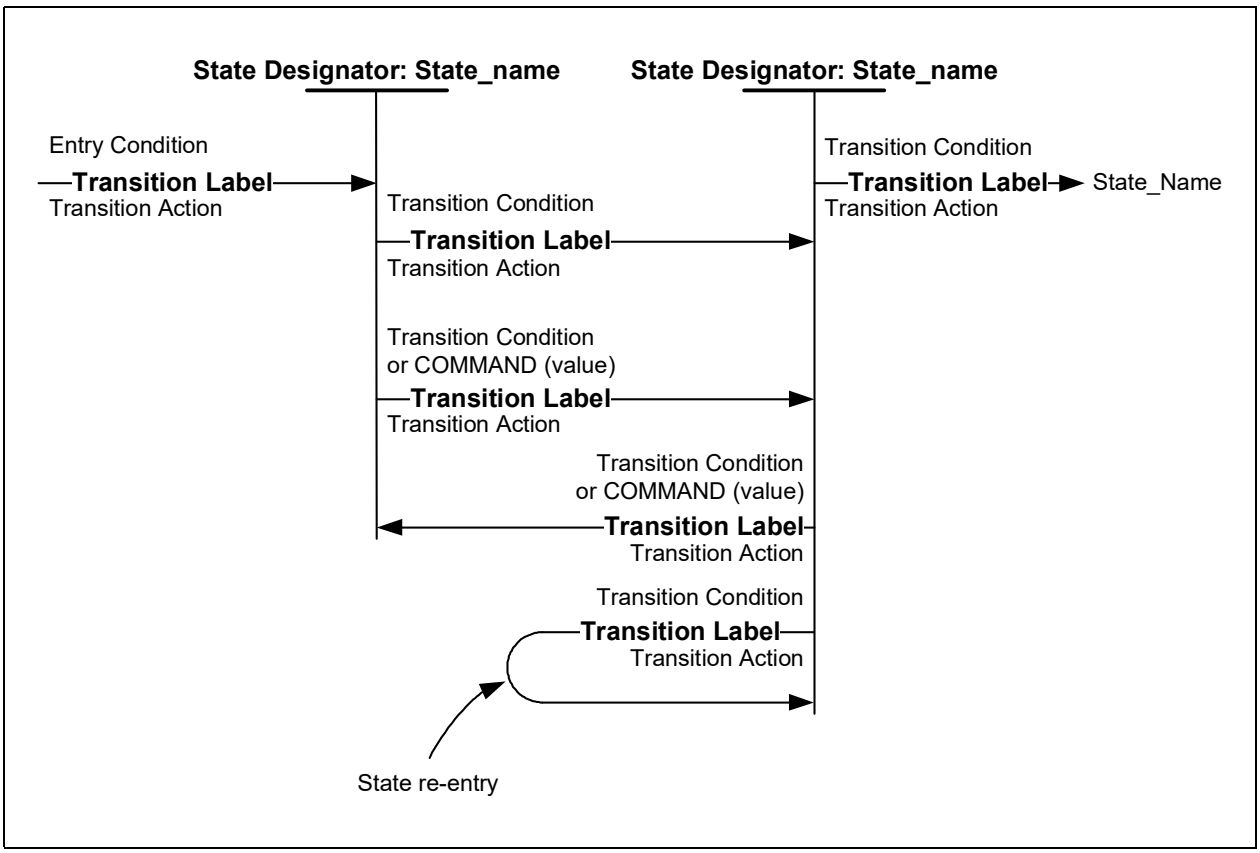

Figure 2 — State diagram convention

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 standard. 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, then the primary functions 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, a transition condition, and optionally by a transition action. 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. 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 processed. 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. A transition action may be included, indicated in italics, that is taken when the transition occurs. This action is described in the transition description text.

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

Each state machine is instantiated based on the Entry Conditions. An Entry Condition is a transition based on an action occurring outside of the state machine.

All transitions shall be instantaneous.

The notation COMMAND (value), as a transition condition, refers to the device receiving the command with a specific value or values. For example:

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a) CRYPTO SCRAMBLE EXT (failure exit allowed) means the device processes a CRYPTO SCRAMBLE EXT command with the FAILURE MODE bit set to one; or
b) CRYPTO SCRAMBLE EXT (hard failure required) means the device processes CRYPTO SCRAMBLE EXT command with the FAILURE MODE bit cleared to zero.

If the (value) notation is not present on a transition, then the transition occurs for any parameter combination of the command.

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3.4.8 Byte, word, DWord, QWord, and DQWord Relationships

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

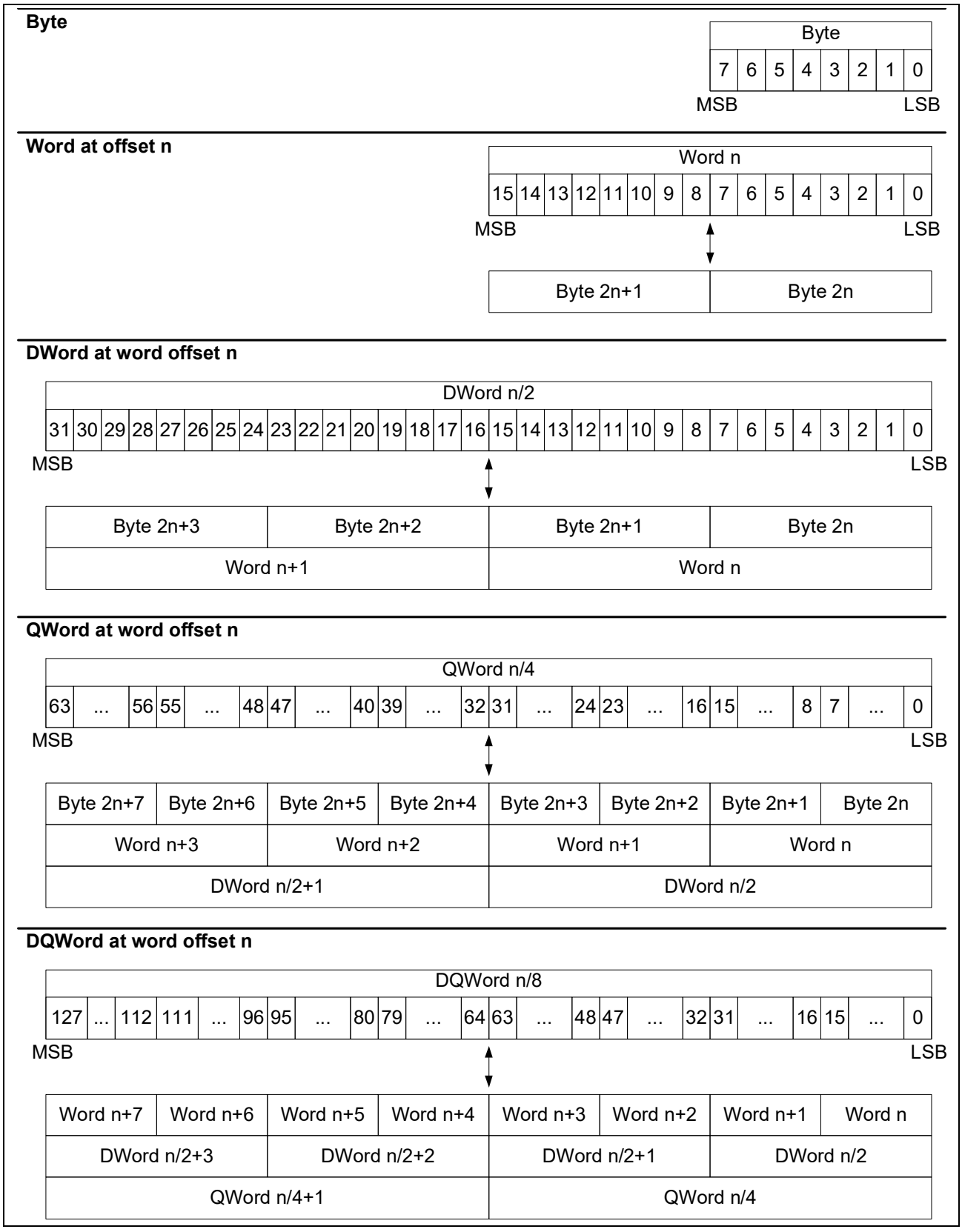

Figure 3 — Byte, word, DWord, QWord, and DQWord relationships

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Unless stated or defined otherwise, in a field containing a multi-byte value (e.g., a word, DWord, or QWord), the byte containing the LSB is stored at the lowest offset and the byte containing the MSB is stored at the highest offset.

EXAMPLE 1 - If the two-byte field (i.e., word) in SCT command (see table 203) word 0 contains 0007h, then:

a) byte 0 contains 07h; and
b) byte 1 contains 00h.

EXAMPLE 2 - If the four-byte field (i.e., DWord) at IDENTIFY DEVICE data words 60..61 (see table 57) contains 8001_0203h (i.e., 2 147 549 699), then:

a) byte 120 contains 03h;
b) byte 121 contains 02h;
c) byte 122 contains 01h; and
d) byte 123 contains 80h.

EXAMPLE 3 - If an eight-byte field (i.e., QWord) in the SCT Write Same command words 2..5 (see table 205) contains 0000_0504_0302_0100h), then:

a) byte 4 contains 00h;
b) byte 5 contains 01h;
c) byte 6 contains 02h;
d) byte 7 contains 03h;
e) byte 8 contains 04h;
f) byte 9 contains 05h;
g) byte 10 contains 00h; and
h) byte 11 contains 00h.

Exceptions to this convention include:

a) each field containing an ATA string (e.g., fields in the ATA Strings log page (see 9.10.7)) is considered to be an array of bytes, not a multi-byte value, and is handled as described in 3.4.9;
b) the IDENTIFY DEVICE data World Wide Name field consists of four word fields rather than one QWord field and is handled as described in 7.13.6.58; and
c) parameter data in the TRUSTED RECEIVE command (see 7.52), TRUSTED RECEIVE DMA command (see 7.53), TRUSTED SEND command (see 7.54), and TRUSTED SEND DMA command (see 7.55) is formatted as defined in those subclauses or in the standard defining the security protocol.

3.4.9 ATA string convention

ATA strings (e.g., the MODEL NUMBER field (see 9.10.7.4)) are sequences of bytes containing ASCII graphic characters in the range of 20h-7Eh. ATA strings shall not contain values in the range of 00h-1Fh or 7Fh-FFh.

Each pair of bytes in an ATA string is swapped as shown in table 2.

Table 2 — ATA string byte swapping

Word	Offset	Character in string
0	0	Second character
	1	First character
1	2	Fourth character
	3	Third character
…	…	…
n	2n	Last character
	2n+1	Second-to-last character

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Using the ATA string that contains firmware revision information as an example, table 3 shows the contents of the FIRMWARE REVISION field (see 9.10.7.3) in the Strings page (see 9.10.7) in IDENTIFY DEVICE data log (see 9.10). In this example, the firmware revision string is “abcdefg ”, including one padding space character at the end of the string. Table 3 also shows the copy of the FIRMWARE REVISION field that uses the word format of the IDENTIFY DEVICE input from device to host data structure (see 7.13.6).

Table 3 — FIRMWARE REVISION field example

Strings page [a] offset	Value	Copy of FIRMWARE REVISION field in IDENTIFY DEVICE data [b]		
		Offset	Word	Value
32	62h (i.e., “b”)	46	23	6162h (i.e., “ba”)
33	61h (i.e., “a”)	47		
34	64h (i.e., “d”)	48	24	6364h (i.e., “dc”)
35	63h (i.e., “c”)	49		
36	66h (i.e., “f”)	50	25	6566h (i.e., “fe”)
37	65h (i.e., “e”)	51		
38	20h (i.e., “ “, the space character)	52	26	6720h (i.e., “ g”)
39	67h (i.e., “g”)	53		

[a] See Strings page (see 9.10.7) in IDENTIFY DEVICE data log (see 9.10).
[b] See table 57.

3.4.10 Offset Convention

An offset is a byte value used as an index into a larger data structure.

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4 Feature set definitions

4.1 Overview

4.1.1 Feature set summary

Table 4 lists the feature sets in alphabetical order and shows whether a feature set is mandatory, optional, or prohibited for ATA devices.

Table 4 — Feature set summary

Feature set	ATA devices
48-bit Address feature set (see 4.3)	O
Accessible Max Address Configuration feature set (see 4.4)	O
Advanced Background Operation feature set (ABO) (see 4.5)	O
Advanced Power Management (APM) feature set (see 4.6)	O
Command Duration Limits feature set (see 4.7)	O
Device Statistics Notifications (DSN) feature set (see 4.8)	O
Extended Power Conditions (EPC) feature set (see 4.9)	O
Free-fall Control feature set (see 4.10)	O
General feature set (see 4.2)	M
General Purpose Logging (GPL) feature set (see 4.11)	M
Hybrid Information feature set (see 4.12)	O
Long Logical Sector (LLS) feature set (see 4.13)	O
Long Physical Sector (LPS) feature set (see 4.14)	O
Native Command Queuing (NCQ) feature set (see 4.15)	O
Out Of Band Management Interface (see 4.16)	O
Power Management feature set (see 4.17)	M
Power-Up In Standby (PUIS) feature set (see 4.18)	O
Rebuild Assist feature set (see 4.19)	O
Sanitize Device feature set (see 4.20)	O
SATA Hardware Feature Control feature set (see 4.21)	O
Security feature set (see 4.22)	O
Self-Monitoring, Analysis, and Reporting Technology (SMART) feature set (see 4.23)	O
Sense Data Reporting feature set (see 4.24)	O
Software Settings Preservation (SSP) feature set (see 4.25)	O
Storage Element Depopulation feature set (see 4.26)	O
Streaming feature set (see 4.27)	O
Trusted Computing feature set (see 4.28)	O
User Data Initialization feature set (see 4.29)	O
Write-Read-Verify feature set (see 4.30)	O
Key: M – Mandatory, O – Optional	

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